

Radian Research, Inc.

RD-21

Portable Single-phase
Electricity Reference Standard

Operations Manual

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1.0	Product Introduction	5
1.1	Enhanced Design Features	6
1.2	Laboratory Applications	8
1.3	Test Table Applications	8
1.4	Field Testing Applications	8
1.5	Harmonic Analysis	8
1.6	Customer Load Testing	8
1.7	Analog Sense	9
1.8	Automatic Calculations	9
1.9	Software Packages	9
1.10	Safety Design	10
1.11	Keypad Control	10
2.0	Configurations Available	11
2.1	Generating RD-21 Model Numbers	11
3.0	Specifications	13
3.1	Accuracy	13
3.2	Input/Output	13
3.3	Normal Operating Conditions	14
3.4	Extended Operating Conditions	15
3.5	Protection	15
3.6	Physical Description	15
4.0	Operations Overview	16
4.1	Measurement Principle	16
4.2	Internal Reference Set	16
4.3	Output Stage	16
4.4	Voltage and Current Inputs*	17
4.5	Clamp-On CT Input	19
4.6	Port 1 Input/Output Terminal	19
4.7	Port 2 Output Terminal/Standard Testing Input	20
4.8	Port 3 Synchronization/Analog Sense Terminal	22



- 4.9 Serial Port Communications Terminal.....22
- 4.10 Pickup Terminal23
- 4.11 Keypad and Display23

- 5.0 Service & Routine Maintenance.....24**
- 5.1 Cleaning24
- 5.2 Repair24
- 5.3 Recalibration24
- 5.4 Fuse Replacement.....25

- 6.0 Warranty26**

- 7.0 Quality.....27**

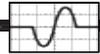
- 8.0 Menu Structure.....28**
- 8.1 Startup Screen28
- 8.2 Measurement Screens29
- 8.3 Main Menu Screen30
- 8.4 Run Test Screen30
- 8.5 Harmonics Screens31
- 8.6 Setup Screen31
- 8.7 Self Test Screen32
- 8.8 About Screen32

- 9.0 Configuring the RD-21.....33**

- 10.0 Application Information.....36**
- 10.1 Meter Testing36
- 10.1.1 Manual Meter Testing36
- 10.1.2 Sensor Meter Testing39
- 10.2 Standard Testing42
- 10.3 Analog Sense Testing44
- 10.4 Testing without the Built-in Comparator Option45
- 10.4.1 Using the RD-21 with a RM-11045

- 11.0 Test Accessories46**

- Appendix: RD Current Connector Locking Mechanism.....49**
- * Appendix: RD Current Connector Locking Mechanism.....49



1.0 Product Introduction

The RD-21 Portable Single-phase Electricity Reference Standard uses the same lightweight, compact package as the RD-20 Portable Standard, while providing a higher level of accuracy through design enhancements. The RD-21 has a typical accuracy of 0.005% and a maximum worst case accuracy specification of 0.02%. This specification includes variables of stability, temperature, power factor, traceability uncertainty, and test system errors. In addition, this accuracy applies across the entire voltage and current operating range of the product.

The RD-21 utilizes Radian's new Dytronic measurement technology consisting of a Radian designed Integrating Analog to Digital Signal Converter. The RD-21's Dytronic A/D Converter is combined with Radian's renowned electronically compensated voltage and current input transformers and a hermetically sealed reference set to provide the highest degree of accuracy, stability and versatility offered in a portable primary single-phase electricity standard.

The RD-21 provides four quadrant single-phase simultaneous measurements for active and reactive energy and power with forward and reverse energy flow also measured. The potential input, current input and auxiliary power input are totally autoranging. This autoranging feature was pioneered by Radian Research and makes it impossible to damage the unit by applying a signal to the wrong tap. The potential input range is 60 to 600 volts, the current input range is available as either one input ranging from 0.02 to 120 amps, or as three inputs each ranging from 0.02 to 67 amps. The auxiliary power ranges from 80 to 600 volts.

The RD-21 can be used for laboratory applications as a primary standard to test portable field standards or it can be used as a portable field standard whenever a higher level of accuracy is required. In fact, due to its light weight of only 2.5 kg (5.5 pounds) the RD-21 serves remarkably well in field testing applications. In the field, the RD-21 can be used with a controlled current load, or it can be used with a clamp-on current transformer available from Radian Research to perform customer load tests. In this field application, the optional harmonic analysis capability can analyze customer load through the 50th harmonic order. In addition, for improved efficiency, the RD-21 optionally can automatically calculate and display the error of the meter under test as well as the error of portable field



standards being tested. The RD-21 also provides a serial communications port which allows direct connection to the RS-232 serial port of a personal computer. Multiple software packages are available to suit various applications.

The RD-21 is available in a variety of models offering measurement functions and options to suit specific needs.

1.1 Enhanced Design Features

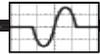
Many design features have been added or improved through the engineering process of designing the RD-21 Dytronic. The addition of A/D and DSP technology, increased PC support and an enhanced version of Radian's revolutionary voltage current transformer input design make the RD-21 the absolute pinnacle of portable standards. The RD-21 utilizes Radian Research designed Analog/Digital circuitry coupled with Digital Signal Processing techniques. These advancements provide a high degree of flexibility including simultaneous multifunction measurements and harmonics analysis capabilities.

A/D and DSP Technology

In order to accelerate the testing process, Radian Research has designed and incorporated a custom integrating Analog to Digital Converter into the RD-21. There is separate A/D circuitry for both the voltage and current axes. Couple this enhancement with the utilization of DSP technology and the RD-21's abilities are greatly enhanced. The RD-21 can effortlessly collect the converted digital signals from the A/D converters and process the data to display every measurement function supported during a single collection of analog voltage and current.

PC Support

For enhanced analysis and testing, each RD-21 is equipped with a communications port. This port will allow the user to connect to a personal computer running Radian Research software packages; which will in turn increase the customization of the standard. Different configurations containing communications port designations, LCD menu operation and other parameters can be stored in RD-Configure software and downloaded to any RD-21 unit for complete user customization. In addition, the RD-21



can analyze harmonic distortion complete with each order's phase and amplitude. This information can be studied in the laboratory with Radian software for a more complete understanding of conditions at specific meter installations. Additionally, voltage and current waveforms can be viewed in real-time and then captured for later investigation. Test results of both revenue billing meters and field standards can be stored in a personal computer enabling complete and detailed histories to be recorded.

Clamp On Current Transformer Input

The RD-21 features a clamp-on current transformer input. This option allows true customer load testing without removing the meter from service. True three phase customer load testing can also be accomplished with three RD-21s coupled with Radian clamp-on current transformers.

Voltage and Current Inputs

The RD-21 provides full autoranging capability for the Potential Input, Auxiliary Power Input and Current Input using electronically compensated input transformers designed by Radian. The voltage and current inputs contain an enhanced design of Radian's original electronically compensated transformer. This feature ensures the unit will never be damaged by applying a signal to the incorrect input. In addition to its autoranging capabilities, the RD-21 features an option of three summing current inputs which can be used to perform closed link testing. With each input having a maximum rating of 66.7 amps, a test current of 200 amps can be easily achieved. Current input options are a clamp-on current transformer plus one 120 Amp current input, and a clamp-on current transformer plus three 66.7 Amp current inputs.

In order to accommodate a keypad on the unit, the orientation of the current inputs have been changed. With the safety of the user in mind, the connections have been updated to an insulated socket design. The Potential Input and Auxiliary Power are 4mm connections and the Current Inputs are 6mm connections respectively. These two features not only make the unit easier to operate, but help protect the user at the same time. It is now virtually impossible to touch any live connection while the unit is in operation, thus eliminating the possibility of electrical shock and increasing customer confidence.



1.2 Laboratory Applications

As a portable primary standard the accuracy and precision provided by the RD-21 allows it to easily test portable field standards. The optional built-in comparator allows for automatic test result calculations for the field standard being tested.

