FINISAR

Product Specification

High Bandwidth Integrated Coherent Receiver

CPRV4220A

PRODUCT FEATURES

- Fully integrated dual polarization coherent receiver:
    - Polarization beam splitter
    - Optical 90° hybrids with integrated balanced photodetectors
    - Linear trans-impedance amplifiers with peak indicator output
    - Selectable automatic / manual gain control
    - Signal monitor photodiode and variable optical attenuator (VOA)
    - C-band
- Conforms with OIF-DPC-MRX-02.0 Class 40 implementation agreement
- Up to 64 Gbaud symbol rate
- Typ. >40 GHz bandwidth on each lane

APPLICATIONS

- 200 Gb/s DP-QPSK coherent transmission systems
- 400 Gb/s DP-16QAM coherent transmission systems
- 600 Gb/s DP-64QAM coherent transmission systems

Finisar's CPRV4220A High Bandwidth Integrated Coherent Receiver combines polarization beam splitting optics for the signal and local oscillator inputs, two matched optical 90° hybrids with monolithically integrated balanced photodetectors, and four linear trans-impedance amplifiers (TIAs) with differential outputs in a compact surface-mount package. At the signal input there is a monitor photodiode for input signal monitoring in front of a variable optical attenuator (VOA).
The CPRV4220A HB-ICR takes advantage of Finisar's industry leading high speed photodetector technology and has been optimized to address emerging high baud rate coherent transmission applications, requiring receiver bandwidths of more than 40 GHz. The CPRV4220A HB-ICR conforms to the OIF[1] implementation agreement for High Bandwidth Integrated Coherent Receivers. The Integrated Coherent Receiver is RoHS compliant per Directive 2011/65/EU[1].

PRODUCT SELECTION

CPRV4220A-LP

A: AC-coupled
LP: LC/PC optical connector

An evaluation kit is available, part number EVA-KIT CPRV3XXX/4XXX

I. DC Pin Descriptions

Pin	Symbol	Description	Pin	Symbol	Description
1	RFU	Reserved for future use	34	RFU	Reserved for future use
2	RFU	Reserved for future use	33	RFU	Reserved for future use
3	MC	Mode control (AGC/MGC)	32	SD	Amplifier shutdown
4	MPD+	Monitor photodiode cathode	31	VOA1	VOA adjust voltage 1
5	MPD-	Monitor photodiode anode	30	VOA2	VOA adjust voltage 2
6	PD-YI	Photodiode bias voltage YI	29	PD-XQ	Photodiode bias voltage XQ
7	N/C	Not connected	28	N/C	Not connected
8	PD-YQ	Photodiode bias voltage YQ	27	PD-XI	Photodiode bias voltage XI
9	N/C	Not connected	26	N/C	Not connected
10	PI-YI	Peak indicator YI	25	PI-XQ	Peak indicator XQ
11	GA-YI	Gain adjust YI	24	GA-XQ	Gain adjust XQ
12	OA-YI	Output amplitude adjust YI	23	OA-XQ	Output amplitude adjust XQ
13	VCC-Y	Amplifier supply voltage Y	22	VCC-X	Amplifier supply voltage X
14	GND	Ground reference	21	GND	Ground reference
15	OA-YQ	Output amplitude adjust YQ	20	OA-XI	Output amplitude adjust XI
16	GA-YQ	Gain adjust YQ	19	GA-XI	Gain adjust XI
17	PI-YQ	Peak indicator YQ	18	PI-XI	Peak indicator XI

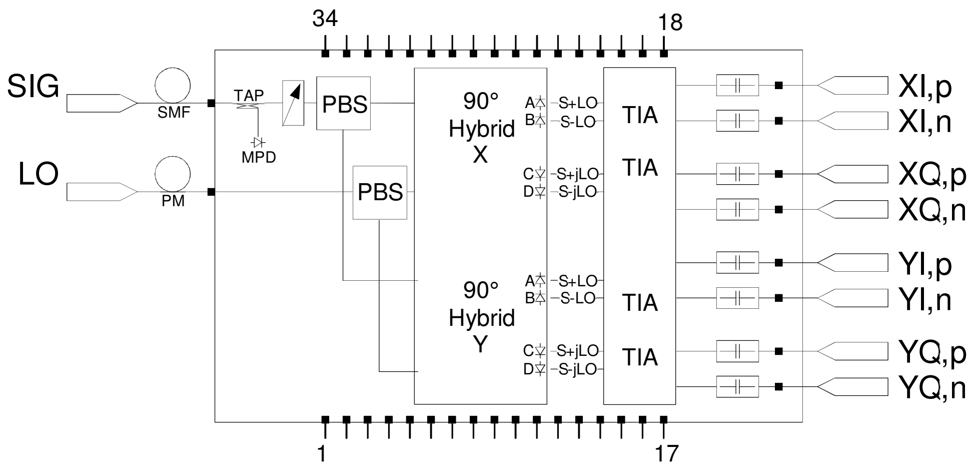

Figure 1. Block diagram of the CPRV4220A integrated coherent receiver with pin numbers.

II. Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect device reliability.

Parameter	Symbol	Min	Typ	Max	Unit	Ref.
Storage temperature	T_S	-40		85	°C	
Relative humidity	RH	5		85	%	1
Amplifier supply voltage	V_{CC}	0		3.47	V	7,9
Amplifier mode control voltage	V_{MC}	0		2.7	V	9
Amplifier shutdown voltage	V_{SD}	0		2.7	V	9
Amplifier output adjust voltage	V_{OA}	0		2.7	V	9
Amplifier gain adjust voltage	V_{GA}	0		2.7	V	9
Photodiode bias voltage	V_{PD}	0		3.5	V	8
VOA control voltage	V_{VOA}	0		5.0	V	2
Average optical input power – Signal	P_{SIG}			18	dBm	3, 5
Average optical input power – Local oscillator	P_{LO}			18	dBm	4, 5
Electrostatic discharge rating	ESD	-250		250	V	6
Minimum fiber bend radius				7.5	mm	

Notes:

1. Non-condensing.
2. Voltage applied between VOA1 and VOA2 pins (arbitrary polarity).
3. Un-polarized CW input.
4. Polarized CW input.
5. If both signal and local oscillator optical inputs are applied simultaneously, then the total optical input power should not exceed the maximum rated for the individual inputs.
6. HBM ESDS Component Sensitivity Class 1B
7. Amplifier supply voltage shall have a ramp time higher than 500µs, turn on Vcc-X and Vcc-Y simultaneously
8. V_{PD} must be > 1.5V in case TIA is power up
9. Do not exceed voltages specified in electrical characteristics (0V..2.7V for DC control pins of TIAs)

CAUTION

This device is susceptible to damage as a result of electrostatic discharge (ESD). Devices have been tested according to ESDA/JEDEC Joint Standard for Electrostatic Discharge Sensitivity Testing – Human Body Model (HBM) JS-001-2014 [2] and classified as HBM ESDS Component Sensitivity Class 1B.
To prevent ESD-induced damage and/or degradation, take proper precautions during both handling and testing. Follow guidelines such as JEDEC standard JESD625B (January 2012) [3] and documents referenced therein.

III. Environmental Specifications

Parameter	Symbol	Min	Typ	Max	Unit	Ref.
Operating case temperature	T_{OP}	0		80	°C	1
Storage temperature	T_S	-40		85	°C	
Relative humidity	RH	5		85	%	2

Notes:

1. Surface temperature of the device, measured in the hot zone of the case, see Figure 6 and Figure 7.
2. Non-condensing

IV. Electrical Characteristics

Parameter		Symbol	Min	Typ	Max	Unit	Ref.
Photodiode bias voltage		V_{PD}	3.14		3.47	V	1
Amplifier supply voltage		V_{CC}	3.14	3.3	3.47	V	1
Amplifier supply current		I_{CC}		370		mA	2
Total power consumption		P_{Total}		1220		mW	
Mode control voltage	MGC	V_{MC}	0		0.6	V	3
Mode control voltage	AGC	V_{MC}	2.0	open	2.7	V	3, 4
Amplifier gain adjust voltage (MGC mode)	Analog control: min ZT	V_{GA}	0		0.2	V	3
Amplifier gain adjust voltage (MGC mode)	Analog control: max ZT	V_{GA}	2.3		2.7		3
Amplifier output amplitude adjust voltage (AGC mode)	Analog control: OA	V_{OA}	0		0.2		3
Amplifier output amplitude adjust voltage (AGC mode)	Analog control: OA	V_{OA}	2.3		2.7	V	3
Amplifier shutdown voltage	Output shutdown mode	V_{SD}	0		0.6	V	5
Amplifier shutdown voltage	Normal operating mode	V_{SD}	2.0	open	2.7	V	4
Monitor photodiode bias voltage		V_{MPD}	3.14		5.25	V	
VOA control voltage		V_{VOA}			3.5	V	6
VOA control current		I_{VOA}			60	mA	
Expected TIA DC control pin currents (GA, OA, MC, SD)		$I_{DC,cntl}$		150		µA	
Peak indicator (output peak detector monitoring function)				tbd			

Notes:

1. The photodiode bias voltage should always be applied before applying the amplifier supply voltage, otherwise the photodiodes may be damaged.
2. Sum of input currents on VCC-X and VCC-Y pins.
3. MGC = Manual Gain Control, AGC = Automatic Gain Control.
4. Internal pull-up.
5. Differential output voltage when shutdown enabled: 2 mV (rms, typical).
6. Voltage applied between VOA1 and VOA2 pins (arbitrary polarity).

