EG&G ORTEC

Model 661
Ratemeter
Operating and Service Manual

PFE: 88.056.

Model 661
Ratemeter
Operating and Service Manual

This manual applies to instruments marked
"Rev 00" on rear panel

Printed in U.S.A. EG&G ORTEC Part Number 740380 3862 0388

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for
EG&G ORTEC Nuclear Electronic Instruments

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If it becomes necessary to return this instrument for repair, it is essential that Customer Services be contacted in advance of its return so that a Return Authorization Number can be assigned to the unit. Also, EG&G ORTEC must be informed, either in writing, by telephone [(615) 482-4411] or by telex (55-7450) of the nature of the fault of the instrument being returned and of the model, serial, and revision ("Rev" on rear panel) numbers. Failure to do so may cause unnecessary delays in getting the unit repaired. The EG&G ORTEC standard procedure requires that instruments returned for repair pass the same quality control tests that are used for new-production instruments. Instruments that are returned should be packed so that they will withstand normal transit handling and must be shipped **PREPAID** via Air Parcel Post or United Parcel Service to the nearest EG&G ORTEC repair center. (In the case where the instrument did not function upon purchase, EG&G ORTEC will pay shipment costs both ways.) The address label and the package should include the Return Authorization Number assigned. Instruments being returned that are damaged in transit due to inadequate packing will be repaired at the sender's expense, and it will be the sender's responsibility to make claim with the shipper. Instruments not in warranty will be repaired at the standard charge unless they have been grossly misused or mishandled, in which case the user will be notified prior to the repair being done. A quotation will be sent with the notification.

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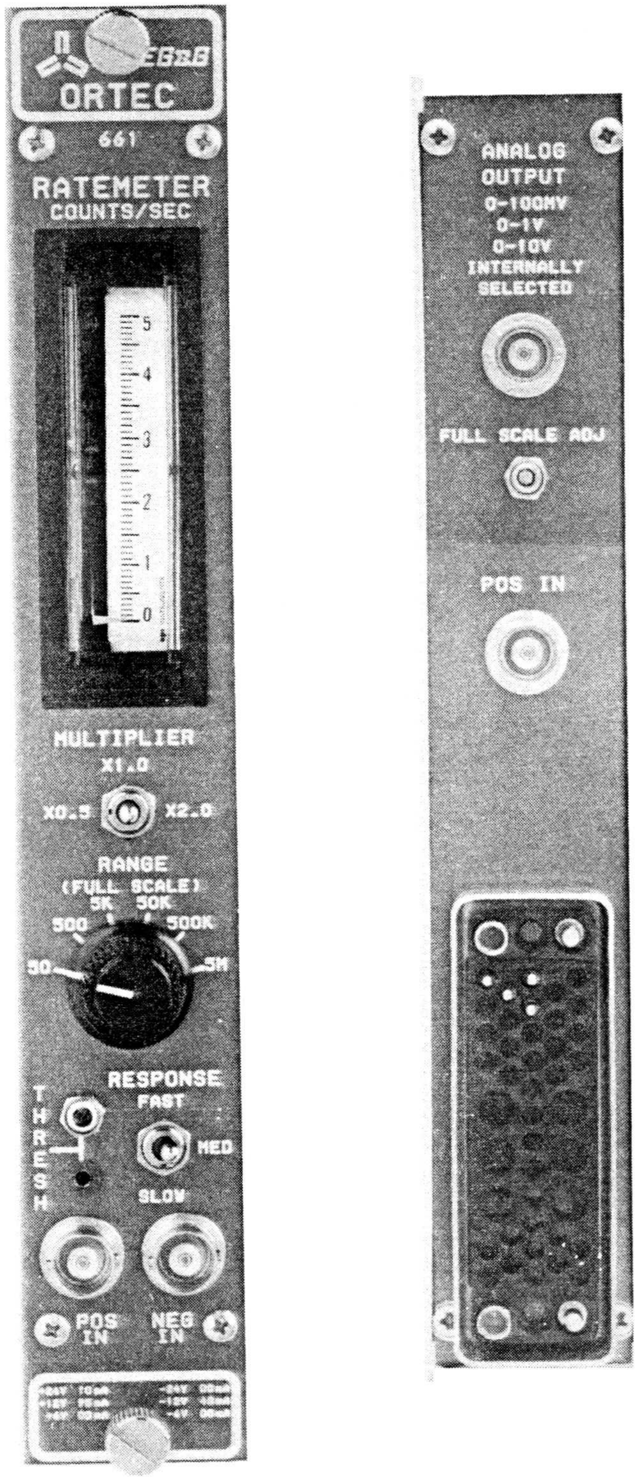

