HiTECH Technologies, Inc.

PENETRATING PULSE TECHNOLOGY

A Hitech safe, economical, non-contact, non-invasive, "through the wall" digital technology for accurate level measurement.

1. Overview

For many years the processing industry has been seeking a safe, economical, non-contact, non-invasive, "through the wall" technique for measuring or detecting liquid levels. This is now possible with the unique digital **PPT** (**penetrating pulse technology)**.

This is the measurement principle employed in the SONOMETER and SONOCONTROL series of **"through the wall"** liquid level measurement instruments supplied by HiTECH Technologies, Inc. of Yardley, PA 19067 (www.hitechtech.com). Some of the major advantages of this technology are listed as follows:

- External mount (outside of the vessel) non-intrusive and non-contact Acoustic Energy (AE) Transducers
    - ➢ No physical contact with the liquid
    - ➢ Absolutely no possibility of leakage or contamination
- Measurement is independent of
    - ➢ Pressure in the vessel
    - ➢ Vapor above the liquid
    - ➢ Foam on the surface of the liquid
- Measurement unaffected by liquids that are:
    - ➢ Chemically toxic
    - ➢ Aggressive or corrosive
- Easily retrofits existing vessels
    - ➢ No welding
    - ➢ No pressure vessel re-certification

2. Principle of Operation

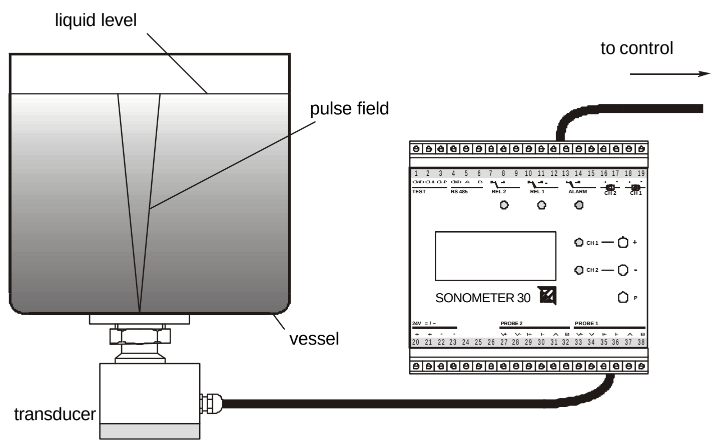
The fundamental measurement principle is simple and easy to understand. A special acoustic energy (AE) transducer, mounted in direct contact with the outside vessel wall emits a short "penetrating pulse" of acoustic energy. The pulse penetrates the vessel wall and eventual lining and travels through the liquid. Depending on the operating mode chosen, the pulse either is reflected back to the transducer or detected by another transducer and the transit time is measured. Together with other parameters about the application the actual level in the vessel is computed.

While the same basic "penetrating pulse" technique can be applied for continuous level measurement, SONOMETER, and point level detection, SONOCONTROL, in each case its implementation is somewhat different as described in more detail below.

