OH2214

MODEL
360
VECTOR NETWORK ANALYZER

OPERATION MANUAL

Software Version: 2.01

WILTRON

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SECTION I
GENERAL INFORMATION

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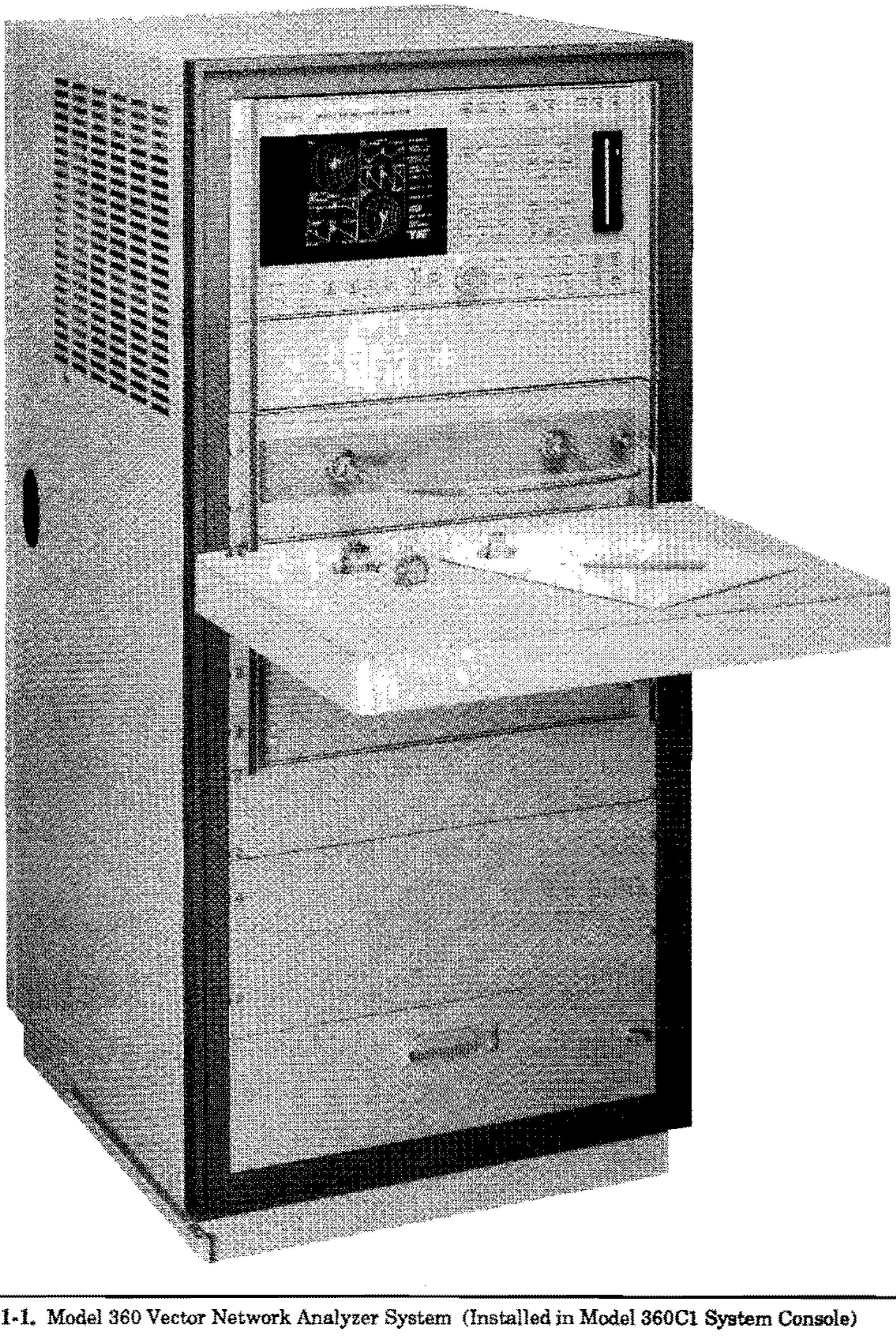


Figure 1-1. Model 360 Vector Network Analyzer System (Installed in Model 360C1 System Console)

SECTION I
GENERAL INFORMATION

1-1 SCOPE OF MANUAL

This manual provides general information, installation, and operating information—both control (front) panel and GPIB—for the Model 360 Vector Network Analyzer system. The manual is organized as shown in the table of contents.

1-2 INTRODUCTION

This section provides general information about the 360 system, which consists of the network analyzer, a test set, a signal (frequency) source, and one or more component kits. The section also provides system specifications and a listing of recommended test equipment needed for operation, verification, calibration, and service.

1-3 IDENTIFICATION NUMBER

All WILTRON instruments are assigned a unique six-digit ID number, such as"701001." This number is affixed to a decal on the rear panel of each unit. For the signal source, this number is the serial number of the microwave deck assembly. The basic frame assembly also has a serial number assigned. It is affixed to the *inside* of the rear panel. In any correspondence with WILTRON Customer Service, please use the serial number located on the outside rear panel. The system operating software is keyed to the analyzer identification number. For systems having the time-domain option installed, the operating-system will only load on the serial-numbered 360 one for which it is identified.

1-4 RELATED MANUALS

The 360 requires five manuals for complete coverage. These manuals are described in Table 1-1. This table also lists and describes the 360 optional-equipment manuals.

1-5 SYSTEM DESCRIPTION

1-5.1 Network Analyzer

The 360 network analyzer is the control and display unit for all versions of the system. Its control (front) panel controls provide menu selections for test functions, test parameters, measurement enhancements, and frequencies. Frequency information is sent to the signal (frequency) source over a dedicated system GPIB. Test parameters, system status, and measurement data are displayed on the large color screen and hard copied on a printer or plotter.

1-5.2 Test Set

Test sets are available that allow microwave vector measurements—including S parameter measurements of both active and passive devices—frequency conversion measurements, antenna measurements, and receiver measurements. Frequency range is 10 MHz to 40 GHz. Millimeter-wave test sets to 110 GHz are also available.

1-5.3 Signal Source

Two signal sources are available—10 MHz to 18 GHz and 10 MHz to 40 GHz. The signal source is controlled by the network analyzer from a dedicated IEEE-488 bus. It provides clean, phase-locked test signals for precise test data. Frequency resolution is 100 kHz. Standard 6600B models are also compatible and could be used in place of the 360SS45 and 360SS69 sources.

Table 1-1. List of Related Manuals

Manual Title	Description	Part Number
Model 360 Operating Manual (360 OM)	This manual provides general information, specifications, installation instructions, and local (front panel), and remote (GPIB) operating data and procedural information for the 360 system.	10410-00022
Model 360 Performance Verification and Calibration Maintenance Manual (360 PV&C MM	This manual provides performance verification and calibration procedures for the system.	10410-00028
Model 360 Network Analyzer Maintenance Manual (360 MM)	This manual provides service information for the network analyzer. It includes parts lists, circuit descriptions, block diagrams, schematic diagrams, and removal and installation instructions for certain analyzer subassemblies.	10410-00032
Model 36XX Test Set Maintenance Manual (36XX TSMM)	This manual provides service information for the Models 3610, 3611, 3620, and 3621 Test Sets. It includes parts lists, circuit descriptions, block diagrams, schematic diagrams, and removal and installation instructions for certain test set subassemblies.	10410-00036
Model 360SSXX Signal Source Maintenance Manual (360SSXX MM)	This manual provides service information for the Models 36SS45 and 36SS59 Signal Sources. It includes parts lists, circuit descriptions, block diagrams, schematic diagrams, and removal and installation instructions for certain signal source subassemblies.	10410-00040
Model 36XX Calibration Kit Operation and Maintenance Manual (36XXCK OMM).	This manual provides operating and maintenance data and procedures for the various components in the Models 3650, 3651, 3652, and 3653 Calibration Kits.	10100-00014
Model 36XX Verification Kit Operation and Maintenance Manual (36XXVK OMM).	This manual provides operating and maintenance data and procedures for the various components in the Models 3666, 3667, and 3668 Verification Kits.	10100-00022
WILTRON 2360-1/2360-2 Software User's Guide (2360-X SUG)	This SUG provides operating information, data, and procedures for the Standard Network Analyzer software, P/N 2360-1, and Time Domain software, P/N 2360-2.	10550-00042

1-6 PRECISION COMPONENT KITS

Two types of precision-component kits are available: calibration and verification. The calibration kit contain components used to identify and separate the error sources inherent in a microwave test setup. The verification kit consists of components with characteristics traceable to NBS. This kit is usually kept in the metrology laboratory where it provides the most dependable means of checking system accuracy. Each of these kits contains a microfloppy disk providing coefficient data for each component. Details of these kits are described in the following paragraphs.

1-6.1 Model 3650 SMA/3.5 mm Calibration Kit

The 3650 Calibration Kit (Figure 1-2) contains all the precision components and tools required to calibrate the 360 for 12-term error-corrected measurements of test devices with SMA or 3.5 mm connectors. Components are included for calibrating both male and female test ports. The kit supports calibration with broadband loads. Option 1 adds sliding loads.

The 3650 consists of the following components:

- 23S50 Short, SMA/3.5mm Male
- 23SF50 Short, SMA/3.5mm Female
- 24S50 Open, SMA/3.5mm Male
- 24SF50 Open, SMA/3.5mm Female
- 28S50–2 Termination, SMA/3.5mm Male, 2 ea. (dc–26.5 GHz)
- 28SF50—2 Termination, SMA/3.5mm Female, 2 ea. (dc–26.5 GHz)
- 33SFSF50 Insertable, SMA/3.5mm Female/-Female, 2 ea.
- 33SS50 Insertable, SMA/3.5mm Male/Male, 2 ea.
  33SSF50 Insertable, SMA/3.5mm Male-/Female
- 34AS50–2 Adapter, GPC-7 to SMA/3.5mm Male, 2 ea. 34ASF50–2 Adapter, GPC-7 to SMA/3.5mm Female, 2 ea.
- 01–201 Torque Wrench
- 01–210 Reference Flat
- 01–222 Connector Gauge
- 01–223 Gauge Kit Adapter
- Data Disk

Option 1: Adds 17S50 Sliding Load, SMA/3.5mm Male; 17SF50 Sliding Load, SMA/3.5mm Female; 01–211 Female Flush Short; and 01–212 Male Flush Short.

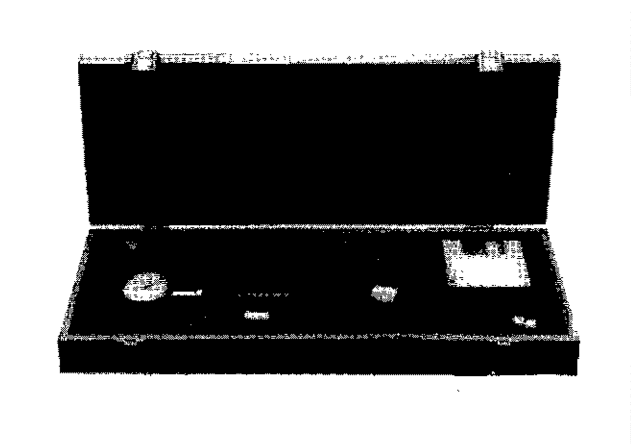


Figure 1-2. Typical Model 3650X Calibration Kit

1-6.2 Model 3651 GPC-7 Calibration Kit

The 3651 Calibration Kit (Figure 1-2) contains all the precision components and tools required to calibrate the 360 for 12-term error-corrected measurements of test devices with GPC–7 connectors. The kit supports calibration with broadband loads. Option 1 adds a sliding load.

The 3651 consists of the following components:

- 23A50 Short, GPC–7
- 24A50 Open, GPC–7
- 28A50–2 Termination, GPC-7, 2 ea. (dc–18 GHz)
- 01–200 Torque Wrench
- 01–210 Reference Flat
  01-221 Collet Extractor Tool and Vial of 4 Collets
- Data Disk

Option 1: Adds 17A50 Sliding Load, GPC–7; and 01–220 GPC–7 Connector Gauge.

1-6.3 Model 3652 K Connector Calibration Kit:

The 3652 Calibration Kit (Figure 1-2) contains all the precision components and tools required to calibrate the 360 for 12-term error-corrected measurements of test devices with K Connectors. Components are included for calibrating both male and female test ports. The kit supports calibration with broadband loads. Option 1 adds sliding loads.

The 3652 consists of the following components:

- 23K50 Short, K Male
- 23KF50 Short, K Female
- 24K50 Open, K Male
- 24KF50 Open, K Female
- 28K50–2 Termination, K Male, 2 ea. (dc–40 GHz)
- 28KF50-2 Termination, K Female, 2 ea. (dc–40 GHz)
- 33KK50 Insertable, K Male/Male
- 33KFKF50 Insertable, K Female/Female, 2 ea.
- 33KKF50 Insertable, K Male/Female, 2 ea.
- 34AK50 Adapter, GPC–7/K Male, 2 ea.
- 34AKF50 Adapter, GPC–7/K Female, 2 ea.
- 01–201 Torque Wrench
- 01–210 Reference Flat
- 01–222 Connector Gauge
- 01–223 Gauge Kit Adapter
- Data Disk

Option 1: Adds 17K50 Sliding Load, K Male; 17KF50 Sliding Load, K Female; 01–211 Female Flush Short; and 01–212 Male Flush Short.

1-6.4 Model 3653 Type N Calibration Kit

The 3653 Calibration Kit (Figure 1-2) contains all the precision components and tools required to calibrate the 360 for 12-term error-corrected measurements of test devices with Type N connectors. Components are included for calibrating both male and female test ports. The kit supports calibration with broadband loads. Option 1 for sliding loads is not available in this calibration kit.

The 3653 consists of the following components:
- 23N50 Short, N Male
- 23NF50 Short, N Female
- 24N50 Open, N Male
- 24NF50 Open, N Female
- 28N50–2 Termination, N Male, 2 ea. (dc–18 GHz)
- 28NF50–2 Termination, N Female, 2 ea. (dc–18 GHz)
- 34AN50–2 Adapter, GPC–7/N Male, 2 ea.
- 34ANF50–2 Adapter, GPC–7/N Female, 2 ea.
- 01–213 Type N Reference Gauge
- 01–224 Type N Connector Gauge
- Data Disk

1-6.5 Model 3666 3.5 mm Verification Kit

The 3666 Verification Kit (Figure 1-3) contains precision 3.5 mm components with characteristics that are traceable to the National Bureau of Standards. Used primarily by the metrology laboratory, these components provide the most dependable means of determining system accuracy. A disk containing factory-measured test data for all components is supplied for comparison with customer-measured data.

The 3666 consists of the following components:
- 19S50–10 10 cm Air Line
- 19S50–10B 10 cm Stepped Impedance Air Line (Beatty Standard)
- 41SB–20 20 dB Attenuator
- 41SB–50 50 dB Attenuator

1-6.6 Model 3667 GPC–7 Verification Kit

The 3667 Verification Kit (Figure 1-4) contains precision GPC–7 components with characteristics that are traceable to the National Bureau of Standards. Used primarily by the metrology laboratory, these components provide the most dependable means of determining system accuracy. A disk containing factory-measured test data for each component is supplied for comparison with customer-measured data.

The 3667 consists of the following components:
- 10A50–10B 10 cm Stepped Impedance Air Line (Beatty Standard)
- 18A50–10 10 cm Air Line
- 41AA–20 20 dB Attenuator
- 41AA–50 50 dB Attenuator

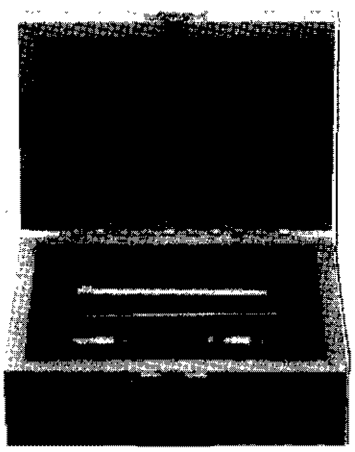


Figure 1-3. Model 3666 or 3668 Verification Kit

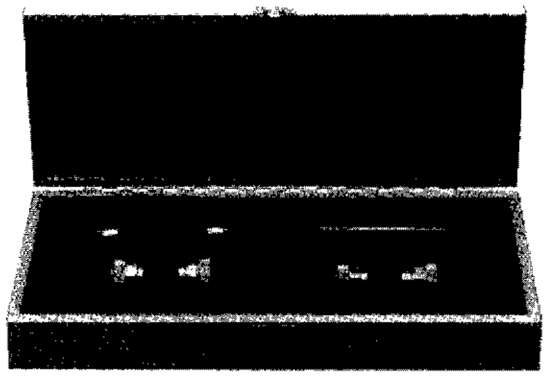


Figure 1-4. Model 3667 Verification Kit

1-6.7 3668 K Connector Verification Kit

The 3668 Verification Kit (Figure 1-3) contains precision K Connector components with characteristics that are traceable to the National Bureau of Standards. Used primarily by the metrology laboratory, these components provide the most dependable means of determining system accuracy. A disk containing factory-measured test data for each component is supplied for comparison with customer-measured data.

- The 3668 consists of the following components:
- 19K50–10 10 cm Air Line
- 19K50–10B 10 cm Stepped Impedance Air Line (Beatty Standard)
- 41KC–20 20 dB Attenuator
- 41KC–50 50 dB Attenuator

1-7 OPTIONS

a. Network Analyzer:
- Option 1: Rack Mount Slides and Ears.
- Option 1S: Instruments are configured for installation in the 360C1 Console or 360C2 Cabinet.
- Option 16: Monochrome Display

b. Test Set
- Option 1: Rack Mount Slides and Ears.
- Option 1S: Instruments are configured for installation in the 360C1 Console or 360C2 Cabinet

c. Signal Source
- Option 1: Rack Mount Slides and Ears.
- Option 1S: Instruments are configured for installation in the 360C1 Console or 360C2 Cabinet

NOTE

The Wiltron 6600B Series Sweep Generators and the 6700A Swept Frequency Synthesizers (1 kHz resolution) are also compatible with the 360.

1-8 TEST PORT CABLES

a. **Semirigid:**
- **3670A50–1 Test Port Cable,** dc to 18 GHz, GPC–7 connectors,1-foot long, 2 each required.
- **3670A50–2 Test Port Cable,** dc to 18 GHz, GPC–7 connectors, 2-feet long, 1 ea.required.
- **3670K50–1 Test Port Cable,** dc to 40 GHz, K Connectors, 1-foot long, female/female, 2 each required.
- **3670K50–2 Test Port Cable,** dc to 40 GHz, K Connectors, 2-feet long, female/female.

b. **Flexible:**
- 3671A50–1 Test Port Cable, dc to 18 GHz, GPC–7 Connectors, 1-foot long, 2 each required.
- **3671A50–2 Test Port Cable,** dc to 18 GHz, GPC–7 connectors, 2-feet long.
- **3671K50–1 Test Port Cable,** dc to 40 GHz, K Connectors, 1-foot long, female/female, 2 each required.
- **3671K50–2 Test Port Cable,** dc to 40 GHz, K Connectors, 2-feet long, female/female.

1-9 TEST PORT ADAPTERS

Test port adapters are available for use with the 3611 and 3621 Test Sets.
- 34UA50 Test Port Adapter, Universal/GPC–7
- 34UK50 Test Port Adapter, Universal/K Connector, male.
- 34UN50 Test Port Adapter, Universal/N, male.
- 34UNF50 Test Port Adapter, Universal/N, female.

1-10 SYSTEM SOFTWARE

- Time Domain Software, P/N 2360–2, including Standard Network Analyzer Measurement Software, P/N 2360–1.
- 2300–10 ANACAT Software.

1-11 CABINETS

- 360C1 System Console, including a work shelf, support rails, component storage drawer, and power distribution.
- 360C2 System Cabinet, including support rails and power distribution.

1-12 ACCESSORIES

- 2225C InkJet Dot-Matrix Printer, including 360 Centronics printer cable
- 2225–2 Replacement InkJet Cartridges, 2 each
- 2225–3 Fan-Fold InkJet Printer Paper, 2500 sheets
- 2000–209 3.5-inch Blank Diskettes, Box of 10

1-13 PERFORMANCE SPECIFICATIONS

System performance specifications are given in Table 1-2.

Table 1-2. Performance Specifications (1 of 5)

MEASUREMENT CAPABILITIES

Number of Channels: Four measurement channels.

Parameters: S_{11}, S_{21}, S_{22}, S_{12}; complex input and output impedance; complex input or output admittance; and complex forward and reverse transmission. All measurements are made without the need to manually reverse the test device.

Domains: Frequency Domain and optional Time Domain (2360–2). Measurements from both domains can be displayed simultaneously.

Formats: Log Magnitude, Phase, Log Magnitude and Phase, Smith Chart (Impedance), Smith Chart (Admittance), Linear Polar, Log Polar, Group Delay, Linear Magnitude, Linear Magnitude and Phase, Real, Imaginary, Real and Imaginary, and SWR.

Data Points: 501. Can be switched to a nominal 168 or a nominal 85 points without recalibration.

Reference Delay: Can be entered in time or in distance (when the dielectric constant is entered). Automatic reference delay feature adds the correct electrical length compensation at the push of a button. Software compensation for the electrical length difference between reference and test is always accurate and stable since measurement frequencies are always synthesized. In addition, WILTRON offers Reference Phase Delay for dispersive transmission media, such as waveguide and microstrip.

Markers: Six independent markers can be used to read out measurement data. In delta-reference mode, any one marker can be selected to become the reference for the other five. Markers can be directed automatically to the minimum or maximum of a data trace.

Limits: Limit lines are available to indicate test limits.

Limit Frequency: This mode allows the user to determine the ±X dB bandwidth of amplifiers, filters, or any type of frequency sensitive device.

Measurement Frequency Range: Frequency range of measurement can be narrowed within calibration range without recalibration. CW mode permits single frequency measurements, also without recalibration. In addition, the system accepts N discrete frequency points where $2 \leq N \leq 501$.

Resolution of Readout (Maximum):

- **Log:** 0.001 dB
- **Linear:** 0.001 pU (units)
- **Phase:** 0.01 degrees
- **Group Delay:** 0.001 fs
- **SWR:** 0.001 pU
- **Real:** 0.001 pU
- **Imaginary:** 0.001 pU
- **Time:** 0.001 ps
- **Distance:** 0.001 mm

DYNAMIC RANGE

The dynamic range of the signal level at Port 2 is defined to be the maximum signal level (0.2 dB compression) minus the noise floor for the various test sets. (The noise floor is determined using minimum video bandwidth and 1028 averages.) The noise floor and dynamic range of each test set are shown in the table below.

MEASUREMENT ENHANCEMENT

Vector Error Correction: Three methods of calibration are offered, they include: standard calibrations using either open circuits or offset short circuits and LRL calibration. Four vector error corrections—Full 12-Term, One Path-Two Port, Frequency Response, Reflection Only. Full 12-term can always be used if desired, as all test sets automatically reverse the test signal. Front panel LEDs indicate the type of calibration, which is stored in memory. Front panel button selects whether calibration is to be applied, and an LED lights when calibration data are being applied.

Calibration Standards: Can select SMA, GPC–7, Type N, and K Connector from calibration menu. Use of fixed or sliding load can be selected for each connector type. Open cir-

36XX Series Test Sets

Test Set Model	Frequency Range (GHz)	Maximum Signal (dBm)	Noise Floor (dBm)	Dynamic Range (dB)
3610	0.5 to 18.0	0	–110	110
3611	0.5 to 18.6	–3	–113	110
	18.0 to 26.5	–3	–108	105
	26.5 to 40	–3	–103	100
3620	0.5 to 18	40*	–110	150
3621	0.5 to 18.0	37*	–113	150
		37*	–108	145
		37*	–100	140

*Attenuator #3 set to 40 dB.

Table 1-2. Performance Specifications (2 of 5)

circuit capacitance coefficients can be modified manually or through the GPIB interface.

Data Averaging: Averaging of 1 to 4095 points can be selected. Averaging can be turned on/off with front panel button. Front panel LED indicates when averaging is active.

Video IF Bandwidth: Front panel switch selects three levels of IF bandwidth. NORMAL, REDUCED, and MIN selections correspond to approximately 10 kHz, 1 kHz, and 100 Hz, respectively.

Trace Smoothing: Functions similarly to Frequency Averaging. Trace width to be smoothed can be selected from 0 to 20% of trace. Front panel button turns smoothing on/off and front panel LED indicates when smoothing is active.

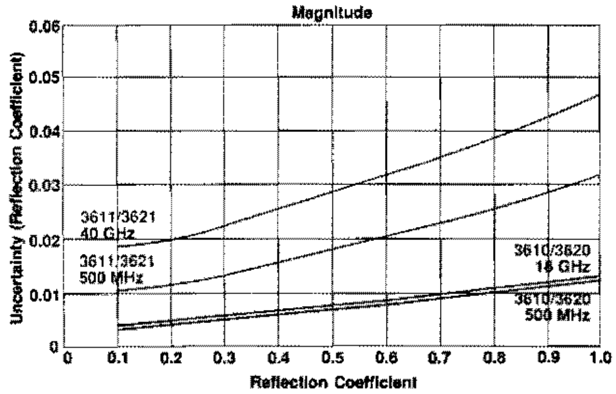
SOURCE CONTROL

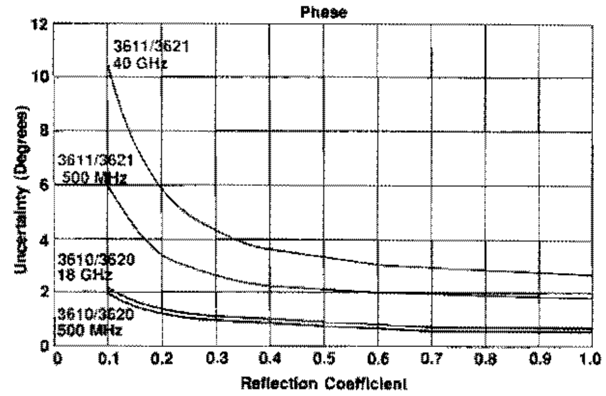
Compatibility: The 360 is compatible with the WILTRON 360SS System Sources and the 6600B Sweep Generators. The phase-locked output frequency of both is controlled by the 360 which sends frequency information through a dedicated GPIB system interface bus. The output frequency is then phase locked with the frequency accuracy of the internal 10 MHz crystal standard. Phase-lock time is typically 2 ms. Frequency resolution is 100 kHz.

MEASUREMENT ACCURACY

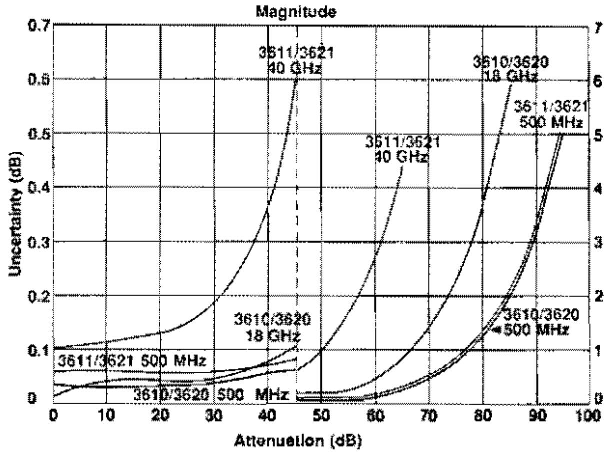
The following graphs give typical measurement accuracy after 12-term vector error correction. The errors are root-sum-of-the-squares (RSS) calculations of the contributions of residual directivity, load and source match, frequency response, isolation, network analyzer dynamic accuracy, and connector repeatability. In preparing the following graphs, a reduced video IF bandwidth and averaging of 128 points were used. Changes in the video IF bandwidth or averaging can result in variations at low levels.

Reflection Measurements





Transmission Measurements



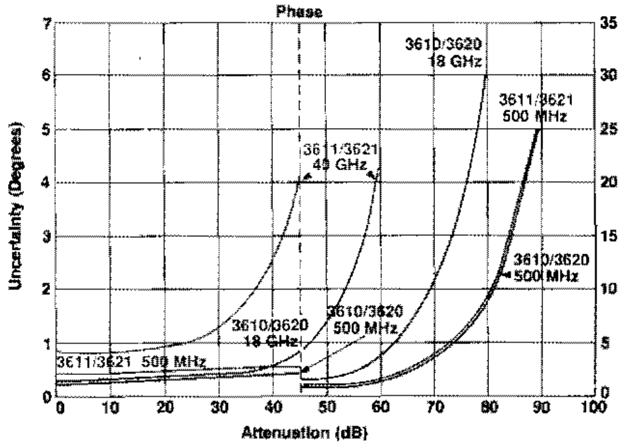


Table 1-2. Performance Specifications (3 of 5)

GROUP DELAY ACCURACY

Group Delay is measured by computing the phase change in degrees across a frequency step by applying the formula:

$$\tau_g = -1/360\ d\phi/df$$

Aperture: Determined by the number of steps within a frequency range. The number of steps can be changed without recalibration. The minimum aperture is 0.002 x frequency range (501 steps) and can be increased to 20% of the frequency range without recalibration. The frequency width of the aperture is displayed automatically.

Range: The maximum delay range is limited to measuring no more than 180 degrees of phase change within the aperture set by the number of frequency points. With a frequency step size of 100 kHz, this corresponds to 10 µs.

Measurement Repeatability (Sweep to Sweep): For continuous measurement of a through connection, RSS fluctuations due to phase and FM noise are:

$$\pm \frac{1.41\ [(\text{Phase Noise in deg})^2 + (\tau_g \times \text{Residual FM Noise in Hz})^2]^{1/2}}{360\ (\text{Aperture in Hz})}$$

Accuracy:

$$\text{Error in } \tau_g = \frac{\dfrac{\text{Error in Phase (deg)}}{360} + \tau_g \times \text{Aperture Frequency Error (Hz)}}{\text{Aperture (Hz)}}$$

DISPLAY CAPABILITIES:

Number of Channels: Four, each of which can display any S parameter in any format with up to two traces per channel for a maximum of eight traces simultaneously. A single channel, two channels (1 and 3 or 2 and 4) or all four channels can be displayed simultaneously.

CRT: Color display. Graticules are displayed in green, measurement data in red, and markers and limits in blue (cyan optional). Trace data stored in memory is displayed in green.

Trace Memory: A separate memory for each channel can be used to store measurement data for later display or for subtraction, addition, multiplication or division with current measurement data.

Scale Resolution (Minimum):

- **Log Magnitude:** 0.001 dB/div
- **Linear Magnitude:** 1 pU (units)
- **Phase:** 0.01 degrees/div
- **Group Delay:** 0.001 ps
- **Time:** 0.001 µs
- **Distance:** 0.001 µm
- **SWR:** 1 pU

Autoscale: Automatically sets Resolution and Offset to fully display measurement data.

Reference Position: Can be set at any graticule line.

Annotation: Type of measurement, vertical scale resolution, start and stop frequencies, reference position, and horizontal scale resolution.

TEST PORT CHARACTERISITICS

The specifications in the listing on the next page apply to all test sets up to 18 GHz. Specifications above 18 GHz apply only to Models 3611 and 3621. Specifications under GPC–7 apply to Models 3610 and 3620. Specifications under K and 3.5 mm apply to Models 3611 and 3621 and to 3610 and 3620 when 34AK50 or 34AK50 GPC–7-to-K Connector adapters are used. All specifications apply after 12-term error correction. The environment temperature is 23 ±3 degrees centigrade.

Characteristic	Test Ports: GPC–7 (dB)	3.5 mm (dB)	K (dB)
Directivity			
0.5 to 18 GHz	>50	>40	>40
18 to 26.5 GHz	–	>40	>40
26.5 to 40 GHz	–	–	>35
Source Match			
0.5 to 18 GHz	>40	>30	>30
18 to 26.5 GHz	–	>30	>30
26.5 to 40 GHz	–	–	>27
Load Match			
0.5 to 18 GHz	>40	>35	>35
18 to 26.5 GHz	–	>30	>30
26.5 to 40 GHz	–	–	>27
Reflection Freq. Response			
0.5 to 18 GHz	±0.1	±0.25	±0.25
18 to 26.5 GHz	–	±0.25	±0.25
26.5 to 40 GHz	–	–	±0.35
Transmission Freq. Response			
0.5 to 18 GHz	±0.02	±0.05	±0.05
18 to 26.5 GHz	–	±0.06	±0.06
26.5 to 40 GHz	–	–	±0.1
Isolation[1]			
0.5 to 18 GHz	>90	>90	>90
18 to 26.5 GHz	–	>85	>85
26.5 to 40 GHz	–	–	>75

[1]Measured with terminations on ports 1 and 2 and using a minimum of 128 point averaging and 20% smoothing.

HARD COPY

Dot Matrix Printer: Menu selects full screen, graphical, or tabular data. The number of data points of tabular data can be selected as well as data at markers only. Compatible with the HP ThinkJet printer. Parallel (Centronics) interface.

GPIB Plotter: The 360 is compatible with HP Models 7440A, 7470A or 7475A. Menu selects plotting of any subset of the display. Plotter is connected to the dedicated system bus. This bus also controls the microwave source.

Table 1-2. Performance Specifications (4 of 5)

Buffer: Hard Copy data is loaded into buffer memory in approximately 12 seconds. Full front panel operation and measurement capability is then restored to the user during the remainder of the hard copy generation (printer only).

DISK DRIVE
3.5-inch microdiskette drive with 720K bytes formatted capacity. All files are MS-DOS compatible. Disk is used to load measurement programs and can be used to store measurement and calibration data and front panel setups. File names can be 1 to 8 characters long.
Measurement Data: 25.6K bytes per 501 point S-parameter data file.
Calibration Data: 58K bytes per 501 point, 12-term calibration plus front panel setup.
Trace Memory File: 4K bytes per 501 point channel.

REMOTE PROGRAMMING
Interface: GPIB, IEEE 488-1978
Addressing: Address can be set from the front panel and can range from 0 to 30. Defaults to address 6.
Transfer Formats: ASCII, 32 bit floating point, 64 bit floating point.
Speed: 40K bytes/s
Interface Function Codes: SH1, AH1, T6, TE0, L4, LE0, SRI, RLI, PPI, DTI, DCO, CO.

TIME DOMAIN
Time Domain Software, P/N 2360–2, adds signal processing and Fourier transform technology to the 360. Data collected as an array of complex frequency points are processed, which enables the user to:

1. Obtain a time (or distance) presentation for location of discontinuities.
2. Obtain a presentation that indicates the nature (inductive or capacitive) of a discontinuity—a new capability for processing bandpass data.
3. Isolate a discontinuity and return to the frequency domain to observe its characteristics, independent of others.

Modes of Operation:

1. Bandpass processing resulting in time domain display with arbitrary start and stop times.
2. Phasor Impluse Processing of bandpass data to provide a low-pass equivalent impulse response for a real and/or imaginary presentation.
3. Frequency Response with a time gate applied.
4. True Low Pass Processing resulting in a time domain display with arbitrary start and stop times. The traditional TDR step response is available in this mode. A harmonically related series of frequency points is required.

Specifications:

Type of Window (Number of Terms)	1st Side Lobe Relative to Peak (dB)	Impulse Width[1]
Rectangular (1)	–13	1.2 W
Nominal-Hamming (2)	–43	1.8 W
Low Side Lobe Blackman-Harris (3)	–67	2.1 W
Min. Side Lobe Blackman-Harris (4)	–92	2.7 W

1 W (Bin Width) = 1/2Δf.
Example: When Δf = 10 GHz, W = 50 ps

GENERAL
Rear Panel Connectors and Controls:
RGB VIDEO: TTL compatible, 15 pin D subminiature.
COMP VIDEO: Connects to external video display, phono jack (mono only).
CRT INTEN: Continuous control of CRT intensity.
CRT DEGAUSS: Pushbutton control degausses CRT.
PRINTER: Connects to external printer with Centronics interface, 36 pin ribbon.
10 MHz REF IN: Connects to external reference frequency standard, 10 MHz, +5 dBm to –5 dBm, 50 ohms, BNC female.
10 MHz REF OUT: Connects to internal reference frequency standard, 10 MHz, 1 ppm 0–55C, 0 dBm, 50 ohms, BNC female. If an external 10 MHz input is applied, the 10 MHz REF OUT is looped through.

Temperature Range:
Operating: 0°C to 55°C (45C maximum for disk drive)
Storage: –40°C to 75°C

Power Requirements:
Network Analyzer: 100V/120V/220V/240V +5%, –10%, 48-63 Hz, 350 VA maximum.
System Sources: 100V/120V/220V/240V +5%, –10%, 50–60 Hz, 250 VA maximum
Test Sets: None. Power is supplied by the 360.

Dimensions:
Network Analyzer: 222 H x 432 W x 603 D mm (8.75 H x 17 W x 23.75 D in.)
System Sources: 133 H x 432 W x 476 D mm (5.25 H x 17 W x 18.75 D in.)

Table 1-2. Performance Specifications (5 of 5)

Dimensions (Continued):	Weight:
Test Sets: 133 H x 432 W x 603 D mm (5.25 H x 17 W x 23.75 D in.) **Printer:** 89 H x 292 W x 203 D mm (3.5 H x 11.5 W x 8 D in.) **System Cabinet:** 572 H x 559 W x 699 D mm (22.5 H x 22 W x 27.5 D in.) **System Console:** 1245 H x 559 W x 699 D mm (49 H x 22 W x 27.5 D in.)	**Network Analyzer:** 25 kg (55 lb) **System Sources:** 16 kg (35.4 lb) maximum. **Test Sets:** 14.3 kg (31.5 lb) **Printer:** 3.2 kg (7 lb) **System Cabinet (Empty):** 40.8 kg (90 lb) **System Console (Empty):**88.4 kg (195 lb)

1-14 RECOMMENDED TEST EQUIPMENT

Table 1-3 provides a lists of recommended test equipment needed to check and service the 360 system. The entries are coded to show for which types of testing the equipment is used. These codes are described below.

Code	*Type of Testing*
C	Calibration
O	Operational Checkout
P	Performance Verification
T	Troubleshooting

Table 1-3. Recommended Test Equipment

INSTRUMENT	CRITICAL SPECIFICATION	RECOMMENDED MANUFACTURER	USE
Spectrum Analyzer	*Frequency:* 1 Hz to 40 MHz *Resolution:* 10 Hz	Hewlett-Packard Model 3585A	P, C
Spectrum Analyzer with External Mixer	*Frequency:* 0.01 to 100 GHz *Resolution:* 100 Hz	Tektronix, Model 494, with Ext Mixer PN: 015-3085-00	O, P, T, C
Frequency Counter	*Frequency*: 0.01 to 40 GHz *Input Impedance:* 50 ohms *Resolution:* 1 Hz *Other:* Ext Time Base Input	EIP Microwaves, Inc. Model 548A, with frequency ex-tended	O, P, T
Power Meter	*Power Range:* –30 to +20 dBm	Hewlett-Packard , Model 436A	O, P, T
Power Sensor	*Frequency Range:* 0.01 to 26.5 GHz	Hewlett-Packard, Model 8485A	O, P, T
Digital Multimeter	Resolution: 4-1/2 digits (to 20V) *DC Accuracy:* 0.002% + 2 counts *DC Input Impedance:* 10 MΩ *AC Accuracy:* 0.07% + 100 counts (to 20 kHz) *AC Input Impedance:* 1 megohm	John Fluke, Inc., Model 8840A, with Option 8840A-09 True RMS AC	O, P, T
Synthesizer	*Frequency:* 1 Hz to 10 MHz *Power:* -60 to 20 dBm, 50 Ohms	Hewlett-Packard Model 3325A	O, P, T
Oscilloscope	*Bandwidth*: DC to 200 MHz *Sensitivity:* 2 mV *Horiz. Sensitivity:* 50 ns/division	Tektronix, Inc. Model 2445	O, P, T, C
DC Block	0.18 µF, 200V, 10 MHz, BNC Connector	Hewlett-Packard, Model 10240B	P
Variac	300W, V, I, P Meters	TechniPower, Model WSMT3AW	O, P, T
Component Verification Kit	Components Traceable to United States National Bureau of Standards (NBS)	WILTRON, Model 3666, 3667 or 3668 (as applicable)	O, P, C, T
Frequency Standard	*Frequency:* 10 MHz *Accuracy:* 1×10^{-10} Hz /day *Power:* 0 dBm into 50 Ohms	Spectracom Corp. Model 8161	P, C
Modulation Analyzer	AM, FM NOISE MEAS Less than 100 Hz Input Frequency: 5-30 MHz	Hewlett-Packard, Model 8901A	P

SECTION II
INSTALLATION

CONTENTS

SECTION II
INSTALLATION

2-1 INTRODUCTION

This section provides information on initial inspection, preparation for use, and General Purpose Interface Bus (GPIB) interconnections. It also includes reshipment and storage information.

2-2 INITIAL INSPECTION

Inspect the shipping container for damage. If the container or cushioning material is damaged, retain until the contents of the shipment have been checked against the packing list and the instrument has been checked for mechanical and electrical operation.

If any network analyzer instruments or components are damaged mechanically, notify your local sales representative or WILTRON Customer Service. If either the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as WILTRON. Keep the shipping materials for the carrier's inspection.

2-3 PREPARATION FOR USE, 360C1 SYSTEM CONSOLE

The 360 system comes packaged in six boxes- Preparation for use consists of the following:

1. Inventorying the shipment, including the attaching-parts kit contained in Box 5.
2. Unpacking the equipment
3. Assembling the console.
4. Installing the system instruments.
5. Installing the shelf.
6. Cabling the instruments.
7. Checking the line voltage setting; resetting for the line-voltage value in your area, if appropriate.

Figure 2-1 shows the attaching-parts kit, and Table 2-1 provides a listing of the hardware. Using these two illustrations, ensure that all of the required parts are available before beginning the assembly of the console. The steps required to assembly the console are given in the pictorial in Figure 2-2.

NOTE

The empty console weights 65.9 kg (145 lb). We recommend employing two or more people to lift it off of the shipping pallet (Figure 2-2, Step 2).

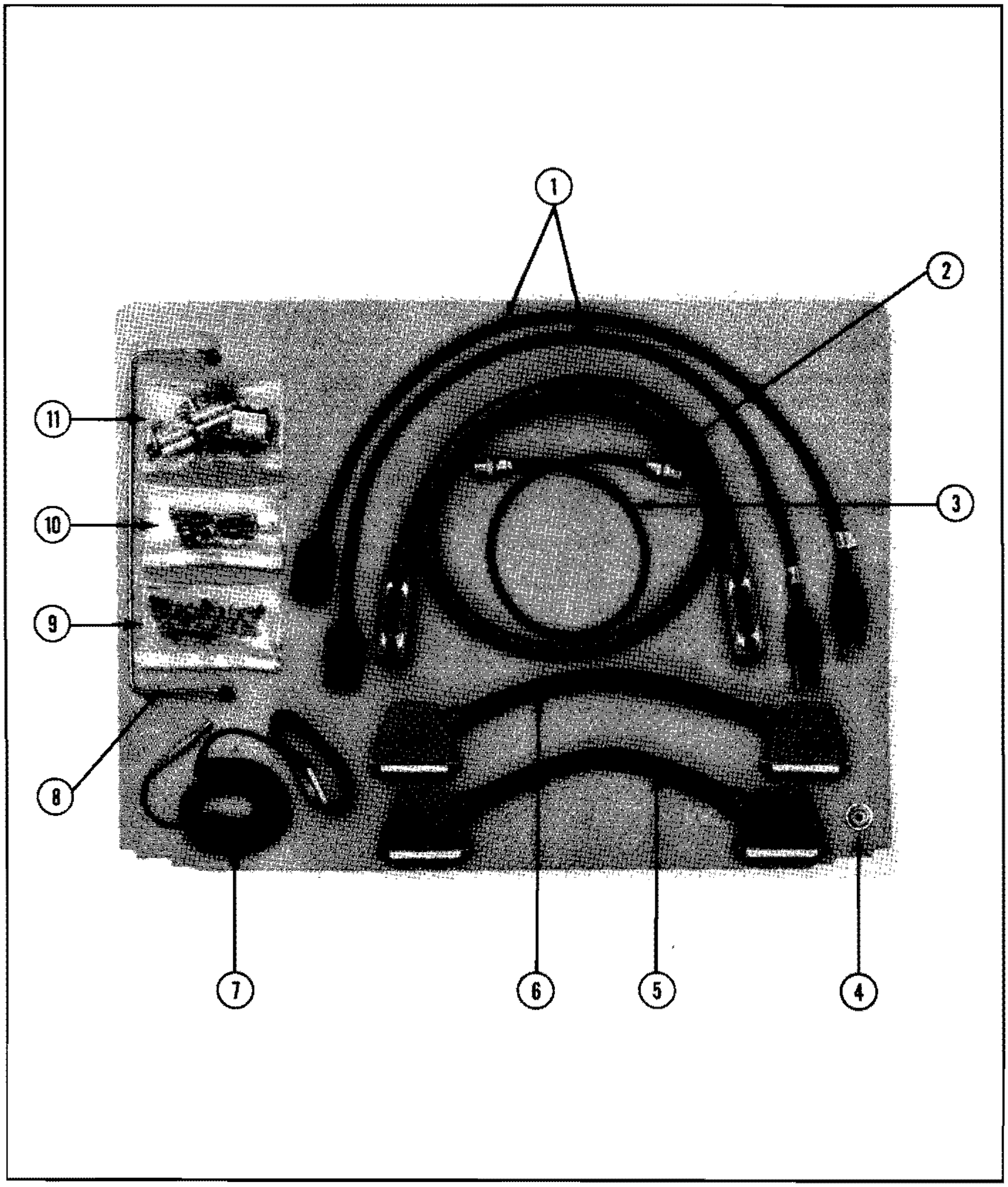
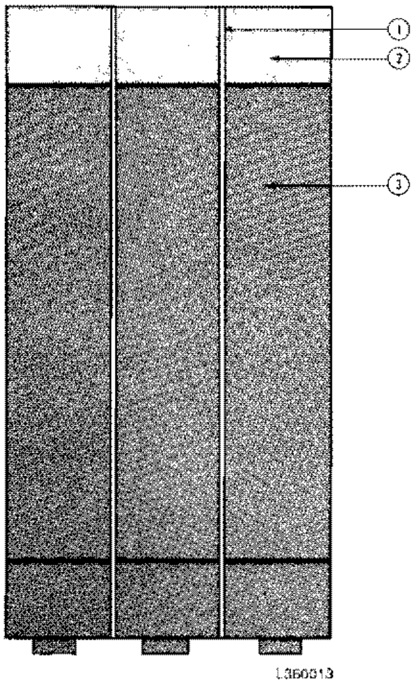


Figure 2-1. Attaching Parts Used for Assembling the Console

Table 2-1. List of Attaching Parts, Console

Index No.	Description	Part No.	Qty
1	Cords for connecting analyzer and source to ac bus.	800-279	2
2	Interconnect cable having GPIB connectors on each end, 1 m long. Used to connect analyzer to source.	2100-1	1
3	Signal cable having BNC female connectors on each end, 3 ft long. Used to connect between FM ØLOCK ports on source and analyzer.	800-124	1
4	Mat for dissipating static electricity.	2000-204	1
5	Interface cable used to connect between CONTROL ports on analyzer and test set.	800-280	1
6	Interface cable used to connect between SIGNAL ports on analyzer and test set.	C33015-1	1
7	Strap and cord for connecting between operator's wrist and static dissipative mat.	783-163	1
8	RF cable between test set and source. Cable has male WILTRON K Connectors™ on each end.	B33268-1	1
9	Grey, decorative screws used to secure the analyzer, test set, and source to the front panel of the console.	900-609	12
10	Writing shelf assembly parts, consisting of the following:		
	Washer, #10, Split Lk	900-396	8
	Screw, Pan Hd, 10-32x0.5 inch, Phillips. Used to mount the rails to the writing surface and the console rail guides.	900-223	8
	Nut, Kep, 10-32x0.375 inch	900-338	2
	Washer, #10, Flat, 0.375 inch	900-352	2
11	Bracket-clip assembly parts, consisting of the following:		
	Bracket-clip used to retain analyzer, test set, and source to the rear of their individual support brackets.	A32339	6
	Nut, Kep, 8-32 x 0.343 inch	900-336	12
	Washer, #8, Flat, 0.375 inch	900-351	12

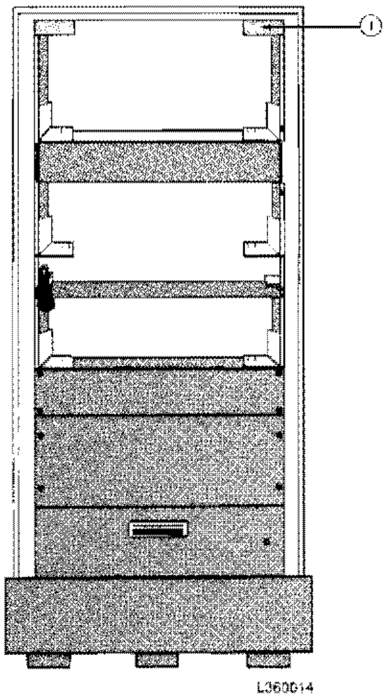
Step 1



Remove the console from its shipping container, as follows:

- Cut the bands ①.
- Lift off the top ②.
- Remove the cardboard sleeve ③ by pulling straight up and away.
- Remove the packing materials.
- Remove the writing surface from atop the console and set it aside. You will be directed to complete its assembly in a later step.

Step 2



Remove the console from the shipping pallet, as follows:

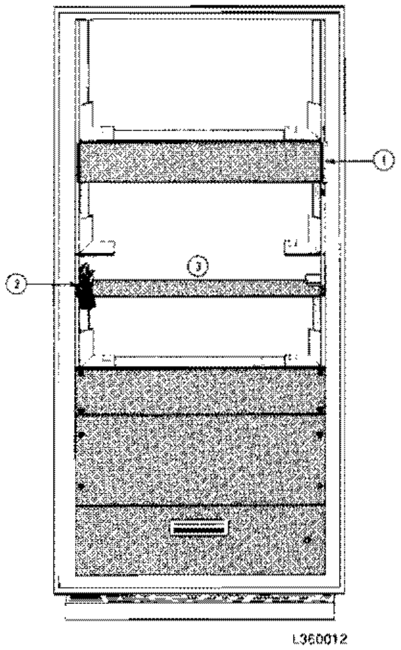
- Insert two 4-to-6 foot lengths of 2x4-inch lumber through the top opening in the console ①.
- With a person stationed on the front side and another on the back side, use the 2x4's to lift the console off and away from the pallet.

Alternate Procedure

- Tilt the console on its back, being careful not to scratch the paint.
- Remove the pallet.

Figure 2-2. Unpacking and Assembling the Console (1 of 4)

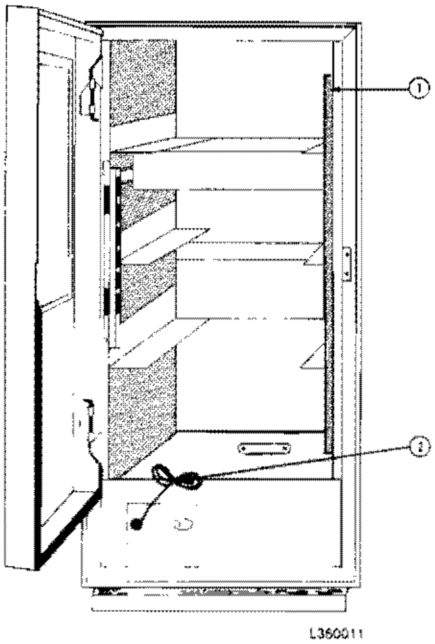
Step 3



Prepare the front of the console for installation of the equipment, as follows:

- Remove the drawer retaining bracket ①.
- Cut the tie wrap from the Wrist Strap/Table Mat Ground Port ②, bring it out through the opening above the small panel ③, and let it hang free and out of the way.

Step 4

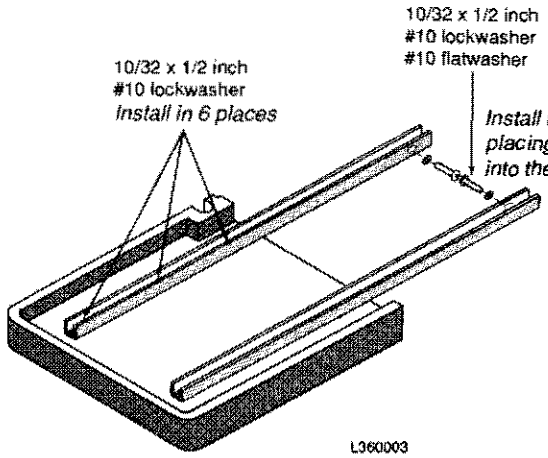


Prepare the rear of the console for installation of the equipment, as follows:

- Open the rear door, cut the tie wraps from the writing-surface rails ①, and remove the rails from the console.
- Cut the tie wrap from the Line Cord ②, and uncoil the cord.

Figure 2-2. Unpacking and Assembling the Console (2 of 4)

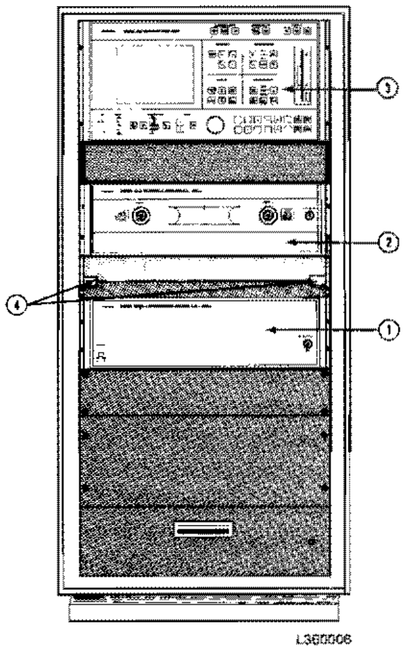
Step 5



Prepare the Writing Surface, as follows:

- Attach the two rails as shown, using the 10/32 x 1-inch screws and #10 split-lockwashers supplied in the attaching-parts kit.

Step 6

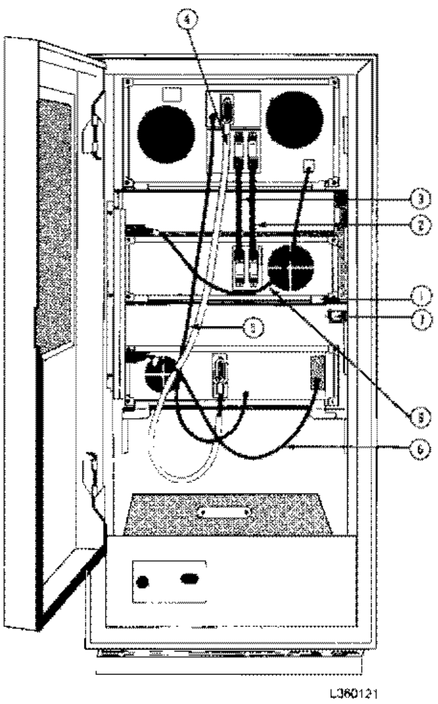


Install the instruments as follows:

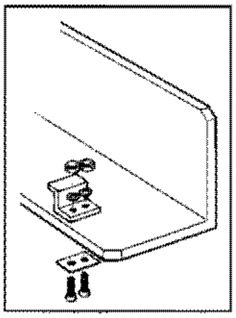
- Unpack the Frequency Source, and install it in the lower opening ① of the console.
- Push the Source into the console until it is flush with the front of the opening.
- Secure the Source using four of the panel screws supplied in the attaching-parts kit.
- In a like manner, install the Test Set ② and Analyzer ③
- Install the Writing Surface by inserting its rails into the rail guides ④ and pushing in until its rear is flush with the front of the console.

Figure 2-2. Unpacking and Assembling the Console (3 of 4)

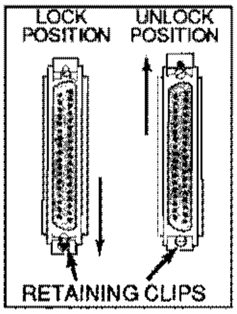
Step 7



DETAIL A



DETAIL B



Secure the instruments and install the interconnecting cables, as follows:

- Install the Retainer Clips ① on the rear of the Support Brackets (Detail A). Secure the three instruments. Use 8/32 kept nuts and #8 flat-washers.
- Install the Control ② and Signal ③ cables. Ensure their retaining clips (Detail B) are unlocked before plugging in the connectors. Lock the retaining clips over the projecting studs on the analyzer and test set.
- Install the System Bus cable ④. If a GPIB connection is also required, connect to the GPIB connector, below. *DO NOT MATE AN EXTERNAL GPIB CABLE WITH THIS CONNECTOR.*
- Install the EXT Ø LOCK OUTPUT cable ⑤ .
- Connect the Line Cords on the Analyzer and Source ⑥ to the ac receptical.
- Secure the Writing Surface rails to the tapped hole in each rail guides ⑦. Use two 10/32 x 1/2-inch screws and #10 split-lockwashers from the attaching-parts kit.

Figure 2-2. Unpacking and Assembling the Console (4 of 4)

2–4 PREPARATION FOR USE, 360C2 CABINET

The 360 system comes packaged in six boxes- Preparation for use consists of the following:

1. Inventorying the shipment, including the attaching-parts kit contained in Box 5.
2. Unpacking the equipment
3. Assembling the cabinet.
4. Installing the system instruments.
5. Cabling the instruments.
6. Checking the line voltage setting; resetting for the line-voltage value in your area, if appropriate.

Figure 2-3 shows the attaching-parts kit, and Table 2-2 provides a listing of the hardware. Using these two illustrations, ensure that all of the required parts are available before beginning the assembly of the console. The steps required to assembly the console are given in the pictorial in Figure 2-4.

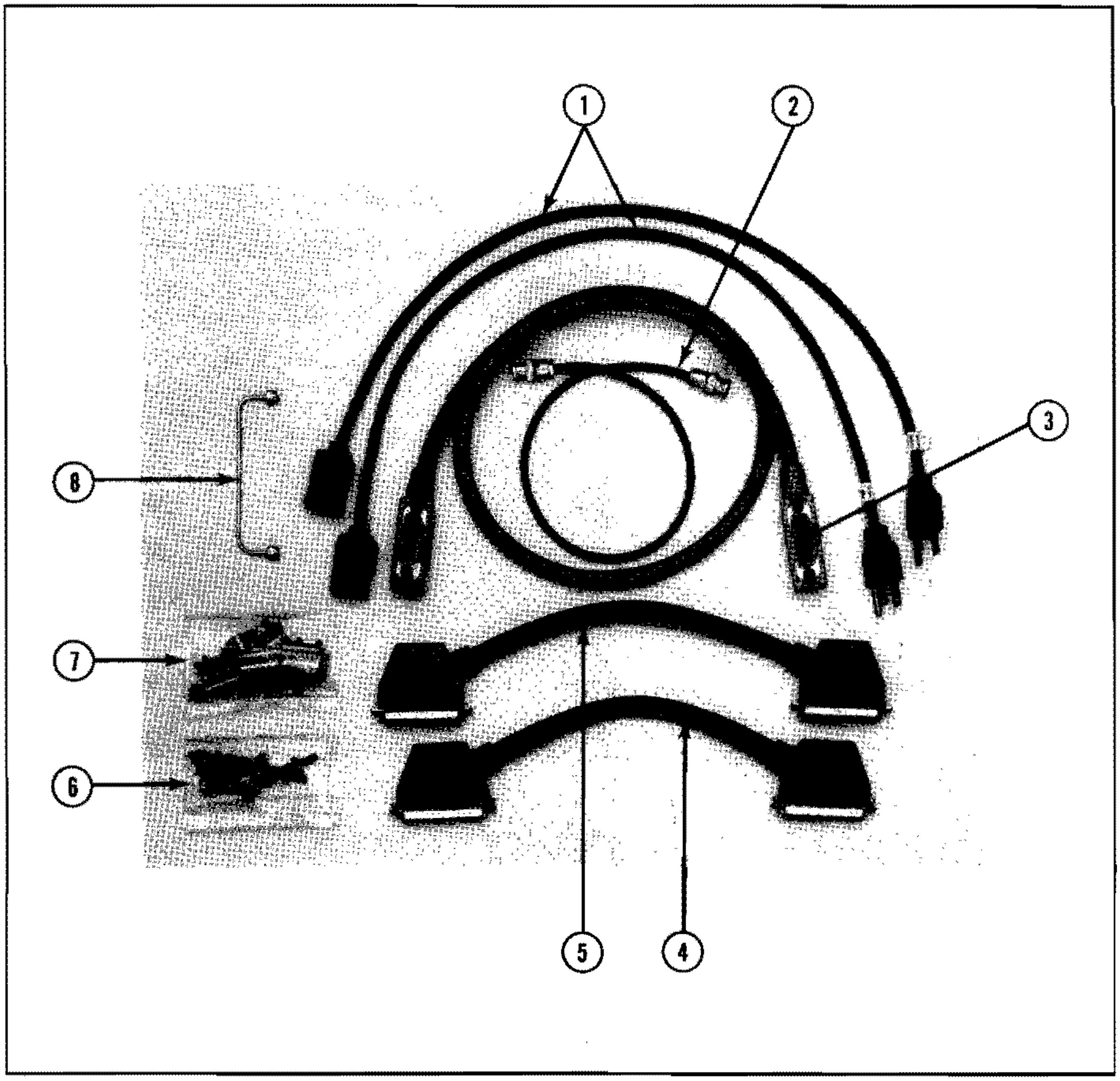
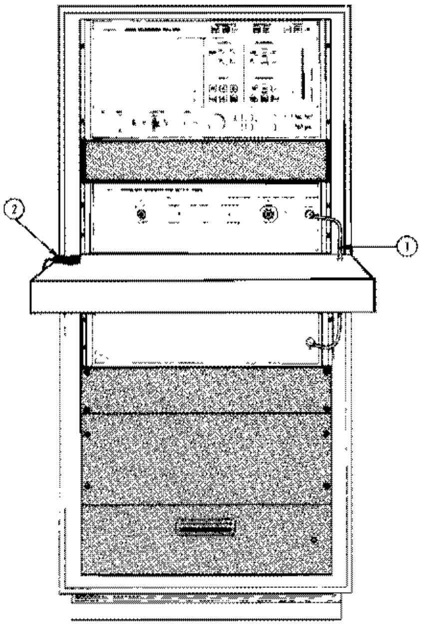


Figure 2-3. Attaching Parts Used for Assembling the Cabinet

Step 8



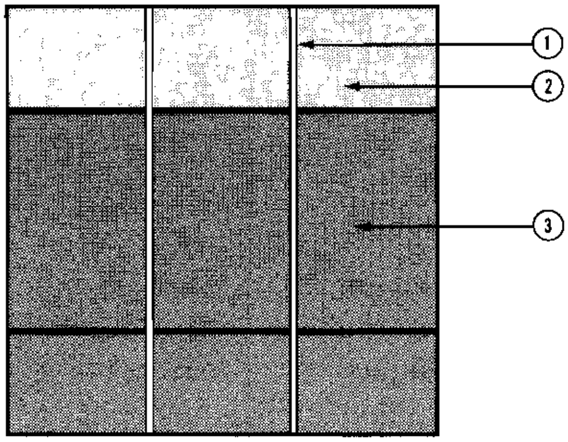
Complete the assembly, as follows:

- Install the semirigid RF output cable ① between the Source and the Test Set.
- Lay the Static Mat onto the Writing Surface.
- Snap the Wrist Strap/Ground Port ② to the Static Mat.
- Plug the end of the Wrist Strap into the Wrist Strap/Ground Port. Cut the tie wrap and uncoil the cable.
- Check the line voltage setting on the rear of the Analyzer and Source. If either differs from the voltage present in your area, refer to paragraph 2-5 for instructions.

Table 2-2. List of Attaching Parts, Cabinet

Name	Description	Part No.	Quantity
1	Cord for connecting analyzer and source to ac bus.	800-279	2
2	Signal cable having BNC female connectors on each end 18 in. long. Used to connect between FM ØLOCK ports on source and analyzer.	800-118	1
3	Interconnect cable having GPIB connectors on each end, 0.5 m long. Used to connect analyzer to source.	2100-5	1
4	Interface cable used to connect between CONTROL ports on analyzer and test set.	800-281	1
5	Interface cable used to connect between SIGNAL ports on analyzer and test set.	C33015-2	1
6	Grey, decorative screws used to secure the analyzer, test set, and source to the front panel of the cabinet.	900-609	12
7	Bracket-clip assembly parts, consisting of the following:		
	Bracket-clip used to retain analyzer, test set, and source to the r ear of their individual support brackets.	A33261	6
	Nut, Kep, 8-32 x 0.343 inch	900-336	12
	Washer, #8, Flat, 0.375 inch	900-351	12
8	RF cable between test set and source. Cable has male WILTRON K Connectors™ on each end.	B23368-2	1

Step 1

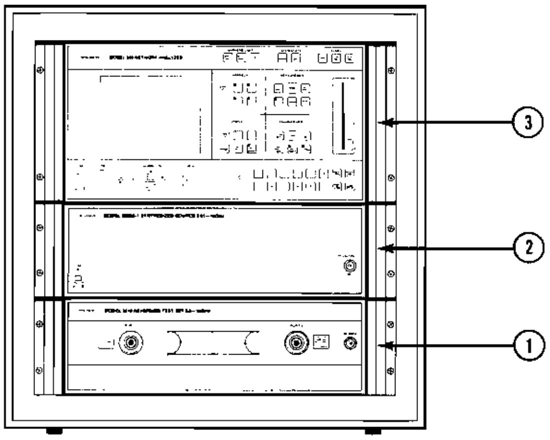


L360020

Remove the cabinet from its shipping container, as follows:

- Cut the bands ①.
- Lift off the top ②.
- Remove the cardboard sleeve ③ by pulling straight up and away.
- Remove the packing materials.

Step 2



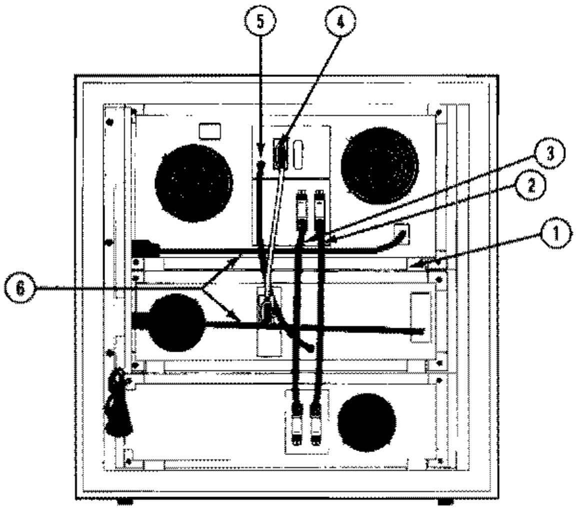
L360009

Install the instruments as follows:

- Unpack the Test Set, and install it in the lower opening ① of the cabinet.
- Push the Test Set into the cabinet until it is flush with the front of the opening.
- Secure the Test Set using four of the panel screws supplied in the attaching-parts kit.
- In a like manner, install the Source ② and Analyzer ③ .

Figure 2-4. Unpacking and Assembling the Cabinet (1 of 2)

Step 3

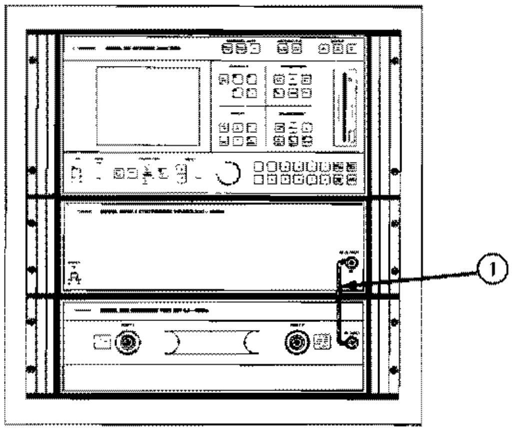


L360005

Secure the instruments and install the interconnecting cables, as follows:

- Install the Retainer Clips ① on the rear of the Support Brackets, and secure the three instruments. Use 8/32 kept nuts and #8 flatwashers.
- Install the Control ② and Signal ③ cables.
- Install the System Bus cable ④. If a GPIB connection is also required, connect to the GPIB connector, below. *DO NOT MATE AN EXTERNAL GPIB CABLE WITH THIS CONNECTOR.*
- Install the EXT Ø LOCK OUTPUT cable ⑤.
- Connect the Line Cords on the Analyzer and Source ⑥ to the ac receptical.

Step 4



L360019

Complete the assembly, as follows:

- Install the semirigid RF output cable ① between the Source and the Test Set.
- Check the line voltage setting on the rear of the Analyzer and Source. If either differs from the voltage present in your area, refer to paragraph 2-5 for instructions.

Figure 2-4. Unpacking and Assembling the Cabinet (2 of 2)

2-5 CHANGING THE LINE VOLTAGE

Line voltage modules are installed on the Analyzer and Source. These modules provide for setting the instrument to any of four international line voltages: 100, 115/120, 200, 230/240 Vac. Prior to leaving the factory, the instruments are set to the proper line voltage for the area for which the instruments are destined. If these settings are incorrect, refer to Figure 2-7 for instructions on how to change the line voltage settings.

Change the switch setting shown below to the other value (110 or 220) as appropriate.

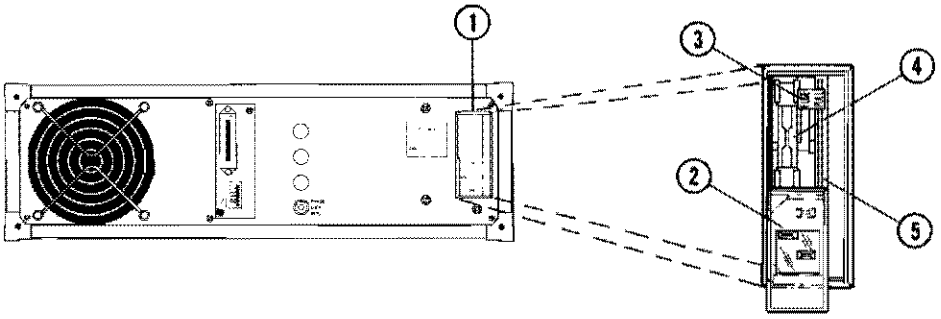
LINE SELECTION

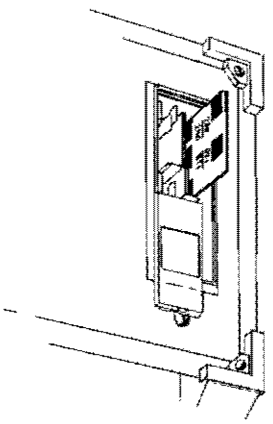
NOTE

For line voltages lower than 90V (180V) or higher than 121V (242V), use a variac bring the line voltage into the required range.

Analyzer

1. Disconnect the power cord from the voltage selector module ① and slide the cover ② down to gain access to the fuse compartment.
2. Pull on the FUSE PULL lever ③; remove the line fuse ④ and PCB board ⑤.
3. Using the example for 115/120 Vac below as a guide, reinstall the PC board. For the correct installation of this board, the desired line-voltage callout should be located:
   a. Adjacent to the input receptacle.
   b. Facing toward the BNC connector bank.
4. Push the FUSE PULL lever back to its normal position and insert a fuse of the proper value into the fuse holder. (Fuse values for the various line voltages are shown on the right side of the module.)





