ELEMENTY OPTOELEKTRONICZNE

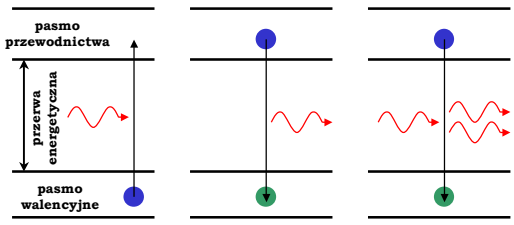
UKŁADY NADAWCZO-ODBIORCZE

Plan wykładu:

1. **Oddziaływanie fotonów z materią**
2. **Fotodioda**
3. **Dioda świecąca**
4. **Lasery półprzewodnikowe**
5. **Układy odbiorcze**
6. **Układy nadawcze**

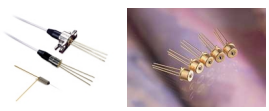
DOSTĘP DO BIBLIOTEKI

Oddziaływanie fotonów z materią

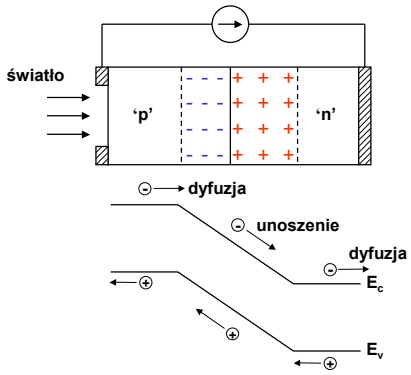


absorpcja | emisja spontaniczna | emisja wymuszona

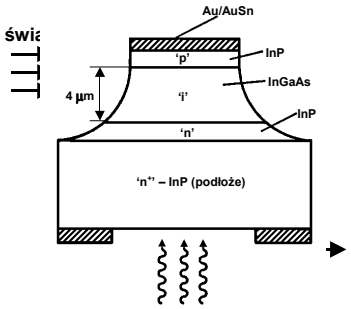
FOTODIODY



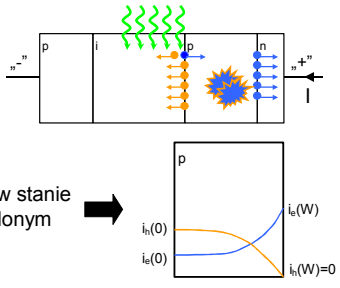
Fotodioda p-n



Fotodioda p-i-n

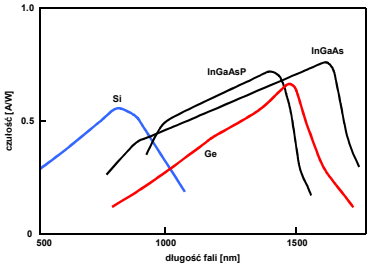


Fotodioda lawinowa (APD)

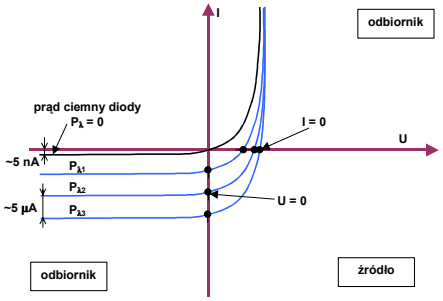


Czułość i charakterystyka spektralna

$$R = \frac{I_F}{P_\lambda} = \eta \frac{q}{h} \frac{\lambda_0}{c}$$



Charakterystyka statyczna fotodiody



Przykładowe parametry fotodiod p-i-n

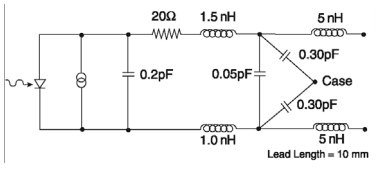
Parametr		Si	Ge	InGaAs
długość fali	µm	0.4÷1.1	0.8÷1.8	1.0÷1.7
czułość	A/W	0.4÷0.6	0.5÷0.7	0.6÷0.9
sprawność kwantowa	%	75÷90	50÷55	60÷70
prąd ciemny	nA	1÷10	50÷500	1÷20
czas narastania	ns	0.5÷1	0.1÷0.5	0.05÷0.5
pasmo	GHz	0.3÷0.6	0.5÷3	1÷5
napięcie	V	50÷100	6÷10	5÷6

