INSTRUCTION MANUAL

TYPE 1156-A

DECADE SCALER

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GENERAL RADIO COMPANY

A

INSTRUCTION MANUAL

TYPE 1156-A

DECADE SCALER

Form 1156-0100-A
ID-1115
June, 1966

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

• CONTENTS

• CONDENSED OPERATING INSTRUCTIONS

CAUTION

Be sure the LINE switch on the rear of the instrument is set for the proper line voltage.

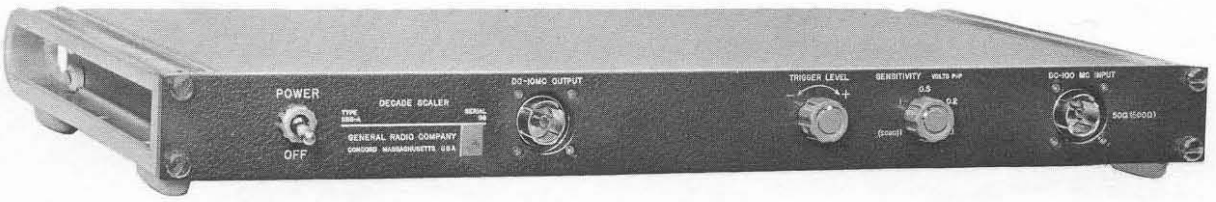
a. Connect the Type 1156-A Decade Scaler to the power line and to the frequency meter (or other instrument).

b. Turn the POWER switch on.

c. Set the SENSITIVITY control for the desired sensitivity and attach the input signal to the INPUT connector.

d. Set the TRIGGER LEVEL control for proper triggering. The TRIGGER LEVEL control will normally be set with the white dot straight up.

• SPECIFICATIONS



	Frequency	*Impedance*	*Remarks*
INPUT	**Dc to 100 Mc/s	50 or 500 Ω	**VSWR:** 1.1 max at 100 Mc/s (50 Ω). **Reflection:** 10% max with 0.4-ns step (50 Ω).
OUTPUT	Dc to 10 Mc/s	250 Ω	Approximately square-wave output, 20 mA; 1 V into 50 Ω, over 5 V open circuit, all p-to-p.

Sensitivity: 0.1, 0.2, 0.5, and 1 V, p-to-p, at 50 Ω; 1 V, p-to-p, at 500 Ω. Maximum input is 20 times sensitivity or ½ W, whichever is smaller.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 15 W.

Terminals: GR874 Locking Connectors. For connection to other types of coaxial connectors, use a locking adaptor, which locks securely in place, yet is easily removed.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.
Accessories Available: TYPE 874-K Coupling Capacitor for ac coupling to input or output connectors.
Mechanical Data: Rack-Bench Cabinet

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	2⅛	54	12¼	315	10¾	4.9	25	11.5
Rack	19	485	1¾	45	11⅜*	288	10¾	4.9	25	11.5

General Radio *Experimeter* reference: Vol 39, No. 9, Sept. 1965
U. S. Patent No. 2,548,457

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* Behind panel
** Dc to 125 Mc/s at reduced sensitivity (300 mV).

SECTION 1

INTRODUCTION

● 1.1 PURPOSE

The Type 1156-A Decade Scaler extends the upper frequency limit of any General Radio counter, counters of other makes, oscilloscope trigger circuits, analog frequency meters, or any instrument requiring 10-to-1 frequency division.

● 1.2 DESCRIPTION

The Scaler is a completely, self-contained, 100-Mc, direct-counting frequency divider.

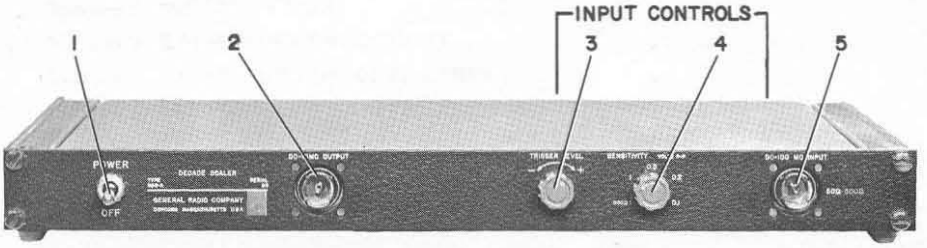
The input circuitry consists of a GR874 locking connector, an attenuator with four 50-ohm positions and one 500-ohm position, and an input amplifier, which provides 100-millivolt sensitivity and also isolates the input from noise generated by the switching circuits. The input amplifier is followed by two Schmitt circuits, a self-clearing ring that scales by five, and a flip-flop that scales by two. This flip-flop drives a high-current Schmitt circuit, which delivers 30-milliampere square waves to a GR874 locking connector.

A level control permits optimum triggering with a variety of inputs including sine waves, pulses, and noisy signals. The input and output connectors can be attached to either the front or the rear of the instrument.

● 1.3 ACCESSORIES SUPPLIED

Quantity	*Description*	*Part Number*
1	Instruction manual	1156-0100
2	Cable connectors, Type 874-C58A	0874-9414
1	Power cord, Type CAP-22	4200-9622
1	Fuse, 0.25 A	5330-0700

● 1.4 FRONT-PANEL CONTROLS AND CONNECTORS



1 **POWER**..... Two-position toggle switch. Applies line voltage to instrument.

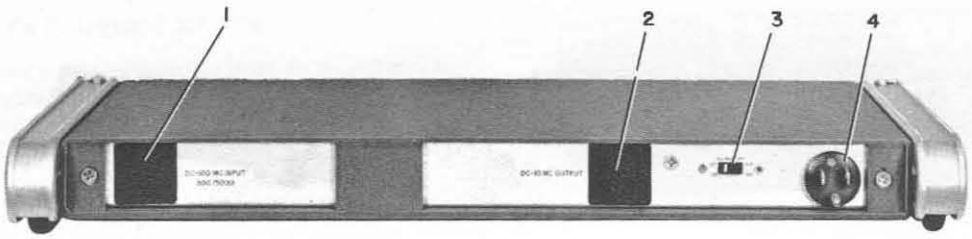
2 **OUTPUT**..... GR874 recessed locking connector; can be moved to the rear. Output is 30-mA, p-to-p, square waves (1.5V into 50Ω, 5V into open-circuit). Output frequency is dc to 10 Mc/s (1/10 of input frequency).

3 **TRIGGER LEVEL**. Continuously adjustable potentiometer. Adjusts for proper triggering over a wide range of input wave shapes.

4 **SENSITIVITY**..... Five-position rotary switch. Sets input impedance and sensitivity: 0.1, 0.2, 0.5, or 1V, p-to-p, at 50Ω or 1V, p-to-p, at 500Ω.

5 **INPUT**..... GR874 recessed locking connector; can be moved to the rear. Input capability is dc to 100 Mc/s. Maximum input is 20 times SENSITIVITY control setting or ½W, whichever is smaller.

● 1.5 REAR-PANEL CONTROLS AND CONNECTORS



1 **INPUT**.....Hole and snap-in cover plate; optional location of INPUT connector.

2 **OUTPUT**.....Hole and snap-in cover plate; optional location of OUTPUT connector.

3 **LINE**.....Two-position slide switch. Selects line voltage range, 115 V or 230 V.

4 **Power connector**.....Three-pin male connector. For connection to power line.

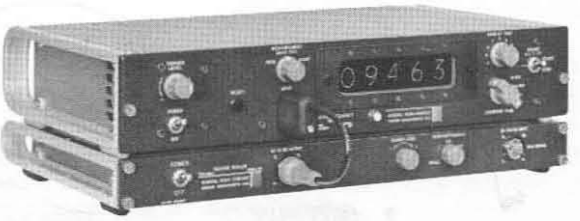
● 1.6 ACCESSORIES AND SUPPLEMENTARY EQUIPMENT AVAILABLE

AC COUPLER

For ac coupling to the INPUT or OUTPUT connectors, the Type 874-K or 874-KL (locking connectors). Coupling Capacitor is available.

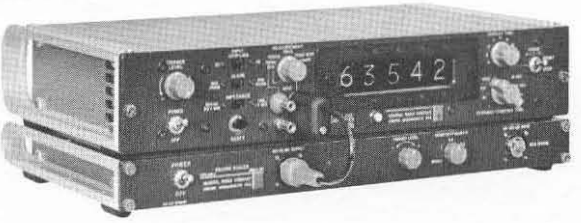
4-Mc DIGITAL FREQUENCY METER

For digital frequency measurements from 10 c/s to 4 Mc/s, the Type 1150 Digital Frequency Meter can be used with the decade scaler.



4-Mc DIGITAL TIME AND FREQUENCY METER

For digital time and frequency measurements from dc to 4 Mc/s, the Type 1151 Digital Time and Frequency Meter can be used with the decade scaler.

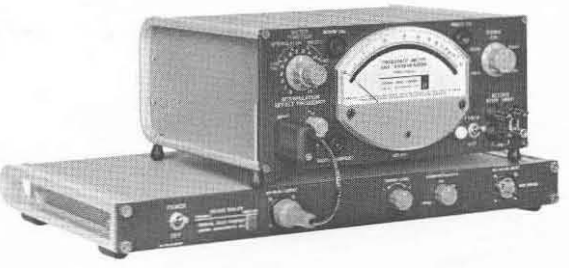


10-Mc DIGITAL FREQUENCY METER

For digital frequency measurements from dc to 10 Mc/s the Type 1150-BH Digital Frequency Meter can be used with the decade scaler.

15-Mc ANALOG FREQUENCY METER

For analog frequency measurements from 3 c/s to 15 Mc/s, the Type 1142 Frequency Meter and Discriminator can be used with the decade scaler.



100-Mc DIGITAL FREQUENCY METER

For digital frequency measurements from dc to 100 Mc/s, the Type 1153 Digital Frequency Meter can be used with the decade scaler. This combination is available as an assembly, the Type 1144 100-Mc Digital Frequency Meter.

RECORDERS AND CONVERTERS

The Type 1137 Data Printer converts the decimal-coded output of a digital frequency meter into permanent, printed form.

The Type 1136 Digital-to-Analog Converter translates the decimal-coded output of a digital frequency meter into an analog voltage or current. The converter output can then be monitored on any suitable indicator such as a meter, an oscilloscope, or a recorder.

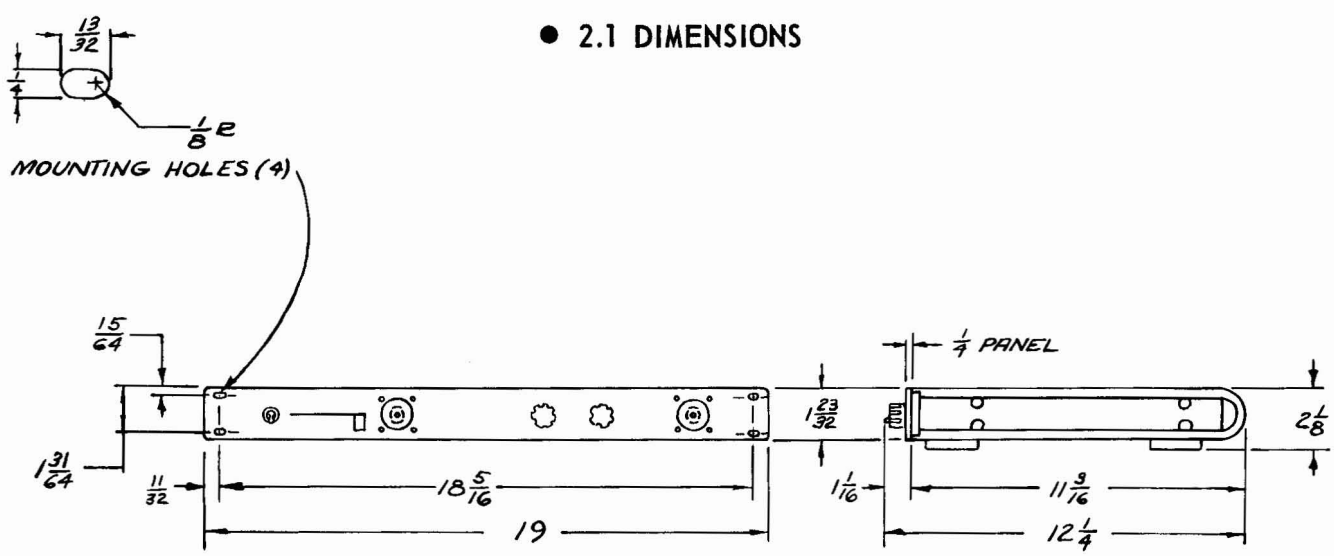
The Type 1521 Graphic Level Recorder permanently records the analog data from a Type 1142 Frequency Meter and Discriminator or a Type 1136 Digital-to-Analog Converter.

