OMEGA ENGINEERING, INC.
An OMEGA Group Company

Model DP900
Digital Temperature Indicator

Operator's Manual

WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of one (1) year from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive current, heat, moisture, vibration, or misuse. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

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Direct all warranty and repair requests/inquiries to OMEGA Customer Service Department, telephone number (203) 359-1660. Before returning any instrument, please contact the OMEGA Customer Service Department to obtain an authorized return (AR) number. The designated AR number should then be marked on the outside of the return package.

To avoid processing delays, also please be sure to include:

1. Returnee's name, address, and phone number.
2. Model and Serial numbers.
3. Repair instructions.

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Section 1
GENERAL DESCRIPTION

1.1 GENERAL DESCRIPTION

1.1.1 *Input Ranges.* The single input digital temperature indicator is a rugged and compact panel mount instrument for temperature measurement. The microcontroller based instrument is switch selectable to accept as input, one of the following NBS type thermocouple ranges: (1) Type J, (2) Type K, (3) Type T, (4) Type E, (5) Type R, and (6) Type S.

1.1.2 *Temperature Scale/Resolution.* The temperature scale is switch selectable for degrees Celsius or degrees Fahrenheit without affecting calibration of the instrument. Measurement resolution of the instrument is 1°C/1°F.

1.1.3 *Display.* The front panel consists of an easy to read 4-digit seven segment LED display readout with 1.42 cm (.56") high digits. Indications are shown on the display for conditions of negative polarity (minus sign, "–"), positive overrange (– – –), and negative overrange/break detect (– – – –). Leading zeros are suppressed.

1.1.4 *Instrument Connections.* Quick connect terminal blocks behind the rear panel are used for the power input, signal input, and analog output option connections. The BCD output option is provided with a connector receptacle which is accessible through a rear panel cutout. Refer to 1.1.6 for a description on available options.

1.1.5 *Power.* Depending on the initial order, the indicator is configured by the factory to operate from AC mains or a DC power source. The power selection is as follows: (1) 100/120/200/240 VAC, 48-400 Hz and (2) DC: 10-16 or 22-26 VDC.

1.1.6 *Options.* Two isolated output options are available for the indicator: Analog output, and Tri-state BCD output. These tions feature an output which is isolated from the input to accommodate relatively large common mode voltage differentials. Also available as an option is a rack panel for installing the indicator in a 19" rack.

1.1.6.1 *Analog Output Option.* The analog output option provides a voltage output that is proportional to the indicator display. The output is ideal for use with strip chart recorders or other applications where an analog voltage input is required.

1.1.6.2 *BCD Output Option.* The tri-state BCD output features handshake input/output signals and tri-state lines for data communication to a variety of devices. Four BCD digits of binary weighted 8-4-2-1 lines are provided for the numerical data. All lines are LSTTL/CMOS compatible.

1.1.6.3 *Rack Mount Option.* A 19" rack mount panel is available with 1-4 indicator cutouts to allow various indicator combinations to be mounted in a standard 19" rack.

1.1.7 *Physical Description.* The indicator is housed in an extruded aluminum case which provides EMI/RFI shielding and excellent protection of the electronic components within. The panel cutout dimensions are 45 mm high by 92 mm wide (1.77" H x 3.62" W). Overall dimensions of the indicator are 48 mm high by 96 mm wide by 179.05 mm deep (1.89" H x 3.78" W x 7.05" L). Maximum weight is approximately 822 grams (1 lb., 13 oz.).

1.2 SPECIFICATIONS

1.2.1 *Functional*

1.2.1.1 *Input Impedance:* 100 Megohms

1.2.1.2 *Display:* 4-digit LED display with 1.42 cm (.56") digit height.

1.2.1.3 *Measurement Resolution:* 1°C or 1°F

1.2.1.4 *Power:*

AC: 100/120/200/240 VAC ±10%, 48-400 Hz @ 8 W
DC: 10-16 or 22-26 VDC @ .4 A

1.2.1.5 *Range/Span*

RANGE	SPAN
Type K (Chromel-Alumel)	-130°C to +1370°C (-200°F to +2500°F)
Type J (Iron-Constantan)	-200°C to + 760°C (-330°F to +1400°F)
Type T (Copper-Constantan)	-200°C to + 400°C (-330°F to + 750°F)
Type E (Chromel-Constantan)	-200°C to +1000°C (-330°F to 1830°F)
Type S (Pt/Pt-10% Rh)	0°C to +1760°C (+32°F to +3200°F)
Type R (Pt/Pt-13% Rh)	0°C to +1760°C (+32°F to +3200°F)

1.2.2 *Performance*

1.2.2.1 *Noise Rejection*

NMRR: greater than 60 dB @ 50/60 Hz.

CMRR: greater than 120 dB @ 50/60 Hz.
(250 ohm unbalance, up to 230 V DC or AC RMS)

1.2.2.2 *Overload Protection (CMV):*

Thermocouple low lead to ground: 230 V, DC or AC RMS
Power Lead to ground: 1.5 kV, DC or AC RMS

1.2.2.3 *Accuracy @ 25°C (77°F) Ambient Temperature*

Types K, J, T and E thermocouples: ±1°C
(Types K, J: ±1.8°F; Type E: ±1.7°F; Type T: ±2°F)
Types R and S thermocouples:
±5°C (rdgs less than +299°C), ±2°C (rdgs greater than +299°C)
±10°F (rdgs less than +571°F), ±4°F (rdgs greater than +571°F)

1.2.2.4 *Stability with Temperature*

Zero: 1.0 μV/°C
Span: 0.01% rdg/°C
Reference Junction Tracking: 0.05°C/°C

1.2.2.5 *Stability with Time:* 1°/year

1.2.3 *Physical/Environmental*

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

1.2.3.2 *Storage Range:* -40°C to +85°C (-40°F to 185°F)

1.2.3.3 *Relative Humidity:* 0 to 90%, non-condensing

1.2.3.4 *Size:* 48 mm H x 96 mm W x 179.05 mm L (1.89" H x 3.78" W x 7.05" L)

1.2.3.5 *Maximum Weight:* approximately 822 grams (1 lb, 13 oz)

1.3 UNPACKING INSPECTION

1.3.1 *Inspection.* Before placing the indicator in service, inspect the indicator for possible shipping damage, inventory contents for correct accessories and options, and check the indicator for proper operation. Promptly report physical damage, missing items, or improper operation to the factory.

1.3.2 *Repair or Warranty Service.* When returning the indicator for repair or warranty service, please enclose a letter of transmittal. The following information in the letter will expedite service:

- Model and serial number of instrument.
- Description of problem and circumstances of failure.
- Request warranty service if appropriate (refer to original shipping date.
- Name and telephone number of person responsible for returning the instrument.
- Billing address.
- Shipping address.

Section 2
OPERATION

2.1 GENERAL

This section describes installation, configuration, and operation of the instrument.

2.2 INSTALLATION

2.2.1 *Mounting.* Standard mounting configuration of the indicator is for a panel installation. The panel cutout dimensions are 45 mm high by 92 mm wide (1.77"H x 3.62"W). Mounting of the indicator in the optional rack panel is similar to a panel installation. A drawing of the rack panel option is in the back of the manual. See Figure 2-1 for panel mounting details.

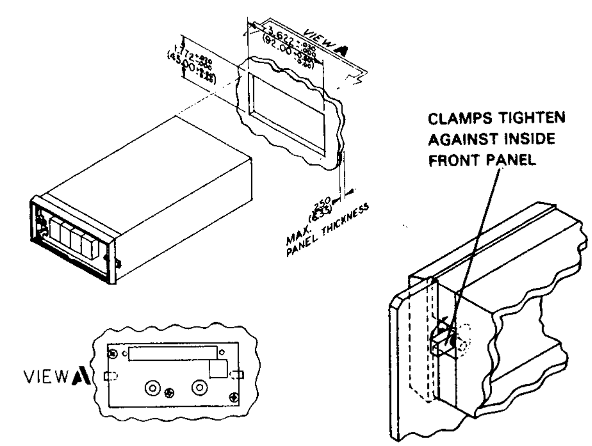


FIGURE 2-1. PANEL MOUNTING

2.2.1.1 *Option Boards Installation.* If the instrument is ordered with an output option, the option is installed in the chassis at the factory. However, an output option can be ordered separately for field installation in the instrument. Refer to the following instructions and the indicator assembly drawing in the back of the manual for installation of an output option board.

NOTE

Numbers in parentheses are ID numbers of parts which correspond to the indicator assembly drawing in the back of the manual

a. Make sure that power is removed from instrument before proceeding.

b. Remove plastic lens (5) from bezel (3) by carefully prying on one side of lens with a small knife, then pulling lens out from side.

c. Loosen panel mounting clamps (11) and slide instrument out from panel cutout.

d. Remove grounding screw (8) and two attaching screws (9) from rear panel (4).

e. Remove rear panel from case (2).

f. Remove four screws (10) attaching front panel assembly to case.

g. Remove front panel and main board (1) from case by sliding entire assembly outward.

h. Carefully align option board connector pins over main board socket and press down firmly.

i. Attach option board to main board standoff using a 4-40 x ¼ screw and #4 star washer (both supplied).

j. Configure instrument for type of output option installed. Refer to 2.3.1.e and 2.3.1.f.

k. Slide front panel/main board/option board assembly into case with main board and option board in its respective card slot.

l. Reassembly is reverse of removal. Replace rear panel with panel supplied with option board. Figure 2-2 shows how BCD mating connector is fastened to option board.

