203A
DIGITAL PANEL METER

04979-01

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1.0 DESCRIPTION

1.1 GENERAL

Newport Model 203A Digital Panel Voltmeter is a low-cost, reliable instrument for digital display of analog bipolar voltages. The display is 1999 counts on any of four ranges from 199.9 mV to 199.9 V.

The Model 203A DPVM is a line-powered meter with 14 mm high, 7-segment LED readout. The housing is a break-resistant black phenylene oxide case. Full-scale adjustment is easily accessible with the front lens removed.

Accuracy at the low end of each range is not degraded by normal mode noise because the Model 203A performs true-bipolar signal integration around zero. Many competitive meters rectify the signal before integration which erroneously adds the absolute value of the normal mode noise to the signal reading. The Model 203A average-value circuit provides full normal-mode and superior AC line-transient noise rejection at signal levels from zero to full scale.

Ratio measurements are possible with the Model 203A without modifications or external logic. The configuration is 3-wire (common ground) and the reference must be within a specified voltage range.

Data output lines are parallel BCD, compatible with TTL and DTL. External control signals are also TTL and DTL compatible and increase the flexibility and ease of interfacing the Model 203A with other instruments.

1.2 SPECIFICATIONS

1.2.1 Input

<table>
<thead>
<tr>
<th>Model</th>
<th>203A-2</th>
<th>203A-3</th>
<th>203A-4</th>
<th>203A-5</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>0.2</td>
<td>2</td>
<td>20</td>
<td>200</td>
<td>V</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.1</td>
<td>1</td>
<td>10</td>
<td>100</td>
<td>mV</td>
</tr>
<tr>
<td>Overdrive Protection</td>
<td>100</td>
<td>100</td>
<td>250</td>
<td>250</td>
<td>V</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>1000</td>
<td>1000</td>
<td>1.1</td>
<td>1</td>
<td>MΩ</td>
</tr>
<tr>
<td>Input Bias Current</td>
<td>2</td>
<td>2</td>
<td>0.2</td>
<td>0.02</td>
<td>nA</td>
</tr>
<tr>
<td>Reading Tempco (Typ)</td>
<td>±0.01%</td>
<td></td>
<td></td>
<td></td>
<td>%R/ºC</td>
</tr>
<tr>
<td>Zero Noise Digits (Typ)</td>
<td>0.1</td>
<td>0.1</td>
<td></td>
<td></td>
<td>P-P Counts</td>
</tr>
<tr>
<td>Full Scale Noise Digits (Typ)</td>
<td>0.3</td>
<td>0.2</td>
<td></td>
<td></td>
<td>P-P Counts</td>
</tr>
<tr>
<td>Non-linearity</td>
<td>&lt;1.5</td>
<td>&lt;1</td>
<td></td>
<td></td>
<td>Counts</td>
</tr>
<tr>
<td>External Reference Voltage</td>
<td>+0.5 → +.4</td>
<td>+0.5 → +2.00</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio Accuracy</td>
<td>99.9±.1</td>
<td></td>
<td></td>
<td></td>
<td>%R</td>
</tr>
<tr>
<td>Ratio Linearity</td>
<td>±0.1</td>
<td></td>
<td></td>
<td></td>
<td>%R</td>
</tr>
<tr>
<td>Ext Ref Input Resistance</td>
<td>430</td>
<td>4.3 k</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
</tbody>
</table>

(1) A higher resistance is available with the HZ option.
1.2.2 Accuracy at 25°C

- Total error: ±0.05% reading ±1.5 counts
- Offset tempco: 10 µV/°C
- Warmup time: < 1 minute

1.2.3 Conversion

- Technique: Dual slope, average value
- Signal integration period: 3.3 milliseconds
- Read rate: 4/second, 0-4/second with external control
- Polarity: Automatic

1.2.4 Input Characteristics

- Type: Single-ended (analog ground common to signal low)
- Settling time: 2 readings (Asynchronous Input Step)
- NMR: 20 dB at 50 or 60 Hz
- CMR: 100 dB at 50 or 60 Hz
- Zero: Automatic
- Ratio measurement: 3-wire

1.2.5 Calibration Controls

- Full scale adjust (R25): 1 turn, accessible behind front lens; ±3.1%, 2.1%/count at full scale

