MODEL 458

FUNCTION GENERATOR

OPERATING MANUAL

KIKUSUI ELECTRONICS CORP.

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1. GENERAL DESCRIPTION

KIKUSUI's MODEL 458 is a function generator which provides signal of sine-wave, triangular-wave, square-wave and variable slope sawtooth waveform 0.01Hz to 100kHz. Output voltage can be obtained max.30Vp-p at open circuit, 15Vp-p with rated load 600Ω.

Oscillation frequency is variable with manual control divided in 7 ranges decade and also VCG function is employed , which has variable range of 1:1000.
Then the frequency is proportional to input voltage (10mV~ 10V).

A half period of triangular and square-wave is variable, if DC offset of output wave is required, it is easily obtained for all waveforms with offset control on front panel.

To control the start of oscillation, trigger function (generation of one cycle of waveform) and gated function (generation of tone burst wave form) are provided using external signal or manual operation.
The phase at the start and stop of the oscillation frequency can also be varied within a range of zero to ±90 degrees.

Model 458 can be used as a voltage control generator, tone burst generator for special waveforms as well as an ordinary generator. Therefore , it is widely applied to many types of mesurements and tests such as frequency response mesurement of feedback amplifiers, tests of servo equipment in automatic control systems, tests of analog computer, function generators, signal tests of vibration exciters and sound equipment.

2. SPECIFICATIONS

Functions	1. Frequency Control	MANUAL or VCG
	2. Oscillation Mode	*MANUAL Triggering mode Gated mode *External Trigering mode Gated mode *Continuous oscillation
	3. DC offset	available

Frequency	0.01Hz ~ 100kHz
Range	x0.01, x0.1, x1, x10, x100, x1k, x10k
Dial Scale	1 ~ 10, equally devided
Accuracy	±(2%+0.5% of dial scale)
Frequency Stability	within ±5% with respect to ±10% fluctuation of power line.
Output Waveforms	Symmetry waveforms Sine(∿), Square(⊓⊔), Triangular(/\/) Unsymmetry Sawtooth(/_/), (_/\\), Square(⊓__), (⊔‾‾)
Output Voltage	(open circuit) more than 30Vp-p
Frequency Response	within ±0.3dB with respect to 1kHz
Output Resistamce	600Ω ± 20%
Amplitude Stability	within ±0.5% with respect tc ±10% fluctuation of power line voltage
Output Voltage difference	(between waveforms) Less than 5% at 1kHz
Distortion (Sine)	Less than 0.6% from 20Hz to 30kHz Less than 1.5% from 30kHz to 100kHz
DC offset	Less than ±15V, (± Output Voltage added offset voltage)
Unsymmetry waveforms	100 times variable at 10 of dial scale (when Range Switch is set on "1 ~ 10k")

VCG	
Control Voltage	Approx. 10mV ~ 10V
Frequency	0.01Hz ~ 100kHz
Range	x1, x10, x100, x1k, x10k
Frequency Variable Range	1:1000 in a Range
Input Resistance	Approx. 10kΩ unbalance
Input Frequency Range	DC ~ 10kHz
Trigger Level	Adjustable within 1Vp-p ~ 10Vp-p
Trigger. Slope	+ or – with selector switch
Start-Stop point	variable approx. 0 ~ ±90 in sine or triangular wave
Manual trigger	equipped
Sync Signal Output	
Pulse Amplitude	more than –5V peak
Pulse Width	less than 5μsec.
Power Source	V 50/60Hz approx. 9.5VA
Dimensions	138W x 159H x 280D
(Max. Dimensions)	140W x 190H x 340D
Weight	Approx. 3.2kg
Accessories	Operational Manual

3. OPERATION

3-1 Front Panel and Controls (See Fig. 3-1)

1. POWER — Power pushbutton switch. when pushed and locked, Power is on and the pilot lamp lights to indicate a ready state

2. MODE — A Selection switch of Oscillation Mode. In case of not continuous oscillation, the switch is set to "CONT" position. If the equipment is used in gated or triggering mode for generation of pulse or burst waveforms, Set the switch to "EXT TRIG" or "EXT GATE".
For one cycle or manual start oscillation, select a position of "MANUAL TRIG" or "MANUAL GATE"

3. RANGE — Selection switch for frequency range Reading value of dial, multiplied by Range multiplier indicates output frequency .
When the dial is used, multiplier from 0.01 to 10k.
In VCG operation multiplier is limited within 1 to 10k.

4. FREQUENCY — Frequency variable dial. To turn it clockwise, the frequency increases. When equipment is used as VCG, turn the dial fully counter-clockwise, then VCG function is ready for generation of frequency to be proportional to input applied voltage

5. FINE — Fine frequency adjustment knob. Turning it clockwise, the frequency increases. The dial is calibrated at "CAL'D" position.

6. FUNCTION — Selection switch of waveforms.
Sine(∿), Triangular(/\/), Square(⊓⊔) or
Variable duty(⌒⌣), (⌣⌒), (⊓⊔), (⊔⊓) can be obtaind

7. OUTPUT — Continuous Variable control knob for the output voltage. Clockwise rotation increases the output voltage, and full counter-clockwise rotation decrease the output voltage to -20dB. If offset voltage of the output is required. Adjust the output voltage properly with this control. (Dose not use attenuator in offset adjustment)

8. ATTEN — An attenuator of the output. Attenuation of -40dB, -20dB and 0dB can be obtained

9. Output Terminal — An output terminal which have output impedance of 600Ω can feed max. 30Vp-p. The outside of BNC receptacle which is connected to signal ground is floated to the case of the equipment.