A combination of the Type 1136 Digital-to-Analog Converter and the Type 1521 Graphic Level Recorder is available as an assembly, the Type 1510 Digital-to-Graphic Recording Assembly.

SECTION 2

INSTALLATION

• 2.1 DIMENSIONS



• 2.2 MOUNTING

2.2.1 BENCH/RACK CONVERSION

The Type 1156-A Decade Scaler is supplied in two models, bench mount and rack mount. Either model can be converted to the other by the installation of a conversion set.

CONVERSION SETS

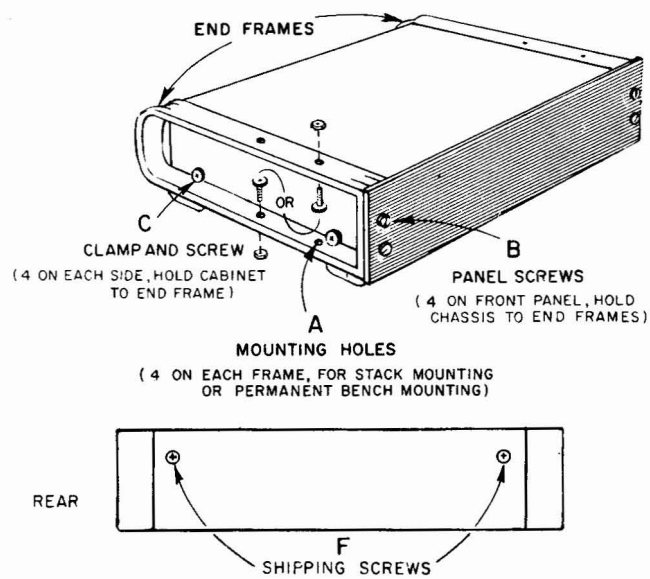
Model	*Use*	*Conversion Set*
Bench	For bench mounting or stack mounting	None required. Simply remove end frames and secure to rack with panel screws.
Rack	For mounting in standard 19-inch relay rack	5310-9610 end frame set converts rack model to bench model.

2.2.2 BENCH MOUNTING (bench model)

The scaler normally rests on four rubber feet on top of a bench or shelf. However, holes (A) are provided in each end frame to allow permanent mounting on top or under a bench or shelf.

At the rear of the instrument, remove the two 10-32 binder-head shipping screws that hold the cabinet to the chassis. These are used only for shipment and can be discarded.

This type of mounting permits either the chassis or the cabinet to be withdrawn independently. To remove the chassis and leave the cabinet mounted, loosen the four panel screws (B) and slide the instrument forward out of the cabinet. To remove the cabinet and leave the chassis mounted, remove the eight clamps and screws (C) and pull the cabinet back off the chassis from the rear of the instrument.

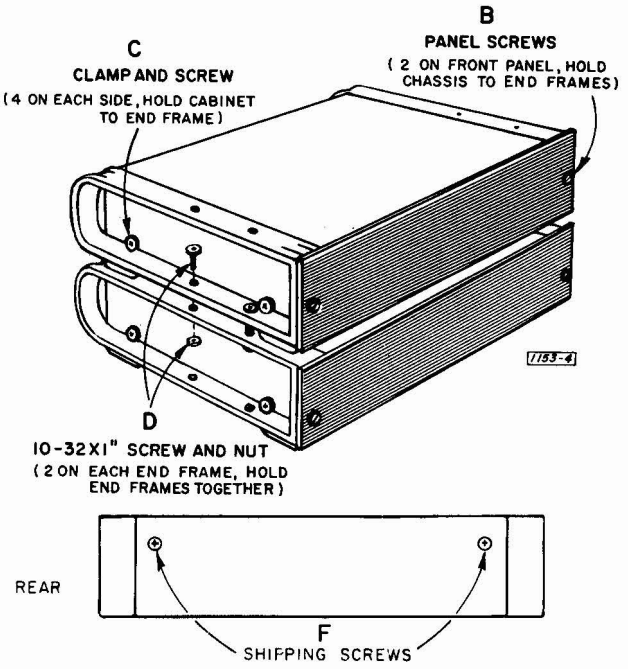


2.2.3 STACK MOUNTING (bench model)

The scaler can be permanently assembled with another rack-bench instrument, such as the Type 1153-A Digital Frequency Meter, by bolting the end frames together with four 10-32 x 1-inch screws and four 10-32 nuts.

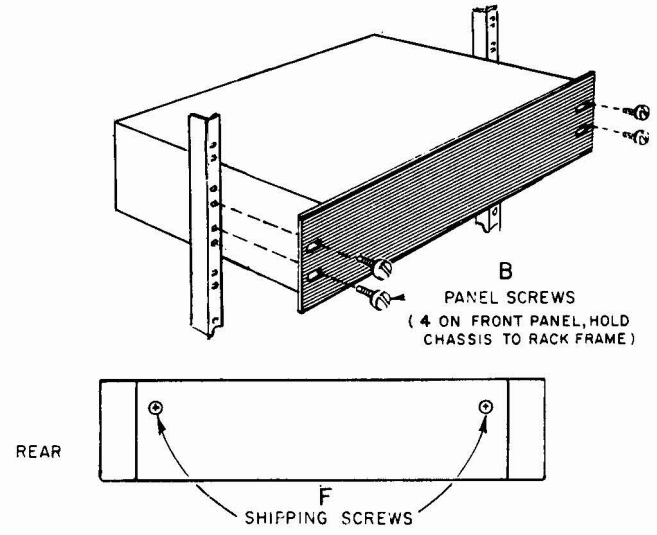
At the rear of the instrument, remove the two 10-32 binder-head shipping screws that hold the cabinet to the chassis. These are used only for shipment and can be discarded.

This type of mounting permits the chassis of each instrument to be withdrawn independently. To remove the chassis, loosen the four panel screws (B) and slide the instrument forward out of the rack.



2.2.4 RACK MOUNTING (rack model)

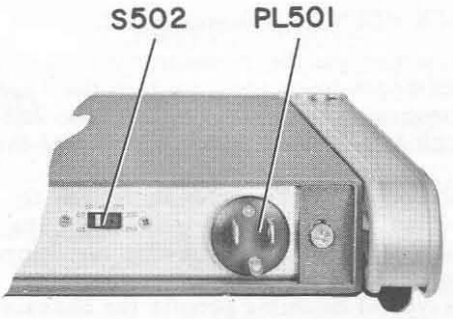
Hold the scaler into position in the rack, Insert the four panel screws with attached washers (B) through the front panel and screw them into the rack. The washers are provided to protect the face of the instrument.



• 2.3 POWER CONNECTION

Power requirements are 105 to 125 volts or 210 to 250 volts, 50 to 60 cycles, 15 watts, A LINE switch, S502, is provided on the rear of the instrument to convert from one line-voltage range to the other. Fuses remain the same for either range.

Connection to the power line is made by means of a three-wire power cord which attaches to the power input plug, PL501, on the rear of the instrument.

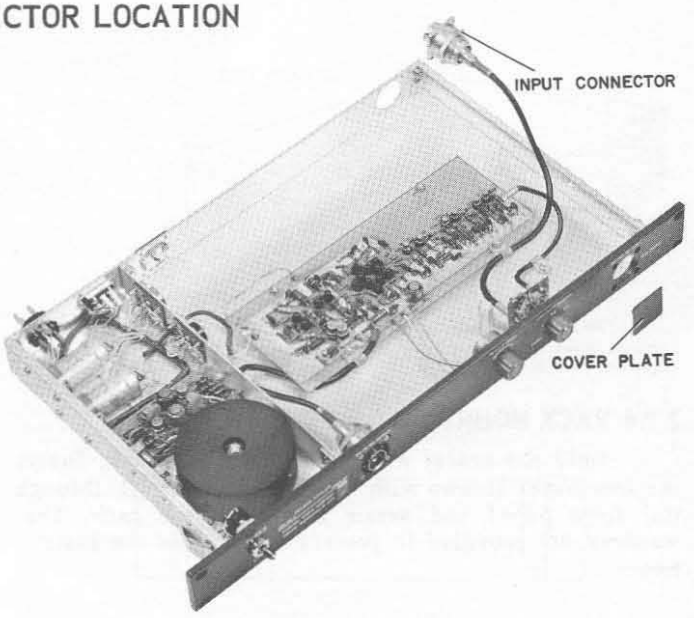


• 2.4 SIGNAL-CONNECTOR LOCATION

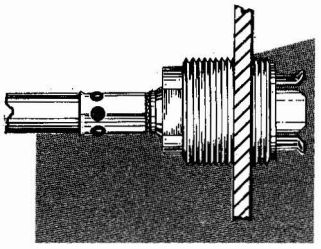
The INPUT and OUTPUT connectors are normally mounted on the front panel but can be moved to the rear as follows:

a. Remove the four screws that secure the connector to the front panel.
b. Remove the snap-in cover plate from the rear.
c. Move the connector to the rear, reinsert the screws, and secure in place.
d. Snap the cover plate in place in the opening left by the connector on the front panel.

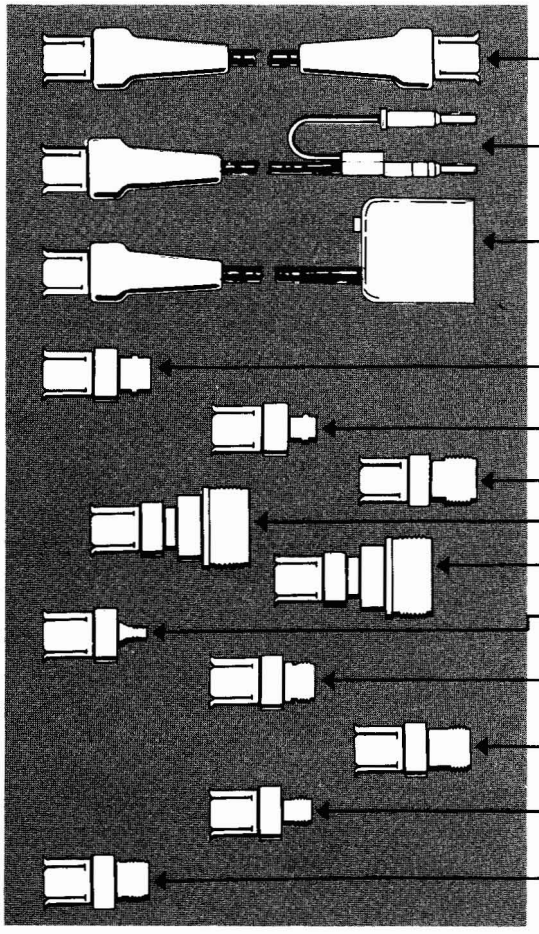
The operating characteristics of the instrument remain the same regardless of the location of the connectors.



