Various Technics of Liquids and Solids Level Measurements (Part 4)

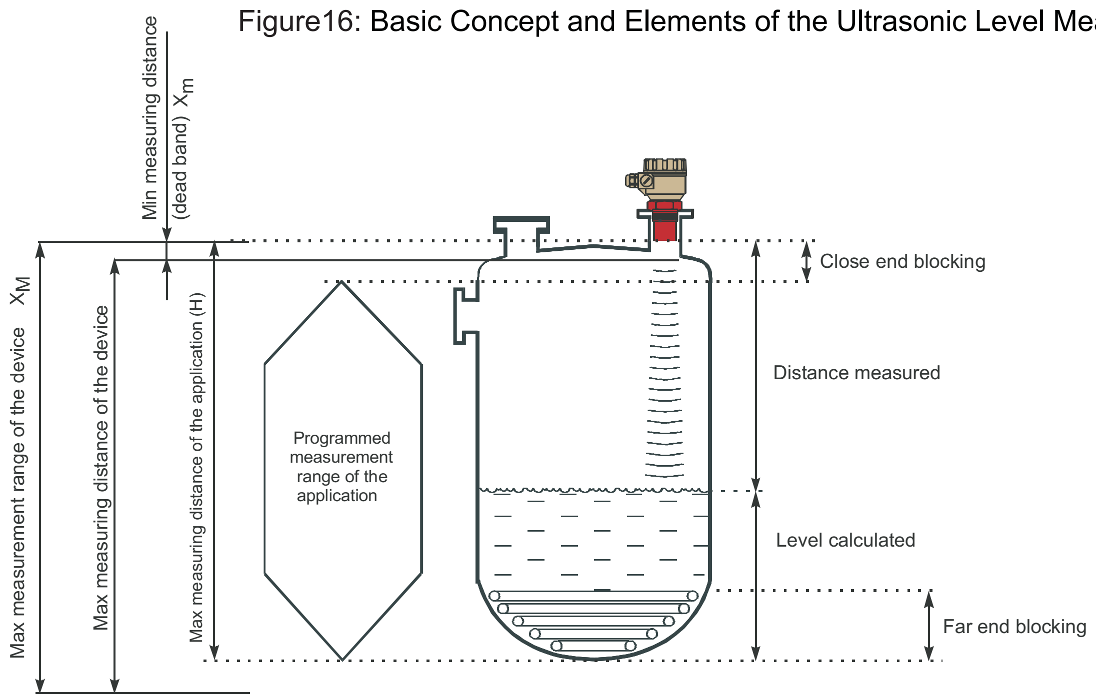
In part one of this series of articles, level measurement using a floating system was discusses and the instruments were recommended for each application. In the second part of these articles, level measurement with the aid of pressure instruments was discussed. In the third part of this series of articles, radar level measurement basics and parameters affecting its efficiency were explained and in this section of these articles, level measurement with the aid of ultrasonic waves will be discussed.

ULTRASONIC LEVEL MEASUREMENT BASICS

Ultrasonic level instruments operate on the basic principle of using sound waves to determine liquid/solid/slurries level. In addition to standard level or volume measurement, they can monitor open channel flow, determine the actual volumetric throughput in lift stations, measure differential level and control the pumps.

Ultrasonic Level Transmitters consist of two elements; 1) a high efficiency transducer and, 2) an associated electronic transceiver. Together, they operate to determine the time for a transmitted ultrasonic pulse and its reflected echo to make a complete return trip between the non-contacting transducer and the sensed material level. As shown in Figure 16, a top-of-tank mounted transducer directs waves downward in bursts onto the surface of the material whose level is to be measured. A piezoelectric crystal inside the transducer converts electrical pulses into sound energy that travels in the form of a wave at the established frequency and at a constant speed in a given medium. Echoes of these waves return to the

Figure16: Basic Concept and Elements of the Ultrasonic Level Measurement



Minimum measuring distance (X_m): (also known as the "Dead Band") is a feature common to all ultrasonic level meters. This is a short range in front of the sensor within which the ultrasonic device can not measure.

