

The Series 400 is a level transmitter providing a two-wire 4 to 20 mA output to indicate level of liquids, powders and bulk materials. State of the art sensing technology in the 400, using impulse RF admittance measurement provides excellent accuracy and stability. The 400 senses capacitance changes resulting from the height of the material in the tank between the probe and the tank wall. In non-metallic tanks or tanks that do not have the wall parallel to the probe a ground reference must be used.

The 400 comes with either a rigid or flexible probe depending on application installation need and probe length required. Featured in the 400 is easy push button calibration of zero and span. Custom order the 400 to any length probe that you need for your application. FEP covered probe is ideal for use with corrosive media.

SPECIFICATIONS

Service: Liquids, powders, and bulk materials compatible with wetted materials.

Wetted Materials: Standard: rod/cable: FEP; connection: 316 SS. Ground Option: rod/cable and connection: 316 SS; cable spacers: PVC. Flange Option: material of flange.

Capacitance Range: 0 to 2000 pF.

Sensitivity: 0.15 pF.

Minimum Span: 8 pF.

Accuracy: ± 0.5 pF or $\pm 0.25\%$ of span, whichever is greater.

Repeatability: ± 0.25 pF or $\pm 0.1\%$ of span, whichever is greater.

Temperature Limits:

Ambient: -40 to 185°F (-40 to 85°C); Process: -40 to 250°F (-40 to 121°C); HP option: -40 to 100°F (-40 to 37°C).

Pressure Limit: 100 psi (6.9 bar); HP option: 1200 psi (82.7 bar).

Power Requirements: 12 to 35 VDC.

Output Signal: 4 to 20 mA or 20 to 4 mA, 2 wire.

Response Time: 0.5 seconds.

Electrical Connection: Screw terminal.

Conduit Connection: 1/2" NPT female.

Process Connection: Standard: 3/4" NPT male. Optional: See model chart.

Enclosure Rating: NEMA 4X (IP66) weather-tight/corrosion resistant.

Spark/Static Protection: 10^6 Ohm dissipation resistance with spark gap. Surge current to 100A max.

Calibration: Zero, Span, 4 mA, 20 mA.

Mounting Orientation: Vertical.

Weight: 6 ft rod type: 3.6 lb (1.63 kg).



OPERATING PRINCIPLE

Capacitance and Dielectrics

Capacitance is the property of two or more conductors to store a charge when there is a voltage difference between the conductors. In other words capacitance relates the voltage between two conductors and the amount of charge that can be held on the conductors (i.e., the number of electrons).

Capacitance is measured in Farads. Since a Farad of capacitance represents a very large charge storage capacity, most capacitance encountered is generally measured in microFarads (μF , 10^{-6}) or picoFarads (pF , 10^{-12}). Capacitances encountered in level sensing applications are generally in the 10's or 100's of pico Farads range.

The material between the conductors affects the capacitance also. Insulating materials do not allow free movement of electrons, however in an electric field the molecules of these materials will tend to align with the field thus storing energy. This is called the dielectric effect and these materials are often referred to as dielectrics. When placed between two conductors the energy storage capability of these dielectrics will allow more charge to be stored on the conductors for a given voltage difference thus increasing the capacitance between the conductors. The ratio of capacitance change caused by these dielectrics is referred to as the dielectric constant. Different materials have differing dielectric constants and will consequently change the capacitance between two conductors more or less depending on the value of this constant. This value ranges from 1.0 for a vacuum to over 100 for certain materials. The dielectric constant for air is very close to 1.0 and usually assumed to be exactly 1.0.

Capacitive level sensors determine the level of material by changes in probe capacitance resulting from the movement of dielectric materials between the probe and the reference ground electrode such as a tank wall. Since measuring very small capacitance changes (less than 1 pF) can be problematic in industrial environments, capacitance level sensing tends to be most effective for materials with a dielectric constant greater than 1.2. Since the difference in capacitance is being measured, it is also possible to detect the level of two immiscible liquids that have different dielectric constants such as oil and water.

Measurement

The 400 uses an impulse RF admittance measurement technique to measure the probe capacitance. The impulse admittance measurement offers advantages over other techniques in that it produces minimal emissions to interfere with other communication or instrumentation systems. The CRF2 continuously measures the probe capacitance. Using this capacitance measurement, it computes a linear value with 0% at the zero calibration value and 100% at the span calibration value. From this the output current is computed and generated. Since no assumptions are made regarding the relative value of the zero and span calibration capacitances, the output can be set to measure from low to high capacitance or high to low capacitance.

INSTALLATION

Unpacking

Remove the 400 from the shipping carton and inspect for damage. If damage is found, notify the carrier immediately.