EG&G
ORTEC
661
RATEMETER
COUNTS/SEC
MULTIPLIER
X1.0
X0.5
X2.0
RANGE
(FULL SCALE)
50
500
5K
50K
500K
5M
RESPONSE
FAST
MED
SLOW
THRESH
POS IN
NEG IN
ANALOG
OUTPUT
0-100MV
0-1V
0-10V
INTERNALLY
SELECTED
FULL SCALE ADJ
POS IN

EG&G ORTEC MODEL 661 RATEMETER

1. DESCRIPTION

The EG&G ORTEC Model 661 Ratemeter measures the counting rate of randomly arriving pulses, or the frequency of periodic signals in the range of 0 to 10^7 counts/s (0 to 10 MHz). This range of counting rates is covered with 18 different scales. The scales are arranged in a 25, 50, 100 sequence from 25 counts/s to 10^7 counts/s full scale.

A positive input accepts and counts signals in the amplitude range of +150 mV to +10 V. The signals can be either positive unipolar pulses or bipolar pulses. With bipolar pulses, only the positive lobe will be counted. The positive input includes a discriminator whose threshold can be adjusted over the range of 150 mV to 10 V. In many cases this eliminates the need for an external precision discriminator. Only those pulses whose amplitudes exceed the positive discriminator threshold are counted.

A negative input is provided to count NIM-standard fast negative logic pulses in the amplitude range of −600 to −1800 mV. The negative input threshold is fixed at −250 mV. Pulses as narrow as 4 ns can be counted through this input.

A front-panel switch permits selection of the ratemeter response time, which determines the random error in the measurement. Three response times are provided, FAST, MED, and SLOW. When measuring the steady state counting rate of randomly arriving pulses, the standard deviation of the instantaneous meter reading is <1% on the SLOW response, <3% on the MED response, and <10% on the FAST response setting (Table 1).

The settling time for 1% precision on the SLOW response time can be quite long at low counting rates. To overcome this limitation the 661 Ratemeter includes a special, fast response circuit. With this feature the measurement can be started with the RESPONSE switch in the FAST position. When the meter has settled, the RESPONSE switch is moved to the MED position, and then to the SLOW setting. This technique significantly reduces the time to settle to 1% precision, since the FAST, MED, and SLOW response times are maintained in a 1:9:100 ratio.

A rear-panel ANALOG OUTPUT is included for use with strip chart recorders. The full-scale output can be selected to be 100 mV, 1 V, or 10 V. A ±10% fine-adjustment potentiometer is provided for the calibration of this output.

2. SPECIFICATIONS*

2.1. PERFORMANCE

COUNTING RATES Measures counting rates in the range of 0 to 10 MHz (0 to 10^7 counts/s).

METER RANGES Provides 18 full-scale meter ranges from 25 counts/s to 10^7 counts/s in a 25, 50, 100 step sequence.

ANALOG OUTPUT RANGES Same as meter ranges. Full-scale output can be selected as 100 mV, 1 V, or 10 V.

PULSE PAIR RESOLUTION <40 ns on both positive and negative inputs.

STANDARD DEVIATION The ratemeter time constants yield a standard deviation in the instantaneous meter reading of <10% for the FAST RESPONSE, <3% for the MED RESPONSE, and <1% for the SLOW RESPONSE setting, when measuring the steady state counting rate of randomly spaced events. See Table 1 for details.

CALIBRATION ACCURACY
Meter: <2% of full scale.
Analog Output: <1% of full scale.

NONLINEARITY <±0.1% of full scale at the analog output.

TEMPERATURE SENSITIVITY <0.02% of full scale per °C, 0 to 50 °C.

*Specifications subject to change without notice.

2.2. CONTROLS AND INDICATORS

METER Front-panel meter provides visual reading of the counting rate. Actual value for the full-scale reading is determined by the product of the RANGE and MULTIPLIER switch settings.

RANGE Front-panel six-position switch provides the coarse selection of the full-scale counting rate. Coarse ranges of 50, 500, 5000, 50,000, 500,000, and 5,000,000 counts/s are selectable.

MULTIPLIER Front-panel three-position switch provides a fine adjustment of the full-scale value selected by the RANGE switch. The full-scale counting rate is the product of the RANGE and MULTIPLIER values. The MULTIPLIER switch selects a multiplying factor of 0.5, 1.0, or 2.0.

