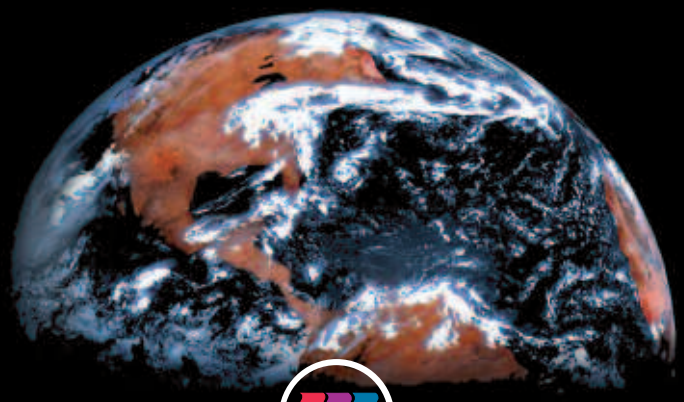

# PULSE BURST RADAR



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.

PULSAR RX5

MODEL R82

## CONTENTS



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 automatically 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:

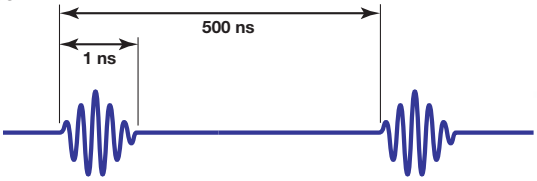
$$\text{Distance} = C \times \frac{\text{Transit time}}{2} \qquad (C = \text{speed of light})$$

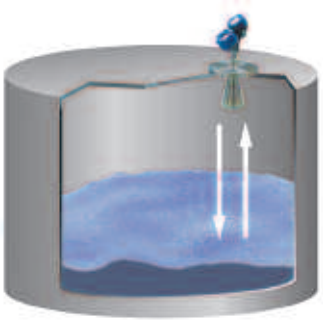
The Level value is then developed by factoring in Tank Height and Sensor Offset information. The exact reference point for distance and level calculations is the Sensor Reference Point—bottom of an NPT thread, top of a BSP thread, or face of a flange.

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.

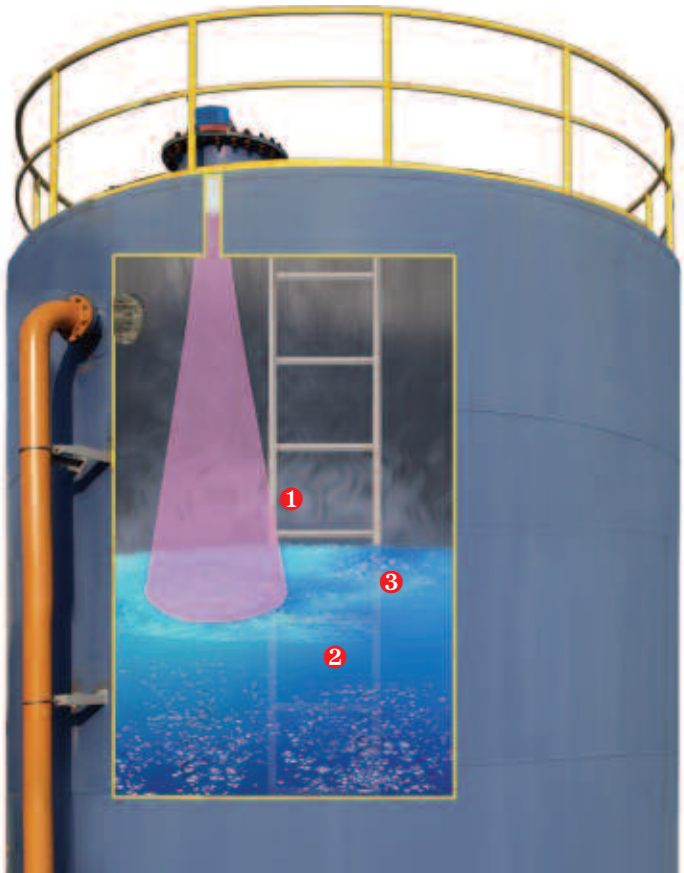
**INSTALLATION.** A Quick Start installation procedure provides the key steps for mounting, wiring and configuring Magnetrol transmitters. Though transmitters come configured from the factory, they can be reconfigured in the shop. Bench configuration provides a convenient and efficient way to set up 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.**



# PULSAR RX5

Magnetrol®

## Basic Radar Instrument Configurations AT A GLANCE

**Quick Disconnect feature:** Transmitter and antenna separation can be accomplished without opening the tank and compromising process uptime.