Maximum measuring distance (X_M): The longest range under ideal condition within which the device can measure. No measurement is possible beyond this distance.

transducer, which performs calculations to convert the distance of wave travel into a measure of level in the tank. The time lapse between firing the sound burst and receiving the return echo is directly proportional to the distance between the transducer and the material in the vessel. The medium is normally air over the material's surface but it could be a blanket of some other gases or vapours. The instrument measures the time for the bursts to travel down to the reflecting surface and return. This time will be proportional to the distance from the transducer to the surface and can be used to determine the level of fluid in the tank. This basic principle lies at the heart of the ultrasonic measurement technology and is illustrated in the equation: Distance = (Velocity of Sound x Time)/2. These noncontact devices are available in models that can convert readings into 4–20 mA outputs to DCSs, PLCs, or other remote controls.

The frequency range for ultrasonic methods is in the range of 15...200 kHz. The lower frequency instruments are used for more difficult applications; such as longer distances and solid level measurements and those with higher frequency are used for shorter liquid level measurements.

For practical applications of ultrasonic measurement method, a number of factors must be considered. A few key points are:

• The speed of sound through the medium (usually air) varies with the medium's temperature. The transducer may contain a temperature sensor to compensate for changes in operating temperature that would alter the speed of sound and hence the distance calculation that determines an accurate level measurement. Temperature compensation is provided to account for uniform temperature variances of the sound medium. The temperature sensor is placed inside the transducer and the signal is sent to the transceiver via the transducer's wiring. Optionally, an alternate temperature sensor can be used to provide a temperature input, rather than by using the integral temperature sensor. If the temperature of the sound medium is to remain constant, instead of using either the integral temperature compensation or the remote sensor, the desired temperature may be entered during the transceiver configuration.

• The presence of heavy foam/dust on the surface of the material can act as a sound absorbent. In some cases, the absorption may be sufficient to preclude use of the ultrasonic technique. To enhance performance where foam/dust or other factors affect the wave travel to and from the liquid surface, some models can have a beam guide attached to the transducer.

• Extreme turbulence of the liquid can cause fluctuating readings. Use of a damping adjustment in the instrument or a response delay may help overcome this problem. The transceiver provides damping to control the maximum changing rate of the displayed material level and fluctuation of the mA output signal. Damping slows down the rate of response of the display especially when liquid surfaces are in agitation or material falls into the sound path during filling.

Indumart Ultrasonic Level Transmitter is capable of monitoring virtually any short to medium range non-contact ultrasonic level measurements of most free flowing solids (granules and powders) and liquids. In applications characterized by dust, the instrument demonstrates notable stability by adjusting itself to the severity of the process.

A definite advantage of some models of Indumart Ultrasonic Level Transmitter is their narrow total beam angle of 5° or 6° at -3 dB. As a result of narrow beam angle, the emitted ultrasonic signal ensures outstanding focusing and good penetration trough dust, and furthermore, provides reliable measurements in narrow silos with uneven side walls and protruding objects (Fig. 17).

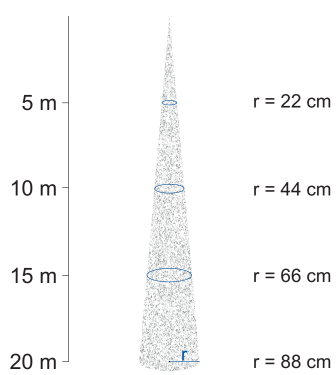


Figure17:
Radii corresponding to 5° beam angle

These transducer are virtually immune to buildups as condensation is atomized on contact with their highly active closed cell face. The lower frequency models operates in extremely hostile environment such as cement, sugar silos, stone crushers, gravel bins, etc.

They incorporates current output directly or inversely proportional to the span. Remote programming of and acquiring information, such as viewing of the primary measurement values, from the transmitter are performed by a configuration software, which runs under Windows®. Programmable system is usually recommended, which gives the opportunity to easily entering all configuration data, such as low and high level precisely without actual simulation, and to declare the severity of the process to optimize level measurements. Other features of the software include: (1) viewing of the measurement values on a computer via EXCEL® application; (2) diagnosing the system with individual error message; (3) parameters read out, which reports on the operating conditions of the system to facilitate installation and troubleshooting. The optional RS485 with MODBUS® protocol may also be acquired for monitoring, data acquisition and remote programming of the transmitter. The ultrasonic instrument with HART and the configuration software enables remote programming of up to 15 field devices and viewing of the primary measurement values on a PC.

