PRELIMINARY

INSTRUCTION MANUAL

TC 178/TC 178P

QUAD PREAMP/QUAD PULSER

WARRANTY

TENNELEC, INC. warrants that the products or components manufactured by it shall be free from defects in material or workmanship for a period of two years from the date of delivery to purchaser. If such product or component is determined to be defective by TENNELEC, its sole warranty obligation shall be limited to either replacing or repairing such defective product or component or allowing credit therefor, at TENNELEC's option. Such warranty is further conditioned upon the purchaser's giving prompt notice of any such defect and satisfactory proof thereof to TENNELEC's customer service manager, thereafter upon TENNELEC's approval, the purchaser shall return such defective product or component to TENNELEC's factory at Oak Ridge, Tennessee, all transportation charges prepaid. TENNELEC shall be responsible only for transportation charges incurred in returning such product or component to purchaser. All customs, brokerage and duty charges shall be at the expense of the purchaser. Damage in transit due to inadequate packaging will be repaired at purchaser's expense. Any repairs or replacements by the purchaser without TENNELEC's approval, any willful abuse or any evidence that the product or component was not properly used and maintained, would automatically void this warranty.

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1.0 [redacted]

The TENNELEC TC 178 and TC 178P are designed to operate together as a pair. The TC 178 is a four channel, ac-coupled charge sensitive preamplifier designed for use with detectors having an equivalent capacitance of from OpF to greater than 1000pF. The TC 178P is a four channel pulser used to drive the TC 178 internal pulser and provide amplitude and rate control.

1.1 TC 178 QUAD PREAMPLIFIER

The TC 178 Quad Preamplifier contains four independent charge-sensitive preamplifiers. Each channel has three independent energy *ranges* selected via front-panel mounted toggle, awitches. The internal puleer polarity is selected independently for each channel via toggle switches accessible through the bottom of the TC 178 case. The pulser calibration for each channel is accessible through the bottom of the preamplifier case. The pulser calfbratkon is independent for each channel and energy range. Visual indication of pulse processing for each channel is provided by LED indicators. A preamplifier power LED indicator illuminates when supply voltage levels are within acceptable limits and extinguishes if any of the supply voltages fall outside these limits.

Each preamplifier channel accepts detector bias up to l.OkV through an SHV connector. The detector bias network has a' total resistance of 3.0 megohm, of which, 1.0 megohm is the detector load 'resistor. The detector signal is coupled to the preamplifier input via SHV connectors.

The risetime of each preamplifier is independently adjustable for optimizing the preamplifier response with, various detectors. The preamplifier dc-off set adjustment is available to the *user* but will generally only need adjustment if the input FET is replaced.

1.2 TC 178P QUAD PULSER

The TC 178P Quad Pulser is a single-wide NIM that is specifically dedicated for use with the TC 178 Quad Preamplff ier. The *TC* 178P provides a dc reference level and a trigger pulse to the TC 178 TEST IN connector. The dc reference is independent for each channel and is used to determine the level of the pulse.

generated by the internal pulser of the TC 178. The rate of operation is commontoallfour channels and is continuously variable from 1 Hz to 11 **kHz** through four ranges. An **external input is** provided to **allow** inputs **from** random pulsers or rates **up to** approximately 100 **kHz.**

The TC **178P,** when used with the TC 178, can be calibrated to read directly in terms of equivalent energy. The calibration feature allows for both testing and calibration of nuclear counting system electronics.

2.0 SPECIFICATIONS

2.1 TC **178** (per channel except where noted).

2.1.1 PERFORMANCE*

NOISE (FWHM referred to a **silicon** detector with W= 3.6 **eV** per electionhole pair).

NOISE (keV) FWHM (1)

DETECTOR CAPAC. (pF)	ENERGY RANGE: 0.1 GeV, t_p=4usec TYP	MAX	t_p=1usec TYP	1.0 GeV, t_p=4usec TYP	MAX	t_p=1usec TYP	10 GeV, t_p=4usec TYP	WAX	t_p=1usec TYP
0	11.6	25.0	11.0	14.6	30.0	16.0	71	150	112
10	11.8		11.7	14.8		16.6	71		112
20	12.0		12.0	15.0		16.9	71		113
50	12.6		13.3	15.6		18.0	72		113
100	14.0	35.0	15.7	16.7	40.0	20.0	73	160	114
200	16.8		21.4	19.6		25.0	76		121
500	27.0		38.5	29.2		41.0	85		132
1000	43.7	110.0	68.0	47.0	120.0	70.0	100	250	153

TYP INTERCEPT 11.0keV TYP SLOPE 30 eV/pF — TYP INTERCEPT 16.0keV TYP SLOPE 30 eV/pF — TYP INTERCEPT 71.0keV TYP SLOPE 30 eV/pF

(1) "t_p" refers to the peaking time in **usec.** The **peaking time** is a measureof **the time from the 1%** level to the 100% level of the shaped pulse. The peaking time is approximately two times **the** shaping time. The noise measurements were made using a TC 243 shaping amplifier in the triangular mode.

***Where** appropriate, all performance specifications given are for a 4 **usec** peaking **(2 usec** shaping) time.

See Figure 2.1 and Figure 2.2 for graphs of TC 178 Electronic Noise vs Equivalent Detector Capacitance at peaking times of 4 usec and1 sec.

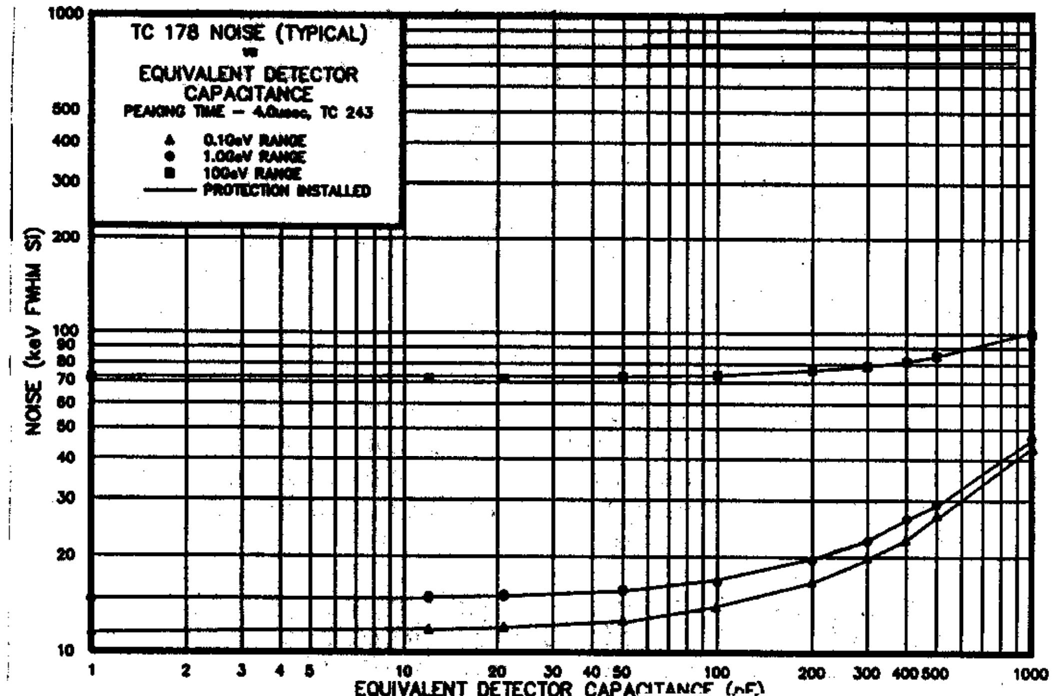


Figure 2.1 Electronic Noise vs Equivalent Detector Capacitance (Peaking Time of 4.0 usec)

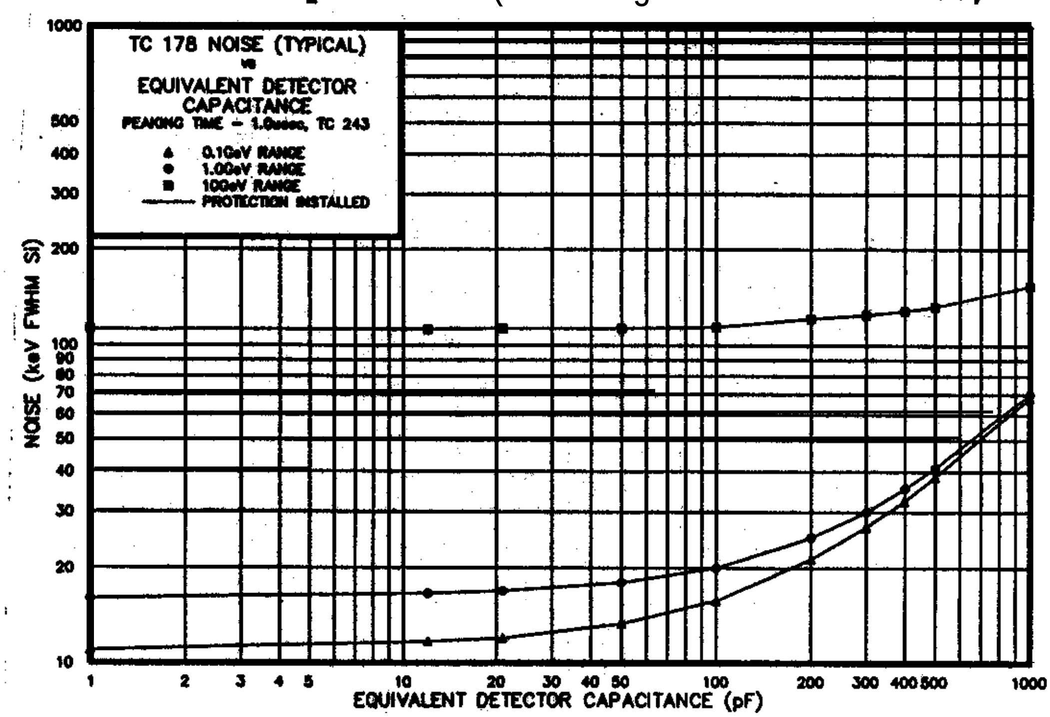


Figure 2.2 Electronic Noise vs Equivalent Detector Capacitance (Peaking Time of 1.0 usec)

RISETIME (2)

DETECTOR CAPAC. (pF)	RISETIME nsec (10% - 90%) ENERGY RANGE 0.1 Gev TYP	MAX	1.0 Gev TYP	MAX	10 Gev TYP	MAX
0	17	25	14	20	10	15
10	17		14		10	
20	19		14		10	
50	21		15		11	
100	25		21		13	
200	38	50	48	25	19	20
500	80					
1000	160		100		80	

(2) Based on a full scale equivalent input, **risetime** adjustment optimized at each measurement, E OUT terminated in 50 ohms, measurement made with an external test-input capacitor, and internal protection network installed.

See Figure **2.3** for a graph of the TC 178 **Risetime** as a function of **equivalent detector** capacitance. The typical transient response of the TC 178 is shown in Figure 2.4.

