The elusive search for Non-Contact Radar Nirvana

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AMETEK® SENSORS, TEST & CALIBRATION

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Nirvana for every instrument person is to find a trouble-free, loop-powered level transmitter that can be mounted, wired and forgotten. As instrument shops' staffing has been whittled back to a minimum, it has become the goal of many manufacturers to meet that challenging need for "plug and play" devices. So, how close have we gotten to applying two wires and walking away? We'll answer that in just a moment. But first, a little background may be helpful.

The birth of a new age

In the late 1990s/early 2000s, low-cost, loop-powered radar burst onto the scene. It was enthusiastically applied due to its ability to work even in the changing conditions that plagued the most popular technologies of the time. No longer would changing specific gravity ruin the accuracy of DP cells or displacers, or changing dielectric spoil the performance of RF capacitance devices, or vapor space changes affect the propagation consistency of ultrasonics. In short, a new age was upon us.

Radar had already evolved into two variations: Non-contact/through-air (antenna-based) and Contact/Guided Wave (probe-based). In a perfect world all transmitters would be non-contact as they would not have to contend with contacting the dirty, coating-prone, turbulent liquids that can wreak havoc with performance and mechanical integrity. However, since Guided Wave Radar (GWR) employed a metallic probe, a highly efficient electrical path is provided to propagate the signal. This allows for extremely strong radar reflections from the liquid surface, thus providing excellent performance in difficult conditions. We're closing in on Nirvana.

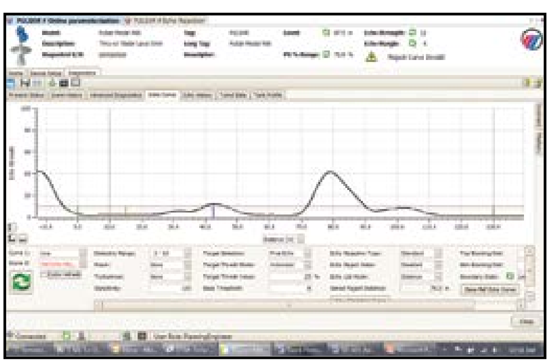

Figure 1. Echo curve (being shown in DTM utilizing PACTware) being shown after having been automatically captured by transmitter.

A love/hate relationship

Non-Contact Radar (NCR) slowly became the technology many people love to hate. Theoretically, NCR can be so effective it should be everyone's first choice. It is small and easy to install. This means that measurement in tall tanks did not create a long, expensive and unwieldy probe like GWR and it sat up high in the tank away from the tank contents. However, the vagary of launching an electromagnetic signal into space and waiting for its return is fraught with potential complications: false reflections from objects in the vessel, severe turbulence that can scatter the signal and foam that can absorb it are just some of the issues that exist to render NCR ineffective. Users reported challenges getting these devices ideally configured; too much baby-sitting.

The "Goldilocks dilemma"

Two of the keys to the effective use of NCR are correct installation and proper configuration. Installation includes avoiding sidewall and false target reflections. Configuration is getting the gain (amplification) settings just right. This is the "Goldilocks dilemma"— it can't be too hot or too cold—too hot (excessive gain) and the echo saturates (distorts) deteriorating accuracy; too cold (insufficient gain) and the weak signal is lost. Optimal configuration is not an impossible task but one that has eluded many, good instrument personnel. How do we take that "spookiness" out of this endeavor?

Circular polarization helps

Electromagnetic energy can be launched using linear or circular polarization. Linear polarization has a constant E-field and needs adjusting to avoid sidewall reflections. To remove these launcher adjustments, the new Pulsar® Model R86 Non-Contact Radar Transmitter from Magnetrol® employs circular polarization which has a rotating E-field. In this way, no antenna adjustment is necessary during commissioning, getting the user closer to the "plug and play" goal we all desire.

Four ways that software assists configuration

Configuration issues can often be mitigated with modern software, including that which is embedded in the transmitter firmware.

The following are four innovative software approaches that have made life much easier for NCR users.

1. Pre-configuration

This is the perfect place to start. Many manufacturers require an application sheet which shows the most needed information. This gives experienced, factory personnel the opportunity to accept or reject an application. Add to this a Pre-configuration Form complete with all the necessary setup information, and the transmitter will arrive ready to be installed and wired.

Sounds great, so can we plug and play then walk away? Not just yet, because there are two important caveats for NCR:

False target reflections (if any) in a vessel can only be addressed after the transmitter is installed. This is not difficult, nor always necessary; it is just something to consider.

Process information in a "pre-config" form must correctly reflect the actual conditions. It is not uncommon for a factory representative to hear a distressed customer exclaim, "I did not know there was *that* much foam in my application!" An even more common mistake occurs in setting up the device for a 10m tall storage tank and configuring for no turbulence. The customer confidently assumes, "It is a storage tank...there are no mixers and there is NO turbulence." However, this classic mistake neglects the fact that the tank may be filled from the top, which can cause significant turbulence when the vessel is almost empty.

