ABB MEASUREMENT & ANALYTICS | WHITE PAPER

Level measurement

Demystifying the benefits of magnetostrictive technology

Understanding magnetostrictive level technology through the features and benefits of ABB's LMT Series.

Measurement made easy

LMT Series are used in wide range of applications across various industry segments

Introduction

Liquid level measurement is extremely important in controlling inventory of supply, treatment chemicals and end product in the water and wastewater treatment industry (or any other industry). Several measurement-sensing technologies are available to the industry – magnetostrictive, radars, ultrasonic, hydrostatic and potentiometers, to name a few. While each technology has its advantages for various steps of the treatment process, they are not all created equal.

This article will discuss the common benefits of the magnetostrictive technology in the context of the water & wastewater industry where the belief that for liquid level measurement in the water & wastewater industry, supremacy centers only on the product price! The customer, either a municipal or industrial water and wastewater processor, has a need and responsibility to source, treat, distribute and discharge water in a sustainable, cost-effective and safe way.

Like in an oil & gas, petrochemical or other process industry, the water & wastewater processors are looking for sustainable, cost-effective and safe solutions. This translates to a transmitter in terms of accuracy, installation and maintenance costs, calibration, ease of setup, and other specific parameters, which are weighed differently by each end-user to determine the total cost of ownership.

Magnetostrictive transmitters are often associated with magnetic level indicators/gauges given the synergy between the technologies and their extensive adoption in hazardous and toxic liquids at high pressure & temperature in oil, gas & petrochemical industries, but magnetostrictive technology can be also a stand alone in a host of process applications and environments. ABB's LMT100 model is such a standalone level transmitter solution that can be mounted directly into the tank without the need for a magnetic level indicator.

Magnetostrictive technology is one of the best technologies for liquid level measurement which is the most accurate and highest resolution level sensors on the market. This continuous liquid level solution can determine level within only a few millimeters but remains one of the least known or understood. In this article, let's demystify this technology and its benefits.

What is a magnetostrictive sensor?

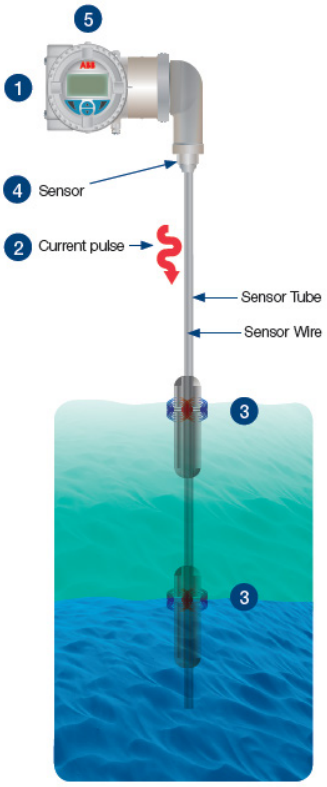
Developed in the 1970s, magnetostrictive sensors work on the principle of magnetostriction, a property of ferromagnetic materials, in which the application of a magnetic field causes strain which results in a change in the size or shape of the material. Magnetostrictive sensors use a ferromagnetic sensing element usually referred to as a waveguide. The waveguide serves as a conductor of the torsional wave to the pulse converter.

A pulse is induced in a specially designed magnetostrictive waveguide by the momentary interaction of two magnetic fields. One field comes from a movable permanent magnet, which passes along the outside of the sensor tube. The other field comes from a current pulse or interrogation pulse applied along the waveguide. The interaction of the two magnetic fields produces a strain pulse, which travels at sonic speed along the waveguide until the pulse is detected at the head of the sensor. The position of the magnet is determined with high precision by measuring the elapsed time between the application of the interrogation pulse and the arrival of the resulting strain pulse.

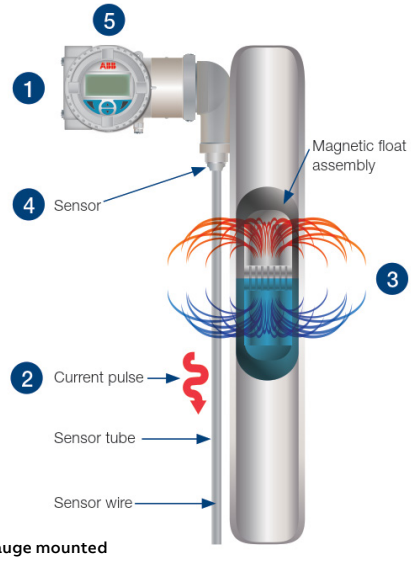
1 The device electronics generates a low energy current pulse at fixed intervals.
2 The electrical pulses create a magnetic field which travels down a specialized wire inside the senor tube.
3 The interaction of the magnetic field around the wire and the magnetic float causes a torsional stress wave to be induced in the wire. This torsion propagates along the wire at a known velocity, from the position of the magnetic float and toward both ends of the wire.
4 A patented sensing element placed in the transmitter assembly converts the received mechanical torsion into an electrical return pulse.
5 The microprocessor-based electronics measures the elapsed time between the start and return pulses (Time of Flight) and converts it into a position measurement which is proportional to the position(level) of the float.

