NEC

DATA BOOK

OPTICAL SEMICONDUCTOR DEVICES

1989

DANGER

INVISIBLE LASER RADIATION
AVOID DIRECT EXPOSURE TO BEAM
OUTPUT POWER___mw MAX
WAVELENGTH________nm
CLASS IIIb LASER PRODUCT

SELECTION GUIDE 1

DATA SHEET 2

APPLICATION NOTE 3

CONTENTS

I. SELECTION GUIDE

1

(1) Introduction

We live in an age of information. This information is in the form of voice conversations, music, TV pictures, digital data, recorded messages — the list goes on and on. And as the amount of information increases, a transmission medium to deliver it to the destination with accuracy, density and speed becomes ever more important.

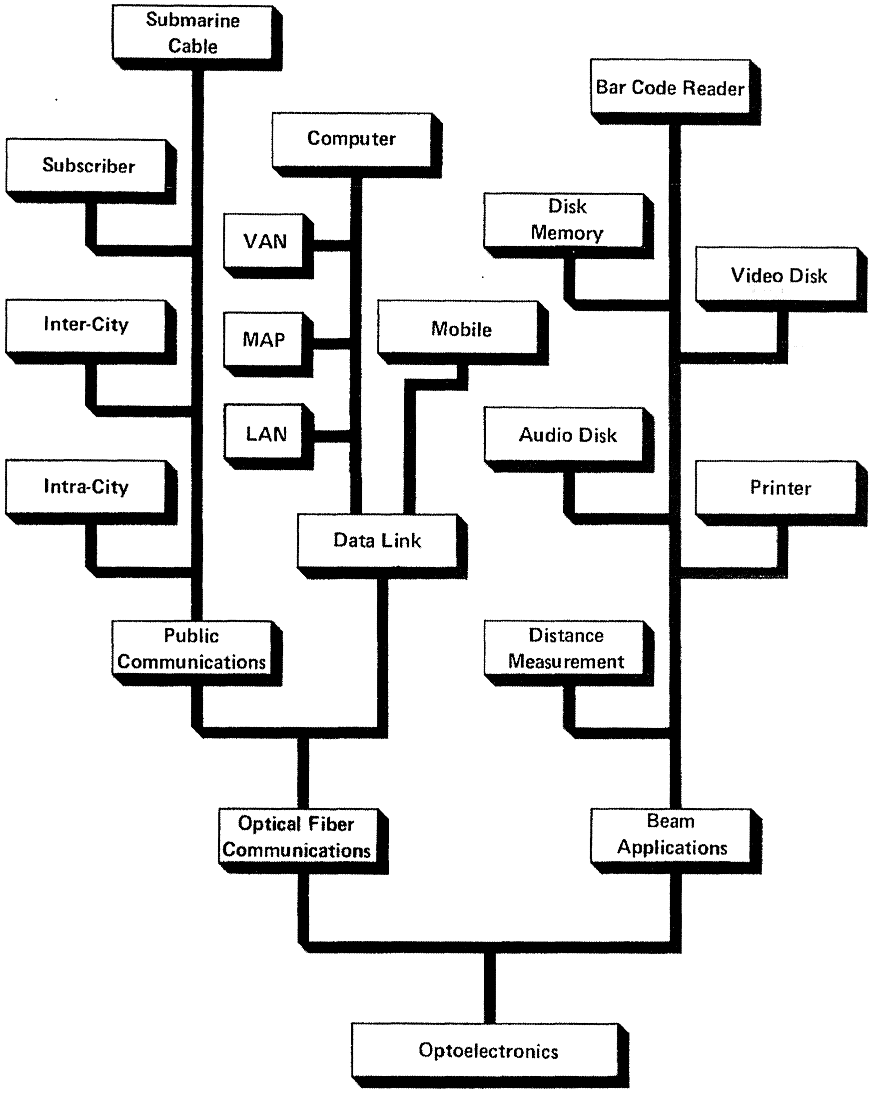
Now, a remarkable new medium has emerged to challenge the wire and microwave telephone circuits, radio waves, and satellite communications, that handle the bulk of today's information.

The new medium is called optoelectronics. And it offers several advantages compared to other forms of communications. These advantages include lower weight and cost, high transmission capacity, and extraordinarily good immunity to noise.

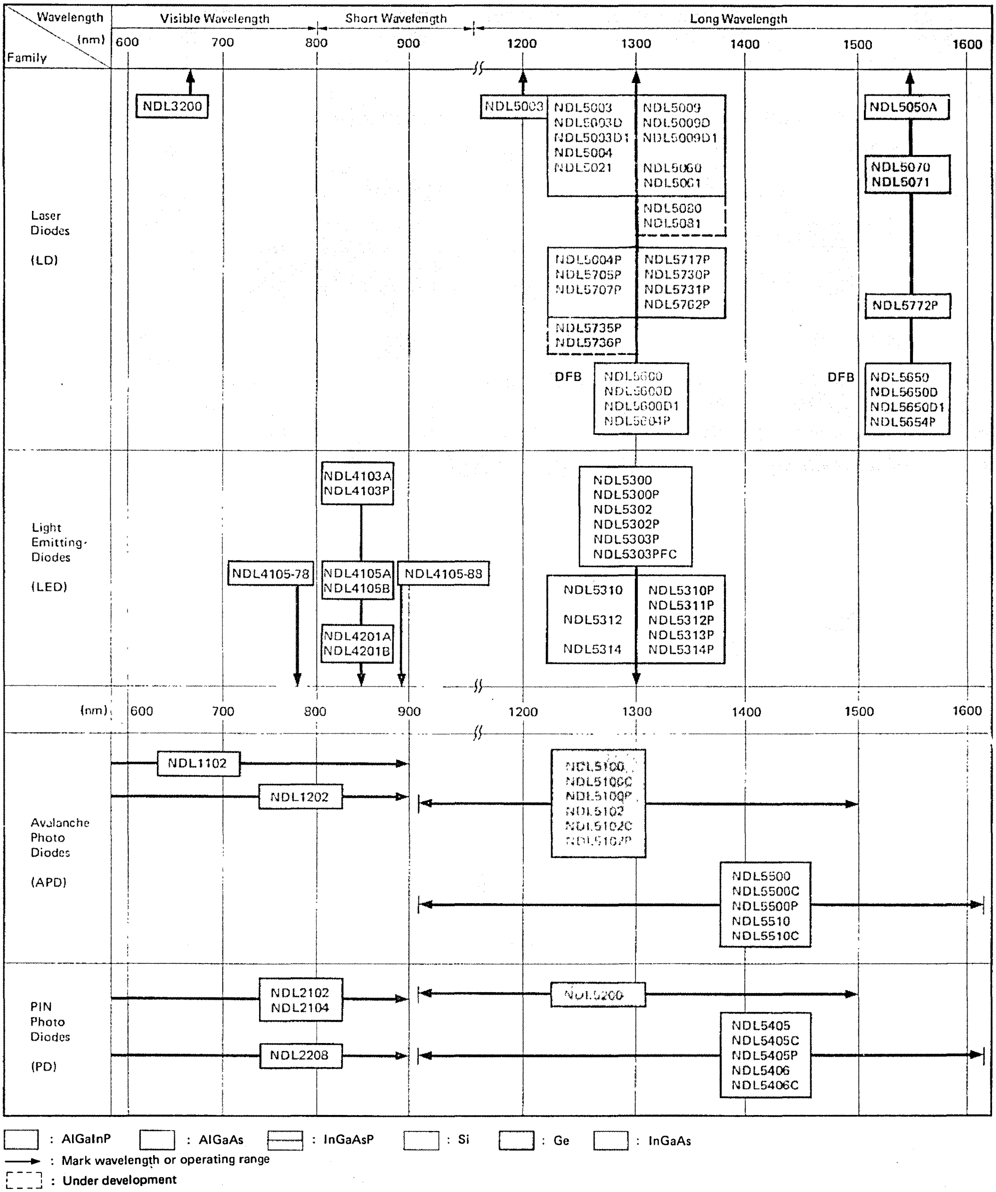
NEC was among the first to recognize the future of optoelectronics. Today we can boast many years of experience in the technological development and practical use of this remarkable medium, and we can also offer a full line of products covering a wide range of applications.

One of the keys to NEC's success in optoelectronics lies in our Optical Semiconductor Devices. These devices are outstanding examples of NEC technology and know-how at work: Each is the result of extensive research and development; and before an optical semiconductor device can be listed in our catalog, it first undergoes an additional period of rigorous on-the-job testing. This synthesis of technical sophistication and hard-nosed practicality means that NEC Optical Semiconductor Devices are both highly reliable and extremely cost-effective — no matter how you use them.

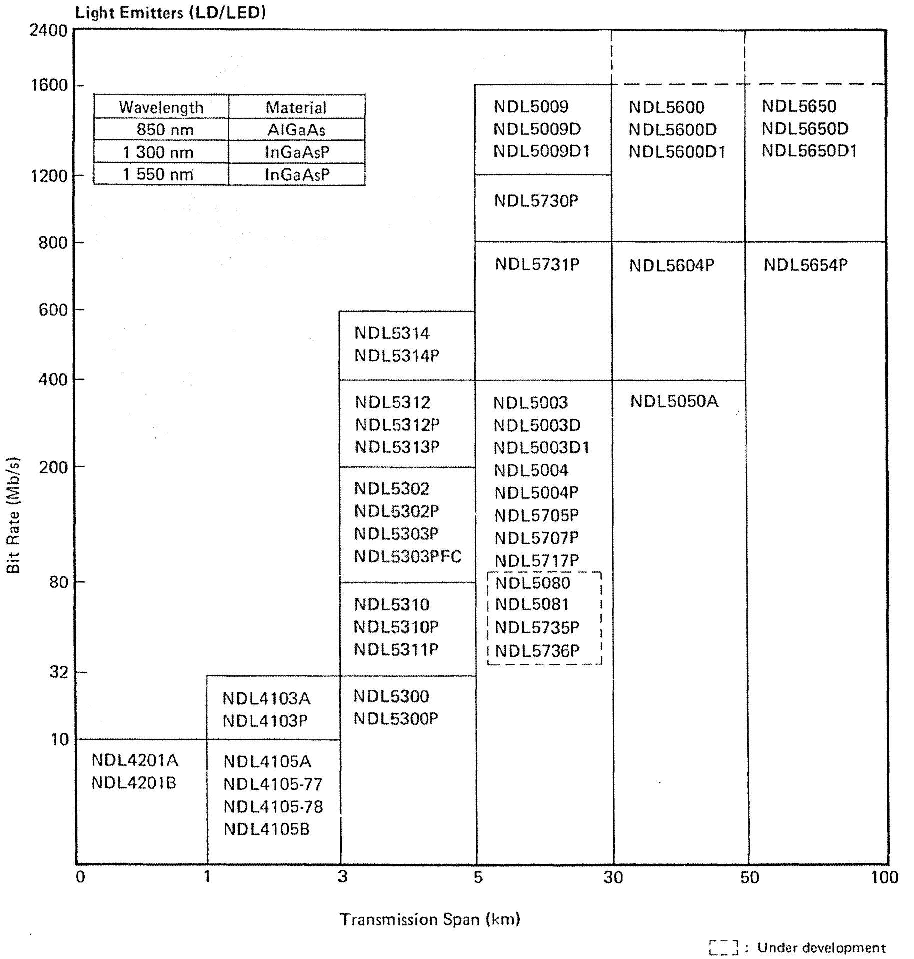
(2) Applications

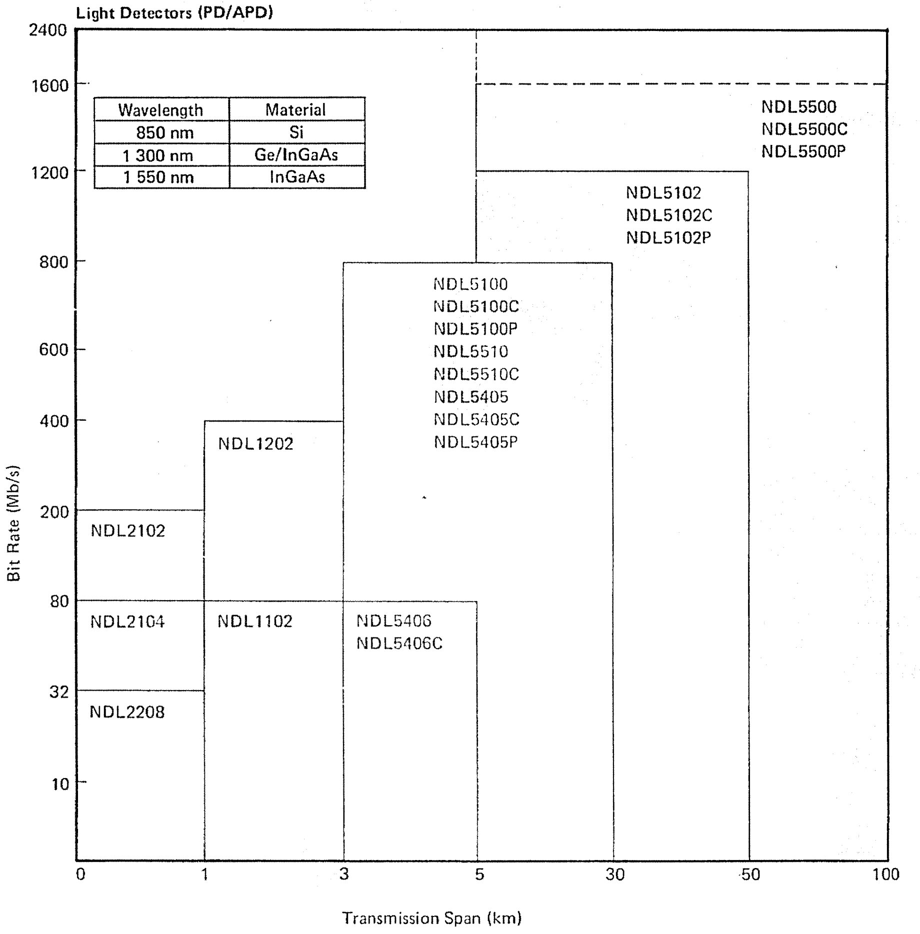


(3) Wavelengths Map



(4) Bit Rate vs. Transmission Span




Light Detectors (PD/APD)
Bit Rate (Mb/s)
2400
1600
1200
800
600
400
200
80
32
10
Wavelength | Material
850 nm | Si
1 300 nm | Ge/InGaAs
1 550 nm | InGaAs
NDL5500
NDL5500C
NDL5500P
NDL5102
NDL5102C
NDL5102P
NDL5100
NDL5100C
NDL5100P
NDL5510
NDL5510C
NDL5405
NDL5405C
NDL5405P
NDL1202
NDL2102
NDL2104
NDL1102
NDL5406
NDL5406C
NDL2208
0
1
3
5
30
50
100
Transmission Span (km)

SELECTION GUIDE

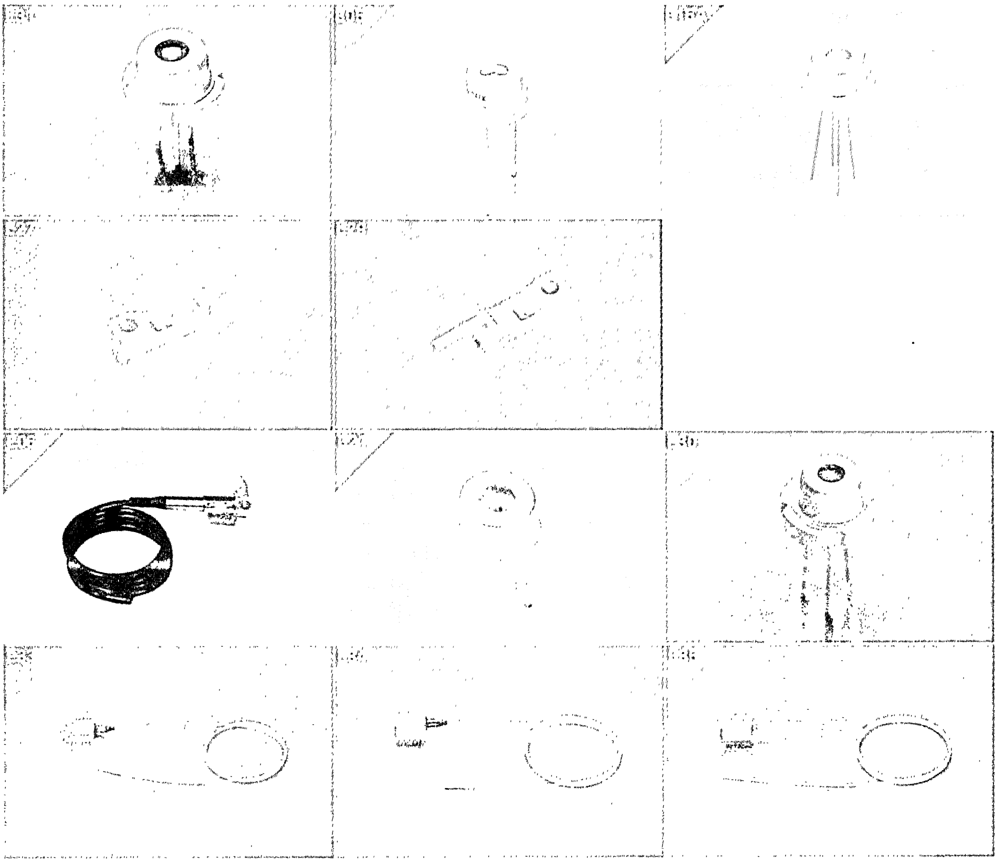
(5) Specifications

Laser Diodes

NDL Part Number	Absolute Maximum Ratings (T_a = 25 °C) V_R (V)	I_F (mA)	P_o (mW)	T_c (°C)	T_{stg} (°C)	Typical Characteristics (T_a = 25 °C) I_{th} (mA) Typ.	P_o, P_f I_{op} (mA)	P_o, P_f (mW) Typ.	λ_p (nm) Typ.	$\Delta\lambda$ (nm) Max.	t_r, t_f (ns) Typ.	Remarks	Package Code
NDL3200	2	–	4.0	–10 to +50	–40 to +85	90	100	3.0	670	–	–	with monitor PD	L31
NDL5003	2	–	10.0	–40 to +70	–55 to +125	20	I_{th}+30	8.0	1300	4.0	0.5/0.7		L05
NDL5003D	2	–	15.0	–40 to +70	–55 to +125	20	I_{th}+30	8.0	1300	4.0	0.5/0.7	Chip on carrier	L27
NDL5003D1	2	–	15.0	–40 to +70	–55 to +125	20	I_{th}+30	8.0	1300	4.0	0.5/0.7	Chip on carrier	L29
NDL5004	2	–	10.0	–40 to +70	–55 to +125	20	I_{th}+30	8.0	1300	4.0	0.5/0.7		L15A
NDL5004P	2	–	4.0	–20 to +60	–40 to +70	20	I_{th}+30	2.5	1300	4.0	0.5/0.7	with GI-50	L06
NDL5008	2	–	10.0	–20 to +60	–55 to +125	20	I_{th}+30	7.0	1200	4.0	0.5/0.7		L15A
NDL5009	2	–	15.0	–10 to +70	–55 to +125	20	I_{th}+30	8.0	1310	4.0	0.2	f_c = 1.2 GHz MIN.	L15A
NDL5009D	2	–	15.0	–40 to +70	–55 to +125	20	I_{th}+30	8.0	1310	4.0	0.2	Chip on carrier	L27
NDL5009D1	2	–	15.0	–40 to +70	–55 to +125	20	I_{th}+30	8.0	1310	4.0	0.2	Chip on carrier	L29
NDL5021	2	150	10.0	–40 to +60	–55 to +125	20	I_{th}+25	5.0*1	1300	4.0	0.5/0.7	with Ball Lens	L21
NDL5050A	2	–	10.0	–40 to +70	–55 to +125	40	I_{th}+30	5.0	1550	8.0	0.5/0.7	with Ball Lens	L21
NDL5060	2	400*3	–	–40 to +70	–55 to +125	20	250*3	50.0*1	1310	10.0	0.5/0.7	with Ball Lens	L21
NDL5061	2	600*3	–	–40 to +70	–55 to +125	20	400*3	90.0*1	1310	10.0	0.5/0.7	with Ball Lens	L21
NDL5070	2	400*3	–	–40 to +70	–55 to +125	40	250*3	30.0*1	1550	20.0	0.5/0.7	with Ball Lens	L21
NDL5071	2	600*3	–	–40 to +70	–55 to +125	40	400*3	50.0*1	1550	20.0	0.5/0.7	with Ball Lens	L21
NDL5080 (dashed box)	2	–	5.0	–40 to +70	–55 to +125	20	–	3.0	1310	30.0	0.5/0.7	Small package	L30
NDL5081 (dashed box)	2	–	5.0	–40 to +70	–55 to +125	20	–	3.0	1310	30.0	0.5/0.7	Small package	L30
NDL5600	2	–	15.0	–40 to +70	–55 to +100	15	I_{th}+30	8.0	1310	0.1	0.2		L15A
NDL5600D	2	–	15.0	–40 to +70	–55 to +100	15	I_{th}+30	8.0	1310	0.1	0.2	Chip on carrier	L27
NDL5600D1	2	–	15.0	–40 to +70	–55 to +100	15	I_{th}+30	8.0	1310	0.1	0.2	Chip on carrier	L29
NDL5604P	2	I_{th}+50	–	–20 to +65	–40 to +70	15	I_{th}+25	1.2	1310	0.1*2	0.3/0.4	with SMF	L34
NDL5650	2	–	10.0	–40 to +70	–55 to +100	20	I_{th}+30	5.0	1550	0.1	0.2		L15A
NDL5650D	2	–	10.0	–40 to +70	–55 to +100	20	I_{th}+30	5.0	1550	0.1	0.2	Chip on carrier	L27
NDL5650D1	2	–	10.0	–40 to +70	–55 to +100	20	I_{th}+30	5.0	1550	0.1	0.2	Chip on carrier	L29
NDL5654P	2	I_{th}+50	–	–20 to +65	–40 to +70	20	I_{th}+35	1.2	1550	0.1*2	0.3/0.4	with SMF	L34
NDL5707P	2	I_{th}+50	–	–20 to +65	–40 to +70	20	I_{th}+30	3.0	1300	2.0*2	0.5/0.7	with GI-50	L34
NDL5717P	2	I_{th}+50	–	–20 to +65	–40 to +70	20	I_{th}+30	2.0	1310	2.0*2	0.5/0.7	with SMF	L34
NDL5730P	2	I_{th}+50	–	–20 to +65	–40 to +70	20	I_{th}+30	2.0	1310	2.0*2	0.2/0.3	with SMF	L33
NDL5731P	2	I_{th}+50	–	–20 to +65	–40 to +70	20	I_{th}+30	2.0	1310	2.0*2	0.3/0.4	with SMF	L34
NDL5735P (dashed box)	2	I_{th}+50	–	0 to +65	–40 to +70	20	I_{th}+20	0.7	1300	6.0	0.5/0.7	with SMF, w/o TEC	L35
NDL5736P (dashed box)	2	I_{th}+50	–	0 to +65	–40 to +70	20	I_{th}+20	0.2	1300	6.0	0.5/0.7	with SMF, w/o TEC	L35
NDL5762P	2	600*3	–	0 to +60	–40 to +70	20	400*3	30.0	1310	20.0	0.5/0.7	with SMF, w/o PD	L34
NDL5772P	2	600*3	–	0 to +60	–40 to +70	40	400*3	15.0	1550	40.0	0.5/0.7	with SMF, w/o PD	L34

*1 MIN. *2 TYP. *3 Pulse Drive (PW = 1 μs, Duty = 1 %)

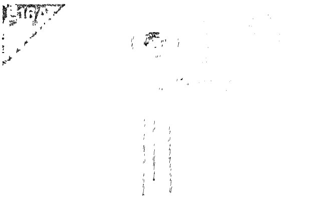
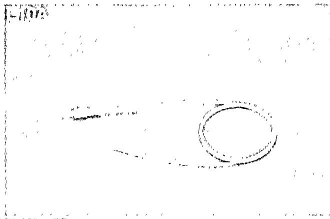
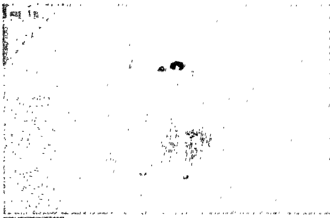
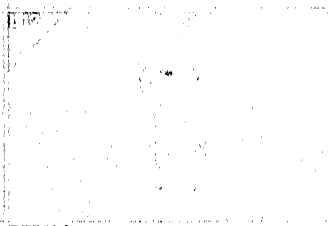
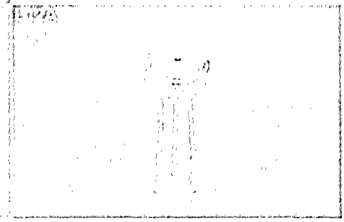
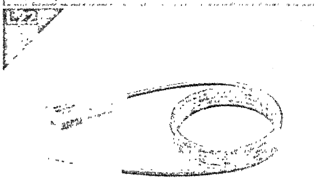
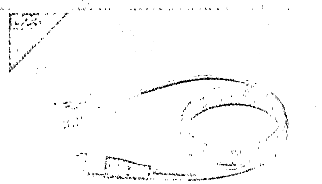
[- - - -] : Under development



Light Emitting Diodes

NDL Part Number	Absolute Maximum Ratings (T_a = 25 °C)				Typical Characteristics (T_a = 25 °C)					Remarks	Package Code
	V_R (V)	I_F (mA)	T_c (°C)	T_{stg} (°C)	P_o, P_f (mW) I_F (mA)	P_o, P_f (mW) Typ.	λ_p (nm) Typ.	$\Delta\lambda$ (nm) Max.	t_r, t_f (ns) Typ.		
NDL4103A	2	150	–40 to +80	–55 to +125	100	2.0	850	60	10		L16A
NDL4103P	2	150	–20 to +60	–40 to +70	100	50.0*4	850	60	10	with GI-50	L10A
NDL4105A	2	150	–40 to +70	–40 to +90	100	3.5	850	50	–	f_c = 35 MHz	L16A
NDL4105-78	2	150	–40 to +70	–40 to +90	100	3.5	780	50	–	f_c = 35 MHz	L16A
NDL4105-88	2	150	–40 to +70	–40 to +90	100	3.5	880	50	–	f_c = 35 MHz	L16A
NDL4105B	2	150	–40 to +70	–40 to +90	100	2.0	850	50	–	with Ball Lens f_c = 35 MHz	L12A
NDL4201A	2	80	–40 to +70	–40 to +90	50	1.0	850	50	–	f_c = 35 MHz	L11
NDL4201B	2	80	–40 to +70	–40 to +90	50	0.7	850	50	–	with Ball Lens f_c = 35 MHz	L12
NDL5300	2	150	–40 to +80	–55 to +125	100	1.0	1300	140	12/18		L16A
NDL5300P	2	150	–20 to +60	–40 to +70	100	30.0*4	1300	140	12/18	with GI-50	L10A
NDL5302	1	150	–40 to +80	–55 to +125	100	0.8	1300	160	2/3		L16A
NDL5302P	1	150	–20 to +60	–40 to +70	100	25.0*4	1300	160	2/3	with GI-50	L10A
NDL5303P	1	150	–40 to +65	–40 to +70	100	25.0*4	1300	160	2/3	with GI-50	L22
NDL5303PFC	1	150	–40 to +65	–40 to +70	100	25.0*4	1300	160	2/3	with GI-50, FC connector	L23
NDL5310	2	120	–40 to +80	–55 to +125	80	1.5	1300	150	4/8		L16A
NDL5310P	2	120	–20 to +60	–40 to +70	80	40.0*4	1300	150	4/8	with GI-50	L10A
NDL5311P	2	120	–40 to +65	–40 to +70	80	40.0*4	1300	150	4/8	with GI-50	L22
NDL5312	2	120	–40 to +80	–55 to +125	80	1.0	1300	150*5	1/2		L16A
NDL5312P	2	120	–20 to +60	–40 to +70	80	30.0*4	1300	150*5	1/2	with GI-50	L10A
NDL5313P	2	120	–40 to +65	–40 to +70	80	30.0*4	1300	150*5	1/2	with GI-50	L22
NDL5314	2	120	–40 to +80	–55 to +125	80	0.8	1300	150*5	0.8/1.5		L16A
NDL5314P	2	120	–20 to +60	–40 to +70	80	25.0*4	1300	150*5	0.8/1.5	with GI-50	L10A

*4 P_f(μW) *5 TYP.

1

Avalanche Photo-Diode

NDL Part Number	Absolute Maximum Ratings (T_a = 25 °C) I_F (mA)	I_R (mA)	T_{stg} (°C)	Typical Characteristics (T_a = 25 °C) Detecting Area Size (μm) Typ.	$V_{(BR)R}$ (V) Typ.	I_D V_R (V)	I_D (nA) Max.	M Typ.	η λ (nm)	η (%) Typ.	t_r, t_f (ns) Typ.	Remarks	Package Code
NDL1102	100	–	−65 to +150	φ 240	120	$V_{(BR)R}$−1.0	1.0*6	150	630 850	65 65	0.5 10		L09A
NDL1202	100	–	−65 to +150	φ 240	200	$V_{(BR)R}$−2.0	1.0*6	150	850	70	1.0*6		L09A
NDL5100	50	0.5	−55 to +125	φ 100	29	$V_{(BR)R}$×0.9	200	40	1300	75	0.5		L09A
NDL5100C	50	0.5	−55 to +125	φ 100	29	$V_{(BR)R}$×0.9	200	40	1300	75	0.5	Chip on carrier	L36
NDL5100P	50	0.5	−40 to +70	φ 100	29	$V_{(BR)R}$×0.9	200	40	1300	75	0.5	with GI-50	L13A
NDL5102	50	0.5	−55 to +125	φ 30	35	$V_{(BR)R}$×0.9	80	50	1300	75	0.3		L09A
NDL5102C	50	0.5	−55 to +125	φ 30	35	$V_{(BR)R}$×0.9	80	50	1300	75	0.3	Chip on carrier	L36
NDL5102P	50	0.5	−30 to +70	φ 30	35	$V_{(BR)R}$×0.9	80	50	1300	75	0.3	with SMF	L13A
NDL5500	10	0.5	−55 to +100	φ 50	70	$V_{(BR)R}$×0.9	20	40	1300 1550	85 80	–	f_c = 1.0 GHz MIN.	L09A
NDL5500C	10	0.5	−55 to +100	φ 50	70	$V_{(BR)R}$×0.9	20	40	1300 1550	85 80	–	Chip on carrier f_c = 1.0 GHz MIN.	L36
NDL5500P	10	0.5	−40 to +70	φ 50	70	$V_{(BR)R}$×0.9	20	40	1300 1550	85 80	–	with GI-50, f_c = 1.0 GHz MIN.	L13A
NDL5510	10	0.5	−55 to +100	φ 80	75	$V_{(BR)R}$×0.9	60	40	1300 1550	85 80	–	f_c = 700 MHz MIN.	L09A
NDL5510C	10	0.5	−55 to +100	φ 80	75	$V_{(BR)R}$×0.9	60	40	1300 1550	85 80	–	Chip on carrier f_c = 700 MHz MIN.	L36

L09A

L36

L13A

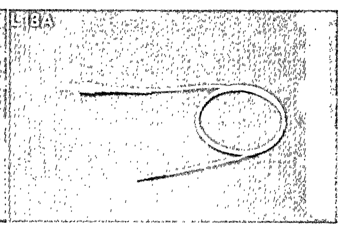
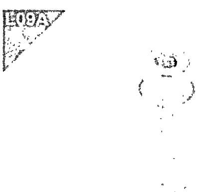
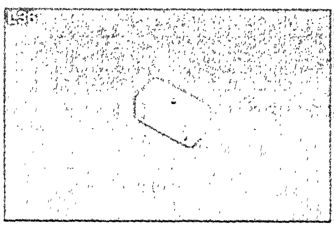


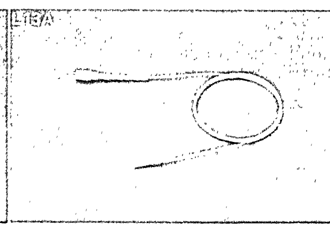
Photo Diode

NDL Part Number	Absolute Maximum Ratings (T_a = 25 °C)			Typical Characteristics (T_a = 25 °C)								Remarks	Package Code
	I_F (mA)	I_R (V)	T_{stg} (°C)	Detecting Area Size (μm)	I_D		C_t		η		t_r, t_f (ns)		
				Typ.	V_R (V)	(nA) Typ.	V_R (V)	(pF) Typ.	λ (nm)	(%) Typ.	Typ.		
NDL2102	100	–	–65 to +150	φ 240	10	1.0*6	10	1.5	850	70	1.0		L09A
NDL2104	100	–	–65 to +150	φ 440	10	1.0*6	10	2.8	850	70	4.0		L09A
NDL2208	100	–	–65 to +150	φ 880	10	1.0*6	10	1.5	850	85	10		L09A
NDL5200	50	5.0	–55 to +125	φ 240	6	500	6	7.0	1300	75	3.0		L09A
NDL5405	10	0.5	–55 to +150	φ 80	5	0.1	5	1.0	1300 1550	85 80	0.3		L09A
NDL5405C	10	0.5	–55 to +150	φ 80	5	0.1	5	1.0	1300 1550	85 80	0.3	Chip on carrier	L36
NDL5405P	10	0.5	–40 to +70	φ 80	5	0.1	5	1.0	1300 1550	85 80	0.3	with GI-50	L13A
NDL5406	10	5.0	–55 to +150	270x330	5	0.5	5	4.5	1300 1550	85 80	4.0		L09A
NDL5406C	10	5.0	–55 to +150	270x330	5	0.5	5	4.5	1300 1550	85 80	4.0	Chip on carrier	L36

*6 MAX.







(6) QUICK REFERENCE TABLE

Si APD/PD FAMILY

PACKAGE \ FEATURES		APD		PIN-PD			REMARKS	
		ϕ240 μm	ϕ240 μm	ϕ240 μm	ϕ440 μm	ϕ880 μm		
TO-18 TYPE CAN		NDL1102	NDL1202	NDL2102	NDL2104	NDL2208		
MAIN CHARACTERISTICS (T_a = 25 °C)							UNIT	CONDITIONS
BREAKDOWN VOLTAGE	$V_{(BR)R}$	120	200	–	–	–	V	I_D = 10 nA
QUANTUM EFFICIENCY	η	63	70	70	70	85	%	λ = 850 nm
DARK CURRENT	I_D	1.0*6	1.0*6	1.0*6	1.0*6	1.0*6	nA	V = V_{op}
RISE TIME	t_r	10	1.0*6	1.0	4.0	10	ns	10–90 %
FALL TIME	t_f	10	1.0*6	1.0	4.0	10	ns	90–10 %

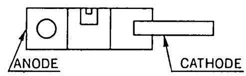
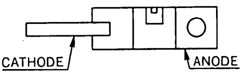
*6 : MAX.

AlGaAs LED FAMILY

PACKAGES \ FEATURES		WAVELENGTH					REMARKS	
		850 nm			780 nm	880 nm		
TO-18 TYPE CAN		NDL4103A	NDL4105A	–	NDL4105-78	NDL4105-88	3 PIN	
RESIN SEALED TYPE CAN		–	–	NDL4201A	–	–	2 PIN	
CAN WITH BALL LENS		–	NDL4105B	NDL4201B	–	–	2 PIN	
COAXIAL MODULE WITH MULTI-MODE FIBER (MMF)		NDL4103P	–	–	–	–	P_f = 50 μW	
MAIN CHARACTERISTICS (T_a = 25 °C)							UNIT	CONDITIONS
OPTICAL OUTPUT POWER	P_O	2.0	3.5	1.0*7	3.5	3.5	mW	I_F = 100 mA
		–	1.8	0.6*7	–	–	mW	P_O FROM BALL LENS
RISE TIME	t_r	10	f_c = 35 MHz	f_c=35 MHz*7	f_c = 35 MHz	f_c = 35 MHz	ns	10–90 %
FALL TIME	t_f	10					ns	90–10 %

*7 : I_F = 50 mA

FABRY-REPOT DC-PBH LD FAMILY (CAN & CHIP ON CARRIER)

PACKAGES \ FEATURES		WAVELENGTH 1.2 μm	1.3 μm		1.55 μm	REMARKS	
CAN W/O MONITOR PD		–	NDL5003 NDL5021	–	NDL5050A	NDL5021, 5050A: WITH BALL LENS	
CAN WITH MONITOR PD		NDL5008	NDL5004	NDL5009	–	4 PIN	
SMALL CAN WITH MONITOR PD		–	NDL5080 NDL5081	–	–	3 PIN, P_O = 3 mW, NEGATIVE BIAS 3 PIN, P_O = 3 mW, POSITIVE BIAS	
CHIP ON CARRIER WITH RIBBON LEAD (D TYPE)		–	NDL5003D	NDL5009D	–		
CHIP ON CARRIER WITH RIBBON LEAD (D1 TYPE)		–	NDL5003D1	NDL5009D1	–		
MAIN CHARACTERISTICS (T_a = 25 °C)						UNIT	CONDITIONS
OPTICAL OUTPUT POWER	P_O	7.0	8.0	8.0	5.0	mW	$I_F = I_{th} + 30$ mA
THRESHOLD CURRENT	I_{th}	25	20	20	40	mA	
RISE TIME	t_r	0.5	0.5	0.2	0.5	ns	10–90 %
FALL TIME	t_f	0.7	0.7	0.2	0.7	ns	90–10 %

1.3 μm FABRY–PEROT DC–PBH LD MODULE FAMILY

PACKAGES \ FEATURES		RESPONSE SPEED ~ 400 Mb/s	~ 800 Mb/s	~ 1.2 Gb/s	REMARKS	
14 PIN DIP MODULE WITH SINGLE-MODE FIBER (SMF)		NDL5717P	NDL5731P	———	WITH MONITOR PD, TEC, THERMISTOR	
		NDL5735P NDL5736P	———	———	P_f=0.7 mW,W/O TEC,WITH InGaAs MONITOR PD P_f=0.2 mW,W/O TEC,WITH InGaAs MONITOR PD	
14 PIN BFY MODULE WITH SMF		———→	———→	NDL5730P	WITH MONITOR PD, TEC, THERMISTOR	
14 PIN DIP MODULE WITH MMF		NDL5707P	———	———	WITH MONITOR PD, TEC, THERMISTOR	
14 PIN BFY MODULE WITH MMF		NDL5705P	———	———	WITH MONITOR PD, TEC, THERMISTOR	
MAIN CHARACTERISTICS (T_a = 25 °C)					UNIT	CONDITIONS
OPTICAL OUTPUT POWER	P_f	2.0 (SMF) 3.0 (MMF)	2.0	2.0	mW	$I_F = I_{th} + 30$ mA
THRESHOLD CURRENT	I_{th}	20	20	20	mA	
RISE TIME	t_r	0.5	0.3	0.2	ns	10 – 90 %
FALL TIME	t_f	0.7	0.4	0.3	ns	90 – 10 %

1

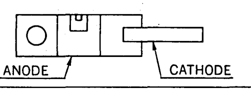
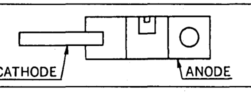
SELECTION GUIDE

HIGH POWER PULSED LD FAMILY

PACKAGES \ FEATURES	WAVELENGTH 1.3 μm	WAVELENGTH 1.55 μm	REMARKS
CAN WITH BALL LENS	NDL5060 NDL5061	NDL5070 NDL5071	I_{FP} = 250 mA I_{FP} = 400 mA
14 PIN DIP MODULE WITH SMF	NDL5762P	NDL5772P	WITH TEC, THERMISTOR
14 PIN DIP MODULE WITH MMF	(NDL5764P)	–	WITH TEC, THERMISTOR UNDER DEVELOPMENT

MAIN CHARACTERISTICS (T_a = 25 °C)				UNIT	CONDITIONS
OPTICAL OUTPUT POWER	P_O	50 MIN. 90 MIN.	30 MIN. 50 MIN.	mW	I_{FP} = 250 mA I_{FP} = 400 mA
	P_f	30	15	mW	I_{FP} = 400 mA, DIP WITH SMF
SPECTRAL WIDTH	$\Delta\lambda$	10 MAX. 20 MAX.	20 MAX. 40 MAX.	nm nm	CAN DIP WITH SMF

PHASE-SHIFTED DFB-DC-PBH LD FAMILY

PACKAGES \ FEATURES	WAVELENGTH 1.3 μm	WAVELENGTH 1.55 μm	REMARKS
TO-5 TYPE CAN	NDL5600	NDL5650	4 PIN, WITH InGaAs MONITOR PD
CHIP ON CARRIER WITH RIBBON LEAD (D-TYPE)	NDL5600D	NDL5650D	
CHIP ON CARRIER WITH RIBBON LEAD (D1-TYPE)	NDL5600D1	NDL5650D1	
14 PIN DIP MODULE WITH SMF	NDL5604P	NDL5654P	WITH InGaAs MONITOR PD, TEC, THERMISTOR

MAIN CHARACTERISTICS (T_a = 25 °C)				UNIT	CONDITIONS
OPTICAL OUTPUT POWER	P_O	8.0	5.0	mW	$I_F = I_{th}$+30 mA
	P_f	1.2	1.2	mW	$I_F = I_{th}$+25 mA $I_F = I_{th}$+35 mA
THRESHOLD CURRENT	I_{th}	15	20	mA	
SUB-MODE SUPPRESSION RATIO	SMSR	35	35	dB	
RISE, FALL TIME	t_r, t_f	0.2 0.3	0.2 0.4	ns	TO-5, C/C DIP

Ge APD/PD FAMILY

PACKAGES \ FEATURES		APD		PIN-PD	REMARKS	
		ϕ100 µm	ϕ30 µm	ϕ240 µm		
TO-18 TYPE CAN		NDL5100	NDL5102	NDL5200	3 PIN	
CHIP ON CARRIER		NDL5100C	NDL5102C	–		
COAXIAL MODULE WITH MMF		NDL5100P	–	–	3 PIN	
COAXIAL MODULE WITH SMF		–	NDL5102P	–	3 PIN	
MAIN CHARACTERISTICS (T_a = 25 °C)					UNIT	CONDITIONS
BREAKDOWN VOLTAGE	$V_{(BR)R}$	29	35	–	V	I_D = 100 µA
QUANTUM EFFICIENCY	η	75	75	75	%	λ = 1 300 nm
DARK CURRENT	I_D	200	80	500	nA	V = V_{op}
RISE TIME	t_r	0.5	0.3	3	ns	10–90 %
FALL TIME	t_f	0.5	0.3	5	ns	90–10 %

InGaAs APD/PD FAMILY

PACKAGES \ FEATURES		APD		PIN-PD		REMARKS	
		ϕ50 µm	ϕ80 µm	ϕ80 µm	270 µm x 330 µm		
TO-18 TYPE CAN		NDL5500	NDL5510	NDL5405	NDL5406	3 PIN	
CHIP ON CARRIER		NDL5500C	NDL5510C	NDL5405C	NDL5406C		
COAXIAL MODULE WITH MMF		NDL5500P	–	NDL5405P	–	3 PIN	
MAIN CHARACTERISTICS (T_a = 25 °C)						UNIT	CONDITIONS
BREAKDOWN VOLTAGE	$V_{(BR)R}$	70	75	–	–	V	I_D = 100 µA
QUANTUM EFFICIENCY	η	85	85	85	85	%	λ = 1 300 nm
		80	80	80	80		λ = 1 550 nm
DARK CURRENT	I_D	20	60	0.1	0.5	nA	V = V_{op}
RISE TIME	t_r	f_c = 1.0 GHz MIN.	f_c = 700 MHz MIN.	0.3	4.0	ns	10–90 %
FALL TIME	t_f			0.3	4.0	ns	90–10 %

1.3 μm PLANAR-TYPE LED FAMILY

PACKAGES \ FEATURES	HIGH POWER	HIGH SPEED	REMARKS
TO-18 TYPE CAN	NDL5300	NDL5302	3 PIN
COAXIAL MODULE WITH MMF	NDL5300P	NDL5302P	3 PIN
14-PIN DIP MODULE WITH MMF	–	NDL5303P	
14-PIN DIP MODULE WITH MMF AND FC-CONNECTOR	–	NDL5303PFC	

MAIN CHARACTERISTICS (T_a = 25 °C)				UNIT	CONDITIONS
OPTICAL OUTPUT POWER	P_O	1.0	0.8	mW	I_F = 100 mA
	P_f	30	25	mW	I_F = 100 mA
RISE TIME	t_r	12	2	ns	10–90 %
FALL TIME	t_f	18	3	ns	90–10 %

1.3 μm MESA-TYPE LED FAMILY

PACKAGES \ FEATURES	HIGH POWER	HIGH SPEED	ULTRA HIGH SPEED	REMARKS
TO-18 TYPE CAN	NDL5310	NDL5312	NDL5314	3 PIN
COAXIAL MODULE WITH MMF	NDL5310P	NDL5312P	NDL5314P	3 PIN
14-PIN DIP MODULE WITH MMF	NDL5311P	NDL5313P	–	

MAIN CHARACTERISTICS (T_a = 25 °C)					UNIT	CONDITIONS
OPTICAL OUTPUT POWER	P_O	1.5	1.0	0.8	mW	I_F = 80 mA
	P_f	40	30	25	mW	I_F = 80 mA
RISE TIME	t_f	4	1	0.8	ns	10–90 %
FALL TIME	t_f	8	2	1.5	ns	90–10 %

Ⅱ. DATA SHEET

2

PHOTO DIODE
NDL1102

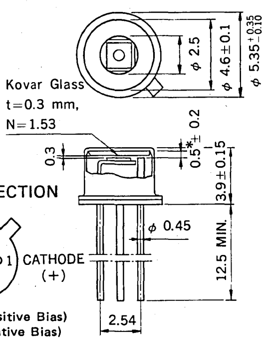
OPTICAL FIBER COMMUNICATIONS
SILICON AVALANCHE PHOTO DIODE

DESCRIPTION

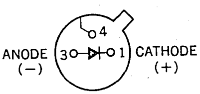
NDL1102 is a widely used general purpose silicon avalanche photodiode detector. It is designed for moderate speed (4 to 30 Mb/s), medium distance (0.1–5 km) telecommunication systems. NDL1102 has a high speed response time and a wide spectral sensitivity, making it ideal for systems operating between 600 and 900 nm. It is also recommended to use as a detector in distance measurement equipment. Because of its short optical length between detecting surface and window surface, coupling with optical fiber cables is easy. NDL1102 is hermetically sealed in a rugged TO-18 can-type package with a kovar window and floating leads.

2

PACKAGE DIMENSIONS
in millimeters



LEAD CONNECTION



1. Cathode (Positive Bias)
3. Anode (Negative Bias)
4. Case

* Optical length

FEATURES

- Low cost.
- Low bias voltage. V_{op} = 100 to 140 V
- Low temperature dependence of $V_{(BR)R}$. 0.12 %/°C
- High quantum efficiency. 65 % @ 630 nm
- Low excess noise factor. 0.25 @ 850 nm
- Short optical length. 0.5 mm
- Detecting area size. ϕ 240 μm

ABSOLUTE MAXIMUM RATINGS (T_a=25 °C)

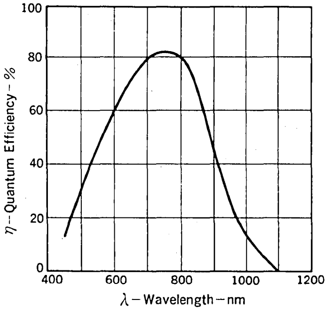
Power Dissipation	P	100	mW
Forward Current	I_F	100	mA
Storage Temperature	T_{stg}	−65 to +150	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

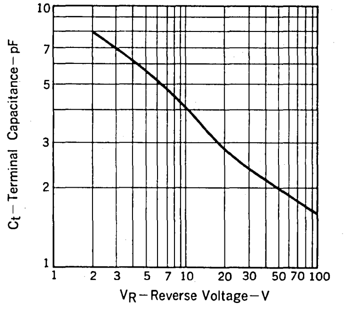
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Breakdown Voltage	$V_{(BR)R}$	100	120	140	V	I_D = 10 nA
Dark Current	I_D			1.0	nA	$V_R = V_{(BR)R} - 1$ V
Terminal Capacitance	C_t		2.5	5.0	pF	V_R = 30 V
Sensitivity	S	0.25	0.33		A/W	λ = 630 nm
			0.43			λ = 850 nm
Quantum Efficiency	η	50	65		%	λ = 630 nm
Rise, Fall Time	t_r, t_f		0.5		ns	λ = 630 nm, M = 100, R_L = 50 Ω, 10 – 90 %
			10			λ = 850 nm, M = 100, R_L = 50 Ω, 10 – 90 %
Excess Noise Factor	x		0.25			λ = 850 nm, M = 100
Multiplication Factor	M	100	150			$V_R = V_{(BR)R} - 1.0$ V
Maximum Multiplication Factor	M_m		600			$V_R = V_{(BR)R}$

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

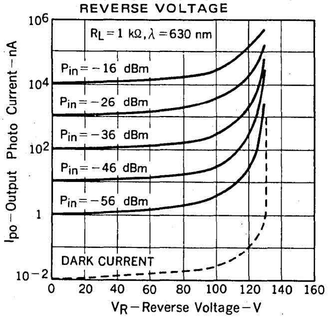
QUANTUM EFFICIENCY vs. WAVELENGTH



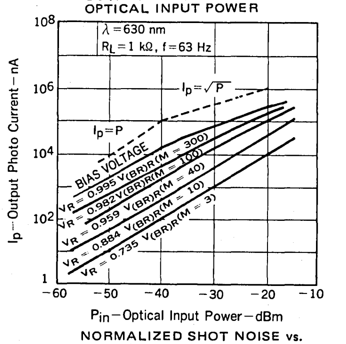
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



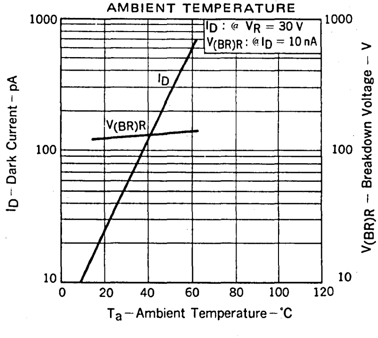
OUTPUT PHOTO CURRENT vs. REVERSE VOLTAGE



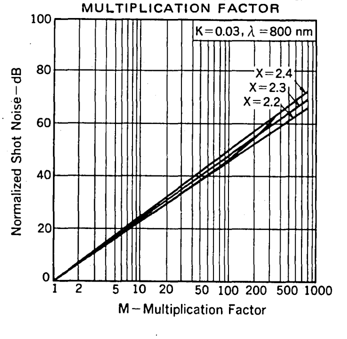
OUTPUT PHOTO CURRENT vs. OPTICAL INPUT POWER



DARK CURRENT vs. AMBIENT TEMPERATURE



NORMALIZED SHOT NOISE vs. MULTIPLICATION FACTOR



NDL1202

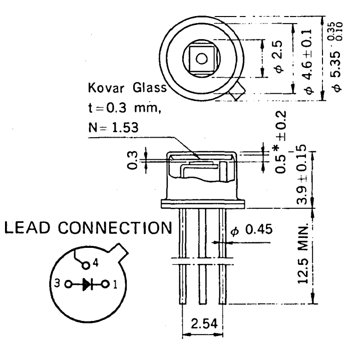
OPTICAL FIBER COMMUNICATIONS
SILICON AVALANCHE PHOTO DIODE

DESCRIPTION

NDL1202 is an Avalanche Photo Diode especially designed for a detector of large capacity and long distance optical fiber communication systems. It has a high speed response time and a wide spectral sensitivity between 500 and 1 000 nm.

PACKAGE DIMENSIONS

in millimeters



1. Cathode (Positive Bias)
3. Anode (Negative Bias)
4. Case

* Optical length

FEATURES

- High sensitivity. η = 70 % @ 850 nm
- Small dark current. I_D = 1.0 nA MAX.
- High speed response. t_r, t_f = 1.0 ns MAX.
- Short optical length. 0.5 mm
- Detecting area size. ϕ 240 μm

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

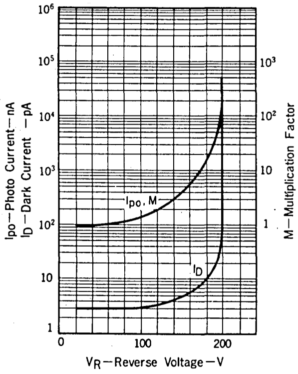
Power Dissipation	P	100	mW
Forward Current	I_F	100	mA
Storage Temperature	T_{stg}	−65 to +150	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

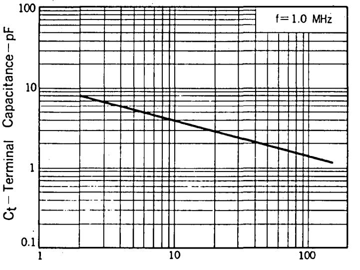
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	180	200	220	V	I_D = 10 nA
Dark Current	I_D			1.0	nA	$V_R = V_{(BR)R}$−2.0 V
Terminal Capacitance	C_t		1.3	2.5	pF	V_R = 150 V, f = 1.0 MHz
Quantum Efficiency	η	60	70		%	λ = 850 nm
Current Multiplication Factor	M	100	150			$V_R = V_{(BR)R}$−2.0 V
Maximum Multiplication Factor	Mm		600			$V_R = V_{(BR)R}$
Rise Time	t_r			1.0	ns	λ = 850 nm, M = 100, 10–90 %, R_L = 50 Ω
Fall Time	t_f			1.0	ns	λ = 850 nm, M = 100, 10–90 %, R_L = 50 Ω
Excess Noise Factor	x		0.25	0.30		λ = 850 nm, M = 100

TYPICAL CHARACTERISTICS ($T_a = 25$ °C)

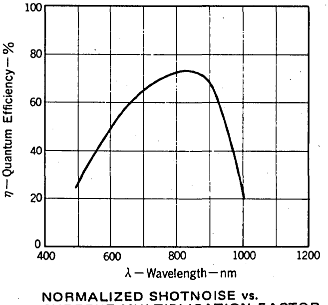
PHOTO CURRENT, DARK CURRENT, MULTIPLICATION FACTOR vs. REVERSE VOLTAGE



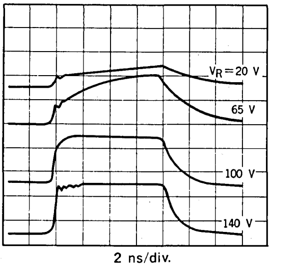
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



QUANTUM EFFICIENCY vs. WAVELENGTH

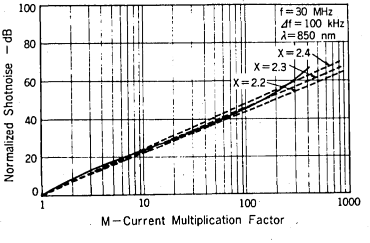


RESPONSE TIME CHARACTERISTICS



2 ns/div.

NORMALIZED SHOTNOISE vs. CURRENT MULTIPLICATION FACTOR



OPTICAL FIBER COMMUNICATIONS
SILICON PIN PHOTO DIODE

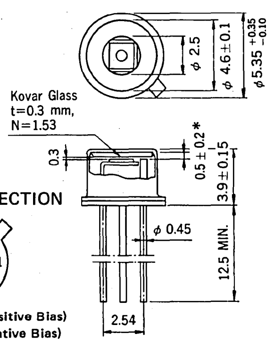
DESCRIPTION

NDL2102 is an epitaxial PIN photodiode detectors with excellent quantum efficiency, switching speed, and spectral range. This photodetector is designed for a detector of communications system and as general purpose detectors for 550 to 950 nm spectral range. It is hermetically sealed in a rugged TO-18 type package with a window and floating leads.

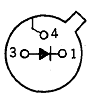
2

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION



1. Cathode (Positive Bias)
3. Anode (Negative Bias)
4. Case
 * Optical length

FEATURES

- High quantum efficiency. 70 % @ 850 nm
- Low operating voltage.
- High speed response. t_r, t_f = 1.0 ns
- Short optical length. 0.5 mm
- Detecting area size. φ 240 μm

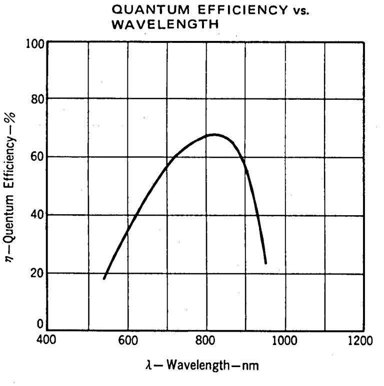
ABSOLUTE MAXIMUM RATINGS (T_a=25 °C)

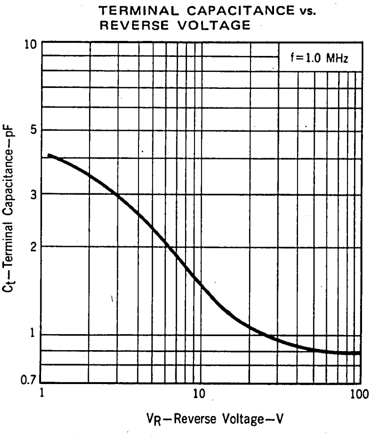
Forward Current	I_F	100	mA
Reverse Voltage	V_R	100	V
Power Dissipation	P	100	mW
Operating Case Temperature	T_C	−65 to +150	°C
Storage Temperature	T_{stg}	−65 to +150	°C

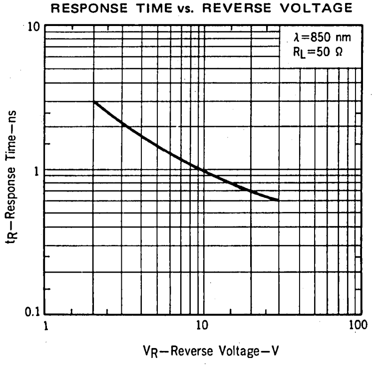
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D			1.0	nA	V_R = 10 V
Terminal Capacitance	C_t		1.5	2.5	pF	V_R = 10 V
Quantum Efficiency	η	60	70		%	V_R = 10 V, λ = 850 nm
Rise Time	t_r		1.0		ns	V_R = 10 V, λ = 850 nm, R_L = 50 Ω, 10 − 90 %
Fall Time	t_f		1.0		ns	V_R = 10 V, λ = 850 nm, R_L = 50 Ω, 90 − 10 %

TYPICAL CHARACTERISTICS (T_a=25 °C)







NDL2104

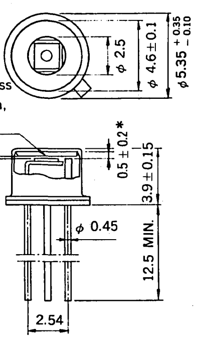
OPTICAL FIBER COMMUNICATIONS
SILICON PIN PHOTO DIODE

DESCRIPTION

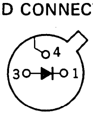
NDL2104, is an epitaxial PIN photodiode detectors with excellent quantum efficiency, switching speed, and spectral range. This photodetector is designed for a detector of communications system and as general purpose detectors for 550 to 1 000 nm spectral range. It is hermetically sealed in a rugged TO-18 type package with a window and floating leads.

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION



1. Cathode (Positive Bias)
3. Anode (Negative Bias)
4. Case

* Optical length

FEATURES

- High quantum efficiency. 70 % @ 850 nm
- Low operating voltage.
- High speed response. t_r, t_f = 4.0 ns
- Short optical length. 0.5 mm
- Detecting area size. ϕ 440 μm

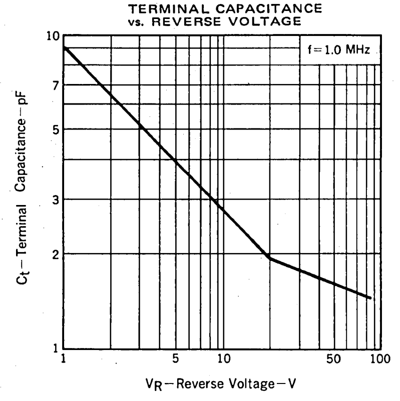
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

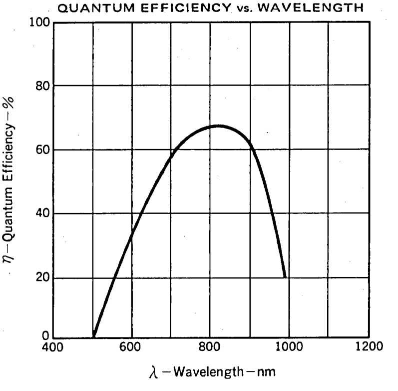
Forward Current	I_F	100	mA
Reverse Voltage	V_R	100	V
Power Dissipation	P	100	mW
Operating Case Temperature	T_C	−65 to +150	°C
Storage Temperature	T_{stg}	−65 to +150	°C

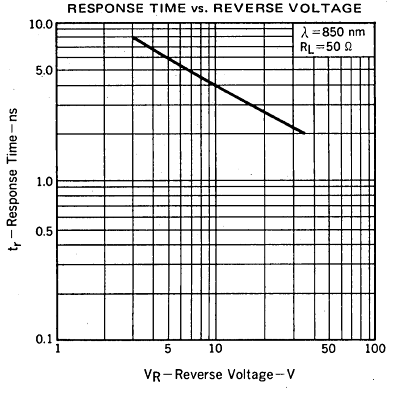
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D			1.0	nA	V_R = 10 V
Terminal Capacitance	C_t		2.8	4.0	pF	V_R = 10 V
Quantum Efficiency	η	60	70		%	V_R = 10 V, λ = 850 nm
Rise Time	t_r		4.0		ns	V_R = 10 V, λ = 850 nm, R_L = 50 Ω, 10 − 90 %
Fall Time	t_f		4.0		ns	V_R = 10 V, λ = 850 nm, R_L = 50 Ω, 90 − 10 %

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)







NDL2208

OPTICAL FIBER COMMUNICATIONS
SILICON PIN PHOTO DIODE

DESCRIPTION

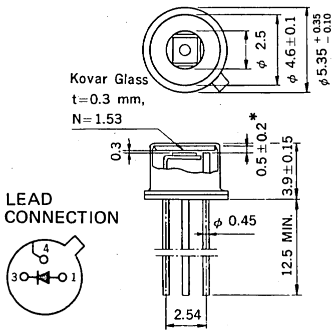
NDL2208 is a PIN photodiode detectors with excellent quantum efficiency, switching speed, and spectral range. This photodetector is designed for a detector of communications system and as general purpose detector for 600 to 1 100 nm spectral range.

It is hermetically sealed in a rugged TO-18 type package with a window and floating leads.