1.3 Test Table Applications

Due to its small package size, the RD-21 can easily be used as the reference within test tables whenever a higher level of accuracy is desired. Programmable pulse outputs coupled with an RS-232 communications port make it easy to receive data from the RD-21.

1.4 Field Testing Applications

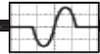
With a light weight of only 2.5 kg (5.5 pounds), the RD-21 is conducive to field testing applications where a higher level of accuracy is desired. The optional built-in comparator allows for automatic test result calculations of the meter being tested.

1.5 Harmonic Analysis

Unlike off-the-shelf A/D Converters used in other instruments, Radian's Dytronic A/D Converter is specifically designed and optimized for power and energy measurement. This unique design makes the RD-21 absolutely unsurpassed in its ability to accurately measure non sinusoidal waveforms up to and including the 50th harmonic order. Measurement parameters include the phase and amplitude of each harmonic as well as the total harmonic distortion. The unprecedented accuracy of measuring distorted waveforms combines with this optional harmonic analysis capability to clearly distinguish the RD-21 as the definitive portable primary single-phase electricity standard for both meter testing and power quality applications. This harmonic analysis option is also useful when testing meters using customer load.

1.6 Customer Load Testing

For those applications where meter testing with customer load is desired, the RD-21 is an obvious choice because of its ability to accurately measure energy and power even with distorted waveforms. In addition, three RD-21s may be used with optional clamp-on current transformers to perform a true three-phase test of the meter using customer load. The optional clamp-on current transformer allows for testing the meter using customer load without the need of interrupting service.



1.7 Analog Sense

The optional Analog Sense functionality allows the RD-21 to effectively test transducers as well as first generation electronic meters that have an analog output for calibration. The RD-21 will not only test these instruments, but it will also automatically calculate and display the error.

1.8 Automatic Calculations

Optionally, The RD-21 offers a built-in comparator for two types of applications. For laboratory applications, the built in comparator can accept output pulses from a portable field standard and automatically calculate and display the error. For field testing applications, it can also automatically calculate and display the error of the meter under test. In this field testing application, various sensors (for disk rotation, infrared calibration pulses, KYZ pulses, etc.) may be connected directly to the RD-21 and parameters for the test may be easily entered via the keypad. At the conclusion of the test, the results are automatically calculated and displayed on the LCD. Optional sensors include the RR-DS Meter Disk Sensor, RR-1H Infrared Optical Pickup, RM-1H/v Visible Optical Pickup, and RR-KYZ Pulse Input Adapter.

1.9 Software Packages

The RD-21 also provides a serial communications port which allows direct connection to the RS-232 serial port of a personal computer. In addition, Radian offers software packages to suit various applications.

RR-PCSuite is a set of simple yet extremely powerful software tools. It allows the change of the configuration, view, power analysis and perform meter and station test.

RR-Kit software provides a library of subroutines for those customers that desire to write their own programs to communicate with the RD-21.

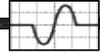


1.10 Safety Design

For enhanced safety, the potential, current and auxiliary power input connections to the RD-21 are designed such that no harmful signals are accessible on the front of the standard. Lead kits may be purchased from Radian Research.

1.11 Keypad Control

The RD-21's five-button keypad allows the operator to control operation and functionality of the standard. The intuitive menu-driven interface provides for simple configuration.



2.0 Configurations Available

2.1 RD-21 Model Numbers

<u>MODEL</u>	<u>MEASUREMENT FUNCTIONS</u>
RD-21-112	Dytronic Portable Standard, 0.02% Accuracy, Built-In Comparator, Three 67Amp Current Inputs (200Amp Single Phase), Whrs, Volts, Amps, VARhrs
RD-21-232	Dytronic Portable Standard, 0.02% Accuracy, Built-In Comparator, Harmonic Analysis, Three 67Amp Current Inputs (200Amp Single Phase), Whrs, Volts, Amps, VARhrs, VAhrs, Qhrs, Watts, VARs, VA, Phase Angle, Power Factor, Frequency
RD-21-332	Dytronic Portable Standard, 0.02% Accuracy, Built-In Comparator, Current Clamp Input, Harmonic Analysis, Three 67Amp Current Inputs (200Amp Single Phase), Whrs, Volts, Amps, VARhrs, VAhrs, Qhrs, Watts, VARs, VA, Phase Angle, Power Factor, Frequency, Vhr, Ahr, V2hr, A2hr, Min & Max Measurements: All Indicating Functions



- RD-21-372** Dytronic Portable Standard, 0.02% Accuracy, Built-In Comparator, Current Clamp Input, Harmonic Analysis, Analog Sense, Three 67Amp Current Inputs (200Amp Single Phase), Whrs, Volts, Amps, VARhrs, VAhrs, Qhrs, Watts, VARs, VA, Phase Angle, Power Factor, Frequency, Vhr, Ahr, V2hr, A2hr, Min & Max Measurements: All Indicating Functions
- RD-21-433** Dytronic Portable Standard, 0.02% Accuracy, Built-In Comparator, Current Clamp Input, Harmonic Analysis, Three 75Amp Current Inputs (225Amp Single Phase), Whrs, Volts, Amps, VARhrs, VAhrs, Qhrs, Watts, VARs, VA, Phase Angle, Power Factor, Frequency, Vhr, Ahr, V2hr, A2hr, Min & Max Measurements: All Indicating Functions, AVG Response: VAhrs, VA, Volt, Vhrs, Amps, Ahrs



3.0 Specifications

3.1 Accuracy

All measurement functions excluding harmonic evaluation available on the RD-21 exhibit the same transfer accuracy at any combination of the normal operating conditions. The errors associated with these functions are in percent of reading displayed and include variables of stability, temperature, power factor, traceability uncertainty, and test system errors.

Typical: +/- 0.005%

Maximum: +/- 0.02%

For harmonic evaluation, an RD-21 will exhibit different accuracies of harmonic measurement depending on their order. The errors associated with these harmonics are in percent of reading at any combination of the normal operating conditions.

1st – 23rd Harmonic: +/- 0.10%

24th – 50th Harmonic: +/- 0.20%

Harmonic accuracy applies when harmonic amplitude is within operating range.

3.2 Input/Output

Port 1

Input/Gating Terminal: BNC (Programmable)
Output Terminal: BNC
Pulse Value: 0.00001 Watthour/Pulse
(Programmable)

Port 2

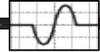
Output Terminal: BNC
Pulse Value: 0.00001 Watthour/Pulse
(Programmable)

Port 3

3 ohms Synchronization Terminal: BNC
or
Analog Sense Input: BNC (Optional – 20 mA maximum input)

Serial Port

Communication Terminal: 8 Pin RJ-45 Jack



Keypad	Five button membrane UP, DOWN, ESC/RESET/LEFT, ENTER/RIGHT, MODE
Display Readout:	Backlit LCD 4 line x 16 character All functions per model designation
Pickup Sensor Input Terminal:	4 Pin Lemo
Clamp-On CT Input	Current Transformer Input: 7 Pin Input for Radian engineered CT

3.3 Normal Operating Conditions

Input Potential:	60 to 600 VAC (Autoranging)
Input Current Options:	0.02 to 66.7 Amperes (Autoranging) 0.02 to 120 Amperes (Autoranging) Clamp-On Current Transformer
Auxiliary Power:	80 to 600 VAC (Autoranging)
Power Factor:	0.5 Leading to 0.5 lagging
Operating Temperature:	20°C to 30°C (68°F to 86°F)
Humidity:	0% to 95%
Frequency:	45 to 65 Hertz
Orientation:	Within 90° of vertical
Recalibration Interval:	365 Days
Warm-up:	60 seconds
Shock and Vibration:	Any which is nondestructive



