FUNCTION GENERATOR

4502

INSTRUCTION MANUAL

KIKUSUI

Part No. Z1-403-820, IB001962

Power Requirements of this Product

Power requirements of this product have been changed and the relevant sections of the Operation Manual should be revised accordingly.
(Revision should be applied to items indicated by a check mark ☑.)

☐ Input voltage

The input voltage of this product is _____ VAC,
and the voltage range is _____ to _____ VAC. Use the product within this range only.

☐ Input fuse

The rating of this product's input fuse is _____A, _____VAC, and _____.

WARNING

- To avoid electrical shock, always disconnect the AC power cable or turn off the switch on the switchboard before attempting to check or replace the fuse.
- Use a fuse element having a shape, rating, and characteristics suitable for this product. The use of a fuse with a different rating or one that short circuits the fuse holder may result in fire, electric shock, or irreparable damage.

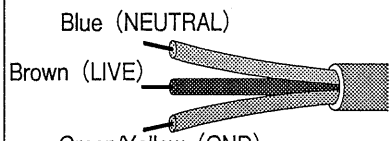
☐ AC power cable

The product is porvided with AC power cables described below. If the cable has no power plug, attach a power plug or crimp-style terminals to the cable in accordance with the wire colors specified in the drawing.

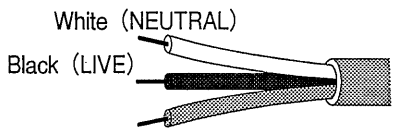
WARNING

- The attachment of a power plug or crimp-style terminals must be carried out by qualified personnel.

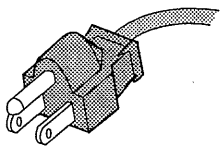
☐ Without a power plug



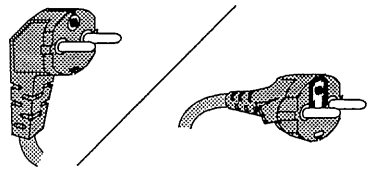
☐ Without a power plug



☐ Plugs for USA



☐ Plugs for Europe



☐ Provided by Kikusui agents

Kikusui agents can provide you with suitable AC power cable.
For further information, contact your Kikusui agent.

☐ Another Cable _____

 Kikusui Part No. Z9-000-027 IB001681

KIKUSUI

TABLE OF CONTENTS

1. GENERAL

Model 4502 Function Generator is a versatile instrument which supplys an output signal of 0 - 30 Vp-p, covering a total frequency range of 0.001 Hz - 20 MHz in a sine, triangular, or square waveform. Symmetry of the triangular or square waveform is adjustable. The 4502 is incorporated also with the various control functions.

The oscillating frequency can be set with a dial in ten decimal ranges or can be controlled with an external voltage in a VCG (voltage-controlled generator) system. With the VCG function, the oscillating frequency can be changed up to 1000 times in one range by means of an external control voltage of +10 mV to +10 V. Symmetry of the triangular or square waveform is adjustable for a range of 1:19 to 19:1. DC offset for overall waveform can be effected with a panel control or with an external signal.

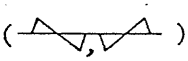
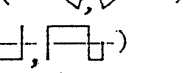
The start/stop point of oscillation is adjustable with panel controls or with an external signal. Oscillation of a single cycle can be accomplished by employing the trigger function and that of multiple cycles by employing the gate function.

The 4502 has a VCA (voltage-controlled amplitude) function to control the amplitude of the output signal with an external signal and is capable of delivering an amplitude-modulated signal and a balance-modulated signal.

The 4502 can be widely used for such purposes as a signal source for frequency response test of amplifiers or linearity test of recorders, as a signal source for vibration test stand exciters, or as a pulse generator, a V/F converter, or a tone burst generator.

2. SPECIFICATIONS

Functions

Frequency setting:	Dial controls or VCG
Oscillation control:	Continuous oscillation
	Triggered or gated oscillation with
Start/stop point adjustment:	Continuously variable
Amplitude modulation:	VCA
DC offset:	continuously variable
Total frequency range:	0.001 Hz - 20 MHz
Individual frequency ranges:	×0.001, ×0.01, ×0.1, ×1, ×10, ×100, ×1k, ×10k, ×100k, ×1M. (Ten ranges)
Frequency dial scale:	Linear scale, 2 to 20
Frequency accuracy	
0.002 Hz to less than 2 MHz:	±(3% + 0.05 of scale) or better
2 MHz to 20 MHz:	±(5% + 0.05 of scale) or better
Fine frequency adjustment:	Variable down to approx. -5% of dial setting
Frequency stability:	±0.3% or better against ±10% change of line voltage
Output waveform:	Sine wave ()
	Triangular wave ()
	Square wave ()
	Symmetry adjustment
	Triangular wave ()
	Square wave ()

Output voltage:	30 Vp-p maximum (at 1 kHz, with output terminal open)
Attenuator:	0, -10, -20, -30, -40, -50 and -60 dB. 0 to -10 dB with continuously-variable control.
Output resistance:	50 ohms

Frequency response (with reference to 1 kHz)

Sine wave

0.001 Hz - 10 MHz:	1 dB or less
1 kHz - 20 MHz:	2.5 dB or less

Triangular wave

0.001 Hz - 2 MHz:	0.5 dB or less
1 kHz - 20 MHz:	3.5 dB or less

Square wave rise/fall time: 15 ns or less (with 50-ohm termination)

Sine wave distortion (50-ohm termination, at maximum output)

10 Hz - less than 20 kHz:	0.5% or less
20 kHz - 600 kHz:	1.5% or less

Mutual voltage deviation (at 1 kHz): 5% or less

Amplitude stability (for ±10% line voltage change): 1% or less

Symmetry adjustment:	Continuously variable for a range of 1:19 to 19:1. (When the symmetry adjustment mode is selected, the oscillating frequency becomes one tenth of the set frequency.)
DC offset:	Approx. ±15V (with output terminal open and attenuator at 0 dB)

External offset

Input voltage:	-10 V to +10 V (with output terminal open, gain 1.5 times)
Input resistance:	10 kΩ
Input frequency range:	DC to 10 kHz

VCG

Control voltage	
When VCG is ON:	+10 mV to +10 V
When VCG is OFF:	-10 V to +10 V
Input resistance:	10 kΩ
Control frequency range:	DC - 10 kHz
Controlled frequency range:	0.002 Hz - 20 MHz
Ranges:	×0.1 - ×1M (8 ranges)
Variable frequency range:	1000 times or over per range

GCV OUT signal

Output voltage:	+10 mV to +10 V
Output resistance:	1 ohm or less
Output current:	5 mA maximum

VCA

Control voltage:	-10 V to +10 V
Input resistance:	10 kΩ
Control frequency range:	DC - 10 kHz
Variable frequency range:	0 to -20 dB or over (for sine wave or triangular wave, at 1 kHz)

Triggered/gated mode

Control method:	Local (with panel switch) or remote (with external signal)
Triggerable frequency range:	0.001 Hz - 10 MHz

Trigger signal level:	±0.5 V to ±10 V
Triggering slope:	"+" or "−"
Start/stop point adjustment:	Continuously variable for approximately (0° ± 90°), at 0.001 Hz − 2 MHz
Input voltage:	−10 to +10 V
Input resistance:	10 kΩ
Input frequency range:	DC − 10 MHz
Minimum pulse width:	50 ns
TTL (SYNC OUT) signal	
Waveform and level:	Square wave, TTL level
Rise/fall time:	12 ns or faster
Output resistance:	50 ohms
Power requirements:	100 V ±10%, 50/60 Hz AC, approx. 43 VA
Ambient temperature range	
Operable temperature range:	0 to 40°C (32 to 104°F)
To satisfy specifications:	10 to 35°C (50 to 95°F)
Case dimensions:	200 W × 140 H × 370 D mm (5.08 W × 5.51 H × 12.60 in.)
Dimensions including extrusions:	200 W × 160 H × 370 D mm (5.08 W × 6.30 H × 14.56 D in.)
Weight (net):	Approx. 6.1 kg (13.5 lbs)
Accessories:	Instruction manual 1
	Power cord 1
	AC plug adaptor 1

3. OPERATION METHOD

3.1 Description of Front Panel Items (See Figure 3-1.)

① POWER switch:

When this pushbutton switch is depressed and locked, the instrument power is turned on.

② Power pilot lamp:

This lamp (green LED) turns on to indicate that the instrument power is on.

③ MODE switch:

To select an oscillating modes for the instrument

CONT:	Continuous oscillation
MANUAL GATE:	Oscillation starts as you press this button and stops as you release it.
EXT GATE:	Oscillation start/stop can be controlled with an external signal
MANUAL TRIG:	As you press this button, oscillation starts and lasts only for one cycle.
EXT TRIG:	The one-cycle oscillation can be controlled with an external signal.

④ RANGE (Hz) switch:

To select an oscillating frequency range. The instrument oscillates at the frequency indicated by the FREQUENCY dial and multiplied by the range factor selected by this switch. Note that the VARIABLE knob must be in the CAL position (clockwise extreme position) when determining the oscillating frequency in this manner.

[Oscillating frequency] = [DIAL reading] × [RANGE]

⑤ FREQUENCY dial:

For continuously-variable adjustment of the oscillating frequency. The oscillating frequency increases as this dial is turned clockwise.

⑥ (FREQUENCY) VARIABLE knob:

This knob is for vernier control of the oscillating frequency. The FREQUENCY dial is calibrated with this knob set in the clockwise extreme position (CAL position). By turning this knob counterclockwise, the oscillating frequency can be finely adjusted to an extent of approximately -5% of the frequency set by the dial.

⑦ FUNCTION switch:

Selects the output signal waveform for sine (), triangular (), or square ().

⑧ ATTEN (dB) switch:

Attenuator for stepwise attenuation of the output voltage, for down to -60 dB in -10 dB steps when terminated with 50 ohms.

⑨ (ATTEN) VARIABLE [PULL HF LIMIT] knob:

This knob is for continuously-variable control of the output voltage. By turning this knob counterclockwise, the output voltage can be reduced by -10 dB or more.

Note that this knob should be used for waveform amplitude adjustment when reducing the signal waveform and applying a DC offset for the output. If the ATTEN is used, almost no DC offset can be successfully applied and the output amplifier is saturated.

If you pull out this knob, a high-cut filter (low-pass filter) is connected in the output circuit for betterment of low-frequency output signal waveform. Note, however, that the frequency responce may be degraded for frequencies higher than 1 MHz.

