BNC

Precision Pulse Generator Model PB-4

INSTRUCTION MANUAL

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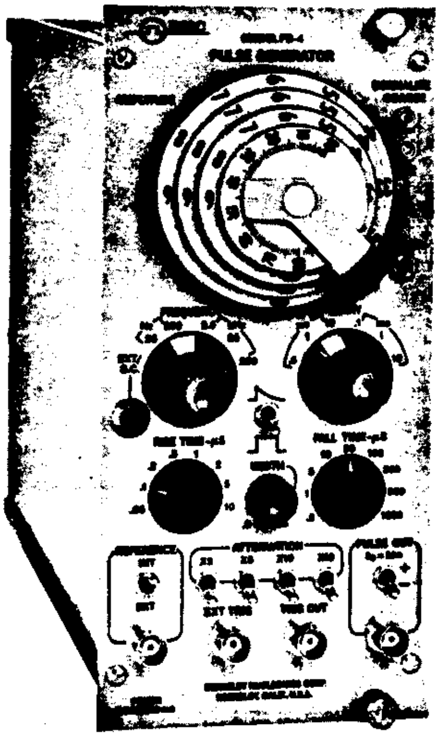
Warranty

Berkeley Nucleonics Corporation warrants all instruments, including component parts, to be free from defects in material and workmanship, under normal use and service for a period of one year. If repairs are required during the warranty period, contact the factory for component replacement or shipping instructions. Include serial number of the instrument. This warranty is void if the unit is repaired or altered by others than those authorized by the Berkeley Nucleonics Corporation.



SECTION 1
SPECIFICATIONS

REPETITION RATE:	2.5 Hz to 250 kHz, continuously variable.
EXTERNAL TRIGGER:	0 to 250 kHz. Requires 1 V, positive pulse, with a rise time of less than 1 ms.
SINGLE CYCLE:	Front panel pushbutton provides one output pulse each time the button is pressed.
DELAY:	0.25 μs to 10 ms, continuously variable. (Delay is time between trigger out and pulse out.)
PULSE SHAPE:	Tail or Flat Top Pulse (by front panel toggle).
TAIL PULSE:	Rise Time (10% - 90%): 0.05 μs to 10 μs, in 8 steps. Decay Time Constant (100% - 37%): 0.5 μs to 1 ms, in 9 steps. Rise and Decay Time independently adjustable for Decay Time/Rise Time < 10.
FLAT TOP PULSE:	Width: 0.5 μs to 25 μs, continuously adjustable. Pulse Top Droop: Less than 0.02% with 10 μs pulse width. Rise and Decay Time: Same as Tail Pulse.

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PULSE TOP:	a) Stability: ±5 ppm/^{o}C of full scale or 20 μV/^{o}C, whichever is greater. This specification holds for unattenuated output. When attenuation is switched in, the ±5 ppm/^{o}C is constant, while 20 μV/^{o}C is reduced by the attenuation factor. b) Integral Nonlinearity: ±0.005% (50 ppm). c) Differential Nonlinearity: ±0.03%. d) Amplitude Jitter (Resolution): 0.001% rms (10 ppm). e) Setability of Pulse Amplitude: 5 ppm. f) Line Voltage Coefficient: Less than 0.5 ppm/V when used with a NIM power supply or Berkeley Nucleonics Portanim Models AP-1 and AP-2.
AMPLITUDE:	0 to 10 V.
NORMALIZE:	Fine and coarse front panel trimmers vary output amplitude by 20%.
POLARITY:	Positive or negative.
ATTENUATORS:	Four toggles with X2, X5, X10, X10 attenuation, 50 Ω impedance.
OUTPUT IMPEDANCE:	50 Ω ±2%.
AMPLITUDE SHIFT WITH DUTY FACTOR:	Less than 0.03% change up to 50% duty factor.
REPETITION RATE AND DELAY JITTER:	Less than 0.05%.
TRIGGER OUTPUT:	2 V positive pulse, 30 ns rise time, 0.1 μs width, 50 Ω output impedance.
EXTERNAL REFERENCE INPUT:	±11 V maximum. Input impedance 1 K. Primary function is to connect with an external ramp generator to provide a sliding pulse train.
POWER REQUIRED:	±24 V at 240 mA.
MECHANICAL DIMENSIONS:	Triple-width AEC module 4.05" wide x 8.70" high in accordance with TID-20893 (Rev. 3).
WEIGHT:	6-1/2 lbs net, 9 lbs shipping.

SECTION 2
OPERATING INFORMATION

2.1 INTRODUCTION

The Model PB-4 is a precision pulse generator designed to test stability, linearity and resolution of nuclear instruments employed in high resolution spectroscopy.

Typical applications of the Model PB-4 include:

a) Use as a reference peak for spectrum stabilization.

b) Testing base line shifts up to 250 kHz.

c) Measuring differential and integral linearity of pulse height analyzers.

d) Measuring noise contributions from preamplifiers.

An unusual feature of the Model PB-4, hitherto unavailable in high rep rate precision pulse generators, is the capability of driving 50 Ω loads without affecting the stability, linearity or pulse shape.

2.2 PRINCIPLES OF OPERATION

Since the Model PB-4 is a high precision instrument, it is well to be aware of the principles of operation to maximize its performance. Refer to the simplified schematic in Figure 1. The 24 V supply provides 17.1 mA of current through R1. Part of this current passes through the reference zener, D1, and the balance passes through the NORMALIZE potentiometer and REFERENCE switch to the AMPLITUDE control. The output of the AMPLITUDE potentiometer is connected to a high-input impedance voltage follower. The output of the voltage follower appears across C1. The voltage across C1 is now sampled by a chopper to produce pulses of stable amplitudes. The chopper closes for a period of time as set by the front panel Tail Pulse / Flat Top Pulse toggle. (If the toggle is in the Flat Top Pulse position, the chopper is closed for a period of