Turbulence and foam are two conditions that can significantly reduce the strength and effectiveness of a reflected signal. If configuration settings do not accurately reflect conditions in the vessel, problems can arise.

2. Echo Curve

The capture and analysis of an echo curve (automated capture) is critical to the understanding NCR application issues.

Strategic capture has always been the central issue. Can the internal software monitoring capability eliminate baby-sitting? How many times have issues occurred at 2:00 AM when there is no one around to react? This issue has been resolved in modern transmitters by automatically triggering echo captures based on known issues like complete loss of the echo or simply weak echo amplitude. Once captured, these echo curves are stored in the transmitter until they are downloaded for analysis by common programs like PACTware.

Key points to make for the echo curve shown in Figure 1 are:

1. Level target is at ~79 inches (Distance)
2. Small false target at 42 inches (Distance) is fooling transmitter into reporting an invalid measurement. Note the blue cursor confirming that the transmitter mistakenly believes this is the correct echo.
3. Simply running an Echo Rejection routine would effectively eliminate the false target, creating a very clean radar scene.
4. How would you know what to do at 8:00 AM if this happened momentarily at 2:00 AM? Automated echo capture (internal monitoring) offers the solution.

3. Tank Profiling

One of the more interesting and effective of the new analysis tools is one called tank profiling. It is similar to common trend/data log approaches that capture information like level, echo strength and loop current data based on a time scale. However, this approach differs in some key areas:

Figure 2. Tank profile graph showing collection of minimum and maximum values for echo strength and echo margin

Only echo strength and echo margin data are captured. This data is the most crucial for providing insight into configuring gain adjustments like turbulence and foam. Echo strength, essentially amplitude, is the most common bit of information used by all radar personnel to assess the health of an application.

Echo margin is a form of signal-to-noise ratio that is customized for use in level measurement. It not only calculates the difference of the key level reflection to noise (false targets), it also calculates their relative strength in relation to the current threshold. In this way, echo margin alerts users when a false target is getting close to rising above the threshold, thereby becoming a "valid" target that could be reported as an invalid level value.

Maximum and minimum values are captured and displayed for each interval in the cycle. If the tank profiling process finds no new data that exceed "max" on the top or "min" on the bottom, no changes are made to the stored information. However, if data in subsequent cycles exceed these values a new "max/min" point is placed on the graph. By taking these max/min values into account, adjustments made to echo strength can avoid the pitfalls of too little gain which can cause echo loss, and/or too much gain which could saturate/distort the reflection.

The capturing of information is not based on time, but on level measurement intervals (e.g. 1 inch) and tank cycles (full/empty), regardless the amount of time it takes. It is well known by radar personnel that optimizing configuration settings based on a single point in the vessel is far from optimal. It is far more effective to know WORST case conditions, regardless their position in the vessel, and configure appropriately. This approach can run for several cycles gathering information throughout many changes to the liquid surface conditions.

There are always a few important takeaways to look for in any tank profile information:

Look for areas of poor minimum echo strength values. In the example shown in Figure 2, ~118" of level is 10, which is dangerously close to a loss of echo. At that same point, the maximum echo strength is only 48, which allows plenty of head room for increasing the amplitude of the echo by increasing a gain parameter.

Look for the point where the echo margin value decreases while echo strength remains high (not shown in this example). The position at which the echo margin reaches its lowest value is where to look for a false target. Running echo rejection while liquid level is above this point, will cancel the false target. This will allow echo margin to remain strong through the area in question.

4. On-board HELP text

How many times have you heard this comment: "Does anyone know where we put the *instruction manual?*"

Often a few bits of simple information are all that is needed to yield needed insight into a configuration or troubleshooting issue. Now, context-sensitive HELP text can be found on the transmitter. Simply hold down the ENTER key. Another option is provided in the DTM: by a simple cursor "flyover" you can burn the manual.

Non-Contact Radar is one of the most effective level measurement technologies on the market today. There are tens of thousands of transmitters installed globally, operating in an extremely wide range of applications.

Magnetrol's new PULSAR Model R86 Non-Contact Radar Transmitters employ all of the advanced features mentioned in this article. When configured properly, the Model R86 can be everyone's go-to transmitter. Having said that, no transmitter ever made is totally trouble-free. But if problems occur, MAGNETROL should have the ability to diagnose them quickly and bring the device back on line as fast as possible.

That means no more waiting for the trouble-free, loop-powered level transmitter that can be mounted, wired and forgotten. Non-Contact Radar nirvana is finally here.

This article originally published in IPP&T, April 10th, 2017

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