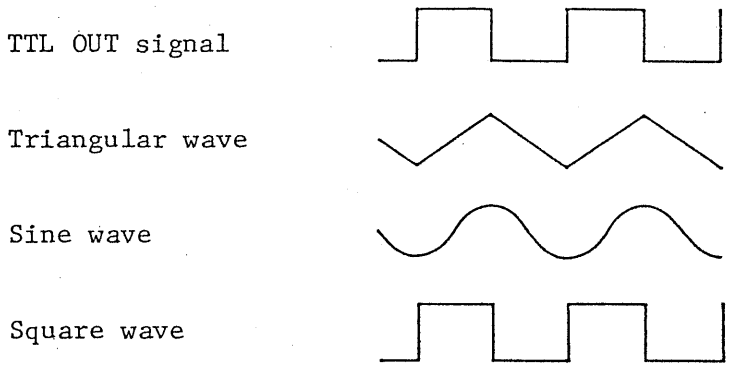
⑩ OUTPUT [50Ω] terminal (BNC type):

This terminal is the main output terminal of the instrument and delivers the output signal of the waveform selected by the FUNCTION switch. The output resistance is 50 ohms. The maximum output voltage is 30 Vp-p when the terminal is open or 15 Vp-p when it is shorted with a 50-ohm resistor.

The output resistances of both OUTPUT terminal and TTL OUT terminals are 50 ohms. For operation at high frequencies, use a coaxial cable of characteristic impedance 50 ohms (such as 3D-2V or RG-58A/U) and a 50-ohm terminating device in order to prevent waveform distortions which can be caused by impedance mismatching.

⑪ TTL OUT [50Ω] terminal (BNC type):

This terminal provides a TTL-level square wave output signal which is synchronized with the signal of the OUTPUT terminal. The TTL signal may be used as a trigger signal for an oscilloscope or to drive a TTL-level circuit.



⑫ DC OFFSET [PULL ON] knob:

If you pull out this knob, DC offset is effected. The DC offset voltage increases as you turn this knob clockwise. The DC offset voltage range is from -15 V to +15 V. Note that the output signal is saturated if the sum of the signal voltage plus DC offset voltage exceeds ±15 V. Also note that, if you attempt to reduce

the output signal with the ATTEN, the DC offset component also will be reduced.

⑬ VCG [PUSH ON] switch:

If you push in this button, the functions of the FREQUENCY dial and VARIABLE knob are disabled and the oscillating frequency can be controlled with an external control signal.

If you pull out this button, the external control signal is added to the FREQUENCY dial signal, thereby attaining a frequency modulation operation with the former as a modulating signal and the latter as a carrier signal.

⑭ VCG [10k] input terminal (BNC type):

This terminal is the input terminal for the external control signal for the VCG operation. The oscillating frequency is variable up to 1000 times in one range. The effects of the external control signal on the oscillating frequency are as follows:

When VCG is ON

$$f = 2 \times V \times R \quad \ldots\ldots \quad \text{Eq. } 3.1.1$$

Condition: $+0.01\ V \leq V \leq +10\ V$

Where, f: Oscillating frequency

V: External control voltage [V]

R: Range

D: Dial reading

When VCG is OFF

$$f = 2 \times \left(\frac{D}{2} + V \right) \times R \quad \ldots\ldots \quad \text{Eq. } 3.1.2$$

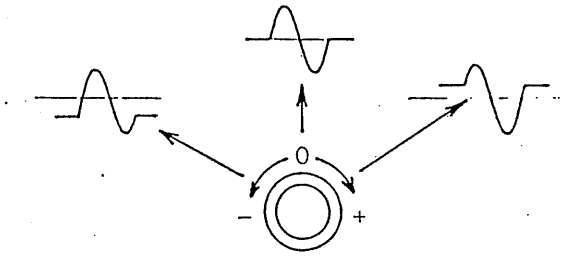
Conditions: $+0.01\ V \leq \left(\frac{D}{2} + V \right) \leq +10\ V$

⑮ TRIG LEVEL control:

To adjust the triggering level when in the triggered/gated mode of operation with an external signal. As this control is turned clockwise from its center position, the triggering level increases in the positive direction; as it is turned counterclockwise, the triggering level becomes deeper in the negative direction. The trigger voltage range is -10 V to +10 V.

⑯ START POINT control:

Up to ±90° of continuously-variable adjustment of the start/stop phase of sine or triangular oscillation waveform. The phase goes positive as this control is turned clockwise, and vice versa.



⑰ SLOPE ["+", "-"] switch:

To select a triggering slope on the external trigger signal. The "+" (⊓) state is for triggering with a positive-going slope and the "-" (⊔) state is for triggering with a negative-going slope.

⑱ MANUAL TRIG [PUSH ON] switch:

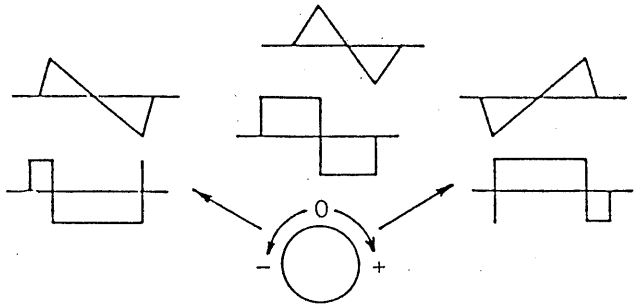
This momentarily-return type of pushbutton switch is for manual triggered/gated oscillation. When in the MANUAL TRIG mode, one cycle of oscillation at the set frequency occurs each time you press this button. When in the MANUAL GATE mode, oscillation continues during the period you keep this button depressed.

⑲ EXT (TRIG IN) [10kΩ] input terminal (BNC type):

The input terminal for the external signal for the triggered/ gated oscillation.

⑳ SYMMETRY [PUSH ON] control:

To adjust the symmetry of the oscillating triangular wave or square wave continuously-variably within a range of 1:19 to 19:1. As you pull out this knob for symmetry adjustment, the oscillating frequency becomes one-tenth of the set oscillating frequency.



㉑ VCA GAIN control:

For gain adjustment of VCA input. As you turn this control clockwise, the gain increases. The VCA input ±10 V at the maximum state is for the maximum output.

㉒ NULL [PULL ON] control:

As you pull out this knob, the VCA function is turned on.

㉓ VCA IN [10kΩ] input terminal (BNC type):

The input terminal for the external signal for the VCA function for balanced modulation or amplitude modulation.

㉔ Case stand:

The instrument front can be raised by approximately 85 mm (3.35 in.) for ease of operation and viewing of the front panel of the instrument on a bench.

3.2 Description of Rear Panel Items (See Figure 3-2.)

(25) DC OFFSET [10kΩ] input terminal (BNC type):

The input terminal for the DC offset voltage. The relationship between the input voltage and the offset voltage is +1.5 times when the terminal is open or +0.75 times when the terminal is terminated with 50 ohms. The peak values of the output signal must not exceed ±15 V. Note that the offset voltage also is attenuated if the output voltage is attenuated by the attenuator.

(26) GCV OUT terminal (BNC type):

This terminal provides a voltage signal which represents oscillating frequency within one frequency range. When the oscillating frequency is the maximum frequency (dial reading 20) of the range, the output voltage is +10 V.

$$\text{GCV OUT} = \frac{f}{R} \div 2 \times 10 \text{ [V]} \quad \ldots\ldots \quad \text{Eq. 3.1.3}$$

(27) LINE IN receptacle:

The receptacle for the AC line input power. Connect the AC power cord (supplied as an accessory) to this receptacle. The center pin (ground line) of the receptacle is connected to the instrument casing.

(28) FUSE:

The fuse of the AC input power line. Use a fuse of the correct rating in conformity with the AC line voltage.

(29) LINE VOLTAGE SELECTOR switch:

To select the AC line voltage on which the instrument is to be operated. Be sure to check that the switch is set in the correct position for the line voltage before connecting the AC power cord to the AC line outlet. To change the switch setting, use a small screwdriver.

Caution: Note that the instrument may not properly operate or may be permanently damaged if it is connected to an AC line outlet of wrong voltage.

Selector Switch	Line Voltage	Fuse
100 V 115 V	90 - 110 V 104 - 126 V	1 A
200 V 220 V 240 V	180 - 220 V 198 - 242 V 216 - 262 V	0.5 A

(30) GND terminal:

To ground the instrument casing. The input/output circuits and the internal circuits are electrically isolated from the instrument casing.

3.3 Notes for Use

(1) Before connecting the AC power cord of the instrument to an AC line outlet, make sure that the LINE VOLTAGE SELECTOR switch on the rear panel of the instrument is set at the correct position for the AC line voltage.

(2) The AC power cord with plug which accompanies the standard model of instrument is for 125 V AC. To operate the instrument on an AC line of a higher voltage, use an AC power cord of the required ratings.

(3) To reduce the output voltage to a small value, reduce it by means of the 10-dB-step attenuator. Note that the output signal waveform may be slightly distorted if you attempt to reduce it by means of the VARIABLE control.

(4) When the instrument is operated in the DIAL mode, the VCG input terminal is electrically connected for frequency modulation. When no frequency modulation is needed, do not connect any item to the VCG input terminal.

(5) This instrument is a wide band oscillator with an output impedance of 50 ohms. When using the instrument, pay attention to impedance matching. When operating the instrument at a low frequency range, it is recommendable to turn on the HF LIMIT switch so that the low-pass filter is connected in the circuit and a better waveform is obtained.

(6) The input circuits are with input resistance 10 kΩ and maximum allowable input voltage ±30 V. Note that the input circuits may be damaged if an unreasonably large voltage is applied.

The output circuits are protected against short-circuiting. Note, however, that they may be damaged if an unreasonably large voltage is applied.

