



PULSE BURST RADAR



Magnetrol®

Worldwide Level and Flow Solutions™

The Total Spectrum of Solutions ►

Magnetrol's products employ a number of technologies to meet the challenges of level and flow control. Pulsar® and Model R82 Radar Transmitters utilize Pulse Burst Radar for accurate and reliable level control.



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Magnetrol International—a world leader in level and flow measurement technology—designs, manufactures, markets and services level and flow instrumentation worldwide.

Magnetrol's product groups are based upon these technologies:

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

The industries we serve include:

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

Liquid Level Sensing with Pulse Burst Radar



EVOLUTION. First developed during WWII, practical radar instrumentation has grown to include a myriad



of sensors and transmitters. Today, radar serves us in applications that range from the commonplace to the cosmic. Radar maps the topology of distant planets and pinpoints weather fronts on earth (doppler radar); it automati-

cally opens supermarket doors (continuous wave radar); and it cooks our meals with microwaves (cavity magnetron radar). Radar is presently the fastest growing measurement technology for industrial level control.

But radar's beginnings were less than auspicious. Early level instruments were costly, bulky, over-specialized and complicated. The development of simpler, less costly and easier-to-use devices would be made possible by solid state components and by a growing fund of applications knowledge.

TYPES. Radar level sensing devices detect the position of process liquids by measuring the interval between the emission and return of high frequency radio waves. Guided Wave Radar, used by Magnetrol's Eclipse® and Horizon™ transmitters, is a contact technology that launches its signal along a waveguide that runs directly into the process media. Pulse Burst Radar, utilized by Pulsar® and the Model R82, is a non-contact technology that launches its signal into open air along a trajectory directed toward the process media.

PULSE RADAR. Of the two operational technologies commonly used for radar, Magnetrol products employ a pulse burst approach rather than frequency modulated continuous wave (FMCW). Pulse Burst Radar operates in the time domain and does not require complex and expensive processing as needed to enable FMCW. Because echoes are discrete and separated in time, Pulse Burst Radar is better able to sort through extraneous echoes and

select the one generated by true level. Pulse Burst Radar also has excellent averaging characteristics, important in those applications where a return signal is attenuated by the factors described below.

Unlike true pulse devices that transmit a single, sharp (fast rise-time) waveform of wide-band energy, Magnetrol products emit short bursts of 5.8/6.3 GHz (Pulsar) or 26 GHz (Model R82) energy and measures the transit time of the signal reflected from the liquid surface. Distance is calculated utilizing the equation:

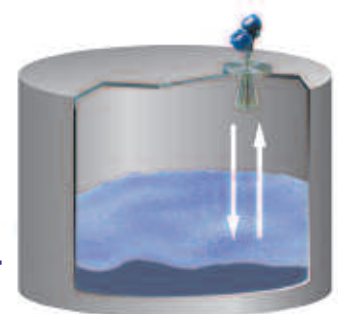
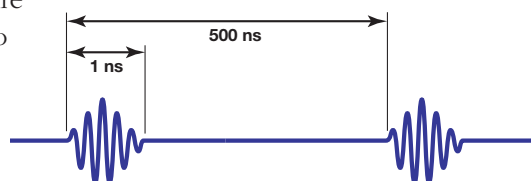
$$\text{Distance} = C \times \frac{\text{Transit time}}{2} \quad (C = \text{speed of light})$$

The Level value is then developed by factoring in Tank Height and Sensor Offset information. The exact reference point for distance and level calculations is the Sensor Reference Point—bottom of an NPT thread, top of a BSP thread, or face of a flange.

Equivalent Time Sampling (ETS) measures the high speed, low power electromagnetic energy (EM). ETS is critical in the application of radar to vessel level measurement. The high-speed EM energy is difficult to measure over short distances and at the resolution required in the process industry. ETS captures the EM signals in real time (nanoseconds) and reconstructs them in equivalent time (milliseconds), which is much easier to measure with today's technology.

ETS is accomplished by scanning the waveguide to collect thousands of samples. The round trip event on a 65 foot (20 meter) tank takes only 133 nanoseconds in real time. After it is reconstructed in equivalent time it measures 200 milliseconds.