• 2.5 SIGNAL CONNECTIONS



The INPUT and OUTPUT connectors are GR874 Recessed Locking connectors. These 50-ohm coaxial connectors are hermaphrodite, i.e., any two, although identical, can be plugged together. A full line of adaptors is also available to convert the connectors for use with nearly every type of commercial and military coaxial connector.



874-R20A	Coaxial patch cord, low-loss	0874-9680
874-R20LA	Coaxial patch cord, low-loss cable, locking connectors	0874-9681
874-R22A	Coaxial patch cord, general-purpose cable	0874-9682
874-R22LA	Coaxial patch cord, general-purpose cable, locking connectors	0874-9683
874-R33	Coaxial patch cord, two plugs to GR874, 36'' long	0874-9690
874-R34	Coaxial patch cord, double plug to GR874, 36'' long	0874-9692
874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9695
-------	Coaxial patch cord, double plug to GR874, terminated in 50Ω to reduce output and reflections, when used with high impedance inputs	1144-2000
874-QBJA	Adaptor, GR874 to Type BNC	0874-9700
874-QBJL	Locking adaptor, GR874 to Type BNC	0874-9701
874-QCJA	Adaptor, GR874 to Type C	0874-9702
874-QCJL	Locking adaptor, GR874 to Type C	0874-9703
874-QHJA	Adaptor, GR874 to Type HN	0874-9704
874-QLJA	Adaptor, GR874 to Type LC	0874-9706
874-QLTJ	Adaptor, GR874 to Type LT	0874-9708
874-QMDJ	Adaptor, GR874 to Type Microdot	0874-9720
874-QMDJL	Locking adaptor, GR874 to Type Microdot	0874-9721
874-QNJA	Adaptor, GR874 to Type N	0874-9710
874-QNJL	Locking adaptor, GR874 to Type N	0874-9711
874-QSCJ	Adaptor, GR874 to Type SC	0874-9712
874-QSCJL	Locking adaptor, GR874 to Type SC	0874-9713
874-QTNJ	Adaptor, GR874 to Type TNC	0874-9716
874-QTNJL	Locking adaptor, GR874 to Type TNC	0874-9717
874-QUJ	Adaptor, GR874 to Type UHF	0874-9718
874-QUJL	Locking adaptor, GR874 to Type UHF	0874-9719

1156-30

● 2.6 INTER-UNIT CONNECTIONS

100-Mc DIGITAL FREQUENCY METER

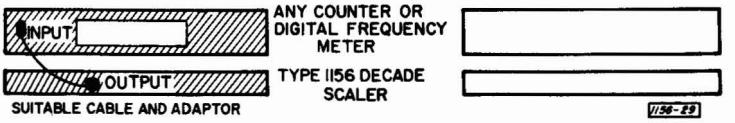
Connections to the Type 1153 Digital Frequency Meter

15-Mc ANALOG FREQUENCY METER

Connections to the Type 1142 Frequency Meter and Discriminator

UNIVERSAL RANGE EXTENDER

The scaler OUTPUT is sufficient to drive any known counter over its entire range.



SECTION 3 OPERATING PROCEDURE

CAUTION

Be sure the LINE switch on the rear of the instrument is set for the proper line voltage.

● 3.1 OPERATION

a. Connect the Type 1156-A Decade Scaler to the power line and to the frequency meter (or other instrument).
b. Turn the POWER switch on.
c. Set the SENSITIVITY control for the desired sensitivity and attach the input signal to the INPUT connector.
d. Set the TRIGGER LEVEL control for proper triggering. The TRIGGER LEVEL control will normally be set with the white dot straight up.

• 3.2 CHARACTERISTICS

3.2.1 INPUT

Frequency: Dc to 100 Mc/s

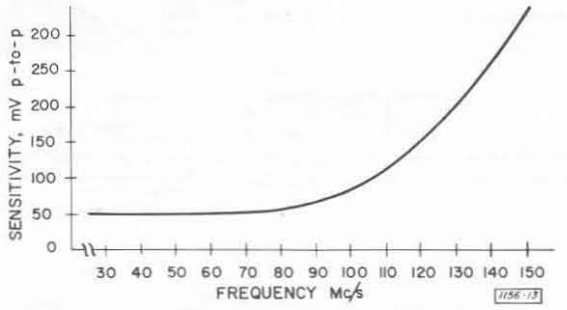
Impedance: Set by SENSITIVITY control; four 50-ohm positions and one 500-ohm position.

Maximum input: Maximum input voltage is determined by attenuator resistors and base-to-emitter breakdown voltage of input transistor (2 volts, conservatively).

SENSITIVITY control setting	*Dc*	*Maximum inputs* **pulse peak*	*sinewave, rms*
0.1V	± 2 V	± 2V	1.4V
0.2V	± 4 V	± 4V	2.8V
0.5V	± 5 V	±10V	5 V
1.0V	± 5 V	±20V	5 V
1.0V (500Ω)	±15.8V	±20V	14 V

* Duty ratio such that average input power is $< \frac{1}{2}$ W.

Sensitivity vs frequency:



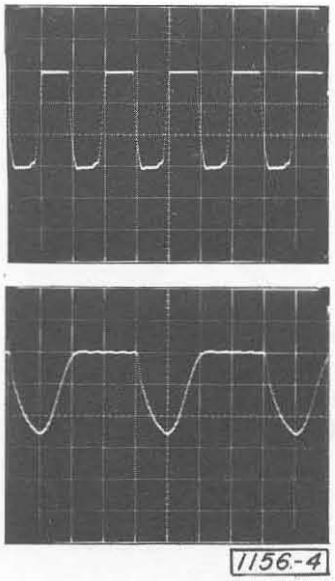
The input circuit is dc coupled. A Type GR874-K or GR874-KL Coupling Capacitor is recommended when ac coupling is necessary.

3.2.2 OUTPUT

The OUTPUT signal approximates a square wave and is one-tenth the INPUT frequency or repetition rate. The output circuit is a current source and provides typically 30 mA peak-to-peak with a source resistance of 250 ohms (open-circuit output voltage is approximately 7 volts). The output circuit is dc coupled. A Type GR874-K or GR874-KL Coupling Capacitor is recommended when ac coupling is necessary.

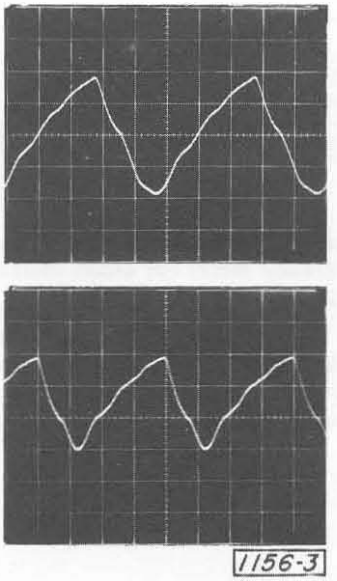
RESISTIVE TERMINATION

OUTPUT terminated in 50Ω. Vertical deflection factor is 0.5 volt per division.



REACTIVE TERMINATION (simulates most counter inputs)

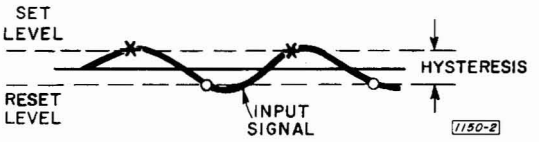
OUTPUT connected to 3-foot 50-ohm cable (GR Type 874-R22) terminated in 47pF. Vertical deflection factor is 1 volt per division.



● 3.3 TRIGGER LEVEL CONTROL

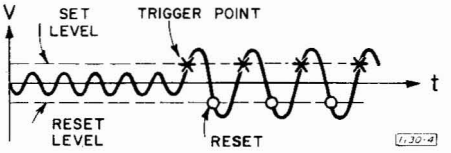
3.3.1 DESCRIPTION

The trigger circuit consists of a Schmitt multivibrator which exhibits a hysteresis effect. That is, after the circuit has triggered on the positive-going transition of the input signal, the input signal must then swing to a less positive level to reset the trigger circuit. The maximum sensitivity of the instrument is the magnitude of this hysteresis voltage (100 mV, p-to-p).



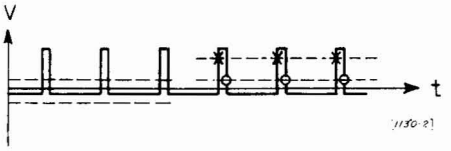
3.3.2 USES

Signal too small; must be increased.

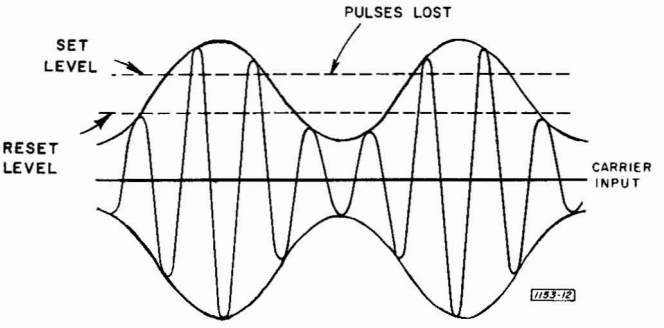


Too large a negative offset to the TRIGGER LEVEL control. Corrected by reducing offset.

Low duty-ratio pulse signal. Corrected by raising triggering level.



A-M error with trigger level offset.



● 3.4 APPLICATIONS

3.4.1 COUNTER RANGE-EXTENSION

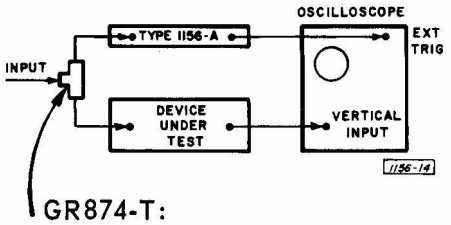
When the Type 1156-A Decade Scaler is used to extend the frequency range of a counter, the frequency to be measured is applied to the INPUT of the Type 1156-A and the OUTPUT of the Type 1156-A is applied to the input of the counter. The scaler OUTPUT is sufficient to drive any known counter over its entire range.

The frequency is read from the counter by moving the decimal point in the counter display one place to the right. The accuracy of the measurement is not affected by the scaler. Accuracy is strictly a function of the counter and is usually specified as ±1 count ± crystal-oscillator stability.

3.4.2 OSCILLOSCOPE TRIGGER

The Type 1156-A is especially valuable in the trigger path of an oscilloscope whose trigger capabilities are inadequate to properly lock all signals within its vertical passband.

It is equally useful in the testing of scalers or frequency dividers even at lower frequencies. If the trigger is taken from the output of the device under test and the output waveform changes or the device fails, the trigger is lost. But if the trigger is taken ahead of the device the trigger is independent of the device.This is also an advantage when making time relationship measurements of several points in the device since the output from the Type 1156-A can be used as a time reference.



GR874-T:

Type 874-T, Tee connector	0874-9910
Type 874-TL, Tee connector with locking connectors	0874-9911
*Type 874-TPD, Power divider	0874-9912
*Type 874-TPPL, Power divider with locking connectors	0874-9913

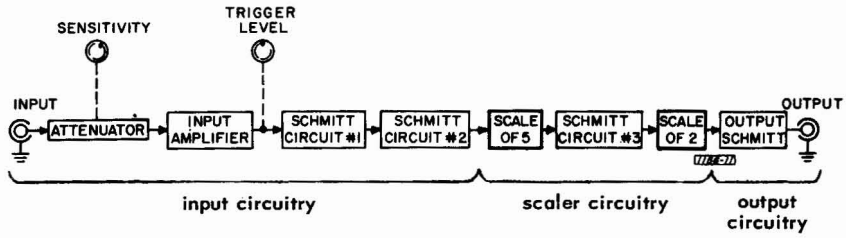
* Coaxial tee; matched at any port when the other two ports are terminated in 50 ohms.

3.4.3 1-Mc OUTPUT

Two Type 1156-A Decade Scalers can be connected in series to provide 100-to-1 frequency division (the upper limit remains 100-Mc/s, however).