3.4 Extended Operating Conditions

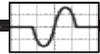
Temperature Influence:	+/- 0.00025%/°C Maximum (outside normal operating temperature)
Orientation:	90° Vertical +/- 0.005%
Power Factor:	PF<0.5, Accuracy 0.02%/2*PF
Extended Temperature Range:	-20°C to 70°C (-4°F to 158°F)
Extended Current Range:	0.01 - 0.02A, Accuracy = 0.02% x $\frac{0.02A}{\text{Test Current}}$
Extended Voltage Range:	30 - 60VAC, Accuracy = 0.02% x $\frac{60VAC}{\text{Test Voltage}}$

3.5 Protection

Isolation:	Complete Input/Output/Power/Case/ Control
Dielectric Withstand:	2.3 kVrms, 60Hz, 60 Seconds
Surge Withstand:	IEEE 472 and ANSI 37.90
Fuses:	Potential Input and Auxiliary Power Schurter 034.31.17

3.6 Physical Description

Size:	190.5 mm (7.5") High 139.7 mm (5.5") Wide 139.7 mm (5.5") Deep excluding latches and strap
Weight:	2.5 kg (5.5 lbs)
Shipping Weight:	3.6 kg (8.0 lbs)
Shipping Dimensions:	305 mm (12") High 248 mm (9.75") Wide 248 mm (9.75") Deep



4.0 Operations Overview

4.1 Measurement Principle

The measurement principle is based upon the fundamentals of a high speed charge-balance integrating analog to digital signal converter. This is a Radian innovation, but it is based upon accepted metrology parameters. Radian Research implemented its own analog to digital converter in the Dytronic family of standards which are specifically designed for power measurement. In order to measure power with extreme accuracy and wide bandwidth, extensive requirements must be imposed on the converter.

The RD-21 Dytronic utilizes two separate A/D converters. One accepts a current signal and is linked with two current references. The other accepts a voltage signal and is linked with two voltage references. These of course are for the analog voltage and current inputs of the RD-21. Both operate independently to provide the digital signal processor with signals accurate enough to meet the requirements of a true primary transfer standard.

By designing an analog to digital converter specifically for power measurements, Radian is able to reduce many errors associated with current designs. Gain error, charge timer resolution, signal to noise ratio and signal distortion were major areas dealt with and improved in development.

4.2 Internal Reference Set

The RD-21's internal reference set is hermetically sealed in order to protect it from environmental variables. The internal reference set consists of a voltage reference, a resistive reference and a crystal time reference.

4.3 Output Stage

The RD-21's output stage displays the measurements and provides pulse outputs for the selected measurements. Computer control, with Radian software, allows for customization of output information, such as programmable pulse output constants.



4.4 Voltage and Current Inputs*

The voltage and current inputs are completely autoranging – a design feature that was pioneered by Radian Research in their first product offering in 1985. The voltage and current inputs consist of a toroidal autoranging electronically compensated transformer. The Radian toroid transformer provides superior immunity to stray fields and the electronic compensation eliminates practically all of the transformer error.

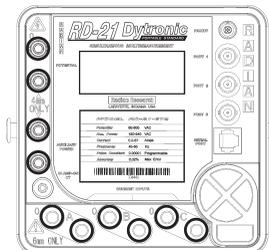
INTERNAL VOLTAGE AUTORANGING POINTS

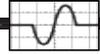
RANGE NUMBER	INCREASING VOLTAGE	DECREASING VOLTAGE
1	0 - 210.9375	191.4062 - 0
2	210.9376 - 421.8750	382.8124 - 191.4063
3	421.8751 - 600	600 - 382.8125

INTERNAL CURRENT AUTORANGING POINTS

1 INPUT, 120-AMPERE MODELS

RANGE NUMBER	INCREASING CURRENT	DECREASING CURRENT
1	0 - 0.0328	0.0319 - 0
2	0.0329 - 0.0656	0.0639 - 0.0320
3	0.0657 - 0.1312	0.1279 - 0.0640
4	0.1313 - 0.2624	0.2559 - 0.1280
5	0.2625 - 0.5248	0.5119 - 0.2560
6	0.5249 - 1.0496	1.0239 - 0.5120
7	1.0497 - 2.0992	2.0479 - 1.0240
8	2.0993 - 4.1984	4.0959 - 2.0480
9	4.1985 - 8.3968	8.1919 - 4.0960
10	8.3969 - 16.7936	16.3839 - 8.1920
11	16.7937 - 33.5872	32.7679 - 16.3840
12	33.5873 - 67.1744	65.5359 - 32.7680
13	67.1745 - 120	120 - 65.5360





INTERNAL CURRENT AUTORANGING POINTS

3 INPUT, 200-AMPERE MODELS (66.7 AMPS PER INPUT)

<u>RANGE NUMBER</u>	<u>INCREASING CURRENT</u>	<u>DECREASING CURRENT</u>
1	0 - 0.0328	0.0319 - 0
2	0.0329 - 0.0656	0.0639 - 0.0320
3	0.0657 - 0.1312	0.1279 - 0.0640
4	0.1313 - 0.2624	0.2559 - 0.1280
5	0.2625 - 0.5248	0.5119 - 0.2560
6	0.5249 - 1.0496	1.0239 - 0.5120
7	1.0497 - 2.0992	2.0479 - 1.0240
8	2.0993 - 4.1984	4.0959 - 2.0480
9	4.1985 - 8.3968	8.1919 - 4.0960
10	8.3969 - 16.7936	16.3839 - 8.1920
11	16.7937 - 33.5872	32.7679 - 16.3840
12	33.5873 - 67.1744	65.5359 - 32.7680
13	67.1745 - 200	200 - 65.5360

INTERNAL CURRENT AUTORANGING POINTS

3 INPUT, 225-AMPERE MODELS (75 AMPS PER INPUT)

<u>RANGE NUMBER</u>	<u>INCREASING CURRENT</u>	<u>DECREASING CURRENT</u>
1	0 - 0.0349	0.0339 - 0
2	0.0350 - 0.0697	0.0679 - 0.0340
3	0.0698 - 0.1394	0.1359 - 0.0680
4	0.1395 - 0.2788	0.2719 - 0.1360
5	0.2789 - 0.5576	0.5439 - 0.2720
6	0.5577 - 1.1152	1.0879 - 0.5440
7	1.1153 - 2.2304	2.1759 - 1.0880
8	2.2305 - 4.4608	4.3519 - 2.1760
9	4.4609 - 8.9216	8.7039 - 4.3520
10	8.9217 - 17.8432	17.4079 - 8.7040
11	17.8433 - 35.6864	34.8159 - 17.4080
12	35.6865 - 71.3728	69.6319 - 34.8160
13	71.3729 - 225	225 - 69.6320

To utilize the 200 or 225 ampere input capability, the three current inputs must be paralleled as shown below. Use #4 or larger cables, making sure the total length of the three current paths are equal. Tightly bundle the cables and route them as indicated in the following drawing. The routing is critical because at high current inputs the magnetic field created may affect the accuracy of the standard.



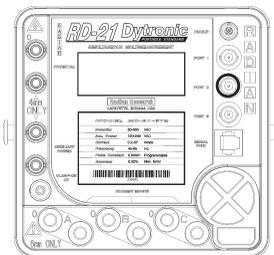
stops it after the test duration, freezing the last reading for as long as desired, and a third push will reset the counters to zero for the next test.

Removal of the switch will, within fifteen seconds, permit the unit to enter the continuous run mode, where it may be gated by the potential input. In this mode the unit will behave identical to older electronic and mechanical standards. This would normally be done in retrofit applications where changing an existing photometer or test board to display gating might not be a justifiable expense. Radian recommends the RM-1A Photo Counter Interface for retrofit applications. This adapter will permit older test boards to do single or two revolution testing in many applications.

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. Gating of the potential input does, of course, effect both the display and the output.

