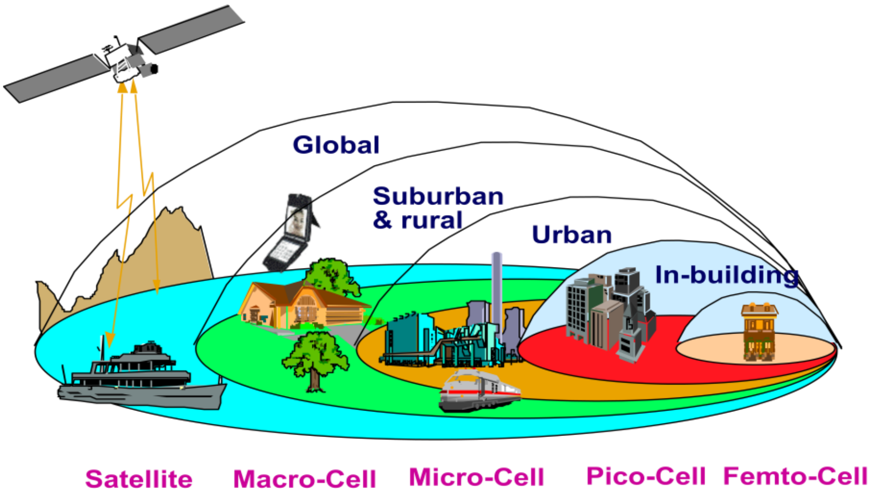
EEE6420 Solutions 2012-13

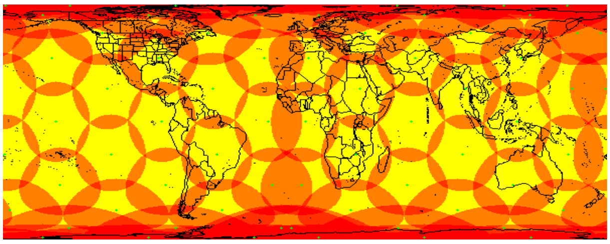
Question 1



(a)

Students should describe a global system, integrating large and small wireless systems **4 marks**

(b) Iridium or Globalstar system. Low earth orbit satellites giving cellular coverage, cells about 200km across. Spot beams. Large numbers of satellites needed (50-66), handover due to 2 hour orbit visibility, Doppler problems, etc.


Cell coverage from multiple beams. **6 marks**

(c) Calculation

$$\left(\frac{C}{N}\right)_U = E_e - L_U - M + G_s - N_U$$

E_e = earth station eirp = P_e x G_e

L_U = uplink path loss

M = operating margin

G_s = satellite antenna gain

N_U = uplink thermal noise = k T_s B_{RF}

= -228.6 + 10log T_e + 10log B_{RF} dB

B_{RF} = bandwidth

T_s = satellite transponder noise temperature (antenna + receiver)

E_e = 7.78 + 0 dB = 7.78 dBW

L_u = 92.5 + 20logd + 20 log 1.6 = 92.5 + 20logd + 4.08 = 96.6 + 20logd dB

Satellite antenna gain = $4\pi A\eta/\lambda^2$ = $4\pi.\ \pi.0.6.0.6.0.8/0.1875^2$ = 323.4 = 25.1 dB

Receiver noise = kTB = N_u
F = 2 dB = 1.585
Temp T = antenna noise temp + (F-1)290 = 600 + 0.585.290 = 770 K
N_u = kTB = 1.38 x 10^{-23} x 770 x 150000 = 1.59 x 10^{-15} W = -148 dBW

Hence uplink equation gives 10 = 7.78 – 96.6 – 20logd -15 + 25.1 +148 = 69.28 + 20logd
log d =59.3/20, hence d = 922 km.

10 marks

Question 2

(a) Description of Cassegrain or Gregorian system and its design. Some points to include:
(i) Offset/non offset reflector, smooth metal surface, feed at focus with preamp.
(ii)Efficiency - Tapered illumination, spillover minimised, offsetting feed reduces blockage.
(iii) Noise – reduce backlobe, spillover, **7 marks**

(b)

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots\ldots\ldots \frac{F_n - 1}{G_1 G_2 .. G_{n-1}} \qquad F = 1 + \frac{T_e}{T_0}$$

(i)
Antenna amplifier gain G_1 = 7 dB = 5 and
F_1 = 1 + 100/290 = 1.345
Receiver F_2 = 2 dB = 1.585
Hence F = 1.345 + (1.585 – 1)/5 = 1.462 = 1.65 dB

(ii)
Add lossy cable $$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2}$$

Antenna amplifier gain G_1 = 5 and F_1 = 1.345
Receiver F_3= 2 dB = 1.585
Lossy cable F_2 = 3 dB = 2 and G_2 = -3 dB = 0.5
Hence F = 1.345 + (2 – 1) / 5 + (1.585 – 1)/(5x0.5) = 1.8
F = 2.5 dB **7 marks**

(c) Because of operating frequency and bandwidth limitations, payloads typically employ polarisation frequency reuse schemes to maximize the system capacity.
frequency reuse is accomplished by using orthogonally polarized beams

- linear polarization schemes use vertical and horizontal electric field (e-field) beams
- circular polarization schemes use left and right hand circularly rotating e-field beams
- Alternatively spatial reuse is possible – multiple beams to earth can use same frequency if beams do not overlap or if they do on a cell type system can still be reused but less often.

