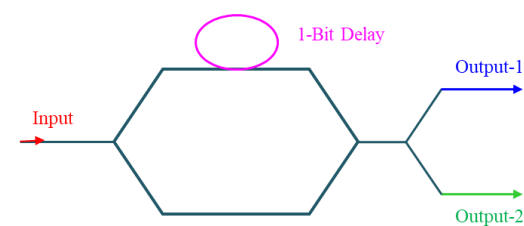

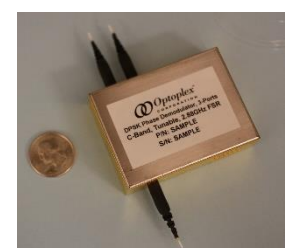


DPSK Phase Demodulators

Optoplex's **Optical DPSK Demodulator**, also known as **Delay Line Interferometer (DLI)**, converts *phase modulation* to *amplitude modulation* over the entire C+L band in support of data transmission rates of 2.5, 10 or 40 Gb/s. The DPSK demodulator is designed for phase modulated optical communication systems utilized in commercial, defense and space exploration markets. The device plays a key role in improving signal quality and performance to meet the expanding demand for higher data rates and more complex transmission formats within current and next generation systems without major capital expenditure. Optoplex's DPSK Demodulator is based on a patented free-space optical design, which is compact, athermal and polarization-independent. The measured frequency drift over temperature is only ~ 0.02 GHz/ $^{\circ}$ C for our standard passive device. Further, this DPSK Demodulator exhibits a total polarization-dependent phase shift of less than 2 degrees over the entire operating temperature range with a high extinction ratio. Optoplex's DPSK Demodulators can be configured to be fully tunable, colorless tunable or purely passive. Dual-Rate DPSK Demodulator is also available.

Since its release of the DPSK products in 2006, Optoplex has been the dominant supplier of DPSK DLIs in the global market for optical communications for terrestrial, subsea and aerospace applications.

Table 1, DPSK Performance Specifications			Table 2, Wavelength Bands		Table 3, Available FSRs					
Parameter	Unit	Specification	Wavelength Band	Wavelength Range (nm)	Data Rate (Gb/s)	Typical FSR (GHz)				
Wavelength Range ¹	nm	See Table 2	C-Band	1525 ~ 1570	40	66.67, 57, 50				
Free Spectral Range (FSR) ²	GHz	See Table 3	L-Band	1570 ~ 1610	20	21.5, 21.9				
FSR Error ³	%	< 1	C+L Band	1525 ~ 1610	10	12.5, 12.25, 11.4, 10.7, 10				
Insertion Loss (including two connectors)	dB	1.8	O-Band-1	1250 ~ 1310	5	5				
Extinction Ratio	dB	> 18	O-Band-2	1310 ~ 1370	3	3.33				
PMD	ps	< 0.1	O-Band	1260 ~ 1360	2.5	2.88, 2.67, 2.50, 2.488				
Return Loss	dB	> 40	1064	1064 +/- 5	1	1.25, 1.0				
PDL	dB	< 0.2	 <p>Fig 1. Schematic of DPSK DLI</p>							
PDFS	deg	< 3								
TDFS ⁴	MHz/ $^{\circ}$ C	< 20								
Optical Path Delay (between the two receiving ports)	ps	< 1.0								
Tuning Time Constant ⁵	sec	< 1.0								
Tuning Range ⁶	FSR	1.5 ~ 3								
Tuning Voltage ⁶	V	0 ~ 5								
Power Consumption ⁶	W	0.5								
Maximum Input Optical Power	mW	300								
Operating Temperature ⁸	$^{\circ}$ C	-5 ~ +70								
Notes							Designs of DPSK			
<ol style="list-style-type: none"> Wavelength bands available from C-, L-, C+L, and O-Band. Other wavelength ranges can be made upon request Listed FSRs are the standard offers. Custom FSR available upon request. Standard FSR error is 1%. More precise FSR can be made. Contact Optoplex for your requirements. TDFS are applied to PASSIVE and Semi-Tunable versions. It is not required in Tunable version. Time constant, or tuning speed, is measured at the output from 0 ~ 50% of the output amplitude. Faster tuning can be made. Contact Optoplex. For standard design with tuning range of 1.5 ~ 3 FSR at driving voltage from 0 ~ 5V and power consumption of 0.5W typically. Wider tuning range, such as 5FSR or even 10FSR (+/-5FSR) can be made at higher driving voltage (0 ~ 7V) and therefore higher power consumption. Contact Optoplex for more details about larger tuning range. <p>A. By default, single mode fiber (SMF-28e or equivalent) is used. Options are bare fiber, 900um tight buffer, or 900um loose tube. B. B: The device dimension varies depending on the FSR. Contact Optoplex for details.</p>							<p>Tunable – the output spectrum of the DPSK can be tuned (shifted) when a driving voltage is applied (VDC: 0 ~ 5V). The default design has a tuning range of >1.5 FSR.</p> <p>Semi-Tunable: The output spectrum of the DPSK can be slightly tuned (shifted). The max range is usually 0.5GHz.</p> <p>Passive – There is no tuner built-in the DPSK device. The spectrum can not be tuned (shifted). In manufacturing, we will align the spectral peak to customer specific frequency position. By default, it will be aligned to ITU grids. This is good when the DPSK is used in colorless DWDM system.</p>			
Key Features and Benefits							Applications			
<ul style="list-style-type: none"> Athermal design C+L band coverage by a single device Low temperature-dependent frequency shift (TDFS) Low polarization-dependent frequency shift (PDFS) Low insertion loss & PDL High power handling Passive, colorless tunable (both aligned to ITU Grid) or fully tunable Telcordia GR-1221 qualified 							<ul style="list-style-type: none"> High-Speed (DPSK) optical communications systems DPSK signal receptions Free-space laser communications Satellite optical communications LiDar Fiber optic sensing, such as DAS Precise optical interference measurement Optical spectroscopy 		<ul style="list-style-type: none"> Quantum communication systems <ul style="list-style-type: none"> – QKD systems – Quantum Cryptography – Quantum random noise generator (QRNG) – Signal Synchronization Quantum Computing Quantum Sensors 	
 <p>Fig 1. Standard package design</p>										

