BECKWITH BELECTRIC

Current Loop Interface Module M-2025D

Current-to-Voltage Analog Converter used with the M-2001 Series Digital Tapchanger Control and M-2948 Tap Position Sensors to provide positive tap position knowledge



- Includes dual functionality to convert current loop outputs from INCON® 1250 series to voltage signals for M-2001 Series Tapchanger Controls and accepts direct current inputs from Beckwith Electric M-2948 Tap Position Sensors
- Beckwith Electric Tap Position Sensors directly mechanically replace Selsyn-Type tap position sensors
- Connects easily to the M-2001 Series Digital Tapchanger Control using a 6-pin connector
- Provides a 9-position terminal block for easy connections
- Enclosed components permit user to select one of four current range configurations
- Small size permits mounting on any flat surface at least 6-1/2" wide and 2-5/8" high



The M-2025D Current Loop Interface Module is a current-to-voltage analog converter that accepts a standard 4-20, 0-1, 0-2 or ±1 mA input or inputs from the Beckwith Electric M-2948 Tap Position Sensor.

Beckwith Electric Tap Position Sensors are absolute position indicators that directly mechanically replace Selsyn-Type (relative position) tap position sensors. The Beckwith Electric Tap Position Sensors provide a 4-20 mA dc current loop output. The lowest current value corresponds to the lowest tap number. The highest current value corresponds to the highest tap number. The current signals are converted to a voltage signal using a shunt resistor (see <u>Table 2</u>) on the voltage input to the M-2025D. The resultant voltage signal is conditioned in the M-2025D and routed to the M-2001 series Tapchanger Control where the voltage is converted to a corresponding tap position number.

In <u>Figure 1</u>, the jumper wire from pins 5 to 6, on terminal block one, selects a Unipolar input. Unipolar is defined as positive-only current loop values as listed in <u>Table 2</u>. For a Bipolar input application (containing a negative current component) the jumper is placed on pins 4 to 5 as indicated in Row 5 of <u>Table 2</u>.

■ NOTE: The Bipolar input application is not compatible with the M-2948 Tap Position Sensor.

The M-2025D also accepts inputs from INCON1250 Series Rotary Position Indicator (Figure 2).

■ NOTE: The M-2025D is designed to operate with the tap position devices described above. This device is not designed to provide signal conditioning or calibration for a series resistive voltage divider chain (Figure 3). A suitable interface device with a current loop output will be required.

Older installations may use the Crompton Model 253-TRTU transducer or the Rochester Instrument Systems Model PR-2050 transducer, both of which are now obsolete. The Beckwith Electric M-2943 can be used in new installations or to replace failed obsolete transducers. The scheme can be used with all M-2001 Series Load Tapchanger models, M-2001 through M-2001D. This output can then be provided to the Current Loop Interface Module and then input to a M-2001 using the XFMR EXT #2 configuration setting (Table 3).

M-2025D Current Loop Interface Module Applications

Beckwith Electric M-2001B, M-2001C and M-2001D Digital Tapchanger Controls: The M-2025D Current Loop Interface Module connects to the control through the B-0753 interface (6 pin to 6 pin) cable. The control provides low-voltage dc to power the M-2025D and accepts an analog voltage input as described above. The M-2001 control includes a tap calibration screen to establish a reference tap position and it allows the current tap position to be viewed. The B-0753 interface cable is available in 3, 6, 8, 12, 15, and 25 foot lengths.

Beckwith Electric M-2001, M-2001A or M-2001A-1 Tapchanger Control: The M-2025D Current Loop Interface Module connects to the M-2001, M-2001A, or M-2001A-1 through the B-0752 interface cable (5 pins on one end and 6 pins on the other end). These controls provide low-voltage dc to power the M-2025D, and accept an analog voltage input as described above. They also include a tap calibration screen to establish a reference tap position and it allows the current tap position to be viewed.

Incon 1250 Series Rotary Position Indicator

Another configuration commonly encountered is the Selsyn position indicator (Figure 2). These tap position sensors are traditionally used with a Tap Position Monitoring device such as the Incon 1250 series devices. The Selsyn encoder is an electromagnetic device that resembles a small electric motor. Although using various configurations of internal windings, they typically excite rotor winding(s), and induce AC signal voltages in the stator windings which can be compared in amplitude and polarity to determine the angular position of the rotor shaft.

