USB Programmable, DIN Form B Connection Head Transmitter

Model ST133-1600 & ST133-1610 Two-Wire Transmitter, T/C Input

USER'S MANUAL

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Symbols on equipment:

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

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For additional information, please visit our web site at www.acromag.com and download our whitepaper 8500-904, Introduction to Two-Wire Transmitters.

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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.

GETTING STARTED

TECHNICAL REFERENCE

DESCRIPTION

The ST133-16x0 is an ANSI/ISA Type II transmitter designed to interface with a thermocouple sensor (Type J, K, T, R. S, B, E, N), or millivoltage (±100mV) input source, isolate the input signal, and modulate a 4-20mA current signal to drive a two-wire current loop. This unit is setup and calibrated using configuration software and a USB connection to Windows-based PC's (Windows XP and later versions only). The unit provides an adjustable input range, T/C linearization, input isolation, break detection, variable input filter, and cold-junction compensation.

Key Features

- **Digitally setup and calibrated w/ Windows software via USB.**
- **Designed for DIN Form B sensor head mounting.**
- **High measurement accuracy and linearity.**
- **T/C Type J, K, T, R, S, B, E, N, or ±100mV input support.**
- **T/C inputs are linearized with respect to temperature.**
- **T/C inputs include accurate Cold Junction Compensation.**
- **Supports both Celsius and Fahrenheit temperature units.**
- **Adjustable input ranges.**
- **Variable Input Filter Adjustment.**
- **Normal or Reverse Acting output.**
- **Up-scale or down-scale lead-break/burnout detection.**
- **Non-polarized two-wire current loop connections.**
- **Convenient two-wire loop power.**
- **Namur compliant loop current.**
- **Wide ambient temperature operation.**
- **Hardened For Harsh Environments.**
- **Optional DIN Rail Adapter for T-type & G-type DIN rail.**
- **CE Approved.**
- **Model ST133-1610 is UL Listed (USA & Canada) suitable for use in Class I, Division 2, Groups A, B, C, D Hazardous Locations, or Nonhazardous Locations only.**
- **Model ST133-1610 is ATEX Certified for Explosive Atmospheres.**
  Ⓔx II 3 G Ex nA IIC T4 Gc -40°C ≤ Ta ≤ +80°C
  DEMKO 13 ATEX 1113348X

Application

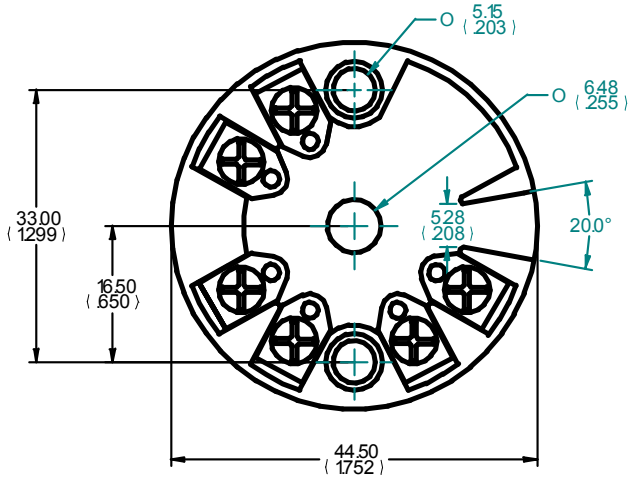
This transmitter is designed for mounting in DIN Form B connection/sensor heads commonly used in thermowell applications for sensing temperature or for use in an enclosure with suitable strength and rigidity. Optionally, a DIN-rail adapter may be purchased for mounting the unit to T-type, or G-type DIN rail. The transmitter must be installed in an ATEX Certified enclosure with a minimum ingress protection rating of at least IP54. Enclosure must have a door or cover accessible only by the use of a tool (See page 28 for details).

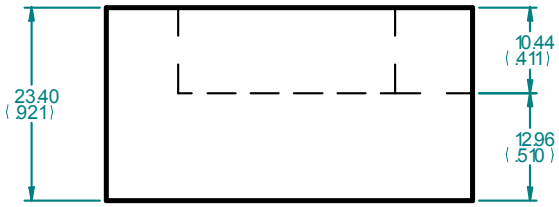
This model isolates its input signal and can mate with grounded or non-grounded thermocouple temperature probes common to thermowell applications. It provides an output current linearized to the T/C sensor temperature. Optionally, it supports a ±100mV input range and will drive an output current linear to the sensor millivoltage.

The output signal is transmitted via a two-wire, 4-20mA current loop. The two-wire current signal can be transmitted over long distances with high noise immunity. Sensor lead-break detection and the inherent live-zero output offset offers convenient I/O fault detection, should an input or output wire break.

Mechanical Dimensions

Connection Head Mounting





DIN Rail Mounting

35mm T-Type DIN Rail

G-Type DIN Rail

Dimensions in millimeters (inches)

Note that this transmitter conforms to the mechanical limits set forth in the German standard DIN 43 729, for the Form B head style, and can be easily mounted in DIN Form B connection and thermowell protection heads, similar to the figure at upper left.

The M4 mounting screws and relief springs used to attach the transmitter to the connection head are ordered separately via Acromag Mounting Kit ST130-MTG (see Accessories section).

The unit may be optionally mounted to 35mm T-type or G-type DIN rail using the optional DIN mounting kit ST130-DIN as shown at left (see Accessories section).

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.

ELECTRICAL CONNECTIONS

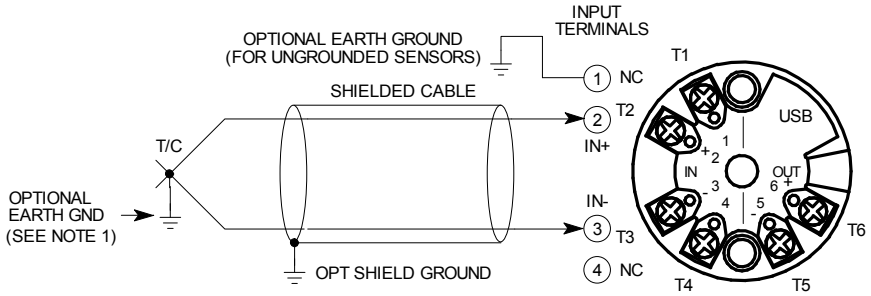
Wire terminals can accommodate 14-28 AWG (2.08-0.081mm^2) solid or stranded wire. Input wiring may be shielded or unshielded type. Ideally, output wires should be twisted pair. Strip back wire insulation 3/8-inch on each lead and wrap the bare wire in a clockwise direction around the terminal screw and below the SEMS washer. Tighten the screw to secure the wire at a torque rating range of 0.226 to 0.282 N-m. Terminals include wire loops for test clip attachment, or for redundant soldered wire connection required for heavy shock and vibration applications. Since common mode voltages can exist on signal wiring, adequate wire insulation should be used and proper wiring practices followed. Output wires are normally separated from input wiring for safety, as well as for low noise pickup. Cables and/or conductors in conduit must have a minimum temperature rating of 110°C.

Sensor Input Connections

Sensor wires are passed up through the center of the transmitter and wire directly to transmitter input terminals 2 and 3, as shown in the connection drawings below. Observe proper polarity when making input connections.

- **Input signal is isolated**.
- **T/C inputs use input terminals 2 & 3 –** Terminal 2 is the positive input, and terminal three is the negative input. Observe proper polarity. See connection figure below. Note that you can optionally connect earth ground at terminal 1 if the input sensor is un-grounded. This will help improve transient input protection in noisy environments.

MODEL ST133-1600 INPUT SENSOR WIRING



NOTE 1: DO NOT GROUND THE INPUT SENSOR IF UNIT IS CONNECTED TO A PC WITHOUT USING A USB ISOLATOR, OR IF CONNECTING EARTH GROUND AT TERMINAL 1.

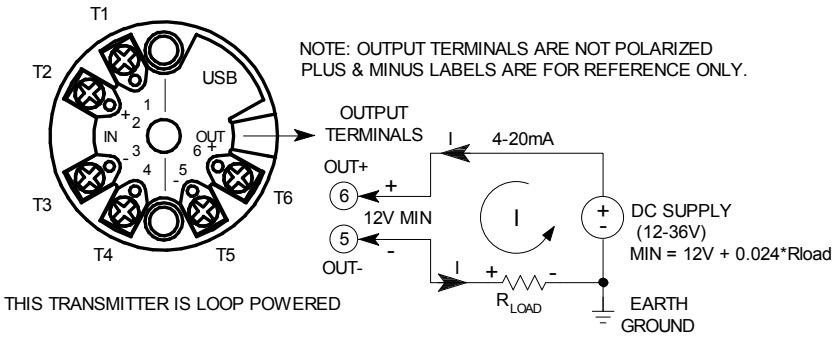
ELECTRICAL CONNECTIONS

Output/Power Connections

This transmitter has an ANSI/ISA Type 2 output in which the unit's power and output signal share the same two leads, and the transmitter output has a floating connection with respect to earth ground. In these applications, output wires normally pass through the output channel on top of the transmitter and are drawn through the egress path of the connection head. Connect a DC power supply and load in series in the two-wire loop as shown in the drawing below.