SECTION 4 PRINCIPLES OF OPERATION

● 4.1 BLOCK



The input circuitry consists of a GR874 locking connector, an attenuator with four 50-ohm positions and one 500-ohm position, and an input amplifier which provides 100-millivolt sensitivity and also isolates the input from noise generated by the switching circuits.

The input amplifier is followed by two Schmitt circuits, a self-clearing ring that scales by five, and a flip-flop that scales by two. This flip-flop drives a high-current Schmitt circuit, which delivers 30-milliampere square waves to a GR874 locking connector.

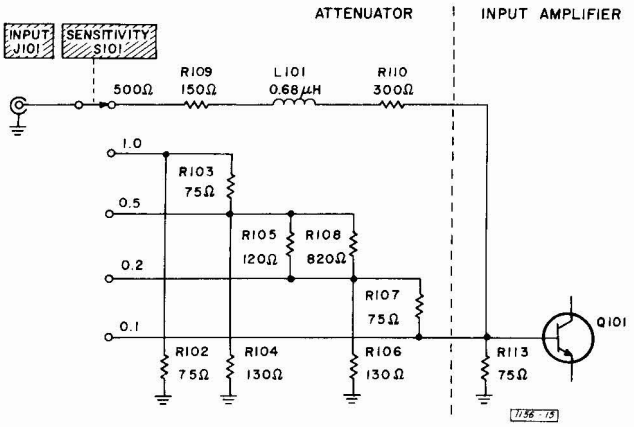
● 4.2 ATTENUATOR

A ladder-type attenuator reduces the level of signals applied to the INPUT connector to allow noisy signals to be measured and large amplitude signals to be applied without damage to the input circuitry.

In the 500-Ω position, the input impedance is 500 ohms and is made up of the series combination of R109, R110, and R113 (R113 is in the base circuit of the input stage, Q101). The ratio of R109 and R110 to 500Ω is 9:10 so that the signal applied to the INPUT connector is attenuated by a factor of 10 before it reaches the input stage.

In the 50-Ω positions (1, 0.5, 0.2, and 0.1), the input impedance is 50 ohms and is made up of the series and parallel combinations of R113 and R102 through R108. The configuration is such that the signal is attenuated by a factor of 10 in the 1 position, 5 in the 0.5 position, 2 in the 0.2 position, and 1 (straight through or no attenuation) in the 0.1 position.

Attenuator components are carefully placed with respect to a well-defined ground plane and coaxial cables with special fittings are used to connect the assembly to the INPUT connector and the input amplifier to insure low VSWR and low reflections at all frequencies within the passband of the instrument.

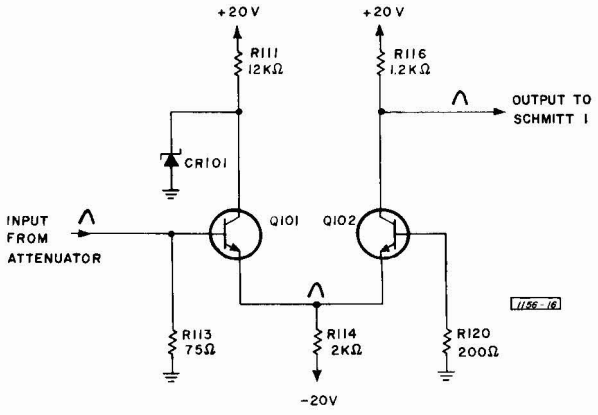


● 4.3 INPUT AMPLIFIER

The input amplifier increases the INPUT-signal level to drive the next stage, Schmitt 1, and provides isolation between the INPUT connector and the switching transients generated by Schmitt 1.

It is a two-transistor, emitter-coupled, dc amplifier with a gain of four and no phase inversion. A signal of 100 mV, p-to-p, applied to the base of Q101 results in a 400 mV, p-to-p, signal at the collector of Q102 which is sufficient to drive Schmitt 1.

The amplifier will clip signals of over ±1 V applied to the base of Q101, will operate reliably, with signals of over ±2 V, but will be damaged by signals of over ±3 V.

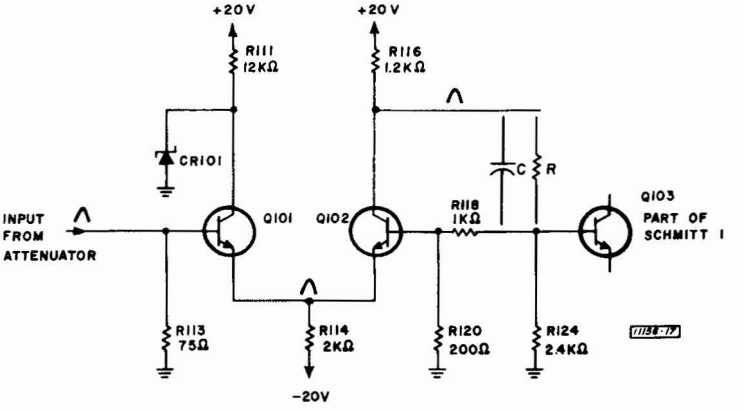


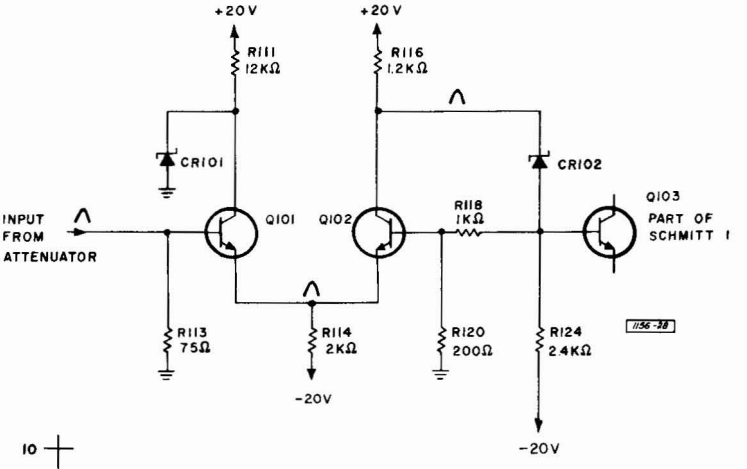
4.3.1 DC TRANSLATION

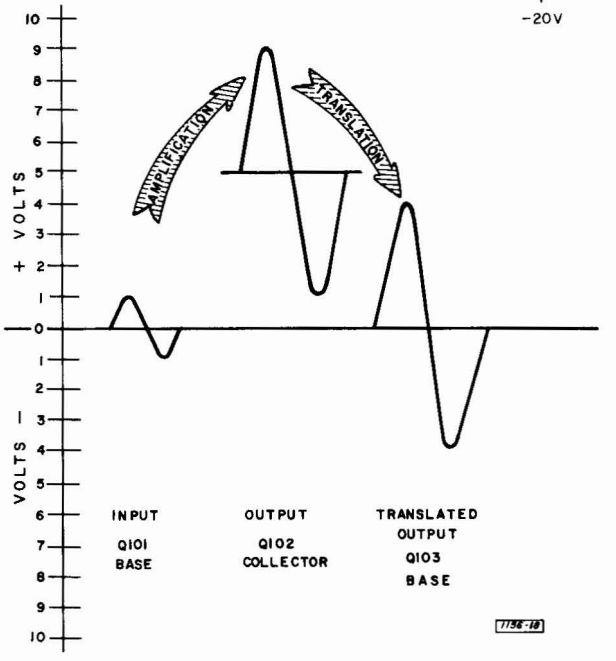
The input amplifier must accept positive and negative signals (with respect to ground) and is therefore biased class A. This means current flows in both transistors at all times, with or without an input signal, and the collector of Q102 rests at about ±5 V due to the divider action of R116, Q102, R114, CR104, and R124. The base of Q103 in the next stage rests at about 0 V and must maintain this bias level for proper operation. Therefore it is necessary to couple the output of Q102 to the input of Q103 without disturbing the dc potentials at either point.

A zener-diode is used to couple the two points. A zener diode maintains a constant voltage drop across itself within a broad range of currents through it. If a 5-volt zener, CR102, is used for coupling, the voltage at the base of Q103 becomes +5 - 5 = 0 V. If an INPUT signal causes the collector of Q102 to rise to +9 V, the base of Q103 becomes +9 - 5 = +4 V and if the collector of Q102 decreases to +1 V, the base of Q103 becomes +1 - 5 = -4 V.

Thus, CR102 *translates* a ±4-volt swing about a ±5-volt baseline to a ±4-volt swing about a 0-volt baseline; the dc potentials at the collector of Q102 and the base of Q103 remain intact, and the signal amplitude is not attenuated.







● 4.4 SCHMITT CIRCUITS

All Schmitt circuits used in the Type 1156-A are conventional, emitter-coupled circuits with zener-diode dc translation between the output of the first transistor to the input of the second. Schmitt 1 shapes input signals of arbitrary waveform to square waves with fast transitions for use by the other circuits in the instrument. It differs slightly because the base bias of the first transistor (Q103) is adjustable by means of two potentiometers, R201 (an internal adjustment) and R101 (a front-panel control, TRIGGER LEVEL).

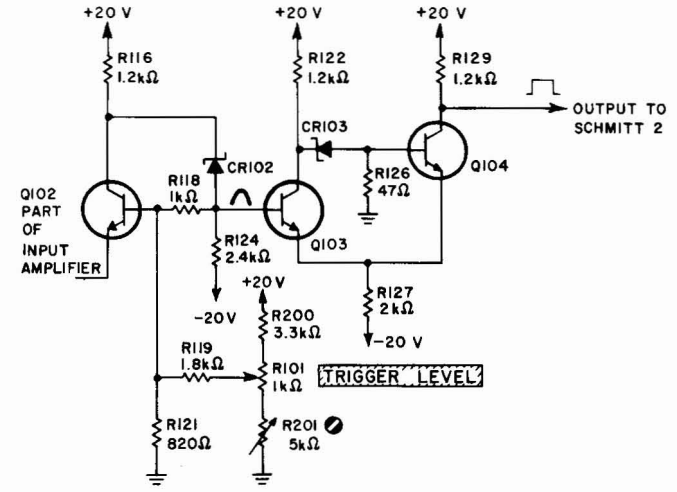
Assume for the moment, that R201 and the TRIGGER LEVEL control are fixed and have been set so that, with no input signal, the 4 voltage translation from the collector level of Q102 results in a 0-volt level at the base of Q103. Q103 and Q104 form a Schmitt circuit so that when one transistor is off (not conducting), the other is on (conducting); assume Q103 is off.

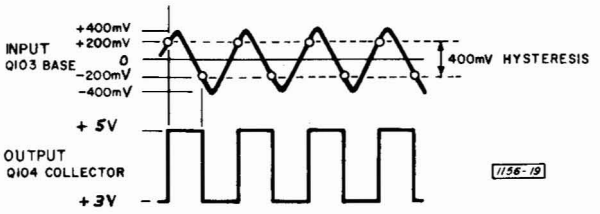
A 200 millivolt signal with a 0-volt base line is applied to the INPUT connector, is amplified by the input amplifier, and appears at Q102 collector as an 800-millivolt signal with a +4-volt base line. CR102 translates the base line 4 volts so that an 800-millivolt signal with a 0-volt base line appears at Q103 base.

A 200-millivolt positive level is necessary to turn on Q103. When the signal at Q103 base reaches +200 millivolts, Q103 turns on; the resulting drop in its collector potential is coupled through CR103 (one of the regenerative paths, the other is the common-emitter connection) and turns off Q104. When Q104 turns off, its collector level changes from about 3 volts to about 5 volts.

The input signal continues up to its peak positive value and then begins to decrease. When it reaches -200 millivolts, Q103 turns off. This difference in the turn-on and turn-off levels is known as hysteresis and amounts to about 400 millivolts for Schmitt 1.

