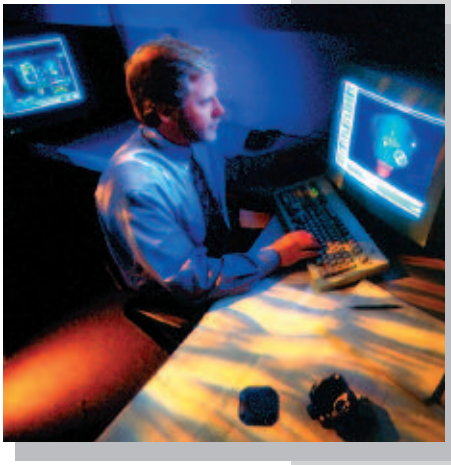
KOTRON® RF CAPACITANCE

Magnetrol®

Worldwide Level and Flow Solutions℠



CAD & 3-D Modeling improve productivity in both the design and production functions at Magnetrol's USA facility. Level and flow control products are also engineered and manufactured in Zele, Belgium.

Magnetrol International, a world leader in level and flow technology, designs, develops, manufactures, markets, and services level and flow controls worldwide.

Magnetrol's product groups are based upon these technologies:

- Air Sonar
- Buoyancy
- Contact Ultrasound
- Non-Contact Ultrasound
- Guided Wave Radar
- Pulse Burst Radar
- RF Capacitance
- Thermal Dispersion
- Vibration
- Visual Indicators

The industries we serve include:

- Petroleum Production
- Petroleum Refining
- Power Generation
- Petrochemical
- Chemical
- Water & Wastewater
- Pulp & Paper
- Food & Beverage
- Pharmaceutical

C O N T E N T S

TECHNICAL DATA

Introducing KOTRON RF CAPACITANCE

Magnetrol's RF Capacitance products discussed in the pages ahead include Kotron Point Sensors for alarm and control functions and Kotron Transmitters for continuous level measurement. As an introduction, this chart summarizes the characteristics of each Kotron product.

	Tip-Sensitive Switch	80/81 Single Point Switch	810 Point Switch	811 Point Switch	Sentinel Multi-point Switch	82CE Two-Wire Transmitter	Model 801 Transmitter	Model 804 Transmitter	Model 805 Smart Transmitter
Page Number	**8**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Single Point	●	●	●	●	●				
Multi-Point					●				
Transmitter						●	●	●	●
Controller							●	●	
Volume							●		
Open Channel Flow							●		
Integral Mount	●	●	●	●	●	●		●	●
Remote Mount		●		●	●	●	●	●	
Self Diagnostics					●		●	●	●
4–20 mA Output						●	●	●	●
Display					**LED**	**ALG**	**LCD**	**LCD**	**LCD**

LEGEND

ALG Analog **LCD** LCD Display **LED** 4-Digit LED

RF Capacitance: An Overview

After more than four decades of proven reliability and versatility, RF Capacitance technology has become a standard worldwide.

Principle of Operation

RF Capacitance-based level measurement is founded on a time-proven method which requires no moving parts. The operation of an RF Capacitance level control is based on a basic electronic component—the capacitor. Capacitance is a measure of the amount of energy a capacitor can store. It is important to note that RF Capacitance level controls do not store energy in the probe; instead, they measure the amount of energy that can be stored. The unit of measurement for capacitance is the farad (named after Michael Faraday). In RF Capacitance level measurement, we are dealing with very small amounts of capacitance, typically measured in picofarads (1×10^{-12} farads).

A capacitor consists of two conductive plates separated by an insulator as shown in Figure 1 below.

