Model 448
Research Pulser
Operating and Service Manual

This manual applies to instruments marked
"Rev 37" on rear panel

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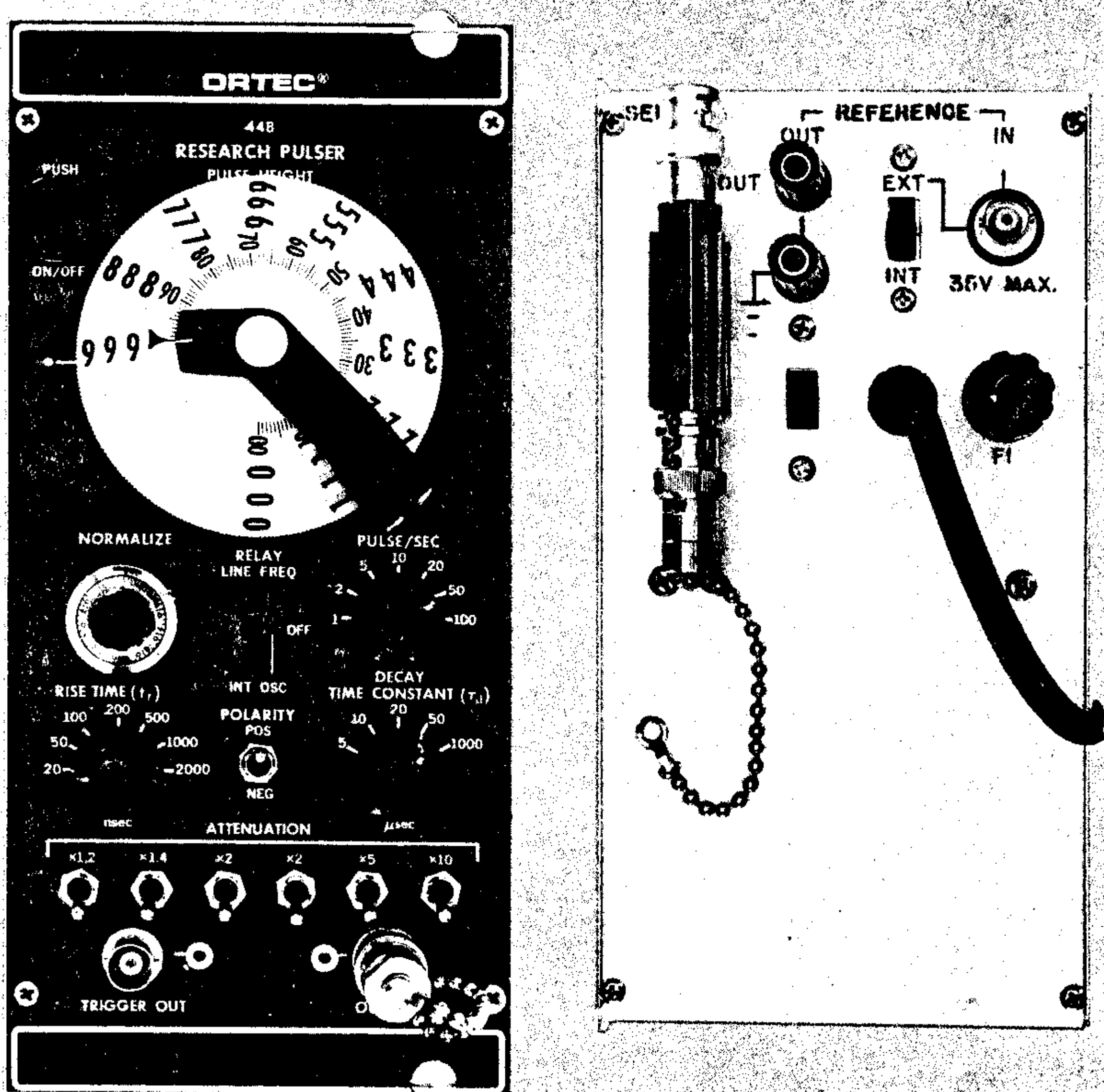
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ORTEC 448 RESEARCH PULSER

1. DESCRIPTION

The ORTEC 448 Research Pulser is designed to serve the researcher as a laboratory standard for a precision signal reference. The output pulse height, or energy reference, is selected with a direct-reading precision Kelvin-Varley decade voltage divider. In addition to providing a long tail pulse to simulate the detection of a nuclear particle reaction in a solid-state or scintillation detector, the 448 provides sufficient selectability of rise and fall times to allow ADC calibration measurements without the use of a shaping amplifier.

Some of the outstanding features of the ORTEC 448 Research Pulser include 0.001% stability, 0.002% integral nonlinearity, and 0.001% setting and resetting precision. The Normalize control furnishes ±10% adjustability of the output pulse height and operates with the six Attenuation switches to provide 100% normalization of the output signal. This means that the Pulser can be calibrated so that the Pulse Height dial settings read directly in terms of equivalent energy deposited in a detector.

The maximum output pulse height is ±11 V, using the Internal power supply reference. The six pi-type attenuator switches provide a maximum attenuation of 336:1. Pulses are generated with a mercury-wetted relay, operating at the power line frequency or at a rate controlled by an internal oscillator. The internal oscillator runs asynchronously from the power line frequency and allows measurement of ac hum effects in the system. The low frequencies are useful for monitoring gain stability by providing a control pulse in accelerator experiments, with typical running times up to 10 hr. Since the storage capacity of many multichannel analyzers is typically 10^5 counts/channel, the maximum pulse rate for a pulser filling two channels would then be approximately 5 pulses/sec. The maximum repetition rate for output pulses, 100 per second, is limited by mechanical characteristics of the relay.

1.1. OPERATING FLEXIBILITY

The ORTEC 448 Research Pulser includes two power switches. One is a master power On/Off illuminated push-push switch. The other is a 3-position slide switch with a center standby position marked Off, and a choice of power line or internal oscillator drive rate for the internal Relay in its two On positions. By keeping this switch set at Off when output pulses are not actually being used, the lifetime of the relay is preserved and extended.

The 448 includes a Trigger output pulse that is independent of, and time coincident with, the Output pulse. This is a rectangular trigger for use in monitoring equipment, such as an oscilloscope, and prevents loading of the main Output.

An Internal/External Reference switch and Input connector are included on the rear panel. When the switch is set at Internal, pulse height is based on the highly stable internal power supply reference level, generated in the internal power supply. When the switch is set at External, the basis for pulse height adjustment is the level of an arbitrary wide-range external reference voltage or waveshape. The limits on the externally generated reference are +35 to -35 V. Output pulse heights have a range to 50% of the reference level and have the same polarity as the reference.

1.2. ACCESSORIES FURNISHED

Two terminators are provided with the ORTEC 448: a Charge Terminator and a 100Ω Resistive Terminator. The Charge Terminator is used to convert the voltage Output pulse into a charge pulse at the input to a charge-sensitive preamplifier and to terminate the output circuit of the 448 properly. The Resistive Terminator is used at the remote end of the cable when applying the Output pulses to any other instrument, and assumes that the instrument will have an input impedance ≥1000Ω; this will terminate the 448 output circuit properly, and requires a type BNC tee connector to complete the connection. A holder is provided on the rear panel of the 448 to store the terminators when they are not in use.

1.3. ACCESSORY RECOMMENDED

The ORTEC 227 Carrying Case is designed to accommodate the triple-width module 448 Research Pulser and to protect the instrument and shield it from stray interference. To obtain the utmost precision in operating stability, the Pulser should be operated either in this Carrying Case or in a NIM-standard Bin such as one of the ORTEC 401 Series.

1.4. POWER REQUIREMENTS

The 448 derives power directly from an ac power source through the 3-wire standard NEMA line cord in the rear panel. Power consumption is no more than 5 W, and a slide switch permits use of either 115- or 230-V ac power. The unit is fused with a 1/4-A fuse. No dc power is required, and the module is furnished without a mating power connector for bin installation.

