INSTRUCTION MANUAL

Serial Number ____________

TYPE 10A1 PLUG-IN UNIT

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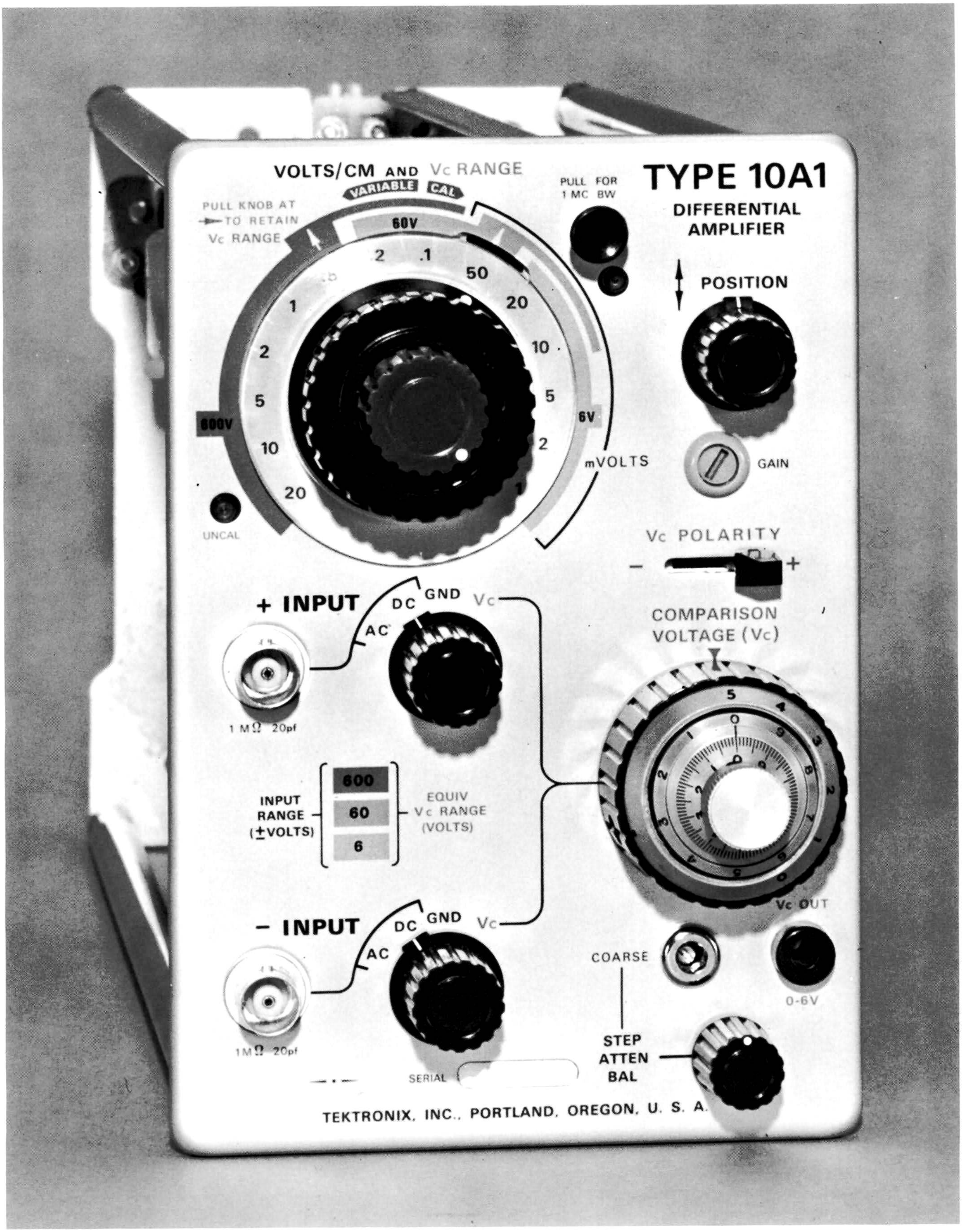
070-464 365



VOLTS/CM AND Vc RANGE
VARIABLE
CAL
PULL KNOB AT
TO RETAIN
Vc RANGE
60V
.2
.1
50
20
10
5
2
1
1
2
5
10
20
600V
6V
mVOLTS
UNCAL
PULL FOR
1 MC BW
TYPE 10A1
DIFFERENTIAL
AMPLIFIER
POSITION
GAIN
Vc POLARITY
COMPARISON
VOLTAGE (Vc)
+ INPUT
AC
DC
GND
Vc
1 MΩ 20pf
INPUT
RANGE
(±VOLTS)
600
60
6
EQUIV
Vc RANGE
(VOLTS)
- INPUT
AC
DC
GND
Vc
1 MΩ 20pf
Vc OUT
0-6V
COARSE
STEP
ATTEN
BAL
SERIAL
TEKTRONIX, INC., PORTLAND, OREGON, U. S. A.

SECTION 1
CHARACTERISTICS

General Information

The Type 10A1 Differential Amplifier is a multi-purpose vertical plug-in unit for the Type 647 Oscilloscope. It combines these features: high-gain, ac or dc input coupling, wide-band; operates as a conventional amplifier, a differential amplifier or a differential comparator.

As a conventional amplifier, passband is greater than 45 mc at calibrated deflection factors of 5 mv/cm to 20 v/cm. At a maximum sensitivity of 1 mv/cm, the passband is greater than 35 mc.

As a differential amplifier, common-mode rejection (CMR) exceeds 20,000:1 below 100 kc and 10,000:1 to 1 mc. CMR is defined as the ratio of common-mode input voltage to a differential output voltage. Differential output voltage is the peak-to-peak display amplitude in centimeters multiplied by the vertical deflection factor.

As a differential comparator, the slide-back technique is used to make voltage measurements. The built-in highly-accurate comparison voltage (Vc) is applied differentially to the Type 10A1 input stage so precise voltage measurements can be made. Comparison voltage ranges are in direct-reading equivalent ranges of 6, 60 and 600 volts. The range in use is selected by means of a combination switch that simultaneously selects the vertical deflection factor and Vc range. Table 1-1 lists the order of selection.

TABLE 1-1

Vc RANGE	Volts/Cm: Normal Use	Volts/Cm: When using "Pull Knob To Retain Vc Range"
6 v	1 mv through 20 mv	
60 v	50 mv through 0.2 v	10 mv through 0.2 v
600 v	0.5 v through 20 v	0.1 v through 20 v

The electrical characteristics are divided into groups according to the following operating modes: conventional amplifier, differential amplifier and differential comparator.

AS A CONVENTIONAL AMPLIFIER

Deflection Factors

1 mv/cm to 20 v/cm in 14 calibrated steps. Sequence is 1-2-5. A variable control with at least 2.5:1 uncalibrated range provides for continuously-variable adjustment between steps and extends the 20 volts/cm deflection factor to 50 volts/cm.

Volts/Cm Accuracy

TABLE 1-2

Volts/Cm*	0° C to +40° C	−30° C to +65° C
1 mv (also 10 mv and 0.1 v in retained Vc range)	±2.5%	±4%
2 mv through 2 v (except 10 mv and 0.1 v in retained Vc range)	±1.5%	±2.5%
5 v through 20 v	±3%	±4%

***Measured after GAIN control has been accurately adjusted at 5 mv/cm. Standard Square-Wave Calibrator signal (1 kc, amplitude accuracy ¼%) applied to produce 4 cm vertical deflection.**

Risetime and Equivalent Frequency Response

Table 1-3 lists the system risetime and equivalent frequency response for signals that do not overscan the screen. To obtain the system-risetime measurement, a 1.5-nsec risetime pulse is used to drive the Type 10A1 in a Type 647 Oscilloscope.

The equivalent upper frequency response is the −30% voltage point. This is determined by using the following formula:

$$\text{Equivalent Frequency Response (at 30\% down point)} = \frac{0.35}{\text{System Risetime}}$$

TABLE 1-3

Volts/Cm	0° C to +40° C	−30° C to +65° C
5 mv to 20 v, dc-coupled.	Risetime: ≤7.8 nsec. Equivalent Response: dc to ≥ 45 mc.	Risetime: ≤8.75 nsec. Equivalent Response: dc to ≥ 40 mc.
1 mv and 2 mv; 10 mv, 20 mv, 0.1 v and 0.2 v in retained Vc range; dc-coupled.	Risetime: ≤ 10 nsec. Equivalent Response: dc to ≥ 35 mc	Risetime: ≤11.7 nsec. Equivalent Response: dc to ≥ 30 mc.

Low-Frequency Response Using AC Coupling: ≥ 2 cps at −30% voltage point.