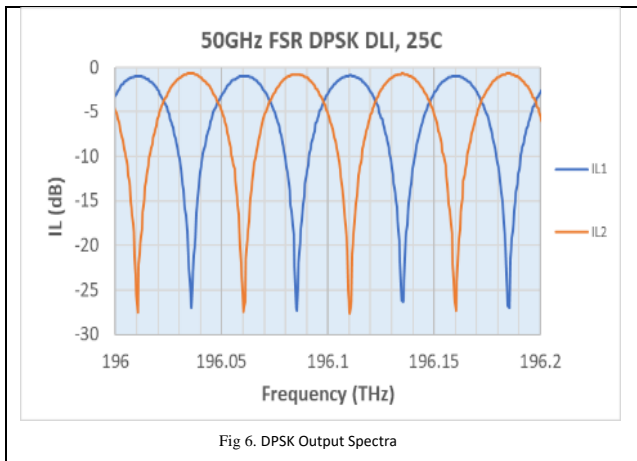


Fig 6. DPSK Output Spectra

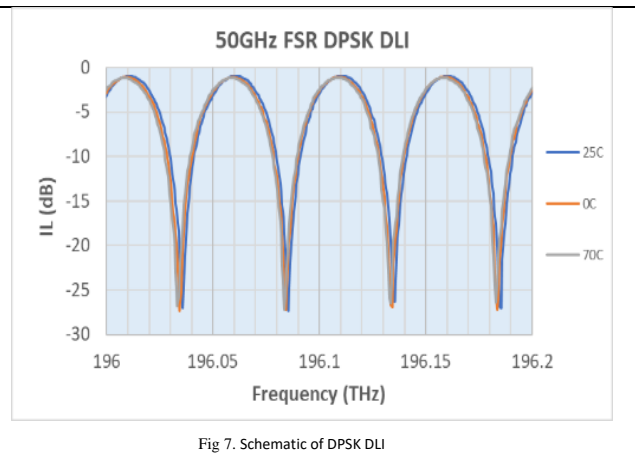
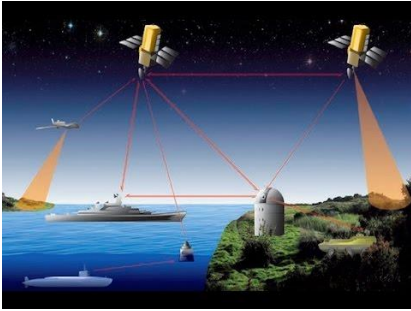