Electro-Optical Specifications

Parameter			Symbol	Min	Typ	Max	Unit	Ref.
Frequency range	C-band		ν_2	191.35		196.20	THz	
Optical input power		Signal	P_{SIG}	-20		6	dBm	1
		LO	P_{LO}			16	dBm	2
Polarization extinction ratio		Signal	PER_{SIG}	20			dBo	
Optical return loss			ORL	27			dBo	
Hybrid phase deviation from 90° at RT			$\Delta\varphi$	-6		+7	°	22
Maximum change of pahse deviation from 90° reference to RT				-1.5		0.5	°	
Photodiode Responsivity	C-band , RT	Signal	R_{SIG}	0.07	0.1		A/W	3,20
		LO	R_{LO}	0.03	0.05		A/W	4,20
Change of Responsivity over Temperature to RT						0.5	dB	
Change of Responsivity EOL to BOL						0.22	dB	
Photodiode dark current			I_{DARK}		160	2400	nA	5
Leakage current at PD bias Pad		V_{PD}=3.3V	I_{leak}		10		µA	5
Common mode rejection ratio (DC)		Signal	$CMRR_{SIG}$		-25	-20	dBe	6
		LO	$CMRR_{LO}$		-25	-16	dBe	
Imbalance		Signal	I_{Sig}			2	dBo	18
		LO	I_{LO}			2	dBo	18
Monitor photodiode responsivity			$R_{MPD,SIG}$		0.05		A/W	17
Monitor photodiode dark current			$I_{DARK,MPD}$		1	40	nA	7
Monitor photodiode crosstalk			X_{MPD}			-35	dBo	8
Maximum VOA attenuation			$\lvert\alpha_{SIG,max}\rvert$	10	15		dBo	
VOA response time			t_r			60	ms	9
TIA differential input current			$I_{in,diff,pp}$			3	mApp	10
TIA DC input current			$I_{in,DC}$			4	mA	11
Differential output voltage in AGC mode	0.1 $mA_{pp,diff} \leq I_{IN} \leq 0.7$ $mA_{pp,diff}$ $V_{OA} < 0.2V$, Min Amplitude Setting		$V_{out,pp,diff}$		150		mVpp	
	0.4 $mA_{pp,diff} \leq I_{IN} \leq 3.0$ $mA_{pp,diff}$ $V_{OA} > 2.3V$, Max Amplitude Setting				700		mVpp	
Differential transimpedance in MGC mode	$V_{GA} < 0.2V$, Min gain Setting		Z_T		150		Ω	16
	$V_{GA} > 2.3V$, Max gain Setting				5000		Ω	
Total harmonic distortion	$V_{out,pp,diff} < 0.7$ V, $I_{in,diff} < 3mA_{pp}$				1		%	10,12
O/E transfer function low frequency cut-off			$f_{3dB,low}$			1	MHz	
O/E transfer function high frequency cut-off			$f_{3dB,high}$		40		GHz	13
Rf transmission s21 at 37 GHz, RT nominal gain			Il_{37GHz}	1		7	dB	21

Parameter		Symbol	Min	Typ	Max	Unit	Ref.
Change of Il_{37GHz} over whole operation range to RT					5	dB	
Max. Peaking RT nominal gain					8.5	dB	21
Change of peaking over whole operation range to RT					5	dB	
Output electrical return loss	f < 32 GHz	S_{22}		-10		dBe	13
	32 < f < 49 GHz			-8		dBe	
	49 < f < 62 GHz			-6		dBe	
Differential input referred noise density	$Z_{T,diff}$=500Ω	i_n		90		pA/√Hz	19
	$Z_{T,diff}$=1000Ω			50			
	$Z_{T,diff}$=5000Ω			25			
Skew between complementary signals within a channel (XI, XQ, YI, or YQ)			-1		1	ps	
Skew between polarisations (X and Y)					10	ps	13
Channel skew variation (I to Q)					5	ps	15

Notes:

1. Modulated signal input (DP-QPSK, DP-16QAM, …), single channel. For each signal power, the local oscillator power should be set such that the maximum TIA differential input current and maximum TIA DC input current are not exceeded (see also notes 10 and 11).
2. Continuous wave (CW) input.
3. Linearly polarized, optimized for maximum transmission through the polarization beam splitter.
4. Including 3 dB splitting loss.
5. Sum of dark currents for all photodiodes. Not measureable on receiver level because of TIA integrated bias network.
6. $\mathrm{DC\ CMRR} = 20 \cdot \log(|\Delta R| / \sum R)$where ΔR is the difference in responsivity between the PDs in a balanced pair (XI, XQ, YI, or YQ) and ∑R is the sum of the responsivities of the same PD pair. Note: CMRR is not ~~be~~ directly measureable on receiver level since no individual PD (p,n) bias pins are available. 100% measured on Chip level at RT
7. Measured at room temperature, 25°C.
8. Monitor PD crosstalk $X_{MPD} = 10 \cdot \log(R_{MPD,LO}/R_{MPD,SIG})$.
9. Rise / fall time between 10% and 90% of the change in attenuation.
10. TIA differential input current [mA] is calculated as:
$$I_{in,diff,pp} = 8\sqrt{R_{SIG} \cdot R_{LO} \cdot 10^{(P_{SIG,S}+P_{LO})/10}}$$
where R_{SIG} and R_{LO} are the Signal and LO responsivities of a single PD [A/W], $P_{SIG,S}$ is the signal power [dBm] in the channel of interest in a single polarization (S = X or Y), and P_{LO} is the local oscillator power [dBm]; add optical power in dBm
11. TIA DC input current [mA] is calculated as:
$$I_{in,DC} = R_{SIG} \cdot 10^{P_{SIG,total,S}/10} + R_{LO} \cdot 10^{P_{LO}/10}$$
where R_{SIG} and R_{LO} are the Signal and LO responsivities of a single PD [A/W], $P_{SIG,total,S}$ is the total signal power [dBm] of all channels in a single polarization (S = X or Y), and P_{LO} is the local oscillator power [dBm]
12. Measured for a fundamental frequency of 1 GHz, taking first 5 harmonics into account, with a differential input current to the TIA of 1 mA peak-to-peak.
13. Soldered to board and deembeded to reference point.
14. Includes channel skew variation.
15. Variation in the skew between any 2 channels (XI; XQ, YI, or YQ) due to case temperature, wavelength, input optical power, amplifier gain, and aging.
16. Differential output swing is TIA transimpedance multiplied by $I_{in,diff,pp}$ from note 10
17. Responsivity of MPD based on a 5% Splitter for power monitoring purpose
18. 10*log(Rmax/Rmin) for each port respectively
19. $I_n := 2 * V_{noise,RMS,single\text{-}ended} / (Z_{T,diff@1GHz} * \mathrm{sqrt}(f_{3dB}))$

20. Including connector loss and for signal including 5% splitting loss of monitoring photodiode. Measured with a measurement accuracy of 0.09dB (1 sigma)
21. The S21 transfer functions is measured at nominal TIA gain condition and µICR RT. All S21 responses arre normalized to the response at 1GHz. Data l be de-embedded to the RF reference point. The RF reference point is defined as the point on the Host PCB RF traces that is 2.5mm beyond the maximum extent of the µICR RF lead pad. Not soldered with measurement accuracy around 0.3dB (sigma)
22. A phase modulated signal is generated by an optical homodyne source and a NF-driven optical phase modulator. The electrical RF output signals Ip ;In & Qp ; Qn is detected by an oscilloscope and then the phase error can be calculated on the prevailing phase relationship of this output signals. Measured with an accuracy of around 0.25°(sigma)

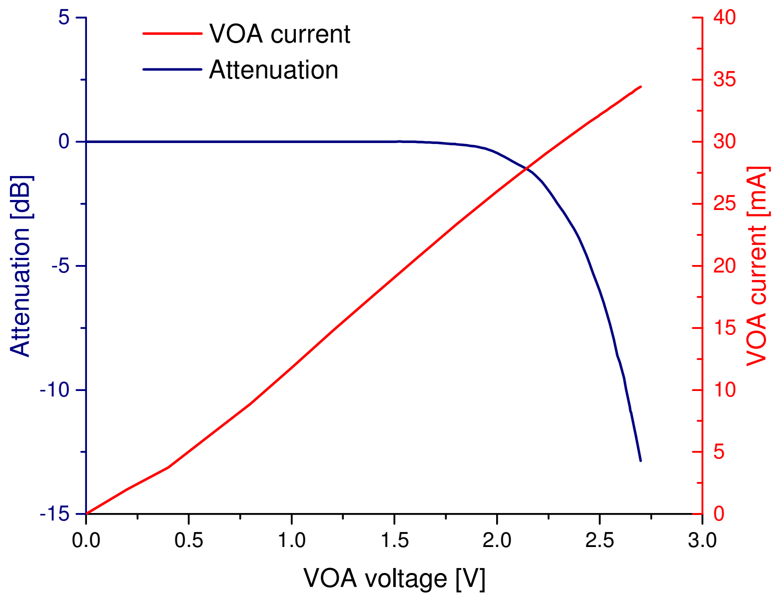

Figure 2. Typical variable optical attenuator (VOA) characteristic.

