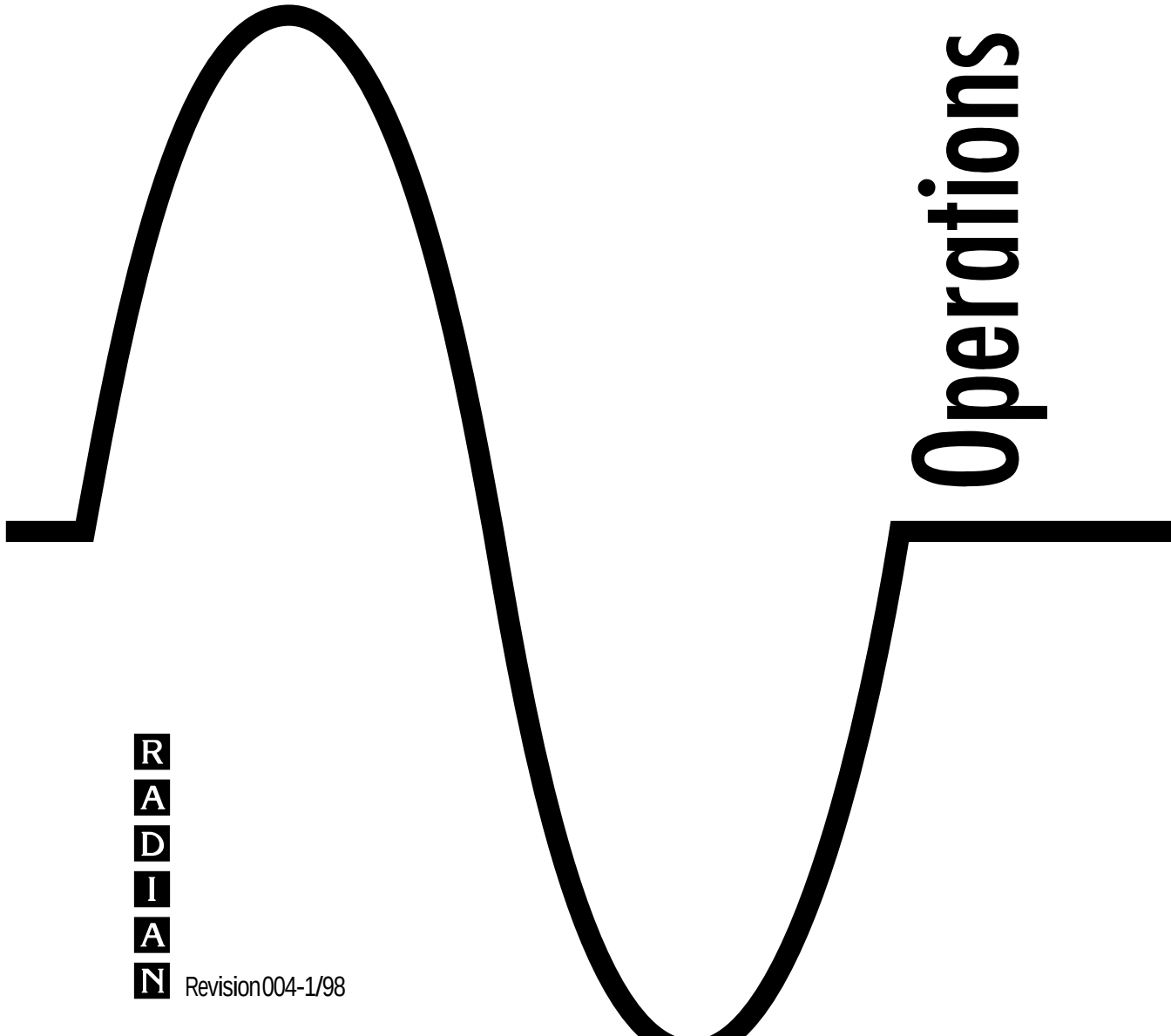
Radian Research, Inc.

RM-11

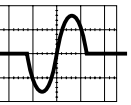
Primary Metronic Standard

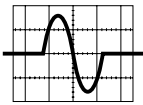


Operations Manual

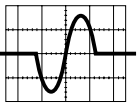
RADIAN

Revision 004-1/98





Contents



1.0 Product Introduction

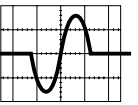
The RM-11 Metronic Primary Watthour Standard is by far the most accurate self-contained primary watthour standard manufactured in the United States, with typical accuracies in the 0.003% range and repeatabilities in the 0.001% range. It is essentially an enhanced version of the RM-10 Portable Watthour Standard, optimized for accuracy and stability and retaining the same lightweight, package for portability and economy. By retaining 70% of the same circuitry, which is mass produced, the RM-11 easily outperforms primary standards costing three to six times as much. It represents the present state of the art in electronic watthour reference standards with a conservative accuracy specification of 0.025% worst case for one year. Stability is included within this maximum accuracy specification. Also, the accuracy applies to all operating points between 0.2 and 50 amperes and 60 to 600 VAC. Autoranging potential and current inputs coupled with an inherent extremely wide operating range permit these specifications. The Radian RM-703 automated calibration system tests the RM-11 standards automatically on overnight runs, including temperature testing. A total of 300 calibration points are taken at final test with over a thousand points taken during pretest and subassembly testing.

The RM-11 utilizes the following accuracy enhancing design techniques:

• **Supermalloy cores** are used simultaneously with the electronically compensated cores from the RM-10 design. This reduces transformer errors to approximately the 0.0005 to 0.0001 percent level (one to five parts per million).

• **Burned in references** are selected for stability and checked for drift for three months prior to incorporation within the RM-11. At this point in time, the drift histories of the references selected must assure that stability is more than sufficient to meet drift specifications.

• **An ultra low noise power supply** reduces errors at low levels. The RM-11 operates only at 120 to 240 VAC and is therefore not directly interchangeable with the RM-10 for field use. The circuitry to permit potential gating is absent as well, for higher accuracy.



• **Fifteen ranges** in the autoranging circuit are used to reduce low level errors by 50%.

These changes reduce typical errors from the 0.015% level to the 0.003% level at room temperature and reduce typical errors from the .035% level to the .012% level over temperature compared to the RM-10.

The RM-11 has *no* potentiometers whatsoever so the need of hand carrying standards to and from NIST for the best accuracy is totally eliminated. Three units within 0.001% of each other when shipped by UPS have been observed to be within 0.001% of each other upon arrival.

1.1 Design Features

The RM-11 Metronic Watthour Standard is a true second generation electronic watthour standard. It represents a new standard of performance in primary watthour standards, completely surpassing the previous generation of electronic watthour standards in all areas of performance. Novel features include very superior accuracy of 0.003% typical and 0.025% maximum, as well as very superior time and temperature stability. Other features pioneered by Radian include transparent automatic range changing on potential and current inputs, true display in watthours on all ranges (Kh of 1) and substantially greater resolution. The superior performance and many advanced features eliminates the need to use calibration correction factors. A simple six function memory calculator converts watthours to percent registration in a single simple calculation.

Four revolutionary features utilizing novel and innovative design are primarily responsible for the superior performance of the RM-11:

• **Transparent automatic current range changing** makes the RM-11 watthour standard unequalled in ease-of-use in actual laboratory operations. The input has sufficient internal ranges to measure all currents from 0.2 amperes to 50 amperes with full rated worst case accuracy of 0.025%. The correct and optimum range is found by the instrument after current is applied and before the measurement is started. The output to the digital display and to the pulse output are also ranged simultaneously so as to retain calibration in watthours regardless of the range selected.

"Transparent" means there is no external or visible effect to the range changing except enhanced accuracy. The output pulse rate, digital display, etc. are unaffected. The automatic range changing also gives complete protection from failures due to application of high currents to the wrong range.

• **Transparent automatic voltage range changing** performs exactly the same functions on the voltage axis and also protects the standard from failure due to operator error.

• **An ultra high resolution output** is capable of supplying an output frequency of up to 1000 times that of older models and with improved accuracy as well. This permits full rated accuracy at test times of 3.6 seconds.

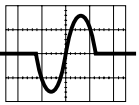
In addition to these revolutionary features, a number of other advanced features solve the problems which have kept older designs from attaining their stated 0.1% accuracies in most realistic field situations:

• **All toroidal input transformers** provide superior immunity to stray fields. Close physical proximity to load boxes or to a high current bus is permitted without derating accuracy. The small influences are included in the basic accuracy specifications.

• **Electronic transformer compensation** eliminates almost all transformer error. This alone eliminates 75% of the error present in older designs and eliminates the need for using correction factors. This feature permits a conservative 0.025% accuracy at 0.5 power factor worst case.

• **100% hermetic, burned-in internal references** are a first for a primary device. The reference set is also the theoretical minimum number of references required for a watthour instrument, also a first for a primary device. Together, these have permitted the achievement of typical stabilities below 0.005% per year in drift. With such low drifts, the RM-11 is specified to meet 0.025% worst case accuracy for a period of one full year after recalibration.

• **An advanced Pulse Width Modulation (PWM) multiplier** is used. PWM is still among the best approaches to watthour measurement and has the advantage of known and few limitations in standards use. The most serious limitations, high errors on the popular voltage gating test approach and



subharmonic beat frequency errors, have been substantially reduced in the advanced design of the RM-11.

• **Warmup drift has been dramatically reduced** by the elimination of electrolytic capacitors from the measurement signal path, by the use of significantly improved hermetic internal references and by the use of an aluminum enclosure to substantially reduce internal heating. The RM-11 will deliver full rated performance within 15 minutes of power on.

•**The elimination of potentiometers** permits the full rated performance of the RM-11 to be retained in the presence of the severe handling, shock and vibration. There are no potentiometer wipers to be knocked out of calibration. The calibration is accomplished by digital decade switches with a total adjustment range of +.099 to -.099%. Shock or vibration short of damaging or catastrophic levels will not have a measurable influence on the performance of the RM-11. The reference elements are shock mounted to prevent severe shocks from influencing them.

• **Remote digital gating** of the register with the remote switch or digital input eliminates the need for switching of the potential input and the associated errors. The remote switch works on a three cycle control. In the reset condition the display reads zeros and does not count. A push of the switch (or a digital input) enables the display and watthours will register. A second push freezes the display and a value other than zero will be visible to indicate this state. A third push will reset the display to zero ready for another measurement with no need to push the reset button adjacent to live and hazardous terminals.

• **Summing current inputs** permit closed link testing on all types of watthour meters. For normal testing, any one of the three current inputs may be used. The sum of all three currents is limited to 150 amperes, with a 50 ampere limit per input. For closed link testing, three isolated current sources are required in place of the usual one current source.

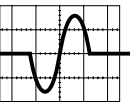
2.0 Configurations Available

2.1 RM-11 Models

RM-11-01 Primary Watthour Standard
RM-11-02 Primary Watthour 200 Amp Standard
RM-11-03 Primary Watthour Standard with I/O Communications Port
RM-11-06 Primary Watthour/VARhour Standard
RM-11-07 Primary Watthour/VARhour/Qhour Standard
RM-11-08 Primary Watthour/VARhour/200 Amp Standard
RM-11-09 Primary Watthour/VARhour/Qhour/200 Amp Standard

•The RM-11-02, -03, -06, -07, -08 and -09 are provided with an I/O Communications Port

Figure 2.1 RM-11 Metronic Primary Watthour Standard



3.0 Specifications

3.1 Accuracy

All errors are in percent of reading at any combination of the normal operating conditions. Note that stability is included within the maximum accuracy specifications for Watthours, VARhours and Qhours. *Power factor is referenced to Watthours and it is also assumed that voltage is the reference vector.

	Watthour
At Unity Power Factor* (0°):	*±0.003% typical, ±0.025% maximum*
At 0.5 Lag Power Factor* (-60°):	*±0.007% typical, ±0.025% maximum*
At Power Factor* P< 0.5 (f between -60° and -90°):	*±0.025%/P maximum*
	VARhour
At 0.0 Lag Power Factor* (-90°):	*±0.05% typical, ±0.1% maximum*
At 0.866 Lag Power Factor* (-30°):	*±0.05% typical, ±0.1% maximum*
	Qhour
At Unity Power Factor* (0°):	*±0.05% typical, ±0.1% maximum*
At 0.5 Lag Power Factor* (-60°):	*±0.05% typical, ±0.1% maximum*

3.2 Input

Input Terminal: *BNC, digital display gate*

3.3 Output

Output Terminal: *BNC*

Pulse Value: *Watthour 0.00001*
Watthour 0.00002 (200 Amp Version)

The percent of nominal VARhour and Qhour output can be calculated by using the following formulas:

$$\% \text{ OUTPUT}_{\text{VARhour}} = \sqrt{1 - \text{pf}^2} \times 100$$

$$\% \text{ OUTPUT}_{\text{Qhour}} = .5(\text{pf} + \sqrt{3} \times \sqrt{1 - \text{pf}^2}) \times 100^*$$

*(pf of 1.0 to 0.0 lag)

3.4 Normal Operating Conditions

Input Voltage:	*60 to 600 VAC (Autoranging)*
Input Current:	*0.2 to 50.0 Amperes (Autoranging)*
	150 Amps maximum when paralleling 3 inputs
Power Factor:	*Any (see accuracy definition)*
Ambient Temperature:	*20° to 30° C (68° to 86° F)*
Relative Humidity:	*0 to 95 %*
Auxiliary Power Voltage:	*120 to 240 VAC (Autoranging)*
Frequency:	*59 to 61 Hz or 48 to 52 Hz*
	For Varhour and Qhour correction at other frequencies refer to page 37.
Orientation:	*Any*
Recalibration Interval:	*365 days*
Warm-up:	*15 minutes*
Shock and Vibration:	*Any which is nondestructive*

3.5 Influences Affecting Accuracy

Temperature:	*±0.0003%/°C typical, ±0.001%/°C maximum (Watthours)*
	-20° to 70° C (-4° to 158° F)
	±0.001%/°C typical, ±0.005%/°C maximum (VARhour/ Qhour only)
	-20° to 70° C (-4° to 158° F)

3.6 Protection

Isolation:	*Complete: Inputs/Output/Power/Case/Control*
Dielectric Withstand:	*2.3 kVrms, 60 Hz, 60 seconds*
Surge Withstand:	*IEEE 472 and ANSI 37.90*
Fuses:	*Schurter #0342516 or Radian #3001000*

