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SECTION 1
DESCRIPTION

1.1 General Applications

The Series 2000A/S Digital Panel Meters offer a low cost, reliable approach to digital display of analog voltages and currents for applications requiring up to .0025% resolution. Series 2000A/S DPM's provide up to +39999 count readings of four D.C. voltage and five D.C. current ranges.

Using highly stable integrating techniques, the Series 2000A/S can complete up to 20 readings per second, externally controllable. Upon command, all Series 2000A/S DPM's will digitally store a reading for the duration of the command.

Use of a guard-shield and transformer coupling between the measuring and output circuits produces high common-mode noise isolation and prevents ground loops, thereby reducing system trouble-shooting.

The BCD outputs and the external control inputs and outputs are compatible with DTL and TTL IC's for ease in interfacing with other instruments. The gated BCD output allows a "wire or" digital multiplexer to be formed by several DPM's and/or other instruments and a common recorder or display. Each DPM can be sequentially enabled and its BCD data put on the buss lines driving the recorder. Buffers provide isolation between the BCD outputs and the reading stored in the DPM.

The Series 2000A/S DPM's can be used in a wide variety of applications as a system component due to the many external control features designed into the standard instrument. A measurement can be made upon command, with the conversion complete signal used to close the loop. The display can be blanked upon command to reduce reading confusion in a large monitoring system, or to eliminate false or undesired data. The display automatically blanks the 4 least significant digits when the input exceeds the meter's range. The BCD outputs can be bussed and enabled as required. A SERIAL output as well as the parallel BCD OUTPUTS are provided so that a remote display can be used for readout.

For ruggedness, appearance, and shielding against external noise, the Series 2000A/S DPM's are housed in an extruded aluminum case.
### Specifications

#### DC Voltage Meters

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Scale</td>
<td>+399.99mV</td>
<td>+3.9999V</td>
<td>+39.999V</td>
<td>+399.99V</td>
</tr>
<tr>
<td>Resolution</td>
<td>10μV</td>
<td>100μV</td>
<td>1mV</td>
<td>10mV</td>
</tr>
<tr>
<td>Impedance</td>
<td>1G Ohm Min</td>
<td></td>
<td>10 Meg Ohm</td>
<td></td>
</tr>
<tr>
<td>Input Bias Current (adjustable to zero)</td>
<td>&lt; 200pA Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Overdrive</td>
<td>200V</td>
<td></td>
<td>500V</td>
<td></td>
</tr>
<tr>
<td>Maximum Error 8 hrs. @25°C</td>
<td>0.005%R</td>
<td>+0.005%FS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Error 15-35°C, 30 days</td>
<td>0.01%R</td>
<td>+0.01%FS</td>
<td>0.01%R</td>
<td>+0.01%FS</td>
</tr>
<tr>
<td></td>
<td>+0.0005%FS</td>
<td>+0.0005%FS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature Stability</td>
<td>0.001%R</td>
<td>+0.001%</td>
<td>0.001%</td>
<td>+0.0005%FS</td>
</tr>
<tr>
<td>0 to 15°C and 35 to 50°C</td>
<td>+0.0005%FS</td>
<td>+0.0005%FS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Current Meters

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Scale</td>
<td>+39.999uA</td>
<td>+399.99uA</td>
<td>+3.9999mA</td>
<td>+39.999mA</td>
<td>+399.99mA</td>
</tr>
<tr>
<td>Resolution</td>
<td>1nA</td>
<td>10nA</td>
<td>100nA</td>
<td>1μA</td>
<td>10μA</td>
</tr>
<tr>
<td>Voltage Drop @ Full Scale</td>
<td></td>
<td></td>
<td></td>
<td>400mV</td>
<td></td>
</tr>
<tr>
<td>Maximum Overdrive</td>
<td>3mA</td>
<td>10mA</td>
<td>30mA</td>
<td>200mA</td>
<td>800mA</td>
</tr>
<tr>
<td>Maximum Error 8 hrs. @25°C</td>
<td>.01%R</td>
<td>+.01%FS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Error 15-35°C, 30 days</td>
<td>.02%R</td>
<td>+.015%FS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature Stability</td>
<td>.002%R</td>
<td>+.001%FS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 15°C and 35 to 50°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reading Rate

From less than 1/2 per sec to 20 per sec. programmable by external resistance.

Settling Time

After full scale step input, to rated accuracy, 200ms standard. See Filter Characteristic Table (Section 3.2).

Normal Mode Rejection

40db, 50 Hz and above, standard. See Filter Characteristic Table (Section 3.2).

Polarity

Automatic

Common Mode Rejection, DC to 60 Hz, 1K Ohm Imbalance

To Power Line, case

120 db

To BCD Common

100 db

Common Mode Voltage to meet CMR specification

To Power Line, case

300V max.

To BCD Common from input low side

300V max.

Remote Controls

BCD enable, reading enable, transfer inhibit, and display blanking.

Calibration

Full scale and zero pots accessible from rear panel.

Operating Temperature Range

0 to +55°C

Storage Temperature Range

-40 to +80°C

Display

0.55 inch, 7 segment, planar, gas discharge numerals with + and - indication.

Power

115/230 VAC ±10%, 50 to 400 Hz, 10.5 watts nominal.

