



Model TCSMA

Conductivity Measurement System

(Toroid Sensor, Blind, 2-Wire 4-20mA Transmitter)

Operation and Maintenance Manual



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Part 1 - Introduction

1.1 General The Model TCSMA is a blind, loop-powered monitoring system, designed for the continuous measurement of solution conductivity. The full scale operating range of the transmitter may be user adjusted to any value between 500 uS and 1,000,000 uS using the same sensor. The sensing system will operate on water streams with temperatures from -5°C to 110°C.

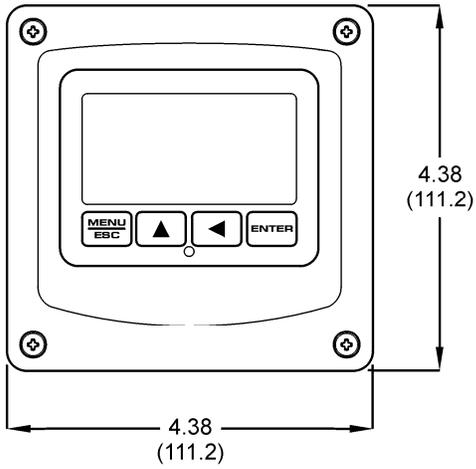
- 1.2 Features**
- Special toroidal sensor design greatly minimizes sensor fouling and, therefore, reduces maintenance requirements.
 - Standard main module is designed to be a fully isolated, loop powered instrument for 2-wire DC applications.
 - Can be user-adjusted for specific application span from 500 uS to 1,000,000 uS using the same sensor.
 - Direct/Reverse operation allows 4-20 mA output direction to be flipped.
 - Adjustable temperature compensation from 0% to 4% per °C to match solution requirements.
 - Loop indicator LED glows to indicate loop current level.
 - Instrument supplied in rugged NEMA 4X enclosure with multi-purpose mounting bracket.

1.3 TCSMA System Specifications

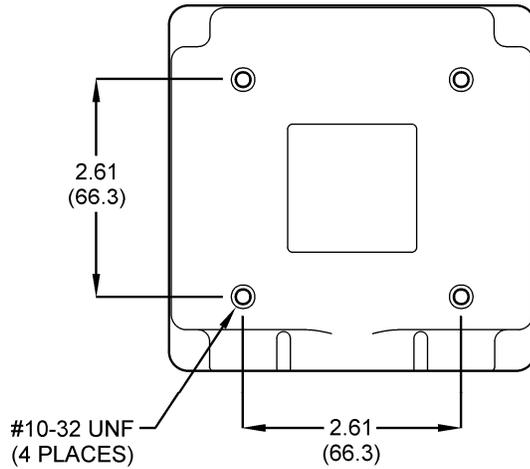
Measuring Range	Manual selection of one of the following ranges, 500 to 2,500 uS/cm 2,500 to 15,000 uS/cm 15,000 to 100,000 uS/cm 100,000 to 1,000,000 uS/cm
Enclosure	NEMA 4X, IP66, polycarbonate, stainless steel hardware, weatherproof and corrosion resistant, HWD: 4.4" (112 mm) x 4.4" (112 mm) x 3.5" (89 mm)
Mounting Options	Wall, panel, pipe, DIN rail, or integral-sensor.
Conduit Openings	Standard: 1 - PG-9 opening, 1 - 1" NPT center opening, cordgrips and PG-11 adapter included.
Weight	1 lb. (0.45 kg)
Ambient Temperature	Transmitter Service, -20 to 60 °C (-4 to 140 °F) Sensor Service, -5 to 110°C (23 to 230 °F)** Storage, -30 to 70 °C (-22 to 158 °F)
Ambient Humidity	0 to 95%, non-condensing
Location	Designed for hazardous and non-hazardous areas
EMI/RFI Influence	Designed to EN 61326-1
Output Isolation	Inherently isolated by sensor design
Temperature Input	Pt1000 RTD with automatic compensation, compensation adjustable from 0.0 to 4.0%/°C.
Sensor	Noryl body toroidal, 150 psig max, ¾" NPT rear process connection, P1000 RTD, CPVC 20 ft length integral cable.
Max. Sensor-to-Transmitter Distance	200 feet (61 meters)
Power	16-35 VDC (2-wire device)
DC Cable Type	Belden twisted-pair, shielded, Maximum length 3000 ft (914 meters)
Insertion Loss	16 VDC