2

PACKAGE DIMENSIONS

in millimeters



1. Anode (Negative Bias)
3. Cathode (Positive Bias)
4. Case

* Optical length

FEATURES

- High quantum efficiency. $\eta = 85$ %, @850 nm
- Low operating voltage.
- Small dark current. $I_D = 1.0$ nA MAX.
- Short optical length 0.5 mm
- Large detecting area size. φ 880 μm

ABSOLUTE MAXIMUM RATINGS ($T_a = 25$ °C)

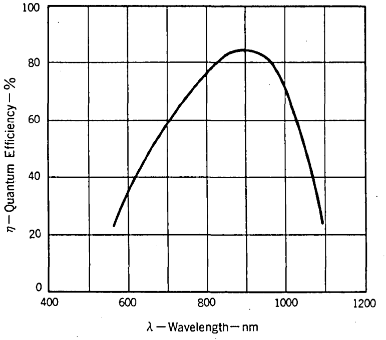
Reverse Voltage	V_R	50	V
Forward Current	I_F	100	mA
Power Dissipation	P_T	100	mW
Operating Temperature	T_{opt}	−65 to +150	°C
Storage Temperature	T_{stg}	−65 to +150	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25$ °C)

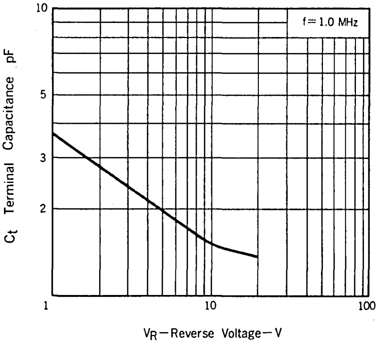
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D			1.0	nA	$V_R = 10$ V
Terminal Capacitance	C_t		1.5	3.0	pF	$V_R = 10$ V, f = 1.0 MHz
Quantum Efficiency	η	70	85		%	λ = 850 nm
Rise Time	t_r		10		ns	V_R=10 V, λ=850 nm, 10−90 %, R_L=50 Ω
Fall Time	t_f		10		ns	V_R=10 V, λ=850 nm, 90−10 %, R_L=50 Ω

TYPICAL CHARACTERISTICS ($T_a = 25\ °C$)

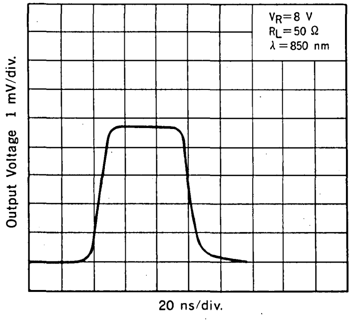
QUANTUM EFFICIENCY vs. WAVELENGTH



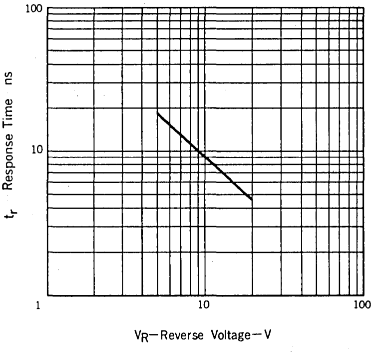
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



RESPONSE TIME CHARACTERISTIC



RESPONSE TIME vs. REVERSE VOLTAGE



LIGHT EMITTING DIODE

NDL4103A

850 nm OPTICAL FIBER COMMUNICATIONS AlGaAs LIGHT EMITTING DIODE

DESCRIPTION

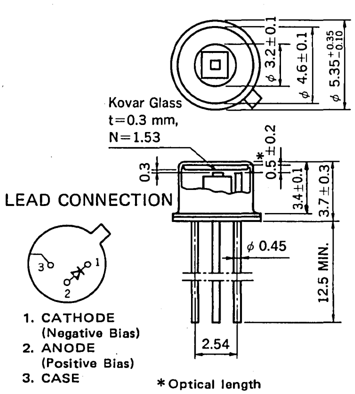
NDL4103A is an AlGaAs double heterostructure light emitting diode, especially designed for a light source for optical fiber communication systems.

FEATURES

- High optical power output. $P_O = 2.0$ mW
- High speed response. t_r, t_f = 10 ns
- Hermetically sealded.

PACKAGE DIMENSIONS

in millimeters



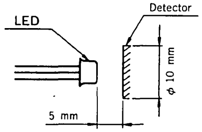
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage	V_R	2.0	V
Forward Current	I_F	150	mA
Operating Case Temperature	T_C	−40 to +80	°C
Storage Temperature	T_{stg}	−55 to +125	°C

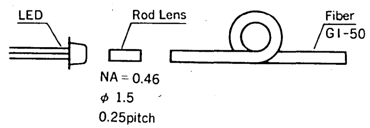
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Optical Output Power	P_O	1.5	2.0		mW	I_F = 100 mA, *1
Forward Voltage	V_F		1.6	2.3	V	I_F = 100 mA
Peak Emission Wavelength	λ_P	830	850	870	nm	I_F = 100 mA
Half Power Spectral Width	$\Delta\lambda$		50	60	nm	I_F = 100 mA, *2
Rise Time	t_r		10		ns	I_{peak} = 100 mA, 10−90 %
Fall Time	t_f		10		ns	I_{peak} = 100 mA, 90−10 %
Emitting Area Diameter	ϕ		35		μm	

*1

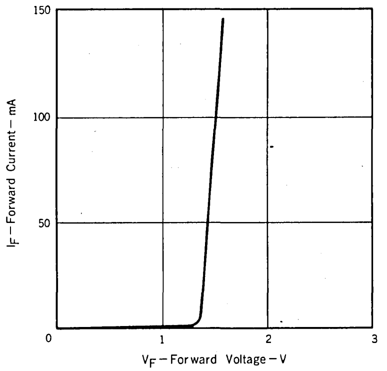


*2

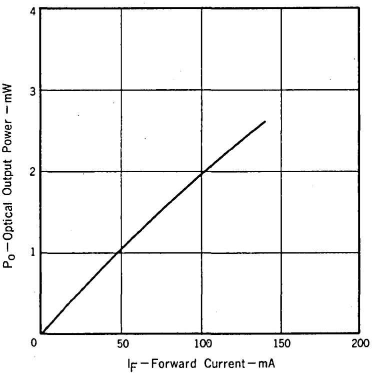


TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

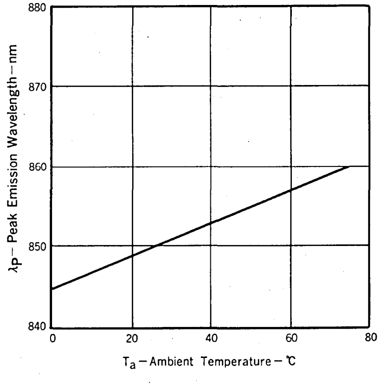
FORWARD CURRENT vs. FORWARD VOLTAGE



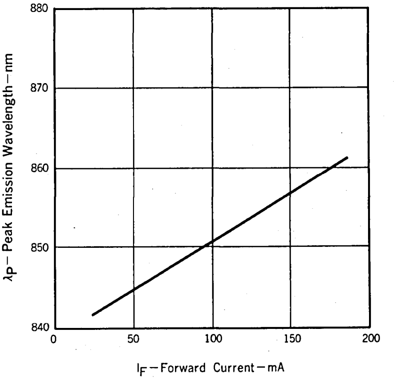
OPTICAL OUTPUT POWER vs. FORWARD CURRENT



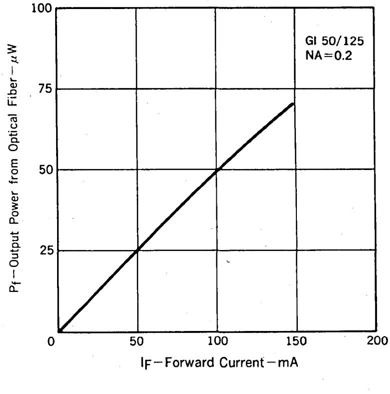
PEAK EMISSION WAVELENGTH vs. AMBIENT TEMPERATURE



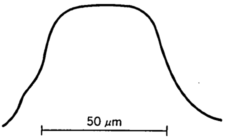
PEAK EMISSION WAVELENGTH vs. FORWARD CURRENT



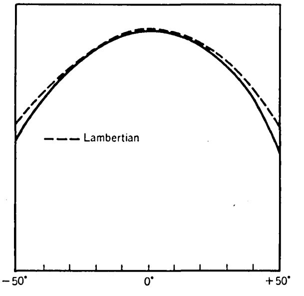
OUTPUT POWER FROM OPTICAL FIBER vs. FORWARD CURRENT



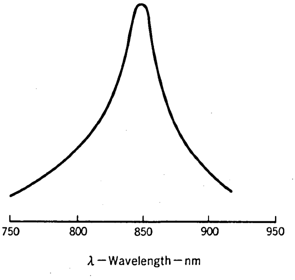
NEAR FIELD PATTERN



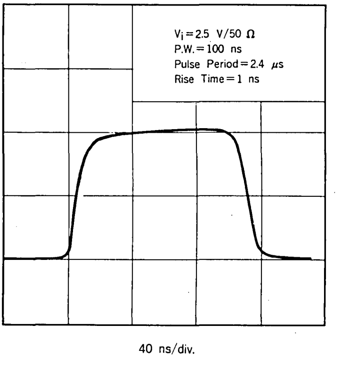
FAR FIELD PATTERN



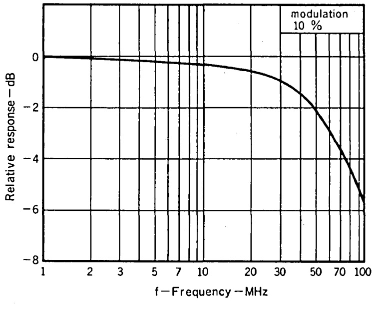
EMISSION SPECTRUM



RESPONSE CHARACTERISTIC



FREQUENCY CHARACTERISTICS



LIGHT EMITTING DIODE
NDL4103P

850 nm OPTICAL FIBER COMMUNICATIONS AlGaAs LIGHT EMITTING DIODE MODULE

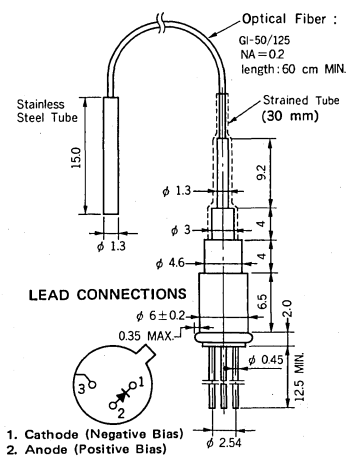
DESCRIPTION

NDL4103P is a double heterostructure AlGaAs light emitting diode with optical fiber.
It is designed for high speed, moderate distance optical fiber communication systems.

FEATURES

- High Output Power. $P_f = 50\ \mu W$ TYP.
- High Speed. t_r, $t_f = 10$ ns TYP.
- Long Life, High Reliability.

PACKAGE DIMENSIONS
in millimeters



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

ABSOLUTE MAXIMUM RATINGS ($T_a = 25\ °C$)

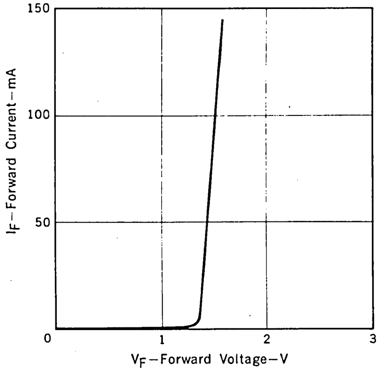
Forward Current	I_F	150	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	−20 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25\ °C$)

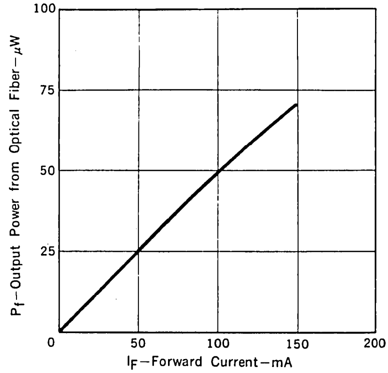
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Optical Output Power From Fiber	P_f	30	50		μW	$I_F = 100$ mA
Forward Voltage	V_F		1.6	2.3	V	$I_F = 100$ mA
Peak Emission Wavelength	λ_p	830	850	870	nm	$I_F = 100$ mA
Half Power Spectral Width	$\Delta\lambda$		50	60	nm	$I_F = 100$ mA
Rise Time	t_r		10		ns	$I_{peak} = 100$ mA, 10–90 %
Fall Time	t_f		10		ns	$I_{peak} = 100$ mA, 90–10 %

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

FORWARD CURRENT vs. FORWARD VOLTAGE

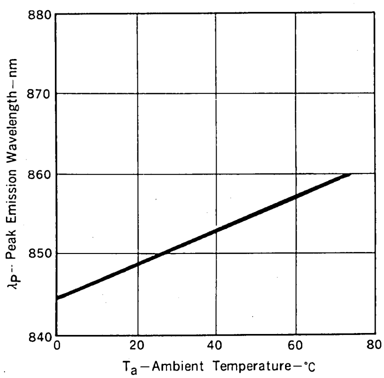


OUTPUT POWER FROM OPTICAL FIBER vs. FORWARD CURRENT

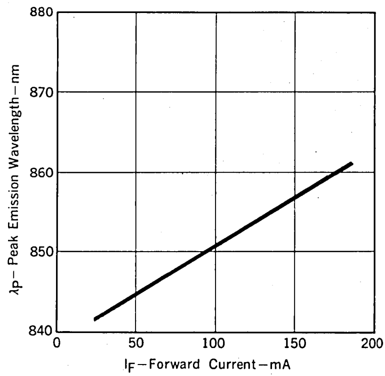


2

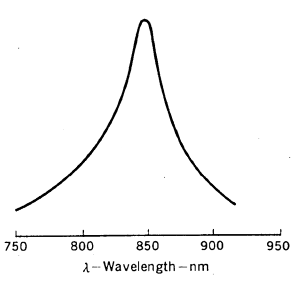
PEAK EMISSION WAVELENGTH vs. AMBIENT TEMPERATURE



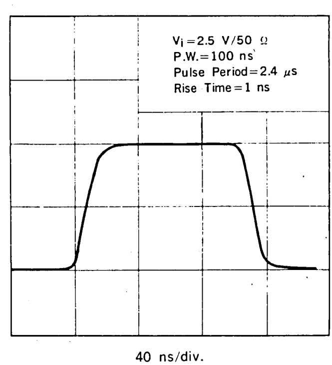
PEAK EMISSION WAVELENGTH vs. FORWARD CURRENT

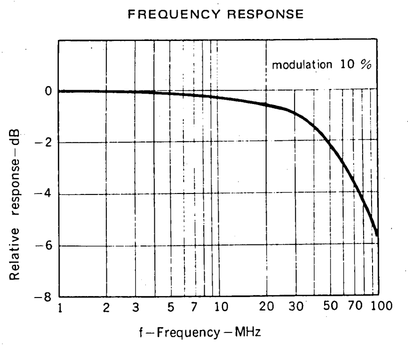


EMISSION SPECTRUM



RESPONSE




FREQUENCY RESPONSE
modulation 10 %
Relative response – dB
0
–2
–4
–6
–8
1
2
3
5
7
10
20
30
50
70
100
f – Frequency – MHz

NDL4105A,4105-78,4105-88

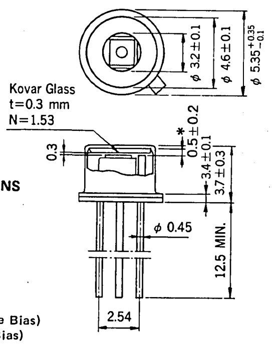
850 nm,780 nm,880 nm OPTICAL FIBER COMMUNICATIONS AlGaAs LIGHT EMITTING DIODE

DESCRIPTION

NDL4105A, NDL4105-78, NDL4105-88 are AlGaAs light emitting diodes. These LEDs have suitable wavelength variation for the light sources of WDM (Wavelength Division Multiplex) system.

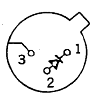
PACKAGE DIMENSIONS

in millimeters



* Optical length

LEAD CONNECTIONS



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

FEATURES

- High output power. P_O = 3.5 mW @I_F = 100 mA
- Suitable wavelength variation for WDM system.

  NDL4105A λ_P = 850 nm
  NDL4105-78 λ_P = 780 nm
  NDL4105-88 λ_P = 880 nm

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	150	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	−40 to +70	°C
Storage Temperature	T_{stg}	−40 to +90	°C

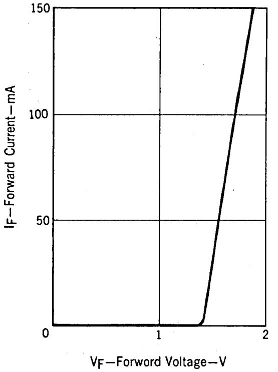
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	NDL4105A			UNIT	TEST CONDITIONS
		MIN.	TYP.	MAX.		
Optical Output Power	P_O	3.0	3.5		mW	I_F = 100 mA
Forward Voltage	V_F		1.7	2.3	V	I_F = 100 mA
Peak Emission Wavelength	λ_P	840	850	870	nm	I_F = 100 mA
Spectral Half Width	$\Delta\lambda$		45	50	nm	I_F = 100 mA
Cutoff Frequency	f_c	30	35		MHz	I_F = 100 mA, I_S = 10 mA_{p-p}, P_O = −3 dB
Emitting Area Diameter	ϕ		35		μm	

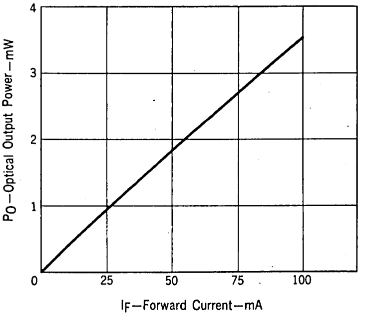
CHARACTERISTIC	SYMBOL	NDL4105-78			NDL4105-88			UNIT	TEST CONDITIONS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.		
Optical Output Power	P_O	3.0	3.5		3.0	3.5		mW	I_F = 100 mA
Forward Voltage	V_F		1.7	2.3		1.7	2.3	V	I_F = 100 mA
Peak Emission Wavelength	λ_P	775	780	785	875	880	885	nm	I_F = 100 mA
Spectral Half Width	$\Delta\lambda$		45	50		45	50	nm	I_F = 100 mA

TYPICAL CHARACTERISTICS (T_a = 25 °C)

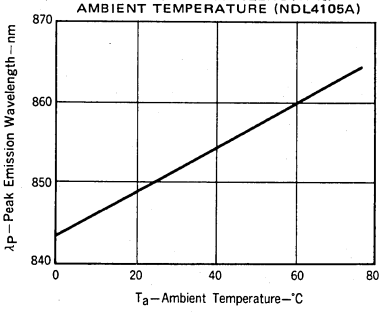
FORWARD CURRENT vs. FORWARD VOLTAGE



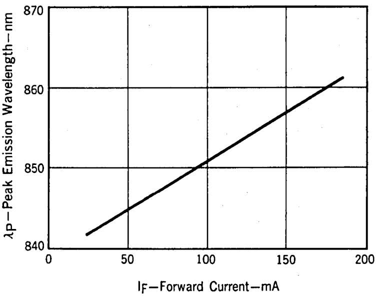
OPTICAL OUTPUT POWER vs. FORWARD CURRENT



PEAK EMISSION WAVELENGTH vs. AMBIENT TEMPERATURE (NDL4105A)



PEAK EMISSION WAVELENGTH vs. FORWARD CURRENT (NDL4105A)



NDL4105B

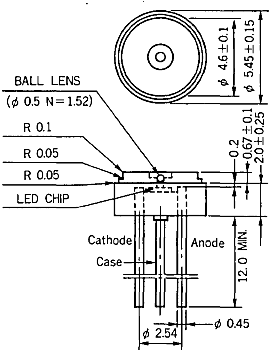
850 nm OPTICAL FIBER COMMUNICATIONS AlGaAs LIGHT EMITTING DIODE

DESCRIPTION

NDL4105B is an AlGaAs double heterostructure light emitting diode.
It adopts a package with ball lens to achieve easy optical coupling.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High output power P_O = 1.8 mW TYP. @I_F = 100 mA
- A ball lens is attached at the top of the package for easy optical coupling.
- Cutoff frequency f_c = 35 MHz TYP.

2

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

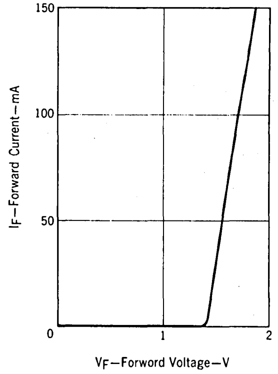
Forward Current	I_F	150	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_c	–40 to +70	°C
Storage Temperature	T_{stg}	–40 to +90	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

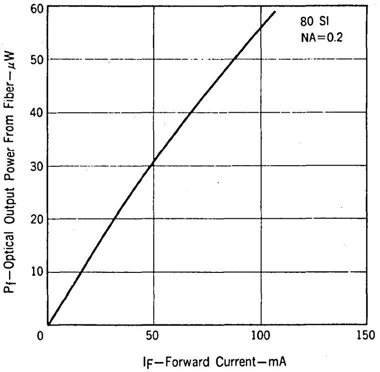
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Optical Output Power	P_O	1.2	1.8		mW	I_F = 100 mA
Forward Voltage	V_F		1.7	2.3	V	I_F = 100 mA
Peak Emission Wavelength	λ_P	840	850	870	nm	I_F = 100 mA
Spectral Half Width	$\Delta\lambda$		45	50	nm	I_F = 100 mA
Cutoff Frequency	f_c	30	35		MHz	I_F = 100 mA, I_S = 10 $mA_{p\text{-}p}$, P_O = –3 dB

TYPICAL CHARACTERISTICS (T_a = 25 °C)

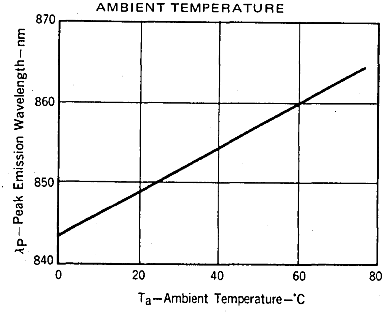
FORWARD CURRENT vs. FORWARD VOLTAGE



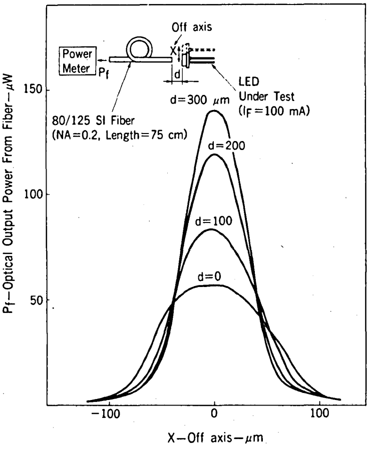
OPTICAL OUTPUT POWER FROM FIBER vs. FORWARD CURRENT



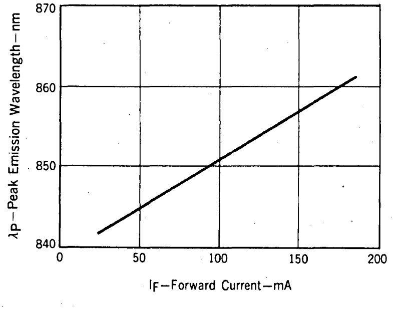
PEAK EMISSION WAVELENGTH vs. AMBIENT TEMPERATURE



OPTICAL OUTPUT POWER FROM FIBER vs. OFF AXIS OF FIBER



PEAK EMISSION WAVELENGTH vs. FORWARD CURRENT



NDL4201A

850 nm OPTICAL FIBER COMMUNICATIONS
AlGaAs LIGHT EMITTING DIODE

DESCRIPTION

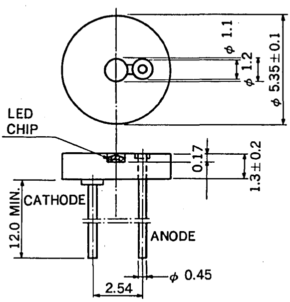
NDL4201A is an AlGaAs double heterostructure light emitting diode designed for a light source of medium distance and medium transmission capacity data link.

FEATURES

- Optical output power P_O = 1.0 mW TYP.
- Cutoff frequency f_c = 35 MHz TYP.

2

PACKAGE DIMENSIONS
in millimeters



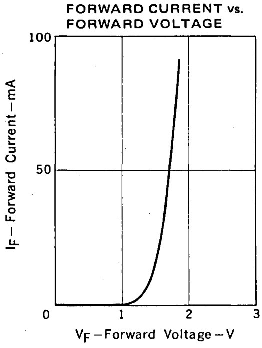
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

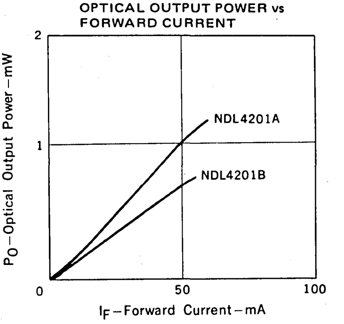
Forward Current	I_F	80	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	–40 to +70	°C
Storage Temperature	T_{stg}	–40 to +90	°C

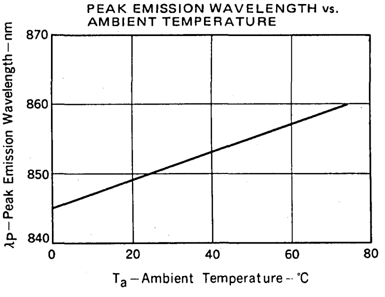
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

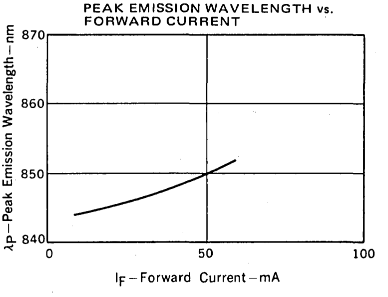
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Optical Output Power	P_O	0.6	1.0		mW	I_F = 50 mA
Forward Voltage	V_F		1.7	2.3	V	I_F = 50 mA
Peak Emission Wavelength	λ_p	840	850	870	nm	I_F = 50 mA
Spectral Half Width	$\Delta\lambda$		45	50	nm	I_F = 50 mA
Cutoff Frequency	f_c	30	35		MHz	I_F = 50 mA, I_S = 10 mA_{p-p}, P_O = –3 dB
Emitting Area Diameter	ϕ		35		μm	

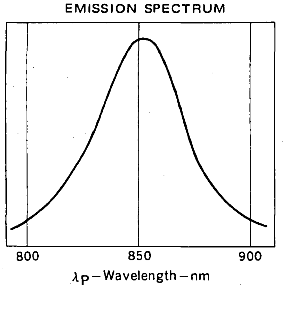
TYPICAL CHARACTERISTICS ($T_a = 25\ °C$)











NDL4201B

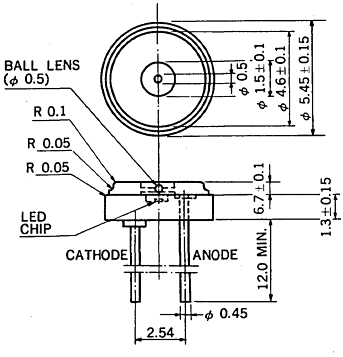
850 nm OPTICAL FIBER COMMUNICATIONS AlGaAs LIGHT EMITTING DIODE

DESCRIPTION

NDL4201B is an AlGaAs double heterostructure light emitting diode.
It adopts a package with ball lens to achieve easy optical coupling.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- Optical output power P_O = 0.6 mW TYP.
- A ball lens is attached at the top of the package for easy optical coupling .
- Hermetically sealed package.
- Cutoff frequency f_c = 35 MHz TYP.

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

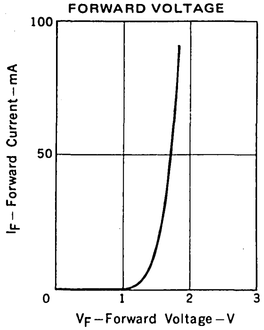
Forward Current	I_F	80	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_c	–40 to +70	°C
Storage Temperature	T_{stg}	–40 to +90	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

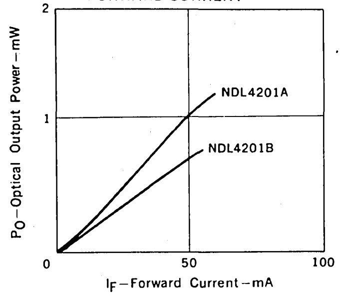
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Optical Output Power	P_O	0.4	0.6		mW	I_F = 50 mA
Forward Voltage	V_F		1.7	2.3	V	I_F = 50 mA
Peak Emission Wavelength	λ_p	840	850	870	nm	I_F = 50 mA
Spectral Half Width	$\Delta\lambda$		45	50	nm	I_F = 50 mA
Cutoff Frequency	f_c	30	35		MHz	I_F = 50 mA, I_S = 10 mA_{p-p}, P_O = –3 dB

TYPICAL CHARACTERISTICS (T_a = 25 °C)

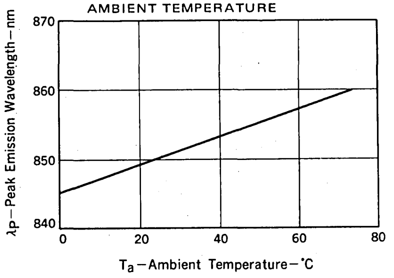
FORWARD CURRENT vs. FORWARD VOLTAGE



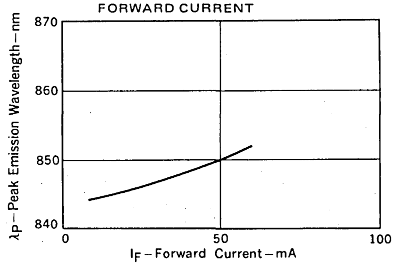
OPTICAL OUTPUT POWER vs FORWARD CURRENT



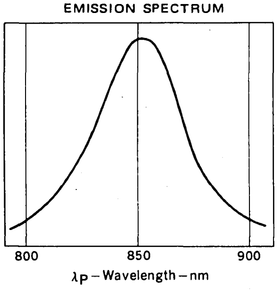
PEAK EMISSION WAVELENGTH vs. AMBIENT TEMPERATURE



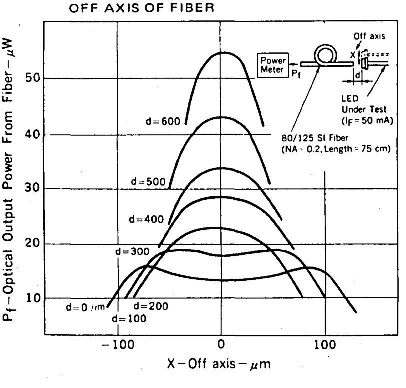
PEAK EMISSION WAVELENGTH vs. FORWARD CURRENT



EMISSION SPECTRUM



OPTICAL OUTPUT POWER FROM FIBER vs. OFF AXIS OF FIBER



NDL5003

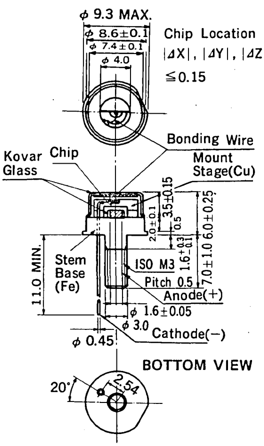
1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LASER DIODE

DESCRIPTION

NDL5003 is a long wavelength laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High output power. P_O = 8 mW TYP. @$I_F = I_{th}$ +30 mA
- Fundamental transverse mode.
- Wide operating temperature range.
- Long wavelength. λ_p = 1 300 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle
  $\theta_\perp \times \theta_{/\!/} = 35° \times 28°$

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	15	mW
Operating Case Temperature	T_C	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

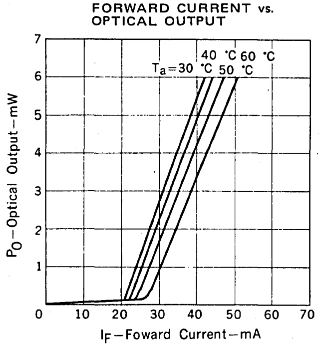
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_O	6.0	8.0		mW	$I_F = I_{th}$ +30 mA
Monitor Output Power	P_m	0.5	1.0		mW	P_O = 6.0 mW
Peak Emission Wavelength	λ_p	1270	1300	1330	nm	P_O = 6.0 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 6.0 mW
Vertical Beam Angle	$\theta_\perp$		35		deg.	P_O = 6.0 mW, FAHM *
Lateral Beam Angle	$\theta_{/\!/}$		28		deg.	P_O = 6.0 mW, FAHM *
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

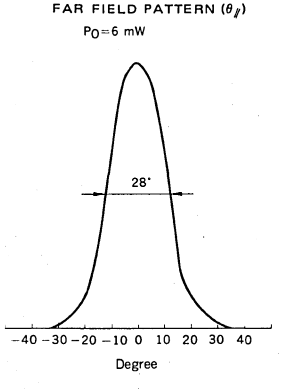
* FAHM: Full Angle at Half Maximum

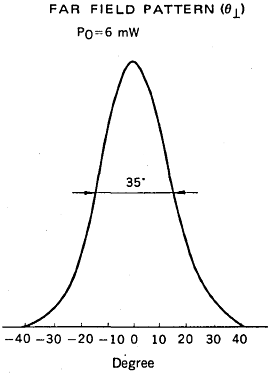
ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 60\ ^\circ C$)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITION
Forward Voltage	V_F			1.3	V	$I_F = 30$ mA
Threshold Current	I_{th}		40	60	mA	
Optical Output Power	P_O	5.0			mW	$I_F = I_{th} + 30$ mA
Peak Emission Wavelength	λ_p	1275	1315	1350	nm	$P_O = 5.0$ mW
Monitor Output Power	P_m	300			μW	$P_O = 5.0$ mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	$P_O = 5.0$ mW
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time			0.7	1.0	ns	90–10 %

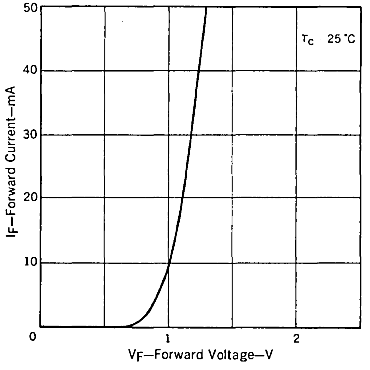
TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)



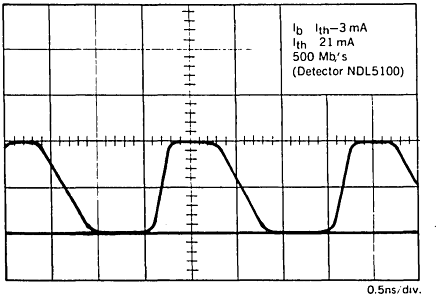




FORWARD CURRENT vs.
FORWARD VOLTAGE

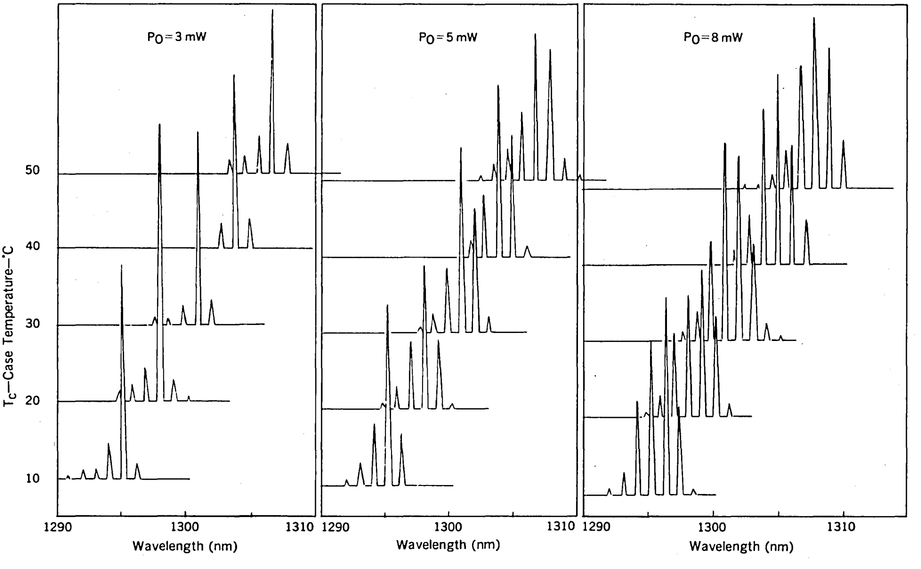


PULSE RESPONSE



2

LONGITUDINAL MODE EMISSION SPECTRUM



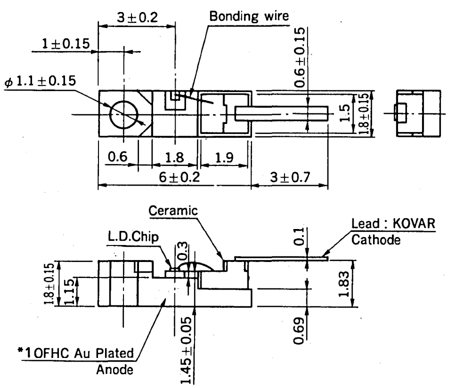
LASER DIODE
NDL5003D

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DC-PBH LASER DIODE

DESCRIPTION

NDL5003D is a 1 300 nm laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.
NEC has two types of laser diode chip on carrier with ribbon lead. One is the D-type like NDL5003D, another is a D1-type like NDL5003D1.

PACKAGE DIMENSIONS
in millimeters



*1 OFHC: Oxygen Free High-Conductivity Copper

FEATURES

- High output power. P_O = 8 mW TYP. @$I_F = I_{th}$ +30 mA
- Long wavelength. λ_P = 1 300 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle
  $\theta_\perp \times \theta_{/\!/} = 35° \times 28°$
- Fundamental transverse mode.
- Wide operating temperature range.
- Chip-on-carrier with ribbon lead.

ABSOLUTE MAXIMUM RATINGS
(T_a = 25 °C, in dry nitrogen atmosphere)

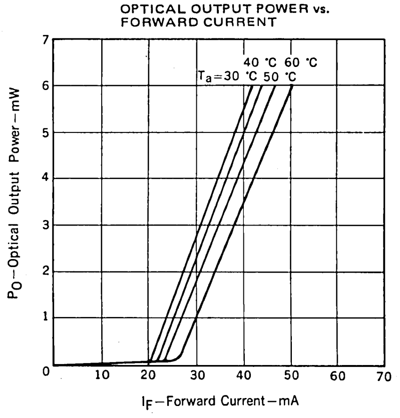
Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	15	mW
Operating Temperature	T_{op}	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C

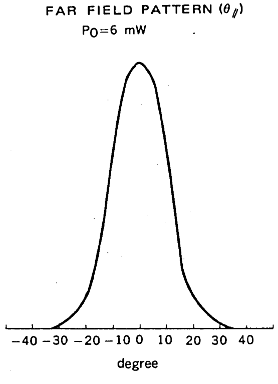
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

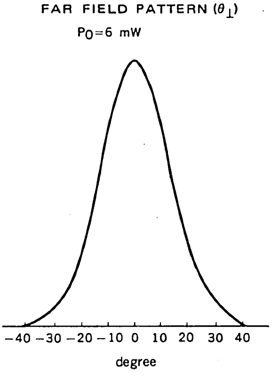
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_O	6.0	8.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	P_O = 6.0 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 6.0 mW, FWHM *2
Vertical Beam Angle	$\theta_\perp$		35		deg.	P_O = 6.0 mW, FAHM *3
Lateral Beam Angle	$\theta_{/\!/}$		28		deg.	P_O = 6.0 mW, FAHM *3
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

*2 FWHM: Full Width at Half Maximum
*3 FAHM: Full Angle at Half Maximum

TYPICAL CHARACTERISTICS (T_a = 25 °C)

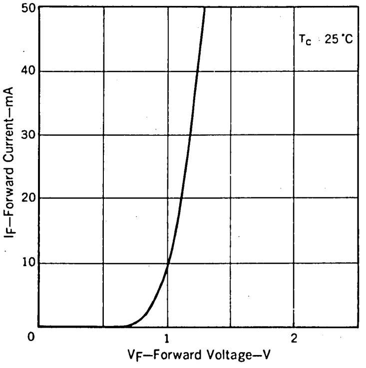




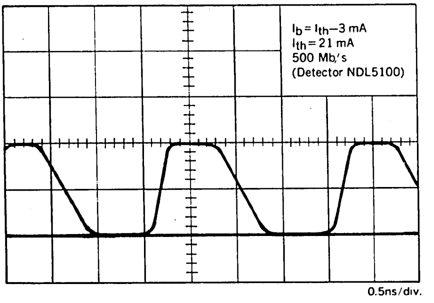


2

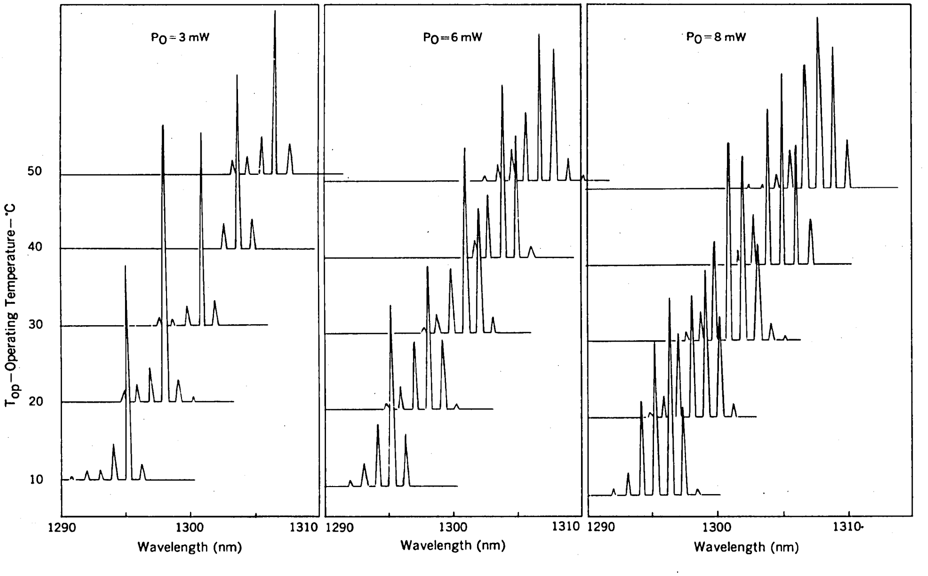
FORWARD CURRENT vs. FORWARD VOLTAGE



PULSE RESPONSE



LONGITUDINAL MODE EMISSION SPECTRUM



LASER DIODE CHIP ON CARRIER HANDLING PRECAUTION

LASER DIODE CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, FOLLOWING CONDITION SHOULD BE MAINTAINED. (DURING CUSTOMER'S ASSEMBLY PROCESS, THE CONDITION ALSO SHOULD BE APPLIED FOR THE UNSEALED PACKAGE WHICH IS EQUIPPED WITH THE DEVICE.)

STORAGE TEMPERATURE: +20 TO +30 °C
CONTAINER: CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS: AIR OR NITROGEN (DEW POINT: LESS THAN −30 °C)

RECOMMENDABLE STORAGE PERIOD IS AS FOLLOWS.

2

STORAGE CONDITION	STORAGE DURATION
IN NEC'S CONTAINER BEFORE SEAL BREAK	3 MONTHS MAX.
AFTER SEAL BREAK	1 MONTH MAX.

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE
ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) CHIP FACETS
CLEAN CONDITION OF LASER DIODE CHIP FACETS SHOULD BE KEPT.

2-3) DIE ATTACHMENT
WHEN THE DEVICE IS MOUNTED INTO CUSTOMER'S PACKAGE, THE DEVICE SHOULD BE PREVENTED FROM ANY SCRATCHES, CRACKS, CHIP OUT AND CONTAMINATION ON CHIP SURFACE (TOP AND FACETS).

2-4) ESD PROTECTION
DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

2-5) SOLDERING CONDITION
THE FOLLOWING CONDITIONS SHOULD BE KEPT.
OTHERWISE, THERE IS A POSSIBILITY THAT THERE IS THE INFLUENCE ON ELECTRO-OPTICAL CHARACTERISTICS AND RELIABILITY OF THE DEVICE.

TEMPERATURE: +140 °C MAX.
DURATION: 30 sec. MAX.
ATMOSPHERE: INERT GAS (EX. NITROGEN)

2-6) HERMETIC SEALING
THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec.

LASER DIODE
NDL5003D1

1 300 nm OPTICAL FIBER COMMUNICATIONS InGaAsP DC-PBH LASER DIODE

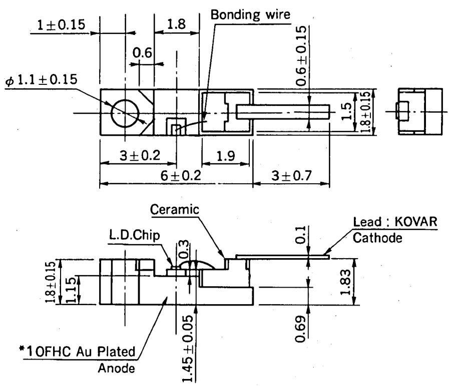
DESCRIPTION

NDL5003D1 is a 1 300 nm laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.

NEC has two types of laser diode chip on carrier with ribbon lead. One is the D1-type like NDL5003D1, another is a D-type like NDL5003D.

PACKAGE DIMENSIONS

in millimeters



*1 OFHC: Oxygen Free High-Conductivity Copper

FEATURES

- High output power. P_O = 8 mW TYP. @$I_F = I_{th}$ +30 mA
- Long wavelength. λ_P = 1 300 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle
  $\theta_\perp \times \theta_{/\!/} = 35^\circ \times 28^\circ$
- Fundamental transverse mode.
- Wide operating temperature range.
- Chip-on-carrier with ribbon lead.

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

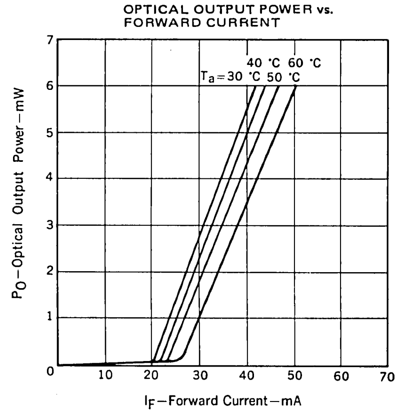
Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	15	mW
Operating Temperature	T_{op}	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C

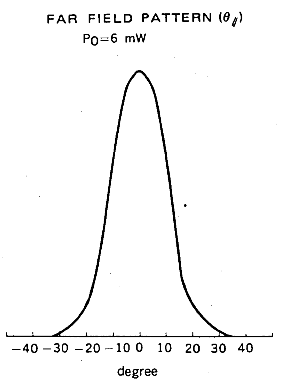
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

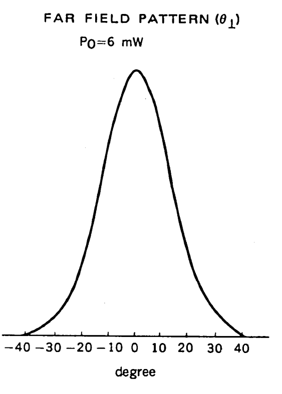
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_O	6.0	8.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	P_O = 6.0 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 6.0 mW, FWHM *2
Vertical Beam Angle	$\theta_\perp$		35		deg.	P_O = 6.0 mW, FAHM *3
Lateral Beam Angle	$\theta_{/\!/}$		28		deg.	P_O = 6.0 mW, FAHM *3
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

*2 FWHM: Full Width at Half Maximum
*3 FAHM: Full Angle at Half Maximum

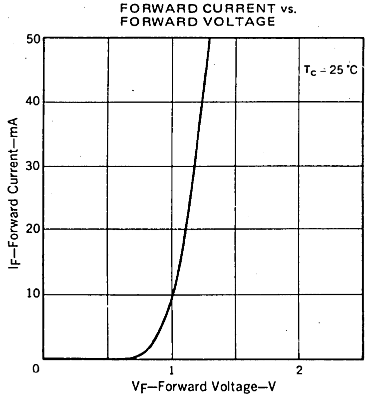
TYPICAL CHARACTERISTICS (T_a = 25 °C)

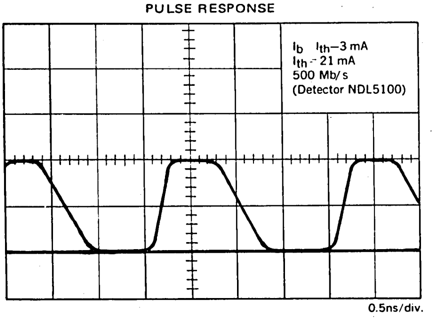


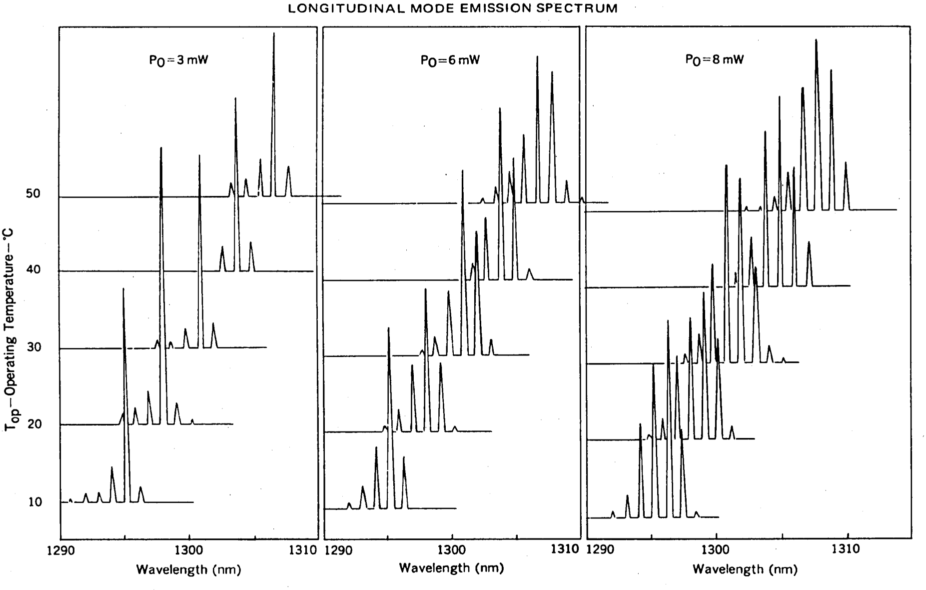




2


FORWARD CURRENT vs.
FORWARD VOLTAGE
$T_c = 25\,^\circ C$
I_F—Forward Current—mA
V_F—Forward Voltage—V
0
1
2
10
20
30
40
50


PULSE RESPONSE
I_b I_{th}−3 mA
I_{th} = 21 mA
500 Mb/s
(Detector NDL5100)
0.5ns/div.


LONGITUDINAL MODE EMISSION SPECTRUM
P_O = 3 mW
P_O = 6 mW
P_O = 8 mW
T_{op}—Operating Temperature—°C
10
20
30
40
50
1290
1300
1310
Wavelength (nm)

LASER DIODE CHIP ON CARRIER HANDLING PRECAUTION

LASER DIODE CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, FOLLOWING CONDITION SHOULD BE MAINTAINED. (DURING CUSTOMER'S ASSEMBLY PROCESS, THE CONDITION ALSO SHOULD BE APPLIED FOR THE UNSEALED PACKAGE WHICH IS EQUIPPED WITH THE DEVICE.)

STORAGE TEMPERATURE: +20 TO +30 °C
CONTAINER: CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS: AIR OR NITROGEN (DEW POINT: LESS THAN −30 °C)

RECOMMENDABLE STORAGE PERIOD IS AS FOLLOWS.

2

STORAGE CONDITION	STORAGE DURATION
IN NEC'S CONTAINER BEFORE SEAL BREAK	3 MONTHS MAX.
AFTER SEAL BREAK	1 MONTH MAX.

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE
ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) CHIP FACETS
CLEAN CONDITION OF LASER DIODE CHIP FACETS SHOULD BE KEPT.

2-3) DIE ATTACHMENT
WHEN THE DEVICE IS MOUNTED INTO CUSTOMER'S PACKAGE, THE DEVICE SHOULD BE PREVENTED FROM ANY SCRATCHES, CRACKS, CHIP OUT AND CONTAMINATION ON CHIP SURFACE (TOP AND FACETS).

2-4) ESD PROTECTION
DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

2-5) SOLDERING CONDITION
THE FOLLOWING CONDITIONS SHOULD BE KEPT.
OTHERWISE, THERE IS A POSSIBILITY THAT THERE IS THE INFLUENCE ON ELECTRO-OPTICAL CHARACTERISTICS AND RELIABILITY OF THE DEVICE.

TEMPERATURE. +140 °C MAX.
DURATION: 30 sec. MAX.
ATMOSPHERE: INERT GAS (EX. NITROGEN)

2-6) HERMETIC SEALING
THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec.

LASER DIODE
NDL5004

1 300 nm OPTICAL FIBER COMMUNICATIONS InGaAsP DOUBLE HETEROSTRUCTURE LASER DIODE

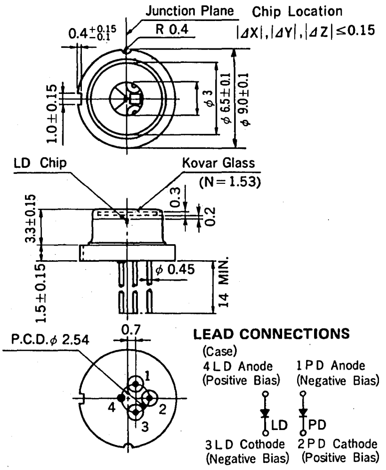
DESCRIPTION

NDL5004 is a long wavelength laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.

FEATURES

- High output power. P_O = 8 mW TYP. @I_F = I_{th} +30 mA
- Fundamental transverse mode.
- Wide operating temperature range.
- Long wavelength. λ_P = 1 300 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle
  $\theta_{\perp} \times \theta_{/\!/} = 35^\circ \times 28^\circ$

PACKAGE DIMENSIONS
in millimeters



ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage of LD	V_R	2.0	V
Optical Output Power of LD	P_O	15	mW
Operating Case Temperature	T_C	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_O	6.0	8.0		mW	I_F = I_{th} +30 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	P_O = 6.0 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 6.0 mW
Vertical Beam Angle	$\theta_{\perp}$		35		deg.	P_O = 6.0 mW, FAHM*
Lateral Beam Angle	$\theta_{/\!/}$		28		deg.	P_O = 6.0 mW, FAHM*
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %
Monitor Current of PD	I_m	300	500	1500	μA	V_R = 5 V, P_O = 6.0 mW
Dark Current of PD	I_D			3	μA	V_R = 5 V

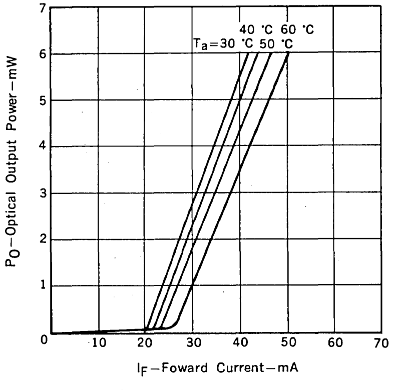
* FAHM : Full Angle at Half Maximum

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 60\ ^\circ C$)

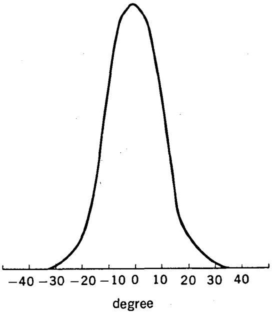
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Threshold Current	I_{th}		40	60	mA	
Optical Output Power	P_O	5.0			mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_p	1275	1315	1350	nm	P_O = 5.0 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 5.0 mW
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %
Monitor Current of PD	I_m	200			μA	V_R = 5 V, P_O = 5.0 mW
Dark Current of PD	I_D		12	25	μA	V_R = 5 V

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

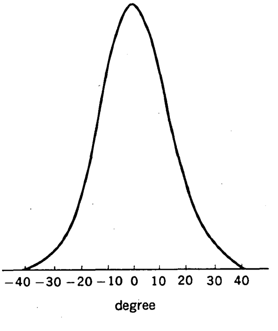
OPTICAL OUTPUT POWER vs. FORWARD CURRENT



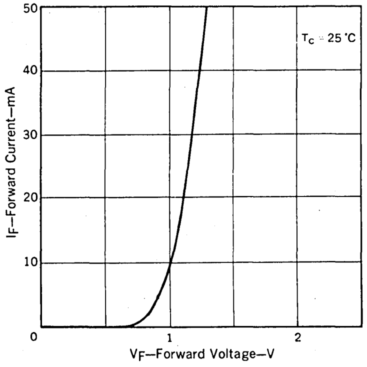
FAR FIELD PATTERN ($\theta_{/\!/}$)
P_O=6 mW



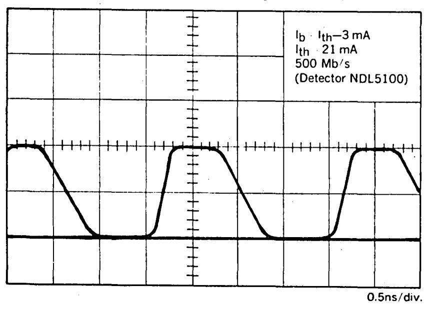
FAR FIELD PATTERN ($\theta_\perp$)
P_O=6 mW



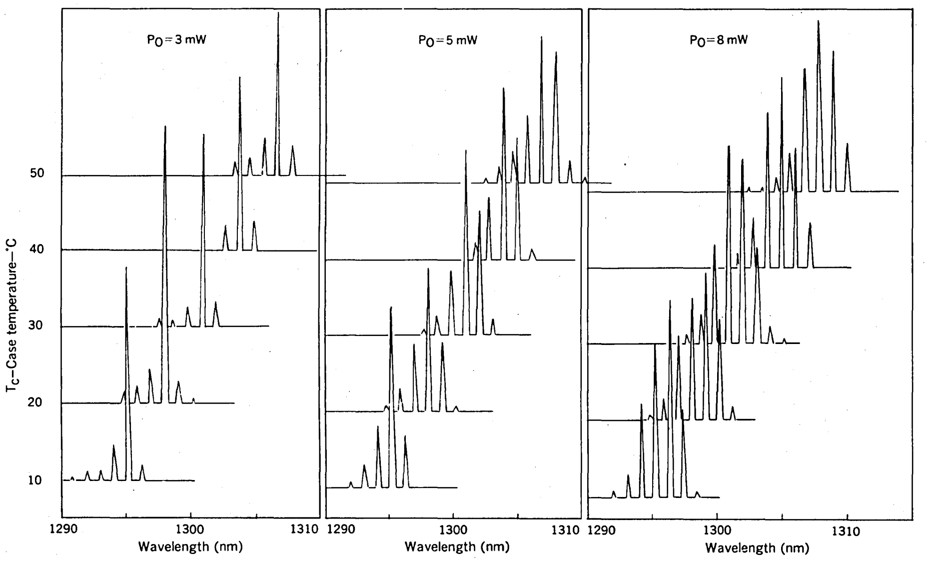
FORWARD CURRENT vs. FORWARD VOLTAGE



PULSE RESPONSE



LONGITUDINAL MODE EMISSION SPECTRUM



LASER DIODE

NDL5004P

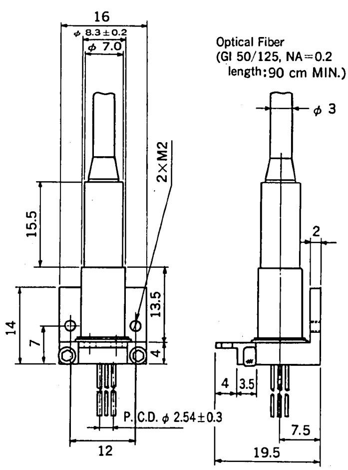
1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LASER DIODE MODULE

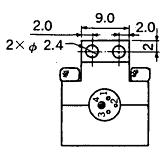
DESCRIPTION

NDL5004P is an InGaAsP Laser Diode Module especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve high power output and stable fundamental oscillation in wide temperature range.

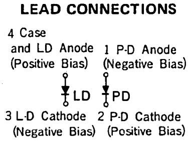
PACKAGE DIMENSIONS

in millimeters





LEAD CONNECTIONS



FEATURES

- High output power from fiber. $P_f = 2.5$ mW TYP.
- Long wavelength. $\lambda_P = 1\,300$ nm
- Low threshold current. $I_{th} = 20$ mA TYP.
- Fundamental transverse mode operation.
- High reliability.
- Hermetically Sealed.
- Monitor photodiode incorporated.

