

## 1 – Description

The COH24 is a single polarization 90° optical hybrid that enables to extract phase and amplitude from a single polarization signal by performing four 90° phase stepped interferences between the signal and a Local Oscillator (LO). The COH24-X is a new generation optical hybrid with improved performances (among other things, a wider operating wavelength range and much better dual uniformities).

The COH28 and COH28-X are based on two single polarization 90° optical hybrids that enable to extract phase, amplitude and polarization from a signal with any polarization.

These products are purely passive and athermal.

The COH24-X and COH28-X also feature a phase tunability option in order to perfectly adjust the 90° of the hybrid depending on the wavelength used.

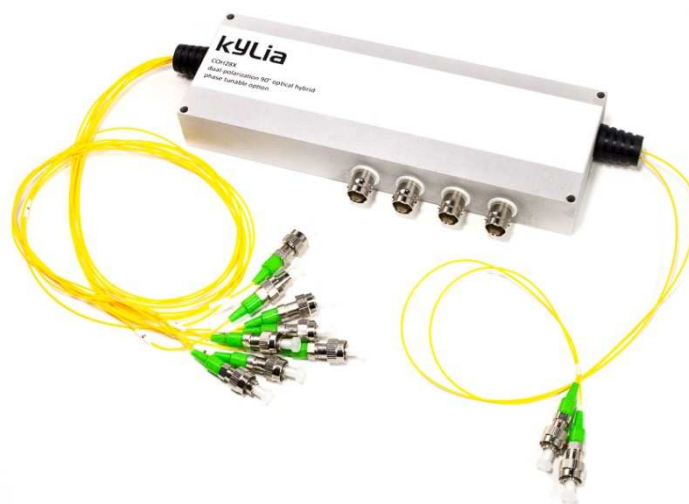
Kylia also offers a dual polarization 180° hybrid named COH22.



