GENERAL DESCRIPTION
The Model Series 380D Millivolt Converter Module accepts a dc voltage input signal and converts it to a proportional output current. The input circuit is electrically isolated from both the output section and the Model Series 380 Card Cage power supply. This allows the input to operate at up to 100 Vdc above ground.

The Module is available in four factory determined input span ranges (see Model Designation section). The output circuit of any Module can be changed in the field via two jumper wires to produce an output range of either 4 to 20 mA or 10 to 50 mA. A protective circuit limits the output current to 150% of the maximum current range, thus preventing possible damage to the connected instruments. Two 22-turn trimpots provide the necessary zero and span adjustments.

The Millivolt Converter Module is designed to be plugged into a Model Series 380 Card Cage Enclosure equipped with a common power supply (see Service Instruction SD380D).

MODEL DESIGNATION

<table>
<thead>
<tr>
<th>Model</th>
<th>Zero (R42)</th>
<th>Span (R45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>380D1</td>
<td>trim</td>
<td>trim</td>
</tr>
<tr>
<td>380D2</td>
<td>-5 to +25 mV</td>
<td>5 to 50 mV</td>
</tr>
<tr>
<td>380D3</td>
<td>-25 to +125 mV</td>
<td>25 to 250 mV</td>
</tr>
<tr>
<td>380D4</td>
<td>±10% of span</td>
<td>±15% of span</td>
</tr>
</tbody>
</table>

OUTPUT

<table>
<thead>
<tr>
<th>Field Selectable Range</th>
<th>Permissible Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Powered Enclosures</td>
<td>0 to 1000 Ohms</td>
</tr>
<tr>
<td>24 Vdc Powered Enclosures</td>
<td>0 to 900 Ohms</td>
</tr>
</tbody>
</table>

Load Effect: Less than 0.1% within the permissible load range.

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

RESPONSE TIME: 500 mSec (typical) to reach 98% of output span.

ACCURACY*: ±0.15% (max.) all except 380D1
            ±0.3% (max.) Model 380D1

OPERATING TEMP.: 32 to 122°F (0 to 50°C)

TEMP. EFFECT*: ±0.35%/100°F (max.)
               ±0.7%/100°F (max.) Model 380D1 over the specified operating temp. range

*Performance at 25°C ambient with 0 to 10 mV, with 100 Ohm source input signal and 4 to 20 mA output into a 500 Ohm load.

Isolation: The input circuit is electrically isolated from the output and power circuits, permitting it to operate at up to 100 Vdc above ground.
INSTALLATION
The Model Series 380D Millivolt Converter 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 the customer drawing for the designated slot or assign a convenient slot for it.

The safety keys of the designated slot in the card cage must be set before the Module can be plugged in. Service Instruction SD3801 identifies these safety keys and gives the procedure for setting them. The positions of the keys for the Millivolt Converter Module are as follows:

- Left Key: H (Horizontal)
- Right Key: V (Vertical)

The input and output connections are made to the terminal strips provided at the front or the rear of a card cage enclosure (depending on model). Each terminal strip is identified by a number that matches a corresponding slot number. Service instruction SD3801 provides complete physical and electrical description of the various Series 380 Card Cage Enclosures.

The Module’s input and output connections are identified in Figure 1, Connection Diagram.

WARNING
Remove power from all wires to be connected.

All plug-in modules in a card cage share a common power supply. The output signals of these modules are referenced to one signal common which is also the negative bus of the power supply.

The input circuit of the Millivolt Converter Module is isolated from both the output circuit and the power supply. Thus, each input circuit may be independently grounded without fear of creating interfering ground loops.

CALIBRATION
GENERAL
The Millivolt Converter Module is normally shipped factory calibrated for a specific, customer designed range. Such a module requires no additional adjustment and can be put into service immediately.

Modules ordered without a specific calibration request must be calibrated by the user.

To assure continued accuracy, it is recommended to check the calibration after the first 30 days of operation and then at regular intervals dictated by the severity of the operating environment or whenever an inaccuracy is suspected.

Use the following procedure to perform periodic calibration checks or to calibrate the Module for a new range. Figure 2 shows the location of all jumper wires and trimpots.

REQUIRED EQUIPMENT
Calibration of the Module requires the use of the following equipment.

