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

Instruction Leaflet
I.L. 41-121.2

Type MMCO Multi-Phase Overcurrent Relay

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TABLE OF CONTENTS

CAUTION

It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet before energizing the relay. Failure to do so may result in injury to personnel or damage to the equipment, and may affect the equipment warranty. The relay contains static sensitive components. Electrostatic Discharge (ESD) precautions must be practiced when handling printed circuit boards and components. Use of antistatic handling materials and grounding procedures is required.

Before putting relay into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment. Operate the relay to check the settings and electrical contacts.

The operation of this relay is based on ABB proprietary software, resident-in-memory components. Purchase of this relay includes a restrictive license for the use of any and all programs solely as part of the protective functions. ABB 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.

1. APPLICATION

The MMCO is a multi-phase (2 or 3 phase) and ground, time and instantaneous ac overcurrent relay (see Block Diagram, Figure 1). It is used to sense a current level above a particular setting and to trip a circuit breaker to clear faults. A wide range of time-current characteristics permit applications involving fuses, reclosers, cold-load pickup, and motor starting, in addition to essentially fixed-time applications. Typical applications of the MMCO relay are described, in Table 1, with respect to familiar CO or IEC equivalents.

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 this particular installation, operation or maintenance of this equipment, the local ABB Power T&D Company Inc. representative should be contacted.

TABLE 1:
MMCO APPLICATIONS RELATED TO INVERSE TIME CURVES

CURVE TYPE	DESCRIPTION	TYPICAL APPLICATIONS
MMCO-2	Short	1) Differential protection where saturation of current transformers is not expected, or where insensitive setting and 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.
MMCO-5	Long	Motor-locked rotor protection where allowable locked rotor time is approximately between 10 and 70 seconds.
MMCO-6	Definite	Overcurrent protection where coordination with downstream devices is not involved and MMCO-2 is too fast. The operating time of this relay does not vary greatly as current level varies.
MMCO-7 (IEC-A)	Moderately	1) Overcurrent protection where coordination with other devices is required, and generation varies. 2) Backup protection for relays on other circuits.
MMCO-8	Inverse	
MMCO-9 (IEC-B)	Very Inverse	
MMCO-11 (IEC-C)	Extremely Inverse	Motor protection where allowable locked rotor time is less than 10 seconds. Overcurrent protection where coordination with fuses and reclosers is involved, or where cold-load pickup or transformer inrush are factors.

Options are provided for a real-time clock and external directional control. An external 3-phase device (e.g., KD-10 or H3) is required to supervise phase tripping, and a single ground directional unit (e.g., KRC, KRP or KRD) is required to supervise ground tripping. When this option is included and selected as being operative, timing will not start until the external contact closes. An alternate option allows resetting to be accomplished externally (without using the communication channel), but only when directional control is not supplied. Options for current are as follows:

- 3 PH Ground
- 3 PH No Ground
- 2 PH Ground

An INCOM communications device may be purchased separately to allow for access to the MMCO relay, using an access code.

The following remote operations may be performed using an INCOM communications device:

- Read all information available on front panel display
- Read data for pervious 16 fault cases (targets).
- Make all settings using password entry.

The following types of INCOM devices are available:

- INCOM PONI (to access MMCO relay through INCOM network)
- RS-232 PONI (to access MMCO relay through RS-232 lines)

2. CONSTRUCTION

The MMCO is a microprocessor-based relay consisting of 5 printed circuit modules which are packaged in a standard FT-22 flexitest case (see Figure 2). Refer to I.L.41-076 for detailed information on the FT-22 case. The 5 modules are as follows (see Section 6 CIRCUIT DESCRIPTIONS):

- Power Supply
- Current Transformer (ct)
- Microprocessor
- Display

- Input/Output (I/O)

2.1. POWER SUPPLY

The Power Supply is available in two versions: 48 to 125 Vdc or 250 Vdc. The Power Supply module contains components of a dc/dc converter, an ABB custom linear IC, a +5 Volt reference and adjustment potentiometers for the + 5 V reference. dc/dc converter converts 48 - 125 Vdc or 250 Vdc to 21 Vdc and 5 Vdc.

2.2. CURRENT TRANSFORMER (CT)

The ct module contains a current transformer for each phase and ground input, as well as input waveform conditioning and surge protection. Ct module outputs are sent to the Microprocessor module.

2.3. MICROPROCESSOR

The Microprocessor module contains a microcomputer chip which includes an analog to digital (A/D) converter, input and output ports and timers. The module also includes memory, a real-time clock (optional). Relay pickup calibration is part of this module, as well as a trimmer capacitor for adjustment of the optional real-time clock.

2.4. INPUT/OUTPUT

The INPUT/OUTPUT module contains contact closure outputs and optically isolated inputs. A reed relay detects the trip current flow through trip contacts.

2.4.1. Contact Closure Outputs (See Section 6.6)

Time Delay Trip	(TDTRIP)
Instantaneous Trip	(ITRIP)
Time Delay Annunciator	(TDANUNLO)
Instantaneous Annunciator	(IANUNLO)
Alarm Output	(ALARMLO)

2.4.2. Optically-Isolated Inputs (w/Directional Control Option)

Phase Directional Control	(TCP)
Ground Directional Control	(TCG)

2.4.3. Optically-isolated Inputs (w/Remote Reset Option)

Remote Reset	(RR)

2.5. DISPLAY MODULE

The Display module includes (see Figure 3):

A 16 x 2 character alphanumeric LCD for display of the last four trip targets, settings, metering, relay catalog number, software versions, and time and date (optional).

A red "TRIP" LED which blinks when input current is above time-delay pickup level; is steady for time-delay or instantaneous trip; and seals-in when breaker trip current flow is detected.

An amber "MONITOR" LED which is "ON" during normal relay operation, for power-on and self-check indication. This LED will be "OFF" if there is a relay hardware failure or alarm condition.

There are five keypad push-buttons as follows:

1) "SELECT" button (SW1).
   Selects between the settings mode, targets display, time setting and metering display.

2) "SCROLL" button (SW2).
   Accesses the different categories within each mode.

3 & 4) "RAISE" (SW3) and "LOWER" (SW4) buttons.
   Select the actual value of the parameter in the settings mode. When "RAISE" or "LOWER" has been pushed, it is not possible to "SELECT" or "SCROLL" new parameters without pushing "ENTER" first.

5) "ENTER" button (SW8).
   Relay accepts the setting which is shown on the alphanumeric display.

In addition, there are three other external buttons that are activated as follows:

1. "EXTERNAL SCROLL" button (SW7).
   Can be pushed without opening the relay case. This button scrolls the display.

2. "TARGET RESET button (SW6).
   Can be reset without opening the relay case. This button resets the trip LED if the trip LED has been sealed-in by breaker trip current flow. All target information (16 targets stored in the relay)

may be erased by pushing this button for 6 seconds.

3. "TRIP TEST" button (SW5).
   This button causes the relay to trip, activating all outputs except the Alarm output (2.4 above). A pen or other slender object is required to push this button (prevents accidental activation).

3. CHARACTERISTICS

Standards	Meets all applicable ANSI C37.90 and IEC 255 stds.
Temperature Range	-20 to +55 deg. C (operating) -40 to +70 deg. C (storage)
Frequency	50 Hz or 60 Hz (selectable)
Time Delay Pickup Settings 5 Amp ct 1 Amp ct	 0.5 Amps to 12 Amps in 1. Amp steps 01 Amps to 2.4 Amps in .01 Amp steps
Pickup Accuracy	5% for TD setting 5% for IT setting
Inverse Curves (U.S.A. version)	Seven sets of time curves from CO-2 to CO-11. Each set includes 63 curves. (See Table 2 and Figures 4 thru 10)
Inverse Curves (IEC version)	Three sets of time curves, IEC-A, IEC-B and IEC-C. Each set includes 63 curves. (See Table 3 and Figures 11 thru 13.)
Timing Accuracy	At 5 times pickup 10% or 3 cycles whichever is greater Δ At 20 times pickup 10% or 3 cycles whichever is greater Δ Δ NOTE: 10 ms pickup time must be added to curves for TDTRIP output relay.
Dropout Ratio (Time delay & Inst. contacts)	98% Min.
TRIP Reset Time	2.5 cycles typical 3.5 cycles max.
TRIP Seal-In Current	.5A dc current minimum required thru TRIP contact circuits to Seal-in TRIP contacts and TRIP LED
Instantaneous Unit Pickup Settings	Pickup (with 5 Amp ct): 1 Amp to 127 Amps in 1 Amp steps. Pickup (with 1 Amp ct): 0.2 Amps to 25.5 Amps in .1 Amp steps. Maximum Pickup time: 1.5 cycles @ current = 3 x pickup 2 cycles @ current = 2 x instantaneous setting 4 cycles @ current = 1.2 x instantaneous setting
Trip Contacts	N.O. contact for time delay trip N.O. contact for instantaneous trip
Alarm Contact	N.C. contact (contact closed if loss of power or self-check failure)
Annunciator Contacts	N.O. contact for time delay trip N.O. contact for instantaneous trip

CHARACTERISTICS, cont'd.

Contact Rating	Make: 30 Amp at 250 Vdc for 1 sec (one shot) Break: 50 W Resistive up to 250 Vdc
Directional Control (Option)	One input requires battery voltage to enable phase tripping. Second input requires battery voltage to enable ground tripping. Directional control can be enabled or bypassed on any combination of the four Trip Units (ϕ-TC, ϕ-INST, GRND-TOC, GRND-INST) via settings with this option.
Remote Reset (Option)	Input which causes reset of sealed-in trip LED when battery voltage is applied to it.
Real-time Clock (Option)	Targets are dated and time-tagged. Current date and time can also be read. (Uses lithium battery backup.)
DC Power Supply	Nominal Voltage: 48/125 Vdc; 250 Vdc Operating Voltage: 38-140 Vdc; 200-280 Vdc DC Power Drain: 8 Watts max.; 10 Watts max.
AC Ratings	ct Type: 5A ct; 1 A ct Continuous Rating: 16 Amps; 5 Amps OHMIC Burden: .005 Ω; .025 Ω 1 Second Rating: 200 Amps; 100 Amps

Table 2: USA (CO) TYPE TIME CURVE CALIBRATION POINTS

CURVE TYPE	TIME DIAL	CURRENT APPLIED TIMES P/U VALUE	OPERATING TIME IN SECONDS
MMCO-2	30	5X 20X	0.352 0.188
MMCO-5	30	5X 10X	14.693 12.186
MMCO-6	30	5X 10X	1.201 1.025
MMCO-7	30	5X 20X	1.585 0.859
MMCO-8	30	5X 20X	1.979 0.872
MMCO-9	30	5X 20X	1.331 0.572
MMCO-11	30	5X 20X	1.226 0.195
NOTE: 10 msec pickup time, for the TD relay, must be added to the above operate times for total MMCO relay operate time.			

Table 3: IEC (CO) TYPE TIME CURVE CALIBRATION POINTS

CURVE TYPE	TIME DIAL	CURRENT APPLIED TIMES P/U VALUE	OPERATING TIME IN SECONDS
A	30	5x 20x	2.038 1.080
B	30	5X 20X	1.607 0.338
C	30	5X 20X	1.587 0.095
NOTE: 10 milliseconds pickup time for the TD relay must be added to the above operate times for total operate time of the MMCO relay.			

4. SETTINGS

4.1. TIME OVERCURRENT FUNCTION

The level and time settings are dictated by those normal system phenomena which must be ignored, and by the minimum current the system is expected to deliver to a fault in the protected zone of the relay.

For the phase units, pick up and time settings must be chosen with due consideration given to such long or moderate time phenomena as:

1. Maximum load
2. Cold-load pickup
3. Motor starting

Pickup and time settings above any of these influencing factors must be chosen. Coordination with other devices must also be achieved. A time of 0.3 seconds plus breaker time is generally recommended as a coordinating time interval (CTI) between adjacent relays being coordinated. With careful evaluation of current transformer errors, setting accuracy and worst case relay errors, a lower CTI may be used.

Where a ground setting is chosen, attention should be given to:

1. Maximum residual load unbalance
2. Loss of largest single-phase load (for example, as a result of fuse-blowing)

Pickup for ground sensing should be set at a current level above these conditions. Time delay for ground tripping should be set to coordinate with other devices.

Curve shapes may be chosen independently for the phase and ground functions. A single setting establishes the curve shape for the 2 (or 3) phases.

4.2. INSTANTANEOUS OVERCURRENT FUNCTION

The instantaneous settings must be chosen to be above:

1. Transformer inrush
2. Capacitor inrush
3. Faults having magnitudes associated with locations at or beyond the next protective device.

Consideration must be given to the added effect of dc offset in the phenomenon listed. In general, a setting of 120% of the symmetrical current (no dc offset present) will provide adequate security.

4.3. INVERSE TIME CURVES

The MMCO relay simulates the traditional inverse curve sets (USA or IEC version), which are permanently stored in memory.

4.3.1. USA Version/CO Curves

There are seven families of CO curves:

1. MMCO-2 - Short Inverse
2. MMCO-5 - Long Inverse
3. MMCO-6 - Definite Inverse
4. MMCO-7 - Moderate Inverse
5. MMCO-8 - Standard Inverse
6. MMCO-9 - Very Inverse
7. MMCO-11- Extreme Inverse

Each family contains 63 curves determined by the time dial setting (see Figures 4 thru 10). The expressions for the CO curves are shown in equation (1) for I/I0 greater than 1.5 per unit, and equation (2) for I/I0 between 1.0 and 1.5 per unit.

$$T = [To + K / (I/I0 - C)P] \times D/24{,}000 \quad (1)$$

$$T = [R / (I/I0-1.0)] \times D/24{,}000 \quad (2)$$

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 inversions
- D = time dial setting from 1 to 63

Table 4 indicates all values of pre-determined parameters (To, K, C, P and R) in the program for each curve. Parameters I_0 and D are user-selectable via pickup setting and time dial switches, respectively.

Table 4:
TIME CURVE PARAMETERS

CURVE	To	K	C	P	R
MMCO-2	112	735	0.675	1	510
MMCO-5	8197	13769	1.130	1	22705
MMCO-6	785	671	1.190	1	1475
MMCO-7	525	3121	0.800	1	2491
MMCO-8	478	4122	1.270	1	9200
MMCO-9	310	2756	1.350	1	9342
MMCO-11	110	17640	0.500	2	8875

4.3.2. IEC Curves

There are three families of IEC curves; IEC-A, IEC-B, IEC-C. Each family contains 63 curves determined by the time dial setting (see Figures 11 thru 13). The expression for the IEC curves is shown in the equation (3) below:

$$T=(K \times D /63) / [G / Gs) a-1](3) \quad (3)$$

where

- T = Theoretical operating time (seconds)
- K = constant characterizing the relay (seconds)
- D = time dial setting from 1 to 63
- G = value of the characteristic quantity (i.e., current through relay ct).
- Gs = setting value of characteristic quantity (i.e., pickup setting)
- a = index characterizing the algebraic function

The following values are used for a and K:

	Standard Inverse Time (A)	Very Inverse Time (B)	Extreme Inverse Time (C)
K	0.14	13.5	80.0
a	0.02	1.0	2.0

5. OPERATION

The MMCO relay continually executes its protective functions whenever DC power is applied to the relay. Concurrently with this protective function, four modes may be selected using the front panel keypad switches.

The modes are:

- Metering
- Settings
- Targets

Set Time (Only with optional real-time clock)

In addition to the keypad switches which select the relay modes, there are three switches accessible from the front panel dedicated to special functions.

These functions are:

- TRIP TEST
- TARGET RESET
- EXTERNAL SCROLL

A flow chart for MMCO relay keypad operation is included (Figure 16) for reference.

5.1. METERING MODE ("M" IN UPPER LEFT CORNER OF DISPLAY)

When dc power is applied to the relay it displays the metering mode with IA, IB, and S (status) appearing on the front panel. When the relay is not in the Metering Mode the "SELECT" button can be used to go to this mode. The following additional information can be displayed using the scroll button: IC, I0, and with the real time clock option: day, date and time.

When in the Metering Mode, the status, "S", appears in the upper right hand corner of the display. When there is an internal hardware or software failure in the relay the amber MONITOR LED goes out and the value of the status indicates the cause of the failure. The meaning of the status coded (S = "") are as follows:

	A/D	EEPROM	RAM	EPROM
S = 00	pass	pass	pass	pass
S = 01	pass	pass	pass	fail
S = 02	pass	pass	fail	pass
S = 03	pass	pass	fail	fail
S = 04	pass	fail	pass	pass
S = 05	pass	fail	pass	fail
S = 06	pass	fail	fail	pass
S = 07	pass	fail	fail	fail
S = 08	fail	pass	pass	pass
S = 09	fail	pass	pass	fail
S = 10	fail	pass	fail	pass
S = 11	fail	pass	fail	fail
S = 12	fail	fail	pass	pass
S = 13	fail	fail	pass	fail
S = 14	fail	fail	fail	pass
S = 15	fail	fail	fail	fail

5.2. SETTINGS MODE ("S" IN UPPER LEFT CORNER OF DISPLAY)

This mode is selected by pushing the "SELECT" button. Initially the software "Version #" appears on the display. Using the "SCROLL" button the following settings may be selected:

- PHASE PICKUP
- GRND PICKUP
- PHASE INST.
- GROUND INST.
- PH TIME DIAL
- GRND TIME DIAL
- OPTION (not changeable)
- PHASE CURVE
- GROUND CURVE
- FREQUENCY
- DIR CONTROL (only with directional control option)
- INCOM KEY (for use with INCOM accessories)
- MMCO RELAY VERSION #

When the relay is in one of the above setting modes, the value of the setting can be changed using the raise or lower buttons. Once the value of the setting has been changed, the "ENTER" button must be pushed before the relay can be scrolled to the next setting. The "ENTER" button also causes the relay to accept the new setting.