When Q103 turns off, Q104 turns on and its collector level reverts to 3 volts, thus producing a square wave output that follows the input waveform.



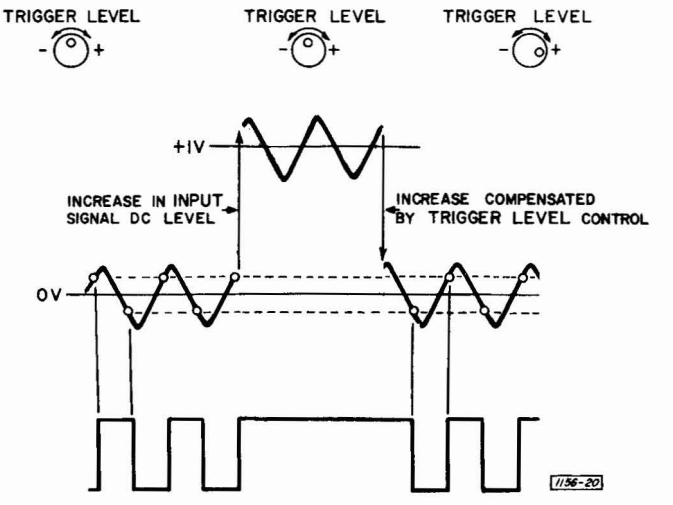


4.4.1 TRIGGER LEVEL CONTROL.

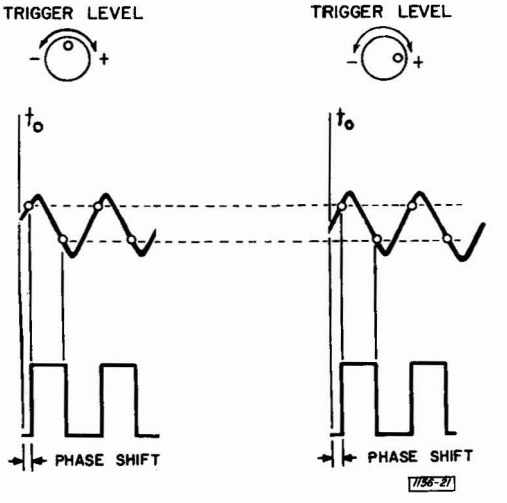
An input signal with other than a 0-volt base line will not operate the Schmitt circuit if the signal's dc component moves it out of the Schmitt's hysteresis spread. For instance, an 800-millivolt signal with a 1-volt base line applied to Q103 base will never move sufficiently negative to turn off Q103. Several methods can be used to prevent this base line shift or dc component from affecting the operation of the schmitt circuit: ac couple the input circuit, move the hysteresis spread to center about the base line, or move the base line to the center of the hysteresis spread.

The latter method is used in the Type 1156-A and is accomplished by the TRIGGER LEVEL control, R101. If the input-signal base line moves positive 1 volt, the TRIGGER LEVEL control is adjusted to move the potential at its center-arm *negative* 1 volt, and the resultant dc potential at Q103 base remains 0 volts. A similar but reverse action occurs with negative dc components.

The total swing of the TRIGGER LEVEL control is ±200 mV, sufficient to handle dc components equal to the SENSITIVITY control setting, i.e., with a SENSITIVITY control setting of 0.5 V. The Schmitt circuit will operate properly with INPUT dc components up to ±0.5 volts.



The TRIGGER LEVEL control can also be used to shift the phase, slightly, of the Schmitt circuit output by shifting the base bias of Q103.



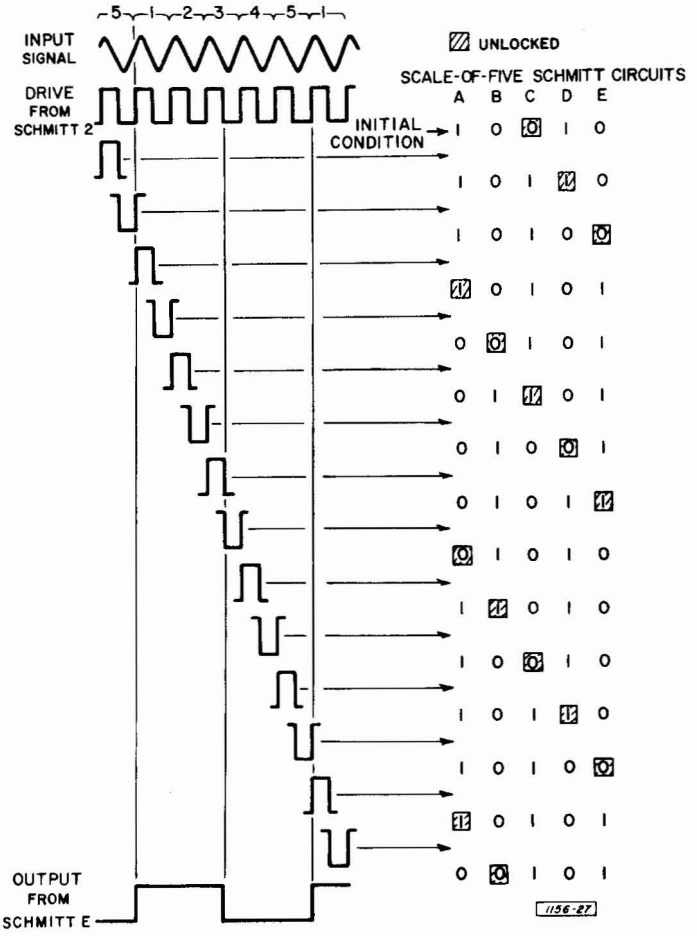
● 4.5 SCALE-OF-FIVE

The scale-of-five circuit performs the first division of the input signal. It consists of five specially biased Schmitt circuits connected in the form of a ring and driven by the output of Schmitt 2. The biasing is arranged so that only one Schmitt is allowed to change state when the drive signal is applied, the other four are locked out.

State terminology: The terms 0 and 1 are used to describe the state of a Schmitt and are defined here as the state of the output potential; 0 state if the potential is minimum and 1 state if the potential is maximum.

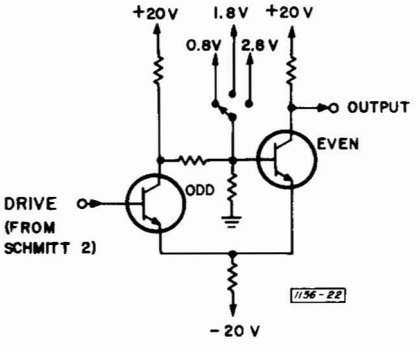
Assume the initial condition is as shown in the diagram. The output is taken from Schmitt E and since Schmitt E is in the 0 state, the output is minimum. Although the drive signal is applied to each Schmitt, it only affects the state of the unlocked Schmitt. A Schmitt is unlocked when the preceding Schmitt is in the same state.

In the initial condition, Schmitt C is unlocked and in the 0 state. A positive drive pulse changes it to the 1 state which unlocks Schmitt D. The next drive pulse changes Schmitt D to the 0 state and unlocks Schmitt E. The action is such that each time a Schmitt changes state it locks itself, unlocks the next Schmitt, and produces an output at Schmitt E which is one-fifth of the input frequency.



4.5.1 LOCKING

A special bias arrangement permits the Schmitts in the scale-of-five circuit to be locked or unlocked. Each even transistor has three bias levels: 0.8, 1.8, and 2.8 volts. When 0.8 volt is applied, the even transistor is turned off and cannot be turned on. Since it is held off, the odd side is held on and a drive pulse has no effect on the Schmitt (the Schmitt is locked in the 1 state). When 1.8 volts is applied the Schmitt is free to change states when a drive signal is applied (unlocked). When 2.8 volts is applied the Schmitt is locked in the 0 state.



4.5.2 BIASING

The even transistor of each Schmitt is biased by its odd transistor and by the even transistor of the preceding Schmitt. For example:

When Schmitt D is in the 0 state, the even transistor, Q114, is on and the odd transistor, Q113, is off. With Q113 off, current path I2 is open. When Schmitt C is in the 1 state, its even

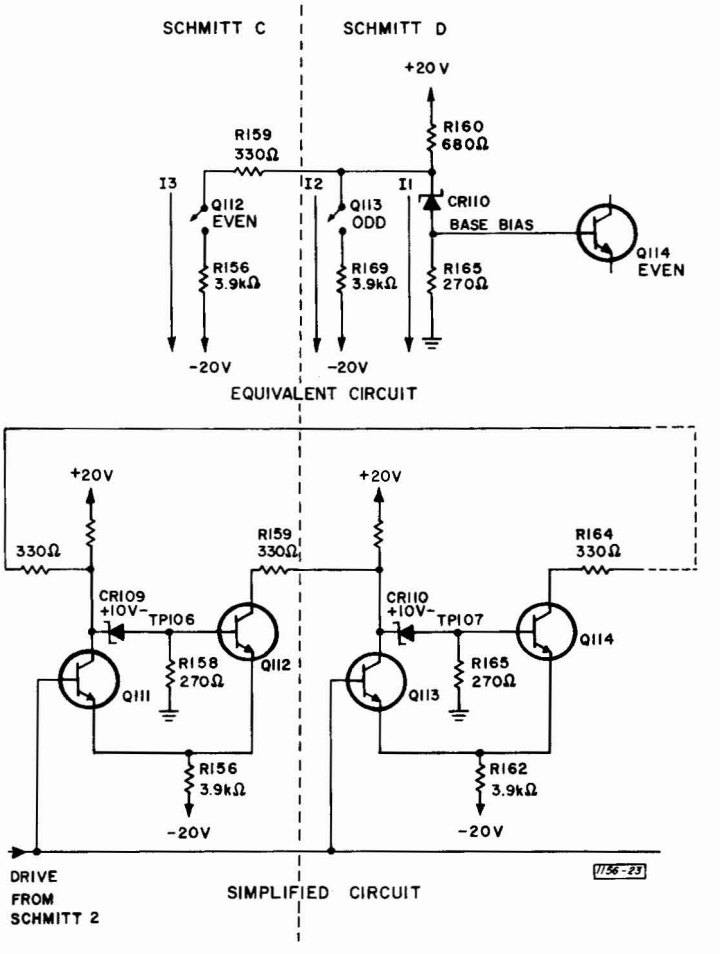
2.8 V transistor, Q112, is off and current path I3 is open. The bias for Q114 is then determined solely by current path I1 which sets the base bias of Q114 to 2.8 volts and locks Schmitt D in the 0 state.

When the preceding Schmitt, Schmitt C, changes states from 1 to 0, Q112 turns on and

1.8 V switches in current path I3. Current path I3 brings the bias of Q114 more negative to 1.8 volts and unlocks Schmitt D.

With Schmitt D unlocked, a positive drive pulse will turn on Q113 and change Schmitt D to the 1 state. With Q113 on, current path I2 is

0.8 V switched in which brings the bias of Q114 further negative to 0.8 volts and locks Schmitt D in the 1 state.



● 4.6 SCHMITT 3

Schmitt E consists of Q117 and Q118 and acts as a buffer-amplifier and pulse shaper for the scale-of-two circuit. The input from TP108 of the scale-of-five circuit is applied to Q117 base. The output is taken from Q118 collector and coupled through a dc-translation diode, CR113, to the input of the scale-of-two circuit.

● 4.7 SCALE-OF-TWO

The scale-of-two circuit consists of Q119 and Q120 and is a conventional, emitter-coupled, bistable multivibrator which is triggered by positive pulses from the output of Schmitt 3.

● 4.8 SCHMITT 4

Schmitt 4 consists of Q121 and Q122 and provides the necessary high-current drive (20 milliamperes) to the OUTPUT connector.

● 4.9 POWER SUPPLY

The power supply contains two regulators which provide two outputs, +20 volts and -20 volts.

