EG&G

INSTRUCTION MANUAL

NUMBER B-3658

T140/N (T140) QUAD ZERO-CROSSING DISCRIMINATOR MODULE

Approved for Publication

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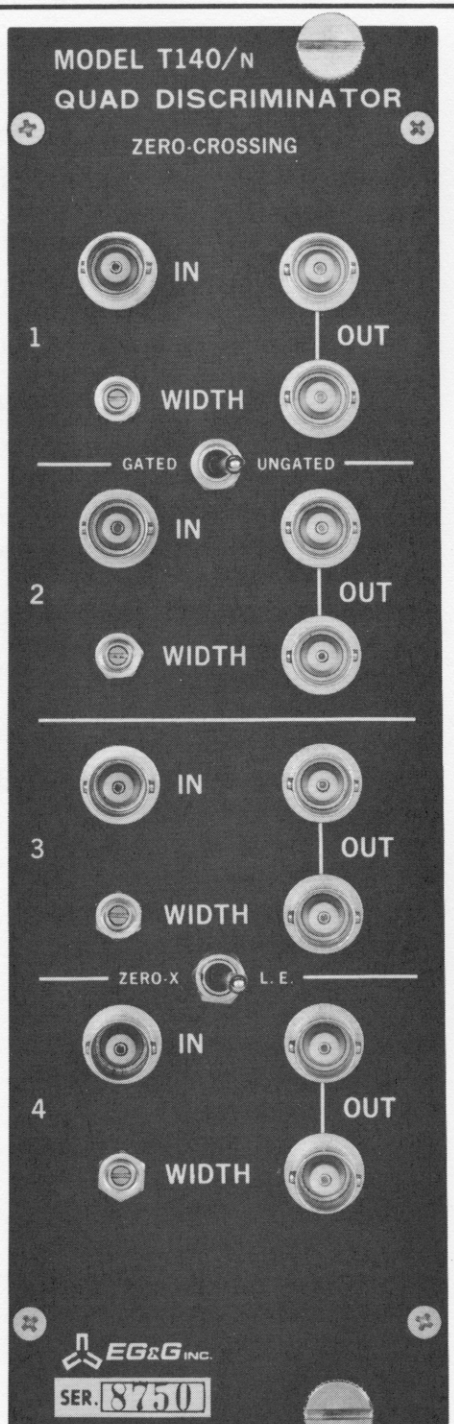

Fig. 1. Front View of T140/N QUAD ZERO-CROSSING DISCRIMINATOR MODULE.

EG&G/ORTEC T140/N QUAD
ZERO-CROSSING DISCRIMINATOR

Manual Change Sheet

Rev 01
July 11, 1974

On Page 9, in Section 3, in the eleventh line up from the bottom of the page, change "3 mA." to read "2.4 mA." instead.

On Page 21, in Table 2, change the indicated value of R31 from "4.02 K, 1%" to "5.11 K, 1%".

On Page 22, in Figure 9, change the indicated value of R31 from "4.02K 1%" to "5.11K 1%". Note the fact that this change affects R131, R231, and R331, as well as R31.

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LIST OF ILLUSTRATIONS

1.1 GENERAL

The T140/N QUAD ZERO-CROSSING DISCRIMINATOR Module (Fig. 1) is designed for low cost per channel in applications where many discriminators are required. Each T140/N Module contains four independent discriminators.

The unit may be operated in the zero-crossing mode, to provide excellent timing at high repetition rates with relative independence from input signal amplitude variations and noise. The T140/N combines both amplitude discrimination, for noise independence, with zero-crossing discrimination to minimize dispersion due to amplitude and risetime variations of photomultiplier signals.

The T140/N may also be operated as a conventional leading-edge integral discriminator for positive signals. Gating in either mode is provided via the system gating line, to allow many T140/N modules to be simultaneously inhibited or enabled.

1.2 SPECIFICATIONS

INPUT: Protected limiting input for photomultiplier signals. 50 ohm input impedance, with less than 10% reflections from -10 V, 1 nsec risetime signals. Maximum non-destructive input limits: ±5 V dc; ±10 V, 100 nsec pulses of duty-factor less than 10%; ±100 V fast transients. Overload recovery typically 2 nsec from -5 V input.

THRESHOLD: Typically -200 mV (-250 mV maximum) in zero-crossing mode; typically +250 mV in leading-edge mode.

OUTPUT:	"Dual" NIM-standard fast logic signal* output, for fanout factor of two. T_{01} and T_{10} less than 2 nsec. Width adjustable by recessed front-panel multiturn control from less than 5 nsec to greater than 10 nsec.
DELAY:	Typically 8 nsec, from input zero-crossing to half-amplitude output.
MAXIMUM RATE:	Typically ±150 psec from threshold crossing detector maintains timing to typically 250 MHz.
SLEWING:	Typically ±150 nsec from threshold to 10X threshold in zero-crossing mode; typically less than 1 nsec from threshold to 10X threshold in leading-edge mode.
GATING:	Switch-selected NIM-standard slow logic signal gating via system gating line at power connector. -2 V to +1.5 V or low impedance to ground inhibits unit; +3 V to +12 V or high impedance to ground enables unit. Gate input impedance greater than 2.5 K. Gate response time less than 50 nsec for +5 V gating signal.
TEMPERATURE RANGE:	-15°C to +60°C.

*ZERO = 0 ± 50 mV; ONE = -800 ± 100 mV; T_{01} denotes -100 mV to -600 mV transition; T_{10} denotes -600 mV to -100 mV transition.

POWER REQUIREMENT:	+24 V, 210 mA.
	+12 V, 220 mA.
	-12 V, 190 mA.
	-24 V, 195 mA.
PANEL COLOR:	Black.

2.1 ZERO-CROSSING OPERATION

In the zero-crossing mode (the "ZERO-X" position of the front-panel switch) the T140/N accepts clipped photomultiplier anode signals. A typical clipped anode signal is illustrated in Fig. 2. The discrimination level is fixed in each section at typically -200 mV, and the discrimination level may vary from section to section over the range -150 mV to -250 mV. When the negative portion of the output signal exceeds the discrimination level, the zero-crossing detector is armed. When the subsequent zero-crossing occurs, the circuit produces a timing signal. This timing signal initiates an output signal whose width is adjusted by the WIDTH control on the front panel.

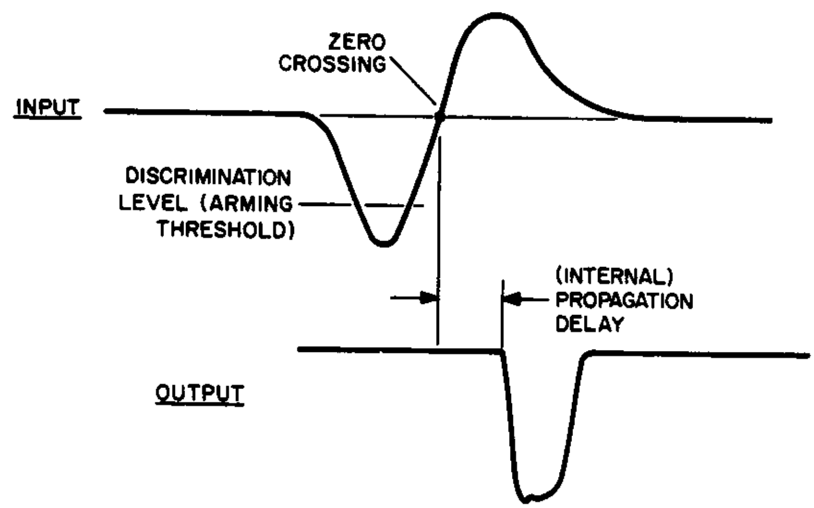

Fig. 2. Zero-crossing discrimination upon clipped anode signal.

