

## SMT Hybrid Couplers, RF Parameters and Applications

A 90 degree hybrid coupler is a four-port device used to equally split an input signal into two signals with a 90 degree phase shift between them. The 90 degree hybrid coupler can also be used to combine two signals, while maintaining high isolation between them.

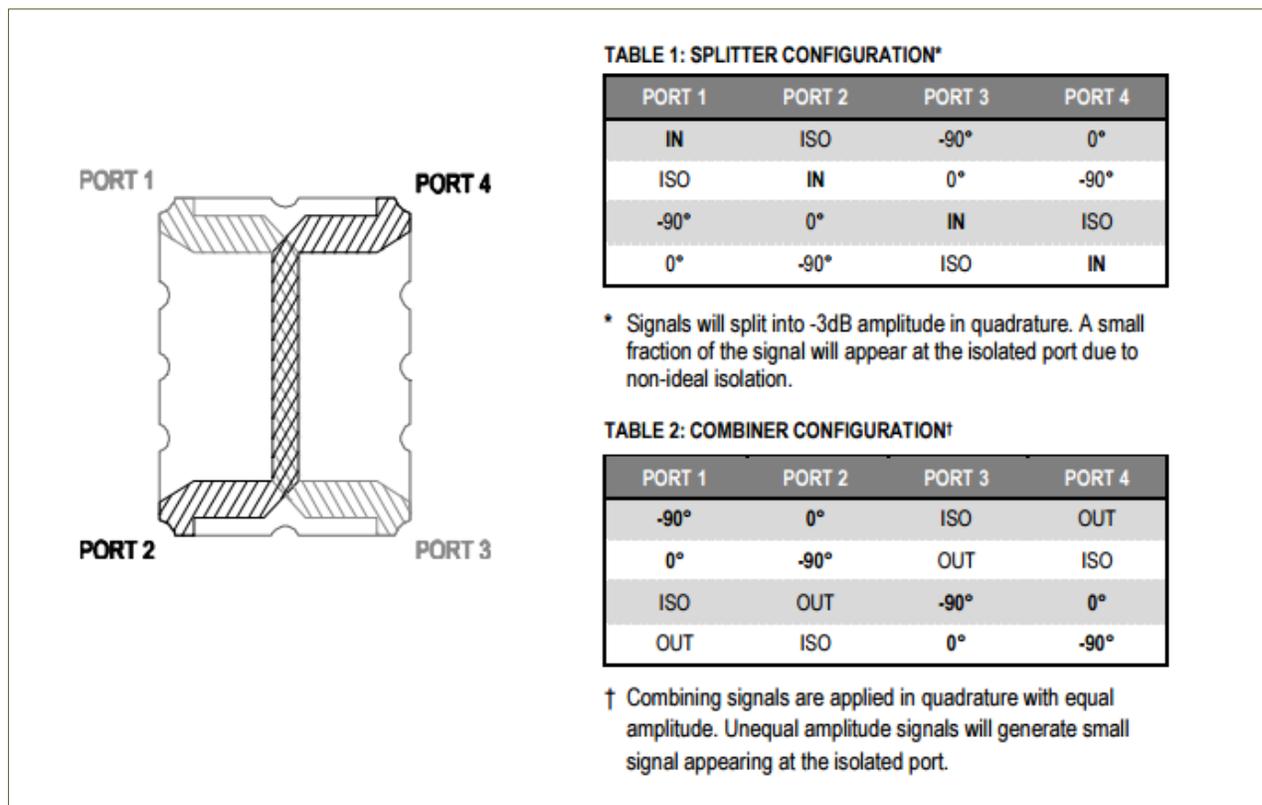


Most surface-mount hybrid couplers use a multilayered broadside coupling construction in comparison to a microstrip edge coupled structure. Typical construction of a hybrid coupler consists of two transmission lines in close proximity. RF energy travelling through one of the transmission lines couples to the other transmission line. There is a 90° phase difference between the output ports of a hybrid coupler.

