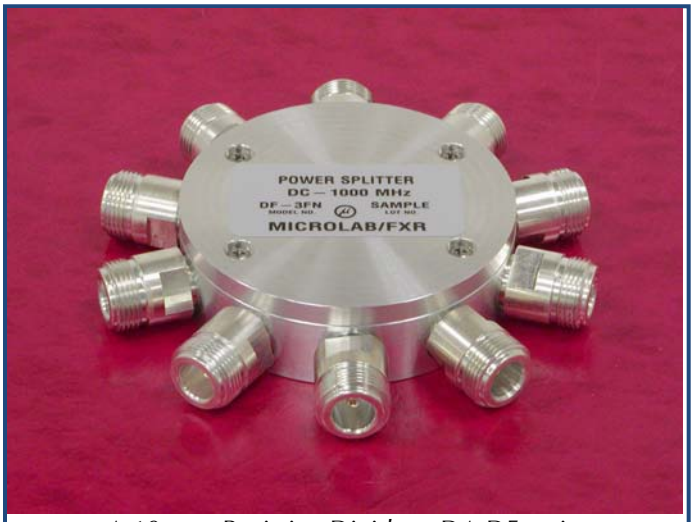
DIVIDERS & COMBINERS

A wide and often confusing assortment of power dividing and combining methods are available to the system designer, each of which has its own attributes and deficiencies. In addition, the same component can often be used to both divide and combine. This application note is intended to guide the system designer in the selection of the optimum component for any particular need.

POWER DIVIDERS or POWER SPLITTERS

Power dividers are devices that divide an RF signal into two or more signals with roughly the same amplitude. The most common methods of power division include resistive and reactive power dividers and hybrids. These are tabulated below:

Resistive Dividers (DA Series): These most simple forms of power dividers contain internal resistive matching networks, which provide matched input and output impedances. They are available with two or more outputs and operate from DC to several Gigahertz or more. In contrast to most other dividers, these devices dissipate a portion of the input power in their resistive networks. Furthermore, they are generally (but not always) symmetrical and do not provide output arm isolation in excess of the input-to-output insertion loss. They are low cost, small size dividers that are frequently used in low power applications where their losses can be afforded and where their low cost and broadband properties are attractive.



A 10 port Resistive Dividers, DA-DF series

DIFFERENT TYPES OF DIVIDERS

DIVIDERI HYBRID TYPE	FREQUENCY RANGE (GHz)	BAND-WIDTH	LOW COST	TYPICAL MAX. POWER	TWO WAY EQUAL OUTPUT DIVIDER				SUITABILITY FOR:	
					PATH LOSS	OUTPUT ISOLATION	OUTPUT PHASE	MATCHED OUTPUTS	3 PLUS OUTPUTS	USE AS COMBINER
Resistive	DC - 18	Broad	Yes	2W	6 dB	6 dB	0°	Yes	3 to 12+	Yes
Reactive	0.2 - 18	Octave+	Yes	750W	3 dB	6 dB	0°	No	3 to 6+	Unsuitable
Wilkinson	*0.5 - 40	Octave+	No	5W	3 dB	20+ dB	0°	Yes	3 to 16+	Coherent only
Quadrature	*0.2 - 12	Octave+	No	100W	3 dB	20+ dB	0/90°	Yes	N/A	Quadrature coherent only
Branch Line	1 - 18	10%	No	1W						
Ring (Magic-T)	*0.3 - 18	20%	No	5W	3 dB	20+ dB	0/180°	Yes	N/A	0/180° only
Junction	0.1 - 2	Broad	Yes	100W	3 dB	6 dB	0°	No	3 to 4	Suitable with no match

*lumped element based products have low limit of about 100 kHz

These devices are also used as power combiners. They permit signals of any frequency or phase to be combined. They are generally supplied with the minimum loss necessary to provide proper impedance match but can be designed for maximum isolation.

Reactive Dividers These devices consist of a single input and two or more outputs. They contain a broadband impedance transformer to match the impedance at the junction of the multiple outputs to hat of the transmission line, generally 50 ohms. They are lossless, broadband devices with excellent output amplitude and phase balance.

2 & 3 way reactive Power Splitters, D2/3-85FD, for high power wireless base station applications

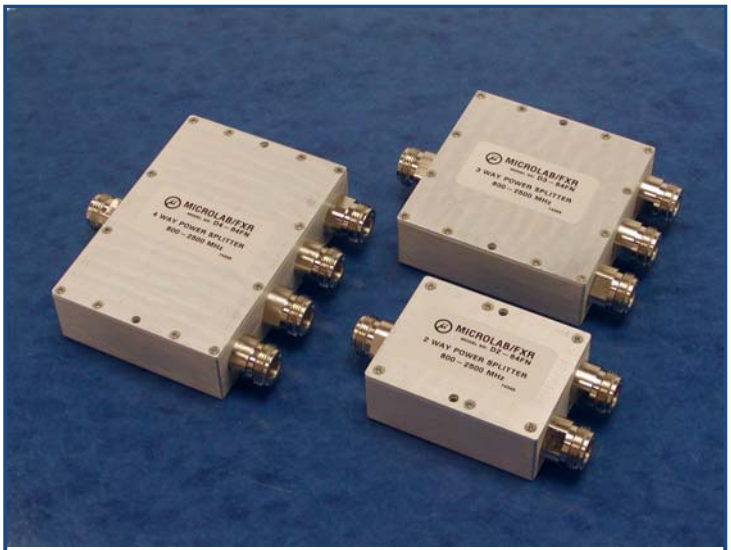
These features make the reactive splitter especially suitable for high power applications, such as is found at a cellular wireless base station. Here the transmission signal needs to be split up to feed multiple antennas, which are aimed to provide omni-directional signal distribution, and inhibit multipath effects using space diversity.