2. SPECIFICATIONS

PERFORMANCE

AMPLITUDE STABILITY Typically ≤±10 ppm/°C (0.001%), 15°C to 40°C; guaranteed <15 ppm/°C when operated in ORTEC 401 Series Bin or ORTEC 227 Carrying Case.

LONG-TERM STABILITY Long-term drift is ≤15 ppm for a 24-hr period with voltage and temperature constant.

RIPPLE AND NOISE ≤10 ppm (0.001%).

INTEGRAL NONLINEARITY ≤20 ppm.

SETTABILITY ≤10 ppm (resolution 0.0003%) using 3-decade switches and a slidewire adjustment with 100 marked dial divisions.

CONTROLS

PULSE HEIGHT Front panel direct-reading concentric controls to select amplitudes from 0.0000 through 10.0000 V when using Internal Reference. Equivalent energy range, using charge terminator, is 20 pC (picocoulombs), or 440 MeV referred to a silicon semiconductor detector.

NORMALIZE Front panel 10-turn potentiometer for amplitude control range of ±10%. When used with Attenuation switches, permits Pulse Height dial to be read directly in equivalent energy for either silicon or germanium systems.

RELAY Front panel 3-position switch, selects standby (Off) or the output pulse repetition rate at Line Freq or Int Osc.

PULSE/SEC Front panel 7-position switch, selects output pulse repetition rate when Relay switch is at Int Osc; rates are 1, 2, 5, 10, 20, 50, and 100 Hz.

POLARITY Front panel toggle switch, selects either output polarity when using Internal Reference.

RISE TIME (t_r) Front panel 7-position switch, selects pulse rise time from 10% to 90%; times are from 20 to 2000 nsec.

DECAY TIME CONSTANT (τ_d) Front panel 5-position switch, selects pulse fall time constant; time constants are from 5 to 1000 µsec.

ATTENUATION Front panel 6-step attenuators may be used in any combination for maximum attenuation of 336:1; steps are X1.2, X1.4, X2, X2, X5, and X10.

REFERENCE EXT/INT Rear panel slide switch, selects reference level source for basis of pulse amplitude range.

POWER ON/OFF Front panel push-push switch and integral pilot lamp, controls ac power input.

INPUT

REFERENCE INPUT When slide switch is on Ext, accepts optional external dc reference level through rear panel BNC (UG-1094/U) connector; ±35 V maximum; input impedance, 1000Ω maximum, 22Ω minimum in series with charging capacitor of 5 µF.

OUTPUTS

OUTPUT Front Panel BNC (UG-1094/U) connector.

Amplitude 0- to 10-V positive or negative full-scale pulses into 100Ω load; amplitude selected by decade Pulse Height control, Normalize control, choice of 6-step attenuators, and optional External Reference level.

Pulse Shaping Basic pulse generated with mercury-wetted relay and subsequently shaped by separately selected Rise Time and Decay Time Constant.

Repetition Rate Set by power line frequency or from internal oscillator, 1 to 100 Hz.

Output Impedance 100Ω, dc-coupled.

REFERENCE OUT Reference level from decade Pulse Height control through rear panel connectors that can be used as binding posts or for Banana plugs; red for decade output level, black for ground. Impedance varies with setting of Pulse Height control from a minimum of 10 KΩ to a maximum of 10.4 kΩ.

TRIGGER OUT Front panel BNC (UG-1094/U) connector.

Amplitude Nominal +5 V on 1-kΩ load, 2.5 V on 100Ω load.
Time Shift ≤15 nsec for Pulse Height control settings >15/1000.

ELECTRICAL AND MECHANICAL

POWER REQUIRED 115 V ac ±10% or 230 V ac ±10%, 50/60 Hz, 5 W; instrument includes NEMA-standard power line cord, fuse, 115/230-V switch, power On/Off switch.

WEIGHT (Shipping) 10 lb (4.5 kg).

WEIGHT (Net) 7.5 lb (3.4 kg).

DIMENSIONS NIM-standard triple-width module (4.05 x 8.714 x 9.75 in.) per TID-20893 (Rev.)

ACCESSORIES FURNISHED

RESISTIVE TERMINATOR One 100Ω (±0.1%) resistive terminator.

CHARGE TERMINATOR One, provides maximum charge equal to 20 pC for 10-V output, equivalent to 440-MeV pulse from a silicon semiconductor detector, assuming 3.6 eV/ion pair.

OPTIONAL

ORTEC 227 Carrying Case, attractive blue finish, handle included. Accommodates one triple-width NIM module or the equivalent in single- and double-width modules. Power supply is not included.

3. INSTALLATION

The ORTEC 448 includes a power supply that furnishes all of the required operating dc voltages; power from a bin and power supply is not required. The module can, however, be placed in a standard bin if desired, or the Pulser can be used remotely from any bin. A companion ORTEC 227 Carrying Case is recommended for housing the 448 when it is used outside a bin.

If the instrument is operated in a standard bin, the bin is rack-mounted, and vacuum tube equipment is operated in the same rack, be sure that there is sufficient cooling air circulating to prevent any localized heating of the all-transistor circuitry used throughout the 448. The temperature of equipment mounted in racks can exceed 120°F (50°C) easily unless precautions are taken. The 448 should *not be subjected to temperatures in excess of 120°F.*

3.1. CONNECTION TO POWER

Input ac power for the 448 must be furnished through the 3-wire line cord with standard NEMA male connector. The instrument includes a 1/4-A extractor post fuse. A rear panel slide switch permits selection of either 115 or 230 V ac for the power input, and the instrument will operate at either 50 or 60 Hz.

3.2. USE OF EXTERNAL REFERENCE VOLTAGE

An external reference voltage can be furnished to the 448 to control the full range of Pulse Height adjustments. This can be any arbitrary waveshape, either dc or a waveform such as a linear ramp, connected to the External Reference Input BNC connector on the rear panel. The polarity of the Output pulses will be the same as the reference, and the full range of Pulse Height amplitudes will be 50% of the external reference level, which should not exceed ±35 V. The front panel Pulse Height dials, Relay switch, Pulse/Sec switch, shaping Time Constant controls, and Attenuation switches all operate in the same manner for either External or Internal Reference. The Normalize control has no effect when using External Reference. The Polarity switch has no effect on the Output pulses, but must be set to correspond to the External Reference polarity to obtain a proper Trigger Output. When using an External Reference that is other than a dc level, the rate of change of the reference waveform must be slow by comparison to the pulse repetition rate, or there will be considerable distortion in the Output pulse amplitude.

4. OPERATING INSTRUCTIONS

4.1. FRONT PANEL CONTROL FUNCTIONS

POWER ON/OFF An illuminated push-push front panel switch that is lighted when power is connected and the switch is set at On.

PULSE HEIGHT A precision Kelvin-Varley voltage divider containing 3-decade switches and a slidewire interpolating potentiometer using 100 dial divisions. The selected pulse height, adjusted from zero volts to a maximum determined by the Normalize control and/or the Reference level, can be monitored through the rear panel Reference Out connectors. Using the Internal Reference and with the Normalize control adjusted to mid-range (500 of 1000 dial divisions), the maximum pulse height is ±10 V. All adjusted settings of the Pulse Height control can be read directly on its four dials, except for the extreme maximum level and any intermediate level where the center dial is set at its maximum position, 100 dial divisions. The Pulse Height control has a resolution of 0.0003% and a long-term terminal nonlinearity of ≤±20 ppm + 0.5 dial *division.*

NORMALIZE A10-turn precision potentiometer that provides an approximately ±10% continuously adjustable control of the Output pulse height. Its standard setting is mid-range, or 500 of 1000 dial divisions, and it operates with the Attenuation switches to provide normalization so that the Pulse Height dial readings can be interpreted directly as equivalent energy levels. This control is not effective when the rear panel Reference switch is set at External.

