ABB Power T & D Company Inc.
Relay Division
Allentown, PA 18106

Instruction Leaflet
41-120B

Type MCO Microprocessor Overcurrent Relay

Effective: June 1993
Supersedes 41-120A dated October 1991
*Denotes change since previous issue

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 cirucit 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.

The following describes typical applications of the MCO relay:

MCO Time Curve	CO Curve	Time Equivalent	Curve Typical Applications
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.

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

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

where T = trip time in seconds
- To = definite time term
- I = input current
- Io = 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. Io and D are user selectable parameters via Tap Setting and Time Dial selecting switches respectively.

TABLE I

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

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 SETTINGS 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

Table 2			Table 3			Table 4		
S1	S2	Selected Input	R1	R2	Gain	Current Input	Gain	Current Output
0	0	A	0	0	1	0-100 uA	1	0-100 uA
0	1	B	0	1	1/2	100-200 uA	1/2	50-100 uA
1	0	C	1	1	1/4	200-400 uA	1/4	50-100 uA
1	1	G	1	0	1/16	400-1600 uA	1/16	25-100 uA

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 pick up 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 24Vdc and 5V dc supplies. L1 and C18 store the energy for the 24V supply. If the dc output voltage is higher than 24V, U7 turns on Q2 and turns off Q1 which stops charging of C18. If the voltage of C18 is below 24V, 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

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

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 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.

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

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

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 recloses 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 "0" 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 poorly 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 handing 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 5

MCO CURVE	CO TYPE	TIME DIAL	CURRENT APPLIED	OPERATING TIME
1	CO-2	30	2X 5X 20X	0.833 0.352 0.188
2	CO-5	30	2X 5X 10X	30.029 14.693 12.186
3	CO-6	30	2X 5X 20X	2.016 1.201 1.025
4	CO-7	30	2X 5X 20X	3.907 1.585 0.859
5	CO-8	30	2X 5X 20X	7.656 1.979 0.872
6	CO-9	30	2X 5X 20X	5.688 1.331 0.572
7	CO-11	30	2X 5X 20X	9.938 1.226 0.195

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.

e) Set the Tap Setting pickup to 10 times the minimum setting and repeat steps 3 & 4 to verify the accuracy (±5%).

f) Turn off ac and dc sources and then apply only dc supply. The time trip LED should be on again.

g) Reset the LED by pressing the reset pushbutton.

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.

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 lease 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.

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.

REFERENCE DRAWINGS

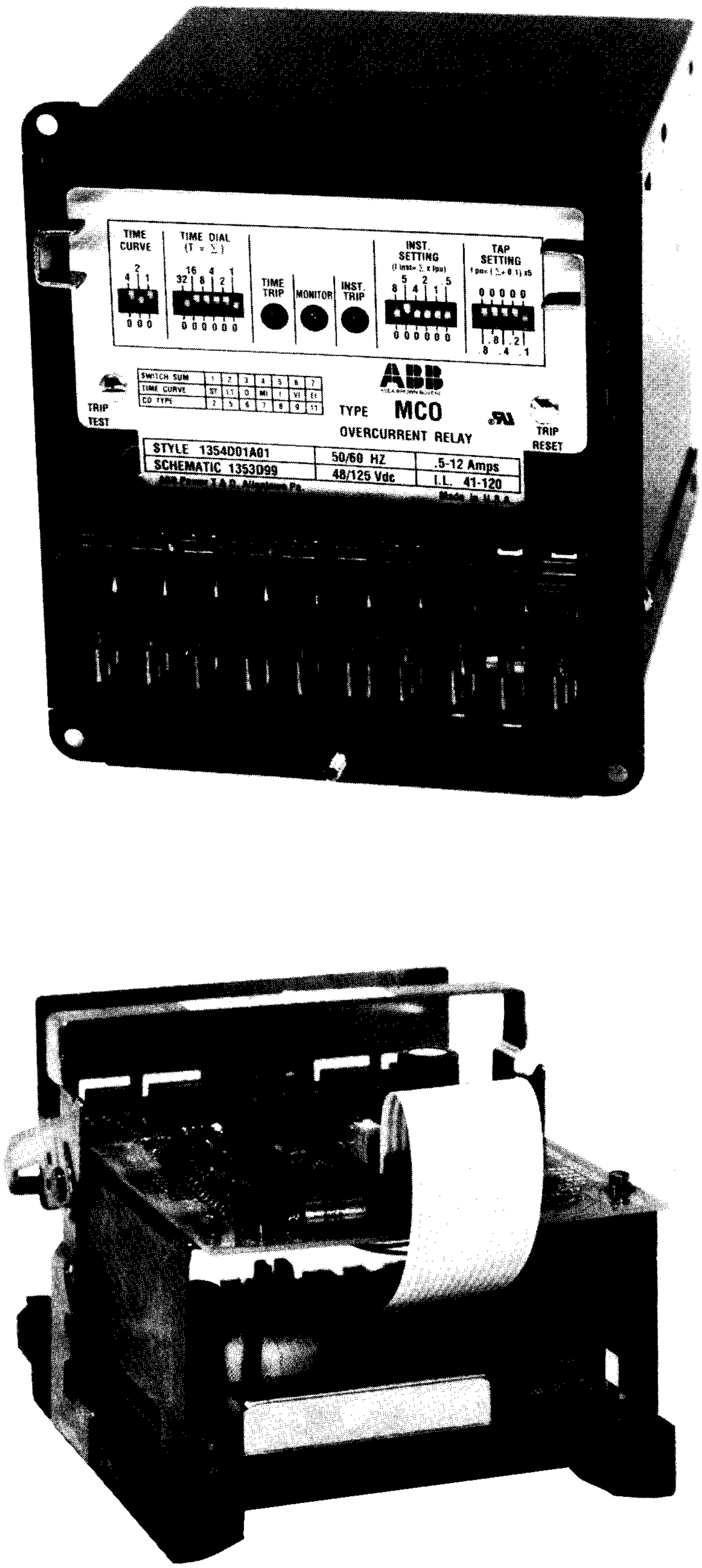
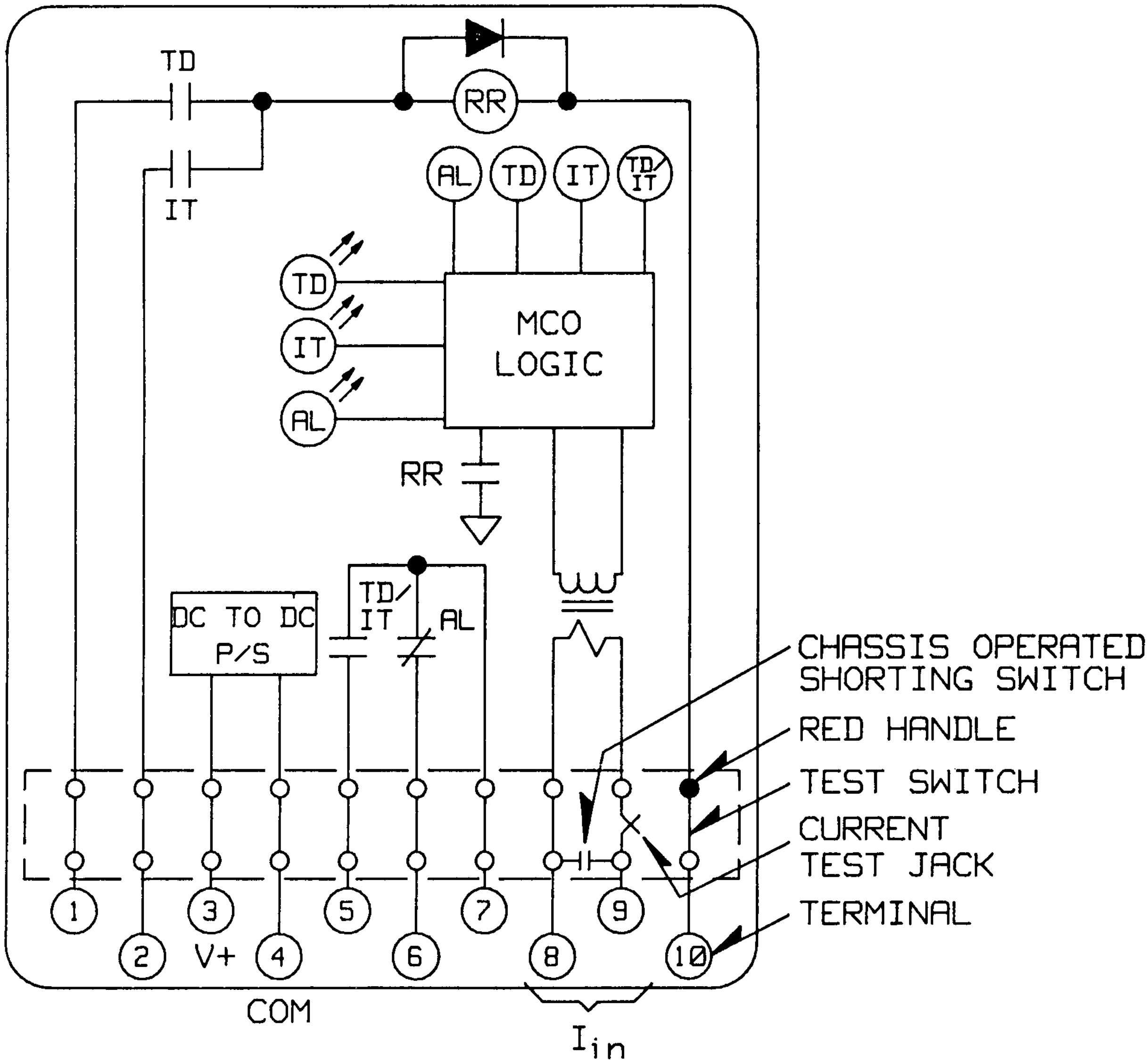


