INSTRUCTION MANUAL

R.C. SYSTEMS CO. INC.

MODEL ST-46A NON-INTRUSIVE CALIBRATOR

(REVISION 4.0)

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SECTION I

1.1 DESCRIPTION:

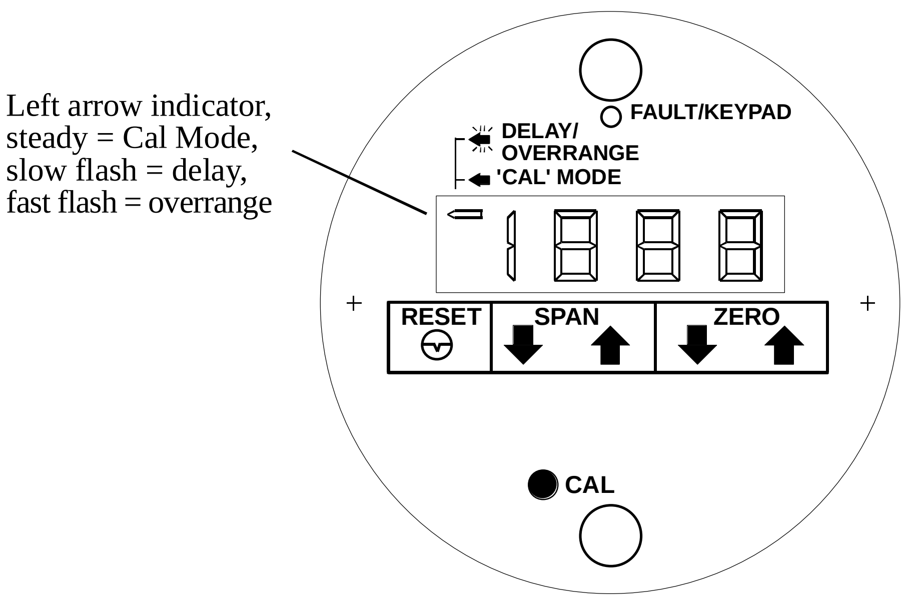
This manual describes the R. C. Systems Co. Inc. microprocessor based ST-46A Gas Detector with Non-Intrusive calibration. Two models of the ST-46A are described within this manual. The ST-46A/LEL accepts catalytic bead combustible sensors and the ST-46A/EC accepts electrochemical toxic and oxygen sensors. Section 4 discusses the ST-46A/LEL and section 5 the ST-46A/EC. Options available to enhance ST-46A performance are described in section 6 of this manual. These include an isolated 4-20mA output, an RS-485 Modbus® serial interface, or, an alarm providing 5 amp form C relays for FAULT, WARN and HIGH alarm conditions.

The Model ST-46A/LEL & ST-46A/EC Gas Detectors accept a wide range of gas detection sensors. These sensors connect to the ST-46A electronics via the R. C. Systems Co. Inc. Universal Sensor Head. A 4-20mA output and 3½ digit LCD readout provide analog and visual indications of gas concentration and events such as calibrations and sensor failures. The magnetic keypad allows complete "end to end" calibrations of the transmitter section without opening the explosion-proof enclosure. This is especially useful when the area is classified as potentially hazardous and declassification is required to open enclosures. FAULT conditions, such as catalytic bead sensor failures, missing EC sensor, or negative drift below 2.4mA (-10% of full scale), are detected and flagged by the ST-46A. FAULT conditions are indicated by 0mA at the 4-20mA output, **FLt** displayed on the LCD, and by flashing the KEYPAD/FAULT red LED.

The only tool required to calibrate the ST-46A is a small magnet provided on a key chain. The LCD readout displays appropriate engineering units such as percent of LEL (lower explosive limit) or PPM (parts per million). Section 3.7 describes how to configure the full-scale range of the ST-46A’s LCD readout. Prior to calibration the ST-46A must be placed in CAL MODE by holding the magnet over the CAL key on the front panel. The ST-46A responds by briefly overwriting the display with ‘CAL’, and illuminating a left arrow on the LCD. During CAL MODE the 4-

20mA output is held at 1.5mA to prevent alarms or other instrumentation from being affected by calibration levels. Calibration is performed by appropriately exciting the sensor and holding the magnet over the UP/DOWN ZERO or UP/DOWN SPAN keys as needed to obtain correct readings on the LCD readout. ZERO and SPAN keys do not interact when the zero adjustment is performed first. The UNITY key places the ST-46A in UNITY GAIN MODE with ZERO / SPAN keys returned to the center of their adjustment range and offset set to zero and gain set to one. Range of adjustment for the magnetic controls is limited to ± 15% for ZERO and .5-2 for SPAN. Current ZERO and SPAN settings may be seen by without entering the CAL MODE, the UP SPAN key displays ZERO and DOWN SPAN the SPAN. This is useful for tracking sensor sensitivity that may deteriorate with age. When sensitivity falls to half of when the sensor was new, requiring doubling the gain, it is approaching time to replace that particular sensor.

A non-volatile memory device provides indefinite battery backup of calibration values during power interruptions.



ST-46A FRONT PANEL

FIGURE 1.1

1.2 SPECIFICATIONS:

1.2.1 CATALYTIC BEAD SENSOR VOLTAGE (ST-46A/LEL):

NOMINAL 2 VOLTS ACCROSS THE SENSOR

1.2.2 SIGNAL OUTPUT:

4-20mA INTO 750 OHMS MAX WITH 24VDC POWER STANDARD

1.2.3 POWER SUPPLY:

18-30VDC; LESS THAN 4 WATTS

1.2.4 CALIBRATION RANGE:

ZERO - ± 15 % OF FULL SCALE

SPAN - TURN UP TO GAIN OF 2, DOWN TO GAIN OF .5

1.2.5 CALIBRATION RESOLUTION:

.1% OF FULL SCALE

1.2.6 ACCURACY:

± .1% OF FULL-SCALE ± 1 COUNT

1.2.7 AMBIENT TEMPERATURE RANGE:

-40 TO +60 DEGREES CENTIGRADE

1.2.8 TEMPERATURE DRIFT:

LESS THAN .1% PER DEGREE C OVER AMBIENT TEMPERATURE RANGE

1.2.9 HOUSING:

EXPLOSION-PROOF CLASS 1, GROUPS B, C, D AND CLASS 2, GROUP E, F, G WITH CSA AND FM APPROVAL

SECTION II

INSTALLATION

2.1 MOUNTING:

The ST-46A is packaged in an explosion-proof housing with two 3/4 inch N.P.T. conduit hubs located in line and across the housing from each other (see figure 8.1). This housing has symmetrical mounting holes for the electronics drilled so conduit hubs may be oriented across the bottom, top, left side or right side. Simply mount the housing as desired and remove the four screws holding the ST-46A I/O printed circuit board in place. Orient the I/O PCB so the LCD reads properly and replace the mounting screws. The sensor housing must be screwed in the downward aimed conduit entry.

