Confidential

# OFC 2025 Product Overview

April, 2025 Fiber Optic Devices Group NEC Corporation



### **Tunable SFP Extended Reach**



# 25G Tunable SFP28 40km

#### **Electrical Dispersion Compensation technology is employed for reach extension**

#### Features

- 40km reach achieved by employing EDC
  - Without EDC, 15km reach is the limitation by fiber dispersion of C-band at 25Gb/s
  - EDC enables to achieve 40km reach by compensating the degradation of received waveform
- Higher link budget >20dB
- Power consumption <2.5W
- Ecology and Economy
  - Reduces CAPEX by re-use current topology
  - Reduces the inventory of transceiver

#### Status

- Alpha sample available
- Beta: June 2025
- GA: July 2025

unable SFP	401	25Gb/s, km tran	, NRZ smissio	on	Tunable SF	Ρ
Item	Unit	Min	Тур	Max	Note	
Power Consumption	W			2.5	E-Temp	
Data Rate	Gbps	24.3	25.78			
Center Frequency Range	THz	191.3		196.2		
Grid Spacing	GHz	100				
SMSR	dB	30				
Output Power	dBm	0		4		
Extinction Ratio	dB	5				
Chromatic Dispersion load	ps/nm	700				
Sensitivity	dBm			-20	25.78 Gbps, PRBS31,CD=700ps/nm	
Overload	dBm	-5				
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#### 25G Tunable SFP 40km

### Confirmed Feasibility of 40km Transmission with Received Sensitivity Below -22dBm in Our SFP-Sized Prototype



25G Tunable SFP 40km

### Achieve Power Consumption of 2.5W or Less Across an Extended Temperature Range of -20 to 85 deg.C





#### 25G Tunable SFP 40km

# Standard SFP Size with Built-in EDC Chip through High-Density Integration



# **Tunable SFP family**

#### Tunable SFP family based on NEC's in-house Silicon photonics tunable laser technology

			Wavelength	Reach	Power consumption	Technology
10G	80km		C-band, Tunable	80km	2W -20 to +85 deg. C	SiPh tunable laser and MZ modulator
25G	15km	C.	C-band, Tunable	15km	2.5W -20 to +85 deg. C	SiPh tunable laser and MZ modulator
	40km	C. C	C-band, Tunable	40km	2.5W -20 to +85 deg. C	SiPh tunable laser and MZ modulator plus EDC in receiver side
50G	10km	under study	C-band, Tunable	10km	3W (TBD) -20 to +85 deg. C	SiPh tunable laser and high speed MZ modulator

# NEC's Tunable DWDM SFP by Silicon photonics technology

### NEC's Tunable DWDM SFP employs in-house Silicon photonics technology

#### Benefits of NEC's Tunable SFP

- In-house Silicon photonics tunable laser inside
  - Monolithically integrate wavelength tunable filter, wavelength locker, MZ modulator and monitor PD
  - External cavity laser is structured by combination with SOA using high precision alignment
  - Wide bandwidth MZ modulator over 25Gb/s
  - High optical output power employing BOA for output side
  - Competitive for volume production
  - Low power consumption

#### Full-band Tunable DWDM SFP





In-house Silicon photonics Tunable laser inside



Block diagram of In-house Silicon photonics chip

## Principle of NEC's Silicon photonics tunable laser

#### External cavity laser is structured by Silicon photonics double-ring filter Vernier effect caused by different lengths between Ring 1 and Ring 2 provides wavelength-tuning

### Principle

- Tunable function is obtained by vernier effect of double-ring structure
- Lasing operation is appeared at the overlapped spectrum of Ring 1 and Ring 2
- Wavelength is tuned by controlling lengths of Ring 1 and/or Ring 2 with heater on Silicon chip



Silicon photonics double-ring External cavity laser structure





### **BiDi Transceivers**



# 25G SFP28 family

#### 25Gb/s transmission over one single fiber by Bi-directional technology

			Wavelength	Link Budget	Reach	Power consumption	Technology
	BR10		1270nm / 1330nm 1270nm / 1310nm	8dB	15km	1.3W -40 to +85 deg. C	uncooled DML and PIN
	BR40		1289nm / 1314nm	19dB	40km	2W -40 to +85 deg. C	cooled EML and APD
BiDi	NEW! BR40+	C. C	1289nm / 1314nm	22dB	40km+	2W -40 to +85 deg. C	cooled EML and APD
	NEW! 60km	C. C	1289nm / 1314nm	27dB	60km	2.5W -40 to +85 deg. C	cooled EML and APD
	NEW! 80km		1296nm / 1309nm	30dB	80km	3W -40 to +85 deg. C	cooled EML and SOA+PIN