It is required, of course, that the photomultiplier anode signal be clipped with an appropriate shorted coaxial stub. It is conventional to use a stub whose length is somewhat less than 1/2 the minimum risetime from the photomultiplier, so that the zero-crossing point is determined by twice the transit time of the cable and not by the decay, overshoot or ringing of the photomultiplier signal. Conventional 50-ohm cable such as

RG58A/U has a delay of 5.06 nsec per meter. If the photomultiplier has a minimum risetime of 3 nsec, a suitable clipping time might, for example, be 2 nsec. This would be accomplished with a shorted stub 20 centimeters in length.

The zero-crossing level of each section is adjusted by a potentiometer on the top rear edge of the chassis. As supplied, the T140/N is adjusted for zero-crossing within approximately ±20 mV. The zero-crossing point may be changed by the user if desired. The zero-crossing point will, of course, be somewhat influenced by the characteristics of the photomultiplier signal, due to the finite bandwidth of the T140/N input limiting amplifier and zero-crossing detector.

2.2 LEADING-EDGE DISCRIMINATION

The T140/N may also be used as a conventional integral discriminator, as indicated by the "LE" position of the front-panel switch. In this mode, the discriminator is intended to be driven from a (positive) photomultiplier dynode signal or from an inverted (negative) anode signal. The EG&G IT100 INVERTING TRANSFORMER may be useful for inverting anode signals.

As indicated in Fig. 3, the discriminator has a fixed threshold at approximately +250 mV, which may vary between sections from approximately +175 mV to +350 mV. When the input signal exceeds the threshold, the circuit produces a timing signal which generates output signals. Width is adjusted by the WIDTH control on the front panel. The circuit will provide an output signal each time the input crosses the threshold level, up to a rate of approximately 100 MHz.

If it is desired to change the LE threshold, the zero-crossing calibration control may be readjusted. Note, however, that if the setting of this calibration control is disturbed, the T140/N zero-crossing detection will not occur at zero.

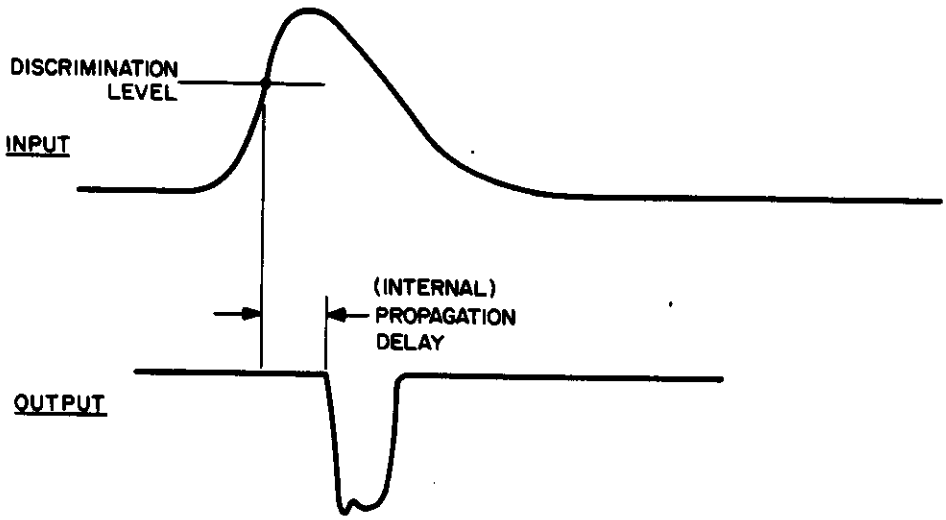

Fig. 3. Leading-edge discrimination upon dynode signal.

2.3 OTHER FEATURES

Each section of the T140/N is provided with a "dual" output which provides a fanout of two NIM-standard logic signals. Fig. 4 illustrates some of the ways the dual output may be used.

Output width is preset by the front-panel control. The width is stable and quite low in jitter; however, for extremely precise coincidence operation near maximum width, the output signal may be clipped with a shorted stub, with the width control set somewhat greater than the clipped output width. This will produce a signal whose width is virtually invariant, as determined by the length of the cable.

NIM-standard slow logic signal gating is available at pin 36 of the module power connector, which is bussed throughout the manifold and is accessible via the GATE BNC connector on the rear of the manifold. A signal level from -2 V to +1.5 V (or a low impedance to ground) will inhibit the T140/N. A signal level from +3 V to +12 V or more (or a high impedance to ground) will enable the T140/N.

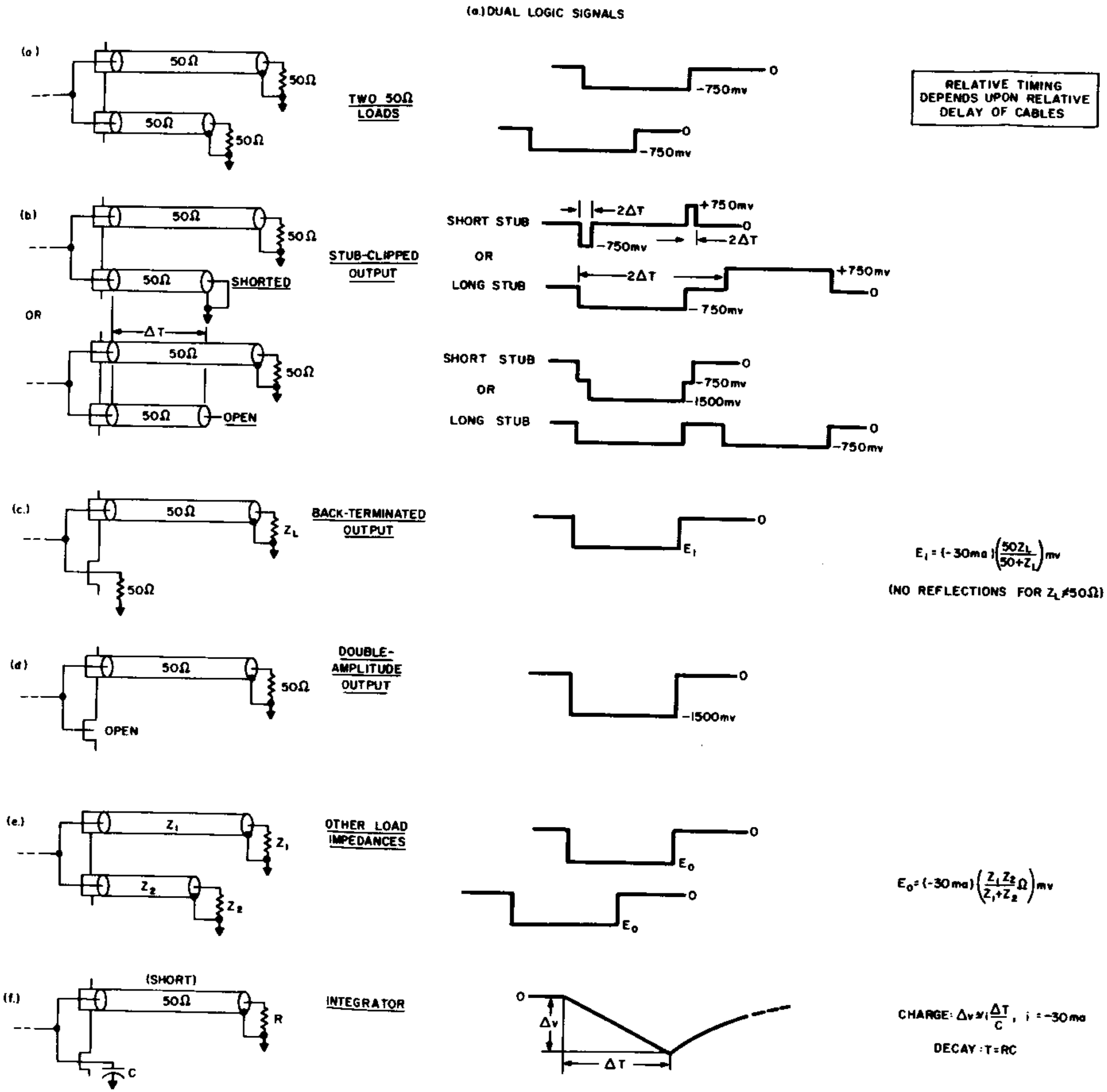

Fig.4. Use of dual outputs.