Note: To gain access to the I/O PCB for wiring or mounting purposes, loosen the two captive thumb screws in the ST-46A front panel and remove the PANEL/CPU PCB assembly as far as allowed by the ribbon cable. The front panel and attached PCB may then be removed from the ST-46A housing leaving the I/O PCB fully exposed. To replace the front panel assembly, align the two thumb screws with their mating stand-offs and firmly hand tighten. Tighten thumbscrews with a screwdriver for applications in higher vibration areas

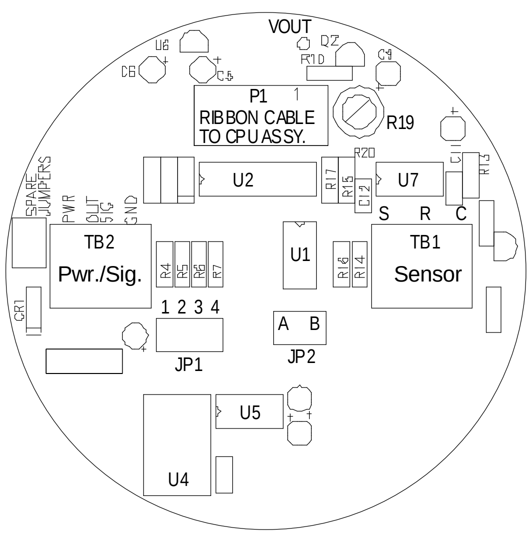
2.2 ELECTRICAL CONNECTIONS:

Please see the above note for instructions how to access the ST-46A I/O terminals for field wiring.

The ST-46A is a 3-wire device. There is a positive 24VDC power wire (12VDC power is selected by adding solder in jumper option JO4) and a positive 4-20 milliamp output signal wire. The third wire is system common and serves as power supply and signal returns. These connect to the three point terminal block labeled TB2. An earth ground lug inside the enclosure is provided for earth grounding of the enclosure.

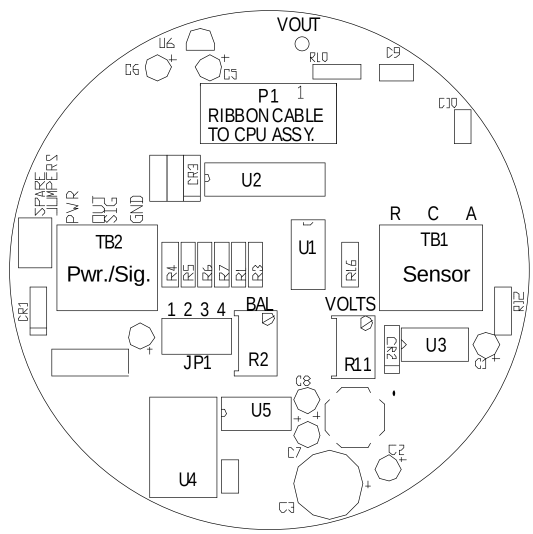
Since the ST-46A is designed to function with gas sensors, there is also a three point terminal block labeled TB1 provided for sensor wires. ST-46A/LEL TB1 terminals are labeled R, C, and A. R is for the reference wire, C for the junction of the reference and analytical wires, and A for the analytical wire. A is the same as system common. Sensor excitation voltage may be measured across A and R. ST-46A/EC TB1 terminals are labeled S, R, and C. S for the SENSE wire, R for the REFERENCE wire and C for the COUNTER wire.

TB1 and TB2 accept wire sizes up to 14 AWG. It is suggested the wires be stripped 1/4 inch and tinned with solder to prevent shorting of loose strands.



ST-46A/EC I/O PCB FOR
ELECTROCHEMICAL SENSORS

FIGURE 2.1



ST-46A/LEL I/O PCB FOR
CATALYTIC BEAD SENSORS

FIGURE 2.2

SECTION III

OPERATING PROCEDURES

3.1 'NORMAL MODE' OPERATION:

Note: If the ST-46A is being powered for the first time after a new sensor is installed procedures in sections 4.2 (LEL sensor) or 5.2 (electrochemical sensor) should be followed.

The NORMAL MODE is present any time the LCD's left arrow is not illuminated. During NORMAL MODE the ST-46A functions as a 4-20mA transmitter with a digital LCD readout. LCD readouts are typically configured to display engineering units monitored by the sensor.

During NORMAL MODE, the 4-20mA output and LCD readout do not track input values between 0% and –10% of full-scale. Below –10% the FAULT alarm is tripped. This prevents erroneous and momentary negative noise from being transmitted and displayed. This feature requires NORMAL MODE be exited and CAL MODE entered prior to exposing the sensor to ZERO gas for checking ZERO drift. **Negative ZERO drift is only displayed during CAL MODE.**

3.2 OVER-RANGE:

The sensor signal is converted to a .4 - 2 volt signal on the I/O PCB and then applied to a 10 bit analog to digital (A-D) converter on the CPU PCB. If gain settings are too high on the I/O PCB (see sections 4.2.3 for LEL's or 5.2.3 for EC's), or if gas values are too high, it is possible for upscale inputs to exceed 2 volts. The A-D converter saturates at readings above 103% of full-scale, or, about 2.06 volts. This causes an OVERRANGE indication by overwriting the LCD reading with three horizontal dashes **(- - -**) and a fast flashing of the left hand arrow. If OVERRANGE occurs during a SPAN calibration it should be halted since the analog voltage being applied to the A-D converter is too high. Either the SPAN gas is incorrect, or, the FIXED GAIN jumper setting on the I/O PCB is too high for the gas being monitored (see sections 4.2.3 for ST-46A/LEL or 5.2.3 for the ST-46A/EC).

3.3 ROUTINE CALIBRATIONS USING 'CAL MODE':

Routine calibrations of gas readings are easily performed using the magnet tool provided with each ST-46A Gas Detector. To enter CAL MODE, briefly hold the magnet over the CAL key located on the lower left of the front panel. The left arrow on the upper left side of the LCD illuminates and the 4-20mA output holds at 1.5mA to prevent alarm trips and indicate CAL MODE. Expose the sensor to a ZERO gas and observe the LCD readout. If it does not return to the correct ZERO reading a ZERO adjustment is needed. Hold the magnet over the UP ZERO or DOWN ZERO keys and adjust the reading to the correct ZERO value. Next, expose the sensor to an appropriate SPAN gas, such as 50% of the gas being monitored. If the LCD does not display the correct SPAN value a SPAN adjustment is needed. With the left arrow still on, hold the magnet over the UP SPAN or DOWN SPAN keys and adjust the reading to the correct SPAN value. The monitor is now calibrated. Touching the CAL key again exits CAL MODE and returns to NORMAL MODE after a 1-minute delay (see section 3.5). If the CAL MODE is not exited it terminates automatically after 5 minutes of inactivity.

3.3.1 READING SENSOR ZERO / SPAN SETTINGS ON THE LCD:

ZERO and SPAN values applied during CAL MODE may be viewed on the front panel LCD. After exiting the CAL MODE, the UP SPAN key causes the LCD to indicate, in percent of full-scale, the amount of ZERO offset applied. The DOWN SPAN key indicates the amount of gain applied, which may range between .5 and 2. Since sensor output sensitivity deteriorates with age, it is useful knowing how much gain has been applied over the lifetime of sensor.

3.4 UNITY GAIN MODE:

A UNITY key is available during CAL MODE to allow ZERO and SPAN adjustments to be centered within their range. Identified as the UNITY GAIN MODE, this is similar to setting a potentiometer's wiper exactly halfway between its clockwise and counterclockwise terminals. In UNITY GAIN the ZERO keys have a ±15% of full-scale adjustment range. For example, if the sensor's ZERO output has drifted so high it reads 15% with ZERO gas applied, the DOWN ZERO key could still bring the ST-46A reading to ZERO. However, it will be at the end of its adjustment range. If the ZERO adjustment required is greater than ±10% of full scale, a BALANCE adjustment should be performed as described in section 4.2.2.

In UNITY GAIN the UP / DOWN SPAN keys have a gain adjustment range of from .5 to 2. For example, if sensor output sensitivity is reduced such that 50% SPAN gas provides only a 25% reading, the UP SPAN key could still calibrate the reading to the proper value of 50%. However, it will be at the end of its adjustment range.

3.5 DELAY MODES:

The POWER UP DELAY and the CAL MODE EXIT DELAY are both indicated by a slow flashing of the LCD’s left arrow. The LCD readout is active but the 4-20mA output is held at 4mA during delays.

