Examen Optoelectronică
27.01.2006

1. (3p) Trebuie să realizați o legătură pe fibră optică pe o distanță de 50 km între un emițător şi un receptor caracterizați:

Emițător: 1310nm, P_o = 1.5mW	NA = 0.17	Φ = 13μm
Pierderi splice	0.15 dB/splice	
Pierderi conector	0.5 dB/conector	
Cablu conexiune (x2): L = 20m	NA = 0.12	fibră: 11/125 μm
Receptor: Sensitivitate = 1μW	NA = 0.25	Φ = 30μm

Aveți în stoc Fibra 3: 8 cabluri de 5km lungime fiecare.
La mijlocul distanței există deja poziționate 2 cabluri de 5km fiecare (Fibra 4) pe care le puteți folosi.
Va funcționa legătura? Justificați.

2. (2p) Dacă în aceeaşi situație emițătorul emite lungimea de undă de 1550 nm, care este viteza maximă a legăturii (presupunând că banda B/2 Hz este suficientă pentru o viteză de B b/s)?

3. (1p) Panoul unui dispozitiv conține două LED-uri de semnalizare, unul de culoare verde şi unul roşu standard. Doriți ca ambele să ofere aceeaşi luminozitate relativă şi cât mai mare posibilă. Dacă ambele LED-uri acceptă un curent maxim de 50 mA, calculați curentul prin cele două LED-uri.

4. (1p) Un LED pe GaAs are eficiența cuantică η = 0.2. Când curentul prin diodă este de 50 mA să se determine puterea optică emisă.

5. (2p) Controlul puterii în emițătoarele cu diodă laser. Necesitate, schemă tipică, comportare în frecvență.

6. (1p) Trebuie să realizați o legătură pe fibră optică pe o distanță de 2km, la o viteză de 200Mb/s. Distribuitorul cu care lucrează firma la care lucrați vă oferă doar Fibra 1 şi Fibra 2. Perechile emițător/receptor la care aveți acces au raport (putere emisă /senzitivitate) = 4. Ce fibră alegeți? Se va avea în vedere un cost minim.

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Timp: 2h

As. ing. R. Damian

Rezolvari

27.01.2006

Problema 1

Sistemul este compus in ordine din:

1. Emitator
2. Cablu de conexiune
3. Fibra 3 (4 cabluri a 5 km fiecare: 3a,3b,3c,3d)
4. Fibra 4 (2 cabluri a 5 km fiecare: 4a,4b)
5. Fibra 3 (4 cabluri a 5 km fiecare: 5a,5b,5c,5d)
6. Cablu de conexiune
7. Receptor

Deoarece sistemul lucreaza la 1300nm unde ambele fibre au dispersie nula functionarea corecta poate fi perturbata doar de atenuarea puterii optice.

Atenuare datorata conectorilor

Fiecare cablu introduce doi conectori cu pierderile aferente: 1->2, 2->3a, 5d->6, 6->7

$Ac := 4 \cdot 0.5$ dB/conector $\qquad Ac = 2$ dB

Atenuare datorata splice-urilor

Exista cate un splice intre fiecare doua tronsoane de fibra consecutive. Pentru 10 tronsoane vom avea 9 splice-uri

$As := 9 \cdot 0.15$ dB/splice $\qquad As = 1.35$ dB

Atenuare in fibra

Din catalog se observa ca ambele fibre au o atenuare maxima egala cu 0.35dB/km la 1300nm.Vom avea 10 tronsoane de cate 5km lungime deci 50km de fibra (3+4+5)

$$Af := 10 \cdot 0.35 \cdot 5\,km \cdot \frac{dB}{km} \qquad Af = 17.5 \text{ dB}$$

Atenuare datorata diferentelor de apertura numerica

Apare la trecerea de la un dispozitiv cu NA mai mare la un dispozitiv cu NA mai mic, situatie intilnita la trecerile 1->2, 5d->6

$$Ana12 := 10 \cdot \log\left(\frac{0.17^2}{0.12^2}\right) dB \qquad Ana12 = 3.025 \text{ dB}$$

$$Ana56 := 10 \cdot \log\left(\frac{0.14^2}{0.12^2}\right) dB \qquad Ana56 = 1.339 \text{ dB}$$

$$Ana := Ana12 + Ana56 \qquad Ana = 4.364 \text{ dB}$$

Atenuare datorata diferentelor de diametru

Apare la trecerea de la un dispozitiv cu diametru mai mare la un dispozitiv cu diametru mai mic, situatie intilnita la trecerile 1->2, 2->3a, 3d->4a

In toate cazurile avem fibre monomod deci vom folosi relatia:

$$A\phi ab(w1,w2) := -20\log\left(\frac{2w1\cdot w2}{w1^2 + w2^2}\right)$$ w1,w2 fiind diametrele ocupate de modul fundamental in dispozitive

$$A\phi := A\phi ab(13,11) + A\phi ab(11,9.4) + A\phi ab(9.4,9.2) \qquad A\phi = 0.23 \quad dB$$

Atenuarea totala

$$At := Ac + As + Af + Ana + A\phi \qquad At = 25.444 \; dB$$

Puterea emisa

$$Po := 10\log\left(\frac{1.5mW}{1mW}\right) \qquad Po = 1.761 \quad dBm$$

Puterea receptionata

$$Pr := Po - At \qquad Pr = -23.683 \; dBm$$

Sensibilitatea receptorului

$$Sr := 10\log\left(\frac{1\mu W}{1mW}\right) \qquad Sr = -30 \; dBm$$

$Pr > Sr$ deci legatura **va functiona** cu o rezerva de 6dB

Problema 2

$$\Delta\lambda := 2nm$$

Din catalog dispersiile introduse de cele doua fibre la 1550nm:

$$D3 := 18\frac{ps}{nm\cdot km}$$

$$D4 := 18\frac{ps}{nm\cdot km}$$

Primul tronson din fibra 3 (4 cabluri a cite 5km lungime) introduce o dispersie:

$$L1 := 4\cdot 5km$$

$$\Delta t1 := D3\cdot L1\cdot\Delta\lambda \qquad \Delta t1 = 720\,ps$$

Al doilea tronson din fibra 4 (2 cabluri a cite 5km lungime) introduce dispersia

$$L2 := 2\cdot 5km$$

$$\Delta t2 := D4\cdot L2\cdot\Delta\lambda \qquad \Delta t2 = 360\,ps$$

Al treilea tronson din fibra 3 (4 cabluri a cite 5km lungime) introduce o dispersie:

$$L3 := 4\cdot 5km$$

$$\Delta t3 := D3\cdot L3\cdot\Delta\lambda \qquad \Delta t3 = 720\,ps$$

Dispersia totala este:

$\Delta t := \Delta t1 + \Delta t2 + \Delta t3 \qquad \Delta t = 1.8\,ns$

Banda sistemului este:

$B := \frac{0.44}{\Delta t} \qquad B = 244.444\,MHz$ ceea ce corespunde unei viteze: $V := 2 \cdot B$

$V = 488.889\,\frac{Mb}{s}$

Problema 3

Eficientele luminoase pentru cele doua LED-uri sunt:

$\eta r := 60\,\frac{lm}{W} \qquad \eta v := 640\,\frac{lm}{W}$

Luminozitatea LED-ului depinde de puterea optica emisa si de eficienta luminoasa la lungimea de unda emisa Pentru luminozitati egale LED-ul rosu va trebui sa emita o putere optica mai mare. Deoarece se doreste ca aceasta putere sa fie maxima:

$Ir := 50mA$

Luminozitatile sunt egale deci:

$r \cdot Ir \cdot \eta r = r \cdot Iv \cdot \eta v$ (Am considerat LED-urile avand aceeasi responsivitate)

