



HPC0402 RF CAPACITORS

ANH110

Maximizing use of High-Precision HPC RF Capacitors with Vishay’s Capacitance vs. Frequency Cross-Reference and Selection Guide



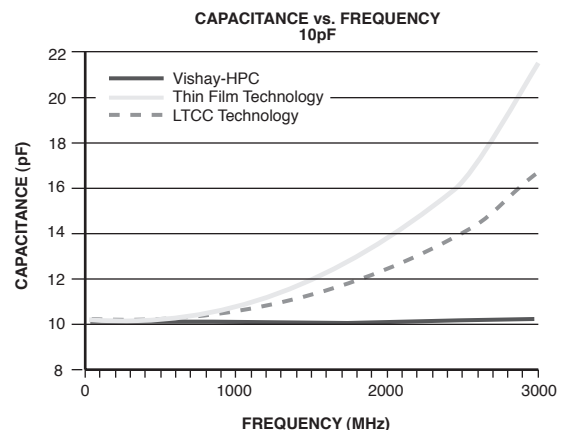
Vishay’s HPC series of high-precision silicon RF capacitors features unprecedented capacitance vs. frequency stability. That is, the capacitance curve relative to frequency is very flat. This feature enhances high-frequency applications because frequency drift in the circuit does not cause any significant change in capacitance over a wide range around the working frequency. As a result, HPC capacitors are significantly more stable than traditional capacitors.

Historically, precision RF capacitors have been either single-layer, low-temperature, co-fired ceramic chip (LTCC) capacitors or single-layer, thin film (TF) dielectric capacitors. Prior to the introduction of Vishay HPC capacitors, these were recognized as the most stable types of chip capacitors at high frequencies with the highest self-resonant frequency (SRF). Frequency performance is summarized by a set of data points known as S-parameters, which indicate the transmission vs. loss characteristics. The value of using S-parameters is well known in the industry, and simulation systems have used these parameters to characterize HPC capacitors over a wide range of frequencies. Figure 1 shows how much a 10-pF capacitor representing Vishay’s HPC series, as well as LTCC and TF technologies, will change at frequencies up to 3 GHz.



As these curves approach vertical, each capacitor reaches its SRF. At SRF, the capacitance immediately drops to zero and, because it is no longer functioning as a capacitor, the device typically is not effective above its SRF. In fact, it is generally recommended that capacitors not be used even below their SRF value in the frequency range where the capacitance changes rapidly with a small change in frequency above 2 GHz (See Figure 1). Therefore, a rule of thumb for traditional RF capacitors is to limit their use to operation at less than one-third of their SRF.

Figure 1: Capacitance vs. Frequency for 10-pF HPC, LTCC, and TF Capacitors



MEASURED ON AGILENT 4287 A + 16197 A

TECHNICAL NOTE

In a typical application, such as impedance matching between the power amplifier (PA) and the antenna in a mobile phone, any small drift in frequency will cause a large change in capacitance. The large change in capacitance will cause a mismatch in impedance, resulting in much of the signal output of the PA being reflected back into the phone instead of being transmitted by the antenna. The phone will then attempt to boost the output signal, draining the battery without increasing the transmitted signal. The capacitance stability of the 10-pF HPC0402 silicon capacitor, shown in Figure 1, demonstrates much better frequency stability than the other technologies.

Figure 2 illustrates the data with which a capacitor may be selected for a specific operating frequency.

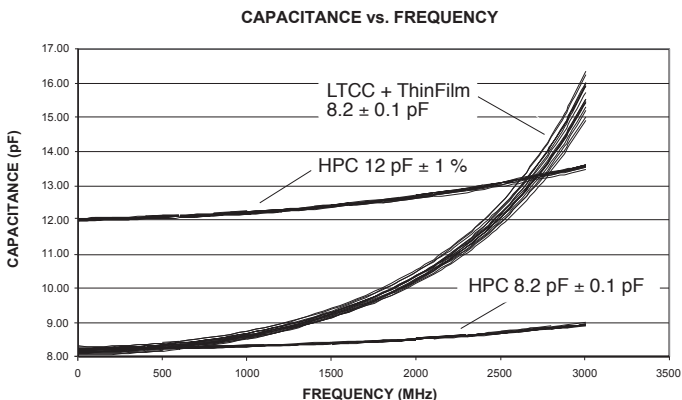


Figure 2: Capacitance vs. Frequency Data for Capacitor Selection

Consider, for example, the case in which a user requires a 13-pF capacitor at 2.7 GHz. Capacitors are supplied as the capacitance value measured at 1 MHz. The user consults the characterization data and finds that a value of 13-pF at 2.7 GHz demands an 8.2-pF LTCC or TF capacitor. The drawback to working with these technologies is twofold. The capacitor is working in a region where the capacitance will change quickly with a small change of frequency, and the LTCC and TF curves both diverge with a wider tolerance drift as frequency increases. As a result, the

user must specify and order a tighter tolerance at 1 MHz to remain within the allowable error envelope at the operating frequency. By comparison, HPC silicon capacitors provide a much more uniform capacitance curve over a change in frequency. In contrast to the capacitance increase of the LTCC and TF devices with a rise in frequency, the HPC silicon capacitor demonstrates a stable capacitance value of just 8.8-pF at 2.7 GHz (Figure 2).

To take advantage of the flatter curve of the HPC silicon capacitor, the circuit designer must use a 12-pF HPC capacitor for applications that normally would require an 8.2-pF LTCC or TF capacitor. Because the characteristic curves of the LTCC and TF technologies rise so quickly at higher frequencies, the HPC value that would intersect these curves would be different depending upon the frequency of interest.

To identify the HPC value and part number that would replace LTCC and TF technologies in a particular application, the designer must insert the capacitance value used for the other capacitor types, along with the operating frequency, into the conversion program. An online conversion guide created exactly for that purpose is available for use or download at <http://www.vishay.com/capacitors/silicon/calculator-list>

Suppose, for example, a designer has been using AVX's Accu-P 0402 series capacitor specified for 10-pF \pm 1% at 2600 MHz. Insertion of this data into the conversion guide will show that the Accu-P 10-pF capacitor has an effective capacitance of 19.752-pF at 2600 MHz. It also shows that the HPC capacitor with a capacitance value of 19.752-pF at 2600 MHz features a 16-pF nominal capacitance. For designers' convenience, the conversion program provides a complete part number (HPC0402A160FXYT) for the Vishay capacitor suitable for this application. In this way the conversion program eliminates the need for the user to run the S-parameters through simulation programs to get the same end results.

When the designer wants to show multiple sources on the Bill of Materials (BOM) they would simply include

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the appropriate part number for each technology. For example:

<u>ITEM</u>	<u>MANUFACTURER</u>	<u>MANUFACTURER'S PART NUMBER</u>
C115	VISHAY AVX	HPC0402A160FXYT 0402J100FBWTR

Note that each item on the BOM may show different values for the different technologies in the same application. There is no other way to take advantage of the superior stability of the HPC precision capacitor while still holding positions on the BOM for competing products.

When the designer is using the HPC directly, he can put in the value and tolerance required at the desired operating frequency and the conversion will yield the effective capacitance of the HPC and its part number.

Note: A Technical paper describing these effects in greater detail titled: "0.1-pF – 180-pF 0402 RF Capacitor Capacitance Stability From 1 MHz to Several GHz."

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