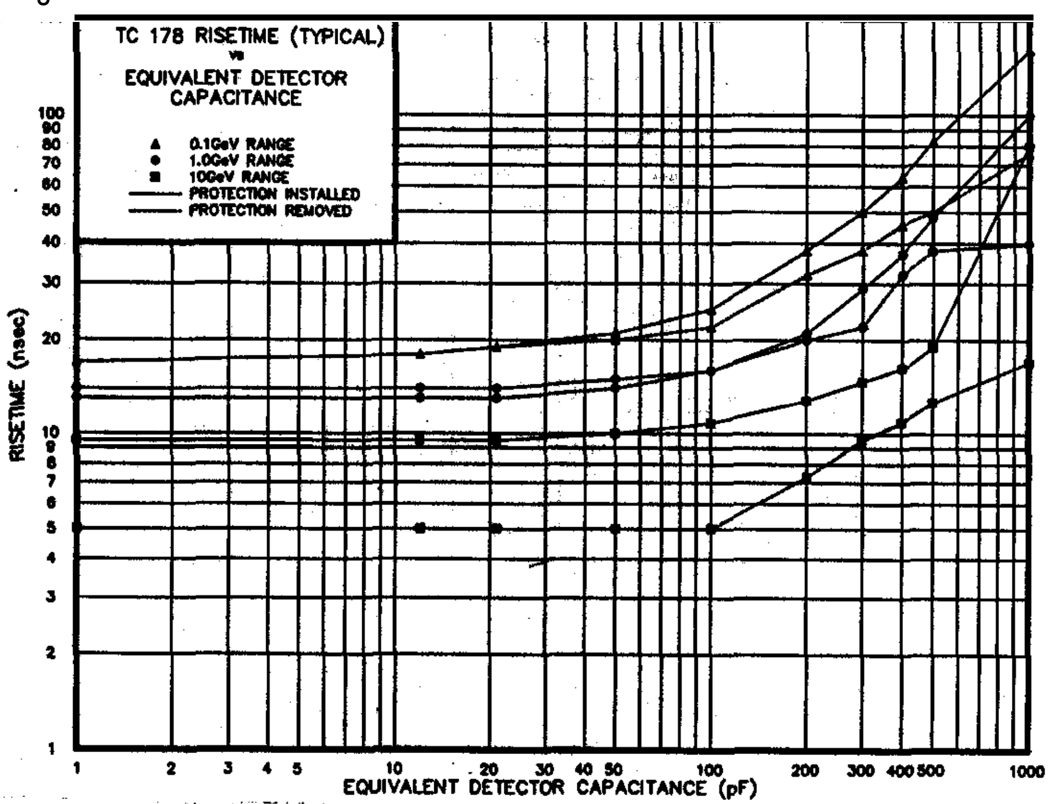
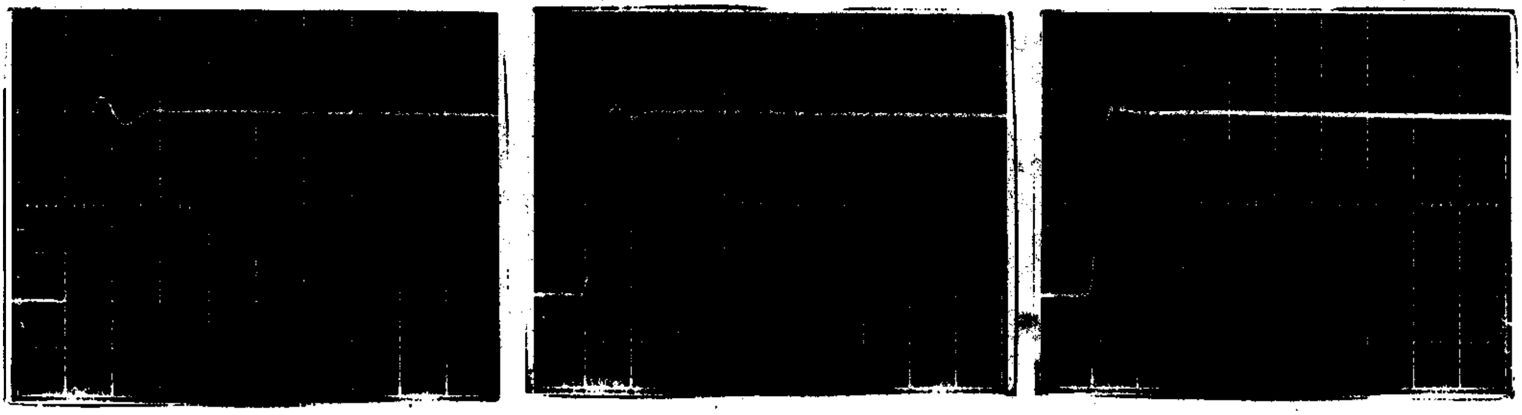


Figure 2.3 Typical **Risetime vs** Equivalent Detector Capacitance



A B C

Figure 2.4 Typical Transient Response
A) 0.1 GeV, B) 1.0 GeV, C) 10 GeV

CONVERSION GAIN (Si)	
RANGE	
0 - 0.1 GeV	20 mV/MeV
0 - 1.0 GeV	2.0 mV/MeV
0 - 10 GeV	0.2 mV/MeV
CONVERSION GAIN TEMPERATURE INSTABILITY	
RANGE	
0 - 1.0 GeV	≤ ±100 ppm/°C
0 - 1.0 GeV	≤ ±75 ppm/°C
0 - 10 GeV	≤ ±50 ppm/°C
OPERATING TEMPERATURE RANGE	0 to 50°C
INTEGRAL NONLINEARITY	
0 to ±10V	1.05% MAX., typically 10.02%
0 to ±2V	≤.02% MAX., typically 10.005%
DIFFERENTIAL NONLINEARITY	
0 to ±10V	Typically 10.03%

DYNAMIC INPUT CAPACITANCE	
RANGE	
0 - 0.1 GeV	≥10kpF; typically >15kpF
0 - 1.0 GeV	≥20kpF; typically >60kpF
0 - 10 GeV	≥30kpF; typically, >85kpF
MAXIMUM ENERGY	
RANGE	
0 - 0.1 GeV	>500 MeV (Si)
0 - 1.0 GeV	>5 GeV (Si)
0 - 10 GeV	>50 GeV (Si)
COUNT RATE CAPABILITY (5% of pulses in non-linear range)	
RANGE	
0 - 0.1 GeV	$>1X10^5$ cps @ 100 MeV (Si)
0 - 1.0 GeV	$>1X10^5$ cps @ 1.0 GeV (Si)
0 - 10 GeV	$>1X10^5$ cps @ 10 GeV (Si)
DECAY TIME CONSTANT (NOMINAL)	50 usec
DETECTOR LOAD RESISTOR	1 megohm
DETECTOR BIAS CAPABILITY	±1,000V Maximum
SIGNAL POLARITY	
INWT	POSITIVE OR NEGATIVE
E CDT	INVERSE OF INPUT
TEST IN	POSITIVE (dc level plus trigger pulse from TC 178P)

2.1.2 CONTROLS

2.1.2A FRONT-PANEL CONTROLS

RANGE Locking toggle switch for selection of energy range, 0.1, 1.0, or 10 GeV full scale.

2.1.2B INTERNAL CONTROLS

DC-OFFSET Screwdriver-adjustable multiturn potentiometer (accessible through the top of the preamplifier case) used to adjust input FET drain current and dc offset voltage. NO user adjustment normally required unless input FET is replaced. One per channel.

RISETIME Screwdriver adjustable single-turn potentiometer (accessible through the top of the preamplifier case) used to optimize the preamplifier transient response for each detector preamplifier combination. One per channel.

PULSER POLARITY Two-position toggle switch selects either positive (POS) or negative (NEG) pulser polarity. One per channel, accessible through bottom of case.

PULSER CALIBRATION Three variable capacitors, one per channel, accessible through bottom of case, used to calibrate pulser amplitude for each range.

2.1.3 CONNECTORS

2.1.3A FRONT PANEL

INPUT SBV (AMP 51494-2) connector accepts positive or negative charge from the detector and applies high voltage to the detector. One per channel.

2.1.3B REAR PANEL

H.V. IN SHV (AMP 51494-2) 'connector accepts up to ±1000V and applies it to the detector throuoh the INPUT connector . One per channel.

TEST IN BNC (UG-1094/U) connector accepts pulser level and trigger signals from TC 178P. One per channel.

E OUT BNC (UG-1094/U) connector provides energy output signal, dc-coupled, Zo = 50 ohm ±1%, dc offset approximately -100 mV. One per channel.

POWER 9-pin male, Amphenol 17-20090 or equivalent. One per TC 178.

2.1.4 INDICATORS

E-OUT LED is illuminated when the E-OUT level exceeds approximately 2% of full scale range (2 MeV, 20 MeV or 200 MeV).

POWER ON LED is illuminated when supply voltage levels are within acceptable limits} extinguishes if any of the supply voltages fall outside of these limits.

2.1.5 POWER REQUIREMENTS +24V @ 160 mA +12V @ 210 mA
-24V @ 130 mA -12V @ 0 mA

2.1.6 OTHER INFORMATION

WEIGHT	(SHIPPING)	6.0 lbs (2.7 kg)
	(NET)	4.0 lbs (1.8 kg)

DIMENSIONS (L X W X H) 8.5 x 5 x 3 inches (21.6 X 12.7 X 7.6 cm)

INSTRUCTION MANUAL One provided with each instrument ordered.

ACCESSORY One TENNELEC NC-PAC-10, 10 ft. preamplifier power cable provided with each preamplifier ordered; Amphenol 17-20090 to Amphenol 17-10090 connectors.

2.2 TC 178P

2.2.1 PERFORMANCE

REPETITION RATE	1 Hz to 11 kHz in 4 ranges; continuously variable for each range
RATE INACCURACY	≤ ±2% of setting, typically < ±1%
RATE TEMPERATURE INSTABILITY	≤ ±200ppm/°C, typically ≤ ±50ppm/°C referenced to +24V
RATE INSTABILITY	≤4.25%/V for variations of the +24V NIM supply voltage; independent of 115V line voltage variations
PULSE AMPLITUDE RANGE	0 to +10.0V dc
PULSE AMPLITUDE INACCURACY	< ± [25 mV + (Vo DIAL X 2.8 mV)] typically ≤ ±10 mV
PULSE AMPLITUDE TEMPERATURE INSTABILITY	
Vo <0.4V	≤ ±50ppm/°C; typically ≤ ±20ppm/°C
Vo ≥0.4V	≤ ±40ppm/°C; typically ≤ ±20ppm/°C

PULSE **AMPLITUDE** INSTABILITY	**≤0.1 mV/V** for variations of the **+24V** NIM supply voltage; independent of 115V line variations.

2.2.2 CONTROLS

RATE Front-panel, six-position rotary switch selects pulse repetition rates of 1, 10, 100, **1kHz,** OFF, or **external** (EXT) for all four channels.

MULT Front-panel 10-turn potentiometer provides multiplier for **repetition rate for** all four channels! factors are X1.0 **to X11,** continuously variable.

PULSE AMPLITUDE Front-panel lo-turn potentiometer provides **adjustment of** output **dc** level for each channel from 0 to **+10V** open circuit,; One per channel.

ON-OFF **Two-position toggle** switch to enable or **disable** the **respective pulser** channel. One per **channel.**

2.2.3 CONNECTORS

2.2.3A FRONT PANEL

EXT IN Front-panel BNC (UG-1094/U) connector, **dc-**coupled, accepts positive NIM input **(+5V, 500 nsec** wide) to provide pulse repetition rates **up** to 100 **kHz** for all four channels. 'The EXT IN signal minimum usable width **is** typically **≤100** nsec. The, **EXT** IN connector is duplicated on the Rear Panel.

SYNC OUT Front-panel BNC (UG-1094/U) **connector** provides de-coupled, 0 to **+5V** signal open circuit (0 to **+2.5V** terminated into **50 ohms).** Signal width is typically 60 naec. The SYNC OUT connector is duplicated on the Rear Panel. See Figure 2.5 for a typical SYNC OUT signal.

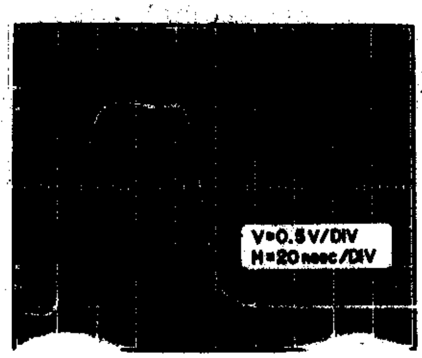


Figure 2.5 Typical Sync Out Signal

2.2.3B REAR PANEL

PULSER OUT Rear-panel BNC (Amphenal **31-010,** insulated **BNC),** dc-coupled, provides the TC **178 trigger** pulse (TTL level) and the TC 178 level control, **0** to **+10.0V** dc open circuit. One per channel. See Figure 2.6 **for** a typical PULSER OUT signal.

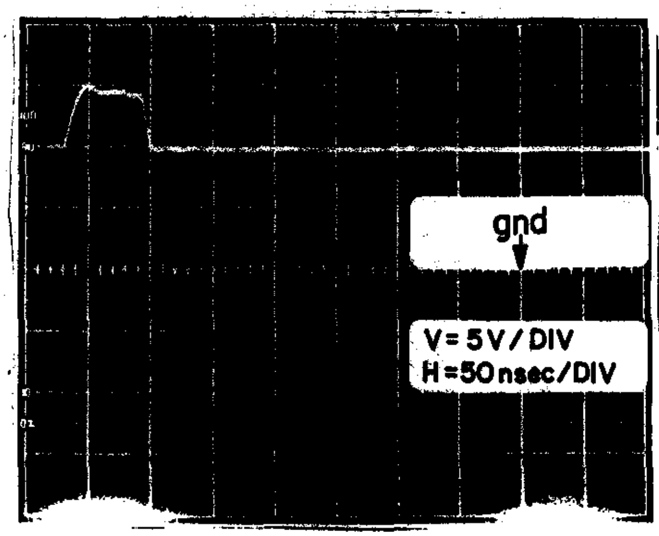


Figure 2.6 Typical Pulser Out Signal

EXT IN Refer to Section **2.2.3A.**

SYNC OUT 'Refer to Section **2.2.3A.**

2.2.4 POWER REQUIREMENTS **+24V @** 30 **mA** **+12V @** 125 **mA**
-24V **@** 0 **mA** -12v @ 0 **mA**

2.2.5 **OTHER** INFORMATION

WEIGHT	**(SHIPPING)**	3.2 lbs. (1.45 kg)
	(NET)	2.1 lbs. **(.95** kg)

DIWENSIONS Standard single width **NIM** module (1.35 x 8.714 in.) per **TID 20893** (Rev.).

