CAUTION

It is recommended that the user become acquainted with the information in this instruction leaflet before energizing the equipment. Failure to observe this precaution may result in damage to the equipment.

SOFTWARE CAUTION NOTICE

The operation of this relay is based on ABB Power T&D proprietary software, resident in memory components. Purchase of this relay includes a restricted license for the use of any and all programs solely as part of the protective functions. ABB Power T&D reserves the right to request return of the memory components should the relay no longer be used as a protective device. The programs may not be copied, transferred or applied to any other device.

ELECTROSTATIC DISCHARGE CAUTION NOTICE

This relay contains static sensitive components. Electrostatic Discharge (ESD) procedures must be practiced when handling printed circuit boards and components. Use of anti-static handling materials and grounded personnel is required.

1. APPLICATION

The MCO relay is a single phase microprocessor based non-directional inverse-time and instantaneous overcurrent relay. It is used to sense current level above the setting and normally is used to trip a circuit breaker to clear faults. A wide range of characteristics permits applications involving coordination with fuses, reclosers, cold load pickup, motor starting, or essentially fixed time applications.

The MCO relay is equipped with an instantaneous trip feature with separate trip output to provide high speed tripping for high current faults. Instantaneous trip units can be applied effectively where wide variations in fault currents occur for different fault locations, but have limited applications where wide variations in fault current occurs for a fixed fault location. It must be set to override conditions such as transformer inrush, motor locked rotor, and faults outside of the desired trip zone.

Independent contact trip outputs and separate LED indication are provided for the instantaneous and time delay trip. The LED indicators will not be sealed in unless there is current flow in the trip circuit contacts. LED indicator reset is accomplished manually. A self-check monitor LED indication and alarm output contact are also provided.

See SETTINGS section for further application data.

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local ABB Power T&D Company representative should be contacted.

REVISED INFORMATION

EFFECTIVE JUNE 1993
The following describes typical applications of the MCO relay:

<table>
<thead>
<tr>
<th>MCO Time Curve</th>
<th>CO Equivalent</th>
<th>Curve</th>
<th>Typical Applications</th>
</tr>
</thead>
</table>
| 1              | CO-2          | Short   | 1) Differential protection where saturation of current transformers is not expected, or where delayed tripping is permissible.  
|                |               |         | 2) Overcurrent protection, phase or ground, where coordination with downstream devices is not involved and 2 to 60 cycle tripping is allowable. |
| 2              | CO-5          | Long    | Motor locked rotor protection where allowable locked rotor time is approximately between 10 and 70 seconds. |
| 3              | CO-6          | Definite| Overcurrent protection where coordination with downstream devices is not involved and curve #1 is too fast. The operating time of this relay does not vary greatly as current level varies. |
| 4              | CO-7          | Moderately Inverse | 1) Overcurrent protection where coordination with other devices is required, and generation varies.  
|                |               |         | 2) Backup protection for relays on other circuits. |
| 5              | CO-8          | Inverse |                                                          |
| 6              | CO-9          | Very Inverse |                                                          |
| 7              | CO-11         | Extremely Inverse | 1) Motor protection where allowable locked rotor time is less than 10 seconds.  
|                |               |         | 2) Overcurrent protection where coordination with fuses and reclosers is involved, or where cold load pickup or transformer inrush are factors. |

2. CONSTRUCTION

The MCO relay is a microprocessor based relay consisting of 2 printed circuit modules and a front panel, packaged in an FT-11 case. For detailed information on the flexitest case, refer to I.L.41-076. The photographs in Figure 1 show the MCO relay.

2.1 Interface Module

The interface module, mounted at the bottom of the relay, contains a current transformer, four miniature high-power relays and one reed relay.

The input current transformer is wound on a tape wound toroidal core. Pickup setting range is between 0.5 and 12 amperes or 0.1 and 2.4 amperes, depending on relay style. The functions of the four miniature relays are as follows:

a) Time delay trip (TD).

b) Instantaneous trip (IT).

c) Trip contact for either TD or IT trip.

d) Alarm (NC contact) for software and hardware self-check and loss of dc battery voltage.