The Tap Position Monitor generates the voltage signals supplied to the rotor winding(s). It then measures the resulting signals from the stator winding to determine the shaft's rotational position. This information is converted to a tap number and displayed on the front panel numeric readout. An analog current signal is also generated which corresponds to tap position. The M-2025D Current Loop Interface module accepts this analog current signal.



■ NOTE: When used with the M-2948 Tap Sensor, the TB1-1 Black wire is internally connected to ground. The current loop circuit must NOT be grounded elsewhere as damage to current loop components may occur. DO NOT connect the Green wire to ground! The green wire is for Factory use only.

Figure 1 Typical External Tap Position Interface with M-2948 Tap Position Sensor



Figure 2 External Tap Position Interface With Selsyn Type Indicator as Example



Figure 3 Series Resistor Voltage Divider Example

Beckwith Electric M-2948 Tap Position Sensors

Most LTC tapchangers have an output shaft on the tapchanger mechanism whose angular position is a mechanical analog of the tapchanger tap position. In many cases, the total range of tap positions is represented by less than one complete rotation of this position output shaft. The typical values of shaft movement on 33 and 35 tap mechanisms are 9° or 10° of mechanical rotation per tap position.

<u>Figure 1</u> represents a typical application of the Beckwith Electric M-2948 Tap Position Sensor. The Tap Position Sensor (<u>Figure 4</u>) is a rotary shaft encoder with built-in microprocessors that provide stepped output signals in 9 or 10 degree increments. The electrical output of these sensors is a 4-20 mA current loop that converts easily to a voltage signal at the input of the M-2025D with the addition of a shunt resistor (<u>Table 2</u>).

The Tap Position Sensors are available in both clockwise and counter-clockwise rotation configurations for increasing tap position. They have Tap Min to Tap Max rotations of 210, 297, 306, 315, 325, 330, 340 and 350 degrees respectively for ± 8 or ± 16 taps and 1, 2, 3, 5 or 6 neutral positions.

Refer to <u>Table 1</u> for M-2948 configuration options. A typical tapchanger mechanism is illustrated in <u>Figure 5</u> as an example of determining the correct rotation.

Additional information about selecting Tap Position Sensors is available in the M-2948 Specification document. Other angular rotation values may be encountered. Therefore, contact Beckwith Electric for information regarding sensor availability for specific requirements.

Input

- +12 Vdc Power input supplied from the M-2001C(D)
- M-2025D Transient protected to ANSI/IEEE C37.90.1-1989

Output

- 4 to 20 mA relative to tap position
- 2 digital outputs for mechanical calibration



Figure 4 Beckwith Electric M-2948 Tap Position Sensor (with optional mounting bracket)

Sensor	Rotation	Degrees/ Tap	Taps	Neutrals
M-2948-91N	Negative	9°	±16	1
M-2948-91P	Positive	9°	±16	1
M-2948-92N	Negative	9°	±16	2
M-2948-92P	Positive	9°	±16	2
M-2948-93N	Negative	9°	±16	3
M-2948-93P	Positive	9°	±16	3
M-2948-95N	Negative	9°	±16	5
M-2948-95P	Positive	9°	±16	5
M-2948-11N	Negative	10°	±16	1
M-2948-11P	Positive	10°	±16	1
M-2948-12N	Negative	10°	±16	2
M-2948-12P	Positive	10°	±16	2
M-2948-13N	Negative	10°	±16	3
M-2948-13P	Positive	10°	±16	3
M-2948-16N	Negative	10°	±8	6
M-2948-16P	Positive	10°	±8	6

■ NOTE: Tap Position Sensors are available with either a positive "P" or negative "N" rotation. With **positive** rotation, the shaft of the M-2948 rotates **clockwise** while raising taps. With **negative** rotation, the shaft of the M-2948 rotates **counter-clockwise** while raising taps.