Przykładowe parametry fotodiod APD

Parametr		Si	Ge	InGaAs
długość fali	µm	0.4÷1.1	0.8÷1.8	1.0÷1.7
czułość	A/W	80÷130	3÷30	5÷20
wzmocnienie	–	100÷500	50÷200	10÷40
wsp. k	–	0.02÷0.05	0.7÷1	0.5÷0.7
prąd ciemny	nA	1÷10	50÷500	1÷20
czas narastania	ns	0.5÷1	0.5÷0.8	0.1÷0.5
pasmo	GHz	0.2÷1	0.4÷0.7	1÷3
napięcie	V	200÷250	20÷40	20÷60

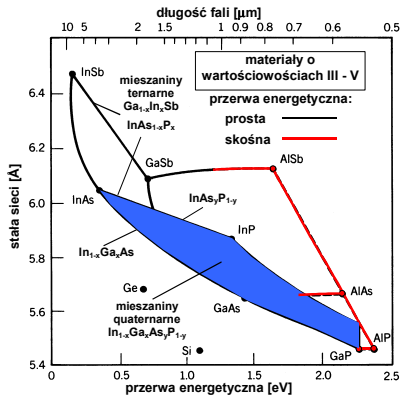
Fotodiody - podsumowanie

półzłącze „pigtail”

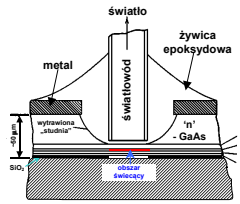


DIODY ŚWIECĄCE (LED)

Elementy świecące - materiały



Dioda świecąca (LED)

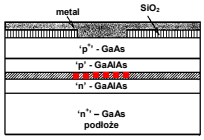


struktura powierzchniowa

(Burrus'a)

Moc sprzęgnięta do włókna:

- **gradientowe - 20 µW**
- **jednomodowe - 1-2 µW**

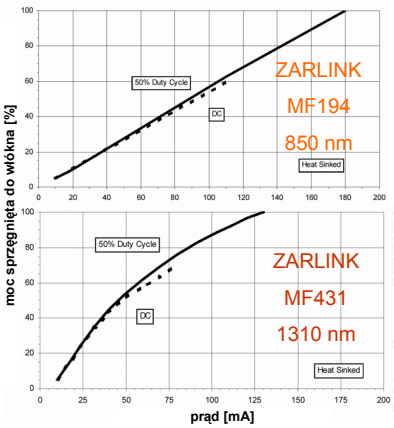


struktura krawędziowa

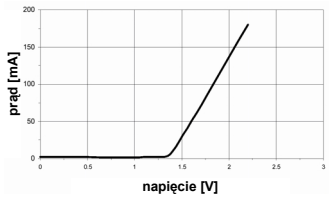
Moc sprzęgnięta do włókna:

- **gradientowe - 50 µW**
- **jednomodowe - 30 µW**

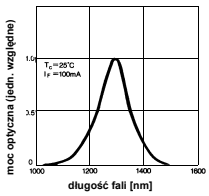
Charakterystyka statyczna



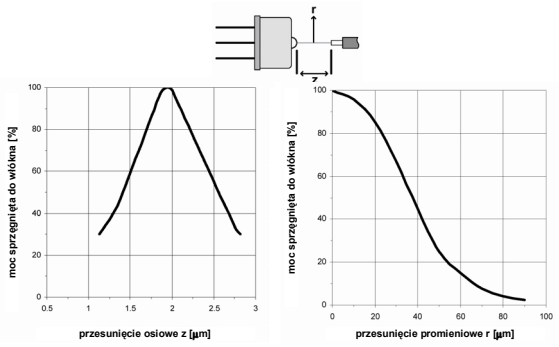
Charakterystyka U(I)



Charakterystyka spektralna



Moc sprzęgnięta do włókna



MF431 Data Sheet

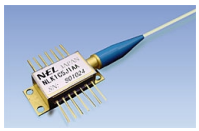
Optical and Electrical Characteristics - Case Temperature 25°C