PC BOARD INSTALLATION
FOR 115/120 Vac OPERATION

Source

Figure 2-5. Changing the Line Voltage Settings for the Analyzer and Source

2-6 GPIB SETUP AND INTERCONNECTION

The network analyzer system provides automated microwave measurements via the GPIB. The following paragraphs provide information about interface connections, cable requirements, and the addressing of the network analyzer.

2-6.1 Interface Connector

Interface between the network analyzer and other devices on the GPIB is via a 24-wire interface cable. This cable uses connector shells having two connector faces. These double-faced connectors allow for the parallel connection of two or more cables to a single device.

2-6.2 Cable Length Restrictions

The GPIB system can accommodate up to 15 instruments at any one time. To achieve design performance on the bus, proper timing and voltage level relationships must be maintained. If either the cable length between separate instruments or the accumulated cable length between all instruments is too long, the data and control lines cannot be driven properly and the system may fail to perform. Cable length restrictions are as follows:

No more than 15 instruments may be installed on the bus.

Total accumulative cable length in meters may not exceed two times the number of bus instruments or 20 meters—whichever is less.

NOTE

For low EMI applications, the GPIB cable should be a fully shielded type, with well-grounded metal-shell connectors

2-6.3 GPIB Interconnection

The only interconnection required for GPIB operation is between the network analyzer and the controller. This interconnection is via a special GPIB cable. The WILTRON Part number for such a cable is 2000-1, -2, or -4 (1, 2, or 4 meters in length).

2-6.4 GPIB Address

The network analyzer leaves the factory preset to address 6. If a different address is desired, it can be set from Menu GP7 (refer to Section III, paragraph 3-8.11 and Figure 3-124)

2-6.5 Data Delimiting (CR-CR/LF Switch)

Data is delimited on the GPIB by either the carriage return (CR) ASCII character or both the carriage return and line feed (CR/LF) ASCII characters. Which character is used depends upon the requirements of the system controller. Most modern controllers can use either CR or CR/LF, while many older controllers require one or the other. Consult the controller's manual for its particular requirements.

As with the address, you can select which delimiting character to use from Menu GP7.

2-7 PREPARATION FOR STORAGE AND/OR SHIPMENT

Paragraphs 2-7.1 and 2-7.2 give instructions for preparing the network analyzer for storage or shipment.

2-7.1 Preparation for Storage

Preparing the network analyzer for storage consists of cleaning the units, packing the inside with moisture-absorbing dessicant crystals, and storing the them in a temperature environment that is maintained between -40 and +70 degrees centigrade.

2-7.2 Preparation for Shipment

To provide maximum protection against damage in transit, the network analyzer instruments should be repackaged in their original shipping containers. If these containers are no longer available and the instruments are being returned to WILTRON for repair, advise WILTRON Customer Service; they will send new shipping containers free of charge. In the event neither of these two options is possible, instructions for packaging and shipment are given below.

a. ***Use a Suitable Container.*** Obtain a corrugated cardboard carton with a 275-pound test strength. This carton should have inside dimensions of no less than six inches larger than the instrument dimensions to allow for cushioning.

b. ***Protect the Instrument.*** Surround the instrument with polyethylene sheeting to protect the finish.

c. ***Cushion the Instrument.*** Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument. Provide at least three inches of dunnage on all sides.

d. ***Seal the Container.*** Seal the carton by using either shipping tape or an industrial stapler.

e. ***Address the Container.*** If the instrument is being returned to WILTRON for service, mark the WILTRON address and your return address on the carton in one or more prominent locations. For international customers, use the address of your local representative (see Table 2-3). For U.S.A. customers, use the the WILTRON address shown below:

WILTRON Company
ATTN: Customer Service
490 Jarvis Drive
Morgan Hill, CA 95037–0289.

SECTION III
CONTROL (FRONT) PANEL OPERATION

CONTENTS

CONTENTS (Continued)

SECTION III
CONTROL (FRONT) PANEL OPERATION

3-1 INTRODUCTION

This section provides control panel operating and measurement application information and data. It includes subsections that describe

1. Basic measurements and how to make them
2. Instrument operation
3. Error and status messages
4. Stored data
5. Source control
6. Disk storage/interface
7. Control panel controls and menus
8. Rear panel connectors
9. Measurement calibration

It also provides discussions on various types of measurements. These include Smith charts, phase, low-level, time domain, group delay, and active-device measurements.

3-2 GENERAL DESCRIPTION

The Model 360 Vector Network Analyzer System measures the magnitude and phase characteristics of networks, such as filters, amplifiers, attenuators, and antennas. It does so by comparing the incident signal leaving the analyzer with the signal transmitted through the test device or reflected from its input circuit. Figure 3-1 illustrates the types of measurements that the 360 is capable of making.

The 360 is a self-contained, fully integrated measurement system that includes an optional time domain capability. The system hardware consists of an analyzer, a test set, a signal source, and all of the precision components required for calibration and performance verification. The 360 system instruments perform the following functions:

a. ***Signal Source***

This instrument provides the stimulus to the device under test. The frequency range of the source and test set establish the frequency range of the system. The 360 provides two ranges: 500 MHz to 18 GHz and 500 MHz to 40 GHz. The frequency stability of the source is an important factor in the accuracy (especially phase accuracy)

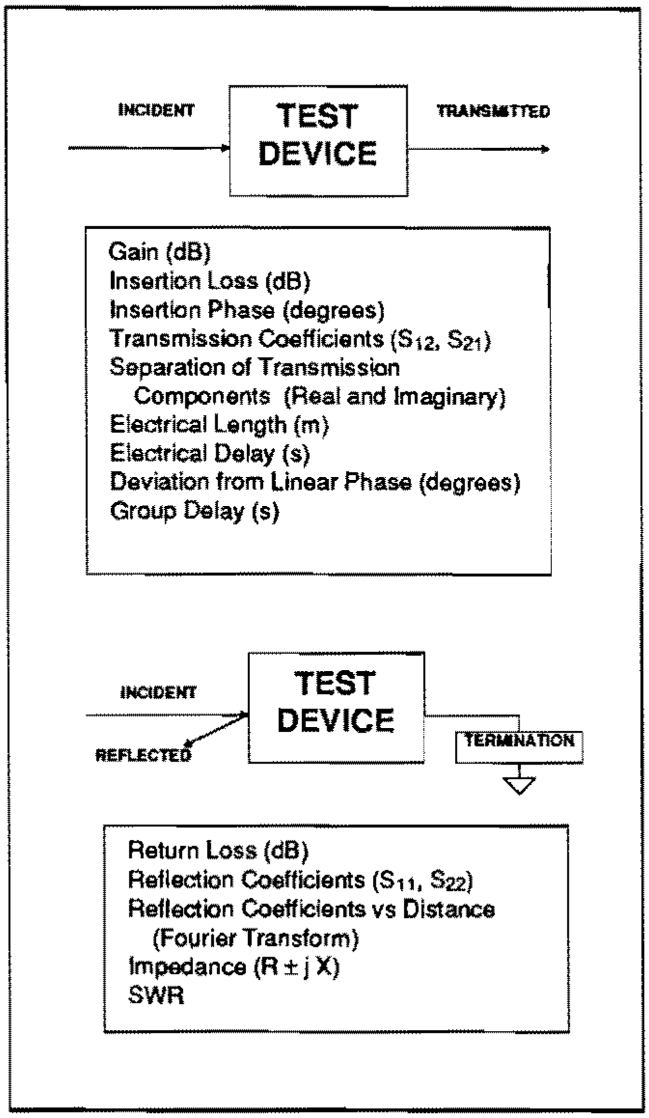


Figure 3-1. Transmission and Reflection Measurements

of the network analyzer. Because of this, the 360 always phase locks the source to an internal 10 MHz crystal reference.

b. Test Set
The test set samples the incident, reflected, and transmitted signals. The type of test port connector used is important, as is a feature called "Auto Reversing." Auto Reversing means that the input/output ports on the test device are reversed automatically. This saves you from having to reverse the test device physically to measure all four scattering parameters (S-parameters). Frequency conversion (1st, 2nd, and 3rd IFs) occurs in the test set.

c. Analyzer
The analyzer analyzes the 3rd IF signal for phase and magnitude data. It then displays the results of this analysis on a large (190 mm [7-1/2 inch] diagonal) color display. This display can show all four S-parameters simultaneously. In addition to the installed display, you can also view the measurement results on an external color monitor.

3-3 INTRODUCTION TO NETWORK ANALYZERS

We will begin this discussion with a subject familiar to most WILTRON customers: scalar network analysis. After showing comparisons, we will proceed to the fundamentals of network analyzer terminology and techniques. This discussion serves as an introduction to topics presented in greater detail later in this section. This discussion will touch on new concepts that include the following:

- Reference Delay
- S-Parameters: what they are and how are they displayed
- Complex Impedance and Smith Charts

a. Scalar Analyzer Comparison
Network Analyzers do everything that scalar analyzers do except display absolute power. In addition, they add the ability to measure the phase characteristics of microwave devices and allow greater dynamic range. If all a Network Analyzer added was the capability for measuring phase characteristics, its usefulness would be limited. While phase measurements are important in themselves, it is really the availability of this phase information that unlocks many new features for complex measurements. These feature include Smith Charts, Time Domain, and Group Delay. Phase information also allows greater accuracy through *vector error correction* of the measured signal.

Let us begin our discussion with a familiar subject, scalar network analyzers (SNAs). SNAs measure microwave signals by converting them to a DC voltage using a diode detector (Figure 3-2). This DC voltage is proportional to the magnitude of the incoming signal. The detection process, however, ignores any information regarding the phase of the microwave signal.

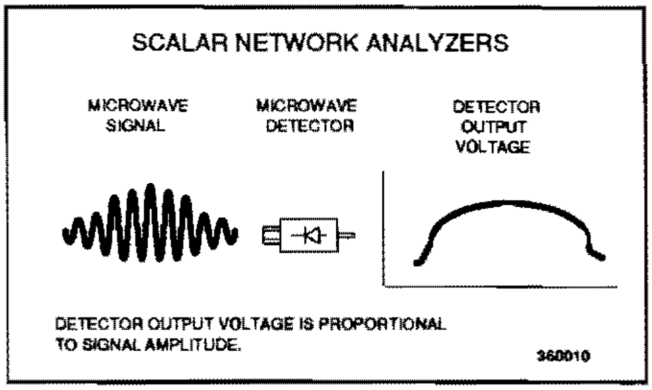


Figure 3-2. Scalar Analyzer Detection

In a network analyzer access is needed to both the magnitude and phase of a microwave signal. There are several different ways to perform the measurement. The method WILTRON employs (called Harmonic Sampling or Harmonic Mixing) is to down-convert the signal to a lower intermediate frequency (IF). This signal can then be measured directly by a tuned receiver. The tuned receiver approach gives the system greater dynamic range. The system is also much less sensitive to interfering signals, including harmonics.

b. Vector Network Analyzer Basics
The network analyzer is a tuned receiver (Figure 3-3). The microwave signal is down converted

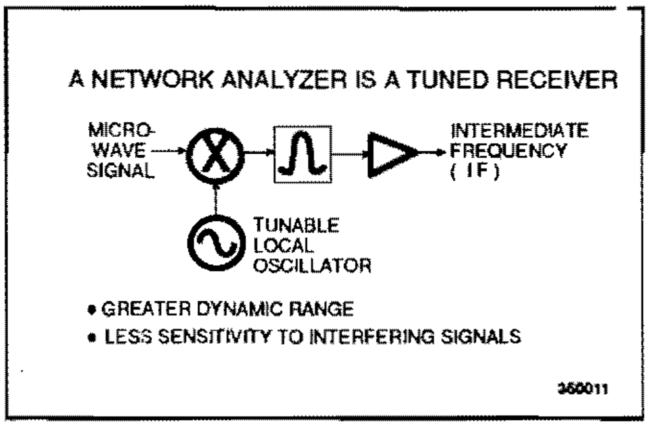


Figure 3-3. Network Analyzer Is a Tuned Receiver

into the passband of the IF. To measure the phase of this signal, we must have a reference to compare it with. If the phase of a signal is 90 degrees, it is 90 degrees different from the reference signal (Figure 3-4). The network analyzer would read this as –90°, since the test signal is delayed by 90° with respect to the reference signal.

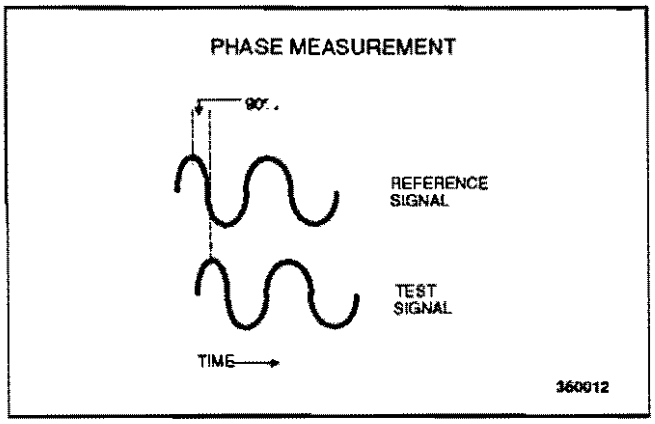


Figure 3-4. Signals with a 90° Phase Difference

This phase reference can be obtained by splitting off some of the microwave signal before the measurement (Figure 3-5). The phase of the microwave signal after it has passed through the device under test (DUT) is then compared with the reference signal. A network analyzer test set automatically samples the reference signal, so no external hardware is needed.

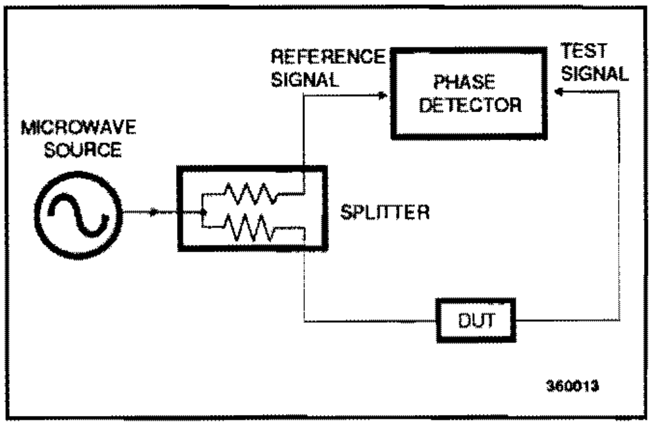


Figure 3-5. Splitting the Microwave Signal

Let us consider for a moment that you remove the DUT and substitute a length of transmission line (Figure 3-6). Note that the path length of the test signal is longer than that of the reference signal. Now let us see how this affects our measurement.

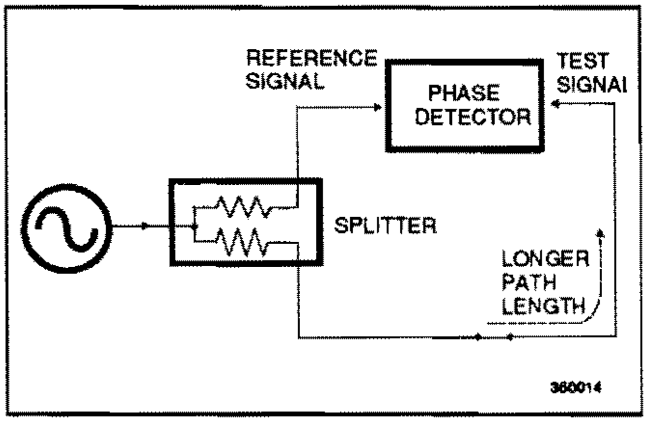


Figure 3-6. Split Signal Where a Length of Line Replaces the DUT

Assume that we are making a measurement at 1GHz and that the difference in path-length between the two signals is exactly 1 wavelength. This means that test signal is lagging the reference signal by 360 degrees (Figure 3-7). We cannot really tell the difference between one sine wave maxima and the next (they are all identical), so the network analyzer would measure a phase difference of 0 degrees.

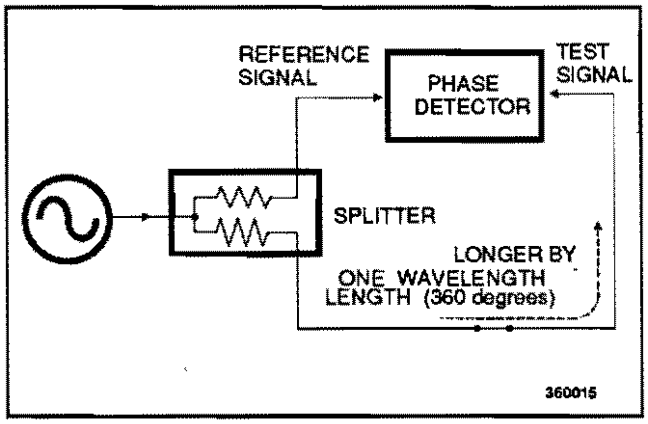


Figure 3-7. Split Signal Where Path Length Differs by Exactly One Wavelength

Now consider that we make this same measurement at 1.1GHz. The frequency is higher by 10 percent so therefore the wavelength is shorter by 10 percent. The test signal path length is now 0.1 wavelength longer than that of the reference signal (Figure 3-8). This test signal is

1.1 X 360 = 396 degrees.

This is 36 degrees different from the phase measurement at 1GHz. The network analyzer will display this phase difference as –36 degrees.

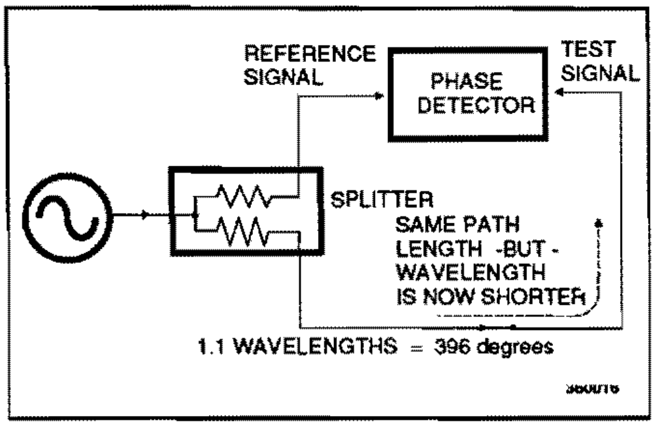


Figure 3-8. Split Signal Where Path Length Differs by Exactly One Wavelength

The test signal at 1.1 GHz is delayed by 36 degrees more than the test signal at 1GHz.

You can see that if the measurement frequency is 1.2 GHz we will get a reading of –72 degrees, –108 degrees for 1.3 GHz, etc (Figure 3-9). There is an electrical delay between the reference and test signals. For this delay we will use the common industry term of reference delay. You may also hear it referred to as phase delay. In older network analyzers you had to equalize the length of the reference arm with that of the test arm in order to make an appropriate measurement of phase vs frequency.

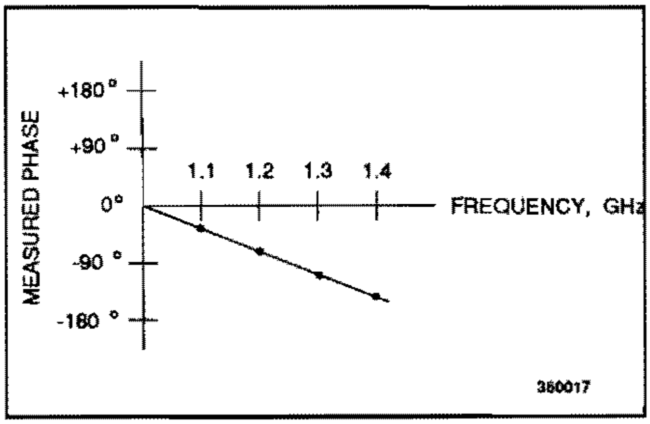


Figure 3-9. Electrical Delay

To measure phase on a DUT, we want to remove this phase-change-vs-frequency-due-to changes in the electrical length. This will allow us to view the actual phase characteristics. These characteristics may be much smaller than the phase-change-due-to-electrical-length difference.

There are two ways of accomplishing this. The most obvious way is to insert a length of line into the reference signal path to make both paths of equal length (Figure 3-10). With perfect transmission lines and a perfect splitter, we would then measure a constant phase as we change the frequency. The problem using this approach is that we must change the line length with each measurement setup.

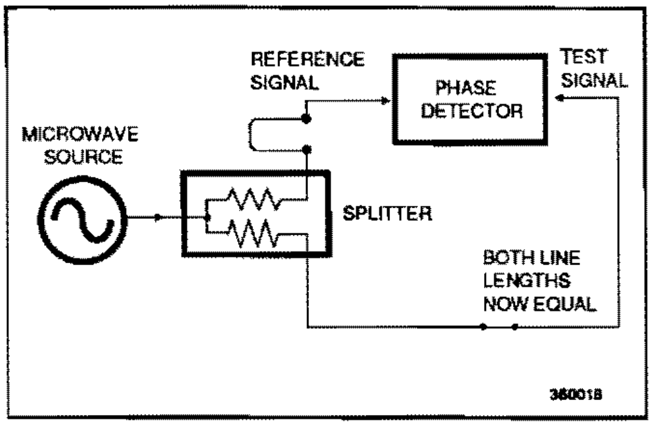


Figure 3-10. Split Signal Where the Paths are of Equal Length

Another approach is to handle the path length difference in software. Figure 3-11 displays the phase-vs-frequency of a device. This device has different effects on the output phase at different frequencies. Because of these differences, we do not have a perfectly linear phase response. We can easily detect this phase deviation by compensating for the linear phase. The size of the phase difference increases linearly with frequency so we can modify the phase display to eliminate this delay.

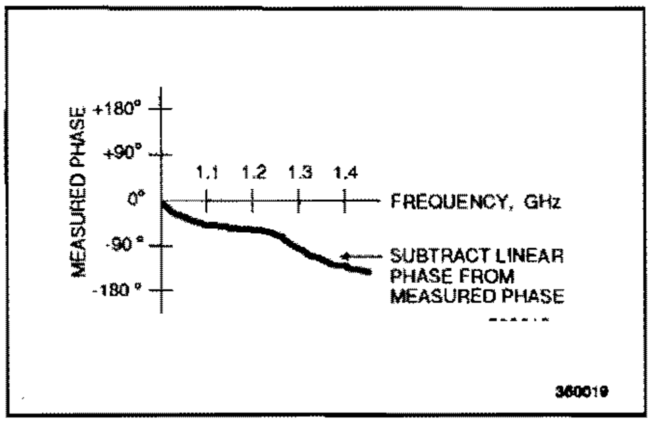


Figure 3-11. Phase Difference Increases Linearly with Changes in Frequency

The 360 offers *automatic* reference delay compensation with the push of a button. Figure 3-12 shows the resultant measurement when we compensate path length. In a system application you can usually correct for length differences; however, the residual phase characteristics are critical.

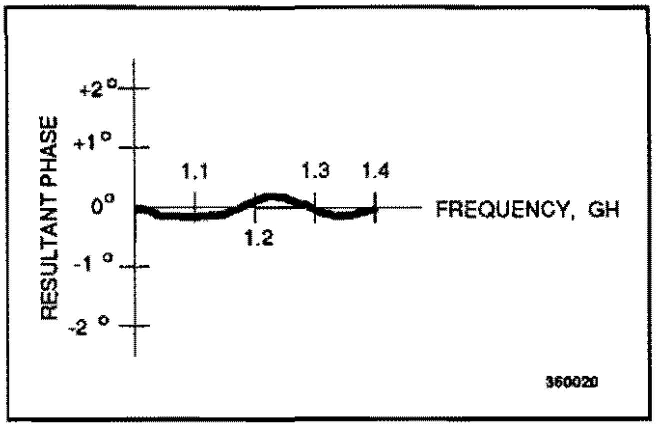


Figure 3-12. Resultant Phase With Path Length Compensation In Place

c. ***Network Analyzer Measurements***

Now let us consider measuring the DUT. Consider a two port device; that is, a device with a connector on each end. What measurements would be of interest?

First, we could measure the reflection characteristics at either end with the other end terminated into 50 ohms. If we designate one end as the normal place for the input, that gives a reference. We can then define the reflection characteristics from the reference end as forward reflection, and those from the other end as reverse reflection (Figure 3-13).

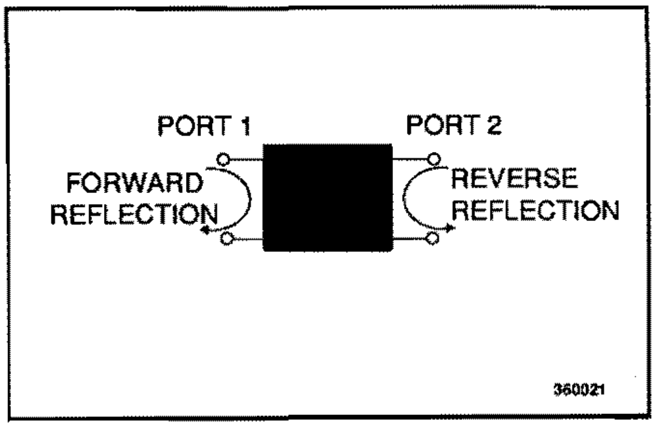


Figure 3-13. Forward and Reverse Measurements

Second, we can measure the forward and reverse transmission characteristics. However, instead of saying "forward", "reverse", "reflection", and "transmission" all of the time, we use a shorthand. That is all that S-Parameters are, a shorthand! The "S" stands for scattering. The first number is the port that the signal is being injected into, while the second is the port that the signal is leaving. S11, therefore, is the signal being injected into port 1 relative to the signal leaving port 1. The four scattering parameters (Figure 3-14):

- S11 Forward Reflection
- S21 Forward Transmission
- S22 Reverse Reflection
- S12 Reverse Transmission

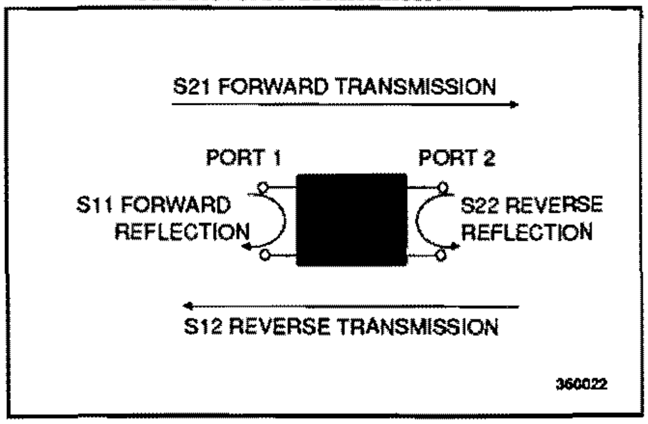


Figure 3-14. S-Parameters

S-Parameters can be displayed in many ways. An S-parameter consists of a magnitude and a phase. We can display the magnitude in dB, just like a scalar network analyzer. We often call this term *log magnitude.*

We can display phase as "linear phase" (Figure 3-15). As discussed earlier, we can't tell the difference between one cycle and the next. Therefore, after going through 360 degrees we are back to where we began. We can display the measurement from –180 to +180 degrees. The –180 to +180 approach is more common. It keeps the display discontinuity removed from the important 0 degree area used as the phase reference.

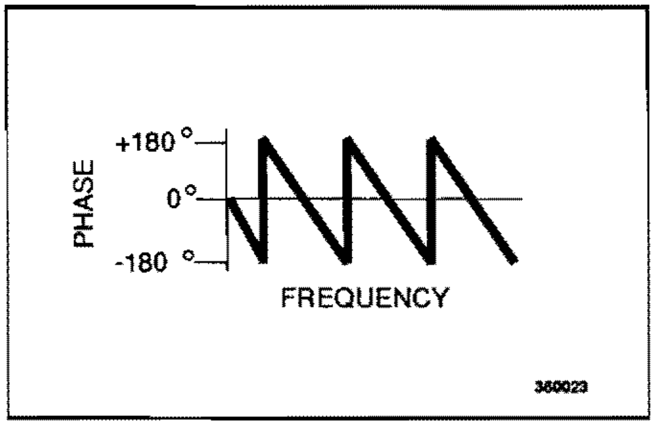


Figure 3-15. Linear Phase-With-Frequency Waveform

There are several ways in which all the information can be displayed on one trace. One method is a polar display (Figure 3-16). The radial parameter (distance from the center) is magnitude. The rotation around the circle is phase. We sometimes use polar displays to view transmission measurements, especially on cascaded devices (devices in series). The transmission result is the addition of the phase and log magnitude (dB) information of each device's polar display.

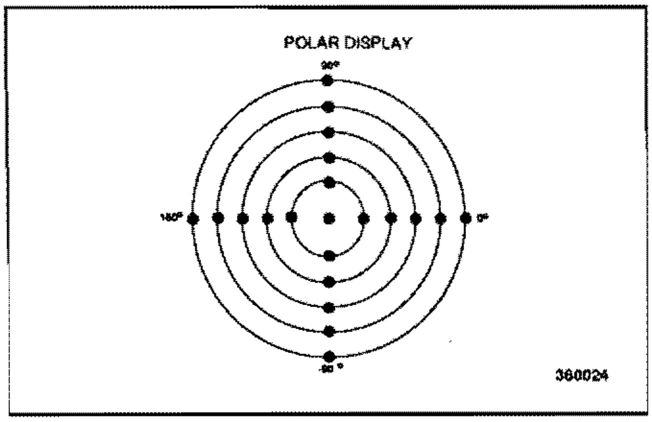


Figure 3-16. Polar Display

As we have discussed, the signal reflected from a DUT has both magnitude and phase. This is because the impedance of the device has both a resistive and a reactive term of the form r+jx. We refer to the "r" as the *real* or *resistive* term, while we call "x" the *imaginary* or *reactive* term. The "j", which we sometimes denote as "i," is an imaginary number. It is the square root of –1. If x is positive, the impedance is inductive, if x is negative the impedance is capacitive.

The size and polarity of the reactive component x is important in impedance matching. The best match to a complex impedance is the *complex conjugate*. This complex-sounding term simply means an impedance with the same value of r and x, but with x of opposite polarity. This term is best analyzed using a Smith Chart (Figure 3-17), which is a plot of r and x. We will discuss Smith Charts in greater detail in paragraph 3-14.

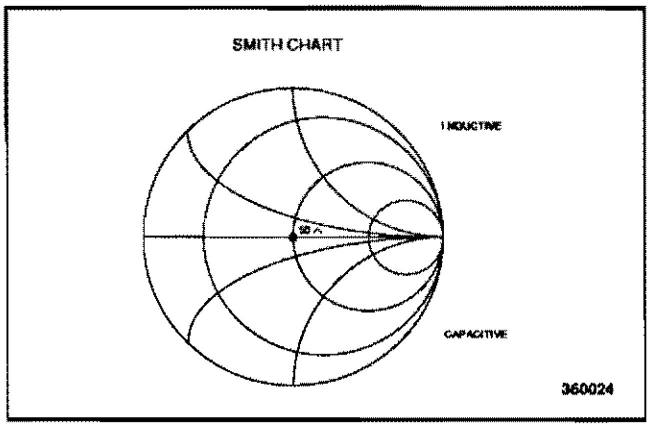


Figure 3-17. Smith Chart

To display all the information on a single S-parameter requires one or two traces, depending upon format we want. A very common requirement is to view forward reflection on a Smith Chart (one trace) while observing forward transmission in Log Magnitude and Phase (two traces). Let us see how to accomplish this on the 360.

The 360 has four channels. Each channel can display a complete S-Parameter in any format on either one or two traces. All four S-Parameters can be seen simultaneously in any desired format. A total of eight traces can be viewed at the same time. While this is a lot of information to digest, the 360's large color display makes recognizing and analyzing the data surprisingly easy.

Another important parameter we can measure when phase information is available is group delay. In linear devices, the phase change through the DUT is linear-with-frequency. Thus, doubling the frequency also doubles the phase change. An important measurement, especially for communications system users, is the rate of change of phase-vs-frequency (group delay). If the rate of phase-change-vs-frequency is not constant, the DUT is nonlinear. This nonlinearity can create distortion in communications systems. We will discuss this in greater detail in paragraph 3-17.

d. Measurement Error Correction

Since we can measure microwave signals in both magnitude and phase, it is possible to correct for six major error terms:

- Source Test Port Match
- Load Test Port Match
- Directivity
- Isolation
- Transmission Frequency Response
- Reflection Frequency Response

We can correct for each of these six error terms in both the forward and reverse directions, hence the name 12-term error correction. Since 12-term error correction requires both forward and reverse measurement information, the test set must be *reversing*. "Reversing" means that it must be able to apply the measurement signal in either the forward or reverse direction.

To accomplish this error correction, we measure the magnitude and phase of each error signal (Figure 3-18). Magnitude and phase information appear as a vector that is mathematically applied to the measurement signal. This process is termed *vector error correction*. We will discuss this concept in greater detail in paragraph 3-12.

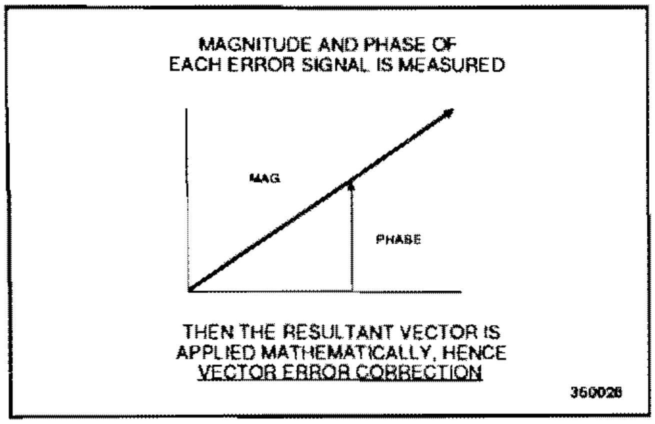


Figure 3-18. Magnitude and Phase Measurements

e. Test Sets

We have now learned about reference delay. We have discussed S-Parameters. We know what they are, how to measure them, and how to display them. We have also learned a little about vector error correction. Let us now turn to the 360 Test Sets. We will see how well they meet our measurement needs.

The basic WILTRON Test Set is called a "Reversing Test Set" (Figure 3-19). It contains an internal switch to select the direction of the microwave signal. Each port has a directional device. Any S-Parameter can be measured and 12-term error correction can be applied automatically. In fact, we can mesure all four S-Parameters simultaneously and apply a 12-term error correction to each. Also, with the dedicated synthesized source, we update the display rapidly enough to allow real-time tuning of the DUT.

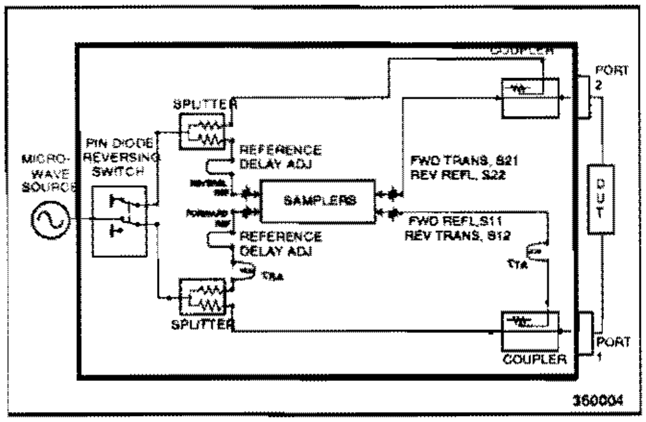


Figure 3-19. WILTRON Reversing Test Sets

Note that the coupler on Port 2 is aligned different from the coupler on Port 1. The through-line of the Port 2 coupler goes directly into the forward transmission test sampler. There is no coupling-factor loss. This design approach optimizes the dynamic range of forward-transmission measurements. Coupling-factor loss is the most important requirement for large dynamic range measurements.

The two Reference Delay Lines (one for each port) are internal connections. Since the Wiltron system always uses a synthesized signal, we can accurately compensate reference delay in software. While the capability for changing the actual line length is still present, most people will rarely need to use it.

The Wiltron 40GHz Test Set (Model 3611) does not contain internally accessible reference delay loops. The additional line length would significantly affect dynamic range at high frequencies. You can change these internal line lengths.

The Models 3620 and 3621 Active Device Test Sets (Figure 3-20) are similar to the two reversing models. The exception is a third step attenuator located in the forward transmission line just ahead of the sampler. This step attenuator provides for measuring devices with output powers greater than –10dBm. This additional step attenuator can be used to reduce the power into the forward transmission measurement sampler. Reverse transmission and output match measurements are unaffected by the step attenuator. The input match and attenuation of the step attenuator is measured and stored with the calibration data during the calibration process.

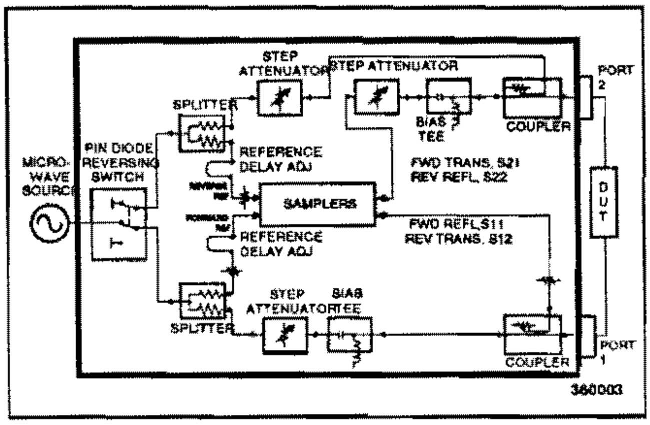


Figure 3-20. WILTRON Active Device Test Sets

3-4 GETTING STARTED

This tutorial introduces you to the 360 control panel and three basic measurement operations. It guides you through a typical calibration sequence and two basic network analyzer measurements: transmission and reflection.

3-4.1 General

a. Equipment Needed

360	Network Analyzer
3610	Test Set
360SS47	Source
3650	Cal Kit
3670A50-2	Through Cable

b. Initialize the System

Install the system disk and turn the power on. The 360 automatically performs a self test and comes on line with the same control panel settings as when exited last.

c. Backup the System Diskette

1. Remove the system diskette and install a blank diskette in its place.
2. Press the UTILITY MENU key (Figure 3-21).

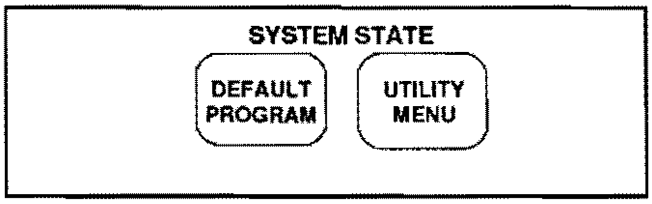


Figure 3-21. DEFAULT PROGRAM Key

3. Using the MENU cursor and ENTER keys (Figure 3-22), select the menu options shown below:

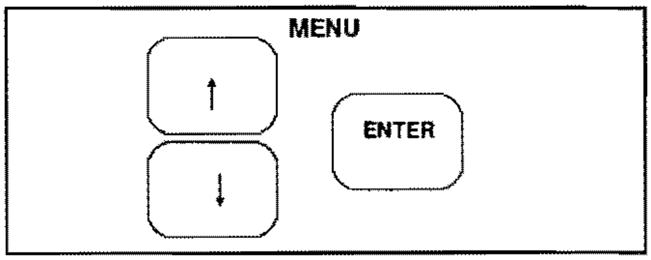


Figure 3-22. MENU Keys

4. Select **GENERAL DISK UTILITIES** when Menu U1, Utility Menu appears.
5. Select **INITIALIZE DISK WITH PROGRAM** when Menu U2, Disk Utilities Functions appears.
6. Follow the instructions displayed on the screen to complete the backup procedure.

d. Load Calibration Kit Data

1. Install the data diskette from the Model 3651, 3652, or 3653 Calibration Kit.
2. Press the UTILITY MENU key.
3. Select **CALIBRATION COMPONENT UTILITIES** when Menu U1, Utilities Menu appears.
4. Select **INSTALL CALIBRATION COMPONENT INFORMATION FROM DISK** when Menu U4, Calibration Component Utilities appears.
5. To ensure that correct calibration data has been loaded, select **DISPLAY INSTALLED CALIBRATION COMPONENT INFORMATION** on Menu U4.
6. Select the appropriate component type (SMA[M], SMA[F], K-CONN[M], etc.) when Menu U5, Display Installed Calibration Components Information appears.
7. When the Readout Text associated with Menu U5 appears in the display area of the CRT, check that the serial number of your Open or Short device is correct for the component in your kit

3-4.2 Full 12 Term Calibration, Precision Broadband Termination

WILTRON's precision broadband terminations are the ideal impedance reference for calibrating network analyzers. They are easier to use, more repeatable, and less expensive than sliding loads. However, sliding loads , when correctly used and perfectly aligned can be more accurate.

a. Connect the Thruline

Install the thru cable, PN 3670A50, to Port 2 on the Test Set. We will refer to the unterminated end of this cable as Port 2 for all calibration and measurement steps.

b. Begin the Calibration

1. Press the DEFAULT PROGRAM key (Figure 3-21).
2. Press the BEGIN CAL key (Figure 3-23).

NOTE

Selecting these menu options automatically calls the next menu in the listed sequence.

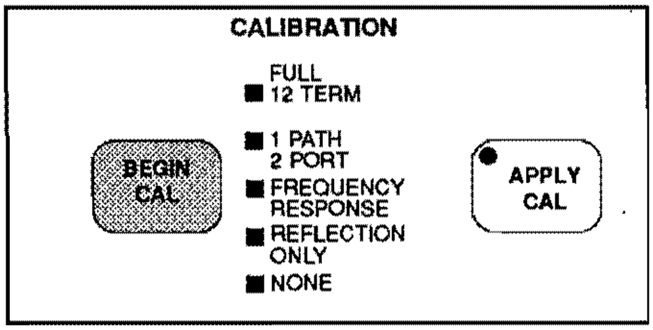


Figure 3-23. CALIBRATION Keys and Indicators

3. Select **FULL 12 TERM** when Menu C5, Select Calibration appears.
4. Select **NORMAL** when Menu C1, Select Calibration Data Points appears.
5. Set to **0.5-18 GHz** when Menu C2, Frequency Range Of Calibration appears.
6. Select **CHANGE PORT 1 CONN** when Menu C3, Confirm Calibration Parameters appears.
7. Select **GPC-7** when menu C4, Select Connector Type appears.
8. Select **CHANGE PORT 2 CONN** when Menu C3 re appears.
9. Select **GPC-7** when menu C4 reappears.
10. Select **CHANGE LOAD TYPE** when Menu C3, reappears.
11. Select **BROADBAND LOAD** when Menu C6, Select Load Type appears.
12. Select **START CAL** when Menu C3 reappears.
13. Follow the instructions in each of the upcoming Calibration Sequence menus. Each step allows you to view the calibration data being taken and to retake the data if desired. This saves you from having to repeat the complete calibration because of an undetected error—*such as, a poorly mated connection.*
14. When Menu C10, Calibration Sequence Completed appears, you can choose to store the calibration data on a disk. You should always choose to do this; steps 15 thru 19 show you how.
15. Press the SAVE/RECALL MENU key (Figure 3-24).

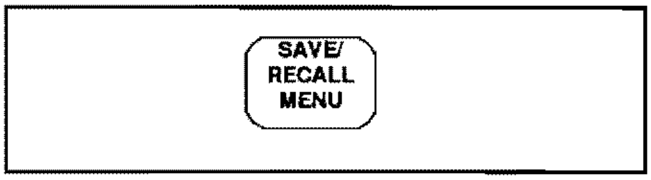


Figure 3-24. SAVE/RECALL MENU Key

16. Select **SAVE** when Menu SR1, Save/Recall Front Panel Information appears.
17. Select **SAVE CAL DATA AND FRONT PANEL SETUP ON DISK,** when Menu SR2, Recall or Save appears.
18. Select **CREATE NEW FILE,** when the GP1-3, Select File menu appears.
19. Enter CAL 1 and your initials using the knob, when the Menu GP5, Select Name appears. When finished, move to **DONE** and press the ENTER key. You can assign an 8 character file name and up to 15 additional spaces for other information.

c. Discussion:

During calibration, the 360 automatically

1. Sets the number of points to maximum—501 points.
2. Sets averaging to 128 while the loads are being measured.
3. Sets the Video IF bandwidth to the REDUCED value (1 kHz).

NOTE

The above values are default values that can be changed through menu selection.

A lower noise floor can be achieved by reducing the Video IF bandwidth and averaging several measurements. However, the default values have been found to be optimum for providing a comprimise between a low noise floor and data-taking speed. Reducing the Video IF bandwidth eliminates unwanted noise by more closely tracking the desired frequency. Averaging several measurements removes random variations and effectively improves noise floor performance. However, reducing Video IF bandwidth and increasing the number of averages causes an increase in sweep time.

Smoothing is not necessary nor desireable during calibration, since it does not affect the actual measurement data and will mask any rapid response variations displayed. This can lead to a sense of false confidence, both when performing the calibration and when monitoring the displayed calibration data for measurement errors.

3-4.3 Measuring Transmission

Now let us consider the effect of calibration on transmission measurements. Press the APPLY CAL key, to turn off the calibration. Leave the throughline connected between Port 1 and Port 2.

Let us look only at S_{21} (forward transmission). Set up the 360 for a single display with Log Mag and Phase using channel 3 and the graph menu, as follows:

1. Press the CHANNEL MENU key (Figure 3-25).

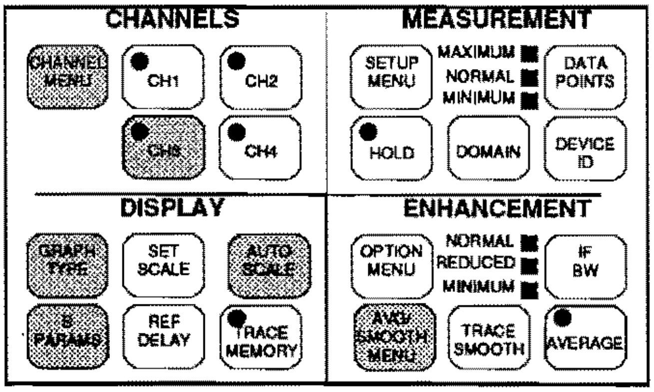


Figure 3-25. CHANNELS, MEASUREMENT, DISPLAY, and ENHANCEMENT Keys

2. Select **SINGLE DISPLAY** when Menu CM, Select Display Mode appears.
3. Press the CH3 key.
4. Press the S PARAMS key.
5. Select **S21 FWD TRANS** when Menu SP, Select S-Parameter appears.
6. Press the GRAPH TYPE key.
7. Select **LOG MAGNITUDE AND PHASE** when Menu GT1, Select Graph Type appears.
8. Press the AUTOSCALE key.
9. Notice the sawtooth pattern of the phase display. This represents the phase shift resulting from the physical difference in length between the reference arm and the S_{21} test arm.
10. Press the APPLY CAL key to apply the calibration.
11. Notice that both the magnitude and phase appear to be flat. The amplitude and phase uncertainties have been removed from the magnitude measurement. A software phase correction has been added. It makes the reference arm and the test arm appear to be the same length.
12. The test arm now incudes the same cable used in the calibration. Therefore, any deviation from 0 dB magnitude and 0 degree phase constitute the uncertainty of the measurement. This uncertainty results from random errors such as connector repeatability. It is dependent on the quality of both the calibration and the calibration components.
13. Press the AUTOSCALE key.
14. Set averaging for best performance, as follows:
    (a) Press the AVG/SMOOTH MENU key.
    (b) Enter 50 from the keypad for the **AVERAGING XXXX MEAS PER POINT** option..
    (c) Press the X1 terminator key (Figure 3-26).

    NOTE

    Fifty averages typically provide a good balance between a smoother waveform and its tradeoff, increased total measurement time.

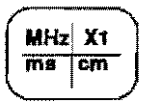


Figure 3-26. X1 Terminator Key

    (d) Press the AVERAGE key to enable the Averaging Function.

3-4.4 Measuring Reflection

Now let us consider the effect of calibration on reflection measurements.

1. Press the APPLY CAL key (Figure 3-22) to disable the calibration.

2. Press the AVERAGE key (Figure 3-27) to disable the Averaging Function.

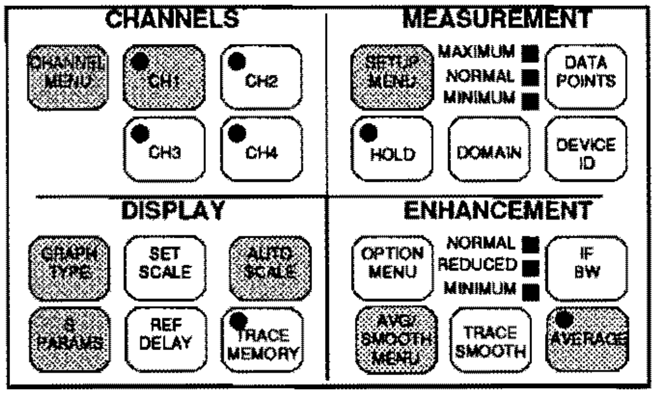


Figure 3-27. CHANNELS, MEASUREMENT, DISPLAY, and ENHANCEMENT Keys

3. Remove the throughline.
4. Connect the broadband load to Port 1.
5. Set the start frequency to 2 GHz, as follows:
   (a) Press the SETUP MENU key .
   (b) Change the **START** frequency to 2 GHz and press ENTER, when Menu SU1, Sweep Setup appears.
6. Set up the 360 to measure S_{11} (return loss) as follows:
   (a) Press the CHANNEL MENU key.
   (b) Select **SINGLE DISPLAY** when Menu CM, Select Display Mode appears.
   (c) Press the S PARAMS key.
   (d) Select **S11 FWD REFL** when Menu SP, Select S-Parameter appears.
   (e) Press the CH1 key.
   (f) Press the GRAPH TYPE key.
   (g) Select **LOG MAGNITUDE** when Menu GT1, Select Graph Type appears.
7. Press the AUTOSCALE key.
8. Using Marker 1 and the Readout Marker feature, find the worst case return loss as follows:

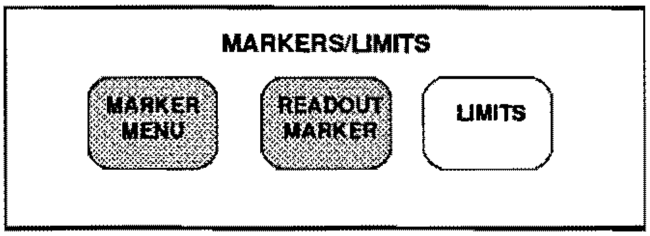


Figure 3-28. Marker Keys

   (a) Press the MARKER MENU key Figure 3-28.
   (b) Place the cursor on **MARKER 1** and press the ENTER key, when Menu M1, Set Markers appears.
   (c) Press the READOUT MARKER key.
   (d) Choose **MARKER TO MAX** and press the ENTER key, when Marker M4, Readout Marker appears.
9. This ends this tutorial. In later paragraphs, you will be taken step-by-step through calibration and measurement procedures. Calibration is covered in paragraph 3-11, while measurments start with paragraphs 3-12.

3-5 INSTRUMENT OPERATION—AN OVERVIEW

3-5.1 Power-Up Characteristics

When initially turned on (powered up), the 360 comes on line with the factory-selected default settings. On subsequent power-ups, it generally returns to the exact status and display that it was in when powered down last. (An exception is when the stored control panel setup data has been lost, then it comes on with the default settings.)

After coming on line, the 360 executes a self test. It then attempts to load its operating software from the installed disk. If unable to do so, it attempts to load from an internal ROM cartridge. If neither option is possible, it displays the message: "DISK NOT READY - PRESS ENTER TO TRY AGAIN." It then waits for you to take the appropriate action.

During the self test if the program detects a system fault, it shuts the system down and displays an error message. (A system fault is one that occurs in the 360, the test set, or the source.) If the program detects a fault in a peripheral device (such as the printer), it does not shut the system down. It only displays an error message.

3-5.2 Measurement Control

Measurement control is provided through selections of start, stop, and marker frequencies, as follows:

a. ***Start and Stop Frequencies***
Start and stop frequencies must meet the following criteria:

1. Be within the range of the frequency source and test set.
2. Have a span that provides 100 kHz resolution for the 360SSXX source.
3. Have a start frequency lower than the stop frequency.

NOTE

You may change the start and stop frequencies after calibration. However, your new frequencies must fall within the calibrated range when the calibration is applied.

b. ***Marker Frequencies***
If there are markers at frequencies other than the equally spaced set of calibration frequencies, they will be readjusted to a calibration frequency.

3-5.3 Data Enhancement

a. ***Vector Error Correction***
The 360 provides software correction for inherent measurement-setup error terms. Additionally, you can select software correction for any four measurements: Frequency Response, Reflection Only, One Path-Two Port, or Full 12-Term.

b. ***Data Averaging***
You can average measurements over time for a more accurate readout of noisy, rapidly changing amplitude data. In averaging, you select the number of points for which you wish averaging calculated. The sweep then stops at each frequency point and takes that number of readings. The program then averages the amplitude readings at that frequency point and writes the average value on the displayed graph-type. For calibration, the averaging function defaults to 128. You may reset it to any other value, however.

c. ***Smoothing***
You can smooth (amplitude only) measurement variations over a frequency span of from 0 to 20 percent of the sweep. The smoothing process uses a raised Hamming window to average the data from a span of frequencies. For example, in Figure 3-29 if the program averages all data points from A to B to give point X, then the average of all points from A+1 to B+1 is X+1.

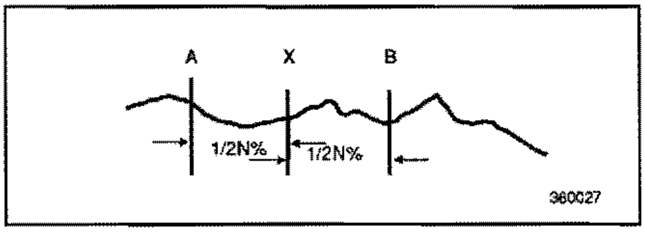


Figure 3-29. Example of Smoothing

d. ***Normalization (Trace Memory)***
Normalization means taking data from a standard component (filter or attenuator, for example), then later comparing it with another like item. To normalize data means to add, subtract, multiply, or divide it by standard data taken earlier and stored in memory. When the measured data taken from the two components are the same, the

360 displays a straight line. If they differ, however, it displays the degree of departure of the new data from the stored data.

3-5.4 Human Interface

The 360 interfaces with the user through a system of informative menus coordinated with control panel keys. You are always prompted by the menus to complete an action by pressing one or more keys. If the key is one of the menu-allowed choices, then the 360 responds in one of the following ways:

- It displays a different menu.
- It enters a numeric value.
- It allows a choice in the current menu.

If the key is not one of the above choices, the 360 beeps.

a. Channel Concept

The 360 has four measurement channels that you can display simultaneously, individually, or in pairs. You can display a different S-Parameter on each channel. Or, you can display the same S-Parameter on one or more channels. You can control the four channels separately for some functions and parameters, while others must be the same for all channels. The parameters that can be different for the different channels are as follows:

- Graph-Type (Rectilinear, Polar, Or Smith Chart)
- Amplitude Scales
- Reference Delay Setting
- Normalization Memory
- S-Parameters

The parameters that must be the same for all four channels are as follows:

- Start and Stop Frequencies
- Error Correction Type
- Calibration Type And Range
- Averaging
- IF Bandwidth
- Smoothing
- Marker Frequencies, Times, Distances

b. Display of Messages

The 360 displays on-screen text giving error and other messages. This text concisely states the condition causing the message, specifies an action needed, or both.

c. Active Parameter

The active parameter is the only one that you can change using the Data Entry keys or knob. We define a parameter as a frequency, time, degree, distance, or other numeric value that you can enter. (You enter a parameter using the keypad or knob and end it using one of the Terminator keys [Figure 3-39, Index 11]). You open such a parameter for modification by pointing a menu cursor at it. That makes it *active*. You close a parameter by moving the cursor away from it. Or, alternatively, you erase or replace the menu.

3-5.5 Stored Data

The 360 can store control panel setups along with normalization, measurement, and calibration data. The following is a list of the items saved. (The 360 saves these parameters for all active channels.)

a. Display Parameters

- Offset
- Resolution
- Reference Line
- Limits (Enabled, On/Off/Values)
- Minimum and Maximum Values
- Selected S-Parameter
- Display Type
- Active Channel
- Display Mode
- S-Parameter For Each Channel
- Blank Frequency Display Active, Color Plane
- Reference Delay
- Dielectric Used
- Dielectric Constant
- Normalize Mode

b. Measurement Parameters

- Start of Sweep
- End of Sweep
- Source Power and Attenuator Settings
- Frequency Resolution
- Device-Under-Test ID

c. Enhancement

- Smoothing Enabled
- Averaging Enabled
- Smoothing % of Sweep
- Number of Points Averaged
- IF Bandwidth

d. Output

- Type of Output
- Options Enabled (Model, Device ID, Date, Operator)
- Resolution

e. Calibration

- Size
- Frequencies
- Port Connector Types
- Calibration Type
- Correction Type

- Load Type
- Capacitance Coefficient for Connector
- Connector Offset Length for Each Port

f. ***Miscellaneous***
- Markers (Enabled, On/Off, Values)
- Delta Reference Mode
- Marker Frequencies, Times, Distances
- GPIB Addresses and Termination Unit

g. ***Disk Identification***
- Calibration File Name

h. ***Control Panel Setups***

You can store the instrument state (measurement parameters and operating modes) in internal non-volatile memory or on the installed disk. You select the storage media using the SAVE/RECALL MENU key and its related menus. You can save up to four control panel setups, along with calibration data, in internal memory and more on the disk. Additionally, the 360 saves certain parameters each time you turn it off. It automatically saves (1) the current control panel setup, (2) all measurement, display, calibration, and other parameters and functions. This allows it to return to its exact same state when powered up next.

i. ***Normalization Memory***

The 360 can store up to four channels of normalization data (S-Parameter measurements) in volatile RAM. To prevent the loss of this data when you turn the system off, you may also save it to the disk.

j. ***Measured Data***

You can also save measured data on the disk. The 360 stores it as ASCII-encoded text. The format is the same as that used for the tabular printout. This feature lets you make a computer analysis of the measured data, provided your computer has a compatible disk drive.

k. ***Calibration Data***

The 12-term error correction coefficients for each data point covered by the calibration being saved are stored as 12 single precision (32-bit real, 32-bit imaginary) complex numbers. This results in 96 bytes per point, or 48 KBytes for a 501 point calibration.

3-5.6 External and Peripheral Interfaces

a. ***Microfloppy Disks***

The 360 employs an integrally mounted disk drive for 3-1/2 inch microfloppy disks.

b. ***GPIB Interface***

The 360 has two GPIB interfaces: *Source Control* (Master) and *System Control* (Slave). You can program each of these interfaces for address, delimiting character, etc. using a menu. The 360 provides GPIB status in a menu.

GPIB Specifications are as follows:
- ***Interface:***
  - IEEE-488 standard GPIB.
- ***System Interface:*** IEEE-488 port used exclusively by the 360 to control and extract information from a Model 360SSXX frequency source.
  - *Addressing:* Controller is address = 0 and source is address = 5. Address are settable by menu ; for the 360SSXX, it is also settable from the rear panel.
  - *Speed:* 200 µs/bus cycle (device dependent).
  - *Interface Function codes:* SH1, AH1, T8, TE0, L4, LE0, SR0, RL0, PP0, DT0, DC0, C1, C2, C3, C27.
- ***360 GPIB (System Control or Slave):***
  - *Interface:* IEEE-488 standard GPIB.
  - *System Interface:* IEEE-488 port by which an external controller may take control of the 360. The controller can perform all control panel operations.
  - *Addressing:* Defaults to address 6, settable by menu control.

c. ***Parallel Printer Port***

The printer port is compatible with a standard "Centronics" interface. The 360 has the capability for an exact pixel-by-pixel dump of the CRT screen, when used with the WILTRON model 2225C inkjet printer. The output can be any of the following.

1. A full-screen dump.
2. A data-display dump that does not reproduce the menu.
3. A tabulated listing of the data.

d. ***Test Set Control Interface***

The Power and Data interfaces use 37-pin "D" subminiature connectors. The Signal and RF interfaces use 17-pin, 7 coaxial "D" subminiature connectors.

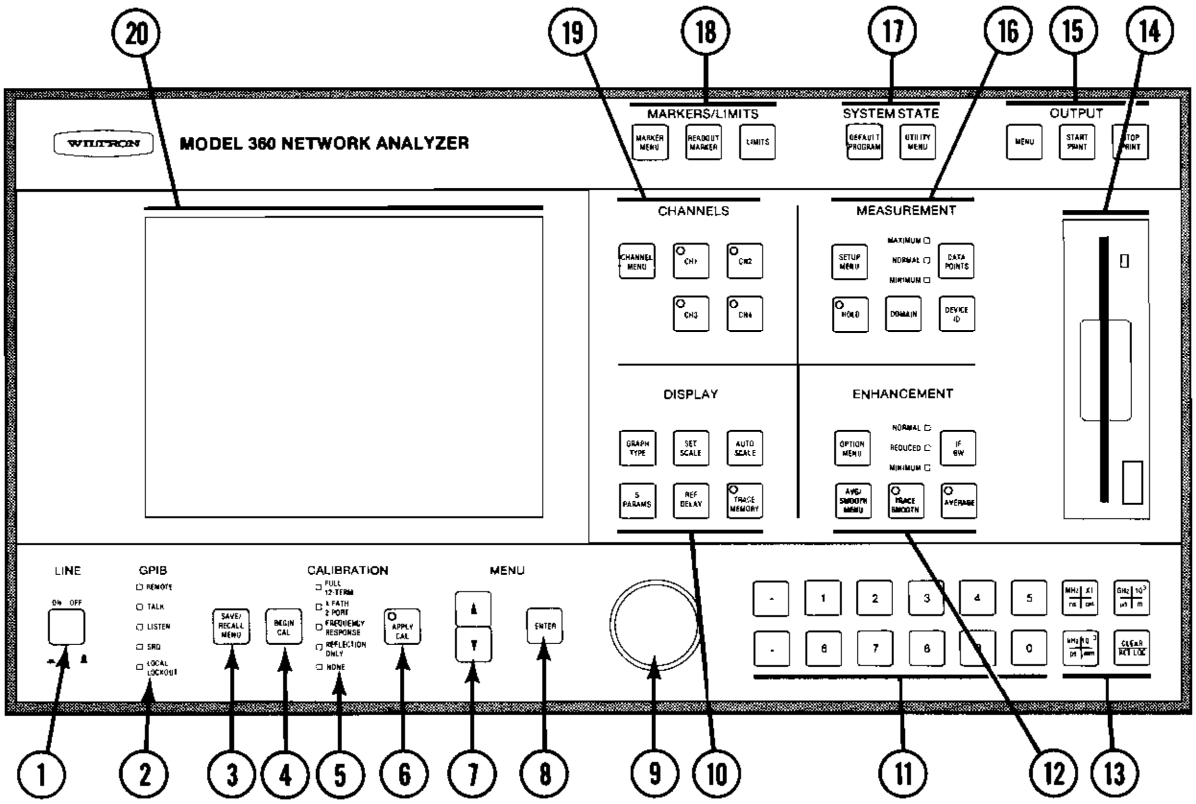
e. ***Video Interface***

The 360 provides two video outputs, as follows:

1. *Composite Monochrome Output.* This output has rear-panel screwdriver adjustments for relative mix levels of red, green, and blue. You can adjust the mix to display shades of gray on an external monitor.
2. *Separate R-G-B, TTL Level Outputs.* You control the level using the same adjustment as for 1, above. Additionally, the 360 has positive-true and negative-true horizontal and vertical drive signals available. All video signals are nominally either TTL levels or 1-volt, zero-to-peak-into-75-ohm levels. The signals appear on a dedicated 15-pin "D" subminiature connector mounted on the rear panel. The composite video is also available on an RCA-type phono connector.

3-6 MODEL 360 CONTROL PANEL CONTROLS

The 360 control panel controls are shown and described in Figure 3-30.



(1) **LINE ON/OFF:** Turns the 360 on and off. When pressed to ON, the program runs a self test then recalls the parameters and functions in effect when powered down last.

(2) **GPIB Indicators**

REMOTE: Lights when the 360 goes under GPIB control. It remains lit until the unit returns to local control.

TALK: Lights when you address the 360 to talk and remains lit until unaddressed.

LISTEN: Lights when you address the 360 to listen and remains lit until unaddressed.

SRQ: Lights when the 360 requests service from the controller (sends out a SRQ). The LED remains lit until the 360 receives a serial poll or until the controller resets the SRQ function.

LOCAL LOCKOUT: Lights when a local lockout message is received. The LED remains lit until the message is rescinded. When lit, you cannot return the 360 to local control via the front panel.

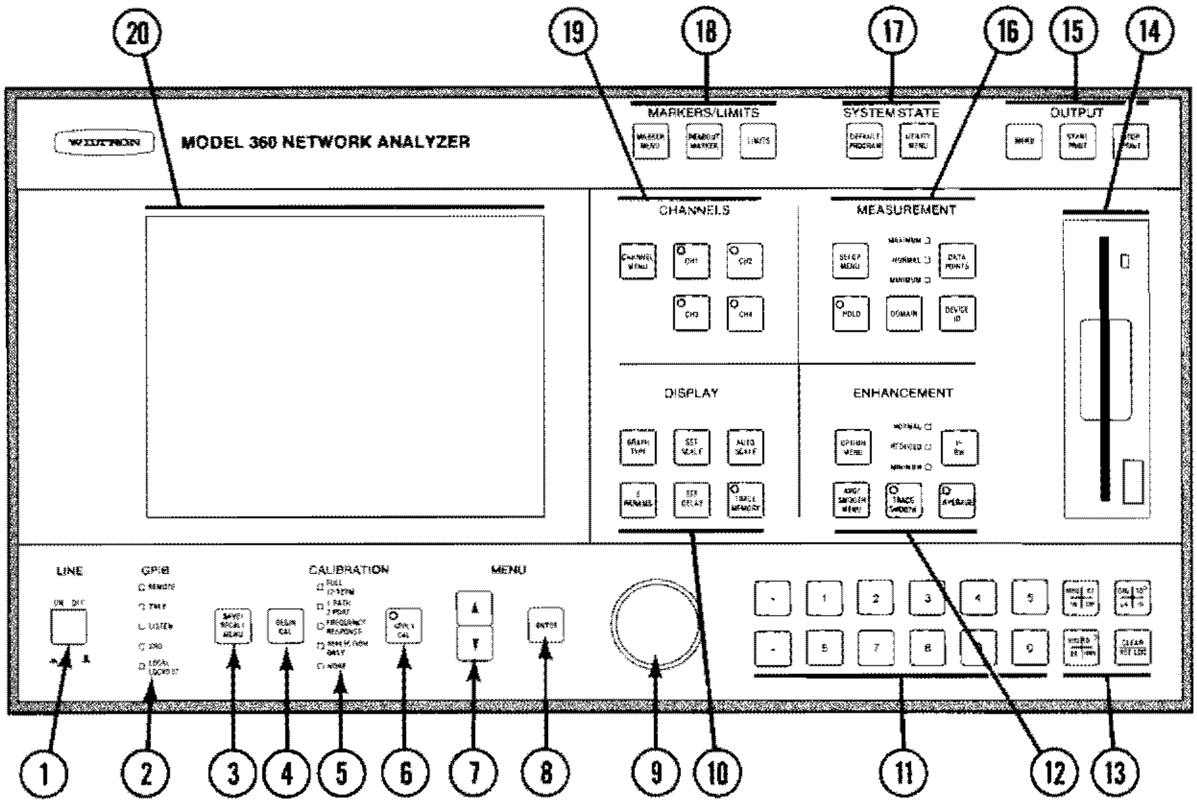
(3) **SAVE/RECALL MENU:** Displays the first of three-menus that let you save the current calibration or control panel setup or recall a previously saved calibration or setup.

(4) **BEGIN CAL:** Calls up the first in a sequence of menus that guide you through a measurement calibration. Refer to paragraph 3-8.1 for a detailed discussion of the calibration keys, indicators, and menus.

(5) **CALIBRATION Indicators:** Shows the calibration state of the 360.

(6) **APPLY CAL:** Turns on and off the applied error correction displayed by the calibration indicators.

Figure 3-30. Model 360 Control Panel Controls (Sheet 1 of 4)



(7) **MENU:** The ↑ key moves the menu cursor up and the ↓ key moves it down to select between entries appearing in the menu area of the CRT.

(8) **ENTER:** Implements the menu selection chosen using the MENU arrow keys.

(9) **ROTARY KNOB:** Used to alter measurement values for the *active parameter* (Start Frequency, Stop Frequency, Offset, etc).

(10) DISPLAY Keys

GRAPH TYPE: Displays either of two menus that let you choose the type of display and its s-parameter that appears for the active channel.

SET SCALE: Displays the appropriate scaling menu, based on the type of graph and its S-parameter being displayed for the active channel.

AUTO SCALE: Automatically scales the active channel for optimum viewing.

S PARAMS: Displays Menu SP, which lets you choose between S_{11}, S_{12}, S_{21}, or S_{22}. You may display the same parameter on two or more channels.

REF DELAY: Displays the first of two menus that let you enter a reference-delay in time or distance. For a correct distance readout, you must set the dielectric constant to the correct value. Refer to the discussion in Menu RD2 (Figure 3-82).

TRACE MEMORY: Displays a menu that lets you do one of the following. (1) Store the measured data in memory. (2) View the stored data. (3) Add, subtract, multiply, or divide the measured data from the stored data (normalize to the stored memory). (4) View both the measured and the stored data simultaneously on the active channel. Four memories exist—one for each channel. This lets you normalize the data in each channel independently. The LED on this button lights only when the active channel is displaying measurement data normalized to memory.

Figure 3-30. Model 360 Control Panel Controls (Sheet 2 of 4)

(11) **KEYPAD:** Provides for entering values for the active parameter. The active parameter is the one to which the menu cursor is pointing.

(12) ENHANCEMENT Keys and LED

IF BW: Cycles between NORMAL, REDUCED, and MINIMUM intermediate frequency (IF) bandwidths. The appropriate indicator lights to display the selected value.

AVG/SMOOTH MENU: Displays a menu that lets you enter values for AVERAGING and SMOOTHING.

OPTION MENU: Displays a menu showing the choice of options installed. (This key is not active unless you have options other than Time Domain installed.)

TRACE SMOOTH: Turns the trace smoothing function on and off.

AVERAGE: Turns the averaging function on and off.

