DESCRIPTION

The Model Series 380GD Deviation Amplifier Module provides an output current that is proportional to the difference between its two input voltages. It incorporates an adjustable gain amplifier that can scale the difference signal by a factor of 0.1 to 100. An internal bias, adjustable from 0 to ±5 Volts, can be used to offset the deviation base to any point in the output range.

The Module is designed to be plugged into a Model Series 380 Card Cage Enclosure equipped with a common power supply (see Service Instruction SD3801).

A simplified schematic of the complete Module is shown in Figure 1. Standard 1 to +5V input signals, $V_A$ and $V_B$, are each buffered by IC1B and IC1A, respectively, and are then applied to differential amplifier IC1D. The resulting deviation signal ($V_D = V_A - V_B$) appearing at IC1D output, is led to the input of adjustable gain amplifier IC2D, and is also made available at test point TP-DEV and at card cage terminal 9. Amplifier IC2D is equipped with an input potentiometer (R14) and a three position range selector jumper. When the jumper plug is in the X1 position, the potentiometer can set a gain of 0.1 to 1.0. With the jumper plug in the X10 and X100 positions, the potentiometer's gain settings are appropriately multiplied. The scaled deviation signal ($G_{IC2D}V_D$), which should not exceed ±4 Volts, is brought out to test point TP-GAIN and is also applied to summing amplifier IC2A. Here it is summed with a buffered internal or external 0 to ±5 Volt bias ($V_C$) to provide the required amount of offset.

![Simplified Schematic](image-url)

**FIGURE 1** Simplified Schematic

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to the duty cycle (when \( V_{DEVI} = 0 \)). The offset deviation signal \((G_0 V_{DEVI} + V_B)\) is then fed to the output section where it is converted to a proportional output current \(I_O\). An output range of 4 to 20 mA or 10 to 50 mA can be selected by means of jumper wire J1 located on the solder side of the P.C. board.

The selection of internal or external bias and the polarity of the internal bias voltage is made by means of jumper plugs situated on the component side of the P.C. board.

An adjustable (0 to +6 Volt) setpoint voltage is available at terminal 6 of the card cage.

All inputs and outputs, including the bias and setpoint signals, are referenced to one common which is also the power supply common serving all the other plug-in modules in the card cage.

Current input signals are accommodated by placing precision resistors across the input terminals in the card cage enclosure. This permits removal of the Module without interrupting the input current loop.

The Deviation Amplifier Module can be used as a "proportional only" controller by connecting the internal setpoint to one of the inputs and a process variable signal to the other. For direct action the process variable must be applied to input A and the setpoint to B. Reverse these connections to obtain inverse controller action.

The following equation defines the input/output relationship of this module.

\[
I_O = \frac{1}{R_O} \left[ G_O (V_A - V_B) + V_C \right]
\]

Where,

- \( I_O \) = Output Current (4-20 mA or 10-50 mA)
- \( R_O \) = Voltage to Current Transfer Constant
- \( G_O \) = Amplifier Gain (0.1 to 100)
- \( V_A \) = Input A (1 to 5 Volts)
- \( V_B \) = Input B (1 to 5 Volts)
- \( V_C \) = Bias (0 to ±5 Volts), internal or from an external source

All \( I_O \) computations must have a zero or positive result, negative results will not appear in the output.

For exact adjustment parameters and operating limitations refer to the SPECIFICATIONS section.

**MODEL DESIGNATION**

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Function Module Description: 380 GD 1

Gain and Bias Adj. Configuration:

- \( G_0 \) Blind gain and bias adj. (uses 22-turn trimpots)
- \( G_0 \) Graduated gain and bias adj. (uses single-turn pots with graduated diads)

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**SPECIFICATIONS**

**INPUTS (\( V_A, V_B \))**

- **Range:** 1 to +5 Volts
- **Impedance:** 5 Megohms (Min.)
- **Overload:** ±30 Volts (Max.)
- **Gain \((G_0)\):**
  - 3 Ranges:
    - X1: 0.1 to 1.0
    - X10: 1.0 to 10
    - X100: 10 to 100

**BIAS \((V_C)\)**

- **Internal Source:**
  - 2 Ranges:
    - 0 to +5 Volts
    - 0 to -5 Volts
- **External:** ±5 Volts (Max.)
- **External Input Impedance:** 5 Megohms (min.)