Sensors based on magnetostrictive technology are small, high-performance and noise-immune. Other characteristics of the technology include a wide operating temperature range, a low and stable offset and low sensitivity to mechanical stress

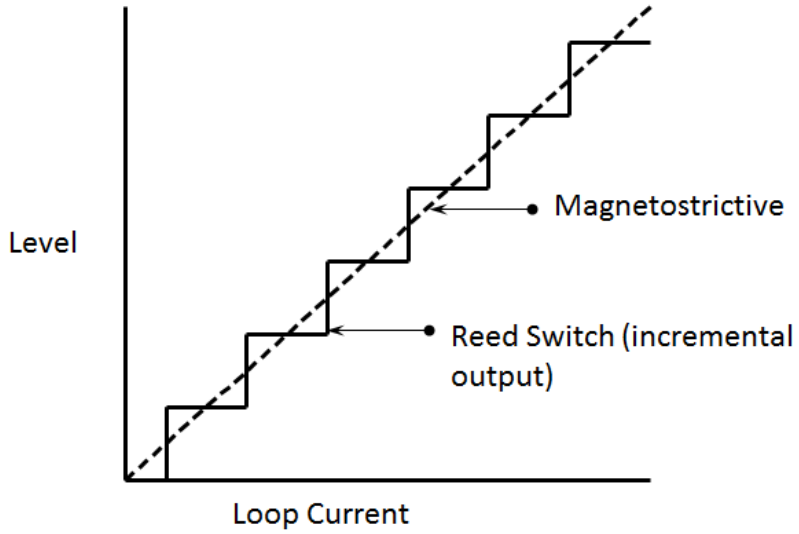
ABB's patented magnetostrictive sensor
There are different types of sensor design that are used in the magnetostrictive transmitters. The lowest cost, low-performance is the "reed-switch" based transmitters, which are not true continuous transmitters but provide step output that has a low resolution or provides level reading increments of several inches.



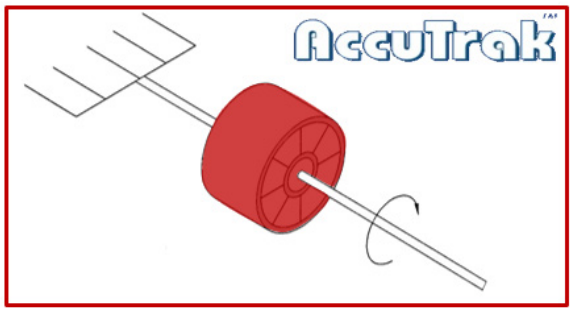
LMT100 - Direct insertion



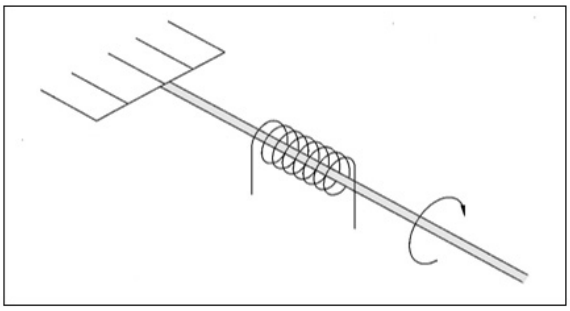
LMT200 - Gauge mounted



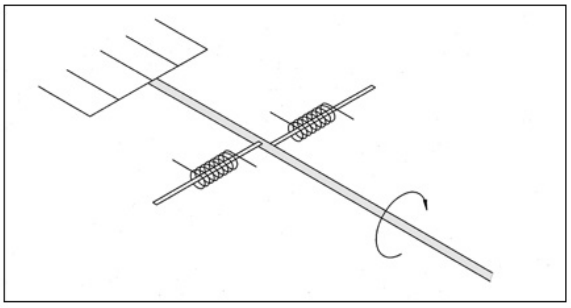
Low accuracy, Low Resolution Step Output vs Real continuous high accuracy magnetostrictive



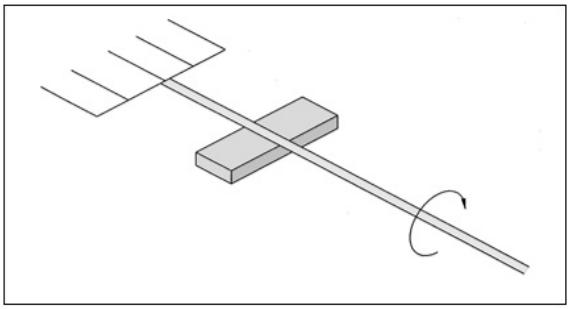
ABB's piezo sensor



Coil sensor



Strain gage sensor



Piezo plate sensor

Magnetostrictive sensor designs

All magnetostrictive transmitters in the market currently use sensors that create a voltage when the torsional wave from the magnetostrictive effect is detected. However, the performance of the transmitters differs significantly with this difference.

