INSTRUCTION MANUAL

For

AUTOMATIC CIRCUIT RECLOSER
TEST SET

MODEL OCR-8015
AND
OCR-8015 WITH INTERFACE OPTION

This test set includes ROM-resident computer program.

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It is essential that this instruction book be read thoroughly before putting the equipment in service.
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THEORY OF OPERATION

GENERAL DESCRIPTION

The Multi-Amp Model OCR-8015 is a portable low voltage, high current unit designed for testing automatic oil, and vacuum, circuit reclosers and other current actuated devices. The unit incorporates a variable high current ac output, with an impedance matching network to stabilize the output current, and appropriate instrumentation and control circuitry to monitor contact closure and opening.

The OCR-8015 with interface option is a standard test set plus an RS-232 interface for external computer control, Centronix standard parallel printer port and thumbwheel control for variable time-on duration.

SAFETY PRECAUTIONS

WARNING

Potentially lethal voltages can be present on the output leads, when test set is in operation. The operator is responsible for ensuring the safety of all personnel while he is operating it. While making tests, keep all personnel at a safe distance from the device being tested.

CAUTION

For safety of the operator, it is absolutely essential that the test set be properly and effectively grounded.

DESCRIPTION OF CONTROLS

This section of the instruction manual describes the function of all the various controls switches, etc., which are located on the Multi-Amp Model OCR-8015. All controls are clearly marked and logically grouped so that continual reference to the instruction manual should not be necessary after the operator has become acquainted with the operation of the test set.

Output Control
A variable autotransformer to provide continuous control of the output current from zero to maximum.

Circuit Breaker
Functions as the input POWER ON/OFF Switch and also provides short-circuit and overload protection.

AMMETER RANGE Buttons
Selects the full scale range of the ammeter.

AMMETER
Indicates the value of output current.

TIMERS
These are specially designed solid-state electronic digital timers for indicating the elapsed time of the test in either cycles or seconds. One timer indicates the TRIP TIME, the other indicates RECLOSE and TOTAL TIME.
SECONDS/CYCLES Switch
Selects the mode of count in either seconds or cycles.

RECLOSURE TIME/TOTAL TIME Lamps
Indicates which time is being displayed on second timer display.

Ground Alarm
In the event the ground circuit is broken or no ground is established, an alarm will sound.

**MONITOR Section**

POWER ON Lamp
Indicates when the circuit breaker is ON and input power is available.

TEST ON Lamp
Indicates when test in progress.

LAMP TEST Button
When pressed all lamps and numeric displays are exercised. Additionally, this button is used to reset the microprocessor.

OUTPUT ENERGIZED Lamp
Indicates when the output is energized.

**TEST MODE Section**

MINIMUM PICKUP Button
When pressed, the microprocessor is used to determine minimum pickup of the recloser.

MANUAL Button
When pressed the test set can be used in a manual mode of operation.

EXTERNAL CONTACT STOP Button
When pressed the digital timer will stop and the test set de-initiates upon the opening of NORMALLY CLOSED or closing of NORMALLY OPEN contacts. This button is used when in the MANUAL MAINTAINED and MOM. positions only.

**OUTPUT CONTROL Section**

START Button
Energizes the output of the test set.

MOMENTARY Button
When this button is pressed and lit, the output of the test set will remain energized for four (4) cycles. This position is used for setting test current prior to a timing test.

MAINTAIN Button
When this button is pressed the output will remain energized, upon pressing the START Button, until the STOP Button is pressed, or EXTERNAL CONTACT STOP or SAFETY Switch is operated. (The SAFETY Switch is a function of the matching impedance selector switch. When the switch is pressed down to change impedance, the SAFETY Switch de-energizes the output).
STOP Button

When pressed the output is de-energized and the test is terminated.

OCR OPERATION Section

OPERATIONS RECORDED Lamps
Indicates how many operations occurred and were recorded.

OPERATIONS EXPECTED Lamps
Indicates how many operations are expected to lockout, thereby programming the microprocessor.

OCR TIMING Button
When pressed, this commands the microprocessor to prepare for a timing test (see Special Control Feature, p. 6).

LOCKOUT Button
Allows the operator to program for less than 4 shots to lockout.

EXCESS Shot
Indicates to the operator when the recloser took an extra shot to lockout.

EXCESS Time
Indicates to the operator when the recloser took too long to achieve lockout.

Safety Interlock Footswitch
In addition to other safety features of the OCR-8015, this switch is intended as a safety interlock to keep the operator from leaving the control area of the test set while the output is still energized. This is so that the operator does not come into contact with live, or energized apparatus.

INPUT CIRCUIT

INPUT VOLTAGE

Multi-Amp OCR-8015 is designed to operate from any of several input voltages in order to accommodate the various voltages encountered by users in the field. It is necessary to change the input terminal connections to match the available input voltage. This change is made on a terminal board located inside the right side access panel. It is recommended that the test set be disconnected from the source before changing input terminals.

SELECTION OF INPUT LEADS

Due to the wide variation in individual user requirements with regard to wire sizes, terminations and length of leads, all units are supplied with input socket and matching plug only. The plug will accept a wide range of wire sizes more than adequate for the duty required. The power source must have sufficient capacity, and the input leads must be large enough to maintain RATED input voltage at the INPUT terminals of the test set. Although the test set is designed to operate satisfactorily at 95-105% of rated voltage, any drop in voltage below RATED at the input terminals will result in a proportional decrease in the maximum available output.
NOTE: To achieve published output currents, the rated input voltage must be maintained at the test set terminals during the test.

When utilizing maximum output from the test set, the input line currents may be as high as 400% of nameplate rating. The following table has been prepared to aid in selecting the proper wire size for the input leads. To use the table, refer to the following four steps:

1. Determine the rated input current from the nameplate on the test set. Be sure to choose the correct current for the input voltage being used.

2. Multiply this value by four.

3. Determine the length of input lead required. This is in circuit-feet, therefore it is the one-way distance from the test set to the power source.

4. Select the proper wire size from the table using factors 2 and 3 above.

Example: Step 1 - 100 amperes (from nameplate)  
Step 2 - 4 x 100 = 400 amperes  
Step 3 - 60 ft. (Distance from test to input power source.)  
Step 4 - # 2 wire (from Chart)

For safety, a ground wire should be connected to the test set frame. The size of this conductor should be not less than 1/2 the cross section of the current carrying input leads (three-wire sizes less) and in no event smaller than #10. An audible alarm is sounded if the test set is not properly grounded.
SELECTOR CHART FOR INPUT LEADS

LENGTH OF INPUT LEADS
DISTANCE FROM TEST SET TO POWER SOURCE

FOUR TIMES (4X)
RATED INPUT POWER  20  40  60  80  100  120  140  FEET

MINIMUM WIRE SIZE A. W. G.