4.7 Port 2 Output Terminal/Standard Testing Input

The Port 2 Output Terminal of the RD-21 is calibrated at 10 microwatthours per pulse (0.00001 watthours per pulse or 100,000 pulses per watthour.)



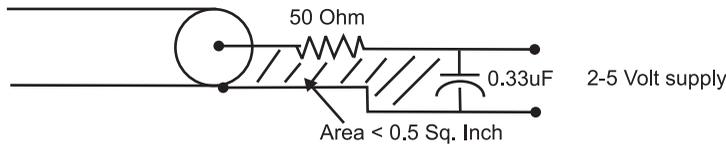
This calibration is the same for all measurement functions across all voltage and current ranges. However, the measurement function and output pulse value can be re-programmed with optional Radian software.



The Maximum output frequency of the RD-21 is 3.2 Megahertz. This provides excellent repeatability over very wide operating ranges, but to achieve these results it requires some care in termination of the output pulse.

For the most ideal circumstances, with a “slow” CMOS inverter sensing the terminated coax, a 150 ohm termination resistor can be used to achieve biases of 2-5 volts.

For more demanding situations, with coax runs of greater than 6 feet, or with high speed detectors with low thresholds (0.2 -- 1.2Vdc) greater care must be used. Both coax and termination resistors must be 50 ohms and the termination resistor can not be a wire wound. A decoupling capacitor for the DC bias must be .33 MFD ceramic. The enclosed area inclusive of the termination of the coax, the termination resistor, and the ceramic termination capacitor must be substantially under 0.5 square inches (See graphic below).



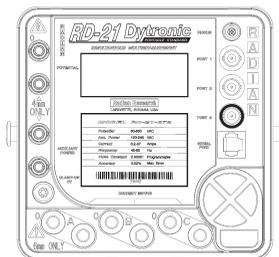
For test board interface development work, there is not substitute for a close inspection of the output waveform at maximum frequencies with an oscilloscope to verify that there are absolutely no problems with pulses being missed.



4.8 Port 3 Synchronization/Analog Sense Terminal

The BNC Connector on the RD-21 labeled Port 3 is a synchronization terminal that will allow three RD-21s to be utilized for true three phase testing. Optionally, this terminal may be used for an Analog Sense Input if the model designation supports that functionality. See 2.1 Generating RD-21 Model Numbers for further information.

The optional Analog Sense functionality allows the RD-21 to effectively test transducers as well as first generation electronic meters that have an analog output for calibration. The RD-21 will not only test these instruments, but it will also automatically calculate and display the error.

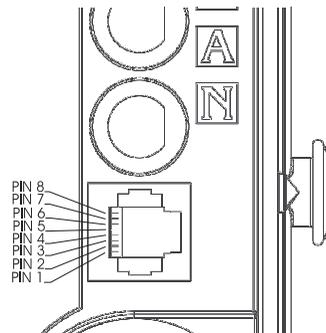


4.9 Serial Port Communications Terminal

The communications terminal is interfaced via an 8-pin RJ-45 connector. Through the use of this terminal, a myriad of capabilities present themselves. Not only can each RD-21 software package be utilized, but the Dytronic can actually be re-calibrated through this terminal. Additionally, the flash memory storage for both the DSP and Xilinx programs is accessible through this terminal making the RD-21 field upgradable.

8-Pin RJ-45 Receptacle

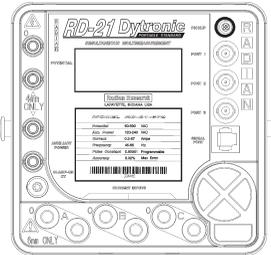
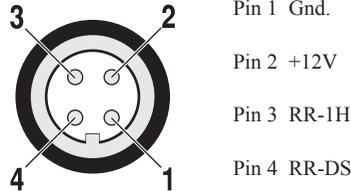
Pin	Description	Abbreviation	Input/Output*	9-Pin RS-232 Connector
1	Request To Send	RTS	Input	7 (blue)
2	Data Terminal Ready	DTR	Input	4 (orange)
3	Signal Ground	GND		5 (black)
4	Data Transmit	TX	Input	3 (red)
5	Data Receive	RX	Output	2 (green)
6	Data Carrier Detect	DCD	Output	1 (yellow)
7	Data Set Ready	DSR	Output	6 (brown)
8	Clear To Send	CTS	Output	8 (white)
N/C	Ring Indicator	RI	Output	9 (blank)





4.10 Pickup Terminal

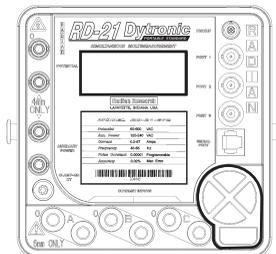
The sensor input terminal on the RD-21 comes in the form of a 4 Pin Lemo connector. Disk sensors, infrared and visible LED optical pickups can be utilized to sense disk rotation or equivalent revolutions if the built-in comparator functionality is supported. See 2.1 Generating RD-21 Model Numbers for further information.

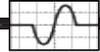


4.11 Keypad and Display

The screen on the RD-21 is a backlit LCD with 4 line x 16 character capability. Depending on which model designation is purchased, all metrics may not fit on the screen at the same time.

The five button membrane keypad on the RD-21 will allow the user to manipulate the display and effectively scroll to whichever metric or menu item they are interested in during a specific testing application.





5.0 Service & Routine Maintenance

The RD-21 Dytronic Primary Transfer 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.

5.1 Cleaning

Cleaning of the RD-21 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.

5.2 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. If the RD-21 is in need of repair then contact Radian Research or your local Radian Research Representative and request a Return Material Authorization (RMA) number. You will need to provide the model number and serial number as well as a detailed description of the problem.

5.3 Recalibration

Recalibration is recommended yearly. A periodic cross check against a Radian RD-21 or RD-22 is recommended to preclude the possibility of a failure in either. Prudence would dictate having a dedicated RD-21 or RD-22 for cross check purposes. With the RD-21 or RD-22 it is feasible to sample test units at various points as a “backup” test. In addition, it is recommended that one take advantage of Radian’s recalibration service as a very cost effective alternative to manual recalibration. Radian Research’s Calibration Laboratory maintains primary transfer

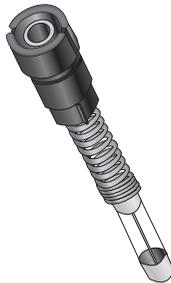


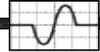
standards that are directly traceable to NIST. Radian Research's Calibration Laboratory also maintains several RS-703A Automated Calibration Systems as working secondary standards. The RS-703A Automated Calibration System collects a data point on a Radian standard every thirty seconds on up to sixteen standards simultaneously, collecting literally thousands of data points on an overnight run. In addition each RS-703A provides computer control over an environmental chamber to ensure proper temperature range operation of the standard being tested. Please contact Radian Research for further information on recalibration.

5.4 Fuse Replacment

Fuse replacement is not very likely because of the elimination of the 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.
2. Replace both fuses on the circuit if one is bad.
3. Remove the terminals of the circuit with bad fuses by rotating 90° counter-clockwise and then lift out the unit.
4. Remove the fuse by rotating it clockwise in the retaining screw.
5. Replace the fuse by rotating it clockwise in the retaining fuse.
6. Replace the terminal in the same orientation it was removed and rotate it 90° clockwise to lock in place.





6.0 Warranty

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, proved 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 Dytronic Multimeasurement 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.

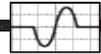
For a period of ten years, we warranty any fully autoranging reference standard from catastrophic failure caused by failure to range properly. This warranty is voided by disassembly of the units beyond removal of the case for recalibration.

If warranty service is required then contact Radian Research or your local Radian Research Representative and request a Return Material Authorization (RMA) number. You will need to provide the model number and serial number as well as a detailed description of the problem.