3.7 Burden Values

Potential Input:	**Impedance**	**Input Voltage**	**Burden (V^2/R)**
	10 pF	*120 V*	*0.0001 VA*
		240 V	*0.0003 VA*
		480 V	*0.001 VA*
		600 V	*0.002 VA*

Current Input:	**Impedance**	**Input Current**	**Burden(I^2R) single input**	**Burden($I^2R/3$) 3 inputs in parallel**
	0.001ohm.	*0.2 A*	*0.00004 VA*	*0.000013 VA*
		0.5 A	*0.00025 VA*	*0.00008 VA*
		5 A	*0.025 VA*	*0.008 VA*
		50 A	*2.5 VA*	*0.8 VA*
		150 A	***DO NOT USE***	*7.5 VA*

Auxiliary Power: *3.5 W for RM-11*
4.0 W for multifunction RM-11
<10 VA for all units

3.8 Physical Description

Size: *190.5 mm (7.5") **High** excluding rubber feet*
*139.7 mm (5.5") **Wide***
*139.7 mm (5.5") **Deep** excluding latches and strap*

Weight: *2.5 kg (5.5 lbs); 3.6 kg (8 lbs) shipping weight*

Shipping Dimensions: *305 mm (12") **High***
*248 mm (9.75") **Wide***
*248 mm (9.75") **Deep***

Display: *12.7 mm (0.5") LCD, 6 digits*
Readout in Watthours, VARhours, Qhours

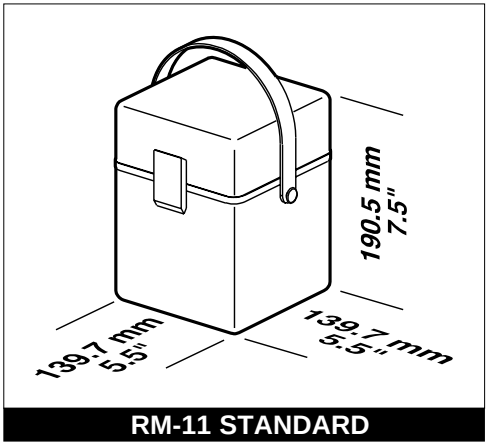


Figure 3.8 RM-11 Physical Dimensions

4.0 Operations Overview

4.1 Auxiliary Power

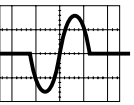
Auxiliary Power is required to power the electronic watt converter, current to frequency converter, display and transformers. Auxiliary power must be supplied independent from the potential input source. The voltage can range from 120 to 240 VAC at any frequency from 48 to 500 Hz. Because of an absence of ranges to be selected, either manually or automatically, it is very unlikely that a fuse will ever be blown. Fuse replacement may be required if the display fails to indicate. Press the panel reset once if the display is not lit, then verify a.c. power on the auxiliary power terminals with a voltmeter. If power is present, consult Section 5 for fuse replacement instructions. The fuses are mounted underneath the connection terminals and are accessible externally.

For laboratory and OEM use (incorporated within test panels), the RM-11 auxiliary power is best connected to any convenient a.c. source which is independent of the potential signal. The source used may be any voltage between 120 and 240 VAC. For optimum performance use a twisted pair not run in the same bundle as the current leads.

4.2 Current Input

The RM-11 has three separate and isolated current inputs. All are identical and interchangeable, and may be paralleled for lower burden (rarely necessary) or put in series to increase sensitivity. This configuration facilitates easy and accurate closed link testing (Section 4.7) when used with test boards and load boxes with multiple floating current outputs. For most existing applications connect the current leads to any one of the current inputs and ignore the other two current inputs. Leave the unused current inputs floating (open). NEVER short an unused current input on any type of watthour standard.

The current input of the RM-11 is autoranging and covers the entire range from 0.2 amperes to 50 amperes in five ranges on only a single input and to 150 amperes with the three inputs in parallel. The five ranges keep the watt



converter of the RM-11 close enough to full scale so that full rated accuracy is obtained over this 750:1 range. The display is also ranged such that the display always registers in watthours. Hysteresis is provided at the ranging threshold points. The unit is designed for the input current to be set prior to the start of a test to preclude ranging during the course of a test. Tests performed with load boxes or in test panels are performed in this way. Small additional errors will occur on unstable loads, but this additional error is typically less than 0.002% for each range change within a 30 second test. Following are the ranging points for the current axis:

	CURRENT AUTORANGING				
	Range 1	**Range 2**	**Range 3**	**Range 4**	**Range 5**
Increasing Current	0 - 0.432A	0.433 - 1.731A	1.732 - 6.925A	6.926 - 27.7A	27.71 - 50A
Decreasing Current	0.356 - 0A	1.425 - 0.357A	5.7 - 1.462A	22.80 - 5.701A	50 - 22.81A

Table 4.2 Current Autoranging Points

4.3 Potential Input

The potential input of the RM-11 is entirely autoranging from a range of 60 to 600 VAC. Following are the ranging points for the potential axis:

	POTENTIAL AUTORANGING		
	Range 1	**Range 2**	**Range 3**
Increasing Voltage	0 - 152V	153 - 263V	264 - 600V
Decreasing Voltage	129 - 0V	248 - 130V	600 - 249V

Table 4.3 Potential Autoranging Points

The potential input is totally autoranging so there is no need to manually select a voltage range. Since both the potential and auxiliary power do not require an operator selection of range, the usual fuse replacement and reliability problems associated with this function are eliminated. Both of these inputs are fused with the fuses being underneath the input terminals. Refer to Section 6.1 for replacement.

Phasing must be observed when connecting the potential. If the phasing is wrong, reverse power flow will not be indicated and the instrument will not register. If no energy is registering, check the phasing and also verify with a voltmeter and a clamp-on type ammeter that the signals are actually present.

4.4 Remote Reset Switch Input

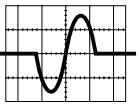
The INPUT connector on the RM-11 is for connection of a control input to gate the display on and off and to reset it. This input connection replaces both the reset switch and the click switch or photocounter control which gates the potential input. Gating the register rather than the potential input is definitely more accurate on any standard since the measurement circuitry then gets a flying start on the measurement. Potential gating has only been done historically because of lack of alternatives.

The most common input is the Radian RM-1S Remote Reset Switch. It connects directly to the INPUT connection of the RM-11 by means of a BNC shielded connector. A momentary push of the button starts the counter. A second push stops it after the test duration (frequently 10 revolutions), freezing the last reading for as long as desired and a third push will reset the counters to zero for the next test.

The INPUT will also accept a normally closed contact or normally on transistor open collector from any source. The common of the INPUT is fully isolated from the internal common of the standard to eliminate noise or hipot problems. A momentary pulse (open) lasting between .05 and one second will trigger the input. The display circuit will sense the leading edge of the contact open. The INPUT control has no effect on the pulse output.

4.5 Percent Registration Calculation

The output of the RM-11 is used to calculate the percent registration of the Unit Under Test. The formula by which this is accomplished is much simpler than the conventional calculation. The output of the RM-11 reads out in watthours, with a Kh of 1.00 on all ranges. The RM-11 is also accurate enough and linear enough that there is little necessity in using correction factors for the standard. Hence, the simple calculation of percent registration. The formula to be used is:



$$\%REG = 100 \times Kh \times \frac{REV}{(DISPLAY \times EL)}$$

where "%REG" is the percent registration, "Kh" is the watthour constant of the Unit Under Test," REV" is the number of revolutions of the test, "DISPLAY" is the displayed value in watthours and "EL" is the number of elements energized with the same current on the meter under test.

For two and one half element meters (two elements, three current leads for four wire circuits), use the value of four for the "EL" in the above calculations.

For one and one half element meters (residential Form 2S meters) a factor of one is used for a standard test and 0.5 elements for a closed link (two current elements on the RM-11) test.

4.6 Pulse Output

The pulse output is available on the RM-11 display panel as a BNC shielded connector labeled OUTPUT. The extreme resolution of the RM-11 yields an output with a calibration of 10 microwatthours per pulse (0.00001 watthours per pulse or 100,000 pulses per watthour). This calibration is the same on all voltage and current ranges.

Table 4.6 lists the pulse frequencies which are obtained at typical operating voltages and currents. All the values are reduced by 50% at 0.5 power factor. All values are multiplied by the number of current inputs used (EL).

The output frequency may be calculated at any voltage, current and power factor by the following formula:

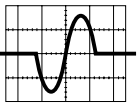
$$FREQ = EL \times VOLTS \times AMPS \times \frac{PF}{(3600 \times 0{,}00001)}$$

where 3600 is the number of seconds in an hour and 0.00001 is the number of watthours per pulse.

To reach the maximum frequency out when designing an interface to a commercial counter or systems interface to the RM-11, a pull-up resistor of 1000 ohms or less is recommended so that the capacitance of the connecting cables can be overcome without losing counts. If a cable run of more than six feet is necessary, lower the pull-up resistor value accordingly. The RM-11 can sink a maximum of 50 milliamperes, permitting a pull-up resistor limitation of 100 ohms minimum at five volts. If the available power supply cannot supply the current for low resistor values, consider using low capacitance cable for long runs. For test board interface development work, there is no substitute for a close inspection of the output waveform at maximum frequencies with an oscilloscope to verify that there are absolutely no problems with pulses being missed.

The frequencies which are obtained, ranging from 666.7 to 666.667 Kilohertz in Table 4.6, are beyond the input capabilities of some calibration equipment. A variable divide down device makes interface with the older calibration equipment straightforward. The RM-1D Frequency Divider available from Radian Research can solve this problem (see Section 10.4).

A typical laboratory configuration using multiple primary standards is detailed in Section 11.2 Testing a Radian Standard using the Averaging of Three Inputs. The output pulses from three primary standards are fed into the input ports of the RM-110 Automated Comparator. The RM-110 is used to average or sum the input pulses and control the device under test. This configuration can be used to calibrate field standards and meter calibration test tables. In addition, the RM-11 and RM-110, when used with the appropriate accessories, can be used to calibrate both solid state and induction meters. Refer to Section 11 Testing Applications for more information.



@1.0 pf	120v	240v	480v
0.20a	666.7	1333.3	2666.7
0.25a	833.3	1666.7	3333.3
0.50a	1666.7	3333.3	6666.7
1.00a	3333.3	6666.7	13333.3
2.00a	6666.7	13333.3	26666.7
2.50a	8333.3	16666.7	33333.3
5.00a	16666.7	33333.3	66666.7
10.00a	33333.3	66666.7	133333.3
15.00a	50000.0	100000.0	200000.0
20.00a	66666.7	133333.3	266666.7
25.00a	83333.3	166666.7	333333.3
45.00a	150000.0	300000.0	600000.0
50.00a	166666.7	333333.3	666666.7

Table 4.6 Pulse Frequency Table (pulses per second)

4.7 Closed Link Testing

Three sets of input terminals are provided for the purpose of closed link testing. The input transformer of the RM-11 has three identical input windings, arbitrarily labeled A, B and C. Each of these is put in series with a separate floating current source. Because the current sources and the separate inputs of the RM-11 are isolated from each other, there is no need to open the potential link or make a connection to the opened link. The advantages to this extend beyond the necessity of using meters without links to discourage power diversion.

The current sources cannot be wound on a common core because the loads being driven are not nearly identical enough. Two or three separate cores are necessary to create the high impedance current sources to make this technique work.

5.0 Theory of Operation

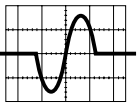
The RM-11 Metronic Primary Watthour Standard consists of seven basic blocks as illustrated in Figure 5.7. These include an input potential circuit, an input current circuit, an auxiliary power supply, a watt converter, a current to frequency converter (watthour converter), a range control circuit and a digital display/output circuit.

5.1 Input Potential Circuit

The Input Potential Circuit senses potential input voltages in the range of zero to 630 VAC, with full rated accuracy in the range of 60 to 600 VAC. The circuit consists of a toroid wound potential transformer with electronic means of sensing and removing over 99% of the error. The transformer is so accurate that it is not a significant source of error regardless of the input level. The range selection is accomplished on the secondary side, with much greater accuracy and reliability than can be achieved with primary side switching. Operator error does not enter into the range selection which is automatic. Typical accuracy is 0.001% on all three ranges without calibration, selection of components or trimming of any kind. Unlike resistive inputs, there is no hipot problem (5KV typical breakdown), no adjustment is required, and the temperature drift, time instability and warmup drift are all immeasurable (less than 0.0001%).

5.2 Input Current Circuit

The Input Current Circuit accepts a current in the range of 0.2 to 50 amperes (150 amperes total) and isolates, ranges and scales the current to maintain an input current to the watt converter in the range of 1 to 5 milliamperes. The construction is of the toroidal type so that there is no problem with stray fields. Electronic compensation reduces errors to below our measurement threshold (0.0001%) at most operating currents, and to below 0.001% over the entire specified region. With this low error it is feasible to do all tap changing on the secondary side at essentially dry circuit levels, thereby getting about 100 times the life expectancy of primary side switching. The input burden is also drastically reduced with about 0.02 VA at five amperes. Two



additional current inputs are provided for closed link testing in conjunction with three isolated current sources.

5.3 Auxiliary Power Supply

The Auxiliary Power Supply is able to operate efficiently at any voltage between 120 and 240 VAC. No relay contacts or range changing is required to accomplish this so reliability is excellent. The auxiliary power supply has an overall efficiency of 70% which changes very little with input voltage. This high efficiency results in a very low power consumption of about 3.5 watts which, in conjunction with an aluminum case, results in a very low internal temperature rise. This, coupled with a typical temperature coefficient below 0.0003% per degree C, results in negligible warmup drift. VA consumption varies between 5 and 9 VA depending on the input voltage.

5.4 Watt Converter

The Watt Converter is of the pulse width modulation type. A pulse width modulation multiplier forms a product by producing a pulse train the height of which is proportional to one input and the width of which (duty cycle) is proportional to a second input. A filter performs an integration, producing an average value proportional to the area under the pulses, which is proportional to the product of the two inputs.