** Note – sensor cable limited to 105°C max temperature when dry and 70°C max temperature if submerged.

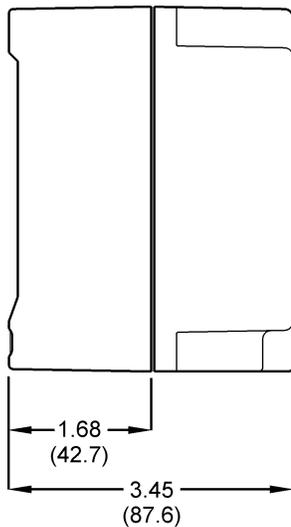
Inches (mm)



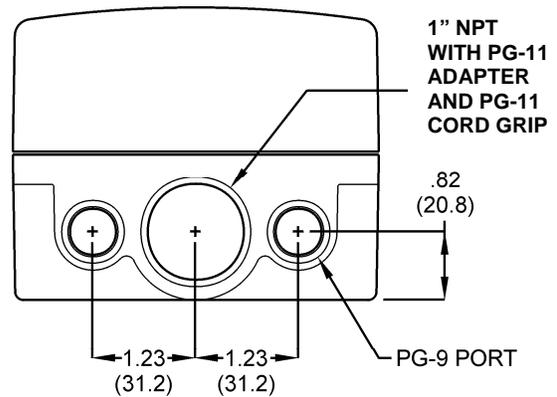
FRONT VIEW



BACK VIEW



SIDE VIEW



BOTTOM VIEW

Figure 1-1 Specifications - Views

1.4 TCSMA Performance Specifications

Repeatability	0.2% of selected range
Sensitivity	0.1% of selected range
Non-linearity	0.5% of selected range
Stability	0.2% of range per 24 hours, non-cumulative
Temperature Drift	0.06% of range/°C, span or zero
Response Time	2 seconds to 90% of full-scale step input

Part 2 – Transmitter Mounting

2.1 General

A bracket is included with each unit that allows mounting to walls, pipes and DIN rail. In all cases, choose a location that is readily accessible for calibrations. Also consider that it may be necessary to utilize a location where solutions can be used during the calibration process.

Locate the instrument in close proximity to the point of sensor installation - this will allow easy access during calibration. The sensor-to-instrument distance should not exceed 200 feet. To maximize signal-to-noise ratio however, work with the shortest sensor cable possible. The standard cable length of the sensor is 20 feet (6.1 meters).

2.2 Wall Mount

The instrument may be easily wall mounted (see Figure 2-1 details). The multi-purpose bracket is attached to the rear of the enclosure using the four provided pan head screws. The protrusion side of the multi-purpose bracket should face into the depression on the rear of the instrument enclosure. The instrument is then attached to the wall using the four outer mounting holes in the bracket.

2.3 Pipe Mount

For the pipe-mounting configuration, the multipurpose bracket is attached to the rear of the enclosure with the four provided screws. The protrusion on the bracket must face outward. The bracket may be rotated for proper alignment prior to mounting (see Figure 2-1 for details).

Once the bracket is fastened to the rear of the enclosure, the provided pipe clamp must be completely opened and slipped through the two slots in the multi-purpose mounting bracket. The clamp is then looped around the pipe, re-attached, and tightened.