The reed relay is for monitoring and indication of the actual trip current flow through the trip contacts.
2.2 Microprocessor Module

The microprocessor module, located at the top of the relay, contains the microprocessor, an analog-to-digital (A/D) converter, a custom linear IC, a dc-to-dc power supply, three LED indicators and four DIP switches. The four switches allow selection of the time curve, time dial, tap setting and instantaneous setting. The interface and microprocessor modules are interconnected by a plug-in cable assembly.

2.3 Front Panel

The front panel shows all style, indication and setting information. Two labels, “trip reset” and “trip test”, also printed on the panel, indicate location of the pushbutton switches. These pushbutton switches perform the following functions:

1. Trip Reset - The function of the trip reset is to reset the trip LEDs after they are sealed in by the trip current flow. This switch is located behind the “trip reset” label on the right-hand side of the front panel.

2. Trip Test - The trip test switch is on the left-hand side below the “trip test” label on the front panel. It is a push-to-test switch protected from accidental activation by a shield guard which requires a definite depression of the switch by some device that fits inside the guard, i.e. pencil, slender rod, etc. Once it is depressed, the TD trip relay will pickup.

3. THEORY OF OPERATION

The MCO is a single-phase inverse-time overcurrent relay. A block diagram of the MCO is shown in Fig. 3. The relay simulates the traditional CO curves which are permanently stored in memory and can be called out one at a time depending on the curve number and time dial settings. There are seven curve family sets and each set contains 63 curves. The expressions for these curves are shown in equation (1), for (I/Io) greater than 1.5 per unit, and equation (2) for (I/Io) between 1.0 and 1.5 per unit.

\[
T = \frac{[To + K/(I/Io - C)]^P}{D} \times 24,000 \quad (1)
\]

\[
T = \frac{[R/(I/Io - 1.0)]}{D} \times 24,000 \quad (2)
\]

where
- \(T\) = trip time in seconds
- \(To\) = definite time term
- \(I\) = input current
- \(I_0\) = pickup current settings
- \(K\) = scale factor for the basic inverse time
- \(C\) = a constant
- \(R\) = a constant
- \(P\) = an exponent determining the inverseness
- \(D\) = time dial setting from 1 to 63

To, K, C, P, and R are pre-determined parameters in the program for each curve. Table I shows all values selected in the program. \(I_0\) and D are user selectable parameters via Tap Setting and Time Dial selecting switches respectively.

<table>
<thead>
<tr>
<th>Curve</th>
<th>To</th>
<th>K</th>
<th>C</th>
<th>P</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>112</td>
<td>735</td>
<td>0.675</td>
<td>1</td>
<td>501</td>
</tr>
<tr>
<td>2</td>
<td>8197</td>
<td>13769</td>
<td>1.130</td>
<td>1</td>
<td>22705</td>
</tr>
<tr>
<td>3</td>
<td>785</td>
<td>671</td>
<td>1.190</td>
<td>1</td>
<td>1475</td>
</tr>
<tr>
<td>4</td>
<td>525</td>
<td>3121</td>
<td>0.800</td>
<td>1</td>
<td>2491</td>
</tr>
<tr>
<td>5</td>
<td>478</td>
<td>4122</td>
<td>1.270</td>
<td>1</td>
<td>9200</td>
</tr>
<tr>
<td>6</td>
<td>310</td>
<td>2756</td>
<td>1.350</td>
<td>1</td>
<td>9342</td>
</tr>
<tr>
<td>7</td>
<td>110</td>
<td>17640</td>
<td>0.500</td>
<td>2</td>
<td>8875</td>
</tr>
</tbody>
</table>

The MCO internal schematic is shown in Fig. 4. The input current from terminals 8 and 9 is applied to the current transformer TX1. Rectifier DB1 generates a negative going full-wave rectified voltage across load resistors R4 to R8, at pins 1 and 3 of the connector J2. Resistors R4 to R8 are designed to match the binary numbers selected by switch SW4. If all switches in SW4 are open, a tap setting of 0.5 amperes (0.1 for relays with a 0.1 to 2.4 amp range) has been selected. Refer to the SETTNGS section for the equations used to select tap settings.

Load resistors R4 to R9 are set up as a current divider to provide a negative going 36.5 microamps for a one per-unit input current, for each tap setting. This current is input to the custom linear integrated circuit U7. This chip contains a 4 channel analog multiplexer and a programmable gain amplifier.