ABSOLUTE MAXIMUM RATINGS ($T_a = 25$ °C)

Operating Case Temperature	T_C	−20 to +65	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Optical Output Power			
From Fiber	P_f	4.0	mW
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	50	mA
Reverse Voltage of PD	V_R	20	V

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
DC Threshold Current	$I_{th(dc)}$		20	35	mA	
DC Forward Voltage	$V_{F(dc)}$			1.3	V	I_F = 30 mA
Optical Output Power From Fiber	P_f	2.2	2.5		mW	$I_F = I_{th}$ +30 mA CW
Peak Emission Wavelength	λ_p	1280	1300	1330	nm	P_f = 2.2 mW
Spectral Width	$\Delta\lambda$			4.0	nm	P_f = 2.2 mW
P_f Rise Time	t_r		0.5	1.0	ns	10–90 %
P_f Fall Time	t_f		0.7	1.0	ns	90–10 %
Spontaneous Emission Power From Fiber	P_s			150	μW	$I_b = I_{th}$ −3 mA
Diode Monitor Current	I_m	300	500	1500	μA	V_R = 5.0 V, P_f = 2.2 mW
Front/Back Tracking Error	γ *1			10	%	$I_{th} \leq I_F \leq I_{th}$ +30 mA 0 °C $\leq T_c \leq$ 60 °C
Diode Dark Current	I_D *1		1.5	3.0	μA	V_R = 5 V

*1 Monitor diode

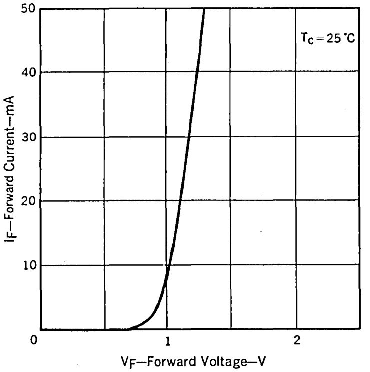
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 60 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
DC Threshold Current	$I_{th(dc)}$		40	60	mA	
DC Forward Voltage	$V_{F(dc)}$			1.3	V	I_F = 30 mA
Optical Output Power From Fiber	P_f	1.3			mW	$I_F = I_{th}$ +30 mA CW
Peak Emission Wavelength	λ_p	1285		1345	nm	P_f = 1.3 mW
Spectral Width	$\Delta\lambda$			4.0	nm	P_f = 1.3 mW
P_f Rise Time	t_r		0.5		ns	10–90 %
P_f Fall Time	t_f		0.7		ns	90–10 %
Spontaneous Emission Power From Fiber	P_s			300	μW	$I_b = I_{th}$ −3 mA
Diode Monitor Current	I_m *1	200			μA	V_R = 5.0 V, P_f = 1.3 mW
Diode Dark Current	I_D *1		12	25	μA	V_R = 5 V

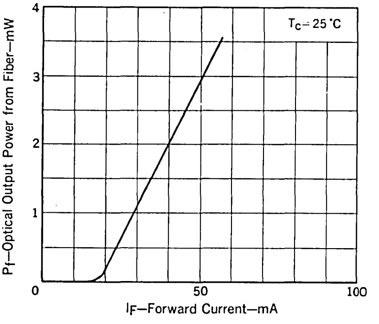
*1 : Monitor diode

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

FORWARD CURRENT vs.
FORWARD VOLTAGE

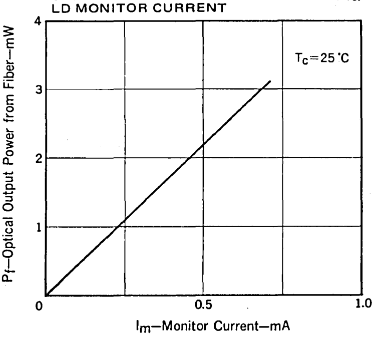


OPTICAL OUTPUT POWER FROM FIBER vs.
LD FORWARD CURRENT

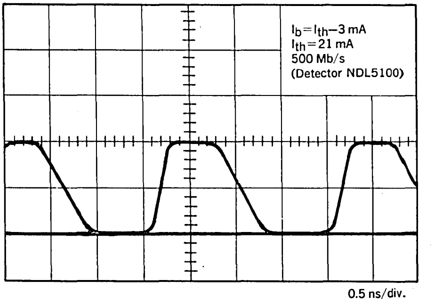


2

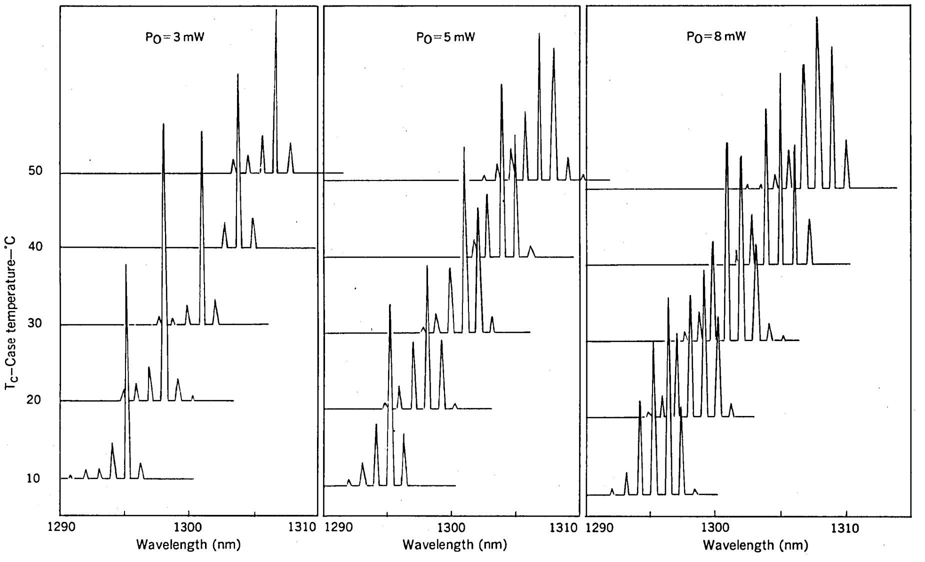
OPTICAL OUTPUT POWER FROM FIBER vs.
LD MONITOR CURRENT



PULSE RESPONSE



LONGITUDINAL MODE EMISSION SPECTRUM



NDL5008

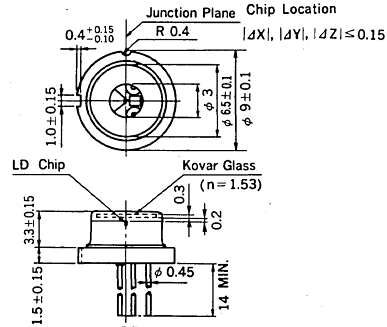
1 200 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LASER DIODE

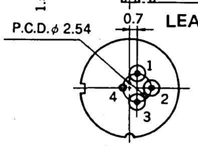
DESCRIPTION

NDL5008 is a long wavelength laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.

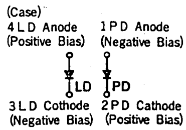
PACKAGE DIMENSIONS

in millimeters





LEAD CONNECTION



FEATURES

- High output power. P_O = 7.0 mW TYP. @I_F = I_{th} +30 mA
- Fundamental transverse mode.
- Wide operating temperature range.
- Long wavelength. λ_P = 1 200 nm
- Low threshold current. I_{th} = 25 mA TYP.
- Narrow vertical angle and wide lateral beam angle $\theta_{\perp} \times \theta_{/\!/}$ = 30 x 25
- WDM is applicable with NDL5004

2

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

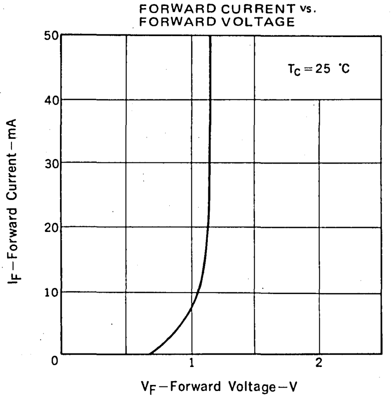
Reverse Voltage of LD	V_R	2.0	V
Optical Output Power of LD	P_D	10	mW
Operating Case Temperature	T_C	−20 to +60	°C
Storage Temperature	T_{stg}	−55 to +125	°C
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

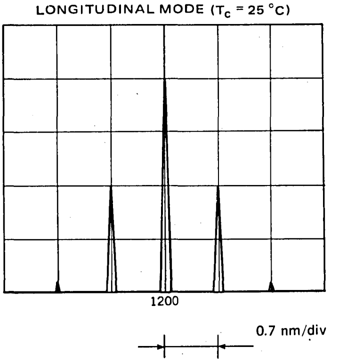
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

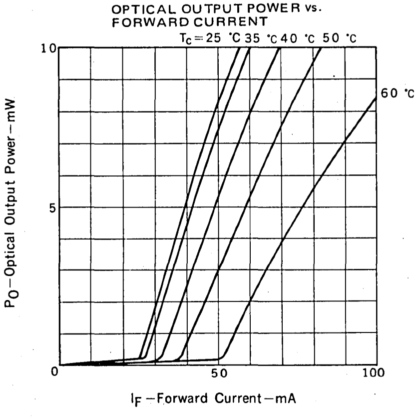
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.2	1.5	V	I_F = 30 mA
Threshold Current	I_{th}		25	40	mA	
Optical Output Power	P_O	5.0	7.0		mW	I_F = I_{th} +30 mA
Peak Emission Wavelength	λ_P	1170	1200	1230	nm	P_O = 5.0 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 5.0 mW
Vertical Beam Angle	$\theta_{\perp}$		30		deg.	P_O = 5.0 mW, FAHM *
Lateral Beam Angle	$\theta_{/\!/}$		25		deg.	P_O = 5.0 mW, FAHM *
Rise Time	t_r		0.5	1.0	ns	10−90 %
Fall Time	t_f		0.7	1.0	ns	90−10 %
Monitor Current of PD	I_m	120	500		μA	V_R = 5 V, P_O = 5.0 mW
Dark Current of PD	I_D			3.0	μA	V_R = 5 V

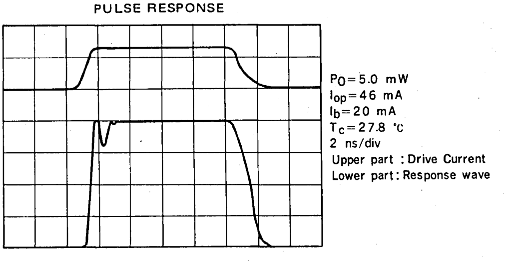
* FAHM: Full Angle at Half Maximum

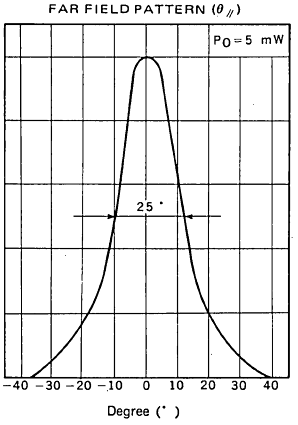
TYPICAL CHARACTERISTICS ($T_a = 25$ °C)

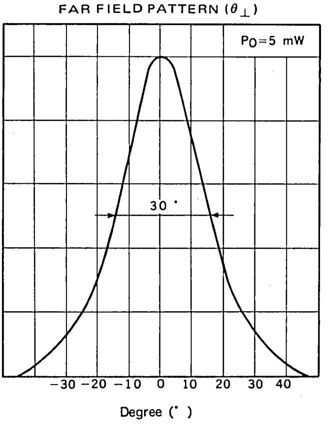









FAR FIELD PATTERN (θ//)
Po=5 mW
25°
−40 −30 −20 −10 0 10 20 30 40
Degree (°)


FAR FIELD PATTERN (θ⊥)
Po=5 mW
30°
−30 −20 −10 0 10 20 30 40
Degree (°)

2

NDL5009

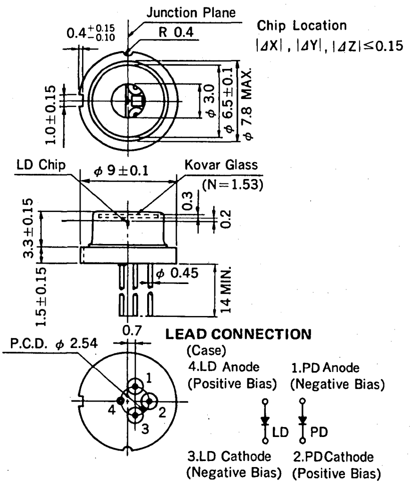
1 310 nm OPTICAL FIBER COMMUNICATIONS InGaAsP DOUBLE HETEROSTRUCTURE LASER DIODE

DESCRIPTION

NDL5009 is a long wavelength laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High speed response. ≧ 565 Mb/s
- High output power. P_O = 8 mW TYP. @ $I_F = I_{th}$ +30 mA
- Fundamental transverse mode.
- Wide operating temperature range.
- Long wavelength. λ_P = 1 310 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle. $\theta_{\perp} \times \theta_{/\!/} = 35° \times 28°$

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage of LD	V_R	2.0	V
Optical Output Power of LD	P_O	15	mW
Operating Case Temperature	T_C	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

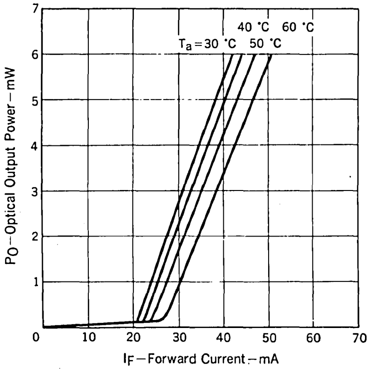
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.9	1.1	1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_O	6.0	8.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1 290	1 310	1 330	nm	P_O = 10 mW, CW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 10 mW, CW
Vertical Beam Angle	$\theta_{\perp}$		35		deg.	P_O = 10 mW, FAHM *
Lateral Beam Angle	$\theta_{/\!/}$		28		deg.	P_O = 10 mW, FAHM *
Cutoff Frequency	f_c	1.2			GHz	$I_b = I_{th} \times 2$, −3 dB
Monitor Current of PD	I_m	500			μA	V_R = 6 V, P_O = 10 mW
Dark Current of PD	I_D		0.5	1.0	μA	V_R = 6 V

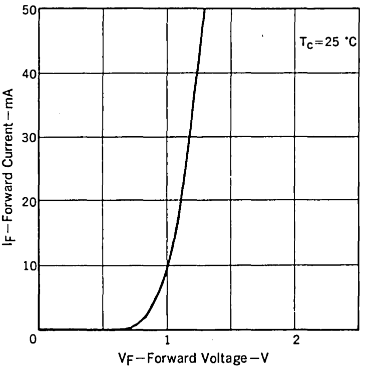
* FAHM: Full Angle at Half Maximum

TYPICAL CHARACTERISTICS (T_a = 25 °C)

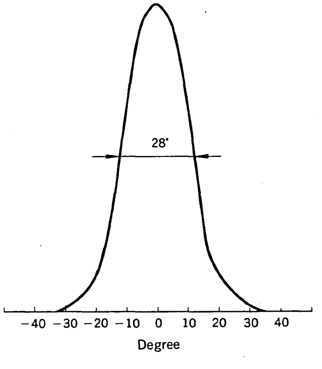
OPTICAL OUTPUT POWER vs. FORWARD CURRENT



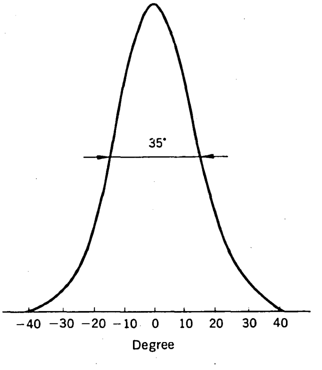
FORWARD CURRENT vs. FORWARD VOLTAGE



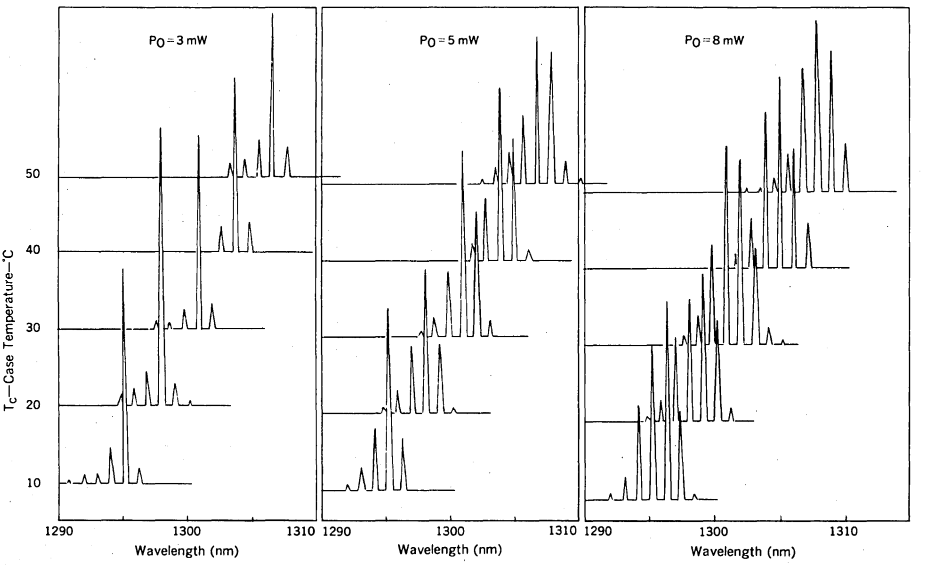
FAR FIELD PATTERN ($\theta_{//}$)
P_O = 6 mW



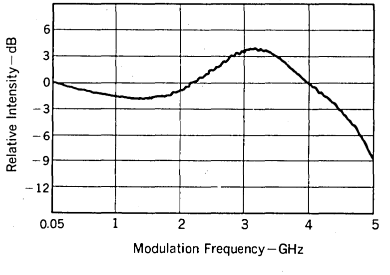
FAR FIELD PATTERN ($\theta_{\perp}$)
P_O = 6 mW



LONGITUDINAL MODE EMISSION SPECTRUM



FREQUENCY CHARACTERISTICS



LASER DIODE
NDL5009D

1 310 nm OPTICAL FIBER COMMUNICATIONS InGaAsP DC-PBH LASER DIODE

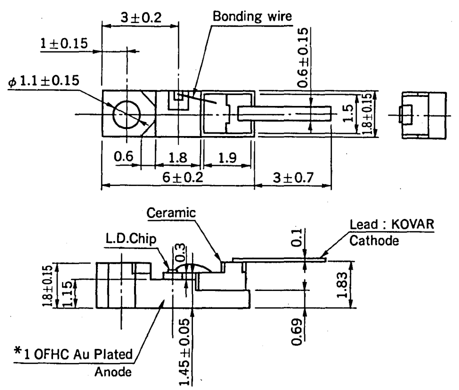
DESCRIPTION

NDL5009D is a 1 310 nm laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.

NEC has two types of laser diode chip on carrier with ribbon lead. One is the D-type like NDL5009D, another is a D1-type like NDL5009D1.

PACKAGE DIMENSIONS

in millimeters



*1 OFHC: Oxygen Free High-Conductivity Copper

FEATURES

- High speed response. ≧565 Mb/s
- High output power. P_O = 8 mW TYP. @I_F = I_{th} +30 mA
- Long wavelength. λ_P = 1 310 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle $\theta_\perp \times \theta_{/\!/} = 35° \times 28°$
- Fundamental transverse mode.
- Wide operating temperature range.
- Chip-on-carrier with ribbon lead

2

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	15	mW
Operating Temperature	T_{op}	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +125	°C

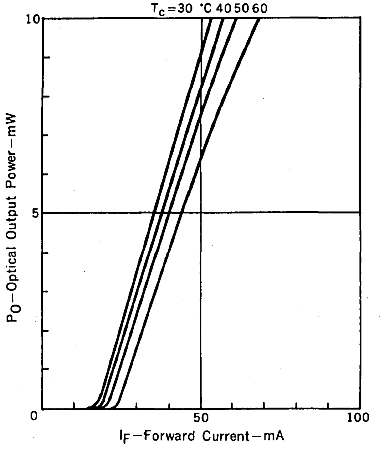
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.9	1.1	1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_O	6.0	8.0		mW	I_F = I_{th} +30 mA
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_O = 10 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 10 mW, FWHM *2
Vertical Beam Angle	$\theta_\perp$		35		deg.	P_O = 10 mW, FAHM *3
Lateral Beam Angle	$\theta_{/\!/}$		28		deg.	P_O = 10 mW, FAHM *3
Cutoff Frequency	f_c	1.2			GHz	I_b = I_{th}x2, –3 dB

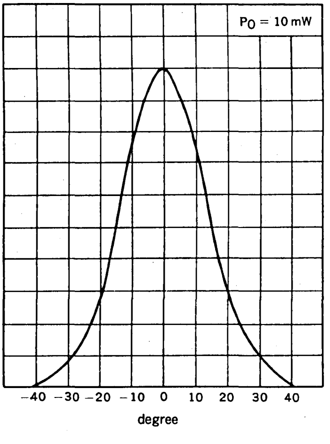
*2 FWHM: Full Width at Half Maximum.
*3 FAHM: Full Angle at Half Maximum.

TYPICAL CHARACTERISTICS (T_a = 25 °C)

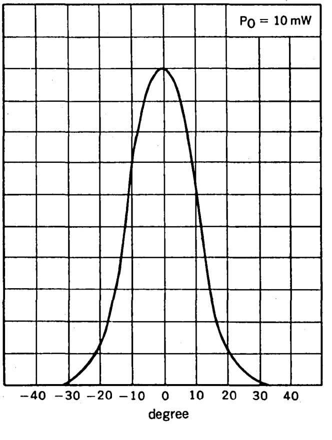
OPTICAL OUTPUT POWER vs. FORWARD CURRENT



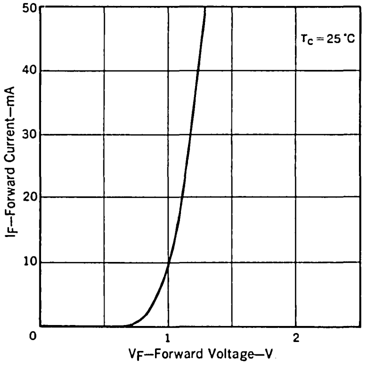
FAR FIELD PATTERN ($\theta_\perp$)



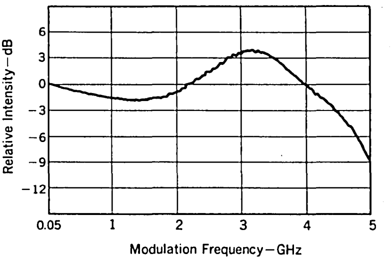
FAR FIELD PATTERN ($\theta_\parallel$)



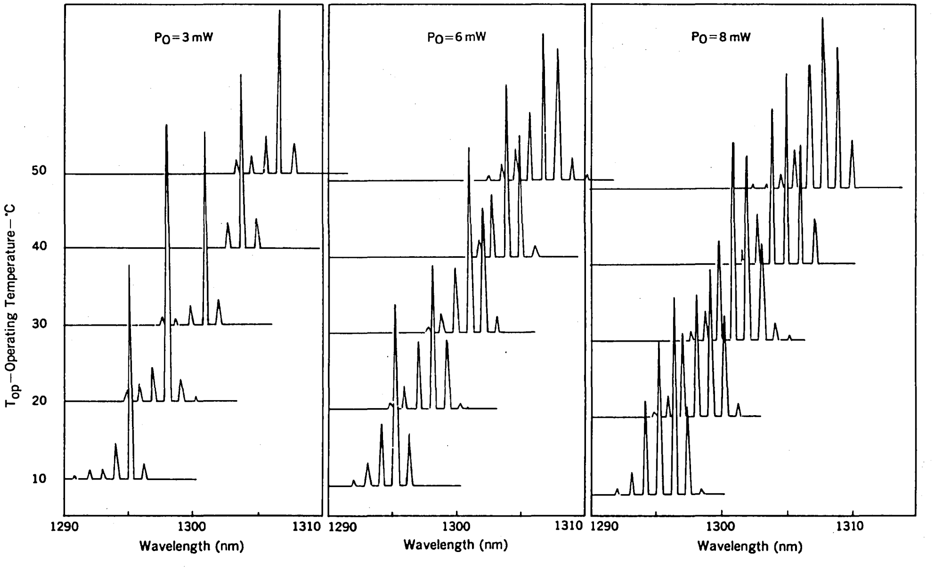
FORWARD CURRENT vs. FORWARD VOLTAGE



FREQUENCY CHARACTERISTICS



LONGITUDINAL MODE EMISSION SPECTRUM



LASER DIODE CHIP ON CARRIER HANDLING PRECAUTION

LASER DIODE CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, FOLLOWING CONDITION SHOULD BE MAINTAINED. (DURING CUSTOMER'S ASSEMBLY PROCESS THE CONDITION ALSO SHOULD BE APPLIED FOR THE UNSEALED PACKAGE WHICH IS EQUIPPED WITH THE DEVICE.)

STORAGE TEMPERATURE: +20 TO +30 °C
CONTAINER: CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS: AIR OR NITROGEN (DEW POINT: LESS THAN −30 °C)

RECOMMENDABLE STORAGE PERIOD IS AS FOLLOWS.

STORAGE CONDITION	STORAGE DURATION
IN NEC'S CONTAINER BEFORE SEAL BREAK	3 MONTHS MAX.
AFTER SEAL BREAK	1 MONTH MAX.

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE
ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) CHIP FACETS
CLEAN CONDITION OF LASER DIODE CHIP FACETS SHOULD BE KEPT.

2-3) DIE ATTACHMENT
WHEN THE DEVICE IS MOUNTED INTO CUSTOMER'S PACKAGE, THE DEVICE SHOULD BE PREVENTED FROM ANY SCRATCHES, CRACKS, CHIP OUT AND CONTAMINATION ON CHIP SURFACE (TOP AND FACETS).

2-4) ESD PROTECTION
DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

2-5) SOLDERING CONDITION
THE FOLLOWING CONDITIONS SHOULD BE KEPT.
OTHERWISE, THERE IS A POSSIBILITY THAT THERE IS THE INFLUENCE ON ELECTRO-OPTICAL CHARACTERISTICS AND RELIABILITY OF THE DEVICE.

TEMPERATURE +140 °C MAX.
DURATION: 30 sec. MAX.
ATMOSPHERE INERT GAS (EX. NITROGEN)

2-6) HERMETIC SEALING
THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec.

NDL5009D1

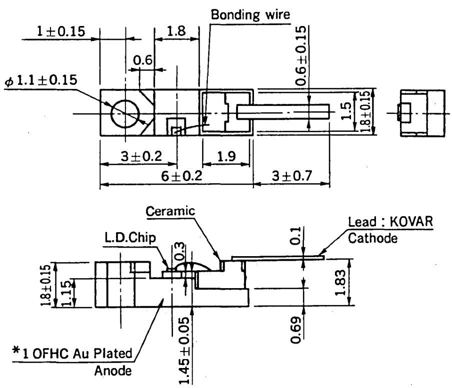
1 310 nm OPTICAL FIBER COMMUNICATIONS InGaAsP DC-PBH LASER DIODE

DESCRIPTION

NDL5009D1 is a 1 310 nm laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.
NEC has two types of laser diode chip on carrier with ribbon lead. One is the D1-type like NDL5009D1, another is a D-type like NDL5009D.

PACKAGE DIMENSIONS

in millimeters



*1 OFHC: Oxygen Free High-Conductivity Copper

FEATURES

- High speed response. ≧ 565 Mb/s
- High output power. P_O = 8 mW TYP. @I_F = I_{th} +30 mA
- Long wavelength. λ_P = 1 310 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle $\theta_\perp \times \theta_{/\!/} = 35° \times 28°$
- Fundamental transverse mode.
- Wide operating temperature range.
- Chip-on-carrier with ribbon lead

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	15	mW
Operating Temperature	T_{op}	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C

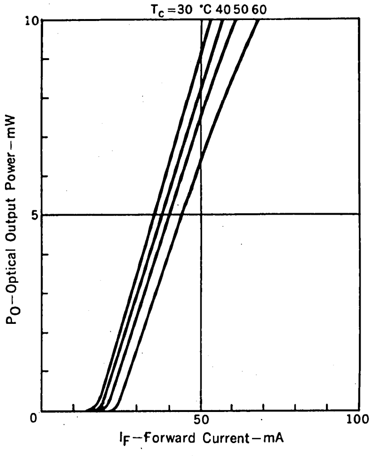
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.9	1.1	1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_O	6.0	8.0		mW	I_F = I_{th} +30 mA
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_O = 10 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 10 mW, FWHM *2
Vertical Beam Angle	$\theta_\perp$		35		deg.	P_O = 10 mW, FAHM *3
Lateral Beam Angle	$\theta_{/\!/}$		28		deg.	P_O = 10 mW, FAHM *3
Cutoff Frequency	f_c	1.2			GHz	I_b = I_{th}×2, −3 dB

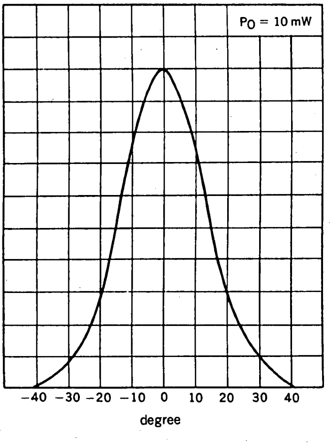
*2 FWHM: Full Width at Half Maximum
*3 FAHM: Full Angle at Half Maximum

TYPICAL CHARACTERISTICS ($T_a = 25\ °C$)

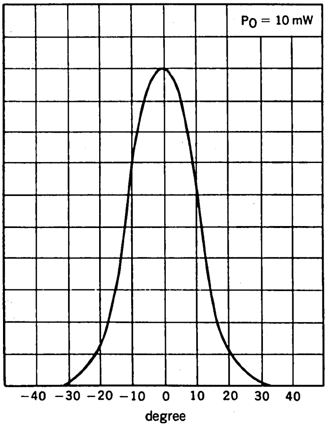
OPTICAL OUTPUT POWER vs. FORWARD CURRENT

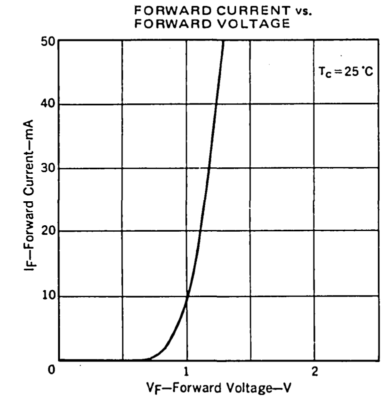


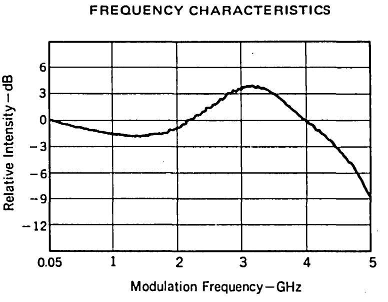
FAR FIELD PATTERN ($\theta_\perp$)

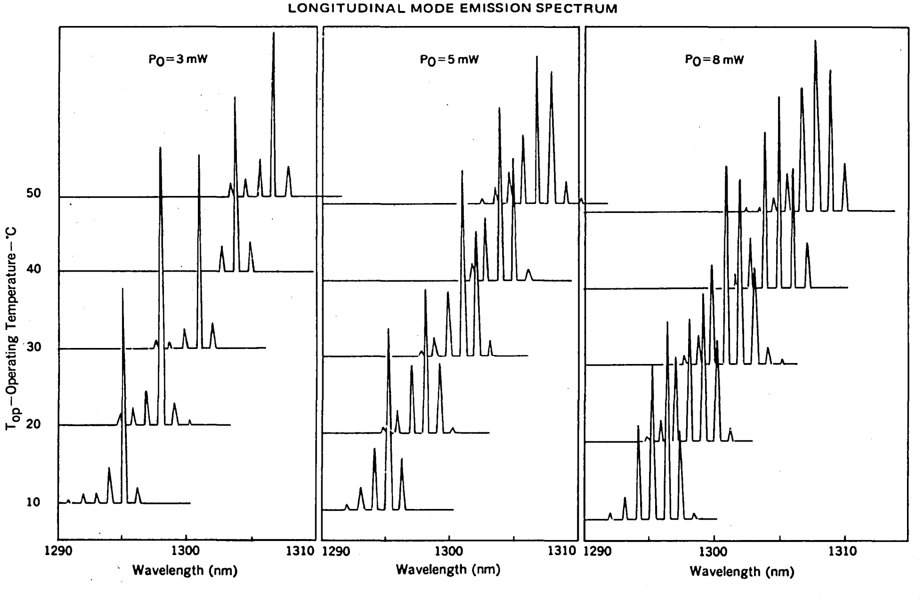


FAR FIELD PATTERN ($\theta_{/\!/}$)




FORWARD CURRENT vs.
FORWARD VOLTAGE
T_c = 25 °C
I_F—Forward Current—mA
V_F—Forward Voltage—V
0
10
20
30
40
50
1
2


FREQUENCY CHARACTERISTICS
Relative Intensity—dB
Modulation Frequency—GHz
6
3
0
−3
−6
−9
−12
0.05
1
2
3
4
5


LONGITUDINAL MODE EMISSION SPECTRUM
P_O = 3 mW
P_O = 5 mW
P_O = 8 mW
T_{op}—Operating Temperature—°C
10
20
30
40
50
1290
1300
1310
Wavelength (nm)

LASER DIODE CHIP ON CARRIER HANDLING PRECAUTION

LASER DIODE CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, FOLLOWING CONDITION SHOULD BE MAINTAINED. (DURING CUSTOMER'S ASSEMBLY PROCESS, THE CONDITION ALSO SHOULD BE APPLIED FOR THE UNSEALED PACKAGE WHICH IS EQUIPPED WITH THE DEVICE.)

STORAGE TEMPERATURE: +20 TO +30 °C
CONTAINER: CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS: AIR OR NITROGEN (DEW POINT: LESS THAN −30 °C)

RECOMMENDABLE STORAGE PERIOD IS AS FOLLOWS.

STORAGE CONDITION	STORAGE DURATION
IN NEC'S CONTAINER BEFORE SEAL BREAK	3 MONTHS MAX.
AFTER SEAL BREAK	1 MONTH MAX.

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE
ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) CHIP FACETS
CLEAN CONDITION OF LASER DIODE CHIP FACETS SHOULD BE KEPT.

2-3) DIE ATTACHMENT
WHEN THE DEVICE IS MOUNTED INTO CUSTOMER'S PACKAGE, THE DEVICE SHOULD BE PREVENTED FROM ANY SCRATCHES, CRACKS, CHIP OUT AND CONTAMINATION ON CHIP SURFACE (TOP AND FACETS).

2-4) ESD PROTECTION
DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

2-5) SOLDERING CONDITION
THE FOLLOWING CONDITIONS SHOULD BE KEPT.
OTHERWISE, THERE IS A POSSIBILITY THAT THERE IS THE INFLUENCE ON ELECTRO-OPTICAL CHARACTERISTICS AND RELIABILITY OF THE DEVICE.

TEMPERATURE: +140 °C MAX.
DURATION: 30 sec. MAX.
ATMOSPHERE: INERT GAS (EX. NITROGEN)

2-6) HERMETIC SEALING
THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec.

NDL5021

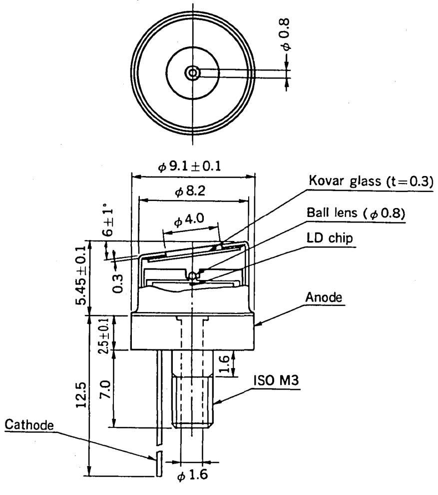
1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LASER DIODE

DESCRIPTION

NDL5021 is a long wavelength laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range. NDL5021 incorporates ball lens and achieves collimated beam.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- Ball lens incorporated.
- High output power. P_O = 5 mW MIN. @ $I_F = I_{th}$ + 25 mA
- Fundamental transverse mode.
- Long wavelength. λ_P = 1 300 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Wide operating temperature range.

2

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage	V_R	2.0	V
Forward Current	I_F	150	mA
Optical Output Power	P_O	10	mW
Operating Case Temperature	T_C	−40 to +60	°C
Storage Temperature	T_{stg}	−55 to +125	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_O	5.0			mW	$I_F = I_{th}$ +25 mA
Monitor Output Power	P_m	0.5			mW	P_O = 5.0 mW
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	P_O = 5.0 mW
Half Power Spectral Width	$\Delta\lambda$			4.0	nm	P_O = 5.0 mW
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

LASER DIODE

NDL5050A

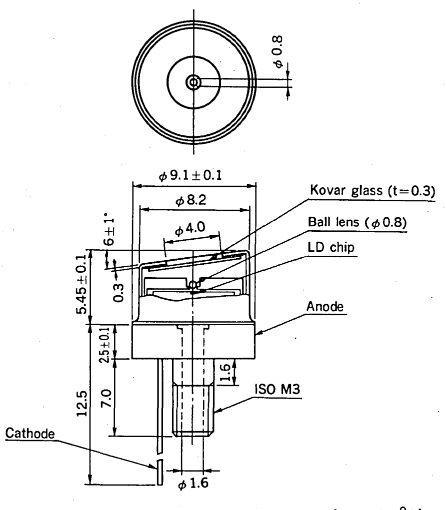
1 550 nm OPTICAL FIBER COMMUNICATIONS InGaAsP DOUBLE HETERO STRUCTURE LASER DIODE

DESCRIPTION

NDL5050A is a long wavelength laser diode especially designed for long distance high capacity transmission systems. The DC-PBH (Double Channel Planar Buried Hetero structure) can achieve stable fundamental oscillation in wide temperature range. The NDL5050A incorporates ball lens and achieves collimated beam.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High output power. P_O = 5 mW TYP. @ $I_F = I_{th}$ + 30 mA
- Fundamental transverse mode.
- Ball lens incorporated.
- Wide operating temperature range.
- Long wavelength. λ_P = 1 550 nm
- Low threshold current. I_{th} = 40 mA TYP.

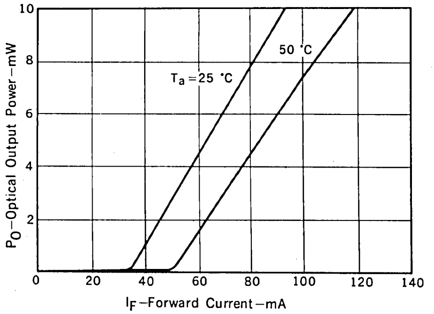
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

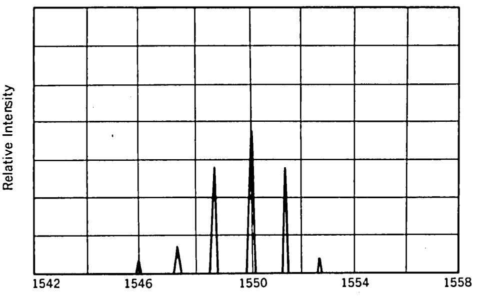
Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	10	mW
Operating Case Temperature	T_C	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.2	1.5	V	I_F = 30 mA
Threshold Current	I_{th}		40	60	mA	
Optical Output Power	P_O	3.0	5.0		mW	$I_F = I_{th}$ +30 mA
Monitor Output Power	P_m	0.3	0.8		mW	P_O = 3.0 mW
Peak Emission Wavelength	λ_P	1520	1550	1580	nm	P_O = 3.0 mW
Half Power Spectral Width	$\Delta\lambda$		4.0	8.0	nm	P_O = 3.0 mW
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)





2

o

LASER DIODE

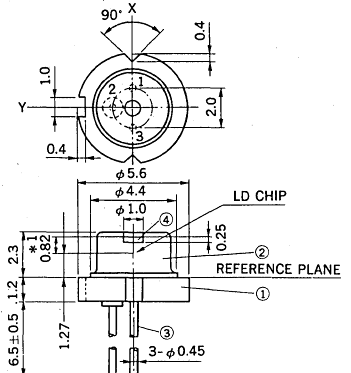
NDL5080

1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LASER DIODE

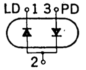
DESCRIPTION

NDL5080 is a 1 310 nm laser diode especially designed for optical data communications. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.
NEC has two types of small-packaged laser diodes. One is the NDL5080, another is a NDL5081 that has reverse pin connection of the NDL5080.

PACKAGE DIMENSIONS (Unit : mm)



PIN CONNECTION



COMMON (HEAT SINK)

①	STEM
②	CAP
③	LEAD
④	CAP GLASS *2

*1 OPTICAL LENGTH
*2 n = 1.48 BOLOSILICATE GLASS

FEATURES

- Long wavelength. λ_P = 1 310 nm
- Small package. φ 5.6 mm
- Fundamental transverse mode.
- Wide operating temperature range.
- Negative bias application

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage of LD	V_R	2.0	V
Optical Output Power	P_O	5	mW
Operating Case Temperature	T_c	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +125	°C
Forward Current of PD	I_F	10	mA
Reverse Voltage of PD	V_R	15	V

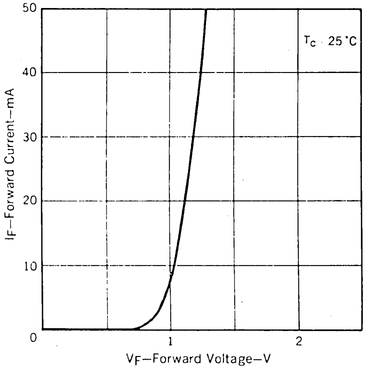
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		0	1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	50	mA	
Peak Emission Wavelength	λ_P	1270	1310	1350	nm	P_O = 3 mW
Half Power Spectral Width	$\Delta\lambda$		3.0	30	nm	P_O = 3 mW, FWHM *
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %
Monitor Current of PD	I_m	150	500		μA	V_R = 6 V, P_O = 3 mW
Dark Current of PD	I_D		0.5	3	μA	V_R = 6 V

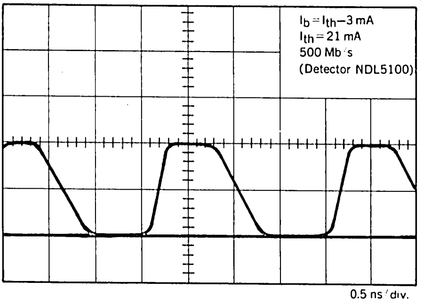
* FWHM : Full Width at Half Maximum

TYPICAL CHARACTERISTICS ($T_a = 25$ °C)

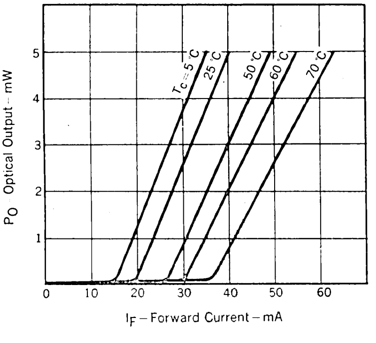
FORWARD CURRENT vs. FORWARD VOLTAGE



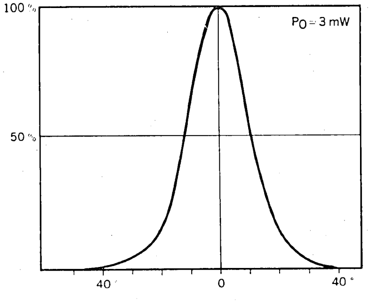
PULSE RESPONCE



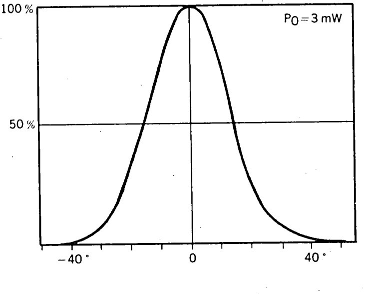
FORWARD CURRENT vs. OPTICAL OUTPUT



FAR FIELD PATTERN ($\theta_{//}$)

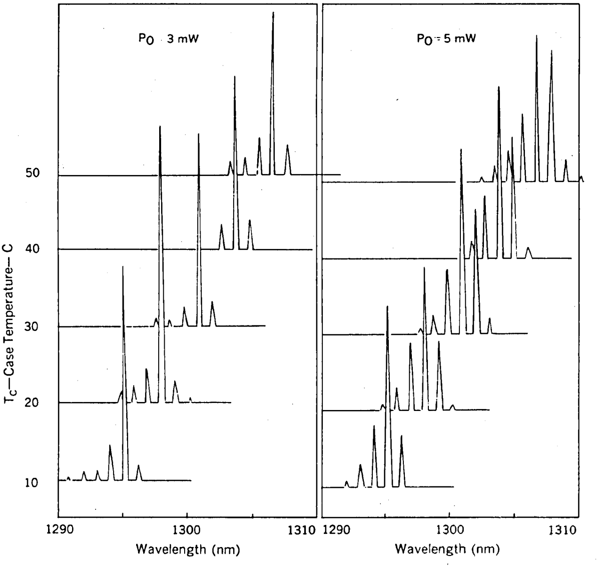


FAR FIELD PATTERN ($\theta_{\perp}$)



2

LONGITUDINAL MODE EMISSION SPECTRUM



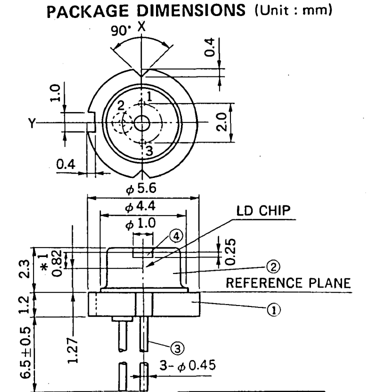
1 310 nm OPTICAL FIBER COMMUNICATIONS InGaAsP DOUBLE HETEROSTRUCTURE LASER DIODE

DESCRIPTION

NDL5081 is a 1 310 nm laser diode especially designed for optical data communications. The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.

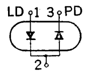
NEC has two types of small-packaged laser diodes. One is the NDL5081, another is a NDL5080 that has reverse pin connection of the NDL5081.

PACKAGE DIMENSIONS (Unit : mm)



①	STEM
②	CAP
③	LEAD
④	CAP GLASS *2

PIN CONNECTION



COMMON (HEAT SINK)

*1 OPTICAL LENGTH
*2 n = 1.48 BOLOSILICATE GLASS

FEATURES

- Long wavelength. λ_P = 1 310 nm
- Small package. ϕ 5.6 mm
- Fundamental transverse mode.
- Wide operating temperature range.
- Positive bias application

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

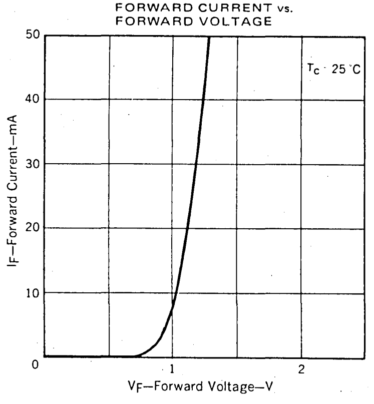
Reverse Voltage of LD	V_R	2.0	V
Optical Output Power	P_O	5	mW
Operating Case Temperature	T_c	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C
Forward Current of PD	I_F	10	mA
Reverse Voltage of PD	V_R	15	V

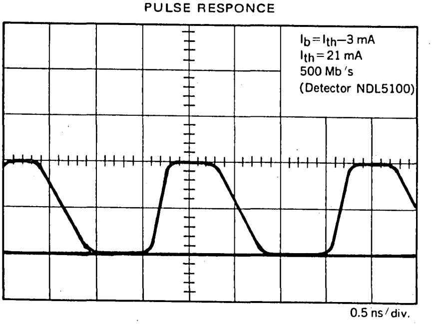
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

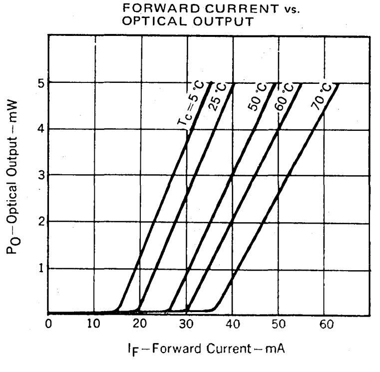
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	50	mA	
Peak Emission Wavelength	λ_P	1270	1310	1350	nm	P_O = 3 mW
Half Power Spectral Width	$\Delta\lambda$		3.0	30	nm	P_O = 3 mW, FWHM *
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %
Monitor Current of PD	I_m	150	500		μA	V_R = 6 V, P_O = 3 mW
Dark Current of PD	I_D		0.5	3	μA	V_R = 6 V

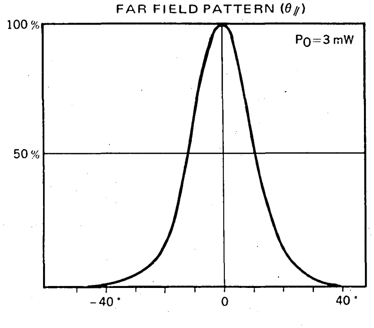
* FWHM : Full Width at Half Maximum

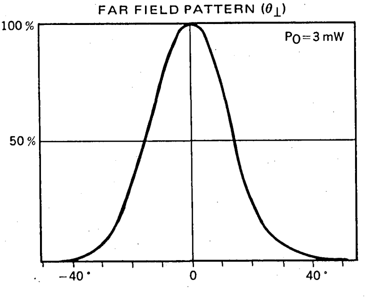
TYPICAL CHARACTERISTICS (T_a = 25 °C)



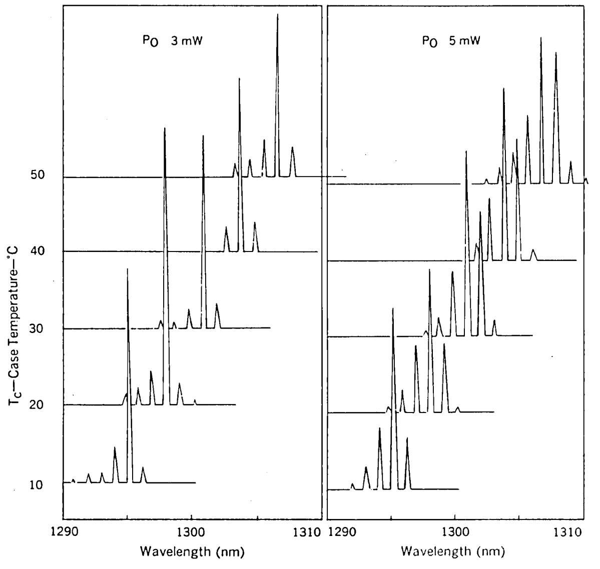








LONGITUDINAL MODE EMISSION SPECTRUM



LASER DIODE MODULE
NDL5707P

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DC-PBH LASER DIODE MODULE

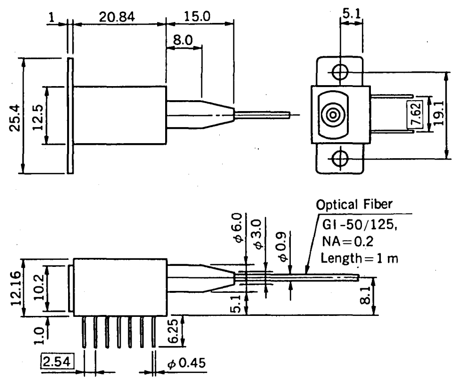
DESCRIPTION

NDL5707P is a 1 300 nm laser diode DIP module with multimode fiber and internal thermo-electric cooler. It is designed for a light source of up to 400 Mb/s long-distance transmission systems.

In addition, it incorporates lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High output power. P_f = 3.0 mW
- High speed. t_r = 0.5 ns, t_f = 0.7 ns
- Low threshold current. I_{th} = 20 mA
- Long wavelength. λ_P = 1 300 nm
- Internal thermo-electric cooler.
- Hermetically sealed 14 pin Dual-In-Line Package.
- Multimode fiber pigtail.
- Wide operating temperature range.
- High reliability.

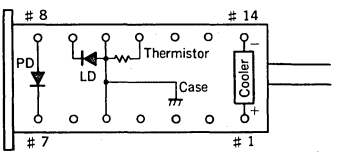
PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	COOLER ANODE	8	PD ANODE
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND, and THERMISTOR
4	NC		
5	LASER ANODE, CASE GROUND, and THERMISTOR	11	THERMISTOR
		12	NC
6	NC	13	NC
7	PD CATHODE	14	COOLER CATHODE

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Operating Case Temperature	T_c	−20 to +65	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Lead Soldering Temperature (10 s)	T_s	260	°C
Forward Current of LD	I_F	I_{th}+50	mA
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

BOTTOM VIEW



ELECTRO-OPTICAL CHARACTERISTICS (T_{LD} = 25 °C, T_c = −20 °C to +65 °C)

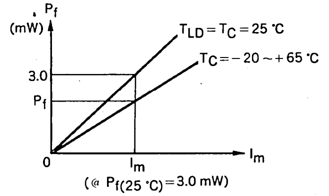
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}		20	35	mA	
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Optical Output Power from Fiber	P_f	2.25	3.0		mW	$I_F = I_{th}$+30 mA
Spontaneous Emission Power from Fiber	P_s			150	μW	$I_F = I_{th}$
Peak Emission Wavelength	λ_P	1280	1300	1330	nm	P_f = 3.0 mW
Spectral Width	$\Delta\lambda$		2.0		nm	P_f = 3.0 mW
Differential Quantum Efficiency from Fiber	DQE	0.075	0.1		mW/mA	$I_{th} \leqq I_F \leqq I_{th}$+30 mA
Rise Time	t_r		0.5	1.0	ns	10 − 90 %
Fall Time	t_f		0.7	1.0	ns	90 − 10 %

ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Monitor PD : T_{LD} = 25 °C, T_c = −20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Monitor Current	I_m	150		500	μA	V_R = 5 V, P_f = 3.0 mW
Rise Time	t_r		3	5	ns	V_R = 5 V, R_L = 100 Ω
Fall Time	t_f		5	8	ns	V_R = 5 V, R_L = 100 Ω
Dark Current	I_D			1.0	μA	V_R = 5 V
Tracking Error	γ *1			0.5	dB	I_m = const.

*1 Tracking Error : γ

$$\gamma = \left| 10 \log \frac{P_f}{3.0\ \text{mW}} \right|$$



ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Thermistor and TE Cooler : T_{LD} = 25 °C, T_c = −20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Thermistor Resistance	R *2	9.5	10	10.5	kΩ	T_{LD} = 25 °C
Cooler Current	I_c		0.6	1.0	A	ΔT = 40 K
Cooler Voltage	V_c		1.1	1.5	V	ΔT = 40 K
Cooling Capacity	ΔT *3	40			K	I_C = 1.0 A, P_f = 3.0 mW

*2 B Constant (= 3 400±100 K)

*3 $\Delta T = |T_c - T_{LD}|$

2

LASER DIODE MODULE
NDL5717P

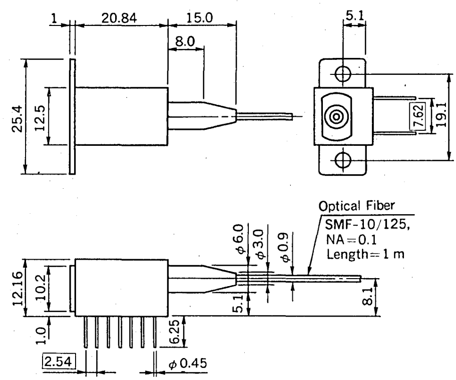
1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DC-PBH LASER DIODE MODULE

DESCRIPTION

NDL5717P is a 1 310 nm laser diode DIP module with singlemode fiber and internal thermo-electric cooler. It is designed for a light source of up to 400 Mb/s long-distance transmission systems.

In addition, it incorporates lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range.

PACKAGE DIMENSIONS
in millimeters



FEATURES

- High output power. P_f = 2.0 mW
- High speed. t_r = 0.5 ns, t_f = 0.7 ns
- Low threshold current. I_{th} = 20 mA
- Long wavelength. λ_P = 1 310 nm
- Internal thermo-electric cooler.
- Hermetically sealed 14 pin Dual-In-Line Package.
- Singlemode fiber pigtail.
- Wide operating temperature range.
- High reliability.

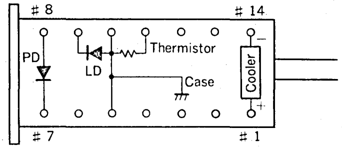
PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	COOLER ANODE	8	PD ANODE
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND, and THERMISTOR
4	NC		
5	LASER ANODE, CASE GROUND, and THERMISTOR	11	THERMISTOR
		12	NC
6	NC	13	NC
7	PD CATHODE	14	COOLER CATHODE

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Operating Case Temperature	T_c	−20 to +65	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Lead Soldering Temperature (10 s)	T_s	260	°C
Forward Current of LD	I_F	I_{th}+50	mA
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

BOTTOM VIEW



ELECTRO-OPTICAL CHARACTERISTICS (T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}		20	35	mA	
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Optical Output Power from Fiber	P_f	1.0	2.0		mW	$I_F = I_{th}$+30 mA
Spontaneous Emission Power from Fiber	P_s			40	μW	$I_F = I_{th}$
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_f = 1.0 mW
Spectral Width	$\Delta\lambda$		2.0		nm	P_f = 1.0 mW
Differential Quantum Efficiency from Fiber	DQE	0.033	0.1		mW/mA	$I_{th} \leqq I_F \leqq I_{th}$+30 mA
Rise Time	t_r		0.5	1.0	ns	10 – 90 %
Fall Time	t_f		0.7	1.0	ns	90 – 10 %

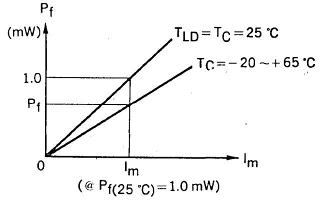
ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Monitor PD : T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Monitor Current	I_m	150		500	μA	V_R = 5 V, P_f = 1.0 mW
Rise Time	t_r		3	5	ns	V_R = 5 V, R_L = 100 Ω
Fall Time	t_f		5	8	ns	V_R = 5 V, R_L = 100 Ω
Dark Current	I_D			1.0	μA	V_R = 5 V
Tracking Error	γ *1			0.5	dB	I_m = const.

2

*1 Tracking Error : γ

$$\gamma = \left| 10 \log \frac{P_f}{1.0 \text{ mW}} \right|$$



ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Thermistor and TE Cooler : T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Thermistor Resistance	R *2	9.5	10	10.5	kΩ	T_{LD} = 25 °C
Cooler Current	I_c		0.6	1.0	A	ΔT = 40 K
Cooler Voltage	V_c		1.1	1.5	V	ΔT = 40 K
Cooling Capacity	ΔT *3	40			K	I_C = 1.0 A, P_f = 1.0 mW

*2 B Constant (= 3 400±100 K)

*3 $\Delta T = |T_c - T_{LD}|$

LASER DIODE MODULE
NDL5730P

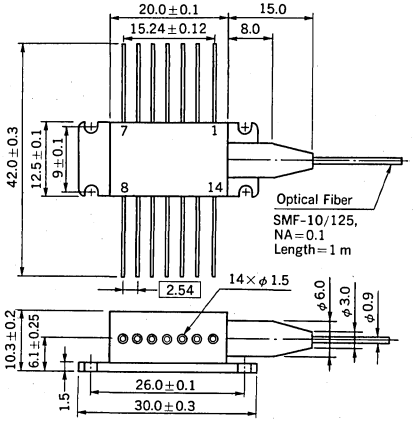
1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DC-PBH LASER DIODE MODULE

DESCRIPTION

NDL5730P is a 1 310 nm laser diode Butterfly Package module with singlemode fiber and internal thermo-electric cooler. It is designed for a light source of up to 1.2 Gb/s long-distance transmission systems.
In addition, it incorporates lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High speed. $t_r = 0.2$ ns, $t_f = 0.3$ ns
- High output power. $P_f = 2.0$ mW
- Low threshold current. $I_{th} = 20$ mA
- Long wavelength. $\lambda_P = 1\,310$ nm
- Internal thermo-electric cooler.
- Hermetically sealed 14 pin Butterfly Package.
- Singlemode fiber pigtail.
- Wide operating temperature range.
- High reliability.

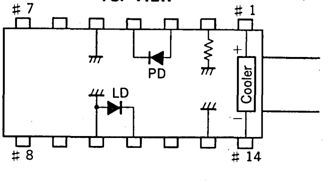
ABSOLUTE MAXIMUM RATINGS ($T_a = 25\ °C$)

Operating Case Temperature	T_c	–20 to +65	°C
Storage Temperature	T_{stg}	–40 to +70	°C
Lead Soldering Temperature (10 s)	T_s	260	°C
Forward Current of LD	I_F	I_{th}+50	mA
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

PIN CONNECTION

PIN No.	FUNCTION	PIN No.	FUNCTION
1	COOLER ANODE	8	NC
2	THERMISTOR	9	NC
3	PD ANODE	10	LD ANODE, CASE GROUND
4	PD CATHODE	11	LD CATHODE
5	CASE GROUND	12	NC
6	NC	13	CASE GROUND
7	NC	14	COOLER CATHODE

TOP VIEW



ELECTRO-OPTICAL CHARACTERISTICS (T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

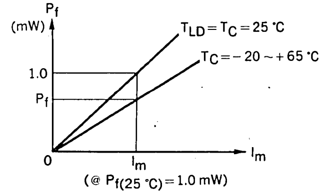
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}		20	35	mA	
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Optical Output Power from Fiber	P_f	1.0	2.0		mW	$I_F = I_{th}$+30 mA
Spontaneous Emission Power from Fiber	P_s			40	μW	$I_F = I_{th}$
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_f = 1.0 mW
Spectral Width	$\Delta\lambda$		2.0		nm	P_f = 1.0 mW
Differential Quantum Efficiency from Fiber	DQE	0.033	0.1		mW/mA	$I_{th} \leqq I_F \leqq I_{th}$+30 mA
Rise Time	t_r		0.2	0.3	ns	10 – 90 %
Fall Time	t_f		0.3	0.5	ns	90 – 10 %

ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Monitor PD : T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Monitor Current	I_m	150		500	μA	V_R = 5 V, P_f = 1.0 mW
Rise Time	t_r		3	5	ns	V_R = 5 V, R_L = 100 Ω
Fall Time	t_f		5	8	ns	V_R = 5 V, R_L = 100 Ω
Dark Current	I_D			1.0	μA	V_R = 5 V
Tracking Error	γ *1			0.5	dB	I_m = const.

*1 Tracking Error : γ

$$\gamma = \left| 10 \log \frac{P_f}{1.0\ \text{mW}} \right|$$



ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Thermistor and TE Cooler : T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Thermistor Resistance	R *2	9.5	10	10.5	kΩ	T_{LD} = 25 °C
Cooler Current	I_c		0.6	1.0	A	ΔT = 40 K
Cooler Voltage	V_c		1.1	1.5	V	ΔT = 40 K
Cooling Capacity	ΔT *3	40			K	I_C = 1.0 A, P_f = 1.0 mW

*2 B Constant (= 3 400±100 K)

*3 $\Delta T = |T_c - T_{LD}|$

LASER DIODE MODULE
NDL5731P

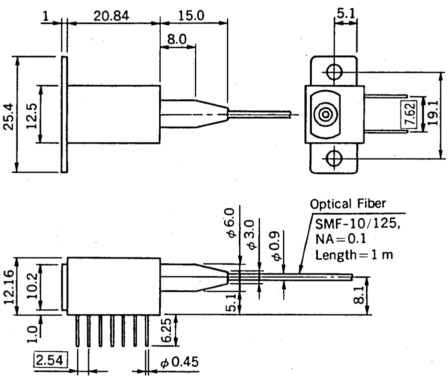
1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DC-PBH LASER DIODE MODULE

DESCRIPTION

NDL5731P is a 1 310 nm laser diode DIP module with singlemode fiber and internal thermo-electric cooler. It is designed for a light source of up to 800 Mb/s long-distance transmission systems.
In addition, it incorporates lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range.

PACKAGE DIMENSIONS

in millimeters



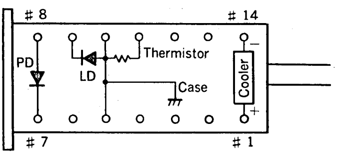
FEATURES

- High speed. $t_r = 0.3$ ns, $t_f = 0.4$ ns
- High output power. $P_f = 2.0$ mW
- Low threshold current. $I_{th} = 20$ mA
- Long wavelength. $\lambda_P = 1\,310$ nm
- Internal thermo-electric cooler.
- Hermetically sealed 14 pin Dual-In-Line Package.
- Singlemode fiber pigtail.
- Wide operating temperature range.
- High reliability.

PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	COOLER ANODE	8	PD ANODE
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND, and THERMISTOR
4	NC	11	THERMISTOR
5	LASER ANODE, CASE GROUND, and THERMISTOR	12	NC
6	NC	13	NC
7	PD CATHODE	14	COOLER CATHODE

BOTTOM VIEW



ABSOLUTE MAXIMUM RATINGS ($T_a = 25\,^\circ C$)

Operating Case Temperature	T_c	−20 to +65	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Lead Soldering Temperature (10 s)	T_s	260	°C
Forward Current of LD	I_F	I_{th}+50	mA
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

ELECTRO-OPTICAL CHARACTERISTICS (T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

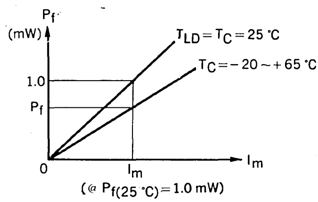
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}		20	35	mA	
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Optical Output Power from Fiber	P_f	1.0	2.0		mW	$I_F = I_{th}$+30 mA
Spontaneous Emission Power from Fiber	P_s			40	μW	$I_F = I_{th}$
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_f = 1.0 mW
Spectral Width	$\Delta\lambda$		2.0		nm	P_f = 1.0 mW
Differential Quantum Efficiency from Fiber	DQE	0.033	0.1		mW/mA	$I_{th} \leqq I_F \leqq I_{th}$+30 mA
Rise Time	t_r		0.3	0.4	ns	10 – 90 %
Fall Time	t_f		0.4	0.5	ns	90 – 10 %

ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Monitor PD:T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Monitor Current	I_m	150		500	μA	V_R = 5 V, P_f = 1.0 mW
Rise Time	t_r		3	5	ns	V_R = 5 V, R_L = 100 Ω
Fall Time	t_f		5	8	ns	V_R = 5 V, R_L = 100 Ω
Dark Current	I_D			1.0	μA	V_R = 5 V
Tracking Error	γ *1			0.5	dB	I_m = const.

