



# TECHNICAL INFORMATION

## TIGHT TOLERANCE KAVX ACCU-P® RF CAPACITORS IMPROVE ANTENNA EFFICIENCY

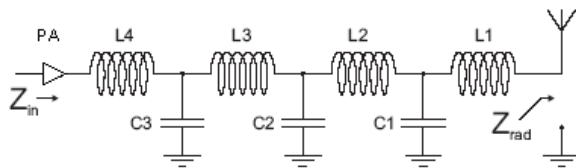
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### **Abstract:**

KAVX Accu-P® capacitors are the ideal component for improving antenna efficiency due to the repeatability of their RF performance and the availability of non-standard values and ultra-tight tolerances.

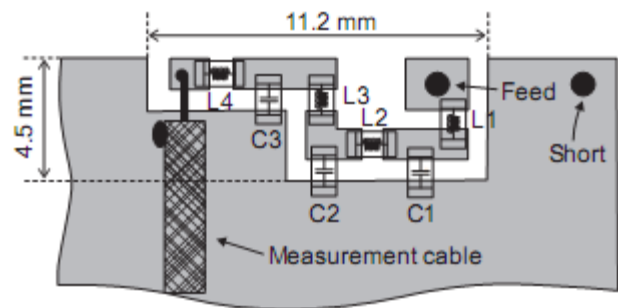
## Tight Tolerance KAVX Accu-P® RF Capacitors Improve Cellular F-Antenna Efficiency

In order to increase the antenna efficiency it is necessary to match the antenna to the source resistance. See below a typical matching scheme.



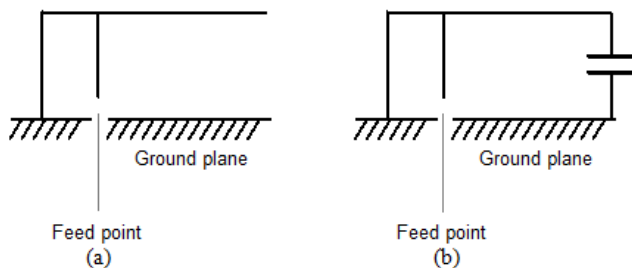
Standard antenna matching scheme

Antenna matching circuits are synthesized using different CAD tools, often resulting in non-standard values of capacitors and inductors.



Example of matching network layout

Inverted-F antennas are widely used in cell phones, LA hardware, and other small wireless devices. The performance is similar to a quarter-wave ground plane.



Inverted F-antenna (a) with capacitive load (b)

It is found that a capacitive load decreases the resonance length from  $\lambda/4$  to less than  $\lambda/8$ , i.e. it greatly reduces the size of the antenna. Capacitive load can be applied to different antenna types. For standard PIFA, approximately 0.1-2.0pF of loading capacitance is required. The tuning sensitivity to that capacitance is 250 MHz shift per 0.1 pF change. It is therefore of utmost importance for the capacitor used to be both accurate and repeatable. Accu-P® capacitors are the ideal choice.

Using the closest standard parts instead of the non-standard values will significantly change the matching quality.

KAVX provides tight tolerance capacitors with any requested non-standard value for precisely implementing the matching circuit.

Their main features are:

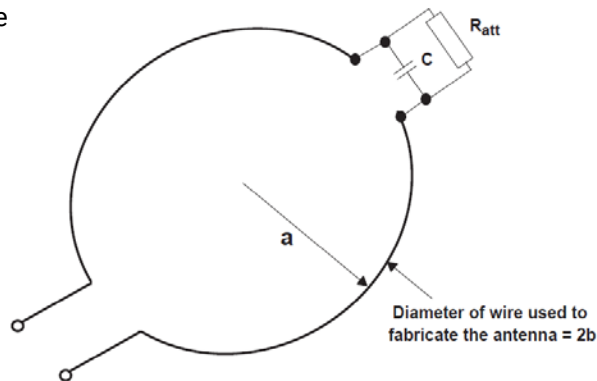
- Tight capacitance tolerances – as low as 0.01pF.
- Low ESR and high Q.
- High IR.
- High SRF uniformity.
- Repeatable CEFF, ESR and  $Q$  vs. Frequency.
- Intermediate, non-standard values readily available.
- Engineering Kits and S-Parameters are available.

They are ideal for use in modules and mobile phone antenna matching circuits

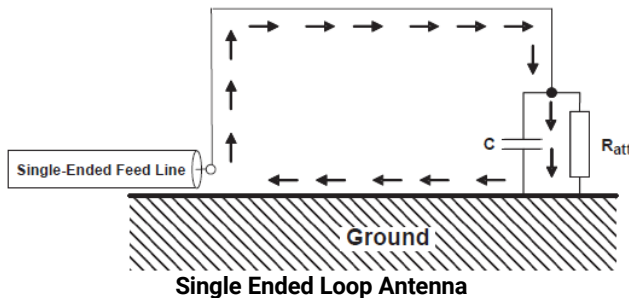
## Tight Tolerance KAVX Accu-P® RF Capacitors Improve Cellular Loop Antenna Efficiency

### Loop Antennas

Loop antennas are often used for body-worn or hand-held equipment such as mobile phones. Since they are magnetic antennas, they are not detuned by the dielectric constant of the material in their reactive network.