**OUTPUT \( I_O \)**

**Load Effect:** Less than ±0.1% within the allowable load range.

**Current Limiting:** Output will not exceed 150% of full scale when input is overdriven.

**Accuracy:** ±0.25% of output span

**Response Time:** 150 msec (Max.) to reach 98% of output span. (For step change in input)

**VOLTAGE TO CURRENT TRANSFER CONSTANT:**

- 0.250 (for 16 mA output span)
- 0.100 (for 40 mA output span)

**DEVATION OUTPUT \((V_{DEVI})\):**

- 0 to ±4 Volts (Max.)

**Output Impedance:** 100 Ohms

**Load Current**

- 1.0 mA (Max.) @ 4 Vdc

**SETPOINT OUTPUT**

- 0 to +6 Volts

- Load Current: 100 uA (Max.)

**AMBIENT TEMP.:** 32°F to 122°F (0-50°C)

**TEMPERATURE EFFECT:**

Input/Output transfer function changes less than 0.008%/°F

Setpoint and internal bias change less than ±0.004%/°F

**ELECTRICAL ISOLATION:** All inputs and outputs are referenced to same common.
INSTALLATION

The Deviation Amplifier Module must be installed in a Model Series 380 Card Cage Enclosure. It can be plugged into any of the slots in the enclosure. Refer to customer drawings for the designated slot or assign a convenient slot for it.

WARNING

Remove all power on signal and power supply wires before making any connections or setting the safety keys in the card cage enclosure.

The safety keys in the card cage enclosure must be set before the module can be plugged in. Service Instruction SD3801 identifies those safety keys and gives the procedure for setting them. The positions of the keys for the Deviation Amplifier Module are as follows:

Left Key: V (Vertical)
Right Key: V (Vertical)

The input and output connections are made to the terminal strips provided at the front or the rear of the card cage enclosure (depending on model). Each terminal strip is identified by a number that matches a corresponding slot number. Refer to the Connection Diagram (Figure 2) in this instruction and to Service Instruction SD3801.

NOTE

All the plug-in modules in the card cage share the same SIGNAL COMMON bus line due to their common power supply. Be careful when connecting various signal lines to avoid possible ground loops or shorts.

To use the Module as a proportional controller with direct action, connect the Setpoint Output (terminal 6) to input B (terminal 2) and the process variable signal to input A (terminal 1). To obtain reverse controller action, the Setpoint (terminal 6) is connected to input A (terminal 1) and the process variable to input B (terminal 2).

If external bias is required, connect it to terminals 7 (+) and 8 (−), and be sure to place jumper plug J3 in position E (see Figure 3).

The deviation signal (V_{dc}) is available at terminals 9 (+) and 8 (−). This signal is not buffered, so be sure to comply with its loading restriction given in the SPECIFICATIONS section.

To convert a current signal to a voltage signal, select an appropriate conditioning resistor listed below, and connect it across the required input or output terminals.

<table>
<thead>
<tr>
<th>Current Signal</th>
<th>Conditioning Resistor (to obtain 1 to 5 Volts)</th>
<th>MPCo. Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 5 mA</td>
<td>1000 Ohms ± 0.1%</td>
<td>15037-228</td>
</tr>
<tr>
<td>4 to 20 mA</td>
<td>250 Ohms ± 0.1%</td>
<td>15037-229</td>
</tr>
<tr>
<td>10 to 50 mA</td>
<td>100 Ohms ± 0.1%</td>
<td>15037-230</td>
</tr>
</tbody>
</table>

When connecting several conditioning resistors in series in a current loop, make sure the total loop resistance does not exceed the permissible load resistance of the source. Also, watch out for inadvertently connecting several resistors in parallel.

TERMINAL STRIPS ON SERIES 3800 RACK ENCLOSURES

1. + INPUT A (NOTE 1 & 2)
2. + INPUT B
3. − COMMON
4. + OUTPUT
5. R_{i} (NOTE 3)
6. −
7. + SETPOINT OUTPUT (NOTE 4)
8. + INPUT C (NOTE 1 & 2)
9. − COMMON
10. + DEVIATION OUTPUT (NOTE 4)

FIGURE 2 Connection Diagram
CALIBRATION

GENERAL

The Deviation Amplifier Module is normally ordered calibrated for a specific application. Such a module requires no additional adjustment, and can be put immediately into service. It is accompanied by a calibration drawing containing the required hook-up diagram and the calibration equation. The data given in the calibration equation is needed for future calibration checks.

Modules ordered without a specific application request, must be calibrated by the user at a later time.