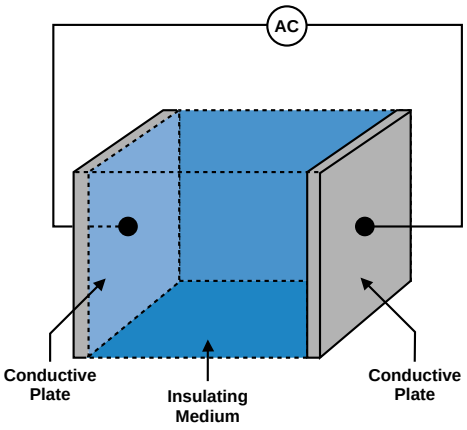


Figure 1

There are three factors that affect the amount of capacitance in a capacitor:

1. **The area of the plates**–Larger plates have more area to store energy.

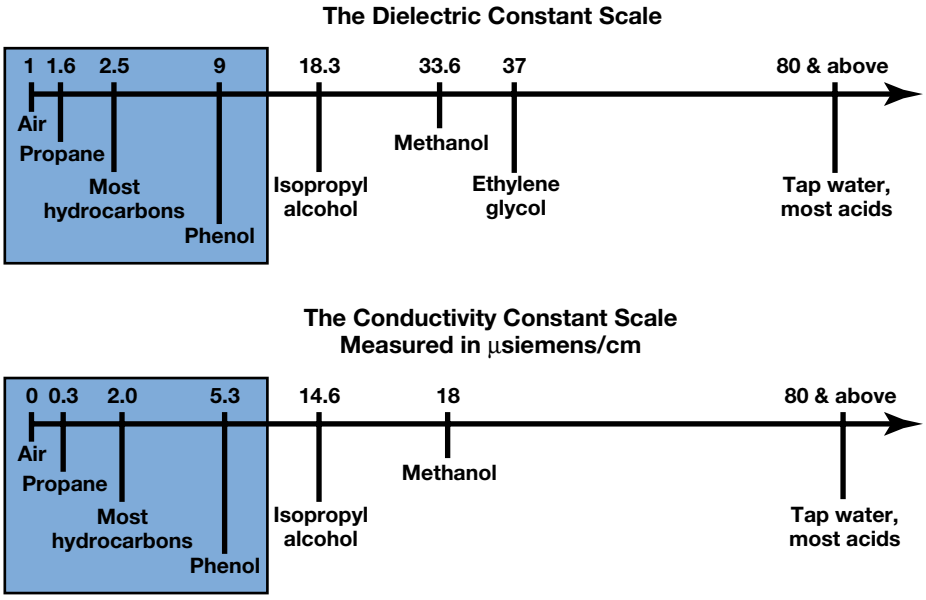


Figure 2

2. **The distance between the plates –** A small distance between the plates will cause more "charge" attraction than a greater distance.
3. **The dielectric constant of the media between the plates –** A higher dielectric constant will allow more energy to be stored.

The dielectric is where the actual capacitance is developed. The dielectric constant is a scale used to indicate how well a given material will allow capacitance to be developed. The scale uses vacuum as the reference. Figure 2 above shows the dielectric constant relationship between different materials.

The other term frequently used is conductivity. We categorize materials as either conductive or non-conductive. Basically, any media with a dielectric less than 10 or a conductivity less than 10 µsiemens/cm is considered to be non-conductive. Any media with a value of 10 or greater is considered to be conductive. You'll also notice that the relationships are similar; non-conductive materials generally have low dielectric constants, and conductive materials generally have higher constants.

Non-Conductive Media

In an actual level application, the form of the capacitor changes, as shown in Figure 3 below.

In this case, one plate is the probe and the other plate is the tank wall. The probe and the tank size are fixed; therefore, the plate area does not change. The distance between the probe and the tank wall is also fixed. The only variable is the dielectric constant (K). Air has a dielectric constant of one (K = 1). Any other media has a dielectric value greater than one.

Initially, when the tank is empty, K = 1 (air). As the media level rises, the dielectric of the media replaces the air, causing the capacitance to increase. This increase in capacitance is linear with the level increase. A switch is calibrated to trip at a specific capacitance value, equal to the set point level desired.