1.2.6 Display

- Type: 14 mm
- Symbols: -1.888
- Decimal points: Three (to the left of the three LSDs)
- Overload indicator: Display flashes
- Color: Red filter
- Polarity sign: Minus

### DIGITAL I/O DRIVE REQUIREMENTS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LOGICAL '0'</th>
<th>LOGICAL '1'</th>
<th>I SINK</th>
<th>I SOURCE</th>
<th>INPUT</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel BCD</td>
<td>0 - .4 V</td>
<td>2.4 - 5.0 V</td>
<td>4.8 mA</td>
<td>.4 mA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>+ POLARITY</td>
<td>0 - .4 V</td>
<td>2.4 - 5.0 V</td>
<td>16 mA</td>
<td>.4 mA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>HOLD</td>
<td>0 - .6 V</td>
<td>2.0 - 5.0 V</td>
<td>.04 mA</td>
<td>1.2 mA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DATA READY</td>
<td>0 - .4 V</td>
<td>2.4 - 5.0 V</td>
<td>16 mA</td>
<td>.8 mA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Overload</td>
<td>0 - .4 V</td>
<td>2.4 - 5.0 V</td>
<td>14.4 mA</td>
<td>.4 mA</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
1.2.8 AC Power

Input Voltage 115 V ac ±10%
Frequency Range 47 to 63 Hz
Input Power 3.5W (4W max)
Optional Input Voltages
C1 - 230 V ac, ±10%, 50/60 Hz
C5 - 100 V ac, ±10%, 50/60 Hz
C8 - 24 V ac, ±10%, 50/60 Hz
C3 - 5 V dc, ±5%
Output Voltage +4.9 V ±.25 V @ 50 mA (mutually exclusive with all upper board options)

1.2.9 General

Operating Temp. 0°C to 50°C
Storage Temp. -40°C to 75°C
Humidity Up to 95% non-condensing at ≤40°C
Weight 480g
Case Material Black Phenylene Oxide
Case Size - DIN 1A
Bezel(WxHxT) 96x48x6 mm (3.78x1.89x0.24in)
Depth Behind Bezel w/Conn. 135.4 mm (5.33in)
Panel Cutout 92x45 mm (3.62x1.77in)
Case Size - NEMA (Optional)
Bezel 104x48x19 mm (4.09x1.88x0.75in)
Depth Behind Bezel w/Conn. 125 mm (4.91in)
Panel Cutout 99.6x42.9 mm (3.92x1.69in)
2.0 RECEIVING AND INSTALLATION

2.1 UNPACKING AND INSPECTION

Your Model 203A was fully inspected and tested, then carefully packed before shipment. Unpack the meter carefully and inspect it for obvious shipping damage.

2.2 INITIAL CHECKOUT PROCEDURE

CAUTION

Meters are internally connected for 24, 100, 115, or 230 V ac or 5 V dc power. Check label on meter for proper supply voltage.

2.2.1 Required Equipment

(1) Appropriate power source (4 watts) as indicated by the label.

(2) Calibrated voltage source.

2.2.2 Test Procedure (Refer to Figure 2-1)

(1) Connect signal as follows:
- SIGNAL IN to Pin 17.
- ANALOG GND IN to Pin 16.

(2) Connect power as follows:
- AC HI to Pin A.
- AC LO to Pin 2.
- AC GND to Pin C.

(3) Verify that a key is between Pins 3 and 4.

(4) Pins 1, 3 and B must be removed from connector.

(5) Apply power and check that the meter reads correctly for its specified range.

Figure 2-1 Power and Signal Input Connections
2.3 MECHANICAL INSTRUCTIONS

DIN IA

The drawing number 06896 illustrates the mounting method for your panel volt meter. The unit is inserted from the front of the panel and held in place by two extrusions. The panel thickness may be between .8 mm (.03") and 6.4 mm (.25").

NEMA (Optional)

The drawing number 05169 illustrates the mounting method for your panel volt meter. The unit is inserted from the front of the panel and held in place by a "U" bracket. The panel thickness may be between .75 mm (.03") and 6.35 mm (.25").