RELAY Selects the source of driving signals for the internal mercury relay. The center Off position selects a standby condition, in which the main power switch can be On and power applied to all circuits in the 448 except for the relay. When it is set at Line Freq, the relay will be driven at the power line frequency rate, 50 or 60 Hz. When it is set at Int Osc, the relay will be driven at the rate selected by the Pulse/Sec switch, derived from an internal oscillator which operates asynchronously with respect to the power line frequency. To conserve the lifetime of the relay, leave switch in its center Off position whenever Output pulses are not required.

PULSE/SEC A front panel 7-position selector switch that selects the repetition rate for Output pulses when the Relay switch is set at Int Osc. The pulse rates are 1, 2, 5, 10, 20, 50, and 100 pulses/sec.

NOTE

The 448 has a built-in frequency cutback when the duty cycle of the Output pulse is exceeded. When the Decay Time Constant switch selects 1000 μsec, the maximum Output pulse repetition rate is 20 pulses/sec, effective with this switch set at 20, 50, or 100.

DECAY TIME CONSTANT (τ_d) A front panel 5-position rotary switch that selects the RC Decay (or Fall) Time Constant, τ_d, of the Output pulse. The available time constants are 5, 10, 20, 50, and 1000 μsec.

RISE TIME (t_r) A front panel 7-position rotary switch that selects the Rise Time, t_r, of the Output pulse, measured from 10% to 90% of the maximum pulse height. The available Rise Times are 20, 50, 100, 200, 500, 1000, and 2000 nsec.

NOTE

The 448 Output pulse shaping network is purely passive, meaning that the Rise Time and Decay Time Constant controls are *not* independent of each other. The actual t_r in an Output pulse will be closest to the setting of the Rise Time control when long Decay Time Constants are used. The actual τ_d of an Output pulse will be closest to the setting of the Decay Time Constant control when fast rise times are used.

POLARITY When using Internal Reference, selects the polarity of the Output pulses to be either Positive or Negative. When using External Reference, this switch does not affect the Output pulse polarity, but must be set at the polarity of the external reference input to provide proper Trigger Out pulses.

ATTENUATION Six front-panel 2-position toggle switches that select either Out (down) or in (up) for the six pi-type attenuators in the output circuit. They may be used in any combination to provide attenuation of the output from 1:1 to 336:1, and fine control is then provided by either the Normalize control or the External Reference level. The attenuation steps have an accuracy controlled by 0.1%-precision metal film resistors with a low temperature coefficient and depend upon the Output pulse being terminated in a stable 100Ω impedance.

4.2. REAR PANEL CONTROL FUNCTIONS

REFERENCE EXT/INT A 2-position slide switch that selects the reference level to be applied to the Pulse Height control. When it is set at Internal, an internal power supply reference level is used, and the maximum range (with Normalize set at 500 dial divisions) is ±10 V; the Pulse Height dial may be read directly in volts and the Output pulse amplitude will be affected only by the Attenuation switches. When it is set at External, the reference level will be that which is furnished through the adjacent Reference Input BNC connector; the maximum external reference level is ±35 V; the maximum range of the Pulse Height control is 50% of the external reference level; the Output pulse polarity is determined by the polarity of the external reference; and the Normalize and Polarity front panel switches do not affect the Output pulses. For proper Trigger Out pulses the Polarity switch must be set to the external reference polarity, when this is used.

115/230 A rear panel slide switch that sets the power supply input circuit for either 115- or 230-V ac operation.

4.3. CONNECTOR DATA

OUTPUT CONNECTOR (CN1, Front Panel, Type BNC) The main Research Pulser Output is dc-coupled through a series output impedance of 100Ω. The Output pulse should always be terminated in 100Ω at the remote end of the interconnecting cable, using either the Charge Terminator or the Resistive Terminator furnished with the instrument.

OUTPUT TEST POINT (TP4) Front panel test point for monitoring the Output pulse with an oscilloscope. The test point is connected to CN1 through a 470Ω series resistor. Avoid loading the output by any connections made to the test point.

TRIGGER OUT CONNECTOR (CN2, Front Panel, Type BNC) This output pulse is time coincident with the main Output pulse and can be used to trigger monitoring equipment such as an oscilloscope. The pulse is rectangular, 1 μsec wide, with 5-V amplitude on 1000Ω or 2.5 V on 100Ω.

TRIGGER OUT TEST POINT (TP5) Front panel test point for monitoring the Trigger Out pulse with an oscilloscope. This test point is connected to CN2 through a 470Ω series resistor.

EXT REFERENCE (CN3, Rear Panel, Type BNC) Accepts an External Reference voltage level, ±35 V maximum, to be applied to the Pulse Height control; adjacent slide switch must be set at Reference Ext to dc-couple this input into the 1000Ω Pulse Height control circuit. Due to the passive shaping network of the 448, the maximum Output pulse amplitude in the external reference mode of operation is 50% of the External Reference input level.

REFERENCE OUT (Rear Panel Connectors) This is intended as a connection for an external meter for monitoring the voltage level adjusted with the Kelvin-Varley voltage divider. It is wired internally through 10 kΩ to the output of the Pulse Height control. The black connector is instrument-ground, and the red connector is for either polarity of output voltage.

4.4. TERMINATORS

Two terminators are provided with the ORTEC 448 Research Pulser. One is a 100Ω Resistive Terminator and the other is a Charge Terminator. These terminators are housed in a clip on the rear panel, convenient for storage when they are not being used.

4.5. TYPICAL OPERATING CONSIDERATIONS

Charge Termination The Charge Terminator consists of a 100Ω shunt resistor and a 2-pf series capacitor, housed in a pair of BNC connectors. It is used at the Output cable connection to a charge-sensitive preamplifier such as the ORTEC 109A, where it will both load the Pulser Output properly and convert the voltage pulse to a charge pulse to simulate the normal detector output pulse. The maximum pulse height of 10 V is converted into a 20-pC charge pulse at the preamplifier input, which is equivalent to a pulse from a silicon detector for a 440-MeV energy pulse. Use 100Ω cable, such as RG-62/U, from the 448 to the Charge Terminator, and attach the Charge Terminator to the input of the preamplifier.

The Charge Terminator may be used either with or without a detector connected to the preamplifier input. If the detector is also connected to the input, detector bias must be applied to reduce the effective detector capacity. For this combination, the Charge Terminator effectively adds 2.5-pF of shunt capacity and will degrade the signal-to-noise performance of the preamplifier correspondingly.

Resistive Termination For voltage drive to an instrument under test, use coaxial cable with a characteristic impedance of 100Ω, such as RG-62/U. The cable ***must*** be receiving-end-terminated in a 100Ω load. The Resistive Terminator is included for convenience in making this termination, where the input impedance of the instrument under test is 1000Ω or more (the normal input circuit of ORTEC instruments). Use a type BNC tee connector to connect both the cable and the Resistive Terminator to the input connector of the instrument.

4.6. NORMALIZING

For information on adjusting the 448 Research Pulser so that its Pulse Height control reads directly in equivalent energy, see Section 7.1.

4.7. DRIVING AN ADC

The 448 output can be used as the input into an ADC directly, without passing through an amplifier or other shaping network. The most satisfactory results are always obtained with long rise times (>1000 nsec).

5. CIRCUIT DESCRIPTION
(Refer to Schematic 448-0101-S1)

The ORTEC 448 Research Pulser operates directly from an ac power input at either 115 or 230 V (±10%), and includes an internal power supply from which all of its operating and internal reference levels are obtained. The fused power input circuit includes power switch S14 and 115/230-V switch S1 for the primary windings of transformer T1. Indicator I1 illuminates the power switch when power is on for the instrument.

Each of the three secondary windings of transformer T1 is rectified with a full wave bridge rectifier and is regulated for the proper internal application in the 448. Rectifier D1, with transistors Q1 through Q3 and D15, provide a +20-V regulated supply; this is filtered further by L1, C7, and C9 for use in the Trigger Out circuit. Rectifier D2, with transistors Q5 through Q7 and D16, provide a -20-V regulated supply, and this is further filtered by L2, C8, and C10. Rectifier D3, with transistors Q21 and Q23 through Q25, integrated circuit IC2, and diode D4, furnishes a floating stable internal reference voltage, which can be varied through a range of +10% to -10% around 20 V with the Normalize control; the Polarity switch connects either side of this supply to ground.

