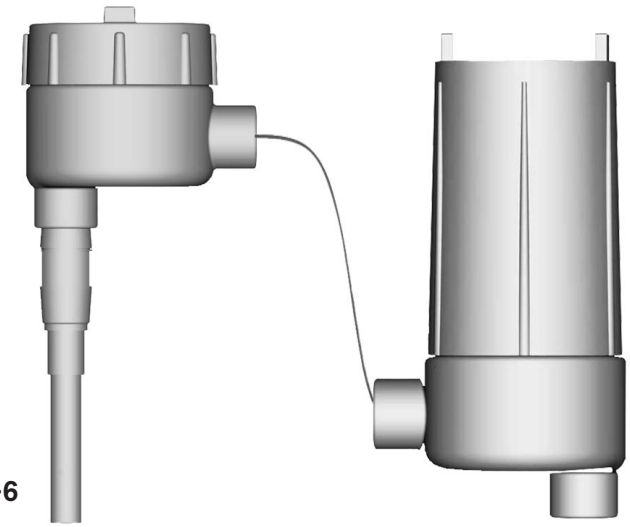
RF Capacitance Level Controls

Form 1100



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Features and Benefits

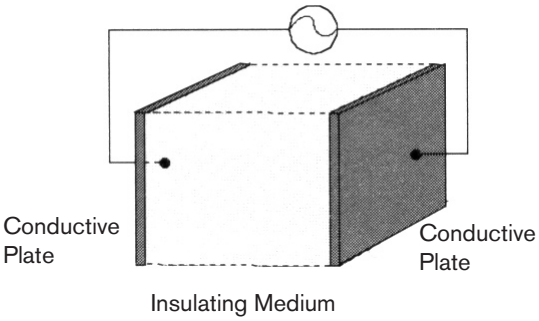
- Reliability
- Low maintenance costs
- No moving parts
- Interface measurement with on/off and continuous output
- Unaffected by changes in pressure, temperature, specific gravity, vapor or density
- Versatile - can be used with both conductive and non-conductive substances. Manages a variety of liquids, granular solids, powders and slurries.
- Dielectric range is unlimited
- 316SS, Telflon® or Kynar probes
- Can be used in virtually every type of chamber
- Set point/span are completely adjustable
- Withstands temperatures up to 400°F (204°C)
- Withstands pressure up to 4000 psig (275 bar)

RF Capacitance Level Controls

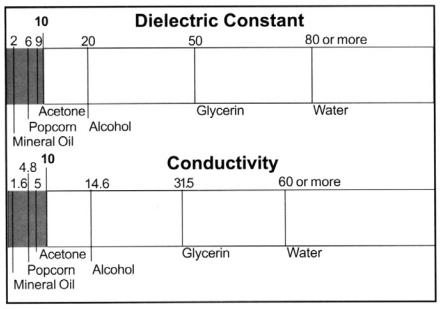
Operating Principle

RF Capacitance level controls are based on an electronic device called a capacitor. The capacitor is a device that stores energy. This energy is not stored in the probe; rather, the RF Capacitance level control is merely measuring how much energy can be stored. The amount of capacitance the RF Capacitance level control is measuring is extremely small and is measured in picofarads (1 X 10^{-12}) farads.

The capacitor is made up of two conductive plates parallel to each other. Separating the two plates is an insulator.



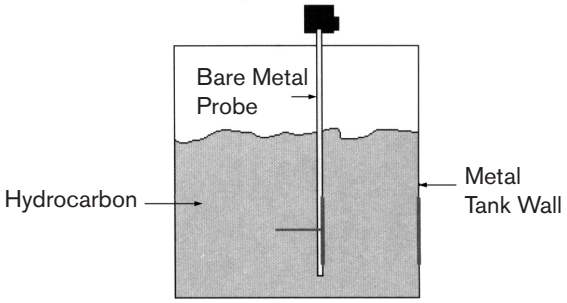
The amount of energy a capacitor can store is influenced by several things. First, a larger plate area results in more space to store energy. Second, more space between the plates reduces the amount of energy storage. Finally, a higher dielectric constant media can contain more energy than a lower dielectric media. The dielectric is where the actual capacitance is developed. The following chart shows the dielectric constant and conductivity for some sample materials.



Substances are considered either conductive or non-conductive. Non-conductive materials have a dielectric less than 10 or a conductivity less than 10µsiemens/cm. Conductive materials have a dielectric constant greater than 10 or a conductivity greater than 10 µsiemens/cm. Interestingly, there is a similar relationship between dielectric constant and conductivity. Non-conductive substances tend to have low dielectric constants and conductive substances tend to have high dielectric constants.