An often overlooked aspect of using pulse width modulation for power conversion is that the current axis (load dependent) is much more likely to be distorted than the potential axis (line dependent). In pulse width modulation the axis which determines pulse height (the multiplexor axis) is much less sensitive to distortion. In the RM-11 this is the axis which senses the current input to minimize distortion sensitivity. Standards designed with the axes reversed will work fine on the calibration bench (low distortion) but may not work satisfactorily for customer load testing.

The watt converter has a voltage and a current input (units of watts) and has a current output. Since input:output is watts:current which is equivalent to volts, a voltage reference is required to reference the watt converter. No

other component within the watt converter has a significant effect upon the calibration.

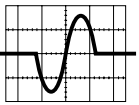
5.5 Current To Frequency Converter

The Current to Frequency Converter (watthour circuit) converts the current output of the Watt Converter into a pulse train with each pulse proportional to watthours of energy. It is referenced by a highly advanced charge balance integrator which can produce a much higher frequency (two megahertz or 7 billion pulses per hour) than older converters limited to pulse rates of only 400 hertz or 1.5 million pulses per hour. The circuit delivers this degree of resolution without compromise of the accuracy, which is typically 0.003%. The high resolution is of advantage in field testing because it permits the autoranging on the current axis which in turn will ultimately permit closed link testing.

The current to frequency integrator works on the charge balance principle. The input current is proportional to watts. The input current over a period of time is proportional to watthours. The units of current times time is charge, so that the charge accumulated in a capacitor over a period of time is directly proportional to watthours. Quanta of charge are removed from the capacitor after they have accumulated for a fixed period of time. Each quanta of charge which is removed is directly proportional to ten microwatthours. The removal of charge is accomplished by injecting a current of known amplitude and known duration. The amplitude of the current is determined by the ratio of an extremely precise voltage reference to an extremely precise resistor. The duration of the pulse is determined by one clock cycle of a 2.09 megahertz crystal.

5.6 Range Control Circuit

The Range Control Circuit accepts the pulse train from the current to frequency converter and scales the signal according to the range it has selected for the potential and current input transformers. The range selected is the optimum range for accuracy for the two signals sensed. The scaled frequency coming from the range control circuit has a direct calibration of ten microwatthours on all current and voltage ranges. The output frequency at



100 amperes and 600 VAC is 1.6666666 megahertz and the output frequency at 0.1 amperes and 120 volts is a modest 333.333 Hertz. The energy per pulse value remains the same over the entire range.

5.7 Digital Display/Output Circuit

The Digital Display/Output Circuit accepts the pulse train from the Range Control Circuit and counts it. The counter is controlled by the Input connection to the RM-11. A pulse at this input resets the counter and the display to zero. A second pulse starts the counter. A third pulse stops the counter and freezes the display until a further pulse starts the process over again. The Display Circuit also has a simulation mode: it detects the absence of a signal source at the input and simulates the operation of competitive products. In this mode the counter runs continuously in the presence of a watthour input signal and is reset to zero by a panel reset switch.

The Digital Display/Output Circuit also creates an isolated open (transistor) collector pulse output. This Output is optically coupled for high isolation and low noise. The calibration of the output signal is identical to the calibration of one count to the display which is ten microwatthours/pulse.

The Digital Display/Output Circuit display section displays six digits of a ten digit counter. When the count is less than 9.99999 watthours, the decimal point is placed as X.XXXXX to show all available resolution. When the count exceeds that number the decimal point shifts one number to the right. With this system it is possible to supply a large, easy to read liquid crystal display and still display all of the resolution when fairly low count numbers are being observed. The display will continue to advance and display accurately until it reaches 9999.99 watthours.

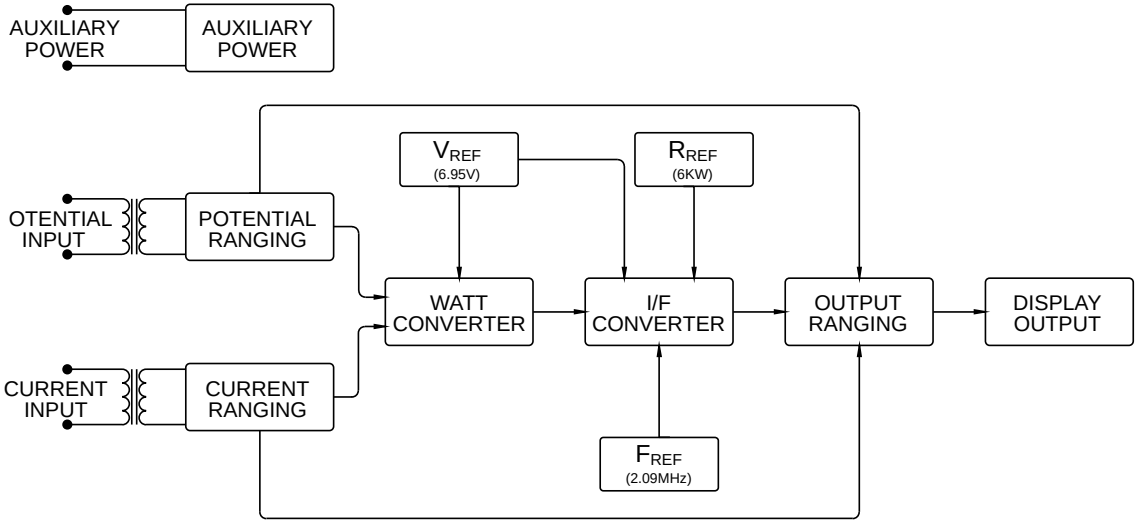
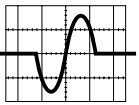


Figure 5.7 RM-11 Block Diagram



6.0 Service & Routing Maintenance

The RM-11 Metronic Primary Watthour Standard is virtually maintenance free. The use of a highly advanced all hermetic referencing system reduces drift an order of magnitude and therefore permits yearly recalibrations with no degradation in performance. The elimination of all contacts, switches and tap selections on the primary side of the input transformers significantly improves reliability by eliminating both service components and the opportunity for operator error. Other than cleaning of the outside surface and the yearly recalibration, no routine maintenance is required.

6.1 Fuse Replacement

Fuse replacement is not very likely because of the elimination of primary side switching. However, fuses are included and are accessible without disassembly. There are four fuses: two potential input and two auxiliary power. Fuse replacement is performed as follows:

1. Test for blown fuses. Approximately 14 to 17 Kohms of impedance on the potential input circuit is normal; approximately .08 amperes of current draw is normal at 120 VAC of the auxiliary power.
2. Replace both fuses on a circuit if one is bad.
3. Remove the terminal knobs of the circuit with bad fuses.
4. Remove the stainless steel set screws underneath each of the two terminals with a 1/8 inch Allen (hex key) wrench.
5. Remove the fuses underneath by turning the RM-11 upside down and shaking the fuses out.
6. Replace the fuses with 5 x 20 mm 1 ampere medium blow fuses. Schurter #0342516 or Radian #3001000 are recommended. If the unit blows the fuses again, the unit needs to be serviced.

6.2 Cleaning

Cleaning of the RM-11 may be performed with a clean, dry lint-free cloth dampened slightly with a mild window cleaner. The areas around the top terminals should be buffed dry with another cloth which is completely clean and totally dry. This is to maintain dielectric with complete assurance for voltages of 480 volts and higher.

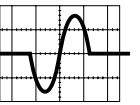
6.3 Repair

Repair is recommended to be performed by Radian Research. We have excellent automated testers with which every internal module can be tested quickly to original factory specifications. A final calibration and quality control inspection to original factory specifications is performed quickly and thoroughly.

6.4 Case Removal

Removal of the case is required to obtain access to the digital decade switches to set calibration. Since the unit is readily subject to damage when out of the case, it is recommended that the change in calibration be determined prior to case removal. For instance, suppose that it is determined that the unit is running 0.007% slow and that the records show that the present setting of the calibration is +0.034%. The new number must be 0.007% higher to correct for the slow output. The RM-11 can therefore be removed from the case and the switches changed to +0.041.

To remove the case first ease the leather strap off of the strap retainers. Secondly, remove the retainers by inserting a 3/64″ Allen (hex key) wrench through the hole and carefully remove the strap retainer so as not to damage the paint. The RM-11 can then be slid carefully out of the case by pulling on the lip of the black thermoplastic top panel (DO NOT use a screwdriver to pry the RM-11 from the case). After recalibration reassemble in the reverse order being careful to replace the internal insulating paper. The internal insulating paper is best wrapped around the RM-11 and then slid into the case with it. The internal paint can withstand the rated hipot voltage but the insulating paper provides insurance against a breakdown due to scratches.



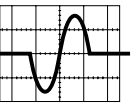
6.5 Recalibration

Recalibration is recommended yearly. Section 7 details the procedure of recalibrating the RM-11. A periodic cross check against another RM-11 is recommended to preclude the possibility of a failure in either.

7.0 Recalibration

Recalibration is recommended at yearly net intervals. We highly recommend the use of Radian's recalibration service as a very cost effective alternative to manual recalibration by the utility. Our RS-703A Syntron Automated Calibration System has a repeatability of better than 0.001% and an accuracy limited by available calibration from the National Institute of Standards and Technology. Our RS-703A Syntron Automated Calibration System collects a data point on a Radian standard every fifteen seconds on up to sixteen standards simultaneously, collecting literally thousands of data points on an overnight run. When using this service, and economics permit, prudence would dictate having a dedicated RM-10 or an RM-11 primary standard which is checked by NIST or NRC (National Research Council in Canada). With this instrument it is feasible to sample test units at various points as a "backup" test.

Historically, watthour standards have had to run at each power setting for considerable periods of time to be calibrated. This has been due to two interacting effects within the input transformers. The high burden of first generation electronic watthour standards causes heating in the input transformers. The accuracy of the transformers and stability of the electronics renders a sensitivity to this heating which must stabilize out for data to be taken. The RM-11 has such low input burden that this heating is very small. The electronically compensated transformers and advanced references of the RM-11 are highly immune to heating even if it were not small. Our extremely accurate and cost effective automated recalibration system permits highly accurate data points to be taken within a few seconds of each other (See Figure 7.0a).



CALIBRATION REPORT

RM-11-06 METRONIC PRIMARY WATTHOUR STANDARD

MODE..... WATTHOURS

DATE..... 20-Jan-98

SERIAL NUMBER..... **501204**

THE FOLLOWING DATA WAS COLLECTED BY AN RS-703A SYNTRON AUTOMATED CALIBRATION SYSTEM. THE RS-703A CALIBRATION SYSTEM INCORPORATES AN RM-11 PRIMARY REFERENCE STANDARD CALIBRATED BY THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY TO AN UNCERTAINTY OF 0.005% AT UNITY POWER FACTOR AND 0.010% AT 0.5 POWER FACTOR. THE TEST PARAMETERS WERE 23 DEGREES CENTIGRADE WITH A TEST TIME OF 15 SECONDS PER POINT. THE TIMING WAS DONE BY GATING THE PULSE OUTPUT. FOR LAGGING POWER FACTORS, THE CURRENT LAGGED THE VOLTAGE.

VOLTAGE & PHASE ANGLE

AMPS	120 UNITY	120 60' LAG	240 UNITY	240 60' LAG	480 UNITY	480 60' LAG	600 UNITY	600 60' LAG
0.5	0.002	0.000	0.000	0.003	0.001	0.003	0.001	0.006
1.0	0.000	0.001	-0.002	0.003	-0.002	0.004	-0.001	0.006
2.0	-0.002	-0.002	-0.003	0.000	-0.003	0.002	-0.002	0.004
2.5	-0.001	-0.002	-0.004	0.001	-0.004	0.002	-0.002	0.005
3.0	-0.003	-0.002	-0.003	0.000	-0.004	0.002	-0.002	0.005
5.0	0.000	0.000	-0.001	0.001	-0.002	0.004	0.001	0.006
6.0	0.000	0.000	-0.002	0.002	-0.002	0.004	-0.001	0.006
10.0	-0.001	-0.003	-0.001	0.002	-0.001	0.002	-0.001	0.005
12.0	0.000	-0.001	-0.001	0.001	-0.001	0.004	0.000	0.006
15.0	0.000	0.001	-0.002	0.002	-0.002	0.003	0.001	0.006
20.0	0.001	0.001	-0.001	0.002	-0.002	0.005	0.000	0.007
25.0	0.000	-0.001	-0.001	0.003	-0.001	0.005	0.001	0.006
30.0	0.000	0.000	-0.001	0.002	-0.001	0.005	0.000	0.006
40.0	0.001	0.001	-0.001	0.002	-0.002	0.005	0.000	0.007
45.0	0.001	0.001	-0.001	0.004	-0.002	0.005	0.001	0.007
50.0	0.001	0.001	-0.002	0.002	-0.002	0.005	0.000	0.007
AVERAGE	**0.000**	**0.000**	**-0.002**	**0.002**	**-0.002**	**0.004**	**0.000**	**0.006**
MAXIMUM	0.002	0.001	0.000	0.004	0.001	0.005	0.001	0.007
MINIMUM	-0.003	-0.003	-0.004	0.000	-0.004	0.002	-0.002	0.004

OVERALL

	UNITY	60' LAG
AVERAGE	-0.001	0.003
MAXIMUM	0.002	0.007
MINIMUM	-0.004	-0.003

Figure 7.0a Typical Radian Calibration Report

The watthour calibration of the RM-11 is changed by the setting of two ten-position digital switches located on the bottom printed circuit board of the standard. The switches have 199 possible settings between +0.099 and -0.099%. As referenced to Figure 7.0b, Switch 1 changes the second calibration digit to the right of the decimal point and Switch 2 changes the third calibration digit to the right of the decimal point. Switch 3 changes the registration from negative (left position) to positive (right position). To adjust to 100.000% registration, mathematically subtract the percent error of the standard from the number derived by reading the three switches. To illustrate the process of recalibrating a Radian standard using the digital switches, the following four examples are given:

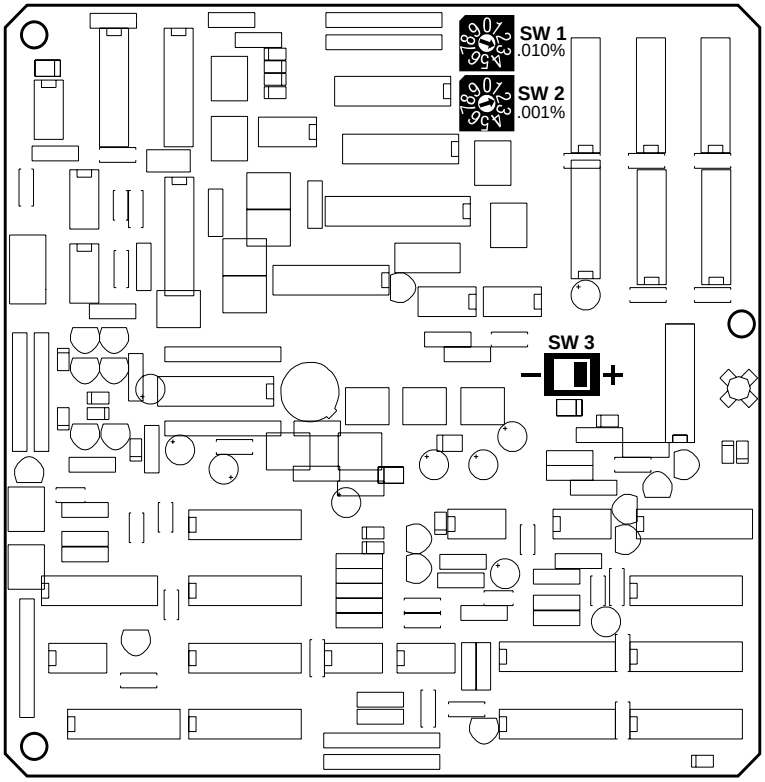
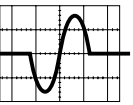


Figure 7.0b Digital Switch Location



1. Initial switch settings are SW1=3, SW2=2 and SW3=right (+0.032) and the percent error of the standard is –0.005%. Therefore, the standard is running at 99.995% registration or 0.005% slow. To adjust to 100.000% registration the new switch settings would be SW1=3, SW2=7 and SW3=right (+0.037). [+0.032 – (–0.005) = +0.037]

2. Initial switch settings are SW1=3, SW2=2 and SW3=right (+0.032) and the percent error of the standard is +0.005%. Therefore, the standard is running at 100.005% registration or 0.005% fast. To adjust to 100.000% registration the new switch settings would be SW1=2, SW2=7 and SW3=right (+0.027). [+0.032 – (+0.005) = +0.027]

3. Initial switch settings are SW1=1, SW2=8 and SW3=left (–0.018%) and the percent error of the standard is –0.007%. Therefore, the standard is running at 99.993% registration or 0.007% slow. To adjust to 100.000% registration the new switch settings would be SW1=1, SW2=1 and SW3=left (+0.011). [–0.018 – (–0.007) = –0.011]

4. Initial switch settings are SW1=0, SW2=1 and SW3=right (+0.001%) and the percent error of the standard is +0.004%. Therefore, the standard is running at 100.004% registration or 0.004% fast. To adjust to 100.000% registration the new switch settings would be SW1=0, SW2=3 and SW3=left (–0.003). [+0.001 – (+0.004) = –0.003]

Historically, calibration factors have been used instead of adjusting standards. The primary intent was to maintain a calibration history. Units with substantial drift could be detected by virtue of a continuously changing calibration factor with time. The problem with readjustment was that potentiometers and other screw adjustments became more unstable mechanically after adjustment than before. The digital decade switches of the RM-11 cannot be bumped or jarred from their setting in transportation or handling and the switches themselves provide the calibration history. The switch settings should definitely be recorded with the date at the time of each recalibration. A typical sheet may look as follows:

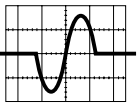
Date	Setting	Notes
3/06/94	+.032	NEW UNIT, AS RECEIVED
6/06/94	+.037	THREE MONTH CHECK OF NEW UNIT
3/06/95	+.039	ROUTINE YEARLY RECALIBRATION
3/09/96	+.039	ROUTINE YEARLY RECALIBRATION
3/06/97	+.039	ROUTINE YEARLY RECALIBRATION

Table 7.0c Typical Recalibration Sheet

A recalibration is normally performed at 120 VAC, 5 amperes and unity power factor. A reason for checking for power factor error and for error on each range is to check against the very remote possibility of a failure which may have occurred which is not apparent at the reference point.

To verify full accuracy on every internal range it is sufficient to check the RM-11 approximately every factor of two on current and voltage: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20 and 50 ampere checks as well as 80, 120, 240 and 480 volt checks will assure that all ranges are properly functioning. The RM-11 should be within 0.025% at all unity power factor points and at all 0.5 power factor points.

Gang testing is the most economical method of calibration verification on RM-11 Standards. A number of standards are powered with auxiliary power in parallel, potential inputs in parallel and currents in series (unused currents inputs are open of course). The “Input” connections on the RM-11 registers are paralleled using one RM-1G cable per RM-11 so that one RM-1S Remote Switch controls all RM-11 Standards. Optionally, an RM-110 Automated Comparator may be used in place of the RM-1S. If testing other types of standards along with RM-11 Standards then the RM-110 Automated Comparator is necessary.



8.0 VARhour / Qhour Models

8.1 Potential Gating

Potential gating, a time honored approach which today should be avoided because of more accurate approaches, is fundamentally incompatible with the VARhour or Qhour function. All Radian standards are designed for gating of the register rather than the potential, thus making a VARhour or Qhour standard practical. The Radian RM-1A Photocounter Interface is recommended to eliminate the need for potential gating for applications where the hardware or procedures already exist; such as with older test board designs.

8.2 Stability

The stability of the VARhour and Qhour function of the RM-11 is significantly improved over that of older VARhour circuits. The stability is improved by eliminating electrolytic capacitors from the signal path and by using all hermetically sealed reference components. The capacitors used are the most stable type film capacitors known. 90 day recalibration and avoidance of temperature excursions beyond 10 to 40 degrees Celsius are recommended to attain the highest possible stability. Recalibration should be performed at 120 Volts, 5 Amperes and 100% output. The phase error of the VARhour or Qhour circuit is small enough that it never needs to be calibrated.

Stability of the VARhour or Qhour function is enhanced considerably by avoiding temperature extremes. There is a hysteresis of about 0.02% by going from temperature extremes for long periods (greater than 12 hours) and then returning to room temperature. The hysteresis set can be eliminated by temperature cycling (-20, +70, -10, +60, +0, +50, +10, +40, +20 ℃).

8.3 Function Select

To change from one measurement parameter (ie: Watthours, VARhours or Qhours) to another, simply press the "Select" pushbutton on the RM-11 top panel (Figure 2.1). Annunciators on the custom liquid crystal display indicate the measurement mode of the standard.

8.4 I/O Control / Communications Port

On all multifunction RM-11 Standards an Input/Output port is located in the upper right corner of the top panel. The I/O port can function as a direct control port or as an intelligent communication port.

In the direct control mode the I/O port can be used to: (1) select the measurement mode and (2) cycle the display from one mode to another (ie: free run, stop or reset). Detailed technical information on the direct control mode of the I/O port is presented on the following two pages.

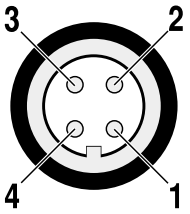
In addition to the direct control mode, the I/O port can be used as an intelligent computer communication interface. In this mode any PC-compatible computer can be used to do the following:

1. Select the measurement mode
2. Cycle the display from one mode to another
3. Read the display value
4. Input and read the serial number of the standard
5. Input and read the last calibration date of the standard
6. Input and read other record keeping data

The Radian Research RM-PCA Computer Interface Adapter connects to the I/O port and to the serial port of a computer. The RM-PCA provides access to the standard's display through the PCA-Link™ Meter Test Software or PCA-Lab™ Standard Test Software.

Contact our headquarters for more detailed technical information.

Pin Description:



Pin 1 (black) : Common
Pin 2 (green) : Display Control
Pin 3 (red) : VARhour Control-(serial clock)
Pin 4 (white) : Qhour Control-(serial data)

Figure 8.4a I / O Port Pin Description

Drive Options:

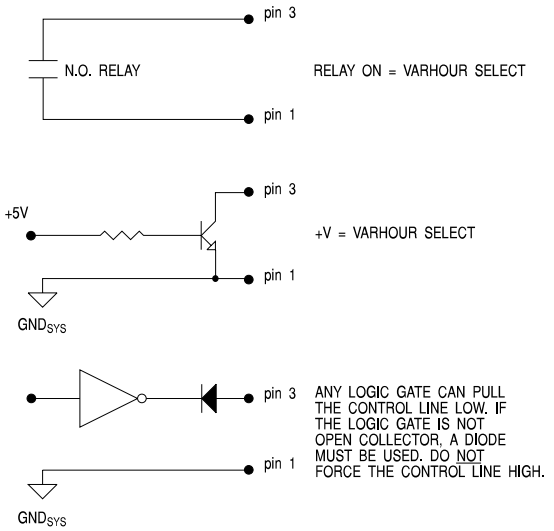


Figure 8.4b Drive Options

Mode Select Options:

To select a mode, the control line must be pulled to common (need to sink 3 mA at no more than 0.7V).

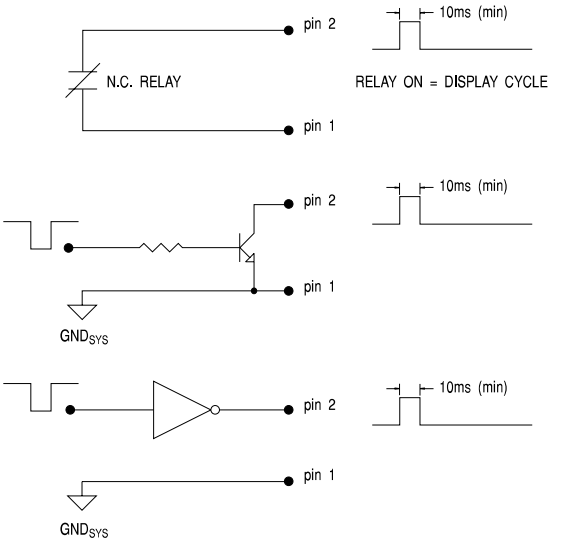


Figure 8.4c Mode Select Options

Display Control Options:

The display control is accomplished by making a connection between pins 1 and 2. This connection signals the display to enter the display gate mode. The connection can be accomplished with a normally-closed relay, an open collector output or a driven output. To cycle the display this circuit must be opened for at least 10ms. The rising edge is the timing marker.

Low (closed) = 1mA at less than 0.7 volts

High (open) = 4.5 volts (pulled up internally)

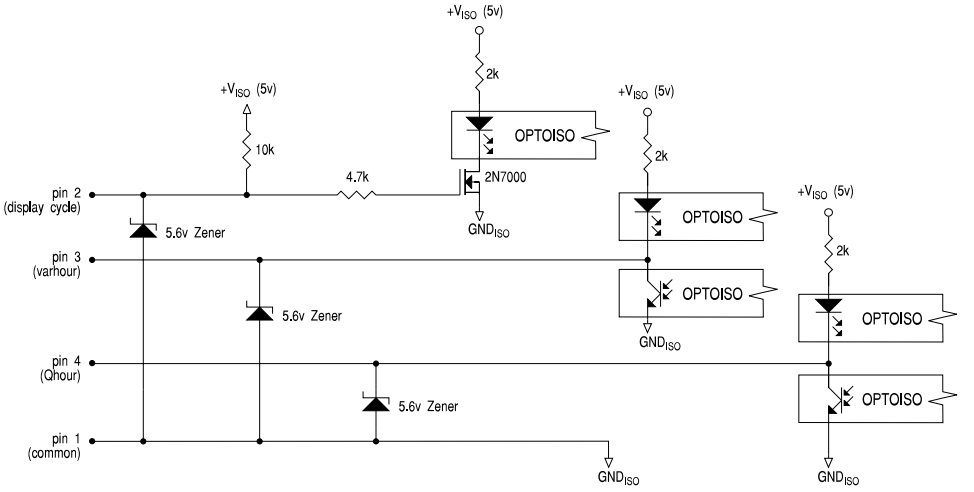


Figure 8.4d Display Control Options

- Varhour correction formula for RM standard calibated at 60 Hertz but used at a different frequency:

$$\text{Varhour Actual} = \text{Varhour}_{RM} \times \frac{\text{Actual Frequency}}{60}$$

- Varhour correction formula for RM standard calibrated at 50 Hertz but used at a different frequency:

$$\text{Varhour Actual} = \text{Varhour}_{RM} \times \frac{\text{Actual Frequency}}{50}$$

- Qhour correction formula for RM standard calibrated at 60 Hertz but used at a different frequency:

$$\text{Qhour Actual} = \text{Qhour}_{RM} \times \left(\frac{\sqrt{1 + 3\left(\frac{f}{60}\right)^2}}{2} \right) \left(\frac{\cos(\theta + 60^\circ)}{\cos\left[\theta + \tan^{-1}\left(\sqrt{3}\,\frac{f}{60}\right)\right]} \right)$$

- Qhour correction formula for RM standard calibrated at 50 Hertz but used at a different frequency:

$$\text{Qhour Actual} = \text{Qhour}_{RM} \times \left(\frac{\sqrt{1 + 3\left(\frac{f}{50}\right)^2}}{2} \right) \left(\frac{\cos(\theta + 50^\circ)}{\cos\left[\theta + \tan^{-1}\left(\sqrt{3}\,\frac{f}{50}\right)\right]} \right)$$

Where:

Varhour Actual = the corrected Varhour accumulation
Qhour Actual = the corrected Qhour accumulation
f = frequency
Varhour RM = the RM standard's Varhour accumulation
Qhour RM = the RM standard's Qhour accumulation
θ = phase angle difference between voltage and current

9.0 200 Amp Models

The RM-11 Standard has a 50 ampere per input current specification (150 amperes total). The RM-11 is also available in a 200 ampere configuration. To achieve the 150 or 200 ampere current input capacity the three current inputs must be paralleled (Figure 9.0).

Use #4 or larger cable making sure that the total length of the three current paths are equal. Tightly bundle the leads and route as indicated in Figure 9.0. The routing is important as at high current inputs the magnetic field created can affect the accuracy of the unit. Also, make sure the current input knobs are securely tightened.