THE THREE DS. Radar applications are influenced by three basic conditions: (1) the **Dielectric** of the process medium; (2) the **Distance**, or measuring range



of the application; and (3) a variety of **Disturbances** that attenuate or distort the radar signal.

The Distance, or measurement range, is a function of the instrument's frequency and selected antenna, the dielectric constant of the media, and the presence of signal interference. Disturbances caused by turbulence, foam, false targets (interior tank obstructions causing false echoes), multiple reflections (reflections from off the tank roof), or a high rate of level change, can weaken, scatter or multiply radar signals. Very high and very low liquid levels can also be problematic.

SIGNAL PROCESSING. Radar's signal processing function is critically important because radar exhibits interference effects similar to those that affect light. It is the quality of a device's signal processing that separates today's leading-edge radar transmitters from the others.

Most disturbances mentioned above can be readily managed by Pulsar and Model R82 signal processing capabilities where true level can be extracted from false targets and other background noise. Using extremely energy-efficient circuits, no duty cycling is necessary to accomplish effective measurement. For this reason, Magnetrol's Pulse Burst Radar products can also track high rates of change that have been impossible with other loop-powered radar transmitters. Although these products feature powerful False Target Recognition and Rejection routines, minimizing false target reflections is significantly affected by proper installation and orientation.

ANTENNAS. The transmitter's antenna transmits and receives the radar signal. Pulsar offers dielectric rod and horn types while the Model R82 uses an encapsulated horn antenna. Maximum measuring range of the instruments is chiefly dependent upon the instrument's capabilities, dielectric constants, and the degree of turbulence. Dielectric constant, temperature, and pressure capabilities for our radar products are shown on page 6.

INSTALLATION. A Quick Start installation procedure provides the key steps for mounting, wiring and configuring Magnetrol transmitters. Though transmitters come configured from the factory, they can be reconfigured in the shop. Bench configuration provides a convenient and efficient way to set up the transmitter before going to the tank site to complete the installation. The transmitter is password protected to protect configuration values.

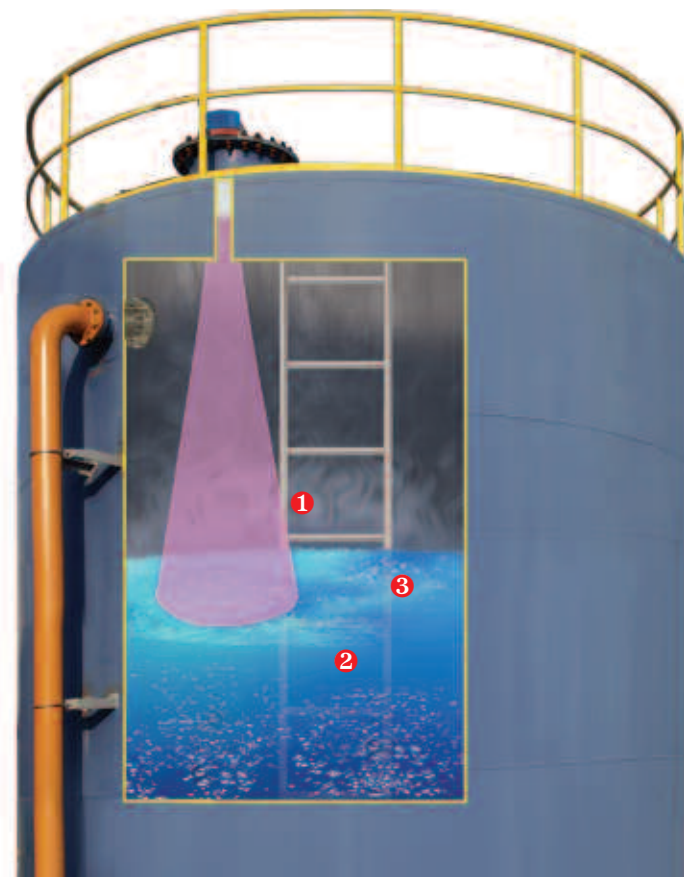
A HART® remote unit, such as a HART communicator, can be used to provide a communication link to the Pulsar and R82 transmitters. When connected to the control loop, the measurement readings shown on the transmitter will be shown on the communicator. The

communicator can also be used to configure and troubleshoot the transmitter. See page 11 for information on PACTware, today's leading configuration and diagnostics software.

