

CAPACITORS FOR RF APPLICATIONS

A brief overview of currently available devices in an electronic component group whose significance for telecommunications and radio circuits is often grossly underestimated.

Today's electronic component market offers a vast range of capacitors for use in high-frequency circuits. Many design engineers and home constructors are, therefore, often faced with a real dilemma when it comes to choosing and mounting the right capacitor in the right place. In many cases, parts lists of construction projects will provide the value of the capacitor, but references like 'PTFE foil trimmer', 'coffin-type leadless ceramic', 'ceramic NP0', 'tubular', and many more, may not be familiar.

Ceramic capacitors

These small devices are probably the best known types for use in RF circuits because they are cheap and have been with us for many years. The lead spacing is usually 2.5 or 5 mm for the modern disc and plate types, of which some have rims below the capacitor body to facilitate their fitting at a uniform height above the PCB surface (Stettner's 'Hot Pants™' types). Values range from 0.68 pF to 100 nF. Types with values greater than about 47 nF usually have a working voltage of 63 V, or 12 V for sub-miniature types. Tubular capacitors are rapidly becoming obsolete and are not recommended for new designs.

The blue 'Sibatit' types from Siemens are often used as decoupling capacitors in video and digital circuits because they line up nicely with DIL ICs, require little

space and offer excellent RF and pulse characteristics. Sibatit capacitors must not be confused with MKT types, which are also blue but use a multi-layer polythelate dielectric structure. Popular values of Sibatit capacitors are 10 nF, 47 nF and 100 nF. The terminal pitch is usually 5 mm, and the maximum working voltage 63 V.

Unfortunately, the value of the common ceramic plate and capacitor is often not immediately evident from the print on the device, so that a capacitance meter is required in case of doubt. Space restrictions do not allow, say, 220p or 220pF to be printed on the capacitor body. Instead, the value is printed as, for instance, 'n22', avoiding problems with a (tiny) decimal point, or confusion with trailing zeroes. Similarly, a value of, say, 47 nF, is often printed as '473', meaning '47' with three zeroes: 47,000 pF.

The temperature coefficient of a ceramic capacitor is indicated by the coloured band at the top of the body. Although many manufacturers deviate from the standard, a zero-coefficient, or 'NP0', capacitor is generally marked with a black band. NP0 capacitors are often used in oscillators to prevent temperature changes causing frequency drift.

Filters

Polystyrene and polypropylene capaci-

tors are fine for filters in audio and video equipment and radio circuits (but not RF power amplifiers) for up to 30 MHz. Also known as 'styroflex' types (a trademark of Norddeutschen Seckabelwerke AG, of Nordenham, Federal Germany) manufactured by Siemens, these capacitors are usually supplied with relatively thin axial leads, although radial, plastic encapsulated types are also available. The black or red band on the white, greyish or silver-coloured capacitor body indicates the terminal that is connected to the outer foil layers. If applicable to the circuit, this terminal must be connected to ground to provide a screening function. Special polystyrene types are available as parallel pairs for calibration purposes. These capacitors have a non-standard, but accurately defined, value at a tolerance of 0.5% or better, which makes them eminently suitable for calibration of inductance and capacitance meters.

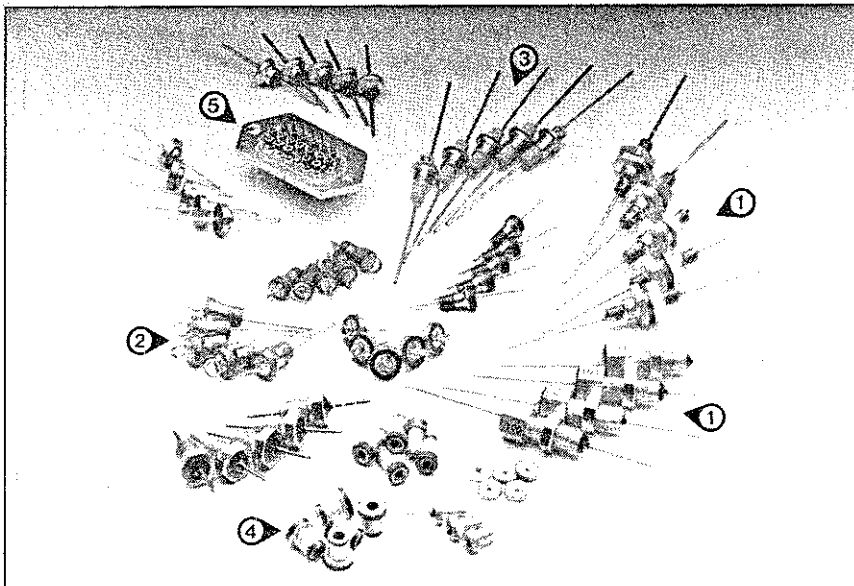
The differences between polystyrene and polypropylene capacitors mainly entail the loss factor, permissible humidity, self-resonance frequency and insulation resistance. For most practical applications, however, polystyrene and styroflex types are all right. The version with the thin axial leads will be superseded by plastic encapsulated radial types because these have a fixed size and lead spacing and are, therefore, easier to handle in automated PCB solder machines.