Figure 2-2 Rear View of Unit
### 3.0 OPERATING INSTRUCTIONS

#### 3.1 PIN ASSIGNMENTS

<table>
<thead>
<tr>
<th>PIN</th>
<th>NAME</th>
<th>PIN</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Connection</td>
<td>A</td>
<td>AC HI</td>
</tr>
<tr>
<td>2</td>
<td>AC LO</td>
<td>B</td>
<td>No Connection</td>
</tr>
<tr>
<td>3</td>
<td>No Connection</td>
<td>C</td>
<td>AC GND</td>
</tr>
<tr>
<td>4</td>
<td>1.XXX (DP1)</td>
<td>D</td>
<td>BCD 1</td>
</tr>
<tr>
<td>5</td>
<td>1X.XX (DP2)</td>
<td>E</td>
<td>BCD 2</td>
</tr>
<tr>
<td>6</td>
<td>1XX.X (DP3)</td>
<td>F</td>
<td>BCD 4</td>
</tr>
<tr>
<td>7</td>
<td>No Connection</td>
<td>H</td>
<td>BCD 8</td>
</tr>
<tr>
<td>8</td>
<td>BCD 80</td>
<td>J</td>
<td>BCD 100</td>
</tr>
<tr>
<td>9</td>
<td>BCD 40</td>
<td>K</td>
<td>BCD 200</td>
</tr>
<tr>
<td>10</td>
<td>BCD 20</td>
<td>L</td>
<td>BCD 400</td>
</tr>
<tr>
<td>11</td>
<td>BCD 10</td>
<td>M</td>
<td>BCD 800</td>
</tr>
<tr>
<td>12</td>
<td>BCD 1 k</td>
<td>N</td>
<td>+ POLARITY</td>
</tr>
<tr>
<td>13</td>
<td>BCD 2 k (Overload)</td>
<td>P</td>
<td>DATA READY</td>
</tr>
<tr>
<td>14</td>
<td>Spare</td>
<td>R</td>
<td>HOLD</td>
</tr>
<tr>
<td>15</td>
<td>+4.9 V (50 mA max)</td>
<td>S</td>
<td>Spare</td>
</tr>
<tr>
<td>16</td>
<td>ANALOG GND IN</td>
<td>T</td>
<td>DIGITAL GND</td>
</tr>
<tr>
<td>17</td>
<td>SIGNAL IN</td>
<td>U</td>
<td>No Connection</td>
</tr>
<tr>
<td>18</td>
<td>No Connection</td>
<td>V</td>
<td>REFERENCE HI IN</td>
</tr>
</tbody>
</table>

Connector Type

- SAE
- ELCO

*SCC18D/1-2*

Figure 3-1 Rear View of Connector Pin Orientation

*Pins 1, 3 & B must be removed.*
3.2 POWER

3.2.1 Input Voltage

The standard meter operates from 115 V ±10%, 50/60 Hz. It consumes about 3.5 watts. A three-wire connection should be used to connect power to the meter. Two conductors provide power and the third provides a ground for noise rejection.

3.2.2 Input Voltage Change

To change the input voltage requirements of the meter from 115 V to 230 V, in the field, the following procedure should be used:

(1) Remove power lines from the meter and remove the meter from the case.
(2) Remove jumpers W1 and W2 located on the transformer (see Figure 3-2).
(3) Add jumper W3 on the printed circuit board. The meter is now wired for 230 V.

![Figure 3-2 Jumper Locations](image)

If other input voltages are required, contact the factory.

3.2.3 Output Voltage

The ±4.9 V output is a regulated supply with the voltage range 4.9 V ±0.25 V. A maximum current of 50 mA is available for external use.
Below is an assembly diagram identifying the location of resistors which can be changed to modify the power ranges as discussed in Section 3.3.2.

Figure 3-3  Modification Points
3.3 SIGNAL INPUT

3.3.1 Signal

For best results, shielded, twisted cable should be used for the input signal, with the shield terminated to ANALOG GND IN (Pin 16) at the connector.

Analog Ground and Digital Ground are internally connected and should not be connected externally. If the meter has a noisy input signal, the input filter time constant may be lengthened for better noise rejection. For the 200 mV and 2 V ranges, a 47 kOhm resistor in series with SIGNAL IN (Pin 17) will provide 6 dB more rejection. The sum of the series resistor and the source impedance should be no greater than 100 kOhms. Some zero offset due to bias current may be observed on the 200 mV range.

