USB Programmable, DIN Rail Mount, DC-Powered Signal Splitters w/ Thermocouple/mV Input and Dual Isolated Current and Voltage Output

Model SP333-0700, Thermocouple & ±100mV/±1V Input

USER'S MANUAL

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IMPORTANT SAFETY CONSIDERATIONS

You must consider the possible negative effects of power, wiring, component, sensor, or software failure in the design of any type of control or monitoring system. This is very important where property loss or human life is involved. It is important that you perform satisfactory overall system design and it is agreed between you and Acromag, that this is your responsibility.

This manual is for our 4-wire SP333 transmitter (w/separate isolated power) that converts a thermocouple or low DC voltage signal to dual isolated voltage/current output signals. To similarly split microBlox (uB) module inputs, please refer to our uBSP-P-1 model. However, if your application requires a dual 2-wire (loop-powered) output, please refer to the similar SP233 model. For DC voltage and current input signals, please refer to other SP300 (4-wire) and SP200 (2-wire loop-powered) models.

GETTING STARTED

DESCRIPTION

Symbols on equipment:

Means “Refer to User’s Manual (this manual) for additional information”.

The SP333-0700 is modeled after ANSI/ISA Type IV transmitters, but with dual isolated outputs, commonly referred to as a signal splitter or repeater. This model is designed to interface with a thermocouple sensor (type J, K, T, R, S, B, E or N) or ±100mV/±1V inputs, isolate the input signal, and modulate two isolated DC outputs that may output current or voltage. Units are set up, calibrated, and rescaled using configuration software and a USB connection to Windows-based PC’s (Windows 7 and later versions only), or using a USB-OTG cable to Android smartphones or tablets using the Agility mobile app. Units provide adjustable input and output ranges, dual output signals for voltage or current, three-way isolation, lead-break detection, cold-junction compensation, and variable input filtering.

Key Features

- **Digitally configured and calibrated w/ Windows software via USB, or a wired USB-OTG connection to Android smartphones or tablets.**
- **Thin 17.5mm wide enclosure for high-density DIN-rail mounting.**
- **High measurement accuracy and linearity with 16-bit conversion.**
- **Adjustable/scalable input/output ranges.**
- **TC Type J, K, T, R, S, B, E, N, ±100mV, or ±1V input signal support.**
- **TC inputs are linearized with respect to temperature.**
- **TC inputs include Cold-Junction Compensation which may be turned on/off.**
- **Supports both Celsius and Fahrenheit temperature units.**
- **Dual isolated tandem voltage and current output terminals support your choice of ±10V, ±5V, 0-10V, 0-5V, or 0-20mA, 4-20mA output signals at each output channel.**
- **Normal or Reverse Acting output.**
- **Variable digital input filter adjustment.**
- **Up-scale or down-scale lead-break/burnout detection.**
- **Wide-range DC power input from 6-32V.**
- **Bussed power and/or redundant power ready.**
- **Wide ambient temperature operation from -40°C to +75°C.**
- **Thoroughly tested and hardened for harsh environments.**
- **CE Approved & includes UL/cUL Class 1, Division 2 approvals.**
- **FCC Conformity Class B.**
- **ATEX / IECEx Certified for Explosive Atmospheres.**
  Ⓔx II 3 G Ex nA IIC T4 Gc - 40ºC ≤ Ta ≤ +75ºC
  DEMKO 18 ATEX 2086X IECEx UL 18.0092X

Application

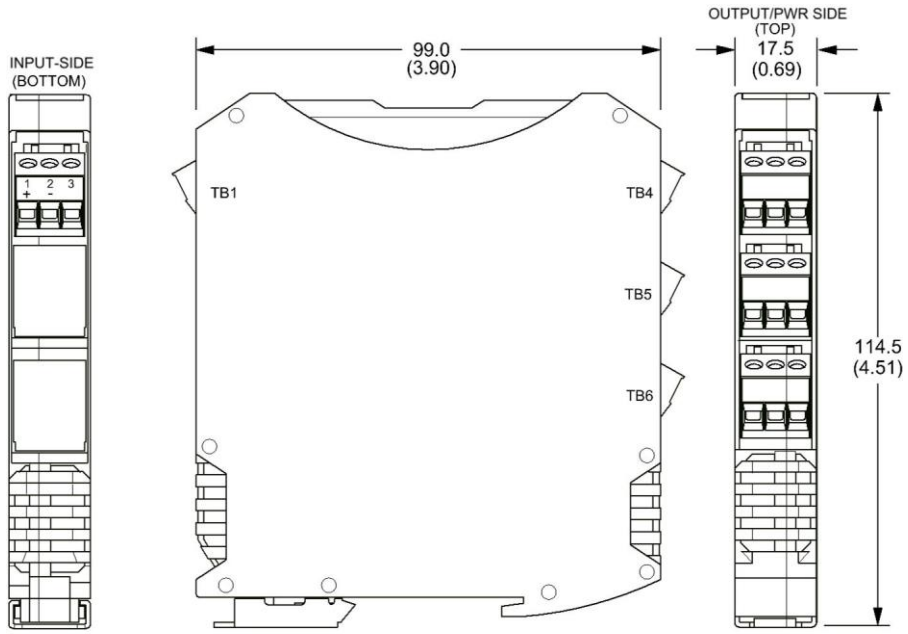
For additional information on these devices and related topics, please visit our web site at www.acromag.com.

These splitters are designed for high-density mounting on T-type DIN rails. Units may be mounted side-by-side on 0.7-inch (17.5mm) centers and support 6-32V DC power via terminals on the unit, or optionally via power wired to a DIN-rail bus connector. Models isolate thermocouple or low voltage input signals and can mate with grounded or non-grounded sensors. They drive separately isolated outputs that drive current or voltage at each output channel with support for 0-20mA, 4-20mA, or ±10V, ±5V, 0-10V, and 0-5V output ranges.

Mechanical Dimensions

Units may be mounted to 35mm "T" type DIN rail (35mm, type EN50022), and side-by-side on 0.7-inch centers.

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

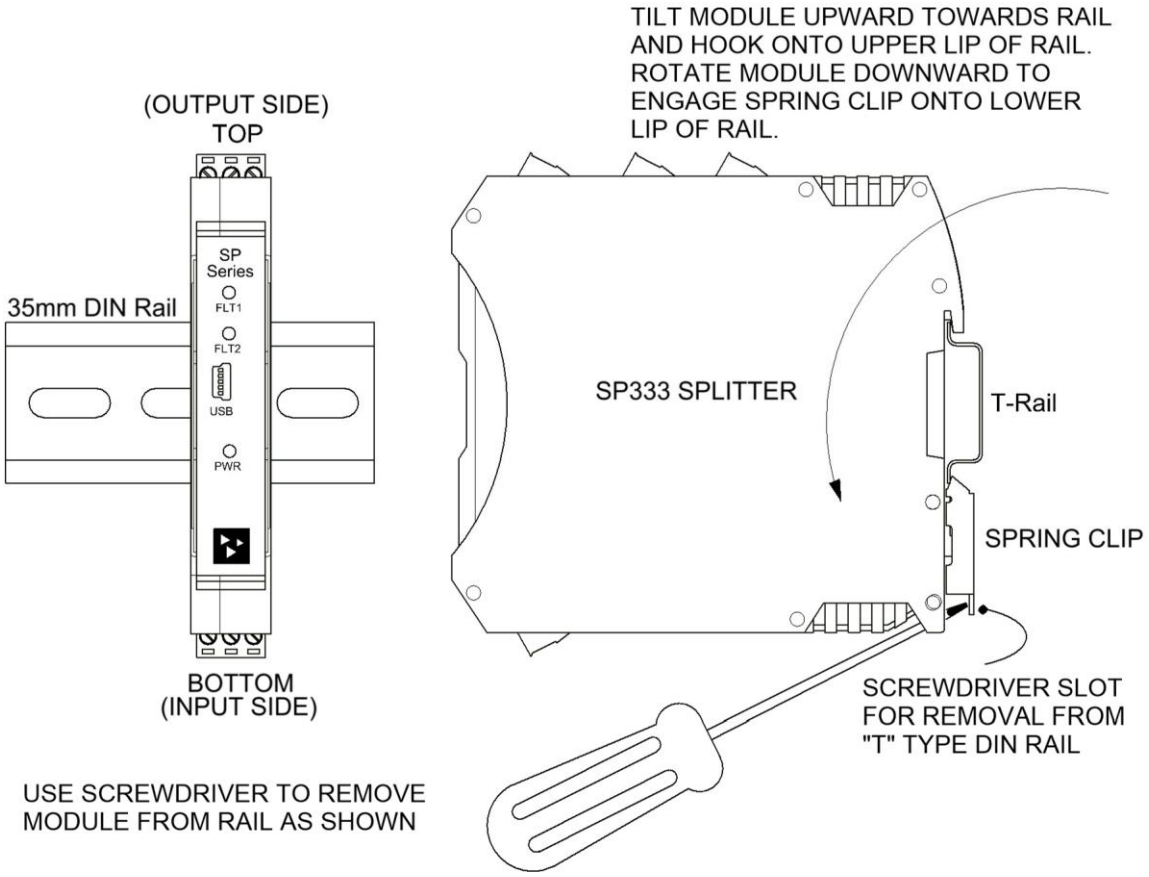


DIMENSIONS ARE IN MILLIMETERS (INCHES)

DIN Rail Mounting & Removal

Refer to the following figure for attaching and removing a unit from the DIN rail. A spring-loaded DIN clip is located on the input side bottom. The opposite rounded edge at the bottom of the output side allows you to tilt the unit upward to lift it from the rail while prying the spring clip back with a screwdriver. To attach the module to T-type DIN rail, angle the top of the unit towards the rail and place the top groove of the module over the upper lip of the DIN rail. Firmly push the unit downward towards the rail until it snaps into place. To remove it from the DIN rail, first separate the input terminal blocks from the bottom side of the module to create a clearance to the DIN mounting area. You can use a screwdriver to pry the pluggable terminals out of their sockets. Next, while holding the module in place from above, insert a screwdriver into the lower path of the bottom of the module to the DIN rail clip and use it as a lever to force the DIN rail spring clip down while pulling the bottom of the module outward until it disengages from the rail. Then simply lift it from the rail.

SP333 SPLITTER DIN RAIL MOUNTING AND REMOVAL



ELECTRICAL CONNECTIONS

WARNING – EXPLOSION HAZARD – Do not disconnect equipment unless power has been removed or the area is known to be non-hazardous.
WARNING – EXPLOSION HAZARD – Substitution of any components may impair suitability for Class I, Division 2.
WARNING – EXPLOSION HAZARD – The area must be known to be non-hazardous before servicing/replacing the unit and before installing.

Wire terminals can accommodate 14–26 AWG (2.08–0.13mm^2) solid or stranded wire with a minimum temperature rating of 85°C. Input wiring may be shielded or unshielded type. Ideally, output wires should be twisted pair, or shielded twisted pair. Terminals are pluggable and can be removed from their sockets by prying outward from the top with a flat-head screwdriver blade. This model allows thermocouples or low voltage inputs to be wired to TB1 and drivers separate outputs. Strip back wire insulation 0.25-inch on each lead and insert the wire ends into the cage clamp connector of the terminal block. Use a screwdriver to tighten the screw by turning it in a clockwise direction to secure the wire (0.5-0.6Nm torque). Since common mode voltages can exist on signal wiring, adequate wire insulation should be used and proper wiring practices followed. As a rule, output wires are normally separated from input wiring for safety, as well as for low noise pickup.

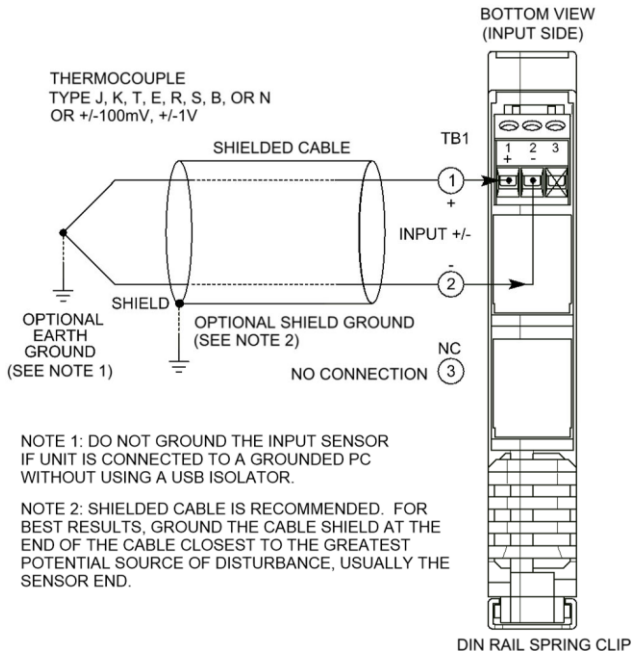
Important – End Stops: For hazardous location installations (Class I, Division 2 or ATEX / IECEx Zone 2), it should utilize two end stops (like Acromag 1027-222) to help secure modules to the DIN rail (not shown).

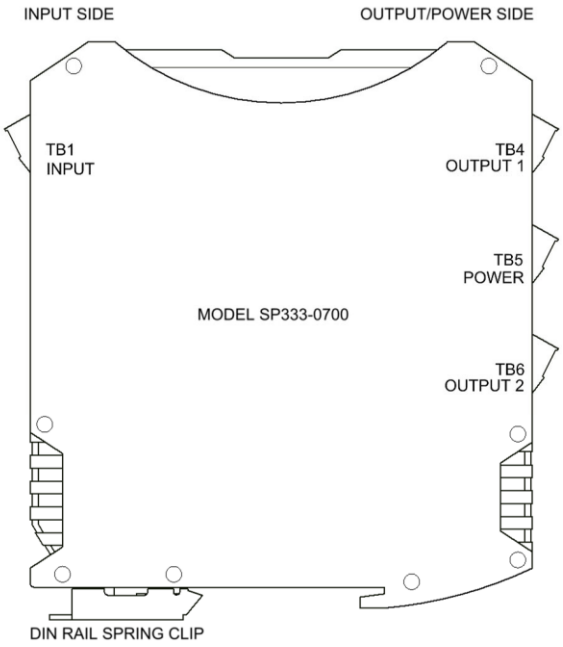
Sensor Input Connections

Sensor wires are wired directly to transmitter input terminal TB1 at the bottom of the module (the spring-loaded DIN clip side), as shown in the connection drawing below. Observe proper polarity when making input connections.