Before any module can be calibrated, it is necessary to produce a calibration equation that will establish the operating parameter of the module. Refer to the CALIBRATION EQUATION section for a general discussion of this procedure.

Modules provided with individual calibration equations can be calibrated by referring to the REQUIRED DATA and subsequent sections.

To assure continued accuracy, it is recommended that modules be calibrated at regular intervals dictated by the severity of the operation environment or whenever an inaccuracy is suspected.

CALIBRATION EQUATION

The calibration equation establishes the module’s operating parameter for a specific application. Shown below is a slightly rearranged form of the basic calibration equation appearing in the DESCRIPTION section.

\[ I_0 = \frac{G_0 V_{DEVP}}{R_0} + \frac{V_C}{R_0} \]  
(1)

It shows that the output current \( I_0 \) is determined by the sum of two separate components of the equation.

If the second component of the equation is made to equal zero by setting bias to zero \( (V_C = 0) \), then the output current \( I_0 \) becomes solely determined by the first component of the equation:

\[ I_0 = \frac{G_0 V_{DEVP}}{R_0} \]  
(2)

The SPECIFICATIONS section indicates that for a 16 mA output span, the voltage to current transfer constant \( (R_0) \) must be 0.25. To obtain a 40 mA output span, \( R_0 \) must equal 0.10.

The first component of the equation deals with the gain-deviation voltage \( (G_0 V_{DEVP}) \). A gain-deviation signal of 4.0 Volts will produce full-scale output currents, when appropriate \( R_0 \) values are selected:

\[ \begin{align*}
16 \text{ mA} &= \frac{4.0\text{ V}}{0.25} \quad \text{(See Equation 2)} \\
40 \text{ mA} &= \frac{4.0\text{ V}}{0.10} \quad \text{(See Equation 2)}
\end{align*} \]

The second component of the equation is typically used to provide an offset to the gain-deviation output signal.

If, for example, the \( V_{DEVP} \) is set to + 1.0V, it will add a 4 mA offset when \( R_0 = 0.25 \), and a 10 mA offset when \( R_0 = 0.10 \).

Thus, if a 1.0 Volt bias is added to the gain-deviation signal of 4.0 Volts, the current output \( I_0 \) becomes:

\[ \begin{align*}
20 \text{ mA} &= \frac{4.0\text{ V}}{0.25} + \frac{1.0\text{ V}}{0.25} \\&= \text{(See Equation 1)} \\
50 \text{ mA} &= \frac{4.0\text{ V}}{0.10} + \frac{1.0\text{ V}}{0.10} \\&= \text{(See Equation 1)}
\end{align*} \]

And, if the first component of the equation becomes zero \((G_0 = 0 \text{ and/or } V_{DEVP} = 0)\), the bias voltage \( V_C \) alone is converted to the output current \( I_0 \). Thus, with \( V_C = 1.0V \), the output will drop to:

\[ \begin{align*}
4 \text{ mA} &= \frac{1.0\text{ V}}{0.25} \quad \text{(See Equation 1, where } G_0 V_{DEVP} = 0) \\
10 \text{ mA} &= \frac{1.0\text{ V}}{0.10} \quad \text{(See Equation 1, where } G_0 V_{DEVP} = 0)
\end{align*} \]

In the above example, the 1.0 Volt bias \( (V_C) \), combined with the 4.0 Volt span of the gain-deviation signal \((G_0 V_{DEVP})\), served to produce the required 4-20 mA or 10-50 mA output current \( I_0 \).

In other applications, it may be desirable to output a deviation signal that can be positive or negative. To accomplish this, the bias \( (V_C) \) is set to \pm 3.0 Volts. This brings the output current to the middle of its span (12 mA or 30 mA) when deviation \((V_{DEVP})\) is at zero. Then, as the deviation increases to \pm 2.0 Volts, the current output rises to full scale (20 mA or 50 mA).

Similarly, as the deviation reverses polarity and drops to \pm 20 Volts, the current output falls to zero scale (4 mA or 10 mA).

REQUIRED DATA

To properly calibrate the module, the following information must be retrieved from the calibration equation:

1. Output current span \( I_0 \).
2. Gain level \( (G_0) \).
3. Bias polarity and level \( (\pm V_C) \).

If the OUTPUT CURRENT span is not indicated directly, it can be determined by the value of the voltage to current transfer constant \( R_0 \). This relationship is shown below.

\[ \begin{align*}
R_0 &= 0.25 & I_0 (\text{Span}) &= 16 \text{ mA} \\
R_0 &= 0.10 & I_0 (\text{Span}) &= 40 \text{ mA}
\end{align*} \]

Note that the shown output current spans will be typically offset by a 1.0 Volt bias\( / R_0 \) factor to produce the standard 4 to 20 mA and 10 to 50 mA output ranges, respectively.
The GAIN level \( G_0 \) appears in the calibration equation directly. It may be any whole number and/or fraction ranging from less than 0.1 to 100.

