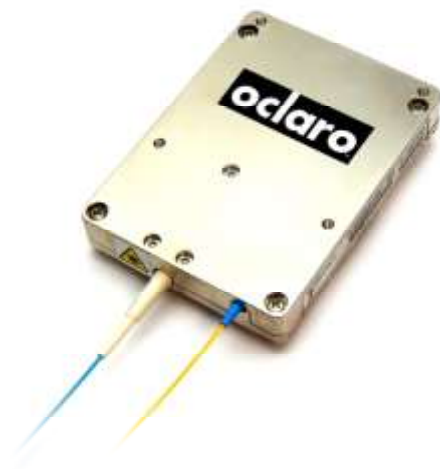


# 10Gb/s 300-pin MSA Transponder Wideband Tunable SFF Negative Chirp, Long Reach Tx, APD Rx

TL9000NACBH-R57



The Oclaro TL9000 module is a 300-pin MSA compatible, 10Gbps, long reach, wideband tunable transponder module suitable for 50GHz channel spaced C-band applications requiring a negative chirp transmitter. The module supports data rates from 9.9Gbps to 11.3Gbps and is provided in a low profile (11.4mm high) Small Form Factor (SFF) industry standard mechanical outline.

The module supports bi-directional conversion of high speed optical signals to / from low speed electrical signals. The electrical interface provides a 16-bit parallel LVDS interface as defined in OIF-SFI4-01.0.

The transmit path comprises a 16-bit multiplexer, high speed modulator driver and optical transmitter. The optical transmitter utilizes Oclaro's LambdaFLEX™ Tunable InP M-Z to provide a co-packaged, high performance, low cost solution. Channel tuning is supported on the ITU-T 50GHz grid across full C-band with  $\pm 20\text{pm}$  stability.

The receive path comprises an APD receiver with linear amplifier, CDR and 16-bit demultiplexer. For optimum system performance in noise loaded applications support is provided for external control of the receiver decision threshold.

An external 2-wire serial interface is provided to support extensive control, monitor and diagnostic functions in accordance with I2C MSA Ed 4.2.

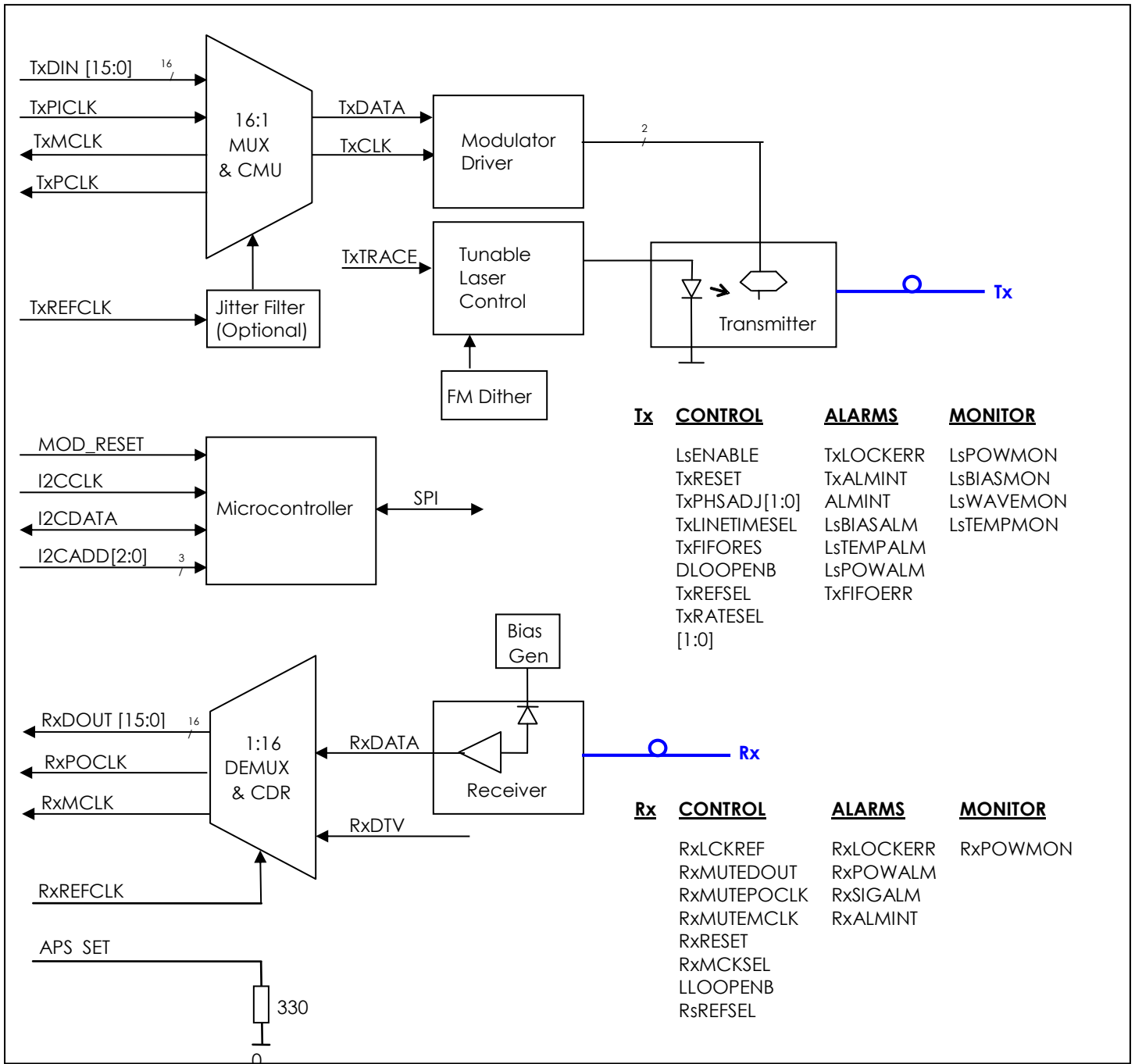
## Features:

- 300-pin MSA compliant 10Gbps wideband tunable SFF transponder suitable for negative chirp applications
- Rate selectable applications including SONET/10GbE with or without FEC encoding (9.9Gbps up to 11.3Gbps)
- OIF-SFI4-01.0 compliant low speed electrical interface
- Co-packaged full band tunable laser source and integrated InP M-Z optical transmitter
- +4.0dBm nom output power with  $\pm 1\text{dB}$  power stability over operating range
- $\pm 2.5\text{GHz}$  wavelength stability on 50GHz ITU-T channel spacing (C band)
- APD receiver with support for decision threshold control adjust and optical damage protection to +12dBm typical
- FM and AM tone insertion supported
- Software configurable, dual line rate
- Source/line timing modes and loopback diagnostics
- MSA Ed 4.2 I<sup>2</sup>C compliant interface for control/alarm and monitor diagnostics
- Low profile SFF outline 76 x 56 x 11.4 mm
- Low power dissipation 7W typical
- Wide operating case temp range -5°C to +70°C
- RoHS 6/6 compliant

## Applications:

- Long Reach applications based on Telcordia GR-253-CORE, ITU-T G.691 and IEEE 802.3ae system architectures
- Regional Metro

Block Diagram



## Optical Characteristics

The following parametric limits detailed are for a case temperature range of -5°C to 70°C EOL unless otherwise stated.

Parameter	Min	Typ	Max	Unit	Conditions
Mean Modulated Output Power	+3.8	+4	+4.3	dBm	BOL
Mean Modulated Output Power	+3.0	+4		dBm	
Shuttered Optical Output Power			-30	dBm	
Power deviation over band	-0.5		0.5	dB	SOL, 30°C
Optical Power Stability	-1.0		+1.0	dB	
Wavelength Range	1528.77		1563.90	nm	
Frequency Range	191.7		196.1	THz	
Nominal Channel Spacing		50		GHz	89 channels on 50GHz grid
Wavelength Deviation	-2.5		+2.5	GHz	±20pm
Tuning Speed		1		s	Note 1
Spectral Width		0.3	0.5	nm	Note 2
Side Mode Suppression Ratio	40	45		dB	
Linewidth Broadening		500	1000	MHz	10kHz-50kHz, 1% AM max (triangular or sine)
Optical Return Loss	27			dB	Towards the module
Extinction Ratio	10.5	11.5			Note 3
Optical Crossing Point	45		55	%	Note 3, Unfiltered Eye
Optical Rise/Fall Time			35	ps	20-80%
Dispersion range	0		1600	ps/nm	Noise Loaded Negative Chirp
Tx/Rx OSNR Performance			15	dB	Negative Chirp, Note 4
Receiver Dynamic Range	-20		-6	dBm	At specified OSNR
Receiver Sensitivity			-26	dBm	Note 5
Receiver Overload	-5	-3		dBm	Note 5
Receiver Reflectance			-27	dB	
Receiver damage threshold	+7	+12		dBm	
Jitter	Compliant to GR253, ITUT G.8251				