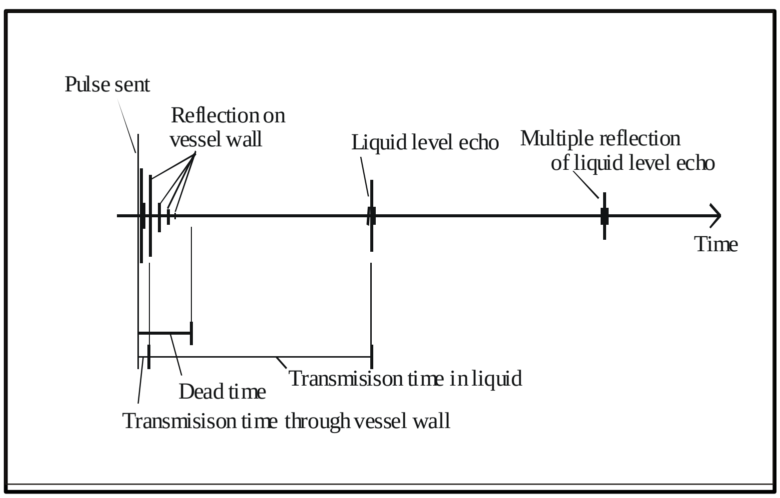
A. Continuous Level Measurement

A special acoustic energy (AE) transducer, mounted in direct contact with the outside vessel wall emits a short “penetrating pulse” of acoustic energy. This pulse is transmitted “through the vessel wall” of the bottom of the vessel into the liquid. The pulse is then reflected back to the transducer from the liquid/air or liquid/liquid interface.

From the time required for the pulse to travel to the liquid surface and back, the actual level is computed. The computation is based on a sophisticated algorithm built into the instrument. It combines the pulse transit time with other parameters, such as process temperature, material characteristics, wall thickness, vessel shape, etc., to accurately calculate the liquid level.



A graphic representation of the pulse vs. time is shown below.



A part of the transmitted pulse causes multiple reflections from the inside wall of the vessel. The transducer detects these reflections as early echo. These wall echoes are an interference that must be eliminated, as they obscure the level reflection. This is achieved through the application of a “dead time” during which any echo is ignored. This means that levels cannot be measured all the way down to zero level.

A mean (average) of the measured transmission times is calculated. A tolerance band “window” (expected range) is placed around the calculated transmission time mean. Only measured values inside the expected range are included in the calculation of further mean values.

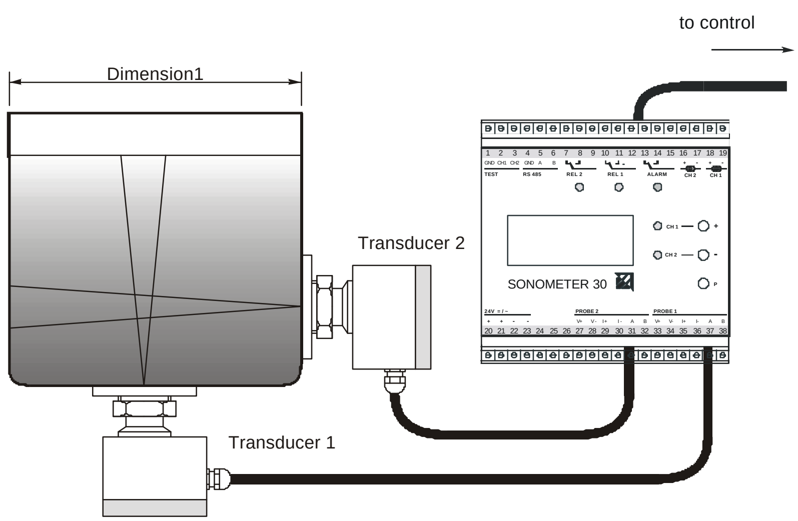
From the calculated mean transmission time, the level in is calculated in engineering units (millimeters) on the basis of the speed of sound. As the speed of sound depends on the kind of liquid, concentration and temperature, a sound velocity speed correction can be programmed for a specific liquid or a temperature compensation may be required if the operating temperature changes substantially.

Compensation with integrated temperature sensor

Compensation with integrated temperature sensor
If the vessel always contains the same liquid, changes of the speed of sound due to temperature can be eliminated by a first approximation. This can be done with transducers having an integral temperature sensor. However, inaccurate measured data are still possible because of the layers of different temperature in the liquid.

Compensation with reference measurement

If the vessel is filled with another liquid, the concentration or chemical composition of the liquid changes, and the acoustic transmission characteristics may change also. In applications of this type, the second measuring channel of a dual channel SONOMETER is used to monitor the acoustic characteristics of the liquid as reference measurement. This measurement is used with the first channel to calculate the actual level. The transducer in the second channel must be mounted to ensure that the sound signal travels horizontally through the vessel.



Engineering unit conversion
Percentage level is the basis for all subsequent calculations and outputs. To convert the liquid level from percentage to volume the vessel shape and its actual dimensions are required. At set-up, these are programmed into the SONOMETER. This results in the output being scaled in preferred units of measure, such as gallons, cubic feet, etc..