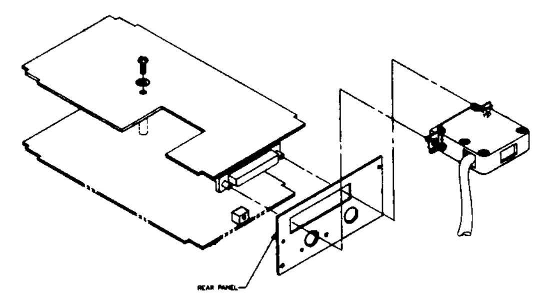


FIGURE 2-2. ATTACHING BCD MATING CONNECTOR

2.3 CONFIGURATION

2.3.1 *Configuration Switch.* A mini-DIP switch assembly is used to configure the indicator for the input type, output option type, and temperature scale. See Figure 2-3. Nominal settings for the indicator are for Type K input; with Fahrenheit readout selected for 120 VAC and DC power units, and Celsius readout selected for 100/200/240 VAC units. The configuration switch is easily reset to accommodate different requirements. To gain access to this switch, remove the front panel assembly as follows:

NOTE

Numbers in parentheses are ID numbers of parts which correspond to the indicator assembly drawing in the back of the manual

a. Make sure that power is removed from instrument before proceeding.

b. Remove plastic lens (5) from bezel (3) by carefully prying on one side of lens with a small knife, then pulling lens out from side.

c. Loosen panel mounting clamps (11) and slide instrument halfway out from panel cutout.

d. Remove four screws (10) attaching front panel assembly to case.

e. Detach front panel assembly from case. Configuration switch assembly is on left front of main board. Configure instrument for desired range, output option (if used), and °C or °F readout per Figure 2-3.

TYPE	S1 2	S1 3	S1 4
K			
J	●		
T		●	
E	●	●	
S			●
R	●		●
CAL	●	●	●

● - ON UNMARKED - OFF

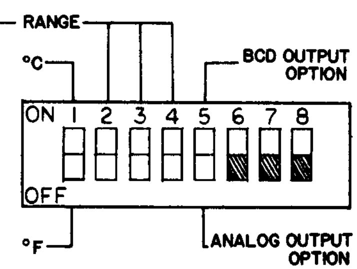


FIGURE 2-3. INSTRUMENT CONFIGURATION SWITCH ASSEMBLY

f. Place self-adhesive label (6) showing input type on desired side of reversible lens (either °C or °F display) as shown on the indicator assembly drawing. Self-adhesive labels for all available thermocouple types are supplied with the indicator.

g. Reassembly is reverse of removal.

2.3.2 *AC Power Configuration.* The instrument can be reconfigured for a different AC power voltage by modifying the main board PCB in the area adjacent to the AC input terminal block. (First remove the PCB assembly per instructions in 2.2.1.1.) The standard power configuration is for 120 VAC which requires no jumpers or cutting of clad on the PCB. Other power configurations require the addition of jumpers and the cutting of clad on the PCB as shown in Figure 2-4.

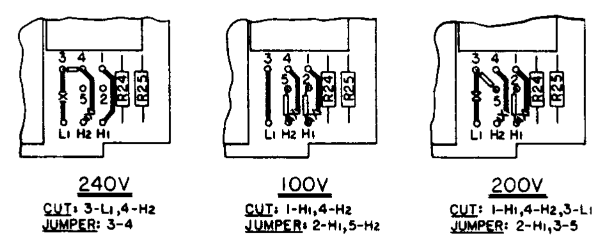


FIGURE 2-4. AC POWER CONFIGURATION, MAIN BOARD

2.4 CONNECTIONS

All instrument connections are made at the rear. Power, signal input, and analog output cables are routed through the grommeted rear panel feedthroughs for connection to terminal blocks. Remove the indicator rear panel (extract three screws) for access to the terminal blocks. See Figure 2-5 for terminal locations and polarity assignments.

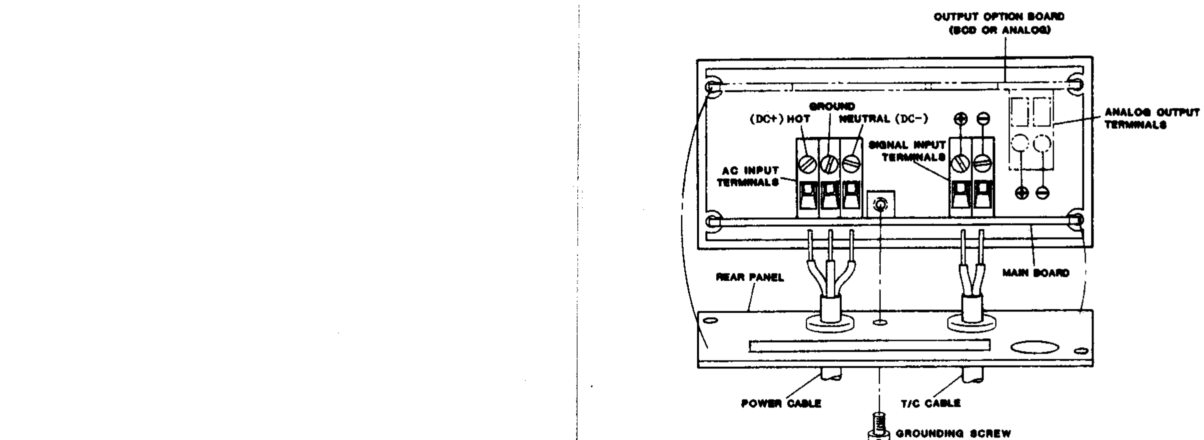


FIGURE 2-5. INDICATOR REAR VIEW

2.4.1 *Power Connections.* The indicator uses one of two types of terminal block for the power connection. Both types of terminal block accommodate either solid or stranded 18-14 AWG wire. To avoid shock hazard and/or instrument damage, remember to always remove power from the instrument before performing any kind of wiring change.

a. One type of terminal block (which is similar to the one used for the signal input) uses quick connect screw terminals to clamp or loosen the wire connection. To make a connection, loosen the screw, insert the stripped lead into the terminal block and re-tighten the screw.

b. The other type of terminal block uses terminals which are individually spring loaded. To insert or remove a wire, push the tip of a small screwdriver into the slot on front of the terminal block above the wire entrance and press down on the spring. If the circuit board is removed from the housing, insert the tip of a small screwdriver in the slot on top of the terminal block and push down on the spring. See Figure 2-6.

WARNING

To avoid shock hazard, a three wire AC input power connection must always be used by connecting the AC ground terminal to earth ground. When using an AC power cord with the indicator, always use a power cord with a three prong plug.

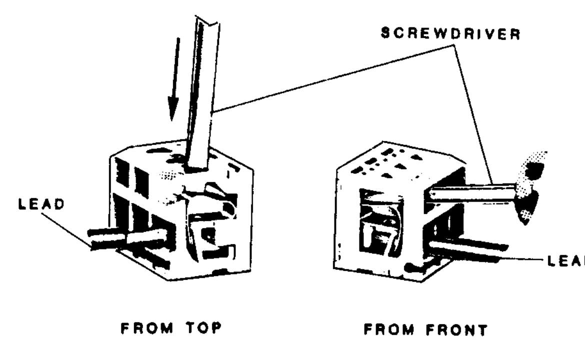


FIGURE 2-6. SPRING LOADED TERMINALS, INSTALLATION/REMOVAL OF WIRES

2.4.2 *Signal Input Connections.* The signal input is connected to a pair of quick connect screw terminals. To make a connection, loosen the screw, insert the stripped lead into the terminal block and re-tighten the screw. Acceptable wire size is 24-12 AWG.

2.4.2.1 *Sensor Grounding.* For better noise rejection in most applications, the sensor and shield (if used) should be grounded at the instrument end using the ground screw provided at the rear panel. This is the ideal point to ground the sensor. Do not use this point for grounding if the sensor is already grounded elsewhere (such as to a bulkhead). Never ground the sensor or shield at two points.

2.4.3 *Analog Output Connections.* The analog output is available from a pair of quick connect screw terminals on the optional Analog Output board. Refer to 2.4.2 above. The voltage output is proportional to the display reading with 1 mV (±2 mV) per degree. Maximum current drive is 2 mA. Observe proper polarity when using the output terminals. Use a twisted pair cable for connecting the analog output to the external device input. See Figure 2-5.

2.4.4 *BCD Output Connections.* All BCD Output option lines are LSTTL/CMOS compatible. These lines are provided by the PCB's connector receptacle which mates to a male 25-pin "D" type connector (supplied). All output lines (except DATA VALID) are tri-state controlled. Pin assignments of the BCD Output option are shown in Figure 2-7. The following summarizes operation of the BCD lines.