- Output connections are not polarized. The + and – designations are for reference only with current normally input to Output+ and returned via Output- (current sinking).
- Loop supply voltage should be from 12-32V DC with the minimum voltage level adjusted to supply over-range current to the load, plus 12V across the transmitter, plus any transmission line drop.
- Variations in power supply voltage between the minimum required and 32V maximum, has negligible effect on transmitter accuracy.
- Variation in load resistance has negligible effect on output accuracy, as long as the loop supply voltage is set accordingly.
- Note the traditional placement of earth ground in the current loop. The transmitter output floats off this ground by the voltage drop in the load resistance and lead-wire.
- Always connect the output/power wires and apply loop power before connecting the unit to USB.

ST133-16X0 OUTPUT/POWER WIRING

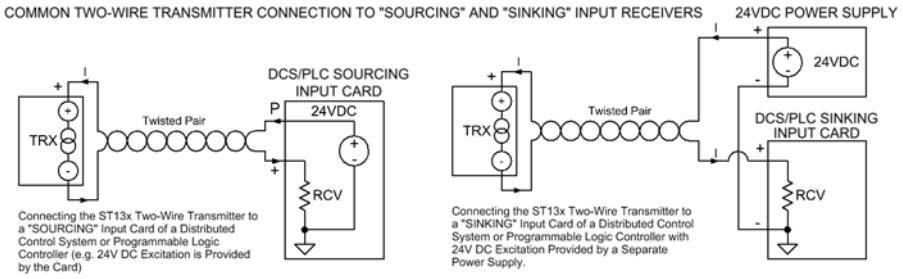


The output of this transmitter has a floating connection relative to ground which makes it flexible in the way it connects to various "Receiver" devices. In most installations, the loop power supply will be local to either the transmitter, or local to the remote receiver. Shielded twisted pair wiring is often used to connect the longest distance between the field transmitter and the remote receiver. The receiver device is commonly the input channel of a Programmable Logic Controller (PLC), a Digital Control System (DCS), or a panel meter. Some receivers already provide excitation for the transmitter and these are referred to as "sourcing" inputs. Other receivers that do not provide excitation are referred to as "sinking" inputs, and these will require that a separate power supply connect within the loop. Here are example transmitter connection diagrams for "sourcing" and "sinking" receiver types:

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.

ELECTRICAL CONNECTIONS

Output/Power Connections



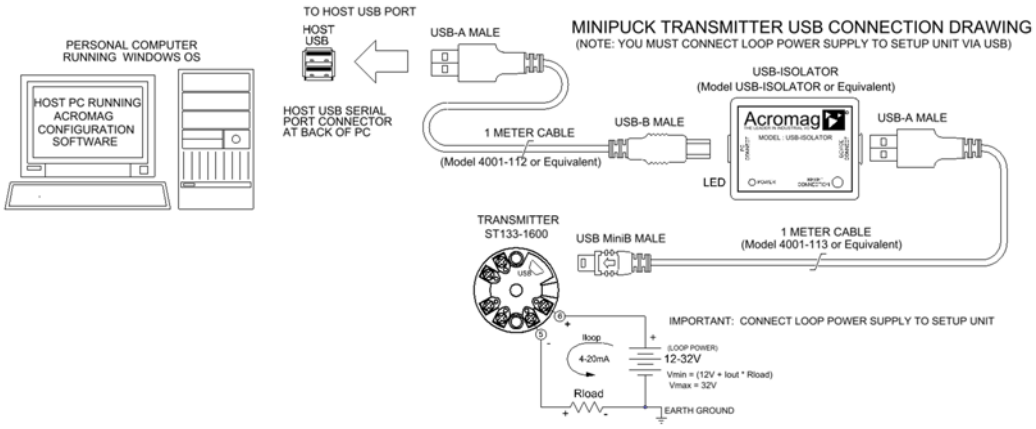
TIP - Ripple & Noise: Power supply ripple at 60Hz/120Hz is normally reduced at the load by the transmitter, but additional filtering at the load can reduce this ripple further. For large 60Hz supply ripple, connect an external 1uF or larger capacitor directly across the load to reduce excessive ripple. 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, as close to the load as possible.

TIP - Inductive Loads: If the two-wire current loop includes a highly inductive load (such as an I/P current-to-pressure 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.

Earth Ground Connections

The unit 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 and you should connect the metal enclosure's ground terminal (green screw) to earth ground using suitable wire per applicable codes. See the Electrical Connections Drawing for Output/Power and note the traditional position of earth ground for the two-wire output current loop. The Type II transmitter output terminals have a floating connection relative to earth ground. Earth ground is normally applied at the output loop power minus terminal and in common with the loop load or loop receiver minus. Earth ground may optionally be applied at input terminal 1, if you are connected to an ungrounded input signal.

- Respect the traditional position of earth ground in a two-wire current loop and avoid inadvertent connections to earth ground at other points, which would drive ground loops and negatively affect operation.
- Input connections and USB connections are isolated from the output. Grounded or un-grounded input probes may be used. A USB isolator is recommended for safety and noise suppression, but is not required for this model, except when connected to a grounded input signal. Note that most Personal Computers earth ground their USB ports and this makes contact with both the signal and shield grounds which is held in common to the input circuit ground.



ELECTRICAL CONNECTIONS

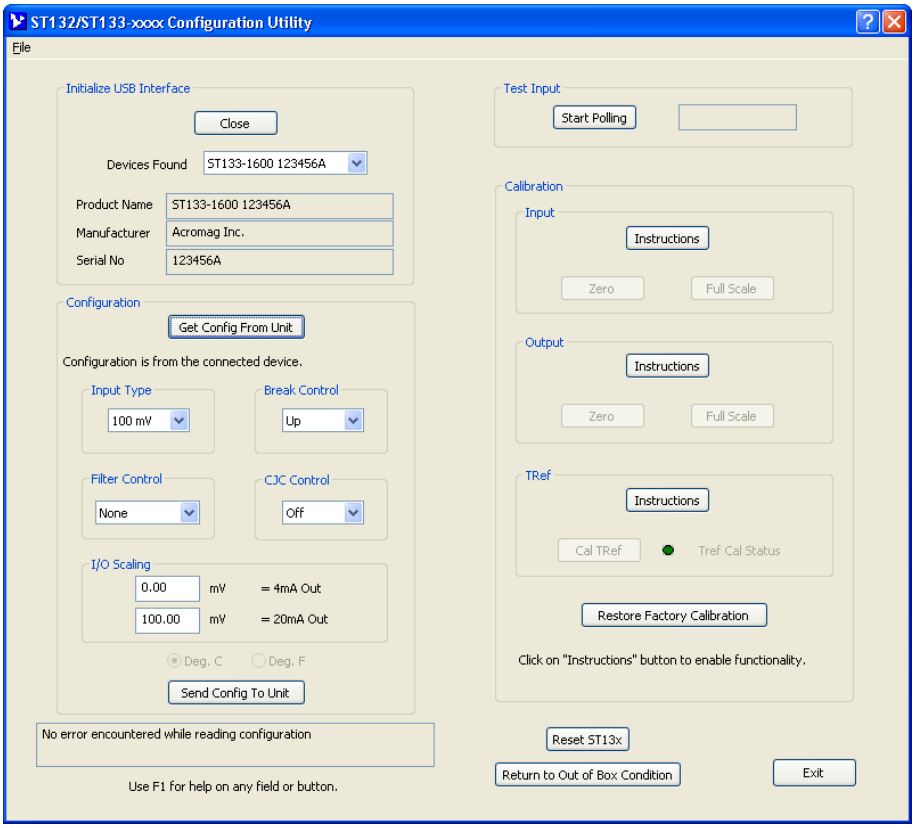
USB Connections

This transmitter is setup, configured, and calibrated via configuration software that runs on a Windows-based PC connected to the unit via USB (Windows XP or later version required). Refer to the drawing below to connect your PC or laptop to the transmitter for the purpose of reconfiguration and calibration using this software.

WARNING – USB Connector is not for operational or maintenance use in hazardous locations. The intent of mating USB with this transmitter is so that it can be conveniently setup and calibrated in a safe area, then installed in its connection head, 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 also connected to a grounded input –** Input and USB connections are isolated from the output of this model. USB Isolation is recommended for safety and noise suppression reasons, but required when the input signal is also grounded (i.e. when non-insulated or grounded probes are used). 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).
- **Reconfiguration Requires USB and Loop Power** - This transmitter draws power from both the current loop, and from USB during setup and calibration for any step that requires feedback of the output signal. Otherwise, USB power alone is sufficient to change setup parameters that do not refer to the output signal level.
- **Connect Loop Power Before USB** - Always connect the transmitter to its loop power supply before connecting USB in order to calibrate the unit, or erratic operation may result.

IMPORTANT: USB logic signals to the transmitter are referenced to the potential of the transmitter's input ground. This ground is held in common with USB ground and USB cable shield ground. While the input circuit and USB circuit are isolated from the output, the USB port is not isolated from the input. If the T/C or input signal is also earth grounded, then a ground-loop will develop between the T/C ground and the earth ground of the PC connected via USB, unless a USB isolator is used. The presence of this ground loop causes the input bias to connect to ground and will negatively affect performance. An isolator is required when the input signal is grounded and the unit is connected to the USB port of a PC, or if input terminal 1 is connected to earth ground. You could avoid the use of an isolator if a battery powered laptop was used to connect to the transmitter, and the laptop has no other earth ground connection.