3.5.1 POWER UP DELAY:

The 4-20mA output is held at 4mA for 1-minute after power is applied. This allows the sensor to stabilize and reduce the possibility of causing an erroneous alarm condition within the gas detection system.

3.5.2 ‘CAL MODE’ EXIT DELAY:

SPAN values are typically the last gas applied during a routine calibration. If the CAL MODE is exited immediately after removing SPAN gas from the sensor, the reading may still correspond to the SPAN value and trip alarms. Therefore, the 4-20mA output is held at 4mA for 1-minute after exiting the CAL MODE.

3.5.3 AUTOMATIC ‘CAL MODE’ EXIT TIMER:

The 4-20mA output is held at 1.5mA during the CAL MODE. This alerts any loop monitoring devices that a special condition is present. Since it is possible for an operator to forget to return the ST-46A to the NORMAL MODE, a 5-minute timer monitors the magnetic keypad during the CAL MODE. If no keystroke occurs during a 5-minute interval, the CAL MODE is exited and the 4-20mA output becomes active again.

3.5.4 ABORTING THE DELAY MODES:

Trouble-shooting and other testing procedures may be easier without the delay periods described above. These may be aborted by removing power, holding the magnet over the UP ZERO key, and reapplying power. The sensor must not be in a FAULT condition when power is applied. Any subsequent power up without holding the magnet to the UP ZERO key returns the delay periods.

3.6 FAULT CONDITIONS:

The FAULT / KEYPAD LED is a dual-purpose indicator. It illuminates to provide visual feedback when the magnet tool is activating a key and flashes to signal a FAULT condition. A FAULT also causes the 4-20mA output to be held at 0mA. Negative sensor drift below -10% of full scale automatically causes a FAULT indication. Sensor failures, as described in sections 4 & 5, also cause the FAULT indication.

3.7 LCD METER SPAN SETUP MODE:

The 3½ digit LCD meter span and decimal points may be configured for full scale ranges such as 0-100, 0-25.0, 0-10.0, 0-1000 and many others. Zero percent of full-scale readings, or those corresponding to 4mA, are always assumed to equal a reading of 0. Holding the magnet over the CAL key for at least 5 seconds enters the LCD METER SPAN SETUP MODE. After this, the current setting for 100% full-scale is displayed and may be modified using the UP/DOWN SPAN keys. This sets the LCD reading displayed when the 4-20mA output equals 20mA. Decimal points are added with the UNITY key.

3.8 4-20MA SOURCE MODE:

During NORMAL MODE operation, holding the magnet over the DOWN ZERO key for at least 10 seconds places the unit into a 4-20mA SOURCE MODE. The LCD indicates directly in milliamps the actual value of the 4-20mA output and is irregardless of gas on the sensor. The UP / DOWN SPAN keys are used to set this value between 4mA and 20mA. This feature is provided to make it easier to test display and alarm devices connected to the ST-46A's 4-20mA output without exposing the sensor to test gas. 4-20mA SOURCE MODE exits back to NORMAL MODE by touching the UNITY key or automatically after 5 minutes without operator input.

3.9 "END OF SENSOR LIFE" INDICATION

Old sensors near the end of their service life require higher gain settings. The ST-46A "END OF SENSOR LIFE" (ESL) feature may be used to indicate this condition. A span trip point may be entered that when exceeded, causes the LCD to flash an ESL reading for 2-seconds each 10 seconds. Holding the magnet to the UNITY key for at least 5 seconds brings to the LCD a span value set-point reading for setting when the ESL indication trips. CAL MODE GAIN adjustments range between .5 and 2 and the ESL set-point is adjustable between 1.5 and 2.01 with 2.01 turning the ESL feature off. The current span setting may be viewed on the LCD during NORMAL MODE by touching the DOWN SPAN key.

SECTION IV

MODEL ST-46A LEL CATALYTIC BEAD SENSORS

4.1 GENERAL DESCRIPTION:

Catalytic bead combustible sensors consist of an analytical and reference element. The analytical element is coated with a catalyst causing it to react with combustible gas compounds, raising its temperature and therefore its resistance. The reference element remains stable in the presence of these gases. Sensors interfaced to the ST-

46A/LEL are powered by a high efficiency switching power supply with an adjustable output. An input bridge circuit and balance adjustment allows matching each combustible sensor to the ST-46A/LEL input.

4.1.1 SENSOR POISONING:

It is important to understand that all catalytic sensors may be poisoned, causing loss of sensitivity. Silicon, sulfur and lead containing compounds are especially detrimental. Although R. C. Systems Co. Inc. sensors have special poison resistant qualities; all combustible gas detectors operating in these environments should be calibrated more frequently.

Please see ISA publication RP12.13 Part II-1987 (www.isa.org) for additional information concerning recommended operating procedures for these detectors.

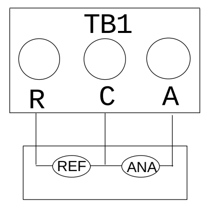
4.2 ST-46A/LEL INITIAL START-UP AND CALIBRATION PROCEDURE:

***Note:* Units shipped from R. C. Systems Co. Inc. with the sensor installed have had adjustments described in sections 4.2 and 4.3 already performed at the factory! This information is provided to assist users replacing defective sensors; installing ST-46A/LEL detectors with remotely mounted sensors, or changing the calibration to another combustible compound. The front panel assembly must be removed as described in section 2.1 to access potentiometers and perform these adjustments.**

IMPORTANT: Be sure to classify the area as non-hazardous prior to opening the ST-46A or any other electronic enclosures.

4.2.1 SENSOR VOLTAGE ADJUSTMENT:

The sensor voltage adjustment, using SENSOR VOLTAGE ADJUST potentiometer R11 on the I/O PCB (see FIGURE 4.2), is done upon initial installation of the catalytic bead sensor to the ST-46A/LEL monitor. Typical applications call for the R. C. Systems Co. Inc. Universal Sensor head mounted directly to the ST-46A/LEL's housing. In these cases the 2-volt sensor voltage across the A & R terminals is preset at the factory prior to shipment. Applications requiring the sensor mounted remotely from the ST-46A/LEL enclosure should have a provision for measuring the voltage near the sensor. High currents flowing through long wires cause voltage losses across the wires. To compensate for the loss it is often necessary to set the voltage at the ST-46A/LEL A & R terminals higher than the desired 2-volt sensor voltage. It is then recommended the R11 potentiometer screw be covered with a small dollop of RTV or epoxy to prevent an accidental over-voltage condition for the sensor.



CATALYTIC BEAD LEL SENSOR
(ST-46A/LEL)

FIGURE 4.1

4.2.1 MONITORING THE VOUT TEST POINT:

The VOUT test point on the I/O PCB may be monitored during the remainder of this section to verify correct initial set-up. An alternative is to attach the LCD assembly ribbon cable and monitor VOUT using the ST-46A LCD. The LCD assembly must be placed in UNITY GAIN (see section 3.4).

To use a voltmeter, the minus lead is attached to the power supply return, or 0 volt terminal, and the plus lead to the VOUT test point. The active range of VOUT is .4 - 2 volts, corresponding to 0-100% of full scale. Therefore, 0% = .4 volts, 25% = .8 volts, 50% = 1.2 volts, 75% = 1.6 volts and 100% = 2.0 volts. The I/O board may be considered properly configured when VOUT is within 20% of the desired span reading without exceeding the desired value. For example, if 50% of LEL SPAN gas reads between 1.0 and 1.2 volts, this is an acceptable value if 100% of LEL is full-scale.