1. Model Series 380 Card Cage Enclosure with power supply.

2. Precision Millivolt Source
   Output Range: 0 to 250 mVdc
   0 to 100 Vdc (for Model 300D4)
   This Millivolt Source must be adjustable to an accuracy of ±0.1% or better and must provide a source resistance of 100 Ohms or less.

3. Digital Output Meter
   The following devices may serve as output meters:
   a) Digital Milliammeter
      Range: 0 to 50 mA
      Insertion Resistance: 200 Ohms (max.)
   b) Digital Voltmeter
      Range: 0 to 5 Vdc
      Input Impedance: 1 Megohm (min.)
      Either device must have an overall accuracy of ±0.1% or better.

4. Conditioning Resistor
   To convert output current to voltage if a voltmeter is used as an output meter.

OUTPUT RANGE SELECTION
Refer to Figure 2 for the location of the two jumper wires used in the following procedure. The output range of the Module is determined by the presence or absence of jumper wires J1 and J2 located on the solder side of the P.C. Board. With both jumper wires intact, the output range is 10 to 50 mA; with both removed, the range is 4 to 20 mA.

Perform the necessary range change by cutting out or soldering in jumper wires J1 and J2. Both jumper wires must be intact or both must be out; do not change the state of only one and not the other.

NOTE
After making a range change, the Module must always be recalibrated.

Following the range selection, plug the Module into its designated slot in the card cage, turn on the power supply, and let it warm up for five minutes before proceeding with the calibration outlined below.

PROCEDURE
Refer to Figure 1 for the connection of test equipment and to Figure 2 for the location of the zero and span trimpots and their respective jumper wires.

1. Complete all the instructions listed in the PRELIMINARY ADJUSTMENT section.

2. Connect the precision millivolt source to terminals 1 (+) and 2 (−) of the designated terminal strip on the card cage.

3. Connect the digital output meter to terminals 4 (+) and 5 (−) of the designated terminal strip on the card cage.

4. Set the millivolt source to the required minimum input voltage.

5. Adjust the ZERO trimpot (P42) to read the minimum output current on the output meter. This reading is 4 mA for the 4 to 20 mA output range, 10 mA for the 10 to 50 mA range, or 1 Volt if a 1 to 5 Volt conditioning resistor is used.
If the ZERO trimpot reaches full travel before the calibration point is reached, cut jumper wire Z to increase the adjustment range of the trimpot.

6. Set the millivolt source to the required maximum input voltage.

7. Adjust the SPAN trimpot (R45) to read the maximum output current on the output meter. This reading is 20 mA for the 4 to 20 mA output range, 50 mA for the 10 to 50 mA range, or 5 Volts if a 1 to 5 Volt conditioning resistor is used.

If the SPAN trimpot reaches full travel before the calibration point is reached, cut jumper wire S to increase the adjustment range of the trimpot.

8. Repeat steps 4 through 7 until proper calibration is achieved. This is necessary due to some interaction between the zero and span adjustments.

This completes the calibration procedure.

FIGURE 1 Connection Diagram

FIGURE 2 P. C. Board
CIRCUIT DESCRIPTION

GENERAL

The Millivolt Converter circuit can be divided into four basic blocks as shown in Figure 3.

The DC to AC Inverter changes the 15 Vdc input to an alternating current that is applied to the primary (P1) of transformer T1. One of the T1 secondaries (S2) is used to feed the Bipolar Power Supply which provides regulated dc voltages to the Input Section. The remaining T1 secondary (S1) is coupled via the Input Section to the primary (P2) of current transformer T2; the current flow through these windings is controlled by the Input Section. The millivolt input signal entering the Input Section effectively adjusts the level of current that is passed through the T2 primary (P2). The resultant current induced in the T2 secondary (S3) is fed to the Output Section. An impedance match is performed there to permit the use of a wide range of load resistances. Any change in the millivolt input signal produces a proportional change in the output current (I_o).

Note that the Output Section and the DC to AC inverter share the same common of the card cage power supply. However, the signal common of the Input Section is completely dc isolated from the card cage power supply by means of transformers T1 and T2.

During the detailed circuit descriptions given in the next four sections refer to Figure 4, Schematic.

