performances in Figure 6.13(*b*) and Figure 6.14(*b*), the optimum design demonstrates substantially improved performance with a steeper stopband response.

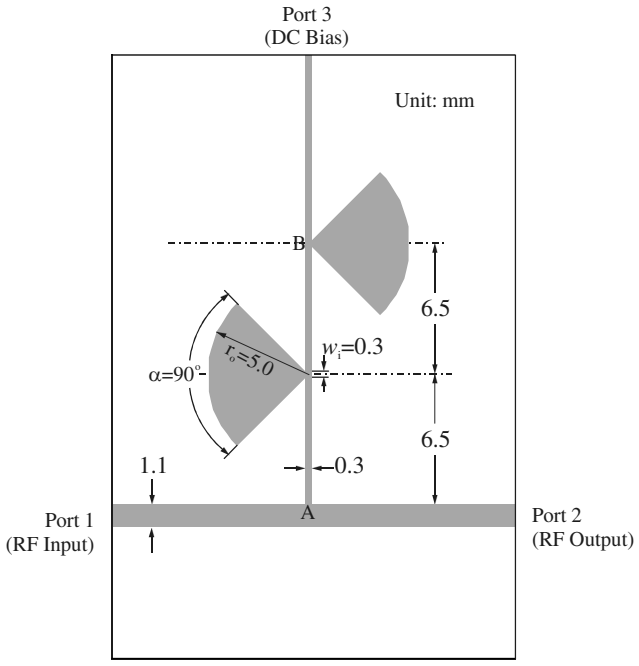
6.2.4 Bandstop Filters for RF Chokes

A bandstop filter with quarter-wavelength, open-circuited stubs may be designed as a pseudolowpass filter. Such a bandstop filter should function efficiently in a bias network to choke off RF transmission over its stopband, while maintaining a perfect transmission for direct current.

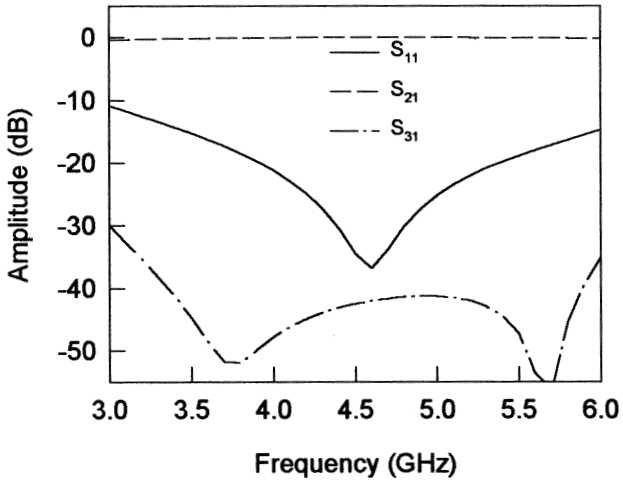
Figure 6.15(*a*) shows a basic bias network incorporating a bandstop filter (from points *A* to *B*). This type of network is also referred to as a bias T. A bias T is commonly used for feeding dc into active RF components in such a way that the RF behavior is not affected at all by the dc connection. Referring to Figure 6.15(*a*), the connection of the bandstop filter should not affect the RF transmission from ports 1 to 2. In other words, the bandstop filter should produce an RF open circuit at the connecting point *A*. Since RF active components such as amplifiers and oscillators operate over a limited frequency band, it is normally only necessary for a dc bias circuit to choke off the RF over such an operation bandwidth. On this ground, to use a stub bandstop filter instead of a lowpass filter would be preferred, because the open-circuited stubs, which are quarter-wavelength long at the center frequency of the operation bandwidth, can more efficiently choke off the operating RF signals.

In many situations, such a bandstop filter composed of a single section of an open-circuited stub and a quarter-wavelength connecting line, may be found to be adequate for the required RF choke. To obtain a wider stopband, more sections may be cascaded. Furthermore, the open-circuited stub may take a different form than a conventional straight line. For instance, the bandstop filter in Figure 6.15(*a*) consists of two radial stubs and two quarter-wavelength connecting lines between points *A* and *B*. The dc bias is applied to point *B* through another line of arbitrary length from port 3. The radial stub is another common component used in both hybrid and monolithic microstrip circuits to provide a low impedance level at a well-specified insertion point in a wide frequency band [7]–[9].

For the design of a bandstop filter of the type in Figure 6.15(*a*), a radial stub such as a conventional quarter-wavelength open-circuited stub is designed to short out the RF transmission, so as to cause an attenuation pole at a midband frequency of the stopband. The outer radius r_o of a radial stub will mainly decide the attenuation pole frequency, whereas the angle α mainly affects the bandwidth. It is obvious that a larger radius r_o results in a lower attenuation pole frequency. It can also be shown that as the angle α is increased, the reactance slope of input reactance of the radial stub is decreased, and as a consequence, the bandwidth of attenuation is increased. The input port width w_i [refer to Figure 6.15(*a*)] of a radial stub can have some effect on both the attenuation pole frequency and the bandwidth. For other parameters fixed, increasing the input port width w_i will in general increase the attenuation pole frequency and the bandwidth. In practice, w_i should be very small compared to the guided wavelength in order to excite only the dominant TEM radial mode and to



(*a*)



(*b*)

FIGURE 6.15 (*a*) A microstrip bias T incorporating a bandstop (pseudolowpass) filter for RF choke. (*b*) EM simulated performance of the microstrip bias T.

have a well-defined point of low impedance at its input. Usually, w_i may be chosen to be the same as the width of connecting inductive line.

The connecting inductive line for each radial stub is $\lambda_{g0}/4$ long, where λ_{g0} is the guided wavelength of the inductive line at the midband frequency of the desired stopband for RF choke. A quarter-wavelength inductive line at the input of a bandstop filter is necessary for transforming an RF short circuit resulting from a radial stub into an RF open circuit at the input port of the filter, or at junction point *A* in a bias T circuit, as shown in Figure 6.15(*a*). To achieve a wider stopband and better RF choke, the width of inductive lines should be chosen to be as narrow as possible; in other words, the characteristic impedance should be as high as possible. In practice, the possible narrow line width will be limited by fabrication tolerance and handling capability of dc current.

The dimensions given in Figure 6.15(*a*) are for a microstrip bias T on a RT/D 6010 substrate with a relative dielectric constant of 10.8 and a thickness of 1.27 mm. The bandstop filter is designed to provide an RF rejection better than 40 dB over an operating frequency band from 3.5 GHz to 5.5 GHz. The EM simulated performance of the microstrip bias T is illustrated in Figure 6.15(*b*), showing a good RF choke (S_{31}) over the desired frequency band.

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