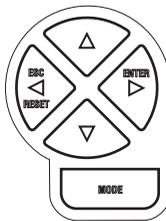
7.0 Quality

- The RD-21 meets all applicable ANSI and IEC specifications.
- Radian Research's calibration procedures are in compliance with MIL-STD-45662A and ANSI/NCSL Z540-1-1994.
- Radian Research's primary transfer standards are traceable to NIST.
- Radian Research's quality system is ISO-9001 certified.



8.0 Menu Structure

The RD-21 has an extensive menu structure that is facilitated through the use of its five button keypad. The RD-21's keypad will allow the user to navigate through the menu structure with ease. The up and down arrows will allow scrolling throughout any specific screen that has that capability. The ESC/left arrow/RESET button will allow the user to escape out of any screen and return to the previous. The ENTER/right arrow button will select any option on the screen that the cursor is pointing at. Lastly, the MODE button will toggle throughout the main screens on the RD-21. These are the Instantaneous Metrics screen, Accumulating Metrics screen, Main Menu screen and Minimum & Maximum Measurements screens (if supported by model number). Please note that the model number designation of the standard will determine the extent of sub-menus that are available.



8.1 Startup Screen

When the unit is first powered, a screen containing relevant information such as model number, serial number, calibration number and firmware version will appear.





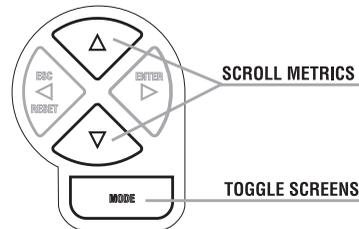
8.2 Measurement Screens

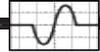
The RD-21 will then begin to display measurement functions that it supports. There is a different screen for Instantaneous Measurements, Accumulating Measurements, and Minimum and Maximum Measurements.

By pressing MODE on the keypad the unit will toggle between Instantaneous Measurements, Accumulating Measurements, Minimum Measurements, Maximum Measurements and a Main Menu screen. Depending on model number, minimum and maximum measurements may not be supported, and all measurements may not fit on the screen at once. If this is the case, the display is scrollable by using the up and down arrows on the keypad.

INS	0.00000	V
RMS	0.00000	A
	0.00000	KW
	0.00000	KVA

ACC	0.00000	Wh
RMS	0.00000	VARh
	0.00000	Qh
	0.00000	Vah

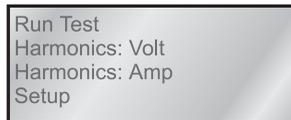




8.3 Main Menu Screen

The main menu screen is obtainable by pressing MODE on the keypad. This button will toggle between metrics screens and the main menu screen. This menu allows the user to gain access to the immense functionality of the RD-21 quickly and easily. From this screen the user will be able to gain access to the options of built-in comparator, harmonic analysis and analog sense testing. They will also be able to setup the configuration of the RD-21 as well as perform self test procedures, calibrate the unit and print vital information pertaining to measurements taken.

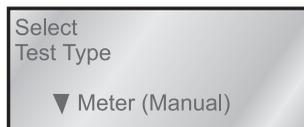
All menu options will not be visible on the screen at once. Simply scroll through the main menu by using the up and down arrow keys and press ENTER when the cursor is pointing at the desired choice.



Self Test
About

8.4 Run Test Screen

By pressing ENTER on the keypad when the cursor is pointing at Run Test, the user will be able to select which type of test they would like to run. Different variables can be entered whether a meter, standard, or analog sense test is to be performed.



Meter (Sensor)
Standard
Analog sense



8.5 Harmonics Screens

The RD-21 can analyze harmonics up to the 50th order. If the user presses ENTER when the cursor is pointing at Harmonics: Volt or Harmonics: Amp, the harmonics are viewable by their order (which is scrollable by using the up and down arrow buttons), magnitude, phase and total harmonic distortion.

Harmonic	V ▼ 01
Mag.	0.00000
Phs.	0.00000
THD.	0.00000

Harmonic	A ▼ 01
Mag.	0.00000
Phs.	0.00000
THD.	0.00000

THD is total harmonic distortion. The formula for % THD is:

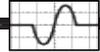
$$\%THD = 100 \sqrt{\frac{\sum_{k=2}^{K=N} I_k^2}{\sum_{k=1}^{K=N} I_k^2}}$$

8.6 Setup Screen

The configuration of the RD-21 can be modified by pressing the ENTER key when the cursor is pointing to Setup. Options available are changing the operation of BNC Ports 1, 2 and 3, enabling or disabling the backlit display, auto-scrolling of the screens, selecting RMS or AVG response, enabling or disabling the standard's audible beeps and returning the RD-21 to original factory default values.

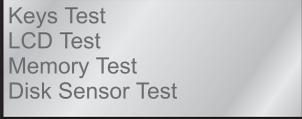
Port 1
Port 2
Port 3
Port Polarity

- Measure Type
- Beep
- Backlight
- Factory Default



8.7 Self Test Screen

If it is expected that an aspect of the RD-21 is not functioning correctly, the user may press ENTER when the cursor is pointing to Self Test to try and diagnose the problem. A list will be displayed and allow the user to scroll through the options and pick which portion of the RD-21 they wish to test. A self test of the RD-21 may be performed on the keypad, LCD, memory, sensors, RS-232 connection, and BNC Port 1, 2 and 3. Simply scroll to the portion that is to be tested and press ENTER for directions



```
Keys Test
LCD Test
Memory Test
Disk Sensor Test
```

```
RS-232 Loopback
BNC1 Test
BNC2 Test
BNC3 Test
```

8.8 About Screen

By pressing the ENTER key when the cursor is pointing at About, the same information will be displayed as the Startup screen. Model number, serial number, calibration number and firmware version of the RD-21 will appear.

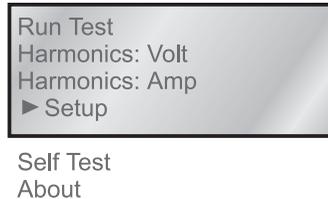


```
RD-21-111      V0.00
S/N: 00000000
Cal: YYYYMMDD
Copyright 2001
```



9.0 Configuring the RD-21

The setup configuration of the RD-21 can be reached by entering the main menu, scrolling to Setup and pressing ENTER. Note that certain configuration options are dependent on the model of the RD-21.



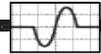
Port 1 Function

The functionality of Port 1 can be configured by selecting Port 1 and pressing ENTER. The user can scroll through three (3) options. Scroll to the functionality that is desired and then press ENTER.

Start/stop/clear will setup Port 1 for use with a snap-switch. The actuation of the snap-switch will start the accumulation of metrics, and subsequent actuations of the snap-switch will stop the accumulation of metrics, then reset the metrics to zero, then re-start the accumulation of metrics...etc.

Clr-start/stop will also setup Port 1 for use with a snap-switch. The actuation of the snap-switch will clear and then start the accumulation of metrics. Subsequent actuations of the snap-switch will stop the accumulation of metrics, then clear and re-start the accumulation of metrics, then stop the accumulation of metrics...etc.

Pulse Output will configure Port 1 of the RD-21 as an output. Port polarity is also selectable to configure Port 1 to output either negative or positive pulses. Note that when pulse output is selected, the measurement function and pulse constant for Port 1 will be the same as Port 2. However, Port 1 and Port 2 will always have opposite polarity.



Port 2 Function

The function of *Port 2* can be configured by selecting *Port 2* and pressing ENTER. The user can then scroll through and select whichever measurement function *Port 2* will output pulses. Once the measurement function is chosen by pressing ENTER, the pulse constant for that function can also be edited. If the default value is desired, then press ENTER to accept. If the default value is not desired, then press ESC to edit the value.

To edit the pulse constant value, use the left and right arrows to select which digit to edit and then use the up and down arrows to edit the digit. Scroll to the last digit and press ENTER to set the pulse constant. After the pulse constant is chosen, port polarity is selectable for the ports that are configured as outputs.

Port 3 Function

The function of Port 3 can be seen by selecting *Port 3* and pressing ENTER.