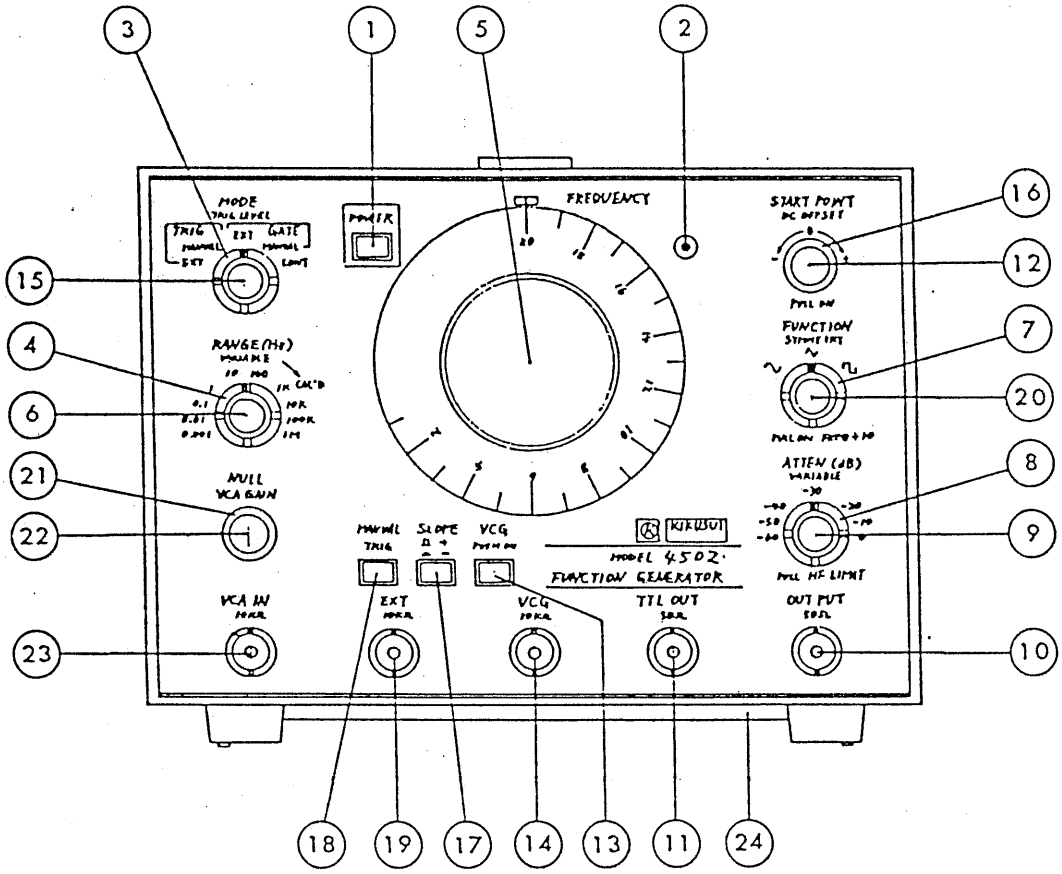


Figure 3-1. Front Panel

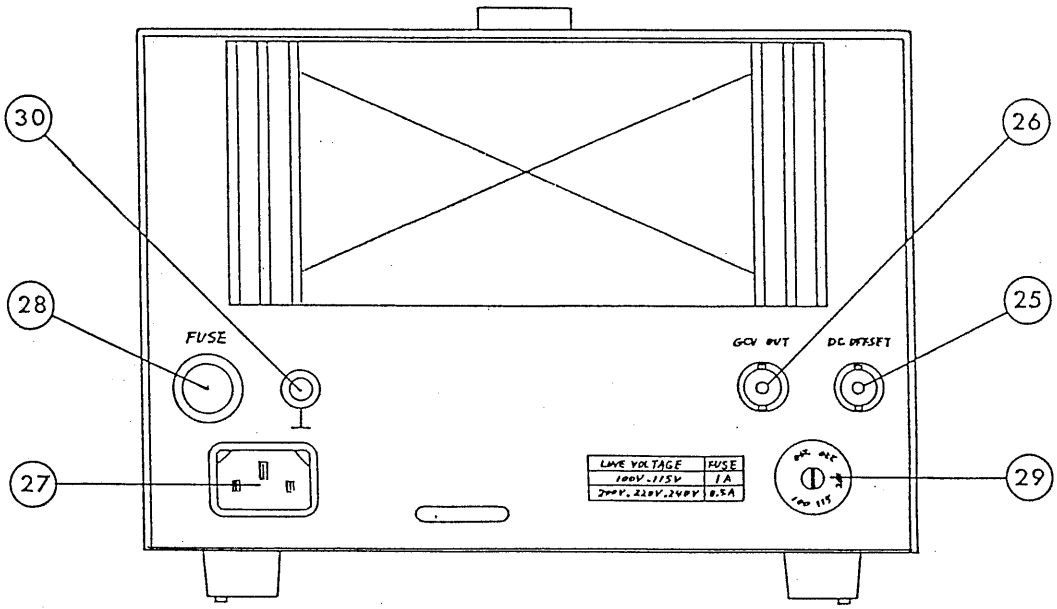


Figure 3-2. Rear Panel

4. OPERATING PRINCIPLES

4.1 Block Diagram

A block diagram of the 4502 Function Generator excluding the power supply circuit is shown in Figure 4.

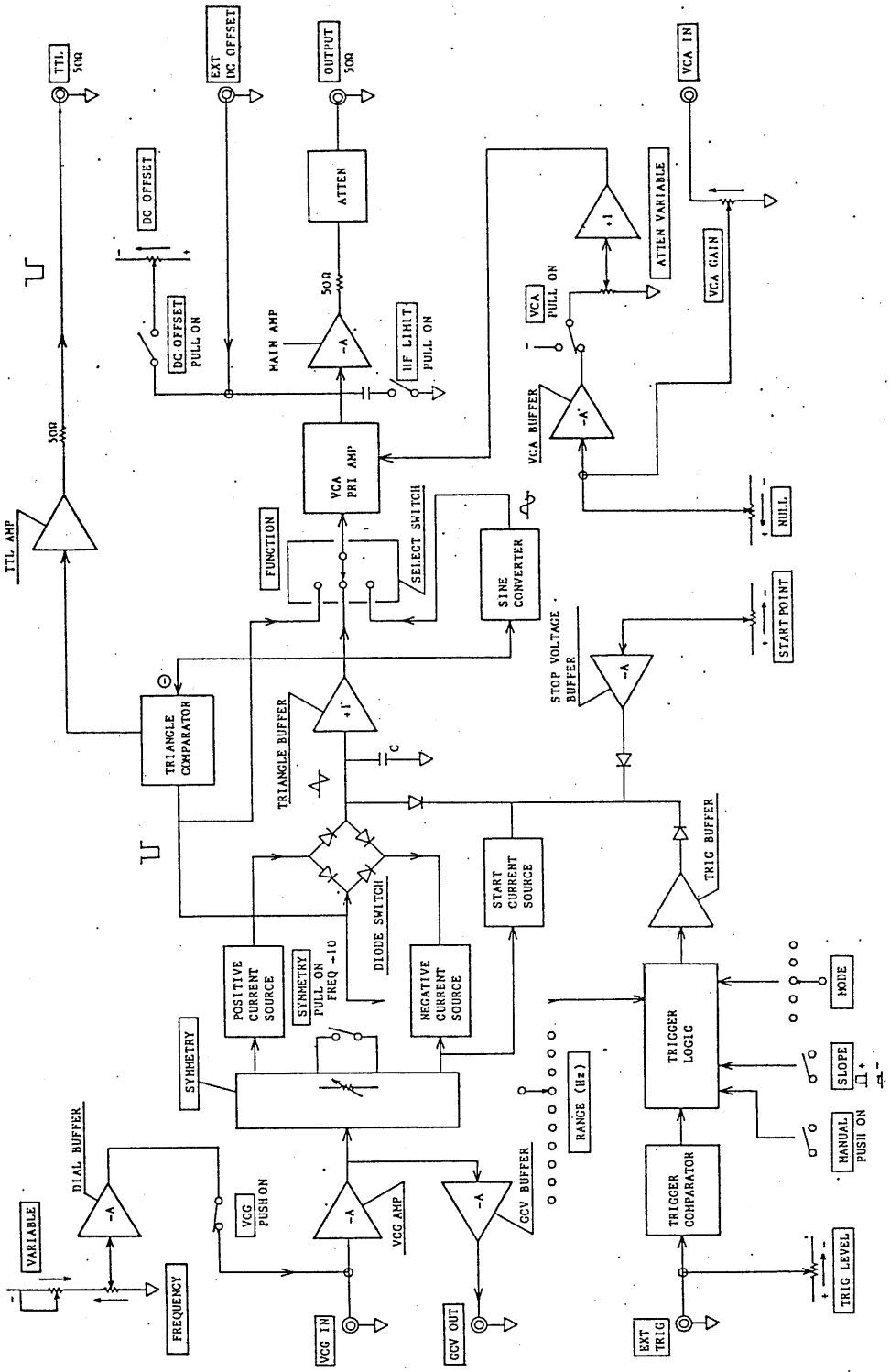


Figure 4

4.2 Basic Oscillator Circuit

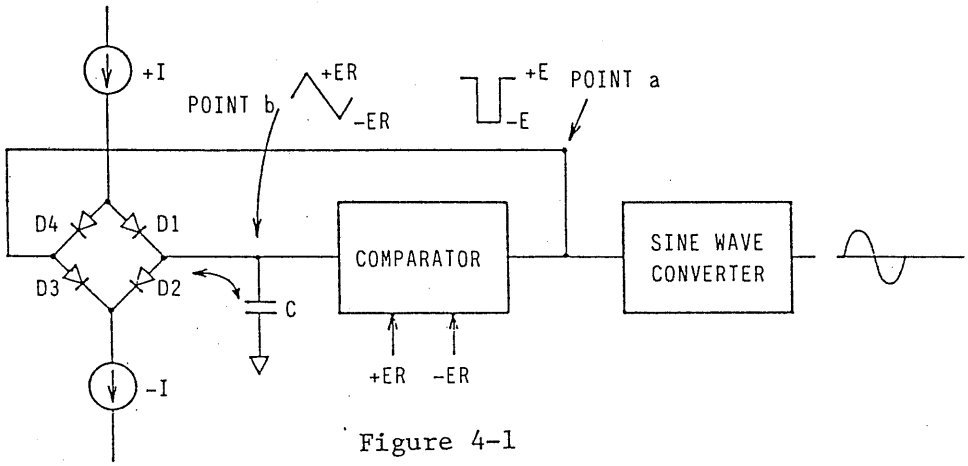


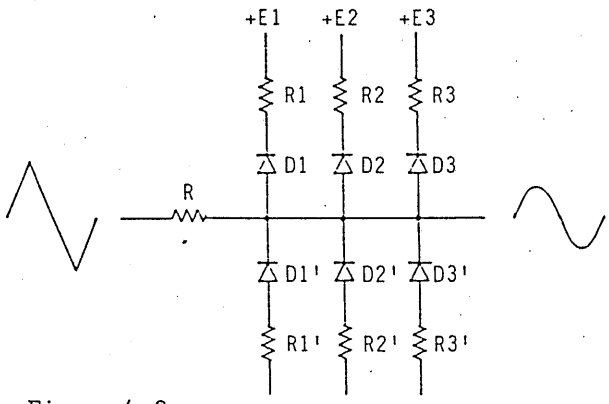
Figure 4-1

Figure 4-1 shows a basic block diagram of the oscillator circuit of the 4502 Function Generator. It is comprised of a positive and a negative constant-current supplies, a diode switching circuit, an integrating capacitor, a comparator, and a sine wave converter.