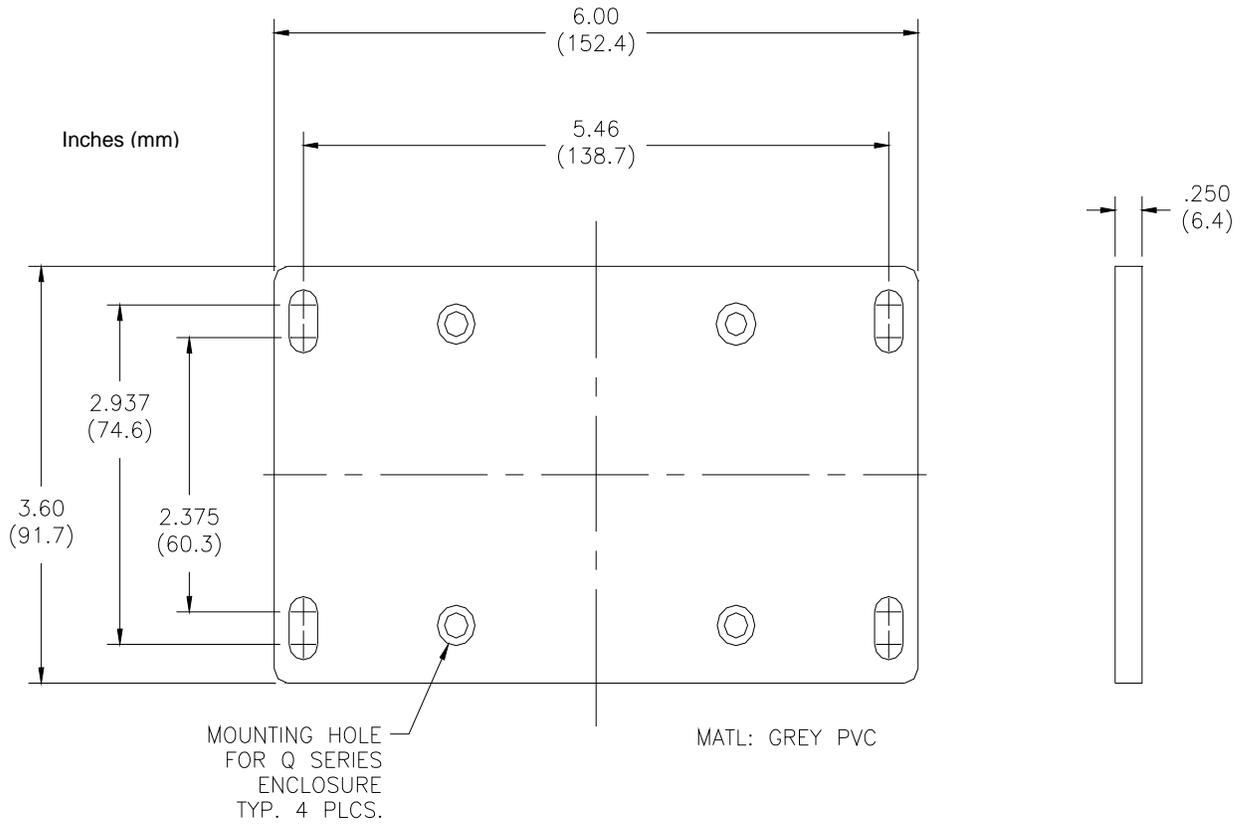


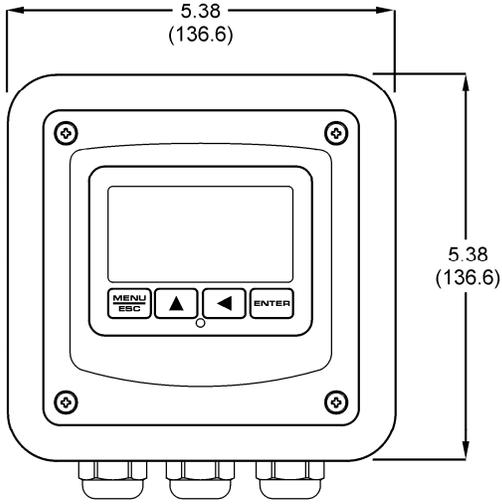
Figure 2-1 Mounting Bracket Details

2.4 Panel Mount In the panel mount configuration, the entire enclosure is panel-mounted using a special optional sealing flange – as shown in Figure 2-2. The panel mount kit, part number 07-0204, must be ordered separately.