INSTRUCTION MANUAL One-provided with each instrument.

3.0 INSTALLATION

3.1 TC 178

3.1.1 POWER

The TC 178 Quad Preamplifier is not self-powered and must be connected. via' the power cable to a main amplifier with provisions for providing preamplifier power or a seperate preamplifier power supply. Refer to the CAUTION at the beginning of the manual before connecting the TC 178 power cable to TENNELEC main amplifiers other than the TC 240 series.

3.1.2 CONNECTIONS

3.1.2A DETECTOR CONNECTION

To preserve the low-noise characteristics of the system, the capacitance to ground at the input of the preamplifier should be kept to a minimum. If a cable between detector and preamplifier must be used, it should be as short as possible and it must be shielded with one end of the shield connected to' the detector housing and the other to the preamplifier housing. Double shielded cable (RG71/U) is preferable to single shielded cable (RG62/U).

To avoid microphonics, it is desirable that the geometrical relationship between detector and preamplifier be kept rigidly fixed.

The length of cable connecting the preamplifier and the detector should be kept to a minimum for reasons of stability in addition to noise considerations. The cable connecting the preamplif ier and detector introduces a phase shift into the preamplifier feedback loop which adversely affects stability. A maximum length of cable cannot be assigned to the large number of detector and cable combinations, but a typical maximum length for the TC 178 is 10 ft.

The noise performance of. the preamplifier can be estimated from the sum of connecting cable and detector capacitance. The noise as a function of this input capacitance is shown in Figure0 2.1 and 2.2 for peaking times of 4 usec and 1 usec.

3.1.2B BIAS SUPPLY CONNECTION

In the TC 178, the bias connection is routed through the preamplifier case.

If a battery pack is used for bias, no special precautions need be taken in cable routing to avoid' noise pickup provided the case of the battery pack is connected to the preamplifier.

If a power line operated supply is used, or if a battery pack is used which is grounded to the main amplifier frame, then it is desirable to take the following precautions to avoid ground-loop pickup.

a. Locate the power supply physically close to the main amplifier.

b. Ground the supply to the main amplifier with large-gauge wire or shield braid at least 1/4" (6mm) wide.

c. Cut the high voltage cable to approximately the same length as the preamplifier signal cable and twist or taps the two together.

d. Never plug the main amplifier and HV supply into different wall outlets. If necessary, use a local distribution box for all components of a spectrometer system 'to avoid making the building part of a ground loop.

3.1.2C ENERGY OUTPUT CONNECTION

The energy output (E OUT) is intended to drive a 50 ohm line (RG 58/U) which may be connected directly to the input of the main amplifier. A50 ohm termination is not required as the preamplifier is stable unterminated. The preamplifier will drive any length of cable; however, for long cable lengths, cable losses must be considered..

To minimize ground-loop noise pickup, the following pattern of connections is recommended.

a. Place the test pulse generator as close to the main ampifier as possible.

b. Cut the signal and test pulse cables to approximately the same length as the ±12V, ±24V wires. Twist or tape all cables into one bundle.

The purpose of instruction.(a) is to prevent power supply noise spikes (which nearly always exist between widely spaced ground points in a NIM bin) from appearing in series with the signal ground returns. The purpose of instruction (b) is to avoid local radio station pickup which frequently occurs because of the loop-antenna effect in a network of spread-out cables.

The TC 178 E OUT signal is terminated at the sending end by resistor R105 (CHANNEL A) R129 (CHANNEL B), R131 (CHANNEL C) and R133 (CHANNEL D) as shown on the TC 178 schematic. In the TC 178, these resistors are nominally 49.9 ohms each to match 50 ohm cables. Other cable impedances may be used by changing to resistors of appropriate values.

3.1.2D TEST IN CONNECTION

The TC 178 TEST IN connector (one per channel) may be used in conjunction with a TC 178P Quad Pulser to operate the TC 178 internal pulser. The TC 178P controls the rate and amplitude, the polarity is controlled by the TC 178 PULSER POLARITY control (one per channel). The TC 178 TEST IN connector CANNOT be used in conjunction with a standard pulse generator. The signal to the TEST IN connector must provide a trigger pulse (TTL level) and a dc level to provide the pulse amplitude information.

If the TC 178 is used without a TC 178P, a test pulse can be injected at the TC 178 INPUT by using an external test capacitor and terminating resistor as shown in Figure 3.1. The use of an external test capacitor will give a more accurate representation of the TC 178 transient response thanusing the TC 178 internal pulser.

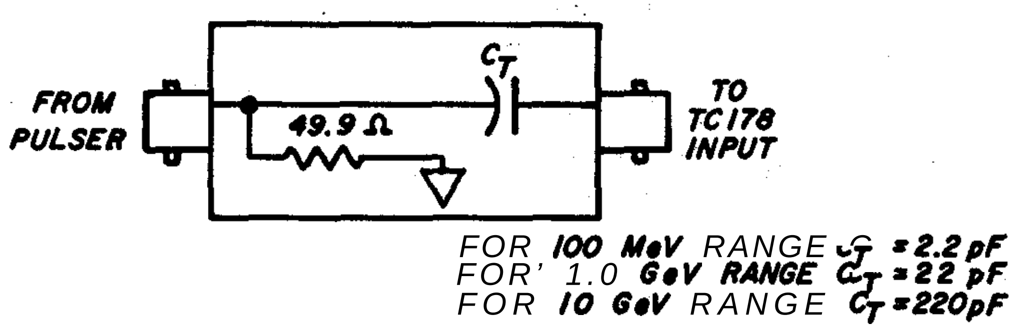


Figure 3.1 External Test Input Terminator

3.1.3 GENERAL PRECAUTIONS

3.1.3A FET PROTECTION

In the TC 178, a FET connected as a diode and a resistor in series with the input are used to protect the input FET against accidental short circuits. The protection network degrades the preamplifier noise slightly (refer to Section 5.1 and Figures 5.1 through 5.3 for more detail). The major noise source of the protection network (especially at short peaking times, and detector capacitance of 100pF or greater) is resistor R4 (47 ohm). This resistor is easily removed or replaced with a lower value to retain some protection with improved preamplifier noise performance.

IMPORTANT: See Section 7.1 for instructions on how to properly open or remove the TC 178 case.

3.1.3B APPLYING BIAS VOLTAGE

In the following statements, it is essential that the user recognize the distinction between rapid voltage changes at the B.V. IN connector and the signal INPUT connector.

The TENNELEC TC 178 preamplifier can safely withstand the application of detector bias voltage in ±500V steps spaced 10 sec apart, with or without protection for the FET, if the voltage is applied through the H.V. IN connector.

Without protection, short circuits at the signal INPUT terminal, may cause FET damage if the bias exceeds 50V. Connecting a preamplifier to a detector with bias voltage applied, either through the preamplifier or directly to the detector, is nearly equivalent to a short circuit.

With the protection network installed, an occasional short circuit at the signal INPUT terminal will not cause FET damage if the bias is 500V or less.

With or without protection, the preamplifier may be disconnected from a charged detector, but not reconnected except within the limits stated above for short-circuiting the signal INPUT terminal. When a preamplifier is disconnected from a charged detector,.

the signal;. **INPUT** terminal should not -be short-circuited except **within** the limits **given** above, Additionally, **the** detector **bias supply should** not be disconnected **without first** reducing the voltage to zero in 500V steps spaced 10 **sec** apart and then waiting. for an additional minute **to allow** the preamplifier filter **network** to discharge.. **The reason** for this last precaution is that **without** a **return** path through the **power supply, neither the** filter **capacitors** nor the input coupling capacitor.. **will** have **a discharge path;** it may **take** an hour **for discharge** to **occur** through leakage resistance alone.

The **user is** reminded at this point that because of their vulnerability to accidental damage, the **FETs** are not covered by warranty.

3.1.3C DETECTOR BIAS NETWORK

The TC 178 detector **bias** network **consists** of two 1 **megohm** resistors in the filter network and one 1 **megohm** resistor for, **the** detector **load resistor.**

If the detector load **resistor** and bias **resistors** supplied as **standard** are **inappropriate,** the user can install **different** values. The, noise performance of the **preamplifiers** will **not** improve significantly if the detector load resistor is **increased** unless the **charge-loop** feedback resistor is **increased.** For **modif ications** of this nature, see Section **7.3.**

3.1.3D DETECTOR BIAS LEVEL

If a system containing a **room-temperature surface-barrier** detector is assembled and turned on in the absence of bias voltage, the **electronic** noise will be high. As **the bias** voltage is **increased,** the noise (observed as “grass* on an oscilloscope connected to the output of the **main** amplifier) should drop sharply. As the voltage is increased further, the noise should continue to drop up to the point where rated detector voltage is reached, then it should increase again. The appearance of this **noise** at this higher than rated-bias level will **not be clean "grass"** as observed earlier, but will appear as a **series** of **discontinuities** on the baseline. This later appearance ‘is characteristic of avalanche **breakdown** in the- **detector.** The correct operating voltage for the **detector** is about 10% **below** this avalanche level. If the load resistor is too high, for the leakage current of the detector, the noise level, will not drop as the bias voltage is increased until it exceeds the IR drop in the load resistor. In extreme cases, this will not', occur until the bias voltage as indicate8 on 'the, power supply exceeds the detector manufacturer's specif iea maximum. NOTE: To compensate for the voltage drop in the detector bias network, the total dc resistance is 3 megohm. This resistance times the detector bias current will give the voltage drop across the detector bias network. The voltage applied to the detector is the power supply voltage minus the voltage drop across the detector bias network.

The detector voltage is given by'

$$V_{DET} = V_{BIAS} - (I_{LEAKAGE} \times R_{LOAD})$$

where V_{BIAS} is the output voltage to the high voltage power supply, $I_{LEAKAGE}$ is 'the detector bias current and R_{LOAD} is the total resistance in the preamplifier detector bias network (3 megohm for' the TC '178).

CAUTION: The user is encouraged to discuss the detector break'down characteristics with the manufacturer of the detector. TENNELEC cannot assume responsibility for damage to th'e detector caused by improper load-resistor selection or by improper application of detector bias voltage; With some detectors, permanent damage will result from over-voltage.

With time and radiation damage, the onset of avalanche noise (also known as "flicker" noise), may drop to a level below 'the ratings of the defector, requiring a reduction of operating voltage for acceptable energy resolution (or background count rate).

3.2 TC 178P

3.2.1 POWER

The TC 178P QUAD PULSER requires a standard NIM bin and power supply, such as the TB3/TC 911, for operation. The bin provides mmchanical mounting and power supply distribution. Always turn OFF the bin power supply when inserting or removing any modules.

The TC 178P is designed so that it is not possible to overload the power supply, even with a full compliment of modules in the bin. Since this maynotbetrue when the bin contains modules other, than those of TENNELEC design, the power supply voltages should be checked after all modules have been inserted. The TENNELEC Bin and Power Supply provides power supply test points on the bin control panel for monitoring the dc voltage levels.

The TC 178P PULSE AMPLITUDE accuracy does not depend upon the +24V power supply level or level changes except to a very 'minor degree (<.1 mV per Volt variations of the +24V level).

The accuracy of the TC 178P RATE control is dependent on the +24V power supply level. The TC 178 RATE varies approximately directly with changes of the +24V level. For optimum RATE accuracy, the +24V power supply level should be +23.9 to +24.1V. The TB3/TC 911 Nim Bin and Power Supply is furnished with trimming controls for precisely setting the' voltages., On TENNELEC bin supplies, all bias voltages are of instrument-grade quality, highly regulated and very stable.