3.3.2 Range Change

The standard meter is a 203A-2. To change from ±199.9 mV to ±1.999 V full scale, use Procedure A; from ±199.9 mV to ±19.99 V full scale, use Procedure B; from ±199.9 V full scale, use Procedure C.

### Procedure A: ±199.9 mV to ±1.999 V

1. Remove R14 and R20.
2. Recalibrate the meter. The meter is now ±1.999 V full scale.

### Procedure B: ±199.9 mV to ±19.99 V

1. Remove R14 and R20.
2. Replace R4 with Newport Part 8291004, 1 megohm, ±1%, 1/2 W, metal film resistor.
4. Recalibrate the meter for ±19.99 V full scale.

### Procedure C: ±199.9 mV to 199.9 V

1. Remove R14 and R20.
2. Replace R4 with Newport Part 8291004, 1 megohm, ±1%, 1/2 W, metal film resistor.
3. Install R3 Newport Part 8211002, 10 k, ±1%, 1/8 W, metal film resistor.
4. Recalibrate the meter for ±199.9 V full scale.

When changing any range, the span of the full scale pot may not be sufficient to recalibrate the meter. In this event, R21 (511 k ±1% metal film P/N 8215113) must be clipped out or soldered into the circuit board. If the meter reads too high, R21 must be soldered in. If the meter reads too low, R21 must be removed.
3.3.3 Ground Precautions

It is essential that the ground connections to the Model 203A be proper for accurate readings. The input stage is single-ended and analog ground is internally connected to digital ground through a low internal resistance.

![Diagram of internal grounds](image)

**Figure 3-4 Internal Grounds**

The contact resistances resulting from the connection between the connector and the printed circuit board are shown as lumped resistors, \( RC_{17} \), \( RC_{16} \), and \( RC_T \). The internal resistance between the analog and digital grounds is shown as \( R_I \).

**CORRECT GROUNDING**

The correct grounding method is to connect the low side of the signal to ANALOG GND IN and the common for the digital outputs to DIGITAL GROUND. This allows the digital current to flow only through \( RC_T \), causing a voltage drop on the digital line only. There will be no voltage drop across \( RC_{16} \) or \( R_I \) and the meter will read the signal correctly. There will exist a small voltage difference between Pin 16 and Pin T.

**INCORRECT GROUNDING**

An improper ground connection is to use a single ground pin for both analog and digital ground. When this is done, the return current for the digital outputs flows through either \( RC_{16} \) or \( RC_T \). This causes a voltage drop in series with the input signal and the meter reading will be incorrect. An improper system ground connection for the Model 203A is to tie the two ground connections together at the source. This creates a ground loop and the voltage drop across \( RC_T \) appears across \( RC_{16} \) and \( R_I \) simultaneously. This presents an erroneous reading as in the previous case with a single tie point at the connector.
3.4 RATIO

The reference input allows an external voltage to be used as the reference source for conversion. In this mode, the meter reads the ratio of the signal voltage to the reference voltage rather than the true value of the input.

\[
\text{Reading in Counts} = 1000 \times \frac{\text{Signal voltage}}{\text{Reference voltage}}
\]

On the 20 V and 200 V ranges, the reference voltage must be scaled by 1/10 or 1/100, respectively. The reference input impedance for the 200 mV range is about 430 ohms. For the 2 V, 20 V, and 200 V ranges, the impedance is 4.3 kOhms. The reference voltage must be between the limits specified and must be positive with respect to signal low.

3.5 DIGITAL SIGNALS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>LOGICAL '0'</th>
<th>LOGICAL '1'</th>
<th>I SINK</th>
<th>I SOURCE</th>
<th>INPUT</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel BCD</td>
<td>0 - .4 V</td>
<td>2.4 - 5.0 V</td>
<td>4.8 mA</td>
<td>.4 mA</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>+ POLARITY</td>
<td>0 - .4 V</td>
<td>2.4 - 5.0 V</td>
<td>16 mA</td>
<td>.4 mA</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>HOLD</td>
<td>0 - .6 V</td>
<td>2.0 - 5.0 V</td>
<td>.04 mA</td>
<td>1.2 mA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DATA READY</td>
<td>0 - .4 V</td>
<td>2.4 - 5.0 V</td>
<td>16 mA</td>
<td>.8 mA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Overload</td>
<td>0 - .4 V</td>
<td>2.4 - 5.0 V</td>
<td>14.4 mA</td>
<td>.4 mA</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

DIGITAL I/O DRIVE REQUIREMENTS

3.5.1 Parallel BCD Outputs

The data outputs are parallel BCD and are TTL and DTL compatible. The outputs are stable and valid while DATA READY (Pin P) is low.