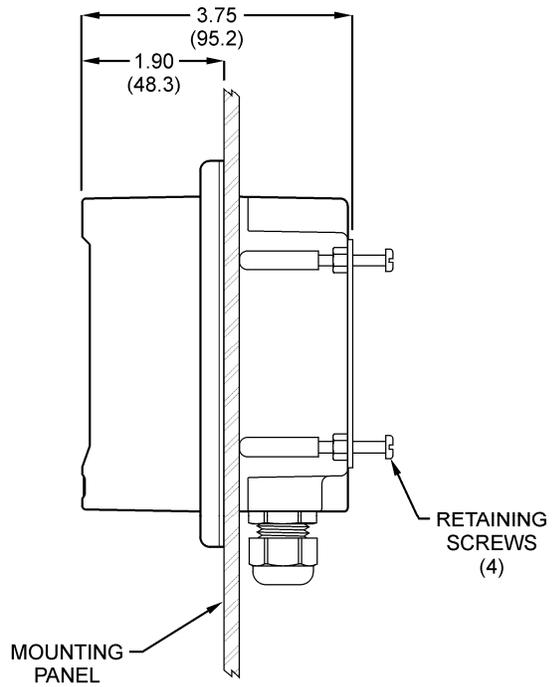
The sealing flange must first be attached to the enclosure. Fasten the flange to the rear half of the enclosure using the four hex retainers. The flange gasket material must face towards the rear of the enclosure. The flange is now installed. Seal up the finished enclosure by tightening down the four enclosure screws prior to mounting.

A special cut-out is required for this configuration, as shown in Figure 2-2. Once the cut-out has been completed, insert the flanged enclosure through the cut-out. The mounting bracket is then attached to the rear of the enclosure as shown. Install the four tension screws through the four mounting holes in the bracket, and place the no-slip rubber boots on each screw. Tighten all screws down to seal the enclosure flange onto the panel.

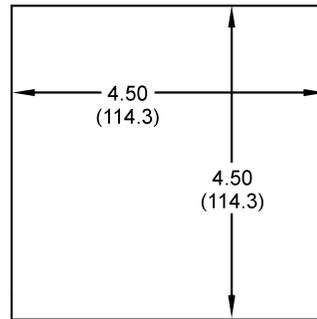
Inches (mm)



FRONT VIEW



SIDE VIEW



PANEL CUT-OUT

Figure 2-3 Panel Mount and Cut-out

Part 3 – Sensor Mounting

3.1 General

Select a location within the maximum sensor cable length for mounting of the sensor flow cell. Locate sensor away from pumps, adjustable frequency drive systems, or other sources of high frequency EMI if possible. Once submerged, verify that the sensor has the proper minimum 2” clearance to tank walls or other objects nearby the sensor mounting. Close proximity to objects can cause the sensor to read falsely high or low. If in-line mounted, as in a tee application, the sensor will stay cleaner if it is faced up or down stream so that the line flow goes directly through the sensor bore. Contact the factory for information on submersion hardware mounts and tee mounts.

Part 4 – Transmitter Electrical Installation

4.1 General

The TCSMA loop-powered instrument is a 16-35 VDC powered transmitter.

WARNING: Do not connect AC line power to the 2-wire module. Severe damage will result.

Important Notes:

1. Use wiring practices that conform to all national, state and local electrical codes.
2. Do NOT run sensor cables or instrument 4-20 mA output wiring in the same conduit that contains AC power wiring. AC power wiring should be run in a dedicated conduit to prevent electrical noise from coupling with the instrumentation signals.

4.2 Power

A separate DC power supply must be used to power the instrument. The exact connection of this power supply is dependent on the control system into which the instrument will connect. See Figure 4-1 for further details. Any general twisted pair shielded cable can be used for connection of the instrument to the power supply. Route signal cable away from AC power lines, adjustable frequency drives, motors, or other noisy electrical signal lines. Do not run sensor or signal cables in conduit that contains AC power lines or motor leads.