Limited Bandwidth Frequency Response: With PULL FOR 1 MC BW switch pulled out and VOLTS/CM switch set to any position, frequency response is dc to 1 mc (±10%) using dc coupling; ≤ 2 cps to 1 mc (±10%) using ac coupling. The limited-bandwidth switch position is useful for reducing on-screen noise at high sensitivities.

Input R and C

1 megohm (±1%) paralleled by approximately 20 pf.

Maximum Dynamic Linear Range — Maximum Combined DC and Peak AC Input Voltage

TABLE 1-4

Input Voltage		
Dynamic range, linear	Max. combined DC and Peak AC	Volts/Cm
±6 v	±20 v	1 mv/cm to 20 mv/cm
±60 v	±600 v	10 mv/cm to 0.2 v/cm*
±600 v	±600 v	0.1 v/cm to 20 v/cm**

***10 and 20 mv/cm in retained range.**

****0.1 and 0.2 v/cm in retained range.**

Maximum Input Grid Current

≤1 nanoampere. Equivalent to ≤1 cm trace displacement at 1 mv/cm.

Input Isolation

≥5000:1. Measured with driven grid in Gnd or Vc, undriven grid in Gnd, 1 mv/cm deflection factor, and using a 10-v peak-to-peak 100-kc square wave as the drive signal.

Input Crosstalk

≤10 mv or ≤1%, whichever is smaller.

Measured when driven grid is dc-coupled, 5 mv/cm deflection factor, using a 5-v peak-to-peak 1-kc square wave as the drive signal. Undriven grid is switched from DC to Gnd and peak-to-peak change in amplitude of front corner is noted.

DC Thermal Drift

≤ 0.5 mv/°C.

Environmental Capability

Non-operating: —55° C to +75° C to 50,000 ft.

Operating: —30° C to +65° C to 15,000 ft.

The Type 10A1 Differential Amplifier can be stored alone, or in the Type 647 Oscilloscope at any temperature between —55° C or +75° C. After storage at either extreme, the instrument must be allowed sufficient time for all components to return to the operating ambient temperature range of —30° C to +65° C.

AS A DIFFERENTIAL AMPLIFIER

Input Voltage

See Table 1-4.

Overload Recovery Time

For an off-screen to on-screen step of as much as 6 v applied in the 1-mv/cm position, the amplifier recovers within ±2 mv of the final signal value in less than 0.3 μsec; within ±0.5 mv in less than 1 msec. 0° C to +40° C.

Common-Mode Rejection (CMR)

TABLE 1-5

Common-Mode Rejection*

Common-Mode Input Voltage Peak-to-Peak	Input Coupling	Input Voltage Sine-Wave Frequency	Common-Mode Rejection
10 v	dc	dc to 100 kc	≥20,000:1
10 v	dc	100 kc to 1 mc	≥10,000:1
5 v	dc	2 mc	≥5,000:1
2 v	dc	5 mc	≥2,000:1
1 v	dc	10 mc	≥1,000:1
1 v	dc	20 mc	≥100:1
10 v	ac	60 cps	≥2,000:1

***Volts/CM switch set to 1 mv/cm; 0° C to +40° C.**

Common-Mode rejection ratio of 10× attenuator (10 and 20 mv/cm in retained range; 50 mv to .2 v) is ≥ 2,000:1 using a 20-v peak-to-peak 10-kc sine-wave common-mode input signal.

Input Attenuation Accuracy

TABLE 1-6

Attenuator[1]	Volts/Cm	Input Attenuation Accuracy 0° C to +40° C	—30° C to +65° C
10×	10 mv/cm to 0.2 v/cm[2]	≤ ±0.125%	≤ ±0.25%
100×	0.1 v/cm to 2 v/cm[3]	≤ ±0.25%	≤ ±0.5%
1000×	5 v/cm to 20 v/cm	≤ ±2%	≤ ±2.5%

[1] **Attenuators are automatically switched into the amplifier input circuits when Volts/Cm switch is set to positions listed in second column.**

[2] **10 and 20 mv/cm in retained range.**

[3] **0.1 and 0.2 v/cm in retained range.**

Input Resistance Matching

1× input resistance adjustable to match 10× resistance within ±0.2% (0° C to +40° C), within ±0.4% (—30° C to +65° C).

AS A DIFFERENTIAL COMPARATOR

Comparison Voltage (Vc) Range

0 to ±6 v.

Comparison Voltage Accuracy

±(0.1% +5 mv), 0° C to +40° C.

±(0.15% +8 mv), —30° C to +65° C.

Slide-Back Measurement Accuracy

TABLE 1-7

Equivalent Range At Input	Slide-Back Measurement Accuracy*	
	0° C to +40° C	—30° C to +65° C
0 to ±6 v	±(0.1% + 5 mv)	±(0.15% + 8 mv)
0 to ±60 v	±(0.225% + 50 mv)	±(0.4% + 80 mv)
0 to ±600 v	±(0.35% + 0.5 v)	±(0.65% + 0.8 v)

***Accuracy is the sum of the Vc accuracy and attenuator accuracy.**

TABLE 1-8

Equivalent Range At P6023 Probe Tip	Slide-Back Measurement Accuracy With P6023 Probe*	
	0° C to +40° C	—30° C to +65° C
0 to ±60 v	±(0.225% +50 mv)	±(0.4% + 80 mv)
0 to ±600 v	±(0.5% + 0.5 v)	±(0.95% + 0.8 v)
0 to ±6000 v**	±(1% + 5 v)	±(2% + 8 v)

***Probe attenuation is matched to 10X attenuator and accuracy includes effect of input resistance tolerance.**

****Input voltage rating of P6023 Probe is 1000 v maximum.**

Readout Resolution

≤0.5 mv on 6-v range. Measured by taking the difference between two Vc readings. Vc controls were rotated to the zero differential reference point from opposite directions to obtain the two readings. Resulting readings are a combination of readout and resolution.

Input Attenuation Accuracy

See Table 1-6.

Input Voltage Rating

See Table 1-4.

MECHANICAL

Construction

Aluminum-alloy chassis with chrome-plated brass side rails.

Finish

Photo-etched, anodized aluminum panel.

Dimensions

6¼ inches high, 4¼ inches wide, 14½ inches deep overall.

Weight

4 pounds, 13 ounces net.

Accessories

Two instruction manuals, Tektronix Part No. 070-464.

SECTION 3
CIRCUIT DESCRIPTION

BLOCK DIAGRAM DESCRIPTION

This description is based primarily on the block diagram located in Section 6 of this manual. Signals applied to the + and —INPUT connectors pass through the + and —INPUT switches and input attenuators to the Input Amplifier stages. The INPUT switches control mode of operation and the input attenuators control the magnitude of the signals applied to the input stages.

Accurate ±dc comparison voltages are obtained from the Vc supply. These voltages can be applied to the input of either Input Amplifier by means of the + and —INPUT switches. In differential-comparator mode of operation, for example, the voltage is applied to one Input Amplifier and the signal is applied to the other.

The low-capacitance, high-impedance input of the Input Amplifier stages isolate the input circuit from the suceeding stages. The Input Amplifier stages are designed to accept input signals as great as ±6 volts without being overloaded. Special constant-current and bootstrap circuits prevent the input cathode followers from cutting off or drawing grid current when large signals (±6 v) are applied.

The output from either Input Amplifier stage is applied to the Signal Disconnect Switch. This stage limits overload signals so they do not overdrive the following stages. Immediately following the Signal Disconnect Switch is the Differential Amplifier. This stage amplifies differential signals but not common-mode signals within the operational limits of the Type 10A1.

Differential signals from the Differential Amplifier are applied to the Gain Switching stage, which provides a 20-to-1 gain switching ratio so signals do not overdrive the following stages. Gain switching is accomplished by means of the VOLTS/CM switch.

Signals from the Gain Switching stage are applied to the Output Amplifier. Here the signals are further amplified and then applied to the input of the oscilloscope vertical amplifier through pins 5 and 7 of the interconnecting plug.

Signals from the Output Amplifier are also applied to the Trigger Amplifier stage. This stage provides + and — internal triggers to drive the trigger generator circuit in the time-base plug-in unit.

In the detailed description that follows, refer to the schematic diagrams in Section 6 of this manual.

DETAILED CIRCUIT DESCRIPTION

Comparison Voltage Supply

To make the Type 10A1 comparison voltage (Vc) supply operate at its specified accuracy, the Vc supply must maintain a constant voltage independent of environmental temperature changes and differences in the regulated power supply voltages between one oscilloscope and another. To obtain this high accuracy the comparison voltage is derived from a temperature-stable reference element D582. Its output is nominally 9 volts and this voltage remains constant within 0.001% per degree centigrade change.