*COH packaging*



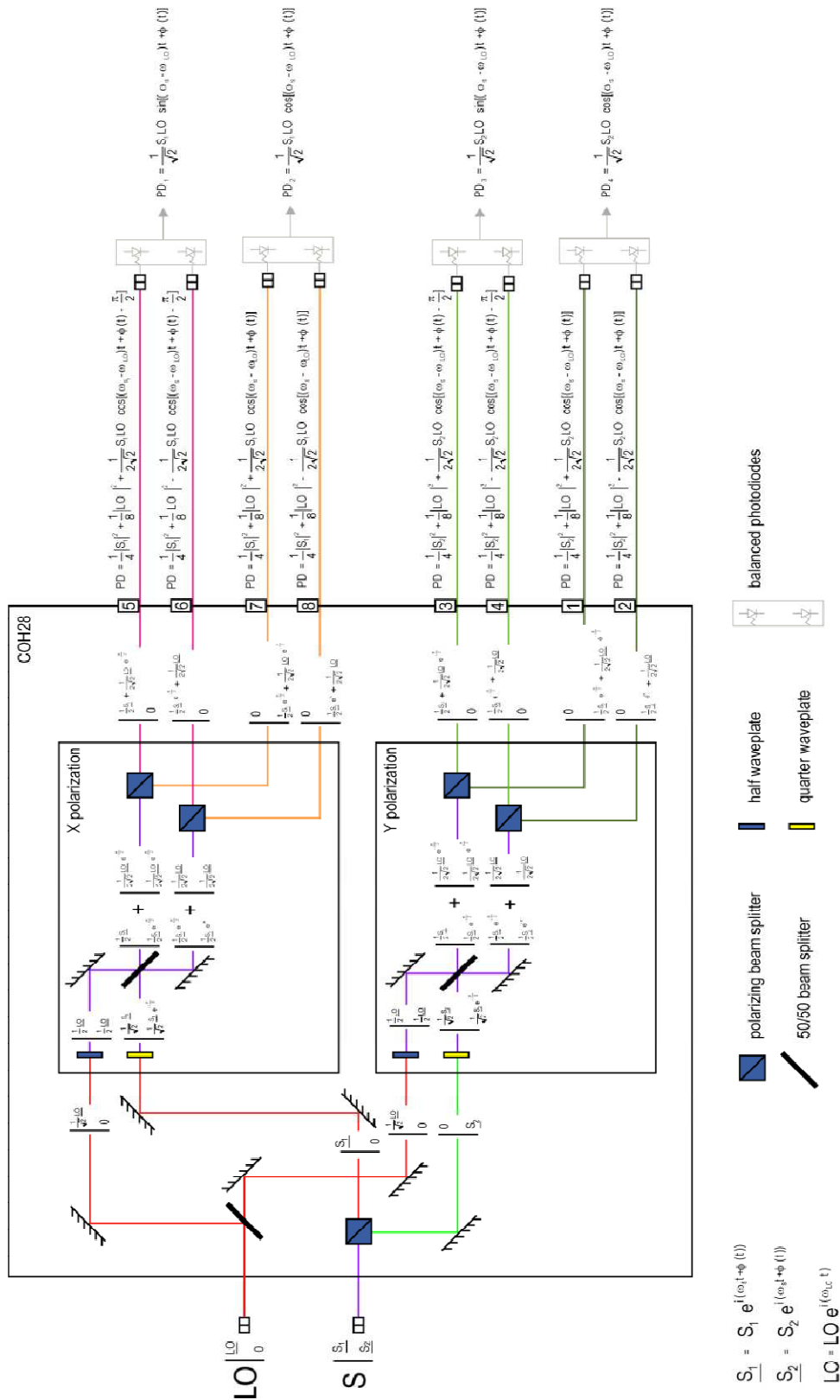
*COHX packaging*



*COHX phase tunable packaging*

## 2 – Block diagram

Below is a block diagram showing how the four 90° phase stepped. Interferences are done in the optical hybrid.



### 3 – Absolute maximum ratings

Parameter	Symbol	Min	Typ.	Max	Unit	Remarks/Conditions
Maximal optical input power	Opln			300	mW	
Storage temperature range	STR	-40		80	°C	
Humidity	RH	5		85	%	Non condensing
Fiber bend radius		20			mm	
Maximal input voltage <sup>1</sup>	U			4	V	

<sup>1</sup> for phase tunability option only (COH24-X and COH28-X)

### 4 – Operating conditions

Parameter	Symbol	Min	Typ.	Max	Unit	Remarks/Conditions
Operating wavelength	COH	1520		1570	nm	
	COH-X	1520		1625		
Operating temperature range	OTR	0		70	°C	

### 5 – Specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Remarks/Conditions	
Insertion Losses from Signal <sup>2</sup>	COH24/COH24-X	IL→S		7.0	8.5	dB	Including 6dB of natural losses
	COH28/COH28-X			7.0	8.5		Including 6dB of natural losses
Insertion Losses from LO <sup>2</sup>	COH24/COH24-X	IL→LO		7.0	8.5	dB	Including 6dB of natural losses
	COH28/COH28-X			10.0	11.5		Including 9dB of natural losses
IL uniformity <sup>2,3</sup>	COH	ΔIL		1.0	2.0	dB	Without connectors
	COH-X			0.5	1.0		
IL dual uniformity <sup>2,3</sup>	COH	Δdual		0.5	1.0	dB	Between balanced outputs Without connectors
	COH-X			0.2	0.5		
Phase shift between I and Q <sup>2</sup>	φ	85		95	deg		
Skew <sup>4</sup>			0.5	1	ps	Measured at connectors end	
Optical return loss	ORL	35			dB		
Polarization splitting ratio <sup>5</sup>	PSR	20			dB	Separation of X and Y polarization at the Signal input by the PBS	
Phase shift tunability <sup>2,6</sup>	Δφ	+/-20			deg	For a 3V voltage	
Packaging size <sup>7</sup>	COH	70 x 52 x 10			mm <sup>3</sup>		
	COH-X	180 x 32 x 19.5					
Fiber Pigtail Type	SM	SMF-28				With 900μm loose tube	
	PM	PANDA PM					
Fiber Pigtail Length		0.9	1.0	1.1	m	Other lengths on request	