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THE WIRE SIZES IN THIS CHART WILL RESULT IN VOLTAGE DROPS OF 10 VOLTS OR LESS.
OUTPUT CIRCUIT

SELECTION OF OUTPUT TERMINAL

Several output terminals at various voltage and current ratings are provided to adapt the Multi-Amp Recloser Test Set to a wide variety of test circuit impedances. The current ratings shown on the output taps are the continuous duty ratings. The test set works at peak efficiency when the outputs are used at 2 to 3 times their continuous rating. In this way, finer adjustment can be obtained by making maximum use of the variable autotransformer range and matching impedance network. The LOW CURRENT terminals should be used when testing high impedance devices where higher current terminals do not have sufficient voltage to "push" the desired test current through the device. For example, to test a recloser with a 50 amp coil rating at a test multiple of 5x (250 amperes), the operator should use the 100A output tap (not the 250A tap). Only when the test current exceeds 300A should the 250A tap be used.

SELECTION OF COMMON TERMINALS

The ammeter circuit of the recloser test set utilizes two current transducers to measure both the very low and high currents available from this unit. For the ammeter to correctly measure the output current of the test set, the proper common terminal must be selected. For currents of 20 amperes and below, COMMON 1 Terminal must be used; and, similarly, when test currents exceed 20 amperes, COMMON 2 Terminal must be used.

SELECTION OF MATCHING IMPEDANCE

The impedance matching network is incorporated to swamp-out the changing impedance of the recloser. As the operating plunger moves through the coil of the recloser the impedance increases, experience has shown that the higher the matching impedance on the primary of the output transformer, the less effect the changing impedance of the recloser has on the output current. The limiting factor is the available power of the test set. The more matching impedance, means more power consumed by the test set and less available output current. To select the appropriate matching impedance to conduct timing tests, first select the appropriate output tap and common, i.e. for a test current of 200 amperes use the 150V-100A tap (see SELECTION OF OUTPUT TERMINAL). The appropriate matching impedance for a given recloser will be determined through experience. Until such time, move the impedance tap selector switch to position 10. Rotate the Output Control wheel to the 90% position.

Upon operation of the test set, in the momentary position, if the test current indicated is too low, switch the IMPEDANCE TAP SELECTOR Switch to position 11 and repeat the procedure. Switching to position 11 decreased the matching impedance, therefore, allows more output test current. If the test current is too high, switch the impedance tap selector switch to position 9 to increase the matching impedance, thus reducing the output test current and repeat the procedure. Fine adjustment of the current is made with the Output Control wheel.
It is suggested that the **LOAD COMPENSATOR** switch never be moved to position #15 during a recloser timing test. The lack of any matching impedance could result in inaccurate results and possible damage to the test set.

**OUTPUT CONNECTIONS**

The testing of devices requires the use of test leads for connections between the test set and the device being tested. The following information on the selection of output leads will provide the user with a guide for choosing the proper test leads for this application.

Due to the voltage drop from the inductive reactance of the test circuit, a significant loss of current will result for each inch of test lead. Therefore, when choosing test leads, the length and size of lead chosen will determine the maximum available test current. It is worthwhile to sacrifice cross section of test leads for the sake of reducing length. Every inch of lead that can be eliminated provides worthwhile increase in available test current. Heating is not a significant problem in testing, even though the leads can become hot. The use of 4/0 welding or motion picture cable is convenient for constructing test leads. Paralleling of sufficient cables provides higher test currents. Each cable can be fitted with a compression lug on each end, then bolted to the output terminals of the test set and the breaker.

The two cables between the test set and the device under test should be twisted together or bundled with tape or cord to maintain the close proximity which minimizes inductive reactance.

**MICROPROCESSOR-CONTROLLED OPERATION**

The microprocessor based control and instrumentation system ensures simple operation and precise test results. The microprocessor automatically detects the minimum pick-up current. It will signal when minimum pick-up is achieved and display the magnitude of the pick-up current. The microprocessor stores the current magnitude, trip time and reclose times for each operation of the recloser and can be displayed by pushbutton selection of the desired operation. The microprocessor will also indicate if the recloser took excessive shots to lock-out. Additionally, the microprocessor will de-initiate the test set if the recloser is exceeding the allowed time to lock-out and will indicate to the operator excess time to lock-out. The microprocessor can also be used to control a test sequence to verify the proper operation of sectionalizers. Additionally, the microprocessor is programmed to detect errors associated with operation of the test set or the device under test.

**SPECIAL CONTROL FEATURE**

If your unit contains the interface option, there is a Thumbwheel Control for setting the time on duration (1 - 199 seconds) for a Timing Test (see pp. 8-9). Where, time on duration refers to the amount of time that current flows through the device being tested. If the Thumbwheel Control is set at zero, the time on duration is automatically set at a default value of 20 seconds. This is used in conjunction with the new Mc Graw Edison form 4A ME Control, which can take up to 140 seconds (total time) to lock out.
ERROR STATEMENTS

The microprocessor is programmed to detect three types of errors associated with the operation of the test set. To reset the error statement, press the LAMP TEST Button.

OPERATOR ERRORS

In the event the operator fails to setup the test set properly for testing or misoperates the unit, the test set will indicate the error made.

Code E01; means that the operator failed to set a Current Range or failed to select a Mode of operation.

Code E02; means the IMPEDANCE TAP SELECTOR Switch was operated during a test. The switch should not be moved while a test is in progress.

DEVICE RELATED ERRORS

In the event the device under test misoperates, such as contact bounce, the test set will indicate what type of error occurred.

Code E52; means the external contacts associated with the EXTERNAL CONTACT STOP Button operated without the button being selected. If it is desired to de-initiate the test set and record the tripping action of an external set of contacts, the EXTERNAL CONTACT STOP Mode must be selected.

Code E96; means that an attempt was made to initiate a test without having satisfied one or more of the interlocks.

INTERNAL ERRORS

Code E90, 91 or 92 indicates a hardware/software problem with the microprocessor, the factory should be notified.
TEST PROCEDURES

SERIES TYPE RECLOSERS

MINIMUM PICK-UP TEST

1. Connect output of test set to OCR under test. To save time, select an output tap which coincides with the desired test current used in the TIMING TEST (see SELECTION OF OUTPUT TERMINAL on page 5).

2. Turn input power to test set ON, allow 1 to 2 minutes for the digital instruments to warm up.

3. Depress LAMP TEST Pushbutton and observe that all indicators and instrument display segments are lit. Instrument displays should read 000.