Loop Antenna with Differential Feed



Single Ended Loop Antenna

Together with the capacitor  $C$ , the inductance of the wire or PCB trace  $L$  builds a resonant circuit. Often a resistor  $R_{att}$  is added to reduce the quality factor of the antenna to make it less sensitive to capacitor tolerances. Of course, this resistor dissipates energy and reduces the antenna's efficiency. By using tight capacitance tolerances  $R_{att}$  may be reduced or eliminated thus increasing the antenna efficiency.

The maximum usable quality factor is a function of the capacitor

$$Q = \frac{1}{\sqrt{1 - \frac{C}{C} - 1}}$$

$$\eta = \frac{Q}{2\pi} \frac{R_r}{fL} \quad R_r \text{ radiation resistance}$$



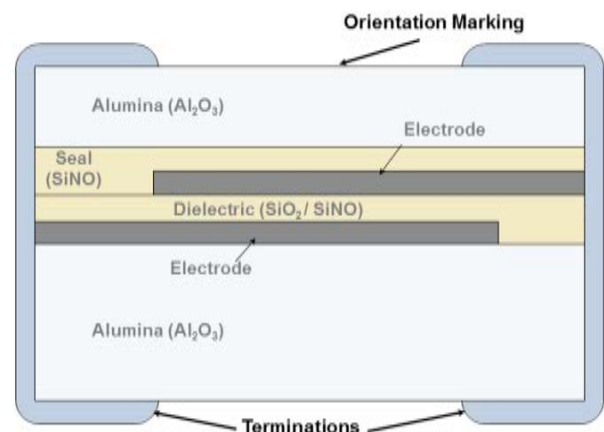
In order to increase the antenna efficiency, it is therefore essential to maximize  $Q$ . This is achieved by using tight capacitance tolerances which results in a low  $\frac{\Delta C}{C}$ .

An accurate and repeatable capacitor is critical. KAVX Accu-P® capacitors are the ideal component for this application due to the repeatability of their RF performance and the availability of tight tolerances.

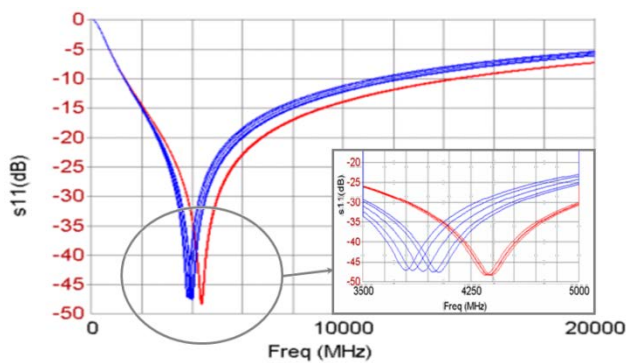
### KAVX Accu-P® RF Capacitors

KAVX Accu-P® RF Capacitors are made by Thin-Film Technology and exhibit nearly ideal characteristics. Their main features are:

- High purity electrodes for very low and repeatable ESR
- Highly pure, low-K dielectric for high breakdown voltage, high insulation resistance and low losses at frequencies up to 40 GHz.
- Very tight dimensional control for uniform and stable frequency characteristics, unit to unit, batch to batch, year after year.
- Tight capacitance tolerances  $\pm 0.01\text{pF}$
- Easy availability of non-standard values.



Accu-P® capacitor structure



Typical SRF distribution for **Thin Film** vs. **ceramic MLCC**

### Accu-P® Tight Tolerance Engineering Kits

**Accu-P® 01005**  
Designer Kit Type 3100LF  
Order Number: Accu-P® C005KITL1

| Volts | Capacitors Value pF | Tolerance |
|-------|---------------------|-----------|
| 16    | 0.05                | P         |
|       | 0.1                 | P         |
|       | 0.2                 | P         |
|       | 0.3                 | P         |
|       | 0.4                 | P         |
|       | 0.5                 | P         |
|       | 0.6                 | P         |
|       | 0.7                 | P         |
|       | 0.8                 | P         |
|       | 0.9                 | P         |
|       | 1.0                 | Q         |
|       | 1.2                 | Q         |
|       | 1.5                 | Q         |
|       | 1.8                 | Q         |
|       | 2.2                 | Q         |

