A Simplified Approach to Choosing a DC Blocking Capacitor

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Abstract

- All capacitors block DC, but the selection of a capacitor for a specific application is often a time-consuming process. One option is iterative testing of different capacitors and measuring the performance. Alternatively, one can speed the selection by using a capacitor capable of blocking across a wide frequency range. However, while a shorter path, this could be a costly solution and may present other problems. A new approach is to select from a series of capacitors already characterized for common frequency bands with known transmission characteristics.

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Uses Of DC Blocking Caps

- DC Blocking capacitors are connected in series and used to isolate or “block” the DC power levels between stages of electronics in devices such as amplifiers, radios, and telecom equipment.
- Blocking caps are also synonymous with coupling. Beyond the function of isolating potentially disturbing DC interference, they must allow the desired AC signal to pass.
- So, Blocking caps must be chosen carefully to ensure they provide minimal signal attenuation across the desired Radio Frequency bandwidth.

Insertion Loss, S_{21}, Attenuation

- The measure of signal attenuation attributed to the blocking cap is known as series insertion loss.
- Insertion loss is usually expressed in magnitude dB and is represented by the transmission coefficient S_{21} with capacitor serially inserted between signal ports.
- Increasingly negative values of S_{21} magnitude correlates to greater signal loss:
  - An S_{21} of -3.0 dB would result in a 50 % power loss.
  - An S_{21} of -0.5 dB represents a 10 % power loss.

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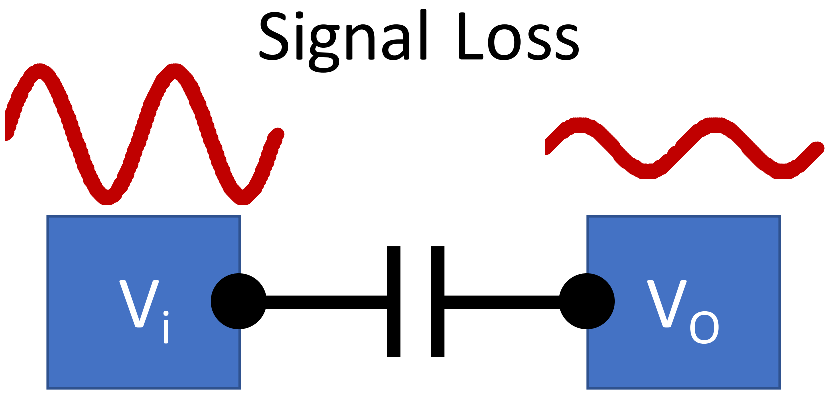
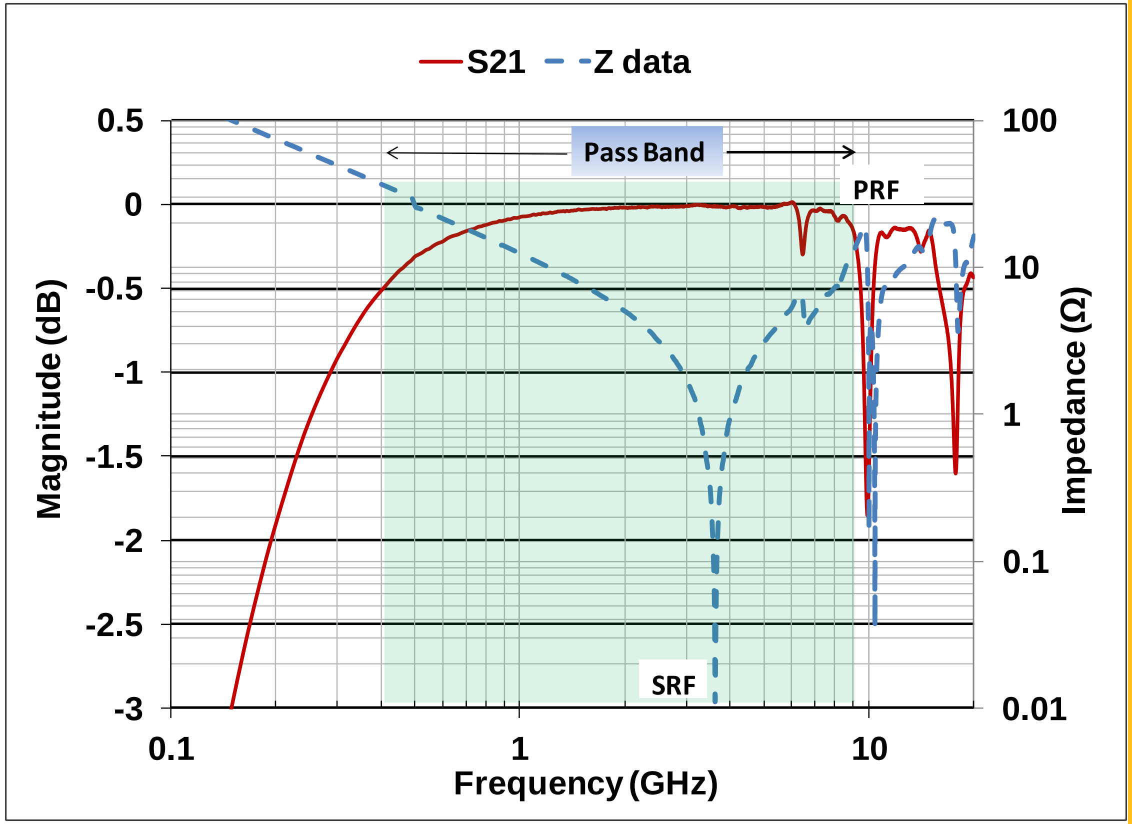
Design parameters for selecting a DC blocking capacitor