10. SLOPE CONT — A control knob for variable slope triangular waveform and variable duty square waveform. Turning the knob clockwise, a half period of waveform increases, and ratio would reach to 1:100 at full rotation.

11. DC OFFSET — A pushbutton is a switch for ON-OFF OFFSET voltage. A knob under the switch controls continuously OFFSET value from the negative to the positive. In case of offset voltage applied, a following caution is needed.

Keep the sum of peak output voltage and offset voltage within ±15V, if not so the output amplifier would saturate and cause excessive distortion.

12. START POINT — A control knob for start-stpp point of sine and triangular waveform. If the start-stop point set nearby +90° or more, the equipment will begin to oscillate continuously.

13. TRIG LEVEL — Triggering level control knob for triggering or gated oscillation.

14. EXT. TRIG SLOPE — A slope selection switch for triggering. "+" or "-" means positive-going or negative-going respectively.

15. MANUAL TRIG — A triggering or gate switch for manual operation.

16. EXT — An external input terminal of triggering. Max. input voltage should be less than 10Vp-p.

17. VCG — An input terminal of voltage control generator (input voltage controls the frequency). Acceptable voltage range is from 10mV to 10V

3-2 Rear Panel Description (see Fig.3-2)

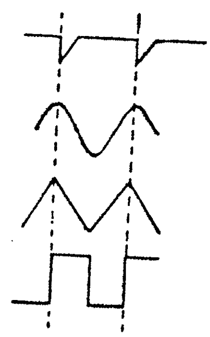
18. SYNC OUTPUT — A synchronization output terminal. More than -10V peak output signal synchronizing with the positive peak of sine-wave or triangular-wave, or with the fall of square-wave can be obtained.