<sup>2</sup> measured over OTR and OWR for all states of polarization

<sup>3</sup> from Signal or LO

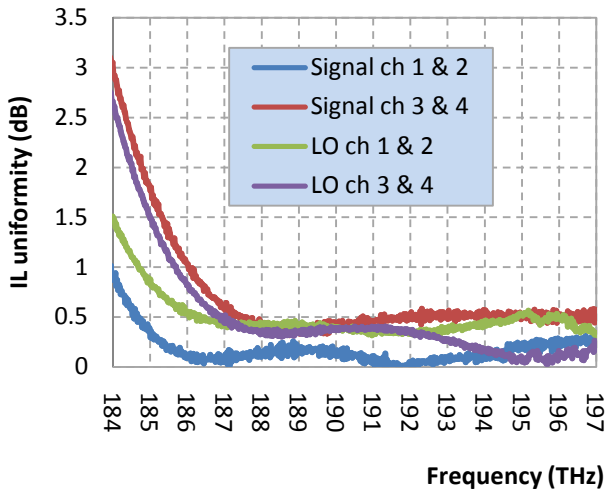
<sup>4</sup> for all outputs

<sup>5</sup> for COH28 and COH28-X only

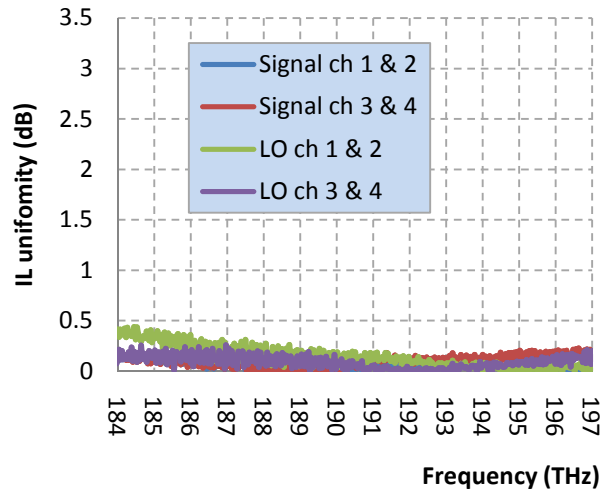
<sup>6</sup> for phase tunability option only

<sup>7</sup> excluding fiber boots

## 6 – COH-X and COH dual uniformities



COH24 IL dual uniformities vs frequency



COH24-X IL dual uniformities vs frequency

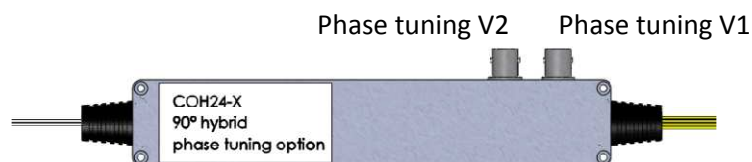
The graphs above compare the dual uniformities, a key parameter of 90° optical hybrids, for the Signal and LO of a standard hybrid (COH) and a new generation one (COH-X). We can clearly see that COH-X exhibits much better dual uniformities over a wider range.

## 7 – Phase tuning option

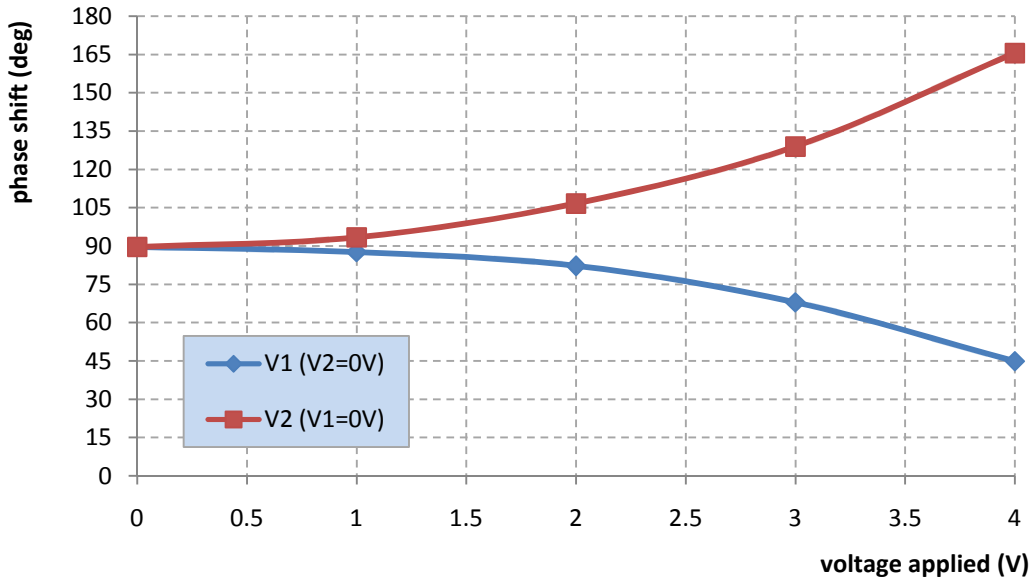
The 90° phase shift of the hybrids depends slightly on the wavelength. For example, it increases of about 2° to 3° over the C-band. That means that if at 191THz the phase shift is 88.5° it will be approximately 91.5° at 197THz (see next paragraph for some typical measurements).

For some applications it can be useful to have a very precise 90° phase shift whatever the wavelength you are working at. That is what the phase tunability option on COH-X enables. With this option, two voltages (V1 and V2) between 0V and 4V can be applied on the hybrid. One will increase the phase shift when the second one will decrease it. Hence for any wavelength in the OWR the phase shift can be adjusted to be precisely equal to 90°.