The circuit description refers to Fig. 9, the T140/N schematic diagram. The four sections of the module are identical and only circuit 1 will be described.

Input signals at J1 are terminated by R7 in series with the low input impedance of Q3 and, for large negative signals, the low impedance of D4. The base of Q3 is biased by D5 and R9 so that the emitter voltage of Q3 is zero. The base of Q4 is appropriately biased by D7 and R13. Signals from the collector of Q3 are conducted by Q4 or D6.

Q3 and Q4 are serial, opposite-polarity common-base stages and they provide a current gain of approximately 1 for signals within their linear range. Large negative signals turn Q3 off, and Q3 is protected by D4. Large positive signals turn Q4 off, and Q4 is protected by D6. The design of the limiter is such that its recovery is quite fast.

Tunnel diode D8 is the zero-crossing detector. It is biased by R16, R18, and R19 and by the quiescent current in Q4. R17 places a low impedance load line across D5 and this load line is shown graphically in Fig. 5. D5 is normally in its high-voltage state near the valley point

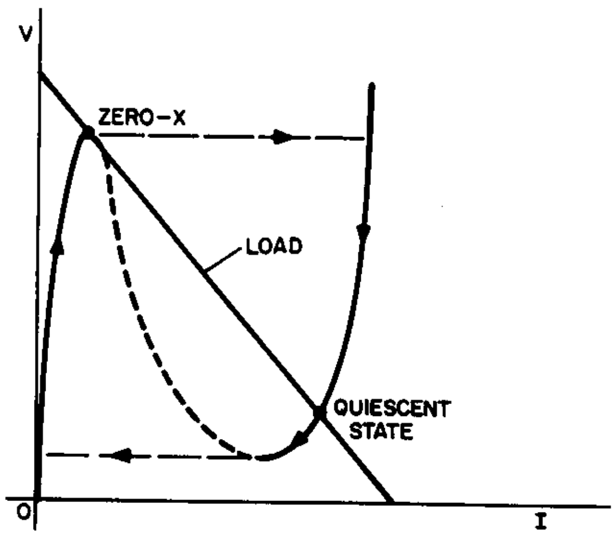

Fig. 5. Zero-crossing discrimination by D8.

and it is switched to its low voltage state by a negative input signal which is larger than approximately 4 mA, as determined by R17, the valley-point current of D8, and by the bias. When D8 is in its low voltage state, it is biased so that zero signal corresponds exactly to the peak current point of D8 with R17. At the zero-crossing D8 is switched through its peak point to its high-voltage state. At that point the signal across D8 is a positive step of approximately 400 mV.

Current-switching pair Q5-Q6 switches the emitter current determined by R21. The base of Q6 is normally biased slightly positive so that Q6 is on and Q5 is slightly on. C10 provides emitter degeneration, so that for positive fast signals Q5 is the common-emitter mode.

The zero-crossing step signal is differentiated by C9 and R20. This positive differential is amplified by Q5. The resulting negative trigger signal at the collector of Q5 is capacitively coupled with short time constant into the emitter of slightly-on common-base stage Q7. Q7 drives tunnel diode D10, and minimizes the modulation of D10 by blocking positive differentiated output signals from Q5 due to the arming of D8.

D10 is a 5 mA peak-current tunnel diode, and it is biased at approximately 3 mA. The amplified zero-crossing signal from D8 is sufficient to switch D10 from its (normally) low-voltage state to its high-voltage state. The resulting negative signal at the base of Q8 turns Q8 on.

Q9 and Q10 comprise a current-switching pair, which switches the emitter current determined by R37. Q9 is normally on, and Q10 is normally off. The turn-on of Q8 turns Q10 on to generate output signals at J2 and J3.

Q9, normally on, conducts approximately 30 mA. R32, R33, and R43 provide approximately 6 to 23 mA. Thus, there is normally a negative current in D1. When Q10 turns on, Q9 must turn off. The resulting positive current charges the parallel combination of C14 and C15 positively until D11 turns on. When D11 turns on, the positive current is applied to D10 to switch D10 from its high-voltage state back to its low-voltage state. The width is thus determined by the adjustable charging current into capacitors C14-C15.

When D10 is switched to its low voltage state, Q8 turns off, Q10 turns off, and the output signals end. Q9 turns on, and this discharges C14 and C15 until D1 comes into conduction, at which time the capacitors are recharged.

Gating of the unit is accomplished by current-switching pair Q1-Q2. Normally, the base of Q2 is biased with approximately 1 mA forward-bias in D1. The base of Q1 is more positive than the base of Q2; Q1 is off, and Q2 is on. If the GATED mode is chosen by S1 and the gating line (P1-36) sees a low impedance to ground or a voltage near zero, the current in R1 is sufficient to overcome the bias from R2, causing D2 to conduct. Q1 is then on, and Q2 is off.

The current from Q1 is divided among the four sections by, for example, R27. This current from Q1 causes the base of Q6 to be sufficiently positive so that the differentiated zero-crossing signal from D8 can never turn Q5 on. Therefore, outputs cannot be triggered.

The change from the zero-crossing mode to the leading edge mode is accomplished in all four sections by S2. When S2 is switched to the leading-edge mode, approximately -6 mA bias is introduced at the zero-crossing discriminator D8. As shown in Fig. 6, this has the effect of forcing D8 to be normally in its low-voltage state. A sufficiently positive signal will switch D8 to its high-voltage state, producing a positive step. The output signal generation is exactly the same as in the zero-crossing mode. Note that when the input signal ends, D8 switches back to its low-voltage state, and it is then ready to be triggered again.

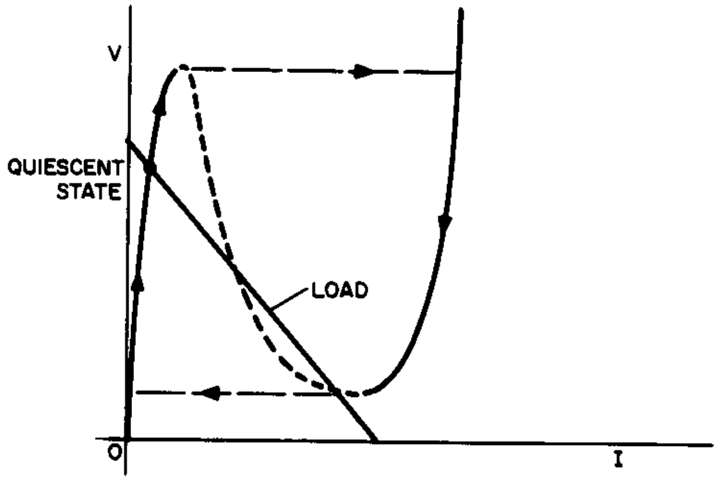

Fig. 6. Leading-edge discrimination by D8.