3.2.2 CONNECTIONS

3.2.2A PULSER OUT

Each channel of the TC 178P has a PULSER OUT connector on the rear panel. The PULSER OUT signal 'is intended to be connected to the TC 178 TEST IN connector via coax cable such as RG58/U. The PULSER OUT signal consists of a TTL signal superimposed on a dc level. The PULSER OUT signal is separated into its components in the TC 178.

DO NOT TERMINATE TEE PULSER OUT SIGNAL. Coaxial cables other than RG58/U may be used; however, the cable characteristic impedance should be 50 ohms as the TC 178P PULSBR OUT signal is series terminated in 50 ohms.

Do not connect the TC 178P PULSER OUT to the TC 178 Preamplifier using a test capacitor. The TC 178P is not designed to be used in this manner.

3.2.2B SYNC OUT

The TC 178P has a SYNC OUT connector on the front panel and the rear panel. 'The outputs are identical and driven from the same point; The output signal (see Section 2, Figure 2.5 for a typical waveform) is a 60 nsec **wide** positive pulse. The output is series terminated and the output impedance is 50 ohms. The SYNC OUT signal can be used to trigger oscilloscopes or gate instruments to allow observation of the test signal from the TC 178. When using the SYNC OUT signal as a trigger or gate signal, the signal should be connected using 50 ohm characteristic impedance coaxial cable such as **RG58/U** or **RG174/U** and be terminated into 50 ohms.

3.2.2C EXT IN

The TC 178P has an EXT IN connector on the front panel and the rear panel. The inputs are identical and drive the **same** point. The **input** signal requirements are **$\geq$ +2V, $\geq$100** nsec wide. A typical EXT IN signal would be a TTL or NIM logic pulse, approximately **+5V** and 100 nsec to 500 nsec wide. The EXT IN signal can'be used to trigger the TC **178P** from **a** random source or to synchronize several TC **178Ps** by use of an external generator or synch'ronixe several TC **178Ps** to a master TC 178P.

4.0 OPERATING PROCEDURES

4.1 FIRST-TIME OPERATION

Users will find **it helpful** to familiarize themselves with the TC 178 QUAD' PREAMPLIFIER and TC **178P** QUAD PULSER by conducting a few simple tests.

4.1.1 **EQUIPMENT** REQUIRED

1. NIM Bin and Power **Supply (TENNELEC TB3/TC** 911 or equivalent).
2. Oscilloscope (TEKTRONIX 465 or equivalent).
3. Shielded 50 ohm cables with **BNC** connectors;
4. BNC **TEEs** and 50 ohm terminators.
5. Vacuum chamber (TBNNELEC TV-l or equivalent).

6. Charged Particle detector (TENNELEC Surface Barrier Detector, or equivalent, size not critical).

7. Alpha source such as Am^{241} or Po^{210}.

8. High Voltage Bias Supply (TENNELEC TC 908 or equivalent).

9. Shaping Amplifier (TENNELEC TC 243 or equivalent).

10. Multichannel Analyzer (NUCLEUS Spectrum 88 or equivalent).

4.1.2 INITIAL TEST SETUP

Set the TC 178 controls as follows:

RANGE	0.1 GeV
RISETIME	FULLY COUNTERCLOCKWISE (use insulated screwdriver)
DC OFFSET	NO ADJUSTMENT REQUIRED
PULSER POLARITY	NEG

Set the TC 178P controls as follows:

RATE	1.0k
MULT	10.0
PULSE AMPLITUDE (CHANNEL A - D)	10.0
ON/OFF (CHANNEL A - D)	ON

Set the OSCILLOSCOPE controls as follows:

VERTICAL MODE	CH1
CH1 VERT SENS	0.5V/DIV (dc-coupled)
HORIZ SWEEP	50 nsec/DIV
TRIGGER	AC/NORM/EXT/+

The TC 243 is' used as a source of preamplifier power in this test and the control settings are not important.

Connect the TC 178 power cable to the TC 243 preamplifier power connector.

Install the TC 178P and TC 243 in the NIM Bin and Power supply and apply power.

Connect the equipment as shown in Figure 4.1.

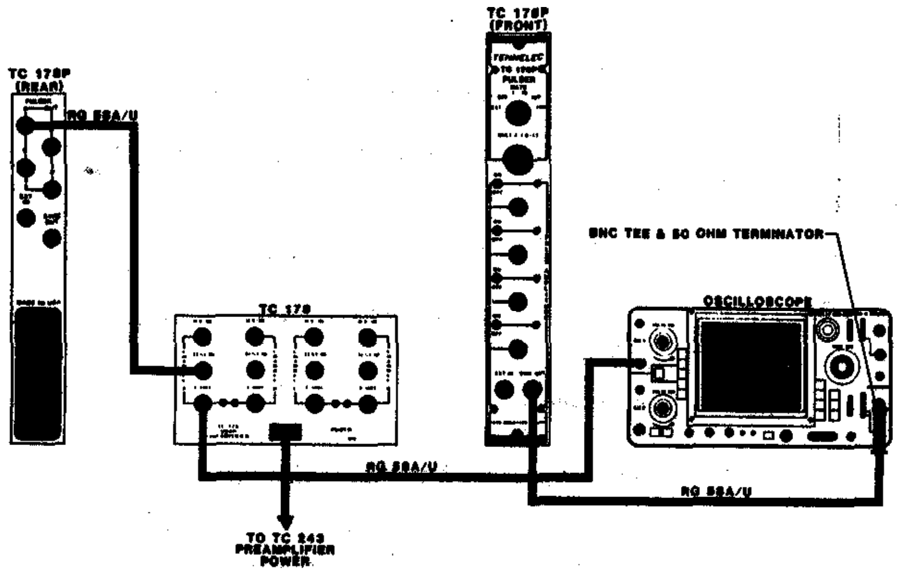


Figure ~4.1 Initial Test Setup

Observe a waveform on the OSCILLOSCOPE similar to Figure 4.2. Vary the RISETIME control (use an insulated blade screwdriver) for best transient response. The amplitude of the waveform should be +1.9 to +2.1V. If the amplitude is outside these limits, use the 0.1 GeV PULSER CALIBRATION control to obtain a +2.0V amplitude (use an insulated blade screwdriver).

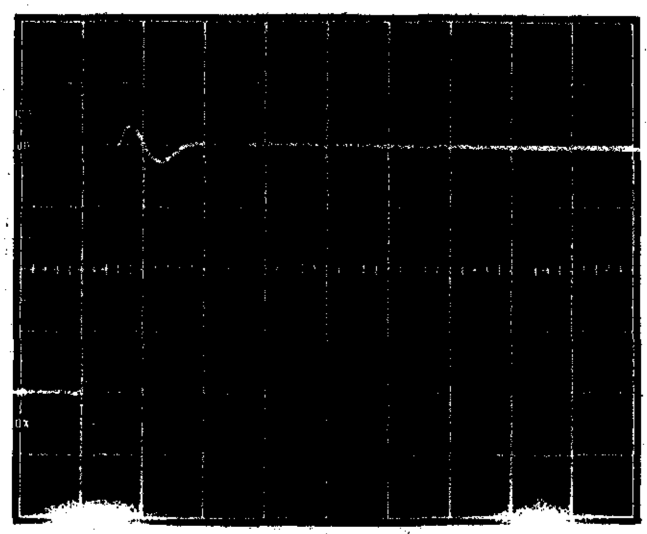


Figure 4.2 Typical TC 178 Output, 0.1 Gev Range

Set the TC 178 **RANGE switch** to 1.0 **GeV** and adjust the **RISETIME** control (use **an insulated** blade screwdriver) **for** best **trancient** response. The waveform should be similar to *Figure* **4.3** and the amplitude. should be **+1.9** to **+2.1V.** If the amplitude is outside these limits, uae the 1.0 **GeV** PULSER **CALIBRATION** control to obtain a **+2.0V** amplitude **(use an insulated blade** screwdriver).

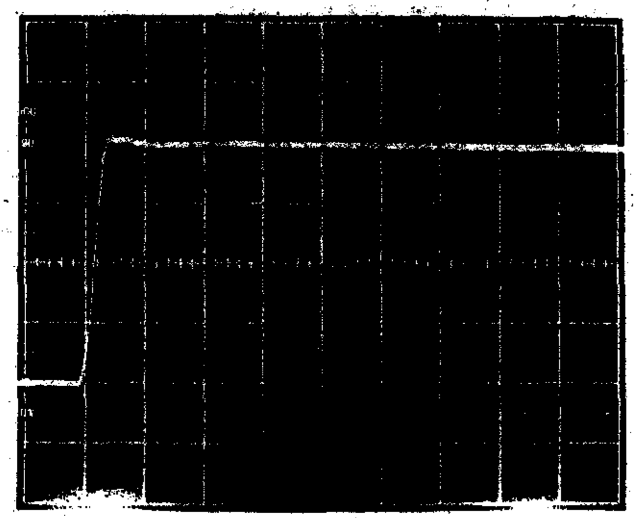


Figure 4.3 Typical **TC 178** Output, **1.0 GeV** Range

Set the TC **178** RANGE switch **to 10 GeV and adjust** the **RISETIME** control (use an **insulated blade** screwdriver) for best tranaient response. 'The waveform should be **similar** to Figure 4.4 and the amplitude should be **+1.9** to **+2.1V.** If the amplitude is **outside** these limits, uae the 10 **GeV** PULSER **CALIBRATION** control to obtain a **+2.0V** amplitude **(use an insulated** 'blade screwdriver).

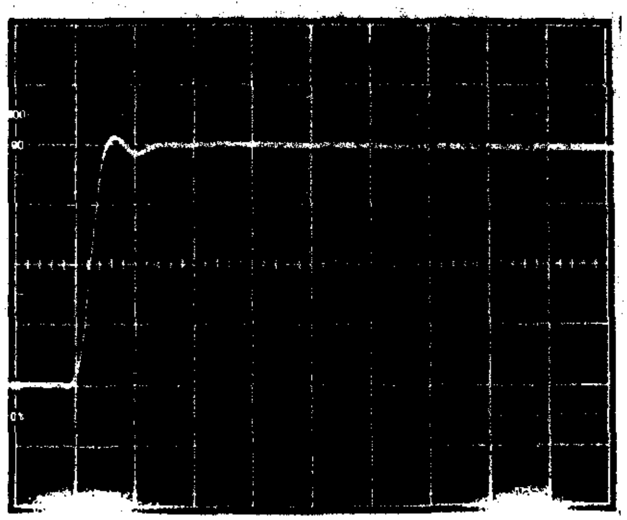


Figure **4.4 Typical TC** 178 Output, 10.0 **GeV** Range

The RISETIME, control has 'greater range. and is more sensitive for the 1.0 GeV and 10 GeV energy ranges. The risetime'range can be verified f.or a detector and cable combination by installing a coaxial cable of the same length used to connect the detector and preamplifier and 'a capacitor that represents the equivalent detector capacitance on the TC 178 INPUT. This will allow easy evaluation of any problems associated with cable length between the detector and preamplifier.

By decreasing the TC 178P PULSE AMPLITUDE control, the trigger point of the TC ,178 E OUT LEDs can be verified. This level should occur at approximately 2% of full scale. Full scale is 0.1, GeV, 1.0 GeV and 10 GeV and the energy of the test pulse is indicated by the PULSE AMPLITUDE dial.

The response of the TC 178 is optimized for output signals in the positive direction. However, operation in the negative direction is 'easily verified by changing the TC 178 PULSER POLARITY to positive (PGS). The internal pulser is optimized f'or use in the NEG position (positive preamplifier output). The negative transient response of the TC 178, using the internal pulser in the POS position, will not be as accurate as the TC 178 positive transient response. To properly evaluate the transient response in either direction, an external pulser 'and test capacitor should be connected to the TC 178 INPUT.

NOTE: The internal pulser of the TC 178 provides a rectangular pulse. The initial edge is used as the input pulse. The trailing edge of the rectangular pulse will produce an output pulse of the opposite polarity of the initial output pulse. The trailing edge pulse will occur approximately 40 usec after the leading edge.

4.1.3 PULSBR CALIBRATION

To properly calibrate the TC 178 pulser requires a detector amd radioactive with either a primary peak such as Am^{241} or a monoenergetic source such as Po^{210}. The use of natural alpha sources will only allow calibration on the lower 10% of the 0.1 GeV range.

When the TC **178** and TC 178P are used at higher energy8 a8 with an accelerator, the ability **to calibrate** to a beam energy will allow greater flexability in verifying overall system calibration.