### Dielectric Rod Antennas

TFE | PP | All-PP | All-Halar®

**Minimum Dielectric:**

2.0 $\varepsilon_r$

**Maximum Pressure:**

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

**Maximum Temperature:**

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

### Antenna Extentions

HORN:
3" (7.6 cm)
ROD:
4" (10.16 cm)
8" (20.3 cm)
12" (30.4 cm)

### Horn Antennas

Three-inch (7.6 cm) | Four-inch (10.16 cm) | Six-inch (15.24 cm)

**Minimum Dielectric:**

1.7 $\varepsilon_r$

**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 $\varepsilon_r$

**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 $\varepsilon_r$

**Maximum Pressure:**

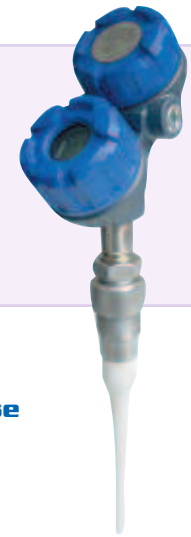
200 psig
14 bar

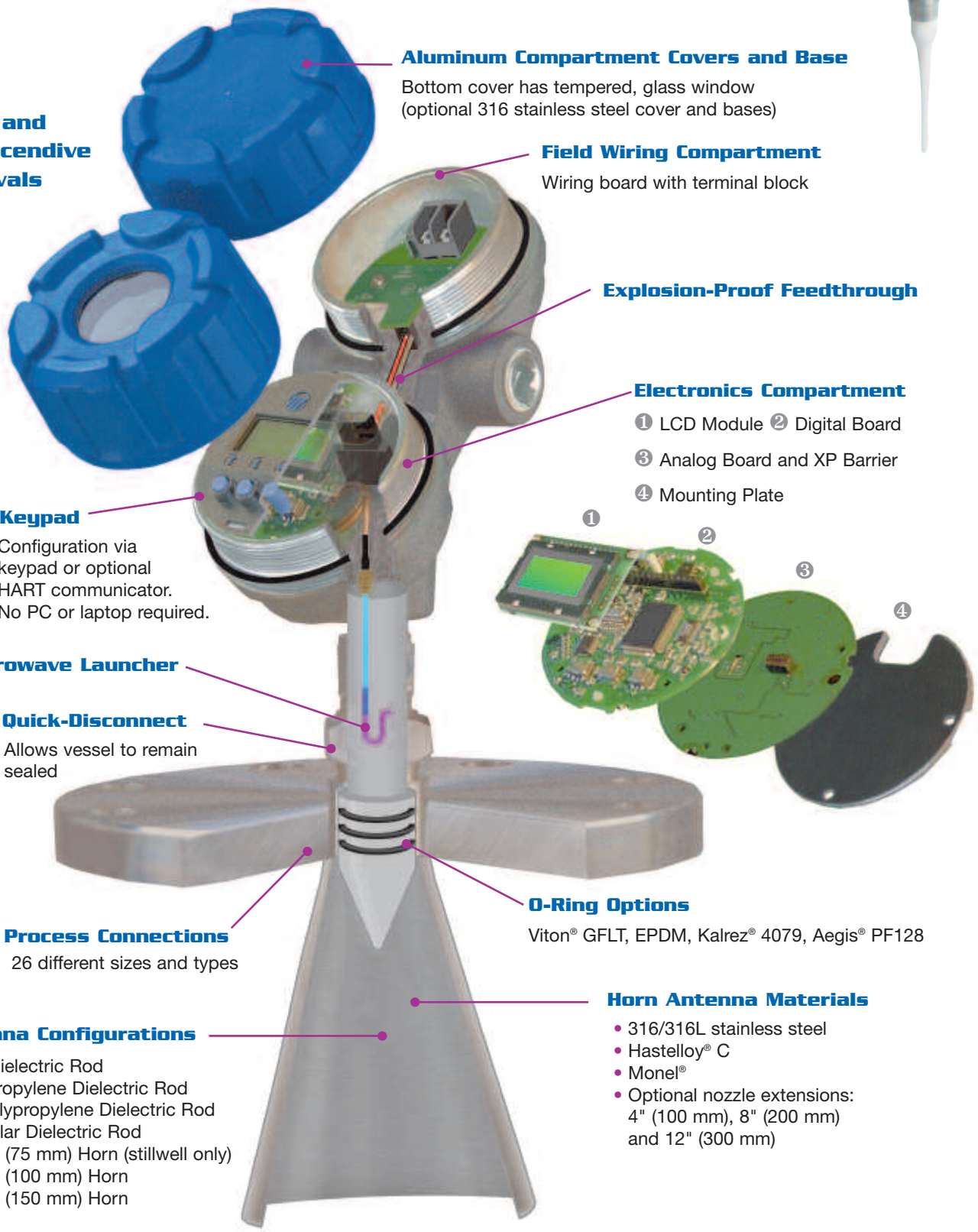
**Maximum Temperature:**

+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.