INPUT LINES:

$\overline{\text{DATA HOLD}}$: This line, when low, holds the BCD data at its current value if the data is also valid (DATA VALID high). If the data is not valid when $\overline{\text{DATA HOLD}}$ is low, the data will be held once the data becomes valid. The DATA VALID line will remain high until the $\overline{\text{DATA HOLD}}$ line goes high.

TRI-STATE CONTROL lines: Three active low inputs provide independent tri-state control of portions of the data. These inputs can be tied together for tri-state control of all 18 data output lines at once. They can also be used selectively in conjunction with $\overline{\text{HOLD}}$ for data output in 8-bit bytes.

$\overline{\text{TSC0}}$ — Digits 1 and 2
$\overline{\text{TSC1}}$ — Digits 3 and 4
$\overline{\text{TSC2}}$ — Polarity and Overload

OUTPUT LINES:

DIGIT DATA: A single digit of data is represented by four lines with binary weighting of 8-4-2-1. A total of four digits of data is provided (16 lines). The data output is positive true.

POLARITY: This line indicates polarity of the data; high for positive readings, low for negative readings.

OVERLOAD: This line, when high, indicates an input overload condition (overrange or open input).

DATA VALID: This line, when high, indicates that valid data is present at the output lines.

PIN #	FUNCTION	PIN #	FUNCTION
1	Chassis Gnd.	14	Data Gnd.
2	$\overline{\text{DATA HOLD}}$	15	$\overline{\text{TSC1}}$
3	DATA VALID	16	POLARITY
4	$\overline{\text{TSC2}}$	17	OVERLOAD
5	$\overline{\text{TSC0}}$	18	Digit 3 (8)
6	Digit 2 (1)	19	Digit 3 (4)
7	Digit 2 (2)	20	Digit 3 (2)
8	Digit 2 (4)	21	Digit 3 (1)
9	Digit 2 (8)	22	Digit 4 (8)
10	Digit 1 (1)	23	Digit 4 (4)
11	Digit 1 (2)	24	Digit 4 (2)
12	Digit 1 (4)	25	Digit 4 (1)
13	Digit 1 (8)		

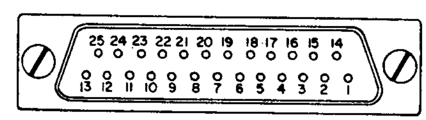


FIGURE 2-7. BCD OUTPUT OPTION PIN ASSIGNMENTS

2.5 OPERATION

2.5.1 *Applying Power.* Power is applied to the instrument as long as the instrument is plugged into an active AC/DC source. To remove power, unplug the power cord at the outlet or turn off the AC/DC at the controlling source.

WARNING

> To avoid shock hazard and/or possible instrument damage, always remove power from the instrument before making a configuration switch change or rewiring the sensor input.

2.5.2 *Using the Instrument.* Once the instrument is configured for the desired range (refer to 2.3) measurements can be made by connecting the appropriate sensor to the input terminals (refer to 2.4).

Section 3
CALIBRATION

3.1 CALIBRATION PROCEDURE

Equipment Required:

Precision millivolt source:
resolution, 1μV; accuracy ±.01% (±2μV)
Thermocouple probe
Digital Voltmeter, 4½ digits
Ice Bath, 0.00°C ±0.05°C

NOTE

> Refer to the appropriate PCB assembly drawing (Main board or Analog Output board) in the back of this manual for location of potentiometer adjustments.

3.1.1 *Basic Calibration (Main Board)*

a. Remove power from indicator.

b. Observing proper polarity, connect appropriate type thermocouple probe to signal input terminals. Refer to 2.4.1 and Figure 2-5.

c. Insert probe in ice bath, Apply power to indicator and allow five minutes for stabilization.

d. Depending on temperature scale selected, slowly adjust R1 for a display reading of 32°F or 0°C (reading takes about 3 seconds to stabilize).

e. Remove power from indicator. Remove thermocouple probe from signal input terminals.

f. Configure indicator to CALIBRATE (linear) mode by setting switch S1-2 through S1-4 CLOSED/ON. Refer to 2.3.1.

g. Observing proper polarity, connect calibrator source to signal input terminals.

h. Apply power to indicator. Allow five minutes for stabilization.

i. Adjust calibrator source output to 90.000 mV.

j. Adjust pot R12 for a display reading of 9000 counts.

k. After calibration adjustment is complete, re-set switch S1 for desired thermocouple type and re-assemble instrument.

3.1.2 *Analog Output Option Calibration*

a. Remove power from indicator. Remove thermocouple probe from signal input terminals.

b. Configure indicator to CALIBRATE mode (S1-2 through S1-4 set CLOSED/ON) with Analog Output option selected (S1-5 set OPEN/OFF). Refer to 2.3.1.

c. Observing proper polarity, connect calibrator source to signal input terminals. Refer to 2.4.1 and Figure 2-5.

d. Apply power to indicator. Allow five minutes for stabilization.

e. Connect DVM HI lead to Analog Output board positive output terminal.

f. Connect DVM LO lead to Analog Output board negative output terminal.

g. Adjust calibrator source output to 0.000 mV.

h. Adjust pot R21 on Analog Output board for a DVM reading of 0.000 V $\pm$0.002 V

i. Adjust calibrator source output to 40.00 mV.

j. Adjust pot R22 on Analog Output board for a DVM reading of 4.000 V $\pm$0.002 V.

k. Re-set S1 for desired thermocouple type and re-assemble instrument.

Section 4
THEORY OF OPERATION

4.1 GENERAL

This section describes circuit operation of the digital temperature indicator. The main board circuit description is divided into four sections: Microcontroller Circuits, A/D Conversion, Display, and Power Supply. Refer to the Main Board schematic diagram.

4.2 MICROCONTROLLER CIRCUITS

4.2.1 *Microcontroller.* Operation of the indicator revolves around the Intel 8051/8031 microcontroller IC (Z10). IC Z10 handles all analog timing, linearization, and display strobing. The Data bus, from PORT 0, also functions as the lower 8 bits of the 16-bit ROM address. The ALE signal from Z10 pin 30 is used to qualify the 8-bits from PORT 0 as the lower order ROM address.

4.2.2 *Crystal Oscillator.* Crystal Y1 (6 MHz) provides the input to the microcontroller's clock generator. The clock generator divides the input frequency by two which provides a two-phase 3 MHz clock signal for system timing.

4.2.3 *ROM.* Program information is stored in ROM. If the 8031 microcontroller is used, the ROM is external (Z12). If the 8051 microcontroller is used, the internal 4K ROM is utilized. The information stored in ROM contains linearization curves for all thermocouple types, °C/°F conversion, and timing sequences for analog and digital circuitry.

4.2.3.1 *ROM Latch/Output Enable.* Latch Z11, in conjunction with the ALE line, provides the lower order byte address to external ROM Z12. The $\overline{\text{PSEN}}$ line is used to access the external ROM. When $\overline{\text{PSEN}}$ is low, the addressed memory location is read by Z10 via the data bus.

4.2.4 *Configuration Switches.* Switch assembly S1, in conjunction with resistor network RN2, is used to configure the instrument to the desired operating parameters (i.e. T/C range, temperature scale, output option used). The switch lines, either grounded low (closed) or pulled high (open) by RN2, are read by Z10 over the data bus via line driver Z13 enabled by A14 and $\overline{\text{PSEN}}$.

4.2.5 *Reset Circuit.* The reset circuit consists of one half of dual comparator Z5, transistor Q2, diode CR7, and related components. The reset circuit monitors operation of microcontroller Z10 by periodically charging capacitor C11 with the autozero (AZ) signal. If Z10 malfunctions, the AZ signal is interrupted, and C11 discharges. When the charge in C11 drops below the threshold set at Z5 pin 3, the output at Z5 pin 1 goes high, providing the RST input to Z10 pin 9. The reset re-initializes Z10 in an attempt to recover from faulty operation.

4.3 A/D CONVERSION

4.3.1 *A/D Conversion Summary.* The analog-to-digital conversion is accomplished by a unipolar dual-slope integrator circuit consisting of op-amp stages Z2 (integrating amp), Z4 (slope amp), and one half of Z5 (zero crossing comparator). Every conversion has three sequential phases — autozero, signal integrate, and reference integrate.

4.3.1.1 *Autozero.* The autozero phase establishes a zero reference by introducing a fixed offset voltage, which is stored in capacitor C3, at the summing node of the integrator (Z2 pin 2). The offset is about +12 mV above actual ground. This allows negative inputs to be ramped positive without the need for a separate negative reference source (hence the term "unipolar"). Input offset at Z2 pin 3 is nulled by closing the loop around Z2 and Z4 via resistor R13. Duration of the autozero phase is 200 ms.

4.3.1.2 *Signal Integrate.* Op-amp Z2 integrates the input signal by charging capacitor C6 for a duration of 100 ms. The amount of charge in C6 is dependent on the signal level. The input signal is selected by input multiplexer Z1.