4.2 **ADJUSTMENTS**

4.2.1 **TC** 178

4.2.1A DC OFFSET VOLTAGE

Each **channel of** the TC 17.8 has anadjustmentfor thedc **offset** voltage as **measured** at the TC 178 E **OUT.** The DC OFFSET adjustment of the TC 178 is accessible through a **hole (one** per channel) in the preamplifier case. This hole is normally covered with a press-fit **plug** to reduce electrical pickup. The. DC OFFSET potentiometer is R23 a8 shown **on the** TC 178 schematic included in **this** manual, **This adjustment** affect8 the drain current of the input FET **(Q1)** and therefore the noise performance.

To. ensure the optimum **noise performance,** the DC offset should be adjusted for -100 **mV** as measured at the energy output connector. This measurement is made with the energy output connector unterminated. The DC offset voltage of the TC 178 is adjusted **to** -100 **mV (±50 mV)** before leaving the factory and should not require further adjustment unless the input **FET** is replaced.

4.2.1B **RISETIME**

Each channel of the **TC 178** has **arisetime** adjustment. ALWAYS USE AW **INSULATED** SCREWDRIVER (either plastic shaft or covered metal **shaft).** The **risetime** adjustment correspond8 to **R21 on** the TC 178 schematic. To obtain optimum transient response and timing performance, the **risetime** adjustment must be set with the detector (or an equivalent detector capacitance) and any connecting cable connected **to the** preamplifier input and bias applied (if an equivalent detector capacitance is used in place of the **detector,** no high voltage bias is **necessary).** When **minimumrisetime** is obtained, a short period overshoot of 10% **to** 20% will be observed. This overshoot ha8 **no effect** on noise performance or linearity within the normal dynamic range.

Additionally, the overshoot will have no adverse affect on timing measurements. Further improvement in timing performance can be obtained by adjusting the risetime control for a shorter risetime and mote overshoot. The increased overshoot will be accompanied, by some ringing which limits the minimum risetime. Some ringing can be tolerated if the discriminator has an adjustable deadtime control.

NOTE: Detector inductance has a very important bearing on preamplifier signal risetime and circuit stability. It is essential when operating the preamplifier for the first time to match it to the specific detector characteristics. To do this, connect a fast oscilloscope to the output of the preamplifier and excite the detector with a weak radiation source that generates only one spectral line. Po^{210} is a good source for this purpose with 'room temperature silicon detectors. The oscilloscope should have a bandwidth of 250 MHz or more, and should be triggered internally. A continuously changing ensemble of randomly occurring pulses will be seen, making observation of the pulse difficult. Unfortunately, not much can be done about this.

The adjustment is made by turning the risetime control to obtain the optimum balance between ringing and risetime.

Depending on the equivalent circuit of the detector, some settings may cause oscillation. This is normal. A stubborn case of oscillation indicates excessive detector inductance or connecting cable length. If the oscillation is difficult to eliminate, or elimination results in slower than expected risetime, it is recommended that the connecting cable be reduced to as short as practical. The TC 178 normally will be stable with up to 10 feet of cable between detector and preamplifier.

Typical risetime versus detector capacitance is shown in Section 2.1. Due to the fast risetimes of the TC 178, it is recommended that a pulser and oscilloscope with 1 nsec or less risetime be used to check and adjust the transient response when not using a detector and source. The actual preamplifier risetime (t_{rpa}) is

$$t_{rpa} = (t_{ra}^2 - t_{rb}^2)^{1/2}$$

where t_{ra} is the risetime of the preamplifier, pulser and oscilloscope, and trb is the risetime of the pulser and oscilloscope only., By using the equation given above, the risetime contributions of the pulser and oscilloscope can be removed. All risetime specifications apply when the output is terminated in its characteristic impedance (50 ohms).

4.2.1C PULSER CALIBRATION

The TC 178 QUAD PREAMPLIFIER is shipped with the PULSER CALIBRATION controls set to deliver nominally +2.0V E OUT pulses for a 10.0V (Full Scale) setting on the TC 178P PULSE AMPLITUDE control (TC 178 PULSE POLARITY set to NEG.). This setting (in terms of energy) should be within ±5% for the selected energy range. The largest error will be for the 0.1 GeV range as stray feedback capacitance and feedback capacitor tolerance represent a larger percentage error for this range. The TC 178 PULSER CALIBRATION can be accomplished by either of two methods. One method requires a source of known energy and a detector., The energy should be greater than 10% of the full scale range to allow for greater accuracy in calibration (minimum energy of 10 MeV, 100 MeV and 1 GeV). The second, and more practical, requires injecting a known amount of charge into the input of the TC 178 and adjusting the TC 178 PULSER CALIBRATION for a corresponding output amplitude. The actual preamplifier output voltage or a shaped signal can be ueed for the adjustment. For instance, given a 1pF 'test capacitor, 'to inject a charge equivalent to 10 MeV (Si) requires a 0.439V signal, 100 MeV (Si) requires a 4.39V signal. To generate a 1.0 GeV signal, a test capacitor of 10pF requires a 4.39V signal. The 10 GeV signal *can* be simulated by using a 100pF test capacitor and a signal voltage' of 4.39V. Use of test capacitors over 100pF are not recommended. The smaller the test capacitor, the less are the effects on transient response and noise. The use of a nonmetallic screwdriver is recommended for adjusting the PULSER CALIBRATION control. The controls are accessible from the bottom of the TC 178 and the proper sequence of adjustment is 0.1 GeV, 1.0 GeV, and 10 GeV. There is some interaction and the adjustment sequence should be repeated until sufficient accuracy is obtained.

4.2.2 Tc 178P

No user adjustments, other than front panel controls, are required.

'5.0 NOISE

NOISE PERFORMANCE

To convert from full-width-at-half-maximum (FWHM) Si to a different reference, use Table 1.

TABLE 1

CONVERSION OF FWHM Si TO OTHER REFERENCE VALUES

Reference	Multiply eV FWHM Si by:
FWHM Si	1.00 (W=3.6 eV/electron-hole pair)
FWHM Ge	0.819 (W=2.95 eV/electron-hole pair)
FWHM P10	6.94 (W=25 eV/electron-hole pair)
Ion pairs rms	0.144
Coulombs rms	2.3 x 10^{-20}

'The noise performance of the TC 178 for a peaking time of 1.0 usec and 4.0 usec is given in Section 2.1. The noise performance of the TC 178 at var'ious shaping times and detector load resistance, with and without the protection network, is shown in Figures 5.1 through 5.3. With the aid of this data, the noise performance of the preamplifier can be predicted for almost any combination of detector capacitance and shaping time. It is stressed that the foregoing figures are noise levels and not spectral resolution. The final spectral resolution depends not only'-on the preamplifier noise but also on the type of detector used, the count rate, and other factors. An additional consideration in evaluating preamplifier noise limitations is the detector leakage current. All the previous noise data is representative of the preamplifier detector combination with zero detector leakage' current.