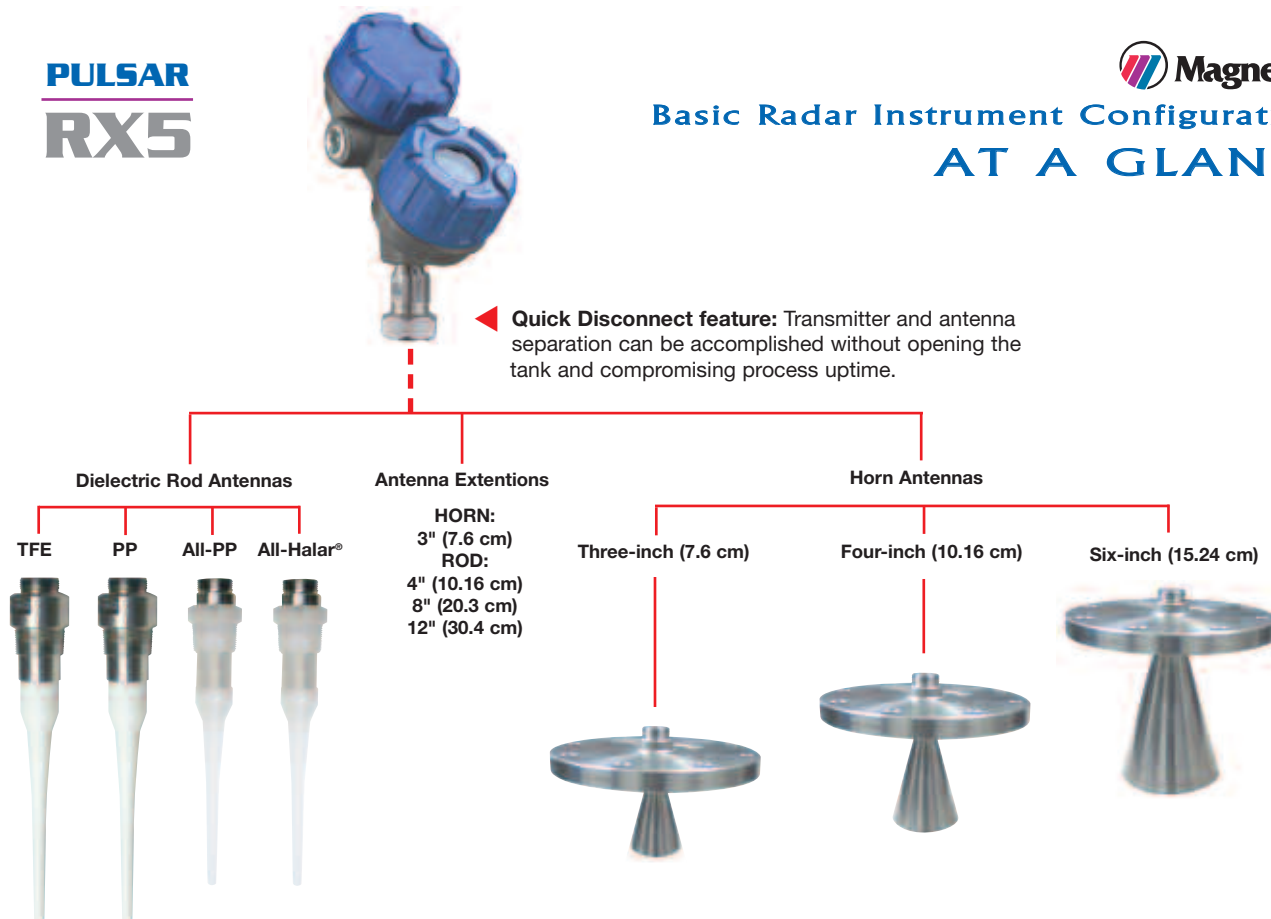
BENEFITS. Magnetrol Radar products are engineered to measure a large number of liquid media in a broad range of process conditions, from calm product surfaces and water-based media to turbulent surfaces and aggressive hydrocarbon media. As a non-contact device, these products are not susceptible to the complications that arise whenever a probe contacts the process media, such as coating by viscous media or corrosive attack due to aggressive chemicals. The greater the measuring range, the more does radar prove itself to be the economical solution, given the cost of extended probe lengths.

