MULTI-AMP® Model SR-98

- **Digital Signal Processor Based technology**
- **High Current/High Power output**
- **New CA mode captures high speed trip on MCCB**
- **0 to 360° Phase Shift capability**
- **RS-232 and Parallel printer ports**
- **Optional software automates record keeping**

Universal Protective Relay Test Set

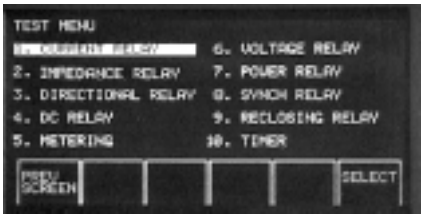
DESCRIPTION

The Multi-Amp Model SR-98 is the newest addition to the long, successful line of Multi-Amp "SR" series, like the SR-51, SR-76 and SR-90 relay tests. With over 50 years of relay testing experience, the SR-98 incorporates the latest in Digital Signal Processor (DSP) and microprocessor-based technology to provide a powerful, easy to use relay test set.

The SR-98 is a multipurpose, lightweight, field portable test set capable of testing a wide variety of electromechanical, solid-state and microprocessor-based protective relays. New CA mode captures test current and high speed trip operation of single-pole, small molded case circuit breakers, motor overload relays and similar protective devices.

The SR-98 incorporates a large, easy to read, even in direct sunlight, LCD display, which shows AC and DC Amperes, AC and DC Volts, and Time in both Seconds and Cycles. Depending on the type of test selected, other values may be displayed, such as Ohms, Watts, VARS, Phase Angle, Frequency or Power Factor. Metered quantities such as AC Amperes, AC Volts, DC Volts or DC Amperes, and Time are simultaneously displayed on the screen. The read-and-hold metering feature provides a fast and accurate preset of test values.

A relay specific test screen is included in the menu list. The user simply selects different testing applications from a menu screen. For example see the TEST MENU below.



The SR-98 can test a wide selection of relay types. Its advanced phase shift capability allows the unit to continuously adjust the phase angle relationship between the voltage and current outputs. Therefore, values like reach, maximum angle of torque, directional balance points, and closing angles can be easily tested. In addition, breaker contact simulation provides swift and easy testing of reclosing type relays.

APPLICATIONS

The SR-98 provides powerful testing capabilities. For example, the AC Current output can provide 16.66, 33.3, 25, 100 or 125 Hz for testing light rail transit system relays. In addition, the AC Current can be programmed to provide 2nd, 3rd and 5th harmonic currents for testing harmonic restraint elements in transformer differential relays.

Other types of relays not specifically listed in the menu above can be tested using one of the menu selections. For example, current differential, voltage controlled/restrained overcurrent and current balance relays are tested using the CURRENT RELAY test screen. All single-phase impedance type relays and some three-phase relays are tested using the IMPEDANCE RELAY test screen. For example, the SR-98 can test single-phase impedance relays. The test screen for an impedance relay is shown below.

In the above example, not only does the display screen show metered values, but it also displays the OHMS value where the relay picks up (different formulas for calculating OHMS are selectable using the OHM SELECT function button). This would include transmission line protection and loss of field type relays. The SYNCH RELAY Test Screen is used to test synchronizing, sync check relays, as well as negative sequence under/over voltage, reverse phase and phase sequence relays that can be tested with an Open-Delta test potential.

The Metering Screen provides powerful multi-purpose metering functions. Values like Volts, Amperes, Phase Angle, Power, Reactive Power and Power Factor are all simultaneously displayed.

The SR98 is designed to test virtually any single-phase relay. Some two and three-phase relays can be tested using the SR98's capability to phase shift between two voltage outputs (using the open-delta test method).

Even more importantly, the phase shift between the Main AC current output and the AC voltage output means the SR98 can completely test single phase Impedance relays such as distance and loss of excitation, as well as three-phase relays (which can be tested with currents in series and potentials in parallel).