Synchronize pulse

Sine-wave

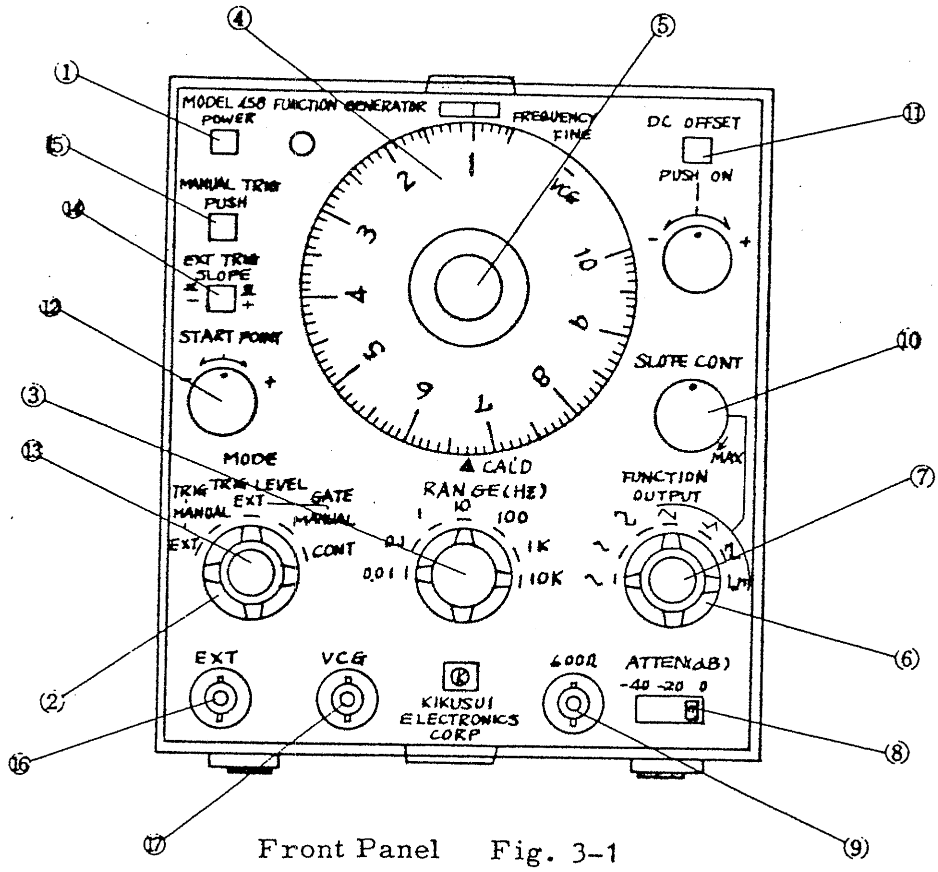
Triangular-wave

Square-wave

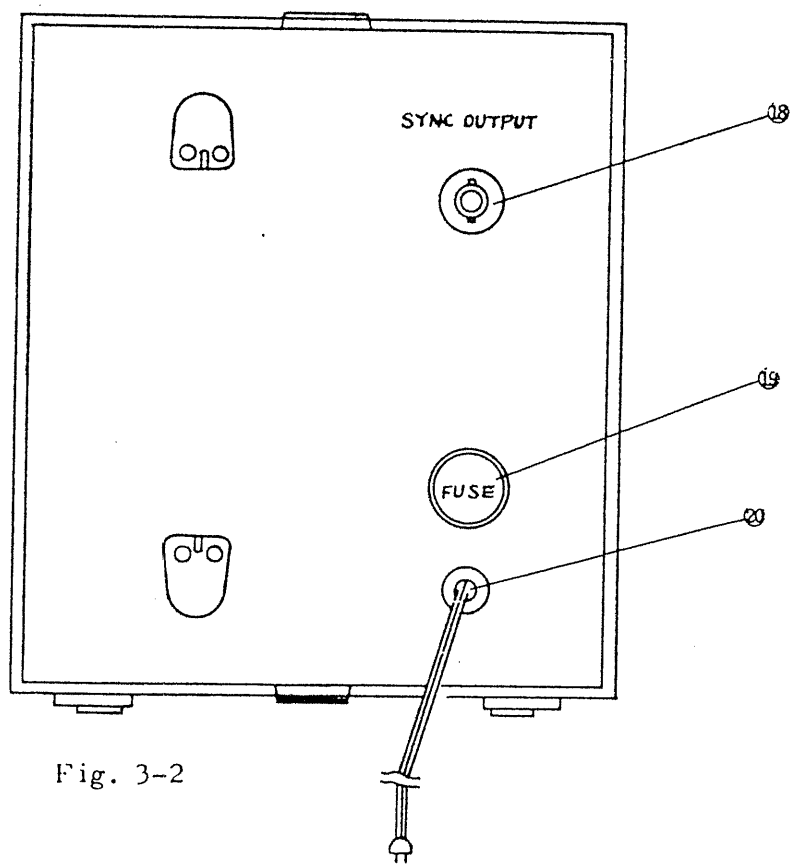


19. Fuse — A rated 0.5A fuse for AC 100V source

20. Power Cord — Connected to 50/60 Hz AC source.



Front Panel Fig. 3-1



Rear Panel Fig. 3-2

4. PRINCIPLE OF OPERATION

4-1 Fundamental Operation

Fig.4-1 shows the fundamental block diagram of Model 458 function generator which is composed of a flip-flop circuit, integrator, voltage comparator and sine synthesizing circuit.

When the potential "a" in the flip-flop circuit is -E and the electric charge of capacitor C is zero immediately after power is turned on, the integrated oudput voltage at point "b" increase in the positive slope. When it reaches ±Er, the voltage comparator generates a trigger pulse to invert the flip-flop circuit, causing the potential at point "a" to become +E.

Next, the potential at output point "b" of the integrator begins to decrease from +E. When it reaches -Er, the voltage comparator generates a trigger pulse to change the flip-flop back to the former. A series of these operational procedures make the oscillation continue.

The oscillation frequency is set by voltage Er at point "a" , setting of R1 and values of R2 and C. In general, after approximate oscillation range is set by R2 and C, the frequency is continuously adjusted by potentiometer R1.

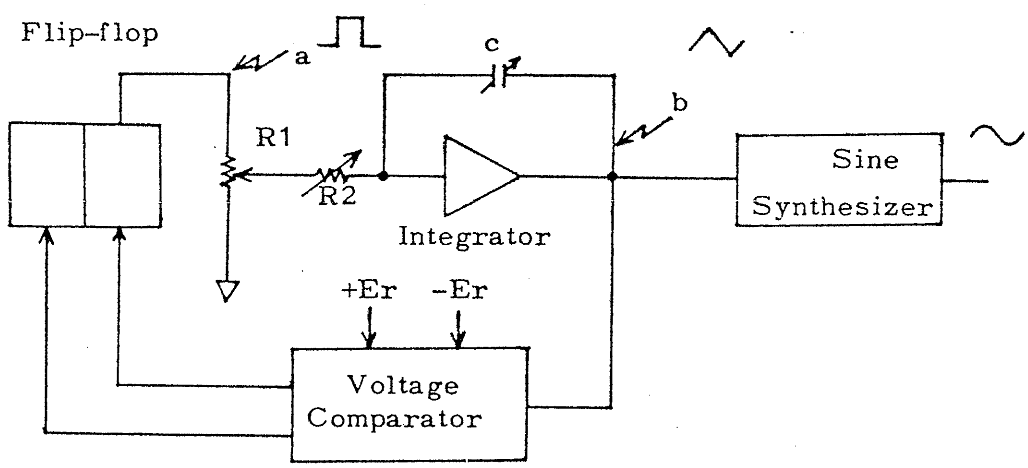


Fig. 4-1

Sine-wave is synthesized from the triangular-wave on integrator output. Fig. 4-2 shows this principle.

Diodes D1 through D6 and D1' through D6' are connected as shown in Fig. 4-2. All diodes are connected with associated weighted resistors in series in order to obtain the optimum piecewise approximation curve when instantaneous value e of the triangular-wave input is $0 < e < +E1$, all the diodes are cutt off.

Therefore, the input waveform appears in the same slope on the output side as it was.

In the case of $+E1 < e < +E2$, D1 becomes conductive and the slope of the output decreases to R1/(R1+R) when D3 through D6 become conductive by turns, the slope becomes looser.

The negative process is the same as the positive one D1' through D6' become conductive by turn and a sine-wave approximating to the pieswise can be obtaindd or the output side.