### Notes:

Note 1: Absolute tuning speed dependent on required power and wavelength mask requirements

Note 2: Full spectral width measured 20dB down from centre wavelength peak under full modulation

Note 3: Measured with a Tektronix CSA8000 DCA and 80C02 optical plug-in module

Note 4: Measured at 10.709Gbps, BER of 1E-4, 2<sup>31</sup>-1 PRBS and into a receiver with optimised decision threshold

Note 5: Measured at 10.709Gbps, BER of 1E-12, 35dB OSNR, 2<sup>31</sup>-1 PRBS and into a receiver with optimised decision threshold

## Signal Description (Transmitter)

Signal Classification				
Group	Name	I/O	Type	Description
Data	TxDin[15:0]P	In	LVDS	6xxMbps/s differential data bits [15:0] normal
	TxDin[0:15]N	In	LVDS	6xxMbps/s differential data bits [15:0] inverted
Clocks	TxREFCLKP	In	LVPECL	1xx / 6xxMHz Tx Reference clock normal
	TxREFCLKN	In	LVPECL	1xx / 6xxMHz Tx Reference clock inverted
	TxPCLKP	Out	LVDS	6xxMHz Tx parallel output clock normal
	TxPCLKN	Out	LVDS	6xxMHz Tx parallel output clock inverted
	TxPICKLP	In	LVDS	6xxMHz Tx parallel input clock normal
	TxPICKLN	In	LVDS	6xxMHz Tx parallel input clock inverted
	TxMCLKP	Out	LVDS	6xxMHz Tx CMU output clock normal
	TxMCLN	Out	LVDS	6xxMHz Tx CMU output clock inverted
Control	LsENABLE	In	LVTTTL	Laser Enable (active low) [pull-down]
	TxRESET	In	LVTTTL	Tx asynchronous system reset (active low) [pull-up]
	TxTRACE	In	Analogue	External Tone Input
	TxPHSADJ[1:0]	In	LVTTTL	TxPCLK Phase Adjust (0, 90, 180, 270 degrees)
	TxRATESEL[1:0]	In	LVTTTL	Tx Rate Select [MSB:LSB]
	TxLineTimeSEL	In	LVTTTL	Line Timing Mode (active low, RXPOCLK = TXREFCK)
	TxFIFORESET	In	LVTTTL	MUX FIFO Reset Control (active Low)
	DLOOPENB	In	LVTTTL	Low Speed 6xxM TX-RX Diag Loopback Enable (active Low)
	TxREFSEL	In	LVTTTL	1xxM / 6xxMHz TxREFCLK select (Low selects 1xxMHz)
	TxLOCKERR	Out	LVTTTL	Loss of lock of Tx PLL (active low)
Alarms	TxALMINT	Out	OD	TX Alarm (activeLow)
	ALMINT	Out	OD	Combined TX/ RX Alarm (activeLow)
	LsBIASALM	Out	LVTTTL	Laser Bias Alarm (active Low)
	LsTEMPALM	Out	LVTTTL	Laser Temperature Alarm (active Low)
	LsPOWALM	Out	LVTTTL	Laser Nominal Power Alarm (3dB degradation, Active Low)
	TxFIFOERR	Out	LVTTTL	MUX FIFO overflow / underflow (active low)
Monitors	LsPOWMON	Out	Analogue	Laser output power monitor
	LsBIASMON	Out	Analogue	Laser bias current monitor
	LsWAVEMON	Out	Analogue	Laser Wavelength Monitor
	LsTEMPMON	Out	Analogue	Laser sub-mount temperature
Serial interface	I2CDATA	In	I <sup>2</sup> C	Serial data [pull-up]
	I2CCLK	In	I <sup>2</sup> C	Serial clock [pull-up]
	I2CAD[2:0]	In	LVTTTL	I2C Module Address