1 - RS-232 Interface port for computer

2 - Interface port for another SR-98 or Models PVS/EPS-1000 three-phase, phase shifters

3 - Interface port for printer

4 - Reset fuses for the circuit breaker simulator circuit

5 - Normally Closed/Open contacts for the circuit breaker simulator circuit

6 - Timer Start and Stop Gates

7 - Resistor bank

8 - Power input terminal

9 - Fuses associated with power input

10 - Ground terminal associated with power input

11 - Main current output terminals

12 - On lamp for main current output terminals

13 - External voltage and current measurement terminals

14 - AC, (AUX) voltage output terminals

15 - DC, (AUX) voltage output terminals

16 - Control switches associated with AC, DC (AUX) voltage outputs

17 - System reset button

18 - Control knob

19 - Power on switch

20 - LCD display screen

21 - Alarm reset switch

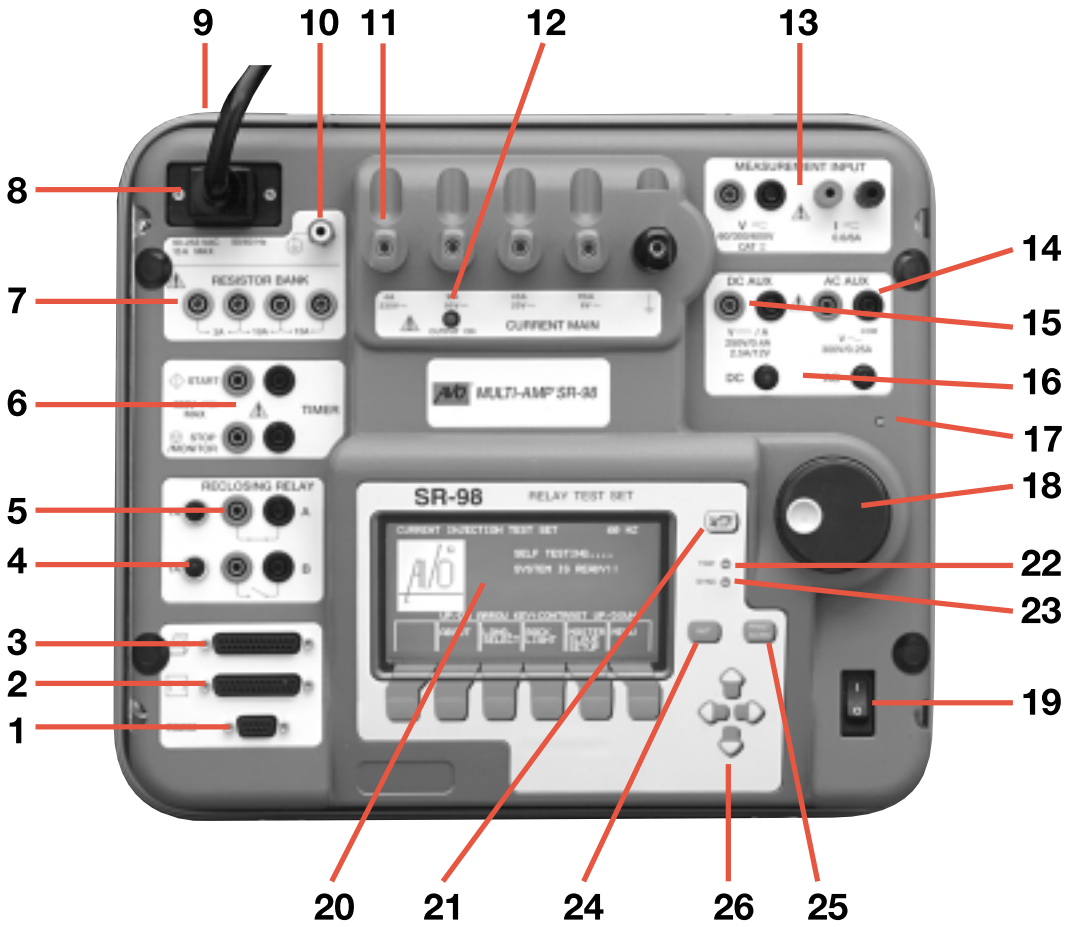
22 - TRIP LED lamp

23 - SYNC LED lamp

24 - Initiate switch

25 - Print Screen button

26 - Associated with the up/down, right/left cursor keys



Below are some of the test screens, with descriptions, incorporated in the SR-98.