**Fig. 1 MCO RELAY*

MCO TERMINAL CONNECTIONS



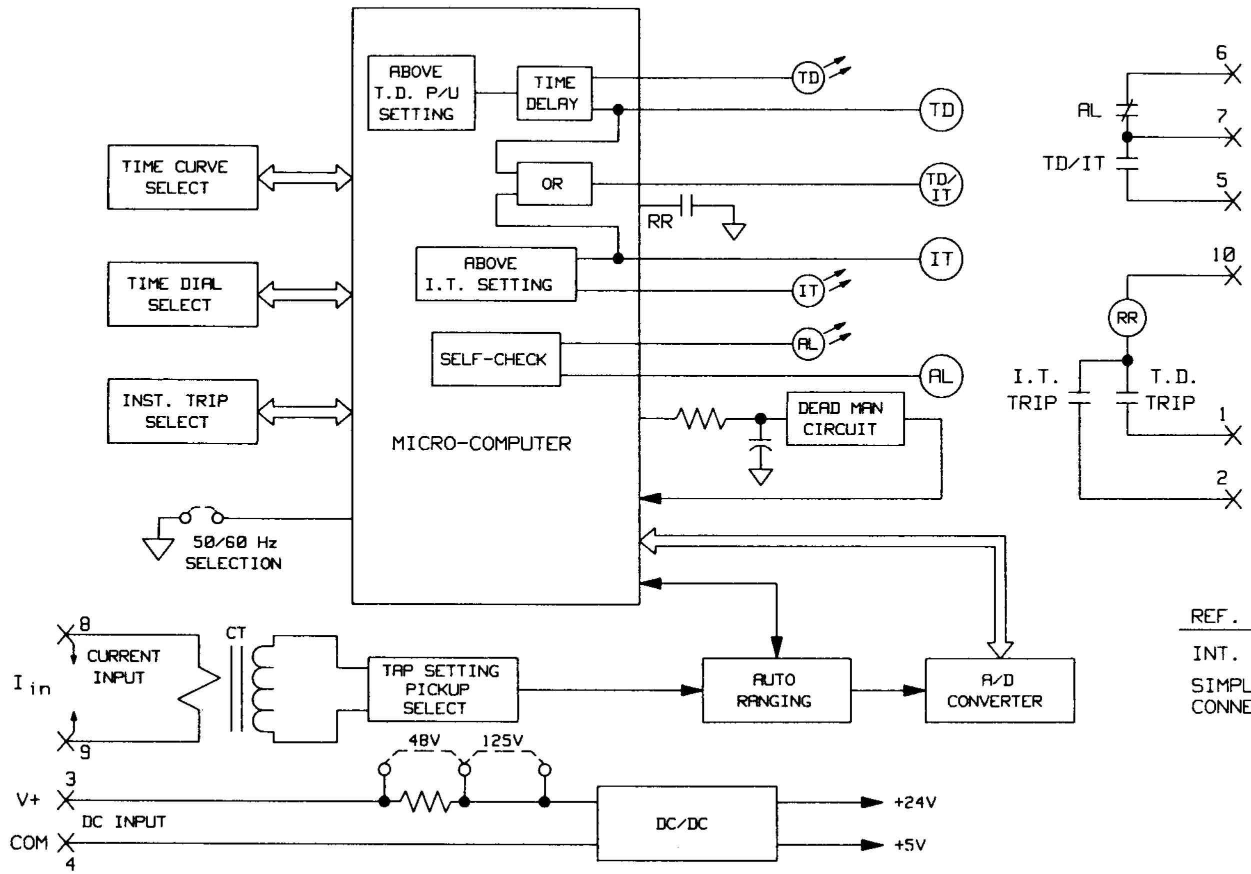
FRONT VIEW
FT-11 CASE

REF. DWGS:

BLOCK DIAGRAM --------- 1494B72
INT. SCHEMATIC -------- 1353D99
GEN. DRAWING ---------- 1354D01
TEST DRAWING ---------- 9645A32

Sub 3
9644A78

Fig. 2 Simplified Terminal Connection Drawing



REF. DWGS:

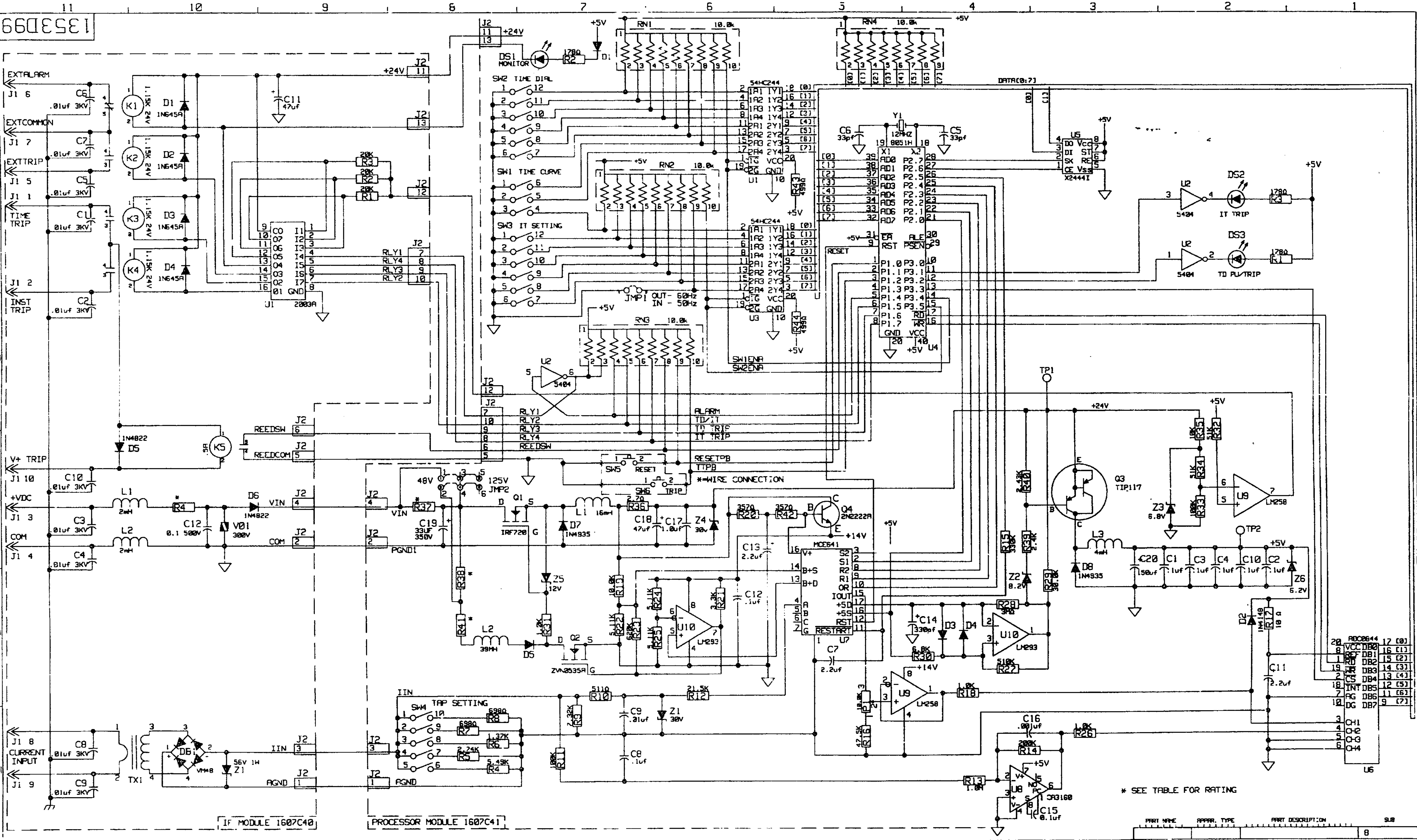
INT. SCHEMATIC -------1353D99

SIMPLIFIED TERMINAL CONNECTION DWG. ------9644A78

Fig. 3 MCO Block Diagram

Sub 3

1494B72



1353D99
EXTALARM
EXTCOMMON
EXTTRIP
TIME TRIP
INST TRIP
V+ TRIP
+VDC
COM
CURRENT INPUT
SW2 TIME DIAL
SW1 TIME CURVE
SW3 IT SETTING
SW4 TAP SETTING
54HC244
8051H
X2444I
ADC0844
MC6641
LM293
LM258
5404
2003A
TIP117
2N2222A
IRF720
ZVN0535A
CA3160
DATA[0:7]
MONITOR
IT TRIP
TD PU/TRIP
JMP1 OUT - 60Hz IN - 50Hz
JMP2
*=WIRE CONNECTION
RESET
TRIP
RESETPB
TTPB
ALARM
TD/IT
TD TRIP
IT TRIP
REEDSW
REEDCOM
RLY1
RLY2
RLY3
RLY4
SW1ENA
SW2ENA
VIN
PGND1
IIN
AGND
* SEE TABLE FOR RATING
IF MODULE 1607C40
PROCESSOR MODULE 1607C41
PART NAME
APPAR. TYPE
PART DESCRIPTION

