Acromag®

Series 655T/656T
Single/Dual Channel Two-Wire Transmitters
mV/TC Input

USER'S MANUAL

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Safety Summary - Symbols on equipment:

Means “Caution, refer to this manual for additional information”.

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IMPORTANT SAFETY CONSIDERATIONS

It is very important for the user to consider the possible adverse effects of power, wiring, component, sensor, or software failures in designing any type of control or monitoring system. This is especially important where economic property loss or human life is involved. It is important that the user employ satisfactory overall system design. It is agreed between the Buyer and Acromag, that this is the Buyer's responsibility.

1.0 INTRODUCTION

These instructions cover the hardware functionality of the transmitter models listed in Table 1. Supplementary sheets are attached for units with special options or features.

Table 1: Models Covered in This Manual

Series/ Input/Type	-Options/Output/ Enclosure/Approvals[1]	-Factory Configuration[2]
655T	-0600[3]	-C
656T	-0600[3]	-C
656T	-E600	-C

Notes (Table 1):
1. Approvals: cULus Listed.
   Hazardous Locations: Class I; Division 2; Groups A,B,C,D. (See specifications).
2. Include the “-C” suffix to specify factory configuration option. Otherwise, no suffix is required for standard configuration.
3. Model 655T-0600 units have one I/O channel, while 656T-0600 transmitters have two independent I/O channels. Economy Model 656T-E600 operates the same as 656T-0600, but only supports the TC type J & K, and 0-125mV input ranges, and provides no TC linearization.

DESCRIPTION

Series 655T/656T Transmitters are members of the popular Acromag transmitter, isolator, and alarm family. These models are simple, low cost, isolated, two-wire transmitters for multi-range thermocouple or DC voltage input signals, in single (655T), and dual (656T) channel configurations. These models are fully reconfigurable via external DIP and toggle switches on the module.

These models provide one or two inputs for either DC millivolts or thermocouple input signals. The dual channels of Model 656T units operate completely isolated and independent of one another. Thermocouple reference-junction compensation, linearization, and open circuit or TC break detection is included. Front panel toggle switches are used to facilitate field calibration of zero and full-scale. Side access DIP switches select the input range & type, disable/enable TC break, set TC break upscale or down-scale, turn CJC On/Off, turn linearization On/Off, and lock/unlock zero/full-scale adjustment. The unit may be calibrated for a normal or reverse acting output response.

The module uses a high resolution, low noise, Sigma-Delta, Analog to Digital Converter (Σ-Δ ADC) to accurately convert the input signal into a digitized value. An optically isolated PWM circuit provides the corresponding process current output. These units contain an advanced technology microcontroller with integrated downloadable flash memory and EEPROM for non-volatile program, configuration, calibration, and parameter data storage. Flexible transmitter functionality, variable range inputs, plus convenient switch programming makes this instrument extremely versatile over a broad range of applications.

These modules are designed to withstand harsh industrial environments. They feature RFI, EMI, ESD, EFT, and surge protection, plus low temperature drift, wide ambient temperature operation, and isolation between input and power/output. They also have low radiated emissions per CE requirements.

Units are DIN-rail mounted and removable terminal blocks facilitate ease of installation and replacement, without having to remove wiring. Connectors are an industry standard screw clamp type and accept a wide range of wire sizes.

The safe, compact, rugged, reconfigurable, and reliable design of this transmitter makes it an ideal choice for control room and field applications. Custom module configurations are also possible (please consult the factory).

Key 656T Features

- **Easy Switch Configuration** - The unit is fully configurable via DIP switches. Scaling of the zero and full-scale I/O points is accomplished via front-panel toggle switches. No additional software, adapters, or host computer are required to program this transmitter.
- **Convenient Two-Wire Loop Power** - The output signal and power share the same two-wire connections.
- **Fully Isolated** - Input and output/power are isolated from each other for safety and increased noise immunity. Dual channel units are also isolated channel-to-channel.
- **Linearized or Non-Linearized Output Response** - A DIP switch is used to enable/disable thermocouple linearization. Model 656T-E600 units do not support TC linearization.
- **Normal or Reverse Acting Output Direction** - The output of this transmitter may be configured for a normal acting (ascending), or reverse acting (descending) response.
- **Configuration Lock** - A DIP switch is used to lock and unlock reconfiguration capability and help prevent inadvertent reconfiguration or tampering in the field. Plastic covers (packaged separately) are also provided to conceal the DIP switches.
- **Flexible Multi-Range DC Millivolt or TC Inputs** - Accepts either DC millivolt or thermocouple input signals in a wide variety of ranges. Linearization, break detection, and TC reference junction compensation are included.
- **High-Resolution Precise A/D Conversion** - Transmitters include a high-resolution, low noise, Sigma-Delta Analog to Digital Converter (Σ-Δ ADC) for high accuracy and reliability.
- **Automatic Self-Calibration** - Self-calibration is built-in to correct for temperature drift of the input circuit.
- **Wide Ambient Operation** - The unit is designed for reliable operation over a wide ambient temperature range.
- **Hardened For Harsh Environments** - The unit will operate reliably in harsh industrial environments and includes protection from RFI, EMI, ESD, EFT, and surges, plus low radiated emissions per CE requirements.
- **Convenient Mounting, Removal, & Replacement** - The DIN-rail mount and plug-in type terminal blocks make module removal and replacement easy.

2.0 PREPARATION FOR USE

UNPACKING AND INSPECTION

Upon receipt of this product, inspect the shipping carton for evidence of mishandling during transit. If the shipping carton is badly damaged or water stained, request that the carrier's agent be present when the carton is opened. If the carrier's agent is absent when the carton is opened and the contents of the carton are damaged, keep the carton and packing material for the agent's inspection.

For repairs to a product damaged in shipment, refer to the Acromag Service Policy to obtain return instructions. It is suggested that salvageable shipping cartons and packing material be saved for future use in the event the product must be shipped.

This module is physically protected with packing material and electrically protected with an anti-static bag during shipment. However, it is recommended that the module be visually inspected for evidence of mishandling prior to applying power.

This circuit utilizes static sensitive components and should only be handled at a static-safe workstation.

INSTALLATION

The transmitter module is packaged in a general purpose plastic enclosure. Use an auxiliary enclosure to protect the unit in unfavorable environments or vulnerable locations, or to maintain conformance to applicable safety standards. Stay within the specified operating temperature range. As shipped from the factory, the unit is factory calibrated for all valid input ranges, the full input range is scaled to 4 to 20mA at the output, and has the default configuration shown in Table 2 below:

WARNING: Applicable IEC Safety Standards may require that this device be mounted within an approved metal enclosure or sub-system, particularly for applications with voltages greater than or equal to 75VDC or 50VAC.