USB Interface

- Scans for connected transmitters and allows you to selectively open communications with them.
- Devices Found: Connected transmitters are listed in this pull-down select menu. Click to highlight a transmitter and then click the “Open” button to open communications with it.
- Open/Close Button: Click this button to open or close communication with the selected transmitter listed in the Devices Found field.
- Displays the model number (Product Name), Manufacturer, and Serial Number of the connected/selected transmitter.

The software automatically scans for connected transmitters when it is booted. You can select a connected transmitter and open communications with it from the Device Found pull-down menu. The connected/selected transmitter’s ID info (Product Name/serial, Manufacturer, & Serial Number) is also displayed. Device connection status messages are also indicated in the System Message Window at the bottom of the screen.

Configuration Area

- **Input Type:** Set the Input Type, J, K, T, E, R, S, B, N, or ±100mV.
- **Break Control:** Set the break detection direction (Up or Down).
- **Filter Control:** Set the level of filtering to be applied to the input signal.
- **CJC Control:** Select if the CJC is used (On or Off).
- **I/O Scaling:** Select the input range endpoints to scale to the 4 to 20mA output range endpoints. You can optionally set this up for a reverse-acting output by swapping the signals.

CONFIGURATION SOFTWARE

Introduction

This transmitter can only be configured and calibrated via its Configuration Software and a USB connection to your PC or laptop. The configuration software can be downloaded free of charge from our web site at www.acromag.com. This software is also included on a CDROM bundled with the Configuration Kit ST13C-SIP (see Accessories section). For this model, look for program ST133Config.exe. The software is compatible with XP or later versions of the Windows operating system.

The configuration software screen for this model is shown at left. The configuration screen is divided into five sections as follows: USB Interface, Configuration, Test, Calibration, and the Message Bar and controls at the bottom of the screen. Additionally, there is a Reset button, a button to restore the unit to the factory default state, and a button to exit the program. A short description of each of these groups follows. For a detailed explanation, see Configuration Step-by-Step in the Technical Reference section of this manual.

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 to point to a field or control to get a Help message pertaining to the item you pointed to.

CONFIGURATION SOFTWARE

Introduction

You can click on "File" in the upper left hand corner to open a previously saved file, save your own file, or print out your configuration.

You can refer to the Configuration Step-by-Step section of the Technical Reference portion of this manual for a more detailed description of every control described here.

Use the controls of the Configuration section to select an input type, the break detent, filter level, CJC on/off, and input range scaling.

Test Input Area

- **Polling Toggle & Input Display Field:** This button will toggle polling of the input on/off and display the input level in the adjacent field.

Calibration Area (See Configuration Step-by-Step for Procedure)

- **Input:** This section calibrates the selected input range.
- **Output:** This section calibrates the 4 to 20mA output.
- **TRef:** This section calibrates the cold-junction temperature reference for cold junction compensation of the T/C.
- **Restore Factory Calibration Button:** This button will restore only the original factory calibration to the unit. Note that this will not reset any of the configuration settings.

This section is used to calibrate the input, output, and CJC temperature sensor of the unit. Instructions on how to calibrate the unit is detailed in the Configuration Step-by-Step section of the Technical Reference portion of this manual.

Message Bar

- Displays the Fault Status of your transmitter input signal.
- Displays prompt instructions during calibration.

The system message bar at the bottom of the screen will display & repeat prompt instructions as you step through calibration. It also displays diagnostic messages (see Configuration Step-by-Step section for specific messages).

Other Options:

- **Reset ST133:** This button will reset the ST133 unit.
- **Restore to Out of Box Condition:** This button will restore **ALL** configuration settings and calibration to the their original factory settings.

You can click the "Restore Factory Settings" button if you ever mis calibrate or misconfigure a transmitter in such a way that its operation appears erratic.

TROUBLE-SHOOTING

Diagnostics Table

POSSIBLE CAUSE	POSSIBLE FIX
Cannot Communicate with Transmitter via USB…	
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 a USB isolator, a ground loop is created between a grounded input signal source and earth ground of the PC USB port. It's best to connect to USB via a USB isolator for this reason, and for increased safety and noise immunity. 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.

TROUBLE-SHOOTING

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 loop and that your loop power supply voltage is sufficient to supply over-scale current into the load (MIN 0.020*Rload), plus 9V at the unit terminals, plus any line drop.*

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 Calibrate The Output…	
Loop power ON to the unit?	Unit requires a loop power connection, even when connected to USB if you are calibrating. The loop power supply should also be present before connecting to USB.
Software Fails to Scan/Detect Transmitter…	
Bad USB Connection	Recheck USB Cable Connection
Loop power was enabled after connecting to USB.	You must enable the loop power supply before connecting to USB. With loop power present, disconnect then reconnect the USB cable to the transmitter.
USB has not enumerated the device.	Use the reset button on the Acromag USB isolator to trigger renumeration of the transmitter, or simply unplug/replug the USB cable to the transmitter.
Communication or power was interrupted while USB was connected and the configuration software was running.	Close the current connection with the software, re-scan the transmitter, select and re-open the transmitter for communication (or simply exit the Configuration software and reboot it).
Output Erratic, Not operational, or at Wrong Value…	
Missing USB isolation with grounded input signal source. OR You are also connecting earth ground to terminal 1 and your input sensor is already grounded. The optional ground connection at Terminal 1 is only for ungrounded input sensors.	Even though the input is isolated from the output, if your input sensor is grounded, then connecting USB to the transmitter will drive a ground loop between your input and earth ground at the PC. Use USB signal isolation, or alternatively, you can connect to a battery-powered laptop, which does not earth ground its USB connection. Otherwise, you may have connected earth ground at terminal 1 with your input sensor already grounded, which would cause the 1.25V input bias to connect to input ground.
Otherwise…	Verify loop power and voltage level. Ideally, your supply voltage must be adequate to provide 12V to the transmitter, plus the IR drop in the load, plus the IR drop in the lead wires, and all at the maximum loop current (24mA).
For input step, 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 signal, it takes two samples for the A/D to charge up to its final value, and this is evident when using a scope to examine the output transition in response to a step change at the input, which appears to make two steps to arrive at its final level.

TROUBLE-SHOOTING

Diagnostics Table

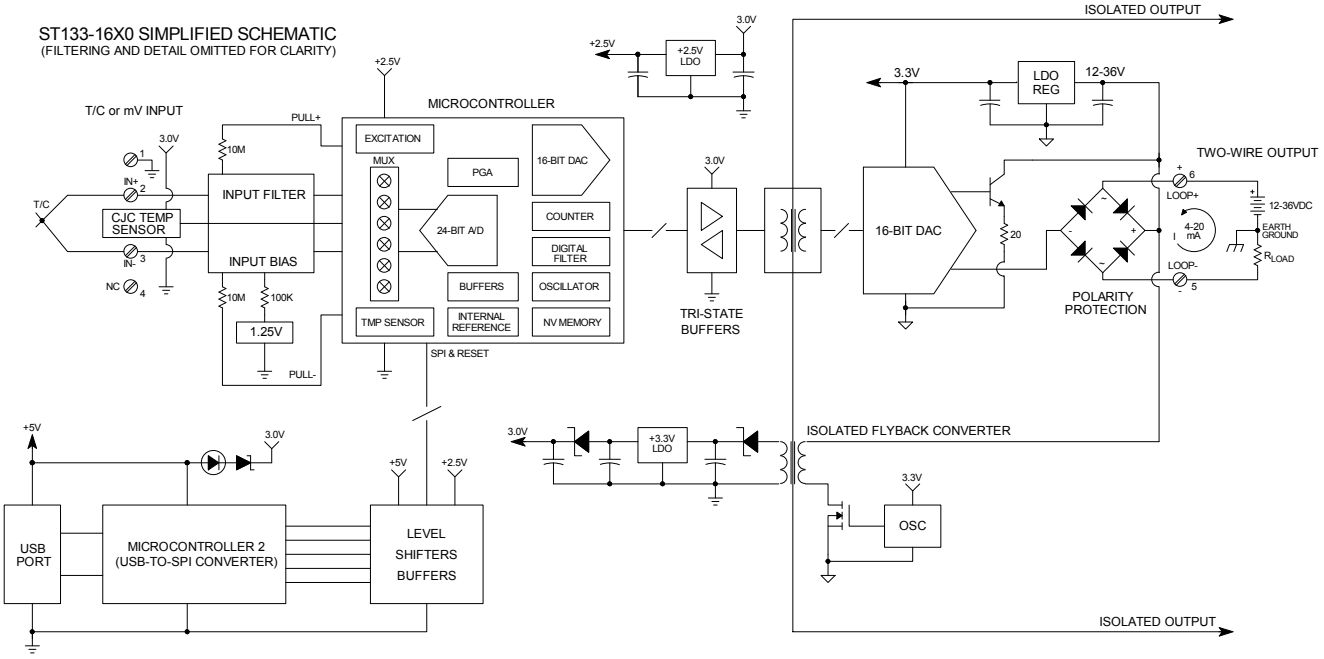
Service & Repair Assistance

This unit contains solid-state components and requires no maintenance, except for periodic cleaning and transmitter configuration parameter (zero and full-scale) verification. The potted Surface Mounted Technology (SMT) board contained within this enclosure is nearly impossible to repair, except for firmware. It is highly recommended that a non-functioning transmitter be returned to Acromag for repair, replacement, or re-programming. Acromag has automated test equipment that thoroughly checks and calibrates the performance of each transmitter, and restores its firmware. Please refer to Acromag's Service Policy and Warranty Bulletins on our web site, or contact Acromag for complete details on how to obtain repair or replacement.