SYNC (Synchronizing) RELAY Test Screen:

The SYNCH RELAY Test Screen is used to test synchronizing and sync check relays. In addition, this screen is used to test negative sequence under/over voltage, reverse phase and phase sequence relays that can be tested with an open-delta test potential. The two voltage sources used to test synchronizing type relays are the 230 V / 4 A CURRENT MAIN output terminal, with common, and the AC AUX, 300 V / 0.25 A output terminals. The phase angle between the two voltages is displayed as ϕ Vm lags V , where Vm is the Main output and the other voltage V is from the AC AUX output.

POWER RELAY Test Screen:

The POWER RELAY Test Screen is used to test over power, reverse power or synchronous motor loss of excitation relays, that are calibrated in Watts. The WATTS displayed is the calculated value based on the displayed formula, directly beneath (W) = Watts. The three formulas available are (VI*COS ∅), (W*1.7) (Watts* Square Root 3) and (W/1.7) (Watts/ Square Root 3). The formula is selected by pressing the WATT SELECT function button. These three formulas cover virtually all single-phase power, and some three-phase power and loss of field relays.

VOLTAGE RELAY Test Screen:

The VOLTAGE RELAY Test Screen is used to test all single-phase AC under and overvoltage relays.

The SET FAULT VOLTS button is used to preset the desired “fault” under or over voltage value.

FAULT VOLTS (AC)

The value displayed is the measured output voltage from the AC AUX output terminals. The “fault” voltage is set first. Then the “normal” is set and displayed on the AC VOLTS display. When the test is initiated, the normal voltage is removed and the fault is applied. The timer is started when the fault voltage is applied. When the relay trips, the timer stops and the output is turned off.

DIRECTIONAL RELAY Test Screen:

The DIRECTIONAL RELAY Test Screen is used to test all single-phase directional elements in directional overcurrent and ground overcurrent relays. The phase angle displayed is the measured phase angle between the AC CURRENT MAIN output and the AC AUX Output. The phase shifter is used in testing the sensitivity setting of the directional element.

IMPEDANCE RELAY Test Screen:

The IMPEDANCE RELAY Test Screen is used to test all single-phase distance, impedance, or three-phase impedance relays (where the voltages may be paralleled and currents series). The OHMS displayed is the calculated value based on the displayed formula. The two formulas available are V/I and V/2I. These two formulas cover virtually all single-phase impedance relays, phase to ground and phase to phase tests. The Phase Angle, ϕ I lags V, display is the measured phase angle between the AC CURRENT MAIN output and the AC AUX Output.

RECLOSE RELAY Test Screen:

The RECLOSE RELAY Test Screen is used to test reclosing type relays.

The reclosing relay test screen has the same measured values as the OVERCURRENT RELAY test screen. RECLOSE SHOT: # is where the user enters the number of reclose operations that the relay is set for. As the relay goes through each reclose operation, the appropriate RECLOSE TIME is recorded for each operation. A maximum of 10 reclose operations (shots) may be recorded.

CURRENT RELAY Test Screen:

The CURRENT RELAY Test Screen is used for testing all overcurrent, voltage controlled overcurrent, voltage restrained overcurrent and other AC current controlled relays, including motor overload relays and small molded case circuit breakers.

This test screen is also used to do pick-up and timing tests on current differential relays. Two SR-98 units may be used together to perform slope and 2nd, 3rd or 5th harmonic restraint tests, (*) see Interface Port.

The following table lists relays by IEEE device number that the SR98 can test.

IEEE Device Number	Relay Types
2	Time-delay starting relay
21	Distance (1∅, including max torque angle)
25	Synchronizing and Synch-Check
27/59	AC/DC Under/Overvoltage
32	Directional Power (1∅ and 3 ∅ Open-Delta)
37	Under current relays
40	Loss of Field
47	Phase Sequence Voltage (3 ∅ Open-Delta)
50	Instantaneous Overcurrent (up to 115 Amperes)
51	Time Overcurrent (up to 115 Amperes @ 920VA)
60	Voltage Balance (2 ∅ or 3 ∅ Open-Delta)
67	Directional Overcurrent
67N	Directional Ground Overcurrent
79	AC Reclosing relay
82	DC Reclosing relay
85	Carrier or Pilot Wire relay
86	Lock Out relays
87	Differential (*)
87T	Transformer Differential with 2nd, 3rd and 5th harmonic restraint (*)
94	Tripping relays

FEATURES AND BENEFITS

• **Large variable contrast LCD display screen** - Easy to read, no interpolation of analog meter scales. This saves time in testing relays and reduces human error.