Only one input channel to the multiplexer can be selected at a time and this is controlled by microprocessor generated signals to pins S1 and S2 on the custom chip. Table 2 is the truth table for the S1, S2 pins and the selected channel. For the MCO relay, channels B, C and G are not used.

The gain of the programmable amplifier is controlled by the R1 and R2 pins on the custom chip. Table 3 is the truth table for R1, R2 and the selected gain. The programmable gain amplifier only works on a negative current, i.e. the current must flow out of the summing junction and to pins labeled A, B, C or G. The negative full-wave rectified voltage at pin 3 of connector J2 is connected to channel A. To take a voltage sample from the input, the microprocessor sets S1 and S2 to zero and selects the proper gain on the programmable amplifier, i.e. select proper R1 and R2 gain control inputs to the custom chip.

The custom chip is designed to produce a current output between 0 and 100 microamperes proportional to the current input at a given gain. Table 4 shows the relationship between current input, gain and current output. The microprocessor initializes the gain to unity. If the input current is
greater than 100 microamperes the overrange output pin on the custom chip (pin 10) will be a logic 1. Once the processor detects this, it will then switch to a gain of 1/2 and again examine the overrange output pin. If the overrange is still a logic 1, the processor will switch to a gain of 1/4, then 1/16. The input signal range is such that no overrange will occur at a gain of 1/16 and amplitude of 20 per-unit.

Trimpot P1 is for gain adjustment to obtain the exact pickup setting. The sampled analog signal feeds a buffer amplifier U9 and the A/D converter U6. The microprocessor has read the time curve and time dial switches and automatically selects one of the inverse-time curves which are permanently stored in memory. The microprocessor reads the contents of the A/D converter 8 times every cycle. It then updates the RMS value and the register for the elapsed time every cycle, and compares the number stored in this register with the calculated trip time from equations (1) and (2). When the input current exceeds the pickup setting the time LED flashes and starts the time delay operation. If the number in the time register is equal to or greater than the calculated trip time, the microprocessor energizes the TD trip relay and the LED lights solidly. (Note: If the time dial is set to zero, the relay will default to a time dial = 1. If the time curve setting is zero, no tripping will occur.) The trip relay and LED remain energized until the input current is below drop-out and trip contact current flow is no longer present. If trip current flow was detected, the time LED will be sealed on.

The microprocessor also reads the setting of the instantaneous trip switch. The minimum IT trip current level is equal to the product of the IT and TD pickup settings. For instantaneous trip there are two paths to determine the trip condition:

a) For input current less than 20 times TD pickup setting, the microprocessor compares the input amplitude with the setting, which is the product of IT multiple and TD pickup settings. The IT trip relay will be energized if the input is greater than the IT setting. This current is sampled 4 times every cycle and averaged every half cycle.

b) For input current greater than 20 times TD pickup setting, U8 detects this condition and the microprocessor energizes the IT trip relay immediately. This current is sampled 8 times every cycle.

The IT relay and LED remain energized until the input current is below drop-out (1 x IT setting for all settings above “1”) and trip contact current flow is no longer present. If trip current flow was detected, the IT LED will be sealed on.

If the TD or IT trip LED is sealed on, the LED condition is stored in non-volatile RAM and will remain there until reset. If DC power supply voltage is removed from the relay, then re-applied, the LED will again light until reset.

The LED’s may be reset one of two ways. Manual reset is done by depressing the reset button behind the right side of the front panel. The LED’s are also automatically reset by the occurrence of another trip event at least 2 minutes after the previous trip event. For example, an instantaneous trip occurs and the IT LED seals on. If the LED was not manually reset and a time trip occurs greater than 2 minutes after the IT trip, the TD LED will light and the IT LED will reset and turn off. If the time trip occurred less than 2 minutes after the IT trip, the TD LED will light and the IT LED will remain on.

Due to one-cycle evaluation time, half-cycle undetermined waveform and half-cycle operating time of the trip relay, a maximum trip time for IT operation is 2 cycles. Since the microprocessor averages the value every half cycle, the trip time will be approximately between 18 and 22 ms for the input current greater than 5 x IT setting.