Enclosure

2.4" high x 5.0" wide x 7.5" deep with connector. Extruded aluminum case; bezel (Option A3) has removable name plates for replacement by customer nomenclature.
Weight

Less than 4 pounds, net; 6 pounds shipping.

Connectors Required

Analog: SAE # SAC 15S/1-2 or CINCH # 250-15-30-170
Digital: SAE # SAC 22D/1-2 or CINCH # 251-22-30-160
Key: SAE # 007900 or CINCH # 456-99-99-193

Connector Key Position

Analog - between pins 6 and 7
Digital - between pins 10 and 11

Options

Basic Series 2000A/S instruments are bipolar with buffered, isolated, gated, stored BCD outputs. (BIGS-BCD)

A1
Mounts case on studs behind front panel.

A2
Mounts case by screws through front panel.

A3
Mounts case with decorative bezel and hardware.

C1
Operation on 115/230 VAC, 50 Hz.

D2
Two P.C. edge connectors with solder terminals.

AF1
Active filter, 60 db @50 Hz, and above, 1000ms settling.

AF5
Passive filter, 50 db @60 Hz, 200ms settling time.

AF4
No filter, 40 db @60 Hz, and at multiples of 60 Hz, 10ms settling.

FP
Front Panel zero, full scale pots.

FS1
Special full scale, specify volts or amps full scale.

E5
Ratio 2V Nominal Reference

E2
Ratio 4V Nominal Reference

E3
Ratio 10V Nominal Reference
Options (Continued)

E4

Ratio 1V Nominal Reference

Ratio input is 3-wire with respect to signal input. That is, Signal Low and Reference Low are connected together.

Ratio Specifications

Maximum Error

Add 0.01% FS to specs.

Maximum Overdrive

50V

Input Impedance

$>10\text{M Ohm}$ except 10V range which is 10K Ohm.

Reference Voltage Range

$+10\%, -50\%$
SECTION 2
RECEIVING AND INSTALLATION

2.1 Unpacking and Inspection

Your Series 2000A/S Digital Panel Meter has been carefully inspected and tested before shipment. Unpack the meter and perform a visual inspection to assure that no mechanical damage has occurred during shipment or handling. These meters are factory sealed units. The only controls that may require periodic adjustment are accessible through the rear panel. Because extensive damage could result from attempts to measure circuit parameters or to trouble-shoot the meter by non-qualified personnel, the warranty is voided if the units have been removed from their cases and show evidence of unauthorized repair.

2.2 Initial Checkout Procedure

1. Connect a voltage source (e.g., power supply) between pins 12 and 9 of the upper (analog) connector. On ratio meters, also connect a voltage source between pins 14 and 9 with pin 14 positive.

2. Connect a jumper between pins 9 and 1 of the same connector.

3. Connect a jumper between pins 16 and X on the bottom (digital) connector.

4. Connect a power cord to the lower (digital) connector as follows:

115V
A. Connect the high or "hot" lead to pins 12 and N.
B. Connect the low or "cold" lead to pins 11 and M.
C. Connect the earth ground on "third wire" to pins 13 and P.

230V
A. Connect the high lead to pin N.
B. Connect the low lead to pin M.
C. Connect a jumper between pins 11 and 12.
D. Connect the earth ground to pins 13 and P.
2.2 (Continued)

5. Apply 115/230, ±10%, 60 Hz to the power cord (If option C1 has been provided use 50 Hz power).

6. Adjust the input voltage source(s) to be within the measurement range of the meter and verify that the meter is reading correctly.

(Convert voltage to current by adding a resistance R for current meters only. For voltage meters R is shorted out).

115 VAC WIRING

J1 WIRING FOR 230 VOLT POWER

INITIAL CHECKOUT
2.3 Installation - Mechanical

Drawing 04486 illustrates the detailed method of mounting the panel meters for each of the three mounting options. All critical dimensions are shown including those for the panel cutout.

<table>
<thead>
<tr>
<th>MOUNTING STYLE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Unit is mounted flush on studs behind a rack panel.</td>
</tr>
<tr>
<td>A2</td>
<td>Unit is mounted behind a rack panel by inserting the finished 6-32 screws through the rack panel and into threaded holes in the case.</td>
</tr>
<tr>
<td>A3</td>
<td>Unit is mounted through the rack panel from the front and held in place from the rear by a &quot;U&quot; bracket. The mounting cutout is hidden by the instrument bezel.</td>
</tr>
</tbody>
</table>
3.1 Power

Description

The standard meter operates from a 115 VAC or 230 VAC ±10%, 50-60 Hertz power source. It dissipates approximately 8 watts. It should be connected to the power source by a three conductor cable. Two conductors provide the power to the meter and the third provides safe grounding of the case. The third conductor should connect to earth ground at the power end of the cable and to the Digital Connector (J1) at the meter end of the cable. Two screws on the rear panel connect the case to an internal bracket which completes case grounding.

Wiring Detail, 115V Operation

The power cable is connected as follows to the bottom or Digital board (J1).

(a) Connect the high or "hot" side of the 115v power line to pins 12 and N.

(b) Connect the low or "cold" side of the 115v power line to pins 11 and M.