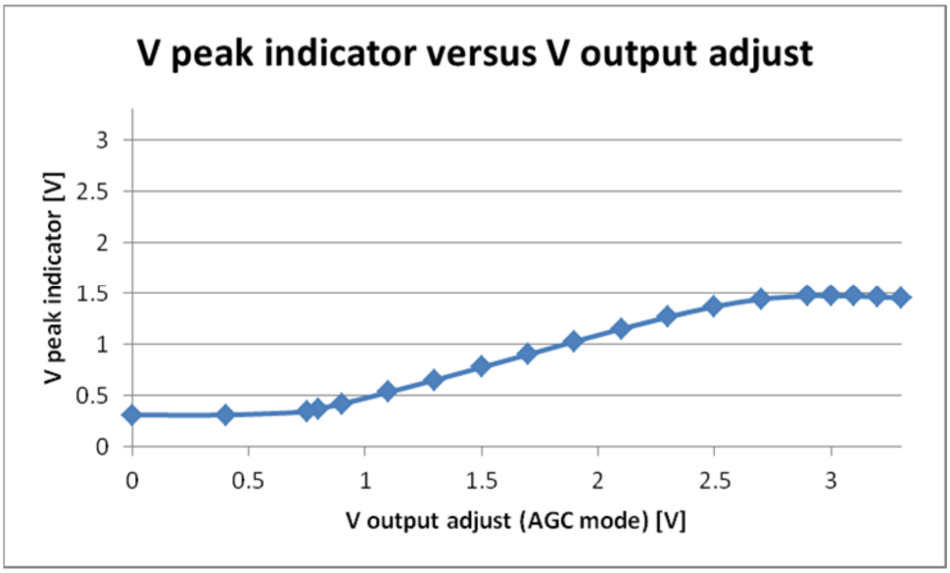

Figure 3: Typical V_{PI} versus TIA-V_{OA} setting in AGC mode with 1GHz sinus input signal

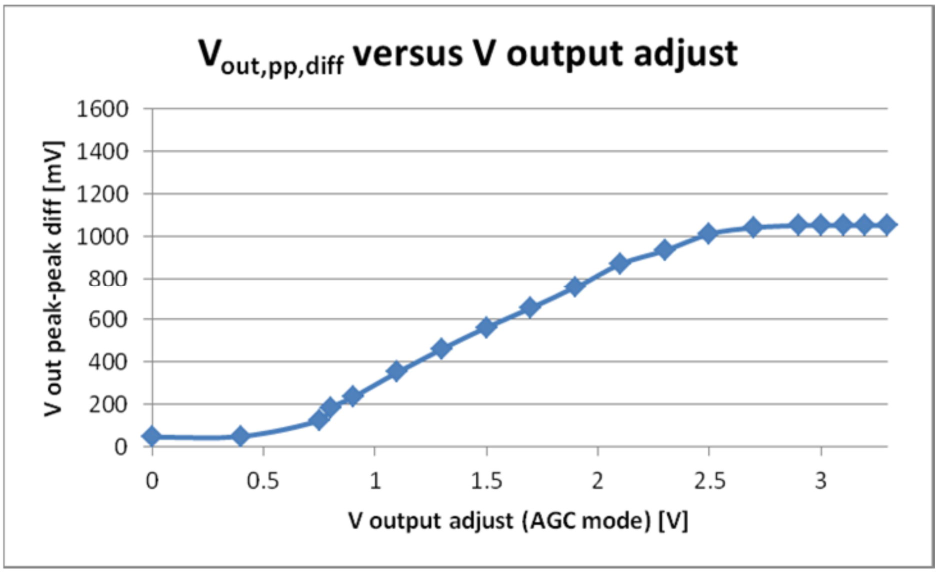

Figure 4: Vout,pp,diff versus TIA-V_{OA} setting in AGC mode with 1GHz sinus input

Note: Internal gain setting in AGC mode can be overwritten by applying external voltage to V_{GA}.
External capacitors at GA will reduce AGC loop bandwidth in AGC mode.