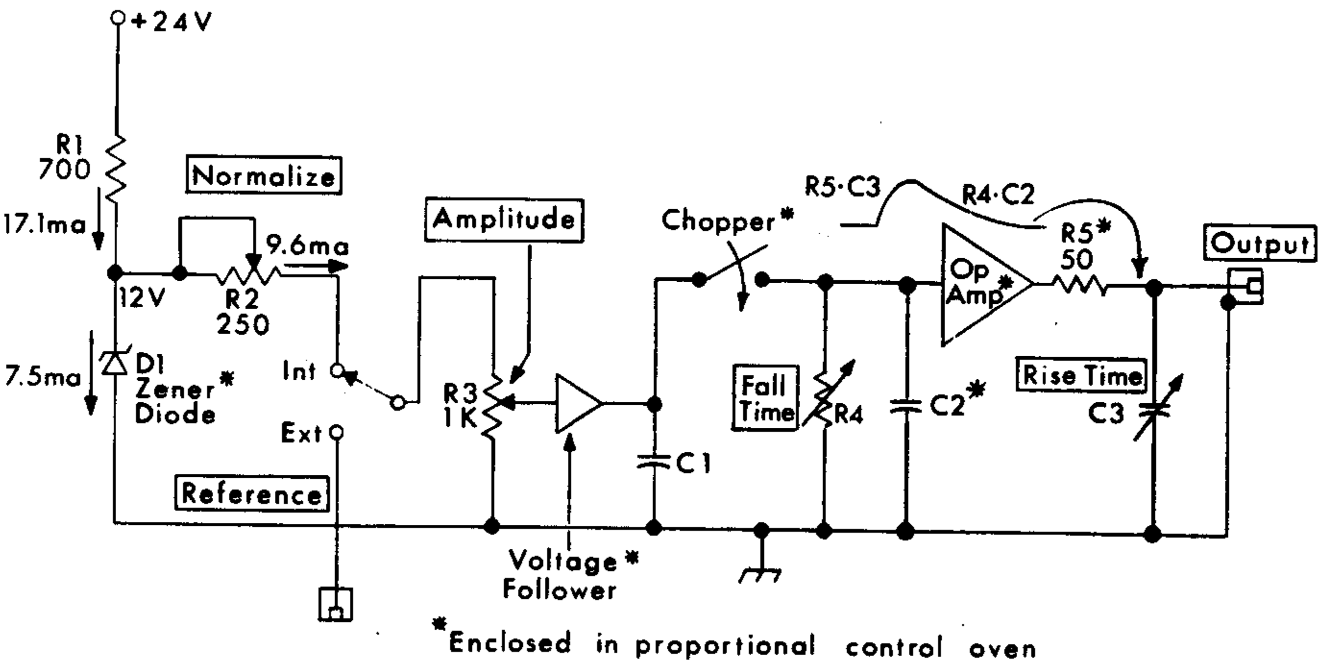

Fig. 1. Simplified Schematic of Model PB-4.

time adjustable from 0.5 - 25 μs. If it is set in the Tail Pulse position, the chopper is closed for 0.1 μs.) The voltage across C1 now appears across C2. The chopper then opens and the charge on C2 decays through R4. The time constant R4-C2 controls the decay time. R4 is adjustable by the front panel FALL TIME control.

The pulse now passes through a high gain, fast slew rate operational amplifier. The input of the amplifier is a high impedance and does not affect the pulse shape or stability. The output of the amplifier then passes through a 50 Ω output resistor, R5, which functions with C3 to provide variable rise time. The value of C3 is adjustable by the front panel control, RISE TIME.

The operational amplifier has the capability of providing 100 mA output current without affecting the linearity and stability specifications of the pulse. This implies the output may be loaded into 50 Ω, but substantially less than this value may cause limiting or degraded specifications.

2.3 FUNCTION OF CONTROLS & CONNECTORS

FREQUENCY:

Concentric six-position switch and potentiometer adjusts repetition rate of output pulses. Black knob selects frequency range; red knob provides 10:1 vernier adjustment.

When the switch is in the EXT/S.C. (external or single cycle) position, the internal frequency multivibrator is disabled. An output pulse will occur each time the S.C. (single cycle) button is depressed. Output pulses will also occur if an external trigger is connected to the EXT TRIG connector.

DELAY:

Concentric six-position switch and potentiometer adjusts delay (or time interval) between the TRIG OUT (trigger output or synchronizing) pulse and leading edge of the output pulse. Black knob selects delay range; red knob provides 10:1 vernier adjustment.

TAIL PULSE / FLAT TOP PULSE
(indicated by front panel waveforms):

This toggle selects either a Tail Pulse (fast rise and long exponential decay) or a Flat Top Pulse.

WIDTH:

This one-turn potentiometer adjusts the Flat Top Pulse width from 0.5 - 25 μs.

RISE TIME:

Eight-position rotary switch controls the 10% - 90% rise time of both Tail and Flat Top Pulses.

FALL TIME:

Nine-position rotary switch controls the 100% - 37% decay time constant of both the Tail and Flat Top Pulses.

AMPLITUDE:

Four concentric dials permit five-digit resolution of output pulse amplitude.

NORMALIZE (COARSE and FINE):

Screwdriver adjustable trimmers vary output amplitude by 20%. Used to calibrate AMPLITUDE control with respect to unit being tested.

--------------- NOTE ---------------

NORMALIZE controls are inoperative when using EXT REFERENCE.

OFFSET:

Screwdriver adjustable trimmer varies the output base line by ±100 mV from ground.

REFERENCE - INT / EXT:

Toggle switch connects output chopper to either the internal DC reference voltage or an externally supplied reference voltage. In the EXT REFERENCE position, the amplitude and polarity of the output pulse will be determined by the amplitude and polarity of the external reference voltage. The EXT REFERENCE connector is primarily intended for use with the Berkeley Nucleonics Model LG-1 Ramp Generator to provide a sliding pulse train.

-------------- NOTE -------------

The maximum voltage which should be applied to the EXT REFERENCE input is ±11 V when connected.

ATTENUATION:

Four toggle switches provide attenuation of the output pulse by a factor of X2, X5, X10 and X10.

PULSE OUT (+ or −):

Toggle switch selects the polarity of the output pulse when the REFERENCE switch is in the INT position.

CONNECTORS:

1) REFERENCE (INT or EXT):

   Used to connect an external amplitude reference to the instrument. Voltage may be either DC or time varying such as a ramp. Maximum amplitude is ± 11 V when connected.

2) EXT TRIG:

   Accepts a drive pulse from an external source to establish the output repetition rate.

3) TRIG OUT:

   Provides a synchronizing pulse which precedes the output pulse by a time determined by the DELAY control.

4) PULSE OUT:

   Provides the output pulse from the PB-4.

2.4 OPTIMUM PERFORMANCE

In order to achieve optimum performance of the Model PB-4, the following considerations should be kept in mind.

2.4.1 NIM POWER SUPPLY

The Model PB-4 is a NIM module and depends upon power from an external power supply. It is important that the power supply is in good condition and meets all regulation, stability and ripple specifications as described in U.S. AEC report TID-20893 (Rev. 3). If a NIM power supply is inadvertently overloaded, the PB-4 will continue to function but the specifications will be degraded. For highest accuracy, the Berkeley Nucleonics Portanim Model AP-1 is recommended to power the Model PB-4.

2.4.2 EXTERNAL REFERENCE

The external reference connector is primarily designed to accept the output of Berkeley Nucleonics Model LG-1 Ramp Generator to provide a sliding pulse train. If another ramp generator is employed, the loaded amplitude at the connector should not be greater than ±11 V in order not to exceed the operating range of the voltage follower.

2.4.3 OUTPUT LOADING

The output of the Model PB-4 is designed to provide 100 mA of current. The output impedance is 50 Ω and, therefore, a 10 V open circuit pulse should not be loaded into less than 50 Ω to maintain specified linearity and stability.

Due to the very low temperature coefficient of the Model PB-4 (±5 ppm/$^{\circ}$C), the temperature coefficient of the load should also be considered when using the PB-4 in stability tests. For example, if the load resistance is 1 K, its temperature coefficient should be better than ±100 ppm/$^{\circ}$C to achieve accurate measurements. Metal film resistors typically have this temperature coefficient (or better) but carbon composition resistors may be five times worse.

2.4.4 NORMALIZE CONTROLS

The NORMALIZE control consists of two trimmers for FINE and COARSE adjustment to vary the output amplitude by 20%. The 20% limit was set so as not to appreciably change the standing current in the zener reference which, in turn, affects the temperature coefficient. If it is desired to normalize the output pulse below 80% of maximum amplitude, it is necessary to decrease the largest AMPLITUDE dial setting and multiply by the appropriate scale factor or switch in the appropriate attenuators.