Fig 7. Schematic of DPSK DLI

Special DPSK and Applications

Satellite and Aerospace Application	Quantum Optical Communications	Precise Motion Control
 <p>Today, 2.5Gbps DPSK DLI is widely used in satellite and other aerospace optical communications. Available FSRs are 2.488, 2.50, 2.65 and 2.88GHz. Among them, 2.88GHz is the most popular one. A smaller FSR, 1.25GHz, is also available for such application. 3-Port or 4-Port Configuration is available. For special doppler application in aerospace, very large tuning range, such as 5, 7, or even 10FSR, is required. With proprietary design, Optoplex's DPSK DLI can be specially made to meet the requirements.</p>	 <p>DPSK Delay Line Interferometer with a delay of 1ns (1GHz FSR) is now being used in Quantum Cryptographic application. Very accurate FSR (or delay in time) is necessary and extremely environmentally stable a must.</p>	 <p>Precise measurement and motion control in sub-nanometer is demanding such as in today's most advanced lithography system in semiconductor process where transistor linewidth of 7nm or 5nm is fabricated. With DPSK DLI, extremely small distance (length) change is transferred into the optical phase shift, enabling the precise measurement (and therefore the control) of sub-nanometer possible. Optoplex's athermal design of DPSK is an ideal DLI for such cutting-edge application.</p>

Military and Aerospace-Grade DPSK DLIs

Optoplex has developed manufacturing process compliant with MIL- and AS- standards and the 2.5Gbps DPSK DLIs have been qualified for aerospace (including GEO satellite) applications).

Contact Optoplex for details.


Product Ordering Information			
DI — W F X Y Y Z n n n			
W - Wavelength C = C-Band L = L-Band T = C+L-Band Q = O-Band A = 1064nm	F - FSR (GHz) 1 = 40 ~ 67 0 = 20 ~ 25 A = 10 ~ 12.5 B = 5 ~ 6.5 C = 2.5 ~ 3 D = 1 ~ 1.25	X: Type C = Passive D = Semi-Tunable E = Tunable	YY: Connector FA = FC/APC FC = FC/UPC LA = LC/APC LC = LC/UPC SC = SC/UPC
		Z: Made S = Standard C = Custom	nnn: Sequential (to be assigned by Optoplex)