Table 1	<i>M-2948</i>	Model	Applicatio	n Information
			11	0



Figure 5 Tap Position Sensor Rotation Direction Example

Configuring M-2025D Current Loop Interface Module

M-2025D can be configured for one of four current ranges: 0 to 1 mA, 0 to 2 mA, -1 to 1 mA, or 4 to 20 mA. The current range is set by the use of an external resistor and a jumper which are provided with the M-2025D. The current ranges are set as follows:

- 1. Select the correct resistor from the Resistor Selection Table (<u>Table 2</u>) for the desired current range.
- 2. Connect the resistor between TB1-1 and TB1-2 (TB1 refers to the M-2025D Terminal Block).
- 3. Connect the provided jumper between TB1-5 and the appropriate TB1 connection, as determined from <u>Table 2</u>. Continue as follows, based on use of M-2948 Tap Position Sensor:

Configuration WITHOUT M-2948 Tap Position Sensor

- 1. Perform the current range setup as described above.
- 2. Connect TB1-3 to an appropriate earth ground.
- 3. Connect the proper interface cable (B-0753 for M-2001B/C/D, B-0752 for all others) as follows:
 - a. For the M-2001B, C, or D, ensure that the conductor end key tab is pointing toward the front of the control, then connect the six conductor cable between connector J1 of the M-2025D and P1 on the bottom of the M-2001B, C, or D.
 - b. For M-2001, M-2001A, or M-2001A-1, ensure that the five-conductor end key tab is pointed towards the front of the tapchanger control. Then connect the five-conductor cable end to P1 on the bottom of the tapchanger control and the six-conductor cable end to J1 of the M-2025D.

Configuration WITH M-2948 Tap Position Sensor

- 1. Perform the current range setup as described above.
- 2. To install the M-2948 sensor, connect positive output (Brown wire) to TB1-2.
- 3. Connect the M-2948 ground (Black wire) to TB1-1.
- ▲ CAUTION: Internally, TB1-1 is connected to ground. The current loop circuit must NOT be grounded elsewhere as damage to current loop components may occur.
 - 4. Connect the Red wire to TB1-7 (sensor power)
 - 5. Connect the Yellow wire to TB1-8 (Calibration Input #1)
 - 6. Connect the Orange wire to TB1-9 (Calibration Input #2)
 - 7. Green wire is for Factory use only. DO NOT connect to ground or M-2948 will be damaged!
 - 8. Connect the proper interface cable (B-0753 for M-2001B/C/D, B-0752 for all others) as described above in Step 3 of "*Configuration WITHOUT M-2948 Tap Position Sensor*".

Current Range	Resistor between TB1-1 & TB1-2	Beckwith Electric Part Number	Jumper Position
0 to 1 mA	3.01 KΩ	B-1786-03	TB1-5 to TB1-6
0 to 2 mA	1.5 ΚΩ	B-1786-02	TB1-5 to TB1-6
4 to 20 mA	150 Ω	B-1786-01	TB1-5 to TB1-6
4 to 20 mA With M-2948	150 Ω	B-1786-01	TB1-5 to TB1-6
-1 to 1 mA	1.5 ΚΩ	B-1786-02	TB1-4 to TB1-5 Do not use with M-2948 Tap Position Sensor

 Table 2
 Current Loop Range Resistor Selection Table

Configuring M-2001 Series Digital Tapchanger Controls

The M-2001 configuration menu provides a selection screen to disable or to select whether the M-2001 uses the Contact KeepTrack, Shaft Coupled KeepTrack, Resistor Divider KeepTrack or Motor Direct Drive KeepTrack method for tap position knowledge. The correct current range (<u>Table 3</u>) must be selected in this M-2001 configuration menu.



The following table outlines the ten selections available on the TAP INFORMATION screen.