Time response of measurement
The response time of the instrument can be adjusted by programming the time intervals in which the output results are updated. This will impact all the measured values; the local display panel, the current outputs and the switching signals.

B. Point Level Detection

In point level, as in continuous level, a special acoustic energy (AE) transducer, mounted in direct contact with the outside vessel wall is used to emit a short "penetrating pulse" of acoustic energy. The pulse penetrates the wall of the vessel, enters and propagates in the liquid, however, depending on the particular measuring mode being employed, the reflected pulse may be received as an echo by the same transducer, or can be detected by a separate transducer mounted on the other side of the vessel.

After triggering, the received pulses are referenced to a time window (gate) and the result is output. A micro-controller takes over all control functions.

Implemented in the controller software is point level algorithm together with a pre-set threshold value. This effectively suppresses all faults. Besides, intolerable jitter of the switched output can be prevented by a programmable time integration function.

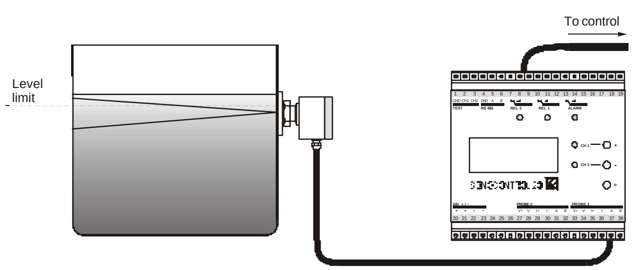
The controller supports several operating modes:

- Pulse-echo mode with one sensor
- Pulse-echo mode with two sensors
- Pulse transmission with two sensors
- Dying out pulse with one sensor

These measuring methods are described below, with reference to typical applications.

Pulse-echo method with lateral transducer attachment

The transducer is attached laterally, at the height of the level switch point, on the outside of the vessel. It sends a brief pulse through the wall of the vessel. If the vessel is filled with liquid to the specified level, the pulse travels through the liquid and is reflected by the opposite wall of the vessel and the transducer receives the reflected echo. If no liquid is present at this level, there is no echo. The presence or absence of echo at the expected point is evaluated by the link-up with the time window (gate) and the instrument outputs the corresponding signal.



Applications

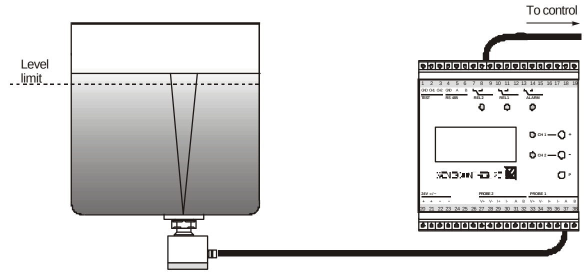
- Vessels whose walls are parallel with each other, or pipes (reflection at the rear wall)
  Metal, glass: approx. 8" to max. 66 feet. Plastic material: approx. 2" to max. 66 feet
- No agitator or internal fittings at height of level detection point
- Pure (low-absorbing) liquids, free of bubbles and solids particles
- Ice level monitoring in ice silos of flake ice makers in refrigeration systems
- Detection of chemical reactions such as crystallization or polymerization
- Pig detection in pipelines carrying liquids

Pulse-echo method with vertical sensor attachment

The transducer is attached externally on the underside of the vessel so that the pulse is directed vertically upward (max 2-3° off the vertical line are tolerated). The pulse is reflected at the surface of the liquid and returns to the sensor. The gate setting is now conveniently used to set the monitored filling level. The temperature drift of the velocity of acoustic transmission and the time needed for the pulse to return as echo must be taken into consideration.