5.1. RELAY DRIVE

The mercury relay, K1, accepts a dc reference voltage level while energized and charges the selected Decay Time Constant capacitor, C32 through C36, to this voltage. When it is de-energized, the relay completes a discharge path to form an Output pulse.

The relay driving rate is obtained through Relay switch S2. When this switch is set at Off, the relay remains de-energized and the Pulser, with power on, is effectively in a standby condition. When the switch is set at Line Freq, pulses at the power line frequency determine the Output pulse repetition rate. When the switch is set at Int Osc, transistor Q16 through Q18 operate as a hybrid unijunction—biopolar transistor oscillator for a repetition rate selected by the Pulse/Sec switch, S3. When the Decay Time Constant switch, S4, is set at 1000 μsec, the maximum repetition rate is restricted to 20 pulses/sec for either On position of Relay switch S2; this is a duty-cycle limitation network.

The repetition rate is set by the pulse source, above, and the pulses are connected through driver stages Q19 and Q20 to alternately energize and de-energize relay K1.

5.2. PULSE HEIGHT CONTROL

When switch S13 is set at Internal, as shown in Schematic 448-0101-S1, the voltage applied across the Pulse Height control, R30, is obtained from the stable floating supply through Polarity switch S6. The control is a precision Kelvin-Varley voltage divider with 100,000 effective settings for the full range of Output pulse heights. The actual voltage to which it is set can be monitored through rear panel connectors, Reference Out, using an external meter. Depending on the setting of the Normalize control, R69, the full range of settings of R30 will provide 0 to 20 V (±10%) to the Reference Out. Resistor R101 is a precision 10-kΩ resistor which then is a part of the effective external meter circuit and prevents loading of the regulated Pulse Height control selection. The selected level is applied through R99 to the selected Decay Time Constant capacitor each time that the relay is energized.

When switch S13 is set at External, either a positive or negative External Reference voltage level, furnished through connector CN3, is supplied directly to the Pulse Height control, R30, and the special internal reference supply is disconnected. The maximum external reference level which can be accommodated is 35 V, and the remainder of the Pulse Height control circuit operates the same for External Reference as for Internal Reference, above.

5.3. OUTPUT CIRCUIT

After relay K1 has been energized and a Decay Time Constant capacitor has been charged to the voltage selected by the Pulse Height control, the Relay is de-energized. This closes a circuit for discharge of the Decay Time Constant capacitor, through R76, and a selected Rise Time capacitor in parallel with the Output load. The Output begins to rise with a time constant set by the parallel RC combination of the Rise Time capacitor selected by switch S5 and the 50Ω resistance which is effective. The decay time constant of the Output pulse is given by the parallel RC combination of the Decay Time Constant capacitor selected by switch S4 and the resistance which it sees, approximately 200Ω (for $\tau_d >> t_r$).

Resistors R78 through R96 form a series of constant-impedance pi-type attenuators, through which the Output pulse passes and is presented at the Output BNC, CN1, to be developed across the 100Ω terminating impedance of the Charge or Resistive Terminator.

5.4. TRIGGER OUT

Each pulse that is furnished through the Output circuit will also be applied through field effect transistor Q9 to the circuit including transistors Q10 through Q15 and integrated circuit IC1. The Trigger Out signal, through connector CN2, may be used to trigger a response in a monitoring circuit such as an oscilloscope. The pulse has a fixed amplitude and width and will not load the main Output circuit. The purpose of IC1 is to provide high gain for a wide dynamic range. Either pulse polarity can be used to generate a Trigger Out Pulse. When operating with the Internal Reference level, one section of Polarity switch S6 selects the proper connection for the selected Output Pulse polarity. When operating with the External Reference level, the polarity of the main Output pulses is determined by the polarity of the reference level, and the Polarity switch must then be set to agree with the reference polarity in order to obtain Trigger Out pulses.

6. MAINTENANCE

6.1. TESTING PERFORMANCE

The following is intended as an aid for installation and checkout of the 448 Research Pulser.

The equipment required is as follows:

Oscilloscope; Tektronix 540 Series, or equivalent. Dual trace plug-in unit, Tektronix 1A1, or equivalent. Digital Voltmeter, HP3439A, or equivalent.

Check the module visually for possible damage during shipping and then take the following preliminary steps:

1. Set the 115/230-V slide switch according to available ac power.

2. Connect the line cord to the ac power source.

3. Press the Push On/Off switch, and check to see that power is turned on and off alternately by observing the illuminated switch. Leave power turned to On.

Test the performance of the 448 by the following procedure:

1. Set rear panel Reference switch at Internal.

2. Set Pulse Height control at maximum (9 – 9 – 9 – 100).

3. Set Normalize control at 500 dial divisions.

4. Set Pulse/Sec switch at 50.

5. Set Relay switch at Int Osc.

6. Set Rise Time switch at 20.

7. Set Polarity to Positive.

8. Set Decay Time Constant switch at 50.

9. Set all Attenuation switches in the down position (Out).

10. Connect the Output to one channel of the oscilloscope, using the 100Ω Resistive Terminator at the oscilloscope input.

11. Connect the Trigger Out to the other channel of the oscilloscope. Observe an Output pulse with a +10-V maximum amplitude, approximately 20-nsec rise time, and 50-μsec decay time constant. The Trigger Out pulse should be time coincident, 1 μsec wide, with +5-V amplitude. The repetition rate should be approximately 50 pulses/sec.

12. Observe that the Normalize control can be used to vary the Output pulse amplitude from about 9 V to 11 V. Return Normalize to 500 dial divisions.

13. Reduce the Pulse Height control to 01500. Observe that the Trigger Out pulse is still present and has shifted no more than 15 nsec in time. Observe the Output pulse amplitude; it should be +0.15 V. Change the Polarity switch to Negative and observe the Output pulse amplitude, which should be -0.15 V. The Trigger Out pulse should still be present. Return the Pulse Height control to maximum and the Polarity switch to Positive.

14. Turn the Decay Time Constant switch to 1000. Observe that the repetition rate of the Output is reduced to approximately 20 pulses/sec. Turn the Pulse/Sec switch to 100; then set the Relay switch at Line Freq and observe that the repetition rate remains at 20 pulses/sec while τ_d = 1000 μsec. Return the Decay Time Constant switch to 50, the Relay switch to Int Osc, and the Pulse/Sec switch to 50.

15. Set each Attenuation switch at In, that at Out. Observe the following Output amplitude while each switch is set at In: X1.2/8.34 V, X1.4/7.15 V, X2/5.00 V, X2/5.00 V, X5/2.00 V, and X10/1.00 V.

16. Set the Decay Time Constant switch at 1000. Turn the Rise Time switch through each of its positions, and observe the 10% to 90% rise time of the Output pulse for each position. The approximate rise times should be 20/20 nsec, 50/50 nsec, 100/100 nsec, 200/200 nsec, 500/500 nsec, 1000/1 μsec, and 2000/2 μsec.

17. Return the Rise Time switch to 20. If desired, measure the 90% to 10% decay time of the Output pulse for all settings of the Decay Time Constant switch. Since $\tau_d \cong t_d/2.2$, the approximate decay times are 5/11 μsec, 10/22 μsec, 20/44 μsec, 50/110 μsec, and 1000/2.2 msec.

18. Set the Decay Time Constant switch at 50. Measure the pulse period for each setting of the Pulse/Sec switch. The approximate times should be 1/1.0 sec, 2/500 msec, 5/200 msec, 10/100 msec, 20/50 msec, 50/20 msec, and 100/10 msec.

19. Observe the leading edge of the Output pulse closely to detect any possible perturbation of the pulse shape which could be caused by erratic behavior of the Relay.

20. With the Pulse Height control set at maximum and Normalize at 500 dial divisions, measure the Reference Out voltage with the digital voltmeter. It should be approximately 20 V dc.