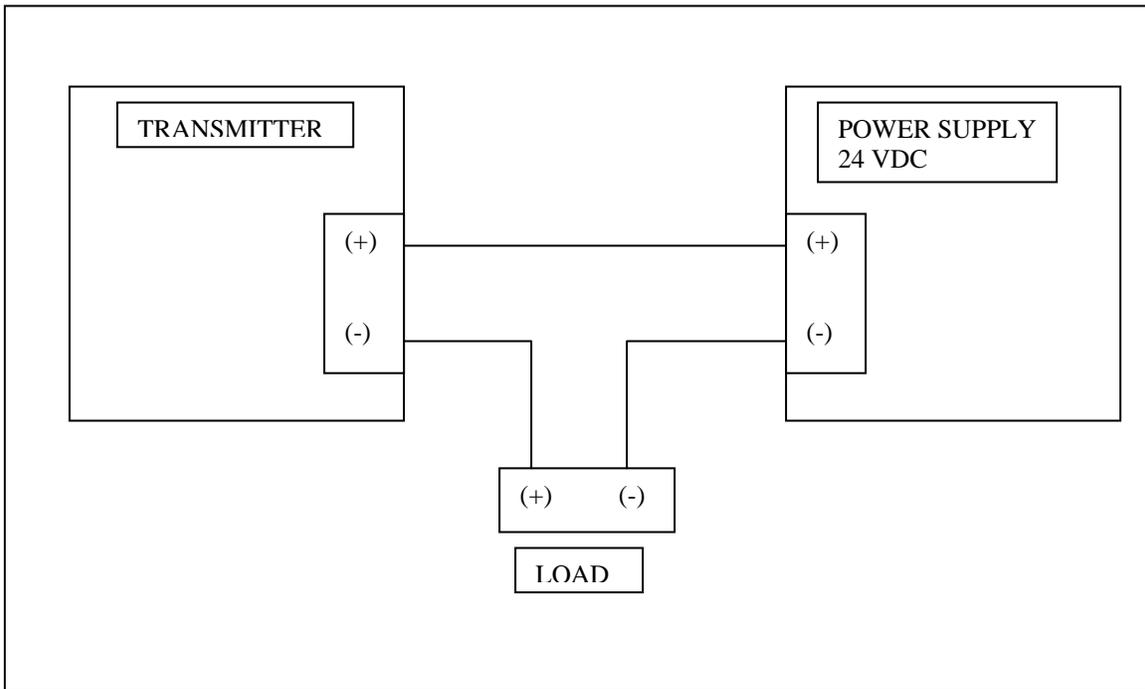


Figure 4-1 Loop-Power Connection

4.3 Load Drive

The two-wire instrument can operate on a power supply voltage of between 16 and 35 VDC. The available load drive capability can be calculated by applying the formula $V/I=R$, where V =load drive voltage, I =maximum loop current (in Amperes), and R =maximum resistance load (in Ohms).

To find the load drive voltage of the two-wire TCSMA, subtract 16 VDC from the actual power supply voltage being used (the 16 VDC represents insertion loss). For example, if a 24 VDC power supply is being used, the load drive voltage is 8 VDC.

The maximum loop current of the two-wire TCSMA is always 20.00 mA, or .02 A. Therefore,

$$\frac{(\text{Power Supply Voltage} - 16)}{.02} = R_{\text{MAX}}$$

For example, if the power supply voltage is 24 VDC, first subtract 16 VDC, then divide the remainder by .02. $8/.02 = 400$; therefore, a 400 Ohm maximum load can be inserted into the loop with a 24 VDC power supply.

Similarly, the following values can be calculated:

Power Supply Voltage (VDC)	Total Load (Ohms)
16.0	0
20.0	200
24.0	400
30.0	700
35.0	950

Part 5 – Sensor Electrical Connection

5.1 General

The sensor cable can be quickly connected to the TCSMA terminal strip by matching the wire colors on the cable conductors. A junction box is suggested to provide a quick-disconnect point for the sensor, or a break point for very long sensor cable runs. Route signal cable away from AC power lines, adjustable frequency drives, motors, or other noisy electrical signal lines. Do not run sensor or signal cables in conduit that contains AC power lines or motor leads.

5.2 Direct Sensor Connection

Route the sensor cable into the enclosure through the center PG-11 cord grip only. If the cord-grip devices are used for sealing the cable, make sure the cord-grips are snugly tightened after electrical connections have been made to prevent moisture incursion. When stripping cables, leave adequate length for connections in the transmitter enclosure, as shown below.

