Internet Copy Rev A

POWER DIVIDERS

Overview

Various RF applications require power to be distributed among various paths. The simplest way this can be done is by using a power splitter/divider. Power dividers are reciprocal devices, i.e. they can also be used to combine power from output ports into the input port. The two main categories of power dividers are, reactive and resistive, with each suited for its own specific application. This article explains the different types of power divider, key parameters and some considerations that need to be taken into account when incorporating power dividers into your design.

Figure 1: Broadwave Power Dividers

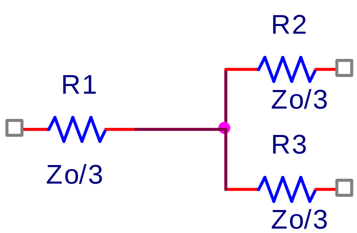

Figure 2: Layout of 2-Way resistive divider

Calculations

Resistor values for a N-way resistive divider:

R = Zo * ((N-1)/(N+1))

Where Zo is the characteristic impedance of the system

Transferred power ratio = $(1/N)^2$

Resistive power dividers

Resistive power splitters have inherent characteristics that make them an excellent choice for certain applications but unsuitable for others.

Figure 2 shows the layout of a simple 2-Way resistive power divider. Zo denotes the characteristic impedance of the system.

Here are some advantages and disadvantages of the resistive divider :

Advantages:

- Generally these units are smaller because they are made utilizing lumped elements.
- These units are can be extremely broadband and are the only type of dividers that operate DC onwards.

Disadvantages:

- These units have poor power handling capability, usually limited by the power tolerances of the resistors.
- These units tend to have high loss and poor isolation, making them a poor choice for applications where insertion loss and isolation are critical factors.

Things to consider

- A resistive power divider has a power ratio of $(1/N)^2$ (where N is the number of outputs) when compared to a reactive power divider which has a power ration of 1/N. This means for a 2-Way divider with 1 watt input power, a reactive unit's output port will have 0.5 watts (50% or 3 dB loss) of power on each port, while a resistive divider's output will have 0.25 watts (25% or 6 dB loss) of power on each port.
- Resistive divider's loss includes distribution loss and inherent resistive loss, unlike the "lossless" reactive dividers (which only have distribution loss). So as a general rule, insertion loss of a resistive power divider is *double* that of a similar reactive unit (see Table 1).
- In a resistive power divider, insertion loss = isolation.

Reactive power divider

Reactive power dividers come in various forms and cover a wide range of frequencies. They can have multiple output ports, but those with odd number of output ports are usually referred to as N way power dividers. They can be realized using waveguide, stripline, microstrip, transformer and various other technologies. These dividers come in in-phase, 180° out of phase (180° hybrids), 90° out of phase (quadrature hybrids) and other specialized configurations. One of the main advantages of using reactive power dividers is that they are "lossless". Table 1 (see parameter definitions page) gives the number of output ports and the insertion loss that is associated with them. It is beyond the scope of this article to explain the theory and operation of these devices, instead a brief explanation is given on some of the devices, with the Wilkinson type explored more in detail. Some key parameters and some things to consider , when incorporating these devices into your design, are explained.

Figure 3 shows the general layout of a 2-Way divider. Higher order devices like (4, 6, 8 way etc) are usually realized by cascading the 2 way in various configurations. Figure 4 shows the layout of a N way power divider (a 3 way is shown). Note that all ports connected in a manner that makes them mutually isolated from one another.

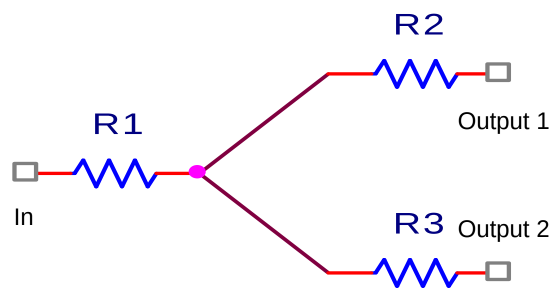

Figure 3: Layout of a 2 way power divider

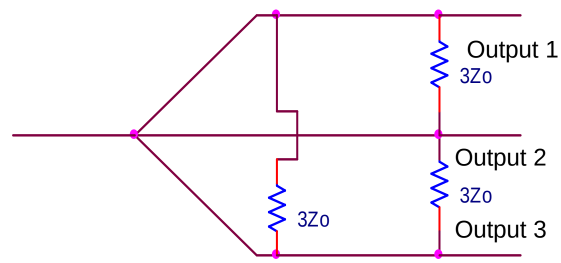

Figure 4: Layout of a 3-Way power divider

The Wilkinson power divider

At higher frequencies (above 500 Mhz) these devices are usually realized as a microstrip or stripline Wilkinson design. All Browadwave reactive power dividers are Wilkinson types. Figure 5 shows a simple 2-Way Wilkinson power divider. Being a lossless reciprocal three port network, it inherits all its properties which state that this type of network cannot have all the ports simultaneously matched. To solve this an isolating resistor is placed between the two output ports, since no current flows through the resistor (there is no potential difference between the output ports), this resistor does not contribute to any resistive loss. This makes an ideal Wilkinson a 100% efficient device. This resistor also provides excellent isolation even when the device is used as a combiner. Another property of the Wilkinson divider is that it is broken down into quater wavelength (λ/4) sections. This device is useful for limited bandwidth applications, but to achieve a wider bandwidth a multi section Wilkinson design is used as shown in Figure 6. As a general rule, the greater the bandwidth the more sections added to the design. But by doing so, makes devices become larger and more importantly lossy. These devices can be designed for octave bandwidths and are sometimes cascaded to form higher order devices.