Materials

The 400 may be used to detect level of a variety of materials. Conductive materials such as water require an insulated probe for proper operation. When used with a conductive material, the material itself must be grounded to the reference ground of the 400. This may be done through a conductive tank wall or using an optional reference ground electrode. Dry non-conductive materials may use either an insulated or uninsulated probe. Capacitance level measurement is best applied when the material dielectric constant is greater than 1.2. With non-conductive materials, particularly low dielectric materials, the probe should be spaced more closely to the reference ground to increase the base capacitance and ensure reasonable sensitivity. The limiting factor for spacing will be to ensure that material buildup around the probe is avoided. For conductive materials this will be less of a concern since the dielectric insulator around the probe is the predominant factor in the capacitance changes with level.



Mounting Location

- The process temperature and ambient temperature must be within the specified limits.
- The probe must be located away from tank inlets or chutes where material may fall on the probe during filling or emptying.
- Avoid placing the probe close to agitators or other such devices.
- When used with high density bulk material, the probe must be protected from material shifts that would bend or shift the probe.
- If a cable probe is used, make sure that shifting bulk material will not exert too much strain on the cable connections.

The accuracy of the 400 is very dependent on the installation of the probe. The probe must be installed vertically and parallel to the reference ground, particularly for non-conductive materials. The reference ground may be a conductive tank wall or other internal parallel metallic structure. If these are unavailable then a reference electrode must be installed with the probe (See Figure 1). Support for the probe and reference electrode must be provided to ensure these components maintain their parallelism.

In nonmetallic tanks a ground reference must be provided. If the probe is near the wall of the tank an adhesive backed metallic sheet may be applied to the outside tank wall nearest to the probe. Other metallic objects may be used also if they are in close proximity to the tank wall. If the probe is located further than 6 inches from the wall, an internal conductor must be provided parallel to and within 6 inches of the probe. Maintain a minimum of 1 inch spacing between the probe and the reference conductor. These conductors must be connected to the case ground of the sensor. An internal ground clamp is provided for this if other grounding is not available.

If turbulence or material movement within the tank could cause probe movement, the probe must be supported appropriately with non-conductive material to minimize this movement (See Figure 2).

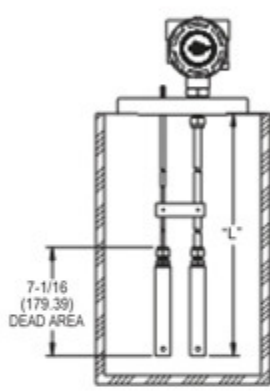


Figure 1: Attached Ground Rod Option

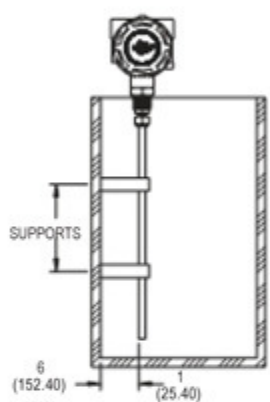


Figure 2: Supports to Tank Side Wall

When installing a unit that has a Remote Mount Housing, the probe should be installed before the coaxial cable is connected. This will prevent twisting of the cable and possible damage to the unit. The housing can be mounted in any position using the bracket provided, being careful to prevent kinking or pulling the cable. The cable should be connected to probe by inserting the cable through the cable gland on the probe's conduit enclosure and pushing the quick connect onto the spade terminal provided. Be sure to replace the enclosure cover and tighten the cable gland to protect and seal the connections.

Electrical Connection (See Figure 3)

CAUTION: Do not exceed the specified supply voltage rating. Permanent damage not covered by the warranty may result. This unit is not designed for AC voltage operation-

NOTE: Installation must be made in accordance with local codes and regulations. When fishing wire through the conduit connection do not allow the wire to touch or press on components on the boards. Damage to the circuitry may result. Make sure that the wire is routed so it will not interfere with the calibration switches.

The 400 provides a 1/2" NPT female port for conduit connection. The conduit connection must be made such that condensation is not allowed to enter the sensor housing. If necessary install a conduit breather drain in a separate conduit body to prevent buildup of moisture. If nonmetallic conduit is used the protective ground may be connected to the internal ground connection screw.

The 400 transmitter is designed as a two wire 4-20 mA device. Connection to the board is through a two pin terminal block. The circuitry is non-polarized so the positive and negative leads may be connected to either pin. It is recommended that shielded twisted pair wire be used if the potential exists for interference from external noise sources. Ground the shield at the case using the internal ground screw and leave the other end of the shield open. Do not use the shield as one of the current loop conductors.

The body of the 400 must be grounded to the tank or other earth ground using the internal ground screw provided. If the tank is non-conductive then a reference electrode must be provided. This reference electrode must be connected to the case ground.

Power Supply

The transmitter requires a minimum of 10 Volts DC at its connection for proper operation, and a maximum of 35 Volts. Choose a power supply with a voltage and current rating sufficient to meet this power specification under all operational conditions. If the supply is unregulated, make sure that the output voltage remains within the required voltage range under all power line conditions. Ripple on the supply should not exceed 100 mV.