- **Transmitter input signal is isolated from each output channel and power.**
- **TC input uses ± polarized terminals at TB1, observe proper polarity.** The positive input is on the left and labeled "+", and the negative input is to its right. See connection figure below per input model.
- **Single Input drives both outputs at one time**. Each active output may drive current or voltage from separate terminals that share a return. The input may be scaled differently for each output.

MODEL SP333-0700 INPUT SENSOR WIRING

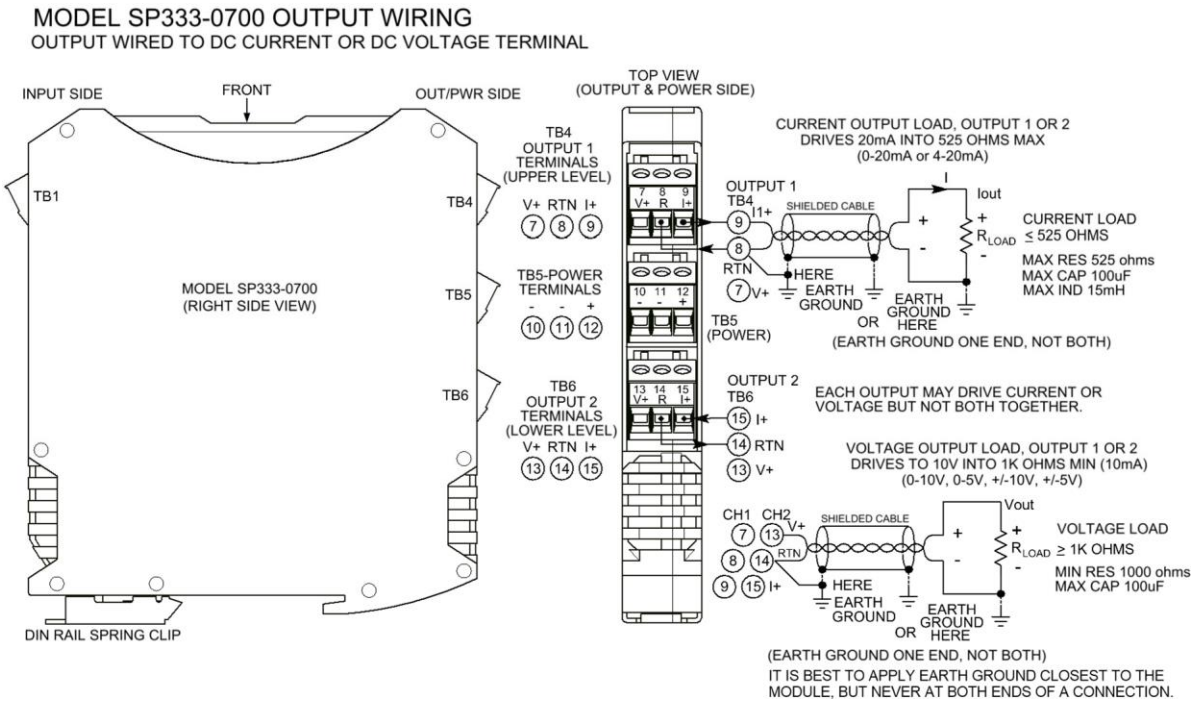




Output Connections (To DC Current or Voltage Terminals)

This transmitter is modeled after ANSI/ISA Type 4 transmitters in which unit power, is separate from the input and output circuits, except this unit includes two outputs.

- **Output connections are polarized.** Tandem current and voltage output terminals at each isolated output channel share an output return (RTN). Current output is sourced from I Out+ and returned to RTN. Voltage output is sourced positive at V Out+ with respect to RTN. Only one channel output terminal (voltage or current) may be loaded at a time.
- **Variations in load resistance have negligible effect on output accuracy** when load limits are respected with respect to output type (see below).



Observe proper polarity. Note that twisted-pair wiring is often used to connect the longest distance between each field transmitter output and the remote load as shown above. Additionally, shielded twisted pair wiring is recommended for best results. An output connection to earth ground at each output return will help protect the circuit from damage in noisy environments.

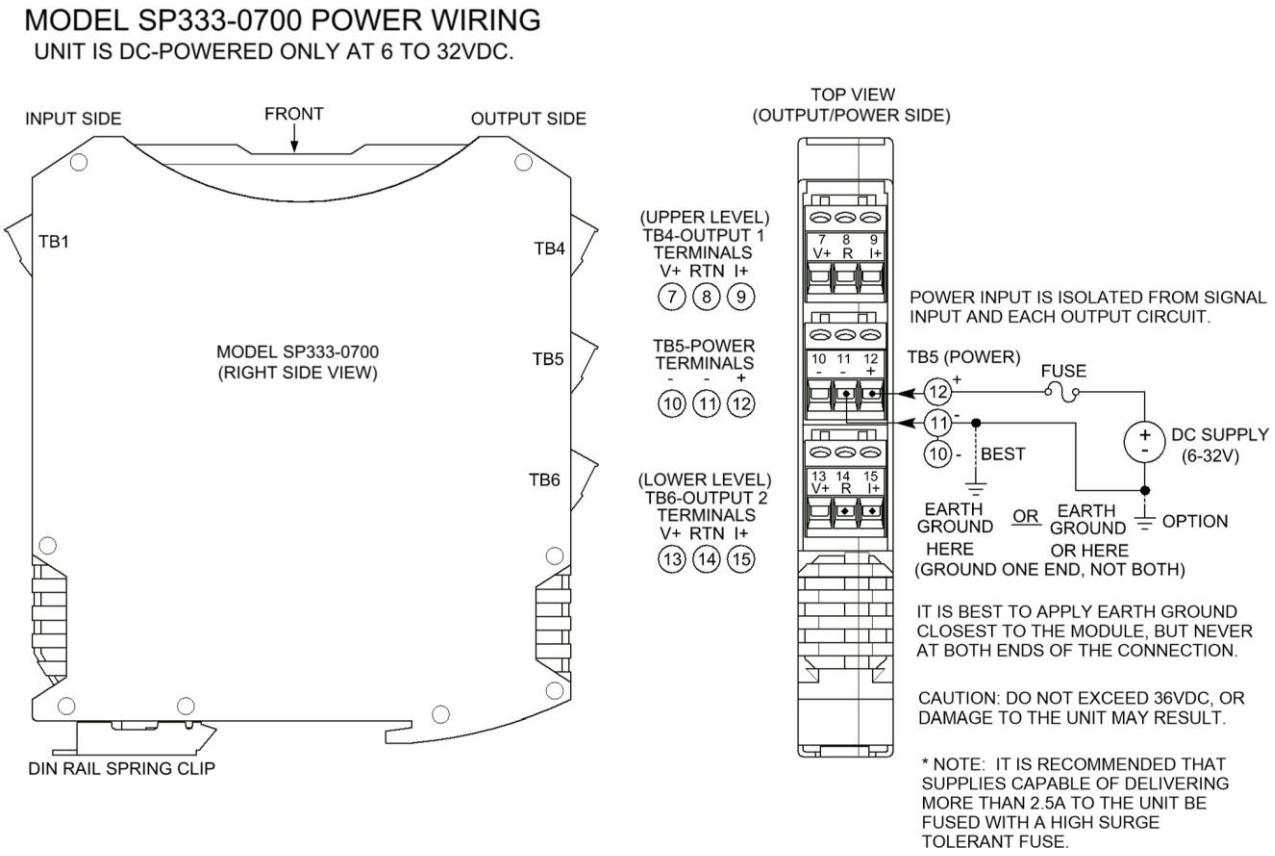
> **WARNING:** For compliance to applicable safety and performance standards, the use of twisted pair output wiring is recommended. Failure to adhere to sound wiring and grounding practices as instructed may compromise safety, performance, and possibly damage the unit.

TIP - Ripple & Noise: Place additional capacitance at the load to help reduce the 60Hz/120Hz ripple sometimes present in industrial applications. For large 60Hz ripple, connect an external 1uF or larger capacitor directly across the load to reduce excess ripple. For sensitive applications with high-speed acquisition at the load, high frequency noise may be reduced significantly by placing a 0.1uF capacitor directly across the load, and as close to the load as possible.

Power Connections

The unit is powered from 6-32V DC (36V DC peak) by connecting power as shown below. This transmitter can be optionally powered (or redundantly powered) via the DIN rail bus when coupled to an optional DIN rail bus connector (Acromag Model 1005-063) with a bus terminal block (Acromag 1005-220 or 1005-221). This optional power connection method can allow several modules to share a single power supply without wiring power to each power terminal block individually.

- Power connections are isolated from the input and each output. The supply voltage should be from 6-32V DC. This voltage must never exceed 36V DC peak, or damage to the unit may result.
- Variations in power supply voltage between the minimum required and 32V maximum, has negligible effect on transmitter accuracy.
- Note the placement of earth ground at power. The power cable shield and DC- should ideally be grounded closest to the module. The input and output circuit commons are capacitively coupled to earth ground at DC- through high-voltage isolation capacitors, offering some protection if their circuits happen to float relative to power (not recommended).



Power Connections…

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

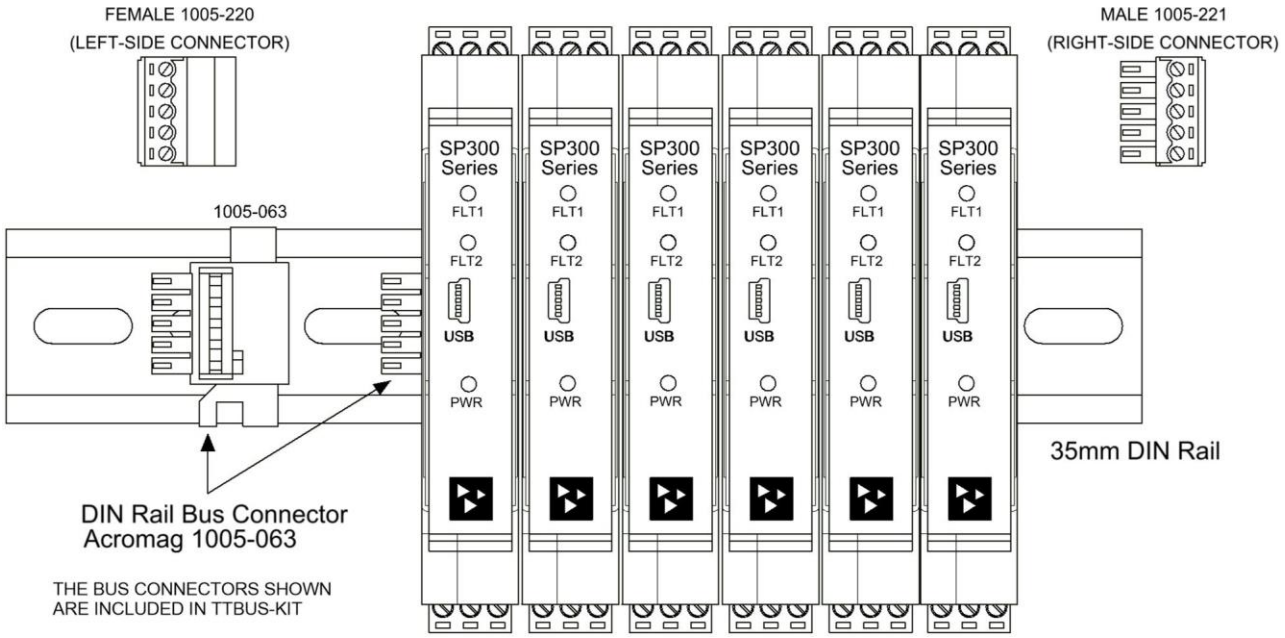
IMPORTANT – External Fuse: If unit is powered from a supply capable of delivering more than 2.5A to the unit, it is recommended that this current be limited via a high surge tolerant fuse rated for a maximum current of 2.5A or less (for example, see Bel Fuse MJS or RJS fuse types).

Optional Bus Power Connections

Power is normally wired to the TB5 terminals of the unit as shown on the previous page. However, this device is equipped to be optionally or redundantly powered via a DIN rail bus connector (Acromag 1005-063) mated to an optional plug-in terminal block (Acromag 1005-220 or 1005-221, depending on left or right-side wire entry). Any power input via the bus connector is diode-coupled to the same point in the circuit as unit power connected at power terminal TB5. You could power multiple units by snapping them together along the DIN rail bus using connector 1005-063, then connecting a mating terminal block (select a Left or Right-side connector, see figure below). While the intent of the bus power connector is to allow several units to conveniently share a single supply, you could also use the bus power connector to redundantly power units (with local power also applied at TB5), allowing a backup supply to maintain power to the units should the main supply at TB5 fail.