SECTION 4

MAINTENANCE

4.1 PREVENTIVE MAINTENANCE

The only preventive maintenance required is reasonable attention to mechanical details. Keep the signal connectors clean and remove the cover plates and inspect the module for excessive dust accumulation. Clean as often as required by local conditions (normally about once in 12 months).

CAUTION

Handle printed-circuit board with care.

4.2 CORRECTIVE MAINTENANCE

When replacing components on a printed-circuit board, care must be taken to insure that the board is not damaged due to excessive heating. Heat the solder joint as little as possible while maintaining a pull on the component lead to assure prompt removal of the lead. After component removal, redrill the hole with a No. 66 or No. 60 drill, depending on the size of the component lead. Make certain that the drill is sharp and do not use excessive pressure. A very common method of cleaning a hole is to apply heat and push through a wire. DO NOT use this method as the copper will likely peel off.

4.3 VOLTAGE READINGS

The voltages listed in Table 1 are typical of a properly operating circuit with no input signals present, all yellow BNC connectors terminated in 50 ohms, the ZERO-X and UNGATED modes. Use a high-impedance d-c voltmeter.

Table 1. Voltage Readings.

TEST POINT		VOLTAGE	TEST POINT		VOLTAGE
Q1	E	+5.8 V	Q6	B	+40 mV
	B	+5.7 V		C	+4.3 V
	C	+42 mV	Q7	E	-5.8 V
Q2	B	+5.1 V		B	-5.2 V
	C	+3.6 V		C	-30 mV
Q3	E	0 V	Q8	E	+230 mV
	B	-350 mV		B	-38 mV
	C	-6.2 V		C	-5.4 V
Q4	E	-6.2 V	Q9	E	-5.6 V
	B	-5.5 V		B	-5 V
	C	+30 mV		C	-1.75 V
Q5	E	-700 mV	Q10	C	0 V
	B	0 V			
	C	+4.7 V			

CALIBRATION

Calibration of the T140/N is best done with signals from a photomultiplier which is similar in characteristics to the tube with which the T140/N is to be used, and a fast-rise sampling scope (such as the Tektronix 561/3S76/3T77 or 661/4S1/5T1) capable of displaying a rise-time significantly lower than 1 nsec.

The photomultiplier should be equipped with a small plastic scintillator and medium intensity source such as Co^{60}. A suitable clipping cable should be used at the anode signal output. The clipped anode output signal should be split (a resistive TEE is good) and the signal applied both to the input of the T140/N and, with suitable delay, to the scope input as illustrated in Fig. 7. The T140/N output signal should trigger the oscilloscope.

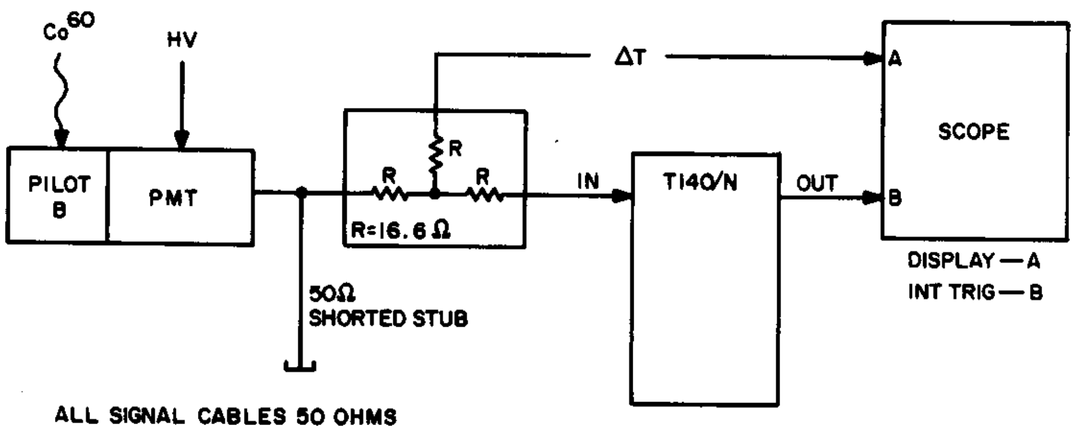

Fig. 7. T140/N calibration setup.

Adjust the zero-crossing calibration control at the rear of the chassis so that the T140/N triggers at zero; i. e., so that the photomultiplier signal has minimum dispersion at the zero level (see Fig. 8).

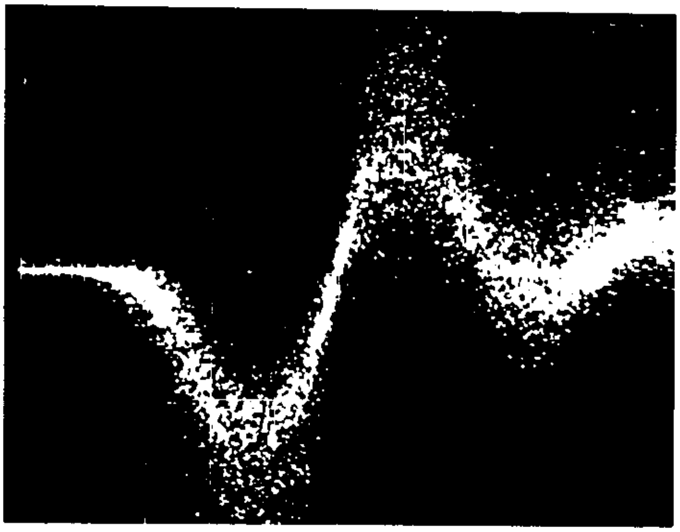

Fig. 8. Correct adjustment of T140/N zero-crossing
100 mV/cm vertical, 2 nsec/cm horizontal.

SECTION 6
PARTS LIST

Table 2 identifies the components of the T140/N module with reference designators corresponding to Fig. 9, the schematic diagram. Component replacement, if required, should be made in accordance with Table 2.

Table 2. Parts List.

REF. DES.	PART DESCRIPTION	MANUF. IDENT.	MANUF. PART NO.
C1	Capacitor, ceramic, .02 μf, 30 V	CRL	DA-203
C2	Same as C1		
C3	Capacitor, mica, 10 pf, 100 V	Elmenco	SCDM-15
C4	Capacitor, ceramic, 270 pf, 50 V	Mucon	ID27ORLAM
C5	Capacitor, mica, 1000 pf, 100 V	Elmenco	SCDM-15
C6	Capacitor, mica, 20 pf, 100 V	Elmenco	SCDM-15
C7	Same as C4		
C8	Same as C5		
C9	Capacitor, mica, 15 pf, 100 V	Elmenco	SCDM-15
C10	Capacitor, mica, 100 pf, 100 V	Elmenco	SCDM-15
C11	Capacitor, mica, 51 pf, 100 V	Elmenco	SCDM-15
C12	Same as C5		
C13	Same as C4		
C14	Same as C9		
C15	Same as C9		
C16	Same as C5		
C17	Same as C3		
C18	Same as C5		
C19 through C26	Same as C1		
C103 through C322	Same as C3 through C22		
D1	Diode, silicon	Fairchild	FD777
D2	Same as D1		
D3	Diode, silicon zener, 5.1 V ±5%, 400 MW	Motorola	1N751A

Table 2. Parts List Cont.