(c) Connect the ground or third wire to pin P and/or pin 13.
Wiring Detail, 230 VAC Operation

The power cable is connected as follows to the bottom or Digital board (J1).

(a) Connect the high or "hot" side of the 230V power line to pin N.

(b) Connect the low or "cold" side of the 230V power line to pin M.

(c) Connect the ground or third wire to pins 13 and/or pin P.

230 VAC Connections
3.2 Input Connection

The 2000A/S Series of panel meters employs a bipolar input circuit with 300 volts of common mode rejection between the low input lead and digital ground.

The 0.4 and 4 volt meters have an input impedance of over 1G Ohm. The source impedance may be as high as 100K Ohm without appreciable loading error. Bias current imbalance can cause reading errors if source impedances are high. Typically, the Series 2000A/S has less than 200pA offset current, which may be adjusted to zero.

A guard-shield encloses the analog circuitry for maximum protection from external noise sources. Both the inputs and the guard-shield withstand 300 volts common-mode with respect to the BCD output lines or case ground. Common-mode noise sources, are rejected by 100db at 60 Hz with 1K Ohm imbalance.

Wiring Detail: Connect the signal's highest impedance point to J2 Pin 12 (DC INPUT), the signal common to J2 Pin 8 or 9 (SIGNAL COMMON) and connect J2 Pins 1 and 15 (GUARD) to signal common at the signal or at J2.

The standard 3-pole active filter attenuates all noise over 50 Hz by at least 40db. Attenuation increases at 18db/octave up to 100db. Filter Characteristics are:

<table>
<thead>
<tr>
<th></th>
<th>STANDARD</th>
<th>OPTION AF1</th>
<th>OPTION AF4</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMR @ 60 Hz</td>
<td>60db</td>
<td>80db</td>
<td>40db</td>
</tr>
<tr>
<td>NMR @ 50 Hz</td>
<td>40db</td>
<td>60db</td>
<td></td>
</tr>
<tr>
<td>Settling Time</td>
<td>200 msec</td>
<td>1 sec</td>
<td>10 msec</td>
</tr>
</tbody>
</table>

3.3 Range Changing

The utility of the Series 2000A/S is expanded by the addition of remote range changing. Decade ranges, i.e., 0.4v, 4v, 40v, 400v are typical; however, any full scale range from 0.4v to 400 volts is possible. Ranging accuracy is a function of the quality of external components, lead lengths, contact resistance and mounting techniques. Guaranteed accuracy is for factory-adjusted ranges only.
Millivolt-Level Ranging

In applications requiring range changing to less than 4 volts FS, the Model 2000A/S-1R should be ordered. Delivered standard 2000A/S-1 units should be returned to the factory for internal conversion to 2000A/S-1R configuration. Consult factory before making any internal changes. External range switching of the 2000A/S-1R between 0.4v and 4v full scale is as follows:

In Figure 1, close S1 for 0.4 volt full scale, open for 4 volt range.

For 0.4v full scale, ±0.5% span, values are:

- R1 = 353.5 Ohm, 0.1%
- R2 = 20K Ohm, 1%
- R3 = 20K Ohm, multi-turn trimmer

Figure 1

If the application requires a non-standard sensitivity somewhere between 0.4v and 4v full scale, the following empirical method is suggested for selecting R1.

1. Apply desired full-scale voltage to the Model 2000A/S-1R input, pins 9 and 12.
2. Adjust full scale pot to center of travel.
3. Connect a decade resistance box (0.1 Ohm increments) from pin 8 to 10 and adjust resistance until meter reads full scale.
4. Install a precision 0.1% wirewound resistor equal to the decade box settings or construct a network similar to R1, R2 and R3 if switched ranges are required. If full-scale stability of 1 digit/°C is acceptable, R1 may be a metal film resistor, otherwise it should be a wirewound resistor.
High-Level Ranging

For ranges of 4v, 40v and 400v, select the standard Model 2000A/S-2. Use the following instructions and Figure 2.

1. If no calibration pots are needed (basic attenuator resistors are equal to or greater than desired accuracy), use 90K for R1 and replace R4 and R5 with jumpers.

2. If 100K ohms input impedance is too low, all values may be multiplied by a common number multiplier not to exceed "10" for a 400mv DPM or "100" for a 4v DPM.

3. If it is desirable to have a high input impedance on the lowest range, the attenuator impedance may be disconnected from the input lead as shown in Figure 3. This requires an extra pole on the switch.