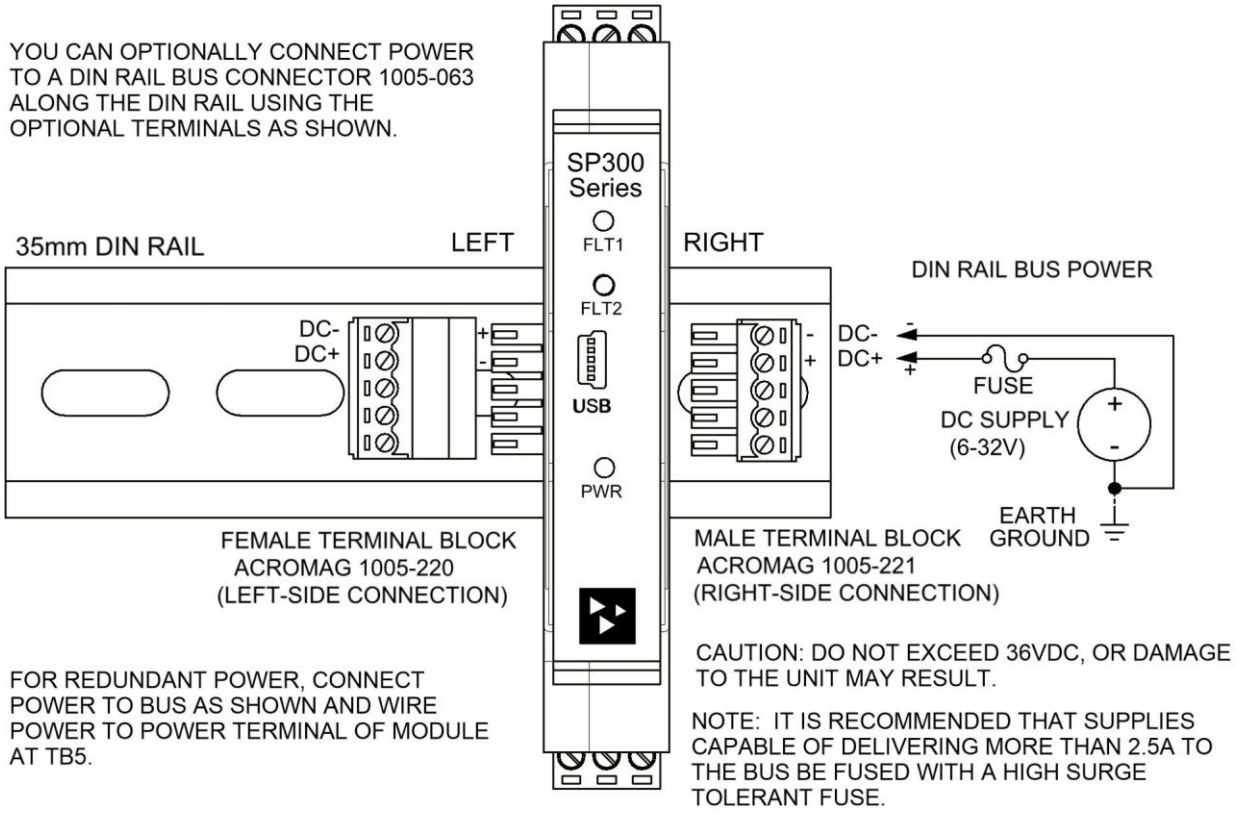
Acromag TTBUS-KIT connector kit contains bus connector 1005-063, plus left-side terminal 1005-220, and right-side terminal 1005-221, allowing units to snap together, side-by-side, along the DIN rail and share the power connection.

Important – End Stops: If this module uses the optionally powered (or redundantly powered) via the DIN rail bus for hazardous location installations (Class I, Division 2 or ATEX / IECEx Zone 2) it should use two end stops (like Acromag 1027-222) to secure the terminal block and module (not shown).



Optional Bus Power Connections…

The figure below shows how to wire power to the optional bus terminal block when mated to the bus connector. Note that power is wired to the rightmost bus terminals on the right, or the left-most terminals on the left. Observe proper polarity.



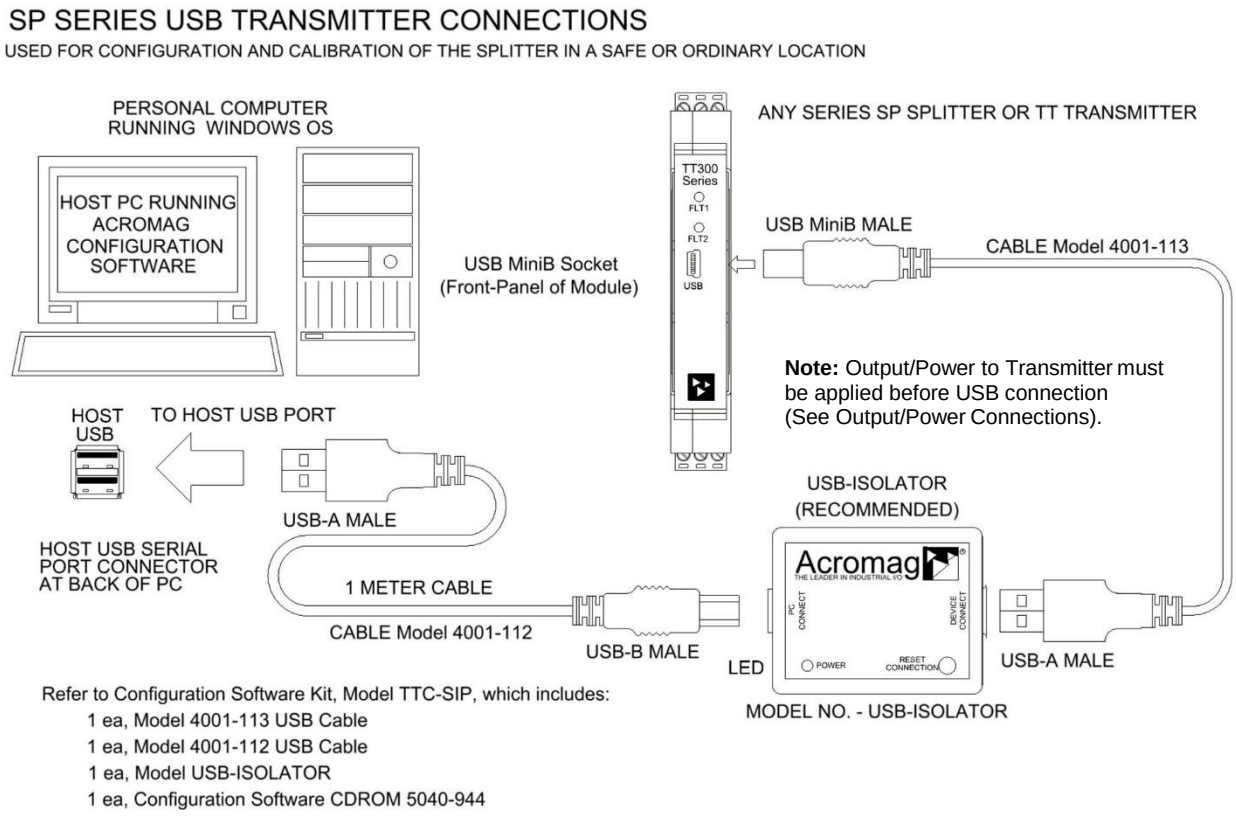
Earth Ground Connections

The unit housing is plastic and does not require an earth ground connection. The internal input, each output, and power circuits are electrically isolated from each other, allowing these circuits to be individually earth grounded as indicated. Additionally, if the transmitter is mounted in a metal housing, a ground wire connection is typically required for the enclosure and you should connect that metal enclosure's ground terminal (green screw) to earth ground using suitable wire per applicable codes. See the Electrical Connections Drawings for Input, Outputs, and Power, and note the position of earth ground for each isolated circuit. Earth ground provides a safe destination for potentially destructive transient energy in each isolated circuit, helping to prevent damage to circuitry, as all of the circuit capacitors and transient voltage suppressors steer towards the negative terminals of their circuits, where earth ground is normally applied.

- Avoid inadvertent connections to earth ground at other points than those indicated, as this could drive ground loops and negatively affect operation.
- A USB isolator is recommended when configuring or calibrating a unit to avoid the ground loop that occurs if your input is also earth grounded (A PC commonly earth grounds its USB port contacting both the USB signal and shield ground which are held in common to the input circuit ground of this transmitter).

USB Connections

This transmitter is configured and calibrated via configuration software that runs on a Windows-based PC connected to the unit via USB (Windows 7 or later required), or via a USB-OTG connection to an Android smartphone or tablet using the Acromag Agility mobile app. Refer to the following drawing to connect your PC or laptop to the transmitter to reconfigure or calibrate it using this software.



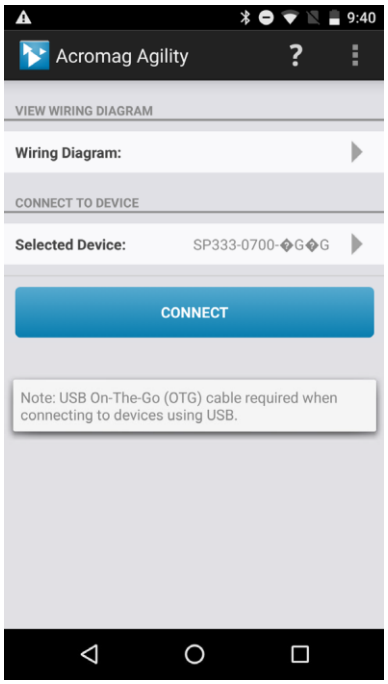
WARNING: The intent of mating USB with this transmitter is so that it can be conveniently set up and calibrated in a safe area, then installed in the field which may be in a hazardous area. Do not attempt to connect a PC or laptop to this unit while installed in a hazardous area, as USB energy levels could ignite explosive gases or particles in the air.

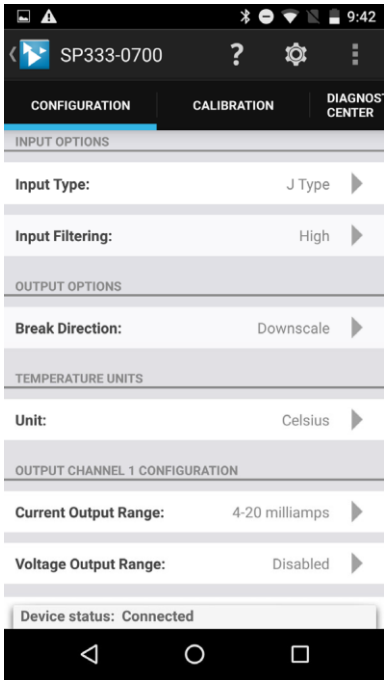
- USB Signal Isolation is recommended and required when connected to a grounded input – Input and USB connections are isolated from each output and power of this model. USB Isolation is recommended for safety and noise suppression, but required when the input signal happens to be grounded. You may use Acromag model USB-ISOLATOR to isolate your USB port, or you can optionally use another USB signal isolator that supports USB Full Speed operation (12Mbps).

IMPORTANT: USB logic signals to the transmitter are referenced to the potential of the transmitter's input circuit ground. This ground is held in common with USB ground and USB cable shield ground. Thus, an isolator is required when the input signal is grounded and the unit is connected to the USB port of an earth-grounded PC. You could avoid the use of an isolator if a battery powered laptop was instead used to connect to the transmitter, and the laptop had no other earth ground connection, either directly or indirectly via a connected peripheral.

CONFIGURATION SOFTWARE

Quick Overview – Android





This transmitter/splitter can be setup & calibrated via the Acromag Agility™ Config Tool. This software APP can be downloaded free of charge from play.google.com. To connect to this transmitter, a USB OTG (On-The-Go) cable (5028-565) and USB A to Mini-B cable (4001-113) are required. This app is compatible with Android devices using Ice Cream Sandwich (4.0) or later.

The initial connection screen of the app is shown at left. Once a device is connected, the main portion of the app will launch. The screen is divided into three tabs for this model. A short description of each tab follows.

Connection Screen Set up – DEVICE SELECT (First Connect to Unit Here)

- Select from connected transmitters by tapping the **[Select Device]** button. This will bring up a list of attached devices. Select the desired device and tap the Connect button to open the device.
- To view wiring diagrams of a transmitter, tap the **[Wiring Diagram]** button and select the desired model. Swipe left or right to view more diagrams. No connection is required to view the diagrams.
- Android requires user permission to access external hardware. If the Device List displays "No Device Permission", select this device and when prompted to give permission to access the USB device, tap **[OK]**.

Configuration Tab – CONFIGURE I/O

- Once connected, the app will automatically read your transmitter and display its current configuration.
- Changing any option on this page will send the changes to the transmitter instantly. The device status at the bottom of the page will report if the changes were sent successfully.

Calibration Tab – (Calibrate the Input and/or Output if Needed)

- On screen instruction guides the set up to properly calibrate the transmitter. After completing instructions, tap the **[Calibrate]** button.
- The device status at the bottom of the page will report if the calibration was sent successfully.

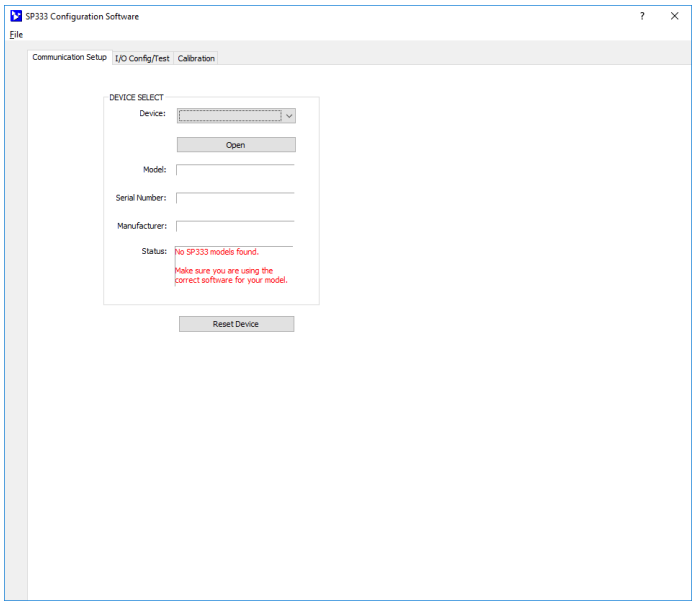
Diagnostic Center Tab – (Verify Input operation)

- Select the polling indicator by tapping the **[Indicator]** button.
- Start polling by tapping the **[Start Polling]** button.