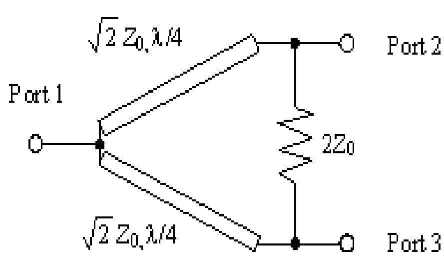

Figure 5: 2-Way Wilkinson power divider

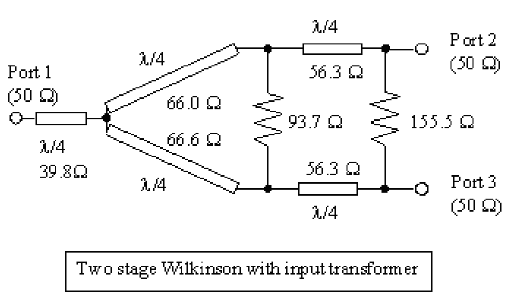

Figure 6: 2 stage Wilkinson power divider

POWER DIVIDERS

Terms and Definitions

When choosing a power dividers, here are some key parameters you need to consider.

Frequency Range (Hz): This is application specific.

VSWR: Voltage Standing Wave Ratio (VSWR) is the ratio of maximum and minimum voltage at a given point along a transmission line. VSWR is a good measure of power transfer efficiency. A low VSWR (i.e. closer to unity with little or no reflections) means more power is delivered from the source to the load, while a high VSWR (i.e. much greater than 1 with lots of reflection within unit) has less power delivered to the load.

Insertion Loss (dB): Insertion loss is the decrease in the transmitted signal power due to the insertion of a device in a transmission line. It is defined as the ratio of the output to input power.

Coupling Factor (dB): Ratio of power transferred to coupled port with respect to the input port.

Isolation (dB): Ratio of input power with respect to power at isolated port or vice versa. The output ports of the divider are isolated from one another (the input port is isolated from the output port if the unit is used as a combiner) by the isolating resistor. Ideally no current flows through the resistor as the ports are of the same potential, but if non-identical signals which are out of phase are combined a voltage differential is formed between the ports causing current to flow through the resistor, reducing the isolation. Isolation is a critical factor when determining interference or “crosstalk” between the ports.

Amplitude Tracking (dB): The difference between the amplitude of the output signals measured at the output ports of the dividers. It is defined as the ratio of the maximum amplitude of signal at any port to the minimum of any other ports, expressed in decibels. This is also sometimes specified as amplitude balance (or imbalance)

Phase Tracking (degrees): The maximum deviation, from theoretical value, between the phase measured between two output signals. This is also sometimes specified as phase balance (or imbalance).

Octave Bands (Hz): A doubling in frequency is represented by an octave. 1-2 Ghz is an octave, while 8-12 Ghz is half an octave.

Input Power (W): Both average and peak power need to be taken into account when choosing a divider.

No. of output ports (N)	Insertion Loss (dB)
2	3.01
3	4.77
4	6.02
5	7
6	7.78
8	9.03
10	10
N	10log(N)

Table 1: Number of power divider outputs vs. corresponding insertion loss

Things to consider

- *Bandwidth tradeoffs:* For a wide bandwidth application, a multi-section Wilkinson unit will be suitable. But as the number of sections increase, so does the insertion loss. At Broadwave, we encourage the customer to contact us directly so that we can narrow down a particular unit to work very well at the specific limited bandwidth rather than getting something for a much broader bandwidth. Broader bandwidth units not only suffer the insertion loss problems mentioned above, but also are generally more expensive.
- *Power distribution:* The average power specified only applies to the input port. This is the *total* amount of power that can be divided or combined. This means, for a 2-Way divider with 10 watts input power source, it can be split into two 5 watts sources, but two 10 watts sources cannot be combined into a 20 watt source. Simply put, the power specified is the maximum amount of power that can be input or output (combined) at the common port.
- *Connector types:* All Broadwave units can be customized for specific connector types for both input and output ports. This solves the problem of buying a non compatible connector type unit for your application and having to add unnecessary adapters, which not only increase cost, but also degrade performance parameters like VSWR and insertion loss.

Applications

- Base stations
- Antenna arrays
- In building wireless communication systems
- Transmission line fault testing
- Ratio measurements
- Signal processing applications

Broadwave Technologies Power Dividers

Given below are some of the general specifications of Broadwaves's power dividers. Most are available in octave, multi-octave bands. Many connector types are available. Both 50 Ω and 75 Ω models are available (contact us for 75 Ω models). For more detailed information, specifications or to view entire catalog, please visit our website. If you are unable to find something to your specifications, feel free to contact us.

Directional Power Dividers (Part no: 15X-XXX-XXX)	
Connector Types	F,SMA, N, TNC, BNC
No. of outputs	Up to 64 way
Input Power (Average)	Up to 10 Watts (Resistive)
	Up to 40 Watts
Design	In phase Wilkinson type
Frequency Range *	DC to 6 Ghz (Resistive)
	20 Mhz to 18 Ghz (Reactive)
Operating Temperature * *	- 55 ^{o}C to +125 ^{o}C
Mounting options	Special rack mounting available

Note: * Octave, multi-octave dividers are available. Specific bandwidth models are available upon request.

** Special weather resistant models are also available.

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