4.3.1.3 *Reference Integration.* After the signal integration period, capacitor C6 is discharged by connecting a reference voltage to it. At the same time, Z10 starts counting. This is the reference integration period (RI). The time it takes for C6 to discharge to zero volts (the discharge rate) is proportional to the signal level. The reference voltage is provided by resistor R19, zener diode CR6, and capacitor C9. This source is connected to C6 via two CMOS analog switches connected in parallel (Z3) which are activated by the RI line. Pot R12 provides an adjustment of the discharge current which effectively varies the slope (rate) of the discharge ramp. Op-amp Z4 amplifies the discharge ramp for input to the zero crossing comparator Z5.

4.3.1.3.1 *Zero Crossing.* One half of IC Z5 functions as the zero crossing detect comparator. One input is referenced to ground and the other input

is the output from Z4. When the output from Z4 crosses the zero axis, a negative going pulse is output from Z5 pin 7 which serves to stop Z10 from counting. The resulting count value is the raw counts.

4.3.2 *Input Multiplexer.* The instrument operates in a similar manner as a three channel indicator. In addition to the thermocouple input signal, the indicator reads (converts) a zero channel and a reference junction channel. The value shown on the display is a composite of these three input readings. The reading of these two "extra channels" is accomplished by input multiplexer Z1. Multiplexer Z1 selects one of four signals to the input of the dual-slope integrator depending on the state of the A and B inputs (controlled by Z10):

Compensated zero offset (AB=00) — The integrator input is shorted to ground via resistor R29. In this condition, the sum total of offset currents produced by Z1 and Z2 are converted and read by Z10. Subsequent external input and reference junction readings are compensated for this offset value.

External input (AB=10) — The external input at TB1 is connected to the integrator input. In this condition, the thermocouple signal is converted and read by Z10.

Reference junction (AB=01) — The divided down (by R10 and R11) reference junction diode is connected to the integrator input. In this condition, the reference junction compensation voltage is converted and read by Z10.

Shorted input (AB=11) — The integrator input is shorted directly to ground during the autozero period and reference integrate period.

4.3.2.1 *Break Detect.* Input break detect is accomplished by charging capacitor C1 via R3 tied to -5 volts. During input signal integration, the charge stored in C1 is normally discharged through the source resistance. If a break exists in the input, C1 does not discharge and the input is then driven to negative overload. The negative overload is shown on the display as a row of four dashes.

4.4 DISPLAY

4.4.1 *Port Control.* Port 1 of Z10 controls the seven-segment LED display. Bits 4-7 of Port 1 serve to turn on transistors Q4-Q7 in sequence one at a time. The sequential strobe sinks the selected digit's common cathode to ground, causing the digit to illuminate. Bits 0-3 of Port 1 provide the BCD data to the segment driver.

4.4.2 *BCD-to-7 Segment Driver.* The BCD data is input to BCD-to-7 segment driver Z9 which drives the segments (anodes) of the LED display to form a digit. Current through each segment is limited by resistor network RN1.

4.4.3 *Overload Indication.* Transistor Q8, diodes CR10 and CR11, and resistors R27 and R28 make up the circuit to display dashes in the event of an overload. Since the "g" segment alone cannot be driven by Z9, this circuit is used to drive the "g" segments in order to display the input overload indication. The input overload display indication is three or four dashes in a row (positive and negative overload respectively). A BCD value of 1111 (Fh) is provided at the input of Z9 during overload conditions. This causes the segment driver to blank a digit. The two most significant bits are input to diodes CR10 and CR11. When these bits are high, Q8 is turned on and the "g" segment is driven. Resistor R27 limits current through the segments. Positive or negative overload display (3 and 4 dashes respectively) is determined by the segment driver input for the first digit. If the overload is positive, the segment driver input is 1100 BCD (Ah) for the first digit only, with the input for the remaining digits being 1111 BCD (Fh). This yields a display of three dashes. If the overload is negative, all digits have a segment driver input of 1111 BCD (Fh). This yields a display of four dashes.

4.5 POWER SUPPLY

4.5.1 *AC Power Transformer.* The AC power input is stepped down by power transformer T1. The primary side of T1 has two tapped windings. Depending on how they are connected, these windings provide the transformer with various step-down ratios to accomodate a particular AC voltage. Resistors R24 and R25 serve as fuses in the event the primary draws excessive current.

4.5.2 *Secondary.* The voltage across the secondary winding of T1 is nominally 25 VAC p-p ±4 VAC p-p. The secondary voltage is rectified by bridge rectifier CR8 and filtered by capacitor C13. The nominal voltage across C13 is 10 VDC ±2.5 VDC. The rectified and filtered secondary voltage provides the input to the 3-terminal regulators for the +5 volts supply. Capacitor C12 decouples spurious noise from circuit ground to chassis ground.

4.5.3 *+5 Volts Supply.* Two 3-terminal regulators are used to supply the +5 volts required for operation. The use of two 3-terminal regulators splits the load to a manageable level. This saves space by avoiding the use

of a larger device with the requisite heatsink. Regulator Z7 supplies the Display and I/O (output option) circuits. Capacitor C16 filters the output from Z7. Regulator Z6 supplies the remaining digital circuitry. Capacitor C15 filters the output from Z6. All .1μF capacitors at the output of the 3-terminal regulators are power bus bypass capacitors for various ICs. These capacitors are located close to the power pins of the IC and bypass spurious noise from the power bus (+5 V) to ground.

4.5.4 *Negative Supply.* IC Z8 is a monolithic voltage converter which is configured to convert a positive voltage (DIG +5) into a negative voltage (-5 V). Capacitor C18 filters the negative voltage output from Z8.

4.5.5 *DC Pre-regulator.* The DC pre-regulator is used for DC powered instruments only. For DC power applications, the power transformer and input resistors are removed with jumpers JMP4 and JMP5 connecting the DC input to CR8. Jumper JMP3 is removed for DC power. CR8 provides protection from reverse polarity DC input. The input DC voltage is processed by the DC pre-regulator consisting of zener CR9, transistor Q3, and resistor R26. The DC pre-regulator is basically a zener referenced series pass transistor which provides a fixed DC output of approximately 7.5 volts for input to the 3-terminal regulators.

4.6 BCD OUTPUT

The following paragraphs describe circuit operation of the BCD Output option. Refer to the BCD Output option schematic diagram.

4.6.1 *Isolated Power Supply.* The BCD Output circuitry is powered by an onboard power supply in order to achieve isolation from the main indicator circuits. The power supply consists of counter Z4, transistors Q3 and Q4, step-up transformer T1, diodes CR1-CR6, and related components. The ALE signal supplies the clock input to Z4 where the signal is divided to provide various frequency outputs. Jumper JMP1 selects the Q4 output of Z4 which switches Q3 at 64 kHz rate. Transistor Q3 drives transistor Q4; switching I/O +5 volts through the T1 primary and inducing an AC voltage in the T1 secondary. The secondary AC voltage is full-wave rectified by diodes CR2-CR5 in a bridge rectifier configuration. The DC output from the bridge is filtered by capacitors C2 and C9 and regulated to +5 volts by zener CR6. Final filtering of the output is provided by capacitor C3. Capacitors C6-C8 are power bus bypass capacitors for ICs Z2, Z3, and Z8.

4.6.2 *Input Opto-coupler Circuits.* The BCD input signals are the I/O CLOCK and I/O DATA. Both of these signals come from PORT 3 of microcontroller chip Z10. The I/O CLOCK signal synchronizes transmission of I/O DATA. The I/O DATA signal is a serial BCD data stream with the least significant digit (LSD) bits sent first. Isolation from the main indicator circuits is achieved by opto-coupling the two input signals. Opto-coupler Z5 couples the I/O CLOCK signal to the clock input of shift registers Z2, Z3, and Z8. Opto-coupler Z1 couples the I/O DATA signal to the D input of shift register Z2. OR gate Z7 (output pins 8 and 11) in conjunction with resistors R3 and R6 shapes the optically coupled signals for optimum triggering.

4.6.3 *Data Shift and Strobe.* The I/O data is shifted through shift registers Z2, Z3, and Z8 with each positive pulse from I/O CLOCK. With the falling edge of the first I/O CLOCK pulse, one shot Z6 (Q output pin 6) is triggered. This one-shot times out when all I/O data bits are shifted in, which in turn, triggers the next one shot (low at Z6 pin 11). The resulting high at Z6 pin 10 strobes the shifted data to the output latches of the three registers. NOR gate Z7 (output pin 3) buffers the strobe signal to provide the DATA VALID output signal.

4.6.4 *Data Hold.* OR gate Z7 (output pin 6) gates the $\overline{\text{DATA HOLD}}$ input signal with the low strobe signal. The output at Z7 pin 6 drives the clear input at Z6 pin 13. With $\overline{\text{DATA HOLD}}$ present at the input, the one shot will clear (Z6 pin 10 low) once the strobe signal times out. This holds the data at the register outputs by preventing later data shifts from being strobed.