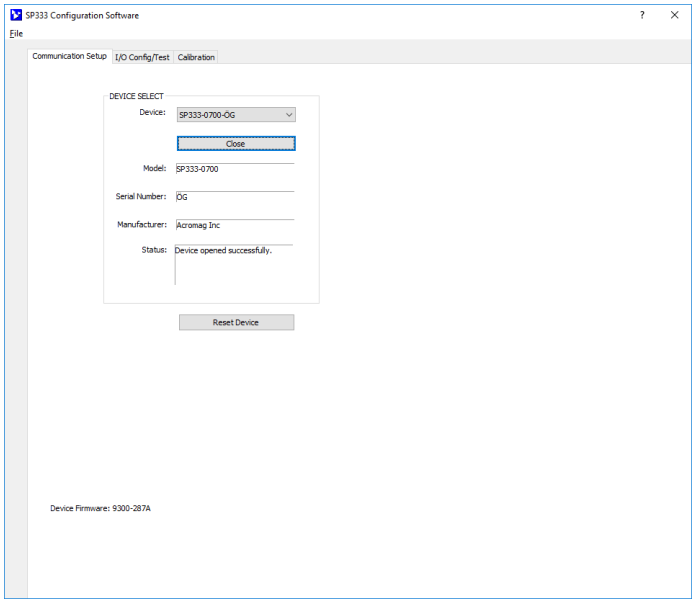
Utility Page – (Reboot or Restore Settings)

- Tap the **[Gear]** in the Action bar to access the Utility Page.
- You can tap the **[Restore/Reset Factory]** utility buttons to get out of trouble if you ever misconfigure or improperly calibrate a transmitter.

Quick Overview – Windows



*Click **"Open"** to connect to the SP333-0700 and your screen will like:*



HELP – You can press F1 for Help on a selected or highlighted field or control. You can also click the [?] button in the upper-right hand corner of the screen and then click again to point to a field or control to get a Help message pertaining to the item you pointed to.

This transmitter can be configured and calibrated via its USB Configuration Software and a USB connection to your Windows PC or laptop. The USB software can be downloaded free of charge from our web site at www.acromag.com, and included on a CDROM bundled with the Configuration Kit TT-SIP (see Accessories section). For this model, look for the program SP333Config.exe. This software is compatible with v7 or later versions of the Windows operating system.

The initial USB configuration software screen for this model is shown at left. Configuration information is divided across three separately tabbed pages as follows: Communication Set up, I/O Config/Test, and Calibration. A short description of each of these configuration pages follows:

Communication Set up (First Connect to Unit Here)

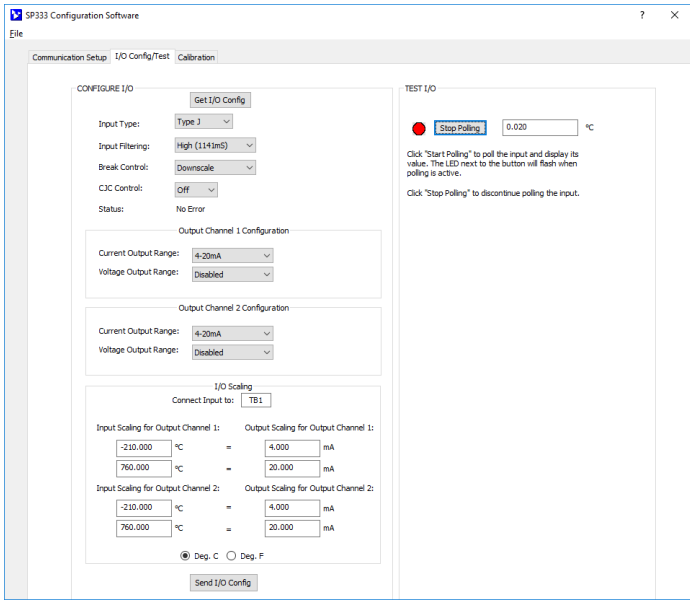
- Select from connected transmitters and Open/Close communication with them.
- Display the Model, Serial Number, and Manufacturer of the connected transmitter and report the status of communication with it.

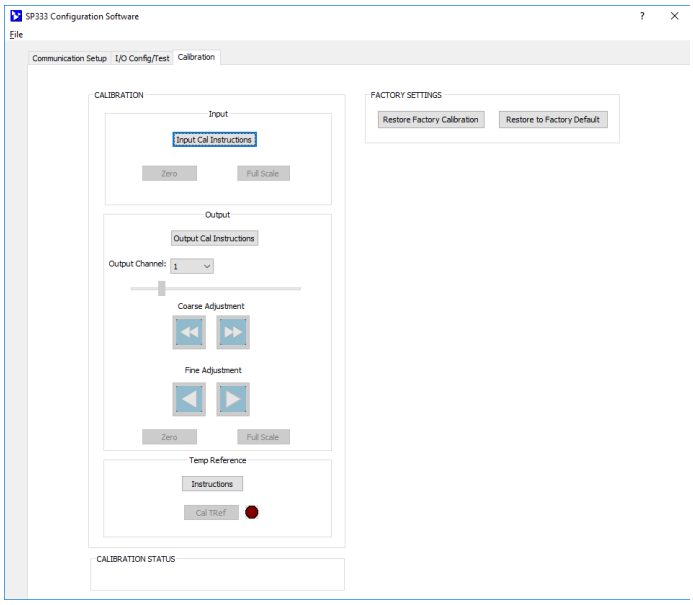
This section is used to select a connected transmitter, and open/close communication with it. Device connection Status is also indicated here, along with the connected transmitter's ID info (Product Name/serial, Manufacturer, & Serial Number).

I/O Config/Test (Configure and/or Test the Unit Here)

- You can click the **[Get I/O Config]** button to retrieve the I/O configuration of the currently connected transmitter.
- Select the Input Range. You can select TC types J, K, T, R, S, E, B, N, or ±100mV, or ±1V wired to TB1.
- Set the level of digital filtering to High, Medium, Low, or None (No digital filter). The corresponding I/O response time varies with filter selection and is indicated in parenthesis next to your selection (see Specifications).
- Set the Output Range to ±10V, ±5V, 0-5V, 0-10V, ±20mA, 0-20mA, or 4-20mA.
- View the unit's configuration message status in the Status field.

Quick Overview – Windows...





HELP – You can press F1 for Help on a selected or highlighted field or control. You can also click the [?] button in the upper-right hand corner of the screen and then click again to point to a field or control to get a Help message pertaining to the item you pointed to.

I/O Config...continued

- Use the I/O Scaling fields to specify the specific input range endpoints that are to correspond to the output range zero and full-scale endpoints (some over/under-range is included).
- Last, after making I/O changes, send your settings to the unit by clicking the **[Send I/O Config]** button and follow the on-screen prompts.

For detailed configuration and calibration procedures, see the Operation Step-By-Step section of the Technical Reference on page 18 of this manual.

Test I/O (Optional, Verify Unit Operation Here)

After making I/O configuration changes, you can use the TEST I/O controls to start/stop polling the input channel to check your input readings.

- Click the **[Start Polling]** button to periodically read your input channel and validate its operation. Click **[Stop Polling]** to stop polling the input channel. Note the simulated red lamp to the left of the button flashes slowly when the software is polling the input channel. Stop polling before sending a configuration or selecting another page.

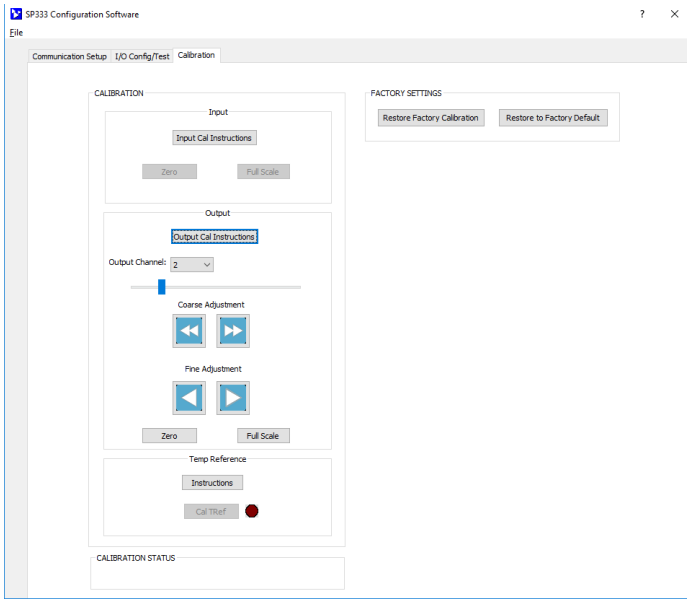
CALIBRATION (Calibrate Input or Output if Needed)

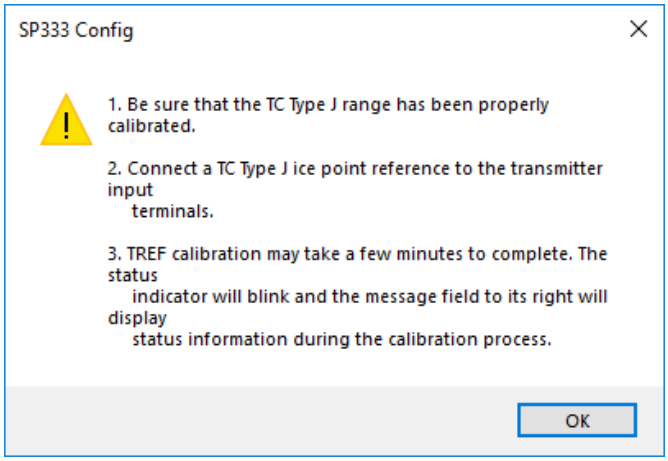
This unit has already been factory calibrated. If you encounter excessive error, you can choose to click the Calibration tab to display the Calibration control page shown in the second screen at left.

To calibrate the Input or Output stage of this model, simply click the respective “Cal Instructions” button and follow the on-screen prompts.

Note that only nominal I/O ranges are used for calibration, not your scaled I/O ranges.

Quick Overview – Windows...





Calibration Status (At Bottom of Calibration Screen)...

- Displays communication status messages for the calibration process.

The CALIBRATION STATUS message bar at the bottom of the screen will display status messages relative to calibration.

CALIBRATION...continued

Input…

Before attempting calibration, set the Input Range to calibrate in the I/O Config/Test page and be sure to click the **[Send I/O Config]** button. In the Calibration page, click **[Input Cal Instructions]** to begin input calibration.

When you click the **[Zero]** or **[Full Scale]** buttons of the Input Calibration section, you will be prompted to apply a specific voltage signal at TB1 corresponding to your selected input range. Once you have applied this signal at TB1, click the **[OK]** button of the prompt and follow the on-screen instructions to complete input calibration.

Output…

Click the **[Output Cal Instructions]** button to begin output calibration. You will be prompted to adjust the input signal as required to drive the output to its precise output range zero or full-scale level. Then once the output is set to zero or full-scale, you simply click the corresponding **[Zero]** or **[Full-Scale]** button of the CALIBRATION - Output section to set the output range zero or full-scale endpoint.

Temperature Reference...

This model embeds a very accurate temperature sensor in the plastic around the input + and – terminals to cold-junction compensate the thermocouple signal wires. To explain, the voltage measured from a T/C reflects the difference in temperature between each end. To discern the actual temperature being sensed, it is necessary to know the temperature at the other end, and this is usually referred to as the Cold Junction.

This section calibrates the cold-junction temperature reference used for cold junction compensation of all T/C input types. Click the **[Instructions]** button to begin reference calibration and you will be prompted to connect a TC Type J ice point reference to the input (see screen at left). Note that you must already have the Type J TC range calibrated to accomplish CJC calibration.

Factory Settings...

(Use in Case of Trouble or for Sanitation Purposes)

- Restore unit to its original factory calibration.
- Restore unit to its initial factory configuration.

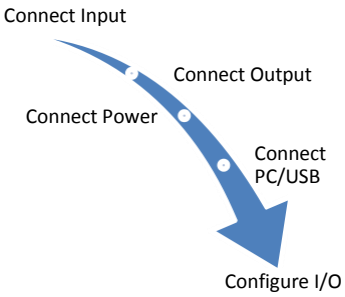
You can click the “Restore Factory” buttons if you ever misconfigure or improperly calibrate a transmitter such that its operation appears erratic, or for sanitation purposes when decommissioning a module.

TECHNICAL REFERENCE

OPERATION STEP-BY-STEP

Connections

This section will walk you through the Connection-Configuration-Calibration process step-by-step. But before you attempt to reconfigure or recalibrate this transmitter, please make the following electrical connections



Note: Input source, output meters, and load resistors (current outputs) must be accurate beyond unit specifications, or better than ±0.1%. A good rule of thumb is that equipment accuracy should be four times better than rated accuracy you wish to achieve.

Calibration Connections:

1. **Connect Input:** Connect a precise millivoltage source or T/C calibrator to the TB1 input, as required for your input type/range. Observe proper polarity.

   In the absence of a thermocouple calibrator, a convenient method of configuring the TC input would be to use a precision mV source with this module's CJC set to OFF. 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 T/C input range, specific to each T/C type. Refer to the table on the next page for a list of supported thermocouple voltages at specific temperatures. After setting the range zero and full-scale this way, CJC should be returned to ON to enable cold junction compensation when the input is wired using thermocouple wires. For best results, set the input filter as desired before calibrating an input.

2. **Connect to one output signal, Voltage or Current at each output channel:** Wire load appropriate for either current or voltage, as required by your application. You must measure output current or voltage accurately to calibrate an output. You may connect a current meter in series with the load to read the output current directly, or a digital voltmeter in parallel with the load to measure output voltage. Alternatively, you could connect a voltmeter across a precision load resistor to accurately read output current as a function of the IR voltage drop in the load resistor (recommended for current outputs).

