DESCRIPTION

The Model 380M Multiplier/Divider Module accepts two or three analog input signals and provides an analog output that is proportional to the product and/or ratio of the inputs. Some of the possible computations are shown below.

\[ X = AC \]
\[ X = \frac{A}{B} \]
\[ X = A^2 \]
\[ X = \sqrt{C} \]

Where, \( X \) = Output Signal;
A, B, & C = Input Signals

A block diagram of the complete Module is shown in Figure 1. Input signals A, B, and C are each applied to an input amplifier. Each input amplifier is equipped with a zero and span control, making it possible to condition the input signals individually by providing an offset and a scaling factor as required. The conditioned signals from amplifiers B and C are fed to a divider which computes \( \frac{C}{B} \). The divider's output \( \frac{C}{B} \) and the conditioned signal from amplifier A are, in turn, fed to a multiplier, performing computation \( AC \). The resultant signal which is in the form of a voltage level is then applied to the output section where it is converted into a proportional output current. An output range of 4 to 20 mA or 10 to 50 mA can be selected by means of jumper wire J1. The output section is also equipped with a zero and span control for precise adjustment of the output range.

An adjustable reference voltage (0 to +6 Volts) is available at the Module for use as a fixed reference for unused inputs or as a calibration source.

For specific application information, refer to the customer calibration drawing. Such drawings are jointly developed by the customer and Moore Products Co. personnel. Modules intended for such specific applications are shipped calibrated and require no additional adjustments. To install a calibrated Module, refer directly to the INSTALLATION section.

Due to the Module's complex input/output relationship and its many qualifications, it is recommended that all customer applications be jointly developed with Moore Products Co. personnel.

**FIGURE 1 Block Diagram**

MOORE PRODUCTS CO., Spring House, Pa. 19477
**FUNCTIONAL PARAMETERS**

**INPUT/OUTPUT RELATIONSHIP:**

\[ I_o = \frac{G_o}{R_o} \left( \frac{(G_A \cdot V_A b_A) - (G_B \cdot V_B b_B)}{V_0} \right) \]

Where:

- \( I_o \) = Output Current
- \( G_o \) = Output Gain (OUTPUT SPAN); adjustable 0.5 to 1.9
- \( G_A, G_B, G_C \) = Input Gain (INPUT SPAN); adjustable to 1.8
- \( V_A, V_B, V_C \) = Input Signals; 1 to 5 Volts dc
- 0 to 6 Volts dc (max.)
- \( b_A, b_B, b_C \) = Input Bias (INPUT ZERO); adjustable to \( \pm 6 \) Volts dc
- \( K_0 \) = Output Bias (OUTPUT ZERO); adjustable 0 to 50% of full scale output span
- \( R_o \) = Voltage/Current Transfer Constant

**QUALIFICATIONS**

1. This device is a single quadrant multiplier/divider. All computational results must be positive or equal to zero; negative results will not appear in the output.

2. The input B expression \( G_B \cdot V_B b_B \) must always be offset by an additional \(-1.0 \text{V}\) whenever this input is calibrated.

3. The ratio \( \frac{(G_C \cdot V_C b_C)}{(G_B \cdot V_B b_B)} \) must be restricted to a numeric value of 0 to +1 inclusive.

**SPECIFICATIONS**

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

- **Range** ............... 1 to 5 Volts dc
- **Max. Range** ............ 0 to 6 Volts dc
- **Impedance** ............. 1 Megohm minimum
- **Zero (Bias \( b_A, b_B, b_C) \)** ............ 0 to \( \pm 6 \) Volts
- **Span** (Gain \( G_A, G_B, G_C) \) ............ 0 to 1.8

**OUTPUT (I_o)**

<table>
<thead>
<tr>
<th>Field Selectable Range</th>
<th>Permissible Load</th>
<th>AC Powered Enclosures</th>
<th>24V dc Powered Enclosures</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 20 mA</td>
<td>0 to 900 Ohms</td>
<td>0 to 700 Ohms</td>
<td></td>
</tr>
<tr>
<td>10 to 50 mA</td>
<td>0 to 360 Ohms</td>
<td>0 to 280 Ohms</td>
<td></td>
</tr>
</tbody>
</table>