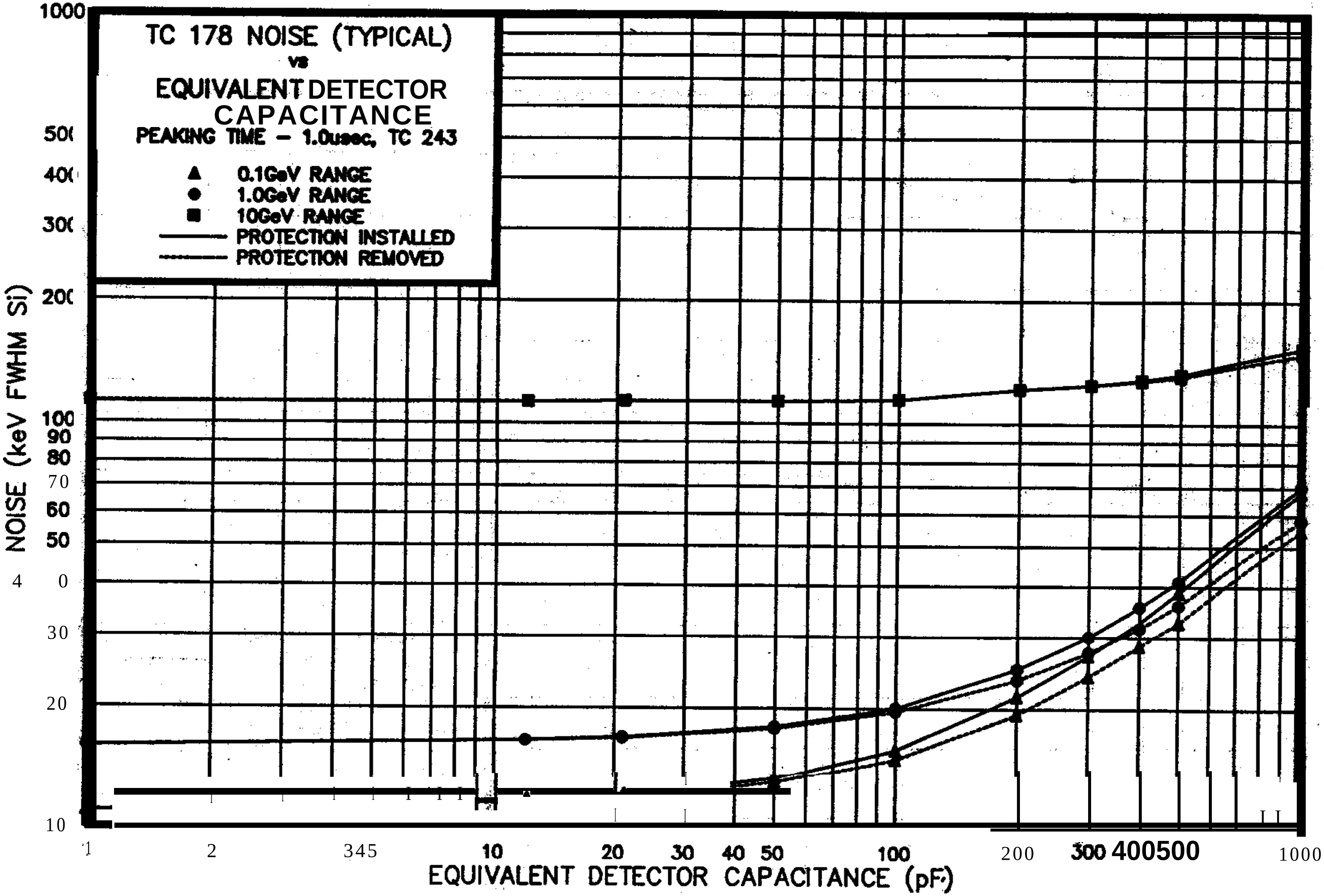


Figure 5.1 Electronic Noise vs Equivalent Detector Capacitance

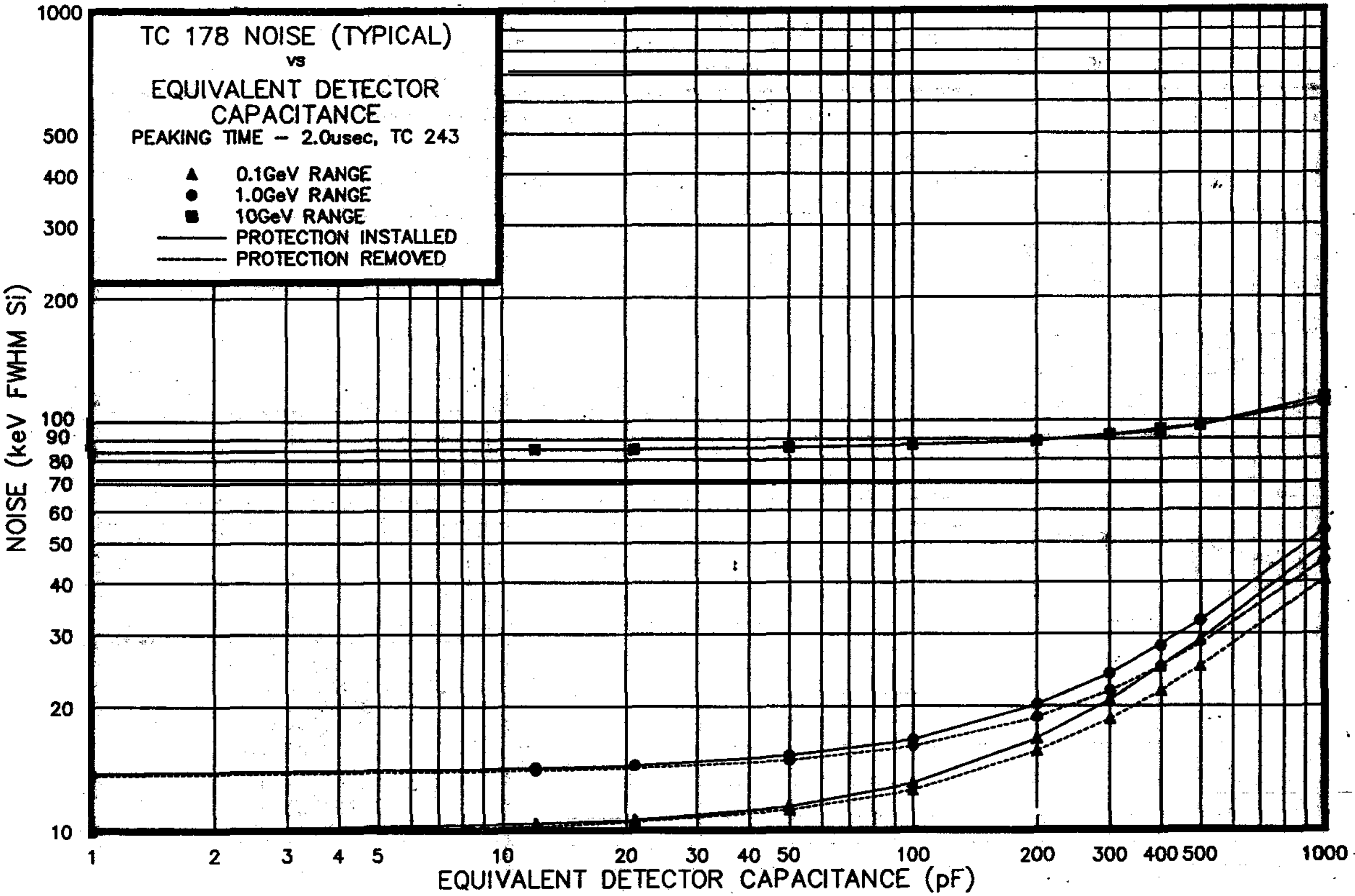


Figure 5.2 Electronic Noise vs Equivalent Detector Capacitance

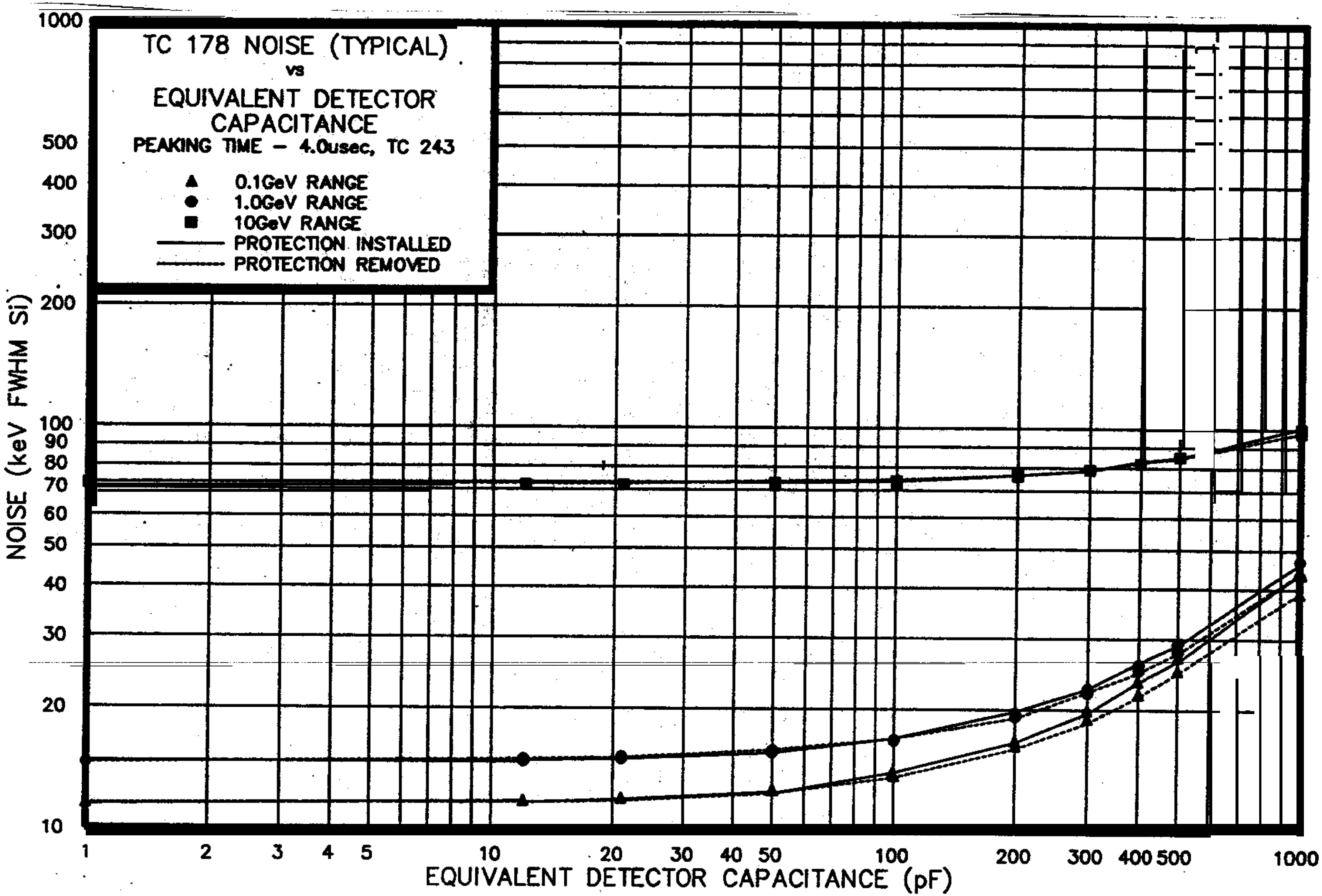


Figure 5.3 Electronic Noise vs Equivalent Detector Capacitance

5.2 NOISE MEASUREMENTS

To verify the proper operation of the preamplifier, *noise* measurements can be made by either of two methods. These measurements can be compared with the values given in Section 2.1 and Figure 5.1 through 5.3.

One method requires a calibrated step-generator (e.g. TENNELEC TC812), a shaping main-amplifier (TC 205A, TC 240, TC 241, TC 242, TC 243, or TC 244), and a multichannel pulse height analyzer. After the shaping time constant has been chosen and the analyzer has been calibrated in terms of energy per channel, pulses are fed through the test' capacitor and the line width recorded by the analyzer is measured. For this test, as for any measurement of absolute noise of the preamplifier, the detector should be replaced by a dummy capacitor of the same capacitance. The FWHM of the line should be close to th,e values given in Section 2.1 for typical performance and the typical data given in Figures 5.1 through 5.3. If the noise at 4.0 usec peaking time exceeds the guaranteed values given in Section 2.1, verify that the correct detector load resistor is installed.

The second method requires the use of a' calibrated pulse generator, a shaping main-amplifier, an average-type ac voltmeter (such as a Hewlett-Packard 400D, 400H, or 400L) or a true rms voltmeter (such as a Hewlett-Packard 3400A), and a calibrated oscilloscope. A step of known amplitude V_i is applied to the input. through the test capacitor C_T, resulting in a charge transfer to the input of $V_i \times C_T$ coulombs. The resulting main-amplifier pulse height V_o is recorded with the oscilloscope. The pulse generator is then turned off, *and* the true rms noise level V_n is *measured* at the output of the main amplifier; If a true rms voltmeter is used, the reading is directly V_n. If an average-type voltmeter is used, the reading V should be multiplied by the factor 1.128 to obtain V_n. The level in keV FWHM referred to Si detectors is given by

$$\text{Noise (FWHM)} = \frac{V_n \times V_i \times C_T}{V_o} \times 5.298 \times 10^{16}$$

where 5.298×10^{16} is a factor that contains the charge of an electron in coulombs, the energy necessary to produce one election-hole pair in silicon, and the conversion constant between rme and FWHM.

For detectors, other- than silicon, choose the appropriate, multiplier, from Table 1.

If **a problem with** excessive: **noise should occur, either** of. the two **procedures described should be** used to evaluate the noise **performance.** The preamplifier noise performance can **be** verified **by** replacing **the detector with a** suitable capacitor having: **the** same capacitance value. as the **detector.** If this:, noise is. within specifications at 4.0 **usec** -peaking **time,** or **similiar** to data given in section 5.1, the **problem is** associated with the detector. **The** total noise of the system is given by

$$N_{total} = [(N_{preamplifier})^2 + (N_{detector})^2]^{1/2}.$$

Using **the** 'above **equation and** the noise **of** the **preamplifier** (as previously determined) the noise of **the** detector oan be calculated and compared with the manuf**acturer's** data.

6.0 COUNT RATE EFFECTS

6.1 RESOLUTION

The shape of a typical spectral line is **Gaussian** as shown in **Figure** 6.1.

The **resolution,** or **ability of a** nuclear spectrometer to **separate** different **radiation energies, is** usually **expressed** in terms **of the full** width of the spectral lines **measured** at **half their** maximum height. This quantity is denoted by the letters **FWHM** and is given in units **of** energy. The **FWHM is 2.35 σ** where, **σ is** the **standard** deviation. **If noise alone** controls the **resolution,** then **σ and** the **rms** noise level are synonymous. We have **been using FWHM to characterize preamplifier** noise levels' **in** the **previous section.**

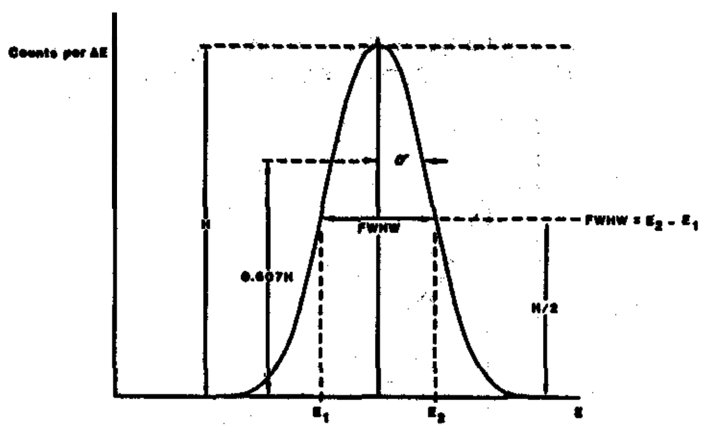


Figure 6.1. The shape of a typical spectral line (Gaussian).

The resolution obtained in any particular spectral measurement is the result of several factors: preamplifier noise, detector characteristics, count rate, radiation energy, overall system stability, proper interfacing between instruments within the system, etc. In an experimental situation in which the count rate is low enough so that the pulse shape can be adjusted for the best signal-to-noise ratio without being affected by pile-up or -baseline shift but high enough so that effects due to long term drifts can be neglected, the resolution will be determined by three factors: (a) detector resolution for the particular radiation 'energy being observed, (b) electronic noise, and (c) interfacing. Furthermore, if it is assumed that the different components of the system are properly matched, the line-width is a function of only the detector resolution and the electronic noise. The two noise components are related in the following way:

$$R^2 = (\text{Total Resolution})22 = (\text{Detector Resolution})^2 + (\text{Electronic Noise})$$

We shall call R the intrinsic resolution of the system. In a counting situation in which the conditions are not ideal, the measured resolution will be worse than the intrinsic resolution. Usually, the main factor in line-width broadening is count rate. Count rate can have a deleterious effect in spectral resolution through several mechanisms. The three most commonly found are pile-up of pulses, baseline shifts, and thermal effects in components. The last two can ueually be neglected in properly designed systems; the first one is more difficult to contend with.

Usually, pile-up of shaped pulses in the main amplifier will set the practical upper count, rate limit. However, at very high energy (lowest gain settings of the main amplifier), the limitation may occur in the preamplifier. A discussion of preamplifier pile-up follows, plus the technique of computing the upper count rate limit. The pulse obtained at the output of the preamplifier appears as shown in Figure 6.2.