- **Desired frequency band for coupling**
  - Defines minimum frequency (F_{min}) and maximum frequency (F_{max}) coupling frequencies
  - For example
    - UHF Band ranges from 300 MHz to 3 GHz, so F_{min} = 300 MHz & F_{max} = 3.0 GHz
    - S Band is 2 GHz to 4 GHz, so F_{min} = 2.0 GHz & F_{max} = 4.0 GHz
- **Acceptable Insertion Loss, S_{21} expressed in magnitude dB**
  - Defines the maximum RF signal loss tolerated within the desired frequency band.
  - $S_{21} = 20*\log_{10}(V_o/V_i)$
  - $S_{21} = 10*\log_{10}(P_o/P_i)$
- **DC Voltage rating**
- DC voltage potential across capacitor



What about the signal?

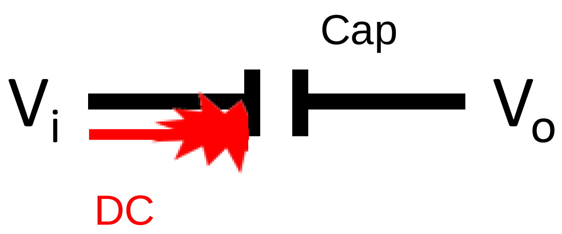
- The purpose of the DC Blocking Capacitor is also to pass or "couple" signals.
- However, their reactive dependence upon frequency influences RF signal loss.
- Signal loss S_{21} is minimized by selecting the proper capacitance value for the desired frequency band.
- A capacitor having sufficiently low impedance throughout the desired frequency band will also have a low insertion loss S_{21} throughout the band.
- So, capacitance value has been a primary variable when choosing the DC Blocking capacitor



What are the DC voltage considerations?

- DC Blocking capacitors are serially connected between circuits to isolate or “block” the DC bias of one stage from interfering with the next.
- They are often used in:
  - Communication equipment, signal coupling for band specific radios, telecom modems, routers, WiFi, IoT etc.
  - Amplifiers, signal coupling and DC blocking between amplification stages.
  - Audio circuits, unwanted DC is removed from audio signals at load

- A key specification is the maximum DC voltage rating (V_R) required.
  - The rated voltage should be greater than or equal to the voltage difference between stages, or either side of the MLCC, $V_R = \Delta V = | V_0 – V_i |$



Selecting a DC Blocking Capacitor

The insertion loss is dependent on the capacitance value and operating frequency. How do you choose the correct capacitor to meet operating Frequency and insertion loss?

- **Estimation by testing**
  - Iterative testing: Place component. Test. Remove. Repeat.
  - This could also be done using modeling software: Select PN. Model. Repeat
    - Modelithics, Cadence AWR, even Supplier's Software / modeling tools
  - Still, a time-consuming process
- **Use a broad band capacitor**
  - Super fast
  - However, could be an expensive solution
  - Also, may be limited by the voltage rating

