Hybrid90deg

90-degree Optical Hybrid (or Quadrature Optical Hybrid)

Purpose

This module represents a generic 2x4 quadrature optical hybrid. It combines two input signals (an incoming signal and a local oscillator reference signal) and generates four optical signals with a 90-degree phase difference. A typical application is coherent signal demodulation, in combination with two pairs of balanced photoreceivers, to recover the relative phase information between the input signals.

Keywords

Coherent Detection, Demodulation, Optical Coupler, Optical Hybrid

Inputs

Port	Purpose	Signal/Data Type
signalInput1	optical signal	Optical Samples, Optical Blocks
signalInput2	local oscillator	Optical Samples, Optical Blocks

Outputs

Port	Purpose	Signal/Data Type
signalOutput0grad	output 0 degree phase difference	Optical Samples, Optical Blocks
signalOutput180grad	output 180 degree phase difference	Optical Samples, Optical Blocks
signalOutput90grad	output 90 degree phase difference	Optical Samples, Optical Blocks
signalOutput270grad	output 270 degree phase difference	Optical Samples, Optical Blocks

Parameters

In this section:

Physical

Name and Description	Unit	Type	Volatile	Value Range	Default Value
InsertionLossSignal Insertion loss of the signal input.	dB	float	yes	[0;∞][a]	0.0
InsertionLossLocalOscillator Insertion loss of the local oscillator input.	dB	float	yes	[0;∞][a]	0.0
PhaseImbalance_SignalLocalOscillator Phase difference between the signal and the local oscillator inputs.	deg	float	yes	[0;360][a]	0.0
PhaseImbalance_IQ Phase difference between the two balanced branches; outputs 1 and 2, and outputs 3 and 4.	deg	float	yes	[0;360][a]	0.0
InsertionLossImbalanceI Insertion loss difference between the outputs 1 and 2 (branch I).	dB	float	yes	[0;∞][a]	0.0
InsertionLossImbalanceQ Insertion loss difference between the outputs 3 and 4 (branch Q).	dB	float	yes	[0;∞][a]	0.0

Description

The 90-degree hybrid is described by its transmission matrix:

$$\begin{pmatrix} E_{1,out} \\ E_{2,out} \\ E_{3,out} \\ E_{4,out} \end{pmatrix} = \frac{1}{2}\begin{pmatrix} IL_S & IL_{LO} \cdot \exp(j\varphi_{SLO}) \\ IL_S \cdot Imb_I & -IL_{LO} \cdot Imb_I \cdot \exp(j\varphi_{SLO}) \\ IL_S & j \cdot IL_{LO} \cdot \exp(j(\varphi_{SLOrad} + \varphi_{IQ})) \\ IL_S \cdot Imb_Q & j \cdot IL_{LO} \cdot Imb_Q \cdot \exp(j(\varphi_{SLOrad} + \varphi_{IQ})) \end{pmatrix} \begin{pmatrix} E_{1,in} \\ E_{2,in} \end{pmatrix} \quad (1)$$

where $E_{i,out}$ and $E_{i,in}$ are the electrical fields at the output and input ports of the module and IL_S, IL_{LO}, Imb_I, Imb_Q are the respective linear values related to the signal amplitudes for the parameters **InsertionLossSignal**, **InsertionLossLocalOscillator**, **InsertionLossImbalanceI** and **InsertionLossImbalanceQ**. The module parameters specified in dB can be converted to the aforementioned linear units, for example:

$$IL_S = 10^{(0.5 \times IL_{S\_dB})}$$

The phases ϕ_{SLO} and ϕ_{SIQ} are the parameters **PhaseImbalance_SignalLocalOscillator** and **PhaseImbalance_IQ** expressed in radians.

The default parameters represent the ideal case. In that case, the transfer matrix is simplified as:

(2)

$$\begin{pmatrix} E_{1,out} \\ E_{2,out} \\ E_{3,out} \\ E_{4,out} \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 1 & 1 \\ 1 & -1 \\ 1 & j \\ 1 & -j \end{pmatrix}\begin{pmatrix} E_{1,in} \\ E_{2,in} \end{pmatrix}$$

Examples

For a simulation showing the use of this module, see the demonstration

Optical Systems Demos > Modulation Multilevel > Coherent 8PSK System

References

[1] Matthias Seimetz and Carl-Michael Weinert, 'Options, Feasibility, and Availability of 2 x 4 90° Hybrids for Coherent Optical systems', Journal of Lightwave Technology, Vol. 24, No. 3, March 2006.