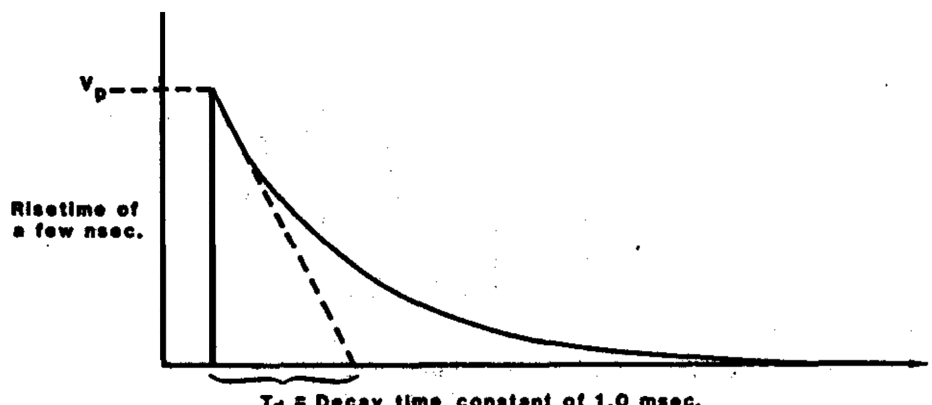


Figure 6.2 Pulse Shape at the Output of a Preamplifier

When pulses come in rapid succession, the wave form at the output of the preamplifier appears as shown in Figure 6.3. The dotted line at the top of Figure 6.3 indicates the limit of the linear range of the preamplifier.

If the count rate is high enough, some of the pulses will rise beyond the linear range and therefore, their amplitudes will be distorted. (The meaning of "linearity" is explained in Section 6.2.) If we assume 10V to be the limit of the linear range, the preamplifier sensitivity to be 20 mV/MeV, the average radiation energy to be 100 MeV, and the decay time constant to be 50 usec, we can compute the count rate that will be necessary to make 5% of the pulses fall beyond the linear range from the formula

$$\text{where} \quad n = \frac{2}{T_d}\left[\frac{V_m - E\,G_c}{2.5\,E\,G_c}\right]^2$$

n = count rate in cps.
T_d = decay time constant in sec.
V_m = linear range in volts
E = radiation energy in MeV
G_c = preamplifier sensitivity in V/MeV.

Replacing symbols by actual numbers,

$$n = 102 \times 10^3 \text{ cps @ } 100 \text{ MeV}$$

Since the TC 178 charge loop is ac-coupled, a count-rate product cannot be assigned with any useful units as the number would apply only for one specific energy. The minimum count rate at full scale for each range of the TC 178 is given in Section 2.1.

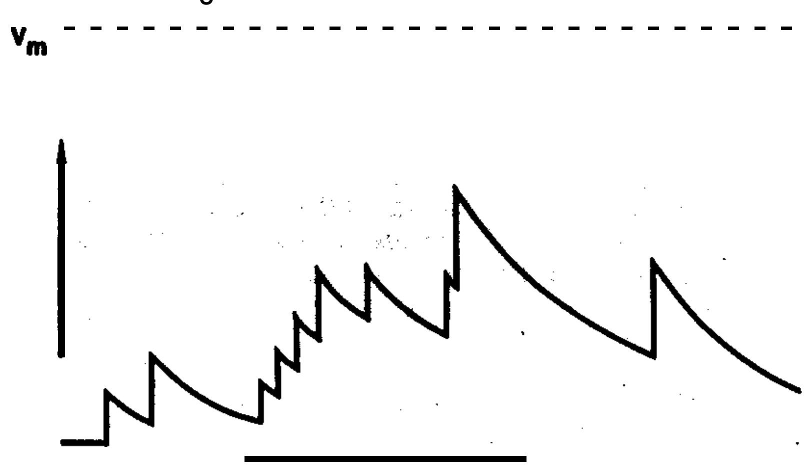


Figure 6.3 The Waveform at the Output of a Preamplifier with Pulser Applied to the Input in Rapid Succession

6.2 NONLINEARITY

If a graph of output, signal level V_o vs. input pulse height: V_i (dynamic characteristic) is drawn, a perfectly straight line passing through the origin should result. In practice, the dynamic characteristic could have a slight curvature up to a certain signal level, beyond which the curvature increases drastically. The onset of this drastic change is usually considered to be the upper limit of the normal dynamic range (rated. output).

Integral nonlinearity is defined as the maximum deviation of the measured preamplifier response from the ideal response, expraesed as a percentage of the rated output (as described in the preceding. paragraph). This definition is useful only for isolated preamplifier pulses as shown in Figure 6.2. When pileup occurs as the result of anansemble of closely spaced small pulses (Figure 6.3), we are interested not only in the integral nonlinearity but also in the deviation of height of individual steps (within the 'linear' range of the preamplifier) from the expected height. This incremental deviation in $\Delta V_o/\Delta V_i$ from the value at zero volts on the dynamic characteristic is described as the differential nonlinearity. It is this definition which is used in the table of specifications.

7.0 PREAMPLIFIER MODIFICATIONS

REMOVING THE CASE

Remove the 24 press fit plugs, the four mounting screws on the bottom of the case, and carefully remove the preamp from the case.

7.1 CHANGING PREAMPLIFIER SENSITIVITY

Reducing the preamplifier sensitivity will almost certainly cause it to oscillate unless the stabilization networks are changed as well. For this change the user is requested to return the instrument, to TENNELEC for modification. In&easing the sensitivity will not cause oscillation, but may degrade the risetime and pulse shape,

7.2 FRONT-END MODIFICATIONS

The TC 178 is supplied with one 1 megohm resistor for the detector load resistor and two 1 megohm resistors in the detector bias voltage filter network. If these values are not appropriate (too low), the 1 megohm detector. load resistor should be increased. Do not increase the detector bias voltage filter network resistors.

If any resistors in the detector bias network are changed, it is very important that all solder joints in the high voltage chain be smooth-surfaced and have no protruding sharp points. Furthermore, it is important that all capacitors and high megohm resistors used in this part of the circuit be free of surface contamination. Components that are contaminated can cause increases in preamplifier noise, leakage current, noise spikes from arcing, etc.

7.3 MODIFICATION OF FET DRAIN CURRENT

The FET drain current of the TC 174 can be changed by adjusting R8. However, this will affect the dc offset, which should never be set to less than -50 mV. The normal dc offset voltage is -100 mV, which, is close to the value resulting from operating the input FET near I_{dss}. Best noise performance is obtained at or near the I_{dss} level.

7.4 ELECTRONIC NOISE REDUCTION

The noise performance of the TC 178 can be changed significantly by eliminating the series protection resistor, increasing the detector load to 10 megohm, and changing the feedback resistor to a higher value such as 100 megohm. Changes of this nature are best performed at TENNELEC.

8.0 SHIPPING DAMAGE

Upon receipt of the instrument, examine it for shipping damage. Damage claims should be filed with the carrier. The claims agent should receive a full report: a copy of that'rtport should be sent to TENNELEC, Inc., P.O. Box 2560, Oak Ridge, Tenneeaee 37830-2560. The model number -and serial number of the instrument must be included in the report. Any remedial action taken by TENNELEC, Inc., will be based on the information contained 'in this report.

9.0 SERVICING

In the event of a component failure, replacement may be done in the field or the instrument may be returned to our plant for repair. There will be no charge for repairs that fall within the warranty.

10.0 WARRANTY

In connection with TENNELEC's warranty (inside front cover), TENNELEC suggests that if a fault develops, the customer should immediately notify the' TENNELEC Customer Service Manager. He may be able to prescribe repairs and send replacement parts which will enable you to get the instrument operating sooner and at less expense than if you returned it.

Should return prove necessary, the TBNNELEC Customer Service Manager must be informed in WRITING, BY CABLE or TWX of the nature of the fault and the model number and serial number of the Instrument. Pack the instrument, well and ship PREPAID and 'INSURED to TENNELEC, Inc., 601 oak Ridge Turnpike, Oak Ridge, Tennessee 37830-2560. As stated in the warranty DAMAGE IN TRANSIT WILL BE REPAIRED AT THE SENDER'S EXPENSE as will damage that obviously resulted from abuse or misuse of the instrument.

Quotations **for** repair of such damage will be sent for your approval before repair is undertaken.

* *

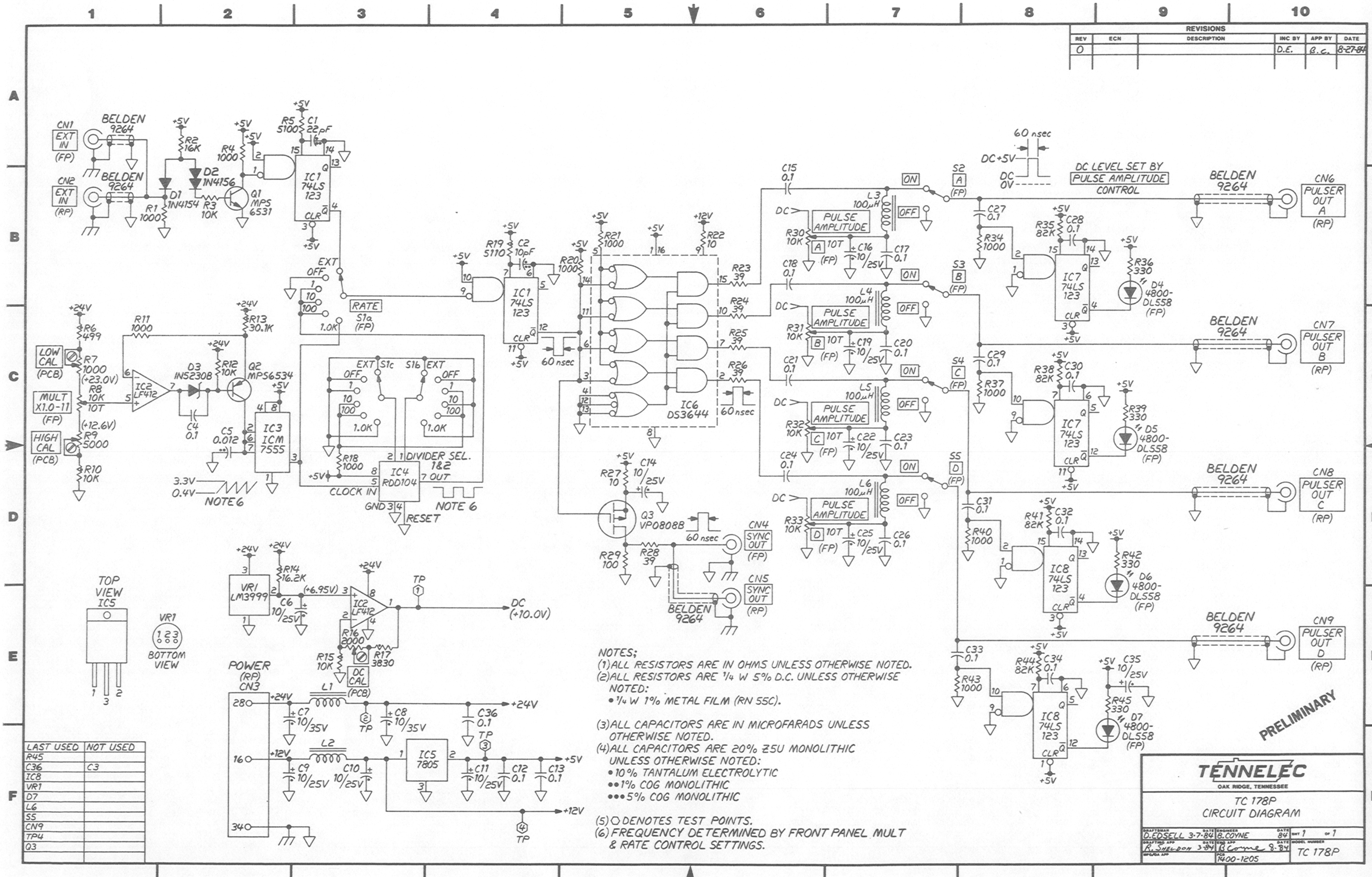
TENNELEC'S Quality Assurance Program requires that each and every instrument be fully aged, vibrated, and electronically checked.

Should the user require a copy of the **Quality** control Procedure and Test Record, **please** call the Customer Service **Department** of TENNELEC. Both model number and Serial number are required.

