Reverse-acting radar level transmitter -
tackling the most difficult level applications

by J Oliver, Krohne France
Electricity + Control February 2000

Tackling the 'inverted interface' application - where the heavier product has the lower dielectric constant - has become a major issue in industry. This article deals with exactly this application.

The article uses as an example a time domain reflectometry (TDR) level instrument, the Krohne BM100. In the interface level measurement sector Krohne has been able to address itself to the majority of applications with the BM100 where the lower dielectric product has a lower specific gravity and lays on top of the higher dielectric product (for example a hydrocarbon on water). Approximately 14% of the BM100s sales have been on interface applications. TDR is well suited to interface applications in that the same probe can measure simultaneously the surface level and the interface level, without any moving parts. In addition, the surface level measurement is independent of the top product's dielectric and the interface measurement less sensitive to dielectric drift than capacitance probes.

The challenge of the inverted interface

In gaining this experience in interface measurement, Krohne encountered numerous clients with 'inverted interface' applications, where the heavier specific gravity product has in fact the lower dielectric (for example phosphor, dichloroethane (EDC), chloromethane, carbon disulfide). With the classic mounting of the BM100 on top of the tank, it is not possible for the energy of the pulse travelling along the probe to cross through the high dielectric (ie >20) top product. In the case of water, approximately 80% of the energy is reflected back to the electronics from the water's surface.

One way of getting around this problem is to mount the BM100 from the bottom of the tank. The BM100 then measures the distance between its flange and the underside of the interface between the products. The pulse travels from the BM100 through the bottom product and is then reflected from the higher dielectric top product. For this configuration the BM100 uses the dielectric of the bottom product for its dielectric of 'air' parameter. Mounting of the BM100 underneath can even enable products with dielectrics higher than 20 to be measured. Tests have been successfully carried out on an interface measurement of 2 m between furfurol and water, where the dielectric of furfurol is 40. It was possible to cross such a high bottom product dielectric because the pulse travels directly from the flange assembly into the furfurol with no surface reflection and therefore with much less energy loss.

However, due to the mechanical modification requirements to the tank and concerns about leakage from connections at the bottom of the tank, the ideal mounting position remains at the top of the tank. In response to the operational requirements of the customer, whilst taking into account the safety and ease of installation aspects, Krohne developed the 'G' probe specifically for the 'inverted interface' applications. The instrument is only different from the standard BM100 in its mechanical construction (flange assembly and probe) using the standard electronics and software.

The 'G' probe

The 'G' probe takes the application scope of TDR beyond that of any other TDR instrument, allowing the top mounting of the instrument with the probe immersed directly through the two products. The concept behind the 'G' probe is to omit the pulse from the bottom of the probe upwards, avoiding the reflection from the high dielectric top product.
As can be seen in the sequence below, the pulse is generated in the electronics and transmitted through the flange assembly (1). The scan displayed at the bottom of the diagram shows the generation of the negative 2.5 V pulse. Instead of being externalised at the flange (ie the left hand probe becomes the 'positive' pulse guide and the left probe the reference), the pulse is contained in the left hand tube (2). This left hand tube is effectively a continuation of the flexible coax cable directly from the electronics, where the central wire is the positive conductor and the inside of the tube is the reference. Shorting of the wire to the inside of the tube is prevented by an insulating PTFE sheath. This left hand tube is completely sealed from the process. The pulse thus continues to travel at the speed of light (V1) through the top and bottom product (3) and (4). At point (5), the pulse reaches the end of the tube where the positive central wire is connected directly to the probe shunt (horizontal rod). A PTFE and Viton seal assembly insulates the left hand tube from the shunt and seals the tube's end. The pulse is then externalised, following its path along the shunt and upwards along the outside of the right hand rod. The outside of the left hand tube then becomes the reference, creating a pulse field identical to that of a standard probe. The pulse travels at a reduced speed (V2) upwards through the bottom product, V2 depending on the dielectric of the bottom product (Er3).

The pulse encounters the positive change in impedance at the interface of the two products (6), and is reflected downwards (7). The sequence is then reversed with the pulse returning to the shunt and back into the left hand tube (8). A positive reflection is recorded at (9) once the pulse reaches the electronics. Because the time for the pulse to travel to the bottom of the probe is known, the time travelled through the bottom product can be measured. Using the dielectric value Er3 of the bottom product, the distance between the shunt and the interface can be calculated.

With the 'G' probe it is not possible to measure simultaneously the surface of the top product.

Specifications

The 'G' probe is rigid and can be up to 6 m long. The maximum bottom product dielectric (Er3) is 10 and there must be a difference of at least 10 higher for the top product's dielectric for there to be a distinct interface reflection. The 'G' probe is ExE approved.

Installation

The 'G' probe can be installed on any flange greater than 2” and requires a free space of 100 mm around the measuring part of the probe (ie from the bottom of the probe to the highest interface level). Care
needs to be taken in the case where there are deposits at the bottom of the tank. The probe end needs to be kept out of such deposits to ensure the correct emission of the pulse.

If the dielectric of the product is not known, it can be tuned on site if a comparative measurement is available. If not, the dielectric can be measured using a standard BM100 in Direct Mode, immersed in just the bottom product.

Applications

The 'G' probe has been successfully installed in the paper industry on carbon disulfide/water and in the petrochemical industry on dichloroethane (EDC)/water and chloromethane/water (vinyl/PVC production). Additionally the 'G' probe has been successfully applied to phosphor and water interface measurement.

In one particular case a customer had already used capacitance probes to solve an inverted interface application, but suffered drifting in the measurement, due to slight changes in properties of the two products. TDR has the advantage of measuring just the bottom product and is therefore immune to property changes in the top product. Any changes in the bottom product will affect the measurement by a reduced factor due to V2 being based on the square root of the bottom product's dielectric.

With the 'G' probe, Krohne has once again proved itself capable to meet the most demanding of customer's applications, breaking new ground in the application of the latest instrumentation technology.

Conclusion

This recent development - the 'G' probe - has allowed designers to tackle a particularly challenging application. By emitting the pulse from the bottom of the probe, reflection from the higher dielectric top product is avoided.

Take Note

The BM100 Time Domain Reflectometry contact level instrument was launched by Krohne France in 1996. The sales figures for what has been the most rapid selling Krohne instrument have now passed the 4000 units mark. Throughout the first three years of the BM100s life, Krohne tackled some of the most difficult level applications in industry, at times replacing nuclear level instruments and even other TDR instruments.