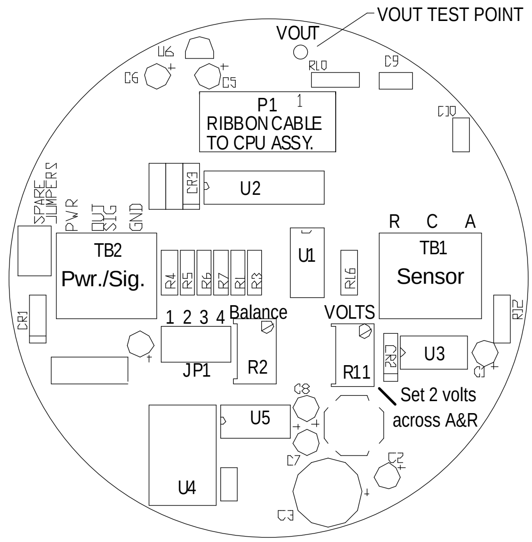


FIGURE 4.2

4.2.2 BALANCE ADJUSTMENT:

Differences in element resistance from sensor to sensor necessitate a BALANCE adjustment that simply matches a particular sensor to the ST-46A/LEL bridge circuit. This adjustment need only be made once with a new sensor and is preset at the factory for units shipped with the sensor installed. With the new sensor exposed to a ZERO gas (usually ambient air) adjust BALANCE potentiometer R2, until the VOUT test point equals .4 volts. THIS IS AN APPROXIMATE ADJUSTMENT. THE FINAL PRECISION ADJUSTMENT IS MADE VIA THE MAGNETIC ZERO CONTROLS. The UP/DOWN ZERO magnetic controls have a ±15% of full-scale adjustment range that the sensors' ZERO drift must exceed before requiring another BALANCE adjustment.

4.2.3 ST-46A/LEL INITIAL FIXED GAIN ADJUSTMENT:

The ST-46A I/O PCB has 4 fixed ranges of sensitivity, selectable via JP1 and labeled 1, 2, 3 & 4. In review, the VOUT test point on the I/O PCB has a range of .4 - 2 volts for 0 - 100% of the measurement range. The BALANCE potentiometer sets the .4 volt value with ZERO gas applied as described in section 4.2.2. JP1 sets the coarse upscale SPAN value by setting the gain of the bridge circuit. JP1 is set correctly if 50% of full-scale span gas reads between 1.0 & 1.4 volts at VOUT. Fine-tuning of these settings is done later by adjusting the ST-46A magnetic controls. JP1 jumpers require reconfiguring only if a new sensor is installed or if the monitoring range is changed.

JP1 gain values are as follows:

JP1 with jumper in position 1 = GAIN = 51

JP1 with jumper in position 2 = GAIN = 26

JP1 with jumper in position 3= GAIN = 12.5

JP1 with jumper in position 4 = GAIN = 7

JP1 with no jumper = GAIN = 1

More than one jumper may be installed to allow additional gain values. Multiple jumpers are additive in relation to the gain value. For example, if a gain of 20 is needed, jumpers may be placed in positions 3 and 4 to provide a gain of 19.5.

The gain value required for an application may be determined either by applying a known value of gas and configuring JP1 for the correct VOUT value, or, by reviewing the sensor's mV per %LEL specification and predicting the correct gain. When using the front panel LCD to read the output and configure JP1, it is important to place the ST-46A in UNITY GAIN MODE (see section 3.4) to insure additional gain is not being applied by the magnetic controls. The following equation describes the relationship between sensor millivolts and gain requirements:

JP1 GAIN REQUIRED = 1600 / sensor millivolts full scale

For example, if the application is to monitor 0-100% LEL of methane and the sensor provides .5 mV per % LEL, then the full-scale millivolt range is 50 millivolts. The gain required by JP1 is equal to 1600 / 50 = 32. To avoid over-range conditions caused by upscale gas concentrations it is best not to exceed the calculated gain value. Therefore, for this example with a calculated gain of 32, the most desirable JP1 setting would be position 2 for a gain of 26. Remember, this is only a coarse setting! The precision adjustment is made at the final magnetic control stage that has a minimum gain of .5 and maximum of 2. The JP1 gain of 26 can be reduced to 13 or increased to 52 by the magnetic controls!

4.3 LEL SENSOR FAULT SUPERVISION:

The typical failure mode of catalytic bead sensors is the reference or active beads open circuit. In rare cases a short circuit may develop. The ST-46A/LEL is equipped with fault detection circuitry that detects either condition. A FAULT is also signaled if the output drifts below-10% of full scale. The ST-46A/LEL signals a FAULT condition exists by overwriting the LCD with a FLt message, flashing the red LED on the front panel and clamping the 4-20mA output at 0mA. These conditions remain until the FAULT is corrected.

4.4 SENSOR REPLACEMENT:

IMPORTANT: Be sure to reclassify the area non-hazardous before opening the ST-46A or any other electronic enclosures.

SECTION V

MODEL ST-46A/EC FOR ELECTROCHEMICAL SENSORS

5.1 GENERAL DESCRIPTION:

The Model ST-46A/EC accepts electrochemical sensors directly, without need of other transmitters or electronics. The low level output from the sensor is converted to a .4-2 volt level by an ultra-stable pre-amplifier on the ST-46A/EC I/O PCB.

Since the ST-46A/EC is designed to accept electrochemical gas sensors, there is a three point terminal block labeled TB1 provided for sensor wiring. TB1 has SENSE, REFERENCE, and COUNTER terminals that connect directly to sensor terminals having the same names.

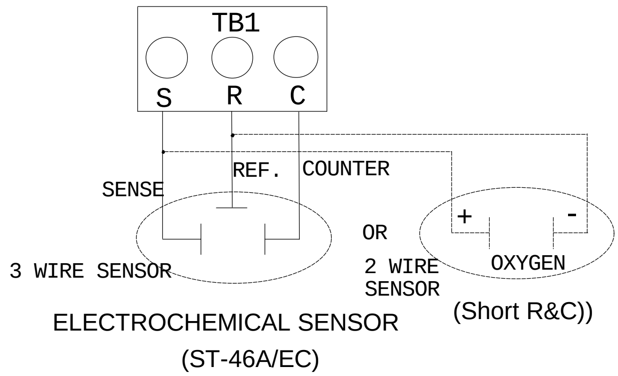


FIGURE 5.1

5.2 ST-46A/EC INITIAL START-UP AND CALIBRATION PROCEDURE:

*Note: After all power and signal connections have been checked, apply power and wait one hour for the system to stabilize. For the **initial** start-up procedure only, the front panel assembly must be removed as described in section 2.1 to perform the following adjustments.*

IMPORTANT: Be sure to reclassify the area non-hazardous before opening the ST-46A or any other electronic enclosures.

5.2.1 SENSOR RESPONSE COEFFICIENT:

Jumper header JP2, located on the I/O PCB, allows the **ST-46A/EC** to be configured to accept either positive or negative coefficient sensors. JP2s' dual jumpers must **both** be placed in either the 'A' or 'B' positions. 'A' position corresponds to positive coefficient output sensors and 'B' to a negative.

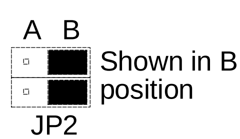


FIGURE 5.1

5.2.2 SELECTING PRE-AMP GAIN RESISTOR R13:

Note: R13 is preset at the factory and only needs to be changed if the measurement gas or range are to be modified dramatically after shipment.