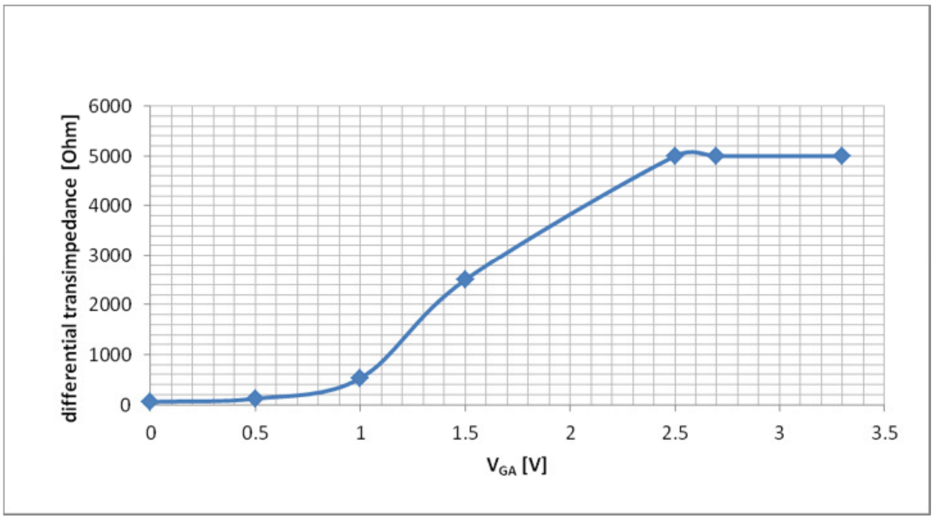

Figure 5. Typical differential transimpedance setting versus V_{GA} in MGC and AGC mode

V. Mechanical Specifications

All dimensions are in mm.

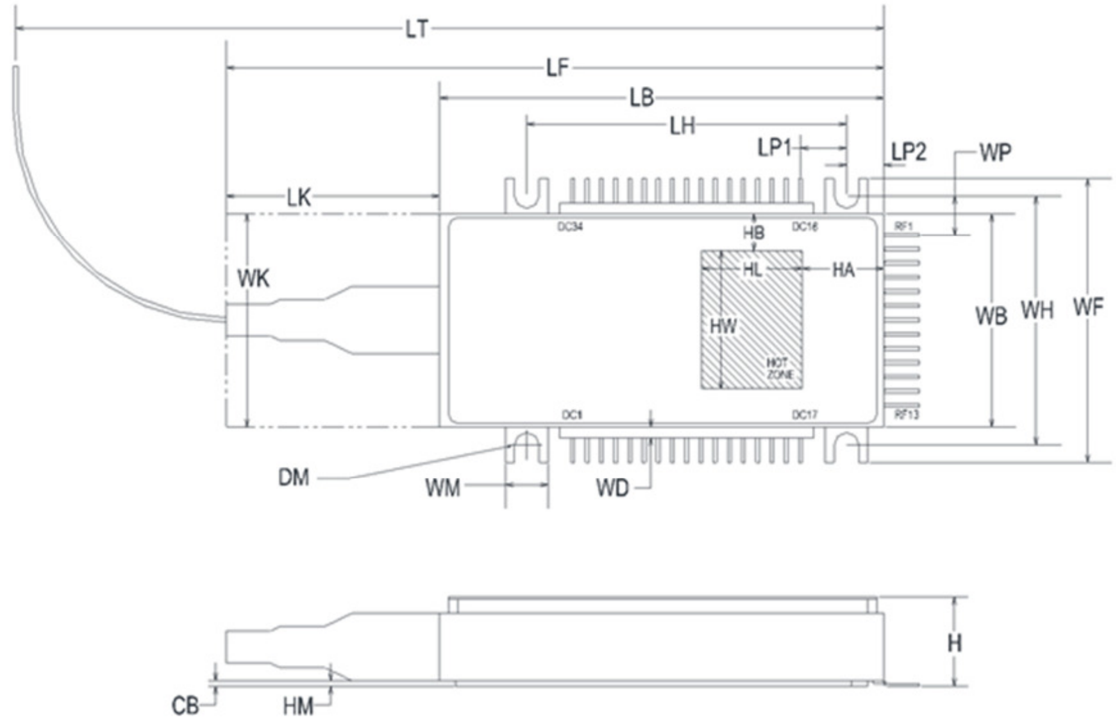

Figure 6. Mechanical dimensions and landing pad dimensions of the CPRV4220A integrated coherent receiver.