*1 Tracking Error : γ

$$\gamma = \left| 10 \log \frac{P_f}{1.0\ \text{mW}} \right|$$



ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Thermistor and TE Cooler:T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Thermistor Resistance	R *2	9.5	10	10.5	kΩ	T_{LD} = 25 °C
Cooler Current	I_c		0.6	1.0	A	ΔT = 40 K
Cooler Voltage	V_c		1.1	1.5	V	ΔT = 40 K
Cooling Capacity	ΔT *3	40			K	I_C = 1.0 A, P_f = 1.0 mW

*2 B Constant (= 3 400±100 K)

*3 $\Delta T = \left| T_c - T_{LD} \right|$

LASER DIODE
NDL5735P

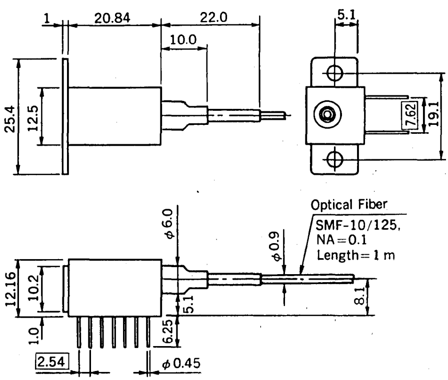
1 300 nm OPTICAL FIBER COMMUNICATIONS InGaAsP DC-PBH LASER DIODE MODULE

DESCRIPTION

NDL5735P is a 1 300 nm laser diode DIP module with singlemode fiber without thermo-electric cooler. It incorporates InGaAs monitor photo diode that achieves low dark current. It is designed for a light source of up to 400 Mb/s long-distance transmission systems.

In addition, it incorporates lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range (0 to 60 °C) without thermo-electric cooler.

PACKAGE DIMENSIONS
in millimeters



FEATURES

- Optical output power from fiber. P_f = 0.7 mW
- Long wavelength. λ_P = 1 300 nm
- Low threshold current. I_{th} = 20 mA
- Wide operating temperature range.
- Hermetically sealed 14 pin Dual In-Line Package.
- Singlemode fiber pigtail.
- Internal InGaAs monitor PD.

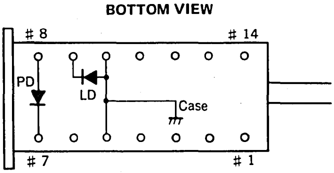
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Operating Case Temperature	T_c	0 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Lead Soldering Temperature (10 s)	T_s	260	°C
Forward Current of LD	I_F	I_{th}+50	mA
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	10	mA
Reverse Voltage of PD	V_R	20	V

PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	NC	8	PD ANODE
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND
4	NC	11	NC
5	LASER ANODE, CASE GROUND	12	NC
6	NC	13	NC
7	PD CATHODE	14	NC

BOTTOM VIEW



ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

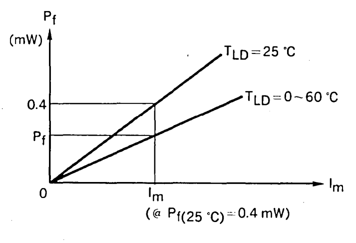
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}		20	35	mA	
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Optical Output Power from Fiber	P_f	0.4	0.7		mW	$I_F = I_{th}$+20 mA
Spontaneous Emission Power from Fiber	P_s			15	μW	$I_b = I_{th}$
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	P_f = 0.4 mW
Spectral Width	$\Delta\lambda$			6.0	nm	P_f = 0.4 mW
Rise Time	t_r		0.5	1.0	ns	10 – 90 %
Fall Time	t_f		0.7	1.0	ns	90 – 10 %
Monitor Current of PD	I_m	150	400	800	μA	V_R = 5 V, P_f = 0.4 mW
Dark Current of PD	I_D		1.0	10	nA	V_R = 5 V

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 0 °C to +60 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}			60	mA	
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Optical Output Power from Fiber	P_f	0.3			mW	$I_F = I_{th}$+20 mA
Spontaneous Emission Power from Fiber	P_s			20	μW	$I_b = I_{th}$
Peak Emission Wavelength	λ_P	1260		1345	nm	P_f = 0.4 mW
Temperature Dependence of Peak Emission Wavelength	$\Delta\lambda_p/\Delta T_a$		0.35		nm/°C	
Spectral Width	$\Delta\lambda$			10	nm	P_f = 0.4 mW
Rise Time	t_r		0.5	1.0	ns	10 – 90 %
Fall Time	t_f		0.7	1.0	ns	90 – 10 %
Monitor Current of PD	I_m	150			μA	V_R = 5 V, P_f = 0.4 mW
Dark Current of PD	I_D		10	100	nA	V_R = 5 V, T_a = 60 °C
Tracking Error	γ *1			1.0	dB	I_m = const.

*1 Tracking Error : γ

$$\gamma = \left| 10 \log \frac{P_f}{0.4\ \text{mW}} \right|$$



2

LASER DIODE
NDL5736P

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DC-PBH LASER DIODE MODULE

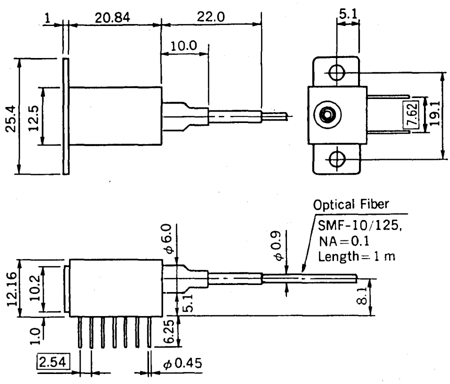
DESCRIPTION

NDL5736P is a 1 300 nm laser diode DIP module with singlemode fiber without thermo-electric cooler. It incorporates InGaAs monitor photo diode that achieves low dark current. It is designed for a light source of up to 400 Mb/s long-distance transmission systems.

In addition, it incorporates lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range (0 to 60 °C) without thermo-electric cooler.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- Optical output power from fiber. P_f = 0.2 mW
- Long wavelength. λ_P = 1 300 nm
- Low threshold current. I_{th} = 20 mA
- Wide operating temperature range.
- Hermetically sealed 14 pin Dual In-Line Package.
- Singlemode fiber pigtail.
- Internal InGaAs monitor PD.

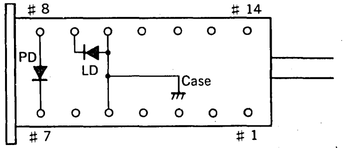
PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	NC	8	PD ANODE
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND
4	NC		
5	LASER ANODE, CASE GROUND	11	NC
		12	NC
6	NC	13	NC
7	PD CATHODE	14	NC

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Operating Case Temperature	T_c	0 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Lead Soldering Temperature (10 s)	T_s	260	°C
Forward Current of LD	I_F	I_{th}+50	mA
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	10	mA
Reverse Voltage of PD	V_R	20	V

BOTTOM VIEW



ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

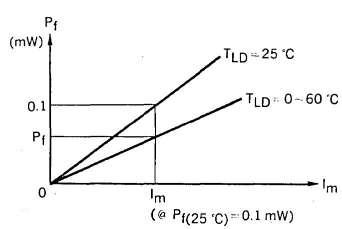
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}		20	35	mA	
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Optical Output Power from Fiber	P_f	0.1	0.2		mW	$I_F = I_{th}$+20 mA
Spontaneous Emission Power from Fiber	P_s			10	μW	$I_b = I_{th}$
Peak Emission Wavelength	λp	1270	1300	1330	nm	P_f = 0.1 mW
Spectral Width	$\Delta\lambda$			6.0	nm	P_f = 0.1 mW
Rise Time	t_r		0.5	1.0	ns	10 – 90 %
Fall Time	t_f		0.7	1.0	ns	90 – 10 %
Monitor Current of PD	I_m	150	400	800	μA	V_R = 5 V, P_f = 0.1 mW
Dark Current of PD	I_D		1.0	10	nA	V_R = 5 V

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 0 °C to +60 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}			60	mA	
Forward Voltage	V_F			1.3	V	I_F = 30 mA
Optical Output Power from Fiber	P_f	0.07			mW	$I_F = I_{th}$+20 mA
Spontaneous Emission Power from Fiber	P_s			12	μW	$I_b = I_{th}$
Peak Emission Wavelength	λp	1260		1345	nm	P_f = 0.1 mW
Temperature Dependence of Peak Emission Wavelength	$\Delta\lambda p/\Delta T_a$		0.35		nm/°C	
Spectral Width	$\Delta\lambda$			10	nm	P_f = 0.1 mW
Rise Time	t_r		0.5	1.0	ns	10 – 90 %
Fall Time	t_f		0.7	1.0	ns	90 – 10 %
Monitor Current	I_m	150			μA	V_R = 5 V, P_f = 0.1 mW
Dark Current of PD	I_D		10	100	nA	V_R = 5 V, T_a = 60 °C
Tracking Error of PD	γ *1			1.0	dB	I_m = const., T_{LD} = 0 ~ 60 °C

*1 Tracking Error : γ

$$\gamma = \left| 10 \log \frac{P_f}{0.1\ \text{mW}} \right|$$



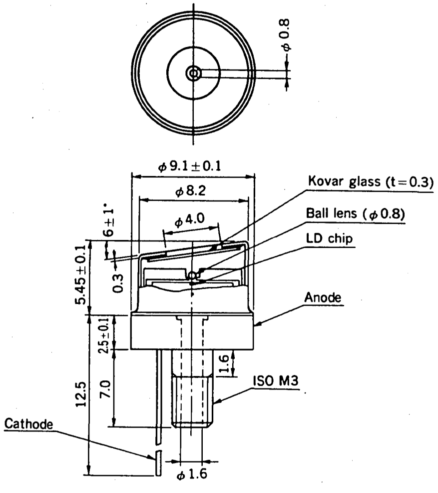
LASER DIODE
NDL5060

1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE PULSED LASER DIODE

DESCRIPTION

NDL5060 is a 1 310 nm pulsed laser diode especially designed for optical measurement equipment (OTDR). The CD-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.
It incorporates ball lens and achieves collimated beam for easy optical coupling.

PACKAGE DIMENSIONS
in millimeters



FEATURES

- High output power. P_P = 50 mW MIN. @I_{FP} = 250 mA *
- Long wavelength. λ_P = 1 310 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Internal ball lens.
- Wide operating temperature range.

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage	V_R	2.0	V
Pulse Forward Current *	I_{FP}	400	mA
Operating Case Temperature	T_c	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +125	°C

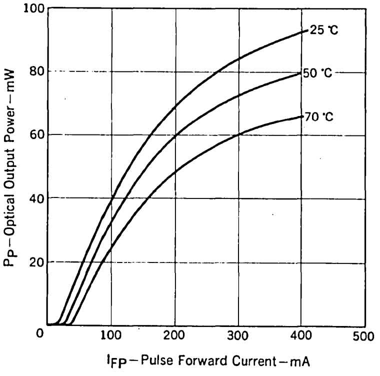
* Pulse Condition : PW (Pulse Width) = 1 μs, Duty = 1 %

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

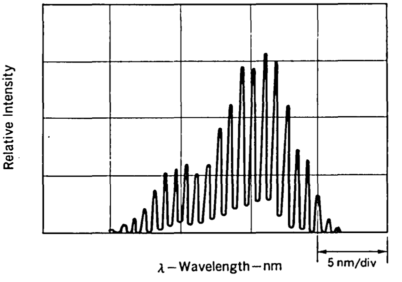
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.0	1.5	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_P	50			mW	I_{FP} = 250 mA, PW = 1 μs, Duty = 1 %
Center Wavelength	λ_0	1290	1310	1330	nm	I_{FP} = 250 mA, PW = 1 μs, Duty = 1 %
Half Power Spectral Width	$\Delta\lambda$			10	nm	I_{FP} = 250 mA, PW = 1 μs, Duty = 1 %
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)

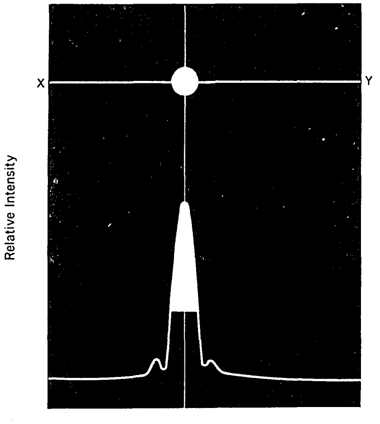
OPTICAL OUTPUT POWER vs. PULSE FORWARD CURRENT



LONGITUDINAL MODE



BEAM PROFILE



X–Y Beam Profile

2

LASER DIODE
NDL5061

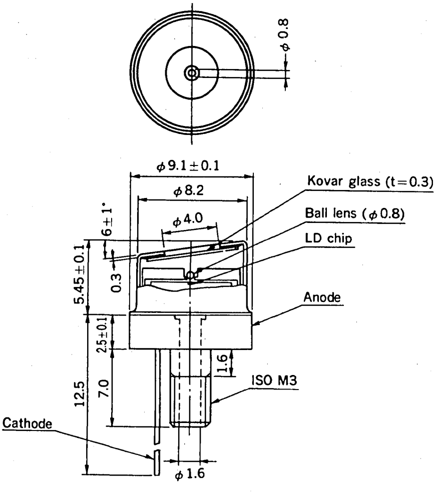
1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE PULSED LASER DIODE

DESCRIPTION

NDL5061 is a 1 310 nm pulsed laser diode especially designed for optical measurement equipment (OTDR). The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.
It incorporates ball lens and achieves collimated beam for easy optical coupling.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High output power. P_P = 90 mW MIN. @I_{FP} = 400 mA *
- Long wavelength. λ_P = 1 310 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Internal ball lens.
- Wide operating temperature range.

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage	V_R	2.0	V
Pulse Forward Current *	I_{FP}	600	mA
Operating Case Temperature	T_c	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +125	°C

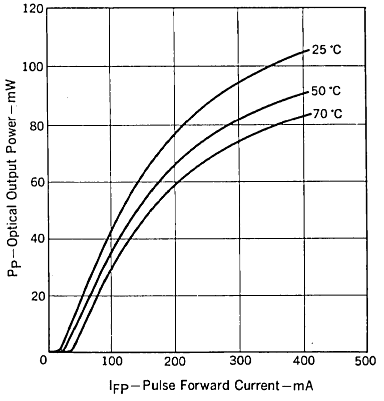
* Pulse Condition : PW (Pulse Width) = 1 μs, Duty = 1 %

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

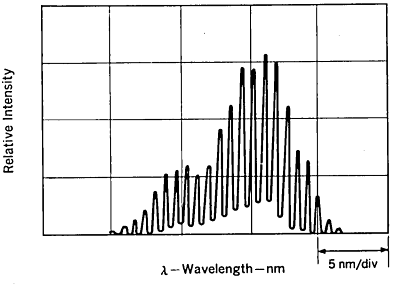
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.0	1.5	V	I_F = 30 mA
Threshold Current	I_{th}		20	35	mA	
Optical Output Power	P_P	90			mW	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Center Wavelength	λ_0	1290	1310	1330	nm	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Half Power Spectral Width	$\Delta\lambda$			10	nm	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)

OPTICAL OUTPUT POWER vs. PULSE FORWARD CURRENT

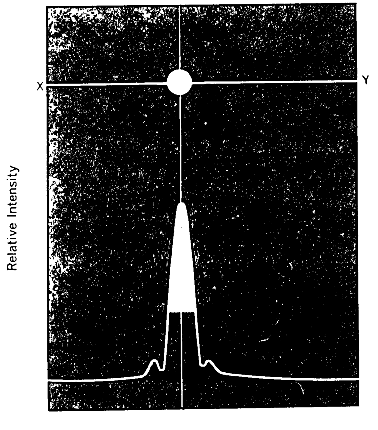


LONGITUDINAL MODE



2

BEAM PROFILE



X—Y Beam Profile

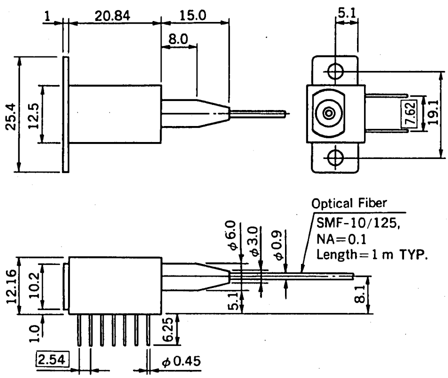
LASER DIODE MODULE
NDL5762P

1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DC-PBH PULSED LASER DIODE MODULE

DESCRIPTION

NDL5762P is a 1 310 nm pulsed laser diode DIP module with singlemode fiber and internal thermo-electric cooler. It is designed for a light source of optical measurement equipment (OTDR) and optical transmission systems.
In addition, it incorporates a lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range.

PACKAGE DIMENSIONS
in millimeters



FEATURES

- High output power. $P_f = 30$ mW TYP. @$I_{FP} = 400$ mA *1
- Long wavelength $\lambda_0 = 1\,310$ nm
- Internal thermo-electric cooler.
- Hermetically sealed 14 pin Dual-In-Line Package.
- Singlemode fiber pigtail.
- High reliability.

ABSOLUTE MAXIMUM RATINGS ($T_a = 25$ °C)

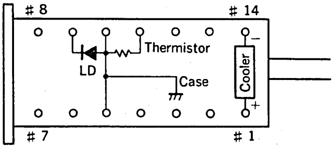
Pulsed Forward Current *1	I_{FP}	600	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	0 to +60	°C
Storage Temperature	T_{stg}	–40 to +70	°C
Lead Soldering Temperature (10 s)	T_{sld}	260	°C

*1 Pulse Condition: Pulse Width = 1 μs, Duty = 1 %

PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	COOLER ANODE	8	NC
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND and THERMISTOR
4	NC		
5	LASER ANODE, CASE GROUND and THERMISTOR	11	THERMISTOR
		12	NC
6	NC	13	NC
7	NC	14	COOLER CATHODE

BOTTOM VIEW



ELECTRO-OPTICAL CHARACTERISTICS (T_{LD} = 25 °C, T_c = 0 to +60 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
DC Forward Voltage	V_F			1.5	V	I_F = 30 mA
DC Threshold Current	I_{th}		20	35	mA	
Optical Output Power from Fiber	P_f	20	30		mW	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Center Wavelength	λ_0	1290	1310	1330	nm	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Spectral Width	$\Delta\lambda$			20	nm	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
P_f Rise Time	t_r		0.5	1.0	ns	10 – 90 %
P_f Fall Time	t_f		0.7	1.0	ns	90 – 10 %

ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Thermistor and TE Cooler: T_{LD} = 25 °C, T_c = 0 to +60 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Thermistor Resistance	R*2	9.5	10	10.5	kΩ	T_{LD} = 25 °C
Cooler Current	I_c		0.6	1.0	A	ΔT = 40 K
Cooler Voltage	V_c		1.1	1.5	V	ΔT = 40 K
Cooling Capacity	ΔT*3	40			K	I_C = 1.0 A

*2 B Constant (= 3 400±100 K)
*3 $\Delta T = |T_c - T_{LD}|$

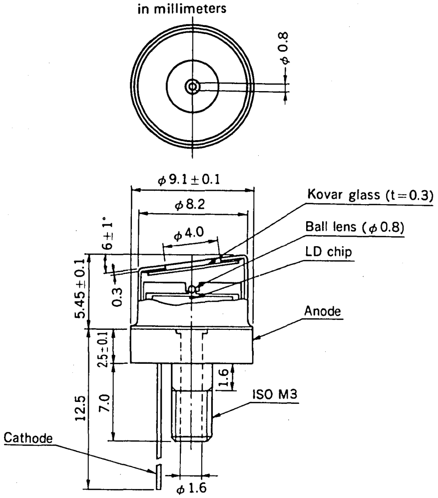
LASER DIODE
NDL5070

1 550 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE PULSED LASER DIODE

DESCRIPTION

NDL5070 is a 1 550 nm pulsed laser diode especially designed for optical measurement equipment (OTDR). The DC·PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.
It incorporates ball lens and achieves collimated beam for easy optical coupling.

PACKAGE DIMENSIONS
in millimeters



FEATURES

- High output power. P_P = 30 mW MIN. @I_{FP} = 250 mA *
- Long wavelength. λ_P = 1 550 nm
- Low threshold current. I_{th} = 40 mA TYP.
- Internal ball lens.
- Wide operating temperature range.

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

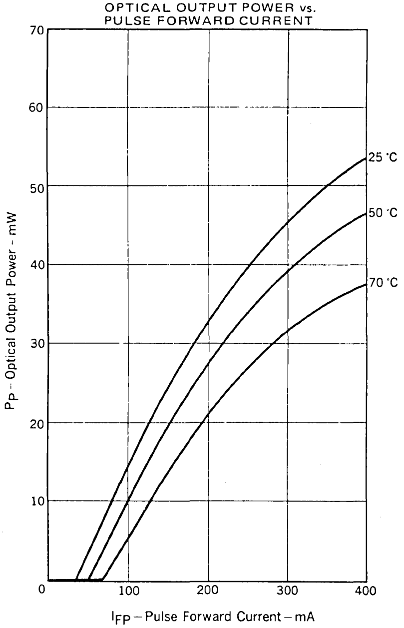
Reverse Voltage	V_R	2.0	V
Pulse Forward Current *	I_{FP}	400	mA
Operating Case Temperature	T_c	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +125	°C

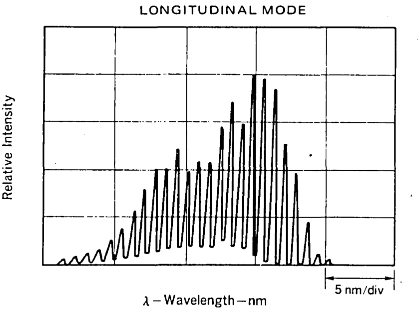
* Pulse Condition : PW (Pulse Width) = 1 μs, Duty = 1 %

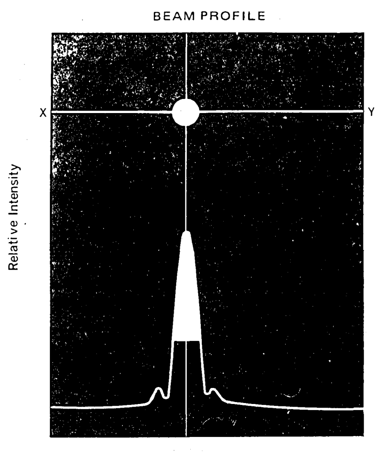
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.0	1.5	V	I_F = 30 mA
Threshold Current	I_{th}		40	60	mA	
Optical Output Power	P_P	30			mW	I_{FP} = 250 mA, PW = 1 μs, Duty = 1 %
Center Wavelength	λ_0	1520	1550	1580	nm	I_{FP} = 250 mA, PW = 1 μs, Duty = 1 %
Half Power Spectral Width	$\Delta\lambda$			20	nm	I_{FP} = 250 mA, PW = 1 μs, Duty = 1 %
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)







X – Y Beam Profile

2

LASER DIODE

NDL5071

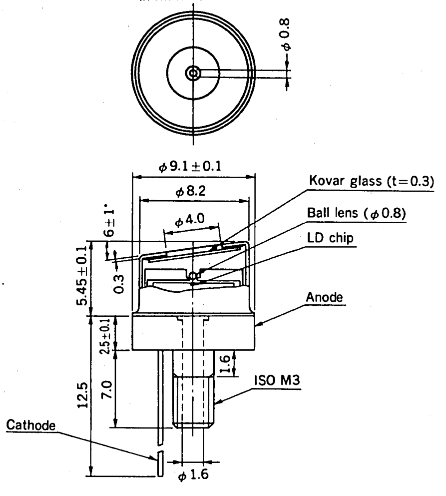
1 550 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE PULSED LASER DIODE

DESCRIPTION

NDL5071 is a 1 550 nm pulsed laser diode especially designed for optical measurement equipment (OTDR). The DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable fundamental oscillation in wide temperature range.
It incorporates ball lens and achieves collimated beam for easy optical coupling.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High output power. P_P = 50 mW MIN. @I_{FP} = 400 mA *
- Long wavelength. λ_P = 1 550 nm
- Low threshold current. I_{th} = 40 mA TYP.
- Internal ball lens.
- Wide operating temperature range.

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage	V_R	2.0	V
Pulse Forward Current *	I_{FP}	600	mA
Operating Case Temperature	T_c	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +125	°C

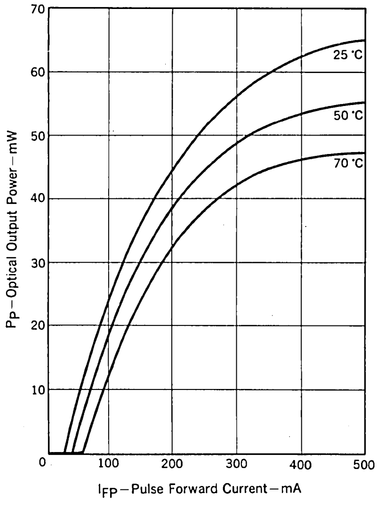
* Pulse Condition : PW (Pulse Width) = 1 μs, Duty = 1 %

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

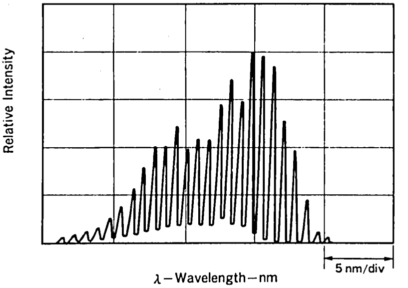
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.0	1.5	V	I_F = 30 mA
Threshold Current	I_{th}		40	60	mA	
Optical Output Power	P_P	50			mW	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Center Wavelength	λ_0	1520	1550	1580	nm	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Half Power Spectral Width	$\Delta\lambda$			20	nm	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Rise Time	t_r		0.5	1.0	ns	10–90 %
Fall Time	t_f		0.7	1.0	ns	90–10 %

TYPICAL CHARACTERISTICS ($T_a = 25\,°C$)

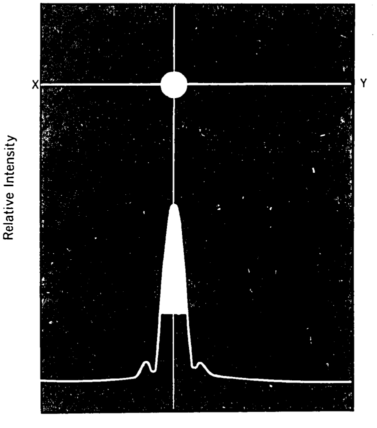
OPTICAL OUTPUT POWER vs. PULSE FORWARD CURRENT



LONGITUDINAL MODE



BEAM PROFILE



X – Y Beam Profile

2

LASER DIODE MODULE
NDL5772P

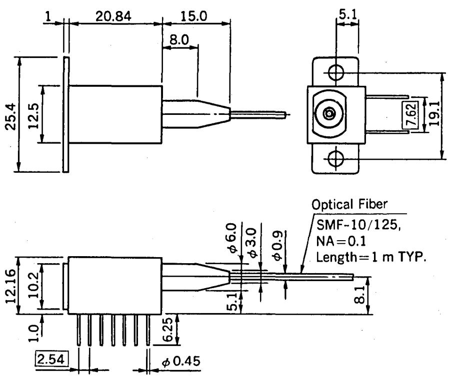
1 550 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DC-PBH PULSED LASER DIODE MODULE

DESCRIPTION

NDL5772P is a 1 550 nm pulsed laser diode DIP module with singlemode fiber and internal thermo-electric cooler. It is designed for a light source of optical measurement equipment (OTDR) and optical transmission systems.
In addition, it incorporates a lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High output power. P_f = 15 mW TYP. @I_{FP} = 400 mA *1
- Long wavelength λ_0 = 1 550 nm
- Internal thermo-electric cooler.
- Hermetically sealed 14 pin Dual-In-Line Package.
- Singlemode fiber pigtail.
- High reliability.

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

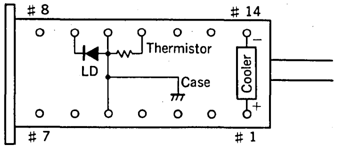
Pulsed Forward Current *1	I_{FP}	600	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	0 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Lead Soldering Temperature (10 s)	T_{sld}	260	°C

*1 Pulse Condition: Pulse Width = 1 μs, Duty = 1 %

PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	COOLER ANODE	8	NC
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND and THERMISTOR
4	NC		
5	LASER ANODE, CASE GROUND and THERMISTOR	11	THERMISTOR
		12	NC
6	NC	13	NC
7	NC	14	COOLER CATHODE

BOTTOM VIEW



ELECTRO-OPTICAL CHARACTERISTICS (T_{LD} = 25 °C, T_c = 0 to +60 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
DC Forward Voltage	V_F			1.5	V	I_F = 30 mA
DC Threshold Current	I_{th}		40	60	mA	
Optical Output Power from Fiber	P_f	10	15		mW	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Center Wavelength	λ_0	1520	1550	1580	nm	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
Spectral Width	$\Delta\lambda$			40	nm	I_{FP} = 400 mA, PW = 1 μs, Duty = 1 %
P_f Rise Time	t_r		0.5	1.0	ns	10 – 90 %
P_f Fall Time	t_f		0.7	1.0	ns	90 – 10 %

ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Thermistor and TE Cooler: T_{LD} = 25 °C, T_c = 0 to +60 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Thermistor Resistance	R*2	9.5	10	10.5	kΩ	T_{LD} = 25 °C
Cooler Current	I_c		0.6	1.0	A	ΔT = 40 K
Cooler Voltage	V_c		1.1	1.5	V	ΔT = 40 K
Cooling Capacity	ΔT*3	40			K	I_C = 1.0 A

*2 B Constant (= 3 400±100 K)
*3 $\Delta T = |T_c - T_{LD}|$

2

LASER DIODE

NDL5600

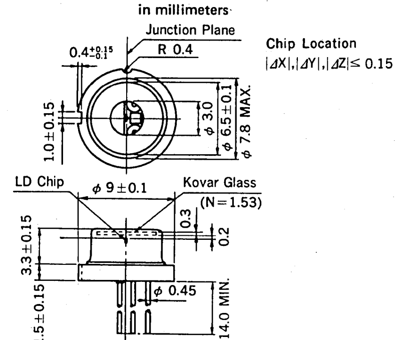
1 310 nm OPTICAL FIBER COMMUNICATIONS InGaAsP PHASE-SHIFTED DFB-DC-PBH LASER DIODE

DESCRIPTION

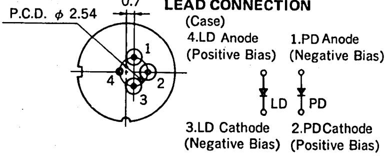
NDL5600 is a 1 310 nm DFB (Distributed Feed-back) laser diode especially designed for long distance high capacity transmission systems. The phase-shifted DFB-DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable single longitudinal mode oscillation under high speed modulation as well as in wide temperature range.

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION



FEATURES

- High output power. P_O = 8 mW TYP. @I_F = I_{th} +30 mA
- Single longitudinal mode. SMSR = 35 dB TYP.
- High speed. t_r , t_f = 0.2 ns TYP.
- Long wavelength. λ_P = 1 310 nm
- Low threshold current. I_{th} = 15 mA TYP.
- Narrow vertical angle and wide lateral beam angle $\theta_{\perp} \times \theta_{/\!/} = 40° \times 30°$
- Fundamental transverse mode.
- Wide operating temperature range.
- High reliability

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage of LD	V_R	2.0	V
Optical Output Power	P_O	15	mW
Operating Case Temperature	T_C	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +100	°C
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

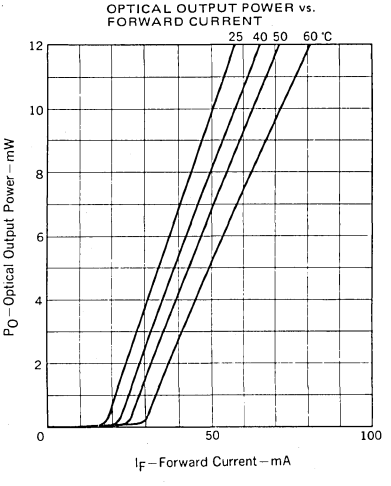
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

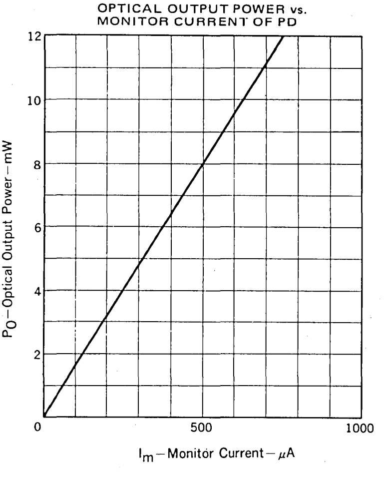
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.9	1.2	1.4	V	I_F = 30 mA
Threshold Current	I_{th}		15	35	mA	
Optical Output Power	P_O	5.0	8.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_O = 8.0 mW
Half Power Spectral Width	$\Delta\lambda$			0.1	nm	P_O = 8.0 mW
Sub-mode Suppression Ratio	SMSR	30	35		dB	P_O = 8.0 mW
Vertical Beam Angle	$\theta_\perp$		40		deg.	P_O = 8.0 mW, FAHM*
Lateral Beam Angle	$\theta_{/\!/}$		30		deg.	P_O = 8.0 mW, FAHM*
Rise Time	t_r		0.2	0.3	ns	10 – 90 %
Fall Time	t_f		0.2	0.4	ns	90 – 10 %
Monitor Current of PD	I_m		500		μA	V_R = 6 V, P_O = 8.0 mW
Dark Current of PD	I_D		2.0		nA	V_R = 6 V

* FAHM: Full Angle at Half Maximum

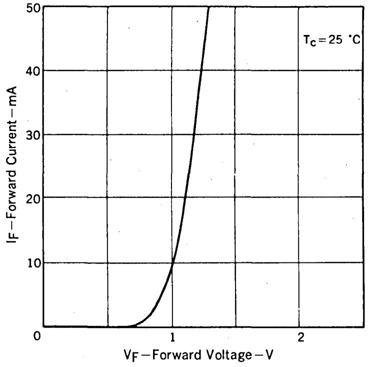
2

TYPICAL CHARACTERISTICS (T_a = 25 °C)

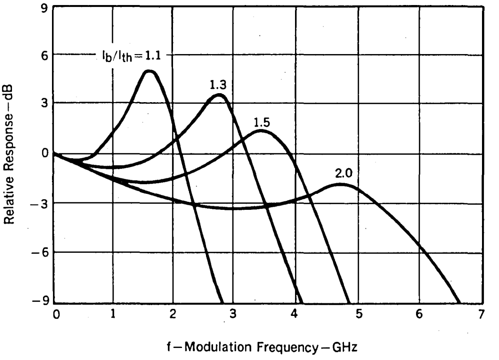




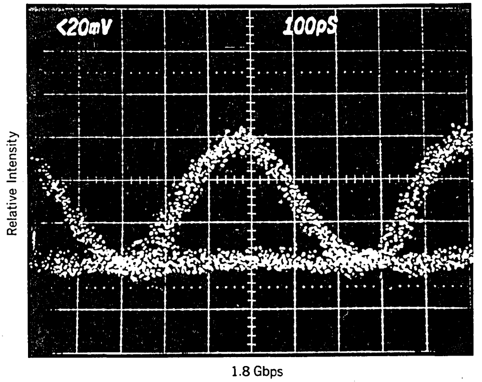
FORWARD CURRENT vs. FORWARD VOLTAGE



FREQUENCY CHARACTERISTICS

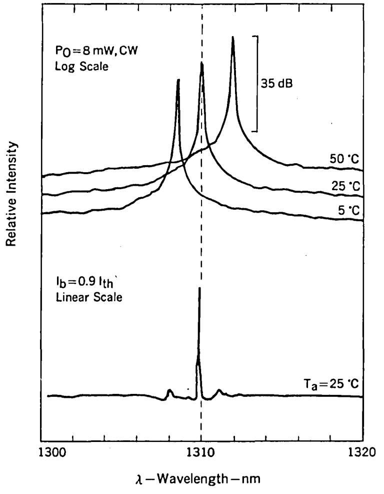


PULSE RESPONSE

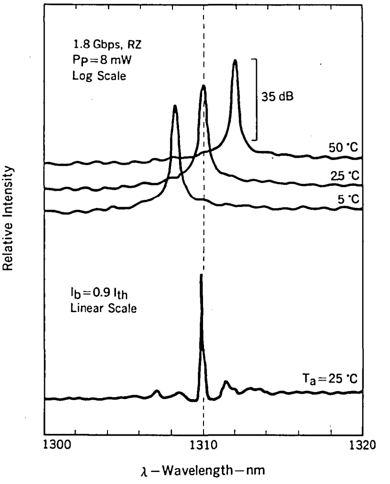


1.8 Gbps

LONGITUDINAL MODE (CW)



LONGITUDINAL MODE (1.8 Gb/s)



LASER DIODE
NDL5600D

1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP PHASE-SHIFTED DFB-DC-PBH LASER DIODE

DESCRIPTION

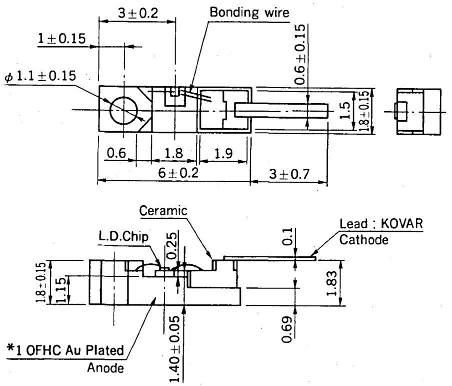
NDL5600D is a 1 310 nm DFB (Distributed Feed-back) laser diode chip on carrier with ribbon lead.

It is designed for long distance high capacity transmission systems. The phase-shifted DFB-DC-PBH (Double Channel Planar Buried Heterostrucuture) can achieve stable single longitudinal mode oscillation under high speed modulation as well as in wide temperature range.

NEC has two types of laser diode chip on carriers with ribbon lead. One is the D-type like NDL5600D, another is a D1-type like NDL5600D1.

PACKAGE DIMENSIONS

in millimeters



*1 OFHC: Oxygen Free High-Conductivity Copper

FEATURES

- High output power. P_O = 8 mW TYP. @I_F = I_{th} +30 mA
- Single longitudinal mode. SMSR = 35 dB TYP.
- High speed. t_r , t_f = 0.2 ns TYP.
- Long wavelength. λ_P = 1 310 nm
- Low threshold current. I_{th} = 25 mA TYP.
- Narrow vertical angle and wide lateral beam angle
  $\theta_{\perp} \times \theta_{\parallel} = 40^\circ \times 30^\circ$
- Fundamental transverse mode.
- Wide operating temperature range.
- High reliability
- Chip-on-carrier with ribbon lead

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	15	mW
Operating Temperature	T_{op}	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +100	°C

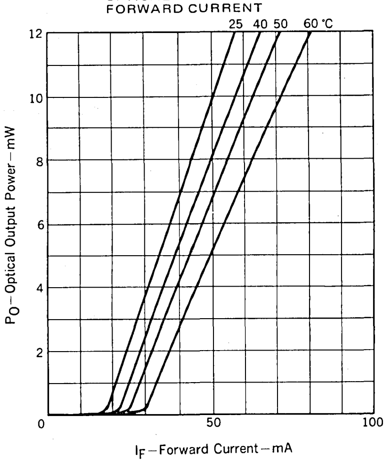
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.9	1.2	1.4	V	I_F = 30 mA
Threshold Current	I_{th}		15	35	mA	
Optical Output Power	P_O	5.0	8.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_O = 8.0 mW
Half Power Spectral Width	$\Delta\lambda$			0.1	nm	P_O = 8.0 mW
Sub-mode Suppression Ratio	SMSR	30	35		dB	P_O = 8.0 mW
Vertical Beam Angle	$\theta_\perp$		40		deg.	P_O = 8.0 mW, FAHM*2
Lateral Beam Angle	$\theta_{/\!/}$		30		deg.	P_O = 8.0 mW, FAHM*2
Rise Time	t_r		0.2	0.3	ns	10 – 90 %
Fall Time	t_f		0.2	0.4	ns	90 – 10 %

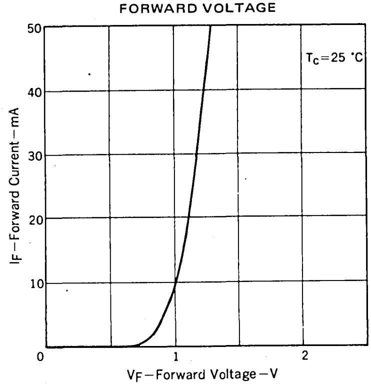
*2 FAHM: Full Angle at Half Maximum

TYPICAL CHARACTERISTICS (T_a = 25 °C)

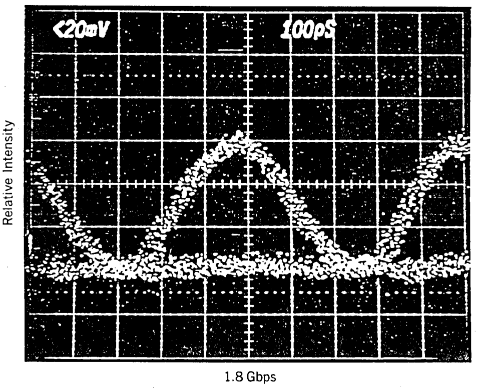
OPTICAL OUTPUT POWER vs. FORWARD CURRENT



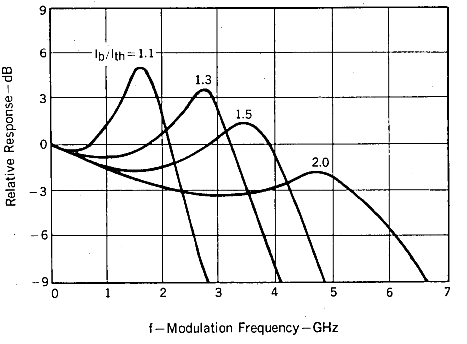
FORWARD CURRENT vs. FORWARD VOLTAGE



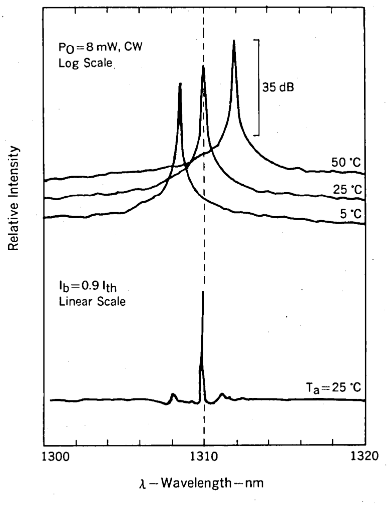
PULSE RESPONSE



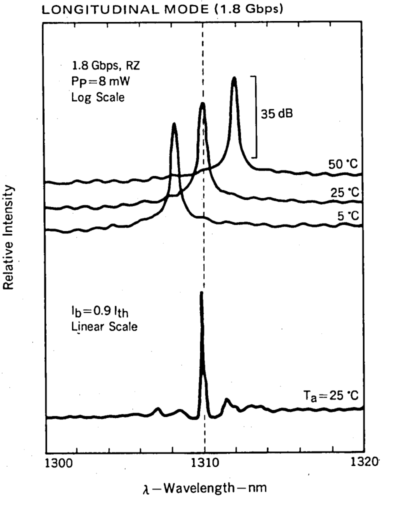
FREQUENCY CHARACTERISTICS



LONGITUDINAL MODE (CW)



LONGITUDINAL MODE (1.8 Gbps)



LASER DIODE CHIP ON CARRIER HANDLING PRECAUTION

LASER DIODE CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, FOLLOWING CONDITION SHOULD BE MAINTAINED. (DURING CUSTOMER'S ASSEMBLY PROCESS, THE CONDITION ALSO SHOULD BE APPLIED FOR THE UNSEALED PACKAGE WHICH IS EQUIPPED WITH THE DEVICE.)

STORAGE TEMPERATURE: +20 TO +30 °C
CONTAINER: CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS: AIR OR NITROGEN (DEW POINT: LESS THAN −30 °C)

RECOMMENDABLE STORAGE PERIOD IS AS FOLLOWS.

STORAGE CONDITION	STORAGE DURATION
IN NEC'S CONTAINER BEFORE SEAL BREAK	3 MONTHS MAX.
AFTER SEAL BREAK	1 MONTH MAX.

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE
ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) CHIP FACETS
CLEAN CONDITION OF LASER DIODE CHIP FACETS SHOULD BE KEPT.

2-3) DIE ATTACHMENT
WHEN THE DEVICE IS MOUNTED INTO CUSTOMER'S PACKAGE, THE DEVICE SHOULD BE PREVENTED FROM ANY SCRATCHES, CRACKS, CHIP OUT AND CONTAMINATION ON CHIP SURFACE (TOP AND FACETS).

2-4) ESD PROTECTION
DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

2-5) SOLDERING CONDITION
THE FOLLOWING CONDITIONS SHOULD BE KEPT.
OTHERWISE, THERE IS A POSSIBILITY THAT THERE IS THE INFLUENCE ON ELECTRO-OPTICAL CHARACTERISTICS AND RELIABILITY OF THE DEVICE.

TEMPERATURE: +140 °C MAX.
DURATION: 30 sec. MAX.
ATMOSPHERE: INERT GAS (EX. NITROGEN)

2-6) HERMETIC SEALING
THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec.

LASER DIODE
NDL5600D1

1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP PHASE-SHIFTED DFB-DC-PBH LASER DIODE

DESCRIPTION

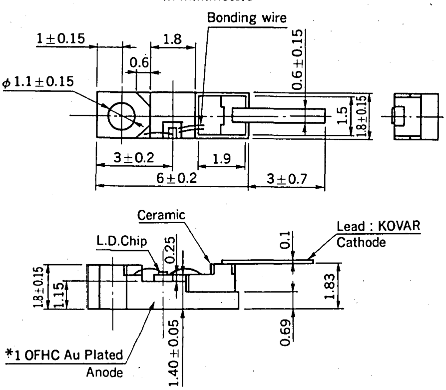
NDL5600D1 is a 1 310 nm DFB (Distributed Feed-back) laser diode chip on carrier with ribbon lead.

It is designed for long distance high capacity transmission systems. The phase-shifted DFB-DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable single longitudinal mode oscillation under high speed modulation as well as in wide temperature range.

NEC has two types of laser diode chip on carriers with ribbon lead. One is the D1-type like NDL5600D1, another is a D-type like NDL5600D.

PACKAGE DIMENSIONS

in millimeters



*1 OFHC: Oxygen Free High-Conductivity Copper

FEATURES

- High output power. P_O = 8 mW TYP. @I_F = I_{th} +30 mA
- Single longitudinal mode. SMSR = 35 dB TYP.
- High speed. t_r , t_f = 0.2 ns TYP.
- Long wavelength. λ_P = 1 310 nm
- Low threshold current. I_{th} = 15 mA TYP.
- Narrow vertical angle and wide lateral beam angle
  $\theta_\perp \times \theta_{/\!/} = 40^\circ \times 30^\circ$
- Fundamental transverse mode.
- Wide operating temperature range.
- High reliability
- Chip-on-carrier with ribbon lead

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	15	mW
Operating Temperature	T_{op}	0 to +60	°C
Storage Temperature	T_{stg}	0 to +70	°C

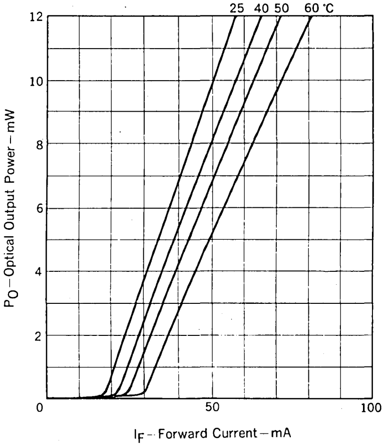
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.9	1.2	1.4	V	I_F = 30 mA
Threshold Current	I_{th}		15	35	mA	
Optical Output Power	P_O	5.0	8.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_O = 8.0 mW
Half Power Spectral Width	$\Delta\lambda$			0.1	nm	P_O = 8.0 mW
Sub-mode Suppression Ratio	SMSR	30	35		dB	P_O = 8.0 mW
Vertical Beam Angle	$\theta_\perp$		40		deg.	P_O = 8.0 mW, FAHM*2
Lateral Beam Angle	$\theta_{/\!/}$		30		deg.	P_O = 8.0 mW, FAHM*2
Rise Time	t_r		0.2	0.3	ns	10 – 90 %
Fall Time	t_f		0.2	0.4	ns	90 – 10 %

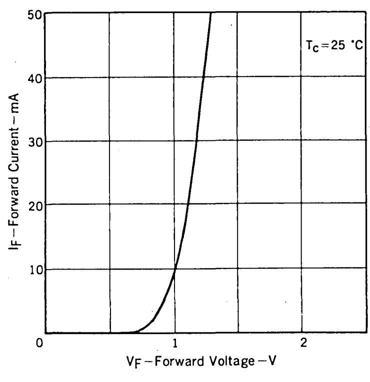
*2 FAHM: Full Angle at Half Maximum

TYPICAL CHARACTERISTICS (T_a = 25 °C)

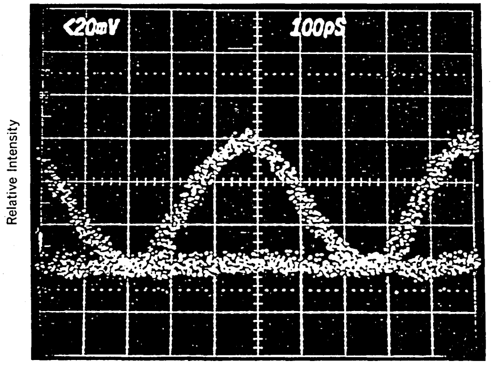
OPTICAL OUTPUT POWER vs. FORWARD CURRENT



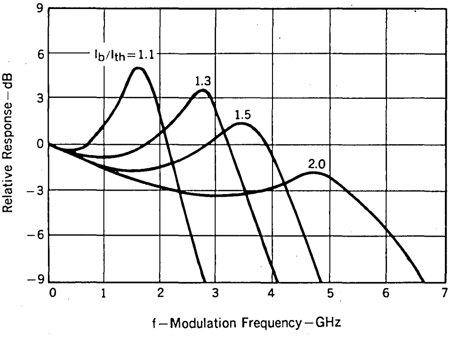
FORWARD CURRENT vs. FORWARD VOLTAGE



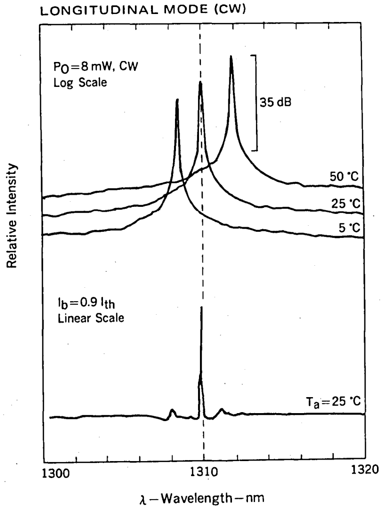
PULSE RESPONSE



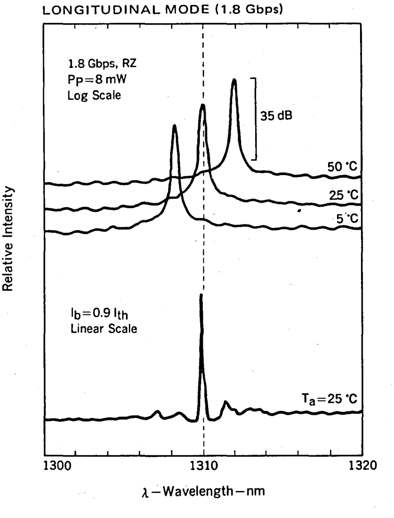
FREQUENCY CHARACTERISTICS



LONGITUDINAL MODE (CW)



LONGITUDINAL MODE (1.8 Gbps)



LASER DIODE CHIP ON CARRIER HANDLING PRECAUTION

LASER DIODE CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, FOLLOWING CONDITION SHOULD BE MAINTAINED. (DURING CUSTOMER'S ASSEMBLY PROCESS, THE CONDITION ALSO SHOULD BE APPLIED FOR THE UNSEALED PACKAGE WHICH IS EQUIPPED WITH THE DEVICE.)

STORAGE TEMPERATURE: +20 TO +30 °C
CONTAINER: CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS: AIR OR NITROGEN (DEW POINT: LESS THAN −30 °C)

RECOMMENDABLE STORAGE PERIOD IS AS FOLLOWS.

STORAGE CONDITION	STORAGE DURATION
IN NEC'S CONTAINER BEFORE SEAL BREAK	3 MONTHS MAX.
AFTER SEAL BREAK	1 MONTH MAX.

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE
ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) CHIP FACETS
CLEAN CONDITION OF LASER DIODE CHIP FACETS SHOULD BE KEPT.

2-3) DIE ATTACHMENT
WHEN THE DEVICE IS MOUNTED INTO CUSTOMER'S PACKAGE, THE DEVICE SHOULD BE PREVENTED FROM ANY SCRATCHES, CRACKS, CHIP OUT AND CONTAMINATION ON CHIP SURFACE (TOP AND FACETS).

2-4) ESD PROTECTION
DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

2-5) SOLDERING CONDITION
THE FOLLOWING CONDITIONS SHOULD BE KEPT.
OTHERWISE, THERE IS A POSSIBILITY THAT THERE IS THE INFLUENCE ON ELECTRO-OPTICAL CHARACTERISTICS AND RELIABILITY OF THE DEVICE.

TEMPERATURE: +140 °C MAX.
DURATION: 30 sec. MAX.
ATMOSPHERE: INERT GAS (EX. NITROGEN)

2-6) HERMETIC SEALING
THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec.

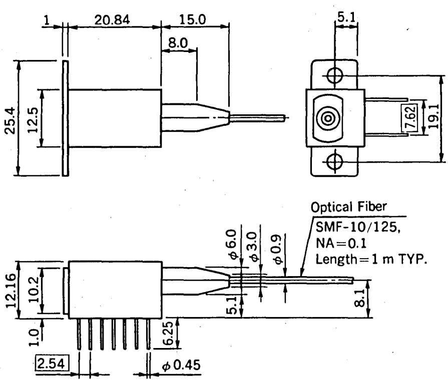
LASER DIODE MODULE
NDL5604P

1 310 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP PHASE-SHIFTED DFB-DC-PBH LASER DIODE MODULE

DESCRIPTION

NDL5604P is a 1 310 nm phase-shifted DFB (Distributed Feed-Back) laser diode DIP module with singlemode fiber. It incorporates an InGaAs monitor photo diode and thermo-electric cooler.It is designed for a light source of up to 800 Mb/s long-distance transmission systems. The phase-shifted DFB-DC-PBH (Double channel Planar Buried heterostructure) can achieve stable single longitudinal mode oscillation under high speed modulation in wide temperature range.
In addition, it incorporates a lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range.

PACKAGE DIMENSIONS
in millimeters



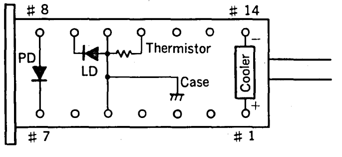
FEATURES

- High speed. t_r = 0.3 ns, t_f = 0.4 ns
- High output power. P_f = 1.2 mW
- Low threshold current. I_{th} = 15 mA
- Long wavelength λ_P = 1 310 nm
- Internal InGaAs monitor PD.
- Internal thermo-electric cooler.
- Hermetically sealed 14 pin Dual-In-Line Package.
- Singlemode fiber pigtail.
- Wide operating temperature range.
- High reliability.

PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	COOLER ANODE	8	PD ANODE
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND and THERMISTOR
4	NC		
5	LASER ANODE, CASE GROUND and THERMISTOR	11	THERMISTOR
		12	NC
6	NC	13	NC
7	PD CATHODE	14	COOLER CATHODE

BOTTOM VIEW



ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Operating Case Temperature	T_C	−20 to +65	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Lead Soldering Temperature (10 s)	T_S	260	°C
Forward Current of LD	I_F	I_{th}+50	mA
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	10	mA
Reverse Voltage of PD	V_R	20.	V

ELECTRO-OPTICAL CHARACTERISTICS (T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}		15	35	mA	
Forward Voltage	V_F			1.8	V	P_f = 1.0 mW
Optical Output Power from Fiber	P_f	1.0	1.2		mW	$I_F = I_{th}$+25 mA
Peak Emission Wavelength	λ_P	1290	1310	1330	nm	P_f = 1.0 mW
Spectral Width	$\Delta\lambda$		0.1		nm	P_f = 0.5 mW, $I_b = I_{th}$, 800 Mb/s
Differential Quantum Efficiency from Fiber	DQE	0.04			mW/mA	$I_{th} \leqq I_F \leqq I_{th}$+25 mA
Rise Time	t_r		0.3	0.4	ns	10 – 90 %
Fall Time	t_f		0.4	0.5	ns	10 – 90 %

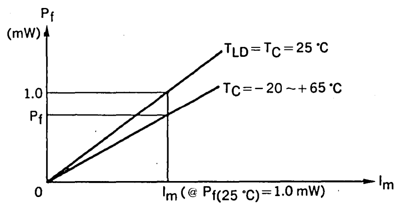
ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Monitor PD: T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Monitor Current	I_m	50	100		μA	V_R = 5 V, P_f = 1.0 mW
Rise Time	t_r		3	5	ns	V_R = 5 V, R_L = 100 Ω
Fall Time	t_f		5	8	ns	V_R = 5 V, R_L = 100 Ω
Dark Current	I_D		2	10	nA	V_R = 5 V
Tracking Error	γ *1			0.5	dB	I_m = const.

2

*1 Tracking Error : γ

$$\gamma = \left| 10 \log \frac{P_f}{1.0 \text{ mW}} \right|$$



ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Thermistor and TE Cooler: T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Thermistor Resistance	R *2	9.5	10	10.5	kΩ	T_{LD} = 25 °C
Cooler Current	I_c		0.6	1.0	A	ΔT = 40 K
Cooler Voltage	V_c		1.1	1.5	V	ΔT = 40 K
Cooling Capacity	ΔT *3	40			K	I_C = 1.0 A, P_f = 1.0 mW

*2 B Constant (= 3 400±100 K)

*3 $\Delta T = |T_c - T_{LD}|$

LASER DIODE
NDL5650

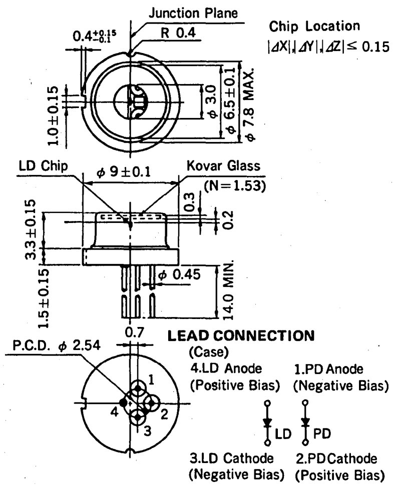
1 550 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP PHASE-SHIFTED DFB-DC-PBH LASER DIODE

DESCRIPTION

NDL5650D is a 1 550 nm DFB (Distributed Feed-back) laser diode especially designed for long distance high capacity transmission systems. The phase-shifted DFB-DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable single longitudinal mode oscillation under high speed modulation as well as in wide temperature range.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High output power. P_O = 5 mW TYP. @I_F = I_{th} +30 mA
- Single longitudinal mode. SMSR = 35 dB TYP.
- High speed. t_r, t_f = 0.2 ns TYP.
- Long wavelength. λ_p = 1 550 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle $\theta_{\perp} \times \theta_{/\!/} = 45^\circ \times 35^\circ$
- Fundamental transverse mode.
- Wide operating temperature range.
- High reliability

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage of LD	V_R	2.0	V
Optical Output Power	P_O	10	mW
Operating Case Temperature	T_C	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +100	°C
Forward Current of PD	I_F	25	mA
Reverse Voltage of PD	V_R	20	V

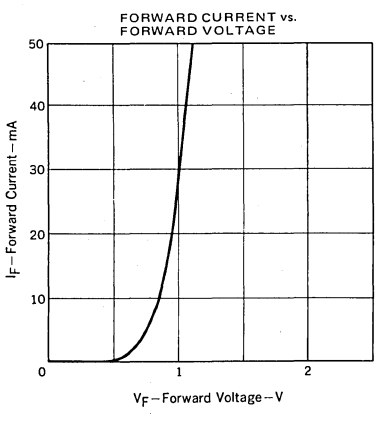
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

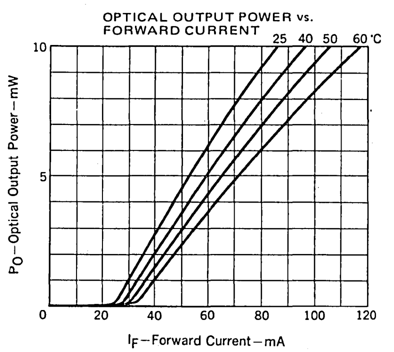
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.8	1.0	1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	40	mA	
Optical Output Power	P_O	3.0	5.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1530	1550	1570	nm	P_O = 5.0 mW
Half Power Spectral Width	$\Delta\lambda$			0.1	nm	P_O = 5.0 mW
Sub-mode Suppression Ratio	SMSR	30	35		dB	P_O = 5.0 mW
Vertical Beam Angle	$\theta_\perp$		45		deg.	P_O = 5.0 mW, FAHM*
Lateral Beam Angle	$\theta_{/\!/}$		35		deg.	P_O = 5.0 mW, FAHM*
Rise Time	t_r		0.2	0.3	ns	10 – 90 %
Fall Time	t_f		0.2	0.4	ns	90 – 10 %
Monitor Current of PD	I_m		300		μA	V_R = 6 V, P_O = 5.0 mW
Dark Current of PD	I_D		2		nA	V_R = 6 V

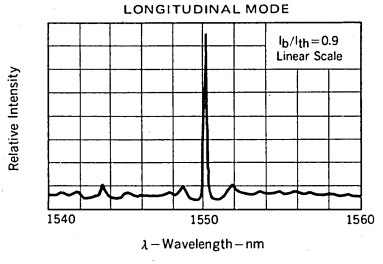
* FAHM: Full Angle at Half Maximum

2

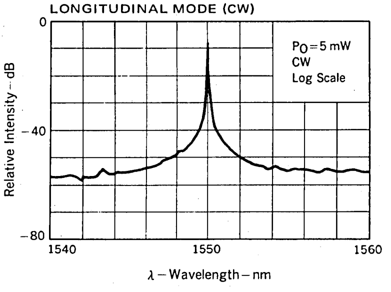
TYPICAL CHARACTERISTICS (T_a = 25 °C)



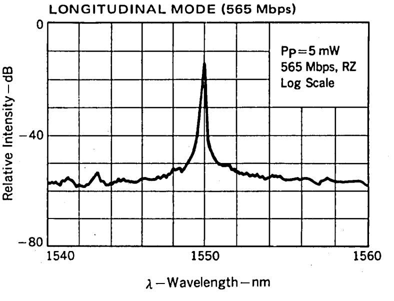




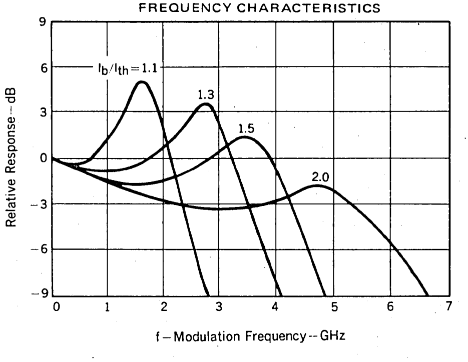
LONGITUDINAL MODE
Relative Intensity
$I_b/I_{th}=0.9$
Linear Scale
1540
1550
1560
λ – Wavelength – nm



LONGITUDINAL MODE (CW)
Relative Intensity – dB
0
–40
–80
$P_O=5$ mW
CW
Log Scale
1540
1550
1560
λ – Wavelength – nm



LONGITUDINAL MODE (565 Mbps)
Relative Intensity – dB
0
–40
–80
$P_P=5$ mW
565 Mbps, RZ
Log Scale
1540
1550
1560
λ – Wavelength – nm



FREQUENCY CHARACTERISTICS
Relative Response – dB
9
6
3
0
–3
–6
–9
$I_b/I_{th}=1.1$
1.3
1.5
2.0
0
1
2
3
4
5
6
7
f – Modulation Frequency – GHz

LASER DIODE

NDL5650D

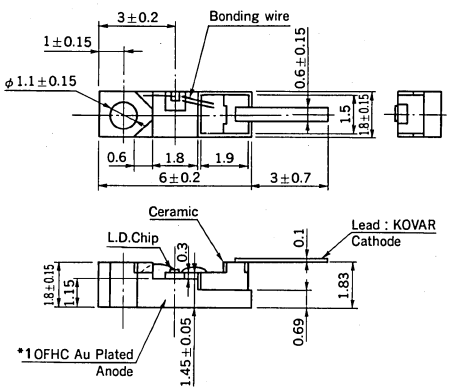
1 550 nm OPTICAL FIBER COMMUNICATIONS InGaAsP PHASE-SHIFTED DFB-DC-PBH LASER DIODE

DESCRIPTION

NDL5650D is a 1 550 nm DFB (Distributed Feed-back) laser diode chip on carrier with ribbon lead.
It is designed for long distance high capacity transmission systems. The phase-shifted DFB-DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable single longitudinal mode oscillation under high speed modulation as well as in wide temperature range.
NEC has two types of laser diode chip on carriers with ribbon lead. One is the D-type like NDL5650D, another is a D1-type like NDL5650D1.