Fig 6. 4-Port DPSK

Popular Product Part Numbers

DPSK Phase Demodulators			DPSK Phase Demodulators – Cont.		
FSR	MPN	Product Description	FSR	MPN	Product Description
1.25	DI-CDEFAC523	DPSK, C-Band, 1.25GHz FSR, Tunable, SMF, FC/APC	26.75	DI-TOEFC005	DPSK, C+L Band, 26.75GHz FSR, Tunable, SMF, FC/UPC
2.488	DI-CDEFCC457	DPSK, C-band, 2.488GHz FSR, Tunable, SMF, FC/UPC	27.75	DI-CODFAC001	DPSK, C-Band, 27.75GHz FSR, Tunable, SMF, FC/APC
2.5	DI-CDEFCC520	DPSK, C-Band, 2.5GHz FSR, Tunable, SMF, FC/APC		DI-COESCS007	DPSK, C-Band, 27.5GHz FSR, Tunable, SMF, SC/UPC
2.67	DI-CDEFCC485	DPSK, C-band, 2.67GHz FSR, Tunable, SMF, FC/APC		DI-CODFAC001	DPSK, C-Band, 27.75GHz FSR, Semi-tunable, PM Fiber , FC/APC
2.88	DI-CDEFCC415	DPSK, C-Band, 2.88GHz FSR, 4-port , SMF, FC/UPC	28	DI-COEFAC464	DPSK, C-band, 28GHz FSR, Tunable, FC/APC
	DI-CDEFAC437	DPSK, C-Band, 2.88GHz FSR, Tunable, SMF, FC/APC		DI-COELCS009	DPSK, L-Band, 28GHz FSR, Tunable, SMF, LC/UPC
	DI-CDEFCC461	DPSK, C-band, 2.88GHz FSR, Push-Pull Tuning for +/-5 FSR , SMF, FC/UPC	31.75	DI-COESCS008	DPSK, C-Band, 31.75GHz FSR, Tunable, SMF, SC/UPC
	DI-CDEFAC463	DPSK, C-band, 2.88GHz FSR, Tuning range >=4.2 FSR , SMF, FC/APC		32.5	DI-COEFCS006
3.33	DI-CDEFAC519	DPSK, C-Band, 3.33GHz FSR, Tunable, SMF, FC/APC	33.33	DI-COELCS495	DPSK, C-Band, 33.33GHz FSR, Tunable, SMF, LC/UPC
5	DI-LBESCS002	DPSK, L-Band, 5GHz FSR, Tunable, SMF, SC/UPC	40	DI-C1FC002	DPSK, C-Band, 40GHz FSR, Tunable, SMF, FC/UPC
	DI-CBEFAC451	DPSK, C-Band, 5GHz FSR, Tunable, SMF, FC/APC		DI-C1CS002	DPSK, C-Band, 40GHz FSR, Tunable, SMF, SC/UPC
5.76	DI-CDEFCC420	DPSK, C-Band, FSR 5.76GHz, Tunable, 4-port , SMF, FC/UPC		DI-L1ESCS003	DPSK, L-Band, 40GHz FSR, Tunable, SMF, SC/UPC
6.25	DI-CBEFCS001	DPSK, C-band, 6.25GHz FSR, Tunable, SMF, FC/UPC		DI-T1EFCC421	DPSK, C+L Band, 40GHz FSR, Tunable, SMF, FSC/UPC
7.83	DI-CAELCC359	DPSK, C-Band, 7.83GHz FSR, Tunable, SMF, LC/UPC		DI-A1EFAP521	DPSK, 1064nm , 40GHz FSR, Tunable, PMF (PM780-HP), FC/APC
8.125	DI-CAESCS001	DPSK, C-Band, 8.125GHz FSR, Tunable, SMF, SC/UPC	40.96	DI-C1EFC006	DPSK, C-Band, 40.96GHz FSR, Tunable, SMF, FC/UPC
10	DI-CAELCC426	DPSK, C-Band, 10GHz FSR, Tunable, SMF, LC/UPC	43	DI-C1EFC003	DPSK, C-Band, 43GHz FSR, Tunable, SMF, FC/UPC
	DI-CADLCC427	DPSK, C-Band, 10GHz FSR, Semi-Tunable , SMF, LC/UPC		DI-C1ELCC003	DPSK, C-Band, 43GHz FSR, Tunable, SMF, LC/UPC
	DI-CACLCC428	DPSK, C-Band, 10GHz FSR, Passive , SMF, LC/UPC		DI-T1EFC003	DPSK, C+L Band, 43GHz FSR, Tunable, SMF, FC/UPC
	DI-TAEFAC465	DPSK, C+L Bband , 10GHz FSR, Tunable, FC/APC		44.4	DI-C1EFC004
	DI-QAEFAC501	DPSK, O-Band , 10GHz FSR, Tunable, SMF, FC/APC	50	DI-T1ESCS001	DPSK, C+L Band, 50GHz FSR, Tunable, SMF, SC/UPC
	DI-CAEFAS522	DPSK, C-Band, 10GHz FSR, Tunable, SMF, FC/APC		DI-C1MLCS503	DPSK, C-Band, 50GHz FSR, Tunable, SMF, LC/UPC
10.24	DI-CAEFC006	DPSK, C-Band, 10.24GHz FSR, Tunable, SMF, FC/UPC		DI-C1EFAS506	DPSK, C-Band, 50GHz FSR, Tunable, SMF, FC/APC
	DI-CADFCC448	DPSK, C-Band, 10.24GHz FSR, Semi-Tunable , SMF, FC/UPC		DI-A1EFAS517	DPSK, 1064nm , 50GHz FSR, Tunable, PMF (PM780-HP), FC/APC