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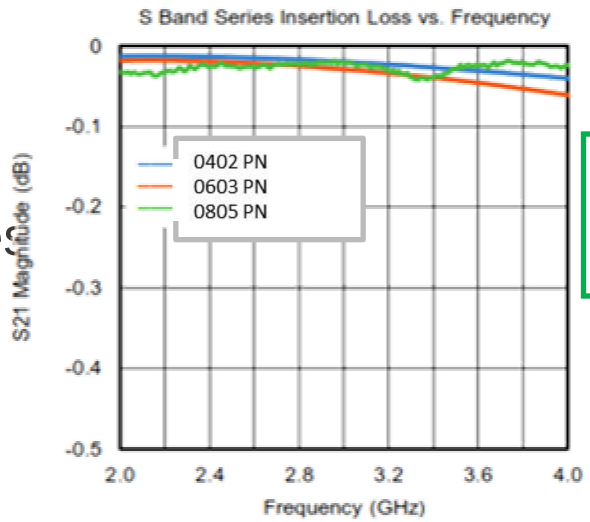
New Approach to Selecting a DC Blocking Cap

- Application focus – not capacitor focus
- Choose from already characterized parts
- Match application with appropriate frequency band
  - Say 2.4 GHz, so S Band
- Select a rated voltage according to application
  - Say 50V
- Choose the desired case size
  - 0402, 0603, 0805,1210 available
- Download corresponding part number S2P files
- Verify characteristics and place order

FREQUENCY BAND	FREQUENCY (MIN.)	FREQUENCY (MAX.)	CASE CODE	RATED VOLTAGE (VDC)
S	2 GHz	4 GHz	0402	25
S	2 GHz	4 GHz	0402	50
S	2 GHz	4 GHz	0603	25
S	2 GHz	4 GHz	0603	50
S	2 GHz	4 GHz	0603	100
S	2 GHz	4 GHz	0805	50
S	2 GHz	4 GHz	0805	100



FREQUENCY BAND	FREQUENCY (MIN.)	FREQUENCY (MAX.)	CASE CODE	RATED VOLTAGE (VDC)
HF	3 MHz	30 MHz	0402	25
HF	3 MHz	30 MHz	0402	50
HF	3 MHz	30 MHz	0603	25
HF	3 MHz	30 MHz	0603	50
HF	3 MHz	30 MHz	0603	100
HF	3 MHz	30 MHz	0805	50
HF	3 MHz	30 MHz	0805	100
HF	3 MHz	30 MHz	1210	500
[illegible]	[illegible]	[illegible]	[illegible]402	25
[illegible]	[illegible]	[illegible]	[illegible]402	50
[illegible]	[illegible]	[illegible]	[illegible]603	25
[illegible]	[illegible]	[illegible]	[illegible]603	50
[illegible]	[illegible]	[illegible]	[illegible]603	100
[illegible]	[illegible]	[illegible]	[illegible]805	50
[illegible]	[illegible]	[illegible]	[illegible]805	100
[illegible]	[illegible]	[illegible]	[illegible]	500
[illegible]	[illegible]	[illegible]	[illegible]402	25
[illegible]	[illegible]	[illegible]	[illegible]402	50
[illegible]	[illegible]	[illegible]	[illegible]	25
[illegible]	[illegible]	[illegible]	[illegible]603	50
[illegible]	[illegible]	[illegible]	[illegible]603	100
[illegible]	[illegible]	[illegible]	[illegible]805	50
[illegible]	[illegible]	[illegible]	[illegible]805	100
UHF	300 MHz	3 GHz	1210	500
L	1 GHz	2 GHz	0402	25
L	1 GHz	2 GHz	0402	50
L	1 GHz	2 GHz	0603	25
L	1 GHz	2 GHz	0603	50
L	1 GHz	2 GHz	0603	100
L	1 GHz	2 GHz	0805	50
L	1 GHz	2 GHz	0805	100
L	1 GHz	2 GHz	1210	500
S	2 GHz	4 GHz	0402	25
S	2 GHz	4 GHz	0402	50
S	2 GHz	4 GHz	0603	25
S	2 GHz	4 GHz	0603	50
S	2 GHz	4 GHz	0603	100
S	2 GHz	4 GHz	0805	50
S	2 GHz	4 GHz	0805	100
C	4 GHz	8 GHz	0402	25
C	4 GHz	8 GHz	0402	50
C	4 GHz	8 GHz	0603	25
C	4 GHz	8 GHz	0603	50
C	4 GHz	8 GHz	0603	100
C	4 GHz	8 GHz	0805	50
C	4 GHz	8 GHz	0805	100
X	8 GHz	12 GHz	0402	25
X	8 GHz	12 GHz	0402	50
X	8 GHz	12 GHz	0603	25
X	8 GHz	12 GHz	0603	50
X	8 GHz	12 GHz	0603	100
Ku	12 GHz	18 GHz	0402	25
Ku	12 GHz	18 GHz	0402	50
Ku	12 GHz	18 GHz	0603	25
Ku	12 GHz	18 GHz	0603	50
Ku	12 GHz	18 GHz	0603	100

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THANK YOU

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