$Iv := Ir \cdot \frac{\eta r}{\eta v} \qquad Iv = 4.688\,mA$

Problema 4

Responsivitatea este marimea de iesire supra cea de intrare

Pentru FD $\quad res(\eta, \lambda) := 0.8 \cdot \eta \cdot \lambda \cdot \frac{1}{\mu m} \cdot \frac{A}{W}$

Pentru LED

$res(\eta, \lambda) := \frac{\eta}{0.8 \cdot \lambda} \cdot \mu m \cdot \frac{W}{A}$

Pentru GaAs λ=900μm deci cel mai probabil un LED bazat pe GaAs va fi realizat cu $\lambda := 850nm$

λ exprimat in μm $\quad \lambda = 0.85\,\mu m$

Se cunoaste $\quad \eta := 0.2$

$r := res(\eta, \lambda) \qquad r = 0.294\,\frac{W}{A}$

Pentru un curent $\quad I := 50mA$

$Po := r \cdot I \qquad Po = 14.706\,mW$

Problema 5

Vezi: Razavi - Design of Integrated Circuits for Optical Comunications, pag. 361-362

Problema 6

Pentru viteza $Vt := 200 \cdot \frac{Mb}{s}$ Banda necesara este $B := \frac{Vt}{2}$ $B = 100\,MHz$

Pentru ca lungimea de transmisie e $Lt := 2km$ fibra va trebui sa fie caracterizata de un produs Banda*Lungime

mai mare decit $BL := B \cdot Lt$

$BL = 200\,MHz \cdot km$

Emitatoarele si receptoarele disponibile au Pout/Sens: $P\_S := 4$ deci este permisa o atenuare maxima de

$A\_total := P\_S$, $A\_total = 6.021\,dB$. Atenuarea maxima pe fiecare km de lungime este: $At := \frac{A\_total \cdot 1km}{Lt}$

$At = 3.01\,dB$

Tinind cont de pretul componentelor care este cu atit mai redus cu cit lungimea de unda este mai mica, vom alege daca se pot indeplini conditiile de banda si atenuare, un sistem emitator/receptor/fibra care sa lucreze la 850nm.

Fibra nr. 2 nu poate functiona cu acesti parametri la 850 nm:
- atenuarea este de 3dB/km fara rezerva pentru conectori si alte pierderi
- prima varianta standard are produsul Banda*Lungime de 160MHz*km - insuficient
- a doua varianta standard are produsul Banda*Lungime de 200MHz*km suficient dar fara rezerva

Se alege **Fibra nr.1**, prima varianta standard din punctul de vedere al produsului Banda*Lungime:

400/400 (MHz*km) la 850/1300nm

- Pret minim pentru emitator/receptor/fibra
- atenuare 2.5dB/km cu rezerva de 1dB pentru alte pierderi
- viteza maxima posibila 400Mb/s

Examen Optoelectronică
14.02.2006

1. (4p) Trebuie să realizați o legătură pe fibră optică pe o distanță de 50 km la o viteză de 1Gb/s.

Aveți în stoc:

Emițători: P_o = 1.5mW ($\Delta\lambda$=2nm, diverse λ)	NA = 0.17	Φ = 13μm
Pierderi splice (tehnologie)	0.15 dB/splice	
Pierderi conector	0.5 dB/conector	
Cablu conexiune: L = 20m	NA = 0.12	fibră: 11/125 μm
Cablu conexiune: L = 20m	NA = 0.15	fibră: 11/125 μm
Fibra 1	8 X 5km	
Fibra 2	4 X 10km	
Fibra 3	8 X 5km	
Fibra 4	4 X 10km	
Receptor: Sensitivitate = 1μW	NA = 0.25	Φ = 30μm

a) (1p) Ce lungime de undă veți alege pentru emițător? Justificați.
b) (2p) Alegeți fibrele pe care le veți utiliza. Justificați. Realizați schița legăturii
c) (1p) Puteți realiza o legătură funcțională? Justificați.

2. (2p) Trebuie să proiectați un semafor cu LED-uri. Parametrii de catalog pentru LED-ul roşu sunt:

Peak Wavelength	λ_p	630 nm
Power Dissipation	P_D	120 mW
Continuous Forward Current	I_{AF}	50 mA
Forward Voltage (I_F = 20 mA)	V_F	2.2÷2.7 V
Luminous Intensity (I_F = 20 mA)	I_V	10000 mcd
Viewing Angle (I_F = 20 mA)	$2\theta_{1/2}$	15°
Spectrum Radiation Bandwidth	$\Delta\lambda$	20 nm

LED-urile de alte culori au în general parametrii identici, responzivitățile fiind egale. Calculați:

a) (1p) Calculați curenții prin cele trei LED-uri pentru luminozitate egală.
b) (1p) Calculați puterea optică emisă de cele 3 LED-uri.

3. (2p) Parametrii amplificatoarelor transimpedanță: zgomot, câştig, răspuns la suprasarcină, impedanță de ieşire.

4. (1p) O sursă luminoasă emite o putere optică de 2mW la intrarea unei fibre de lungime 5 km. Puterea măsurată la ieşire este de 0.1 mW. Care este atenuarea fibrei (dB/km)?.

5. (1p) O rază de lumină trece din GaAs (n_1 = 3.4) în aer (n_2 = 1.0). Dacă unghiul incident este egal cu 5°, care este unghiul de transmisie ?

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Timp: 2h

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Rezolvari

14.02.2006

Problema 1

a) Toate fibrele au dispersie cromatica nula pentru λ=1310nm deci pentru indeplinirea conditiei de viteza este normal sa utilizam aceasta lungime de unda la emisie.

$$\lambda := 1300\text{nm}$$

b) Fibrele 3 si 4 sunt caracterizate de atenuare scazuta la 1300nm si de asemenea sunt fibre monomod (Core diameter - diametrul miezului = 8.2μm fata de 50μm/62.5μm pentru fibrele 1/2). Utilizarea lor elimina dispersia modala si cum este aleasa lungimea de unda de dispersie cromatica nula, conditia de viteza va fi indeplinita in acest caz.

Este normal sa folosim fibra 4 pe cat este posibil, cablurile mai lungi (10km) facand necesare mai putine splice-uri, cu avantajul costului si atenuarii scazute.

Se alege 4*10km fibra 4 + 2*5 fibra 3.

Cele doua cabluri de conexiune au aperturi numerice diferite.

Cablul 1 are $NA1 := 0.12$ Cablul al doilea: $NA2 := 0.15$

Se verifica modalitatea optima de pozitionare tinand cont de atenuarea care apare la trecerea de la un dispozitiv cu NA mai mare la un dispozitiv cu NA mai mic

$$A\_na(na1, na2) := 10 \cdot \log\left(\frac{na1^2}{na2^2}\right)$$

Fibra are $NAf := 0.14$,emitatorul $NAe := 0.17$

Situatia I. Cablul 1 la emitator, cablul 2 la receptor. Atenuarea apare numai la trecerea emitator -> cablul 1.

$$Ana := A\_na(NAe, NA1) \qquad Ana = 3.025\,\text{dB}$$

Situatia II. Cablul 2 la emitator, cablul 1 la receptor. Atenuarea apare la trecerea emitator -> cablul 2, cablul 2 ->fibra, fibra -> cablul 1.

$$A\_na(NAe, NA2) = 1.087\,\text{dB} \quad A\_na(NA2, NAf) = 0.599\,\text{dB} \quad A\_na(NAf, NA1) = 1.339\,\text{dB}$$

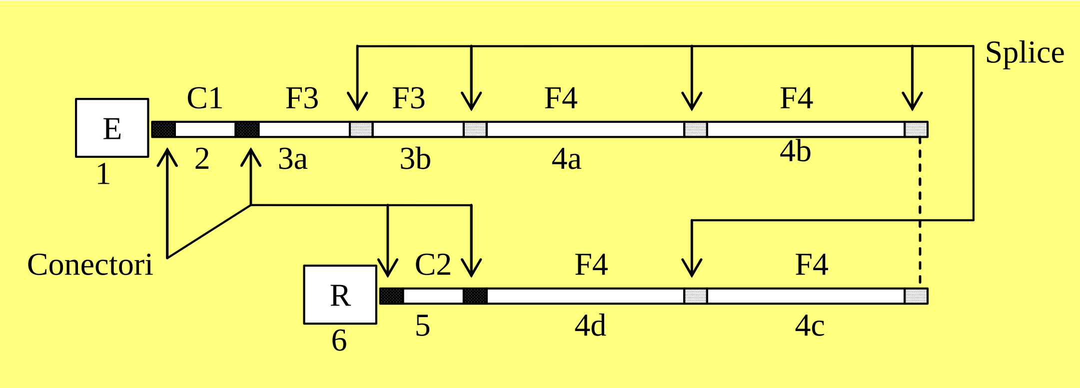
$$Ana := A\_na(NAe, NA2) + A\_na(NA2, NAf) + A\_na(NAf, NA1) \qquad Ana = 3.025\,\text{dB}$$

Pozitionarea cablurilor nu are nici o importanta in acest caz.