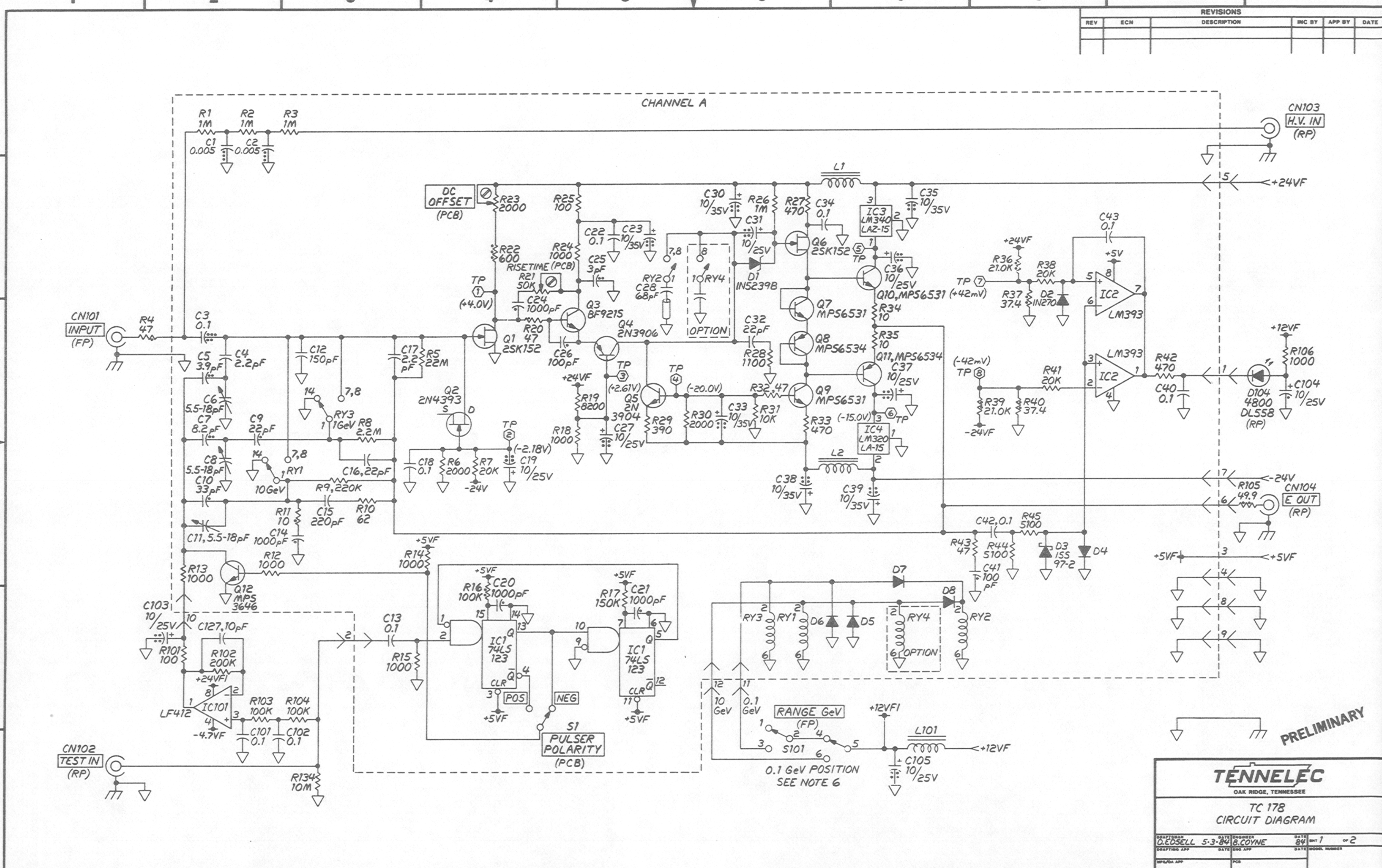
* *

NANUAL REF.'. 0

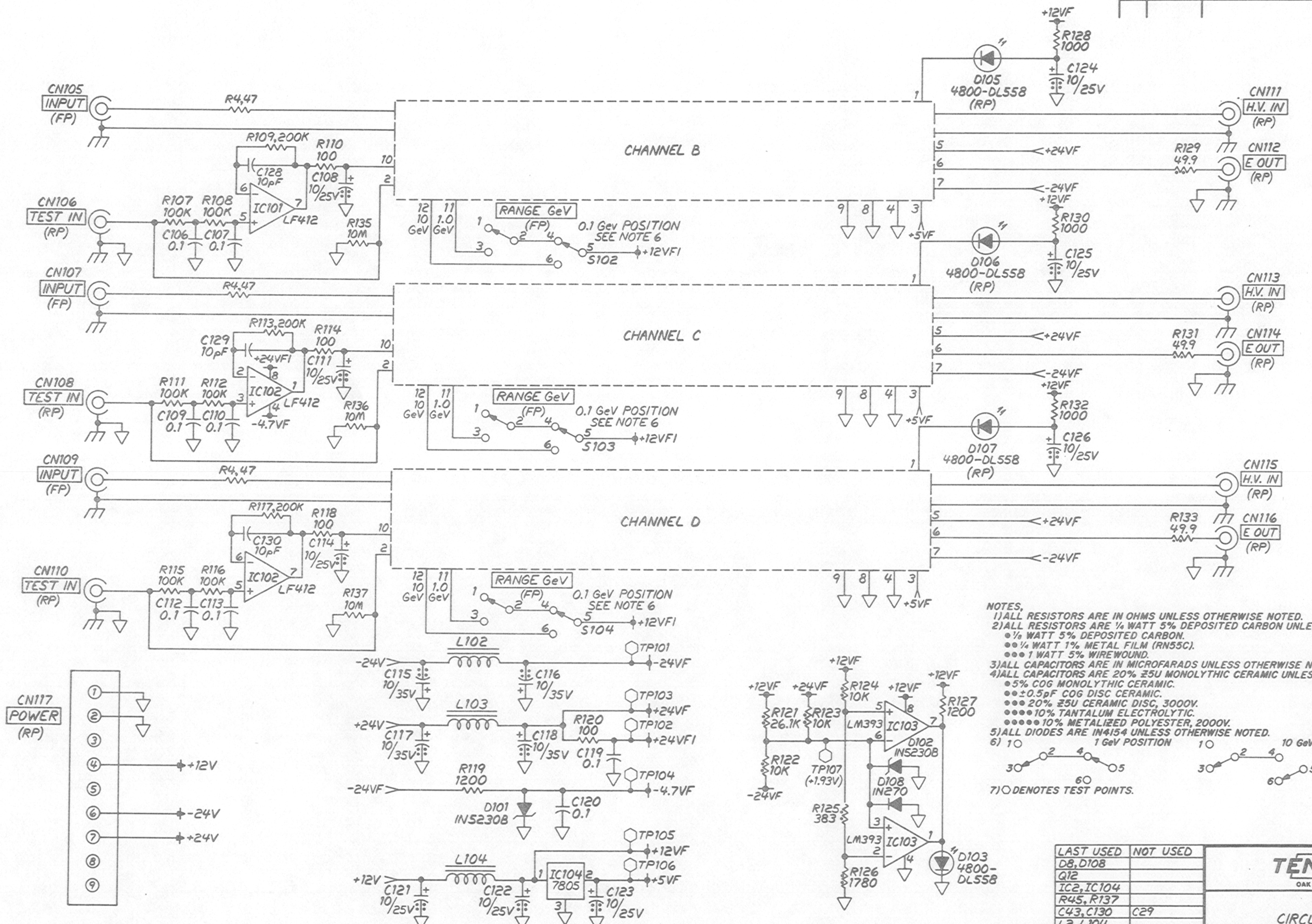
3/85 - Engineering and component improvements may be made after date of printing.



REVISIONS
REV | ECN | DESCRIPTION | INC BY | APP BY | DATE
0 | | | D.E. | B.C. | 8-27-84
BELDEN 9264
CN1 EXT IN (FP)
CN2 EXT IN (RP)
CN6 PULSER OUT A (RP)
CN7 PULSER OUT B (RP)
CN8 PULSER OUT C (RP)
CN9 PULSER OUT D (RP)
CN4 SYNC OUT (FP)
CN5 SYNC OUT (RP)
LOW CAL (PCB)
HIGH CAL (PCB)
MULT X1.0-11 (FP)
RATE S1a (FP)
DIVIDER SEL. 1&2
CLOCK IN
RESET
NOTE 6
PULSE AMPLITUDE
DC LEVEL SET BY PULSE AMPLITUDE CONTROL
60 nsec
DC (+10.0V)
DC CAL (PCB)
POWER (RP) CN3
TOP VIEW IC5
VR1 BOTTOM VIEW
IC1 74LS 123
IC2 LF412
IC3 ICM 7555
IC4 RDD104
IC5 7805
IC6 DS3644
IC7 74LS 123
IC8 74LS 123
VR1 LM3999
Q1 MPS 6531
Q2 MPS6534
Q3 VP0808B
D1 1N4154
D2 1N4156
D3 1N5230B
D4 4800-DL558 (FP)
D5 4800-DL558 (FP)
D6 4800-DL558 (FP)
D7 4800-DL558 (FP)
NOTES;
(1)ALL RESISTORS ARE IN OHMS UNLESS OTHERWISE NOTED.
(2)ALL RESISTORS ARE 1/4 W 5% D.C. UNLESS OTHERWISE NOTED:
•1/4 W 1% METAL FILM (RN 55C).
(3)ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
(4)ALL CAPACITORS ARE 20% Z5U MONOLITHIC UNLESS OTHERWISE NOTED:
•10% TANTALUM ELECTROLYTIC
••1% COG MONOLITHIC
•••5% COG MONOLITHIC
(5)○ DENOTES TEST POINTS.
(6)FREQUENCY DETERMINED BY FRONT PANEL MULT & RATE CONTROL SETTINGS.
LAST USED | NOT USED
R45 |
C36 | C3
IC8 |
VR1 |
D7 |
L6 |
S5 |
CN9 |
TP4 |
Q3 |
PRELIMINARY
TENNELEC
OAK RIDGE, TENNESSEE
TC 178P
CIRCUIT DIAGRAM
DRAFTSMAN D.EDSELL 3-7-84
ENGINEER B.COYNE 84
DRAFTING APP R. SHELDON 3-84
ENG APP B. Coyne 8-84
PCB 1400-1205
SHT 1 OF 1
MODEL NUMBER TC 178P



CHANNEL A
CN101 INPUT (FP)
CN102 TEST IN (RP)
CN103 H.V. IN (RP)
CN104 E OUT (RP)
DC OFFSET (PCB)
RISETIME (PCB)
PULSER POLARITY (PCB)
S1
POS
NEG
RANGE GeV (FP)
S101
0.1 GeV POSITION SEE NOTE 6
OPTION
+24VF
-24V
+12VF
+5VF
LF412
IC101
IC1 74LS 123
IC2 LM393
IC3 LM340 LAZ-15
IC4 LM320 LA-15
Q1 2SK152
Q2 2N4393
Q3 BF921S
Q4 2N3906
Q5 2N 3904
Q6 2SK152
Q7 MPS6531
Q8 MPS6534
Q9 MPS6531
Q10, MPS6531
Q11, MPS6534
Q12 MPS 3646
D1 IN5239B
D104 4800 DL558 (RP)
PRELIMINARY
REVISIONS
REV
ECN
DESCRIPTION
INC BY
APP BY
DATE
TENNELEC
OAK RIDGE, TENNESSEE
TC 178
CIRCUIT DIAGRAM
D.EDSELL 5-3-84
B.COYNE



NOTES,
1) ALL RESISTORS ARE IN OHMS UNLESS OTHERWISE NOTED.
2) ALL RESISTORS ARE ¼ WATT 5% DEPOSITED CARBON UNLESS OTHERWISE NOTED:
- ● ⅛ WATT 5% DEPOSITED CARBON.
- ●● ¼ WATT 1% METAL FILM (RN55C).
- ●●● 1 WATT 5% WIREWOUND.

3) ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
4) ALL CAPACITORS ARE 20% Z5U MONOLYTHIC CERAMIC UNLESS OTHERWISE NOTED:
- ● 5% COG MONOLYTHIC CERAMIC.
- ●● ±0.5pF COG DISC CERAMIC.
- ●●● 20% Z5U CERAMIC DISC, 3000V.
- ●●●● 10% TANTALUM ELECTROLYTIC.
- ●●●●● 10% METALIZED POLYESTER, 2000V.

5) ALL DIODES ARE IN4154 UNLESS OTHERWISE NOTED.
6) 1 GeV POSITION — 10 GeV POSITION
7) ○ DENOTES TEST POINTS.

PRELIMINARY

LAST USED	NOT USED
D8, D108	
Q12	
IC2, IC104	
R45, R137	
C43, C130	C29
L2, L104	
CN117	
S1, S104	
RY3	
TP8, TP107	

TENNELEC
OAK RIDGE, TENNESSEE

TC 178
CIRCUIT DIAGRAM

DRAFTSMAN: D. EDSELL DATE: 5-84 ENGINEER: B. COYNE DATE: 84 SHT 2 OF 2