### 25G SFP28 BR40+

### NEC's BR40+ improves link budget by 3dB while maintaining interconnectivity with BR40

### Features

- Fully compatible with standard SFP28 BR40
- Link budget 22dB, improved by 3dB from SFP28 BR40
- Applicable for high insertion loss system
- 25Gb/s 40km+ transmission over one single fiber
  - 1289 / 1314 nm bi-direction
- Low power consumption: <2W
- Single power supply voltage: +3.3V
- Operating case temperature: -40°C to 85°C
- Technology
  - High power cooled EML
  - High sensitivity APD + TIA



			NEW!	
Item	Unit	BR40	BR40+	Note
Link Budget	dB	19	22	
Optical Output Power	dBm	0 to +6	<b>+1</b> to +6	OMA
Sensitivity	dBm	-19	-21	OMA
Overload	dBm	-4	-4	OMA
Extinction Ratio	dB	4	4	Min
Wavelength	nm	1289/1314	1289/1314	-
Power consumption	W	2	2	-

# 25G BiDi SFP28 higher link budget

### NEC offers original higher link budget products for longer reach and higher loss fibers

### Features

- Applicable for high insertion loss system
- 25Gb/s 60km transmission over one single fiber
  - 1289 / 1314 nm bi-direction
  - High link budget >27dB
- 25Gb/s 80km transmission over one single fiber
  - 1296 / 1309 nm bi-direction
  - High link budget >30dB
- Single power supply voltage: +3.3V
- Operating case temperature: -40°C to 85°C

### Technology

- High power cooled EML
- High sensitivity APD + TIA for 60km
- SOA+PIN for 80km



Item	Unit	BR40	60km	80km	Note
Link Budget	dB	19	27	30	
Optical Output Power	dBm	0 to +6	+4.2 to +9.2	+3.5 to +8.6	OMA
Sensitivity	dBm	-19	-22.8	-26.5	OMA
Overload	dBm	-4	-1.8	-6	OMA
Extinction Ratio	dB	4	7	8	Min
Wavelength	nm	1289/1314	1289/1314	1296/1309	-
Power consumption	W	2	2.5	3	-

# 100G QSFP28/SFP-DD/SFP112 family

#### 100Gb/s transmission over one single fiber by QSFP28 form factor

			Form factor	Reach	Power consumption	Optical interface
	LR1	A second	QSFP28	10km	4.5W (I-temp)	1 x 100G, PAM4
BiDi	ER1	A second	QSFP28	40km	4.5W (I-temp)	1 x 100G, PAM4
	NEW! ZR4	A second	QSFP28	80km	5.5W (C-temp)	4 x 25G, NRZ



# 100G QSFP28 LR1/ER1 BiDi

### 100G single $\lambda$ bi-directional up to 40km transmission over G.652 SMF

### Benefits

- Cost advantage of single LD against conventional 4LDs
- Compatible with conventional QSFP28 electrical interface
- Bi-Directional
  - LR1: 1291 / 1311 nm
  - ER1: 1305 / 1309 nm
- 10km and Extended reach up to 40km
- OTU rate available (option)

### Technology

- 50Gbaud, PAM4 by DSP
- High sensitivity PIN/APD and TIA
- Low dispersion penalty with O-band







# 100G QSFP28 ZR4 BiDi

### 4 x 25Gb/s bi-directional up to 80km transmission over G.652 SMF

### Benefits

- Bi-directional, the cost of renting fibers can be reduced by half
- Extended long reach up to 80 km
  - Applicable for high insertion loss system
  - Link budget: >30dB
- Leveraging legacy QSFP28 slots
  - Compatible with conventional QSFP28 electrical interface
  - Power consumption: <5.5W



- 4 cooled LWDM EML and MUX/DEMUX function inside
- High sensitivity by employing SOA for receiver side
- Low dispersion penalty with O-band