Port Polarity

The port polarity of each configured as an output is selectable by pressing ENTER at port polarity. Note that *Port 1* and *Port 2* must have opposite polarity.

Measure Type

By scrolling to *Measure Type* and pressing ENTER, the user can select between RMS and AVG measurements.

Beep Enable

By scrolling to *Beep Enable* and pressing ENTER, the user can choose whether they want to enable or disable the audible beep of the RD-21.

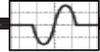
Backlight

The backlight of the RD-21's display can be disabled by selecting *Backlight* and pressing ENTER. Scroll to NO and press ENTER to disable the backlight and scroll to ON and press ENTER to enable the backlight.



Factory Default

The factory default settings can always be re-initiated by selecting *Factory Default* and pressing ENTER.



10.0 Application Information

Please note that all application information in this manual is to describe testing procedures that utilize the RD-21's Built-In Comparator, Analog Sense and Harmonics options. If these options were not purchased, automated meter and standards testing can be accomplished by using an RM-110 Automated Comparator available from Radian Research.

10.1 Meter Testing

The RD-21 can be used in the field or in the laboratory to test meters where a high degree of accuracy is needed. The meter test can be actuated by using a snap-switch, the ENTER key on the keypad of the RD-21, or the many sensors offered by Radian Research that will sense disk revolutions, infrared and visible calibration pulses, and KYZ signals.

10.1.1 Manual Meter Testing

(Testing using a snap-switch or the ENTER key on the RD-21.)

Step 1

Make all appropriate connections so that the D.U.T. (Device Under Test) and RD-21 are powered by the same source. If using a snap-switch, connect the BNC to PORT 1. (See figure 10.01)

Step 2

Press MODE on the keypad until the main menu is reached. Press ENTER when the arrow is pointing to *Run Test*.

Step 3

Press the up and down arrows on the keypad until *Meter (Manual)* is reached and press ENTER.

Step 4

Scroll through the test functions supported by the RD-21 and press ENTER when the correct function is displayed.



Step 5

Use the keypad on the RD-21 to select the correct pulse constant for the D.U.T. and press ENTER. If the correct pulse constant for the D.U.T. is not available, scroll until NEW is displayed and press ENTER. Use the left and right arrows to select the digit of the pulse constant to edit and the up and down arrows to edit the digit. Once the correct constant is displayed, scroll to the far right of the constant to store the value for the test.

Step 6

Use the keypad on the RD-21 to select the correct number of elements of the D.U.T. and press ENTER.

Step 7

Use the keypad on the RD-21 to select the correct number of current inputs being utilized on the RD-21 and press ENTER.

Step 8

Use the keypad on the RD-21 to select the desired number of test revolutions and press ENTER.

Step 9

Either press the ENTER button or activate the snap-switch (which should be attached to Port 1) when the flag on the disk appears to start the test. This will be the start of the first disk revolution of the test.

Step 10

Either press the ENTER button or activate the snap-switch when the correct number of desk revolutions have transpired.

Step 11

Test results will now be displayed. The total amount of Watthours (or whichever function was chosen to test) will be displayed along with the D.U.T.'s percent registration and percent error.

Step 12

Press ENTER when the results are displayed and the user will be given the choice to *Re-run Test, Print Results or Show Results*.

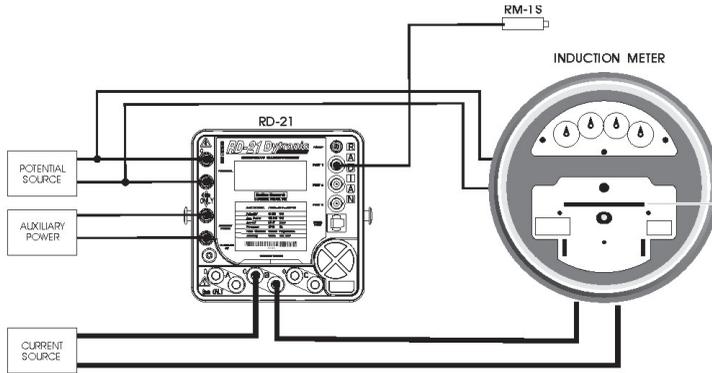
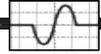


Figure 10.01 Testing a Induction Meter via an RM-1S Remote Reset Switch.

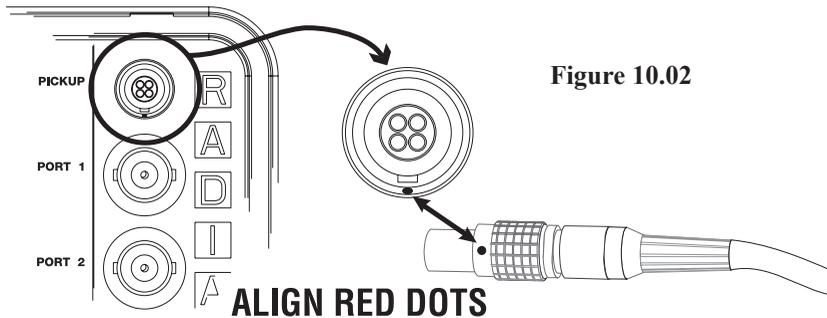


10.1.2 Sensor Meter Testing

(Testing using the RR-DS, RR-1H, RM-1H or RR-KYZ.)

Step 1

Make all appropriate connections so that the D.U.T. (Device Under Test) and RD-21 are powered by the same source. (See figures 10.03, 10.04, 10.05) When connecting sensors, be careful to correctly align the red dots on both the sensor and the PICKUP terminal. (See figure 10.02)



Step 2

Press MODE on the keypad until the main menu is reached. Press ENTER when the arrow is pointing to *Run Test*.

Step 3

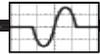
Press the up and down arrows on the keypad until *Meter (Sensor)* is reached and press ENTER.

Step 4

Scroll through the test functions supported by the RD-21 and press ENTER when the correct function is displayed.

Step 5

Use the keypad on the RD-21 to select the correct pulse constant for the D.U.T. and press ENTER. If the correct pulse constant for the D.U.T. is not available, scroll until EDIT is displayed and press ENTER. Use the left and



right arrows to select the digit of the pulse constant to edit and the up and down arrows to edit the digit. Once the correct constant is displayed, scroll to the far right of the constant to store the value for the test.

Step 6

Use the keypad on the RD-21 to select the number of pulses per equivalent revolution on the D.U.T. and press ENTER.

Step 7

Use the keypad on the RD-21 to select the correct number of elements of the D.U.T. and press ENTER.

Step 8

Use the keypad on the RD-21 to select the correct number of current inputs being utilized on the RD-21 and press ENTER.

Step 9

Make sure that the grid on the Align Disk Sensor screen is pulsing each time an equivalent disk revolution is occurring. Once correct sensor operation is ensured, press ENTER.

Step 10

Use the keypad on the RD-21 to select the desired number of test revolutions and press ENTER.

Step 11

The RD-21 will start the test when the next disk revolution is sensed. Once the correct number of revolutions have been accounted for, the test results will be displayed. The total amount of Watthours (or whichever function was chosen to test) will be displayed along with the D.U.T.'s percent registration and percent error.

Step 12

Press ENTER when the results are displayed and the user will be given the choice to *Re-run Test, Print Results or Show Results*.

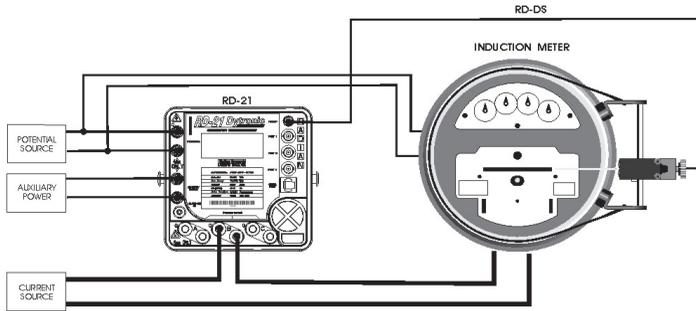


Figure 10.03 Testing a Induction Meter via a RR-DS/f Meter Disk Sensor with Field Mount.