Table 2: 655T/656T Default Configuration (Each I/O Channel)

PARAMETER	CONFIGURATION/CALIBRATION
Input Range	J TC Type (-210°C to +760°C)
TC Break Detection	Disabled
TC Break Direction	Upscale (When Enabled)
CJC	Enabled
Linearization	Enabled (Except 656T-E600)
Z/FS Configuration Lock	Enabled (Locked)
I/O Scaling (Zero/Full-Scale Configuration)	Input for 4mA Output = -210°, Input for 20mA Output = +760°C.

Note: The default configuration noted above corresponds to all DIP switches set to their OFF (open circuit) positions.

Your application may differ from the default configuration noted above and will require that the transmitter be reconfigured to suit your needs. This is accomplished by first setting the DIP switches, then optionally re-scaling your input range to the 4mA and 20mA output range endpoints as described in Section 3.0.

It is generally more convenient to set the DIP switches and configure zero and span prior to completing the installation as described below. As such, you may wish to refer to Section 3.0 at this point to set the DIP switches and configure zero and span per your application, before completing installation.

Mounting

Refer to Enclosure Dimensions Drawing 4501-780 for mounting and clearance dimensions.

DIN Rail Mounting: This module can be mounted on "T" type DIN rails. Use suitable fastening hardware to secure the DIN rail to the mounting surface. Units may be mounted side-by-side on 1-inch centers for limited space applications.

"T" Rail (35mm), Type EN50022: To attach a module to this style of DIN rail, angle the top of the unit towards the rail and locate the top groove of the adapter over the upper lip of the rail. Firmly push the unit towards the rail until it snaps solidly into place. To remove a module, first separate the input terminal block(s) from the bottom side of the module to create a clearance to the DIN mounting area. Next, insert a screwdriver into the lower arm of the DIN rail connector and use it as a lever to force the connector down until the unit disengages from the rail.

Electrical Connections

Terminals can accommodate wire from 14-24 AWG, solid or stranded. Since common mode voltages can exist on signal wiring, adequate wire insulation should be used and proper wiring practices followed. Input wiring may be shielded or unshielded twisted-pair. Output wires should be twisted pair. Strip back wire insulation 1/4-inch on each lead before installing into the terminal block. It is recommended that output wiring be separated from the input wiring for safety, as well as for low noise pickup. Note that each channel's terminal block is of a plug-in type that can be easily removed to facilitate module removal or replacement, without removing individual wires. To prevent electric shock, be sure to remove the I/O signal before unplugging the terminals to uninstall the module or before attempting service. All connections should be made with I/O signals removed.

CAUTION: Risk of Electric Shock - More than one disconnect switch may be required to de-energize the equipment before servicing.

1. **Input (Each Input):** Connect input(s) per Electrical Connections Drawing 4501-778. Observe proper polarity when making connections.

2. **Output/Power Connections (Each Output)**: Connect a DC power supply and load in a two-wire configuration as shown in Electrical Connections Drawing 4501-778. Loop current is input to the OUT+ lead and returned via the OUT- lead. These transmitters operate from DC supplies only. Power supply voltage is not critical and should be from 12-36V DC. Further, the power supply voltage must be adequate to supply full-scale current to the load, plus 12V to the transmitter terminals, plus any transmission line drop. Variations in power supply voltage or load resistance within rated limits has negligible effect on transmitter accuracy.

   Ripple & Noise: Power supply ripple at 60Hz/120Hz is normally reduced at the load by the transmitter. The ripple at the load will generally be less than 0.02% of span per volt peak-to-peak of power supply ripple. Connect an external 1uF capacitor across the load to further reduce this ripple if desired.

   For sensitive applications with high-speed acquisition rates, high frequency noise may be suppressed by placing a 0.1uF capacitor directly across the load.

   Inductive Loads: If the two-wire current loop includes a highly inductive load (such as an I/P transducer), this may reduce output stability. In this case, place a 0.1uF capacitor directly across the inductive load and this will typically cure the problem.

3. **Grounding:** See Electrical Connections Drawing 4501-778. The module housing is plastic and does not require an earth ground connection. If the transmitter is mounted in a metal housing, a ground wire connection is typically required. Connect the metal enclosure's ground terminal (green screw) to earth ground using suitable wire and per applicable codes.

WARNING: For compliance to applicable safety and performance standards, the use of twisted pair wiring is recommended as shown in Drawing 4501-778. Failure to adhere to sound wiring and grounding practices as instructed may compromise safety and performance.

3.0 MODULE CONFIGURATION

This transmitter module needs to be configured for your application. Configuration is accomplished by first setting the DIP switches as required, then optionally re-scaling the input range to the 4-20mA output range endpoints.

All valid input ranges have already been calibrated at the factory. By default, the output 4mA and 20mA range end points are factory set to correspond to the full input range endpoints, but may be optionally adjusted to correspond to a portion of the input range as described below. Reconfiguration of transmitter zero and full-scale is accomplished via momentary toggle switches on the front of the module.

DIP SWITCH SETTINGS

Adjacent to the I/O channel terminals are a bank of 12 DIP switches used to select the input range/type, disable/enable TC break detection, set TC break upscale or down-scale, turn CJC On or Off, enable/disable linearization, and lock/unlock reconfiguration. DIP switch 12 is used to optionally lockout zero/full-scale reconfiguration and must be set ON to facilitate zero and full-scale adjustment. Refer to Drawing 4501-779 and Table 3 below to locate and set these switches as required for your application (shaded entries refer to the factory default configuration). After setting the switches, you will need to configure the zero and full-scale input points via the front panel toggle switches as described below. You should also install the plastic covers (packaged separately) over the DIP switch openings after making your settings (partial enclosure disassembly is required). This helps protect the circuit from penetration by ESD or debris, and prevents tampering in the field.

Table 3A: Input Range/Type Selection - DIP Switch Settings

INPUT RANGE	S1	S2	S3	S4	S5,6,7[2]
J TC	0	0	0	0	NA
K TC	1	0	0	0	NA
T TC	0	1	0	0	NA
R TC	1	1	0	0	NA
S TC	0	0	1	0	NA
E TC	1	0	1	0	NA
B TC	0	1	1	0	NA
N TC	1	1	1	0	NA
0-1.0V[3]	0	0	0	1	NA
0-500mV[3]	1	0	0	1	NA
0-250mV[3]	0	1	0	1	NA
0-125mV[3]	1	1	0	1	NA
±62.5mV	0	0	1	1	NA
±31.3mV	1	0	1	1	NA
±15.6mV	0	1	1	1	NA
Reserved	1	1	1	1	NA

Notes (Table 3A):

1. NA = No Application; Don't Care; 0 = Switch Open/OFF; 1 = Switch Closed/ON.
2. Note that switches SW5, SW6, SW7 have no function and are reserved for future use.
3. The unit will permit calibration below 0V, down to -65mV typical, for these ranges.
4. The economy Model 656T-E600 only provides support for the three ranges indicated in **BOLD** (J, K, 0-125mV).