PACKAGE DIMENSIONS

in millimeters



*1 OFHC: Oxygen Free High-Conductivity Copper

FEATURES

- High output power. P_O = 5 mW TYP. @I_F = I_{th} +30 mA
- Single longitudinal mode. SMSR = 35 dB TYP.
- High speed. t_r, t_f = 0.2 ns TYP.
- Long wavelength. λ_P = 1 550 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle $\theta_\perp \times \theta_\parallel = 45° \times 35°$
- Fundamental transverse mode.
- Wide operating temperature range.
- High reliability
- Chip-on-carrier with ribbon lead

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

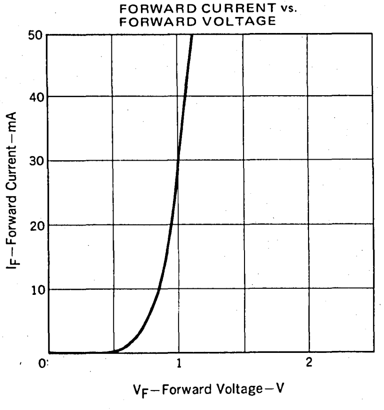
Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	10	mW
Operating Temperature	T_{op}	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +100	°C

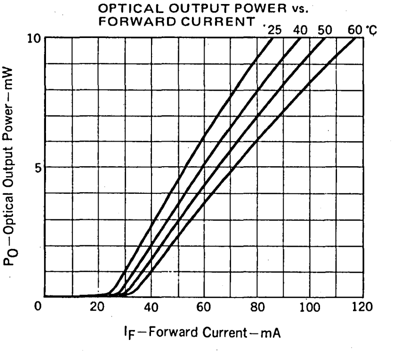
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

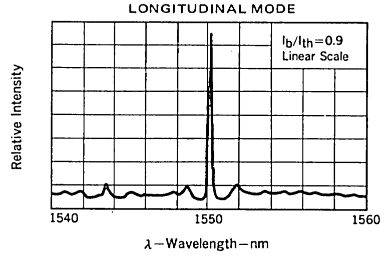
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.8	1.0	1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	40	mA	
Optical Output Power	P_O	3.0	5.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1530	1550	1570	nm	P_O = 5.0 mW
Half Power Spectral Width	$\Delta\lambda$			0.1	nm	P_O = 5.0 mW
Sub-mode Suppression Ratio	SMSR	30	35		dB	P_O = 5.0 mW
Vertical Beam Angle	$\theta_\perp$		45		deg.	P_O = 5.0 mW, FAHM*2
Lateral Beam Angle	$\theta_{/\!/}$		35		deg.	P_O = 5.0 mW, FAHM*2
Rise Time	t_r		0.2	0.3	ns	10 – 90 %
Fall Time	t_f		0.2	0.4	ns	90 – 10 %

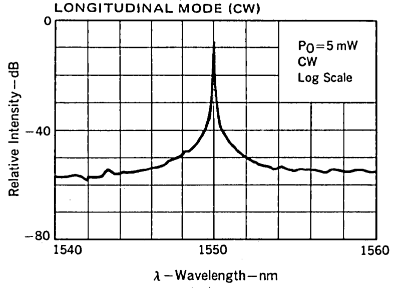
*2 FAHM: Full Angle at Half Maximum

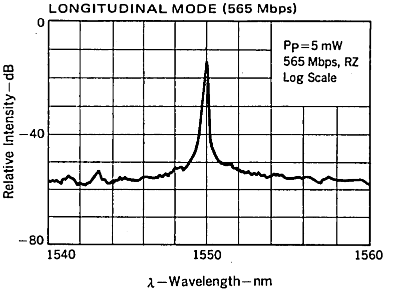
TYPICAL CHARACTERISTICS (T_a = 25 °C)



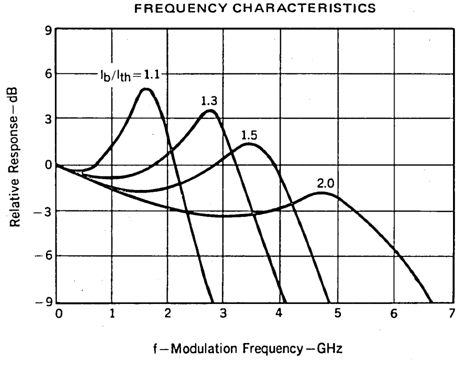



LONGITUDINAL MODE
Ib/Ith=0.9
Linear Scale
Relative Intensity
1540
1550
1560
λ—Wavelength—nm


LONGITUDINAL MODE (CW)
Po=5 mW
CW
Log Scale
0
−40
−80
Relative Intensity—dB
1540
1550
1560
λ—Wavelength—nm


LONGITUDINAL MODE (565 Mbps)
Pp=5 mW
565 Mbps, RZ
Log Scale
0
−40
−80
Relative Intensity—dB
1540
1550
1560
λ—Wavelength—nm

2


FREQUENCY CHARACTERISTICS
Ib/Ith=1.1
1.3
1.5
2.0
9
6
3
0
−3
−6
−9
Relative Response—dB
0
1
2
3
4
5
6
7
f—Modulation Frequency—GHz

LASER DIODE CHIP ON CARRIER HANDLING PRECAUTION

LASER DIODE CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, FOLLOWING CONDITION SHOULD BE MAINTAINED. (DURING CUSTOMER'S ASSEMBLY PROCESS, THE CONDITION ALSO SHOULD BE APPLIED FOR THE UNSEALED PACKAGE WHICH IS EQUIPPED WITH THE DEVICE.)

STORAGE TEMPERATURE: +20 TO +30 °C
CONTAINER: CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS: AIR OR NITROGEN (DEW POINT: LESS THAN −30 °C)

RECOMMENDABLE STORAGE PERIOD IS AS FOLLOWS.

STORAGE CONDITION	STORAGE DURATION
IN NEC'S CONTAINER BEFORE SEAL BREAK	3 MONTHS MAX.
AFTER SEAL BREAK	1 MONTH MAX.

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE
ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) CHIP FACETS
CLEAN CONDITION OF LASER DIODE CHIP FACETS SHOULD BE KEPT.

2-3) DIE ATTACHMENT
WHEN THE DEVICE IS MOUNTED INTO CUSTOMER'S PACKAGE, THE DEVICE SHOULD BE PREVENTED FROM ANY SCRATCHES, CRACKS, CHIP OUT AND CONTAMINATION ON CHIP SURFACE (TOP AND FACETS).

2-4) ESD PROTECTION
DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

2-5) SOLDERING CONDITION
THE FOLLOWING CONDITIONS SHOULD BE KEPT.
OTHERWISE, THERE IS A POSSIBILITY THAT THERE IS THE INFLUENCE ON ELECTRO-OPTICAL CHARACTERISTICS AND RELIABILITY OF THE DEVICE.

TEMPERATURE: +140 °C MAX.
DURATION: 30 sec. MAX.
ATMOSPHERE: INERT GAS (EX. NITROGEN)

2-6) HERMETIC SEALING
THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec.

NDL5650D1

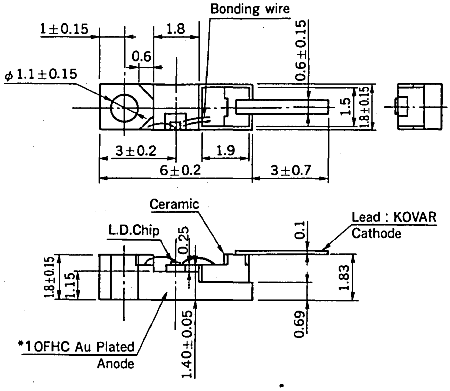
1 550 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP PHASE-SHIFTED DFB-DC-PBH LASER DIODE

DESCRIPTION

NDL5650D1 is a 1 550 nm DFB (Distributed Feed-back) laser diode chip on carrier with ribbon lead.
It is designed for long distance high capacity transmission systems. The phase-shifted DFB-DC-PBH (Double Channel Planar Buried Heterostructure) can achieve stable single longitudinal mode oscillation under high speed modulation as well as in wide temperature range.
NEC has two types of laser diode chip on carriers with ribbon lead. One is the D1-type like NDL5650D1, another is a D-type like NDL5650D.

PACKAGE DIMENSIONS

in millimeters



*1 OFHC: Oxygen Free High-Conductivity Copper

FEATURES

- High output power. P_O = 5 mW TYP. @I_F = I_{th} +30 mA
- Single longitudinal mode. SMSR = 35 dB TYP.
- High speed. t_r, t_f = 0.2 ns TYP.
- Long wavelength. λ_P = 1 550 nm
- Low threshold current. I_{th} = 20 mA TYP.
- Narrow vertical angle and wide lateral beam angle $\theta_\perp \times \theta_{/\!/} = 45^\circ \times 35^\circ$
- Fundamental transverse mode.
- Wide operating temperature range.
- High reliability
- Chip-on-carrier with ribbon lead

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

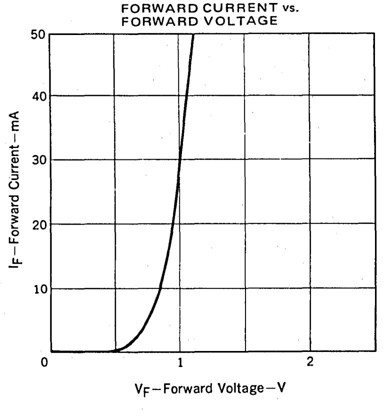
Reverse Voltage	V_R	2.0	V
Optical Output Power	P_O	10	mW
Operating Temperature	T_{op}	−40 to +70	°C
Storage Temperature	T_{stg}	−55 to +100	°C

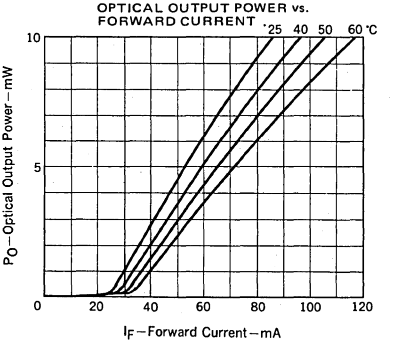
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

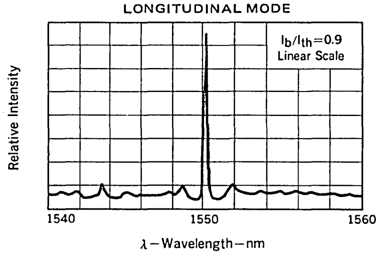
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F	0.8	1.0	1.3	V	I_F = 30 mA
Threshold Current	I_{th}		20	40	mA	
Optical Output Power	P_O	3.0	5.0		mW	$I_F = I_{th}$ +30 mA
Peak Emission Wavelength	λ_P	1530	1550	1570	nm	P_O = 5.0 mW
Half Power Spectral Width	$\Delta\lambda$			0.1	nm	P_O = 5.0 mW
Sub-mode Suppression Ratio	SMSR	30	35		dB	P_O = 5.0 mW
Vertical Beam Angle	$\theta_\perp$		45		deg.	P_O = 5.0 mW, FAHM*2
Lateral Beam Angle	$\theta_\parallel$		35		deg.	P_O = 5.0 mW, FAHM*2
Rise Time	t_r		0.2	0.3	ns	10 – 90 %
Fall Time	t_f		0.2	0.4	ns	90 – 10 %

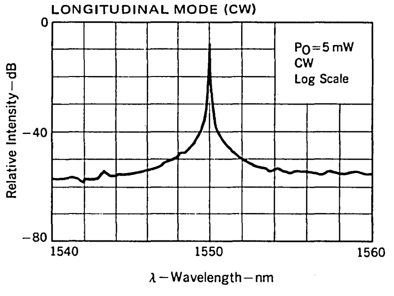
*2 FAHM: Full Angle at Half Maximum

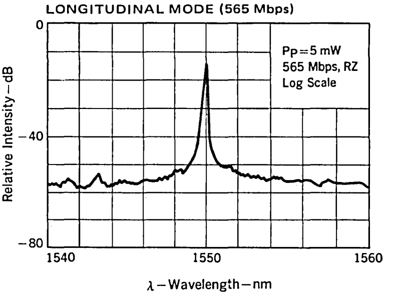
TYPICAL CHARACTERISTICS (T_a = 25 °C)

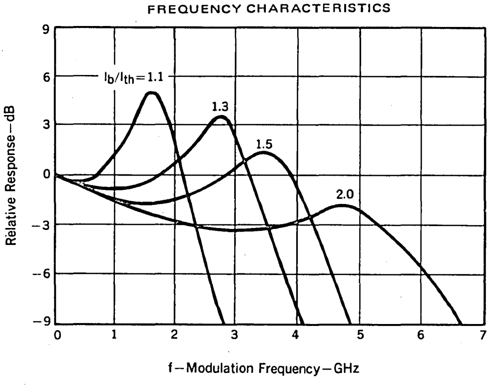





LONGITUDINAL MODE
Ib/Ith=0.9
Linear Scale
Relative Intensity
1540
1550
1560
λ—Wavelength—nm


LONGITUDINAL MODE (CW)
PO=5 mW
CW
Log Scale
Relative Intensity—dB
0
−40
−80
1540
1550
1560
λ—Wavelength—nm


LONGITUDINAL MODE (565 Mbps)
Pp=5 mW
565 Mbps, RZ
Log Scale
Relative Intensity—dB
0
−40
−80
1540
1550
1560
λ—Wavelength—nm


FREQUENCY CHARACTERISTICS
Ib/Ith=1.1
1.3
1.5
2.0
Relative Response—dB
9
6
3
0
−3
−6
−9
0
1
2
3
4
5
6
7
f—Modulation Frequency—GHz

LASER DIODE CHIP ON CARRIER HANDLING PRECAUTION

LASER DIODE CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, FOLLOWING CONDITION SHOULD BE MAINTAINED. (DURING CUSTOMER'S ASSEMBLY PROCESS, THE CONDITION ALSO SHOULD BE APPLIED FOR THE UNSEALED PACKAGE WHICH IS EQUIPPED WITH THE DEVICE.)

STORAGE TEMPERATURE: +20 TO +30 °C
CONTAINER: CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS: AIR OR NITROGEN (DEW POINT: LESS THAN −30 °C)

RECOMMENDABLE STORAGE PERIOD IS AS FOLLOWS.

STORAGE CONDITION	STORAGE DURATION
IN NEC'S CONTAINER BEFORE SEAL BREAK	3 MONTHS MAX.
AFTER SEAL BREAK	1 MONTH MAX.

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE
ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) CHIP FACETS
CLEAN CONDITION OF LASER DIODE CHIP FACETS SHOULD BE KEPT.

2-3) DIE ATTACHMENT
WHEN THE DEVICE IS MOUNTED INTO CUSTOMER'S PACKAGE, THE DEVICE SHOULD BE PREVENTED FROM ANY SCRATCHES, CRACKS, CHIP OUT AND CONTAMINATION ON CHIP SURFACE (TOP AND FACETS).

2-4) ESD PROTECTION
DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

2-5) SOLDERING CONDITION
THE FOLLOWING CONDITIONS SHOULD BE KEPT.
OTHERWISE, THERE IS A POSSIBILITY THAT THERE IS THE INFLUENCE ON ELECTRO-OPTICAL CHARACTERISTICS AND RELIABILITY OF THE DEVICE.

TEMPERATURE: +140 °C MAX.
DURATION: 30 sec. MAX.
ATMOSPHERE: INERT GAS (EX. NITROGEN)

2-6) HERMETIC SEALING
THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec.

LASER DIODE MODULE
NDL5654P

1 550 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP PHASE-SHIFTED DFB-DC-PBH LASER DIODE MODULE

DESCRIPTION

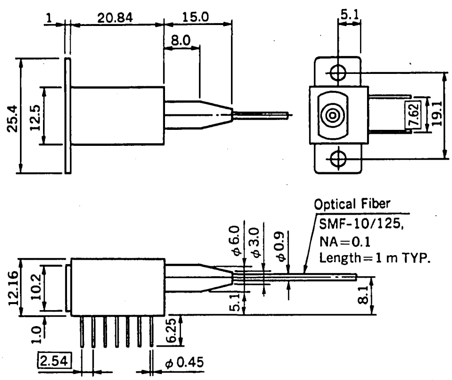
NDL5654P is a 1 550 nm phase-shifted DFB (Distributed Feed-Back) laser diode DIP module with singlemode fiber. It incorporates an InGaAs monitor photo diode and thermo-electric cooler. It is designed for a light source of up to 800 Mb/s long-distance transmission systems. The phase-shifted DFB-DC-PBH (Double channel Planar Buried heterostructure) can achieve stable single longitudinal mode oscillation under high speed modulation in wide temperature range.

In addition, it incorporates a lens for optical coupling between laser chip and optical fiber and YAG laser welding technique is utilized. Therefore, this lens coupling system can achieve stable optical output power as well as high coupling efficiency in wide operating temperature range.

2

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High speed. t_r = 0.3 ns, t_f = 0.4 ns
- High output power. P_f = 1.2 mW
- Low threshold current. I_{th} = 20 mA
- Long wavelength λ_P = 1 550 nm
- Internal InGaAs monitor PD.
- Internal thermo-electric cooler.
- Hermetically sealed 14 pin Dual-In-Line Package.
- Singlemode fiber pigtail.
- Wide operating temperature range.
- High reliability.

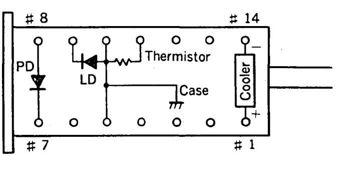
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Operating Case Temperature	T_C	−20 to +65	°C
Storage Temperature	T_{stg}	−40 to +70	°C
Lead Soldering Temperature (10 s)	T_S	260	°C
Forward Current of LD	I_F	I_{th}+50	mA
Reverse Voltage of LD	V_R	2.0	V
Forward Current of PD	I_F	10	mA
Reverse Voltage of PD	V_R	20	V

PIN CONNECTIONS

PIN No.	FUNCTION	PIN No.	FUNCTION
1	COOLER ANODE	8	PD ANODE
2	NC	9	LASER CATHODE
3	NC	10	LASER ANODE, CASE GROUND and THERMISTOR
4	NC		
5	LASER ANODE, CASE GROUND and THERMISTOR	11	THERMISTOR
		12	NC
6	NC	13	NC
7	PD CATHODE	14	COOLER CATHODE

BOTTOM VIEW



ELECTRO-OPTICAL CHARACTERISTICS (T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

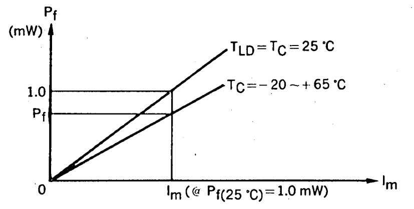
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Threshold Current	I_{th}		20	40	mA	
Forward Voltage	V_F			1.5	V	P_f = 1.0 mW
Optical Output Power from Fiber	P_f	1.0	1.2		mW	$I_F = I_{th}$+35 mA
Peak Emission Wavelength	λ_P	1530	1550	1570	nm	P_f = 1.0 mW
Spectral Width	$\Delta\lambda$		0.1		nm	P_f = 0.5 mW, $I_b = I_{th}$, 800 Mb/s
Differential Quantum Efficiency from Fiber	DQE	0.028			mW/mA	$I_{th} \leq I_F \leq I_{th}$+35 mA
Rise Time	t_r		0.3	0.4	ns	10 – 90 %
Fall Time	t_f		0.4	0.5	ns	10 – 90 %

ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Monitor PD: T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Monitor Current	I_m	50	100		μA	V_R = 5 V, P_f = 1.0 mW
Rise Time	t_r		3	5	ns	V_R = 5 V, R_L = 100 Ω
Fall Time	t_f		5	8	ns	V_R = 5 V, R_L = 100 Ω
Dark Current	I_D		2	10	nA	V_R = 5 V
Tracking Error	γ *1			0.5	dB	I_m = const.

*1 Tracking Error : γ

$$\gamma = \left| 10 \log \frac{P_f}{1.0\ \text{mW}} \right|$$



ELECTRO-OPTICAL CHARACTERISTICS (Applicable to Thermistor and TE Cooler: T_{LD} = 25 °C, T_c = –20 °C to +65 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Thermistor Resistance	R *2	9.5	10	10.5	kΩ	T_{LD} = 25 °C
Cooler Current	I_c		0.6	1.0	A	ΔT = 40 K
Cooler Voltage	V_c		1.1	1.5	V	ΔT = 40 K
Cooling Capacity	ΔT *3	40			K	I_C = 1.0 A, P_f = 1.0 mW

*2 B Constant (= 3 400±100 K)
*3 $\Delta T = |T_c - T_{LD}|$

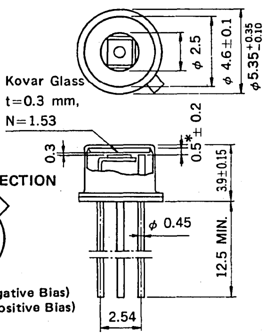
OPTICAL FIBER COMMUNICATIONS
GERMANIUM AVALANCHE PHOTO DIODE

DESCRIPTION

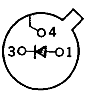
NDL5100 is a Germanium Avalanche Photo diode especially designed for a detector of long wavelength fiber transmission systems.

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION



1. Anode (Negative Bias)
3. Cathode (Positive Bias)
4. Case

*Optical length

FEATURES

- Small dark current. $I_D = 0.2\ \mu A$ TYP.
- High sensitivity. $\eta = 75\ \%$ TYP. @ 1 300 nm
- Short optical length & Hermetically sealded package.
- Detecting area size. ϕ 100 μm

ABSOLUTE MAXIMUM RATINGS ($T_a = 25\ °C$)

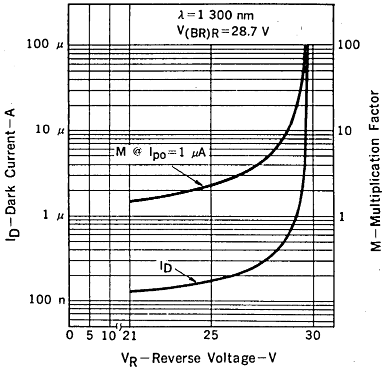
Forward Current	I_F	50	mA
Reverse Current	I_R	0.5	mA
Operating Case Temperature	T_C	−40 to +60	°C
Storage Temperature	T_{stg}	−55 to +125	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25\ °C$)

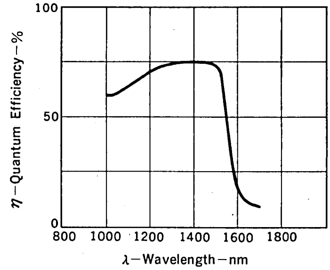
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	25		48	V	$I_D = 100\ \mu A$
Dark Current	I_D		0.2	0.5	μA	$V_R = V_{(BR)R} \times 0.9$
Terminal Capacitance	C_t		2.0	3.0	pF	$V_R = 20$ V, f = 1.0 MHz
Quantum Efficiency	η	70	75		%	λ = 1 300 nm
Multiplication Factor	M	20	40			λ = 1 300 nm, $R_L = 100\ \Omega$ $I_{po} = 1.0\ \mu A$, $V_R = V\ (I_D = 10\ \mu A)$
Rise Time	t_r		0.5	0.8	ns	λ = 1 300 nm, M = 10 $R_L = 50\ \Omega$, $I_{po} = 10\ \mu A$, 10–90 %
Fall Time	t_f		0.5	0.8	ns	λ = 1 300 nm, M = 10 $R_L = 50\ \Omega$, $I_{po} = 10\ \mu A$, 90–10 %
Excess Noise Factor	x		0.95			λ = 1 300 nm, M = 10, $I_{po} = 1.0\ \mu A$ f = 30 MHz, B = 1.0 MHz

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

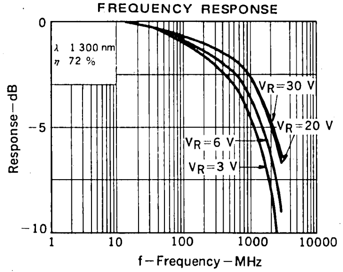
DARK CURRENT, MULTIPLICATION FACTOR vs. REVERSE VOLTAGE



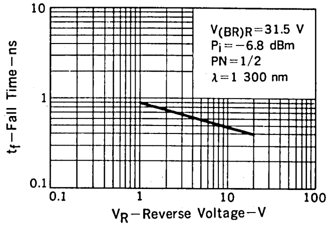
QUANTUM EFFICIENCY vs. WAVELENGTH



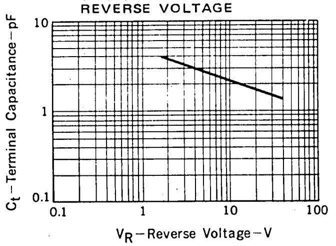
FREQUENCY RESPONSE



FALL TIME vs. REVERSE VOLTAGE



TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



DARK CURRENT vs. REVERSE VOLTAGE

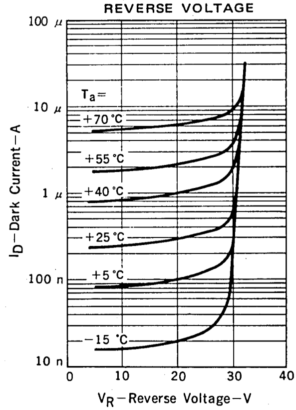


PHOTO DIODE
NDL5100C

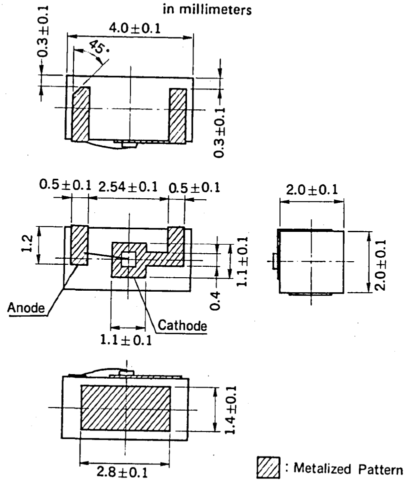
OPTICAL FIBER COMMUNICATIONS
GERMANIUM AVALANCHE PHOTO DIODE

DESCRIPTION

NDL5100C is a Germanium Avalanche Photo diode especially designed for a detector of long wavelength fiber transmission systems.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- Small dark current. $I_D = 0.2\ \mu A$ TYP.
- High sensitivity. $\eta = 75\ \%$ TYP. @1 300 nm
- Detecting area size. ϕ 100 μm

ABSOLUTE MAXIMUM RATINGS

($T_a = 25\ °C$, in dry nitrogen atmosphere)

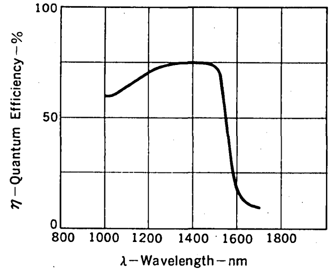
Forward Current	I_F	50	mA
Reverse Current	I_R	0.5	mA
Operating Temperature	T_{op}	−40 to +60	°C
Storage Temperature	T_{stg}	−55 to +125	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25\ °C$)

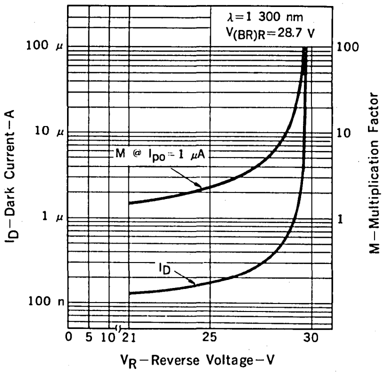
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	25		48	V	$I_D = 100\ \mu A$
Dark Current	I_D		0.2	0.5	μA	$V_R = V_{(BR)R} \times 0.9$
Terminal Capacitance	C_t		2.0	3.0	pF	$V_R = 20$ V, f = 1.0 MHz
Quantum Efficiency	η	70	75		%	$\lambda = 1\ 300$ nm
Multiplication Factor	M	20	40			$\lambda = 1\ 300$ nm, $R_L = 100\ \Omega$ $I_{po} = 1.0\ \mu A$, $V_R = V$ ($I_D = 10\ \mu A$)
Rise Time	t_r		0.5	0.8	ns	$\lambda = 1\ 300$ nm, M = 10 $R_L = 50\ \Omega$, $I_{po} = 10\ \mu A$, 10–90 %
Fall Time	t_f		0.5	0.8	ns	$\lambda = 1\ 300$ nm, M = 10 $R_L = 50\ \Omega$, $I_{po} = 10\ \mu A$, 90–10 %
Excess Noise Factor	x		0.95			$\lambda = 1\ 300$ nm, M = 10, $I_{po} = 1.0\ \mu A$ f = 30 MHz, B = 1.0 MHz

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

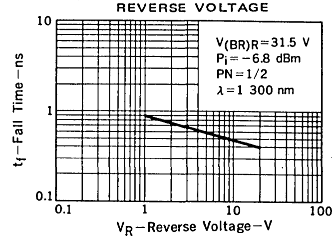
QUANTUM EFFICIENCY vs. WAVELENGTH



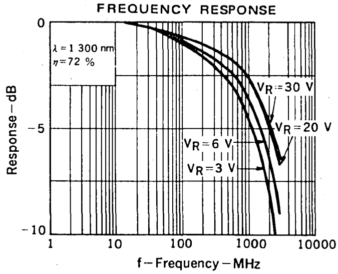
DARK CURRENT, MULTIPLICATION FACTOR vs. REVERSE VOLTAGE



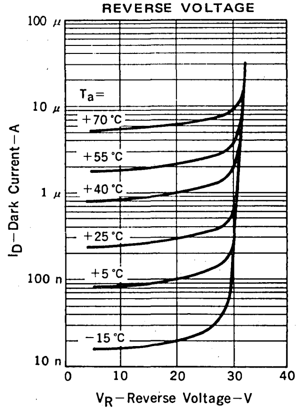
FALL TIME vs. REVERSE VOLTAGE



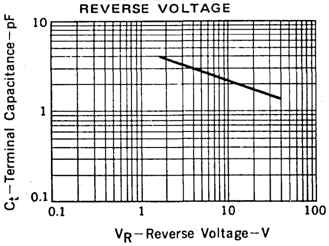
FREQUENCY RESPONSE



DARK CURRENT vs. REVERSE VOLTAGE



TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



DETECTOR CHIP ON CARRIER HANDLING PRE-CAUTION

DETECTOR CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS THE FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, THE FOLLOWING CONDITION SHOULD BE MAINTAINED.

STORAGE TEMPERATURE : +20 °C TO +30 °C
CONTAINER : CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS : DRY NITROGEN ATMOSPHERE

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE

ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) MAXIMUM TEMPERATURE IN ASSEMBLY CONDITIONS

THE FOLLOWING CONDITION SHOULD BE KEPT.

TEMPERATURE	DURATION	AMBIENT GAS
230 °C	1 minute	DRY NITROGEN ATMOSPHERE OR AIR
175 °C	3 hours	AIR
175 °C	24 hours	DRY NITROGEN ATMOSPHERE
130 °C	100 hours	DRY NITROGEN ATMOSPHERE

2-3) PRE-CAP BAKING CONDITION

IN ORDER TO STABILIZE DARK CURRENT, NEC RECOMMENDS ONE OF THE FOLLOWING CONDITIONS FOR PRE-CAP BAKING.

TEMPERATURE	DURATION	AMBIENT GAS
120 °C TO 175 °C	2 hours	VACUUM
120 °C TO 175 °C	24 hours	DRY NITROGEN ATMOSPHERE

2-4) HERMETIC SEALING

THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec BY He LEAKAGE TEST.

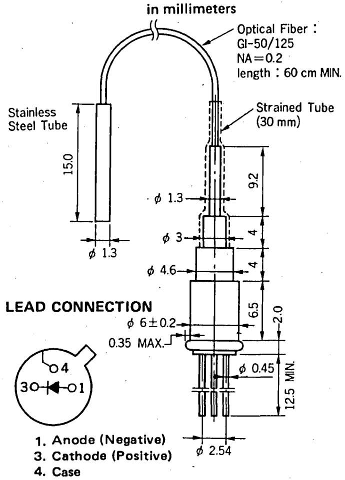
2-5) ELECTRO STATIC DISCHARGE (ESD) PROTECTION

DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

PHOTO DIODE
NDL5100P

OPTICAL FIBER COMMUNICATIONS
GERMANIUM AVALANCHE PHOTO DIODE MODULE

PACKAGE DIMENSIONS
in millimeters



DESCRIPTION

NDL5100P is a Germanium Avalanche Photo Diode with optical fiber, especially designed for a detector of long wavelength fiber transmission systems.

FEATURES

- Small dark current. $I_D = 0.2\ \mu A$
- High sensitivity. $\eta = 75\ \%,\ M = 40$
- Short optical length & Hermetically sealded package.

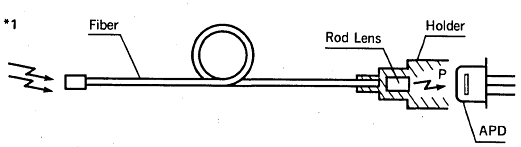
ABSOLUTE MAXIMUM RATINGS ($T_a = 25\ °C$)

Forward Current	I_F	50	mA
Reverse Current	I_R	0.5	mA
Operating Case Temperature	T_c	−40 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25\ °C$)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	25		48	V	$I_D = 100\ \mu A$
Dark Current	I_D		0.2	0.5	μA	$V_R = V_{(BR)R} \times 0.9$
Terminal Capacitance	C_t		2.0	3.0	pF	$V_R = 20$ V, f = 1.0 MHz
Quantum Efficiency	η *1	70	75		%	λ = 1 300 nm
Multiplication Factor	M	20	40			λ = 1 300 nm, $R_L = 100\ \Omega$ $I_{po} = 1.0\ \mu A$, $V_R = V(@\ I_D = 10\ \mu A)$
Rise Time	t_r		0.5	0.8	ns	λ = 1 300 nm, M = 10 $R_L = 50\ \Omega$, $I_{po} = 10\ \mu A$
Fall Time	t_f		0.5	0.8	ns	λ = 1 300 nm, M = 10 $R_L = 50\ \Omega$, $I_{po} = 10\ \mu A$
Excess Noise Factor	x		0.95			λ = 1 300 nm, M = 10, $I_{po} = 1.0\ \mu A$ f = 30 MHz, B = 1.0 MHz

*1



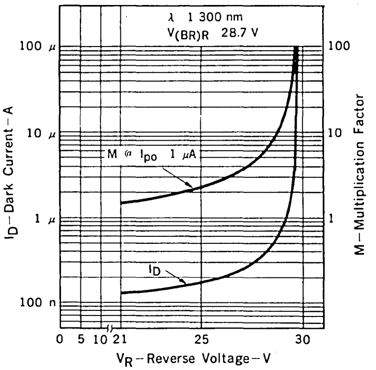
"η=70 % MIN." is guaranteed with the optical output power from a rod lens (P) in the holder.

$$\eta = \frac{h\nu}{q} \cdot \frac{I_P}{P}$$

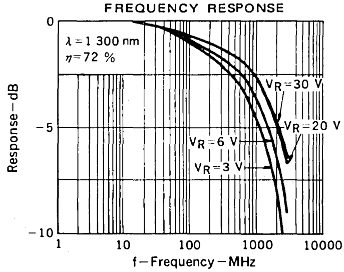
I_P : Photo Current
P : Optical Output Power from internal rod lens

TYPICAL CHARACTERISTICS ($T_a = 25\ °C$)

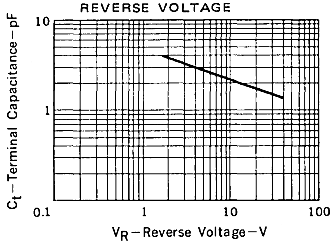
DARK CURRENT, MULTIPLICATION FACTOR vs. REVERSE VOLTAGE



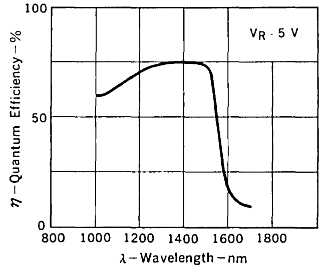
FREQUENCY RESPONSE



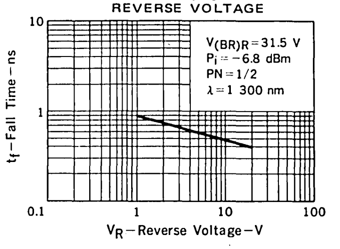
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



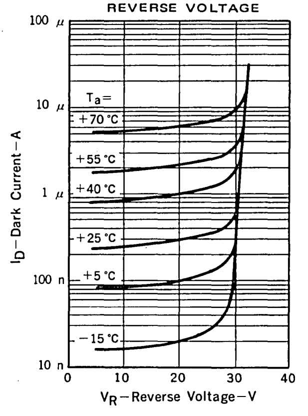
QUANTUM EFFICIENCY vs. WAVELENGTH



FALL TIME vs. REVERSE VOLTAGE



DARK CURRENT vs. REVERSE VOLTAGE



2

NDL5102

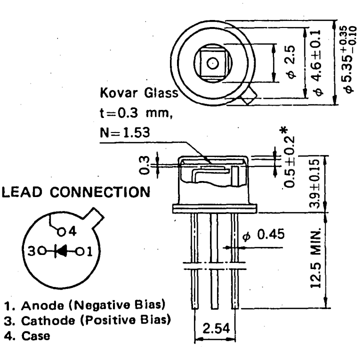
OPTICAL FIBER COMMUNICATIONS GERMANIUM AVALANCHE PHOTO DIODE

DESCRIPTION

NDL5102 is a Germanium Avalanche Photo diode especially designed for a detector of long wavelength fiber transmission systems. It features small dark current and high response speed due to small detecting area size.

PACKAGE DIMENSIONS

in millimeters



1. Anode (Negative Bias)
3. Cathode (Positive Bias)
4. Case

*Optical length

FEATURES

- Small dark current. I_D = 80 nA TYP.
- High sensitivity. η = 75 % TYP. @ 1 300 nm
- Short optical length & Hermetically sealed package.
- Detecting area size. ϕ 30 μm

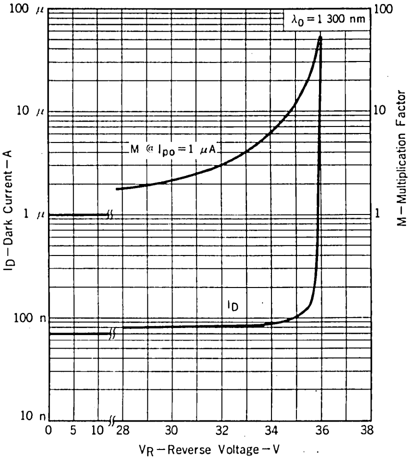
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	50	mA
Reverse Current	I_R	0.5	mA
Operating Case Temperature	T_C	−40 to +60	°C
Storage Temperature	T_{stg}	−55 to +125	°C

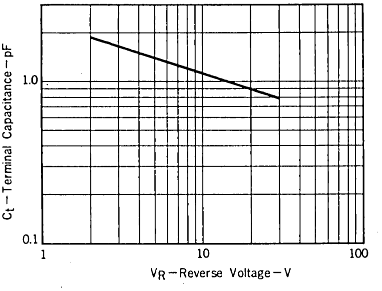
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	30	35	45	V	I_D = 100 μA
Dark Current	I_D		80	200	nA	$V_R = V_{(BR)R} \times 0.9$
Terminal Capacitance	C_t		0.9	1.5	pF	V_R = 20 V, f = 1.0 MHz
Quantum Efficiency	η	70	75		%	λ = 1 300 nm
Multiplication Factor	M	30	50			λ = 1 300 nm, R_L = 100 Ω I_{po} = 1.0 μA, V_R = V (I_D = 5 μA)
Rise Time	t_r		0.3	0.8	ns	λ = 1 300 nm, M = 10 R_L = 50 Ω, I_{po} = 10 μA, 10–90 %
Fall Time	t_f		0.3	0.8	ns	λ = 1 300 nm, M = 10 R_L = 50 Ω, I_{po} = 10 μA, 90–10 %
Excess Noise Factor	x		0.95			λ = 1 300 nm, M = 10, I_{po} = 1.0 μA f = 30 MHz, B = 1.0 MHz

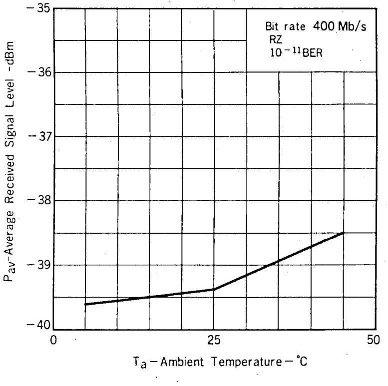
DARK CURRENT vs. REVERSE VOLTAGE



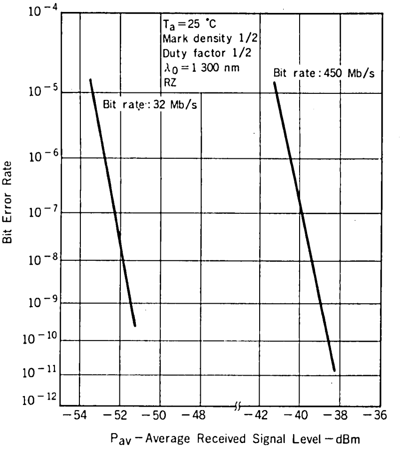
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



AVERAGE RECEIVED SIGNAL LEVEL vs. AMBIENT TEMPERATURE



BIT ERROR RATE vs. AVERAGE RECEIVED SIGNAL LEVEL



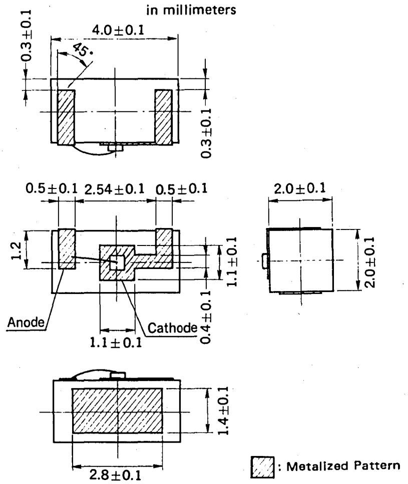
OPTICAL FIBER COMMUNICATIONS
GERMANIUM AVALANCHE PHOTO DIODE

DESCRIPTION

NDL5102C is a Germanium Avalanche Photo diode especially designed for a detector of long wavelength fiber transmission systems. It features small dark current and high response speed due to small detecting area size.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- Small dark current. I_D = 80 nA TYP.
- High sensitivity. η = 75 % TYP. @1 300 nm
- Detecting area size. ϕ 30 μm

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

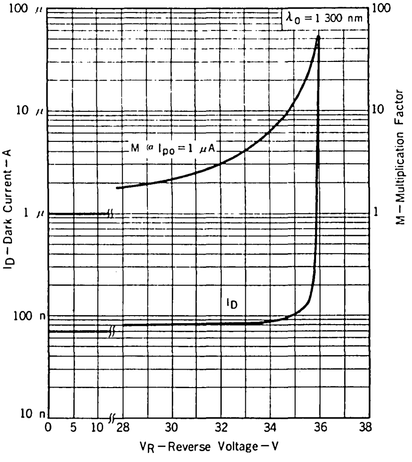
Forward Current	I_F	50	mA
Reverse Current	I_R	0.5	mA
Operating Temperature	T_{op}	−40 to +60	°C
Storage Temperature	T_{stg}	−55 to +125	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

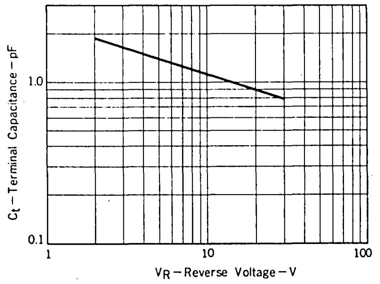
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	30	35	45	V	I_D = 100 μA
Dark Current	I_D		80	200	nA	$V_R = V_{(BR)R} \times 0.9$
Terminal Capacitance	C_t		0.9	1.5	pF	V_R = 20 V, f = 1.0 MHz
Quantum Efficiency	η	70	75		%	λ = 1 300 nm
Multiplication Factor	M	30	50			λ = 1 300 nm, R_L = 100 Ω I_{po} = 1.0 μA, V_R = V (I_D = 5 μA)
Rise Time	t_r		0.3	0.8	ns	λ = 1 300 nm, M = 10 R_L = 50 Ω, I_{po} = 10 μA, 10–90 %
Fall Time	t_f		0.3	0.8	ns	λ = 1 300 nm, M = 10 R_L = 50 Ω, I_{po} = 10 μA, 90–10 %
Excess Noise Factor	x		0.95			λ = 1 300 nm, M = 10, I_{po} = 1.0 μA f = 30 MHz, B = 1.0 MHz

TYPICAL CHARACTERISTICS ($T_a = 25$ °C)

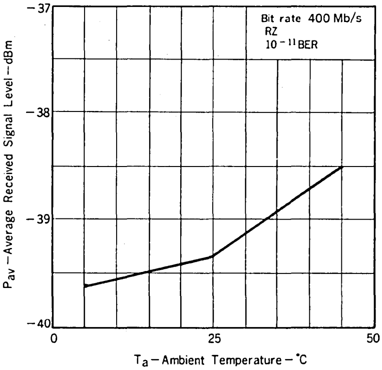
DARK CURRENT vs. REVERSE VOLTAGE



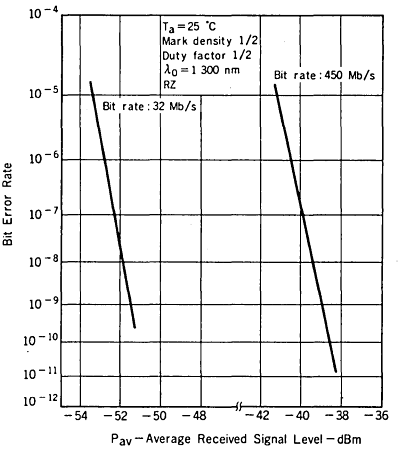
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



AVERAGE RECEIVED SIGNAL LEVEL vs. AMBIENT TEMPERATURE



BIT ERROR RATE vs. AVERAGE RECEIVED SIGNAL LEVEL



DETECTOR CHIP ON CARRIER HANDLING PRE-CAUTION

DETECTOR CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS THE FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, THE FOLLOWING CONDITION SHOULD BE MAINTAINED.

STORAGE TEMPERATURE : +20 °C TO +30 °C
CONTAINER : CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS : DRY NITROGEN ATMOSPHERE

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE

ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) MAXIMUM TEMPERATURE IN ASSEMBLY CONDITIONS

THE FOLLOWING CONDITION SHOULD BE KEPT.

TEMPERATURE	DURATION	AMBIENT GAS
230 °C	1 minute	DRY NITROGEN ATMOSPHERE OR AIR
175 °C	3 hours	AIR
175 °C	24 hours	DRY NITROGEN ATMOSPHERE
130 °C	100 hours	DRY NITROGEN ATMOSPHERE

2-3) PRE-CAP BAKING CONDITION

IN ORDER TO STABILIZE DARK CURRENT, NEC RECOMMENDS ONE OF THE FOLLOWING CONDITIONS FOR PRE-CAP BAKING.

TEMPERATURE	DURATION	AMBIENT GAS
120 °C TO 175 °C	2 hours	VACUUM
120 °C TO 175 °C	24 hours	DRY NITROGEN ATMOSPHERE

2-4) HERMETIC SEALING

THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec BY He LEAKAGE TEST.

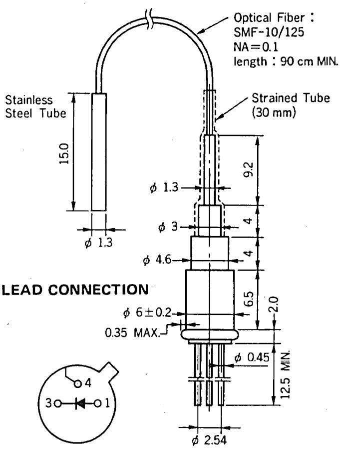
2-5) ELECTRO STATIC DISCHARGE (ESD) PROTECTION

DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

NDL5102P

OPTICAL FIBER COMMUNICATIONS
GERMANIUM AVALANCHE PHOTO DIODE MODULE

PACKAGE DIMENSIONS
in millimeters



LEAD CONNECTION

1. Anode (Negative)
3. Cathode (Positive)
4. Case

DESCRIPTION

NDL5102P is a Germanium Avalanche Photo diode with single mode fiber, especially designed for a detector of long wavelength fiber transmission systems. It features small dark current and high speed response due to small detecting area size.

FEATURES

- Small dark current. I_D = 80 nA TYP.
- High sensitivity. η = 75 % TYP. @1 300 nm
- Single Mode Fiber attached.

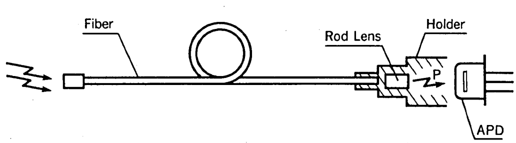
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	50	mA
Reverse Current	I_R	0.5	mA
Operating Case Temperature	T_c	−40 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$		35	45	V	I_D = 100 μA
Dark Current	I_D		80	200	nA	$V_R = V_{(BR)R} \times 0.9$
Terminal Capacitance	C_t		0.9	1.5	pF	V_R = 20 V, f = 1.0 MHz
Quantum Efficiency	η *1	70	75		%	λ = 1 300 nm
Multiplication Factor	M	30	50			λ = 1 300 nm, R_L = 100 Ω I_{po} = 1.0 μA, V_R = V(@ I_D = 5 μA)
Rise Time	t_r		0.3	0.8	ns	λ = 1 300 nm, M = 10 R_L = 50 Ω, I_{po} = 10 μA
Fall Time	t_f		0.3	0.8	ns	λ = 1 300 nm, M = 10 R_L = 50 Ω, I_{po} = 10 μA

*1



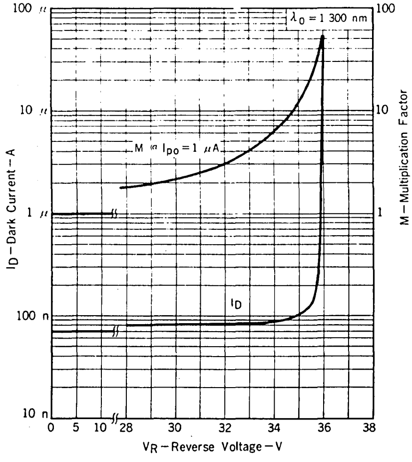
"η=70 % MIN." is guaranteed with the optical output power from a rod lens (P) in the holder.

$$\eta = \frac{h\nu}{q} \cdot \frac{I_P}{P}$$

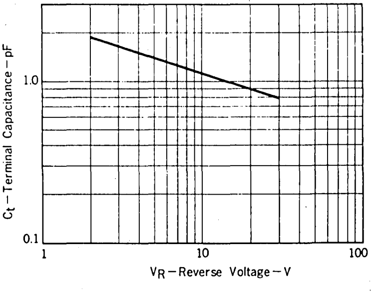
I_P : Photo Current
P : Optical Output Power from internal rod lens

TYPICAL CHARACTERISTICS ($T_a = 25\ °C$)

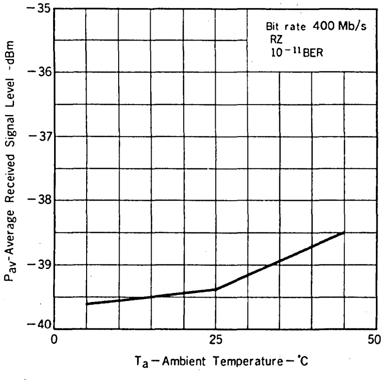
DARK CURRENT vs. REVERSE VOLTAGE



TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



AVERAGE RECEIVED SIGNAL LEVEL vs. AMBIENT TEMPERATURE



BIT ERROR RATE vs. AVERAGE RECEIVED SIGNAL LEVEL

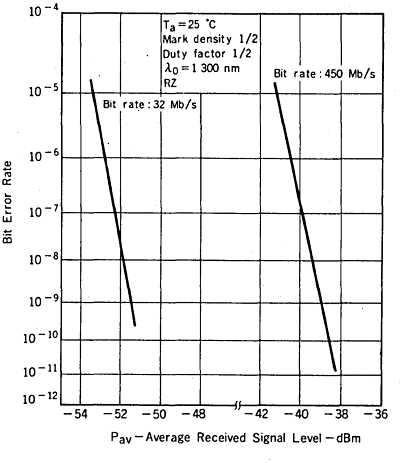


PHOTO DIODE
NDL5200

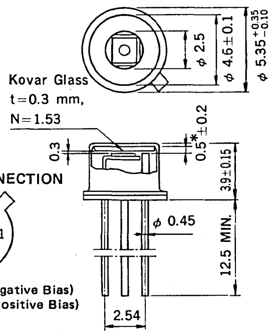
OPTICAL FIBER COMMUNICATIONS
Ge PHOTO DIODE

DESCRIPTION

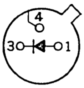
NDL5200 Germanium Photo diode is designed for a detector of long wavelength fiber transmission systems.

