EEE442/6420 Exam solutions 2010

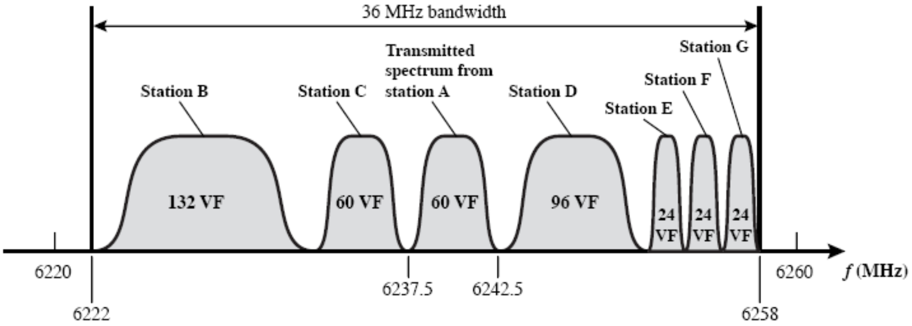
Q1 a.

FDMA uses multi-destination carriers, each earth station pre-assigned carrier and bandwidth according to traffic requirements.

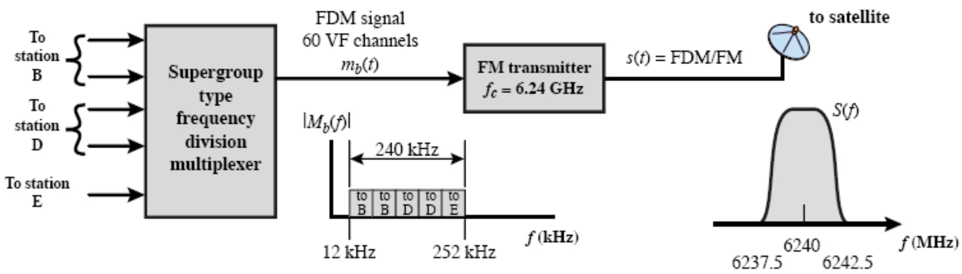
Channels transmitted regardless of destination.

Distant earth stations receive all carriers and select only those wanted by filtering.

Smaller channel assignments need proportionally more bandwidth. FDM/FM signals.



(a) Transponder uplink frequency allocation



(b) Station A ground transmitting equipment

TDMA - Different stations assigned different time slots – digital – uses entire transponder bandwidth – operation and control complex – global clocks needed for synchronisation – only 1 carrier at transponder at any time – no IM products – TWT operates at saturation maximising C/N and efficiency.

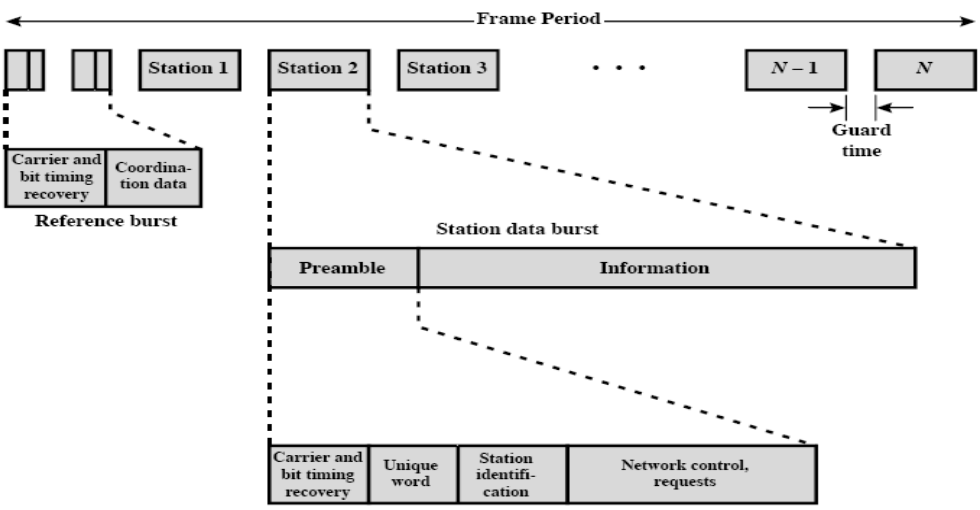


Figure 9.13 Example of TDMA Frame Format

CDMA most used for satellite mobile links.