(13) Terminator Keys

GHz/10^3/µs/m: Terminates a value entered on the keypad in the units shown—that is; gigahertz for frequency, $1X10^3$ power for dimensionless or angle entries, microseconds for time, or meters for length.
MHz/X1/ns/cm: Terminates a value entered on the keypad in the units shown—that is; megahertz for frequency, unity for dimensionless or angle entries, nanoseconds for time, or centimeters for length.
kHz/10^{-3}/ ps/mm: Terminates a value entered on the keypad in the units shown—that is; kilohertz for frequency, $1X10^{-3}$ power for dimensionless or angle entries, picoseconds for time, or millimeters for length.
CLEAR/RET LOC:

a. Local (Non-GPIB) Mode: (1) The key clears entries not yet terminated by one of the terminator keys above, which allows the previously displayed values to redisplay. Or (2) the key turns off the displayed menu, if you have not made any keypad entries needing termination.
GPIB Mode: The key returns the instrument to local (control panel) control, unless the controller has sent a local lockout message (LLO) over the bus.

(14) **DISK DRIVE:** Provides a drive for the 3-1/2 inch floppy disk used to store both the operating system and the selected front panel setups and calibrations. Refer to paragraph 3-6 for a detailed description.

(15) OUTPUT Keys

MENU: Displays option menus that let you define what will happen each time you press the START PRINT key. The displayed menu also selects disk I/O operations.

START PRINT: Tells the printer or plotter to start output based on the current selections or plotting.

STOP PRINT: Immediately stops printing the data, clears the print buffer, and sends a form-feed command to the printer. However, if the printer is not then printing data, the key only sends a form-feed command.

(16) MEASUREMENT Keys and LED

SETUP MENU: Displays the first of three menus that let you enter start/stop frequencies, source power, and attenuation values.

DEVICE ID: Displays a menu asking you to name the test device.

DATA POINTS: Cycles between maximum, normal, and minimum resolution values. The appropriate MAXIMUM, NORMAL, or MINIMUM switch indicator lights to display the selected value.

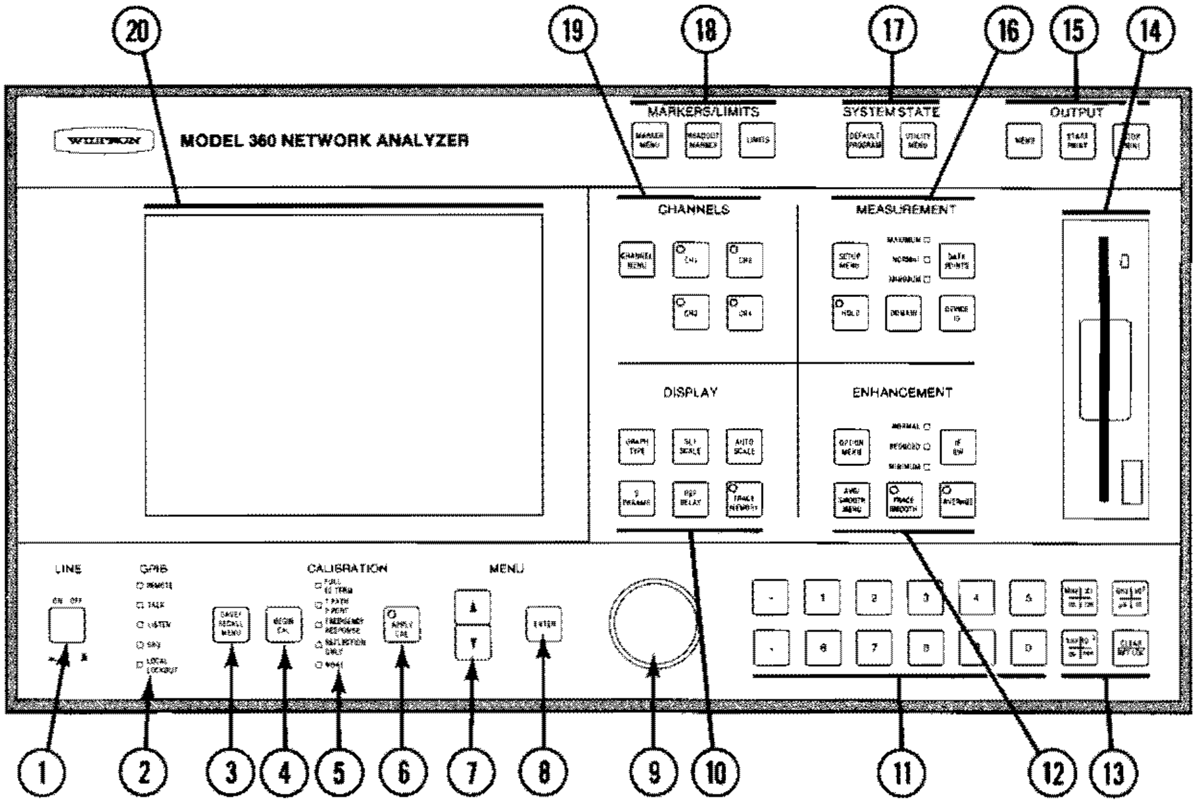
DOMAIN: Displays the first of the menus that let you set the Time Domain display parameters. (This key is only active if you have the Time Domain option.)

(1) If already in the DOMAIN menus, pressing this key will return to the first menu in the sequence.

(2) If in the DOMAIN menus and another (non-time domain) menu is displayed by pushing a menu key, the last displayed time domain menu redisplays when the DOMAIN key is next pressed.

HOLD: Toggles the instrument in and out of the hold mode or triggers a sweep, depending on the function selected in menu SU4.

Figure 3-30. Model 360 Control Panel Controls (Sheet 3 of 4)



(17) SYSTEM STATE Keys

DEFAULT PROGRAM: Resets the control panel to the factory-preset state and displays Menu SU1.

CAUTION

Use of this key will destroy control panel and calibration setup data, unless they have been saved to disk.

UTILITY MENU: Displays the first in a series of menus that let you perform diskette and other utility-type functions and operations.

(18) MARKERS/LIMITS Keys

MARKER MENU: Displays the first in a series of menus that let you set and manipulate marker frequencies, times, and distances.

READOUT MARKER: Displays a menu that lists all of the active markers. If no markers are active, the message "NO ACTIVE MARKERS" displays for four seconds in the message area of the screen.

LIMITS: Displays one of the menus that let you manipulate the Limit 1 and Limit 2 lines displayed on the CRT.

(19) CHANNELS Keys

CHANNEL MENU: Displays a menu that lets you display format for the channels.

CH 1: Makes Channel 1 the active channel. The active channel is the one acted on by the keys in the DISPLAY section. Only one channel can be active at any one time.

CH 2: Makes Channel 2 the active channel.

CH 3: Makes Channel 3 the active channel.

CH 4: Makes Channel 4 the active channel.

(20) CRT Display:

Displays any or all of the four measurement channels.

Figure 3-30. Model 360 Control Panel Controls (Sheet 4 of 4)

3-6.1 CALIBRATION Keys and Indicators (Figure 3-31)

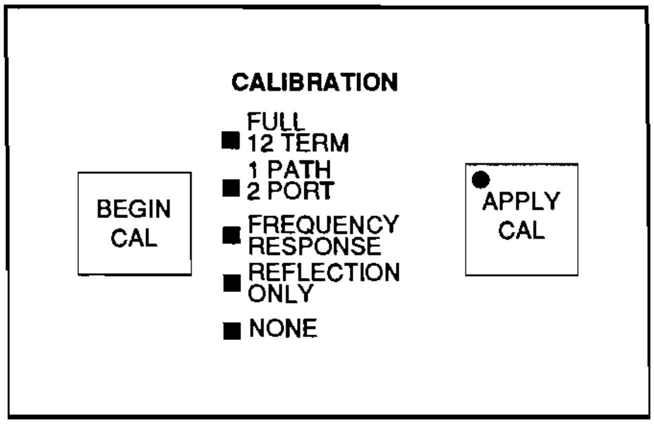


Figure 3-31. CALIBRATION Keys and Indicators

a. BEGIN CAL *Key*
This key displays a menu that lets you initiate the calibration sequence. That is, to begin a sequence of steps that corrects for errors inherent in a 2-port measurement setup.

b. APPLY CAL *Key*
This key turns on and off the error correction that you may apply to the displayed channel(s) using the currently valid error-correction indicator.

c. CALIBRATION *Indicators*
FULL 12 TERM: You have corrected for all twelve error terms associated with a two-port measurement (Figure 3-32).

NOTE

Choosing this calibration in Menu C5 corrects for all possible measurement error terms.

1 PATH, 2 PORT: You have corrected for the four forward-direction error terms (E_{DF}, E_{SF}, E_{RF}, and E_{TF}).

FREQ RESPONSE: You have corrected for one or both of the forward-direction error terms associated with a measurement of S_{11} and S_{21}. This is a subset of the 12-term calibration.

REFLECTION ONLY: You have corrected for the three error terms associated with an S_{11} measurement (E_{DF}, E_{SF}, and E_{RF}). This is a subset of the 12-term calibration.

NONE: No calibration data currently exists.

3-6.2 Calibration Menus

Measurement calibration is aided by the step-by-step procedures contained in the calibration menus. Figure 3-33 provides a flowchart describing the calibration sequence. Figures 3-34 thru 3-52 describe the calibration menus.

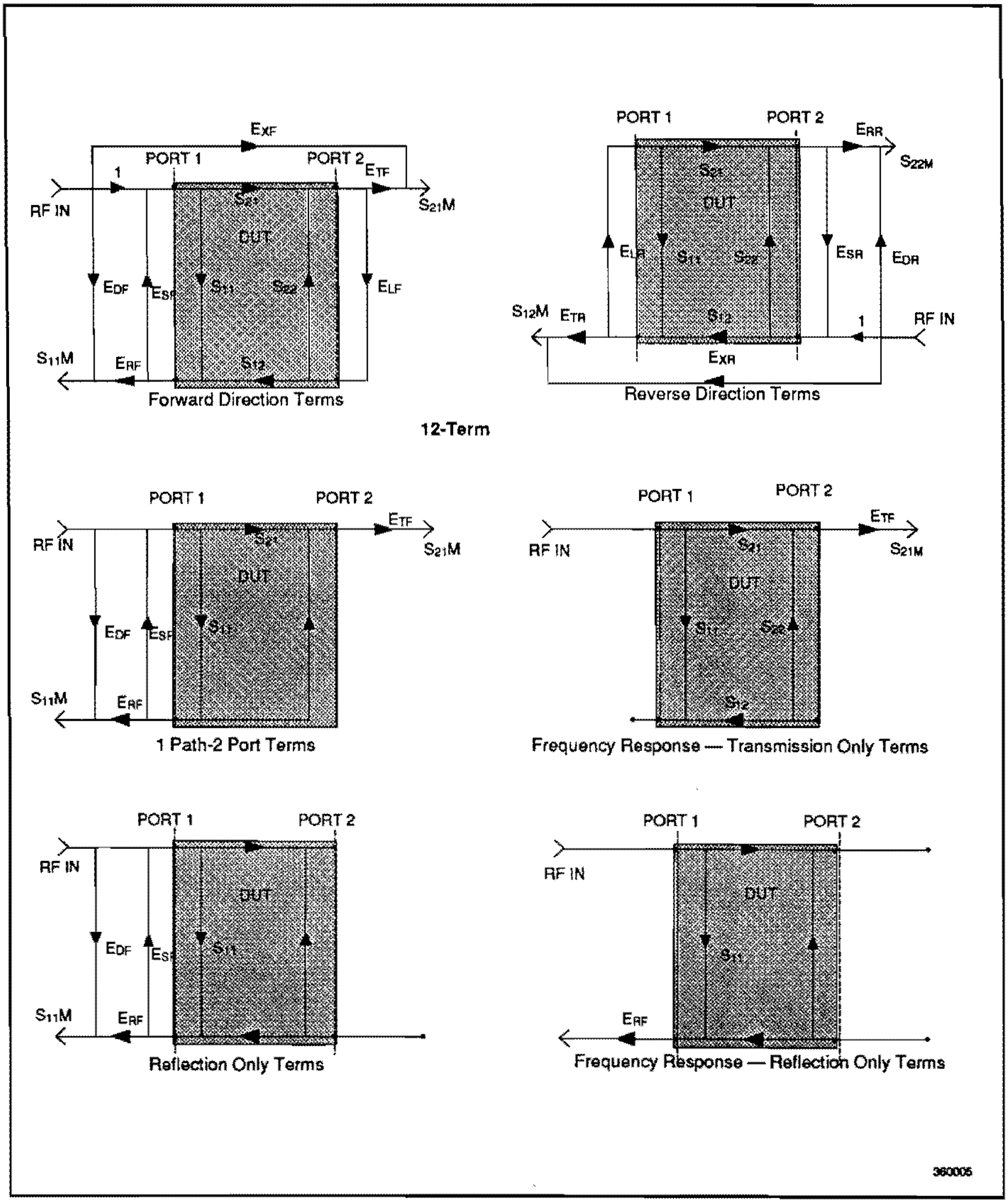


Figure 3-32. Error Models

MENU	DESCRIPTION
SELECT CALIBRATION DATA POINTS	
NORMAL (501 POINTS MAXIMUM)	Selects the standard calibration from a start to a stop frequency that provides for up to 501 equally spaced(except the last) points of data for the defined frequency range. A flowchart of the calibration sequence is shown in Figure 3-40.
C.W. (1 POINT)	Selects the single frequency (C.W.) calibration sequence that provides for 1 data point at a selected frequency.
N-DISCRETE FREQUENCIES (2 TO 501 POINTS)	Selects the discrete frequency calibration mode that lets you input a list of up to 501 individual data point frequencies.
TIME DOMAIN (HARMONIC)	Selects the calibration mode for low-pass time-domain processing.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your selection.

Figure 3-34. Menu C1, Select Calibration Data Points

MENU	
FREQ RANGE OF CALIBRATION	
START XX.XXXXGHz	Enter the sweep-start frequency for calibration. If you desire, you can change this frequency for your meaurement when you reach Menu SU1, which follows the final calibration menu. The only restriction is that your start measurement frequency be greater than or equal to your start calibration frequency.
STOP XX.XXXX GHz	Enter the sweep-stop frequency for calibration. Like the start frequency, this too can be changed for your measurement. The stop frequency must be lower than or equal to your stop calibration frequency. In other words, your measurement frequency span must be equal to or smaller than your calibration frequency span.
XXX DATA PTS USING ABOVE START AND STOP XXX.X MHz STEP SIZE	The program automatically sets the step size, based on the selected start and stop frequencies. The step size will be the smallest possible (largest number of points up to a maximum of 501), based on the chosen frequency span.
NEXT CAL STEP	Displays the next menu in the calibration sequence.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-35. Menu C2, Frequency Range of Calibration

MENU	DESCRIPTION
INSERT INDIVIDUAL FREQUENCIES	
INPUT A FREQ PRESS <ENTER> TO INSERT	
NEXT FREQ. XX.XXXXXX GHz	Move the cursor here and enter the next frequency for which you wish calibration data taken. If the AUTO INCR option is ON, pressing ENTER automatically increments the calibration frequency by the interval in GHz that appears the option.
XXX FREQS. ENTERED, LAST FREQ WAS XX.XXXXXX GHz	Shows the number of frequencies that you have entered and reports the value of the last frequency entered.
AUTO INCR ON (OFF) XX.XXXXXX GHz	Move the cursor here and press ENTER to switch the Auto-Increment mode on or off. If AUTO INCR is on, you may enter the frequency spacing.
PREVIOUS MENU	Displays C2D Menu.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing ENTER will cause actions as described above.

Figure 3-36. Menu C2A, Insert Individual Frequencies

MENU	DESCRIPTION
SINGLE POINT CALIBRATION	
C.W. FREQ XX.XXXXXX GHz	Move cursor here and enter the frequency for which calibration is to be done.
FINISHED ENTRY, NEXT CAL STEP	Move cursor here and press ENTER when finished.
INPUT FREQ AND PRESS <ENTER> TO SELECT	Input the frequency value and press the ENTER key.

Figure 3-37. Menu C2B, Single Point Calibration

MENU	DESCRIPTION
CALIBRATION RANGE	
HARMONIC CAL FOR TIME DOMAIN	
START (STEP) XX.XXXXXX GHz	Move cursor here to enter the desired start frequency. This frequency also will be used as the frequency increment.
APPROX STOP XX.XXXXXX GHz	Move the cursor here to enter the approximate desired stop frequency. The frequency will be adjusted to the nearest harmonic multiple of the start frequency.
USING ABOVE START AND STOP WILL RESULT IN XXX DATA POINTS AND XX.XXXXXX GHz TRUE STOP	The program automatically indicates the number of data points and the true (harmonic) stop frequency.
NEXT CAL STEP	Move the cursor here and press ENTER when finished.
PRESS <ENTER> TO SELECT	

Figure 3-38. Menu C2C, Calibration Range—Harmonic Cal for Time Domain

MENU	DESCRIPTION
FILL FREQUENCY RANGES	
INPUT START, INCR, POINTS, THEN SELECT "FILL RANGE"	This menu is used to create one or more ranges of discrete equally spaced frequency points for calibration.
START FREQ 0.5000 GHz	Enter the first frequency of the range.
INCREMENT 0.1004GHz	Enter the increment (step size) between one frequency and the next.
NUM OF PTS 82 POINTS	Enter the number of frequency points in the range.
STOP FREQ XX.XXXX GHz	
FILL RANGE (ENTERED) 82 FREQS	Moving the cursor here and pressing ENTER fills the range and shows the number of frequencies selected (in NUM OF PTS above).
INSERT INDIVIDUAL FREQUENCIES	Calls Menu C2A, which allows you to set the individual frequencies.
FINISHED ENTRIES, NEXT CAL STEP	Calls Menu C3, the next menu in the calibration sequence.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-39. Menu C2D, Fill Frequency Ranges

MENU	DESCRIPTION
CONFIRM CALIBRATION PARAMETERS	
PORT 1 CONN: SMA(M)	Displays the connector type for which the calibration is set to correct. This should agree with the connector type that both your calibration components and the test device mate with.
PORT 2 CONN : SMA (F)	
LOAD TYPE (BROADBAND)	Displays the type of load (termination) that you will use in the calibration. If you wish a different type, press the ENTER key to display Menu C4).
CHANGE PORT 1 CONN	Move cursor to appropriate line and press ENTER to change connector type.
CHANGE PORT 2 CONN	Move cursor to appropriate line and press ENTER to change connector type.
CHANGE LOAD TYPE	Move cursor to appropriate line and press ENTER to change load type.
START CAL	Starts the calibration sequence.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-40. Menu C3, Confirm Calibration Parameters

MENU	DESCRIPTION
CONFIRM CALIBRATION PARAMETERS	Used with Offset Short Coaxial Calibration.
LOAD TYPE: XXXXXXXX	Displays the type of load (termination) that you will use in the calibration.
CHANGE LOAD TYPE	Allows you to change the type of load that you will use for the measurement.
CHANGE OFFSET LENGTHS (SHORTS)	Allows you to change the offset lengths of the shorts for offset short calibration.
START CAL	Starts the calibration sequence.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-40A. Menu C3A, Confirm Calibration Parameters 1

MENU	DESCRIPTION
CONFIRM CALIBRATION PARAMETERS	Used with Waveguide Cal.
WAVEGUIDE CUTOFF FREQ XX.XXXX GHz	Move cursor to this line and enter the cutoff frequency of the type of waveguide in use.
CUTOFF MUST BE LESS THAN CALIBRATION START FREQ	
LOAD TYPE: XXXXXXXX	Displays the type of load (termination) that you will use in the calibration.
CHANGE LOAD TYPE	Allows you to change the type of load that you will use for the measurement.
CHANGE OFFSET LENGTHS (SHORTS)	Move the cursor to this line and press ENTER to change the offset lengths of the shorts used for waveguide calibration.
START CAL	Starts the calibration sequence.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-40B. Menu C3B, Confirm Calibration Parameters 2

MENU	DESCRIPTION
CONFIRM CALIBRATION PARAMETERS	Used with Microstrip Calibration
LOAD TYPE: XXXXXXXX	Displays the type of load (termination) that you will use in the calibration.
CHANGE LOAD TYPE	Allows you to change the type of load that you will use for the measurement.
CHANGE MICROSTRIP PARAMETERS	Move cursor to this line and press ENTER to change microstrip parameters.
CHANGE OFFSET LENGTHS (SHORTS)	Move the cursor to this line and press ENTER to change the offset lengths of the shorts used for microstrip calibration.
START CAL	Starts the calibration sequence.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-40C. Menu C3C, Confirm Calibration Parameters 3

MENU	DESCRIPTION
CONFIRM CALIBRATION PARAMETERS	Used for Microstrip Calibration
PORT 1 CONN. XXXXXX	Displays the connector type for which the calibration is set to correct. This should agree with the connector type that both your calibration components and the test device mate with.
PORT 2 CONN. XXXXXX	Same as above.
LOAD TYPE: XXXXXXXX	Displays the type of load (termination) that you will use in the calibration.
CHANGE PORT 1 CONN	Allows you to change the Port 1 connector type.
CHANGE PORT 2 CONN	Allows you to change the Port 2 connector type.
CHANGE LOAD TYPE	Allows you to change the type of load that you will use for the measurement.
CHANGE MICROSTRIP PARAMETERS	Allows you to change microstrip parameters.
START CAL	Starts the calibration sequence.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-40D. Menu C3D, Confirm Calibration Parameters 4

MENU	DESCRIPTION
SELECT PORT1 or 2 CONNECTOR TYPE	
SMA (M) SMA (F)	Applies the four capacitance-coefficient values to the Open that are needed to correct for an SMA connector being installed on the test device. Refer to paragraph 3-11.4, "Using Calibration Standards," for a discussion on this topic.
K-CONNECTOR (M) K-CONNECTOR (F)	Same as above, except for K Connector.
TYPE N (M) TYPE N (F)	Same as above, except for Type-N connector.
GPC-7	Same as above, except for GPC-7 connector.
OTHER	Calls Menu C12, which allow you to specify the connector coefficients.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-41. Menu C4, Select Connector Type

MENU	DESCRIPTION
SELECT CALIBRATION TYPE	
KEEP EXISTING CAL DATA	Keeps the existing calibration data, then exits the calibration sequence by calling up Menu C13.
FULL 12-TERM	Corrects for error terms ETF, ETR, ERF, ERR, EDF, EDR, EXF, EXR, ESF, ESR, ELF, and ELR (Figure 3-39), which are all of the error-terms associated with a two-port measurement. Refer to paragraph 3-11.1, "Explaining Measurement Accuracy," for a detailed decussion of these error terms.
1 PATH 2 PORT	Corrects for forward-direction error terms ETF, ERF, EDF, and ESF.
FREQUENCY RESPONSE ONLY	Corrects for forward-direction error terms ERF, and EDF. These provide a frequency-response-only correction for Port 1.
REFLECTION ONLY (PORT 1)	Corrects for forward-direction error terms ERF, EDF, and ESF. These provide a reflection-only correction for Port 1.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-42. Menu C5, Select Calibration Type

MENU	DESCRIPTION
SELECT FREQUENCY RESPONSE TYPE	
TRANSMISSION	For the calibration-correction of the transmission-only frequency-response error term.
REFLECTION	For the calibration-correction of the reflection-only frequency-response error term.
BOTH	For the calibration-correction of both transmission and reflection frequency-response error terms.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your selection.

Figure 3-43. Menu C5A, Select Frequency Response Type

MENU	DESCRIPTION
SELECT TYPE OF LOAD	
BROADBAND FIXED LOAD	Selects calibration based on the broadband load being used.
SLIDING LOAD (FREQS BELOW 2 GHz ALSO REQUIRE FIXED BROADBAND LOAD)	Selects calibration based on the sliding load being used. If your low-end frequency is below 2 GHz, a fixed broadband load is also required.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-44. Menu C6, Select Load Type

MENU	DESCRIPTION
CALIBRATION SEQUENCE	
CONNECT CALIBRATION DEVICES:	
PORT 1: XXXXXXXXXXXX	Connect the required component to Port 1.
PORT 2: XXXXXXXXXXXX	Connect the required component to Port 2.
MESSAGE AREA (See Figure 3-47	

Figure 3-45. Menu C7-Series, Begin Calibration Sequence

MENU	DESCRIPTION
CALIBRATION SEQUENCE	
SLIDE LOAD TO POSITION X	Slide the load to the next position, then press the ENTER key. Moving the slide to six different positions provides sufficient data for the program to accurately calculate the effective directivity of the system
MESSAGE AREA (See Figure 3-47	

Figure 3-46. Menu C8, Slide Load to Position X

The Calibration Sequence consists of several menus, similar in structure but different in content. The content differs only in the type of device (load, open, or short) the menus say to connect to ports 1 and 2. The menus automatically appear in a sequence based on choices made elsewhere in the calibration-menu series. For purposes of this discussion, we will call the menus C7A thru L. Each menu will specify a type of device to be connected to ports 1 and 2 (Table A), and each will provide a procedural message (one of the three types shown in Table B).

Table A

MENU	PORT 1 DEVICE	PORT 2 DEVICE
C7A	BROADBAND LOAD	BROADBAND LOAD
C7B	SLIDING LOAD	BROADBAND LOAD
C7C	SLIDING LOAD	INACTIVE
C7D	BROADBAND LOAD	INACTIVE
C7E	BROADBAND LOAD	SLIDING LOAD
C7F	BROADBAND LOAD	BROADBAND LOAD
C7G	OPEN	SHORT
C7H	SHORT	OPEN
C7I	BROADBAND LOAD	INACTIVE
C7J	OPEN	INACTIVE
C7K	SHORT	INACTIVE
C7L	BROADBAND LOAD	BROADBAND LOAD
C7M	SHORT 1	SHORT 2
C7N	SHORT 2	SHORT 1
C7O	SHORT 1	INACTIVE
C7P	SHORT 2	INACTIVE

Table B

MESSAGE A	MESSAGE B	MESSAGE C
PRESS <ENTER> TO MEASURE DEVICE(S)	MEASURING. . . PRESS <CLEAR> TO RESTART MEASUREMENT	PRESS <ENTER> FOR NEXT CAL STEP *OR* PRESS <CLEAR> TO REMEASURE

Calibration Sequence Flowchart

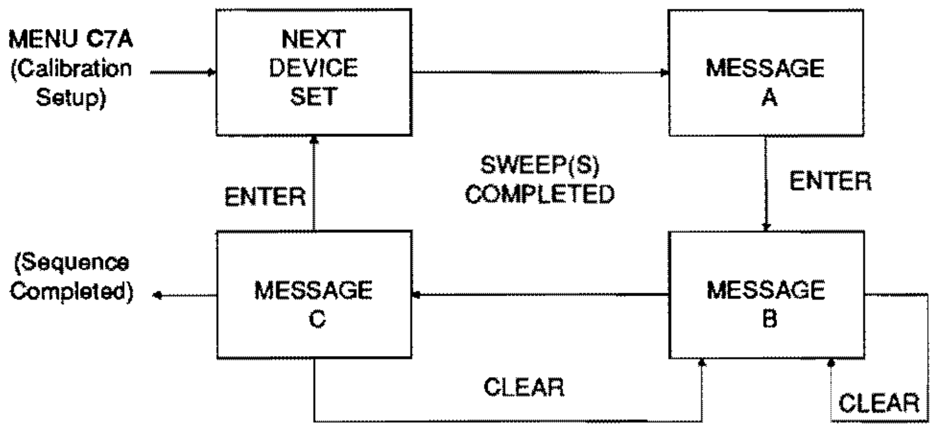


Figure 3-47. Calibration Sequence Messages and Flowchart

MENU	DESCRIPTION
CALIBRATION SEQUENCE	
CONNECT THROUGHLINE BETWEEN TEST PORTS	Connect Ports 1 and 2 together using the Throughline cable
MESSAGE AREA (See Figure 3-47)	

Figure 3-48. Menu C9, Connect Throughline

MENU	DESCRIPTION
CALIBRATION SEQUENCE COMPLETED	
PRESS <SAVE/RECALL> TO STORE CAL DATA ON DISK OR	Pressing the SAVE/RECALL MENU Key displays Menu SR that lets you save your calibration data onto a disk or recall previously saved calibration data from a disk. While this menu provides a convenient point at which to save the calibration data, it is not the only point allowed. You can use the SAVE/RECALL MENU key at any point in the measurment program.
PRESS <ENTER> TO PROCEED	Pressing the ENTER key implements your menu selection.

Figure 3-49. Menu C10, Calibration Sequence Completed

MENU	DESCRIPTION
BEGIN CAL	
KEEP EXISTING CAL DATA	Keeps the existing calibration data.
REPEAT PREVIOUS CAL	Repeats the previous calibration.
CAL METHOD: XXXXXXX	Displays the calibration method that you have selected (12-term; 1-path, 2 port; frequency response; reflection only.
TRANSMISSION LINE TYPE: XXXXXXXX	Indicates type of transmission line currently selected, e.g. coaxial, waveguide, microstrip.
CHANGE CAL METHOD	Allows you to change the calibration method.
CHANGE TRANSMISSION LINE TYPE	Allows you to change the transmission line type.
NEXT CAL STEP	Selects the next calibration step.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-49A. Menu C11, Begin Calibration

MENU	DESCRIPTION
SELECT TRANSMISSION LINE TYPE	
COAXIAL	Selects coaxial cable as the transmission type.
WAVEGUIDE	Selects waveguide as the transmission type.
MICROSTRIP	Selects microstrip as the transmission type.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-49B. Menu C11A, Select Transmission Line Type

MENU	DESCRIPTION
SELECT CAL METHOD	
STANDARD [ ] (NOT USED FOR WAVEGUIDE)	This option and the ones below allow you to select the method (procedure) to be used to calibrate. This method is independent of the calibration type, which may be 12 term, reflection only etc.
OFFSET SHORT	
LRL CAL	
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-49C. Menu C11B, Select Calibration Method

MENU	DESCRIPTION
SELECT WAVEGUIDE KIT TO USE	
- INSTALLED -	The lines below indicate the characteristics of the installed waveguide calibration kit, if applicable.
IDENTIFIER: XXXX	Displays the type of waveguide used.
CUTOFF FREQ: XX.XXX mm	Displays the cutoff frequency of the waveguide.
SHORT 1 XXX.XXX mm	Displays the length of the first calibration short.
SHORT 2: XXX.XXX mm	Displays the length of the second calibration short.
USE INSTALLED KIT	Move the cursor to this line and press ENTER to use the displayed kit.
OTHER	Move the cursor to this line and press ENTER to modify the parameters.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-49D. Menu C11C, Select Waveguide Kit to Use

MENU	DESCRIPTION
PORT 1 OR 2 OPEN DEVICE	Enter the capacitance-coefficient values needed to correct for your Open device.
ENTER THE CAPACITANCE COEFFICIENTS	
TERM 1-C0 ± XXX.XXXe- 15	Enter the term 1 coefficient value.
TERM 2-C1 ± XXX.XXX e - 27	Enter the term 2 coefficient value.
TERM 3-C2 ±XXX.XXX e - 36	Enter the term 3 coefficient value.
TERM 3-C3 ±XXX.XX e - 45	Enter the term 3 coefficient value.
ENTER THE OFFSET LENGTH	Enter the offset length value needed to correct for your Open device
OFFSET LENGTH ±XXX.XX mm	
PRESS <ENTER> WHEN COMPLETE	Pressing the ENTER key implements your menu selection

Figure 3-50. Menu C12, Enter the Capacitance Coefficients for Open Devices

MENU	DESCRIPTION
PORT 2 SHORT DEVICE	
ENTER THE OFFSET LENGTH	Enter the length that the Short is offset from the reference plane.
OFFSET LENGTH ± XXX.XXX mm	
PRESS <ENTER> WHEN COMPLETE	Pressing the ENTER key implements your menu selection.

Figure 3-51. Menu C12A, Enter the Offset Length

MENU	DESCRIPTION
EXISTING CALIBRATION KEPT	Retains the existing calibration data in memory. At the end of three seconds, the appropriate measurement setup menu appears.

Figure 3-52. Menu C13, Existing Calibration Kept

MENU	DESCRIPTION
ENTER OFFSET LENGTHS (SHORTS)	
- PORT 1 -	
SHORT 1 XXX.XXX mm	Enter the length that Short 1 is offset from the reference plane.
SHORT 2 XXX.XXX mm	Enter the length that Short 2 is offset from the reference plane.
IF USING ONLY TWO SHORTS PORT 2 OFFSETS SHOULD EQUAL PORT 1 OFFSETS	
PRESS <ENTER> WHEN COMPLETE	Pressing the ENTER key implements your menu selection.

Figure 3-52A. Menu C14, Enter Offset Lengths (Shorts)

MENU	DESCRIPTION
ENTER WAVEGUIDE PARAMETERS	
WAVEGUIDE CUTOFF FREQ XX.XXXX GHz	Move the cursor to this line and enter the cutoff frequency of the waveguide you are using.
OFFSET LENGTH OF SHORT 1 XXX.XXX mm	Move the cursor to this line and enter the offset length of Short 1.
OFFSET LENGTH OF SHORT2 XXX.XXX mm	Move the cursor to this line and enter the offset length of Short 2.
PRESS <ENTER> WHEN COMPLETE	Pressing the ENTER key implements your menu selection.

Figure 3-52B. Menu C15, Enter Waveguide Parameters

MENU	DESCRIPTION
ENTER MICROSTRIP PARAMETERS	
WIDTH OF STRIP XXX.XXX mm	Move the cursor to this line and enter the width of the microstrip you are using.
THICKNESS OF SUBSTRATE XXX.XXX mm	Move the cursor to this line and enter the thickness of the substrate you are using.
SUBSTRATE DIELECTRIC XXXX.XX	Move the cursor to this line and enter the dielectric type of the substrate you are using.
EFFECTIVE DIELECTRIC XXXX.XX	Displays the dielectric constant of the microstrip.
ZC XXX.XXX Ω	Displays the characteristic impedance of the microstrip.
PRESS <ENTER> WHEN COMPLETE	Pressing the ENTER key implements your menu selection.

Figure 3-52B. Menu C16, Enter Microstrip Parameters

3-6.3 SAVE/RECALL MENU Key And Menus (Figure 3-53)

Pressing this button displays the first of four menus (Figures 3-54 and 3-57) that allow you to save or recall control panel setups and calibration data.

Figure 3-53. SAVE/RECALL MENU Key

MENU TEXT	DESCRIPTION
SAVE/RECALL FRONT PANEL INFORMATION	
SAVE RECALL	Displays Menu SR2, which asks you to select a storage location—internal memory or disk.
PRESS <ENTER> TO SELECT FUNCTION	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-54. Menu SR1, Save/Recall Front Panel Information

MENU TEXT	DESCRIPTION
RECALL (or SAVE)	
FRONT PANEL SETUP IN INTERNAL MEMORY	Calls Menu SR3, which lets you save the control panel setup into or recalls it from internal memory.
CAL DATA AND FRONT PANEL SETUP ON DISK	Saves the calibration data and control panel setup onto the disk or recalls them from the disk. This selection displays Menu DSK9(recall) or DSK11, and GP1-3(save) which asks you to select a disk file.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-55. Menu SR2, Recall or Save

MENU	DESCRIPTION
SAVE TO INTERNAL MEMORY	
MEMORY 1	Causes the current control (front) panel setup to be saved to memory location 1.
MEMORY 2	Same as above, except the setup saves to memory location 2.
MEMORY 3	Same as above, except the setup saves to memory location 3
MEMORY 4	Same as above, except the setup saves to memory location 4
PRESS <ENTER> TO SELECT OR USE KEYPAD	You may press the ENTER key or use the keypad to implement your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-56. Menu SR3, Save to Internal Memory

MENU	DESCRIPTION
WARNING	
INTERNAL MEMORY DOES NOT MATCH CURRENT CAL SETUP	Warns that the setup you are attempting to recall is not compatible with the calibration data stored in memory.
CONTINUING RECALL WILL DESTROY CURRENT CAL	Recalling the setup in question will destroy the calibration data stored in memory.
PRESS <ENTER> TO RECALL OR PRESS <CLEAR> TO ABORT	Pressing the ENTER key recalls the selected setup, while pressing the CLEAR key aborts the selection.

Figure 3-57. Menu SR4, Warning—Internal Memory Does Not Match Current Cal Setup

3-6.4 MEASUREMENT Keys and Menus (Figure 3-58)

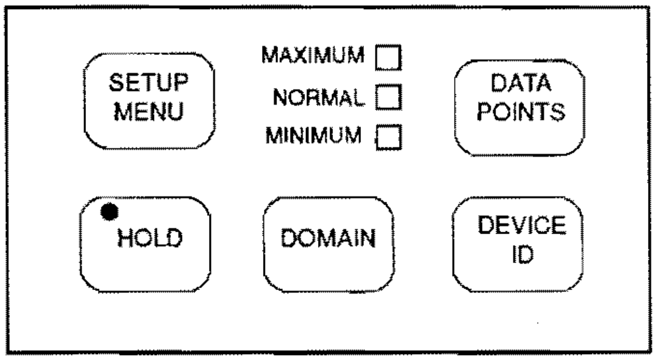


Figure 3-58. MEASUREMENT Keys

a. SETUP *Key*
Pressing this key calls Sweep Setup Menu SU1 (SU3). Depending upon which menu items you select, additional menus SU2 thru SU6 may also be called. Figures 3-59 thru 3-64. describe the six menus.

b. DEVICE ID *Key*
Pressing this key calls a menu that lets you to name the test device. This key has the same effect as selecting "Device ID" in the PM2 menu.

c. HOLD *Key*
If the instrument is sweeping, pressing this key results in the immediate halt of the sweep at the current data point. The LED on the button lights, indicating that the Hold Mode is active.

The instrument may be taken out of the hold mode as follows:

1. By using any of the options described in Menu SU4, Select Function for Hold Button.
2. By pressing the Default Program button. This causes the 360 to revert to a predefined state.
3. By pressing the Begin Cal button. This causes the 360 to resume sweeping and begin the Calibration Menu sequence.

NOTE
See Figure 3-69 (Menu SU4) for a description of the interaction between the Hold Mode and the selection of "Single Sweep" or "Restart Sweep"

If you restart the sweep after performing any disk operations in the Hold Mode (sweep stopped at some data point), the sweep restarts from the beginning.

d. DATA POINTS *Key*
Pressing this key toggles between MAXIMUM, NORMAL, and MINIMUM resolution, lighting the appropriate LED. If MAXIMUM resolution is X data points, MINIMUM resolution will be approximately X/6 data points and NORMAL resolution will be approximately X/3 data points. The nominal values are X=501, X/3=167 and X/10=85.

e. DOMAIN *Key*
See Figure 3-30 for a full description. Additionally, if the Time Domain option is installed, making a selection other than "Frequency Domain" lets you display measured data in the time domain. It also calls a further sequence of Time Domain Menus. Menu TD1 and all other time domain menus, along with a discussion of the time domain measurement, are provided in paragraph 3-16, "Time Domain Measurements."

MENU	DESCRIPTION
SWEEP SETUP	
START XX.XXXXXX GHz	Enter the sweep-start frequency in GHz. The start frequency must be lower than the stop frequency.
STOP XX.XXXXXX GHz	Enter the sweep-stop frequency in GHz. The stop frequency must be higher than the start frequency.
XXX DATA PTS USING ABOVE START AND STOP XXX.X MHz STEP SIZE	Displays the number of frequency points and the spacing between points for the start and stop frequencies selected above. The number of points shown provides the finest frequency resolution possible, based on your DATA POINTS key MAXIMUM-NORMAL- MINIMUM selection.
C.W. MODE ON XX.XXXXXX GHZ	Move cursor here and press ENTER to enable the CW mode. Enter CW frequency for measurements.
MARKER SWEEP	Move cursor here and press ENTER to set the start and stop frequencies (SU5) or the CW frequency (SU6) to the values of any marker
HOLD BUTTON FUNCTION	Displays Menu SU4, which lets you set the action of the HOLD key.
REDUCED TEST SIGNALS	Displays Menu SU2, which lets you set the source power and the values for the attenuators in the Model 3620 Series Test Set.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-59. Menu SU1, Sweep Setup 1

MENU	DESCRIPTION
SWEEP SETUP	
REDUCED TEST SIGNALS	
SOURCE POWER ±XX.XdBm	Enter the output-power level for the sweep generator (frequency source) in dBm.
PORT 1 SOURCE X0 dB (0-70)	Attenuates the microwave source power from 0 to 70 dB, in 10 dB steps. The power is attenuated before being applied to Port 1 for a forward transmission or reflection test (S_{21} or S_{11}, respectively).
PORT 2 SOURCE X0 dB (0-70)	Attenuates the microwave source power from 0 to 70 dB, in 10 dB steps. The power is attenuated before being applied to Port 2 for a reverse transmission or reflection test (S_{12} or S_{22}, respectively).
PORT 2 TEST X0 dB (0-40) (THIS REDUCES SIGNAL FROM AMPLIFIER UNDER TEST)	Attenuates from 0 to 40 dB (10 dB steps) the microwave power being input to Port 2 from the device-under-test (DUT).

Figure 3-60. Menu SU2, Sweep Setup 2

MENU	DESCRIPTION
SINGLE POINT MEASUREMENT SETUP	
C.W. FREQ XX.XXXXXX GHz	Enter the measurement frequency in GHz for continuous wave (CW) operation.
HOLD BUTTON FUNCTION	Displays Menu SU4, which lets you set the action of the HOLD key.
REDUCED TEST SIGNALS	Displays Menu SU2, which lets you set values for the source power and attenuators in the Model 3620 Series Test Set.
RETURN TO SWEEP MODE	Move cursor here and press ENTER to return to the F1-F2 sweep mode.(Menu SU1)
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-61. Menu SU3, Single-Point Measurement Setup

MENU	DESCRIPTION
SELECT FUNCTION FOR HOLD BUTTON	
HOLD/CONTINUE	Causes the hold key (button) to stop and start the sweep.
HOLD/RESTART	Causes the hold key to stop and restart the sweep.
SINGLE SWEEP AND HOLD	Causes the hold key to trigger a single sweep and hold when finished. (Two sweeps, one from Port 1 to 2 and another from Port 2 to 1, are accomplished for a 12-Term measurement.)
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-62. Menu SU4, Select Function for Hold Button

MENU	DESCRIPTION
FREQUENCY MARKER SWEEP	
START SWEEP MARKER (n) XX.XXXX GHz	Pressing a number on the keypad causes the associated marker to be the start frequency of the sweep.
STOP SWEEP MARKER (n) XX.XXXX GHz	Pressing a number on the keypad causes the associated marker to be the stop frequency of the sweep.
USE KEYPAD TO SELECT MARKER (1 - 6)	Use the keypad to select markers 1, 2, 3, 4, 5, or 6.

Figure 3-63. Menu SU5, Frequency Marker Sweep

MENU	DESCRIPTION
FREQUENCY MARKER C.W.	
C.W. FREQ MARKER (n) XX.XXXX GHz	Pressing a number on the keypad causes the associated marker to be the C.W. frequency.
USE KEYPAD TO SELECT MARKER (1 - 6)	Use the keypad to select markers 1, 2, 3, 4, 5, or 6.

Figure 3-64. Menu SU6, Frequency Marker C.W.

3-6.5 CHANNEL Keys and Menu (Figure 3-65)

a. **CH 1-4 *Keys***
These keys define the active channel. One (and only one) must always be active as indicated by the associated LED. Pressing a button makes the indicated channel active. If it is already the active channel, pressing the key has no effect.

The active channel will be the channel acted upon by the S PARAMS, GRAPH TYPE, REF DELAY, TRACE MEMORY, SET SCALE, AUTO SCALE and DOMAIN keys. When in the single channel display mode, the active channel will be the one displayed.

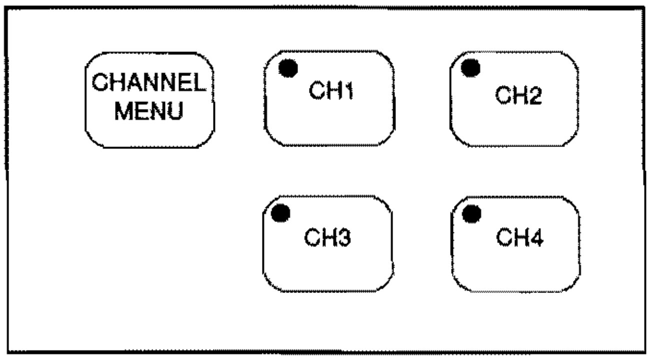


Figure 3-65. CHANNEL Keys

b. **CHANNEL *Menu***
Pressing this key calls menu CM (Figure 3-66). Here, you select the number of channels to be displayed. When in the single display mode, only the active channel will be displayed.

MENU	DESCRIPTION
SELECT DISPLAY MODE	
SINGLE DISPLAY	Selects a single channel for display, which can be log magnitude, phase, log magnitude and phase, or Smith chart. You select the type of display in Menu GT.
DUAL DISPLAY CHANNEL 1 - 3	Selects Channels 1 and 3 for display. You select the type of display in Menu GT.
DUAL DISPLAY CHANNEL 2 - 4	Selects Channels 2 and 4 for display. You select the type of display in Menu GT.
ALL FOUR CHANNELS	Selects all four channels for display. You select the type of display in Menu GT.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-66. Menu CM, Select Display Mode

3-8.1 DISPLAY Keys and Menus (Figure 3-67)

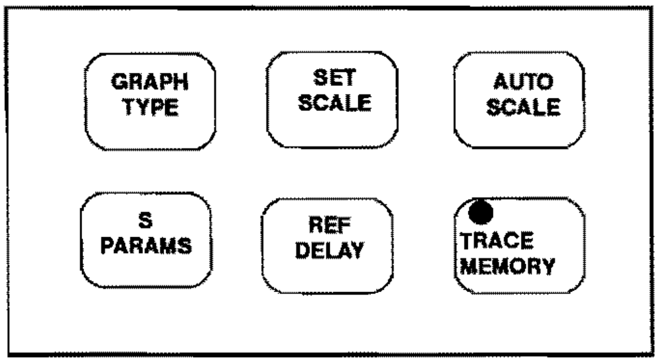


Figure 3-67. DISPLAY Keys

a. **S PARAMS *Key***
Pressing this key calls menu SP. This menu allows you to select the S-Parameter to be displayed by the active channel for the selected s-parameter.

b. **GRAPH TYPE *Key***
Pressing this key calls menu GT1 or GT2. These menus let you select the type of display to appear on the active channel for the selected s-parameter.

c. **SET SCALE Key**
Pressing this key calls the appropriate scaling menu (SSn) depending upon the graph type being displayed on the active channel for the selected s-parameter.

d. **REF DELAY Key**
Pressing this key calls menu RD1. This menu lets you input the reference delay in time or distance. You do this by selecting the appropriate menu item. For a correct distance readout, the dielectric constant must be set to the correct value. This is accomplished by selecting "SET DIELECTRIC", which calls menu RD2.

On menu RD1, selecting "AUTO" and pressing ENTER automatically adjusts the reference delay to unwind the phase. The values for time and distance turn red for one second when you activate "AUTO."

The 360 unwinds the phase as follows:

1. First, it sums the phase increments between each pair of measured data points, then it takes the average "Pdelta" over the entire set of points.
2. Next, it corrects the phase data by applying the following formula:
   Pcorrect = Pmeasured - NxPdelta
   (where Pmeasured is the measured phase of the Nth data point).

Assuming there are fewer than 360 degrees of phase rotation between each data point, the above-discribed operation removes any net phase offset. The endpoints of the phase display then fall at the same phase value.

e. **AUTO SCALE *Key***
Pressing this key autoscales the trace or traces of the active channel. When in one of the scaling menus, the 360 indicates this is happening by turning the menu entries red for 1 second. The new scaling values are then displayed on the menu and graticule. The resolution will be selected from the normal sequence of values you have available using the knob. When the active channel has a Real- and Imaginary -type display, the larger of the two signals will be used to autoscale both the real and imaginary graphs. Both graphs will be displayed at the same resolution.

f. **TRACE MEMORY *Key***
Pressing this key brings up menu NO1. This menu—which relates to the active channel—allows you to store data to memory, view memory, perform operations with the stored memory, and view both data and memory simultaneously. Four memories exist, one for each channel. This allows each channel to be stored and normalized independent of the other channels. Data from the trace memory may be stored on the disk or recalled from it.

g. **DISPLAY Menus**
Figures 3-68 thru 3-75 show the menus associated with the GRAPH TYPE, S PARAMS, and REF DELAY keys. Figures 3-83 and 3-84 show two menus that are representative of the twelve associated with the SET SCALE key.

MENU	DESCRIPTION
SELECT S - PARAMETER	
S21 FWD TRANS	Selects the S_{21} parameter to be displayed on the active channel. The parameter can be displayed in any of the available formats.
S11 FWD REFL	Selects the S_{11} parameter to be displayed on the active channel. The parameter can be displayed in any of the available formats.
S12 REV TRANS	Selects the S_{12} parameter to be displayed on the active channel. The parameter can be displayed in any of the available formats.
S22 REV REFL	Selects the S_{22} parameter to be displayed on the active channel. The parameter can be displayed in any of the available formats.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/LOC key is pressed.

Figure 3-68. Menu SP, Select S Parameter

MENU	DESCRIPTION
SELECT GRAPH TYPE	
LOG MAGNITUDE	Selects a log magnitude graph for display on the active channel's selected s-parameter. The active channel is indicated by its key (CH1, CH2, CH3, CH4) being lit.
PHASE	Selects a phase graph for display on the active channel.
LOG MAGNITUDE AND PHASE	Selects log magnitude and phase graphs for display on the active channel.
SMITH CHART (IMPEDANCES)	Selects a Smith chart for display on the active channel.
SWR	Selects an SWR display for the active channel.
GROUP DELAY	Selects a Group Delay display for the active channel.
MORE	Takes you to additional graph type selections on Menu GT2.
PRESS <ENTER> TO SELECT AND RESUME CALIBRATION	Pressing the ENTER key implements your menu selection and resumes the calibration from where it left off, if iin the calibration mode. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-69. Menu GT1, Select Graph Type

MENU	DESCRIPTION
SELECT GRAPH TYPE	
ADMITTANCE SMITH CHART	Selects an Admittance Smith chart for display on the active channel's s-parameter.
LINEAR POLAR	Selects a Linear Polar graph for display on the active channel's s-parameter.
LOG POLAR	Selects a Log Polar graph for display on the active channel's s-parameter.
LINEAR MAG	Selects a Linear Magnitude graph for display on the active channel's s-parameter.
LINEAR MAG AND PHASE	Selects Linear Magnitude and Phase graphs for display on the channel's s-parameter.
REAL	Selects Real data for display on the active channel's s-parameter.
IMAGINARY	Selects Imaginary data for display on the active channel's s-parameter.
REAL AND IMAGINARY	Selects both Real and Imaginary data for display on the active channel's s-parameter.
MORE	Takes you to additional graph type selections
PRESS <ENTER> TO SELECT AND RESUME CALIBRATION	Pressing the ENTER key implements your menu selection and resumes the calibration from where it left off, if in the calibration mode. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-70. Menu GT2, Select Graph Type

MENU	DESCRIPTION
TRACE MEMORY FUNCTIONS	
VIEW DATA	Displays measured data; that is, the data presently being taken.
VIEW MEMORY	Displays stored data; that is, data that was previously taken and stored in memory.
VIEW DATA AND MEMORY	Displays measured data superimposed over stored data.
VIEW DATA ÷ MEMORY	Displays measured data divided by stored data.
SELECT TRACE MATH	Takes you to Menu NO2 for selection of the type of math operation to be performed.
STORE DATA TO MEMORY	Stores the measured data to internal memory.
DISK FUNCTIONS	Brings up Menu NO3, which allows data to be stored to or recalled from the disk.
MEMORY DATA REF, DELAY XXX.XXX CM	Indicates the reference delay applied to the memory data being displayed.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-71. Menu NO1, Trace Memory Functions

MENU	DESCRIPTION
SELECT TRACE MATH	
ADD (+)	Selects DATA + MEMORY as the math function.
SUBTRACT (–)	Selects DATA – MEMORY as the math function.
MULTIPLY (X)	Selects DATA X MEMORY as the math function.
DIVIDE (÷)	Selects DATA ÷ MEMORY as the math function.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu returns to the NO1 menu.

Figure 3-72. Menu NO2, Select Trace Math

MENU	DESCRIPTION
TRACE MEMORY DISK FUNCTIONS	
CHANNEL X	Indicates the channel to be used (active channel).
STORE TO DISK	Displays GP1-3 or DSK11 menu to select file to store data from selected channel on disk
RECALL FROM DISK	Displays DSK9 menu to select file to recall from disk.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-73. Menu NO3, Trace Memory Disk Functions

MENU	DESCRIPTION
SET REFERENCE DELAY	
AUTO	Automatically sets the reference delay so that the cumulative phase shift is zero. This selection unwinds the phase in a Smith chart display or reduces the phase revolutions in a rectilinear display to less than one.
DISTANCE XXX.XXX mm	Electrically repositions the measurement reference plane, as displayed on the active channel, by a distance value entered in millimeters. This selection lets you compensate for the phase reversals inherent in a length of transmission line connected between the test set's Port 1 connector and the device-under-test (DUT).
TIME XXX.XXX ms	Electrically repositions the measurement reference plane by a distance value that corresponds to the time in milliseconds.
SET DIELECTRIC	Displays Menu RD2, which lets you enter a value for the dielectric constant of your transmission line. The active dielectric, which was selected in menu RD2, displays in blue.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-74. Menu RD1, Set Reference Delay

MENU	DESCRIPTION
SET DIELECTRIC CONSTANT	
AIR (1.00)	Calculates reference delay based on dielectric constant of air (1).
POLYETHYLENE (2.26)	Calculates reference delay based on the dielectric constant of polyethylene (2.26).
TEFLON (2.10)	Calculates reference delay based on the dielectric constant of teflon (2.1).
MICROPOROUS TEFLON (1.69)	Calculates reference delay based on the dielectric constant of microporous teflon (1.69).
OTHER XXXX.XX	Calculates reference delay based on the value you enter. Terminate your entry using any terminator and select with the ENTER key.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selectionand returns you to the RD1 menu.

Figure 3-75. Menu RD1, Set Dielectric Constant

MENU	DESCRIPTION
SET SCALING OR PRESS <AUTOSCALE>	
–LOG MAG–	
RESOLUTION XX.XXX dB/DIV	Sets the resolution for the vertical axis of the active channel's displayed log magnitude graph. Resolution can by set incrementally using the keypad or rotary knob. For the linear polar graph, the center is fixed at 0 units; therefore, changing the resolution also changes the reference value and vice versa
REF VALUE XXX.XXX dB	Sets the value by which the active channel's amplitude measurement is offset on the log-magnitude graph. The offset can be set in increments of 0.001 dB using the keypad or rotary knob.
REFERENCE LINE	Sets the reference line for the active channel's amplitude measurement on the log-magnitude graph. This is the line about which the amplitude expands with different resolution values. The reference line can be set to any vertical division using the rotary knob.
–PHASE–	
RESOLUTION XX.XX DEG/DIV	Sets the resolution for the vertical axis of the active channel's displayed phase graph. Resolution can by set incrementally using the keypad or rotary knob.
REF VALUE XXX.XX DEG	Sets the value by which the active channel's phase measurement is offset on the phase graph. The offset can be set in increments of 0.01 degrees using the keypad or rotary knob.
REFERENCE LINE	Sets the reference line for the active channel's phase measurement on the phase graph. This is the line about which the phase expands with different resolution values. The reference line can be set to any vertical division using the rotary knob.

Figure 3-76. Menu SS1, Set Scaling 1

MENU	DESCRIPTION
SET SCALING OR PRESS <AUTOSCALE>	
IMPEDANCE (ADMITTANCE) SMITH CHART	Scales an Impedance Smith chart for display in the active channel.
NORMAL SMITH (REFL = 1.000 FULL SCALE)	Selects a normal Smith chart for display in the active channel.
EXPAND 10 dB (REFL = 0.316 FULL SCALE)	Selects a 10 dB expansion of the Smith chart being displayed for the active channel.
EXPAND 20 dB (REFL = 0.099 FULL SCALE)	Selects a 20 dB expansion of the Smith chart being displayed for the active channel.
EXPAND 30 dB (REFL = 0.031 FULL SCALE)	Selects a 30 dB expansion of the Smith chart being displayed for the active channel.
COMPRESS 3 dB (REFL =1.413 FULL SCALE)	Selects a 3 dB compression of the Smith Chart being displayed for the active channel.
PRESS <ENTER> TO SELECT AND RESUME CALIBRATION	Pressing the ENTER key implements your menu selection and resumes the calibration from where it left off, if in the calibration mode.. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-77. Menu SS3, Set Scaling 3

3-6.7 ENHANCEMENT Keys and Menus (Figure 3-78)

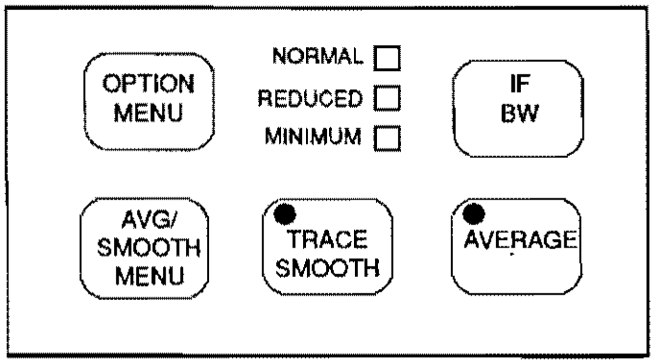


Figure 3-78. ENHANCEMENT Keys

a. **OPTION MENU *Key***
This key is reserved for future options.

b. **AVG/SMOOTH MENU *Key***
Pressing this key brings up the EM Menu (Figure 3-79). When pressed during the calibration sequence, it brings up the EM Cal Menu (Figure 3-80) instead.

c. **TRACE SMOOTH *and* AVERAGE Keys**
The AVERAGE and TRACE SMOOTH keys select their respective functions on and off with the appropriate LED indicating when the function is selected.

d. **IF BW Key**
Pressing this key cycles between three different IF bandwidths. The applicable NORMAL, REDUCED, or MINIMUM LED lights to indicate selection.

MENU	DESCRIPTION
DATA ENHANCEMENT	
AVERAGING XXXX MEAS. PER POINT	Averages the measured data over time, as follows: 1. The sweep stops at the first frequency point and takes a number of readings, based on the selected number of points. 2. The program averages the readings and writes the average value for that frequency point in the displayed graph. 3. The sweep then advances to the next sequential frequency point and repeats the process.
SMOOTHING XX.X PERCENT OF SPAN	Smoothes the measured data over frequency, as follows: 1. The program divides the overall sweep into smaller segments, based on the selected percent-of-span. (Refer to paragraphs 3-5.3 and Figure 3-29 for a description and example of smoothing.) 2. It takes a data reading at each frequency point within that percent-of-span segment. 3. It averages the readings with a raised Hamming window and writes that magnitude value at the mid-frequency point of the segment in the displayed graph or Smith chart. 4. It then advances the percent-of-span segment to encompass the next sequential group of frequency points and repeats the process.

Figure 3-79. Menu EM, Enhancement Menu

MENU	DESCRIPTION
DATA ENHANCEMENT	
AVERAGING XXXX MEAS. PER POINT	Averages the measured data over time, as follows: 1. The sweep stops at the first frequency point and takes a number of readings, based on the selected number of points. 2. The program averages the readings and writes the average value for that frequency point in the displayed graph. 3. The sweep then advances to the next sequential frequency point and repeats the process.
SMOOTHING XX.X PERCENT OF SPAN	Smoothes the measured data over frequency, as follows: 1. The program divides the overall sweep into smaller segments, based on the selected percent-of-span. (Refer to paragraphs 3-5.3 and Figure 3-29 for a description and example of smoothing.) 2. It takes a data reading at each frequency point within that percent-of-span segment. 3. It averages the readings with a raised Hamming window and writes that magnitude value at the mid-frequency point of the segment in the displayed graph or Smith chart. 4. It then advances the percent-of-span segment to encompass the next sequential group of frequency points and repeats the process.

Figure 3-80. Menu EMCal, Enhancement Menu for Calibration

3-6.8 OUTPUT Keys and Menus (Figure 81)

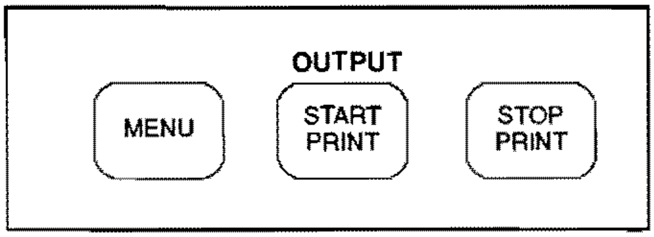


Figure 3-81. OUTPUT Keys

a. MENU *Key*
Pressing this key brings up menu PM1. This menu allows you to define what will happen every time you press the START PRINT key. Figures 3-82 thru 3-85 describe the menu options.

b. START PRINT *Key*
Pressing this key starts outputting the measured data as defined by the setup defined by the selected MENU key

c. STOP PRINT *Key*
Pressing this key can result in any of the following actions if the printer is selected

- If the 360 is not outputting data, the key sends a form feed command to the printer.
- If the printer is active, the key aborts the printing and sends a form feed command to the printer. Aborting the printing clears the print buffer.
- Pressing this key if the printer is not selected and another form of output is active, the key aborts it but *does not* send a form feed to the printer.

d. ***Plotting Functions***
The 360 can plot an image of either the entire screen or subsets of it. Plots can be either full size or they can be quarter size and located in any of the four quadrants. You can select different pens for plotting different parts of the screen. You cannot, however, plot tabular data. The menus for selecting plotter functions are shown in Figures 3-86 thru 3-88.

MENU	DESCRIPTION
SELECT OUTPUT DEVICE	
PRINTER	Selects the printer as your output device.
PLOTTER	Selects the plotter as your output device.
SELECT PRINTER OUTPUT TYPE	
FULL SCREEN	Prints full-screen data, including the menu entries.
GRAPH ONLY	Prints only the graph or Smith chart, including any and all data it contains.
TABULAR DATA	Prints a tabulation of the measured data.
OUTPUT OPTIONS	
SET UP OUTPUT HEADERS	Calls Menu PM2, which allows you to enter the header information.
DISK OPERATION	Calls Menu PM4, which allows you to select disk operations.
PLOT OPTIONS	Calls Menu PL1, which allows you to select between several plot options.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-82. Menu PM1, Select Data Output Type

MENU	DESCRIPTION
DATA OUTPUT HEADERS	
MODEL ON (OFF) XXXXXXXXXXXXXX	Selecting <1>displays Menu GP5, which lets you select the letters and/or numbers in your model identifier.
DEVICE ID ON (OFF) XXXXXXXXXXXX	Selecting <1>displays Menu GP5, which lets you select the letters and/or numbers in your Device I.D. identifier.
DATE ON (OFF) XX/XX/XX	Selecting <1>displays Menu GP5, which lets you select the letters and/or numbers in the date.
OPERATOR ON (OFF) XXXXXXXXXXXXXXX	Selecting <1> displays Menu GP5, which lets you select the letters identifying the operator.
PRESS <ENTER> TO TURN ON/OFF	Pressing the ENTER key selects between menu selections. Pressing the CLEAR/RET LOC key lets you change thebetween ON and OFF states
OR PRESS < 1 > TO CHANGE	Pressing <1> lets you enter the desired label in Menu GP5,

Figure 3-83. Menu PM2, Data Output Headers

MENU	DESCRIPTION
TABULAR OUTPUT FORMAT	
MARKER ON (OFF) DATA	Provides for the printing or not of markers.
SWEEP ON (OFF) DATA	Provides for the printing or not of frequency sweep data. If you elect to print the sweep data, you can choose how many frequency points to print out.
XXX POINTS	Outputs one point every X points
PRESS <ENTER> TO TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.
OR TURN KNOB TO CHANGE NUMBER OF POINTS	Turning the knob on number of points changes the value of X to define the number of points printed.

Figure 3-84. Menu PM3, Tabular Output Format

MENU	DESCRIPTION
DISK OUTPUT OPERATIONS	
TABULAR DATA TO DISK	Outputs tabular data to the disk and takes you to GP1-3 or DSK 11 for selection of a file name.
TABULAR DATA FROM DISK TO PRINTER	Brings up DSK9 for selection of a measurement data file to be output to the printer.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-85. Menu PM4, Disk Output Operations

MENU	DESCRIPTION
PLOT OPTIONS PLOT	
FULL PLOT	The plotter will plot everything displayed on the screen (data traces, graticule, menu text) when START PRINT is pressed.
OPTIONS	
HEADER ON (OFF)	The plot will include an information header if this option is on and START PRINT is pressed.
MENU ON (OFF)	The plot will include the menu text if this option is on and START PRINT is pressed.
MARKERS ON (OFF) AND LIMITS	The plot will include any marker or limit lines if this option is on and START PRINT is pressed.
GRATICULE ON (OFF)	The plot will include the graticule and annotation if this option is on and START PRINT is pressed.The plotter plots the graticule.
DATA ON (OFF) TRACE(S)	The plot will include the data if this option is on and START PRINT is pressed.The plotter plots the graticule.
FORMAT	
PLOT SIZE	Calls Menu PL2, which lets you select the size and location of the plot.
PEN COLORS	Calls Menu PL3, which lets you select pen colors for the various elements of the plot: graticule, data traces, menu text and header. Also lets you select the relative pen speed.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-86. Menu PL1, Plot Options

MENU	DESCRIPTION
SELECT PLOT SIZE	
FULL SIZE	Selects a full size (page) plot.
–QUARTER SIZE PLOTS–	
UPPER LEFT	Selects a quarter-size plot, upper-left quadrant.
UPPER RIGHT	Selects a quarter-size plot, upper-right quadrant.
LOWER LEFT	Selects a quarter-size plot, lower-left quadrant.
LOWER RIGHT	Selects a quarter-size plot, lower-right quadrant.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-87. Menu PL2, Select Plot Size

MENU	DESCRIPTION
SELECT PEN COLORS	
DATA PEN n	Selects the color in which the data will be plotted. The number of the pen displays where the "n" is shown.
GRATICLE PEN n	Selects the color in which the graticule will be plotted. The number of the pen displays where the "n" is shown.
MARKERS AND LIMITS PEN n	Selects the color in which the markers and limits will be plotted. The number of the pen displays where the "n" is shown.
HEADER PEN n	Selects the color in which the header information will be plotted. The number of the pen displays where the "n" is shown.
PEN SPEED 100 PERCENT OF MAXIMUM	Selects the pen's speed as a percentage of the plotter's maximum speed. (Used to optimize plots on transparancies or with worn pens.)
PREVIOUS MENU	Recalls Menu PL1.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-88. Menu PL3, Select Pen Colors

3-6.9 SYSTEM STATE Keys and Menus (Figure 3-89)

a. **DEFAULT PROGRAM *Key***

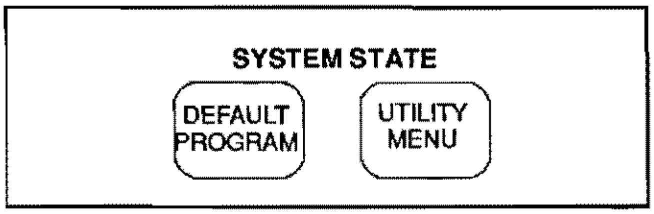


Figure 3-89. SYSTEM STATE Keys

Pressing this key brings up the default menu. If pressed again, it recalls the factory selected default values for the control panel controls. The values are defined in Table 3-3.

CAUTION

Use of this key will destroy control panel and calibration setup data, unless they have been saved to disk.

b. **UTILITY MENU *Key***

Pressing this key calls menu U1. This menu accesses subordinate menus to perform system, disk, and service utilities, as described by the flowchart in Figure 3-97. The only functions performed directly from the U1 Menu are "Blank Frequency Information." and "Alternate Third Color Pen" (blue or cyan).

c. **UTILITY MENU *Key Menus***

Figures 3-98 thru 3-102 describe the UTILITY MENU Key menus.

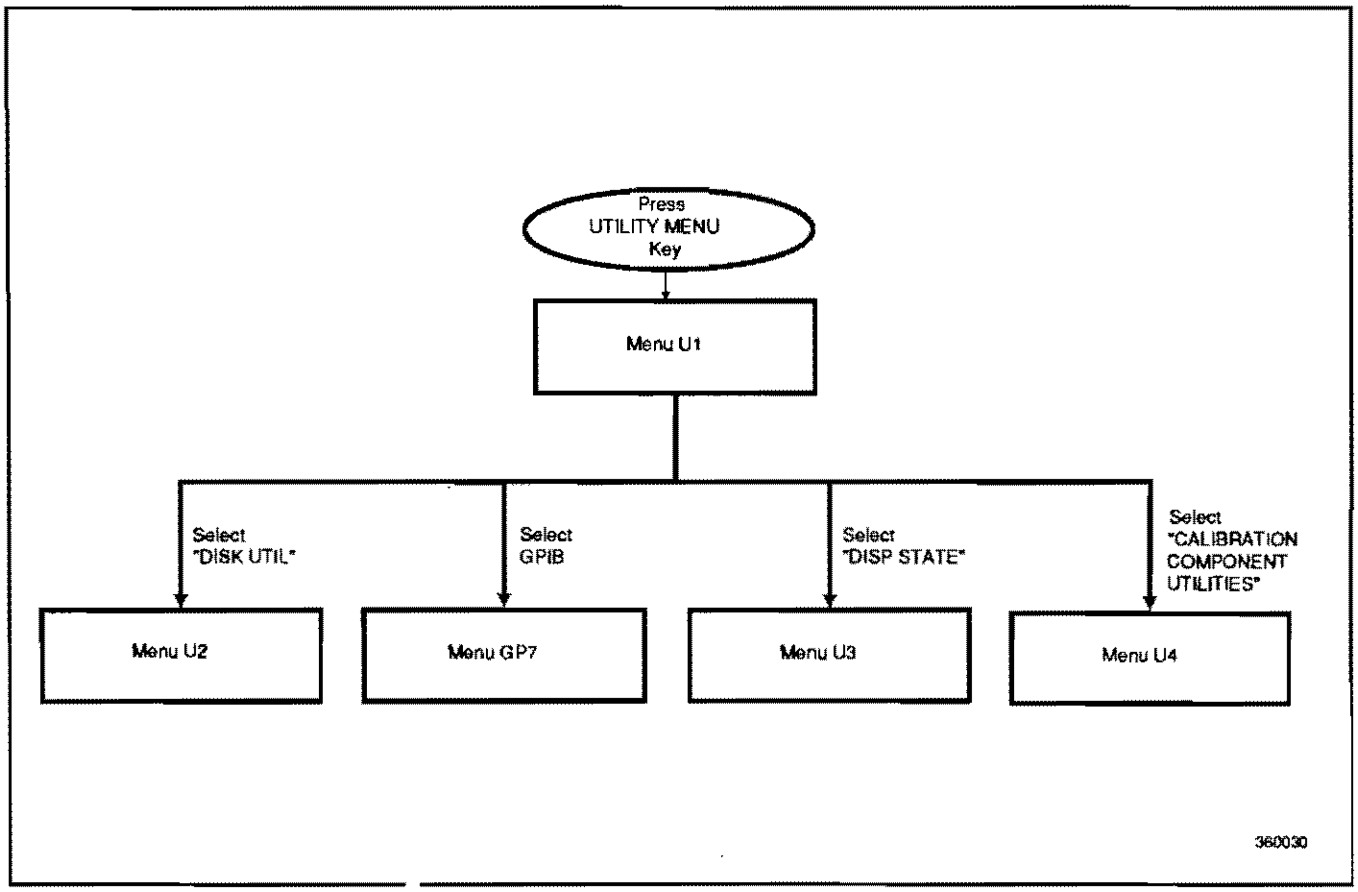


Figure 3-90. UTILITY MENUS Key Flowchart

Table 3-1. Default Settings

Function	Default Setting
INSTRUMENT STATE	Measurement Setup Menu Displayed
MEASUREMENT	Maximum sweep range of source and test set *Source Power:* 0.0 dBm *Resolution:* Normal
CHANNEL	Quad (four-channel) display Channel 1 active
DISPLAY	*Channel 1:* S_{11}, 1:1 Smith Chart *Channel 2:* S_{12}, Log Magnitude and Phase *Channel 3:* S_{21}, Log Magnitude and Phase *Channel 4:* S_{22}, 1:1 Smith Chart *Scale:* 10 dB/Division or 90°/Division *Offset:* 0.000dB or 0.00 degree *Reference Position:* Midscale *Electrical Delay:* 0.00 seconds *Dielectric:* 1.00 (air) Normalization: Off *Normalization Sets:* Unchanged
ENHANCEMENT	*Video IF Bandwidth:* Reduced *Averaging:* Off *Smoothing:* Off
CALIBRATION	*Correction:* Off *Connector:* SMA *Load:* Broadband
MARKERS/LIMITS	*Markers On/Off:* All off *Markers Enabled/Disabled:* All enabled *Marker Frequency:* All set to the start-sweep frequency (or start -time distance *ΔReference:* Off
SYSTEM STATE	*Limits:* All set to reference position value (all off ,all enabled) *GPIB Addresses and Terminators:* Unchanged *Frequency Blanking :* Disengaged, *Error(s):* All cleared *Measurement:* Restarted
OUTPUT	*Output Type:* Printer (full screen, clear headers) *Marker and Sweep Data:* Enabled

MENU	DESCRIPTION
SELECT UTILITY FUNCTION TYPE	
GENERAL DISK UTILITIES	Calls Menu U2, which lets you select between several disk utilities.
CALIBRATION COMPONENT UTILITIES	Calls Menu U4, which lets you select between several calibration-component utilities.
GPIB ADDRESSES	Displays the current GPIB addresses of the various system instruments.
DISPLAY INSTRUMENT STATE	Calls menu U3, which lets you display the various instrument state parameters.
BLANK FREQUENCY INFORMATION	Blanks all frequency-identifier information from the 360 displays, if such information is presently being displayed.
ALTERNATE 3RD COLOR PLANE	Switches between blue and cyan colors
PRESS <ENTER> TO SELECT	Switches between blue and cyan colorsPressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-91. Menu U1, Utility Menu

MENU	DESCRIPTION
DISK UTILITY FUNCTIONS	
RESTORE DISPLAY	
DISPLAY DISK DIRECTORY	Displays disk directory in data area
DELETE FILES FROM DISK	Calls Menu DSK2, which lets you delete files from the disk.
LOAD PROGRAM FROM DISK TO 360	Reloads the operating program from the disk. **CAUTION** Choosing the above option may destroy all of the data in memory.
INITIALIZE DISK WITH PROGRAM	Prepares (formats or initializes) the disk for use with the 360, including the operating program.
INITIALIZE DATA - ONLY DISK	Prepares the disk for use with the 360 but *does not* copy the operating program to the disk **CAUTION** Choosing either of the two options above will destroy all of the data on the disk
COPY DISK TO DISK	Lets you copy one disk to another.

