Dielectric Terminology Glossary

How Piezoceramic Element Works

When a piezoceramic element is stressed electrically by a voltage, its dimensions change. When it is stressed mechanically by a force, it generates an electric charge. If the electrodes are not short-circuited, a voltage associated with the charge appears.

Relationships between applied forces and the resultant responses depend upon:

1. the piezoelectric properties of the ceramic;
2. the size and shape of the piece;
3. and the direction of the electrical and mechanical excitation.

A piezoceramic is therefore capable of acting as either a sensing or transmitting element, or both. Since piezoceramic elements are capable of generating very high voltages, they are compatible with today's generation of solid-state devices - rugged, compact, reliable, and efficient.

Coaxial Resonator

A component in which standing waves are established in a ceramic coaxial line, short- or open-circuited at the end, remote from the drive. These resonators can be either 1/4 λ wavelength or 1/2 λ wavelength type.

Dielectric Dissipation Factor (tanδ)

The dielectric dissipation factor (dielectric loss factor), tanδ , for a ceramic material is the tangent of the dielectric loss angle. tanδ is determined by the ratio of effective conductance to effective susceptance in a parallel circuit, measured by using an impedance bridge. Values for tanδ typically are determined at 1 kHz.

Dielectric Constant (K)

The relative dielectric constant is the ratio of the permittivity of the material, ε, to the permittivity of free space, ε0, in the unconstrained condition, i.e., well below the mechanical resonance of the part.
Equation: K = (permittivity of material ε / permittivity of free space ε0)

Global Positioning System (GPS)

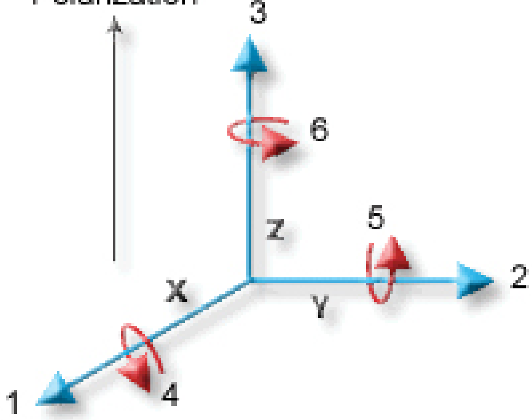
An unmetallized dielectric ceramic which functions similarly to a mechanical resonant cavity at micro-wave frequencies, but has a greatly reduced size because of its high dielectric constant.

Spurious Mode

Output from a dielectric resonator caused by a signal or signals having frequencies other than the resonant frequency desired. The presence of higher resonant modes close to the resonant frequency of the principle mode will interfere with filter or oscillator performance.

Piezoelectric Charge Constant "d"

The piezoelectric constants relating the mechanical strain produced by an applied electric field are termed the strain constants, or the "d" coefficients. The units may then be expressed as meters per meter, per volts per meter (meters per volt). **Equation: d = (strain development / applied electric field)**



Directions of forces on piezoelectric element

It is useful to remember that large dij constants relate to large mechanical displacements which are usually sought in motional transducer devices. Conversely, the coefficient may be viewed as relating the charge collected on the electrodes, to the applied mechanical stress. d33 applies when the force is in the 3 direction (along the polarization axis) and is impressed on the same surface on which the charge is collected. d31 applies when the charge is collected on the same surface as before, but the force is applied at right angles to the polarization axis.

The subscripts in d15 indicate that the charge is collected on electrodes which are at right angles to the original poling electrodes and that the applied mechanical stress is shear. The units for the dij coefficients are commonly expressed as coulombs/square meter per newton/square meter.
Equation: d = (short circuit charge density / applied mechanical stress)

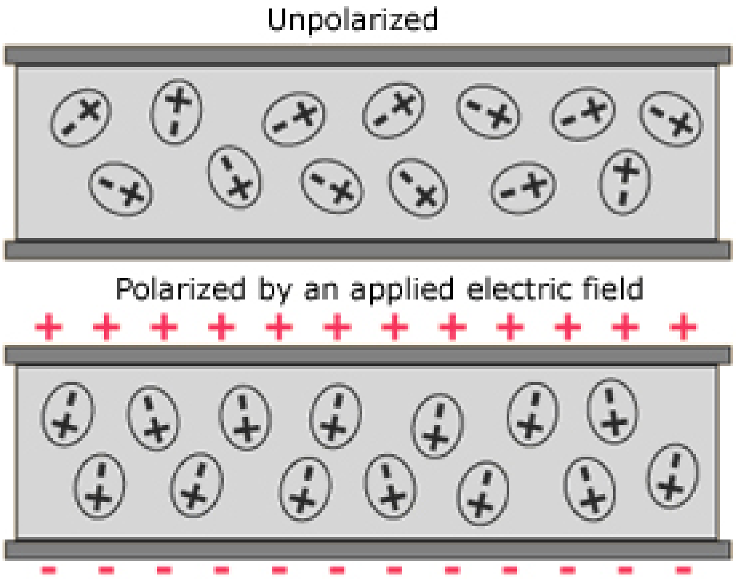
When the force that is applied is distributed over an area which is fully covered by electrodes (even if that is only a portion of the total electrode) the units of the area cancel from the equation and the coefficient may be expressed in terms of change per unit force, coulombs per newton. To view the dij coefficients in this manner is useful when charge generators are contemplated, e.g., accelerometers.

Piezoelectric Voltage Constant "g"

The piezoelectric constants relating the electric field produced by a mechanical stress are termed the voltage constants, or the "g" coefficients. The units may then be expressed as volts/meter per newtons/square meter. **Equation: g = (open circuit electric field / applied mechanical stress)**

Output voltage is obtained by multiplying the calculated electric field by the thickness of ceramic between electrodes. A "33" subscript indicates that the electric field and the mechanical stress are both along the polarization axis. A "31" subscript signifies that the pressure is applied at right angles to the polarization axis, but the voltage appears on the same electrodes as in the "33" case.

A "15" subscript implies that the applied stress is shear and that the resulting electric field is perpendicular to the polarization axis. High gij constants favor large voltage output, and are sought after for sensors. Although the g coefficient are called voltage coefficients, it is also correct to say the gij is the ratio of strain developed over the applied charge density with units of meters per meter over coulombs per square meter.



Polarization of Dielectric

Polarization of Dielectric

If a material contains polar molecules, they will generally be in random orientations when no electric field is applied. An applied electric field will polarize the material by orienting the dipole moments of polar molecules. This decreases the effective electric field between the plates and will increase the capacitance of the parallel plate structure. The dielectric must be a good electric insulator so as to minimize any DC leakage current through a capacitor.

Voltage Standing Wave Ratio (VSWR)

The traditional way to determine the reflection coefficient is to measure the standing wave caused by the superposition of the incident wave and the reflected wave. Traditionally the voltage is measured at a series of points using a slotted line. The ratio of the maximum divided by the minimum is the Voltage Standing Wave Ratio (VSWR). The VSWR is infinite for total reflections because the minimum voltage is zero. If no reflection occurs the VSWR is 1.0. VSWR and reflection coefficient are related as follows: **Equation:** $\mathbf{VSWR = (1 + \rho) / (1 - \rho)}$

Quality Factor ($Q = 1 / \tan\delta$)

The figure of merit for assessing the performance or quality of a resonator, the Quality factor Q, is a measure of energy loss or dissipation per cycle as compared to the energy stored in the fields inside the resonator.