PROCESSOR MODULE
1607C41G01, G02

COMP LOC	STYLE NO.	DESCRIPTION
CAPACITOR		
C01	762A680H14	.1UF 100V 20%
C02	752A680H14	.1UF 100V 20%
C03	762A680H14	.1UF 100V 20%
C04	762A680H14	.1UF 100V 20%
C05	763A209H13	33PF 10% 500V DURA-MICA
C06	763A209H13	33PF 10% 500V DURA-MICA
C07	837A241H16	2.2UF 35V 20% TANTALUM
C08	762A680H14	.1UF 100V 20%
C09	3509A34H02	.01UF 100V 20% CERAMIC
C10	762A680H14	.1UF 100V 20%
C11	837A241H16	2.2UF 35V 20% TANTALUM
C12	762A680H14	1UF 100V 20%
C13	837A241H16	2.2UF 35V 20% TANTALUM
C14	3532A31H53	330PF 500V 2% MICA
C15	762A680H14	.1UF 100V 20%
C16	3532A31H07	.001UF 100V 5% MICA
C17	762A680H14	.1UF 100V 20%
C18	187A508H12	47UF 35V 10%
C19	9645A13H08	33UF 350V
C20	187A506H20	150UF 6V 5%
CRYSTAL		
Y01	879A920H08	12.0 MHZ
DIODE		
D01	836A928H06	1N4148A 75V 20MA
D02	836A928H06	1N4148A 75V 20MA
D03	836A928H06	1N4148A 75V 20MA
D04	836A928H06	1N4148A 75V 20MA
D05	836A928H06	1N4148A 75V 20MA
D07	836A928H09	1N4935 200V 1A
D08	836A928H09	1N4935 200V 1A
LED		
DS1	3508A22H02	YELLOW LED
DS2	3508A22H01	RED LED
DS3	3508A22H01	RED LED
CHOKE		
L01	9645A18H01	16MH .16A 15%
L02	9645A17H01	39MH 395 OHM
L03	9645A18H02	4MH .32A 15%
INT CKT		
U01	9450A44H52	54HC244J OCTAL TS BUFFER (CERAM)
U02	3517A86H01	SN5404J HEX INVERTER
U03	9450A44H51	54HC244J OCTAL TS BUFFER (CERAM)
U04	1607C30H01	D8751H PROCESSOR
U05	9647A05H01	X2444I 16x16 NV RAM
U06	9645A03H01	ADC0844BCN A/D CONVERTER
U07	9449A34H51	MCE641 CUSTOM
U08	3535A16H01	CA3160S MOS FET OP AMP
U09	9640A97H01	LM258JG DUAL OP AMP
U10	9647A06H01	LM293P DUAL COMPARATOR
POT		
P01	3523A42H01	10.0K .5W 10% CERMET
RES NET		
RN1	3532A91H03	10.0K X 9 2% (SIP)
RN2	3532A91H03	10.0K X 9 2% (SIP)
RN3	3532A91H03	10.0K X 9 2% (SIP)
RN4	3532A91H03	10.0K X 9 2% (SIP)
RESISTOR		
R01	3535A39H25	178 OHM .25W 1% METAL FILM
R02	3535A39H25	178 OHM .25W 1% METAL FILM
R03	3535A39H25	178 OHM .25W 1% METAL FILM
R04	3535A38H72	5.49K .25 1% METAL FILM
R05	3535A38H43	2.74K .25W 1% METAL FILM
R06	3535A36H14	1.37K .25W 1% METAL FILM
R07	3535A39H82	698 OHM .25W 1% METAL FILM
R08	3535A39H82	698 OHM .25W 1% METAL FILM
R09	3535A38H84	7.32K .25W 1% METAL FILM
R10	3535A39H69	511 OHM .25W 1% METAL FILM
R11	3532A38H01	100K .25W 1% METAL FILM
R12	3535A37H33	21.5K .25W 1% METAL FILM
R13	848A822H39	1.0 MEG .25W 1% METAL FILM
R14	3532A38H30	200K .25W 1% METAL FILM
R15	3535A41H37	330K .25W 5% CARBON FILM
R16	3535A37H66	47.5K .25W 1% METAL FILM
R17	3535A42H01	10 OHM .25W 1% METAL FILM
R18	3535A38H01	1.0K .25W 1% METAL FILM
R19	3535A37H01	10.0K .25W 1% METAL FILM
R20	3535A39H54	357 OHM .25W 1% METAL FILM
R21	3535A38H51	3.32K .25W 1% METAL FILM
R22	3535A38H69	5.11K .25W 1% METAL FILM
R23	3535A41H44	620K .25W 5% CARBON FILM
R24	3535A38H69	5.11K .25W 1% METAL FILM
R25	3535A38H69	5.11K .25W 1% METAL FILM
R26	3535A38H01	1.0K .25W 1% METAL FILM
R27	3532A38H69	511K .25W 1% METAL FILM
R28	3535A41H60	3.0 MEG .25W 5% CARBON FILM
R29	3535A37H47	30.1K .25W 1% METAL FILM
R30	3535A38H81	6.81K .25W 1% METAL FILM
R31	3535A38H01	1.0K .25W 1% METAL FILM
R32	3535A37H69	51.1K .25W 1% METAL FILM
R33	3532A38H01	100K .25W 1% METAL FILM
R34	3535A37H69	51.1K .25W 1% METAL FILM
R35	3535A37H01	10.0K .25W 1% METAL FILM
R36	3535A40H11	2.7 OHM .25W 5% CARBON FILM
R37	SEE TABLE BELOW	
R38	SEE TABLE BELOW	
R39	3535A38H38	2.43K .25W 1% METAL FILM
R40	3535A38H38	2.43K .25W 1% METAL FILM
R41	SEE TABLE BELOW	
R42	3535A39H54	357 OHM .25W 1% METAL FILM
R43	3535A39H68	499 OHM .25W 1% METAL FILM
R44	3535A39H68	499 OHM .25W 1% METAL FILM
SWITCH		
SW1	9643A19H03	3 POS PIANO DIP
SW2	9643A19H06	6 POS PIANO DIP
SW3	9643A19H06	6 POS PIANO DIP
SW4	9643A19H05	5 POS PIANO DIP
TRANSISTOR		
Q01	9641A07H01	IRF720 400V FET 12A 40W
Q02	9646A90H01	ZVN0535A 350V FET 2A 5W
Q03	3532A45H16	TIP117 100V DARL 2A 50W
Q04	762A672H15	2N2222A NPN 40V .8A .4W
ZENER		
Z01	849A515H05	1N4751A 30V 1W 5%
Z02	837A398H12	1N959 8.2V 400MW
Z03	862A288H07	1N5235B 6.8V .5W
Z04	849A515H05	1N4751A 30V 1W 5%
Z05	837A398H02	1N963 12V 400MW 5%
Z06	837A693H08	1N4460 6.2V 1.5W

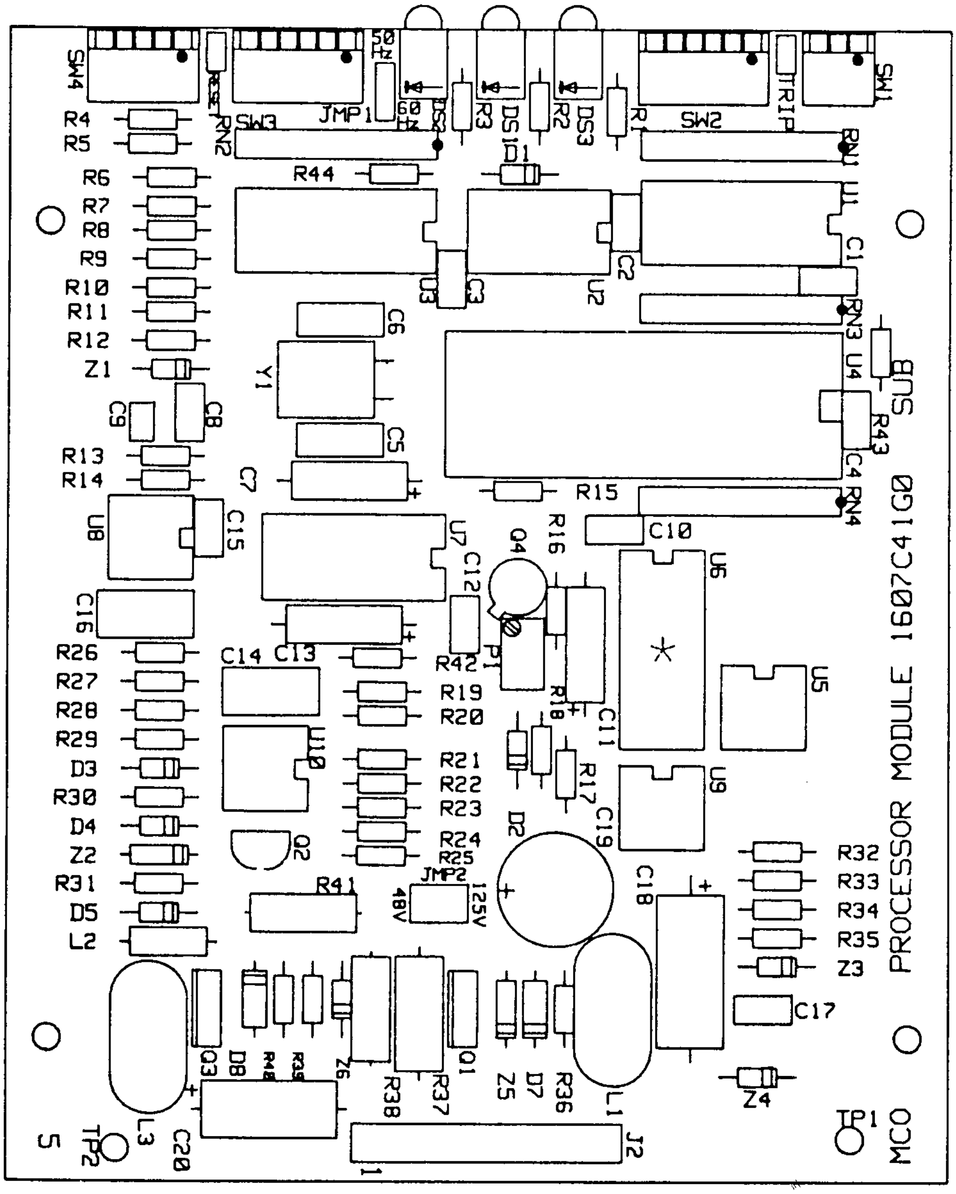
STYLE	RATING	R37	R38,41
1607C41G01	48/125	763A127H16 33Ω 3W 5%	187A643H51 10K 1W 5%
1607C41G02	250	763A127H41 56Ω 3W 5%	763A126H08 20K 4W 1%