Screen Selections	Tap Position Knowledge Method	Current Range	Screens Disabled
XFMR EXTERNAL #3	Current Loop	0 to 1 mA	Primary & Secondary Source Voltage
XFMR EXTERNAL #2	Current Loop	4 to 20 mA	Primary & Secondary Source Voltage
XFMR EXTERNAL #1	Current Loop	0 to 1, 0 to 2, or ±1 mA	Primary & Secondary Source Voltage
REG EXTERNAL #3	Resistor Divider	Not Applicable	None
REG EXTERNAL #2	Current Loop	4 to 20 mA	None
REG EXTERNAL #1	Current Loop	0 to 1, 0 to 2, or ±1 mA	None
INTERNAL KEEPTRACK	Motor Direct Drive KeepTrack	Not Applicable	None
CONTACT KT 1R1L	Direct Contact KeepTrack	Not Applicable	Primary & Secondary Source Voltage
CONTACT KT 1N	Direct Contact KeepTrack	Not Applicable	Primary & Secondary Source Voltage
DISABLE	None	None	Primary & Secondary Source Voltage, Tap Position

Table 3 Tap Information Screen Selections

■ NOTES:

- 1. When using a resistance to current transducer with an internal tap, fitted to supply a current loop to the M-2025D, the **XFMR EXTERNAL#3** selection in the **TAP INFO** menu must be selected.
- 2. XFMR EXTERNAL #3, XFMR EXTERNAL#2 and XFMR EXTERNAL#1 selections may only be used in transformer control applications.
- 3. **REG EXTERNAL#2**, **REG EXTERNAL#1** and **REG INTERNAL** selections may only be used in regulator control applications.
- 4. When using the **M-2948** Tap Sensor, only **XFMR EXTERNAL #2** for transformer application and **REG EXTERNAL #2** for Regulator applications may be used.
- 5. The **DISABLE** selection may be used for either regulator control or transformer control applications.

The following procedure outlines the steps necessary to configure an M-2001 Series Digital Tapchanger Control to use positive tap position knowledge. Level 2 security access is required to program the control to select the method of tap position knowledge or to disable this feature.

- 1. Access the TAP INFORMATION screen in the Configuration menu.
- 2. Select the tap range in **TAP MAX** and **TAP MIN** screens (range of Tap Max or Tap Min = \pm 33). Tap Max – Tap Min <34. For example, 16R – 16L = 32; 32 + 1 Neutral = 33 taps.
- NOTE: Tap ranges for the M-2001 are configurable to display a range of 33 tap positions: 16L to 1L, neutral, and 1R to 16R. These taps are proportional to the entire current range at the input of the M-2025D.
 - 3. Select the correct method of tap position knowledge.
 - 4. Set Intertap Time Delay to a minimum of 1 second.
- NOTE: When using the M-2025D Current Loop Interface Module, and Tap Limits are enabled, a one second intertap time delay should be used. This gives the control time to recognize the new tap position before a subsequent tap operation can occur. This prevents the control from driving past the established Tap Limit.

Calibration

■ NOTE: The M-2948 Tap Position Sensor must be mechanically calibrated at the neutral position. After the mechanical calibration is complete (steps 1-8 below), then perform the calibration of the M-2001 control's displayed tap position.

▲ CAUTION: Calibration of the tap position should be carefully checked, as incorrect tap positioning and limiting can result in improper voltage regulation. If the tap position knowledge function is not to be used, the control Tap Information screen should be set to DISABLE.

WARNING: Do not rely on the M-2001 display of tap position for bypassing a regulator — doing so may result in death, severe injury or damage to the regulator.

Mechanical Calibration of the Tap Position Sensor

The M-2948 Tap Position Sensor must be mechanically calibrated before attempting to read a valid tap position on the control. To calibrate the sensor perform the following:

- 1. Mount the tap sensor in the mounting bracket, leaving the mounting screws loose so that the sensor body can be rotated.
- 2. Connect the shaft of the tap sensor to the Regulator/Transformer tap position measuring shaft.
- 3. Set the Regulator/Transformer to a tap position of Neutral (With 3 neutrals set the Regulator/ Transformer to the middle neutral position).
- 4. Turn the M-2025D Calibration switch to the ON position (up).
- 5. Rotate the body of the tap sensor until the Yellow LED (labeled "NEAR NEUTRAL CAL") on the M-2025D illuminates.
- NOTE: When the Yellow LED is illuminated, it may be necessary to rotate the sensor body as much as 30° to the left or right to cause the Green LED to also illuminate. The Green LED will only illuminate within a window of 2°.
 - 6. Slowly rotate the body of the tap sensor until the Yellow and Green LEDs (labeled "NEAR NEUTRAL CAL" and "NEUTRAL CAL" respectively) on the M-2025D illuminate.
 - 7. Tighten the Sensor Mounting Screws to lock the tap sensor in position with Green LED illuminated.
 - 8. Turn the M-2025D Calibration switch to the OFF position (down). The mechanical calibration is complete.