7500 Capacitors, 500 each of 15 values  
Tolerance P =  $\pm 0.02\text{pF}$   
Q =  $\pm 0.03\text{pF}$

#### Accu-P® 01005 Engineering Kit

**Accu-P®**  
Designer Kit Type 2800LF  
Order Number: Accu-P® 0201KITL5

| Volts | Capacitors Value pF | Tolerance |
|-------|---------------------|-----------|
| 100   | 0.05                | Z         |
|       | 0.10                | Z         |
|       | 0.15                | Z         |
|       | 0.20                | Z         |
|       | 0.25                | Z         |
|       | 0.30                | Z         |
|       | 0.35                | Z         |
|       | 0.40                | Z         |
|       | 0.45                | Z         |
|       | 0.50                | Z         |
| 50    | 0.55                | P         |
|       | 0.60                | P         |
|       | 0.65                | P         |
|       | 0.70                | P         |
|       | 0.75                | P         |
|       | 0.80                | P         |
|       | 0.85                | P         |
|       | 0.90                | P         |
|       | 0.95                | P         |
|       | 1.0                 | P         |
|       | 1.1                 | P         |
|       | 1.2                 | P         |
|       | 1.3                 | P         |
|       | 1.4                 | P         |
|       | 1.5                 | P         |
|       | 1.6                 | P         |
|       | 1.7                 | P         |
| 25    | 1.8                 | P         |
|       | 1.9                 | P         |
|       | 2.0                 | P         |

600 Capacitors, 20 each of 30 values  
Tolerance Z =  $\pm 0.01\text{pF}$   
P =  $\pm 0.02\text{pF}$

#### Accu-P® 0201 Engineering Kit

**Accu-P®**  
Designer Kit Type 2700LF  
Order Number: Accu-P® 0402KITL4

| Volts | Capacitors Value pF | Tolerance |
|-------|---------------------|-----------|
| 100   | 0.05                | Z         |
|       | 0.10                | Z         |
|       | 0.15                | Z         |
|       | 0.20                | Z         |
|       | 0.25                | Z         |
|       | 0.30                | Z         |
|       | 0.35                | Z         |
|       | 0.40                | Z         |
|       | 0.45                | Z         |
|       | 0.50                | P         |
|       | 0.55                | P         |
|       | 0.60                | P         |
|       | 0.65                | P         |
|       | 0.70                | P         |
|       | 0.75                | P         |
|       | 0.80                | P         |
|       | 0.85                | P         |
|       | 0.90                | P         |
|       | 0.95                | P         |
|       | 1.0                 | P         |
| 50    | 1.1                 | P         |
|       | 1.2                 | P         |
|       | 1.3                 | P         |
|       | 1.4                 | P         |
|       | 1.5                 | P         |
|       | 1.6                 | P         |
|       | 1.7                 | P         |
|       | 1.8                 | P         |
|       | 1.9                 | P         |
|       | 2.0                 | P         |

600 Capacitors, 20 each of 30 values  
Tolerance Z =  $\pm 0.01\text{pF}$   
P =  $\pm 0.02\text{pF}$

#### Accu-P® 0402 Engineering Kit

### References

1. ISM-Band and Short Range Device Antennas. Texas Instruments Application Report SWRA046A (2005) Matthew Loy / Iboun Sylla (Editors)

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## T E C H N I C A L   N O T E

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**DATE:** 30/07/2023  
**FROM:** Amir Kopelman – Technical Services Manager  
**RE:** Accu-P® 3 digit Capacitance Ordering Codes

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The following 3 digit capacitance ordering codes should be used for ordering **Intermediate (non standard )** values Accu-P® capacitors:

| Capacitance Range | Ordering Code | Example     |                         |
|-------------------|---------------|-------------|-------------------------|
|                   |               | Capacitance | Ordering P/N            |
| 0.00 to 0.99pF    | <b>Rxx</b>    | 0.15pF      | 04023JR <b>15</b> ABSTR |
| 1.00 to 1.99pF    | <b>Axx</b>    | 1.55pF      | 04023JA <b>55</b> PBSTR |
| 2.00 to 2.99pF    | <b>Bxx</b>    | 2.85pF      | 04023JB <b>85</b> PBSTR |
| 3.00 to 3.99pF    | <b>Cxx</b>    | 3.85pF      | 02013JC <b>85</b> ABSTR |
| 4.00 to 4.99pF    | <b>Dxx</b>    | 4.85pF      | 06033JD <b>85</b> BBSTR |
| 5.00 to 5.99pF    | <b>Exx</b>    | 5.85pF      | 04023JE <b>85</b> ABSTR |
| 6.00 to 6.99pF    | <b>Fxx</b>    | 6.85pF      | 06035JF <b>85</b> BBSTR |
| 7.00 to 7.99pF    | <b>Gxx</b>    | 7.85pF      | 04023JG <b>85</b> BBSTR |
| 8.00 to 8.99pF    | <b>Hxx</b>    | 8.85pF      | 08055JH <b>85</b> BBTTR |
| 9.00 to 9.99pF    | <b>Jxx</b>    | 9.85pF      | 04023JJ <b>85</b> BBSTR |
| 10.0 to 19.9pF    | <b>Kxx</b>    | 13.8pF      | 04023KK <b>38</b> FBSTR |
| 20.0 to 29.9pF    | <b>Lxx</b>    | 22.5pF      | 06033JL <b>25</b> GBSTR |
| 30.0 to 39.9pF    | <b>Mxx</b>    | 33.8pF      | 0402ZKM <b>38</b> FBSTR |
| 40.0 to 49.9pF    | <b>Nxx</b>    | 43.5pF      | 08053KN <b>35</b> FBTTR |

Regards,

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Technical Note 3 digit capacitance Ordering Codes.docx



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