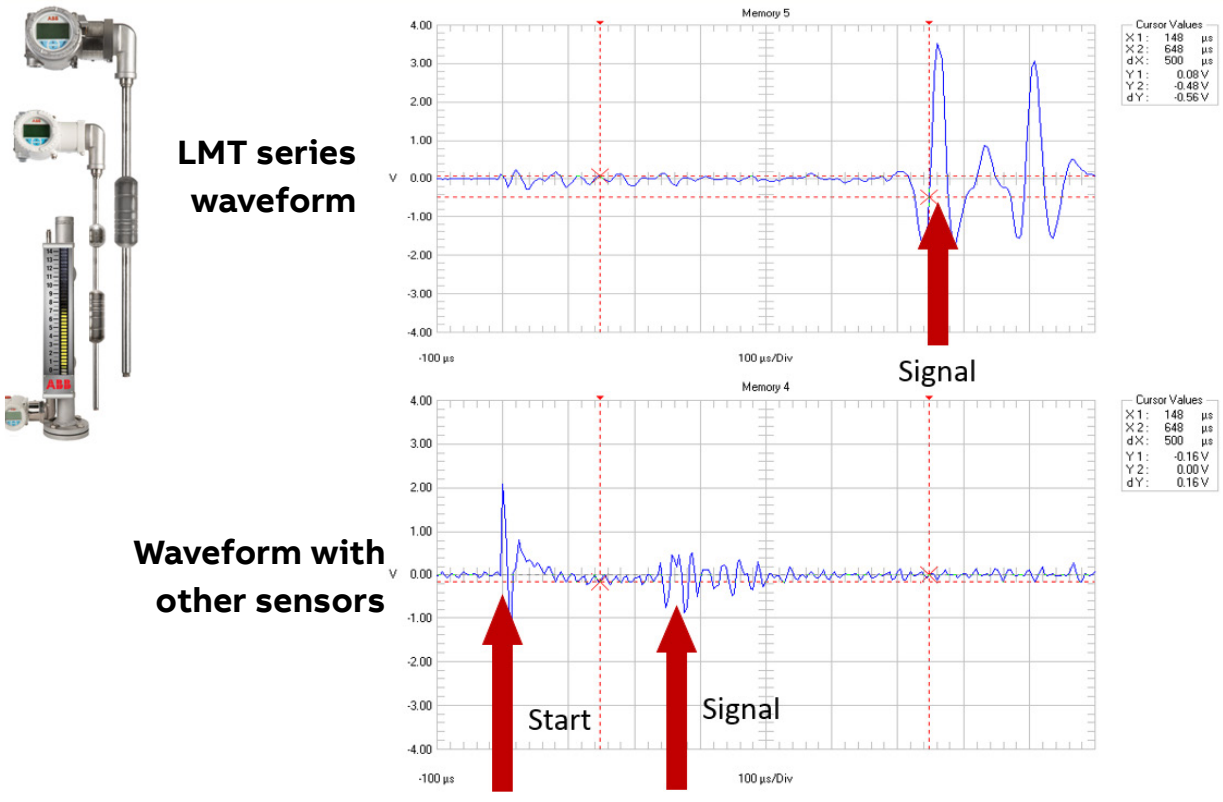
In the first sensor type, two strain gauge type sensors are welded to the magnetostrictive sensor. When the torsional stress wave is detected, a voltage is produced at each strain gauge device when the torque is sensed. This is a very delicate assembly which limits its performance in high vibration applications and the strain sensed by each may vary and the accuracy is thus affected.

In the second sensor type is a coil around the magnetostrictive sensor. When the torque moves the sensor, a voltage is produced across the coil. The torque and movement are small and so is the voltage produced. Simple and cheap but a voltage is produced when the sensor moves due to other effects like vibration and /or temperature variations.

The third sensor type is a piezoceramic plate resting against the magnetostrictive sensor. A voltage is produced across the plate when the torque is sensed. Again, simple and cheap but like the coil sensor, a voltage is produced when the sensor moves due to any vibration. In addition, the contact area between the sensor and the plate are much smaller which requires higher magnetic field or smaller distance between the float and probe. This also limits the capability to convert the low energy torsional waves when the length of the probe increases.

ABB's patented circular piezo sensor outperform all other design that the competition uses in accuracy, vibration, high temperature, probe length capability and in reliability. LMT Series reuses this sensor design from its legacy and industry proven AT Series which has an installed base of more than 100,000 transmitters over the last two decades. ABB's LMT Series uses a patented torsional wave sensor that consists of eight (8) precisely machined piezoceramic segments that surround and are bonded to the magnetostrictive sensor and shrouded in a brass ring. The assembly is polarized so that it only responds to torques, which means that, a voltage is generated from the sensor when the torsional stress wave is detected and to ignore all longitudinal vibrations. This design of the sensor also provides a maximum transfer of the torsional energy and provides self-cancellation of most other vibration influences resulting in an extremely high signal to noise ratio.

Below are typical waveforms used for signal processing from an ABB's K-TEK design and a competitive magnetostrictive transmitter. These waveforms are using an MLG as the magnetic field source. Note the extremely high signal to noise ratio for the ABB's LMT Series waveform as compared to the other. Also note how uniform the LMT waveform is.



Conparison of typical waveforms used for signal processing between ABB's K-TEK design and waveform with other sensors

LMT Series electronics looks for a voltage above a certain threshold. The threshold is set at half the signal strength. When this voltage threshold is surpassed, we use a zero-crossing detector circuit to stop the timer. The result is a very accurate and repeatable measurement. It is difficult for the competitive unit to reliably detect their signal from the noise baseline. Many field complaints of noise will be the result.

Our high-quality patented sensor design is the reason that we perform to longer sensor lengths and higher temperatures than any other manufacturer. As the magnetic target moves further away from the sensor the signal amplitude diminishes, our high signal to noise ratio allows us to measure to longer probe lengths with a loop powered transmitter.

Signal amplitude also diminishes rapidly with distance from the magnetic target source. Our sensor will work reliably at distances further away from the float chamber than any other. This allows us to separate the sensor from the chamber and use insulation in between to do very high temperature applications.