**Aluminum Compartment Covers and Base**

Bottom cover has tempered, glass window (optional 316 stainless steel cover and bases)

**IS, XP and Non-Incendive Approvals**

**Field Wiring Compartment**

Wiring board with terminal block

**Explosion-Proof Feedthrough**

**Electronics Compartment**

❶ LCD Module ❷ Digital Board

❸ Analog Board and XP Barrier

❹ Mounting Plate

**Keypad**

Configuration via keypad or optional HART communicator. No PC or laptop required.

**Microwave Launcher**

**Quick-Disconnect**

Allows vessel to remain sealed

**O-Ring Options**

Viton® GFLT, EPDM, Kalrez® 4079, Aegis® PF128

**Process Connections**

26 different sizes and types

**Horn Antenna Materials**

- 316/316L stainless steel
- Hastelloy® C
- Monel®
- Optional nozzle extensions: 4" (100 mm), 8" (200 mm) and 12" (300 mm)

**Antenna Configurations**

- TFE Dielectric Rod
- Polypropylene Dielectric Rod
- All-Polypropylene Dielectric Rod
- All-Halar Dielectric Rod
- 3 inch (75 mm) Horn (stillwell only)
- 4 inch (100 mm) Horn
- 6 inch (150 mm) Horn

| | |
|---|---|
| **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 × 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 | ¾" 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: 1½" 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 transmitter with a 6" horn antenna**

# Anatomy of a Model R82 Radar Transmitter and Sensor

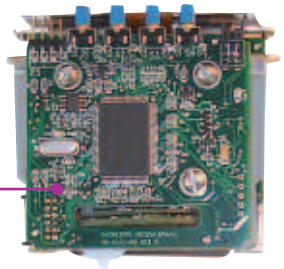
The all-new R82 is a high-performance level transmitter whose low cost makes it ideal for everyday level applications. Its launcher orientation and echo-rejection profiling are simplified for easy use. Its microwave beam is rotatable for optimized operation.

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 PACT*ware*. 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.

MODEL
R82

| | |
|---|---|
| **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 × 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 | ¾" 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 |


**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

PACT*ware* *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.*

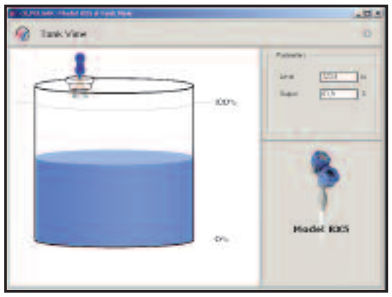

***GET CONNECTED*** Simply connect the HART/RS232 or HART/USB serial interface from the PC to the two-wire loop.

**Level Monitoring Screen** Continuously viewing the level in a tank is the starting point for PACT*ware*. 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.

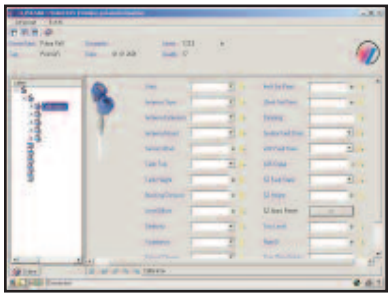
**Parameters Screen** Every parameter in your radar transmitter can be monitored and modified remotely with a few clicks of the mouse. From units of measure to settings for dielectric, each parameter can be viewed or changed to suit application conditions. Parameters can be developed offline or transferred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

**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. PACT*ware* PC software has the ability to track all parameters of your radar device and save them as a text or picture file.

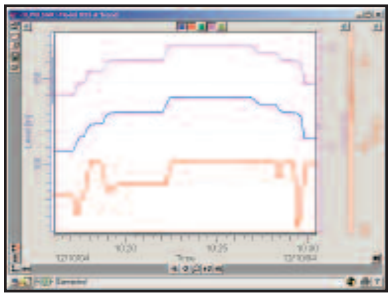
**Echo Wave Form Screen** This screen yields a wealth of useful information: Level (X-axis), Signal Quality (Y-axis), Actual Echo Curve (black line), False Target Profile (red line), and Minimum Threshold (blue line). Blue hash marks show the location and signal quality of the target currently detected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



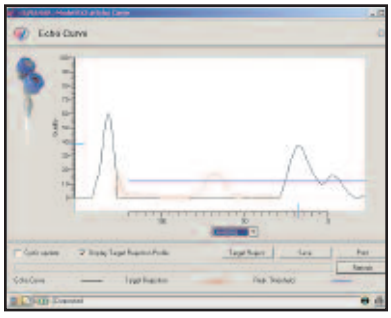
**Level Monitoring Screen**



**Parameters Screen**



**Process Trend Screen**



**Echo Wave Form Screen**

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