RESPONSE Front-panel 3-position switch selects the ratemeter response time. The three response times are also controlled by the RANGE switch to ensure standard deviations of <10% on the FAST setting, <3% on MED, and <1% on the SLOW setting. See Table 1 for details. The FAST, MED, and SLOW response times are maintained in a 1:9:100 ratio. A special circuit permits using the advantage of the shorter time constants on the FAST and MED switch positions to significantly reduce the time taken to settle to 1% precision on the SLOW position. Using this feature, the measurement is started with the RESPONSE switch in the FAST position. When the meter has settled, the RESPONSE switch is moved to the MED position. After the meter has settled again, the switch is moved to the SLOW setting. This technique provides a significantly shorter response time than would be obtained by leaving the ratemeter in the SLOW RESPONSE setting.

Table 1. Standard Deviation for Various Scale and Response Settings.

Full-Scale Frequency	STANDARD DEVIATION (%)		
	SLOW	MED	FAST
25 Hz	1.0	3.0	10.0
50 Hz	0.7	2.0	7.0
100 Hz	0.5	1.5	5.0
250 Hz	1.0	3.0	10.0
500 Hz	0.7	2.0	7.0
1 kHz	0.5	1.5	5.0
2.5 kHz	1.0	3.0	10.0
5 kHz	0.7	2.0	7.0
10 kHz	0.5	1.5	5.0
25 kHz	1.0	3.0	10.0
50 kHz	0.7	2.0	7.0
100 kHz	0.5	1.5	5.0
250 kHz	0.3	1.0	3.0
500 kHz	0.22	0.7	2.0
1 MHz	0.16	0.5	1.6
2.5 MHz	0.1	0.3	1.0
5 MHz	0.07	0.2	0.7
10 MHz	0.05	0.15	0.5

THRESH (Threshold) A front-panel 20-turn potentiometer provides screwdriver adjustment of the positive input discriminator threshold over the range of 150 mV to 10 V.

ANALOG OUTPUT RANGE Printed circuit board jumper, W1, allows selection of a 100 mV, 1 V, or 10 V full-scale output for the ANALOG OUTPUT.

FULL SCALE ADJ A rear-panel 20-turn potentiometer provides a ±10% adjustment of the full-scale output voltage for the selected range of the ANALOG OUTPUT.

2.3. INPUTS

POS IN Front- and rear-panel BNC connectors accept positive polarity inputs for counting. Input signals can be unipolar or bipolar. The ratemeter will count signals whose amplitudes are more positive than the input discriminator threshold (THRESH) setting. Linear input range is 0 to +10 V. Inputs protected to ±25 V. Minimum pulse width above threshold is 20 ns at a 50% duty cycle. Input impedance is 1000 Ω to ground, dc-coupled.

NEG IN Front-panel BNC connector accepts NIM-standard, fast negative logic pulses with amplitudes in the range of −600 to −1800 mV. Negative input discriminator has a fixed threshold of −250 mV. Minimum pulse width at threshold is 4 ns. Input impedance is 50 Ω to ground. Input protected to ±25 V at a 10% duty cycle.

2.4. OUTPUTS

METER 5.08 cm (2 in.) edge reading meter with a 2% meter movement.

ANALOG OUTPUT Rear-panel BNC connector provides an output voltage proportional to the measured counting rate for use with a strip chart recorder. Output is selectable for a 0 to 100 mV, 0 to 1 V, or 0 to 10 V range, using the analog output range jumper. A calibration adjustment of ±10% of full scale is possible with the FULL SCALE ADJ potentiometer. Output impedance is 50 Ω, with short-circuit protection. Maximum output current is 10 mA.

THRESH (Threshold) Front-panel test point adjacent to the THRESH potentiometer monitors the threshold voltage of the positive input discriminator. Test point voltage measured with a high-impedance voltmeter is 1/10 the actual threshold voltage of the positive input discriminator. Output impedance is 15,000 Ω.

2.5. ELECTRICAL AND MECHANICAL

POWER REQUIRED The 661 Ratemeter derives its power from a NIM Bin supplying ±12 V and ±24 V, such as the EG&G ORTEC Model 4001A/4002A NIM Bin and Power Supply. The power required is +12 V at 95 mA, −12 V at 40 mA, and +24 V at 10 mA.

WEIGHT
Net 0.68 kg (1.5 lb).
Shipping 1.6 kg (3.5 lb).

DIMENSIONS Standard single-width NIM module, 3.43 × 22.13 cm (1.35 × 8.714 in.) front panel per TID-20893 (Rev).