   NOTE: It is not necessary to press the LAMP TEST Button after each test, only upon initial power-up operation. The digital displays are auto resetting and do not require resetting using the LAMP TEST Button.

4. Select the proper AMMETER RANGE which will allow measurement of 2 times coil rating of recloser under test. (Example: OCR with 35A coil should have 70A pickup, therefore select 200A range.)

5. Press MIN PICKUP Pushbutton and observe that MIN PICKUP and MAINT Test Mode Indicators are lit.

6. Step on the safety interlock footswitch and press the START Pushbutton. Observe that TEST ON and OUTPUT ENERGIZED Indicators are lit.

7. Increase output control in a clockwise direction. The CURRENT Meter should begin to indicate current flow. Continue to increase output current while observing the MIN PICKUP Indicator Light. Increase output until MIN PICKUP Indicator flashes, then decrease output control to zero.

8. Step off the safety interlock footswitch. Read and record minimum pickup current on CURRENT Display.

   NOTE: Rotating the output control too slowly will induce error into the detection of pickup by the microprocessor.

TIMING TEST

1. Determine test current to be applied to OCR under test. This is usually 4 to 6 times coil rating. (Example: 35A coil tested at 4 times would require 140 amps.)

2. Select proper ammeter range.

3. Use IMPEDANCE TAP SELECTOR Switch to adjust impedance network. (See Selection of Matching Impedance page 5.)

4. Press MANUAL Pushbutton and observe that MANUAL Test Mode and MOM Output Control Indicators are lit.
5. To set test current prior to running timing test, the output is momentarily initiated, the current is read on the ammeter and the output control is then readjusted.

This is done by stepping on the footswitch and then alternately increasing output control in clockwise direction and momentarily pressing START Pushbutton. The test set will initiate for 4 cycles, observe CURRENT Display. Repeat initiating output and increasing output control until proper current value is obtained. Step off the foot switch.

6. Press OCR TIMING Pushbutton. If there are less than 4 operations to lockout, press and release LOCKOUT Pushbutton until the Operations Expected Indicator for the anticipated number of operations to lockout is lit (1, 2 or 3).

7. Be sure to allow the OCR time to completely reset before initiating timing test.

8. Step on the footswitch and press START Pushbutton. Current will flow in the OCR under test and it will begin its sequence of operations. The TEST ON and OUTPUT ENERGIZED Indicators will be lit. The Operations Recorded Indicators will indicate each operation. At the end of the test interval the test set will de-initiate and one of three Indicators will be lit.

   A. **LOCKOUT**

   This indicates the OCR under test has operated the number of times programmed in step 6. When the reclosure goes to lock out, after several (4-5) seconds, the test set will automatically de-initiate.

   B. **EXCESS SHOT**

   This light indicates that the OCR under test has operated more than the programmed number of operations.

   C. **EXCESS TIME**

   This light indicates that the OCR under test has not reached lockout in the prescribed length of time.

   NOTE: If an error statement is displayed, for example E01, see explanation under Error Statements on Page 6.

9. At the completion of the test the TEST ON and OUTPUT ENERGIZED Indications will be extinguished. At this point the operator can step off of the footswitch.

10. Depress the #1 OCR Operation Pushbutton. Read and record CURRENT, TRIP TIME, and RECLOSE TIME as given on the Displays. Pressing the #2 OCR Operation will give the values for the second operation. Repeat for each operation.

    NOTE: The final operation will give a TOTAL TIME value instead of a reclose time.

11. Return output control to zero and turn test set OFF.
TESTING VACUUM TYPE RECLOSERS

Most vacuum reclosers test the same as a series type oil circuit reclosers. The same test procedure may be used to test vacuum reclosers. It must be noted that the contacts used in vacuum reclosers tend to bounce, which can cause timing errors and may also be interpreted by the microprocessor as an excess shot. When testing vacuum reclosers, if an abnormally fast trip time is indicated, or the EXCESS SHOT Lamp illuminates, or if an error statement E53 is illuminated, this would indicate contact bounce has occurred. When this occurs, it may be desirable to retest the recloser. The microprocessor is programmed to ignore contact bounce which occur up to 8 milliseconds. If the problem persists, inspect the recloser for internal problem.

RECLOSERS REQUIRING LINE VOLTAGE FOR CLOSING

It is recommended that reclosers which require line voltage for closing be tested using one of the previous procedures and manually closed after each operation. This procedure will verify the time current operation and avoids the danger of having high voltage in the test area. The recloser must be manually closed within a few seconds after operation in order to establish a normal sequence of operation (prevent the recloser from resetting).

However, if testing with line voltage is required, connect the OCR-8015 to "A-O" of the recloser, and connect the high voltage source to "B" and "C" phases.

WARNING

Do not connect the high voltage source to the same phase as the OCR-8015 is connected.

Perform pick-up and timing tests the same as a series type recloser. To perform tests to B and C phases will require manually reclosing as previously discussed above.
SECTIONALIZERS

TRIP TEST

1. Connect output of test set to sectionalizer under test.

2. Turn test set ON, allow 1 to 2 minutes for the digital instruments to warm up.

3. Depress LAMP TEST Pushbutton and observe that all indicators and instrument display segments are lit. Instrument displays should read 000.

   NOTE: It is not necessary to press the LAMP TEST Button after each test, only upon initial power-up operation. The digital displays are auto resetting and do not require resetting using the LAMP TEST Button.

4. Select the proper AMMETER RANGE for the desired test current to be used. Switch the IMPEDANCE TAP SELECTOR Switch to position 15.

5. Press the MANUAL MODE Button and observe the MANUAL and MOM. Output Control Indicators are lit.

6. Press the MAINT. Pushbutton.

7. Step on the footswitch and press the START Button. Increase the output control clockwise until the desired test current is observed on the CURRENT Display. Press STOP Pushbutton and step off of the footswitch.

8. Press SECT. TEST Pushbutton and observe SECT. TEST and #2 OPERATIONS EXPECTED Indicators are lit. If the sectionalizer to be tested is a three shot sectionalizer, press the LOCKOUT Pushbutton once so that the #3 OPERATIONS EXPECTED Lamp is lit. Allow 1 to 2 minutes for the sectionalizer to reset.

9. Step onto the footswitch and press the START Pushbutton. The test set will initiate and test current will flow. The test set will alternately de-initiate and re-initiate the prescribed number of operations. If the sectionalizer operates properly, the LOCKOUT Lamp will light. If the sectionalizer operates too many shots or no operation, the test set will indicate EXCESS SHOT. If the sectionalizer does not operate enough shots and opens prematurely, the SECT. Light will flash. Step off of the footswitch.