The available curves are listed in Table 1 and graphed in Figures 4 - 13. Time dials range from 1 to 63 for each curve type. The available time and instantaneous pickup settings and frequency settings are listed in section 3 (Characteristics).

Directional control inputs are available as an option. With this option, directional control inputs for phase and ground instantaneous and time delay tripping may be selected using the settings mode. For example, when phase time delay directional control has been selected, battery positive voltage must be applied to relay terminal 18 and battery negative voltage to terminal 20 (Figure 17) in order to enable phase time delay tripping. When ground instantaneous directional control has been selected, battery positive voltage must be applied to terminal 19 and battery negative voltage to terminal 20 in order to enable ground instantaneous tripping.

The directional control option settings are:

Display	Directional Control
--- ---	None
G_T	Grnd. T.D.
GI_	Grnd. Inst.
GIT	Grnd. Inst. & T.D.
P_T	Ph. T.D.
PI_	Ph. Inst.
PIT	Ph. Inst. & T.D.
PI_G_T	Ph. Inst. & Grnd. T.D.
PI_GI_	Ph. Inst & Grnd. Inst.
PI_GIT	Ph. Inst & Grnd. Inst. & T.D.
P_TG_T	Ph. T.D. & Grnd. T.D.
P_TGI_	Ph. T.D. & Grnd. Inst.
P_T GIT	Ph. T.D. & Grnd. Inst. & T.D.
PIT G_T	Ph. Inst. & T.D. & Grnd. T.D.
PIT GI_	Ph. Inst. & T.D. & Grnd. Inst.
PIT GIT	Ph. Inst. & T.D. & Grnd. Inst. & T.D.

The directional control settings are selected using the raise and lower buttons when in the "DIR CONTROL" settings mode.

The INCOM key setting allows the INCOM key number to be changed to an integer between 0 and 255. This key is required to access the relay through a

communications network. If the communications option is not being used, the INCOM key setting should be ignored.

5.3. TARGETS MODE ("T" IN UPPER LEFT CORNER OF DISPLAY)

The Targets (trip data) for the previous four faults ("T1" to "T4") can be displayed by pushing the "SELECT" push-button.

Data for the previous 16 faults can be read remotely if the communications option is used.

The "SCROLL" button is used to scroll through the data for each target, displaying the following information:

Type of trip: Phase or Grnd. & Inst. or Time Delay

- Current at trip time: IA, IB, IC, I0
- Time of trip (option): Day, Date, Time

If the relay is not in the settings mode, the display will jump to the most recent trip data (T1) when a trip occurs.

NOTE: In order to ensure proper fault current target data, the fault current must remain for a minimum of three cycles and at least 1 cycle after trip. For times less than this, the fault current level displayed will be lower than the actual.

5.4. SET TIME MODE (ONLY WITH OPTIONAL REAL-TIME CLOCK)

("ST" in upper left corner of display.)

The Set Time mode can be accessed by pushing the "SELECT" button. Once in this mode, the "SCROLL" button is used to select which parameter is to be changed: day of week, month, day, year, hour (24 hour clock), minute, second. The value of each parameter is changed using the "RAISE" or "LOWER" button to start it running. When the "ENTER" button has been pushed the relay display goes to the metering Mode, displaying the clock information (Day, Date, Time). The real-time clock continues to keep time when power has been removed from the relay although the display goes blank.

5.5. TRIP TEST FUNCTION

The "TRIP TEST" push-button switch is located in the upper right corner of the front panel. It is used to test the trip and annunciator outputs to the relay. When this switch is pushed, the time delay and instantaneous trip and annunciator output contacts close and the trip LED goes on. The test trip data is saved and displayed as "T1" in the same manner as an overcurrent trip The TRIP LED will remain on (Seal in) if there was current flow through the trip contacts. A slender object such as a pen is required to push the "TRIP TEST" switch. This prevents accidental tripping of the MMCO relay.

5.6. TARGET RESET FUNCTION

The "TARGET RESET" push-button switch is located in the lower right corner of the relay front panel. An external lever makes the "TARGET RESET" switch accessible when relay case is closed. When breaker trip current flow is detected by the MMCO, the "TRIP" LED is sealed in (remains on after overcurrent is removed). The sealed in LED is extinguished by pushing the "TARGET RESET" switch. If this switch is held in the on position for 6 seconds, all target information (T1-T16) is erased.

With the remote reset option, the sealed in trip LED may be reset (extinguished) remotely. To reset the trip LED remotely, battery positive voltage must be applied to relay terminal 18 and battery negative voltage to terminal 20 (Figure 17). The remote reset will not reset relay target information available on the LCD display.

5.7. EXTERNAL SCROLL FUNCTION

The "EXTERNAL SCROLL" push-button switch is located in the lower left corner of the relay front panel. An eternal lever makes the "EXTERNAL SCROLL" switch accessible when relay case is closed. When held in the on position, this switch scrolls the display through all relay information (Software Version Number, Settings, Relay Style Number, Target Information, Metering, Time). When the "EXTERNAL SCROLL" switch is released, the relay

remains in the display mode which it was in when the "EXTERNAL SCROLL" switch was released. Settings cannot be changed using the "EXTERNAL SCROLL" button.

6. CIRCUIT DESCRIPTION

Documents referenced are:

- Current Transformer Module Internal Schematic (Figure 18)
- Microprocessor Module Internal Schematic (Figure 20)
- Power Supply Module Internal Schematic (Figure 22)
- Display Module Internal Schematic (Figure 24)
- I/O Module Internal Schematic (Figure 26)

6.1. CURRENT INPUT CIRCUITRY

Since there are four identical sets of circuitry for phase A, B, C, and ground only the circuitry for phase A will be described.

Referring to the ct Module Internal Schematic, Figure 18:

Current is input to the relay at terminals 4 and 5 (for phase A), stepped down by current transformer T1 and full wave rectified by diode bridge BR1. Resistors R1 and R10 convert the input current to voltage. Diodes D1, D5 and CR1 clamp the voltages to safe values. Resistor R5 protects the microprocessor input (U2, on Microprocessor Schematic, Figure 20). For low level current inputs, up to 3.75 Volts across resistor R1, the input voltage is measured directly by the analog to digital (A/D) converter within the microcomputer chip (U2, Microprocessor Module Schematic, Figure 20).

Referring to the Microprocessor Module Internal Schematic, Figure 20:

Each phase and ground go to different pins on the microprocessor U2 and are multiplexed internally by the microprocessor U2. For higher level signals the voltage across resistor R10(ct Module Internal Schematic Figure 18) is scaled by a ranging chip U3 (Power Supply Module Internal Schematic Figure 22) which is controlled by the microprocessor U2. The ranging chip multiplexes the phase and ground inputs. Op amp U1.2, and associated resistors allow for calibration of the high level input voltage to the microprocessor. The calibration is made by adjusting potentiometer P1 so that the relay pickup and metering are correct with the input current set to 4 amps or greater (0.8 A or greater with the 1 A ct).

Referring to Power Supply Module Internal Schematic, Figure 22:

A 5-volt voltage reference for the A/D converter and for the 5 volt power supply is generated by voltage reference Z6, Op amp U2.1 and associated discrete components.

6.2. MICROPROCESSOR SUPPORT CIRCUITRY

Referring to the Microprocessor Module Internal Schematic, Figure 20:

The microprocessor is supported by chip selector U11, address latch U5, 32 K bytes of EPROM (U7), 2K bytes of RAM (U8) and 512 bytes of EEPROM (U6).

A real-time clock chip (U9) is accessed by the microprocessor and gives date and time information.

For relays with the real-time clock option, a lithium battery (BT1) type BR2016 or CR 2016 is in a battery holder on this board. Diode D3 and resistor R44 are in series with the battery in order to insure that the battery will not be charged. Relays without the real-time clock option do not have a battery.

⚠ WARNING

Replace battery with ABB Style 9648a03h01 only. Use of another battery may present the risk of fire or explosion.

CAUTION

Battery may explode if mistreated. DO NOT RECHARGE. Dispose of used battery promptly, in a location where people are not exposed to the battery. DO NOT disassemble or dispose of battery by using fire. Keep away from children.

Referring to Power Supply Module Internal Schematic, Figure 22:

The ranging chip U3 along with discrete components Q6, D6 and R43 serves to reset the microprocessor if the "Deadman" signal is not toggled by the microprocessor. This insures that the system will reset if the software is not functioning properly. OP amp U2.2 and associated discrete circuitry generates the

"Inhibit" signal which prevents writing to RAM (U8 and real-time clock chip U9, Microprocessor Module Schematic, Figure 20) on power up and power down via the memory select chip U11. The inhibit signal also disables the relay outputs during power up or down conditions via relay driver chip Q1 (I/O Internal Schematic Figure 26).

6.3. RELAY INPUT/OUTPUT CIRCUITRY

Referring to the I/O Internal Schematic Figure 26:

The trip relays (K1,K3), annunciator relays (K2,K4) and alarm relay (K5) are driven by the microprocessor via relay driver chip Q1. All the relay contacts are normally open except for the alarm relay (K5) which has a normally-closed contact. The alarm relay (K5) is energized (open contacts) when there is no alarm condition. A reed relay (K6) is monitored by the microprocessor and is used to detect breaker trip current flow. The Inhibit signal, along with associated diodes and resistors and relay driver chip Q1, is used to disable the output relays on loss of battery power to the relay. Two optoisolators (U1, U2) and associated discrete components function as isolated inputs to the relay for either the directional control input option or the remote reset option.

6.4. POWER SUPPLY CIRCUITRY

Referring to the Power Supply Internal Schematic, Figure 22:

A switching dc to dc voltage converter steps the 48-125 Vdc (250 Vdc for 250 V option) down to 21 volts dc for output relay operation and 5 volts for digital circuitry. A linear voltage conversion to 26 V is also generated. The active power elements in the power supply are Q1 which linearly generates the 26 V output, Q3 which switches L1 to generate the 21 V output and Q4 which switches L2 to generate the 5 V output.

OP Amps U1 is used to control the switching regulator and OP Amp U2.1 is used to generate the 5V reference and to calibrate the relay pickup level. Both Op amps U2.1 and U1 are powered by the 26 Volts generated on the Power Supply Module.

6.5. USER INTERFACE CIRCUITRY

Referring to the Display Module Internal Schematic, Figure 24:

The display consists of a 16 X 2 character alphanumeric LCD display module (LD1) which is driven directly by the microprocessor (U2 on Microprocessor Schematic, Figure 20). A temperature compensation circuit consisting of Op Amp U1 and temperature sensor U2 is used to bias the display for good readability over the -20C to +60C temperature range. Potentiometer R13 which is accessible through the front panel is used to adjust the display for best readability under various lighting conditions and viewing angles. It is factory set for normal lighting conditions and viewing angles. A voltage inverter chip (U4) is used to supply the negative supply voltage for the display bias circuitry. Red LED LE1 (TRIP) and amber LED LE2 (MONITOR) are driven by the microprocessor through mosfet transistors Q1 and Q2. The switches on the front panel board are input into a parallel to serial shift register (U8) and their values are read from the shift register serially by the microprocessor.

6.6. CONTACT CLOSURE OUTPUTS

ALARMLO	Alarm output; contact closes for alarm condition.
IANUNLO	Instantaneous annunciator output; contact closes on instantaneous trip.
ITRIP	Instantaneous trip output; contact closes on instantaneous trip.
TDANUNLO	Time delay annunciator output; contact closes on time delay trip.
TD TRIP	Tim delay trip output; contact closes on time delay trip.
ANUNCOM	Common connection for time delay annunciator, instantaneous annunciator and alarm.
TRIPCOM	Common connection for time delay trip and instantaneous trip outputs.

7. ACCEPTANCE TEST

7.1. ACCEPTANCE CHECK

It is recommended that a performance check be applied to the MMCO relay to verify that the circuits are functioning properly. (See MMCO test diagram in Figure 14.) Proper energization of the relay is also shown in this figure.

⚠ CAUTION

While handling the relay out of its case, electrostatic discharge procedures must be followed. Refer to the Electrostatic Discharge (ESD) Caution on page 1 of this I.L.

a. Connect AC current source to one of the relay current inputs (A, B, C or N - Figure 14).

b. Before energizing the relay, make sure that the relay has the proper DC voltage supply (48-125 or 250 Vdc). The supply voltage appears on the front panel.

c. Apply rated dc power to relay terminal 10 (+) and 1 (-). (See Figure 14).

d. Set the relay frequency to match the line frequency (50 Hz or 60 Hz).

7.2. MINIMUM TRIP

a. Set the phase and ground pickup setting to 0.1 Amp for 1 Amp ct, or to 0.5 Amp for 5 Amp ct. Set phase and ground time dial to 63, and set phase and ground curves to MMCO-11 (or IEC-C). If the relay has directional control option, disable directional control by setting "Dir Control" to blanks (See Sec. 5.2).

b. Increase ac current to 5% below pickup value. Trip LED should not blink.

c. Increase ac current to 5% above pickup value. Trip LED should blink. Change time dial setting from 63 to 1. Time trip LED should blink briefly and then light steadily.

d. Set pickup setting to 10 times the minimum setting and repeat steps b and c (above) to verify accuracy (5%).

e. Turn off ac and dc sources; then apply dc supply only. Trip LED should be on (sealed in).

f. Reset LED by depressing the reset push-button.

g. Repeat the above test (steps a through f) with AC input to each of the remaining current inputs (A, B, C or N - Figure 14).

h. If the relay has the directional control option, use the directional control setting to enable the phase and ground time, and instantaneous directional control (setting = "PIT GIT"). Apply current above pickup to any of the relay current inputs (terminals 2&3, 4&5, 6&7 or 8&9). Note that battery voltage is required on directional control inputs (battery positive on terminals 18 and 19, battery negative on terminal 20) in order to enable relay tripping.

i. If the relay has the remote reset option, note that battery voltage applied between terminals 18 and 20, with current reduced to zero, resets the trip LED if it is sealed-in.

7.3. TIME CURVE

Time curve calibration points are shown in Tables 2 and 3. With time dial set to the indicated position, apply currents specified in Table 2 or 3, and measure the operating time of the relay. The operating times should equal those of Table 2 or 3, within 10% or 3 cycles, whichever is larger.

7.4. INSTANTANEOUS TRIP

a. Set the phase and ground pickup to 4.5 amps (0.9 Amps for 1 Amp ct). Set the phase and ground instantaneous pickup to 5 Amps (1 Amp for 1 Amp ct). Set the phase and ground curve to CO-11 and time dial to 63.

b. Apply 5.1 Amps (1.1 Amps for a 1 Amp ct) to the ground ct input of the relay. An instantaneous trip should occur. Verify by reading the most recent target (T1) information.

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

d. Repeat steps b and c (above) with current applied to each of the remaining inputs.

e. This completes the acceptance test; return all settings to the desired position.

8. ADJUSTMENTS

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. Under unusual lighting conditions or large viewing angles, the LCD display may be adjusted for better contrast as described in the "Display Adjustment" portion of this section (8.2).

8.1. CALIBRATION

The relay has been calibrated in the factory by using potentiometers (P1 on the Microprocessor PC Board and R29 on Power Supply Board). Further adjustment is unnecessary unless the relay is found to be out of calibration on the Acceptance Test.

Before performing relay calibration, check that the relay has been set for the rated frequency, and that the relay style matches the required dc battery voltage and ct type.

a. Adjust R29 on Power Supply Board so that +5.0 Vdc appears between VA REF (TP2, red test jack) and ground (TP1, black test jack), on Display PC Board.

b. Set the phase and ground time pickup to 5 amps. Set the phase and ground instantaneous pickup to 20 amps. Set the phase and ground curves to MMCO-11 with time dial of 63.

c. Apply 5.0 Amps to phase A terminals. Adjust P1 so that IA = 5.0 Amps appears on the display.

d. Vary the phase A current and verify that the trip light begins to blink when the current applied to phase A is between 4.75 Amps and 5.25 Amps. If not, adjust P1 so that the trip LED begins to blink when 5 Amps is applied to phase A.

8.2. DISPLAY ADJUSTMENT

The LCD display is factory adjusted for general purpose viewing. The display adjustment on the upper-left hand corner of the front panel can be used to optimize the display readability for the particular lighting and viewing angle conditions in which the relay is situated. With the relay in the lighting conditions and location in which it is used, turn the display adjust potentiometer until the display may be read easily.

8.3. ADJUSTMENT FOR OPTIONAL REAL-TIME CLOCK

NOTE: The real-time clock adjustment is made in the factory. It is not recommended that the customer attempt this adjustment because it involves removing the Microprocessor module.

To adjust the real-time clock, connect a frequency counter (with at least 6 decimal places of resolution) between digital ground and the "time" test point on the Microprocessor module. Apply dc power to the relay. Adjust trimmer capacitor (C18) on the Microprocessor PC Board so that the measured frequency is as close to 1.000000 Hertz as possible. If a period is measured, it should be as close as possible to 1.000000 second.