## Signal Description (Receiver)

Signal Classification				
Group	Name	I/O	Type	Description
Data	RxDout[15:0]P	Out	LVDS	6xxMbits / s differential re-timed data bits [15:0] normal
	RxDout[15:0]N	Out	LVDS	6xxMbits / s differential re-timed data bits [15:0] inverted
Clocks	RxREFCLKP	In	LVPECL	1xx / 6xxMHz Rx Reference clock normal
	RxREFCLKN	In	LVPECL	1xx / 6xxMHz Rx Reference clock inverted
	RxPOCLKP	Out	LVDS	6xxMHz RX Recovered parallel output clock normal
	RxPOCLKN	Out	LVDS	6xxMHz Rx Recovered parallel output clock inverted
	RxMCLKP	Out	LVDS	6xxMHz VCO derived output clock normal
	RxMCLKN	Out	LVDS	6xxMHz VCO derived output clock inverted
Control	MOD_RESET	In	LVTTL	Asynchronous Module Reset (active Low)
	RxLCKREF	In	LVTTL	Locks RxPOCLK to RxREFCLK (active Low)
	RxDTV	In	Analogue	RX Decision Threshold Input Control
	RxMuteDout	In	LVTTL	RxDout[15:0] Mute Control (active Low)
	RxMutePOCLK	In	LVTTL	RxPOCLK Mute Control (active Low)
	RxMuteMCLK	In	LVTTL	RxMCLK Mute Control (active Low)
	RxRESET	In	LVTTL	Rx asynchronous system reset (active low) [pull-up]
	RxMCLKSEL	In	LVTTL	1xx / 6xxMHz RxMCLK Select (Low selects 1xxMHz)
	LLOOPENB	In	LVTTL	High Speed 10G RX –TX Line Loopback Enable (active Low)
RxREFSEL	In	LVTTL	1xxM / 6xxMHz RxREFCLK Select (low selects 1xxMHz)	
Alarms	RxLOCKERR	Out	LVTTL	Loss of lock of RxPOCLK (active low)
	RxPOWALM	Out	LVTTL	Loss of RX Average Optical Power Alarm (active Low)
	RXSIGALM	Out	LVTTL	Receiver loss of ac signal - LOS (active low)
	RXALMINT	Out	OD	RX Alarm (active Low)
Monitors	RxPOWMON	Out	Analogue	RX Optical Input Mean Power Monitor (ac + dc)

## Electrical Characteristics

## DC Characteristics

Parameter	Test Conditions	Min	Typ	Max	Unit
<b>LVPECL Inputs (TxREFCLK, RxREFCLK)</b>					
CLOCK AMPLITUDE	Diff drive (pp per side)	150		1000	mV
COMMON MODE VOLTAGE	VDD = 1.8V		0.66 * VDD		V
INPUT HIGH VOLTAGE		VDD-0.6V		VDD – 0V	V
INPUT LOW VOLTAGE		VDD-1.2V		VDD – 0.575V	V
<b>LVDS Inputs (TxDIN[15:0], TxPICKL)</b>					
TERMINATION RESISTANCE		80		120	Ω
DIFF INPUT VOLTAGE	Across 100 Ω (per side)	100			mVpp
INPUT VOLTAGE RANGE	VDD = 1.8V	800		2000	mV
INPUT VOLTAGE RANGE	VDD = 3.3V	800		2400	mV
<b>LVDS Outputs (RxDOOUT[15:0], TxPCLK, TxMCLK, RxPOCLK)</b>					
OUTPUT VOLTAGE SWING	Across 100 Ω (per side)	250		400	mVpp
OUTPUT COMMON MODE		1.1	1.15	1.3	V
OUTPUT HIGH VOLTAGE				1475	mV
OUTPUT LOW RANGE		925			mV
OUTPUT IMPEDANCE		40		140	Ω
<b>LVTTTL I/O</b>					
INPUT HIGH VOLTAGE	VDDIO = 3.3V	2		VDD	V
INPUT LOW VOLTAGE		VSS		0.8	V
OUTPUT HIGH VOLTAGE		2.4			V
OUTPUT LOW VOLTAGE		VSS		0.4	V
<b>LVPECL Inputs (TxREFCLK, RxREFCLK)</b>					
FREQ TOLERANCE		-100		+100	ppm
DUTY CYCLE		40		60	%
RISE / FALL TIME	20-80%			500	ps
<b>LVDS Inputs (TxDIN[15:0], TxPICKL)</b>					
TxPICKL DUTY CYCLE		40		60	%
DATA SETUP TIME	wrt TxPICKLP edge	250			ps
DATA HOLD TIME	wrt TxPICKLP edge	250			ps
DATA / CLOCK TRANSITION	20-80%	100		250	ps
<b>LVDS Outputs (RxDOOUT[15:0], TxPCLK, TxMCLK, RxPOCLK)</b>					
RxPOCLK DUTY CYCLE		45		55	%
DATA OUTPUT SKEW	wrt RxPOCLKP edge	-200		200	ps
DATA / CLOCK TRANSITION	20-80%	100		250	ps