Sistemul este compus in ordine din:

1. Emitator
2. Cablu 1 de conexiune
3. Fibra 3 (2 cabluri a 5 km fiecare: 3a,3b)
4. Fibra 4 (4 cabluri a 10 km fiecare: 4a,4b,4c,4d)
5. Cablu 2 de conexiune
6. Receptor

Nota: Se cere in mod expres schita legaturii astfel ca desenul **trebuie** facut.



c)

Atenuare datorata conectorilor

Fiecare cablu introduce doi conectori cu pierderile aferente: 1->2, 2->3a, 4d->5, 5->6

$Ac := 4 \cdot 0.5$ dB/conector $\qquad Ac = 2$ dB

Atenuare datorata splice-urilor

Exista cate un splice intre fiecare doua tronsoane de fibra consecutive. Pentru 6 tronsoane vom avea 5 splice-uri

$As := 5 \cdot 0.15$ dB/splice $\qquad As = 0.75$ dB

Atenuare in fibra

Din catalog se observa ca ambele fibre au o atenuare maxima egala cu 0.35dB/km la 1300nm.Vom avea 4 tronsoane de cate 10km lungime si 2 tronsoane de cate 5km deci 50km de fibra (3+4)

$$Af := (4 \cdot 10 + 2 \cdot 5) \cdot 0.35 \quad km \cdot \frac{dB}{km} \qquad Af = 17.5 \text{ dB}$$

Atenuare datorata diferentelor de apertura numerica

Este deja calculata:

$Ana = 3.025$ dB

Atenuare datorata diferentelor de diametru

Apare la trecerea de la un dispozitiv cu diametru mai mare la un dispozitiv cu diametru mai mic, situatie intilnita la trecerile 1->2, 2->3a, 3b->4a

In toate cazurile avem fibre monomod deci vom folosi relatia:

$$A\phi ab(w1, w2) := -20 \log\left(\frac{2w1 \cdot w2}{w1^2 + w2^2}\right)$$

w1,w2 fiind diametrele ocupate de modul fundamental in dispozitive

$$A\phi := A\phi ab(13, 11) + A\phi ab(11, 9.4) + A\phi ab(9.4, 9.2) \qquad A\phi = 0.23 \text{ dB}$$

Atenuarea totala

$$At := Ac + As + Af + Ana + A\phi \qquad At = 23.505 \text{ dB}$$

Puterea emisa

$$Po := 10 \log\left(\frac{1.5mW}{1mW}\right) \qquad Po = 1.761 \text{ dBm}$$

Puterea receptionata

$Pr := Po - At$ $\qquad$ $Pr = -21.744$ dBm

Sensibilitatea receptorului

$Sr := 10\log\left(\frac{1\mu W}{1mW}\right)$ $\qquad$ $Sr = -30$ dBm

$Pr > Sr$ deci legatura **va functiona** cu o rezerva de 8dB

Problema 2

a) Eficientele luminoase pentru cele trei LED-uri sunt:

$\eta v := 640\frac{lm}{W}$ $\quad$ $\eta g := 540\frac{lm}{W}$ $\quad$ $\eta r := 135\frac{lm}{W}$ $\quad$ Avem λ=630nm deci Led-ul rosu e de inalta eficienta

Luminozitatea LED-ului depinde de puterea optica emisa si de eficienta luminoasa la lungimea de unda emisa Pentru luminozitati egale LED-ul rosu va trebui sa emita o putere optica mai mare decat cel galben care la randul sau va emite o putere mai mare decat cel verde. Deoarece se doreste puterea sa fie maxima:

$Ir := 50mA$

Luminozitatile sunt egale deci:

$r\cdot Ir\cdot\eta r = r\cdot Ig\cdot\eta g = r\cdot Iv\cdot\eta v$ $\qquad$ (LED-urile au aceeasi responsivitate)

$Iv := Ir\cdot\frac{\eta r}{\eta v}$ $\qquad$ $Iv = 10.547\,mA$

$Ig := Ir\cdot\frac{\eta r}{\eta g}$ $\qquad$ $Ig = 12.5\,mA$

b) Pentru LED-ul rosu: $\quad$ $IF := 20mA$ $\quad$ $Ivr := 10cd$ $\quad$ (Intensitatea luminoasa)

Unghiul liniar sub care este emisa lumina este $\theta=2*\theta_{1/2}$ $\quad$ $\theta := 15deg$ $\quad$ caruia ii corespunde un unghi solid:

$\Omega r := \pi\cdot\sin(\theta)^2$ $\qquad$ $\Omega r = 0.21\ sr$ $\qquad$ $\Omega r = 0.21$

Observatie: Unghiul liniar maxim sub care se emite lumina va fi mai mare, dar de asemenea intensitatea luminoasa scade odata cu cresterea unghiului. Considerand emisie constanta sub un unghi strict $\theta=2*\theta_{1/2}$ eroarea este minima.

Fluxul luminos emis de LED :

$\Phi vr := Ivr\cdot\Omega r$ $\qquad$ $\Phi vr = 2.104\,lm$

Fluxul energetic emis de LED:

$\Phi er := \frac{\Phi vr}{\eta r}$ $\qquad$ $\Phi er = 15.589\,mW$

Fluxul energetic pentru unghiul $\theta=2*\theta_{1/2}$ reprezinta "viteza cu care energia" iese din LED pentru tot unghiul solid de emisie, ceea ce corespunde definitiei puterii optice emise.

$Por\_20mA := \Phi er$ $\qquad$ $Por\_20mA = 15.589\,mW$

Responsivitatea LED-ului rosu este deci:

$r := \frac{Por\_20mA}{IF}$ $\qquad$ $r = 0.779\frac{W}{A}$

LED-urile au aceeasi resposivitate deci puterile optice emise sunt:

$Por := r \cdot Ir$ $Por = 38.972\,mW$

$Pog := r \cdot Ig$ $Pog = 9.743\,mW$

$Pov := r \cdot Iv$ $Pov = 8.221\,mW$

Problema 3

Vezi: Razavi - Design of Integrated Circuits for Optical Comunications, pag. 64 si 67-69.