NOTE: The frequency counter should be set to trigger on a negative edge of the clock output square wave

9. INSTALLATION

The MMCO relay can be released from its case by pushing the chassis mounted latching levers. The left-hand lever is extendible to make its operation easier.

The relay should be mounted on a switchboard panel or its equivalent in a location free from dirt, moisture, excessive vibration, corrosive fumes and heat. The temperature outside the relay case should be between -20 to +55 degrees C for normal operation.

Mount the relay vertically by means of four mounting holes on the flanges for semi-flush mounting or by means of the rear stud or studs for projection mounting.

NOTE: Projection mounting is not possible with the INCOM communications accessory installed.

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 (Figure 31), to facilitate making a good electrical connection between the relay case, its mounting screw 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 terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench. For detailed FT22 case information, refer to I.L. 41-076.

9.1. UNIQUE REMOTE COMMUNICATION (WRELCOM) PROGRAM

Two types of remote interface can be ordered.

- RS232C — for single point computer communication.
- INCOM — for local network communication.
- A special software (WRELCOM) program is provided for obtaining or sending the setting information to the MMCO. The MMCO front panel shows two fault events (last and previous), but thru the remote communication, 16 fault events and 16 records of intermediate target data can be obtained and stored. Each record of the intermediate target data contains 8-cycle information (1-prefault and 7 post-fault), with 7 analog inputs and 24 digital data (at the sampling rate of 8 per cycle). ***Refer to WRELCOM manual for detailed information. (See IL 40-606.)***

10. MAINTENANCE AND REPAIR

All relays should be inspected periodically and 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 for the particular application.

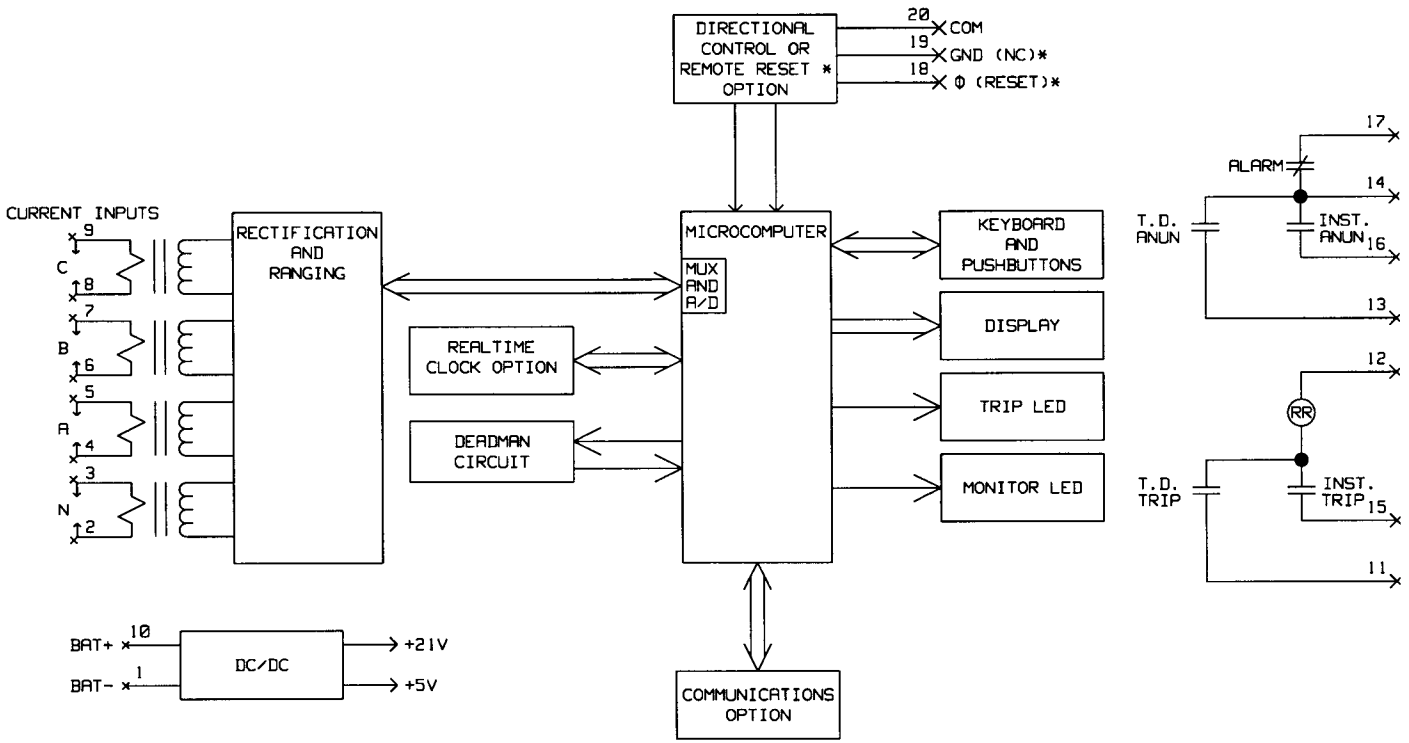
CAUTION

While handling the relay out of its case, Electrostatic Discharge (ESD) procedure must be followed (see Page 1).

11. RENEWAL PARTS

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

List of Figures



9650A74
Sub 1

Figure 1. MMCO Block Diagram

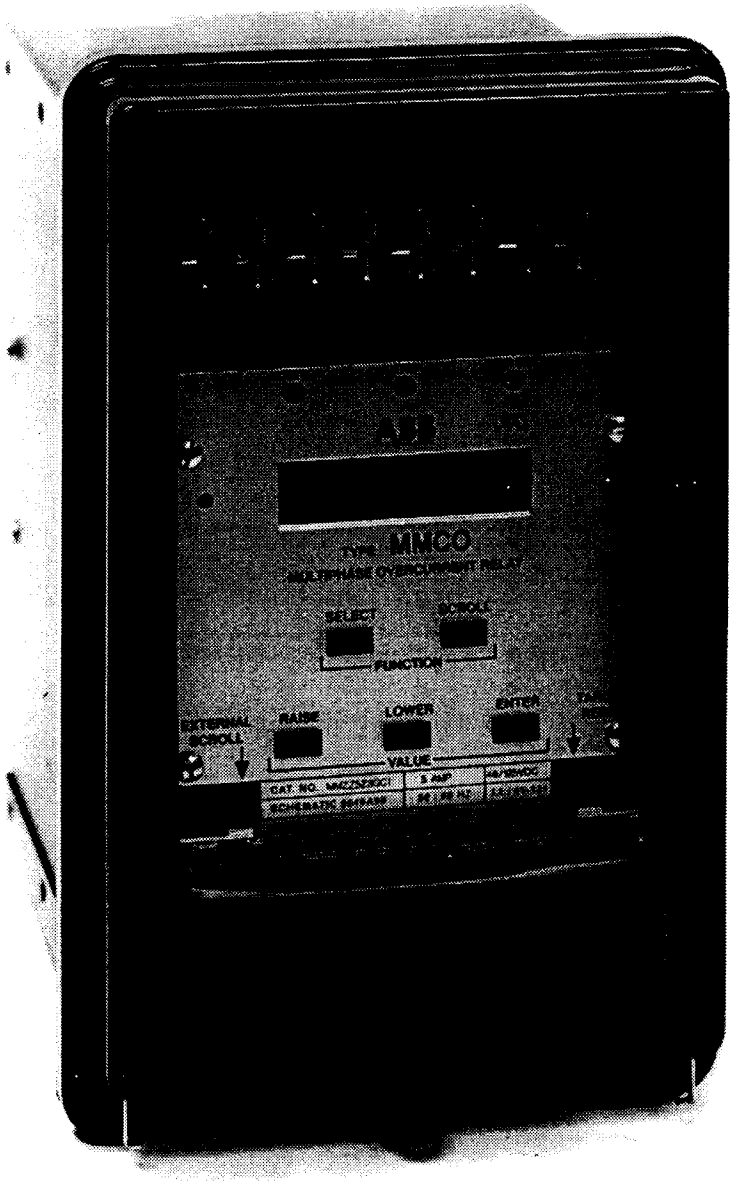


FIGURE 2. MMCO Multiphase Overcurrent Relay

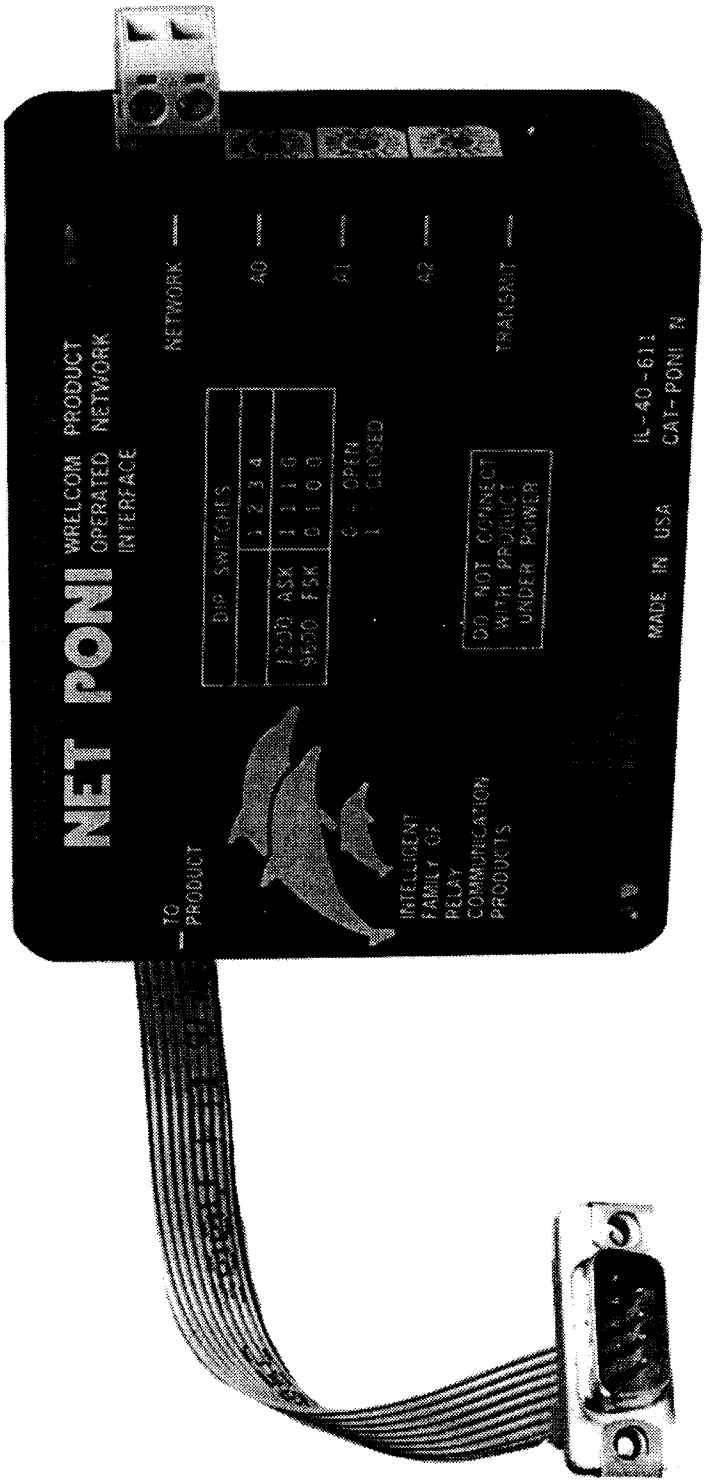
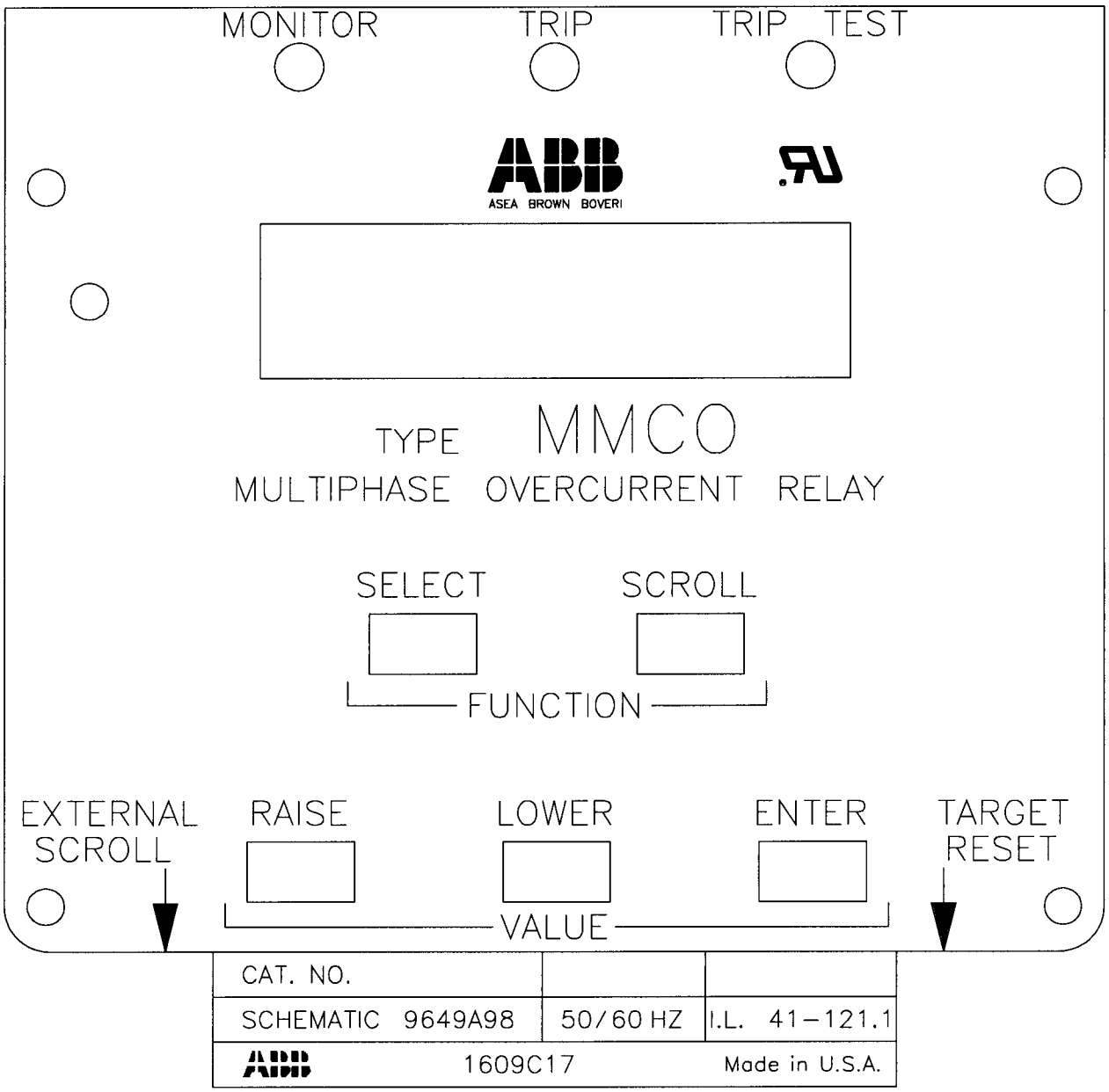
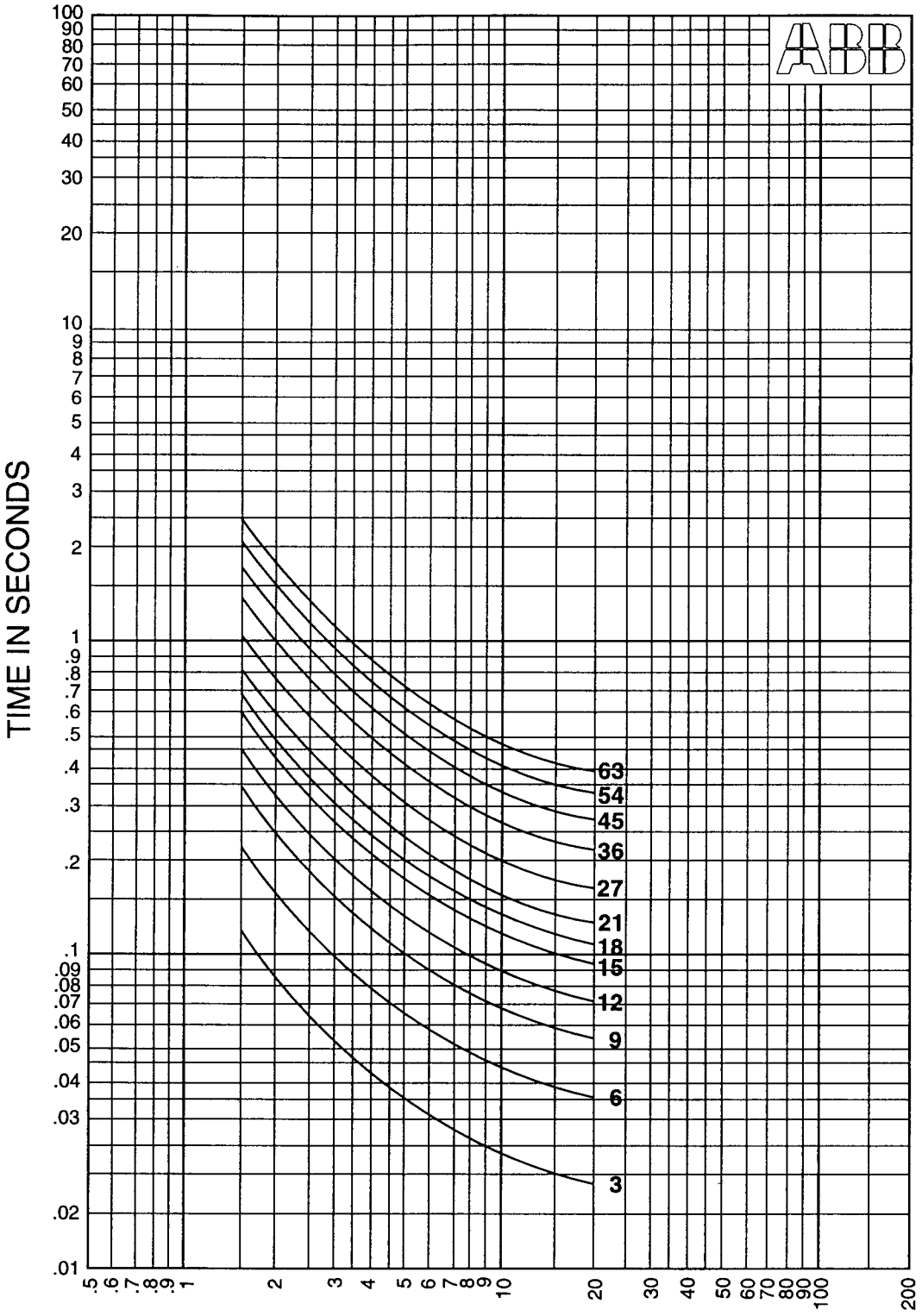