The multilayered hybrid couplers offer good insertion loss, high isolation, and a small footprint. Most surface-mount hybrid couplers are made with high frequency PTFE materials.

Hybrid couplers are used in many RF and microwave circuit designs for power combining and power dividing, and can also be viewed as directional couplers with a -3 dB coupling factor.

A standard pin assignment and split/combine matrix for an smt hybrid coupler is shown in Figure 1.



**Figure 1.** Standard smt hybrid couplers pin configuration.

## Key Parameters, Definitions, and Performance Plots

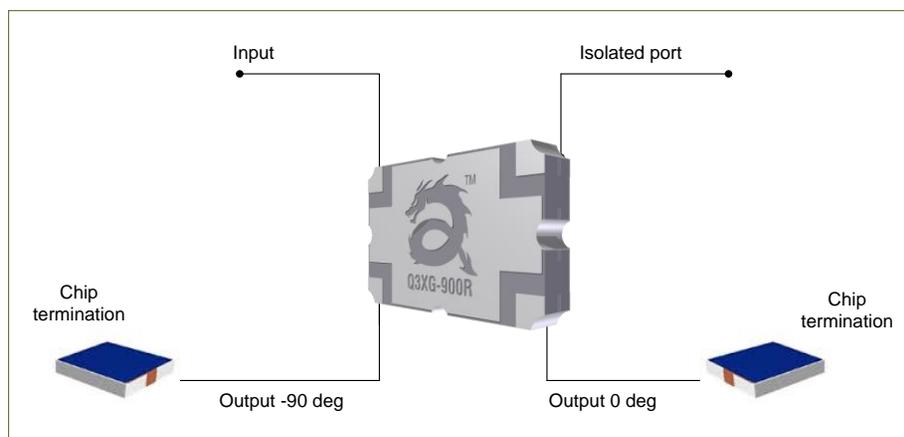
All hybrid coupler data sheets have many specification parameters to characterize the performance of the device. Some of these key parameters are discussed below.

### Frequency Bandwidth

Standard couplers made from a single-section typically cover about one octave band (i.e 1GHz-2 GHz). Couplers made from multiple coupled sections extend the frequency band, but with decreased isolation and impedance match.

### Isolation

Isolation is the signal difference in dB between the input and isolated port of the hybrid coupler when the output ports (ports 3 and 4 in Fig. 1) are terminated in 50 Ohms. This is presented in Figure 2.



**Figure 2.** Hybrid coupler with output ports terminated in 50 Ohms

### VSWR

The Voltage Standing Wave Ratio (VSWR) is a frequency independent parameter and measures input and output impedance match to 50 Ohms. With proper design technique, this parameter can be optimized to minimize the effects of the impedance mismatch.

### Insertion Loss

Insertion loss in a hybrid coupler is a sum of several losses. The loss is a function of the amount of dissipated heat, the loss due to impedance mismatch at the input and output ports, and the loss due to directivity of the coupler.

### Amplitude Balance

The amplitude balance represents the signal difference (in dB) between the 0° port and the -90° output port compared to the average output signal level.

### Phase Balance

A phase difference between the output ports.