Table 3B: Miscellaneous Options - DIP Switch Settings

MISCELLANEOUS OPTIONS	SW 8	SW 9	SW 10	SW 11	SW 12
Break Detection ON	1				
Break Detection OFF	0				
TC Break Downscale		1			
TC Break Upscale		0			
CJC OFF			1		
CJC ON			0		
Linearization[3] OFF				1	
Linearization[3] ON				0	
Configuration Lock OFF					1
Configuration Lock ON					0

Notes (Table 3B):

1. 0 = Switch Open/OFF; 1 = Switch Closed/ON.
2. The Default Configuration is all switches OFF (0). This corresponds to the factory default configuration of J TC type, TC Break OFF, TC Break Upscale, CJC ON, Linearization Enabled, and Reconfiguration Locked Out.
3. The economy Model 656T-E600 does not support TC linearization (set via SW11) and this setting will be ignored.

These units were packaged with one or more plastic covers for installation over the DIP switch openings. Do not install the DIP switch cover(s) until you have completed the zero and span configuration procedure outlined in the following section. This is done to maintain access to the Configuration Lock switch (SW12), which should be locked following zero and span reconfiguration to help prevent inadvertent miscalibration or tampering in the field.

ZERO AND SPAN CONFIGURATION

IMPORTANT: You must set your DIP switches according to your application prior to configuring the zero and full-scale input points as described below (see above).

UNLOCK RECONFIGURATION: Reconfiguration of zero and full-scale is locked out by default and must be unlocked before making adjustments to zero and full-scale--DIP switch 12 must be set ON to unlock the front-panel Z/FS toggle switches.

After setting the DIP switches as required for your application, you may optionally re-scale your input range to the output 4mA and 20mA endpoints as described here. Configuration of the zero & full-scale I/O points (essentially input to output scaling) is accomplished via the transmitter module's "Z" and "FS" Up/Down toggle switches located on the front panel (see Drawing 4501-779).

Equipment Required

An accurate input source adjustable over the range desired for zero and full-scale is required. A thermocouple calibrator may also be used. An accurate current or voltage meter is also required to monitor the output level. For best results, the input source and output meter must be accurate beyond the required specifications. For voltage inputs, use a voltage source with an output impedance of 100Ω or less.

In the absence of a thermocouple calibrator, a convenient method of configuring the TC input would be to use a precision mV source with the module's CJC set to OFF. Using this method allows the mV source to be wired directly to the input terminals using copper wires. The module's cold junction compensation is turned off and the mV values applied to the input are the equivalent thermoelectric voltages that correspond to the minimum and maximum temperatures of your desired input range and are specific to each TC type. Refer to Table 4 of the following page for a list of thermocouple voltages at specific temperatures. After setting zero and full-scale in this manner, the CJC switch should be returned to the ON position to enable cold junction compensation.

Transmitter Zero/Full-Scale Configuration Procedure

CAUTION: Input levels outside of the nominal range of the selected input will not be accepted for configuration of zero or full-scale. Since input levels cannot be validated during field programming, entering incorrect signals may produce an undesired output response.

Note: The transmitter's input range/type, TC break on/off, TC break up/down direction, CJC on/off, linearization, and zero/full-scale reconfiguration lock/unlock is set via the DIP switches. Each input range is already factory calibrated and scaled to the 4 to 20mA output by default. However, you may use the front panel toggle switches to scale virtually any part of the nominal input range to the 4-20mA output range. For example, use the 0 to 200°C portion of the type J TC input to drive the 4 to 20mA output range--this configuration will be used as an example in the following procedure.

Refer to the Table 4 of the following page when using a precision millivoltage source to configure the zero and full-scale input range endpoints (with CJC turned Off).

Transmitter Zero/Full-Scale Configuration Procedure

1. Set DIP switch 12 of the channel to the up/ON or "Unlock" position to allow the front panel toggle switches to make adjustments to zero and full-scale.
2. Connect a precision voltage source or thermocouple calibrator to the input, as required. Connect a current milliampmeter (in series with the loop), or voltmeter (across a precision load resistor), to accurately read the output signal. Apply power to the transmitter.
3. Adjust the input source to the zero level (this level must be within the input range selected). For our example: use 0°C.
4. If the measured output is not precisely at zero (4.000mA), depress the **Zero** "Z" toggle switch to the **"UP"** or "**DN**" position as required, to precisely adjust the output current to 4.000mA.
   Note: *The Zero Up/Down toggle functions as a trim adjustment for the zero output loop current level. Successive depressions of the "UP" or "DN" toggle positions will increment or decrement the output current by a small amount, while holding the toggle switch in the "UP' or "DN" position will increase the amount of increment or decrement.*
   Reverse Acting Outputs: A reverse acting output can be easily obtained by using the Up/Down toggle to adjust the output level accordingly. For a reverse acting output, you would adjust the zero output level to a higher level here (20.000mA) in response to the zero input, and a lower level (4.000mA) in response to a full-scale input signal (step 6).
5. Adjust the input source to the full-scale level (the input value must be within the input range selected). For our example: use 200°C.
   Note: *The full-scale input value must be greater than the zero input value. If the zero and full-scale points are too close together, performance will be degraded.*
6. If the output is not exactly at the full-scale level (20.000mA), press the **Full-Scale** "FS" Up/Down toggle to the **"UP"** or **"DN"** position, as required to precisely adjust the output current to 20.000mA.
   Note: *The FS Up/Down toggle functions as a trim adjustment for the full-scale output loop current level. Successive depressions of the "UP" or "DN" toggle positions will increment or decrement the output current by a small amount, while holding the toggle switch in "UP' or "DN" position will increase the amount of increment or decrement.*
   Reverse Acting Outputs: A reverse acting output can be easily obtained by using the Up/Down toggle to adjust the output level accordingly. For a reverse acting output, you would adjust the output level to a lower level (4.000mA) in response to the full-scale input here, and a higher level (20.000mA) in response to a zero input signal (step 4).
7. After completing zero and full-scale adjustment, be sure to return DIP switch 12 to the down or "Lock" position after waiting at least 15 seconds. This will help prevent inadvertent reconfiguration or tampering in the field by locking out adjustment via the front panel zero and full-scale toggle switches. Repeat this procedure for the second channel of dual channel units.