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition	
Fiber-Coupled Power (Figures 3, 4, and 5) (Table 1)	P_{fiber}	43			µW	I_F=60 mA (Note 1)	Fiber:
Rise and Fall Time (10-90%)	t_r,t_f		2.5		ns	I_F=60 mA (no bias)	62.5/125 µm Graded Index
Bandwidth (3dB$_{el}$)	f_c		125		MHz	I_F=60 mA	
Peak Center Wavelength	λ_p		1320		nm	I_F=60 mA	
Spectral Width (FWHM)	$\Delta\lambda$		135		nm	I_F=60 mA	
Forward Voltage (Figure 7)	V_F		1.3	1.65	V	I_F=60 mA	
Reverse Current	I_R			100	µA	V_R=1 V	
Capacitance	C		200		pF	V_R=0 V, f=1 MHz	

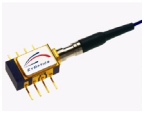
Note 1: Measured at the exit of 100 meters of fiber.

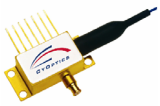
Absolute Maximum Ratings

Parameter	Symbol	Limit
Storage Temperature	T_{stg}	-55 to +125°C
Operating Temperature (derating: Figure 6)	T_{op}	-40 to +85°C
Electrical Power Dissipation (derating: Figure 6)	P_{tot}	160 mW
Continuous Forward Current (f<10 kHz)	I_F	80 mA
Peak Forward Current (duty cycle<50%,f>1 MHz	I_{FRM}	130 mA
Reverse Voltage	V_R	0.5 V
Soldering Temperature (2 mm from the case for 10 sec.)	T_{sld}	260°C

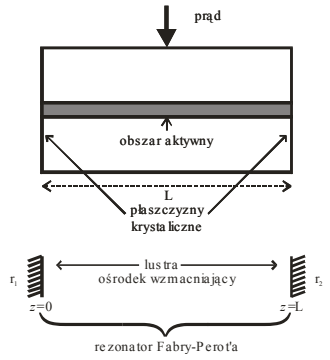


LASERY PÓŁPRZEWODNIKOWE





Poglądowy model lasera

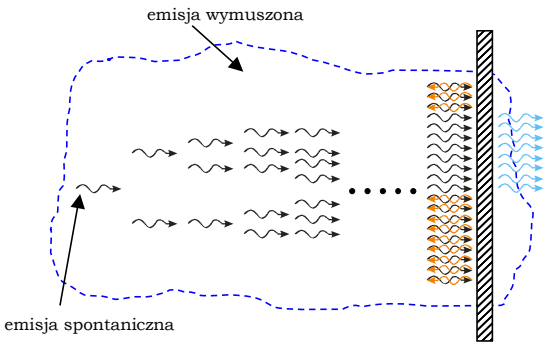


Właściwości podstawowych „składników” lasera:

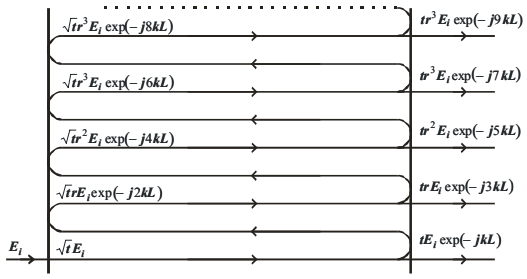
ośrodek aktywny

rezonator

Wzmocnienie w obszarze aktywnym lasera

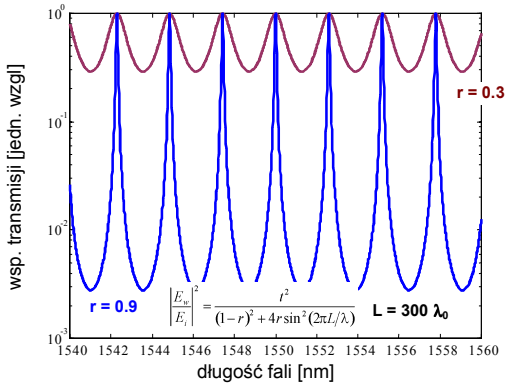


Rezonator Fabry-Perot (*longitudinal confinement*)