Below are the packaging of a COH24-X with the phase tuning option and a typical measurement of the phase shift versus voltage for a COH24-X device:



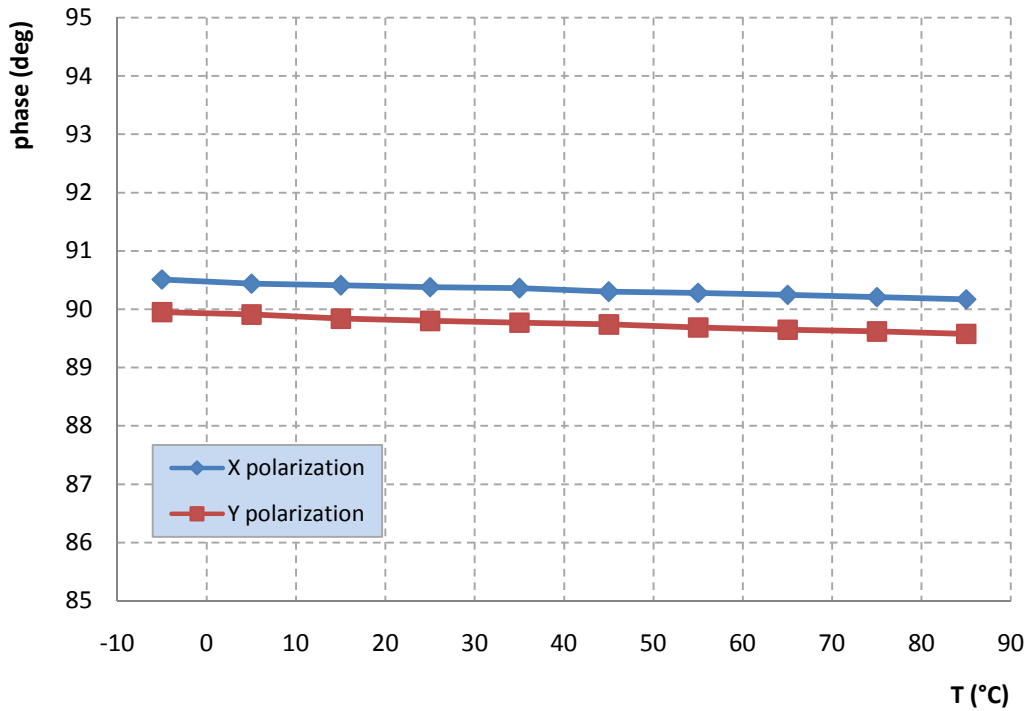
COH24-X with phase tuning option packaging



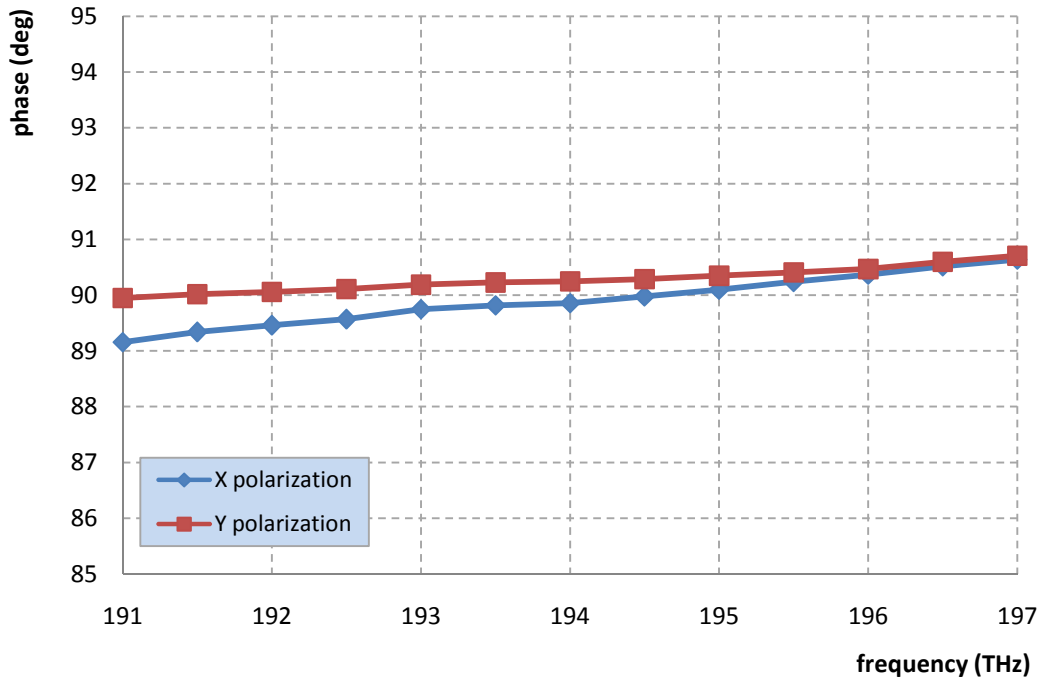
Graph: phase vs voltage for a COH24-X with phase tuning option