6.2. CALIBRATION ADJUSTMENTS

The 448 contains a fine adjust for each of the three 20-V regulated supplies. These are factory-adjusted, and should require no further attention except after replacement of a faulty IC or transistor. When readjustment is necessary, set the Polarity switch at Positive and trim the following control settings: Adjust R6 for +20.00 V dc on TP 1, adjust R12 for -20.00 V dc on TP 2, and adjust R66 for +20.00 V dc on TP 3.

6.3. TROUBLESHOOTING SUGGESTIONS

When the 448 is suspected of a malfunction, verify it first by observing the simple pulse waveform at the Output. Disconnect the 448 from its position in any system, but leave the 100Ω Resistive Terminator connected during this examination.

The mercury-wetted relay has a finite lifetime, as specified by the manufacturer, of ~10^9 operations. Occasional replacement may be required, depending on the use duty factor of the 448.

If no Output pulse can be obtained, check the voltage regulators as outlined in Section 6.2. If the power supply levels are correct and it appears that the Relay is not receiving drive pulses (a faint hum is normally present when the Relay is operating), remove the Relay *very carefully* from its socket in the 448. Place an oscilloscope probe in pin 8 of the relay socket and set the Relay switch at either Int Osc or Line Freq. A square wave with approximately 3.2 V amplitude is the normal drive pulse, and the repetition rate will depend on the switch settings.

The 448 may be returned to ORTEC for repair service at nominal cost. Our standard procedure requires that each repaired instrument receive the same extensive quality control tests that a new instrument receives. Contact our Customer Service Department, (615) 482-4411, for shipping instructions before returning an instrument.

7. APPLICATIONS

7.1. CALIBRATING THE 448 FOR ENERGY MEASUREMENTS

In most applications where semiconductor detectors are used with amplifier systems and multichannel analyzers, a direct calibration by comparison to a source of particles of known energy is usually possible. This calibration of the 448, for the purpose of reading energy levels directly on the Pulse Height control, is known as normalizing.

To normalize the 448, set up the analyzer system with the Pulser connected to the preamplifier and with the Relay switch set at Off. Adjust the spectrum on the analyzer, in response to the source or particle, for a photopeak of known energy at a convenient channel; best results will usually be obtained when a high channel number is used. Then remove the energy source from the area where it will affect the detector. Now set the Pulse Height control to read the energy level directly on its dial, and adjust the Attenuation switches and the Normalize dial until the amplitude of the pulser Output provides a photopeak at the same channel number in the analyzer. Be careful to prevent changing any of the system settings during this procedure. The Normalize control setting may be locked, and its dial reading can be recorded, together with the Attenuation switch settings, for future reference. The Pulse Height control is now normalized for direct readout in equivalent energy as long as the same Charge Terminator is used; note that a charge terminator may be built into the preamplifier and may be used in lieu of the terminator furnished with the 448, provided that it furnishes the 100Ω shunt termination that is essential to proper operation of the 448.

7.2. AMPLIFIER NOISE AND RESOLUTION MEASUREMENTS

As shown in Fig. 7.1, amplifier noise and resolution measurements require the 448 Research Pulser, a preamplifier, amplifier, oscilloscope, and a wide-band rms voltmeter such as the Hewlett-Packard 400D. Connect a suitable capacitor to the input to simulate the detector capacitance desired. To obtain resolution spread due to electronic noise:

1. measure the rms noise voltage, E_{rms}, at the linear amplifier output,
2. turn on the 448 and adjust the linear amplifier output to any convenient readable voltage, E_O, as determined by the oscilloscope,
3. full width at half maximum (FWHM) resolution spread due to the amplifier noise is then *N* (FWHM) = 2.66 (E_{rms}) (E_{dial})/E_O, where E_{dial} = pulser dial

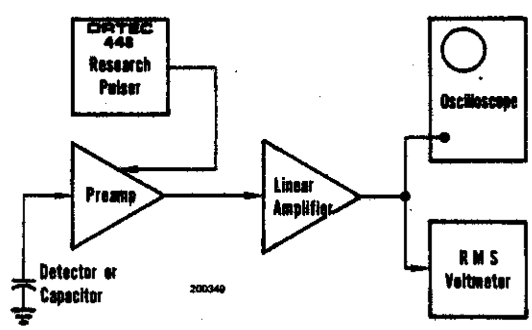


Fig. 7.1. Measuring Amplifier and Detector Noise Resolution Using an Oscilloscope or rms Voltmeter.

reading in MeV, and 2.66 = correction factor, rms to FWHM (2.35) and noise to rms meter correction (1.13) for average indicating voltmeters such as the Hewlett-Packard 400D. The resolution spread will depend upon the total input capacity, since the capacitance degrades the signal-to-noise ratio.

7.3. AMPLIFIER NOISE AND RESOLUTION MEASUREMENTS USING A PULSE HEIGHT ANALYZER

Probably the most convenient method for making resolution measurements is with a pulse height analyzer, as shown in Fig. 7.2. The amplifier noise resolution spread can be measured correctly with a pulse height analyzer and the 448 Research Pulser as follows:

1. Select the energy level of interest with the 448, and adjust the linear amplifier and biased amplifier gains to place the peak in a convenient channel of the analyzer.

2. Calibrate the analyzer in terms of equivalent energy, as described in Section 7.1.

3. Obtain the amplifier noise resolution by measuring the full width at half maximum for the pulser spectrum.

The detector noise resolution spread can be determined in the same manner, by connecting a detector to the preamplifier input instead of a capacitor. After the total spread due to both the detector and electronics has been measured, the amplifier noise resolution spread can be subtracted to obtain the spread due to the detector. The detector noise will vary with detector size, bias conditions, and possibly ambient temperature.

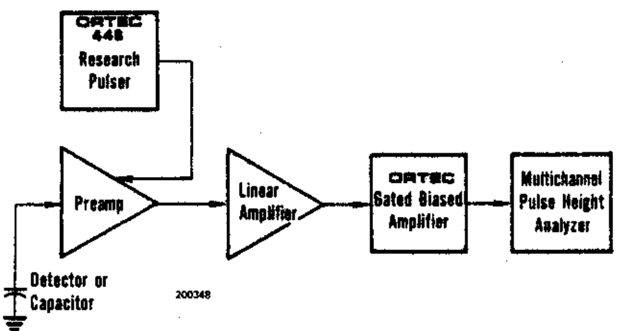


Fig. 7.2. Measuring Amplifier and Detector Noise Resolution Using a Multichannel Pulse Height Analyzer.

7.4. AMPLIFIER LINEARITY MEASUREMENTS

The null-balance method is recommended for measurement of amplifier linearity, as shown in Fig. 7.3. This method consists in connecting two voltages from low-impedance sources and measuring the amplitude differential at a null point.

The driving source impedance of the 448 Output is 100Ω. The amplifier must be set for an inverting mode of operation; i.e., for the negative input shown, the amplifier must

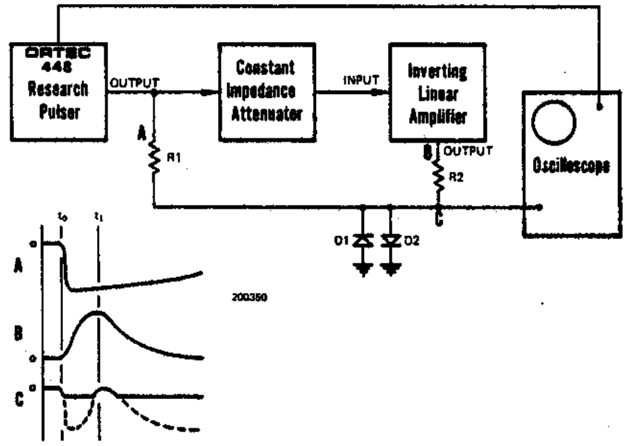


Fig. 7.3. Measuring Linearity, Using the Null-Balance Method.

produce a positive output pulse. The impedance from point C to signal ground through point A should be equal to the impedance from point C to ground through point B. Use germanium diodes with high G_m for diodes D1 and D2. These diodes can be replaced with high-frequency germanium transistors, with the base connected to the collector so that the emitter-base junction serves as a diode. Transistors suitable for this test include 2N779, 2N964, 2N976, and 2N2048.