Problema 4

Puterile la intrare/iesire

$P\_in := 2mW$ $P\_out := 0.1mW$

Atenuarea totala:

$A\_total := \frac{P\_in}{P\_out}$ $A\_total = 20$ $A\_total = 13.01\,dB$ $A\_dB := 10 \cdot \log(A\_total)$ $A\_dB = 13.01$

Lungimea $Lt := 5km$

Atenuarea pe fiecare km de lungime este: $At := \frac{A\_dB \cdot 1km}{Lt}$

$At = 2.602$ dB/km

Problema 5

Legea lui Snell:

$n1 \cdot \sin(\theta 1) = n2 \cdot \sin(\theta 2)$

$n1 := 3.4$ $n2 := 1$ $\theta 1 := 5deg$

$\theta 2 := \operatorname{asin}\left(n1 \cdot \frac{\sin(\theta 1)}{n2}\right)$

$\theta 2 = 17.237\,deg$

Examen Optoelectronică (timp alocat: 2h)
22.01.2009

1. (3p) Trebuie să proiectaţi un semafor cu LED-uri. LED-urile care intră în componenţa sa sunt caracterizate de eficienţă cuantică egală (aceeaşi tehnologie), iar parametrii de catalog pentru LED-ul roşu sunt:

Peak Wavelength	λ_p	630 nm
Power Dissipation	P_D	120 mW
Continuous Forward Current	I_{AF}	50 mA
Forward Voltage (I_F = 20 mA)	V_F	2.2÷2.7 V
Luminous Intensity (I_F = 20 mA)	I_V	10000 mcd
Viewing Angle (I_F = 20 mA)	$2\theta_{1/2}$	15°
Spectrum Radiation Bandwidth	$\Delta\lambda$	20 nm

Proiectaţi semaforul, pentru a obţine o iluminare la 5m, pe direcţie normală, de 50 lx pe timp de zi şi 2 lx pe timp de noapte.
Cerinţe: luminozitate egală pentru cele 3 culori, alegerea numărului de LED-uri (considerente electronice/practice), necesităţile de curent ale fiecărui LED, parametrii pentru sursa de alimentare, parametrii unui sistem de control a intensităţii luminoase pentru reglare zi/noapte.

2. (2p) Fibra din anexă este utilizată pentru a realiza o legatură cu viteza de 1Gb/s. Emiţătorul e caracterizat de o putere de ieşire de 0.5mW şi o lăţime spectrală de 1nm, iar receptorul are o sensibilitate de 100nW. Care este lungimea maximă pe care puteţi realiza această legătură dacă lungimea de undă a emiţătorului este: a) 1310nm b) 1550nm

Relaţia care dă dispersia fibrei: $D(\lambda) = \frac{S_0}{4}\left(\lambda - \frac{\lambda_0^4}{\lambda^3}\right)$ ps/(nm·km)

3. (1p) O fibră are atenuarea de 5 dB/km şi lucrează la lungimea de undă de 1.55 μm.
a) Care este raportul între puterea de ieşire şi puterea de intrare pentru un segment de 10km din această fibră?
b) Dacă puterea de intrare este -3 dBm, care este puterea de ieşire în mW?
c) Câţi fotoni sunt detectaţi la ieşire în 1 ns?

4. (1p) a) O rază de lumină trece din GaAs (n_1 = 3.4) în aer (n_2 = 1.0). Dacă unghiul incident este 5°, care este unghiul de transmisie? b) La care tranziţie apare unghiul critic (GaAs - aer sau aer - GaAs) şi care este valoarea sa?

5. (2p) Parametrii de performanţă ai circuitelor de control a diodelor laser. Viteză, curent de ieşire, impedanţe de intrare şi ieşire.

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Şl.dr.ing. R. Damian

Draka

Draka Comteq | Optical Fibre

Issue date: 11/07
Supersedes: 03/07

BendBright^{XS} Single Mode Optical Fibre

Enhanced low macrobending sensitive, low water peak fibre

Product Type: G.652D, G.657A&B

Coating Type: ColorLock™ and Natural

Numerical Aperture (custom)= 0.14

Optical Specifications (Uncabled fibre)

Attenuation	Max. Value (dB/km)
Attenuation at 1310 nm	0.33 – 0.35
Attenuation at 1383 nm H2 aged*	0.32 – 0.35
Attenuation at 1460 nm	0.25
Attenuation at 1550 nm	0.19 – 0.20
Attenuation at 1625 nm	0.20 – 0.21

** Hydrogen aging per IEC 60793-2-50, type B.1.3*

Other values available on request.

Attenuation vs. Wavelength

Maximum attenuation change over the window from reference

Wavelength range (nm)	Reference λ (nm)	Change (dB/km)
1285 - 1330	1310	≤ 0.03
1525 - 1575	1550	≤ 0.02
1460 - 1625	1550	≤ 0.04

Attenuation Uniformity

No point discontinuity greater than 0.05 dB at 1310 nm and 1550 nm.

Attenuation with Bending

Number of Turns	Mandrel Radius (mm)	Wavelength (nm)	Induced attenuation (dB)
10	15	1550	≤ 0.03
10	15	1625	≤ 0.1
1	10	1550	≤ 0.1
1	10	1625	≤ 0.2
1	7.5	1550	≤ 0.5
1	7.5	1625	≤ 1.0

Cutoff Wavelength

Cable Cutoff wavelength ≤ 1260 nm

Mode Field Diameter

Wavelength (nm)	MFD (µm)
1310	8.5 – 9.3
1550	9.4 – 10.4

Chromatic Dispersion

Zero Dispersion Wavelength (λ_0): 1300 - 1324 nm

Slope (S_0) at λ_0: ≤ 0.092 ps/(nm^2.km)

Polarization Mode Dispersion (PMD)

	(ps/√km)
PMD Link Design Value**	≤ 0.06
Max. Individual Fibre	≤ 0.1

*** According to IEC 60794 -3, Ed 3 (Q=0.01%)*

Geometrical Specifications

Glass Geometry

Cladding Diameter	125.0 ± 0.7 µm
Core/Cladding Concentricity	≤ 0.5 µm
Cladding Non-Circularity	≤ 0.7 %
Fibre Curl (radius)	≥ 4 m

Coating Geometry

Coating Diameter	242 ± 7 µm
Coating / Cladding Concentricity	≤ 10 µm
Coating Non-Circularity	≤ 5 %

Lengths Standards lengths up to 25.2 km

Other lengths available on request.

Mechanical Specifications

Proof test

The entire length is subjected to a tensile proof stress > 0.7 GPa (100 kpsi); 1% strain equivalent.

Tensile Strength

Dynamic tensile strength (0.5 meter gauge length):

Aged*** and unaged: median > 3.8 GPa (550 kpsi)

*** Aging at 85°C, 85% RH, 30 days

Dynamic and Static Fatigue

Dynamic fatigue, unaged and aged*** n_d > 20

Static fatigue, aged*** n_s > 23

Coating Performance

Coating strip force unaged and aged****:

- Average strip force: 1 N to 3 N
- Peak strip force: 1.3 N to 8.9 N

**** Aging:

- 23°C, 0°C and 45°C
- 30 days at 85°C and 85% RH
- 14 days water immersion at 23°C
- Wasp spray exposure (Telcordia)

Environmental Specifications

Environmental Test	Test Conditions	Induced Attenuation at 1310, 1550 nm (dB/km)
Temperature cycling	–60°C to 85°C	≤ 0.05
Temperature-Humidity cycling	–10°C to 85°C, 4-98% RH	≤ 0.05
Water Immersion	23°C, 14 days	≤ 0.05
Dry Heat	85°C, 30 days	≤ 0.05
Damp Heat	85°C; 85% RH, 30 days	≤ 0.05

Typical Characterisation Values

Nominal Zero Dispersion Slope 0.087 ps/(nm^2.km)

Effective group index @ 1310 nm	1.467
Effective group index @ 1550 nm	1.467
Effective group index @ 1625 nm	1.468

Rayleigh Backscatter Coefficient for 1 ns pulse width:

@ 1310 nm	–79.1 dB
@ 1550 nm	–81.4 dB
@ 1625 nm	-82.2 dB

Median Dynamic Tensile Strength 5.3 GPa (750 kpsi)
(Aged at 85ºC, 85% RH, 30 days; 0,5 m gauge length)

Rezolvari

22.01.2008

Problema 1

Eficientele luminoase pentru cele trei LED-uri sunt:

Fotopic (zi) - Sharpe

$$Vr\_f := 190 \frac{lm}{W} \quad Vv\_f := 361 \frac{lm}{W} \quad Vg\_f := 659 \frac{lm}{W}$$