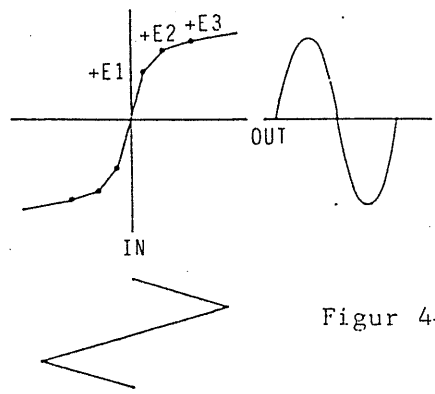
Assume that, when the instrument power is turned on, the charge of capacitor C is zero and the comparator output at point a is +E. Diodes D1 and D3 will conduct and diodes D2 and D4 will not conduct, current +I will flow into capacitor C, and the voltage of point b will rise. When the voltage of point b has reached the preset voltage +ER, the comparator operation will be inverted and the voltage of point b will become -E. Diodes D2 and D4 will start conducting and diodes D1 and D3 will stop conducting, current -I will flow into capacitor C and the voltage of point b will fall. When the voltage of point b has reached the preset voltage -ER, the comparator operation will be inverted back and the voltage of point b will rise again to +ER. The above operations will be repeated periodically, thereby generating a triangular wave or a square wave.

The oscillating frequency depends on the comparator voltages (±ER), capacitor C, and constant-current supplies (±I). Of this function generator, the capacitance of capacitor C is changed for range change and the values of constant-current supplies (±I) are adjusted for continuously-variable frequency adjustment.

A sine wave is produced by processing the triangular wave with a sine wave converter (brolen line approximation circuit). The principle of the sine wave converter os shown on Figure 4-2. Resistore D1 - D3 and D1' - D3' are connected with their weighted resistors as shown in Figure 4-2. The functions of the weighted resistors are to provide optimal gradients for approximation.



Figur 4-2



Figur 4-3

When the instantaneous value (e) of the triangular input wave is in the state of $0 < e < +E1$, all diodes do not conduct and consequently the gradient of the triangular input wave is directly conveyed to the sine output wave. When the triangular input wave has become $+E1 < e < +E2$, D1 conducts and the gradient for the sine output wave is reduced by a factor of $R1/(R1 + R)$. In a similar manner, as D2 and D3 also become conducting, the gradient is reduced more and more. For the negative cycle, approximation is done with diodes D1' - D6' which are sequentially turned on. Thus, the triangular input wave is converted into a sine output wave by means of approximation broken lines with conversion characteristics as shown in Figure 4-3.

4.3 VCG (Voltage-controlled Generator) Function

A generator or an oscillator whose oscillating frequency can be controlled with a voltage signal is called VCG or VCO. Of the 4502 Function Generator, the oscillating frequency is controlled by varying the constant-current supplies. The constant-current supplies are fed through voltage-to-current converters. The control voltages for the voltage-to-current converters

are provided with the FREQUENCY DIAL potentiometer or as an external control signal. A block diagram of the VCG circuit of the 4502 is shown in Figure 4-4.

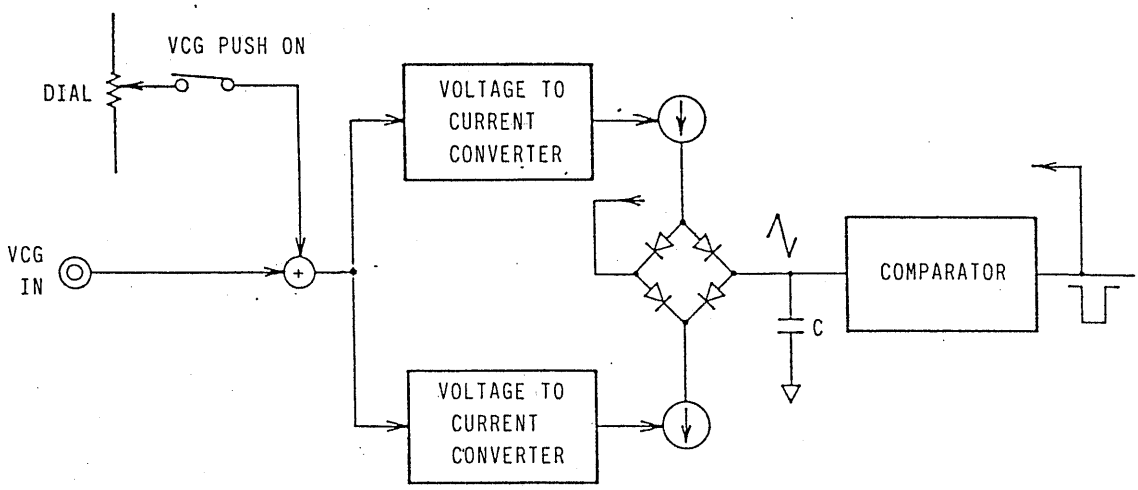


Figure 4-4

Denoting by I the charging constant-current of integrating capacitor C, by +ER and -ER the set voltages of the comparator, and by t the period needed by the voltage to change from +ER to -ER, the following equation can be written:

$$2 \cdot ER = \frac{I \cdot t}{C} \quad \ldots\ldots \quad \text{Eq. 4.3.1}$$

The oscillating frequency f which is $1/2 \cdot t$ can be expressed as follows:

$$f = \frac{1}{4 \cdot ER \cdot C} \quad \ldots\ldots \quad \text{Eq. 4.3.2}$$

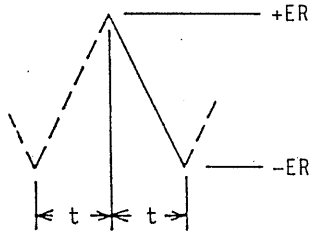


Figure 4-5

Assuming that capacitance C and voltage ER in Equation 4.3.2 are constant, oscillating frequency f is directly proportional to charging constant-current I. Charging constant-current I with which to charge integrating capacitor C is provided by the voltage-to-current converter. Consequently, the oscillating frequency can be controlled by varying the input voltage of the voltage-to-current converter, thereby accomplishing a VCG function. The polarity of the current is switched by a diode switching circuit in order to maintain oscillation.

4.4 SYMMETRY Circuit

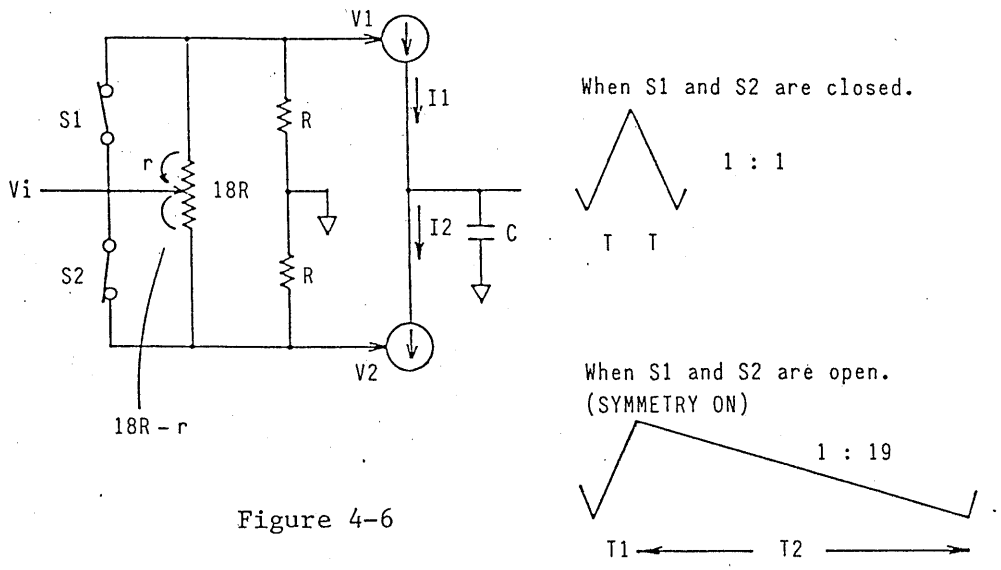


Figure 4-6

The principle of the SYMMETRY adjustment circuit is shown in Figure 4-6. Current I1 is directly proportional to voltage V1 and time T1 is inversely proportional to current I1. Therefore, time T1 is inversely proportional to voltage V1. When switches S1 and S2 are closed, the relationship between voltage Vi and time T is expressed as follows:

$$Vi = V1 = V2 = \frac{K}{T}$$

where, K: Voltage-to-current conversion constant

$$T = \frac{K}{Vi}$$

Therefore, one period is expressed as follows:

$$2 \cdot T = \frac{2 \cdot K}{Vi}$$

When switches S1 and S2 are made open for symmetry adjustment, the circuit operation can be expressed as follows:

$$V1 = Vi \times \frac{R}{r + R} = \frac{K}{T1}$$

$$T1 = \frac{K}{Vi} \times \frac{r + R}{R} = T \times \frac{r + R}{R}$$

The circuit constants have been selected to meet the conditions of $1 \leq (r+R)/R \leq 19$ so that T1 is adjustable for T to 19T. T2 also is adjustable from T to 19T.

$$V2 = Vi \times \frac{R}{18R - r + R} = \frac{K}{T2}$$

$$T2 = \frac{K}{Vi} \times \frac{18R - r + R}{R} = T \times \frac{18R - r + R}{R}$$

$$T1 + T2 = \frac{2K}{Vi} \times 10 = 2T \times 10$$

When set to the symmetry adjustment state, the oscillating period becomes 10 times (the oscillating frequency becomes 1/10) of the set frequency and the instrument oscillates at this frequency regardless of setting of the SYMMETRY ADJUSTMENT potentiometer. That is, symmetry of the output signal waveform is adjustable with the potentiometer without causing variation of the oscillating frequency.