3. INSTALLATION

3.1. GENERAL

The 661 Ratemeter operates on power that must be furnished from a NIM-standard bin and power supply such as the EG&G ORTEC 4001/4002 Series. The bin and power supply is designed for relay rack mounting. If the equipment is to be rack mounted, be sure that there is adequate ventilation to prevent any localized heating of the components that are used in the 661. The temperature of equipment mounted in racks can easily exceed the maximum limit of 50° C unless precautions are taken.

3.2. CONNECTION TO POWER

The 661 contains no internal power supply; therefore, it must obtain power from a NIM-standard bin and power supply. Always turn the bin power off before inserting or removing modules. After all modules have been installed in the bin, check the dc voltage levels from the power supply to see that they are not overloaded. All EG&G ORTEC bins and power supplies have convenient test points on the power supply control panel to permit monitoring these dc levels. If any one or more of the dc levels indicates an overload, some of the modules will need to be moved to another bin to achieve operation.

3.3. SIGNAL CONNECTIONS TO THE 661 INPUTS

The 661 is equipped with two separate input circuits. One is for positive input signals and the other one is for negative-NIM signals. These two inputs are "OR-ed" together inside the module, so you can make a connection to one or the other but not to both.

For positive input signals the input labeled POS IN should be used. The input is available on both the front and rear panels. The positive input signal goes through a lower-level discriminator inside the module. The discriminator level is set by the trimpot located on the front panel labeled THRESHOLD. The discriminator voltage may be monitored on the test point below the trimpot. The voltage read at the test point is 1/10 the actual discriminator voltage.

The negative-NIM input is located on the front panel only, and it is labeled NEG IN.

3.4. SELECTING ANALOG OUTPUT RANGE

The 661 Ratemeter has three analog output ranges: 100 mV, 1 V and 10 V. The selection of the output range is made by moving a jumper located inside the module. The 100-mV range is selected when the unit is shipped. Do the following to change the output range:

1. Remove all cables connected to the 661 and remove the module from the NIM bin.
2. Lay the module on its right side and remove the four screws that hold the left side plate in place; then remove the left side plate.
3. Locate jumper W1. It is located in the upper left-hand corner of the circuit board and is labeled W1. See Fig. 3.1.

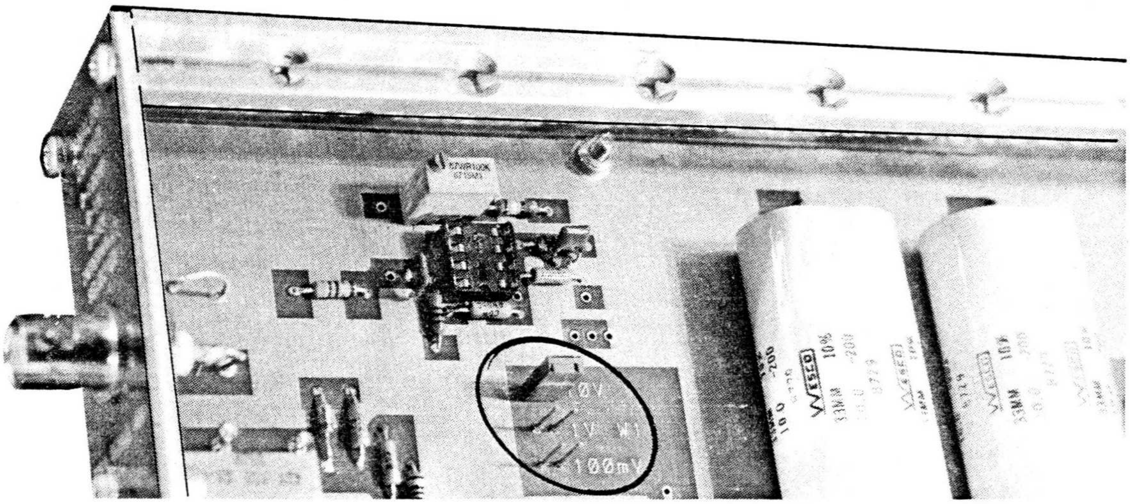

Fig. 3.1. Location of Analog Output Selection Jumper.

4. Move the jumper to the appropriate row of pins. For 10 V the jumper should be toward the top of the module. For 1 V range the jumper should be located on the center row of pins, and for 100 mV the jumper should be located on the lower row of pins.
5. Replace the left side plate and the four screws that hold it in place.