When the Vc POLARITY switch SW580 is set to —, D582 cathode is connected to ground and the anode is connected through R580 to the —15-volt supply. The 6V CAL adjustment R583 is set so the Vc is exactly —6 volts at the top end of the Kelvin-Varley divider. Resistors R587A through R587G make up the divider. The top end of the divider is the end farthest from ground or the top end of R587A. For the adjustment to be made properly, SW710 must be set to a "straight-thru" position (see 1F and 1R of SW710 on the Switch Details diagram). All 1F and 1R positions of SW710 are straight through except the 5, 10 or 20 VOLTS/CM positions.

When the Vc POLARITY switch SW580 is set to +, D582 cathode connects through R580 to the +15-volt supply and the anode connects to ground. Thus, a +6-volt comparison voltage is now applied to the divider load for all VOLTS/CM positions except those mentioned in the previous paragraph.

Comparison Voltage Ranges

The internal comparison voltage ranges are actually two basic ranges: 0 to 6 volts and 0 to 0.6 volts (refer to the Comparison Voltage Generator schematic diagram). For all VOLTS/CM switch positions except 5, 10 and 20 v/cm (see SW710 Switch Details), the 6-volt comparison voltage is applied to the Kelvin-Varley divider. In the 5, 10 and 20 VOLTS/CM switch positions divider resistors R727 and R730 are connected into the circuit dividing the voltage by 10 and supplying the Kelvin-Varley divider with a 0.6-volt range.

Comparison Voltage Output Circuit

The comparison voltage output circuit consists of the COMPARISON VOLTAGE (Vc) control and associated circuitry. The COMPARISON VOLTAGE control is a combination of two controls to provide direct 4-digit readout. Switch SW590 is a Kelvin-Varley bridge that selects the first digit within the range set by SW710 and the 10-turn potentiometer R595 selects the remaining digits.

Seven resistors in the bridge, R587A through R587G, make up the divider for SW590. As mentioned previously, the comparison voltage is applied to the top end of the divider; the bottom end is connected to ground. A shunt divider consisting of R590, R594 and R595 is connected across two of the resistors in the divider by means of switch SW-590. The equivalent resistance of the shunted portion of the divider is equal to 1 k. The 1V CAL control R590 provides the means for setting this resistance accurately. Thus the divider is actually divided into six equal divisions of 1000 Ω each. If the Vc output is 6 volts, for example, there will be one-volt drop across each 1000 Ω divisions of resistance.

Switch SW710 has 6 positions to permit switching the shunt divider across two resistors at a time along the string of resistors in the divider. Each position corresponds to one digit of voltage. Variable control R595 in the shunt circuit is the vernier control for dividing the comparison voltage further so the remaining digits of voltage can be measured.

The comparison voltage set by R595 is applied through the + and/or —INPUT switches directly to the corresponding Input Amplifier stages. In contrast, any signals applied to the + or —INPUT connectors must pass through input attenuators before being applied to the Input Amplifiers. SW110 and SW310 of the VOLTS/CM switch are used to select the input attenuation of the signal as follows: 1×, 10×, 100×, and 1000×.

The comparison voltage is also applied directly to the Vc OUT 0-6 V jack. This jack permits connecting any null type, or an "infinite-impedance-type" of voltmeter to this point for the purpose of monitoring the comparison voltage. The output voltage at this jack is very limited in current output; therefore, meters which draw negligible current should be the type used to prevent measurement errors. For further information refer to topic "Vc OUT 0-6 V Jack" in the Operating Instructions section of this manual.

INPUT Switches

The separate + and —INPUT switches control the mode of operation for the Type 10A1. SW101 controls the +input side of the amplifier and SW301 controls the —input side. These switches permit connecting one input or the other, or both, to the Input Amplifier stages. The Vc position of the INPUT switches applies the comparison voltage, instead of the signal, to one or both sides of the amplifier.

NOTE

The two sides of the Type 10A1 differential amplifier are similar. To minimize duplication, the +input side of the amplifier is described in more detail throughout this description.

When the +INPUT switch SW101 is set to AC, the ac component of the input signal is coupled through C102 and then through the input attenuator to the grid of V113; the dc component is blocked by C102. When SW101 is set to DC, both ac and dc components of the signal are fed through the input attenuator; C102 is disconnected.

In the GND position of SW101, the grid of V113 is connected to ground and the signal is disconnected but not grounded. In the Vc position of SW101 the comparison voltage is applied directly to the grid and the signal is automatically disconnected.

Input Attenuators

SW110 and SW310 of the VOLTS/CM switch select the various attenuator sections for both inputs simultaneously. There are four attenuators that can be switched into the input circuits to attenuate the signal to the desired amplitude. These are: ×1, ×10, ×100 and ×1000 (see Attenuators schematic).

The attenuator networks are frequency-compensated rc dividers. At dc and very low frequencies, the dividers are resistive because the impedance of the capacitors is high and their effect in the circuit is negligible. As the frequency of the input signal increases, however, the impedance of the capacitors decreases and their effect in the circuit becomes more pronounced.

When the VOLTS/CM switch is set to 50 mVOLTS, for example, R106E adjusts the dc attenuator ratio so it is exactly 10 to 1. For higher frequencies, C106C is used to frequency-compensate the divider so the capacitive reactance ratio is equal to the resistance ratio. The adjustments in the 10× attenuator of the —input side of the amplifier are adjusted the same as the +input adjustments. When the input attenuator adjustments are accurately set so the + and —input attenuators match each other, optimum common-mode rejection is achieved.

C106A in the 10× attenuator is adjusted so the input rc of the attenuator is 20 pf × 1 meg, using an Input Time-Constant Standardizer as the reference. Each attenuator is "standardized" in this manner. Thus, an attenuator probe, when connected to either input connector and properly adjusted, will work into the same input time constant regardless of the VOLTS/CM switch position.

To prevent trace shift on the screen due to grid current, the GRID CURRENT BAL controls in the grid circuit are adjusted so a small negative voltage will offset the current.

Input Amplifier Stage

A signal from the +INPUT connector is applied to the +Input Amplifier stage. This stage consists of V113, Q114, Q123A, Q134, Q138 and Q143 with associated components. Fig. 3-1 is a simplified schematic of the stage to show the important operating conditions.

This stage provides ×1 gain at low output impedance. It has a linear operating range for signals up to ±6 volts in amplitude. Dc drift is low and is free of thermal effects down to the 0.2-mv level.

Tube V113 functions as the input cathode follower and it has a wide dynamic operating range because constant-current operation and bootstrapping is used. Q134 and Q114 are the constant-current transistors. Q138 and Q143 work together as a bootstrap amplifier for V113. Q143 also supplies a bootstrap signal to a common-mode point in the Differential Amplifier stage. Q123A is the emitter follower for the singal from V113 cathode. Capacitors C118 and C130 prevent noise, originating in the Zeners (D117 and D118), from getting into the signal path. Bootstrapping minimizes V113 changes in characteristics by keeping the plate-to-cathode voltage change as small as possible with large signal swings.

Diode D111 protects V113 against extreme turn-on conditions such as those encountered when plugging the Type 10A1 in a turned-on oscilloscope. During turn on, the diode conducts and limits the grid-to-cathode bias voltage to about +0.6 volt until V113 starts conducting normally.

The COARSE adjustment R275 adjusts the heater voltages of the input cathode follower tubes V113 and V313. This control is adjusted to balance the bias on the tubes. Thus, tubes that vary considerably in characteristics can be made to operate at about the same bias. The +BAL adjustment R130 is adjusted so the Q123A collector-to-emitter voltage is equal to the voltage across the collector load thermal-balance resistor R123 under no signal conditions.