FIGURE 2a. WRELCOM/PONI Communications Interface Device



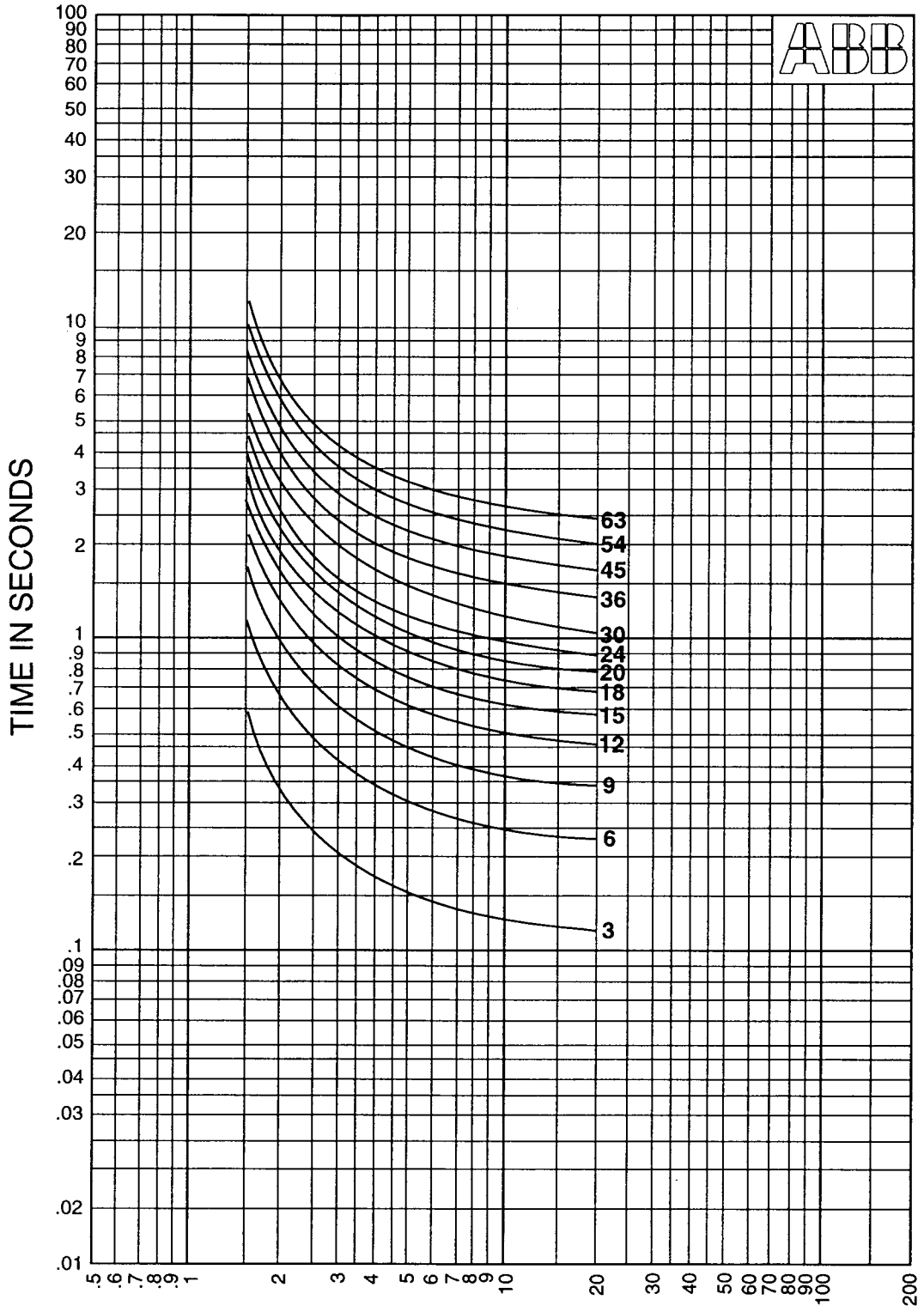
1609C17
Sub 13

Figure 3. MMCO Front Panel



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

FIGURE 4



DATE		DWG NO	REV
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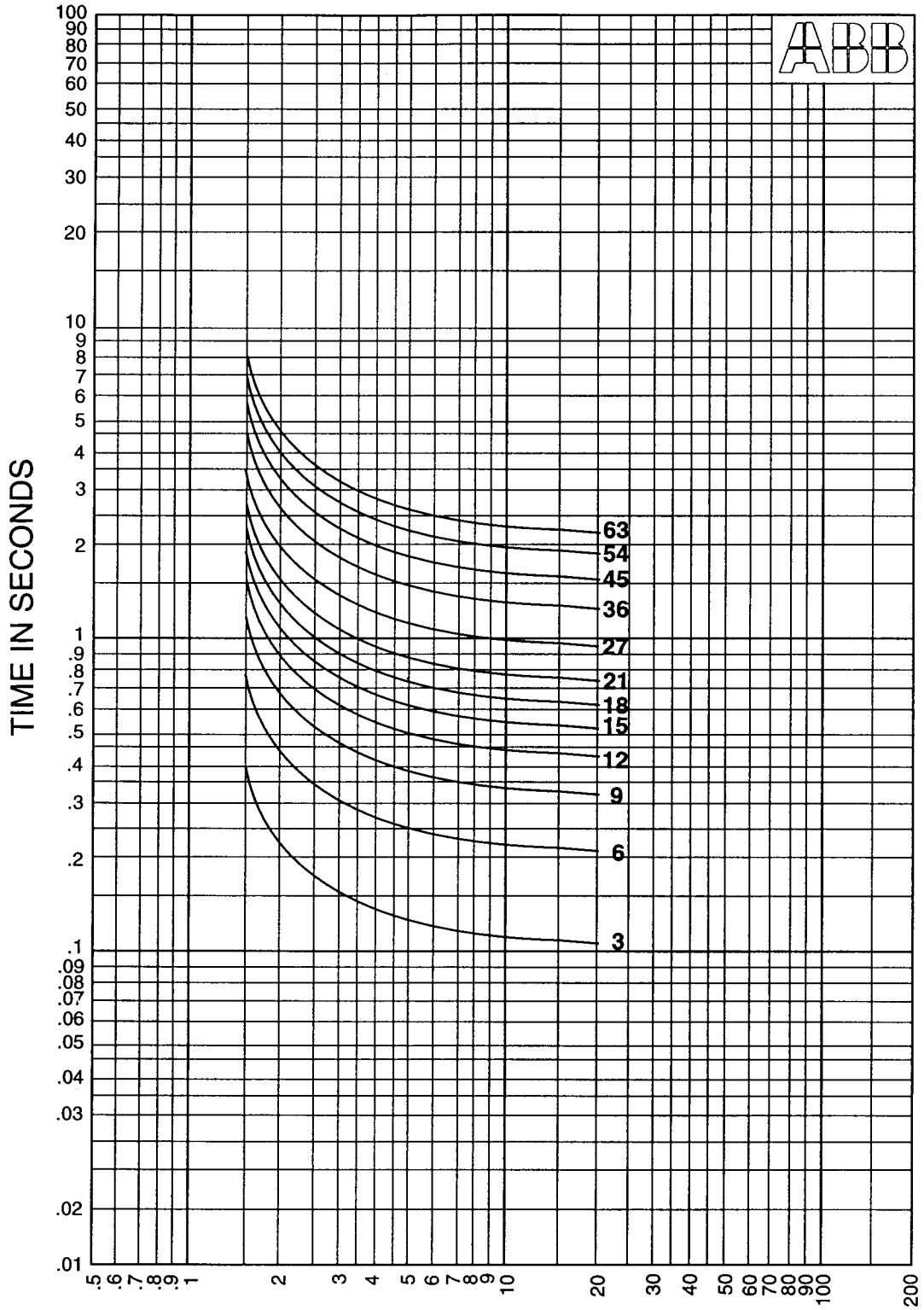
FIGURE 5



DATE		DWG NO	REV
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FIGURE 6

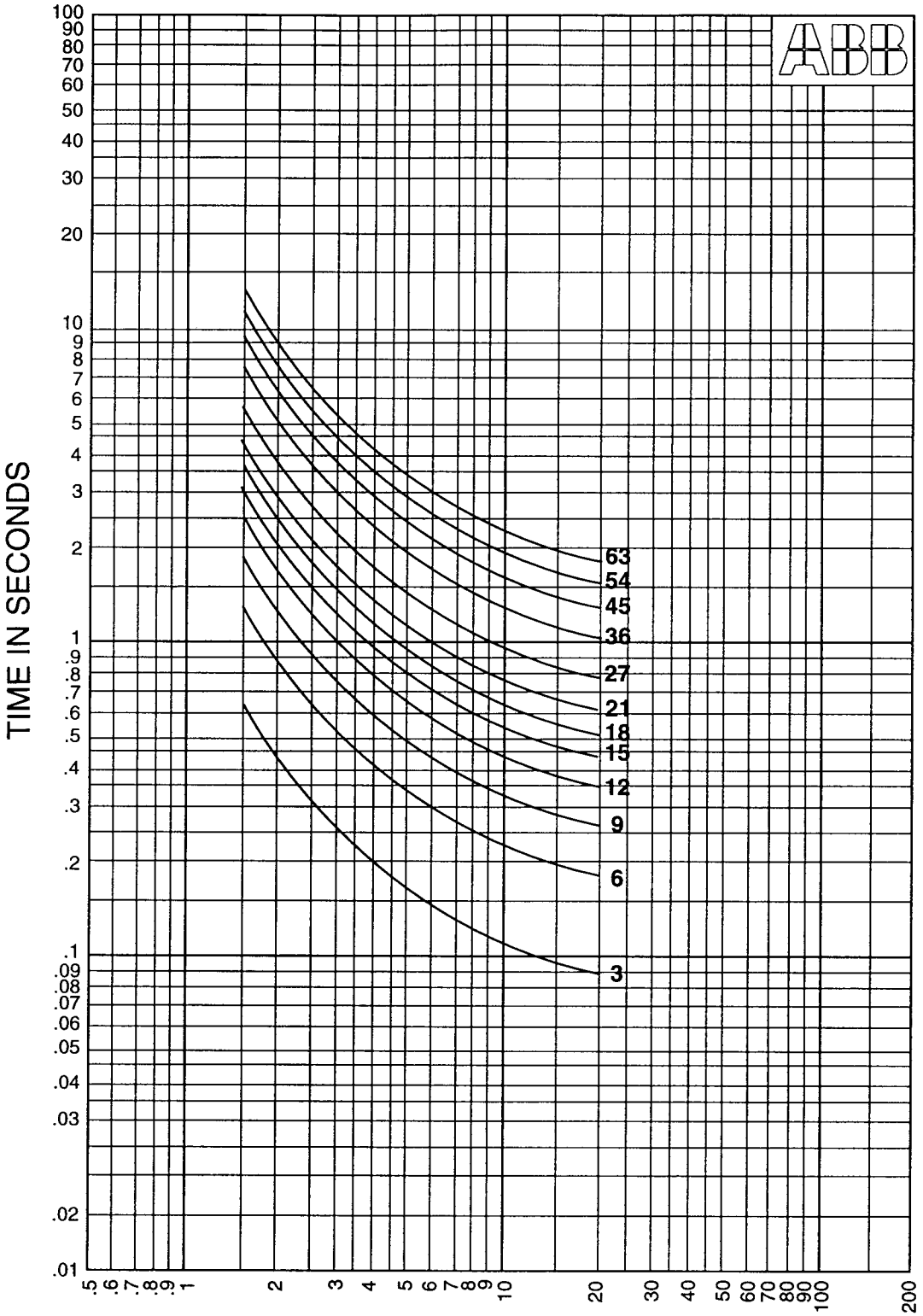

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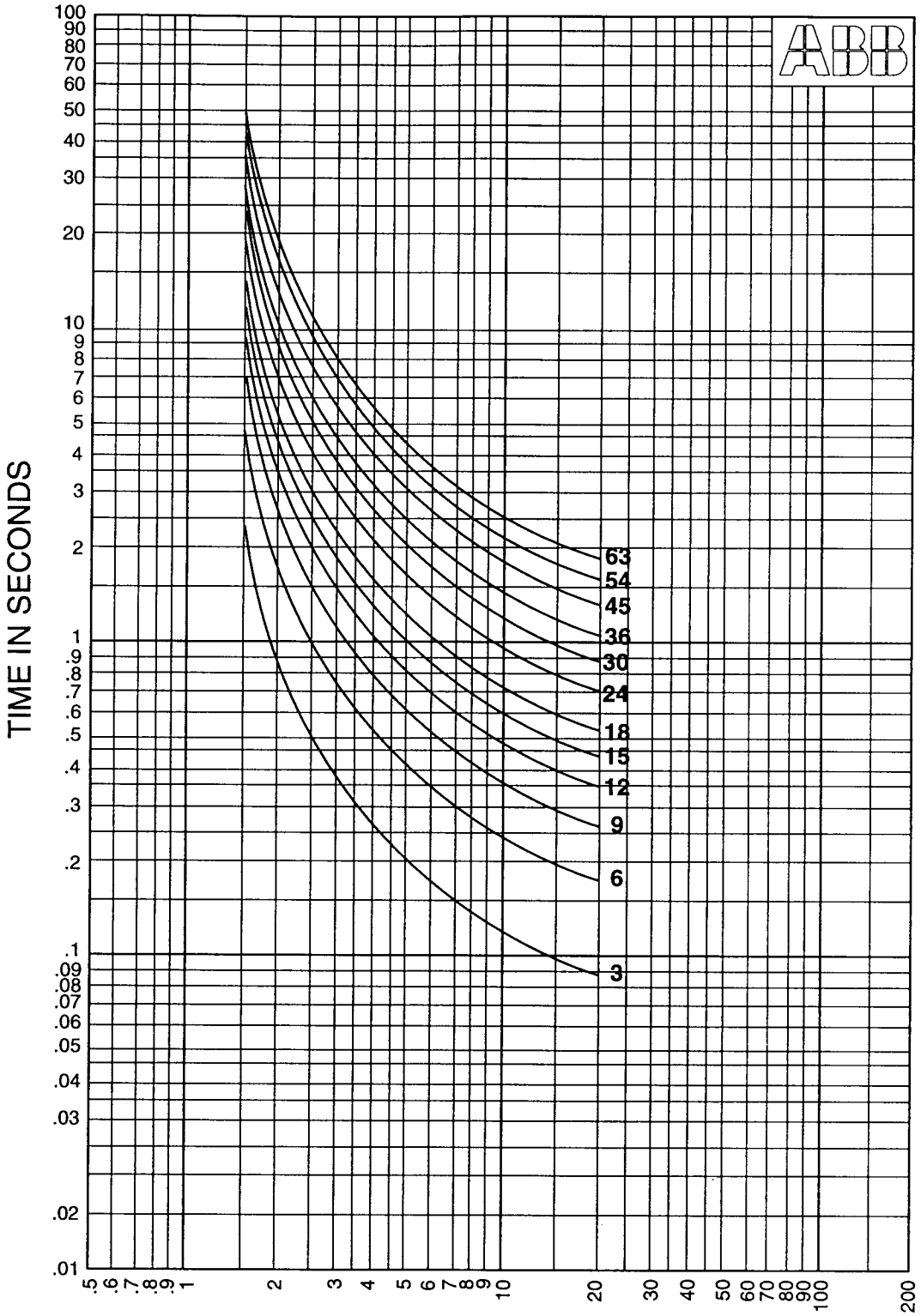
FIGURE 7