Scotopic (noapte)

$$Vr\_s := 5 \frac{lm}{W} \quad Vv\_s := 1695 \frac{lm}{W} \quad Vg\_s := 353 \frac{lm}{W}$$

Responsivitatea este marimea de iesire supra cea de intrare

Pentru FD $\quad res(\eta, \lambda) := 0.8 \cdot \eta \cdot \lambda \cdot \frac{1}{\mu m} \cdot \frac{A}{W}$

Pentru LED $\quad res(\eta, \lambda) := \frac{\eta}{0.8 \cdot \lambda} \cdot \mu m \cdot \frac{W}{A}$

Luminozitatile sunt egale deci:

$$rr \cdot Ir \cdot Vr = rv \cdot Iv \cdot Vv = rg \cdot Iv \cdot Vv$$

Aceeasi eficienta cuantica:

$$\frac{Ir \cdot Vr}{\lambda r} = \frac{Iv \cdot Vv}{\lambda v} = \frac{Iv \cdot Vv}{\lambda v}$$

$$\lambda r := 630nm \quad \lambda v := 510nm \quad \lambda g := 570nm$$

In ambele situatii rosu are eficienta luminoasa minima deci va fi parcurs de curentul maxim

$$Iv = Ir \cdot \frac{\lambda v}{\lambda r} \cdot \frac{Vr}{Vv} \qquad Ig = Ir \cdot \frac{\lambda g}{\lambda r} \cdot \frac{Vr}{Vg}$$

Iluminarea [lx]:

$$Ev = \frac{d\Phi v}{dS}$$

Intensitatea [cd]

$$Iv = \frac{d\Phi v}{d\Omega}$$

Unghiul solid [sr]:

$$d\Omega = \frac{dS}{r^2}$$

Deci: $\quad Ev = \frac{Iv}{r^2}$

Intensitatea luminoasa totala pentru fiecare culoare, diferita zi/noapte:

$$I = E \cdot r^2$$

$r := 5m$ $\qquad E\_f := 50lx$ $\qquad E\_s := 2lx$

$I\_f := E\_f \cdot r^2$ $\qquad I\_f = 1.25 \times 10^3\ cd$ $\qquad I\_s := E\_s \cdot r^2$ $\qquad I\_s = 50\ cd$

Intensitate maxima necesara ziua. Led-ul rosu ofera 10cd la un curent de 20mA, la un curent de 50mA ofera u
maxim:

$I\_max := \frac{50}{20} \cdot 10cd$ $\qquad I\_max = 25\ cd$

Numarul minim de led-uri rosii:

$Nr\_min := \frac{I\_f}{I\_max}$ $\qquad Nr\_min = 50$

Din considerente practice:

$$Nr\_rosu = Nr\_verde = Nr\_galben$$

Presupunem ca alegem din considerente de dimensiune, asezare, pret, etc. $\quad N\_led := 100$

Intensitatea luminoasa pentru toate LED-urile:

$I\_led\_f := \frac{I\_f}{N\_led}$ $\qquad I\_led\_f = 12.5\ cd$

$I\_led\_s := \frac{I\_s}{N\_led}$ $\qquad I\_led\_s = 0.5\ cd$

Curentul maxim -> prin LED-ul rosu

$Ir\_f := I\_led\_f \cdot \frac{20mA}{10cd}$ $\qquad Ir\_f = 25\ mA$

$Ir\_s := I\_led\_s \cdot \frac{20mA}{10cd}$ $\qquad Ir\_s = 1\ mA$

Curentii prin celelalte LED-uri:

$Iv\_f := Ir\_f \cdot \frac{\lambda v}{\lambda r} \cdot \frac{Vr\_f}{Vv\_f}$ $\qquad Iv\_f = 10.652\ mA$

$Iv\_s := Ir\_s \cdot \frac{\lambda v}{\lambda r} \cdot \frac{Vr\_s}{Vv\_s}$ $\qquad Iv\_s = 2.388 \times 10^{-3}\ mA$

$Ig\_f := Ir\_f \cdot \frac{\lambda g}{\lambda r} \cdot \frac{Vr\_f}{Vg\_f}$ $\qquad Ig\_f = 6.521\ mA$

$Ig\_s := Ir\_s \cdot \frac{\lambda g}{\lambda r} \cdot \frac{Vr\_s}{Vg\_s}$ $\qquad Ig\_s = 0.013\ mA$

Necesitati totale de curent:

Fotopic : $I\_tot\_f := \max(Ir\_f, Iv\_f, Ig\_f)\ N\_led$ $I\_tot\_f = 2.5\ A$

Scotopic : $I\_tot\_s := \max(Ir\_s, Iv\_s, Ig\_s)\ N\_led$ $I\_tot\_s = 0.1\ A$

Nota: Pot exista discutii privind necesitatea aprinderii simultane a doua culori: galben/verde si galben/rosu d
nu sunt necesare pentru obtinerea punctajului.

Parametrii sistemului de reglaj constau in varierea curentului individual intre limitele deja calculate zi/noapte

Problema 2

Limitarea lungimii poate aparea prin efectul atenuarii si/sau dispersiei.

Atenuarea

Puterile la intrare/iesire

$P\_in := 0.5mW$ $P\_out := 100nW$

Atenuarea maxima permisa:

$A\_max := \frac{P\_in}{P\_out}$ $A\_max = 5 \times 10^{3}$ $A\_max = 36.99\ dB$

$A\_max\_dB := 10 \cdot \log(A\_max)$ $A\_max\_dB = 36.99$

Dispersia

$Vit := 1 \cdot \frac{Gb}{s}$

$B\_el := \frac{1}{2} \cdot Vit$ (Relatia corecta, in curs e gresit inversat, oricare din variante acceptata)

$B\_el = 0.5\ GHz$

$B\_opt := B\_el \cdot \sqrt{2}$ $B\_opt = 0.707\ GHz$

$\Delta t\_max := \frac{0.44}{B\_opt}$ $\Delta t\_max = 622.254\ ps$

1300 nm

Dispersie nula.

Atenuare : $A\_1300 := 0.35\ \frac{dB}{km}$

Lungimea maxima: $L\_max\_1300 := \frac{A\_max\_dB}{A\_1300}$ $L\_max\_1300 = 105.685\ km$

1550 nm

Atenuare : $A\_1550 := 0.2\frac{1}{km}\ dB$

Lungimea limitata de atenuare $L\_at\_1550 := \frac{A\_max\_dB}{A\_1550}$ $L\_at\_1550 = 184.949\ km$

Dispersia $D(\lambda) := \frac{S0}{4}\cdot\left(\lambda - \frac{\lambda0^4}{\lambda^3}\right)$ $S0 := 0.092\frac{ps}{nm^2\cdot km}$ $\lambda0 := 1310nm$

$D(1550nm) = 17.461\frac{ps}{nm\cdot km}$

$\Delta\lambda := 2nm$

Lungimea limitata de dispersie $L\_ds\_1550 := \frac{\Delta t\_max}{D(1550nm)\cdot\Delta\lambda}$ $L\_ds\_1550 = 17.819\ km$

$L\_max\_1550 := \min(L\_at\_1550, L\_ds\_1550)$ $L\_max\_1550 = 17.819\ km$

Problema 3

a) Atenuare : $A\_1550 := 5\frac{1}{km}\ dB$ $Lf := 10km$

$Af := A\_1550\cdot Lf$ $Af = 50\ \ dB$

$\frac{Pin}{Pout} = Af\_lin$ $Af\_lin := 10^{\frac{Af}{10}}$ $Af\_lin = 1\times10^5$

b) $Pin\_dBm := -3\ dBm$ $Pin := 1mW\cdot10^{\frac{Pin\_dBm}{10}}$ $Pin = 0.501\ mW$

$Pout := \frac{Pin}{Af\_lin}$ $Pout = 5.012\times10^{-6}\ mW$

c) Energia unui foton $\lambda := 1.55\mu m$ $\nu := \frac{c}{\lambda}$ $\nu = 1.934 \times 10^{14}\,Hz$