Figure 3-92. Menu U2, Disk Utility Functions

MENU	DESCRIPTION
DISPLAY INSTRUMENT STATE	
RESTORE DISPLAY	Restores the normal data display.
A SYSTEM PARAMETERS	Displays all of the system parameters (Readout Text U4 a thru e, Figure 3-101).
B CALIBRATION PARAMETERS	Displays the calibration parameters.
C GLOBAL OPERATING PARAMETERS	Displays the global operating parameters.
D CHANNEL 1 - 2 OPERATING PARAMETERS	Displays the Channel 1-2 operating parameters.
E CHANNEL 3 - 4 OPERATING PARAMETERS	Displays the Channel 3-4 operating parameters.
NEXT PAGE	Alternately displays Readout Text U4 a thru e.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-93. Menu U3, Display Instrument State

Readout Text U3a, Global Operating Parameters

Parameter	Display Format
Number of Points	xxx
Source Power	xxx.x dBm
Port 1 Source	x0 dB
Port 2 Source	x0 dB
Reference	x0 dB
Z0	50 Ohm
Averaging	xxMeas/Pts
	Off/On
Smoothing	xx.x % SPAN
	Off/on

Readout Text U3d, System Parameters

Parameter	Display Format
360 GPIB	
Address	xx
Terminator	xxxxxxx
Primary SRQ Mask	xxxxxxx
Secondary SRQ Mask	xxxxxxx
System Bus	
Instrument Address	xx
Source Address	xx
Plotter Address	xx
Terminator	xxxxxxx
Software	
Version	xxx.xx
Serial Number	xxx.xx

Readout Text U3b and U3c, Operating Parameters

Parameter	Display Format	
	Channel 1-3	Channel 2-4
S-Parameters	xxx	xxx
Reference Delay	xxx.xxx ps	xxx.xxx µs
	xxxxxxxxx	xxxxxxxx
Time Domain Mode	XXXXXXXXXX	XXXXXXXXXX
Start	xxx.xxx ns	xxx.xxx ps
Stop	xxx.xxx ns	xxx.xxx ps
Window Type	xxxxxxxxxx	xxxxxxxxxx
Gate Start	xxx.xxx ns	xxx.xxx ns
Gate Stop	xxx.xxx ns	xxx.xxx ns
Gate Shape	xxxxxxxxxx	xxxxxxxxxx

Figure 3-94. Readout Text, Menus U3a thru e, Global, System, and Operating Parameters (Sheet 1 of 2)

Readout Text U3e, Calibration Parameters

Parameter	Display Format	
Number Of Points	XXX	
Source Power	XXX dBm	
Cal Type	xxxx	
Start Frequency	XX.XXX GHz	
Stop Frequency	XX.XXX GHz	
Load Type	XXXXXXXXX	
Connector	–PORT1–	–PORT 2–
	XXXXXXXXX	XXXXXXXXX
Open Device	*NOT INSTALLED	*NOT INSTALLED
C0 (e–15)	–XXX.XXX	–XXX.XXX
C1 (e–27)	–XXX.XXX	–XXX.XXX
C2 (e–36)	–XXX.XXX	–XXX.XXX
C3 (e–45)	–XXX.XXX	–XXX.XXX
Offset Length	–XXX.XXX mm	–XXX.XXX mm
	*	
Serial Number	XXXXXXXXX	XXXXXXXXX
Short Device	*NOT INSTALLED	*NOT INSTALLED
Offset Length	–XXX.XXX mm	–XXX.XXX mm
Serial Number	XXXXXXXXX	XXXXXXXXX
Atten Settings		
Source	XXdB	XX. dB
Test		XX dB
* If not installed, displays "NOT INSTALLED"		

Figure 3-94. Readout Text, Menus U3a thru e, Global, System, and Operating Parameters (Sheet 2 of 2)

MENU	DESCRIPTION
CALIBRATION COMPONENT UTILITIES	
INSTALL CALIBRATION COMPONENT INFORMATION FROM DISK	Reads into memory the coefficient data from the calibration-components disk supplied with the calibration kits.
DISPLAY INSTALLED CALIBRATION COMPONENT INFORMATION	Calls Menu U5, which lets you display the connector information for the various connectors supported.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-95. Menu U4, Calibration Component Utilities

MENU	DESCRIPTION
DISPLAY INSTALLED CALIBRATION COMPONENT INFORMATION	This menu lets you view coefficient data on the components listed (Figure 3-104). The data appears in the display area of the screen.
SMA (M)	Select coefficient data to display for the SMA male components.
SMA (F)	Select coefficient data to display for the SMA female components.
K – CONN (M)	Select coefficient data to display for the K Connector™ male components.
K – CONN (F)	Select coefficient data to display for the K Connector fe male components.
TYPE N (M)	Select coefficient data to display for the Type N male components.
TYPE N (F)	Select coefficient data to display for the Type N female components.
GPC - 7	Select coefficient data to display for the sexless GPC-7 components.
NEXT COMPONENT	Cycles through selections SMA (M) to GPG7.
PREVIOUS MENU	Displays menu U4.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-96. Menu U5, Display Installed Calibration Components Information

Parameter	Display Format
Connector Type	*NOT INSTALLED
Open Device	
C0 (e–15)	–XXX.XXXe–15
C1 (e–27)	–XXX.XXX e–27
C2 (e–36)	–XXX.XXX e–36
C3 (e–45)	–XXX.XXX e–45
Offset Length	–XXX.XXX mm
Serial Number	XXXXXXXXX
Short Device	*NOT INSTALLED
Offset Length	–XXX.XXX mm
Serial Number	XXXXXXXXX
* if not installed from disk, "NOT INSTALLED" is dis layed	

Figure 3-97. Readout Text Associated With Menu U5

MENU	DESCRIPTION
SELECT TYPE OF COMPONENT INFORMATION TO DISPLAY	
COAXIAL	Selects the values for coaxial line to be displayed.
WAVEGUIDE	Selects the values for waveguide to be displayed.
PREVIOUS MENU	Returns you to the previous menu.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection.

Figure 3-97A. Menu U6, Select Type of Component Information to Display

3-6.10 Disk Storage Interface and General Purpose Menus

a. Disk Characteristics

The 360 has an integrally mounted disk drive of the 3-1/2 inch removable media type. The format, files, and directory are compatible with PC(MS)-DOS, Version 3.2.

1. *Disk Format* . Disks are MS-DOS compatible. The 360 formats them to have 80 data tracks per side on 2 sides, with 9 sectors of 512 bytes per sector. This yields a total of 720 KBytes per disk. Any of the following file types, in any combination may be stored on the disk. Table 3-2 shows these file extensions.

Table 3-2. File Extensions

File Type	File Extension
Calibration, Normal	.CAL
Trace Memory	.NRM
Measured Data	.DAT
Program	.PRG

2. *Disk Files.* You may find any of the following file-types on the 360 disk.
   (a) Program Files. These are binary files used to load the operating program. Application-type programs cannot read them.
   (b) Calibration Data Files: These are binary files used to store and retrieve calibration and other data. Application-type programs cannot read them. File size depends on calibration type. For example, 58 KBytes for 12 term and 501 points.
   (c) Measured Data Files. These are ASCII files used to store actual measurement data. They can be read by application-type programs. File size depends on selected options. For example, 25.6 KBytes for 501 points and 1 S-Parameter.
   (d) Trace Memory Files. These are data stored in a display, rather than in a floating-point format. Application-type programs cannot read them. You use them to perform trace math operations on data. File size is 4 KBytes.

b. Disk User Interface

A disk is capable of holding up to 720K bytes of data. Using the data size assumptions above, a disk would be capable of holding:

12-Plus Calibration and Front Panel Setups
or
180 Sets of Normalization Data
or
28-Plus Sets of Measurement Data

You can also store a downloaded operating program on the disk. However, this reduces the number of the above items that you could store. The disk format imposes a limitation of 112 on the total number of data items. This means the full 360 sets of normalization data could not be stored on the disk.

c. Disk and General Purpose Menus

1. *Disk Menus.* A set of DSK menus used to implement the disks functions are provided in Figures3-98 thru 3-103.
2. *General Purpose Menus.* The menus shown in Figures 3-104 thru 3-106 appear as a result of choices made in certain of the Disk and Print menus.

MENU	DESCRIPTION
NO ROOM FOR NEW DATA FILES	
OVERWRITE EXISTING FILES	Allows you to overwrite an existing file on the current data disk.
DELETE EXISTING FILES	Allows you to delete an existing file on the current data disk.
PRESS <ENTER> TO SELECT	Pressing ENTER implements your menu selection. You will be returned to the previous menu when your selection is made.

Figure 3-98. Menu DSK3, No Room for New Data Files

MENU	DESCRIPTION
DISK UTILITY FUNCTIONS	
DELETE CAL & FRONT PANEL SETUPS FROM DISK	Allows you to delete specific calibration and control (front) panel setup files from the current data disk.
DELETE NORMALIZATION FILES FROM DISK	Allows you to delete specific normalization (trace memory) files from the current data disk.
DELETE MEASUREMENT FILES FROM DISK	Allows you to delete specific measurement data files from the current data disk.
PREVIOUS MENU	Returns you to the previous menu
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEARE/LOC key is pressed.

Figure 3-99. Menu DSK4, Disk Utility Functions

MENU	DESCRIPTION
SELECT CAL & FRONT PANEL SETUP TO DELETE	
FILENAME 2	Selects the file named on this line to be deleted. (The actual name of the file, not "FILENAME 2" will appear.)
FILENAME 3	Same as for Filename 2 above.
FILENAME 4	Same as for Filename 2 above.
FILENAME 5	Same as for Filename 2 above.
FILENAME 6	Same as for Filename 2 above.
FILENAME 7	Same as for Filename 2 above.
FILENAME 8	Same as for Filename 2 above.
FILENAME 9	Same as for Filename 2 above.
MORE	The "More" option only displays if there are more than nine files.
PREVIOUS MENU	Returns to the previous menu in this series.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. You are returned to the previous menu.

Figure 3-100. Menu DSK5, Select Cal & Front Panel Setup To Delete

MENU	DESCRIPTION
SELECT NORMALIZATION FILE TO DELETE	
FILENAME 1	Selects the file named on this line to be deleted. (The actual name of the file, not "FILENAME 1" will appear.)
FILENAME 2	Same as for Filename 1 above.
FILENAME 3	Same as for Filename 1 above.
FILENAME 4	Same as for Filename 1 above.
FILENAME 5	Same as for Filename 1 above.
FILENAME 6	Same as for Filename 1 above.
FILENAME 7	Same as for Filename 1 above.
FILENAME 8	Same as for Filename 1 above.
MORE	The "More" option only displays if there are more than nine files.
PREVIOUS MENU	Returns to the previous menu in this series.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. You are returned to the previous menu.

Figure 3-101. Menu DSK6, Select Normalization File To Delete

MENU	DESCRIPTION
SELECT MEASUREMENT FILE TO DELETE	
FILENAME 1	Selects the file named on this line to be deleted. (The actual name of the file, not "FILENAME 1" will appear.)
FILENAME 2	Same as for Filename 1 above.
FILENAME 3	Same as for Filename 1 above.
FILENAME 4	Same as for Filename 1 above.
FILENAME 5	Same as for Filename 1 above.
FILENAME 6	Same as for Filename 1 above.
FILENAME 7	Same as for Filename 1 above.
FILENAME 8	Same as for Filename 1 above.
MORE	The "More" option only displays if there are more than nine files.
PREVIOUS MENU	Returns to the previous menu in this series.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. You are returned to the previous menu

Figure 3-102. Menu DSK7, Select Measurement File To Delete

MENU	DESCRIPTION
SELECT FILE TO READ	
FILENAME 1	Selects the file named on this line to be read. (The actual name of the file, not "FILENAME 1" will appear.)
FILENAME 2	Same as for Filename 1 above.
FILENAME 3	Same as for Filename 1 above.
FILENAME 4	Same as for Filename 1 above.
FILENAME 5	Same as for Filename 1 above.
FILENAME 6	Same as for Filename 1 above.
FILENAME 7	Same as for Filename 1 above.
FILENAME 8	Same as for Filename 1 above.
MORE	The "More" option only displays if there are more than nine files.
PREVIOUS MENU	Returns to the previous menu in this series
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. You are returned to the previous menu

Figure 3-103. Menu DSK9, Select File To Read

MENU	DESCRIPTION
SELECT FILE TO OVERWRITE OR CREATE NEW FILE	
FILENAME 1	Selects disk File 1 for storing the calibration data or front (control) panel setup. Name the file using Menu GP5.
FILENAME 2	Selects disk File 2 for storage of data.
FILENAME 3	Selects disk File 3 for storage of data.
FILENAME 4	Selects disk File 4 for storage of data.
FILENAME 5	Selects disk File 5 for storage of data.
FILENAME 6	Selects disk File 6 for storage of data.
FILENAME 7	Selects disk File 7 for storage of data.
FILENAME 8	Selects disk File 8 for storage of data.
MORE	Displays additional menus.
PREVIOUS MENU	Displays the previous menu.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-104. Menu GP1-3, Select File to Overwrite or Create New File

MENU	DESCRIPTION
SELECT NAME - - - - - - - - ABCDEFGHIJKLM NOPQRSTUVWXYZ 0123456789-/#	Name your file using the rotary knob to select letters, numbers, or both. A letter or number turns red to indicate that the letter/number has been chosen for selection. Pressing the ENTER key selects the letter or number. The name you spell out displays in the area below "SELECT NAME." You are allowed up to eight characters for a file name and twelve characters for a label.
DEL CLEAR DONE	Selecting "DEL" deletes the last letter in the name displayed above. Selecting "CLEAR" deletes the entire name. Selecting "DONE" signals that you have finished writing the name.
TURN KNOB TO INDICATE CHARACTER OR FUNCTION	Use the rotary knob to indicate the letter or number you wish to select. You can use the up-arrow and down-arrow keys to move between rows.
PRESS <ENTER> TO MAKE SELECTION	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.
NUMBERS MAY ALSO BE SELECTED USING KEYPAD	You may also select numbers using the keypad.

Figure 3-105. Menu GP5, Select Name

MENU	DESCRIPTION
GPIB SETUP	
–360 GPIB–	
CR/CR-LF	Selects either the CR (carriage return) character or the CR-LF (Carriage Return-Line Feed) characters as the data terminator for GPIB transmissions.
ADDRESS: 6	Selects the GPIB address for the 360 analyzer. The 360 is set to address 6 before leaving the factory.
–SYSTEM BUS–	
CR/CR-LF	Selects either the CR (carriage return) character or the CR-LF (Carriage Return-Line Feed) characters as the data terminator for System Bus transmissions.
INSTR ADDR 0	Selects the address for the System Bus controller. This is the address the 360 uses to address the Source. The 360 is set to address 0 before leaving the factory.
SOURCE ADDR 5	Selects the address for the Source. The Source is set to address 5 before leaving the factory.
PLOTTER ADDR 7	Selects the address for a compatible plotter.
PRESS <ENTER> TOSELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for displayor until the CLEAR/RET LOC key is pressed.

Figure 3-106. Menu GP7, Display GPIB Status

3-6.11 MARKERS/LIMITS Keys and Menus (Figure 3-107).

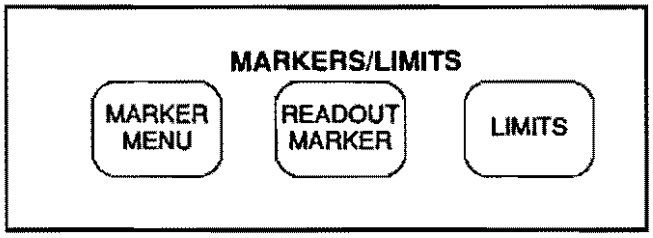


Figure 3-107. MARKERS/LIMITS Keys

a. **MARKER MENU *Key***
Pressing the MARKER MENU key calls Menu M1). This menu lets you toggle markers on and off and set marker frequencies, times, or distances.

b. **MARKER READOUT Key**

1. Pressing this key calls menu M3 under the following conditions.
   (a) If the Δ Reference mode is off and
   (1)there is no selected marker, or
   (2)the selected marker is not in the sweep range.
   (b) If the Δ Reference mode is on and
   (1)the Δ Reference marker is not in the sweep range, or
   (2)no Delta ref marker has been selected.

2. Pressing this key calls menu M4 if the ΔReference mode is off and the selected marker is in the current sweep range (or time/distance).

3. Pressing this key calls menu M5 if the ΔReference mode and marker are both on and and the ΔReference marker is in the selected sweep range (or time/distance).

c. **MARKERS *Keys Menus***
The menus associated with the two MARKERS keys are described in Figures 3-108 thru 3-112.

d. ***Limit Frequency Readout Function***
The 360 is equipped with a Limit-Frequency Readout function. This function allows dB values to be read at a specified point (such as the 3 dB point) on the data trace. This function is only available for certain rectilinear graph-types. These graph-types are listed below.

1. Log Magnitude
2. Log Magnitude And Phase
3. Phase
4. Linear Magnitude And Phase
5. SWR
6. Group Delay

Figure 3-113 shows an example of a Limit Frequency (LF) Menu.

e. ***LIMITS Key***
Pressing this key calls the appropriate Limit (Ln) menu. The Limit menus are described in Figures 3-114 thru 3-123.

MENU	DESCRIPTION
SET MARKERS	
MARKER 1 ON (OFF) XX.XXXXXX GHz	Turns Marker 1 on or off (activates or deactivates). When on (active), the frequency, time, or distance may be set using the keypad or rotary knob. *NOTE* In this text, markers will be referred to as being active and as being selected. Any marker that has been turned on and assigned a frequency is considered to be active. The marker to which the cursor presently points is considered to be selected. The selected marker is the only one for which you can change the frequency.
MARKER 2 ΔREF XX.XXXXXX GHz	
MARKER 3 ON (OFF) XX.XXXXXX GHz	Turns Marker 3 on or off (activates or deactivates). When on (active), the frequency, time, or distance may be set using the keypad or rotary knob.
MARKER 4ON (OFF)	Turns Marker 4 on or off (activates or deactivates). When on (active), the frequency, time, or distance may be set using the keypad or rotary knob.
MARKER 5ON (OFF)	Turns Marker 5 on or off (activates or deactivates). When on (active), the frequency, time, or distance may be set using the keypad or rotary knob.
MARKER 6ON (OFF) XX.XXXXXX GHz	Turns Marker 6 on or off (activates or deactivates). When on (active), the frequency, time, or distance may be set using the keypad or rotary knob.
MARKERS DISABLED	Disables all markers.
ΔREF MODE ON (OFF)	Selects and deselects the ΔReference Mode
SELECT ΔREF MARKER	Calls Menu M2, which lets you select the ΔREF Marker.
PRESS <ENTER> OR TURN ON/OFF TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-108. Menu M1, Set Markers

MENU	DESCRIPTION
SELECT ΔREF MARKER	
MARKER 1 XX.XXXXXX GHz	Marker 1 only appears if it has been activated in Menu M1. Placing the cursor on Marker 1 and pressing the ENTER key here selects it as the ΔREF marker. The ΔREF marker is the one from which the other active markers are compared and their difference frequency measured and displayed in Menu M3. The marker frequency may be set using the keypad or rotary knob.
MARKER 3 XX.XXXXXX GHz	Same as above, but for Marker 3
MARKER 4 XX.XXXXXX GHz	Same as above, but for Marker 4
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-109. Menu M2, Select ΔREF Marker

MENU	DESCRIPTION
SELECT READOUT MARKER	
MARKER 1 XX.XXXXXX GHz	Displays the frequency and S-Parameter value(s) of Marker 1 on all CRT-displayed graphs and Smith Charts. The frequency of Marker 1 also displays here. If Marker 1 was activated in Menu M2 as the REF marker, REF appears as shown for Marker M5 below.
MARKER 2 XX.XXXXXX GHz	Same as for above, but for Marker 2.
MARKER 5 XX.XXXXXX GHz	Same as for above, but for Marker 5.
ΔREF MODE IS ON	Indicates the status of the ΔREF mode.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-110. Menu M3, Select Readout Marker

MENU	DESCRIPTION
CH1—S11	Selects channel for readout
XX.XXX PS DLY	
MARKER 1 XX.XXXXXX GHz XX.XXX dB XXX.XXX DEG	The selected marker—that is, the one to which the cursor points in Menu M1—and its frequency, time, or distance display here. This could be any one of the six available markers: Marker 1 thru Marker 6.
MARKER TO MAX	Causes the active marker to go to the frequency with the *greatest* S-Parameter value on the active channel.
MARKER TO MIN	Causes the selected marker to go to the frequency with the *smallest* S-Parameter value on the active channel.
2 XX.XXXX GHz XX.XXX dB XXX.XXX DEG	Displays the frequency, magnitude, and phase of the active S Parameter at marker 2, if the marker is enabled.
3 XX.XXXX GHz XX.XXX dB XXX.XXX DEG	Displays the frequency, magnitude, and phase of the active S Parameter at marker 3, if the marker is enabled.
4 XX.XXXX GHz XX.XXX dB XXX.XXX DEG	Displays the frequency, magnitude, and phase of the active S Parameter at marker 4, if the marker is enabled.
5 XX.XXXX GHz XX.XXX dB XXX.XXX DEG	Displays the frequency, magnitude, and phase of the active S Parameter at marker 5, if the marker is enabled.
6 XX.XXXX GHz XX.XXX dB XXX.XXX DEG	Displays the frequency, magnitude, and phase of the active S Parameter at marker 6, if the marker is enabled.

Figure 3-111. Menu M4, Readout Marker

MENU	DESCRIPTION
CH 1 – S11	
XXX.XXX ns DLY	
MARKER 1 ΔREF XX.XXXXXX GHz MARKER TO MAX MARKER TO MIN	The REF marker, as activated in Menu M2, its frequency, its reference delay, and the channel on which it appears display here. The REF marker could be any one of the six available markers: M1-M6. The frequency of the REF marker can be changed using the keypad or rotary knob.
Δ(1 - 2) XX.XXXXX GHz XX.XXX dB (XXX.XX DEG)	The marker numbers of the REF marker and the next lowest-numbered active marker appear between the parentheses. This example assumes Marker 1 as the Ref marker and Marker 2 as the next lowest-numbered active marker. The lines below display the difference frequency, (or time/distance) and trace value(s) between these two markers on the active channel.
Δ(1 - 3) XX.XXXXX GHz XX.XXX dB (XXX.XX DEG)	The marker numbers of the REF marker and the next lowest-numbered active marker appear between the parentheses. This example assumes Marker 1 as the Ref marker and Marker 3 as the next lowest-numbered active marker. The lines below display the difference frequency, (or time/distance) and trace value(s) between these two markers on the active channel.
Δ(1 - 4) XX.XXXXX GHz XX.XXX dB (XXX.XX DEG)	The marker numbers of the REF marker and the next lowest-numbered active marker appear between the parentheses. This example assumes Marker 1 as the Ref marker and Marker 4 as the next lowest-numbered active marker. The lines below display the difference frequency, (or time/distance) and trace value(s) between these two markers on the active channel.
Δ(1 - 5) XX.XXXXX GHz XX.XXX dB (XXX.XX DEG)	The marker numbers of the REF marker and the next lowest-numbered active marker appear between the parentheses. This example assumes Marker 1 as the Ref marker and Marker5 as the next lowest-numbered active marker. The lines below display the difference frequency, (or time/distance) and trace value(s) between these two markers on the active channel.
Δ(1 - 6) XX.XXXXX GHz XX.XXX dB (XXX.XX DEG)	The marker numbers of the REF marker and the next lowest-numbered active marker appear between the parentheses. This example assumes Marker 1 as the Ref marker and Marker 6 as the next lowest-numbered active marker. The lines below display the difference frequency, (or time/distance) and trace value(s) between these two markers on the active channel.

Figure 3-112. Menu M5, Set ΔREF Marker Readout

MENU	DESCRIPTION
READOUT LIMIT FREQUENCIES	This menu shows all of the frequencies where the active S-Parameter value is equal to either Limit 1 or Limit 2.
-LOG MAG-	
LIMIT 1 (REF) x.xxx dB	Displays the value of Limit 1.
LIMIT 2 x.xxx dB	Displays the value of Limit 2.
LIMIT Δ(1/2) x.xxx dB	Displays the difference in value between Limit 1 and Limit 2.
FREQUENCIES AT LIMIT 2	Displays all points where the S Parameter is equal to Limit 2.
2.9843 GHz 5.7210 GHz 7.4412 GHz 9.8764 GHz 10.3901 GHz 15.5648 GHz	

Figure 3-113. Menu LFX, Readout Limit Frequencies

NOTE

There are five "Readout Limit Frequencies" menus. All are essentially identical, except for the graph type.

- Menu LF1 is as shown.
- Menu LF2 is for a "Phase" graph type.
- Menu LF3 is for a "Group Delay" graph type.
- Menu LF4 is for a "Linear Mag" graph type.
- Menu LF5 is for an "SWR" graph type.

MENU	DESCRIPTION
SET LIMITS	
-LOG MAG-	
LIMIT 1 ON (OFF) XXX.XXX dB	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your log-magnitude graph beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX dB	Turns the Limit 2 line on or off for the active channel on the log-magnitude graph.
READOUT LIMIT FREQUENCIES	Displays Menu LF1, which shows all points where the current s-parameter equals the limit values.
-PHASE-	
LIMIT 1 ON (OFF) XXX.XX DEG	Turns the Limit 1 line on or off for the active channel on the phase graph.
LIMIT 2 ON (OFF) XXX.XX DEG	Turns the Limit 2 line on or off for the active channel on the phase graph.
READOUT LIMIT FREQUENCIES	Displays Menu LF1, which shows all points where the current s-parameter equals the limit values.
LIMITS ENABLED (DISABLED)	Enables both limit lines for the active channel on both the log-magnitude and phase graphs.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-114. Menu L1, Set Limits—Magnitude and Phase

MENU	DESCRIPTION
SET LIMITS	
–LINEAR POLAR– (–SMITH CHART–)	
LIMIT 1 ON (OFF) XXX.XXX mV	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Smith chart or polar display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX mV	Turns the Limit 2 line on or off for the active channel on your Smith chart or polar display.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Smith chart or polar display.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-115. Menu L3, Set Limits—Linear Polar/Smith Chart

MENU	DESCRIPTION
SET LIMITS	
–LOG MAG–	
LIMIT 1 ON (OFF) XXX.XXX dB	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Log Mag display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX dB	Turns the Limit 2 line on or off for the active channel on your Log Mag display.
READOUT LIMIT FREQUENCIES	Displays Menu LF1, which shows all points where the current s-parameter equals the limit values.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Log Mag display.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-116. Menu L4, Set Limits—Log Magnitude

MENU	DESCRIPTION
SET LIMITS –PHASE–	
LIMIT 1 ON (OFF) XXX.XX DEG	Turns the Limit 1 line on or off for the active channel on the phase graph.
LIMIT 2 ON (OFF) XXX.XX DEG	Turns the Limit 2 line on or off for the active channel on the phase graph.
READOUT LIMIT FREQUENCIES	Displays Menu LF1, which shows all points where the current s-parameter equals the limit values.
LIMITS ENABLED	Enables both limit lines for the active channel on a phase graph.
PRESS <ENTER> TO ELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-117. Menu L5, Set Limits—Phase

MENU	DESCRIPTION
SET LIMITS –LOG POLAR–	
LIMIT 1 ON (OFF) XXX.XXX dB	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Log Polar display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX dB	Turns the Limit 2 line on or off for the active channel on your Log Polar display.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Log Polar display.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-118. Menu L6, Set Limits—Log Polar

MENU	DESCRIPTION
SET LIMITS –GROUP DELAY–	
LIMIT 1 ON (OFF) XXX.XXX dB	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Group Delay display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX dB	Turns the Limit 2 line on or off for the active channel on your Group Delay display.
READOUT LIMIT FREQUENCIES	Displays Menu LF1, which shows all points where the current s-parameter equals the limit values.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Group Delay display.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-119. Menu L7, Set Limits—Group Delay

MENU	DESCRIPTION
SET LIMITS	
–LINEAR MAG–	
LIMIT 1 ON (OFF) XXX.XXX dB	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Linear Mag display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX dB	Turns the Limit 2 line on or off for the active channel on your Linear Mag display.
READOUT LIMIT FREQUENCIES	Displays Menu LF1, which shows all points where the current s-parameter equals the limit values.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Linear Mag display.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-120. Menu L8, Set Limits—Linear Magnitude

MENU	DESCRIPTION
SET LIMITS	
–LINEAR MAG–	
LIMIT 1 ON (OFF) XXX.XXX dB	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Linear Mag display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX dB	Turns the Limit 2 line on or off for the active channel on your Linear Mag display.
READOUT LIMIT FREQUENCY	Displays Menu LF1, which shows all points where the current s-arameter equals the limit values.
-PHASE-	
LIMIT 1 ON (OFF) XXX.XXX dB	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Phase display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX dB	Turns the Limit 2 line on or off for the active channel on your Phase display.
READOUT LIMIT FREQUENCIES	Displays Menu LF1, which shows all points where the current s-parameter equals the limit values.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Phase display.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-121. Menu L9, Set Limits—Linear Magnitude and Phase

MENU	DESCRIPTION
SET LIMITS	
-REAL-	
LIMIT 1 ON (OFF) XXX.XXX pU	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Real values display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX pU	Turns the Limit 2 line on or off for the active channel on your Real values display.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Real values display.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-122. Menu L10, Set Limits—Real Values

MENU	DESCRIPTION
SET LIMITS	
-IMAGINARY-	
LIMIT 1 ON (OFF) XXX.XXX mU	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Imaginary values display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX mU	Turns the Limit 2 line on or off for the active channel on your Imaginary values display.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Imaginary values display.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-123. Menu L11, Set Limits—Imaginary Values

MENU	DESCRIPTION
SET LIMITS	
–REAL–	
LIMIT 1 ON (OFF) XXX.XXX mU	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Real values display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX mU	Turns the Limit 2 line on or off for the active channel on your Real values display.
–IMAGINARY–	
LIMIT 1 ON (OFF) XXX.XXX pU	Turns the Limit 1 line on or off for the active channel. For your convenience, the arbitrarily set limit lines allow you to delineate a go/no go line on your Imaginiary values display beyond which the measured values are unacceptable.
LIMIT 2 ON (OFF) XXX.XXX pU	Turns the Limit 2 line on or off for the active channel on your Imaginiary values display.
LIMITS ENABLED	Enables both previously set limit lines to appear for the active channel on your Imaginiary values display.
PRESS TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-124. Menu L12, Set Limits—Real and Imaginary Values

3-7 ERROR AND STATUS MESSAGES

Error and status messages are described below.

3-7.1 Message Types

The basic types of messages are categorized by the first digit of their code number, as follows:

000-099 Power Up Self Diagnostic
- 000-019 Main #2
- 020-039 Main #1
- 040-049 IO Proc
- 050-099 Analog Hardware

100-199 System Status
- 100-109 Program Load

110-129 Program Initialization
- 130-149 Disk Related
- 150-169 Peripheral Related

200-299 Front Panel Operations
300-399 Measurement Related
400-499 GPIB

3-7.2 Fatal Errors

Some errors are "fatal" in that they cause the instrument to terminate operations until you correct the condition causing the error. These errors are listed with an "X" in the column marked "FATAL."

3-7.3 Message Definitions

Table 3-3 provides a listing of error message definitions.

Table 3-3. Error Codes and Status Messages (1 of 4)

CODE	MESSAGE TEXT	FATAL	MEANING
	Self Test, Main Microprocessor #2		
000	FIFO RESET FAILURE	X	FIFO failed to reset, PCB A12
002	PROM CHECKSUM FAILURE #2	X	Prom failure, PCB A12
003	BATTERY BACKED RAM FAILURE	X	Non volitile RAM failure, PCB A12
004	EXTENDED MEMORY FAILURE	X	Failure in the extended memory, PCB A12
005	DYNAMIC RAM FAILURE #2	X	Dynamic RAM failure, PCB A12
006	TIMER FAILURE #2	X	Programmable timer failure,PCB A12
007	INTERRUPT CONTROLLER FAILURE #2	X	Interrupt comtroller failure PCB , A12
008	NUMERIC PROCESSOR FAILURE #2	X	Numeric processor failure , PCB A12
009	FRONT PANEL INTERFACE FAILURE	X	Interface failure , front panel, PCB A12
010	PRINTER INTERFACE FAILURE	X	Printer or interface failure PCB A12
	Self Test, Main Microprocessor #1		
020	FIFO TO # 2 FAILED RESET	X	Interface failure with FIFO , PCB A12
022	FIFO TO I/O FAILED RESET		Interface failure with FIFO PCB A13
023	PROM CHECKSUM FAILURE #1	X	Checksum error , PROM PCB A13
024	DYNAMIC RAM FAILURE #1	X	Dynamic RAM failure , PCB A13
025	TIMER FAILURE #1	X	Programmable timer failure PCB A13
026	INTERRUPT CONTROLLER FAILURE #1	X	Interrupt controller failure PCB A13
027	DISK DRIVE CONTROLLER FAILURE		Disk drive controller failure ,PCB A13
028	DISK DRIVE FAILURE		Disk drive SEEK failure, PCB A13
029	NUMERIC PROCESSOR FAILURE #1	X	8087 math coprocessor failure
030	PROM CARTRIDGEE CHECKSUM ERROR		PROM cartridge failure PCB A13
031	DISK DRIVE NOT READY FOR TEST		Diskette is not in disk drive
	Self Test, I/O Processor		
040	PROM CHECKSUM FAILURE I/O	X	PROM failure, PCB A11
041	RAM FAILURE I/O	X	RAM failure, PCB A11
042	TIMER/INTERRUPT LOOPBACK FAILURE	X	Programmable timer failure, PCB A11
043	GPIB INTERFACE FAILURE I/O		GPIB failure , PCB A11
044	FIFO FAILURE I/O	X	FIFO failure, PCB A11

Table 3-3. Error Codes and Status Messages (2 of 4)

CODE	MESSAGE TEXT	FATAL	MEANING
050	A1 COMMUNICATIONS FAILURE		LO 1 Phase Lock PCB Error
051	A2 COMMUNICATIONS FAILURE		LO 2 Phase Lock PCB Failure
052	A3 COMMUNICATIONS FAILURE		Cal/Third Local O scillator PCB Failure
053	A4 COMMUNICATIOONS FAILURE		Analog to digital PCB failure
054	A5 COMMUNICATIONS FAILURE		10Mhz Reference PCB failure
055	A6 COMMUNICATIONS FAILURE		Source lock PCB failure
056	A10 COMMUNICATIONS FAILURE		Bandswitch blank/sync PCB
057	8 BIT A/D CONVERTER FAILURE		Failure A/D PCB A4
058	STEERING DAC FAILURE		Failure A/D PCB A4
059	12 BIT A/D OR STEERING DAC FAILURE		Failure A/D PCB A4
060	TEST SET NOT CONNECTED OR NOT WORKING		General failure of test set
061	TEST SET CHAN A CAL PHASING FAILURE		Test set CHAN A failure
062	TEST SET CHAN A CAL LEVEL FAILURE		Test set CHAN A failure
063	TEST SET CHAN A GAIN FAILURE		Test set CHAN A failure
064	TEST SET CHAN A PHASE RANGING FAILURE		Test set CHAN A failure
065	TEST SET CHAN B CAL PHASING FAILURE		Test set CHAN B failure
067	TEST SET CHAN B GAIN FAILURE		Test set CHAN B failure
068	TEST SET CHAN B PHASE RANGING FAILURE		Test set CHAN B failure
069	TEST SET REF CHAN CAL PHASING FAILURE		Test set REF CHAN failure
070	TEST SET REF CHAN CAL LEVEL FAILURE		Test set REF CHAN failure
071	TEST SET REF CHAN GAIN FAILURE		Test set REF CHAN failure
072'	TEST SET REF CHAN PHASE RANGING		Test set REF CHAN failure
	System Status, Program Load		
100	DISK DRIVE NOT READY	X	Program failed to load from disk, (disk installed?)
101	PROGRAM DATA ERROR	X	Program failed to load from disk.
102	PROGRAM FILE MISSING		Loader could not find system files
103	DISK ERROR		The 360 is unable to read the diskette
104	UNKNOWN DISK ERROR		Loader failed a consistency check
105	PROGRAM DATA ERROR ON # 2		Program for processor #2 failed to load
	Program Initialization		
110	SOURCE ID FAILURE		No sweeper ID on GPIB; sweeper may not be connected.
111	TEST SET NOT CONNECTED	X	Initialization detects a descrepancy.
112	TEST SET FREQ. RANGE DOES NOT MATCH SOURCE	X	Initialization detects a descrepancy.
113	CAL DATA NOT FOUND: CHANGE DISK AND PRESS <ENTER>		File not found on disk with name matching that in battery backed RAM.
114	PROGRAM ERROR	X	Program corrupted.
115	PROCESSOR COM ERROR	X	FIFO Synch problem Disk Related.
	Program Initialization, Disk Related		
131	DISK READ ERROR		Hard error reading from disk.
132	DISK WRITE ERROR		Hard error writing to disk.
133	FILE DELETION ERROR		Write protect tab is in "read only" position.
134	DISK NOT READY		Disk not in unit or not formatted
135	DISK WRITE PROTECTED		Write protect tab is in "read only" position.

Table 3-3. Error Codes and Status Messages (3 of 4)

CODE	MESSAGE TEXT	FATAL	MEANING
136	OUT OF DISK SPACE		Disk file space full
137	FILE IS INCOMPATIBLE		File is not a 360 data or program file.
138	NO SPACE FOR NEW DATA FILE		Disk file space full.
139	FILE MARKED READ ONLY		Read-only attribute set on file.
140	NO FILES REMAIN TO OVERWRITE		All files of the type have been deleted.
141	NO FILES REMAIN TO DELETE		All files of the type have been deleted.
	Program Initialization, Peripheral		
170	PRINTER NOT READY		Printer "off line" or not connected.
171	PLOTTER NOT READY		Plotter "off line" or not connected.
	Control Panel		
200	SELECTED FREQUENCY OUT OF CAL RANGE		Cal. range does not include selected frequency.
201	MARKERS SELECTED FOR READOUT NOT ACTIVE IN SWEEP RANGE		Sweep range does not include selected frequency.
208	OUT OF RANGE		Attempted to enter an out-of-range parameter.
209	START GREATER THAN STOP		Attempted to a set start frequency that was greater than the stop frequency.
210	OUT OF RANGE,20 PERCENT MAX		Attempted to enter a smoothing or group delay factor that was greater than 20%.
213	OUT OF H/W RANGE		Attempted to enter a frequency that is outside of the system hardware range.
216	TOO MANY POINTS, 501 MAXIMUM		Attempted to set too many discrete frequency points.
217	TOO FEW POINTS, 2 MINIMUM		Attempted to set too few discrete frequency points.
219	DISCRETE FREQS LOST		Setup changed in N-discrete frequency mode.
220	OUT OF SWEEP RANGE		Attempt to set marker outside sweep range.
221	OPTION NOT INSTALLED		The selected opttion is not installed
222	MEAS. DATA NOT AVAILABLE FOR STORAGE		No measured data on channel to be stored.
223	NO STORED MEMORY DATA		No data available in memory for channel.
224	SYSTEM BUS ADDRESSES MUST BE UNIQUE		Attempt to set GPIB addresses to same value.
225	SYSTEM UNCALIBRATED		no cal exists.
226	MEMORY LOCATION CORRUPTED		Saved state data is invalid.
227	SETUP INCONSISTENT RECALL ABORTED		Saved state not compatible with hardware or software version
228	WINDOW TOO SMALL		Attempt to set start greater than or equal to stop.
229	OUT OF WINDOW RANGE		Attempt to set marker outside start to stop range.
230	ATTENUATOR UNAVAILABLE		Selected attenuators not available in test set
231	START MUST BE LESS THAN STOP		Attempt to set start greater than or equal to stop in marker sweep
232	ILLEGAL IN C.W. MODE		Attempt to readout limit frequency.
233	ILLEGAL IN TIME DOMAIN		Attempt to readout limit frequency.
234	BOTH LIMITS MUST BE ON		Attempt to readout limit frequency.
235	Stop is Over Range		Discrete fill parameters cause stop to go over hardware range

Table 3-3. Error Codes and Status Messages (4 of 4)

CODE	MESSAGE TEXT	FATAL	MEANING
238	Out of Ramge 10 % Minimum		Attempt to set pen speed to below 10%
270	UNCALIBRATED		Channel has S parameter for which calibration does not exist.
271	PRINTER NOT READY		Printer not connected or paper out.
272	TOO MUCH PRINT DATA		Print buffer is full. Reduce number of channels or data points.
273	PLOTTER NOT READY		Plotter not connected.
280	CAL INVALID		Calibration is incorrect for S parameter displayed.
281	TIME DOMAIN INVALID		Time domain cannot be used in current setup
282	GROUP DELAY INVALID		Group delay cannot be used in current setup
. 283	GATE MUST BE ON		Attempt to select Frequency With Time Gate with gate off.
284	SMOOTHING INVALID		Attempt to use smoothing while in C.W. mode.
285	MEMORY DATA INVALID		Setup has changed since data was stored.
Measurement Related			
300	LOW IF		Insufficient signal level detected: Device under test may not be connected.
301	LOCK FAILURE		RF source failed to lock to reference oscillator in 360 testset.
302	A/D FAILURE		Analog to Digital convertor not functioning in 360 mainframe.
303	RF OVERLOAD		Test signal level is too high: reduce source level or add attenuation.
310	SWPR ID FAILURE		Communications lost with RF source.
311	SWPR SELF TEST FAILURE		RF source failed power on self test program.
312	NO TEST SET		Test set not connected . Reconnect and cycle power to clear
GPIB Related			
400	GPIB ERROR		Data transmission error on GPIB

3-8 DATA DISPLAYS

3-8.1 Display Modes and Examples

The 360 displays measurement data using a "Channel Concept." This means that each channel can display a different S-Parameter and a different graph type for each S Parameter. As you select each channel the graph type, scaling, reference delay, S-Parameter, etc. associated with that channel appear on the screen. You can display the same S-Parameter on two or more channels. Figure 3-125 shows the possible displays. Figures 3-126 thru 3-129 show examples of each display format.

3-8.2 Graph Types

Several graph-types are possible: polar, rectilinear, Smith chart . The rectilinear graph-type may be magnitude, phase, magnitude and phase, SWR, group delay, real, imaginary, and real and imaginary. The Smith chart graph-type is one specifically designed to plot complex impedances.

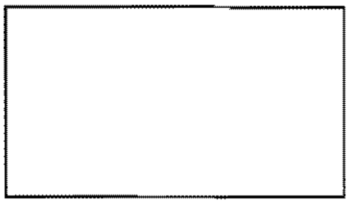
a. *Graph Data Types*

The data types (real, imaginary, magnitude, phase) used in the displayed graph-types reflect the possible ways in which S-Parameter data can be represented in polar, Smith, or rectilinear graphs. For example: Complex data—that is, data in which both phase and magnitude are graphed—may be represented and displayed in any of the ways shown below.

1. Complex Impedance; displayed on a Smith chart graph.
2. Real and imaginary; displayed on areal and imaginary graph.
3. Phase and magnitude components; displayed on a rectilinear (Cartesian) or polar graph.

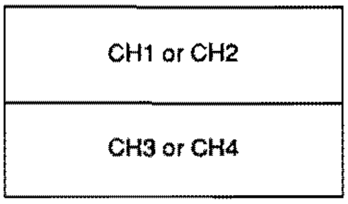
In addition to the above, the 360 can display the data as a group delay plot. In this graph-type, the group-delay measurement units are time. Those of the associated aperture are frequency and SWR.

Single Channel Display



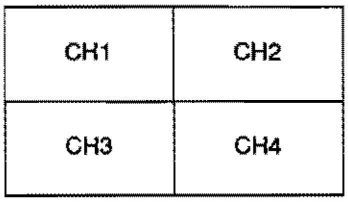
Channel 1, 2, 3, or 4. You select this display type by choosing "single display" on menu CM (Figure 3-73). Possible graph-types are either single Smith, polar, or rectilinear or dual rectilinear (magnitude and phase).

Dual Channel Display



Channels 1 and 3 or 2 and 4. If you have chosen to display magnitude and phase, the affected area of the CRT screen is subdivided into two smaller portions. You select this display type by choosing "Dual Display" in Menu CM.

Four Channel Display



Channels 1, 2, 3 and 4. From four-to-eight graph-types are displayed. In each quadrant, the graph-type can be any of the possible choices listed in the GT menus (Figure 3-76 and 3-77) . If you have chosen to display magnitude and phase for a channel, the quadrant displaying that channel is further subdivided as described above. You select this display type by choosing "All Four Channels" in menu CM.

Figure 3-125. Types of Displays

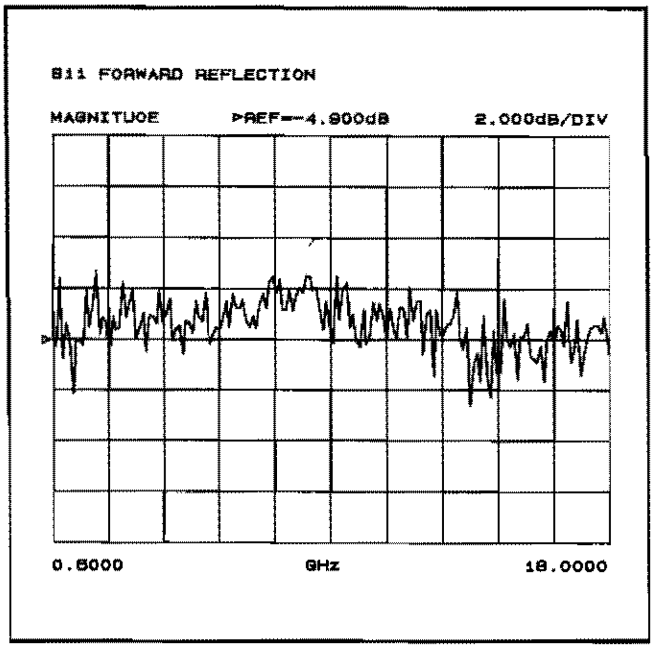


Figure 3-126. Single Display

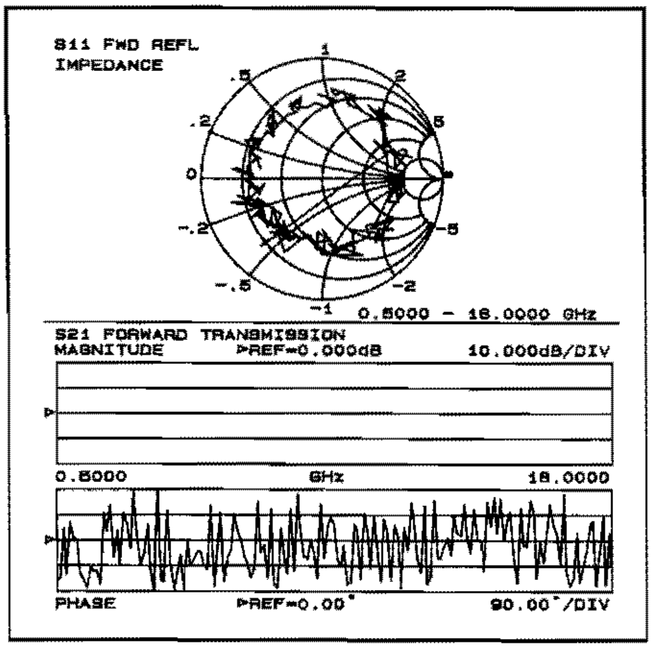


Figure 3-128. Dual Display

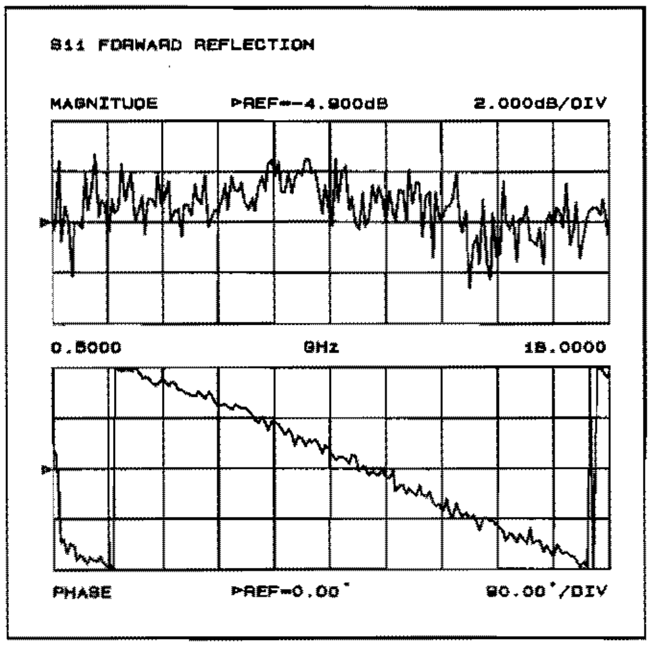


Figure 3-127. Single Display, Log Magnitude and Phase

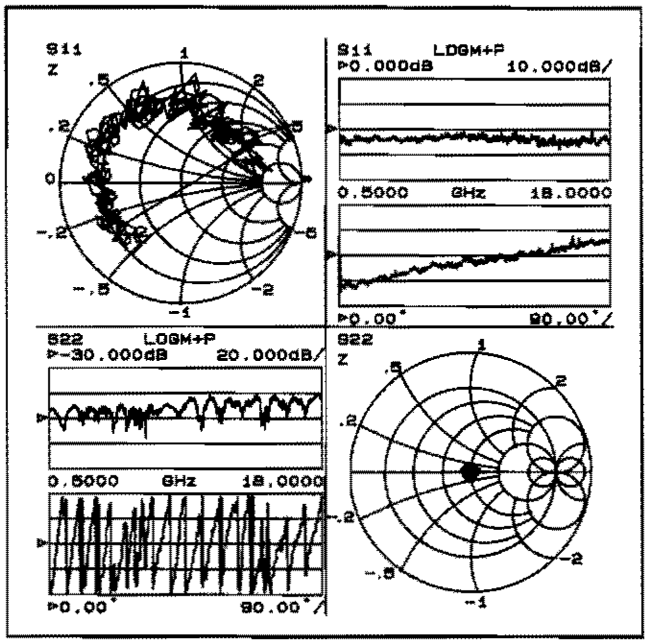


Figure 3-129. Four Channel Display

The quantity group delay is displayed using a modified rectilinear-magnitude format. In this format the vertical scale is in linear units of time (ps-ns-µs). With one exception, the reference-value and -line functions operate the same as they do with a normal magnitude display. The exception is that they appear in units of time instead of magnitude.

b. *Graph Type Examples*

Figures 3-130 thru 3-135 show examples of each graph-type.

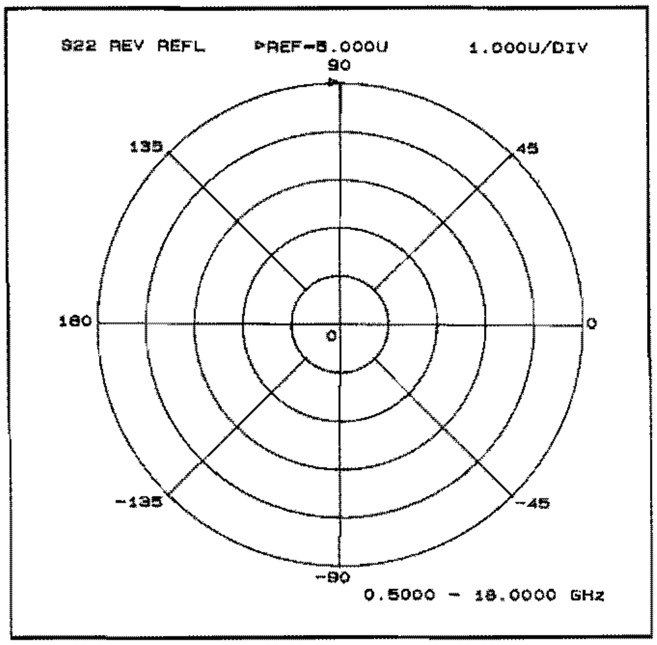


Figure 3-130. Linear Polar Graticule

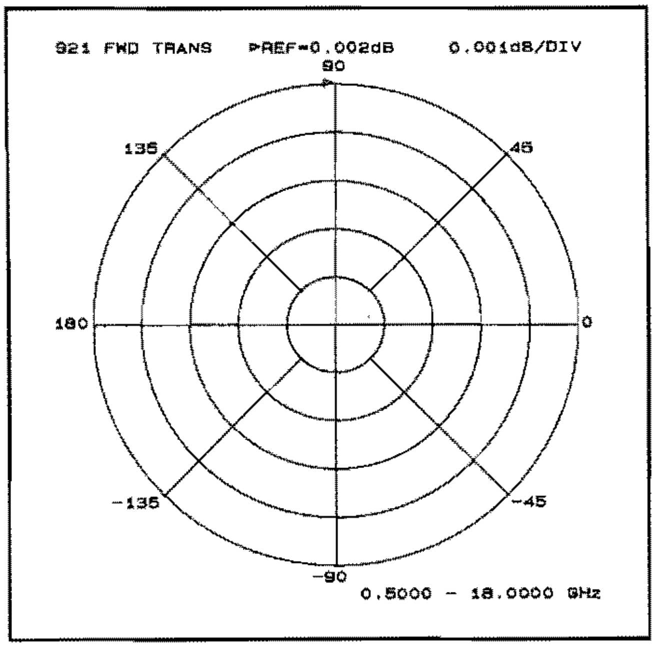


Figure 3-131. Log Polar Graticule

3-8.3 Frequency Markers

a. *Marker Annotation*

Figure 3-136 shows how the 360 annotates markers for the different graph-types. Each

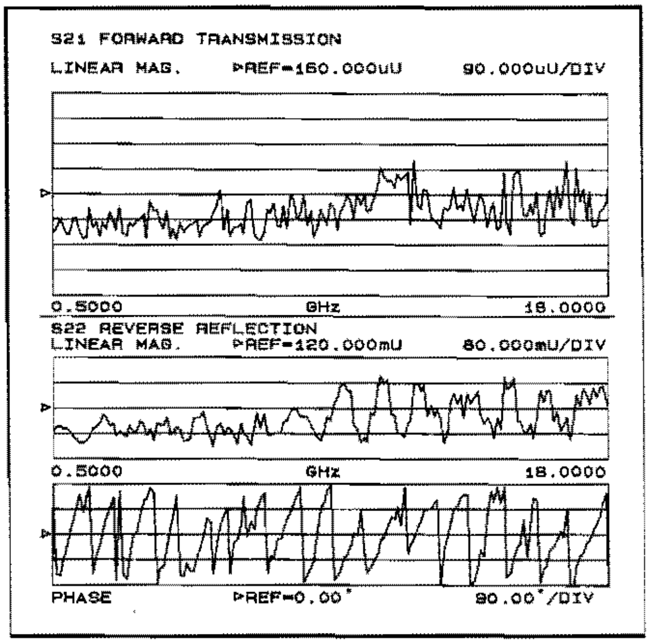


Figure 3-132. Dual Channel Rectilinear Graticule

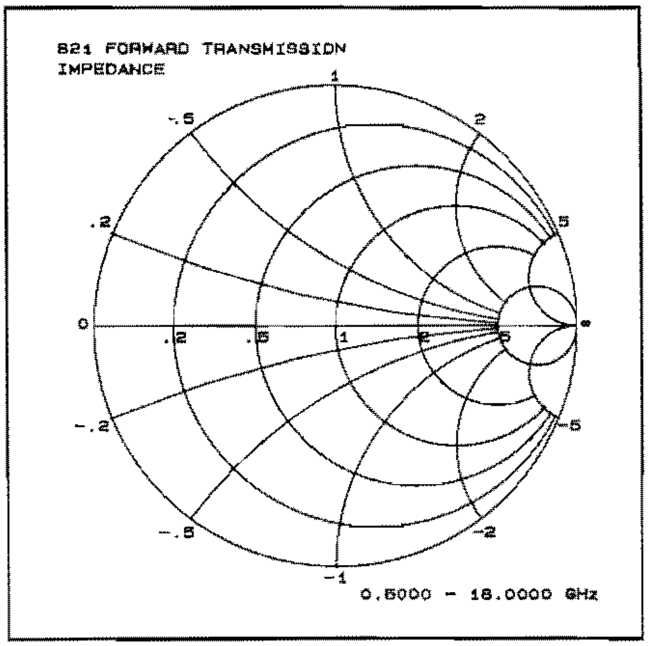


Figure 3-133. Normal Smith Chart

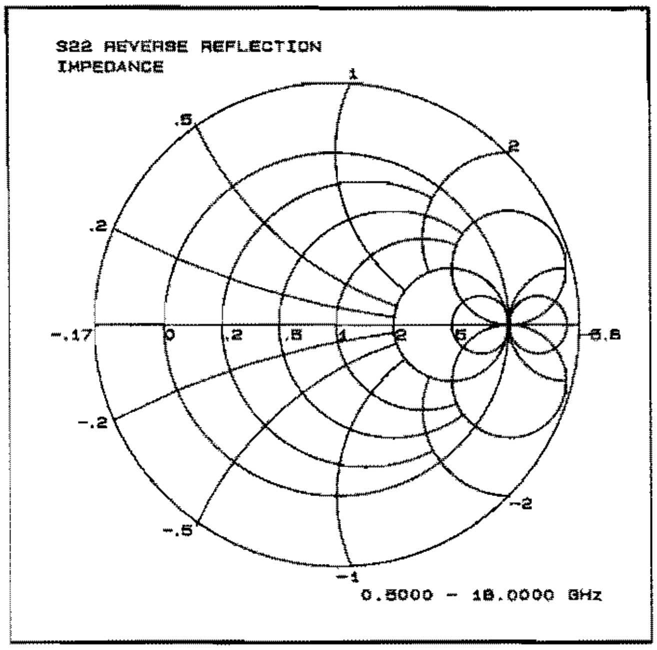


Figure 3-134. 3 dB Compressed Smith Chart

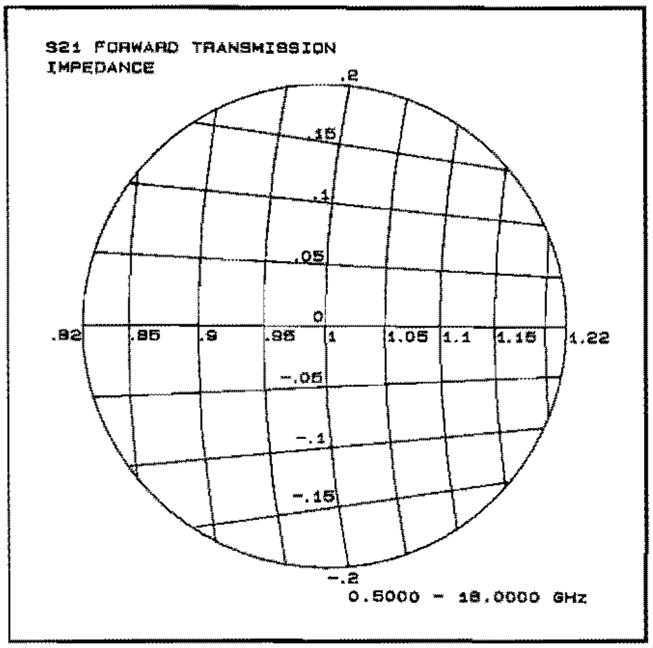


Figure 3-135. 20 dB Expanded Smith Chart

marker is identified with its own number. When a marker reaches the top of its graticule, it will flip over and its number will appear below the symbol.

When markers approach the same frequency, they will overlap. Their number will appear as close to the marker as possible without overlapping.

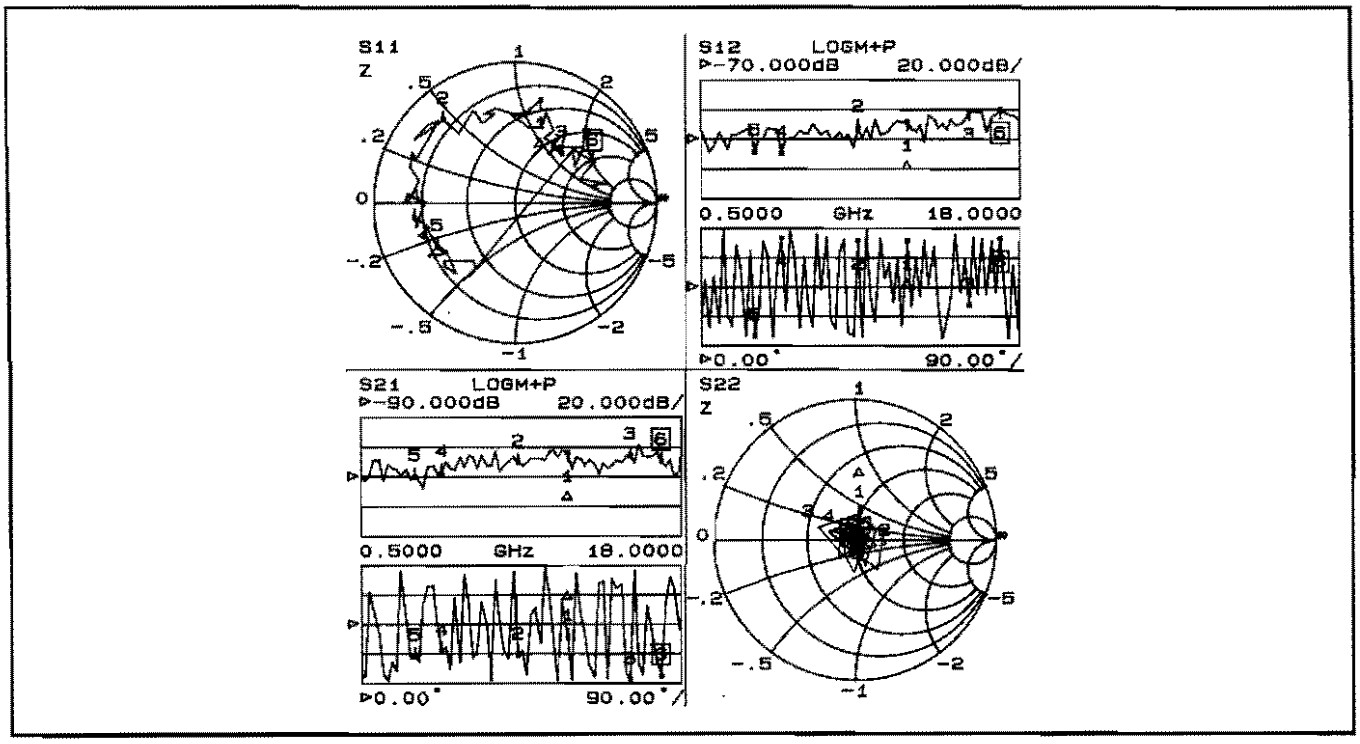


Figure 3-136. Marker Annotation

b. Marker Designation

Depending on menu selection, you may designate a marker as the "active" or the "delta reference" marker. If you choose a marker to be active—indicated by its number being enclosed in a square box—you may change its frequency or time (distance) with the Data Entry keypad or knob. If you have chosen it to be the delta-reference marker, a delta symbol (Δ) appears one character space above the marker number (or one character space below a "flipped" marker). If the marker is both active and the delta reference marker, the number and the delta symbol appear above (below) the marker. The delta symbol appears above (below) the number.

3-8.4 Limits

Limit lines function as settable maximum and minimum indicators for the value of displayed data. These lines are settable in the basic units of the measurement on a channel-by-channel basis. If the display is rescaled the limit line(s) will move automatically and thereby maintain their correct value(s).

Each channel has two limit lines (four for dual displays), each of which may take on any value. Limit lines are either horizontal lines in rectilinear displays or concentric circles around the origin in Smith and polar displays.

3-8.5 Status Display

In addition to the graticules, data, markers, and marker annotation, the 360 displays certain instrument status information in the data display area. This information is described below.

a. Reference Position Marker

The Reference Position Marker indicates the location of the reference value. It is displayed at the left edge of each rectilinear graph-type. It consists of a triangular symbol identical to the cursor displayed in the menu area. You can center this symbol on one of the vertical graticule divisions and move it up or down using the "Reference Position" option. When you do this, the data trace will follow this marker. If you also select the value option, the marker will remain stationary and the trace will move with the maximum allowable resolution. When changing from a full-screen display to half- or quarter-screen display, the marker will stay as close to the same position as possible.

b. Analog Instrument Status

The 360 displays analog-instrument-status messages (in red when appropriate) in the upper right corner of the data-display area (Figure 3-137). They appear at the same vertical position as line 2 of the menu area. If more than one message appears, they stack up on below that line.

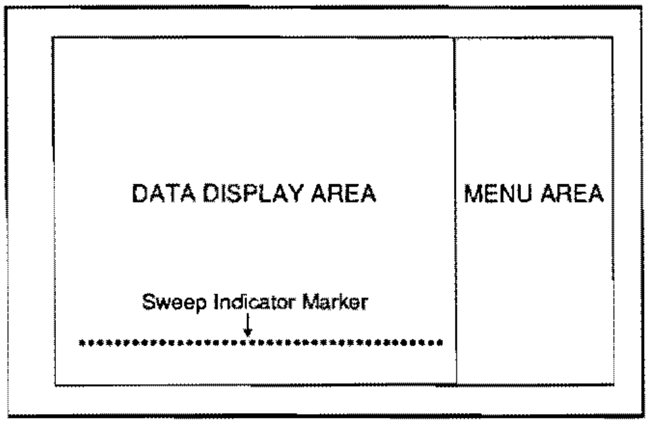


Figure 3-137. Display Screen Showing the Data-Display and Menu Areas and Sweep Indicator Marker

c. Measurement Status

The 360 displays measurement-status messages (in red when appropriate) in the upper-right corner of the graticule (channel) to which they apply.

d. Sweep Indicator Marker

The sweep indicator marker (Figure 3-137) indicates the progress of the current sweep. When measuring quiet data—that is, data having few or no perturbations—this indicator assures that the instrument is indeed sweeping.

The indicator—a blue horizontal line segment 15 pixels long by 1 pixel high—appears along the bottom edge of the data display area. Its position is proportional to the number of data points measured in the current sweep. When this sweep completes, the line segment will have traveled the full width of the data display area. If the sweep should stop for some reason, the position of the indicator will stop changing until the sweep resumes.

