Technology Leadership Across the Board

Accu-P® Thin-Film Capacitors Act as Band Reject Filters

ABSTRACT:

AVX Accu-P® capacitors exhibit excellent resonance stability which makes them ideal for Band Reject Filters, whereas Ceramic capacitors are unsuitable due to their wide SRF scatter.

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Definition of Band Reject Filters (BRF)

An Outline of Band Reject Filers

Band reject, or notch, filters are used to reject a narrow frequency band and pass a wide frequency range.

Traditionally, BRF's are custom designed for each specific frequency application.

Basic design

A BRF can be realized by a simple shunt capacitor (Figure 1) or by a more elaborate Twin T design (Figure 2)

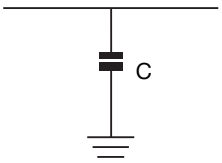


Figure 1.
Shunt Capacitor Design

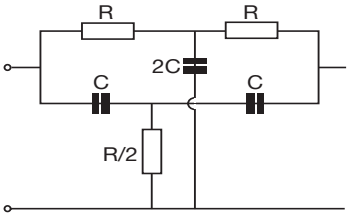


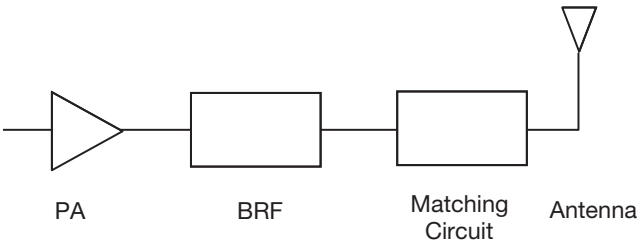
Figure 2.
Twin T Design

Major applications

Band reject filters (BRF) perform several basic functions in RF circuits.

A. Additional filtering of the basic signal harmonics (2F0, 3F0, 4F0).

In this case, the BRF is located either at the PA output or next to the antenna:



Harmonic rejection is usually performed by a LPF located after the PA, but the need often arises to suppress a spurious harmonic at a later stage of development or when the circuit is actually in production. In these cases an AVX Accu-P® Thin-Film RF capacitor is the preferred solution.

The exact capacitance value should be determined experimentally as it will be affected by the surrounding circuit.

B. Intermodulation frequencies suppression.
Transceiver characteristics may be affected by internally generated frequencies. In these cases the signal frequency and amplitude are known so that a narrow band BRF is ideally suited for the application.

C. Multi-Band Systems. In multi-band transceivers, which operate at several frequencies, BRF are used as additional decoupling elements both in the receiving and the transmitting channel. When several RF systems work simultaneously, e.g. WCDMA at 1.9 GHz and short range accessories at 2.4 GHz or 5.2 GHz, parasitic signals may form in the main channel, lowering the receiver sensitivity.

BRF realization using Accu-P® Capacitors

AVX's **Accu-P®** Thin-Film RF capacitors are a simple BRF that is both cost effective and miniature. Until recently, most high frequency/microwave capacitors were based on fired-ceramic (porcelain) technology. Layers of ceramic dielectric material and metal alloy electrode paste are interleaved and then sintered in a high temperature oven. This technology exhibits component variability in dielectric properties (losses, dielectric constant and insulation resistance), variability in electrode conductivity and variability in physical size.

The Thin-Film Capacitors developed by AVX virtually eliminate these variances. Thin-Film technology is commonly used for producing semiconductor devices. In the last two decades, this technology has developed tremendously, both in performance and in process control. Today line definitions of below 1 µm and layer thickness control of 100Å (10-2 µm) are possible. Applying this technology to the manufacture of capacitors has enabled the development of components where both electrical and physical properties can be tightly controlled.

Accu-P® RF Capacitors are made by Thin-Film Technology (see Figure 3) and exhibit nearly ideal characteristics.