Radar is virtually unaffected by the presence of vapors, or air movement within a vessel's free space. Changes in specific gravity, conductivity and dielectric constants also have no effect on measurement accuracy. As a 100% electronic instrument, the absence of moving parts translates into low maintenance costs. As a two-wire, loop-powered device, power requirements and installation are greatly simplified. ■

Pulse Burst Radar technology and advanced signal processing help manage common disturbances: ❶ False echoes caused by obstructions, or multi-path reflections caused by waves hitting a sidewall; ❷ Turbulence generated by agitators or aggressive chemical reactions; and ❸ A layer of light to medium density foam.



Basic Radar Instrument Configurations AT A GLANCE



Minimum Dielectric:

2.0 ϵ_r

Maximum Pressure:

675 psig | 750 psig | 200 psig | 50 psig
46.5 bar | 51.7 bar | 14 bar | 3.5 bar

Maximum Temperature:

+400° F | +200° F | +200° F | +300° F
+204° C | +93° C | +93° C | +150° C

Minimum Dielectric:

1.7 ϵ_r

Maximum Pressure:

675 psig
46.5 bar

Maximum Temperature:

+400° F
+204° C

MODEL R82

Model R82 shown with a cast aluminum housing and a 2" (50 mm) and 8" (200 mm) Tefzel® antenna



Minimum Dielectric:

1.7 ϵ_r

Maximum Pressure:

200 psig
14 bar

Maximum Temperature:

+200° F
+93° C

Model R82 shown with a Lexan housing and a 2" (50 mm) and 8" (200 mm) polypropylene antenna



Minimum Dielectric:

1.7 ϵ_r

Maximum Pressure:

200 psig
14 bar

Maximum Temperature:

+200° F
+93° C



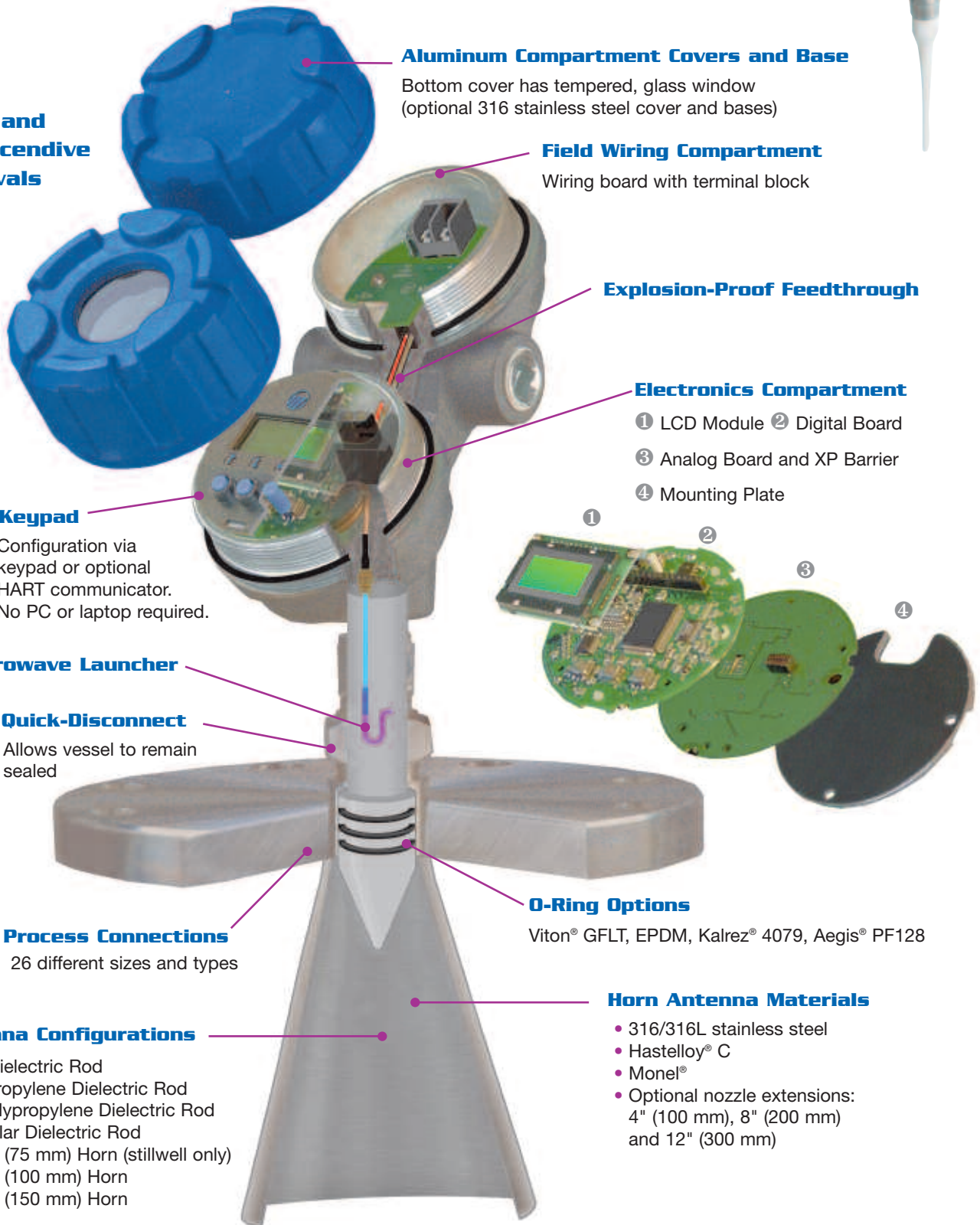
Anatomy of a Pulsar Transmitter and Sensor

Pulsar's dual enclosures orient wiring and electronics on the same plane for convenient wiring, configuration and

display. The display features a two-line, eight-character LCD. A three-button keypad provides the user interface.



IS, XP and Non-Incendive Approvals



SYSTEM DESIGN

Measurement Principle Pulse Burst Radar @ 5.8 GHz (Europe), 6.3 GHz (U.S.)

INPUT

Measured Variable Level, determined by the time-of-flight of a radar pulse from the transmitter to the product surface and back

Zero and Span 0.5 to 65 feet (0.2 to 20 meters)

OUTPUT

Type Analog: 4–20 mA or 4–20 mA with optional HART digital signal

Range Analog: 3.8 to 20.5 mA useable; Digital: 0 to 999" (0 to 999 cm)

Resolution Analog: 0.01 mA; Digital: 0.1"

Loop Resistance GP/IS/XP 350 Ω @ 24 VDC/22 mA; 400 Ω @ 24 VDC/20 mA

Diagnostic Alarm Adjustable 3.6 mA, 22 mA, HOLD

Damping Adjustable 0–45

USER INTERFACE

Keypad Three-button, menu-driven data entry and system security

Indication Two-line $\times$ eight-character display

Digital Communication HART version 5 compatible (communicator sold separately)

POWER (Measured at instrument terminals)

GP: 16 to 36 VDC; **IS:** 16 to 28.6 VDC; **XP:** 16 to 36 VDC

HOUSING

Material Aluminum A356T6 (< 0.25% copper), 316 stainless steel (optional)

Cable Entry $\frac{3}{4}$ " NPT, M20

ANTENNAS

Type TFE, polypropylene or Halar dielectric rod / 3" 4" or 6" horn

Materials (wetted parts) Dielectric rod: TFE, polypropylene or Halar

Mounting nut: 316 SS (Hastelloy C, Monel, or All-Polypropylene optional)

Viton® O-rings (standard)