2.4.5 PROPORTIONAL CONTROL OVEN

As can be seen from Figure 1, the reference zener, voltage follower and chopper are in a proportional control oven. The oven has a slope of 0.01° C change of internal temperature per 1° C change of ambient temperature. The oven requires 15 minutes of heating before it is stabilized. In addition, it is desirable that the ambient temperature should be kept below 45°C (113° F). This is required because the oven operates at 55° C and best results are obtained with a minimum of 10° C differential.

2.4.6 AMPLITUDE SETTING NEAR ZERO VOLTS

When the AMPLITUDE control is operated near zero volts, small (10 mV) switching transients may be observed on the pulse top. These transients may produce erroneous measurements, depending on the frequency response of the system under test. In order to minimize these transient effects with low level pulses, it is desirable to set the AMPLITUDE control at the highest possible level and then switch in the ATTENUATOR to obtain the required low level pulses.

2.5 USING THE MODEL PB-4 INTO THE TEST INPUT OF A PREAMPLIFIER

The output pulse of the Model PB-4 in the Tail Pulse mode has a rise time of 50 ns. Sometimes an experimenter may be concerned about using this pulse for the test signal of a charge-sensitive preamplifier insofar as the pulses from solid-state detectors sometimes have shorter rise times. The 50 ns rise time pulse is perfectly satisfactory to use in testing linearity, stability and resolution of a preamplifier. The following comments are provided to clarify this matter.*

It can be shown that the amount of injected charge from the pulser into a preamplifier is given by Q = CV where C is the coupling capacitance and V is the pulse amplitude. The only restraint is that C be much smaller than the input capacitance of the preamplifier. As long as the rise time of the injected pulse is much shorter than the decay time-constant of the preamplifier, essentially all the charge will be collected. A corollary of this is that the test pulser rise time need not be as short as the detector pulse to simulate the same charge.

*For further discussion on this point, refer to IEEE Standard No. 301. Test Procedures for Amplifiers and Preamplifiers, 1969, Institute of Electrical and Electronic Engineers, New York, New York.

These conditions are fulfilled by the Model PB-4 which provides a rise time of 50 ns versus the usual preamplifier decay time-constant of 50 μs or more.

2.6 MEASURING DIFFERENTIAL LINEARITY IN A PHA

The Model PB-4 is designed to be used with the Berkeley Nucleonics Model LG-1 Ramp Generator to measure differential linearity of a pulse height analyzer (PHA).

Differential nonlinearity (DNL) in a PHA describes the change in relative width of one or more channels with respect to the average width of all the channels. DNL can be determined by manually setting a pulse amplitude to both edges of each channel and calculating the width of each channel individually. DNL may be much more conveniently and quickly determined by using the sliding pulser method, where a constant frequency pulse is swept in amplitude at a constant rate. Where the channel widths are identical, the pulses will fall in each channel for an equal length of time and the number of counts accumulated in each channel will be equal. The PHA display for zero DNL would then be a horizontal straight line.

DNL measurements on a PHA are typically made as follows:

1) Connect the ramp generator OUTPUT to the EXT REFERENCE (external reference) connector on the Model PB-4. Throw the REFERENCE-EXT/INT toggle to the EXT position. Throw the POLARITY switch of the Model LG-1 into the position corresponding to the desired input polarity for the PHA.

2) Connect the output of the Model PB-4 to an amplifier preceding the analyzer or the analyzer input.

------------- NOTE -------------

The pulse shape being analyzed is important for optimum linearity tests. See the PHA manufacturers' instructions for the proper rise time and pulse width and make these settings on the Model PB-4.

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3) Set the PERIOD switch of the Model LG-1 to 5 s and press the RESET button.

4) Set the FREQUENCY control of the Model PB-4 to the desired rate, 1 kHz for example. The maximum usable frequency is determined by the maximum dead time in the PHA.

5) Erase the storage in the PHA and then set it in the STORE mode.

6) Press the START button on the Model LG-1 and observe the highest channel counting at the peak of the sliding pulse train. Adjust the PHA gain or the Model PB-4 AMPLITUDE control so that the pulse amplitude sweeps beyond the highest channel.

7) Select the desired LG-1 ramp period. Reset the Model LG-1, erase the PHA memory and then set the PHA in the STORE mode.

8) For a single triangular amplitude sweep, set the REP-SINGLE CYCLE switch to SINGLE CYCLE. When the START button is operated, the ramp will complete one cycle and then stop. For multiple ramp cycles, set the switch to the REP position.

9) Press the START button of the LG-1 and accumulation of counts in the PHA will begin.

10) When sufficient counts have been accumulated for the statistical accuracy desired, press the STOP button on the Model LG-1. The ramp cycle will stop at the next zero crossing of the ramp.

The amount of noise in the system, and whether it is statistical or non-statistical, will affect the time required to smooth out irregularities in the DNL display on the oscilloscope. The maximum error of the DNL measurement will be inversely proportional to the square root of the number of counts accumulated in each channel plus the error in the sliding pulse train. The differential linearity of the combined Model PB-4 and Model LG-1 is ±0.1%. Most PHAs have a DNL of ±0.5% or poorer, therefore, the contribution to the nonlinearity from the pulse and ramp generators in minimal and may be subtracted from the overall test data.

The differential nonlinearity (DNL) of the analyzer may then be computed by:

$$DNL = 100 \left[1 - \frac{N_x}{N_{(av)}} \right] \%$$

where N_x = number of counts in Channel x,

$N_{(av)}$ = average number of counts in all channels.

N_x is generally taken as the worst case deviation from the average. In some cases, one channel address may be defective and it is not included in the measurement.

The choice of the ramp speed is usually a matter only of convenience, though some PHA manufacturers may specify a particular time range for linearity measurements. Visual verification of correct operation is easier on the 5 second ramp period and should theoretically produce the same result as with the 50 second period. Different results for DNL (with the same number of counts per channel) may be attributed in some cases to channel boundary anomalies. The channel boundary profile will vary with different analyzers.

SECTION 3
THEORY OF OPERATION

3.1 CIRCUIT DESCRIPTION

(Refer to Schematic PB-401 in Section 5.)

3.1.1 FREE-RUNNING MULTIVIBRATOR

The FREE-RUNNING MULTIVIBRATOR is provided by Q1 and Q2 when the FREQUENCY switch, S1, is in one of the continuous frequency positions. The frequency range of the multivibrator is selected by C3 - C7 on S1. R7 provides a continuously variable adjustment of frequency. Frequency jitter is minimized by regulating the collector supply of Q1 and Q2 with zener diode D1. The signal on the emitter of Q2 is coupled through R10 to the base of emitter follower Q3. The positive-going edge of the signal on the emitter of Q3 is coupled through C12 and D4 to the base of Q6 in the trigger output generator, Q6 and Q7.

3.1.2 TRIGGER OUTPUT GENERATOR

The TRIGGER OUTPUT GENERATOR consists of Q6 and Q7 connected as a one-shot. The base of Q7 is connected to +7.2 V through R32. The base of Q6 is pulled negative by R27 and is clamped at about +6.6 V by D7. Therefore, Q6 is conducting and Q7 is cut off in the quiescent state of the one-shot. A positive signal on the base of Q6 cuts off Q6, initiating the one-shot cycle. When Q7 turns on, its collector current passes through R117 and R31. The signal developed across R31 is the Trigger Output.