IMPORTANT: Note that the zero and full-scale adjustments take effect immediately and are saved to non-volatile memory after 15 seconds of toggle switch inactivity. Please wait at least 15 seconds following adjustment before powering down or setting DIP switch 12 to the "Lock" position or your new configuration settings will be lost.

After setting the DIP switches as required by your application and configuring zero and span, be sure to install the plastic cover(s) over the DIP switch openings. To install these covers, you will have to remove the left side cover by prying at each corner with a screwdriver, then sliding the DIP switch covers into the switch opening. Replace the left side cover by snapping it into place and applying pressure at each corner to secure.

4.0 THEORY OF OPERATION

Refer to Simplified Schematic 4501-777 to gain a better understanding of the circuit. A portion of the output loop current is routed to a transformer while being driven in an alternating push-pull fashion to generate an input supply. The remaining output current is pulled through a current steering circuit that regulates the loop current based on an optically coupled input signal. The transmitter will accept a thermocouple or voltage input, and condition it to a voltage signal for the A/D converter. A reference temperature sensor signal voltage is also input to the A/D. The A/D converter stage then applies appropriate gain to these signals, performs analog-to-digital conversion, and digitally filters the signals. The digitized signals are then transmitted serially to a microcontroller. The microcontroller completes the transfer function according to the input type and configuration, and sends a corresponding output signal to an optocoupler and filter circuit. A corresponding analog output voltage is generated and used to drive the amplifier used to modulate the loop current. The embedded configuration and calibration parameters are stored in non-volatile memory integrated within the micro-controller.

Table 4: Thermocouple milliVoltage Versus Temperature
(From the National Institute of Standards and Technology (NIST) Thermocouple Tables)

TEMP	Thermoelectric Voltage In milliVolts (With Reference Junction at 0°C)						
°C	J	K	T	E	R	S	B
- 250	---	-6.404	-6.181	-9.719	---	---	---
- 200	-7.890	-5.891	-5.603	-8.824	---	---	---
- 150	-6.499	-4.912	-4.648	-7.279	---	---	---
- 100	-4.632	-3.553	-3.378	-5.237	---	---	---
- 50	-2.431	-1.889	-1.819	-2.787	---	---	---
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+ 50	2.585	2.022	2.035	3.047	0.296	0.299	---
+ 100	5.268	4.095	4.277	6.317	0.647	0.645	---
+ 150	8.008	6.137	6.702	9.787	1.041	1.029	---
+ 200	10.777	8.137	9.286	13.419	1.468	1.440	---
+ 250	13.553	10.151	12.011	17.178	1.923	1.873	---
+ 300	16.325	12.207	14.860	21.033	2.400	2.323	---
+ 350	19.089	14.292	17.816	24.961	2.896	2.786	---
+ 400	21.846	16.395	20.869	28.943	3.407	3.260	---
+ 450	24.607	18.513	---	32.960	3.933	3.743	1.002
+ 500	27.388	20.640	---	36.999	4.471	4.234	1.241
+ 550	30.210	22.772	---	41.045	5.021	4.732	1.505
+ 600	33.096	24.902	---	45.085	5.582	5.237	1.791
+ 650	36.066	27.022	---	49.109	6.155	5.751	2.100
+ 700	39.130	29.128	---	53.110	6.741	6.274	2.430
+ 800	---	33.277	---	61.022	7.949	7.345	3.154
+ 900	---	37.325	---	68.783	9.203	8.448	3.957
+1000	---	41.269	---	76.358	10.503	9.585	4.833
+1200	---	48.828	---	---	13.224	11.947	6.783
+1400	---	---	---	---	16.035	14.368	8.952
+1600	---	---	---	---	18.842	16.771	11.257
+1700	---	---	---	---	20.215	17.942	12.462
+1750	---	---	---	---	20.878	18.504	13.008
+1800	---	---	---	---	---	---	13.585

5.0 SERVICE AND REPAIR

CAUTION: Risk of Electric Shock - More than one disconnect switch may be required to de-energize the equipment before servicing.

SERVICE AND REPAIR ASSISTANCE

This module contains solid-state components and requires no maintenance, except for periodic cleaning and transmitter configuration parameter (zero and full-scale) verification. Since Surface Mounted Technology (SMT) boards are generally difficult to repair, it is highly recommended that a non-functioning module be returned to Acromag for repair. The board can be damaged unless special SMT repair and service tools are used. Further, Acromag has automated test equipment that thoroughly checks and calibrates the performance of each module. Please refer to Acromag's Service Policy Bulletin or contact Acromag for complete details on how to obtain service parts and repair.

PRELIMINARY SERVICE PROCEDURE

Before beginning repair, be sure that all installation and configuration procedures have been followed and that the unit is wired properly. Verify that power is applied and that your power supply voltage is sufficient to supply full-scale current into the load (0.020*R), plus 12V at the module terminals, plus any line drop. If you continue to have a problem with the unit after making these checks, then an effective and convenient fault diagnosis method is to exchange the questionable module with a known good unit.

Acromag's Application Engineers can provide further technical assistance if required. When needed, complete repair services are available from Acromag.

6.0 SPECIFICATIONS

655T-0600, Single, 2-Wire, mV/TC Isolated Channel
656T-0600, Dual, Independent 2-Wire, mV/TC Isolated Channels
656T-E600, Dual, Independent 2-Wire, mV/TC Isolated Channels

General: The Model 655T/656T-0600 Two-Wire Transmitters accept either thermocouple or voltage input(s), provide input-to-output and channel-to-channel isolation, and generate 4 to 20mA two-wire output signal(s). The 655T-0600 unit provides a single isolated I/O channel, while the 656T-0600 unit provides two independent isolated I/O channels. The economy Model 656T-E600 is similar to the 656T-0600, but only supports the TC type J & K, and 0-125mV input ranges, and provides no TC linearization. Units are fully configured via external DIP and toggle switches. The transmitters are connected in two-wire fashion with the output signal and power sharing the same leads. These transmitters are DIN-rail mounted with plug-in type terminal blocks. Non-volatile reprogrammable memory within the module stores calibration and configuration information.

MODEL NUMBER DEFINITION

Transmitters are color coded with a white label. The prefix "6" denotes the Series 600 family of transmitters and isolators, while the "T" suffix specifies that this device is primarily a process transmitter.