To avoid problems caused by repose formation of the solids, aiming (tilting) of the device is required. The aiming device for carrying out the most appropriate level measurement in tanks/silos is offered for most models.

The programmer/display module (D400) may also be added to your level/volume measurement system to indicate the process value on its 6-digit display and be used to enable full parameter programming with access to all features of the *LTU400 or LTU200 Series* (Fig. 18). The bargraph display of this programmer provides visual information on the signal strength or the measurement value. These series features 32 point linearisation, over 10 pre-programmed tank shapes (Fig. 19) for calculation of volume/weight, as well as the ability to suppress the interface of an echo from a fixed object inside the container. Other features of them include: (1) access lock by secret code to prevent unauthorized access and programming; (2) fully self diagnostic system with individual error message for appropriate action; (3) service and test parameters read out, which reports on the operating conditions such as sensor gain, echo amplitude, noise level and more to facilitate the installation and troubleshooting of the system; (4) simulation mode, which is used for checking the instrument's output by simulating static or continuous change of level with selectable parameters such as low level, high level and cycle time; (5) revealing the device history such as total operating hours, operation after last switch-on, number of switching actions for each relay, minimum and maximum temperatures registered, etc.

Other features of D400 are: two independent volume flow totalisers (one of them is resettable); trend monitoring and rate of level changing, temperature monitoring; individually coded error messages. Also, indication of the device history, such as total operating hours, time of operation after the last switch-on, minimum and maximum temperatures, etc. Five onboard multi-purpose relays are provided to be used as high/low alarms for level, flow rate or temperature. In addition, these relays may be used as pump control with automatic sequencing or be applied in many other control functions as the circuitry of the transceiver provides 14 modes of relay operations. Five LED's are also provided to indicate the alarm status.

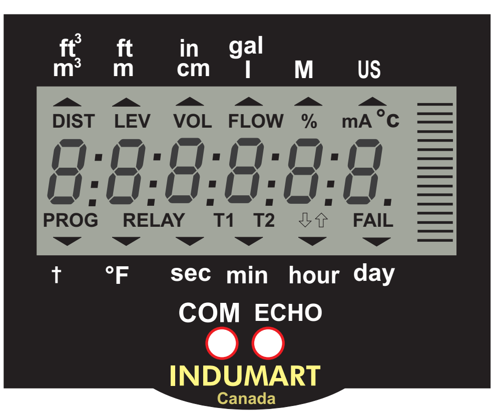


Figure 18: D400 Display and programming module

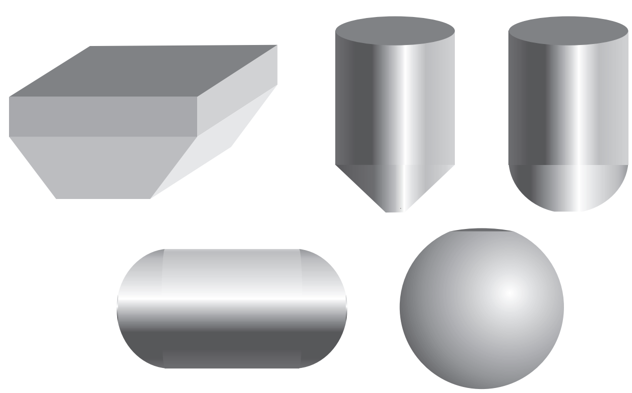
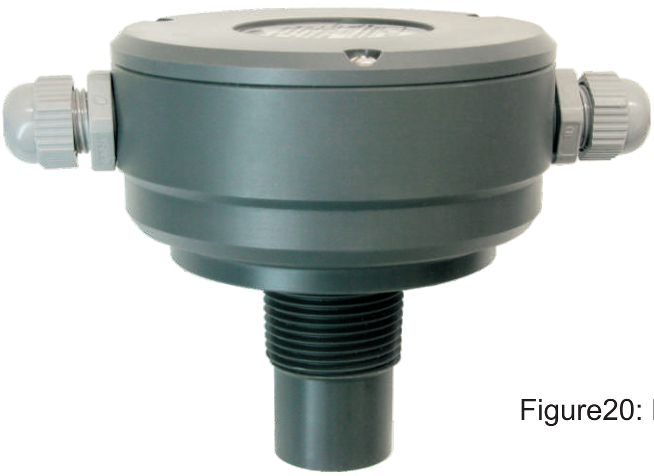