POSSIBLE CAUSE	POSSIBLE FIX
Output shifts off-range when you connect USB…	
Indicative of a ground fault between earth ground at the PC and earth ground applied at the input sensor, which causes the 1.25V input bias to connect to input ground.	Only connect to the unit via isolated USB if your input sensor is grounded. You can connect without USB isolation if the input signal is not already grounded.
Output goes to Over-Range (24mA) or Under-Range Limit (3.5mA)…	
This indicates that either the input signal is out of range, or a sensor lead has broken and caused lead break detection to send the output to its upscale or downscale detent. 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 range and reduce or increase as required to drive the output current within its linear operating range. A fully upscale or down-scale signal is normally driven by a sensor fault, such as an open sensor or broken sensor lead, and this behavior follows the break control setting. Also check the wiring of your input sensor. If you are not isolating USB, check for a ground loop between a grounded T/C and earth ground of the PC USB port.
Unit fails to operate or exhibits an output shift…	
Is input grounded at terminal 1 and at the sensor? Is USB isolation not being used with a grounded sensor?	Isolated models are intended for use with ungrounded or grounded sensors, but you can only connect to grounded sensors if the USB signals are isolated. Only connect earth ground at terminal 1 if your input is ungrounded. The input is normally biased 1.25V off input ground to allow negative signals, and a grounded probe could inadvertently connect this bias to earth ground with a non-isolated USB connection to a PC, or with earth ground already connected at terminal 1.
Unit drives a low current, but fails to drive current at/near/above 20mA…	
Loop supply voltage is too low to support a full-scale or over-range current level in the loop load.	Check power voltage level. Make sure it is at least 12V plus 0.020*Rload. If transmission distance is long, then it must have additional voltage to support the IR drop in the wire. Ideally, the voltage should have ample overhead to drive the load at the maximum upscale output current of 24mA.
Output holds last value when I connect USB…	
Unit is awaiting initialization via its configuration software used to set it up and configure it.	Boot the configuration software to regain operation. The USB port is intended for setup and configuration of the module and it should not be left connected to USB without also booting the software.
Cannot Calibrate Input Channel…	
Is input wired properly?	Check that input is wired to input terminals 2 & 3 using correct polarity.

TECHNICAL REFERENCE

Block Diagram



This transmitter uses a microcontroller with an embedded multiplexer and high-resolution A/D to convert the input signal to a serial digital pulse stream that is then isolated via a pulse transformer and transmitted to a current-loop DAC. Power for the isolated input side of the circuit is provided via an isolated flyback converter that operates in parallel with the output loop. Another microcontroller of the circuit is used to convert the external USB signals to an internal SPI bus signal during reconfiguration. Setup involves selecting the input type (T/C or Mv), upscale or downscale break detection, turning CJC on or off as desired, selecting a filter level, and scaling the input range endpoints to 4Ma and 20Ma at the output. A cold junction compensation temperature sensor is located in the divider between the input terminals. Output scaling can also be done in reverse to produce a reverse acting output signal. The maximum over-range output signal is approximately 24Ma, the under-range signal is 3.3Ma. Refer to the block diagram above to gain a better understanding of how this transmitter works.

The input/USB and output/power circuits are isolated from each other. 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 could 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 affect of pulling the input bias supply to ground.

Key Points of Operation

- Unit is Loop Powered
- Input is Isolated
- Input is Differential
- Output/Power Terminals are Not Polarized
- Input circuit ground is common to USB ground.
- USB powers a portion of the input when connected.

CONFIGURATION STEP-BY-STEP

Calibration Connections

IMPORTANT: Do not connect the transmitter to your PC via USB without also booting the configuration software. Connection to USB is intended as a temporary connection for the purpose of setup and reconfiguration only. If you connect to USB but do not boot the configuration, the output DAC will hold its last programmed value as the unit's microcontroller awaits initialization via the host running configuration software.

This section of the manual will walk you through the reconfiguration process step-by-step. But before you attempt to reconfigure or recalibrate this transmitter, please make the following electrical connections:

Calibration Connections:

1. Connect a precision voltage source or thermocouple calibrator to the input as required, and observe proper polarity.

   An accurate input source adjustable over the range desired for zero and full-scale is required. A thermocouple calibrator may also be used. The input source must be accurate beyond the unit specifications (better than ±0.1%). A good rule of thumb is that your source accuracy should be four times better than the rated accuracy you are trying to achieve with the transmitter. 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 T/C 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 specific to each T/C type. Refer to the table 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 back to the ON position to enable cold junction compensation.

2. Wire an output current loop to the transmitter as shown in the Electrical Connections section. You will need to measure the output current accurately in order to calibrate the unit. You could connect a current meter in series in this loop to read the loop current directly. Alternatively, you could simply connect a voltmeter across a series connected precision load resistor in the loop, then accurately read the output current as a function of the voltage IR drop produced in this resistor (recommended). In any case, be sure to power the loop with a voltage that minimally must be greater than the 12V required by the transmitter, plus the IR drop of the wiring and terminals, plus the IR drop in the load. To compute the IR drop, be sure to use a current level that considers the over-scale current (~24Ma). The output load resistance and meter must be accurate beyond the unit specifications (better than ±0.1%). A good rule of thumb is that your load and meter accuracy should be four times better than the rated accuracy that you are trying to achieve with the transmitter.

   Loop Power Supply: Make sure that your power supply voltage level is at least 12V plus 0.020*load_resistance. Ideally, it should be great enough to drive the over-range current of ~24Ma into your load (i.e. greater than or equal to 12V+ 0.024*Rload, assuming the line drop is negligible and the maximum possible over-range current.

   Apply power to the transmitter output loop and always power the loop before connecting to USB. You will not be able to calibrate the unit without loop power applied.

CONFIGURATION STEP-BY-STEP

Calibration Connections

3. Connect the transmitter to the PC using the USB isolator and cables provided in Configuration Kit ST13C-SIP (refer to Electrical Connections section). You may omit the isolator if you are using a battery powered laptop to connect to the unit, or if your input source is not already grounded.

   Now that you have wired the unit, applied power, and connected the unit to USB, you can execute the Configuration Software program for your model (ST132-ST133Config.exe) to begin reconfiguration. This software is only compatible with XP or later versions of the Windows operating system.

Thermocouple cromag tage 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	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**	---

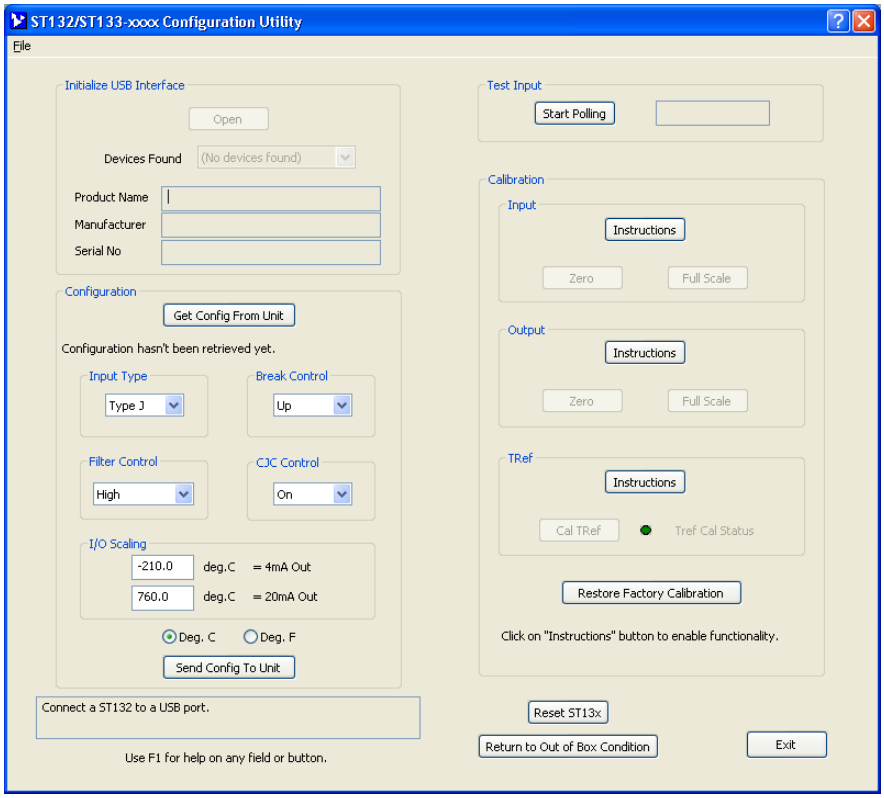
Note (Table): Shaded cells refer to the calibration range end points used to calibrate the T/C type for this model. Bold column entries refer to the nominal T/C input range end points of this model.