Applications

- Cost-effective substitute for continuous level
- Vessels with height from approx. 2” to 66 feet
- No agitator or internal fittings in pulse path
- Liquids, free of bubbles and solids

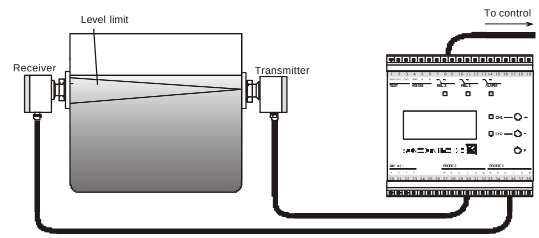


Pulse transmission

For pulse transmission, two transducers are attached externally to the side of the vessel at opposite locations. One functions as the transmitter sending out penetrating pulses; the other transducer is the receiver detecting the pulse delayed by the time needed in transmission. This method requires a dual channel SONOCONTROL.

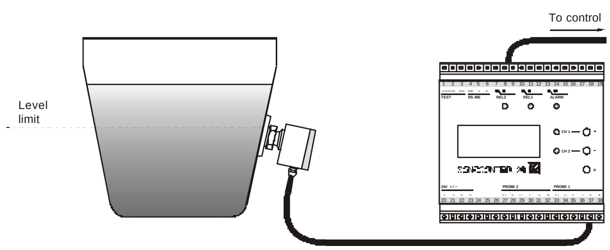
Applications

- Sound-absorbing liquids
- Level in pipes (special angle adapters)
- Vessels of up to 66 feet diameter



Dying down

Dying down involves the evaluation of the decay of the sensor after emitting the ultrasonic pulse and the subsequent reflections in the vessel wall. The sensor is attached externally to the side of the vessel on the same level as the liquid limit.



If no liquid is present at this level, the metal wall is not attenuated and vibrates for a long time under the impact of the ultrasonic pulse. If liquid is present at this level, this vibration is eliminated.

Applications

- Metal vessels with a diameter of more than 8” and wall thickness of 0.08” to 0.8”
- Sound-absorbing liquids (e.g. with gas bubbles, contaminants such as solid particles)
- The liquid must not leave any residue on the wall of the vessel.
- No reflecting wall or internal fittings in the vessel

C. **Acoustic Energy (AE) Transducers**

One major breakthrough that has enabled the successful application of the penetrating pulse technology to liquid level measurement was the development and design of the AE series of Acoustic Energy transducers.

Transducer selection is dependent upon a number of factors including:

- the geometrical shape of the vessel
- the material of which the vessel is made
- the nature of the monitored liquid

Along with these proprietary transducers, the appropriate mounting configuration and acoustic coupling between the transducer and vessel wall are critical to accurate level measurement. Therefore the following points should be observed when mounting a transducer.

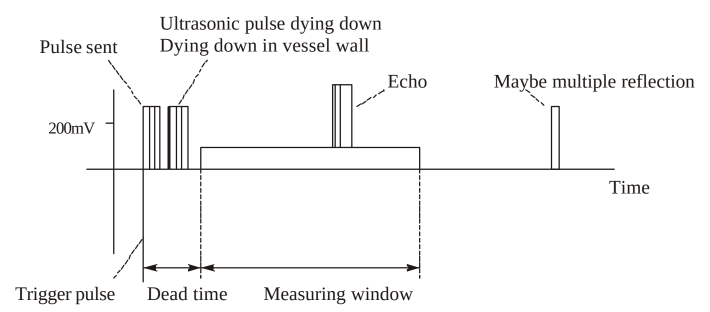
1. Mounting surface where the transducer is attached must be extremely plane and smooth.
2. Paint or surface treatment are detrimental and should be removed from the mounting face.
3. Mounting surface must be flat and free of peaks, to avoid transducer damage at installation.
4. Use only the factory supplied acoustic mounting compound between transducer and vessel.
5. Attachment surface unevenness can be <u>somewhat</u> compensated by the mounting compound.

Because there are numerous application considerations required to select the most appropriate transducer and mounting configuration, we strongly recommend that you discuss your specific application in detail with one of our application engineers, who are trained in penetrating pulse technology and can make the correct recommendation for your specific application.

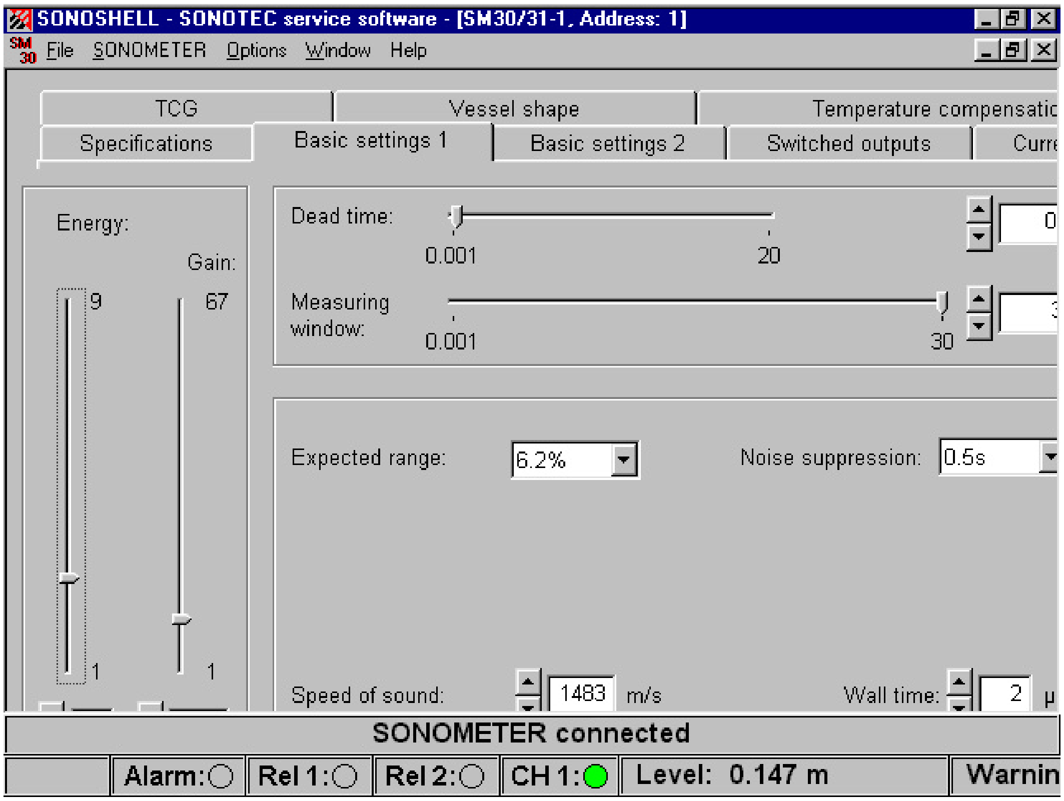
3. <u>Startup</u>

Until recently an oscilloscope was required for the initial installation, start-up and programming.

However, with the introduction of the new SONSHELL software, installation and start-up of penetrating pulse technology systems have been greatly simplified due to the built-in oscilloscope function in the new SONSHELL software and the need for an additional oscilloscope has been eliminated.



Graphic view of oscilloscope set-up screen
that SONSHELL software simulates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Noise suppression:
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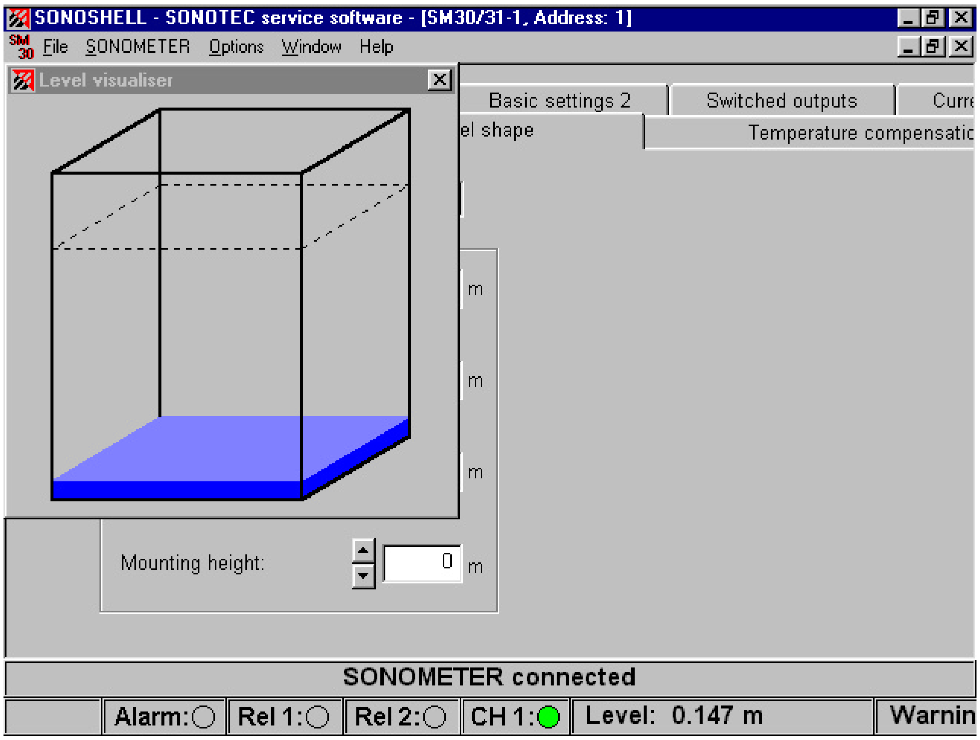

The new SONSHELL software operates under Windows 95, 98 and 2000 and now only a notebook computer is required for programming up to 99 parameters and start-up.

4. Conclusion

Although there are numerous factors involved in properly applying this technology, the ability to measure liquid level:

- without physically penetrating the vessel
- without contaminating the liquid
- without sensor wear or maintenance
- without concern for pressure in the vessel,
- without concern for vapors above the liquid
- without concern for foam on the liquid surface
- without concern for the toxicity or aggressive nature of the liquid
- without limitations for wall thickness below 2” (51 mm)

are rapidly making penetrating pulse technology a very desirable level measurement alternative, particularly in the Biotech, Chemical, Food & Beverage, Liquefied Gas, Oil Pipeline and Pharmaceutical industries. A major chemical manufacturer recommends its manufacturing facilities to replace existing nuclear and radar level systems with the Sonometer and Sonocontrol level systems to completely eliminate the possibility of leakage as well as bureaucratic night-mares with licensing and wipe tests, etc.

This technology is especially suitable for Propane/Butane vessels as well as any other liquefied gas due to the easy installation without any welding or drilling, either with a special glue that bonds the stainless steel mounting bracket in less than five minutes or with the strap-on stainless steel tapes.

In addition to all known and conventional applications HiTECH Technologies specializes in customizing their level technologies for some very unusual applications and here is one example:

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: ED01-0230-4 Date: August 13, 2001 Photo by: Carla Thomas
The Helios Prototype aircraft at approximately 10,000 feet flying above cloud cover northwest of Kauai, Hawaii.

The flying wing in the picture is named Helios. This project is funded by the NASA ERAST program, but all the design, development and production is by AeroVironment. AeroVironment is using customized HiTECH/SONOTECH PPT systems for their level instruments to measure among other liquids De-Ionized water levels. The ultimate goal with this unmanned flying wing is that it will take off and then fly for 6 months in the stratosphere performing surveillance equal to a satellite but at a much lower initial as well as operating cost. During the day Helios will be powered by the sun and during the night it will maintain altitude with the help of fuel cells allowing the wing to remain in the air for six months. Detailed technical information is restricted.

For further information on the PPT technology and any other specific applications, please call Leif Lindvall, HiTECH Technologies, Inc., Yardley, PA 19067 at 215. 321. 6012 or log on to our web site www.hitechtech.com or via email at DrLevel@DrLevel.com.