$h := 6.626 \times 10^{-34} J\cdot s$

$Ef := h\cdot\nu$ $Ef = 1.282 \times 10^{-19}\,J$

$Pout = \frac{Nf\cdot Ef}{\Delta t}$ $\Delta t := 1ns$

$Nf := \frac{Pout}{Ef}\cdot\Delta t$ $Nf = 39.107$ $Nf := 39$

Problema 4

Legea lui Snell:

$n1\cdot\sin(\theta 1) = n2\cdot\sin(\theta 2)$

$n1 := 3.4$ $n2 := 1$ $\theta 1 := 5deg$

$\theta 2 := asin\left(n1\cdot\frac{\sin(\theta 1)}{n2}\right)$

$\theta 2 = 17.237\,deg$

Unghi critic

$\theta 2 := 90deg$

$n1\cdot\sin(\theta 1) = n2\cdot\sin(\theta 2)$

$\theta c := asin\left(n2\cdot\frac{\sin(\theta 2)}{n1}\right)$

$\theta c = 17.105\,deg$

Problema 5

Vezi: Razavi - Design of Integrated Circuits for Optical Comunications, pag. 351-352 si 354-355

Corning leads the industry in standards development through its cooperative efforts with standards organizations worldwide. These include Telecommunications Industry Association (TIA), the Institute of Electrical and Electronics Engineers, Inc. (IEEE), ATM Forum and Fibre Channel.

Technical Support

Every reel of Corning fiber is supported by hundreds of technical experts, ready to address any concerns related to optical fiber and its deployment. Corning's state-of-the-art tracking systems provide answers to specific questions on every reel of fiber produced and purchased.

Optical Specifications

Attenuation

≤ 2.5/0.8 dB/km @ 850/1300 nm

- No point discontinuity greater than 0.2 dB
- The attenuation at 1380 nm does not exceed the attenuation at 1300 nm by more than 3.0 dB/km
- The induced attenuation caused by wrapping the fiber 100 turns around a 75 mm mandrel shall not exceed 0.5 dB at 850 nm and 1300 nm

Special attenuation cells available upon request.

Bandwidth

Standard Bandwidth Cells
850/1300 nm (MHz•km)
400/400
400/600
400/1200
500/500
600/600
600/1000

Other bandwidth cells available upon request.

Chromatic Dispersion

- Zero Dispersion Wavelength (λ_0): 1300 nm ≤ λ_0 ≤ 1320 nm
- Zero Dispersion Slope (S_0): ≤ 0.101 ps/(nm²•km)

$$\text{Dispersion} = D(\lambda) :\approx \frac{S_0}{4}\left[\lambda - \frac{\lambda_0^4}{\lambda^3}\right] \text{ps/(nm•km)}$$

For 750 nm ≤ λ ≤ 1450 nm, λ = Operating Wavelength

Fibra nr. 1

Core Diameter

- 50.0 ± 3.0 µm

Numerical Aperture

- 0.200 ± 0.015

Environmental Specifications

Environmental Test Condition	Induced Attenuation (dB/km) 850 nm	Induced Attenuation (dB/km) 1300 nm
Temperature Dependence -60°C to +85°C	≤ 0.20	≤ 0.20
Temperature - Humidity Cycling -10°C to +85°C and 4% to 98% RH	≤ 0.20	≤ 0.20

Operating Temperature Range -60°C to +85°C

Dimensional Specifications

Standard Length (km/reel)

- 1.1 - 8.8
  Special lengths available upon request.

Glass Geometry

- Cladding Diameter: 125.0 ± 2.0 µm
- Core-Clad Concentricity: ≤ 3.0 µm
- Cladding Non-Circularity: < 2.0%
- Core Non-Circularity: ≤ 5%

Non-Circularity is defined as:

$$\left[1 - \frac{\text{Min. Cladding Diameter}}{\text{Max. Cladding Diameter}}\right] \times 100$$

Coating Geometry

- Coating Diameter: 245 ± 5 µm
- Coating-Cladding Concentricity: < 12 µm

Mechanical Specifications

Proof Test

- The entire length of fiber is subjected to a tensile proof stress ≥ 100 kpsi (0.7 GN/m²).

Performance Characterizations

Characterized parameters are typical values.

Characterized Group Index of Refraction (N_{eff})

- 1.481 at 850 nm
- 1.476 at 1300 nm

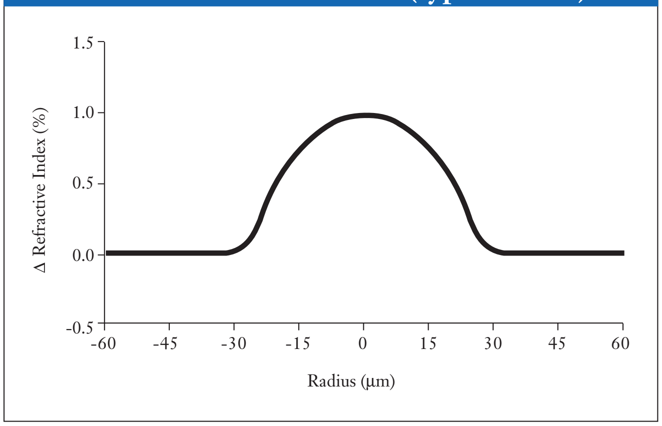
N_{eff} was empirically derived to the third decimal place using a specific commercially available OTDR.

Fatigue Resistance Parameter (n_d): 20

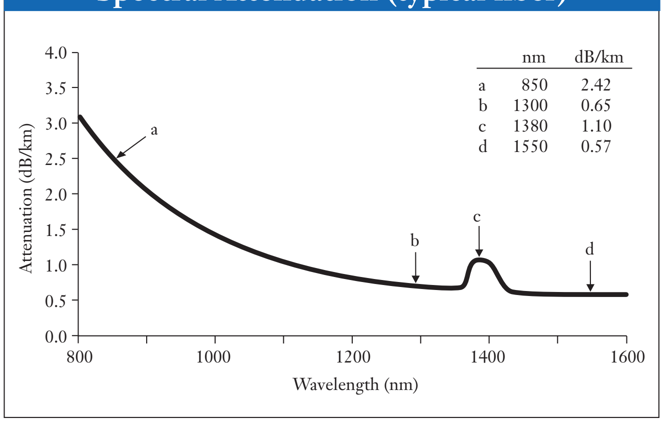
Coating Strip Force

- Dry: 0.6 lbs (2.7 N)
- Wet: 14 days in 23°C water soak: 0.6 lbs (2.7 N)

Refractive Index Profile (typical fiber)



Spectral Attenuation (typical fiber)



Ordering Information

To order Corning® 50/125 optical fiber, contact your sales representative, or call the Optical Fiber Customer Service Department at **607-248-2000** or **+44-1244-287-437** in Europe. Please specify the following parameters when ordering.

Fiber Type:	50/125 µm Multimode Fiber
Fiber Quantity:	kms
Proof Test:	100 kpsi (0.7 GN/m²)
Other:	(Requested ship date, desired attenuation cell, desired bandwidth cell, etc.)

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Technical Support

Every reel of Corning fiber is supported by hundreds of technical experts, ready to address any concerns related to optical fiber and its deployment. Corning's state-of-the-art tracking systems provide answers to specific questions on every reel of fiber produced and purchased.

Optical Specifications

Attenuation

≤ 3.0/0.7 dB/km @ 850/1300 nm

- No point discontinuity greater than 0.2 dB
- The attenuation at 1380 nm does not exceed the attenuation at 1300 nm by more than 1.0 dB/km
- The induced attenuation caused by wrapping the fiber 100 turns around a 75 mm mandrel shall not exceed 0.5 dB at 850 nm and 1300 nm

Special attenuation cells available upon request.

Bandwidth

Standard Bandwidth Cells
850/1300 nm (MHz•km)
160/500
200/500

Other bandwidth cells available upon request.