In order to satisfy different antenna designs, Microlab/FXR offers splitters configured to divide the signal into two, three, four, five and six ways. Antenna designs also require different mechanical layouts to suit the physical environment. A feed cable feeding to the top platform of a tower may well require a splitter that sends the signal in all directions at right angles to the output path. On the other hand, when mounted on a wall or pole, a splitter should be in a single plane configuration.

Reactive Splitters/Dividers do not provide extra isolation between their outputs and do not present matched output impedances. Thus, in contrast with some other dividers, they are not usually suitable for use as power combiners unless there is precise amplitude and phase coherence.

Wilkinson Dividers: Wilkinson dividers are similar to reactive dividers in that they are lossless, broadband devices with an input transformer and with excellent amplitude and phase balance.
In addition, their small internal terminating resistor enables them to provide high output isolation and matched output impedances. The terminating resistors severely limits their power ratings, particularly with mismatched loads, so they are most commonly found in small signal and signal processing applications.

Microlab has a wide range of such dividers extending from 70 MHz to 6 GHz to meet a wide variety of requirements.



Three way Reactive Power Splitter, D3-14FN, designed for dual band wireless applications, 800 – 2200 MHz

Parallel Line Hybrids, Quadrature Dividers or Hybrid Couplers (CA Series): These are the most frequently used hybrids (a special case of power dividers). They consist of quarter-wave parallel line coupled sections. They are lossless, broadband, high power devices with matched, isolated outputs. While they, like the Wilkinson divider, require fourth-port terminations, these terminations may be mounted at a distance and are not power limiting. Output signals are in phase quadrature.

Hybrid Coupler CA-84D designed to cover dual wireless bands, 698 – 2700 MHz

The characteristics of the quadrature hybrid are useful when splitting a signal to two similar impedance mismatches, such as amplifiers or antenna elements. In such a case, the signal applied to the input sees a 50 Ohm impedance regardless of the degree of mismatch being presented by the two output loads. All reflections will combine at the isolated port, and cancel at the input, preserving the impedance match to the source. A similar situation occurs in reverse when the quadrature hybrid is used as a combiner of identical signals differing by 90° in phase. Now any reflections from similar source mismatches will combine at the isolated port and cancel at the output.

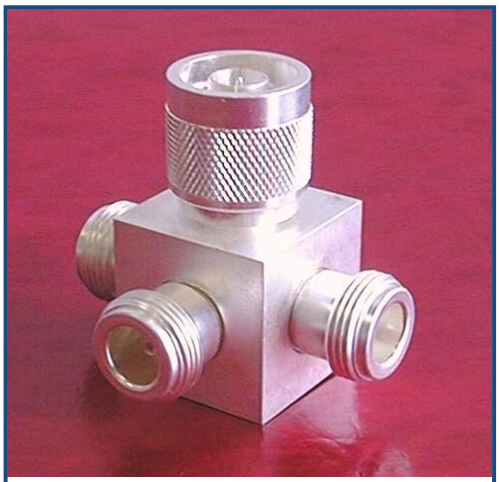
The quadrature hybrid is also used to combine non-coherent signals, in which case half of the signal will be directed to the output and half to the isolated port. If the split power can be used in say different antenna elements that are well isolated from each other, then the combiner can be considered practically lossless.

The majority of hybrids used have just a single quarter wave section, in which case bandwidth is limited to 5 to 10% on either side of the center frequency. Multi-section versions are available from specialist manufacturers for applications where output balance is required over multi-octave frequency bands.

Ring Hybrid: The ring hybrid (also known as the magic tee or rat race) consists of a ring 1½ wave-lengths in circumference with four arms each separated by 90°. When used as a power divider, one of the arms is the input, two are outputs, and the fourth arm is terminated. When used as a combiner, two arms are inputs, the third is the output and the remaining arm is terminated They are lossless devices with excellent amplitude and phase balance, high output isolation and matched output impedances. They are suitable for high power because the external termination may be as large as required. Bandwidth is limited to approximately 20%. Output phase relationship is either 0° or 180° depending on the selection of the input terminal.

Branch Line Hybrids: This is a direct coupled device with four arms arranged in a square configuration with ¼ wavelength on a side. They are similar in operation to the ring hybrid except that the output phase relationship is 90° and the bandwidth is limited to approximately 10%.

Junctions: In circuits where impedance match and isolation are unimportant, a single point junction can suffice. In practice these are essentially connectors with a common ground and all center conductors joined together. Commonly available in 3, 4 and 5 way junctions, they may be the inexpensive option for non-demanding signal division or combination.


Junction, J4-1TN

Microlab/FXR hopes you have found this information useful. Please refer to our catalog data sheets for specific model numbers and performance specifications. We welcome your suggestions. If you have any questions, our Sales and Technical Staff is available to help. We feature delivery from stock on many items and the ability to provide custom components for your specific needs.

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