Parameter	Test Conditions	Min	Typ	Max	Unit
+1.8V Supply Voltage		Not required			
+3.3V Supply Voltage		3.135	3.30	3.465	V
+5V Supply Voltage		4.75	5.00	5.25	V
-5.2V Supply Voltage		-5.46	-5.20	-4.94	V
Operating Case Temperature		-5		70	°C
Line Bit Rate		9.9		11.3	Gbps

## Power Supply Requirements

The TL9000 transponder module operates from the supply rails detailed below. The use of an APS supply is not supported by this product.

Supply rail	Rail	Min	Nom	Max	Unit
+1.8V Current (note 1)	P1V8	Not required			
+3.3V Current	P3V3		1600	3000	mA
+5.0V Current	P5V0		50	200	mA
-5.2V Current	M5V2		30	100	mA
Supply Noise (6kHz – 2MHz)	All Rails			50	mVpp
Total Power Consumption			5	8.5	W

Note 1: APS not supported

## Absolute Maximum Ratings

The TL9000 transponder module shall withstand the conditions over the ranges specified below. Stresses beyond those listed may cause permanent damage or adversely affect the module reliability.

Parameter	Test Conditions	Min	Typ	Max	Unit
<b>Electrical</b>					
+1.8V Supply Voltage		Not required			
+3.3V Supply Voltage		-0.3		3.63	V
+5V Supply Voltage		-0.3		6.0	V
-5.2V Supply Voltage		-6.0		+0.3	V
Voltage on any LVDS pin		-0.3		2.1	V
ESD (Human Body Model)	TA-TSY-000870 Class 2	500			V
<b>Optical</b>					
Receiver Optical Input Power (Mean)			+12	+7	dBm
<b>Environmental</b>					
Operating Relative Humidity	Non-condensing	5		85	%
Storage / Transportation Temperature	Non-condensing	-40		70	°C
Storage Temperature (72hr max)	Non-condensing	-40		85	°C
Storage / Transportation Rel Humidity		5		85	%
Flammability	Fibre UL94-HB <1gm mass		V0		

## Control Interface

The TL9000 module supports all 300-pin MSA defined control inputs with the exception of TxPICKSEL, TxSKEWSEL[1:0], LsTWEAK, LsTUNE[2:0], RxRATESEL[1:0] and RxTRACE. Specifically, the module supports both line and loopback diagnostic modes, line and source timing and all reset functions.

## Alarm Interface

The TL9000 module supports all 300-pin MSA defined alarms outputs with the exception of MODBiasALM. The alarm characteristics can be customised for specific customer applications as required.

## Monitor Interface

The TL9000 module supports all 300-pin MSA defined monitor outputs with the exception of MODBiasMON and RxSIGMON. The monitor characteristics can be customised for specific customer applications as required.

