เฉลยกลางภาค ๒/๒๕๕๘

การสื่อสารทางแสง

(4)

$P_{owerส่ง} = 20\ dBm$

$Loss = 150\ km \times 0.2\ dB/km$

$= 30\ dB$

$connector\ loss = 5 \times 0.4\ dB$

$= 2\ dB$

$P_{receive} = Powerส่ง - Loss - Connector\ loss$

$= 20 - 30 - 2$

$P_{receive} = -12\ dBm$

ข้อ ⑤

(เส้นผ่านศูนย์กลาง)

$a/b = 9/125\ \mu m$

$\lambda = 1310\ nm$

Loss $= 0.3\ dB/km$

ความกว้างของ pulse $= 0.012\ nm$

$n_1 = 1.448$

$\Delta = 0.19\ \%$

Sol^n Brillouin scattering (P_B)

$$P_B = (17.6\times10^{-3})(a\lambda)^2 \alpha \Delta\nu$$

a = รัศมี core (μm)

λ = ความยาวคลื่น (μm)

α = การลดทอนในสาย (dB/km)

$\Delta\nu$ = ความกว้างของแถบพัลส์ของคลื่นแสง (GHz)

$$\Delta\nu = \frac{c}{\lambda^2}\Delta\lambda = \frac{3\times10^{8}}{(1310\times10^{-9})^2}\times 0.012\times10^{-9}$$

$\Delta\nu = 2.097\ GHz$ $\quad 1310\ nm = 1.31\ \mu m$

$a = \frac{9}{2} = 4.5\ \mu m$

$$P_B = (1.76\times10^{-3})(4.5\times1.31)^2(0.3)(2.097)$$

$P_B = 0.0384\ W. = 38.4\ mW.$ ——#

Raman scattering

$$P_R = (23.6 \times 10^{-2})(9)^2 \lambda \alpha$$

$$P_R = (23.6 \times 10^{-2})(4.5)^2 (1.31)(0.7)$$

$$P_R = 1.898 \text{ watt}$$

vs (6) single mode

$2a = 4\ \mu m$

$a = 2\ \mu m$ → 50 ps.

$2b = 125\ \mu m$

$b = 62.5\ \mu m$

$n_1 = 1.5$, $n_2 = 1.48$

$L = 100\ km$

$\lambda = 1550\ nm$

$FWHM = (\Delta t) = 2\ \mu s$

$\sigma_\lambda = 2\ nm$

$\sigma_{mat} = \frac{1}{\pi}\left(\frac{d^2 n}{d\lambda^2}\right) = 4 \times 10^{15}\ m^{-3}$

$\frac{d^2(Vb)}{dV^2}$ ~~x0.1502~~ parameter $\sigma_{wg} = 0.7$

so $\frac{1}{2}$

$$\Delta = \frac{n_1^2 - n_2^2}{2n_1^2}$$

$$\Delta = \frac{(1.5)^2 - (1.48)^2}{2(1.5)^2}$$

$$\Delta = \frac{2.25 - 2.1904}{4.5}$$

$$\Delta = 0.013244$$

$$V = K_a N_A = \frac{2\pi a}{\lambda} n_1 \sqrt{2\Delta}$$

$$= \frac{2\pi(2\times10^{-6})}{1550\times10^{-9}}(1.5)\sqrt{2\times0.013244}$$

$$V = 1.9992$$

$$\delta_{mat} = \delta_\lambda L \frac{\lambda}{c}\left(\frac{dn^2}{d\lambda^2}\right)$$

หน่วยไม่ตรง ~~ที่~~ δ ที่หามา parameter คือ $\frac{1}{\lambda}\left(\frac{dn^2}{d\lambda^2}\right) = 4\times10^{10}$ ม$^{-1}$

นั้นคือ $\delta_{mat} = \delta_\lambda L \frac{\lambda^2}{c}\left(\frac{1}{\lambda}\left(\frac{dn^2}{d\lambda^2}\right)\right)$

$$\delta_{mat} = (2\times10^{-9})(100\times10^{3})\frac{(1550\times10^{-9})^2}{(3\times10^{8})}\times4\times10^{15}$$

$$\delta_{mat} = 6.4 \text{ ns}$$

$$\delta_{mat} = 6.4\times10^{-9} \text{ sec.}$$

$$\delta_{wg} = \delta_\lambda L \frac{\Delta n_2}{c\lambda} V \frac{d^2(Vb)}{dV^2}$$

$$= (2\times10^{-9})(100\times10^{3})\frac{(0.013244)(1.48)}{(3\times10^{8})(1550\times10^{-9})}(1.9992)(0.7)$$

$$\gamma_{wg} = 1.168 \times 10^{-8}$$

$$= 11.68 \times 10^{-9}$$

$$\gamma_{wg} = 11.68 \text{ ns} \quad \text{——} \not\text{B}$$

$$\gamma_{out} = \sqrt{\gamma_{in}^2 + \gamma_{int}^2 + \gamma_{intra}^2}$$

$$= \sqrt{\gamma_{in}^2 + \gamma_{int}^2 + (\gamma_{mat} + \gamma_{wg})^2}$$

ಇಲ್ಲಿ γ_{in} ಮತ್ತು γ_{int} ಸಮಾನ.

$$\gamma_{out} = \sqrt{(\gamma_{mat} + \gamma_{wg})^2} = \gamma_{mat} + \gamma_{wg}$$

$$\gamma_{out} = 6.4 + 11.68 \text{ ns}$$

$$\gamma_{out} = 18.08 \text{ ns} \quad \text{——} \not\text{B}$$

$$B = \frac{0.25}{\gamma_{out}} = \frac{0.25}{18.08 \times 10^{-9}} = 13.82 \text{ Mbps}$$

BL - product $= B \times l = 13.82 \times 100 = 1.38 \text{ Gbps.km}$

(9) $2a = 50\ \mu m$

$n_1 = 1.48$

$n_2 = 1.46$

$\alpha = 2$

$\lambda = 850\ nm.$

Soln

$$\Delta = \frac{n_1 - n_2}{n_1} = \frac{1.48 - 1.46}{1.48} = 0.01351$$

$$V = k_a NA = \frac{2\pi a n_1 \sqrt{2\Delta}}{\lambda}$$

$$V = \frac{2\pi \times 25 \times 10^{-6} (1.48) \sqrt{2 \times 0.01351}}{850 \times 10^{-9}}$$

$$V = \frac{\pi \times 50 \times 10^{-6} \times (1.48) \times \sqrt{2 \times 0.01351}}{850 \times 10^{-9}}$$

$$V = 44.95 \quad \text{---} \ b$$

MSO

$$V = \frac{2\pi a}{\lambda}\sqrt{(n_1^2 - n_2^2)}$$

$$V = \frac{2\times\pi\times 25\times10^{-6}}{850\times10^{-9}}\sqrt{(1.48)^2 - (1.46)^2}$$

$$V = 44.81$$

Single mode :

$$M = \frac{\alpha}{2+2} a^2 k^2 n_1^2 \Delta$$

$$M = \frac{2}{2+2}(25\times10^{-6})^2\left(\frac{2\pi}{\lambda}\right)^2\times(1.48)^2\times0.01351$$

$$M = 0.5\times(6.25\times10^{-10})\times(5.464\times10^{13})\times(2.1904)$$

$$\times 0.01351$$

$$M = 505.2$$

MSO $\quad M = \frac{V^2}{2} = \frac{(44.95)^2}{2} = 1010.25$