If the required gain is given as a proportional band (PB), it can be converted by the following formula.

\[ G_0 = 100 \]

\[ \text{PB} \]

The module has an equivalent proportional band range of 1 to 1000%.

Although the gain may be set directly on modules equipped with calibrated dials, for high accuracy, all modules should be calibrated by means of a digital voltmeter and an external precision voltage source.

Such a calibration procedure requires generation of a specific deviation voltage \( V_{\text{DEVI}} \) to appear at test point TP—DEV. The module’s gain potentiometer can then be adjusted to produce exactly 4.000 Volts at test point TP—GAIN. To determine the needed deviation voltage \( V_{\text{DEVI}} \), divide 4.000 by the required gain factor \( G_0 \).

The BIAS polarity and level \( (+V_C) \) is shown in the calibration equation directly. It is adjusted by reading the output current. For this reason, its voltage level must be converted to the equivalent output current by means of the prescribed \( R_0 \) value.

For example, with \( V_{\text{DEVI}} = 0 \) and \( R_0 = 0.25 \), a +1.0 Volt bias would appear at the output as 4.0 mA.

If the bias adjustment is made in the presence of a deviation signal, it will be necessary to add the effect of the deviation signal to the output current reading. For example, with \( V_{\text{DEVI}} = 0.4 \) Volts, \( G_0 = 10 \), \( V_C = 1.0 \) Volt, and \( R_0 = 0.25 \), the output current should be exactly 20 mA.

An external bias source, if specified, may be adjusted to a fixed level in the same manner as discussed above. In this instance, jumper plug J3 must be placed in position E, however, no other bias adjustments would be necessary on the module.

**REQUIRED EQUIPMENT**

The following equipment is required to properly check and calibrate the Deviation Amplifier Module:

1. Model Series 380 Card Cage with power supply.

2. Adjustable Signal Source(s). The following devices may serve as signal sources:
   a. Voltage Source - typically 0 to 5 Vdc
   b. Current Source - typically 0 to 50 mA dc
   c. Transmitter - adjustable over required range

   These devices must be adjustable to an accuracy of 0.10%.

3. Digital Voltmeter . . . Range: 0 to 5 Volts dc
   Accuracy: ± 0.05%
   Impedance: 10 Megohms
   (min.)

4. Digital Output Meter

   The following devices may serve this purpose:
   a. Digital Voltmeter
      0 to 5 Vdc

1 Megohm minimum input impedance

- Digital Milliammeter
  0 to 50 mA dc
  200 Ohms maximum insertion resistance

Both devices must have an overall accuracy of 0.10% or better.

5. Conditioning Resistors

   Required quantity of appropriate value to convert current signals to voltage where necessary. (See INSTALLATION section for available values.)

**PRELIMINARY ADJUSTMENTS**

Refer to a previously prepared calibration equation for all the required adjustments. A discussion of the calibration equation data is presented in the CALIBRATION EQUATION section. Figure 3 shows the location of the various jumpers and jacks.

1. Determine the required output current range \( I_O \). If necessary change the state of range jumper J1 located on the solder side of the module.

2. Determine the required gain \( G_0 \). Place the gain range jumper plug \( J2 \) into the appropriate jack \( X1, X10, \) or \( X100 \) located on the component side of the module.

3. Determine whether external or internal bias \( V_C \) is required. Place the bias source jumper plug \( J3 \) into jack E for EXTERNAL or into jack P for INTERNAL bias source selection.

4. If internal bias is specified, determine the required polarity. Place the bias polarity jumper plug (J4) into the +6 or -6 jack as required.

5. Plug the module into the specified or a convenient slot in the card cage, turn on the power supply, and let it warm up for five minutes.

**CALIBRATION PROCEDURE**

1. Obtain all the required calibration data listed and described in the REQUIRED DATA section.

2. Obtain the equipment listed in the REQUIRED EQUIPMENT section.

3. Perform all the adjustments outlined in the PRELIMINARY ADJUSTMENTS section.

4. Adjust the GAIN \( G_0 \) by completing the following steps:

   a. Calculate the needed deviation signal \( V_{\text{DEVI}} \) to produce 4.000 Volts at TP—GAIN when the gain \( G_0 \) is adjusted to the specified value.