Depending upon the gas being monitored, electrochemical sensors have a very wide range of micro-amps per PPM (parts per million) output signal. Socketed resistor R13 is the gain resistor for the pre-amplifier converting these micro-amps to a more suitable voltage range. The formula for selecting the value of R13 is as follows:

R13 (ohms) = 1,000,000 / uamps full scale input

For example, if the sensor output is 1 uamp per PPM, and the measurement range is 0-100 PPM, then 100 uamps is the full scale input. Therefore, R13 should = 1,000,000 / 100, or 10K ohms. This should be considered a coarse setting since there are 2 additional gain adjustments available after the preamp signal. A high quality 1% metal film grade of resistor should be used for R13.

5.2.3 ST-46A/EC INITIAL FIXED GAIN ADJUSTMENT:

The ST-46A I/O PCB has 4 fixed ranges of sensitivity selectable via JP1 labeled 1, 2, 3 & 4. In review, the VOUT test point on the I/O PCB has a range of .4 - 2 volts for 0 - 100% of the measurement range. JP1 jumpers set the coarse upscale SPAN values by affecting the gain of the analog circuit. JP1 is set correctly if 50% of full-scale gas reads between 1.0 & 1.2 volts on VOUT. Fine-tuning of these settings is done later by adjusting the ST-46A magnetic controls. JP1 jumpers normally only require configuring if a new sensor is installed or if the monitoring range is changed.

JP1 gain values are as follows:

JP1 with jumper in position 1 = GAIN = 5.5

JP1 with jumper in position 2 = GAIN = 4

JP1 with jumper in position 3= GAIN = 2.3

JP1 with jumper in position 4 = GAIN = 1.5

JP1 with no jumper = GAIN = 1

More than one jumper may be installed to allow additional gain values. Multiple jumpers are additive in relation to the gain value. For example, if a gain of 6.5 is needed, jumpers should be placed in positions 2 and 3 to provide a gain of 6.3.

What gain value is required for the application may be determined either by applying a known value of gas and configuring JP1 for the correct voltage on the VOUT test point, or by reviewing the sensor's uamp per PPM specification and predicting the correct gain. When using the front panel LCD to read the output and configure JP1, it is important to place the ST-46A in UNITY GAIN MODE (see section 3.4) to insure additional gain is not being applied by the magnetic controls. The following equation describes the relationship between sensor uamps, R13, and gain requirements:

JP1 GAIN = 1,600,000 / (sensor uamps)(R13)

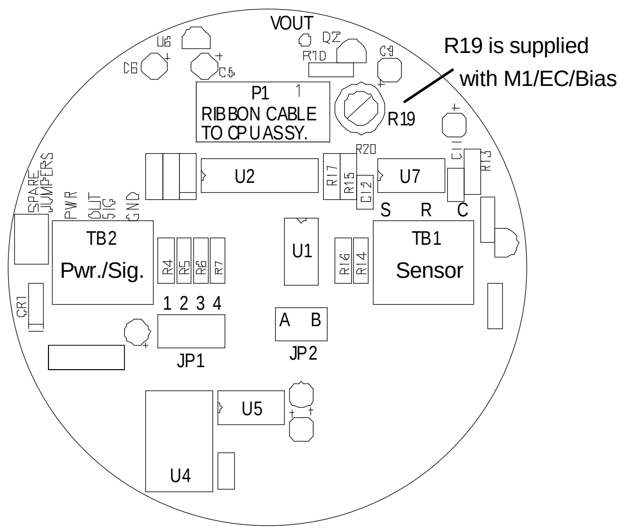
For example, if the application is to monitor 0-10 PPM of carbon monoxide and the sensor provides .8 uamp per PPM, then the full-scale uamp range is 8 uamps. The calculated value for R13 from the above equation is 125K ohms so we may assume a common value of 100K ohms for the actual R13 value. The gain required by JP1 is equal to 1,600,000 / (8)(100,000) = 2. To avoid saturating the analog to digital converter by upscale gas values, it is best not to exceed the calculated gain value. Therefore, for this example of a calculated gain of 2, the most desirable JP1 setting would be position 4 for a gain of 1.5. Remember, this is only a coarse setting! The precision adjustment is made at the final magnetic control stage with a minimum gain of .5 and maximum of 2. The JP1 gain of 1.5 may be reduced to .75 or increased to 3 by the magnetic controls.

5.3 MISSING ELECTROCHEMICAL SENSOR FAULT SUPERVISION:

Many electrochemical sensor housings allow for easy replacement of defective sensors by making the sensors 'plug in'. A problem is that if the sensor is removed, many transmitters continue to display the safe reading of 0 PPM. The ST-46A/EC is equipped with fault detection circuitry that detects a missing sensor. Within several minutes of removing an EC sensor, the ST-46A/EC will signal a FAULT condition. A FAULT is also detected if the sensor output drifts below -10% of full scale. The ST-46A/EC demonstrates a FAULT condition exists by overwriting the LCD reading with FLt, illuminating the red LED on the front panel and by clamping the 4-20mA output at 0mA. These conditions exist until the FAULT is corrected.

5.4 ST-46A/EC/BIAS MODEL SUPPORTS BIASED SENSOR TYPES:

Certain specialized electrochemical sensors are designed to work with the *sensing* electrode potential above that of the *reference* electrode, otherwise known as 'biased' operation. A special model of the ST-46A/EC is available to support this by adding a ***/BIAS*** suffix to the model number. Additional circuitry is included on the ST-46A/EC/BIAS I/O board. Most noticeable is potentiometer R19 used for setting the sensors' bias millivolts. Sensors requiring biased operation oftentimes require as much as 24 hours stabilization after power is applied.



M1/EC I/O PCB FOR
ELECTROCHEMICAL SENSORS

FIGURE 5.2

5.5 SENSOR REPLACEMENT:

See section 4.5.

SECTION VI

OPTIONAL FEATURES

6.1 GENERAL DESCRIPTION:

Space is provided behind the front panel/CPU assembly to add a single circuit board for adding features not provided on the standard ST-46A. Field wiring should be an important consideration when determining if an option is required. Each option board contains terminals for wiring that are located behind the front panel / CPU assembly. Space for field wiring inside the ST-46A enclosure is limited and extra care must be taken to cut wires to only the length needed to complete the connections.

6.2 ISOLATED 4-20 MILLIAMP OUTPUT OPTION:

An isolated 4-20mA output board, shown in Figure 6.1, is available. A 2-point terminal strip provides the 1500 V isolated 4-20mA output signal. This option should be used when it is necessary that the 4-20mA output be isolated from the ST-46A power supply and sensor inputs.

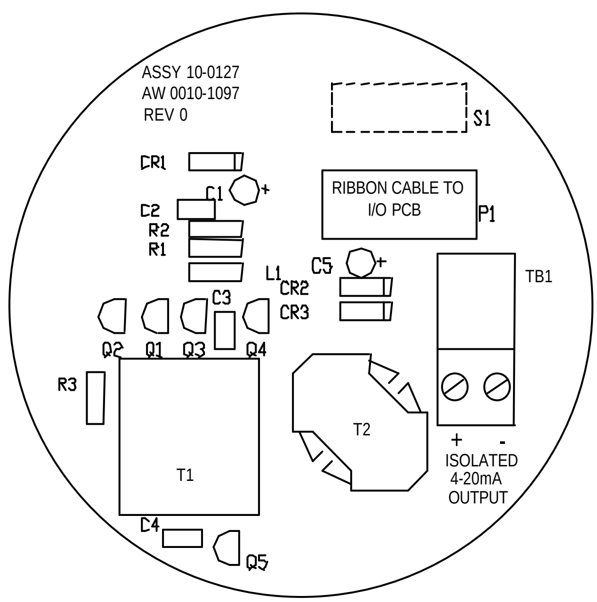


FIGURE 6.2 / OPTIONAL ISOLATED 4-20mA OUTPUT PCB

6.3 MODBUS® RS-485 SERIAL INTERFACE OPTION:

The 10-0128 Modbus RS-485 serial interface option allows up to 128 ST-46A Transmitters to communicate to a Modbus master device on a single cable. Modbus is the *protocol*, or language used by the ST-46A to communicate with other devices. The ST-46A is a Modbus *slave*, requiring a Modbus *master* to interrogate it and retrieve information made available in specific register locations. The RS-485 electrical standard allows cable lengths up to 4000 feet between Modbus master and slave. Both 4-wire full duplex and 2-wire half duplex connections are supported by the ST-46A serial interface option. Recommended cables are Belden part # 9841 for 2-wire and # 9842 for 4-wire. Technical papers offering valuable information concerning RS-485 networks are available at our website at www.rcsystemsco.com.