MCO/MMCO - 8
INVERSE

DATE	DWG NO	REV
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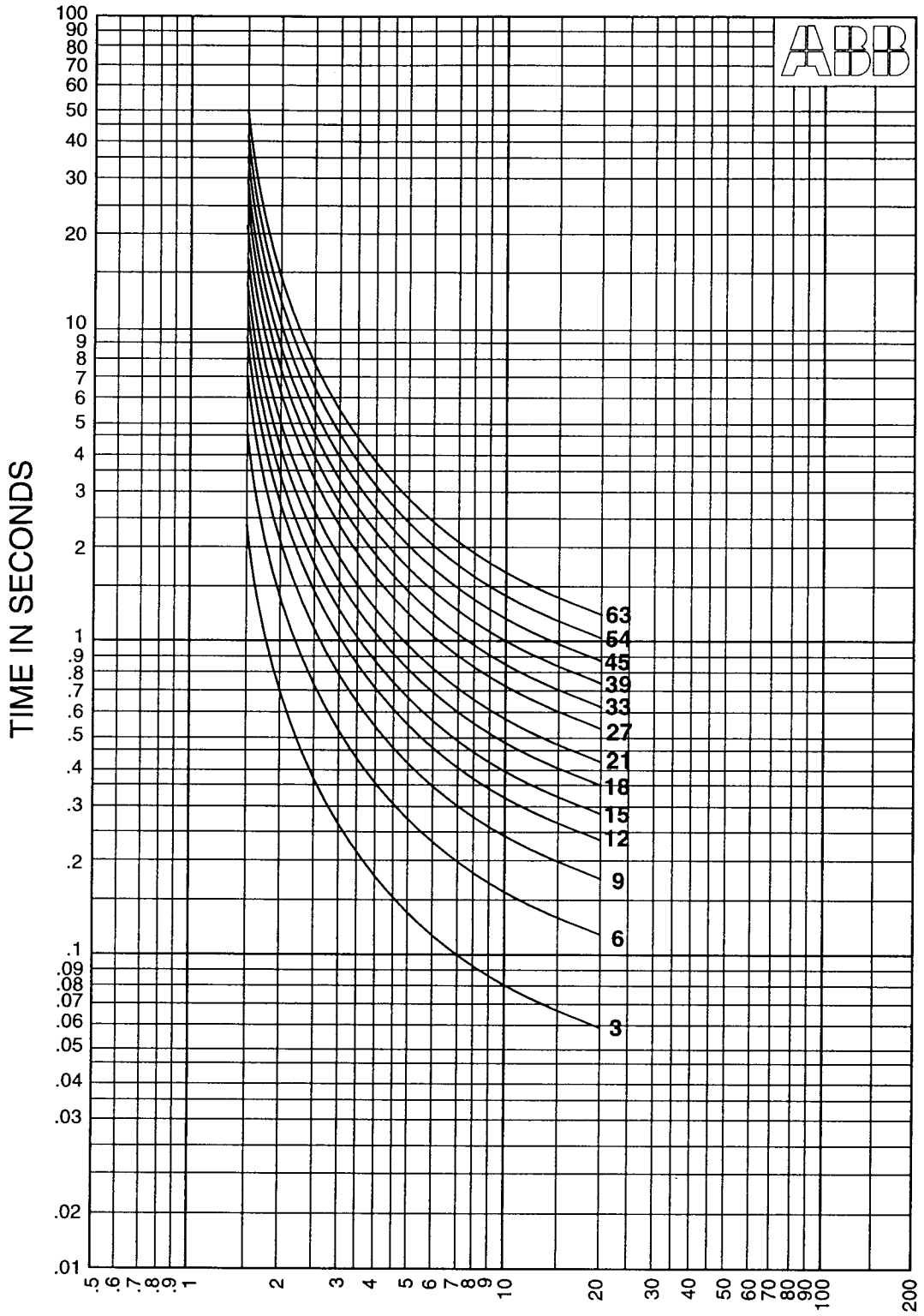
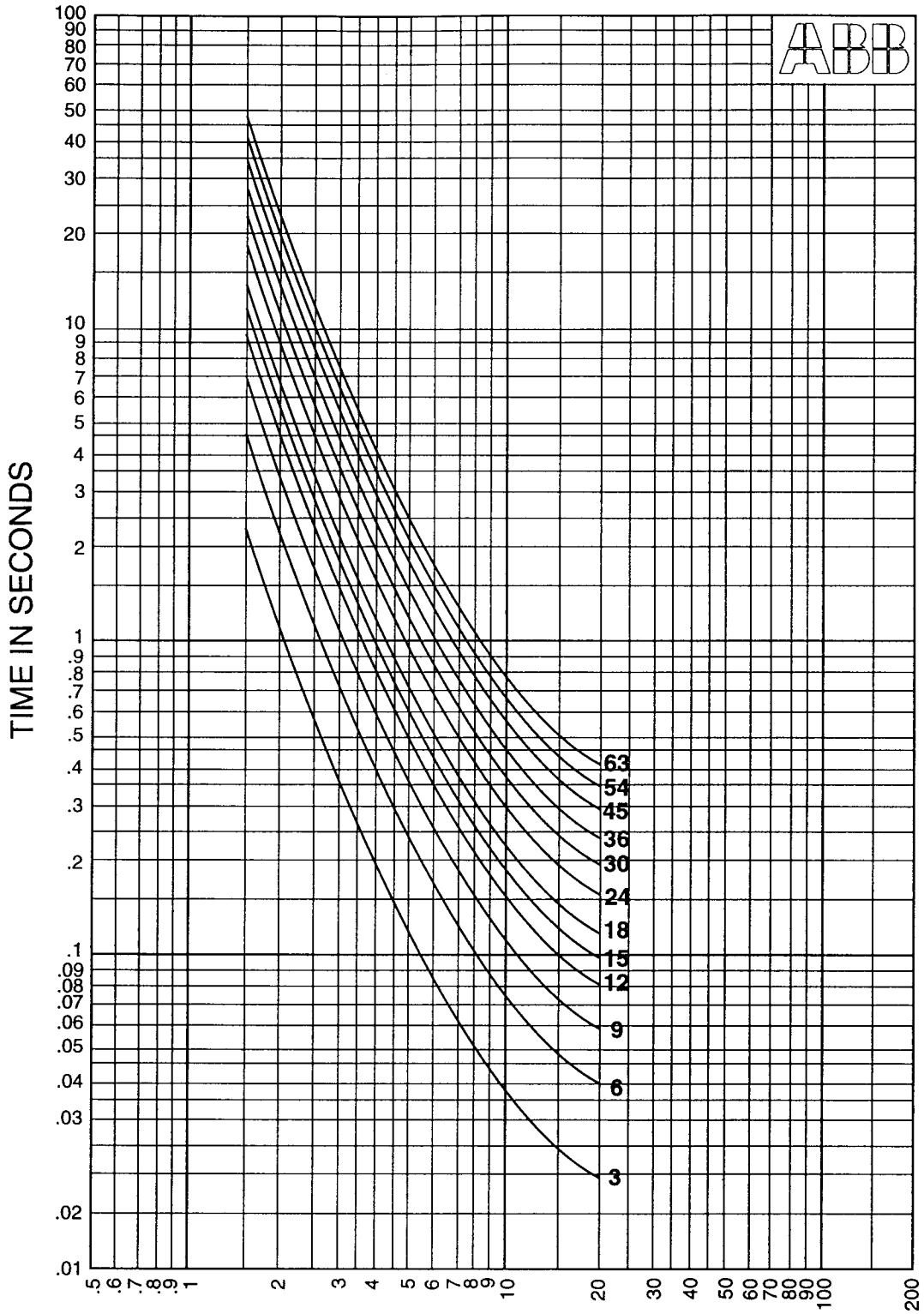
FIGURE 8



DATE		DWG NO	REV
OCTOBER 1992	**MCO/MMCO - 9 VERY INVERSE**	**605877**	**0**

FIGURE 9



MCO/MMCO - 11
EXTREMELY INVERSE

DATE	DWG NO	REV
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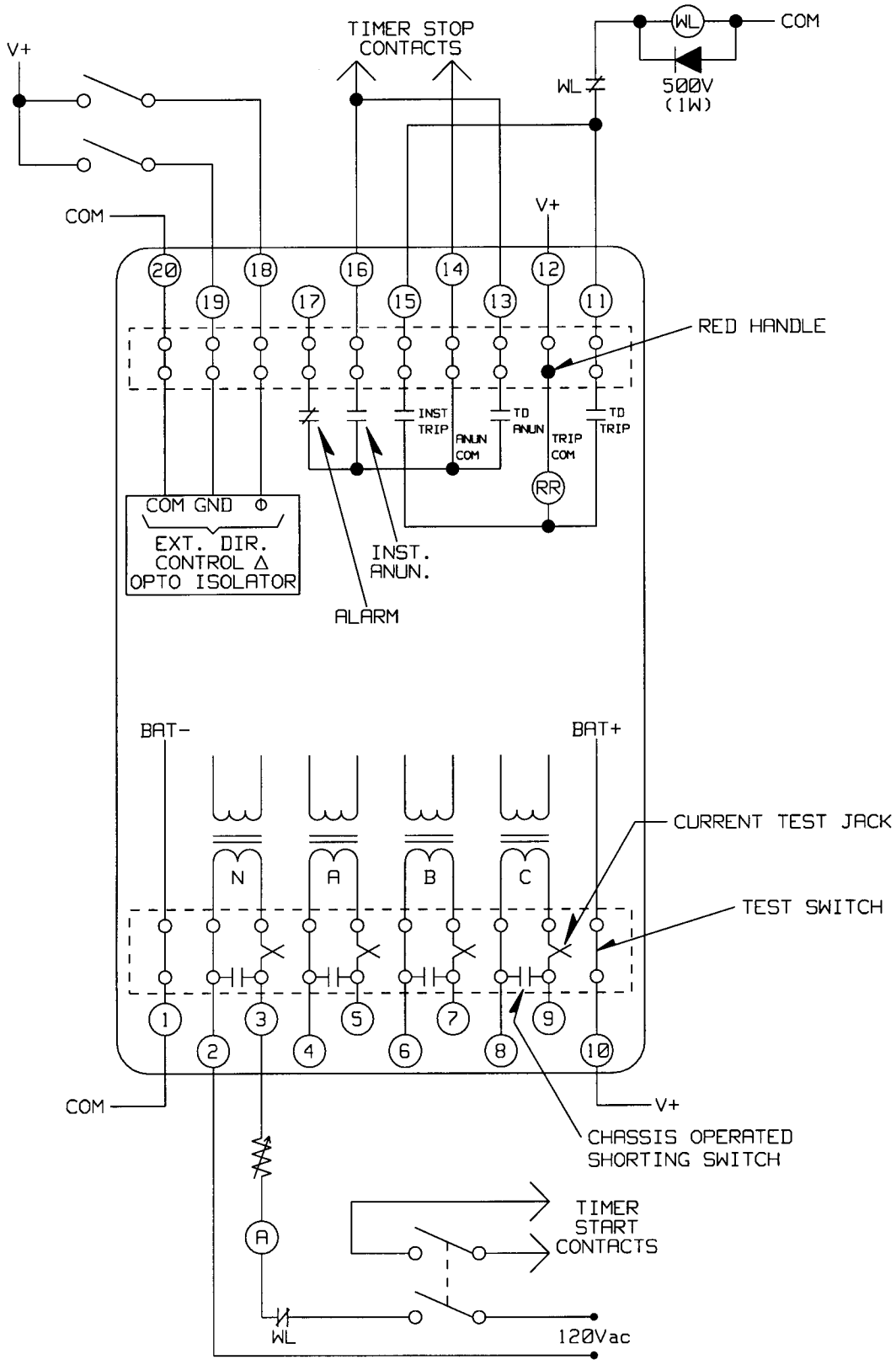
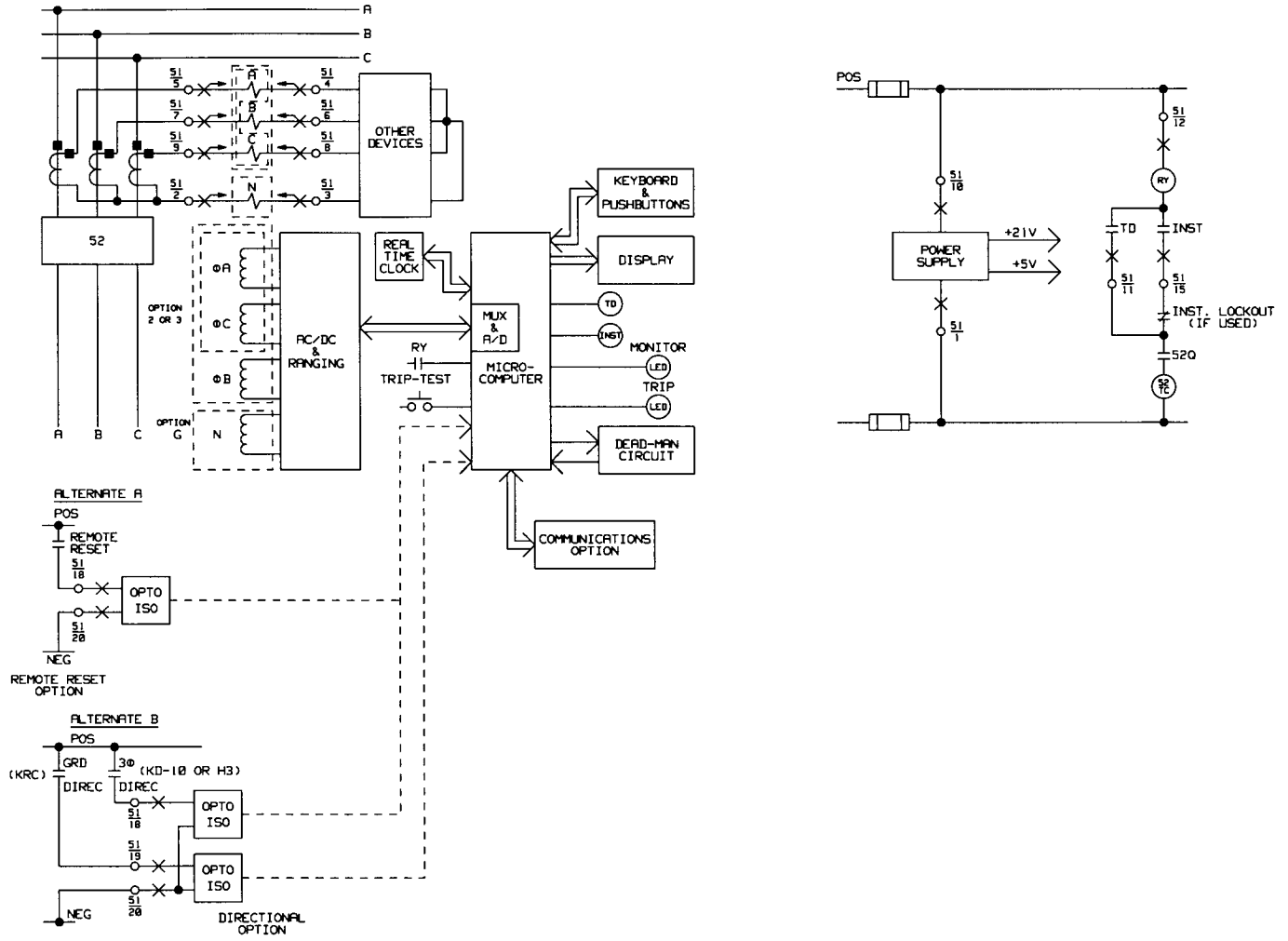
FIGURE 10



1499B70
Sub 4

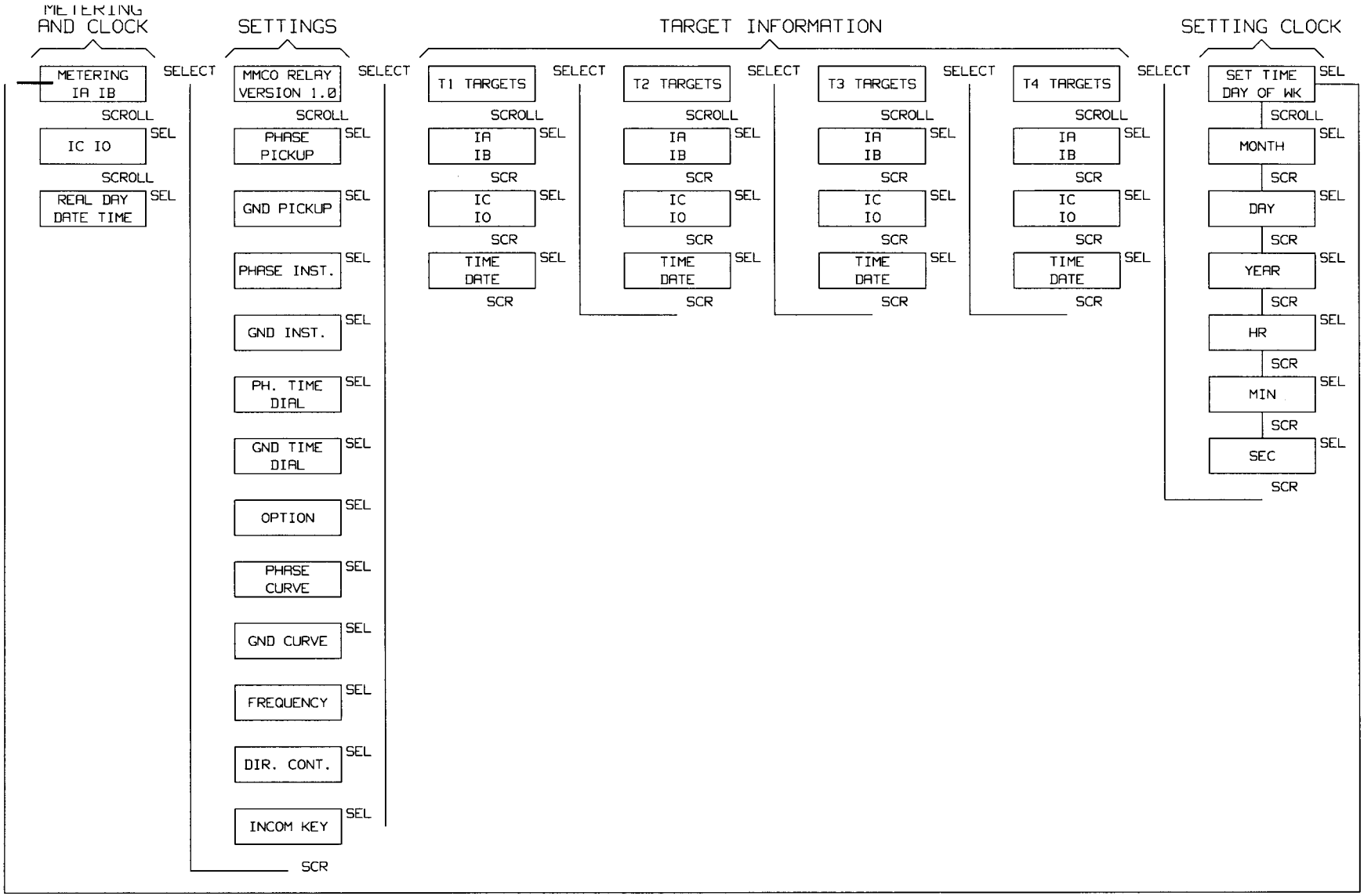
Figure 11. Typical Time Curve "C" (IEC)