4. Shielding of the attenuator should not be needed if care is taken to mount all resistors close together and separated from power lines and transformers. Also care should be taken to avoid leakage paths around high value resistors such as R1. The lower the attenuator resistance, the less critical is the shielding.
ATTENUATOR
3 RANGE
CONSTANT IMPEDANCE
Figure 2

See Fig. 3

ATTENUATOR INPUT

R1
R4A
R2
R5A
R3
R4
SW1
R6
4V
40V
400V
GND

DPM INPUT

2000A/S DPM
pin 12
pin 8,1
J-2

Fig. 3

ATTENUATOR INPUT

SPDT
TO DPM INPUT LINE

TO R1

OPTIONAL: High impedance on lowest range

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RESISTOR</th>
<th>TOLERANCE</th>
<th>VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>W/W</td>
<td>0.1%</td>
<td>90.320K Ohms</td>
</tr>
<tr>
<td>R2</td>
<td>W/W</td>
<td>0.1%</td>
<td>9.000K Ohms</td>
</tr>
<tr>
<td>R3</td>
<td>W/W</td>
<td>0.1%</td>
<td>1K Ohm</td>
</tr>
<tr>
<td>R4</td>
<td>Pot</td>
<td>20%</td>
<td>100 Ohms</td>
</tr>
<tr>
<td>R4A</td>
<td>Carbon</td>
<td>5%</td>
<td>4.2 Ohms</td>
</tr>
<tr>
<td>R5</td>
<td>Pot</td>
<td>20%</td>
<td>100 Ohms</td>
</tr>
<tr>
<td>R5A</td>
<td>Carbon</td>
<td>5%</td>
<td>56 Ohms</td>
</tr>
<tr>
<td>R6</td>
<td>Carbon</td>
<td>5%</td>
<td>9.1K Ohms</td>
</tr>
<tr>
<td>R7</td>
<td>Carbon</td>
<td>5%</td>
<td>8.2K Ohms</td>
</tr>
</tbody>
</table>

03115
14
3.4 **Digital Inputs/Outputs**

The logic levels present at the digital connector are DTL and TTL compatible.

(a) **Input Requirements:**
- \(0V \leq \text{Low Level} \leq 0.8V, I_{\text{Sink}} = 1.6\text{mA}\)
- \(2.0V \leq \text{High Level} \leq 5.0V, I_{\text{source}} = 0.1\text{mA}\)

(b) **Output Specifications:**
- \(0V \leq \text{Low Level} \leq 0.5V, I_{\text{Sink}} = 10\text{mA}\)
- \(2.4V \leq \text{High Level} \leq 5.5V, R_{\text{source}} = 6K \text{Ohm}\)

3.4.1 **External Control**

The digital panel meter provides a choice of several external control modes. This choice of modes allows the meter to satisfy a wide variety of interface requirements when used as a system component.

The meter has two basic maximum read rates of 4 and 20 conversions per second and can be externally controlled from 0 to the selected maximum rate by applying external pulses. Maximum read rate on 50 Hz power is 15/sec.

The internal read rate is set by a variable delay generator which can also be used to set a fixed delay of 15ms to greater than 3 sec between the read enable pulse and the start of the next conversion. This delay can then allow for settling of input signals that are being switched.
MODE 1
INTERNAL CONTROL P1
FIXED READING RATE

DIGITAL 4/SEC 20/SEC
GND READ RATE READ RATE
(READ RATE)

16 T X 19

OPTIONAL
HOLD SWITCH
OPEN TO
HOLD LAST
READING

SELECT ONE

MODE 2
INTERNAL CONTROL P1
VARIABLE READING RATE

DIGITAL 4/SEC 20/SEC
GND READ RATE READ RATE
(READ RATE)

16 T X 19

OPTIONAL
HOLD SW
R1
SELECT ONE

R1

Read Generator Delay
3 sec 1 sec 200ms 100ms 30ms 15ms

20K
100K
200K
1M
3M

R1 to Pin X
R1 to Pin 19

TYPICAL READING RATE
(Readings/Sec)
1 5 10 15 20
MODE 3
EXTERNAL READ COMMAND

P1 LEVEL CONTROL

DIG GND +5V MEASUREMENT ENABLE (IN) MEASUREMENT ENABLE (IN) MEASUREMENT ENABLE (OUT) 4/SEC READ RATE (IN) 20/SEC READ RATE (IN)

16 T U V 15 R X 19

COMPLEMENT "AND" GATE INPUTS

Readings will occur at selected maximum reading rate while both inputs of the complement "AND" gate are true (V to U, 15 to 16). Last reading will be held if either input goes false.

<table>
<thead>
<tr>
<th>PIN</th>
<th>TRUE</th>
<th>FALSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>POS TRUE ENABLE</td>
<td>V 2v to 5v into 5K Ohms</td>
<td>0 to .5v</td>
</tr>
<tr>
<td>NEG TRUE ENABLE</td>
<td>15 0 to .5v</td>
<td>2v to 5v</td>
</tr>
</tbody>
</table>

All voltages are with respect to DIGITAL GND Pin 16 or T.

MODE 4
EXTERNAL READ COMMAND
POSITIVE TRANSIENT CONTROL

P1 DIG GND +5V MEASUREMENT ENABLE (IN) MEASUREMENT ENABLE (IN) MEASUREMENT ENABLE (OUT) 4/SEC READ RATE (IN) 20/SEC READ RATE (IN)

16 T U 15 V R X 19

2 TO 5 VOLTS

C1 (.01uF)

AC coupling for single reading-POSITIVE edge trigger.
MODE 5
EXTERNAL READ COMMAND
NEGATIVE TRANSIENT CONTROL

AC coupling for single reading NEGATIVE edge trigger.