The R. C. Systems Co. Inc. ST-71 Controller is a typical Modbus master device capable of retrieving monitored data from the ST-46A. Since the ST-71 is often connected as a Modbus *master* to a network of as many as 16 ST-46A's the correct ST-71 controller Modbus menu information is provided. Configure the ST-71 controller channel the ST-46A is to provide input data to as follows: **Data From** menu = **Modbus 10bit**, **Min RAW** = **00200**, **MAX RAW** = **01000**, **Remote ID** = [must match RTU address of ST-46A, typically 1-16], **Alias** = **33001**. The ST-71 Controller only requests the 10 bit gas value from register 33001 of the ST-46A monitor. All alarm processing and ASCII nomenclature assigned to a channel is performed by the ST-71 controller.

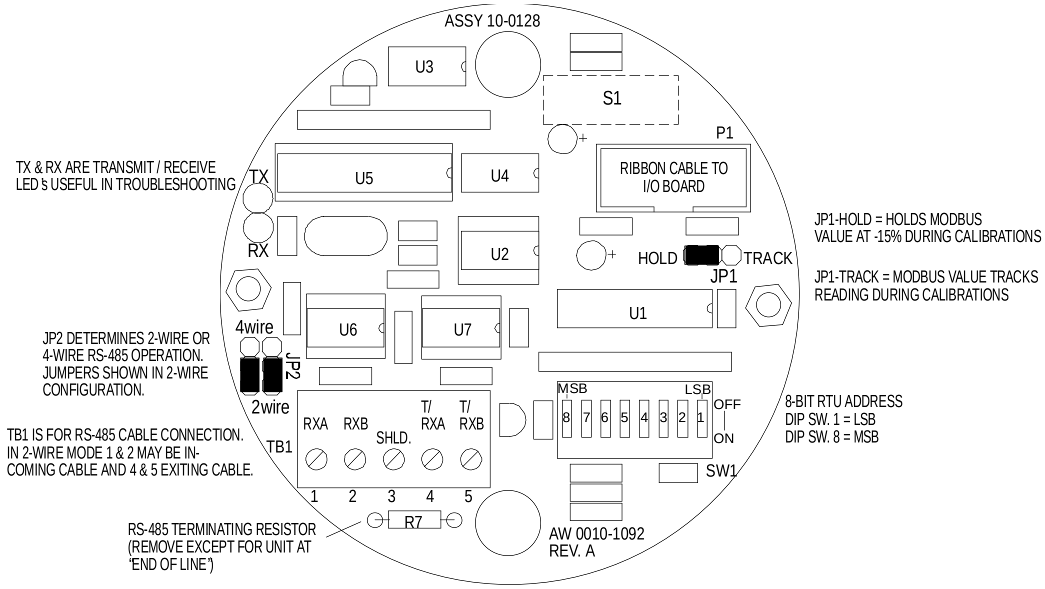


FIGURE 6.3 / 10-0128 OPTIONAL MODBUS RS-485 PCB

6.3.1 RTU ADDRESSES AND TERMINATING RESISTORS:

Up to 128 ST-46A 10-0128 RS-485 options may be "multi-dropped" onto the same RS-485 cable. Its 8-position DIP switch allows unique RTU addresses be assigned to each ST-46A, necessary for the modbus master to be able to address ST-46A's separately. The 8 DIP switches represent an 8 bit binary number with 1 = LSB and 8 = MSB. For example, OFF, ON, ON, OFF, ON, OFF, OFF, OFF = 0110 1000 = RTU address 104. A different RTU address must be assigned for each ST-46A communicating on the same RS-485 port. **IMPORTANT: DIP switch RTU address changes only take effect after M1 power is cycled from OFF to ON.**

ST-46A 10-0128 options are shipped with terminating resistors (R7) installed. R7 should be removed from all except the ST-46A located at "end of line". This means the cable leaves the Modbus master and goes to the 1st ST-46A, then to the 2nd, then to the 3rd and so on until reaching the final ST-46A. R7 should only be installed in the *final* ST-46A.

6.3.2 MODBUS DATA REGISTERS AND FUNCTION CODES:

The following table identifies the ST-46A Modbus register locations and function codes available:

MODBUS REGISTER SUMMARY

VARIABLE	ALIAS	READ FUNCTION CODE	WRITE FUNCTION CODE
FAULT BIT	**12000**	**2**	**NA**

0 = OK

1 = Fault

ALARMS	**12008**	**2**	**NA**

Returned as 8 discrete bits packed in the low byte of the response data.

12008:bit 0 = Fault (tracks 12000)

12008:bit 1 = AlarST-46A

12008:bit 2 = Alarm2

12008:bit 3 = Not Used

12008:bit 4 = Not Used

12008:bit 5 = Not Used

12008:bit 6 = Alarm2 Acknowledgeable

12008:bit 7 = Not Used

A2D Raw	**33000**	**3&4**	**NA**

10 bit value representing the A2D value of 0 to 1023 for -20 to 103 %FS (197=0% & 1003=100%).

A2D ASCII	**31010 (6 bytes)**	**3&4**	**NA**

6 bytes of data representing the scaled span value including the decimal point. The first 5 bytes contain the value with the last byte being a space. They are arranged with the first byte as the MSD with leading zero spacing. For example, with a span value of 1234 with 1 decimal point, the correct value of 123.4 is returned for 100% of full scale as follows:

Byte 0 1 2 3 4 5 6 7 8 9 10

Response [address] [04] [06] [31] [32] [33] [2E] [34] [20] [Crcl] [Crch]

ASCII Char [address] [? ???? ???? ????? ????? ???????????? ???sp] [Crcl] [Crch]

With the same settings a 50% of full scale reading of 617 would be:

Byte 0 1 2 3 4 5 6 7 8 9 10

Response [address] [04] [06] [20] [36] [31] [2E] [37] [20] [Crcl] [Crch]

ASCII Char [address] [? ???? ???sp???? ????? ???????????? ???sp] [Crcl] [Crch]

EUNITS	**40319-40324**	**3**	**6**

6 ASCII characters assigned to the engineering units read as bytes.

Measurement Name **40325-40340** **3** **6**

16 ASCII characters assigned to the unit identifier read as bytes.

Span **40343** **3** **6**

An integer from 1 to 9999 used to scale the A2D ASCII value.

AlST-46ASetpoint **40345** **3**
6

Alm2Setpoint **40347** **3** **6**

Integer compared to the A2D Raw value to determine alarm 1 or 2 status. The 0 to 100% set point must be scaled from 197 to 1003. This is done by using (Alarm% * 806) + Offset .

Example: A 40% set point would be computed as (.4 * 806) + 197

D.P.Position **40349** **3** **6**

Determines how many decimal positions return with the A2D ASCII value. Valid range is 0 to 3.

AlST-46ATrip **40351** **3** **6**

Alm2Trip **40359** **3** **6**

Set to 255 alarms on high, set to 0 alarm on low.