3.1.3 DELAY AND WIDTH GENERATOR

The DELAY GENERATOR consists of Q8 and Q9 connected as a one-shot. The signal from the collector of Q7 is coupled by C17 and D9 to the base of Q8. The base of Q8 is returned to +7.2 V through R34. The base of Q9 is pulled positive by R41, R42 and R44 and is clamped at about +7.9 V by D10. Therefore, Q8 is cut off and Q9 is turned on in the quiescent state of the one-shot. A positive signal on the base of Q8 turns on Q8, initiating the one-shot cycle. The collector of Q8 goes negative, applying a negative step to timing capacitors C19 - C24. This signal is coupled to the base of Q9, turning off Q9. The timing capacitors C19 - C24 charge toward +23 V through R41, R42 and R44 at a rate determined by the values of the selected capacitance and resistance. When the base of Q9 becomes more positive than the base of Q8, Q9 conducts, terminating the one-shot cycle.

The signal at the collector of Q9 is coupled through Q10 and C25 to trigger the WIDTH GENERATOR. This circuit functions in a similar manner to the DELAY GENERATOR except for the inclusion of a Mode switch (Tail Pulse/Flat Top Pulse). When this switch is in the Tail Pulse position, the pulse width is determined by C26 and R112. The pulse width is approximately 0.1 μs. When the Mode Switch is in the Flat Top Pulse position, the pulse width is determined by C27, R113 and R114. Then the pulse is adjustable by R114 from 0.5 - 25 μs. The output of the WIDTH GENERATOR at the collector of Q12 drives the CHOPPER DRIVER.

3.1.4 CHOPPER DRIVER

The CHOPPER DRIVER is Q14. The signal from the collector of Q12 is coupled through C30 to the base of Q14. The signal from Q12 turns on Q14 and the collector of Q14 goes negative. Q14 is connected with C32 as a Miller integrator to provide controlled rise and fall times at the collector of Q14. When Q14 saturates, about 130 mA flows in the primary winding of T1 through R60.

The secondary winding of T1 drives CHOPPER transistors Q16 and Q17 into saturation through R62, R63 and R64. Trimmer R64 balances the saturation voltages of Q16 and Q17 by varying the ratio of the drive currents in their respective bases. When Q16 and Q17 saturate, the voltage level at the collector of Q16 appears at the collector of Q17 for the duration of the drive current from T1. This causes the voltage across C40 to rise to the same level as that at the output of a voltage follower, LM310. When the drive current from T1 decreases to the point where Q16 and Q17 are no longer saturated, the chopper opens and the charge across C40 decays through R83 and R74 - R82. The leading edge of the pulse was produced when the chopper transistors Q16 and Q17 saturated. and the trailing edge by the decay through R74 - R82. The Flat Top and Tail Pulse are generated in essentially the same way except for the length of time the chopper is closed.

3.1.5 BASE LINE CLAMPING

A base line clamping circuit is provided by a FET, Q15, whose drain is connected to the collector of Q17 and source is connected to ground. This circuit is present to overcome the problem of leakage through Q16 and Q17 appearing as a voltage across R74 - R82, when the chopper is open. The gate of Q15 is connected via R103, D18 and C49 to the collector of the chopper driver Q14. When Q14 saturates, Q18 is an open circuit and the output pulse is not affected. However, when Q14 is in its quiescent state, Q18 is turned on, which connects the collector of Q17 to ground through R104 and the "on" resistance of Q18 (about 2k). The leakage current through the combined resistance of R104 and Q18 produces negligible offset voltage which would not be the case if the leakage passed through R82, 3 megohms.

The function of R105 - R111 in conjunction with C50 is to track the fall time of the output pulse. Note that R105 - R111 on switch wafer S7-B is ganged to the fall time resistors, R74 - R82 on switch wafer S7-A. When the fall time waveform of the output pulse is close to ground, Q15 is switched on, which clamps the base line to ground. This produces a pedestal on the tail of the pulse as the pulse approaches ground. The pedestal is negligible with short fall times and increases to about 1% of pulse amplitude at 1 ms fall time.

After the pulse is formed by the chopper, it then passes through operational amplifier, A-440. The A-440 provides a high impedance to the pulse-forming circuits and a low impedance to the external load. The output of the A-440 passes through R85 and four attenuators to the Pulse Out connector. Capacitors C42 - C48, in conjunction with R85, function to integrate the rise time of the pulse. The offset trimmer, R84, adjusts the bias in the A-440 so that its quiescent output is at ground. A440 is enclosed in the proportional control oven to obtain specified stability.

3.1.6 SINGLE CYCLE OPERATION

When the FREQUENCY switch is set to EXT/S.C., the timing capacitor C3 - C7 for the frequency multivibrator Q1 and Q2 is disconnected. With the timing capacitor disconnected, the timing trigger is obtained from either the EXT/S.C. pushbutton or the EXT TRIG connector. In the Single Cycle mode, tie point D on the EXT/S.C. pushbutton is normally at +6 V. When the pushbutton is momentarily closed, tie point D rises rapidly to +23 V and then decays back to +6 V as set by the time constant of R20, R21 and C11. The pulse developed across R21 passes through C14 and D6 to trigger the TRIGGER OUTPUT GENERATOR.

3.1.7 EXTERNAL TRIGGER DISCRIMINATOR

The EXTERNAL TRIGGER DISCRIMINATOR is provided by Q4 and Q5. In this mode, a signal applied to the EXT TRIG connector is coupled through C9 and R14 to the base of Q4. Q4 and Q5 are connected as a one-shot with a long period. However, the operating levels are chosen so that the circuit operates as a Schmitt Discriminator. Operation of the circuit is as follows: The base of Q5 is connected to +7.2 V through R19. The base of Q4 is pulled negative by R15 and is clamped at about +6.7 V by D3, cutting off Q4. A positive trigger signal turns on Q4, causing its collector to go negative. This negative signal is coupled to the base of Q5 through C10. The amplitude of the signal on the base of Q5 is less than the level required to trigger the circuit at the base of Q4. When the trigger signal returns to its base line, the base of Q4 is again clamped to +6.7 V by D3. This level is more negative than the level at the base of Q5, causing Q4 to turn off and Q5 to turn on. The signal from the collector, Q5, is coupled through C13 and D5 to the base of Q6, initiating a single pulse.

3.1.8 DC REFERENCE VOLTAGE

The reference voltage for the chopper is derived from the ±24 V supply. Refer to the lower left-hand section of the schematic next to the POLARITY switch. The +24 V bus is dropped down to +18 V across zener diodes D15 and D16. The -24 V bus is dropped down to -18 V across D22 and D17. The POLARITY switch, S5, selects either +18 V or -18 V and directs the respective voltage through R101 to the reference zener diode, D19. The voltage across D19 is 11.7 V and is dropped down to 10 V by R53 and R65. The NORMALIZE resistors, R66, R67, and R68 further drop the voltage to the desired level across the AMPLITUDE Dekapot, R70. The output of the Dekapot is fed into a high impedance IC voltage follower to minimize loading. The output of the voltage follower is at a low impedance and is the reference voltage for the chopper.

The reference zener, voltage follower and chopper are all contained within a proportional control oven to achieve the specified stability.

SECTION 4
MAINTENANCE

4.1 GENERAL

If service is required on the Model PB-4, refer to the schematic diagram in Section 5 for the proper waveforms and voltages.

The linearity and stability specifications are measured with special equipment which is not available commercially. If calibration of these parameters is required, consult the factory.

4.2 ADJUSTMENTS

There are two adjustment trimmers in the Model PB-4: 10 V ADJUST, R65, and PEDESTAL ADJUST, R64. The 10 V ADJUST trimmer provides a 10 V open circuit pulse at the output connector. A Tektronix W or Z plug-in is recommended for this measurement.

