Couplers Remain Important Products, Using New Manufacturing Techniques

Couplers are classic RF/microwave circuits. They perform the necessary signal processing, sampling and routing functions that make systems work the way they are intended. Sometimes regarded as mundane building blocks in larger systems, couplers have recently taken on new roles at both the highest performance and lowest cost range of engineering design.

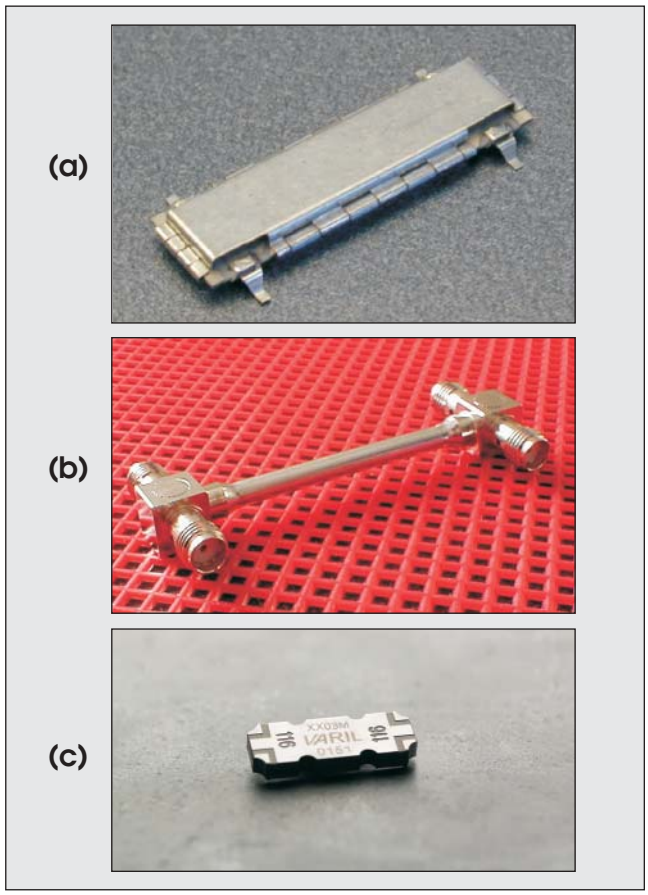
What are couplers used for? Here is a list of some applications (not necessarily complete):

- Power measurement
- VSWR measurement
- Signal sampling for monitoring or testing
- Equal or unequal power division
- Phase shifting (particularly 90° and 180°)
- Feed-forward signal injection
- Isolation of signal sources

At the low cost end of the spectrum, LTCC (low temperature co-fired ceramic) technology has become important for component-style couplers. The high dielectric constants achievable with this manufacturing technology enable greater miniaturization than has previously been possible. With market pressure to make wireless devices as small as possible, the popularity of LTCC is understandable.

The Vari-L unit in photo (c) measures just a little more than 1/2 inch on the longest dimension, yet it operates in the 3G band of 2000-2300 MHz, where a 1/4 wavelength in free space is about 1.4 inches, which is closer to the dimensions of the full-size high power Filtronic Sage Labs unit in photo (a), which operates in a similar frequency range.

Two other alternatives for lowest cost are microstrip couplers printed on the product's p.c. board, and stripline couplers built using signal and ground traces of a multilayer p.c. board. These two techniques eliminate the coupler as a bill-of-materials component, but require some board real estate for their fabrication. Printed microstrip couplers are probably most commonly used for forward power signal sampling in power monitoring and control applications, or for reverse power sampling in VSWR protection circuits.



Three different methods of manufacturing quadrature hybrids: (a) A high power (200 watt) coupler using suspended stripline from Filtronic Sage Laboratories; (b) A low-profile coupler using a unique multi-conductor transmission line from Response Microwave; and (c) a miniaturized coupler using LTCC fabrication technology from Vari-L Company. (photos are not be to the same scale)

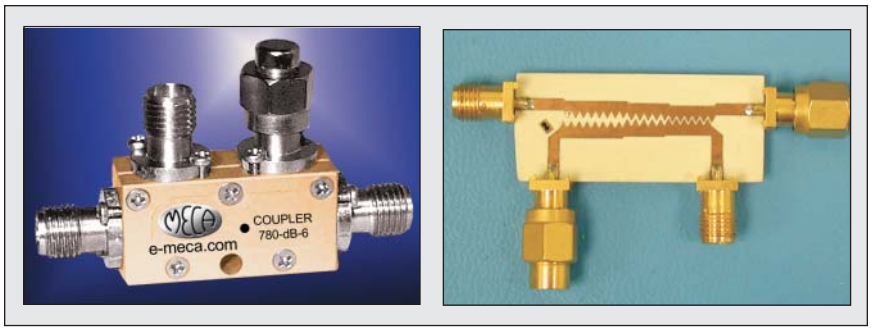
Microstrip couplers also are the choice for many packaged products. Common manufacturing processes can be used to etch the boards, assuring consistent performance from one unit to the next, with easy

From January 2003 *High Frequency Electronics*

assembly into a formed or machined enclosure with pins or tabs for the external connections.

Embedded stripline couplers have proven valuable where high mechanical reliability is required. The strength and stability of a multilayer printed circuit board is an advantage in military and space applications. These structures can also match the shielding capabilities of a separate metal package, while simplifying interconnections with the surrounding circuitry.

Although the production cost of precision multilayer boards is not as high as a typical packaged coupler, this may not be the choice for lowest cost.



Here are two construction options for directional couplers. The MECA unit on the left is a classic design with a machined metal case. On the right is a printed coupler designed by Dana Brady of CAP Wireless, as described in the September 2002 issue of *High Frequency Electronics*. The design on the right could be included on a larger p.c. board with additional circuitry, or placed in its own connectorized package like the unit on the left.

High Performance Couplers

There remain many applications for couplers with the highest possible performance, particularly in instrumentation. For example, vector network analyzers require couplers with wide bandwidth, flat frequency response and long-term stability. Of course, correction factors are programmed into the instrument to accommodate performance variations, but smaller corrections result in better measurement speed and repeatability.

Passive intermodulation is a new performance factor that applies to couplers, as well as other hardware in the signal path. The co-location of transmitters and receivers in wireless networks requires that an absolute minimum of spurious energy be generated by system components.

Reducing passive IMD involves the proper selection of materials to minimize the effects of dissimilar metal connections, eddy currents in magnetic materials. The mechanical assembly needs attention as well, to maintain full-contact connections over time, with temperature variations and, often, in an outdoor environment.

Summary

Couplers are a mature technology—after all, they are just transmission line segments with specific topologies to achieve the desired behavior. The materials, mechanical construction, and manufacturability of couplers continue to be important, since these common devices are essential components in virtually all RF and microwave transmission systems, and in many measuring instruments.