AlST-46ALatch **40353** **3** **6**

Alm2Latch **40355** **3** **6**

Set to 0 causes alarm 1 or 2 to auto reset, set to 255 causes alarms 1 or 2 to latch.

AlmZoneWord **40357** **3** **6**

16 bit value which may be used as a zone alarm mask for the master.

AlarmReset **2000** **NA** **5**

Setting to 255 causes any latched or acknowledgeable alarms to reset.

InitRtu **2010** **NA** **5**

Setting to 255 causes a re-start which applies updated configuration variables.

6.3.3 MODBUS CONFIGURATION SOFTWARE:

All of the register values described in 6.3.2 above must be configured via the serial port. This is a *one time only* requirement unless changes within the application necessitate adjustments after the initial installation. This functionality may be built into the Modbus Master, or, may easily be performed with a portable computer running a simple software application available from our website at: www.gdscorp.net. This application consists of 2 recipe screens as shown in Figure 6.4. Masters with zone relays may use the AlmZoneWord register 40357 to track certain transmitters to their respective zone relays. The second screen in figure 6.4 may configure this register.

```
07:52:55            RC Systems ST-46/47 MODBUS Configurator            Ver 1.02

                                STATION ID 1

                           33.6       EUNITS
                           Measurement  Name

    <1> Span =  1000                              OFF Fault Bit
    <2> Decimal Point  1                          ON  Alarm 1 Bit
    <3> Alarm1 %FS =  20 % Non-Latching           OFF Alarm 2 Bit
    <4> Alarm1 Type = High                        OFF Acknowledge Bit
    <5> Alarm2 %FS =  40 % Non-Latching           <R> Send Alarm Reset
    <6> Alarm2 Type = High                        <I> Re-Initialize RTU
    <E> Change EUNITS                             <Z> Alarm Zone bits
    <M> Change Measurement Name                   A2D Counts =  468
    <S> Change STATION ID

   <Esc>QUIT             <U>Upload            <D>Download         <H>HELP
```

```
08:05:45            RC Systems ST-46/47 MODBUS Configurator            Ver 1.02

       When connected to an ST-75, the zone alarm bits determine
       which zone relays activate during an alarm for this RTU.

       1 = ACTIVE, 0 = INACTIVE.

       To change the bit status press the key which corresponds
       with the bit.

            lsb              ZONE ALARM BITS              msb
             |                                             |
         BIT: 0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
      STATUS: 1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0

   <Esc>QUIT
```

FIGURE 6.4 / MODBUS CONFIGURATION SOFTWARE SCREENS

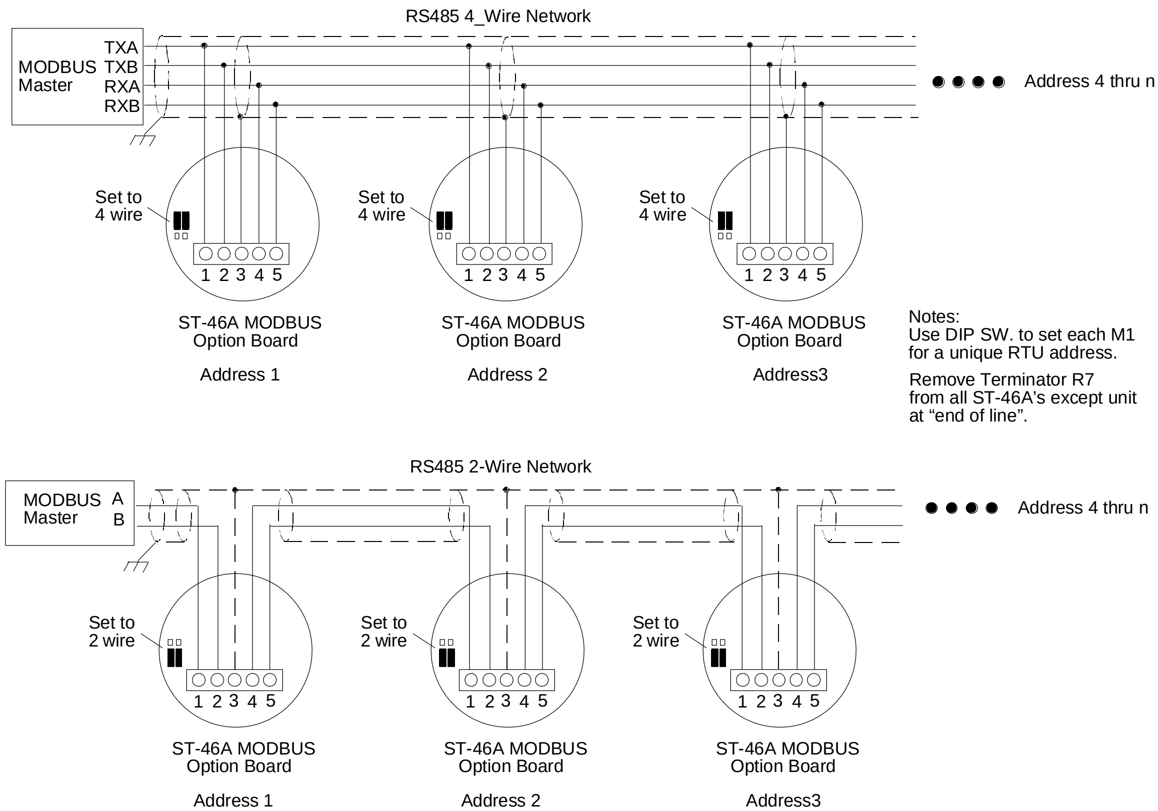


FIGURE 6.5 / TYPICAL RS-485 WIRING

6.4 ALARM RELAYS OPTION:

The alarm option provides 5-amp resistive form C relays for ALARM 1, ALARM 2 and ALARM 3 conditions. Explosion-proof housings of units equipped with alarms have an additional ¾ inch NPT conduit entry to accommodate the additional field wiring.

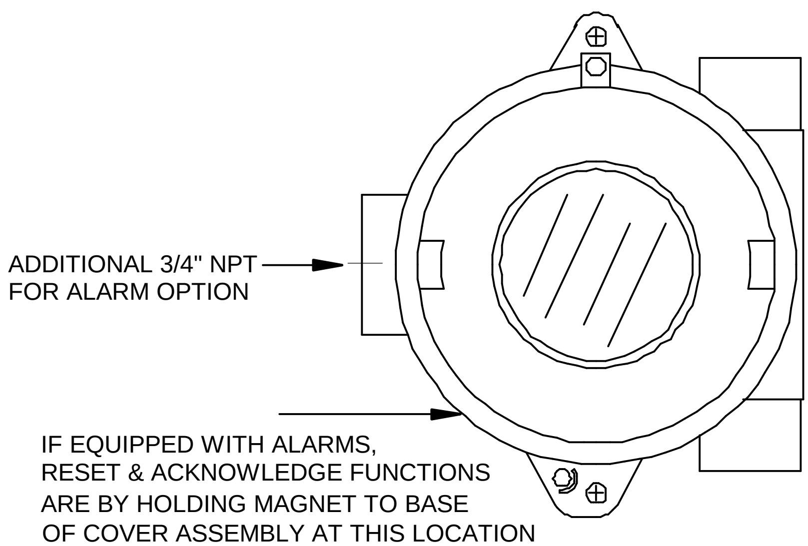
ALARM 3 is typically a *fail-safe* FAULT relay and is activated by the defective sensor conditions described in sections 4.3 and 5.3 of this manual. Since it is fail safe, it also indicates loss of power conditions at the ST-46A. If the FAULT relay is not required, it is possible to configure the ALARM 3 relay to trip with ALARM 2. This configuration is useful if ALARM 2 is to drive an audible device, which needs to be *acknowledgeable*, but another ALARM 2 relay is needed for driving another *non-acknowledgeable* device such as a fan.