The PEDESTAL ADJUST is provided to adjust the current in the chopper so that the saturation voltages across Q16 and Q17 are equal. To perform this measurement, proceed as follows:

1) Set the AMPLITUDE control at 0.1 V, the WIDTH at 10 μs, FREQUENCY at 1 kHz, RISE TIME at 0.05 μs, and zero attenuation.

2) Terminate the output connector in 50 Ω and observe the output waveforms on a 50 MHz oscilloscope.

3) Switch the POLARITY toggle to + and − positions and check that the respective pulses are 50 mV ±5 mV and their droops are less than 10 mV. If this condition does not exist, adjust the PEDESTAL ADJUST trimmer for no greater than a 5 mV difference between the pulse amplitudes. If the trimmer cannot bring the pulses into this specification, check for defective chopper transistors.

The chopper transistors are selected at the factory for minimum switching transient and best saturation voltage cancellation. If replacement is required, consult the factory.

SECTION 5
PARTS LIST

ABBREVIATIONS

cer	ceramic	μH	microhenry
comp	composition carbon	μF	microfarad
elec	electrolytic, metal case	pF	picofarad
mic	mica	pos	positions
myl	mylar	tan	tantalum
K	kilohm	V	working volts DC
M	megohm	var	variable
m	milli	W	watts
MF	metal film	ww	wirewound

---------------- NOTE ----------------

The last number after each part description is BERKELEY NUCLEONICS part number for re-ordering.

CAPACITORS

C1	50 μF	elec	25 V		120-006
C2	0.05 μF	cer	25 V		110-019
C3	0.002 μF	myl	600 V	5%	114-002
C4	0.02 μF	myl	100 V	10%	114-013
C5	2x.1 μF	myl	100 V	10%	114-020
C6	2.2 μF	tan	20 V	10%	122-010
C7	22 μF	tan	15 V	10%	122-011
C8	10 pF	cer	1 KV	10%	110-002
C9	25 μF	elec	25 V		120-005
C10	470 pF	cer	1 KV	10%	110-010
C11	5 μF	elec	25 V		120-004
C12	100 pF	cer	1 KV	10%	110-006
C13	100 pF	cer	1 KV	10%	110-006
C14	100 pF	cer	1 KV	10%	110-006
C15	100 pF	mic	500 V	5%	112-004
C16	0.01 μF	cer	1 KV		110-014
C17	50 pF	cer	1 KV	10%	110-005
C18	25 μF	elec	25 V		120-005
C19	4.7 μF	tan	35 V	10%	122-004
C20	0.47 μF	myl	100 V	10%	114-023
C21	0.047 μF	myl	200 V	10%	114-018
C22	0.0047 μF	myl	400 V	10%	114-008
C23	0.001 μF	myl	600 V	10%	114-001
C24	680 pF	mic	500 V	5%	112-014
C25	50 pF	cer	1 KV	10%	110-005
C26	100 pF	mic	500 V	5%	112-004
C27	0.0047 μF	myl	400 V	10%	114-008
C29	100 μF	elec	25 V		120-008
C30	5 μF	elec	25 V		120-004
C31	100 μF	elec	25 V		120-008
C32	10 pF	cer	1 KV	10%	110-002
C33	5 μF	elec	25 V		120-004
C34	25 μF	elec	25 V		120-005
C36	25 μF	elec	25 V		120-005
C37	100 μF	elec	16 V		120-007
C38	100 μF	elec	16 V		120-007
C39	0.05 μF	cer	25 V		110-019
C40	270 pF	mic	500 V	5%	112-009
C41	0.05 μF	cer	25 V		110-019
C42	0.001 μF	myl	600 V	10%	114-001
C43	0.003 μF	myl	600 V	10%	114-004
C44	0.01 μF	myl	200 V	10%	114-025
C45	0.018 μF	myl	100 V	10%	114-026
C46	0.033 μF	myl	100 V	10%	114-024
C47	0.1 μF	myl	100 V	10%	114-020
C48	2x0.1 μF	myl	100 V	10%	114-020
C49	470 pF	cer	1 KV	10%	110-010
C50	330 pF	mic	500 V	5%	112-010
C51	0.05 μF	cer	25 V		110-019
C52	0.1 μF	cer	25 V		110-026
C53	0.05 μF	cer	25 V		110-019
C54	0.05 μF	cer	25 V		110-019

DIODES

D1	1N966B	412-007
D2	1N4154	411-003
D3	1N4154	411-003
D4	1N4154	411-003
D5	1N4154	411-003
D6	1N4154	411-003
D7	1N4154	411-003
D8	1N4154	411-003
D9	1N4154	411-003
D10	1N4154	411-003
D11	1N4154	411-003
D12	1N4154	411-003
D13	1N4154	411-003
D14	1N4154	411-003
D15	1N935	412-002
D16	1N935	412-002
D17	1N935	412-002
D18	1N4154	411-003
D19	1N944	412-004