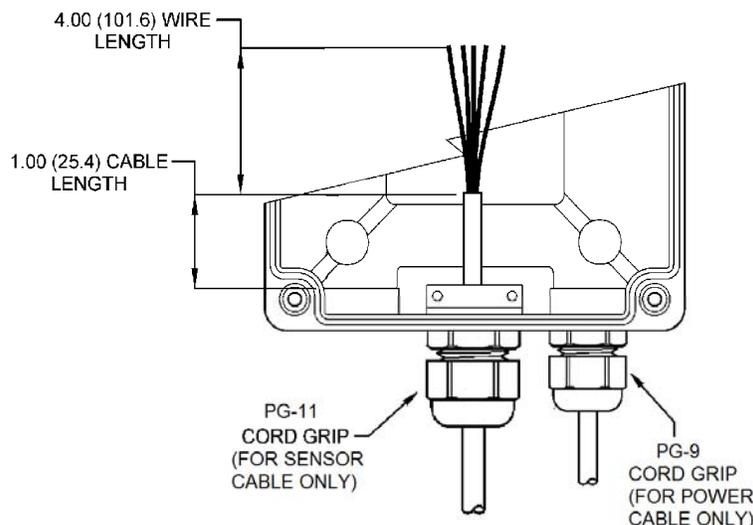


Figure 5-1 Bulkhead Connection

Once inside the enclosure, the individual colored sensor sensor cable leads can be connected directly to the SENSOR connection terminals by matching the wire colors.

5.3 J-Box

Connection

For installations where the sensor is to be located more than 20 feet from the transmitter, a customer supplied junction box should be used.

Part 6 – Calibration

6.1 General The transmitter is factory calibrated in a default range of 0-10,000 uS/cm. The transmitter must be re-calibrated with the actual sensor for optimum accuracy using the following procedure.

6.2 User Interface The user interface controls for the transmitter are quite simple, and they are described below.

6.21 Offset Adjustment The offset adjustment sets the 4 mA output current point for the system. This adjustment is made after the proper range has been selected, and the sensor is held in air. Offset adjustments can only be made to zero-signal conductivity.

6.22 Coarse Span Adjustment The coarse span adjustment sets the initial 20 mA output current point for the system. This adjustment is used to make the initial rough adjustment on the sensor span.

6.23 Fine Span Adjustment The fine span adjustment sets the final 20 mA output current point for the system. This adjustment is used to make the final, precise, adjustment on the sensor span.

6.24 Range Selection This dipswitch selects the general range of operation for the transmitter. Pick the range to be larger than the maximum operating conductivity value of the transmitter.

	RANGE	CELL DRV
500 uS – 2,500 uS	1-ON, 2-ON	1-ON, 2-OFF
2,500 uS – 15,000 uS	1-ON, 2-OFF	1-ON, 2-OFF
15,000 uS – 100,000 uS	1-OFF, 2-OFF	1-ON, 2-OFF
100,000 uS – 1,000,000 uS	1-OFF, 2-OFF	1-OFF, 2-ON

Due to the nature of the sensor design, it is recommended to use the largest range possible for the application. The higher instrument ranges are easier to user calibrate, as they require less back-and-forth zero/span adjustments.

6.25 Temperature Compensation Adjustment

The TC % PER C adjustment sets the specific linear temperature compensation factor for the measured solution. The range of adjustment is from 0-4%/C. Since the majority of aqueous solutions are compensated at approximately 2%/C, leave this setting at the default 2%/C setting if the exact compensation requirement is not known. The following list contains some common factor settings:

- 1.9 Sodium Hydroxide
- 1.5 Hydrochloric Acid
- 1.5 Sulfuric Acid
- 1.5 Nitric Acid
- 1.1 Phosphoric Acid
- 2.1 Sodium Chloride
- 2.4 Sodium Sulfate
- 2.2 Sodium Nitrate
- 2.0 Potassium Chloride

6.26 REV/DIR Switch

This switch sets the direction of output change for the system. In the direct mode (DIR), the output current will increase to 20 mA as the conductivity increases. In the reverse mode (REV), the output current will decrease to 4 mA as conductivity increases.

6.27 Loop Current

This indicator glows when the transmitter is powered and operating correctly. The intensity of the light will increase with increasing output current.

6.28 Cell Drive

This switch sets the sensor drive potential and is used to set the instrument range of operation (see section 6.24.)

6.3 Conductivity Calibration

This section details the procedure to change the factory calibration of the transmitter.

The instrument may be calibrated using a reference instrument, using pre-mixed calibration solutions, or by mixing NaCl calibration solutions for the application. In any of these cases, use a calibration solution that is close to the maximum operating level of the process.

To prepare a specific conductivity solution for an application, use the following table to determine the amount of sodium chloride to be added to 1 liter of distilled water.