• **Display screen prompts operator** - The display screen prompts the user with easy to understand and use function keys. Single button operation saves time in testing relays and reduces human error.

• **Display screen provides five different languages** - The display screen prompts the user in English, Spanish, Portuguese, French and German.

• **Output current and voltage sinewaves are generated digitally** - Outputs do not vary with sudden changes in input voltage or frequency, which increases test accuracy and saves testing time.

• **Memory hold metering** - Allows the user to set test currents and voltages faster. Reduces heating of device under test.

• **AC/DC voltage outputs can be operated independently of AC current output** - Can provide DC logic voltage to solid-state relays prior to applying simulated fault current. This also allows users to test voltage controlled/restraint overcurrent relays without blocking voltage element contacts closed eliminating the need for elaborate test circuit connections and purchasing a separate DC voltage source or using station battery.

• **Timer has independent Start and Stop Gates** - Perform timing functions independent of relay test set operation. Eliminates the need to purchase a separate timer for timing circuit breakers.

• **Current Accurate mode** - Multi-purpose test set capable of testing small molded-case circuit breakers and motor overload relays commonly found in industrial applications. **New!** Now measures test current and trip time for breakers that trip in less than 1 cycle.

• **Interface port** - Provides interface to other SR-98's or AVO Phase Shifters. (*)The SR-98 unit can be used with another SR-98 to test slope and harmonic restraint characteristics on current differential relays. The SR-98 unit can also be used with a three-phase phase shifter to test complex three-phase relays. This saves time in making test connections and the multi-purpose test system saves money.

• **Phase shift capability (0 to 359.9°)** - The SR-98 provides phase shift between the main AC current and auxiliary AC voltage outputs (for testing complex relays) or between the 230 volt output terminal of the main AC current and the auxiliary AC voltage outputs (for testing synchronizing relays).

• **Selectable output frequencies** - The output frequency of the AC main current can be set for 16.66, 25 and 33.3 Hz (for testing light rail transit relays); 50, 60 Hz (standard power frequency); 100, 120, 125, 150, 180, 250 and 300 Hz (for testing harmonic restraint on transformer differential relays). Multi-purpose test system saves time and money.

• **Circuit breaker simulator** - Normally closed and normally open contacts are provided to simulate breaker operation for testing reclosing relays. Sequence of operation, timing, and lockout are easily tested.

• **Non-volatile RAM** - Provides storage of special test set-up screens.

• **RS-232 and parallel printer ports** - The RS-232 port provides for computer interface. The parallel printer port allows user to easily print test results.

• **Universal input voltage** - Models SR98-1 and SR98-2 can use virtually any standard source in the world. The Model SR98-3 is designed for 230 Volt operation only.

SPECIFICATIONS

Input Power

Model Numbers SR98-1/60 and SR98-2/50: 90 to 253 Volts AC, 1ϕ, 50/60 Hz, 1500 VA Max.

Model Number SR98-3/50: 230 Volts AC, ±10%, 1ϕ, 50/60 Hz, 1500 VA Max.

Outputs

Three independently controlled, adjustable outputs are available from the test set; one AC current, one AC voltage and one DC voltage/current. All outputs are independent from sudden changes in line voltage and frequency. This provides stable outputs not effected by sudden changes in the source, which is a common problem with traditional transformer loads.

Selectable Output Frequencies

The output frequency of the AC Main Current and AC AUX voltage can be set for 16.66, 25, 33.3, 50, 60, 100, 120, 125, 150, 180, 250 and 300 Hz .

AC Main Output Current

The AC Main Current output is rated for 920 VA with four different output terminals for better impedance matching to the load. Outputs are continuously adjustable in the following Ranges:

Output Current	Full Load Voltage
0 - 4 Ampres	230 Volts
0 - 10 Ampres	90 Volts
0 - 45 Ampres	20 Volts
0 - 115 Ampres	8 Volts

Output Current Duty Cycle

At full rated output, maximum time on is 3 minutes followed by 20 minutes off. Duty is reduced to 1 minute on and 20 minutes off at an ambient temperature of 122° F (50° C) [1].