b.
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 = P_e + 0 dB
L_u = 92.5 + 20log800 + 20 log 1.6 = 92.5 + 58.06 + 4.08 = 154.64 dB

Satellite antenna gain = $4\pi A\eta/\lambda^2$ = 4π. π.0.5.0.5.0.8/0.1875^2 = 225 = 23.52 dB

Receiver noise = kTB = N_u
Temp T = antenna noise temp + (F-1)290 = 500 + 290 = 790 K
N_u = kTB = 1.38 x 10^{-23} x 790 x 150000 = 1.63 x 10^{-15} W = -147.9 dBW

Hence uplink equation gives 10 = Pe – 154.64 -15 + 23.52 + 147.9 = Pe +1.78
Pe = 8.22 dBw = 6.6 W

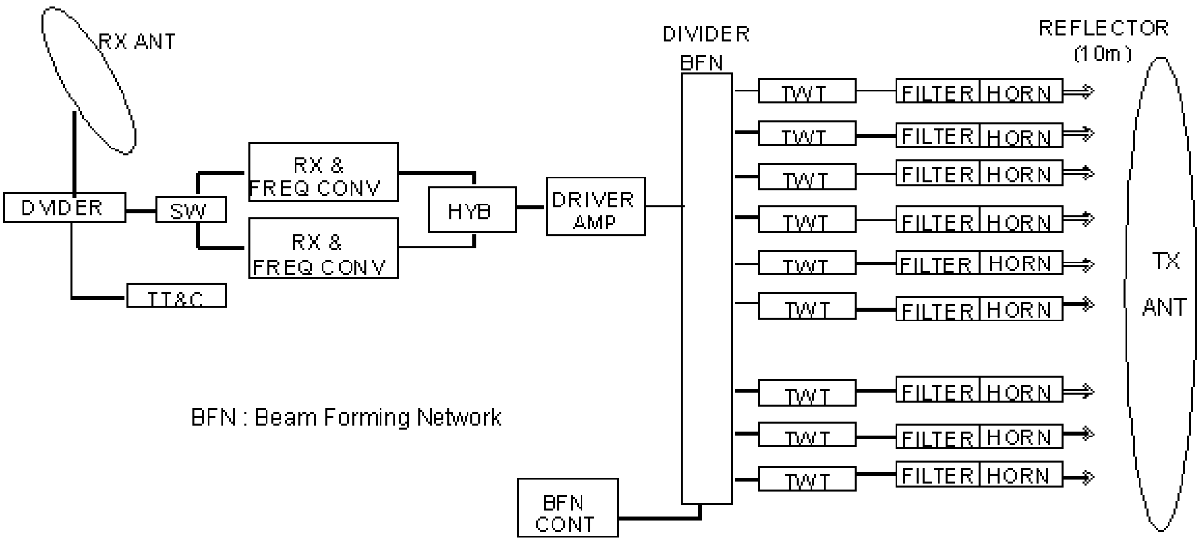
(12)

Large power from handset so battery will deteriorate rapidly.

Q2.
a.
Main Advantages
- Extend capability of existing terrestrial cellular system
- Coverage in remote locations
- Large coverage area
- Seamless service to subscriber in any part of the world

Challenges
- Propagation delay
- Attenuation – path loss 200 dB
- Low Spectral efficiency
- Costs – $100M+
- Power limited
- Reliability – 10 years + lifetime (5)

b.