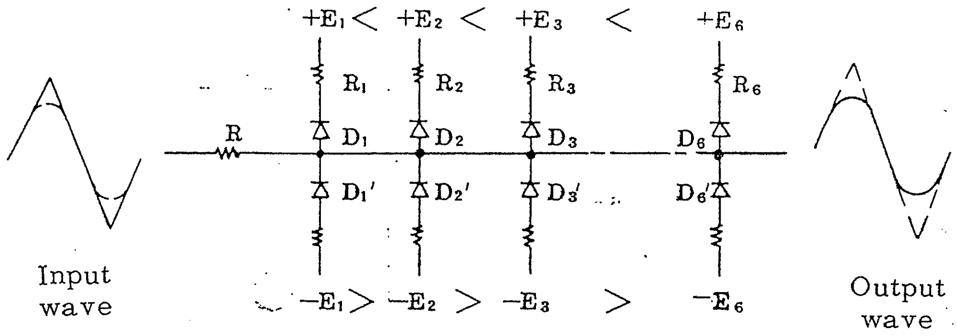


Fig. 4-2

4-2 VCG (VOLTAGE CONTROL GENERATOR) operation

Generators which can control the oscillation frequency by voltage are termed VCG or VCO.

There are the following two methods of voltage control function generators. In one , integrator time constant CR remains constant and the input voltage is controlled.

In the other , a constant current charging capacitor C is controlled.

Model 458 uses the later method (current control system) in order to extend the variable frequency range. Fig. 4-3 shows ablock diagram of this method.

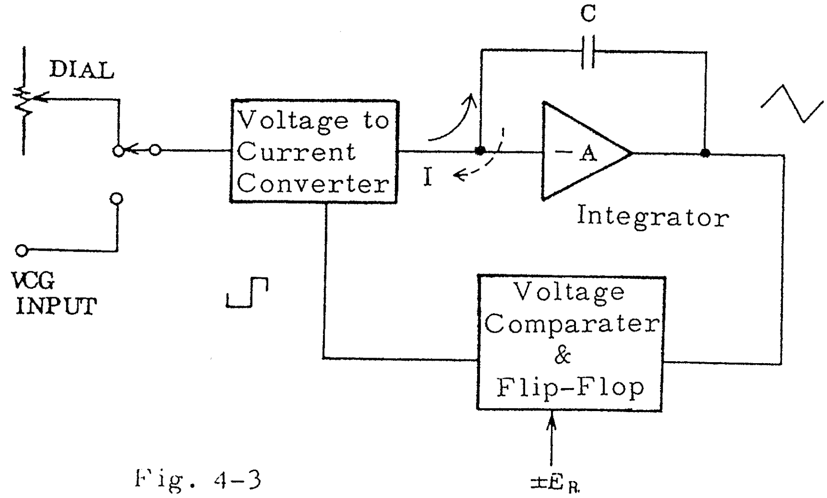


Fig. 4-3

When the constant current that is charging capacitor C is expressed as I, and the voltage comparator is set at −E and +E, and time interval t from +E to −E at the output of integrator is set as shown in Fig. 4-4, the following formula (1) can be obtained

$$2Er = \frac{I \cdot t}{C} \quad \cdots\cdots\cdots\cdots\cdots (1)$$

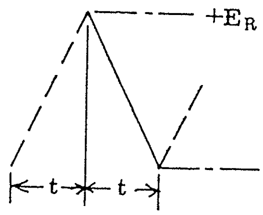


Fig.4-4

Since oscillation frequency f is t/2 as shown in Fig.4-4, formula (1) is expressed as follows;

$$f = \frac{I}{4ErC} \quad \cdots\cdots\cdots\cdots\cdots (2)$$

When capacitor C and the reference voltage of the comparator are made constant in formula (2), oscillation frequency f is proportional to the constant current. Thus, it can be controlled by varying the current.

The voltage/current converter converts the input voltage into proportional current to charge integrating capacitor C. Polarity of the current is controlled by the flip-flop circuit to maintain oscillation.

4-3 Slope Control

In section 4-2 charge and discharge current of integrator |−I| ,|−I| are both equal. The output is a symmetrical triangular waveform. If one of charge or discharge current is variable, the other fixed, variable slope (when triangular-wave selected) or variable duty (when square-wave selected) can be obtained. Fig. 4-5 shows this principle diagram.

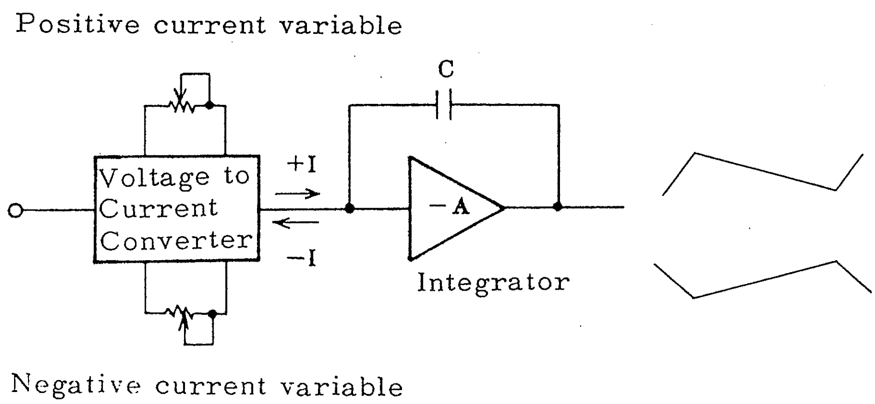


Fig. 4-5

4-4 DC offset

As shown Fig.4-6, dc offset voltage is added to the waveforms voltage at the summing point of output amplifier.