51 - TIME OVERCURRENT RELAY MMCO
52 - CIRCUIT BREAKER

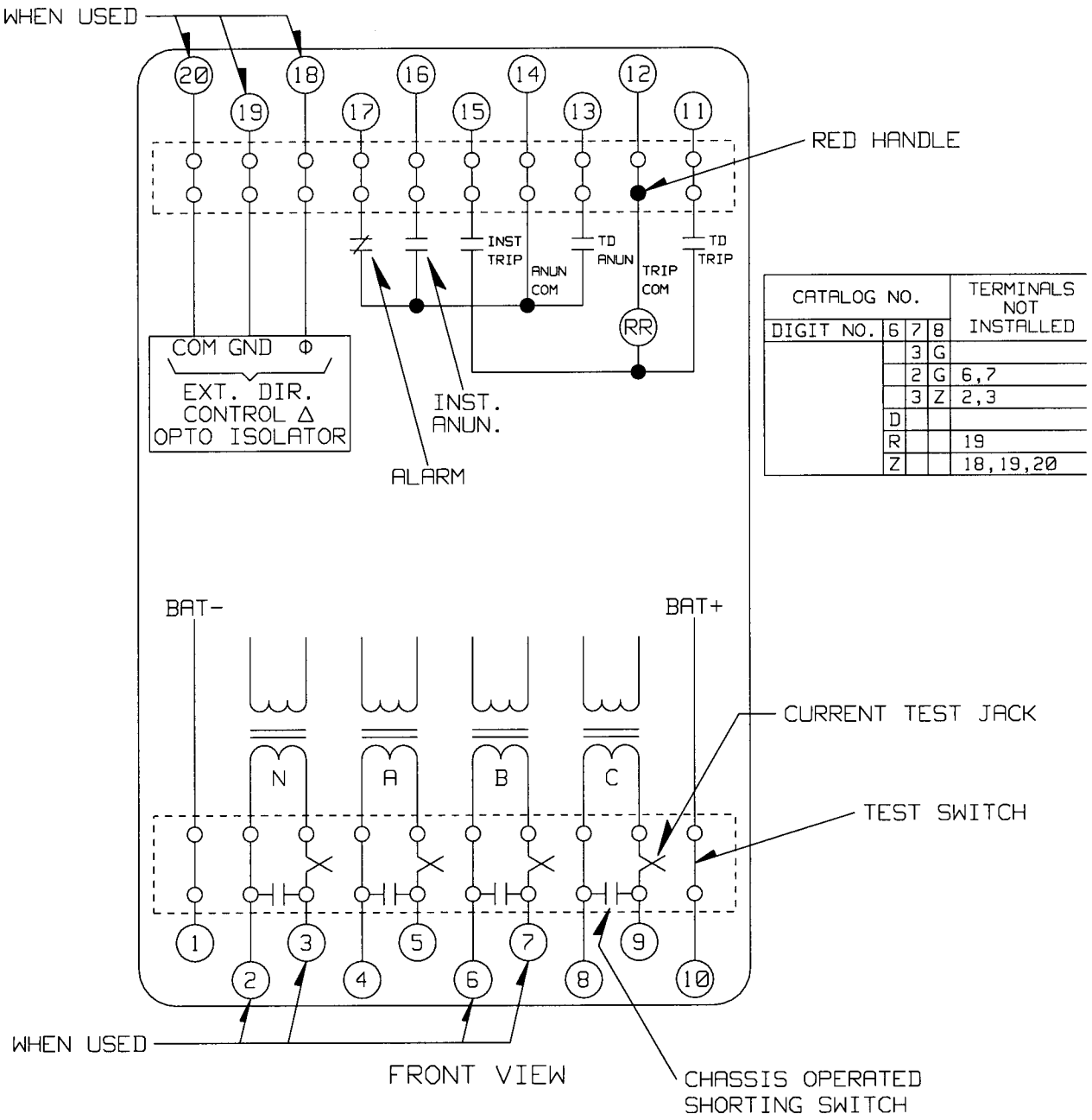
1609C74
Sub 1

Figure 12. MMCO External Schematic



1499B84
Sub 1

Figure 13. MMCO Keypad Operation



Δ = FOR REMOTE RESET OPTION: (18) = RESET, (19) = N.C.

9649A98
Sub 3

Figure 14. MMCO Terminal Connection Drawing

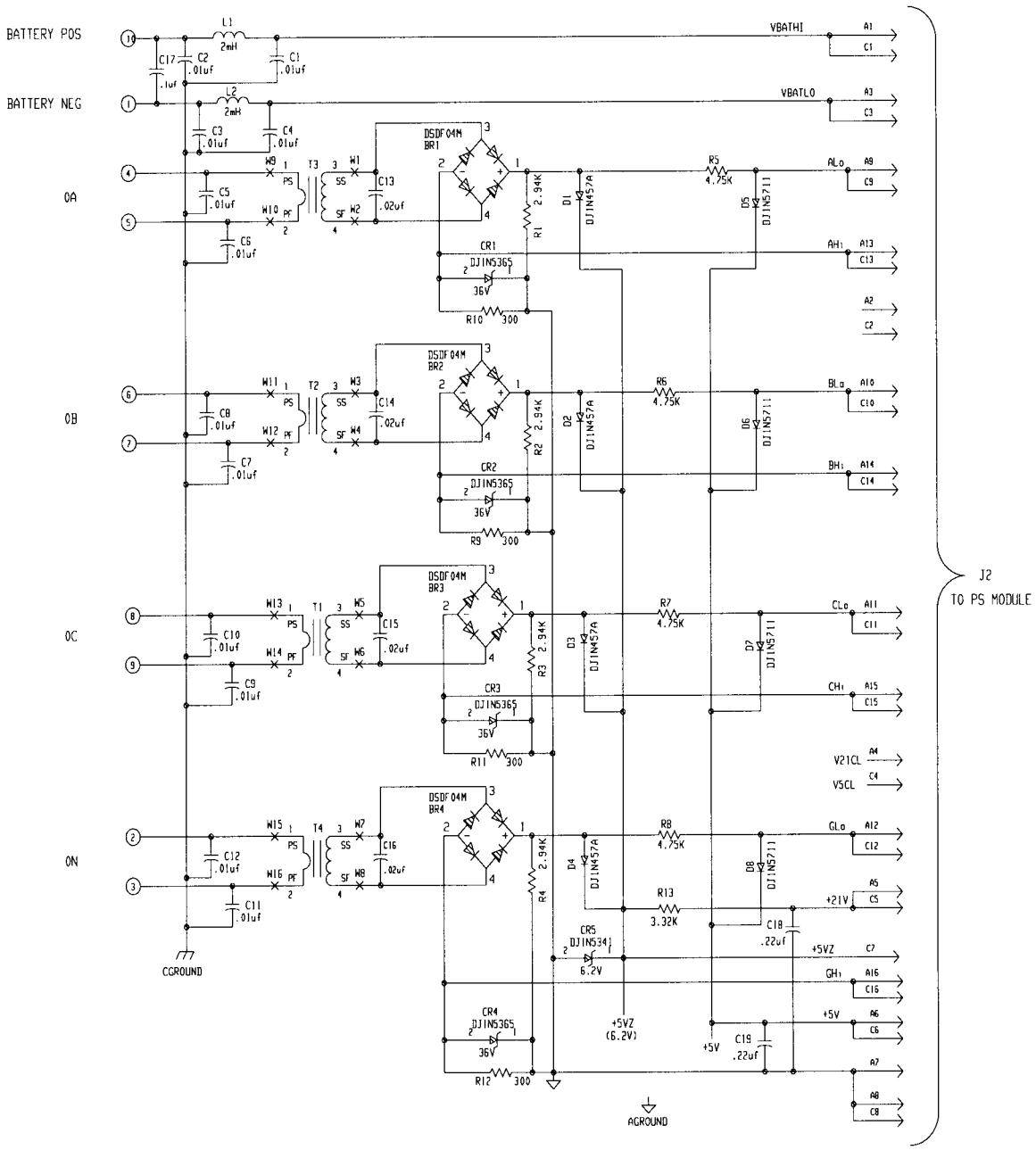


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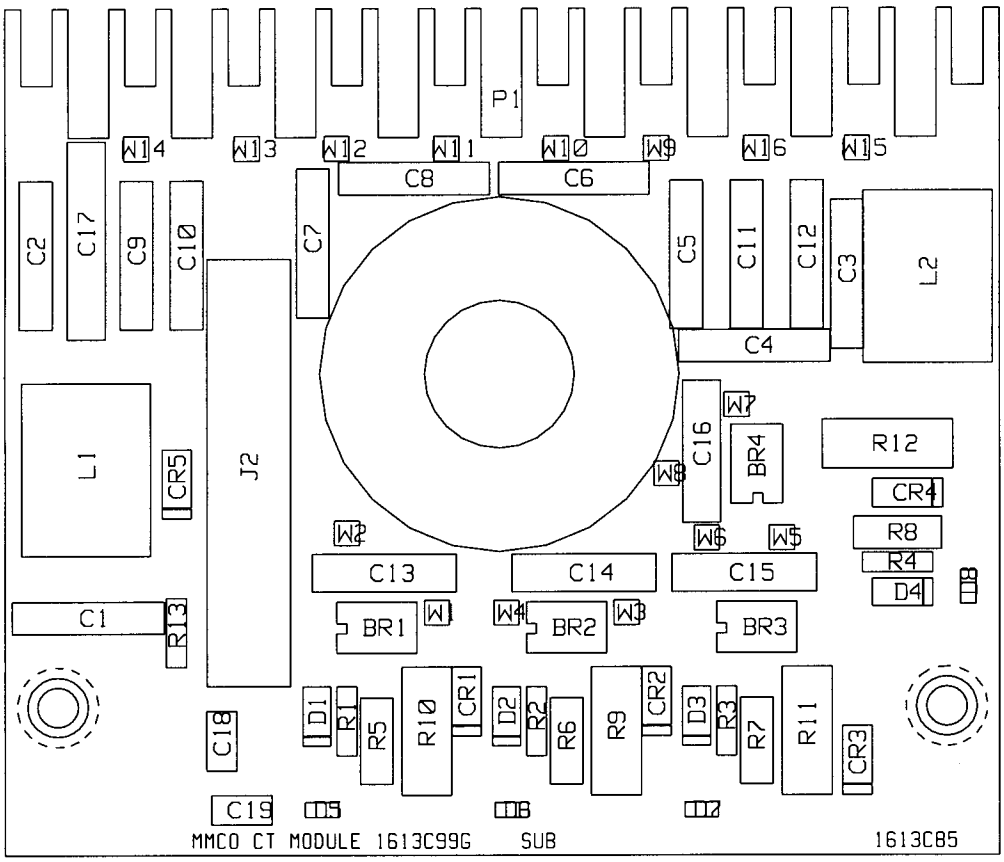
Figure 15. MMCO ct Module Internal Schematic (Bottom)



1613C99
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Figure 16. MMCO ct Module Assembly (Bottom)

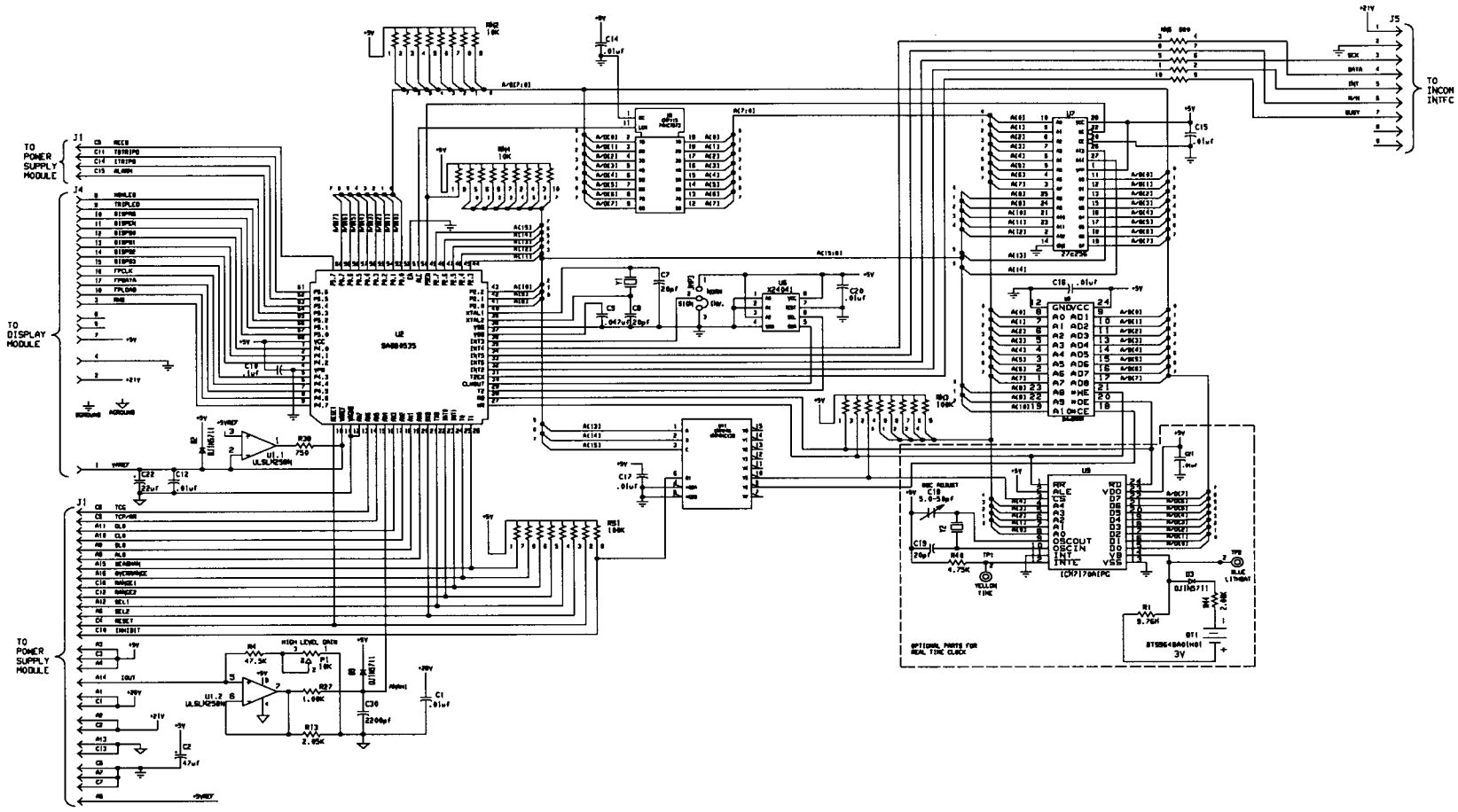
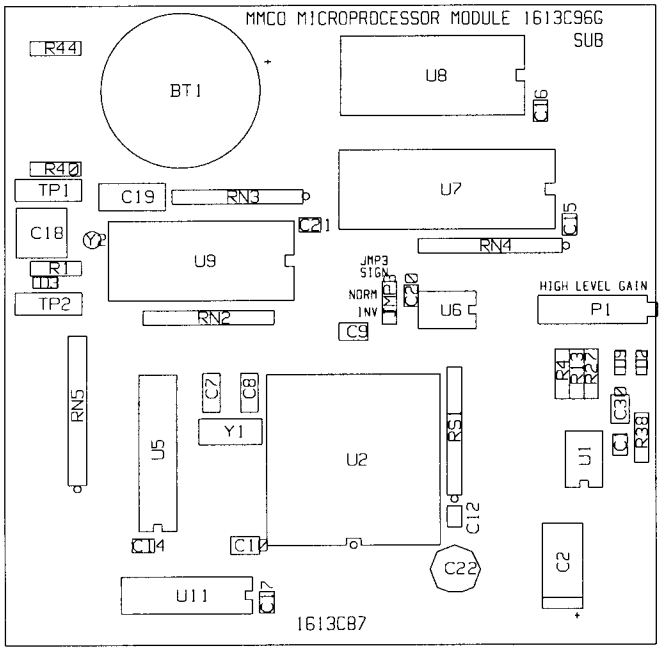