### Power Handling

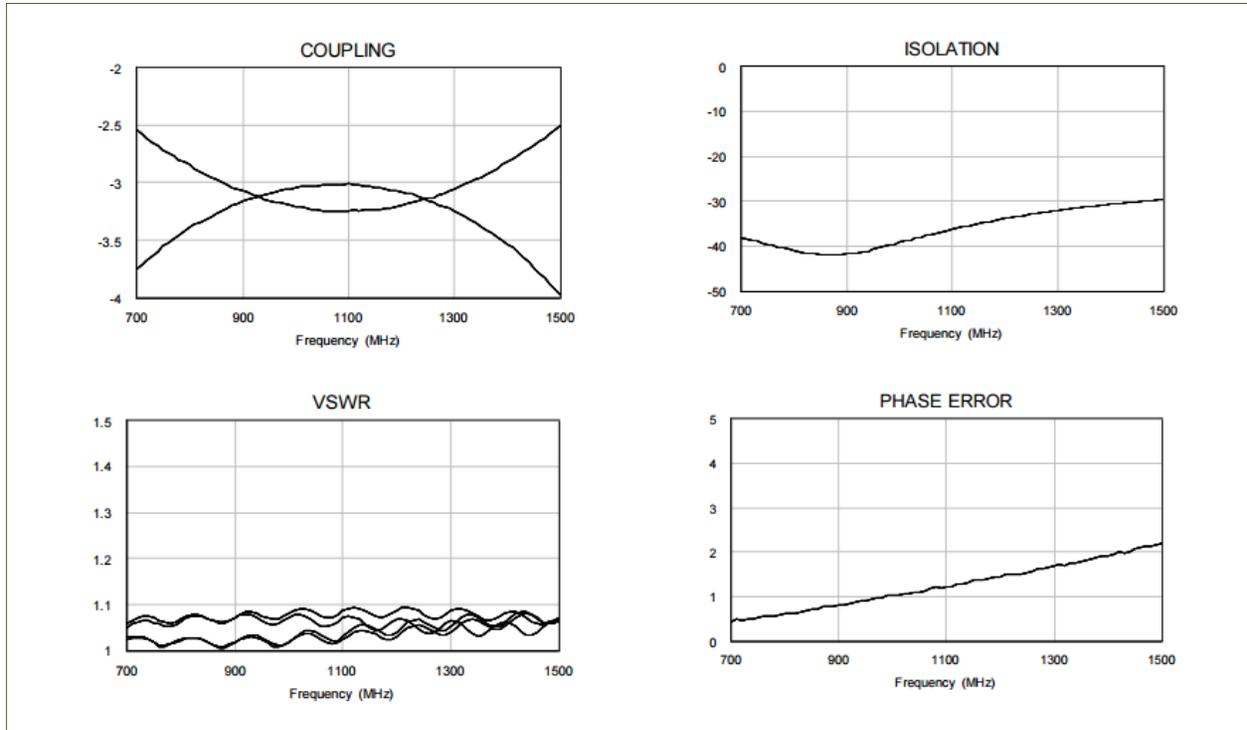
Power handling is dependent on the size of the coupler, type of material used, and frequency.

The mathematical equations used to calculate some of the above parameters are summarized in Table 1 below.

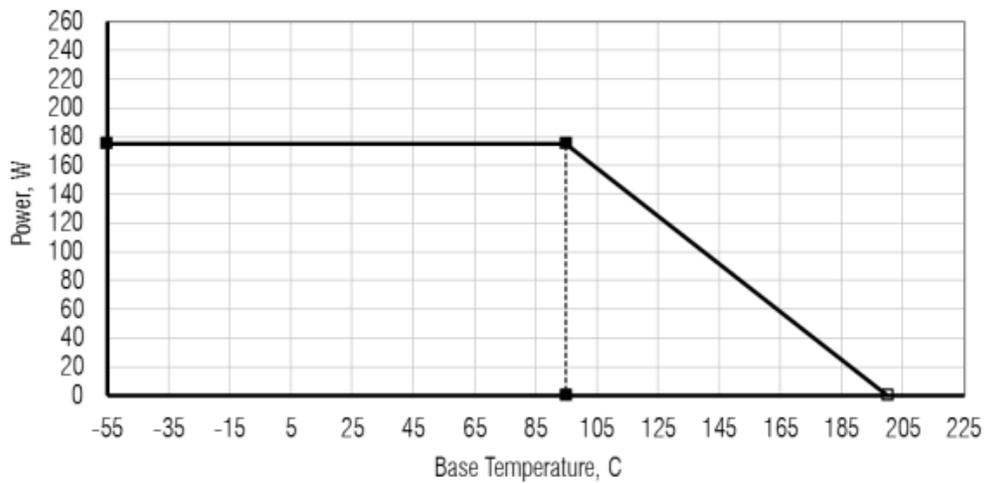
VSWR	$VSWR = \frac{V_{\max}}{V_{\min}}$
Return Loss	$RL(dB) = 20 \cdot \log\left(\frac{VSWR + 1}{VSWR - 1}\right)$
Insertion Loss	$IL(dB) = 10 \cdot \log\left(\frac{P_{in}}{P_{coupled} + P_{direct}}\right)$
Isolation	$Isolation(dB) = 10 \cdot \log\left(\frac{P_{in}}{P_{isolated}}\right)$
Phase Balance	$PhaseBalance = Phase_{coupled} - Phase_{direct}$
Amplitude Balance	$\text{Amplitude Balance, coupled port (dB)} = 10 \cdot \log\left(\frac{P_{coupled}}{\left(\frac{P_{coupled} + P_{direct}}{2}\right)}\right)$
	$\text{Amplitude Balance, direct port (dB)} = 10 \cdot \log\left(\frac{P_{direct}}{\left(\frac{P_{coupled} + P_{direct}}{2}\right)}\right)$