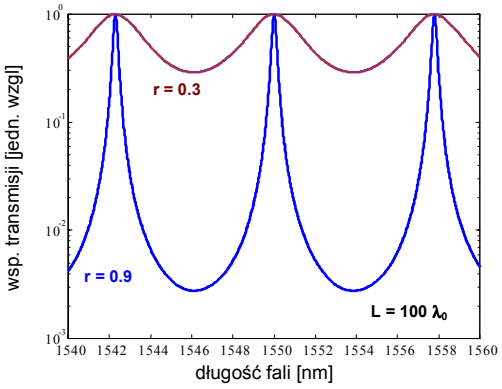


t, r - zdefiniowane dla MOCY

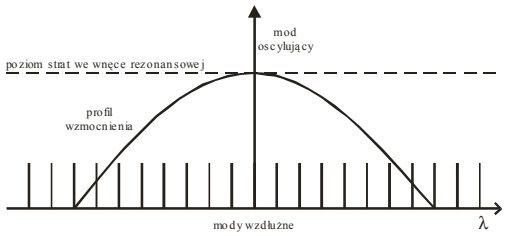
Charakterystyka rezonatora Fabry-Perot



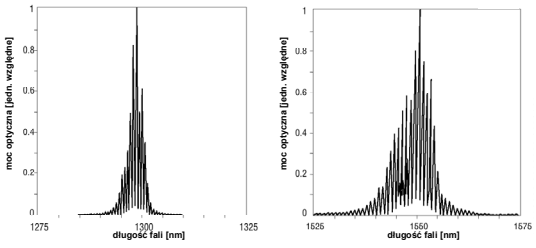
Charakterystyka rezonatora Fabry-Perot



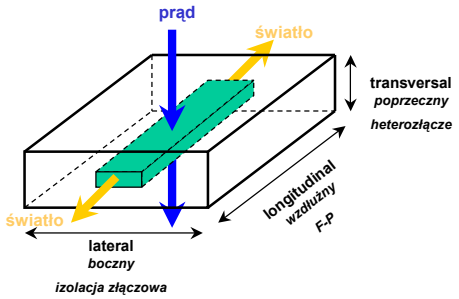
Warunki akcji laserowej



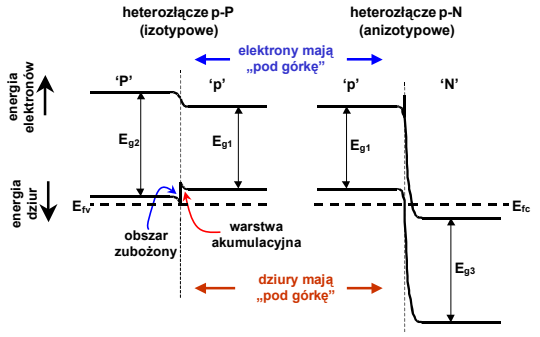
Charakterystyka spektralna (FP)



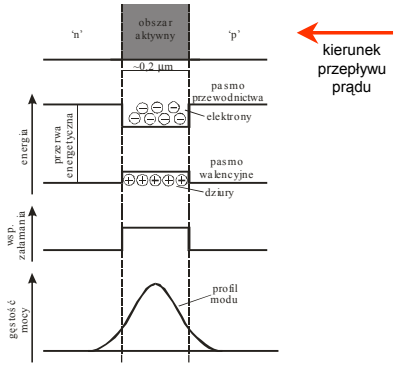
Obszar aktywny lasera



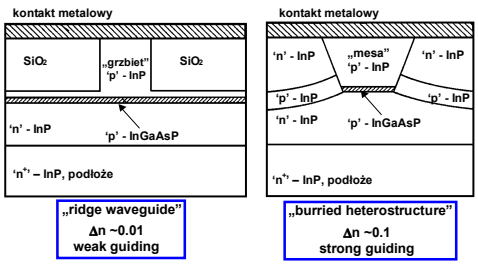
Heterozłącza
(*transversal confinement*)



Laser biheterozłączowy (*transversal confinement*)



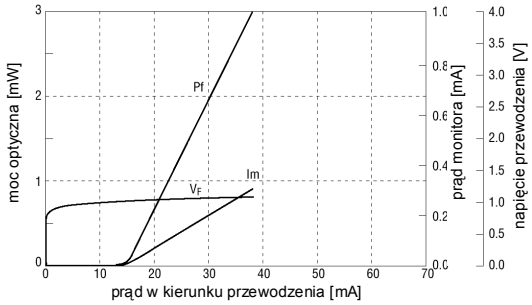
Laser biheterozłączowy (*lateral confinement*)