4.5 Triggered Oscillation Mode

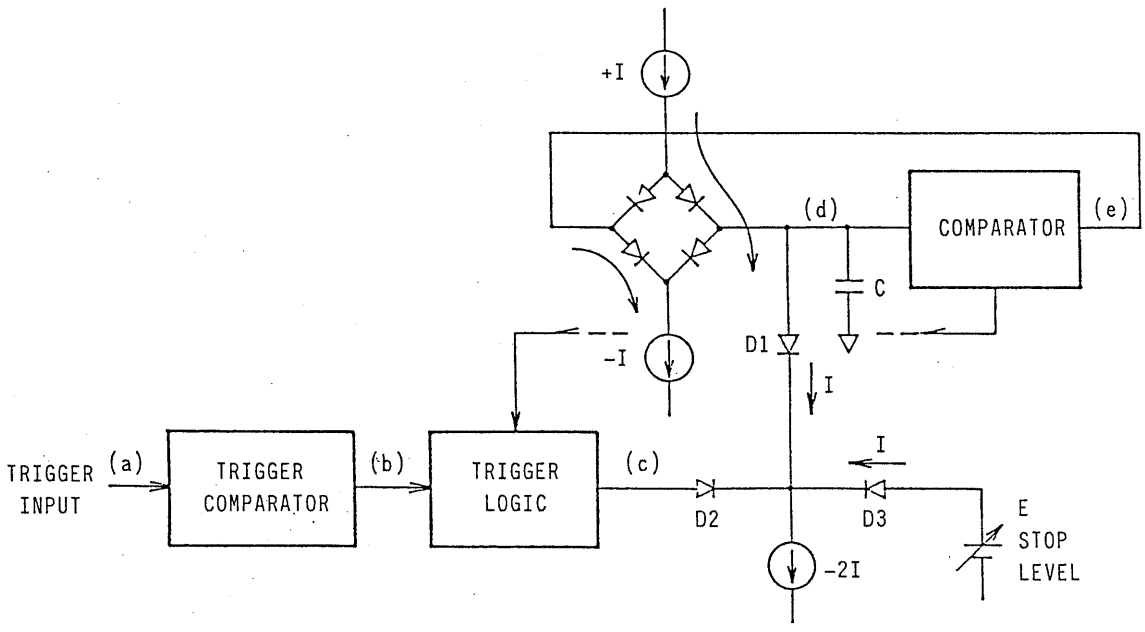


Figure 4-7

A block diagram of the trigger circuit is shown in Figure 4-7. The triggered oscillation mode is such that the Function Generator delivers a single cycle of output signal when it is triggered with its front panel switch (MANUAL TRIG switch) or with an external trigger signal.

Before application of the manual or external trigger signal, the trigger logic output potential c is negative and diode D2 is not conducting. In this case, the comparator output potential e is positive and the diode switch circuit will attempt to charge capacitor C with current +I. However, as D1 and D3 are on, current +I flows through D1. Due to the constant-current supply of -2I, current I flows also through D3 and, since the forward voltages V_{D1} and V_{D3} of D1 and D3 are equal, the potential of point d is held at stop level E. By varying stop level E, the start/stop point can be varied.

When a trigger signal is applied, the trigger comparator operates and the trigger logic output potential c becomes positive, diode D2 conducts, and diodes D1 and D3 are turned off. As D1 is turned off and capacitor C is charged with current +I, potential of point d rises and the circuit oscillates in the regular mode. When the potential of point d has fallen and the comparator is inverted, a reset signal of trigger logic appears at point f, the potential of point c becomes negative again, and diode D2 is cut off. In this case, although diode D3 is turned on, since the potential of point d is lower than E, diode D1 operates with current +I until the potential of point d becomes equal with E. When they have become equal, the potential of point d is held at E and the triggered oscillation stops.

The signal waveforms of the triggered oscillator circuit are shown in Figure 4-8.

The oscillating waveforms which are obtained by varying the start/stop point are shown in Figure 4-9.

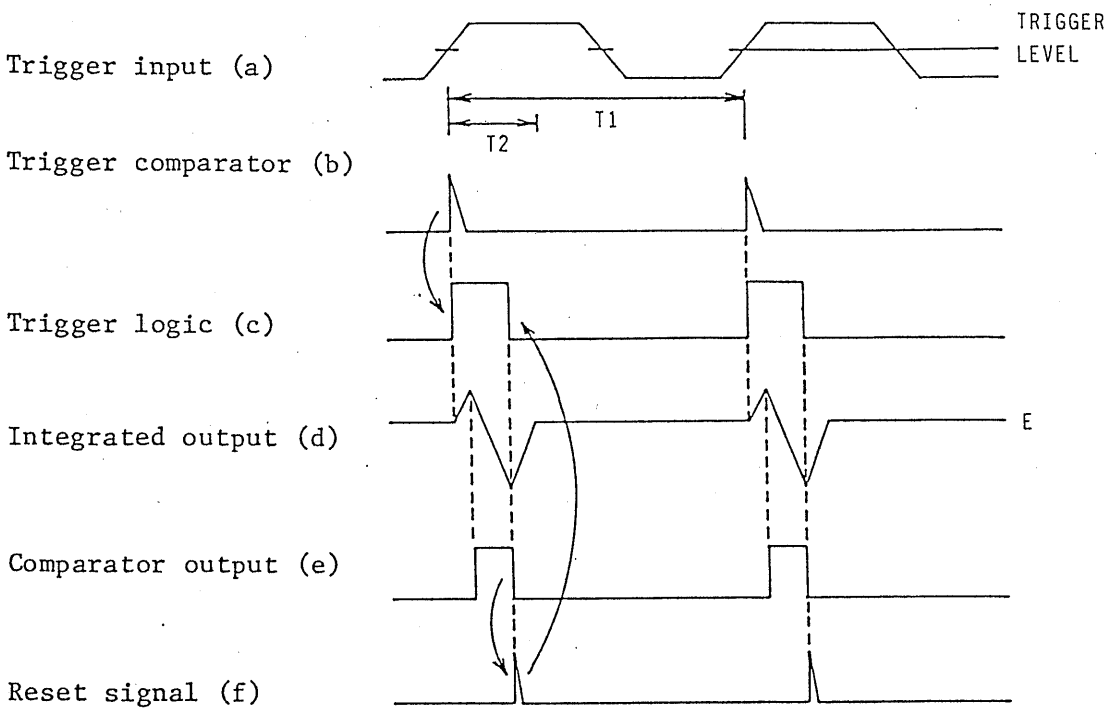


Figure 4-8

Note: T1 denotes the trigger input period and T2 the oscillation period.

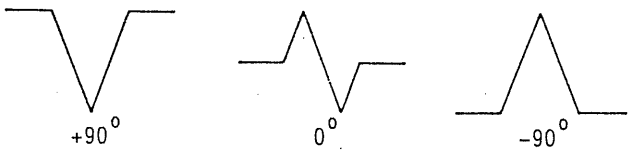


Figure 4-9

4.6 Gated Oscillation Mode

While the triggered oscillation is only for one cycle of oscillation each time a trigger signal is applied, the gated oscillation is for multiple cycles of oscillation during the period the gate is kept open by the gate signal generated by the trigger comparator.

When in the gated oscillation mode, the comparator output is used as a level output signal and the trigger logic circuit continues oscillation until the comparator output collapses. The block diagram of Figure 4-7 is applicable to the gated oscillator circuit as well. The signal waveforms of the gated oscillator circuit are shown in Figure 4-10.

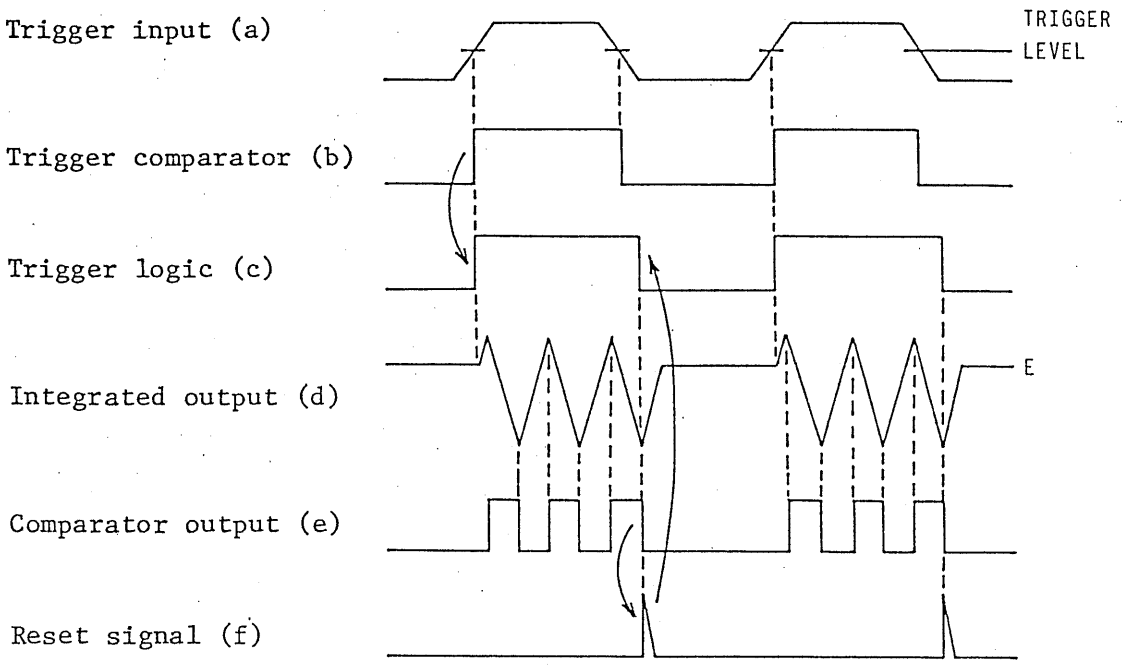


Figure 4-10

The start/stop point can be varied as in the case of the triggered oscillation. By employing a trigger input signal of approximately ±1 V to ±10 V of triangular wave or sine wave, the output cycles can be varied from one cycle to multiple cycles.

4.7 VCA (Voltage-controlled Amplitude) Function

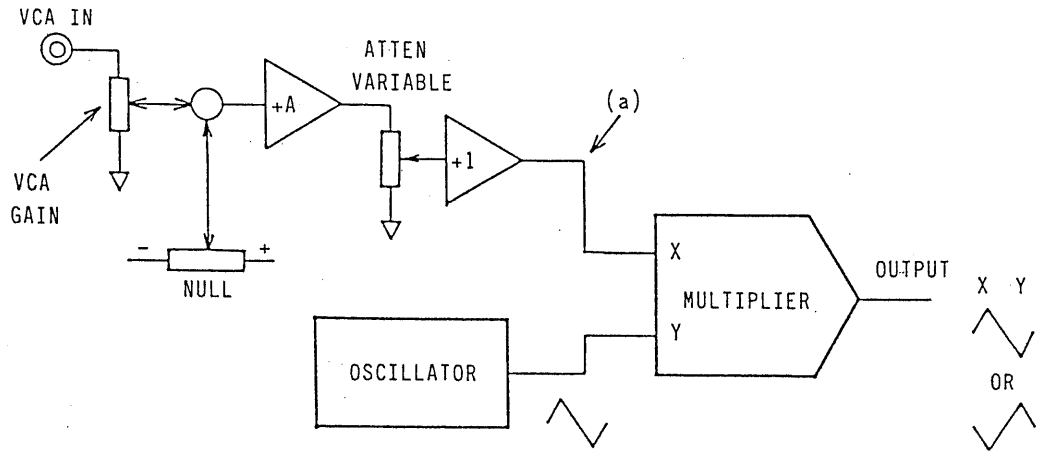


Figure 4-11

The VCA functional is to control the amplitude of the output signal with an external control signal. Of the 4502 Function Generator, the VCA function is accomplished by employing a transconductance multiplier system making use of voltage-to-conductance change characteristics of a transistor. A block diagram of the VCA circuit is shown in Figure 4-11.