This relay is equipped with self-check and test features. The deadman circuit monitors the programming routine and the crystal timing. The voltage drop on the capacitor C7 should be between 1.66 and 3.3 volts. If the programming routine is upset or the timing frequency becomes irregular, the microprocessor will be restarted and the alarm relay will drop out. The microprocessor also checks all bits in the read-only-memory every minute. Any defective bit change in the memory will cause the alarm relay to drop out. The switching dc-to-dc converter is regulated by the cus-
Tom chip U7 which controls transistors Q1, Q2 and Q3 for the 24 Vdc and 5 V dc supplies. L1 and C18 store the energy for the 24 V supply. If the dc output voltage is higher than 24 V, U7 turns on Q2 and turns off Q1 which stops charging of C18. If the voltage of C18 is below 24 V, U7 turns off Q2 and turns on Q1 which charges C18. Similarly, U7 controls Q3 and regulates the 5 Vdc supply through components L3 and C20.

4. CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Range</td>
<td>-20°C to +55°C.</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz or 60 Hz (selectable)</td>
</tr>
<tr>
<td>Pickup Setting</td>
<td>1345D01A01: 0.5 to 12 amps in 0.5 amp/step</td>
</tr>
<tr>
<td></td>
<td>1354D01A02: 0.1 to 2.4 amps in 0.1 amp/step.</td>
</tr>
<tr>
<td>Pickup Accuracy</td>
<td>± 5% for TD setting</td>
</tr>
<tr>
<td></td>
<td>± 10% for IT setting</td>
</tr>
<tr>
<td>Continuous Rating</td>
<td>16 amps (5 amp rated)</td>
</tr>
<tr>
<td></td>
<td>5 amps (1 amp rated)</td>
</tr>
<tr>
<td>One Second Rating</td>
<td>200 amps (5 amp rated)</td>
</tr>
<tr>
<td></td>
<td>100 amps (1 amp rated)</td>
</tr>
<tr>
<td>Inverse Curves</td>
<td>Seven time curve sets to match the curves from CO-2</td>
</tr>
<tr>
<td></td>
<td>to CO-11. Each set includes 63 curves.</td>
</tr>
<tr>
<td>Timing Accuracy</td>
<td>± 5% or 1.5 cycles whichever is larger. (16 ms relay pickup time delay must be added to these curves.</td>
</tr>
<tr>
<td>Time Delay Dropout Ratio</td>
<td>98% (approx.)</td>
</tr>
<tr>
<td>Reset Time</td>
<td>2 cycles</td>
</tr>
<tr>
<td>Instantaneous Unit</td>
<td>Pickup: 1 to 20 times TD pickup setting in 0.5 steps.</td>
</tr>
<tr>
<td></td>
<td>Pickup Time: 2 cycles (max).</td>
</tr>
<tr>
<td>Alarm Contacts</td>
<td>NC contact for self-check or loss of dc power supply.</td>
</tr>
<tr>
<td>Trip Contacts</td>
<td>NO contact for time delay trip. NO contact for instantaneous trip. NO contact for either TD or IT trip.</td>
</tr>
<tr>
<td>LED Indication</td>
<td>1) Monitor LED for power-on and self-check indication.</td>
</tr>
<tr>
<td></td>
<td>2) Time delay trip (solid) and above TD pickup setting (flashing).</td>
</tr>
<tr>
<td></td>
<td>3) Instantaneous trip.</td>
</tr>
<tr>
<td>Contact Rating</td>
<td>Make: 30 amp at 250 Vdc for 1 second.</td>
</tr>
<tr>
<td></td>
<td>Break: 0.25 amp at 250 Vdc</td>
</tr>
<tr>
<td>DC Power Supply</td>
<td>48/125 V (selectable)</td>
</tr>
<tr>
<td>DC Power Drain</td>
<td>3.5 W at 125 Vdc</td>
</tr>
<tr>
<td>AC Current Burden</td>
<td>1) 0.3 VA at 5 amp input for range 0.5 to 12 amps.</td>
</tr>
<tr>
<td></td>
<td>2) 0.45 VA at 1 amp input for range 0.1 to 2.4 amps.</td>
</tr>
</tbody>
</table>
5. SETTINGS