The specifications of all 200 Ampere models are identical to the standard 150 Ampere models with the following exception:

OUTPUT PULSE VALUE = 0.00002 watthours per pulse

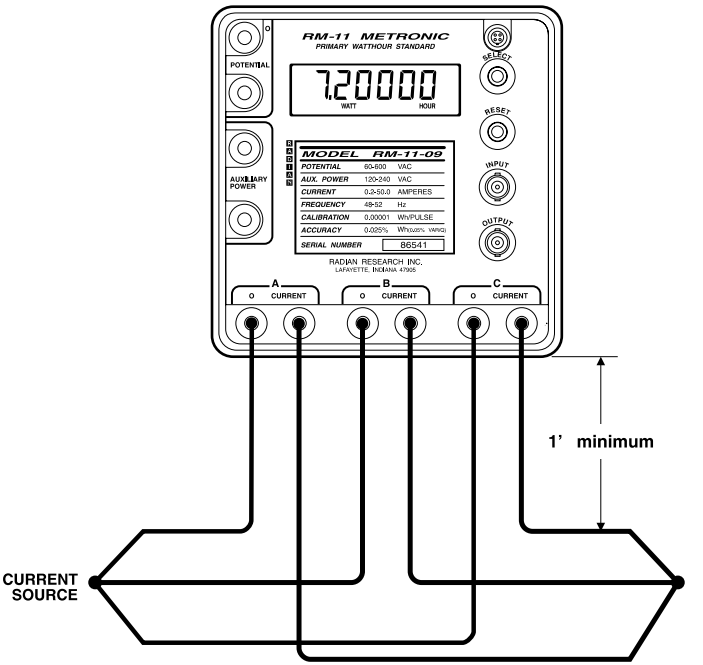
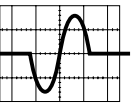


Figure 9.0 Paralleling the Three Current Inputs



10.0 Test Accessories

10.1 Rm-110 Automated Comparator

The RM-110 Automated Comparator is the definitive test accessory for use with Radian reference standards. The RM-110 eliminates manual calculation and recordkeeping associated with two primary applications: field testing of watthour billing meters and laboratory testing of reference standards. The RM-110 uses precise digital counters to count and compare calibration pulses from reference standards and billing meters. Upon entering test parameters, such as Kh and test duration, the RM-110 facilitates the testing process then calculates, displays and stores the results of the test. The RM-110 versatility enables strategic automation of field and lab testing operations while maintaining compatibility with existing test equipment.

In the standards lab, the RM-110 automates testing of any electronic or electromechanical watthour reference standards. Up to three standards can be averaged for improved stability and repeatability. Three single-phase standards can be summed by the RM-110 to simulate one poly-phase standard. Test results are again calculated and displayed on the RM-110. Optimum test efficiency is achieved by interfacing the RM-110 to a PC running Radian PCA-Lab™ software. This combination allows any existing voltage and current source to be transformed into an automated standards test system with powerful data collection, calculation and management capabilities.

The RM-110 provides universal compatibility with all existing Radian standards and test accessories. When testing a solid state meter the input pulse to the RM-110 are received via the RM-1H Infrared Optical Pickup (or the RM-1H/v for visible calibration pulses). When testing induction meters, the RM-DS Meter Disk Sensor is used to reflectively sense disk rotations. The RM-DS is available in three different mounting arrangements increasing testing flexibility. Both solid state and induction meters can be tested from their KYZ output with the RM-KYZ Pulse Input Adapter. Interfaces to PCA-Lab are achieved using an RM-PCA Computer Interface Adapter that is included in the software package.

Further benefit is attained with the RM-110's ability to fully test the accuracy of a meter test board. Using the RM-110 Automated Comparator and a Radian RM-11 Primary Watthour reference standard most watthour meter forms can be simulated with unparalleled measurement accuracy. The interface to the board is achieved via the open collector input or by using an optional RM-1P Electronic Light Valve. Pulse division with user definable divisor ratios round out the applications of the RM-110.

Specifications

RM-110 Automated Comparator

PHYSICAL

Length:	*190mm (7.5")*
Width:	*105mm (4.0")*
Height:	*33mm (1.25") approx.*
Weight:	*.75 lbs. approx.*
Case:	*Flame resistant ABS plastic with Polycarbonate label/keypad. Keypad good for 1 million cycles.*

ELECTRICAL

Power:	*9 volt battery or 9-12v AC adapter*
Power Consumption:	*150 mW typical, 350 mW maximum*

ENVIRONMENTAL

Temperature:	*-20/ to 70/ C (-4/ to 158/ F) Normal Operating conditions*
Relative Humidity:	*0 - 95%*
Shock and Vibration:	*Any which is nondestructive*
Water Resistance:	*Unit is splash proof, but not submersible*
Orientation:	*Any*

ACCURACY

Digital Gating	
Total % Error:	*Open Collector less than: .0001*

INPUTS (PORTS A, B, C AND D)

Pull-up:	*150 ohm / 1000 ohm, user defined, 5 volts clamped at 5.7 volts*
Frequency:	*2.1 Mhz maximum per port, 200nS pulse width minimum*

OUTPUTS (PORT D ONLY)

Type:	*Open collector*
Imax Pull Down:	*120 mA*
Vmax Pull Up:	*24 volts clamped at 27 volts*
Typical State:	*Pulled down*
Trigger:	*Leading edge of 10 mS pulse (pulled up)*

Figure 10.1 RM-110 Automated Comparator

10.2 RM-1S Remote Reset Switch

The RM-1S Remote Reset Switch is a normally closed push button switch. The RM-1S will connect directly to the "Input" BNC of a Radian standard or to the RM-1S Input of the RM-1N Solid State Meter Interface. The switch of the RM-1S is hermetically sealed to provide increased reliability during field use. The push-button has tactile feel to provide instantaneous feedback of switch actuation.

Specifications

Application:	*Used to reset the display of a Radian standard and re-arm the RM-1N*
Switch:	*Normally closed contact; momentary open*
Size:	*Handle; 19 mm (.75") dia. x 79 mm (3.1")*
	RM-1S Cable; 1727 mm (68") Length
	RM-2S Cable; 2743 mm (108") Length
Weight:	*RM-1S, .12 kg (.26 lbs)*
	RM-2S, .15 kg (.33 lbs)

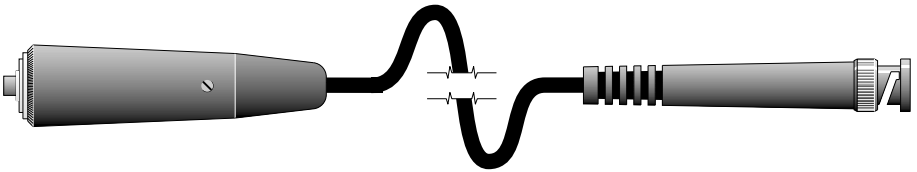


Figure 10.2 RM-1S Remote Reset Switch

10.3 RM-1A Photo Counter Interface

The RM-1A Photo Counter Interface permits direct control of the register of one or more RM-11 Metronic Watthour Standards. This permits use of equipment which had been previously designed for potential gating to use the superior register gating input of the RM-11. By using the RM-1A higher accuracy, single revolution testing, multiple RM-11 testing and ease of retrofit can be had in a variety of applications.

The “Input” of the RM-1A is connected directly to a floating normally open contact by means of the included cable. If this same contact has previously been used to potential gate another standard then remove the two potential wires from the contact and permanently connect them to each other. No other wires should be connected to these contacts. The RM-1A senses the closure of the contact attached to the “Input” and initiates a pulse at its output. It also senses the opening of this contact and initiates another pulse to stop the register.

The “Input” contact is generally derived from an older photocounter. The signal necessary to sense the contact closure is supplied by the RM-1A with no external source being required.

The “Output” of the RM-1A is connected to the RM-11 “Input” with the included BNC cable. The RM-11 register is then directly controlled by the contact connected to the “Input.”

The operation of the RM-1A is dependent on the three cycle Input of the RM-11. To initiate a test, press the “Reset” button of the RM-11 and begin the test. The RM-11 register will start when the contact connected to the “Input” of the RM-1A is closed and will stop when it is opened. Press the “Reset” button again to initialize the RM-11 for another test.

Specifications

Application:	*Converts relay contact signal (open/close) to a display gating signal for a Radian standard.*
Size:	*112 mm (4.4") **H** x 83 mm (3.25") **W** x 45 mm (1.75") **D** (excluding BNCs and pushbutton)*
Weight:	*.57 kg (1.26 lbs)*
Cables:	*Female BNC to Female BNC; 1219 mm (48"), .08 kg (.17 lbs)* *Female BNC to 2 Spade Lugs; 1981 mm (78"), .08 kg (.17 lbs)*
Battery Type:	*3 Volt lithium* *Use Radian #800000, Duracell 123A or Panasonic Br-$^{2}/_{3}$A 3V*
Battery Life:	*Approximately 2000 hours of operation*

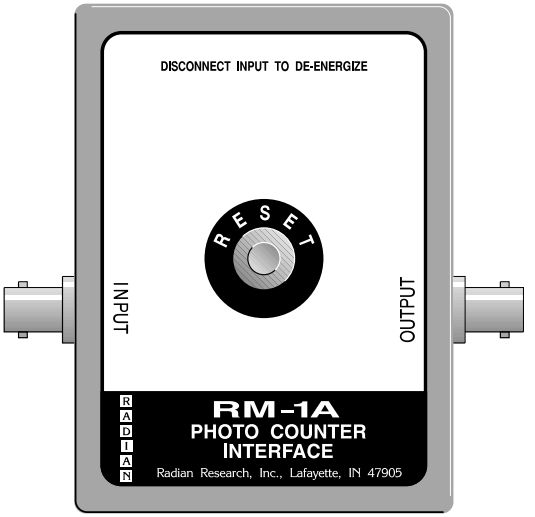


Figure 10.3 RM-1A Photo Counter Interface

10.4 RM-1D Frequency Divider

The RM-1D Frequency Divider is designed primarily to reduce the output frequency of the RM-11 to interface to older equipment. The RM-1D can also be used for other scaling operations by creating an output with no diode drops for compatibility with all logic types.

The output pulse rate of the RM-11 standard is 10 microwatthours per pulse (0.00001 watthours per pulse) which is high enough resolution for the most demanding single revolution or high accuracy testing requirements. The calibration factor goes up proportionally to the divide ratio selected:

Ratio	**Kp in Watthours/Pulse**
2	0.00002
10	0.00010
20	0.00020
100	0.00100
200	0.00200
1000	0.01000
2000	0.02000
10000	0.10000

The Output of the RM-1D is an open collector. It will interface to all commercial test equipment designed to accept an open collector input. It will not drive a commercial counter such as those from Fluke, Hewlett-Packard or Phillips because they have no internal pull-up. A one Kohm pull-up resistor and a 1.5 to 5 volt D.C. source will work to provide the signal to commercial counters. We recommend that the counter input be set on D.C. with a slight positive threshold shift. Using the counter on A.C. works fine for high frequency outputs but may cause errors on very low frequency outputs or on the start of a test.

Accuracy is not directly affected by using the RM-1D. Indirectly, accuracy (resolution) is degraded to some degree any time a frequency divider is used. However, this degradation is unavoidable if the instrument being used is incapable of accepting a high frequency.

Specifications

Application:	*Divides the pulse output frequency of Radian standard*
Size:	*112 mm (4.4") **H** x 83 mm (3.25") **W** x 45 mm (1.75") **D** (excluding BNCs and knob)*
Weight:	*.18 kg (.39 lbs)*
Cable:	*Female BNC to Female BNC; 610 mm (24"), .05 kg (.11 lbs)*
Battery Type:	*3 Volt lithium*
	Use Radian #800000, Duracell 123A or Panasonic Br-$^{2}/_{3}$A 3V
Battery Life:	*Approximately 600-800 hours of operation*

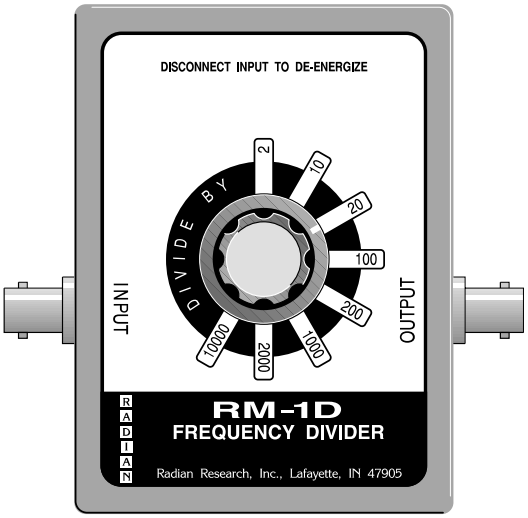


Figure 10.4 RM-1D Frequency Divider

10.5 RM-1P Electronic Light Valve

The RM-1P Electronic Light Valve is used to interface the output of the RM-109 Digital Watthour Comparator with the optics of a calibration test board. The RM-1P will operate with both incandescent and infrared optic assemblies. To trigger incandescent source optics, the RM-1P uses a super luminous LED. This red visible light LED must be aligned with the sensing assembly of the test board's optics. To trigger infrared (modulated or non-modulated) source optics, the RM-1P uses an infrared sensor and emitter combination. With the use of the RM-1P with the RM-109 and RM-11, older design test boards can be effectively tested.

