Application Notes

All About RF Power Splitters

By Brian Baxter, Posted Thu May 02 2024 21:12:40 GMT-0500 (Central Daylight Time)

RF power splitters play a crucial role in distributing RF signals efficiently and accurately across various electronic systems. Whether used in telecommunications, radar systems, or test and measurement equipment, power splitters enable signal distribution while maintaining signal integrity and minimizing losses. In this article, we'll explore the various types and classes of RF power splitters, highlighting their key characteristics, advantages, and applications.

What are RF power splitters?

RF power splitters, also known as power dividers, are passive devices designed to split an input signal into two or more output signals with equal or proportional power levels. They are essential components in RF systems where signal distribution is required, such as in antenna arrays, distributed amplification systems, and RF test setups. Power splitters are available in a variety of types, each offering unique performance characteristics to suit different application requirements. Please see Marki Microwave's full line of connectorized, waveguide, surface mount, and bare die splitters by clicking here.



Types of RF Power Splitters

As mentioned above, there are several types of RF power splitters, each with its own design and operating principles. Some common types include:

Wilkinson Power Splitters: Wilkinson power splitters are widely used in RF and microwave systems due to their excellent performance characteristics. They provide low insertion loss, good isolation between output ports, and maintain phase coherence between output signals. Wilkinson splitters are typically available in 2-way, 3-way, and 4-way configurations, with the number of ports determining the signal splitting capability.



Resistive Power Splitters: Resistive power splitters, also known as resistive dividers, are a basic type of power splitter that use resistors to divide the input signal into two or more output signals. They are simple in design and provide equal amplitude splitting, with each output signal being attenuated by a certain amount compared to the input signal. Resistive splitters offer excellent bandwidth at the expense of very low port-to-port isolation. Resistive splitters are commonly available in 2-way and 3-way configurations, with each

configuration offering different levels of insertion loss and isolation between output ports.



Hybrid Couplers: Hybrid couplers, also known as quadrature hybrids, are another type of RF power splitter commonly used in balanced signal distribution applications. They provide equal power splitting and maintain a 90-degree phase difference between output signals.



Directional Couplers: Directional couplers are passive devices that split an input signal into two output signals while maintaining a defined coupling ratio between the input and output ports. They are commonly used in RF systems for signal monitoring, signal sampling, and power measurement applications.



Rat-Race Couplers: Rat-race couplers, also known as 180-degree hybrids, are specialized RF power splitters designed to split an input signal into two output signals with a 180-degree phase difference. They are often used in applications such as phase shifters, balanced amplifiers, and image reject mixers. Rat-race couplers typically have 4 ports, with each port serving a specific phase-shifting function in the signal distribution process. Rat-race couplers are typically built using microstrip and have good port-to-port isolation, good phase and gain balance but as a result of the microstrip construction have larger size and narrower bandwidth than other options.

Marki does not offer Rat-Race couplers or 180 degree hybrids, as typically customers do not require the isolated port and can use baluns instead.

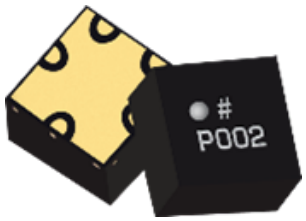
Classes of RF Power Splitters

In addition to different types, RF power splitters are classified based on their performance characteristics and specifications. Some common classes of RF power splitters include:

Classical Power Splitters: Classical power splitters, such as resistive dividers and simple Wilkinson splitters, provide basic power splitting functionality with relatively simple circuit designs. They are suitable for applications where cost-effectiveness and simplicity are prioritized over performance.

High-Performance Power Splitters: High-performance power splitters, such as advanced Wilkinson splitters and hybrid couplers, offer superior performance characteristics such as low insertion loss, high isolation, and excellent phase coherence. They are ideal for high-frequency applications, critical signal distribution systems, and precision measurement setups. Another example is Marki's PBR series of bridge-based splitters/combiners that offer excellent isolation when compared to other topologies.

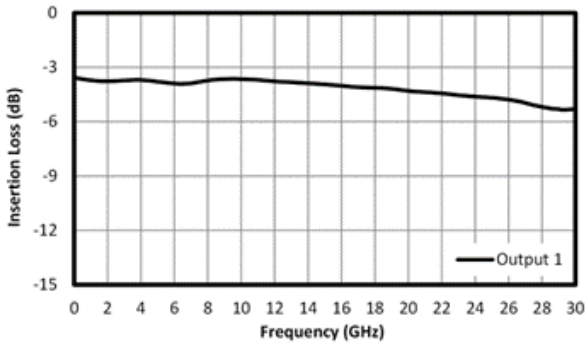
Application-Specific Power Splitters: Some power splitters are designed for specific applications or operating conditions, such as high-power splitters for RF amplifiers, broadband splitters for wideband signals, and surface-mount splitters for compact electronic devices. These splitters are tailored to meet the unique requirements of their intended applications. Marki produces a line of MMIC based power splitters in state-of-the-art chip-scale surface mount packaging for use in applications that are space constrained or require a large number of devices.