REF. DES.	PART DESCRIPTION	MANUF. IDENT.	MANUF. PART NO.
D4	Diode, germanium tunnel, 1 mA	GE	1N3712
D5	Diode, germanium	ITT	1N270
D6	Same as D1		
D7	Diode, silicon, zener, 5.6 V ±5%, 400 MW	Motorola	1N752A
D8	Diode, germanium tunnel, 20 mA	Microstate	MS1305
D9	Diode, silicon zener, 6.8 V, ±5%, 400 MW	Motorola	1N754A
D10	Diode, germanium tunnel, 5 mA	Microstate	MS1302
D11	Same as D1		
D12	Same as D9		
D13	Diode, silicon hot carrier	HP Associates	HPA2333
D104 through D313	Same as D4 through D11		
J1	Connector, BNC, green teflon center		UG1094/U
J2	Connector, BNC, yellow teflon center		UG294/U
J3	same as J2		
J101 through J303	Same as J1 through J3		
L1	Inductor, 22 μH	Delavan	1537-22
L2	Same as L1		
L3 through L7	Inductor, .22 μH	Delavan	1537-02

Table 2. Parts List Cont.

REF. DES.	PART DESCRIPTION	MANUF. IDENT.	MANUF. PART NO.
L103 through L307	Same as L3 through L7		
P1	Connector		
Q1	Transistor, silicon PNP	Motorola	2N3906
Q2	Same as Q1		
Q3	Transistor, germanium PNP	Motorola	2N1195
Q4 through Q6	Transistor, silicon NPN	Fairchild	2N709
Q7	Transistor, silicon NPN	Fairchild	FT117
Q8	Same as Q3		
Q9	Same as Q7		
Q10	Same as Q7		
Q103 through Q310	Same as Q1 through Q10		
	NOTE For resistors R1 through R343: "1/4 W" denotes 1/4 W, 5% carbon resistor, Ohmite; "1%" denotes 1/2 W, 1% carbon film resistor, Penn FCA-15.		
R1	2.67 K, 1%		
R2	19.1 K, 1%		
R3	768 ohms, 1%		
R4	150 ohms, 1/4 W		

Table 2. Parts List Cont.

REF. DES.	PART DESCRIPTION	MANUF. IDENT.	MANUF. PART NO.
R5	680 ohms, 1/4 W		
R6	56 ohms, 1/4 W		
R7	47.5 ohms, 1%		
R8	2.05 K, 1%		
R9	1.5 K, 1/4 W		
R10	10 ohms, 1/4 W		
R11	887 ohms, 1%		
R12	39 ohms, 1/4 W		
R13	1.5 K, 1/4 W		
R14	3.9 K, 1%		
R15	33 ohms, 1/4 W		
R16	1.21 K, 1%		
R17	13 ohms, 1%		
R18	1.21 K, 1%		
R19	Potentiometer, 2 K, 22-turn	Bourns	271-1-202M
R20	51 ohms, 1/4 W		
R21	620 ohms, 1/4 W		
R22	150 ohms, 1/4 W		
R23	51 ohms, 1/4 W		
R24	10 ohms, 1/4 W		
R25	24.9 K, 1%		
R26	51 ohms, 1/4 W		
R27	510 ohms, 1/4 W		
R28	5.1 K, 1/4 W		
R29	100 ohms, 1%		
R30	10 ohms, 1/4 W		

Table 2. Parts List Cont.

REF. DES.	PART DESCRIPTION	MANUF. IDENT.	MANUF. PART NO.
R31	4.02 K, 1%		
R32	536 ohms, 1%		
R33	Same as R19		
R34	330 ohms, 1/4 W		
R35	47 ohms, 1/4 W		
R36	100 ohms, 1/4 W		
R37	604 ohms, 1%		
R38	1.5 K, 1/4 W		
R39	15 ohms, 1/4 W		
R40	24 ohms, 1/4 W		
R41	1.2 K, 1/4 W		
R42	33 ohms, 1/4 W		
R43	4.3 K, 1/4 W		
R106 through R343	Same as R6 through R43		
S1	Switch, SPDT, miniature toggle	Alco	105D
S2	Same as S1		

REVISION NOTICE:
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1. R9, R109, R209 and R309 have been changed to 2.4 K, 1/4 W, 5% carbon resistors.
2. R44, 10-ohm, 1/4 W, 5% carbon resistor from D5 to ground has been added.
3. R144, 10-ohm, 1/4 W, 5% carbon resistor from D105 to ground has been added.
4. R244, 10-ohm, 1/4 W, 5% carbon resistor from D205 to ground has been added.
5. R344, 10-ohm, 1/4 W, 5% carbon resistor from D305 to ground has been added.
6. R29 has been changed to 100-ohm, 1/4 W, 5% carbon resistor.
7. Modules with date code 8038 (located on top, rear of module) or greater have modifications incorporated.
8. T140/N schematic (Figure 9) does not reflect above modifications.