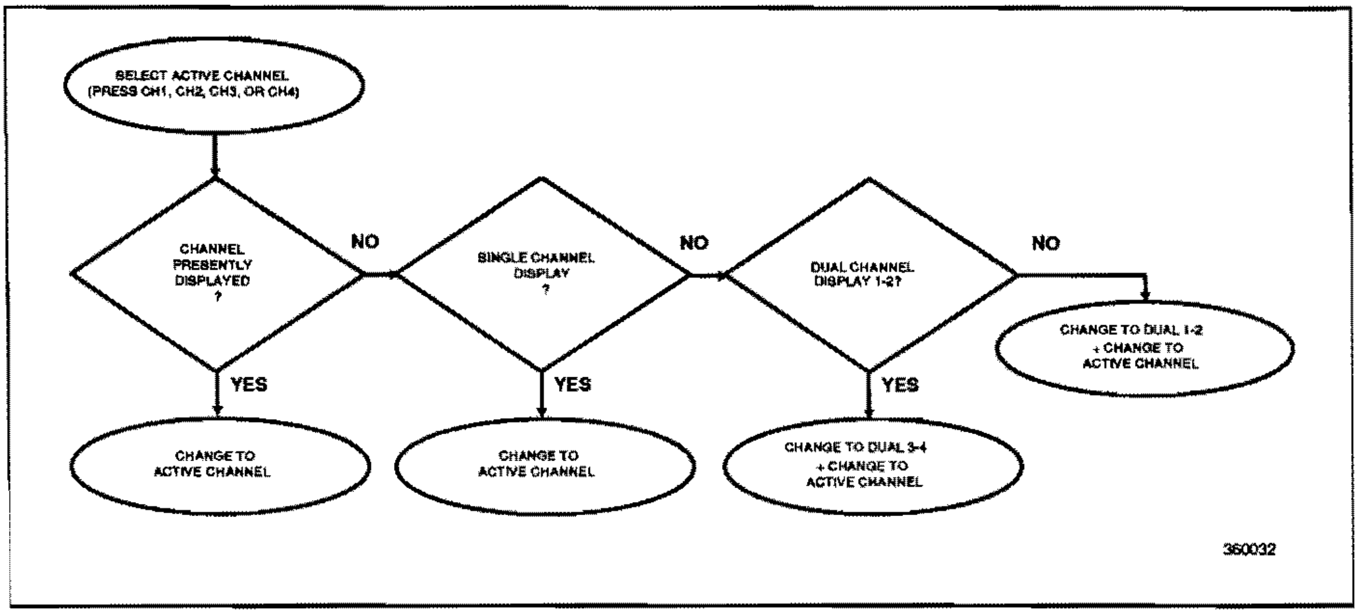


Figure 3-138. Active Channel Algorithm

3-8.6 Data Display Control

a. Active Channel Selection

Figure 3-138 shows the algorithm that the 360 uses to display the active channel.

b. S-Parameter Selection

If you select a new S-Parameter using Menu SP (Figure 3-71), it appears on the then-active channel in the same graph-type it was displayed-in last. Table 3-4 shows the displayable S-Parameters based on the type of correction you have in place. If you attempt to display other S-Parameters, an error message displays. In cases when there is no last-displayed S-Parameter stored, the display will default as shown in the Table 3-4.

If you select an S-Parameter (or if the 360 defaults to one) for which there was no last-displayed graph-type, the display defaults to the following:

S_{21} and S_{12}: Log Magnitude and Phase
S_{11} and S_{22}: Smith.

c. Data Display Update

When you change a control panel parameter that affects the appearance of the display, the entire display changes immediately to reflect that change. For example, if you press AUTOSCALE, the entire display rescales immediately. You do not have to wait for the next sweep to see the results of the change. The following parameters are supported for this feature:

Table 3-4. Display Types and Defaults by Correction Type

Correction Type	Displayable S-Parameters	Defaults			
		CH1	CH2	CH3	CH4
None	All	S_{11}	S_{12}	S_{21}	S_{22}
Frequency Response					
Transmission	S21	S_{21}	S_{21}	S_{21}	S_{21}
Reflection	S11	S_{11}	S_{11}	S_{11}	S_{11}
Both	S11, S21	S_{11}	S_{11}	S_{21}	S_{21}
1-Path 2-Port	S11, S21	S_{11}	S_{11}	S_{21}	S_{21}
12-Term	All	S_{11}	S_{12}	S_{21}	S_{22}
Reflection Only	S11	S_{11}	S_{11}	S_{11}	S_{11}

Reference Delay, Offset, Scaling, Auto Scale, Auto Reference Delay, Trace Math, IF BW, and Smoothing. In the case of Averaging, the sweep restarts.

If the knob is used to vary any of the above parameters, the change occurs as the measurement progresses—that is, the continuing trace will reflect the new setting(s).

When you change a marker frequency or time (distance), the readout parameters will change. The changes reflect by the marker's new frequency, using data stored from the previous sweep.

d. ***Display of Markers***
Once you have selected a marker to display, it will always display. It does not matter what resolution you have selected. When you set a marker to another calibrated frequency, then lower the resolution, that frequency and the marker will continue to display. It will display even if its frequency is not consistent with the data points in the lower-resolution sweep.

e. ***Hard Copy and Disk Output***
In addition to the CRT display, the Model 360 is capable of outputting measured data as a

1. tabular printout,
2. screen-image printout,
3. pen plot,
4. disk image of the tabular data values.

The selection and initiation of this output is controlled by the OUTPUT keys.

f. ***Tabular Printout***
Tables 3-5 thru 3-7 contain examples of the printout formats. These formats are used as follows:

1. *Tabular Printout Format:* Used when printing three or four channels.
2. *Alternate Data Format:* Used when printing one or two channels.

In tabular printouts, the 360 shifts the data columns to the left when an S-Parameter is omitted. Leading zeroes are always suppressed. The heading (Model, Device I/O, Date, Operator, Page) appears on each page. When using the 360SS sweeper, frequencies are in the format "XX.XXXX." When using the WILTRON Model 2225C Ink Jet printer, place all of the rear panel MODE SELECT switches in the down (OFF) POSITION.

g. ***Screen-Image Printout***
In a Screen-Image Printout, the exact data displayed on the screen is dumped to the printer. The dump is in the graphics mode, on a pixel by pixel basis. A header (Table 3-7) prints before the screen data prints.

h. ***Plotter Output***
The protocol used to control plotters is "HP-GL" (Hewlett-Packard Graphics Language). HP-GL contains a comprehensive set of "vector graphics" type commands. These commands are explained in the *Interfacing and Programming Manual* for any current model Hewlett-Packard plotter, such as the 7470A.

When the plotter is selected as the output device, it is capable of drawing the graph shown on the screen or of drawing only the data trace(s), so that multiple traces may be drawn on a single sheet of paper (in different colors, if needed).

i. ***Disk Output***
The 360 can write-to or read-from the disk all measured data. This data is stored as an ASCII file in the exact same format as that shown in the Table 3-5. If read back from the disk, the data is output to the printer. There, it prints as tabular data.

Table 3-5. Example of a Tabular Printout

WILTRON
360 NETWORK ANALYZER

MODEL: TEST_DEVICE — DATE: 8/28/87 — Page 1
DEVICE ID: 12345678 — OPERATOR: ROY_STEWART

SWEEP DATA

START:	0.5000 GHz	GATE START:	-	ERROR CORR:	NONE
STOP:	18.0000 GHz	GATE STOP:	-	AVERAGING:	1 PTS
STEP:	350.0 MHz	GATE:	-	IF BNDWDTH:	REDUCED
		WINDOW:	-		

	CH1	CH2	CH3	CH4
S-PARAMETER:	S11	S12	S21	S22
NORMALIZATION:	OFF	OFF	OFF	OFF
REF DELAY:	0.000 ps	0.000 ps	0.000 ps	0.000 ps
SMOOTHING:	0.0 PERCENT	0.0 PERCENT	0.0 PERCENT	0.0 PERCENT
DELAY APERTURE:	-	-	-	-

MARKERS:

MKR #	FREQ GHz	RESISTANCE OHMS	REACTANCE OHMS	MAGNITUDE dB	PHASE Deg	MAGNITUDE dB	PHASE Deg	RESISTANCE OHMS	REACTANCE OHMS
1	7.8500	85.703E+00	-11.970E+00	3.718	-151.694	12.011	80.736	19.825E+00	20.716E+00
3	4.6650	37.349E+00	-4.518E+00	4.207	-0.861	12.489	-21.145	68.958E+00	-34.059E+00
5	13.4850	41.725E+00	-6.519E+00	3.511	59.233	11.128	-105.400	34.309E+00	-6.206E+00
6	10.5450	38.332E+00	-28.090E+00	4.372	29.832	11.941	45.988	73.673E+00	-55.871E+00

FREQUENCY POINTS:

PNT #	FREQ GHz	RESISTANCE OHMS	REACTANCE OHMS	MAGNITUDE dB	PHASE Deg	MAGNITUDE dB	PHASE Deg	RESISTANCE OHMS	REACTANCE OHMS
1	0.5000	47.243E+00	-14.043E+00	4.628	116.710	13.006	-8.887	117.751E+00	56.388E+00
2	1.2350	63.165E+00	-5.036E+00	4.454	-37.849	12.883	-32.621	48.275E+00	16.530E+00
3	1.9700	42.529E+00	-7.470E+00	6.421	166.838	12.568	22.254	26.752E+00	17.790E+00
4	2.7050	60.408E+00	13.569E+00	6.168	-17.869	12.237	73.697	34.823E+00	3.727E+00
5	3.4400	39.521E+00	-7.783E+00	4.295	176.085	12.546	128.759	50.463E+00	-4.268E+00
6	4.1750				6.918	12.338	-177.085	29.115E+00	15.016E+00
							-124.935	28.507E+00	4.322E+00
		50.438E+00	4.925E+00	5.309					
	15.9350	59.046E+00	8.758E+00	3.455	61.612	11.250			
23	16.6700	50.326E+00	-21.596E+00	4.389	-112.332	9.722	12.829	[illegible]	[illegible]
24	17.4050	66.534E+00	-31.892E+00	4.374	55.676	9.880	59.387	41.193E+00	21.928E+00
25	18.0000	59.154E+00	7.583E+00	3.536	155.557	10.683	9.061	160.743E+00	40.409E+00

Table 3-6. Example of an Alternate-Data Tabular Printout

HILTRON
360 NETWORK ANALYZER

MODEL: TEST_DEVICE	DATE: 8/28/87		Page	1
DEVICE ID: 12345678	OPERATOR: ROY_STEWART			

SWEEP DATA

START:	0.5000 GHz	GATE START:	-	ERROR CORR:	NONE
STOP:	18.0000 GHz	GATE STOP:	-	AVERAGING:	1 PTS
STEP:	350.0 MHz	GATE:	-	IF BNDWDTH:	REDUCED
		WINDOW:	-		

	------------CH1------------	------------CH3------------
S-PARAMETER:	S11	S21
NORMALIZATION:	OFF	OFF
REF DELAY:	0.000 ps	0.000 ps
SMOOTHING:	0.0 PERCENT	0.0 PERCENT
DELAY APERTURE:	-	-

MARKERS:

MKR #	FREQ GHz	RESISTANCE OHMS	REACTANCE OHMS	MAGNITUDE dB	PHASE Deg
1	7.8500	85.621E+00	-11.990E+00	12.005	88.681
3	4.6650	37.355E+00	-4.512E+00	12.482	-21.169
5	13.4850	41.736E+00	-6.530E+00	11.121	-105.378
6	10.5450	38.324E+00	-28.107E+00	11.939	45.982

FREQUENCY POINTS:

PNT #	FREQ GHz	RESISTANCE OHMS	REACTANCE OHMS	MAGNITUDE dB	PHASE Deg
1	0.5000	47.248E+00	-14.036E+00	13.006	-8.877
2	1.2350	63.171E+00	-5.023E+00	12.874	-32.635
3	1.9700	42.523E+00	-7.461E+00	12.557	22.233
4	2.7050	60.396E+00	13.547E+00	12.226	73.679
5	3.4400	39.521E+00	-7.777E+00	12.538	128.750
6	4.1750	42.178E+00	6.193E+00	12.328	-177.098
7	4.9100	65.105E+00	377.203E-03	12.097	-124.948
8	5.6450	50.254E+00	-7.799E+00	12.627	-69.019
9	6.3800	71.803E+00	26.052E+00	12.001	-18.102
10	7.1150	55.862E+00	-1.837E+00	12.188	35.397
11	7.8500	85.621E+00	-11.990E+00	12.005	88.681
12	8.5850	41.437E+00	24.506E+00	11.976	143.947

Table 3-7. Example of a Screen-Dump Header

WILTRON

360 NETWORK ANALYZER

MODEL: TEST_DEVICE
DEVICE ID: 12345678

DATE: 8/28/87
OPERATOR: ROY_STEWART

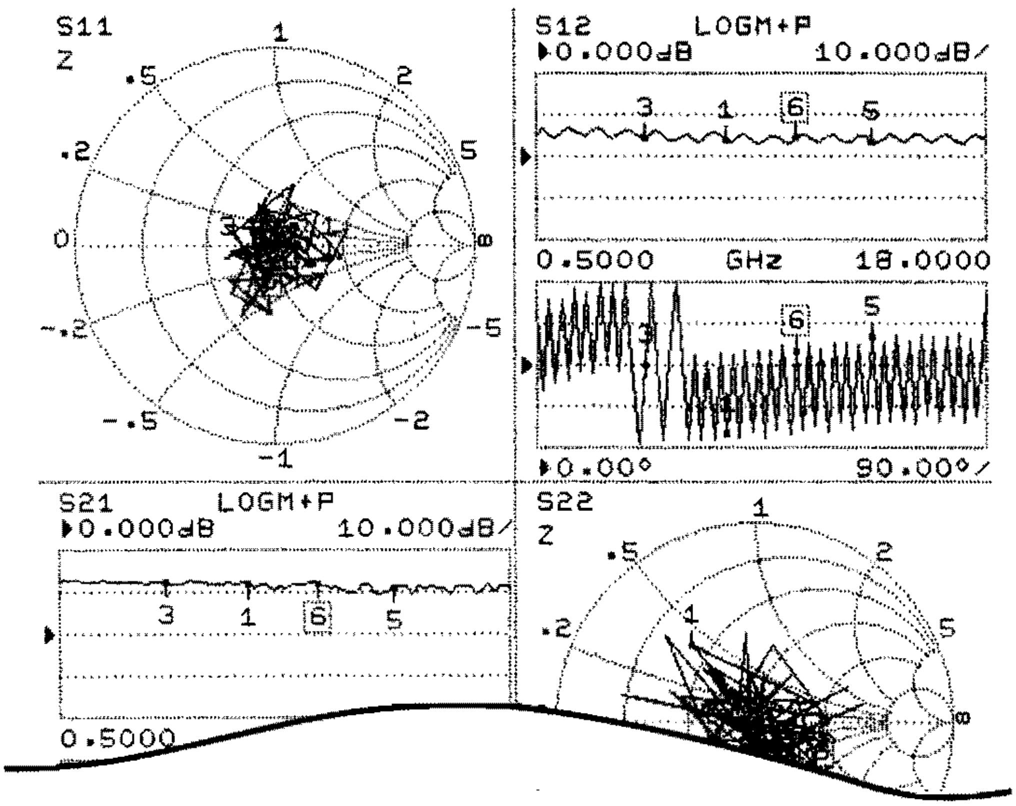
Page 1

SWEEP DATA
START: 0.5000 GHz
STOP: 18.0000 GHz
STEP: 350.0 MHz

GATE START: -
GATE STOP: -
GATE: -
WINDOW: -

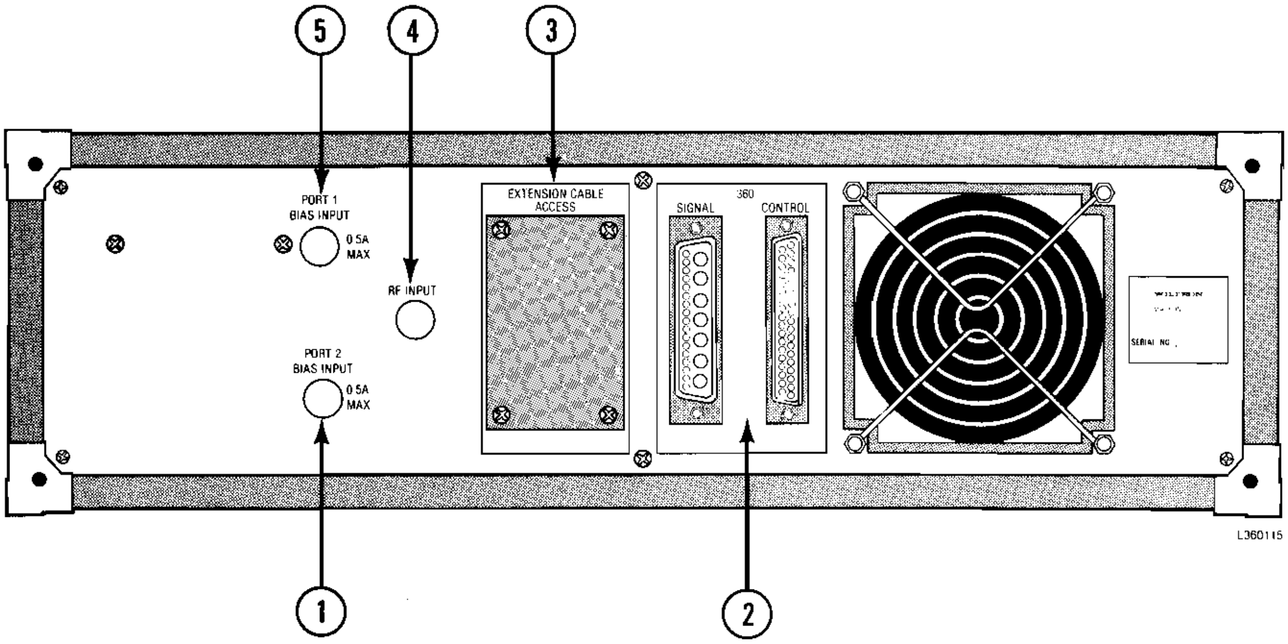
ERROR CORR: NONE
AVERAGING: 1 PTS
IF BNDWDTH: REDUCED

	CH1	CH2	CH3	CH4
S-PARAMETER:	S11	S12	S21	S22
NORMALIZATION:	OFF	OFF	OFF	OFF
REF DELAY:	0.000 ps	0.000 ps	0.000 ps	0.000 ps
SMOOTHING:	0.0 PERCENT	0.0 PERCENT	0.0 PERCENT	0.0 PERCENT
DELAY APERTURE:	-	-	-	-



3-9 MODEL 360 SYSTEM REAR PANEL CONNECTORS

Figures 3-139 thru 3-146 describe the rear panel connectors for the 360 system instruments.



(1) **PORT 2 BIAS INPUT:** Provides for applying an external bias to the active device connected to test port 2 without disturbing the accuracy of the 360 measurement.

(2) **360**
SIGNAL: 17-pin/7-video connector that provides signal and control lines for the companion analyzer. Figure 3-143 describes the signal lines and shows the connector pinout.
CONTROL: 37-pin connector that provides signal and control lines for the companion test set. Figure 3-145 describes the signal lines and shows the connector pinout.

(3) **EXTENSION CABLE ACCESS:**
Removal cover that allows for special customer needs in which phase-compensation cables need to be located outside of the test set.

(4) **RF INPUT:** Inpu port for the RF/microwave signal from the frequency Source.

(5) **PORT 1 BIAS INPUT:** Provides for applying an external bias to the active device connected to test port 1 without disturbing the accuracy of the 360 measurement.

Figure 3-139. Model 36XX Test Set Rear Panel Connectors

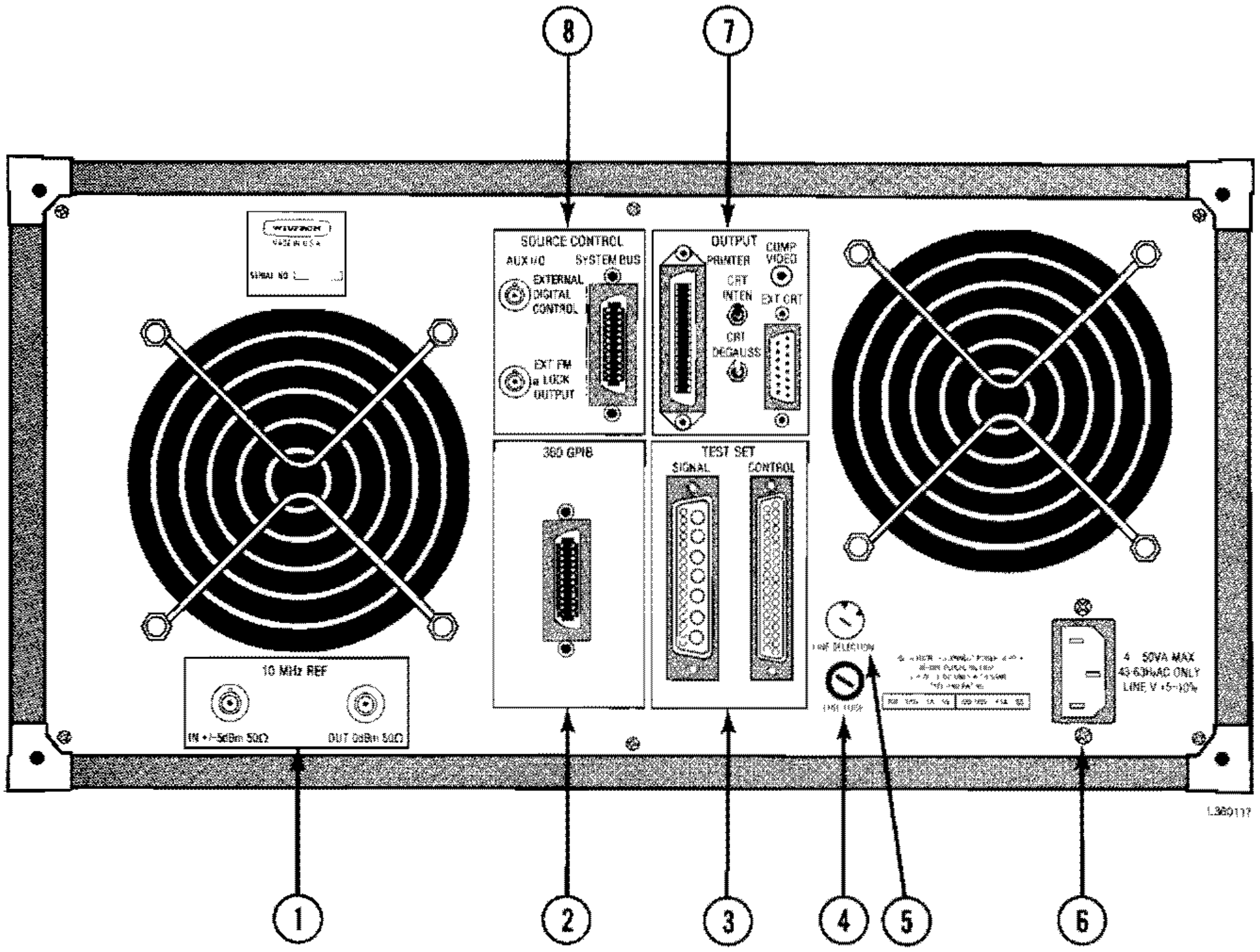


Figure 3-140. Model 360 Network Analyzer Rear Panel Connectors (1 of 2)

(1) **10 MHz REF**
IN: BNC connector that allows an external 10 MHz signal (–5 to +5 dBm) to be used as the frequency reference for phase locking the source frequency. 50Ω impedance.
OUT: BNC connector that allows the internal 10 MHz reference to be used to phase lock an external counter or other measuring instrument. Level is typically 0 dBm into 50Ω impedance.

(2) **360 GPIB:** 24-pin connector that provides for remotely controlling the 360 from the IEEE-488 bus (GPIB). Figure 3-142 provides a pinout diagram.

(3) **TEST SET:**
SIGNAL: 17-pin/7-video connector that provides signal and control lines for the companion test set. Figure 3-143 describes the signal lines and shows the connector pinout.
CONTROL: 37-pin connector that provides signal and control lines for the companion test set. Figure 3-145 describes the signal lines and shows the connector pinout.

(4) **LINE FUSE:** 3 AG fuse cartridge that protects for an input-overcurrent condition. The fuse should be 4A for line voltages between 100 and 120 Vac and 2A for line voltages between 220 and 240 Vac.

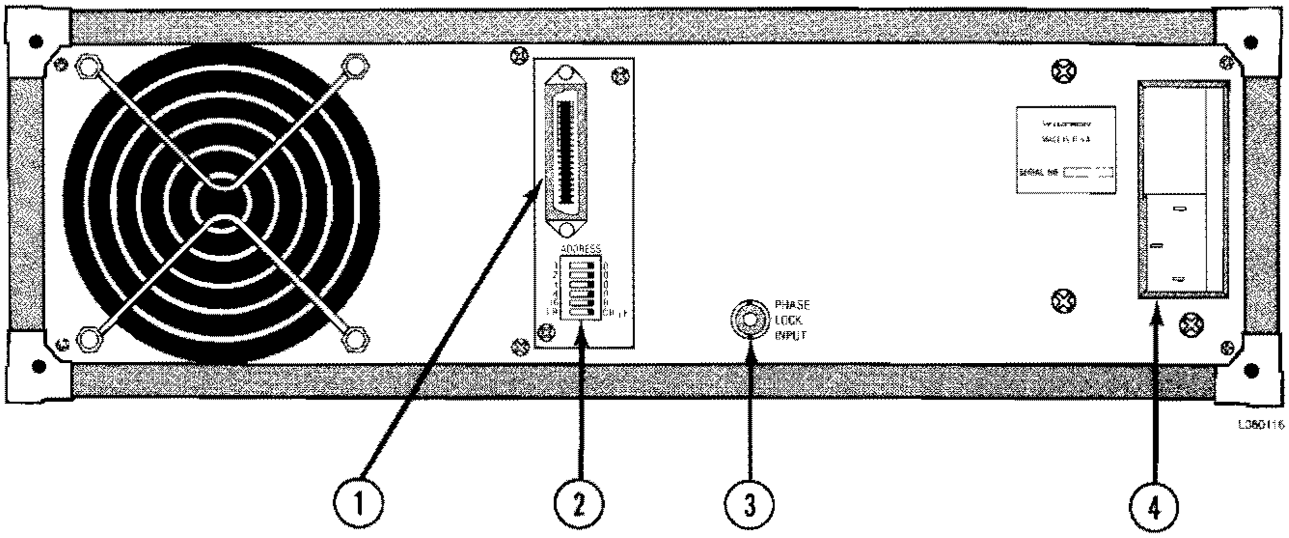
(5) **LINE SELECTION:** Slotted control that switches between 110 and 220 Vac line voltages.

(6) **Line Voltage Module:** Three-prong ac plug and module that provides filtering for the 50/60 hertz input-line power. The line voltage must be between + 5% and –10% of the nominal, input 100-120 or 220-240 Vac value.

(7) **OUTPUT**
PRINTER: 36-pin connector that provides a parallel interface to the companion printer. Figure 3-144 describes the signal lines and shows the connector pinout.
COMP VIDEO: RCA phono jack that provides a television composite-video signal for displaying the 360 CRT display(s) on an external black and white (B/W) television monitor.
EXT CRT: 15-pin connector that provides a variety of signals for displaying the 360 CRT display(s) on different types of color and B/W monitors. Figure 3-146 describes the signal lines and shows the connector pinout.
CRT INTEN: Control that adjusts the screen intensity of the external monitor.
CRT DEGAUSS: Momentary-on pushbutton that degauses the internal color monitor. It has no effect on a monochrome monitor.

(8) **SOURCE CONTROL**
BANDSWITCH BLANKING. Not presently used.
EXT FM ∅LOCK OUTPUT. Provides a –6 MHz/Volt signal to phase lock the sweeper to the internal (crystal) reference for exact frequency control.
SYSTEM BUS: 24-pin connector that provides for remotely controlling the frequency source and plotter—from the 360—via the IEEE-488 bus (GPIB). Figure 3-142 provides a pinout diagram.

Figure 3-140. Model 360 Network Analyzer Rear Panel Connectors (2 of 2)



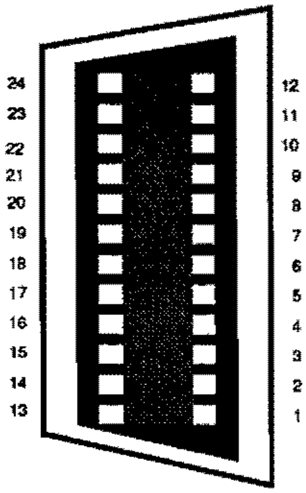
(1) **GPIB Interface:** 24-pin connector that provides for remotely controlling the frequency source from the IEEE-488 bus (GPIB)—via the 360 system bus. Figure 3-140 provides a pinout diagram.

(2) **ADDRESS SWITCH:** Provides for changing the GPIB address. The address is set to 5 before leaving the factory. Refer to Section 2, paragraph 2-6 for instructions.

(3) **EXT FM ∅LOCK INPUT** Accepts a −6 MHz/ Volt signal to phase lock the sweeper to the internal (crystal) reference for exact frequency control.

(4) **Line Selector Module:** Provides for selecting between four international line voltages: 100, 110/120, 200, 220/240 Vac. Refer to Section 2, paragraph 2-5 for instructions on how to change to a different line voltage.

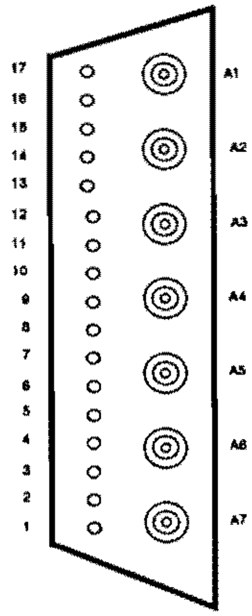
Figure 3-141. Model 360SSXX Frequency Source Rear Panel Connectors



Pinout Diagram

PIN	NAME	DESCRIPTION
1-4	DIO 1 thru DIO 4	*Data Input/Output.* Bits are HIGH with the data is logical 0 and LOW when the data is logical 1.
5	EOI	*End Or Identify.* A low-true state indicates that the last byte of a multibyte message has been placed on the line.
6	DAV	*Data Valid.* A low-true state indicates that the talker has (1) sensed that NRFD is LOW , (2) placed a byte of data on the bus, and (3) waited an appropriate length of time for the data to settle.
7	NRFD	*Not Ready For Data.* A high-true state indicates that valid data has not yet been accepted by a listener.
8	NDAC	*Not Data Accepted.* A low-true state indicates that the current data byte has been accepted for internal processing by a listener.
9	IFC	*Interface Clear.* A low-true state places all bus instruments in a known state—such as, unaddressed to talk, unaddressed to listen, and service request idle.
10	SRQ	*Service Request.* A low-true state indicates that a bus instrument needs service from the controller.
11	ATN	*Attention.* A low-true state enables the controller to respond both to its own listen/talk address and to appropriate interface messages-- such as, device clear and serial poll.
12	Shield	Ground point.
13-16	DIO 5 thru DIO 8	*Data Input/Output.* Bits are HIGH with the data is logical 0 and LOW when the data is logical 1.
17	REN	*Remote Enable.* A low-true state enables bus instruments to be operated remotely, when addressed.
18-24	GND	Logic ground.

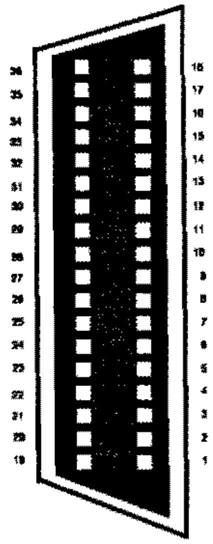
Figure 3-142. Pinout Diagram, GPIB Connector



Pinout Diagram

PIN	NAME	DESCRIPTION
1	EXT A/D	External analog-to-digital-converter input.
2	EXT A/D RTN	Return for EXT A/D converter input.
3-8	Spare	
9	LO2 LOCK	2nd local oscillator phase-lock error signal.
10	LO2 LOCK RTN	Return for 2nd LO phase-lock error signal.
11	LO2 DAC	Local Oscillator 2 loop gain.
12	LO2 DAC RTN	Return for LO2 DAC loop gain.
13	Spare	
14	LO1 LOCK	1st local oscillator phase-lock error signal.
15	LO1 LOCK RTN	Return for 1st local oscillator phase-lock error signal.
16	LO1 DAC	Local oscillator loop gain.
17	LO1 DAC RTN	Return for LO1 loop gain.
A1	CHN A IF	Channel A 3rd IF.
A2	FIRST LO	First local oscillator reference.
A3	SOURCE LOCK	Source lock IF signal.
A4	3rd LO/CAL	3rd local oscillator/83 1/3 kHz IF cal.
A5	CHN REF	Reference channel, 3rd IF.
A6	SECOND LO	Second local oscillator reference.
A7	CHN B IF	Channel B 3rd IF.

Figure 3-143. Pinout Diagram, Signal Connector



360033

Pinout Diagram

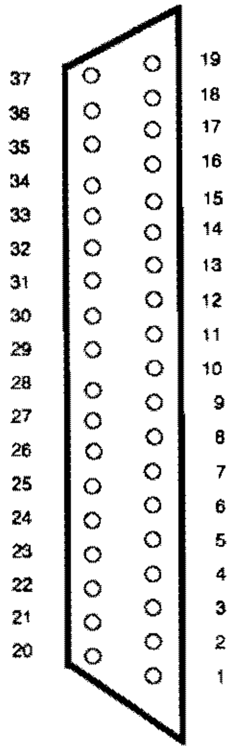
PIN	NAME	DESCRIPTION
1	$\overline{\text{STROBE}}$	*Printer Strobe.* A low-true pulse that tells the printer valid data has been placed on the bus.
2-9	DATA1 thru DATA8	*Data Lines.* Bits are HIGH when the data is a logical 1 and LOW when the data is a logical 0.
10	$\overline{\text{ACK NLG}}$	*Printer Acknowledgement.* A low-true, approximately 5 µs, pulse sent back by the printer to acknowledge that the data has been accepted.
11	BUSY	*Printer Busy.* High-true level sent by the printer to indicate that it is not available. This line is HIGH at the following times: (1) During data entry. (2) While printing. (3) When off-line. (4) When a printer-error has been signaled.
12	PE	*Printer Error.* High-true level sent by the printer to indicate that it is out of paper.
13	SLCT	*Select.* A high-true logic level.
14	$\overline{\text{AUTO FEED XT}}$	*Automatic Paper Feed.* A low-true level that tells the printer to feed the paper automatically.
15	NC	No Connection
16	OV	Logic GND Level
17	CHASSIS GND	Chassis ground, which is isolated from logic ground.
18	NC	No Connection
19	$\overline{\text{STROBE}}$ RTN	Return line for $\overline{\text{STROBE}}$ signal.
20-27	DATA RTN	Return lines for DATA1 thru DATA8 lines.

Figure 3-144. Pinout Diagram, Printer Connector (1 of 2)

Pinout Diagram (Continlued)

PIN	NAME	DESCRIPTION
28	$\overline{\text{ACKNLG}}$ RTN	Return line for $\overline{\text{ACKNLG}}$ signal.
29	BUSY RTN	Return line for BUSY signal.
30	PE RTN	Return line for PE signal.
31	$\overline{\text{INIT}}$	*Printer Initial State.* A low-true pulse that tells the printer to assume its initial state and clear its print buffer.
32	$\overline{\text{ERROR}}$	*Printer Error.* A low-true signal that indicates the printer is (1) out of paper, (2) off line, or (3) in an error state.
33	GND	Ground level.
34	NC	No Connection
35	+5V	+5 volt dc level.
36	$\overline{\text{SLCT IN}}$	*Printer Select Input.* A low-true level that permits the printer to accept data.

Figure 3-144. Pinout Diagram, Printer Connector (2 of 2)



Pinout Diagram

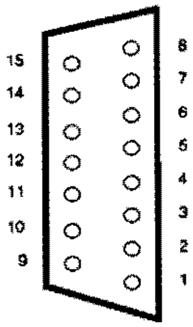
PIN	NAME	DESCRIPTION
1	Chassis ground	
2	+8V RTN	Return for the +8V input.
3	+8V	+8V input.
4	+18V RTN	Return for the +18V input.
5	+18V RTN	Return for the +18V input.
6	+18V	+18V input.
7	−18V	+18V input.
8	+27V RTN	Return for the +27V input.
9	+27V	+27V input.
10	Spare	
11	STATUS	A logic-low-signal level indicates that the status of the test set is not satisfactory for the measurement of data.
12	Spare	
13	L LOAD RTN	Return for the L LOAD signal.
14	TS STROBE RTN	Return for the Test Set STOBE signal.
15	DATA RTN	Return for the D0-D7 data/address lines.
16	D1	*Data/Address Lines.* Bits are HIGH when the data/address signal is a

Figure 3-145. Pinout Diagram, Control Connector (1 of 2)

Pinout Diagram (Continued)

PIN	NAME	DESCRIPTION
17	D3	Same as above.
18	D5	Same as above.
19	D7	Same as above.
20	Spare	
22	+8V	+8V input.
23	+18V RTN	Return for the +18V input.
24	+18V	+18V input.
25	+18V	+18V input.
26	–18V	–18V input.
27	–27V RTN	Return for the –27V input.
28	–27V	–27V input.
29	STATUS RTN	Return for the STATUS signal input.
30	Spare	
31	Shield	
32	L LOAD IN	A logic low signal causes all of the required data for the next frequency point to be loaded.
33	TS STROBE	TTL pulse that strobes address information into the test set on the falling edgeand data information on the rising edge.
34	D0	Data/Address lines. Bits are HIGH when the data/address signal is a logic-1 and LOW when the data/address signal is a logic-0.
35	D2	Same as above.
36	D4	Same as above.
37	D6	Same as above.

Figure 3-145. Pinout Diagram, Control Connector (2 of 2)



Pinout Diagram

PIN	NAME	DESCRIPTION
1	EXT HORIZ +/-	*External Horizontal Plus or Minus.* Jumpering this pin to pin 6 or changes the polarity of the External Horizontal signal to negative-going.
2	EXT VERT +/-	*External Vertical Plus or Minus.* Jumpering this pin to pin 6 or 7 changes the polarity of the External Vertical signal to negative- going.
3	BG ENABLE	*Blue-Green Enable.* Jumpering this pin to pin 6 or 7 disables the blue color-video signal and produces cyan in its place.
4		Spare
5	EXT BLUE VIDEO	*External Blue Video.* Blue color-video signal for external color monitor.
6	VIDEO GND	Video Ground.
7	VIDEO GND	Video Ground.
8	COMP VIDEO	*Composite Video.* Provides a Composite Video signal for a B/W monitor.
9	EXT HORIZ OUT	*External Horizontal Out.* Provides an External Horizontal signal that can be either positive- or negative-going, depending on whether or not pin 1 is jumpered to pin 6 or 7.
10	EXT VERT OUT	*External Vertical Out.* Provides an External Vertical signal that can be either positive- or negative-going, depending on whether or not pin 2 is jumpered to pin 6 or 7.
11	EXT COMP SYNC	*External Composite Sync.* Provides a Composite Sync signal that contains both Horizontal and Vertical Sync pulses and Retrace pulses.
12		Spare
13	EXT RED VIDEO	*External Red Video.* Provides a red color-video signal for an external color monitor.
14	EXT GRN VIDEO	*External Green Video.* Provides a green color-video signal for an external color monitor.
15	EXT WHT VIDEO	*External White Video.* Provides a white signal for an external B/W monitor. Use with EXT HORIZ OUT, EXT VERT OUT, or EXT COMP SYNC, depending on external monitor requirements.

Figure 3-146. Pinout Diagram, EXT CRT Connector

3-10 MEASUREMENT CALIBRATION

3-10.1 Measurement Calibration—Discussion

Measurements always include a degree of uncertainty due to imperfections in the measurement system. The measured value is always a combination of the actual value plus the systematic measurement errors. Calibration, as it applies to network analysis, characterizes the systematic measurement errors and subtracts them from the measured value to obtain the actual value.

The calibration process requires that you establish the test ports, perform the calibration, and confirm its quality. Let us examine each of these steps.

a. ***Establishing the Test Ports***
The simplest approach is to use Port 1 as our test port, which is fine if it is the right connector type. We could also use Port 2 as the second port, unfortunately not many devices-under-test (DUT's) would mate. Therefore, for two port measurements we must have a cable. The end of this cable becomes Port 2 (Figure 3-147).

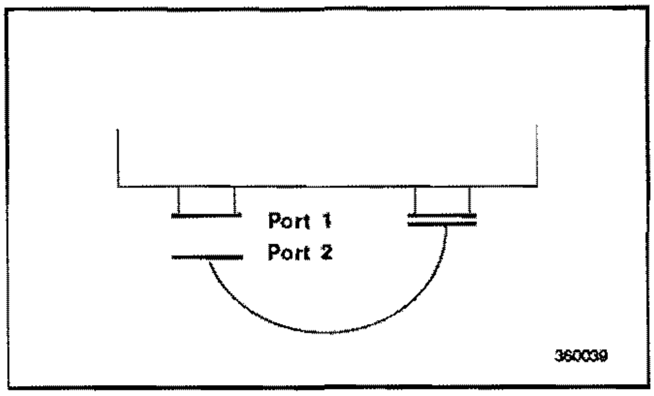


Figure 3-147. Establishing the Test Port

In many cases, you may need adapters to change between connector types (N, SMA, GPC-7, etc) or between genders (male [M] or female [F]). You may also need two cables (Figure 3-148).

In any case, you should include a phase-equal insertable (PEI) at both test ports. This insertable minimizes the cost of replacing worn or damaged cables and test port connectors. It also allows you to test non-insertable devices, if needed (Figure 3-149).

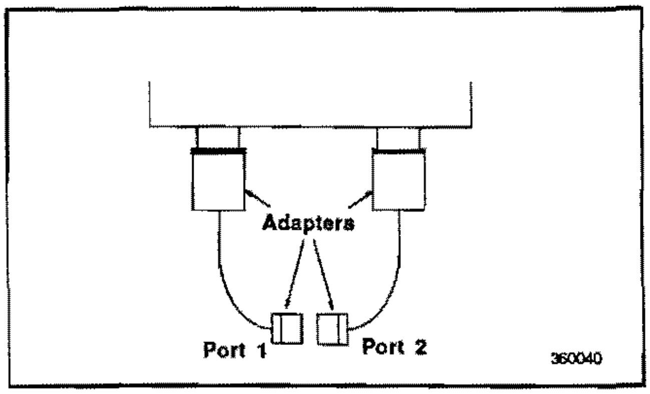


Figure 3-148. Using Adapters on the Test Port

NOTE

In this and other discussions, we will talk about "insertable" and "non-insertable" devices. Insertable devices (insertables) have precisely the same electrical length—that is, they are phase-equal. Insertables are typically used to change a connector's gender. A non-insertable device has the same gender as the device it needs to connect to. Therefore, "non-insertables" cannot be connected directly into the measurement path without an adapter.

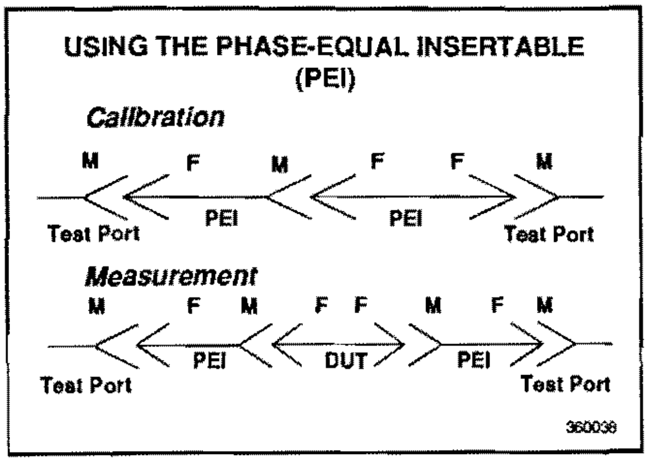


Figure 3-149. Using Phase-Equal Insertables

b. ***Understanding the Calibration System***
Measurement errors must be reduced by a process that uses calibration standards. The standards most commonly used are Opens, Shorts, and Zo (Characteristic Impedance) Loads. In conjunction with a through connection, these standards can correct for the major errors in a microwave test system. These errors are Direc-

tivity, Source Match, Load Match, and Frequency Tracking.

ERRORS REDUCED BY CALIBRATION
- Directivity
- Source Match
- Load Match
- Frequency Sensitivity (Tracking)
- Internal System Errors

Calibration also corrects for many internal system errors, such as RF leakage, IF leakage, and system component interaction.

INTERNAL SYSTEM ERRORS
- RF Leakage
- IF Leakage
- System Interaction

Random errors such as noise, temperature, connector repeatability, DUT sensitive leakages, frequency repeatability, and calibration variables are not completely correctable. However, some of them can be minimized by careful control. For instance: temperature effects can be reduced by room temperature control, calibration variables can be reduced through improved technique and training, and frequency errors can be virtually eliminated by source locking.

RANDOM ERRORS
- Frequency
- Repeatability
- Noise
- Connector Repeatability
- Temperature/Environmental Changes
- Calibration Variables

We know that adapters and cables degrade the basic directivity of the system, but these errors are compensated by vector error correction.

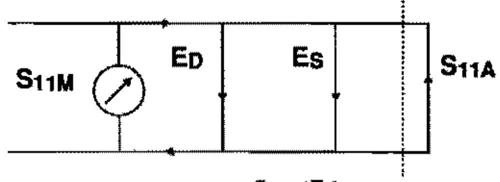
In general, transmission measurement errors are source match, load match, and tracking; while reflection measurement errors are source match, directivity, and tracking.

TRANSMISSION MEASUREMENT ERRORS
- Source Match
- Load Match
- Tracking

REFLECTION MEASUREMENT ERRORS
- Source Match
- Directivity
- Tracking

Error modeling and flowgraphs are techniques used to analyze the errors in a system. Error models describe the errors, while flowgraphs show how these errors influence the system. Error models (Figure 3-150) can become quite complex. While they provide help for the circuit designer, they are of little importance to the average user.

DIRECTIVITY, SOURCE MATCH, AND TRACKING ERRORS
DISTORTED MEASUREMENT



$$S_{11M} = E_D + \frac{S_{11A}(E_T)}{1-E_S(S_{11A})}$$

360042

Figure 3-150. Example of Error Modeling

The 360 offers a selection of calibration possibilities depending on the user's needs. These possibilities are Frequency Response; Reflection Only—1 Port; 1 Path, 2 Port; 12 Term—2 Port, Both Directions. These calibration types are described below.

CALIBRATION TYPES
- Frequency Response
- Reflection Only—1 Port
- 1 Path, 2 Port
- 12 Term—2 Port, Both Directions

Frequency Response: Corrects for one or both of the forward-direction-error terms associated with a measurement of S_{21}.

Reflection Only: Corrects for the three error terms associated with an S_{11} measurement (E_{DF}, E_{SF}, and E_{RF}).

1 Path, 2 Port: Corrects for the four forward-direction error terms (E_{DF}, E_{SF}, E_{RF}, and E_{TF}).

NOTE

For more information on error terms, refer to paragraph 3-3,"Introduction to Network Analyzers"; for information on flowcharts, refer to paragraph 3-6.1, "CALIBRATION Keys and Indicators."

Full 12 Term: Corrects for all twelve error terms associated with a two-port measurement.

Measurement calibration using the 360 is straight forward and menu directed. A short time spent in preparation and preplanning will make the process simple and routine. (Example: Adjusting the coaxial cables used in the measurement setup such that insertion of the DUT causes minimal flexing of these cables).

The screen prompts on the 360 guide you through the calibration process—a process that consists of connecting and disconnecting connectors and moving the slide on a sliding load (if one is used).

The most critical part of the calibration process is properly seating and torquing the connectors. Also, you will notice that the calibration takes longer when the ports are terminated with a load. This is intentional. It allows for more averaging during the isolation measurement.

c. ***Calibrating for a Measurement***

Let us assume that we want to correct for three errors in the reflection measurement: source match, directivity, and tracking. We accomplish this using three standards.

CALIBRATING FOR A REFLECTION MEASUREMENT USES THREE STANDARDS:

- Short
- Open
- Termination

Shorts are the easiest to visualize. They totally reflect all of the incident RF energy output at a precise phase. The terms zero-ohms impedance, voltage null, and 180° phase all define an RF Short.

Opens are similar to Shorts, but their response is more complex. The terms voltage maximum, infinite impedance, and 0° phase all define a perfect Open. A perfect Open, however, is only a concept. In reality Opens always have a small fringing capacitance.

To account for the fact that the Open will not predictably reflect impedance at an exact 0° phase reference, we alter its response using coefficients that accurately characterize the fringing capacitance. The coefficients are different for each coaxial line size, since each size has a different fringing capacitance.

As Opens and Shorts provide two references for a full reflection, Z_0 terminations provide a zero-reflection reference.

Ideal Z_0 terminations must consist of two parts, a perfect connector and an infinite-length perfect transmission line that absorbs all of the RF energy that enters it (no reflections).

IDEAL TERMINATIONS

- Reflectionless
- Perfect Connector
- Infinite-Length, Dimensionally Exact, Reflectionless Transmission Line

Infinite length transmission lines are unwieldy at best, so you must use less-than-ideal terminations. For calibration purposes there are two common types: broadband loads and sliding terminations.

PRACTICAL Z_0 TERMINATIONS

- Broadband Load
- Sliding Termination

Broadband loads are in wide usage. An example is the WILTRON 28 Series Termination. These terminations are easy to use as calibration tools, and are adequate for most applications.

BROADBAND LOAD
- Easy to Use
- Inexpensive
- Adequatea for Most Applications

Sliding Loads are the traditional vector network analyzer Z_0 calibration reference. They provide the best performance when the application requires high-precision return loss measurements. Sliding loads consist of a connector, a long section of precision transmission line, and a microwave load that is movable within the transmission line. One thing to remember with sliding loads is that they have a low-frequency limit and must be used with a fixed load below this cutoff frequency for full frequency coverage. WILTRON sliding loads cut off at 2 GHz.

SLIDING LOAD
- Connector
- Long Transmission Line
- Movable Microwave Load

Pin depth—the relationship between the interface positions of the outer and center conductors—is the most critical parameter under your control in a sliding load. An example of its criticality is that an incorrect pin depth of 0.001 inch can cause a reflection return loss of 44 dB. And, since we are trying to calibrate to accurately measure a 50 dB return loss, correct pin depth makes a *big difference!*

Cables in the measurement system are another cause for concern. The main criteria for a cable are stability and repeatability. WILTRON offers two types of cables that meet these criteria: semi-rigid and flexible. Our semi-rigid cables provide maximum stability with limited flexibility of movement. Our flexible cables allow more freedom of movement (along with its associated degradation of phase stability).

d. ***Evaluating the Calibration***

The 360 provides an accurate representation of complex data. However, it can only provide accuracy to the extent of the supplied calibration data. For this reason, it is necessary to periodically verify the calibration data and the 360 system performance.

Calibration verification reveals problems such as a poor contact with one of the calibration components, improper torquing, or a test port out of specification. Problems like these can easily occur during a calibration procedure. Anyone who has experienced one of these problems and stored bad data—after having performed a complete calibration procedure—knows the frustration it can cause. Additionally, it can be very costly to use incorrectly taken measurement data for design or quality assurance purposes.

The best way to confirm a calibration is to measure a precision, known-good device and confirm its specifications.

e. ***Verification Kits***

WILTRON has developed three precision-component kits: one for 3.5 mm connectors, another for GPC-7 connectors, and a third for our own K Connector™. These are, respectively, the Models 3666, 3667, and 3668 Accuracy Verification Kit.

Each of the kits contain 20 dB and 50 dB attenuators, a 10 cm air line beaded at one end, and a 10 cm Beatty Standard. A Beatty Standard is a two-port mismatch similar to a beadless airline. It consists of a center conductor with a discontinuity in the middle providing the mismatch (Figure 3-151).

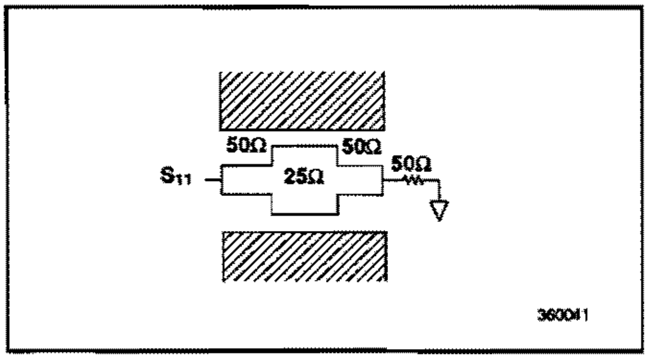


Figure 3-151. The Beatty Standard

Typically, these verification kits will be used by calibration or metrology labs. Each of the kits contain several precision components, all of which have been characterized at twenty specified frequencies. The data on these components is stored on a disk provided with the verification kit.

VERIFICATION KIT
- Used by Calibration and Metrology Labs
- Contains Components That Have Been Completely Characterized

The verification of the kit components is straight forward. The components are first measured with the 360, then compared with the data recorded on the disk. If the measured data compares favorably with the recorded data (taking tolerances into consideration), then the system is known to be operating properly and providing accurate data.

There is one caution that you need to observe when using these kits. Because the verification components have been characterized, you must handle them carefully so that you do not change their known characteristics. Consequently, you should not have them in daily use. Rather, you should use them for the accuracy verification checks taken every 6-to-12 months or at any other time the system's integrity is in doubt.

This completes the discussion on calibration. Turn to paragraph 3-10.2 for a hands-on tutorial and paragraph 3-10.3 for a procedure on calibrating the sliding load.

3-10.2 Measurement Calibration—Tutorial

This tutorial guides you through a typical calibration sequence. It is excerpted from paragraph 3-4,"Getting Started." If you have worked through the calibration portion of that tutorial, you are familiar with the 360 calibration process.

a. Equipment Required

360	Network Analyzer
3610	Test Set
360SS47	Source
365X	Cal Kit
3670A50-2	Through Cable

b. Initialize the System

Install the system disk and turn the power on. The 360 automatically performs a self test and comes on line with the same control panel settings as when exited last. Allow at least a 1 hour warm-up before making measurements.

c. Load Calibration Kit Data

1. Install the data diskette from the Model 3651, 3652, or 3653 Calibration Kit.
2. Press the UTILITY MENU key (Figure 152).

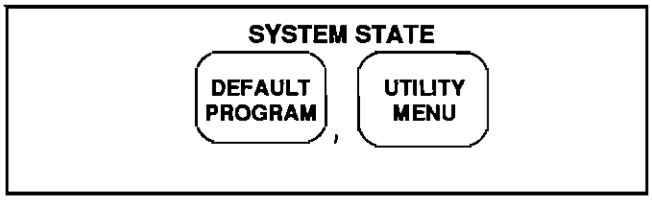


Figure 3-152. DEFAULT PROGRAM and UTILITY MENU Keys

3. Using the MENU up-arrow or down-arrow keys (Figure 3-153), select **CALIBRATION COMPONENT UTILITIES** when Menu U1, Utilities Menu appears.

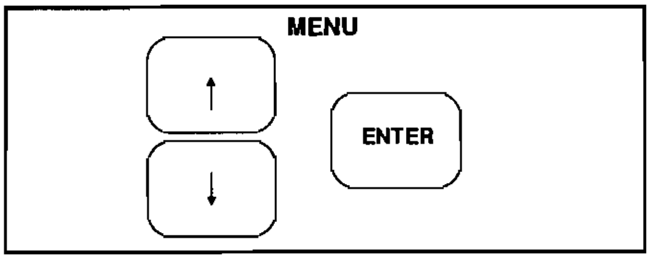


Figure 3-153. MENU Keys

4. Select **INSTALL CALIBRATION COMPONENT INFORMATION FROM DISK** when Menu U4, Calibration Component Utilities appears.
5. To ensure that correct calibration data has been loaded, select **DISPLAY INSTALLED CALIBRATION COMPONENT INFORMATION** on Menu U4.
6. Select the appropriate component type (SMA[M], SMA[F], K-CONN[M], etc.) when Menu U5, Display Installed Calibration Components Information appears.
7. When the Readout Text associated with Menu U5 appears in the display area of the CRT, check that the serial number of the Open or Short device matches the component in your kit.

d. Connect the Throughline

Install the throughline cable, PN 3670A50, to Port 2 on the Test Set. We will refer to the unterminated end of this cable as Port 2 for all calibration and measurement steps.

e. Begin the Calibration

1. Press the DEFAULT PROGRAM key twice (Figure 3-152).
2. Press the BEGIN CAL key (Figure 3-154).

NOTE

Selecting these menu options automatically calls the next menu in the listed sequence.

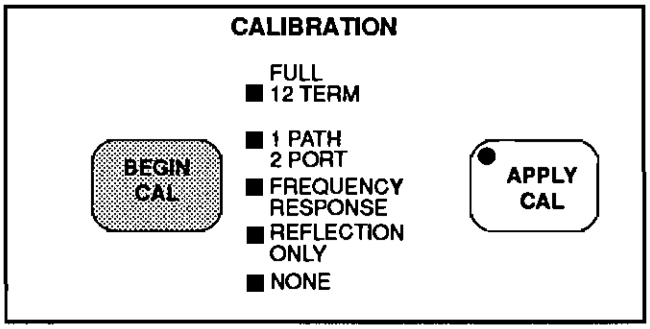


Figure 3-154. CALIBRATION Keys and Indicators

3. Select **FULL 12 TERM** when Menu C5, Select Calibration appears.
4. Select **NORMAL** when Menu C1, Select Calibration Data Points appears.

5. Set to **0.5-18 GHz** when Menu C2, Frequency Range of Calibration appears.
6. Select **CHANGE PORT 1 CONN** when Menu C3, Confirm Calibration Parameters appears.
7. Select **GPC-7** when menu C4, Select Connector Type appears.
8. Select **CHANGE PORT 2 CONN** when Menu C3 reappears.
9. Select **GPC-7** when menu C4 reappears.
10. Select **CHANGE LOAD TYPE** when Menu C3, reappears.
11. Select **BROADBAND LOAD** when Menu C6, Select Load Type appears.
12. Select **START CAL** when Menu C3 reappears.
13. Follow the instructions in each of the upcoming Calibration Sequence menus. Each step allows you to view the calibration data being taken and to retake the data if desired. This saves you from having to repeat the complete calibration because of an undetected error—*such as a poorly mated connection.*
14. When Menu C10, Calibration Sequence Completed appears, you can choose to store the calibration data on a disk. You should always choose to do this; steps 15 thru 19 show how.
15. Press the SAVE/RECALL MENU key (Figure 3-155).

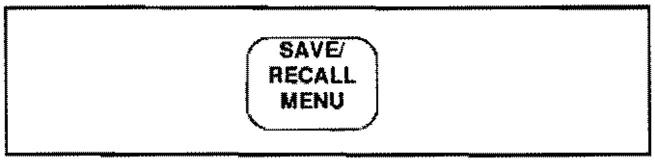


Figure 3-155. SAVE/RECALL MENU Key

16. Select **SAVE** when Menu SR1, Save/Recall Front Panel Information appears.
17. Select **SAVE CAL DATA AND FRONT PANEL SETUP ON DISK**, when Menu SR2, Recall or Save appears.
18. Select **CREATE NEW FILE,** when the GP1-3, Select File menu appears.
19. Enter CAL 1 and your initials using the knob, when the Menu GP5, Select Name appears. When finished, move to **DONE** and press the ENTER key. You can assign an 8 character file name and up to 15 additional spaces for other information.

f. ***Discussion:***

During calibration, the 360 automatically

1. Sets the number of points to maximum—501 points.
2. Sets averaging to 128 while the loads are being measured.
3. Sets the Video IF bandwidth to the REDUCED value (1 kHz).

A lower noise floor can be achieved by reducing the Video IF bandwidth and averaging several measurements. However, the default values have been found to be optimum for providing a compromise between a low noise floor and data-taking speed. Reducing the Video IF bandwidth lowers unwanted noise. Averaging removes random variations and effectively improves noise floor performance. However, reducing Video IF bandwidth and increasing the number of averages causes an increase in sweep time.

Smoothing is neither necessary nor desireable for calibration, since it does not affect the actual measurement data and will mask any rapid response variations displayed. This can lead to a sense of false confidence, both when performing the calibration and when monitoring the displayed calibration data for measurement errors.

3-10.3 Measurement Calibration—Sliding Termination

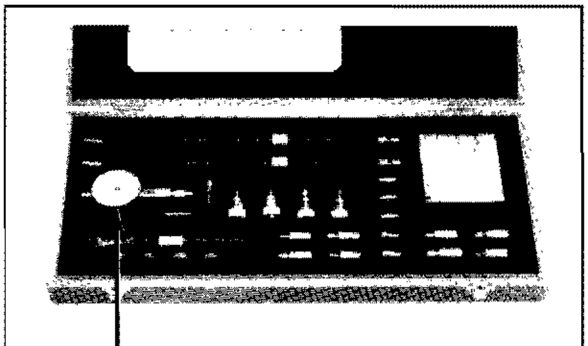
Sliding terminations (loads) are the traditional Z_0 calibration-reference devices for vector network analyzer calibration. When correctly used and perfectly aligned, they can be more accurate than precision fixed loads. However, sliding terminations have a 2 GHz low-frequency limit and must be used with a fixed load for full frequency-range coverage.

Sliding terminations consist of a connector, a long section of precision transmission line, and a microwave load that is movable within the transmission line. Pin depth—the relationship between the interface positions of the outer and center conductors—is the most critical parameter that you can control in a sliding termination. An example of its criticality is that an incorrect pin depth of 0.001 inch can cause a reflection return loss of 44 dB. And, since you are usually calibrating to accurately measure a greater than 40 dB return loss, correct pin depth is essential.

Since setting an accurate pin depth is so important, this discussion centers on describing how to set the pin depth for male and female sliding terminations (Table 3-8). Calibration with the sliding termination is essentially the same as described in paragraph 3-10.2 for the broadband load.

The procedure in Table 3-8 uses the Model 3652 Calibration Kit and its 17KF50 and 17K50 Sliding Terminations. The procedures are similar for the Model 3650 SMA/3.5mm and Model GPC-7 kits. For the 3651, the procedure is simpler: Because the GPC-7 connector is sexless, there is only one sliding termination.

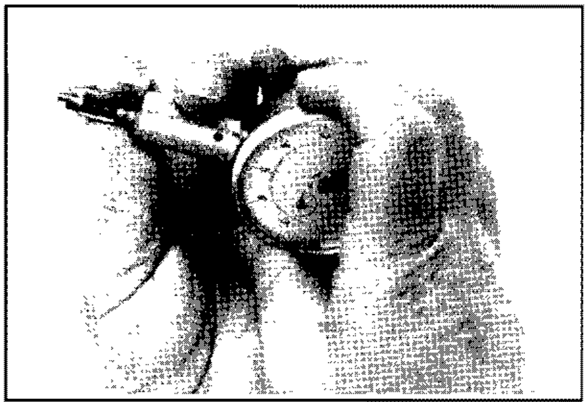
Table 3-8. Setting Center Conductor Pin Depth on a Sliding Termination (1 of 7)



1. Calibrate the Pin-Depth Gauge for Zero, as follows:

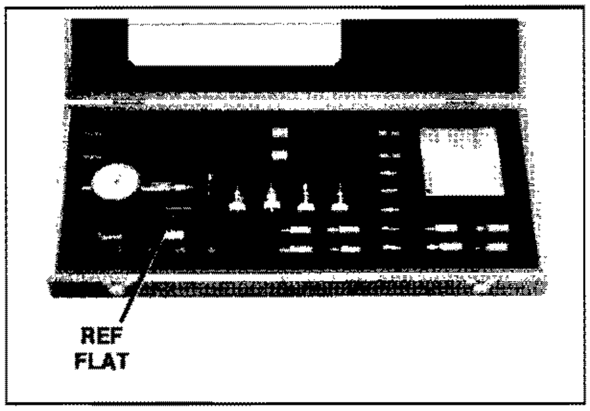
   a. Remove the Pin Depth Gauge from the kit, place it on the bench top.

   NOTE
   The meter is convertable between male and female. The following procedure describes the zeroing process for the female fitting. The procedure for the male fitting is given in step 4.

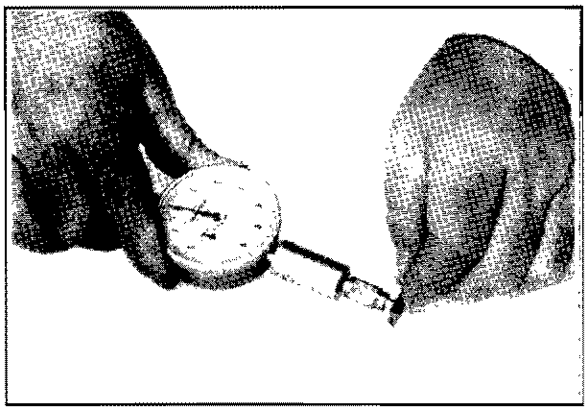


   b. Push the outer locking ring towards the gauge to expose the center pin.

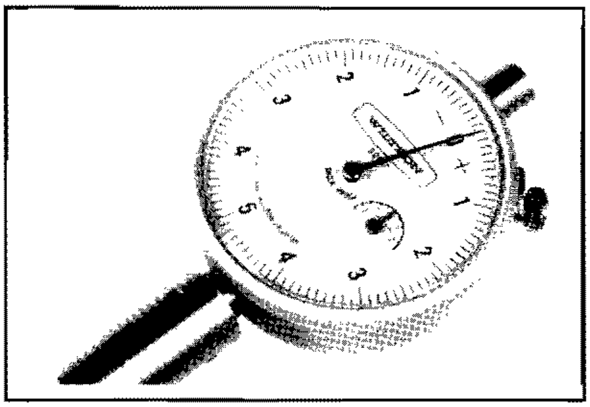
Table 3-8. Setting Center Conductor Pin Depth on a Sliding Termination (2 of 7)



c. Take the 01-210 Ref Flat from the kit.



d. While holding the gauge as shown, press the Ref Flat firmly against the end of the exposed center pin.

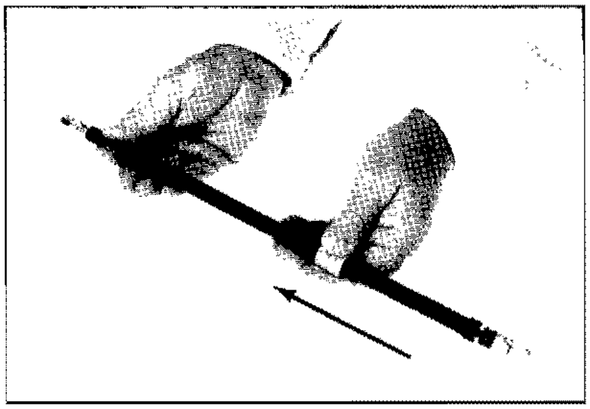


e. While pressing the Ref Flat against the center pin, check that the pointer aligns with the "0" mark. If it does not, loosen the bezel lockscrew and rotate the bezel to align the pointer with the "0" mark. Tighten the bezel lock screw.

NOTE

Gently rock the Ref Flat against the center pin to ensure that it is fully depressed and you have accurately set the gauge for zero.

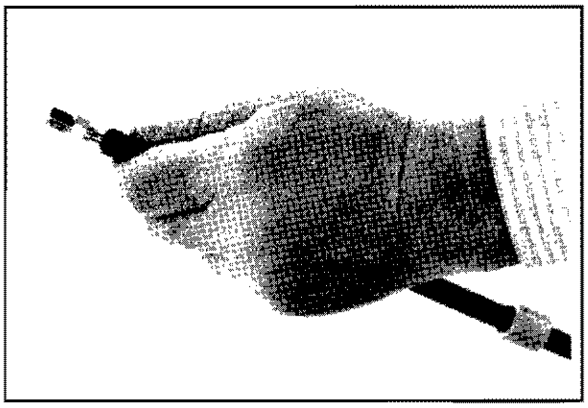
Table 3-8. Setting Center Conductor Pin Depth on a Sliding Termination (3 of 7)



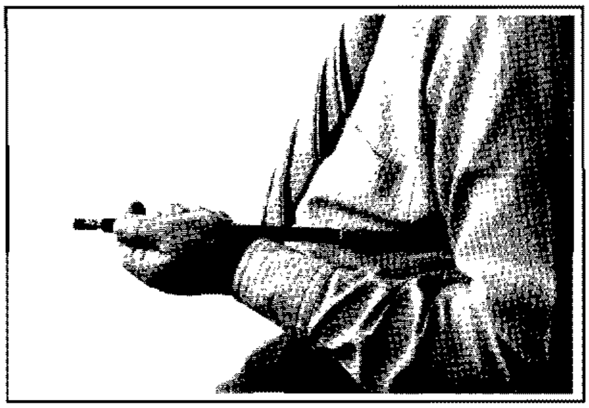
2. Fine adjust the Sliding Termination for Zero, as follows:

   a. Remove the sliding termination with the female-connector (17KF50, for this example) from the kit.

   b. Slide the load all the way toward the end closest to the connector.

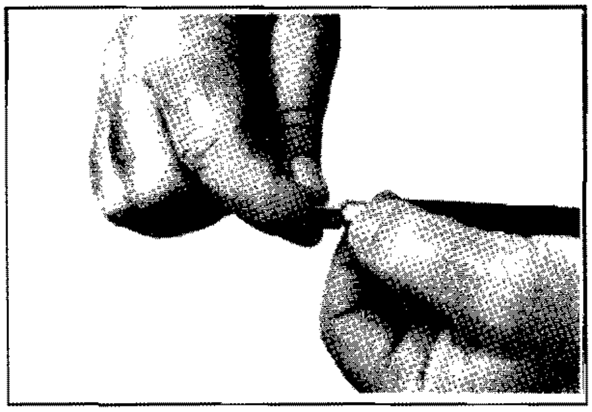


   c. With either hand, pick up the sliding termination near its connector end.

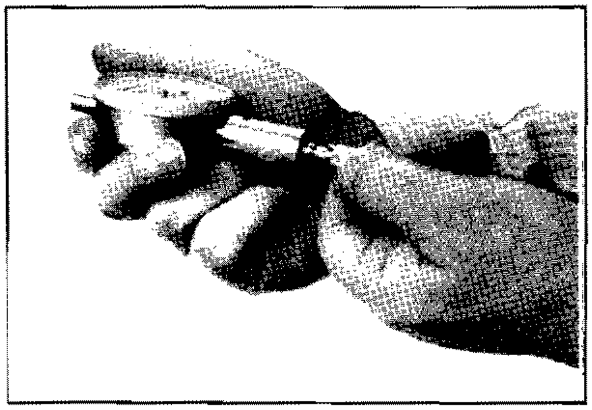


   d. Cup the sliding termination in your palm, and support the barrel between your body and crooked elbow.

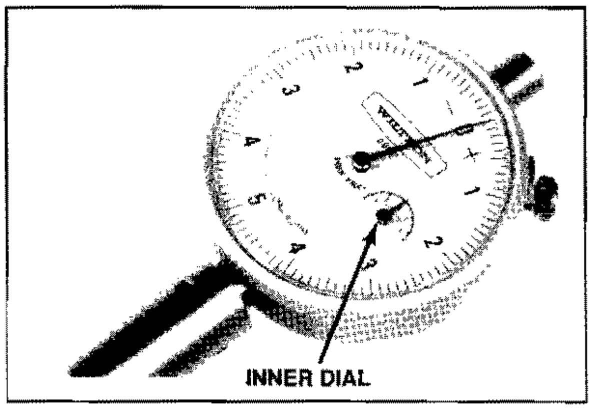
Table 3-8. Setting Center Conductor Pin Depth on a Sliding Termination (4 of 7)



e. Remove the flush short by holding its body and unscrewing its connector.

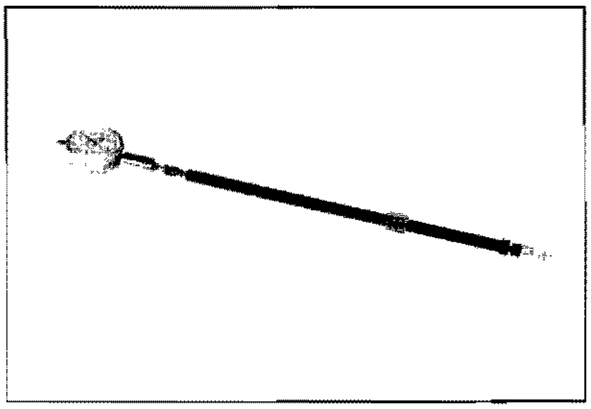


f. Install the gauge onto the end of the sliding termination.