MODE 6
Single reading command from push button
(no bounce circuit)

USING POSITIVE ENABLE (MEASUREMENT ENABLE)

USING NEGATIVE ENABLE (MEASUREMENT ENABLE)
## PULSE WIDTH REQUIREMENTS

<table>
<thead>
<tr>
<th>P1-R Connected To</th>
<th>MAXIMUM READING RATE</th>
<th>MINIMUM ENABLE PULSE WIDTH</th>
<th>MAXIMUM ENABLE PULSE FOR ONE READING</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>4/sec</td>
<td>2us</td>
<td>200ms</td>
</tr>
<tr>
<td>19</td>
<td>20/sec</td>
<td>2us</td>
<td>20ms</td>
</tr>
<tr>
<td>19</td>
<td>15/sec on 50 Hz power</td>
<td>2us</td>
<td>20ms</td>
</tr>
</tbody>
</table>
3.4.2 Decimal Points

The decimal point locations are designated by representing the four full decimal digits by 9's and placing the decimal point in the position corresponding to its display location. The decimal point connections are available on the lower (Digital) connector (P1).

(a) Pin 1  Decimal Point 3999.9  (DP1)
(b) Pin A  Decimal Point 399.99 (DP2)
(c) Pin 22  Decimal Point 39.999 (DP3)
(d) Pin 21  Decimal Point 3.9999 (DP4)
(e) Pins T,16  Ground Return  (DIG GND)

Any decimal point may be lighted by connecting the designated pin to ground. A solid state switch could be used if it is rated for 1mA in the ON state and is capable of blocking 70V with a leakage of less than 1uA in the OFF state.

3.4.3 BCD Outputs

Stored positive true BCD outputs representing each digit of the readout as well as OVERLOAD and NEGATIVE POLARITY are standard. The OVERLOAD output goes true when the input voltage exceeds the full scale rating of the meter. The NEGATIVE POLARITY output goes true when the input signal is negative.

The BCD Data, NEGATIVE POLARITY, and OVERLOAD outputs have settled and represent the latest reading when the CONVERSION COMPLETE signal goes true. The data may be held indefinitely by maintaining a low level at the MEASUREMENT ENABLE input, a high level at the MEASUREMENT ENABLE input, or a high level at the TRANSFER INHIBIT input.

Because the measurement enable circuit is reset during the TRANSFER STROBE pulse, a low level at MEAS. ENABLE or high level at MEAS. ENABLE must occur before the TRANSFER STROBE pulse is issued. For this reason, when interfacing to a data printer with an INHIBIT (or PRINTER BUSY) output, INHIBIT should be returned to TRANSFER INHIBIT input, to prevent data from changing during print cycle. An alternate approach is to bypass the measurement enable circuit and return INHIBIT directly to a read rate input (P1-X or 19). This action is not necessary if the meter is commanded to read by an external pulse or the printer has input storage.
3.4.3 (Continued)

The BCD outputs are buffered, isolated, gated and stored (BIGS-BCD). Connecting a high signal (or open) to the BCD ENABLE input (pin W) enables the data to be read out. A low signal on pin W causes all the BCD outputs to be high. The gated BCD lines from several meters may be multiplexed by parallel wiring the outputs, then by sequentially enabling a meter its BCD outputs will appear on the common buss.

3.4.4 SERIAL OUTPUT

The SERIAL OUTPUT is a gated burst of 1.8 MHz pulses during the reference integrate time. The number of pulses in the burst is equal to the number indicated on the front panel display. See the Basic Timing diagram in Section 4.2 for timing relationships.

3.4.5 BLANKING (IN)

The display can be blanked by a ground (logic low) applied to pin Z of the digital connector.

3.4.6 TRANSFER INHIBIT (IN)

A +5V (1mA source) signal applied to pin 18 of the digital connector prevents the display and BCD outputs from updating. This will not stop conversion or the serial output pulses.

3.4.7 CONVERSION COMPLETE (OUT)

The CONVERSION COMPLETE signal at pin 17 of the digital connector goes high during the time between the end of the reference integrator period and the start of the next measurement cycle. The rising edge of this signal can be used to indicate the end of conversion.

3.4.8 TRANSFER STROBE (OUT)

A 10 usec pulse is available at pin S of the digital connector during the time the display is being updated. The falling edge of this pulse can be used to indicate conversion complete. The falling edge occurs at the same time that CONVERSION COMPLETE goes high.
### 3.5 2000A/S Pin Assignments

**P2 - Analog Board Upper Connector**

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,15</td>
<td>GUARD</td>
<td>Must be tied to &quot;SIG COMMON&quot; at connector or signal source.</td>
</tr>
<tr>
<td>12</td>
<td>DC INPUT</td>
<td>Signal Input Hi Side</td>
</tr>
<tr>
<td>8,9</td>
<td>SIG COMMON</td>
<td>Signal Return (Analog GND)</td>
</tr>
<tr>
<td>3</td>
<td>+ REF</td>
<td>+6.3V, Hi-Impedance</td>
</tr>
<tr>
<td>4</td>
<td>- REF</td>
<td>-6.3V, Will Supply 1mA</td>
</tr>
<tr>
<td>5</td>
<td>- PS</td>
<td>Neg. 13V, Will Supply 2mA</td>
</tr>
<tr>
<td>6</td>
<td>+ PS</td>
<td>Pos. 13V, Will Supply 2mA</td>
</tr>
<tr>
<td>2</td>
<td>PS COMMON</td>
<td>Internal Connection to 8,9 for PS current return.</td>
</tr>
<tr>
<td>10</td>
<td>GAIN</td>
<td>Resistance between 10 and 8,9 will raise input amp gain.</td>
</tr>
<tr>
<td>7,11</td>
<td>OPTION INPUTS</td>
<td>Used for options</td>
</tr>
<tr>
<td>13</td>
<td>SPARE</td>
<td>No internal connection on standard meter.</td>
</tr>
<tr>
<td>14</td>
<td>REFERENCE INPUT</td>
<td>Positive voltage reference used on ratio meter only.</td>
</tr>
</tbody>
</table>
### Pl - Digital Board Lower Connector