4.6.5 *Tri-state Inputs.* An output enable input is provided for each output register at pin 15. The OE input is normally pulled up high to enable the outputs as they are strobed. An externally provided low to any of the $\overline{\text{TSCx}}$ inputs causes a particular register to tri-state its outputs (high impedance). When the low input is removed, the data that was strobed last appears at the output.

4.7 ANALOG OUTPUT

The following paragraphs describe circuit operation of the Analog Output option. Refer to the Analog Output option schematic diagram.

4.7.1 *Isolated Power Supply.* The Analog Output circuitry is powered by an on-board power supply in order to achieve isolation from the main indicator circuits. The power supply consists of counter Z1, transistors Q1 and Q2, step-up transformer T1, diodes CR1-CR4, and related components. The ALE signal supplies the clock input to Z1 where the signal is divided to provide various frequency outputs. The Q4 output of Z1 switches transistor Q1 at a 128 kHz rate. Transistor Q1 drives transistor Q2; switching I/O +5 volts through the T1 primary and inducing an AC voltage in T1 secondary. The secondary voltage is half-wave rectified by diodes CR2 and CR3 to form a dual supply (positive and negative respectively). Resistors R2 and zener CR4 provides regulation of the +10 supply. Capacitors C2 and C3 provide output filtering. Capacitors C4, C9, C10, and C15 are power bus bypass capacitors for various ICs.

4.7.2 *Input Opto-coupler Circuits.* The Analog input signals are the I/O CLOCK and I/O DATA. Both of these signals come from PORT 3 of microcontroller chip Z10. The I/O CLOCK signal synchronizes transmission of I/O DATA. The I/O DATA signal is a serial 16-bit binary datastream with the least significant bit sent first. Isolation from the main indicator circuits is achieved by opto-coupling the two input signals. Opto-coupler Z2 couples the I/O CLOCK signal to the clock input of shift registers Z9 and Z11. Opto-coupler Z3 couples the I/O DATA signal to the D input of shift register Z11. Inverter Z5, in conjunction with resistors R7 and R9, shapes the optically coupled signals for optimum triggering.

4.7.3 *Data Shift and Strobe.* The I/O data is shifted through shift registers Z9 and Z11 with each positive pulse from I/O CLOCK. With the falling edge of the first I/O CLOCK pulse, one shot Z4 (Q output pin 6) is triggered. This one-shot times out when all I/O data bits are shifted in, which in turn, triggers the next one-shot (low at Z6 pin 11). The resulting high at Z4 pin 10 strobes the shifted data to the output latches of Z9 and Z11 for input to DAC Z10.

4.7.4 *Digital-to-Analog Converter (DAC).* IC Z10 is a Digital-to-Analog converter which converts a binary encoded input to a proportional analog output. A dc amplifier consisting of zener CR8, op-amp Z12, and related components establishes the DAC's full scale output. The DAC output is buffered and inverted by op-amp Z6 for input to op-amp Z8.

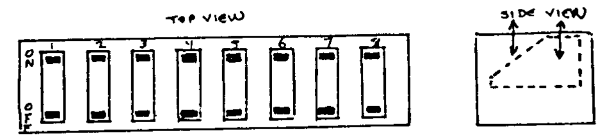
4.7.5 *Polarity Switching Output Stage.* Since the DAC output is positive only, multiplexer Z7 selects the inverting or non-inverting input of the second stage op-amp (Z8) according to the polarity of the actual data. The A input of Z7 is connected to Z11 pin 4 which is the 16th bit of the serial datastream. This bit indicates polarity of the data. If the data polarity is positive, the A input is low, and the Y0 input is selected. This grounds the non-inverting input of Z8 and routes the Z6 output to the inverting input of Z8. Hence, the inverted DAC output is inverted again to yield a positive output. If the data polarity is negative, the A input is high, and the Y1 input is selected. This routes the Z6 output to the non-inverting input of Z8.

Hence, the inverted DAC output is passed with no added inversion to yield a negative output. Trimmer R21 provides Z8 with offset null adjustment. Diodes CR6 and CR7 protect the output from outside voltage sources in excess of approximately 10 volts. An RC filter consisting of capacitor C12 and resistor R20 damps oscillation resulting from high capacitance loads.

MANUAL ADDENDUM -- HOW TO ACTUATE THE VARIOUS DIP SWITCH TYPES

Your instrument may use one or more of the DIP switch types shown below. This addendum shows you how to actuate each type.

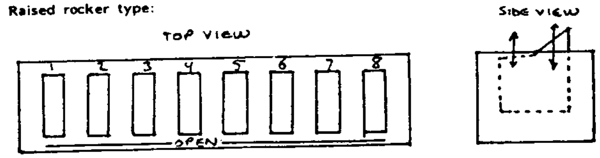
a. Recessed rocker type:



Push down on the "ON" to side to set the switch ON/CLOSED.

Push down on the "OFF" side to set the switch OFF/OPEN.

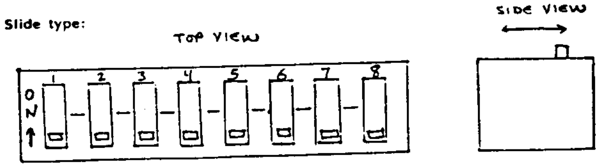
b. Raised rocker type:



Push down on the numbered side to set the switch ON/CLOSED.

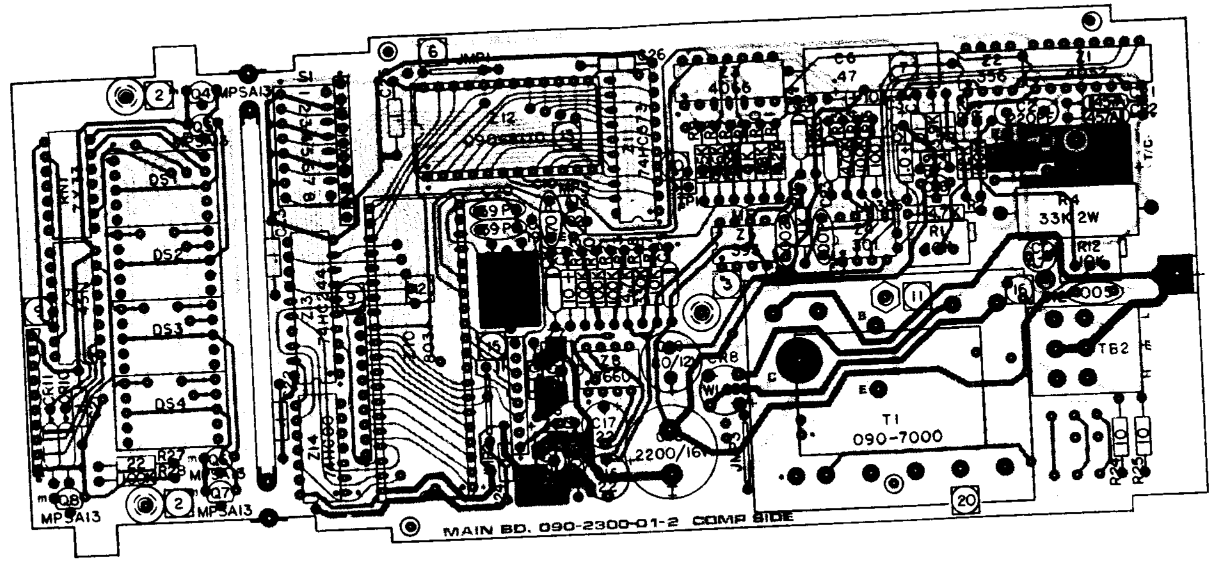
Push down on the "OPEN" side to set the switch OFF/OPEN.

c. Slide type:

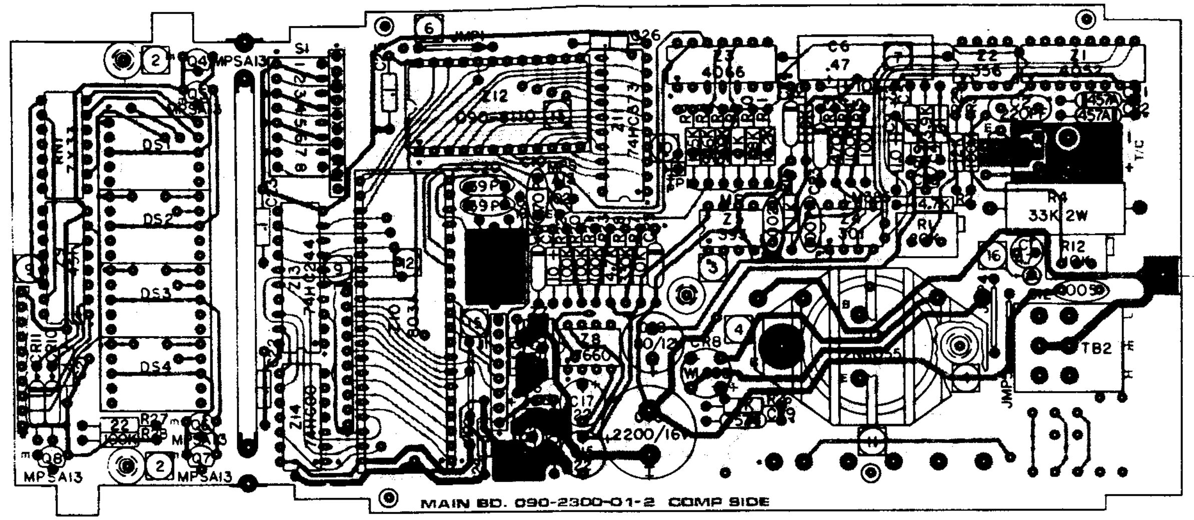


Slide the tip toward the numbers to set the switch ON/CLOSED.

