Application Note: Bias Tee for CMPA0060025F GaN MMIC

Introduction

A bias tee for the CMPA0060025F, operating from 20 MHz to 6000 MHz, at output power levels up to 44 dBm is implemented using a ferrite core wire wound inductor, blocking capacitor, and surface mount thermal conductor on a 20 mil RO4003B substrate. Alternate designs, using commercial off the shelf (COTS) components, are presented that can operate from 200 MHz and 500 MHz to 6000 MHz. The insertion loss does not exceed 1 dB across the band.

Figure 1 shows the insertion loss of various Bias Tee architectures used with the CMPA0060025F depending on the desired frequency range.

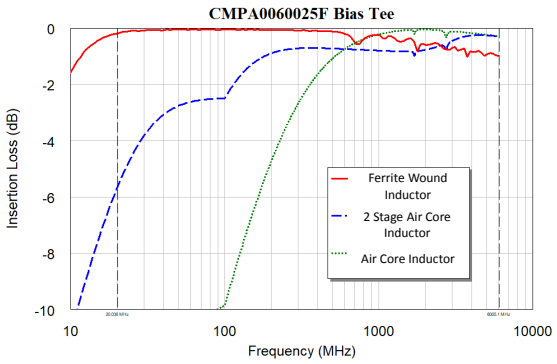

Figure 1.

Figure 2 shows the schematic for a bias tee operating from 20 MHz to 6000 MHz at 44 dBm. A custom ferrite wound inductor is used for the RF choke along with a 240 pF ATC 600F capacitor for the DC block. A QB0805A40W thermal conductor from the ATC Q-bridge series is used to stabilize the temperature of the RF choke.

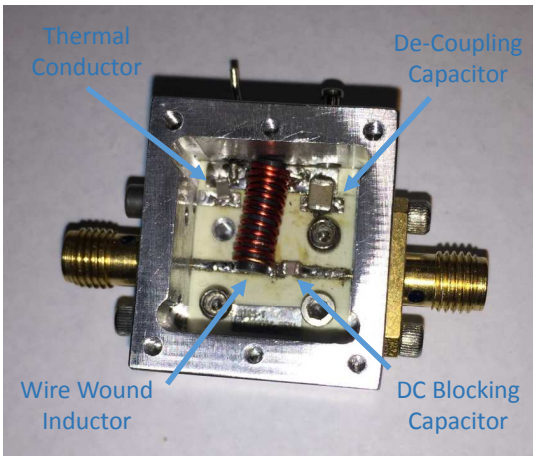

Figure 2.

Figure 3 shows the implementation of the bias tee on the schematic in Figure 2 and the results for the Ferrite Core Wire Wound Inductor in Figure 1.

DC Blocking and Decoupling Capacitor

The blocking capacitor should be selected such that it presents a low impedance at all frequencies in the band, can handle the output voltage swing, and has an SRF outside the operating band. An ATC 600F 240 pF capacitor was selected to minimize resonances in band while maintaining a low impedance at 20 MHz.

Decoupling capacitors should be added after the RF choke to minimize effects of the DC line and limit the noise coupled in/out of the system. For this application, an ATC 700B 1000 pF capacitor was selected. Additional capacitors can be added to improve noise suppression.

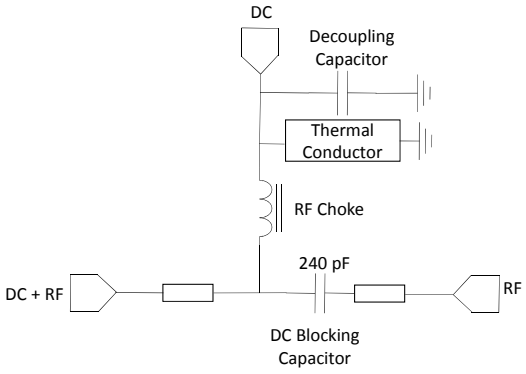

Figure 3.