AC Voltage Output

The AC AUX voltage output is independently controlled and may be phase shifted relative to the Main AC Current/Voltage outputs. The SR-98 provides 0 to 359.9° phase shift between the Main AC Current and AC Auxiliary voltage outputs (for testing complex relays) or between the 230 volt output terminal of the Main AC Current and AC Auxiliary voltage outputs (for testing synchronizing relays).

Output Voltage	Current Rating
0 - 300 Volts	0.25 Amp (AC AUX)
0 - 230 Volts	4 Amp (AC CURRENT MAIN)

DC Voltage/Current Output
(Switch Selected)

Output Voltage	Current Rating
0 - 240 Volts	0.4 Amp

Output Current	Voltage Rating
0 - 2.5 Amps	12 Volts

AC/DC Output Voltage Duty Cycle

30 Minutes on followed by 30 minutes off.

Metering

Measured quantities such as AC Amperes, AC Volts, DC Volts or DC Amperes, and Time are simultaneously displayed on the large variable contrast LCD screen. The read-and-hold feature of the metering provides fast and accurate preset of test values. The AC Amperes also displays a percent value when rotating the control knob for easy reference by the user. The AC and DC Volts display the approximate voltage output prior to initiation of the voltage outputs. This provides a fast, easy method for preset of voltage outputs. As a safety feature, the SR-98 alerts the user to the expected voltage output prior to turning on the voltage outputs. Other values, which may be displayed depending on which test screen is in view, are Phase Angle, Power, Reactive Power and Power Factor. Maximum current, external measurement mode, is 6 Amperes AC or DC. Maximum voltage, external measurement mode, is 600 Volts AC or DC. The large characters and variable contrast make the display easy to read from 3 to 4 feet (1 meter) away, even in direct sunlight. All Accuracy stated below are from 10 to 100% of the range at 50/60 Hz.

AC Amperes (Auto Ranging)
Ranges
0 to 15/30/60/120 Amperes

Overall Ammeter Accuracy
Continuous:
±1% of reading
Pulse (4 to 10 cycles):
±1.5% of reading
Pulse (1 to < 4cycles):
±2.0% of reading
Resolution: .001/.01/.1

Measurements: True RMS

AC Volts (Auto Ranging)
Ranges
0 to 30/60/125/300

Accuracy: ±1% of reading

Resolution: .001/.01/.1

Measurements: True RMS

DC Volts (Auto Ranging)
Ranges
0 to 30/60/125/250

Accuracy: ±1% of reading

Resolution: .001/.01/.1

Measurements: Average

DC Amperes (Auto Ranging)
Ranges 0 to 1.3/2.5 Amperes

Accuracy: ± 1 % of reading

Resolution: .001

Measurements: Average

Phase Angle
Ranges 0 to 359.9 degrees

Accuracy: ± 0.5°

Power Factor
Ranges and Resolution -0.99 to +0.99, with 0.01 resolution

Accuracy: ± 0.02

Power (Auto Ranging)
Ranges and Resolution 0 to 4 kW in 6 Ranges, with 0.1 % resolution

Accuracy: ±1.5 % of VA ±1 least significant digit

Reactive Power (Auto Ranging)
Ranges and Resolution 0 to 4 kVAR in 6 Ranges, with 0.1 % resolution

Accuracy: ±1.5 % of VA ±1 least significant digit

External Voltmeter Inputs
Ranges 0 to 75/150/300/600 Volts

Accuracy: +/- 1 % of reading

Resolution: .001/.01/.1

External Ammeter Input
Range 0 to 6 Amperes

Accuracy: +/- 1 % of reading

Resolution: .001

Duty cycle: currents above 5 amperes 5 min. on, 5 min. off

Timer
Range and Resolution: Displays in Seconds and Cycles, with the following range and resolution:

Seconds: 0.0001 to 99999.9 (Auto Ranging)

Cycles: 0.01 to 99999.9 (Auto Ranging)

Accuracy: ±1 least significant digit or ±.005% of reading, whichever is greater.