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION



1. Anode (Negative Bias)
3. Cathode (Positive Bias)
4. Case

*Optical length

FEATURES

- High quantum efficiency. $\eta = 75$ % (@ 1 300 nm)
- Small dark current. $I_D = 0.5$ μA
- Short optical length & hermetically sealed package.
- Detecting area size. φ 240 μm

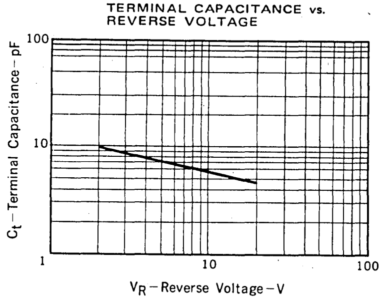
ABSOLUTE MAXIMUM RATINGS ($T_a = 25$ °C)

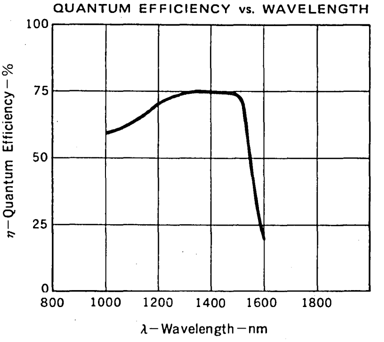
Reverse Voltage	V_R	20	V
Forward Current	I_F	50	mA
Reverse Current	I_R	5	mA
Operating Case Temperature	T_C	−40 to +60	°C
Storage Temperature	T_{stg}	−65 to +125	°C

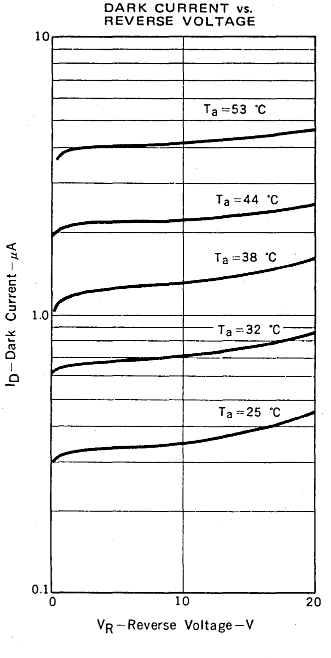
ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25$ °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D		0.5	1.0	μA	$V_R = 6.0$ V
Terminal Capacitance	C_t		7	20	pF	$V_R = 6.0$ V, f = 1.0 MHz
Quantum Efficiency	η	70	75		%	$V_R = 6.0$ V, λ = 1 300 nm

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)







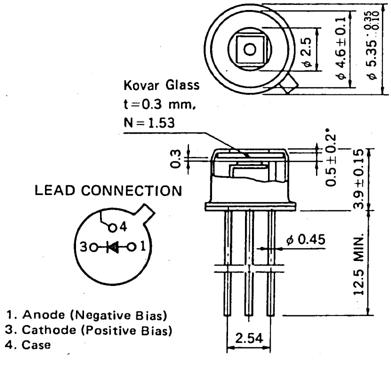
NDL5500

1 000 to 1 600 nm OPTICAL FIBER COMMUNICATIONS
ϕ50 μm InGaAs AVALANCHE PHOTO DIODE

DESCRIPTION

NDL5500 is an InGaAs Avalanche Photodiode especially designed for a detector of long wavelength optical fiber communication systems. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS
in millimeters



*Optical length

FEATURES

- Small dark current. I_D = 20 nA TYP.
- High sensitivity. η = 85 % TYP. @1 300 nm
  η = 80 % TYP. @1 550 nm
- High speed response. f_c = 1.0 GHz MIN.
- Short optical length. 0.5 mm
- Detecting area size. ϕ50 μm

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

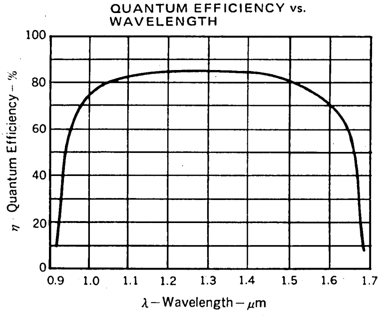
Forward Current	I_F	10	mA
Reverse Current	I_R	500	μA
Operating Case Temperature	T_C	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +100	°C

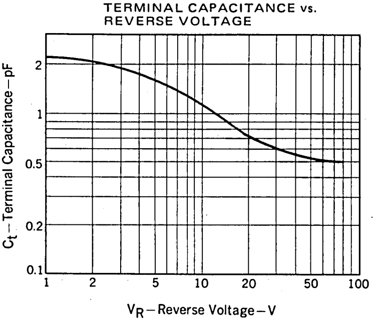
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	60	80	120	V	I_D = 100 μA
Temperature Coefficient of Reverse Breakdown Voltage	δ *1		0.15		%/°C	
Dark Current	I_D		20	100	nA	$V_R = V_{(BR)R}$ ×0.9
Multiplied Dark Current	I_{DM}			10	nA	M = 2
Terminal Capacitance	C_t		0.5	1.0	pF	$V_R = V_{(BR)R}$ ×0.9
Cut-off Frequency	f_c	1			GHz	M = 10
Quantum Efficiency	η	70	85		%	λ = 1 300 mm
			80		%	λ = 1 550 mm
Sensitivity	S	0.73	0.89		A/W	λ = 1 300 nm
			1.00			λ = 1 550 nm
Multiplication Factor	M	20	40			λ = 1 550 nm, I_{PO} = 1.0 μA V_R = V (@I_D = 1 μA)
Excess Noise Factor	x		0.7			λ = 1 300 nm, 1 550 nm, I_{PO} = 1.0 μA M = 10, f = 35 MHz, B = 1 MHz
Excess Noise Coefficient	F		5			
Effective Detecting Area Size	φE	30	40		μm	M = 10, 80 % of Peak

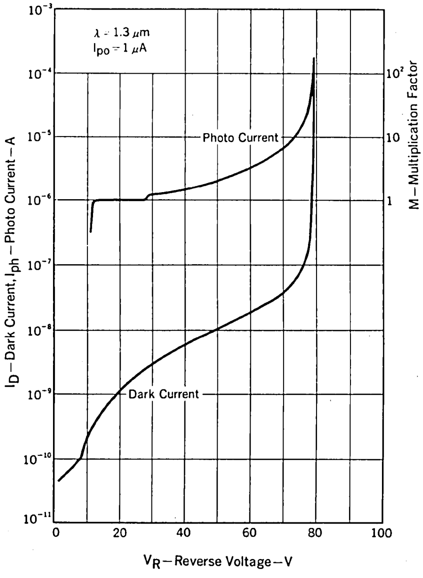
*1 : $\delta = \dfrac{V_{(BR)R} < 25\,°C + \Delta T\,°C > - V_{(BR)R} < 25\,°C >}{\Delta T\,°C \cdot V_{(BR)R} < 25\,°C >}$

TYPICAL CHARACTERISTICS (T_a = 25 °C)

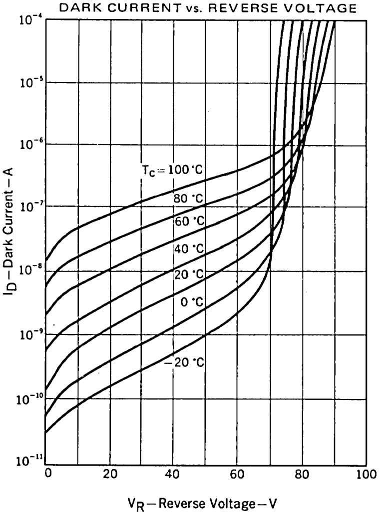




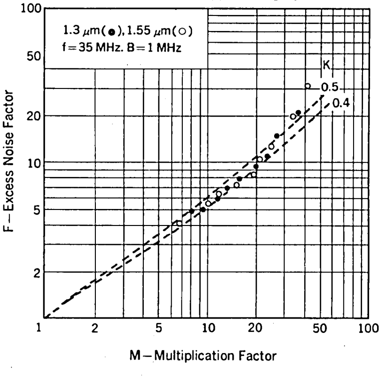
DARK CURRENT and PHOTO CURRENT vs. REVERSE VOLTAGE



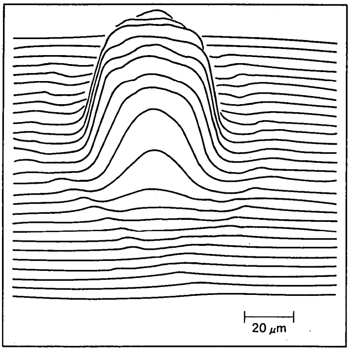
DARK CURRENT vs. REVERSE VOLTAGE

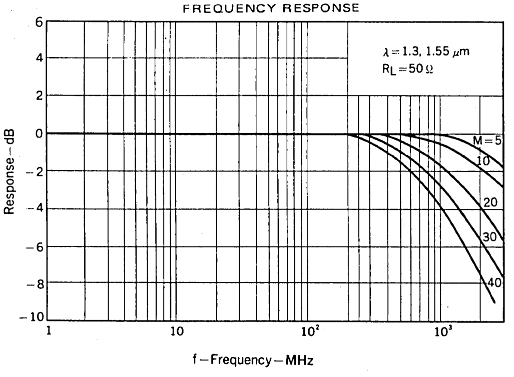


EXCESS NOISE FACTOR vs. MULTIPLICATION FACTOR



MULTIPLICATION MAP




FREQUENCY RESPONSE
λ = 1.3, 1.55 μm
RL = 50 Ω
Response – dB
6
4
2
0
–2
–4
–6
–8
–10
1
10
10²
10³
f – Frequency – MHz
M = 5
10
20
30
40

NDL5500C

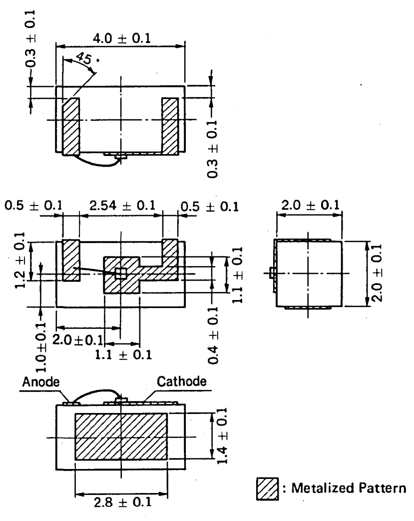
1 000 to 1 600 nm OPTICAL FIBER COMMUNICATION ϕ50 μm InGaAs AVALANCHE PHOTO DIODE

DESCRIPTION

NDL5500C is an InGaAs Avalanche Photodiode especially designed for a detector of long wavelength optical fiber communication systems. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- Small dark current. I_D = 20 nA TYP.
- High sensitivity. η = 85 % TYP. @1 300 nm
  η = 80 % TYP. @1 550 nm
- High speed response. f_c = 1.0 GHz MIN.
- Detecting area size. ϕ50 μm

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

Forward Current	I_F	10	mA
Reverse Current	I_R	500	μA
Operating Temperature	T_{op}	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +100	°C

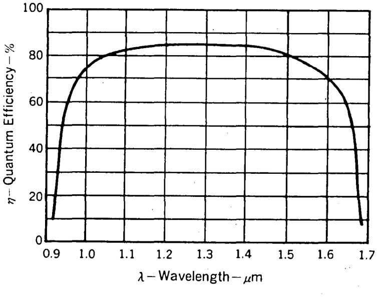
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	60	80	120	V	I_D = 100 μA
Temperature Coefficient of Reverse Breakdown Voltage	δ *1		0.15		%/°C	
Dark Current	I_D		20	100	nA	$V_R = V_{(BR)R}$ ×0.9
Multiplied Dark Current	I_{DM}			10	nA	M = 2
Terminal Capacitance	C_t		0.5	1.0	pF	$V_R = V_{(BR)R}$ ×0.9
Cut-off Frequency	f_c	1			GHz	M = 10
Quantum Efficiency	η	70	85		%	λ = 1 300 nm
			80		%	λ = 1 550 nm
Sensitivity	S	0.73	0.89		A/W	λ = 1 300 nm
			1.00			λ = 1 550 nm
Multiplication Factor	M	20	40			λ = 1 550 nm, I_{PO} = 1.0 μA V_R = V (@I_D = 1 μA)
Excess Noise Factor	x		0.7			λ = 1 300 nm, 1 550 nm, I_{PO} = 1.0 μA M = 10, f = 35 MHz, B = 1 MHz
Excess Noise Coefficient	F		5			
Effective Detecting Area Size	ϕ_E	30	40		μm	M = 10, 80 % of Peak

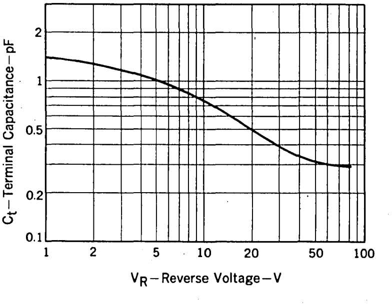
$$*1 : \delta = \frac{V_{(BR)R} < 25\,°C + \Delta T\,°C > - V_{(BR)R} < 25\,°C >}{\Delta T\,°C \cdot V_{(BR)R} < 25\,°C >}$$

TYPICAL CHARACTERISTICS (T_a = 25 °C)

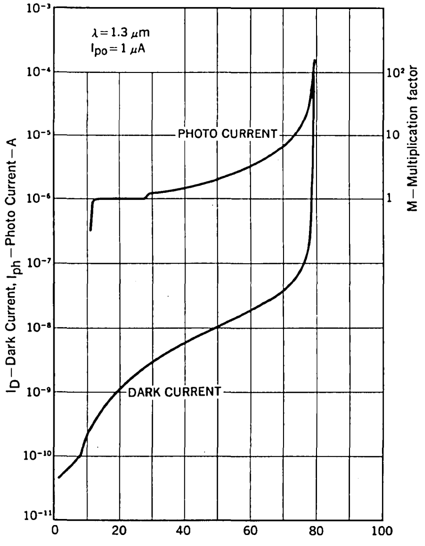
QUANTUM EFFICIENCY vs. WAVELENGTH



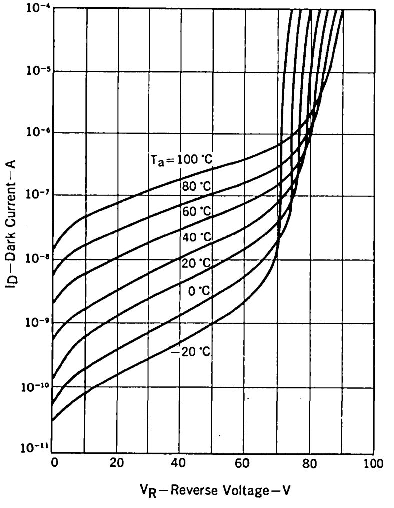
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



DARK CURRENT and PHOTO CURRENT vs. REVERSE VOLTAGE

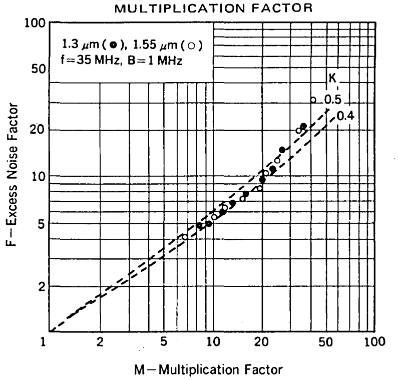


DARK CURRENT vs. REVERSE VOLTAGE

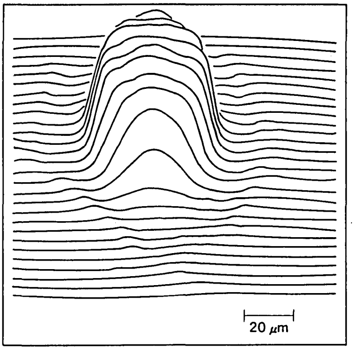


2

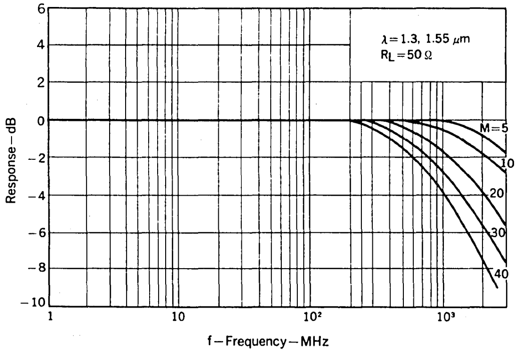
EXCESS NOISE FACTOR vs. MULTIPLICATION FACTOR



MULTIPLICATION MAP



FREQUENCY RESPONSE



DETECTOR CHIP ON CARRIER HANDLING PRE-CAUTION

DETECTOR CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS THE FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, THE FOLLOWING CONDITION SHOULD BE MAINTAINED.

STORAGE TEMPERATURE : +20 °C TO +30 °C
CONTAINER : CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS : DRY NITROGEN ATMOSPHERE

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE

ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) MAXIMUM TEMPERATURE IN ASSEMBLY CONDITIONS

THE FOLLOWING CONDITION SHOULD BE KEPT.

TEMPERATURE	DURATION	AMBIENT GAS
230 °C	1 minute	DRY NITROGEN ATMOSPHERE OR AIR
175 °C	3 hours	AIR
175 °C	24 hours	DRY NITROGEN ATMOSPHERE
130 °C	100 hours	DRY NITROGEN ATMOSPHERE

2-3) PRE-CAP BAKING CONDITION

IN ORDER TO STABILIZE DARK CURRENT, NEC RECOMMENDS ONE OF THE FOLLOWING CONDITIONS FOR PRE-CAP BAKING.

TEMPERATURE	DURATION	AMBIENT GAS
120 °C TO 175 °C	2 hours	VACUUM
120 °C TO 175 °C	24 hours	DRY NITROGEN ATMOSPHERE

2-4) HERMETIC SEALING

THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec BY He LEAKAGE TEST.

2-5) ELECTRO STATIC DISCHARGE (ESD) PROTECTION

DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

PHOTO DIODE

NDL5500P

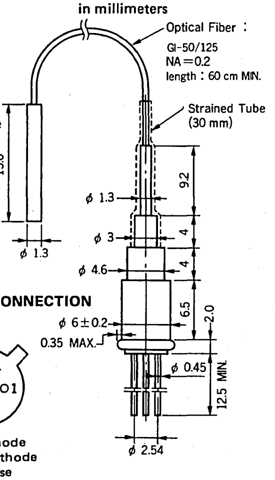
1 000 to 1 600 nm OPTICAL FIBER COMMUNICATIONS
ϕ50 μm InGaAs AVALANCHE PHOTO DIODE MODULE

DESCRIPTION

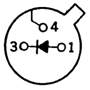
NDL5500P is an InGaAs Avalanche Photodiode especially designed for a detector of long wavelength optical fiber communication systems. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION



1. Anode
3. Cathode
4. Case

FEATURES

- Small dark current. I_D = 20 nA TYP.
- High sensitivity. η = 85 % TYP. @1 300 nm
  η = 80 % TYP. @1 550 nm
- High speed response. f_c = 1.0 GHz MIN.
- Short optical length. 0.5 mm

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

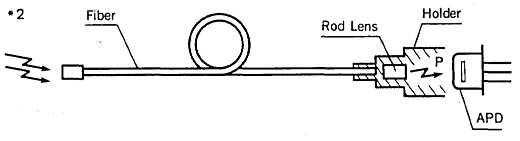
Forward Current	I_F	10	mA
Reverse Current	I_R	500	μA
Operating Case Temperature	T_C	−40 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25\ °C$)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	60	80	120	V	$I_D = 100\ \mu A$
Temperature Coefficient of Reverse Breakdown Voltage	δ *1		0.15		%/°C	
Dark Current	I_D		20	100	nA	$V_R = V_{(BR)R} \times 0.9$
Multiplied Dark Current	I_{DM}			10	nA	M = 2
Terminal Capacitance	C_t		0.5	1.0	pF	$V_R = V_{(BR)R} \times 0.9$
Cut-off Frequency	f_c	1			GHz	M = 10
Quantum Efficiency	η *2	70	85		%	λ = 1 300 mm
			80		%	λ = 1 550 mm
Sensitivity	S	0.73	0.89		A/W	λ = 1 300 nm
			1.00			λ = 1 550 nm
Multiplication Factor	M	20	40			λ = 1 550 nm, $I_{PO} = 1.0\ \mu A$ $V_R = V\ (@I_D = 1\ \mu A)$
Excess Noise Factor	x		0.7			λ = 1 300 nm, 1550 nm, $I_{PO} = 1.0\ \mu A$, M = 10, f = 35 MHz, B = 1 MHz
Excess Noise Coefficient	F		5			

*1 : $\delta = \frac{V_{(BR)R} < 25\ °C + \Delta T\ °C > - V_{(BR)R} < 25\ °C >}{\Delta T\ °C \cdot V_{(BR)R} < 25\ °C >}$

*2

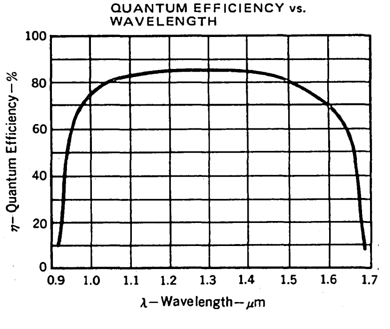


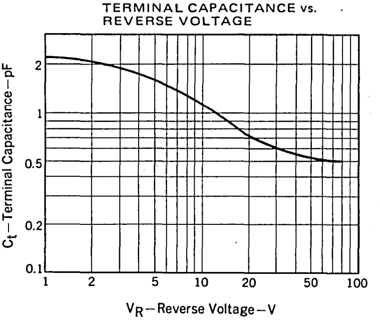
"η = 70 % MIN." is guaranteed with the optical output power from a rod lens (P) in the holder.

$$\eta = \frac{h\nu}{q} \cdot \frac{I_P}{P} = \frac{h\nu}{q} \cdot S$$

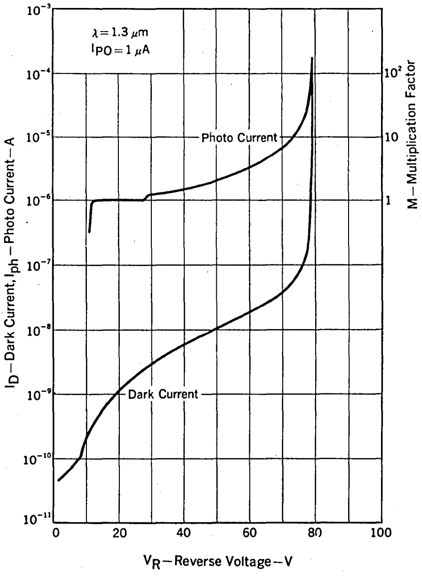
I_P : Photo Current
P : Optical Output Power from internal rod lens

TYPICAL CHARACTERISTICS ($T_a = 25\ °C$)

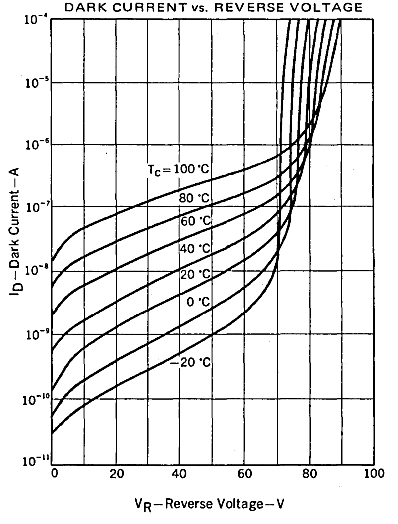




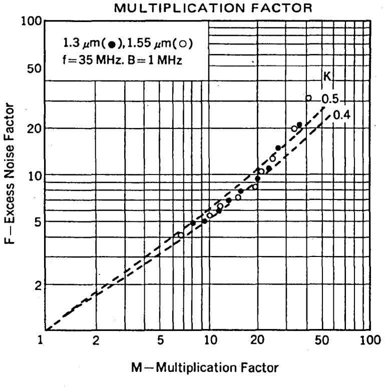
DARK CURRENT and PHOTO CURRENT vs. REVERSE VOLTAGE



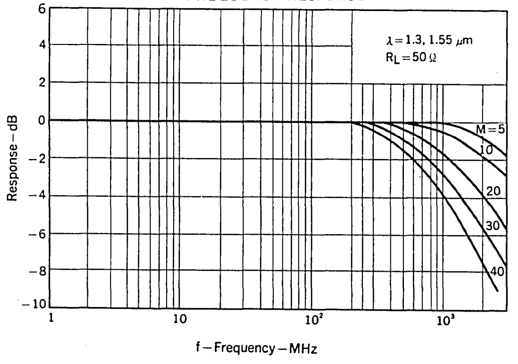
DARK CURRENT vs. REVERSE VOLTAGE



EXCESS NOISE FACTOR vs. MULTIPLICATION FACTOR



FREQUENCY RESPONSE



2

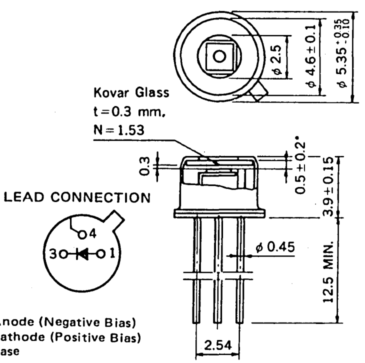
PHOTO DIODE
NDL5510

1 000 to 1 600 nm OPTICAL FIBER COMMUNICATIONS ϕ80 μm InGaAs AVALANCHE PHOTO DIODE

DESCRIPTION

NDL5510 is an InGaAs Avalanche Photodiode especially designed for a detector of long wavelength optical fiber communication systems and optical measurement equipment. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS
in millimeters



1. Anode (Negative Bias)
3. Cathode (Positive Bias)
4. Case

*Optical length

FEATURES

- Small dark current. $I_D = 60$ nA
- High sensitivity. η = 85 % @1 300 nm
  η = 80 % @1 550 nm
- High speed response. f_c = 700 MHz MIN.
- Short optical length. 0.5 mm
- Detecting area size. ϕ80 μm

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	10	mA
Reverse Current	I_R	500	μA
Operating Case Temperature	T_C	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +100	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	50	75	100	V	I_D = 100 μA
Temperature Coefficient of Reverse Breakdown Voltage	δ *1		0.15		%/°C	
Dark Current	I_D		60	200	nA	$V_R = V_{(BR)R}$ ×0.9
Multiplied Dark Current	I_{DM}		10		nA	M = 2 ~ 10
Terminal Capacitance	C_t		1.0	2.0	pF	$V_R = V_{(BR)R}$ ×0.9
Cut-off Frequency	f_c	700			MHz	M = 10
Quantum Efficiency	η	70	85		%	λ = 1 300 mm
			80		%	λ = 1 550 mm
Sensitivity	S	0.73	0.89		A/W	λ = 1 300 nm
			1.00			λ = 1 550 nm
Multiplication Factor	M	20	40			λ = 1 550 nm, I_{PO} = 1.0 μA V_R = V (@I_D = 1 μA)
Excess Noise Factor	x		0.7			λ = 1 300 nm, 1 550 nm, I_{PO} = 1.0 μA M = 10, f = 35 MHz, B = 1 MHz
Excess Noise Coefficient	F		5			
Effective Detecting Area Size	φE	60	70		μm	M = 10, 80 % of Peak

*1 : $\delta = \dfrac{V_{(BR)R} < 25\,^\circ C + \Delta T\,^\circ C > - V_{(BR)R} < 25\,^\circ C >}{\Delta T\,^\circ C \cdot V_{(BR)R} < 25\,^\circ C >}$

TYPICAL CHARACTERISTICS (T_a = 25 °C)

QUANTUM EFFICIENCY vs. WAVELENGTH

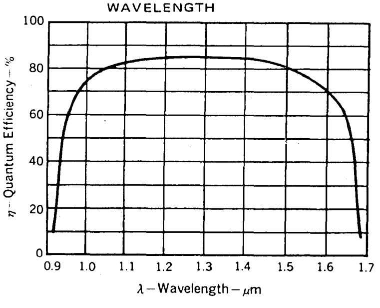


PHOTO DIODE

NDL5510C

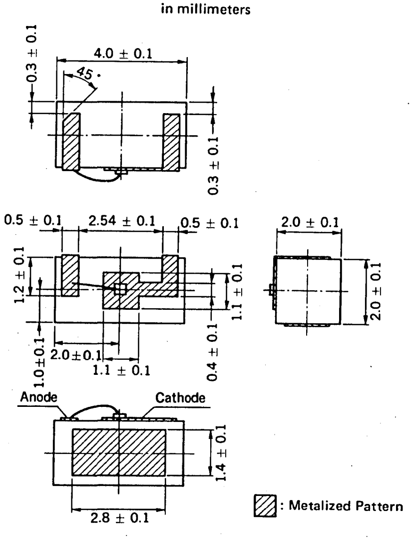
1 000 to 1 600 nm OPTICAL FIBER COMMUNICATIONS
ϕ80 μm InGaAs AVALANCHE PHOTO DIODE

DESCRIPTION

NDL5510C is an InGaAs Avalanche Photodiode especially designed for a detector of long wavelength optical fiber communications systems and optical measurement equipment. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- Small dark current. I_D = 60 nA
- High sensitivity. η = 85 % @1 300 nm
  η = 80 % @1 550 nm
- High speed response. f_c = 700 MHz MIN.
- Detecting area size. ϕ80 μm

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

Forward Current	I_F	10	mA
Reverse Current	I_R	500	μA
Operating Temperature	T_{op}	–40 to +70	°C
Storage Temperature	T_{stg}	–55 to +100	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

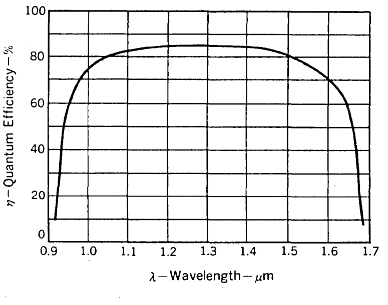
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Reverse Breakdown Voltage	$V_{(BR)R}$	50	75	100	V	I_D = 100 μA
Temperature Coefficient of Reverse Breakdown Voltage	δ *1		0.15		%/°C	
Dark Current	I_D		60	200	nA	$V_R = V_{(BR)R}$ ×0.9
Multiplied Dark Current	I_{DM}		10		nA	M = 2 ~ 10
Terminal Capacitance	C_t		1.0	2.0	pF	$V_R = V_{(BR)R}$ ×0.9
Cut-off Frequency	f_c	700			MHz	M = 10
Quantum Efficiency	η	70	85		%	λ = 1 300 nm
			80		%	λ = 1 550 nm
Sensitivity	S	0.73	0.89		A/W	λ = 1 300 nm
			1.00			λ = 1 550 nm
Multiplication Factor	M	20	40			λ = 1 550 nm, I_{PO} = 1.0 μA V_R = V (@I_D = 1 μA)
Excess Noise Factor	x		0.7			λ = 1 300 nm, 1 550 nm, I_{PO} = 1.0 μA M = 10, f = 35 MHz, B = 1 MHz
Excess Noise Coefficient	F		5			
Effective Detecting Area Size	ϕE	60	70		μm	M = 10, 80 % of Peak

*1 : $\delta = \dfrac{V_{(BR)R} < 25\,°C + \Delta T\,°C > - V_{(BR)R} < 25\,°C >}{\Delta T\,°C \quad V_{(BR)R} < 25\,°C >}$

2

TYPICAL CHARACTERISTICS (T_a = 25 °C)

QUANTUM EFFICIENCY vs. WAVELENGTH



DETECTOR CHIP ON CARRIER HANDLING PRE-CAUTION

DETECTOR CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS THE FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, THE FOLLOWING CONDITION SHOULD BE MAINTAINED.

STORAGE TEMPERATURE : +20 °C TO +30 °C
CONTAINER : CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS : DRY NITROGEN ATMOSPHERE

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE

ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) MAXIMUM TEMPERATURE IN ASSEMBLY CONDITIONS

THE FOLLOWING CONDITION SHOULD BE KEPT.

TEMPERATURE	DURATION	AMBIENT GAS
230 °C	1 minute	DRY NITROGEN ATMOSPHERE OR AIR
175 °C	3 hours	AIR
175 °C	24 hours	DRY NITROGEN ATMOSPHERE
130 °C	100 hours	DRY NITROGEN ATMOSPHERE

2-3) PRE-CAP BAKING CONDITION

IN ORDER TO STABILIZE DARK CURRENT, NEC RECOMMENDS ONE OF THE FOLLOWING CONDITIONS FOR PRE-CAP BAKING.

TEMPERATURE	DURATION	AMBIENT GAS
120 °C TO 175 °C	2 hours	VACUUM
120 °C TO 175 °C	24 hours	DRY NITROGEN ATMOSPHERE

2-4) HERMETIC SEALING

THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec BY He LEAKAGE TEST.

2-5) ELECTRO STATIC DISCHARGE (ESD) PROTECTION

DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

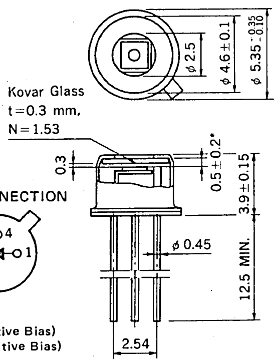
PHOTO DIODE
NDL5405

1 000 to 1600 nm OPTICAL FIBER COMMUNICATIONS
ϕ80 μm InGaAs PIN PHOTO DIODE

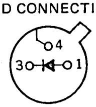
DESCRIPTION

NDL5405 is an InGaAs PIN photo diode for a light detector of long wavelength transmission systems. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS
in millimeters



LEAD CONNECTION



1. Anode (Negative Bias)
3. Cathode (Positive Bias)
4. Case

*Optical length

FEATURES

- High quantum efficiency. η = 85 % TYP. @1 300 nm
  η = 80 % TYP. @1 550 nm
- Small dark current. I_D = 0.1 nA TYP.
- Low operating voltage.
- High speed response. t_r, t_f = 0.3 ns TYP.
- Detecting area size. ϕ 80 μm

2

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

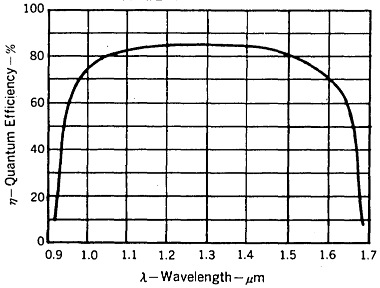
Reverse Voltage	V_R	20	V
Forward Current	I_F	10	mA
Reverse Current	I_R	0.5	mA
Operating Temperature	T_C	–40 to +85	°C
Storage Temperature	T_{stg}	–55 to +150	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

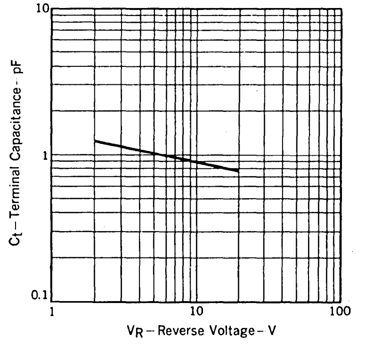
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D		0.1	5.0	nA	V_R = 5 V
Terminal Capacitance	C_t		1.0	1.5	pF	V_R = 5 V, f = 1.0 MHz
Quantum Efficiency	η	70	85		%	λ = 1 300 nm
			80			λ = 1 550 nm
Sensitivity	S	0.73	0.89		A/W	λ = 1 300 nm
			1.00			λ = 1 550 nm
Rise, Fall Time	t_r, t_f		0.3	1.0	ns	V_R = 5 V, λ = 1 300 nm, R_L = 50 Ω, 10–90 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)

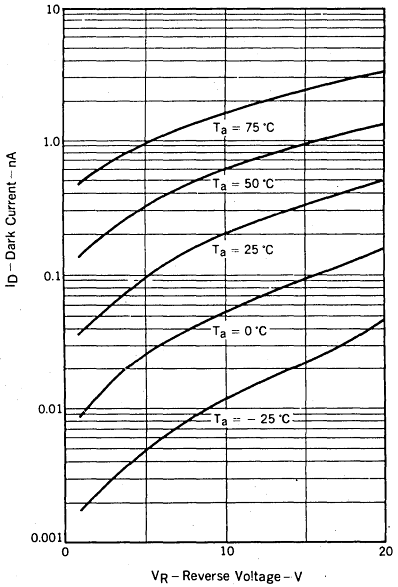
QUANTUM EFFICIENCY vs. WAVELENGTH



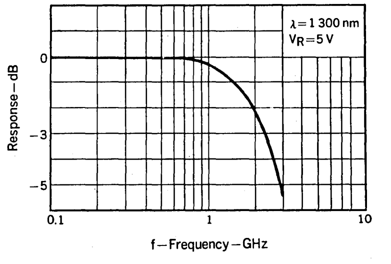
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



DARK CURRENT vs. REVERSE VOLTAGE



FREQUENCY RESPONSE



NDL5405C

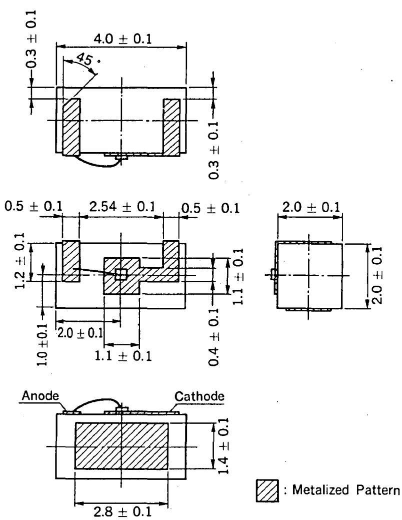
1 000 to 1600 nm OPTICAL FIBER COMMUNICATIONS
ϕ80 μm InGaAs PIN PHOTO DIODE

DESCRIPTION

NDL5405C is an InGaAs PIN photo diode for a light detector of long wavelength transmission systems. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High quantum efficiency. η = 85 % TYP. @1 300 nm
  η = 80 % TYP. @1 550 nm
- Small dark current. I_D = 0.1 nA TYP.
- Low operating voltage.
- High speed response. t_r, t_f = 0.3 ns TYP.
- Detecting area size. ϕ 80 μm

ABSOLUTE MAXIMUM RATINGS

(T_a = 25 °C, in dry nitrogen atmosphere)

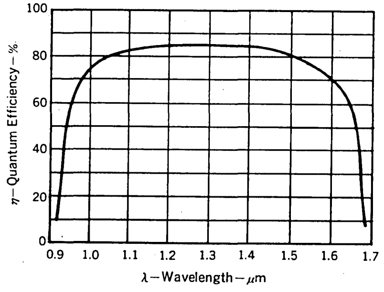
Reverse Voltage	V_R	20	V
Forward Current	I_F	10	mA
Reverse Current	I_R	0.5	mA
Operating Temperature	T_{op}	−40 to +85	°C
Storage Temperature	T_{stg}	−55 to +150	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

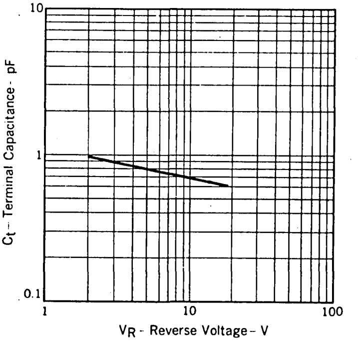
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D		0.1	5.0	nA	V_R = 5 V
Terminal Capacitance	C_t		0.8	1.4	pF	V_R = 5 V, f = 1.0 MHz
Quantum Efficiency	η	70	85		%	λ = 1 300 nm
			80			λ = 1 550 nm
Sensitivity	S	0.73	0.89		A/W	λ = 1 300 nm
			1.00			λ = 1 550 nm
Rise, Fall Time	t_r, t_f		0.3	1.0	ns	V_R = 5 V, λ = 1 300 nm, R_L = 50 Ω, 10–90 %

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

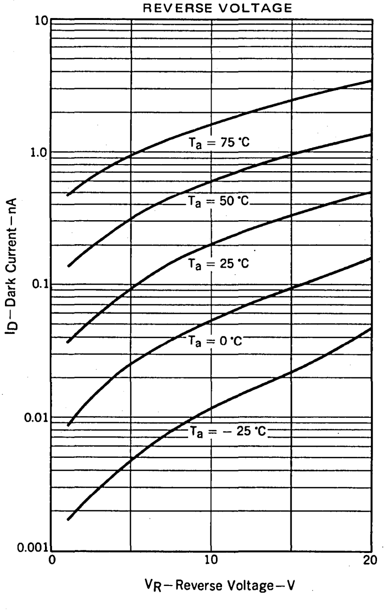
QUANTUM EFFICIENCY vs. WAVELENGTH



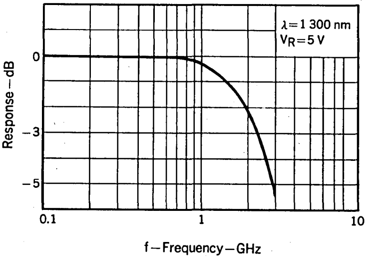
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



DARK CURRENT vs. REVERSE VOLTAGE



FREQUENCY RESPONSE



DETECTOR CHIP ON CARRIER HANDLING PRE-CAUTION

DETECTOR CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS THE FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, THE FOLLOWING CONDITION SHOULD BE MAINTAINED.

STORAGE TEMPERATURE : +20 °C TO +30 °C
CONTAINER : CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS : DRY NITROGEN ATMOSPHERE

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE

ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) MAXIMUM TEMPERATURE IN ASSEMBLY CONDITIONS

THE FOLLOWING CONDITION SHOULD BE KEPT.

TEMPERATURE	DURATION	AMBIENT GAS
230 °C	1 minute	DRY NITROGEN ATMOSPHERE OR AIR
175 °C	3 hours	AIR
175 °C	24 hours	DRY NITROGEN ATMOSPHERE
130 °C	100 hours	DRY NITROGEN ATMOSPHERE

2-3) PRE-CAP BAKING CONDITION

IN ORDER TO STABILIZE DARK CURRENT, NEC RECOMMENDS ONE OF THE FOLLOWING CONDITIONS FOR PRE-CAP BAKING.

TEMPERATURE	DURATION	AMBIENT GAS
120 °C TO 175 °C	2 hours	VACUUM
120 °C TO 175 °C	24 hours	DRY NITROGEN ATMOSPHERE

2-4) HERMETIC SEALING

THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec BY He LEAKAGE TEST.

2-5) ELECTRO STATIC DISCHARGE (ESD) PROTECTION

DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

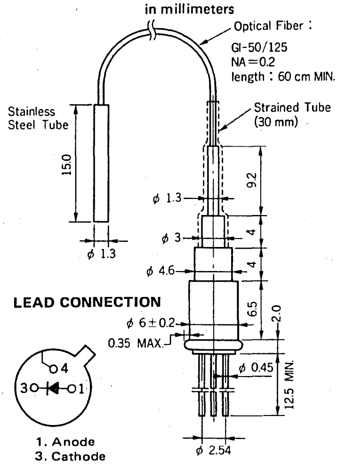
PHOTO DIODE
NDL5405P

1 000 to 1 600 nm OPTICAL FIBER COMMUNICATIONS
ϕ80 μm InGaAs PIN PHOTO DIODE MMF MODULE

NDL5405P is an InGaAs PIN photo diode module with multimode fiber pigtail. It is designed for a light detector of long wavelength transmission systems. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION

1. Anode
3. Cathode
4. Case

FEATURES

- High quantum efficiency. η = 85 %. @ λ = 1 300 nm
  η = 80 %. @ λ = 1 550 nm
- Small dark current. I_D = 0.1 nA TYP.
- Low operating voltage.
- High speed response. t_r, t_f = 0.3 ns TYP.
- Coaxitial module with multimode fiber (MMF)

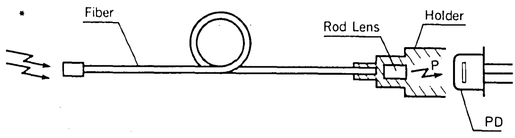
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage	V_R	20	V
Forward Current	I_F	10	mA
Reverse Current	I_R	0.5	mA
Operating Case Temperature	T_C	–40 to +60	°C
Storage Temperature	T_{stg}	–40 to +70	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D		0.1	5.0	nA	V_R = 5 V
Terminal Capacitance	C_t		1.0	1.5	pF	V_R = 5 V, f = 1.0 MHz
Quantum Efficiency	η *1	70	85		%	λ = 1 300 nm
			80			λ = 1 550 nm
Sensitivity	S *1	0.73	0.89		A/W	λ = 1 300 nm
			1.00			λ = 1 550 nm
Rise, Fall Time	t_r, t_f		0.3	1.0	ns	V_R = 5 V, λ = 1 300 nm, R_L = 50 Ω

*1 Refer to the next page



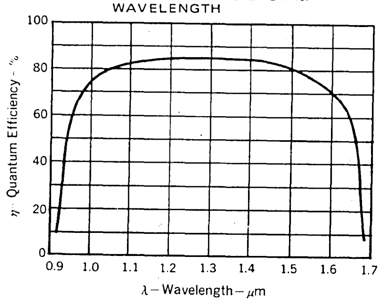
"η = 70 % MIN. (S = 0.73 A/W MIN.)" is guaranteed with the optical output power from a rod lens (P) in the holder.

$$\eta = \frac{h\nu}{q} \cdot \frac{I_P}{P} = \frac{h\nu}{q} \cdot S$$

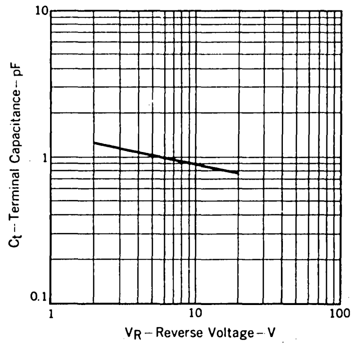
I_P : Photo Current
P : Optical Output Power from internal rod lens

TYPICAL CHARACTERISTICS (T_a = 25 °C)

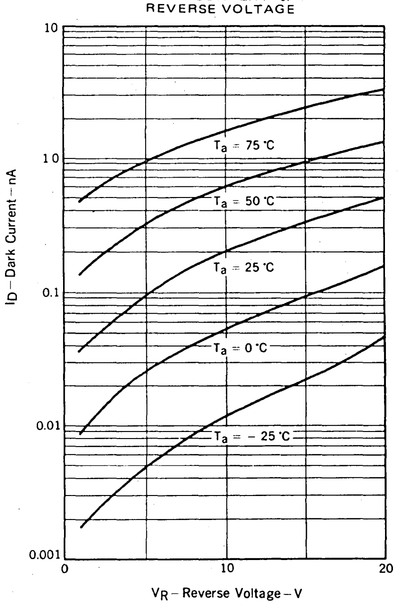
QUANTUM EFFICIENCY vs. WAVELENGTH



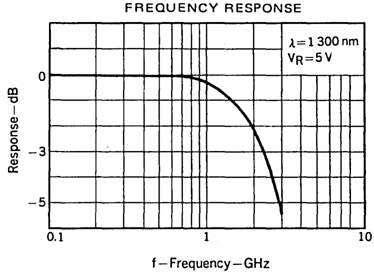
TERMINAL CAPACITANCE vs. REVERSE VOLTAGE



DARK CURRENT vs. REVERSE VOLTAGE



FREQUENCY RESPONSE



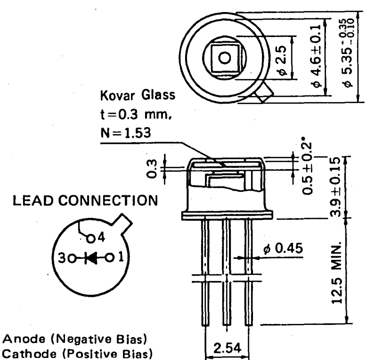
NDL5406

OPTICAL FIBER COMMUNICATIONS
InGaAs PIN PHOTO DIODE

DESCRIPTION

NDL5406 is a 270 μm x 330 μm InGaAs PIN photo diode for a light detector. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS
in millimeters



1. Anode (Negative Bias)
3. Cathode (Positive Bias)
4. Case

*Optical length

FEATURES

- High quantum efficiency. η = 85 % TYP. @1 300 nm
  η = 80 % TYP. @1 550 nm
- Small dark current. I_D = 0.5 nA TYP.
- Low operating voltage.
- Detecting area size. 270 μm x 330 μm

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Reverse Voltage	V_R	20	V
Forward Current	I_F	10	mA
Reverse Current	I_R	5	mA
Operating Temperature	T_C	−40 to +85	°C
Storage Temperature	T_{stg}	−55 to +150	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D		0.5	7.0	nA	V_R = 5 V
Terminal Capacitance	C_t		4.0	7.5	pF	V_R = 5 V, f = 1.0 MHz
Quantum Efficiency	η	70	85		%	λ = 1 300 nm
			80			λ = 1 550 nm
Rise, Fall Time	t_r, t_f		4		ns	V_R = 5 V, λ = 1 300 nm, R_L = 50 Ω, 10–90 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)

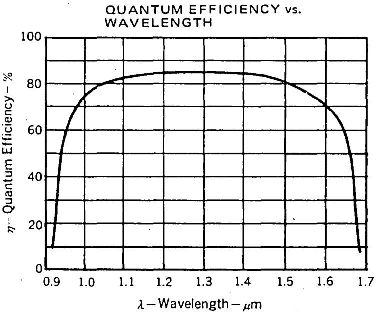


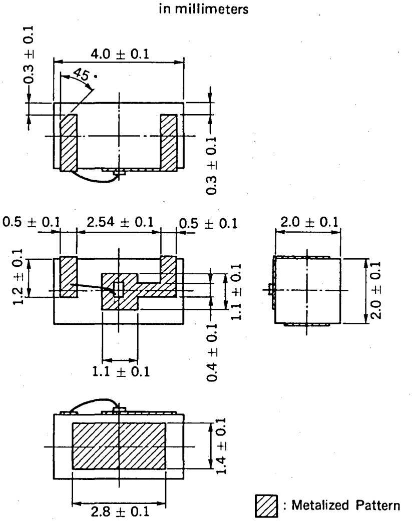
PHOTO DIODE
NDL5406C

OPTICAL FIBER COMMUNICATIONS
InGaAs PIN PHOTO DIODE

DESCRIPTION

NDL5406C is a 270 μm x 330 μm InGaAs PIN photo diode for a light detector. It covers the wavelength range between 1 000 and 1 600 nm with high sensitivity.

PACKAGE DIMENSIONS
in millimeters



FEATURES

- High quantum efficiency. $\eta = 85$ % TYP. @1 300 nm
  $\eta = 80$ % TYP. @1 550 nm
- Small dark current. $I_D = 0.5$ nA TYP.
- Low operating voltage.
- Detecting area size. 270 μm x 330 μm

ABSOLUTE MAXIMUM RATINGS
($T_a = 25$ °C, in dry nitrogen atmosphere)

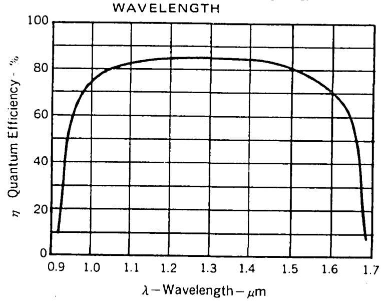
Reverse Voltage	V_R	20	V
Forward Current	I_F	10	mA
Reverse Current	I_R	5	mA
Operating Temperature	T_{op}	−40 to +85	°C
Storage Temperature	T_{stg}	−55 to +150	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25$ °C)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Dark Current	I_D		0.5	7.0	nA	$V_R = 5$ V
Terminal Capacitance	C_t		4.0	7.5	pF	$V_R = 5$ V, f = 1.0 MHz
Quantum Efficiency	η	70	85		%	λ = 1 300 nm
			80			λ = 1 550 nm
Rise, Fall Time	t_r, t_f		4		ns	$V_R = 5$ V, λ = 1 300 nm, $R_L = 50$ Ω, 10–90 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)

QUANTUM EFFICIENCY vs. WAVELENGTH



2

DETECTOR CHIP ON CARRIER HANDLING PRE-CAUTION

DETECTOR CHIP ON CARRIER IS NON HERMETIC SEALED DEVICE.
THEREFORE, THERE IS A POSSIBILITY THAT RELIABILITY OF THE DEVICE IS AFFECTED BY STORAGE AND/OR ASSEMBLY CONDITION. IN ORDER TO ASSURE DEVICE RELIABILITY, NEC RECOMMENDS THE FOLLOWING CONDITIONS FOR HANDLING.

1) STORAGE CONDITION

WHEN THE DEVICE IS PRESERVED AFTER BREAKING CONTAINER SEAL, THE FOLLOWING CONDITION SHOULD BE MAINTAINED.

STORAGE TEMPERATURE : +20 °C TO +30 °C
CONTAINER : CLEAN DRY BOX WITH ESD PROTECTION
AMBIENT GAS : DRY NITROGEN ATMOSPHERE

2) HANDLING/ASSEMBLY CONDITIONS

2-1) BONDING WIRE

ANY CONTACT TO BONDING WIRE SHOULD BE AVOIDED.

2-2) MAXIMUM TEMPERATURE IN ASSEMBLY CONDITIONS

THE FOLLOWING CONDITION SHOULD BE KEPT.

TEMPERATURE	DURATION	AMBIENT GAS
230 °C	1 minute	DRY NITROGEN ATMOSPHERE OR AIR
175 °C	3 hours	AIR
175 °C	24 hours	DRY NITROGEN ATMOSPHERE
130 °C	100 hours	DRY NITROGEN ATMOSPHERE

2-3) PRE-CAP BAKING CONDITION

IN ORDER TO STABILIZE DARK CURRENT, NEC RECOMMENDS ONE OF THE FOLLOWING CONDITIONS FOR PRE-CAP BAKING.

TEMPERATURE	DURATION	AMBIENT GAS
120 °C TO 175 °C	2 hours	VACUUM
120 °C TO 175 °C	24 hours	DRY NITROGEN ATMOSPHERE

2-4) HERMETIC SEALING

THE DEVICE SHOULD BE FINALLY INSTALLED IN HERMETIC SEALED PACKAGE.
INERT GAS ATMOSPHERE SUCH AS NITROGEN IS RECOMMENDED.
HERMETISITY SHOULD BE LESS THAN 10^{-8} atm.cc/sec BY He LEAKAGE TEST.

2-5) ELECTRO STATIC DISCHARGE (ESD) PROTECTION

DURING HANDLING PROCESS, ESD PROTECTION SUCH AS EARTH-BAND SHOULD BE CARRIED OUT.

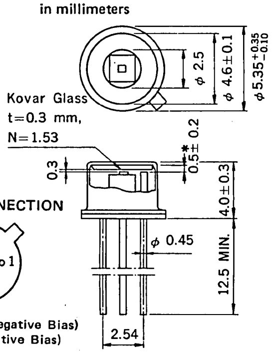
1 300 nm OPTICAL FIBER COMMUNICATIONS InGaAsP LIGHT EMITTING DIODE

DESCRIPTION

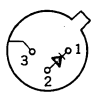
NDL5300 is an InGaAsP double heterostructure long wavelength LED.

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

*Optical length

FEATURES

- High optical output power P_O = 0.8 mW
- Long wavelength λ_P = 1 300 nm.
- Short optical length & Hermetically sealded package.

2

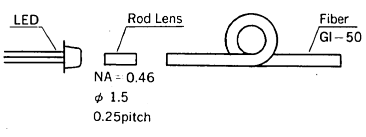
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	150	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	−40 to +80	°C
Storage Temperature	T_{stg}	−55 to +125	°C

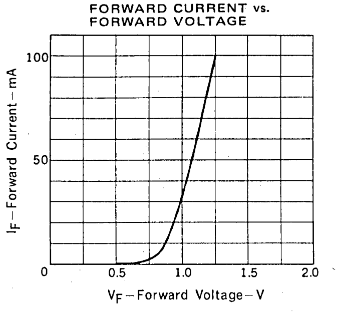
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

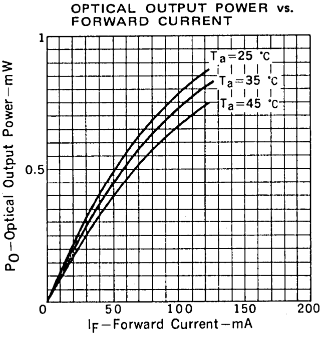
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Optical Output Power	P_O	0.6	0.8		mW	I_F = 100 mA
Forward Voltage	V_F			2.0	V	I_F = 100 mA
Peak Emission Wavelength	λ_P *	1270	1300	1330	nm	I_F = 100 mA
Spectral Half Width	$\Delta\lambda$ *			140	nm	I_F = 100 mA
Rise Time	t_r		12	15	ns	I_{peak} = 100 mA, 10−90 %
Fall Time	t_f		18	25	ns	I_{peak} = 100 mA, 90−10 %
Emitting Area Diameter	ϕA		40		μm	

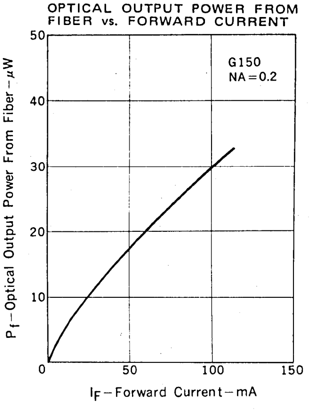
*

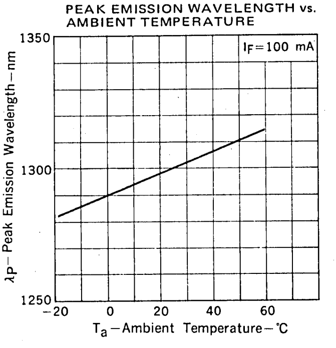


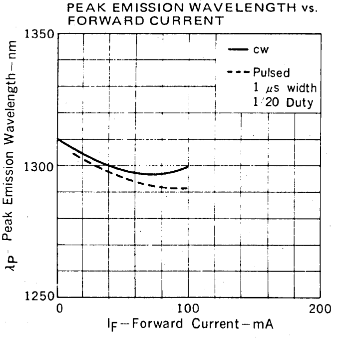
TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

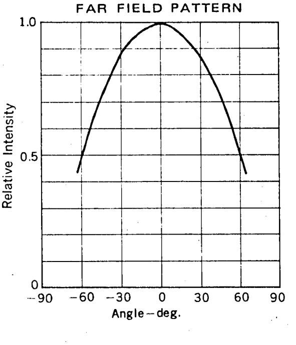












NDL5300P

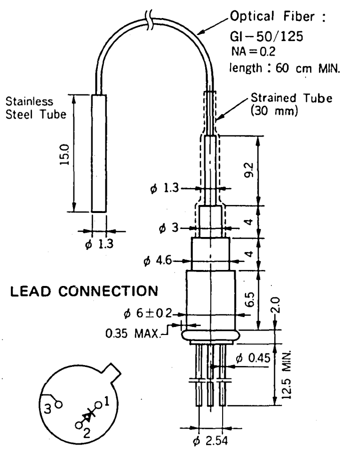
1 300 nm OPTICAL FIBER COMMUNICATIONS InGaAsP LIGHT EMITTING DIODE MODULE

DESCRIPTION

NDL5300P is an InGaAsP double heterostructure long wavelength LED module.

PACKAGE DIMENSIONS

in millimeters



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

FEATURES

- High optical output power from fiber P_f = 30 μW TYP.
- Long wavelength λ_P = 1 300 nm.
- Hermetically sealded package.

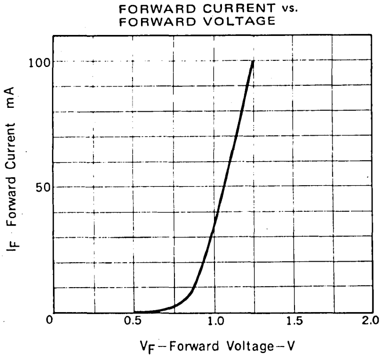
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

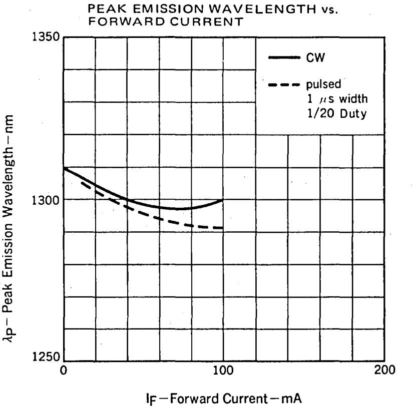
Forward Current	I_F	150	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	−20 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C

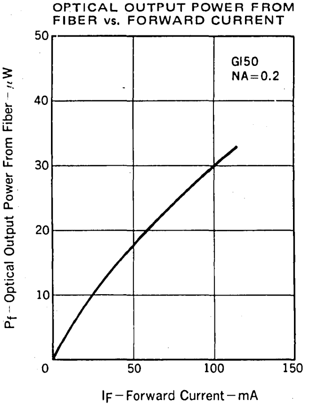
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

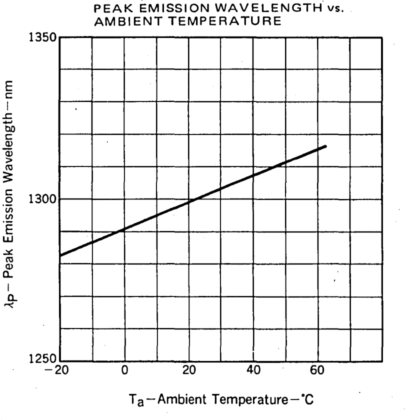
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Optical Output Power from Fiber	P_f	20	30		μW	I_F = 100 mA
Forward Voltage	V_F			2.0	V	I_F = 100 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	I_F = 100 mA
Spectral Half Width	$\Delta\lambda$			140	nm	I_F = 100 mA
Rise Time	t_r		12	15	ns	I_{peak} = 100 mA, 10−90 %
Fall Time	t_f		18	25	ns	I_{peak} = 100 mA, 90−10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)









LIGHT EMITTING DIODE
NDL5302

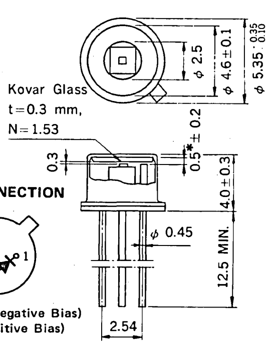
1 300 nm OPTICAL FIBER COMMUNICATIONS InGaAsP LIGHT EMITTING DIODE

DESCRIPTION

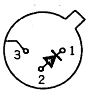
NDL5302 is an InGaAsP double heterostructure long wavelength LED.
It is designed for high speed, long distance optical fiber communication systems.

PACKAGE DIMENSIONS

in millimeters



LEAD CONNECTION



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

*Optical length

FEATURES

- High speed $t_r = 2$ ns, $t_f = 3$ ns TYP.
- High optical output power $P_O = 0.7$ mW
- Long wavelength $\lambda_P = 1\,300$ nm.
- Short optical length & Hermetically sealed package.

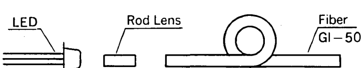
ABSOLUTE MAXIMUM RATINGS ($T_a = 25$ °C)

Forward Current	I_F	150	mA
Reverse Voltage	V_R	1.0	V
Operating Case Temperature	T_C	−40 to +80	°C
Storage Temperature	T_{stg}	−55 to +125	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25$ °C)

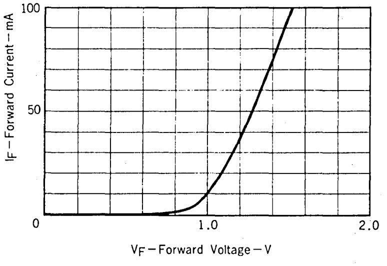
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.4	2.0	V	$I_F = 100$ mA
Optical Output Power	P_O	0.4	0.7		mW	$I_F = 100$ mA
Peak Emission Wavelength	λ_P *	1270	1300	1330	nm	$I_F = 100$ mA
Spectral Half Width	$\Delta\lambda$ *		140	160	nm	$I_F = 100$ mA
Rise Time	t_r		2	3	ns	I_{peak}=100 mA, 10−90 %
Fall Time	t_f		3	4	ns	I_{peak}=100 mA, 90−10 %
Emitting Area Diameter	ϕA		25		μm	

*

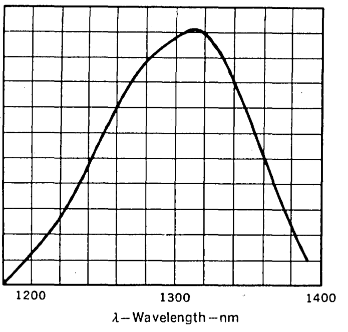


TYPICAL CHARACTERISTICS (T_a = 25 °C)

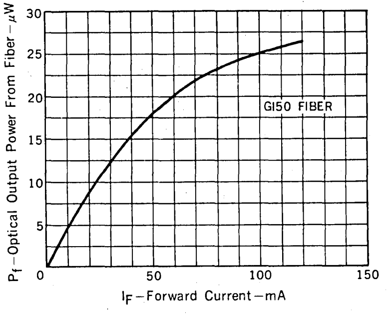
FORWARD CURRENT vs. FORWARD VOLTAGE



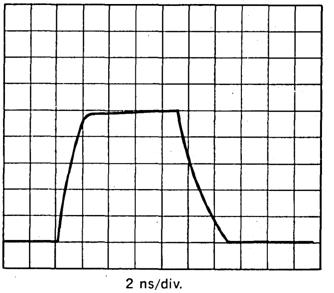
EMISSION SPECTRUM



OPTICAL OUTPUT POWER FROM FIBER vs. FORWARD CURRENT

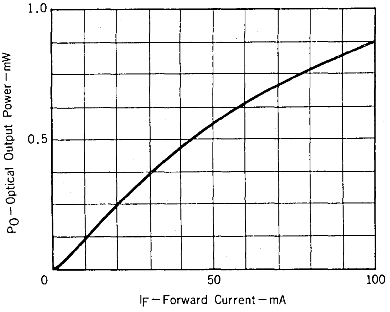


PULSE RESPONSE



2 ns/div.

OPTICAL OUTPUT POWER vs. FORWARD CURRENT



NDL5302P

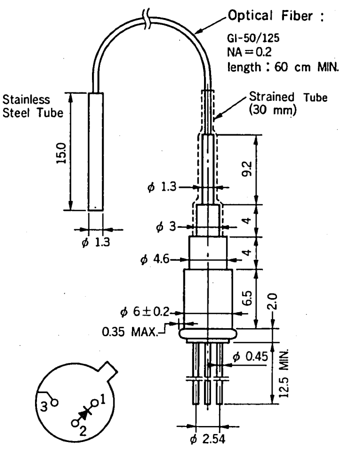
1 300 nm OPTICAL FIBER COMMUNICATIONS InGaAsP LIGHT EMITTING DIODE MODULE

DESCRIPTION

NDL5302P is an InGaAsP double heterostructure long wavelength LED with fiber pigtail. It is designed for high speed, long distance optical fiber communication systems.

PACKAGE DIMENSIONS

in millimeters



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

FEATURES

- High speed $t_r = 2$ ns, $t_f = 3$ ns TYP.
- High optical power output from fiber $P_f = 25\ \mu W$ TYP.
- Long wavelength λ_P = 1 300 nm
- Hermetically sealded package.

ABSOLUTE MAXIMUM RATINGS ($T_a = 25\ °C$)

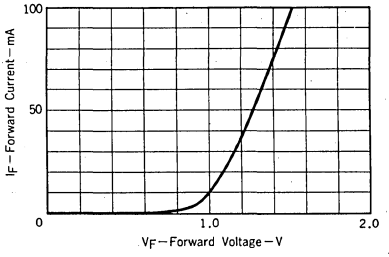
Forward Current	I_F	150	mA
Reverse Voltage	V_R	1.0	V
Operating Case Temperature	T_C	−20 to +60	°C
Storage Temperature	T_{stg}	−40 to +70	°C

ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25\ °C$)

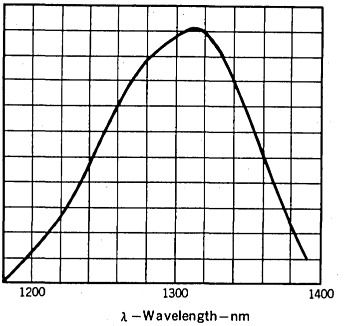
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.4	2.0	V	I_F = 100 mA
Optical Power Output from Fiber	P_f	15	25		μW	I_F = 100 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	I_F = 100 mA
Spectral Half Width	$\Delta\lambda$		140	160	nm	I_F = 100 mA
Rise Time	t_r		2	3	ns	I_{peak} = 100 mA 10 – 90 %
Fall Time	t_f		3	4	ns	I_{peak} = 100 mA 90 – 10 %

TYPICAL CHARACTERISTICS ($T_a = 25\ ^\circ C$)

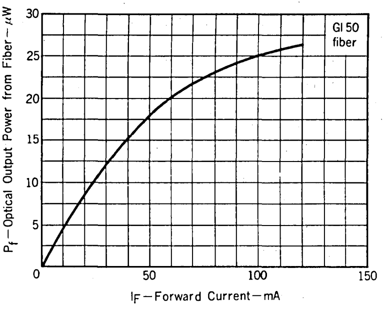
FORWARD CURRENT vs. FORWARD VOLTAGE



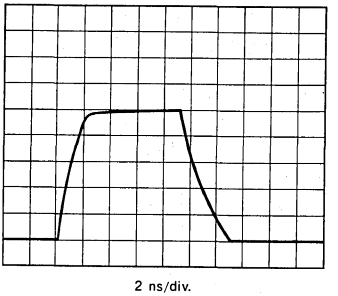
EMISSION SPECTRUM



OPTICAL OUTPUT POWER FROM FIBER vs. FORWARD CURRENT



PULSE RESPONSE



2 ns/div.