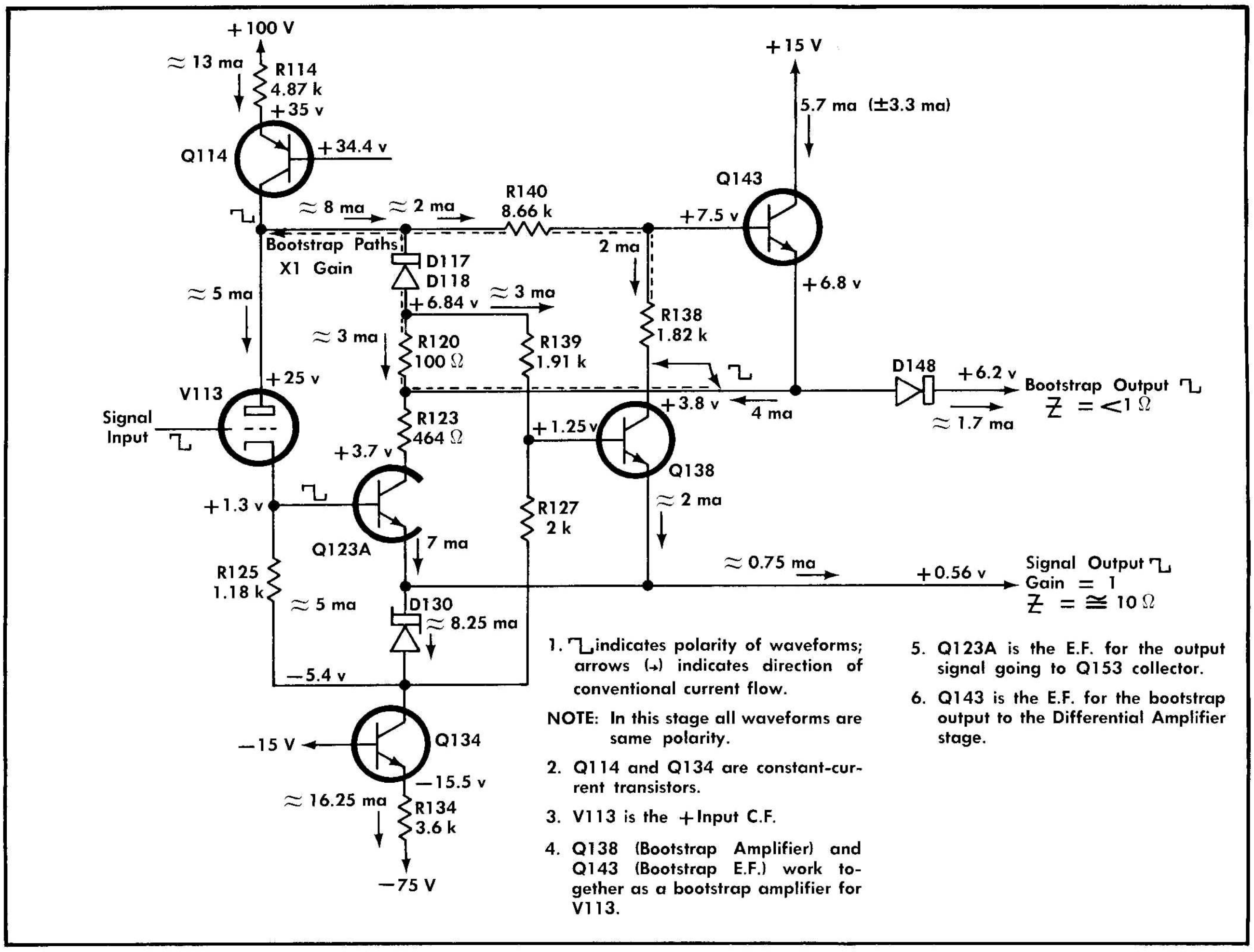


Fig. 3-1. Simplified +Input Amplifier stage.

High-frequency common-mode adjustments are provided in the +Input Amplifier stage. These are: C111, C115 and C125. C111 is adjusted to make the high frequency drive to the grid of V113 equal to the drive to V313 grid. C115 loads the plate of V113 to balance up the bootstrapping and C125 sets the high-frequency loading on V113 cathode so the voltage equals the voltage at the cathode of V313.

Signal Disconnect Switch Stage

The signal from the emitter of Q123A is applied to the collector of Q153 in the Signal Disconnect Switch stage. The active components that make up this stage are Q153, Q353, D155 and D156 (see Fig. 3-2). The main purpose of this stage is to limit overload signal amplitude so the following stage is not overdriven.

Under normal signal conditions, Q153 and Q353 are in saturation. Diodes D155 and D156 are zero biased. Thus, a signal applied to the +input side (collector of Q153) passes through Q153 and appears at the emitter of Q153. There is no signal attenuation because gain is ×1 for signals up to ±0.6 volt in amplitude. However, if a positive going overdrive signal is applied, D156 conducts and Q353 disconnects the —Input Amplifier. The result is that both sides of the amplifier are connected to the +input side through D156 and Q353 emitter-base junction.

Differential Amplifier Stage

The Differential Amplifier stage consists of Q158, Q164, Q174, Q184, Q374 and Q384 with associated components and circuitry. Fig. 3-3 is a simplified diagram of the stage. Q158 operates as a constant-current transistor, Q164A and B with associated components is the differential amplifier and the remaining transistors form a common-base stage.

The stage provides ×2.5 voltage gain per side for single and differential signals but virtually no gain for common-mode signals. It remains linear for signal amplitudes of 1.2 volts or less and is able to handle common-mode signals up to 12 volts.

Variable capacitor C365 is a common-mode adjustment which balances the stray capacitance so Q184 and Q384

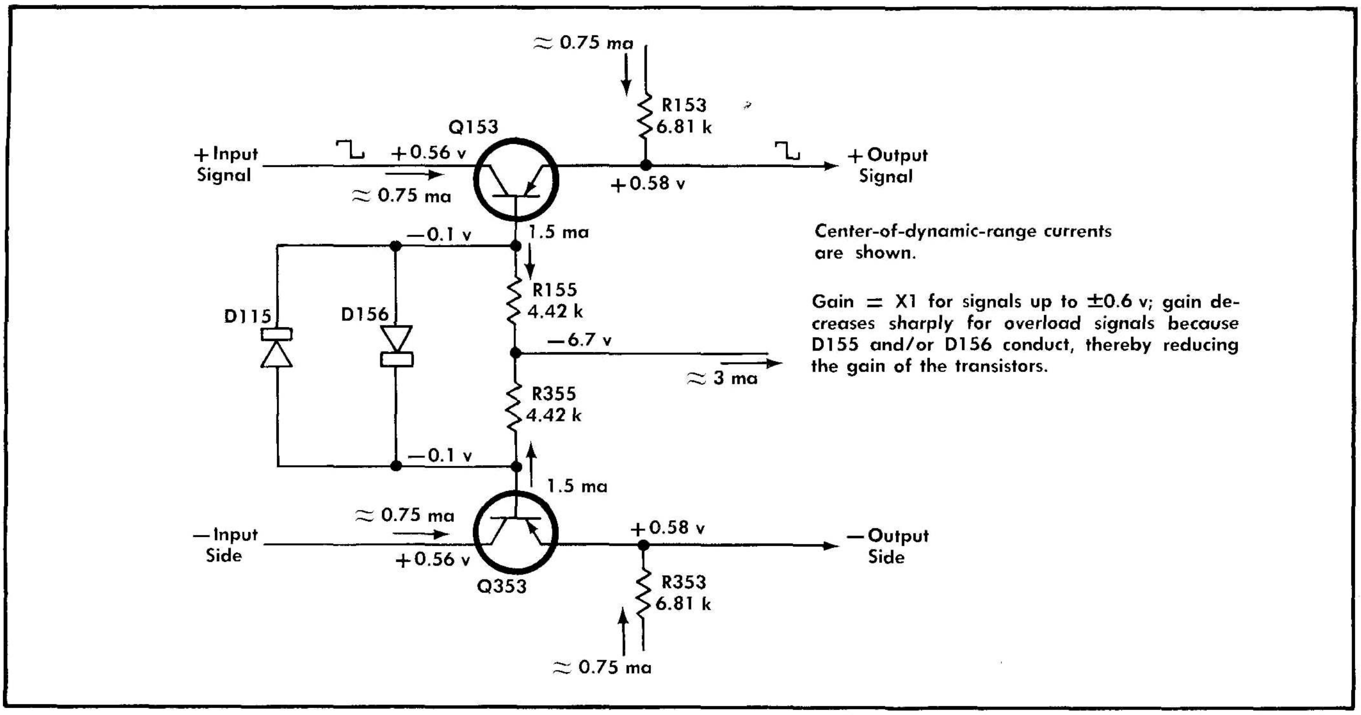


Fig. 3-2. Schematic diagram of Signal Disconnect Switch stage.

