Electromagnetic meters: the most effective residential meter technology for the Indian market

India has a water distribution problem, brought about by climate change, rapid industrialisation, a growing population and a water supply network that has not kept up with demand. Currently, the water supply is often rationed across different districts by "key turners," who turn it off for hours a day. However, this approach, alongside the condition of the pipework and pumps, produces its own problems for the distribution network in the form of water hammer, pockets of air or vapour, and entrained air in the water (bubbles of air throughout the majority of water in a pipe that often turns the water a milky colour).

Mechanical meters typically used today degrade quickly under these conditions, suffering from clogged jets, pitting of impeller blades and excessive mechanical wear, resulting in a rapid loss of accuracy. So what are the alternatives? The most commonly selected are solid-state meters utilising either ultrasonic or electromagnetic technology.

Ultrasonic Technology

Ultrasonic meters produce very accurate measurements on the test bench, however, certain field conditions affect their performance including turbulence created by upstream valves or elbow joints, temperature, particulates, salinity and viscosity.

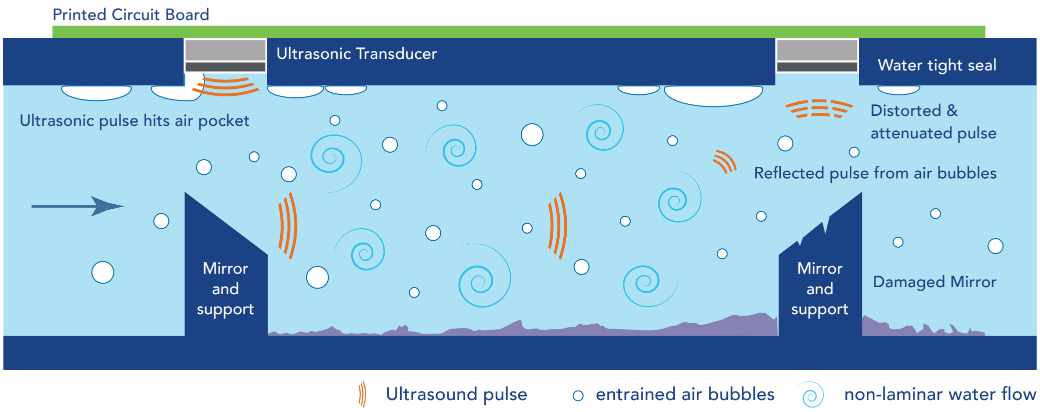
Residential ultrasonic meters measure the instantaneous speed of the water, not the volume directly. They do this by measuring the difference in transit time of sound pulses both with and against the direction of flow at discrete points in time. The speed along the path of the pulses through the water is then calculated. Each manufacturer has a different path profile, but it is important to note that the speed of the pulse only reflects the flow of water along that path and not the average speed through the full cross-section of the meter measuring tube. The speed of pulses along the path and the true average speed of the water flowing through the meter differ because the speed is not uniform over the cross-section. Typically, the flow is faster in the middle than at the edges, and the distribution of speeds across the measuring tube profile changes in a complex way dependent on geometry, flow rate, and water properties such as viscosity, which is a parameter that varies substantially with temperature. Consequently, the raw measurement of time difference is not related in a linear way to average speed, and all ultrasonic meters must use complex, temperature-dependent, calculations to make the conversion. This algorithmic compensation is relatively large and can amount to a variation of up to 30% over a wide range of flow rates. In a laboratory environment, with a new meter, clean water and perfect flow conditions, a good linear response can be achieved, but in the field in a real-world meter installation, it does not take much variance to throw a meter outside the bounds of the finely balanced complex linearization correction.

When subjected to regular periods where the water is turned-off and the measuring tube dries out, sediment can accumulate and narrow the effective diameter, affecting the calculated volume. In addition, installation effects, debris, wear etc. all contribute to cause the meter to misread.

Particulates and bubbles can also be especially problematic, as they scatter and reflect ultrasonic pulses. This typically results in the meter's electronics generating an invalid dataset and it stopping measuring. The result is under-registration and unaccounted-for water. For poorer quality water, these problems can negate any register accuracy advantage over mechanical meters. Also of concern is the potential for degradation or damage to the reflectors. These sensitive and critical components are constantly exposed to the flow and any sediment in the water, and can become heavily worn and scratched over time, further affecting the accuracy of the measurement.

Due to the complex algorithmic processing, pulse generation and associated battery power consumption, ultrasonic meters only take measurements at discrete points in time, so any sporadic or variable flow can lead to aliasing effects – where the output does not reflect the changing flow accurately.

While ultrasonic technology is very effective for measuring larger pipe diameters, problems exist with small diameter pipes, such as those that supply residential properties. In most designs, mirrors and supports are installed in line with the flow to reflect acoustic signals, which then create convoluted flow paths within the meter and disturbances that affect accuracy. This is especially true if the water flow entering the meter has swirl or drifting flow created by multiple pipe bends close to the meter. To prevent such flow effects from occurring, one guideline commonly adopted is to ensure a straight section of pipe feeds the meter and its length be 5 or even 10 times, the bore diameter. However, in practical deployment it will be necessary to fit the meter close to multiple pipe bends in order for it to fit into a suitable position.