INTERFACE MODULE
1607C40G01, G02, G03, G04

COMP LOC	STYLE NO.	DESCRIPTION
CAPACITOR		
C01	3536A32H02	.01UF 3KV 20% CERAMIC
C02	3536A32H02	.01UF 3KV 20% CERAMIC
C03	3536A32H02	.01UF 3KV 20% CERAMIC
C04	3536A32H02	.01UF 3KV 20% CERAMIC
C05	3536A32H02	.01UF 3KV 20% CERAMIC
C06	3536A32H02	.01UF 3KV 20% CERAMIC
C07	3536A32H02	.01UF 3KV 20% CERAMIC
C08	3536A32H02	.01UF 3KV 20% CERAMIC
C09	3536A32H02	.01UF 3KV 20% CERAMIC
C10	3536A32H02	.01UF 3KV 20% CERAMIC
C11	187A508H12	47UF 50V 5% TANTALUM
C12	184A663H14	0.1UF 500V 20% CERAMIC
DIODE		
D01	837A692H03	1N645A 225V 400MA
D02	837A692H03	1N645A 225V 400MA
D03	837A692H03	1N645A 225V 400MA
D04	837A692H03	1N645A 225V 400MA
D05	188A342H11	1N4822 600V
D06	188A342H11	1N4822 600V
INT CKT		
U01	3533A01H01	ULQ2003A SEPTAL OCTAL DRIVER
CHOKE		
L01	3500A27H01	2.0MH 1.3MHZ .8A
L02	3500A27H01	2.0MH 1.3MHZ .8A
RECTIFIER		
DB1	3511A90H01	VM46 400V 1A
RESISTOR		
R01	3535A37H30	20.0K .25W 1% METAL FILM
R02	3535A37H30	20.0K .25W 1% METAL FILM
R03	3535A37H30	20.0K .25W 1% METAL FILM
R04	SEE TABLE BELOW	
RELAY		
K01	9645A10H02	SPDT 24V 10A
K02	9645A10H02	SPDT 24V 10A
K03	9645A10H02	SPDT 24V 10A
K04	9645A10H02	SPDT 24V 10A
K05	1442C62G01	REED RELAY
TRANSFORMER		
TX1	SEE TABLE BELOW	
VARISTOR		
V01	3509A31H18	300V
ZENERDIODE		
Z01	862A257H04	1N3038B 56V 1W 5%

STYLE	RATING	R4	TX1
1607C40G01	48/125 Vdc 5A	184A859H01 20Ω 3W 5%	1496B76G01 5A
1607C40G02	48/125 Vdc 1A	184A859H01 20Ω 3W 5%	1496B76G01 5A
1607C40G03	250 Vdc 5A	763A127H41 56Ω 3W 5%	1496B76G02 1A
1607C40G04	250 Vdc 1A	763A127H41 56Ω 3W 5%	1496B76G02 1A