Specifications

Application:	*Interface with optics of calibration test board*
Emitter for Incandescent Optics:	*Superluminous LED with 5000mcd luminous intensity and peak emission wavelength of 660nm*
Sensor/Emitter for Infrared Optics:	*Infrared sensor with peak sensitivity wavelength of 960nm. Two sets of infrared emitter LED's with peak emission wavelength of 950nm.*
Size:	*Case; 61 mm (2.4") H x 97 mm (3.8") W x 23 mm (.9") D* *Rod; 356 mm (14") Length* *Clamp Assembly; 89 mm (3.5") H x 38mm (1.5") W x 19 mm (.75") D* *Cable; 1219 mm (48") Length*
Weight:	*.25 kg (.55 lbs)*
Battery Life:	*Approximately 1700-1800 hours of operation*

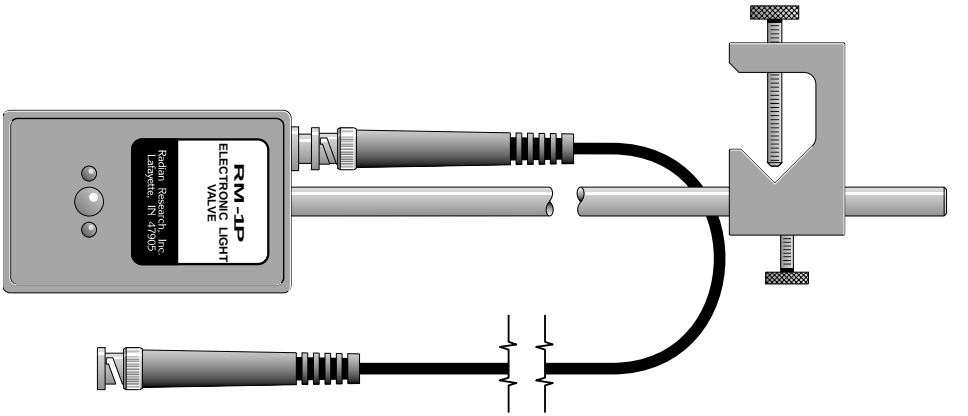


Figure 10.5 RM-1P Electronic Light Valve

10.6 RM-TC Transit Container

The RM-TC Transit Container is an excellent packaging solution for safe shipment of Radian standards. Applications may include internal company shipments of Radian standards as well as for shipments back to Radian Research for recertification services. The RM-TC provides absolute protection of your Radian standard in the most extreme environmental, shipping and handling conditions. The RM-TC's composition consists of a structural foam resin making it resilient to denting, cracking or corrosion. To further ensure the integrity of your Radian standard during shipment, the RM-TC is also watertight, airtight, dust-proof and rustproof. Internally, the RM-TC uses industrial grade photographic cushions for maximum shock protection of your Radian standard.

Specifications

Application:	*Transit container for shipment of Radian Standard.*
Exterior Dimensions:	*273 mm (10.75") **L** x 248 mm (9.75") **W** x 178 cm (7") **D***
Interior Dimensions:	*241 mm (9.5") **L** x 191mm (7.5") **W** x 165 mm (6.5") **D***
Weight:	*1.8 kg (4 lbs); 2.25 kg (5 lbs) shipping weight*
Color:	*Charcoal Black*
Foam:	*Industrial grade photographic foam*
Watertight:	*To 30' (27 m) O-ring is easily replaced if damaged*

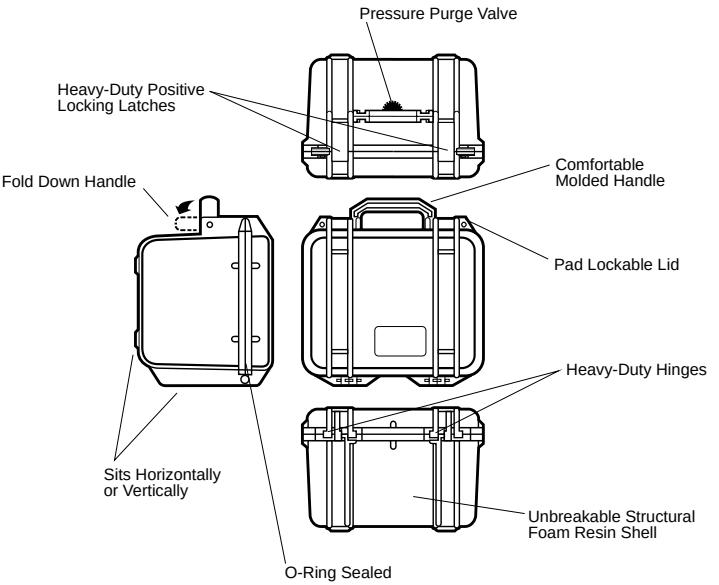


Figure 10.6 RM-TC Transit Container Features

11.0 Testing Aplications

All test applications shown use the RM-110 Automated Comparator. If using the RM-109 Digital Watthour Comparator please refer to the RM-109 manual.

11.1 Testing a Radian Standard

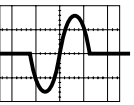
Equipment Needed:

- RM-110 Automated Comparator
- One, Two or Three Radian RM-11 Primary Reference Watthour Standards
- One, Two or Three Radian Standards to be Tested (Device Under Test, D.U.T's)

Test Steps:

1. Make the appropriate connections so that the standard(s) under test (D.U.T's)and the RM-11 Primary Reference Standard(s) are powered from the same voltage and current source.

2. Apply test voltage, current and auxiliary power. At this point, the RM-11 Reference Standard(s) should be counting. Reset the standard(s) under test's display. If this applies there should be zero's across the entire display if correctly reset.



Note:

- The RM-11 Primary Reference Watthour Standard will output pulses continuously once auxiliary power, voltage and current have been applied.
- The Kh of all Radian 150 amp standards is 1.0000. The Kh of all Radian 200 amp standards is 2.0000.

3. Turn on the RM-110. Go to the **PREFERENCE** menu and select **REFERENCE STANDARDS**. Enter the number of reference standards that will be used. In this application one reference standards is defined. Select one reference standard and press ENTER to continue. Select RM-110 **INPUT TYPE**. This defines the reference standard output pull-up value. Select **RADIAN** (150 ohm). Press ENTER. Enter the number of current inputs one, two or three used on the reference standard. Enter 0.00001 as the pulse constant of the reference standard. Answer YES, reference standard is Autoranging. Enter reference standard serial number. Press CANCEL to return to Main Menu. CANCEL out to the Main Menu.

4. From the Main Menu select **RUN TEST**.

5. Select **TEST STANDARD**.

6. Select the **TEST DURATION**, Select **PULSES**.

7. Enter in the number of pulses for the reference standard to output before stopping the test.

Note:

- The output pulse rate of the Radian 150 amp standard is 100,000 pulses per watthour or 0.00001 watthours per pulse. The output pulse rate of the Radian 200 amp standard is 0.00002.

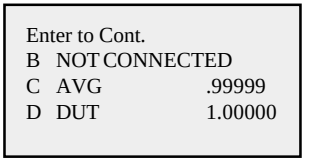
8. Select **COUNT PULSES** for the Gating method.

9. Select standard under test's (D.U.T) **OUTPUT TYPE**. For this application select **RADIAN**.

10. Enter 0.00001 as the **PULSE CONSTANT** of the (D.U.T.). See page 71 for other pulse constants.

11. Follow the prompts on the RM-110 to make the appropriate connections. See Figure 11.1 “Testing a Radian Standard”. The number of reference standards defined in the Preference menu determine how the ports are configured. This application tests only one standard which connects to port D. For one refer ence standard only, port A will be configured. Once connections are complete press ENTER to start the test.

12. The RM-110 counts the number of pulses from both the reference standard(s) and the standard(s) under test. The watthour count will be displayed when the specified number of pulses have been counted. The RM-110 averages the multiple reference standards internally then calculates the averaged value in the results.

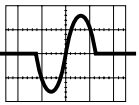


Note:

- The average of A will be hidden under the "Enter to Cont". prompt.

- RM-11 is shown connected to port C on the RM-110.

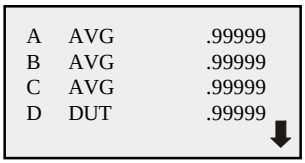
13. The test is now complete. To process the results press ENTER. To move to the Main Menu press CANCEL.

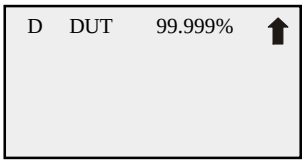


Processing Standard Test Results

14. To re-run a test select **RE-RUN TEST**. The pulses are counted again and the new count is displayed on the RM-110. Press ENTER to continue or CANCEL to return to the Main Menu.

15. To show the calculated results select **SHOW RESULTS**. The end count is displayed along with a DOWN ARROW icon in the lower right corner. This icon references the DOWN ARROW key on the RM-110 hand controller. By pressing the DOWN ARROW key the RM-110 displays the calculated results.Using the UP/DOWN ARROW keys the user can move between the watthour count and the calculated results.





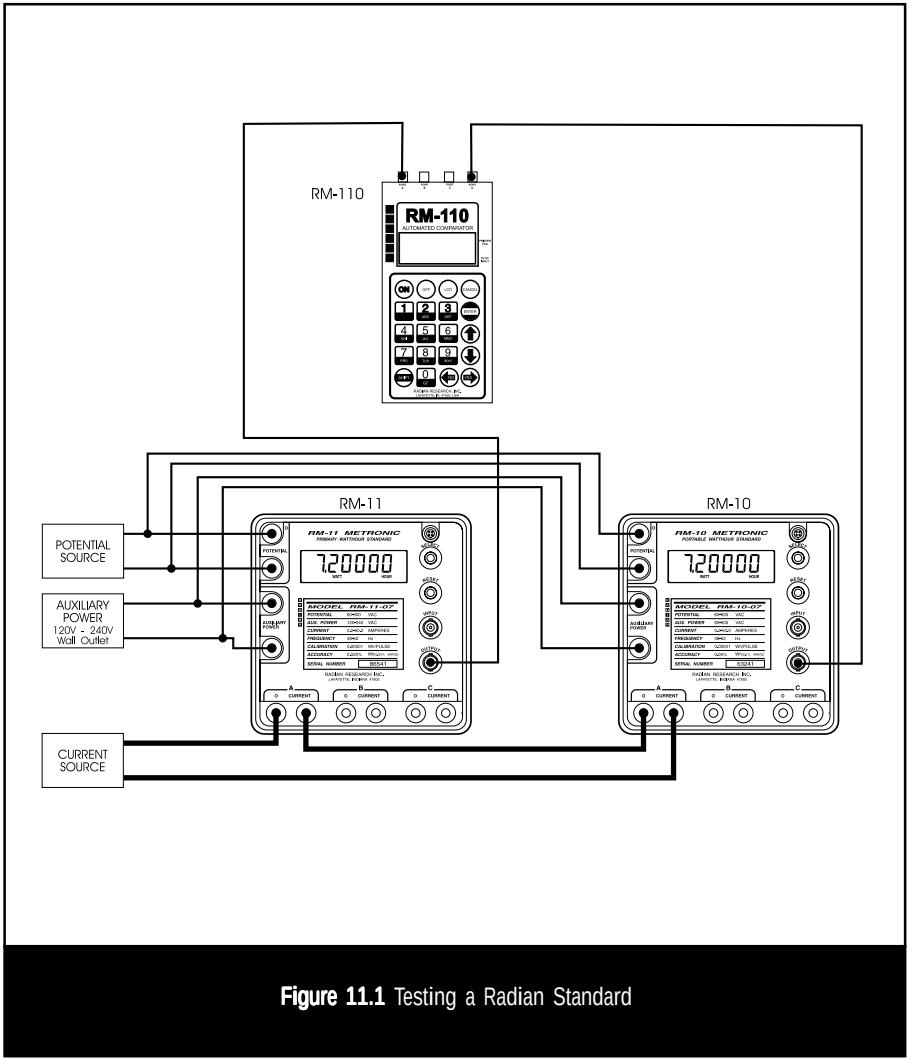
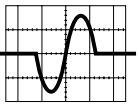


Figure 11.1 Testing a Radian Standard



11.2 Testing a Radian Standard using the Average of Three Inputs

Equipment Needed:

- RM-110 Automated Comparator
- Three Radian RM-11 Primary Reference Watthour Standards
- One Radian Standard to be Tested (Device Under Test, D.U.T's)

Test Steps:

1. Make the appropriate connections so that the standard(s) under test (D.U.T's)and the RM-11 Primary Reference Standard(s) are powered from the samevoltage and current source.

2. Apply test voltage, current and auxiliary power. At this point, the RM-11 Reference Standard(s) should be counting. Reset the standard under test's display. If this applies there should be zero's across the entire display if correctly reset.

Note:

- The RM-11 Primary Reference Watthour Standard will output pulses continuously once auxiliary power, voltage and current have been applied.
- The Kh of all Radian 150 amp standards is 1.0000. The Kh of all Radian 200 amp standards is 2.0000.

3. Turn on the RM-110. Go to the **PREFERENCE** menu and select **REFERENCE STANDARDS**. Enter the number of reference standards that will be used. In this application three reference standards are defined. Select three reference standards and press ENTER to continue. If more than one reference standard is used the user must choose between single-phase or polyphase modes of operation. Select Single-phase/average for this applica tion. Select RM-110 **INPUT TYPE**. This defines the reference standard output pull-up value. Select **RADIAN** (150 ohm). Press ENTER. Enter the number of current inputs one, two or three used on the reference standard. Enter the pulse constant of 0.00001 the reference standard. Answer YES, that reference standard is Autoranging. Enter reference standard serial number. Press CANCEL to return to Main Menu. CANCEL out to the Main Menu.

4. From the Main Menu select **RUN TEST**.

5. Select **TEST STANDARD**.

6. Select the **TEST DURATION**, Select **PULSES**.

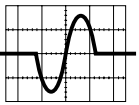
7. Enter in the number of pulses for the reference standard(s) to output before stopping the test.

Note:

- The output pulse rate of the Radian 150 amp standard is 100,000 pulses per watthour or 0.00001 watthours per pulse. The output pulse rate of the Radian 200 amp standard is 0.00002.

8. Select **COUNT PULSES** for the Gating method.

9. Select standard under test's (D.U.T) **OUTPUT TYPE**. For this application select **RADIAN**.



10. Enter 0.00001 as the **PULSE CONSTANT** of the (D.U.T.). See page 71 for other pulse constants.

11. Follow the prompts on the RM-110 to make the appropriate connections. See Figure 11.2 "Testing a Radian Standard Using the Average of Three Inputs." The number of reference standards defined in the Preference menu determine how the ports are configured. If three reference standards are used then ports A, B and C will be configured and their results averaged. This configuration allows only one standard to be tested which connects to port D. Once connections are complete press ENTER to start the test.

12. The RM-110 counts the number of pulses from both the reference standard(s) and the standard(s) under test. The watthour count will be displayed when the specified number of pulses have been counted. The RM-110 averages the multiple reference standards internally then calculates the averaged value in the results.

Enter to Cont.	
B AVG	.99999
C AVG	.99999
D DUT	1.00000

Note:

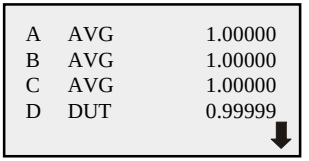
- The average of A (A AVG .99999) is hidden under the Enter to Cont. prompt.

