Signal-Conditioning Electronics

for Discrete Capacitive Sensors

NASA's Marshall Space Flight Center has developed and patented a novel system for sensing changes in electric capacitance. This system is being used by NASA to detect the levels of liquid rocket propellants in storage tanks. It provides improved performance over existing technologies due to its ability to eliminate the effects of stray cable capacitance.

Benefits

This technology provides improved performance over competing liquid-level sensors at similar cost and of similar size. Specific benefits include the following:

- Eliminates effects of cable capacitance
- Can be implemented with a self-calibrating feature
- Uses industry-standard VMEbus.

Commercial Applications

This technology is useful in a wide variety of applications, particularly for sensing the level of liquid or material in a tank. It is ideal for users who need to monitor available liquid or detect leaks. The lone requirement is that the liquid or material be dielectric. Potential application areas include

- Petroleum storage tanks
- Chemical storage tanks
- Grain elevators.

National
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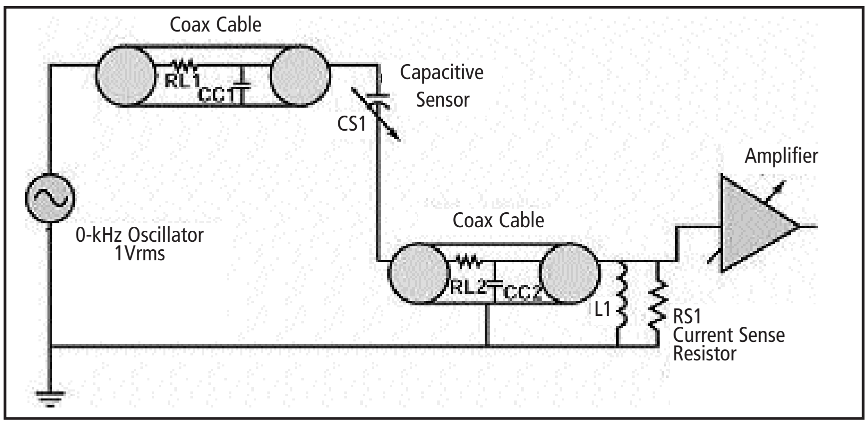
The Technology

This newly developed instrument, uses the resistance to alternating current running through a device to measure variances in capacitance. This device detects the presence or absence of dielectric material between the plates of a capacitor. The technology was developed to improve sensing of levels in liquid oxygen tanks for space propulsion systems. Low voltage and wide capacitor spacing ensure safe operation in a combustible liquid-filled environment.

Previously, capacitance-measuring instruments were designed to measure one or more quantities (amplitude, frequency, or phase) that make up an alternating current waveform. However, these instruments were plagued by stray capacitance, solder traces, and connectors. This device allows engineers to apply Ohm's law to make an impedance measurement of the sensor by detecting the voltage across the sensor and the current running through the sensor.

An inductive circuit is in parallel with stray capacitance from the sensor cable, connectors, and solder traces on the printed circuit board within this device. This unique design puts the inductor and stray capacitance (including cable capacitance at the end of a 300- to 400-ft [90- to 120-m] cable) in a parallel resonant circuit that completely nullifies the effects of stray capacitance.

The signal-conditioning electronics for this instrument are shown in the abbreviated schematic below.



The sensor is excited by a 1-V (rms) sine wave operated at 10 kHz. The signal is then sent through a coaxial cable, which shields the signal from any outside disturbance, to the capacitive sensor. The signal is picked off from another coaxial cable to the right of the sensor and sent to the instrument in a series across the resistor. The resistor prevents current flow across the sensor from loading down the signal. The resulting signal is then fed to an amplifier, and the amplified signal is fed to a comparator circuit. If the voltage on the non-inverting terminal of the comparator exceeds the trip voltage setting on the inverting terminal, the output of the comparator goes high, turning the transistor ON, indicating that the capacitive plates are covered by the dielectric material. An OFF transistor reading indicates the sensor is no longer exposed to the dielectric material.

Partnership Opportunities

This technology is part of NASA's technology transfer program, which seeks to stimulate commercial use of NASA-developed technology. MSFC has been awarded U.S. Patent No. 6,227,046 for the technology, and companies are invited to explore licensing the technology. NASA is flexible in its agreements—opportunities exist for exclusive, nonexclusive, or exclusive field-of-use patent licensing.

For More Information

If you would like more information about this technology or about NASA's technology transfer program, please contact:

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