CONDUCTIVITY REFERENCE SOLUTIONS

Desired Cond.	NaCl Added (grams)
2,000 uS	1.01
5,000 uS	2.61
10,000 uS	5.56
20,000 uS	11.59
50,000 uS	31.95
100,000 uS	72.71

Once calibration solution is available, and instrument is properly connected and powered, use the following procedure to complete calibration.

1. Set range switches (RANGE and CELL DRIVE).

Pick the range to be larger than the maximum operating conductivity value of the transmitter.

	RANGE	CELL DRV
500 uS – 2,500 uS	1-ON, 2-ON	1-ON, 2-OFF
2,500 uS – 15,000 uS	1-ON, 2-OFF	1-ON, 2-OFF
15,000 uS – 100,000 uS	1-OFF, 2-OFF	1-ON, 2-OFF
100,000 uS – 1,000,000 uS	1-OFF, 2-OFF	1-OFF, 2-ON

Due to the nature of the sensor design, it is recommended to use the largest range setting possible for the application when using the 500-2,500 uS range. The higher instrument ranges are easier to user calibrate, as they require less back-and-forth zero/span adjustments. For example, even though the instrument can be calibrated from 0-500 uS over 4-20 mA, the instrument calibration will be much easier if the calibration is 0-1000 uS or 0-2000 uS over the 4-20 mA span.

2. Set these initial settings on other controls:

OFFSET – leave at current position

COARSE SPAN – FULL CCW

FINE SPAN – MID SCALE*

TC %/°C – ADJUST FOR SOLUTION (see 6.25)

REV/DIR - DIR

** Note- control pots are 25 turn. To get to mid position, turn full CCW until a “clicking” sound is heard, then rotate CW 12 turns.*

3. Hold the sensor in air away from any nearby objects. Sensor should be clean. Adjust the OFFSET control until the output current from the transmitter is 4.00 mA.
4. Place the sensor in solution and allow the sensor's to temperature equilibrate. To minimize error, it is best if solution is as close as possible to room temperature. Allow the system to operate undisturbed for 15-30 minutes to allow for temperature element to stabilize. The sensor must sit in the center of the beaker containing the conductivity reference solution, without touching the sides or bottom. Maintain at least 2” clearance on all sides of the round sensing portion of the sensor to prevent errors. When first placing the sensor into solution, swirl slightly and then rap gently to dislodge any bubbles from the sensor.
5. Adjust **ROUGH SPAN** until output current is approximately **20mA**, within approximately 0.5-1.0 mA.

6. While still in solution, adjust the **FINE SPAN** to dial in the final value to **20.00 mA**.
7. Pull sensor back into air, rinse, and gently shake off solution. Re-adjust 4 mA point with **OFFSET** control if necessary. Repeat steps 6-7 with **FINE SPAN** and **OFFSET**, going back into solution and back out, until no additional adjustment is necessary. Do not re-adjust the **ROUGH SPAN** during this final process.

6.4 Reverse Operation

If reverse operation is desired (output current falls to 4 mA as conductivity increases), complete the following procedure after calibration steps are performed from 6.3.

1. Place the **REV/DIR** switch in the **REV** position.
2. Hold sensor in air away from any nearby objects. Sensor should be clean and dry. Adjust the **OFFSET** control until the output current from the transmitter is **exactly 20.00 mA**.
3. Place the sensor in solution and allow the sensor to temperature equilibrate. To minimize error, it is best if solution is as close to possible to room temperature. Allow the system to operate undisturbed for 15-30 minutes. The sensor must sit in the center of the beaker containing the conductivity reference solution, without touching the sides or bottom. Maintain at least 2" clearance on all sides of the round sensing portion of the sensor to prevent errors.
4. Adjust **FINE SPAN** until output current is exactly 4.00 mA. Repeat steps 2-4 until no additional adjustment is necessary.

Part 7 – System Maintenance

- 7.1 General** The TCSMA Conductivity System will generally provide unattended operation over long periods of time. With proper care, the system should continue to provide measurements indefinitely. For reliable operation, some minimal level of maintenance on the system must be done on a regular schedule.
- 7.2 Transmitter Maintenance** No unusual maintenance of the analyzer is required if installed according to the guidelines of this operating manual. If the enclosure door is frequently opened and closed, it would be wise to periodically inspect the enclosure's sealing gasket for breaks or tears.
- 7.3 Sensor Maintenance** Sensor maintenance required is very minimal due to the nature of the sensor design. From time-to-time, the sensor should be inspected for any material which may have built up – particularly in the sensor bore. If cleaning is required, simply wash off with soapy water to clean sensor.