3.5.2 + POLARITY (Pin N)

The + Polarity output is a logical '1' when the meter indicates a positive reading.

3.5.3 HOLD (Pin R)

When a logical '0' is applied to the HOLD input, the meter will finish the conversion cycle it is on and will hold that reading. If it is applied before the beginning of a conversion, the meter will not start that conversion. Upon a logical '1' at the HOLD input, a new conversion will begin within 250 milliseconds.
3.5.4 **DATA READY (Pin P)**

DATA READY will go to a logical '0' at the end of a conversion cycle and to logical '1' at the beginning of a conversion cycle.

3.5.5 **Overload (Pin 13)**

Overload is the parallel BCD 2 k bit. Overload will go to a logical '1' if the display is greater than 1999. It is stable while DATA READY is low.

3.6 **DECIMAL POINTS**

Any of the three decimal points to the left of the three least significant digits can be lighted.

<table>
<thead>
<tr>
<th>DECIMAL POINT</th>
<th>GROUND P1 PIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.XXX (DP1)</td>
<td>4</td>
</tr>
<tr>
<td>1X.XXX (DP2)</td>
<td>5</td>
</tr>
<tr>
<td>1XX.XX (DP3)</td>
<td>6</td>
</tr>
</tbody>
</table>

Decimal Point Configuration

Decimal points are lit by grounding the appropriate pin (to J1-Pin T). If a pin is grounded, the grounding device must be capable of sinking 15 mA.
4.0 THEORY OF OPERATION

The Model 203A Panel Voltmeter uses the dual slope method of conversion. Many state-of-the-art panel meters use dual slope conversion, but the Model 203A includes automatic zeroing before each reading and does so with a minimum of parts for increased reliability.

At the beginning of a conversion, the voltage across C is zero. The signal is then applied to the integrator and the voltage across C rises by the formula:

\[ V_{\text{capacitor}} = V_{\text{in}} \times \frac{\text{time (sec)}}{RC} \]

At the end of a fixed period of 1000 counts, the counters are reset to 0000. The signal input is turned off and a stable reference voltage of the opposite polarity is now applied to the input. Since the reference voltage is constant, the slope, in volts/sec, during this second period is constant and independent of input signal levels. The time required to discharge the capacitor back to zero volts is then proportional to the signal voltage.

Note: Capacitor voltage is equal to \( e_2 - e_1 \)
Figure 4-2 Voltage Wave Forms at e1 and e2

After the clock is stopped by the capacitor voltage reaching zero, a third period allows the circuit to zero the integrator and comparator for the next reading.

The readings are synchronized to the AC power since the read-rate generator is clocked by the AC line frequency. A '0' on the HOLD input prevents the read-rate generator from clocking.
5.0 ADJUSTMENT AND CALIBRATION

The Model 203A was calibrated at the factory with a precision voltage source. Frequent calibration is not necessary due to the stability and internal accuracy of the meter. If recalibration is necessary, use the following procedure:

5.1 Plug the Model 203A to be tested into an appropriate test cable. Turn on the power and adjust for 115 V ac or 230 V ac as required.

5.2 Apply an input signal equal to +1900.5 and slowly adjust R25 (full scale: 500 ohm) until the display is bouncing between 1900 and 1901.

5.3 Using the voltage source, check linearity at 10, 100, 500, 1000, 1500 and 1990 counts. Verify that linearity is not worse than 1 count throughout this range in both polarities.

NOTE: This test requires the effects of zero offset and full scale turnover to be taken into account.

5.4 Using the voltage source, observe the DPM readout.

1. Check all numbers for proper decoding.

2. Check for Dim/Dead/Bright segments.

3. Check individual displays for the same relative intensity/illumination.

4. Check minus polarity sign.
Figure 6-1 Assembly Diagram PCBAD, 203A, DPVM
Figure 6-3 Schematic Diagram, 3 1/2 DPVM, (LED)
Figure 6-5 Outline and Mounting - NEMA