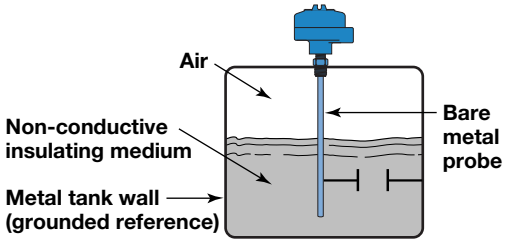


Figure 3

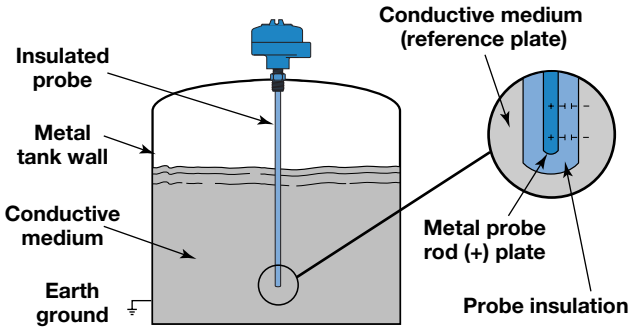


Figure 4

A transmitter provides a linear output proportional to the capacitance measured. This system works perfectly in non-conductive, low dielectric media. What about a conductive, high dielectric media?

Conductive Media

To have a capacitor, the media between the plates must be an insulator. A conductive media between the plates will result in an electrical "short". The solution is to put an insulator around the probe, such as Teflon®, Kynar®, or Halar® as shown in Figure 4 above. The conductive media creates an electrical connection between the tank wall and probe insulation. As the level rises, our capacitor is formed by the probe rod (metal), the media, which act as the plates, and the probe insulation, which is the dielectric. Like the non-conductive application, the distance between the plates and the plate size is fixed. However, instead of measuring the dielectric of the media, we are measuring the dielectric of the probe insulation which is covered by the media.

Application Flexibility

Since your tank and process media are actual components of an RF Capacitance level system, RF level technology precisely fits your application. The goal is to match the right electronics with the right probe.

Choosing The Right Electronics

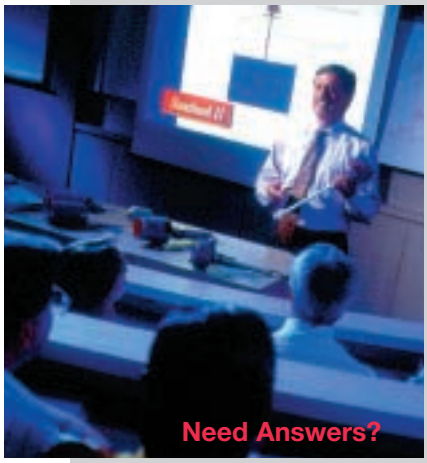
Magnetrol's offering of point sensors ranges from simple, inexpensive single-point devices to microprocessor-based multipoint devices. Continuous transmitters range from two-wire transmitters that supply 4–20 mA output to micro-based devices that can supply 4–20 mA and digital communications. There are also full-featured devices that can supply control and measurement, and can combine level, volume, open channel flow, calculated outputs, data logging, output linearization, and multi-probe inputs in one device.

Choosing The Right Probe

Probe selection is the most critical part of applying an RF Capacitance device for a given application. The goal is to select the probe that will give the maximum capacitance change per unit level change (pF/inch). The following are some general guidelines to utilize when selecting a probe for a given application:

- Use bare probes for non-conductive fluids.
- Use insulated probes for conductive fluids.
- Use a probe with an integral ground reference when measuring non-conductive fluids in horizontal tanks, or when measuring any fluid in non-metallic tanks.
- Use a flexible (cable) probe when the measurement range is greater than 10 feet. Rigid (rod) probes are available in longer lengths, but they can be difficult to handle .

