

Broadband Biasing of Amplifiers

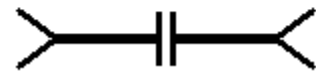
Introduction

Hittite has designed various amplifiers that require external biasing. These amplifiers are typically broadband with bandwidths greater than 10 GHz and usually have a low start frequency of less than 2 GHz. These amplifiers give the designer flexibility in biasing the amplifier. There also are various switches and attenuators that also require DC blocking capacitors on the RF lines. This application note will aid the designer in determining the critical parameters for component selection.

Decoupling Capacitor

If the datasheet for a part states that blocking capacitors are required before and/or after an amplifier a capacitor is required to block the bias or DC voltage. This is best done with a series capacitor which is commonly referred to as a DC blocking capacitor. Our datasheets will typically define the pin as DC coupled in the **Pin Descriptions** Table which implies that a DC blocking capacitor is required. The impedance of capacitor is inversely proportional to the frequency and the value of the capacitor. Since most systems are designed in a characteristic impedance of 50 ohms a general rule of thumb is that a series capacitor should have less than 10 ohms of impedance at the lowest frequency of operation. Hittite actually recommends that the impedance be less than 1 ohm. With this in mind, a 100 pF capacitor has 1 ohm of impedance at 1.6 GHz. This takes care of the lowest frequency of operation.

$$Z_c = \frac{1}{2\pi fC}$$



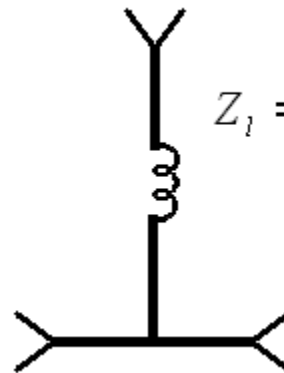
A second consideration for the capacitor is the highest frequency of operation. When single layer capacitors are used this is usually not a concern. It will be a concern with using a multilayer capacitor when a surface mounted devices (SMD) is used. Most SMD's have parasitic elements, i.e. inductance, which could have an effect at higher frequency. As the capacitor becomes lower in impedance with increasing frequency, the parasitic element could become the dominate element. The designer must be mindful that the capacitor needs to behave properly to the highest operating frequency. One parameter to review is the self resonance frequency. Above the self resonance frequency the capacitor will not act like a capacitor any more. Most capacitor datasheets list this information.

The final consideration for the capacitor is voltage. The maximum voltage applied to our amplifiers is 15 Volts. An output signal of 1 Watt (30 dBm) generates a peak voltage of 10 Volts, therefore the capacitor must be able to handle at least 25 Volts. There are products that use GaN which may require higher voltages.

Bias Inductor

If the datasheet for a part states that the part requires a bias current to be applied through one of the RF ports, you do not want the RF signal to travel this path. Ideally you would have a short at DC, and an open circuit for all RF signals. This is best accomplished with an inductor. The inductor will carry the RF current to the part while isolating the RF signal from the DC power source. Since most systems are designed in a characteristic impedance of 50 ohms a general rule of thumb is that the bias (shunt) inductor should have more than 200 ohms at the lowest frequency of operation. This generates a voltage stand wave ratio of 4:1 or return loss of 4.4 dB. With this in mind, a 10 nH inductor has 200 ohms of impedance at 3.26 GHz. This takes care of the low frequency of operation.

$$Z_l = 2\pi fL$$



A second consideration for the inductor is the high frequency of operation which is mostly required with surface mounted devices (SMD). As with the SMD capacitors there are parasitic elements, resistors and capacitors, which limit the high frequency of operation. Most datasheets list this information. For very large bandwidth it is best to use a conical inductor. The construction of a conical inductor is a wirewound wire with a varying

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diameter. This construction yields very large bandwidths. Conical inductors do not have large reactive parasitic elements. You may have to take into account the resistive parasitic element in your design.

The final consideration for the inductor is current. The wire must be able to handle maximum current require by the amplifier. The conical inductor will tend to have higher have more DC resistance with higher current capability.

Bias Tees

Some products require bias tees. In this case a combination of bias inductor and decoupling capacitors are used.

Products

Hittite does not recommend any one company for capacitors and inductors. Here is a small list of companies that do sell these components:

Capacitors

Murata www.murata.com
 AVX www.avx.com
 ATC www.atceramics.com
 Dielectric Labs <http://www.dilabs.com/>

Inductors

CoilCraft www.coilcraft.com
 Murata www.murata.com
 Piconics www.piconics.com
 Toko www.toko.com

Conical Inductors

CoilCraft www.coilcraft.com
 Piconics www.piconics.com