PART NAME APPAR. TYPE PART DESCRIPTION



*: "-FUS" Hardware Module Location

Sub 5
1496B68

Fig. 5 Component Location Microprocessor Module

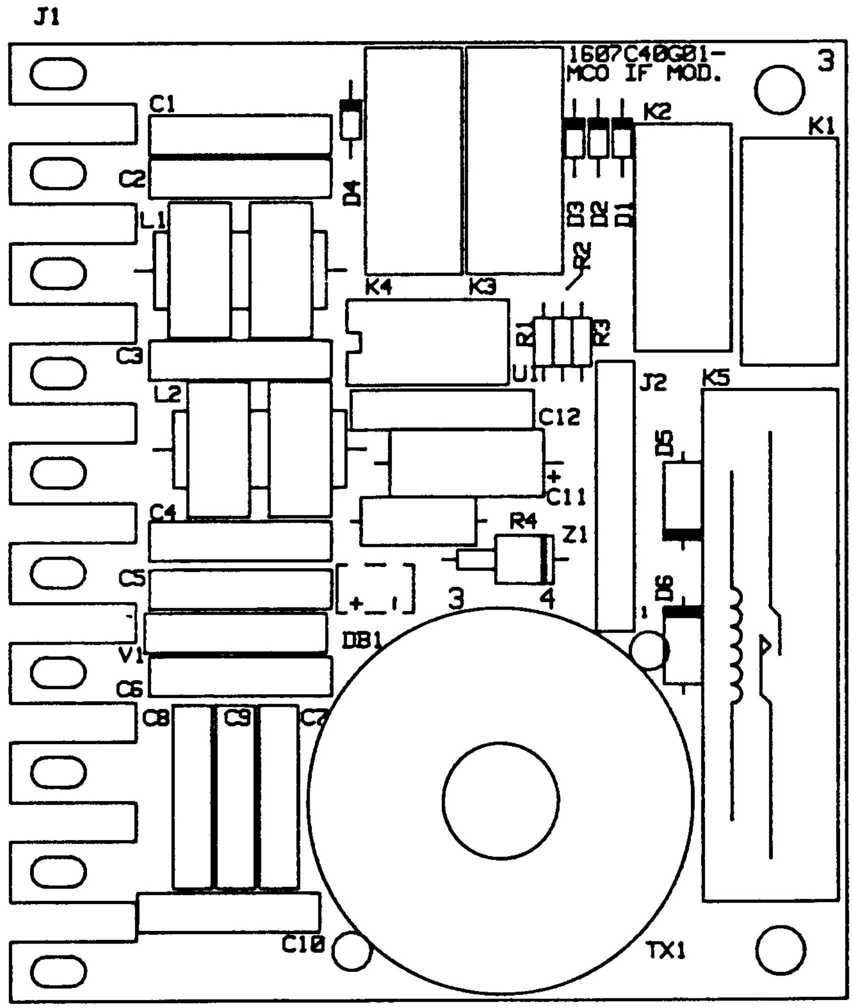
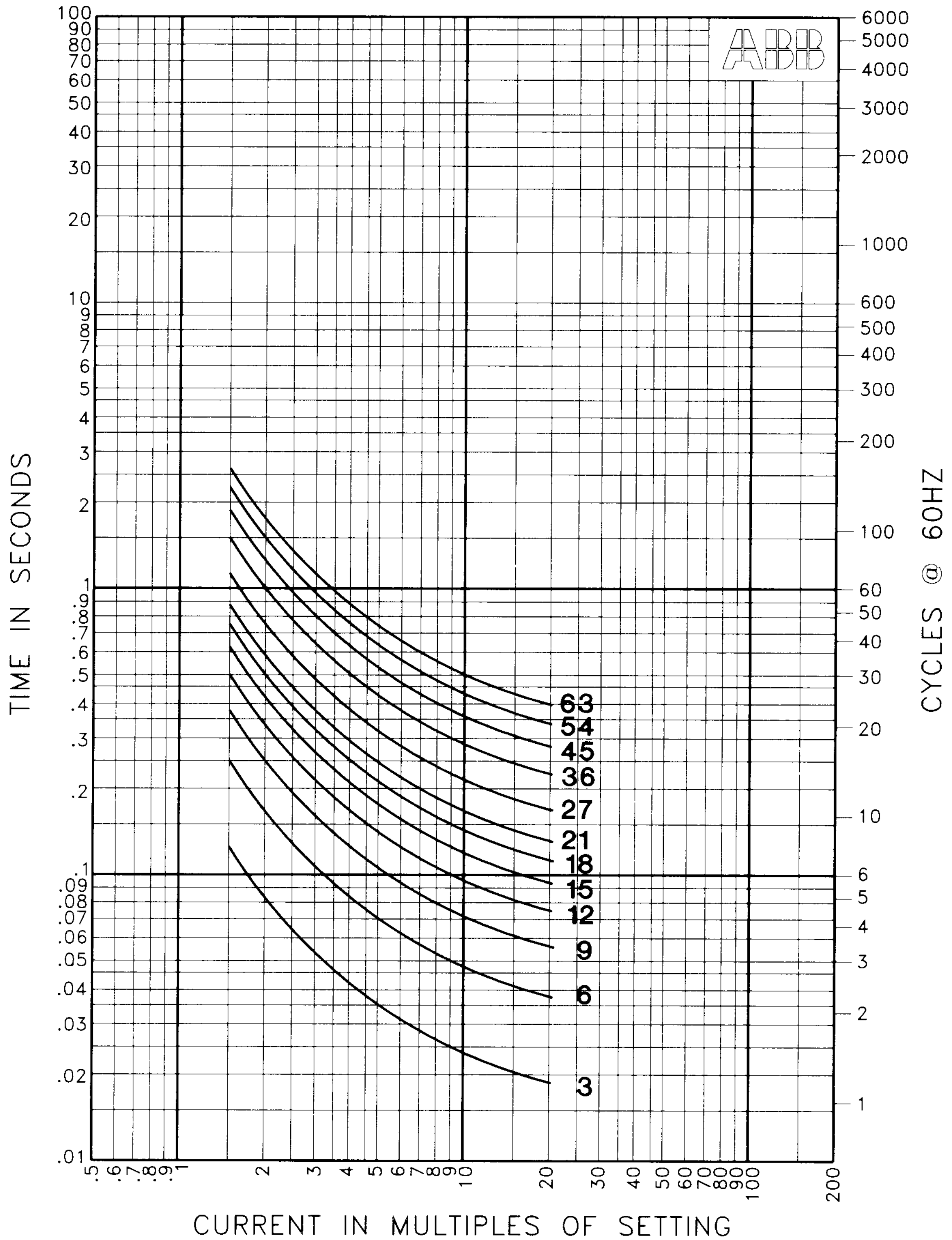
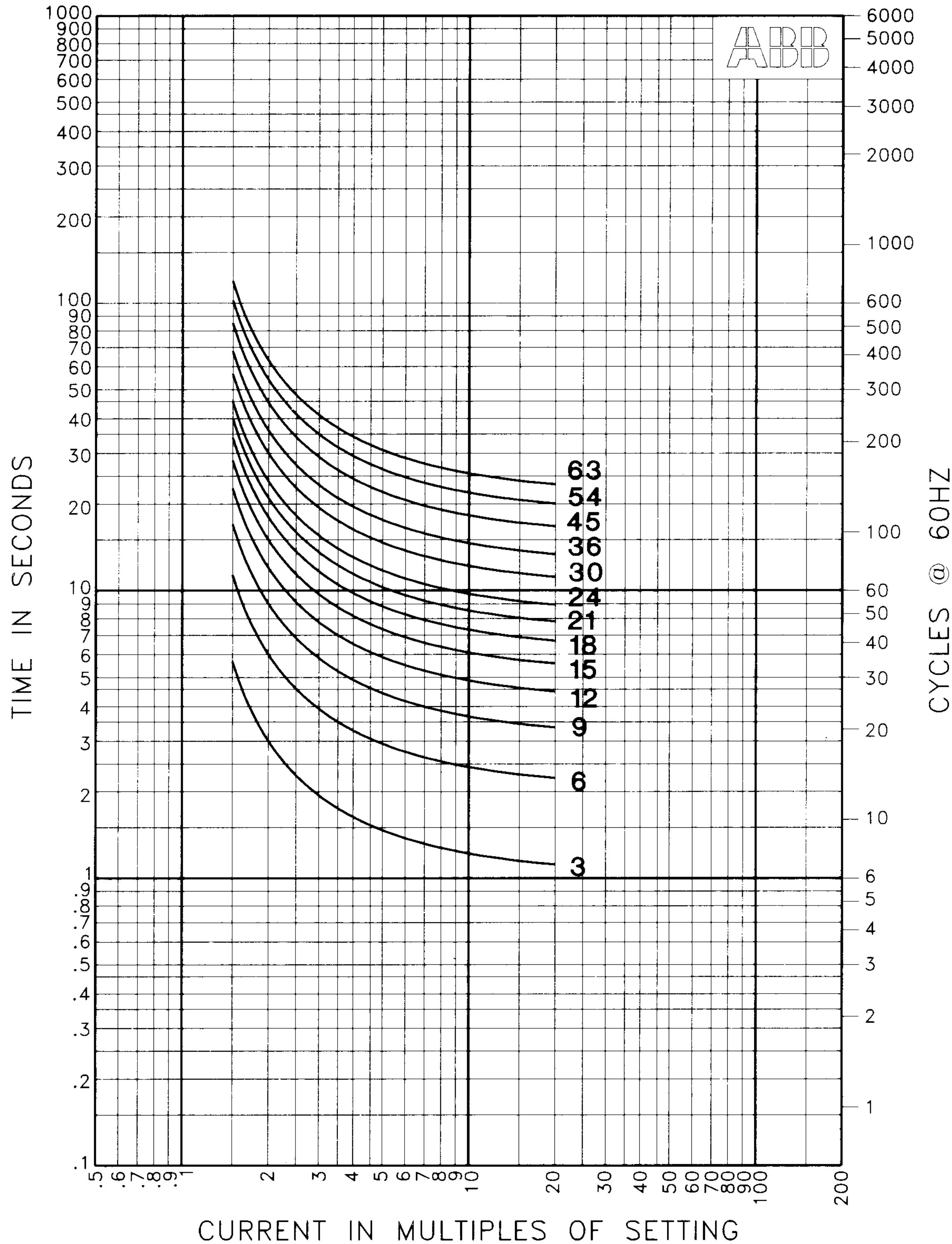


Fig 6. Componenent Location Interface Module



DATE	MCO/MMCO-2	DWG NO	REV
OCTOBER 1992	SHORT TIME INVERSE	605879	0

**Fig. 7 Typical Time Curve #1 (CO-2)*



DATE	MCO/MMCO-5	DWG NO	REV
OCTOBER 1992	LONG TIME INVERSE	605882	0

**Fig. 8. Typical Time Curve #2 (CO-5)*

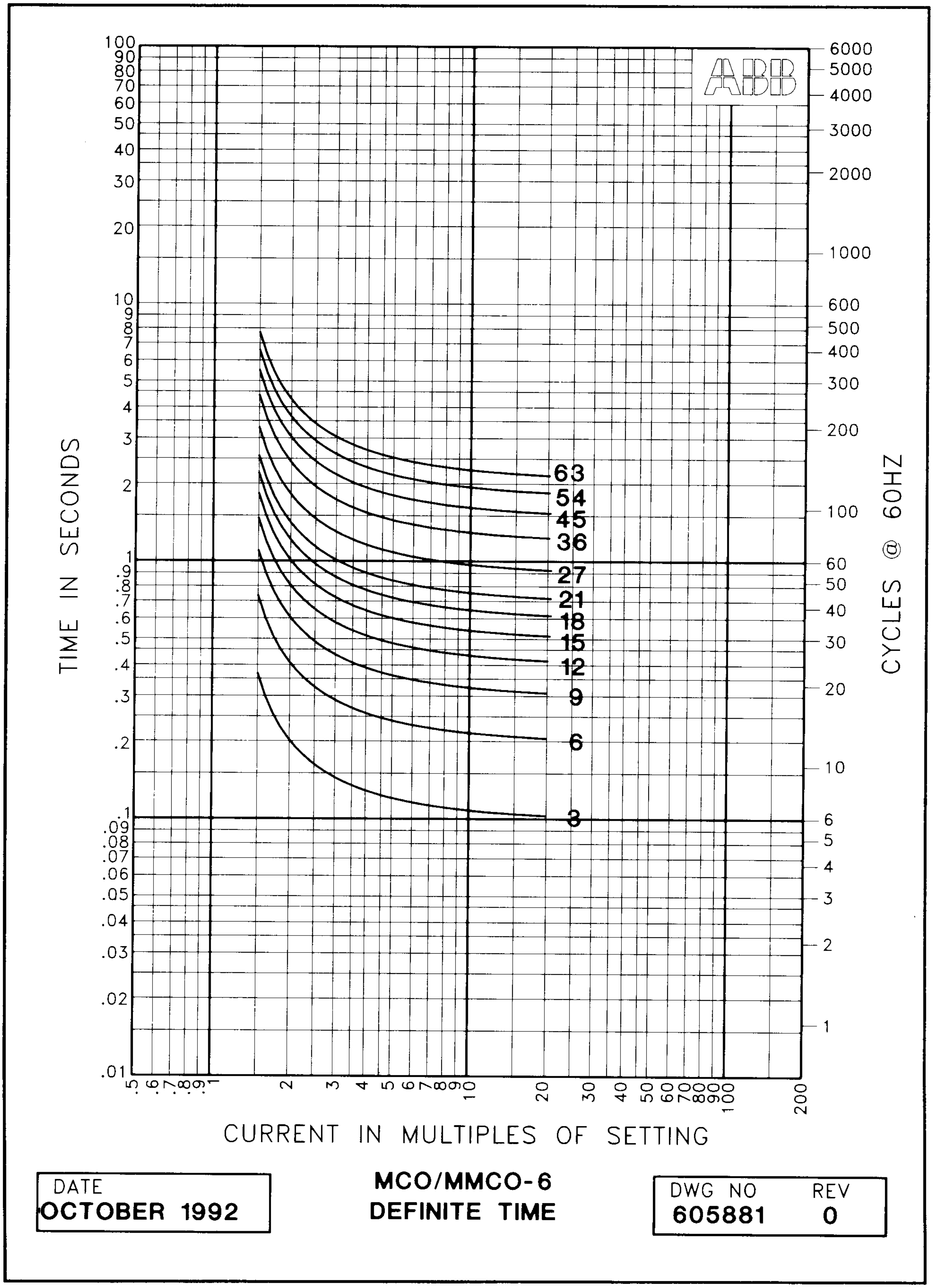


Fig. 9. Typical Time Curve #3 (CO-6)