65xT: Two-wire, single channel (655T), or dual channel (656T) transmitters for mV/TC inputs.

-0600: The four digits of this model suffix represent the following options, respectively:

0 = Option specifier - 0=Standard, E=Economy Model;
6 = Output is DC current;
0 = Enclosure is DIN rail mounted;
0 = Approvals: cULus Listed, UL file E199702 & E202242.
Hazardous Locations: Class I; Division 2; Group A, B, C, D.

INPUT SPECIFICATIONS

Unit must be wired and configured for the intended input type and range (see Installation Section for details). The unit can be configured to accept any one of the input types described below via the DIP switches. Note that economy Model 656T-E600 units only support the TC type J & K, and 0-125mV input ranges, with no TC linearization provided. Toggle switches on the unit are used to scale the input to the 4-20mA output. The following paragraphs summarize this module's input types, ranges, and applicable specifications.

Thermocouple: User-configured for the eight types of thermocouples shown in Table 5. Model 656T-E600 units only support J & K TC types, plus the 0-125mV input range. Linearization (separately enabled), Cold-Junction Compensation (CJC), and open circuit or lead break detection are included. Model 656T-E600 units do not support TC linearization.

TC Input Reference Test Conditions: TC Configured for a 10mV TC span (e.g. Type J at 186°C); Ambient Temperature = 25°C; Power Supply = 24V DC, R-load=500Ω.
Thermocouple Reference: Accurate to better than ±0.4°C typical at 25°C. Ambient temperature effect of the CJC circuit is ±0.01°C/°C typical.
Note: DIP switch SW10 allows CJC to be switched off to allow direct connection of a mV source to the input in order to complete zero and full-scale calibration of a TC input if desired. CJC is ignored for voltage input ranges.
IMPORTANT: CJC temperature is only resolved to 0.1°C. As such, units calibrated for smaller spans may appear less accurate with CJC ON as ±0.1°C becomes a greater percentage of span. Keep this in mind when resolving measurements with smaller spans and higher gains.
TC Linearization (Separately Enabled): Within ±0.25°C of the NIST tables. Model 656T-E600 units do not support TC linearization.

Table 5: TC Types, Ranges, and Accuracy

TC Type	TC Material	ISA/ANSI Color	°C Temp Range	Typical Accuracy
J	+Iron, -Constantan	white red	-210 to + 760°C	±0.5°C
K	+Chromel, -Alumel	yellow black	-200 to +1372°C	±0.5°C
T	+Copper, -Constantan	blue red	-260 to + 400°C	±0.5°C
R	+Pt/13%Rh, -Constantan	black red	- 50 to +1768°C	±1.0°C
S	+Pt/10%Rh, -Constantan	black red	- 50 to +1768°C	±1.0°C
E	+Chromel, -Constantan	purple red	-200 to +1000°C	±0.5°C
B	+Pt/10%Rh, -Pt/6%Rh	gray red	+260 to 1820°C	±1.0°C
N	+Nicrosil, -NISIL	orange red	-230 to -170°C; -170 to +1300°C	±1.0°C ±0.5°C

DC Voltage: User-configured for the following DC voltage ranges: ±15.6mV, ±31.3mV, ±62.5mV, 0-125mV, 0-250mV, 0-500mV, 0-1.0V.
Voltage Input Reference Test Conditions: ±62.5mV input range configured with a 10mV span; Ambient Temperature = 25°C; Power Supply = 24V DC; R-load=500Ω.
Accuracy for mV Inputs: Better than ±0.1% of span.

General Input Specifications
Input Filter Bandwidth: -3dB at 3Hz, typical.
Input Bias Current: 25nA typical.
Noise Rejection (Normal Mode): Better than 40dB @ 60Hz, typical with 100Ω input unbalance.
Noise Rejection (Common Mode): Better than 140dB @ 60Hz, typical with 100Ω input unbalance.
Analog to Digital Converter (A/D): A 16-bit Σ-Δ converter.
Input Filter: Normal mode filtering, plus digital filtering optimized and fixed per input range within the Σ-Δ ADC.

OUTPUT SPECIFICATIONS

DC Process Current Output Specifications:

Output Range: 4 to 20mA DC, 3.8 to 23.8mA range typical.
Output Ripple: Less than ±0.1% of output span.
Output Limiting: Output current is limited to less than 25mA, typical.
Output Maximum Current: 23.8mA typical, 25mA maximum.
Output Compliance: 12V Minimum, 13V Typical, with a 24V supply and 20mA loop current.
Output Resolution: The output stage resolves to 1 part in 6546 for a 4 to 20mA output span. Note that input resolution is limited to 0.1°C (TC inputs). Thus, the effective resolution is controlled by the output stage for TC input spans greater than 655°C (resolves 1 part in 6546), or the input stage for TC input spans less than 655° (resolves to 0.1°C). For most voltage input ranges, the effective resolution is controlled by the output stage (resolves to 1 part in 6546).

General Output Specifications:

Response Time: For a step change in input signal, the analog output reaches 98% of final value in less than 980ms typical, with a 500Ω load. Response time will vary with load resistance.
Accuracy: Typical TC accuracy is listed in Table 5. Voltage accuracy is better than ±0.1% of output span (±16uA), typical. CJC resolution may degrade accuracy for smaller input spans. This error includes the combined effects of isolator repeatability, hysteresis, terminal point linearity, and adjustment resolution. It does not include sensor error. Relative accuracy will vary with calibrated input span and effective resolution.
Accuracy Versus Temperature: Better than ±0.010% of input span per °F (±0.018% per °C or ±180ppm/°C) over the ambient temperature range for reference test conditions. This specification includes the combined effects of zero and span drift over temperature.
Output Power Supply: 12-36V DC Class 2, 24mA. The supply voltage must be chosen to provide full-scale current to the load (0.020*R), plus 12V to the isolator terminals, plus any line drop. Reverse polarity protection is included.
Power Supply Effect: Less than ±0.001% of output span effect per volt DC change, or ±0.015% of output span effect per volt peak-to-peak of 60Hz/120Hz power supply ripple.
Output Load Resistance Effect: Less than ±0.01% of output span effect for ±100Ω change in load resistance.
Load Resistance Range Equation: R_{load} (Maximum) = (V_{supply} - 12V)/0.020A (assuming negligible line drop). At a 24V DC supply, R_{load} = 0-600Ω.
Note: For sensitive applications with high-speed acquisition rates, high frequency noise may be reduced considerably by simply placing a 0.1uF capacitor directly across the load.
Output Conversion Rate: Every 50ms or 20 conversions per second (millivoltage ranges), every 306ms or 3 conversions per second (thermocouple ranges).