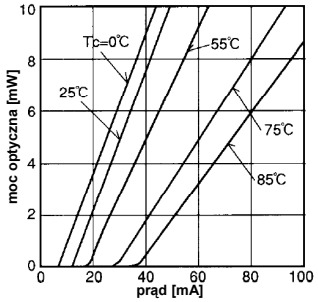
lasery „index guided”

obszar świecący ~0.1×1µm
mało zależny od prądu strującego laser

Charakterystyka statyczna I

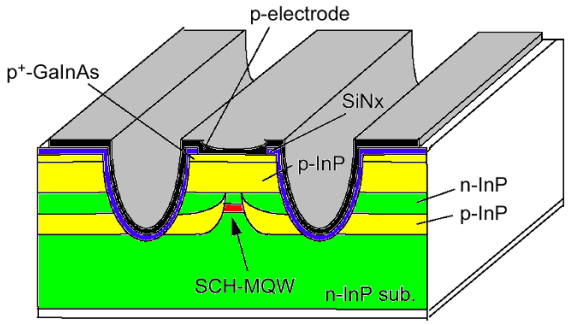


Charakterystyka statyczna II



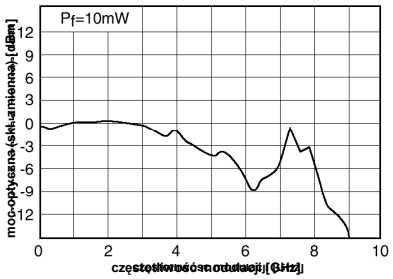
Laser MQW (Multi Quantum Well)

Struktura półprzewodnikowa



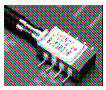
Podstawowe charakterystyki laserów

charakterystyka modulacyjna



Przykładowe dane katalogowe

Lucent D370



Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Operating Temperature Range	T	—	–40	—	85	°C
Optical Output Power*	P_F	CW, nominal	—	1	—	mW
Threshold Current	I_{TH}	T = 25 °C T = full range	5 2	9 —	15 45	mA mA
Modulation Current	I_{MOD}	CW, P_F = 1.0 mW, T = 25 °C CW, I_{MON} = constant, T = full range	10 8	15 —	20 35	mA mA
Slope Efficiency†	SE	CW, P_F = 1.0 mW, T = 25 °C	50	75	100	µW/mA
Center Wavelength	λ_C	P_F = 1.0 mW, CW	1270	—	1350	nm
RMS Spectral Width	$\Delta\lambda$	P_F = 1.0 mW, 155 Mbits/s	—	2	3	nm
Tracking Error	TE	I_{MON} = constant, CW	—	0.5	±1	dB
Spontaneous Emission	P_{TH}	I = I_{TH} x 0.9	—	—	50	µW
Rise/Fall Times	t_R, t_F	10%—90% pulse, T = 25 °C	—	0.25	0.5	ns
Forward Voltage	V_F	CW	—	1.1	1.6	V
Input Impedance	R	—	3	—	8	Ω
Monitor Current	I_{MON}	V_R‡ = 5 V	150	—	750	µA
Monitor Dark Current	I_D	V_R‡ = 5 V	—	10	200	nA
Wavelength Temperature Coefficient	—	—	—	0.4	0.5	nm/°C