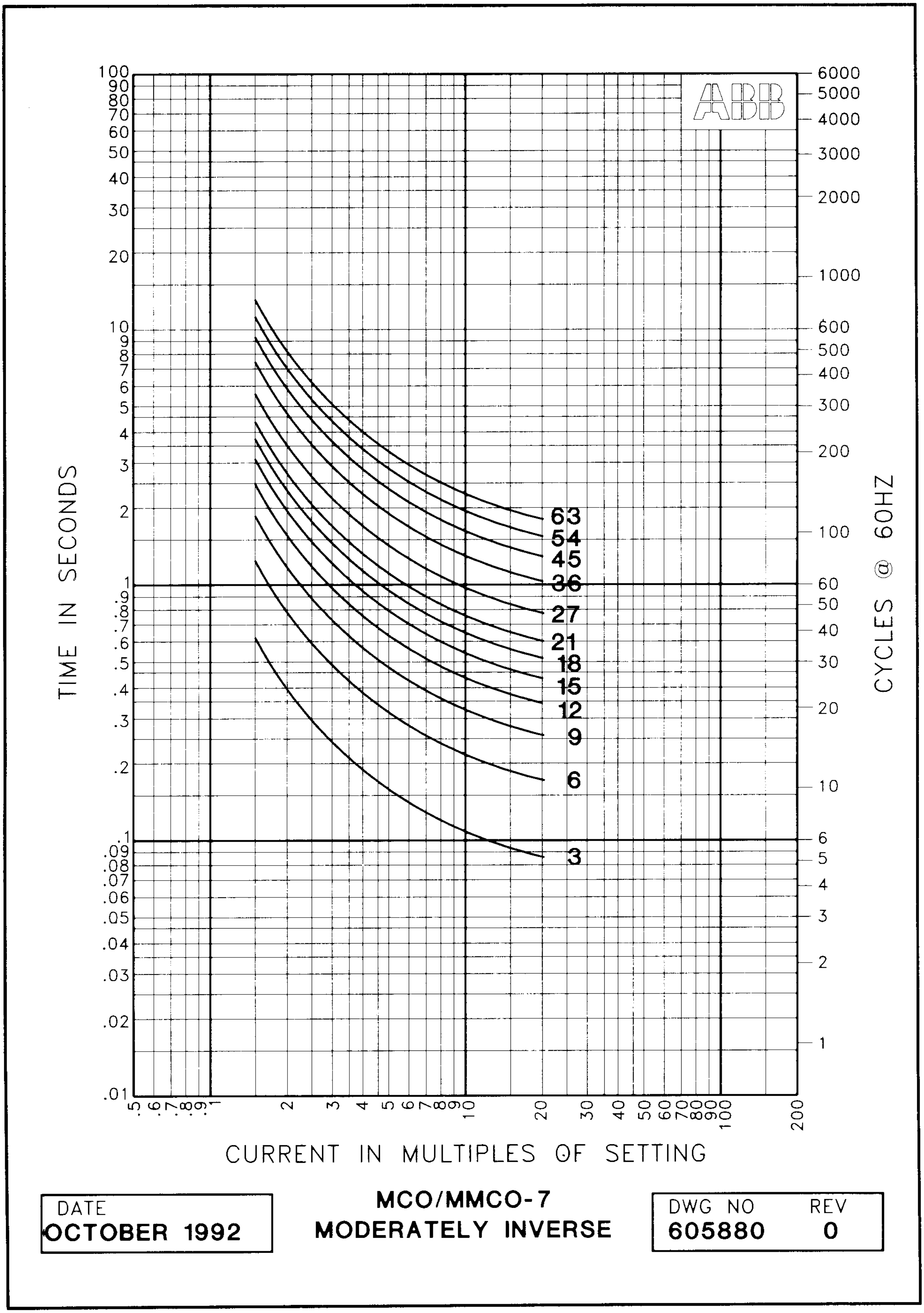


*Fig. 10. Typical Time Curve #4 (CO-7)

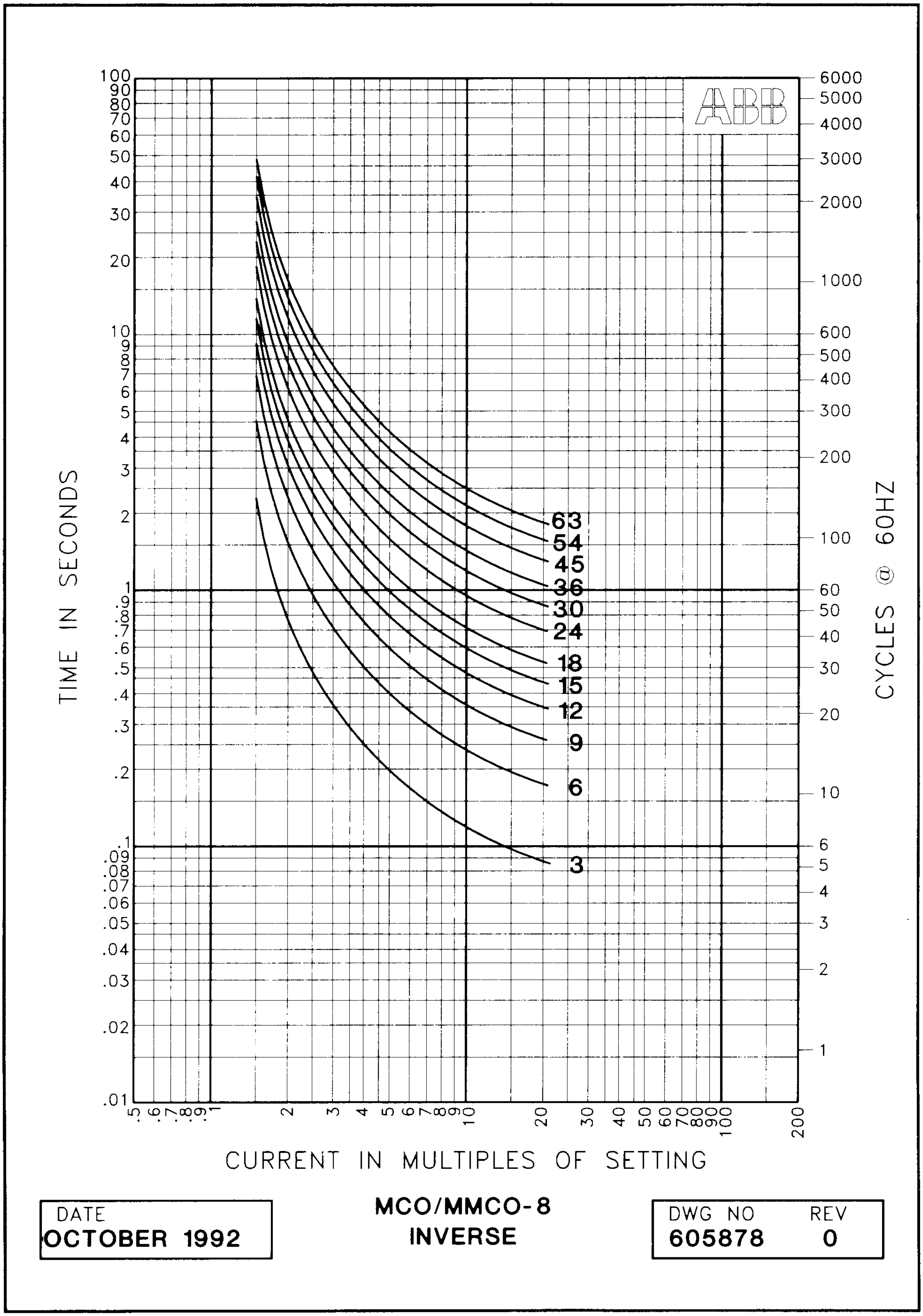


Fig. 11. Typical Time Curve #5 (CO-8)