## Integrated Jitter Filter

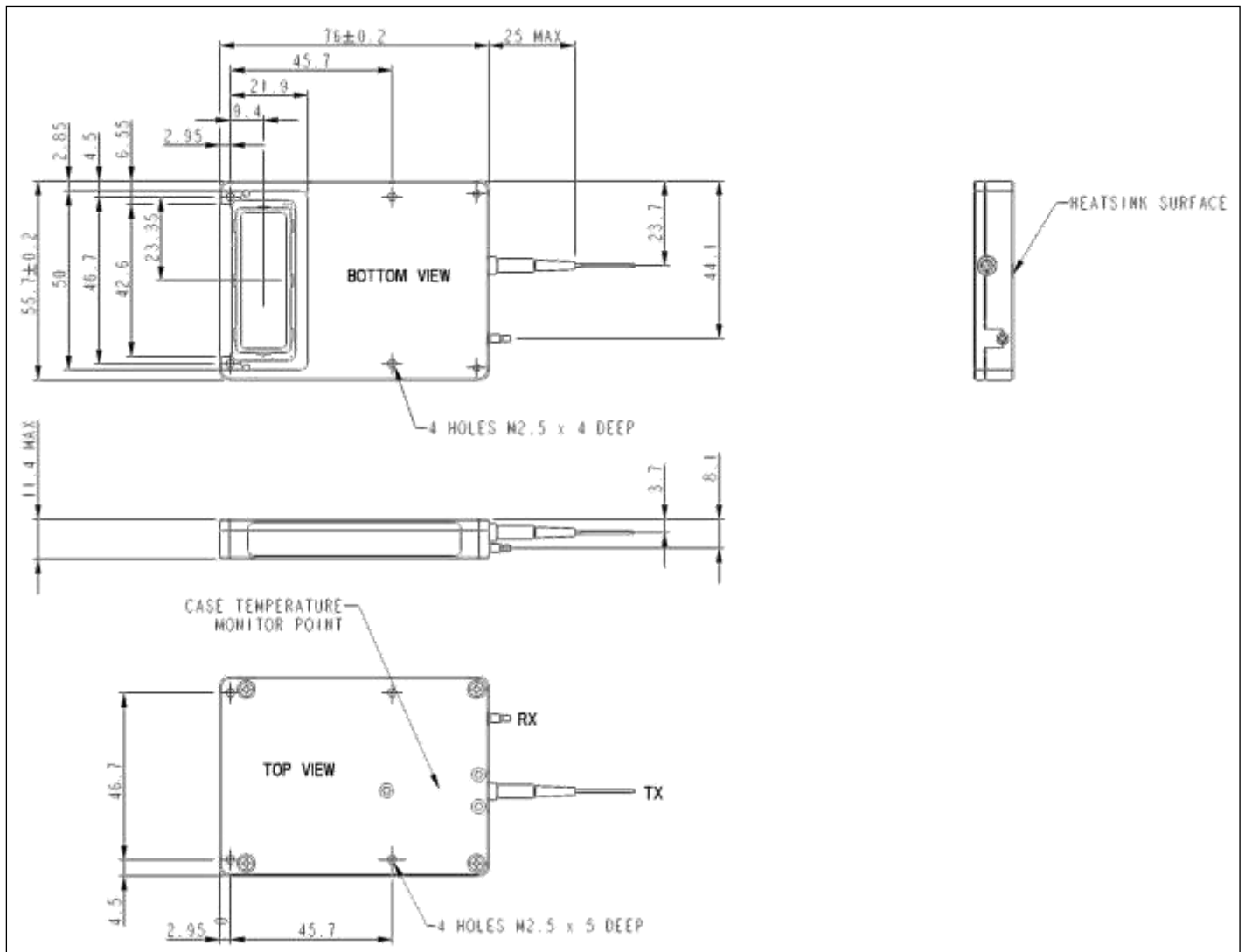
The TL9000 module can be supplied without an integrated jitter filter or with either a single rate or dual rate jitter filter dependent on the customer application. Please contact your Oclaro Account Manager for further details.

## Configuration Information

Option	Configurations	Notes
Transmitter Type	Negative Chirp	+4.0dBm BOL modulated Power
Channel Spacing	50GHz	
Jitter Filter	None, Single or Dual Rate	
Receiver Type	APD	
Mechanical Height	11.4mm	
Optical Connector	LC (R57)	Others available on request



## Mechanical Details



## Module Attachment

The module is secured to the host card using 4 off M2.5 fixing locations as shown above. The electrical connections are provided through a 4mm stack height, 300-pin Berg MEGArray connector. The module is populated with the receptacle part number 84501-201 (Telcordia GR-1217-CORE compliant) for direct connection to the plug (Part No. 84500-xxx) on the system card. An optional insulating pad for the bottom of the transponder is available.

## Optical Interface

The module provides two secondary coated, tight buffered, single mode fibre pigtails terminated with LC optical connectors (other connectors styles available on request). The nominal pigtail lengths are  $1000 \pm 100$  mm. The transmitter fibre is coloured blue and the receiver fibre coloured yellow. Minimum fibre bend radius is 25mm.