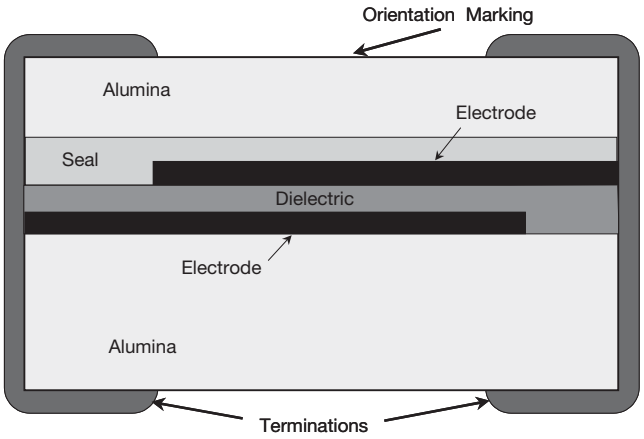


Figure 3.
Accu-P® Capacitor Structure

The main features of Accu-P® may be summarized as follows:

- High purity of 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 40GHz.
- Very tight dimensional control for uniform and stable frequency characteristics, unit to unit, batch to batch, year after year.
- Very tight capacitance tolerances for high frequency signal applications.

Accu-P® capacitors are the ideal component for realizing the simple notch filter shown in Figure 1. For each capacitance value a very stable impedance is displayed over a wide range of frequencies, see Figure 4.

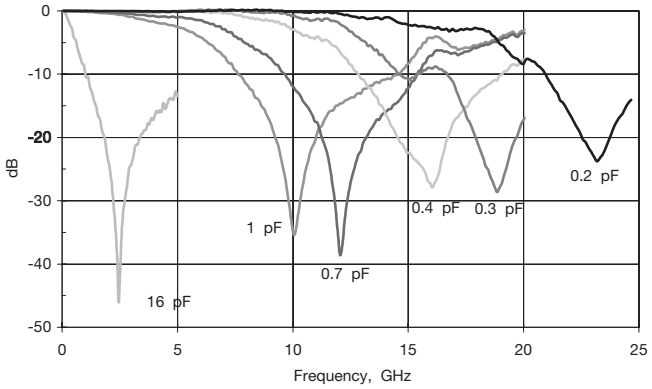


Figure 4.
S21 for Several Capacitance Values, Accu-P® 0402

The capacitance value is experimentally determined for each specific application.

Table 1 and Figure 5. show Accu-P®'s excellent resonance stability compared to ceramic capacitors which cannot be used as BRF's because of their wide SRF scatter.

Table 1

SRF [MHz] for Accu-P® 0402, 0.2 pF
4 different production batches.

#	Batch 1	Batch 2	Batch 3	Batch 4
1	23,256	23,256	23,459	23,198
2	23,199	23,290	23,479	23,246
3	23,256	23,256	23,483	23,204
4	23,238	23,199	23,479	23,161
5	23,217	23,199	23,461	23,170
6	23,199	23,276	23,479	23,178
7	23,272	23,296	23,472	23,210
8	23,238	23,260	23,479	23,188
9	23,256	23,288	23,461	23,226
10	23,232	23,238	23,441	23,179
AVG	23,236	23,256	23,470	23,196
MAX	23,272	23,296	23,483	23,246
MIN	23,199	23,199	23,441	23,161
STD	25	35	14	26

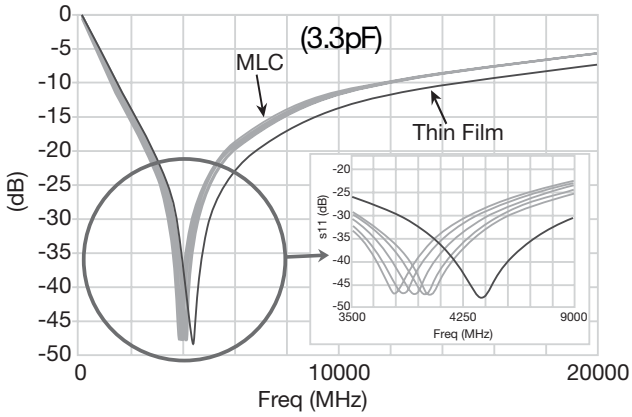
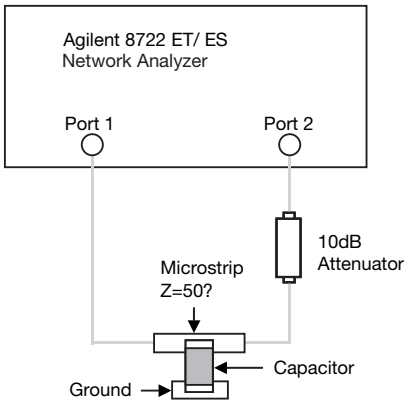


Figure 5.
Typical Thin-Film vs. Ceramic MLC SRF Distribution.