10. Return Output Control to zero, turn test set OFF.
TESTING OF MOTOR OVERLOAD RELAYS

GENERAL INFORMATION

Always refer to the manufacturer's literature applicable to the particular overload relay before testing. The test operator should be familiar with the operating characteristics of the relay, the tolerances applicable to the operating characteristics and any means of adjusting the relay.

The test usually performed on these devices is to verify the time delay characteristics of the relay when subjected to an overload. One test point is usually suggested to establish whether the relay is operating correctly and within the band of the time-current curve for the relay. The suggested test current is three times (3x) the normal current rating of thermal overload relays or three times (3x) the pick-up current (setting) of magnetic overload relays.

It is, of course, easiest to make the connections and perform the tests on the relays if they are removed from the starter. However, it is not necessary to remove the relay as long as the power circuit is de-energized and the test leads can be connected to the device. The high current leads from the test set to the relay under test should be kept as short as possible and should be twisted to minimize loses caused by inductive reactance.

Run the test and note the time required for the overload relay to trip. If the tripping time exceeds the desired value, or if the relay does not trip at all, the relay may not be protecting the motor properly. If the relay operates too quickly, it may result in unnecessary nuisance trips. It should be remembered that these devices operate over a wide band and precise results should not be sought. A tolerance of $\pm 15\%$ is usually acceptable.

If a thermal overload relay is not operating properly, tripping too soon or too late, remove the heater element. Note its type, rating, etc., and compare with manufacturer's data for operating characteristics of the motor. If correct for the application, substitute a new heater of the same rating and retest. If either under- or over-sized heater elements are being used, replace with the proper size heater and retest.

If a magnetic overload relay is not operating properly, refer to the relay manufacturer's literature for instructions on making adjustments of the timer delay. If the relay is operating improperly, it also may be desirable to verify the pick-up point (minimum operating point) of the relay. To perform this test, it is necessary to disengage the timer delay feature of the overload relay. Refer to the manufacturer's literature for detailed instructions.
TESTING OF TIME DELAY

1. Connect the test set to a suitable source of power. Be sure that the circuit breaker on the test set is OFF.

2. Make sure the motor circuit is de-energized.

3. Connect the output of the test set to the terminal of the heater of operating coil to be tested. (See SELECTION OF OUTPUT TERMINAL).

4. Connect a set of light leads from the binding posts marked EXT. CONTACT (located above output terminals) to the control circuit contacts of the relay being tested.

5. Turn test set's circuit breaker ON, allow 1 to 2 minutes for the digital instruments to warm up.

6. Depress LAMP TEST Pushbutton and observe that all Indicators and instrument Display Segments are lit. Instrument displays should read 000. It is not necessary to press the LAMP TEST Button after each test, only upon initial power-up. The digital meters are autoresetting.

7. Select proper AMMETER RANGE. Select timing Mode i.e. SECONDS or CYCLES. Switch the IMPEDANCE LOAD COMPENSATOR Switch to position 15.

8. Press MANUAL Pushbutton and observe that MANUAL Test Mode and MOM. Output Control Indicators are lit.

9. To set test current prior to running timing test, the output is momentarily initiated, the current is read on the ammeter and the output control is then readjusted. This is done by first stepping onto the footswitch and then alternately increasing output control in clockwise direction (about 10% at a time) and momentarily pressing START Pushbutton. The test set will initiate for 4 cycles, observe CURRENT Display. Repeat initiating output and increasing output control until proper current value is obtained. Step off of the footswitch.

10. Wait several minutes to allow the overload relay to cool or the plunger to settle in the dash pot.

11. Press the MAINT. Output Control Pushbutton and the EXT. CONTACT STOP Test Mode Pushbutton. Indicators should be lit.

12. Initiate unit by stepping onto the footswitch and then pressing START Button. The timer will stop and the output will automatically de-energize when the overload relay operates. Step off of the footswitch.

    NOTE: Check the ammeter reading during the test for accuracy, minor adjustments may be made with the OUTPUT CONTROL while the test is in progress.

13. Record the results and compare them to the manufacturer's specifications.

14. Return output control to zero. Turn test set OFF.
GENERAL INFORMATION

The OCR-8015 is capable of testing the time delay of molded case and low voltage power circuit breakers rated up to 800 amperes. It will provide up to 6,000 amperes for testing the short time delay or instantaneous trip elements of breakers rated up to 600 amperes.

Always refer to the manufacturer's literature applicable to the particular circuit breaker before testing. The test operator should be familiar with the operating characteristics of the circuit breaker, the tolerances applicable to the operation characteristics and any means for adjusting the circuit breakers.

Molded case breakers are usually tested for verification of the time delay characteristics and the minimum operating point (pick-up point) of the instantaneous element. Low voltage power breakers with solid-state or electro-mechanical trip devices are usually tested for verification of the time delay characteristics of the long time delay and short time delay elements and for the minimum operating point (pick-up point) of the instantaneous element. Each breaker pole should be tested independently so that all trip devices are tested.

One test point is usually sufficient to establish whether the long time delay or short time delay element is operating properly and within the band width of its time-current characteristics. For molded case breakers the suggested test current of the time delay element is three times \(3x\) the current rating of the breaker; for low voltage power circuit breakers, suggested test current is three times \(3x\) the pick-up setting of the long time delay element and one and one half times \(1.5x\) the short time delay setting where the type of trip characteristics is incorporated on the trip device.

On both molded case and low voltage power breakers, the instantaneous element is tested to verify the minimum current necessary to cause the breaker to consistently trip instantaneously.

When testing instantaneous trip elements, run the test to find the minimum current required to trip the breaker instantaneously and compare to the setting. Remember the instantaneous elements have an operating tolerance of from \(\pm 10\%\) to \(\pm 25\%\) of setting, depending on the particular trip device. On molded case circuit breakers, it is suggested that the time delay elements be tested before any instantaneous tests are performed.

Most modern low voltage power circuit breakers are of the "draw-out" type. These breakers should be tested using Multi-Amp Models CB equipped with the appropriate stabs to directly connect the breaker to the test set. However, these breakers can be tested with the OCR-8015 with the appropriate test leads clamped to the breaker terminals. When testing molded case breakers or any other breaker where leads are required to connect it to the test set, the leads should be as short as possible and twisted to minimize losses. See section on OUTPUT CONNECTIONS.
TESTING OF TIME DELAY

1. Connect the test set to a suitable source of power. Be sure that the circuit breaker on the test set is OFF.

2. Make sure the line side circuit of the breaker to be tested is de-energized or disconnected. Close the breaker to be tested.