Normally, the voltage applied to the X input (point a) of the multiplier is positive and the output signal is in phase with the Y input signal. If a negative voltage is applied to the X input by the VCA IN input signal, output signal is inverted.

4.8 DC Offset Function

A DC offset voltage can be superimposed on the signal waveform at the output amplifier.

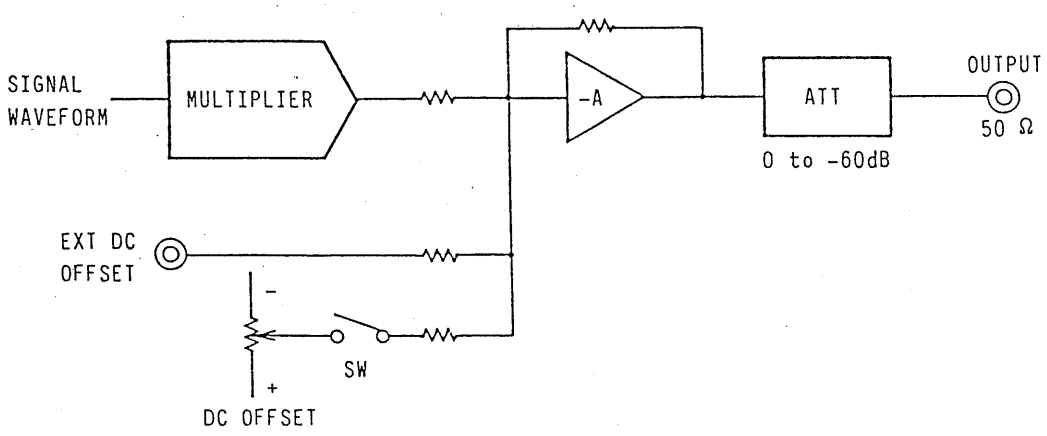


Figure 4-12

5. EXAMPLES OF USES

5.1 Frequency-swept Waveform

For example, frequencies of 20 Hz to 20 kHz can be linearly swept with a sweep period of 10 sec as follows:

(1) MODE: CONT

(2) VCG: PUSH ON

(3) RANGE: ×1 kHz

(4) VCG INPUT

From Eq. 3.1.1,

$f_L = 2 \times V_L \times R$

$V_L = +10$ mV

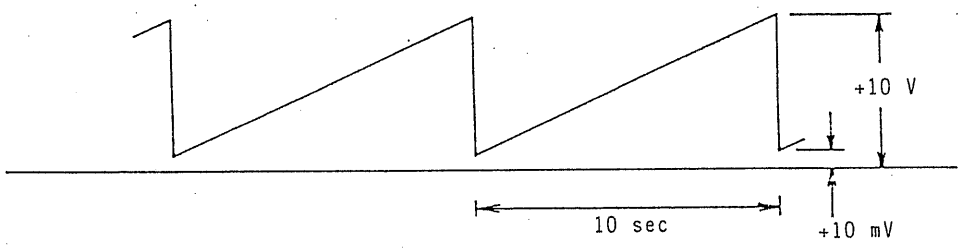
$f_H = 2 \times V_H \times R$

$V_H = +10$ V

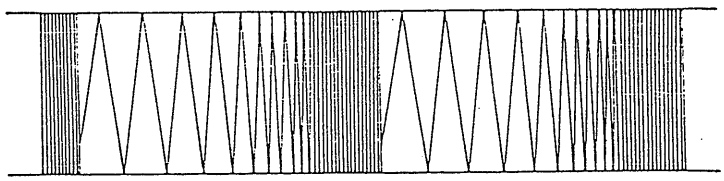
f: Oscillating frequency

V: VCG input voltage

R: Range



Example of frequency-swept triangular waveform



5.2 FM Waveform

For example, a frequency-modulated waveform with carrier frequency 1 MHz, degree of modulation 10 kHz and modulating frequency 1 kHz can be produced as follows:

(1) MODE: CONT

(2) VCG: OFF

(3) RANGE: ×100k

(4) DIAL: Position 10 (1 MHz)

(5) VCG INPUT

From Eq. 3.1.2,

$$f_H = 2 \times \left(\frac{D}{2} + V_H\right) \times R$$

$V_H = +0.05$ V

$$f_H = 2 \times \left(\frac{D}{2} + V_L\right) \times R$$

$V_L = -0.05$ V

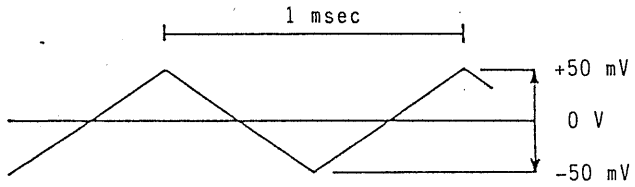
f: Oscillating frequency

V: VCG input voltage

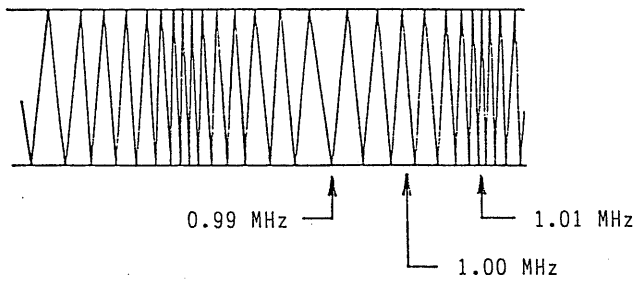
R: Range

D: Dial reading

VCG input waveform



Output waveform



5.3 AM Waveform

For example, an amplitude-modulated waveform with carrier frequency 1 MHz, degree of modulation 50%, and modulating frequency 1 kHz can be produced as follows:

(1) MODE: CONT

(2) RANGE: 10 kHz

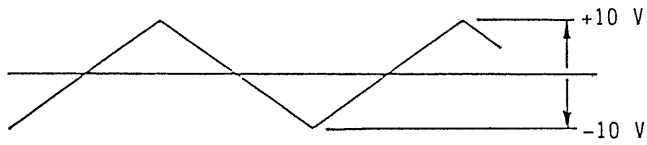
(3) DIAL: Position 10 (1 MHz)

(4) VCA INPUT: Apply a triangular wave of 1 kHz, 10 Vp-p.

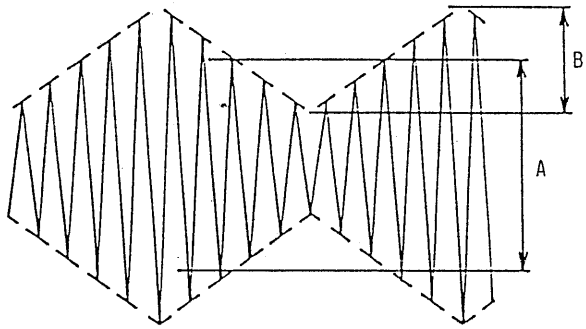
(5) VCA: Pull out the NULL knob to turn on the VCA function.

(6) VCA GAIN/NULL: Adjust the degree of modulation to 50% with both controls.

VCA input waveform



Output waveform



A:B = 2:1

5.4 Tone Burst Waveforms

(A) For example, a multi-cycle tone burst waveform can be produced as follows:

(1) Frequency control: DIAL or VCG

(2) MODE: EXT GATE

(3) EXT TRIG INPUT: Apply a sine, triangular, or square wave of repetition period T1 shown in the below illustration.

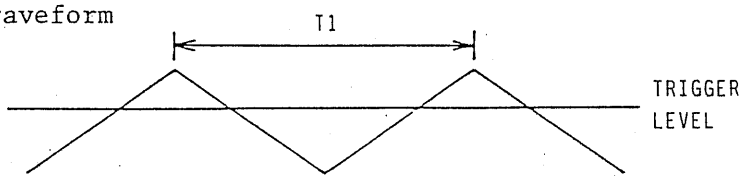
(4) START/STOP: Mid-position

(5) LEVEL: Mid-position

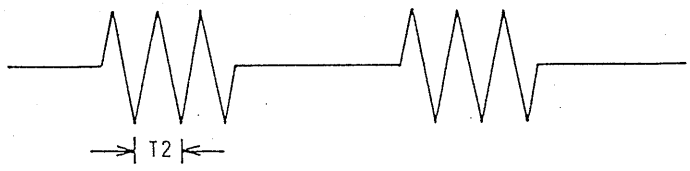
(6) SLOPE: "+" or "-"

Monitoring the output waveform with an oscilloscope, adjust the cycle of the tone burst waveform with the LEVEL control. Period T2 shown in the below illustration is adjustable with the FREQUENCY DIAL or the VCG input voltage.

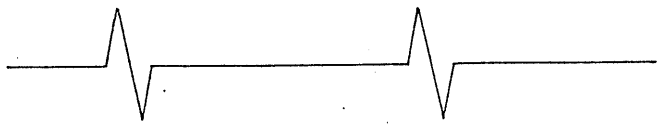
Input waveform



Output waveform (multi-cycle bursts)



(B) A one-cycle burst waveform can be produced in the same procedure as is the case of a multi-cycle burst waveform, the only exception being that the MODE selector switch should be set to the EXT TRIG state.



Note: The start/stop phase (voltage) is adjustable by means of the START/STOP control.