6 marks

Question 3

a) Attenuation and dispersion **2 marks**

b)
i. 1550 nm as optical amplification is available and fibre has lower loss
ii. laser – narrow spectral bandwidth
iii. APDs – more sensitive
iv. optical amps have much wider bandwidth
v. coherent detection – more sensitivity **5 marks**

c)
(i) Power budget: $P_T = P_R + (\alpha_{fc} + \alpha_j)L + L_c + M$
$5 = -60 + (2 + 0.2)L + 2x3 + 10$ **3 marks**
hence L = 49/2 = 22.3 km

(ii) Dispersion over length L, $\tau = 0.7 \times 20.1 = 15.61$ ns **3 marks**
Max bite rate $B_T = 1/2\tau$ = 32 Mb/s

(iii)
Commonly used criterion is that broadening $\Delta t \leq T_B/4$
$\Delta t = L\Delta\lambda\ D(\lambda)$
$L\Delta\lambda\ D(\lambda) \leq T_B/4$
$BL\Delta\lambda\ D(\lambda) \leq 1/4$
$BL=1/[4\ \Delta\lambda\ D(\lambda)]$
Note: $\Delta\lambda\ D(\lambda)$ often quoted as dispersion in ns/km

So bit rate - length product is $B \times L = 1/(4\ \Delta\lambda\ D(\lambda))$ MHz.km
For a length of 20 km, B = 1/(4x0.7x20) = 17.9 MB/s. **5 marks**

d)
Dispersion constant is difficult but the line width can be narrowed. **2 marks**

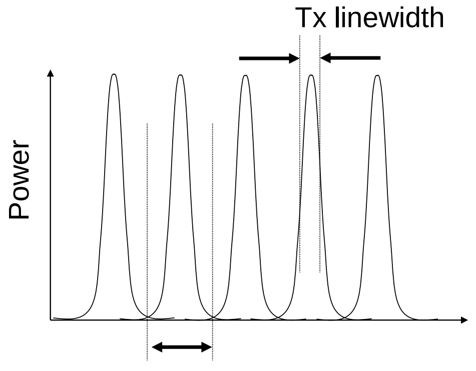
Question 4

a.

i.

<u>Wavelength Division Multiplexing</u>

Many channels can be deployed massively increasing available bandwidth of one fibre



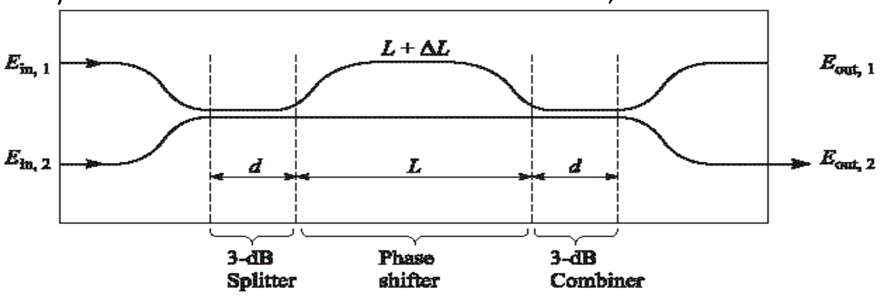
Coarse – CWDM – large spacing between channels compared to laser linewidth (~10nm)

Dense – DWDM – small spacing between channels (~<1nm)
High capacity 256 channels

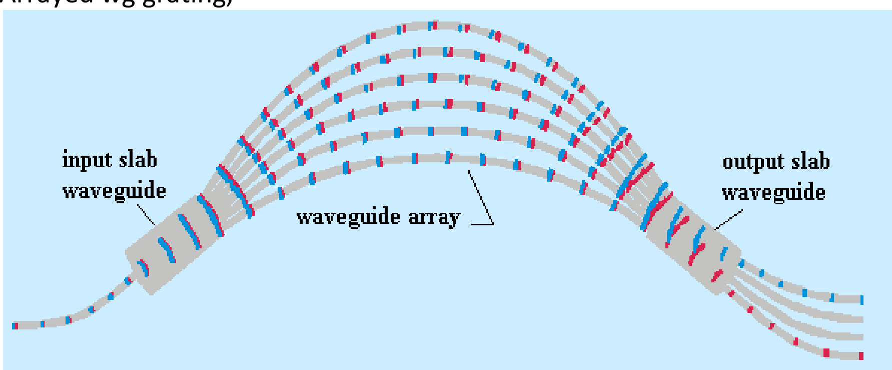
2 marks

ii.

