Model 9349
Log/Lin Ratemeter
Operating and Service Manual

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Advanced Measurement Technology, Inc.

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

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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.

CONTENTS

WARRANTY ii

SAFETY INSTRUCTIONS AND SYMBOLS iv

SAFETY WARNINGS AND CLEANING INSTRUCTIONS v

1. DESCRIPTION 1
   1.1. GENERAL 1
   1.2. DATA AVAILABILITY 1

2. SPECIFICATIONS (0 TO 50°C) 2
   2.1. PERFORMANCE 2
   2.2. CONTROLS AND INDICATOR 2
   2.3. INPUT 2
   2.4. OUTPUTS 2
   2.5. ELECTRICAL AND MECHANICAL 2

3. INSTALLATION 3
   3.1. GENERAL 3
   3.2. CONNECTION TO POWER 3
   3.3. INPUT CONNECTION 3
   3.4. ANALOG OUTPUTS 3

4. OPERATION 4
   4.1. GENERAL 4
   4.2. THEORY OF OPERATIONS 4
   4.3. LINEAR OPERATION 5
   4.4. ACCURACY OF LINEAR RANGES 7
   4.5. LOGARITHMIC OPERATION 7
   4.6. ACCURACY OF
        LOGARITHMIC RANGE 9
   4.7. RESPONSE TO AN INPUT RATE CHANGE 9

5. CALIBRATION 10
   5.1. EQUIPMENT REQUIRED 10
   5.2. MEASUREMENT OF TEST POINT VOLTAGES 10
   5.3. OUTPUT ZERO LEVEL 10
   5.4. RANGE CALIBRATION 10
   5.5. TROUBLESHOOTING 11
   5.6. FACTORY REPAIR 11

   5.6. FACTORY REPAIR 11

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.

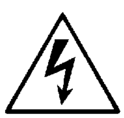
WARNING Indicates a hazard that could result in bodily harm if the safety instruction is not observed.

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.

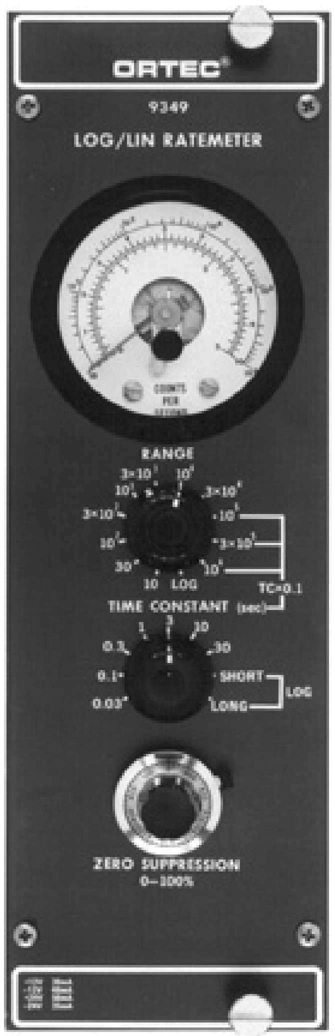
Cleaning Instructions

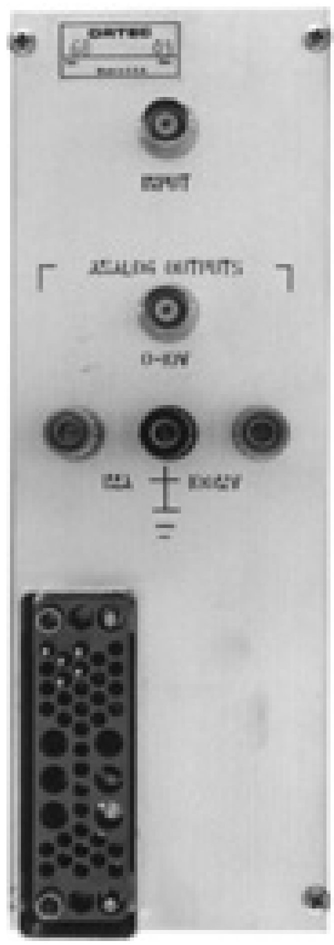
To clean the instrument exterior:

- 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
9349
LOG/LIN RATEMETER
RANGE
TC=0.1
TIME CONSTANT (sec)
SHORT
LONG
LOG
ZERO SUPPRESSION
0–100%


ORTEC
INPUT

ORTEC 9349 LOG/LIN RATEMETER

1. DESCRIPTION

1.1. GENERAL

The ORTEC 9349 Log/Lin Ratemeter is a double width NIM-standard module that is designed for measurement of the average count rate of input pulses. It can be used for photon or ion beam counting applications, as well as for many others where NIM-standard fast negative pulses are available to be counted.

The measurements are based on a selected full-scale rate. There are 11 rates from which to select the range that is appropriate when linear deflections are desired. The range can be matched to the input pulse rate, whether it is low (<10 counts/s), medium, or high (to 10^6 counts/s). When the pulse rate varies through a wide range, the 9349 can be used with a logarithmic range to expand the lower portion of the scale for better interpretation of changes when the count rate is low and will still accommodate the high count rates within the same total range. The range of the logarithmic scale is 10^1 through 10^6 counts/s in five decades.

With the aid of the front panel Zero Suppression control the range of any linear scale can be offset so that its zero indication is any count level between 0 and 100% of the full-scale setting. The span of the setting is the same full-scale range above the preselected zero reference level. For example, with the Zero Suppression control set at mid-scale, 500 dial divisions, and the Range switch set at 10^4 (for 10,000 counts/s), the indications on the meter will be for a span from 5000 to 15,000 counts/s.