Struktury złożone

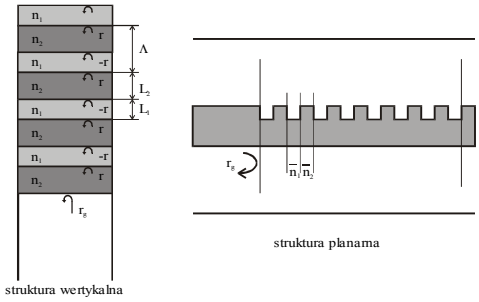
DFB

DBR

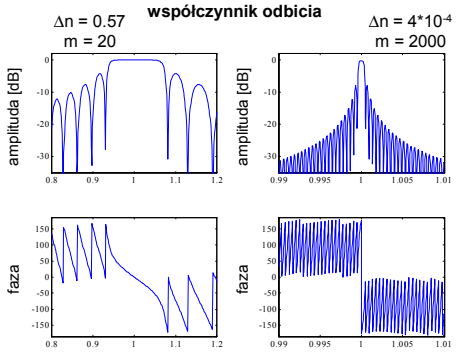
VCSEL

RCLED

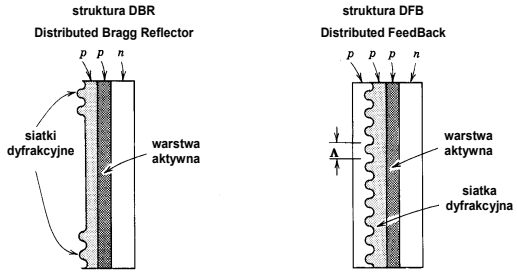
Lustra złożone - siatka Bragg'a



Charakterystyki częstotliwościowe

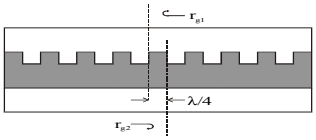


Lasery z siatką Bragg'a



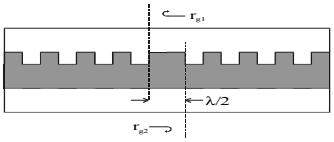
Lasery DFB

Laser DFB klasyczny



nie oscyluje na długości fali Bragg'a

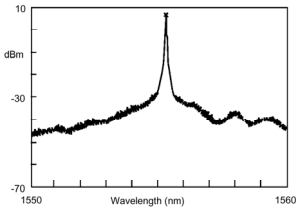
Laser DFB z przesunięciem fazy o λ/4

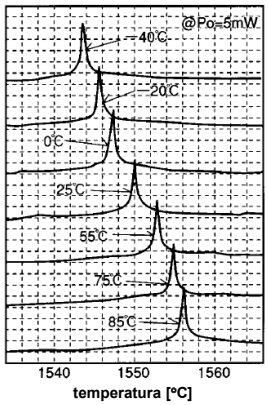


oscyluje na długości fali Bragg'a

Lasery DFB

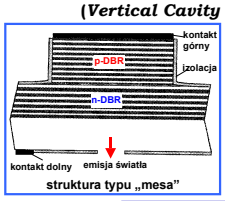
charakterystyka spektralna



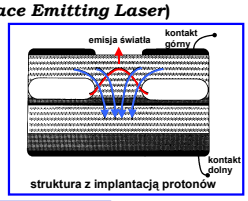


Struktury VCSEL

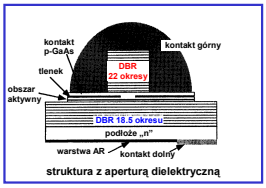
(Vertical Cavity Surface Emitting Laser)



struktura typu „mesa"



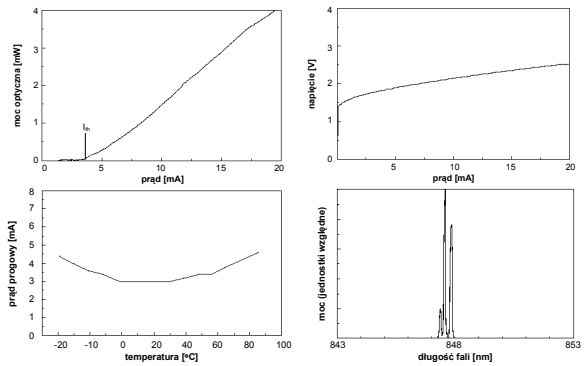
struktura z implantacją protonów



struktura z aperturą dielektryczną

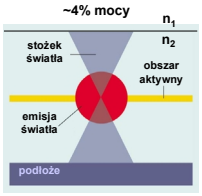
Struktury VCSEL

podstawowe charakterystyki

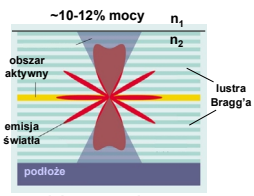


RCLED (Resonant Cavity LED)