CONFIGURATION STEP-BY-STEP

Reconfiguration

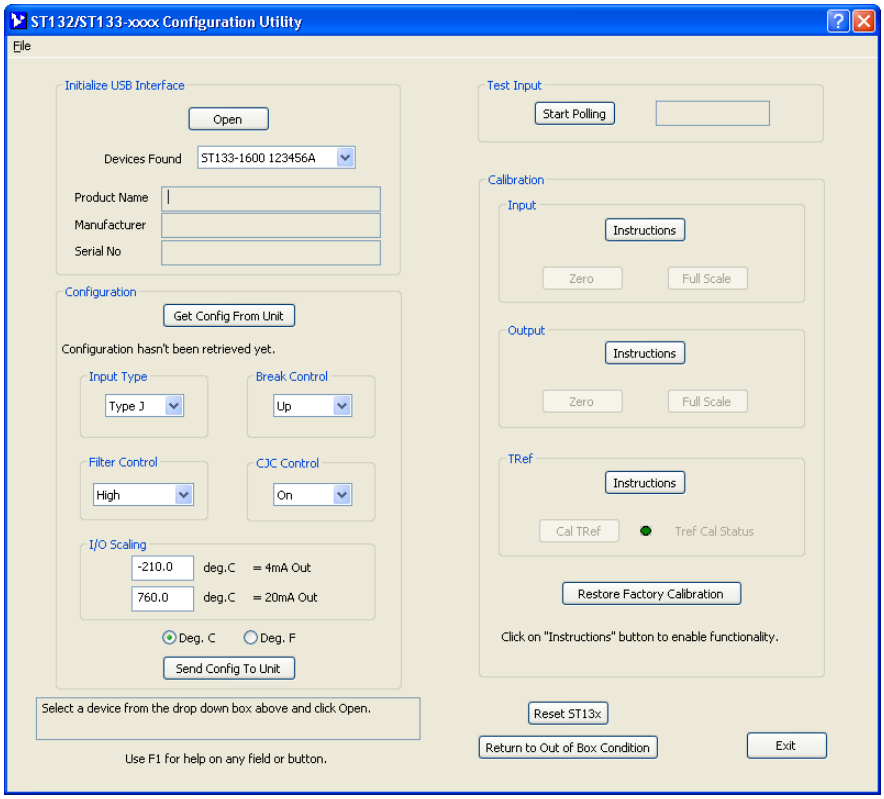
After executing the Acromag Configuration software for this model, a screen similar to the one at right will appear, if you have not already connected to your transmitter via USB (note some fields are faded out under these conditions).

Note that without a device already connected via USB, the System Status window at the bottom of the screen prompts you to “Connect a ST133 to a USB port”.



After you connect a transmitter to the USB port, the software will automatically detect it and the screen will change similar to the one at right.

Note that with a device already connected via USB, the System Status window prompts you to “Select a device from the drop down box above and click Open”.



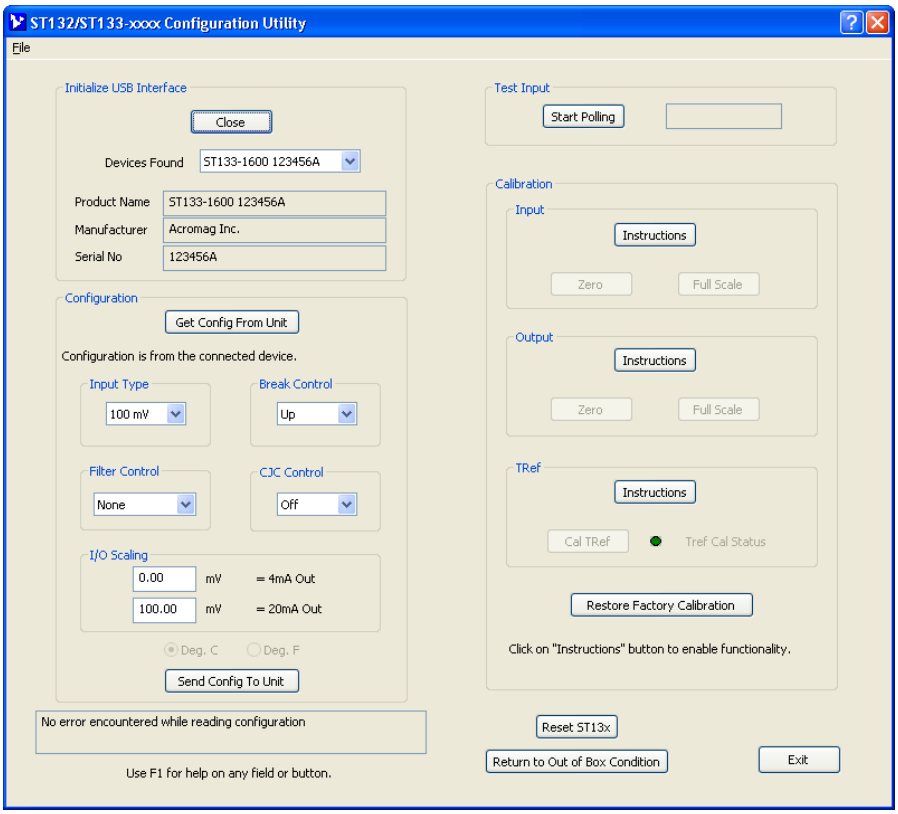
HELP – You can press F1 for Help on a selected or highlighted field or control. You can also click the [?] button in the upper-right hand corner of the screen and click to point to a field or control to get a Help message pertaining to the item you pointed to.

CONFIGURATION & CALIBRATION

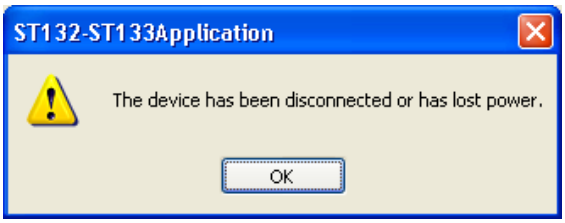
Reconfiguration

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.

At this point, you can select a device from the "Devices Found" field pull-down menu by clicking on it, then clicking the "Open" button to connect to the device for the purpose of reconfiguration and/or test (use the serial number to discern a particular transmitter). The screen should then appear similar to the one shown below. Note that "No error encountered while reading configuration" is displayed in the System Message Window at the lower left corner of the screen. Additionally, the device Product Name field displays the Model, the Manufacturer field displays "Acromag, Inc.", and the Serial field displays this model's serial number. Additionally, most of the other fields and controls are not faded out and await your input.



If more than one transmitter was connected via USB through a hub, you can discern which transmitter to open by referring to the product's unique serial number appended to the Product Name. If your intent was to open a different transmitter on the hub, then you simply "Close" the current connection and use the Devices Found scroll bar to select another transmitter (discern by serial number), then click "Open" to open it for communication. If you break the USB connection to a transmitter, the software will display the following:



CONFIGURATION STEP-BY-STEP

Reconfiguration

After clicking "OK", the software closes the connection and the screen returns back to its initial state, prior to connecting a module to USB. When you reconnect the USB cable, you will have to click "Open" to reopen communication with the transmitter. If you have more than one transmitter connected via a hub, then you will have to use the Device Name scroll bar to first select a transmitter (discern unit by serial number), and then click "Open" to open communication with it.

Note that if you intend to Test or Calibrate any elements of this transmitter, you should already have loop power connected to the transmitter before you execute this software.

At this point, the connected transmitter is ready for reconfiguration and the appropriate configuration fields become active and await your input.

If you want to see how the connected unit is already configured before changing its configuration, click the "Get Config From Unit" button of the Configuration controls section to retrieve its current configuration information. Note the message bar at the bottom of the screen and it should display a message like "No error encountered while reading configuration"

Select the Input Type (T/C Type or ±100Mvdc)…

In the Configuration section of this screen, select an input type: T/C Type J, K, T, R, S, E, B, N, or 100Mv.

- If you select any T/C type, your output will be linear with respect to sensor temperature, not sensor millivolts.
- If you select "100Mv", your output current will be linear with respect to input voltage, not temperature, and no special linearization will be performed. Note that "100Mv" represents ±100Mv range capability.

Select Upscale or Downscale Lead Break Detection…

Upon sensor burnout or a broken sensor lead, you can select **"Downscale**" to send the output current to its down-scale limit (~3.5Ma), or **"Upscale"** to send the output current to the over-scale limit (~24Ma). You can usually discern, a lead break or open sensor from an over-range or under-range input signal by noting its current level. Note that outputs can be reverse acting, and upscale for a reverse acting output will remain ~24Ma. Likewise, downscale for a reverse acting output still corresponds to a current level ~3.5Ma.

Select a Filter Control Level (None, Low, Medium, or High)…

Note that in addition to the analog filters of this unit, it also has the capability of applying digital filtering. Increased filtering is useful to help minimize the negative effects of noisy input signals, but will increase the response time of the unit accordingly. You can select the amount of filtering as None, Low, Medium, or High. Note the approximate response times indicated next to each filter level.

Turn Cold Junction Compensation (CJC) On, or Off…

This model embeds a very accurate temperature sensor in the space between the input + and – terminals in order to cold-junction compensate the thermocouple signal. To explain, the voltage measured from the T/C reflects the difference in temperature between each end. Thus, in order 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.