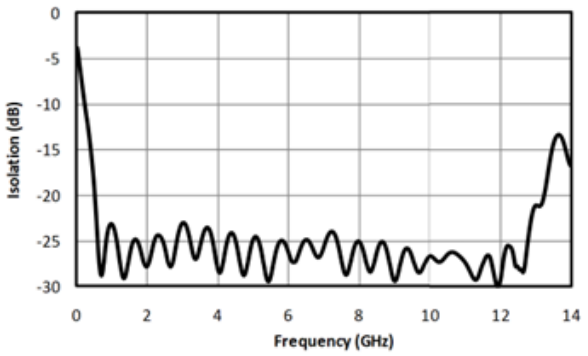
Power Splitter Performance Metrics

When selecting an RF power splitter for a particular application, several key factors should be considered:

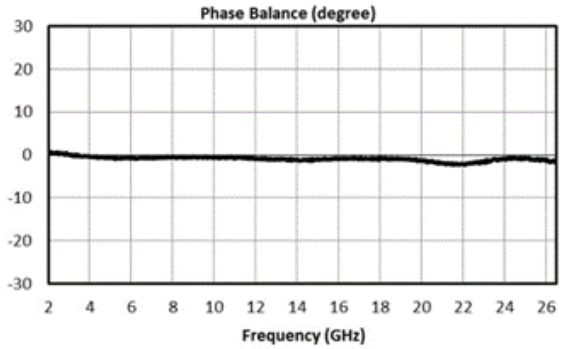
Insertion Loss: The insertion loss of a power splitter refers to the amount of signal power lost when passing through the device. Lower insertion loss is desirable, especially in applications where signal fidelity and efficiency are critical. The graph below shows insertion loss for a 2-way Wilkinson power splitter, the surface mount PD-0530SMG. Ideal loss would be 3dB but real-world performance introduces excess insertion loss beyond the ideal 3dB introduced by power splitting.



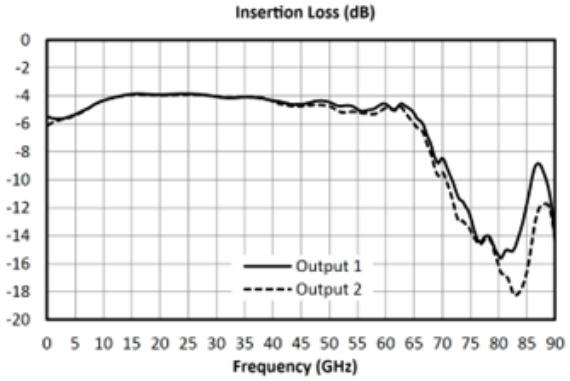
Isolation: Isolation between output ports is essential to prevent signal leakage and interference between different branches of the system. High isolation ensures clean signal distribution and minimizes crosstalk between channels.



Phase Balance: Maintaining phase balance between output signals is crucial in applications such as phased array antennas, coherent communication systems, and beamforming applications. Power splitters that maintain consistent phase relationships between output signals are preferred in such applications.



Frequency Range: The frequency range of a power splitter determines its suitability for specific RF and microwave applications. Splitters designed for wider frequency ranges offer greater flexibility and compatibility with diverse signal sources and systems. The plot below shows the exceptional bandwidth performance of the MDPW-0670CSP2 2-way Wilkinson splitter packaged in a 2.5x2.5mm chip-scale package.



Power Handling Capacity: Power splitters must be capable of handling the power levels present in the system without distortion or damage. High-power splitters are required in applications such as RF amplification, high-power testing, and broadcasting.

Conclusion

In conclusion, RF power splitters are essential components in RF and microwave systems, providing efficient and accurate signal distribution for a wide range of applications. By understanding the various types, classes, and characteristics of power splitters, engineers and designers can select the most suitable splitter for their specific requirements. Whether it's achieving balanced signal distribution for phased array systems, maintaining phase coherence in clock distribution trees, or minimizing signal losses, there's a power splitter available to meet the needs of virtually any RF system.

You can find more helpful information about power splitters by viewing these related application notes and white papers:

Power Dividers & Directional Couplers Primer

6 Ways to Make an N-Way Power Splitter

Application Examples for MQS and MQH Quad Hybrid MMIC die

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