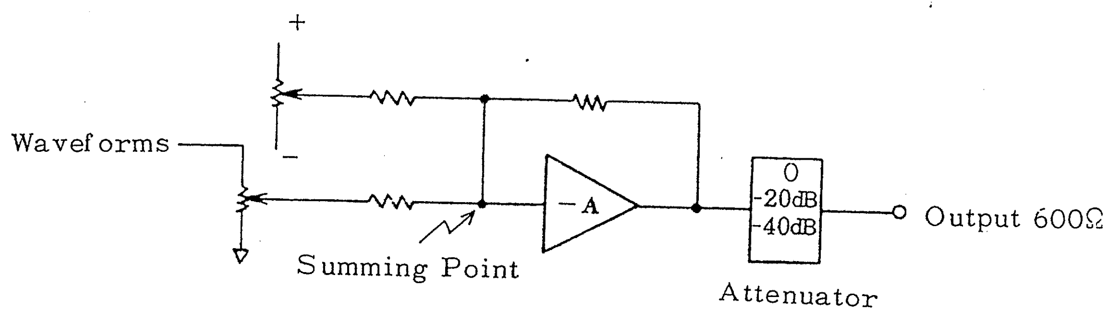


Fig.4-6

4-5 Triggering Oscillation

In this mode, the generator provides only one cycle of oscillation by means of the manual switch or external trigger signal, namely, it performs a mono-stable operation. Fig.4-7 shows the block diagram for triggering oscillation mode. First, the circuit conditions prior to application of external trigger signal are set as follows;

Output (b) is negative and CR1 is cutoff and the current polarity of the converter for the flip-flop circuit is set as shown in Fig.4-7

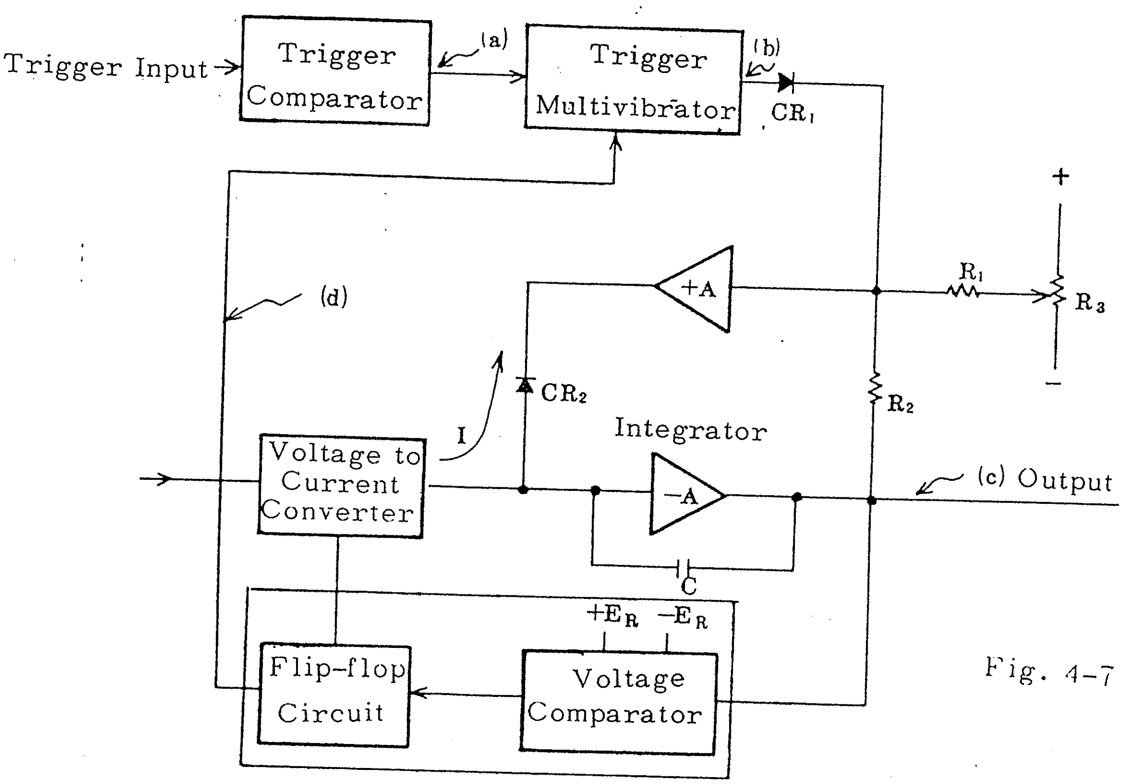


Fig. 4-7

Therefore. CR2 is conducting due to current I. Amplifier -A (integrator) and the non-inverting amplifier +A and R2 compose a closed loop circuit. The potential of output (C) can then be set positively or negatively byeoptionally setting R3. Whereby the start and stop points of oscillation are also set.

When the trigger signal is applied, the trigger comparator is turned on and generates a trigger pluse to change the state of trigger multivibrator, causing the voltage at (b) to be positive. Diode CR1 then become conductive and the current through +A cuts CR2 off.

The closed loop is then opened and current I starts to charge integrating capacitor C for integration. When output (C) reaches -E, the voltage comparator is energized and output (C) begins to increase. When it reaches +Er, the voltage comparator is energized, the state of flip-flop is inverted.