Further, the connection between the thermocouple and the copper terminals of the cold junction introduces additional thermocouples into the circuit. However, because these errant thermocouples that occur at the junctions of the ± terminals are close together and at identical temperatures, their effect on the principal measurement cancels out of the derivation. But to keep error to a minimum, you should still avoid any environmental or installation effects that could drive a difference in temperature between the ± input terminals. For example, touching one terminal and not the other.

You normally turn CJC On via this control for making T/C measurements, but you can elect to turn it off temporarily, if you wish to calibrate the T/C input using a voltage source that connects to the module via copper wires (as opposed to the wire materials of the various thermocouple types).

Note: *CJC temperature values are only resolved to 0.1°C using the internal lookup tables for the T/C type. As such, units configured for small input spans may appear less accurate with CJC ON, as ±0.1°C becomes a greater percentage of a smaller span. Keep this in mind when resolving measurements with short spans and high gains.*

Set the I/O Scaling (You can set this up to be Reverse Acting, too) …

This control is used to map your input range, or a portion of your input range, to the nominal 4Ma (0%) and 20Ma (100%) output range endpoints. Refer to the specifications to determine the full input range capability of the various input types. Then select valid input range endpoints to map to 4Ma and to 20Ma. Note that it is possible to exchange the order of these value assignments in order to define a reverse-acting output signal.

You need to select the input temperature or millivoltage that is to correspond to 4Ma of output signal and type this value into the corresponding field for 4Ma output. You also need to do this for the 20Ma output endpoint.

Note: Note that the effective input resolution does not rescale itself for input spans smaller than the nominal input range. That is, input resolution diminishes proportionally as you reduce the input span with smaller input ranges than nominal (see Specifications section for nominal ranges and resolution).

Note that some under-range and over-range is built-into the unit, as the output can swing as low as 3.5Ma, and as high as 24Ma. Actual endpoint limits will vary slightly between units.

CONFIGURATION STEP-BY-STEP

Reconfiguration

If the input zero and full-scale points are chosen too close together (span too small), resolution is diminished and the performance will be degraded. A minimum effective span of 10Mv is recommended. Also, you should pick your values carefully, as you will have to precisely drive the corresponding input signal values for zero and full-scale in order to calibrate your input range later.

(Optional) Test Your Input…

The Test Input area of your screen is useful to view your continuously variable input measurement in the field adjacent to the Start/Stop Polling button. Simply click the "Start Polling" toggle button, and the input will be repeatedly polled and displayed in the adjacent field. Click this button again to turn polling off.

Note that if CJC is ON, and your input signal is at 0°C (0.000Mv), the temperature value displayed will be equivalent to the ambient temperature at the input terminals (i.e. your cold junction). You can get a feel for how stable CJC temperatures are by doing this.

You should turn polling off while trying to calibrate the unit, or change its configuration.

Zero & Full-Scale Calibration

Calibration of Input, Output, and Tref …

This section is used to calibrate the input, output, and cold junction temperature reference of the unit. You can begin calibration of any of these three stages by clicking the corresponding "Instructions" button and following the on-screen prompts. Note that the button text will change according to the step.

Each calibration is an interactive process in which the software prompts you to apply input signals and then measure the corresponding output current. First, it will prompt you to apply the zero input signal, then measure and record the corresponding zero output signal current. Second, it does the same for the full-scale input signal and the corresponding full-scale output current signal. Note that as the span is reduced, resolution also diminishes. The Configuration Software will usually let you know when you need to adjust your desired limits as you enter them.

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

Calibration Section

Input Calibration

Use this procedure to calibrate the selected input range.

1. Turn off CJC.
2. Select your Input Type and click the “Send Config” button.
3. Click on the Calibration-Input “Instructions” button.
4. Click on the “Zero” button.
5. Input the required voltage displayed in the pop-up box and click “OK”.
6. Click on the “Full Scale” button.
7. Input the required voltage displayed in the pop-up box and click “OK”.
8. Repeat steps 2-6 until all required input ranges have been calibrated. Note that some ranges are calibrated coincidentally. For example, Type K and Type N are calibrated by calibrating Type J. Type R and Type S are calibrated by calibrating by calibrating Type T.

Input Calibration Values For Supported Input Ranges

Available Input Ranges	INPUT CALIBRATION POINTS	
	LOW CALIBRATION POINT (Cal Lo)	HIGH CALIBRATION POINT (Cal Hi)
Type J TC	0.0° (0.000Mv)	700.0° (39.130Mv)
Type K TC	0.0° (0.000Mv)	1300.0° (52.410Mv)
Type N TC	0.0° (0.000Mv)	1200.0° (43.846Mv)
Type T TC	0.0° (0.000Mv)	390.0° (20.255Mv)
Type R TC	0.0° (0.000Mv)	1700.0° (20.222Mv)
Type S TC	0.0° (0.000Mv)	1700.0° (17.947Mv)
Type E TC	0.0° (0.000Mv)	950.0° (72.603Mv)
Type B TC	260° (0.317Mv)	1700° (12.433Mv)
±100 Mvdc	-100.000 Mvdc	100.000 Mvdc

Output Calibration

Use this procedure to calibrate the 4-20Ma output range endpoints

1. Turn off CJC.
2. Select your Input Type and click the “Send Config” button.
3. Click on the Calibration-Output “Instructions” button.
4. Click on the “Zero” button.
5. Input the required voltage displayed in the pop-up box and click “OK”.
6. Click on the “Full Scale” button.
7. Input the required voltage displayed in the pop-up box and click “OK”.

Tref Calibration

Use this procedure to calibrate the cold junction compensation.

1. First, calibrate the TC Type J input range as shown above.
2. Connect a TC Type J ice point reference to the device input terminals.
3. Click on the “Tref-Cal” button.
4. In the pop-up box, click “OK”.

CONFIGURATION SOFTWARE

Calibration

If your output appears imprecise, you may need to repeat calibration, but being very careful to take accurate measurements and to input the correct signal levels. If measuring voltage across the output load resistance, make sure that you use the exact input resistance when calculating the current measured. Also, make sure that you have an adequate input span, as too-tight input spans have diminished resolution and may magnify error.

CONFIGURATION STEP-BY-STEP

Calibration – Restore Factory Calibration

If you make an error in recalibration, such that the unit has degraded performance, then you can click the "Restore Factory Calibration" button to restore the unit to the original factory calibration. Note that doing so will not change/restore any configuration settings, only the range calibrations. You should only click the "Restore Factory Calibration" button if you ever mis-calibrate or misconfigure a transmitter in such a way that its operation appears erratic.

Other Configuration Controls

Reset ST13x Button

You can use **"Reset ST13x"** to reset the transmitter and cause it to revert to its power-up conditions (e.g. equivalent to a power-on reset). This might be useful if you ever encounter erratic operation.

Return to Out-of-Box Condition

You can use this button to restore the transmitter configuration to the original factory state (see Specifications Reference Test Conditions). This control provides a potential recovery path should the configuration ever become corrupted during recalibration, perhaps due to miscalibration. For example, if during calibration you break the USB connection before completing calibration, a memory transfer checksum value could be corrupted and this would inhibit normal operation. Alternately, this button can be used as a sanitation tool to restore the unit to its initial configuration. Note that the "Restore Factory Calibration" control of Calibration just affects the calibration of the unit, different from this control which sends the unit to its initial factory configuration and calibration. This button will restore **ALL** configuration settings and calibration to the their original factory settings.

Message Bar

The system message bar at the bottom of the screen will display & repeat prompt instructions as you step through calibration. It also displays diagnostic messages. For example:

"No devices found"
"Connect a ST13x to a USB port."
"Select a device from the drop down box above."
"Unable to read from the device."
"Interface Configured"
"Sending configuration, this takes several seconds."
"Error encountered while sending configuration."
"No error encountered while sending configuration."
"Getting configuration, this takes several seconds."
"Error encountered while reading configuration."
"No error encountered while reading configuration."
"No error encountered on read of input."
"Error encountered on read of input."
"Calibrating input zero, this takes several seconds."
"Error occurred during calibration, try again."
"Calibration successful."

"Calibration cancelled."
"Calibrating input full scale, this takes several seconds."
"Calibrating output zero, this takes several seconds."
"Calibrating output full scale, this takes several seconds."
"Restoring factory calibration."
"Error occurred during calibration restore, try again."
"Restore successful"
"Restore cancelled"
"Restoring to "Out-of-Box" condition."
"Error occurred during restore, try again."
""Out-of-Box" restore successful."
""Out-of-Box" restore cancelled."
"Resetting ST13x."
"Reset complete."

CONFIGURATION STEP-BY-STEP

Other Configuration Controls

Model Numbers

ST13/Input-Isolation/Power/Approvals/SIL w/Optional Factory Calibration

ST13 is the model Series w/ prefix "ST13" denoting the "Smart Transmitter 130" family. The trailing "3" digit denotes the isolated T/C input type. The "1" after the hyphen denotes isolated, the "6" that follows denotes 2-wire loop powered. The "0" or "1" following denotes CE Approvals Only, or CE and UL/Cul Class 1, Division 2 Approvals. The last "0" digit refers to No SIL Approvals. An optional factory calibration is ordered to your own specifications as a separate line item, and on a per unit basis.