Cross section of an ultrasonic meter showing causes of mismeasurement with time & conditions

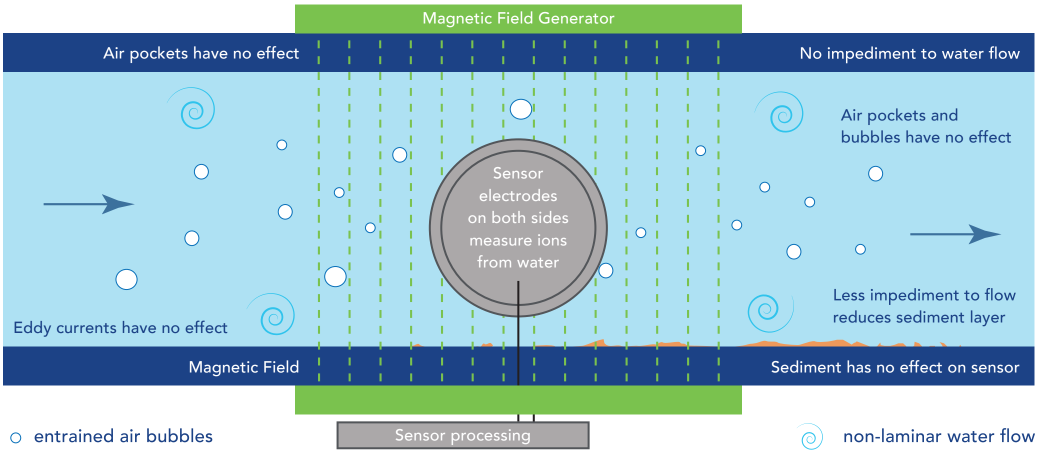
Electromagnetic Technology

Electromagnetic metering is a long-established method of flow measurement for larger diameter pipes and when the technology is adapted to residential meters, it offers several advantages over other static meter technologies. Such meters measure the velocity of the water based on the voltage generated across a pair of electrodes when water passes through an adjacent magnetic field in a section of insulating pipe, and then calculate an average volume of flow by multiplying by the cross-sectional area of the pipe over very short intervals of time. This calculation is linear over a much wider range than any other flow metering technology, and does not require processor intensive algorithmic correction and temperature compensation unlike ultrasonic meters. In addition, the high rate of sampling ensures that there is no detrimental aliasing effect, so the output measurements are correct even for rapidly changing flow characteristics.

Older and larger electromagnetic meters used standard electromagnets at the core of the meters primary sensor. However, this approach is wasteful of power, as electricity has to flow continuously to create, maintain and reverse the magnetic field. This design restriction initially limited electromagnetic technology use in metering applications to larger C&I and industrial meters, where mains power was more readily available. The key breakthrough occurred when magnets were developed which had sufficient "remanence" to sustain a magnetic field without a constant flow of electricity, but whose magnetic field direction could still be flipped to ensure that old charged ions were released from the relevant electrode after each measurement cycle removing any spurious build-up of charge on the electrodes. The design of the electrodes is also important, as is the material used to form the measuring tube, to ensure very low noise properties. This is because more power is required to overcome noise effects, so the greater the noise, the greater the power required to generate a strong magnetic field to direct the charged ions in the water to the electrodes to overcome the spurious noise.

In addition, the standard circular measuring tube used in some older electromagnetic meters does not allow for an even distribution of magnetic field, and is therefore more sensitive to the issues of "swirl" and velocity gradients in the water flow. The solution to this problem is very straightforward, as changing the geometry of the measuring tube from a circular profile to a rectangular profile, negates these detrimental effects and provides the correct average speed irrespective of the properties of the water flow.

Both the use of remanence-effect magnetic technology and a rectangular tube profile innovations are used in the design of the Sensus iPERL® electromagnetic residential meter, ensuring the flow measurement is inherently linear and requires no recalibration throughout its 20-year lifetime. It is also fundamentally immune to real-world field disturbances: temperature variation, vibration, particulates, air bubbles, installation orientation and variable flow patterns have no effect on the meter's accuracy. In addition, there are no impediments within the pipe to disturb the water flow, or sensitive reflectors and other components that can be subsequently degraded by any contaminants it contains. This means that uniquely for residential meters, iPERL electromagnetic residential meters can be installed right next to valves, T-connectors and elbow joints that are typically found in meter pits and residential block basements, without requiring unjointed sections of pipe before and after the meter to ensure accurate measurements are obtained. This makes the choice of iPERL the low-risk choice, as any plumbing work necessary to meet the straight lengths runs in pipes requirements of ultrasonic and mechanical meters can substantially add to their overall true cost, and failing to do so can lead to them providing misleading measurements, whose measurement accuracy can vary without any discernible or predictive pattern.



Cross section of an electromagnetic meter showing no disruption to flow and immunity to misreading due to air bubbles and particulates

Electromagnetic: The best residential metering technology for the Indian market

Indian water utilities require a smart meter technology that is reliable and dependable throughout its long life, in what can be a very demanding environment. Simplicity of installation and ongoing operation is also important, saving rework and unnecessary maintenance costs.

Sensus iPerl - residential electromagnetic meter

Utilities that use electromagnetic water meters can expect the following benefits:

- High degree of accuracy over the lifetime of the meter
- Ability to measure with great accuracy at very low flow
- Better high-flow durability even in the presence of particulate contamination
- No restrictions on installation orientation
- No effects from flow perturbations
- Not affected by field disturbances–vibration, temperature, particulates, air bubbles
- No algorithmic linearization and correction
- Continuous measurement for great accuracy with intermittent/sporadic flow
- Reliable detection of empty pipe and backflow conditions
- No components within the pipe to disturb the flow pattern or be exposed to damage

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