. . . continued

D20	1N4737	413-009
D21	1N4737	413-009
D22	1N935	411-002

INDUCTIVE COMPONENTS

L1	10 μH	Choke	310-008
L2	2.2 μH	Choke	310-005
T1	Pulse Transformer		312-001

OPERATIONAL AMPLIFIERS

Z1	A-440	440-018
Z2	LF356A	440-116

OVEN

DR-1	Oven	640-028

OVEN BOARD

PB4-2	Amplifier P.C. Bd.	639-064

RESISTORS

R1	330 Ω	1/2 W	comp	5%	212-331
R2	3.9 K	1/2 W	comp	5%	212-392
R3	3.3 K	1/2 W	comp	5%	212-332
R4	680 Ω	1/2 W	comp	5%	212-681
R5	100 Ω	1/2 W	comp	5%	212-101
R6	3.3 K	1/2 W	comp	5%	212-332
R7	75 K	2 W	var	10%	610-012
R8	2.7 K	1/2 W	comp	5%	212-272
R9	2.0 K	1/2 W	comp	5%	212-202
R10	150 Ω	1/2 W	comp	5%	212-151
R11	150 Ω	1/2 W	comp	5%	212-151
R12	2.0 K	1/2 W	comp	5%	212-202
R13	1 K	1/2 W	comp	5%	212-102
R14	150 Ω	1/2 W	comp	5%	212-151
R15	10 K	1/2 W	comp	5%	212-103
R16	39 Ω	1/2 W	comp	5%	212-390
R17	470 Ω	1/2 W	comp	5%	212-471
R18	330 Ω	1/2 W	comp	5%	212-331
R19	4.7 K	1/2 W	comp	5%	212-472
R20	180 K	1/2 W	comp	5%	212-184
R21	68 K	1/2 W	comp	5%	212-683
R22	10 Ω	1/2 W	comp	5%	212-100
R23	1 K	1/2 W	comp	5%	212-102
R24	1 K	1/2 W	comp	5%	212-102
R25	1 K	1/2 W	comp	5%	212-102
R26	680 Ω	1/2 W	comp	5%	212-681
R27	2.2 K	1/2 W	comp	5%	212-222
R28	82 Ω	1/2 W	comp	5%	212-820
R29	330 Ω	1W	comp	5%	212-331
R31	51 Ω	1/2 W	comp	5%	212-510
R32	470 Ω	1/2 W	comp	5%	212-471
R33	470 Ω	1/2 W	comp	5%	212-471
R34	470 Ω	1/2 W	comp	5%	212-471
R35	220 Ω	1/2 W	comp	5%	212-221
R36	560 Ω	1/2 W	comp	5%	212-561
R37	470 Ω	1/2 W	comp	5%	212-471
R38	560 Ω	1/2 W	comp	5%	212-561
R39	470 Ω	1/2 W	comp	5%	212-471
R40	220 Ω	1/2 W	comp	5%	212-221
R41	39 K	1/2 W	comp	5%	212-393
R42	3.3 K	1/2 W	comp	5%	212-332
R43	1 K	1/2 W	comp	5%	212-102
R44	75 K	2 W	var	10%	610-012
R45	220 Ω	1/2 W	comp	5%	212-221
R46	560 Ω	1/2 W	comp	5%	212-561
R47	470 Ω	1/2 W	comp	5%	212-471
R48	560 Ω	1/2 W	comp	5%	212-561
R49	2.7 K	1/2 W	comp	5%	212-272
R50	1.5 K	1/2 W	comp	5%	212-152
R53	150 Ω	3 W	ww	3%	225-005
R54	750 Ω	1/2 W	comp	5%	212-751
R55	750 Ω	1/2 W	comp	5%	212-751
R56	10 Ω	1/2 W	comp	5%	212-100
R57	1 K	1/2 W	comp	5%	212-102
R58	10 Ω	1/2 W	comp	5%	212-100
R59	47 Ω	1/2 W	comp	5%	212-470
R60	150 Ω	2 W	comp	5%	210-151
R61	100 Ω	1/2 W	comp	5%	212-101
R62	47 Ω	1/2 W	comp	5%	212-470
R63	47 Ω	1/2 W	comp	5%	212-470
R64	50 Ω	1 W	var	10%	244-001
R65	50 Ω	1 W	var	10%	244-001
R66	750 Ω	3 W	ww	3%	225-006
R67	500 Ω	0.75 W	var	5%	244-014
R68	10 Ω	0.75 W	var	5%	244-015
R69	1 K	1/2 W	comp	5%	212-102
R70	1 K	Dekapot			247-001
R71	2.2 K	1/4 W	comp	5%	213-222
R72	10 K	1/2 W	var	10%	244-036
R74	1.4 K	1/4 W	MF	1%	222-085
R75	2.8 K	1/4 W	MF	1%	222-020
R76	14 K	1/4 W	MF	1%	222-083
R77	28 K	1/4 W	MF	1%	222-024
R78	140 K	1/4 W	MF	1%	222-084
R79	280 K	1/4 W	MF	1%	222-086
R80	562 K	1/4 W	MF	1%	222-087
R81	1.4 M	1/2 W	MF	1%	221-088
R82	3.0 M	1/4 W	comp	5%	213-305
R83	82 Ω	1/4 W	comp	5%	213-820
R84	5 K	1/2 W	var	10%	244-006
R85	49.9 Ω	1/4 W	MF	1%	222-003
R86	37.5 Ω	0.3 W	MF	1%	225-007
R87	150 Ω	0.3 W	MF	1%	225-005
R88	150 Ω	0.3 W	MF	1%	225-005
R89	120 Ω	0.3 W	MF	1%	225-010
R90	75 Ω	0.3 W	MF	1%	225-009
R91	75 Ω	0.3 W	MF	1%	225-009
R92	247.5 Ω	0.3 W	MF	1%	225-012

