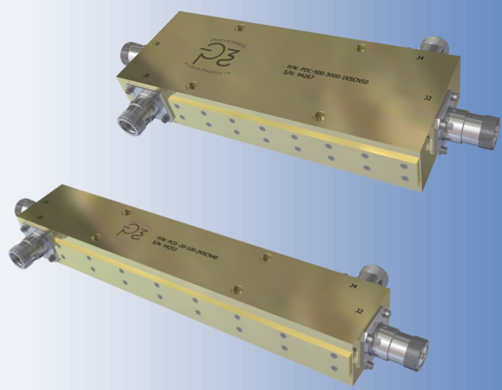
Technical Notes

Directional Couplers



General Description:

The most common form of directional coupler is a pair of coupled transmission lines. They can be realized in a number of technologies including coaxial and the planar technologies (stripline and microstrip). An implementation in stripline is shown in **figure 2** of a quarter-wavelength (λ/4) directional coupler. The power on the coupled line flows in the opposite direction to the power on the main line, hence the port arrangement is not the same as shown in **figure 1**, but the numbering remains the same. For this reason it is sometimes called a backward coupler. The main line is the section between ports 1 and 2 and the coupled line is the section between ports 3 and 4. Since the directional coupler is a linear device, the notations on **figure 2** are arbitrary. Any port can be the input, (an example is seen in figure 20) which will result in the directly connected port being the transmitted port, the adjacent port being the coupled port, and the diagonal port being the isolated port. On some directional couplers, the main line is designed for high power operation (large connectors), while the coupled port may use a small connector, such as an SMA connector. The internal load power rating may also limit operation on the coupled line.

Accuracy of coupling factor depends on the dimensional tolerances for the spacing of the two coupled lines. For planar printed technologies this comes down to the resolution of the printing process which determines the minimum track width that can be produced and also puts a limit on how close the lines can be placed to each other. This becomes a problem when very tight coupling is required and 3 dB couplers often use a different design. However, tightly coupled lines can be produced in air stripline which also permits manufacture by printed planar technology. In this design the two lines are printed on *opposite* sides of the dielectric rather than side by side. The coupling of the two lines across their width is much greater than the coupling when they are edge-on to each other.

The frequency range specified by is that of the coupled line. The main line response is much wider: for instance a coupler specified as 2–4 GHz might have a main line which could operate at 1–5 GHz. As with all distributed element circuits, the coupled response is periodic with frequency. For example, a λ/4 coupled line coupler will have responses at *n*λ/4 where *n* is an odd integer.

A single λ/4 coupled section as in **figure 3** is good for bandwidths of less than an octave. To achieve greater bandwidths multiple λ/4 coupling sections are used as shown in **figure 5**. The design of such couplers proceeds in much the same way as the design of distributed element filters. The sections of the coupler are treated as being sections of a filter, and by adjusting the coupling factor of each section the coupled port can be made to have any of the classic filter responses such as maximally flat (Butterworth filter), equal-ripple (Cauer filter), or a specified-ripple (Chebychev filter) response. Ripple is the maximum variation in output of the coupled port in its passband, usually quoted as plus or minus a value in dB from the nominal coupling factor.

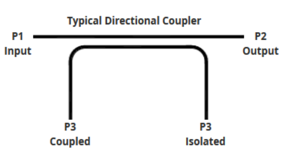


Figure 1

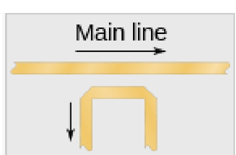
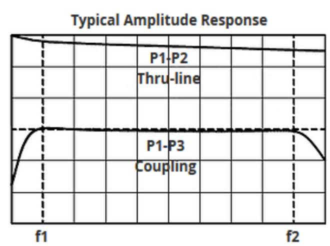
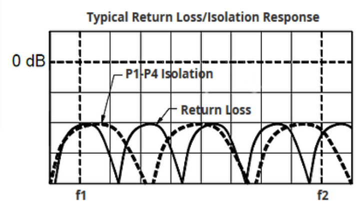


Figure3





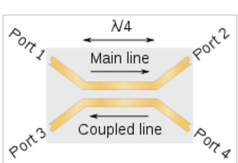


Figure 2

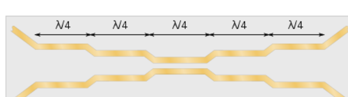
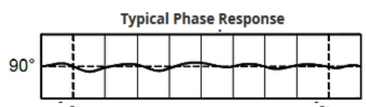


Figure 5



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