This inverted signal reset the trigger multivibrator to the former state. When output voltage (C) reaches the preset value, +A, -A and R2 compose a closed circuit, and thereby oscillation stops. Fig.4-8 shows the relative waveforms in this operational sequence. Fig.4-9 shows the waveforms obtaind when start and stop points change.

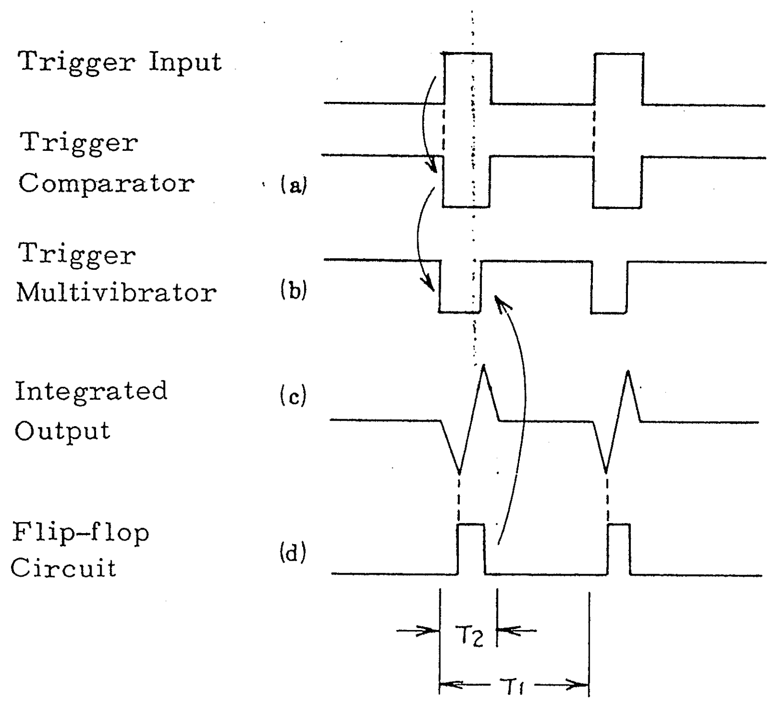


Fig.4-8

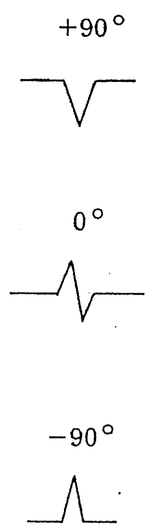


Fig. 4-9

Note: T1 is set by trigger input repetition period.
T2 is set by oscillation period.

4-6 Gated Oscillation

In the trigger oscillation mode, oscillation is triggerd by only one cycle by applying a trigger signal, and it stops until the following trigger is applied.

In the gate oscillation mode, since oscillation is controlled by a gate signal generated in the trigger comparator, a multicycle waveform or tone burst waveform can be obtained.

Fig.4-10 shows the waveforms in every part in the gate oscillation mode. Unlike the trigger oscillation, during the period when output (b) of the trigger comparator is negative, the falling pulse of the flip-flop circuit is gated so that it does not enter the trigger multivibrator.

When the output of the trigger comparator is positive, the gate is opened to reset the trigger multivibrator, causing oscillation to stop. The start and stop points can be varied as with the trigger oscillation mode.
Fig.4-10 shows the waveforms at 0°.

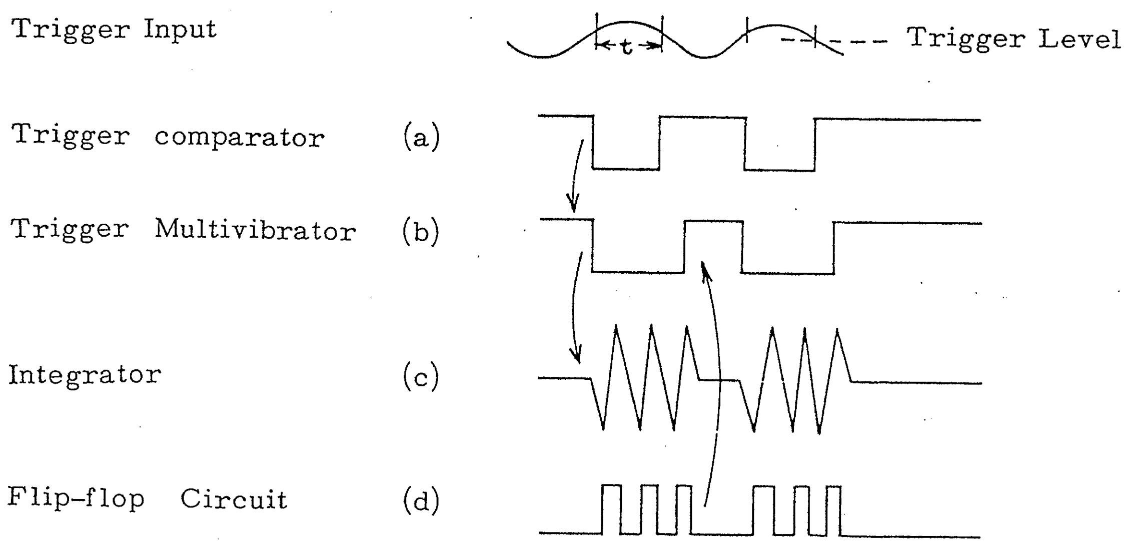


Fig.4-10

When the trigger level is controlled by applying a triangular-wave or sine-wave within a range of ±1 to ±10V to the trigger input terminal, oscillation can be easily varied from one cycle to multicycles.

