Dielectric constant of air

One limit to the maximum detection distance is due to the change of the dielectric constant ε_r of air. At extreme distances, target movement is indistinguishable from ε_r variations. This section calculates the effect of environmental variations on maximum detection distance.

The dielectric constant of air changes slightly with pressure, temperature, and humidity. At standard temperature and pressure, the dielectric constant changes with temperature as 2×10^{-6}/°C for dry air, increasing to 7×10^{-6}/°C for moist air. At 20°C, the dielectric constant change with relative humidity is 7×10^{-5} for an RH change from 40 to 90%. A change of pressure of 1 atm changes the dielectric constant by 10^{-4}. Over a distance of a few tens of meters and a time span of a few hours, the expected variation of these parameters might be typically as shown in Table 6.3.

Table 6.3 Change in dielectric constant of air

	Change	Coefficient	Effect
Temperature	5 °C	5 ppm / °C	25 ppm
Relative humidity	10%	1.4 ppm / %RH	14 ppm
Pressure	0.05 atm	100 ppm / atm	5 ppm
Total			44 ppm

The total of the atmospheric variations above will cause the 1.78 pF capacitor of eq. 2.13 to change by 44 ppm, or by 7.8×10^{-5} pF. Using this new value for C and recalculating the limit of detection of the 16 mm circular plate proximity detector (eq. 6.3) we arrive at

$$L = 0.08 \quad \text{m}$$

so the maximum detection distance has been cut down by a factor of 20 by these environmental effects. A bridge circuit which uses an airgap capacitor as a reference will compensate for these atmospheric variations, but becomes sensitive to temperature and RH gradients, and constructing an air-spaced capacitor with less than 44 ppm drift is not a simple project.

Local motion

Another limit to the sensitivity of proximity detectors is the effect of small movements of local objects which change the mutual capacitance between the measuring electrodes. This motion may be temperature-induced. The temperature coefficient of aluminum, brass, and steel is in the range of 10–20 ppm/ °C. Depending on the orientation of nearby conductors relative to the measurement electrodes, the effect of a nearby conductor moving only a few μm could considerably decrease detection distance.