3. **Connect Power:** Wire 6-32VDC power to the unit at TB5 as shown in the Electrical Connections section. Optionally, you may wire power to the bus terminal as shown in the optional power connections drawing. But in either case, never exceed 36VDC peak, or damage to the unit may result.

   Apply power to the transmitter before connecting to USB. Otherwise, you will not be able to configure or calibrate the unit as no power is drawn from USB.

4. **Connect to PC via USB:** Connect the unit to your PC using the USB isolator and cables provided in Configuration Kit TT-SIP (refer to Accessories). You may omit the isolator only if using a battery powered laptop to connect to the unit, or if your input source is not already grounded.

   Once you have made your connections and applied power, you can execute the SP333Config.exe for your model to begin configuration of the unit (software is compatible with v7 or later versions of the Windows operating system).

Thermocouple Millivoltage Versus Temperature Reference Table

Thermocouple milliVoltage Versus Temperature (Per National Institute of Standards and Technology (NIST/ITS-90) Thermocouple Tables)[1]

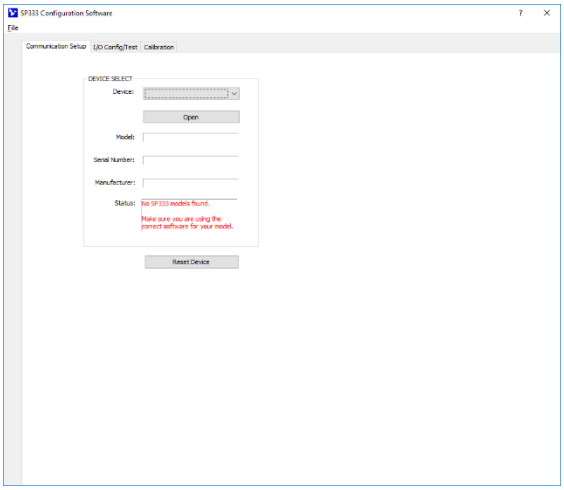
TEMP °C	Thermoelectric Voltage In milliVolts (With Reference Junction at 0°C)							
	J	K	T	E	R	S	B	N
- 260		---	**-6.232**	---	---		---	---
- 250	---	---	-6.180	---	---	---	---	---
- 230	---	---	-6.007	---	---	---	---	**-4.226**
- 210	**-8.095**	---	-5.753	---	---	---	---	-4.083
- 200	-7.890	**-5.891**	-5.603	**-8.825**	---	---	---	-3.990
- 150	-6.500	-4.913	-4.648	-7.279	---	---	---	-3.336
- 100	-4.633	-3.554	-3.379	-5.237	---	---	---	-2.407
- 50	-2.431	-1.889	-1.819	-2.787	**-0.226**	**-0.236**	---	-1.269
0	0.000	0.000	0.000	0.000	0.000	0.000	---	0.000
+ 50	2.585	2.023	2.036	3.048	0.296	0.299	---	1.340
+ 100	5.269	4.096	4.279	6.319	0.647	0.646	---	2.774
+ 150	8.010	6.138	6.704	9.789	1.041	1.029	---	4.302
+ 200	10.779	8.138	9.288	13.421	1.469	1.441	---	5.913
+ 250	13.555	10.153	12.013	17.181	1.923	1.874	---	7.597
+ 260	14.110	10.561	12.574	17.945	2.017	1.962	**0.317**	7.941
+ 300	16.327	12.209	14.862	21.036	2.401	2.323	0.431	9.341
+ 350	19.090	14.293	17.819	24.964	2.896	2.786	0.596	11.136
+ 390	21.297	15.975	20.255	28.146	3.304	3.164	0.746	12.603
+ 400	21.848	16.397	**20.872**	28.946	3.408	3.259	0.787	12.974
+ 450	24.610	18.516	---	32.965	3.933	3.742	1.002	14.848
+ 500	27.393	20.644	---	37.005	4.471	4.233	1.242	16.748
+ 550	30.216	22.776	---	41.053	5.021	4.732	1.505	18.672
+ 600	33.102	24.905	---	45.093	5.583	5.239	1.792	20.613
+ 650	36.071	27.025	---	49.116	6.157	5.753	2.101	22.556
+ 700	39.132	29.129	---	53.112	6.743	6.275	2.431	24.527
+ 760	**42.919**	31.628	---	57.870	7.461	6.913	2.854	26.883
+ 800	---	33.275	---	61.017	7.950	7.345	3.154	28.455
+ 900	---	37.326	---	68.787	9.205	8.449	3.957	32.371
+ 950	---	39.314	---	72.603	9.850	9.014	4.387	34.319
+1000	---	41.276	---	**76.373**	10.506	9.587	4.834	36.256
+1200	---	48.828	---	---	13.228	11.951	6.786	43.846
+1300	---	52.410	---	---	14.629	13.159	7.848	**47.513**
+1372	---	**54.886**	---	---	15.645	14.033	8.642	---
+1400	---	---	---	---	16.040	14.373	8.956	---
+1600	---	---	---	---	18.849	16.777	11.263	---
+1700	---	---	---	---	20.222	17.947	12.433	---
+1750	---	---	---	---	20.877	18.503	13.014	---
+1768	---	---	---	---	**21.101**	**18.693**	13.223	---
+1800	---	---	---	---	---	---	13.591	---
+1820	---	---	---	---	---	---	**13.820**	---

[1]**Note:** Shaded cells refer to the calibration range end points used to calibrate the full range of the T/C type for this model. Bold column entries refer to the nominal T/C input range end points of this model.

[2]**Note:** CJC temperature values are resolved to 0.05°C increments using internal lookup tables corresponding to the T/C type. This means that if an input is scaled to a small input span, its reading may appear less accurate with CJC ON, as ±0.05°C becomes a greater percentage of a smaller span.

The voltage measured from a T/C reflects the difference in temperature between each end. To discern the actual temperature being sensed at the remote end (in the table above), the unit must subtract the equivalent thermoelectric voltage of the other end from its measurement (usually referred to as its Cold Junction reading). This unit senses the temperature of its TB1 terminals to cold-junction compensate its T/C reading and remove the portion of the measured voltage corresponding to its cold junction.

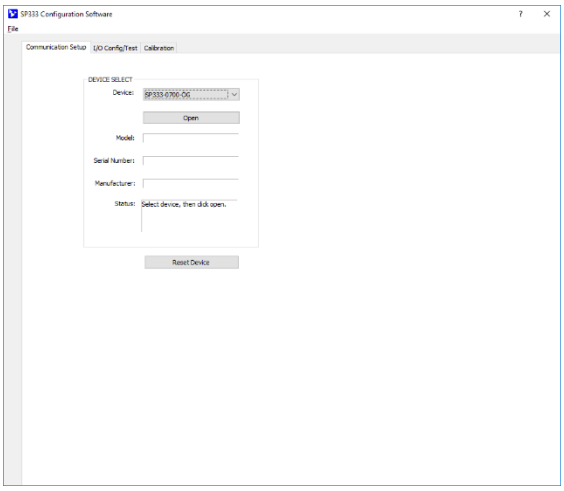
Configuration



Note that you should already have power connected to the transmitter at this point. This model does not utilize USB power and you will not be able to configure, calibrate, or test the unit without power applied.

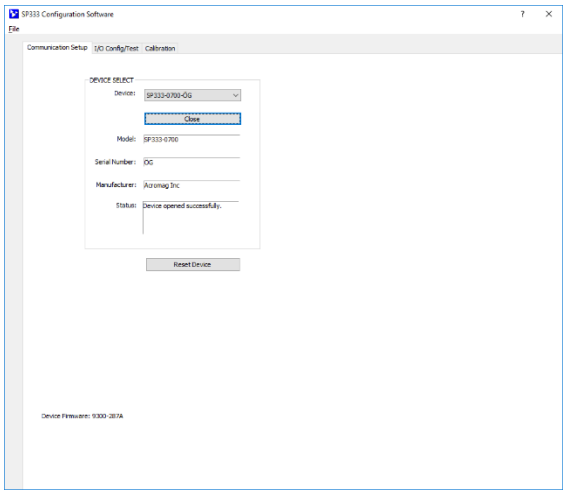
After executing the Acromag Configuration software for this model, the screen shown at left will appear, if you have not already connected to your transmitter via USB (note fields are blank under these conditions).

Connect your PC to the unit via USB, and the unit's model-serial information will appear in the Device field as shown in the second screen at left.



If you happen to be connected to more than one unit via a USB hub, you can use the Device scroll field to select another unit, using the serial information suffix of the Device Model number to discern one unit from another.

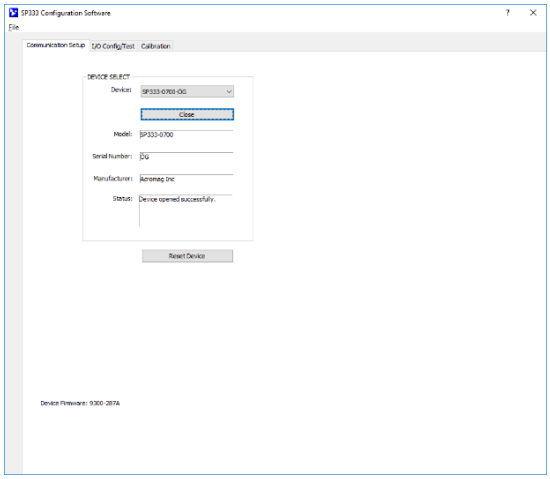
Once you have selected a device, click the **[Open]** button to open communication with the unit.

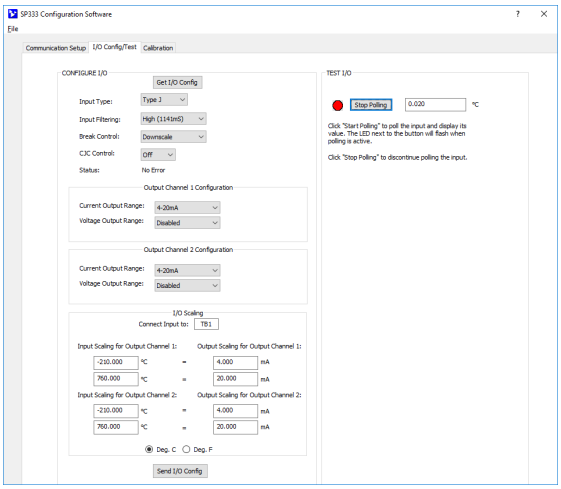


After clicking [Open], the selected unit's Model, Serial Number, Manufacturer, and connection status message will be displayed as shown in the first screen on the next page.

TIP: Always Close a connection with one device before selecting another device. Make sure you have the correct model software for the model you are configuring.

Configuration…





After you connect USB and "Open" communications with a unit, the Status field indicates "Device opened successfully" as shown in the screen at left.

At this point, you can click the **"I/O Config/Test"** tab to begin configuring the unit, or optionally test its operation. The I/O Config/Test screen is the second screen shown at left.

When you click the "I/O Config/Test" tab, the software retrieves the unit's current configuration and displays it like the second screen shown at left.

If you are connected to a module, the initial I/O Config screen represents the current configuration of the connected module before making changes. Otherwise, if you have loaded the configuration from a saved file, or have made changes to any fields, you can click the **[Get I/O Config]** button at the top of the screen to retrieve the connected module's current configuration.

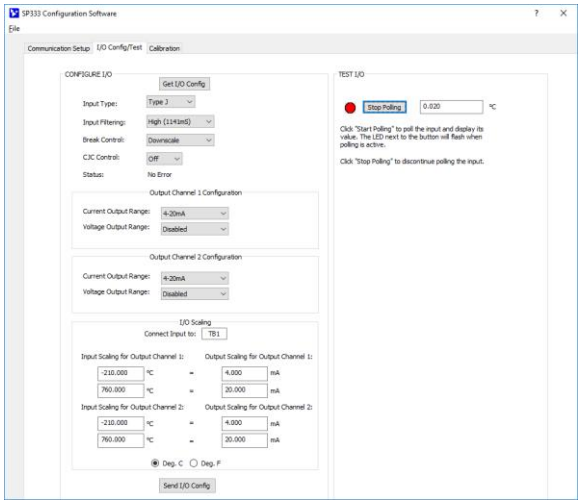
Note that if you make any changes to the selections indicated, the only way to preserve your changes is to write them to the device by clicking the **[Send I/O Config]** button after completing your selections, or to save them to a file by clicking **"File"** in the upper left-hand corner of the screen.

Select the Input Type/Range…

Input Range refers to the nominal input range wired to TB1 and you can select TC types J, K, T, R, S, E, B, N, or ±100mV, or ±1V. Note that input ranges may be rescaled, and the input can be scaled differently per output.

Note that any input range you pick here can be rescaled to the output, allowing you to use only a portion of the selected input range to drive a current or voltage output, as desired. However, resolution will decrease proportionally as you rescale the input signal smaller than the nominal range. Each halving of the nominal range will reduce resolution by 1 bit. This can also magnify error, especially noticeable for very small input ranges which degrade the signal-to-noise ratio of the input and resolution of the analog-to-digital conversion.

Configuration…



HELP – You can press **[F1]** for Help on a selected or highlighted field or control. You can also click the **[?]** button in the upper-right hand corner of the screen and click to point to a field or control to get a Help message pertaining to the item you pointed to.

Select the Input Filtering…

You may select the level of digital filtering to apply to the input channel as Low, Medium, High, or None (No digital filtering). The respective I/O response times are indicated in parenthesis next to your filter selection. Note that higher filter levels result in lower average noise, but with slower I/O response times (See Specifications). Always set the input filter as desired before calibrating an input.

Select the Output 1 and Output 2 Ranges…

This unit has both DC voltage and DC current output terminals at each output channel which share return. Current Output Ranges are 0-20mA, 4-20mA, and Disabled, and the current output will drive up to 525Ω. Voltage Output Ranges are ±10V, ±5V, 0-10V, 0-5V, and Disabled, and the voltage output may drive 1KΩ or higher loads. Only one output, current or voltage may be loaded at one time.