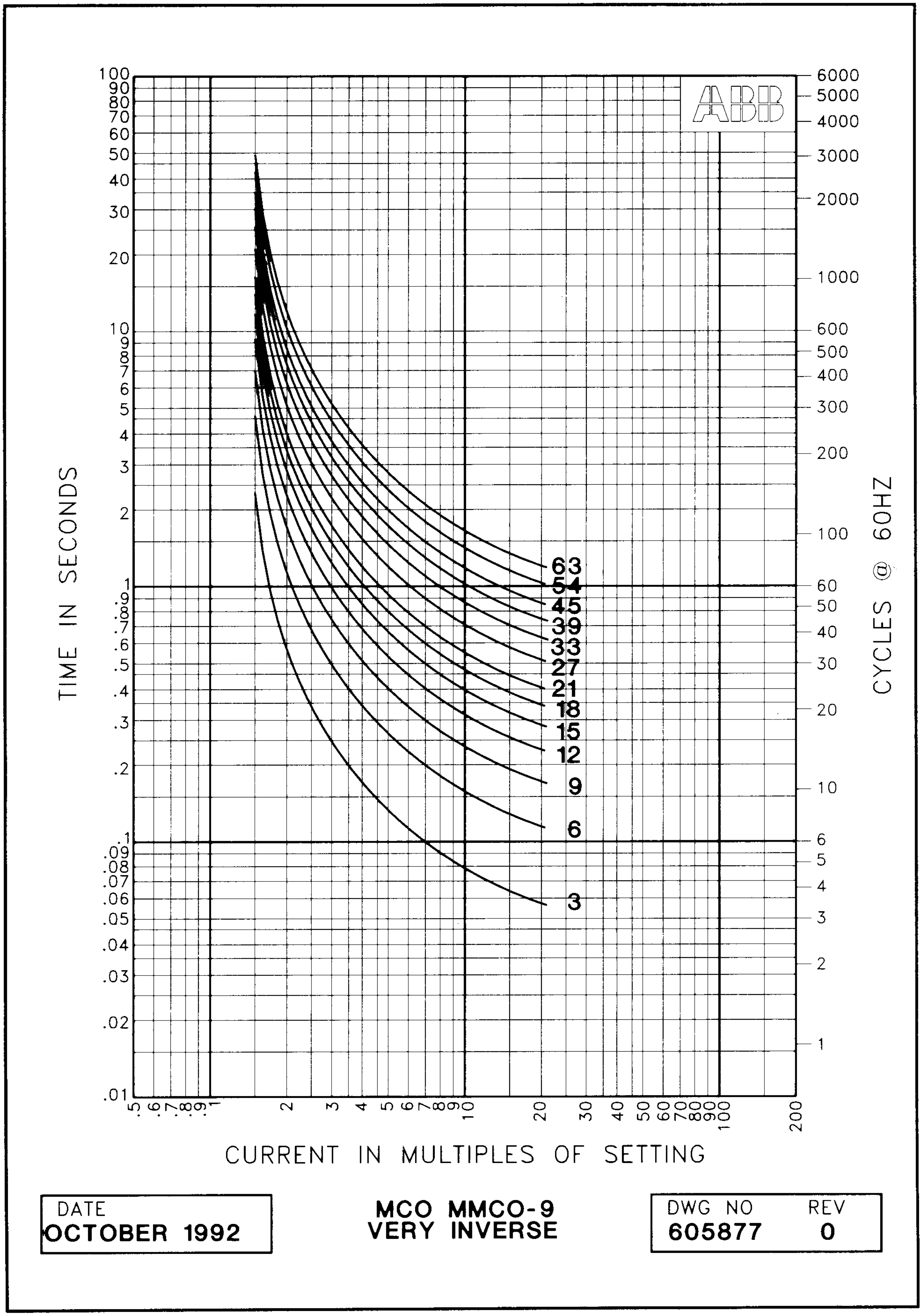


**Fig. 12. Typical Time Curve #6 (CO-9)*

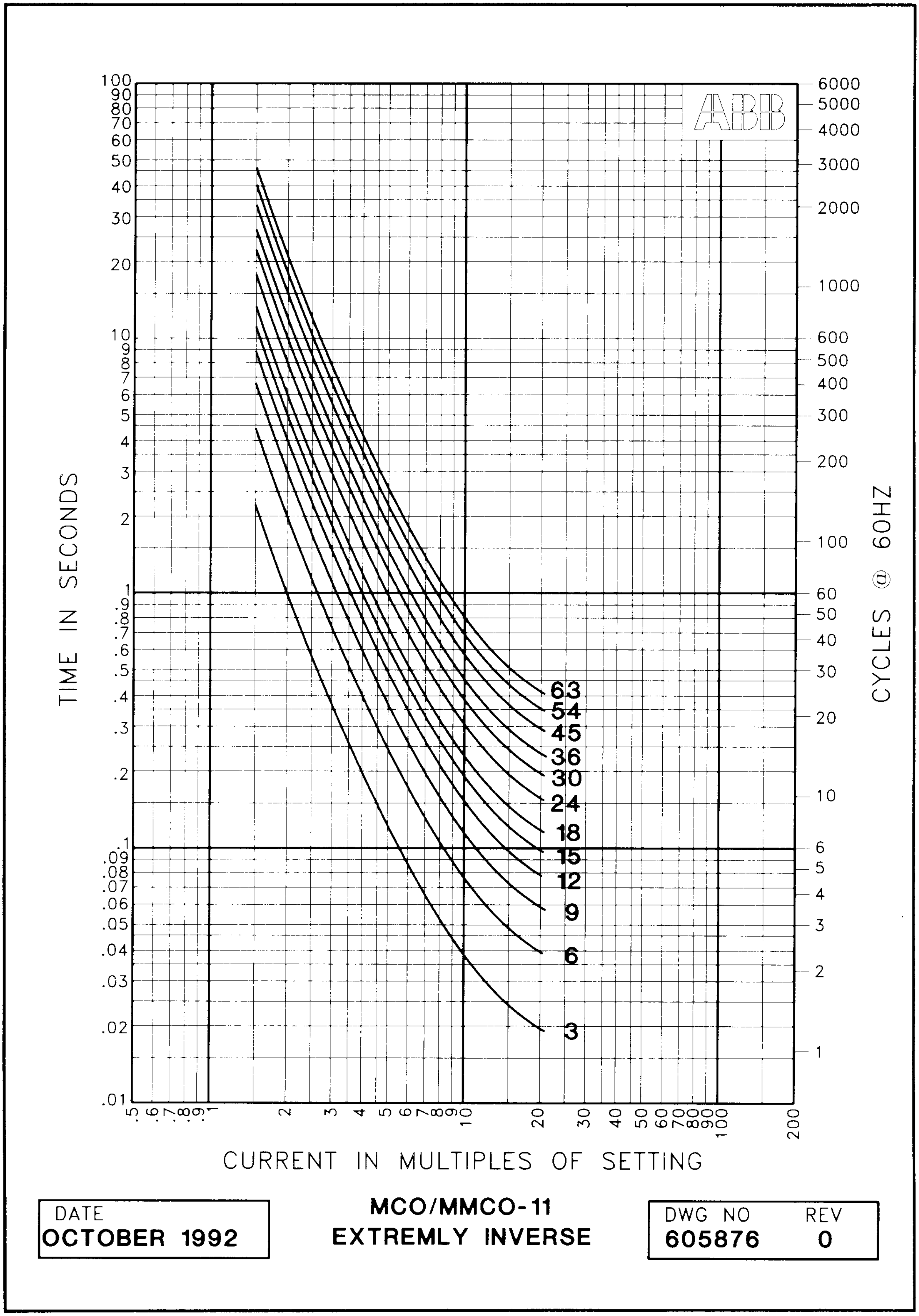
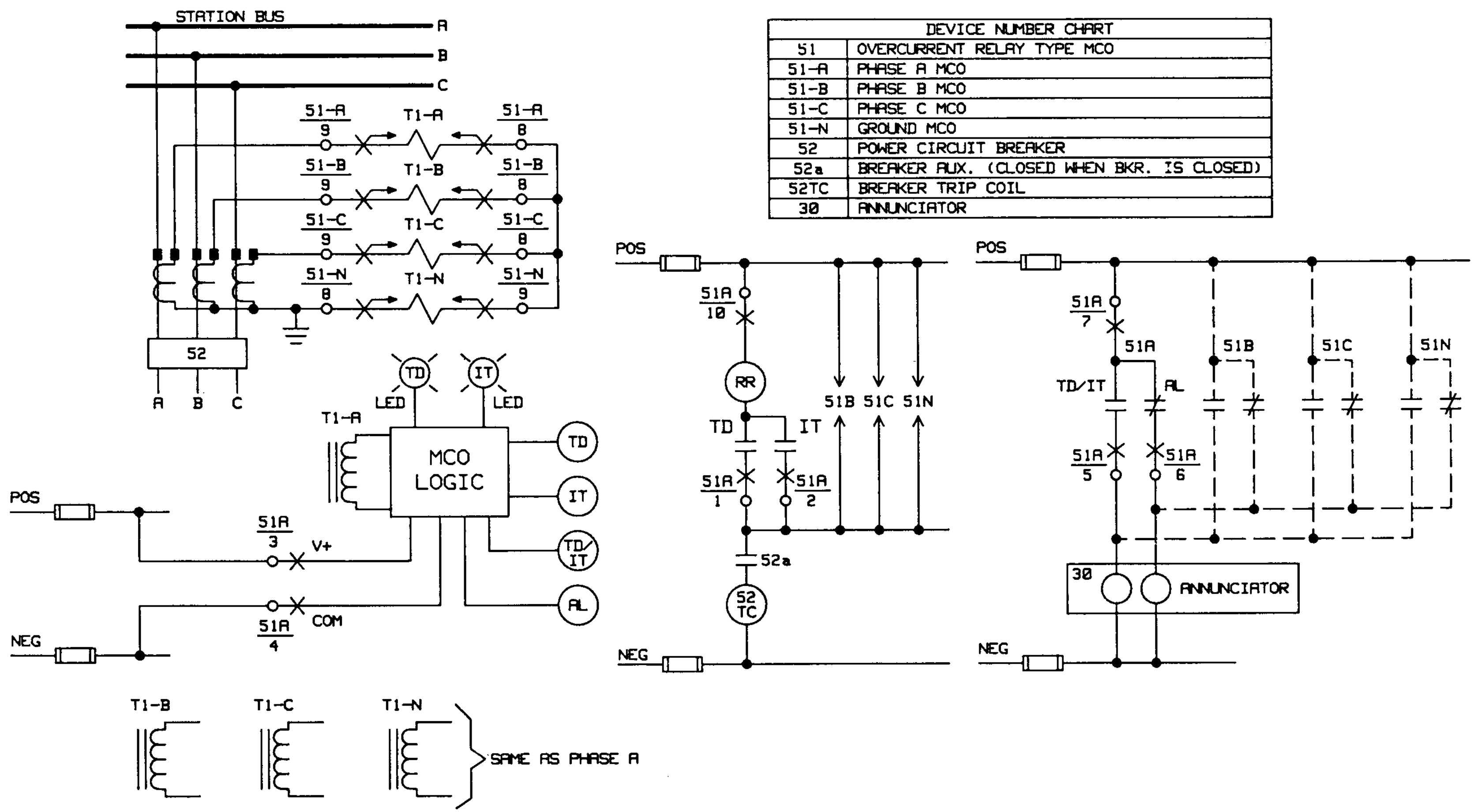


