

**Model 661
Ratemeter
Operating and Service Manual**

Advanced Measurement Technology, Inc.

a/k/a/ ORTEC[®], a subsidiary of AMETEK[®], Inc.

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Quality Control

Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

Repair Service

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, ORTEC must be informed, either in writing, by telephone [(865) 482-4411] or by facsimile transmission [(865) 483-2133], 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 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 designated ORTEC repair center. 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 should follow the same procedure and ORTEC will provide a quotation.

Damage in Transit

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, please notify ORTEC of the circumstances so that assistance can be provided in making damage claims and in providing replacement equipment, if necessary.

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SAFETY INSTRUCTIONS AND SYMBOLS

This manual contains up to three levels of safety instructions that must be observed in order to avoid personal injury and/or damage to equipment or other property. These are:

DANGER Indicates a hazard that could result in death or serious bodily harm if the safety instruction is not observed.

WARNING Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

CAUTION Indicates a hazard that could result in property damage if the safety instruction is not observed.

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

In addition, the following symbol may appear on the product:



ATTENTION – Refer to Manual



DANGER – High Voltage

Please read all safety instructions carefully and make sure you understand them fully before attempting to use this product.

SAFETY WARNINGS AND CLEANING INSTRUCTIONS

DANGER Opening the cover of this instrument is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.

WARNING Using this instrument in a manner not specified by the manufacturer may impair the protection provided by the instrument.

Cleaning Instructions

To clean the instrument exterior:

- Unplug the instrument from the ac power supply.
- Remove loose dust on the outside of the instrument with a lint-free cloth.
- Remove remaining dirt with a lint-free cloth dampened in a general-purpose detergent and water solution. Do not use abrasive cleaners.

CAUTION To prevent moisture inside of the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator.

- Allow the instrument to dry completely before reconnecting it to the power source.



ORTEC MODEL 661 RATEMETER

1. DESCRIPTION

The 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 setting 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 $\pm 10\%$ 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.

*Specifications subject to change without notice.

NONLINEARITY $<\pm 0.1\%$ of full scale at the analog output.

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

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.

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.

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

FULL SCALE ADJ A rear-panel 20-turn potentiometer provides a $\pm 10\%$ 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 $\pm 10\%$ 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 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 NIM-standard single-width module, 3.43 \times 22.13 cm (1.35 \times 8.714 in.) front panel per DOE/ER-0457T.

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 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 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.
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.

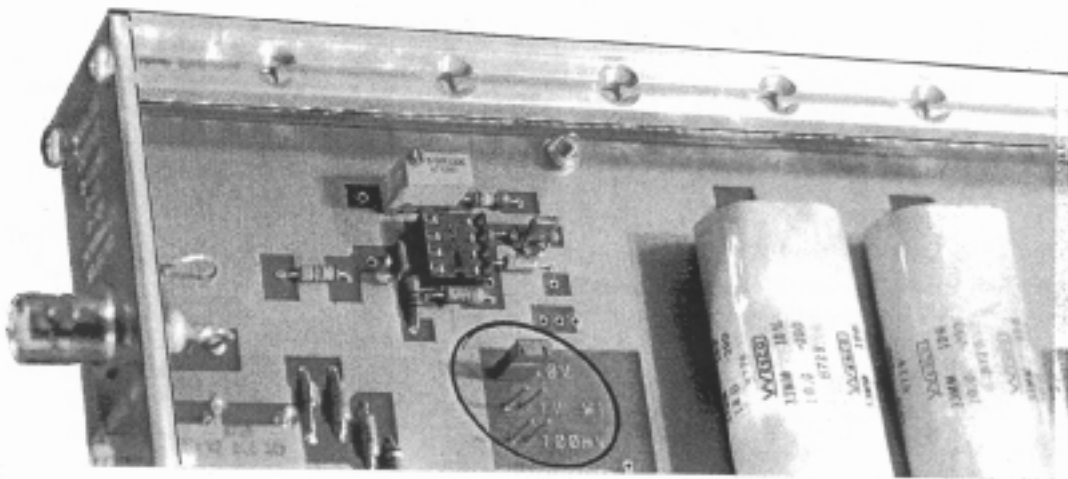


Fig. 3.1. Location of Analog Output Selection Jumper.

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 $\times 0.5$ position, then the value read on the meter should be divided by 2. Likewise, when the multiplier switch is in the $\times 1.0$ position, the count rate may be read directly off the meter, and when the multiplier switch is in the $\times 2.0$ position, the value read off the meter should be multiplied by 2.

4.2. RESPONSE TIME

The front-panel control labeled REPOSE 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 661 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 easily accomplished by means of an operation amplifier with an RC parallel feedback network.

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 monostable 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:

$$e = V(C_3/C_f) \exp(-t/R_f C_f) \quad (1)$$

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

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:

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

and the current through R_f is simply:

$$i_R = E_o/R_f \quad (3)$$

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

$$E_o = nVC_3 R_f \quad (4)$$

The statistical fluctuations of the output for a random input rate can be derived by the use of Campbell's¹ theorem, which says that

$$e_o^2 = n \int_0^{\infty} f(t)^2 dt \quad (5)$$

where

$$\begin{aligned} e_o^2 &= \text{mean squared value of the output} \\ n &= \text{average rate} \\ f(t) &= \text{time response of output} \\ &= V(C_3/C_f) \exp(-t/R_f C_f) \end{aligned}$$

so that

$$e_o^2 = n(C_3)^2 V^2 R_f / 2 C_f \quad (6)$$

The rms variations of the output is

$$e_o(\text{rms}) = (C_3 V / C_f) \times n R_f C_f / 2 = n C_3 V R_f / 2 \quad (7)$$

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

$$\% \text{ Std. Dev.} = 100 \times e_o / E_o = 100 / \sqrt{(2 n R_f C_f)} \quad (8)$$

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

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

¹Campbell, N.R., "The Study of Discontinuous Phenomena," Proc. Camb. Philos. Soc., 15:117 (1908)

6. MAINTENANCE AND ADJUSTMENTS

6.1. 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. With no signal applied, the dc level at the analog output should be zero volts. Adjust Resistor R4 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 ranged 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.

6.2. FACTORY REPAIR SERVICE

This instrument can be returned to ORTEC for service and repair at a nominal cost. Our standard procedure for repair ensures the same quality control and checkout as for new instrument. Always contact the Customer Service Department at ORTEC, (865) 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 STANDARD NUCLEAR INSTRUMENT
MODULES PER DOE/ER-0457T**

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 ORTEC's 4001A and 4001C Modular System Bins.