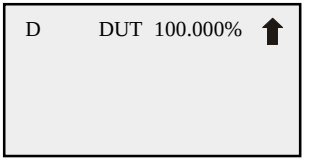
13. The test is now complete. To process the results press ENTER. To move to the Main Menu press CANCEL.

Processing Standard Test Results

14. To re-run a test select **RE-RUN TEST**. The pulses are counted again and the new count is displayed on the RM-110. Press ENTER to continue or CANCEL to return to the Main Menu.

15. To show the calculated results select **SHOW RESULTS**. The end count is displayed along with a DOWN ARROW icon in the lower right corner. This icon references the DOWN ARROW key on the RM-110 hand controller. By pressing the DOWN ARROW key the RM-110 displays the calculated results. Using the UP/DOWN ARROW keys the user can move between the watthourcount and the calculated results.





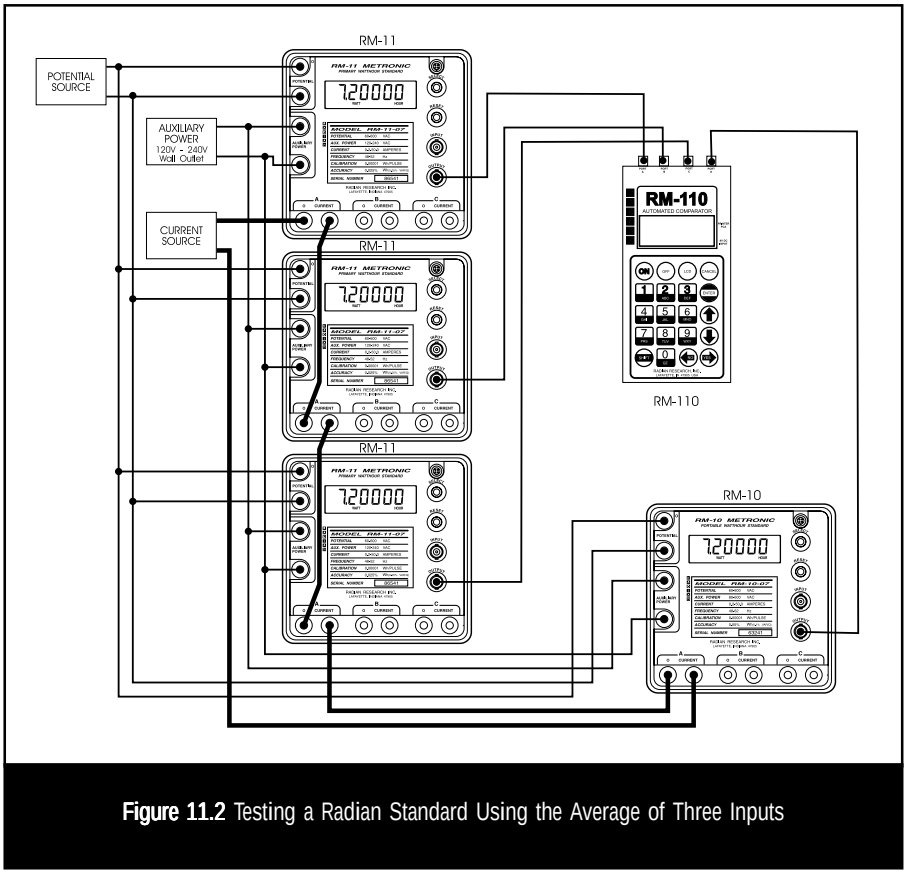


Figure 11.2 Testing a Radian Standard Using the Average of Three Inputs

11.3 Testing an Electromechanical Standard (Potential Gating)

Equipment Needed:

- RM-110 Automated Comparator
- RM-11 Primary Reference Watthour Standard
- Electromechanical Standard to be Tested
- RM-1R Electronic/Mechanical Potential Relay

Test Steps:

1. Make the appropriate connections so that the standard(s) under test and the RM-11 Primary Reference Watthour Standard(s) are powered from the same voltage and current source.

2. Apply test voltage, current and auxiliary power. At this point, the RM-11 Primary Standard(s) should be counting but the electromechanical standard will not be rotating.

Note:
- The RM-11 Primary Reference Watthour Standard outputs pulses continuously once auxiliary power, voltage and current have been applied.

3. Reset the electromechanical standard using it's reset lever on the instrument face.

4. Turn on the RM-110 From the Main Menu and select **PREFERENCES**.

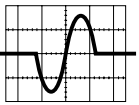
5. Select **REFERENCE STANDARDS** from the Reference Menu. Set the reference standard parameters for an RM-11. See application 1 step 3 for details.

6. Select **RUN TEST**.

7. Select **TEST STANDARD**.

8. Select the **TEST DURATION**, **PULSES**.

9. Enter in the number of pulses for the reference standard to output before removing potential with the RM-1R.



Note:

- Older generation electromechanical and electronic standards display equivalent revolutions instead of watthours. The Kh of these older generation standards is usually 0.6 watthours per equivalent revolution when testing at 120 volts, 5 amps, unity power factor. Therefore, if 000.6000 is selected as the test length, and the test is at 120 volts 5 amps unity power factor the result (of a perfectly calibrated standard) would be 1.000 equivalent revolutions.

10. Select **MECHANICAL GATING**.

11. Enter **D.U.T. Kh CONSTANT**. See Chart on page 71 for commonly used Kh constants.

12. Follow the prompts on the RM-110 to make the appropriate connections. See Figure 11.3 for the applicable wiring diagram. The selections made in the Preference settings will determine how the connections are made. In this application there is one RM-11 Primary Reference Watthour Standard that is connected to port A. The RM-1R Mechanical Relay will go to port D. Press ENTER and verify that the electromechanical standards display has been reset. Once the display is at zero, press ENTER again to start the test.

13. When the test is complete the RM-110 prompts the user to ENTER to continue. The options to **RE-RUN TEST**, **SHOW RESULTS PRINT RESULTS** or **CHANGE TAPS** are now available. Re-running the test will repeat the same test.

14. Showing the results will display the results screen with a DOWN ARROW icon in the lower right corner. The icon references the DOWN ARROW key on the RM-110 keypad. Pressing the DOWN ARROW will prompt the user to enter the D.U.T.'s display reading. Enter that value directly into the keypad and press ENTER. The calculated % registration or % error appears at the bottom of the screen. For multiple D.U.T.'s, enter their respective display readings directly over the previous display reading. Press ENTER for the calculated result. Use the LEFT and RIGHT ARROW keys to move the cursor through the display's digits. The D.U.T. number will increase numerically as multiple entries are made. Repeat his process for all additional test devices.

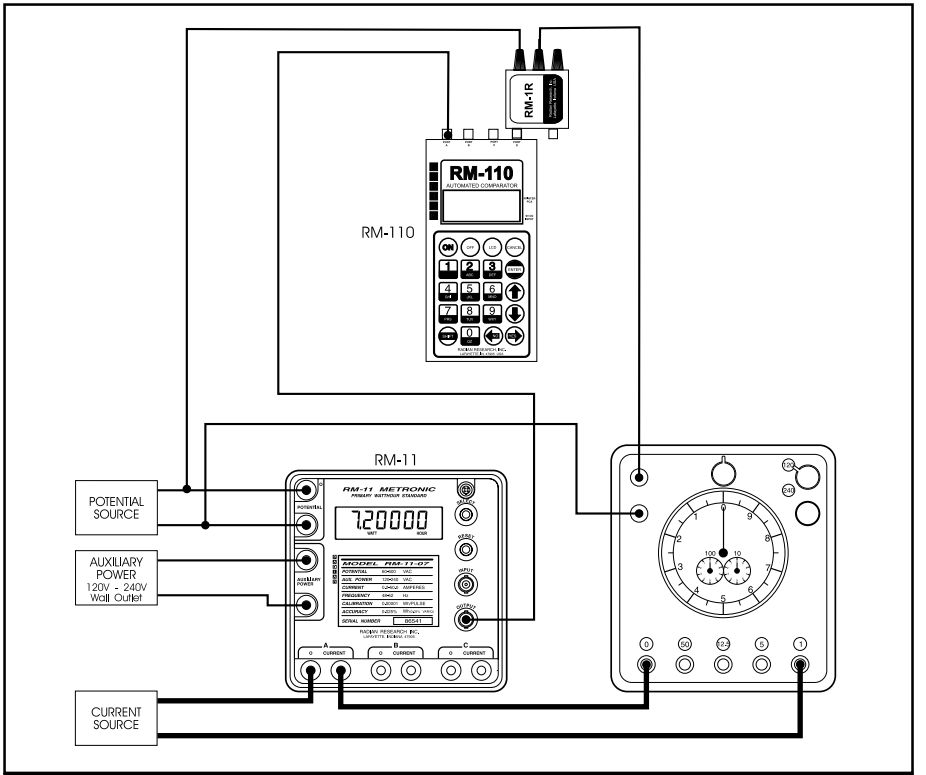
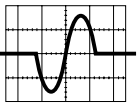


Figure 11.3 Testing an Electromechanical Standard (Potential Gating)



11.4 Testing an Electronic Standard with Taps (Potential Gating)

Equipment Needed:

- RM-110 Automated Comparator
- RM-11 Primary Reference Watthour Standard
- Electronic Standard to be Tested
- RM-1R Electronic/Mechanical Potential Relay

Test Steps:

1. Make the appropriate connections so that the standard(s) under test and the RM-11 Primary Reference Watthour Standard(s) are powered from the same voltage and current source.

2. Apply test voltage, current and auxiliary power. At this point, the RM-11 Primary Standard(s) should be counting but the electromechanical standard will not be rotating.

Note:
- The RM-11 Primary Reference Watthour Standard outputs pulses continuously once auxiliary power, voltage and current have been applied.

3. Turn on the RM-110 From the Main Menu and select **PREFERENCES**.

4. Select **REFERENCE STANDARDS** from the Reference Menu. Set the reference standard parameters for an RM-11. See Application 1 step 3 for details.

5. Select **RUN TEST**.

6. Select **TEST STANDARD**.

8. Select the **TEST DURATION**, **PULSES**.

9. Enter in the number of pulses for the reference standard to output before removing potential with the RM-1R.

Note:

- Older generation electromechanical and electronic standards display equivalent revolutions instead of watthours. The Kh of these older generation standards is usually 0.6 watthours per equivalent revolution when testing at 120 volts, 5 amps, unity power factor. Therefore, if 000.6000 is selected as the test length, and the test is at 120 volts 5 amps unity power factor the result (of a perfectly calibrated standard) would be 1.000 equivalent revolutions.

10. Select **POTENTIAL GATING**.

11. Enter **D.U.T. Kh CONSTANT**. See chart on page 71 for commonly used Kh constants.

12. Follow the prompts on the RM-110 to make the appropriate connections. See Figure 11.4 for the applicable wiring diagram. The selections made in the Preference settings will determine how the connections are made. In this application there is one RM-11 Primary Reference Watthour Standard connected to port A. The RM-1R Mechanical Relay connects to port D. Reset the electronic stanndard using the reset button on the instrument face, press Enter.

13. When the test is complete the RM-110 prompts the user to ENTER to Continue. The options to **RE-RUN TEST**, **SHOW RESULTS PRINT RESULTS** or **CHANGE TAPS** are now available. Re-running the test will repeat the same test.

14. Showing the results will display the results screen with a DOWN ARROW icon in the lower right corner. The icon references the DOWN ARROW key the RM-110 keypad. Pressing the DOWN ARROW will prompt the user to enter the D.U.T.'s display reading. Enter that value directly into the keypad and press ENTER. The calculated % registration or % error appears at the bottom of the screen. For multiple D.U.T.'s, enter their respective display readings directly over the previous display reading. Press ENTER for the calculated result. Use the LEFT and RIGHT ARROW keys to move the cursor through the display's digits. The D.U.T. number will increase numerically as multiple entries are made. Repeat his process for all additional test devices.

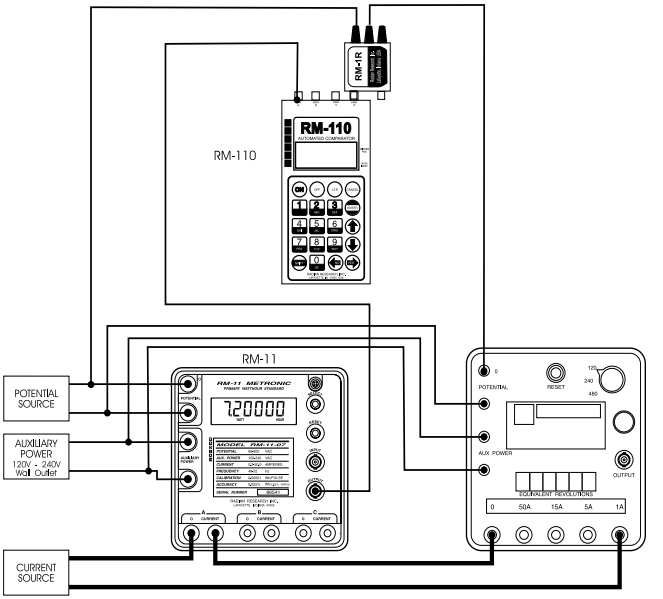


Figure 11.4 Testing an Electronic Standard (Potential Gating)

11.5 Testing an Electronic Standard (Electronic Gating)

Equipment Needed:

- RM-110 Automated Comparator
- RM-11 Primary Reference Watthour Standard
- Electronic standard with a Gate Input
- RM-1R Electronic/Mechanical Potential Relay

Test Steps:

1. Make the appropriate connections so that the electronic standard(s) under test and the RM-11 Primary Reference Standard(s) are powered from the same voltage and current source.

2. Apply test voltage, current and auxiliary power. At this point, the RM-11 Primary Reference Standard(s) should be counting.

Note:

- The RM-11 Primary Reference Watthour Standard outputs pulses continuously once auxiliary power, voltage and current have been applied.

3. Turn the power to the RM-110 on and let the device time out to the Main Menu and select **PREFERENCES**.

4. Select **REFERENCE STANDARDS**. Set the reference standard parameters for a RM-11. See Application 1 step 3 for details.