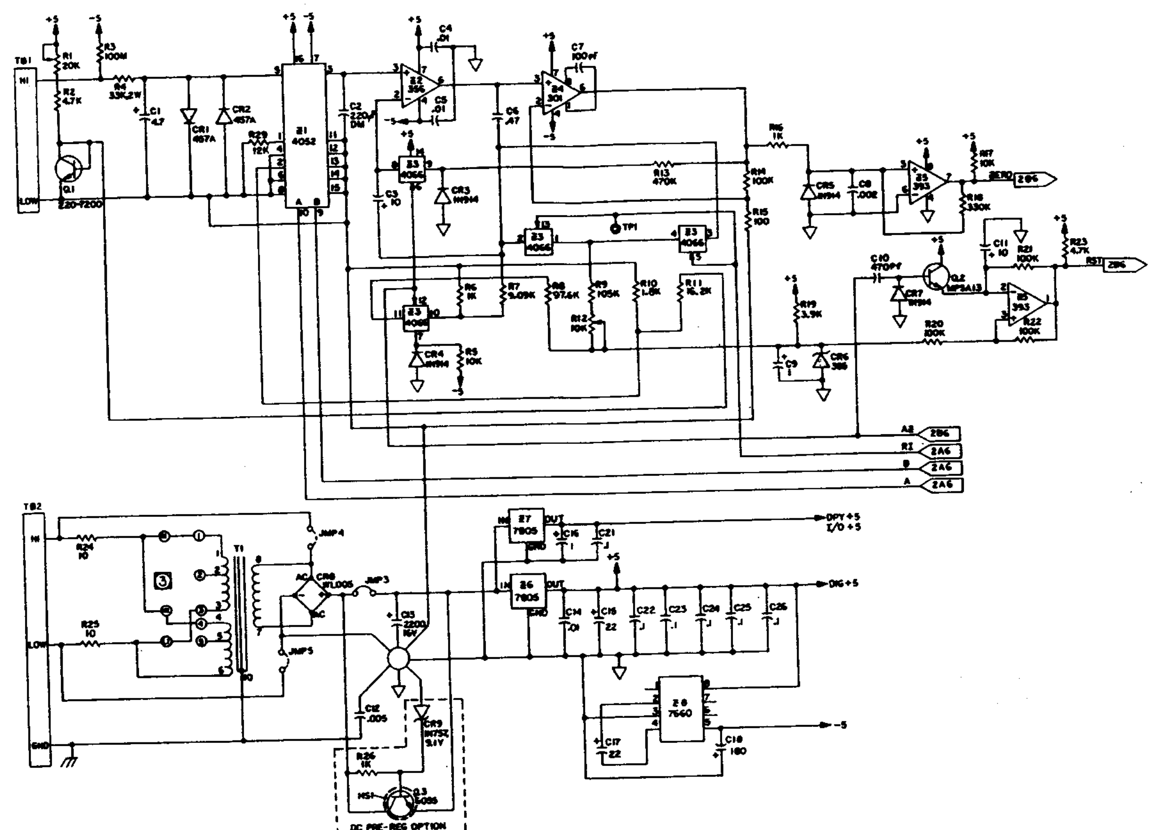
Slide the tip away from the numbers to set the switch OFF/OPEN.