Provided on the front panel of the MCO relay are four DIP switches for making time curve, time dial, tap and instantaneous settings.

a) Time Curve - Time curve selection is a 3PST switch with a binary code configuration. The time curves from 1 to 7 match the CO curves from CO-2 to CO-11 as shown in the APPLICATION section.

b) Time Dial - Time dial selection is a 6PST switch. A number (time dial) from 1 to 63 can be selected. Each number represents an individual curve in the same time curve family. Software versions V5.0 and higher equate time dial = 0 as selection to time dial = 1.

c) Tap Setting - Tap Setting selection is a 5PST switch which is used for the minimum pickup current setting. The following expression (3) is for the MCO style with a setting range (Is) from 0.1 to 2.4 amps and expression (4) is for the MCO style with a setting range (Is) from .5 to 12 amp.

\[ \text{Is} = E + 0.1 \text{amps} \quad (3) \]

\[ \text{Is} = (E + (0.1)) \times 5 \text{amps} \quad (4) \]

Where E is from 0 to 2.3, as determined by the five position setting of the switch.

d) Instantaneous Setting - Instantaneous setting selection is a 6PST switch. A number between 1 and 20 in 0.5 steps can be selected. The selected number times the minimum pickup current is the IT trip setting.

Jumpers are also provided to select 48/125 Vdc and 50/60 Hz. Refer to the note in the Acceptance Test for jumper locations.

5.1 Time Delay

The overcurrent time delay settings can be defined by pickup setting and time dial setting or by pickup setting and a specific time of operation at some current multiple of the pickup setting (e.g., set the pickup at 4 amps and time dial at 15 or set the pickup at 4 amps and 0.6 seconds at 6 times the pickup current value).

The time delay must be set to override the normal conditions to which the relay can be subjected, such as motor starting current, cold load pickup, emergency circuit load and transformer inrush.

5.1.1 Differential protection.

For small transformers and less important buses the MCO differential scheme can be used. A pickup setting above maximum load of any circuit connected to the bus, and a time delay setting for maximum fault current in excess of three times the primary circuit dc time constant, will generally prove to be suitable.

5.1.2. Motor protection

For locked rotor protection, the pickup of the MCO is typically set at one-half locked rotor current, and the time delay is set to allow the motor to start without exceeding the allowable locked rotor time for the particular motor.

5.1.3. Circuit protection

A pickup setting of 2 times maximum circuit loading is typical for the phase relay. The circuit load may reach 5 times normal when reenergized after a long time. It may not drop below 2 times normal for approximately 7 seconds. The relay should not trip for this condition. This is the cold load pickup phenomenon and varies widely with the type of load.

Devices farther away from the source than the MCO and located between the MCO and a fault should be allowed to clear the fault. For all currents seen by both devices, the MCO curve should be approximately 0.3 seconds above the total clearing time of the remote device. Where consideration is given to ct performance, fault current variation and relay accuracy, a coordinating time equal to or less than 0.2 second plus breaker clearing time may be used.

Ground relay pickup must be above the maximum residual load unbalance, including the effect of switching single phase laterals. A pickup setting corresponding to 0.4 of maximum phase load current is typical. The time curve must be above that of all devices farther away from the source than the MCO. This includes fuses and reclosers even though they may respond to phase current only. Adequate coordinating time is 0.3 second. Lower coordinating times may be used as described above.

Similar MCO characteristics curve shapes at a given system voltage level can generally be more efficiently coordinated than dissimilar curve shapes.

5.2 Instantaneous Trip

The instantaneous circuit should be set to the desired setting on the Instantaneous Trip switch from 1 to 20. The actual setting is this number times the pickup current setting (e.g., with a pickup setting of 4 amperes and an instantaneous
multiple setting at 20, the instantaneous pickup setting will be 80 amperes). The relay will trip in less than two cycles if the input current is above this setting. The instantaneous function is disabled by setting the switch to all zeros.

Fuse Coordination Special - Hardware special is available, style # plus "-FUS" suffix, that provides jumper selectable delayed instantaneous trip times for special fuse coordination applications. Use jumper JMP3 to select position "A", "B", or "C" for delays of 3 cycles(50 ms), 6 cycles(100 ms), and trimpot adjustable 12-50 cycles(2-.833 sec). Jumper JMP3 position "O" provides the standard instantaneous trip time of less than two cycles. Jumper JMP3 is located on the hardware module which is inserted in the processor module. Refer to component location, Figure 5.

6. INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, corrosive fumes and heat. The maximum temperature outside the relay case should not exceed +55°C for normal operation (See CHARACTERISTICS for temperature range specifications).

Mount the relay vertically by means of the four mounting holes on the flanges for semi-flush mounting or by means of the rear stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. External toothed washers are provided for use in the locations shown on the outline and drilling plan to facilitate making a good electrical connection between the relay case, its mounting screws or studs, and the relay panel. Ground wires are affixed to the mounting screws or studs as required for properly grounded or insulating panels. Other electrical connections may be made directly to the terminals by means of screws for steel panel mounting or the terminal studs furnished with the relay for thick panel mounting. The terminals studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench. See Figure 16 for Outline and Drilling Plan. For detailed FT case information refer to I.L. 41-076.

7. ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments other than those covered under SETTINGS should be required.

7.1 Acceptance Check

It is recommended that a performance check be applied to the MCO relay to verify that the circuits are functioning properly. The MCO test diagram shown is in Figure 15. Proper energization of the relay is also shown in this figure.

NOTE:

1. CAUTION: While handling the relay out of its case, electrostatic discharge procedures must be followed. Refer to the Electrostatic Discharge Caution on page 1 of this Instruction Leaflet.

2. Before energizing the relay, check the jumper JMP1 position for the correct frequency setting (50/60 Hz). This jumper is located on the processor module between the IT setting switch and the IT trip LED. Refer to Component Location, Figure 5.

3. Check the dc voltage setting jumper JMP2 for the rated dc voltage supply (48 or 125 volts). JMP2 is two small clips in parallel, next to the capacitor C19. Refer to Component Location, Figure 5.

7.1.1 Minimum Trip

a) Set the Tap Setting pickup at 0.1 or 0.5 amp (minimum setting), depending on the style to be tested. Set Instantaneous Setting = 20 and Time Dial = 63.

b) Apply rated dc power supply to relay terminals 3 (+) and 4 (common) and apply the appropriate ac current to terminals 8 and 9.

c) Increase the ac current to 5% below pickup value. The relay should not trip (see characteristic curves for approximate timing).

d) Increase the ac current to 5% above pickup value. The TD LED should flash. Change the time dial setting from 63 to 1. The time trip LED should light solidly. A minimum trip current of 0.5 ampere is necessary to seal in the trip LED.
<table>
<thead>
<tr>
<th>MCO CURVE</th>
<th>CO TYPE</th>
<th>TIME DIAL</th>
<th>CURRENT APPLIED</th>
<th>OPERATING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CO-2</td>
<td>30</td>
<td>2X</td>
<td>0.833</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5X</td>
<td>0.352</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20X</td>
<td>0.188</td>
</tr>
<tr>
<td>2</td>
<td>CO-5</td>
<td>30</td>
<td>2X</td>
<td>30.029</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5X</td>
<td>14.693</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10X</td>
<td>12.186</td>
</tr>
<tr>
<td>3</td>
<td>CO-6</td>
<td>30</td>
<td>2X</td>
<td>2.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5X</td>
<td>1.201</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20X</td>
<td>1.025</td>
</tr>
<tr>
<td>4</td>
<td>CO-7</td>
<td>30</td>
<td>2X</td>
<td>3.907</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5X</td>
<td>1.585</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20X</td>
<td>0.859</td>
</tr>
<tr>
<td>5</td>
<td>CO-8</td>
<td>30</td>
<td>2X</td>
<td>7.656</td>
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<td></td>
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<td></td>
<td>5X</td>
<td>1.979</td>
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<td>20X</td>
<td>0.872</td>
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<tr>
<td>6</td>
<td>CO-9</td>
<td>30</td>
<td>2X</td>
<td>5.688</td>
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<td></td>
<td>5X</td>
<td>1.331</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>20X</td>
<td>0.572</td>
</tr>
<tr>
<td>7</td>
<td>CO-11</td>
<td>30</td>
<td>2X</td>
<td>9.938</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5X</td>
<td>1.226</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20X</td>
<td>0.195</td>
</tr>
</tbody>
</table>

Note: 16 milliseconds pickup time for the TD relay must be added to the above operate times for total operate time of the MCO relay.
7.1.2 Time Curve

The time curve calibration points for the various types of relays are shown in Table 5. With the time dial set to the indicated position, apply the currents specified in Table 5 and measure the operating time of the relay. The operating times should equal those of Table 5, ±5%, or ±25 ms, whichever is greater.