There are hundreds of probe styles, and each has specific uses in a given application. How do you ensure that the correct probe is selected for a given application? The answer is simple: Your Magnetrol sales representative has the applications expertise necessary to help you select the most cost-effective unit for your needs.



Your Magnetrol representative is ready to answer your questions on how capacitance-based level technology can improve your process. Backed by Product Managers who serve as technology specialists, your representative has the skill and support to help you select the right system the *first* time.

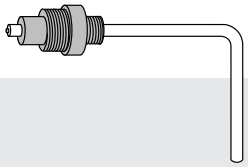
You'll get the most current information, too, because your representative is continuously trained in technology, product knowledge, and customer applications at Magnetrol's Technical Training Center pictured above. Have an applications question? Your answer, as always, is just a phone call away.

Choosing The Right Probe

Selecting the correct probe is the most important part of the unit selection process. Probe length and diameter are important first considerations. Probes shorter than 20 feet (6 m) are usually rigid, while probes longer than 20 feet are flexible.

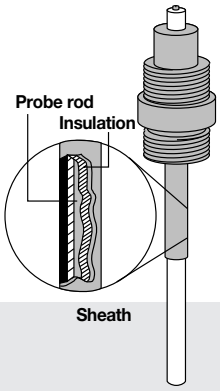
KOTRON Specialty Probes

A variety of specialized probes are available for difficult or special-use applications. These probes are available for use with most Kotron electronics.



Bent Probe

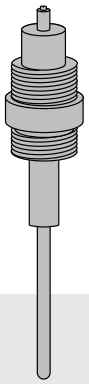
Bent rod probes have a variety of uses. They can provide vertical configurations when only side mounting is available. They can also provide horizontal configurations when only top mounting is available. When top mounted, the horizontal section of the probe can be used to create an extremely stable setpoint by developing a very large capacitance change with a small level change.



Inactive Sheath

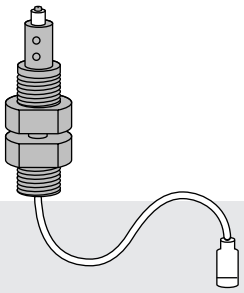
An inactive sheath is a tube that is tightly coupled to the insulation on the probe rod and attached to the mounting nut. The sheath "deadens" the portion of the probe covered. It is used when a false capacitance could be developed by interference, such as:

- Probe penetration through thick tank insulation.
- Collection of debris in a nozzle when probe is horizontally mounted.
- Falling process media entering the tank.



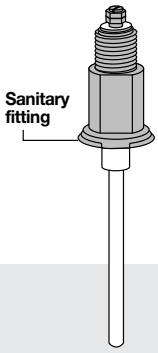
HTHP Probe

High Temperature, High-Pressure probes are bare probes made of 316 stainless steel that use a ceramic seal to allow for higher process temperatures. Temperatures up to 1000° F and pressures up to 5000 PSIG are typical.



Flexible Probe

Flexible probes are typically for measurement ranges of 10 to 150 feet. Rigid probes longer than 10 feet are difficult to ship and unwieldy to install.

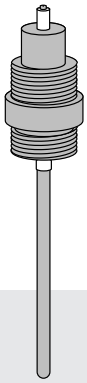


Sanitary Probe

Sanitary probes consist of Teflon insulated probes with a tri-clover process connection. They have been certified by 3A.

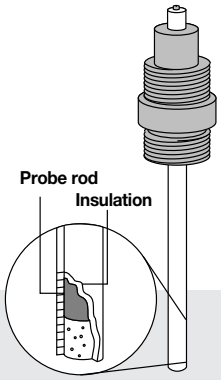
KOTRON Rigid Probes

Rigid probes consist of a mounting nut (process connection) and a probe rod. The rod may take many forms, which depends upon the application.



Bare Probes

Bare rod probes are typically used in non-conductive process media with a dielectric value less than 10 or a conductivity value less than 10 µsiemens/cm. Capacitance is measured from the probe through the process media to the vessel wall.