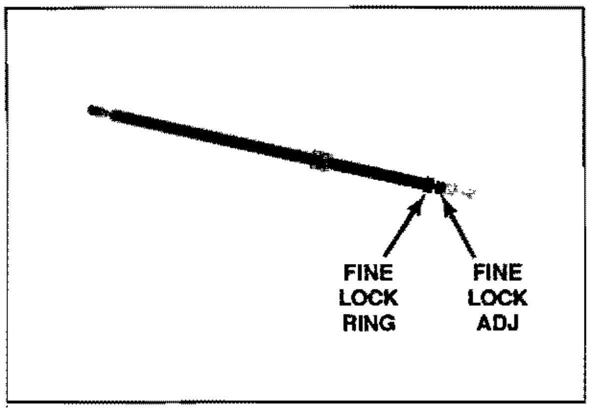


g. If the COARSE SET adjustment—which has been set at the factory—has not moved, the inner dial on the gauge will read "0." If it doesn't, perform the Coarse Set Adjustment in step 3.

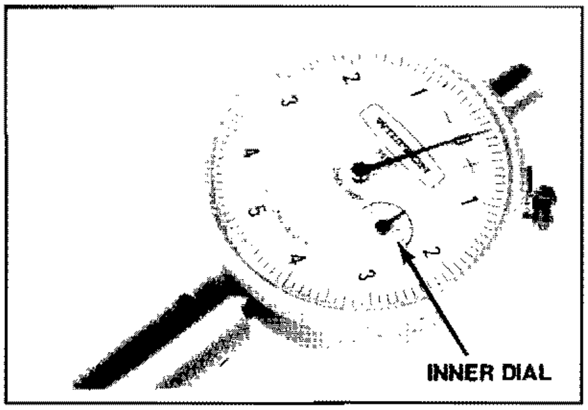
Table 3-8. Setting Center Conductor Pin Depth on a Sliding Termination (5 of 7)



h. Place the sliding termination, with the gauge attached, on the bench top.



i. Loosen the FINE LOCK ring and turn the FINE ADJ ring to position the gauge pointer 2-3 small divisions on the "–" side of zero.

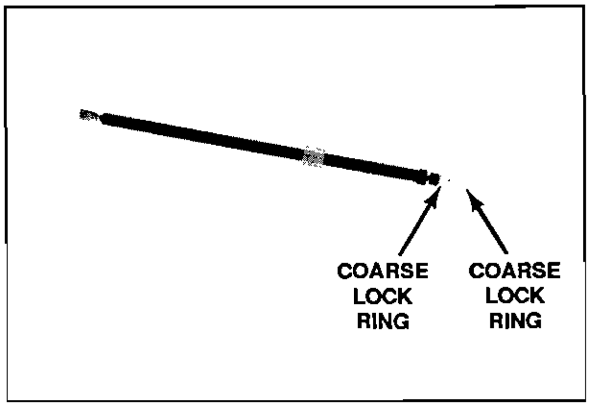


j. Turn the FINE LOCK ring clockwise to both tighten the adjustment and place the pointer exactly to "0." The Sliding Termination is now ready to use.

NOTE

Ensure that the inner dial read "0."

Table 3-8. Setting Center Conductor Pin Depth on a Sliding Termination (6 of 7)

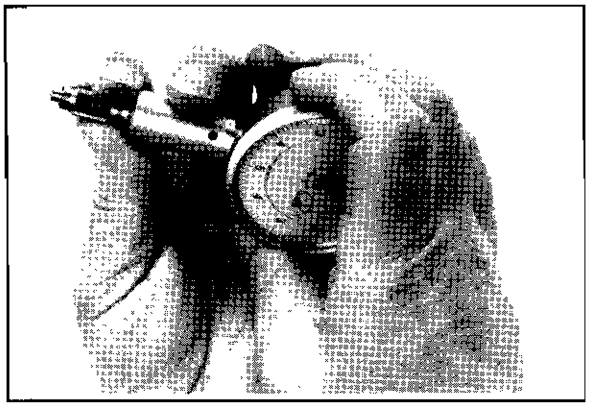


3. Coarse set the sliding termination for zero, as follows:

NOTE

This procedure is not normally necessary. It needs to be done only if the adjustment has changed since it was set at the factory.

With the 01-211 Flush Short installed, loosen the COARSE LOCK and gently push the COARSE SET adjustment rod in as far as it will go. This coarsely sets the center conductor to be flush against the attached short. Return to step 2.

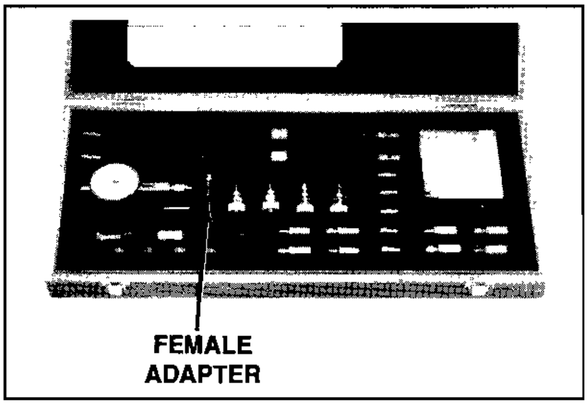


4. The procedure for adjusting the male-connector sliding termination is essentially the same as that described above. The only difference is that you must install the female adapter on the end of the gauge shaft, over the center conductor. To install this adapter, proceed as follows:

   a. Zero-set the gauge as described in step 2 above.

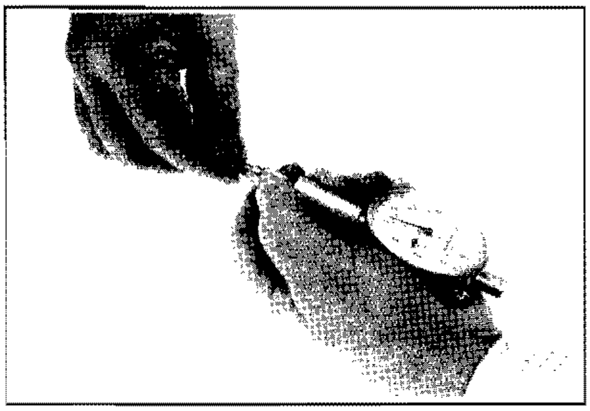
   b. Push the outer locking ring back toward the gauge and turn it clockwise onto the exposed threads.

   c. Loosen the lock ring one turn in a counterclockwise direction.



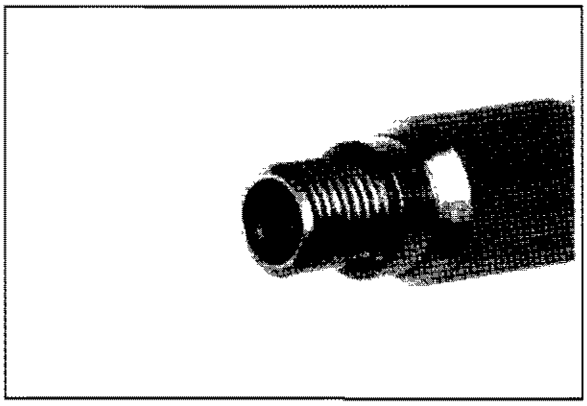
   d. Remove the 01-223 Female Adapter ("F ADAPTER FOR PIN GAUGE") from the kit.

Table 3-8. Setting Center Conductor Pin Depth on a Sliding Termination (7 of 7)



e. Install the female adapter over the center pin and screw it into the locking ring.

f. Tighten the outer ring until it is snug against the housing.



g. Inspect the end of the adapter, you should see no more than two exposed threads. If so, repeat steps c, d, e and f. above.

5. Connect the gauge to the sliding termination and zero set the center pin using the FINE ADJ as previously described in step 2 above.

3-11 TRANSMISSION AND REFLECTION MEASUREMENTS

This discussion provides information on general measurement considerations and transmission and reflection measurements using the 360.

3-11.1 Setup and Calibration Procedures and Measurement Options

To get started, apply power to the system. Do this by first turning on the 360SS45 or 69 source power switch then the analyzer power—the order is important. If the analyzer is powered-up before the source, it will not be able to find the source and will probably fail the self test.

APPLY POWER TO THE SYSTEM

- First, Turn On the Source
- Then, Turn On the Analyzer

After turning on the power, allow the system to warm up for at least 30 minutes before operation.

SETUP

- System Should Be Warmed Up for At Least 30 Minutes

In normal operation, the system comes on line in the state that it was in when last turned off. If you want to return the system to its default state, you can do so by pressing the DEFAULT PROGRAM key twice.

The default parameters provide a known starting point. For example, they reset the start and stop frequencies to their maximum values, the source power to 0 dBm, and the display resolution to 501 data points.

DEFAULT PARAMETERS

- Known-Good Starting Point
- Selected With the DEFAULT PROGRAM Key

The Sweep Setup menu should now appear on the display (it also can be displayed using the SETUP MENU key). If you like, you can select a new start frequency, stop frequency, or source power.

The actual power level at Port 1 is about 10 dB less than the source power level due to internal losses in the test set.

SWEEP TEST MENU

- Start and Stop Frequencies
- Source Power Level

NOTE:
The Port 1 power level is about 10 dB less than the source power level.

If the 360 system has an Active Device Test Set, you can further reduce the power level at Ports 1 and 2 with the built-in attenuators. Using the Reduced Test Signals option in the Sweep Setup menu, you can change the settings of the Ports 1 and 2 source attenuators over a range of from 0 to 70 dB. The Port 2 test attenuator has a range of from 0 to 40 dB (in 10 dB steps).

SWEEP SETUP MENU

- Use the "Reduced Test Signals" Option to Add Attenuation With the 3620 or 3621 Active Device Test Sets

Selecting the BEGIN CAL key starts the calibration process. The Calibration menus step you through the calibration process, as follows:

1. Select the type of calibration desired.
2. Select the frequency range of calibration. You can choose the normal 501 points, CW (one point), or N-discrete frequencies (from 2 to 501 points).
3. Install the calibration kit devices to the test ports as instructed by the menu. Both the capacitance coefficients for the Open and the offset lengths for the Open and Short can be modified or defined.

CALIBRATION

- Select BEGIN CAL Key
- Select Type of Calibration
- Select Frequency Range of Calibration
- Install Calibration Kit Devices As Instructed by the Menu
- Modify the Capacitance Coefficients and the Offset Lengths, If Required
- Store the Calibration Data Internally or to Disk

When the calibration is completed, you can store the calibration data in the internal memory or on a disk. You are now ready to install the test device and proceed with the measurement. At this point you have a number of measurement options to consider such as displays, markers, limits, outputs, sweeps, and enhancements.

MEASUREMENT OPTIONS

- Displays
- Markers
- Limits
- Outputs
- Sweeps
- Enhancements

You can select any of the available graph types and display them for any calibrated parameter on any of the four channels.

DISPLAYS

- Four Channels
- Each Channel Can Display Up to Two Graph Types
- Calibration Parameters Can Be Selected By Any Channel

Up to six markers are available. Using the Marker Menu, you can set the frequency of each one, you can set each one in the delta marker mode, and you can set each marker's level to maximum or minimum.

MARKERS

- Selectable User Marker Menu
- 6 Markers Available
- Delta And Max/Min Modes

In some cases—such as in a production environment—limit lines are desireable. Options within the menu called up using the LIMITS key, provide two limit lines for each channel. These limit lines function with all of the graph types, including Smith and admittance. The color of of the limit lines differs from that of the measurement trace. This allows for easy analysis of results.

LIMITS

- Selectable Using LIMITS Key
- Two Limit Lines Available for Each Channel
- Functions With All Graph Types

The Output Menu (Figure 3-156) gives you a choice between a printer and a colored-pen plotter. It also lets you choose the data-output type, output head, and disk output functions.

SELECT OUTPUT DEVICE
PRINTER
PLOTTER
SELECT PRINTER OUTPUT TYPE
FULL SCREEN
GRAPH ONLY
TABULAR DATA
OUTPUT OPTIONS
▸ SETUP OUTPUT HEADERS
DISK OUTPUT OPERATIONS
PLOT OPTIONS
PRESS <ENTER> TO SELECT

Figure 3-156. Output Menu

To output the display, press the START PRINT key. The default setting provides for a full display printout from the associated printer.

OUTPUT

- Select START PRINT Key to Output Display
- Use the Output Menu to Choose Output Type and Output Device

To label the output, select Setup Output Headers in the Output Menu or press the DEVICE ID key.

OUTPUT HEADERS

- Selected With DEVICE ID Key or From the Output Menu Under the Setup Output Headers Option
- Labels Output With Device/Serial Number, Date, And Operator's Name

On the output to the printer, plotter, or disk. a menu then appears that lets you specify the device name/serial number, the date, and the operator's name (Figure 3-157).

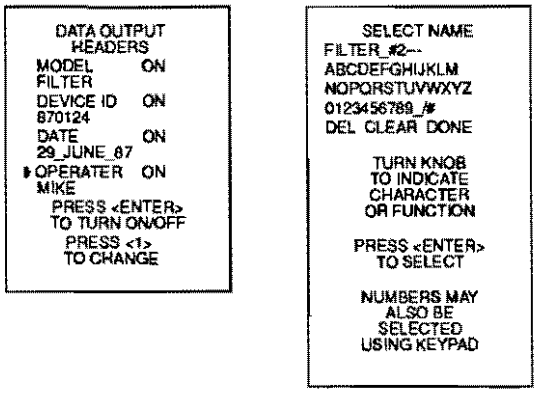


Figure 3-157. Label Menus

Sweep frequencies can be changed with the calibration applied as long as the frequencies are between the calibration start and stop frequencies.

Additionally, a marker sweep can be selected from the Setup Menu. This allows you to sweep between any two active markers as long as the frequency of each falls between the calibrated start and stop frequencies.

Using the DATA POINTS key, you can select the number of data points for optimal resolution-vs-speed.

SWEEPS

- Start/Stop Frequencies Can Be Changed With Calibration Applied
- Marker Sweep Available From the Setup Menu
- Data Points Selectable Using the DATA POINTS Key

Finally, you can enhance the measurement data by reducing the IF bandwidth and using averaging and/or smoothing (see below).

- Change the IF bandwidth by selecting the IF BW key.
- Set the averaging and smoothing values by selecting the AVG/SMOOTH MENU key.
- Turn on the averaging and smoothing using the TRACE SMOOTH and AVERAGE keys, which have LED's to let you know that the enhancement is being applied.

ENHANCEMENTS

- Intermediate Frequency Bandwidth Changed Using the IF BW Key
- Averaging and Smoothing Values Set Using AVE/SMOOTH MENU Key
- Averaging and Smoothing Turned On or Off Using TRACE SMOOTH and AVERAGE Keys

3-11.2 Transmission and Reflection Measurement s

Before going any further, let us take a few moments to review some basic principles of network measurements. First, we apply incident energy to the input of a test device. If the device's input impedance differs from the measurement system's impedance, some of that energy is reflected. The remainder is transmitted through the device. We call the ratio of reflected-to-incident energy the reflection coefficient. The ratio of transmitted-to-incident energy we call the transmission coefficient (Figure 3-158).

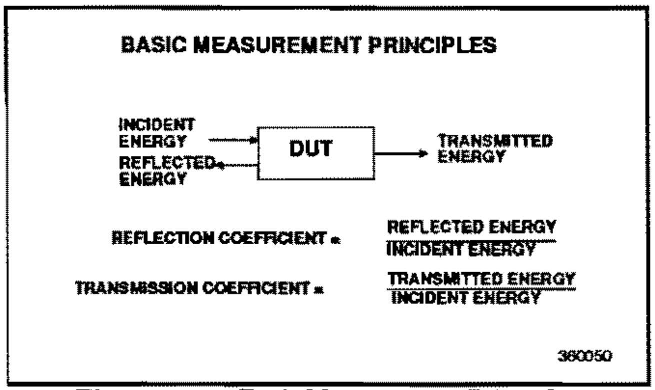


Figure 3-158. Basic Measurement Principles

These ratios are complex quantities that have magnitude and phase components. Using vector representation, the vector magnitude is the ratio of reflected-to-incident magnitude (or transmitted-to-incident magnitude), while the vector phase is the difference in phase between the incident energy and the reflected/transmitted energy (Figure 3-159).

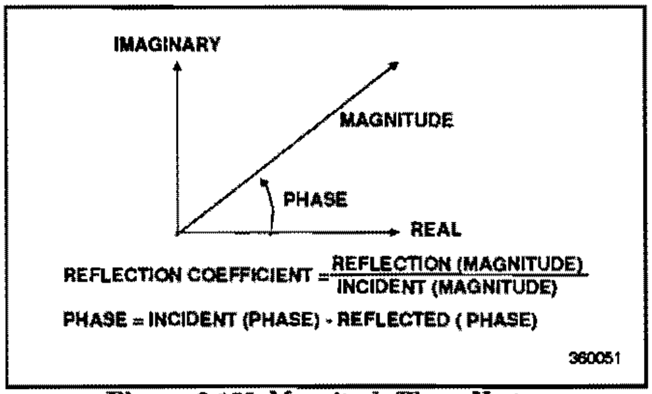


Figure 3-159. Magnitude/Phase Vector

The measurement reference for the incident energy is the point at which the device connects to the measurement system. We call this point the reference plane. The incident energy at the reference plane is defined as having a magnitude of 1 and a phase of 0 degrees. We establish this during the calibration.

REFERENCE PLANE

- Defined At the Test Port Measurement Plane As

  Magnitude = 1
  Phase = 0 Degrees

- Established During Calibration

The ratio of reflected and transmitted energy to the incident energy can be represented by a number of different measurements and units, as shown below.

MEASUREMENTS

- Log Magnitude
- Phase
- Smith Chart (Impedance)
- Group Delay (See paragraph 3-13)
- Admittance Smith Chart
- Linear Polar
- Log Polar
- Linear Magnitude
- Real and Imaginary

The default display for reflection measurements is the Smith chart. The default display for transmission measurements is the Log Magnitude and Phase graph.

DEFAULT DISPLAYS

Reflection

- Smith Chart

Transmission

- Log Magnitude and Phase Graph

The Smith chart is a convenient way to display device impedance and is a useful aid for the graphical design and analysis of microwave circuits (Figure 3-160).

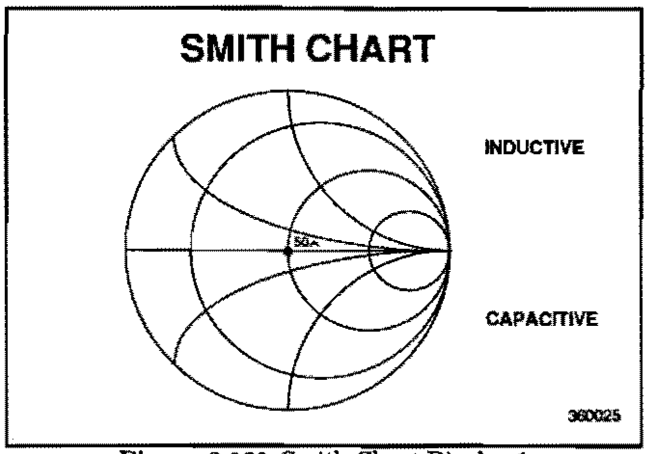


Figure 3-160. Smith Chart Display 1

Let us assume both that our system is already calibrated and that we have equalized the system for the test port in use. We would then

1. *Connect the Short.* A Short always appears as a dot at the left-most edge of the Smith chart's horizontal axis.
2. *Connect a Termination.* Now you will see another dot located at the center (1+j0) of the chart (this assumes a 50-ohm load).
3. *Connect the Open.* An Open appears as an arc on the chart's right edge. This is due to the fringing capacitance of the Open standard (Figure 3-161).

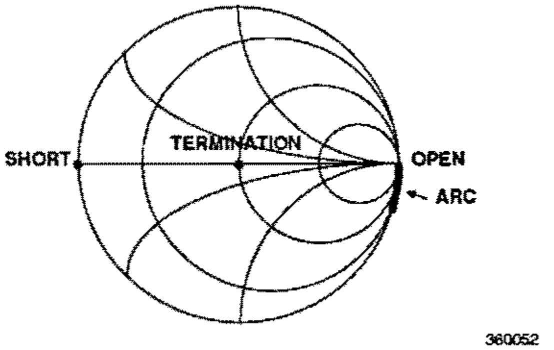


Figure 3-161. Smith Chart Display 2

Now let us perform a reflection measurement on a 20 dB attenuator over the 1-to-18 GHz range.

We need to determine the setup, calibration, and measurement requirements.

REFLECTION MEASUREMENT

Example: 20 dB Attenuator
- Setup
- Calibration
- Measurement

A known good starting point is to reset with DEFAULT PARAMETERS. Since our measurement lies between 1 and 18 GHz, set the Start and Stop frequencies using the Sweep Setup menu that appears on the display following system reset.

SETUP

- Reset With the DEFAULT PARAMETERS Key
- Set the Start Frequency to 1 GHz
- Set the Stop Frequency to 18 GHz

Let us perform a simple calibration, REFLECTION ONLY, which uses an open, a short, and a broadband load. To do this, press the BEGIN CAL key and follow the directions in the menu area.

CALIBRATION

- BEGIN CAL Key
- REFLECTION ONLY

When you complete the calibration, the "CHANNEL 1 WITH S11" Smith chart appears on the display. Now

1. Select the Log Magnitude display and install the attenuator.
2. Select AUTOSCALE to optimize the display data.
3. Use Markers 1 and 2 to find the maximum and minimum impedance.

MEASUREMENT

- Select Log Magnitude Display
- Install DUT
- Autoscale
- Set Marker 1 to Max, Marker 2 to Min

Now let us perform a transmission measurement on the same 20 dB attenuator over the same frequency range. We will follow the same steps as before, but this time we will use additional features.

TRANSMISSION MEASUREMENT

Example: 20 dB Attenuator
- Setup
- Calibration
- Measurement

Once again, reset the system using the DEFAULT PARAMETERS key.

SETUP

- Use Default Parameter Settings

In this calibration we will select the N-Discrete Frequencies menu option and step all frequencies in increments of 50 MHz.

CALIBRATION

- BEGIN CAL Key
- Frequency Response (Transmission Response Only)

When the calibration is complete, Channel 1 will display "S12 FORWARD TRANSMISSION WITH LOG MAGNITUDE AND PHASE." You can use Markers 1 and 2 to find the maximum and minimum values of the attenuators insertion loss.

3-12 LOW LEVEL AND GAIN MEASUREMENTS

This discussion provides methods and techniques for making gain and low-signal-level measurements. It is divided into 360 system considerations and test device considerations.

3-12.1 360 System Considerations

The 360 system is limited in its ability to test low-signal levels by its dynamic range and low signal-to-noise-power ratio. First we will discuss dynamic range, which is the difference between the maximum and minimum acceptable signal levels (Dynamic Range = $P_{max} - P_{min}$).

a. Dynamic Range

The dynamic range of the 360 is limited by the 0.1 dB compression level of the samplers at high signal levels. It is further limited at low signal levels by leakage signals and noise.

DYNAMIC RANGE LIMITS

- High Level Accuracy Limited by the Compression of the Receiver
- Low Level Accuracy Limited by Noise and Leakage Signals

Figure 3-162 shows the detected output signal as a function of the power level at the sampler. The 0.1 dB compression level is on the order of –10 dBm. The 360 is designed such that all other conversions compress at a much greater level, which leaves the samplers as the main source of non-linearity.

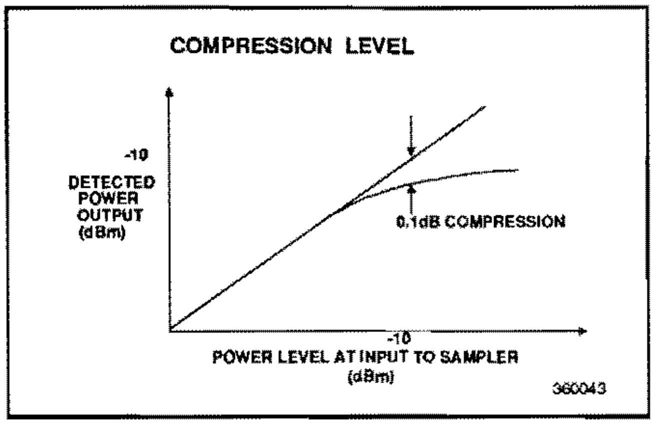


Figure 3-162. Compression at 0.1 dB

The small signal response is limited by errors due to noise and leakage signals. The leakage signals are both from within the 360 and at the device-under-test (DUT) connectors.

The detected signal is the vector sum of the desired signals, the noise signals, and the leakage signals. These signals introduce an error or uncertainty (Figure 3-163).

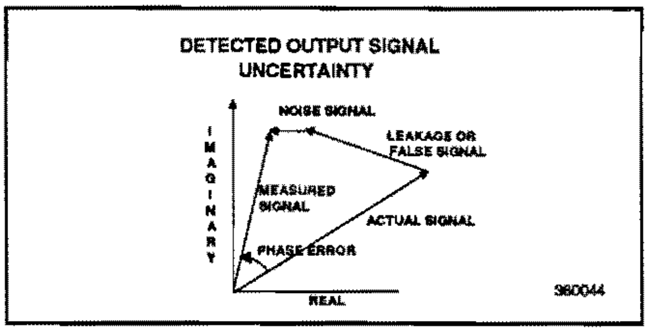


Figure 3-163. Amplitude and Phase Uncertainty

Some of the possible leakage paths for the 360 are the transfer switch, the frequency conversion module, and leakage from the DUT. The system limits these leakages to greater than 100 dB. The 12-term error correction can reduce this leakage to better than 110 dB at 18 GHz and 90 dB at 40 GHz.

LEAKAGE PATHS

- Transfer Switch (120 db)
- Frequency Conversion Module
- DUT Leakage

The DUT connectors should have internally captivated center pins. Those connectors which use external pins to captivate the center conductor should have silver loaded epoxy on the pins to reduce radiation to better than 90 dB.

DUT LEAKAGE

- Should Be Greater Than 90 dB to Assure Accurate Measurements

b. *Signal-to-Noise-Power Ratio*

The signal-to-noise-power ratio for each of the test or reference channels is given by the formula

S/N Ratio = Signal Power/Noise Power

Where "signal power" is the power level of the 83.33 kHz IF signal at the internal synchronous detectors, and "noise power" is total power contained within the bandwidth of the bandpass filter at 83.33 kHz.

The uncertainty, or error, in a measurement is a function of the amplitude of leakage signals and of the noise level. The uncertainty in the measurement of magnitude and phase of the s-parameters are calculable and shown below in Figures 3-164 and 3-165.

Signal To Noise

S/N Ratio For Test or Reference Channel

$$S/N = \frac{\text{Signal Power (dBm)}}{\text{Noise Power (dBm)}}$$

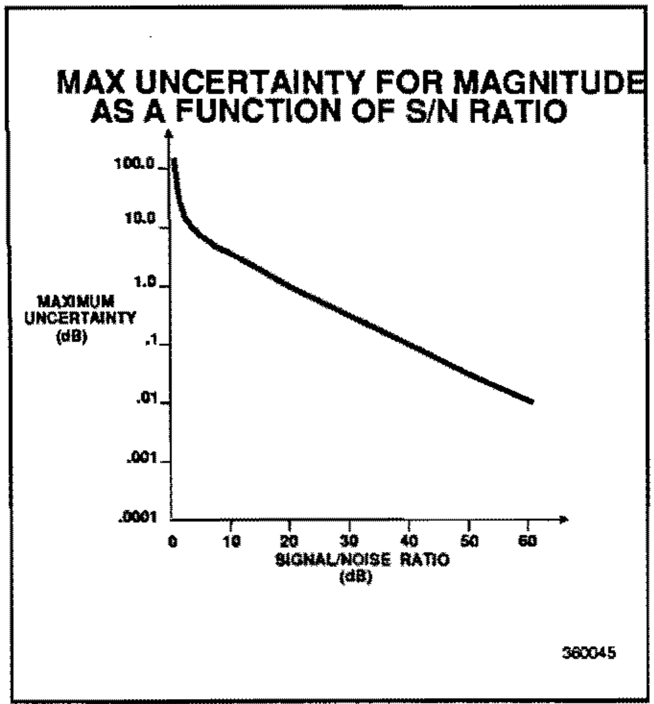


Figure 3-164. The Effect of S/N Ratio On Magnitude Measurements (Noise Only)

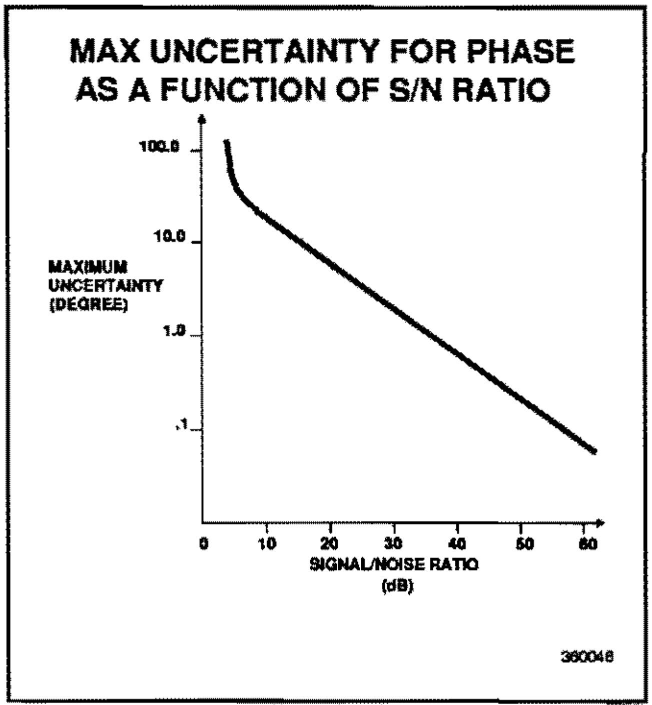


Figure 3-165. The Effect of S/N Ratio On Phase Measurements (Noise Only)

The most difficult types of measurements are those that exercise the full dynamic range of the 360, such as filters (Figure 3-166). Filter measurements are examples of where one must observe both low-insertion loss (in the passband) and high attenuation (in the stop band).

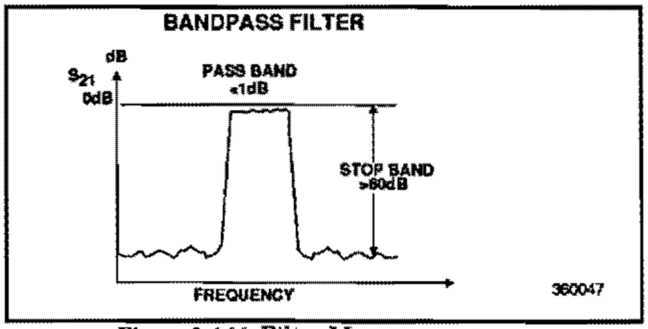


Figure 3-166. Filter Measurements

There are two techniques that you can use to optimize the signal-to-noise ratio. They are (1) maximizing the RF signal level and (2) using signal enhancement.

TECHNIQUES TO MAXIMIZE THE S/N RATIO

- Maximize RF Signal Level
- Signal Enhancement

To maximize the RF signal level, use the default settings of the signal source. The 360SS45 or 69 defaults to 0 dBm—a power level that both maximizes dynamic range and optimizes linearity.

MAXIMIZE RF SIGNAL LEVEL
• Maximum Dynamic Range • Optimum Linearity

The 360 provides two enhancements for improving the signal-to-noise ratio: IF bandwidth reduction and averaging.

ENHANCEMENTS
• IF Bandwidth Reduction • Averaging

Reducing the IF bandwidth is a primary method for enhancing accuracy. The 360 has a choice of three bandwidths available from the front panel: Normal (10 kHz), Reduced (1 kHz), and Minimum (100 Hz). The noise level should decrease by a factor equal to the square root of the IF bandwidth. Using IF Bandwidth reduction makes for faster measurements than with the use of an equivalent amount of averaging.

IF BANDWIDTH REDUCTION
• Three Bandwidths Available • Noise is Decreased • Faster Than Averaging

Averaging is another way to improve accuracy. The improvement is proportional to the square root of the number of averages. The improvement from averaging, however, comes at the expense of increased sweep time.

AVERAGING
• Up to 4095 Averages • Reduces Noise • Increases Sweep Time

Figure 3-167 shows the measured reduction in noise due to bandwidth and averaging.

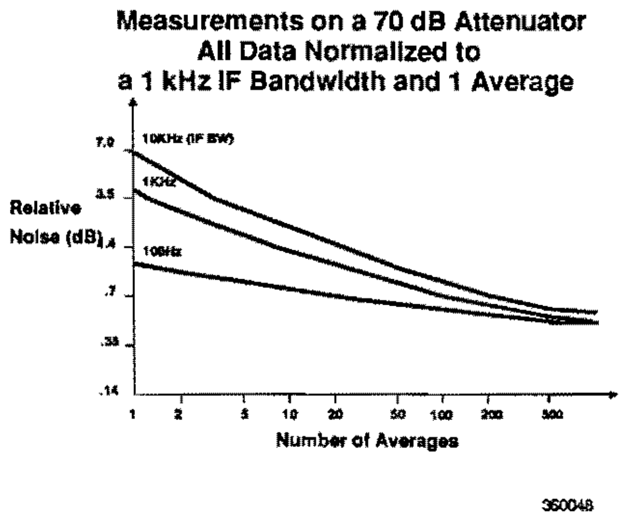


Figure 3-167. Reduction in Noise Using Averaging

For a given bandwidth and number of averages, Table 3-9 states the signal-to-noise ratio improvement and relative-time factor required for the measurement. *Example:* Using 1 kHz BW reduction and 10 averages, you would increase the signal-to-noise ratio by 7.6 dB but would lengthen the time required for the measurement by a factor of 4.3. This example assumes a constant signal power.

Table 3-9. Comparisons of Signal-to-Noise Enhancement Options—1 Channel, 187 Points

IF BW Reduction	Number Of Averages	* S/N Ratio Improvement (dB)	Relative Time Factor
10 kHz	1	0	1
	10	5.3	2.8
	100	9.0	12.5
	500	11.0	59.5
1 kHz	1	2.4	1.6
	10	7.6	4.3
	100	10.1	12.6
	500	11.6	61.0
0.1 kHz	1	7.8	6.2
	10	9.4	8.0
	100	10.5	13.0
	500	11.6	62.2

* Assumes a constant signal power.

3-12.2 Test Device (DUT) Considerations

In order to test a device, the required input RF level and the expected device output RF level must be determined.

The RF level at Port 1 must be set for the device input RF power level required. The power level at Port 1 is about 10 dB less than the RF source power level, or about –10 dBm. Attenuation can be added in steps of 10 dB up to 70 dB using the built-in source attenuator in the Models 3620 and 3621 Active Device Test Sets.

> **PORT 1 RF OUTPUT LEVEL**
>
> - –10 dBm
> - Can Add Up to 70db Attenuation in 10 dB Steps

The RF level into Port 2 should be kept to –10 dBm or less to ensure optimum linearity and to protect internal components from damage. The never-to- exceed RF level into either Port 1 or Port 2 is +20 dBm. You can add up to 40 dB of attenuation (in 10 dB steps) into Port 2 using the built-in test attenuator in the active device test sets.

> **PORT 2 RF INPUT LEVEL**
>
> - –10 dBm Maximum
> - Can Add Up to 40 dB Attenuation in 10 dB Steps

If you are using a test set that does not have built-in attenuators, you should use external attenuators on Port 1 and Port 2 as needed. However, the use of external attenuators invalidates input and output match measurements; whereas, the built-in attenuators are compensated by the calibration and do not affect reflection measurements.

> **EXTERNAL ATTENUATORS**
>
> - Use Only if Internal Attenuator Is Not Available—They Invalidate DUT Match Data

Before calibration, ensure that the test setup is correct by setting the power level and adding attenuation as needed.

> **CALIBRATION**
>
> - Set Desired RF Signal Level
> - Include Attenuation As Needed

The 360 uses enhancements in the calibration to ensure a wide dynamic range. It automatically selects the REDUCED IF bandwidth front panel setting and varies the number of averages with the calibration device. Terminations require the most averages.

> **CALIBRATION**
>
> - IF Bandwidth REDUCED Setting
> - Number of Averages Varies With Calibration Device Measured

If desired, the IF bandwidth and number of averages can be specified for the calibration measurements. Using 100 averages (AVG = 100) appears to be sufficient for most measurements.

> **CALIBRATION**
>
> - Can Select the Desired IF Bandwidth and Averaging

To obtain the maximum performance from the 360 for measurements of attenuation, you can use the capability of the N discrete frequency calibration to spot check measurements in the frequency band of interest.

> **TO MEASURE HIGH ATTENUATION**
>
> - 10 dBm Source Power
> - 100 Averages in Calibration
> - 100 Averages in Measurement

The measurement procedure is straight forward, as shown below.

MEASUREMENT PROCEDURE

- Determine Dut I/O RF Levels
- Set Source RF Level
- Set Port 1 Source Attenuator and Port 2 Test Attenuator

Wide Dynamic Range Device - Filter

Since you do both low-insertion-loss and high-attenuation measurements simultaneously, use the maximum RF signal level and no attenuation. Selecting the REDUCED IF BW setting and 100 averages will likely suffice for this kind of measurement.

EXAMPLE - FILTER

- No Attenuator Needed
- IF Bandwidth "REDUCED" and 100 Averages

High Gain Device - FET

This device has a typical 15 dB gain and requires an input level of about –30 dBm. Set the Port 1 Source Attenuator to 20 dB. Since the device RF output level is –15 dBm (–30 dBm + 15 dB[gain] = –15 dBm) no attenuation is needed at Port 2.

EXAMPLE - FET

- Set Port 1 Source Attenuator to 20 dB
- No Port 2 Attenuator Is Needed
- Calibrate
- Use IF Bandwidth and Averaging As Desired

Medium Power Device - Amplifier

Measure the small signal parameters of a 10 dB gain device that requires an input power level of –10 dBm. Here, Port 1 will have no attenuation. The device RF output level is –10 dBm. This level equals 0 dBm (–10 dBm + 10 dB[gain] = 0 dBm) into Port 2 and will cause compression in the measurement. At least 10 dB of test attenuation will be needed at Port 2, which will reduce the Port 2 RF level to –10 dB.

EXAMPLE - AMPLIFIER

- No Port 1 Attenuator
- Port 2 Test Attenuator to 10dB
- Calibrate
- Use IF Bandwidth and Averaging As Desired

3-13 GROUP DELAY MEASUREMENTS

Group delay is the measure of transit time through a device at a particular frequency. Ideally, we want to measure a constant—or relatively constant—transit time over frequency. The top waveform shown in Figure 3-168 is measured at one frequency. The bottom waveform is identical to the first, simply delayed in time.

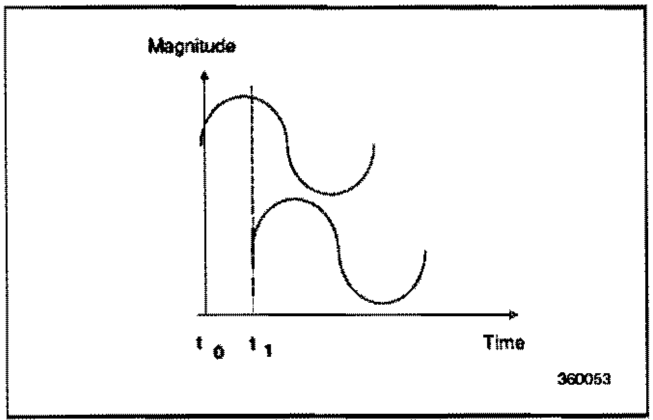


Figure 3-168. Two Waveforms Delayed in Time

Referring to Figure 3-169, the first waveform shown is the original waveform. It is made up of many frequency components. After traveling through a device the signal is delayed in time. Some frequencies are delayed more than others and thus our waveform does not have exactly the same shape as before.

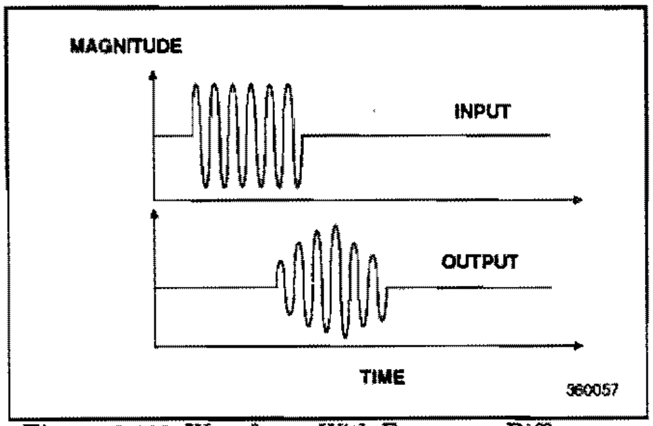


Figure 3-169. Waveforms With Frequency Differences

When delay is nonlinear, as shown above, distortion occurs. By measuring group delay with a network analyzer we can characterize the distortion that occurs from a signal traveling through our test device.

NONLINEAR DELAY = DISTORTION

When designing components it is important to measure group delay so that you can compensate for any distortion caused by the component.

GROUP DELAY

- Measure During Design
- Avoid Distortion Later

You may be able to tune the device so as to optimize the performance of group delay over the frequency range of interest. Outside of the specified frequency range, the group delay may or may not be linear.

GROUP DELAY

- Measure During Test
- Optimize Performance

So how is group delay measured? Signals travel too fast to enable measuring the input and output times of each frequency component. Consequently, we must use mathematical calculations to derive the group delay from the phase slope.

HOW IS GROUP DELAY MEASURED

Mathematical Representation of the Phase Slope

Group delay is mathematically represented by the following equations:

$$\tau = \frac{-d\theta}{d\omega} = \frac{-1}{2\pi} \bullet \frac{d\theta}{df} = \frac{-1}{360} \bullet \frac{d\theta}{df} = \frac{1}{2\pi} \bullet \frac{\Delta\theta}{\Delta f}$$

What this equation shows is that group delay is a measure of the change in phase with relation to the change in frequency.

GROUP DELAY

$$\tau = \frac{-d\theta}{d\omega} = \frac{-1}{2\pi} \bullet \frac{d\theta}{df} = \frac{-1}{360} \bullet \frac{d\theta}{df} = \frac{1}{2\pi} \bullet \frac{\Delta\theta}{\Delta f}$$

The change in frequency is referred to as an aperture.

GROUP DELAY APERTURE

- Δf = Aperture

To measure group delay the frequency aperture must be selected. Depending on the size of aperture, different levels of precision can result for the measurement of group delay.

FREQUENCY APERTURE

$$\text{Aperture} = \frac{\text{Frequency Range}}{\text{\# Of Data Points}}$$

A wide aperture results in a loss of fine-grain variations but gives more sensitivity in the measurement of time delay. A small aperture gives better frequency resolution, but at the cost of lost sensitivity. Thus, for any comparison of group delay data you must know the aperture used to make the measurement (Figure 3-170).

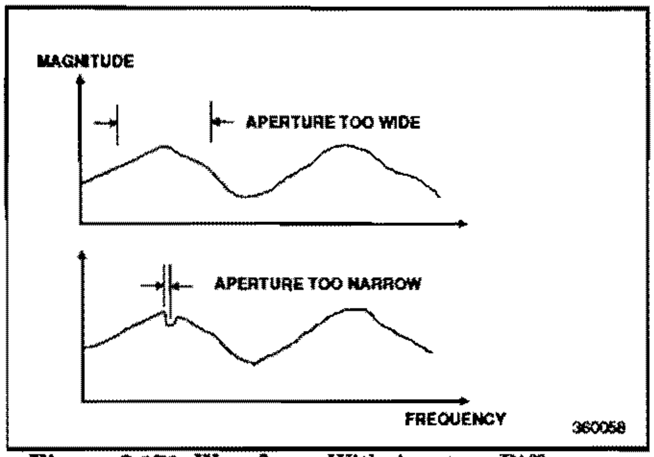


Figure 3-170. Waveforms With Aperture Differences

Let us take a look at a group delay measurement made on the WILTRON 360 Vector Network Analyzer. Group delay, as a measurement option, can be found in the Graph Type menu. After selecting the option, the 360 displays the data in a time-vs-frequency graph, or to be more exact, a group-delay-vs-frequency graph (Figure 3-171).

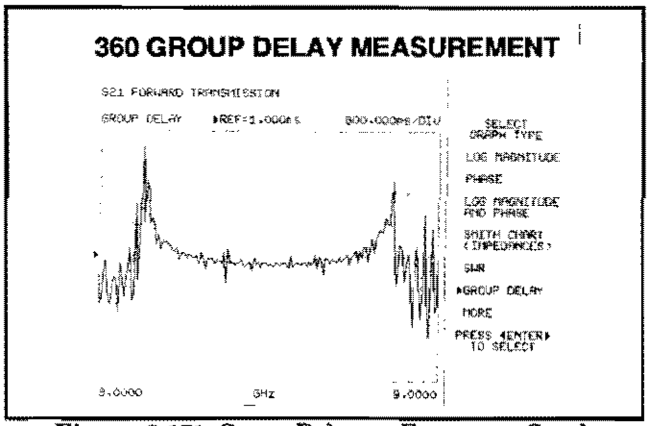


Figure 3-171. Group Delay-vs-Frequency Graph

The 360 automatically selects the frequency spacing between data points—that is, the aperture. Notice that this value is displayed on the screen with the measurement (Figure 3-172).

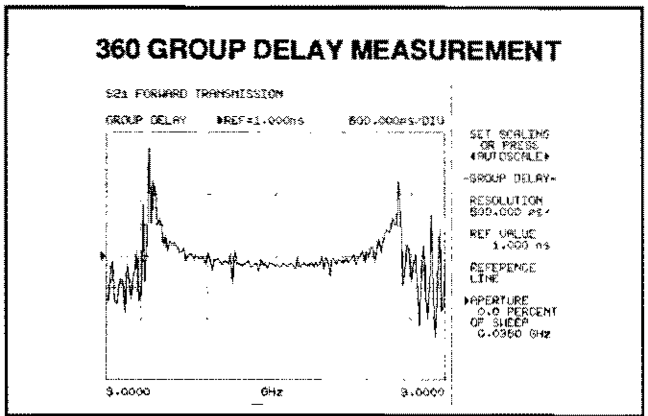


Figure 3-172. Group Delay Screen Showing Aperture

The aperture defaults to the smallest setting for the frequency range and number of data points selected. This value is displayed in the SET SCALING menu when measuring group delay (Figure 3-173).

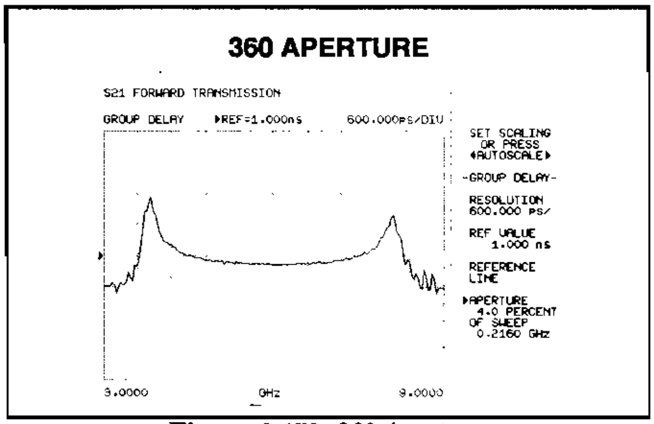


Figure 3-173. 360 Aperture

Group delay applications are found throughout the microwave industry, although the majority of such measurements are made in the telecommunications area.

One occurrence of group delay that you may have experienced is with a long-distance telephone call. Occasionally a phone call can be disturbing because of the delay in time from when you speak and when the other person responds. If there is simply a delay, then time delay—or linear group delay—has occurred. But if the voices are also distorted, then nonlinear group delay has occurred. It is this distortion that we must avoid. We can avoid linear group delay by measuring group delay both during the design and development stages and during recalibration in the field.

One final group-delay application is found in the development of components. In this application, group delay is measured for the transit time of a signal through the device. When time is of the essence in a fast switching system, as in a modern computer, the travel time through a device is critical.

GROUP DELAY APPLICATIONS

- Communications

3-14 ACTIVE DEVICE MEASUREMENTS

Active devices are key components in microwave systems. The microwave future is in smaller integrated microwave packages.

ACTIVE DEVICES

- FETs
- Amplifiers
- MMIC's

Actually, the measurements that are made are the same measurements made on passive devices.

COMMON MEASUREMENTS

- S_{11} Input Match
- S_{21} Gain
- S_{12} Reverse Isolation
- S_{22} Output Match

Active devices come in many shapes and sizes. In most cases we are going to have to develop a fixture in which to mount the device.

WHAT'S DIFFERENT?

- Connectors
  - There May Not Be Any
  - Instead You Will See:
    Tabs-Leads-Pads

Active devices require bias voltages, and in many cases they are easily damaged. High gain amplifiers may saturate with input signals of −50 dBm! With active devices, we have a new set of measurement requirements.

WHAT'S DIFFERENT?

- Voltage-Bias Requirements
- Signal Level Performance
  - Power Output
  - Max Input Level
- Non Linear
  - Gain Compression

WILTRON has developed two models of active device test sets (Models 3620 and 3621) to help you make these types of measurements. These test sets include both step attenuators (70dB) used to adjust operating power levels, and bias tees used to bias the device via the test port center conductor. This approach to bias is useful for testing transistors; however, MMIC's usually require bias injection at other points (Figure 3-174).

ACTIVE DEVICE TEST SETS
ATTENUATORS
Bias Tees

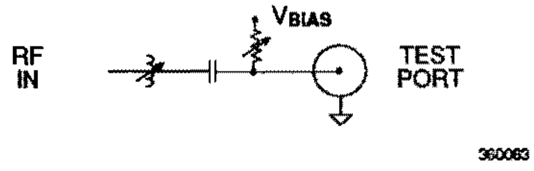


Figure 3-174. Bias Tee

Test fixtures are necessary for mounting the device so that it can be measured in our coaxial (or waveguide) measuring system (Figure 3-175).

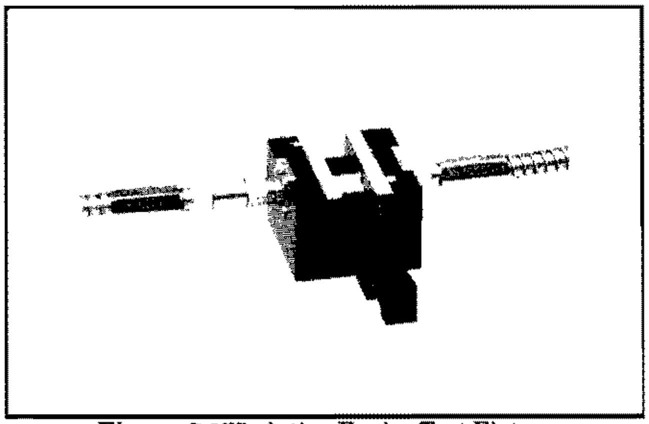


Figure 3-175. Active Device Test Fixture

Now we have an interesting situation. While we can measure the performance at the connector—which is the calibration plane— what we really want to know is how our device performs (Figure 3-176).

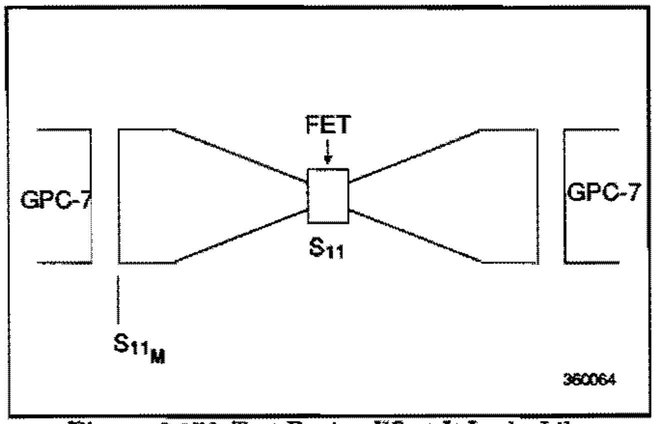


Figure 3-176. Test Device, What It Looks Like

You can consider the device embedded in the fixture and can measure the s-parameters of the fixture with the device installed.

> **DE-EMBEDDING**
>
> ***Remove or "De-embed" The Effects of the Fixture***

The most elementary situation is a system in which the test fixture is electrically ideal or transparent. In this case the solution is simple—merely move the reference plane out to the device (Figure 3-177).

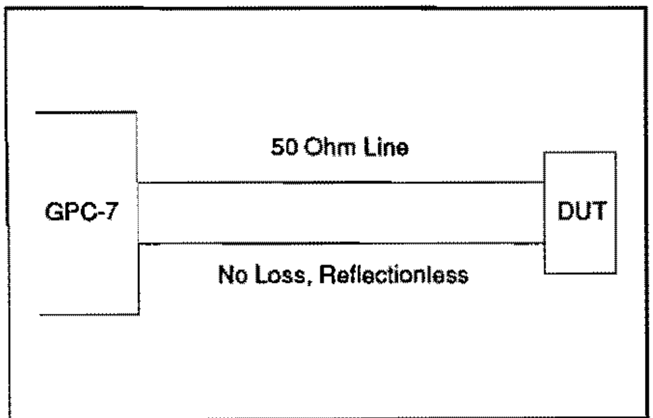


Figure 3-177. Simple Example of De-Embedding

In some cases—depending on the fixture or the device being measured—this is satisfactory. But when it is not, we need to employ other techniques.

One of the reasons that moving the reference plane out to the device does not always work, is that the test fixture includes a transition from coax to a structure such as microstrip, co-planer waveguide, or stripline (Figure 3-178).

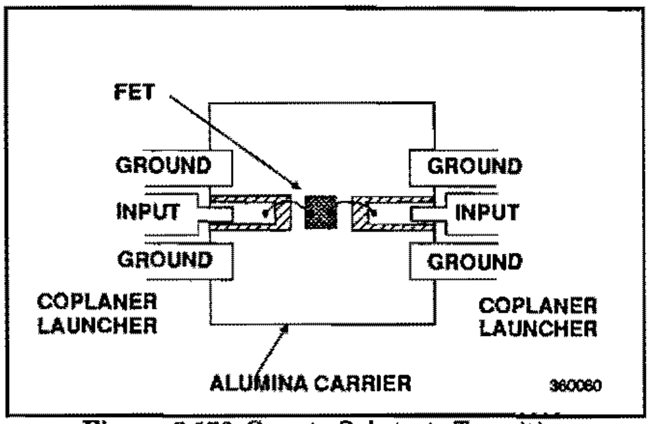


Figure 3-178. Coax-to-Substrate Transition

Engineers have come to grips with the general problem. However, there is no established standard approach. Two of the more common approaches are to calibrate the fixture as a part of the analyzer, and to characterize the fixture and compute the desired result.

> **WHAT DO WE DO?**
> **TWO APPROACHES ARE COMMON**
>
> - Calibrate the Fixture As "Part of the Analyzer"
> - Characterize the Fixture and Compute the Desired Result

In the discussion on calibration (paragraph 3-10) we saw that the calibration components establish the reference plane and determine the quality of the measurement. If we have a good Open, Short and Z_0 load to place at the end of a microstrip line, we can calibrate the system at the point of measurement.

> **APPROACH NUMBER 1**
> **CALIBRATE THE FIXTURE**
>
> - Special Calibration Devices Required

Figure 3-179 shows some of the special test-fixture calibration standards that are available.

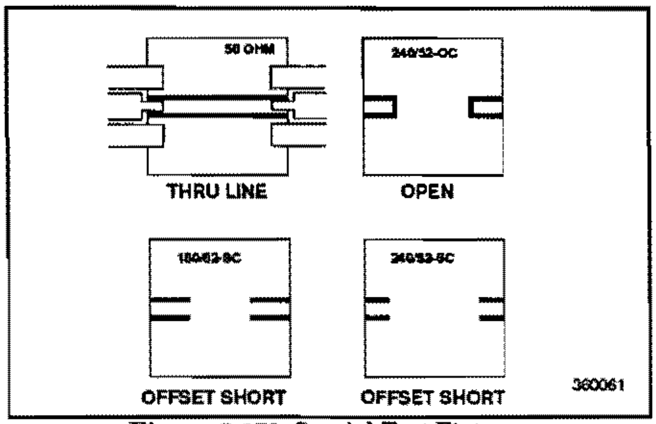


Figure 3-179. Special Test Fixtures

These special calibration kits are far from perfect, but they are superior to our perfect transmission line assumption.

SPECIAL CALIBRATION DEVICES PROBLEMS

- Opens Are Difficult-Radiation Effects
- Good Terminations Are Hard to Find, 20-30 db Is Often the Best That We Can Do and This Determines the "Effective Directivity"

You may have heard of the probe system built to permit on-wafer measurements by Cascade Microtech. It is a good example of a system condusive to this approach.

CASCADE MICROTECH WAFER PROBE

Calibration Standards Are on a Wafer

The Open, Short, termination approach provides three known standards that permit the analyzer to solve for three unknowns (Figure 3-180).

CAUTION

You should turn off or disconnect the bias supplies during the calibration, since you are using a Short as the calibration standard.

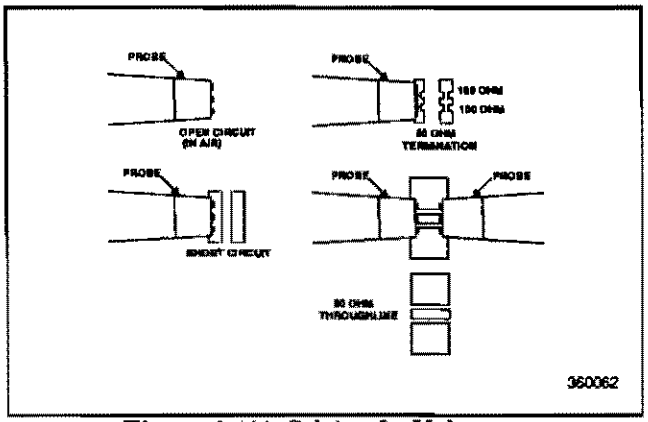


Figure 3-180. Solving for Unknowns

It is also possible to use three known impedances. For instance, a varactor with three voltages applied (Figure 3-181).

SPECIAL CALIBRATION KITS

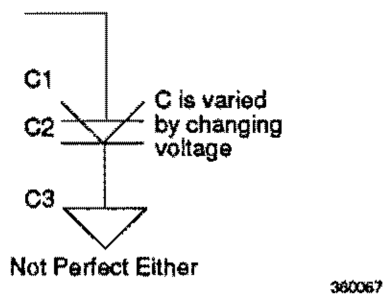


Figure 3-181. Three Known Impedances

The second approach is to model the fixture. Modeling is elegant but of limited use due to the non-ideal characteristics of the fixture. Modeling can be accomplished in a CAD system like Touchstone or Compass.

APPROACH NUMBER 2 CHARACTERIZE THE FIXTURE

- Model
- Measure
- Compute the Desired Result

In summary, there are quite a variety of approaches—all with their own characteristic pitfalls. Engineers try to choose the most appropriate technique for their application.

3-15 TIME DOMAIN MEASUREMENTS

3-15.1 Time Domain Measurements, Discussion

The Option 360-2 Time Domain feature is a useful measurement tool for determining the location of impedance discontinuities. Some typical applications are identifying and analyzing circuit elements, isolating and analyzing a desired response, locating faults in cables, and measuring antennas .

TIME DOMAIN
A USEFUL TOOL FOR:

- Identifying and Analyzing Circuit Elements
- Isolating a Desired Response
- Locating Faults
- Making Antenna Measurements

The relationship between the frequency-domain response and the time-domain response of a network is described mathematically by the Fourier transform. The 360 makes measurements in the frequency domain then calculates the inverse Fourier transform to give the time-domain response. The time-domain response is displayed as a function of time (or distance). This computational technique benefits from the wide dynamic range and the error correction of the frequency-domain data.

RELATIONSHIP OF TIME DOMAIN
TO FREQUENCY DOMAIN

- Indirect Measurement
- Calculated From Frequency Domain (Using Inverse Fourier Transform)
- Displays S-Parameters As a Function of Time or Distance

Let us examine the time-domain capabilities of the Model 360 Vector Network Analyzer. Two measurement modes are available: lowpass and bandpass.

360 TIME DOMAIN MODES

- Lowpass Mode
- Bandpass Mode

We use the lowpass mode with devices that have a dc or low-frequency response. In the lowpass mode two responses to the device-under-test (DUT) are available: impulse or step stimulus. The frequencies used for the test must be harmonically related to the start frequency.

LOWPASS MODE

- Either Impulse or Step Response Available
- Displays Impedance Information
- Requires Harmonically Related Frequencies
- Used When Device Has a DC or Low Frequency Path

The lowpass impulse response displays the location of discontinuities as well as information useful in determining the impedance (R, L, or C) of each discontinuity.

LOWPASS IMPULSE RESPONSE

- Location of Discontinuities
- Information on Type of Discontinuities

The impulse response is a peak that goes positive for $R>Z_0$ and negative for $R<Z_0$. The height of the response is equal to the reflection coefficient ($rho=(R-Z_0)/(R+Z_0)$). The impulse response for a shunt capacitance is a negative-then-positive peak and for a series inductance is a positive-then-negative peak (Figure 3-182).

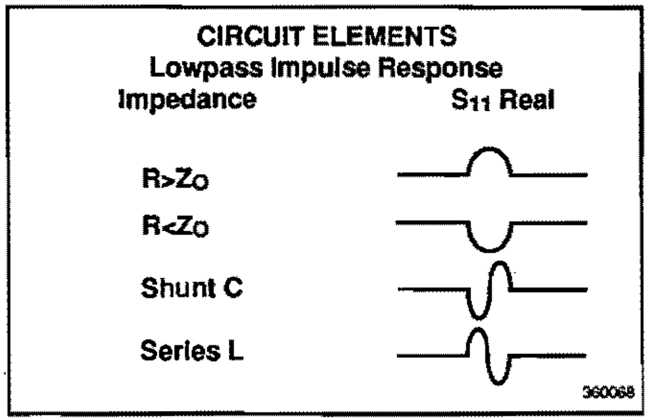


Figure 3-182. Lowpass Impulse Response

An example of using impulse response is circuit impedance analysis. With an impulse response, we can observe the circuit response of a passive device, such as a power splitter, and make final adjustments during the test (Figure 3-183).

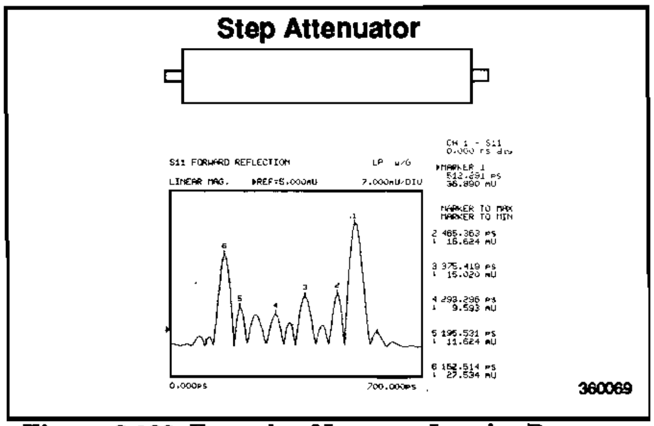


Figure 3-183. Example of Lowpass Impulse Response

The lowpass step response displays the location of discontinuities as well as information useful in determining the impedance (R, L, or C) of each discontinuity. If you are familiar with time-domain reflectometry (TDR) you may feel more comfortable with step response, as the displays are similar.

LOWPASS STEP RESPONSE

- TDR Measurement
- Location of Discontinuities
- Information on Type of Discontinuities

The lowpass step response for a resistive impedance is a positive level shift for $R>Z_0$ and a negative level shift for $R<Z_0$. The height of the response is equal to the reflection coefficient ($rho=(R-Z_0)/(R+Z_0)$). The step response for a shunt capacitance is a negative peak, and for a series inductance it is a positive peak (Figure 3-184).

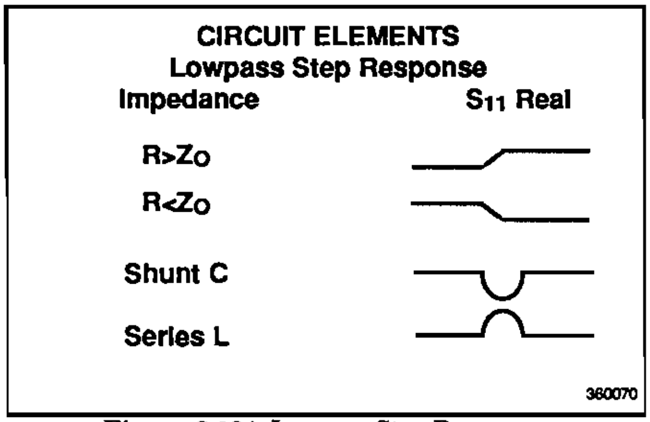


Figure 3-184. Lowpass Step Response

An example of using the lowpass step response is cable fault location. In the frequency domain a cable with a fault exhibits much worse match than a good cable. Using lowpass step response, both the location of the discontinuity and information about its type are available (Figure 3-185).

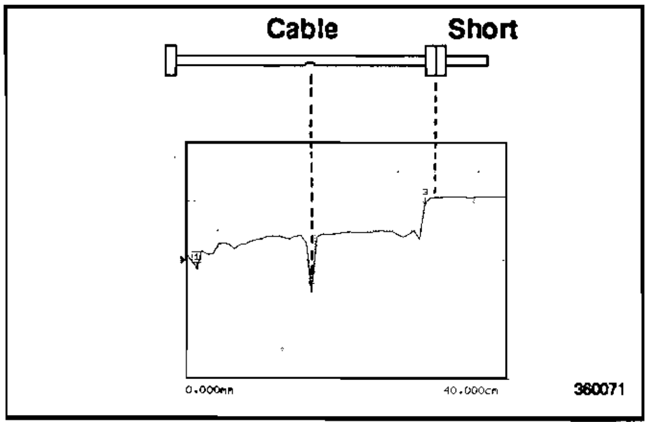


Figure 3-185. Example of Lowpass Step Response

The 360 bandpass mode gives the response of the DUT to an RF-burst stimulus. Two types of response are available: impulse and phasor-impulse. An advantage of the bandpass mode is that any frequency range can be used. Use this mode with devices that do not have a dc or low-frequency path.

BANDPASS MODE

- Calculates Impulse or Phasor-Impulse Response
- Uses Any Frequency Range
- Used When Device Does Not Have a DC or Low-Frequency Path

Use the bandpass-impulse response to show the location of a discontinuity in time or distance, as indicated by changes in its magnitude. Unlike the lowpass mode, no information as to the type of the discontinuity is available. A typical use for this mode is to measure devices—such as, filters, waveguide, high-pass networks, bandpass networks—where a low-frequency response is not available.

BANDPASS IMPULSE RESPONSE

- Magnitude Measurement Only
- Location of Discontinuities
- No Information on Type of Discontinuities

The bandpass-impulse response for various impedance discontinuities is shown in Figure 3-186. As we can see, no information about the type of discontinuity is available.

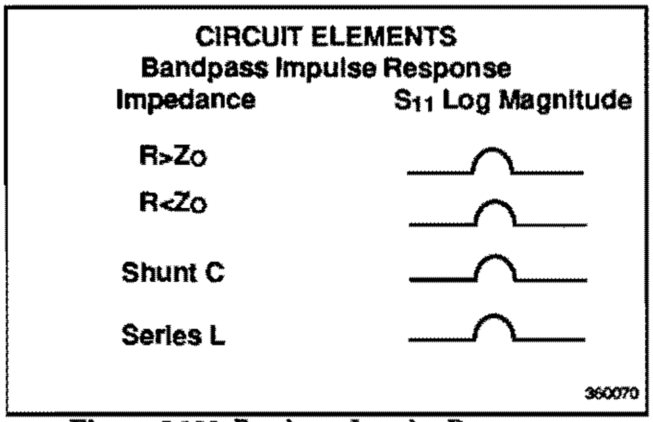


Figure 3-186. Bandpass Impulse Response

An example of using the bandpass-impulse response, is the pulse height, ringing, and pulse envelope of a bandpass filter (Figure 3-187).

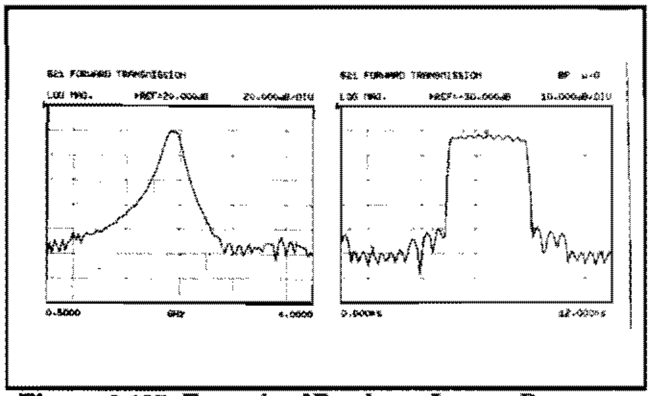


Figure 3-187. Example of Bandpass-Impuse Response

PHASOR IMPULSE BANDPASS RESPONSE

- Real and Imaginary Measurement
- Information On Type of Discontinuity

Use the phasor-impulse response with bandpass response to determine the type of an isolated impedance discontinuity.

After the bandpass-impulse response has been isolated, the phasor-impulse response for a resistive-impedance-level change is a peak that goes positive ($R>Z_0$) for the real part of S_{11} and negative for $R<Z_0$. The imaginary part remains relatively constant. In each case the peak is proportional to the reflection coefficient. The phasor-impulse response for a shunt capacitance is a negative-going peak in the imaginary part of S_{11}. For a series inductance, it is a positive going peak (Figure 3-188).

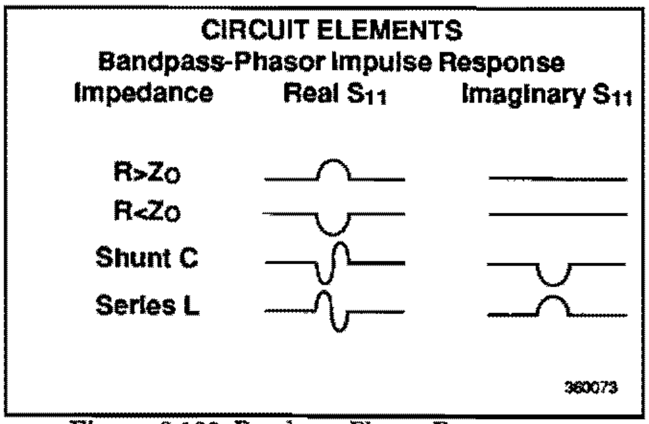


Figure 3-188. Bandpass Phasor Response

Next, let us look at a complex circuit. A resistive impedance change $R<Z_0$ and a shunt capacitance and series inductance. These impedance changes are shown in the time domain for the lowpass-impulse response, lowpass-step response, and bandpass-impulse response (Figure 3-189).