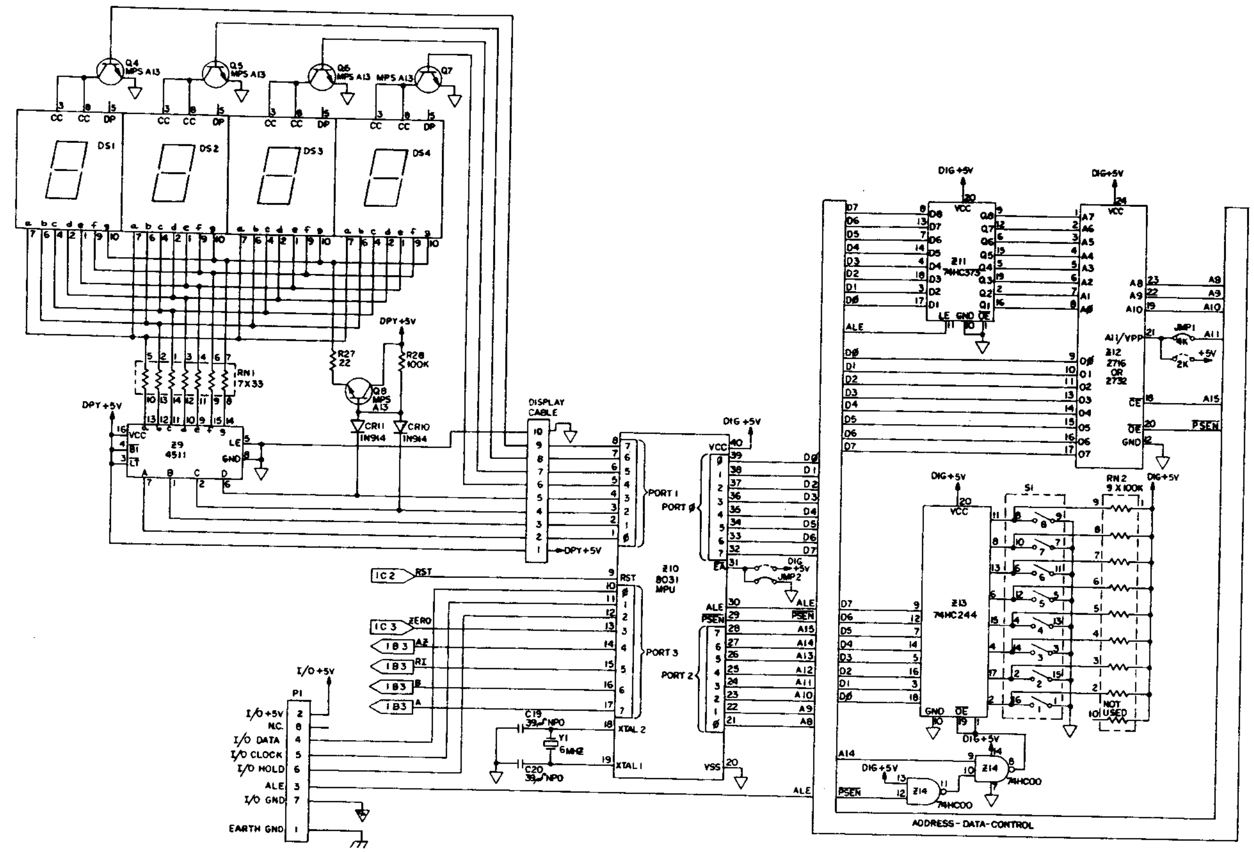
ASSEMBLY
MAIN BOARD (AC)
1 of 1



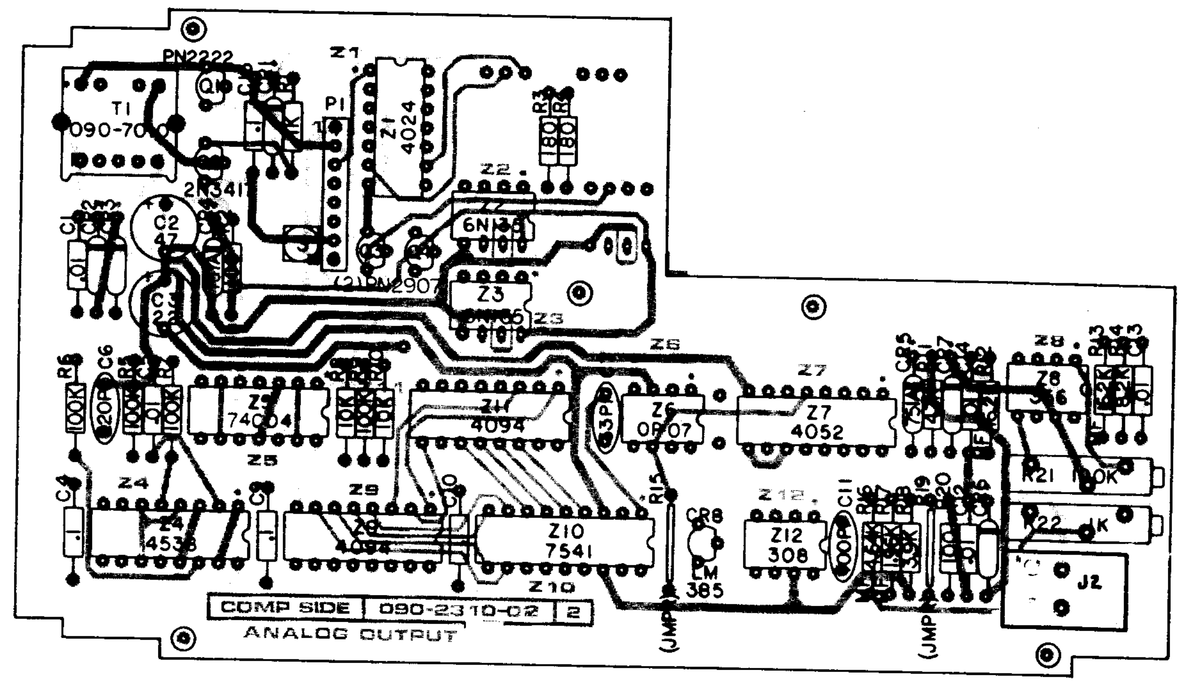
ASSEMBLY
MAIN BOARD (DC)
1 of 1



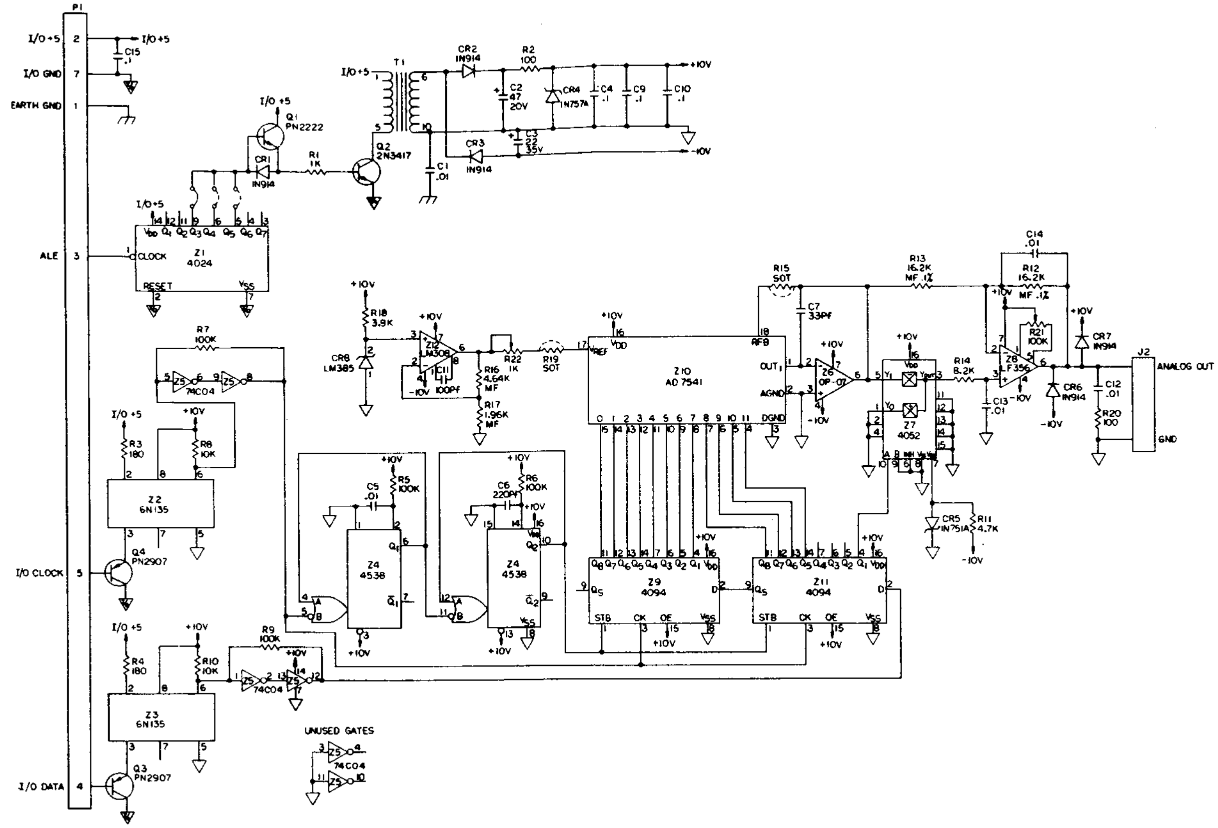
SCHEMATIC DIAGRAM
MAIN BOARD
1 of 2



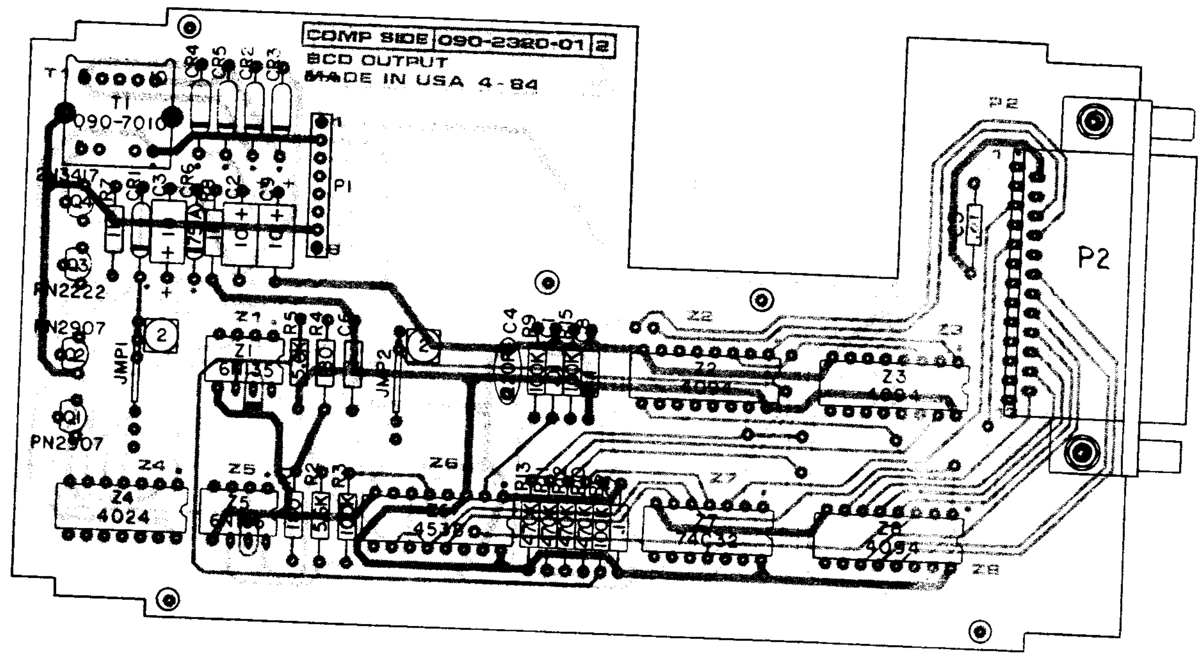
SCHEMATIC DIAGRAM
MAIN BOARD
2 of 2



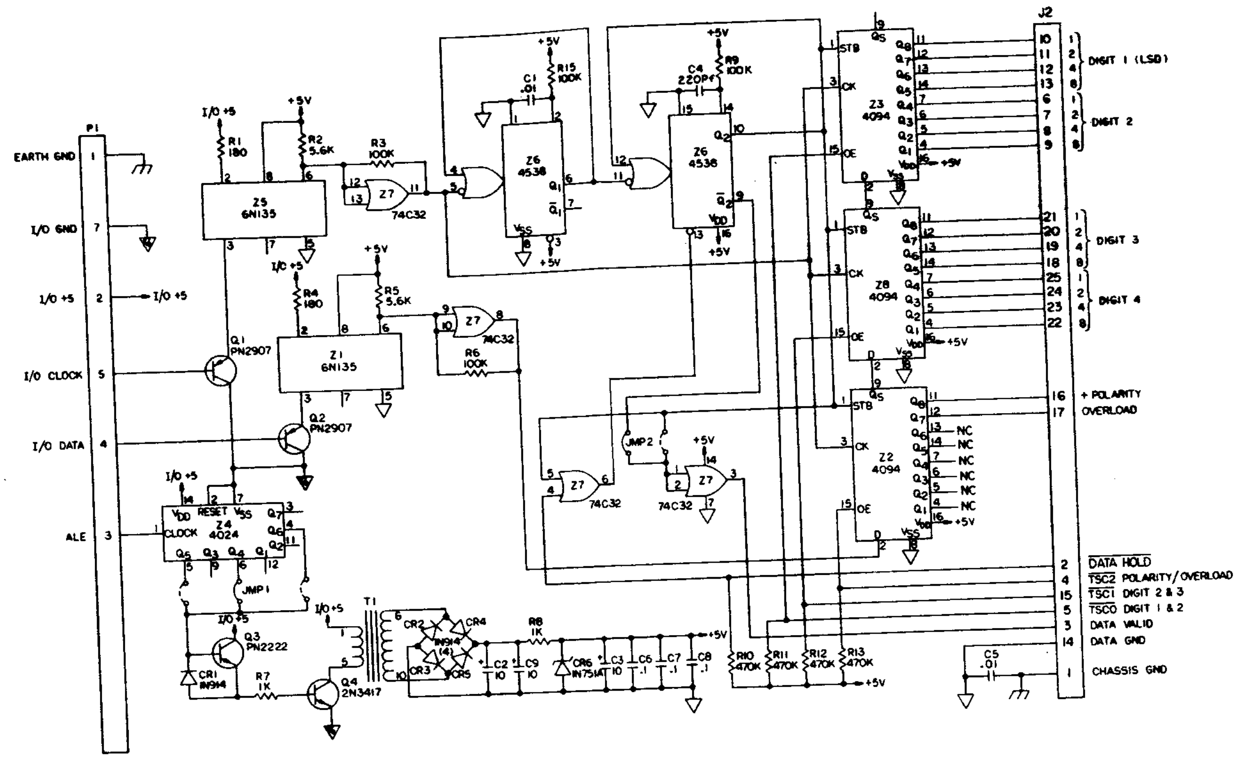