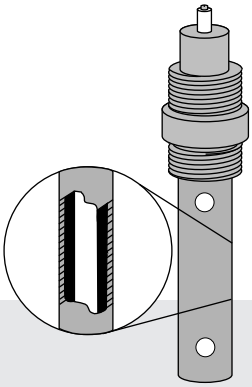


Insulated Probes

Insulated probes are used in conductive process media with a dielectric value greater than 10 or a conductivity value greater than 10 µsiemens/cm. Capacitance is measured from the probe rod through the insulation to the process media, which is at the same potential as the tank wall for conductive media. Probes are insulated with inert thermoplastics. When uncertain about the dielectric constant of your process media, insulated probes are a wise choice.

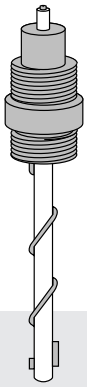
KOTRON Reference Probes

This probe classification covers those that can supply the "second plate of the capacitor" in nonmetallic tanks, or linearize an existing reference (i.e., horizontal cylindrical tanks).



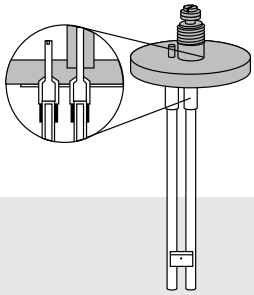
Stillwell

A stillwell is a metallic tube, or pipe, into which a probe is inserted concentrically. It can be used to minimize the effect of turbulence in a vessel and increases the capacitance gain by bringing the ground reference closer to the probe.



Reference Wire

A reference wire is spirally wrapped around an insulated probe to provide a "ground" reference where none exists. It must be used selectively: clean, conductive, and low viscosity processes only.



Reference Rod

A reference rod is mounted parallel with the sensing probe. It is typically used with corrosive process media in nonmetallic tanks where no metal can be introduced to the process.

KOTRON Tip Sensitive Switch

Economical point level control

General Description: The Kotron Tip Sensitive Level Switch is an economical solution to your point level control needs. Its compact size and ease of installation makes set-up quick and easy. The unit consists of an electronic module contained in a NEMA 4X/7/9 enclosure, integral-mounted with a 14" 316 stainless steel probe. The “tip sensitive” name refers to the fact that in conductive fluids, as soon as the media touches any portion of the probe rod, the relay will change state. For conductive fluids, we recommend a minimum 4" probe immersion at the level of the set point.

Applications: Suitable for virtually all non-coating fluids and thin slurries.

Features:

- Probe length can be field modified from 14" to a minimum of 4" for non-conductive fluids, or 2" for conductive fluids.
- Field selectable fail-safe setting.

Model Selection: Refer to Magnetrol Sales Bulletin 50-136 for model numbers and technical information.

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KOTRON Models 80/81 Point Switches

For alarm and control applications

General Description: The Kotron 80/81 series offers an economical switch for alarm or level control. The switch is available with either integral or remote mounting with distances up to 5000 feet (1500 meters).

Applications: Level alarm or level control of liquids and slurries including high pressure/high temperature applications.

Features:

- Usable with all Kotron probes (except guarded) for maximum application flexibility.
- NEMA 4X and explosion proof designs
- Proven, reliable operation

Model Selection: For the Models 80/81 refer to Magnetrol Sales Bulletin 50-135 for model numbers and technical information.
Refer to Sales Bulletin 50-125 for technical information concerning the probes.

FM APPROVED

KOTRON 810 Point Switch

Dependable solution for coatable fluids

General Description: The Model 810 is an economical point level switch that incorporates advanced Guard circuitry to defeat the effects of conductive coating buildup. The Guard prevents the coating from completing the circuit thereby eliminating the cause of false alarms. Only the actual product level will cause the switch to change state. The Model 810 consists of an electronic module contained in a compact NEMA 4X/7/9 enclosure, integral-mounted with a 316 stainless steel/Ryton Guard style probe in either 18" or 36" lengths.