Loop Resistance

The maximum allowable loop resistance is dependent on the power supply voltage. The maximum loop voltage drop must not reduce the transmitter voltage below the 10 Volt minimum. The maximum loop resistance can be calculated using the following equation:

$$R_{MAX} = \frac{V_{PS} - 10.0}{20mA}$$

Where V_{ps} is the power supply voltage.

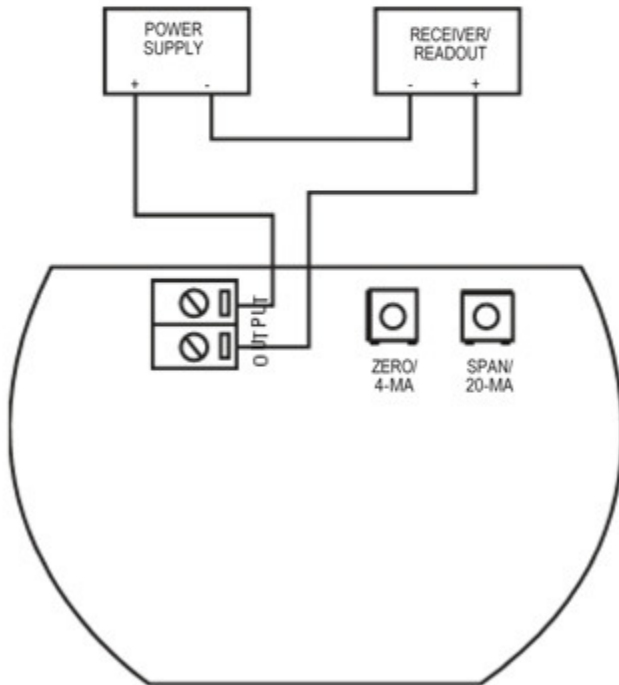


Figure 3: Electrical Wiring Diagram

SETUP & CALIBRATION

Two multi-function buttons are provided for all calibration operations. With these you can set the zero and span points, adjust the 4 and 20 mA calibration points, or reset the 4 and 20 mA calibration points to the factory settings. All settings are stored in nonvolatile memory so they will not be lost if the power is removed.

Zero and Span Calibration

The zero and span calibration is done with the 400 installed in the measured tank or vessel. Calibrating zero or span can be done in either order as these settings are independent of one another. The calibration can be done such that the output can go from 4 to 20 mA or from 20 to 4 mA depending on the desired measurement for full and empty conditions.

The span or zero calibration is activated by pressing and holding the corresponding "Zero" or "Span" button for three seconds. Set the tank level to one endpoint (i.e., full or empty), then press and hold either the Zero or Span button corresponding to the desired endpoint. Set the tank to the other endpoint then press and hold the opposite Span or Zero button. Calibration is now complete.

NOTE: Be careful to press the buttons only once within 3 seconds. Double clicking the switches within 3 seconds will place the unit in current calibration mode. If this happens press both buttons simultaneously to exit the current calibration mode. If the calibration was accidentally changed, the factory calibration can be restored as described later in "Restore Factory Calibration".

Current Calibration

The 4 and 20 mA points of the 400 have been calibrated at the factory and generally will not need to be recalibrated, but if needed the points may be recalibrated. To do this you will need a milliammeter connected in the current loop.

To calibrate the 4 mA calibration point, "double click" the Zero/4 mA button by pressing it twice within 1.5 seconds. The milliammeter will indicate approximately 4.00 mA. Adjust the 4 mA set point by pressing the Zero/4 mA button to decrease the current and the Span/20 mA button to increase the current. When complete, press both the Zero/4 mA and Span/20 mA buttons simultaneously to exit the calibration mode.

To calibrate the 20 mA calibration point, "double click" the Span/20 mA button by pressing it twice within 1.5 seconds. The milliammeter will indicate approximately 20.00 mA. Adjust the 20 mA set point by pressing the Zero/4 mA button to decrease the current and the Span/20 mA button to increase the current. When complete, press both the Zero/4 mA and Span/20 mA buttons simultaneously to exit the calibration mode.

NOTE: If the buttons are not pressed for approximately 4 minutes in calibrate mode, the 400 will automatically revert to the normal operation mode.

Restore Factory Calibration

The factory 4 and 20 mA calibration points may be restored by pressing and holding both the Zero/4 mA and Span/20 mA buttons simultaneously for 3 seconds. This must be done in the normal operation mode.

MAINTENANCE & REPAIR

Other than the controls mentioned in this manual there are no user maintenance adjustments or routine servicing required for this product. The unit is not field repairable and should be returned to the factory if service is required. Disassembly or modifications made by the user will void the warrantee and could impair the continued safety of the product. If repair is required obtain a Returned Goods Authorization (RGA) number and send the unit, freight prepaid, to the address below. Please include a detailed description of the problem and conditions under which the problem was encountered.

When the 400 with Sanitary Process Connection is to be used in a sanitary or hygienic application, the unit must be cleaned and/or sanitized in accordance with appropriate guidelines prior to installation. The 400 with Sanitary Process Connection is suitable for "Clean In Place" methods.

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