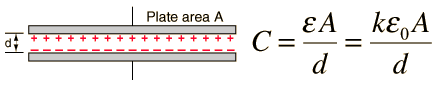
Theoretical Design

The basic design of the water-conductivity sensor resembles a parallel-plate capacitor. The sensor consists of two legs, each made out of a conductive material coated in a thin, uniform layer of insulating material. This insulating material isolates the conductive material of the sensor from the water. The legs of the sensor are immersed in the water to be tested, and the capacitance of the sensor will vary depending on the conductivity of the water.

In their simplest form, capacitors consist of a sandwich of two electrical conductors with a dielectric substance between them. When a voltage difference is exerted between the two conductors, potential energy is stored in the capacitor in the form of a static electric field between the conductors as opposite charges accumulate on the conductors. The dielectric material serves to prevent charges from passing between the conductors.

In an ideal parallel-plate capacitor, the conductors take the form of two metallic plates with an insulator between them. The energy storing capability (capacitance) is described by the formula:

 Where capacitance (C) is determined by the area of the conductors (A), the distance between them (d), and certain electrical properties of the substance between them (permittivity, ε).

In this conductivity sensor, A and d remain constant, while ε varies with the conductivity of the water. In reality, the situation is slightly more complex because of the presence of insulating material on the legs of the sensor between the conductive elements and the water. Thus, there are two ε’s; one describing the permittivity of the insulating coating, and another describing the permittivity of the water. However, since the insulating coating ideally does not vary in permittivity over time, the capacitance of the system should vary only in relation to the conductivity of the water.

Capacitance of this sensor can be measured by imbedding the sensor in an electrical circuit colloquially called a “tank circuit.” This circuit consists of one or more capacitors and inductors connected together such that the assembly behaves as an electrical resonator. Such a circuit will have a characteristic resonant frequency (or multiple frequencies) determined by the values of the components in the circuit. In this case, the capacitance of the sensor will vary relative to the conductivity of the water between its legs, which will in turn vary the resonant frequency of the tank circuit.

Tank circuits have a characteristic frequency response; that is, a sinusoidal signal applied as an input to the circuit will produce an output dependent on the frequency of the input signal. Thus, if the frequency of the input signal is varied while the input magnitude stays constant, both the magnitude and frequency of the output signal will vary. Conversely, if the frequency and magnitude of the input signal both are held constant but the resonant frequency of the tank circuit changes, the magnitude of the output from the circuit will also change.

In summary, the design of this sensor is such that, if a sinusoidal signal (or signals) with static frequency and magnitude is fed to the sensor, the sensor will produce an output signal with a magnitude proportional to the conductivity of the water between the legs of the sensor.