Applications: The Model 810 is suitable for virtually all liquids and slurries, including clean and dirty liquids, viscous slurries, and high pressure fluids. The media must be compatible with 316 stainless steel and Ryton.

Features:

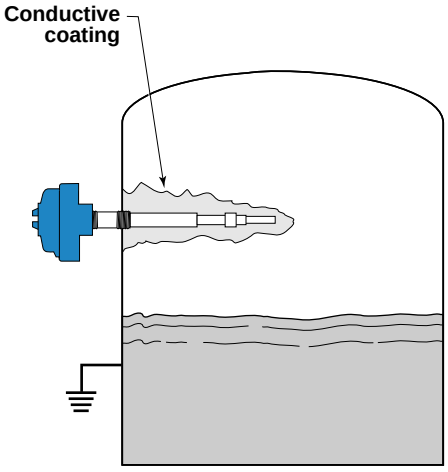
- Sensitive and stable electronics detect even the most non-conductive hydrocarbons.
- Intrinsically Safe probe circuitry allows safe use in hazardous areas.
- Field selectable fail-safe setting.
- Built-in 0 to 45-second time delay eliminates relay “chatter” due to turbulence.

Model Selection: Refer to Magnetrol Sales Bulletin 50-102 for model numbers and technical information.

SPECIFICATIONS

FM APPROVED

Supply Voltage:		120 Vac • 240 Vac • 24 Vdc • 12 Vdc
Output (Relay)	AC	5 amp SPDT
	DC	5 amp SPDT
Set Point Range:		0 to 500 pF
Differential:		0.5 pF
Ambient Temperature Range:		
	Electronics	-40° to +160° F (-40° to +70° C)
Operating Temperature Range:		-40° to +200° F (-40° to +120° C)
Operating Pressure Range:		Vacuum to 3500 PSIG



The probe’s ACTIVE and GUARD sections operate at the same potential, thereby eliminating the path from the active section to ground at the tank wall. The unit therefore shows no alarm condition.

KOTRON Model 811 Point Switch

For alarm and control applications

General Description: The Kotron 811 is a versatile solution for alarm and control applications. Units are available in integral or remote mounting configurations and can be used for either alarm or wide differential control applications (i.e. pump control). When used with the Guard-style probe in alarm applications, the 811 ignores conductive coatings.

Applications: Suitable for virtually all liquids and slurries, including clean and dirty liquids, viscous slurries, and high temperature/pressure fluids.

Features:

- Alarm (narrow differential) and control (wide differential) capabilities.
- Usable with all Kotron probes for maximum application flexibility.
- Model 811 Intrinsically Safe probe circuitry allows safe use in hazardous media.
- Remote mounting, ensures protection of the electronics from high temperature and/or vibration.

Model Selection: For the Model 811 refer to Sales Bulletin 50-103 for model numbers and technical information.
Refer to Sales Bulletin 50-125 for technical information concerning the probes.

SPECIFICATIONS

Supply Voltage:		120 Vac • 240 Vac • 24 Vdc • 12 Vdc
Output (Relay):	AC	10 amp DPDT
	DC	5 amp DPDT
Set Point Range:		0 to 1000 pF
Differential:	Fixed	0.5 pF
	Adjustable	0.5 to 700 pF
Remote Mounting Distance		150 feet
Ambient Temperature Range:	Electronics	-40° to +160° F (-40° to +70° C)
Operating Temperature Range:		-100° to 1000° F (-73° to +540° C)
Operating Pressure Range:		Vacuum to 5000 PSIG (probe dependent)

KOTRON Sentinel Multipoint Switch

Multi-relay combinations

General Description: The Kotron Sentinel series of multipoint switches offers you unparalleled control over your process. Each model features MagneCal Software Calibration that requires only a 2% change of level for setup, and includes advanced diagnostics that actually test the condition of the probe, as well as the electronics. The unit also provides multiple relay combinations.