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>AC LINE HI</td>
<td>Hi side of input power.</td>
</tr>
<tr>
<td>M</td>
<td>AC LINE LOW</td>
<td>Low side of input power.</td>
</tr>
<tr>
<td>12</td>
<td>AC LINE</td>
<td>Connect to Pin N for 117V, Pin 11 for 230V</td>
</tr>
<tr>
<td>11</td>
<td>AC LINE</td>
<td>Connect to Pin M for 117V, Pin 12 for 230V</td>
</tr>
<tr>
<td>P,13</td>
<td>GND CASE AND POWER LINE</td>
<td>Internal connections to case. Connect to 3rd wire ground.</td>
</tr>
<tr>
<td>16,T</td>
<td>DIG GND</td>
<td>Circuit GND reference for all DIGITAL INPUTS &amp; OUTPUTS.</td>
</tr>
<tr>
<td>U</td>
<td>+5V</td>
<td>+5V logic PS thru 10 Ohm resistor.</td>
</tr>
<tr>
<td>Z</td>
<td>BLANKING (IN)</td>
<td>Hi or open for normal readout, Low will blank readout.</td>
</tr>
<tr>
<td>17</td>
<td>CONVERSION COMPLETE (OUT)</td>
<td>Low when meter is converting.</td>
</tr>
<tr>
<td>18</td>
<td>TRANSFER INHIBIT (IN)</td>
<td>Low or open for normal operation, high inhibits readout from updating.</td>
</tr>
<tr>
<td>S</td>
<td>TRANSFER STROBE (OUT)</td>
<td>A 10us positive true pulse at end of conversion (Use falling edge)</td>
</tr>
<tr>
<td>X</td>
<td>4/SECOND READ RATE</td>
<td>Low causes meter to read at 4 readings per second</td>
</tr>
<tr>
<td>19</td>
<td>20/SECOND READ RATE</td>
<td>Low causes meter to read at 20 readings per second</td>
</tr>
<tr>
<td>R</td>
<td>MEASUREMENT ENABLE RATE (OUT)</td>
<td>Externally connected to Pin X or 19 when meter is used in the external command mode.</td>
</tr>
<tr>
<td>PIN NO.</td>
<td>NAME</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>V</td>
<td>MEASUREMENT ENABLE (IN)</td>
<td>Used for positive true external commands</td>
</tr>
<tr>
<td>15</td>
<td>MEASUREMENT ENABLE (IN)</td>
<td>Used for negative true external commands</td>
</tr>
<tr>
<td>14</td>
<td>SERIAL OUTPUT</td>
<td>Provides serial output of readout</td>
</tr>
<tr>
<td>1</td>
<td>DP1</td>
<td>Lights least significant digit decimal point when grounded to Pin 16</td>
</tr>
<tr>
<td>A</td>
<td>DP2</td>
<td>Lights tens digit decimal point when grounded to Pin 16</td>
</tr>
<tr>
<td>22</td>
<td>DP3</td>
<td>Lights hundreds digit decimal point when grounded to Pin 16</td>
</tr>
<tr>
<td>21</td>
<td>DP4</td>
<td>Lights thousands digit decimal point when grounded</td>
</tr>
<tr>
<td>W</td>
<td>BCE ENABLE (IN)</td>
<td>A logic high or open enables the BCD outputs, a low forces all BCD outputs to their high state.</td>
</tr>
</tbody>
</table>

2 - 1 BIT
3 - 2 BIT
B - 4 BIT
C - 8 BIT
E - 10 BIT
D - 20 BIT
6 - 40 BIT
F - 80 BIT
H - 100 BIT
7 - 200 BIT

8 - 400 BIT
J - 800 BIT
K - 1K BIT
9 - 2K BIT
4 - 4K BIT
5 - 8K BIT
L - 10K BIT
Y - 20K BIT
10 - 40K BIT (OL)

Buffered, Isolated, Gated and Stored BCD Outputs, Positive True. (BIGS-BCD)
SECTION 4
THEORY OF OPERATION

4.1 General

The Series 2000A/S Digital Panel Meter accepts a DC voltage at the input, where it is filtered and buffered and compared with a reference voltage by dual slope integration. The second integration time appears in a counter whose stored outputs are available for display and external use.

The inputs to the 400mv and 4v meters are connected directly to the input amplifier-filter. The 40v and 400v full scale meters are basic 4v meters with attenuators at the input. The current meters are basic 400mv full scale meters with a shunt dropping resistor across the input.