10.7	DI-CAEFAC435	DPSK, C-band, 10.7GHz FSR, Tunable, SMF, FC/APC	53.5	DI-T1EFC007	DPSK, C+L Band, 53.5GHz FSR, Tunable, SMF, FC/UPC
	DI-CAELCC438	DPSK, C-band, 10.7GHz FSR, Tunable, SMF, LC/UPC		DI-C1MFCS007	DPSK, C-Band, 53.5GHz FSR, Tunable, SMF, FC/UPC
	DI-TAMSCS525	DPSK, C+L Band, 10.7GHz FSR, Tunable, SMF, SC/UPC	55	DI-C1EFC021	DPSK, C-Band, 55GHz FSR, Tunable, SMF, FC/UPC
11.3	DI-CAELCM509	DPSK, C-Band, 11.3GHz FSR, Tunable, SMF, LC/UPC	57	DI-C1ELCS005	DPSK, C-Band, 57GHz FSR, Tunable, SMF, LC/UPC
12.25	DI-CAEFAS505	DPSK, C-Band, 12.25GHz FSR, Tunable, SMF, FC/APC		DI-C1CLCS005	DPSK, C-Band, 57.14GHz FSR, Tunable, SMF, LC/UPC
	DI-CAELCM510	DPSK, C-Band, 12.25GHz FSR, Tunable, SMF, LC/UPC	60	DI-C1ELCS008	DPSK, C-Band, 60GHz FSR, Tunable, SMF, LC/UPC
12.4	DI-CAEEXC349	DPSK, C-Band, 12.4GHz FSR, Tunable, SMF, No Connector	65	DI-C1MLCC392	DPSK, C-Band, 65GHz FSR, Tunable, SMF, LC/UPC
12.5	DI-CAEFC5425	DPSK, C-Band, 12.5GHz FSR, Tunable, SMF, FC/APC	66.67	DI-C1MLCP010	DPSK, C-Band, 66.67GHz FSR, Tunable, PM Fiber , LC/UPC
	DI-CAELCS524	DPSK, C-Band, 12.5GHz FSR, Tunable, SMF, LC/UPC		DI-L1MLCC407	DPSK, L-Band, 66.67GHz FSR, Tunable, SMF, LC/UPC
13.375	DI-TAEFC008	DPSK, C+L Band, 13.375GHz FSR, Tunable, SMF, FC/UPC		DI-C1MLCC447	DPSK, C-Band, 66.67GHz FSR, Tunable, SMF, LC/UPC
	20	DI-COELCC429		DPSK, C-Band, 20GHz FSR, Tunable, SMF, LC/UPC	DI-A1EFAS518
		DI-CODLCC430	DPSK, C-Band, 20GHz FSR, Semi-Tunable, SMF, LC/UPC	80	DI-C2EFC002
DI-COCLCC431	DPSK, C-Band, 20GHz FSR, Passive, SMF, LC/UPC	DI-C2DFCS001	DPSK, C-Band, 80GHz FSR, Semi-Tunable, SMF, FC/UPC		
21.5	DI-COEFAC499	DPSK, C-Band, 20GHz FSR, Tunable, SMF, FC/APC	100	DI-C3DLC002	DPSK, C-Band, 100GHz FSR, Semi-Tunable , SMF, LC/UPC
	DI-TOEFC003	DPSK, C+L Band, 21.5GHz FSR, Tunable, SMF, FC/UPC		DI-Q2EFC467	DPSK, O-Band , 100GHz FSR, Tunable, SMF, FC/UPC
DI-COELCS515	DPSK, C-Band, 21.5GHz FSR, Tunable, SMF, LC/UPC	125	DI-C3DFCS001	DPSK, C-Band, 125GHz FSR, Semi-Tunable , SMF, LC/UPC	
23	DI-COEFCS001	DPSK, C-Band, 23GHz FSR, Tunable, SMF, FC/UPC	159.25	DI-C4EFC001	DPSK, C-Band, 159.25GHz FSR, Tunable, SMF, FC/UPC
23.75	DI-COELCC378	DPSK, C-Band, 23.75GHz FSR, Tunable, SMF, LC/UPC	163.84	DI-C4EFC002	DPSK, C-Band, 163.84GHz FSR, Tunable, SMF, FC/UPC
24	DI-COJFCC343	DPSK, C-Band, 24GHz FSR, Tunable, SMF, FC/UPC	500	DI-C5ECC453	DPSK, C-Band, 500GHz FSR, Tunable, SMF, SC/UPC
25	DI-COELCC001	DPSK, C-Band, 25GHz FSR, Tunable, SMF, LC/UPC		Dual-FSR DPSK	
	DI-COEFCS424	DPSK, C-Band, Tunable, 25GHz FSR, FC/APC	43/66.67	DI-C1NLCC005	DPSK, C-Band, 42.8/66.67GHz Dual-FSR , Tunable, SMF, LC/UPC
	DI-LOELCS002	DPSK, L-Band, 25GHz FSR, Tunable, SMF, LC/UPC	50/65	DI-C1NLCC002	DPSK, C-Band, 50/65GHz Dual-FSR , Tunable, SMF, LC/UPC
	DI-C1EFAM512	DPSK, C-Band, 25GHz FSR, Tunable, SMF, FC/APC	50/66.67	DI-C1NLAC380	DPSK, C-Band, 50/66.7GHz Dual-FSR , Tunable, SMF, LC/UPC
	DI-TOESCS002	DPSK, C+L Band, 25GHz FSR, Tunable, SMF, SC/UPC			
	DI-TOEFCC456	DPSK, C+L Band, 25GHz FSR, Tunable, FC/UPC			
	DI-QCEFAS491	DPSK, O-Band, 25GHz FSR, Tunable, FC/APC			