A COMPUTER AIDED MEASUREMENT PROGRAM

FOR INTRINSIC INSERTION LOSS OF BILATERAL MICROWAVE DEVICES

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ABSTRACT

A BASIC language program for the measurement of and data reduction for the intrinsic insertion loss of a bilateral device using Deschamp's method has been written for the Hewlett Packard Model 8542B automatic network analyzer. The program has been applied to wideband RF intrinsic loss measurements of helix structures from 2000. to 12400. MHz.

Introduction

The requirement for broadband intrinsic loss measurements on traveling wave tube helix structures in the 2000. to 12400. MHz frequency range with repeatibility goal of less than 0.1 dB has resulted in the development of a BASIC language computer program for Deschamp's method[1,2,3,4] for use with the Hewlett Packard Model 8542B automatic network analyzer.

The standard software measurement packages available for the HP8542B make use of a through connection to allow determination of total insertion loss (the sum of reflective and dissipative losses) where the error model used for data correction assumes 1.) for GPM-1 that port 2 is matched, or 2.) GPM-2 requires the device be reversed to measure all four scattering parameters. GPM-1 or GPM-2 require a flexible cable for through connection, internal switching of the ANA during measurements, and reversal of the device to be tested which disturbs the flexible cables. The desire to eliminate flexible cable problems, the ANA internal switching, and to have the ability to compare results with the manual slotted line method led to the development of this automated version of Deschamp's method. (Another approach to the problem of measuring/computing intrinsic insertion loss would be measurement of all four scattering parameters, and mathematically changing the reference impedance to determine a set of S- parameters where S-11 and S-22 are zero.[5] However, this has not been implemented at this time, and would require the use of a flexible cable for the through connection).

Computer Program

The computer aided measurement program described here requires two independent sets of measurements of S-11 as a function of the position of a sliding short. The first S-11 measurement set is without the test device present but includes all RF adapters and the sliding short, and is needed to determine a loss correction factor for these components. The second S-11 measurement set determines the total loss of all components including the test device. Figure 1 shows the sequence of measurements needed to determine intrinsic loss. The ANA is calibrated in the usual way for a Type 1 measurement using the HP supplied CAL program, and this data is recorded on a tape cassette. The BASIC compiler is loaded, and the BASIC language measurement program entered. The adapters and sliding short are connected to test port one of the ANA, and the program is run. A total of from three to twenty sliding short positions may be used during measurement of the correction factor and/or during total intrinsic loss measurement where the test device is included.

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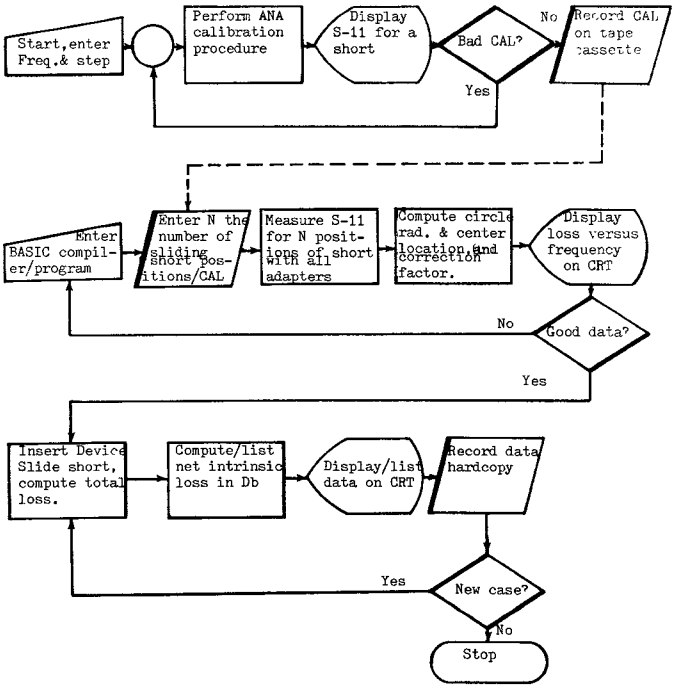

Figure 1. Computer program flow chart for measurement/ computation of intrinsic insertion loss using the automatic network analyzer.