Horn: 316 stainless steel (Hastelloy C optional)

Insert: TFE

Viton O-rings (standard)

Process Connections Dielectric rods: 1 $\frac{1}{2}$ " NPT and BSP; ANSI or DIN flanges

Horns: 4" or 6" ANSI or DIN flanges

Maximum Process Temperature +400° F (+204° C)

Maximum Process Pressure 750 psi (51.7 bar)

Minimum Dielectric 2.0 dielectric rods / 1.7 horns

ENVIRONMENT

Operating Temperature Range -40° to +175° F (-40° to +80° C)

LCD Operating Temp. Range -5° to +160° F (-20° to +70° C)

Storage Temperature -50° to +175° F (-46° to +80° C)

Humidity 0–99%, non-condensing

Electromagnetic Compatibility Meets CE requirements EN 50081-2, EN 50082-2

PERFORMANCE (Reference: Reflection from ideal reflector at +70° F / +20° C)

Linearity ± 0.4 " or 0.1% of tank height

Measured Error ± 0.4 " or 0.1% of tank height

Resolution 0.1"

Repeatability ± 0.2 " or 0.05% of tank height

Warm-up Time 30 seconds

Ambient Temperature Effect Temperature effect 0.05% per 10° C

Process Dielectric Effect < 0.3 inch within selected range

Maximum Rate of Change 15 feet (4.5 meters) / minute

pulsar
PULSE BURST RADAR



HART
COMMUNICATION PROTOCOL



Pulsar transmitter with
a 6" horn antenna



Anatomy of a Model R82 Radar Transmitter and Sensor

The all-new R82 is a high-performance level transmitter whose low cost makes it ideal for everyday level applications. Its launcher orien-

tation and echo-rejection profiling are simplified for easy use. Its microwave beam is rotatable for optimized operation.

Model R82 with a cast aluminum housing and a Tefzel® antenna (below); and a Model 82 with a Lexan® housing and a polypropylene antenna (right).



The Model R82 is a loop-powered, 26 GHz, non-contact radar transmitter that performs liquid level and volume measurements in enclosed vessels. The R82 offers high-performance at an economical price point to reliably measure out to a 40 ft. (12 m) maximum range.

The Model R82 provides unsurpassed ease of configuration with either the menu-driven 4-pushbutton, 2-line x 16-character display, HART digital communications, or PACTware. This allows complete configuration via the local user interface, or remotely with the added capability of capturing echo waveforms, and viewing trend data, diagnostic conditions and all transmitter configuration parameters.



Housing Covers

TOP LEFT: Cast aluminum with a tempered glass window.
TOP RIGHT: Lexan plastic with a transparent cover.



Electronics Module

ABOVE: Module as positioned in compartment shows LCD and four-button keypad.



O-Ring

Aluminum Housing: Viton®
Lexan Housing: Buna-N

Housing Compartment

Shown in aluminum; available in Lexan. Contains field wiring compartment and electronics.

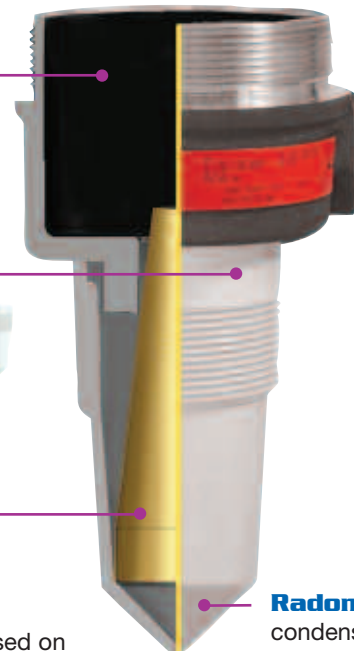


Radar Antenna

Shown in Tefzel; available in polypropylene. Available in two lengths.



Antenna horn is encapsulated within polypropylene or Tefzel.



Radome sheds condensation

Operating Principle The R82 is based on pulse-burst radar technology together with equivalent time sampling circuitry. Short bursts of 26 GHz microwave energy are emitted and subsequently reflected from the liquid level surface.