Applications: Sentinel Switches are suitable for virtually all liquids and slurries, including clean and dirty liquids, viscous slurries, and high temperature/pressure fluids.

Features:

- Available with 2, 3, or 4-relay outputs configurable for either narrow (alarm) or wide (pump control) differential.
- MagneCal calibration requiring only a 2% change in level for full-system calibration.
- Lead/Lag pump control functions are standard in the 3 and 4-relay versions.
- Optional Intrinsically Safe probe circuitry with on-board barriers, allows for maximum safety in hazardous areas.

Model Selection: Refer to Magnetrol Sales Bulletin 50-104 for model numbers and technical information. Refer to Bulletin 50-125 for technical information concerning the probes.

SPECIFICATIONS

FM APPROVED

Supply Voltage:		120 Vac • 240 Vac • 24 Vdc
Ambient Temperature Range:		-40° to +160° F (-40° to +70° C)
Accuracy:		Better than 1.0%
Operator Interface:	Data Entry	3-button keypad
	Display	4-digit LED display
Discrete Output:	Set Point Range	0 to 50,000 pF
	Time Delay	0 to 90 seconds, Level rising, falling or both
Relay Ratings:	AC/DC	10 amp SPDT
Max Remote Cable Length:		Standard: 2,500 feet (760 meters); Intrinsically Safe: 800 feet (240 meters)

KOTRON 82CE Two-Wire Transmitter

Economical level measurement

General Description: The Kotron Model 82CE Two-Wire Level Transmitter is a cost-effective solution for reliable level measurement. The basic unit consists of a loop-powered transmitter in a NEMA 4X/7/9 enclosure integral-mounted with the probe. Options include:120/240 Vac power supply, remote-mounting, and a display.

Applications: Suitable for virtually all non-coating fluids and thin slurries.

Features:

- 4–20 mA isolated output signal (20–4 mA optional).
- FM, CSA, and CENELEC approved models (Intrinsically Safe when used with approved barrier).
- Potted, surface mount electronics module protects unit from moisture and corrosive atmospheres.
- Product meets all CE requirements for RFI/EMI.

Model Selection: Refer to Magnetrol Sales Bulletin 50-123 for model numbers and more detailed technical information.
Refer to Bulletin 50-125 for technical information concerning the probes.

SPECIFICATIONS

FM APPROVED

Supply Voltage: 14 to 40 Vdc
120/240 Vac (4-wire models)

Ambient Temperature Range: -40° to +160° F (-40° to +70° C)

Repeatability: Better than ±1.0%

Linearity: ±1.0%

Operator Interface: Dipswitch/Potentiometer

Continuous Output: 4–20 mA

Max Remote Cable Length: Standard: 20 feet (6 meters)
Optional: 40 feet (12 meters)

KOTRON 801 Transmitter

Two measurements in one transmitter

General Description: The Kotron Model 801 Transmitter has features to meet all of your level measurement needs. It has the capabilities to measure the level in virtually any process and provide a 4–20 mA signal proportional to level or volume, provide control of your process via the four control relays, and communicate digitally via RS-485. The dual channel version allows you to monitor the level or volume of two different vessels, simultaneously. Finally, the Model 801 can provide Open Channel Flow Measurement.

Applications: Virtually all liquids and slurries, including clean and dirty liquids, viscous slurries, and high temperature/pressure fluids.

Features:

- Capable of receiving input from two different vessels (displayed separately, combined or subtracted).
- Level/Volume and Level/Flow characterization is available for all standard shape vessels and flumes/weirs.

Model Selection: Refer to Magnetrol Sales Bulletin 50-105 for model numbers and technical information.
Refer to Bulletin 50-125 for technical information concerning the probes.