*Fig. 13. Typical Time Curve #7 (CO-11)



DEVICE NUMBER CHART	
51	OVERCURRENT RELAY TYPE MCO
51-A	PHASE A MCO
51-B	PHASE B MCO
51-C	PHASE C MCO
51-N	GROUND MCO
52	POWER CIRCUIT BREAKER
52a	BREAKER AUX. (CLOSED WHEN BKR. IS CLOSED)
52TC	BREAKER TRIP COIL
30	ANNUNCIATOR

Sub 2
1494B93

Fig. 14. MCO External Schematic

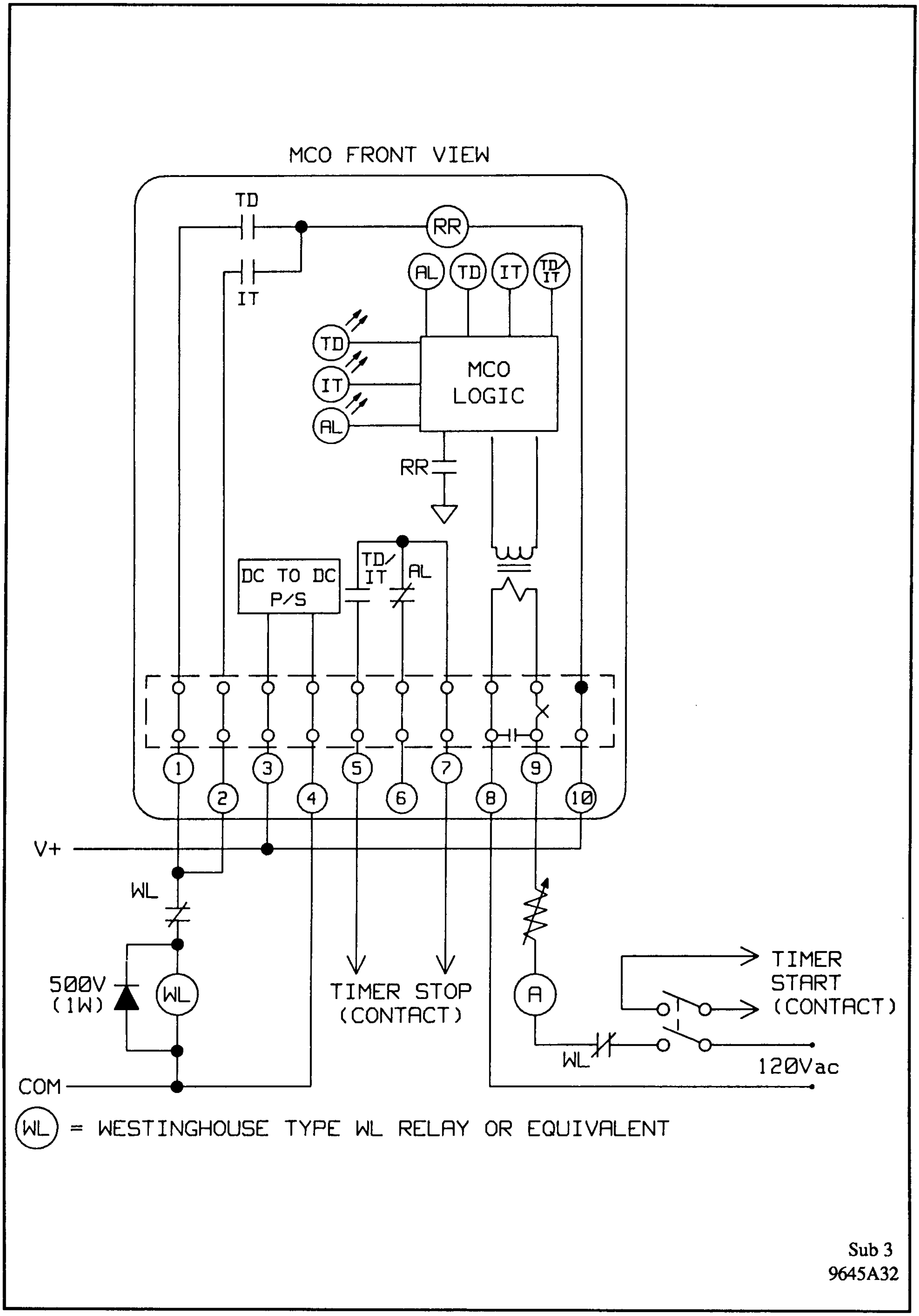


Fig. 15. Diagram of Test Connections for Type MCO Relay

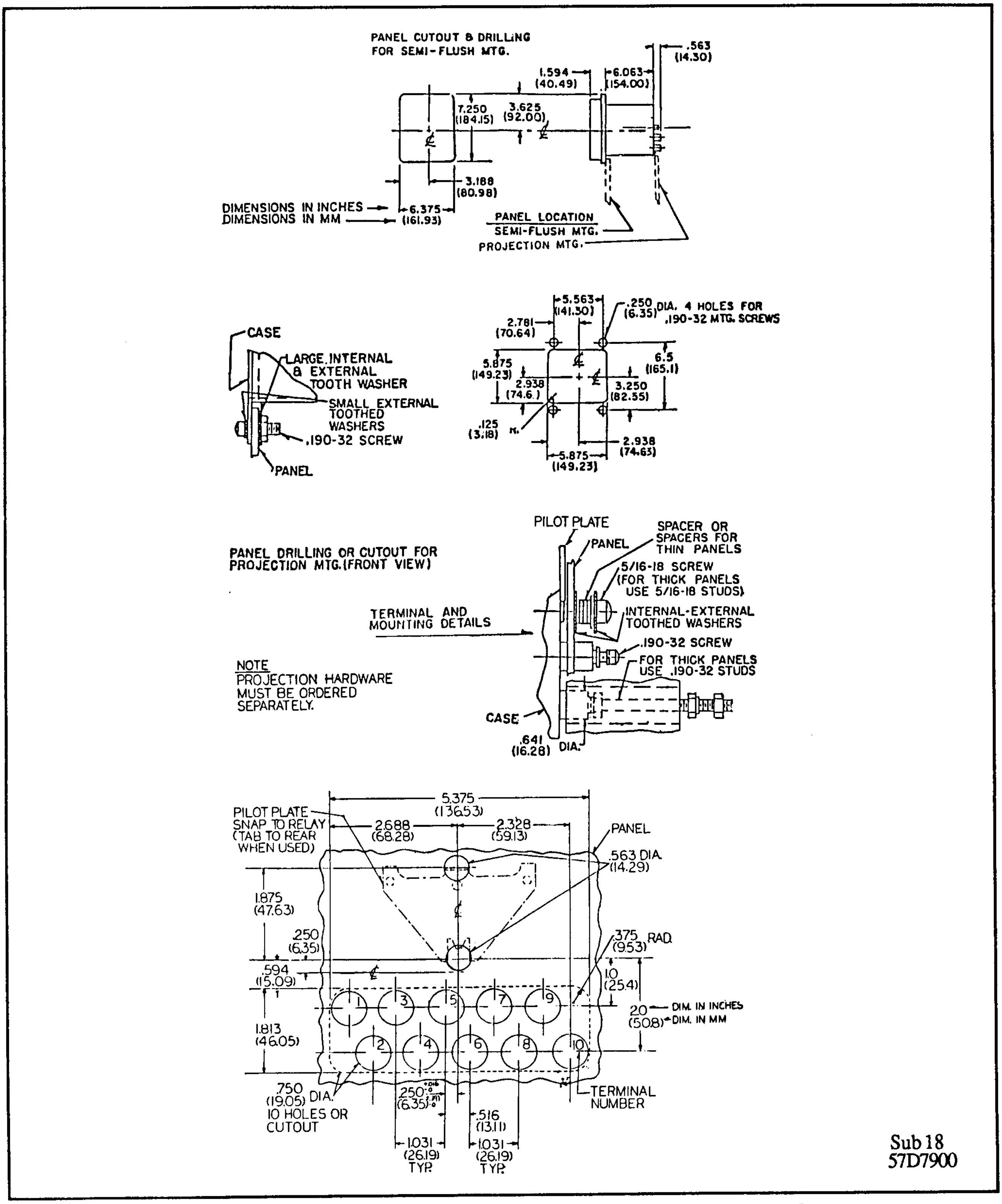


Fig. 16. Outline and Drilling Plan for Type MCO Relay Single Phase in FT-11 Case

ABB POWER T&D COMPANY INC.

Protective Relay Division 7036 Snowdrift Rd.

Allentown, PA 18106 USA

Phone: (215) 395-7333

Fax: (215) 395-1055