Parameter	Symbol	Min	Typ	Max	Unit	Ref.
Package height	H		5.4		mm	
Total length, incl. 90º fiber bend (r = 15 mm)	LT			58	mm	
Full length of package including fiber boots	LF			43	mm	
Length of package body	LB			27	mm	
Longitudinal distance between mounting holes	LH		18		mm	
Distance between mounting hole center and center of last DC pin	LP1		2.6		mm	
Distance between mounting hole center and RF end of package	LP2		2.1		mm	
Width of package, incl. mounting flanges	WF			16	mm	
Width of package body	WB		12		mm	
Lateral distance between mounting foot cutout centers	WH		14		mm	
Distance between mounting hole center and first RF pin center	WP		2.2		mm	
Location of hot region relative to package rear edge	HA	3		5	mm	
Location of hot region relative to package lateral edge	HB				mm	1
Width of hot region	HW			WB	mm	
Length of hot region	HL			10	mm	
Width of fiber boot keep-out region	WK			WB	mm	
Length of fiber boot keep-out region	LK			LF-LB	mm	
Clearance under fiber boot	CB	0.25			mm	
Width of mounting flanges	WM	2	2.4	3	mm	
Height of mounting flanges	HM		0.3	0.4	mm	
Diameter of mounting holes	DM	1.35	1.40	1.45	mm	
Edge of DC feed-through ceramics to edge of package frame	WD	0		0.6	mm	
Pitch of DC-leads			0.8		mm	
Length of DC-leads		1.5	2.0	2.5	mm	
Width of DC-leads		0.1		0.3	mm	
Thickness of DC-leads			0.15		mm	
Pitch of RF-leads			0.8		mm	
Length of RF-leads		1.5	2.0	2.5	mm	
Width of Signal RF-leads		0.1		0.3	mm	
Width of Ground RF-leads		0.1		0.3	mm	
Thickness of RF-leads			0.15		mm	

Notes:

1. Hot region centered laterally with respect to the package body.

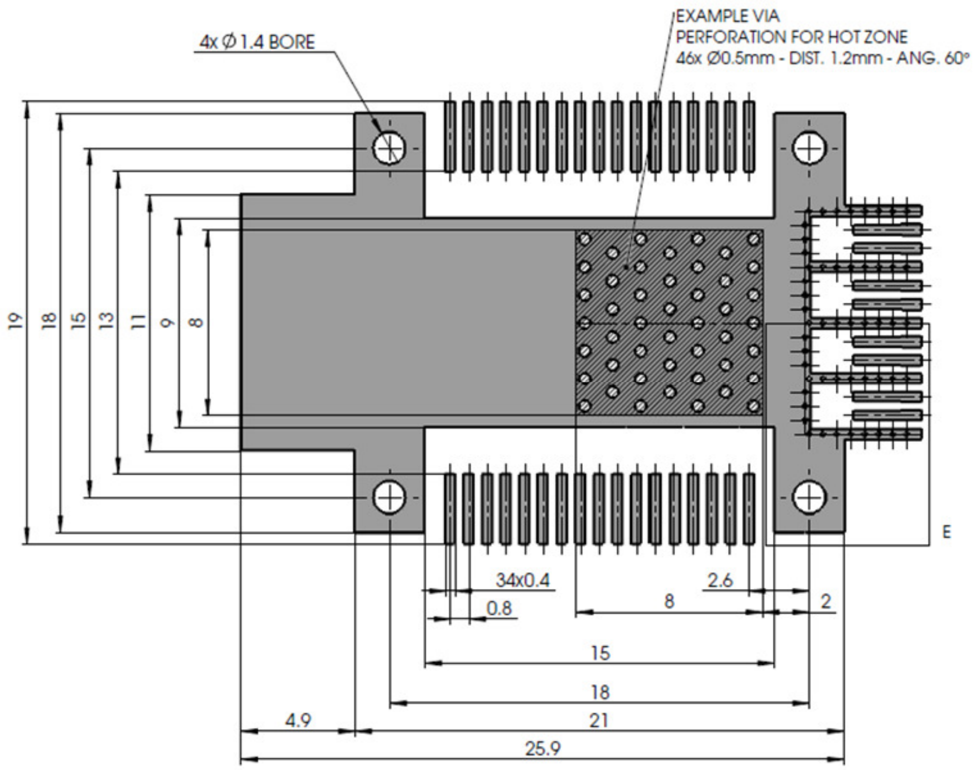

Figure 7. PCB footprint and hot zone of the CPRV4220A integrated coherent receiver.

VI. High Speed Electrical Interface Specification

The high speed electrical interface is co-planar waveguide based, consistent with the pitch and pin definition detailed in the tables and drawing below.

