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Design of Low Power Radar Level Sensor with Improved Accuracy Rate for Sodium Level Detection in PFBR

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ABSTRACT

The objective of this project is to design a non contact RADAR liquid level sensor combines high accuracy with low sensitivity to variations in air temperature and humidity but differs from other liquid level sensors in utilizing an unconfined radar beam aimed vertically downward to the liquid surface. The most notable advantage of radar sensors is their ability to measure liquid level remotely with no parts directly in contact with the liquid column. This non contact radar based liquid sensor is used to monitor the level of sodium liquid which is used as a cooling medium in nuclear combustion chamber of Kalpakkam nuclear power plant, which results in a significant reduction in system hardware components and overall installation and maintenance requirements.

INTRODUCTION

Level sensors detect the level of substances that flow, including liquids, slurries, granular materials, and powders. The substance to be measured can be inside a container or can be in its natural form (e.g., a river or a lake).

The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point.

The selection criteria include the physical: phase (liquid, solid or slurry), temperature, pressure or vacuum, chemistry, dielectric constant of medium, density (specific gravity) of medium, agitation (action), acoustical or electrical noise, vibration, mechanical shock, tank or bin size and shape. Also important are the application constraints: price, accuracy, appearance, response rate, ease of calibration or programming, physical size and mounting of the instrument, monitoring or control of continuous or discrete (point) levels.

Measured radar data were analyzed for possible sources of systematic measurement uncertainty (error) including sensor height above liquid (air gap), air temperature and surface waves. A radar sensor measures liquid level by propagating electromagnetic energy with an antenna. The microwave frequencies used for tank radar systems typically range from 10 to 24 (GHz).

Mutual Inductance Sensor:

The MI type level sensor has certain advantages over the resistance-type level detector. The MI type sensor works on non-contact principle whereas the resistance type sensor works based on its contact with sodium. Besides, MI type is kept in a well or pocket, and so maintenance of the sensor becomes easy. Also the level

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sensor as such is not required to be mounted in the vessel at the time of integrity test of the vessel after fabrication at the manufacturer's shop. Also the non-wetting of sodium with senor does not affect the operation of MI type sensor.

Classification:

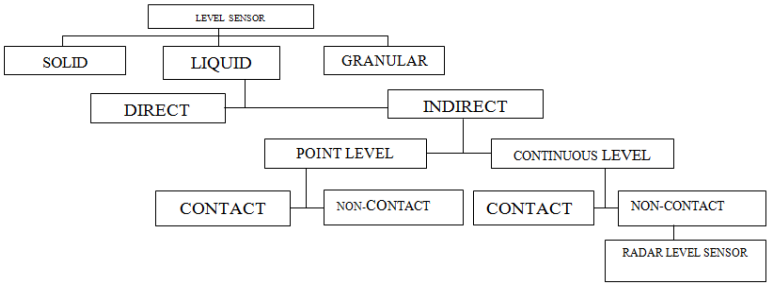

Fig. 1: Classification Of Level Sensors.

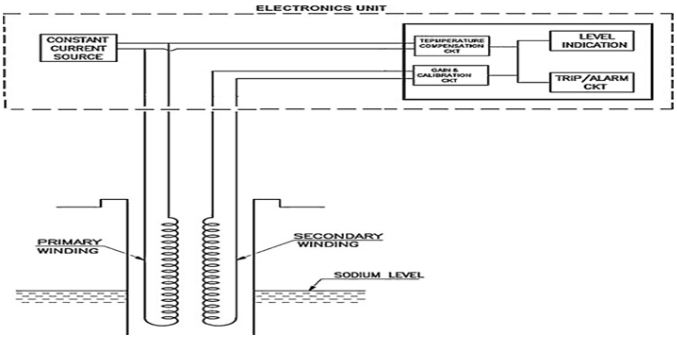

Fig. 2: MI Type Level Probe.

Non-Contact Sensor:

The proposed Radar level sensor non-contact sensor and it does not make any direct contact with the liquid surface. This sensor is fitted on the top of the roof and then, the transceiver converts this signal electrically into distance/level and presents it as an analogue and/or digital signal. The transducer's output can be selected by the user to be directly or inversely proportional to the span.

Pulsed radar:

Pulse radar operates purely within the time domains with millions of pulses are transmitted every second. This pulsed radar technology instead of continuous wave radar technology helps to reduce the power consumption of the sensor.

Short pulses, typically of millisecond or nanosecond duration, are transmitted and the transit time to and from the target are measured. The pulses of pulse radar are not discrete mono pulses with a single peak of electromagnetic energy, but are in fact a short wave packet.

The number of waves and length of the pulse depends upon the pulse duration and the carrier frequency that is used. These regularly repeating pulses have a relatively long time delay between them to allow the return echo to be received before the next pulse is transmitted. The inter pulse period (the time between successive pulses) t is the inverse of the pulse repetition frequency fr or PRF. The pulse duration or pulse width, τ, is a fraction of the inter pulse period. The inter pulse period t effectively defines the maximum range of the radar.

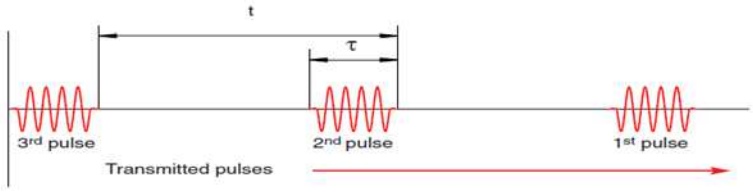

Fig. 3: Basic Pulse Radar.

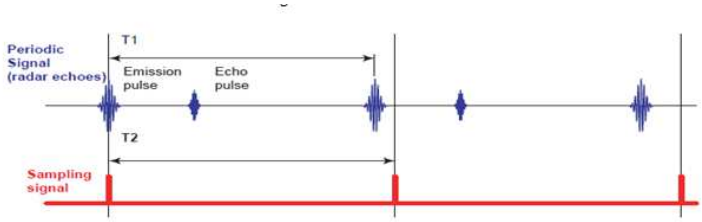

Fig. 4: Sequential sampling of pulse radar echo curve. Millions of pulses per second produce a periodically repeating signal. A sampling signal with a slightly longer periodic time produces a time expanded image of the entire echo curve.

Radar level probe:

Radar level probes are available commercially from various manufacturers for liquid level measurement. These level probes are for high temperature application also (up to 400 deg C). They are rugged and compact. All of them are available from abroad. There are no manufacturers from India. They are not providing source of design. Verification and validation cannot be done on that. Their design reliability cannot be figured out. Due to these reasons safety and security of the level probe is not guaranteed. For maintenance, trouble shouting is also one of the problems. Their obsolescence will be an issue for long time support. For use in safety critical system of reactors, they may not be feasible. For high volume of application, it will not be cost effective also. So there is a requirement for indigenous development of radar level probe.

Challenges:

Internal piping, deposits on the antenna, multiple reflections, or reflections from the wall can interfere with the proper operation of the radar sensor. Other sources of interference are rat-holing and bridging of solids, as well as angled process material surfaces that can reflect the radar beam away from the receiver. The sensor uses pulses to track any target material from the tip of the antenna to the bottom of the tank. Their power, pulse widths, and sensitivity depend on the distance of the target from the antenna and the dielectric constant of the reflecting material. A special time transformation procedure is required to enable the fast short time pulses to be measured accurately. Pulse radar has a regular and periodically repeating signal with a high pulse repetition frequency (PRF).Using a method of sequential sampling, the extremely fast and regular transit times can be readily transformed into an expanded time signal.

Block Diagram:-

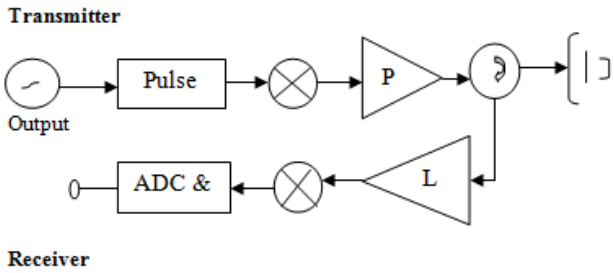

Fig. 5: Block diagram of Radar level probe.

Performance evaluation:

The design of non contact RADAR liquid level sensor for sodium level detection using Model Sim Xilinx simulator produces the measurement of liquid sodium level by having preset reference value. The average transmission output of Radar level probe is only 3.6 μW. In practice this low power is fully shielded in metal vessels. As a comparison: The transmission output of a mobile telephone is about 2 watts.

Temperature and Pressure Ranges of Radar Sensors:-

●Surrounding temperatures on housing:
-40°C up to +70°C.
●Temperature range on flange:
-40°C up to +150°C.

●For high-temperature radar:
-60°C up to +400°C.
●Pressure: From vacuum up to 160 bar.

Stroboscopic Method:

Pulse radar has regular and periodically repeating signal with high pulse repetition frequency (PRF). Using a method of sequential sampling, the extremely fast and regular transit times can be readily transformed in to an expanded time signal. The principle can be achieved with the use of stroboscopic method which is used to slow down the fast periodic movements of the rotating or reciprocating machinery. According to this method, all echoes (real and false) are separated in time by introducing the delay between the periodic pulses and it improves the accuracy rate of the liquid measurement. This allowed multiple echoes caused by reflections from the parabolic tank roof to be easily separated and analyzed.

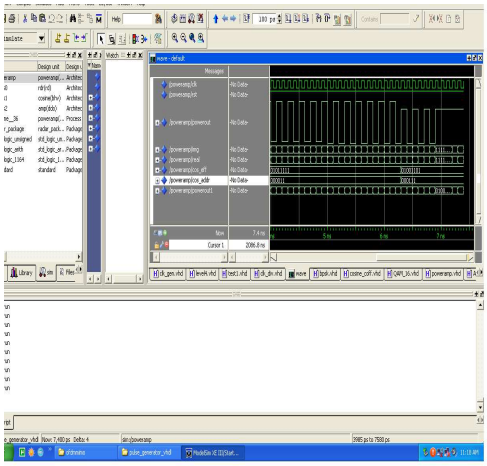

Fig. 6: Generation of Radar Pulses.

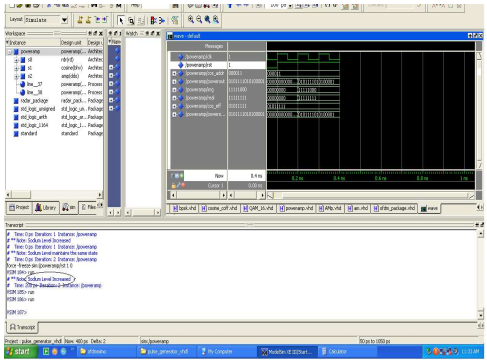

Fig. 7: Final Output For Sodium Level Detection.

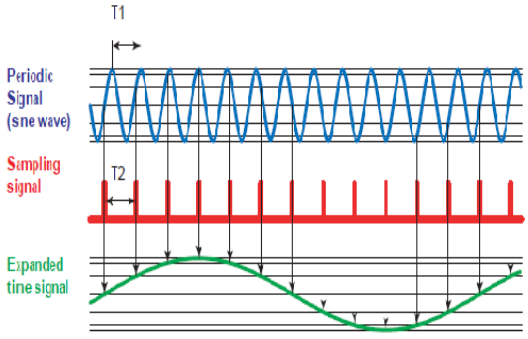

Fig. 8: Principle of sequential sampling with a sine wave as an example.

The principle of sequential sampling with sine wave is given as example, the sampling period T2 is slightly longer than the signal period, T1. The output is a time expanded image of the original signal. Part of the pulse radar transmission pulse is used as a reference pulse that provides automatic temperature compensation within the microwave module circuits. The echoes derived from the pulse radar are discrete and separated in time.

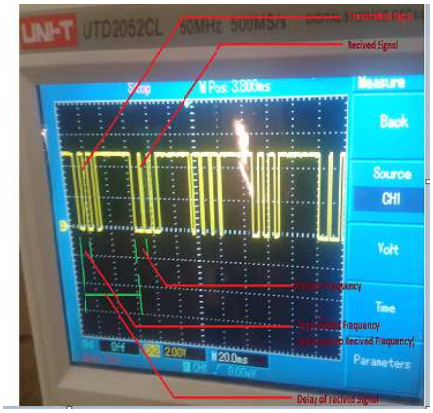

Fig. 9: Transmitted & Received Signals on Scope.

Conclusions:

The radar pulse were generated since Radar sensor is frequency based sensor, the frequency difference between the transmitted and received signal is proportional to the liquid level measured by using Model Sim Xilinx simulator. For final output, the threshold value for liquid sodium level is fixed, then by observing the pulse we can detect the level of the sodium maintains the same state or it sodium level is increased. Pulsed radar technology used in this project provides the reduction of power consumption taken by the sensor by sending pulsed radar instead of continuous radar technology. The accuracy level can be increased with the help of stroboscopic method approach.

REFERENCES

John, D., Boon and Robert M. Heitsenrether and Winston M. Hensley, III- Multi-Sensor Evaluation of Microwave Water Level Measurement Error.

Vital Track, A Doppler Radar Sensor Platform for Monitoring Activity Levels. Gabriel Reyes1, Di Wang, Rakesh Nair, Changzhi Li, Xiaolin Li, and Jenshan Lin.

IEEE, 2012 Smart radar sensor for speech detection and enhancementYing Tian, Sheng Li , Hao Lv, Jianqi Wang, Xijing Jing

Accuracy of Radar Water Level Measurements .Janice M. Fulford, Lee W. Ester2 ,John W. Heaton3.

Vijaya Mohana Rao, P. and J.I. Sylvia IGCAR-Specifications for Mutual inductance type Continuous level probe for Sodium