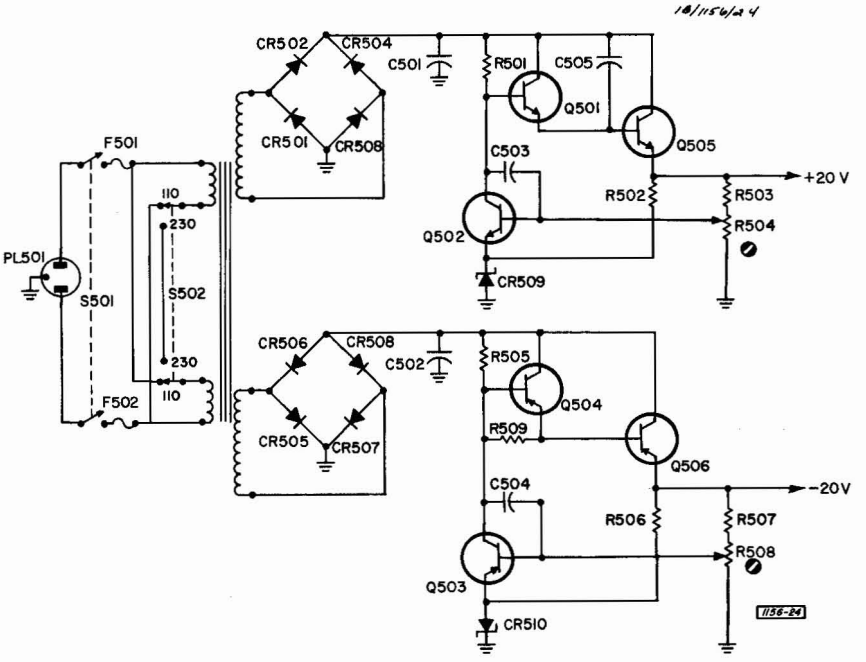
4.9.1 +20-VOLT REGULATOR

The +20-volt supply consists of a full-wave bridge rectifier (CR501 through CR504), a series regulator (Q505), a comparator (Q502), and an error-voltage emitter follower (Q501).

The +20-volt output is taken from the emitter of Q505. Error voltage from the center arm of R504 is applied to the base of the comparator, Q502, whose bias is set by a zener diode, CR509. The comparator amplifies and inverts the error voltage and applies it to the base of the error-voltage emitter follower, Q501, which drives the series regulator to maintain a constant +20-volt output.

4.9.2 -20-VOLT REGULATOR

The -20-volt supply is identical to the +20-volt supply except the rectifiers are reversed and PNP transistors are used instead of NPN transistors.



SECTION 5 SERVICE AND MAINTENANCE

• 5.1 WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, Sales Engineering Office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

• 5.2 SERVICE

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest Sales Engineering Office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

• 5.3 ROUTINE MAINTENANCE

None required.

• 5.4 SCALE-OF-FIVE DC VOLTAGES

The scale-of-five circuit can be checked by means of dc-voltage measurements:

1. Remove any input signal, set the TRIGGER LEVEL control fully cw, and connect a 1-kΩ resistor between AT508 (+20 V) and CR106 anode (scale-of-five input). The dc voltages at the bases of the even transistors in the circuit (Q108, Q110, Q112, Q114, and Q116) should be about 2 V.
2. Move the 1-kΩ resistor to AT507 (-20 V) and set the TRIGGER LEVEL control fully ccw. The dc voltages at the bases of the even transistors should again be about 2 V.

● 5.5 CALIBRATION PROCEDURE

5.5.1 INTRODUCTION

Each step in the calibration procedure should be performed in sequence since one step serves as a foundation for the next. A complete calibration insures that all circuits are operating properly and within specifications. The Type 1156-A Decade Scaler incorporates the high reliability one expects of conservatively designed, semiconductor circuits and routine calibrations are unnecessary.

5.5.2 TEST SETUP AND EQUIPMENT REQUIRED

The following equipment is required for a complete calibration of the Type 1156-A Decade Scaler. The specifications given for the equipment are those necessary for the calibration of the Type 1156-A and are not necessarily those of the suggested equipment.

Metered, adjustable autotransformer

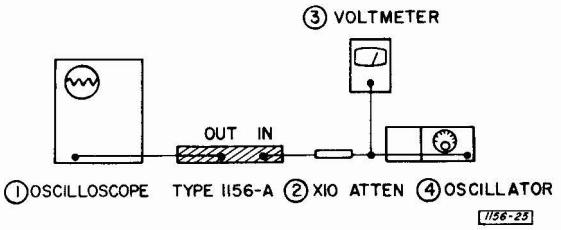
Output: 115 V, 15 W.
Meter: Ac, ±3% accuracy
The Type W5MT3W Metered Variac® Autotransformer can be used.

Oscilloscope

Bandwidth: dc to ≈ 30 Mc/s (-3 dB points)
Sensitivity: 1 to 5 V, p-to-p
Impedance: 50 Ω or greater

X10 attenuator

Attenuator: X10, ±1.5% accuracy
Impedance: 50 Ω
The Type 874-G20 or Type 874-G20L (locking connectors) Fixed Attenuator can be used.



Electronic voltmeter

Voltage : 20 V dc and 0.35V to 1 V, rms, ac; ±2% accuracy
Impedance: 100 kΩ or greater
Frequency: Dc to 100 Mc/s
The Type 1806 Electronic Voltmeter can be used

Oscillator

Frequency: 1 Mc/s and 100 Mc/s
Output: 0.035 to 1 V, rms, into 50 Ω
For 1 Mc/s the Type 1211 Unit Oscillator can be used
For 100 and 125 Mc/s the Type 1208 or 1215 Unit Oscillator can be used

5.5.3 POWER SUPPLY

+20 volts. Set the line voltage to 115 volts and connect a meter and an oscilloscope to AT508. Adjust R504 for +20 volts, dc, and check ripple; must be 120 c/s and less than 60 mV, p-to-p.

Vary the line voltage from 105 to 125 volts and check, (1) dc voltage, must remain within 0.5 volt of +20 volts; (2) ripple, must not increase.

-20 volts. Set the line voltage to 115 volts and connect a meter and an oscilloscope to AT507. Adjust R508 for -20 volts, dc and check ripple; must be 120 c/s and less than 30 mV, p-to-p.

Vary the line voltage from 105 to 125 volts and check, (1) dc voltage, must remain within 0.5 volt of -20 volts; (2) ripple, must not increase.

5.5.4 SENSITIVITY

Adjustment. Check the mechanical position of the TRIGGER LEVEL knob on the shaft: the dot must be straight up at the center of the potentiometers' range.

Set the dot on the TRIGGER LEVEL control straight up and set the SENSITIVITY control to 1 (1 V, p-to-p). Set the oscillator output for 1 V, rms (10 V on meter) at 1 Mc/s and adjust R201 for the proper OUTPUT as displayed on the oscilloscope. Reduce the oscillator output amplitude and adjust R201 so that proper triggering is obtained with the input as low as 0.35 V, rms (3.5 V on meter).

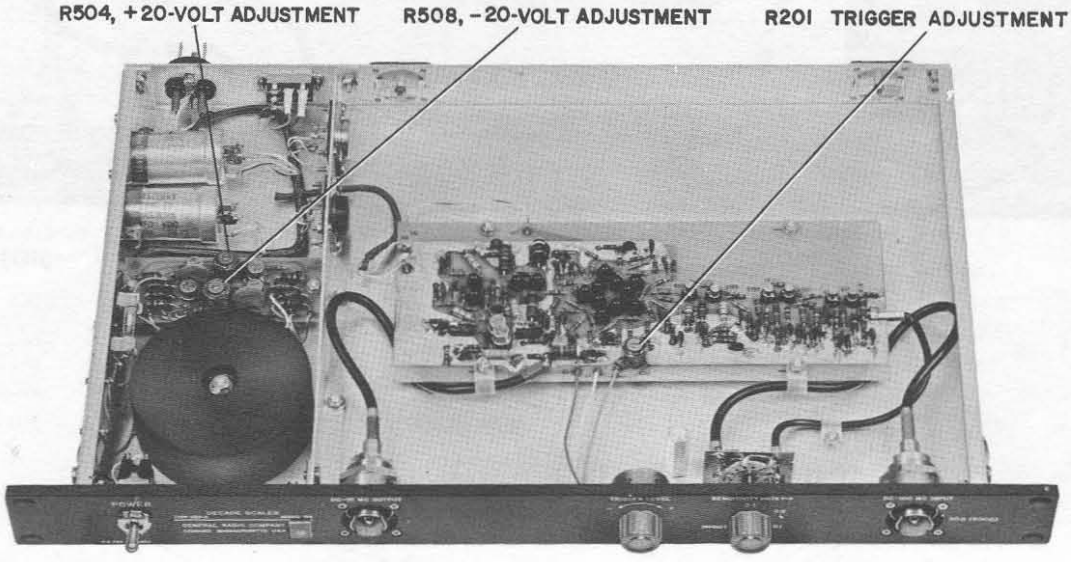
R201

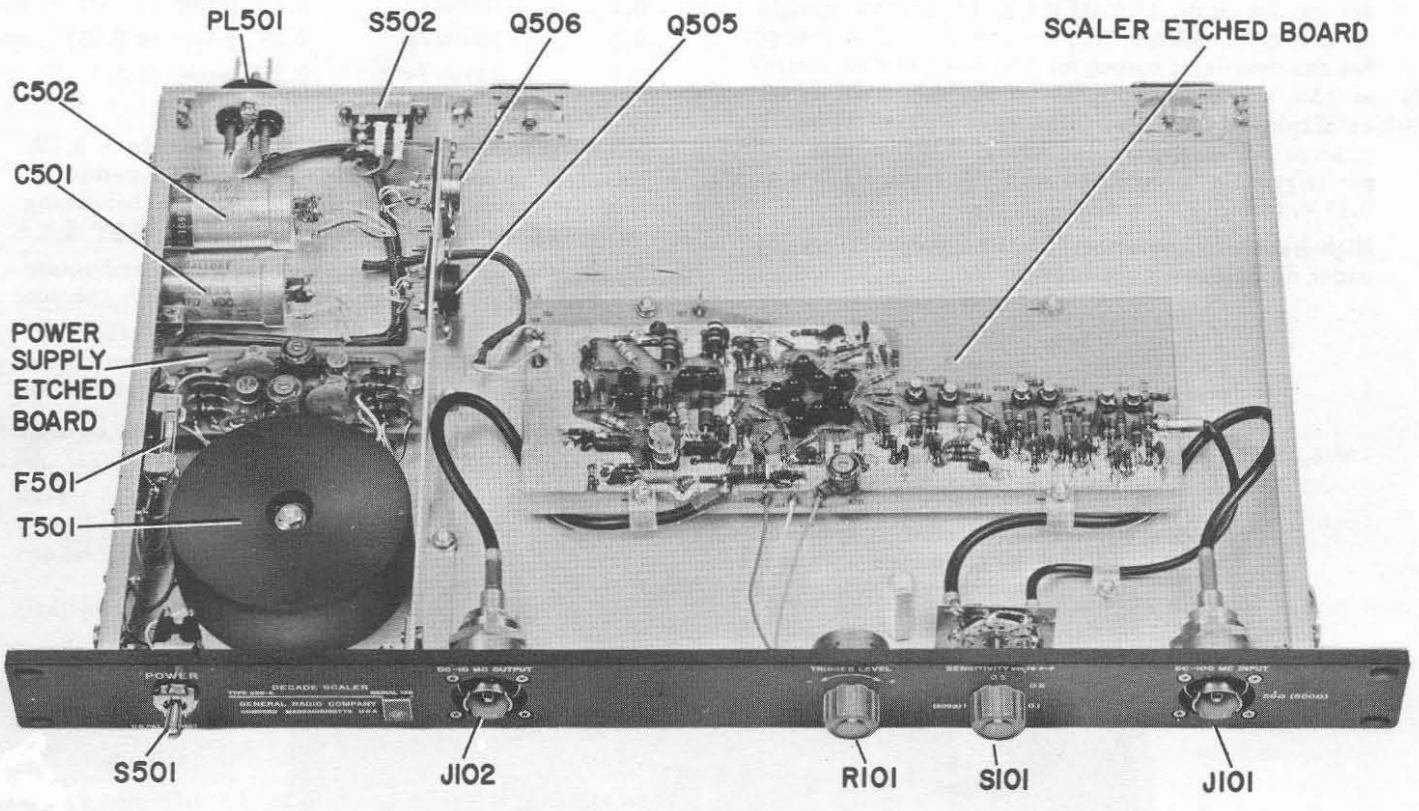
High-frequency operation. Check for proper triggering under the following conditions:

SENSITIVITY control	*Oscillator frequency*	*amplitude at INPUT connector*
1	100Mc/s	1 V, p-to-p or 0.35 V, rms
0.5	100Mc/s	0.5V, p-to-p or 0.175V, rms
0.2	100Mc/s	0.2V, p-to-p or 0.07 V, rms
0.1	100Mc/s	0.1V, p-to-p or 0.035V, rms
0.1	125Mc/s	0.3V, p-to-p or 0.1 V, rms

Maximum input. Set the oscillator amplitude to 0.7V, rms, (7 V on meter) and the SENSITIVITY control to 0.1: the instrument must trigger properly (indicating an input dynamic range of 20:1).