Benefits of magnetostrictive sensors in water & waste water industry

Magnetostrictive liquid-level sensors have numerous applications within the water and wastewater industry. The basic application of liquid-level sensors is to determine the liquid level in a tank and control when pumps start and stop. The high level of accuracy level sensors allows for the additional application of leak detection, flow rate determination, and adding in specific volumes of chemicals during treatment. Other sensing technologies must be combined in multitude and/or with other products to achieve these applications.

One of the arguments against the magnetostrictive sensors is the price disadvantage when compared to low-cost sensors. But these comparisons do not consider the entire cost of the sensor, including maintenance, setup, calibration, tank downtime and the short life span of other sensors. End-users also fail to consider the number of sensors that can be replaced with just one magnetostrictive sensor due to its high accuracy and temperature output. When considering the entire life cycle of the product and the advantage of increased accuracy, magnetostrictive sensors are cost competitive.

Magnetostrictive technology and the use of advanced microprocessors in the electronics along with powerful algorithms allow for premium accuracy along with the ability to measure multiple floats and temperature. The LMT Series magnetostrictive transmitters are accurate up to 0.01% of scale with a repeatability of 0.005% of full scale compared to 0.15% (or greater) of scale with other level measurement technologies.

Magnetostrictive sensors do not fail due to changing environmental conditions such as foam, mist, gas layering, dust, or temperature change that plague other contact or non-contact sensors. In tanks or reservoirs with multiple liquids of varying densities, multiple floats can be set to each material's density, allowing for multiple level readings with a single sensor which is not achieved using the traditional non-contact technologies.

Clean strong noise free signal in an LMT10 with flexible probe even at 478.88"

No maintenance or calibration is required for the life of a magnetostrictive transmitter. If something does happen to the sensor, i.e. a lightning strike, the entire sensor is field-replaceable without removing the housing pipe or disturbing the application. Please also, note the LMT Series can also be offered with an optional surge protection.

Performance

Customer today are constantly trying to achieve more with less, optimizing every aspect of their businesses for increased output, additional optimization and extra profit. In many cases, the difference between being competitive and being able to make a measurement is razor thin – literally. In an era of technologically advanced “smart” instruments, plants and operators are investing and placing more reliance in device networks which deliver reliable level measurement with a high degree of accuracy. Magnetostrictive level transmitters are capable of measuring with an impressive accuracy of 0.05 inches (1.27 mm). This allows facilities tighter tolerances, optimizing their process operations and generating greater ROI.

Insight through seamless system integration

The advent of smart instruments and digital communication protocols has revolutionized the way setup, configuration, and insight into instrument performance versus process conditions is accomplished. When looking at instruments for your operation, the ability to not only utilize software frame programs such as DTMs or Field Information Manager (FIM), but also the ability to render graphical information directly on the transmitter’s local display, should be of primary consideration. Instruments capable of an enhanced user interface, such as using a full graphic display, as opposed to line by line character displays, have accelerated the path to the next generation of magnetostrictive transmitter. The technicians are efficient with those devices with in-built waveform displays and diagnostics tools to do advanced performance analysis. This affords users greater clarity, decreased time spent “dialing” the instrument in, and help at the instrument when you need it.

Integrated HMI

First magnetostrictive transmitter with TTG (Through The Glass) technology.

- Graphic display with four key operation
- Configuration in hazardous areas without powering off the transmitter

EDD in Handheld terminal

Easy to use in field

– **HART 7 & FF ITK 6.3** communication with
  - HHT 475
  - Emerson AMS
  - Emerson DeltaV , Yokogawa, Honeywell & other systems *

DTM in Control Systems

FDT DTM

Efficient intelligent device management

- Open, standardized interface
- Support full device functionality
- Seamless communication with various host control systems

FDI device packages

Field Information Manager

ABB presents the world's first FDI supported device management tool FIM (Field Information Manager) - Seamless communication with various host control systems

- LMT FDI device packages

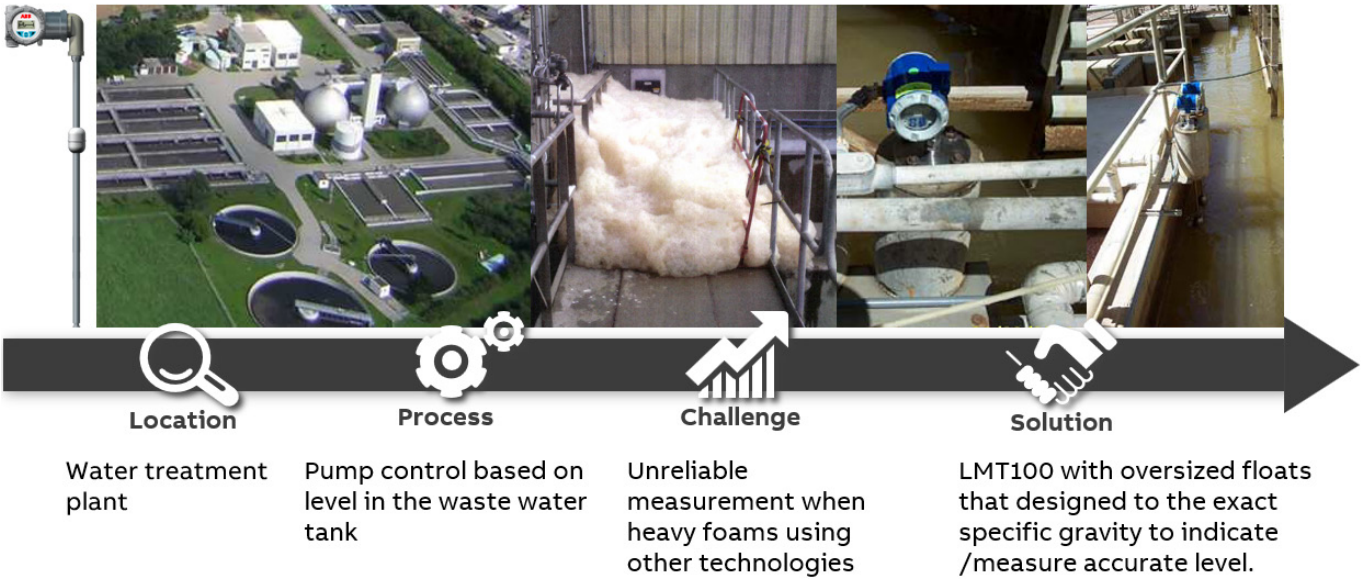
LMT Series: seamless system integration
*All trademarks and logos are owned by rightful owners.