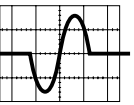
5. Select **RUN TEST**.

6. Select **TEST STANDARD**

.

7. Select the means of the **TEST DURATION**, select **PULSES**.

8. Enter in the number of pulses you want the reference standard to output before removing potential with the RM-1R.



Note:

- Older generation electromechanical and electronic standards display equivalent revolutions instead of watthours. The Kh of these older generation standards is usually 0.6 watthours per equivalent revolution when testing at 120volts, 5 amps, unity power factor. Therefore, if 000.6000 is selected as the test length, and the test is at 120volts 5 amps unity power factor the result (of a perfectly calibrated standard) would be 1.000 equivalent revolutions.

9. Select **ELECTRONIC GATING**.

10. Enter the **D.U.T. Kh CONSTANT**. See chart on page 71 for commonly used Kh pulse constants.

11. Follow the prompts on the RM-110 to make the appropriate connections. See Figure 11.5 for the applicable wiring diagram. The selections made in the Preference settings will determine how the ports are configured. In this application there is one reference standard that is connected into port A. The RM-1R Electronic Relay will go to port D, press ENTER.

Note:

- Maintain the relationship of the RM-1R Electronic relay indicator arrow to the horizon. With the RM-110 laying flat the arrow should point up. This is a wetted relay and must stay within 30^{o} of the horizon.

12. Reset the electronic standard and press ENTER to start test.

13. When the test is complete the RM-110 prompts the user to Enter to Continue. The options to **RE-RUN TEST**, **SHOW RESULTS, PRINT RESULTS** or **CHANGE TAPS** are now available. Re-running the test will repeat the same test.

14. Showing the results will display the results screen with a DOWN ARROW icon in the lower right corner. The icon references the DOWN ARROW key on the RM-110 keypad. Pressing the DOWN ARROW will prompt the user to enter the D.U.T.'s display reading. The calculated % registration or % error will appear at the bottom of the screen. For multiple D.U.T.'s, enter their respective display readings directly over the previous display reading. Press ENTER for the calculated result. Use the LEFT and RIGHT ARROW keys to move the cursor through the display's digits. The D.U.T. number will increase numerically as multiple entries are made. Repeat this process for all additional test devices.

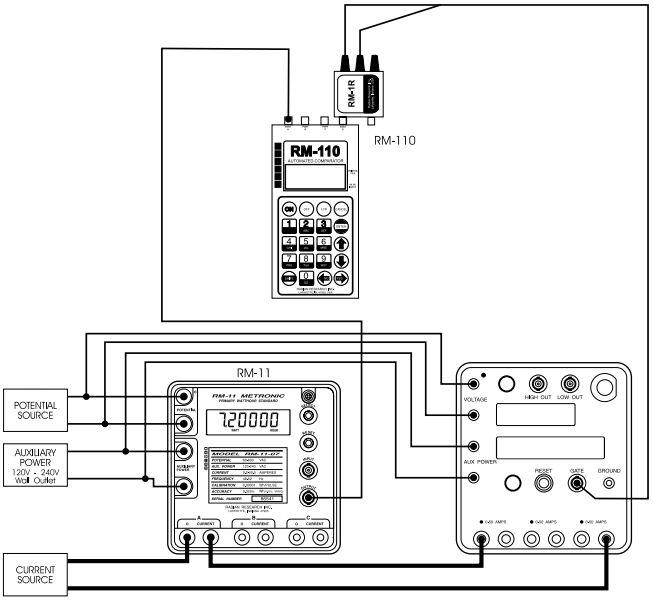
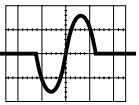


Figure 11.5 Testing an Electronic Standard (Electronic Gating)



11.6 Testing the Accuracy of a Test Board (RM-1P Electronic Light Valve Option)

Equipment Needed:

- RM-110 Automated Comparator
- RM-11 Primary Reference Watthour Standard
- RM-1P Electronic Light Valve
- Meter Test Board
- Commercial adapter or a modified Meter baseplate with the proper leads to bring voltage and current from the test board to the reference standard.

Test Steps:

1. Make connections between the test board and the Radian standard as per Figure 11.6. The RM-11 must get both current and potential from the test board.

2. Position the RM-1P between the test board's light emitter and the light detector.

Note:

- The RM-1P will function with both visible or infrared light.

3. Turn on RM-110 and select **RUN TEST**.

4. Select **TEST BOARD** and **ENTER THE Kh**.

Note:

- The Kh value will appear truncated in the LCD. However, all six places to the right of the decimal point are used in the calculation.
- Do not put a meter on the test board. The RM-1P will simulate a meter for testing purposes.

5. Select the **PULSE OUTPUT TYPE** of the test board For this application select **RM-1P**.

6. Make proper connections to the RM-110, The RM-11 connects to ports A, B and/or C. The RM-1P to port D.

7. Set up the test board as if testing a meter. For this example, the variables will be set for a Form 2S meter: Kh=7.2, 240v, 30 amps, and one revolution.

8. Start the test on the test board, the RM-11 must be on and the test board's light detector should now be waiting for the first pulse to start the test.

9. After the test board's counter has counted the specified number of pulses or disk revolutions it stops the test.

10. The RM-110's display shows the Kh value entered earlier in the test and the end count of the RM-11. The test board itself shows the percent error, which is the percent error of the test board.

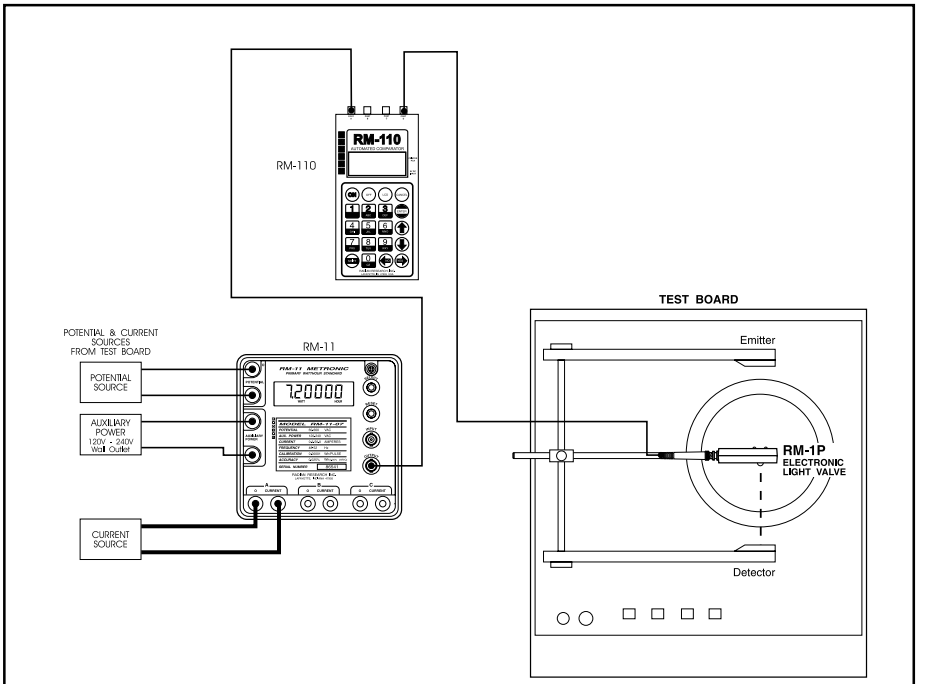
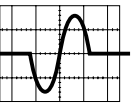


Figure 11.6 Testing the Accuracy of a Test Board (RM-1P Electronic Light Valve Option)



11.7 Testing the Accuracy of a Test Board (Open Collector Option)

Equipment Needed:

- RM-110 Automated Comparator
- RM-11 Primary Reference Watthour Standard
- Meter Test Board with Open Collector Input
- Commercial adapter or a modified meter baseplate with the proper leads to bring voltage and current from the test board to the reference standard.

Test Steps:

1. Make connections between the test board and the RM standards as per Figure 11.7. The RM-11 must get both current and potential from the test board.

2. Turn on RM-110 and select **RUN TEST**.

3. Select **TEST BOARD** and **ENTER THE Kh**.

Note:

- The Kh value will appear truncated in the LCD. However, all six places to the right of the decimal point are used in the calculation.
- Do not put a meter on the test board. A meter will be simulated via the open collector input.

4. Select the **PULSE OUTPUT TYPE** of the test board. For this application select **OPEN COLLECTOR**.

5. Make proper connections to the RM-110 The RM-11 connects to ports A, B and/or C. Test board to port D.

6. Set up the test board as if testing a meter. For this example, the variables are set for a Form 2S meter: Kh=7.2, 240v, 30 amps, and one revolution.

7. Start the test on the test board. The RM-11 is running on and the test board starts receiving pulses from the RM-110. After the RM-110 sends the specified number of pulses (based on the Kh value) to the test board the test will stop.

8. The RM-110's displays show the Kh value entered earlier in the test and the end count of the RM-11. The test board itself shows the percent error, which is the percent error of the test board.

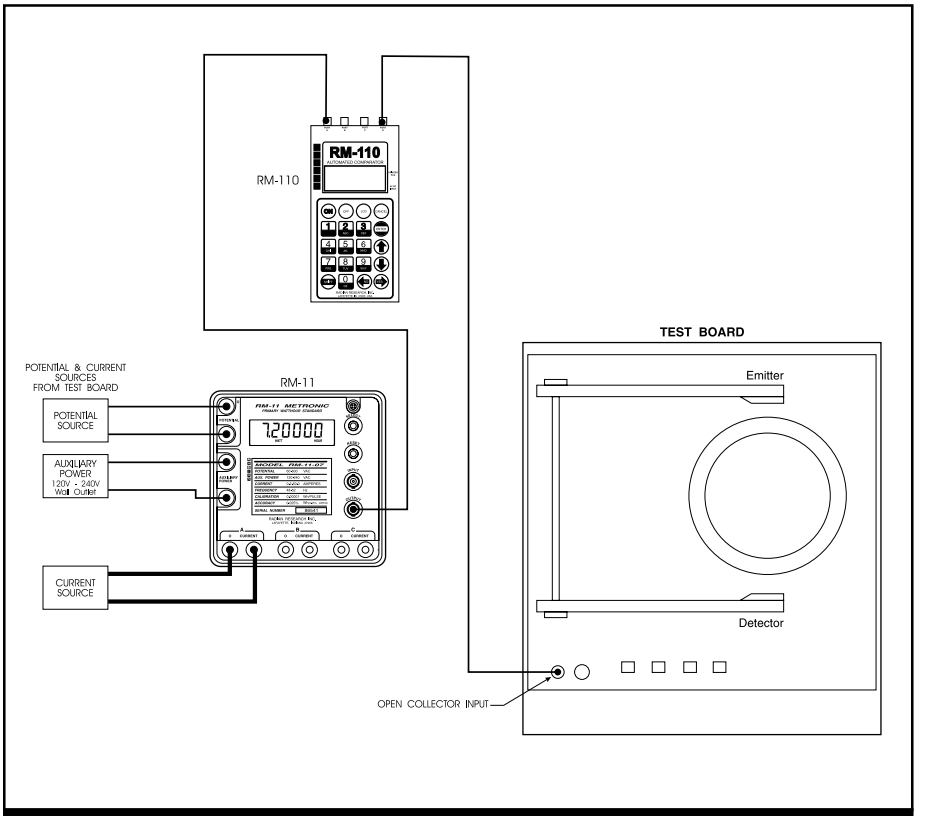
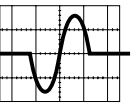


Figure 11.7 Testing the Accuracy of a Test Board (Open Collector Option)



12.0 Pulse Constants and Kh values for the RM-110

(*SC-10, *SC-10v, *SC-30, *A-7, *IB-10 and the RM-16)

Note: When using an RM-16 the position of the Pulse Constant switch located on the front panel, will be the multiplier for the following pulse constants and Kh values. The chart below is applicable for the 1,000 switch setting.

AUTORANGING STANDARDS		
DEVICE & TAPS	**PULSE CONSTANTS**	**Kh VALUE**
RM 150A	0.00001	1.0
RM 200A	0.00002	2..0
SC-30 HI	0.00001	1.0
SC-30LO	0.0001	1.0
NON-AUTORANGING STANDARDS		
DEVICE & TAPS	**PULSE CONSTANTS (SC-10,RM-16)**	**Kh VALUE**
1A 120V	0.00012	0.12
5A 120V	0.0006	0.60
12.5A 120V	0.0015	1.50
15A 120V	0.0018	1.80
50A 120V	0.006	6.00
1A 240V	0.00024	0.24
5A 240V	0.0012	1.20
12.5 240V	0.003	3.00
15A 240V	0.0036	3.60
50A 240V	0.012	12.00
1A 480V	0.00048	0.48
5A 480V	0.0024	2.40
12.5A 480V	0.006	6.00
15A 480V	0.0072	7.20
50A 480V	0.024	24.00

*See page 72

13.0 Warranty & Calibration Service

Radian Research warrants each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or component therein which, within two years after shipment, proves to be defective upon examination. Radian will pay local domestic surface freight costs for return shipment of the product back to the customer.

In addition, all Radian Metronic Watthour Standards are warranted to be substantially stable in calibration over time. If within one year after factory calibration the standard does not meet its specifications, we will repair and recalibrate the unit at our cost. Our calibration records retain the value of each of the three reference elements to six decimal positions.

For a period of ten years, we warrant any fully autoranging reference standard from catastrophic failure caused by failure to range properly. This warranty is voided by disassembly of the unit beyond removal of the case for recalibration.

If warranty service is required, write or call your local Radian Research representative or contact our headquarters in Lafayette, Indiana. You will be given prompt assistance and shipping instructions.

An optional five year extended warranty and calibration service is available on all Radian standards. Contact your local Radian representative or our headquarters for details.

Radian Research, Inc. maintains a complete state-of-the-art recalibration and repair facility in Lafayette, Indiana. Estimates for repairs are available by contacting our headquarters. All recalibrations, which are certified traceable to the National Institute of Standards and Technology are performed on the Radian RM-703 Automated Calibration System. The RM-703 Calibration System is referenced by Radian RM-11 Primary Standards with a short-term repeatability of 0.001% or better.

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IB-10 is a trademark of the General Electric Company.
A7, J44 are trademarks of the Sangamo Company.