Many devices such as Mach-Zender interferometer,



Arrayed wg grating,

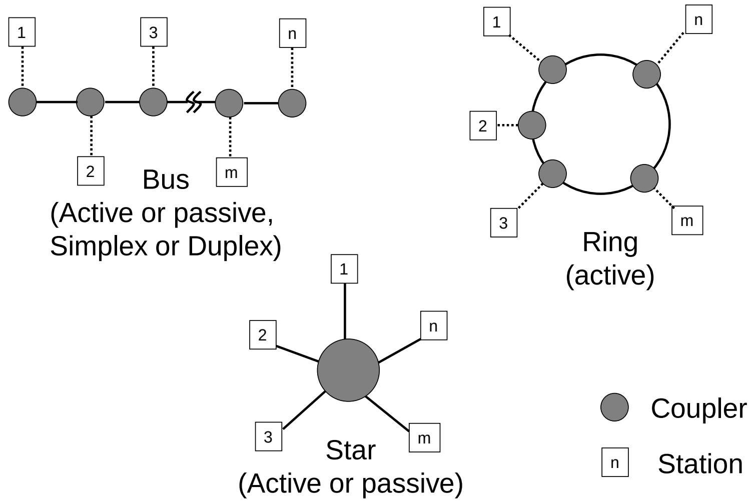


Diffraction grating, interferometer with Fibre bragg grating. **8 marks**

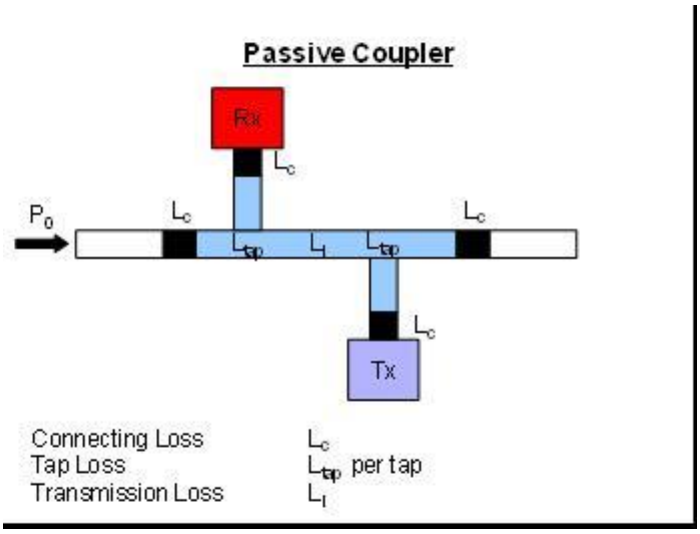
b.

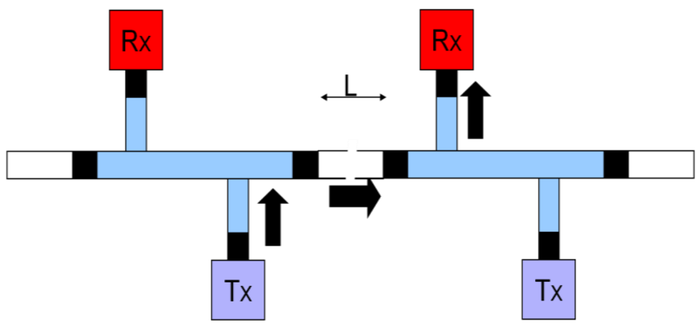
<u>Bus network</u>

Topologies for Fiber Optic Networks



2 marks





Candidates need to know how couplers work and losses associated with them

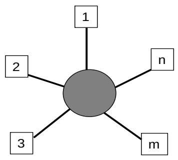
Connecting Loss L_c

Tap Loss (coupling) L_{tap} per tap,

Intrinsic Transmission Loss L_i

Loss Between Nearest Neighbours Tx-Rx
= $\alpha L + 2L_{tap} + 4L_c + 2L_i$ (α L=fibre loss/m)
Loss Between station 1 and N
2 Connectors per station – intrinsic loss at each station
@ transmitting and detector ends– one tap loss
@ intermediate stations – one L_{thru} losses
<u>Total Loss = $(N-1)\alpha L + 2NL_c + 2L_{tap} + (N-2)L_{thru} + NL_i$</u>

Star Network – Losses and Power Budget



Star Coupler - Splitting Loss L_{split} = 10logN

In doing so there is an excess loss L_{excess}

Connector at Transmitter and Receiver

All stations L km from Coupler

Total Loss = $2\alpha L + 2L_c + 10\text{Log}N + L_{excess}$

6 **marks**

Star network loss = 2x0.4/2 + 2 + 10 + 2 = 14.4 dB
Bus loss = 9x0.4/2 + 2x10x1 + 2x10 + 8x0.9 + 10x0.5 = 54 dB **2 marks**