Parameter	Value	Notes
Interface type	Differential	
Number of channels	4	
Channel configuration	G-S-S-G	See Figure 8
Signal line coupling	AC	
Signal line impedance	100 Ω differential	
Channel pin-out	XI XQ YI YQ	See Figure 8
Differential signal pin-out	Signal Complementary signal	p n

Parameter	Symbol	Min	Typ	Max	Unit	Ref.
Lead pitch	A		0.8		mm	
Lead length	B	1.5	2.0	2.5	mm	
Signal lead width	C	0.1		0.3	mm	
Ground lead width	D	0.1		0.3	mm	
Channel pitch	E		2.4		mm	
Signal to complimentary signal pitch	F		0.8		mm	

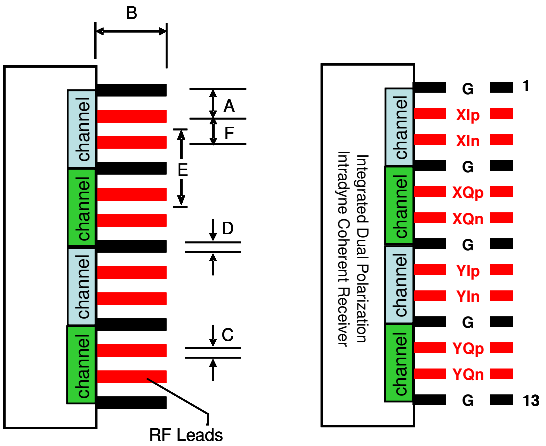

Figure 8. High speed electrical interface definition for the CPRV4220A integrated coherent receiver.

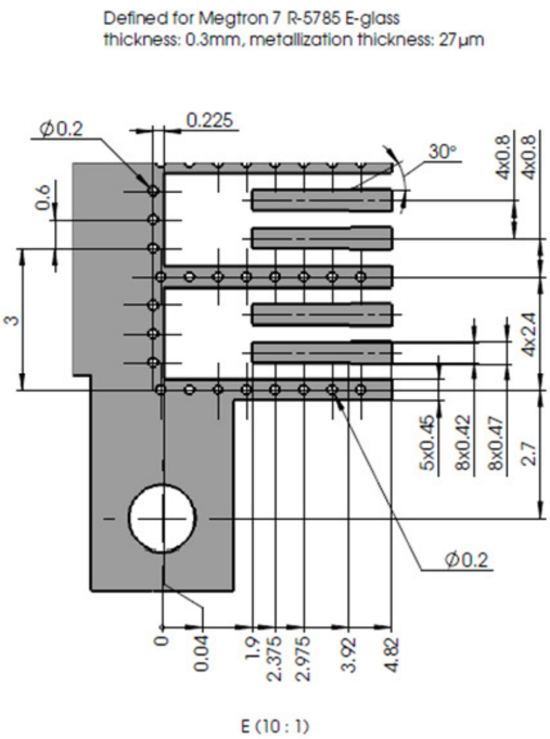

Figure 9. Detail of the recommended RF landing pattern.

VII. Fiber Pigtail and Optical Connector Specifications

Parameter	Value
Fiber type – Signal	Single mode fiber SMF, Designation: Corning Clearcurve ZBL Color of fiber: White
Fibre coating – Signal	242 um OD
Fiber type – LO	Polarization maintaining single mode fiber Designation: Fujikura BISM-15-PX-U25D-H Color of fiber: Transparent
Fiber coating – LO	245 um OD
Fiber length – Signal / LO	1000 +50 / -0 mm
Connector type – Signal / LO	LC/UPC
Connector key alignment – LO	Slow axis of PM fiber

VIII. References

1. OIF “Implementation Agreement for Micro Intradyne Coherent Receivers Class 40- OIF-DPC-MRX-02.0”
1. Directive 2011/65/EU of the European Parliament and of the Council, “on the restriction of the use of certain hazardous substances in electrical and electronic equipment”. Certain products may use one or more exemption as allowed by the Directive.
2. ESDA/JEDEC JS-001-2014 “ESDA/JEDEC Joint Standard for Electrostatic Discharge Sensitivity Testing – Human Body Model (HBM) – Component Level”

3. JEDEC JESD625B (January 2012) “Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices”

IX. Revision History

Revision	Date	Description
00	11.01.15	Review specifications
01	27.04.16	Update
02	01.07.16	Update JAH, GVE, PD
03	05.09.16	Typical graphs for DC pins added
04	06.09.16	Imbalance, absolute maximum ratings, noise update
05	07.11.16	Foot note 9 abs max rating, Picture of module
A00	24.11.16	Official release
B00	05.04.17	Review, update fiber spec, definition of change over temperature, add comments to measurement procedure, update OIF reference, remove PER LO, extend applications

X. For More Information

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