DC to AC INVERTER

DC to AC conversion is accomplished by means of two switching transistors (Q1 and Q2) and a two-phase square-wave generator (IC2). The generator uses two voltage comparators connected in cascade. Multiple feedback loops, including a fixed time constant, assure proper oscillation at approximately 3 kHz. The generator's two outputs are open collector transistors, each being pulled up via a 5.6k and 1k resistor (R8, R9, R10, and R11) to the +15 Volt bus. During operation, each IC2 output transistor conducts at alternate times (180° out of phase). This conduction virtually grounds the lower end of either 5.6k Ohm resistor thus providing enough base bias to turn on the appropriate switching transistor (Q1 or Q2). When Q1 is conducting, it applies +15 Volts to one side of the T1 primary; with the common serving as the return, current passes through this primary in a given direction. Then, as Q1 turns off and Q2 begins to conduct, +15 Volts is switched to the other side of the T1 primary forcing current to flow in the opposite direction. This alternating current is necessary to induce appropriate voltages in the two T1 transformer secondaries. The 500 Ohm trim pot (R6) serves as a factory adjustment to obtain symmetry in the output waveforms.

BIPOLAR POWER SUPPLY

The Bipolar Power Supply provides ±6.2 Volts referenced to an isolated common. These voltages are used by the Input Section which takes advantage of the isolated common of this power supply to provide full input signal isolation for the Module.

The alternating voltage appearing across the S2 secondary of transformer T1 is full-wave rectified by diodes CR8 and CR10. The resulting dc voltage (approx. 15 Volts) is filtered by capacitor C4 and fed to a constant current regulator formed by PNP transistors Q5 and Q6.

Regulator operation occurs as follows. Assume transistor Q5 is initially off. Transistor Q6 will be conducting due to the full forward bias being provided by R22. As the collector current of Q6 increases, so does the voltage drop across thermistor R19 and resistors R20 and R21. When this voltage drop becomes sufficient to forward bias Q5, R22 and Q5 form a variable

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FIGURE 3 Block Diagram
voltage divider which reduces the forward bias to Q6. Reduced collector current in Q6 decreases the bias to Q5. The decreased current through Q5 effectively increases the forward bias to Q6 which again affects Q5 conduction. In reality, the described action occurs almost instantaneously and comes to equilibrium when the Q6 collector current is at approximately 10 mA. This constant current is applied across two series connected 6.2 Volt zener diodes, CR11 and CR12. Capacitors C6, C7, and C10 are used to filter out the noise generated by the zener diodes and to provide a low impedance path to signal common for any other voltage transients that may appear on the power supply buses.

INPUT SECTION

The Input Section controls the alternating current flow through transformer windings S1 and P2 (see Figure 3). Typically, when a low millivolt signal, within a selected input range, is applied to the input, it produces a correspondingly low current flow through windings S1 and P2. A larger input signal results in a proportionately larger current flow. This current can be selected (via J1 and J2) to range between 2 and 10 mA or 5 and 25 mA. Current transformer T2, with its 2 to 1 turns ratio, steps up these half-current ranges to the specified 4 to 20 mA or 10 to 50 mA output ranges.

A millivolt signal applied to the input of the Module first passes through a low-pass filter consisting of C8, R29, C9, and C12. The filter attenuates noise and ac signals that may be present with the dc input signal. Clamping diodes CR13, CR14, and CR18, permit only a signal between -0.7 Volts and +1.4 Volts to enter the noninverting input of Op-Amp IC1. Input signals exceeding 250mV, as in Model 380D4, are attenuated with resistor voltage dividers, R49 and R30. The inverting input of IC1 accepts a millivolt zero adjustment bias originating from trimpot R42 and voltage divider R41, R43, and R44, together with the feedback voltage appearing across trimpot R45.

The gain of Op-Amp IC1 is inversely proportional to the feedback voltage set by the SPAN trimpot (R45); maximum feedback produces low gain, minimum yields high gain. Wire jumper S affects the adjustment range of the SPAN trimpot (R45). With input signal (representing 0% scale) feedback voltage, thus reducing the adjustable gain range of the Op-Amp. Removal of wire jumper S results in a decrease adjustment range of the SPAN trimpot. Wire jumper Z affects the adjustment range of the ZERO trimpot (R42) in a similar manner.

The output of IC1 drives the base of Q7 which together with Q8 forms a high gain Darlington pair. In any given Module model, the drive level to Q7 is determined by the level of the input signal and by the settings of the ZERO and SPAN trimpots. The specified minimum input signal (representing 0% scale) produces enough drive to force the Darlington to draw either 2 mA or 5 mA, depending on the selected output range. The maximum input signal (representing 100% scale) results in 10 mA or 25 mA current flow through the Darlington pair. Selection of the high or low output range is made by means of wire jumpers J1 and J2.