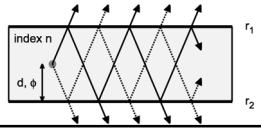
MCLED (MicroCavity LED)



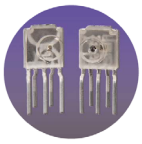
emisja spontaniczna w ośrodku izotropowym



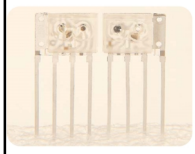
emisja spontaniczna w mikrownęce



FC300R/300D RCLED ROSA/TOSA



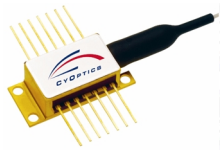
- moc optyczna 1 mm POF: -1.5 dBm
- długość fali: 650 nm
- szerokość spektralna FWHM: 20 nm
- szybkość modulacji: 250 MBit/s

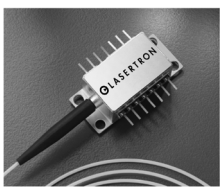


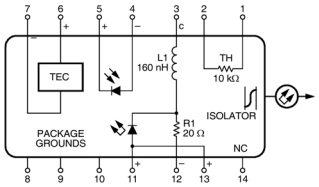
Przykładowe obszary zastosowań:

- przemysł samochodowy
  - IDB 1394: 18 m @ 250 MBit/s
- małe sieci biuro/dom (SOHO):
  - IEEE 1394b S100/Ethernet: 100 m @ 125 MBit/s
  - IEEE 1394b S200: 50 m @ 250 MBit/s

Co można znaleźć w obudowie lasera?

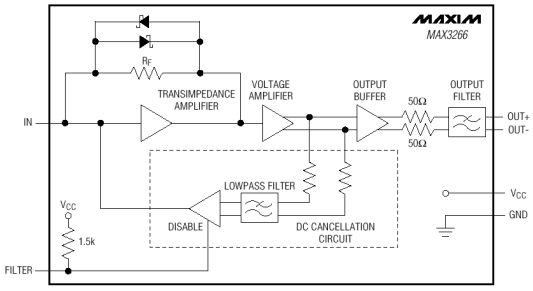




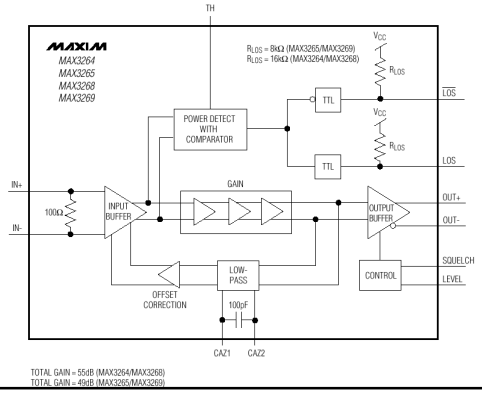


UKŁADY ODBIORCZE I NADAWCZE

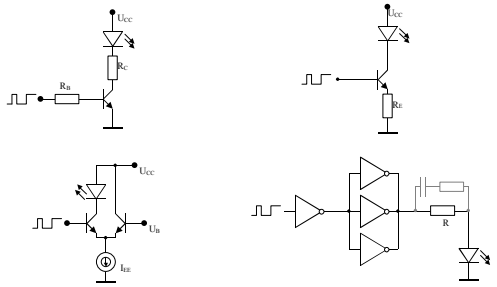
Przykładowy układ odbiorczy „*Front End*”



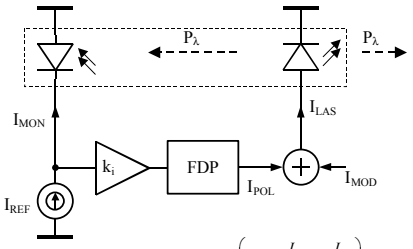
Przykładowy układ odbiorczy „*Limiter*”



Przykładowe układy nadawcze - LED



Przykładowe układy nadawcze - laser



$$P_\lambda = \frac{\varepsilon\left(I_{REF} + \frac{I_{MOD}}{k_i} - \frac{I_{PR}}{k_i}\right)}{\frac{1}{k_i} + \varepsilon R} \xrightarrow{k_i \to \infty} \frac{I_{REF}}{R}$$

Przykładowe układy nadawcze - laser