SYSTEM DESIGN

Measurement Principle Pulse Burst Radar @ 26 GHz

INPUT

Measured Variable Level, determined by the time-of-flight of a radar pulse from the transmitter to the product surface and back

Zero and Span 15" to 40 feet (0.4 to 12.2 m) as measured from threads

OUTPUT

Type Analog: 4–20 mA with optional HART digital signal

Range Analog: 3.8 to 20.5 mA useable (Namur NE43)
Digital: 0 to 999" (0 to 9999 cm)

Resolution Analog: 0.01 mA
Digital: 0.1"

Loop Resistance GP/IS/XP 400 Ω @ 24 VDC/20 mA; 350 Ω @ 24 VDC/22 mA

Diagnostic Alarm Adjustable 3.6 mA, 22 mA, HOLD

Damping Adjustable 0–45

Output at Antenna < 0.1 mW (avg), < 2 mW (max)

USER INTERFACE

Keypad Four-button, menu-driven data entry and system security

Indication Two-line $\times$ 16-character display

Digital Communication HART Version 5 compatible

POWER (Measured at instrument terminals)

General Purpose/Intrinsically Safe 16 to 36 VDC

HOUSING

Material Lexan base and cover or
Cast aluminum A356T6 (< 0.2% copper)

Cable Entry $\frac{3}{4}$ " NPT, M20

Ingress Protection Lexan Housing: NEMA 6P (IP67/68)
Aluminum Housing: NEMA 4X/6P (IP67/68)

ANTENNA

Encapsulated Horn: Polypropylene or Tefzel (optional)

Wetted Surfaces Polypropylene or Tefzel

Maximum Process Temperature -40 to +200° F (-40 to +93° C) @ atmos

Maximum Process Pressure Vacuum to 200 psig @ +70° F (-14.5 to 13.8 bar)

Minimum Dielectric 1.7 (application dependent)

Process Connections 2" NPT/BSP sanitary flanges

ENVIRONMENT

Operating Temperature Range -40° to +175° F (-40° to +80° C)

LCD Operating Temp. Range -5° to +160° F (-20° to +70° C)

Storage Temperature -50° to +175° F (-46° to +80° C)

Humidity 0-99%, non-condensing

Electromagnetic Meets CE requirements EN 50081-2, EN 50082-2

PERFORMANCE

Reference Conditions Reflection from ideal reflector at +70° F (+20° C)

Linearity ± 0.2 " (5 mm) or 0.05% of tank height (whichever is greater)

Measured Error ± 0.2 " (5 mm) or 0.05% of tank height (whichever is greater)

Resolution 0.1" (2.5 mm)

Repeatability ± 0.1 " (2.5 mm) or 0.025% of tank height

Warm-up Time 30 seconds

Ambient Temperature Effect 0.05% per 10° C

Process Dielectric Effect < 0.3 inch within selected range

Maximum Rate of Change 180 inches (450 cm) / minute

MODEL
R82



User Interface
of the Model R82

APPLICATION SUITABILITY

Suitability for some applications below may require optional materials or components

Compare key application parameters of the Pulsar RX5 and Model R82 transmitters

Transmitters are shown in correct relative size

RX5 Radar Transmitter



R82 Radar Transmitter



MEASUREMENT CAPABILITY	Level of Liquid or Slurry	Level or Volume of Liquid or Slurry
OPERATING FREQUENCY	5.8 GHz (Europe) / 6.3 GHz (USA)	26 GHz
VESSEL TYPES	Closed Metallic & Non-metallic Vessels	Closed Metallic, Non-metallic Vessels
STILLWELL	Steel Stillwells Only	2" Metal Stillwell Only
VOLUME	Not Applicable	Utilizes 20-point Table
RANGE 16" to 40 feet (12 m)	Suitable	Suitable
To 65 feet (19.8 m)	Suitable	Not Suitable
MAXIMUM ANTENNA TEMP	To +400° F (+204° C) @ atmos	To +200° F (+93° C) @ atmos
MAXIMUM ANTENNA PRESSURE	To 675 psig (46.5 bar)	To 200 psig (13.8 bar) @ +70° F
MINIMUM DIELECTRIC	1.7 with Horn Antennas	1.7
QUICK CONNECT/DISCONNECT	Yes	No
AGGRESSIVE CHEMICALS	Use All-PP or All-Halar Rod Antennas	Use Tefzel Antenna
FOAM, AGITATION, BUILDUP	Slightly Affected	Moderately Affected
REACTOR MEASUREMENT	Recommended	Marginally Recommended
HYGIENIC, CIP/SIP APPLICATIONS	Not Suitable	Suitable
SAFETY INTEGRITY LEVEL	SIL 1	SIL 1
HAZARDOUS APPROVALS	IS, XP and Non-Incendive	IS and Non-Incendive
TELECOMMUNICATION APPROVALS	FCC, IC, RTTE	FCC, IC, RTTE