Dc operation. Disconnect the oscillator and rotate the TRIGGER LEVEL control back and forth: the output must complete one cycle for every 10 rotations of the TRIGGER LEVEL control.





SCALER etched-board circuit assembly	1156-2710
POWER SUPPLY etched-board circuit assembly	1156-2750

PARTS LIST

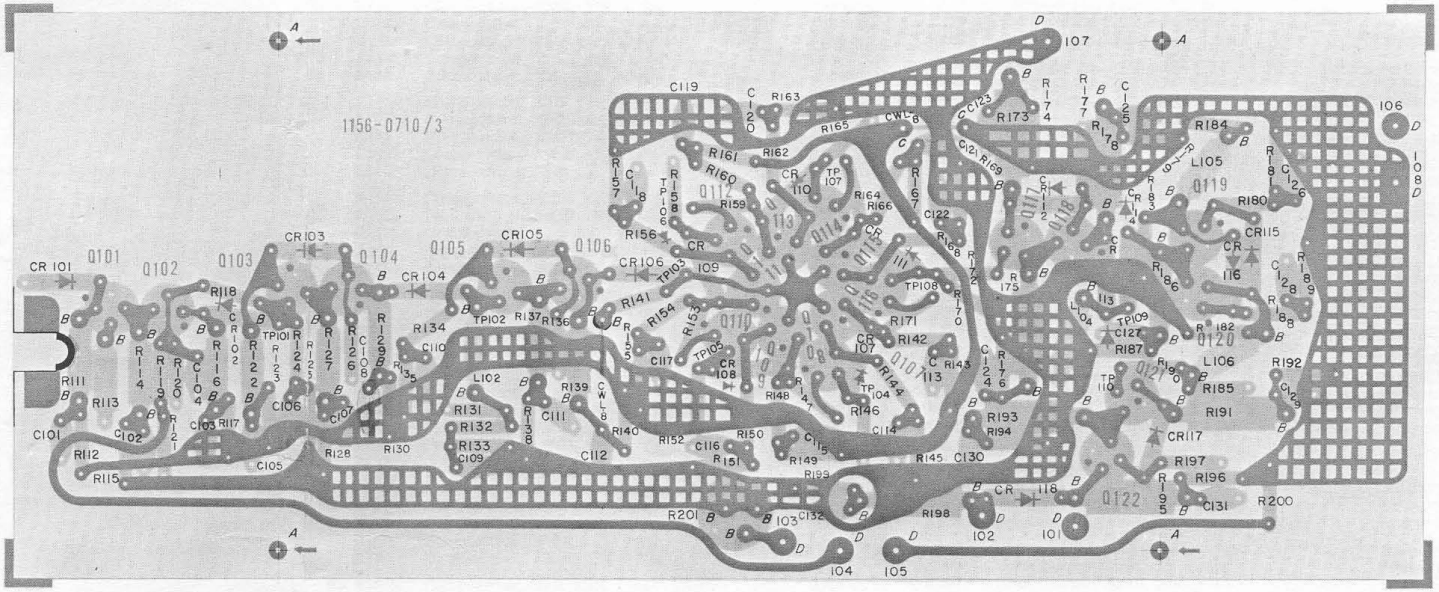
REF NO.	DESCRIPTION	PART NO.
CAPACITORS		
C101	Ceramic, 0.001μF +80-20% 500V	4404-2109
C102	Ceramic, 0.001μF +80-20% 500V	4404-2109
C103	Ceramic, 0.001μF +80-20% 500V	4404-2109
C104	Ceramic, 47pF ±5% 500V	4404-0475
C105 thru C132	Ceramic, 0.001μF +80-20% 500V	4404-2109
C501	Electrolytic, 600μF +100-10% 35V	4450-2400
C502	Electrolytic, 600μF +100-10% 35V	4450-2400
C503	Ceramic, 0.022μF ±20% 500V	4407-3220
C504	Ceramic, 0.022μF ±20% 500V	4407-3220
C505	Ceramic, 0.01μF +80-20% 50V	4401-3100
DIODES		
CR101 thru CR104	Type 1N748A	6083-1002
CR105 thru CR111	Type 1N758A	6083-1012
CR112	Type 1N752	6083-1004
CR113	Type 1N752	6083-1004
CR114	Type 1N995	6082-1002
CR115	Type 1N957B	6083-1009
CR116	Type 1N957B	6083-1009
CR117	Type 1N752	6083-1004
CR118	Type 1N752	6083-1004
CR501 thru CR508	Type 1N3254	6081-1002
CR509	Type 1N758A	6083-1012
CR510	Type 1N758A	6083-1012
FUSE		
F501	0.25A	5330-1400
JACKS		
J101	GR874 recessed locking connector	INPUT 0874-4622
J102	GR874 recessed locking connector	OUTPUT 0874-4622
INDUCTORS		
L101	0.68μH ±20%	4300-0500
L102	1μH ±10%	4300-0700
L103	0.15μH ±20%	4300-0100
L104	1.8μH ±10%	4300-1100
L105	2.2μH ±10%	4300-1200
L106	2.2μH ±10%	4300-1200

REF NO.	DESCRIPTION	PART NO.
PLUG		
PL501	3-terminal power plug; power connector consists of; 2-terminal power plug	4240-0600
	ground pin	4240-0800
TRANSISTORS		
Q101 thru Q106	Type K2037	8210-1088
Q107 thru Q120	Type 2N3563	8210-1066
Q121	Type 2N2218	8210-1028
Q122	Type 2N2218	8210-1028
Q501	Type 2N1304	8210-1304
Q502	Type 2N1304	8210-1304
Q503	Type 2N1304	8210-1305
Q504	Type 2N1305	8210-1305
Q505	Type 2N1702	8210-1065
Q506	Type 2N1544	8210-1014
RESISTORS		
R101	Potentiometer, composition, TRIGGER LEVEL 1kΩ ±10% uses 5540-3000 gray knob	6044-0900
R102	Composition, 75Ω ±5% 1/2w	6100-0755
R103	Composition, 75Ω ±5% 1/4w	6099-0755
R104	Composition, 130Ω ±5% 1/4w	6099-1135
R105	Composition, 120Ω ±5% 1/4w	6099-1125
R106	Composition, 130Ω ±5% 1/4w	6099-1135
R107	Composition, 75Ω ±5% 1/4w	6099-0755
R108	Composition, 820Ω ±5% 1/4w	6099-1825
R109	Composition, 150Ω ±5% 1/4w	6099-1155
R110	Composition, 300Ω ±5% 1/4w	6099-1305
R111	Composition, 1.2kΩ ±5% 1/4w	6099-2125
R112	Composition, 22Ω ±5% 1/4w	6099-0225
R113	Composition, 75Ω ±5% 1/2w	6100-0755
R114	Composition, 2kΩ ±5% 1/2w	6100-2205
R115	Composition, 22Ω ±5% 1/4w	6099-0225
R116	Composition, 1.2kΩ ±5% 1/4w	6099-2125
R117	Composition, 22Ω ±5% 1/4w	6099-0225
R118	Composition, 1kΩ ±5% 1/4w	6099-2105
R119	Composition, 1.8kΩ ±5% 1/4w	6099-2185
R120	Composition, 200Ω ±5% 1/4w	6099-1205
R121	Composition, 820Ω ±5% 1/4w	6099-1825
R122	Composition, 1.2kΩ ±5% 1/4w	6099-2125
R123	Composition, 22Ω ±5% 1/4w	6099-0225