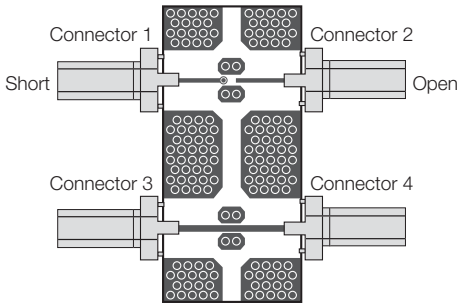
- Determine the frequency FO that needs to be rejected.
- Select an Accu-P® capacitor case size.
- Use the SRF vs. Capacitance graph (Appendix 2) for the selected case size in order to find an Accu-P® capacitance with an SRF closest to FO.
- Order samples of that Accu-P® capacitance as well as of neighboring capacitance values.
- For a wider selection range order Accu-P® Engineering Kits (Appendix 3).
- The best Accu-P® capacitance value for the particular circuit can now be experimentally determined.

BRF Design steps:

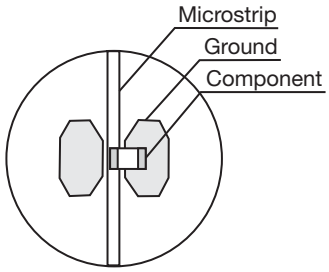
Appendix 1: Measurement Technique



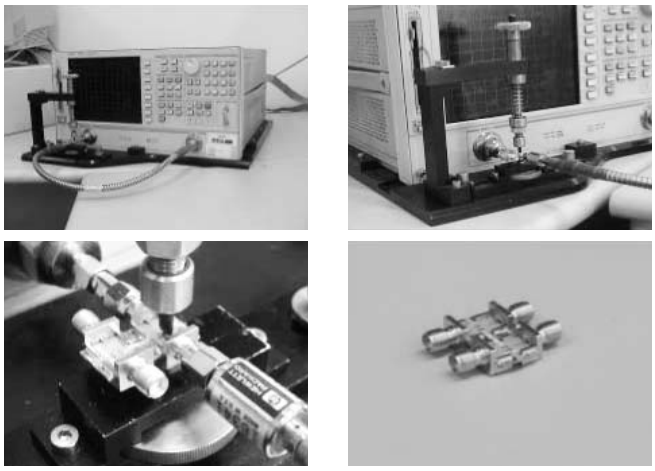
SRF Test Setup



Measurement Jig



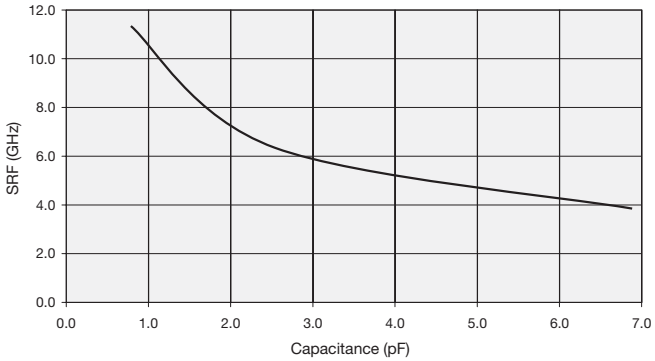
Close-up of Capacitor on Jig



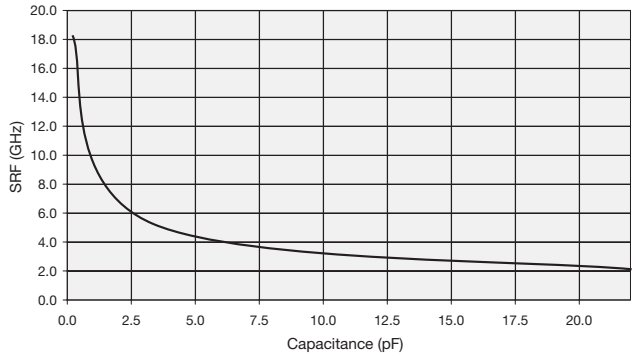
Test Setup

Appendix 2 : SRF vs. Capacitance Graphs

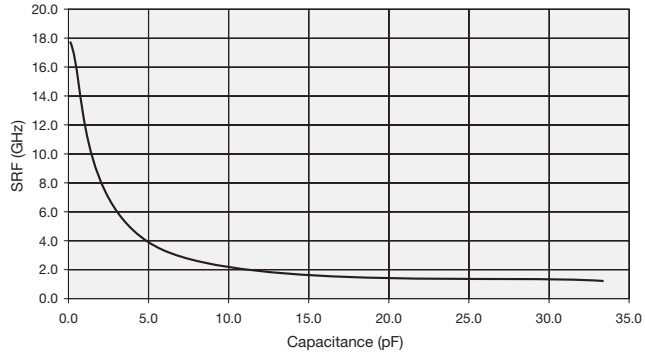
AVX Accu-P® 0201 Capacitors
SRF vs. Capacitance



AVX Accu-P® 0402 Capacitors
SRF vs. Capacitance



AVX Accu-P® 0603 Capacitors
SRF vs. Capacitance



Appendix 3: Engineering Kits

Accu-P®
Designer Kit Type 1700
Order Number: Accu-P® 0201KIT02

Volts	Capacitors Value pF	Tolerance
25	0.1	A
	0.2	A
	0.3	A
	0.4	B
	0.5	B
	0.6	B
	0.7	B
	0.8	B
	0.9	B
	1.0	B
	1.1	B
	1.2	B
	1.3	B