### 8 – Typical measurements

The two following diagrams show the typical behavior of the 90° phase shift. On the first one, one can see that the variation of the phase shift versus the temperature is very small (less than 1°). Hence the hybrid does not need any temperature control to ensure a precise, stable 90° phase shift. On the second diagram, one can see that the variation of the phase shift versus the wavelength is small (less than 3°). However if for some particular application one need to have a very precise 90° phase shift, the phase tunability option available on COH-X will enable to adjust it precisely for any wavelength of the OWR.

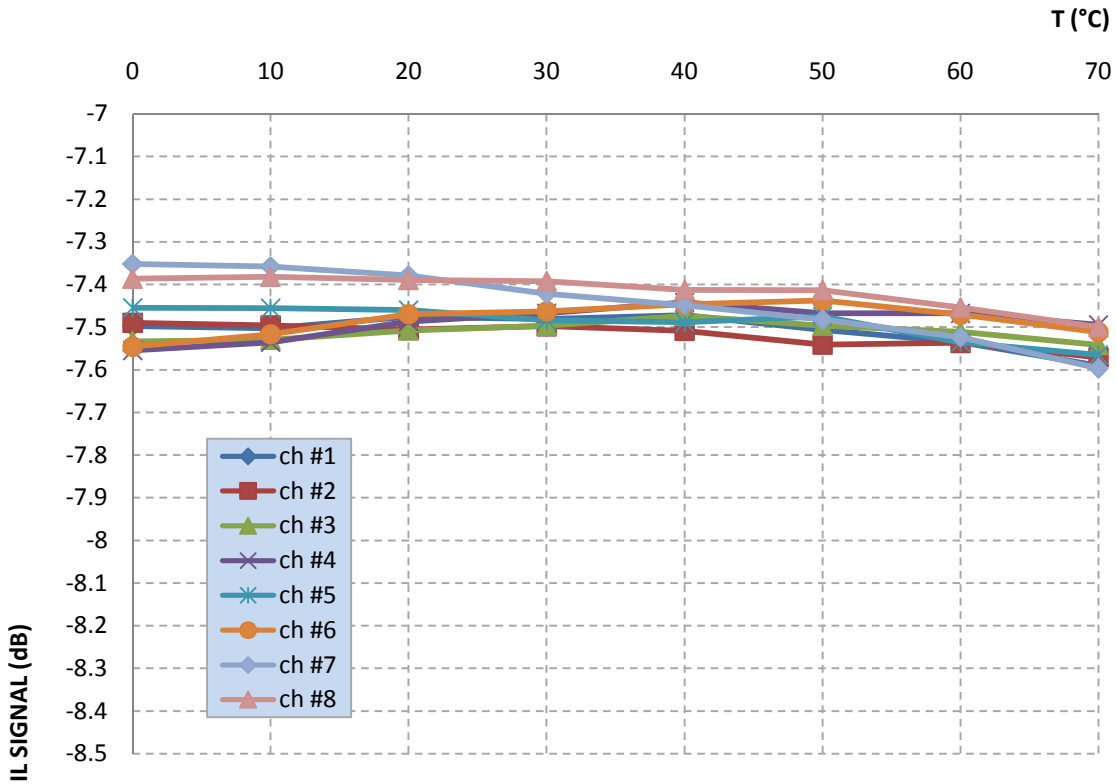


Graph: COH28 phase variation vs temperature



Graph: COH28 phase variation vs frequency

The third diagram shows the IL variations versus the temperature. One can see that each output do not have exactly the same variation but they all remain small, as well as dual and total uniformities.