5. APPLICATION

5-1 In case of linear sweep from 100Hz to 100kHz at rated of 10 periods 1 sec.

Set each control knobs as follows;

1)	DIAL	VCG	
2)	MODE	CONT	
3)	VCG INPUT	Apply 10Vp-p	* sawtooth-wave
4)	RANGE	(100Hz ~ 100kHz)	

*Set the repetition of the sawtooth-wave at 10 sec.

Output waveform
(example of
triangular-wave)

VCG
Input waveform

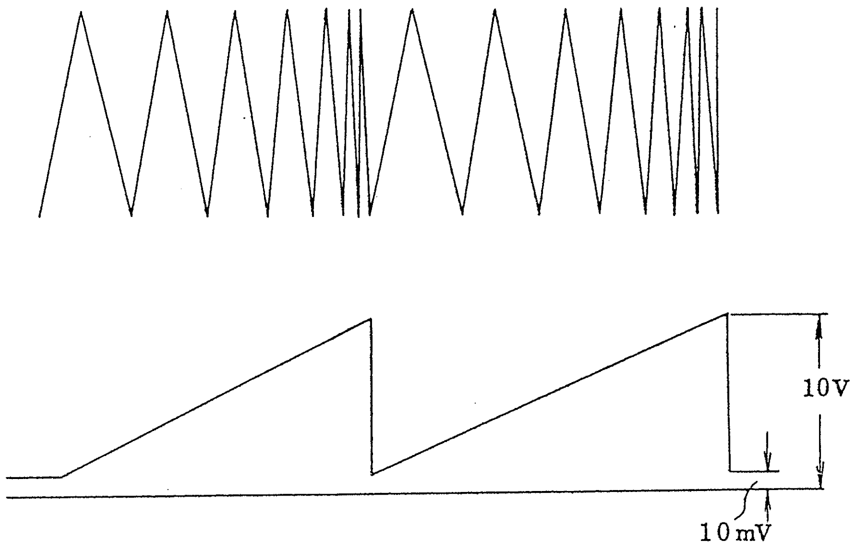


Fig. 5-1

Fig. 5-1 shows a triangular waveform. A sine or square waveform can also be obtaind.

5-2 In case of offset application

(Offset voltage: +10V, output voltage: 10Vp-p, Frequency: 5Hz)

Set each control knobs as follows;

1) MODE CONT
2) RANGE x1
3) DIAL 5
4) ~ FUNCTION
5) DC OFFSET ON
6) ATTEN 0 dB
7) OUTPUT control fully counterclockwise
8) connect DC voltmeter to output terminal, and adjust offset control knob to get a reading of +10V.
9) Observe the output terminal with an oscilloscope, and adjust output control knob to generate 10Vp-p.

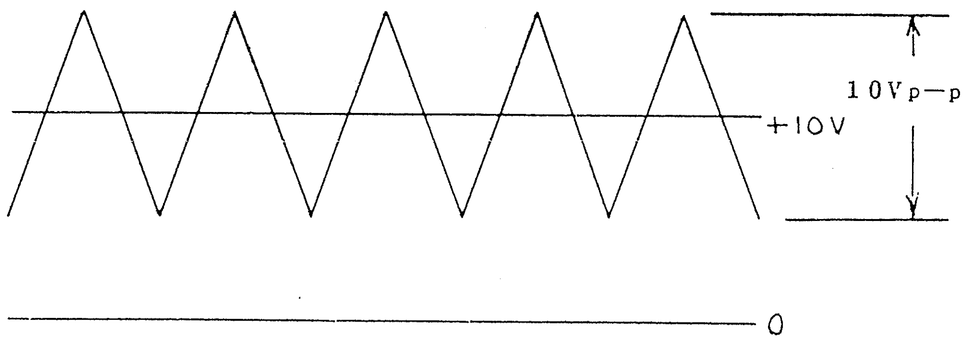


Fig. 5-2

5-3 In case of generation of burst waveform

i) To obtain multicycle

Set each knobs as follows;

1)	Method of frequency control	DIAL or VCG
2)	MODE	GATE (EXT)
3)	TRIGGER INPUT	Apply Sine, Square or Triangular waveform with repetition rate T1 shown as figure bellow. (1 ~ 10Vp-p)
4)	START/STOP	center position
5)	LEVEL	center position
6)	SLOPE	(+) or (-)

Observing the Model 458 output with a oscilloscope, adjust cycle of burst waveform with level control. T2 in the figure depend upon the dial setting of the Model 458 or input level of VCG.