Calibration of the M-2001 Control Displayed Tap Position

- 1. Calibration should be performed at the highest position possible between neutral and the maximum tap position. The higher the tap position during calibration, the more accurate the tap position indication.
- 2. Determine the actual tap position from the mechanical tap position indicator on the LTC Transformer or Regulator.
- 3. Scroll through the M-2001 screens to the **TAP CALIBRATE** screen in the **Configuration** menu.
- 4. Press the **ENTER** pushbutton, a flashing **"C"** indicates that the control is ready to accept data.
- 5. Press the **UP** or **DOWN** pushbutton until the correct tap position is displayed.
- 6. Press the **ENTER** pushbutton, the tap position is now calibrated and the present tap position at which the tapchanger is operating is indicated in the status menu at the **TAP POSITION** screen.
- 7. Verify that the tap position displayed on the M-2001 and the actual tap position agree:
 - If the tap position displayed on the M-2001 and the actual tap position agree, then the calibration is complete.
 - If the tap position displayed on the M-2001 and the actual tap position do not agree, then continue to the following Tap Position Sensor Troubleshooting section.

Tap Position Sensor Troubleshooting

NOTE: The following troubleshooting steps require the use of a voltage measuring device.

- 1. Verify that TB1-1 on the M-2025D does not contain any connections to chassis ground.
- 2. Measure and note the DC voltage across the resistor installed between terminals TB1-1 and TB1-2 of the M-2025D.
- 3. Initiate a tapchange either up or down, then measure and note the DC voltage across the resistor installed between terminals TB1-1 and TB1-2.
- 4. If the measured DC voltage does not change with a change in tap position, then examine the installed tap position sensor for proper operation, and then repeat Step 3.
- Based on the analog current output range of the installed tap position sensor, determine if the measured DC voltage is within ±1% of the DC voltage found in <u>Table 4</u> for the indicated tap position.
- If the measured DC voltage is not within ±1% of the <u>Table 4</u> DC voltage for the indicated tap position, then verify that the correct resistor has been installed across the proper terminals (<u>Table 2</u>).
- 7. If the measured DC voltage is within ± 1% of the <u>Table 4</u> DC voltage for the indicated tap position, then perform the following:
 - a. Ensure that the interface cable is connected to the M-2001C and the M-2025D.
 - b. Measure the DC voltage at the interface cable J1 connector (Figure 6), between pins 1 and 2. A voltage reading of the control wetting supply (12 Vdc) should be present.
 - c. Measure the DC voltage at the interface cable J1 connector, between pins 1 and 4. A voltage reading of approximately 8 Vdc should be present.
 - d. If either voltage reading is not ±10% consistent with the above stated approximate values, then contact Beckwith Electric for further assistance.