3. Connect the test set output terminals to one pole of the breaker to be tested. (See SELECTION OF OUTPUT TERMINALS.)

4. A. If the timer and the test set are to be stopped using external contacts, connect a set of light leads from the EXT. CONTACT Binding Posts to another pole of the breaker under test or the desired auxiliary contact. Use the same test procedure for testing motor overload relays. Go to step 5, on page 13.

   B. If the timer and the test set are to be stopped by the tripping of the circuit breaker, continue to step 5 below.

5. Turn test set circuit breaker ON, allow 1 to 2 minutes for warm up.

6. Depress LAMP TEST Pushbutton and observe that all Indicators and instruments Display Segments are lit. Instrument display should read 000. It is not necessary to press the LAMP TEST Button after each test, only upon initial power-up. The digital meters are autoresetting.

7. Verify proper AMMETER RANGE. Select Timing Mode i.e. SECONDS or CYCLES. Switch the IMPEDANCE TAP SELECTOR Switch to position 15.

8. Press MANUAL Pushbutton and observe that MANUAL Test Mode and MOM Output Control Indicators are lit.

9. To set test current prior to running timing test, the output is momentarily initiated, the current is read on the ammeter and the output control is then readjusted. This is done by first stepping onto the footswitch, and then alternately increasing output control in clockwise direction (about 10% at a time) and momentarily pressing START Pushbutton. The test set will initiate for 4 cycles, observe CURRENT Display. Repeat initiating output and increasing output control until proper current value is obtained. Step off of the footswitch.


11. Initiate unit by stepping onto the footswitch and pressing START Button. The timer will stop and output will automatically de-energize when the circuit breaker operates. Step off of the footswitch.

   NOTE: Monitor the ammeter reading during the test for accuracy; minor adjustments may be made with the output control while test is in progress.

12. Record the results and compare them to the manufacturer's specifications.

13. Return OUTPUT CONTROL to zero, turn test set OFF.
TESTING OF INSTANTANEOUS PICK-UP

1. Repeat steps 2 through 8 above, TESTING OF TIME DELAY.

2. Rotate OUTPUT CONTROL clockwise while stepping onto the footswitch and alternately pressing the START Button until the circuit breaker under test trips instantaneously. Step off of the footswitch. Read ammeter for value of current required to trip breaker.

3. Record the results and compare them to the manufacturer's specifications.

4. Return OUTPUT CONTROL to zero, turn test set OFF.
MAINTENANCE OF PROTECTIVE DEVICES

MAINTENANCE OF MOTOR OVERLOAD RELAYS

APPLICATION

The prime function of the motor overload relay is to prevent operation of a motor for too long a period of time when an overload condition exists.

In general, motor starters are applicable to a given horsepower range of motors. The voltage and current requirements of the application will "size" the starter under NEMA requirements, but the actual starting current, running current, ambient temperature and severity of atmospheric conditions will determine the overload relay rating required to protect the motor without nuisance tripping.

Selection of the properly rated overload relay heater or coil can be made by reference to tables or charts supplied by the manufacturer of the overload relays. Whenever a motor trips out it is poor practice to indiscriminately install a larger heater or coil, since the motor may actually be working under an overload condition or the overload relay may be operating improperly. Installing a larger heater or coil could allow an overloaded motor to continue to run, resulting in deterioration of the motor insulation and reduction motor life. Therefore, careful analysis should be made as to the cause of the trip before changing the rating of the overload relay heater. Operating characteristics of the motor overload relay should be verified at regular intervals. The inspection and test interval can vary widely depending on the type of service involved, the importance of the motor to process or production, and environmental conditions.

TYPES

Motor overload relays incorporate an element which actuates a set of contacts connected to the motor control circuit. These contacts open the circuit of the holding coil in the meter starter and interrupt the power to the motor.

In general, there are three types of motor overload relays in use:

1. Thermal - melting allow or solder pot.
2. Thermal - bimetallic strip.
3. Electromagnetic

In thermal type relays, time-current characteristics are obtained by the thermal properties of the melting alloy or bimetallic strip. In the magnetic type, a damped plunger or moving iron device is used to produce time delays.
1. **Thermal - melting allow or solder pot**

   In this type, tripping is the result of heat generated by the motor overload current passing through a "heater" in the overload relay. This overload relay consists of a brass shaft which is surrounded by solder. Fixed to one end of the shaft is a small ratchet wheel. As long as the solder is solid, this assembly is immobile. When the motor control circuit contacts are closed, a spring in the motor overload relay is held compressed by the immobility of the ratchet wheel. An overload condition in the motor increases the current through the heater, thus melting the solder allowing the ratchet wheel to move, and releasing the energy in the spring. This interrupts the circuit of the holding coil in the motor starter and shuts down the motor.

   The starter may be reset only after the heater has cooled sufficiently to permit the solder to reset and again make the ratchet and shaft immobile. Reset is usually accomplished by an external pushbutton on the face of the starter. Many motor overload relays offer a selection of either manual or automatic reset.

2. **Thermal - Bimetallic strip**

   This type uses a bimetallic strip---two pieces of dissimilar metal bonded together. An increase in heat will cause movement of the bimetallic unit and eventually open a set of contacts in the motor control, thus opening the holding coil circuit and shutting down the motor.

   The principle of operation is the same as the melting alloy type. When the bimetallic element has cooled sufficiently, the motor control circuit may be reset either manually or automatically.

3. **Electromagnetic**

   In this type of motor overload relay, a damped plunger or moving iron device is used to produce the delays required and initiate the trip signal to the interrupting device. In the most common type of magnetic relay, movement of an armature or piston rod is delayed by a dashpot.

   When the electromagnetic field produced by the operating coil is strong enough, the piston in the dashpot moves through the oil to trigger the opening of the relay contacts, shutting down the motor. Usually, magnetic overload relays with oil dashpots have facilities which permit adjusting their minimum operating current (pick-up point) and their time delay characteristics.
PLANNED MAINTENANCE PROGRAM

A scheduled program for maintenance of motor overload relays consists primarily of "good housekeeping" in conjunction with visual inspections, tightening of electrical connections, and electrical testing. A brief outline is given on the next page:

1. **CLEAN**

   All types of motor overload relays should be cleaned periodically to ensure continued, reliable operation. It is possible for dirt or dust created by conditions in the plant to prevent parts of the relay from moving. Also, these same conditions can prevent the proper dissipation of normal heat, resulting in unnecessary operation of thermal type overload relays.

2. **TIGHTEN CONNECTIONS**

   This is particularly important in thermal overload relays. Loose electrical connections can cause extra heat which may result in a nuisance operation of the relay.

3. **INSPECT HEATER SIZE**

   Determine that the specified heater is used in thermal overload relays. Too often, oversized heaters are arbitrarily installed to eliminate unexplained trips. Actually, the original heaters may have oxidized over a period of time, becoming smaller in cross section. Then, the heat required to operate the relay is provided by a smaller amount of current than that intended by the original design. This may make the relay trip prematurely and the heater appear undersized.