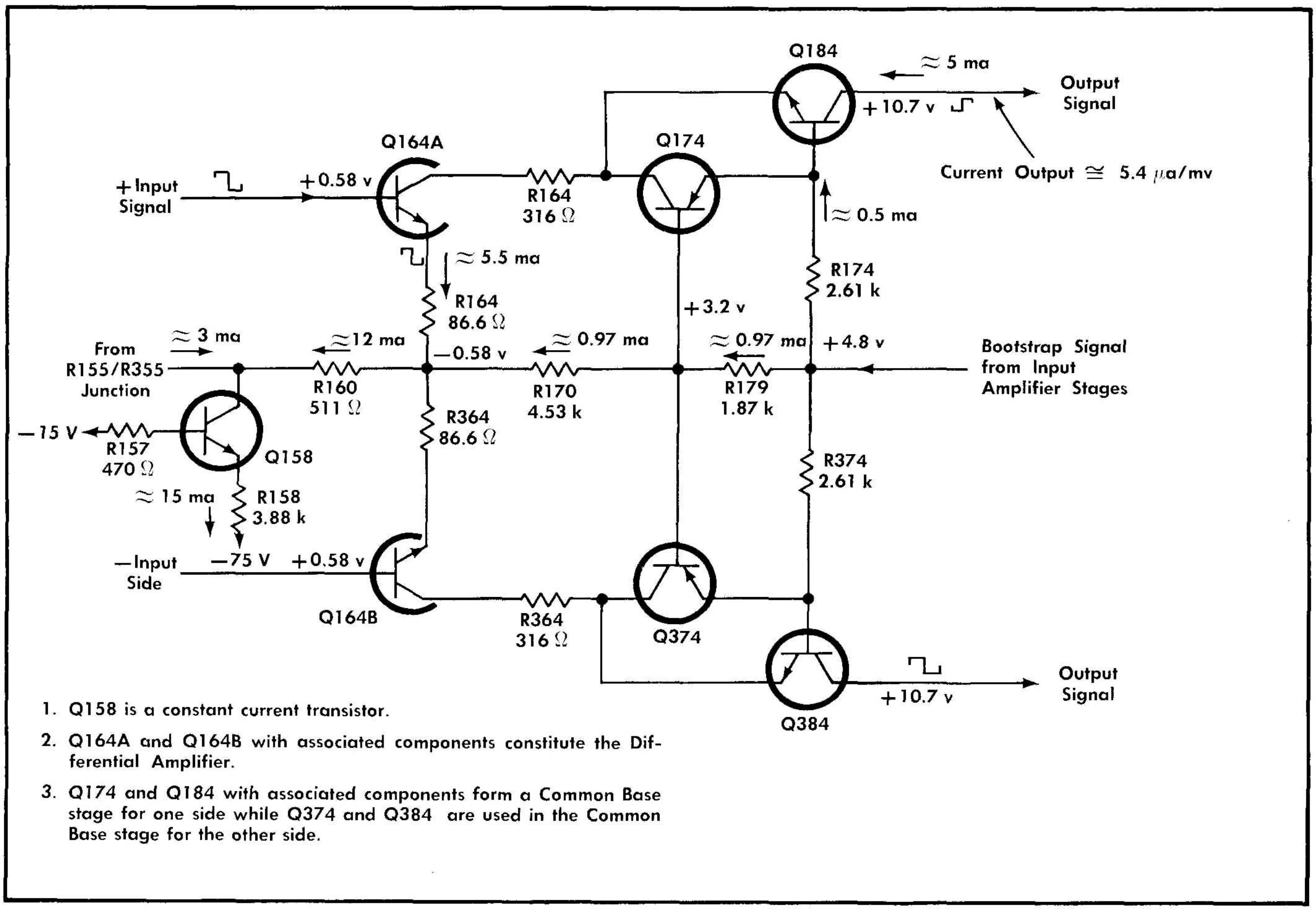


Fig. 3-3. Simplified Differential Amplifier stage.

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high-frequency currents are equal. The COMMON-MODE BAL control R183 is adjusted to provide proper voltage to Q164 for thermal balance.

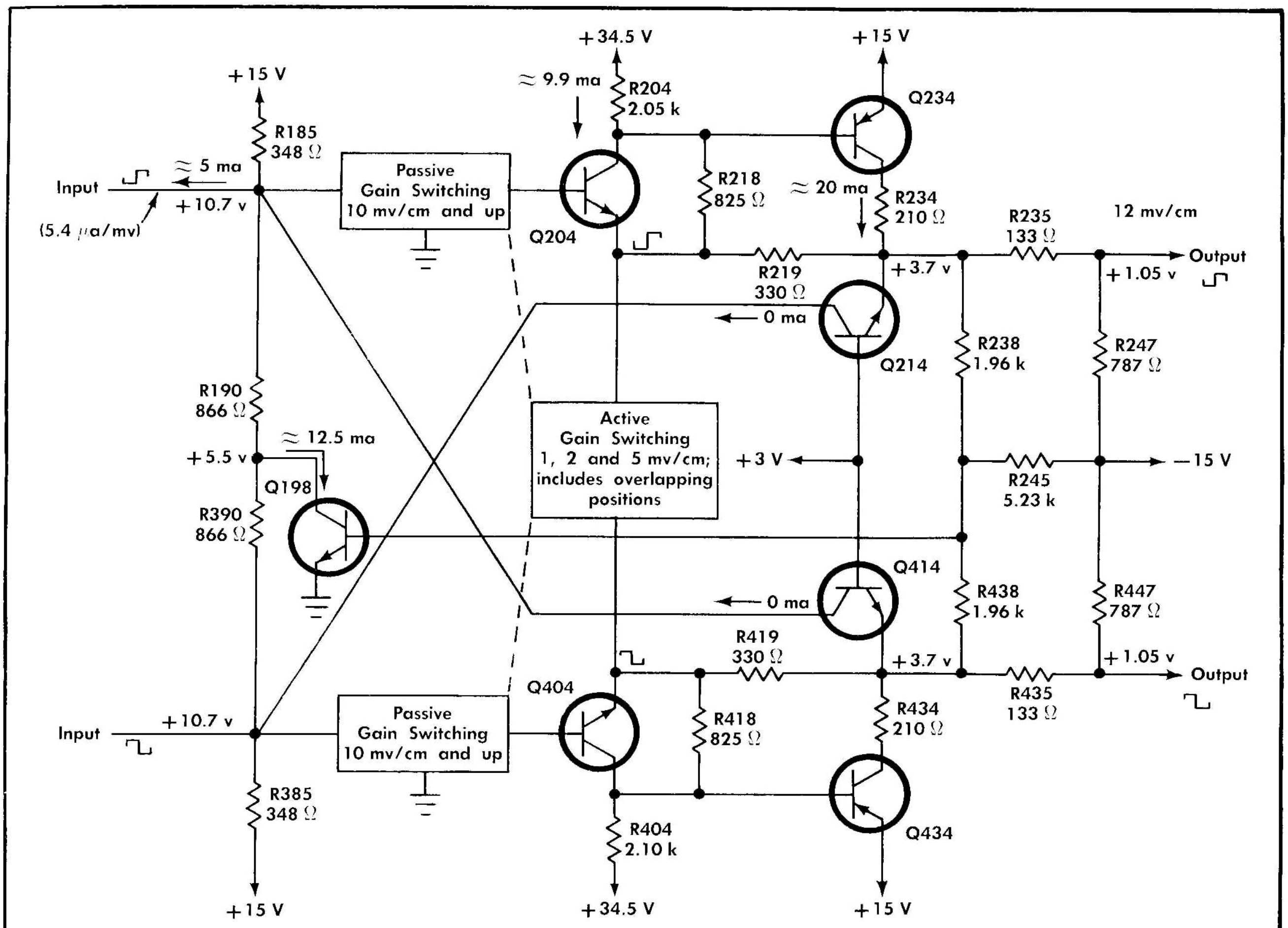
Gain Switching Stage

As shown in Fig. 3-4, the Gain Switching stage consists of seven transistors: Q198, Q204, Q404, Q214, Q414, Q234 and Q434. The function of each trasistor is briefly described in the illustration.

Passive gain switching by means of rc-type dividers is one method used for changing the gain of the stage. Switching of the dividers is accomplished by wafers 2 and 3 of the VOLTS/CM switch SW701 (see Switch Details schematic). Resistors R713B and R715 are the shunt values, R703 and R720 are the series values of resistance. They provide 1×, 2× and 4× attenuation.

Active gain switching is the other method used for controlling gain. Active gain switching takes place in the emitter circuit of Q204 and Q404 by means of wafers 4 and 5 of the VOLTS/CM switch. Attenuation is 1×, 2× and 5× for the 1, 2 and 5 mv/cm positions respectively. For the overlapping ranges, wafers 4 and 5 are actuated to provide the 2× and 1× attenuation. For 5× attenuation the circuit between 4F and 5R is open to provide maximum emitter-to-emitter resistance for signal degeneration; 2× attenuation takes place when R735B is added as shunt resistance; 1× attenuation takes place when a wire strap is connected between 4F and 5R. The combination of the two attenuation methods provides 20 to 1 gain switching ratio.

The Gain Switching stage must be able to handle 6.5 ma



1. Q198 feeds back common-mode signals; aids action of Q214 and Q414.
2. Q214 and Q414 are an overload Limiter stage using cross-coupled feedback. For normal signals Q214 and Q414 do not conduct.
3. Q204 and Q234 with associated circuitry constitute a two-stage feedback amplifier for one side while Q404 and Q434 are used in the amplifier for the other side.