Results

A typical data set of S-11 points is shown in Figure 2 for what is referred to as the output plane. The quantities ρ, the distance to the circle center, and R, the circle radius, are determined by a least-squares circle fit procedure,[6] and are used in the computation of the correction factor. Figure 3 shows a plot of correction factor versus frequency obtained in the 2. to 12.4 GHz frequency band.

Figure 4,5 and 6 are typical S-11 data and loss calculated for this data when the test device is present. The data points of Figure 4 are no longer evenly spaced on the circumference of the fitted circles as a result of the bilinear transformations due to the mismatched test device. Figure 5, and 6 are net intrinsic loss data for a helix structure four inches (5.08 cm) in length over the 2000. to 12400. MHz frequency range. Figures 5 and 6 should be compared from the viewpoint of repeatibility of ANA results over a time period of several weeks where a number of different ANA calibrations have been used. The data points on Figure 6 shown as "x" were measured using CW point-by-point-manual slotted line test equipment.

This computer aided measurement technique has

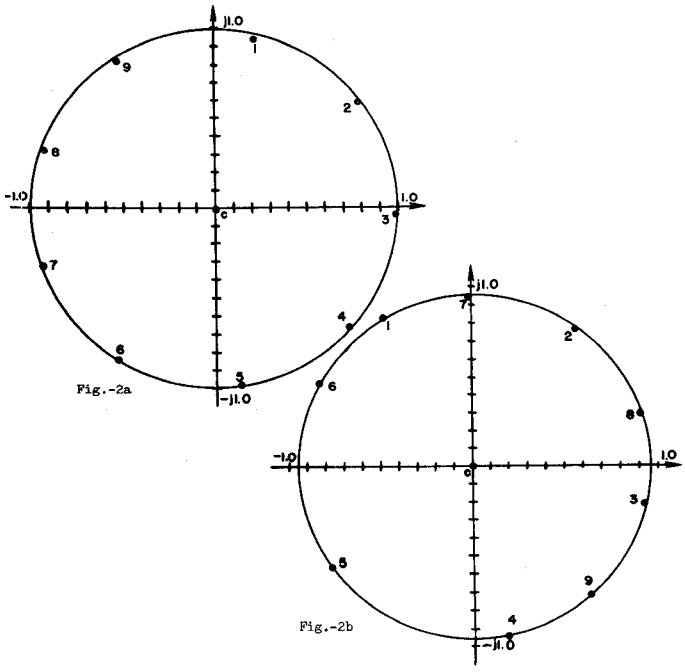

Figure 2. Typical measurements of S-11 for the sliding short/adapter loss correction factor in the output plane. The data points are evenly spaced on the circumference of the circle fitted to the data by a least squares technique. The normalized circle radius and distance on the complex plane to its center are needed in the computation of intrinsic insertion loss. Fig. 2a at 3200. MHz has 0.0445 dB loss. Fig. 2b at 7200. MHz has 0.195 dB loss.