Start/Stop/Monitor Gates:

Two identical, independent, Start/Stop or Monitor Gate circuits are provided. To monitor operation of relay contacts or trip SCR, a continuity light is provided for the Stop gate. Upon sensing continuity the monitor lamp will glow and a tone generator will sound. The following modes are provided for the Start, Stop/Monitor Gates:

1. Timer will start/stop or continuity indicator darkens at the opening of normally closed contacts or when conduction through a semiconductor device such as a triac is interrupted.

2. Timer will start/stop or continuity indicator glows at the closing of normally open contacts or upon conduction through a semiconductor device such as a triac or transistor.

3. Timer will start/stop or continuity indicator glows or darkens upon the application or removal of either an AC or DC voltage (60 to 300 V AC), (5 to 300 V DC). The maximum voltage to be applied is 300 Volts AC or DC.

4. Starting or Stopping with any selected output. The Timer can be started or stopped when turning on or off selected outputs.

5. In the Current Accurate Mode, the Timer stops when output current is interrupted.

Start Latch:
The Timer Start Gate is provided with a latch feature which allows timing to be initiated by a Start Gate and be stopped only by the selected Stop Gate. When unlatched, the Start Latch allows timing to be stopped when the Start Gate is reversed (such as when timing the closing and opening of a single contact as in measuring the trip-free operating time of a circuit breaker).

Stop Latch:
The Timer Stop Gate latch feature which allows timing to be stopped at the first operation of any Stop Gate (thus ignores contact bounce). When unlatched, the Stop Latch allows timing to be stopped by any Stop Gate and then restarted if the Stop Gate reverses (provided a Start Gate is still energized), and then stopped again when the gate reverses (total time including contact bounce).

Protection
Input and outputs are protected from short circuits and prolonged overloads.

Ancillary Interface:
A voltage signal output in phase with the main current output (±3°) is provided for use with the Multi-Amp Models EPS-1000 or PVS-1000 for phase reference. This will allow testing of more complex relays which require phase shifting between a three-phase voltage output (EPS-1000) and a current output (SR-98).

Temperature Range
Operating: 32 to 122° F (0 to 50° C)

[**1] Reduced duty cycle:** Duty cycle is linearly de-rated from 3 minutes on, starting at 104° F (40° C) to 1 minute on at 122° F (50° C), followed by 20 minutes off.

Storage: -40 to 158° F (-40 to 70° C)

Relative Humidity: 90% RH, Non-condensing

Enclosure
The unit comes mounted in a rugged plastic transit case for field portability. The tongue and groove lid protects the unit from rain and dust intrusion. Spring loaded carrying handles are located on each side for carry convenience.

Dimensions
Unit Enclosure
17.75 H x 16.5 W x 15.5 D in.
444 H x 416 W x 387 D mm

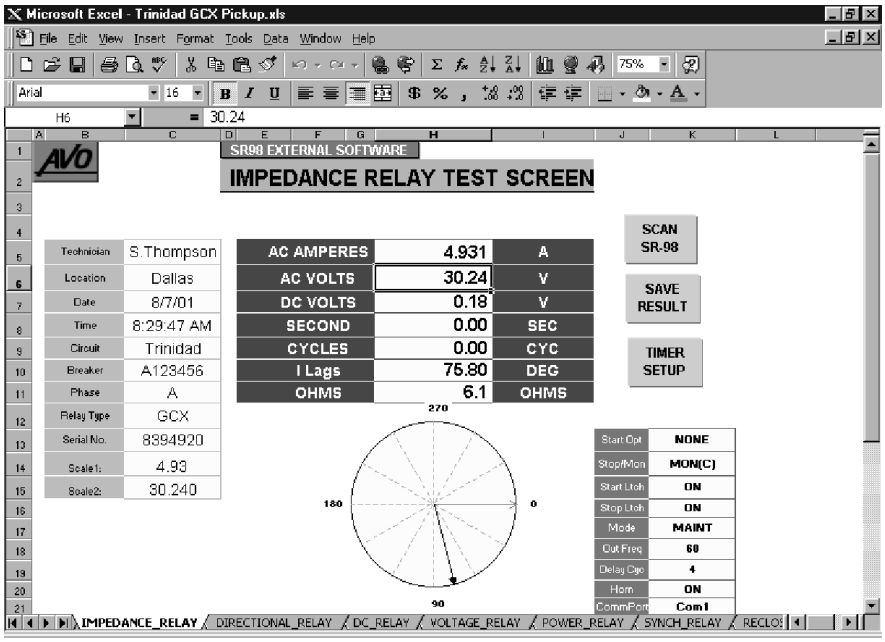
Weight: 51.5 lb. (23.4 kg) cover lid on 48.8 lb. (22.2 kg) cover lid off