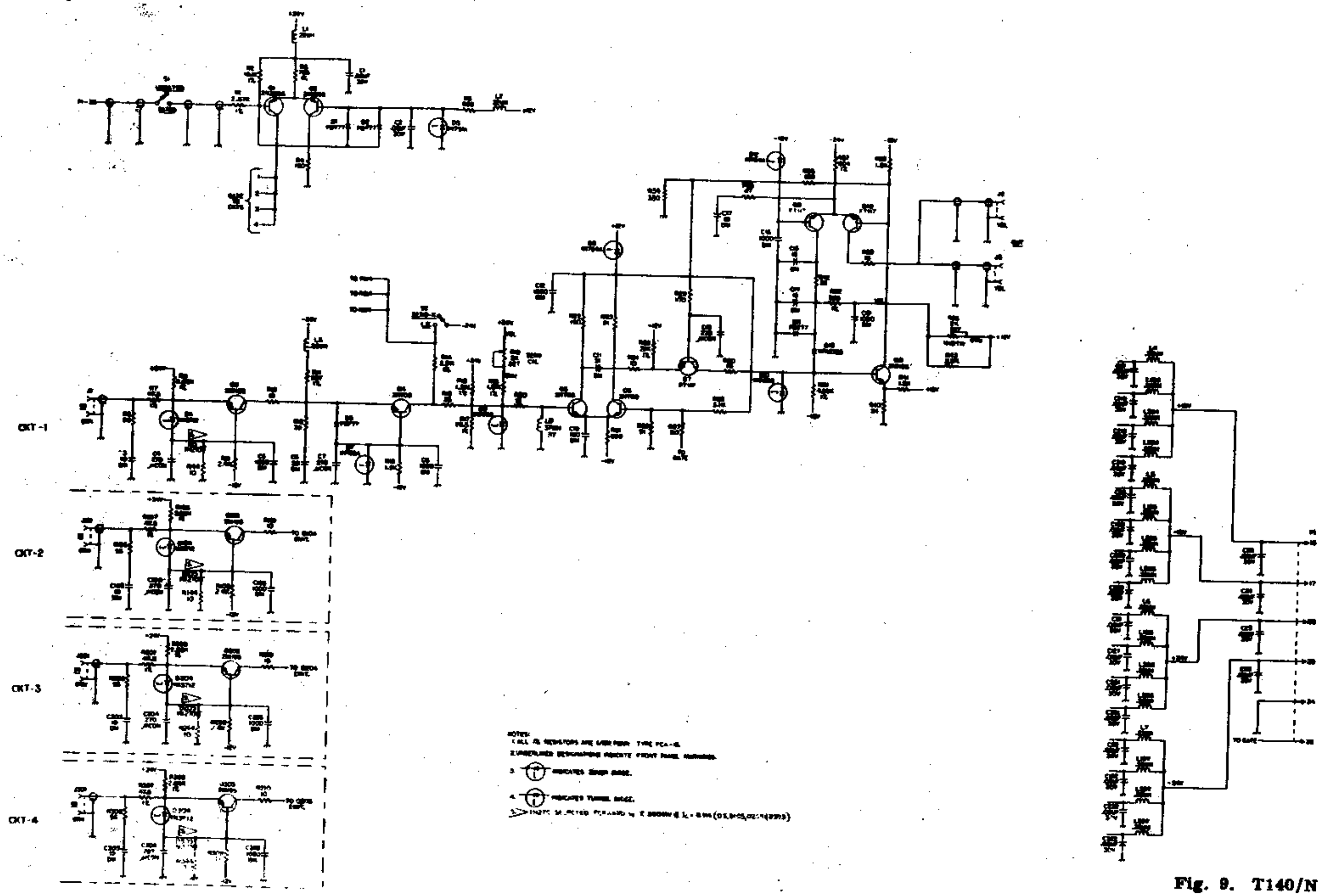
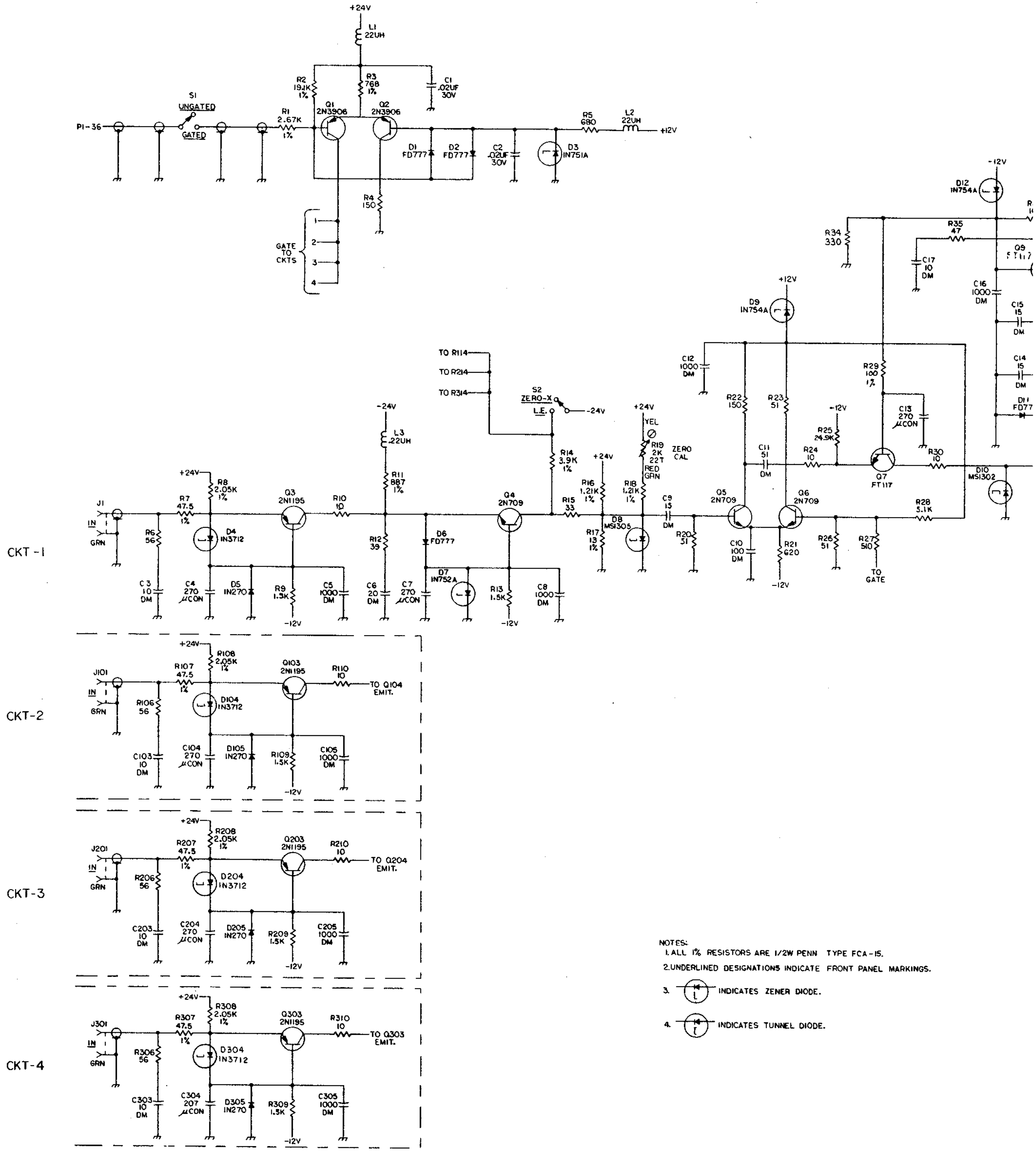


Fig. 9. T140/N schematic diagram.



NOTES:
1. ALL 1% RESISTORS ARE 1/2W PENN TYPE FCA-15.
2. UNDERLINED DESIGNATIONS INDICATE FRONT PANEL MARKINGS.
3. [zener symbol] INDICATES ZENER DIODE.
4. [tunnel diode symbol] INDICATES TUNNEL DIODE.