**E/I Constant \( R_0 \)……………… 0.250 (for 4.20 mA output); 0.100 (for 10-50 mA output)

**Zero (Bias \( K_0) \)……………… 0 to 50% of output span

**Span (Gain \( G_0) \)……………… 0.5 to 1.9

**Load Effect**……………… Less than 0.1% within allowable load range

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

**ACCURACY**

- **Multiplier** (\( V_B @ \) full scale) ………………… \pm 0.2%
- **Divider** (\( V_B @ \) 15% to 100% of full scale) ………………… \pm 1.0%

**REPEATABILITY** ………………… \pm 0.1% of span

**RESPONSE TIME** ………………… 500 mSec to reach 98% of output span (typical)

**TEMPERATURE EFFECT** for 32 to 122°F (0 to 50°C)

- **Multiplier** (\( V_B @ \) full scale) ………………… \pm 0.32%
- **Divider** (\( V_B @ \) 15% to 100% of full scale) ………………… \pm 0.8%

**REFERENCE VOLTAGE**

- **OUTPUT** ………………… Adjustable 0 to \(+6 \) Volts

**INSTALLATION**

The Multiplier/Divider Module must be installed in a Model 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 is plugged in. Service Instruction SD3801 identifies these safety keys and gives the procedure for setting them. The positions of the keys for the Multiplier/Divider 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 of the rear (depending on model) of the card cage enclosure. Each terminal strip is identified with 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.
CALIBRATION

GENERAL

Each Multiplier/Divider Module is shipped factory calibrated for a specific customer application. It is accompanied by a calibration drawing, showing the process flow diagram, the calibration equation, and the hook-up diagram. Such Modules require no additional adjustments and may be put immediately into service as instructed in the INSTALLATION section of this instruction.

To assure continued accuracy, it is suggested that "on-line" calibration checks be made at regular intervals dictated by the severity of the operating environment or whenever an inaccuracy is suspected. Refer to the TEST EQUIPMENT and the CALIBRATION SPOT CHECK sections for further instructions.

Multiplier/Divider Modules being prepared for new applications and requiring complete calibration, must be adjusted "off-line" according to instructions given in the TEST EQUIPMENT and the CALIBRATION PROCEDURE sections.

TEST EQUIPMENT

The following test equipment is required to properly check and calibrate the Multiplier/Divider Module.

1. Model Series 380 Card Cage with power supply.
2. Digital Multimeter. . . . Range: 0-10 Vdc
   0-50 mA dc
   Accuracy: ±0.05%
3. Signal Source. . . . . . . . . 0 to 5 Volts dc;
   (Optional) Adjust ±0.05%, with digital readout.

CALIBRATION SPOT CHECK

The following Calibration Spot Check can be performed "on-line" (connected to an operating control system) in the presence of stable, very slow changing input signals. It involves quickly measuring all the input and output signals, plugging this data into the Calibration Equation, computing the correct output, then comparing it to the measured output.

This calibration check obviously does not cover the full range of all possible input signals, but will give a good indication of the Module's performance at the particular operating point.

1. Measure the voltage levels of all variable input signals (V_X, V_S, & V_O) appearing at the terminals of the card cage enclosure (see Figure 2 for terminal identification).
2. Measure the output voltage (E_O) across one of the possibly several conditioning resistors (R_P) connected in series across terminals 4 (+) and 5 (-) of the card cage enclosure.
3. Plug all the measured input level values into the calibration equation (found in the calibration drawing) and compute the theoretical output current, I_O (calculated).
4. Convert the measured output voltage (E_O) appearing across the conditioning resistor (R_P) in step 2 to an...
equivalent output current, I o (measured). 
I o in milliams = E o in Volts divided by R o in Kilohms.
5. Compare I o (measured) of step 4 to I o (calculated) of step 3.
An acceptable difference between these two signals may be twice or more the maximum deviation listed in the SPECIFICATIONS section. The lower attainable precision by this method is mainly due to the difficulty of making accurate simultaneous measurements of varying input and output signals.
This completes the Calibration Spot Check. If the results attained in step 5 are not acceptable, it will be necessary to perform a complete “off-line” calibration check outlined in the next section.