Students should describe the antennas, low noise front end, frequency conversion mixers, power amps and reliability,

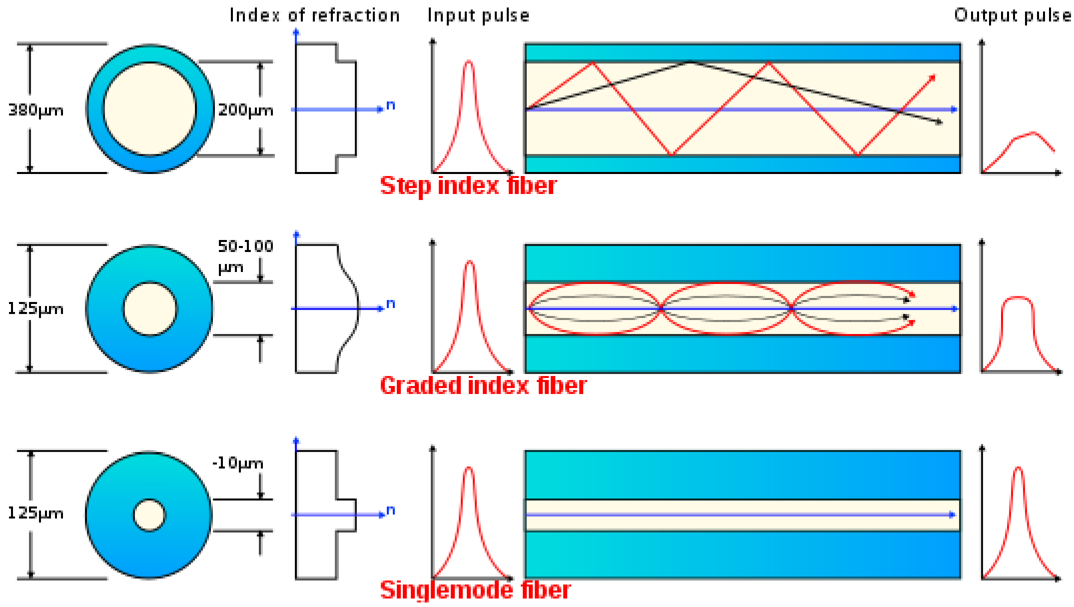
8 marks

c.
Operating frequency:
path loss,
depolarisation below 1 GHz Faraday rotation,
depolarisation due to rain,
atmospheric attenuation – rain, molecular absorption, 4 marks

d.
Increase antenna gain, eirp greater.
Increase frequency 3 marks
Frequency reuse – dual polarisation

Q3

a.



(3)

b.

Single mode fibres - no intermodal dispersion, hence more bandwidth
Advantages – multimode fibres
easier to launch optical power into fibre due to larger core radius
easier to connect fibres together
light can be launched using an LED whereas Single mode fibres need a laser
Disadv – intermodal dispersion reduces bandwidth
GI fibres reduce intermodal dispersion.

(6)

c.

(i) Power budget: $P_T = P_R + (\alpha_{fc} + \alpha_j)L + L_c + M$
 $1 = -50 + (2 + 0.2)L + 2x4 + 10$ (4)
<u>hence L = 15 km</u>