4. OPERATING INSTRUCTIONS

4.1. GENERAL

To operate the 661 Ratemeter, first insert the module into a NIM Bin that supplies ±12 V and +24 V. Connect the input signal and adjust the threshold if necessary. The rate of the input signal is read directly from the front-panel meter. Note that the multiplier switch settings change the meter scale. When the multiplier switch is in the X0.5 position, then the value read on the meter should be divided by 2. Likewise, when the multiplier switch is in the X1.0 position, the count rate may be read directly off the meter, and when the multiplier switch is in the X2.0 position, the value read off the meter should be multiplied by 2.

4.2. RESPONSE TIME

The front-panel control labeled RESPONSE is equivalent to the standard deviation or time constant function found on other ratemeters. The switch has three positions labeled FAST, MED, and SLOW. If the switch is in the SLOW position, the standard deviation of the instantaneous count-rate reading is better than 1%. In the MED position the standard deviation is less than 3%, and in the FAST position the standard deviation is less than 10%. Table 1 gives the actual standard deviations at full scale for the various combinations of scale selections and response time.

The response switch can be moved without affecting the measurement, so an accurate reading can be made very quickly by first placing the response switch in the fast position and then moving it to the medium or slow position for the final reading after the initial charging has taken place.

5. THEORY OF OPERATION

The Ratemeter operates by applying a fixed amount of charge onto a capacitor for each input signal, and by draining this charge off at a rate proportional to the amount of charge. This is most eaily accomplished by means of an operation amplifier with an RC parallel feedback network. (Refer to Block Diagram at the end of this manual.)

The input signal, if accepted by the lower-level discriminator, will produce an output that goes to the prescale network. If the multiplier switch is in the 0.5 position and the range is less than 500 kHz, then the output from the prescaler will change states every time a pulse comes in (i.e., the frequency is divided by 2). This signal goes to the monostables. One of the monostables triggers on the positive edge, and the second triggers on the falling edge. This effectively doubles the frequency back to its original value. Each time one of the monostables triggers, a negative transition occurs at the collector of Q1. This transition passes through C3 and Q2 (diode connected transistor) to the input of the amplifier to produce a positive output signal. When the signal at the collector of Q1 goes positive, the signal path is through C3 and Q5 to ground, with Q2 being cut off so that the output is not changed by the positive transition.

The response of the output to a single input is:

$$e = V(C_3/C_f)\exp(-t/R_fC_f) \qquad (1)$$

so that the amplitude initially "steps up" by an amount equal to VC_3/C_f and falls with an exponential time constant of R_fC_f.

The average value of the output is obtained when the current through R_f is equal to the current supplied from Q1. If n represents the average input rate, then the input current is:

$$i = nQ \quad \text{or} \quad i = nVC_3 \qquad (2)$$

and the current through R_f is simply:

$$i_R = E_0/R_f \qquad (3)$$

where E_0 is the average value of the output voltage. Since these two currents must be equilibrium,

$$E_0 = nVC_3R_f\,. \qquad (4)$$

The statistical fluctuations of the output for a random input rate can be derived by the use of Campbell's* theorem, which says that

$$e_0^2 = n\int_0^\infty f(t)^2\,dt \qquad (5)$$

where

e_0^2 = mean squared value of the output
n = average rate
$f(t)$ = time response of output
$= V(C_3/C_f)\exp(-t/R_fC_f)$

so that

$$e_0^2 = n(C_3)^2V^2R_f/2C_f\,. \qquad (6)$$

The rms variations of the output is

$$e_0(\text{rms}) = (C_3V/C_f) \times nR_fC_f/2 = nC_3VR_f/2\,. \qquad (7)$$

Using Eqs. (4) and (7), the % standard deviation of the average output can be obtained as

$$\%\ \text{Std. Dev.} = 100 \times e_0/E_0 = 100/\sqrt{(2nR_fC_f)}. \qquad (8)$$

At full scale in the 661, these values can be calculated easily for $n = 25$, $R_f = 10^7$, and C_f.

(a) $C_f = 20\ \mu F$ — % Std. Dev. = 1%
(b) $C_f = 2\ \mu F$ — % Std. Dev. = 3%
(c) $C_f = 0.2\ \mu F$ — % Std. Dev. = 10%

In the 661, when n=50 a digital divide by 2 is employed and R_f and C_f are not changed. This effectively divides the standard deviation numbers obtained above by the square root of 2. This is the method that was used to generate the numbers in Table 1.

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*Campbell, N.R., "The Study of Discontinuous Phenomena," Proc. Camb. Philos. Soc., 15:117 (1908)

6. CIRCUIT DESCRIPTION

6.1. POSITIVE AND NEGATIVE INPUT DISCRIMINATORS

The input circuits for the 661 are combined on a single hybrid, A1. The positive input goes to a comparator on the hybrid with a variable threshold set by resistor R10. The negative input goes through a stretching circuit on the hybrid and then to a comparator with a threshold fixed at 250 mV. A TTL compatible signal comes out of the hybrid on pin 8.