6. CALIBRATION

6.1 Layout of Components

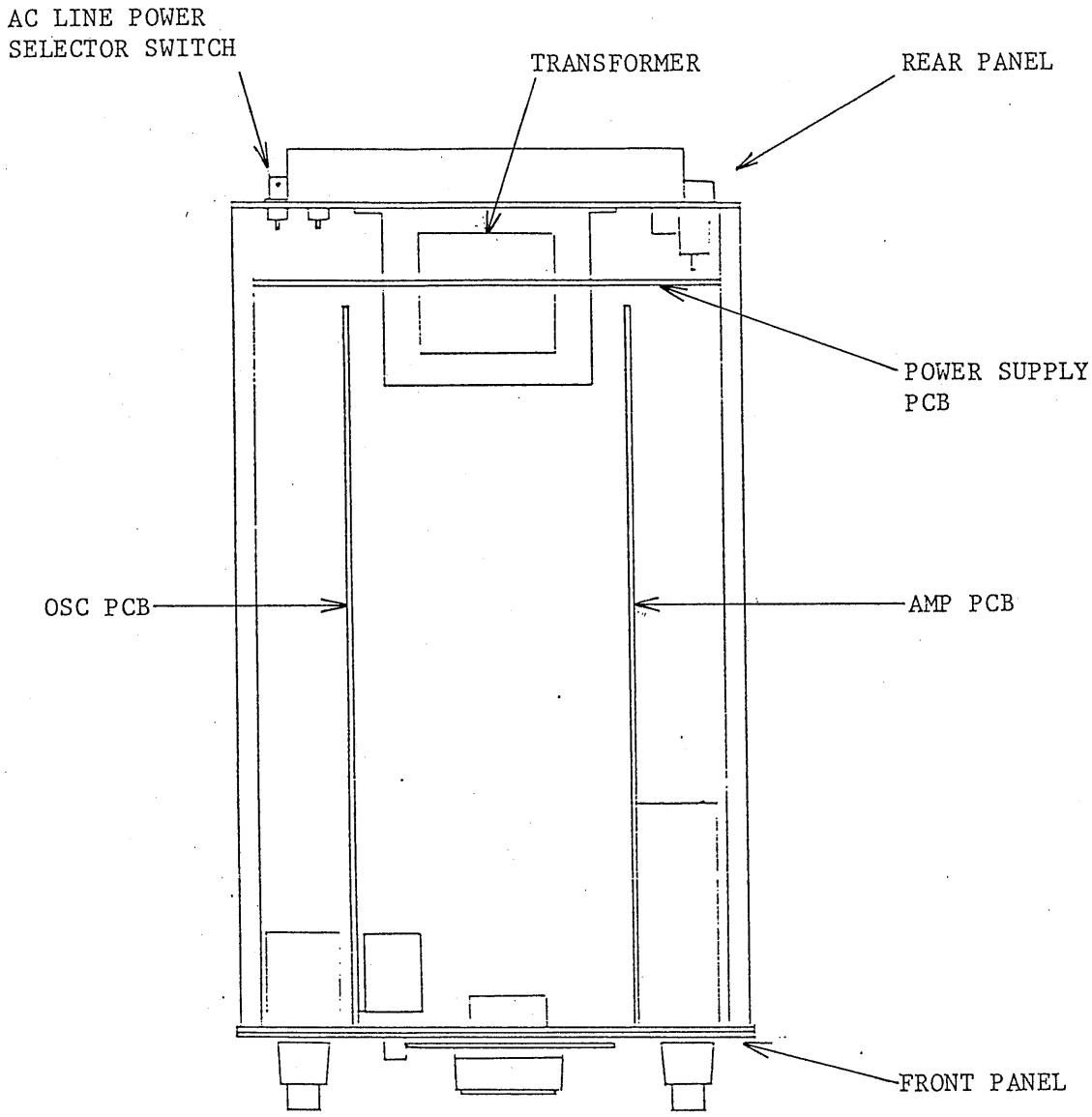


Figure 1

Note: Layout of components of the Function Generator as viewed from the top, with the cover removed.

6.2 Initial Settings

Before starting calibrating the Function Generator, set the switches and controls as follows:

- o POWER: OFF
- o MODE: CONT
- o TRIG LEVEL: Mid-position
- o RANGE (Hz): 1k
- o VARIABLE: CAL
- o VCA GAIN: Minimum
- o NULL (VCA): Mid-position (OFF)
- o START POINT: 0
- o VC OFFSET: 0 (OFF)
- o FUNCTION:
- o SYMMETRY (PULL ON): Mid-position (OFF)
- o ATTEN (dB): 0 dB
- o VARIABLE (HF LIMIT): Maximum (OFF)
- o SLOPE: +
- o VCG [PUSH ON]: OFF

For calibration, perform the procedures of the following sections in the due order.

(1) Power Supply (6.3)

(2) Oscillator (6.4)

(3) Amplifier (6.5)

6.3 Power Supply

For layout of components on the power supply printed circuit board (POWER SUPPLY PB-1152), see Figure 6-2.

Procedure No.	Calibration Item	Setting	Test point	Control	Remarks
1	+24V	POWER ON	OUT 4		+24V ±1V
2	-24V		OUT 5		-24V ±1V
3	+12V		OUT 6	VR2	-12V ±0.03V
4	-12V		OUT 7	VR3	+12V ±0.03V
5	+5.2V		OUT 8	VR1	+5.2V ±0.1V

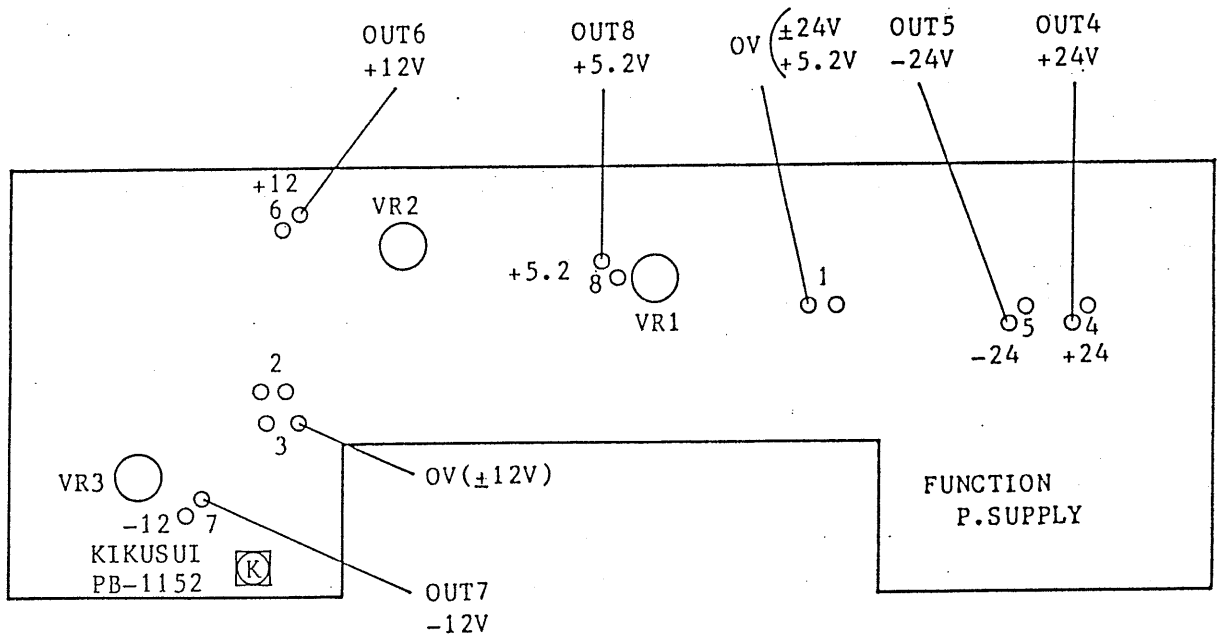
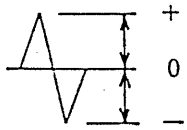
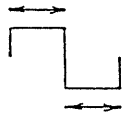


Figure 6-2. Layout of Components of Power Supply PCB

6.4 Oscillator

For layout of components on the oscillator printed circuit board (OSC PB-1153), see Figure 6-3.

Procedure No.	Calibration Item	Setting	Test point	Control	Remarks
1	U2 offset	VCG: ON	TP2	VR3	0V ±100μV
2	U3 offset		GCV OUT	VR4	0V ±100μV
3	U1 gain	VCG: OFF DIAL: 20	TP2	VR1	-8V ±40mV
4	U1 offset	DIAL: 1	TP2	VR2	-0.4V ±4mV
5	U4 offset	VCG: ON	TP4+ TP5	VR6	0V ±100μV
6	U6 offset		TP6+ TP7	VR8	0V ±100μV
7	Triangular wave buffer offset	C12: Short	TP8	VR30	0V ±20mV
8	Triangular wave peak 	C12: Remove short VCG: OFF DIAL: 20	TP8	VR32	+1.25V
9				VR31	-1.25V
10	×1k range	VCG: ON VCG IN: +10V RANGE: ×1k	TTL OUT	VR14	T1: 25μS 
11	×1k range		TTL OUT	VR20	T2: 25μS
12	U5 offset	VCG IN: +10mV	TTL OUT	VR9	T1: 25mS
13	U7 offset		TTL OUT	VR10	T2: 25mS

Procedure No.	Calibration Item	Setting	Test point	Control	Remarks
14	×1M range 2M ADJ	RANGE: ×1M VCG IN: +1V	TTL OUT	VR11 VR17 VC1	Duty 1:1 f: 2MHz
15	20M ADJ	VCG IN: +10V	TTL OUT	VC2 VC3	f: 20MHz
16	×100k range 2M ADJ	RANGE: ×100k	TTL OUT	VR12	T1: 0.25μS
17			TTL OUT	VR18	T2: 0.25μS
18	×10k range 200k ADJ	RANGE: ×10k	TTL OUT	VR13	T1: 2.5μS
19			TTL OUT	VR19	T2: 2.5μS
20	×1k range 20k ADJ	RANGE ×1k	TTL OUT	VR14	T1: 25μS
21			TTL OUT	VR20	T2: 25μS
22	×100 range 2k ADJ	RANGE: ×100	TTL OUT	VR15	T1: 250μS
23			TTL OUT	VR21	T2: 250μS
24	×10 range 200 ADJ	RANGE ×10	TTL OUT	VR16	T1: 2.5mS
25			TTL OUT	VR22	T2: 2.5mS
26	U9 offset		TP11	VR26	0V ±50μV
27	×1 range	RANGE: ×1	TTL OUT	VR25	T1: 25mS
28	×1 range		TTL OUT	VR23	T2: 25mS
29	×0.1 range	RANGE: ×0.1	TTL OUT	VR27	T1+T2: 500mS
30	×0.01 range	RANGE: ×0.01	TTL OUT	VR28	T1+T2: 5S
31	×0.001 range	RANGE: ×0.001	TTL OUT	VR29	T1+T2: 50S

Procedure No.	Calibration Item	Setting	Test point	Control	Remarks
32	SYMMETRY: 1:19	VCG: OFF VCG IN: 0V RANGE: ×100 DIAL: 10 SYMM: ON (left)	TTL OUT	VR5	1:19
33	SYMMETRY: 19:1	SYMM: (right)		VR7	19:1
34		Initial setting			
35	U16 offset	MODE MANUAL TRIG RANGE: ×1 VCG: ON VCG IN: +10V START/STOP: 0V ↓ ↑ VCG IN: +10mV	TP8	VR33	Adjust so that the stop point does not move. (0V ±50mV)
36	×10 stop point	VCG IN: +10V RANGE: ×10	TP8	VR39	0V ±20mV
37	×100 stop point	RANGE: ×100	TP8	VR38	0V ±20mV
38	×1k stop point	RANGE: ×1k	TP8	VR37	0V ±20mV
39	×10k stop point	RANGE: ×10k	TP8	VR36	0V ±20mV
40	×100k stop point	RANGE: ×100k	TP8	VR35	0V ±20mV
41	×1M stop point	RANGE: ×1M	TP8	VR34	0V ±20mV