Rugged

The quest for opportunities often dictates that industrial plants and facilities be in extreme environments and remote locations. Having reliable, rugged instruments is paramount to minimize downtime and maximize uptime. Users should look for instruments which have encapsulated circuit boards to prevent precipitation attack, separate moisture-proof compartments to mitigate total electronic failure, truly a dual compartment housing, and environmentally sealed probe/ sensor assemblies.

Superior performance in foam or mist

Traditionally in waste and water treatment, the sensor of choice has been ultrasonic due in part to cost restrictions. Unlike magnetostrictive sensors, it is a non-contact process that performs well with liquid substances. However, the accuracy of ultrasonic sensors falls short when treatment results in foam or mist, especially dense foam that collects on the top of the liquid and cannot be distinguished from the liquid itself.



Level measurement with foam on top layer is made easy with LMT100 transmitters

LMT series transmitter

Flexibility

Historically, magnetostrictive transmitters have been one-dimensional and non-rotatable HMI displays. In some scenarios, this inflexibility caused issues, where heat or excessive vibration affected the ability of the instrument to perform at the level it is capable of. Less tank climbing means a safer situation and less time invested. Users will also appreciate instruments which allow adjustability in crowded industrial plant environments. By allowing users to rotate the LMT Series head by 340 degrees, operators can position the display in such a manner to allow the greatest view of the display and operation of the unit. With an ergonomically designed “true” dual compartment head with HMI display rotatable in increments of 90degress, reading a transmitter, even in the most crowded environments, is a breeze.

Magnetostrictive technology works well in foam or mist situations because the float can be programmed to the density of the liquid, not that of the foam or mist. Other effects from the harsh environment, such as vapor and spray, will not affect the level accuracy because the sensing element is enclosed in a pipe and does not come in direct contact with the liquid.

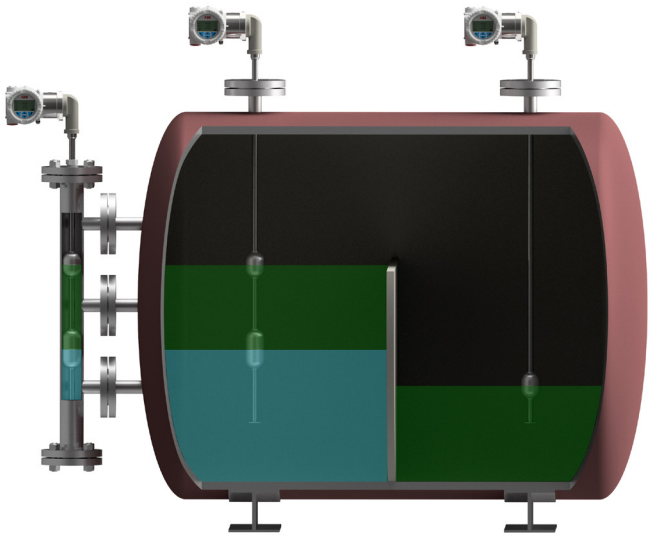
Magnetostrictive liquid-level sensors are ideal for use in waste and water treatment after initial filtering has occurred. As with other sensing technologies, too much particulate in the liquid can negatively affect the sensor readings, as well as clog the float mechanism. These concerns can be addressed with larger internal diameter housings for the float and waveguide(probe) mechanism, so the float can push through the solids.

Knowledge is power

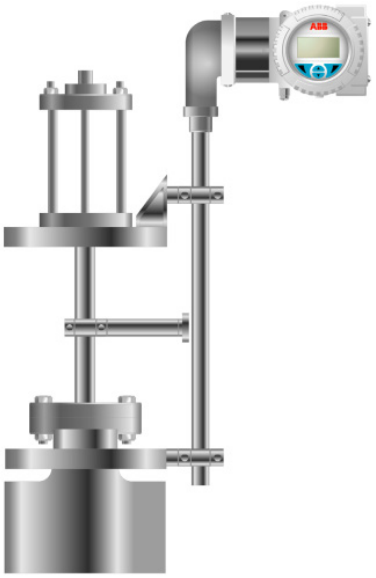
Accuracy, reliability, and ease of use are the leading reasons waste and water treatment plants use magnetostrictive sensors. The most important of these reasons is accuracy, primarily on the clean side of the treatment process where the sensors can be used to measure liquid flow rates as well as level measurements. Some older sensor technologies still rely on ball-float sensors to control valve position in storage tanks. But newer technology comes with smarter controls that can repeatedly and more accurately measure liquid levels.

