THETA-J ASSOCIATES
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DIRECTIONAL COUPLERS
Lumped Element & Stripline
100 kHz to 65 GHz
GENERAL INFORMATION

Product Discussion

A directional coupler inserted in a transmission line allows precise monitoring of the RF energy flow in that line while introducing minimum perturbation of the main line signal in the sampling process. Merrimac directional couplers are precision devices carefully designed for monitoring incident and reflected power.

Merrimac directional couplers are available in four different classes:

1) Three port directional couplers
2) Four port bi-directional couplers
3) Four port, dual directional couplers
4) Three port directional detectors

Three Port Directional Couplers

Three port directional couplers, as illustrated in Figure 1, are four port networks where one port is internally terminated in a resistive load thus becoming the isolated port. The other three ports are:

1) Main line input port
2) Main line output port
2) Coupled output port

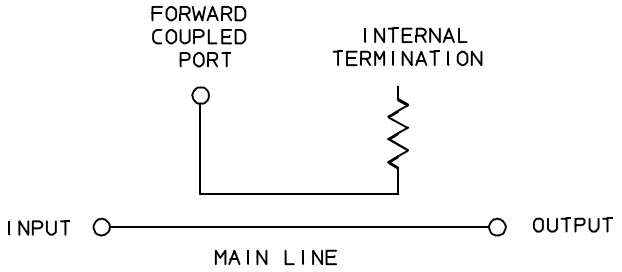

Figure 1: Three Port Directional Coupler

An RF signal applied to the input port splits unequally between the coupled port and the main line output port. The degree of unequal power division is a function of the coupling ratio of the coupler.

The isolated port, commonly known as a ‘‘load port’’ is designed to absorb and dissipate reflected energy in a ‘‘failsafe’’ mode. This termination will survive when open or short circuit conditions occur at the main line output port, while operating to the maximum average input power rating. The power dissipation capability of the internal termination is the major factor determining maximum reverse power ratings.

A complete line of catalog three port directional couplers from 100 kHz to 40 GHz is available from Merrimac. Models below 1 GHz are primarily lumped element designs. They consist of very small packages such as PC mount (CRS and CBP series) and flatpack (CBF series) and various surface mount packages (CBG-A and CRG-B series). (See Figure 2.) Connectorized units are also available in the CR/CRM series.

Figure 2: Surface Mount Three Port Coupler

Above 500 MHz, stripline coupler designs are generally more appropriate either as connectorized units or as Mini-Filmbrid caseless couplers (CSD and CTD series) suitable for direct integration into microstrip mother boards.

For transmitter and power amplifier systems requiring high power monitoring and leveling, directional couplers using an air dielectric are more suitable. For applications up to 600 watts CW, or 10 kW peak, directional couplers are available in the CEN, CENand CGN series.

Four Port Bi-Directional Couplers

The four port network (see Figure 3) has the isolated port externalized with either an RF connector or pin. One advantage of this type coupler is that a higher power termination can be selected to suit higher input power requirements. The four port network can also act as a bi-directional coupler monitoring signals in both directions provided the coupled ports feed into a reasonably constant 50Ω impedance.

For further information contact ***MERRIMAC / 41 Fairfield Pl., West Caldwell, NJ, 07006 / 973-575-1300 / FAX 973-575-0531***

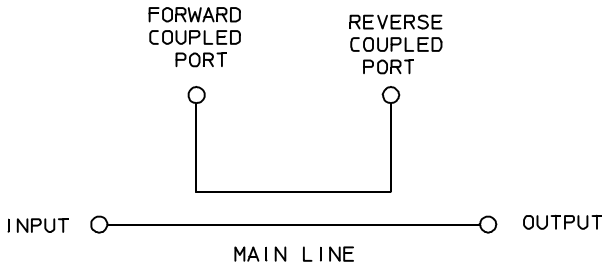

Figure 3. Four Port Bi-Directional Coupler

For low power applications four port couplers are available in various miniature packages, including TO-5 (C114/C115), Meri-Pac (CRP series) and Flatpack (CRF series).

Dual Directional Couplers

Dual directional couplers (see Figure 4) are four port networks that are distinguished from the bi-directional types in that dual directional couplers are two independent four port networks connected in series. Their principal application is in monitoring signals simultaneously in both directions. They are preferred over the simple bi-directional coupler in that they provide higher isolation between coupled ports.

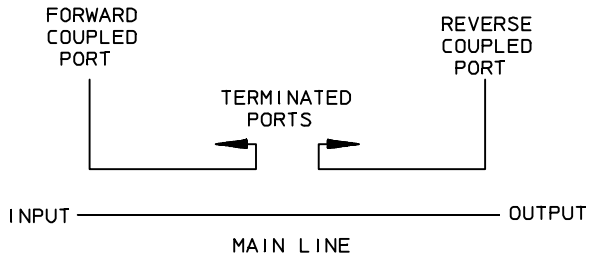

Figure 4. Four Port Dual Directional Coupler

Occasionally, a requirement arises that requires a dual directional coupler monitoring power in the same signal direction. These can be readily supplied as special orders.