Figure 17. MMCO Microprocessor Module Internal Schematic



FRONT VIEW

REAR VIEW

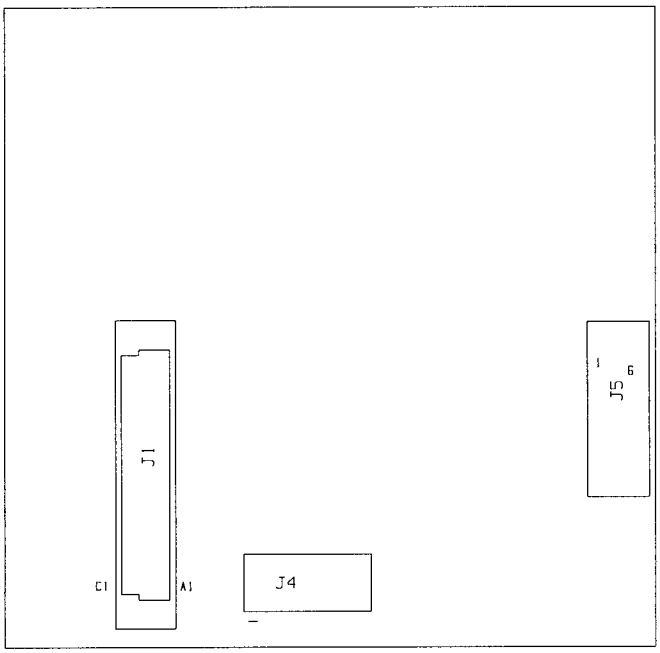


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Figure 18. MMCO Microprocessor Module Assembly

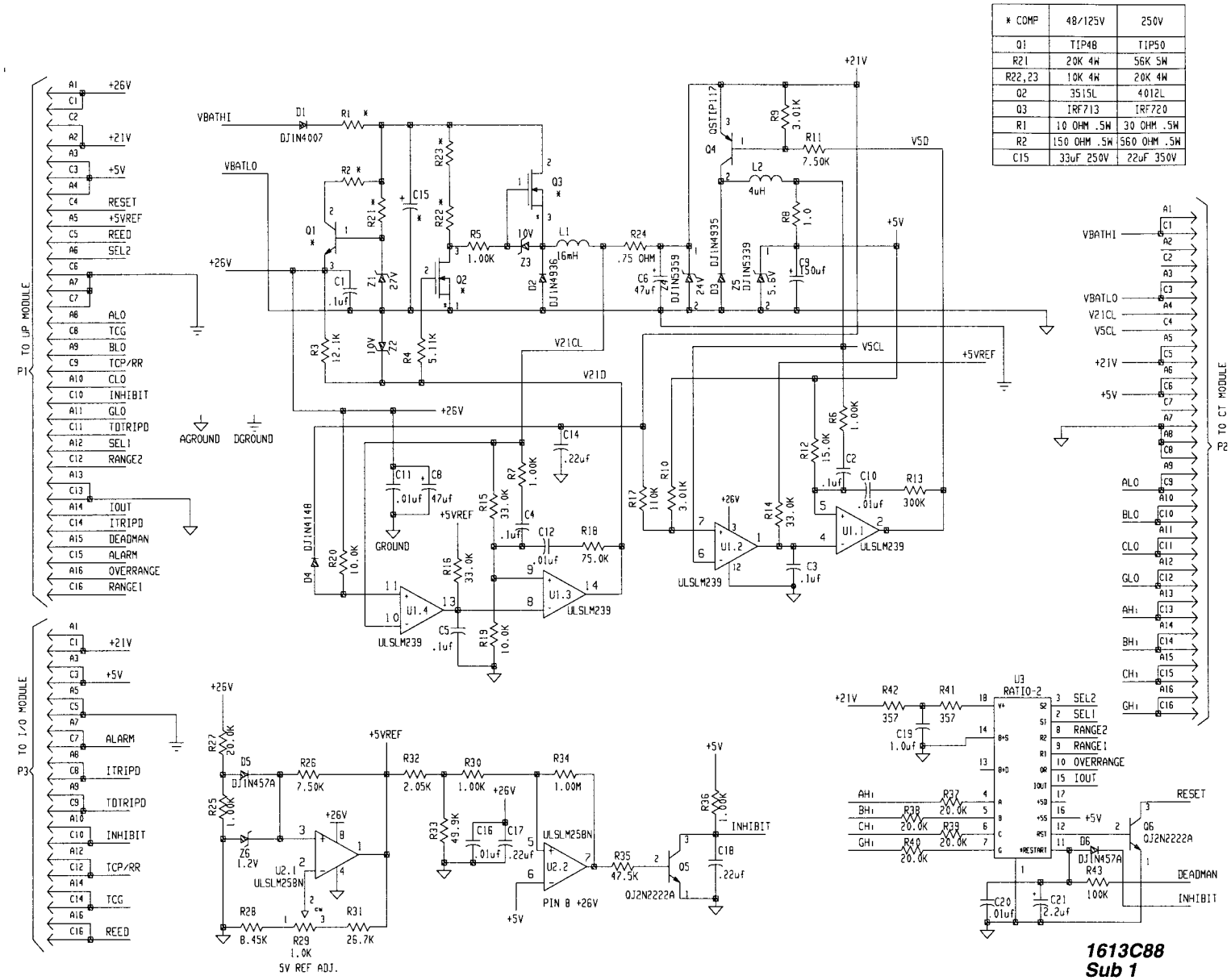

Figure 19. MMCO Power Supply Module Intrnal Schematic

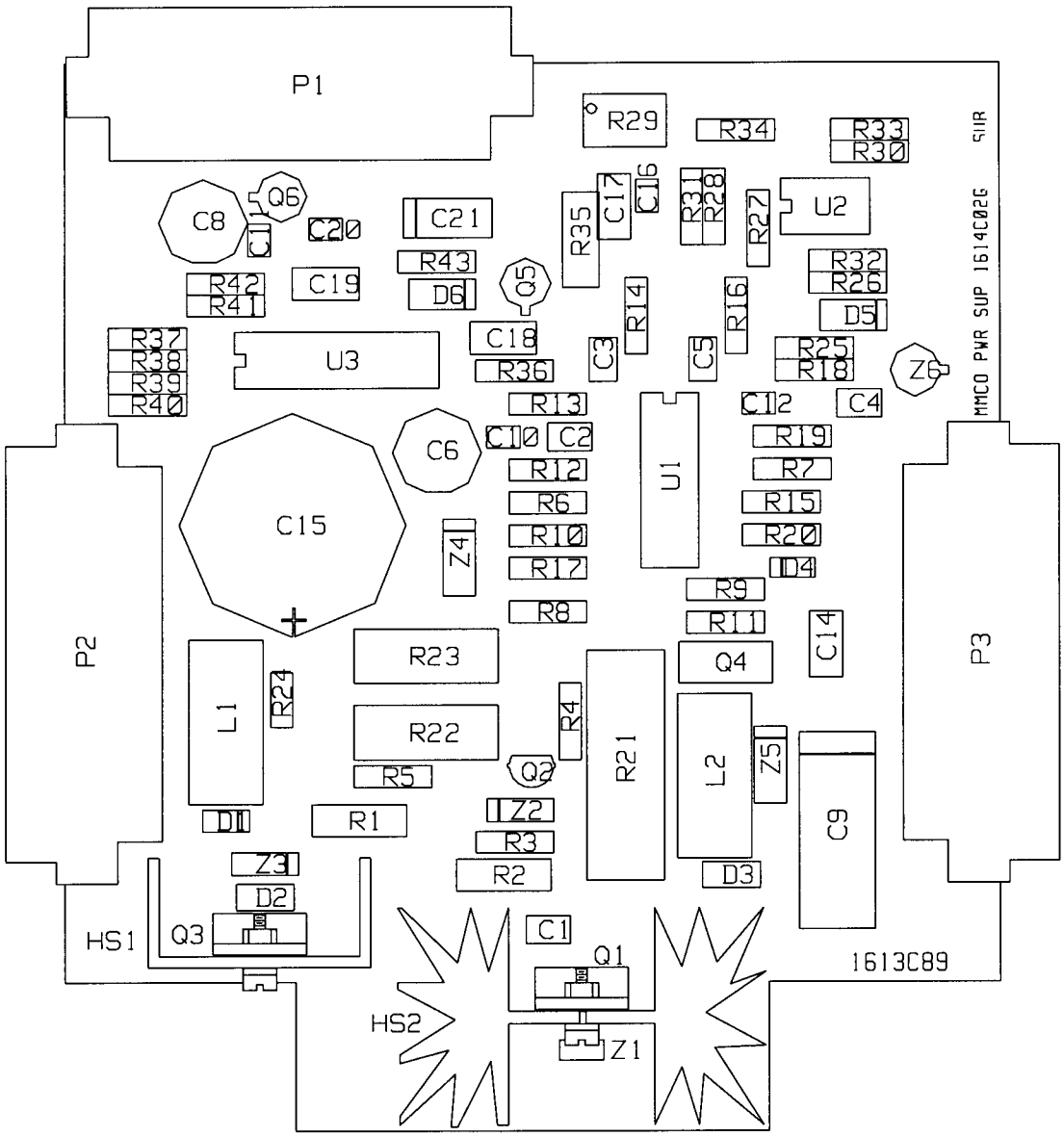

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Figure 20. MMCO Power Supply Module Component Location

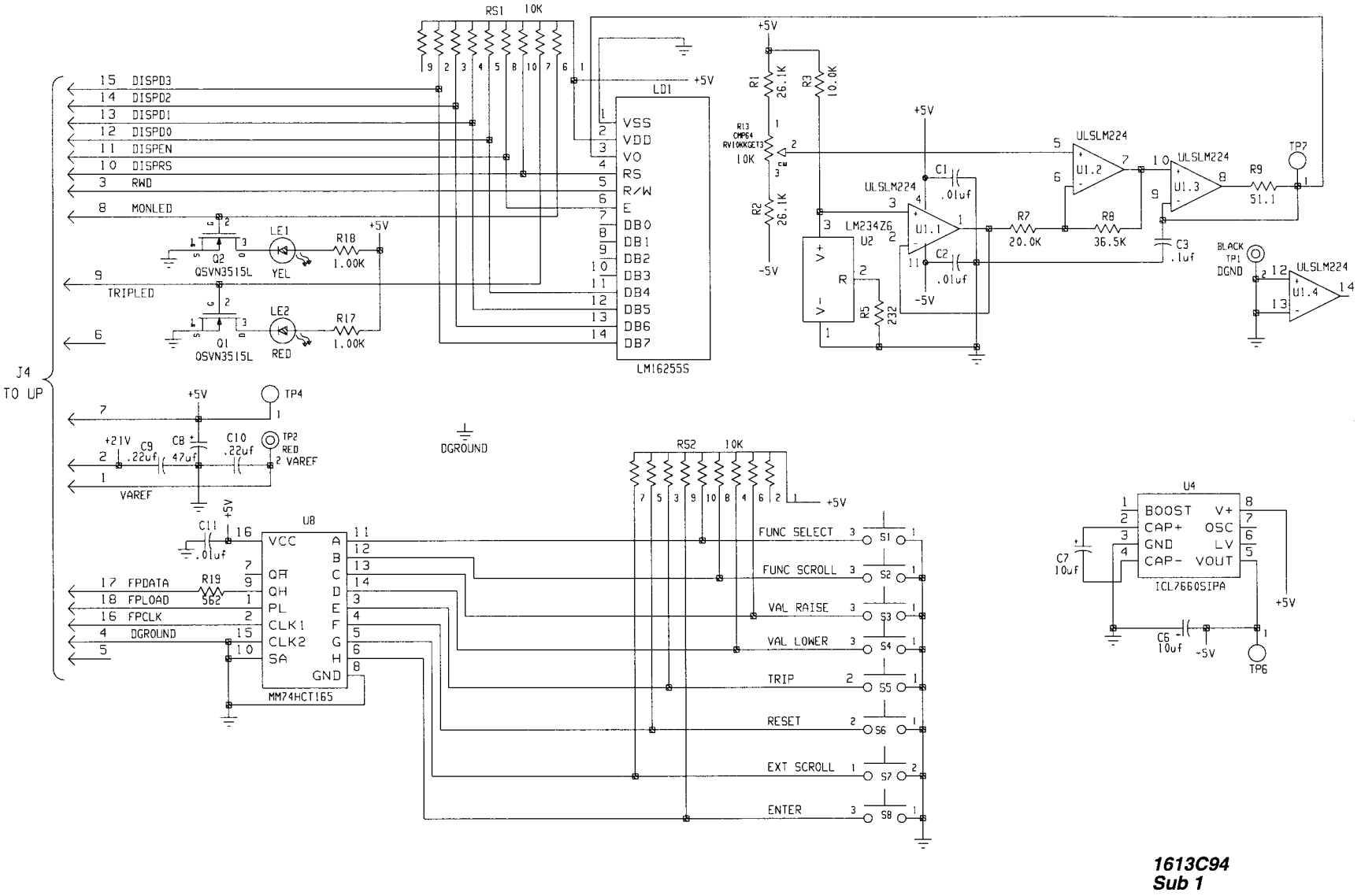
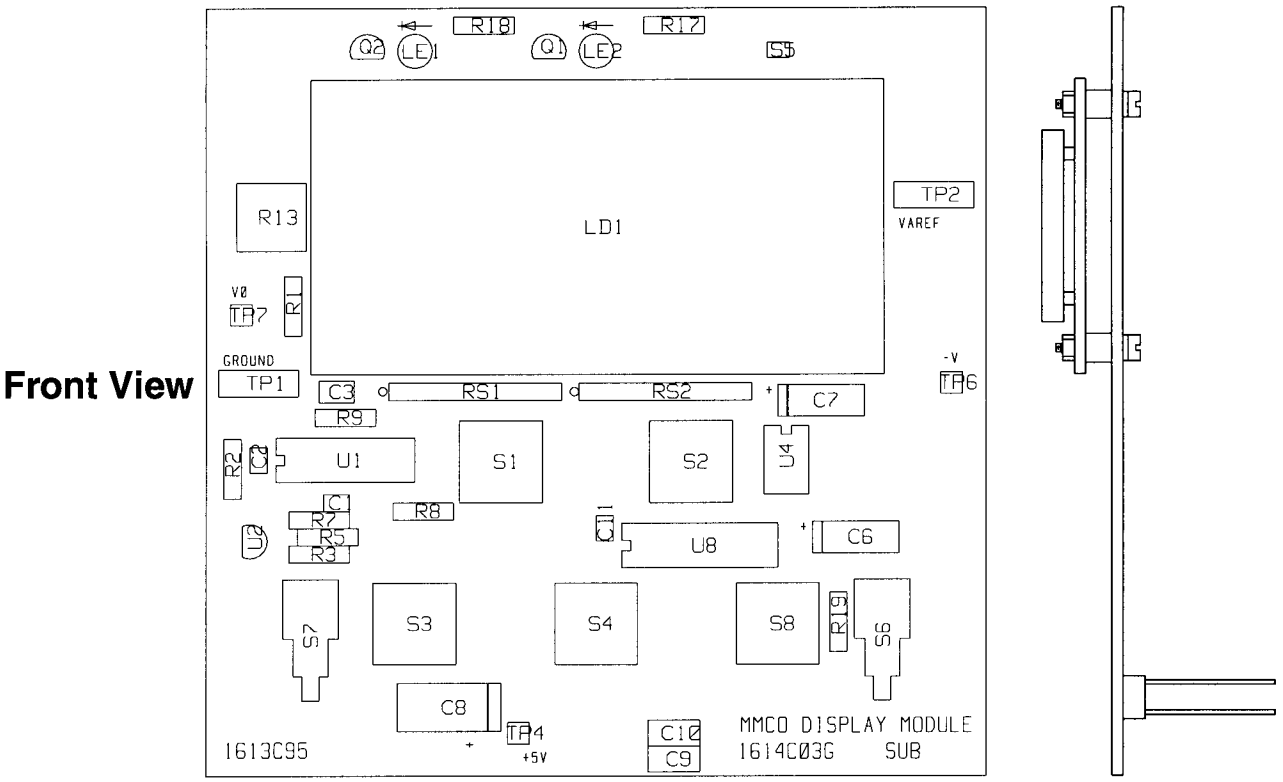
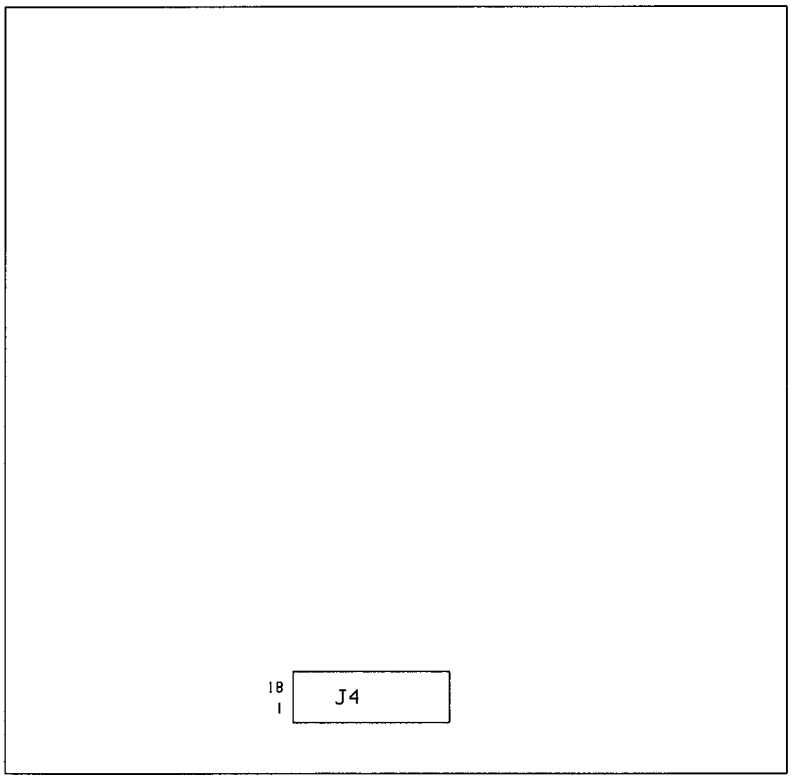