ALARM 1 and ALARM 2 trip points are controlled by 16 position rotary DIP switches. See figure 6.4 for a definition of switch functions for the alarm option PCB. Both alarm set-points incorporate approximately 1.5% hysteresis. Therefore, the signal must drop about 1.5% below the trip level to reset the alarm. This prevents alarm "chatter" when the input signal equals the trip level.

IMPORTANT! The relay contacts are rated for 5 amp *resistive* loads. Appropriate surge suppressers should be installed across loads to prevent arcing on the contacts. Arcing generates high levels of RFI that may interfere with measurement signals.

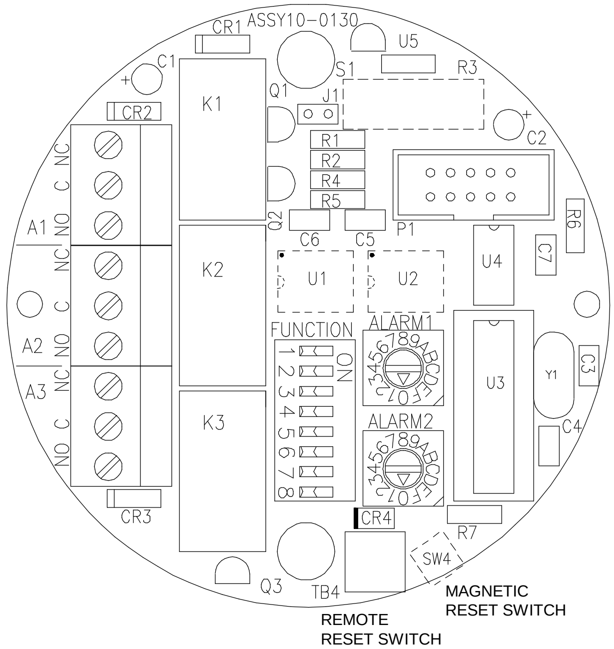
6.4.1 LATCHING ALARMS:

Setting the FUNCTION DIP switches for *latching* operation requires manual reset of alarm conditions. A remotely mounted reset switch may be wired to the 2-position TB4. RESET may also be accomplished locally, without opening the enclosure, by holding the magnet near the southwest angle on the ST-46A enclosure as shown below.



6.4.2 FAIL-SAFE ALARMS:

The FUNCTION DIP switches offer the ability for HIGH and WARN relays to operate in a *fail-safe* condition. This means the relays are energized in the safe, or no alarm condition and when an alarm occurs the relay de-energizes. The advantage of this configuration is “loss of power” conditions create the same relay outputs as alarm conditions. The FAULT relay is always fail-safe.



FUNCTION DIP SWITCH DEFINITIONS

	ON	OFF
1.	A1=HI TRIP	A1=LO TRIP
2.	A1=NON-LATCH	A1=LATCH
3.	A1=NORMAL	A1=FAIL SAFE
4.	A2=HI TRIP	A2=LO TRIP
5.	A2=NON-LATCH	A2=LATCH
6.	A2=NORMAL	A2=FAIL SAFE
7.	A2=NO ACKNOW-LEDGE	A2=ACKNOWLEDGE
8.	A3=FAULT	A3= TRIPS WITH A2

A1 & A2 TRIP POINT ROTARY SWITCHES

POSITION			POSITION		
0	=	ALARM INACTIVE	8	=	40% TRIP LEVEL
1	=	5% TRIP LEVEL	9	=	45% TRIP LEVEL
2	=	10% TRIP LEVEL	A	=	50% TRIP LEVEL
3	=	15% TRIP LEVEL	B	=	55% TRIP LEVEL
4	=	20% TRIP LEVEL	C	=	60% TRIP LEVEL
5	=	25% TRIP LEVEL	D	=	65% TRIP LEVEL
6	=	30% TRIP LEVEL	E	=	70% TRIP LEVEL
7	=	35% TRIP LEVEL	F	=	75% TRIP LEVEL

FIGURE 6.4 / OPTIONAL ALARMS

SECTION VII

FACTORY SERVICE AND WARRANTY

7.1 FACTORY SERVICE:

When factory service is necessary, ship the instrument freight prepaid to:

R. C. Systems Co. Inc. 8621 Hwy. 6 Hitchcock, TX 77563

Please be sure to include the purchase order number with which the unit was ordered.

7.2 WARRANTY:

R. C. Systems Co. Inc. warrants all equipment built by it to be free of defects and workmanship under normal use and service. If any part of the equipment described in this manual proves to be defective in workmanship or material, and if such part is returned to R. C. Systems Co. Inc. factory within twelve months of installation, or eighteen months of the initial shipping date, it will be replace free of charge, F.O.B. factory. **R. C. Systems Co. Inc. assumes no liability whatsoever for the use or misuse by the purchaser, his employees, or others.**

SECTION VIII

PHYSICAL DIMINSIONS

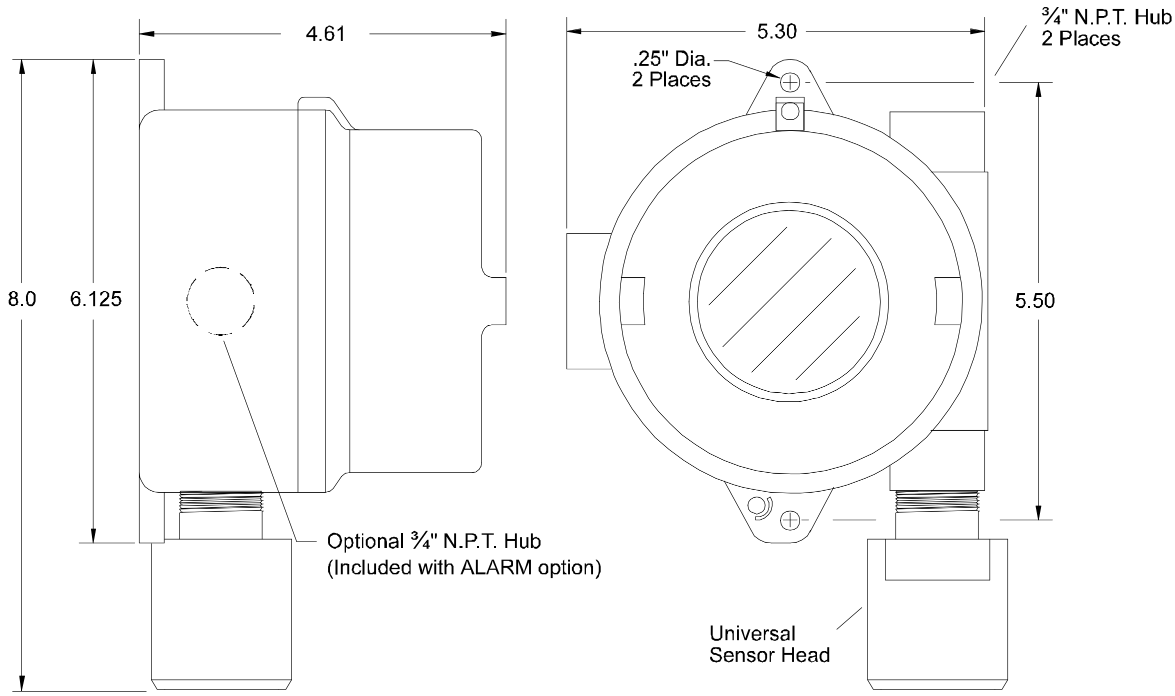


FIGURE 8.1