Non-Conductive Substances

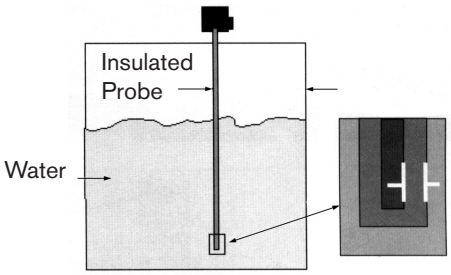
The structure of the capacitor actually changes in a level application. One plate is the probe and the other is the wall of the tank (see following figure). These do not change, nor does the distance between them. The only thing that changes is the dielectric constant. Air has a dielectric constant of one; anything else you measure will have dielectric value greater than one.



When the substance level increases, the dialectic of the substance is replacing the air and causes the capacitance to increase. The preset capacitance value is equal to the set point level wanted and trips a switch when the level is reached. The transmitter creates a linear output in relationship to the capacitance measured.

Conductive Substances

The substance between the two plates has to be an insulator in order to have a capacitor. When a conductive material is between the plates, an electrical short is created. This, in turn, signals the level transmitter to indicate a high level. A Teflon insulator around the sensor will prevent this from happening, as the figure below demonstrates.



An electrical connection is created through the conductive substance from the tank wall and the Teflon probe. When the level in the tank rises, the capacitor is created by the metal probe rod, the substance being measured and the probe insulator (Teflon), where the sensor rod and substance are the plates and insulator is the dielectric. This means that rather than measuring the dielectric of the substance, the dielectric of the probe where it is covered by the substance is being measured.

RF Capacitance Level Controls

Restrictions of RF

- Sensitive to changes in material dielectric (**Note:** dielectric compensation additives help, but the liquid can stratify.)
- Normally needs field calibration, which requires a change in level
- Dependent on contact with the substance being measured
- Conductive coatings can build up on the sensor and create false readings

The Difference Between RF Capacitance and RF Admittance

Contrary to popular belief, there really isn't an application difference between RF Capacitance and RF Admittance. The only difference is in the electronics; the overall performance of the unit remains the same. That's where the "RF" part comes in, as the following will explain:

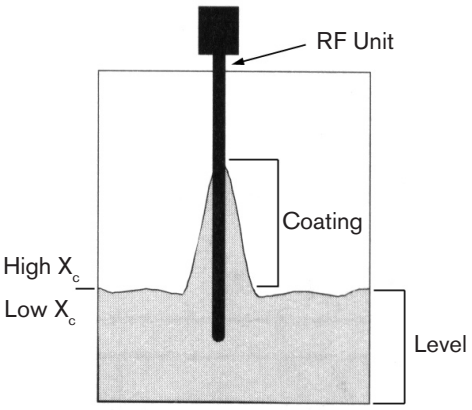
RF measurement is actually measuring capacitance, as well as capacitance reactance (impedance). The energy (Radio Frequency) is traveling from one conductive plate to the other. The following equation represents capacitance reactance:

$$X_c = \frac{1}{2\pi fc}$$

where

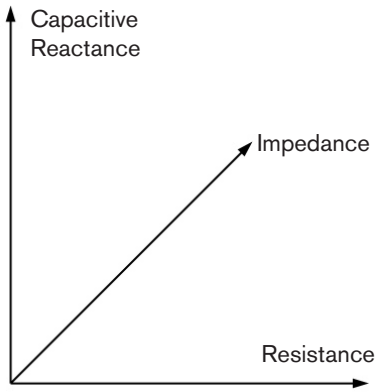
X_c = Capacitance Reactance (Ohms)
2π = Radians in a 360° cycle of AC (alternating current)
f = Frequency of AC (hertz)
C = Capacitance of system (in farads)

When there is a conductive coating on the probe, a non-RF unit will indicate the level at the top of the coating. By looking at the conductivity, an RF system can reduce the error caused by the coating (see following figure). Consider this: At the actual level, the amount of capacitive reactance (impedance) is low because the space between the tank wall and probe is filled with a conductive liquid. However, at the coating on the probe, there is also a large air space between the probe and tank wall. This air space results in a high amount of capacitive reactance.