Part 8 – Service

8.1 General

The information included in this section is intended to be used to quickly resolve an operational problem with the system. During any troubleshooting process, it will save the most time if the operator can first determine if the problem is related to the transmitter, sensor, or some external source. Therefore, this section is organized from the approach of excluding any likely external sources, isolating the transmitter, and finally isolating the sensor. If these procedures still do not resolve the operational problems, any results the operator may have noted here will be very helpful when discussing the problem with the factory technical support group.

8.2 External Sources of Problems

To begin this process, review the connections of the system to all external connections.

1. Verify the proper power input is present (16-35V DC).
2. Verify the loads on any 4-20 mA outputs do not exceed the limits in the Instrument Specifications (see also section 4.3.) During troubleshooting, it is helpful to disconnect all these outputs and place wire-shorts across the terminals in the instrument to isolate the system and evaluate any problems that may be coming down the analog output connections.
3. Do not run sensor cables or analog output wiring in the same conduits as power wiring. If low voltage signal cables must come near power wiring, cross them at 90° to minimize coupling.
4. If rigid conduit has been run directly to the enclosure, check for signs that moisture has followed conduit into the enclosure.

5. Check for possible ground loops. Although the sensor is electrically isolated from the process water, high frequency sources of electrical noise may still cause erratic behavior in extreme conditions. If readings are very erratic after wiring has been checked, check for a possible AC ground loop by temporarily moving the sensor to a sample of solution in a beaker or other container.
6. Carefully examine any junction box connections for loose wiring or bad wire stripping. If possible, connect the sensor directly to the analyzer for testing.
7. Check sensor bore for excessive fouling. Look closely for signs of grease or oil that may be present. Clean if necessary.
8. Verify the sensor has the proper minimum 2” clearance to any nearby objects. Objects 2” or closer can affect the electrical field of the sensor and cause shifts in readings.
9. Note that the thermal response of the sensor can be quite slow, therefore, adequate time must be given to allow the sensor to fully equilibrate during thermal changes. Rapid temperature changes can result in measurement errors if insufficient stabilization time is not allowed.

8.3 Transmitter Tests

When powered and operating, verify loop current LED inside case is glowing. If not, double check polarity of wiring and verify output loop is not open somewhere. Verify loop-load is within specifications for the power supply used.

8.4 Sensor Tests

1. Toroidal sensors can be tested with a digital voltmeter (DVM) to determine if a major sensor problem exists. Follow the steps below to verify sensor integrity:
 - A. Disconnect the nine sensor wires from the terminal strip on the transmitter.

- B. Connect a DVM between the RED and BLACK wires in the red jacket pair. With the DVM set to measure resistance, you should measure between 0.5 and 2.0 Ohms.
- C. Connect a DVM between the WHITE and BLACK wires in the white jacket pair. With the DVM set to measure resistance, you should measure between 0.5 and 2.0 Ohms.
- D. Connect a DVM between the WHITE wire from the in the white jacket pair, and the RED wire from the red jacket pair. With the DVM set to measure resistance, you should measure an open circuit.
- D. Connect a DVM between the GREEN and BLACK wires in the green jacket pair. These are the RTD leads, and you should find a resistance value that depends on the temperature. The table below lists the resistance values for various temperatures.

Temperature °C	Resistance Ω
0	1000
5	1019
10	1039
15	1058
20	1078
25	1097
30	1117
35	1136
40	1155
45	1175
50	1194

Figure 8-1 Pt1000 RTD Table

8.5 Spare Parts List- MODEL TCSMA

<u>PART NO.</u>	<u>DESCRIPTION</u>
TCSMA	TCSMA blind 4-20mA toroidal conductivity transmitter
TCS-3020-P1K	Toroidal Conductivity Sensor, polypropylene, with integral Pt 1000 RTD temperature sensor and 20 ft. cable with tinned leads
FC95C	2" CPVC flow cell for TCS-3020 sensors
07-0204	Panel mount kit