

Choosing the correct trimmer capacitor

Solid-dielectric and air-dielectric piston trimmer capacitors can be designed in two ways: rotating piston or non-rotating piston. Primary differences between the two types are the method of sealing, r.f. current flow, ease of adjustment and tuning linearity. The rotating piston design needs a separate removable cap to seal the unit. The non-rotating design uses an internal O-ring seal.

Method of sealing

The rotating piston design requires a separate seal cap with an internal washer that must be manually installed prior to any post-installation cleaning procedure; removed for trimmer tuning then re-installed again after tuning. Compounding these labor intensive operations are reliability concerns due to loose caps that may leak or even fall off and short circuit exposed terminals.

Non-rotating pistons employ an internal o-ring that provides a dynamic 40 p.s.i. seal against process and atmospheric contamination. Since the o-ring is captivated inside the trimmer body, no external no external sealing devices are necessary and unrestricted tuning may be accomplished at any time.

R.F. current flow

Current flow in the rotating piston design is along the adjustment screw and through the lubricated mating bushing threads. This tenuous contact results in the potential for increased tuning noise, e.s.r. and lower Q due to this higher contact resistance.

Non-rotating pistons utilize special sliding contacts to conduct r.f. current ; the adjustment screw is not in the current path and serves only to mechanically adjust the piston position. This design innovation results in lower tuning noise, lower e.s.r. and higher Q. at the expense of higher manufacturing costs.

Tuning linearity

Rotating piston designs rely on a very short threaded segment on one end of the piston to hold dynamic concentricity with the stator plates. Any machining irregularities on either surface tend to cause orbital eccentricities that result in non-linear tuning and reversals.

Non-rotating piston designs have mating lands and grooves to capture the piston for precise alignment within the tuning bushing. This design guarantees up to a ten fold improvement in tuning linearity over rotating piston designs.

Choice of dielectrics

Among the dielectrics used in modern piston trimmer capacitors are: air, sapphire, glass, quartz and PTFE. Since each has it's own inherent list of advantages and disadvantages, the astute engineer has the ability to optimize tuning choices.

Sapphire is extremely well suited for use in trimmer capacitors because its dielectric constant does not change with frequency, and its low dielectric loss tangent is extremely stable (less than 0.0003 to 10 GHz). Chemically inert, sapphire is totally moisture resistant, and mechanically strong. The Q of sapphire trimmers can be more than 4,000 with capacitance ranges up to 8 pF and temperature coefficients as low as ± 50 ppm/ $^{\circ}\text{C}$.

Another type of trimmer that was recently introduced uses PTFE as a dielectric filler between the plates of an air dielectric-type trimmer. PTFE is an excellent dielectric material that makes the trimmers built with it well suited for high-voltage and high-reliability applications. PTFE dielectric prevents ionization by filling spaces between the trimmer electrodes with a solid medium rather than air. Ionization plagues air dielectric trimmers especially in high-altitude, space, and high-voltage applications.

Solid dielectric trimmers eliminate potential microphonics even under the most adverse conditions of shock and vibration. They have temperature coefficients below ± 100 ppm/ $^{\circ}\text{C}$. Maximum capacitance of this type of PTFE dielectric trimmer is up to 55 pF with voltage ratings as high as 2000 V dc.

For even higher-voltage applications (up to 15 kV), there is a larger plated PTFE dielectric-type trimmer on which metal is plated directly on the PTFE dielectric to form a substrate-like bond. These types are available in capacitance ranges from 1 to 10 pF up to 5-85 pF.

Higher voltage requires larger sizes and these parts are more expensive than the standard low voltage trimmers.

When it comes to choosing a trimmer, there is a wide variety of trimmer types available today, which makes picking the right one for a given application both a challenge and an opportunity. When deciding on a trimmer, designers must consider all of their requirements, such as capacitance range, package style, resolution, SRF, and Q and working voltage. They then must look for the most cost-effective solution for their application.

Although the trimmer capacitor selection process can range from simple to complicated, the price versus performance trade-off is usually a logical place to begin. The next decision is determination of necessary degree of tuning resolution as defined by capacitance change versus tuning screw rotation. The 2 primary choices range from $\frac{1}{2}$ turn to greater than 100 turns. If a half-turn is all that is required, then stick with the low-cost half-turn trimmers provided all other factors are satisfactory. If tuning accuracy is critical, then the multi-turn piston trimmer capacitor is the way to go.

Capacitance range is next. Always choose a trimmer with enough range to meet any possible tolerance variations in your circuit but take care not to over do because tuning resolution will suffer. Then consider size, Q and mounting style while always trying to find the lowest cost solution at each decision point.

In short, trimmers may not be the most glamorous. electronic components in the designer's stable, but they are certainly some of the most versatile. They allow a range of circuit-tuning adjustments to be made during production as well as after the product has been manufactured. This characteristic makes trimmers unique among other circuit-tuning methods such as laser trimming of chip capacitors. The ability to re-tune after the initial setting can reduce overall manufacturing costs by retrieving otherwise detuned circuitry. .

There is a wide variety of trimmers available today to serve any likely application, from high- voltage types to tiny SMT devices for compact products. The designer's task is to choose the optimum one for the application.