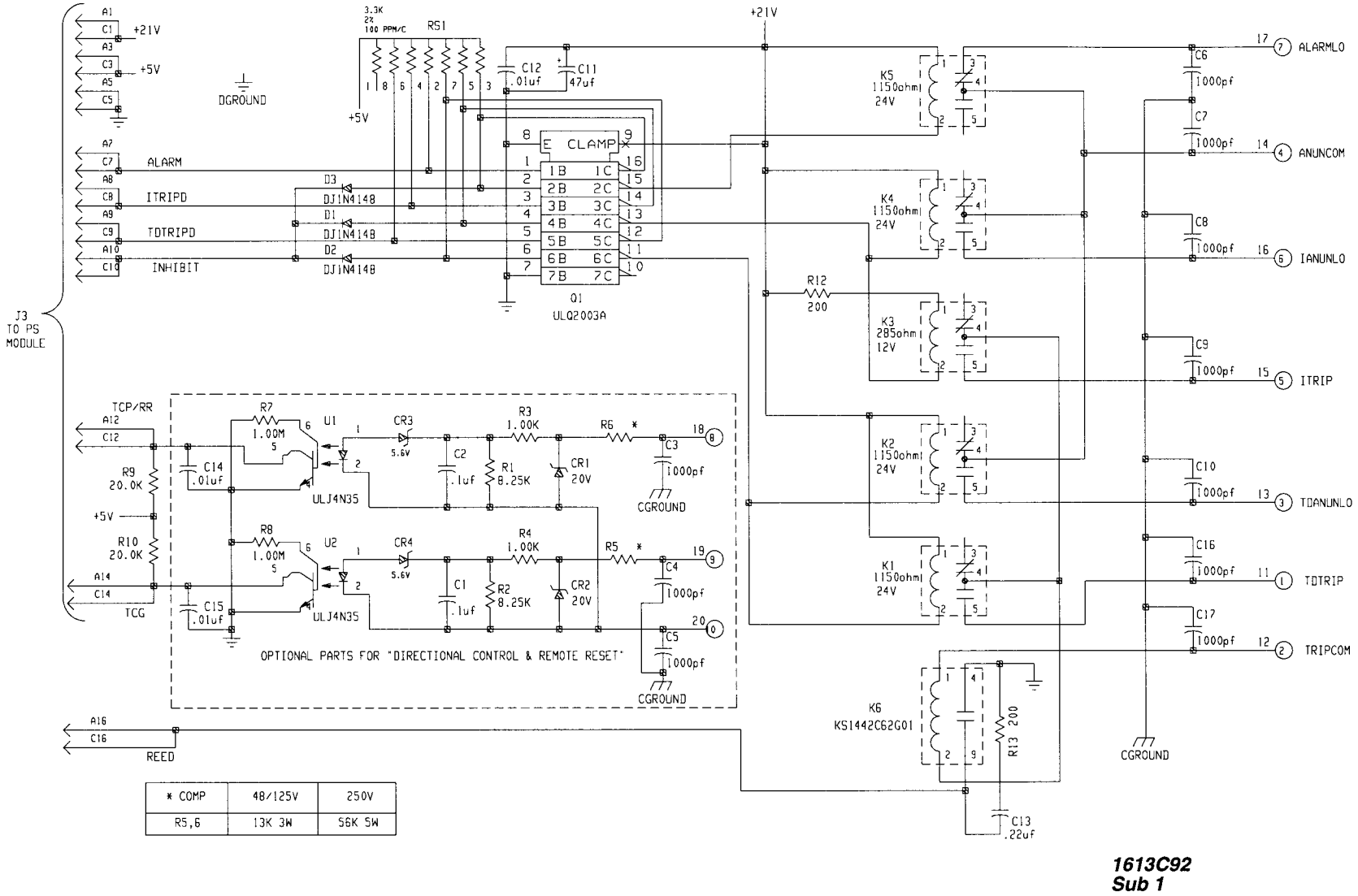
Figure 21. Display Module Internal Schematic





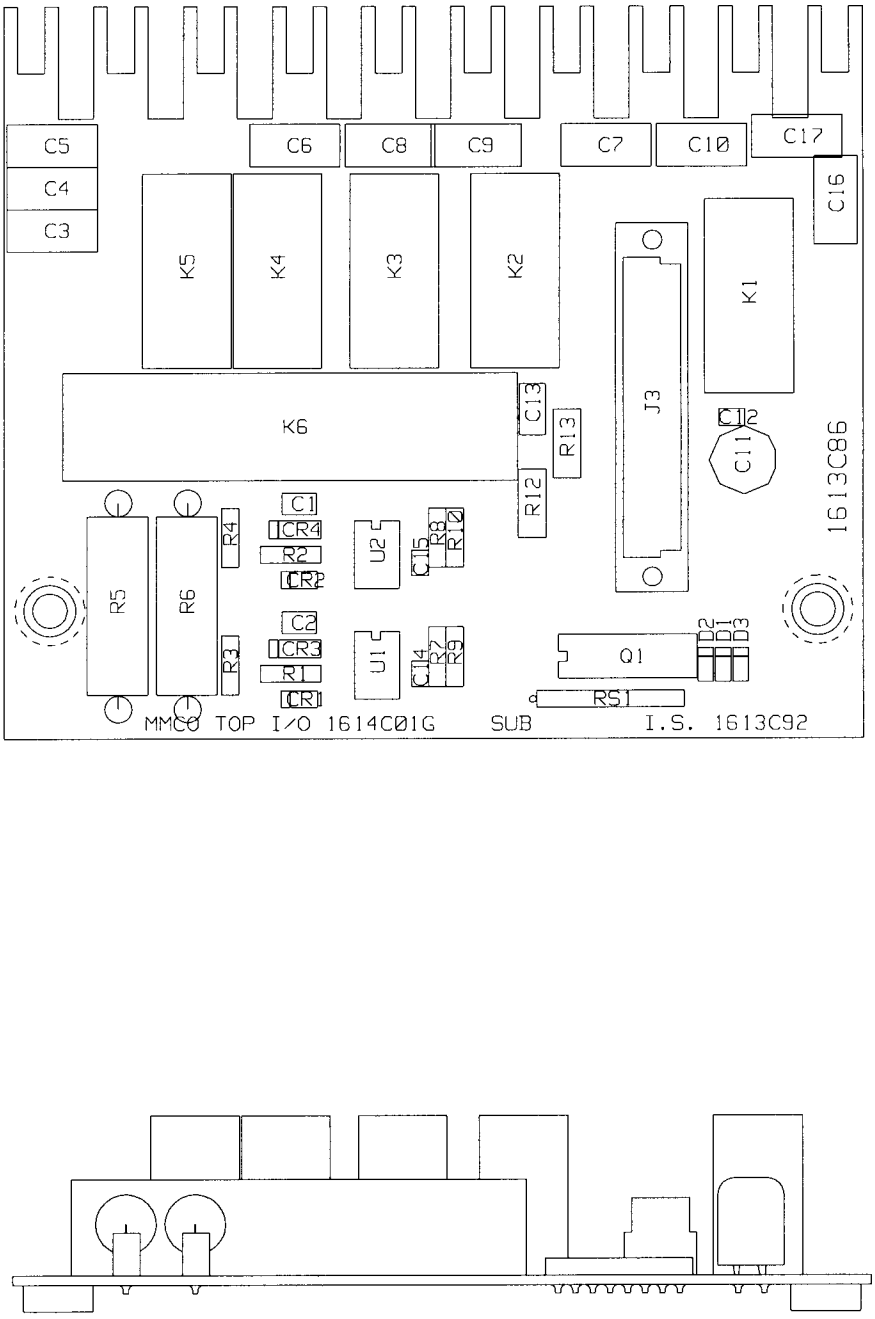
1614C03
Sub 1

Figure 22 Display Module Component Location



* COMP	48/125V	250V
R5,6	13K 3W	56K 5W

Figure 23. MMCO I/O Internal Schematic (Top)



1614C01
Sub 1

Figure 24. MMCO I/O Module Component Location

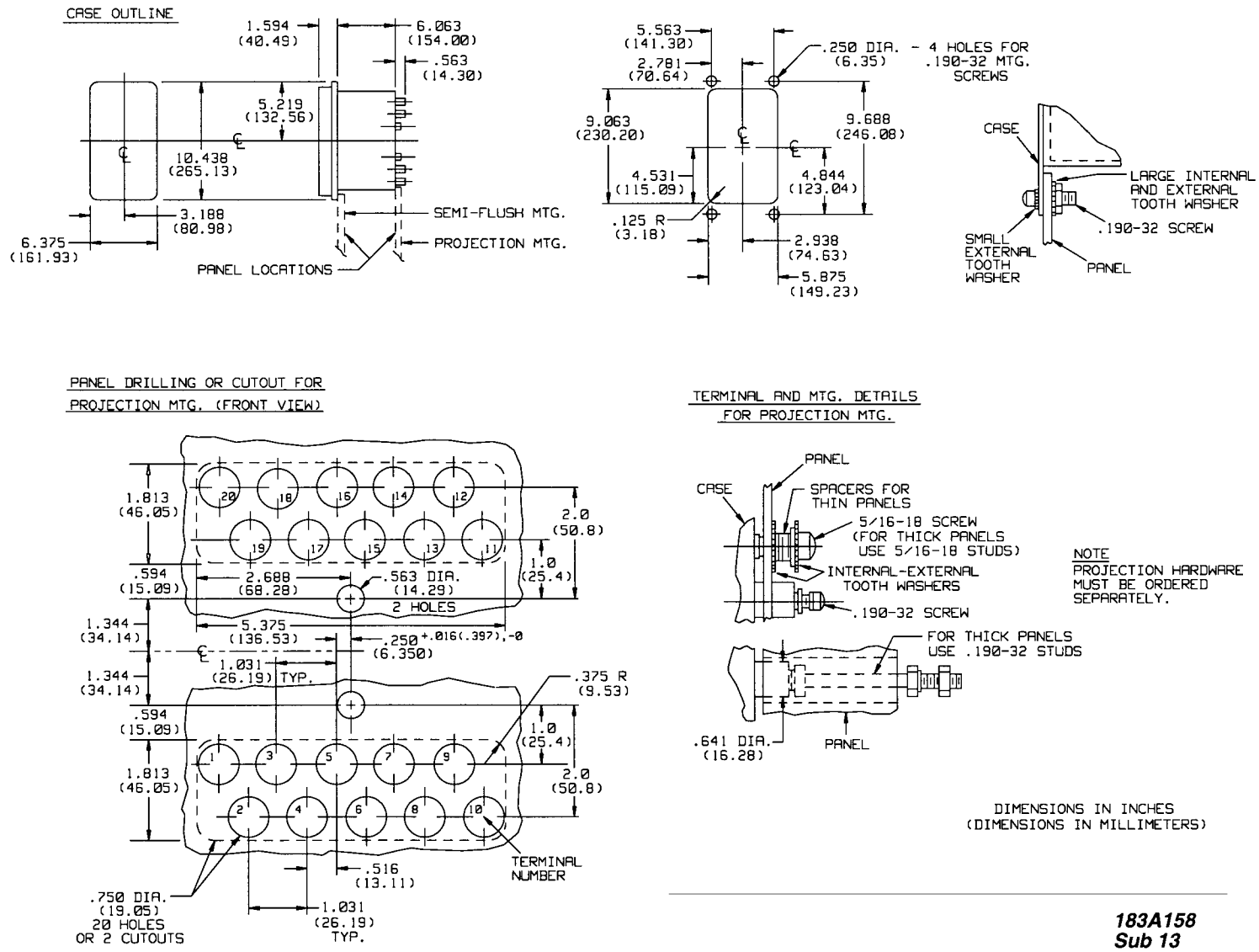
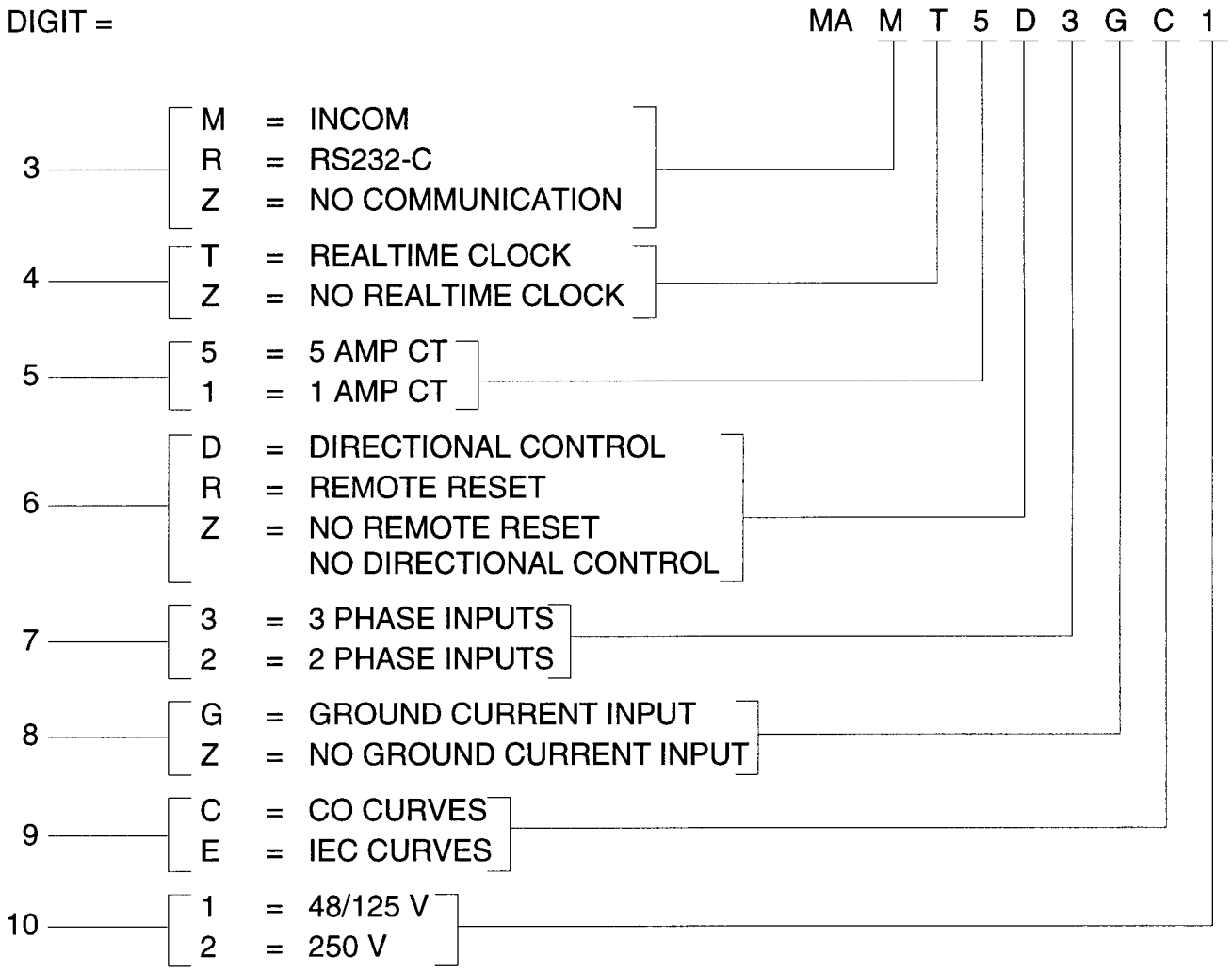


Figure 25. Outline and Drilling Plan for the MMCO Type FT-22 Case



COMMUNICATIONS OPTION

Two types of communication options are available for the MMCO relay. These options consists of a small plastic box mounted in the MMCO relay chassis. The communicaitons connector is accessible from the back of the MMCO relay. The two types of communication available are RS232-C which uses an optionally isolated RS232-C interface and INCOM which allows connection to the INCOM network. The INCOM network is a two wire network which can consist of up to 2500 INCOM equipped relays controlled by a single controller.

An IMAC controller is used to communicate with INCOM equipped MMCO relays. An IBM PC with WRELCOM software installed and a MINT interface box is an alternative method of communication with INCOM equipped MMCO relays. An IBM PC with WRELCOM software installed and an RS232-C interface is used to communicate with an RS232-C equipped MMCO relay.