Potentiometers are traditionally used for position feedback on valves, but that presents mechanical wear and tear breakdown concerns due to the number of moving parts. LMT200 in a Valve positioner configuration becomes a non-contact technology in such applications making it more robust, more accurate and last longer than the contact competition.

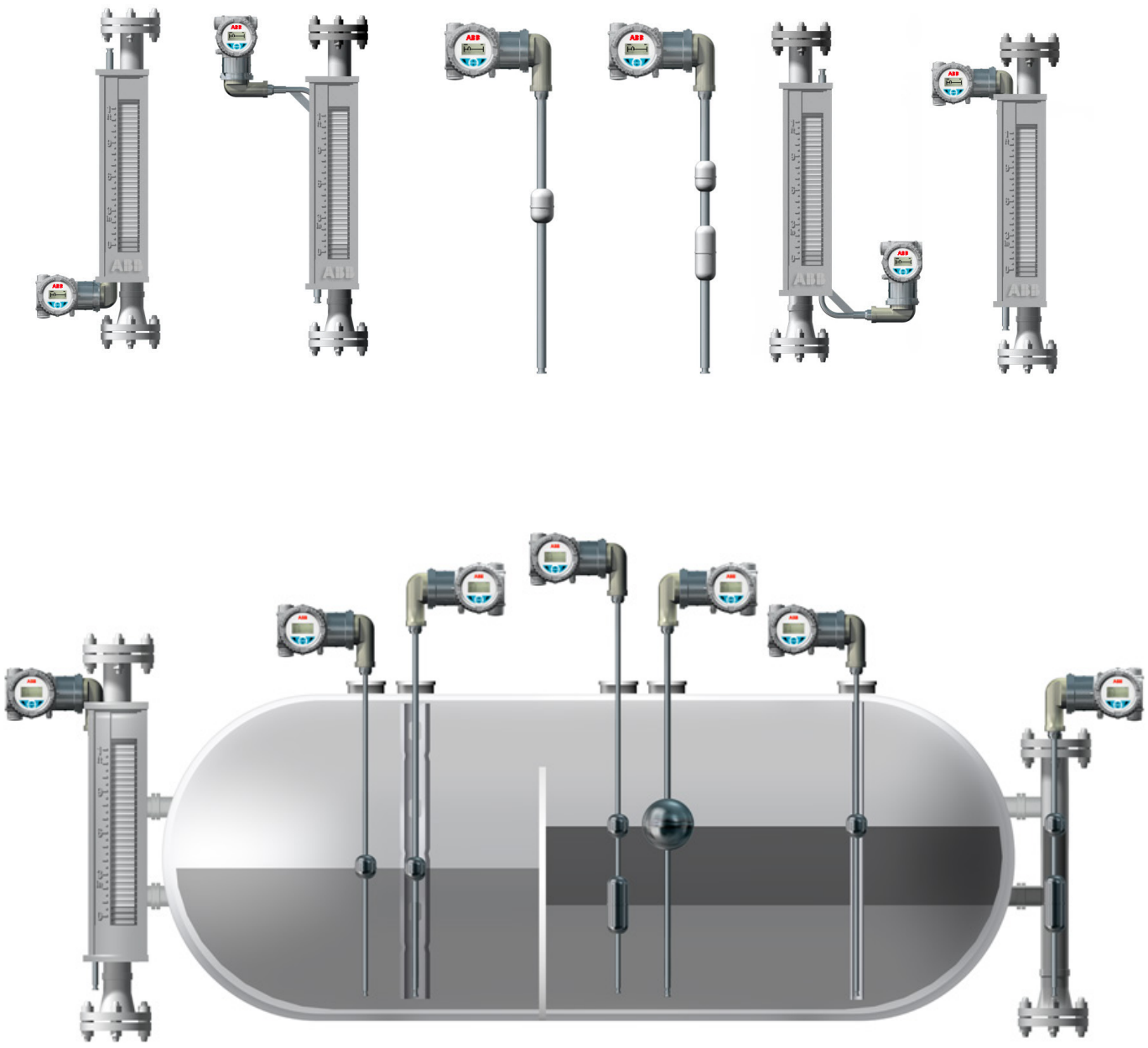
Customers in the waste and water treatment industry rely heavily on sensors of all types to control inventory of supply, treatment chemicals and the end product. In areas where accuracy, reliability and repeatability are paramount, LMT Series magnetostrictive transmitters present the far superior technology. Utilizing all of the benefits of a magnetostrictive sensor can help a facility run more efficiently and save money.