4.2 Circuit Description

Refer to the timing diagram (Figs. 4-1 and 4-3), the block diagram (Fig. 4-2), and schematics 04492 and 02811.

Assume the DFM to be connected for continuous readings at 20 readings per second (P1-Pin R to P1-Pin 19). Assume also that the signal at Pin R goes to 0v to start the cycle.

Q8 and Q9 of the Digital Board form a delay circuit that resets U27A approximately 15 msec. after U27A-Pin 9 goes high, producing a 15 msec. pulse each time U27A is triggered. This signal (RESET) resets the BCD counter to a count of 99990 and resets U27B to inhibit the one-shot formed by U22-Pins 3 and 11 (STROBE).

After 10 counts of the 1.8 MHz oscillator have occurred, the BCD Counter overflows to 00000 and continues counting.

At the overflow time, a pulse (SIG) is sent to the Analog Board which resets the 4 channel multiplexer counter, U7, switching the multiplexer to the reset condition.

The BCD counter continues to count until it reaches a count of 30000 and toggles U27B-Pin 12 to the true (REF) state. The edge of U27B-Pin 13 going low is sent to the Analog board, advancing the multiplexer to one of two reference signals. If the DFM input signal is a positive polarity signal, the output of level detector U3 is negative, enabling gate U6-Pin 6 and disabling U6-Pin 3.
This prevents U7B from being toggled when the multiplexer advance pulse comes, thus setting the multiplexer to the -REF condition. If a negative polarity signal had been applied to the DPM input, gates U6-Pin 6 and U6-Pin 3 would have reversed states and the multiplexer advance pulse would have set the multiplexer to the +REF condition.

When the integrator (U2) ramps back to zero, the level detector sends a pulse (COMP) back to the Digital board. This pulse triggers the one-shot formed by U22-Pins 11 and 3 which toggles the reset one-shot U27A again. This strobes the count contained in the BCD counter into the storage register before resetting the BCD counter to 99990 for the next cycle.

The reset pulse resets U27B which sends a pulse (SIG) to the Analog board which again sets the multiplexer to its reset condition.
BASIC TIMING DIAGRAM

Fig. 4-1

Digital Board
(P1-V) Measurement Enable (Input)

(P1-17)
Conversion Complete

SIGNAL INTEGRATION (E-8)

(U26-Pin 10)
NEG POLARITY (Nonstored)

(P1-14)
SERIAL OUTPUT

1.8 meg hz

(P1-S)
TRANSFER STROBE

⚠ Must be high for 10us and go low before the end of the TRANSFER STROBE PULSE.

⚠ This delay time depends on the resistance between P1-R and 19 can be set from 15ms to $\geq 3$ sec. Delay time (in milliseconds) = 15 + (Ext Resistance $\div$ K Ohms).

⚠ Serial Output shown is for a readout of 3 counts.

⚠ To inhibit readout from updating, TRANSFER INHIBIT (P1-18) must be Hi during all of TRANSFER STROBE TIME.
Read Generator Delay Time 16.7ms 0 to 22ms* ≥ 15ms

U7A-Pin 6 + REF
U7B-Pin 10 - REF

Reset Sig. Integ. Ref. Reset Integ.

* The reference integration time is proportional to the display value. At 20K counts this time is 11ms.
5.1 **General**

There are four rear-panel adjustments available for periodic calibration on the basic meter. These are the ZERO adjustment, the FULL SCALE adjustment, the BIAS adjustment, and the FS BALANCE adjustment.

All controls should be adjusted with an insulated screwdriver in accordance with the following instructions. Always allow at least 30 minutes warm-up time before making the adjustments.

![Diagram of calibration adjustment locations]

5.2 **Calibration - DC Meters**

Recommended interval 90 days.

5.2.1 **Test Equipment Required**

Variable voltage (or current) standard - accuracy .003% such as Fluke 343A.

5.2.2 **Set Up**

See checkout procedure in Section 2.2.
5.2.3 Calibration Adjustments

A. Zero

1. Set reading rate for 4 or 20 readings per second (P1-16 to P1-X or P1-19).

2. On meters with attenuators (i.e. 40v & 400v meters) R6 "BIAS" is set in the full clockwise direction. On other voltage meters adjust R6 for no change in readout when a parallel combination of a 1 Meg resistor and a 0.22 MFD capacitor are placed in series with the input leads.

3. Short input leads and adjust R12 "ZERO" for bouncing polarity sign.

B. Full Scale

1. Set the voltage (or current) standard to a value equal to negative 30000 on the readout (i.e. -3v on 4v meter) and adjust R19 "FULL SCALE" for the correct readout in the negative polarity.

2. Reverse the polarity of the signal and adjust R57 "FS BALANCE" if necessary for same positive display value.

5.3 Calibration - Ratio Meters

Recommended interval - 90 days.

5.3.1 Test Equipment Required

A. Variable voltage supply.

B. Decade voltage divider.

5.3.2 Set Up

Use checkout procedure in Section 2.2. Connect reference voltage to Pin 14 of P2.