   Use the following formula:

   \[ V_{\text{DEVI}} = \frac{4.000}{G_0} \]

   For example, if specified \( G_0 = 10 \), the needed \( V_{\text{DEVI}} = 0.4 \) Volts.

   b. Connect a signal source to INPUT A and another to INPUT B (See Figure 2).

   Set INPUT A to 3 Volts plus \( \frac{1}{2} \) \( V_{\text{DEVI}} \) (example: +3.2V) and INPUT B to 3 Volts minus \( \frac{1}{2} \) \( V_{\text{DEVI}} \) (example: +2.8V).
Make fine adjustment to either signal to read $V_{DEV}$ at TP-GAIN (see Figure 3).

**NOTE**

Current signals applied to any inputs must be converted to voltage signals (1-5V) via appropriate conditioning resistors.

The adjustable SETPOINT OUTPUT (terminal 6) may be used as a 1 to 5 Volt signal source.

c. Adjust gain potentiometer (R14) to read 4.000 Volts at test point TP-GAIN (see Figure 3).

5. Adjust the BIAS ($V_C$) by completing the following steps:

a. Adjust both signal sources, connected to INPUTS A AND B, to 3.000 Volts.

Make a fine adjustment to either signal to read 0 Volts ($\pm 0.001$V) at test point TP-GAIN (see Figure 3). This sets $G_O V_{DEV}$ to zero.

b. Calculate the output current ($I_O$) that will result when the bias ($V_C$) is adjusted to the specified value:

$$I_O = \frac{G_O V_{DEV} + V_C}{R_O}$$

For example, if $V_C = 1.000$V and $R_O = 0.25$, the output must be 4.00 mA.

**NOTE**

All resulting output signals ($I_O$) must be within the selected output range (4 to 20 mA or 10 to 50 mA).

If the specified bias ($V_C$) is negative, its adjustment must be made in conjunction with a positive gain/deviation signal ($G_O V_{DEV}$) to produce a positive output ($I_O$).

c. Connect an appropriate output meter to terminals 4 (+) and 5 (-) of the card cage (see Figure 2).

**NOTE**

If a voltmeter is used to read the output, a conditioning resistor must be used across the output to provide the desired voltage. In this case, step 5b will not be necessary, the output voltage will correspond directly to $G_O V_{DEV} + V_C$.

d. Adjust bias potentiometer R38 (or the external bias source) to read on the output meter the calculated output current ($I_O$) or its equivalent voltage.

### MAINTENANCE

#### GENERAL

Required maintenance for this module should consist of periodic cleaning, visual inspection, and calibration checks. The severity of the environment in which the module is located will determine the required frequency of maintenance.

#### CLEANING

The module should be cleaned as often as operating conditions require. The accumulation of dust and dirt on components prevents efficient heat dissipation which can cause overheating and component breakdown.

 Blow off accumulated dust and dirt with dry, low velocity air. Any dust or dirt that remains should be removed with a soft brush or cloth dampened with a mild detergent and water solution. Cotton-tipped swabs are useful for cleaning in narrow spaces.

**CAUTION**

Avoid the use of chemical agents which may damage plastic components or protective coatings.

#### VISUAL INSPECTION

The module should be inspected occasionally for defects such as loose or broken connections, damaged circuit board, and heat-damaged components.

The corrective action for most visible defects is obvious. However, if a heat-damaged component is found, the cause of overheating must be corrected to prevent a recurrence of the damage.

**CAUTION**

Exceeding the specified ambient temperature limits can adversely affect performance and may cause damage.

#### TROUBLESHOOTING

If the module does not operate properly when initially installed, check the terminal strip wiring. Most problems in new installations can be traced to wiring mistakes. Also, verify that the equipment associated with the input and output circuits is functioning and is properly calibrated.

If the trouble is traced to the module, remove the module and give it a full bench check. A complete schematic of the module is given in Figure 4.

A Part No. 15378.27 Card Extender can be ordered. It extends the module beyond the front edge of the card cage enclosure, providing easy access to both sides of the module's circuit board.

**IMPORTANT**

Warranty repair and replacement requires the module to be returned to Moore Products Co., Spring House, Pa. 19477. The warranty is null and void if repair is attempted at any other location.

#### RECOMMENDED SPARES

There are no recommended spare parts for the Deviation Amplifier Module.

One spare module is recommended for every 1 to 10 in service.