4. **INSPECT SETTINGS (Where applicable)**

   Most magnetic overload relays have adjustable settings for minimum operating current and time delay characteristics. These should be adjusted to the specified settings.

5. **TEST**

   The motor overload relay should be subjected to a simulated overload and the tripping time measured. This time should be compared to the manufacturer's specifications of the relay's time-current curves to make certain that the relay is operating properly. A tolerance of ± 15% is usually acceptable. If the relay's curves or specifications are not available, it is suggested that the Heat Damage Curve of the motor be used as a guide for maximum trip time at 300% of motor full load current.
MAINTENANCE OF MOLDED CASE CIRCUIT BREAKERS

DESCRIPTION

The molded case circuit breaker essentially consists of two separate elements. One element is a set of contacts and suitable mechanical linkage for manual operation of the breaker as a switch in an electric circuit. The other element is a device to sense and react to an overload or short circuit. Normally, the time delay overload device is thermal and the instantaneous overload device, when supplied, is magnetic. Some newer styles include solid-state trip elements and operate very similar to low voltage power circuit breakers (see page 22 for description of characteristics).

The thermal element uses a bimetallic strip—two pieces of dissimilar material bonded together. An overload causes an increase in heat which will result in moving the bimetallic unit, releasing a latching spring which trips the circuit breaker.

A small percentage of molded case circuit breakers achieve their time delay through the use of an electromagnet, whose operation is opposed by a fluid filled dash pot.

The magnetic element operates with no intentional time delay to provide instantaneous protection against high magnitude faults.

In small molded case circuit breakers, the instantaneous element is not adjustable as it is factory set and sealed. In larger molded case breakers, the instantaneous pickup of the trip may be adjustable and is set with an adjustment screw. This type breaker may be shipped from the factory with the instantaneous element set at maximum if the setting is not specified by the purchaser; therefore, it is necessary to check these adjustable instantaneous settings before putting the breaker in service.

PLANNED MAINTENANCE PROGRAM

A scheduled program for maintenance of molded case circuit breakers consists primarily of "good housekeeping" in conjunction with visual inspections, tightening of connections and electrical testing. A brief outline is given below:

1. CLEAN

All types of molded case circuit breakers should be externally cleaned periodically so that the heat produced in normally operation can be dissipated properly. It is possible for dirt or dust caused by normal plant conditions to accumulate and prevent proper dissipation of heat, resulting in a nuisance operation of the breaker.

2. TIGHTEN CONNECTIONS

This is particularly important, because loose electrical connections will cause deterioration of the breaker terminals and an eventual phase to phase or phase to ground fault.
3. **TEST**

The molded case circuit breaker should be subjected to a simulated overload and the tripping time measured. This important because after a period of inactivity, the overload device may become stiff or inoperable. The only way to determine this condition and eliminate the stiffness is to electrically operate the breaker on a periodic basis. Manually opening and closing the main contacts of the breaker does not move any of the mechanical linkage associated with the overload device. Testing may be as often as every 6 months or as long as every 3 or 4 years, depending upon conditions where the breaker is installed.
MAINTENANCE OF LOW VOLTAGE POWER CIRCUIT BREAKERS

APPLICATION

The low voltage power circuit breaker has a wide application and may be used to protect circuits up to 600 volts ac or 250 volts dc. These devices are essentially two separate elements. One element is a set of contacts with suitable mechanical linkage for operating the breaker as a switch. The other element is a device to sense and react to an overload or short circuit condition. Low voltage power circuit breakers are manufactured with either electro-mechanical or solid-state trip devices.

SOLID-STATE TRIP ELEMENTS

This type of breaker uses a sample of the load current to supply a signal to an electronic sensing element. When an overload or short circuit condition exists, the solid-state sensing element sends a signal to a solenoid which releases the latching mechanism and trips the circuit breaker. This type eliminates the magnetic coil and dashpot mechanism of the electro-mechanical trip device.

ELECTRO-MECHANICAL TRIP ELEMENTS

Series tripped, direct acting low voltage power circuit breakers are tripped by the movement of an armature which strikes the trip bar of the breaker. The trip bar operates a latch which releases stored energy to rapidly open the breaker contacts. The armature of the trip unit is attracted to a pole piece through the magnetic field set up by current through a coil. The current through the coil is either the actual load current of the secondary output of a current transformer. For time delay the armature is restrained mechanically. Tripping time is a function of magnitude of current through the breaker.

Low Voltage Power Circuit Breakers are available with three types of tripping characteristics:

1. **LONG TIME DELAY**
   The long time delay characteristic provides overload protection with typical time delays of approximately 10 - 60 seconds at 300% of pickup.

2. **SHORT TIME DELAY**
   The short time delay characteristics provides protection for short circuit or fault conditions. It is used whenever a small delay is necessary for coordination or selectivity with other protective devices. Typical delays of this type characteristics are approximately 6 - 30 cycles.

3. **INSTANTANEOUS**
   The instantaneous trip characteristics is used for short circuit or fault protection and has no intentional time delay.
PLANNED MAINTENANCE PROGRAM

A scheduled program for maintenance of low voltage power circuit breakers consists primarily of "good housekeeping" in conjunction with visual inspection, tightening all connections and non-pivotal joints, and electrical testing.

1. CLEAN AND TIGHTEN

   Low voltage power circuit breakers should be periodically cleaned, tightened and inspected. The manufacturer's instruction book for the breaker should be read thoroughly and his recommendations for lubricating and clearances should be followed closely.

2. TEST

   The voltage power circuit breaker should be subjected to simulated overload conditions to verify that the breaker is operating within its specifications and tolerances. This is important because, after a period of time, vibration and environment conditions can render the breaker inoperable. Manually opening or closing the main contacts of the breaker does not "exercise" the overload trip device.
SERVICE DATA

SERVICING

The test set utilizes straightforward circuits and components which require little or no service except for routine cleaning, tightening of connections, etc. The test set should be serviced in a clean atmosphere away from energized electrical circuits. The following maintenance is recommended:

1. Open the unit every six months and examine for:
   a. dirt/dust
   b. moisture
   c. corrosion

2. Remove dirt/dust with dry, compressed air.

3. Remove moisture as much as possible by putting test set in a warm, dry environment.

4. As corrosion may take many forms, no specific recommendations can be made for its removal. However, it is suggested that the relay contacts be burnished using a diamond burnishing tool or an extra fine sand paper.