Fig. 3-4. Simplified Gain Switching stage.

of signal swing. Q214 and Q414 act as signal limiters for overdrive signals. For proper phase feedback, cross coupling is used. Only one side conducts at any one time. Q198 provides common-mode negative feedback which cancels the common-mode signal caused by Q214 or Q414 conducting.

The STEP ATTEN BAL control R389 is a coarse-fine type of dual control. One section (with wiper arm connected to R387) provides coarse adjustment and the other (with wiper arm connected to R392) is a vernier control having a 60° range before the coarse adjustment is actuated. Under no-signal conditions, the control is adjusted to minimize trace shift as the VOLTS/CM switch is changed from 20 mVOLTS/CM to 5 mVOLTS/CM position. An INT DC BAL control R200 is provided to minimize trace shift as the VOLTS/CM switch is changed from the 5 mVOLTS/CM to 1 mVOLTS/CM position. Once both controls are adjusted as described, the STEP ATTEN BAL control is used to maintain overall dc balance during normal operation of the unit.

The VAR ATTEN BAL R215 is adjusted so the voltage drop across the VARIABLE R252 control is zero under no-signal conditions. Adjustment C213 is a high-frequency peaking control and R213 provides damping. The PULL FOR 1 MC BW switch SW255, when pulled outward, connects C253 in shunt with the output of the Gain Switching Stage to limit bandwidth. At the same time one end of R255 is connected to ground to complete the path for igniting neon B255.

Output Amplifier

The Output Amplifier consists of two stages: a Driver stage Q504 and Q604, and an Output-Feedback stage. Four transistors are used in the Output-Feedback stage: Q524 and Q534 on one side, Q624 and Q634 on the other side.

At the bases of Q504 and Q604 the signal input is 12 mv/cm per side and the output is 280 μa/cm per side. The Driver stage is an emitter-degeneration type with a GAIN R513 adjustment in its emitter circuit. Purpose of the stage is to provide current drive for the stage that follows. Current gain is about 2.7.

The I_b BAL R601 control is adjusted to zero the base current of Q504 to keep the base current from flowing through the VARIABLE control.

The Output-Feedback stage Q524-Q534-Q624-Q634 is current input type and it has a 93-ohm output for reverse termination of the vertical amplifier delay line. Current input is 280 μa/cm and the output is 75 mv/cm per side at pins 5 and 7 of the interconnecting plug. The POSITION control R521 in the input circuit has a range of about $\pm$10 cm. Feedback for the stage is from the emitter of Q534 through R538 to the base of Q524 for one side and through R638 for the other side.

Variable adjustments C540 and R540 are peaking and damping adjustments.

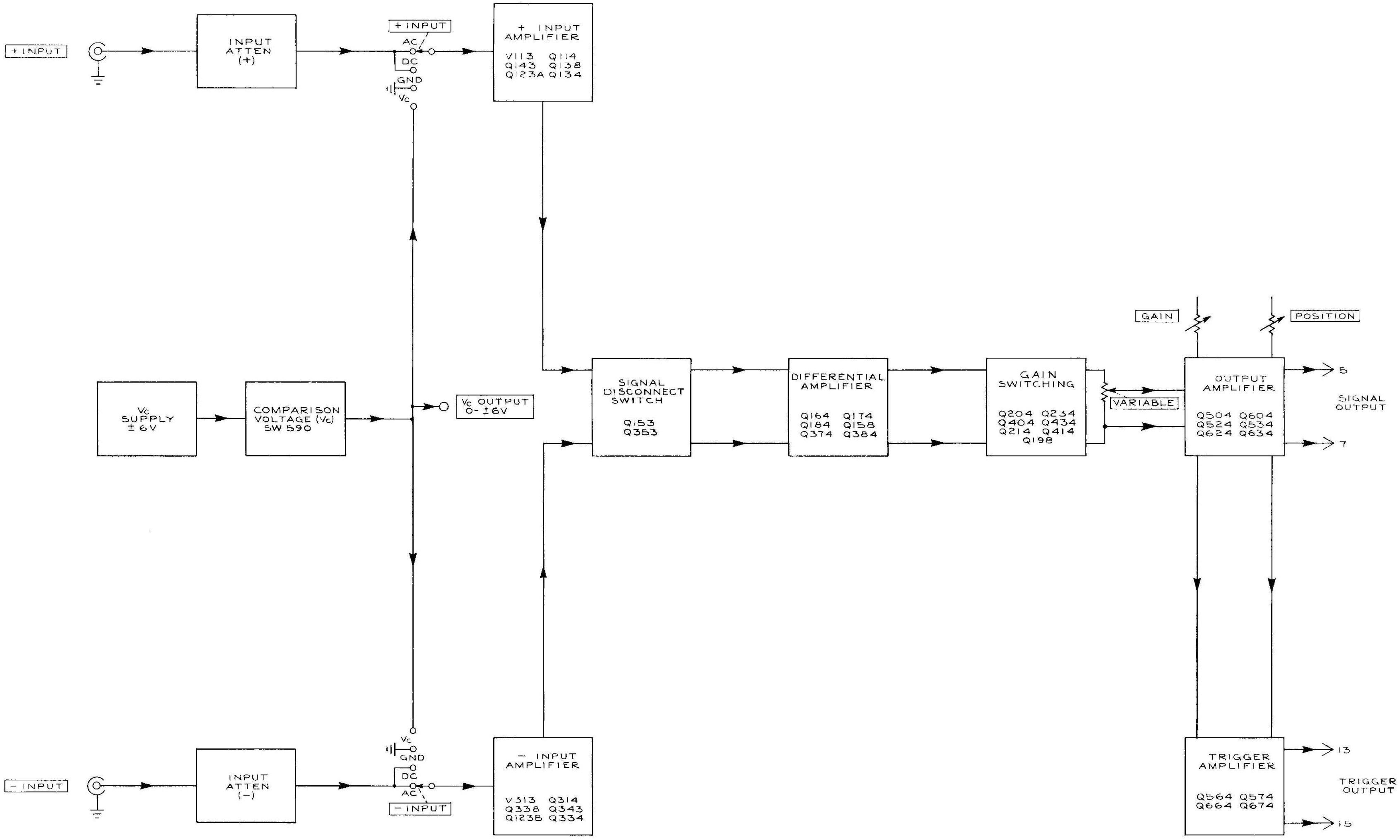
Output signal polarity at pin 5 is the same polarity as the polarity of the signal applied to the +INPUT connector. At pin 7 the signal polarity is opposite to that of pin 5 and the +INPUT connector.

Trigger Amplifier

Push-pull signals are taken from the emitter circuit of Q534 and Q634 for application to the Trigger Amplifier stage. Four transistors are used in the stage: Q564 and Q574 in one side, Q664 and Q674 in the other side.

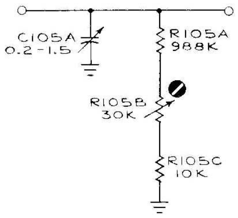
Input voltage swing is 28 mv/cm per side. Output swing is 100 mv/cm into a 100-ohm load. Current gain is approximately 20. Output dc level is zero volts (within $\pm$0.2 v) when the difference voltage between the collectors of Q574 and Q674 is zero.

Output signal polarity at pin 13 is the same as the polarity of the signal applied to the +INPUT connector. At pin 15 the signal polarity is opposite to that at pin 13 and the +INPUT connector.