Trimmers

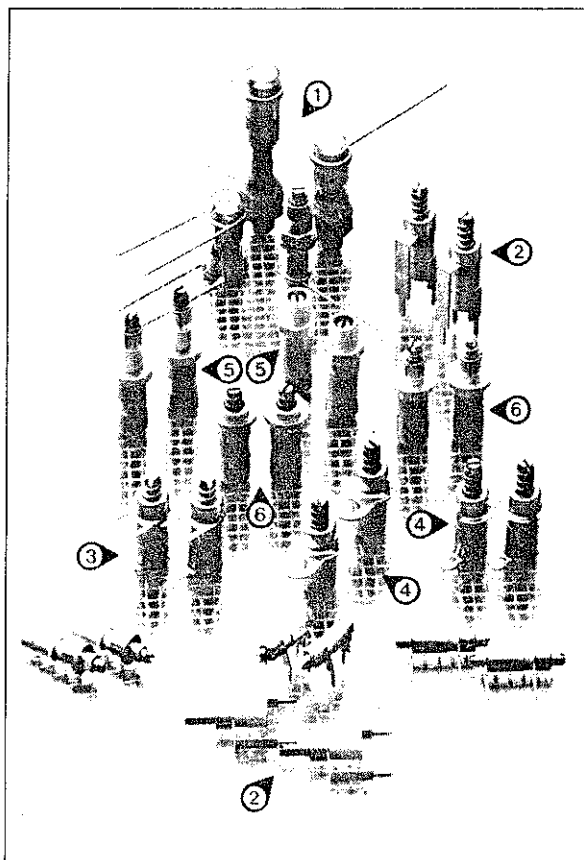
Compression and mica foil trimmers are generally not used at frequencies above 30 MHz or so because their losses increase rapidly, and the Q (quality) factor drops to an unacceptable level. Further, their minimum capacitance is not low enough for tuned circuits in the VHF, UHF and SHF range.

Ceramic trimmers suitable for frequencies up to 500 MHz are available up to a capacitance of 100 pF. The maximum capacitance is, however, nearly always less important than the minimum capacitance, which is typically 15 to 30% of the maximum value.

PIFE foil trimmers are often preferred to ceramic types because the insulating foil layers between the rotor and the stator are transparent. This allows the set capacitance to be deduced readily from the position of the grounded rotor blades with respect to the stator. The foil trimmers from Valvo (Philips Components) are colour-coded to indicate the maxi-



Feedthrough capacitors: ① screw-type heavy duty; ② solder type with eye; ③ axial solder type; ④ low-capacitance feedthrough; ⑤ multiple feedthrough



Tubular trimmers for use in SHF circuits. ① glass dielectric types; ② PCB mount types (vertical); ③ PCB mount types (horizontal); ④ chassis mounting types with screw and solder connection; ⑤ single-hole mounting types.

imum capacitance: grey (55 pF); yellow (10 pF); green (20 pF); grey (40 pF); red (65 pF) and purple (100 pF). The difference between the 55 pF and 40 pF type is immediately apparent from the size.

Tubular ceramic or glass trimmers for chassis and PCB mounting are used in SHF circuits where line inductors or etched striplines are to be tuned at minimum loss. Well-known manufacturers of high-quality air, glass and ceramic tubular trimmers are Johansson, Tronser, Arco, Sky, Jackson and Stettner.