LMT100: direct insertion configuration



LMT200: valve position transmitter



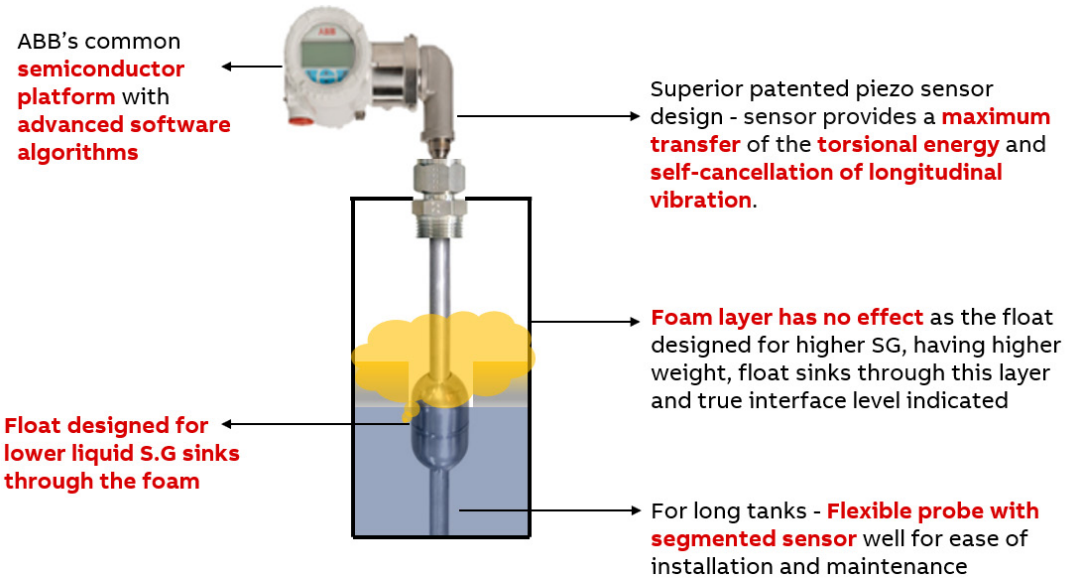
LMT series: easy to apply, powerful results

ABB's LMT Series magnetostrictive transmitter

LMT is available as an insertion style "wetted" transmitter (LMT100) or as an externally mounted, non-intrusive design (LMT200) for use with the market leading KM26 magnetic level gauge or with any other float and level chamber.

LMT Series is a high accuracy magnetostrictive level transmitter for total, interface level & optional temperature measurements, is based upon the magnetostrictive principle. The sensing tube contains a wire, which is pulsed at fixed time intervals and the interaction of the current pulse with the magnetic field created by the magnetic float. This causes a torsional stress wave to be induced in the wire. This torsion propagates along the wire at a known velocity from the position of the magnetic float and toward both ends of the wire. A patented piezo-magnetic sensing element placed in the transmitter assembly converts the received mechanical torsion into an electrical return pulse. The microprocessor-based electronics measures the elapsed time between the start and return pulses and converts it into a 4-20 mA output with digital display, which is proportional to the level being measured.

The magnetic floats are designed and manufactured for each application with a minimum of 75 grams positive buoyancy that shall ensure reliable operation and highest accuracy even in the most demanding situation. The patented piezo sensor and the advanced semiconductor electronics with the most intelligent software algorithm of the LMT Series provides the accurate interface measurement in this critical CS2 level application. The SIL2/3 certified LMT Series with all major hazardous approvals including the ATEX/IECEx, cFMus, INMETRO, EAC, PESO etc. with protection concepts like intrinsic safety and flameproof/explosion proof housing increases the confidence and provides a higher level of safety for the operations. The NAMUR diagnostics and the integrated interactive waveform makes the level measurement easy!



LMT100 direct insertion transmitter to measure accurate level

Key benefits and features of an LMT transmitter

Integrated Interactive Waveform

- Easy for commissioning and/or troubleshooting
- Powerful features with advanced tools for best-in-industry asset optimization
- Threshold, blocking distance, signal polarity and pulse gain adjustments

Adaptable and flexible design to meet any installation challenges

- Elbow design allowing late configuration in mounting orientation
- Rotatable housing and display
- Aluminum or SS dual compartment for increased safety

3-in-1 measurement technology

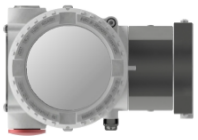
- Single device measures level, interface and temperature
- Most accurate technology for interface measurement
- Wide range of float selection depending on application – no batteries in the float

Meeting NAMUR recommendations

- NE131 NAMUR Standard device- user roles and easy setup
- NE 43 NAMUR Standardization of the signal level
- NE 107 NAMUR Self-monitoring and diagnosis

Digital communications

- DTM, EDDL, FDI and TTG Display - Flexible calibration and verification methods
- HART 7, Foundation Fieldbus* and Profibus* including 4..20mA analog output



Solution for every application

- Direct insertion vs gauge mounted- calibrated and assembled completely from factory
- Wide range probe options and process connection materials
- Works without display, dual compartment Aluminum or SS housing, built-in EMI filter

Common platform across instrumentation

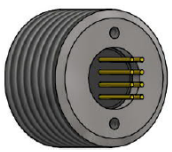
- Common TopWorks platform across instrumentation products
- Simplified operation, maintenance and training – a common user experience!
- First magnetostrictive transmitter with TTG (Through The Glass) technology

Faster measurement when every drop counts

- MCU and FPGA in the sensor board resulting in improved response time
- Improved measuring algorithms and detection techniques
- Advanced semiconductor platform with faster update rate , built-in surge protection option

Advanced on-line verification and diagnostics

- Sensor hardware check including internal connections check and sensor memory failure
- Internal electronics check including user configuration check and operating conditions
- Menu , FDI and DTM based verification