ST133-1600 T/C or Mv Input, Isolated, CE Approved, No SIL Certification
ST133-1610 Same as first but adds UL/Cul Class 1, Division 2 Approval

ST133 models can optionally be ordered with factory calibration to your specifications. This is specified as a separate line item at time of purchase. Factory calibration will require the specification of input type (J, K, T, E, R, S, B, N, or ±100Mv), input range Zero (Mv or °C), Input range Full-Scale, and Sensor Fault Detent (Upscale or Downscale). You can also specify a normal or reverse acting output, a filter level, and whether CJC is ON or OFF. You can obtain form 8500-858 for specifying this calibration from our web site at www.acromag.com.

Standard Models without custom calibration are instead calibrated by default to reference test conditions for T/C Type J, 0°C to 200°C mapped to 4 to 20Ma at the output, with upscale fault detection and CJC ON

Recalibration of any model will require use of an ST13C-SIP configuration kit ordered separately (see Accessories).

Models can be mounted in DIN Form B connection heads using the ST130-MTG mounting kit, or on DIN rail using the ST130-DIN kit. These kits are purchased separately (see Accessories)

SPECIFICATIONS

Model ST133-1600

Signal Transmitter
T/C Input
Isolated
Two-Wire Loop-Powered
CE Approved
No SIL Approvals

Model ST133-1610

Adds UL/Cul Class 1, Division 2 approvals

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

SPECIFICATIONS

INPUT

Input Specifications

Input: T/C or ±100Mv Peak

Input & Accuracy: Configurable for input types/ranges shown below. Output signal is linear with respect to input temperature in degrees Celsius (T/C inputs), or voltage (±100Mv input). Unit provides T/C linearization, T/C Cold-Junction Compensation (CJC), and break detection.

Table 1: Input Ranges & Accuracy

Table 1		ISA/ANSI		Typical[1]
T/C	T/C Material	Color	°C Temp Range	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
Mv	NA	NA	±100Mv	±0.10%

[1]Note (Table 1): Accuracy is ±0.1% of the full-scale span, typical, or per narrow span specification, whichever is greater.

[2]Note (Table 1): Accuracy is given with CJC switched off. CJC uncertainty should be combined with the uncertainty numbers of Table 1 to determine a potential overall inaccuracy. Relative 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.

Measurement Temperature Drift: Better than ±80ppm/°C (±0.0080%/°C).

Input Zero and Full-Scale Adjustment: Input range endpoints are selectable over the full range indicated above for each input type. Input Zero and Full-Scale selections must be within range indicated and will be mapped to 4Ma and 20Ma at the output. Keep in mind that your input resolution is reduced as your programmed input range is reduced. Likewise, error in degrees is magnified as the input span is reduced.

Input Reference Test Conditions: TC Type J with a 10Mv minimum span (e.g. Type J with 200°C span), or ±100Mv range with a 10Mv minimum calibrated span; Ambient = 25°C; Power Supply = 24VDC; R-load = 250Ω.

Break Detection: Can be selected for Upscale or Downscale open sensor or lead break detection.

IMPORTANT: Calibration should be done with the break detection already set as required by the application, as changing it will affect current calibration somewhat.

SPECIFICATIONS

Input Bias Current: ±250Na typical (TC break current).
Input Linearization (T/C Inputs): Within ±0.25°C of the NIST tables.

Input Over-Voltage Protection: Bipolar Transient Voltage Suppressers (TVS), ±5.6V clamp level typical. Also includes differential input diode clamping, capacitive filtering, and series resistance.
Thermocouple CJC Reference: The table below shows the uncalibrated accuracy of the CJC sensor used in this circuit. CJC has been calibrated at 25°C to ±0.1°C. Thus, the accuracy of CJC over the operating range will be ±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

[1]**Note:** Cold Junction Compensation may be switched off to permit the direct connection of a Mv source to the input to simplify calibration. Otherwise a hand-held calibrator may be used. For best results, allow the module to reach thermal equilibrium and warm up for 10 minutes prior to calibrating CJC. Input is normally calibrated with CJC OFF, and CJC calibration is done separately.
Input Filter Bandwidth: Normal mode filtering, plus digital filtering within the Σ-Δ ADC. Varies with filter selection as follows:

Table 3: Bandwidth Per Filtering

FILTER SELECTION	BANDWIDTH
No Digital Filter	4.00Hz
Low Filter	1.19Hz
Medium Filter	0.98Hz
High Filter	0.33Hz

Analog to Digital Converter (A/D): Input utilizes 16-bit Σ-Δ conversion normalized to a bipolar range count of ±20000.
Input Conversion Rate per Filter Selection: See Output Response TimeNo Filter: Better than 8ms, typical. Low Filtering: Better than 0.2 seconds typical. Medium: Better than 0.6 second typical. High: Better than 0.8 seconds typical. Additionally, the internal CJC channel is read at the same speed.
Input Resolution: T/C Input uses 16-bit bipolar conversion with 0Mv corresponding to 32768. Actual resolution is constrained by the input range and its corresponding gain. An indication of relative input resolution is indicated by the number of parts between the calibration low and high endpoints shown in Table 4 below:

SPECIFICATIONS

Table 4: Input Resolution Per Calibration Range	
Input Range	**Effective Resolution Bet Cal LO/ Cal HI**
±100Mv DC	±20000 or 1 part in 40000 for -100 to +100Mv
T/C Type J -210 to +760°C	1 part in 17096 for 0-700°C (0.000Mv to 39.130Mv)
T/C Type K -200 to +1372°C	1 part in 22893 for 0-1300°C (0.000Mv to 52.398Mv)
T/C Type T -260 to +400°C	1 part in 17696 for 0-390°C (0.000Mv to 20.252Mv)
T/C Type R - 50 to +1768°C	1 part in 17664 for 0-1700°C (0.000Mv to 20.215Mv)
T/C Type S - 50 to +1768°C	1 part in 15678 for 0-1700°C (0.000Mv to 17.942Mv)
T/C Type E -200 to +1000°C	1 part in 15858 for 0-950°C (0.000Mv to 72.593Mv)
T/C Type B +260 to 1820°C	1 part in 21162 for 0-1700°C (0.317Mv to 12.426Mv)
T/C Type N -230 to +1300°C	1 part in 19152 for 0-1200°C (0.000Mv to 43.836Mv)
CJC Sensor (Internal)	1 part in 13653 for 25.0°C to 125.0°C (0.375V to 0.875V)

Your input resolution will be proportionally diminished as you reduce the input range. The actual effective I/O resolution of your transmitter will be the lowest resolution of either the input, or the temperature resolution (0.1°C) for T/C inputs. The output resolution is always greater at 1 part in 54613 for 4-20Ma, and will never be the limiting factor. In most cases, your resolution will be dominated by the 0.1°C temperature resolution for thermocouple inputs.

OUTPUT

Output Specifications

Output: 4-20Ma DC

Output Range: 4 to 20Ma DC nominal range endpoints, with under-range capability down to 3.5Ma, and over-range capability up to 24Ma. Upscale and downscale detents are 24Ma and 3.3Ma (DAC error) or 3.5Ma (downscale break) respectively.

Output Compliance: 12V Minimum (transmitter). Will drive 13V typical, with a 24V supply and 20Ma loop current.

Output Ripple: Less than ±0.1% of output span.

POWER

Power: 12-32VDC, SELV, 24Ma Max. Class 2

Output Power Supply: 12-32V DC SELV (Safety Extra Low Voltage), 24Ma maximum. The supply voltage across the transmitter must not exceed 32V, even with a shorted load. The supply voltage level must be chosen to provide a minimum of full-scale current to the load (0.020*R typical), plus 12V minimum to the transmitter terminals, plus any line drop. Ideally, your supply should drive over-scale current levels up to 24Ma into the load. Reverse polarity protection is included, as output terminals are bridge coupled and not polarized. The ± output polarity labels on the enclosure are for reference only.

CAUTION: *Do not exceed 34VDC peak to avoid damage to the unit. Terminal voltage at or above 12V minimum must be maintained across the unit during operation.*

Output Resolution: Output DAC is 16-bit. Its output current is approximated via the expression (pgm_count/65536)*24Ma. The min loop current is 3.34Ma, typical, which is approximated via a DAC program count of 9120. Likewise, 4Ma corresponds to a count value of ~10923. Thus, for the 4-20Ma output range, we have an output resolution of 65536-10923, or 1 part in 54613. The actual effective I/O resolution of the unit will be the lowest resolution of the input, or the 0.1°C temperature resolution of T/C inputs. The output resolution will never be a limiting factor at 1 part in 54613.

Output Response Time: Varies with filter level for a step change in the input signal as follows (step 4-20Ma into 250Ω load, 24V power).

FILTER LEVEL	RESPONSE TIME (TYPICAL)
No Filtering	90-125ms
Low Filter	240-420ms
Medium Filter	550-1020ms
High Filter	900-1500ms

Output Load Resistance Effect: Less than ±0.005% f output span effect for ±100Ω change in load resistance.

Accuracy: Refer to Table 1 for relative accuracy referred to the input. Accuracy will vary with calibrated input and output span. Rated accuracy assumes a 10Mv minimum input span and 16Ma output span. Accuracy includes the effects of repeatability, terminal point conformity, and linearization, but does not include sensor error.