The diodes serve as bipolar voltage clamps to limit the voltage swing at point C to the forward voltage drop across the diodes. The diode-resistor network should be constructed to minimize stray capacitance around the network; it should probably be located on the oscilloscope input connector.

Set the 448 Output amplitude at 10 V initially. Measure this carefully, and consider the output impedance of both the 448 and the amplifier. Observe the wave shape at point C, and adjust the Attenuator and the amplifier fine gain for a null at time t_1. For best resolution of the null measurement, set the oscilloscope sensitivity to 10 mV/cm.

The actual measurement of linearity is made by observing the null while the Pulse Height control is reduced to zero. Since the pulse generator supplies signals in parallel to both the bridge and the amplifier, any variation from zero of the null point will indicate a corresponding nonlinearity of the amplifier. As an example, assume that the amplifier under test has essentially zero output impedance. Use 100Ω Constant Impedance Attenuators, and make R1 equal to 1000Ω and R2 equal to 1050Ω. Let D1 and D2 be diode-connected 2N2048 transistors. With this circuit, half of the change in the output voltage of the amplifier at point A results from the attenuation factor of R1 and the output impedance of the 448 Output; the other half of the change comes from R2. To specify nonlinearity as a percentage of amplifier full output voltage, the calibration of 10 mV/cm will be equivalent to 0.2%/cm. A nonlinearity as small as 0.1% can be identified easily. Other measurements that can be made by this method include temperature stability.

7.5. MULTICHANNEL PULSE HEIGHT ANALYZER CALIBRATION

The ORTEC 448 Research Pulser includes shaping controls that can be set to simulate normal pulse shapes as furnished into a multichannel pulse height analyzer. For example, with the Rise Time control set at 500 to 2000 and the Decay Time Constant switch at 5, the 448 Output pulse approximates the unipolar output of a linear amplifier with single time constants. Because of the passive shaping in the 448, the maximum pulse height, using these settings with Internal Reference, is approximately 6 V but will be extremely stable as long as the shaping remains constant.

Connect the 448 Output directly to the ADC input of the multichannel analyzer, using the 100Ω Resistive Terminator at the ADC input. This arrangement is very useful for making direct calibration, linearity, and stability checks on the multichannel analyzer. The system may be calibrated so that the Pulse Height control of the 448 reads directly in channel number, or in equivalent energy, as outlined in Section 7.1.

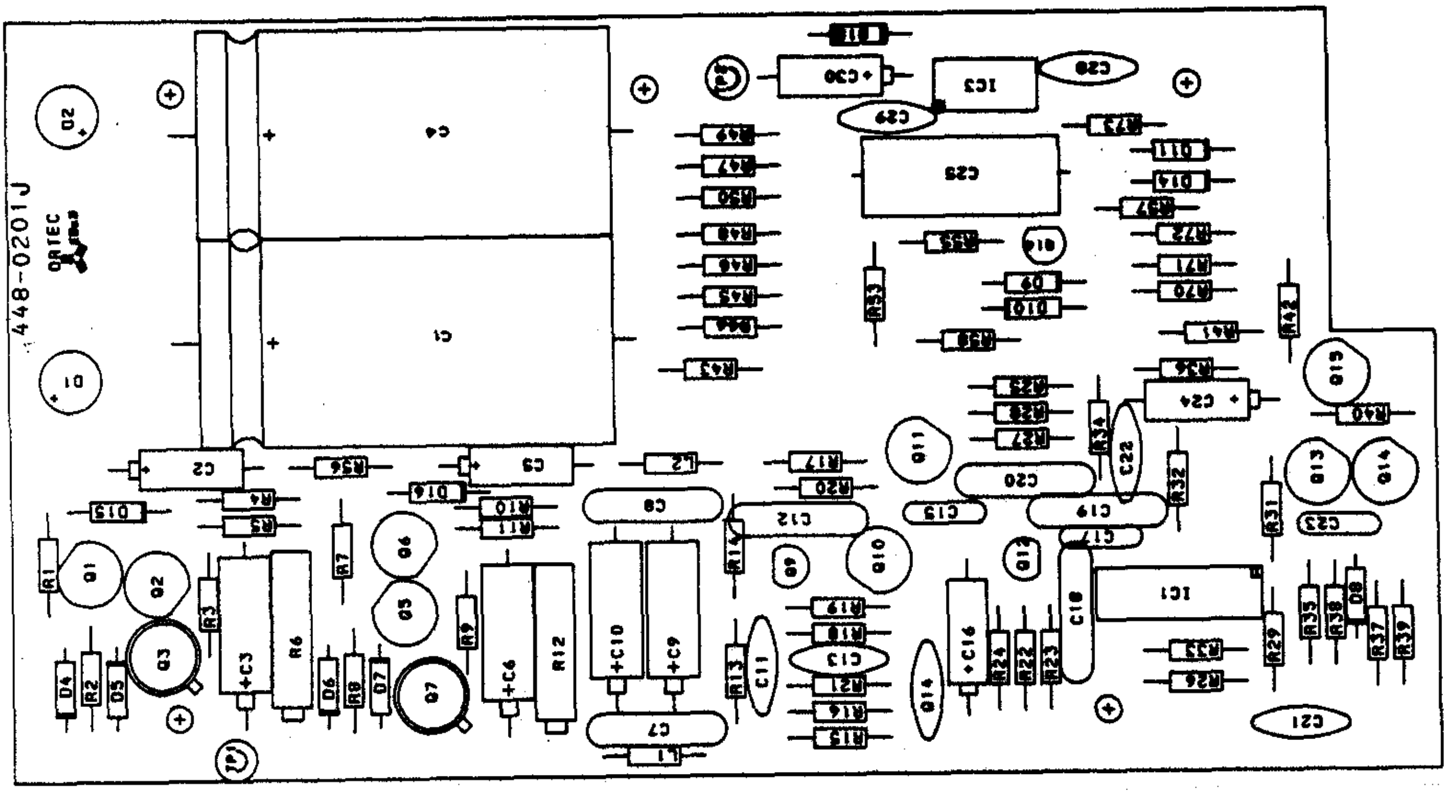
7.6. MULTICHANNEL ANALYZER SYSTEM STABILIZATION

The ORTEC 448 Research Pulser provides an Output pulse that features settability and long-term stability, and is appropriate for use as the reference source for analyzer system stabilization. Connect the system as shown in Fig. 7.2, with an appropriate stabilizer added into the system. Set the 448 Output amplitude so that the pulser peak will fall within the analyzer channels in an area that will not be used for the normal spectrum. Then set the stabilizer to lock the system calibration on the pulser peak. For calibration changes in the system, simply set the 448 Relay switch at Off and adjust system gains and ADC measurement ranges as desired; then turn the pulser on again and adjust its Output and the stabilizer for a peak in an unused portion of the spectrum. Better operation is usually obtained when the stabilizing peak is located above 80% of the available channels.