Process Safety

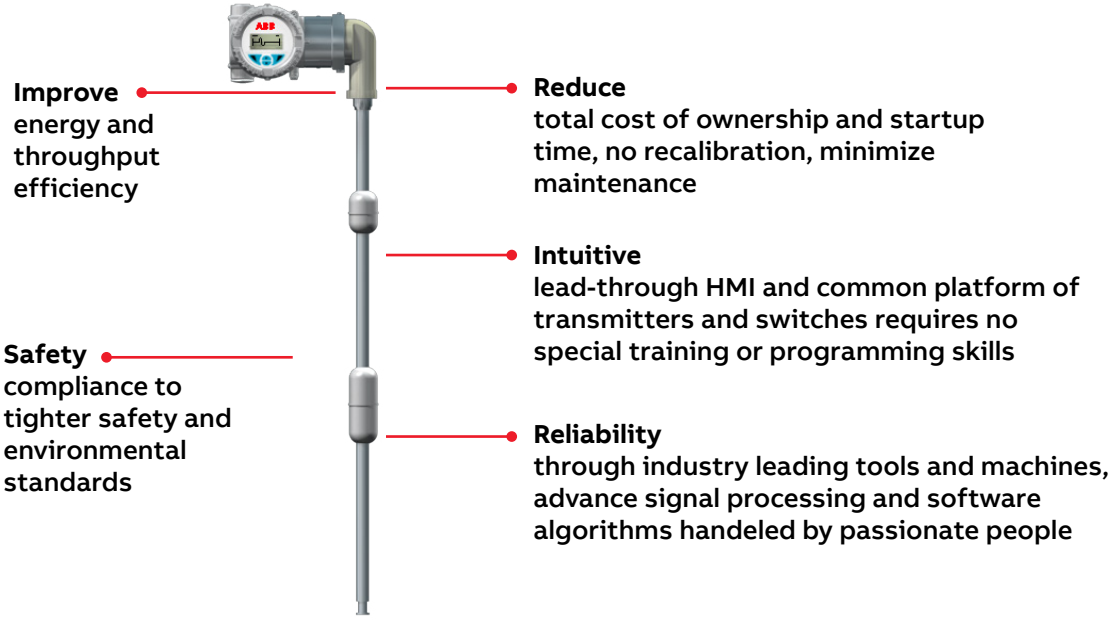
- Secondary process seal for increased safety
- Glass to metal seal tested for more than 2000 psi pressure.
- All probes hydro tested to 1.5 times application pressure

A higher level of measurement confidence

- Hazardous approvals – cFMus, ATEX/IECEx, NEPSI, CRN
- Safety integrity Level 2(SIL2) and Systematic Capability 3 (SC3) according to IEC61508
- Can be used in applications up to SIL2(HFT=0) resp. SIL3 (HFT=1)

The LMT series design has retained the above well proven sensor technology at its core to ensure the accuracy, reliability and superior performance of the magnetostrictive level transmitter while incorporating ABB's latest advanced instrumentation common platform based on state of art semiconductor technology and design.

LMT series – the next generation of ABB's new magnetostrictive level transmitters
Easy to apply. Powerful results



LMT series: a higher level of measurement confidence

Features and benefits

- High accuracy: .01% of Full Scale or +/- 1.27mm
- Easy setup with waveform display - no oscilloscope required
- Not affected by agitation, foam or emulsion layers
- Total and/or interface level measurement
- Temperature range: -195.5 to 426.6ºC (-320 to 800ºF) with options
- Digital communications - HART 7® and FOUNDATION Fieldbus™ ITK6.3.0
- Online self-verification and meeting NAMUR standards
- Global hazardous location approvals (cFMus, ATEX/IECEx, NEPSI, SIL 2/3 capable)
- NAMUR and RoHS compliant

Websites

Web Page | Magnetostrictive level transmitters
https://new.abb.com/products/measurement-products/level/magnetostrictive-level-transmitters

Web Page | LMT100
https://new.abb.com/products/measurement-products/level/magnetostrictive-level-transmitters/lmt100

Web Page | LMT200
https://new.abb.com/products/measurement-products/level/magnetostrictive-level-transmitters/lmt200

Questions & feedback

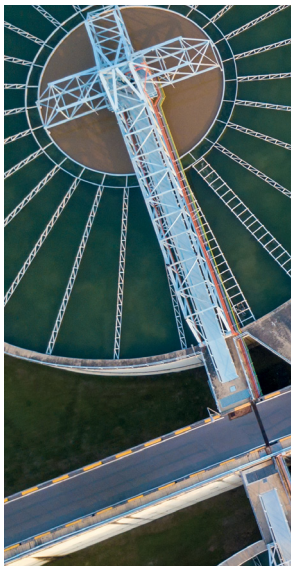
Sreekanth Madhavasherry Sreenivasan (Sree)
Global Product Manager – Level Products
ms.sreekanth@us.abb.com

Sreekanth Madhavasherry Sreenivasan (Sree) the Global Product Manager for the Level Products with ABB Inc, is based out of Baton Rouge, United States of America. Sree has over 20 years of experience in Industrial Process Automation in various roles including Research & Development, Engineering, Commissioning, Field Services and Project Management. He has been with ABB for the last 14 years in Control Systems and Measurement Products businesses within the Industrial Automation Division.

ABB Inc.
Measurement & Analytics
125 E. County Line Road
Warminster PA 18974–4995, USA
Tel: +1 215 674 6000
Fax: +1 215 674 7183

ABB Engineering (Shanghai) Ltd.
No. 4528, KangXin Hwy.
Pudong New District
Shanghai, 201319, P.R. China
Phone: +86 10 64231407
Service: +86 4008209696

abb.com/measurement



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