Figure 19: Pre-programmed tank shapes

The optional remote display with 2 contacts (DIS300) may also be added to your level measurement system to indicate the process value on its 4-digit display and be used to trigger contacts at desirable material levels.

Applying Indumart Ultrasonic Level Measurement instruments has been proven to be reliable with little maintenance, where other high maintenance level detectors are not preferred because of their negative field experience. Their performance is based on self-adjusting circuitry which analyzes the transducer signals through its software process and provides achievable accuracy. In applications characterized by dust, turbulence and steam, or in vessels with agitation, these instruments demonstrate notable stability by adjusting themselves to the severity of the process.



For Liquids

Range In Liquids	0.1 ~ 1.8 m (0.4 ~ 6 ft)
Resolution	0.7 mm (0.03")
Frequency	148 kHz

Figure20: LTU102

For Liquids

Figure21: LTU200 Series

Model	LTU203	LTU204	LTU205	LTU206		LTU207	LTU208	LTU210	LTU212	LTU215
Transducer Material	PTFE	PP, PVFD	PTFE	PP, PVFD	PTFE	316 St. St.	PP, PVFD	PP, PVFD	316 St. St.	PP, PVFD
Max. Distance (m)	3	4	5	6		7	8	10	12	15
Min. Distance (m)	0.2	0.2	0.25	0.25	0.35	0.4	0.35	0.35	0.45	0.55
Total Beam Angle	6°	6°	5°	5°	7°	5°	7°	5°	5°	5°
Frequency (kHz)	80	80	80	80	50	60	50	60	40	40
Process Connection	1½" Thread	1½" Thread	2" Thread	2" Thread		Flush Flange	2" Thread	Flange	Flush Flange	Flange

For Liquids

Model	Range in Liquid	Resolution	Mounting
LTU315 (52 kHz)	0.3 ~ 15 m	5.7mm (0.23")	3" & 2" NPT
LTU309 (70 kHz)	0.25 ~ 9 m	3.4mm (0.13")	3" & 2" NPT
LTU306 (80 kHz)	0.2 ~ 6 m	2.2mm (0.088")	3" & 2" NPT
LTU305 (81 kHz)	0.2 ~ 5 m	1.8mm (0.07")	3" & 1½" NPT
LTU303 (148 kHz)	0.12 ~ 2.7 m	0.98mm (0.04")	3" & 1" NPT

Figure22: LTU300 Series

Figure23: LTU400 Series

For Solids

Type	LTU415	LTU430	LTU460
Mounting (min. flange)	ANSI 6" / DN150	ANSI 6" / DN150	ANSI 12" / DN300
Max. Measuring Distance*	15 m (49 ft)	30 m (98 ft)	60 m (196 ft)
Min. Measuring Distance	0.6 m (2 ft)	0.6 m (2 ft)	1 m (3.33 ft)
Suggested Applications	Recommended for short range monitoring of up to 8 m	Up to 25 m for powder and heavy dusty granules; higher range for non-dusting granules	Up to 50 m for powder and heavy dusty granules; higher range for non-dusting granules
Frequency	30 kHz	30 kHz	15 kHz

* from transducer's face - under optimal conditions

For Solids & Liquids

Model	Range in Solid	Resolution	Mounting
LTU515 (25 kHz)	0.4...15 m	10 mm (0.41")	6" NPT
LTU510 (45 kHz)	0.3...10 m	6.8 mm (0.27")	3" NPT

Figure24: LTU500 Series