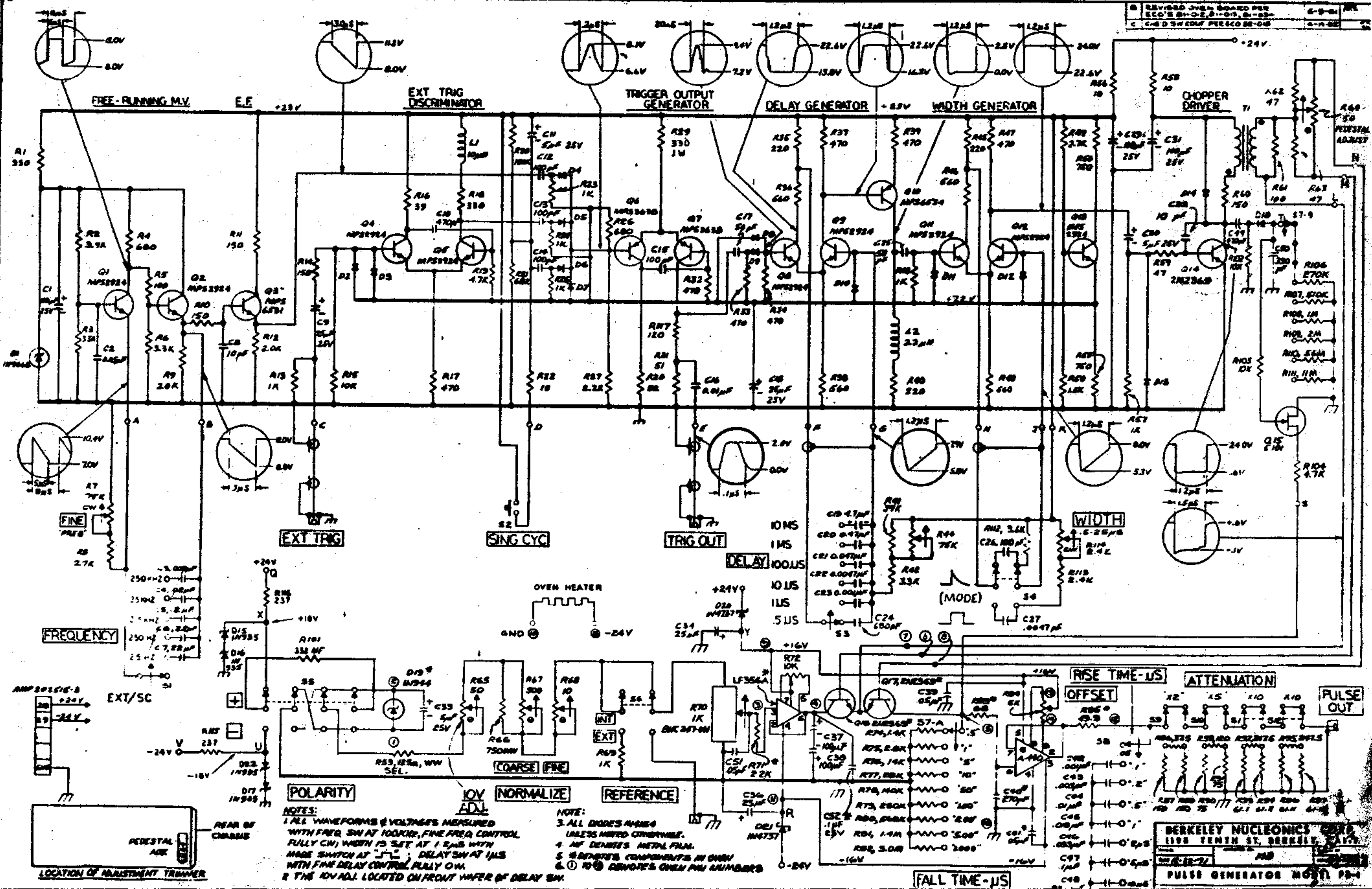
- PARTS LIST -

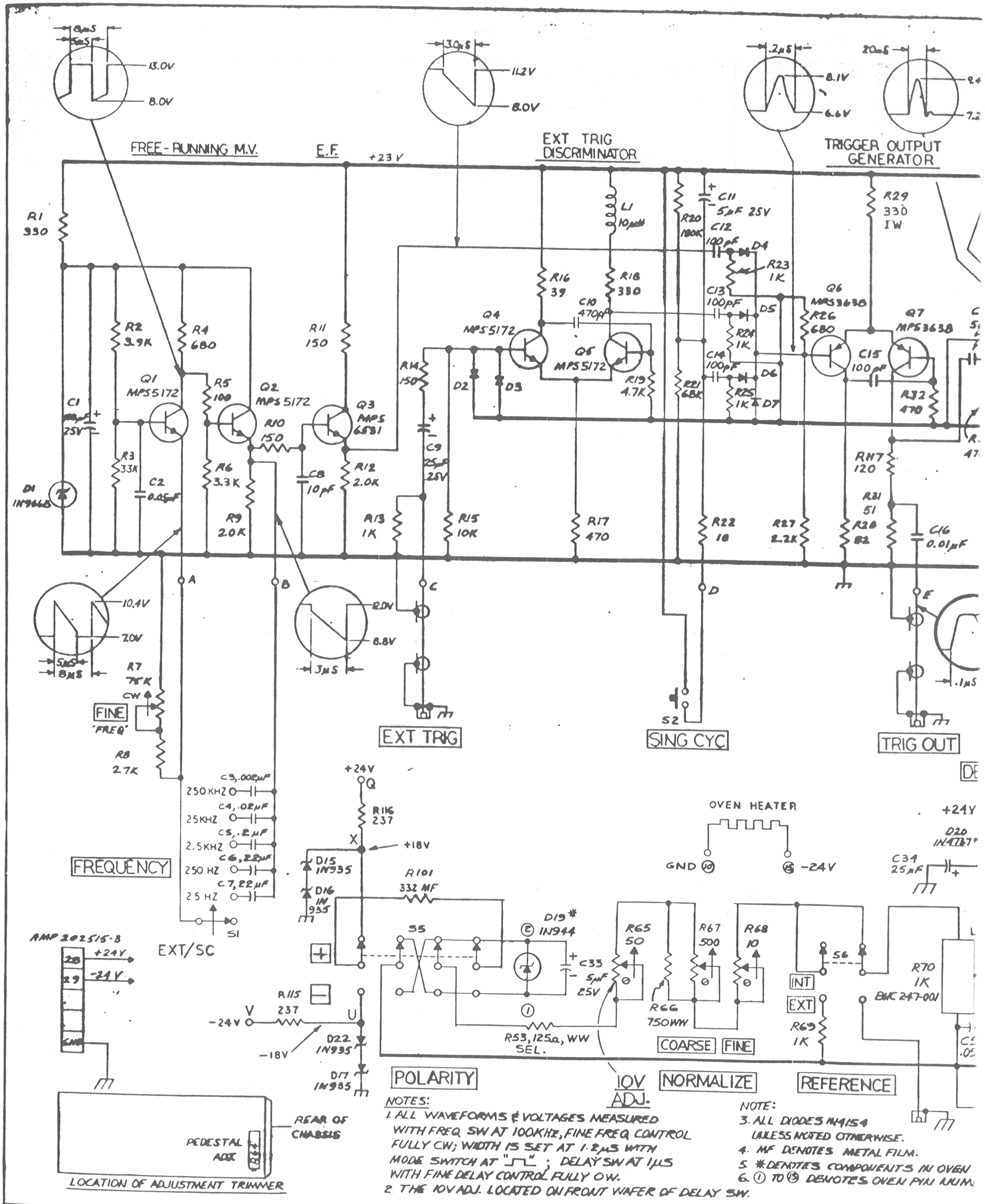
R93	61.11 Ω	0.3 W	MF	1%	225-008
R94	61.11 Ω	0.3 W	MF	1%	225-008
R95	247.5 Ω	0.3 W	MF	1%	225-012
R96	61.11 Ω	0.3 W	MF	1%	225-008
R97	61.11 Ω	0.3 W	MF	1%	225-008
R101	332 Ω	1/2 W	MF	1%	221-011
R102	10 K	1/2 W	comp	5%	212-103
R103	10 K	1/2 W	comp	5%	212-103
R104	4.7 K	1/2 W	comp	5%	212-472
R106	270 K	1/4 W	comp	5%	213-274
R107	510 K	1/4 W	comp	5%	213-514
R108	1 M	1/4 W	comp	5%	213-105
R109	2.2 M	1/4 W	comp	5%	213-225
R110	5.6 M	1/4 W	comp	5%	213-565
R111	11 M	1/4 W	comp	5%	213-116
R112	3.6 K	1/2 W	comp	5%	112-362
R113	2.4 K	1/2 W	comp	5%	112-242
R114	50 K	1 W	var	10%	240-098
R115	237 Ω	1/2 W	MF	1%	221-010
R116	237 Ω	1/2 W	MF	1%	221-010
R117	120 Ω	1/2 W	comp	5%	225-093

TRANSISTORS

Q1		MPS 5172	430-031
Q2		MPS 5172	430-031
Q3		MPS6531	430-017
Q4		MPS 5172	430-031
Q5		MPS 5172	430-031
Q6		MPS3638	430-010
Q7		MPS3638	430-010
Q8		MPS 5172	430-031
Q9		MPS 5172	430-031
Q10		MPS6534	430-018
Q11		MPS5172	430-031
Q12		MPS5172	430-031
Q13		MPS5172	430-031
Q14		2N2369	430-007
Q15	E-101	Siliconix FET	431-001
Q16		2N2369	430-007
Q17		2N2369	430-007

NOTE: Q16 and Q17 matched pair.


FREE-RUNNING M.V.
E.F.
EXT TRIG DISCRIMINATOR
TRIGGER OUTPUT GENERATOR
DELAY GENERATOR
WIDTH GENERATOR
CHOPPER DRIVER
PEDESTAL ADJUST
EXT TRIG
SING CYC
TRIG OUT
DELAY
WIDTH
FREQUENCY
FINE
EXT/SC
OVEN HEATER
(MODE)
POLARITY
10V ADJ.
NORMALIZE
REFERENCE
COARSE
FINE
INT
EXT
RISE TIME-µS
OFFSET
ATTENUATION
PULSE OUT
FALL TIME-µS
LOCATION OF ADJUSTMENT TRIMMER
REAR OF CHASSIS
PEDESTAL ADJ.
NOTES:
1. ALL WAVEFORMS & VOLTAGES MEASURED WITH FREQ SW AT 100KHz, FINE FREQ CONTROL FULLY CW; WIDTH IS SET AT 1.2µS WITH MODE SWITCH AT ; DELAY SW AT 1µS WITH FINE DELAY CONTROL FULLY CW.
2. THE 10V ADJ. LOCATED ON FRONT WAFER OF DELAY SW.
NOTE:
3. ALL DIODES 1N914 UNLESS NOTED OTHERWISE.
4. MF DENOTES METAL FILM.
5. * DENOTES COMPONENTS IN OVEN
6. ① TO ⑮ DENOTES OVEN PIN NUMBERS
BERKELEY NUCLEONICS CORP.
1198 TENTH ST. BERKELEY, CALIF.
PULSE GENERATOR MODEL PB-4