ASSEMBLY
ANALOG OUTPUT OPTION
1 of 1



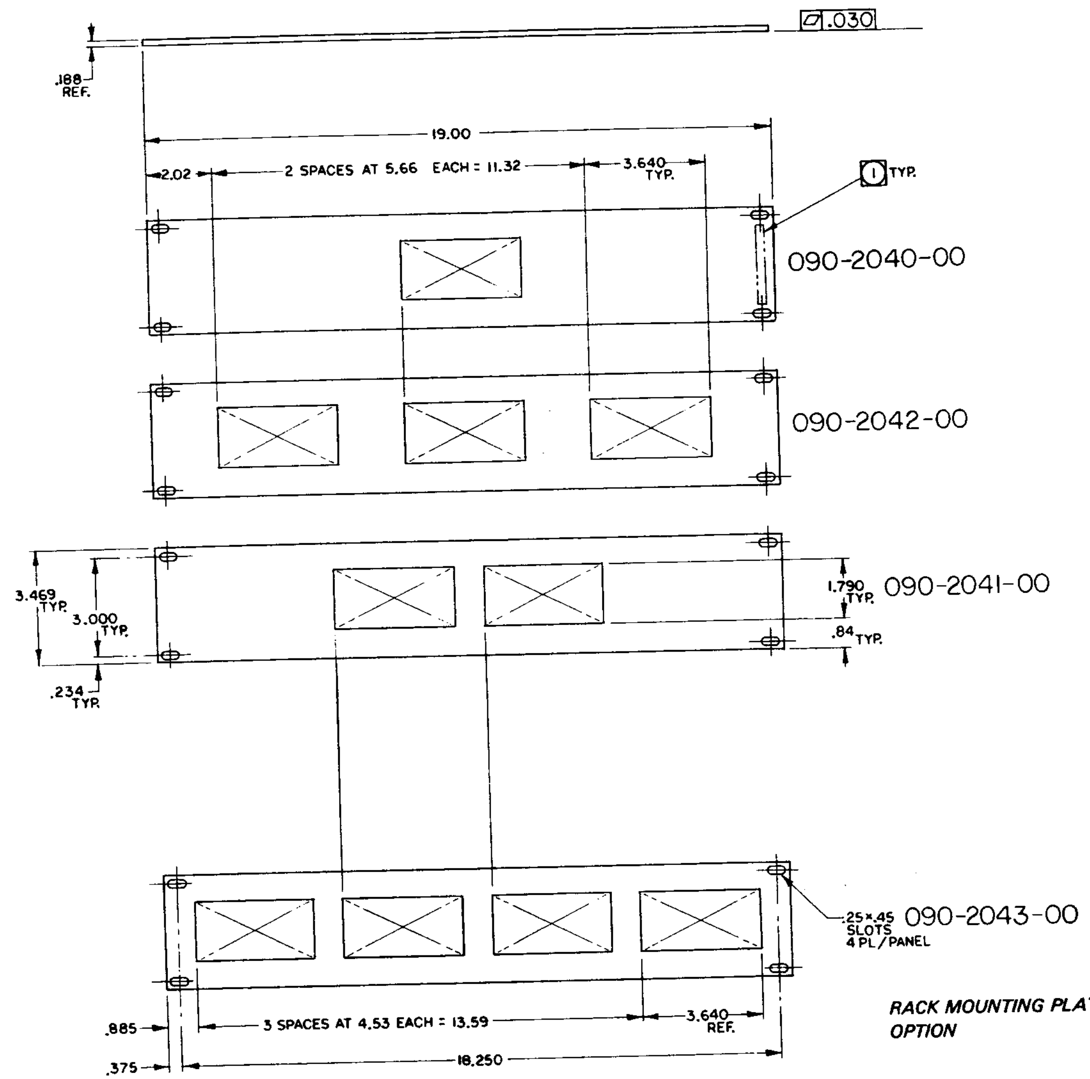
SCHEMATIC DIAGRAM
ANALOG OUTPUT OPTION
1 of 1



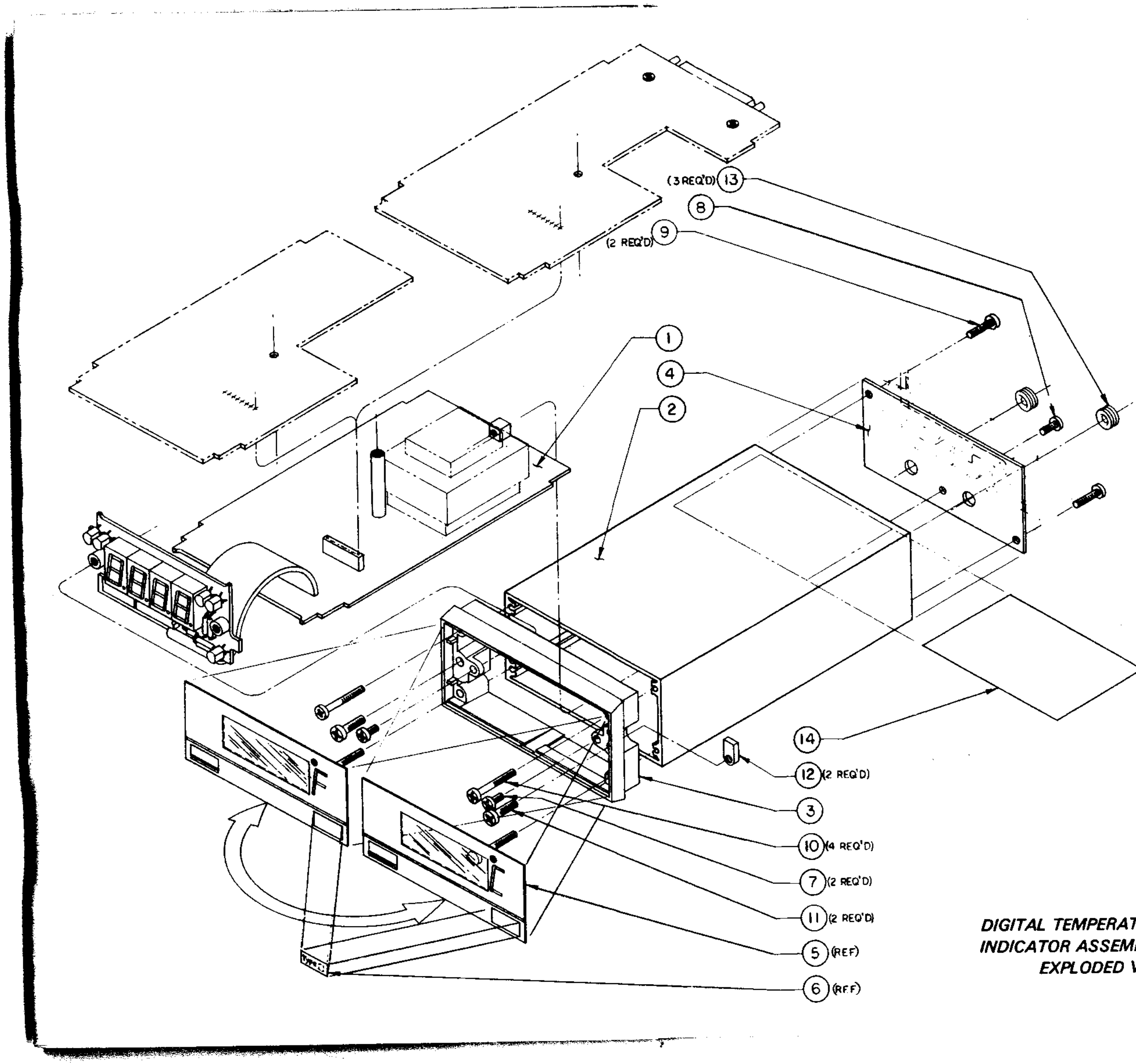
ASSEMBLY
BCD OUTPUT OPTION



SCHEMATIC DIAGRAM
BCD OUTPUT OPTION
1 of 1



RACK MOUNTING PLATE OPTION



DIGITAL TEMPERATURE INDICATOR ASSEMBLY, EXPLODED VIEW