Connector Pin Allocation

	K	J	H	G	F	E	D	C	B	A	
5.0VAnalog	<i>RxTRACE</i>	Frame GND	Frame GND	RxDout12P	<i>APS Digital</i>	RxDout8P	Digital GND	RxDout4P	Digital GND	RxDout0P	Receiver
5.0VAnalog	FFU	Frame GND	Frame GND	RxDout12N	<i>APS Digital</i>	RxDout8N	Digital GND	RxDout4N	Digital GND	RxDout0N	
<i>RxRATESELO</i>	<i>RxRATESEL1</i>	<i>APDTEMPMON</i>	Digital GND	RxPOWMON	Digital GND	<i>I2CAD0</i>	Digital GND	<i>RxDTV</i>	Digital GND	Digital GND	
3.3VAnalog	NUC	FrameGND	FrameGND	RxDout13P	3.3VDigital	RxDout9P	Digital GND	RxDout5P	Digital GND	RxDout1P	
3.3VAnalog	NUC	FrameGND	FrameGND	RxDout13N	3.3VDigital	RxDout9N	Digital GND	RxDout5N	Digital GND	RxDout1N	
<i>RxRESET</i>	NUC	<i>DLOOPENB</i>	Digital GND	<i>RxPOWALM</i>	Digital GND	<i>I2CAD1</i>	Digital GND	<i>RxMUTE Dout</i>	Digital GND	Digital GND	
3.3VAnalog	FFU	Analog GND	Analog GND	RxDout14P	3.3VDigital	RxDout10P	Digital GND	RxDout6P	Digital GND	RxDout2P	
3.3VAnalog	FFU	Analog GND	Analog GND	RxDout14N	3.3VDigital	RxDout10N	Digital GND	RxDout6N	Digital GND	RxDout2N	
<i>RxMUTEPOCLK</i>	NUC	FFU	Digital GND	<i>RxSIGMON</i>	Digital GND	<i>I2CAD2</i>	Digital GND	<i>RxLOCKREF</i>	Digital GND	Digital GND	
-5.2VAnalog	<i>APS Sense</i>	Analog GND	Analog GND	RxDout15P	-5.2VDigital	RxDout11P	Digital GND	RxDout7P	Digital GND	RxDout3P	
-5.2VAnalog	<i>APS Set</i>	Analog GND	Analog GND	RxDout15N	-5.2VDigital	RxDout11N	Digital GND	RxDout7N	Digital GND	RxDout3N	
<i>RxMUTEMCLK</i>	NUC	FFU	Digital GND	<i>RxSIGALM</i>	Digital GND	<i>MOD_RESET</i>	Digital GND	<i>RxMCLKSEL</i>	Digital GND	Digital GND	
-5.2VAnalog	FFU	Analog GND	FFU	-5.2VDigital	RxPOCLKP	Digital GND	<i>RxMCLKP</i>	Digital GND	RxREFCLKP	RxREFCLKP	
-5.2VAnalog	<i>RxALM INT</i>	Analog GND	FFU	-5.2VDigital	RxPOCLKN	Digital GND	<i>RxMCLKN</i>	Digital GND	RxREFCLKN	RxREFCLKN	
<i>I2CLOCK</i>	NUC	<i>ALM_INT</i>	Digital GND	<i>RxREFSEL</i>	Digital GND	FFU	Digital GND	<i>RxLOCKERR</i>	Digital GND	Digital GND	
5.0VAnalog	<i>TxALM INT</i>	Analog GND	TxDin12P	<i>APS Digital</i>	TxDin8P	Digital GND	TxDin4P	Digital GND	TxDin0P	TxDin0P	
5.0VAnalog	FFU	Analog GND	TxDin12N	<i>APS Digital</i>	TxDin8N	Digital GND	TxDin4N	Digital GND	TxDin0N	TxDin0N	
<i>I2CDATA</i>	NUC	<i>LsTUNE0</i>	Digital GND	<i>LsBIASMON</i>	Digital GND	<i>LsPOWMON</i>	Digital GND	<i>TxSKEWSELO</i>	Digital GND	Digital GND	
3.3VAnalog	<i>ModBIASMON</i>	Analog GND	TxDin13P	3.3VDigital	TxDin9P	Digital GND	TxDin5P	Digital GND	TxDin1P	TxDin1P	
3.3VAnalog	<i>ModBIASALM</i>	Analog GND	TxDin13N	3.3VDigital	TxDin9N	Digital GND	TxDin5N	Digital GND	TxDin1N	TxDin1N	
<i>TxRATESELO</i>	<i>TxRATESEL1</i>	<i>LsTUNE1</i>	Digital GND	<i>LsENABLE</i>	Digital GND	<i>LsTEMPMON</i>	Digital GND	<i>TxSKEWSEL1</i>	Digital GND	Digital GND	
3.3VAnalog	FFU	Analog GND	TxDin14P	3.3VDigital	TxDin10P	Digital GND	TxDin6P	Digital GND	TxDin2P	TxDin2P	
3.3VAnalog	FFU	Analog GND	TxDin14N	3.3VDigital	TxDin10N	Digital GND	TxDin6N	Digital GND	TxDin2N	TxDin2N	
TxRESET	NUC	<i>LsTUNE2</i>	Digital GND	<i>LsBIASALM</i>	Digital GND	<i>TxPHSADJ0</i>	Digital GND	<i>LsTWEAK</i>	Digital GND	Digital GND	
-5.2VAnalog	NUC	Frame GND	TxDin15P	-5.2VDigital	TxDin11P	Digital GND	TxDin7P	Digital GND	TxDin3P	TxDin3P	
-5.2VAnalog	NUC	Frame GND	TxDin15N	-5.2VDigital	TxDin11N	Digital GND	TxDin7N	Digital GND	TxDin3N	TxDin3N	
<i>TxFIFO RES</i>	NUC	<i>LLOOPENB</i>	Digital GND	<i>LsTEMPALM</i>	Digital GND	<i>TxPHSADJ1</i>	Digital GND	<i>TxPICKSEL</i>	Digital GND	Digital GND	
-5.2VAnalog	<i>LsWAVEMON</i>	Frame GND	TxPICKLP	-5.2VDigital	TxPCLKP	Digital GND	<i>TxMCLKP</i>	Digital GND	TxREFCLKP	TxREFCLKP	
-5.2VAnalog	<i>TxTRACE</i>	Frame GND	TxPICKLN	-5.2VDigital	TxPCLKN	Digital GND	<i>TxMCLKN</i>	Digital GND	TxREFCLKN	TxREFCLKN	
<i>TxFIFO ERR</i>	NUC	<i>TxLINETIMSEL</i>	Digital GND	<i>TxREFSEL</i>	Digital GND	<i>LsPOWALM</i>	Digital GND	TxLOCKERR	Digital GND	Digital GND	