Chromatic Dispersion

- Zero Dispersion Wavelength (λ_0): 1332 nm ≤ λ_0 ≤ 1354 nm
- Zero Dispersion Slope (S_0): ≤ 0.097 ps/(nm²•km)

$$\text{Dispersion} = D(\lambda) :\approx \frac{S_0}{4}\left[\lambda - \frac{\lambda_0^4}{\lambda^3}\right] \text{ps/(nm•km)}$$

For 750 nm ≤ λ ≤ 1450 nm, λ = Operating Wavelength

Fibra nr. 2

Core Diameter

- 62.5 ± 3.0 μm

Numerical Aperture

- 0.275 ± 0.015

Environmental Specifications

Environmental Test Condition	Induced Attenuation (dB/km) 850 nm	1300 nm
Temperature Dependence -60°C to +85°C	≤ 0.20	≤ 0.20
Temperature - Humidity Cycling -10°C to +85°C and 4% to 98% RH	≤ 0.20	≤ 0.20

Operating Temperature Range -60°C to +85°C

Dimensional Specifications

Standard Length (km/reel)

- 2.2 - 8.8
  Special lengths available upon request.

Glass Geometry

- Cladding Diameter: 125.0 ± 2.0 μm
- Core-Clad Concentricity: ≤ 3.0 μm
- Cladding Non-Circularity: < 2.0%
- Core Non-Circularity: ≤ 5%

  Non-Circularity is defined as:

$$\left[1 - \frac{\text{Min. Cladding Diameter}}{\text{Max. Cladding Diameter}}\right] \times 100$$

Coating Geometry

- Coating Diameter: 245 ± 5 μm
- Coating-Cladding Concentricity: < 12 μm

Mechanical Specifications

Proof Test

- The entire length of fiber is subjected to a tensile proof stress ≥ 100 kpsi (0.7 GN/m²)

Performance Characterizations

Characterized parameters are typical values.

Effective Group Index of Refraction (N_{eff})

- 1.496 at 850 nm
- 1.491 at 1300 nm

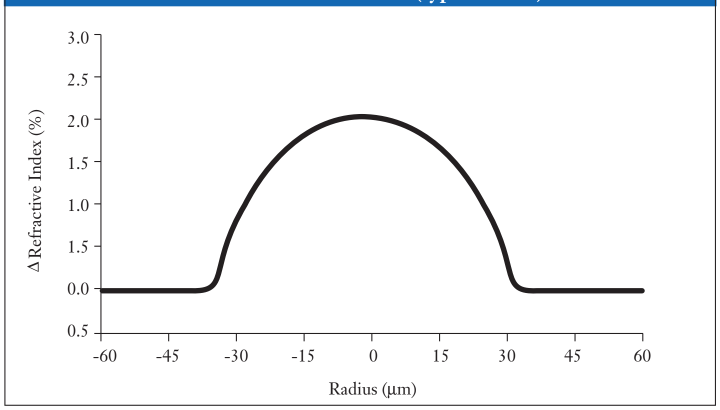
N_{eff} was empirically derived to the third decimal place using a specific commercially available OTDR.

Fatigue Resistance Parameter (n_d): 20

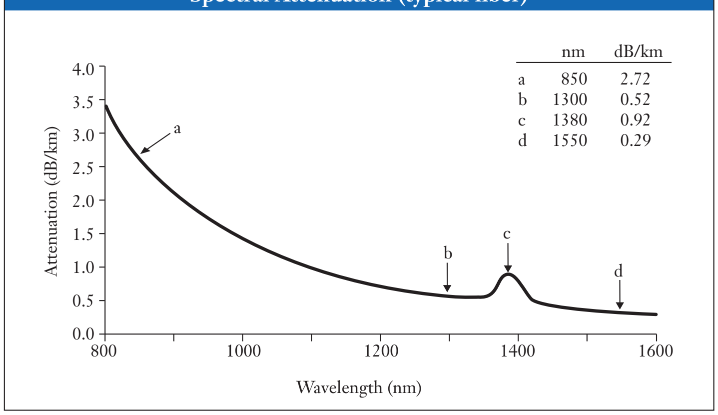
Coating Strip Force

- Dry: 0.6 lbs (2.7 N)
- Wet: 14 days in 23°C water soak: 0.6 lbs (2.7 N)

Refractive Index Profile (typical fiber)



Spectral Attenuation (typical fiber)



Ordering Information

To order Corning® 62.5/125 optical fiber, contact your sales representative, or call the Optical Fiber Customer Service Department at **607-248-2000** or **+44-1244-287-437** in Europe. Please specify the following parameters when ordering.

Fiber Type: 62.5/125 μm Multimode Fiber

Fiber Quantity: kms

Proof Test: 100 kpsi (0.7 GN/m²)

Other: (Requested ship date, desired attenuation cell, desired bandwidth cell, etc.)

Fibra nr. 3

Optical Specifications

Fiber Attenuation

Maximum Attenuation

Wavelength (nm)	Maximum Value* (dB/km)
1310	0.33 – 0.35
1383**	0.31 – 0.35
1490	0.21 – 0.24
1550	0.19 – 0.20
1625	0.20 – 0.23

*Maximum specified attenuation value available within the stated ranges.
**Attenuation values at this wavelength represent post-hydrogen aging performance.
Alternate attenuation offerings available upon request.

Attenuation vs. Wavelength

Range (nm)	Ref. λ (nm)	Max. α Difference (dB/km)
1285 – 1330	1310	0.03
1525 – 1575	1550	0.02

The attenuation in a given wavelength range does not exceed the attenuation of the reference wavelength (λ) by more than the value α.

Macrobend Loss

Mandrel Diameter (mm)	Number of Turns	Wavelength (nm)	Induced Attenuation* (dB)
32	1	1550	≤0.03
50	100	1310	≤0.03
50	100	1550	≤0.03
60	100	1625	≤0.03

*The induced attenuation due to fiber wrapped around a mandrel of a specified diameter.

Point Discontinuity

Wavelength (nm)	Point Discontinuity (dB)
1310	≤0.05
1550	≤0.05

Cable Cutoff Wavelength (λ_{ccf})

λ_{ccf} ≤ 1260 nm

Mode-Field Diameter

Wavelength (nm)	MFD (μm)
1310	9.4 ± 0.4
1550	10.6 ± 0.5

Dispersion

Wavelength (nm)	Dispersion Value [ps/(nm•km)]
1550	≤18
1625	≤23

Zero Dispersion Wavelength (λ_0): 1310 nm ≤ λ_0 ≤ 1324 nm
Zero Dispersion Slope (S_0): ≤ 0.092 ps/(nm^2•km)

Polarization Mode Dispersion (PMD)

	Value (ps/√km)
PMD Link Design Value	≤0.06*
Maximum Individual Fiber	≤0.2

*Complies with IEC 60794-3: 2001, Section 5.5, Method 1, September 2001.

The PMD link design value is a term used to describe the PMD of concatenated lengths of fiber (also known as PMD_Q). This value represents a statistical upper limit for total link PMD. Individual PMD values may change when cabled. Corning's fiber specification supports network design requirements for a 0.5 ps/√km maximum PMD.

Dimensional Specifications

Glass Geometry

Fiber Curl	≥ 4.0 m radius of curvature
Cladding Diameter	125.0 ± 0.7 μm
Core-Clad Concentricity	≤ 0.5 μm
Cladding Non-Circularity	≤ 0.7%

Coating Geometry

Coating Diameter	245 ± 5 μm
Coating-Cladding Concentricity	<12 μm

Environmental Specifications

Environmental Test	Test Condition	Induced Attenuation 1310 nm, 1550 nm & 1625 nm (dB/km)
Temperature Dependence	-60°C to +85°C*	≤0.05
Temperature Humidity Cycling	-10ºC to +85ºC* up to 98% RH	≤0.05
Water Immersion	23º± 2ºC	≤0.05
Heat Aging	85º± 2ºC*	≤0.05

*Reference temperature = +23ºC

Operating Temperature Range: -60ºC to +85ºC

How to Order

Contact your sales representative, or call the Optical Fiber Customer Service Department:
Ph: 607-248-2000 (U.S. and Canada)
+44-1244-287-437 (Europe)
Email: opticalfibcs@corning.com
Please specify the fiber type, attenuation and quantity when ordering.