4	5	6
1	2	3

Figure 6 Interface Cable J1 Connector Pinout

Tap Position	0 - 1 mA Range Vdc	Bipolar 0 - 1 mA Range Vdc	0 - 2 mA Range Vdc	4 - 20 mA Range Vdc
-16	0.0000	-1.5000	0.0000	0.6000
-15	0.0938	-1.4063	0.0938	0.6750
-14	0.1875	-1.3125	0.1875	0.7500
-13	0.2813	-1.2188	0.2813	0.8250
-12	0.3750	-1.1250	0.3750	0.9000
-11	0.4688	-1.0313	0.4688	0.9750
-10	0.5625	-0.9375	0.5625	1.0500
-9	0.6563	-0.8438	0.6563	1.1250
-8	0.7500	-0.7500	0.7500	1.2000
-7	0.8438	-0.6563	0.8438	1.2750
-6	0.9375	-0.5625	0.9375	1.3500
-5	1.0313	-0.4688	1.0313	1.4250
-4	1.1250	-0.3750	1.1250	1.5000
-3	1.2188	-0.2813	1.2188	1.5750
-2	1.3125	-0.1875	1.3125	1.6500
-1	1.4063	-0.0938	1.4063	1.7250
0	1.5000	0.0000	1.5000	1.8000
1	1.5938	0.0938	1.5938	1.8750
2	1.6875	0.1875	1.6875	1.9500
3	1.7813	0.2813	1.7813	2.0250
4	1.8750	0.3750	1.8750	2.1000
5	1.9688	0.4688	1.9688	2.1750
6	2.0625	0.5625	2.0625	2.2500
7	2.1563	0.6563	2.1563	2.3250
8	2.2500	0.7500	2.2500	2.4000
9	2.3438	0.8438	2.3438	2.4750
10	2.4375	0.9375	2.4375	2.5500
11	2.5313	1.0313	2.5313	2.6250
12	2.6250	1.1250	2.6250	2.7000
13	2.7188	1.2188	2.7188	2.7750
14	2.8125	1.3125	2.8125	2.8500
15	2.9063	1.4063	2.9063	2.9250
16	3.0000	1.5000	3.0000	3.0000

 Table 4
 Tap Position versus Vdc Reading For Various Tap Position Sensors

M-2025D Current Loop Interface Module Tests and Standards

Voltage Withstand

Dielectric Withstand

1,500 Vac to chassis

Electrical Environment

Surge Withstand Capability:

IEEE C37.90.1	± 2.5 kV 1 MHz Oscillatory
	± 4 kV 5 kHz Fast Transient Burst
	± 5 kV 1 MHz Fast Transient

Atmospheric Environment

IEC 60068-2-1	Cold -40°C (-40°F) (operating)
IEC 60068-2-2	Dry Heat +85°C (+185°F) (operating)
IEC 60068-2-30	Damp Heat cycles +25°C, +55°C @ 95% _{RH}
IEC 60664-3	Conformal coat grade UV40-250 board protection -50° C (-58° F) to +125° C (+257° F) CAT IV

Physical

Size: 2-5/8" high x 6-1/2" wide x 1-1/8" deep (6.65 cm x 16.76 cm x 2.86 cm)
Approximate Weight: 1 lb (0.45 kg)
Approximate Shipping Weight: 2 lbs (0.91 kg)

Mounting

The M-2025D Current Loop Interface Module may be mounted on any flat surface at least 6-1/2" wide and 2-5/8" high. The figure below depicts the hole drill dimensions for the M-2025D.



Figure 7 Hole Drill Dimensions

M-2948 Tap Position Sensor Tests and Standards

The M-2948 Tap Position Sensor complies with the following Electro Magnetic Compatibility (EMC) standards:

EN55022 (2001) Class B: Emissions Radiated 30-230 MHz: 30 db/µV; 230-1000 MHz: 37 db/µV

EN55024 (2003) Including:

Esd: 8 kV Air; 4 kV Contact
Radiated Immunity: 27 Mhz–1Ghz, 10 V/m
Fast Transient/Burst: 1 kV Supply, .5 kV Signal
Surge Immunity: 1 kV Signal
Conducted Immunity: 150 kHz–80 MHz 10 V emk or 16 V RMS
Magnetic Field Immunity: 30 A/M @ 50 Hz

Atmospheric Environment

Temperature Range:	-40°C to +80°C
Humidity:	Operational to a maximum of 95% relative humidity

Mounting

The Tap Position Sensors directly mount in place of the Incon 1250 Series Tap Sensors.

Options

Mounting Bracket - Part No. 441-41191 (Figure 4)

Physical

Size:	Body	2.5" Long X 1.44" Wide (62.35 mm X 36.5 mm)
	Shaft	0.5" Long X 0.19" Wide (12.7 mm X 4.76 mm)
	Cable Length	12' (3.6 m)

Approximate Weight: 0.7 lbs

Warranty

The M-2025D Current Loop Interface Module and M-2948 Tap Position Sensor are covered by a five year warranty from date of shipment.

TRADEMARKS

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BECKWITH ELECTRIC

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