SPECIFICATIONS

FM APPROVED

Supply Voltage:		120 Vac • 240 Vac • 24 Vdc
Ambient Temperature Range:		-40° to +160° F (-40° to +70° C)
Accuracy:		Better than 1.0%
Repeatability:		±0.01%
Linearity:		±0.5 %
Operator Interface:	Data Entry	16-button keypad
	Display	16-character LCD display
Continuous Output:	Active	4–20 mA (isolated), reversible, maximum 1000 Ohms loop resistance
	Range	0.5 pF minimum, 50,000 pF maximum
Relay Ratings:	AC	10 amp SPDT
	DC	10 amp SPDT
Max Remote Cable Length:		Standard: 2,500 feet (760 meters); Intrinsically Safe: 800 feet (240 meters)

KOTRON Model 804 Transmitter

Superior flexibility, superior performance

General Description: The Kotron Model 804 Transmitter is a powerful level transmitter/controller. It consists of an electronic module that can provide 4–20mA, RS-485 (Modbus), and up to four discrete outputs in one compact package. All calibration and setup parameters are entered locally via a 16-button keypad, with a user-friendly interface and a 2-line by 16-character LCD display.

Applications: The Model 804 is suitable for virtually all liquids and slurries, including clean and dirty liquids, viscous slurries, and high temperature/pressure fluids.

Features:

- 4–20 mA output with active/passive mode selection.
- 2 or 4 control relays, configurable for narrow (alarm) differential or wide (pump control) differential.
- Lead/Lag pump control functions are standard in all relay versions.
- Optional Intrinsically Safe probe circuitry with on-board barriers maximizes safety in hazardous zones.

Model Selection: Refer to Magnetrol Sales Bulletin 50-118 for model numbers and technical information. Refer to Bulletin 50-125 for technical information concerning the probes.

SPECIFICATIONS

FM APPROVED

Supply Voltage:		120 Vac • 240 Vac • 24 Vdc
Ambient Temperature Range:		-40° to +160° F (-40° to +70° C)
Accuracy:		Better than 1.0%
Operator Interface:	Data Entry	16-button keypad
	Display	2-line x 16-character LCD display
Continuous Output:		4–20 mA (isolated), active or passive
	RS-485	Modbus®
	Range	0.5 pF minimum, 50,000 pF maximum
Relay Ratings:	AC/DC	10 amp SPDT
Max Remote Cable Length:		Standard: 2,500 feet (760 meters); Intrinsically Safe: 800 feet (240 meters)

KOTRON Model 805 Transmitter

High performance, loop-powered transmitter

General Description: The Kotron Model 805 Smart Transmitter is a loop-powered, 24 Vdc, liquid-level transmitter encompassing a number of significant engineering accomplishments. This high-performance RF level transmitter is designed to provide reliable measurement performance well beyond that of many competitive units.

Applications: Virtually all liquids and slurries; hydrocarbons to water-based media (dielectric 1.5–100); and process conditions exhibiting visible vapors, surface agitation, bubbling, high fill/empty rates, and low product level.

Features:

- Two-wire, 24 Vdc, loop-powered level transmitter.
- Optional HART® digital communications.
- Optional two-line, 8-character LCD with keypad.
- Intrinsically safe and non-incendive approvals.

Model Selection: Refer to Magnetrol Sales Bulletin 50-160 for model numbers and technical information. Refer to Bulletin 50-125 for technical information concerning the probes.

SPECIFICATIONS

Supply Voltage:		24 Vdc
Ambient Temperature Range:		-40° to +175° F (-40° to +80° C)
Accuracy:		±0.50% of span or 0.1"
Diagnostic Alarm:		Selectable 3.6 mA, 22 mA, HOLD
Operator Interface:	Data Entry	3-button keypad and/or HART communicator
	Display	2-line x 8-character LCD display
Continuous Output:		4–20 mA or 4-20 mA with HART (optional)
	Range	0.5 pF minimum, 10,000 pF maximum
Response Time:		< 1 second (adjustable via damping)

Magnetrol®

Worldwide Level and Flow Solutions℠

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