multicycle

one cycle

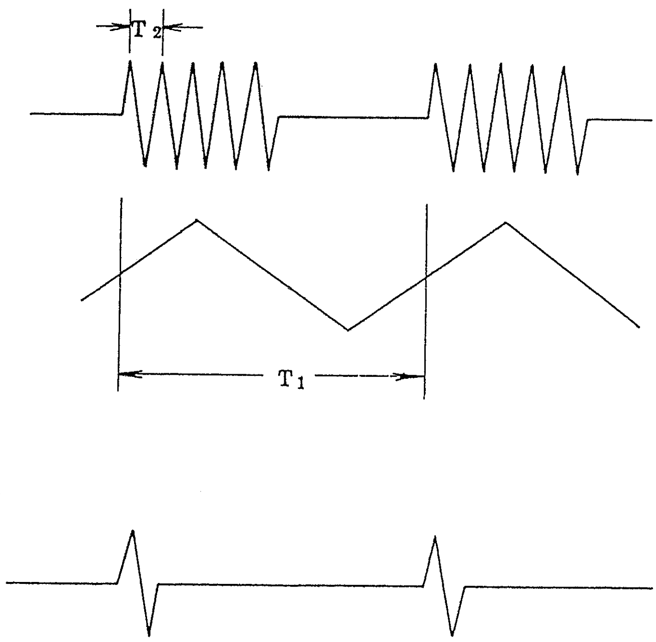


Fig. 5-3

ii) To obtain one cycle of oscillation, set MODE switch to EXT TRIGGER, the other knobs the same as for multicycle.

6. MAINTENANCE

6-1 Internal inspection and check

Opening the case of the equipment, turn minus two screws counterclockwise approx. 180°on the top and the bottom of the case. It will separate into two pieces.

Take care the equipment without the case. If excessive force is applied to the equipment, the printed circuit boards or the rotary switches of the construction may be damage.

Fig.6-2
bottom view

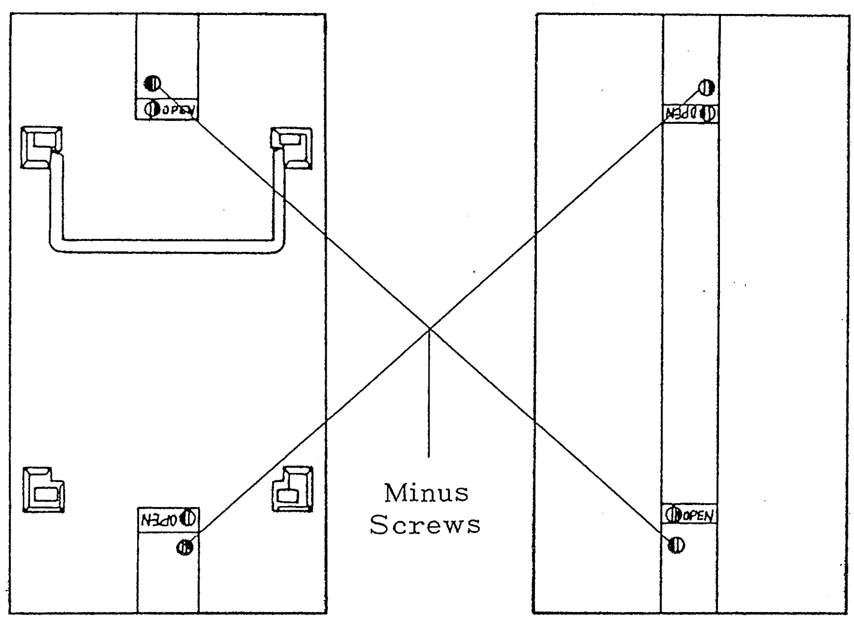


Fig.6-1
top view

6-2 Arrangement

Fig. 6-3 shows the arrangement of main parts

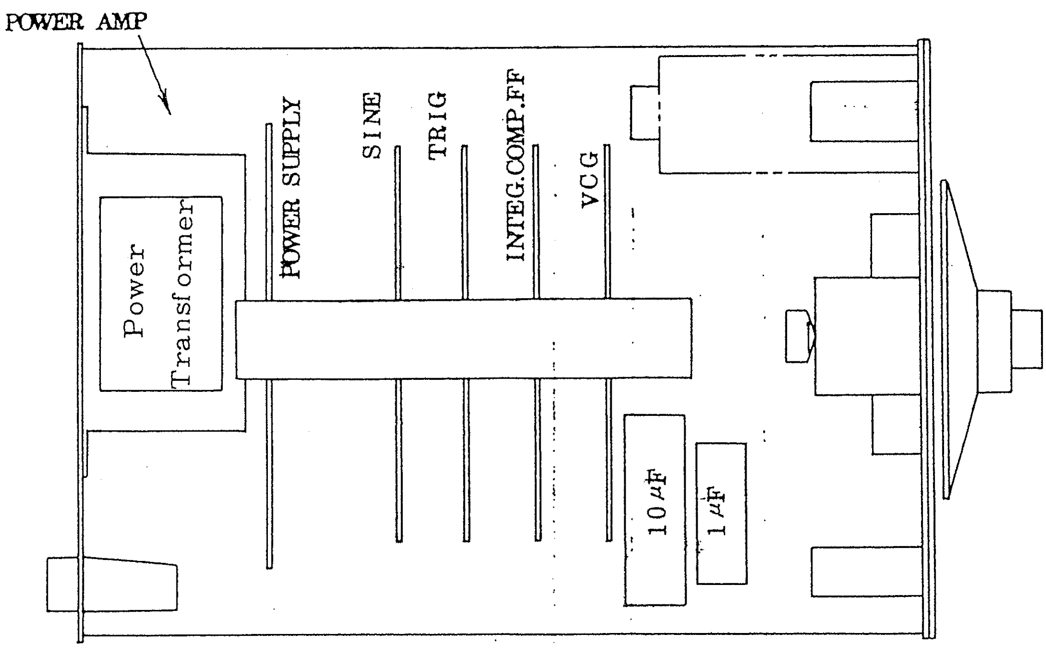


Fig.6-3