7.1.3 Instantaneous Trip

a) Set the Tap Setting pickup at 0.1 or 0.5 amp (minimum setting). Set Instantaneous Setting = 10 and Time Dial = 63.

b) Turn on dc and ac sources and slowly increase the ac current. The IT relay should trip and the IT indicator should light at input current of 10 times tap setting value (+ 10%). A minimum trip current of 0.5 ampere is necessary to seal in the trip LED.

c) Turn off ac and dc sources and then apply dc supply only. The IT trip LED should be on again. Reset the LED.

8.1 Calibration

The proper adjustment of the trimpot P1 has been calibrated by the factory and should not be disturbed unless the relay is out of calibration per Acceptance Check.

Before performing the relay calibration, check jumpers JMP 1 and JMP 2, on the processor module, for the rated frequency and dc power supply settings (Refer to the NOTE in the Acceptance Check section).

a) Set the pickup at 0.2 amperes for the relay with a tap range of 0.1 to 2.4 amps or at 1.0 amp for a tap range of 0.5 to 12 amps.

b) Set the Instantaneous Trips switch to 20 and the Time Dial to 1.

c) Apply rated dc power supply to relay terminals 3 (+) and 4 (common) and the appropriate ac pickup current to terminals 8 and 9.

d) Slowly adjust P1 until the TD LED turns on.

e) Reduce the input current, reset the LED and then slowly increase the current again to verify the pickup current setting.

f) Change the pickup setting shown in step # 1 from 0.2 amp (or 1.0 amp) to 1.0 amp (or 5.0 amps). Increase the input current to verify the pickup setting (+ 5%).

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

At completion of the Acceptance Check, return all settings to desired position.

8. ROUTINE MAINTENANCE

All relays should be inspected periodically and all settings and times of operation should be checked at least once every year or at such other intervals as may be indicated by experience to be suitable to the particular application.

CAUTION: While handling the relay out of its case, electrostatic discharge procedures must be followed. Refer to the Electrostatic Discharge Caution on page 1 of this Instruction Leaflet.
REFERENCE DRAWINGS

Figure 1  MCO Relay Picture
Figure 2  Simplified Terminal Connection Drawing
Figure 3  MCO Block Diagram
Figure 4  Internal Schematic
Figure 5  Component Location - Microprocessor Module
Figure 6  Component Location - Interface Module
Figure 7  Typical Time Curve #1 (CO-2)
Figure 8  Typical Time Curve #2 (CO-5)
Figure 9  Typical Time Curve #3 (CO-6)
Figure 10 Typical Time Curve #4 (CO-7)
Figure 11 Typical Time Curve #5 (CO-8)
Figure 12 Typical Time Curve #6 (CO-9)
Figure 13 Typical Time Curve #7 (CO-11)
Figure 14 External Schematic
Figure 15 Diagram of Test Connections
Figure 16 Outline and Drilling Plan for FT-11 Case
*Fig. 1 MCO RELAY*
Fig. 2 Simplified Terminal Connection Drawing
*: "-FUS" Hardware Module Location

Fig. 5 Component Location Microprocessor Module
Fig 6. Component Location Interface Module
*Fig. 7 Typical Time Curve #1 (CO-2)
*Fig. 8. Typical Time Curve #2 (CO-5)
*Fig. 9. Typical Time Curve #3 (CO-6)
*Fig. 11. Typical Time Curve #5 (CO-8)
*Fig. 12. Typical Time Curve #6 (CO-9)
*Fig. 13. Typical Time Curve #7 (CO-11)
Fig. 15. Diagram of Test Connections for Type MCO Relay
Fig. 16. Outline and Drilling Plan for Type MCO Relay Single Phase in FT-11 Case

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