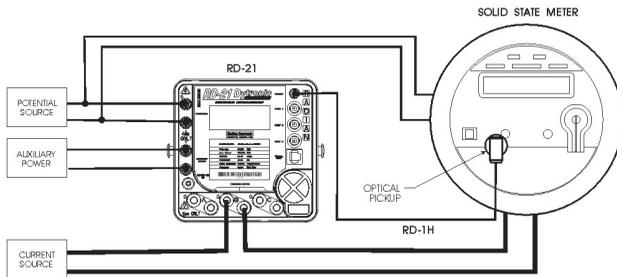


Figure 10.04 Testing a Solid State Meter via a RR-1H Infrared Optical Pickup.

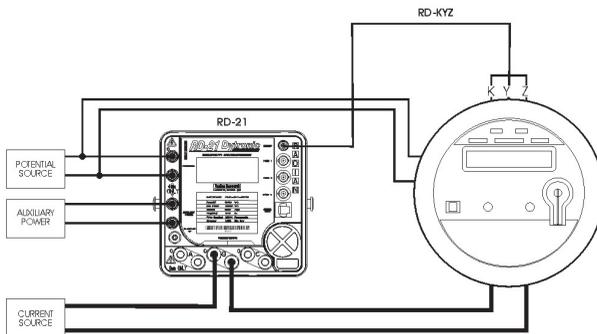
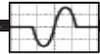


Figure 10.05 Testing a Solid State Meter via a RR-KYZ Pulse Input Adapter.



10.2 Standards Testing

Step 1

Make all appropriate connections so that the D.U.T. (Device Under Test) and RD-21 are powered by the same source. The output pulse of the D.U.T. should be connected to:

Port 1 of the RD-21 if the K_h of the Standard Under test is ≥ 0.01
(See figure 10.06)

Port 2 of the RD-21 if the K_h of the Standard Under test is < 0.01
(See figure 10.07)

Step 2

Press MODE on the keypad until the main menu is reached. Press ENTER when the arrow is pointing to *Run Test*.

Step 3

Press the up and down arrows on the keypad until *Standard* is reached and press ENTER.

Step 4

Scroll through the test functions supported by the RD-21 and press ENTER when the correct function is displayed.

Step 5

Use the keypad on the RD-21 to select the correct pulse constant for the D.U.T. and press ENTER. If the correct pulse constant for the D.U.T. is not available, scroll until EDIT is displayed and press ENTER. Use the left and right arrows to select the digit of the pulse constant to edit and the up and down arrows to edit the digit. Once the correct constant is displayed, scroll to the far right of the constant to store the value for the test.

Step 6

Use the keypad on the RD-21 to select whether the D.U.T. is a Radian or Other Standard and press ENTER.



Step 7

Use the keypad on the RD-21 to select a Test Duration of Time or Pulses and press ENTER.

Step 8

If *Time* is chosen for Test Duration, scroll through the time using the left and right arrows to select the digit to edit. Use the up and down arrows to edit the digits. Scroll all the way to the right to set the duration of time in seconds. Note that this value will be the default value for subsequent tests. The test will now begin and results will be displayed at the end of the test by pressing ENTER..

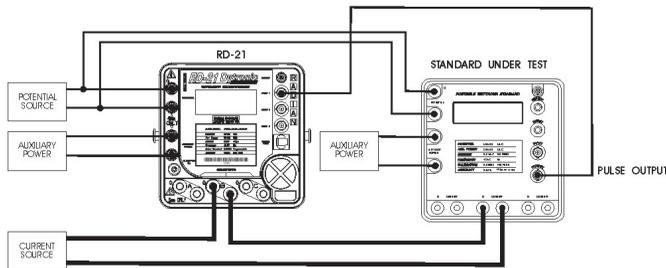


Figure 10.06 RD-21 Performing a Standard Test. (Connected to Port 1)

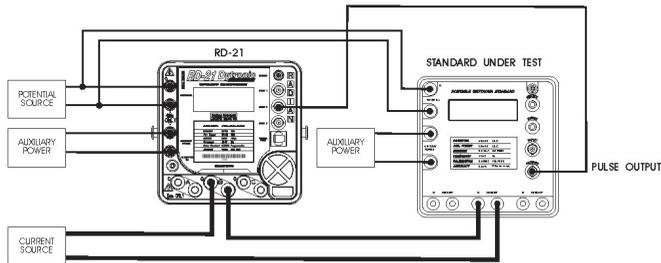


Figure 10.07 RD-21 Performing a Standard Test. (Connected to Port 2)



If *Pulses* is chosen for Test Duration, scroll through the number of pulses using the left and right arrows to select the digit to edit. Use the up and down arrows to edit the digits. Scroll all the way to the right to set the number of pulses to be counted. Note that this value will be the default value for subsequent tests. The test will now begin and results will be displayed at the end of the test by pressing ENTER.

10.3 Analog Sense Testing

The RD-21 will effectively test transducers as well as first generation electronic meters that have an analog output for calibration.

Step 1

Make all appropriate connections so that the D.U.T. (Device Under Test) and RD-21 are powered by the same source. The analog output of the D.U.T. should be connected to Port 3. (See figure 10.08)

Step 2

Press MODE on the keypad until the main menu is reached. Press ENTER when the arrow is pointing to *Run Test*.

Step 3

Press the up and down arrows on the keypad until *Analog Sense* is reached and press ENTER.

Step 4

Scroll through the test functions supported by the RD-21 and press ENTER when the correct function is displayed.

Step 5

Use the keypad on the RD-21 to select the analog sense factor for the D.U.T. and press ENTER. If the correct factor for the D.U.T. is not available, scroll until EDIT is displayed and press ENTER. Use the left and right arrows to select the digit of the pulse constant to edit and the up and down arrows to edit the digit. Once the correct constant is displayed, scroll to the far right of the constant to store the value for the test.

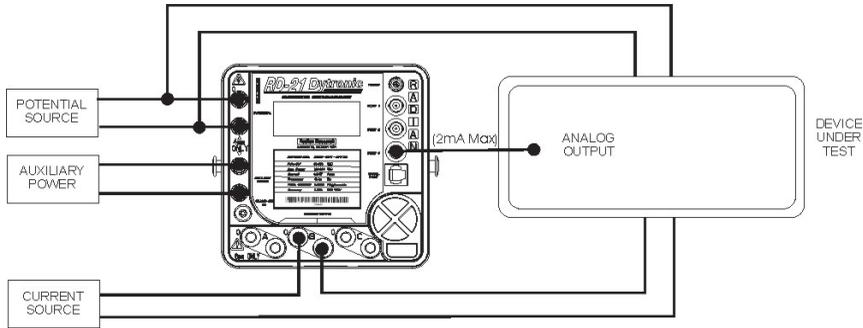


Figure 10.08 Performing an Analog Sense Test.

10.4 Testing without the Built-in Comparator Option

The application information contained in this section is to show how the RD-20, without the built-in comparator may be used for meter or standards testing.

10.4.1 Using the RD-21 with a RM-110

If the built-in comparator option was not purchased for the RD-21, a Radian Research RM-110 may be used in conjunction with the RD-21 to accomplish automated meter and/or standards testing. The RM-110 is an automated, handheld comparator. An example of a RD-21 and RM-110 test configuration is shown in the following figure. The actual test set-up and procedure is detailed in the RM-110 manual.