CALIBRATION PROCEDURE
The following calibration procedure must be performed “off-line”. It can be used to prepare a Module for a totally new application or to correct a calibration deficiency found during the “on-line” Calibration Spot Check.
An “off-line” calibration procedure requires the Module to be completely disconnected from an operating control system.
A carefully prepared calibration drawing, showing the calibration equation and the hook-up diagram, is mandatory for calibration.

Extract the following data from the calibration equation:
1. OUTPUT Range (R 0 )
   Zero (R 0 )
   Span (G 0 )

2. INPUT A Range (V 0 )
   Zero (G 0 )
   Span (G 0 )

3. INPUT A Range (V 0 )
   Zero (G 0 )
   Span (G 0 )

4. INPUT C Range (V 0 )
   Zero (G 0 )
   Span (G 0 )

The calibration drawing is usually jointly prepared by the customer and the Moore Products Co. personnel.
The customer can prepare the calibration equation independently by establishing all the functional requirements and referring to the FUNCTIONAL PARAMETERS and the SPECIFICATIONS sections in this Instruction. However, considerable signal scaling and mathematical manipulation may be required to produce a practical equation that complies with all the qualifications of the Module and associated system components.
The calibration procedure is divided into the following major segments:
1. Output Range Selection
2. Output Adjustment
3. Input A Adjustment
4. Input B Adjustment
5. Input C Adjustment
6. R15 & R23 Adjustments (Factory Sealed)

Adjustment of Inputs A, B, and C can be made independently of each other. However, the Output Adjustment must be made in coordination with special, temporary input settings. It is, therefore, recommended that the Output Adjustment be made first, before setting the final input parameters. Refer to Figure 3 for the location of all the trimpots and test jacks.

CAUTION
Application of more than ±32 Volts to the input terminals may damage the Module.
All measured voltages are referenced to the module common which is accessible via test jack TP-COM at the front of module or at rear terminal 3 of the card cage enclosure.

Output Range Selection
The output range of the Module is determined by the absence or presence of jumper wire J1 (see following table):

<table>
<thead>
<tr>
<th>Output Range</th>
<th>Range Jumper</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 20 mA</td>
<td>J1 Removed</td>
</tr>
<tr>
<td>10 to 50 mA</td>
<td>J1 Intact</td>
</tr>
</tbody>
</table>

The jumper wire location is found on the foil side of the circuit board as shown in Figure 3. If the Module must be unplugged from the card cage enclosure for the installation or removal of the jumper wire.

Determine from the calibration equation the required output range and perform the selection as described above.

Output Adjustment
1. Connect input A (terminal 1), input B (terminal 2), and input C (terminal 7) to common (terminal 3).
2. Adjust trimpots “IN: A ZERO”, “IN: B ZERO”, and “IN: C ZERO” to read 0.000 Volts at test jacks TP-A, TP-B, and TP-C, respectively.
3. Adjust trimpot “REF: ADJ.” to read +4.000 Volts at test jack TP-R.
4. Disconnect input B (terminal 2) and input C (terminal 7) from common (terminal 3) and connect both to the reference source (terminal 9). Leave input A connected to common.
5. Adjust trimpot “IN: B SPAN” to read +3.000 Volts at test jack TP-B.
6. Adjust trimpot “IN: C SPAN” to read +4.000 Volts at test jack TP-C.
7. Connect a digital milliammeter (0-50 mA dc range) across terminals 4 and 5. A digital voltmeter with a range of 0 to +5 Volts can be used in conjunction with an appropriate conditioning resistor if a milliammeter is not available. (See INSTALLATION section for resistor selection.)
8. Adjust trimpot “OUT: ZERO” to read the required value of R G on the digital milliammeter, typically 4.00 mA (or 1.000 Volt). (For this adjustment, input A was set to zero in step 2.)
9. Disconnect input A (terminal 1) from common (terminal 3) and connect it (input A) to the reference source (terminal 9). All three inputs are now connected to the reference source.