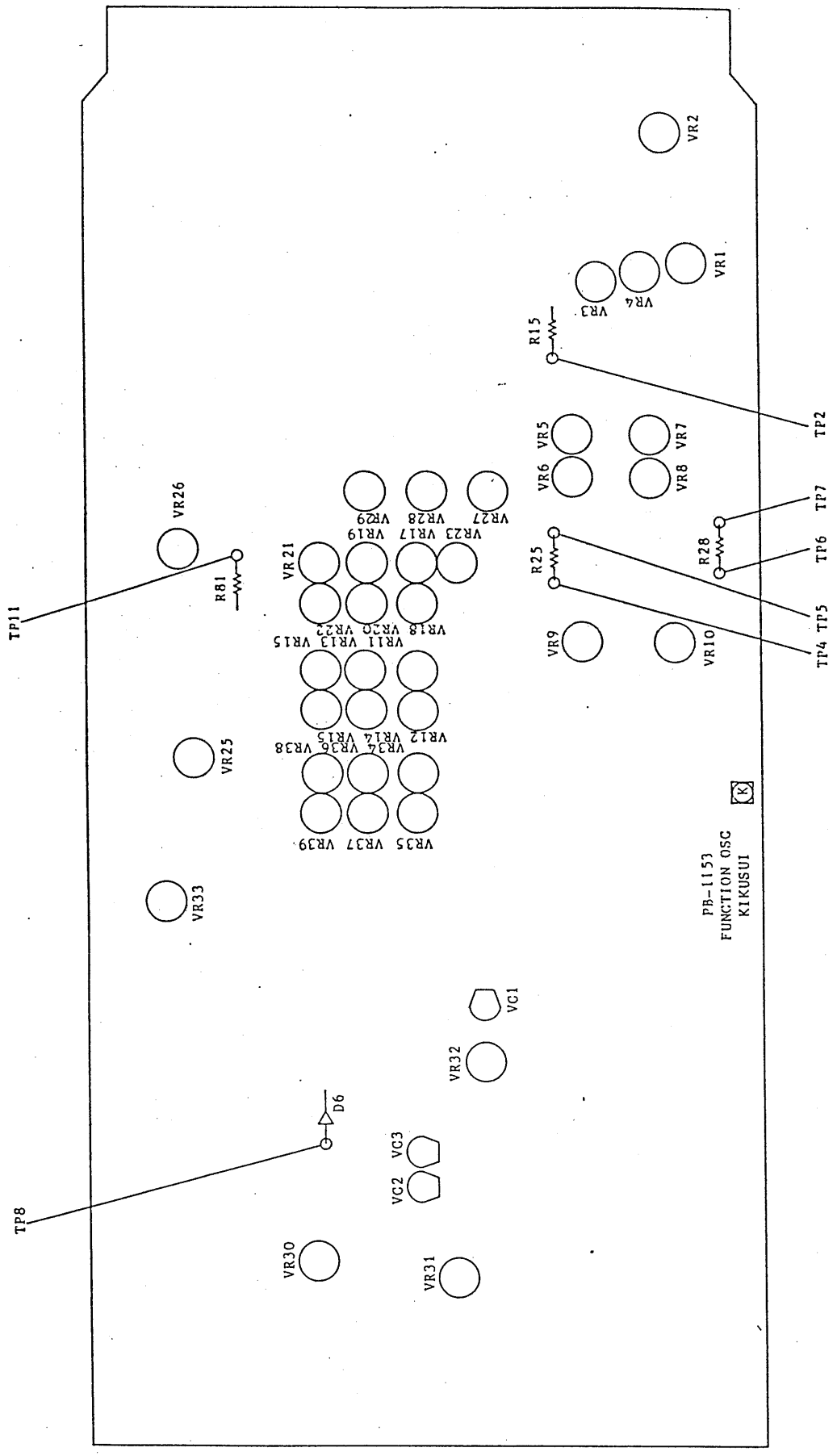
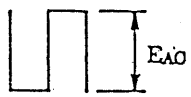
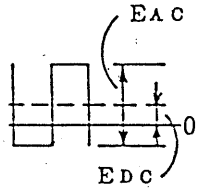
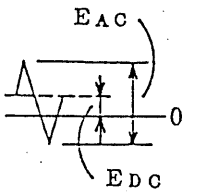
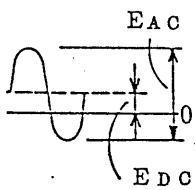


Figure 6-3. Layout of Components of Oscillator PCB

6.5 Amplifier

For layout of components on the amplifier printed circuit board (AMP PB-1154), see Figure 6-4.

Procedure No.	Calibration item	Setting	Test point	Control	Remarks
1		Initial setting			
2	VCA buffer	ATT VARI: Max.	TP2	VR20	-7.5V ±50mV
3	VCA 	VCA: ON NULL (right) ↓ ↑ NULL (left)	OUTPUT	VR13	Make E_{AC} equal.
4	DC offset	Make output minimum with NULL.	OUTPUT	VR19	0V ±50mV
5	Sauare wave VCA 	NULL (right) ↓ ↑ NULL (left)	OUTPUT	VR1	$E_{AC} + E_{DC}$ Make E_{DC} equal.
6					
7		ATT VARI: Min.	OUTPUT		E_{AC} = 0V
8	Triangular wave VCA 	FUNC.  NULL (right) ↓ ↑ NULL (left)	OUTPUT	VR2	Make E_{DC} equal.
9					
10					
11	Sine wave VCA 	FUNC.  NULL (right) ↓ ↑ NULL (left)	OUTPUT	VR3	Make E_{DC} equal.
12		NULL (right)	OUTPUT	VR6	E_{DC} = 0V
13		ATT VARI: MIN.	OUTPUT	VR16	E_{AC} = 0V

Procedure No.	Calibration item	Setting	Test point	Control	Remarks
14	-20dB VCA SYMMETRY	FUNC ∿ ATT VARI: -20dB	OUTPUT	VR17	Make distortion minimum.
15	Maximum output		OUTPUT	VR21	32Vp-p
16	Rise-up fall-down frequency response	FUNC ⊓	OUTPUT	VC2	
17	Sine wave distortion factor	FUNC ∿ RANGE: ×100 DIAL: 10	OUTPUT	VR7 VR12	0.5% or less

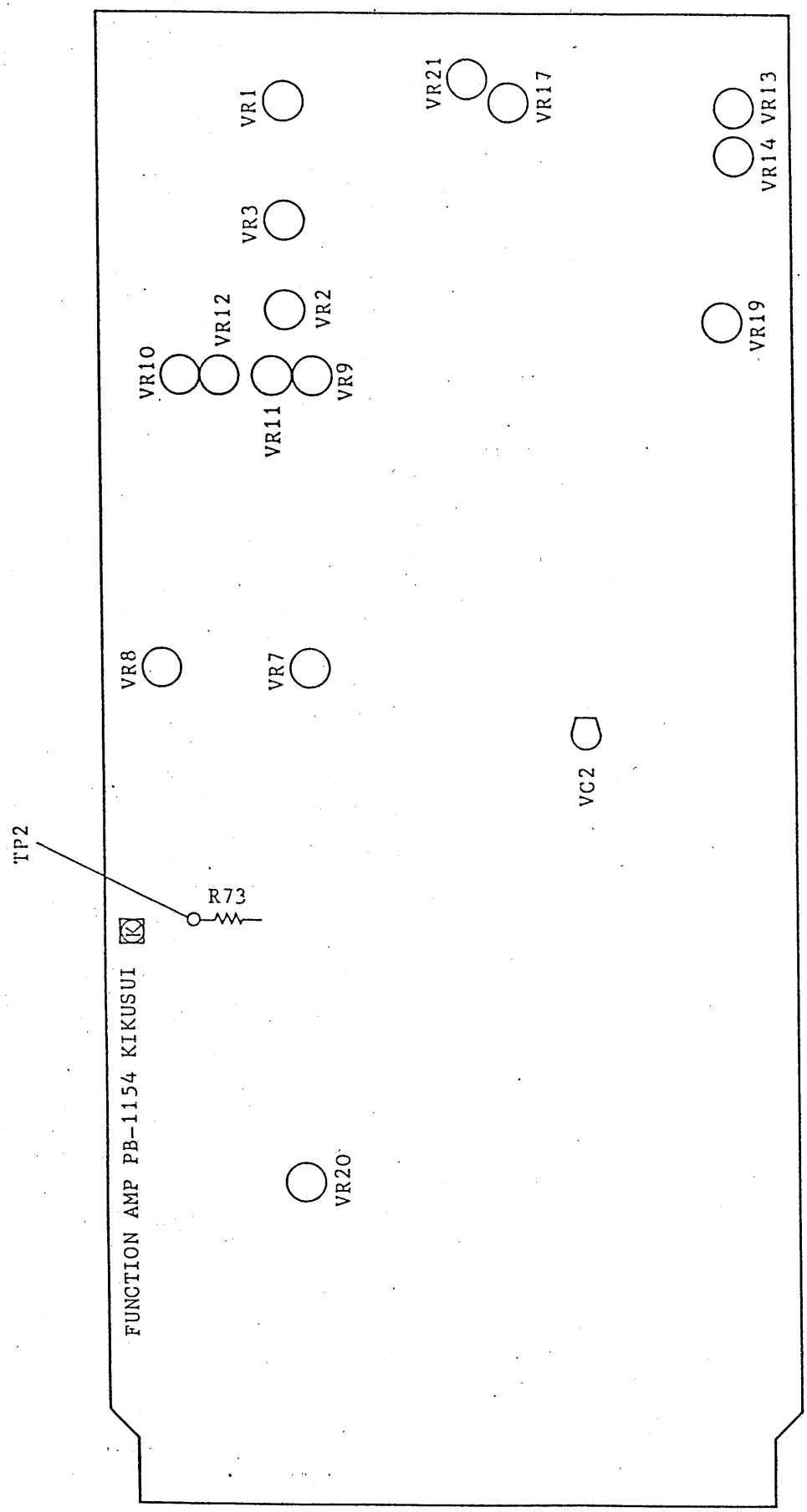


Figure 6-4. Layout of Components of Amplifier PCB

FUNCTION GENERATOR 4502 INSTRUCTION MANUAL