Select the I/O Scaling…

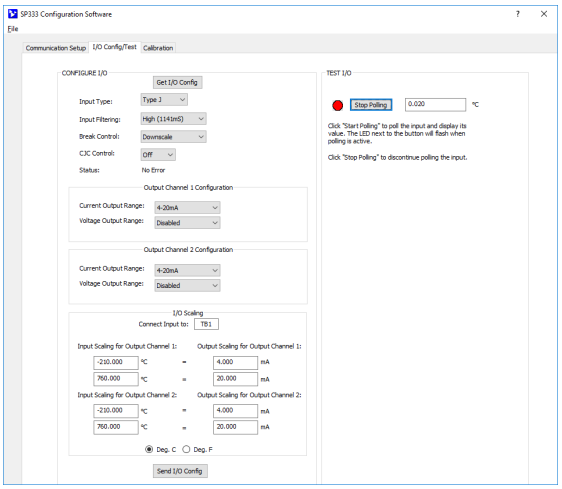
You may rescale a selected input range differently for each output channel and you could choose to use a smaller portion of the nominal input range to drive an output if desired. Likewise, you may rescale an output range. Be careful not to reduce an input or output range too much, as resolution will be proportionally diminished and noise/error magnified (each halving of range reduces respective resolution by 1 bit).

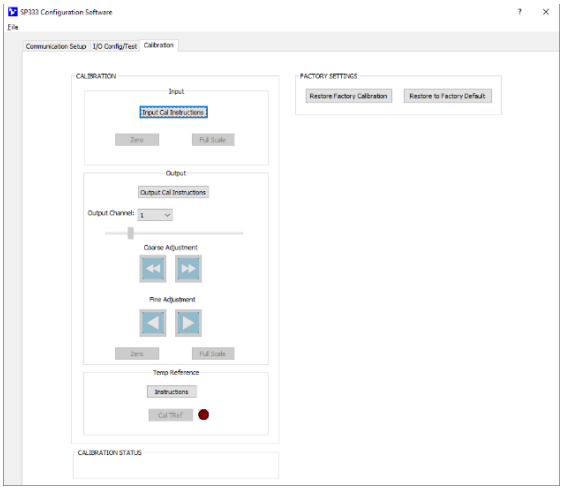
In the Input Scaling fields for each output, set the input signal minimum/zero value inside full range to correspond to the output range zero value (over/under-range included). Set the input signal maximum/full-scale value inside full range to correspond to the output range full-scale value. You may also rescale the output range similarly. You could optionally swap input levels to configure a reverse acting output response if desired. Note that some under and over-range is built into every I/O range and these limits vary.

If the scaled input/output zero and full-scale points are chosen too close together, performance will be degraded.

Once you have made your configuration selections, click the **[Send I/O Config]** button to write them to the module. You can read the Status of your sent message to the unit in the "Status" field. Alternately, you could click **"File"** in the upper left corner to save the settings to a file on your PC, for later reference.

Calibration (Optional)





CAUTION-Input Calibration: Driving inputs outside of the nominal input range of the unit will not be acceptable for calibration of zero or full-scale. Since input levels cannot be validated during calibration, incorrect signal levels will produce an undesired output response.

At this point, you can test the module operation by clicking the **[Start Polling]** button of the TEST I/O section of this page to trigger the software to periodically read the input and display its value in the field to the right of the polling button. Note the simulated lamp next to the button flashes slowly each time it samples the input. Click **[Stop Polling]** to stop polling the input before moving onto the next page.

Once you've configured your unit, you are ready to install it in the field, as the unit has already been factory calibrated. If you later encounter error that is out of specification, you can choose to click the **Calibration** tab to display the Calibration control page shown at lower left.

IMPORTANT: The unit has already had input and output channels factory calibrated with a high level of precision. If you attempt to recalibrate an input/output channel, you could degrade its performance if it is not done properly, or it is done using lower grade equipment. Consider your decision to recalibrate carefully. Set the input filter as desired before calibrating the input.

Calibration of this model is a simple two-part process initiated by simply clicking the Input Cal or Output Cal **"...Instructions"** button to begin and then follow the on-screen prompts to continue.

CALIBRATION – Input

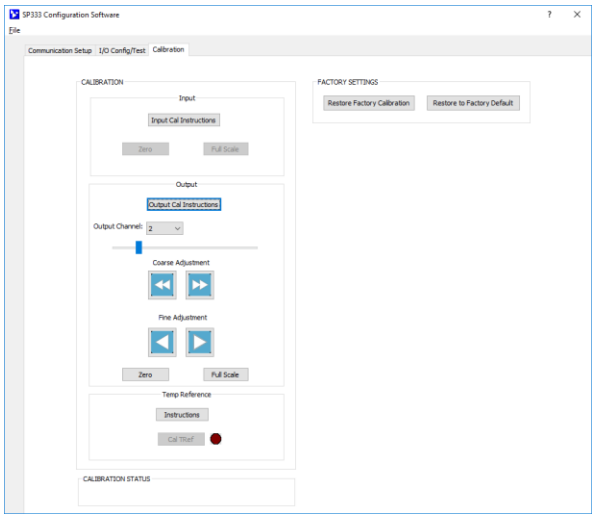
Before attempting input calibration, set the nominal Input Range and input Filtering on the "I/O Config/Test" page to calibrate and make sure you write your selection to the unit by clicking ***[Send I/O Config].*** *Wire your input signal source to TB1.*

After setting the input range, click **[Input Cal Instructions]** button to begin input calibration and enable the Input [Zero] and [Full-Scale] buttons.

Click the Input **[Zero]** and you will be prompted to input the minimum signal of your nominal input range at TB1. This will be the range minimum which varies with the T/C type or Input Range selected (calibration does not use the scaled range zero, but the zero of the nominal input range selected). Once you input the zero precisely, click the **[OK]** button and follow the on-screen prompt to calibrate zero.

Click the Input **[Full-Scale]** and you will be prompted to input the full-scale value of your selected input range at TB1. This will be the range maximum and varies with the T/C type or Input Range selected (calibration does not use the scaled range full-scale, but the full-scale of the nominal input range selected). Once you input full-scale precisely, click the **[OK]** button and follow the on-screen prompt to calibrate full-scale.

Calibration…



CALIBRATION – Each Output Separately

Click the **[Output Cal Instructions]** button to begin output calibration and enable the Output [Zero] and [Full-Scale] buttons.

Adjust the input as necessary to drive the output to its precise nominal zero of its output range (i.e. -20.000mA, 0mA, 4.000mA, -10V, -5V, or 0V, depending on the output range setting). Measure this output level accurately, or performance will be degraded. At the precise output range zero, click Output **[Zero]** of the Calibration Output section to calibrate the output zero.

Next adjust the input as necessary to drive the output to its precise nominal full-scale of its output range (i.e. 20.000mA, 5V, or 10V, depending on the output range setting). Measure this output level accurately, or performance will be degraded. At the precise output range full-scale, click Output **[Full-Scale]** of the Calibration Output section to calibrate the output signal level.

If the output acts erratic or appears imprecise, you may need to repeat input or output calibration, being very careful to take accurate measurements and input correct signal levels. For current outputs, if you are measuring a voltage across an output load resistor, make sure that you use the exact load resistance when calculating the load current being measured. When rescaling an input to a smaller sub-range, make sure that you still have adequate input span, as too-tight input spans have diminished resolution and will magnify error.

CALIBRATION - Temperature Reference

You must already have the Type J TC range calibrated to accomplish CJC calibration. Click the **[Instructions]** button to begin CJC reference calibration for cold-junction compensation for all T/C input types and you will be prompted to connect a TC Type J ice point reference to the input. Follow the on-screen instructions to complete.

Factory Settings

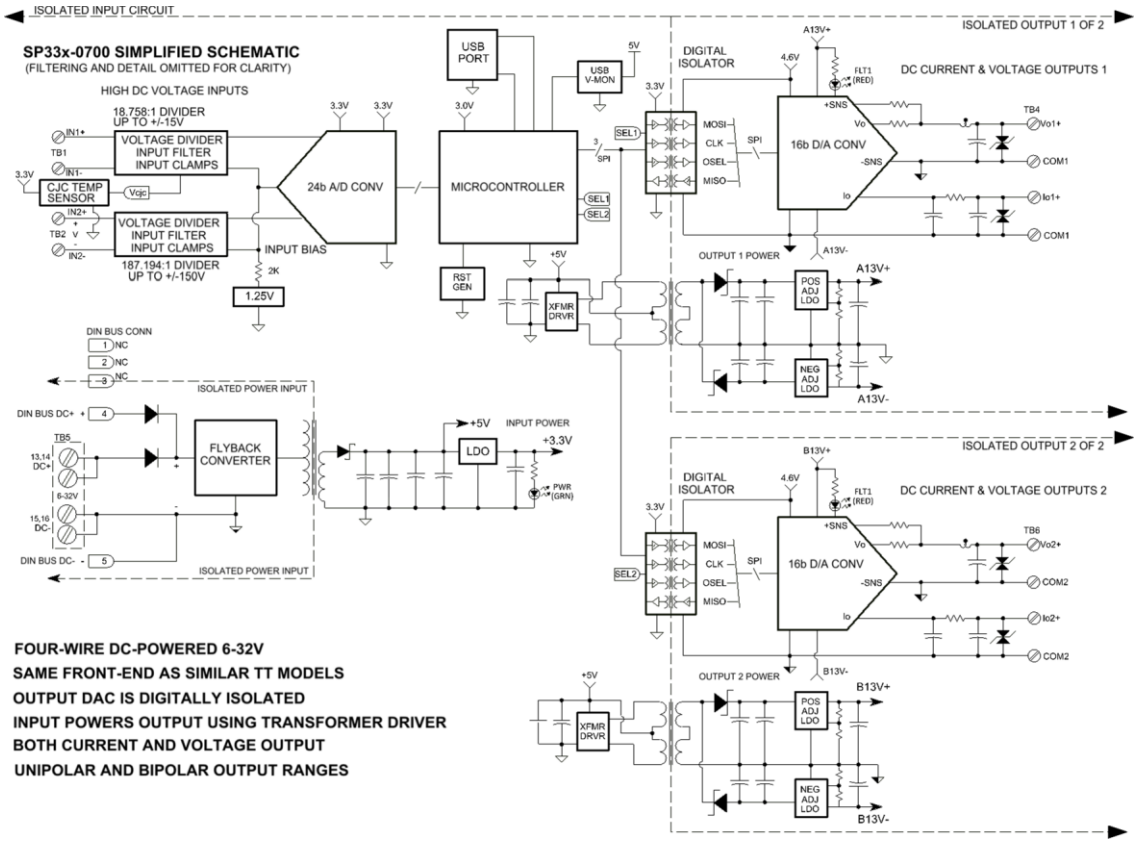
You can use the **[Restore Factory Calibration]** button to restore the transmitter's original factory calibration if you think you made an error during recalibration, degraded its performance, or the I/O channel appears erratic.

You can use the **[Restore to Factory Default]** button to return the unit to its original factory configuration settings. This does not restore calibration, only configuration. Alternately, this button can be used as a sanitation tool to restore the unit to its initial configuration when decommissioning a module.

Calibration Status

This field displays calibration status messages like "No Error", "Transfer Error", and "Timeout Error" during calibration. If you encounter a Transfer or Timeout Error, your calibration did not complete and you may have to repeat the calibration process.

BLOCK DIAGRAM



How It Works

Key Points of Operation

- Unit is DC powered and power is Isolated.
- Input is Differential
- Dual Isolated Output Channels with both current and voltage output terminals.
- Input circuit ground is common to USB ground.

This transmitter uses a 32-bit microcontroller and a high-resolution 24-bit A/D to digitize the input signal and communicate to each output DAC via an SPI bus using digital isolators. This signal is transmitted to 16-bit output DACs which drive separate voltage and current terminals with a shared return. Each output range is user-configured. Power for the isolated input and isolated output circuits is provided via an isolated fly-back converter that operates on voltage wired to the power terminals at TB5, or wired to optional bus power terminals along the DIN rail. Set up involves selecting the input range (T/C type or ±100mV or ±1V), selecting the output range at each output (current or voltage), selecting a filter level, and scaling your input range endpoints to each output range zero/full-scale endpoints. I/O scaling can also be done in reverse to produce a reverse acting output signal. Refer to the block diagram above to gain a better understanding of transmitter operation.

The input/USB, each output, and power circuits are isolated from each other. This unit does not draw power from USB. The USB port ground is common to the input circuit ground. The USB port ground of most PC's is also common to the USB cable shield and earth ground. Input sensors may be grounded or ungrounded. For this reason, it is recommended that USB signals be isolated when connected to a PC to prevent a ground loop from occurring between the PC earth ground and a grounded input sensor, which would have the negative effect of pulling the input bias supply to ground and clipping any negative range.

TROUBLESHOOTING

Diagnostics Table

Before attempting repair or replacement, be sure that all installation and configuration procedures have been followed and that the unit is wired properly. Verify that power is applied to the unit and that your supply voltage is at least 6V. Verify that your load is appropriate to your output type, current or voltage

If your problem still exists after checking your wiring and reviewing this information, or if other evidence points to another problem with the unit, an effective and convenient fault diagnosis method is to exchange the questionable unit with a known good unit.

Acromag's Application Engineers can provide further technical assistance if required. Repair services are also available from Acromag.