APPROVALS (-xxx0)

0:
cULus Listed
Hazardous Locations: Class I ; Division 2; Groups A, B, C, D.

ENCLOSURE/PHYSICAL SPECIFICATIONS

Unit is packaged in a general purpose plastic enclosure that is DIN rail mountable for flexible, high density (approximately 1" wide per unit) mounting. See Enclosure Dimensions Drawing 4501-780 for details.

Dimensions: Width = 1.05 inches, Height = 4.68 inches, Depth = 4.35 inches (see Drawing 4501-780).
DIN Rail Mounting (-xx0x): DIN rail mount, Type EN50022; "T" rail (35mm).
Connectors: Removable plug-in type terminal blocks; Current/ Voltage Ratings: 15A/300V; Wire Range: AWG #14-24 solid or stranded; Separate terminal blocks are provided for each I/O channel.
Case Material: Self-extinguishing NYLON type 6.6 polyamide thermoplastic, UL94 V-2, color beige; general purpose NEMA Type 1 enclosure.
Printed Circuit Boards: Military grade FR-4 epoxy glass.
Shipping Weight: 1 pound (0.45 Kg) packed.

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature: -25°C to +75°C (-13°F to +167°F), Temperature Code: T4.
Storage Temperature: -40°C to +85°C (-40°F to +185°F).
Relative Humidity: 5 to 95%, non-condensing.
Isolation: Inputs, outputs, and channels are isolated from each other for common-mode voltages up to 250VAC, or 354V DC off DC power ground, on a continuous basis (will withstand 1500VAC dielectric strength test for one minute without breakdown). This complies with test requirements outlined in ANSI/ISA-82.01-1988 for the voltage rating specified.
Installation Category: Designed to operate in an Installation Category for use in pollution degree 2.
Radiated Field Immunity (RFI): Designed to comply with IEC1000-4-3 Level 3 (10V/M, 80 to 1000MHz AM & 900MHz keyed) and European Norm EN50082-1.
Electromagnetic Interference Immunity (EMI): No output shift will occur beyond ±0.25% of span, under the influence of EMI from switching solenoids, commutator motors, and drill motors.
Electrical Fast Transient Immunity (EFT): Complies with IEC1000-4-4 Level 3 (2KV) and European Norm EN50082-1.
Electrostatic Discharge (ESD) Immunity: Complies with IEC1000-4-2, Level 3 (8KV/4KV air/direct discharge) to the enclosure port and European Norm EN50082-1.
Surge Immunity: Complies with IEC1000-4-5 Level 3 (2.0KV) and European Norm EN50082-1.
Radiated Emissions: Meets or exceeds European Norm EN50081-1 for class B equipment.

IMPORTANT: Power, input, and output (I/O) wiring must be in accordance with Class I, Division 2 wiring methods Article 501-4(b) of the National Electrical Code, NFPA 70 for installations in the U.S., or as specified in section 18-1J2 of the Canadian Electrical Code for installations within Canada and in accordance with the authority having jurisdiction.

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D, or non-hazardous locations only.

WARNING – EXPLOSION HAZARD – Substitution of components may impair suitability for Class I, Division 2.

WARNING – EXPLOSION HAZARD – Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

CAUTION – To reduce the risk of fire or electric shock, do not interconnect the outputs of different class 2 circuits.

CONFIGURATION CONTROLS

Configuration of this transmitter is accomplished via external DIP switches and toggle switches provided for each channel and described below:

Toggle Switches (Each Channel, See Drawing 4501-779):
The following SPDT toggle switches are used to configure the transmitter's zero and full-scale end points (input to output scaling) and are located on the front panel. Adjustment via these switches may be locked out via DIP switch 12 (see below).

Z (Zero) Up/Down - Used to adjust the **Zero** endpoint during field configuration. With a zero input signal applied, depress this toggle to the UP direction to raise the output zero level, or DN to lower the output zero level.

FS (Full-Scale) Up/Down - Used to adjust the **Full-Scale** endpoint during field configuration. With the full-scale input signal applied, depress this toggle to the UP direction to raise the full-scale output level, or DN direction to lower the full-scale output level.
NOTE: Note that the zero and full-scale adjustments take effect immediately and are saved to non-volatile memory after 15 seconds of toggle switch inactivity. Please wait the requisite time before powering down following adjustment or your configuration settings will be lost.

DIP Switches (See Dwg. 4501-779 For Location):

Options Configuration - Used to select the input range/type, enable or disable TC break detection, set upscale or downscale TC break detection, enable or disable CJC, enable or disable linearization, and lock or unlock zero/full-scale reconfiguration. Refer to Drawing 4501-779 and INSTALLATION section to set switches.

Input - Range (S1-4): The transmitter can be configured to accept any one of fifteen TC and voltage ranges. Input ranges are already factory calibrated.

Input - Break Detection Enable/Disdable (S8): Enable or disable sensor break detection. Set up or down direction separately (switch 9).

Input - Sensor Break (S9): The signal detent for detection of a sensor failure (TC) can be set to upscale or downscale. Ignored if break detection is disabled via switch 8.

Input - CJC (S10): Cold Junction Compensation may be turned ON or OFF for thermocouple input ranges. CJC should be set to ON when directly connecting a thermocouple to the module (default), but CJC can be set to OFF when connecting a millivolt source, representing temperature, directly to the module's input terminals in order to configure zero and full-scale. CJC is ignored for voltage input ranges.

Input - Linearization (S11): Linearization can be turned off for an output response that is linear with millivoltage, or ON for a response that is linear with temperature. Economy Model 656T-E600 units do not support linearization of the TC inputs.