10. Adjust trimpot "IN: A SPAN" to read +4.000 Volts at test jack TP-A. (This provides the 100% output signal setting.)

11. Adjust trimpot "OUT: SPAN" to read at output terminals 4 and 5 the product of input A and the required value of \( G_0 \) plus the value of \( K_0 \) (established in step 8).

   For example, with +4.000 Volts input (step 10), if \( G_0 = 1 \), the output reading should be adjusted to 20.000 mA; if \( G_0 = 0.5 \), the reading should be 12.00 mA.

12. Repeat steps 1, 2 and 6 through 11 until the zero and 100% output signal readings are as required.

   (There is some interaction between the output zero and span controls.)

NOTE: In applications where \( G_0 > 1 \), the input voltage in step 10 should be proportionately smaller to keep the output current within the allowable range as stated in the SPECIFICATIONS section. For example, if \( G_0 = 1.6 \), apply +2.500 Volts to input A and adjust "OUT: SPAN" to read 20.00 mA at the output.

**Input A Adjustment**

This procedure sets the values of components \( G_A \) and \( b_A \) of the total expression \( (G_A \cdot V_A / b_A) \) found in the calibration equation.

Component \( G_A \), the SPAN (multiplier) adjustment, is set first.

1. Ensure that input A offset is adjusted to 0.000 Volts as instructed in steps 1 and 2 of the Output Adjustment. Skip this if the Output Adjustment was just completed.

2. Connect input A (terminal 1) to the reference source (terminal 9). Leave the reference source at +4.000 Volts (step 3 of Output Adjustment).

3. Adjust trimpot "IN: A SPAN" to read at test jack TP-A the product \( G_A \) and \( V_A \).

   For example, with \( V_A \) set at +4.000 Volts (in step 2) and a required \( G_A \) of 1.5, the reading at TP-A should be +6.000 Volts; with a required \( G_A \) of 0.5, the reading should be +2.000 Volts.

Component \( b_A \), the ZERO (offset) adjustment, is set next.

4. Disconnect input A (terminal 1) from the reference source (terminal 9) and connect it (input A) to common (terminal 3).

5. Adjust trimpot "IN: A ZERO" to read to test jack TP-A the required \( \pm b_A \) value. (Typically +1.000 Volts.)

6. Disconnect input A (terminal 1) from common (terminal 3) and connect it (input A) to the reference source (terminal 9). The reading at test jack TP-A should be equal to \( G_A \cdot V_A / b_A \). If necessary, repeat previous steps.

   If the required expression \( G_A \cdot V_A / b_A \) is a fixed constant, connect input A to the reference source and adjust trimpots "IN: A SPAN" and "IN: A ZERO" in any combination necessary to provide at test jack TP-A the required constant value. (Typically +4.000 Volts.)

**Input B Adjustment**

This procedure sets the values of components \( G_B \) and \( b_B \) of the total expression \( (G_B \cdot V_B / b_B) \) found in the calibration equation.

Component \( G_B \), the SPAN (multiplier) adjustment, is set first.

1. Ensure that input B offset is adjusted to 0.000 Volts as instructed in steps 1 and 2 of the Output Adjustment. Skip this if the Output Adjustment was just completed.

2. Disconnect input B from common and connect it (input B) to the reference source (terminal 9). Leave the reference source at +4.000 Volts (step 3 of Output Adjustment).

3. Adjust trimpot "IN: B SPAN" to read at test jack TP-B the product \( G_B \) and \( V_B \).

   For example, with \( V_B \) set at +4.000 Volts (in step 2) and a required \( G_B \) of 1.5, the reading at TP-B should be +6.000 Volts; with a required \( G_B \) of 0.5, the reading should be +2.000 Volts.

Component \( b_B \), the ZERO (offset) adjustment, is set next.

4. Disconnect input B (terminal 2) from the reference source (terminal 9) and connect it (input B) to common (terminal 3).

5. Adjust trimpot "IN: B ZERO" to read at test jack TP-B the required \( \pm b_B \) value plus an additional \(-1.000\) Volts. (Typically \(-2.000\) Volts.)