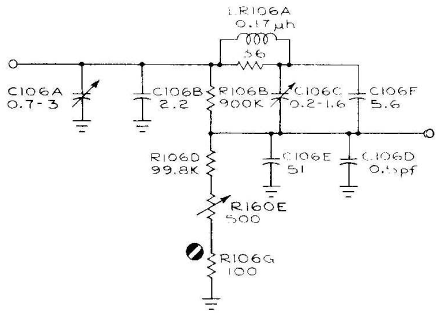


BLOCK DIAGRAM

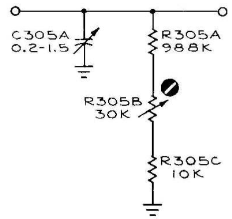
1 X



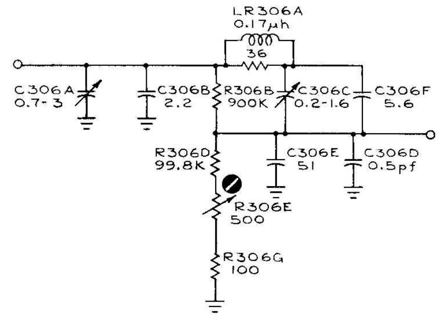
10 X



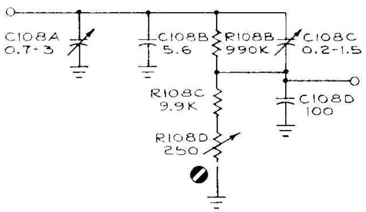
1 X



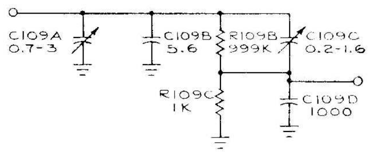
10 X



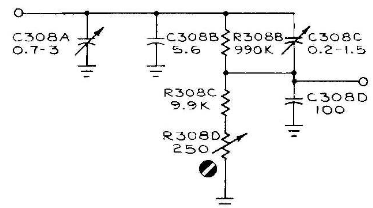
100 X



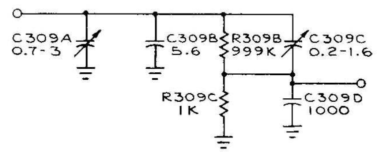
1000 X



100 X



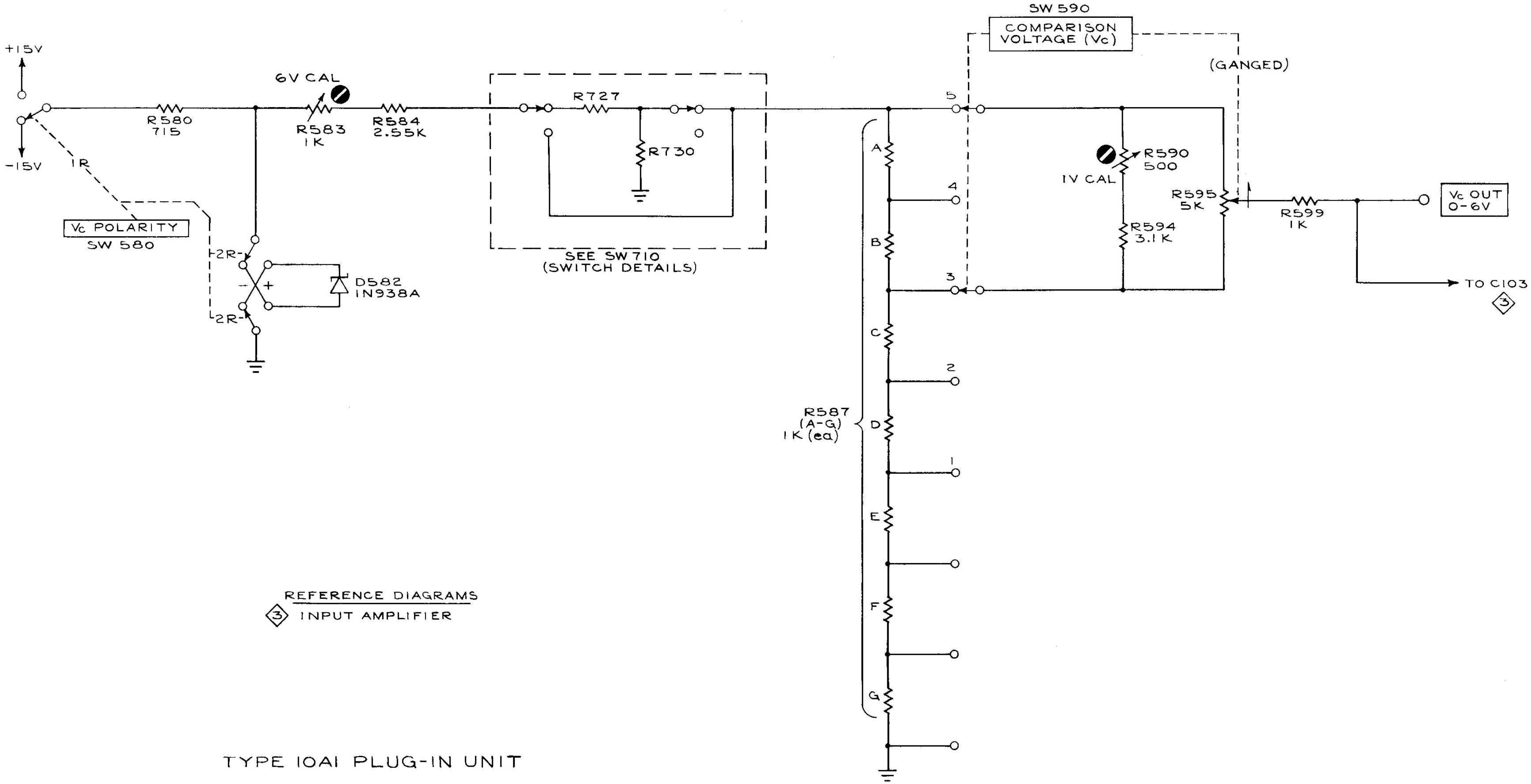
1000 X



+ INPUT

— INPUT

ATTENUATORS ①
PLM
165

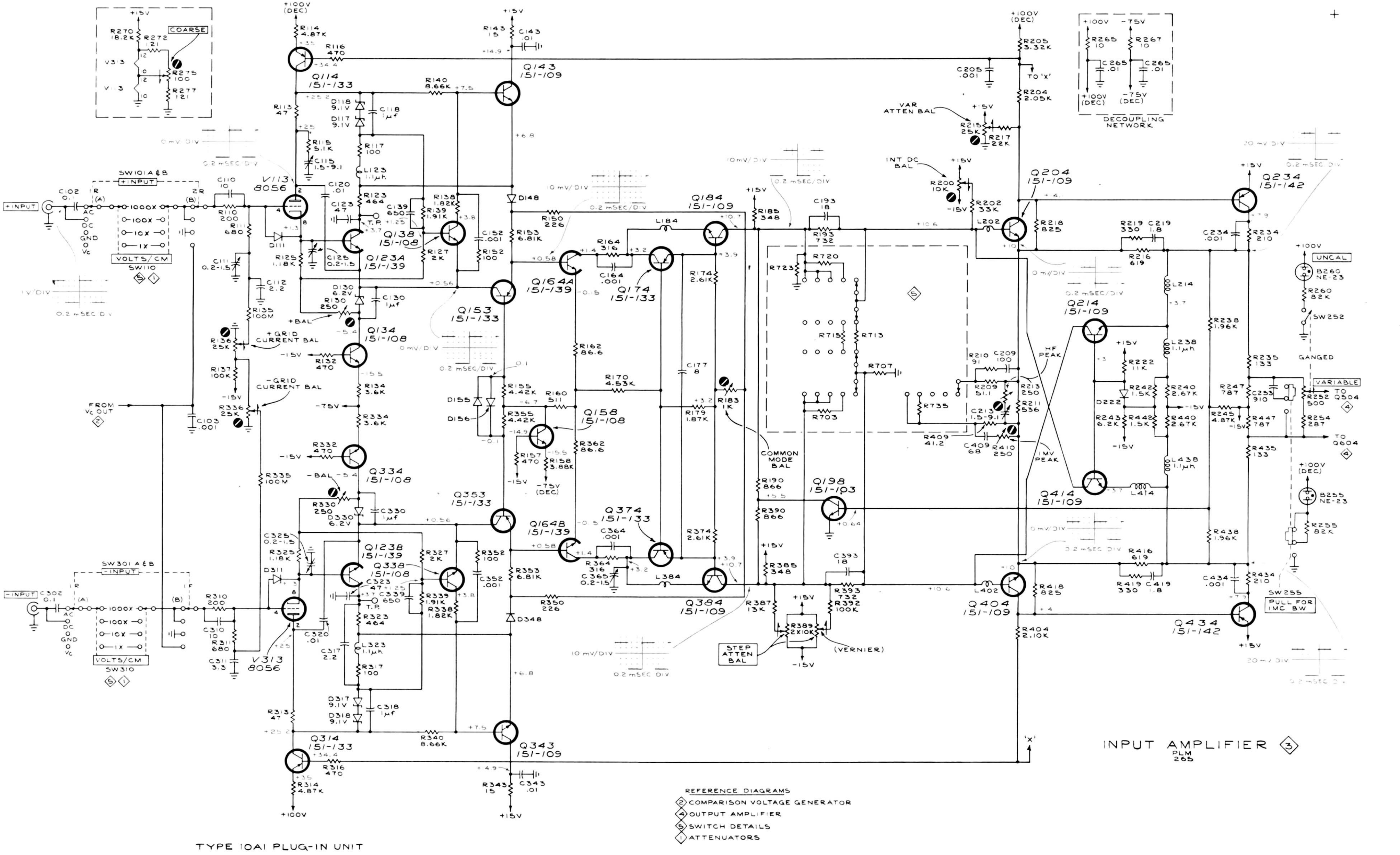


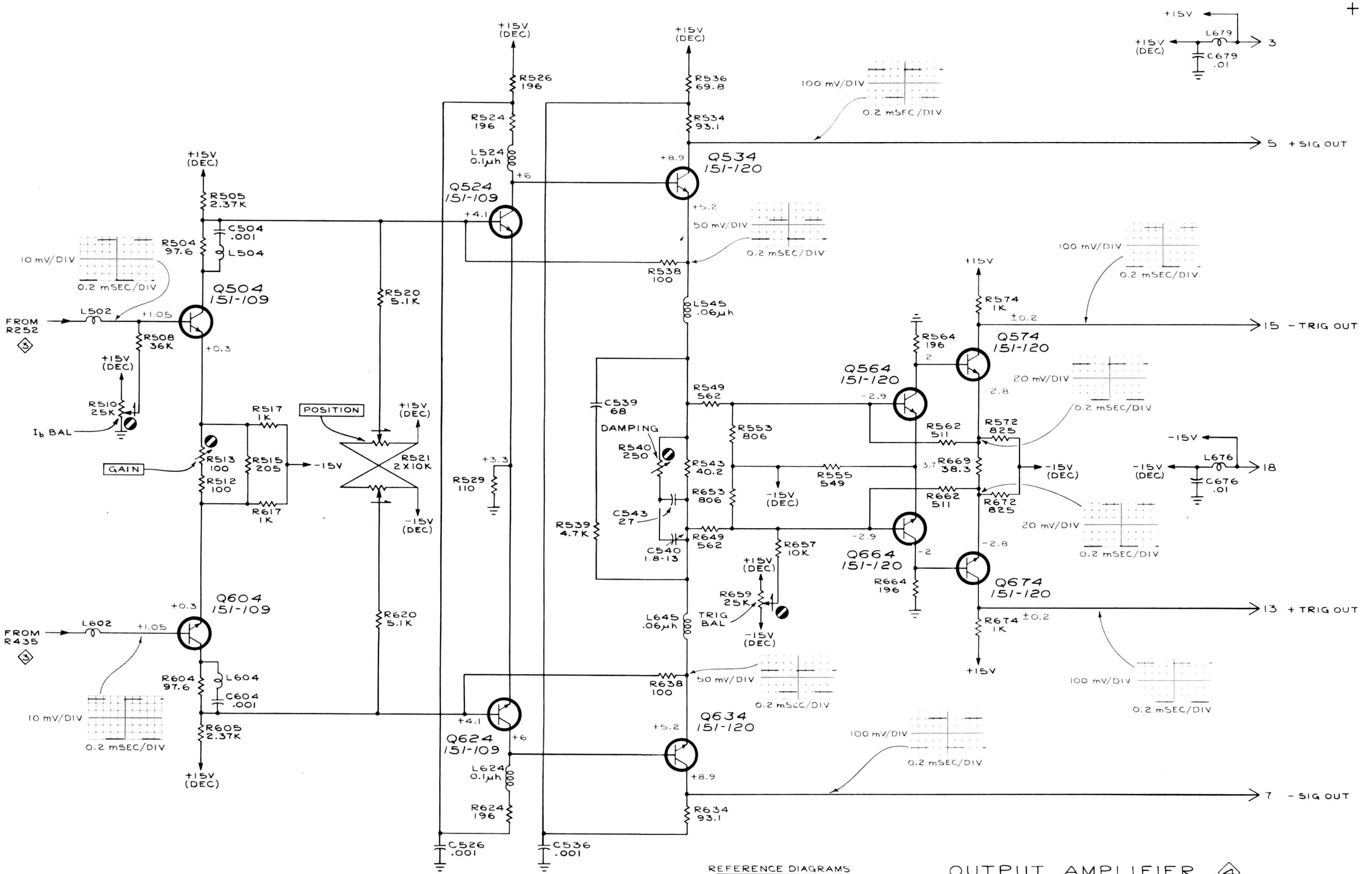
REFERENCE DIAGRAMS
3 INPUT AMPLIFIER