Mechanical Specifications

Proof Test

The entire fiber length is subjected to a tensile stress ≥100 kpsi (0.7 GPa)*.

*Higher proof test levels available.

Length

Fiber lengths available up to 50.4* km/spool.

*Longer spliced lengths available.

Performance Characterizations

Characterized parameters are typical values.

Core Diameter	8.2 µm
Numerical Aperture	0.14 *NA is measured at the one percent power level of a one-dimensional far-field scan at 1310 nm.*
Zero Dispersion Wavelength (λ_0)	1317 nm
Zero Dispersion Slope (S_0)	0.088 ps/(nm²•km)
Effective Group Index of Refraction (N_{eff})	1310 nm: 1.4670 1550 nm: 1.4677
Fatigue Resistance Parameter (N_d)	20
Coating Strip Force	Dry: 0.6 lbs. (3N) Wet, 14-day room temperature: 0.6 lbs. (3N)
Rayleigh Backscatter Coefficient (for 1 ns Pulse Width)	1310 nm: -77 dB 1550 nm: -82 dB
Stimulated Brillouin Scattering Threshold	20 dBm(1)

Notes:
(1) When characterized with a transmitter specifying 17 dBm SBS threshold over standard single-mode fiber. While absolute SBS threshold is a function of distance and signal format, NexCor fiber offers a 3 dB improvement over standard single-mode fiber independent of these variables.

Formulas

Dispersion

$$\text{Dispersion} = D(\lambda) :\approx \frac{S_0}{4}\left[\lambda - \frac{\lambda_0^4}{\lambda^3}\right] \text{ps/(nm•km)},$$

for 1200 nm ≤ λ ≤ 1625 nm

λ = Operating Wavelength

Cladding Non-Circularity

$$\text{Cladding Non-Circularity} = \left[1 - \frac{\text{Min. Cladding Diameter}}{\text{Max. Cladding Diameter}}\right] \times 100$$

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Malaysia
Ph: 1-800-80-3156
Fx: 1-800-80-3155

Philippines
Ph: 1-800-1-116-0338
Fx: 1-800-1-116-0339

Singapore
Ph: 800-1300-955
Fx: 800-1300-956

Thailand
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Fibra nr. 4

Optical Specifications

Fiber Attenuation

Maximum Attenuation

Wavelength (nm)	Maximum Value* (dB/km)
1310	0.33 – 0.35
1383**	0.31 – 0.35
1550	0.19 – 0.20
1625	0.20 – 0.23

*Maximum specified attenuation value available within the stated ranges.
**Attenuation values at this wavelength represent post-hydrogen aging performance.
Alternate attenuation offerings available upon request.

Attenuation vs. Wavelength

Range (nm)	Ref. λ (nm)	Max. α Difference (dB/km)
1285 – 1330	1310	0.03
1525 – 1575	1550	0.02

The attenuation in a given wavelength range does not exceed the attenuation of the reference wavelength (λ) by more than the value α.

Macrobend Loss

Mandrel Diameter (mm)	Number of Turns	Wavelength (nm)	Induced Attenuation* (dB)
32	1	1550	≤0.05
50	100	1310	≤0.05
50	100	1550	≤0.05
60	100	1625	≤0.05

*The induced attenuation due to fiber wrapped around a mandrel of a specified diameter.

Point Discontinuity

Wavelength (nm)	Point Discontinuity (dB)
1310	≤0.05
1550	≤0.05

Cable Cutoff Wavelength (λ_{ccf})

λ_{ccf} ≤ 1260 nm

Mode-Field Diameter

Wavelength (nm)	MFD (μm)
1310	9.2 ± 0.4
1550	10.4 ± 0.5

Dispersion

Wavelength (nm)	Dispersion Value [ps/(nm•km)]
1550	≤18.0
1625	≤22.0

Zero Dispersion Wavelength (λ_0): 1302 nm ≤ λ_0 ≤ 1322 nm
Zero Dispersion Slope (S_0): ≤ 0.089 ps/(nm^2•km)

Polarization Mode Dispersion (PMD)

	Value (ps/√km)
PMD Link Design Value	≤0.06*
Maximum Individual Fiber	≤0.2

*Complies with IEC 60794-3: 2001, Section 5.5, Method 1, (m = 20, Q = 0.01%), September 2001.

The PMD link design value is a term used to describe the PMD of concatenated lengths of fiber (also known as PMD_Q). This value represents a statistical upper limit for total link PMD. Individual PMD values may change when fiber is cabled. Corning's fiber specification supports network design requirements for a 0.20 ps/√km maximum PMD.

Dimensional Specifications

Glass Geometry

Fiber Curl	≥ 4.0 m radius of curvature
Cladding Diameter	125.0 ± 0.7 μm
Core-Clad Concentricity	≤ 0.5 μm
Cladding Non-Circularity	≤ 0.7%

Coating Geometry

Coating Diameter	245 ± 5 μm
Coating-Cladding Concentricity	<12 μm

Environmental Specifications

Environmental Test	Test Condition	Induced Attenuation 1310 nm, 1550 nm & 1625 nm (dB/km)
Temperature Dependence	-60°C to +85°C*	≤0.05
Temperature Humidity Cycling	-10ºC to +85ºC* up to 98% RH	≤0.05
Water Immersion	23°± 2°C	≤0.05
Heat Aging	85°± 2ºC*	≤0.05
Damp Heat	85°C at 85% RH	≤0.05

*Reference temperature = +23ºC

Operating Temperature Range: -60ºC to +85ºC

How to Order

Contact your sales representative, or call the Optical Fiber Customer Service Department:
Ph: 607-248-2000 (U.S. and Canada)
+44-1244-287-437 (Europe)
Email: opticalfibcs@corning.com
Please specify the fiber type, attenuation and quantity when ordering.

Mechanical Specifications

Proof Test

The entire fiber length is subjected to a tensile stress ≥100 kpsi (0.7 GPa)*.

*Higher proof test levels available.

Length

Fiber lengths available up to 50.4* km/spool.

*Longer spliced lengths available.

Performance Characterizations

Characterized parameters are typical values.

Core Diameter	8.2 µm
Numerical Aperture	0.14 *NA is measured at the one percent power level of a one-dimensional far-field scan at 1310 nm.*
Zero Dispersion Wavelength (λ_0)	1313 nm
Zero Dispersion Slope (S_0)	0.086 ps/(nm²•km)
Refractive Index Difference	0.36%
Effective Group Index of Refraction (N_{eff})	1310 nm: 1.4677 1550 nm: 1.4682
Fatigue Resistance Parameter (N_d)	20
Coating Strip Force	Dry: 0.6 lbs. (3N) Wet, 14-day room temperature: 0.6 lbs. (3N)
Rayleigh Backscatter Coefficient (for 1 ns Pulse Width)	1310 nm: -77 dB 1550 nm: -82 dB
Individual Fiber Polarization Mode Dispersion	0.02 ps/√km

Formulas

Dispersion

$$\text{Dispersion} = D(\lambda) :\approx \frac{S_0}{4}\left[\lambda - \frac{\lambda_0^4}{\lambda^3}\right] \text{ps/(nm•km)},$$

for 1200 nm ≤ λ ≤ 1625 nm

λ = Operating Wavelength

Cladding Non-Circularity

$$\text{Cladding Non-Circularity} = \left[1 - \frac{\text{Min. Cladding Diameter}}{\text{Max. Cladding Diameter}}\right] \times 100$$

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