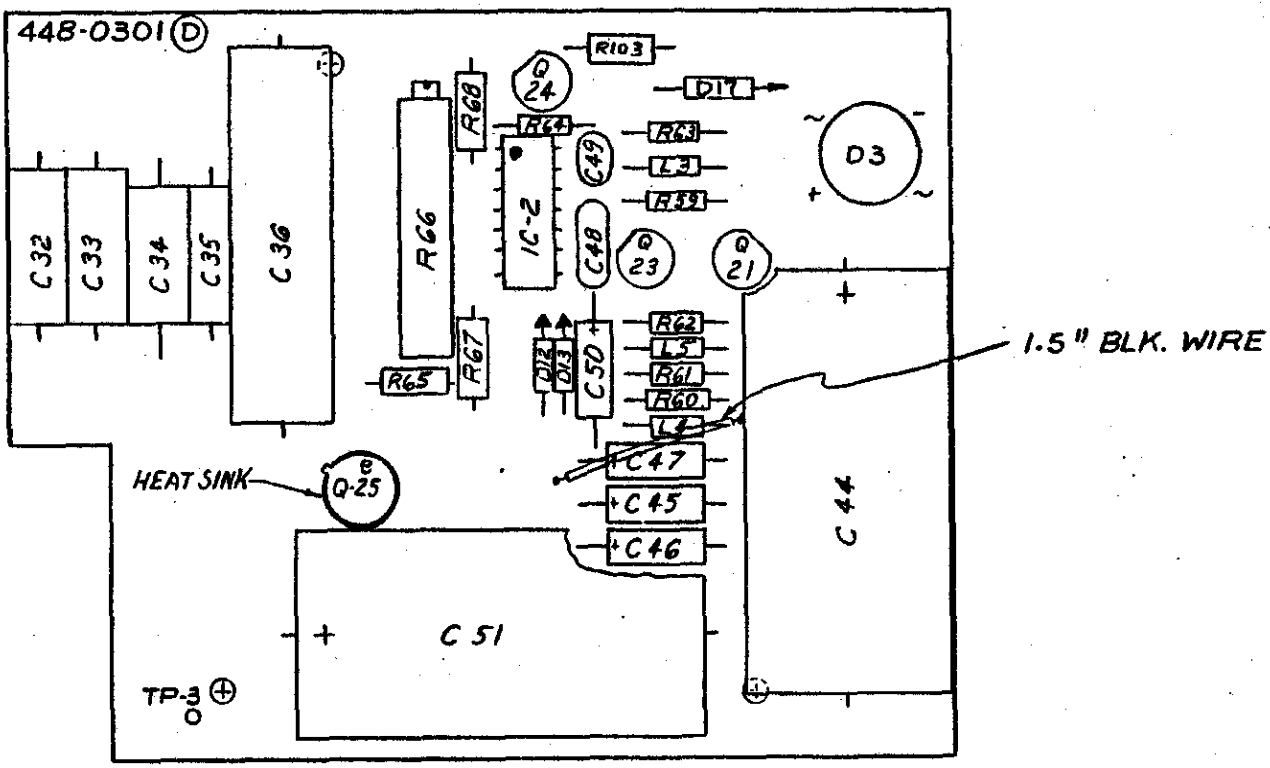
BIN/MODULE CONNECTOR PIN ASSIGNMENTS FOR AEC STANDARD NUCLEAR INSTRUMENT MODULES PER TID-20893

Pin	Function	Pin	Function
1	+3 volts	23	Reserved
2	−3 volts	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 volts
7	Coaxial	*29	−24 volts
8	200 volts dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 volts	32	Spare
*11	−6 volts	*33	115 volts ac (Hot)
12	Reserved Bus	*34	Power Return Ground
13	Spare	**35	Reset (Scaler)
14	Spare	**36	Gate
15	Reserved	**37	Reset (Auxiliary)
*16	+12 volts	38	Coaxial
*17	−12 volts	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	115 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

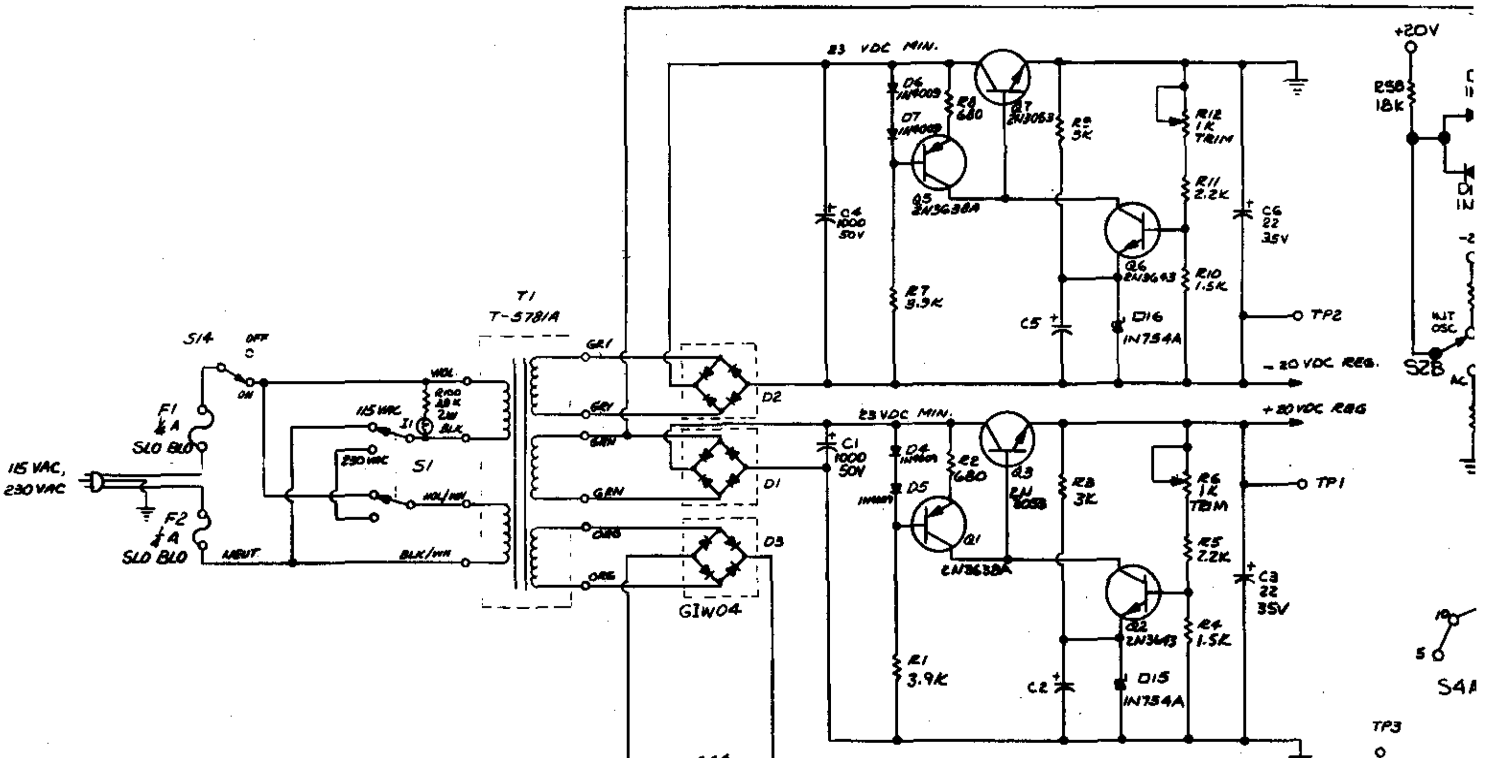
Pins marked (*) are installed and wired in ORTEC 401A and 401B Modular System Bins.
Pins marked (*) and (**) are installed and wired in EG&G/ORTEC–HEP M250/N and M350/N NIMBINS.