[Diagram of circuit connection]
5.3.3 Calibration Adjustments

A. Zero

1. Set reading rate for 4 or 20 readings per second (P1-16 to P1-X or P1-19).

2. Connect a positive voltage supply equal to the normal ratio input (i.e. 10v for 10v external reference meter) to the decade divider input and ratio input (J2-14). Connect the signal leads to the decade divider output (signal common to divider common).

3. On meters with attenuators (i.e. 40v & 400v meters) R6 "BIAS" is set in the fully clockwise direction. On other voltage meters adjust R6 for minimum change in readout when a parallel combination of a 1 Meg resistor and a 0.22 MFD capacitor are placed in series with the input leads.

4. With signal directly to divider (zero volts) adjust R12 "ZERO" for bouncing polarity sign.

B. Full Scale

Set the decade divider to a ratio near full scale on the meter and note the readout value using the nominal reference voltage. Now lower the reference and decade divider voltage to one-half the nominal value and adjust R47 "FS BALANCE" for the same readout. Repeat until there is no change in the readout when the reference voltage is varied. Return the reference voltage to the nominal value and adjust R19 "FULL SCALE" for correct readout.

NOTE: If bipolar or negative signal operation is needed the ratio "Option Adjustment" should be adjusted first instead of R57, using a positive reference voltage and a negative signal voltage, then repeat step (B) using a positive signal and adjust R57.

5.4 Maintenance and Repair

Due to the complex operation of this instrument and special laboratory equipment needed to repair it, it is recommended that the instrument be returned to the factory if it is determined that repair is necessary. No attempt should be made to trouble-shoot the circuit cards in the field by untrained personnel.
Before returning this instrument to the factory every attempt should be made to determine that the instrument is actually at fault and that the trouble is not in the set up. The best way to determine this is by substituting a known working instrument. Alternately, the meter should be removed from the setup and tested by using a battery or power supply as an input source.

If the instrument is found to be at fault, please fill out the Returned Material Authorization and return it with the unit. The best way to insure that the defect will be quickly found and repaired is to include a diagram of the actual test conditions, so that the factory will be able to duplicate the failure easily.

If customer repair is to be undertaken, the following guide will assist in the tracing of a fault to a functional area of the meter.

Ground U26-Pin 3 on the digital board. If the display indicates a reading of + or - 40000 OL, the digital logic is operating properly and the trouble may be in the analog circuitry. In this condition, the digital board is generating all the signals necessary to check out the analog multiplexer, integrator, and comparator circuits.

If the above action indicates that the malfunction is on the analog board, check P2-Pin 3 for +6.3 VDC and P2-Pin 4 for -6.3 VDC and power supplies on the analog board. P2-Pin 10 should follow the input signal (considering a scale factor for other than 4v FS meter) if the input amplifier is operating properly.

Connect the digital and analog grounds together and sync an oscilloscope to the CONVERSION COMPLETE signal on J1-Pin 17. With an input signal near full scale look at the output of amplifier U2 (on the jumper R34), the wave form should be a 10v sawtooth with the polarity opposite that of the input signal. If this waveform is not correct, the trouble is in the analog multiplexer or integrator circuits. If this waveform is correct and the + and - indicators do not follow the input signal check the level detector output U3-Pin 6 (Top of R40), and the logic gates U6.

If grounding Pin 3 of U26 on the digital board does not cause a display of 40000 OL the trouble is on the digital board. Check the digital board power supplies and refer to the theory of operation and timing diagrams in Section 4.
5.5 Maintenance Calibration

The following calibration should be done every one or two years and whenever any components inside the case have been changed.

Attach input leads and power per initial checkout setup (Section 2.2). See drawings 04491 and 02810 for location of parts. Allow 5 minutes for warm-up.

1. Measure the positive 13 volt power supply at P2-Pin 6 for 12.8 to 13.2 volts. If necessary change the value of R72 on the analog board.

2. Measure the frequency of the oscillator on the digital board with a counter at Q16C. Adjust C22 for 1.8 MHz ±2 KHz on a standard 60 Hz meter, 1.5 MHz ±2 KHz for a meter operating on 50 Hz power (Option C1), and 2 MHz ±2 KHz for a meter operating on 400 Hz power.

3. Adjust R12 (ZERO) to its electrical center.
   Short the input leads and note the display value.
   Jumper the top of R29 (Analog board) to circuit ground (P2-Pin 8). If the display changes by more than 10 counts, adjust R49 (integrator zero).
   Remove the jumper and adjust R10 for bouncing polarity sign.

4. Apply a positive signal near full scale (3.5 volts on a 4 volt meter) and note the display value when the meter is reading at 4 readings per second (J1-16 to J1-X). Change the read rate to 20 per second (J1-16 to J1-19) and if the display is not within 1 count, adjust R47 (high speed linearity).

5. Assemble the meter with shields and install in its case. Allow 1 hour to warm up before proceeding.

6. Apply an input signal to produce 10.5 counts (i.e. 1.05mV on a 4V meter) and note the display value, reverse the polarity of the input signal and adjust R12 until the display reads the same in both polarities. If the display is not bouncing between 10 and 11 adjust R37 (ZERO WIDTH) by sliding the meter out of the case. Turn off the power before replacing the meter, then recheck both polarities at 10.5 counts.

7. Assemble the meter completely and calibrate using the procedure in Section 5.