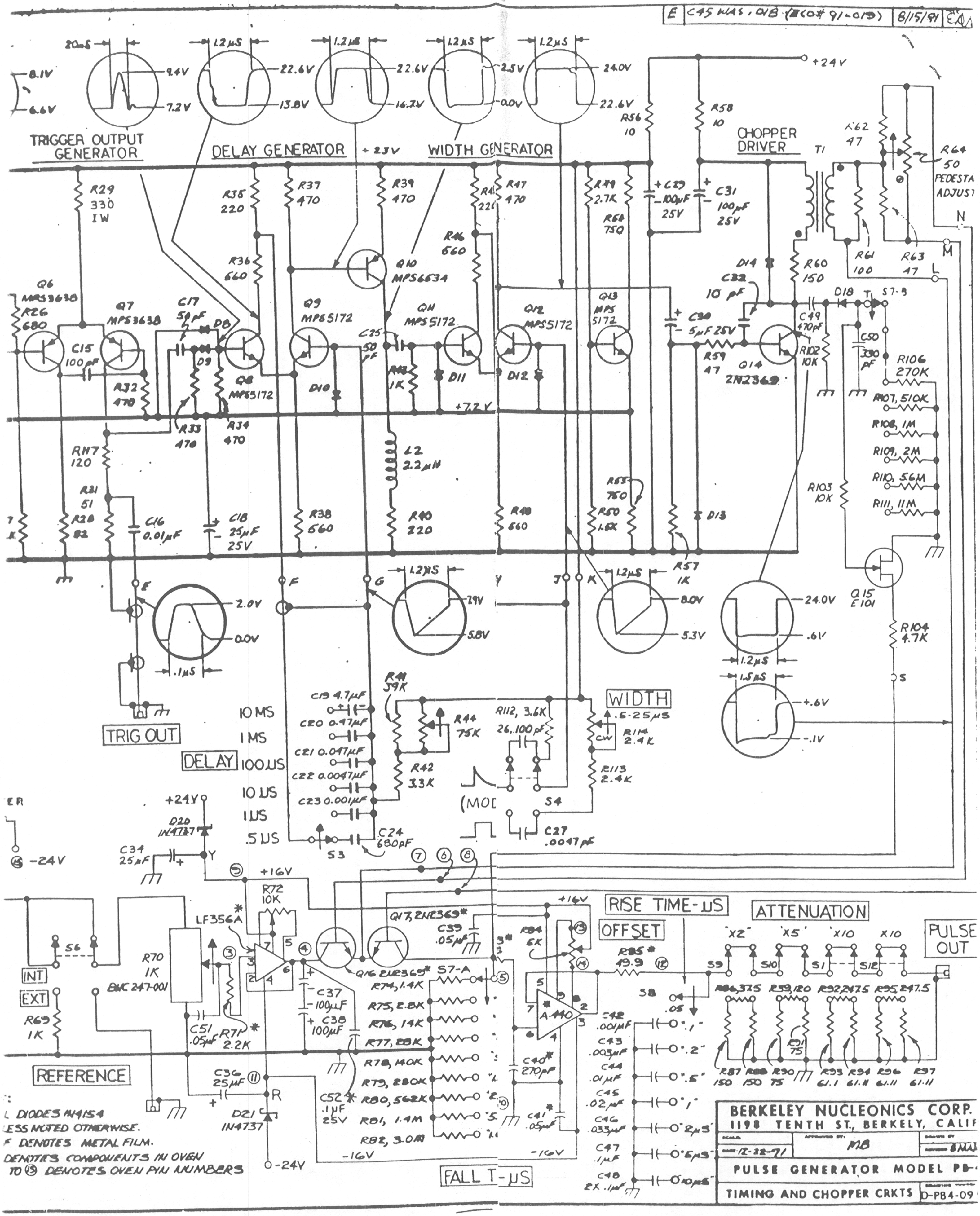


NOTES:

1. ALL WAVEFORMS & VOLTAGES MEASURED WITH FREQ SW AT 100KHz, FINE FREQ CONTROL FULLY CW; WIDTH IS SET AT 1.2µS WITH MODE SWITCH AT "⎍" ; DELAY SW AT 1µS WITH FINE DELAY CONTROL FULLY CW.
2. THE 10V ADJ. LOCATED ON FRONT WAFER OF DELAY SW.

NOTE:

3. ALL DIODES 1N4154 UNLESS NOTED OTHERWISE.
4. MF DENOTES METAL FILM.
5. * DENOTES COMPONENTS IN OVEN
6. ① TO ⑬ DENOTES OVEN PIN NUM…


E C45 WAS .01B (ECO# 91-019) 8/15/91
TRIGGER OUTPUT GENERATOR
DELAY GENERATOR
WIDTH GENERATOR
CHOPPER DRIVER
+24V
+23V
+7.2V
PEDESTAL ADJUST
R64 50
R29 330 1W
R35 220
R37 470
R39 470
R47 470
R49 2.7K
R56 10
R58 10
R62 47
R60 150
R61 100
R63 47
C29 100µF 25V
C31 100µF 25V
Q6 MPS3638
Q7 MPS3638
Q8 MPS5172
Q9 MPS5172
Q10 MPS6534
Q11 MPS5172
Q12 MPS5172
Q13 MPS5172
Q14 2N2369
Q15 E101
C17 50pF
C15 100pF
C16 0.01µF
C18 25µF 25V
L2 2.2µH
R38 560
R40 220
R106 270K
R107, 510K
R108, 1M
R109, 2M
R110, 5.6M
R111, 11M
R103 10K
R104 4.7K
TRIG OUT
DELAY
10 MS
1 MS
100 µS
10 µS
1 µS
.5 µS
C19 4.7µF
C20 0.47µF
C21 0.047µF
C22 0.0047µF
C23 0.001µF
C24 680pF
S3
R41 39K
R44 75K
R42 3.3K
WIDTH .5-25µS
R112, 3.6K
R114 2.4K
R113 2.4K
S4
C27 .0047pF
+24V
D20 1N4737
C34 25µF
-24V
+16V
R72 10K
LF356A
INT
EXT
R69 1K
R70 1K
BNC 247-001
S6
REFERENCE
C51 .05µF
R71 2.2K
C36 25µF
D21 1N4737
Q16 2N2369
Q17, 2N2369
C37 100µF
C38 100µF
C39 .05µF
C52 .1µF 25V
S7-A
R74, 1.4K
R75, 2.8K
R76, 14K
R77, 28K
R78, 140K
R79, 280K
R80, 562K
R81, 1.4M
R82, 3.0M
-16V
FALL T-µS
RISE TIME-µS
OFFSET
R84 5K
R85 49.9
A-440
C40 270pF
C41 .05µF
S8
C42 .001µF
C43 .003µF
C44 .01µF
C45 .02µF
C46 .033µF
C47 .1µF
C48 2X .1µF
ATTENUATION
X2
X5
X10
X10
S9
S10
S11
S12
R86, 37.5
R89, 120
R92, 247.5
R95, 247.5
R87 150
R88 150
R90 75
R91 75
R93 61.1
R94 61.11
R96 61.11
R97 61.11
PULSE OUT
L DIODES 1N4154
LESS NOTED OTHERWISE.
F DENOTES METAL FILM.
DENOTES COMPONENTS IN OVEN
TO ⑬ DENOTES OVEN PIN NUMBERS
BERKELEY NUCLEONICS CORP.
1198 TENTH ST., BERKELY, CALIF
12-22-71
MB
PULSE GENERATOR MODEL PB-
TIMING AND CHOPPER CRKTS
D-PB4-09