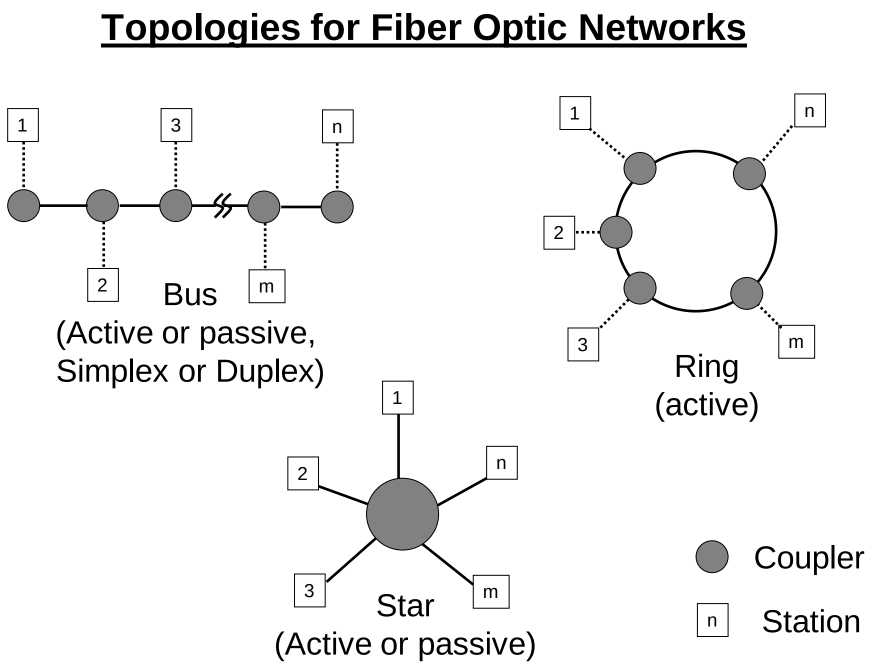
(ii) Dispersion over length L, $\tau = 0.7 \times 15 = 10.5$ ns (3)
Max bite rate $B_T = 1/2\tau =$ <u>47 Mb/s</u>

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

So bandwidth- length product is $B \times L = 1/(4\ \Delta\lambda\ D(\lambda))$ MHz.km
<u>For a length of 30 km, B = 1/(4x0.7x30) = 11.9 MHz.</u>

Q4

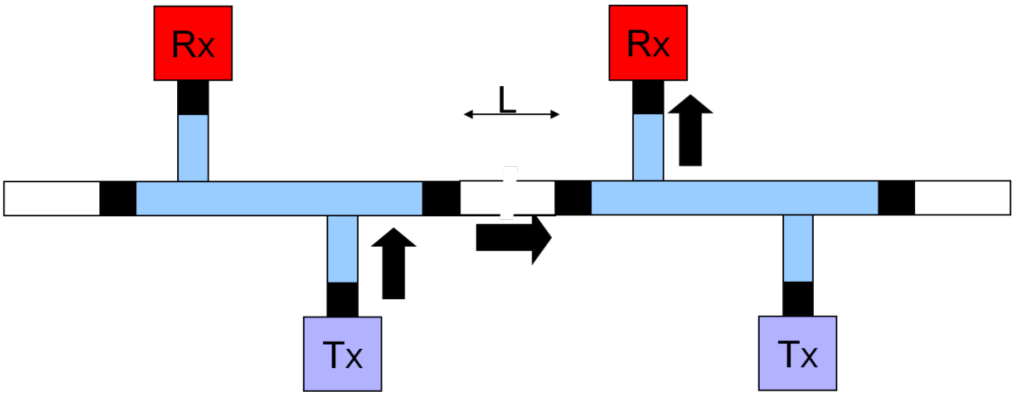
a.



(6)

Star network has much lower losses as the number of stations increases (1)

b.



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> (8)

Detector used in Bus system will detect a large power at station 1 than at station N
The Detector must have a dynamic range equal to that of the Bus system = ratio of power levels received at station 1 and station N
In DB = difference between nearest neighbour and longest length power budget
Dynamic Range = $(N-2)(\alpha L + 2L_c + L_{thru} + L_i)$

Now Tap loss L_{tap} = 10 dB = 10, hence CT = 0.1 and
$L_{thru} = -10 \log (1-C_T)^2 = -20 \log(1-C_T)$ dB = 0.9 dB

Connector loss L_c = 1 dB
Intrinsic transmission loss L_i = 0.5 dB

<u>Hence Dynamic range = 8 x (0.4x0.5 + 2x1 + 0.9 + 0.5) = 8 x 3.6 = 28.8 dB</u> (5)