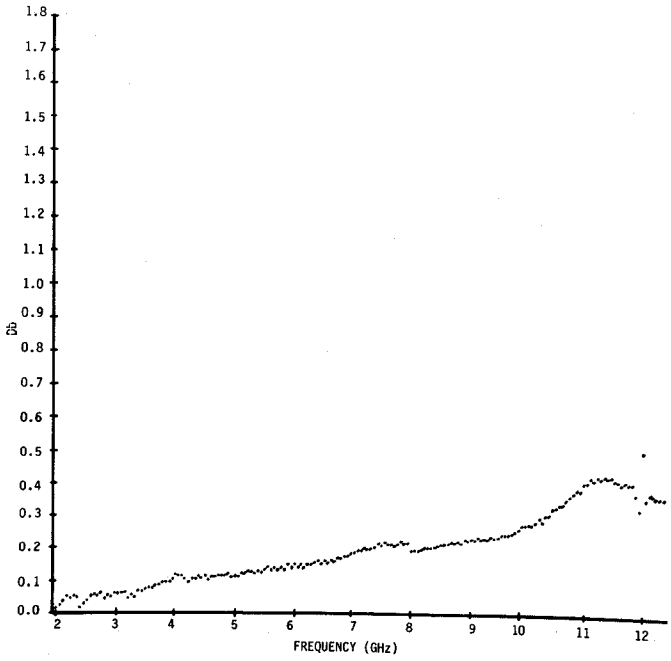

Figure 3. A plot of correction factor for the insertion loss of the sliding short and the APC-7/OSM coaxial adapter.

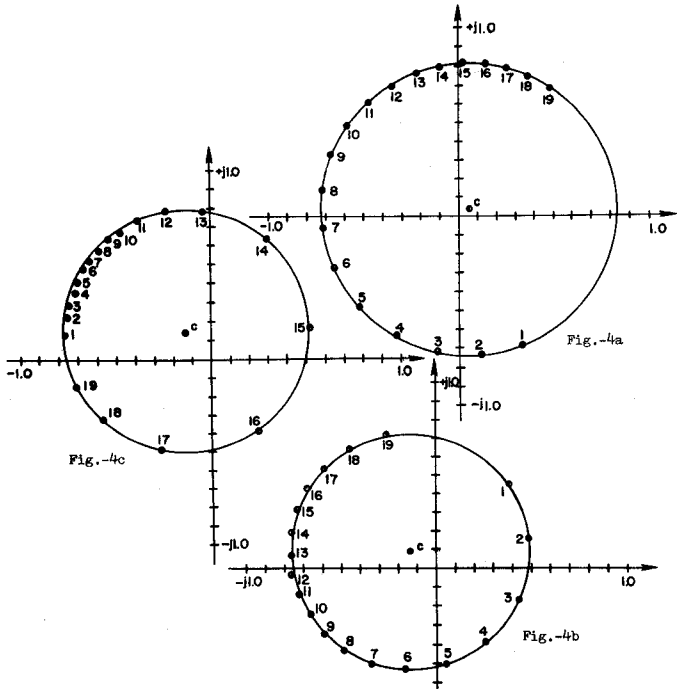

Figure 4. Typical measurements of S-11 in the input plane for the helix structure N. The data points are no longer evenly spaced on the circumference of the least squares fitted circle as a result of the bilinear transformation through the mismatched helix. Fig 4a at 8000. MHz has 1.058 dB loss. Fig.4b at 11371.4 MHz has 1.764 dB loss. Fig 4c at 11657.1 MHz has 1.622 dB loss.

