Optimizing antenna performance through the use of high Q, tight tolerance capacitors

Antenna matching is an important aspect of any RF system. Thinking in traditional terms, a properly designed and matched antenna increases the operating distance of the wireless product. Well matched antennas can transmit more power from the radio – therefore transmit over longer distances.
Likewise, a well matched antenna allows the maximum transfer of energy from the receiving antenna to the receiver front end. Thus, allowing better receive characteristics for the system.

But the use of a capacitor can also have a big impact upon the physical size of an antenna. If the goal is a compact, integrated antenna, the use of a capacitance 'top hat' on a Planar Inverted F antenna can reduce the antenna size by 30% or more. Radiation patterns and efficiencies can be optimized by this matching. Further, the use of a capacitance 'top hat' can match an antenna that's even smaller than an ideal inverted F size for the band of interest. In this case, the capacitor can allow both reduced antenna size and system optimization.

Care must be made in choosing the best capacitor for any type of antenna matching/loading application.

There is a class of high Q, small size, thin film capacitors that allow the selection of infinite capacitance values and exacting lot to lot performance.
These performance features, combine to provide designers an attractive option in antenna optimization and matching.

Background

Capacitive load works similarly for different antenna types. In this particular case we will discuss Planar Inverted-F antennas (PIFA).
These types of antenna are widely used in cell phones, WLAN, and other small sized wireless systems. Inverted F antennas are inherently low cost, small and have well documented use.
However, in some cases a PIFA efficiency suffers when the antenna is much smaller than the designated bands wavelength. The reduced size might be because of package constraints of the system/enclosure, cost or weight constraints. Regardless of the reasons for wanting/needing a shorter antenna size - shortening the antenna affects its impedance.
Impedance mismatch can be compensated for with capacitive top loading. The missing antenna height is replaced with an equivalent circuit, which improves the impedance match and the efficiency.
The capacitor used for loading should be of an exacting and optimized value, low loss, with repeatable characteristics.

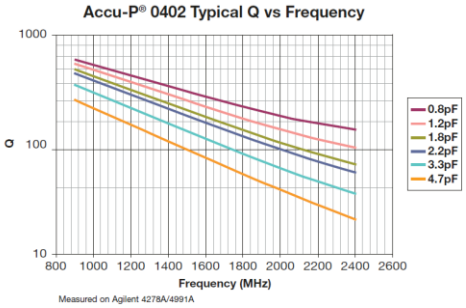
Capacitor Selection, Performance and modeling

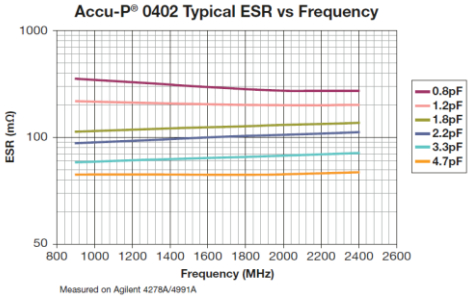
Accu –P capacitors are thin film devices built with semiconductor processing equipment. High vacuum metal deposition is used to create uniform high conductivity electrodes. Plasma enhanced CVD is used for dielectric deposition. Photo lithography equipment is used in electrode patterning thus allowing capacitors of extreme accuracy and infinite values to be manufactured.

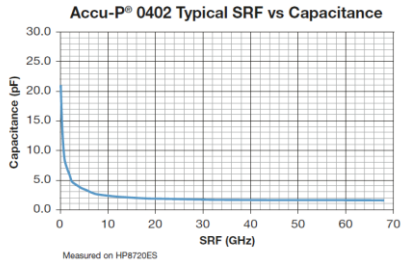
The resulting thin film capacitors are:

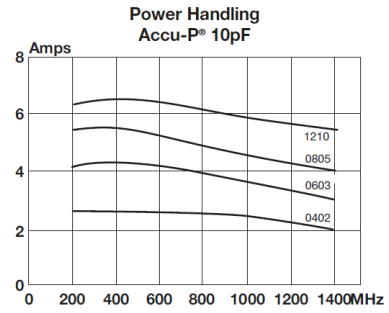
- 0.1pf to 68 pf in range
- High accuracy >/=0.01 pf tolerance
- High Stability 0+/- 30 ppm/°c to 0+/-60ppm/°c
- Small sizes ranging from 01005 to 1210
- High Q/Low ESR (chart below)
- Zero aging
- High Thermal conductivity 18.9 W/mK
- Available in infinite capacitance values from 0.01pf to 68 pf

Typical 0402 performances are shown below:









For additional information regarding AVX Accu-P Capacitors:
http://www.mouser.com/new/AVX/avxAccuPcaps/

Simulation:

Accu – P capacitor simulation is measurement – based and compatible with the latest electronic design automation (EDA) simulation tools. AVX Modelithics models allows end users to track how component performance will change with various input parameters over a specified frequency range. Product simulation models are available at:

https://www.modelithics.com/mvp/AVX

Comparison to ceramics:

Relative to optimized antenna matching, the choice comes down to thick film ceramic capacitors or thin film Accu P devices. Accu P thin film capacitors strength lies in the devices ability to provide previously unthinkable tolerances on any numerical value capacitance between 0.01pf to 68 pf – down to 0.01pf tolerance.

The ability to provide infinite capacitance values allows exact matching of an antenna to occur. Then once the ideal matching value is determined, extremely tight tolerance insure lot to lot performance of antennas matched/loaded with Accu – P devices. A comparison explaining why Accu-P capacitors outperform ceramics is shown below.

	MLC	Thin Film
Dielectric Constant	**Less stable at high frequencies due to changes in structure and composition**	**Very Stable**
Dielectric Thickness Accuracy	**± 2µ at best**	**±0.03 µ**
Metal Electrode Accuracy	**± 5µ at best**	**±0.5 µ**
Material Shrinkage	**Shrinkage due to firing at ~ 1000°C**	**Zero**

Summary

Accu P capacitors extreme performance & ability are a result of class room cleanliness combined with high purity semiconductor materials processing techniques. Material systems are all low loss and optimized. Lithography process accuracies allow Accu – P capacitors to exhibit ideal capacitor parameters – thus optimize antenna matching/loading.

The full spectrum of scalable models at AVX Modelithics allows end users to customize predict Accu – P capacitor response by PCB material, metallization weight, line width and end use orientation.