LIGHT EMITTING DIODE

NDL5303P

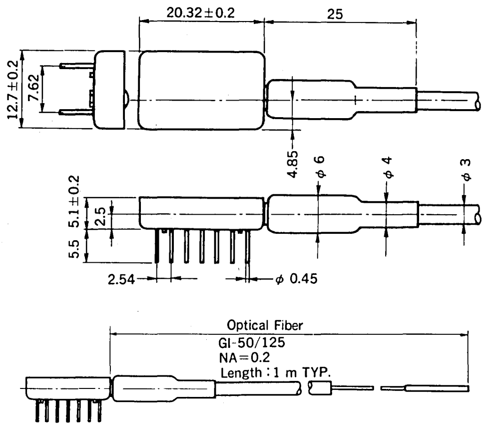
1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED MODULE

DESCRIPTION

NDL5303P is an InGaAsP double heterostructure long wavelength LED DIP module. It is designed for high speed (200 Mb/s) digital transmission systems.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- High speed. t_r = 2 ns, t_f = 3 ns TYP.
- Long wavelength. λ_P = 1 300 nm
- Hermetically sealed 14 Pin Dual In-Line Package.
- High optical power output from fiber.
  P_f = 25 μW TYP.

2

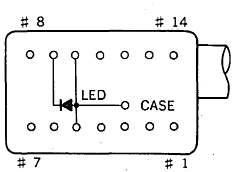
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	150	mA
Reverse Voltage	V_R	1.0	V
Operating Case Temperature	T_C	−40 to +65	°C
Storage Temperature	T_{stg}	−40 to +70	°C

PIN CONNECTION

No.	FUNCTION	No.	FUNCTION
1	NC	8	NC
2	NC	9	LED CATHODE
3	NC	10	LED ANODE, CASE GROUND
4	NC	11	NC
5	LED ANODE, CASE GROUND	12	NC
6	NC	13	NC
7	NC	14	NC

BOTTOM VIEW

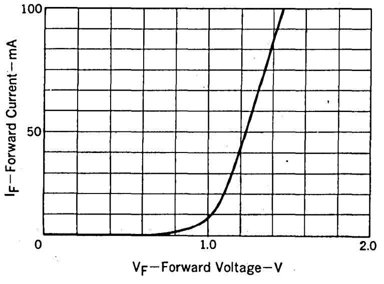


ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

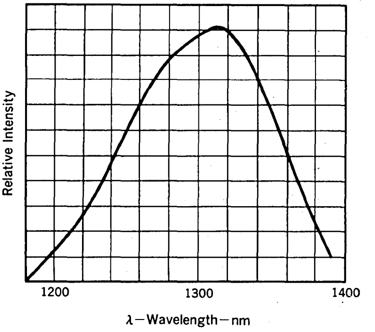
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.4	2.0	V	I_F = 100 mA
Optical Power Output from Fiber	P_f	15	25		μW	I_F = 100 mA
Peak Emission Wavelength	λ_p	1270	1300	1330	nm	I_F = 100 mA
Spectral Half Width	$\Delta\lambda$		140	160	nm	I_F = 100 mA
Rise Time	t_r		2	3	ns	I_{peak} = 100 mA, 10–90 %
Fall Time	t_f		3	4	ns	I_{peak} = 100 mA, 90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)

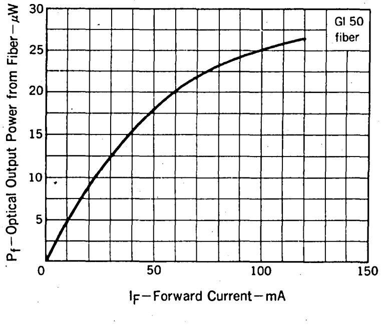
FORWARD CURRENT vs. FORWARD VOLTAGE



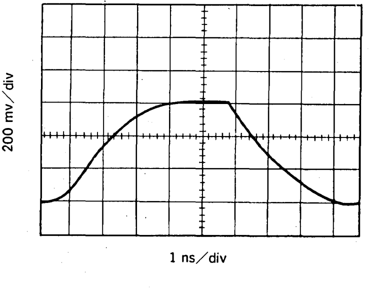
EMISSION SPECTRUM



OPTICAL OUTPUT POWER FROM FIBER vs. FORWARD CURRENT



PULSE RESPONSE



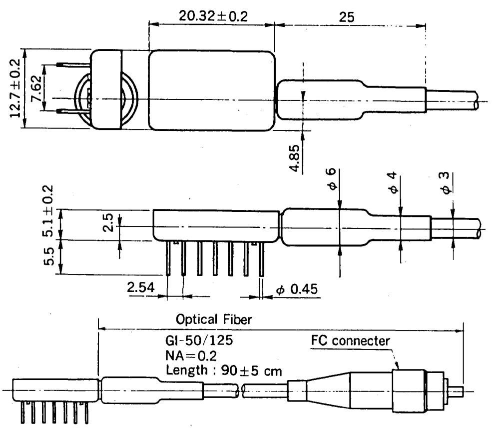
NDL5303PFC

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED MODULE

DESCRIPTION

NDL5303PFC is an InGaAsP double heterostructure long wavelength LED DIP module with FC connector. It is designed for high speed (200 Mb/s) digital transmission systems.

PACKAGE DIMENSIONS
in millimeters



FEATURES

- High speed. t_r = 2 ns, t_f = 3 ns TYP.
- Long wavelength. λ_P = 1 300 nm
- Hermetically sealed 14 Pin Dual In-Line package.
- High optical power output from fiber.
  P_f = 25 μW TYP.

2

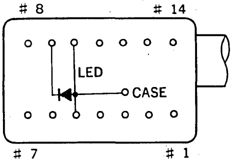
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	150	mA
Reverse Voltage	V_R	1.0	V
Operating Case Temperature	T_C	–40 to +65	°C
Storage Temperature	T_{stg}	–40 to +70	°C

PIN CONNECTION

No.	FUNCTION	No.	FUNCTION
1	NC	8	NC
2	NC	9	LED CATHODE
3	NC	10	LED ANODE, CASE GROUND
4	NC	11	NC
5	LED ANODE, CASE GROUND	12	NC
6	NC	13	NC
7	NC	14	NC

BOTTOM VIEW

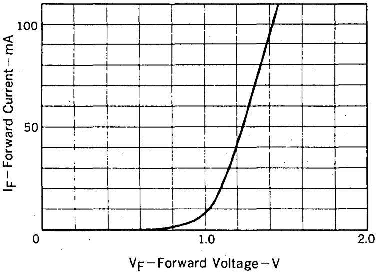


ELECTRO-OPTICAL CHARACTERISTICS ($T_a = 25\ °C$)

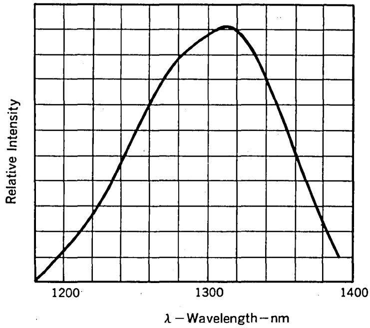
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.4	2.0	V	$I_F = 100$ mA
Optical Power Output from Fiber	P_f	15	25		μW	$I_F = 100$ mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	$I_F = 100$ mA
Spectral Half Width	$\Delta\lambda$		140	160	nm	$I_F = 100$ mA
Rise Time	t_r		2	3	ns	$I_{peak} = 100$ mA, 10–90 %
Fall Time	t_f		3	4	ns	$I_{peak} = 100$ mA, 90–10 %

TYPICAL CHARACTERISTICS ($T_a = 25\ °C$)

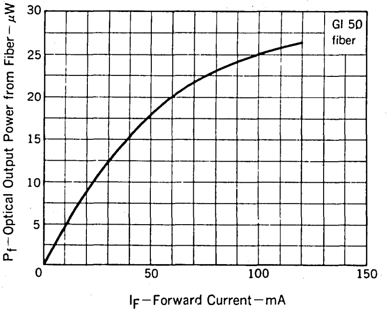
FORWARD CURRENT vs. FORWARD VOLTAGE



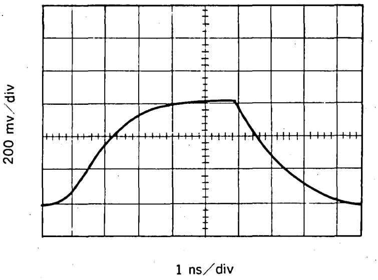
EMISSION SPECTRUM



OPTICAL OUTPUT POWER FROM FIBER vs. FORWARD CURRENT



PULSE RESPONSE



NDL5310

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED

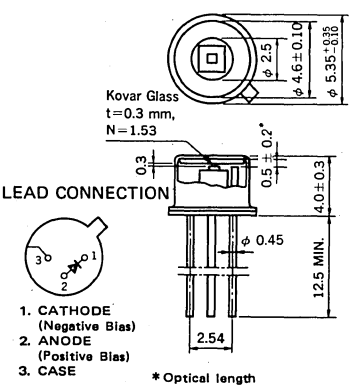
DESCRIPTION

NDL5310 is an InGaAsP double heterostructure long wavelength LED. It can achieve high optical output power.

FEATURES

- High speed t_r = 4 ns, t_f = 8 ns TYP.
- High optical output power P_O = 1.5 mW
- Long wavelength λ_P = 1 300 nm.
- Short optical length & Hermetically sealed package.

PACKAGE DIMENSIONS
in millimeters



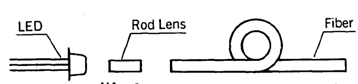
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	120	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	−40 to +80	°C
Storage Temperature	T_{stg}	−55 to +125	°C

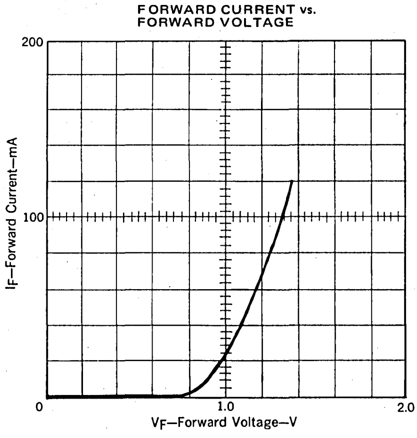
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

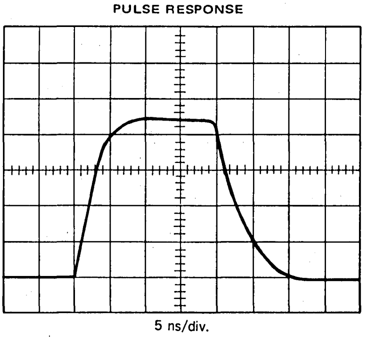
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.3	2.0	V	I_F = 80 mA
Peak Emission Wavelength	λ_P *	1 270	1 300	1 330	nm	I_F = 80 mA
Spectral Half Width	$\Delta\lambda$ *		130	150	nm	I_F = 80 mA
Rise Time	t_r		4	8	ns	I_{peak} = 80 mA, 10 − 90 %
Fall Time	t_f		8	12	ns	I_{peak} = 80 mA, 90 − 10 %
Optical Output Power	P_O	0.8	1.5		mW	I_F = 80 mA
Optical Output Power from Fiber	P_f *	30	40		μW	I_F = 80 mA, GI-50/125
Emitting Area Diameter	ϕ_A		25		μm	

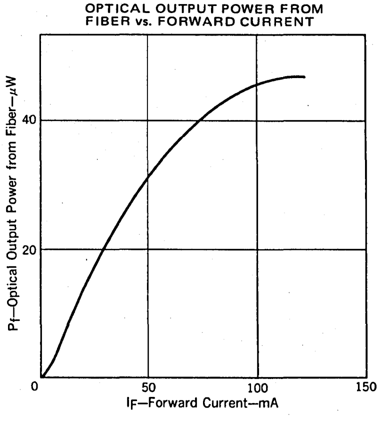
*

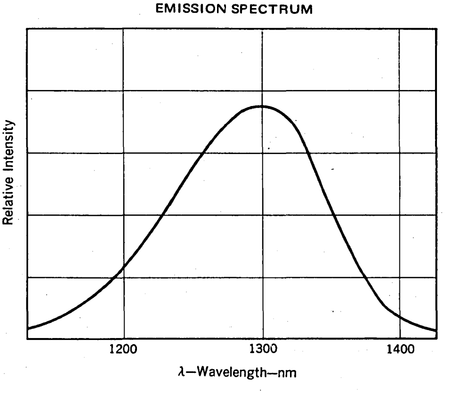


TYPICAL CHARACTERISTICS (T_a = 25 °C)









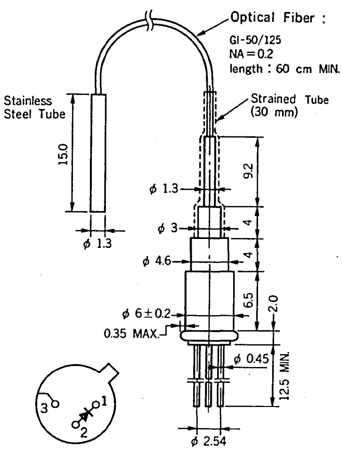
NDL5310P

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED MODULE

DESCRIPTION

NDL5310P is a 1 300 nm InGaAsP double heterostructure LED with fiber pigtail. It can achieve high optical output power from fiber.

PACKAGE DIMENSIONS
in millimeters



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

FEATURES

- High optical power output from fiber
  P_f = 40 μW TYP.
- High speed t_r = 4 ns, t_f = 8 ns TYP.
- Long wavelength λ_P = 1 300 nm
- Hermetically sealed package.
- Coaxial Module with Multi-Mode Fiber (MMF).

2

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

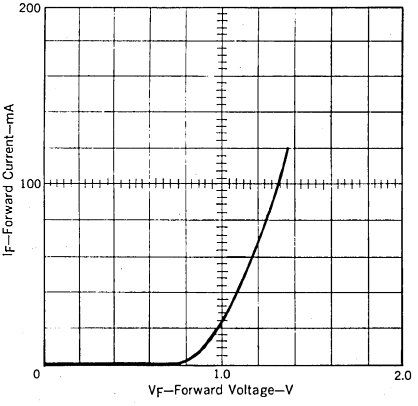
Forward Current	I_F	120	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	–20 to +60	°C
Storage Temperature	T_{stg}	–40 to +70	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

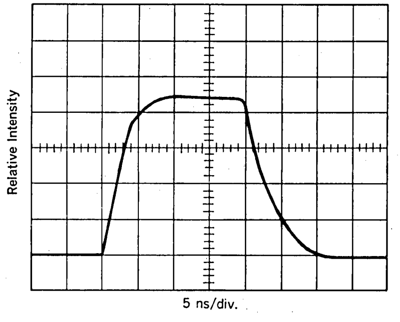
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.3	2.0	V	I_F = 80 mA
Optical Power Output from Fiber	P_f	30	40		μW	I_F = 80 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	I_F = 80 mA
Spectral Half Width	$\Delta\lambda$		130	150	nm	I_F = 80 mA
Rise Time	t_r		4	8	ns	I_{peak} = 80 mA 10–90 %
Fall Time	t_f		8	12	ns	I_{peak} = 80 mA 90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)

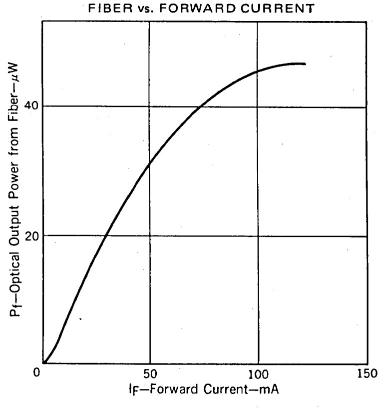
FORWARD CURRENT vs. FORWARD VOLTAGE



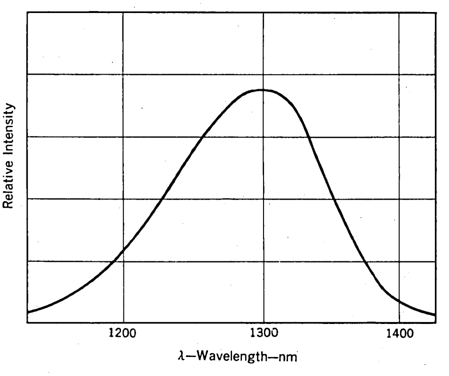
PULSE RESPONSE



OPTICAL OUTPUT POWER FROM FIBER vs. FORWARD CURRENT



EMISSION SPECTRUM



LIGHT EMITTING DIODE
NDL5311P

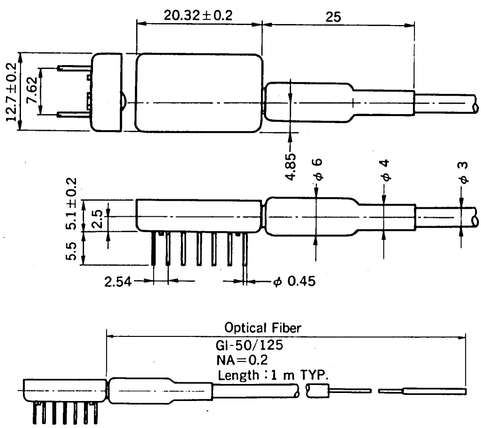
1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED MODULE

2

DESCRIPTION

NDL5311P is a 1 300 nm InGaAsP double heterostructure LED DIP module. It can achieve high optical output power from fiber.

PACKAGE DIMENSIONS
in millimeters



FEATURES

- High optical power output from fiber.
  $P_f = 40\ \mu W$ TYP.
- High speed. $t_r = 4$ ns, $t_f = 8$ ns TYP.
- Long wavelength. $\lambda_P = 1\ 300$ nm
- Hermetically sealed 14 Pin Dual In-Line Package with Multi-Mode Fiber (MMF).

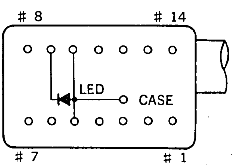
ABSOLUTE MAXIMUM RATINGS ($T_a = 25\ °C$)

Forward Current	I_F	120	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	–40 to +65	°C
Storage Temperature	T_{stg}	–40 to +70	°C

PIN CONNECTION

No.	FUNCTION	No.	FUNCTION
1	NC	8	NC
2	NC	9	LED CATHODE
3	NC	10	LED ANODE, CASE GROUND
4	NC	11	NC
5	LED ANODE, CASE GROUND	12	NC
6	NC	13	NC
7	NC	14	NC

BOTTOM VIEW

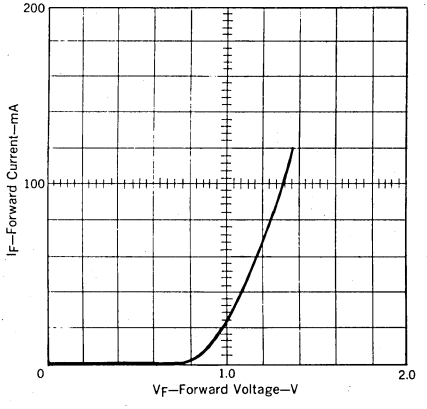


ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

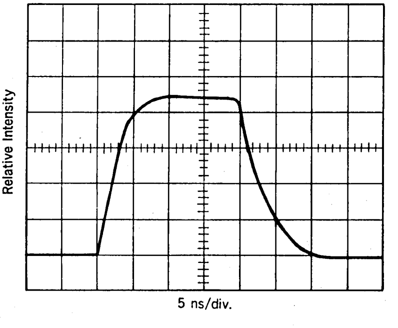
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.3	2.0	V	I_F = 80 mA
Optical Power Output from Fiber	P_f	30	40		μW	I_F = 80 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	I_F = 80 mA
Spectral Half Width	$\Delta\lambda$		130	150	nm	I_F = 80 mA
Rise Time	t_r		4	8	ns	I_{peak} = 80 mA, 10–90 %
Fall Time	t_f		8	12	ns	I_{peak} = 80 mA, 90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)

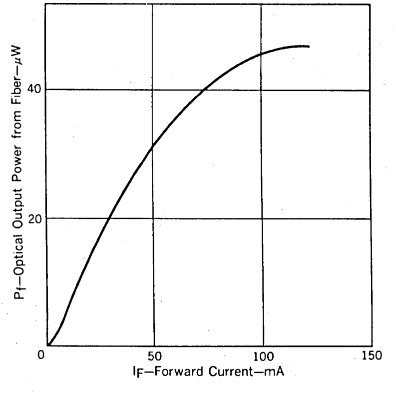
FORWARD CURRENT vs. FORWARD VOLTAGE



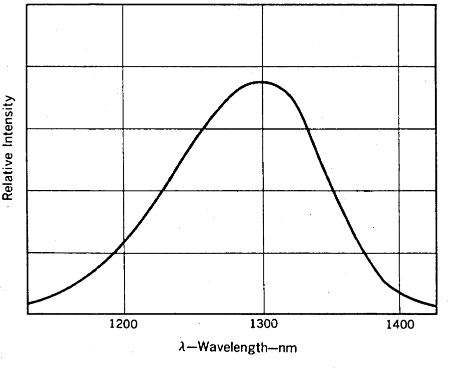
PULSE RESPONSE



OPTICAL OUTPUT POWER FROM FIBER vs. FORWARD CURRENT



EMISSION SPECTRUM



NDL5312

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED

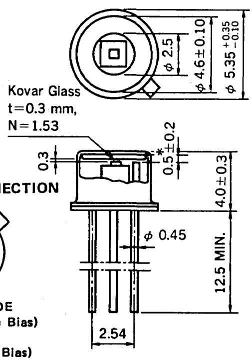
DESCRIPTION

NDL5312 is a 1 300 nm InGaAsP double heterostructure LED. It can achieve high speed response and effective optical coupling with fiber due to optimized doping profile and mesa structure in a chip design. It is suitable for 200 to 400 Mb/s optical data communications.

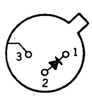
FEATURES

- High speed t_r = 1 ns, t_f = 2 ns
- High optical output power P_O = 1.0 mW
- Long wavelength λ_P = 1 300 nm.
- Short optical length & Hermetically sealed package.

PACKAGE DIMENSIONS
in millimeters



LEAD CONNECTION



1. CATHODE (Negative Bias)
2. ANODE (Positive Bias)
3. CASE

* Optical length

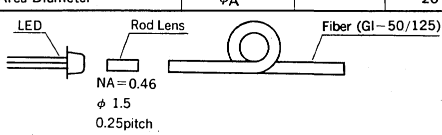
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	120	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	−40 to +80	°C
Storage Temperature	T_{stg}	−55 to +125	°C

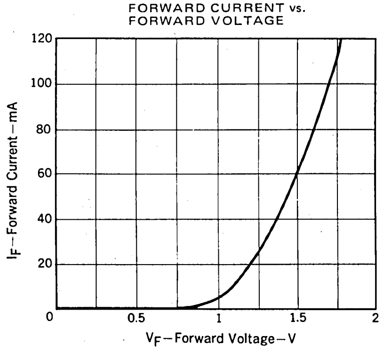
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

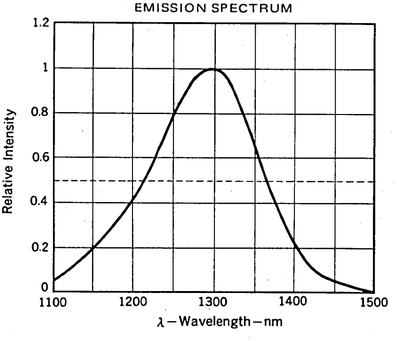
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.6	2.0	V	I_F = 80 mA
Optical Output Power	P_O	0.4	1.0		mW	I_F = 80 mA
Optical Output Power from Fiber	P_f *	20	30		μW	I_F = 80 mA, GI-50/125
Peak Emission Wavelength	λ_P *	1 270	1 300	1 330	nm	I_F = 80 mA
Spectral Half Width	$\Delta\lambda$ *		150	170	nm	I_F = 80 mA
Rise Time	t_r		1	2	ns	I_{peak} = 80 mA, 10–90 %
Fall Time	t_f		2	3	ns	I_{peak} = 80 mA, 90–10 %
Emitting Area Diameter	ϕA		20		μm	

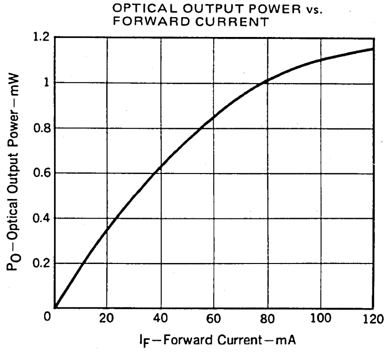
*

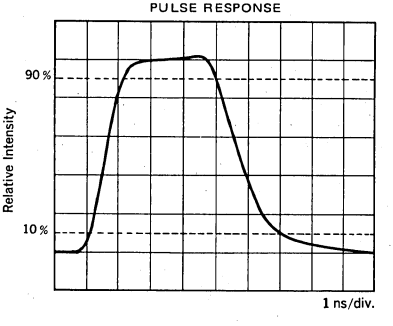


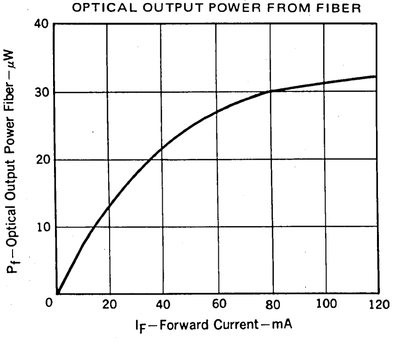
TYPICAL CHARACTERISTICS (T_a = 25 °C)











LIGHT EMITTING DIODE
NDL5312P

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED MODULE

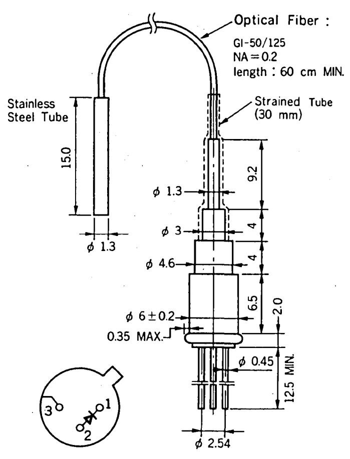
DESCRIPTION

NDL5312P is a 1 300 nm InGaAsP double heterostructure LED module with fiber pigtail. It can achieve high speed response and high optical output power. It is suitable for 200 to 400 Mb/s optical data communications.

FEATURES

- High speed t_r = 1 ns, t_f = 2 ns
- High optical power output from fiber P_f = 30 μW
- Long wavelength λ_P = 1 300 nm
- Hermetically sealed package.
- Coaxial Module with Multi-Mode Fiber (MMF).

PACKAGE DIMENSIONS
in millimeters



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

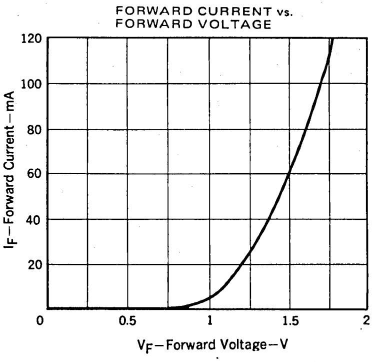
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

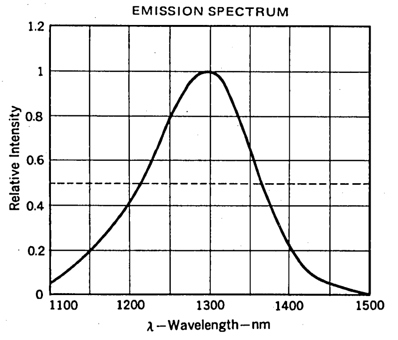
Forward Current	I_F	120	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	–20 to +60	°C
Storage Temperature	T_{stg}	–40 to +70	°C

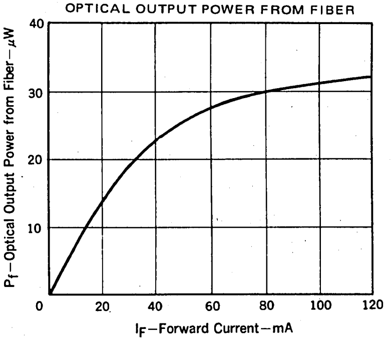
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

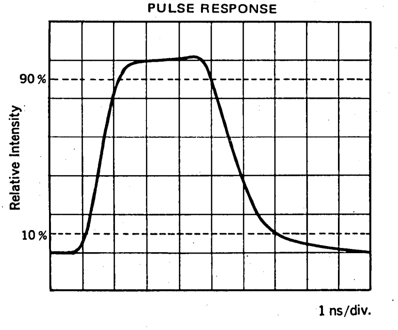
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.6	2.0	V	I_F = 80 mA
Optical Power Output from Fiber	P_f	20	30		μW	I_F = 80 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	I_F = 80 mA
Spectral Half Width	$\Delta\lambda$		150	170	nm	I_F = 80 mA
Rise Time	t_r		1	2	ns	I_{peak} = 80 mA 10–90 %
Fall Time	t_f		2	3	ns	I_{peak} = 80 mA 90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)







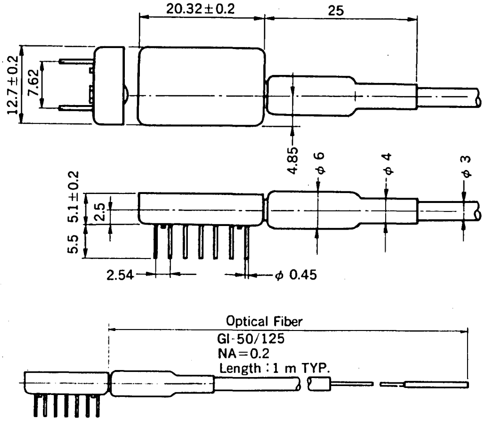


LIGHT EMITTING DIODE

NDL5313P

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED MODULE

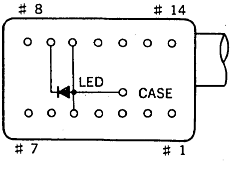
PACKAGE DIMENSIONS
in millimeters



PIN CONNECTION

No.	FUNCTION	No.	FUNCTION
1	NC	8	NC
2	NC	9	LED CATHODE
3	NC	10	LED ANODE, CASE GROUND
4	NC	11	NC
5	LED ANODE, CASE GROUND	12	NC
6	NC	13	NC
7	NC	14	NC

BOTTOM VIEW



DESCRIPTION

NDL5313P is a 1 300 nm InGaAsP double heterostructure LED DIP module. It can achieve high speed response and high optical output power. It is suitable for 200 to 400 Mb/s optical data communications.

2

FEATURES

- High speed. t_r = 1 ns, t_f = 2 ns
- High optical power output from fiber. P_f = 30 μW
- Long wavelength. λ_P = 1 300 nm
- Hermetically sealed 14 Pin Dual In-Line Package with Multi-Mode Fiber (MMF).

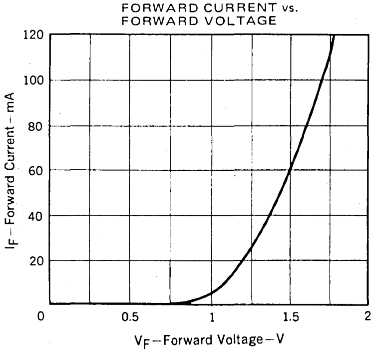
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

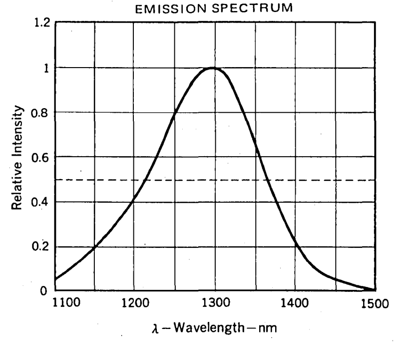
Forward Current	I_F	120	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	–40 to +65	°C
Storage Temperature	T_{stg}	–40 to +70	°C

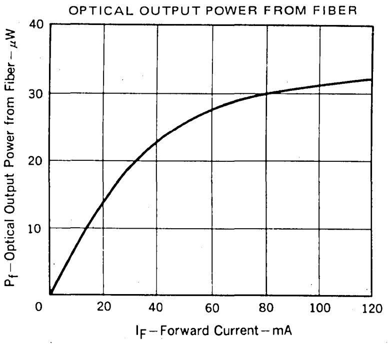
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

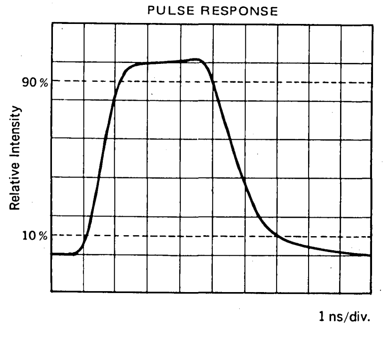
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.6	2.0	V	I_F = 80 mA
Optical Power Output from Fiber	P_f	20	30		μW	I_F = 80 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	I_F = 80 mA
Spectral Half Width	$\Delta\lambda$		150	170	nm	I_F = 80 mA
Rise Time	t_r		1	2	ns	I_{peak} = 80 mA, 10–90 %
Fall Time	t_f		2	3	ns	I_{peak} = 80 mA, 90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)









NDL5314

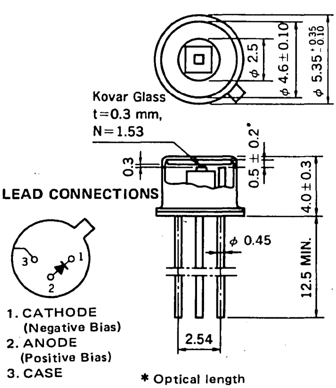
1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED

DESCRIPTION

NDL5314 is a 1 300 nm InGaAsP double heterostructure LED. It is designed for the light source of high speed optical data communications. It can achieve ultra high speed response (more than 400 Mb/s) and effective optical coupling with fiber due to optimized doping profile and mesa structure in a chip design.

PACKAGE DIMENSIONS

in millimeters



FEATURES

- Ultra high speed t_r = 0.8 ns, t_f = 1.5 ns
- High optical output power P_O = 0.8 mW
- Long wavelength λ_P = 1 300 nm.
- Short optical length & Hermetically sealed package.

2

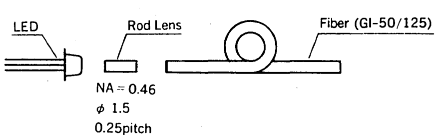
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

Forward Current	I_F	120	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	-40 to +80	°C
Storage Temperature	T_{stg}	-55 to +125	°C

ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

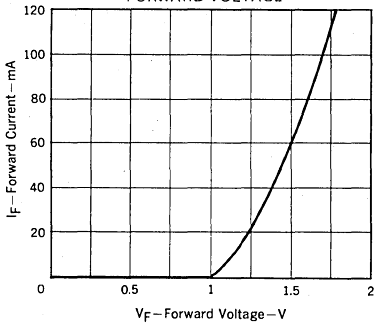
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.6	2.0	V	I_F = 80 mA
Optical Output Power	P_O	0.3	0.8		mW	I_F = 80 mA
Optical Output Power from Fiber	P_f *	15	25		μW	I_F = 80 mA, GI-50/125
Peak Emission Wavelength	λ_P *	1270	1300	1330	nm	I_F = 80 mA
Spectral Half Width	$\Delta\lambda$ *		150	170	nm	I_F = 80 mA
Rise Time	t_r		0.8	1.5	ns	I_{peak} = 80 mA, 10–90 %
Fall Time	t_f		1.5	2.5	ns	I_{peak} = 80 mA, 90–10 %
Emitting Area Diameter	ϕA		20		μm	

*

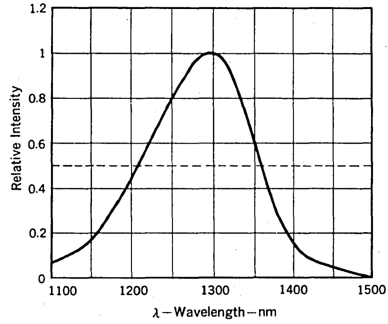


TYPICAL CHARACTERISTICS (T_a = 25 °C)

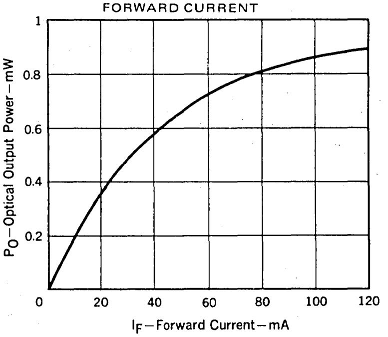
FORWARD CURRENT vs. FORWARD VOLTAGE



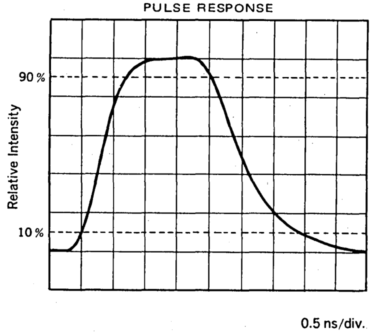
EMISSION SPECTRUM



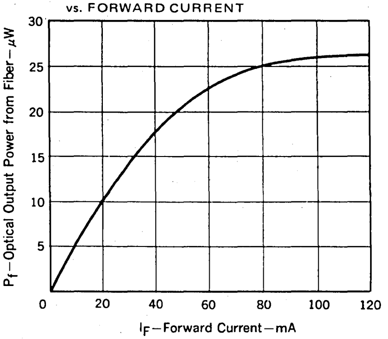
OPTICAL OUTPUT POWER vs. FORWARD CURRENT



PULSE RESPONSE



OPTICAL OUTPUT POWER FROM FIBER vs. FORWARD CURRENT



LIGHT EMITTING DIODE
NDL5314P

1 300 nm OPTICAL FIBER COMMUNICATIONS
InGaAsP DOUBLE HETEROSTRUCTURE LED MODULE

DESCRIPTION

NDL5314P is a 1 300 nm InGaAsP double heterostructure LED with fiber pigtail. It is designed for high speed optical data communication systems. It can achieve ultra high speed response (more than 400 Mb/s).

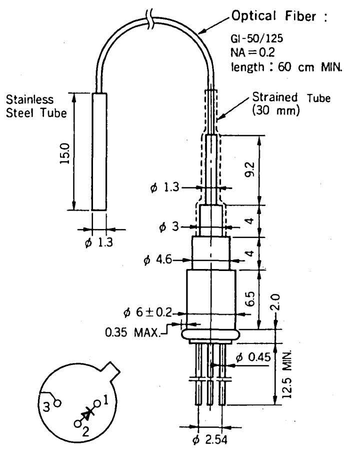
FEATURES

- Ultra high speed t_r = 0.8 ns, t_f = 1.5 ns
- High optical power output from fiber
  P_f = 25 μW
- Long wavelength λ_P = 1 300 nm
- Hermetically sealed package.
- Coaxial Module with Multi-Mode Fiber (MMF).

2

PACKAGE DIMENSIONS

in millimeters



1. Cathode (Negative Bias)
2. Anode (Positive Bias)
3. Case

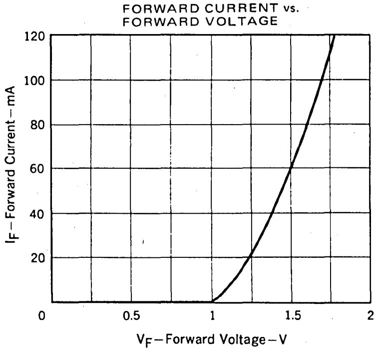
ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

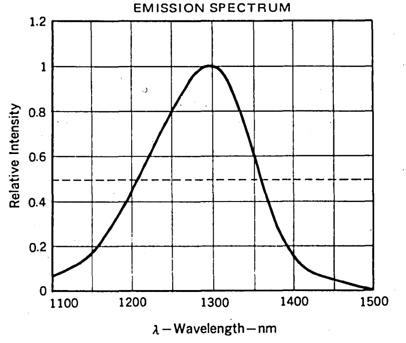
Forward Current	I_F	120	mA
Reverse Voltage	V_R	2.0	V
Operating Case Temperature	T_C	–20 to +60	°C
Storage Temperature	T_{stg}	–40 to +70	°C

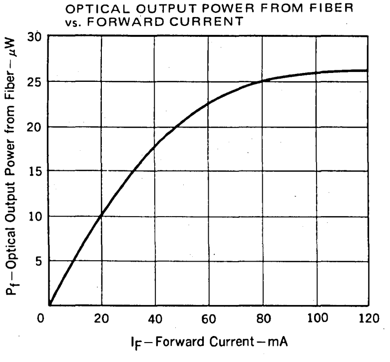
ELECTRO-OPTICAL CHARACTERISTICS (T_a = 25 °C)

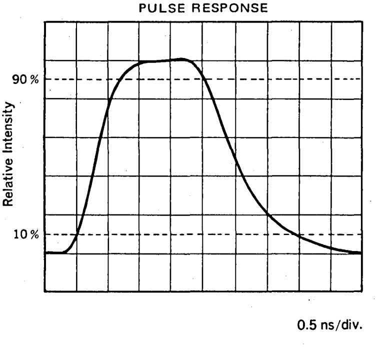
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Forward Voltage	V_F		1.6	2.0	V	I_F = 80 mA
Optical Power Output from Fiber	P_f	15	25		μW	I_F = 80 mA
Peak Emission Wavelength	λ_P	1270	1300	1330	nm	I_F = 80 mA
Spectral Half Width	$\Delta\lambda$		150	170	nm	I_F = 80 mA
Rise Time	t_r		0.8	1.5	ns	I_{peak} = 80 mA 10–90 %
Fall Time	t_f		1.5	2.5	ns	I_{peak} = 80 mA 90–10 %

TYPICAL CHARACTERISTICS (T_a = 25 °C)









Ⅲ. APPLICATION NOTE

3

1. INTRODUCTION

Optical fiber communication will become a major means of transmission of intelligent information in the very near future. This technology has a diverse application, such as large-scale public communication systems, information processing systems, telephone exchange systems and audio/video disk players.

This Application Manual describes the operation principles and handling of the NEC laser diodes. These diodes are the most suitable light source for large capacity, long distance communication systems. The Manual should also assist users to take full advantage of the various merits of the NEC laser diodes.

2. OPERATION PEINCIPLES

2.1 LASER OSCILLATION

A double heterojunction structure (DH) is employed in the NEC AlGaAs laser diodes which are capable of continuous oscillation at room temperature. In this structure, the active layer; n- or p-type $Al_yGa_{1-y}As$ ($y \simeq 0.05$) layer is approximately 0.1 μm in thickness. It is sandwiched between two clad layers of n-$Al_xGa_{1-x}As$ and p-$Al_xGa_{1-x}As$ ($x \simeq 0.35$) as illustrated in Figure 2-1.

These layers are formed on a n-GaAs substrate by the liquid-phase epitaxial method.

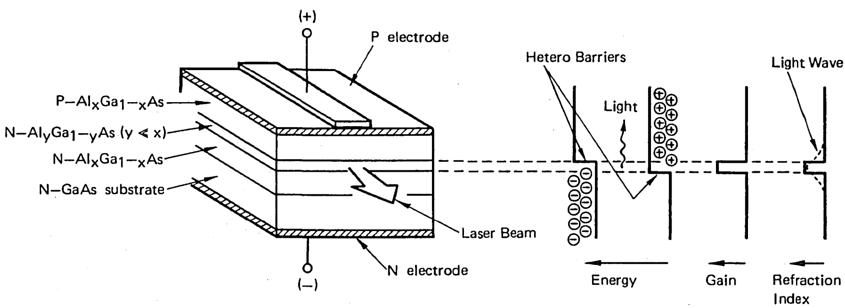


Fig. 2-1 Structure and operation principles of AlGaAs laser diodes

Electrically, the laser diode is an ordinary diode since one side of the heterojunction structure constitutes a p-n junction.

When forward current flows in the diode, electrons from the n-type clad layer and holes from the p-type clad layer are injected into the active (lasing) layer with a small band gap. These injected electrons and holes (carriers) are confined in the active layer by potential barriers at the hetero-boundaries, and thus accumulate to create a population inversion. Since the gain necessary for laser oscillation is proportional to the density of electrons and holes in the active layer, less drive current is needed to acquire a required gain with thinner active layers.

In addition, since the refractive index of the active layer is greater than that of the clad layers, the light wave is also confined to the active layer.

Optical feedback is also required for laser oscillation to take place. This is provided by a pair of smooth reflecting facets at both ends of the laser pellet. These facets which are perpendicular to the active layer are formed simply by cleaving the crystal.

Laser oscillation takes place when the gain becomes large enough to overcome the loss of the resonator. The minimum current required for lasing, called the threshoud current, is an important parameter since it determines the performance and operating conditions of laser diodes.

2.2 CONSTRUCTION OF LASER DIODES

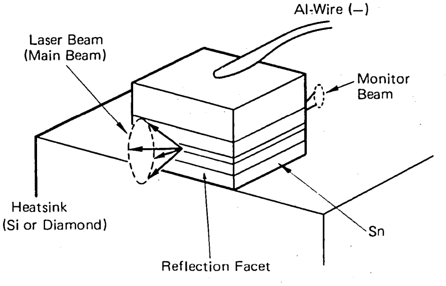
The gain decreases with an increase in temperature of the device. Hence, when a direct current is used, the heat generated in the device acts to suppress laser oscillation.

In order to avoid the problem, the p-electrode (anode) located near the active layer is mounted on a heat sink as shown in Figure 2-2 (a). The edge of a heat sink is aligned with the reflecting facet of the laser crystal. This alignment prevents beam-scattering due to deflection on the heat sink surface.

In turn, this heat sink is mounted on a copper block in the device package which is then connected to an anode lead.

The most common heat sink is a single crystal of silicon, but diamond is also used to improve heat dissipation for special requirements. The n-electrode (cathode) of the laser chip is connected to a cathode lead by an aluminum wire.

The main laser beam is emitted from the reflecting facet which is aligned with the heat sink edge and is propagated outward through a glass window of the package. A second beam with its intensity proportional to that of the main beam is emitted from the reflecting facet in the opposite side. This laser beam is called a monitor beam and travels through a hole in a screw located at the bottom of the package as shown in Figure 2-2 (b). The monitor beam can be used for output power monitoring and automatic power control (APC).



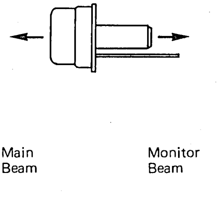


Fig. 2-2 (a) Laser crystla mounted on heat sink (b) Main and monitor beams

2.3 Transverse modes

The standing wave between two reflecting facets of the active region (called the longitudinal or axial mode) propagates through the reflecting facets. The light intensity profile thus created on the reflecting facets is called the near-field pattern (N.F.), while the profile on a plane at distances several mm or more away from the reflecting facets is called the far-field Pattern (F.F.). This spatial distribution of light intensity, N.F. and F.F. is called the transverse mode.

Furthermore, the transverse mode is broken into two components. One component, the vertical transverse mode, is perpendicular to the active layer, and the second, the horizontal transverse mode component is parallel to the active layer as illustrated in Figure 2-3.

Note that the laser beam is a linearly polarized TE wave with an electric field component parallel to the active layer. Althought (TE component)/TM component) > 100 at light output levels of several mW or greater; this ratio becomes smaller the closer the drive current nears the threshold current.

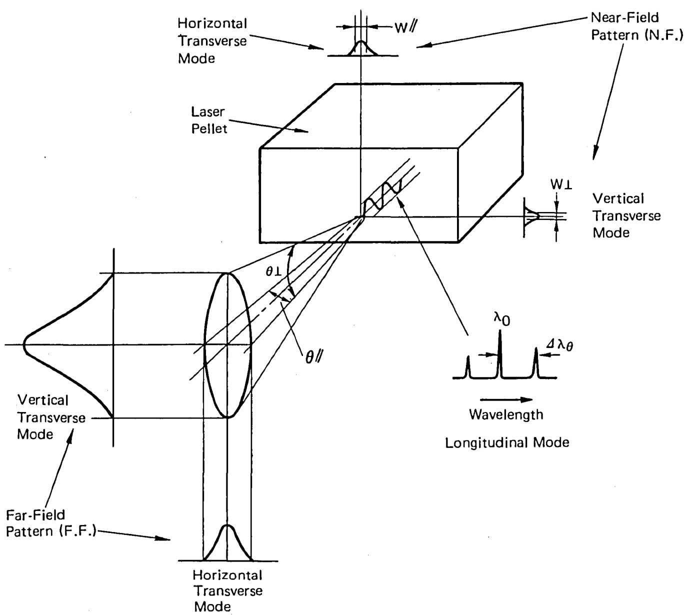


Fig. 2-3 Oscillation modes

a) Vertical transverse mode

The light wave perpendicular to the active layer is confined within the thin active layer by two clad layers with a smaller refractive index, and hence a single-peak fundamental mode can be obtained.

The half-power width of the near-field pattern is approximately 0.3 to 0.5 μm. The emitted laser beam is refracted considerably resulting in a beam with a large emission angle. The half-power angle of the NEC laser diodes is typically 30 ~ 40 °C. For this reason, a lens with a large aperture is required for connecting laser diodes with an optical fiber. This subject will be discussed in Section 3.1.

Note that the vertical transverse mode does not change with the optical output power level.

b) Horizontal transverse mode

Stability of the horizontal transverse mode is very important in order to obtain the light/current characteristics with excellent linearity for lowdistortion analog modulation or high-speed pulsed modulation.

NEC LD achieves a stable fundamental transverse mode operation.

3. APPLICATIONS FOR OPTICAL FIBER COMMUNICATIONS

The optical output power varies in response to the change in forward current as demonstrated in Figure 5-1. This method of modulation is called direct modulation. Diect modulation is one of the most desireable features of laser diodes since no longer external modulation is needed.

Since the laser beam spreads vertically as much as 30 ~ 40 ° as discussed in Section 2.3, a lens is needed to transmit the laser beam efficiently into the small-diameter optical fibers:

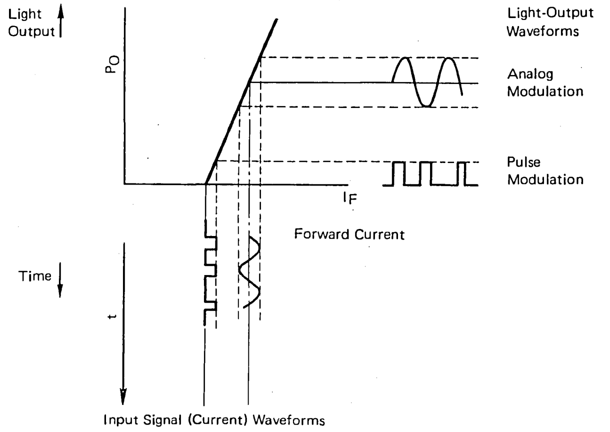


Fig. 3-1 Pulsed and analog modulation

3.1 Pulsed Modulation

When a high-speed pulse current (1 ns or less in rise time) is applied, the laser beam is emitted after a certain delay time, τ_d, and then reaches the steadystate after several GHz dampening oscillation. This dampening oscillation is called "transient oscillation" and must be taken into account when high-speed pulsed modulation is used.

This is illustrated in Figure 3-2.

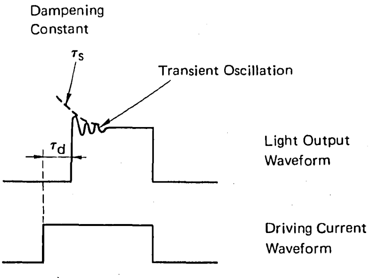


Fig. 3-2 Turn-on delay time

The delay time, τ_d, is the time required for the necessary number of carriers to accumulate in the active region. It can be calculated from the following equation:

$$\tau_d = \tau_s \ \ell n \frac{I - I_b}{I - I_{th}}$$

where τ_s = 2.5 ns, the life time of injected carriers and I_b is d.c. bias current ($I_b \leqq I_{th}$).

3.2 Connection to Optical Fiber

The most common optical fiber used in the communication systems is made of silica, has a core diameter of 50 to 60 μm, a numerial aperture of 0.2 and a graded-index structure.

The laser beam emitted from the pellet spreads in the direction perpendicular to the active layer by approximately 30 ~ 40 °. In order to efficiently transmit this diverged beam into a fiber with a 50 to 60 μm core diameter and 12° reception angle (NA = 0.2), it is necessary to converge the incident angle of the beam close to the fiber reception angle with a lens having a large numerical aperture, and to also make the size of the laser beam smaller than the fiber core diameter.

The exact position of the lens placed between the laser diode and the fiber is determined by the properties of each lens.

Even when the laser beam is correctly transmitted to a optical fiber, sometimes ripples, irregular fluctuations, and/or noise appears in the light/current characteristics. This is caused by the fact that a small portion of the laser beam is reflected back at the incident end of the optical fiber and returns to the laser diode with great efficiency.

To prevent this preblem, the following measures should be taken:

1) Give anti-reflection treatment on the incident end of the optical fiber.
2) Make a slanted surface at the incident end.
3) Shift the incident end of the optical fiber slightly in the axial direction and intentionally avoid the optimum condition. (By doing this, the compling loss increases by 0.5 to 1 dB).

In the P-series of the NEC laser diodes, a special treatment is given to prevent the reflection problem.

4. HANDLING PRECAUTIONS

This section is devoted to basic precautions that must be taken in order to assure the stable operation of NEC laser diodes.

4.1 Absolute Maximum Ratings

The life of the laser diode will be shortened or its performance attenuated if the laser diode is not operated within the absolute maximum ratings. Serious damage to the refecting facets of the laser crystal may result, perticularly when optical output power exceeds the absolute maximum ratings.

Also, the operating temperature should be within the absolute maximum ratings, and preferably as low as possible to ensure long life for the devices.

4.2 Power Supply Circuitry

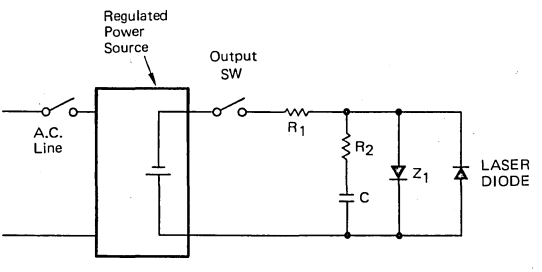
The power supply must be free from any spike surge that may be caused by switching the power line on and off. In some instances, even a surge current with a pulse width of less than 100 ns can destroy the device.

This is because the surge current will instantaneously generate a large output power due to the high-speed responsivity of the laser diodes and cause severe damage to the reflecting facets of the device.

Figure 4-1 shows an example of the surge-preventing circuits. Here R_1 represents a resister to limit current flow. R_2 and C are provided to absorb surges where a value of the capacitor should not be to large (to 0.1 μF). Z_1 is a diode to block reverse-voltage.

A poor connection on the load side of the power supply circuit causes the terminal voltage to rise if it is operated in a constant current mode. The moment the connection is restored a surge current flows.

The connection and disconnection of the laser diodes to or from the power supply must be made only after reducing the voltage to the minimum and then setting the output switch to the off position. There should be no loose connection in the circuit. Wiring with a short shielded wire is also recommended to prevent an external inductive surge from the AC line or elsewhere.



R_1 : 20 to 30 Ω
R_2 : 1 kΩ
C : to 0.1 μF

Fig. 4-1 Typical surge-preventing circuit

4.3 Installation and Heat Dissipation

In laser diodes, like other semiconductors, reliability is closely related to the junction temperature (ocillation region temperature). Optical output power level also affects the lifetime of the devices.

General precautions regarding installation of the devices are as follows:

1) Do no apply any pressure to the glass window
2) Remove dirt of other foreign materials from the glass window, and
3) Do not apply any tension or bending stress to the root of the pigtail.

Requirements for heat dissipation are dependent on the required levels of output, reliability (life) and other factors.

4.4 Safety

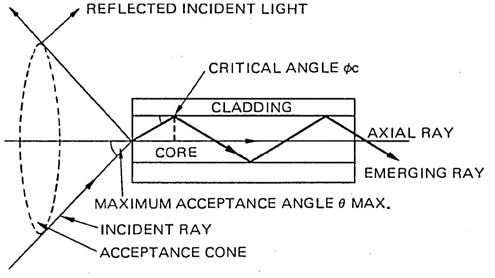
Viewing laser beams directly or through lenses is very hazardous and should be avoided.

The oscillation wavelengths of NEC LDs are in the infrared region and is not visible to the naked eye. Thus phosphor-coated infrared viewing screens, image converters or silicon vidicon TV's are used for viewing.

5. GLOSSARY

Absorption Loss - Attenuation of the optical signal within the fiber optic transmission medium. Usually specified in terms of db/km.

Acceptance Angle - any angle measured from the longitudinal axis of the fiber up to the maximum angle at which a ray may be incident upon the fiber core and accepted for transmission. The maximum acceptance angle (θmax.) is a property of the fiber which is dependent on the indices of refraction if the core and cladding material. θ max. = $\sin^{-1}$ (n^2 core -n^2 clad) $^{1/2}$.



Acceptance Cone - The cone whose included angle is equal to twice the acceptance angle.

Beam Divergence in a given plane - The half angle of divergence of the laser emission at which the intensity of radiation is one half the peak intensity.

Cladding - The covering material which encases the core of an optical fiber. The cladding material is usually of a lower index of refraction than the core material and may be either glass or plastic.

Coherent Radiation - Radiation in which the phase difference between any two points in the radiation field is constant throughout the duration of the radiation.

Core - The center dielectric in an optical fiber through which the optical wave propogates. This material is usually glass and has a higher index of refraction than the cladding material.

Coupler - An optical device used to inter-connect optical fibers.

Coupling loss - The optical power loss incurred in connecting optical fibers. It is usually expressed in terms of decibels loss.

Coupling Efficiency - The fraction of available output from a radiant source which is coupled and transmitted by an optical fiber. The coupling efficiency for a Lambertian radiator is usually equal to the $\sin^2 \theta$max. for the optical fiber being used.

Critical Angle - The smallest angle at which a meridional ray may be totally internally reflected within the fiber at the core-cladding interface. The critical angle depends on the respective index of refraction of the core and cladding and thus determines the numerical aperture of the fiber.

Dark Current - That current that flows in the absence of signal and background radiation. The average or DC value of this current is identified by the symbol Id.

Decibel - The standard unit used to express gain or loss and relative power levels.

$dB = 10 \log (P_2/P_1)$

Dispersion - A measure of the change in refractive index of a given medium as a function of wavelength. This property influences both the effective numberical aperture and the bandwidth of an optical fiber.

Dispersion Effect - The pulse spreading of an optical signal within the fiber which is caused by the difference in material index of refraction at the various wave-lengths present in the optical signal.

Duty Factor (dul) - The product of the pulse duration and the pulse repetition frequency of a wave composed of pulses that occur at regular intervals.

Fiber Bundle - A group of parallel fibers contained within a common jacket. A bundle may contain from just a few to several hundred fibers.

Graded Index Fiber - An optical fiber whose index of refraction decreases as a function of radial distance from the axis. This type of fiber does not depend on interfacial reflections; it uses the index gradient to refocus the rays within the core. It generally exhibits higher bandwidth than "step" index fiber.

Index of Refraction or Refractive Index The ratio of the velocity of light in vacuum to the velocity of light in a given medium.

Infrared -Emitting-Diode- A semi-conductor device in which refractive rècombination of injected minority carriers produce infrared readiant flux when current flows as a result of applied voltage.

Injection Laser - A solide-state semi-conductor device consisting of at least one p-n junction capable of emitting coherent or stimulated radiation under specified conditions. The device will incorporate a resonant optical cavity.

Lambertian Source - A radiant source which has equal radiance in all direction. It emits a radiant flux which is proportional to the cosine of the angle from the normal.

Multimode Effect - Aneffect which results from the time difference required for different rays to reaverse the length of a multimode fiber. Axial rays will have the shortest path length and thus be transmitted in the least time. Rays entering the fiber at the maximum acceptance angle will require the maximum time.

Multimode Fiber - Optical fibers with relatively large core diameters compared to single mode fibers. The core diameter of multimode fibers can range from 25 to 200 μm.

Multimode Laser - Stimultaneous emission at several wavelengths.

Noise Current - Various sources of nois or current fluctuations which interfere with the precise measurement of the signal current. Dark current has a random fluctuation as does signal current. When the individual pulse can be observed, these fluctuations are manifest in the random arrival of the dark or signal pulses. Sometimes, the noise in the associated components, such as thermal noise in the coupling resistor or amplifier noise, is dominant.

Noise Equivalent Power - The radiant flux in watts incident on the detector which gives a gignal-to-noise-ratio of unity. The frequency bandwidth and the frequency at which the radiation is chopped must be specified as well as the spectral content of the radiation. Detectors may be rated in terms of an NFP having units of watts Hz-1/2. Assuming that the noise spectrum is flat withn the range of the specifications and that NFP is normally specified for a bandwidth of one hertz, the two forms of NFP are numberically equal.

Numerical Aperture - A number which defines the light gathering power of a specific fiber. The numberical aperture is equal to the sine of the maximum acceptance angle. It is determined by the index of refraction properties of the fiber and is equal to $(n^2core - n^2clad)^{1/2}$ for step index fibers. Optical Axis - The axis of symnetry of an optical system.

Pulse Length - The time duration of the burst of energy emitted by a pulse laser, also called pulse width. Usually measured at the "half-power" points (0.709 time the full height of a voltage or emitted pulse.)

Pulse Spreading - This term erfers to the widening of the input optical signals as they traverse the length of a fiber and are due to the fact that some rays require less time to transverse the fiber than others. This property limits the useful bandwidth of the fiber and is usually expressed in terms of nanoseconds per kilometer. The principal mechanisms are the dispersion effect and the multimode effect.

Quantum Efficiency (QE) - The quantum efficiency of a source of radiant flux is the ratio of the number of quanta or radiant energy (photons) emitted per second to the number of electrons flowing per second, e.g. photons/electron.

Field Pattern - The representation of the intensity of emission as a function of direction, in a given plane. The axis are to be specified with respect to the junction plane and the cavity face.

Refractive Index - The ratio of the velocity of light in vacuum to the velocity of light in the specified medium.

Responsivity - The term used to described the sensitivity of the photosensor. It is the ratio of the out put current or voltage to the input flux in watts or lumens. When responsivity is indicated at a particular wavelength (in amperes/watt), it connotes the spectral response of the device.

Rise Time (t_r) - The time taken for the radiant flux to increase from 10 % to 90 % of its peak value when the laser is subjected to a step function current pulse or specified amplitude.

Signal-to-Noise Ratio - Usually the signal-to-noise ratio (S/N) is expressed in terms of the noise in a particular bandwidth. It may be expressed in decibels or, in photoelectron counting applications as the ratio of a number to the standard deviation of the number in a particular count duration.

Spectral Bandwidth ($\Delta\lambda$) - The spectral bandwidth for single peak devices is the difference between the wavelengths at which the radiant intensity is 50 % (unless other-wise stated) of the maximum value.

Single Mode Fiber - An optical fiber with a very small core diameter (usually in the range of 2-10 microns). Such fibers are normally used only with laser sources due to their very small acceptance cone. Since the cone diameter approaches the wavelength of the source, only a single mode is propogated.

Spectral Bandwidth - The wavelength interval in which a radiated spectral quantity is not less than half its maximum value.

Step Index Fiber - An optical fiber which has a core and a cladding with an abrupt change in the refractive index at the core-cladding interface. The index of the cladding is usually less than the core index to permit total internal reflection.

Threshold Current (I_{th}) - The minimum forward current for which the laser is in a lasing state at a specified temperature.

Wavelength of Peak Radiant Intensity - The wavelength at which the spectral distribution of radiant intensity is a maximum.

1. INTRODUCTION

Optical fiber communications are being rapidly developed for practical applications because of the high quality mass communications capabilities, and because silicates which are abundantly available are used. The application of optical fiber technology to basic transmission networks, the introduction of Information Network Systems (INS), and the realization of an optical submarine transit project herald a new age.