The 360 processes bandpass-impulse-response data to obtain phasor-impulse response. This becomes most advantageous where both a reactive reflection and an impedance change occur at the same location. The real part of the time-domain response shows the location of impedance level changes, while the imaginary part shows the type of reactive discontinuity. Phasor-impulse response displays one discontinuity at a time (Figure 3-190).

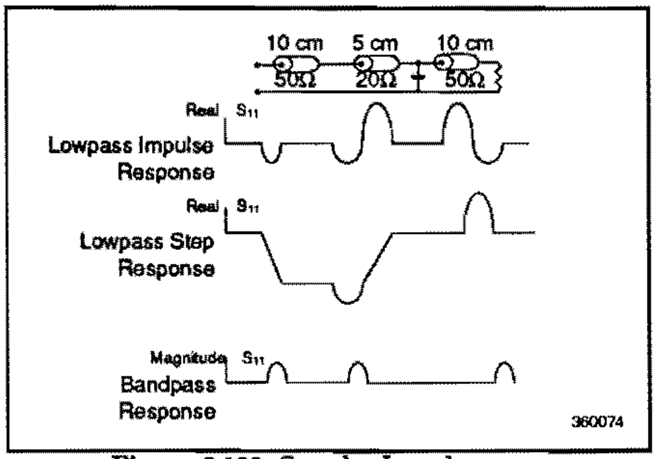


Figure 3-189. Complex Impedances

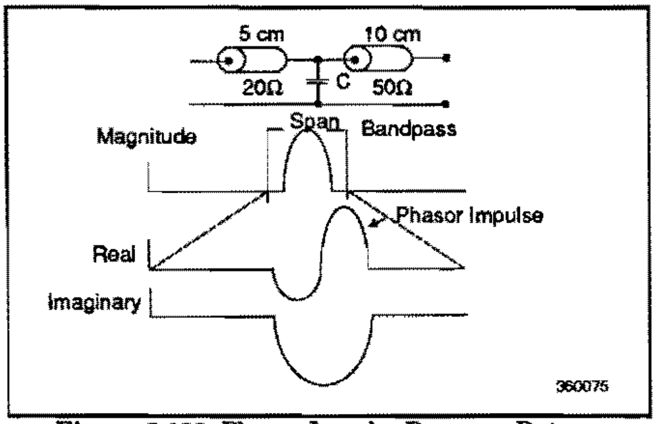


Figure 3-190. Phasor-Impulse Response Data

a. *Operating Time Domain*

To operate in the time domain mode, press the DOMAIN key. A domain menu (Figure 3-191) allows us to select the frequency- or time-domain modes by simple cursor selection. The 360 defaults to the frequency domain.

```
DOMAIN                 DOMAIN                 DOMAIN
▸FREQUENCY             FREQUENCY              FREQUENCY
FREQUENCY              FREQUENCY              FREQUENCY
WITH TIME              WITH TIME              WITH TIME
GATE                   GATE                   GATE
TIME                   ▸TIME                  TIME
LOWPASS MODE           LOWPASS MODE           LOWPASS MODE
TIME                   TIME                   ▸TIME
BANDPASS MODE          BANDPASS MODE          BANDPASS MODE
DISPLAY                DISPLAY                DISPLAY
TIME/DISTANCE          TIME/DISTANCE          TIME/DISTANCE
SET RANGE              SET RANGE              SET RANGE
SET GATE               SET GATE               SET GATE
GATE ON/OFF            GATE ON/OFF            GATE ON/OFF
HELP                   HELP                   HELP
PRESS <ENTER>          PRESS <ENTER>          PRESS <ENTER>
TO SELECT              TO SELECT              TO SELECT
OR SWITCH              OR SWITCH              OR SWITCH
```

Figure 3-191. Domain Menu

Select time or distance for the horizontal axis. The 360 defaults to time axis.

NOTE

If we select distance, be sure to set the dielectric constant in the Reference Delay menu (Figure 3-192).

```
DOMAIN
FREQUENCY
FREQUENCY
WITH TIME
GATE
TIME
LOWPASS MODE
TIME
BANDPASS MODE
DISPLAY
▸TIME/DISTANCE
SET RANGE
SET GATE
GATE ON/OFF
HELP
PRESS <ENTER>
TO SELECT
OR SWITCH
```

Figure 3-192. Time/Distance Menu

Select SET RANGE and use the START/STOP or GATE/SPAN selections to set the range (Figure 3-193).

```
DOMAIN                 LOWPASS TIME           BANDPASS TIME
FREQUENCY              DOMAIN SETUP           DOMAIN SETUP
FREQUENCY              ▸START                 ▸START
WITH TIME              XXX.XXX ps             XXX.XXX ps
GATE                   STOP                   STOP
TIME                   XXX.XXX ps             XXX.XXX ps
LOWPASS MODE           CENTER                 CENTER
TIME                   XXX.XXX ps             XXX.XXX ps
BANDPASS MODE          SPAN                   SPAN
DISPLAY                XXX.XXX ps             XXX.XXX ps
TIME/DISTANCE          MARKER RANGE           MARKER RANGE
▸SET RANGE             RESPONSE               PHASOR ON/OFF
SET GATE               IMPULSE/STEP           IMPULSE
GATE ON/OFF            MORE                   SET RANGE TO
HELP                   PRESS <ENTER>          ISOLATE ONE
PRESS <ENTER>          TO SELECT              DISCONTINUITY
TO SELECT                                     MORE
OR SWITCH                                     PRESS <ENTER>
                                              TO SELECT
```

Figure 3-193. Set Range Menu

For the lowpass mode select either IMPULSE or STEP Response and set the DC term. The 360 defaults to the IMPULSE Response and the AUTO EXTRAPOLATE mode for the DC term (Figure 3-194).

NOTE

The bandpass mode displays Bandpass Impulse Response unless we select Phasor Impulse Response.

LOWPASS TIME DOMAIN SETUP
START XXX.XXX ps
STOP XXX.XXX ps
CENTER XXX.XXX ps
SPAN XXX.XXX ps
MARKER RANGE
♦ RESPONSE IMPULSE/STEP
MORE
PRESS <ENTER> TO SELECT

SET DC TERM FOR LOW PASS PROCESSING
♦AUTO EXTRAPOLATE
LINE IMPEDANCE
OPEN
SHORT
OTHER -XXX.XXX ♦ ABOVE VALUE REPRESENTS A REFLECTION COEFF. OF XX.XXX mU
PRESS <ENTER> TO SELECT

BANDPASS TIME DOMAIN SETUP
START XXX.XXX ps
STOP XXX.XXX ps
CENTER XXX.XXX ps
SPAN XXX.XXX ps
MARKER RANGE
♦ PHASOR ON/OFF IMPULSE
SET RANGE TO ISOLATE ONE DISCONTINUITY
MORE
PRESS <ENTER> TO SELECT

Figure 3-194. Response Menus

The Marker Range menu allows us to zoom in and display the range between two selected markers (Figure 3-195).

LOWPASS TIME DOMAIN SETUP
START XXX.XXX ps
STOP XXX.XXX ps
CENTER XXX.XXX ps
SPAN XXX.XXX ps
♦ MARKER RANGE
RESPONSE IMPULSE/STEP
MORE
PRESS <ENTER> TO SELECT

TIME MARKER RANGE
♦ START TIME MARKER ( ) XXX.XXX nS
STOP TIME MARKER ( ) XXX.XXX nS
RESTORE ORIGINAL RANGE
PREVIOUS MENU
USE KEYPAD TO CHOOSE MARKER (1 - 6) OR PRESS <ENTER> TO SELECT

Figure 3-195. Marker Range Menus

b. Windowing

Windowing is a frequency filter that we apply to the frequency-domain data when we convert it to time-domain data. This filtering rolls off the abrupt transition at F1 and F2. This effectively produces a time-domain response with lower sidelobes. Windowing allows a limited degree of control over the pulse shape, trading off ringing (sidelobes) for pulse width (Figure 3-196).

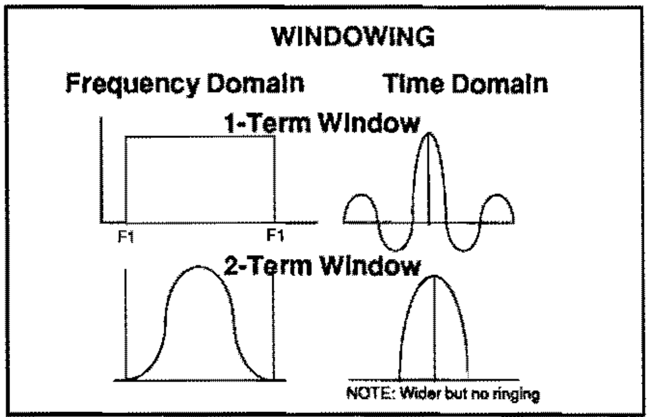


Figure 3-196. Windowing

We select windowing from the Time Domain Setup menu. Four different windows are available: RECTANGLE, NOMINAL, LOW SIDELOBE, and MINIMUM SIDELOBE. The RECTANGLE option provides the narrowest pulse width, while the MINIMUM SIDELOBE option provides the least ringing (fewest sidelobes). The 360 defaults to the NOMINAL option, which is acceptable for most measurements (Figure 3-197).

LOWPASS TIME DOMAIN SETUP
START XXX.XXX ps
STOP XXX.XXX ps
CENTER XXX.XXX ps
SPAN XXX.XXX ps
MARKER RANGE
RESPONSE IMPULSE/STEP
♦ MORE
PRESS <ENTER> TO SELECT

LOWPASS TIME DOMAIN SETUP
♦ WINDOW NOMINAL
SET GATE
SET O.C. TERM XXX.XXX
PREVIOUS MENU
PRESS <ENTER> TO SELECT

SHAPE
♦ RECTANGULAR
NOMINAL
LOW SIDELOBE
MIN SIDELOBE
HELP
PRESS <ENTER> TO SELECT

Figure 3-197. Window Shape Menus

c. *Gating*

Gating is a time filter that allows for removing unwanted time-domain responses by gating the desired response. We can view the isolated response in the both time domain—using the PHASOR IMPULSE RESPONSE option—and in the frequency domain—using the FREQUENCY WITH TIME GATE selection (Figure 3-198).

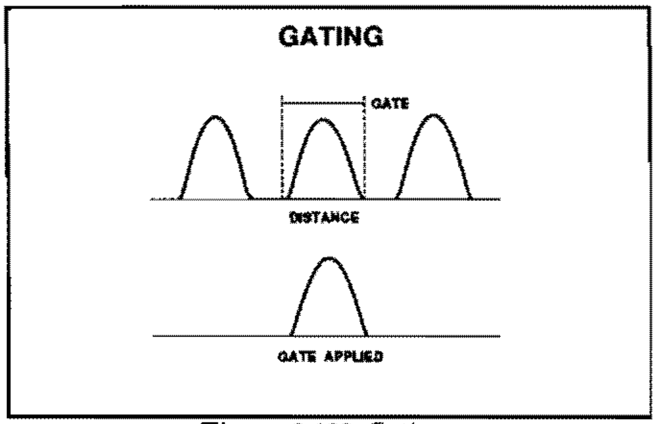


Figure 3-198. Gating

There are four different gate shapes available: RECTANGLE, NOMINAL, LOW SIDELOBE, and MINIMUM SIDELOBE. The 360 defaults to the NOMINAL gate. To specify a different shape simply enter the Gate menu and select the desired gating shape. The RECTANGLE has the largest ripple, while MINIMUM SIDELOBE has the least (Figure 3-199).

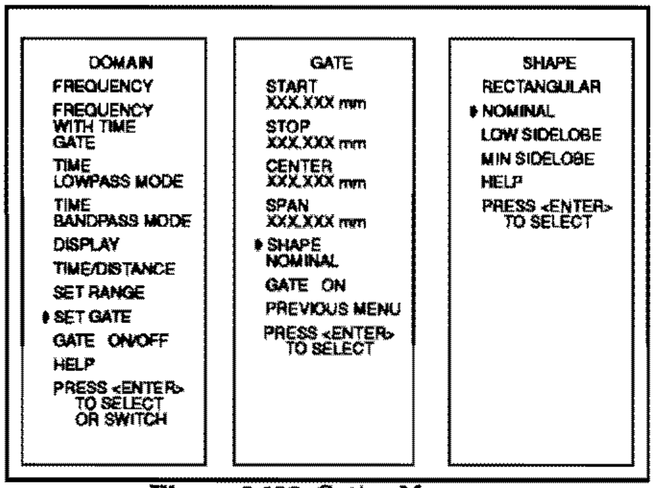


Figure 3-199. Gating Menus

d. *Gating Example*

Let us look at a reflection measurement. A device at the end of a coax cable is measured in the frequency domain. We would like to measure the return loss of this device and characterize its impedance, but to do so we have to eliminate the response of the cable and connectors (Figure 3-200). Steps 1 thru 5 below describe a method for making this measurement.

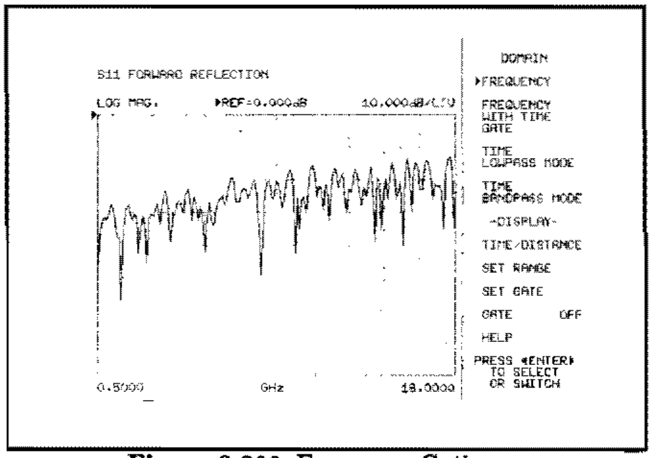


Figure 3-200. Frequency Gating

1. Convert the frequency domain data into the time domain using TIME BANDPASS MODE (Figure 3-201).

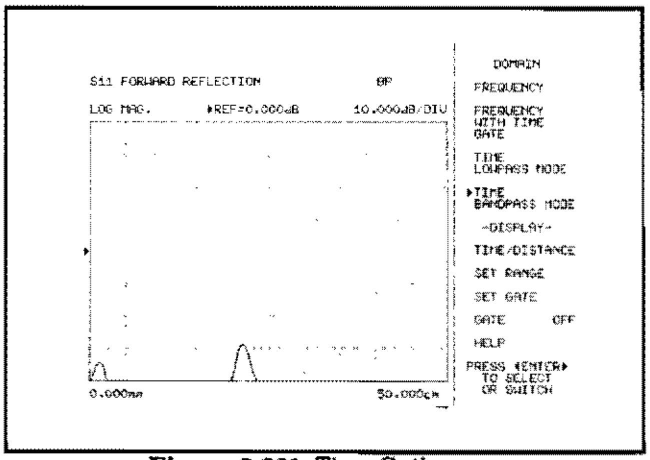


Figure 3-201. Time Gating

2. Select SET GATE in the Domain menu then GATE DISP in the Gate menu. This allows us to put the gate around the discontinuity of interest using the START, STOP, or CENTER/SPAN selections (Figure 3-202).

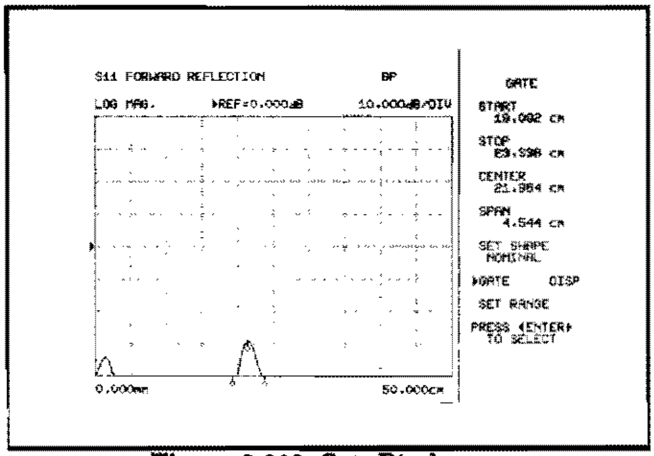


Figure 3-202. Gate Display

3. Select GATE ON in the Gate menu and the unwanted responses are removed (Figure 3-203).

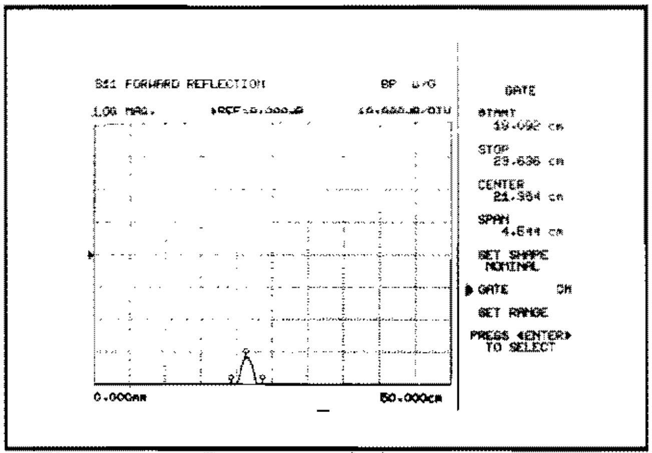


Figure 3-203. Response with GATE ON Selected

4. Select PHASOR IMPULSE ON in the Bandpass menu. The real and imaginary responses of the Phasor Impulse Response are displayed. Based on the display, the divice has a series inductance as well as resistance >50 ohms (Figure 3-204).

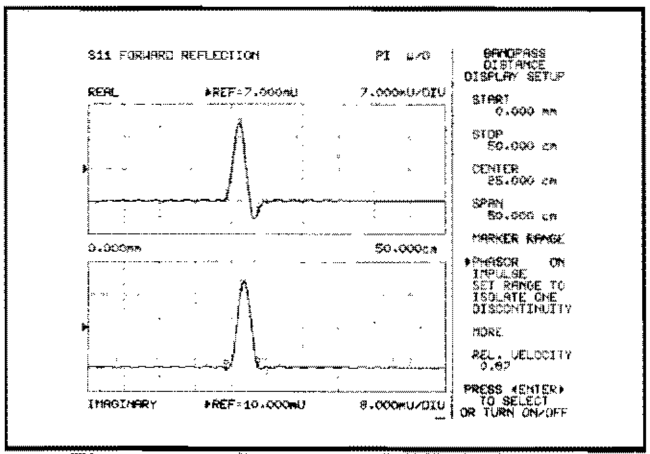


Figure 3-204. Response with PHASOR IMPULSE ON Selected

5. Select FREQUENCY WITH TIME GATE in the Domain menu to display the frequency domain S_{11} forward reflection of the gated time domain response (Figure 3-205).

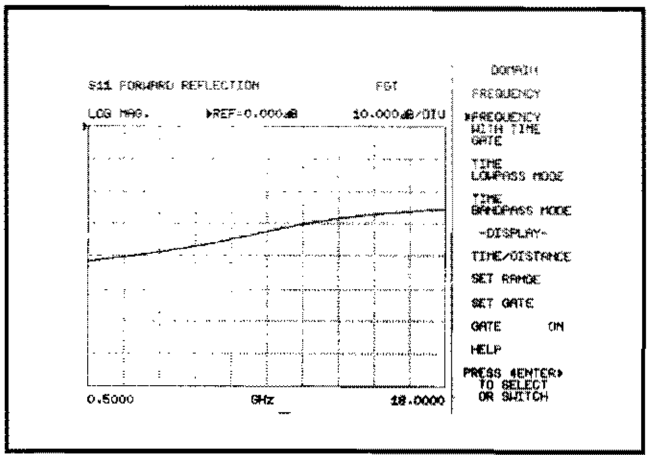


Figure 3-205. Response FREQUENCY WITH TIME GATE Selected

An example of gating a transmission measurement is making an antenna measurement. Gating can remove unwanted ground or chamber reflections that interfere with characterizing an antenna's pattern (Figure 3-206).

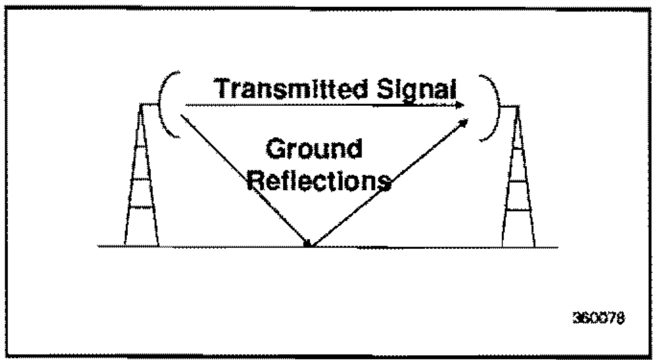


Figure 3-206. Antenna Measurements

Finally, let's look at some measurement considerations and ways to optimize their time-domain results.

MEASUREMENT CONSIDERATIONS

- Small Responses
- Close Responses
- Distant Responses

Small impedance changes cause small responses that can be lost in the noise floor. This is also true of long cable and waveguide runs with high insertion loss.

SMALL RESPONSES

- Small Impedance Changes
- Long Lossy Devices
- High Insertion Loss Paths

To optimize for small responses:

- Use averaging and reduced IF bandwidth to lower the noise floor.
- Use maximum power to provide maximum dynamic range.
- Use the window with the lowest sidelobes to reduce ringing.

OPTIMIZE FOR SMALL RESPONSES

- Use Averaging
- Use Reduced IF Bandwidth
- Use Window With Least Ringing

Elements that are physically close or have similar length transmission paths can have minimal or overlapping time domain responses.

CLOSE RESPONSES

- Physically Close Elements
- Similar Length Transmission Paths

To optimize for close-response measurements and attain the best resolution:

- Use the widest sweep.
- Use the window with the narrowest pulse shape.

OPTIMIZE FOR CLOSE RESPONSES

- Use Widest Sweep
- Use Window with Narrowest Pulse Shape

To maximize the distance measurement capability without causing aliasing (false information), use the minimum-frequency-step size by selecting 501 points and the minimum--required-frequency range.

DISTANT RESPONSES

- Use 501 Points
- Use Minimum Required Frequency Range

In summary, the 360 Time Domain capability is a powerful and versatile tool in performing network analyzer measurements.

TIME DOMAIN
A Powerful and Versatile
Network Analyzer Tool

3-15.2 Time Domain Menus

The menus associated with the Time Domain Option are described in Figures 3-207 thru 3-218.

MENU	DESCRIPTION
DOMAIN	
FREQUENCY	Displays the data in normal frequency domain format.
FREQUENCY WITH TIME GATE	Displays the data in the frequency domain after a specific time range has been sampled by the gate function.
TIME LOWPASS MODE	Displays the data in the time (distance) domain, using true lowpass processing. Data must be taken using a harmonic series calibration and sweep in order to use this mode.
TIME BANDPASS MODE	Displays the data in the time (distance) domain using bandpass processing. Any data sweep range using normal calibration can be used.
DISPLAY	
TIME/DISTANCE	Switches the mode of display between time and distance. This does not affect the actual displayed data, but only the annotation.
SET RANGE	Takes you to Menu TD2, which lets you set range and other display parameters.
SET GATE	Takes you to menu TD4, which lets you set gate parameters.
GATE ON/OFF	Switches the gate on or off each time ENTER is pressed.
HELP	Displays an informational help menu.
PRESS <ENTER> TO SELECT OR SWITCH	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-207. Menu TD1, Domain (Frequency/Display)

MENU	DESCRIPTION
LOWPASS TIME DOMAIN SETUP	
START XXX.XXX ps	Sets the start time of the display.
STOP XXX.XXX ps	Sets the stop time of the display.
CENTER XXX.XXX ps	Sets the center time of the display.
SPAN XXX.XXX ps	Sets the span (Stop - Start) of the display.
MARKER RANGE	Takes you to Menu TD7d/7l, which lets you set the display to a range determined by two of the markers.
RESPONSE IMPULSE/STEP	Switches between Impulse and Step response each time ENTER is pressed.
MORE	Takes you to Menu TD3, which contains additional selections for display setup.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-208. Menu TD2tl, Lowpass Time Domain Setup

MENU	DESCRIPTION
LOWPASS DISTANCE DISPLAY SETUP	
START XXX.XXX mm	Sets the start time of the display.
STOP XXX.XXX mm	Sets the stop time of the display.
CENTER XXX.XXX mm	Sets the center time of the display.
SPAN XXX.XXX mm	Sets the span (Stop - Start) of the display.
MARKER RANGE	Takes you to Menu TD7d/7l, which lets you set the display to a range determined by two of the markers.
RESPONSE IMPULSE/STEP	Switches between Impulse and Step response each time ENTER is pressed.
MORE	Takes you to Menu TD3, which contains additional selections for display setup.
REL. VELOCITY X.X	Indicates the relative velocity of light, as set by the dielectric constant in menu RD2.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-209. Menu TD2dl, Lowpass Distance Display Setup

MENU	DESCRIPTION
BANDPASS TIME DOMAIN SETUP	
START XXX.XXX ps	Sets the start time of the display.
STOP XXX.XXX ps	Sets the stop time of the display.
CENTER XXX.XXX ps	Sets the center time of the display.
SPAN XXX.XXX ps	Sets the span (Stop - Start) of the display.
MARKER RANGE	Takes you to Menu TD7d/7l, which lets you set the display to a range determined by two of the markers.
PHASOR ON/OFF IMPULSE	Switches Phasor Impulse processing on or off each time ENTER is pressed.
HELP – PHASOR IMPULSE	Takes you to one of the help menus.
MORE	Takes you to Menu TD3, which contains additional selections for display setup.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. Or, when the cursor is superimposed on PHASOR IMPULSE, pressing ENTER toggles the phasor between on and off. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-210. Menu TD2tb, Bandpass Time Domain Setup

MENU	DESCRIPTION
BANDPASS DISTANCE DISPLAY SETUP	
START XXX.XXX mm	Sets the start distance of the display.
STOP XXX.XXX mm	Sets the stop distance of the display.
CENTER XXX.XXX mm	Sets the center distance of the display.
SPAN XXX.XXX mm	Sets the span (Stop - Start) of the display.
MARKER RANGE	Takes you to Menu TD7d/7l, which lets you set the display to a range determined by two of the markers.
PHASOR ON/OFF IMPULSE	Switches Phasor Impulse processing on or off each time ENTER is pressed.
HELP – PHASOR IMPULSE	Takes you to one of the help menus.
MORE	Takes you to Menu TD3, which contains additional selections for display setup.
REL. VELOCITY X.X	Indicates the relative velocity of light, as set by the dielectric constant in menu RD2.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. Or, when the cursor is superimposed on PHASOR IMPULSE, pressing ENTER toggles the phasor between on and off. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-211. Menu TD2db, Bandpass Distance Display Setup

MENU	DESCRIPTION
BANDPASS TIME DOMAIN SETUP	
WINDOW NOMINAL	Takes you to Menu TD5, which lets you change the window type.
SET GATE	Takes you to menu TD4, which lets you set the gate.
PREVIOUS MENU	Returns you to Menu TD2.
PRESS <ENTER> TO SELECT OR TURN ON/OFF	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-212. Menu TD3b, Bandpass Time Domain Setup

MENU	DESCRIPTION
LOWPASS TIME DOMAIN SETUP	
WINDOW NOMINAL	Takes you to Menu TD5, which lets you change the window type.
SET GATE	Takes you to menu TD4, which lets you set the gate.
SET D.C. TERM XXX.XXX	Takes you to Menu TD6, which lets you set the D.C. term for lowpass processing.
PREVIOUS MENU	Returns you to Menu TD2
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-213. Menu TD3l, Lowpass Time Domain Setup

MENU	DESCRIPTION
GATE	
START XXX.XXX mm	Sets the start time of the gate.
STOP XXX.XXX mm	Sets the stop time of the gate.
CENTER XXX.XXX mm	Sets the center time of the gate.
SPAN XXX.XXX mm	Sets the span (Stop - Start) of the gate.
SHAPE NOMINAL	Takes you to Menu TD5, which lets you set the shape of the gate.
GATE ON	Switches the gate on or off each time ENTER is pressed.
PREVIOUS MENU	Returns you to the previous menu.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-214. Menu TD4d,Gate (Distance)

MENU	DESCRIPTION
GATE	
START XXX.XXX ns	Sets the start time of the gate.
STOP XXX.XXX ns	Sets the stop time of the gate.
CENTER XXX.XXX ns	Sets the center time of the gate.
SPAN XXX.XXX ns	Sets the span (Stop - Start) of the gate.
SHAPE NOMINAL	Takes you to Menu TD5, which lets you set the shape of the gate.
GATE ON	Switches the gate on or off each time ENTER is pressed.
PREVIOUS MENU	Returns you to the previous menu.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-215. Menu TD4t,Gate (Time)

MENU	DESCRIPTION
SHAPE	
RECTANGULAR	Selects a Rectangular (one-term) shape.
NOMINAL	Selects a two-term Hamming shape.
LOW SIDELOBE	Selects a three-term Blackman-Harris shape.
MIN SIDELOBE	Selects a four-term Blackman-Harris shape.
HELP	Displays an informational help menu.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-216. Menu TD5g/TD5w, Shape

MENU	DESCRIPTION
SET DC TERM FOR LOW PASS PROCESSING	Since it is impossible to measure the true D.C. term required for lowpass processing, a value must be estimated. This menu allows a choice between five different selections for this value.
AUTO EXTRAPOLATE	Sets the D.C. term to a value determined by extrapolating the data points near the zero frequency.
LINE IMPEDANCE	Sets the D.C. term to the characteristic impedance of the transmission medium (Z_0).
OPEN	Sets the D.C. term to correspond to an open circuit.
SHORT	Sets the D.C. term to correspond to a short circuit.
OTHER –XXX.XXX # ABOVE VALUE REPRESENTS A REFLECTION COEFF. OF XX.XXX mU	Sets the D.C. term to the value entered.
PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-217. Menu TD6, Set D.C. Term for Low Pass Processing

MENU	DESCRIPTION
TIME MARKER RANGE	
START TIME MARKER ( ) XXX.XXX nS	Sets the start time to the value of the selected marker.
STOP TIME MARKER ( ) XXX.XXX nS	Sets the stop time to the value of the selected marker.
RESTORE ORIGINAL RANGE	Returns the display to the original time range that was in effect before the marker range was selected.
PREVIOUS MENU	Returns you to the TD2 menu.
USE KEYPAD TO CHOOSE MARKER (1 - 6) OR PRESS <ENTER> TO SELECT	Pressing the ENTER key implements your menu selection. The menu remains on the screen until another menu is selected for display or until the CLEAR/RET LOC key is pressed.

Figure 3-218. Menu TD7d/TD7l, Time Marker Range

SECTION IV
GPIB OPERATION —
BASIC PROGRAMMING

CONTENTS

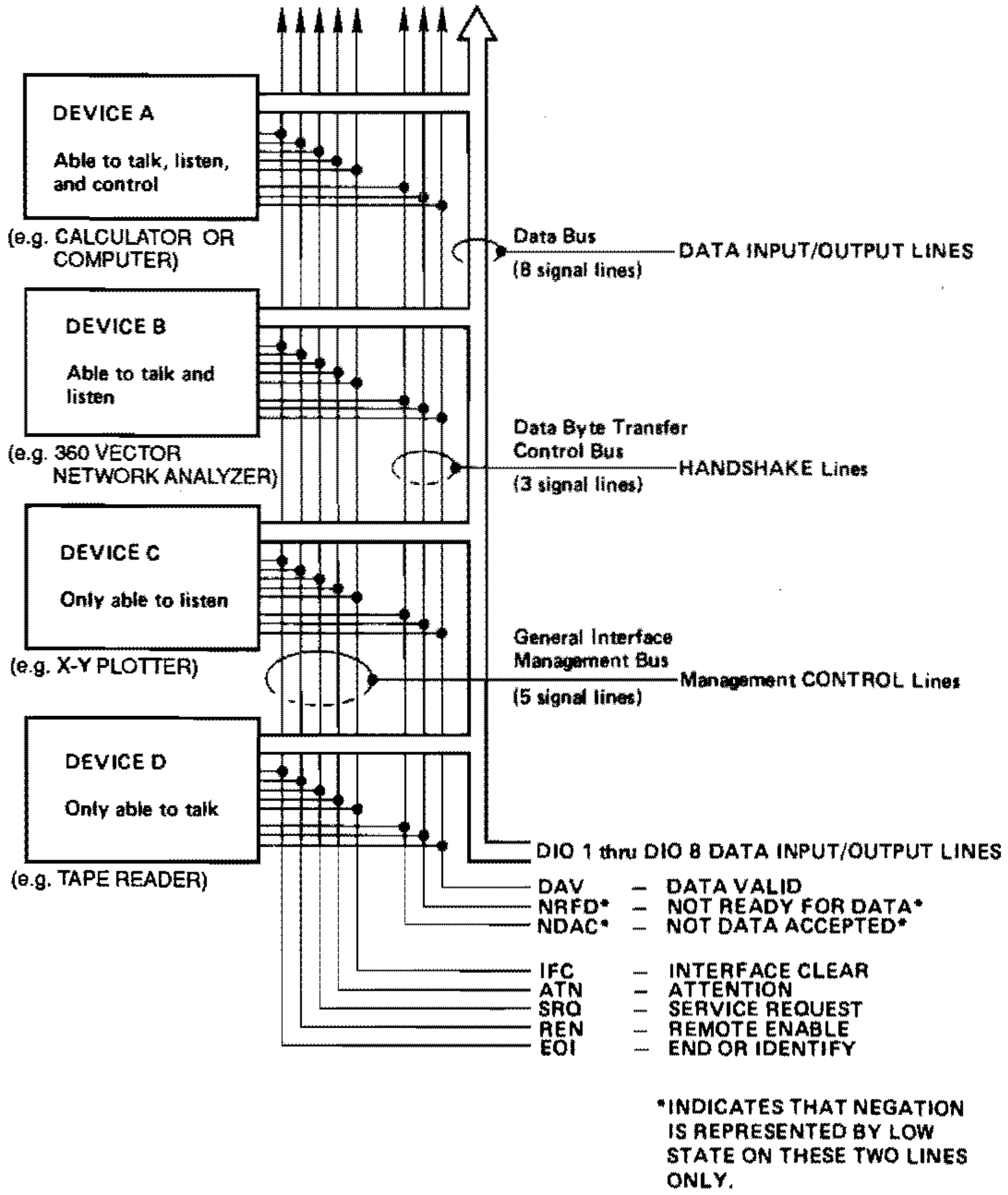


Figure 4-1. Interface Connections and Bus Structure

SECTION IV
GPIB OPERATION — BASIC PROGRAMMING

4-1 INTRODUCTION

This section provides a description of the GPIB and the network analyzer command codes. It also provides several examples of bus programming

4-2 DESCRIPTION OF THE IEEE-488 (IEC-625) INTERFACE BUS

The IEEE-488 General Purpose Interface Bus (GPIB) is an instrumentation interface for integrating instruments, calculators, and computers into systems. The bus uses 16 signal lines to effect transfer of data and commands to as many as 15 instruments.

The instruments on the bus are connected in parallel, as shown in Figure 4-1 (facing page). Eight of the signal lines (DIO 1 thru DIO 8) are used for the transfer of data and other messages in a byte-serial, bit-parallel form. The remaining eight lines are used for communications timing (handshake), control, and status information. Data are transmitted on the eight GPIB data lines as a series of eight-bit characters, referred to as bytes. Data transferral is by means of an interlocked handshake technique.

This technique permits asynchronous communications over a wide range of data rates. The following paragraphs provide an overview of the data, and handshake buses, and describe how these buses interface with the network analyzer.

4-2.1 Data Bus Description

The data bus is the conduit for transmitting information and data between the controller and the network analyzer. It contains eight bi-directional, active-low signal lines. DIO 1 thru DIO 8. One byte of information (eight bits) is transferred over the bus at a time. DIO 1 represents the least-significant bit (LSB) in this byte and DIO 8 represents the most-significant bit (MSB). Each byte represents a peripheral address (either primary or secondary), a control word, or a data byte.

4-2.2 Management Bus Description

The management bus is a group of five lines used to control the operation of the bus system. Functional information regarding the individual control lines is provided below.

a. ***ATN (Attention)***
When this line is TRUE, the network analyzer responds to appropriate interface messages such as, device clear and serial poll and to its own listen/talk address.

b. ***EOI (End Or Identify)***
When this line is TRUE, the last byte of a multibyte message has been placed on the line. The line is also used in conjunction with ATN to indicate a parallel poll.

c. ***IFC (Interface Clear)***
When this line is TRUE, the network analyzer's interface functions are placed in a known state such as, unaddressed to talk, unaddressed to listen, and service request idle.

d. ***REN (Remote Enable)***
When this line is TRUE the network analyzer is enabled upon receipt of its listen address for entry into the remote state. This mode is exited either when the REN line goes FALSE (high) or when the network analyzer receives a go-to-local (GTL) message or an RTL (return to local) command.

e. ***SRQ (Service Request)***
This line is pulled LOW (true) by the network analyzer to indicate that certain preprogrammed conditions exist.

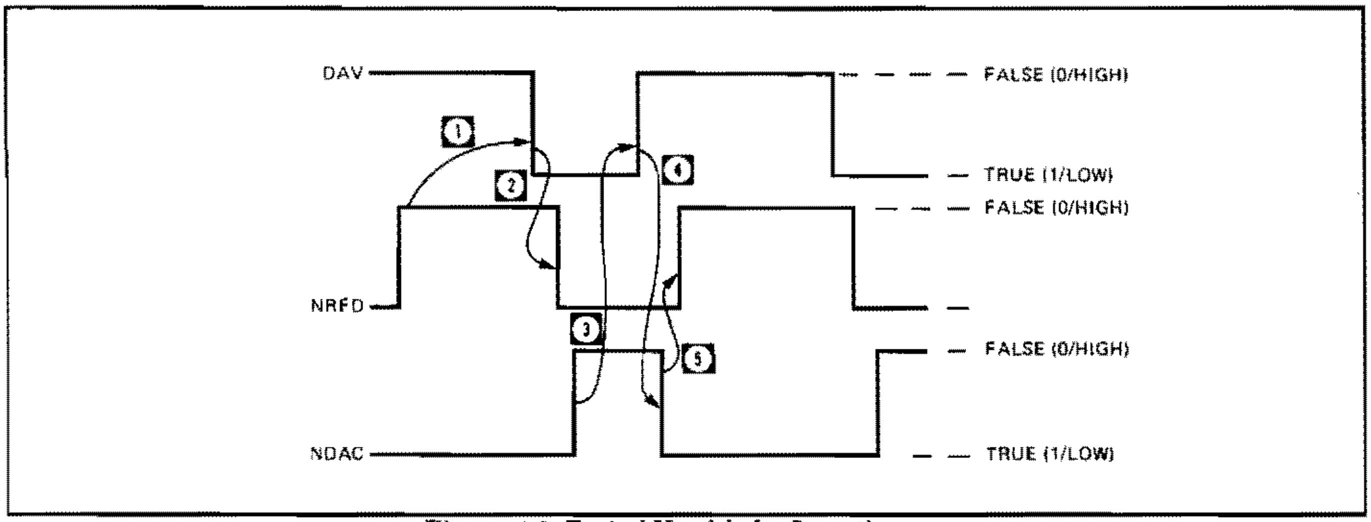


Figure 4-2. Typical Handshake Operation

4-2.3 Data Byte Transfer Control (Handshake) Bus Description

Information is transferred on the data lines by a technique called the three-wire handshake. The three handshake-bus signal lines (Figure 4-2) are described below.

a. ***DAV (Data Valid)***
This line goes TRUE (arrow 1) when the talker has (1) sensed that NRFD is FALSE, (2) placed a byte of data on the bus, and (3) waited an appropriate length of time for the data to settle.

b. ***NRFD (Not Ready For Data).***
This line goes TRUE (arrow 2) when a listener indicates that valid data has not yet been accepted. The time between the events shown by arrows 1 and 2 is variable and depends upon the speed with which a listener can accept the information.

c. ***NDAC (Not Data Accepted).***
This line goes FALSE to indicate that a listener has accepted the current data byte for internal processing. When the data byte has been accepted, the listener releases its hold on NDAC and allows the line to go FALSE. However, since the GPIB is constructed in a wired-OR configuration, NDAC will not go FALSE until all listeners participating in the interchange have also released the line. As shown by arrow 3, when NDAC goes FALSE, DAV follows suit a short time later. The FALSE state of DAV indicates that valid data has been removed; consequently, NDAC goes LOW in preparation for the next data interchange (arrow 4).
Arrow 5 shows the next action in time: NRFD going FALSE after NDAC has returned TRUE. The FALSE state of NRFD indicates that all listeners are ready for the next information interchange. The time between these last two events is variable and depends on how long it takes a listener to process the data byte. In summation, the wired-OR construction forces a talker to wait for the slowest instrument to accept the current data byte before placing a new data byte on the bus.

4-3 GPIB OPERATION

All front panel keys, except for LINE ON/ OFF, are bus controllable. When used on the GPIB, the network analyzer functions as both a listener and a talker. Table 4-1 provides a listing of the GPIB subset functions and gives the capability for each.

4-4 COMMAND CODES, DESCRIPTION

The following paragraphs and tables describe the various GPIB command codes used by the 360.

Table 4-1. 360 IEEE-488 Bus Subset Capability

GPIB SUBSET	FUNCTION	DESCRIPTION
AH1	Acceptor Handshake	Complete Capability
SH1	Source Hand-shake	Complete Capability
T6	Talker	No Talk Only (TON)
TE0	Talker With Ad-dress Extension	No Capability
L4	Listener	No Listen Only (LON)
LE0	Listener With Ad-dress Extension	No Capability
SR1	Service Request	Complete Capability
RL1	Remote/ Local	Complete Capability
PP1	Parallel Poll	Complete Capability
DC1	Device Clear	Complete Capability
DT1	Device Trigger	Complete Capability

4-4.1 Command Codes: Classifications

The GPIB interface for the 360 uses more than 300 commands to implement the various functions. For descriptive purposes, the commands are organized into functional classifications, as shown in Table 4-2. The paragraph, table and page numbers where the codes are described in detail are also provided. An alphabetical listing of the command codes is provided in Table 4-3. Both of these tables include codes that are described in Section V, GPIB Operation—Advanced Programming.

4-4.2 Command Codes: Syntax And Programming Tips

a. Syntax

All mnemonics are three characters long and may be entered in either upper or lower case. Mnemonics which require data *must* have a valid terminator mnemonic after the data. Separators between mnemonics and either data or other mnemonics are optional.

b. Programming Tips

The 360 is a "channel-based" instrument, which means that most commands apply only to the current active channel. Therefore, to set up a desired state on multiple channels, a CH1 - CH4 mnemonic should precede the setup. For example:

"D14 CH1 S11 SMI CH2 S12 MPH CH3 S21 MAG CH4 S22 ISM"

This string sets up a quad display (D14) and then sets the s- parameter and graph type desired for each Channel (Channel 1: S_{11}, Smith chart; Channel 2: S_{12}, log magnitude and phase; Channel 3: S_{21}, log magnitude; Channel 4: S_{22}, inverted Smith chart).

Other command codes are "global" in their extent, meaning they apply to all channels. Examples of these mnemonics: start/stop frequency (SRT,STP), averaging (AVG, AOF), and source power (PWR).

4-4.3 Command Codes: Response To Errors

The following describes how the 360 responds to error conditions

a. Syntax Error

The 360 beeps and sends a Service Request (SRQ), if enabled. It also ignores any further commands until it is programmed to talk or be unlistened.

b. Parameter Out Of Range Error

The 360 moves the cursor to be adjacent to the erroneous entry, beeps, displays the entry in red and sends an SRQ (if enabled). The error is cleared upon execution of the next instruction.

c. Action Requested Not Possible

The 360 sends an SRQ (if enabled) and ignores the command.

Table 4-2 . Command Code Classes (1 of 2)

Cmmand Code	Description	Para.	Table	Page
Channels	DSP, D13 , D24, D14, CH1, CH2, CH3, CH4	4-4.4	4-4	4-16
Data entry	0 thru 9, -, ., GHZ, MHZ, KHZ, PSC, NSC, USC, DBL, DBM, DEG, MMT, CMT, MTR, XX1, XX3, XM3, REU, IMU	4-4.5	4-5	4-16
Measurement Control	S11, S21, S22, S12, SRT, STP, PWR, CWF, FHI, FME, FLO, HLD, TRS, CTN, WFS, SA1, SA2, TA2, SWP	4-4.6	4-6	4-17
Display Control	MAG, PHA, MPH, SWR, SMI, ISM, SME, ISE, SMC, ISC, DLA, PLR, PLG, LIN, LPH, REL, IMG, RIM, SCL, OFF, REF, ASC, APR	4-4.7	4-7	4-19
Enhancement	IFN, IFR, IFM, AVG, AOF, SON, SOF	4-4.8	4-8	4-22
Reference Delay	RDD, RDT, RDA, DIA, DIT, DIP, DIM, DIE	4-4.9	4-9	4-22
Trace Memory	DAT, MEM, DTM, DNM, MIN, DIV, ADD, MUL, STD, SDK, RCK	4-4.10	4-10	4-23
Markers	MK1 – MK6, MOF, MON, MO1 – MO6, DR1 – DR6, DRO, DRF, MR1 – MR6, MMN, MMX, M1S – M6S, M1E – M6E, M1C – M6C	4-4.11	4-11	4-25
Limits	LUP, LLO, LON, LOF, LFR, LFD, LFP	4-4.12	4-12	4-26
Hard copy output	TDD, PFS, PGR, PMK, PTB, PMT, PT0 – PT9, PST, FFD, PLS, PLD, PLT, PMN, PLH, PGT, PFL, PTL, PTR, PBL, PBR, DPN, GPN, MPN, HPN, LDT, LNM, LMS, LID, TDD, RTB, SPD	4-4.13	4-13	4-28
Miscellaneous Functions	RST, FON, FOF, BC0, BC1, BLU, CYN, TST, RTL, DFP, DGS, DCP, DC1, DC3	4-4.14	4-14	4-30
Calibration	C12, C8T, CRF, CFR, CFT, CRL, NOC, SRT, STP, DFC, FRS, FRI, FRP, FIL, DFQ, DFD, CWC, CWF, TDC, P1C, P2C, CMS, CFS, CMK, CFK, CMN, CFN, CM3, CF3, CNG, CND, COO, COS, CC0, CC1, CC2, CC3, BBL, SLD, BEG, TCD, NCS, KEC, CON, COF, A12, A8T, ARF, AFR, AFT, ARL	5-5.1	*	*

Table 4-2. Command Code Classes (2 of 2)

Cmmand Code	Description	Para.	Table	Page
Save/Recall	STO, RLD, SV1 – SV4, RC1 – RC4	5-5.2	*	*
Data Transfer	OM1 – OM6, OAP, OKP, OID, ONP, FMA, FMB, FMC, LSB, MSB, OC1 – OC9, OCA, OCB, OCC, OCL, OCD, IC1 – IC9, ICA, ICB, ICC, ICL, IFV, OFV, OS1 – OS4, OFP, IS1– IS4, IFP, ODR, ORD, OFD, ICD, IFD	5-5.3	*	*
Group Execute Trigger	DEF, END	5-5.4	*	*
Disk Functions	SDK, RCK, STO, RLD, TDD, RTB, DEC, DED, DEN, INT, LKT	5-5.5	*	*
Time Domain	FQD, DBP, TBP, DPI, TPI, DLP, TLP, DCA, DCZ, DCO, DCS, DCV, MRR, LPI , LPS, FGT, GON, GOF, GDS, SRT, STP, GST, GSP, GCT, GSN, GRT, GNM, GLS, GMS, WRT, WNM, WLS, WMS	5-5.6	*	*
Status bytes/SRQ	LPI, LPS, OPB, OEB, IPM, IEM, SQ0, SQ1, CSB	5-5.7	*	*

* Denotes material to be included in Section V of the follow-on packet.

Table 4-3. An Alphabetical List of Command Codes (1 of 9)

Command Code	Description	Para.	Table	Page
ADD	Select Complex Addition as Trace Math	4-4.10	4-10	4-23
AFR	Assume Frequency Response	*	*	*
AFT	Assume Frequency Response – Transmission Only	*	*	*
AOF	Averaging Off	4-4.8	4-8	4-22
APR	Set Group Delay Aperature Percentage	*	*	*
ARF	Assume Reflection Only – One Port	*	*	*
ARL	Assume Frequency Response – Reflection Only	*	*	*
ASC	Autoscale Display	4-4.7	4-7	4-19
AVG (value)	Averaging On and Set to Value	4-4.8	4-8	4-22
A8T	Assume 8 Term	*	*	*

* Denotes material to be included in Section V of the follow-on packet.

Table 4-3 . An Alphabetical List of Command Codes (2 of 9)

Command Code	Description	Para.	Table	Page
A12	Assume 12 Term	*	*	*
BBL	Broadband Load	*	*	*
BC0	Blank CRT	4-4.14	4-14	4-30
BC1	Unblank CRT	4-4.14	4-14	4-30
BEG	Begin Calibration	*	*	*
BLU	Select Blue Color	4-4.14	4-14	4-30
C12	Calibrate Full 12 Term	*	*	*
C8T	Calibrate 8 Term — One Path Two Port)	*	*	*
CC0 – CC3 (value)	Capacitance For Open Device	*	*	*
CFK	Female K Connector™ for the Specified Port	*	*	*
CFN	Female Type N Connector for the Specified Port	*	*	*
CFS	Female SMA Connector for the Specified Port	*	*	*
CFR	Calibrate Frequency Response	*	*	*
CFT	Calibrate Frequency Response — Transmission Only	*	*	*
CH1 – CH4	Select Active Channel 1 Through 4	4-4.4	4-4	4-16
CMK	Male K Connector For The Specified Port	*	*	*
CMN	Male Type N Connector For The Specified Port	*	*	*
CMS	Male SMA Connector For The Specified Port	*	*	*
CMT	Centimeter	4-4.5	4-5	4-16
CM3	Male GPC- 3.5 Connector for the Specified Port	*	*	*
CF3	Female GPC - 3.5 Connector for the Specified Port	*	*	*
CND	Connector Type Other	*	*	*
CNG	Connector Type GPC-7	*	*	*
CNO (value)	Connector Offset Value For "OTHER" connector	*	*	*
COF	Correction Off	*	*	*
CON	Apply Cal Correction	*	*	*
COO (value)	Connector Offset for Open Device	*	*	*
COS (value)	Connector Offset for Short Device	*	*	*
CRF	Calibrate Reflection Only — One Port	*	*	*
CRL	Calibrate Frequency Response — Reflection Only	*	*	*
CSB	Clear Both Status Bytes	*	*	*
CTN	Continue Sweeping From Hold	4-4.6	4-6	4-17
CWC	CW Cal	*	*	*
CWF (value)	CW Frequency	4-4.6	4-6	4-17
CYN	Select Cyan Color	4-4.14	4-14	4-30

Table 4-3 . An Alphabetical List of Command Codes (3 of 9)

Command Code	Description	Para.	Table	Page
D13	Dual Channel 1 and 3 Display	4-4.4	4-4	4-16
D14	Four Channel Display 1 Through 4	4-4.4	4-4	4-16
D24	Dual Channel 2 and 4 Display	4-4.4	4-4	4-16
DAT	Display Data	4-4.10	4-10	4-23
DBL	dB	4-4.5	4-5	4-16
DBM	dBm	4-4.5	4-5	4-16
DBP	Distance Bandpass Mode	*	*	*
DC1	Display Channels 1 and 2 Operating Parameters	4-4.14	4-14	4-30
DC3	Display Channels 3 and 4 Operating Parameters	4-4.14	4-14	4-30
DCA	DC Term For Low Pass, Auto	*	*	*
DCO	DCTerm For Low Pass, Open	*	*	*
DCP	Display Calibration Parameters	*	*	*
DCS	DCTerm For Low Pass, Short	*	*	*
DCV (value)	Set DC Term for Low Pass To Value Specified	*	*	*
DCZ	DC Term for Lowpass, Line Impedance	*	*	*
DEC (filename)	Delete Cal File	*	*	*
DED (filename)	Delete Data File	*	*	*
DEF	Begin Definition of GET Action	*	*	*
DEG	Degree	4-4.5	4-5	4-16
DEN (filename)	Delete Norm File	*	*	*
DFC	Discrete Frequency Cal	*	*	*
DFD	Discrete Frequencies Done	*	*	*
DFP	Display Global Operating Parameters	4-4.14	4-14	4-30
DFQ (value)	Discrete Frequencies	*	*	*
DGS	Display GPIB Status	4-4.14	4-14	4-30
DIA	Set Dielectric Constant to 1.0 for Air	4-4.9	4-9	4-22
DIE (value)	Enter Dielectric Constant	4-4.9	4-9	4-22
DIM	Set Dielectric Constant to 1.69 for Microporous Teflon	4-4.9	4-9	4-22
DIP	Set Dielectric Constant to 2.26 for Polyethylene	4-4.9	4-9	4-22
DIT	Set Dielectric Constant to 2.1 for Teflon	4-4.9	4-9	4-22
DIV	Set Complex Division as Trace Math	4-4.10	4-10	4-23
DLA	Group Delay Display Format	4-4.7	4-7	4-19
DLP	Distance Lowpass Mode	*	*	*
DNM	Display Data Normalized to Memory	4-4.10	4-10	4-23
DPI	Distance Phasor Impulse Mode	*	*	*

Table 4-3 . Alphabetical List of Command Codes (4 of 9)

Command Code	Description	Para.	Table	Page
DPN (value)	Data Pen Number	4-4.13	4-13	4-28
DR1 – DR6	Select Delta Reference Marker	4-4.11	4-11	4-25
DRF	Delta Reference Mode On	4-4.11	4-11	4-25
DRO	Delta Reference Mode Off	4-4.11	4-11	4-25
DSP	Single Channel Display	4-4.4	4-4	4-16
DTM	Display Data and Memory	4-4.10	4-10	4-23
END	End Definition of GET Action	•	•	•
FFD	Form Feed Sent to Printer	•	•	•
FGT	Frequency With Time Gate	•	•	•
FHI	Frequency Resolution High	4-4.6	4-6	4-17
FIL	Fill Range	•	•	•
FLO	Frequency Resolution Low	4-4.6	4-6	4-17
FMA	ASCII Format Data Transfer	•	•	•
FMB	Floating Point Format 64 Bit Data Transfer	•	•	•
FMC	Floating Point Format 32 Bit Data Transfer	•	•	•
FME	Frequency Resolution Medium	4-4.6	4-6	4-17
FOF	Blank All Frequency Information	4-4.14	4-14	4-30
FON	Display All Frequency Information	4-4.14	4-14	4-30
FQD	Frequency Domain	•	•	•
FRI (value)	Fill Range Increment	•	•	•
FRP (value)	Fill Range Points	•	•	•
FRS (value)	Fill Range Start	•	•	•
GCT (value)	Gate Center, Value in Time or Distance	•	•	•
GDS	Gate Symbol Displayed	•	•	•
GHZ	Gigahertz	4-4.5	4-5	4-16
GLS	Gate Shape Low Sidelobe	•	•	•
GMS	Gate Shape Minimum Sidelobe	•	•	•
GNM	Gate Shape Nominal	•	•	•
GOF	Gate Off	•	•	•
GON	Gate On	•	•	•
GPN (value)	Graticule Pen Number	4-4.13	4-13	4-28
GRT	Gate Shape Rectangular	•	•	•
GSN (value)	Gate Span, Value in Time or Distance	•	•	•
GSP (value)	Gate Stop, Value in Time or Distance	•	•	•

Table 4-3 . Alphabetical List of Command Codes (5 of 9)

Command Code	Description	Para.	Table	Page
GST (value)	Gate Start, Value in Time or Distance	*	*	*
HLD	Hold Mode	4-4.6	4-6	4-17
HPN (value)	Header Pen Number	4-4.13	4-13	4-28
IC1 – IC9	Load Cal Coefficients 1 Through 9	*	*	*
ICA – ICC	Load Cal Coefficients 10 Through 12	*	*	*
ICD	Load Corrected Data	*	*	*
ICL	Input 12 Calibration Coefficients in String Format	*	*	*
IEM	Input Extended Status Byte Mask	*	*	*
IFN	Set IF Bandwith to Normal	4-4.8	4-8	4-22
IFR	Set IF Bandwith to Reduced	4-4.8	4-8	4-22
IFM	Set IF Bandwith to Minimum	4-4.8	4-8	4-22
IFD	Load Final Data	*	*	*
IFV	Input List Of Frequencies	*	*	*
IMG	Imaginary Display Format	4-4.7	4-7	4-16
IMU	Imaginary Units	4-4.5	4-5	4-16
INT	Initialize Data Disk	*	*	*
IPM	Input Primary Status Byte Mask	*	*	*
ISC	Select Inverted Compressed Smith Chart for Active Channel	4-4.7	4-7	4-16
ISE (value)	Expand Inverted Smith Chart (10, 20, or 30 dB)	4-4.7	4-7	4-16
ISM	Inverted Smith Chart	4-4.7	4-7	4-16
KEC	Keep Existing Cal	*	*	*
KHZ	Kilohertz	4-4.5	4-5	4-16
LDT (string)	Label Date	4-4.13	4-13	4-28
LFD (value)	Set Limit Delta for Limit Frequency Readout on Active Channel	4-4.12	4-12	4-26
LFP	Select Phase Limit Readout for Active Channel	4-4.12	4-12	4-26
LFR	Select Limit Frequency Readout for Active Channel	4-4.12	4-12	4-26
LIN	Linear Magnitude Display Format	4-4.7	4-7	4-19
LID (string)	Label Device ID	4-4.13	4-13	4-28
LLO (value)	Set Lower Limit	4-4.12	4-12	4-26
LMS (string)	Label Model and Serial Number	4-4.12	4-12	4-26
LNM (string)	Label Operator's Name	4-4.12	4-12	4-26
LOF	Disable Limits	4-4.12	4-12	4-28
LON	Enable Limits	4-4.12	4-12	4-28
LPH	Linear Magnitude and Phase Display Format	4-4.7	4-7	4-19

Table 4-3 . Alphabetical List of Command Codes (6 of 9)

Command Code	Description	Para.	Table	Page
LPI	Lowpass Impulse	*	*	*
LPS	Lowpass Step	*	*	*
LSB	Least Signifigant Byte First Data Transfer Mode	*	*	*
LUP (value)	Set Upper Limit	4-4.12	4-12	4-28
MAG	Log Magnitude Display Format	4-4.7	4-7	4-19
MEM	Display Memory	4-4.10	4-10	4-23
MHZ	Megahertz	4-4.5	4-5	4-16
MIN	Select Complex Subtraction as Trace Math	4-4.10	4-10	4-23
MK1 – MK6(value)	Set Marker To Value	4-4.11	4-11	4-25
MMN	Marker To Min	4-4.11	4-11	4-25
MMT	Millimeter	4-4.11	4-11	4-25
MMX	Marker To Max	4-4.11	4-11	4-25
MO1 – MO6	Markers Off	4-4.11	4-11	4-25
M1C – M6C	Marker Sweep CW Frequency	4-4.11	4-11	4-25
M1E – M6E	Marker Sweep End Frequency	4-4.11	4-11	4-25
M1S – M6S	Marker Sweep Start Frequency	4-4.11	4-11	4-25
MON	Markers Enabled	4-4.11	4-11	4-25
MPH	Log Magnitude and Phase Display Format	4-4.7	4-7	4-19
MPN (value)	Marker Pen Number	4-4.13	4-13	4-28
MR1 – MR6	Marker Selected for Readout and Data Output	4-4.11	4-11	4-25
MRR	Marker Range Restore	*	*	*
MSB	Most Signifigant Byte First Data Transfer Mode	*	*	*
MTR	Meter	4-4.5	4-5	4-16
MUL	Select Complex Multiplication as Trace Math	4-4.10	4-10	4-23
NCS	Next Cal Step	*	*	*
NOC	Normal Cal	*	*	*
NSC	Nanosecond	4-4.5	4-5	4-16
OAP	Output Active Parameter	*	*	*
OC1 – OC9	Output Cal Coefficients 1 Through 9	*	*	*
OCA – OCC	Output Cal Coefficients 10 Through 12	*	*	*
OCD	Output Corrected Data	*	*	*
OCL	Output All 12 Cal Coefficients in String Format	*	*	*
ODR	Output Disk Directory	*	*	*
OEB	Output Extended Status Byte	*	*	*
OFD	Output Final Data	*	*	*

Table 4-3 . Alphabetical List of Command Codes (7 of 9)

Command Code	Description	Para.	Table	Page
OFF (value)	Set Offset Value	4-4.7	4-7	4-19
OFP	Output Front Panel Setup in String Format	*	*	*
OFV	Output Frequency Values	*	*	*
OID	Output Identify	*	*	*
OKP	Output Front Panel Key Pressed	*	*	*
OM1 – OM6	Output Marker Value 1 Through 6	*	*	*
ONP	Output Number Of Data Points	*	*	*
OPB	Output Primary Status Byte	*	*	*
ORD	Output Raw Data	*	*	*
OS1 – OS4	Output Stored Setup In String Format	*	*	*
P1C	Port 1 Connector Specification	*	*	*
P2C	Port 2 Connector Specification	*	*	*
PBL	Plot Bottom Left, 1/4 Screen	4-4.13	4-13	4-28
PBR	Plot Bottom Right, 1/4 Screen	4-4.13	4-13	4-28
PFS	Print Full Screen	4-4.13	4-13	4-28
PGR	Print Graph	4-4.13	4-13	4-28
PGT	Plot Graticule	4-4.13	4-13	4-28
PHA	Phase Display Format	4-4.7	4-7	4-19
PLD	Plot Data Area Only	4-4.13	4-13	4-28
PFL	Full Size Plot	4-4.13	4-13	4-28
PLG	Polar Log Display Format	4-4.7	4-7	4-19
PLH	Plot Header	4-4.13	4-13	4-28
PLM	Plot Markers and Limits	4-4.13	4-13	4-28
PLR	Polar Linear Display Format	4-4.7	4-7	4-19
PLS	Plot Entire Screen	4-4.13	4-13	4-28
PLT	Plot Trace(s)	4-4.13	4-13	4-28
PMK	Print Marker Data Only	4-4.13	4-13	4-28
PMN	Plot Menu	4-4.13	4-13	4-28
PMT	Print Marker And Tabular Data	4-4.13	4-13	4-28
PSC	Picosecond	4-4.5	4-5	4-16
PST	Stop Print /Plot	4-4.13	4-13	4-28
PT0 – PT9	Set Print Tabular Data Density	4-4.13	4-13	4-28
PTB	Print Tabular Data Only	4-4.13	4-13	4-28
PTL	Plot Top left, 1/4 Size	4-4.13	4-13	4-28

Table 4-3 . An Alphabetical List of Command Codes (8 of 9)

Command Code	Description	Para.	Table	Page
PTR	Plot Top Right, 1/4 Size	4-4.13	4-13	4-28
PWR (value)	Set Power Level	4-4.6	4-6	4-17
RC1 – RC4	Recall Front Panel Setup From Internal Memory , Numbers 1 Through 4	4-4.10	4-10	4-23
RCK (filename)	Recall Normalization Data From Disk	4-4.9	4-9	4-22
RDA	Autoadjust Reference Delay	4-4.9	4-9	4-22
RDD (value)	Reference Delay (Value in Distance)	4-4.9	4-9	4-22
RDT (value)	Reference Delay (Value in Time)	4-4.9	4-9	4-22
REF	Set Reference Line of Display on Active Channel	4-4.7	4-7	4-19
REL	Real Display Format	4-4.7	4-7	4-19
REU	Real Units	4-4.5	4-5	4-16
RIM	Real and Imaginary Display Format	4-4.7	4-7	4-19
RLD (filename)	Reload Cal Data And Front Panel Setup From Disk	*	*	*
RST	Reset 360 To Default Parameters	4-4.14	4-14	4-30
RTB (filename)	Recall Tabular Data From Disk	4-4.13	4-13	4-28
RTL	Return to Local	4-4.14	4-14	4-30
S11	Measure S_{11} On Active Channel	4-4.6	4-6	4-17
S12	Measure S_{12} On Active Channel	4-4.6	4-6	4-17
S21	Measure S_{21} On Active Channel	4-4.6	4-6	4-17
S22	Measure S_{22} On Active Channel	4-4.6	4-6	4-17
SA1 (value)	Set Source Attenuator, Port 1	4-4.6	4-6	4-17
SA2 (value)	Set Source Attenuator, Port 2	4-4.6	4-6	4-17
SCL (value)	Set Resolution (scale) of Display	4-4.7	4-7	4-19
SDK (filename)	Store Data on Disk	4-4.10	4-10	4-23
SLD	Sliding Load	*	*	*
SMC (value)	Compressed Smith Chart (dB)	4-4.7	4-7	4-19
SME (value)	Expanded Smith Chart (10, 20 , or 30 dB)	4-4.7	4-7	4-19
SMI	Smith Chart	4-4.7	4-7	4-19
SOF	Smoothing Off	4-4.8	4-8	4-22
SON (value)	Smoothing On and Set to Value	4-4.8	4-8	4-22
SPD (value)	Set Plotter Pen Speed Percentage	4-4.13	4-13	4-28
SQ0	Disable SRQ	*	*	*
SQ1	Enable SRQ	*	*	*
SRT (value)	Start Frequency, Distance, Or Time Value	4-4.6	4-6	4-17
STD	Store Active Channel Data Trace to Memory	4-4.10	4-10	4-23

Table 4-3 . An Alphabetical List of Command Codes (9 of 9)

Command Code	Description	Para.	Table	Page
STO (filename)	Store Cal Data And Front Panel Setup On Disk	•	•	•
STP (value)	Stop Frequency, Distance Or Time Value	4-4.6	4-10	4-23
SV1 – SV4	Save Front Panel Setup to Internal Memory Numbers 1 Through 4	•	•	•
SWP	Select Continuous Sweep Mode	4-4.6	4-10	4-23
SWR	Select SWR Display Format	4-4.7	4-7	4-19
TA2 (value)	Set Test Attenuator , Port 2	4-4.6	4-6	4-17
TBP	Time Bandpass Mode	•	•	•
TCD	Take Cal Data	•	•	•
TDC	Time Domain (Harmonic) Cal	•	•	•
TDD (filename)	Tabular Data to Disk	4-4.13	4-13	4-28
TLP	Time Lowpass Mode	•	•	•
TPI	Time Phasor Impulse Mode	•	•	•
TRS	Trigger / Restart Sweep	4-4.6	4-6	4-17
TST	Self Test	4-4.14	4-14	4-30
USC	Microsecond	4-4.5	4-5	4-16
WFS	Wait Full Sweep	4-4.6	4-6	4-17
WLS	Window Shape Low Sidelobe	•	•	•
WMS	Window Shape Min Sidelobe	•	•	•
WNM	Window Shape Nominal	•	•	•
WRT	Winow Shape Rectangular	•	•	•
XM3	Unitless Terminator X 10^{-3}	4-4.5	4-5	4-16
XX1	Unitless Terminator	4-4.5	4-5	4-16
XX3	Unitless Terminator X 10^{3}	4-4.5	4-5	4-16

4-4.6 Command Codes: Meaurement Control

The command codes listed in Table 4-6 control the parameter being measured on the active channel (S_{11},S_{21},S_{22} & S_{12}) and the basic measurement setup. All command codes except S_{11}, S_{21}, S_{22}, and S_{12} are global, that is, they apply to the entire instrument. The SA1, SA2, and TA2 command codes can only be used with the Models 3630 and 3621 Test Sets with attenuators. Note that the two source attenuators have ranges of 0 to 70 dB while the test attenuator has a range of 0 to 40 dB. The HLD code holds the sweep at the current point and the CTN code continues sweeping from the current point. The TRS command code either restarts the sweep (continuous sweep mode) or triggers a single sweep (in hold

Table 4-6. Measurement Control Command Codes

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
S11	Selects S_{11} as S-Parameter On Active Channel	N/A	N/A
S21	Selects S_{21} as S-Parameter On Active Channel	N/A	N/A
S22	Selects S_{22} as S-Parameter On Active Channel	N/A	N/A
S12	Selects S_{12} as S-Parameter On Active Channel	N/A	N/A
SRT	Sets Start Frequency	Depends On Frequency Range Of Instrument	GHZ,MHZ,KHZ
STP	Sets Stop Frequency	Depends On Frequency Range Of Instrument	GHZ,MHZ,KHZ
CWF	Sets CW Frequency	Depends On Frequency Range Of Instrument	GHZ,MHZ,KHZ
PWR	Sets Source Power	Depends On Power Range Of Source	DBM,XX1,XX3,XM3
FHI	Sets Data Points To Maximum	N/A	N/A
FME	Sets Data Points To Normal	N/A	N/A
FLO	Sets Data Points To Minimum	N/A	N/A
SA1	Sets Source Attenuator For Port 1	0 dB to 70 dB	DBL,DBM,XX1,XX3,XM3
SA2	Sets Source Attenuator For Port 2	0 dB to 70 dB	DBL,DBM,XX1,XX3,XM3
TA2	Sets Test Attenuator For Port 2	0 dB to 40 dB	DBL,DBM,XX1,XX3,XM3
HLD	Holds Sweep At Current Point	N/A	N/A
CTN	Continue Sweep After Hold	N/A	N/A
TRS	Triggers or Restarts a Sweep	N/A	N/A
WFS	Wait full sweep	N/A	N/A
SWP	Selects Continuous Sweep Mode	N/A	N/A

mode). The WFS code causes the 360 to wait a full sweep so that any data on the display is valid. This is useful for scaling the display. It is required when outputting data from the 360, so as to ensure that the data being output is valid (see Section V, paragraph 5-5.3, Command Codes: Data Transfer). The SWP code puts the 360 into continuous swept mode.

4-4.7 Command Codes: Display

The command codes listed in Table 4-7 are for setting up the graph type on the active channel. Most of the commands are straightforward with the exception of the SME, ISE, SMC and ISC codes. Both SME and ISE require values and only allow values of 10, 20, and 30.

Example: `"SME 20 DBL"` This code selects a 20 dB expanded smith chart on the active channel.

Command Codes SMC and ISC also require values and only allow the value 3.

Example: `"SMC 3 DBL"` This code selects a 3 dB compressed smith chart on the active channel.

In addition to the brief description in Table 4-7, codes SCL and REF require additional description as provided in sub-paragraphs a and b, below.

a. SCL Command Code

The SCL code sets the scaling per division of the graph on the active channel. Notice that for graph types with two types of information, the unitless terminators always apply to the *first* type of information.

Example: `"MPH SCL 10 XX1"` This code will select a log magnitude and phase display on the active channel and set the magnitude scaling to 10 dB/div. The only way to scale the degrees part of the graph is by explicit use of the DEG terminator:

Example:`"MPH SCL 45 DEG"` This code selects a log magnitude and phase display on the active channel and sets the phase scaling to 45 degrees/div.