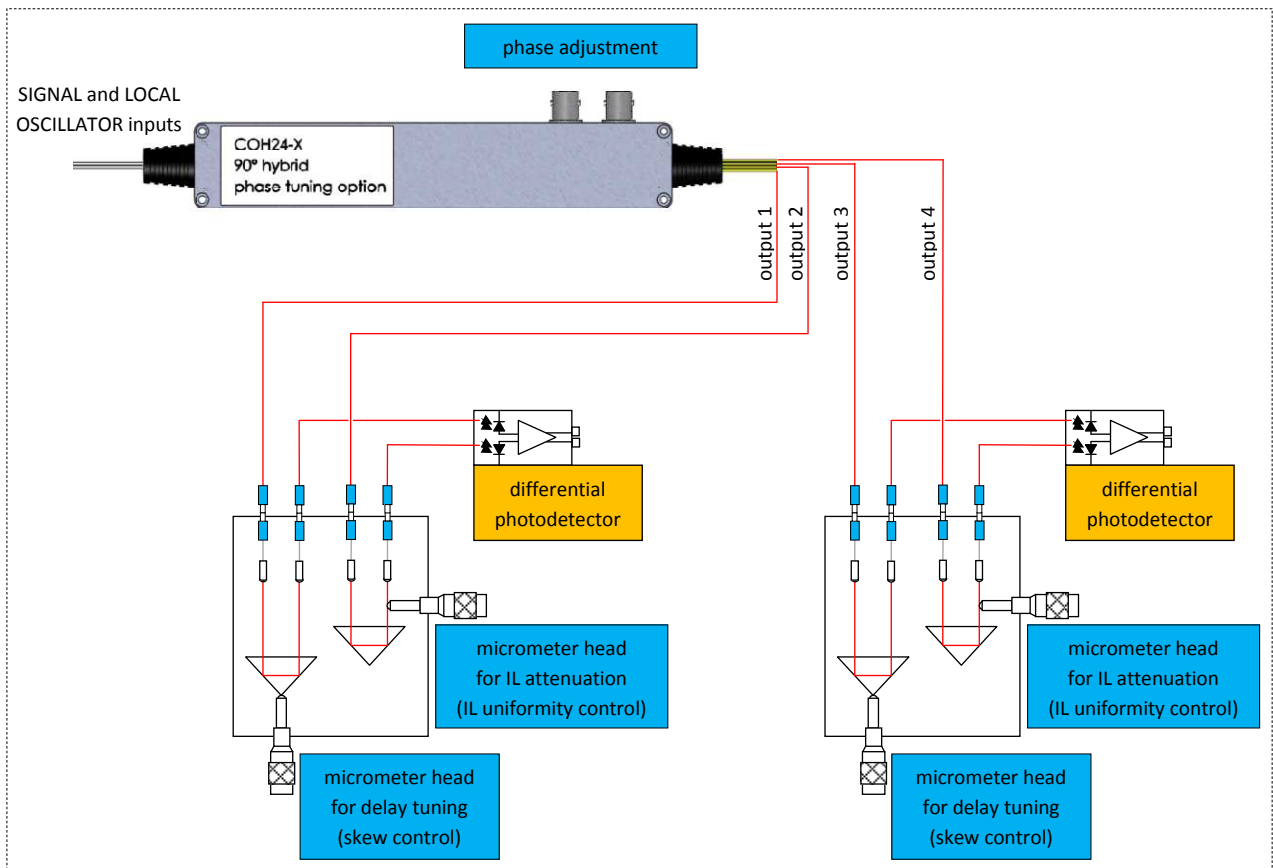


Graph: insertion losses variation vs temperature (SIGNAL → OUTPUTS of a COH28-X)

