Reactive vs. Wilkinson Splitters

Power Dividers for Wireless Distribution

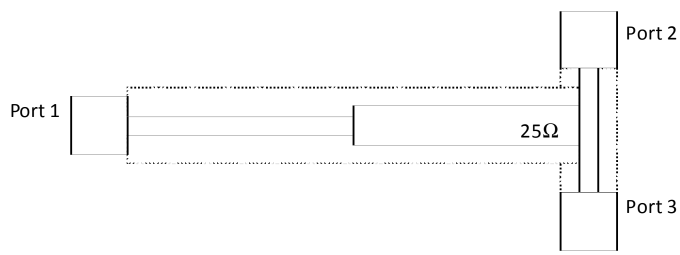
Choosing the Most Appropriate Splitter for the Application

Splitters are used extensively in wireless signal distribution networks, to split the base station transmitted signal, Tx, into many different paths to reach multiple antennas, and at the same time to transmit the signals received by the antennas, Rx, back to the base station receiver.

Two popular types of splitters, Reactive and Wilkinson, generally are used for this purpose, but each has distinctly different benefits. This application note attempts to identify those benefits.

Characteristics of Reactive Splitters and Wilkinson Splitters

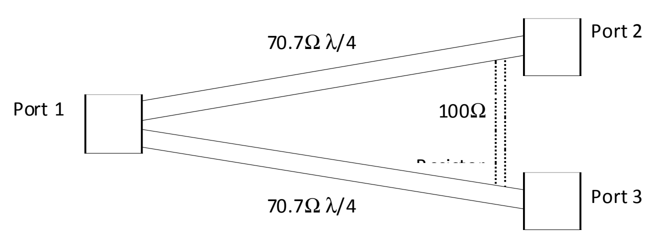
Reactive Splitters are generally coaxial structures. They transform a 50Ω input impedance to 25Ω using different inner to outer conductor ratios. This 25Ω provides a good match for two 50Ω matched outputs in parallel.



Wilkinson Splitters for microwave frequencies generally use a microstrip design. They consist of a pair of quarter wave ($\lambda/4$) transmission line sections with characteristic impedance of 70.7Ω which are series terminated at the output with a 100Ω resistor.

First consider the Tx signal entering at Port 1:

In the Reactive Splitter, the signal entering Port 1 is transformed to 25Ω, which is then matched exactly by the two 50Ω outputs, Ports 2 & 3 in parallel, providing an excellent input VSWR.



In the Wilkinson Splitter, the signal splits into equal amplitude and phase signals appearing at Ports 2 & 3. Since each end of the resistor is at the same potential, no current flows through it. With the characteristic impedance of the quarter wave lines equal to 70.7Ω, ($\sqrt{2}$*50Ω), the input then has a good VSWR provided Ports 2 & 3 are terminated in 50Ω.

Now consider the Rx signal entering at Port 2:

In the Reactive Splitter, a signal at Port 2 is presented with a mismatch. 25% of the signal will be reflected and 25% will be transmitted out of Port 3. The 50% balance will be directed to Port 1, which is an effective 3 dB path loss in the Rx signal. (This can also be explained by the rule of reciprocity: a signal passing through a 2 port passive network will exhibit the same loss irrespective of the signal's direction).

In the Wilkinson Splitter, the signal at Port 2 is presented with a 50Ω match, but then it splits equally between the terminating resistor and Port 1. The resistor therefore serves the function of decoupling Ports 2 and 3, but once again there is a 50% or 3 dB path loss in the Rx signal.

With the benefit of decoupled outputs, why not choose the Wilkinson?

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Reactive Splitters

Wilkinson Splitters

With the benefit of decoupled outputs, why not choose the Wilkinson?

Insertion loss is the enemy of every wireless signal distribution system designer.

Reactive splitters generally use air-line dielectrics with silver plated, brass conductors with aluminium housings, in practice the lowest loss transmission lines available (we exclude the exotic superconductors!). Losses are usually 0.05 dB or less, but are usually quoted as 0.1 dB since measurements of such losses are so difficult.

Wilkinson splitters designed on microstrip boards, have inherent losses from 0.3 to 0.5 dB. It may not sound much individually, but the losses of serial splitters mount up quickly in any multi-story network.

Decoupled or isolated outputs makes a system more reliable. Or does it?

1. If a cable or antenna is damaged it may present a short or open circuit to the splitter. We should be safe in the belief that the problem in one arm will not affect the other arm thanks to the isolation of the outputs. But, now we have the situation of a Tx signal being reflected, a Tx signal many, many times stronger than the Rx signal.

2. The problem arises because the resistor used in the Wilkinson splitter generally has a power rating of just 100mW, and it necessarily has to be a low rating because stripline requires that it be small. This is fine when dissipating an Rx signal levels, but reflected Tx levels that occur when someone open circuits an antenna or short circuits a cable, are often enough to damage this fragile resistor. Once the resistor is damaged, the splitter will never work properly again, and make restoring the network far more difficult.

3. On the other hand a Reactive Splitter has no resistor to burn out, so once the short or open circuit is corrected, its operation returns immediately to normal, a major advantage when restoring a damaged system.

4. Mechanically the size and shape of the Wilkinson is more convenient, however, the reactive is virtually indestructible which can be very beneficial when systems are being installed by inexperienced installers.

So in conclusion, Reactive Splitters and Wilkinson Splitters operate in very similar manners. But Reactive Splitters have much lower loss, and the apparent advantage of isolation is more than offset by the questionable reliability of the isolation resistor.

Microlab offers both Reactive Splitters and Wilkinson Splitters, so the customer may choose the most appropriate style for the application. Reactives are offered in 2, 3, 4 ,5 and 6 way configurations, with either N or 7-16 mm DIN connectors to meet most in-building and wireless infrastructure applications. while Wilkinson splitters are offered in 2, 3, 4, 6 and 8 way styles, in N and SMA connectors.

All are offered in a wide variety of frequency ranges from 70 to 6000 MHz. (06/10)