With both wire jumpers installed, the Darlington collector-resistor (R18) is bypassed and the total emitter load resistance is reduced forcing the Darlington to operate in the high current range (5 to 25 mA). With the wire jumpers removed, the Darlington's total series resistance is increased, permitting it to operate in the low current range of 2 to 10 mA.

The source of the nearly square-wave voltage appearing across the ac terminals of the bridge rectifier (CR5-CR8) is the S1 secondary of power transformer T1. The connection to one side of the bridge is made through the primary (P2) of current transformer T2. The dc voltage developed across filter capacitor C14 is used to power the Darlington circuit. As the Darlington pair is driven into conduction by IC1, the resulting dc current flow is equal to the RMS value of the alternating current passing through secondary S1. Since primary P2 of T2 appears in series, the current through it is identical. It is this translation of the DC input into a proportional alternating current that permits the input circuit to be transformer isolated from the output and power supply circuits.

OUTPUT SECTION

The Output Section functions as an impedance matching device. It matches the low source impedance of transformer T2 secondary (S3) to a much broader load range as listed in the SPECIFICATIONS section.

A Darlington transistor pair (Q3 and Q4), powered by the +24 Volt source of a card cage power supply, is used to control the required currents through the wide load resistances specified. The collectors of Q3 and Q4 are connected through the external load resistance to power supply common. The base of Q4 is fixed at two diode drops (1.4V) below the +24V bus. The Q3 emitter and the Q4 emitter resistor (R18) are returned to the +24V bus via a controlling current source. This current source consists of the T2 secondary (S3), full-wave rectifiers (CR3 and CR4), filter capacitor C3, resistor R17, and diode CR17. As described in the previous section, transformer T2 steps up the half-value alternating current of its primary to the required 4 to 20 mA or 10 to 50 mA alternating current passing through its secondary. The alternating current is rectified by diodes CR3 and CR4; the resulting direct current is then filtered by capacitor C3 and passed via resistor R17 as the controlling current to the Darlington emitter. In normal operation, the voltage across diode CR17 is very small, thus the diode is virtually non-conducting; however, should the controlling current cease to flow due to an open load, the voltage across CR17 will increase but will not go beyond 0.7 Volts (the forward diode drop).

With the controlling current at zero, there is insufficient base bias to put the Darlington pair into conduction. However, as the current source becomes activated, it proceeds to pump current into the Darlington emitters and the transistors begin to conduct. The combined collector currents of the Darlington transistors will pass through the external load and will equal the controlling current derived from the T2 secondary. The external load current will be equal to the controlling current, as long as the load is within the permissible range (see SPECIFICATIONS).
MAINTENANCE

GENERAL

Required maintenance for this Module consists 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 a card cage enclosure, providing easy access to both sides of the Module's circuit board.

RECOMMENDED SPARES

There are no recommended spare parts for the Millivolt Converter Module. One spare module is recommended for every 1 to 10 in service.

WARRANTY

The Company warrants all equipment manufactured by it and bearing its name plate, and all repairs made by it, to be free from defects in material and workmanship under normal use and service. If any part of the equipment herein described, and sold by the Company, proves to be defective in material or workmanship and if such part is within twelve months from date of shipment from the Company's factory, returned to such factory, transportation charges prepaid, and if the same is found by the Company to be defective in material or workmanship, it will be replaced or repaired, free of charge, f.o.b. Company's factory. The Company assumes no liability for the consequences of its use or misuse by Purchaser, his employees or others. A defect in the meaning of this warranty in any part of said equipment shall not, when such part is capable of being renewed, repaired or replaced, operate to condemn such equipment. This warranty is expressly in lieu of all other warranties, guarantees, obligations, or liabilities, expressed or implied, by the Company or its representatives. All statutory or implied warranties other than this, are hereby expressly negated and excluded.

Warranty repair or replacement requires the equipment to be returned to one of the following addresses:

Equipment manufactured or sold by MOORE PRODUCTS CO.
MOORE PRODUCTS CO.
Summervale Pike
Spring House, PA., 19477

Equipment manufactured or sold by MOORE INSTRUMENT CO.
MOORE INSTRUMENT CO.
2911 West of Mississauga Rd., Hwy. 7
Brampton, Ont., Canada

The warranty will be null and void if repair is attempted without prior authorization by a member of the MOORE PRODUCTS CO. Service Department.
FIGURE 4 Schematic