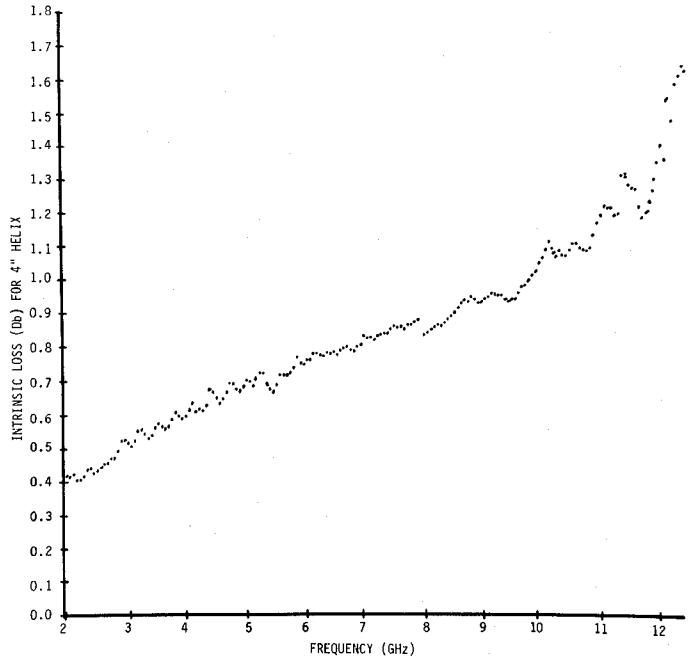

Figure 5. Three separate measurements of net intrinsic insertion loss for helix N for the 2 to 4 (Sept. 20, 1978), 4 to 8 (Sept. 27, 1978), and 8 to 12.4 GHz (Oct. 5, 1978) frequency bands are shown plotted on the same graph. An independent ANA calibration was used in each band. The effect of bandswitching is seen as a discontinuity at the lower edge of the 8 to 12.4 GHz band. Nineteen data points were used in the 8 to 12.4 GHz band, and ten data points were used for the 2 to 8 GHz bands.

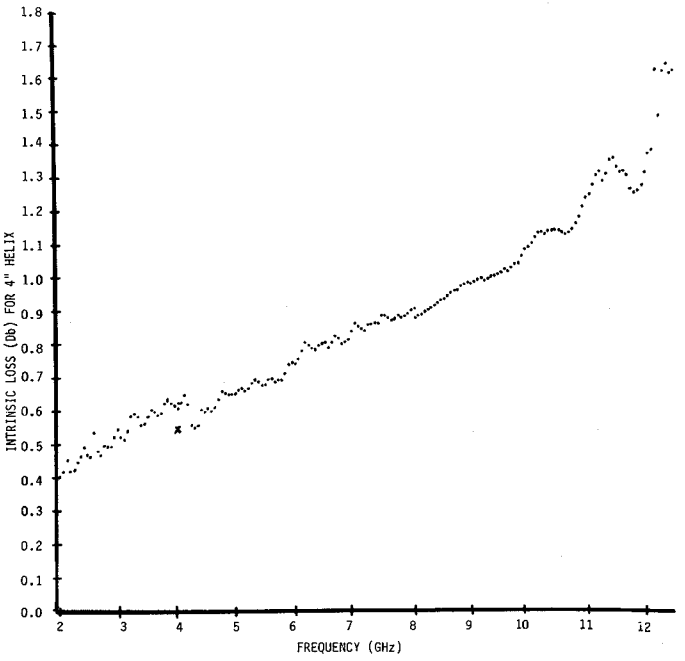

Figure 6. Three separate measurements of net intrinsic insertion loss for helix N for the 2 to 4 (Sept. 12, 1978), 4 to 8 (Sept. 12, 1978), and 8 to 12.4 GHz (Sept. 13, 1978) frequency bands are shown plotted on the same graph. The effects of band switching can be seen as discontinuities at 4 and 8 GHz. Ten data points were used at each frequency. The 'x' s mark data points obtained by use of CW slotted line test equipment in Aug. 1978.

been used to determine the intrinsic loss of well-matched devices such as APC-7 precision pads with 3,6, 10, and 20 dB attenuation values. The correlation between the measured intrinsic loss and the total insertion loss indicated on each pad's calibration chart was within 0.1 dB. The measurement results are not accurate to more than a dB or two when the test device has 25 dB or more attenuation as determined by cascading precision pads. The check on calibration of the HP 8542B as a part of the bi-annual maintenance includes measurement of the insertion loss of a 10 cm long APC-7 50 ohm airline. A measurement of a similar 10 cm airline from an accessary kit yielded values of loss for this well-matched test device which were within the manufacturer's specification tolerances from 2000. to 12400. MHz. No attempt has been made at this time to verify performance using test devices having known attenuation and mismatch.

Conclusions

A computer aided measurement technique has been developed and used for the measurement of intrinsic insertion loss of bilateral microwave devices. Thus, the minimum insertion loss of a mismatched device was determined over a broad band-width without the necessity of designing/building impedance matching structures.

References

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