POSSIBLE CAUSE	POSSIBLE FIX
Cannot Communicate with Unit via USB…	
Output shifts off-range when you connect USB…	
Output Erratic, Not operational, or at Wrong Value…	
Unit fails to operate or exhibits an output shift…	
A missing USB Isolator could cause a ground loop between a grounded input sensor and earth ground at the connected Personal Computer's USB port.	Without USB isolation, a ground loop is possible between a grounded input and earth ground of the PC USB port. The input to this model is normally biased up 1.25V off input ground to process negative-going signals. A grounded signal source could inadvertently short this bias to earth ground and clip the negative input range with a non-isolated USB connection. For this reason and for increased safety and noise immunity, it is best to connect to USB via a USB isolator. Use an isolator like the Acromag USB-ISOLATOR. Otherwise, use a battery powered laptop to configure the transmitter, which does not normally earth ground its USB port.
Software Fails to Detect Transmitter…	
Bad USB Connection	Recheck USB Cable Connection.
(Agility) Your smart device needs permission to connect to the Acromag splitter the first time.	When you first connect to your smart device, it will prompt for permission. Be sure to give your permission or Agility will not discern your device connection. You may have to unplug/replug the USB connection to your tablet/phone to get this prompt.
USB has not enumerated the device.	Use the reset button of the Acromag USB isolator to trigger re-numeration of the splitter, or simply unplug and re-plug the USB cable to the splitter.
Communication or power was interrupted with USB connected while configuration software was running.	Close the current connection with the software, then select and re-open the splitter for communication (or simply exit the Configuration software and reboot it).
For an input step, the output appears to make 2 steps to reach its final value…	
For a step change in the input, the A/D needs 2 input samples to charge to its final level.	When you step the input, it takes two samples for the A/D to charge to its final output level, evident when using a scope to examine the output transition in response to an input step change, which appears to make two steps in its transition to its final level.

Diagnostics Table…

POSSIBLE CAUSE	POSSIBLE FIX
Output goes right to Over-Range (105%) or Under-Range Limit…	
This indicates that either the input signal is out of range, scaling is incorrect, or a sensor lead has broken. It can also occur due to contention between earth ground at the PC USB port and the input sensor.	Check the input signal with respect to its range and reduce or increase it as required to drive the output within its linear operating range. A fully upscale or down-scale signal can be driven by a sensor fault, such as an open or broken sensor lead. Check the wiring of your input sensor. If you are not isolating USB, check for a ground loop between a grounded sensor and earth ground of the PC USB port.
Cannot Calibrate Input Channel…	
Is input wired properly?	Check that input is wired to ± input terminals using correct polarity.
Changing Input Filter Setting Affects Input Calibration…	
You may note a small shift in the input reading when changing the input filter setting.	An input should be calibrated at the desired filter setting. For best results, set the input filter as desired before calibrating the input.
Cannot Measure Input Voltage or Current…	
Have you wired the input to the correct terminals for the range selection?	Input voltage is input to TB1. Make sure that you are wired in the correct ±polarity for your T/C type.
Output Noise Seems Excessive…	
Scaled input or output range is too small.	Scaling the input/output to very small spans diminishes I/O resolution and signal to noise ratio, potentially magnifying error. Every halving of the nominal range reduces resolution by 1-bit. Increase the I/O span.
An orange output fault LED is ON...	
The corresponding current output load is too large to drive it accurately or is an open-circuit, or the output driver has over-heated.	Indicates the current output load is open circuit or its load is too large to maintain output accuracy (≤520Ω), or the IC die temperature has exceeded 142C (resets cool below 124C).

Service & Repair Assistance

This unit contains solid-state components and requires no maintenance, except for periodic cleaning and transmitter calibration (zero and full-scale) and verification. Its enclosure is not meant to be opened for access and can be damaged easily if snapped apart. It is highly recommended that a non-functioning transmitter be returned to Acromag for repair or replacement. Acromag has automated test equipment that thoroughly checks and calibrates the performance of each transmitter, and can restore firmware. Please refer to Acromag's Service Policy and Warranty Bulletins, or contact Acromag for complete details on how to obtain repair or replacement.

ACCESSORIES

Software Interface Package

Software Interface Package/Configuration Kit – Order TT-SIP

- USB Signal Isolator
- USB A-B Cable 4001-112
- USB A-mini B Cable 4001-113
- Configuration Software CDROM 5040-TBD

This kit contains all the essential elements for configuring TT transmitters and SP Splitters. Isolation is recommended for USB port connections to these transmitters and splitters and will block a potential ground loop between your PC and a grounded input. A software CDROM is included that contains the Windows software used to program TT transmitters and SP splitters.

USB Isolator

USB Isolator – Order USB-ISOLATOR

- USB Signal Isolator
- USB A-B Cable 4001-112
- Instructions 8500-900

This kit contains a USB isolator and a 1M USB A-B cable for connection to a PC. This isolator and cable are also included in TT-SIP (see above).

USB A-B Cable

USB A-B Cable – Order 4001-112

USB A-B Cable 4001-112

This is a 1 meter, USB A-B replacement cable for connection between your PC and the USB isolator. It is normally included with the TT-SIP Software Interface Package and with the isolator model USB-ISOLATOR.

USB A-mini B Cable

USB A-mini B Cable – Order 4001-113

- USB A-mini B Cable 4001-113

This is a 1 meter, USB A-miniB replacement cable for connection between the USB isolator and the SP333 splitter. It is normally included in TT-SIP.

Note that software for all SP Series models is available free of charge, online at www.acromag.com.

USB OTG Cable

USB OTG Cable – Order 5028-565

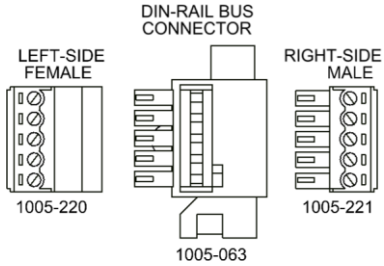
- USB OTG Cable 5028-565

This is a 6 inch, USB On-The-Go cable for connection between the USB A-mini B Cable and a mobile phone or tablet. It is required to use the Acromag Agility™ Config Tool App.

Note that the Acromag Agility ™ Config Tool is available free of charge, online at the Google Play store.

DIN Rail Bus Connector Kit

Bus Connector Kit for DIN Rail Connection to Power – Order TTBUS-KIT



This kit contains one each of the following terminals

- DIN Rail Bus Connector 1005-063 for 17.5mm TT/SP Modules.
- Left Side terminal block, female connector 1005-220.
- Right Side terminal block, male connector 1005-221.
- Two End Stops for 35 mm DIN Rails 1027-222 (not shown).

SP splitters are shipped with their bus port plugged. Remove this plug and insert DIN Rail Bus Connector 1005-063, which allows multiple units to snap together. Then add a left or right-side terminal block to mate to the bus connector to wire power to the bus. These terminals can be used to optionally (or redundantly) drive power to Series TT or SP modules via the DIN rail bus connector, and allowing modules to neatly and conveniently share a connection to Power. Two end stops 1027-222, used to secure the terminal block and module for hazardous location installations.

End Stops

Two End Stops – Order 4001-252

- Two 1027-222 End Stops for 35 mm DIN Rail mounting

For hazardous location installations (Class I, Division 2 or ATEX / IECEx Zone 2), you can use two end stops (Acromag 1027-222) to help secure modules to 35mm DIN rail (not shown).

SPECIFICATIONS

Model Number

Model SP333-0700

Dual Output Signal Transmitter Isolated TC/mV Input Four-Wire w/ Isolated Power CE Approved
Includes UL/cUL Class 1, Division 2 approvals

Custom calibration to your specifications can be added as a separate line item at time of purchase.

The SP333 model prefix denotes a combination Thermocouple/milliVoltage input model of our DIN-Mounted SP300 Splitter family. The trailing "-0700" model suffix denotes a 4-wire transmitter with separate isolated power and output, and with CE and UL/cUL Class 1, Division 2 Approvals included.

Models can be mounted on standard 35mm "T" Type DIN rail. Optional factory calibration to your own specification is ordered as a separate line item at time of purchase, and on a per unit basis. Factory calibration will require the specification of nominal input range, filter level, each output range, scaled input range zero, and scaled input range full-scale. You can also specify a normal or reverse acting output.

A standard model without adding custom factory calibration is calibrated by default for a Type J thermocouple with medium input filter selection, and both splitter outputs mapped to normally acting 4-20mA.

Recalibration of any model will require use of the TT-SIP configuration kit, ordered separately (see Accessories section).

Input

Reference Test Conditions: TC Type J with at least a 10mV span (e.g. Type J with 200°C span), or ±100mV range with a 10mV minimum calibrated span; Output 4-20mA; Ambient = 25°C; Power Supply = 24VDC.
Input & Accuracy: Configurable for native input types/ranges shown in Table 1 below. Unit provides T/C linearization, T/C Cold-Junction Compensation (CJC), and lead break detection.

Table 1: Range/Accuracy		ISA/ANSI Color	°C Temp Range	Typical[1] Accuracy
T/C	T/C Material			
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
mV	NA	NA	±100mV	±0.05%
V	NA	NA	±1V	±0.1% Max

[1]**Note (Table 1):** Accuracy is generally ±0.1% of the full-scale span, typical, or per the table 1 specification, whichever is greater.
[2]**Note (Table 1):** Accuracy of Table 1 is given with CJC switched off. CJC uncertainty should be combined with the numbers of Table 1 to determine potential overall inaccuracy. Inaccuracy with CJC enabled may increase by as much as ±0.5°C during the post power-on warm-up period, but will be ±0.2°C typical after nearing thermal equilibrium in about five minutes.

Input...continued

Break Detection: Can be set for Upscale or Downscale open sensor or lead break detection. Limits are output range dependent. Upscale output limit is approximately 21 mA or 10.5 V, or 5.25V. Downscale limit is approximately -21mA, or 0mA, or 3mA, or -10.5V.
IMPORTANT: Calibration should be done with break detection already set as required by the application, as changing it will affect calibration somewhat.
Input Linearization (T/C Inputs): Within ±0.25°C of the NIST tables.
Input Overvoltage Protection: Bipolar Transient Voltage Suppressers (TVS), 5.6V clamp level typical. Also includes differential input diode clamping, capacitive filtering, and series resistance.
Input Analog to Digital Converter (A/D): Input utilizes a 24-bit, Σ-Δ A/D converter, with only the first 16-bits used. Its signal is then normalized to a bipolar range count of ±25000 to simplify I/O scaling (see Input Resolution below).
Input Sampling Rate (A/D): Input is sampled at a variable rate according to the input filter selection as follows:

A/D SAMPLING RATE (SAMPLES/SECOND) PER INPUT FILTER			
NONE	**LOW**	**MED**	**HIGH**
214.65sps	53.6625sps	13.42sps	1.6775sps

Input Filter: Normal mode RC filtering, plus digital filtering, optimized and fixed per filter selection within the Σ-Δ ADC. See Normal Mode Noise Rejection and Output Response Time.
Input Zero and Full-Scale Adjustment: Input range endpoints are selectable over the full range indicated in Table 1 for each input type. Input Zero and Full-Scale selections must be within the nominal ranges indicated and will be mapped to the output zero and full-scale (100%) current or voltage endpoints, according to output range selected. Keep in mind that your input resolution is reduced as your scaled input range is reduced. Likewise, error in degrees is magnified as the input span is reduced. Rated performance is based on a 10mV minimum input span.
Input Bias Current: ±125nA typical (TC break current).
Noise Rejection (Common Mode): Varies with input filter selection between 93dB (no filter) and 134dB (high filter), typical, with 100Ω input unbalance.
Noise Rejection (Normal Mode): Varies with input filter selection. Table below indicates the typical rejection at 60Hz for each input filter selection. Note that at the medium and high input filter settings, the A/D converter adds 80dB minimum of rejection for frequencies between 49Hz and 61Hz.

	TYPICAL 60Hz REJECTION PER INPUT FILTER			
INPUT	**NONE**	**LOW**	**MED**	**HIGH**
TB1 TC/mV/V	0.5dB	20dB	> 80dB	> 80dB

Input Resolution: The A/D in this splitter divides its input signal into parts calculated by subtracting endpoint A/D counts computed via (Vin*Gain/1.25)* 32768+32768, with Gain=8, 16, 32, or 64, depending on the input Type (see Table 1). This count is then converted to TC temperature via a linearizer function for the TC type (the output is made linear with respect to TC temperature, not voltage). The linearizer to temperature conversion resolves to 0.05C, which can limit the input resolution for small spans (for example, a span of 200°C yields a linearizer resolution of 200/0.05=4000 parts).

Input...continued

The linearized temperature is interpolated to the output based on a straight-line calculation formed by mapping input range endpoints you specify to the output range endpoints of the output range. Input ranges that share the same gain are calibrated by extrapolating from another input range calibration. The effective I/O resolution for a given range will be the lowest resolution of the A/D (see below), or its linearized value (using 0.05C intervals), as the D/A resolution is always greater. Internally for simplification, the raw A/D counts indicated in Table 2 are normalized to ±25000/15.5 bits for ±100% (bipolar ranges), or 0-25000/14.5 bits for 0-100% (unipolar ranges), and the effective input resolution of a range will be the lesser of the raw resolution indicated in Table 2 or this normalized resolution.

SP333 INPUT RANGE	xDIVIDER	xGAIN	A/D INPUT RESOLUTION
V (-1.000V to +1.000V)	NONE	1	6554 to 58982 or 1/52428
mV (-100mV to +100mV)	NONE	8	11796 to 53740 or 1/41943
T/C J (-210 to +760°C) (-8.095mV to 42.919mV)	NONE	16	29373 to 50770 or 1/21397
T/C K (-200 to +1372°C) (-5.891mV to 54.886mV)	NONE	16	30297 to 55789 or 1/25492
T/C T (-260 to +400°C) (-6.232mV to 20.872mV)	NONE	32	27540 to 50277 or 1/22736
T/C R (-50°C to+1768°C) (-0.226mV to 21.101mV)	NONE	32	32578 to 50469 or 1/17890
T/C S (-50°C to+1768°C) (-0.236mV to 18.693mV)	NONE	32	32570 to 48449 or 1/15879
T/C E (-200 to +1000°C) (-8.825mV to 76.373mV)	NONE	8	30917 to 48785 or 1/17867
T/C B (+260 to 1820°C) (0.317mV to 13.820mV)	NONE	64	33300 to 55954 or 1/22654
T/C N (-230 to +1300°C) (-4.226mV to 47.513mV)	NONE	16	30995 to 52696 or 1/21701
Internal CJC from -50°C to 150°C drives 0V to 1V	NONE	1	32768 to 58983 or 1/26214 (Applies to CJC conversion)

The input and output ranges of this device may be rescaled independently, but scaling to smaller input or output spans will proportionally diminish nominal resolution. The actual effective I/O resolution of your transmitter will be the lowest resolution of either the input A/D, the linearization conversion to temperature (resolves to 0.05°C, T/C inputs only), or the output D/A. Output resolution is usually greater at 1 part in 43690 for 4-20mA output, but may become a limiting factor if the output is rescaled smaller. In most cases, for thermocouple ranges, your I/O resolution will be dominated by the 0.05°C temperature resolution of the thermocouple linearizer, especially for small input spans.