5. Check ribbon/cable connections for solid connections and printed circuit boards.

SERVICE AND REPAIR ORDER INSTRUCTIONS

If factory service is required or desired, contact the factory for return instructions.

A Service & Repair Order (SRO) number will be assigned for proper handling of the unit when it arrives at the factory. If desired, a letter with the number and instructions can be provided.

Provide the factory with model number, serial number, nature of the problem or service desired, return address, your name, and where you can be reached should the factory need to contact you.

A purchase order number, cost limit, billing, and return shipping instructions may also be provided if desired.

National Bureau of Standards traceable calibration and certification of two types is available, if desired, at additional cost.

**Class One:** A certificate is provided verifying the traceability and calibration of the equipment.

**Class N:** That which is required for nuclear power plants. A certificate of traceability and calibration along with "as found" and "as left" data are provided.
If an estimate is requested, provide the name and contact information of the person with approval/disapproval authority.

Pack the equipment appropriately to prevent damage during shipment. If a reusable crate or container is used, the unit will be returned in it if in suitable condition.

Put the SRO number on the address label of the shipping container for proper identification and faster handling.

NOTE: Ship the equipment without instruction manuals or nonessential items such as test leads, spare fuses, etc. These items are not needed to conduct repairs. Do ship the equipment with all interconnect cables, etc. which make the unit operational.

PREPARATION FOR RESHIPMENT

Save the shipping container that your unit came in. The shipping container your unit came in is designed to withstand the normal bumps and shocks of shipping via common commercial carrier. For example, you may wish to reship your unit to Multi-Amp for annual calibration certification.

WARRANTY STATEMENT

Multi-Amp warrants to the original purchaser that the product is free from defects in material and workmanship for a period of one (1) year from date of shipment. This warranty is limited and shall not apply to equipment which has damage, or cause of defect, due to accident, negligence, unauthorized modifications, improper operation, faulty installation by purchaser, or improper service or repair by any person, company or corporation not authorized by the Multi-Amp.

Multi-Amp will, at its' option, either repair or replace those parts and/or materials that it deems to be defective. Any costs incurred by the purchaser for the repair or replacement of such parts and/or materials shall be the sole responsibility of the original purchaser.

THE ABOVE WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED ON THE PART OF THE Multi-Amp, AND IN NO EVENT SHALL AVO INTERNATIONAL BE LIABLE FOR THE CONSEQUENTIAL DAMAGES DUE TO THE BREACH THEREOF.
COMPUTER/PRINTER INTERFACE AND CONTROL

GENERAL DESCRIPTION

The unit is equipped with an RS-232 Interface for data retrieval by a remote computer. The unit includes remote control via the RS-232 Interface. When operating, the following data would be captured.

Minimum Trip Current: This test determines the minimum operating (pick-up) point.

Sequence of Operation: This test verifies the number and sequence of operations to lock-out.

Time Current Characteristics: This test determines the operating characteristics of the recloser under simulated fault conditions.

Operating Time: Digital timer measures the elapsed time of each operation.

Reclosing Time: Digital timer measures the reclosing interval between each operation.

Total Clearing Time: Digital timer measures the total elapsed time to lock-out.

INTERFACING CONSIDERATIONS

The 25 pin connector is located on the right-side panel of the control cabinet. Connect the User I/O port on your computer to this connector. Port 0 of the MF9 CPU is used for the RS-232 interface. For interfacing, see Section 2.6 SERIAL PORTS of the MF9 USER'S MANUAL. The characteristics of the port are:

1. 9600 Baud
2. 8 bit Character Length
3. 1 Stop Bit
4. No parity
5. Break Detect

The interface can run at slower speeds, however, it is recommended that the CPU board be returned to Dallas, Texas for reprogramming, (see return instructions on pp. 26-27).

NOTE: When the RS-232 Interface is not in use, the jumper end cap must be in place, or the control panel will "lock up".

The Printer Port is a standard Centronix Parallel Port. For interface to a printer, refer to your printer owner's manual.
COMMAND DATA FORMAT

The OCR-8015 with interface options may be controlled from a computer over the RS-232 port almost exactly as it is controlled by the front panel pushbuttons. The command codes listed on the next page, with a few exceptions marked "*", have the same effect that the corresponding pushbuttons would have and must be used in the correct sequence. The pushbuttons are explained in Section II, Description of Controls.

Each command is passed across the bus in a string of hexadecimal numbers. The command string must be prefixed with a start transmission code, followed by a command (which maybe followed by a data entry), and ended with an end of transmission code.

Each command string must have the following form:

Start Transmission Code (STX)
Command
Variable N (Data Entry in some cases)
End Transmission Code (ETX)

The Start Transmission Code (ASCII - STX) in keystrokes on a standard keyboard is "\texttt{Ctrl-b}" (hold Ctrl key while pressing b).

The Commands are as shown on the next page, in keystrokes. For example, to set the 200 Amp Range the appropriate command is "\texttt{01}".

The End Transmission Code (ASCII - ETX) in keystrokes on a standard keyboard is "\texttt{Ctrl-c}" (hold Ctrl key while pressing c).

Example:

The following is an example of a string of commands, using a keyboard, for selecting the OCR TIMING Mode, selecting the 2KA Range and starting the test.

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>COMMAND STRING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Select OCR TIMING Mode</td>
<td>\texttt{Ctrl-b} (STX) \texttt{12} (OCR TIMING) \texttt{Ctrl-c} (ETX)</td>
</tr>
<tr>
<td>2. Select 2KA Range</td>
<td>\texttt{Ctrl-b} (STX) \texttt{02} (2KA Range) \texttt{Ctrl-c} (ETX)</td>
</tr>
<tr>
<td>3. START Test</td>
<td>\texttt{Ctrl-b} (STX) \texttt{0Ctrl-n} (START Test) \texttt{Ctrl-c} (ETX)</td>
</tr>
</tbody>
</table>

NOTE: When OCR TIMING Mode is selected, the test set automatically defaults to four operations to LOCKOUT and EXCESS TIME is strapped value (normally
20 seconds). If the recloser under test requires a longer limit to lockout, the
EXCESS TIME limit can be programmed to a higher value. For example, to set
an EXCESS TIME limit of 95 seconds, send the additional command prior to
starting the test:
**OPERATION COMMAND STRING**