6. Disconnect input B (terminal 2) from common (terminal 3) and connect it (input B) to the reference source (terminal 9). The reading at test jack TP-B should be equal to \( (G_B \cdot V_B / b_B) - 1.000 \). If necessary, repeat previous steps.

   If the required expression \( G_B \cdot V_B / b_B \) is a fixed constant, connect input B to the reference source and adjust trimpots "IN: B SPAN" and "IN: B ZERO" in any combination necessary to provide at test jack TP-B the required constant value (given in the calibration equation) minus 1.000 Volt. (Typically +3.000 Volts)
Input C Adjustment
This procedure sets the values of components C_2 and b_2 of the total expression (G_C V_C ± b_2) found in the calibration equation.
Component C_2, the SPAN (multiplier) adjustment, is set first.
1. Ensure that input C offset is adjusted to 0.000 Volts as instructed in steps 1 and 2 of the Output Adjustment. Skip this if the Output Adjustment was just completed.
2. Connect input C (terminal 7) to the reference source (terminal 9). Leave the reference source at +4.000 Volts (step 3 of Output Adjustment).
3. Adjust trimpot “IN: C SPAN” to read at test jack TP-C the product G_C and V_C.
   For example, with V_C set at +4.000 Volts (in step 2) and a required G_C of 1.5, the reading at TP-A should be +6.000 Volts; with a required G_C of 0.5, the reading should be +2.000 Volts.
   Component b_2, the ZERO (offset) adjustment, is set next.
4. Disconnect input C (terminal 7) from the reference source (terminal 9) and connect it (input C) to common (terminal 3).
5. Adjust trimpot “IN: C ZERO” to read at test jack TP-C the required ±b_2 value. (Typically -1.000 Volts).
6. Disconnect input C (terminal 7) from common (terminal 3) and connect it (input C) to the reference source (terminal 9). The reading at test jack TP-C should be equal to G_C V_C ±b_2. If necessary, repeat previous steps.
   If the required expression G_C V_C ±b_2 is a fixed constant, connect input C to the reference source and adjust trimpots “IN: C SPAN” and “IN: C ZERO” in any combination necessary to provide at test jack TP-C the required constant value. (Typically +4.000 Volts).
   This completes the normal user-adjustable calibration of the Multiplier/Divider Module.

Sealed Factory Adjustment
Adjustments of trimpots R15 and R23 are set and sealed at the factory. No attempt should be made to adjust these unless their settings were inadvertently changed (check seals) or related parts on the circuit board were replaced.
Trimpots R15 and R23 are located at the lower rear of the Module. Their adjustment requires the use of a Part No. 15378-27 Card Extender with its lower aluminum bracket drilled to gain access to the trimpot adjustment screws.
Use the following procedure only for reasons stated above.
1. Perform the Output Adjustment as outlined under CALIBRATION PROCEDURE. Use the values G_o = 1 and K_o = 4 mA to obtain a 4-20 mA output with 0 to 4 Volts appearing at TP-A.
2. Leave inputs A, B, and C connected to the reference source which remains set to +4.000 Volts. Make appropriate input ZERO and input SPAN adjustments to obtain +4.000 Volts at TP-A, +3.000 Volts at TP-B, and +5.000 Volts at TP-C.
3. Adjust trimpot R15 to read +2.80 Volts at pin 4 of IC3, (voltmeter referenced to TP-COM).
4. Adjust trimpot “IN: C SPAN” to read +0.080 Volts at test jack TP-C. This represents 2% of the 4 Volt input span.
5. Adjust trimpot R23 to read 2% of output span: 4.32 mA (4 to 20 mA range) or +1.080 Volts (if converted to 1 to +5 Volts).
6. Adjust trimpot “IN: C SPAN” to read +3.920 Volts at test jack TP-C. This represents 98% of the 4 Volt input span.
7. Adjust trimpot R15 to read 98% of output span: 19.68 mA (4 to 20 mA range) or +4.920 Volts (if converted to 1 to +5 Volts).
8. Repeat steps 4 through 7 until readings are as required. There is some interaction between these adjustments.
MAINTENANCE

CLEANING

The module should be cleaned as often as operating conditions required. 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 required 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 Multiplier/Divider Module.

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