Decoupling capacitors

Disc- and coffin shaped leadless ceramic capacitors are not so familiar among constructors with little RF experience. These capacitors are characterized by very low inductance, which is mainly by virtue of the absence of connecting wires. Instead, metallized surfaces are used for soldering at both sides of the device. The coffin-shaped capacitor (called *trapezoidal* by Stettner) is inserted and clamped in a 4x0.7 mm PCB slot that keeps the device in place during the soldering process. The printed circuit board tracks to the capacitor should be relatively wide to allow the low inductance of the device to take effect. The value of the coffin-type capacitor is printed on one metallized side. Values

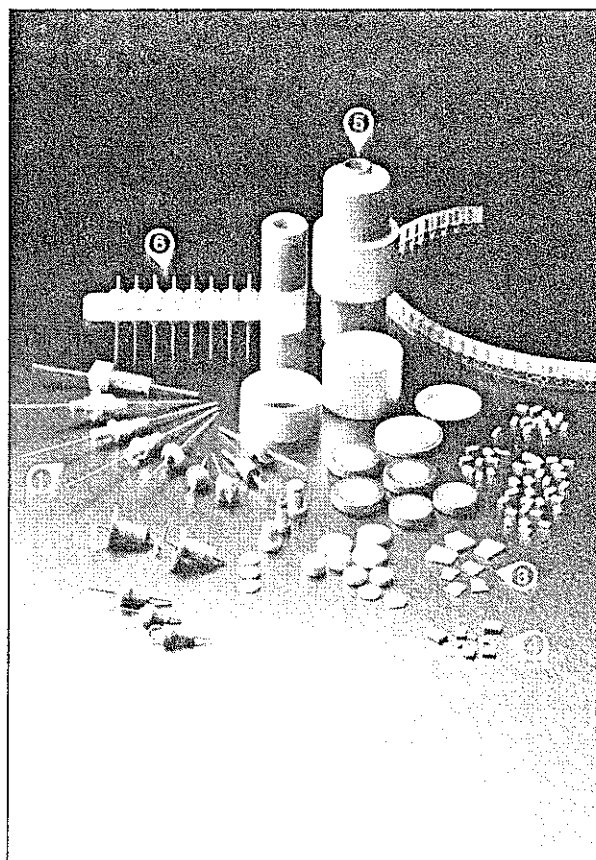
range from about 5 pF to 2 nF at a maximum working voltage of 63 V.

Disc-shaped leadless capacitors are more difficult to handle because they must, in general, be soldered on to a flat surface. It is difficult however, to heat one side of the capacitor and the surface it will rest on, simultaneously. To ensure a good solder joint and sufficient adhesive strength, a small hole is often drilled in the surface, and some hot tin is applied through it from the other side. In general, both the coffin and the disc-shaped leadless ceramic capacitor should be handled with utmost care because they are relatively brittle devices.

The smaller the better?

The increasing use of surface-mount assembly (SMA) components has not gone past unnoticed in the RF engineering field where the size of parts has always been a crucial factor. Not surprisingly, therefore, many RF circuits are currently produced in SMA technology. For capacitors in RF circuits, this brings many benefits because SMA parts generally have a lower stray inductance than their normal-size equivalents.

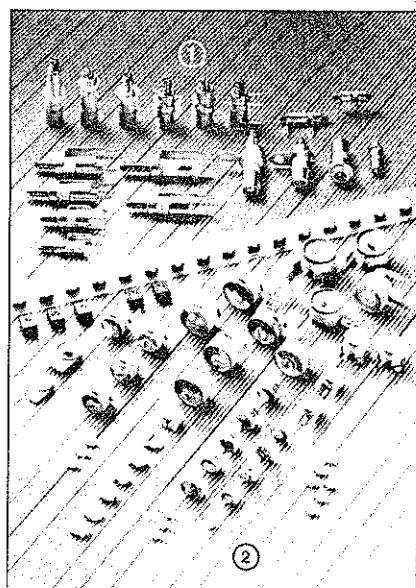
SMA capacitors must not, however, be confused with chip types, which have been around for many years and offer



A selection of RF capacitors. ① screw type feedthrough types; ② solder type feedthrough; ③ coffin-type leadless ceramic; ④ leadless chip; ⑤ heavy-duty ceramic holders for use in high-power RF amplifiers; ⑥ feedthrough connection block.

even lower stray inductance.

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Trimmers ① tubular trimmers; ② ceramic trimmers. The tape at the centre contains SMA trimmers.