This product is CE marked

OVERVIEW OF SR-98 RELAY TEST SOFTWARE OPTION

AVO International offers a distinctive relay test software program option for use with AVO Model SR-98 Universal Relay Test Set. The SR-98 software is an all new software tool designed to simplify tests of the most simple to the most complex protective relays found in generation, transmission and distribution substations.

The SR-98 software provides a unique user interface designed to simplify software and hardware use. They say a picture is worth a thousand words. Depending on the test screen in use, the SR-98 software, displays the voltage, current and phase angle relationship applied to the device under test. In the case of the test screen for Synchronizing, Phase Sequence, Reverse Phase, and Negative Sequence under/over voltage relays, the vectors shown are between two voltages. Vectors are color coded to distinguish between voltage and current. The values displayed are scanned from the SR-98 into the software either in a continuous mode or on demand. When the test is completed the results are easily saved as a Microsoft Excel spreadsheet. No more hand written test reports, while in the field. Test reports can be generated back in the office directly from Excell by importing into a Microsoft Word document or other Microsoft compatible report generation software that can import Excel spreadsheets.



Shown above is a Test Screen for an Impedance Relay. The test result is for a Reach Test on a Impedance relay. The relay operated at 6.1 Ohms at a max torque angle of 75.8 degrees.

The SR-98 software operates with Windows Excel version 7.0 or higher running under Windows 95/98/2000 or NT.

Microsoft Excell, Microsoft Word, Windows 95, Windows 98, Windows 2000 and NT are all registered trademarks of Microsoft Corporation.

ORDERING INFORMATION

Item (Qty)	Cat. No.
Model SR-98, with 90 to 253 Volts input	
Output frequency preset to 60 Hz, North American power cord	SR98-1/60
Output frequency preset to 50 Hz, International color coded line cord	SR98-2/50
Model SR-98, with 230 Volt input	
Output frequency preset to 50 Hz, Continental Europe power cord, does not include test leads, lug adaptors or alligator clips	SR98-3/50

Included Accessories (All Models)

Line cord, North American (Model SR98-1/60) (1 ea)	620000
Line cord, Continental Europe (Model SR98-3/50) (l ea)	50425
Line cord, International (Model SR98-2/50) (1 ea)	51874
Instruction manual (1 ea)	51187
15 A Input fuse, (for 120 Volt input) (5 ea) T rated	963
8 A Input Fuse, (230 Volt input) (5 ea) T rated	962

Included Accessories (SR98-1/60 & SR98-2/50)

Test lead, red, 200 cm, use with voltage outputs and timer (3 ea) CAT II	684000
Test lead, black, 200 cm, use with voltage outputs and timer (3 ea) CAT II	684001
Lug adapter, red, 6.2 mm, use with voltage outputs and timer (2 ea) CAT II	684002
Lug adapter, black, 6.2 mm, use with voltage outputs and timer (2 ea) CAT II	684003
Lug adapter, red, 4.1 mm, use with voltage outputs and timer (2 ea) CAT II	684004
Lug adapter, black, 4.1 mm, use with voltage outputs and timer (2 ea) CAT II	684005
Alligator clip, red, use with voltage outputs and timer (1 ea) CAT II	684006
Alligator clip, black, use with voltage outputs and timer (1 ea) CAT II	684007
Test leads, red/blk, use with current output (includes spades) (1 pr) CAT II	7934
Carry case, test lead	684008

Optional Accessories

SR-98 software	750014
#4 High current test leads, 5 ft. [1.5 m] (1 pr), use when testing molded case breakers	2265
For three-phase applications, an optional Phase Angle Meter (PAM) interface cable is required to interface the SR-98 to Multi-Amp three-phase phase shifters.	
Cable, interface, for models EPS-1000 and PVS-1000 (1ea)	51680
Cable, interface, Master/Slave, for SR-98 to SR-98 (1ea)	51679

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MIL/1.5M/102 AVO-1095 BULLETIN-3 SR-98