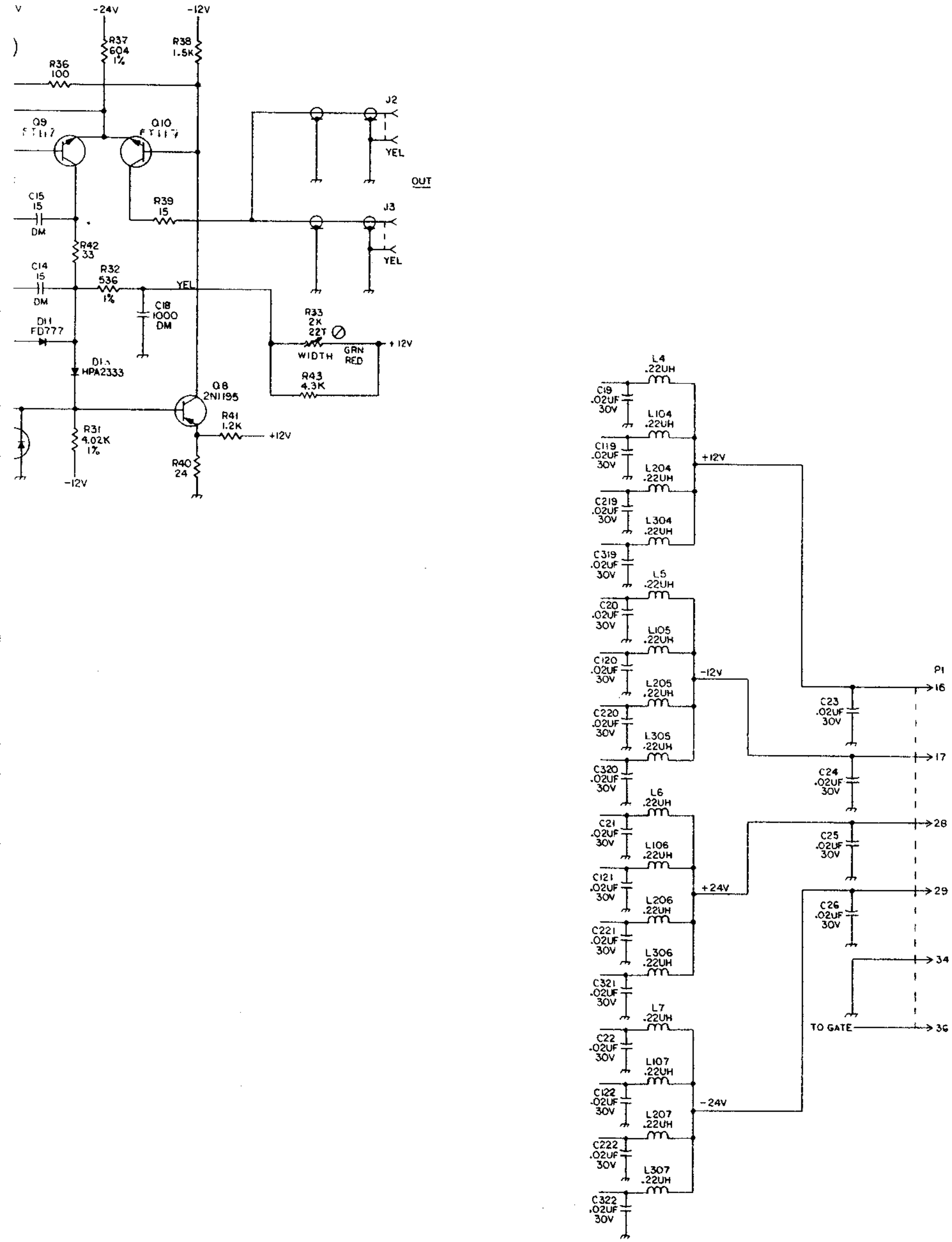


Fig. 9. T140/N schematic diagram.

The following schematic diagram pertains to the T140 QUAD ZERO-CROSSING DISCRIMINATOR MODULE. The manual differs for the T140 as follows:

1. SECTION 1.2 SPECIFICATIONS:

   Power Requirements: +20V, 210 mA.
   +10V, 200 mA.
   -10V, 210 mA.
   -20V, 190 mA.

2. SECTION 4.3 VOLTAGE READINGS:

   In general the voltage readings will be the same, with obvious and straightforward differences due to changes in power supply.

3. SECTION 6 PARTS LIST:

   The parts list differs mainly in some resistor and zener diode values. All values are listed on the T140 schematic.

REVISION NOTICE:
T140 MANUAL
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1. R43 has been changed to 1.8 K, 1/4 W, 5% carbon resistor.
2. R9, R109, R209 and R309 have been changed to 1.2 K, 1/4 W, 5% carbon resistor.
3. R20 has been changed to 51-ohm, 1/4 W, 5% carbon resistor.
4. R25 has been changed to 17.25 K, 1/4 W, 5% carbon resistor.
5. R29 has been changed to 100-ohm, 1/4 W, 5% carbon resistor.
6. C9 has been changed to 15 pf, 100 V, mica capacitor, Elmenco SCDM-15.
7. Connection between R29 and R34 has been added.
8. Connection between R29 and R28 has been added.
9. R41 has been changed to 910-ohm, 1/4 W, 5% carbon resistor.
10. Modules with date code 7219 (located on top, rear of module) or greater have modifications incorporated.
11. The enclosed T140 schematic reflects above modifications.

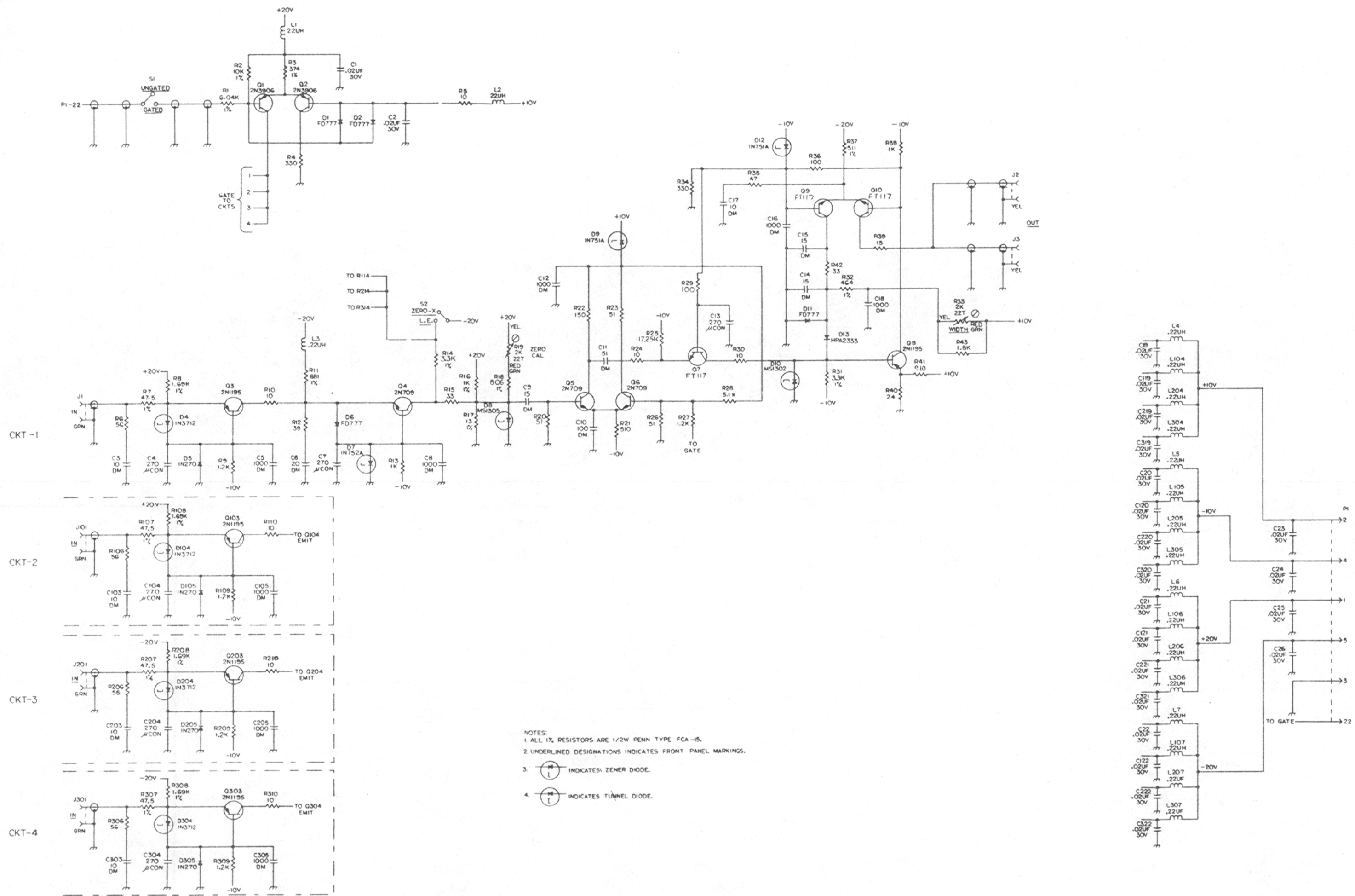
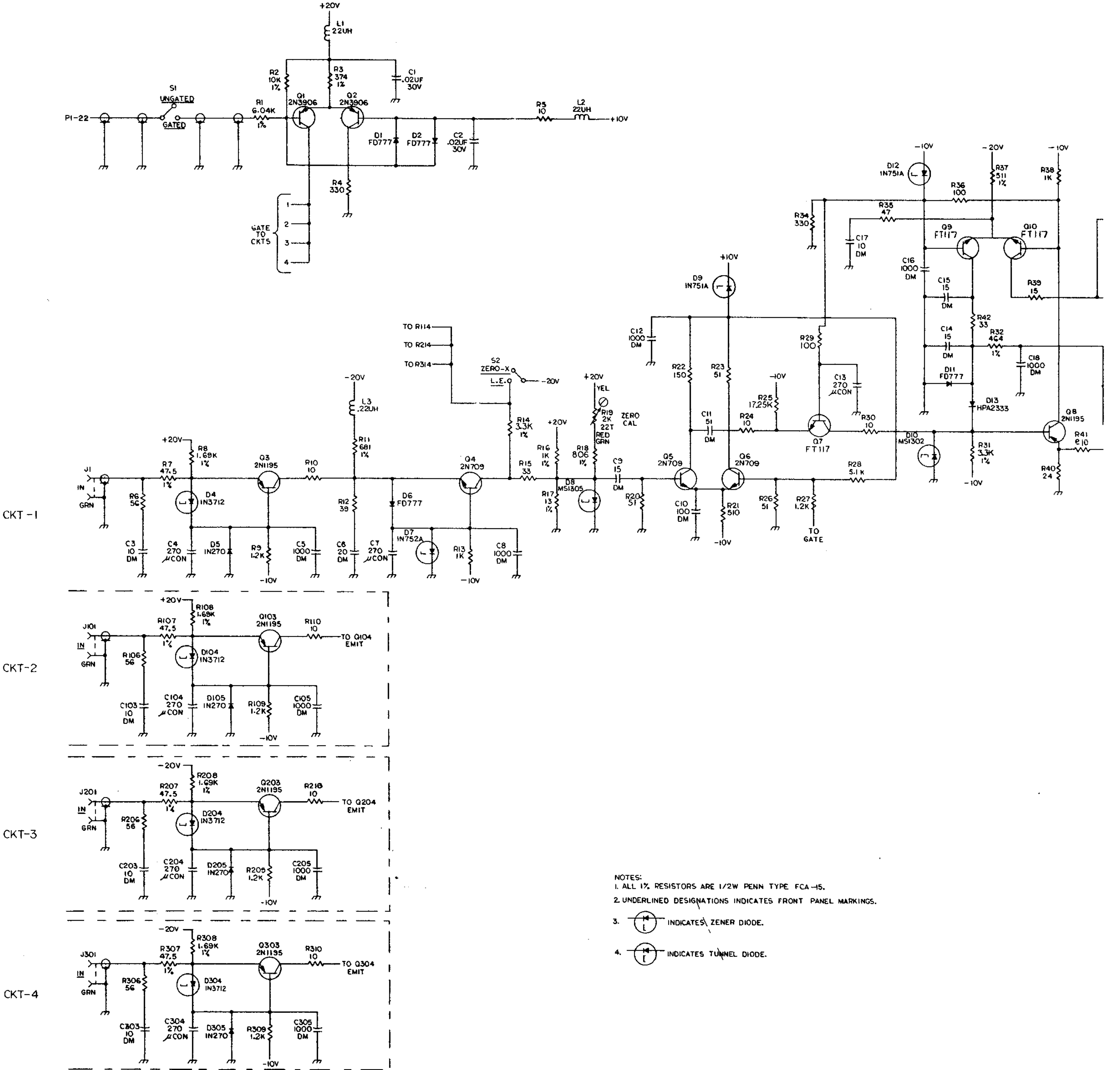