Thermocouple CJC Reference: CJC senses from -50°C to 150°C for 0-1V at an internal resolution of 1/26214, but the unit linearizer only resolves to 0.05°C. Table 2 below shows the relative accuracy of the CJC sensor used in this circuit. CJC has been factory calibrated at 25°C to ±0.1°C. The accuracy of CJC over the full operating range will be about ±1.0°C.

Table 2: CJC[1] Sensor Accuracy

CJC Range	Typical	Maximum
25°C	±0.1°C	±0.3°C
10 to 80°C	±0.3°C	±0.6°C
-40 to 80°C	±0.5°C	±1.2°C

Input...continued

[1]**Note:** Cold Junction Compensation may be switched off to permit the direct connection of a mV source via copper wires to the input to simplify calibration. Otherwise a hand-held calibrator may be used. For best results, allow the module to reach thermal equilibrium by allowing it to warm up 5-10 minutes prior to calibrating CJC, and position the module as it will be in its application. Input is normally calibrated with CJC OFF, and CJC calibration is done separately.

Output

Output Range: Each channel has separate voltage and current output terminals that share a return terminal. Only one output, voltage or current, may be loaded per channel at one time. Supported output ranges with over-range are shown in Table 3 below.
Output Resolution: Each output is driven by a 16-bit voltage/current DAC, Texas Instruments DAC8760IPWPR. The resolution per nominal output range is indicated in the Table 3 below. Note that nominal ranges may be rescaled in the unit and resolution will drop 1 bit for every halving of the range. The actual I/O resolution of a unit will be the lowest resolution of the input A/D, and output D/A relative to the selected/scaled I/O range.

16-bit DAC COUNT	TABLE 3: OUTPUT RANGES AND RESOLUTION w/OVER-RANGE					
	Voltage Output				Current Output	
	0-5V	**0-10V**	**±5V**	**±10V**	**0-20mA**	**4-20mA**
0	**0V**	**0V**	-5.5V	-11V	**0mA**	0mA
2979			**-5.0V**	**-10V**		
10923					4mA	**4mA**
54612					**20mA**	**20mA**
59577	**5.0V**	**10.0V**				
62556			**+5.0V**	**+10V**		
65535	5.5V	11.0V	+5.5V	+11V	24mA	24mA
RES	**1/59577**	**1/59577**	**1/59577**	**1/59577**	**1/54612**	**1/43689**
1 lsb	83.925uV	167.8uV	167.8uV	335.7uV	0.34132uA	0.34132uA
%Span	0.001678%				0.001707%	0.002133%

For rescaled outputs, you can determine the DAC count that drives *YourOutput* in range units using the nominal MIN/MAX endpoints of the range that corresponds to DAC counts 0 and 65535 in Table 3 and the expression: 65535**YourOutput*/(MAXEP-MINEP).

Output Accuracy: Better than ±0.05% of span, typical, and ±0.1% maximum, with nominal input and output ranges. This includes the effects of repeatability, terminal point conformity, and linearization, but does not include sensor error.
Output Noise/Ripple: Less than ±0.1% of output span, typical.
Note (High Speed Acquisition): Additional filtering at the load is recommended for sensitive applications with high-speed acquisition rates. For excessive 60Hz supply ripple with current output, a 1uF or larger bulk capacitor is recommended at the load. High frequency noise is often reduced or eliminated by placing a 0.1uF or 0.01uF capacitor directly across the load (this can also raise RF immunity).
IMPORTANT: Input and output ranges may be rescaled to ranges smaller than nominal, which can increase potential error as resolution and signal-to-noise ratio are diminished for small I/O spans. In general, rated accuracy can be achieved for effective I/O resolution equal or greater than 12-bit (1/4096).
Output Load: The voltage output can drive loads down to 1KΩ minimum. The current output can drive 21mA DC into 0-525Ω.

Output...continued

Output Ambient Temperature Drift: Better than ±80ppm/°C (±0.0080%/°C) over the ambient temperature range. This includes the combined effect of zero and span drift for reference test conditions (see Input Specifications).
Output Response Time: The maximum time measured for the output to reach 98% of its transition for an input step driving the voltage output into a 10KΩ load with a 24V supply and the input set to No filter, Low filter, Medium filter, and High filter.

	RESPONSE TIME TO 98% OF TRANSITION (TYPICAL)
FILTER	**SP333-0700**
NONE	14ms
LOW	41ms
MEDIUM	137ms
HIGH	1141ms

USB

USB MINI-B socket for temporary connection to a PC or laptop for configuration and calibration purposes. USB isolation is required when input is connected to a grounded input sensor (see "IMPORTANT" below). During reconfiguration & recalibration, the transmitter receives its power from its DC power connection (via DIN rail bus or power terminal TB5), not USB. As such, you must connect power to the unit when you connect USB.
CAUTION: Do not attempt to connect USB in a hazardous environment. Transmitter should be set up and configured in a safe environment only.
Data Rate: USB v1.1 full-speed only, at 12Mbps. Up to 32K commands per second. USB 2.0 compatible.
Transient Protection: Adds transient voltage protection on USB power & data lines.
Cable Length/Connection Distance: 5.0meters maximum.
Driver: No special drivers required. Uses the built-in USB Human Interface Device (HID) drivers of the Windows Operating System (Windows XP or later versions only).
USB Connector: 5-pin, Mini USB B-type socket, Hirose UX60-MB-5S8.

USB PIN	DEFINITION
1	+5V Power (Transient Protected, but not used by the module)
2	Differential Data (+)
3	Differential Data (-)
4	NC – Not Connected
5[1]	Power Ground (Connects directly to Signal Ground)
SHLD[1]	Signal Ground (Connects directly to Signal Ground)

[1]**Note:** Most Host Personal Computers (except battery powered laptops) will connect earth ground to the USB shield and signal ground.

IMPORTANT – USB Isolation is Required: The input of this unit is isolated from both outputs and may be connected to grounded or un-grounded input sensors, but input circuit ground connects in common to the USB power/signal/shield ground, which in-turn makes a connection to earth ground at the PC when directly connected to the USB port of a Personal Computer. Failure to connect USB without isolation would short the 1.25V input bias supply to input ground if the sensor is also earth grounded, interfering with operation, truncating the negative input range, and possibly shifting the output. For this reason, USB isolation is strongly recommended when connecting to a PC. In the absence of USB isolation when connected to a grounded input sensor, a battery powered laptop could be used to connect to the unit instead, as the laptop does not normally connect to earth ground.

Power

Power Supply (Connect at TB5 or via DIN Rail Bus Terminal): 6-32V DC SELV (Safety Extra Low Voltage), 1.5W maximum. Observe proper polarity. Reverse voltage protection is included. Current draw varies with power voltage as follows (currents indicated assume fully loaded both current outputs driving 20mA into 500Ω).

SUPPLY	SP333-0700 CURRENT CONSUMPTION
6V	221mA Typical / 250mA Max
12V	105mA Typical / 125mA Max
15V	84mA Typical / 100mA Max
24V	53mA Typical / 62mA Max
32V	41mA Typical / 46mA Max

CAUTION: *Do not exceed 36VDC peak to avoid damage to the unit. Terminal voltage at or above 6V minimum must be maintained across the unit during operation.*

Power Supply Effect: Less than ±0.001% of output span effect per volt DC change.

Enclosure & Physical

General purpose plastic enclosure for mounting on 35mm "T-type" DIN rail.
Case Material: Self-extinguishing polyamide, UL94 V-0 rated, color light gray. General purpose NEMA Type 1 enclosure.
Circuit Board: Military grade fire-retardant epoxy glass per IPC-4101/98.
Unit Weight: 0.35 pounds (0.16 Kg).
Dimensions: Width = 17.5mm (0.69 inches), Length = 114.5mm (4.51 inches), Depth = 99.0mm (3.90 inches). Refer to Mechanical Dimensions drawing.
I/O Connectors: Removable plug-in type terminal blocks rated for 12A/250V; AWG #26-12, stranded or solid copper wire.
Program Connector: 5-pin, Mini USB B-type socket, Hirose UX60-MB-5S8.
DIN-Rail Mounting: Unit is normally mounted to 35x15mm, T-type DIN rails. Refer to the DIN Rail Mounting & Removal section for more details.

LED Indicators (Front-Panel)

Power PWR (Green) – Channel Green ON indicates power is applied to unit (this LED is sourced from isolated internal 3.3V rail).

Fault FLT - Channel Output (Orange, Each Output, FLT1 & FLT2) - Orange FLT LED per output channel. ON indicates current output is open circuit, or the corresponding current output load resistance is too high to drive accurate current to it (load resistance is greater than 550Ω). ON may also indicate over-temperature if the output driver die temperature has exceeded 142°C.

Environmental

These limits represent the minimum requirements of the applicable standard, but this product has typically been tested to comply with higher standards in some cases.
Operating Temperature: -40°C to +75°C (-40°F to +167°F).
Storage Temperature: -40°C to +85°C (-40°F to +185°F).
Relative Humidity: 5 to 95%, non-condensing.
Isolation: Input/USB, each output, and power circuits are all 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). Complies with test requirements of ANSI/ISA-82.01-1988 for voltage rating specified.

Environmental ...continued

Installation Category: Suitable for installation in a Pollution Degree 2 environment with an Installation Category (Over-voltage Category) II rating per IEC 1010-1 (1990).
Shock & Vibration Immunity: Conforms to: IEC 60068-2-6: 10-500 Hz, 4G, 2 Hours/axis, for sinusoidal vibration; IEC 60068-2-64: 10-500 Hz, 4G-rms, 2 Hours/axis, for random vibration, and IEC 60068-2-27: 25g, 11ms half-sine, 18 shocks at 6 orientations, for mechanical shock.

Electromagnetic Compatibility (EMC)

Minimum Immunity per BS EN 61000-6-1:

1) Electrostatic Discharge Immunity (ESD), per IEC 61000-4-2.
2) Radiated Field Immunity (RFI), per IEC 61000-4-3.
3) Electrical Fast Transient Immunity (EFT), per IEC 61000-4-4.
4) Surge Immunity, per IEC 61000-4-5.
5) Conducted RF Immunity (CRFI), per IEC 61000-4-6.

This is a Class B Product with Emissions per BS EN 61000-6-3:

1) Enclosure Port, per CISPR 16.
2) Low Voltage AC Mains Port, per CISPR 14, 16.
3) DC Power Port, per CISPR 16.
4) Telecom / Network Port, per CISPR 22.

Agency Approvals

Electromagnetic Compatibility (EMC): CE Marked, per EMC Directive 2014/30/EU.

FCC Conformity: This device complies with Part 15, Class B of the FCC rules.

Safety Approvals: UL Listed (USA & Canada). Hazardous Locations – Class I, Division 2, Groups A, B, C, D Hazardous Location or Nonhazardous Locations only. These devices are open-type devices that are to be installed in an enclosure suitable for the environment.

ATEX Certified: The SP333-0700 model is ATEX / IECEx Certified for Explosive Atmospheres per ATEX Directive 2014/34/EU which complies with standards IEC 60079-0 Edition 6, IEC 60079-15 Edition 4, EN 60079-0:2012+A11:2013, and EN 60079-15:2010.
Ex II 3 G Ex nA IIC T4 Gc -40°C ≤ Ta ≤ +75°C,
DEMKO 18 ATEX 2086**X** IECEx UL 18.0092**X**

X = Special Conditions

1) The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN/IEC 60664-1.
2) The equipment shall be installed in an enclosure that provides a degree of protection not less than IP 54 and only accessible with the use of a tool in accordance with EN/IEC 60079-15.
3) Transient protection shall be provided set to a level not exceeding 140 % of the peak rated voltage value at the supply terminals to the equipment.

Reliability Prediction

Reliability Prediction
MTBF (Mean Time Between Failure): MTBF in hours using MIL-HDBK-217F, FN2. *Per MIL-HDBK-217, Ground Benign, Controlled,* $G_B G_C$

Temperature	MTBF (Hours)	MTBF (Years)	Failure Rate (FIT)
25°C	TBD hrs	TBD years	TBD
40°C	TBD hrs	TBD years	TBD

Configuration Controls

Software Configuration Only via wired USB or USB-OTG
This transmitter drives dual tandem analog output current and voltage channels proportional to a single sensor input based on the differential voltage measurement across the sensor (a voltage sourced from TB1). No switches or potentiometers are used to adjust this transmitter. Its behavior as an isolated signal amplifier/transducer is determined via programmed variables set using a temporary USB connection to a host computer or laptop running a Windows-compatible configuration software program specific to the transmitter model. This software provides the framework for digital control of all configuration and calibration parameters, and this information is stored in non-volatile memory.

Refer to Operation Step-By-Step in the Technical Reference section of this manual for detailed information on available software control of this model.

Revision History

The following table show the revision history for this document:

Release Date	Version	EGR/DOC	Description of Revision
26 FEB 2018	A	BC/MO	Initial Release.
27 NOV 2018	B	CAP/ARP	Added UL / ATEX / IECEx / FCC statements.