6.2. DIGITAL PRESCALERS

The output from the hybrid goes to flip-flop U1, which is configured to divide the frequency of the incoming signal by 2. Flip-flop U2 is configured to divide the frequency of the signal by 2 or 4. Switch S1 selects either divide by 2, 4, or 8 for multipliers of X0.5, X1.0, and X2.0, respectively. The signal from the previous prescale stages is divided by 10 and 100 by IC U3. These prescalers are switched in when the range switch is in the 500K or 5M positions. A digital multiplexer, IC U5, selects the appropriate prescaled values for the various settings of the range switch. If the switch is in the 50, 500, 5K, or 50K position, the signal from switch S2 is selected. If the switch is in the 500K position, the signal from S2 divided in frequency by 10 is selected. If the switch is in the 5M position, the signal from S2 divided by 100 is selected.

6.3. INTEGRATING CIRCUIT

The signal from the multiplexer goes to a one-shot, U4. This generates a positive pulse that lasts approximately 2 μs. When the pulse goes high, transistor Q1 gets saturated, causing the voltage at the collector of Q1 to go to 0 V. The transition from high to low is transmitted through C3 and Q2 to the input of the amplifier (U8). As indicated in Section 5 of this manual, the output signal has an amplitude of VC_3/C_f, where C_f is the feedback capacitor (C7 and C9, or C10 and C13, or C12). In this term, V is the voltage at the collector of Q1 **before** the pulse is generated. When the pulse at the collector of Q4 goes back high, Q5 is turned on and discharges C3. Note that there are two one-shots used in the circuit. One operates on the output of the multiplexer, and the other operates on the inverted output of the multiplexer. This effectively doubles the frequency of the incoming signal at Q1.

The feedback resistors and capacitors are selected by the range switch and the response time switch. The amplifier has a balance adjust, R4, which is used to null the offset voltage of the amplifier. The output of the amplifier goes through resistors R9 and R8 to the meter. Resistor R9 is used to adjust the gain of the signal going to meter.

6.4. THE ANALOG OUTPUT

The output of the integrating circuit is fed to the analog output amplifier, U7. The signal goes through a trimpot, R16, which is located on the rear panel of the instrument. This allows the user to adjust the full-scale range by approximately 10%. The signal is then divided by 10 and 100 with a string of resistors (R22, R26, and R31). Jumper W1 is then placed in the appropriate location to select a full-scale range of 10 V, 1 V, or 100 mV. The amplifier has a balance adjust (R18) used to null out any offset in the amplifier.

7. MAINTENANCE AND ADJUSTMENTS

7.1. ADJUSTMENTS

1. Integrator DC Balance Adjustment. With no signals applied to the input, the dc level at test point 1 should be zero volts. Use R4 to make the adjustment.

2. Analog DC Balance Adjustment. After adjusting dc offset in the integrator, with no signal applied, the dc level at the analog output should be zero volts. Adjust Resistor R18 to obtain this condition.

3. Meter Zero. With the instrument under power and no input applied, the meter can be zeroed by adjusting the pot located on the back of the meter. This pot should be adjusted until the meter reads 0. This adjustment should not be made until adjustment 1 is made.

4. Meter Calibrate. With a known input rate (preferably periodic of value above 100 cps) adjust R9 so that the meter reads correctly. The range switch should **not** be in the 50 position.

5. 100/50/25 cps Ranges. The 25, 50 and 100 cps ranges are trimmed to read correctly by adjusting R44 after adjustments 1, 3, and 4 have been checked for correctness. To make the adjustment, use a signal of known rate below 100 cps — a line frequency pulse is often convenient. Adjust R44 until meter reads correctly. Take care to allow enough time for the reading to stabilize before changing the value of R44. It takes about four minutes for a stable reading at 60 cps and 1% Std. Dev.

7.2. FACTORY REPAIR SERVICE

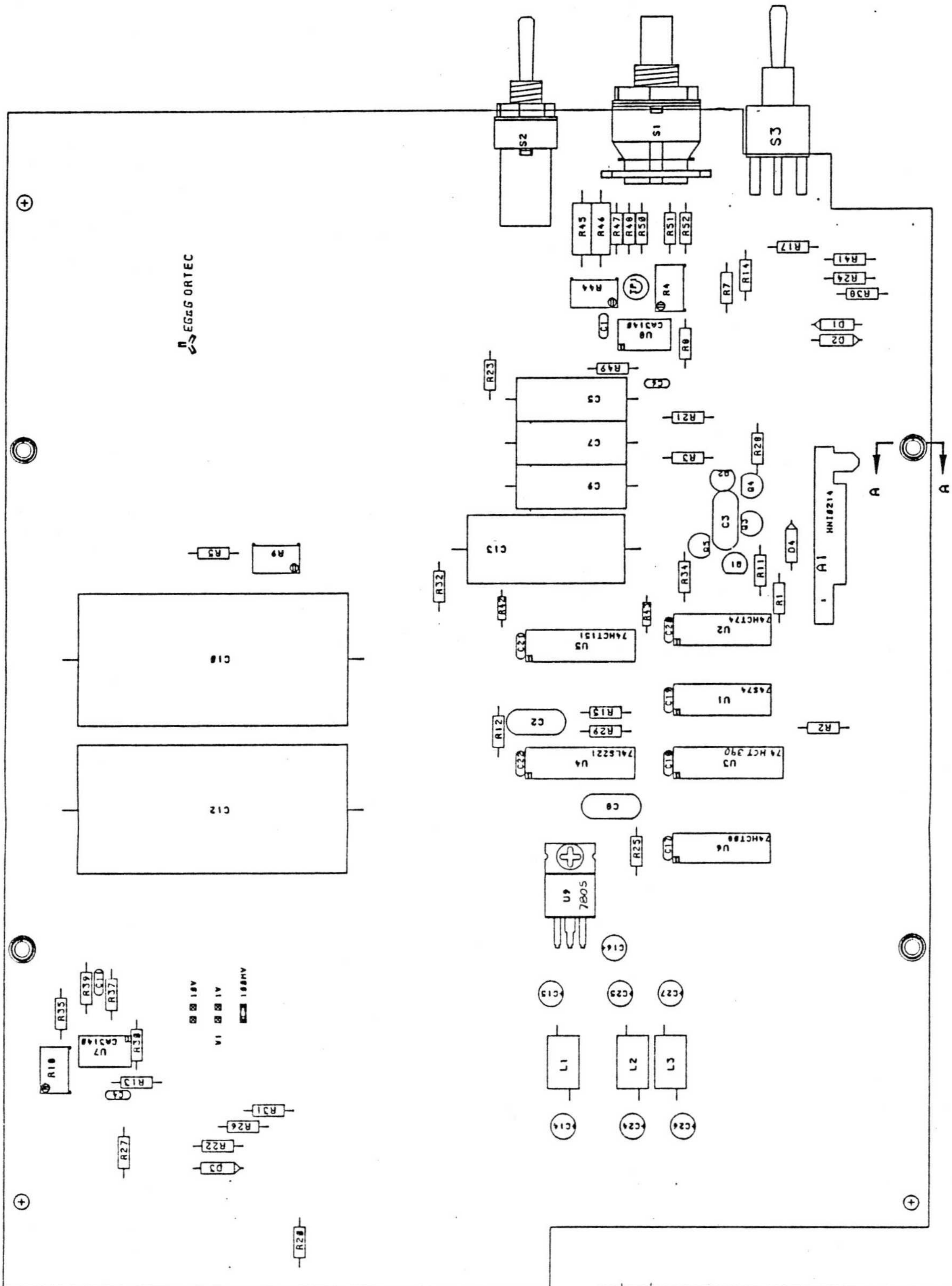
This instrument can be returned to EG&G ORTEC for service and repair at a nominal cost. Our standard procedure for repair ensures the same quality control and checkout as for a new instrument. Always contact the Customer Service Department at EG&G ORTEC, (615) 482-4411, before sending in an instrument for repair to obtain shipping instructions. A Return Authorization Number is required, and will be assigned to the unit. Write this number on the address label and on the package to ensure prompt attention when it reaches the factory.

BIN/MODULE CONNECTOR PIN ASSIGNMENTS FOR AEC STANDARD NUCLEAR INSTRUMENT MODULES PER TID-20893 (Rev 4) (adopted by DOE)

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	117 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	117 volts ac (Neut.)
20	Spare	*42	High Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

Pins marked (*) are installed and wired in EG&G ORTEC's 4001A, 4001B, 4001C, 401A, and 401B Modular System Bins.

Pins marked (*) and (**) are installed in EG&G ORTEC-HEP M250/N and M350/N NIMBINS.



UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES DO NOT SCALE THIS DRAWING TOLERANCES ARE	EG&G ORTEC
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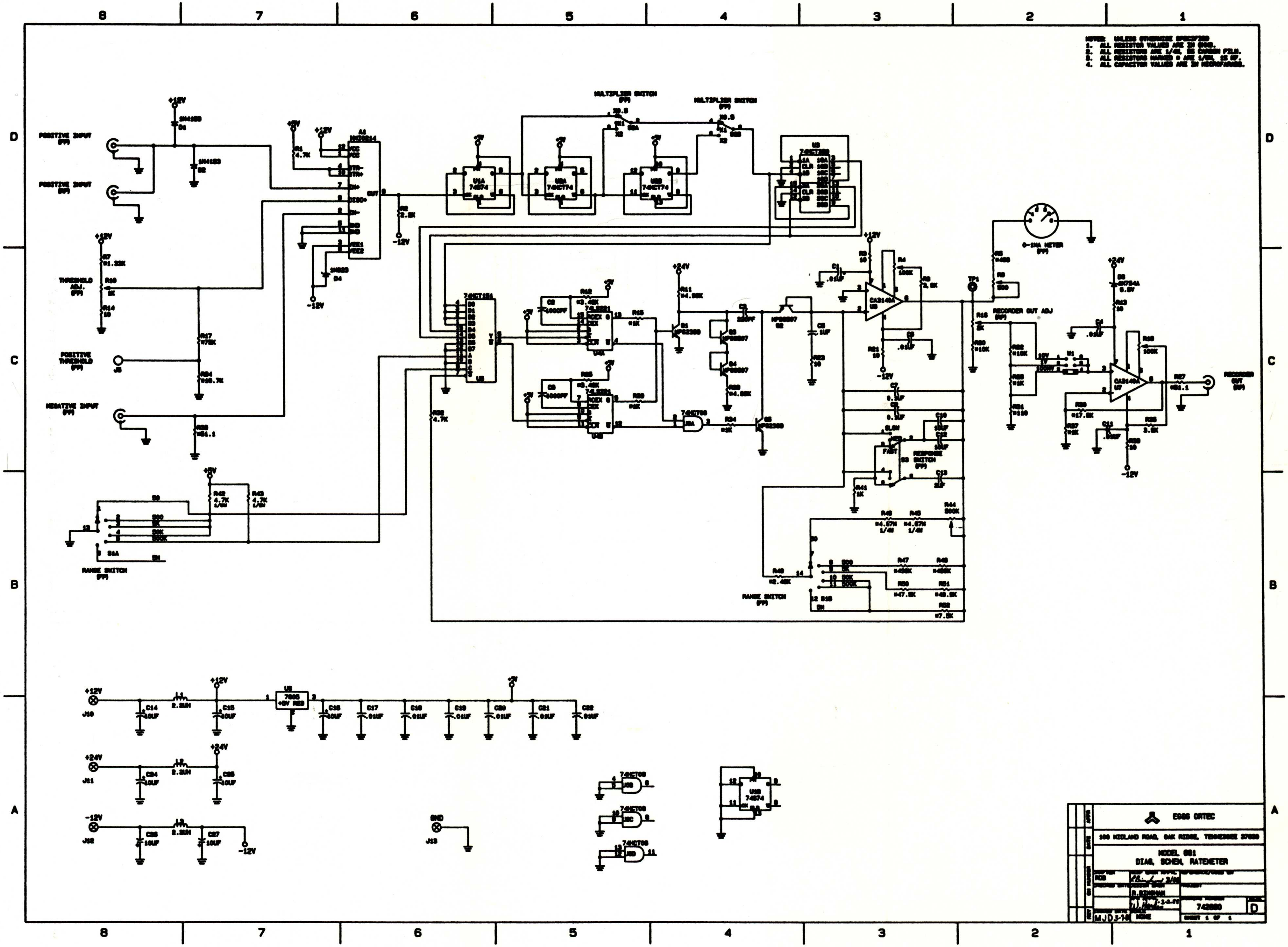
	MODEL 661 PWB ASSY, RATEMETER
GS 12/1/87	P. Bingham 3/88
	P. BINGHAM — 661
D	3-2-88 — 736910
MJD 3-7-88	NONE — SHEET 3 OF 3



POSITIVE INPUT
NEGATIVE INPUT
THRESHOLD ADJ.
POSITIVE THRESHOLD
RANGE SWITCH
MULTIPLIER SWITCH
RESPONSE SWITCH
SLOW
FAST
RECORDER OUT ADJ
RECORDER OUT
0-1MA METER
+12V
+24V
-12V
GND
EG&G ORTEC
DIAG, SCHEM, RATEMETER
NONE
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