### 9 – Application note: full tunable 90° hybrid

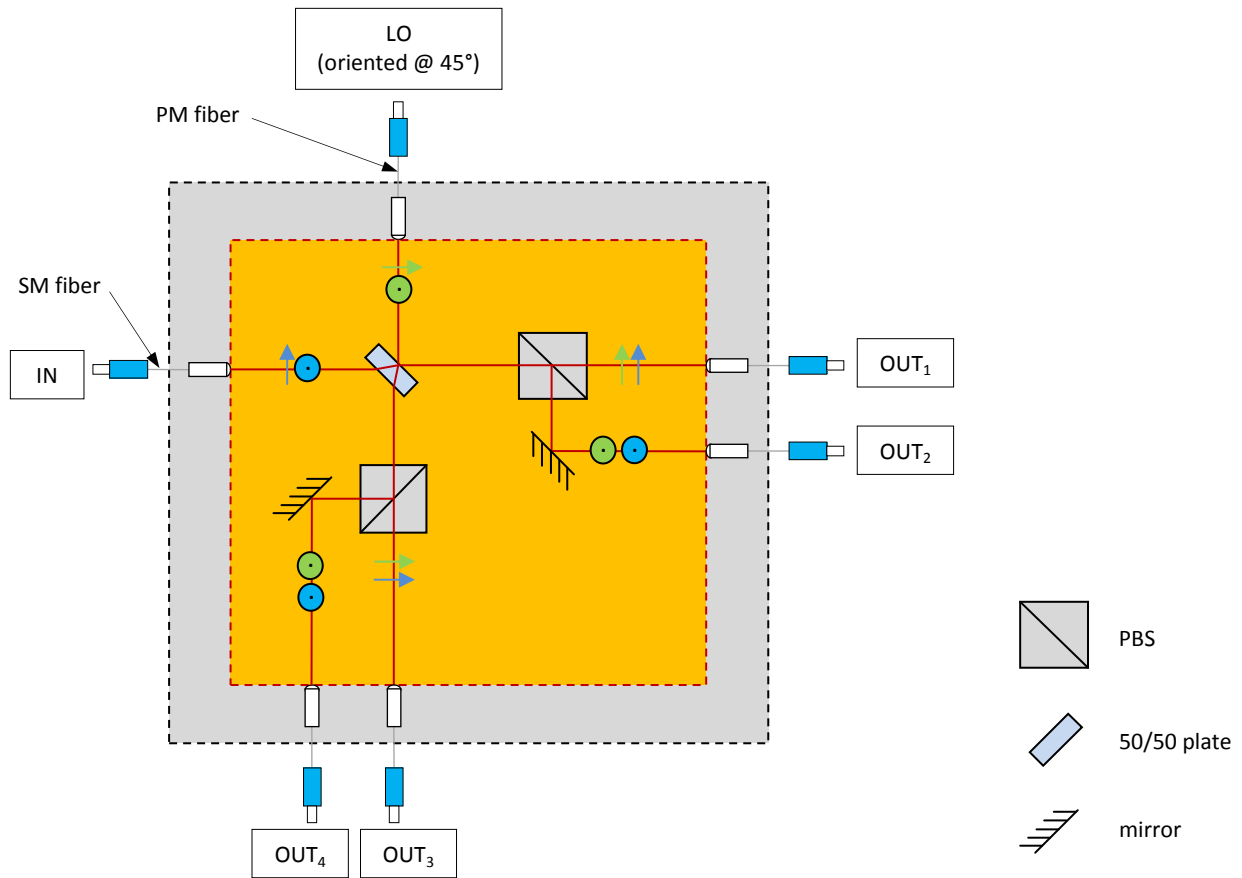
In order to have the possibility to control all the parameter of a COH24-X or a COH28-X, we propose in a 19inches-2U rack a system where the user can adjust:

- the phase
- the insertion losses uniformity
- the skew



## 10 – Dual-Polarization 180° hybrid

Kylia offers a dual-polarization 180° hybrid based on the following block diagram and specifications:



Parameter	Symbol	Min	Typ.	Max	Unit	Remarks/Conditions
Insertion Losses from Signal <sup>1</sup>	IL→S		4.0	5.0	dB	Including 3dB of natural losses
Insertion Losses from LO <sup>1</sup>	IL→LO		7.0	8.0	dB	Including 6dB of natural losses
IL uniformity <sup>1,2</sup>	$\Delta$ IL		0.8	1.5	dB	Without connectors
IL dual uniformity <sup>1,2</sup>	$\Delta$ dual		0.2	0.8	dB	Between balanced outputs Without connectors
Phase shift between I and Q <sup>1</sup>	$\phi$	85		95	deg	
Skew <sup>3</sup>			0.5	1	ps	Measured at connectors end
Optical return loss	ORL	35			dB	
Packaging size <sup>4</sup>		70 x 52 x 10			mm <sup>3</sup>	
Fiber Pigtail Type	SM	SMF-28				With 900 $\mu$ m loose tube
	PM	PANDA PM				
Fiber Pigtail Length		0.9	1.0	1.1	m	Other lengths on request

<sup>1</sup> measured over OTR and OWR for all states of polarization

<sup>2</sup> from Signal or LO

<sup>3</sup> for all outputs

<sup>4</sup> excluding fiber boots



## 11 – Fiber type and connectors

For the single polarization hybrids (COH24 and COH24-X) both the Signal and Local Oscillator have PM fiber. The outputs have SM fiber.

For the dual polarization hybrids (COH22, COH28 and COH28-X), the Local Oscillator has PM fiber and the Signal has SM fiber. The outputs have SM fiber.

For all of these products, the outputs can optionally have PM fiber with a PER of 20dB.