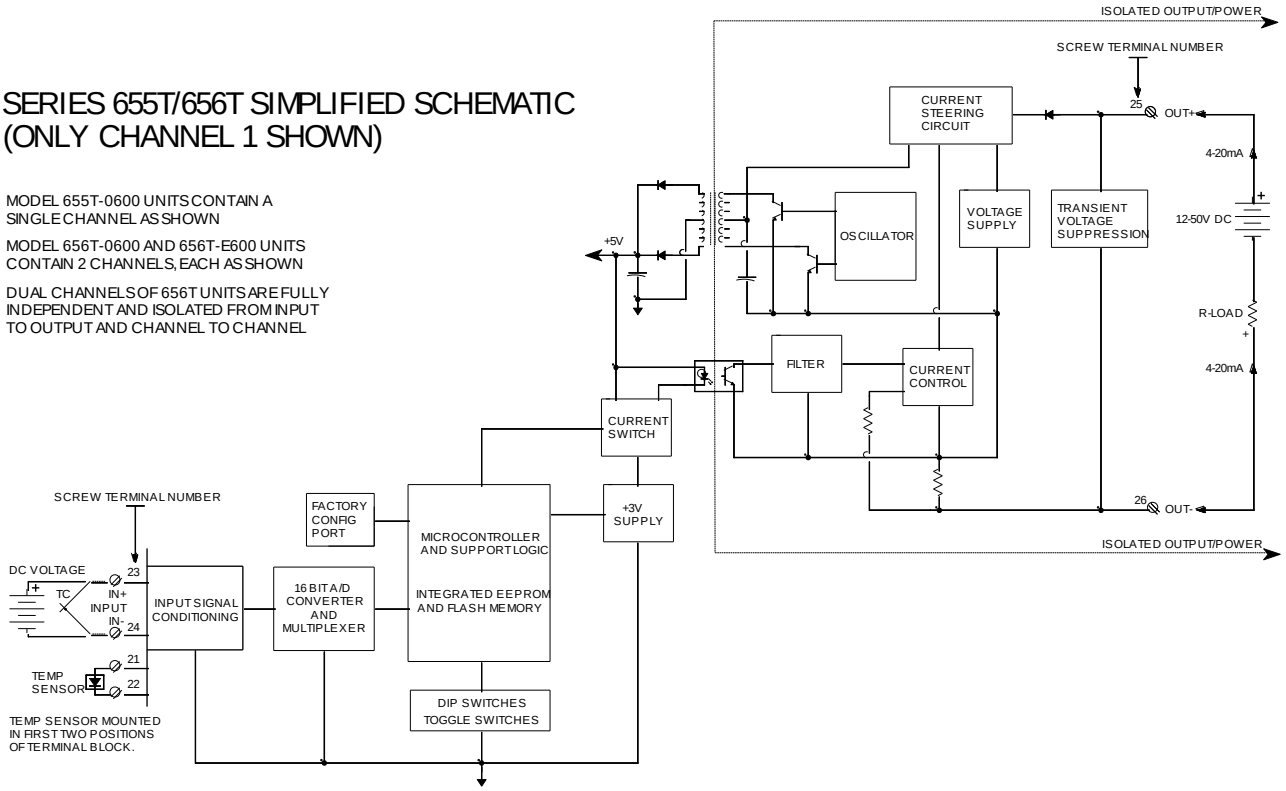
Unlock Reconfiguration (S12): This switch is normally enabled (locked) and must be set ON to unlock the reconfiguration capability of the Z/FS front-panel toggle switches. It is provided as an extra level of security to help prevent inadvertent reconfiguration or tampering in the field.

SERIES 655T/656T SIMPLIFIED SCHEMATIC (ONLY CHANNEL 1 SHOWN)

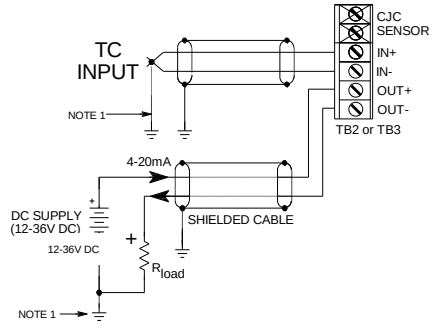
MODEL 655T-0600 UNITS CONTAIN A SINGLE CHANNEL AS SHOWN

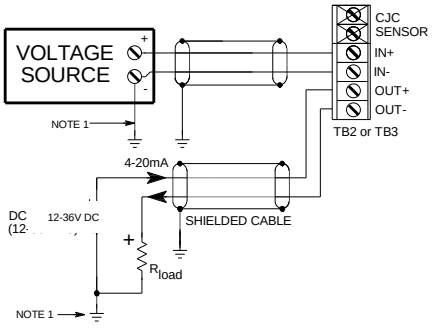
MODEL 656T-0600 AND 656T-E600 UNITS CONTAIN 2 CHANNELS, EACH AS SHOWN

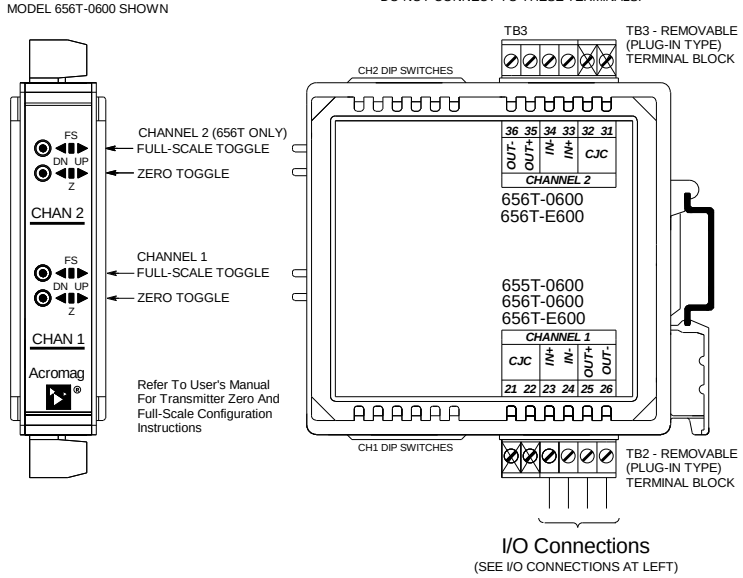
DUAL CHANNELS OF 656T UNITS ARE FULLY INDEPENDENT AND ISOLATED FROM INPUT TO OUTPUT AND CHANNEL TO CHANNEL