A variety of time constants can be selected. The time constant determines the relative averaging capability of the circuit and controls the rate at which the meter indication responds to sudden rate changes. The proper selection is a function of the average counting rate and the purpose for which the measurement is made; a true average rate may be desired, or sudden rate changes may need to be identified quickly. Longer time constants provide better long-term averaging, while shorter time constants reflect rate changes more quickly.

1.2. DATA AVAILABILITY

Any measured counting rate will be shown on the front panel meter with a 240° full-scale deflection for accurate readability. It is also available through rear panel connectors as a proportional analog value of voltage or current. The outputs on the real panel can be used to drive a recorder, an external indicating meter, and/or an oscilloscope.

The full-scale range of the current output is 0 to 1mA. This is intended for an input to a current-type recorder that is adjusted for 1 mA full scale. The full-scale range of the comparable voltage output is 0 to 100 mV, intended for use as the input to a voltage-type recorder that is adjusted for 100 mV full scale. Both outputs are furnished through binding posts that are appropriate for the recorder interconnections.

The full-scale range of the analog output through the rear panel BNC connector is 0 to 10 V, which is furnished through an output impedance of 100Ω.

For any measurement the proportional meter deflection and the proportion of the analog full-scale values will always be equal. For example, when the meter reads 50% of full scale, the three analog outputs will be 500 μA, 50 mV, and 5 V respectively.

2. SPECIFICATIONS (0 TO 50°C)

2.1. PERFORMANCE

Linear Ranges 11 ranges from 10 to 10^6 counts/s full scale in 1-3-10 steps.
Dead Time <100 ns on the 10^6 range; <0.3% of average pulse spacing up to the 3×10^4 range; ≤1% on the 10^5 and 3×10^5 ranges.
Rated Overload Maintains full-scale output for X300 overload or 10^7 counts/s, whichever is smaller.
Temperature Instability ≤±0.05%/°C.
Analog Output Nonlinearity ≤±0.15% of full scale from 10 to 3×10^4 counts/s range; ≤±1.5% of full scale from 10^5 to 10^6 counts/s.
Time Constants 7 selectable time constants, 0.03 to 30 s in 1-3-10 steps.
Zero Suppression 0 to 100% of full scale; nonlinearity, ≤±0.25% of full scale.
Logarithmic Range One 5-decade range from 10 to 10^6 counts/s.
Temperature Instability ≤±0.25% of full scale per °C.
Analog Output Error ≤±2.5% of full scale.
Standard Deviation ~15% with Log Short Time Constant; ~5% with Log Long Time Constant.
Slewing Rate Dependent on input rate; for any rate change, Log Short Time Constant provides 10 times faster response than Log Long Time Constant.

2.2. CONTROLS AND INDICATOR

Range 12-position switch selects the full-scale range and either linear or logarithmic mode; linear ranges are 0-10 counts/s through 0-10^6 counts/s in 1-3-10 steps; log range is 10-10^6 counts/s.

Time Constant 9-position switch selects the time constant for the integrating network; 0.03 to 30 s in a 1-3-10 series for all linear ranges; Short and Long for the log range.

Zero Suppression 10-turn precision potentiometer to suppress the zero reference level for any linear range from 0 to 100%; the same full-scale span is effective above the preselected zero reference level.

Panel Meter 240° circular movement with 3-1/2-in. deflection; accuracy, 2% of full scale; three scale markings, 0-10 and 0-3 for linear ranges and 10-10^6 in five decades for log range.

2.3. INPUT

Input Rear panel BNC connector, accepts negative NIM signal of ≥14-mA peak current and ≥3ns FWHM.

2.4. OUTPUTS

Analog Outputs BNC type UG-1094/U connector on rear panel, provides 0 to 10 V full scale, dc-coupled with 100Ω output impedance.

Recorder Outputs Binding post connectors on rear panel:
100 mV Provides voltage output with 100 mV full scale; dc-coupled with 100Ω output impedance.
1 mA Provides current output of 1 mA full scale; dc-coupled with 10-kΩ output impedance.

2.5. ELECTRICAL AND MECHANICAL

Power Required

+24 V, 50 mA;	+12 V, 30 mA;
−24 V, 35 mA;	−12 V; 45 mA.

Dimensions NIM-standard double-width module (2.70 × 8.714 in.) Per TID-20893.

3. INSTALLATION

3.1. GENERAL

The 9349 Log/Lin Ratemeter is designed for installation and operation in an ORTEC 4001/4002 Series Bin and Power Supply, or equal. The Bin and Power Supply is designed for relay-rack mounting and is usually installed in a rack that houses other electronic equipment. Therefore vacuum tube equipment or other heat source that operates in the same rack with the 9349 must be sufficiently cooled with circulating air to prevent localized heating of the transistorized and integrated circuits in the 9349. The maximum limit for safe operation of the 9349 is 50°C (120°F), and the temperature of equipment mounted in racks can easily exceed this limit unless precautions are taken.

3.2. CONNECTION TO POWER

The 9349 does not include any internal power supply but must obtain its operating power from the standard Bin and Power Supply in which it is installed for operation. Always turn off the power before inserting or removing instrument modules. The ORTEC NIM modules are designed so that a full complement of modules in the Bin will not overload the Bin power supply. However, this may not be true when the Bin contains modules of other than ORTEC design, and Power Supply voltages should be checked when other modules are inserted. The ORTEC 4001/4002 Series have test points on the Power Supply control panel to monitor the dc voltages.

When using the 9349 outside the Bin and Power Supply, be sure that your extension cable includes the Power Supply grounding circuits specified in the recommended standards of TID-20893. Both high-quality and power-return ground connections are specified to ensure proper reference voltage feedback into the Power Supply, and these must be preserved in extension cables. Be careful to avoid ground loops when the module is operated outside the Bin.

3.3. INPUT CONNECTION

Use 50-Ω cable to connect the source of NIM-standard fast negative logic pulses to be counted into the rear panel input connector on the 9349. The input impedance through this connector is 50 Ω, providing the proper termination for the cable to prevent reflections and multiple counts from occurring.

The input signal to the 9349 is normally obtained from the Discriminator output of an ORTEC 9302 Amplifier/Discriminator, a 436 100-MHz Discriminator, or a TD101/N Differential Discriminator.

3.4. ANALOG OUTPUTS

A strip-chart recorder can be connected to the 9349 output in order to obtain a permanent record of the variations in count rates that are measured by the 9349 through any time interval. The three binding posts on the rear panel are intended for connection to the recorder. The black binding post is a common ground for both types of recorder output. One of the red binding posts is marked 1 mA and will be used to connect the output to a current-type recorder input. The other red binding post is marked 100 mV and will be used to connect the output to a voltage-type recorder input.

The 10 V Analog Output BNC connector on the rear panel also furnishes an output voltage that is proportional to the meter deflection for any operating range. The full-scale range of this output circuit is 0 to +10 V, and the output is furnished through an output impedance of 100 Ω.

A direct connection from the 10 V Analog Output can be made to any measuring device that can use this range. This can be a voltmeter, an oscilloscope, or a similar instrument as desired. The input impedance of the measuring instrument should be very high compared with the 100-Ω output impedance of the 9349 in order to use the ±0.5% accuracy of the output to advantage.

A low-impedance loading of any of the three outputs (10 V, 1 mA, and 100 mV) on the 9349 will reflect a decrease in the signal available through all output circuits. Except for this consideration, the output connections can be used simultaneously through more than one output circuit without degradation of the information.

4. OPERATION

4.1. GENERAL

The function of the 9349 Ratemeter is to accept NIM-standard fast negative input pulses and to indicate their average rate in counts per second. The measurement of the rate in counts per second. The measurement of the rate itself may be the desired end result, or the rate can be monitored for variations or for control if a dangerous rate is sensed.

The average input rates of random signals can be expected to vary, but the range of rates will normally lie within some small total range. The variety of selectable full-scale linear ranges is furnished to permit selection of any one range that will accommodate the highest rate to be expected during an experiment and yet position the readings for the normal average rates within the central portion of the full-scale range. Each linear range can be used with zero suppression to accommodate the same span of rates with up to twice the full-scale maximum rate. When a very wide variation of the count rates is encountered, the logarithmic range will generally be preferred because it provides greater resolution for the lower counting rates than is furnished by a linear range with an equivalent full scale of 10^6 counts/s.

A variety of selectable time constants is also furnished in the 9349. The appropriate time constant for any specific application depends on several parameters. In general, shorter time constants will permit faster response to variations in count rates, and longer time constants will tend to smooth out short-term fluctuations. More information is included in the statistical theory discussions that follow.

4.2. THEORY OF OPERATIONS

The Ratemeter operates by applying a fixed amount of charge per input pulse into a tank capacitor. In the interval between input pulses the capacitor discharges through some resistance. As input pulses continue to occur, an equilibrium is reached between the average charging and discharging current, and the voltage across the capacitor is then functionally dependent on the input pulse rate. The 9349 includes a resistor for the capacitor discharge for linear dependence and a transistor for logarithmic dependence. These two types of circuits are discussed separately.

Figure 1 is a block diagram of the ORTEC 9349 Log/Lin Ratemeter that shows the relations between its internal functions.

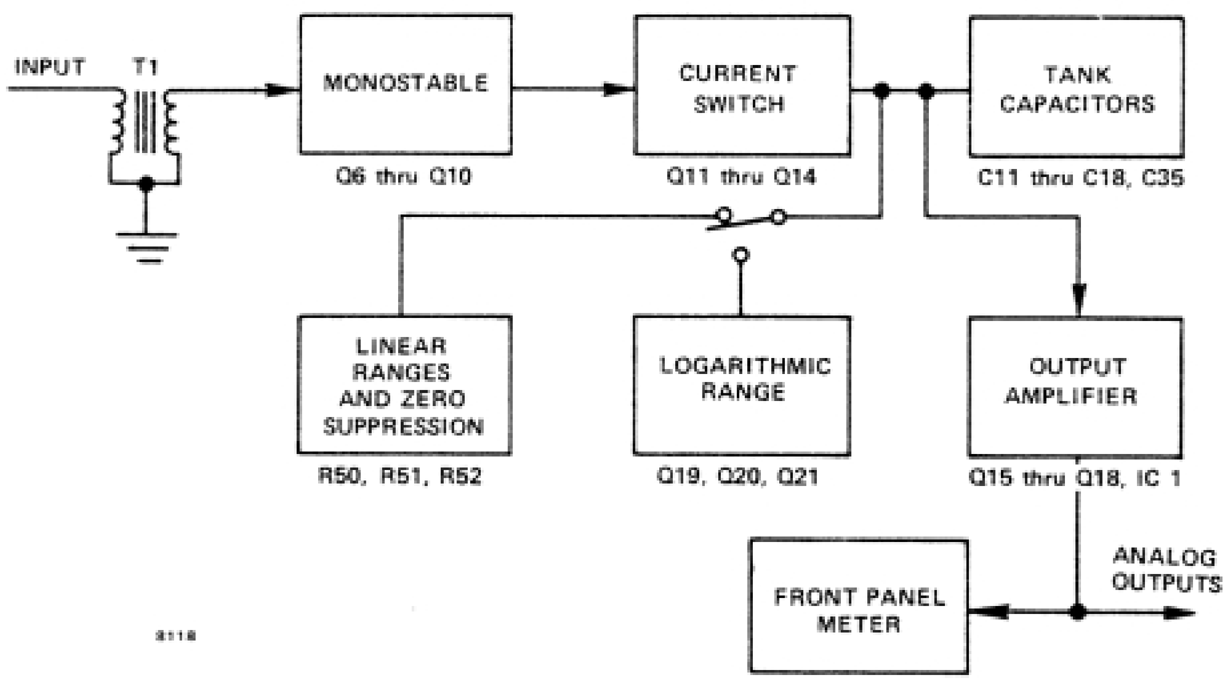


Fig. 1. Simplified Block diagram of ORTEC 9349 Log/Lin Ratemeter.

4.3. LINEAR OPERATION

If the average input pulse rate is *n* and the charge per input pulse is Q_0, then the average charging current is nQ_0. At equilibrium the discharge current *V/R* is equal to the charging current so that

$$\overline{V} = nQ_0R.$$

A simplified equivalent circuit of the tank capacitor circuit is shown in Fig. 2 The waveform at the right shows how the voltage across capacitor C increases to an equilibrium, and the fluctuations suggest that a time constant has been selected that is short with respect to the interval between input pulses. It can be shown that

$$V = \overline{V}(1 - e^{-t/T})$$

where T = RC, which is the time constant of the circuit.

The standard deviation of a single observation for randomly spaced pulses is

$$\overline{V^2} = \frac{1}{2}Q_0^2 nT,$$

$$e = \sqrt{\frac{\overline{V^2}}{\overline{V}}} = \frac{1}{\sqrt{2nT}}$$

The relative standard error (*e*) depends on the input pulse rate and the selected time constant.
These relations are shown in Fig. 3.

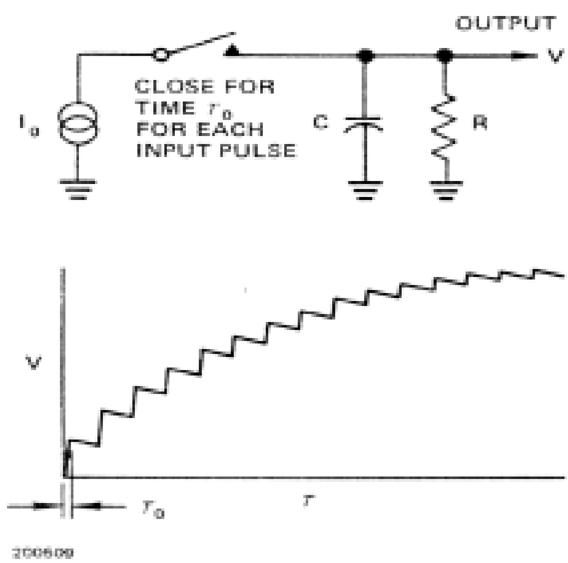


Fig. 2. Simplified Equivalent Tank Capacitor Circuit

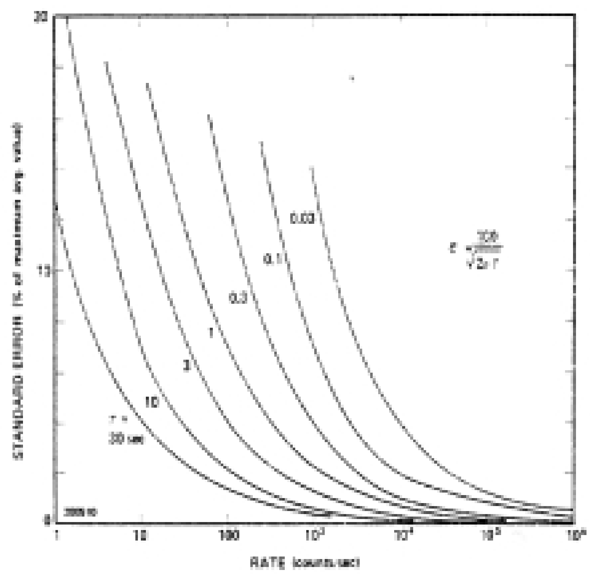


Fig. 3. Relative Standard Error.

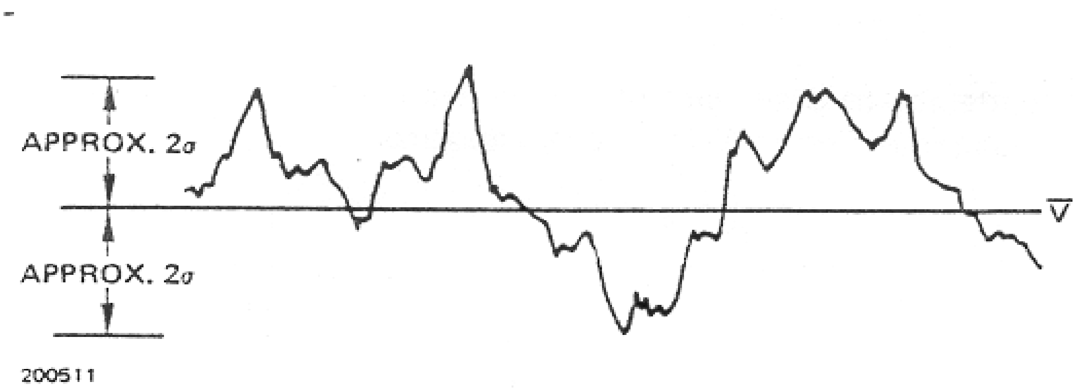


Fig. 4. Typical Recorder Output.

The ratemeter output is often recorded on a strip-chart recorder, and a lower standard error can be obtained by using more data. Figure 4 is a typical graph obtained with a strip-chart recorder. From this figure the mean count rate and the standard deviation can be estimated.

Using the expression T_m to identify the duration of observation in seconds and T for the time constant, the error of the average value found by the above method is reduced by the factor K_α with the following formula:

$$K_\sigma - \{2T/T_m[1-(T/T_m)(1-e-^{T/T}\ m)]\}^{1/2}$$

The curve of Fig. 5 illustrates this relation for T_m/T ratios from 1 through 100.

Equilibrium time is defined as the amount of time that is required for the 9349 indication to reach an average value within one probable error (0.675α).

$$T_e = T \ln\left(\frac{1}{0.675\epsilon}\right) = 1.15\ T \log 4.4nT$$

These relations are shown in Fig. 6.

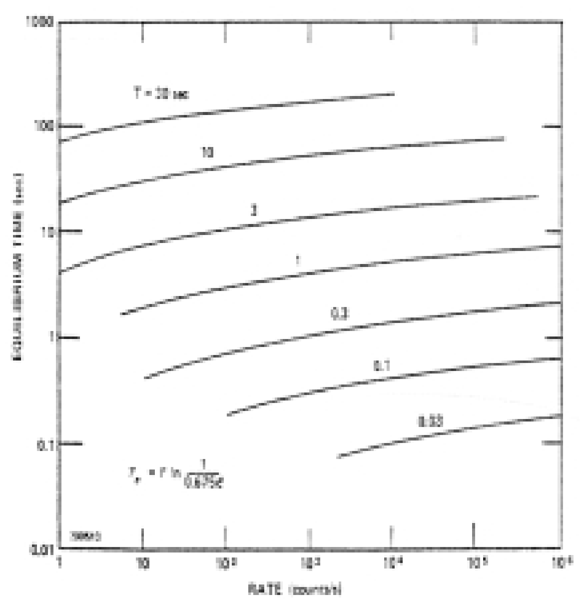


Fig. 5. Correction Factors for Standard Error as a Function of Observation Time.

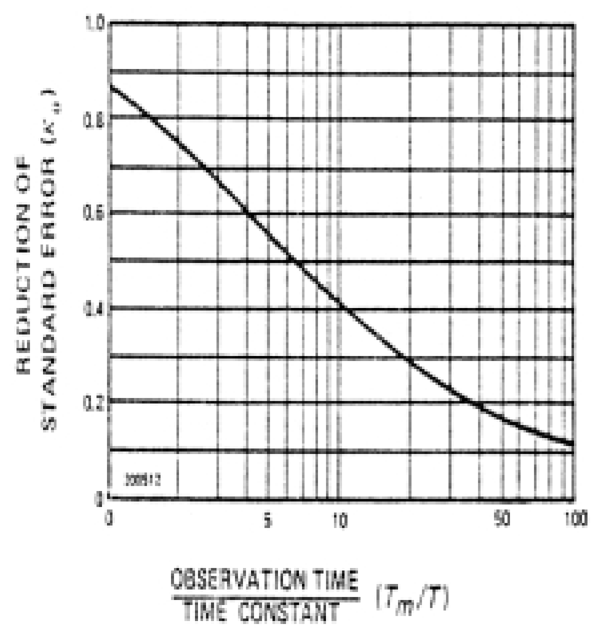


Fig. 6. Equilibrium Time.

4.4. ACCURACY OF LINEAR RANGES

The accuracy of readings on the front panel meter is limited by the meter error, which ±2% of full scale. The accuracy of the analog outputs is much better than the meter indications, as shown in the instrument specifications. This discussion and the specifications shown in Section 2 are related to the accuracy of the analog outputs.

The major cause of error is the finite charging time of the tank capacitor. For all the ranges below 10^5 the error is kept below ±0.15% of full scale. The error increases for the higher ranges: ±0.2% for 10^5, ±0.5% for 3×10^5, and ±1.5% for 10^6. This error is not random and the correction factor can be obtained from Fig. 7. The curves in Fig. 7 are exact for periodic inputs and remain essentially the same for random inputs except for the curve for the 10^6 range, where the dotted portion shows corrections for random inputs. As shown in Fig. 7, the correction factor *M* is a function of both the range being used and the percent of full scale of the indication. This illustrates that the best accuracy is obtained by selection of the range that provides an indication nearest to 80% of full scale for any input:

where

$$M = \frac{1-\epsilon}{\epsilon},$$

$$\varepsilon = \frac{ax(1-1.22x)}{1+1.22ax}$$

$$x = \frac{n}{n_{max}},$$

$$\alpha = 0.8 n_{max}(T_0).$$

The basic accuracy of any linear range can be used to extend the range to twice its normal maximum level with the aid of the zero suppression circuit. The principle of operation is to furnish a constant current that is subtracted from the signal current. The amount of current that is subtracted is determined by the front panel precision 10-turn potentiometer, and the range for zero suppression is equal to the selected full-scale range. The same full-scale range is effective above the offset zero that is selected by the potentiometer adjustment.

The accuracy of the potentiometer setting on its duo-dial is ±0.25%.

An example of the purpose for using zero suppression is an observation of a rate that varies around 150 counts/s. This can be observed at half scale on the 300-count/s range, and the accuracy will be based on the 300-count/s full-scale rate. The same rate can be observed at half scale on the 100-count/s range with the Zero Suppression control advanced to 100%, and the accuracy will be based on the 100-count/s full-scale rate. Another example is the observation of a variable rate that is superimposed on a constant background, where suppression can compensate for the background.

4.5. LOGARITHMIC OPERATION

For the logarithmic range the nonlinear resistance (***r***) of the collector-to-base circuit of a transistor is used as the discharge circuit for the tank capacitor:

$$r = \frac{kT}{qi_r} = \frac{V_T}{i_r} \qquad V = V_T In \frac{i_r}{i_{co}}$$

When the resistance ***r*** is included in the simplified circuit of Fig. 2 in place of the resistance ***R***, the

average indication and standard error can be shown to be

$$V = 2.3 V_T \log \frac{n}{n_0}$$

$$\varepsilon = \frac{rms}{meanvalue} = \sqrt{\frac{Q_0}{2CV_T}}$$

In these equations V_T is thermal voltage, which is ~30 mV at 25°C. The mean value, V, is temperature-dependent, and therefore a differential transistor pair is used to lower the temperature coefficient.

From Eq. (10) the standard error is theoretically independent of the rate. The 9349 Ratemeter provides two time constants for log operation to permit a selection of ϵ. They are called long and short and correspond to approximately 5% and 15%. In practice, however, the observed standard error will always be smaller, especially at higher rates, because of the limited bandwidth of the amplifier and of the meter and recorder.

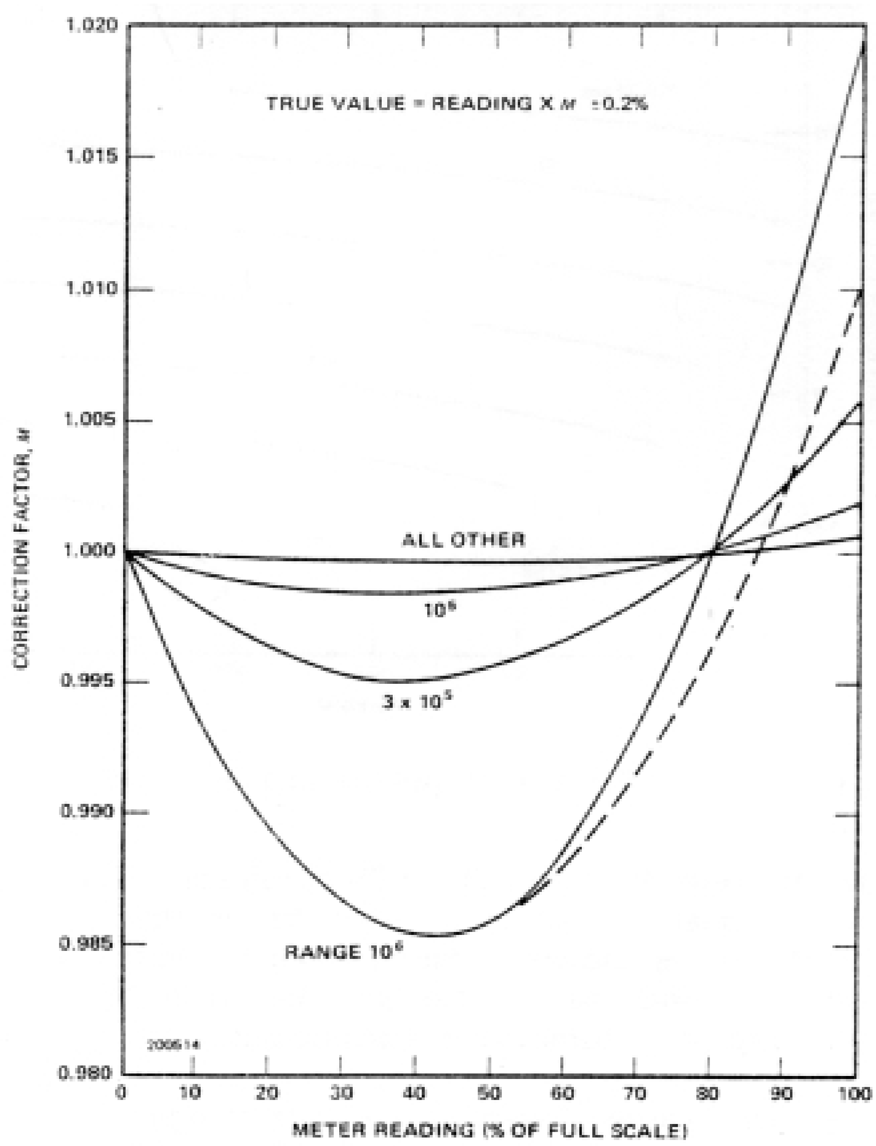


Fig. 7. Accuracy of Meter Readings.

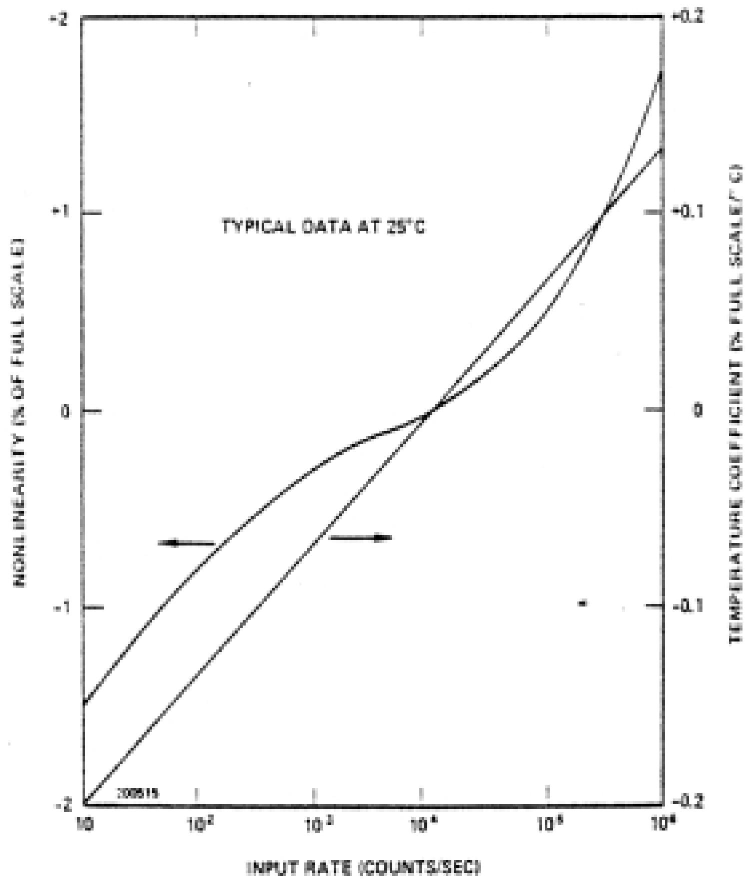


Fig. 8. Nonlinearity and Temperature Coefficient for Log Operation.

4.6. ACCURACY OF LOGARITHMIC RANGE

The accuracy of the log range is less than that for the linear ranges. This is primarily due to the actual difference between the response of the logarithmic circuit and a true logarithmic distribution. The typical nonlinearity and temperature coefficient are shown in Fig. 8.

4.7. RESPONSE TO AN INPUT RATE CHANGE

The response of the 9349, operating as a log ratemeter, to an input rate step change is always monotonic. The speed of response depends on the initial and final rate ratio as shown in Fig. 9.

For any rate change the long time constant has a rise time that is 10 times that of the short time constant.

For example, using Fig. 9, suppose that the input rate changes from 10^2 to 10^5 counts/s. The ρ is $10^5 \div 10^2 = 10^3$. From this, the curve shows that $T_r/T_L = 2.6\times10^{-3}$s or 2.6 ms. If the log time constant is short, T_L = 60/10^2 =0.6, so that
$T_r = 2.6\times10^{-3}\times0.6 = 1.36$ ms.

If the initial rate is <10 counts/s, the rise time for a small rate change (to 10^2) can be extremely long. For larger changes the rise time approximately follows the curve with n (initial) $\geq$ 10 counts/s.

5. CALIBRATION

5.1. EQUIPMENT REQUIRED

The following test equipment, or equal, is required to perform calibration on the 9349 Log/Lin Ratemeter:

Tektronix Type 184 Precision Frequency
Pulse Generator
Digital Voltmeter
Oscilloscope

5.2. MEASUREMENT OF TEST POINT VOLTAGES

Test points TP2 and TP3 provide easy checks of critical voltages in the 9349 to determine that its circuits are operating normally. The voltage at TP2 must be within limits of 0 to 2 mV to indicate a proper quiescent condition in the current switch, Q13 and Q14. The voltage at TP3 indicates the proper condition of the matched FETs and must be 2 ± 1 V.

5.3. OUTPUT ZERO LEVEL

With no input pulses into the 9349 the output dc level at the rear panel BNC connector should be within the limits of −30 mV to 0 V. If it is not, adjust the zero trim potentiometer, R62, to correct.

5.4. RANGE CALIBRATION

Trim potentiometers are used to individually calibrate each range. Each potentiometer is available through the top of the module and its associated range is identified on the printed circuit board adjacent to the potentiometer. Be sure that the protective side covers are mounted on the module before calibrating the instrument, and operate the module outside the 4001/4002 Series Bin and Power Supply by using an ORTEC power extension cable (or equivalent) to furnish operating power to the module.

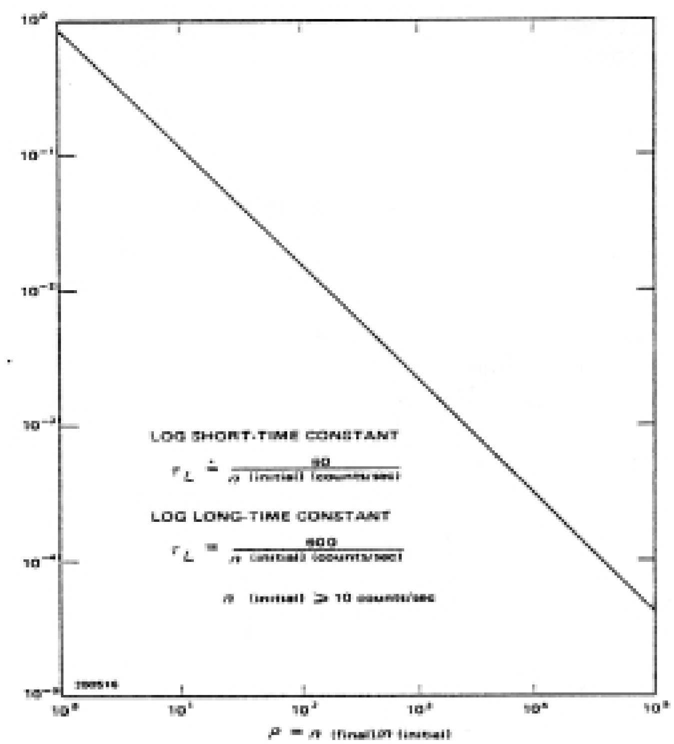


Fig. 9. Response Time for the Log Range.

Set the Zero Suppression control on the front panel at 0. For each range, adjust the corresponding trim potentiometer for a digital voltmeter reading according to Table 1. Be sure that the cable from the precision frequency generator to the 9349 input is terminated properly.

The front panel meter indications should agree with the frequency settings within the ±2% meter tolerance except for the Log range; the meter should read between 8×10^3 and 1.5×10^4 for the check that is made at 10,000 counts/s for this range. If observation of the front panel meter indication is the ultimate use for the 9349 rather than observation of an instrument that is operated with its Analog output, the above calibrations can be made for accurate meter indications rather than for the indicated output voltage levels.

5.5. TROUBLESHOOTING

The following voltages and waveform details are intended to indicate the typical values as a means of detecting malfunctioning in the event of instrument failure. Before checking any of the circuit details, see that the 4001/4002 dc output voltages are within their specified tolerances.

Set the Range switch of the 9349 at 10^4. Set the Time Constant switch at 0.3. Set the Zero Suppression control at 000 dial divisions.

Location	Typical Voltage
Q8 C	+12.0
Q9 E	+1.0
Q13 B	+9.1
Q14 B	+8.0
TP 2	0
TP 3	>+1, <+3
IC 1-3	+11.2
IC 1-7	+17
Q19A B	+0.176
Q19A C	+11.17

Measure the monostable output pulse width at the collector of Q7 for each Range switch setting. Each indicated duration should be withing ±5% of the pulse width shown.

Range	Pulse Width (μs)
10	300
30	100
10^2	30
3×10^2	10
10^3	3
3×10^3	1
10^4	0.3
3×10^4	0.1
10^5	0.1
3×10^5	0.1
10^6	0.1
Log	0.1

5.6. FACTORY REPAIR

This instrument can be returned to the ORTEC factory for service and repair at nominal cost. Our standard procedure for repair ensures the same quality control and checkout that are used for a new instrument. Always contact the Customer Service Department at ORTEC, (865) 483-2231, before sending in an instrument for repair for shipping instructions and so that the required Return Authorization Number can be assigned to the unit. This number should be written on the address label and on the package.

Table 1. Range Calibration.

Range	Use Time Constant	Input Pulse		Analog 10V Output	Adjusting Potentiometer
		Period	Frequency (counts/s)		
10^6	0.3	1 µs	1 M	9.85	R47
3×10^5	0.3	5 µs	200 k	6.70	R34
10^5	0.3	10 µs	100 k	10.00	R36
3×10^4	0.3	50 µs	20 k	6.67	R37
10^4	0.3	0.1 ms	10 k	10.00	R38
3×10^3	0.3	0.5 ms	2 k	6.67	R39
10^3	0.3	1 ms	1 k	10.00	R40
3×10^2	0.3	5 ms	200	6.67	R41
10^2	(0.3)*1	10 ms	100	10.00	R42
3×10^1	(0.3)*1	50 ms	20	6.67	R43
10	(1)*3	0.1 s	10	10.00	R44
Log	Short	0.1 ms	10 k	6.00	R31

*** When two time constants are shown, use the first time constant for a rough setting and follow with the second time constant for fine adjustment.**

Bin/Module Connector Pin Assignments for Standard Nuclear Instrument Modules per DOE/ER-0457T

Pin	Function	Pin	Function
1	+3 V	23	Reserved
2	−3 V	24	Reserved
3	Spare Bus	25	Reserved
4	Reserved Bus	26	Spare
5	Coaxial	27	Spare
6	Coaxial	*28	+24 V
7	Coaxial	*29	−24 V
8	200 V dc	30	Spare Bus
9	Spare	31	Spare
*10	+6 V	32	Spare
*11	−6 V	*33	117 V 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 V	38	Coaxial
*17	−12 V	39	Coaxial
18	Spare Bus	40	Coaxial
19	Reserved Bus	*41	117 V ac (Neutral)
20	Spare	*42	High-Quality Ground
21	Spare	G	Ground Guide Pin
22	Reserved		

Pins marked (*) are installed and wired in ORTEC's Model 4001A and 4001C Modular System Bins.