Choke Inductor

The CMPA0060025F MMIC can operate at power levels as high as 44 dBm, reaching a maximum drain current of 1.6 A. The RF choke for the bias tee should present a high impedance over the frequency band while not exceeding current rating based on DC and RF losses. Several broadband surface mount inductors are available on the market that can meet the DC current and impedance requirements of the application. However, the components achieve high impedance at low frequencies using a high permeability material with frequency dependent losses. It was observed the package temperature of the surface mountable broadband chokes exceeded the absolute rating when operated with the CMPA0060025F at CW saturated output power levels. The low current requirements at the input allow for the use of surface mountable broadband inductors to be use to optimize bandwidth and insertion loss of the bias tee. Parts are available from Coilcraft, Piconics, and Gowanda.

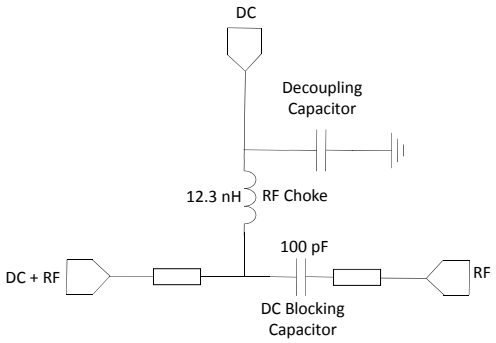

Figure 4.

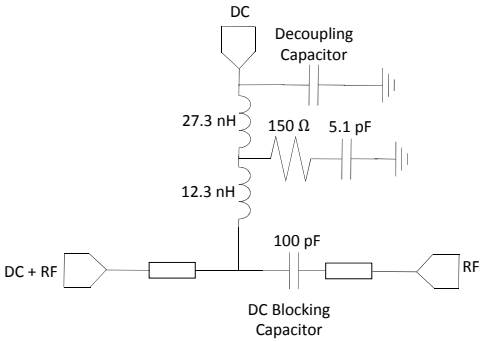

Figure 5.

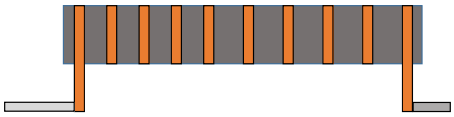

Figure 6.

A ferrite core wire wound inductor was used for the RF choke for the drain to achieve high impedance rejection from 20 MHz to 6000 MHz with a maximum insertion loss of 1 dB across the band. The inductor was wound using 24 AWG magnet wire around a 450 mil long ferrite core (61) with a 150 mil diameter. An inductance of at least 1 uH was achieved with 9 to 12 turns and 10-20 mil spacing between the turns. The Inductor was mounted parallel to the board with a slight elevation. The length of the wire connected to the RF thru line was minimized and mounted perpendicular to the trace close to the DC Blocking Capacitor.

At specific frequencies, saturated output power caused heating in the inductor. An ATC Q-Bridge series thermal conductor was used to stabilize the temperature of the component. The 0805 AIN thermal conductor was mounted on the DC input line of the inductor and connected to a ground pad. Thermal rise in the part was significantly curved.

Air core inductors do not exhibit the thermal issues seen in ferrite core inductors and have lower insertion loss at 6000 MHz. However, the lower end of the frequency band is limited by the size of the inductor required to achieve inductance higher than 1 uH. Additionally, high inductance components tend to have resonances within the 20 MHz to 6000 MHz band. Figure 4 and Figure 5 show the use of a single inductor and a two-inductor ladder circuit. A single inductor can function as an RF choke down to 500 MHz, while the two-inductor ladder circuit works as an RF choke down to 200 MHz.
Figure 4 shows the schematic for the bias tee operating from 500 MHz to 6000 MHz. An AVX AS0612N3 inductor and ATC 600F 100 pF Capacitor are used. Figure 5 shows the schematic for a bias tee implemented using 2 inductors, AVX AS0612N3 and AS0827N3, in a ladder configuration. An ATC 600F 100 pF capacitor is used for DC Block. A Shunt RC is used to dampen a resonance between the 2 inductors.