Coupling Values

Merrimac catalog couplers are available in 6, 10, 12, 15, 20 or 30 dB coupling values depending on the product series. High power units are cataloged only in 30 or 35 dB values. Custom coupling values are available on special order.

Transmission Loss

To determine *total loss* through the main line of a directional coupler, the coupling *loss* (power directed to the coupled arm) must be combined with the insertion loss. Coupling *loss* is a function of the coupling value utilized. Coupling *losses* of standard couplers are shown in Table 1.

Coupling Value	Coupling "Loss"
3 dB	3.010 dB
6 dB	1.250 dB
10 dB	0.460 dB
12 dB	0.283 dB
15 dB	0.140 dB
20 dB	0.044 dB
30 dB	0.004 dB

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Table 1: Coupling Value and Coupling Loss

Phase and Amplitude Tracking

Many microwave systems such as multi-channel receivers, transmitter and antenna systems require uniform phase and amplitude characteristics .Merrimac catalog directional couplers yield good unit-to-unit phase and amplitude uniformity. Merrimac can provide units in matched groups to meet closely matched phase and amplitude requirements either by careful stock selection or by special design.

Figure 5: 500 W Fail-Safe Dual Directional Coupler for Cellular Radio and TACAN

Unequal Power Division

Merrimac directional couplers can be used as two way unequal power dividers by specifying the ratio of power division required.

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Parameter Definitions

Nominal Coupling

The power ratio in dB by which the coupled output port is *decoupled* from the input port when all ports are terminated in reflectionless (matched) terminations. The nominal coupling is specified as the arithmetic average of the of the maximum and the minimum coupling within the frequency band.

Coupling Tolerance

The specified allowable unit-to-unit variation in dB in nominal coupling.

Frequency Sensitivity

The peak-to-peak deviation in dB from the nominal coupling over the specified frequency range.

Insertion Loss

The net unrecoverable power in dB dissipated within the circuit at any frequency within the specified range.The insertion loss is usually specified as *excluding* the coupling loss, but to avoid a complex and perhaps critical calculation, it is expressed as *including* coupling loss for dual directional and high power models.

Coupling "Loss"

The main line signal loss in dB attributable to power being sampled at the coupled port.

Transmission Loss

The sum of the maximum insertion loss and coupling ''loss'' in dB at any frequency in the specified range.

Directivity

Expressed as a power ratio in dB, directivity is a measure of the preferential coupling of RF energy from the mainline to the coupled port in the ''forward'' direction compared to that in the ''reverse'' with all ports terminated in matched (reflectionless) loads.

VSWR

The voltage standing wave ratio specified for either the main line path (input to output) and/or the coupled output port(s).

Average or CW Power Capacity

The CW power handling capacity is the one-way power transmission capacity through the device under matched load conditions. For failsafe power handling capabilities not specified on the particular data sheet, contact Merrimac.

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Applications

1. Directional couplers are used to accurately sample the directional power flow in a transmission line. In conjunction with a calibrated detector or a power bridge, an accurate, continuous measurement of power flow can be obtained. In this function directional couplers can be an essential part of system BITE (built in test equipment).

2. Power leveling can be performed when the coupled output of a directional coupler is used in conjunction with a modulator or a PIN attenuator as a part of a leveling loop.

3. Frequency measurement can be made on a continuous basis when the coupled sample is fed to a suitable frequency counter or equivalent.

4. Frequency stabilization can be obtained when the coupler output is used as the input to an AFC (automatic frequency control) loop.

5. Continuous power reflection measurements such as might result from antenna misalignments can be made using couplers as reflectometers. The power source is fed to the main line *output* port and the coupler main line *input* port is connected to the load (antenna). Reflected power will thus be coupled to the *forward* coupled output where it can be monitored.

6. Signal injection can be obtained by feeding the injectable signal into the mainline via the coupled port. The direction of the inserted signal power flow depends on the coupler polarity in the transmission line.

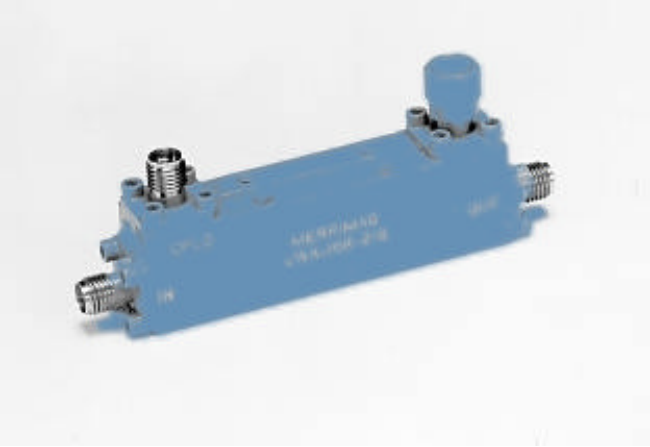

Figure 6. 0.5 to 40 GHz Directional Coupler

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