# 400G QSFP-DD ER4 BiDi

### 4 x 100Gb/s bi-directional up to 40km transmission over G.652 SMF

### Benefits

- Bi-directional, the cost of renting fibers can be reduced by half
- Extended long reach up to 40 km
  - Applicable for high insertion loss system
  - Link budget: >17dB
- Leveraging legacy QSFP-DD slots
  - Compatible with conventional QSFP-DD electrical interface
  - Power consumption: <12W</li>

### Technology

- 50Gbaud, PAM4 by DSP
- High sensitivity APD and TIA
- MUX/DEMUX and WDM inside







400G QSFP-DD ER4 BiDi block diagram

### **800G coherent pluggable**



# 800ZR/ZR+ High Power Pluggable Transceivers

#### **Key Features**

- For DCI/Metro WDM application
- Compatible with OSFP/ QSFP-DD MSA
- OIF 800ZR/OpenZR+ Interoperability
- High performance / Low power consumption DSP inside

#### Descriptions

- Form factor
- Reach 800ZR (16QAM) 120km 800ZR+ (PCS-16QAM) 1,000km

OSFP/QSFP-DD800

- Tx output power
- C-band, L-band (Under study) Wavelength

+1dBm

- Power consumption < 29W (Typ.) at 800ZR+
- Operating temp.

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Client INF

NFC

100GbE, 200GbE, 400GbE, 800GbE **OIF CMIS, OIF Coherent CMIS** Management INF

0 to +75 deg.C. (Standard)



# Line Side Mode and Performance

![](_page_19_Figure_1.jpeg)

- Support 100 to 300G OpenROADM and OpenZR+
- > Support not only standard PCS but also proprietary PCS for 600/800G
- \* Target distance is a value calculated from the dispersion tolerance specifications of the DSP and it changes depending on the characteristics of a transmission line (optical fiber) and an OSNR.

# **Support Client and frame**

Support many kinds of client signal formatSupport Mixed Clients

![](_page_20_Figure_2.jpeg)

Mixed Clients are also available

## 400ZR/OpenZR+ QSFP-DD

#### **Key Features**

- For DCI / Metro WDM application
- Supports: 400ZR / Open ZR+
- High performance NEL "ExaSPEED 400" DSP

#### Status

GA

#### Descriptions

Form factor QSFP-DD
Wavelength C-band tunable wavelength
Reach 400G DP-16QAM 600km
200G DP-QPSK 2,500km
100G DP-QPSK 5,000km
Management INF QSFP-DD-CMIS, OIF Coherent CMIS
Power consumption < 21.5W</li>
Operating temp. 0 to +70 deg.C.

![](_page_21_Picture_9.jpeg)

# **Dual ITLA**

![](_page_22_Picture_1.jpeg)

# **Dual-ITLA**

![](_page_23_Picture_1.jpeg)

Silicon Photonics-Based Compact Dual-ITLA Development Underway for Digital Coherent Transceivers Requiring Tunable Light Sources in Both Transmitter and Receiver

### Dual-ITLA Realization through Tunable SFP Laser Technology

- Silicon Photonics for Compact, Low-Power Integration
- Ensuring Complete Independence of Two ITLAs

(ITLA: Integrable Tunable Laser Assembly)

### Enhancing Digital Coherent Transceiver Functionality

- Envisioning Dual-ITLA Integration in QSFP-DD/OSFP Sizes
- Efficient Wavelength Resource Utilization with Independent Wavelength Settings for Transmitter/Receiver
- Wavelength Conversion Feature Achievable in a Single Transceiver
- Applicable to Single-Fiber Bi-directional Transceivers

![](_page_23_Picture_12.jpeg)

Item	Target specifications
Output Power	Standard: +15dBm High Power: +17dBm
Linewidth	< 100kHz
Power Consumption	<4.5W
Operating Temperature	-5 to 75 deg.C
Wavelength Range	C-band
Beta Sample	C-band : CY2026 4Q
General Availability	C-band : CY2027 2Q

![](_page_23_Picture_14.jpeg)