NOTE

Smith charts and inverted Smith charts can not be scaled using the SCL instruction – the different charts are selected using the SME, ISE, SMC, and ISC mnemonics.

b. REF Command Code

The REF mnemonic selects which graticule line will be considered the "reference." Notice that for graphs with one type of information—such as MAG or PHA—the allowable reference line values are 0 to 8, while for graphs with two types of information the reference line value can only be 0 to 4. As described for the SCL code, for graphs having two types of information present, the unitless terminators apply to the first type of information. There is no reference line defined for Smith charts, inverted Smith charts, linear polar, or log polar displays.

Table 4-7. Display Control Command Codes (1 of 3)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
MAG	Selects Log Magnitude Display for Active Channel	N/A	N/A
PHA	Selects Phase Display for Active Channel	N/A	N/A
MPH	Selects Log Magnitude and Phase Display for Active Channel	N/A	N/A
SMI	Selects Normal Smith Chart Display for Active Channel	N/A	N/A
SWR	Selects SWR Display for Active Channel	N/A	N/A
ISM	Selects Inverted Normal Smith Chart Display for Active Channel	N/A	N/A
DLA	Selects Group Delay Display for Active Channel	N/A	N/A
PLR	Selects Linear Polar Display for Active Channel	N/A	N/A
PLG	Selects Log Polar Display for Active Channel	N/A	N/A
LIN	Selects Linear Magnitude Display for Active Channel	N/A	N/A
LPH	Selects Linear Magnitude and Phase Display for Active Channel	N/A	N/A
REL	Selects Real Display for Active Channel	N/A	N/A
IMG	Selects Imaginary Display for Active Channel	N/A	N/A
RIM	Selects Real And Imaginary Display for Active Channel	N/A	N/A
SME	Selects Expanded Smith Chart Display for Active Channel	10, 20, 30	DBL,XX1
ISE	Selects Inverted Expanded Smith Chart Display for Active Channel	10, 20, 30	DBL,XX1
SMC	Selects Compressed Smith Chart Display for Active Channel	3	DBL,XX1
ISC	Selects Inverted Compressed Smith Chart Display for Active Channel	3	DBL,XX1

Table 4-7. Display Control Command Codes (2 of 3)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
SCL	Sets Scaling Of Display On Active Channel	Depends on Graph Type:	Depends on Graph Type:
	Log Mag and Log Polar:	0.001 to 50 dB/div	DBL,XX1,XX3,XM3
	Phase:	0.01 to 90 degrees/div	DEG (,XX1,XX3 XM3 for PHA display)
	Group Delay:	1 femtosecond/div to 999.999 s/div	PSC,NSC,USC
	Linear Mag & Linear Polar:	1 nanounit/div to 999.999 units/div	XX1,XX3,XM3
	Real:	1 nanounit/div to 999.999 units/div	REU,XX1,XX3,XM3
	Imag:	1 nanounit/div to 999.999 units/div	IMU (,XX1,XX3, XM3 for IMG display)
	Smith/inverted Smith:	N/A	N/A
OFF	Set Offset of Display on Active Channel	Depends On Graph Type:	Depends On Graph Type:
	(This code moves the graph's reference position to the offset value)		
	Log Mag & Log Polar:	–999.999 to 999.999 dB	DBL,XX1,XX3,XM3
	Phase:	–180 to180 degrees	DEG (,XX1,XX3, XM3 for PHA display)
	Group Delay:	–999.999 to 999.999 s	PSC,NSC,USC
	Linear Mag & Linear Polar:	0 to 999.999 units	XX1,XX3,XM3
	Real:	–999.999 to 999.999 units	REU,XX1,XX3,XM3
	Imaginary	–999.999 to 999.999 units	IMU (,XX1,XX3, XM3 for IMG display)
	Smith/Inverted Smith:	N/A	N/A
REF	Set Reference Line of Display on Active Channel	Depends on Graph Type:	Depends on Graph Type:
	Log Magnitude, MAG Display:	0 to 8	DBL,XX1,XX3,XM3
	Log Magnitude, MPH Display:	0 to 4	DBL,XX1,XX3,XM3
	Phase, PHA Display:	0 to 8	DEG,XX1,XX3,XM3

Table 4-7. Display Control Command Codes (3 of 3)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
REF(cont)	Phase, MPH Display:	0 to 4	DEG
	Group Delay:	0 to 8	PSC,NSC,USC,XX1, XX3,XM3
	Linear Magnitude, LIN Display:	0 to 8	XX1,XX3,XM3
	Linear Magnitude, LPH Display:	0 to 4	XX1,XX3,XM3
	Real, REL Display:	0 to 8	REU,XX1,XX3,XM3
	Real, RIM Display:	0 to 4	REU,XX1,XX3,XM3
	Imaginary, IMG Display:	0 to 8	IMU,XX1,XX3,XM3
	Imaginary, RIM Display:	0 to 4	IMU
	Smith/Inverted Smith:	N/A	N/A
	Linear Polar/ Log Polar:	N/A	N/A
ASC	Autoscale Display On Active Channel	N/A	N/A
APR	Set Group Delay Aperture Percentage	0 to 20	XX1,XX3,XM3

4-4.8 Command Codes: Enhancement

The command codes listed in Table 4-8 control the data enhancement functions of IF bandwidth, averaging, and smoothing. Note that the maximum averaging number is 4095 and that the maximum smoothing number is 20%.

Table 4-8. Enhancement Command Codes

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
IFN	Selects Normal IF Bandwidth	N/A	N/A
IFR	Selects Reduced IF Bandwidth	N/A	N/A
IFM	Selects Minimum IF Bandwidth	N/A	N/A
AVG	Turns On Averaging and Sets to Value	1 to 4095	XX1,XX3,XM3
AOF	Turns Off Averaging	N/A	N/A
SON	Turns On Smoothing and Sets to Value	0 to 20	XX1,XX3,XM3
SOF	Turns Off Smoothing	N/A	N/A

4-4.9 Command Codes: Reference Delay

The command codes listed in Table 4-9 are used to set up the reference delay applied to a channel and the relative dielectric constant of the system. Note that RDD, RDT, and RDA change the active channel's reference delay while DIA, DIT, DIP, DIM, and DIE change the system's dielectric constant—a global change. The code RDA should only be used if a valid sweep is present.

Table 4-9. Reference Delay Command Codes

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
RDD	Sets Reference Delay As a Distance Value for the Active Channel	–999.999 to 999.999 m	MMT,CMT,MTR
RDT	Sets Reference Delay As a Time Value for the Active Channel	–999.999 to 999.999 us	PSC,NSC,USC
RDA	Selects Automatic Reference Delay for the Active Channel	N/A	N/A
DIA	Selects Air Dielectric (1.00)	N/A	N/A
DIT	Selects Teflon Dielectric (2.10)	N/A	N/A
DIP	Selects Polyethylene Dielectric (2.26)	N/A	N/A
DIM	Selects Microporous Teflon Dielectric (1.69)	N/A	N/A
DIE	Sets Dielectric to Value	1 to 999.999	XX1,XX3,XM3

4-4.10 Command Codes: Trace Memory

The command codes listed in Table 4-10 control the trace memory function on the active channel and the trace math to be applied to it. These codes also provide for storing and retrieving the active channel's trace memory to and from the disk.

In order to view a display that involves trace memory (MEM, DTM and DNM) or to store trace memory to disk, the data for the channel must have been stored to memory first using the STD code.

Example: "**WFS STD DIV DNM**"

This code causes the 360 to

- Wait a full sweep until data is valid (WFS).
- Store data to memory (STD).
- Select complex division as the trace math (DIV).
- Display the data normalized to memory using this trace math (DNM).

Descriptions of the SDK and RCK mnemonics are covered in Section V, paragraph 5-5.5, Command Codes: Disk Functions.

Table 4-10. Trace Memory Command Codes

COMMAND CODE	DESCRIPTION
DAT	Displays Data Trace on Active Channel
MEM	Displays Memory Trace on Active Channel
DTM	Displays Data and Memory Traces on Active Channel
DNM	Displays Measured Data Normalized to Memory on Active Channel
MIN	Selects Complex Subtraction As Trace Math on Active Channel
DIV	Selects Complex Division As Trace Math on Active Channel
ADD	Selects Complex Addition As Trace Math on Active Channel
MUL	Selects Complex Multiplication As Trace Math on Active Channel
STD	Stores Active Channel's Data Trace to Memory
SDK	Stores Active Channel's Trace Memory to Disk Under The Specified File Name
RCK	Retrieves Active Channel's Trace Memory From Disk File Specified

4-4.11 Command Codes : Markers

The command codes listed in Table 4-11 control the location and display of the markers and the functions related to the markers. The MK1 – MK6 codes are used to set a marker to a desired frequency, time or distance. The terminator mnemonics used must match the active channel's domain (frequency, time, or distance)—Otherwise, an action-not-possible error will result.

Example: `"MK1 1.0000 NSC"` on a frequency domain channel generates an action-not-possible error.

Markers can be individually turned off using the MO1 – MO6 codes or markers can be disabled using the MOF code. A marker is turned on whenever any of the following conditions occur:

- When the marker is set to a value, for example: `"MK2 4.5632 GHZ"`.
- When the marker is selected for readout, for example: `"MR2"`
- When the marker is selected as the delta reference marker, for example : `"DR2"`

The MMN and MMX codes move the active marker to the minimum and maximum trace values on the active channel, respectively. There must be an active marker selected for these mnemonics to execute.The M1S – M6S, M1E – M6E and M1C – M6C mnemonics are used to define a marker sweep using the specified marker for either the start, stop, or CW frequency.

Example: `"WFS MR1 MMX M1S"`

This code sequence causes the 360 to

- Wait for a full sweep of data to be present (WFS).
- Turn on marker 1 and select it for readout (MR1).
- Move marker 1 to the maximum value of the trace on the active channel (MMX).
- Set the start frequency equal to the marker frequency (M1S).

Table 4-11. Marker Command Codes

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
MK1 – MK6	Turns On Marker 1 – 6 and Sets Them to Value As Shown Below:		
	Frequency Markers	Limited to Current Sweep Range	GHZ, MHZ, KHZ
	Time Markers:	Limited to Current Zoom Range	PSC, NSC, USC
	Distance Markers:	Limited to Current Zoom Range	MMT,CMT,MTR
MOF	Disables Markers	N/A	N/A
MON	Enables Markers	N/A	N/A
MO1 – MO6	Turns Off Marker 1 – 6	N/A	N/A
DR1 – DR6	Turns On Marker 1 – 6 As Delta Reference Marker	N/A	N/A
DRF	Turns On Delta Reference Marker Mode	N/A	N/A
DRO	Turns Off Delta Reference Marker Mode	N/A	N/A
MR1 – MR6	Selects Marker 1– 6 As Readout Marker	N/A	N/A
MMX	Moves Active Marker to Maximum Trace Value	N/A	N/A
MMN	Moves Active Marker to Minimum Trace Value	N/A	N/A
M1S – M6S	Marker Sweep With Marker 1 – 6 As Start Frequency	N/A	N/A
M1E – M6E	Marker Sweep With Marker 1 – 6 As Stop Frequency	N/A	N/A
M1C – M6C	CW Marker Sweep With Marker 1 – 6 As CW Frequency	N/A	N/A

4-4.12 Command Codes: Limits

The command codes listed in Table 4-12 are used to (1) set up the upper and lower limit values on the active channel and (2) set the limit delta for the limit frequency readout function. The range of values and allowable terminator mnemonics are dependent on the graph type of the active channel much like the SCL, and REF codes described in paragraph 4-4.7. As described for these codes, for graphs with two types of information present, the unitless terminators apply to the first type of information. The second type of limit line value is accessed by explicit use of the appropriate data terminator mnemonic. Examples:

1. `"LUP 20 XX1"` on a log magnitude and phase display: sets the upper limit on the magnitude display to 20 dB.

2. `"LUP 45 DEG"` must be used to set the upper limit on the phase graph.

Table 4-12. Limits Command Codes

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
LUP	Turns On Limit 1 On the Active Channel and sets It to value, as Shown Below	Depends On Graph Type:	Depends On Graph Type:
LLO	Turn On Limit 2 On the Active Channel And set It to Value, as Shown Below	Depends On Graph Type:	Depends On Graph Type:
LFD	Set Limit Delta On Active Channel for Limit Frequency Readout, as Shown Below	Depends On Graph Type:	Depends On Graph Type:
	Log Mag & Log Polar:	–999.999 to 999.999 dB	DBL,XX1,XX3,XM3
	Phase:	–180 to180 degrees	DEG (,XX1,XX3 XM3 for PHA display)
	Group Delay:	–999.999 to 999.999 s	PSC,NSC,USC
	Linear Mag & Linear Polar:	0 to 999.999 U	XX1,XX3,XM3
	Real:	–999.999 to 999.999U	REU,XX1,XX3,XM3
	Imaginary:	–999.999 to 999.999U	IMU (,XX1,XX3,XM3 for IMG display)
	Smith/Inverted Smith:	0 to 1.413 units	XX1,XX3,XM3
LOF	Disables Limits On Active Channel	N/A	N/A
LON	Enables Limits On Active Channel	N/A	N/A
LFR	Selects Limit Frequency Readout for Active Channel	N/A	N/A
LFP	Selects Phase Limit Frequency Readout for Active Channel for Log Magnitude/linear Magnitude and Phase Displays	N/A	N/A

NOTE

The LFR, LFP, and LFD mnemonic codes, which deal with limit frequency readouts, are only available on the following graph types: log magnitude (MAG), log magnitude and phase (MPH), phase (PHA), linear magnitude (LIN), linear magnitude and phase (LPH), standing wave ratio (SWR), and group delay (DLA). The active channel must be a frequency domain channel. The LFP code can be used to select phase limit frequency readouts on log magnitude and phase and linear magnitude and phase graph types. If the LFR code is used on either of these graph types, the magnitude limit frequency readout menu for the channel is displayed.

4-4.13 Command Codes: Hard Copy

The command codes concerned with hard copy are listed in Table 4-13. These commands are straightforward with the exception of PT0 – PT9. These ten codes set up (1) the density of tabular data points output to the printer for PTB and PMT and (2) the number of data points included in the output file for TDD (tabular data to disk). The number in the PT0 – PT9 mnemonic codes specifies the number of points that are *skipped* during the print. Therefore, PT0 selects the *densest* printing mode while PT9 gives the *fewest* number of data points.

The command codes for plotting fall into two categories: *setup* and *action*. The setup codes are those that specify the desired size and location of the plot (PFL, PTL, PTR, PBL, PBR) and the pen numbers for each element of the plot (DPN, GPN, MPN, HPN). The action mnemonics actually initiate a plot for the subset of the display desired (PLS, PLD, PLT, PMN, PLM, PLH, PGT).

The LMS, LID, LDT, and LNM codes require a string of characters to be sent over the GPIB along with the mnemonic. A string input to the 360 *must* have the quote characters (" ") surrounding the desired characters for the string and *cannot* exceed the maximum number of characters specified for the mnemonics. An example of embedding quote characters in a string sent to the 360 is shown in Figure 4-3. This example is in HP 85 BASIC.

The TDD code allows for outputting tabular data under the current print density mode (PT0 – PT9) to an ASCII file. The RTB code causes the 360 to read an ASCII file assumed to be print data and output it to the printer.

NOTE

The maximum file size that can be handled with the RTB code is 58,000 bytes. Further description of the syntax and operation of the TDD and RTB codes are covered in Section V, paragraph 5-5.5, Command Codes: Disk Functions.

```
10  ! EXAMPLE ON USE OF STRINGS
20 Q$=CHR$(34) ! QUOTE SYMBOL
30 M$="4_TO_8_FILTR" ! MODEL
40 I$="456789" ! I.D.
50 D$="8/25/87" ! DATE
60 O$="GPIB_WHIZ" ! OPERATOR
70 OUTPUT 706 "LMS"&Q$&M$&Q$
80 OUTPUT 706 "LID"&Q$&I$&Q$
90 OUTPUT 706 "LDT"&Q$&D$&Q$
100 OUTPUT 706 "LNM"&Q$&O$&Q$
110 END
```

Figure 4-3 An Example of Hard Copy Code Using Embedded quotes

Table 4-13. Hard Copy Command Codes (1 of 2)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
PFS	Prints Full Screen	N/A	N/A
PGR	Prints Graph Area Only	N/A	N/A
PMK	Prints Tabular Marker Data	N/A	N/A
PTB	Prints Tabular Trace Data	N/A	N/A
PMT	Prints Tabular Marker and Trace Data	N/A	N/A
PT0—PT9	Selects Tabular Printout Point Density	N/A	N/A
PST	Stops Print/Plot	N/A	N/A
FFD	Printer Form Feed	N/A	N/A
PLS	Plots Entire Screen	N/A	N/A
PLD	Plots Graph Area	N/A	N/A
PLT	Plots Data Trace(s)	N/A	N/A
PMN	Plots Menu	N/A	N/A
PLM	Plots Markers and Limits	N/A	N/A
PLH	Plots Header	N/A	N/A
PGT	Plots Graticule	N/A	N/A
PFL	Selects Full Size Plot	N/A	N/A
PTL	Selects 1/4 Size Plot, Top Left	N/A	N/A
PTR	Selects 1/4 Size Plot, Top Right	N/A	N/A
PBL	Selects 1/4 Size Plot, Bottom Left	N/A	N/A
PBR	Selects 1/4 Size Plot, Bottom Right	N/A	N/A
DPN	Sets Pen Number for Plotting Data	1 to 8	XX1
GPN	Sets Pen Number for Plotting Graticule	1 to 8	XX1
MPN	Sets Pen Number for Plotting Markers and Limits	1 to 8	XX1
HPN	Sets Pen Number for Plotting Header	1 to 8	XX1
LMS	Labels Model and Serial Number of Device	String of Characters Up To 12 Characters Long	N/A

Table 4-13. Hard Copy Command Codes (2 of 2)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
LDT	Labels Date of Test	String of Characters Up to 12 Characters Long	N/A
LID	Labels Device ID	String of Characters Up to 12 Characters Long	N/A
LNM	Labels Operator's Name	String of Characters Up to 12 Characters Long	N/A
TDD	Stores Tabular Data to Disk in File Specified (See File Naming Conventions In Paragraph 5-5.5)	N/A	N/A
RTB	Recalls Tabular Data From Disk File Specified to Printer	N/A	N/A
SPD	Sets Plotter Pen Speed Percentage	10 to 100	XX1,XX3,XM3

4-4.14 Command Codes: Miscellaneous

Table 4-14 list the miscellaneous command codes. These are codes that do not fit into any of the other listed categories .

Table 4-14. Miscellaneous Command Codes

COMMAND CODE	DEFINITION	NOTES
RST	Resets 360 to Its Default State	Similar to pressing the "DEFAULT PROGRAM" key.
FOF	Implements Frequency Blanking	Instructs the 360 to blank any frequency information from the screen and any hard copy output. This code is useful for security reasons.
FON	Disables Frequency Blanking	Frequency blanking can be turned off using this code.
BC0	Implements Display Blanking	Allows for the ultimate in security — a totally blank screen. In this mode, the 360 is fully operational over the GPIB but nothing appears on the display.
BC1	Disables Display Blanking	Screen blanking is turned off using the BC1 mnemonic.
BLU	Selects Blue As 3rd Color Plane Color	Allows selection of the third color used by the 360 for markers, limits, and some menu annotation.
CYN	Selects Cyan As 3rd Color Plane Color	Allows selection of the third color used by the 360 for markers, limits, and some menu annotation.
TST	Runs A Self Test	Instructs the 360 to perform a self test. An error in the self test would be reported in the primary status byte, bit 7 (see paragraph 5-5.7).
RTL	Returns to Local Control	Performs the same function as the control panel RETURN TO LOCAL key. This code has no effect if the 360 is in local lockout.
DFP	Displays Global Operating Parameters	Displays Global Operating Parameters in the data area of the screen.
DGS	Displays GPIB System Parameters	Displays GPIB System Parameters in the data area of the screen.
DCP	Displays Calibration Parameters	Displays Calibration Parameters in the data area of the screen.
DC1	Displays Channel 1 and 2 Operating Parameters	Displays Channels 1 and 2 Operating Parameters in the data area of the screen.
DC3	Displays Channel 3 and 4 Operating Parameters	Displays Channels 1 and 2 Operating Parameters in the data area of the screen.

4-5 BUS MESSAGES, 360 RESPONSE TO

Table 4-15 provides a list of IEEE–488 bus messages and describes how the 360 responds to each.

Table 4-15. 360 Response to IEEE–488 Bus Messages

COMMAND CODE	DEFINITION	NOTES
DCL, SDC	Device Clear Selected Device Clear	Resets the 360 to its default state. Equivalent to the RST command.
GTL	Go to local	Returns the 360 to local (control panel) control.
GET	Group Execute Trigger	Executes a string of commands defined by the DEF ... END mnemonics. *NOTE* The GET command is buffered and executed in-line with other commands.
IFC	Interface Clear	Stops the 360 GPIB from talking/listening.
LLO	Local Lockout	Disables the control panel RETURN TO LOCAL key.
REN	Remote Enable	Places the 360 in remote when addressed to listen.
SPE	Serial Poll Enable	Outputs the binary status byte.
SPD	Serial Poll Disable	Disables the serial poll function.
PPC	Parallel Poll Configure	Sets the assigned bus line to reflect its SRQ status.
PPE	Parallel Poll Enable	Enables the 360 for parallel poll operation.
PPU	Parallel Poll Unconfigure	Cancels any previous parallel poll configurations.
PPD	Parallel Poll Disable	Disables the parallel polling function.

SECTION V
GPIB OPERATION —
ADVANCED PROGRAMMING

CONTENTS

SECTION V
GPIB OPERATION — ADVANCED PROGRAMMING

5-1 INTRODUCTION

This section describes the more complex GPIB functions available on the 360. The topics covered in this section are:

- Calibration
- Save/Recall
- Data Transfer
- Group Execute Trigger
- Disk Functions
- Time Domain
- Status Byte Handling

This section assumes the reader is familiar with the material covered in Section IV.

5-2 ADVANCED COMMAND CODES: DESCRIPTIONS

The following tables and paragraphs describe the functions and usage of the advanced GPIB command codes. They also provide programming examples.

5-2.1 Advanced Command Codes: Calibration

Table 5-1 lists the calibration command codes. They are used to:

- Specify the calibration method desired.
- Specify the type of calibration desired.
- Specify the calibration standards used for the calibration.
- Specify the transmission line type and its characteristics used.
- Control the calibration data-taking process.

In addition to the brief descriptions of the calibration codes given in Table 5-1, the following paragraphs provide a more detailed description of many of the calibration codes.

a. ***Specify Normal 501 Point Calibration (NOC)***
This code sets up a normal frequency range calibration.

b. ***Enter Start Frequency for Normal Calibration (SRT)***
This code sets the *lower limit* of the range of frequencies used for the calibration process.

c. ***Enter Stop Frequency for Normal Calibration (STP)***
This code sets the *upper limit* of the range of frequencies used for the calibration process.

d. ***Specify Discrete Frequency Calibration (DFC)***
This code sets up a calibration at discrete frequencies only.

1. Only the points entered using the DFQ, IFV, FRS, FRI, FRP, or FIL codes are used in calibration (2 ≤ number of points ≤ 501).
2. The IFV code allows for a frequency list input of calibration frequencies. Refer to paragraph 5-2.4, Advanced Command Codes: Data Transfer for more details.

e. ***Specify CW Calibration (CWC)***
This code sets up a *continuous wave* (CW) calibration.

f. ***Enter CW Frequency for Calibration (CWF)***
This code is used to enter the frequency employed in the CW calibration.

g. ***Set up to Specify Port One Calibration Standards (P1C)***
This code specifies port one as the port that the subsequent connector-related codes apply to.

h. ***Set up to Specify Port Two Standards (P2C)***
This code specifies port two as the port that the subsequent connector-related codes apply to.

Example:

"P1C CFK P2C CMK"

This sequence of codes sets up a female K connector for port 1 (P1C CFK) and a male K connector for port 2 (P2C CMK).

i. ***Other Connector Specification (CND)***
This code allows a non-standard connector to be specified. This is the same as selecting OTHER from the control panel menu. When specifying the CND code, the connector offset for the open and/or short device and the capacitance coefficients for the open device are entered to characterize the connector.

j. ***Specify Sliding Load for Calibration (SLD)***
This code specifies a sliding load. If specifying the SLD code, the data-taking process for the load includes six slide positions. If any frequencies are below 2 GHz, you *must* use a broadband load.

Table 5-1. Calibration Command Codes (1 of 3)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
RPC	Repeat Previous Calibration	N/A	N/A
LTC	Specify Coaxial Line Type	N/A	N/A
LTU	Specify Microstrip Line Type	N/A	N/A
LTW	Specify Waveguide Line Type	N/A	N/A
SCM	Specify Standard Calibration Method	N/A	N/A
OCM	Specify Offset Short Calibration Method	N/A	N/A
LCM	Specify LRL Calibration Method	N/A	N/A
C12	Begin 12-term Calibration	N/A	N/A
C8T	Begin 8-term (1 Port) Calibration	N/A	N/A
CRF	Begin Reflection Only (1 Port) Calibration	N/A	N/A
CFR	Begin Frequency Response Calibration	N/A	N/A
CFT	Begin Transmission Only Frequency Response Calibration	N/A	N/A
CRL	Begin Reflection Only Frequency Response Calibration	N/A	N/A
NOC	Specify Normal 501-point Calibration	N/A	N/A
DFC	Specify Discrete Frequency Calibration	N/A	N/A
CWC	Specify CW Calibration	N/A	N/A
TDC	Specify Time Domain Harmonic Calibration	N/A	N/A
SRT	Enter Start Frequency for Normal or Harmonic Calibration	Depends on Frequency Range of Instrument	GHZ,MHZ,KHZ
STP	Enter Stop Frequency for Normal or Harmonic Calibration	Depends on Frequency Range of Instrument	GHZ,MHZ,KHZ
DFQ	Enter Discrete Frequency for Calibration	Depends on Frequency Range of Instrument	GHZ,MHZ,KHZ
CWF	Enter CW Frequency for Calibration	Depends on Frequency Range of Instrument	GHZ,MHZ,KHZ

Table 5-1. Calibration Command Codes (2 of 3)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
FRS	Enter Fill Range Start Frequency	Depends on Frequency Range of Instrument	GHZ,MHZ,KHZ
FRI	Enter Fill Range Frequency Increment	Depends on Frequency Range of Instrument	GHZ,MHZ,KHZ
FRP	Enter Fill Range Number of Points	1 to (501 – Current Number of Points)	XX1, XX3, XM3
IFV	Input Frequency List for Calibration	List of Frequencies in Current Data Format	N/A
FIL	Fill Frequency Range Defined by FRS, FRI, and FRP	N/A	N/A
DFD	Discrete Frequency Entry Done	N/A	N/A
WCO	Enter Waveguide Cutoff Frequency	0 – Current Start Frequency	GHZ, MHZ, KHZ
VSW	Enter Microstrip Width	0.001 mm – 1.0 m	MMT, CMT, MTR
SBT	Enter Microstrip Substrate Thickness	0.001 mm – 1.0 m	MMT, CMT, MTR
SBD	Enter Microstrip Substrate Relative Dielectric Constant	1.0 – 9999.99	XX1, XX3, XM3
USE	Enter Microstrip Effective Relative Dielectric Constant	1.0 – 9999.99	XX1, XX3, XM3
USZ	Enter Microstrip Characteristic Impedance	1.0 – 9999.99	XX1, XX3, XM3
P1C	Set Up to Specify Port 1 Calibration Standards	N/A	N/A
P2C	Set Up to Specify Port 2 Calibration Standards	N/A	N/A
CMS	Male SMA Connector for Specified Port	N/A	N/A
CFS	Female SMA Connector for Specified Port	N/A	N/A
CMK	Male K™ Connector for Specified Port	N/A	N/A
CFK	Female K Connector for Specified Port	N/A	N/A
CMN	Male Type N Connector for Specified Port	N/A	N/A
CFN	Female Type N Connector for Specified Port	N/A	N/A
CM3	Male GPC-3.5 Connector for Specified Port	N/A	N/A
CF3	Female GPC-3.5 Connector for Specified Port	N/A	N/A
CNG	GPC-7 Connector for Specified Port	N/A	N/A
CND	Other Connector Specification	N/A	N/A
COO	Connector Offset for Open Device	–999.999 m to 999.999 m	MMT, CMT, MTR
COS	Connector Offset for Short Device	–999.999 m to 999.999 m	MMT, CMT, MTR
CC0	Capacitance Coefficient for Open Device, Implied X 10 E-15	–999.999 to 999.999	XX1
CC1	Capacitance Coefficient for Open Device, Implied X 10 E-27	–999.999 to 999.999	XX1

Table 5-1. Calibration Command Codes (3 of 3)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
CC2	Capacitance Coefficient for Open Device, Implied X 10 E-36	–999.999 to 999.999	XX1
CC3	Capacitance Coefficient for Open Device, Implied X 10 E-45	–999.999 to 999.999	XX1
BBL	Specify Broadband Load for Calibration	N/A	N/A
SLD	Specify Sliding Load for Calibration	N/A	N/A
BEG	Begin Calibration Data Collection Steps	N/A	N/A
TCD	Take Calibration Data for Current Standard	N/A	N/A
NCS	Go on to Next Calibration Step	N/A	N/A
KEC	Keep Existing Calibration	N/A	N/A
COF	Turn Any Vector Error Correction Off	N/A	N/A
CON	Turn Vector Error Correction On If Available	N/A	N/A
A12	Simulate 12-term Calibration	N/A	N/A
A8T	Simulate 8-term (1 Port) Calibration	N/A	N/A
ARF	Simulate Reflection Only (1 Port) Calibration	N/A	N/A
AFR	Simulate Frequency Response Calibration	N/A	N/A
AFT	Simulate Transmission Only Frequency Response Calibration	N/A	N/A
ARL	Simulate Reflection Only Frequency Response Calibration	N/A	N/A

5-2.2 Advanced Command Codes: Calibration Setup and Examples

To completely specify a calibration setup, a specific order for the mnemonic codes *must* be followed. Table 5-2 illustrates the acceptable order.

Example:

```
" SCM LTC C12 NOC SRT 0.5 GHZ STP 18 GHZ
P1C CMK P2C CMK BBL BEG"
```

The previous example code sets up a standard calibration (SCM), using coax cable (LTC), 12-term calibration (C12), using the normal 501 point calibration mode (NOC), from 0.5 GHz (SRT 0.5 GHZ) to 18 GHz (STP 18 GHZ), using male K-connectors on both ports (P1C PMK P2C CMK), and a broadband load (BBL). The BEG code instructs the 360 to begin the calibration-data-taking-process.

After entering the data-collection portion of the calibration process, the only valid command codes are:

- Take Calibration Data for Current Standard (TCD)
- Go on to the Next Calibration Step (NCS)
- Averaging On and Set to Value (AVG)
- Averaging Off (AOF)
- Set IF Bandwith to Normal (IFN)
- Set IF Bandwith to Reduced (IFR)
- Set IF Bandwith to Minimum (IFM)
- Any Graph Type Specification or Scaling Change
- Active Channel Specification (CH1–CH4)

The TCD and NCS codes control the data-taking process. AVG, AOF, IFN, IFR, and IFM codes control the data-enhancement used for a particular measurement (refer to Section IV, paragraph 4-4.8).

In order to use the TCD and NCS codes, you must be aware of the *exact* calibration sequence the 360 uses for a given calibration. As an example, if we were to continue the 12-term calibration from 0.5 to 18 GHz set up in the previous example, the program segment listed in Figure 5-1 would control the rest of the calibration process. The example is in HP-85 BASIC.

The controller should determine if the 360 is ready for the next step of the calibration sequence before prompting the user to connect new calibration standards to the test ports. This can be done by monitoring the status of the 360 or by requesting "dummy" data output from the 360 after executing the NCS mnemonic code. For example:

```
260 OUTPUT 706;"TCD NCS ONP"
270 ENTER 706; N$    ! READ #POINTS WHEN
STEP IS COMPLETE
280 DISP "CALIBRATION STEP COMPLETE"
```

The previous example code instructs the 360 to take calibration data (TCD), go to the next calibration step (NCS), and output the number of points it is measuring (ONP). When the controller is able to read the points string from the 360, the calibration process is complete.

The CON and COF codes are not used during calibration. They are used during normal measurements to apply the current calibration (CON) or to turn off any applied calibration (COF).

The A12, A8T, ARF, AFR, AFT, and ARL codes simulate the completion of a calibration. When used in this manner, mnemonic codes associated with calibration coefficients (IC1 – IC9, ICA – ICC, OC1 – OC9, OCA – OCC) are matched with the corresponding error terms. For additional information, refer to Table 5-6 on page 5-12.

NOTE

The A12, A8T, ARF, AFR, AFT, and ARL codes match up with corresponding calibration type mnemonics. These are typically used for advanced applications that input calibration coefficients into the 360 (refer to paragraph 5-2.4, Advanced Command Codes: Data Transfer).

Table 5-2. Calibration Code Ordering

Order	Item	Command Code Examples	Required (R) or Optional (O)
1	Line Type	LTC, LTW, LTV	O
2	Calibration Method	SCM, OCM, LCM	O
3	Calibration Type	C12, C8T, CRF, CFR, CFT, CRL	R
4	Data Points	NOC, DFC, TDC, CWC	O
5	Frequency		
	Range	SRT, STP	O
	Discrete	DFQ, IFV, FRS, FRI, FRP, FIL	R
	CW	CWF	O
6	Connector Type /Offset Short Values	P1C, P2C, CMS, CFS, CMK, CFK, CMN, CFN, CM3, CF3, CNG, CND, COO, COS, CC0, CC1, CC2, CC3, SH!, SH2	O
7	Load Type	SLD, BBL	O
8	Begin Data Collection Steps	BEG	R

```
10 ! 1ST STEP - BROADBAND LOADS ON BOTH PORTS
20 DISP "CONNECT LOADS TO BOTH PORTS"
30 DISP "HIT END LINE WHEN READY"
40 INPUT N$
50  ! N$ JUST A "DUMMY" - WAIT FOR USER
60  ! TAKE LOAD MEASUREMENT USING 100 AVERAGES
70  OUTPUT 706;"AVG 100 XX1 TCD NCS"
80  ! 2ND STEP - PORT 1: OPEN, PORT 2: SHORT
90 DISP "CONNECT OPEN TO PORT 1"
100 DISP "CONNECT SHORT TO PORT 2"
110 DISP "HIT END LINE WHEN READY"
120 INPUT N$
130 !TAKE OPEN/SHORT MEASUREMENT WITH 20 AVERAGES
140  OUTPUT 706;"AVG 20 XX1 TCD NCS"
150  !3RD STEP - PORT 1: SHORT, PORT 2: OPEN
160 DISP "CONNECT SHORT TO PORT 1"
170 DISP "CONNECT OPEN TO PORT 2"
180 DISP "HIT END LINE WHEN READY"
190 INPUT N$
200 OUTPUT 706;"TCD NCS"
210  ! 4TH STEP - THROUGH LINE
220 DISP "CONNECT THROUGH LINE"
230 DISP "BETWEEN PORTS"
240 DISP "HIT END LINE WHEN READY"
250 INPUT N$
260  OUTPUT 706;"TCD NCS"
270  ! CALIBRATION COMPLETE - SAVE TO DISK !!!
```

Figure 5-1. A Program for Controlling the Calibration Data Collection

5-2.3 Advanced Command Codes: Save/Recall

The Save/Recall command codes (Table 5-3) allow for saving and recalling (1) front panel setup data to and from internal memory and (2) calibration and front panel setup data to and from the disk. The syntax for entering a file name string to the 360 is the same as for the strings in the LMS, LID, LDT and LNM codes described in Section IV, paragraph 4-4.12.

The double quote characters *must* enclose the string sent to the 360. The 360 accepts only MS-DOS compatible file name characters. Refer to paragraph 5-5.5 Disk Functions for more details on file naming conventions.

Table 5-3. Advanced Command Codes: Save /Recall

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
STO	Store calibration data and front panel setup to disk file.	String for file name up to 8 characters long	N/A
RLD	Recall calibration data and front panel setup from disk file	String for file name up to 8 characters long	N/A
SV1 – SV4	Save front panel setup to internal memory location 1–4	N/A	N/A
RC1 – RC4	Recall front panel setup data from internal memory location 1–4	N/A	N/A

5-2.4 Advanced Command Codes: Data Transfer

Table 5-4 describes the data transfer codes. The 360 transfers data in two basic formats: binary and ASCII. All ASCII data values either output by the 360 or expected on input *must* have the following form:

S $\boxed{\text{x x x}}$. $\boxed{\text{y y y y y y y y y y y y y y y}}$ E $\boxed{\text{s}}$ $\boxed{\text{z z}}$

Where:

S = sign, either blank or "–"

x = digits to the left of the decimal (3)

y = digits to the right of the decimal (15)

E = exponential notation indicator

s = exponent sign, either '+' or '–'

z = digits for exponent (2)

. = decimal point

Separate all ASCII transfers that involve data pairs —such as real and imaginary elements— by commas. For transfers involving more than one item of information, separate each item by a line feed. For example, the 360's response to the commands "FMA OCD" would be:

Repeated Number of Points Times

<Real ASCII>,<Imaginary ASCII><LF> EOI on Last Byte

Binary data transfers involving numerical values use 32-bit or 64-bit floating point numbers in IEEE 754 format. The format of string data, as in a front panel setup, is not user-controllable. Binary data is always sent in the standard block format illustrated in Figure 5-2.

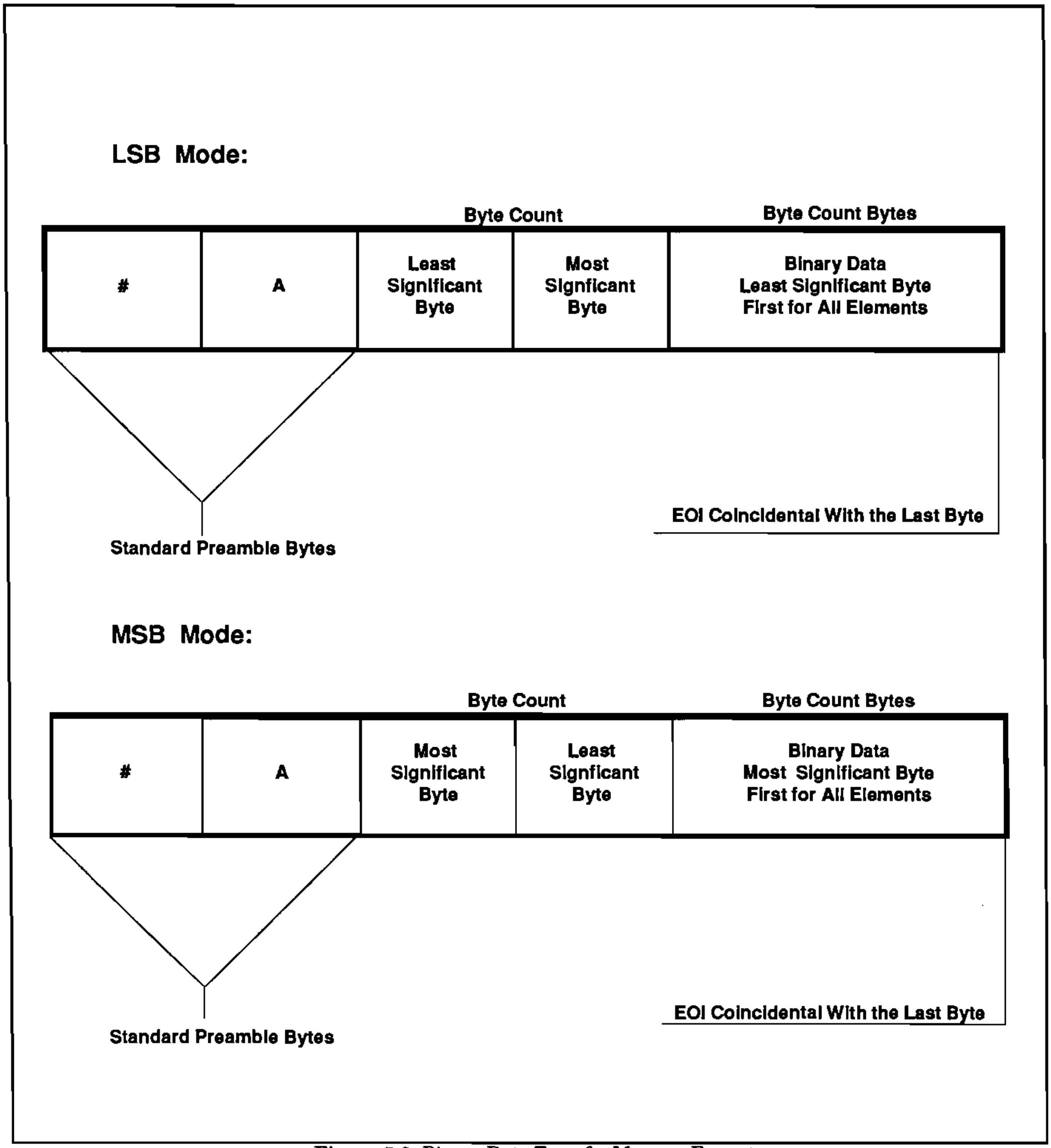


Figure 5-2. Binary Data Transfer Message Format

Table 5-4. Data Transfer Command Codes

COMMAND CODE	DESCRIPTION	DATA FORMATS
OM1 – OM6	Output Marker 1 – 6 Value	ASCII
OAP	Output Active Parameter Value	ASCII
OKP	Output Front Panel Key Pressed	ASCII
OID	Output Identify String	40 byte ASCII String
ONP	Output Number of Points	ASCII
FMA	Select ASCII Data Format	N/A
FMB	Select 64-Bit IEEE 754 Floating Point Data Format	N/A
FMC	Select 32-Bit IEEE 754 Floating Point Data Format	N/A
LSB	Select Least Significant Byte First Data Transfer Mode	N/A
MSB	Select Most Significant Byte First Data Transfer Mode	N/A
OC1 – OC9	Output Calibration Coefficient 1 – 9	FMA, FMB, FMC
OCA – OCC	Output Calibration Coefficient A, B or C	FMA, FMB, FMC
OCL	Output All 12-Term Calibration Coefficients	Binary String
IC1 – IC9	Input Calibration Coefficient 1 – 9	FMA, FMB, FMC
ICA – ICC	Input Calibration Coefficient A, B, or C	FMA, FMB, FMC
ICL	Input All 12-term Calibration Coefficients	Binary String
OFV	Output Frequency Values	FMA, FMB, FMC
IFV	Input List of Frequencies	FMA, FMB, FMC
OS1 – OS4	Output Stored Setup 1 – 4	Binary String
OFP	Output Current Front Panel Setup	Binary String
IS1 – IS4	Input Stored Setup 1 – 4	Binary String
IFP	Input Front Panel Setup	Binary String
ODR	Output Disk Directory	Binary String
ORD	Output Raw (Uncorrected) Data For S-Parameter on Active Channel	FMA, FMB, FMC
OCD	Output Corrected Data for S-Parameter on Active Channel	FMA, FMB, FMC
OFD	Output Final (display Format) Data For S-parameter on Active Channel	FMA, FMB, FMC
ICD	Input Corrected Data For S-Parameter on Active Channel	FMA, FMB, FMC
IFD	Input Final (Display Format) Data For S-Parameter on Active Channel	FMA, FMB, FMC

Table 5-5. Output Values Versus Various GraphTypes

Display Type	Output Values
Log Magnitude	dB,Degrees
Phase	dB,Degrees
Log Mag & Phase	dB,Degrees
Linear Magnitude	Lin Mag(Rho or Tau),Degrees
Linear Mag & Phase	Lin Mag(Rho or Tau),Degrees
Smith Chart	Ohms,Ohms (r + jx)
Inverted Smith	Siemens,Siemens (g + jb)
Group Delay	Seconds,Degrees
Log Polar	dB,Degrees
Linear Polar	Lin Mag(Rho or Tau),Degrees
Real	Real,imag
Imaginary	Real,imag
Real & Imaginary	Real,imag
SWR	SWR, Degrees

The data-format codes (FMA, FMB and FMC) and the byte-ordering codes (LSB and MSB) control the format of the data output or that is expected on input. The data format codes do not affect some data transfers. These codes always output ASCII data or binary data regardless of the current data format. Refer to Table 5-4 for more details.

The most important points to consider about data transfer are (1) the data format to use and (2) the byte ordering desired. When using the FMA data format, the byte ordering selected by the LSB or MSB codes is irrelevant. ASCII data is not dependent on the active byte order. However, even if the 360 is using FMA format, some transfers (such as the OS1 – OS4 codes) still use the binary transfer format affected by the active byte ordering.

Conversely, even if you select FMB or FMC data format, some transfers will always occur in ASCII and are unaffected by the LSB or MSB mnemonic codes.

NOTE

The byte ordering mode (LSB or MSB) also affects the order of the two bytes making up the byte count part of the standard preamble as illustrated in Figure 5-2.

A detailed description of each of the data transfer codes follows:

a. ***OM1 - OM6***
These codes output the value of the trace on the active channel at marker 1– 6. The output is always a pair of ASCII values and is dependent upon the graph type used on the active channel (See Table 5-5).

b. ***OAP***
This code outputs the value of the active parameter as a single ASCII value. If there is no active parameter, a value of 0 is output.

c. ***OKP***
This code outputs a single ASCII value representing the number of the key pressed on the front panel of the 360.

d. ***OID***
This code outputs a 40-byte ASCII string defining the current 360 system configuration. The format of the OID string is shown in Figure 5-3.

Number of Bytes					
4	9	9	6	6	6
xxxx Model #	xx.xxxxxx Low Freq. GHZ	xx.xxxxxx High Freq. GHZ	Sxxx.x Low Pwr dBM	Sxxx.x High Pwr dBM	xxx.xx S.W. Rev.

Figure 5-3. OID Response String

e. ***ONP***
This code outputs the current number of points being measured as a single ASCII value.

f. ***FMA, FMB, FMC***
These codes set up the current active data transfer format.When the current transfer format is unknown, it is a good practice to precede any data transfer mnemonics which depend on these formats with the desired format code.

g. ***LSB, MSB***
These two codes control the ordering of bytes for floating point data transfers. They also control the ordering of the two bytes making up the byte count in the standard block header for binary data transfers. LSB specifies that transfers are to be least significant byte first while MSB specifies most significant byte first.

h. ***OC1–OC9, OCA, OCB, OCC, IC1-IC9, ICA, ICB, ICC, OCL, ICL***

These codes provide for calibration coefficient transfers. Table 5-6 shows the ordering of the calibration coefficients for various calibration types.

For example, if you desire the ETF error term from an 8-term calibration, you would use the OC4 or IC4 codes.

NOTE

Calibration coefficients are output or expected-on-input only for the current sweep frequencies. If data points are not at maximum and/or the frequency range has been zoomed in with error correction turned on, not all calibration coefficients will be output or used on input.

If a request is made for an unavailable calibration coefficient array, the 360 treats it as an impossible request and ignores the command.

i. ***OFV, IFV***

The OFV code outputs the frequencies the 360 is currently measuring.

The IFV code can be used to input an arbitrary list of frequencies into the 360 (2 ≤number of frequencies ≤ 501). This code can be used to specify frequencies to be calibrated at after a calibration type has been specified. IFV can also be used in the normal measurement mode to input frequencies for a special application. In this usage, any existing calibration data is lost.

j. ***OS1 – OS4, OFP***

These mnemonic codes output a binary string of data from either one of the four stored setups (OS1 – OS4) or from the current front panel setup (OFP). The size of a front panel setup is 3 KBytes (3072 bytes).

k. ***IS1 – IS4, IFP***

These mnemonic codes are used to input a binary string of data as stored setup information (IS1– IS4) or as front panel setup information (IFP). The data string must be exactly the length of the string output by the OFP or OS1—OS4 codes and is checked for validity before the operation is performed. If either the number of bytes, or the contents of the string are invalid, a *parameter out of range error* is generated.

Table 5-6. Calibration Coefficient Ordering

	Calibration Type						
Coefficient #	12-term C12	8-term C8T	Reflection Only CRF	Frequency Response CFR	Transmission Freq. Response CFT	Reflection Freq.Response CRL	None
1	EDF	EDF	EDF	ERF	ETF	ERF	-
2	ESF	ESF	ESF	ETF	-	-	-
3	ERF	ERF	ERF	-	-	-	-
4	EXF	ETF	-	-	-	-	-
5	ELF	-	-	-	-	-	-
6	ETF	-	-	-	-	-	-
7	EDR	-	-	-	-	-	-
8	ESR	-	-	-	-	-	-
9	ERR	-	-	-	-	-	-
A	EXR	-	-	-	-	-	-
B	ELR	-	-	-	-	-	-
C	ETR	-	-	-	-	-	-

For the IFP code, if the setup data is valid the 360 will change its setup based on the new front panel setup information.

l. ***ODR***
This code outputs a binary string that is the image of the directory of the current disk in the 360's disk drive. If a disk error occurs, the 360 does a disk-error-status-update and transfers no data. The data string for the directory is exactly 3.5 KBytes (3584 bytes) long.

m. ***ORD, OCD, OFD, ICD, IFD***
These codes transfer data for the s-parameter on the active channel. Only the *current* measurement points will be output (ORD, OCD, OFD) or expected on input (ICD, IFD).

1. The ORD and OCD codes both output data for the s-parameter on the active channel in (real,imaginary) pairs (real, imaginary). Similarly, ICD expects corrected data for the s-parameter on the active channel in pairs.
2. The OFD code outputs data values for the s-parameter on the active channel that depend on the current graph type being used (refer to Table 5-5). The IFD code expects the data being input to match the graph type on the active channel in the same way.
3. When s-parameter data input to the 360 is complete (ICD and IFD) the 360 redraws the s-parameter on the active channel using this data. To prevent the newly drawn data from being overwritten by new measurement data the instrument should be in hold prior to inputting the data.

5-2.5 Data Transfer Program Example and Program Notes

a. Data Transfer Example
Figure 5-4 provides an example program written in Microsoft C. It uses a number of data transfer codes as well as some codes from Section IV. The program is written to run on an IBM-PC or compatible computer with a National Instruments GPIB-PCIIA board and C language interface drivers. The functions performed by the program are:

- Reset the 360 to its default state.
- Read a full array of frequencies from the 360.
- Input a subset of these frequencies into the 360.
- Take S_{21} transmission data.
- Loop this data back into the 360 as error term ETF for a transmission frequency response calibration.
- Turn on correction in the 360 and read in a full corrected sweep of data using this as the error term.
- Print the results on the computer screen.

```
#include "stdio.h"
#include "decl.h"
int pna_360, etf_bytes;
unsigned char ans[10];
/* Array for frequencies in 64-bit form */
double freqs[512];
/* Array to hold the raw S21 data to be used as ETF */
unsigned char etfbufr[512*2*4];
/* Structure template to use for manipulating the block header */
struct std_header
{
char preambl_1;
char preambl_2;
unsigned int msg_count;};
struct std_header hedr;
/* Structure template for the (mag,phase) data pairs for S21 */
struct data_pair
 {
   float dB;
   float degrees;
 };
struct data_pair s21[512];
main()
 {
   int i, num_pts;
   /* Find the 360 on the bus, assuming it's set for address 6 */
   pna_360 = ibfind("DEV6");
   if(pna_360  0)     /* problem finding a device at address 6 */
      printf("ERROR FINDING DEVICE 6");
else
 {
      ibtmo(pna_360,T100s);   /* set the timeout at 100 seconds */
      /* reset to default state, go to high frequency resol. */
      ibwrt(pna_360,"RST FHI",7);
      /* Request frequencies in 64-bit floating point format (LSB) */
      ibwrt(pna_360,"FMB LSB OFV",11);
      /* Read in 1st 4 bytes = header: #A <LSB> <MSB>*/
      ibrd(pna_360,&hedr.preambl_1,4);
      /* Read in rest of data as frequencies */
      /* Byte count in header tells us how much to read */
      ibrd(pna_360,freqs,hedr.msg_count);
      /* Input the first 401 frequencies into the 360 */
      ibwrt(pna_360,"FMB LSB IFV",11);
      hedr.msg_count = (401 * 8);   /* each frequency is 8 bytes long */
      ibwrt(pna_360,&hedr.preambl_1,4); /*output 1st 4 bytes = header*/
      /* Output 401 points of frequency information */
      ibwrt(pna_360,freqs,hedr.msg_count);
      /* 360 is measuring at the inputted frequencies - set up */
      /* for S21 measurement */
      ibwrt(pna_360,"CH1 DSP S21 MPH FHI",19);
      printf("CONNECT THROUGH LINE BETWEEN PORTS.  HIT ENTER WHEN READY\n");
      scanf("%1c",ans);
```

Figure 5-4. A "C" Language Example Program for Data Transfer Using the 360 (1 of 2)

```
      /* Get a full sweep of data and then input raw data */
      /* in 32-bit form into etfbufr[] */
      ibwrt(pna_360,"TRS WFS FMC LSB ORD",19);
      /* Read entire string, INCLUDING HEADER.  Will terminate on EOI */
      ibrd(pna_360,etfbufr,512*4*2);
      etf_bytes = ibcnt;     /* save #bytes read into buffer */
      /* Now we have a full sweep of raw transmission data.  This */
      /* can be used directly as error coefficient ETF for a      */
      /* transmission frequency response calibration.             */
      ibwrt(pna_360,"AFT FMC LSB IC1",15);
      /* "AFT" is used to "fool" the 360 into thinking it has  */
      /* done a trans. frequency response calibration so       */
      /* that cal. coefficient 1 = ETF. Send 360 the IC1 data. */
      ibwrt(pna_360,etfbufr,etf_bytes);
      /* The 360 now has a valid cal. coefficient array - turn */
      /* correction on & get a full error corrected sweep of data */
      ibwrt(pna_360,"CON WFS FMC LSB OFD",19);
      ibrd(pna_360,&hedr.preambl_1,4);     /* read header, then S21 data */
      /* read in S21 data, let read terminate on EOI */
      ibrd(pna_360,&s21[0].dB,(512*4*2));
      /* Print out frequencies and S21 corrected (dB,degrees) data */
      printf("CORRECTED S21 DATA:\n");
      printf("\n");
       printf("  FREQUENCY          MAGNITUDE         PHASE\n");
      printf("    (Hz)               (dB)           (degrees)\n");
      num_pts = (ibcnt / 8); /* each point is (dB,deg) @ 4 bytes each */
      for(i=0; i  num_pts; i++)
         printf("%13e:  %13.6f   %13.6f\n",
         freqs[i], s21[i].dB, s21[i].degrees);
   }
  return
  }
```

Figure 5-4. A "C" Language Example Program for Data Transfer Using the 360 (2 of 2)

b. Data Transfer Program Notes:

- This program uses a large time-out value (100 seconds). This prevents the controller from quitting while the 360 is busy. For example, aftersending `"TRS WFS FMC LSB ORD"` , enough time must be allocated to allow the 360 to complete a new sweep and format the data for output.
- A structure was defined (`struct std_header`) for manipulating the standard block header so that message byte counts are easily accessed.
- All transfers use LSB mode to be compatible with INTEL microprocessors.
- FMB is equivalent to `"double"` in C, FMC is equivalent to `"float"`.
- Before measurement data is read from the 360, the controller sends a `"WFS"` mnemonic to ensure the data is valid.
- Reads can be terminated by (1) reading the header and then using the byte count value or (2) by specifying a maximum value for the transfer count and letting the transfer terminate when the 360 sets the EOI line signaling the end of information.
- The program defines a structure for the S_{21} (mag, phase) data pairs output by the 360 for the OFD code. This allows for easy access to each frequency point's two data values using array indexing.
- The AFT code *must* be sent before the IC1 code so that the 360 can discern what calibration coefficient #1 corresponds to (`ETF` in this example).
- It is good practice to preface a data transfer mnemonic with a format and byte-order mnemonic (ie., "FMB LSB OFV"), although both the format and the byte-order carry on to the next transfer.
- A section of a string may be read (such as the header) followed by the remainder of the string. *However the entire data stream must be read before any subsequent data will be available.*

Table 5-7. Group Execute Trigger Command Codes

COMMAND CODE	DESCRIPTION	VALUES
DEF	Begin Definition of Group Execute Trigger Response	N/A
END	End Definition of Group Execute Trigger Response	N/A

5-2.6 Advanced Command Codes: Group Execute Trigger

The 360 is extremely flexible in its implementation of group execute trigger (GET) functions. There are only two commands specifically designated for implementing group execute trigger functions (DEF and END). However, almost all command codes available on the 360—in any combination—can be set up as the response to a GET.

The response to the GET is set by issuing the DEF code followed by a sequence of command codes terminated with the END code. The sequence of command codes may be any sequence of codes that does not include a data input code. If a data input code is included, the 360 reads the data as additional commands. In this case, a syntax error would most likely occur. The entire string is pre-parsed and compacted. The maximum compacted string size is 255 characters.

An example of the use of DEF and END is shown in the following sequence of codes:

```
"DEF CFT NOC SRT 1 GHZ STP 18 GHZ BEG TCD
NCS MR1 WFS MXM MMN OM1 END"
```

If the preceding sequence of codes is sent to the 360, it is stored as the response to the group execute trigger. The commands between the DEF and END codes will not be executed. From this point on, every time the 360 is triggered by sending the GET code, it will:

- Go through a transmission frequency response calibration from 1 to 18 GHz (CFT NOC SRT GHZ STP 18 GHZ BEG TCD NCS).
- Turn on marker (MR1).
- Wait for a full sweep of data (WFS).
- Move marker 1 to the maximum value on the trace (MMX).
- Output the maximum value (OM1).
- Move marker 1 to the minimum value on the trace (MMN).
- Output the minimum value (OM1).

Thus, every time the 360 is triggered, it outputs the maximum and minimum values for the new calibration just performed.

NOTE

When triggering the 360, the 360 puts the trigger command code (GET) into the command buffer behind any preceding instructions. The commands in the DEF ... END string are executed upon completion of the commands issued prior to the GET code.

5-2.7 Advanced Command Codes: Disk Functions

The Disk Function codes, listed in figure 5-8, are used for the following:

- Reading files from the disk.
- Writing files to the disk.
- Deleting files.
- Formatting a data-only disk.
- Loading calibration kit information from the disk.

All of the Disk Function codes, except the INT and LKT codes, require a file name string. File name strings can be up to 8 characters long and *must* be enclosed by double quote characters (") when they are sent to the 360 (see the descriptions of the LMS, LDT, LID, and LNM codes in Section IV, Paragraph 4-4.12). Only file name characters accepted by MS-DOS are valid. Characters that are *not* acceptable as file names are:

- All ASCII characters with a value lower than the value of the space character (32 decimal).
- . — Decimal Point
- " — Quotation Marks
- / — Slash
- \ — Backslash
- [ ] — Brackets
- : — Colon
- | — Pipe
- > — Greater Than
- < — Less Than
- + — Plus sign
- = — Equal Sign
- ; — Semicolon
- , — Comma

NOTE

Spaces are accepted before characters and after characters but *not between* characters.

Table 5-8. Disk Functions Command Codes

COMMAND CODE	DESCRIPTION	VALUES
SDK	Store Active Channel's Trace Memory to Disk File	String Up to 8 Characters Long for File Name
RCK	Recall Active Channel's Trace Memory From Disk File	String Up to 8 Characters Long for File Name
STO	Store Calibration Data and Front Panel Setup Information to Disk File	String Up to 8 Characters Long for File Name
RLD	Recall Calibration Data and Front Panel Setup Information From Disk File	String Up to 8 Characters Long for File Name
TDD	Store Tabular Printout Data to ASCII Disk File	String Up to 8 Characters Long for File Name
RTB	Recall Tabular Data File From Disk for Output to Printer	String Up to 8 Characters Long for File Name
DEC	Delete Calibration and Front Panel Setup File From Disk	String Up to 8 Characters Long for File Name
DED	Delete Tabular Printout Data File From Disk	String Up to 8 Characters Long for File Name
DEN	Delete Trace Memory File From Disk	String Up to 8 Characters Long for File Name
INT	Initialize (Format) Disk in Drive as a Data-Only Disk	N/A
LKT	Load Calibration Kit Information From Disk	N/A

Examples of the disk function command codes useage are shown in Figure 5-5.

CAUTION

The INT code immediately formats the disk in the 360's drive. Any data on the disk will be destroyed. Use this mnemonic carefully.

```
! EXAMPLE 1 - SAVE CAL AND FRONT
! PANEL SETUP TO DISK
Q$ = CHR$(34)      ! DOUBLE QUOTE SYMBOL(")
C$ = "12_TERM"     ! FILE NAME FOR CAL DATA
! STORE TO DISK FILE "12_TERM.CAL"
OUTPUT 706;"STO"&Q$&C$&Q$
! EXAMPLE 2 - SAVE TABULAR DATA
! TO DISK FILE
Q$ = CHR$(34)      ! DOUBLE QUOTE SYMBOL(")
T$ = "S21_THRU"    ! FILE NAME FOR TAB DATA
! STORE TO DISK FILE "S21_THRU.DAT"
OUTPUT 706;"TDD"&Q$&T$&Q$
! EXAMPLE 3 - SAVE TRACE MEMORY
! TO DISK, RECALL IT ON A DIFFERENT
! CHANNEL AND THEN DELETE FILE
OUTPUT 706;"CH1 D13 S11 CH3 S21 FHI WFS"
OUTPUT 706;"CH1 STD" ! STORE TRACE TO MEMORY
Q$ = CHR$(34)      ! DOUBLE QUOTE SYMBOL(")
N$ = "S11TRACE"    ! FILE NAME FOR TRACE DATA
! STORE TO DISK FILE "S11TRACE.NRM"
OUTPUT 706;"SDK"&Q$&N$&Q$
! RECALL SAME DATA ON CHANNEL 3
OUTPUT 706;"CH3 RCK"&Q$&N$&Q$
! DELETE THE TRACE MEMORY FILE
OUTPUT 706;"DEN"&Q$&N$&Q$
```

Figure 5-5. Disk Functions Command Codes Example

5-2.8 Advanced Command Codes: Status Bytes/SRQ

The status of the 360 is defined by primary and secondary status bytes. These bytes have the following bit representations:

Primary Status Byte:

Bit #							
7	6	5	4	3	2	1	0
Self Test Fail	SRQ	2nd Byte Has Status	Action Not Possible	Out of Range	Syntax Error	Sweep Complete in Hold	Cal Sweep-Complete

Secondary Status Byte:

Bit #							
7	6	5	4	3	2	1	0
Power On	Key Pressed	X*	X	X	Hard-ware Error	X	Disk Error

* X denotes not used.

Explanation of Bit Conditions:

Primary Status:

a. **Cal. Sweep Complete**
This bit updates when a calibration sweep is completed after the TCD code.

b. ***Sweep Complete In Hold***
This bit updates when a full sweep is completed in hold after the TRS code.

c. ***Syntax Error***
This bit updates when a syntax error occurs

d. ***Parameter Out Of Range***
This bit updates when data values are out of the allowable range or the data was found to be invalid.

e. ***Action Not Possible***
This bit updates when a code can not execute in the current instrument state.

f. ***2nd Byte Has Status***
This bit updates when a condition represented in the second status byte is true.

g. ***SRQ***
The Service Request bit sets during the serial poll response when the 360 is requesting service.

h. ***Self Test Failed***
This bit sets true if a self test fails.

Secondary Status:

a. ***Disk Error***
This bit updates when a disk error occurs.

b. ***Hardware Error***
This bit updates when there is a problem with the system hardware.

c. ***Key Pressed***
This bit updates when a key on the front panel is pressed.

d. ***Power On***
This bit updates when the system is first powered on.

Table 5-9 Lists the status byte command codes. These codes are used to:

- Output the status of the 360.
- Input service request enable masks.
- Clear the 360's status.

In order for the 360 to generate a service request for a condition, both the condition bit and the SRQ bit in the appropriate mask must be enabled (bit = 1 – condition enabled). When the 360 requests service, the serial poll response byte will show only one *enabled* bit set. The controller can then always tell which enabled condition generated the Service Request (SRQ). This also implies that the primary status byte — the byte is accessed using the OPB code— and the serial poll response byte will not necessarily be equal. Any true bits for conditions not enabled will show up in the serial poll response byte.

Table 5-9. Status Byte Command Codes

COMMAND CODE	DESCRIPTION	VALUES
OPB	Output Primary Status Byte	One Binary Byte
OEB	Output Extended (Secondary) Status Byte	One Binary Byte
IPM	Input Primary Status Mask	One Binary Byte
IEM	Input Extended (Secondary) Status Mask	One Binary Byte
SQ0	Disable Service Requests	N/A
SQ1	Enable any Unmasked Service Requests	N/A
CSB	Clear Primary and Secondary Status Bytes	N/A

NOTE

The data transfer for the OPB, OEB, IPM and IEM codes involve a single binary byte of data. For the IPM and IEM codes the desired condition mask byte must immediately follow the mnemonic.

Figure 5-6 provides an example of status-byte-enable mask setup and service request handling.

```
! SET UP SERVICE REQUEST SUBROUTINE ADDRESS
ON INTR 7 GOSUB 1000
! ENABLE SRQ CONDITION AS AN INTERRUPT
ENABLE INTR 7;8
REMOTE 706
! ENABLE SRQ, SYNTAX, PARAM,
! OUT OF RANGE AND ACTION
! NOT POSSIBLE ERRORS = BITS
! 2,3,4 & 6
! MASK = 4+8+16+64 = 92
OUTPUT 706 USING "#,AAA,B";"IPM",92
1000  ! SRQ SERVICE ROUTINE
1010  STATUS 7,1;A     ! READ INTERRUPT CAUSE REGISTER
1020  R=SPOLL(706)     ! POLL THE 360
1030  IF BIT(R,2)  1 THEN GOTO 1050
1040  DISP "SYNTAX ERROR"
1050  IF BIT(R,3)  1 THEN GOTO 1070
1060  DISP "PARAMETER OUT OF RANGE"
1070  IF BIT(R,4)  1 THEN GOTO 1090
1080  DISP "ACTION NOT POSSIBLE"
1090  ! READ THE PRIMARY STATUS BYTE
1100  OUTPUT 706;"OPB"
1110  ENTER 706 USING "#,B";B
1120  DISP "PRIMARY STATUS = ",B
1130  ! RE-ENABLE INTERRUPT AND RETURN
1140  ENABLE INTR 7;8 @ RETURN
```

Figure 5-6. An Example of Status-Byte-Enable-Mask Setup and Service Request Handling

5-2.9 Advanced Command Codes: Time Domain

The time domain command codes are available *only* with the 2360-2 Time Domain Software option. The time domain codes (Table 5-10) are used to :

- Specify the Domain of a Channel.
- Set Up Operating Modes and parameters for the Selected Processing Type of the Channel.

Table 5-10. Time Domain Command Codes (1 of 2)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
FQD	Select Frequency Domain for Active Channel	N/A	N/A
TBP	Select Bandpass Mode With Time Readouts for active Channel	N/A	N/A
DBP	Select Bandpass Mode With Distance Readouts for Active Channel	N/A	N/A
TPI	Select Phasor Impulse Mode With Time Readouts for Active Channel	N/A	N/A
DPI	Select Phasor Impulse Mode With Distance Readouts for Active Channel	N/A	N/A
TLP	Select Lowpass Mode With Time Readouts for Active Channel	N/A	N/A
DLP	Select Lowpass Mode With Distance Readouts for Active Channel	N/A	N/A
FGT	Select Frequency With Time Gate Mode	N/A	N/A
LPI	Select Lowpass Impulse Response for Active Channel	N/A	N/A
LPS	Select Lowpass Step Response for Active Channel	N/A	N/A
GON	Turn Gate On on Active Channel	N/A	N/A
GOF	Turn Gate Off on Active Channel	N/A	N/A
GDS	Display Gate Symbols on Active Channel With Gate Off	N/A	N/A
ZST	Set Start of Time Domain Zoom Range for All Channels in Time Domain Time Mode: Distance Mode:	 -999.999 to 999.999 us -999.999 to 999.999 m	 PSC, NSC, USC MMT, CMT, MTR
ZSP	Set Stop of Time Domain Zoom Range for All Channels in Time Domain Time Mode: Distance Mode:	 -999.999 to 999.999 us -999.999 to 999.999 m	 PSC, NSC, USC MMT, CMT, MTR
ZCT	Set Center of Time Domain Zoom Range for All Channels in Time Domain Time Mode: Distance Mode:	 -999.999 to 999.999 us -999.999 to 999.999 m	 PSC, NSC, USC MMT, CMT, MTR
ZSN	Set Span of Time Domain Zoom Range for All Channels in Time Domain Time Mode: Distance Mode:	 0 to 999.999 us 0 to 999.999 m	 PSC, NSC, USC MMT, CMT, MTR

Table 5-10. Time Domain Command Codes (2 of 2)

COMMAND CODE	DESCRIPTION	VALUES	TERMINATORS
GST	Set Gate Start Value for All Channels in Time Domain		
	Time Mode:	–999.999 to 999.999 us	PSC,NSC,USC
	Distance Mode:	–999.999 to 999.999 m	MMT,CMT,MTR
GSP	Set Gate Stop Value for all Channels in Time Domain		
	Time Mode:	–999.999 to 999.999 us	PSC,NSC,USC
	Distance Mode:	–999.999 to 999.999 m	MMT,CMT,MTR
GCT	Set Gate Center Value for All Channels in Time Domain		
	Time Mode:	0.0000 to 999.999 us	PSC,NSC,USC
	Distance Mode:	0.0000 to 999.999 m	MMT,CMT,MTR
GSN	Set Gate Span Value for all Channels in Time Domain		
	Time Mode:	0.0000 to 999.999 us	PSC,NSC,USC
	Distance Mode:	0.0000 to 999.999 m	MMT,CMT,MTR
GRT	Select Rectangular Gate Shape for all Time Domain Channels	N/A	N/A
GNM	Select Nominal Gate Shape for all Time Domain Channels	N/A	N/A
GLS	Select Low Sidelobe Gate Shape for all Time Domain Channels	N/A	N/A
GMS	Select Minumum Sidelobe Gate Shape for all Time Domain Channels	N/A	N/A
WRT	Select Rectangular Window Shape for all Time Domain Channels	N/A	N/A
WNM	Select Nominal Window Shape for all Time Domain Channels	N/A	N/A
WLS	Select Low Sidelobe Window Shape for all Time Domain Channels	N/A	N/A
WMS	Select Minumum Sidelobe Window Shape for all Time Domain Channels	N/A	N/A
MRR	Restore Original Range After a Marker Zoom Operation	N/A	N/A
DCA	Select Auto d.c. term for Low Pass	N/A	N/A
DCZ	Select Line Impedance d.c. term for Low Pass	N/A	N/A
DCO	Select Open d.c. Term for Low Pass	N/A	N/A
DCS	Select Short d.c. Term for Low Pass	N/A	N/A
DCV *	Sect Low Pass d.c Term to Value	-100M Ω to 1000 MΩ	XXl, XX3, XM3

* Certain time domain codes can only be used with particular processing types or instrument states. For example "DCV 25 XX1" sets the d.c. term for low pass to 25 ohms. The 360 can only execute this command string if the active channel is in time domain lowpass mode (TLP or DLP) or if a valid lowpass set of frequencies exist for frequency domain (FQD) or frequency gated by time (FGT).

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