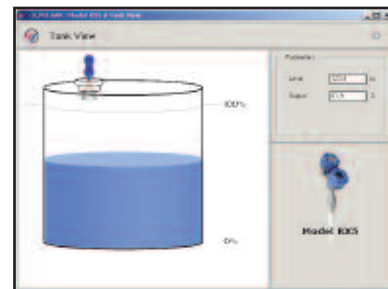
The Most Efficient PC Configuration Tool for Pulsar and Model R82 Transmitters

PACTware is the modern, user-friendly adjustment software that enables quick configuration and diagnostics of your radar transmitters. With your PC connected through a serial interface to the HART loop, all functionality can be managed remotely anywhere on the loop.



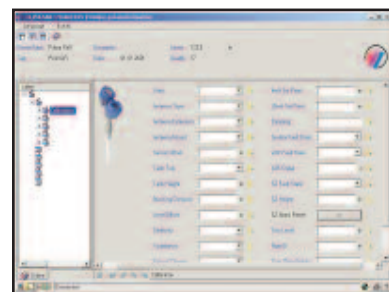
GET CONNECTED Simply connect the HART/RS232 or HART/USB serial interface from the PC to the two-wire loop.

Level Monitoring Screen Continuously viewing the level in a tank is the starting point for PACTware. The position of liquid level can be viewed in a simple visual format on your PC. Level and Output values are shown numerically as well. The screen can be left open to show the relative position of the liquid level.



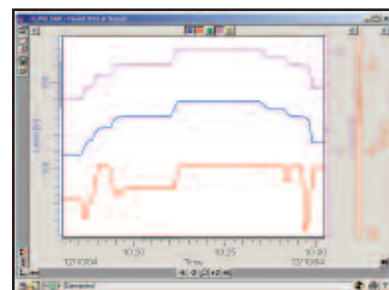
Level Monitoring Screen

Parameters Screen Every parameter in your radar transmitter can be monitored and modified remotely with a few clicks of the mouse. From units of measure to settings for dielectric, each parameter can be viewed or changed to suit application conditions. Parameters can be developed offline or transferred between transmitters.



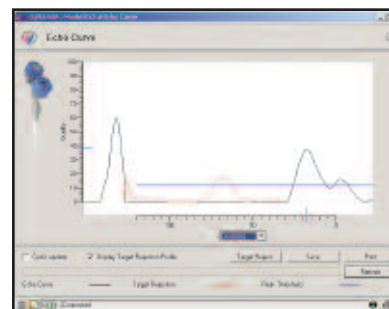
Parameters Screen

Trending Screen The ability to trend data over a period of time allows insight into overall operation of your radar. Trending values are invaluable when attempting advanced configuration or troubleshooting. PACTware PC software has the ability to track all parameters of your radar device and save them as a text or picture file.



Process Trend Screen

Echo Wave Form Screen This screen yields a wealth of useful information: Level (X-axis), Signal Quality (Y-axis), Actual Echo Curve (black line), False Target Profile (red line), and Minimum Threshold (blue line). Blue hash marks show the location and signal quality of the target currently detected as liquid level. False Target Rejection—a common issue among all non-contact, transit-time devices—can be accessed from this screen.



Echo Wave Form Screen



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Worldwide Level and Flow Solutions™

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