Table 1. Equations for hybrid couplers

S-parameters plots showing typical RF parameters like coupling, isolation, phase balance and VSWR for a hybrid coupler are shown in Figure 3. In addition, a power de-rating plot is presented in Figure 4.



**Figure 3.** S-parameters plots for Electro-Photonics LLC hybrid coupler part number Q3XG-1088R.



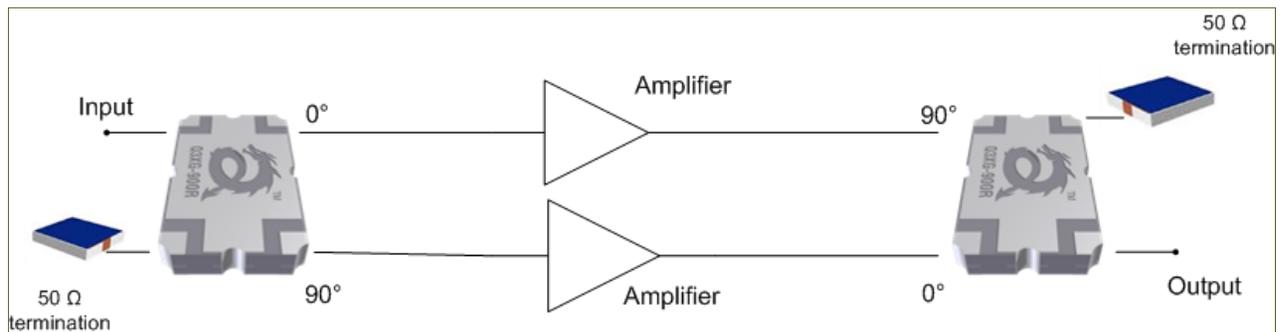
**Figure 4.** Power de-rating for hybrid coupler operating at 175 Watts average power and 95°C base temperature.

## Typical Applications for Hybrid Couplers

There are many applications where hybrid couplers are used. Some examples are shown below.

### Quadrature Amplifier Combining

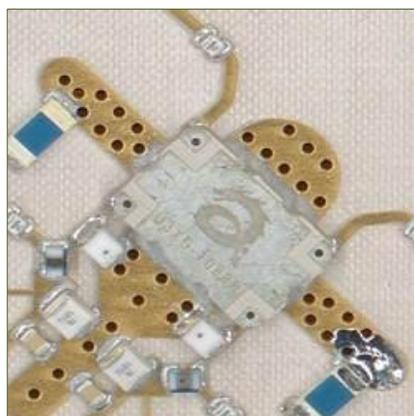
The quadrature combining method is used when combining two amplifiers. This method improves the input and output return loss of the amplifiers, dissipating any reflected power in the RF termination on the isolated port.



**Figure 5.** Quadrature amplifier combining using Electro-Photonics hybrid couplers

### Balanced Pin Diode Voltage-Controlled High Power Attenuator

Another application for the hybrid coupler is a balanced voltage-controlled high power attenuator. A board level implementation of one such voltage-controlled attenuator is shown in Figure 6 below.



**Figure 6.** Voltage-controlled high power attenuator