TYPE 10A1 PLUG-IN UNIT

COMPARISON VOLTAGE GENERATOR 2

PLM
165


INPUT AMPLIFIER 3
PLM 265
REFERENCE DIAGRAMS
2 COMPARISON VOLTAGE GENERATOR
4 OUTPUT AMPLIFIER
5 SWITCH DETAILS
1 ATTENUATORS
TYPE 10A1 PLUG-IN UNIT

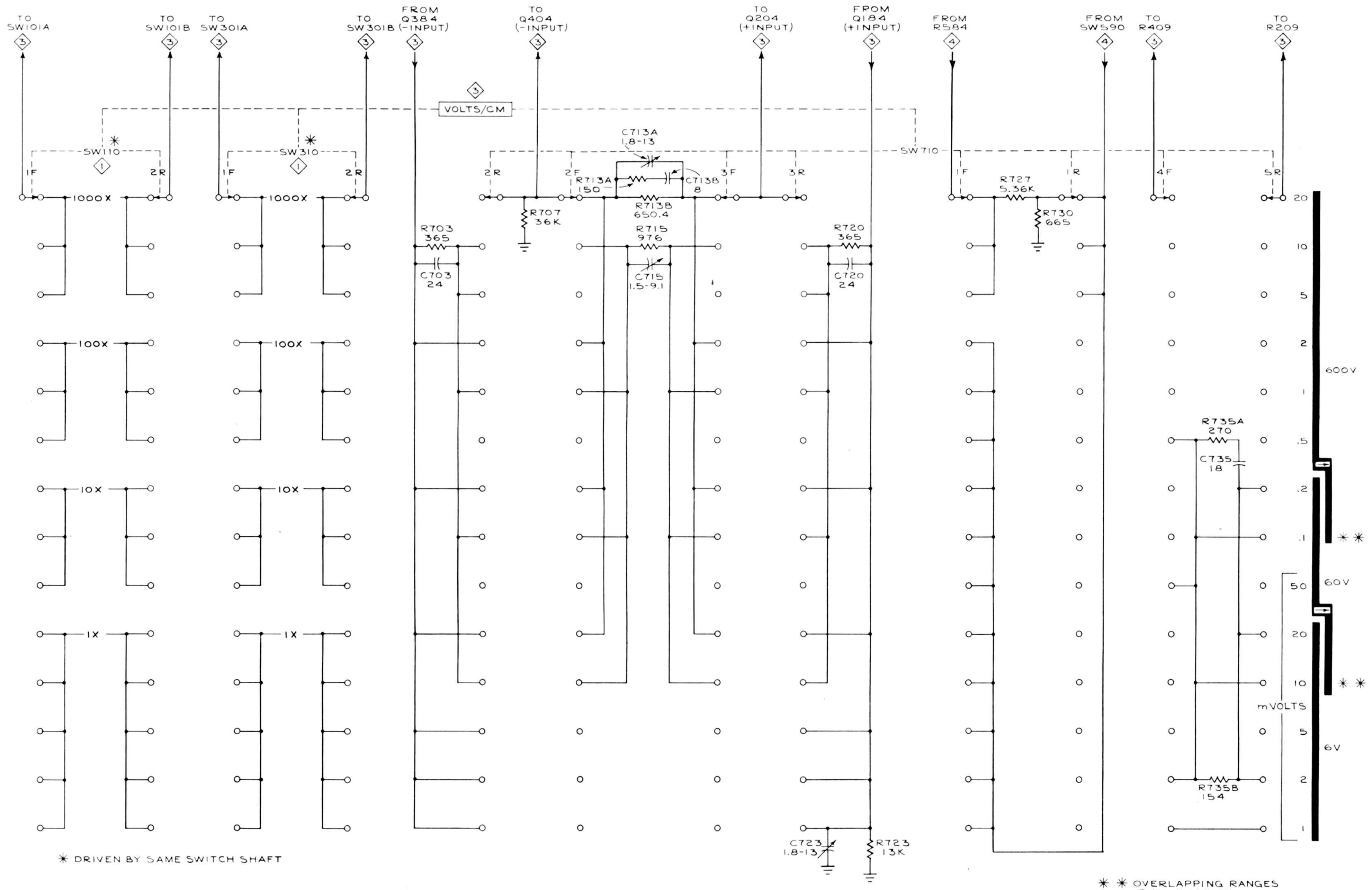


TYPE 10A1 PLUG-IN UNIT

REFERENCE DIAGRAMS
③ INPUT AMPLIFIER

OUTPUT AMPLIFIER ④

PLM
165



✳ DRIVEN BY SAME SWITCH SHAFT

TYPE 10A1 PLUG-IN UNIT

REFERENCE DIAGRAMS
1. ATTENUATORS
3. INPUT AMPLIFIER
4. OUTPUT AMPLIFIER

SWITCH DETAILS
PLM
165

✳✳ OVERLAPPING RANGES
PULL KNOB AT
→ TO RETAIN
V_c RANGE