#### Silicon photonics Micro-Ring Modulator Laser

### Prototype Dual Tunable Laser Unit Mounted in Standard Gold Box, Confirming Simultaneous Dual-Wavelength Emission

![](_page_24_Picture_2.jpeg)

#### [Prototype test sample]

![](_page_24_Picture_4.jpeg)

#### 2 lasers emitted simultaneously

YOKOGAWA AQ6370D HOPCTAL EPECTILUM AMALYZEM

![](_page_24_Picture_7.jpeg)

SiPh chip size: 2x3mm

![](_page_24_Figure_9.jpeg)

![](_page_24_Figure_10.jpeg)

#### Independent Dual-Wavelength Laser Emission Achieved

![](_page_24_Picture_12.jpeg)

### **1.6T Micro-Ring Modulator device**

![](_page_25_Picture_1.jpeg)

# Silicon photonics Micro-Ring Modulator Laser

- Designed for the 1.6T 2xFR4/FR8 Pluggable Transceiver
- Ultra low power consumption by uncooled operation with single DFB Laser

![](_page_26_Figure_3.jpeg)

## Operating Principle of MRM (Microring Modulator)

The size of the microring is less than 20 μ m in diameter, and broadband characteristics are achieved due to optimal Q value and low junction capacitance. The change in the refractive index, caused by the variation in carrier density within the depletion region of the PN junction, shifts the resonant wavelength of the ring, enabling intensity modulation of the CW light. By monitoring the photocurrent with an integrated PD on the rings drop side and adjusting the heater power, it is possible to set the optimal operating point regardless of the DFB lasers wavelength (controllable with heater power below 25mW).

![](_page_27_Figure_2.jpeg)

# **Static characteristics**

Heater efficiency

- > The heater efficiency and modulation efficiency are within our design range.
- The Q factor, calculated from the extinction characteristics of the ring, is approximately 3000., and the frequency characteristic can be achieved more than 60 GHz expected the Q factor.
- > These results indicate that 200G modulation is possible.
- Scheduled to evaluate dynamic characteristics in 2025/1Q

![](_page_28_Picture_5.jpeg)

Corporation

![](_page_28_Figure_6.jpeg)

Modulation efficiency (voltage efficiency of resonance wavelength shift.)

![](_page_28_Figure_8.jpeg)

## Chip design

#### $4CH-MRM(200G \times 4)$

![](_page_29_Picture_2.jpeg)

 $8CH-MRM(200G \times 8)$ 

![](_page_29_Picture_4.jpeg)

#### 4CH-MRM Suitable for MACOM(MAOM010404/625)

![](_page_29_Picture_6.jpeg)

4CH-MRM This design is suitable for Semtech(TN587)

![](_page_29_Picture_8.jpeg)

![](_page_29_Picture_9.jpeg)

### **Target specification**

		Unit	Minimum	Max	Remarks
Bit rate		Gb/s	-	224	112Gbaud PAM4
Opera	ation temperature	°C	0	75	
Maxi	mum input power	dBm	20	-	
Modu	lator Insertion Loss	dB	-	11	CW, 4ch, without coupling loss
		dB	-	14	CW, 8ch, without coupling loss
Band	width	GHz	60	-	f3dB
Operation voltage		V	-	2	Vpp, single end
Wavelength		nm	-	-	O-band
4ch	Average power	dBm	-0.2	5.3	DFB output = 20dBm
	OMA	dBm	2.8	5.0	DFB output = 20dBm
	Power Consumption	W		0.9	Including DFB Laser
8ch	Average power	dBm	-0.2	2.3	DFB output = 20dBm
	OMA	dBm	0.0	2.1	DFB output = 20dBm
	Power Consumption	W		1.1	Including DFB Laser

#### Silicon photonics Micro-Ring Modulator Laser

### NEC can offer either optical subcomponents or transceiver.

![](_page_31_Picture_2.jpeg)

- Offering standalone Siph chips with polished end faces and AR coating
- For optical assembly vendors, high precision alignment technology enables High-volume production and low cost
- Providing transmitter units equipped with SiPh MRM chips and DFB Lasers on a single carrier
- For optical assembly vendors, simplified integration by coupling to fiber with a lens

Considering offerings in OSFP and QSFP-DD form factors

![](_page_31_Picture_8.jpeg)

![](_page_32_Picture_0.jpeg)

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