Set EXCESS TIME Limit to 95 seconds

<table>
<thead>
<tr>
<th>CMD</th>
<th>N</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>-</td>
<td>Set 20 Amp Range</td>
</tr>
<tr>
<td>01</td>
<td>-</td>
<td>Set 200 Amp Range</td>
</tr>
<tr>
<td>02</td>
<td>-</td>
<td>Set 2K Amp Range</td>
</tr>
<tr>
<td>03</td>
<td>-</td>
<td>Set 20K Amp Range</td>
</tr>
<tr>
<td>04</td>
<td>-</td>
<td>Display data from shot 1 (on front panel only)</td>
</tr>
<tr>
<td>05</td>
<td>-</td>
<td>Display data from shot 2 (on front panel only)</td>
</tr>
<tr>
<td>06</td>
<td>-</td>
<td>Display data from shot 3 (on front panel only)</td>
</tr>
<tr>
<td>07</td>
<td>-</td>
<td>Display data from shot 4 (on front panel only)</td>
</tr>
<tr>
<td>08</td>
<td>-</td>
<td>MINimum PICKUP Mode</td>
</tr>
<tr>
<td>09</td>
<td>-</td>
<td>SECTionalizer Mode</td>
</tr>
<tr>
<td>Ctrl-j</td>
<td>-</td>
<td>MANUAL Mode (must be selected before MOMentary or MAINTained Modes)</td>
</tr>
<tr>
<td>Ctrl-k</td>
<td>-</td>
<td>EXTernal STOP enable</td>
</tr>
<tr>
<td>Ctrl-l</td>
<td>-</td>
<td>LAMP TEST/soft reset - clears error code and zeroes displays (also see code 19).</td>
</tr>
<tr>
<td>*0Ctrl-m</td>
<td>[0n]</td>
<td>Set number of operations expected to lockout 1 to 4. Note that a 0 in the data string equals 1, and 3 equals 4 operations to lockout.</td>
</tr>
<tr>
<td>0Ctrl-n</td>
<td>-</td>
<td>Start command</td>
</tr>
<tr>
<td>0Ctrl-o</td>
<td>-</td>
<td>MOMentary Mode</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>OCR TIMING Mode</td>
</tr>
<tr>
<td>11</td>
<td>-</td>
<td>Not used (reserved for future use)</td>
</tr>
<tr>
<td>12</td>
<td>-</td>
<td>Not used (reserved for future use)</td>
</tr>
<tr>
<td>13</td>
<td>-</td>
<td>Not used (reserved for future use)</td>
</tr>
<tr>
<td>*14</td>
<td>[0nnn]</td>
<td>Set EXCESS TIME in seconds 1 to 199 seconds. If left 0, default is value strapped on p.c. board (normally 20 seconds).</td>
</tr>
<tr>
<td>15</td>
<td>-</td>
<td>Computer command to reset excess time, (CMPCTL $1).</td>
</tr>
<tr>
<td>16</td>
<td>-</td>
<td>Computer command to reset cycles, (CMPCTL $2).</td>
</tr>
<tr>
<td>*17</td>
<td>-</td>
<td>Print/repeat - causes data to computer to be repeated and optional printer to print.</td>
</tr>
<tr>
<td>*18</td>
<td>-</td>
<td>STOP</td>
</tr>
<tr>
<td>*19</td>
<td>-</td>
<td>Reset; does a power on (hard) reset (also see code OC)</td>
</tr>
<tr>
<td>1Ctrl-k</td>
<td>[0nnn]</td>
<td>Set variable cycles on for SECTionalizer TEST Mode (test current will be pulsed to sectionalizer in durations of 1 to 199 cycles). Default value is 4 cycles.</td>
</tr>
</tbody>
</table>

**NOTE:**
A Ctrl corresponds to pressing the control (Ctrl) key and the corresponding letter after the "Ctrl" listing. For example 1Ctrl-k corresponds to pressing "1" as the first entry and "Ctrl-k" (both at the same time) as the second entry.
ERROR CONDITIONS

Error conditions are handled in two ways:

1. The test set sends "ERROR^nn^MODE NOT SELECTED" and the condition is automatically reset as through the LAMP TEST (reset) Button had been pressed.

2. The control panel sends "ERROR^nn" and the panel must be reset by pressing the LAMP TEST (reset) Button or from the computer.

The error codes shown as "nn" above are:

Operator Errors

- 01 Incomplete setup; Ammeter RANGE or MODE not set.
- 02 One of the interlocks that are necessary to energize the output of the test set has not been satisfied. This could be the Load Compensator Switch, the Foot Switch, or an External interlock.

Device Related Errors

- 52 External contact operated during an invalid mode.

Computer Related Errors

- 81 Computer selection of Sectionalizer cycles invalid.
- 83 Too many computer selected entries.
- 84 Computer selection of excess time limit invalid.
- 85 Computer status request error.
- 87 Computer communications software error.
- 88 Manual switch setting of sectionalizer cycles invalid.
- 89 Manual selection of excess time limits invalid.

Internal Errors

- 90 Interrupt error.
- 91 Hardware/software/interrupt error.
- 92 Invalid code from keyboard encoder.
- 93 Operations expected out of range; 0 or > 4.
- 95 Printer error.
- 96 Switch check error; stop and safety. This would normally indicate that one of the interlocks that must be satisfied in order to energize the output of the test set is no longer satisfied and is the cause of the test being interrupted.

NOTE: A ^ indicates a space is required.
OUTPUT DATA FORMAT

The panel will automatically transmit (from the RS-232C port), the results of each test upon its completion, no matter what the test mode. The same data will be sent out the optional printer port when it is installed.

The data may be repeated by sending the panel a PRINT/REPEAT command, (see Command Data Format).

Basically each section of data is ended by a carriage return/line feed character. On the printer each section will be a line.

Format

STX (Start Transmission Character; Ctrl-b)

MODE: ____________________________ cr/lf

RESULTS: ____________________________ cr/lf

A1:^5char^A2:^_ _ _ _ _^A3:^_ _ _ _ _^A4:^_ _ _ _ _ cr/lf

T1:^_ _ _^T2:^_ _ _ _ _^T3:^_ _ _ _ _^T4:^_ _ _ _ _ cr/lf

R1:^_ _ _^R2:^_ _ _ _ _^R3:^_ _ _ _ _^TT:^_ _ _ _ _ cr/lf

EXT (End Transmission Character: Ctrl-c)

NOTES:

1. Mode will be: NOT SELECTED, OCR TIMING, MINIMUM PICKUP, SECTIONALIZER, MOMENTARY or MAINTAINED.

2. Results will be EXCESS TIME, LOCKOUT or EXCESS SHOT for OCR timing mode. Other modes will return a blank.

3. In the format above, ^ indicates a space.

4. A1-4, T1-4, and R1-3, refer respectively to amp, trip time and reclose time. TT is the total time until lockout.

5. Each of the A, T and R values will contain five characters including decimal point and spaces. This does not include the spaces defined with a ^ above.

6. Current is given in amperes for all ranges and time is given in seconds.

7. ASCII codes for cr/lf are ctrl-m and ctrl-j.