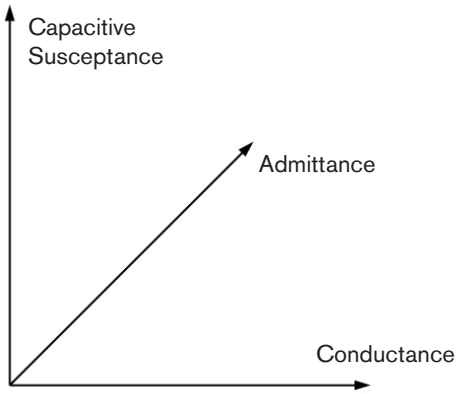
The Difference Between RF Capacitance and RF Admittance

Look at the formula for capacitive reactance. Since we are striving to measure the capacitance, C cannot change, and 2π is a constant and cannot change. The only thing left we can change is the frequency. If the frequency is increased (RF), the capacitive reactance decreases.



The level is represented on the vertical axis in these two graphs. Changes in the resistance are represented on the horizontal axis. A vector representing a combination of the two (impedance) is shown to the left. The inverse of this graph is shown below.

As you can see, an "admittance" measurement is just the inverse of a capacitance measurement. The important part, as previously stated, is the "RF."



Use this chart to select the RF instrument that best meets your needs.

Designator	Line Power	Loop Power
Single Point Sensing		
Integral Mount Electronics	651 Pages 5-6	651 Pages 5-6
Integral Mount Electronics with Sensor Monitor (Self-Test)	681 Pages 7-8	681 Pages 7-8
Remote Mount Electronics with Sensor Monitor (Self-Test)	681 Pages 7-8	681 Pages 7-8
Multiple Point Sensing		
Alarm or Pump Control	660 Pages 9-10	N/A

651 Single Point RF Switch

The 651 provides basic, single-point switching for use as an alarm or indicator. It's virtually immune to process coatings on the probe, making it a useful solution for many tough level applications. This immunity, combined with the absence of any moving parts, makes the 651 well suited for applications that are difficult for other technologies.

Features

- Economical point sensing
- Suitable for 12 VDC service
- FM Approved, CSA Certified hazardous locations
- Field-selectable failsafe

Product Specifications

Input Power - Line	120 VAC, 50/60 Hz 240 VAC, 50/60 Hz 24 VDC 12 VDC
Input Power - Loop	12-28 VDC
Output Type - Line	10A DPDT, 250 VAC 10A DPDT, 30 VDC DC rating shown for resistive loads 5A DPDT for 12 VDC input power
Output Type - Loop	8 mA (alarm), 16 mA (normal)
Loop Resistive	780 ohms maximum @ 24 VDC
Adjustment Range	0 to 1000 pF
Sensitivity	0.5 pF
Repeatability	0.5%
Failsafe	Field-selectable
Maximum Current Draw (line power)	12 VDC - 100 mA 24 VDC - 50 mA 120 VAC - 20 mA 240 VAC - 10 mA

Response Time	0.5 seconds
Time Delay	0 to 60 seconds
Enclosure Environmental Rating	NEMA 4X; IP65
Electrostatic Discharge Protection	8000 volts (Line) 4000 volts (Loop)
Line Surge Suppression	1000 volts line voltage EMC
Conduit Connection	3/4" NPT
Ambient Temperature Range	-40 to 160°F (-40 to 71°C)
Process Temperature Range	Probe Dependent
Maximum Process Pressure	Probe Dependent
Shipping Weight	2.5 lbs. (1.2 kg)

681 Single Point RF Switch with Self Test

Available as an integral or remote-mounted unit, the 681 provides single-point switching, and with its many safe and operation features, is well suited for demanding industrial applications.

Its "Self-Check" function constantly monitors circuit and probe integrity. A dedicated relay (line powered) or current shift (loop powered) indicates if the unit is not functioning properly. An optional, adjustable differential provides control of two set points with one relay, which gives the 681 pump and valve control for maintaining correct process levels.

Features

- Continuous self testing (Self-Check) verifies operation of the unit
- Optional adjustable differential for pump/valve control
- Available as integral or remote-mounted
- Field-selectable failsafe
- Optional on/off time delay eliminates effects of turbulence
- Resists process media coating