4501-777A







ELECTRICAL CONNECTIONS

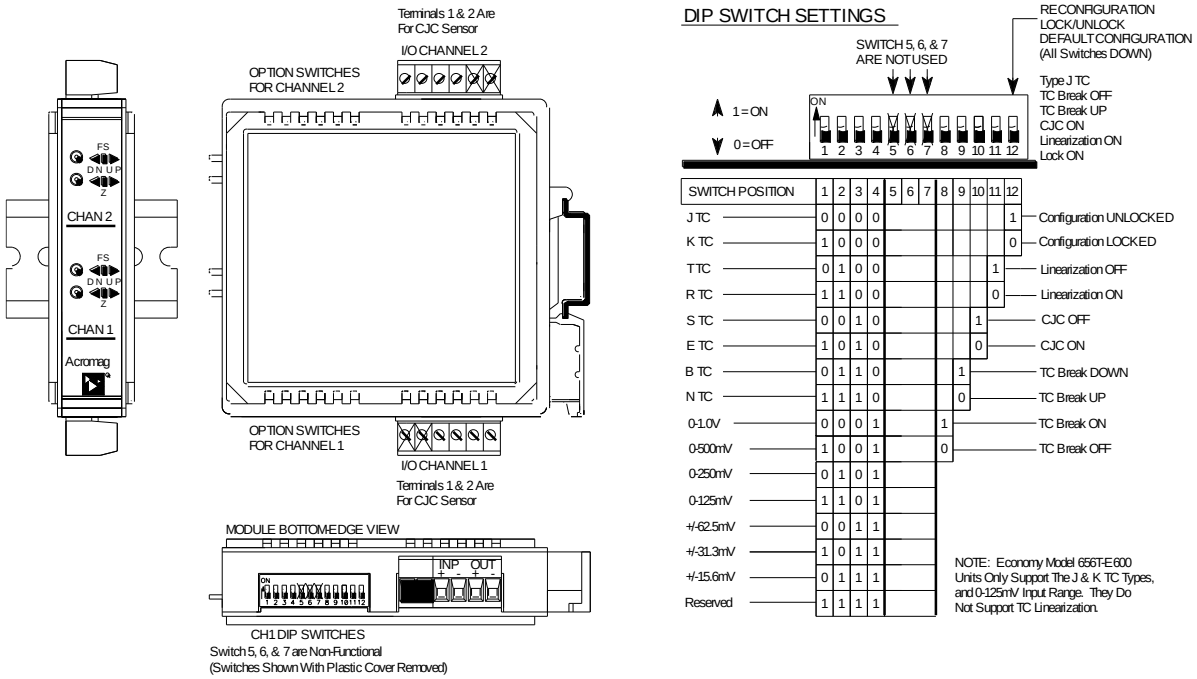
MODELS 656T-0600, 656T-E600, AND 655T-0600

WARNING:
FOR COMPLIANCE TO APPLICABLE SAFETY AND PERFORMANCE STANDARDS, THE USE OF SHIELDED CABLE IS RECOMMENDED AS SHOWN. ADDITIONALLY, THE APPLICATION OF EARTH GROUND MUST BE IN PLACE AS SHOWN IN THIS DRAWING. FAILURE TO ADHERE TO SOUND WIRING AND GROUNDING PRACTICES MAY COMPROMISE SAFETY AND PERFORMANCE.

SAFETY GUIDELINES MAY REQUIRE THAT THIS DEVICE BE HOUSED IN AN APPROVED METAL ENCLOSURE OR SUB-SYSTEM, PARTICULARLY FOR APPLICATIONS WITH VOLTAGES GREATER THAN OR EQUAL TO 75VDC/50VAC.

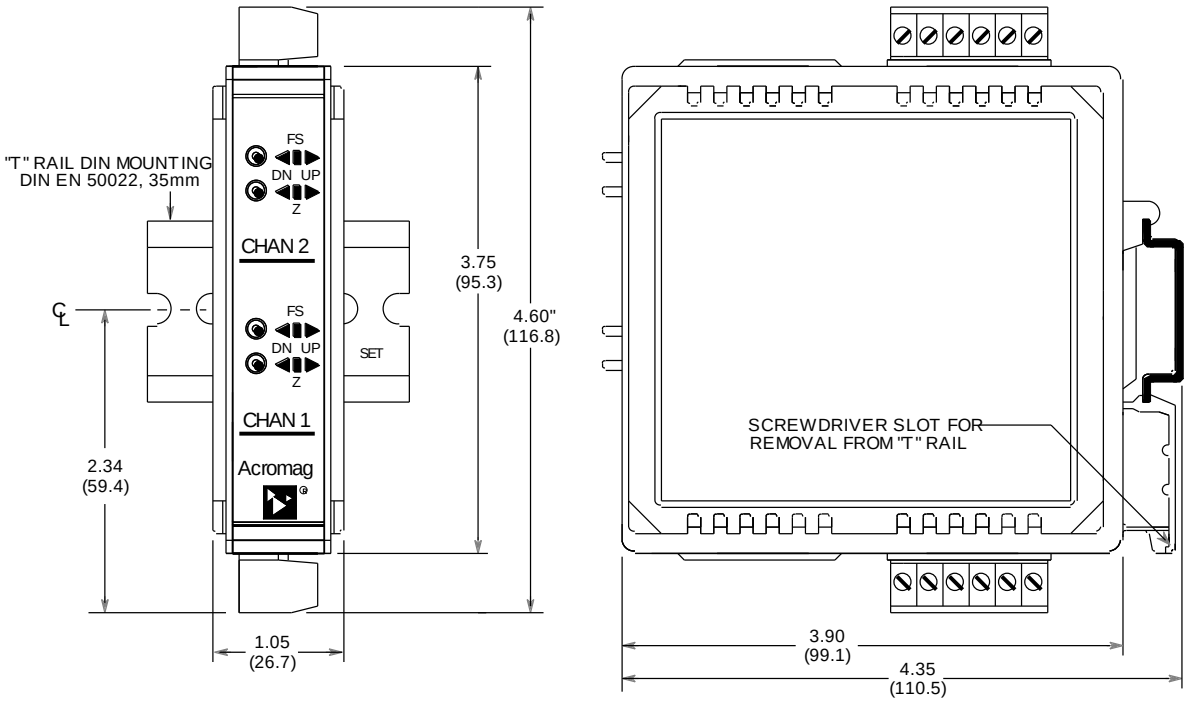
NOTE 1: THIS GROUND CONNECTION IS RECOMMENDED FOR BEST RESULTS. IF SENSORS ARE INHERENTLY CONNECTED TO GROUND, USE CAUTION AND AVOID MAKING ADDITIONAL GROUND CONNECTIONS WHICH COULD GENERATE GROUND LOOPS AND MEASUREMENT ERROR.

4501-778B



MODEL 656T-0600 & 655T-0600 DIP SWITCH SETTINGS

4501-779A



NOTE: ALL DIMENSIONS ARE IN INCHES (MILLIMETERS)

MODEL 65xT-0600 ENCLOSURE DIMENSIONS
(MODEL 655T-0600 & 657T-0600 ARE SIMILAR, BUT ONLY CHANNEL 1 IS PRESENT)

4501–780A

Revision History

The following table details the revision history for this document:

Release Date	Version	EGR/DOC	Description of Revision
3-AUG-2017	H	CAP/JAA	Remove CE Mark due to non-RoHS compliant part. Refer to ECN# 17G016.

Notes: