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A Magnetic Field Response Sensor for Measurement of Liquid Levels

NASA's Langley Research Center (www.larc.nasa.gov) recently reported on the development of a sensor that allows wireless measurement of the level of liquid in closed, electrically-conductive containers such as metal fuel tanks. Magnetic Field Response sensors utilize the absorptive properties of a tuned circuit near the resonant frequency. A simple swept oscillator excites the circuit via magnetic coupling to the inductor, and records the amplitude response versus frequency. The frequency where the response is minimum—due to maximum coupling to, and absorption/radiation by the tuned circuit—corresponds to the value of the tuning capacitance. Thus, a variable capacitance and a fixed inductor are the only components necessary for a passive sensor.

The variable capacitance can be obtained using several structures. Figure 1 shows two of them, an interdigital capacitor and a linear parallel strip capacitor. Immersion in a liquid changes the dielectric constant, which changes the capacitance.

The interdigital structure can have a higher capacitance value than the simpler linear capacitor, resulting in a lower resonant frequency with the same inductor, and generally allowing better measurement resolution. The capacitor can be fabricated on the same substrate as the inductor for a one-piece sensor, or it can be a separate piece, connected by wires to the inductor. This latter arrangement allows installation as shown in Figure 2, placing the capacitor inside the container, while the inductor remains outside where it can be readily accessed by the reader unit. Connection is made by wires that pass through a liquid-tight feedthrough.

The capacitor and inductor must have a spacer between them and the conductive surface of the container to reduce coupling effects. The spacing only needs to be sufficient to permit good coupling to the reader unit. Even if the component values are affected by the conductive container wall, secure mounting will result in stable values and repeatable measurements.

The work is one of several applications developed at NASA Langley using this sensor technology.

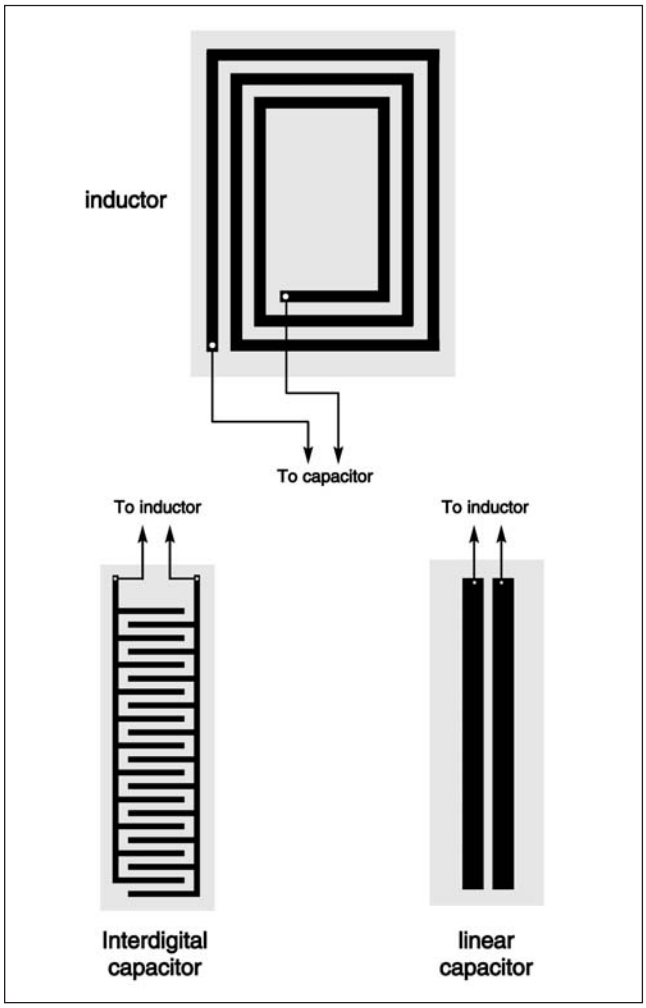

Figure 1 · Printed inductor and capacitor elements for a magnetic field response sensor.

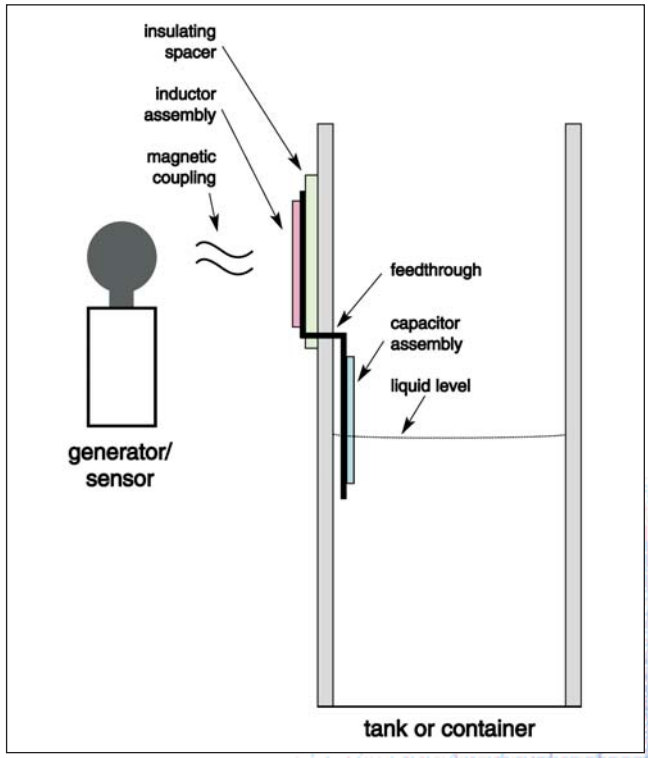

Figure 2 · Mounting method for measurements in a conductive-wall container.