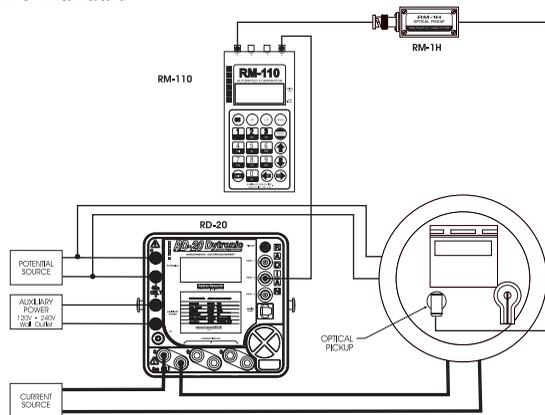
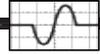


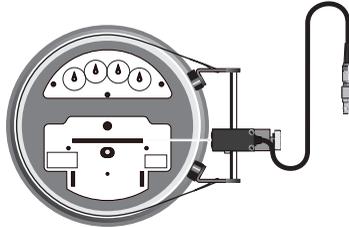
Figure 10.09 Testing without the built-in comparator option



11.0 Test Accessories

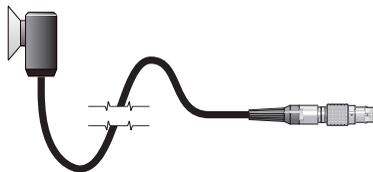
RR-DS Meter Disk Sensor

The RD-DS is a reflective pickup assembly used to sense the disk rotation of an induction type meter. The pulses generated by the RM-DS are fed into the PICKUP port of the RD-21. Evaluation of different types of meter designs is fully automated when the Built In Comparator option is utilized. The RR-DS is available in two (2) different mounting options. The RR-DS/f Disk Sensor with Field Mount features a Velcro strap that attaches around the meter cover. This allows the sensor to sense disk rotation from the side of the meter. The RR-DS/sm Disk Sensor with Suction Mount features an L-bracket with three (3) suction cups that attach to the front of the meter cover. This allows the sensor to sense disk rotation from the front of the meter.



RR-1H Optical Pickup for Infrared LED

The RR-1H is used to sense the infrared pulses from the calibration LED of solid state meters. The pulses from the RR-1H are fed into the PICKUP port of the RD-21. Evaluation of different types of meter designs is fully automated when the Built In Comparator option is utilized. The wide angular displacement of this sensor allows for fast, non-critical alignment. Also, automatic gain control circuitry of the RR-1H assures operation in all ambient sunlight conditions. The RM-1H/v is available for those solid state meters with a visible calibration LED, and terminates in a BNC Connector instead of a lemo connector. Therefore, the RM-1H/v attaches to port 1 instead of the pickup terminal.





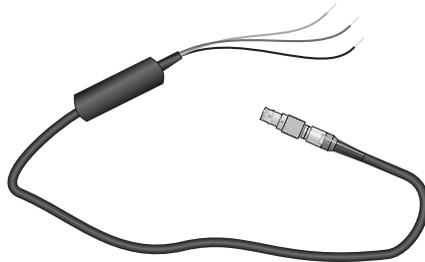
RM-OA Optical Adapter

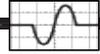
The RM-OA Optical Adapter is used with solid state meters whose infrared calibration pulse is emitted from the optical communications port. The RM-OA magnetically couples to the communication port of solid state meters. The suction cup of the RR-1H is attached to the clear polycarbonate cover of the RM-OA. The RM-OA incorporates a rare earth permanent magnet for exceptional holding power over the life of the product.



RR-KYZ Pulse Input Adapter

The RR-KYZ Pulse Input Adapter is used to sense the KYZ output pulses of induction of solid state meters. The Pulses received from the meter's KYZ output are conditioned and fed into the PICKUP port on the RD-21. The testing of KYZ equipped meters is





RM-1S Remote Reset Switch

The RM-1S Remote Reset Switch is a normally closed push button switch. The RM-1S connects directly to Port 1 of the RD-21. The switch of the RM-1S is hermetically sealed. The push-button has positive tactile feel to provide instantaneous feedback of the switch action.



RM-Metronic Sensors

Older sensor designs such as the RM-DS Disk Sensor, RM-1H Infrared Optical Pickup, RM-1H/v Visible Optical Pickup and RM-KYZ Pulse Input Adapter can be used with the RD-21, but must be connected to Port 1 because they terminate in a BNC connector.

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 calibration and recordkeeping associated with two primary applications: field testing of watt-hour 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.



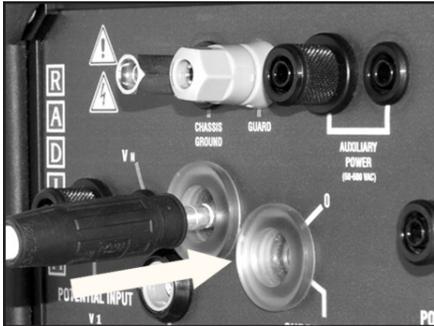


Appendix: RD Current Connector Locking Mechanism

The Radian RD-2X and RD-3X (120A) Dytronic Standards utilize 6mm locking style connectors for the current inputs.

Note: These connectors are very specialized and feature beveled edges and a locking ring. Do NOT use straight 1/4" current connector studs. Radian offers various jumpers and adaptors to fit most applications.

When connecting to the current inputs, insert the 6mm current plugs slowly into the current input receptacles on the RD standard. Do not use excessive pressure when inserting. Only a minimal amount of force is required to engage the locking mechanism.



RD-3x Shown



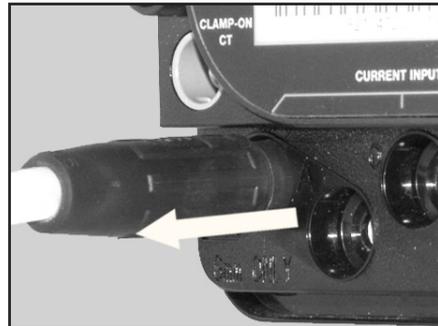
RD-2x Shown

NOTE: Pushing the current plug too hard may engage and then disengage the locking mechanism in one move. To prevent this, gently push the plug into the receptacle and allow the lock to engage.

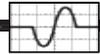
Once the locking mechanism is engaged, pull on the current plug outward. You should NOT be able to remove the plug.



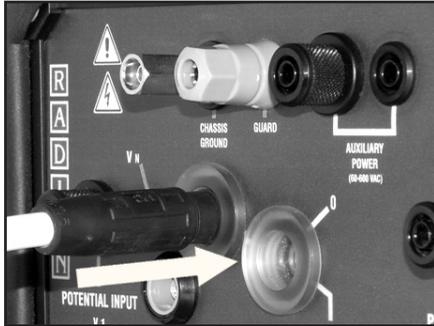
RD-3x Shown



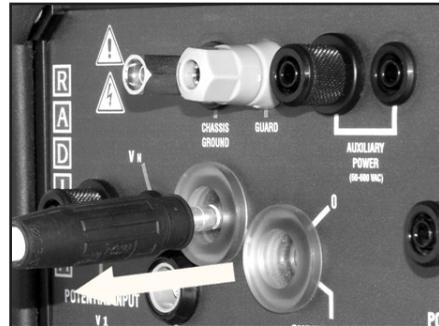
RD-2x Shown



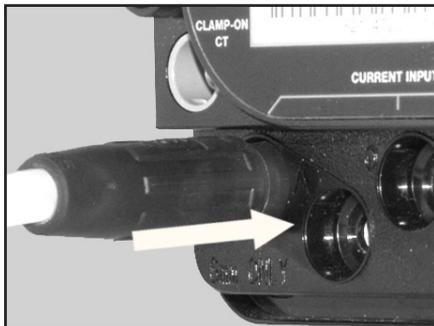
To disengage the locking plug, firmly insert the current input plug further into the receptacle until you feel a slight click. This click indicates that the locking mechanism is disengaged. You can then pull the current plug completely out of the receptacle.



RD-3x Shown



RD-3x Shown



RD-2x Shown



RD-2x Shown