Ambient Temperature Effect: Better than ±0.008% per °C of input span or ±80ppm/°C, over the ambient temperature range for reference test conditions. Includes the combined effects of zero and span drift over temperature.

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

Load Resistance Range Equation: R_{load} (Max) = (V_{supply} - 12V)/0.020A for full-scale output current (assuming negligible line drop). This does not account for 24Ma over-scale current and you should at least adjust the denominator in this expression for your overscale current level. At 24V DC, R_{load} = 0-600Ω typical for 20Ma of loop current and no line drop.

Note – High Speed Acquisition: Additional filtering at the load is recommended for sensitive applications with high-speed acquisition rates. High frequency noise may be reduced or eliminated by placing a 0.1Uf capacitor directly across the load. For excessive 60Hz supply ripple, a 1Uf or larger bulk capacitor is recommended at the load.

USB Interface

Includes a USB socket for temporary connection to a PC or laptop for the purpose of setup and reconfiguration. During reconfiguration and calibration, the transmitter receives power from both the USB port and the output loop. Both power sources must be present to calibrate the unit. USB isolation is required when connected to grounded input sensors (see note at left).

CAUTION: Do not attempt to connect USB in a hazardous environment. Transmitter should be setup 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. Consult the factory for legacy, low speed USB support (1.5Mbps) if required.

SPECIFICATIONS

IMPORTANT – USB Isolation is recommended: The input of this transmitter is isolated from its output and can be connected to grounded or un-grounded input sensors. However, the transmitter's input circuit ground is connected in common to the USB power/signal ground and shield ground. This will make connection to earth ground at the PC when directly connected to the USB port of a Personal Computer without the use of an isolator. Failure to connect USB without isolation would connect the 1.25 input bias supply to input ground if the sensor was also earth grounded. This will interfere with operation and cause the output to shift. For this reason, USB isolation is strongly recommended when connecting to a PC. Otherwise, in the absence of USB isolation, and when connected to a grounded input sensor, a battery powered laptop could be used to connect to the unit, as the laptop does not normally connect to earth ground.

SPECIFICATIONS

Transient Protection: Unit includes transient voltage suppression on USB power and data lines.
USB Connector: 5-pin, Mini USB B-type socket, Molex #5000751517.

PIN	DEFINITION
1	+5V Power (Includes Inrush Current Limiting)
2	Differential Data (+)
3	Differential Data (-)
4	NC – Not Connected
5[1]	Power Ground (Connects to Signal Ground via ferrite bead)
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.

Inrush Current Limiting: Unit includes series inrush current limiting at its USB power connection.
Cable Length/Connection Distance: 5.0 meters maximum.
Driver: No special drivers required. Transmitter uses the built-in USB Human Interface Device (HID) drivers of the Windows Operating System (Windows XP or later versions only).

Agency Approvals

Safety Approvals: Model ST133-1610 is UL Listed (USA & Canada) suitable for use in Class I, Division 2, Groups A, B, C, D Hazardous Locations, or Nonhazardous Locations only

ATEX Certified

ATEX Certified: Model ST133-1610 is ATEX Certified for Explosive Atmospheres per ATEX Directive 94/9/EC which complies with standards BS EN 60079-0:2012 & BS EN 60079-15:2010.
Ⓔx II 3 G Ex Na IIC T4 Gc -40°C ≤ Ta ≤ +80°C
DEMKO 13 ATEX 1113348X
X = Special Conditions

1) Must be installed in an ATEX Certified enclosure with a minimum ingress protection rating of at least IP54 and used in an environment of not more than pollution degree 2.
2) Enclosure must have a door or cover accessible only by the use of a tool.
3) Provisions shall be made to prevent the rated voltages from being exceeded by the transient disturbances of more than 140% of the peak rated voltage.

Enclosure and Physical

Enclosure & Physical
General purpose plastic enclosure intended to be mounted in DIN Form B connection heads. Optionally, a DIN rail adapter is available for mountable to 35mm “T-type” DIN rail, or G-Type DIN rail.
Dimensions: Diameter = 44.5mm (1.752 inches), Height = 23.4mm (0.921 inches). Refer to Mechanical Dimensions drawing. Conforms to DIN 43 729 Form B size requirements.
I/O Connectors: Barrier strip type, captive screw terminals; wire range: AWG #14-28 solid or stranded.
Program Connector: USB Mini B-type, 5-pin.
Case Material: Self-extinguishing polycarbonate ABS plastic, UL94 V-0 rated base material, color blue. USB dust cap material is Santoprene, 251-70W232, color red.
Terminal Material: Captive 4-40 threaded steel screw and 0.040 inch thick Phosphor-Bronze terminal material.

SPECIFICATIONS

Circuit Board: Military grade fire-retardant epoxy glass per IPC-4101/98 with humi-seal conformal coating.
DIN-Rail Mounting: The unit can be optionally mounted to 35x15mm, T-type DIN rails using optional ST130-DIN DIN-rail mounting adapter kit. Refer to the Mounting & Dimensions section for more details.
Shipping Weight: 0.5 pounds (0.22 Kg) packed.

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 +80°C (-40°F to +176°F).
Storage Temperature: -40°C to +85°C (-40°F to +185°F).
Long-Term Stability/Recalibration: Units normally maintain their calibration over very long periods of time without requiring periodic readjustment. Small shifts in adjustment due to component ageing are normal and may occur over time, usually during the first year of service. Other shifts in adjustment may be attributed to shock or vibration, and environmental influences. It is recommended that calibration be initially rechecked after 18 months of service, then successively as required by your company's maintenance schedule. Typically, user calibration schedules are developed with consideration of the application environment, required accuracy, and historical performance. Modules exposed to extreme hot or cold ambient temperatures, and/or noisy electrical environments, may require more frequent calibration checks.
Relative Humidity: 5 to 95%, non-condensing.
Isolation: Input/USB and the output/power circuits 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). Complies with test requirements of ANSI/ISA-82.01-1988 for voltage rating specified.
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).
Operating Shock & Vibration Immunity: Sinusoidal Vibration: 5G, 5-500 Hz, in 3 axis at 2 hours/axis per IEC60068-2-6. Random Vibration: 5G-rms, 5-500 Hz, in 3 axis at 2 hours/axis per IEC60068-2-64. Mechanical Shock: 30g at 11ms half-sine shock pulses and 50g at 3ms half-sine shock pulses in each direction along 3 axis (18 shocks), per IEC60068-2-27.

EMC – CE Marked

Electromagnetic Interference Immunity (EMI): The transmitter output has demonstrated resistance to inadvertent output shifts beyond ±0.25% of span, under the influence of EMI from switching solenoids, commutator motors, and drill motors.

Electromagnetic Compatibility (EMC): CE marked, per EMC Directive 2004/108/EC.

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.

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.

Note: This is a Class B product.

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_BG_C*

Temperature	ST133-16X0
25ºC	1,550,260 hrs
40ºC	1,040,888 hrs

Configuration Controls (Software Configuration Only via USB)

This transmitter produces an analog output current proportional to a sensor input based on the voltage measured differentially across the sensor. No switches or potentiometers are used to make adjustments to 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 the configuration parameters. All configuration information is stored in non-volatile memory.

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

ACCESSORIES

Software Interface Package/Configuration Kit – Order ST13C-SIP

- USB Signal Isolator
- USB A-B Cable 4001-112
- USB A-mini B Cable 4001-113
- Configuration Software CDROM 5039-312

This kit contains all the essential elements for configuring ST130 Smart Transmitters. Isolation is recommended for USB port connections to these transmitters and will block a potential ground loop between your PC and a grounded current loop. A software CDROM is included that contains the Windows software used to program the transmitter.

Transmitter Mounting Kit – Order ST130-MTG

- M4 Mounting Screw 1010-456, 2pcs
- 6-32 Mounting Screw 1010-443, 2pcs
- Relief Spring 1011-358, 2pcs

This kit contains two M4 mounting screws and relief springs for mounting this transmitter in DIN Form B Connection Heads. Two 6-32 screws are included for non-compliant DIN Form B Connection Heads with English threads. The M4 screws in this kit are of a special design that is semi-captive to the ST130 enclosure. Order 1 kit per transmitter.

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 ST131C-SIP (see above).

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 ST13C-SIP Software Interface Package and also with the isolator model USB-ISOLATOR.

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 ST130 transmitter. It is normally included in ST13C-SIP.

ACCESSORIES

Series ST DIN Rail Adapter – Order ST130-DIN

- DIN Rail Adapter 1027-187
- M4 Mounting Screw 1010-456, 2pcs
- Relief Spring 1011-358, 2pcs

This is a DIN rail bracket with mounting screws that connect to the ST130 Smart Transmitter to allow it to be snapped onto 35mm T-type DIN rail, or G-type DIN Rail. The screws and springs of this kit are identical to those provided in the Transmitter Mounting Kit ST130-MTG.

Revision History

The following table shows the revision history for this document:

Release Date	Version	EGR/DOC	Description of Revision
08 APR 2019	G	FJM/ARP	Added Long-Term Stability/Recalibration section.
20 NOV 2019	H	BC/ARP	Correct the drawing on page 13; the drawing content is missing.