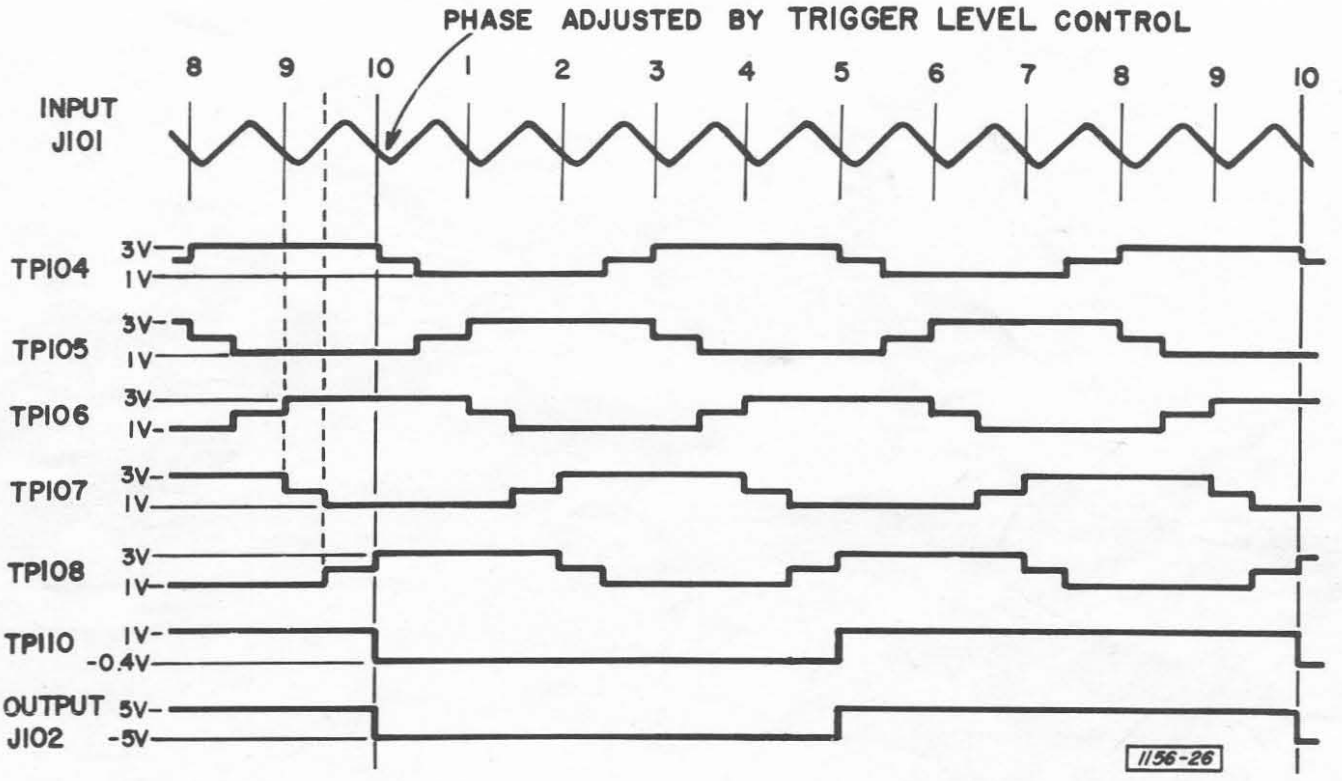
PARTS LIST

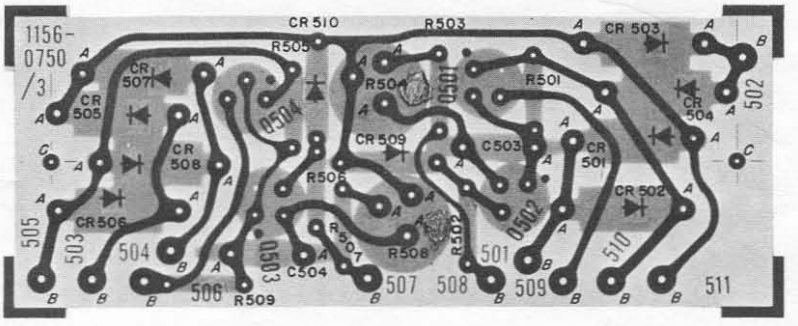
REF NO.	DESCRIPTION	PART NO.
RESISTOR		
R124	Composition, 2.4kΩ ±5% 1/4w	6099-2245
R125	Composition, 22Ω ±5% 1/4w	6099-0225
R126	Composition, ±5% 1/4w value chosen in final calibration	
R127	Composition, 2kΩ ±5% 1/2w	6100-2205
R128	Composition, 22Ω ±5% 1/4w	6099-0225
R129	Composition, 1.2kΩ ±5% 1/4w	6099-2125
R130	Composition, 22Ω ±5% 1/4w	6099-0225
R131	Composition, 220Ω ±5% 1/4w	6099-1225
R132	Composition, 3kΩ ±5% 1/4w	6099-2305
R133	Composition, 22Ω ±5% 1/4w	6099-0225
R134	Composition, 820Ω ±5% 1/4w	6099-1825
R135	Composition, 22Ω ±5% 1/4w	6099-0225
R136	Composition, 33Ω ±5% 1/4w	6099-0335
R137	Composition, 2kΩ ±5% 1/2w	6100-2205
R138	Composition, 22Ω ±5% 1/4w	6099-0225
R139	Composition, 390Ω ±5% 1/2w	6100-1395
R140	Composition, 22Ω ±5% 1/4w	6099-0225
R141	Composition, 120Ω ±5% 1/4w	6099-1125
R142	Composition, 680Ω ±5% 1/4w	6099-1685
R143	Composition, 22Ω ±5% 1/4w	6099-0225
R144	Composition, 3.9kΩ ±5% 1/4w	6099-2395
R145	Composition, 22Ω ±5% 1/4w	6099-0225
R146	Composition, 270Ω ±5% 1/4w	6099-1275
R147	Composition, 330Ω ±5% 1/4w	6099-1335
R148	Composition, 680Ω ±5% 1/4w	6099-1685
R149	Composition, 22Ω ±5% 1/4w	6099-0225
R150	Composition, 3.9kΩ ±5% 1/4w	6099-2395
R151	Composition, 22Ω ±5% 1/4w	6099-0225
R152	Composition, 270Ω ±5% 1/4w	6099-1275
R153	Composition, 330Ω ±5% 1/4w	6099-1335
R154	Composition, 680Ω ±5% 1/4w	6099-1685
R155	Composition, 22Ω ±5% 1/4w	6099-0225
R156	Composition, 3.9kΩ ±5% 1/4w	6099-2395
R157	Composition, 22Ω ±5% 1/4w	6099-0225
R158	Composition, 270Ω ±5% 1/4w	6099-1275
R159	Composition, 330Ω ±5% 1/4w	6099-1335
R160	Composition, 680Ω ±5% 1/4w	6099-1685
R161	Composition, 22Ω ±5% 1/4w	6099-0225
R162	Composition, 3.9kΩ ±5% 1/4w	6099-2395
R163	Composition, 22Ω ±5% 1/4w	6099-0225
R164	Composition, 330Ω ±5% 1/4w	6099-1335
R165	Composition, 270Ω ±5% 1/4w	6099-1275
R166	Composition, 680Ω ±5% 1/4w	6099-1685
R167	Composition, 22Ω ±5% 1/4w	6099-0225
R168	Composition, 3.9kΩ ±5% 1/4w	6099-2395
R169	Composition, 22Ω ±5% 1/4w	6099-0225
R170	Composition, 270Ω ±5% 1/4w	6099-1275

REF NO.	DESCRIPTION	PART NO.
RESISTOR		
R171	Composition, 330Ω ±5% 1/4w	6099-1335
R172	Composition, 470Ω ±5% 1/4w	6099-1475
R173	Composition, 390Ω ±5% 1w	6110-1395
R174	Composition, 22Ω ±5% 1/4w	6099-0225
R175	Compostiion, 1kΩ ±5% 1w	6110-2105
R176	Composition, 22Ω ±5% 1/4w	6099-0225
R177	Composition, 82Ω ±5% 1/4w	6099-0825
R178	Composition, 510Ω ±5% 1w	6110-1515
R179	Composition, 22Ω ±5% 1/4w	6099-0225
R180	Composition, 680Ω ±5% 1/4w	6099-1685
R181	Composition, 22Ω ±5% 1/4w	6099-0225
R182	Composition, 2kΩ ±5% 1/4w	6099-2205
R183	Composition, 2kΩ ±5% 1/4w	6099-2205
R184	Composition, 270Ω ±5% 1/4w	6099-1275
R185	Composition, 270Ω ±5% 1/4w	6099-1275
R186	Composition, 2kΩ ±5% 1/2w	6100-2205
R187	Composition, 22Ω ±5% 1/4w	6099-0225
R188	Composition, 680Ω ±5% 1/4w	6099-1685
R189	Composition, 22Ω ±5% 1/4w	6099-0225
R190	Composition, 470Ω ±5% 1/4w	6099-1475
R191	Wire-wound, 300Ω ±5% 3w	6680-1305
R192	Composition, 22Ω ±5% 1/4w	6099-0225
R193	Wire-wound, 510Ω ±5% 3w	6680-1515
R194	Composition, 22Ω ±5% 1/4w	6099-0225
R195	Wire-wound, 330Ω ±5% 3w	6680-1335
R196	Composition, 22Ω ±5% 1/4w	6099-0225
R197	Composition, 15Ω ±5% 1/4w	6099-0155
R198	Composition, 910Ω ±5% 1/2w	6100-1915
R199	Composition, 22Ω ±5% 1/4w	6099-0225
R200	Composition, 3.3kΩ ±5% 1/4w	6099-2335
R201	Potentiometer, composition, 5kΩ ±20%	6040-0600
R501	Composition, 5.6kΩ ±5% 1/4w	6099-2565
R502	Composition, 1kΩ ±5% 1/4w	6099-2105
R503	Composition, 510Ω ±5% 1/4w	6099-1515
R504	Potentiometer, composition, 1kΩ ±20%	6040-0400
R505	Composition, 5.6kΩ ±5% 1/4w	6099-2565
R506	Composition, 1kΩ ±5% 1/4w	6099-2105
R507	Composition, 510Ω ±5% 1/4w	6099-1515
R508	Potentiometer, composition, 1kΩ ±20%	6040-0400
R509	Composition, 1kΩ ±5% 1/4w	6099-2105
SWITCHES		
S101	Rotary, uses 5540-3000 gray knob SENSITIVITY	7890-4190
S501	Toggle, dpst POWER	7910-1300
S502	Slide LINE	7910-0831
TRANSFORMER		
T501	Power transformer	1156-2020

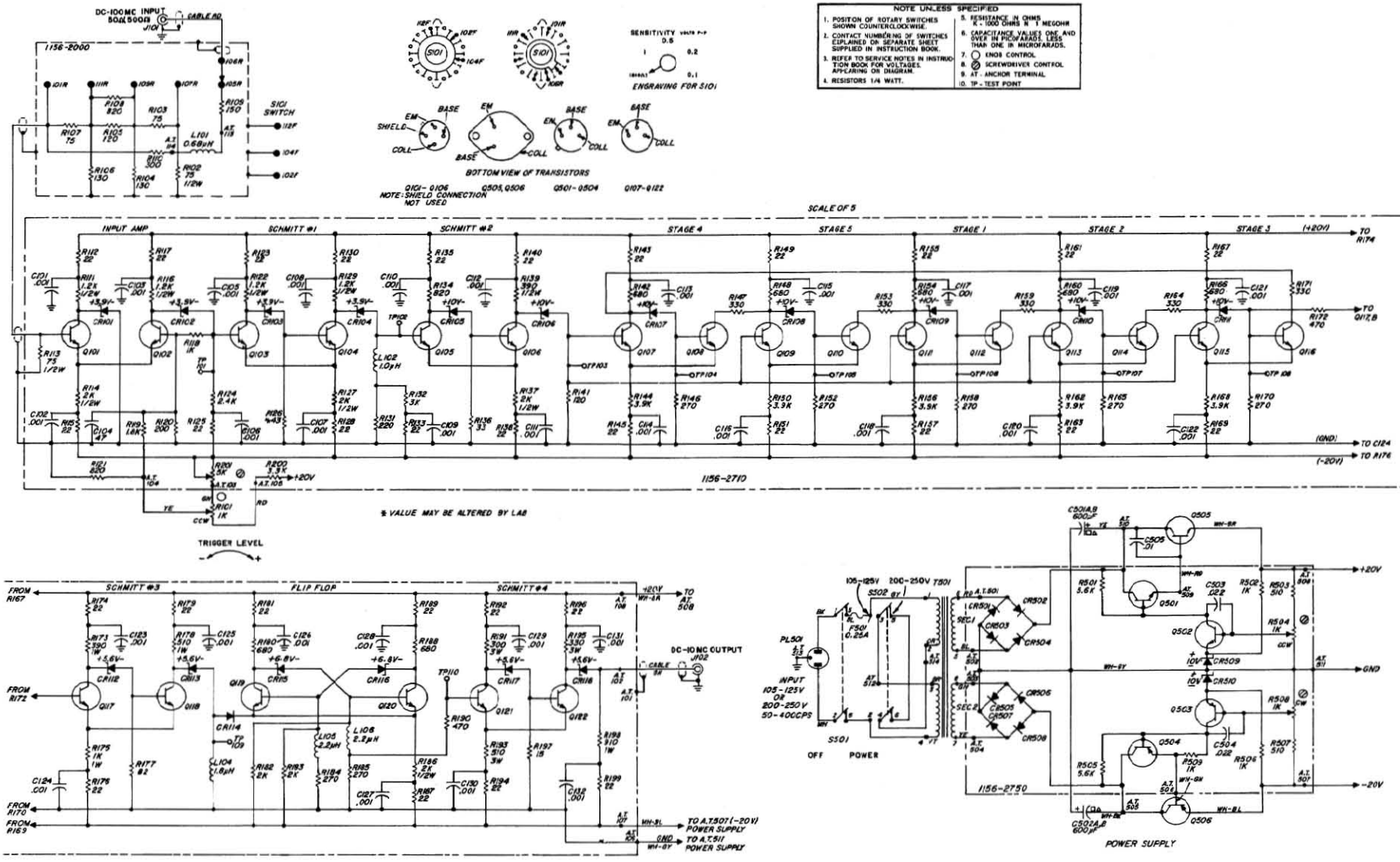


Scaler etched-board circuit assembly of Type 1156-A Decade Scaler





Power Supply etched-board circuit assembly of Type 1156-A Decade Scaler



Schematic diagram of Type 1156-A Decade Scaler

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Telephone 214 637-2240

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