	Receiver power & GND supplies
	Receiver d.c. signals
	622 differential signals

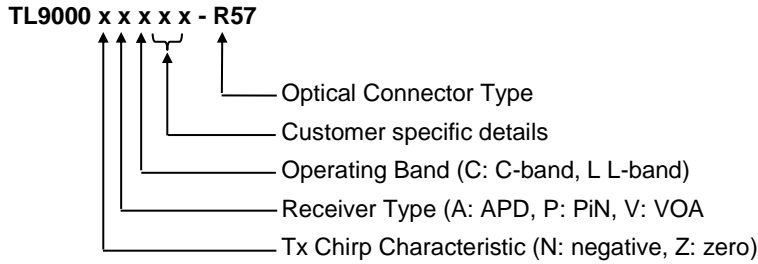
	Transmitter power & GND supplies
	Transmitter d.c. signals

NUC: no user connection  
 FFU: reserved for future use  
*Italics*: optional feature

### RoHS Compliance

Oclaro is fully committed to environment protection and sustainable development and has set in place a comprehensive program for removing polluting and hazardous substances from all of its products. The relevant evidence of RoHS compliance is held as part of our controlled documentation for each of our compliant products. RoHS compliance parts are available to order, please refer to the ordering information section for further details.

### Ordering Information:



Please contact your Oclaro account manager for further product coding information

### Contact Information

[www.oclaro.com](http://www.oclaro.com)

### Important Notice

Performance figures, data and any illustrative material provided in this data sheet are typical and must be specifically confirmed in writing by Oclaro before they become applicable to any particular order or contract. In accordance with the Oclaro policy of continuous improvement specifications may change without notice. Further details are available from any Oclaro sales representative.



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