Optical communications mainly uses the short-wavelength band (800 nm), and the low loss/dispersion long-wavelength band (1 100 to 1 600 nm) of optical fiber. Laser diodes (LD) and light emitting diodes (LED) using AlGaAs, and avalanche photo diodes (APD) and photo diodes (PD) using Si are for the short-wavelength band, and LDs are LEDs using InGaAsP, and APDs and PDs using Ge are mainly for the long-wavelength band.

This publication introduces the chip structure and principal characteristics of InGaAsP Double-Channel Planner Buried Hetero-structure laser diodes (DC-PBH LD) and Ge APDs and PDs, which are excellent for the 1 300 nm band with a lower transmission loss and less material dispersion in optical fiber.

2. SUMMARY

The 1 300 nm band InGaAsP/InP-type laser diode, newly developed as a light source for long-distance high-capacity optical fiber communications has a laser oscillating InGaAsP active layer buried in an InP clad layer. This diode, DC-PBH LD, has the following features:

(1) Can operate with a laser oscillation threshold current as low as about 20 mA.
(2) Stable fundamental transverse mode oscillation.
(3) High efficiency and high output.
(4) Excellent high-temperature performance characteristics and guarantee characteristics at 60 °C.
(5) High reliability. More than 100,000-hour MTTF is estimated with a 5 mW conductivity test at 50 °C.

In addition, Ge-APD/PDs can be used as photo detectors for long-distance high-capacity optical communications, and have the following features:

(1) Small dark current
(2) High quantum efficiency
(3) High-speed response

3. DC-PBH SEMICONDUCTOR LASER DIODE

3.1 CHIP STRUCTURE

This laser basically uses a luminous recombination of the implanted carrier. To realize a low threshold value, high efficiency, and stable fundamental transverse mode oscillation, various trials were made with presently used laser diodes to confine the carrier in a narrow space. The carrier buried in a direction vertical to the junction is made by a double heterostructure, and that parallel to the junction by a stripe structure. One of the typical burial methods is a buried heterostructure that wraps the active region with material having a larger forbidden band width and smaller refractive index. To manufacture a chip with this structure, two crystal growth processes are needed with an etching process for forming the stripe structure inbetween.

Since InGaAsP/InP material for long-wavelength band elements does not contain such easily oxidized elements as Al as are found in AlGaAs/GaAs material for short-wavelength band elements, the second epitaxial growth produces high quality crystals comparatively easily. Consequently, a buried heterostructure is becoming the main one for long-wavelength band laser diodes using InGaAsP/InP.

Figure 1 shows the conceptual element structure of a DC-PBH LD we recently developed for commercial use. Photo 1 is SEM photograph of a cross-section view of an actual diode. The first epitaxial growth forms three layers including an InGaAsP active layer on the n-InP substrate. After a mesa stripe structure that will become the active region by chemically etching two grooves is formed, the second liquid phase epitaxial growth removes these grooves.

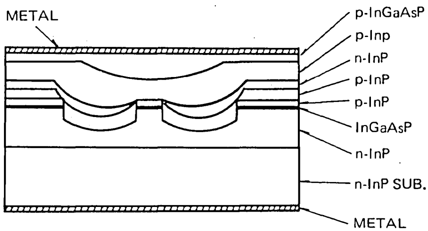


Fig. 1 Conceptual Structure of DC-PBH LD

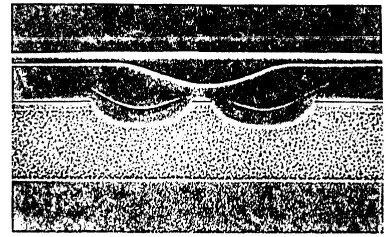


Photo 1 SEM Photograph of Cross-Section View of DC-PBH LD

The feature of this pnpn current confinement structure is having an InGaAsP layer with a narrow forbidden band width outside the grooves. This can be regarded as a thyrister connected to the P-clad layer at the top of the active layer with the P-block layer being the base layer. When the chip is biased in the forward direction, a portion of the injected current works as the gate current for this thyristor.

The InGaAsP layer checks an increase in the leakage current in the high-injection region as if the gate current which is turned a thyristor on, and effectively injects carrier into the stripe-shaped active region to realize a low threshold value, high efficiency, and high output power for the laser diode.

3.2 DEVICE CHARACTERISTICS

DC-PBH LD has an excellent performance for above-mentioned reasons. The principal characteristics are as follows:

(1) Oscillation threshold current

The oscillation threshold current I_{th} is remarkably low, as little as 15 to 20 mA, and the external differential quantum efficiency (η_d) is high, about 50 to 60 percent.

In addition, it has excellent temperature characteristics, with the 70 to 90 K characteristic temperature (T_o) value indicating temperature dependency of the threshold current I_{th}. Figure 2 shows an example of a L-I characteristic curve for DC-PBH LD with a varying ambient temperature. Up to over 70 °C, the L-I curves shows good linearity with very minor increases in I_{th}. In this example, the CW operation threshold temperature reaches 125 °C.

A low threshold-current value, high efficiency, and excellent temperature characteristics mean that under operational conditions the chip can be operated on a low current.

This leads to advantages in exothermic temperature control and lessening of the load for the drive circuit, enabling DC-PBH LD to operate stably in a wide temperature range. Consequently, DC-PBH LD standardizes various characteristics at 60 °C for the first time in the world for LDs for the 1 300 nm band.

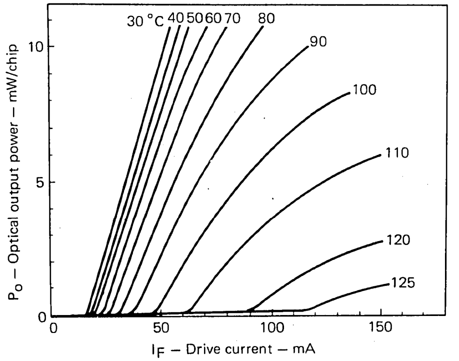


Fig. 2 Temperature Dependency of L-I Characteristics

(2) Fundamental transverse mode oscillation

DC-PBH LD has an excellent output performance at high temperatures because of its structure described in Section 3.1. For example, by CW operation at room temperature, a single-side output of 50 mW for fundamental transverse mode oscillation was realized with approximately 200 to 300 mA of operation current.

For application to optical fiber communications, laser diodes, must meet the requirements for stable fundamental transverse mode oscillation. A laser diode with a buried structure has large difference in refractive index between the active region and chip material that encloses it. This is generally considered a disadvante as it generates a higher mode. Therefore, to suppress the higher mode, the basic design of DC-PBH LD calls for the dimensions of the active region to be as close as possible to the primary mode cut-off conditions.

(3) High efficiency, high output

Radiant beam spread strongly affects the coupling efficiency when optical fiber and a laser diode are coupled. The smaller the vertical/horizontal beam radiation angle ($2\theta_{\perp}/2\theta_{/\!/}$) is against the p-n junction plane of the chip, and the closer the aspect ratio between the radiation angles is to 1, the better the coupling. With DC-PBH LD, 35° and 28° have been realized as standard $2\theta_{\perp}$ and $2\theta_{/\!/}$ values.

Figure 3 shows the optical output plotted against the DC-PBH LD current, and an example of the correspondence between the differential characteristics of the optical output and the near field pattern (NFP) of luminous spots. The graph shows that there are stable transverse mode oscillations with high output operations.

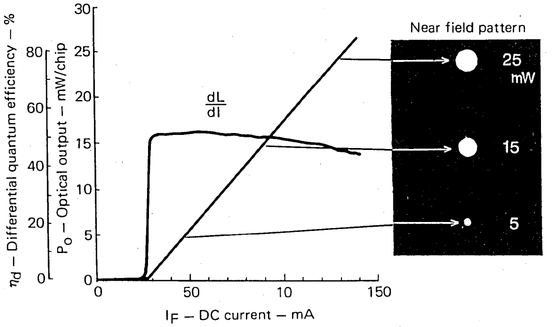


Fig. 3 L-I, dL/dI-I Characteristics and Near Field Pattern

The pnpn junction to be formed inside the chip to block current produces a junction capacitance during modulation and may adversely affect the response characteristics. This problem is overcome by optimizing the doping level of each burial layer to realize good high-speed modulation characteristics. Figure 4 shows an example of a high-speed modulation circuit and the modulated waveform of DC-PBH LD by a 450 Mb/s RZ random pulse.

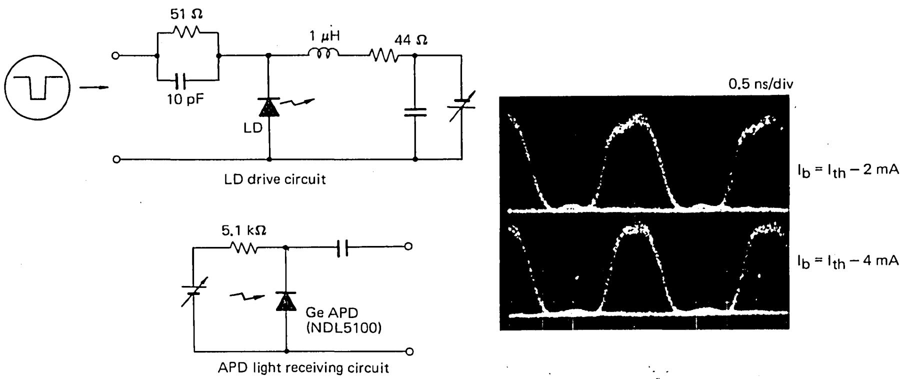


Fig. 4 Pulse Response Characteristics (450 Mb/s, RZ)

3.3 PRINCIPAL CHARACTERISTICS OF DC-PBH LASER DIODES

The products using DC-PBH LD are NDL5003 and NDL5004 installed to TO-5 case. NDL5003 only has an LD chip installed, and produces the main optical output through a glass window in the front of the case, and the monitor optical output through an axial hole in the back of the case. ND5004 has both an LD chip and Ge-photo diode installed within the case where the current via the photo diode monitors the optical output of the LD chip. Table 1 shows the principal characteristics of both products.

3

Table 1 Principal Characteristics of DC-PBH Laser Diodes

ITEM	CODE	CONDITIONS	NDL5003	NDL5004	UNIT
Forward voltage	V_F	$I_F = 30$ mA	1.3 MAX.	1.3 MAX.	V
Threshold current	I_{th}	cw	20	20	mA
Optical output power	P_o	$I_F = I_{th} + 30$ mA	8	8	mW
Monitor optical output power	P_m	$P_o = 6$ mW	1	–	mW
Center wavelength	λ_0	$P_o = 6$ mW	1300 ± 30	1300 ± 30	nm
Half power spectral power	$\Delta\lambda$	$P_o = 6$ mW	4 MAX.	4 MAX.	nm
Vertical/lateral beam angle	$2\theta_{\perp}/2\theta_{/\!/}$	$P_o = 6$ mW	35/28	35/28	deg
Rise/fall time	t_r, t_f	10 ~ 90 %	0.5	0.5	ns
Monitor current	I_m	$V_R = 5$ V $I_F = I_{th} + 30$ mA	–	500	μA
Monitor dark current	I_d	$V_R = 5$ V	–	1.5	μA

3.4 RELIABILITY

The 1300 nm band DC-PBH LD has the following advantages due to its excellent current confining structure:

(1) It has very few crystal defects near the active layer because of the double channel structure.

(2) It has a low threshold current and high quantum efficiency enabling high output with a small drive current.

(3) It has excellent temperature characteristics making low drive currents possible at high temperatures.

These advantages enhance the reliability.

Optical fiber communications require high reliability of the light-emitting device. To evaluate the stability of the device over a long term, tests on its life were conducted. For the drive method for the laser diode, an automatic power control circuit was used to keep the optical output constant as in a real communications system.

As Figure 5 shows, five testing conditions were set up by varying the ambient temperature and optical power output in consideration of various circumstances for the diodes use and acceleration. The total number of samples was 85. The life tests have already exceeded 10000 hours, and there have been no failures observed in any of the test conditions. All forty samples are functioning stably with an ambient temperature of 50 °C and optical output of 5 mW. As Figure 6 shows, there are not any significant fluctuations between initial value and middle value in the drive current.

Therefore, assuming an exponential distribution form failure, MTTF under these testing conditions would be more than 100,000 hours. Figure 6 also shows the variation of drive current against time with the temperature and optical output power being accelerated more than in practical situations (ambient temperature of 70 °C and optical output of 10 mW). With conventional long-wavelength band laser diodes, stable performance for long term at 70 °C is difficult.

However, the 1300 nm band DC-PBH LD having improved optical output characteristics at high temperatures, performs stably at 70 °C with a small drive current of approximately 100 mA. The test against time was made on the oscillation wavelength (λ_0), radiation angle ($2\theta_\perp/2\theta_{/\!/}$), and pulse response under the test conditions described in Fig. 6. All the results indicate that no change occurred in the performance during 10,000 hours of operation.

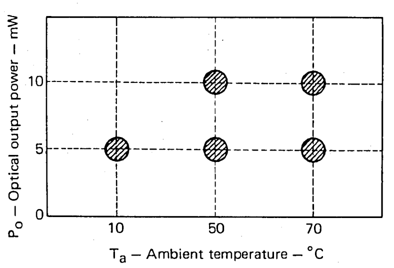


Fig. 5 DC-PBH LD Life Test Conditions

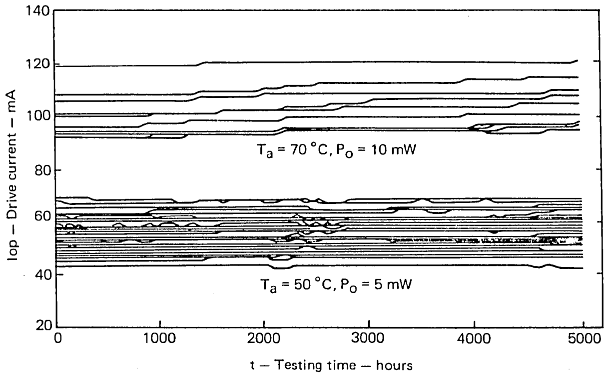


Fig. 6 DC-PBH LD Life Test Conditions

A laser diode degrades itself by the damage to the reflective surface that occurs when the optical output power is accelerated. This is called catastrophic optical damage (COD). For the 1300 nm band DC-PBH LD with a 0.1 μs pulse width, no COD was observed at optical outputs above 100 mW proving that the laser diode is resistant to excess current.

As described above, the life test, excess output test, and environment test have proved that the 1300 nm band DC-PBH LD has the high reliability necessary for a communications semiconductor.

4. Ge-APD/PD

4.1 MANUFACTURING AND STRUCTURE OF CHIP

Ge-APD (NDL5100) and PD (NDL5200) have a planer structure consisting of a p^+n junction as the light receiving section and a guardring in the periphery of the junction. Figure 7 shows a cross-section view of the chip. A facet crystal (111) having Sb doping is used for the substrate, and the guardring is formed by selective dispersion of Zn. The temperature for thermal processing in the manufacturing is set as low as possible to reduce the dark current.

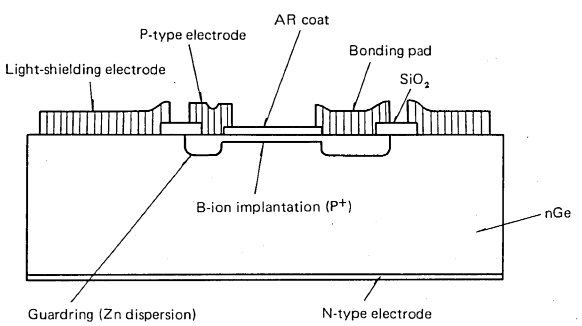


Fig. 7 Ge-APD/PD Structure

The light receiving p+ layer forms a shallow junction by implanting (B^+)-ion. The SiO_2 protects the exposed surface of the pn junction and reduces and stabilizes the dark current. The light receiving surface is coated with anti-reflection coat for a better light receiving efficiency. Al is used for the p-type electrode, and AuGeNi for the n-type.

APD and PD have an almost identical inner structure. A diode with a smaller photo detector diameter of 100 μm is used in the receiving side as the APD, and one with a 240 μm photo detector diameter is used in the transmitting side as a monitor for stabilizing the laser diode output by using the PD function.

4.2 DEVICE CHARACTERISTICS

Figure 8 shows the voltage-current characteristics and voltage-multiplication factor characteristics of Ge-APD with a 100 μm photo detector diameter at room temperature. A dark current I_D of 0.2 to 0.25 μA at 0.9 V_B were obtained with good repeatability. The multiplication factor is also voltage dependent, and the maximum multiplication factor ($M_{MAX.}$), when I_D = 1 μA, is approximately 40. On the other hand, the incremental dark current that strongly affects the receiving ability has a very low value, about 0.03 μA.

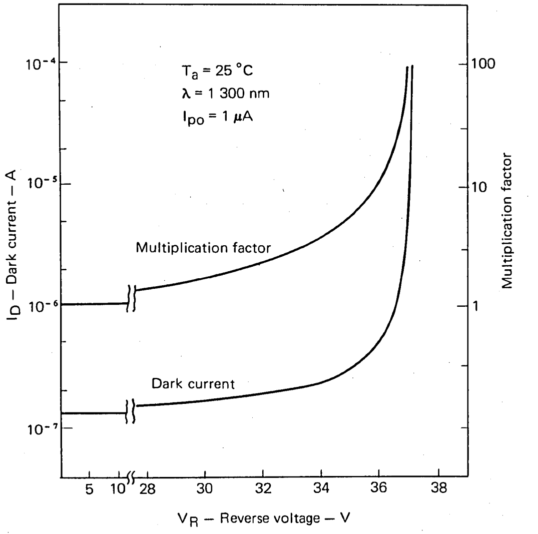


Fig. 8 Voltage Dependency of Dark Current and Multiplication Factor

The wavelength dependency of the quantum efficiency of Ge-APD/PD, as shown in Fig. 9, produces flat characteristics in a wide range of wavelengths, 1 200 to 1 500 nm. Under 1 200 nm the dependency starts to fall slightly, and over 1 500 nm it drops sharply. For anti-reflection coat, SiN film improves the efficiency by about 4 percent over SiO_2 film.

The pulse response characteristics of Ge-APD become t_f=270 ps at the falling edge when the wavelength λ_0 =1 300 nm, and M=10. Cutoff frequency becomes about 1.6 GHz. The noise characteristics are evaluated by using the excess multiplication noise index κ (excess multiplication noise factor $F=M^{\kappa}$). The excess multiplication noise index κ of Ge-APD is 0.93 when λ_0=1 300 nm. Table 2 shows the principal characteristics of Ge-APD.

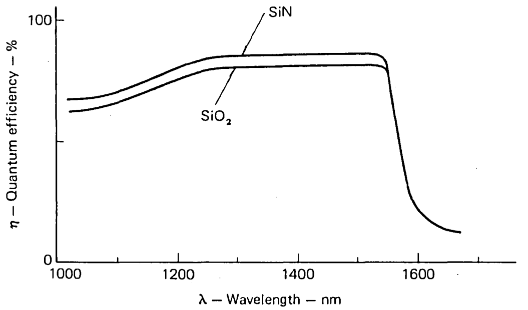


Fig. 9 Wavelength Dependency of Quantum Efficiency

Table 2 Principal Characteristics of Ge-APD/PD

ITEM	CODE	CONDITIONS	APD	PD	UNIT
Dark current	I_D	$V_R = 0.9\ V_B$	0.25	0.5 (V_R = 6 V)	μA
Multiplication dark current	I_{DM}	M = 1	0.030	–	μA
Quantum efficiency	η	V_R = 5 V	75	75	%
Maximum multiplication factor	$M_{MAX.}$	I_{PO} = 1 μA	100	–	–
Terminal capacitance	C_t	V_R = 20 V, f = 1 MHz	1.7	8.5 (V_R = 6 V)	pF
Excess multiplication noise index	κ	f = 30 MHz, B = 1 MHz	0.93	0.93	–
Cutoff frequency	f_c	M = 10, R_L = 50 Ω	1.6	–	GHz
Minimum receiving level	$P_{min.}$	32 Mb/s, Pe = 10^{-9}	–49.7	–	dBm

3

4.3 SENSITIVITY CHARACTERISTICS

Figure 10 shows relationship between the minimum received signal level and bit error rate when Ge-APD is installed in a receiving system. The results of measurement using 15-section PN pattern pulses with a bit rate of 32 Mb/s, a 50 % mark density, a 50 % duty factor, and a wavelength of 1 300 nm that the received signal level where the bit error rate indicates 10^{-9} is –49.7 dBm. Factors that set the receiving sensitivity of APD are the dark current, quantum efficiency, and excess noise index. Of these, the dark current and quantum efficiency most strongly affect the sensitivity, while the effect from the excess noise index is comparatively small.

4.4 RELIABILITY

Reliability tests were conducted at two reliance levels for high temperature reverse duty, and one level for high temperature reverse voltage applications. After 3000 hours of testing no degradation was observed. The performance of Ge-APD was very stable after the 3000 hour accelerated life test.

5. CONCLUSION

The long wavelength LD and APD/PD introduced here are optimum optical semiconductor devices for long-distance high capacity transmission systems such as inter-city basic transmission, optical submarine transit, and INS. Because these systems demand a transmission capacity higher than 400 Mb/s and a repeating interval longer than several kilometers, optical semiconductor devices for the long-wavelength band (1 200 to 1 600 nm band) are necessary for a low transmission loss.

To meet the requirements of the market we have full line-up of long-wavelength optical semiconductor devices at our company. We would appreciate your patronage.

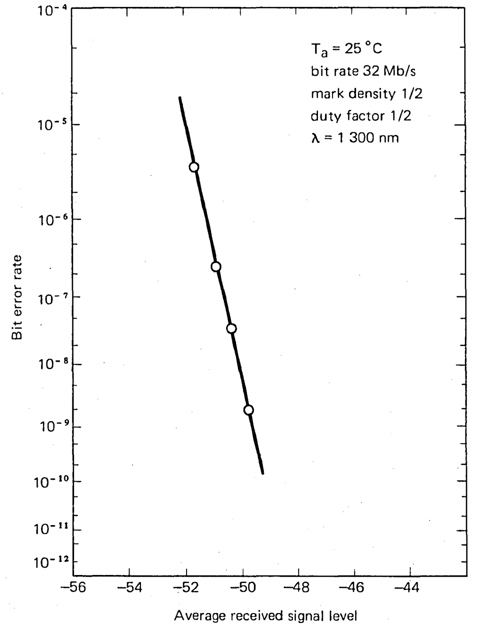


Fig. 10 Received Signal Level Dependency of Failure Rate

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INSTRUCTIONS MANUAL FOR AVALANCHE PHOTO DIODE

An avalanche photodiode (APD) is a high-speed, highly sensitive optoelectric transducer having composite functions of a photodetector and a current amplifier. This product is promising as a photodetector in optical fiber communications equipment and other optical instruments. This manual gives information which will permit a user to take advantage of the features of the APD.

I. THEORY OF OPERATION

(1) PHOTOVOLTAGE

① PN junction

Jointing a P-type and a N-type semiconductor causes the junction (PN junction) to be charged with electricity. A typical PN junction is formed by diffusing boron (P-layer) into phosphorous (N-layer) silicon crystal (substrate).

The reason why the PN junction is charged with electricity is that the negatively ionized P-layer and the positively ionized N-layer contact each other. That is, the electrons in the N-layer recede from the PN junction as being repelled by the negative charges in the boron, and, in the same way, the holes in the P-layer recede from the PN junction as being repelled by the positive charges in the phosphorous. (See Figure 1 (b).)

As a result, there is a region where no carrier exist around the PN junction (this region is known as a depletion layer). The depletion layer in the P-layer is a negative space charge layer and that in the N-layer is a positive space charge layer. Accordingly, an electric field appears in the PN junction where current flows from the N-layer to the P-layer. (This electric field is known as a space field.) An energy band structure indicating this situation is shown in Figure 1 (c).

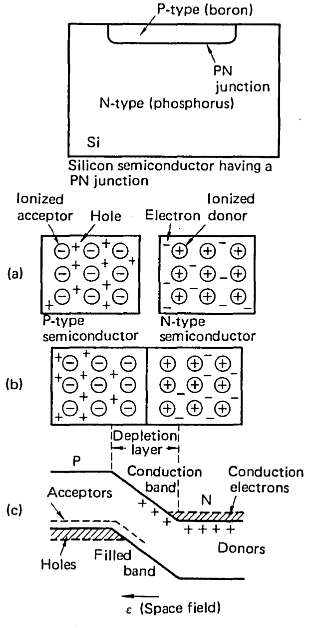


Fig. 1 (a) shows a condition where the N-type and P-type semiconductors are separate from each other, (b) a condition where these semiconductors are jointed, and (c) an energy band structure of the PN junciton.

3

② Solar cell

When a PN junction is exposed to light as shown in Figure 2, electron-hole pairs generated by the light near the PN junction are separated under the influence of the space field: the electrons travel toward the N-layer and the holes toward the P-layer. Electron-hole pairs generated by the light at distances from the PN junction are not influenced by the electric field, so they perform thermal motion. Most of these electrons and holes are lost by recombination during the thermal motion; however, some of them which happen to go toward the PN junction during the thermal motion plunge into the space field and reach the opposite layer through the space field. The current that flows by this process is called diffusion current.

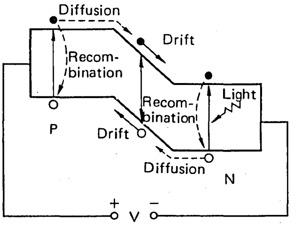


Fig. 2 Photoelectric Effect on a PN Junction

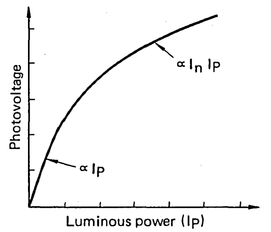


Fig. 3 Solar Cell Output Curve

Consider a case where the external circuit connected to the P- and N-layers is open; then the carriers generated by the light perform the motions described above, so that excess electrons collect in the N-layer and excess holes in the P-layer. These excess charges operate to reduce the original difference of the energy band levels between the P- and N-layers and produce a voltage across the P- and N-layers. This voltage is called photovoltage. This is the theory of operation of a solar cell. The photovoltage is proportional to the luminous power (that is, photocurrent) in a portion where the luminous power is low, and to the logarithm of the luminous power in a portion where the luminous power is high, as shown in Figure 3.

(2) PHOTODIODE

When the external circuit is closed, excess electrons flow in the external circuit and recombine with the excess holes in the P-layer. This current is called photocurrent. Since the PN junction is exposed to light, the width of the space charge region can be increased in proportion to the 1/2 through 1/3 power of the reverse bias voltage.

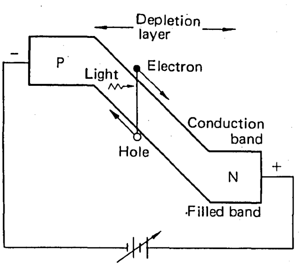


Fig. 4 Energy Band Structure of a Photodiode with a Reverse Bias Voltage Applied

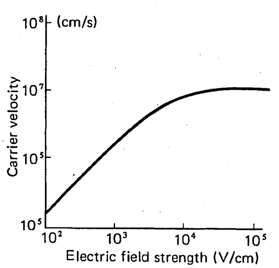


Fig. 5 Carrier Velocity Dependence on Electric Field Strength

The greater the reverse bias voltage applied, the stronger the space field and the greater the carrier velocity, because the carrier velocity is proportional to the electric field strength. The carrier velocity cannot be enhanced unlimitedly, however, since the carriers are under the influence of scattering of lattice atoms in the crystal. The carrier velocity does not exceed a certain value (maximum) however high the reverse bias voltage applied. The maximum carrier velocity is approximately 10^7 cm/s. This characteristic is shown in Figure 5. Sufficient voltage for the carriers to achieve maximum velocity must be applied if a high response speed is required.

There is another effect of the reverse bias voltage for the enhancement of the response speed; that is, the PN junction has a capacitance which is inversely proportional to the width of the space charge region. Therefore, the greater the reverse bias voltage applied, the lower the capacitance, the lower the CR time constnat of the photodiode, and higher the response speed.

(3) V-I CHARACTERISTIC

A PN junction can function either as a solar cell or as a photodiode according to use as described above. These functions are summarized here, using the relationship between the reverse bias voltage applied to the PN junction and the current flowing in the PN junction, that is, the V-I characteristic (shown in Figure 6 (b).) When neither light nor bias voltage is applied, no current flows in the PN junction. This condition is indicated by the origin in the V-I characteristic coordinate system. When a forward bias voltage is applied to inject the electrons in the N-layer into the P-layer, a high forward current flows in proportion to the bias voltage. When a reverse bias voltage is applied, dark current I_S, which is a fixed leakage current, flows.

Incident light, if applied in this condition, produces a forward photovoltage across the P- and N-layers according to its luminous power, which causes a current to flow in the reverse direction. Accordingly, the V-I characteristic curve indicating this condition is identical with the V-I characteristic curve for the condition with no incident light, except that it is moved parallel to the right by the value of the photovoltage produced according to the incident luminous power as shown in Figure 6.

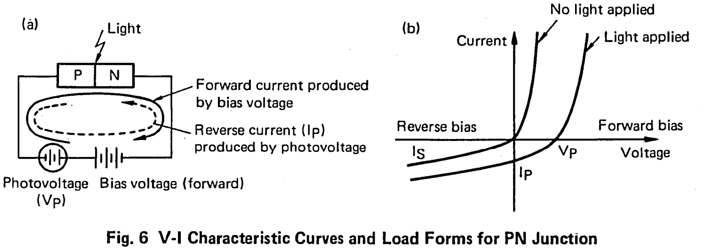


Fig. 6 V-I Characteristic Curves and Load Forms for PN Junction

When an APD is used as a solar cell, photovoltage is produced by applying no bias voltage and connecting resistor R to the external circuit. The photovoltage produced is given by the product of I and V from the V-I characteristic shown in Figure 6 if V = IR.

When an APD is used as a photodiode, reverse bias voltage Va is applied. Then, the current flowing in load resistor R is proportional to the I_P if the I_S is low enough, and a voltage proportional to the incident luminous power is produced across the load resistor.

(4) AVALANCHE MULTIPLICATION

The avalanche multiplication of carriers occurs by impact ionization when an electric field applied to a PN junction reaches the critical value of 200 kV/cm. In the case of silicon, this phenomenon occurs when a breakdown is caused by applying reverse bias to a PN junction which has a dielectric strength of 13 V or higher.

Photocarriers generated by incident light trigger an avalanche multiplication, so an avalanche current varying with luminous power can be obtained.

When an electron in an electric field gains an energy 3/2 times greater than the band gap energy during transit with repetitive impaction in the free process, its impact on the lattice excites an electron in the filled band so that it reaches the conduction band, also exciting a hole at the same time. (See Figure 7.)

The impact ionization repeats and current increases until the carrier enters a region under a weak electric field. The number of times a carrier causes impact ionization during a unit transit is called ionization coefficient.

An APD is 10-20 dB more sensitive than a conventional photodiode because of its internal photocurrent multiplication caused by the electron avalanche described above. For this reason, APDs hold an important position as photodetectors in long-distance optical transmission systems. An APD may be said to be a solid-state photoelectron multiplication tube; however, it is suitable for optical communication systems since its photodetective plane is not degraded, unlike that of a photoelectron multiplication tube; it is compact; and its operating voltage is as low as 100-200 V.

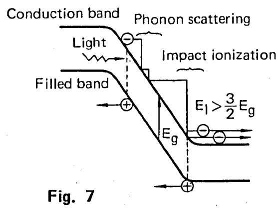


Fig. 7

Avalanche multiplication of carriers by impact ionization; E_I indicates ionization energy and E_g band gap energy.

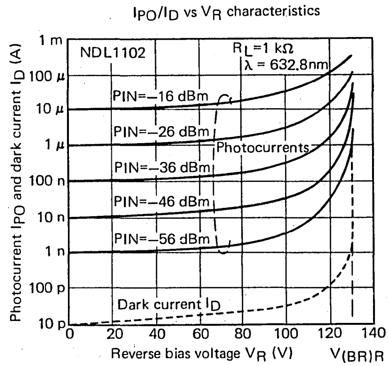


Fig. 8 V-I Characteristic Variation with Incident Luminous Power

II. EXPLANATION OF TERMS

Unique terms, such as avalanche photodiode, are used in the description of optoelectric transducers. The following table gives simple explanations of the unique terms.

Term	Symbol (in NEC)	Explanation
Dark current	I_D	A leakage current flowing at the output of a photodetector, such as a photodiode, when no light is applied. Dark current becomes a background noise against a signal current; however, in a silicon semiconductor, dark current is normally negligible since it is low enough in comparison to the shot noise and thermal noise of the circuit. Dark currents in NEC products do not exceed 1 nA.
Photodetective current (photocurrent)	I_P	A current flowing according to incident light. Photocurrent depends on the level and wavelength of incident light.
Quantum efficiency	η	Carriers are generated in a photodetector according to the energy of incident photons, and an output current (photocurrent) of the photodetector can be obtained when the generated carriers are drifted by an electric field applied externally. The ratio of the number of discharged electrons to the number of incident photons is called quantum efficiency, and is given by the following formula: $\eta = \frac{\text{Number of electrons contributing to photocurrent}}{\text{Number of incident photons}} = \frac{I_P/q}{P_O/h\nu}$ Where: I_P = Photocurrent (A); q = Charge of an electron (1.6×10^{-19} C); P_O = Power of light (W); h = Plancks constnat (6.626×10^{-34} J·s); ν = Frequency of light (s^{-1}); $\nu = \frac{C}{\lambda}$ Where: C = Velocity of light (approx 3×10^8 m/s); λ = Wavelength of light (m)
Sensitivity	S	Sensitivity (S) can be interpreted as an expression of quantum efficiency (η) in a term closer to an electrical term. The unit of sensitivity is A/W. Sensitivity means photocurrent per incident photon. The relationship between sensitivity (S) and quantum efficiency (η) can be shown by the following equation (which is graphically indicated in Figure 9): $S = \frac{I_P}{P_i} = \frac{q\eta}{h\nu} \left(\text{or} = \frac{q\eta\lambda}{hc}\right)$

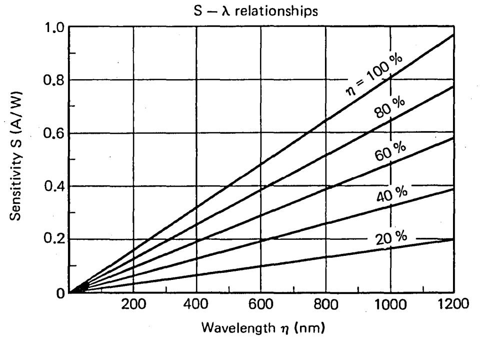
<table>
<tr><th>Term</th><th>Symbol (in NEC)</th><th>Explanation</th></tr>
<tr><td>Sensitivity</td><td>S</td><td>

Fig. 9 Sensitivity VS Wavelength

In the description of an APD, the term "effective sensitivity" (S_M) may be used, which is obtained by multiplying sensitivity S by current multiplication factor M.

$S_M = S \times M$ (A/W)</td></tr>
<tr><td>Current multiplication factor (multiplication factor)</td><td>M</td><td>Multiplication factor means the ratio of the photocurrent (b) in the avalanche operational region to the photocurrent (a) in the photodiode operational region shown in Figure 10.

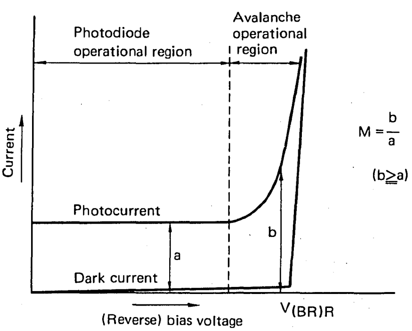
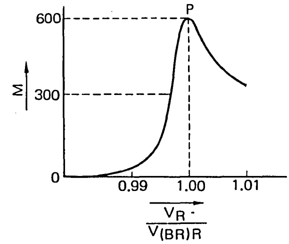
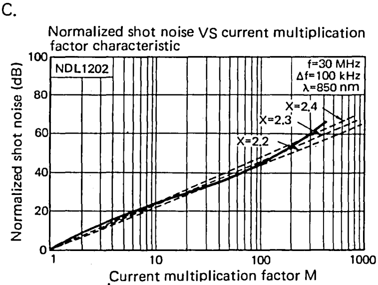


Fig. 10 APD Current VS Reverse Bias Voltage Characteristics</td></tr>
<tr><td>Maximum multiplication factor</td><td>M_m</td><td>This is the current multiplication factor when the reverse bias voltage (V_R) applied to the APD is equal to the reverse breakdown voltage ($V_{(BR)R}$). The dependence of M upon the voltage (reverse bias voltage) is shown in Figure 11. The maximum multiplication factor is indicated by point P in this figure.</td></tr>
</table>

Term	Symbol (in NEC)	Explanation
Maximum multiplication factor	M_m	 **Fig. 11 M VS $\frac{V_R}{V_{(BR)R}}$ Characteristic** The value of M_m for a silicon APD is normally within the range of 500-1000.
Noise multiplication figure	X	The noise current in an APD is multiplied with the signal current. In a normal silicon APD, the noise current is proportional to M^X, where M is the multiplication factor of the signal current. The X takes a value of about 2.25. Fig. 12 shows the relationship between the noise current and current multiplication factor of an APD manufactured by NEC.  **Fig. 12 Normalized Shot Noise VS Current Multiplication Factor Characteristic**
Excess noise figure	x	In many uses of APDs, greater attention is paid to the shot noise than to the thermal noise. Since the shot noise is proportional to the power of incident light, the shot noise value is expected to be proportional to M^2, where M is the current multiplication factor of the APD. The actual shot noise, however, is multiplied by M^{2+x}. So, the x is called the excess noise figure. The value of x of an APD manufactured by NEC is approximately 0.25 when M = 100. The following relationship holds between noise multiplication figure X and excess noise figure x: $X = 2 + x$

III. STRUCTURE

Figures 13 through 15 show pellet cross-sectional views and a pellet pattern diagram of the APDs manufactured by NEC. Figure 13 shows an N^+P type APD, which features high-speed response (0.5 ns max.) within the range of visible light (up to 700 nm) and relatively low operating voltage (approximately 120 V). Figure 14 shows an $N^+P\pi P^+$ type APD, which is designed to permit high-speed response (0.5 ns max.) within the spectrum range up to the near infrared portion (up to 900 nm). High reliability is achieved with both types of APDs by protecting their surfaces with a silicon nitride (Si_3N_4) film. The silicon nitride film also functions as an antireflection coating at the photodetective portions. The following paragraph describes the differences between these two types of APDs in further detail. The width of the depletion layer of an N^+P type APD is as narrow as several micrometers, and most visible light can be absorbed within this region. Since the width of the depletion layer is narrow, the transit time is as high as 100 ps, and high-speed detection can be achieved; however, a long-wave light, if detected by this structure, will reach the P-layer, producing a diffusion current which degrades the response speed. The $N^+P\pi P^+$ is an improved type APD to avoid this inconvenience. This type of APD is has a π-layer having a low impurity density that easily becomes a depletion layer. An APD for detecting lights in the 800 nm portion of the radiation spectrum is designed to have a 20 to 50 μm thick π-layer.

Transit time is lengthened by the π-layer. The transit time of an APD for detecting 800 nm light is several hundred picoseconds. The π-layer permits achievement of high quantum efficiency (η = 60 to 80 %), even in the near infrared portion of the radiation spectrum. The $N^+P\pi P^+$ type APD is also called a reach-through type APD since it is operated where the depletion layer reaches the boundary between the π-layer and the P^+-layer. The reach-through type APD consists of a strong electric field region needed to cause avalanches and a weak electric field region where only photocarrier transit takes place. This type of electric field distribution is effective in keeping the operating voltage low. The operating voltage of the NDL1202 APD is about 200 V. Another feature of the reach-through type APD is low noise. The excess noise of the reach-through type APD is low because most carriers entering the avalanche region are electrons.

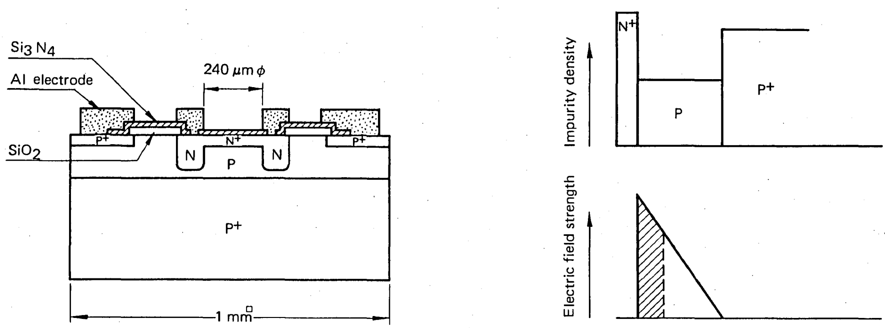


Fig. 13 Structure of N^+P Type APD (NDL1102)

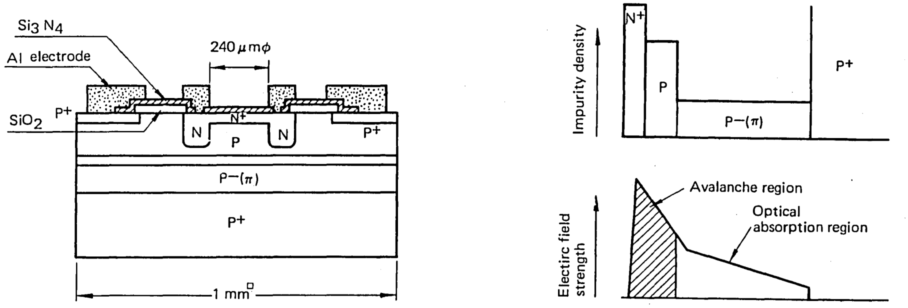


Fig. 14 Structure of $N^+P\pi P^+$ Type APD (NDL1202)

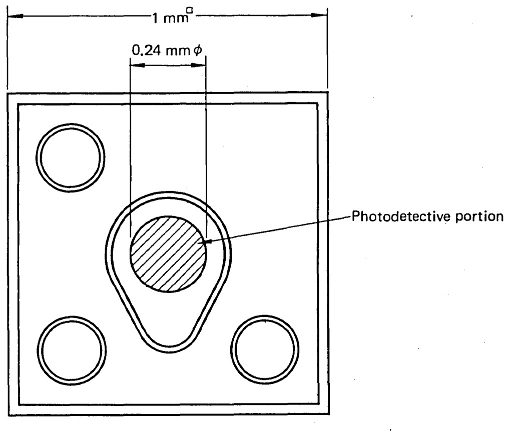


Fig. 15 APD Pellet Pattern Daigram

IV. BIAS CIRCUIT

The bias power must be sufficiently stable since the multiplication factor of the APD abruptly increases near the breakdown voltage. Further, temperature compensation must be taken into consideration according to the environmental conditions since the breakdown voltage varies by temperature.

Basic bias application methods are described in the following:

(1) TEMPERATURE CHARACTERISTIC

Like an ordinary diode, the breakdown voltage of an APD varies by temperature. The temperature coefficient of breakdown voltage $V_{(BR)R}$ of the NDL1102 is about 0.12 %/°C*, and that of the NDL1202 is about 0.15 %/°C*. (See Figure 16.)

Note: $\frac{\Delta V_{(BR)R}}{V_{(BR)R}} \times 100$ (%)

That breakdown voltage $V_{(BR)R}$ varies by temperature means that multiplication factor M varies by temperature if a constant-voltage bias is applied. (See Figure 17.)

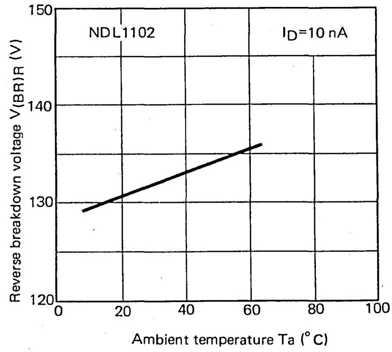


Fig. 16 $V_{(BR)R}$ vs T_a Characteristics

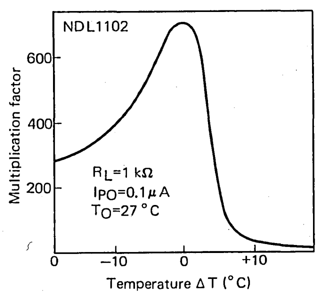


Fig. 17 Variation of Multiplication Factor M by Temperature (with Constant-Voltage Bias Applied)

(2) S/N RATIO AND OPTIMUM MULTIPLICATION FACTOR

The signal-to-noise ratio (SNR), a criterion to indicate the conversion of optical signal to photocurrent without disturbance, is considered in the following. It is needless to say that the higher the SNR, the more exact the signal conversion.

If the photocurrent at M = 1 is I_P (peak value) and the load resistance is R_O, the signal power $S_{p\text{-}p'}$, is given by $S_{p\text{-}p'} = R_O I_P^2 M^2$

The noise (N_{rms}) is expressed by the sum of the shot noise power (N_s) and thermal noise power (N_t). Therefore, the SNR can be calculated as follows:

$$S/N = \frac{R_O I_P^2 M^2}{N_s + N_t} \qquad (4.1)$$

Since N_s can be replaced by $2qB\,R_O\,(I_p + I_d)\,M^2 F$ and N_t by $4kTBF'$, Equation (4.1) can be rewritten as,

$$S/N = \frac{I_p M^2}{2qB\,(I_p + I_d)\,M^{2+x} + 4kTBF'/R_O} \qquad (4.2)$$

where F' is the noise figure of the amplifier connected to the APD, B is the frequency band, x is the Boltzmann constant, and T is the absolute temperature. If the thermal noise is ignored since $F > 1$, Equation (4.1) indicates that the SNR is degraded by multiplication.

It is advantageous to use an APD in place of a photodiode which receives such a faint light that the SNR of the receiving system depends on the thermal noise. The SNR can be enhanced since an APD can increase the signal power by increasing the multiplication factor until the shot noise approaches the thermal noise. The higher the noise (F') of the amplifier, the more noticeable the advantages of an APD.

The SNR of a photodiode is given by Equation (4.1) with M = 1. The thermal noise is the dominant noise normally. An APD differs from a photodiode in that it permits use of the shot noise limit instead of the thermal noise limit as the noise limit. An APD is not advantageous at low frequencies since a photodiode also permits use of the shot noise limit as the noise limit by taking a large value (that is, the maximum value within the limit of CR_O time constant for R_O). At high frequencies above 1 MHz, the SNR of an APD is 10-100 times higher than that of a photodiode.

It can easily be understood from Equations (4.2) that there is an optimum multiplication factor M_{opt} which optimizes the SNR. The value of M_{opt} can be calculated as follows:

$$M_{opt} = \left(\frac{4F'kt}{xqR_O(I_p + I_d)} \right)^{\frac{1}{x+2}} \qquad (4.3)$$

The M_{opt} is far lower than the M_{max}' and is within the range of several tens through two hundred. The higher the frequency and the lower the ionization coefficient, the lower the M_{opt} value.

(3) DRIVING SYSTEMS

① Constant-current system

a. Theory of operation

A constant-current driving system can be regarded as a kind of self-bias system which biases an avalanche diode with a constant current to make its terminal voltage automatically follow the variation of temperature. The actual circuit is an extremely simple bias circuit consisting of a constant-current regulated power supply, large-capacity capacitor C, avalanche photodiode APD, and load resistor R_L, as shown in Figure 17.

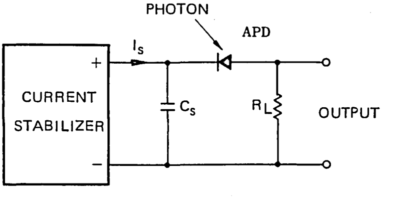


Fig. 17 Constant-current Temperature Compensation Circuit

Capacitor C reduces the internal resistance of the power supply against the signal component of incident light to reduce the decrease of photocurrent multiplication factor M due to series resistance. The greater the capacitance of capacitor C, the lower the frequency that this circuit can respond to; however, the following condition must be satisfied for this circuit to respond to incident light without distortion:

$fm \gg (2\pi CR)^{-1}$

where fm is the modulation frequency of the light, R is the series resistance (including the R_L, internal resistance of the diode, and the power resistance), and C is the capacitance of capacitor C.

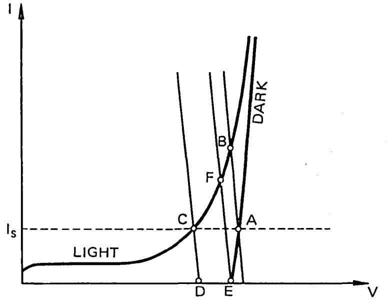


Fig. 18 I-V Characteristics and Constant-current System Operating Points

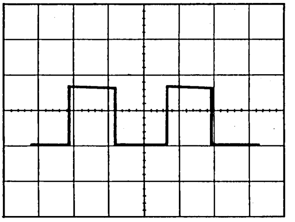
The mean value of the output current in a constant-current system is equal to current value I_S set in the constant-current regulated power supply; therefore, the circuit operates like an automatic gain control circuit, without reflecting variations of temperature and slow variations of luminous intensity to the output.

When the optical signal contains a frequency component that satisfies the condition of $fm \sim (2\pi CR)^{-1}$, the output frequency is subject to the influence of the CR time constant. An APD has a nonlinear I-V characteristic as shown in Figure 8, and the effective internal resistance varies greatly with the luminous power and operating point, varying the CR time constant as well. Accordingly, the influence of the CR time constant is so complicated that it is difficult to express it in a general form. For this reason, the following paragraphs describe only the relationship between the frequency and output waveform when incident light is passed through a chopper to modulate a square wave, using the I-V characteristics.

b. Output waveform for square wave input

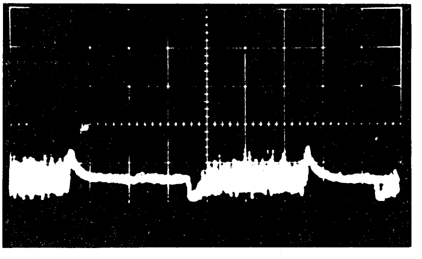
Figure 18 shows the I-V characteristics for incident light (I_{PO} is constant) and for no incident light ($I_{PO}=0$). Letters A through F indicate the operating points. Fine slant lines on which the operating points exist indicate load lines for load resistor R_L. These lines shift horizontally according to the operating state. When the output of the constant-current regulated power supply is set to I_S and a light having a constant intensity is applied through the chopper, the output waveform differs with the repetition frequency fm of the chopper. If $f_m \gg (2\pi CR)^{-1}$, the mean value of the currents at the light and dark operating points equals the I_S as described in a above. In this condition, the operating point shuttles between points E and F along the load line containing points E and F in Figure 18, and the output waveform is a square wave without distortion as shown in Figure 19.

Next, consider a case where the repetition frequency of the chopper is extremely low to satisfy the condition of $f_m \ll (2\pi CR)^{-1}$. When there is no incident light, a dark current equal to I_S flows to hold the operating point at A. In this condition, incident light having a short rise time, if applied, moves the operating point from A to B along the load line. When the luminous



Ordinate 50 μA/DIV.
Abscissa 2 ms/DIV.
$I_{PO}=200$ nA
$P_L=100\ \Omega$
$C_S=10\ \mu F$
$I_s=40\ \mu A$

Fig. 19 Constant-current System Output Waveform (1) $f_m \gg (2\pi CR)^{-1}$

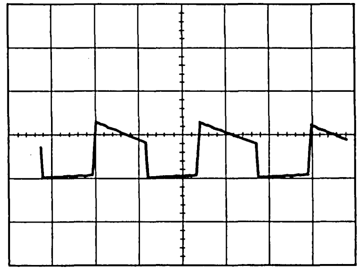


Ordinate 20 μA/DIV.
Abscissa 20 ms/DIV.
133–5
$I_{po}=200$ nA
$R_L=1\ k\Omega$
$C_s=1\ \mu F$
$I_s=10\ \mu A$

Fig. 20 Constant-current System Output Waveform (2) $f_m \ll (2\pi CR)^{-1}$

power reaches a certain value, capacitor C discharges the difference between currents I and I_S, which lowers the applied voltage. The operating point moves through B, F, then C along the I-V characteristic curve together with the load line, until it reaches point C and stays there. When the light is lost in this condition, the current decreases to point D along the load line and capacitor C charges the difference between currents I_S and I, raising the terminal voltage. The operating point moves through D, E, then A along the I-V characteristic curve for the dark current, and stays at A again. Note that the noise increases with the increase of the dark current through the route from E to A. The actual waveform is shown in Figure 20.

In the case of $f_m \sim (2\pi CR)^{-1}$, inversion of the operating point between light and dark takes place before point A or C is reached; therefore, the history of the operating point is a loop inside the loop of ABCD. The higher the frequency, the narrower the loop becomes, approaching a straight line of E-F. Figure 21 shows an example of the output waveform in this condition. The operating point history is shifted if the I_{PO} or I_S is varied. Increasing the I_{PO} or decreasing the I_S shifts it toward the lower voltage, decreasing the dark current component. Decreasing the I_{PO} or increasing the I_S shifts it toward the higher voltage. The maximum output is obtained on load line E-F which intersects the dark current at its rising point.



Ordinate : 20 μA/DIV.
Abscissa : 5 ms/DIV.
I_{PO}=200 nA
R_L=1 kΩ
C_S=1 μF
I_s=10 μA

Fig. 21 Constant-current System Output Waveform (3) $f_m \simeq (2\pi CR)^{-1}$

c. Input-output characteristic and temperature characteristic

The input-output characteristic of a constant-current system for variation of incident luminous power is not linear. If the fm value is large in Figure 18, the load line intersects the dark current at its rising point, and the current value at the midpoint of the load line E-F is equal to I_S. The increase of the luminous power in this condition does not increase the output current as it is restricted by the current value set in the constant-current regulated power supply. Instead, the load line is shifted toward the lower voltage and the multiplication factor decreases in proportion to I_{PO}^{-1}. In this portion, the circuit operates like an automatic gain control circuit. The decrease of the luminous power in reverse increases the dark current by the decreased quantity of the luminous power, shifting the load line toward the higher voltage. The output current would be almost proportional to $I_{PO}^{1/2}$ if there were no dark current; however, the existence of dark current slightly varies the exponent from 1/2, making the input-output characteristic curve rather straight. Figure 22 shows an input-output characteristic curve obtained by an actual measurement, which definitely indicates the tendency described above.

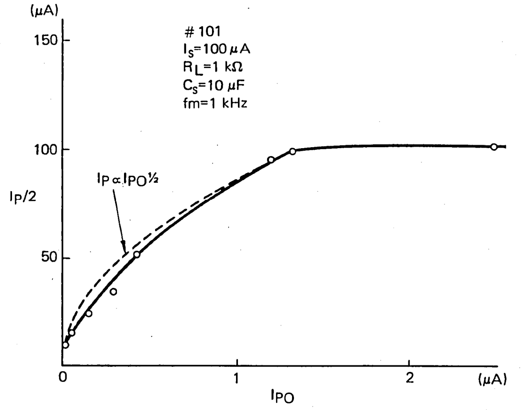


Fig. 22 Input-output Characteristic of Constant-current

Fig. 23 shows the temperature characteristic of the multiplication factor obtained by a constant-current system. The performance of this system is sufficient for practical applications, restricting the multiplication factor variation to within +5 % in a temperature range of −100 to +100 °C.

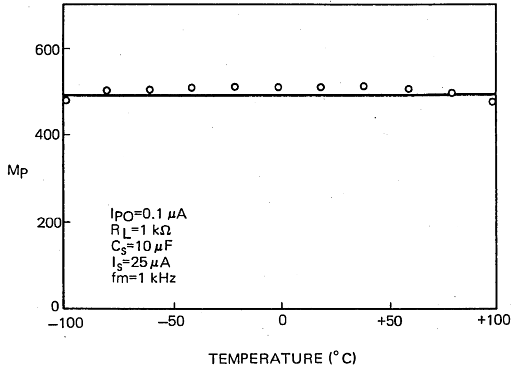
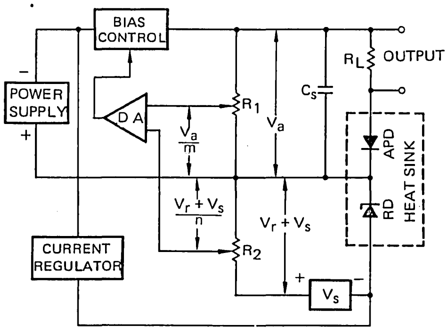


Fig. 23 Temperature Characteristic of Constant-current System

② Voltage-controlled system (multiplication factor stabilizing system)

A constant-voltage regulated power supply generally has a certain degree of temperature coefficient because the zener diode used for the reference voltage has a temperature coefficient. Accordingly, the output of a constant-voltage regulated power supply can be made to follow the temperature variation of the optimum bias if an avalanche diode having the same temperature coefficient as the avalanche photodiode is used for the reference voltage. Nevertheless, it is rather difficult to prepare a pair of diodes having exactly the same characteristics and the operating conditions of a photodiode and a diode for a reference voltage are different; therefore, a menas for obtaining the optimum bias using diodes having different temperature coefficients will be considered in the following.

There is a simple means of temperature compensation: to make the bias voltage of an APD vary following the temperature variation of the terminal voltage of another diode. Figure 24 shows an example of an APD bias control circuit. The RD is a zener diode for the reference voltage, which is in the breakdown state under a bias applied from a constant-current regulated power supply.



DA : Differential amplifier
RD : Zener diode for reference voltage
V_s : Constant-voltage regulated power supply

Fig. 24 Multiplication Factor Stabilizing Bias Circuit Example

Operating voltages under no temperature variation can be given by the following equation:

$$V_a = V_{ao}\,(V_r/V_{ro})^{\beta_a/\beta_r} \qquad (4.4)$$

where β_a is the temperature coefficient of the breakdown voltage (V_a) of the APD,
β_r is the temperature coefficient of the breakdown voltage (V_r) of the RD,
and V_{ao} and V_{ro} are the breakdown voltages of the APD and RD when $T = T_o$ respectively.

Assume that the APD and RD operate at the same temperature (for example, the APD and RD are mounted on the same heat sink) in the temperature range of practical applications, $|\beta_a (T - T_o)| \ll 1$ and $|\beta_r (T - T_o)| \ll 1$. The V_a can also be expressed by the following equation:

$$V_a = K\,(V_r + V_s) \qquad (4.5)$$

where $K = \beta_a V_{ao}/\beta_r V_{ro}$, and (4.6)

$$V_s = [(\beta_r - \beta_a)/\beta_a]\,V_{ro} \qquad (4.7)$$

V_s is a voltage applied from a power supply connected in series to the RD. K is a constant to determine the ratio of m to n, which equals the voltage ratio determined by resistors R_1 and R_2 as shown in Figure 24. When the differential amplifier (DA) detects any difference between the two inputs, it drives the bias control circuit, which in turn makes the value of $\frac{V_a}{m}$ and $\frac{V_r + V_s}{n}$ equal automatically.

Figures 25 and 26 are output waveform and temperature characteristic data of this circuit respectively. The variation of multiplication factor M is restricted to within ±5 % in a temperature range of –50 to +100°C. The constants obtained from the experimental circuit (shown in the following table) sufficiently coincide with the theoretically calculated values of $V_s = -2.9$ V and K = 3.04.

Constants obtained from experimental circuit

V_{ao} = 84 V, V_{ro} = 30.5 V β_a = 0.105 %/°C, β_r = 0.095 %/°C V_s = –3.0 V, K = 3

If $\beta_a = \beta_r$, Equations (4.6) and (4.7) can be simplified as follows:

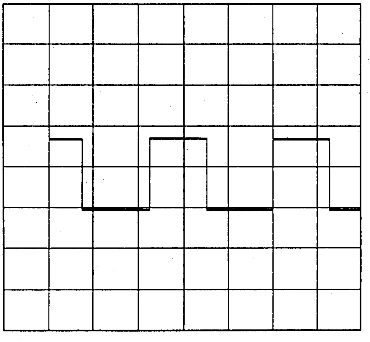
$K = V_{ao}/V_{ro}$, $V_s = 0$

The condition of $\beta_a = \beta_r$ can be satisfied if an APD made of the same type of wafer as the APD used in this circuit is used in lieu of the RD. Naturally, V_s is unnecessary in this case, and circuit adjustment can be simplified.

The circuit shown in Figure 24 has a low-impedance voltage supply basically, so it is applicable to a wide range of frequencies from DC to high frequencies. Figure 27 shows a circuit actually made by way of experiment.

REFERENCES

1. Soejima, Kaibuchi, Optical Fiber Communications, Electirc Communication Technical News Co.
2. Review of Scientific Instruments, Vol. 43, Number 9, September 1972.



Ordinate : 50 μA/DIV.
Abscissa : 2 ms/DIV.
I_{PO}=200 nA
R_L=100
V_a=90, 40 V

Fig. 25 Output Waveform of Voltage-controlled System

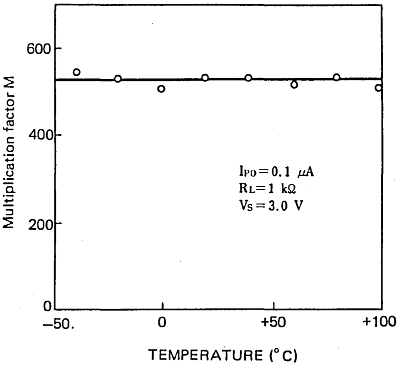


Fig. 26 Temperature Characteristic of Voltage-controlled System

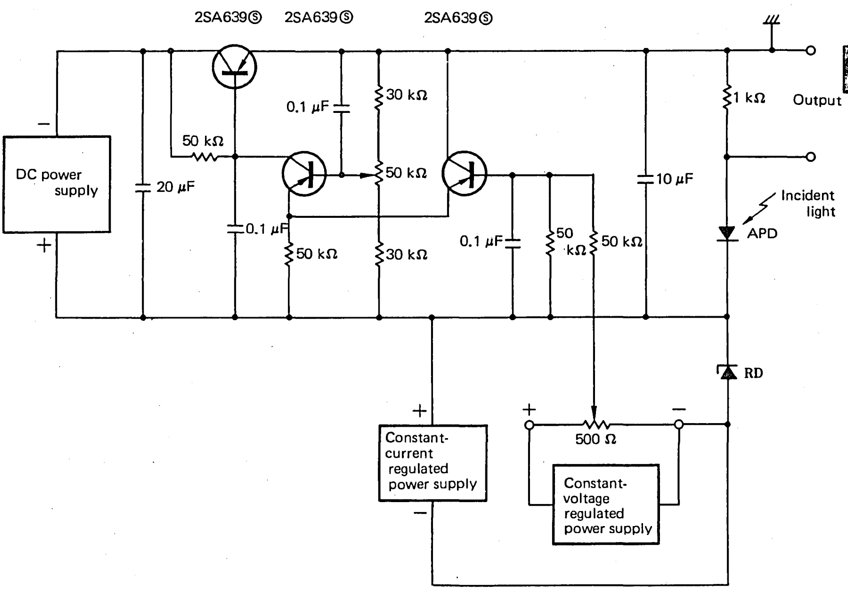


Fig. 27 Experimental Circuit Diagram