	1.5	B
	1.8	B
	2.0	B
	2.2	B
	2.4	B
	2.7	B
16	3.0	B
	3.3	B
	3.6	B
	3.9	B
10	4.7	B
	5.6	B
	6.8	B
	7.5	B
	8.2	B
	10.0	G
	12.0	G

600 Capacitors, 20 each of 30 values
Tolerance A = ± 0.05pF
B = ± 0.1pF
G = ± 2%

Accu-P®
Designer Kit Type 1800
Order Number: Accu-P® 0201KIT03

Volts	Capacitors Value pF	Tolerance
25	1.0	A
	1.1	A
	1.2	A
	1.3	A
	1.4	A
	1.5	A
	1.6	A
	1.7	A
	1.8	A
	1.9	A
	2.0	A
	2.1	B
	2.2	B
	2.3	B
	2.4	B
	2.5	B
	2.6	B
	2.7	B
16	2.8	B
	2.9	B
	3.0	B
	3.1	B
	3.3	B
	3.4	B
	3.6	B
	3.9	B
10	4.1	B
	4.3	B
	4.5	B
	4.7	B

600 Capacitors, 20 each of 30 values
Tolerance A = ± 0.05pF
B = ± 0.1pF

Accu-P®
Designer Kit Type 1300
Order Number: Accu-P® 0402KIT01

Volts	Capacitors Value pF	Tolerance
25	0.1	A
	0.2	A
	0.3	A
	0.4	B
	0.5	B
	0.6	B
	0.7	B
	0.8	B
	0.9	B
	1.0	B
	1.1	B
	1.2	B
	1.5	B
	1.8	B
	2.0	B
	2.2	B
	2.4	B
	2.7	B
	3.0	B
	3.3	B
	3.9	B
	4.7	B
	5.6	B
	6.8	B
16	8.2	B
	10.0	G
10	12.0	G
	15.0	G
	18.0	G
	22.0	G

600 Capacitors, 20 each of 30 values
Tolerance A = ± 0.05pF
B = ± 0.1pF
G = ± 2%

Accu-P®
Designer Kit Type 1400
Order Number: Accu-P® 0402KIT02

Volts	Capacitors Value pF	Tolerance
25	1.0	A
	1.1	A
	1.2	A
	1.3	A
	1.4	A
	1.5	A
	1.6	A
	1.7	A
	1.8	A
	1.9	A
	2.0	A
	2.1	B
	2.2	B
	2.3	B
	2.4	B
	2.5	B
	2.6	B
	2.7	B
	2.8	B
	2.9	B
	3.0	B
	3.1	B
	3.3	B
	3.4	B
	3.6	B
	3.9	B
	4.1	B
	4.3	B
	4.5	B
	4.7	B