Product Specifications

Input Power - Line	120 VAC, 50/60 Hz 240 VAC, 50/60 Hz 24 VDC, 12 VDC
Input Power - Loop	10-30 VDC
Output Type - Line	
Alarm	10A DPDT, 250 VAC 10A DPDT, 30 VDC
Sensor Monitor	10A DPDT, 250 VAC 10A DPDT, 30 VDC DC rating shown for resistive loads
Output Type - Loop	
Alarm	8 mA (Alarm), 16 mA (Normal)
Sensor Monitor	24-27 mA
Loop Resistance	456 ohms maximum @ 24 VDC
Adjustment Range	0 to 1000 pF
Sensitivity	0.5 pF
Adjustment Range (Adjustment Differential)	Range I: 0 to 300 pF 0.5 pF sensitivity Range II: 300 to 1000 pF 1.0 pF sensitivity
Repeatability	0.5%
Failsafe	Field-selectable
Maximum Current Draw (line power)	12 VDC - 100 mA 24 VDC - 100 mA 120 VAC - 25 mA 240 VAC - 13 mA
Response Time	0.1 second
Time Delay (optional)	0 to 30 seconds
Enclosure Environmental Protection	NEMA 4X; IP65
Electrostatic Discharge Protection	8000 volts (line) 4000 volts (loop)
Line Surge Suppression	1000 volts line voltage EMC
Conduit Connection	3/4" NPT
Maximum Remote Distance from Sensor	150 ft. (45.7 m)
Ambient Temperature Range	Probe Dependent
Maximum Probe Pressure	Probe Dependent
Shipping Weight	3 lbs. (1.4 kg) plus 2 lbs. (1 kg) for remote

660 Series Multi-Point RF Switch

The 660 Series provides the options of multiple point switching plus narrow and wide differential switching. By combining these features, the 660 Series units can be used for a wide variety of control needs. The available switching combinations are designed to provide multiple alarms, pump/valve control, or a combination of alarms and equipment control. The 660 Series makes it possible to combine up to four single-point devices into one package for lower costs and reduced maintenance.

Features

- Up to 4-point indication
- Suitable for 12 VDC service
- FM Approved and CSA Certified for hazardous locations
- Field-selectable failsafe
- Resists process media coating

Switching Combinations

The 660 Series has eight different combinations of fixed differential and/or adjustable differential switching points. Each unit is equipped with one of four discreet switching points. These points can be used to provide true point level sensing with no level differential, or latched together to provide wide, adjustable differential.

See page 11 for available combinations. Required combinations are selected using step 1 in the How to Order chart on page 10.

Product Specifications

Input Power	120 VAC, 50/60 Hz 240 VAC, 50/60 Hz 24 VDC, 12 VDC
Output Type	10A DPDT, 250 VAC 10A DPDT, 30 VDC DC rating shown for resistive loads
Adjustment Range	0 to 2000 pF
Sensitivity	0.5 pF
Repeatability	0.5%
Failsafe	Field-selectable
Maximum Current Draw	12 VDC - 245 mA 24 VDC - 123 mA 120 VAC - 74 mA 240 VAC - 36 mA
Response Time	0.5 second (standard)
Time Delay (optional)	0 to 30 seconds

Enclosure Environmental Protection	NEMA 4X; IP65
Electrostatic Discharge Protection	8000 volts
Line Surge Suppression	1000 volts line voltage EMC
Conduit Connection	1" NPT(F)
Maximum Remote Distance from Sensor	4000 feet (1219.2 m)
Ambient Temperature Range	-40 to 160°F (-40 to 71°C)
Process Temperature Range	Probe Dependent
Maximum Probe Pressure	Probe Dependent
Shipping Weight	J Housing: 9 lbs. (4.1 kg) R Housing: 11 lbs. (5 kg) W Housing: 6 lbs. (2.7 kg)

670 RF Transmitter

The 670 provides continuous level measurement and a 4-20 mA linear output. It is a high-performance, general-purpose level transmitter that is well suited for many demanding applications that other technologies cannot handle.

Features

- FM Approved, CSA Certified hazardous locations
- Easy calibration
- Electrostatic discharge protection up to 4000 volts
- Resists process media coating

Product Specifications

Input Power	12-55 VDC 12-30VDC for Intrinsically Safe
Output Type	4-20 mA
Loop Resistance	600 ohms maximum @ 24 VDC
Zero Range	0 to 500 pF
Span Range	50 to 2000 pF
Accuracy	±1.0% of span
Linearity	±0.5% of full scale
Sensitivity	0.5 pF
Repeatability	±0.5% of full scale
Response Time	0.1 second

Enclosure Environmental Rating	NEMA 4X; IP65
Electrostatic Discharge Protection	4000 volts
Conduit Connection	3/4" NPT
Maximum Remote Distance from Sensor	10 ft. (3m)
Ambient Temperature Range	-4 to 160°F (-40 to 71°C)
Process Temperature Range	Probe Dependent
Maximum Process Pressure	Probe Dependent
Shipping Weight	2.5 lbs. (1.2 kg) plus 2 lbs. (1 kg) for remote