448-0201J
ORTEC

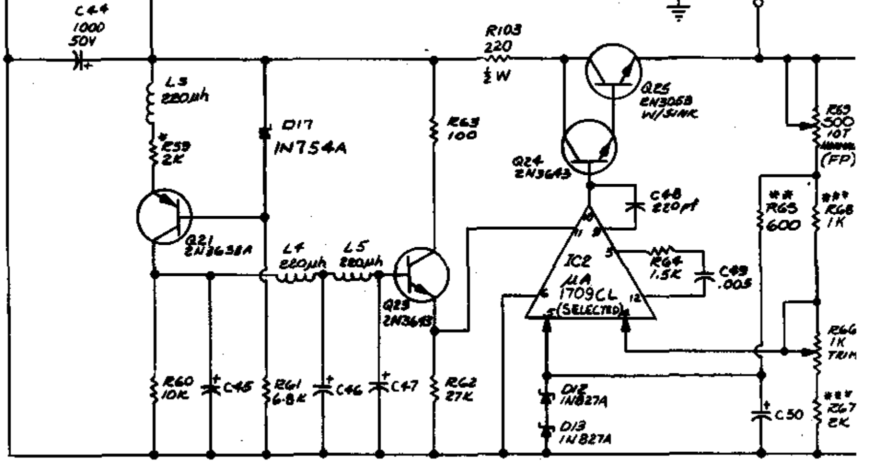


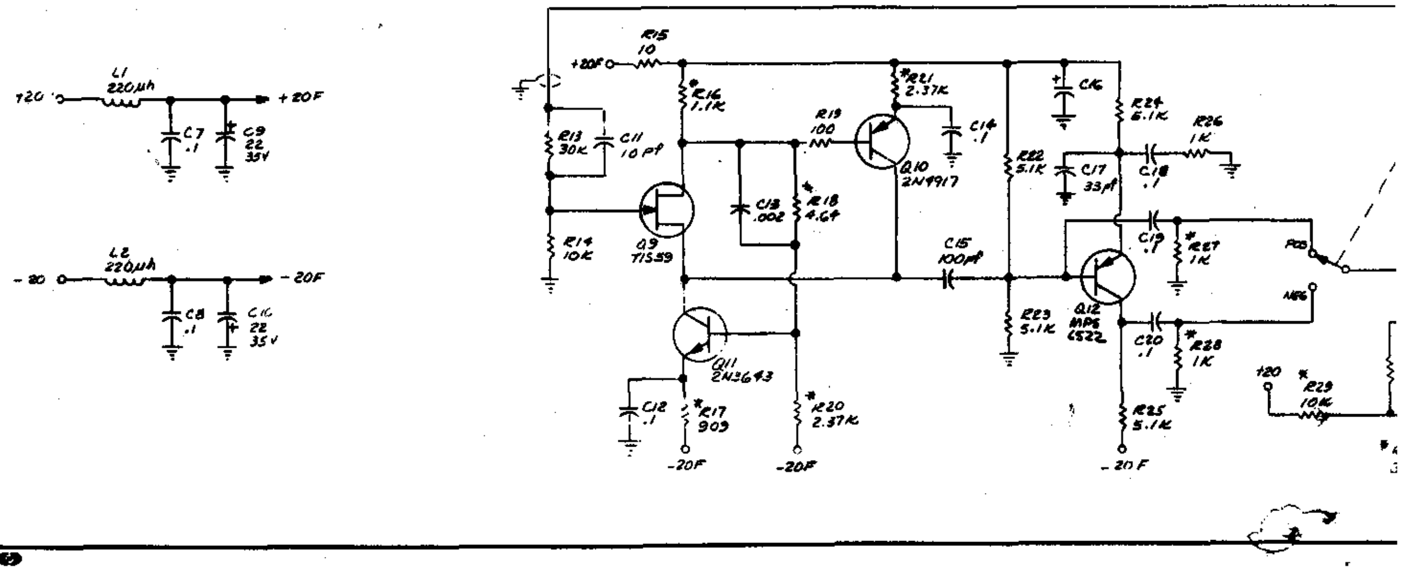
448-0301 D
HEAT SINK
1.5" BLK. WIRE
TP-3

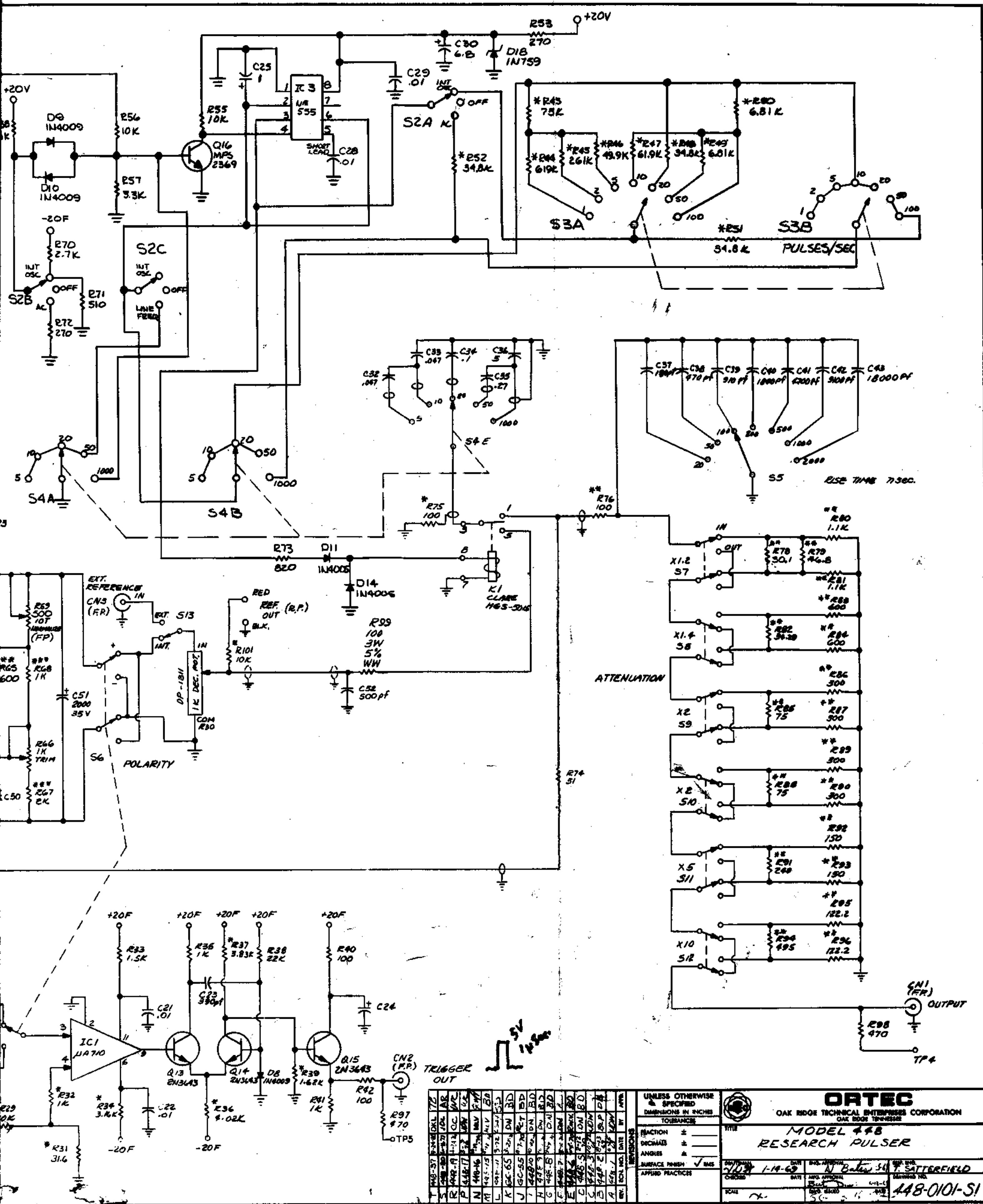


NOTES: UNLESS OTHERWISE SPECIFIED.

1. RESISTORS MARKED * ARE 1%, 1/8W MF
2. CAPACITORS ARE 6.8μf, 35V
3. TRANSISTORS MARKED * ARE ORTEC # 41064
4. ALL RESISTORS ARE IN OHMS.
5. ALL CAPACITORS ARE IN μf.
6. RESISTORS MARKED ** ARE 0.1%, T.C. = 15 PPM/°C METAL FILM.
7. RESISTORS MARKED *** ARE 1%, T.C. = 5PPM/°C WIRE WOUND.







UNLESS OTHERWISE SPECIFIED
DIMENSIONS IN INCHES
TOLERANCES
FRACTION ±
DECIMALS ±
ANGLES ±
SURFACE FINISH √ RMS
APPLIED PRACTICES

ORTEC
OAK RIDGE TECHNICAL ENTERPRISES CORPORATION
OAK RIDGE TENNESSEE

TITLE: MODEL 448 RESEARCH PULSER

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448-0101-S1