600 Capacitors, 20 each of 30 values
Tolerance A = ± 0.05pF
B = ± 0.1pF

Accu-P®
Designer Kit Type 900
Order Number: Accu-P® 0603KIT01

Volts	Capacitors Value pF	Tolerance
50	0.1	A
	0.2	A
	0.3	A
	0.4	B
	0.5	B
	0.6	B
	0.7	B
	0.8	B
	0.9	B
	1.0	B
	1.1	B
	1.2	B
	1.5	B
	1.8	B
	2.0	B
	2.2	B
	2.4	B
	2.7	B
	3.0	B
	3.3	B
	3.9	B
	4.7	B
	5.6	B
	6.8	B
	8.2	B
	10.0	G
	12.0	G
25	15.0	G
	18.0	G
	22.0	G

600 Capacitors, 20 each of 30 values
Tolerance A = ± 0.05pF
B = ± 0.1pF
G = ± 2%

Accu-P®
Designer Kit Type 800
Order Number: Accu-P® 0805KIT02

Volts	Capacitors Value pF	Tolerance
100	0.1	A
	0.2	A
	0.3	A
	0.4	A
	0.5	B
	0.7	B
	0.8	B
	0.9	B
	1.0	B
	1.2	B
	1.5	B
	1.8	B
	2.0	B
	2.2	B
	2.7	B
	3.3	B
	3.9	B
	4.7	B
	5.6	B
	6.8	B
	8.2	B
	10.0	G
50	12.0	G
	15.0	G
	18.0	G
	22.0	G
25	27.0	J
	33.0	J
	39.0	J
	47.0	J

300 Capacitors, 10 each of 30 values
Tolerance A = ± 0.05pF G = ± 2%
B = ± 0.1pF J = ±5%

Appendix 3: Engineering Kits (Cont.)

Accu-P®
Designer Kit Type 700
Order Number: Accu-P® 1210KIT02

Volts	Capacitors Value pF	Tolerance
100	1.0	**B**
	1.5	**B**
	1.8	**B**
	2.2	**B**
	2.7	**B**
	3.3	**B**
	4.7	**B**
	5.6	**B**
	6.8	**B**
	10.0	**G**
	12.0	**G**
	18.0	**G**
	22.0	**G**
	27.0	**G**
	33.0	**G**

150 Capacitors, 10 each of 15 values
Tolerance B = ± 0.1pF
G = ± 2%

Accu-P®
Designer Kit Type 2100
Order Number: Accu-P® 0402KIT03

Volts	Capacitors Value pF	Tolerance
25	0.05	**P**
	0.10	**P**
	0.15	**P**
	0.20	**P**
	0.25	**P**
	0.30	**P**
	0.35	**P**
	0.40	**P**
	0.45	**P**
	0.50	**P**
	0.55	**P**
	0.60	**P**
	0.65	**P**
	0.70	**P**
	0.75	**P**

300 Capacitors, 20 each of 15 values
Tolerance P = ± 0.02pF

Accu-P®
Designer Kit Type 2200
Order Number: Accu-P® 0603KIT02

Volts	Capacitors Value pF	Tolerance
50	0.05	**P**
	0.10	**P**
	0.15	**P**
	0.20	**P**
	0.25	**P**
	0.30	**P**
	0.35	**P**
	0.40	**P**
	0.45	**P**
	0.50	**P**
	0.55	**P**
	0.60	**P**
	0.65	**P**
	0.70	**P**
	0.75	**P**

300 Capacitors, 20 each of 15 values
Tolerance P = ± 0.02pF

Accu-P®
Designer Kit Type 2000
Order Number: Accu-P® 0201KIT04

Volts	Capacitors Value pF	Tolerance
25	0.05	**P**
	0.10	**P**
	0.15	**P**
	0.20	**P**
	0.25	**P**
	0.30	**P**
	0.35	**P**
	0.40	**P**
	0.45	**P**
	0.50	**P**
	0.55	**P**
	0.60	**P**
	0.65	**P**
	0.70	**P**
	0.75	**P**

300 Capacitors, 20 each of 15 values
Tolerance P = ± 0.02pF

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