Fig. 10. T140 schematic diagram.



NOTES:
1. ALL 1% RESISTORS ARE 1/2W PENN TYPE FCA-15.
2. UNDERLINED DESIGNATIONS INDICATES FRONT PANEL MARKINGS.
3. INDICATES ZENER DIODE.
4. INDICATES TUNNEL DIODE.

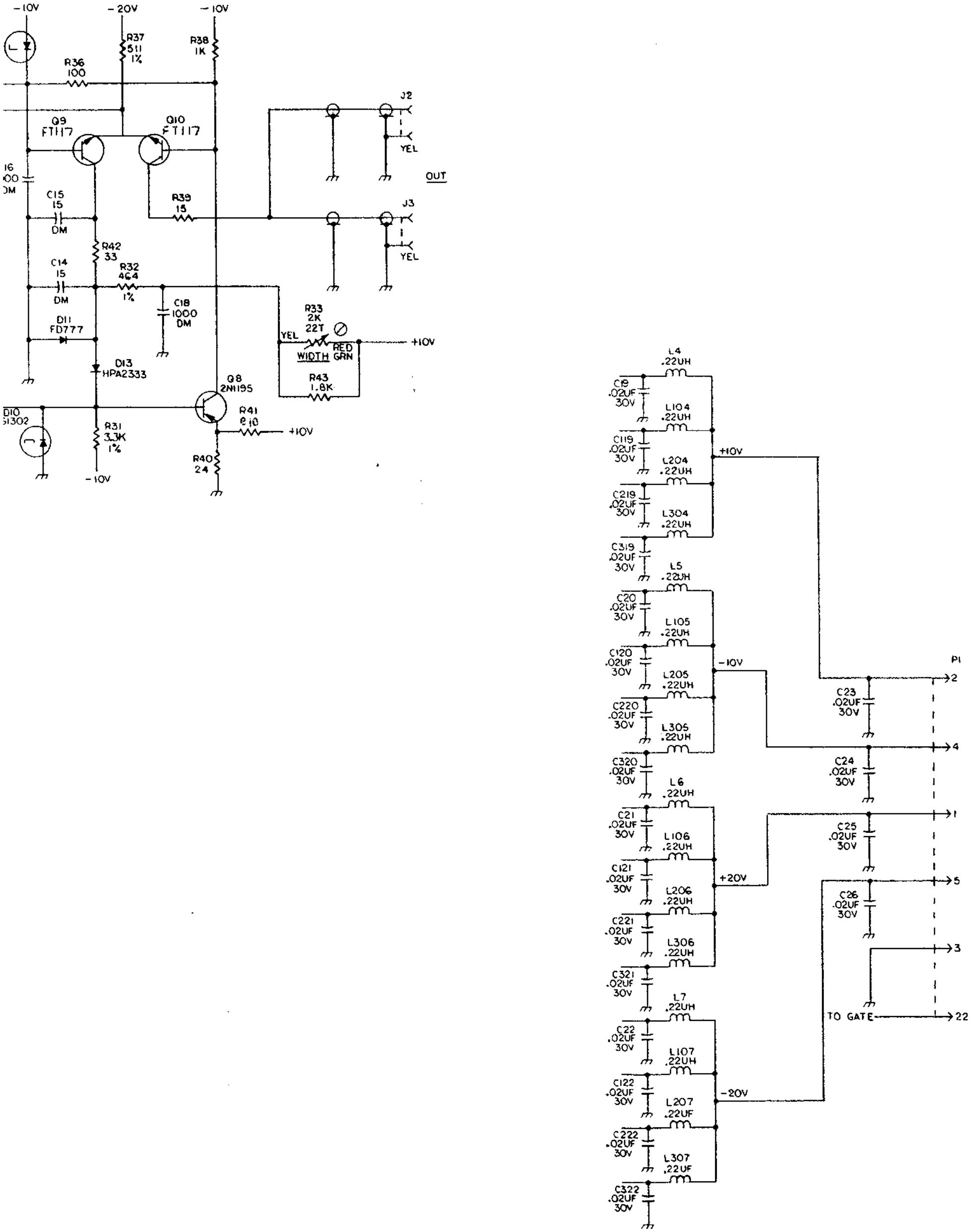


Fig. 10. T140 schematic diagram.