For COH22, COH28 and COH28-X, the Signal input can optionally have a PM fiber aligned such that the slow and fast axes are split by the input PBS. Eventually the fiber can be aligned in a different way upon customer request.

The devices can be proposed with any kind of connectors (FP/UPC, FC/APC, SC/PC, SC/APC, LC/PC, E2000/PC, E2000/APC).

All our COH products are offers with 1m fiber lengths. Other fiber lengths, down to 10cm are available on request.

## 12 – Wavelength range

Both COH-X can be proposed at different wavelength range, from the visible to the IR. The device will be operational on a wavelength range of a tens of nanometers centered on the wavelength required by customer. Products at 1300nm, 1064nm and 800nm have already successfully been manufactured.

## 13 – Splitting ratio

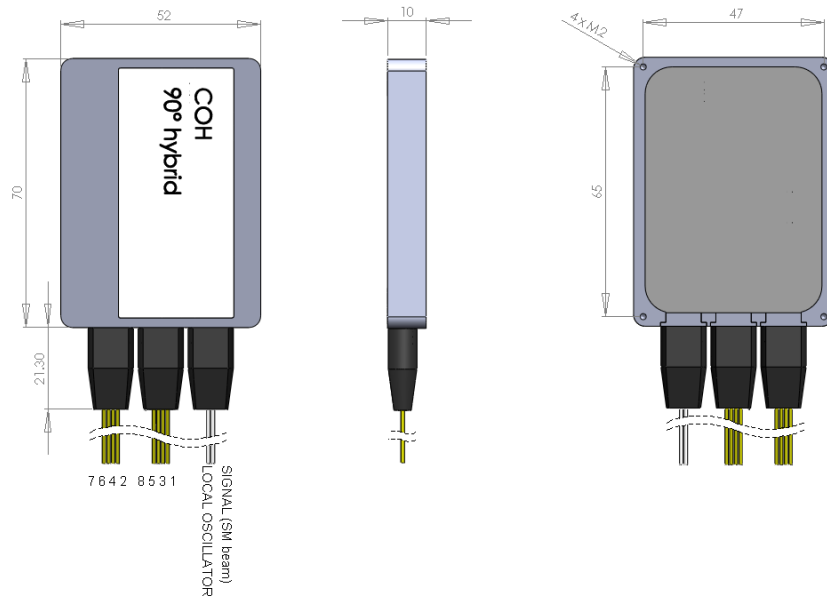
For a standard COH we have 50% of the optical power from SIGNAL (or LO) on I and 50% on Q.

This splitting ratio can be customized. For instance, we can split the optical power from SIGNAL (or LO) in order to have 10% on I and 90% on Q. Splitting ratio of SIGNAL and LO can be different.

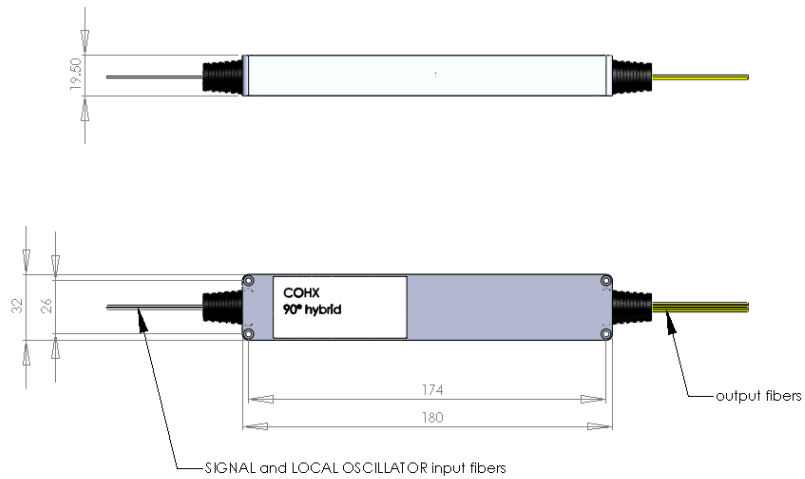
## 14 – Custom product

Thanks to our free-space technology we can easily customize most of our product and so it is for the 90° optical hybrids. Customer can feel free to ask for any customization they need. We will examine the request and do our best to have a positive answer.

### 15 – Package layout



COH28 packaging



COH-X packaging

### 16 – Revision

date	version	Object
March 27, 2013	COH V1.0	Creation
February 3 <sup>rd</sup> , 2015	COH V1.1	Added COH22 (dual-polarization 180° hybrid)
February 24 <sup>th</sup> , 2015	COH V1.2	COH22 specification update