

Lab 7

Data Communications

* ch #6 *

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⇒ P6.1 :

$$BW = 4k.$$

multiplex 10 channels with guard bands of 500 Hz.

required BW = ??

Sol :

→ 10 channels ⇒ 9 guard bands

$$\rightarrow BW = 4k \times 10 + 500 \times 9 = \boxed{44.5 \text{ kHz}}$$

channels can be separated by strips of unused bandwidth (guard band)

guard bands are used to prevent signals from overlapping.

⇒ P6.2 :

transmit 100 digitized voice channels using passband channel of 20 kHz.

ratio of bits / Hz ?

Sol

→ BW allocated to each voice channel is $\frac{20k}{100} = \boxed{200 \text{ Hz}}$

→ As we saw in previous chapters, each digitized

$$\text{voice channel} \Rightarrow N = 8000 \text{ sample} \times 8 \frac{\text{bit}}{\text{sample}} = \boxed{64 \text{ kbps}}$$

$$\Rightarrow \text{ratio} = \frac{64000}{200} = \boxed{320} \text{ bits/Hz.}$$

⇒ P6.3:

Figure 6.9, Find overhead (extra bandwidth for guard band or control) in each hierarchy level.

Sol: حل: مستويات التسلسل الهرمي

total for group level

Group level: overhead = $48k - (12 \times 4k) = \boxed{0} \text{ Hz}$

Supergroup: overhead = $240k - (5 \times 48k) = \boxed{0} \text{ Hz}$

Master group: overhead = $2.52M - (10 \times 240k) = \boxed{120 \text{ kHz}}$

Jumbo group: overhead = $16.984M - (6 \times 2.52M) = \boxed{1.864 \text{ MHz}}$

⇒ P6.4:

use Synchronous TDM and combine 20 digital sources, each of 100 kbps. each output slot carries 1 bit for each digital source. one extra bit is added to each frame for sync.

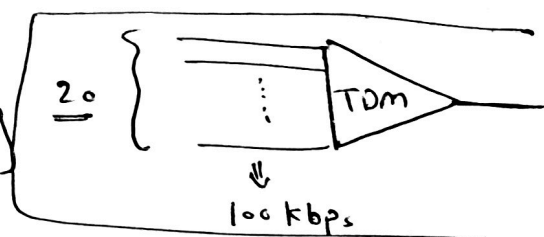
(a) size of output frame in bits?

Sol

→ frame size = $20 + 1 = \boxed{21 \text{ bits}}$

digital source

one extra bit



(b) output frame rate?

Sol

→ each frame carry 1 bit from each digital source

∴ $\boxed{\text{rate} = 100 \text{ k frames/s}}$

© duration of an output frame ?

Sol:

$$\text{Duration} = \frac{1}{\text{Frame rate}} = \frac{1}{100 \text{ k}} = \boxed{10 \mu\text{s}}$$

① output data rate ?

Sol:

$$\begin{aligned} \text{Data rate} &= \text{Frame rate} \times \frac{\text{bits}}{\text{Frame}} \rightarrow (\text{Frame size}) \\ &= 100 \text{ k} \times 21 = \boxed{2100 \text{ kbps}} \end{aligned}$$

② efficiency of the system (ratio of useful bits to the total bits)?

Sol:

(20 bit of each frame)

$$\text{efficiency} = \frac{\text{useful bits}}{\text{total bits}} = \frac{20}{21} = \boxed{0.9523}$$

21 bits,
one bit actually
send per frame.

$$\begin{aligned} \text{percent} &= 0.9523 \times 100\% \\ &= \boxed{95\%} \end{aligned}$$

⇒ P6-5: Repeat 6-4 if each output slot carrier 2 bit from each source.

Sol:

2 bit from each digital source

① frame size = $\frac{20}{\downarrow} \times 2 + 1 = \boxed{41 \text{ bits}}$

(20 digital source) (extra bit)

② frame rate = ??

⇒ each frame carrier 2 bits from each source.

$$\text{Frame rate} = \frac{100 \text{ k}}{2} = \boxed{50,000 \text{ frames/s}}$$

$$c) \text{ Frame duration} = \frac{1}{\text{Frame rate}} = \frac{1}{50,000} = \boxed{20 \mu s}$$

$$d) \text{ Data rate} = \text{Frame rate} \times \text{Frame size} \\ = 50,000 \times 41 \\ = \boxed{2.0 \text{ Mbps}}$$

$$e) \text{ efficiency} = \frac{40}{41} \times 100 \% = \boxed{97.5 \%}$$

P6-6: $\Rightarrow$ 14 sources, each creating 500 8-bits char. per second.
 $\Rightarrow$ Statistical TDM. $\rightarrow$ Some of it are active.
 $\Rightarrow$ each frame carrier 6 slots at time.
 $\Rightarrow$ we need to add 4-bit addresses to each slot.

a) size of output frame is bits?

Sol:

$$\text{Frame size} = (\# \text{ of slots}) \times (\text{char. size} + \text{slot address})$$

$$= 6 \times (8 \text{ bits} + 4 \text{ bits})$$

$$= \boxed{72 \text{ bits}}$$

b) output frame rate?

Sol: we can assume that we have only 6 inputs.
 each frame needs to carry one char. from each line.

$$\therefore \text{Frame rate} = \boxed{500 \text{ frames/s}}$$

(4)

© duration of output frame?

Sol:

$$\text{Frame duration} = \frac{1}{\text{Frame rate}} = \frac{1}{500} = \boxed{2\text{ms}}$$

④ output data rate?

Sol:

$$\begin{aligned} \text{Data rate} &= \left(500 \frac{\text{frames}}{\text{s}}\right) \times \left(72 \frac{\text{bits}}{\text{frame}}\right) \\ &= \boxed{36\text{kbps}}. \end{aligned}$$

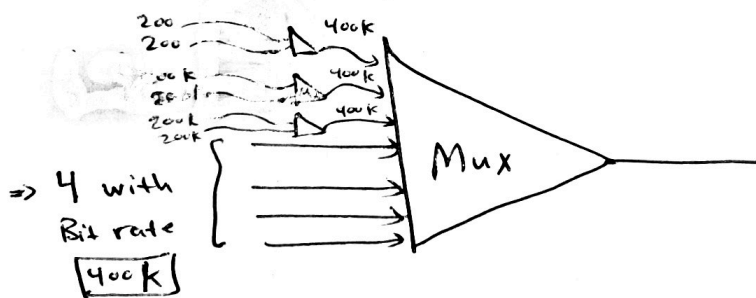
⇒ P6-7: → Ten sources
 → Six with $N = 200\text{ kbps}$,
 → Four with $N = 400\text{ kbps}$.

those combined using multilevel TDM with no syn.

① Size frame? ^{Data rate of sources}

Sol:

⇒ We combine
Six 200-kbps
Source into
three 400 kbps.



∴ we have 7 400 kbps channel.

$$\text{frame size} = 7 \times 1 = \boxed{7\text{bits}} \#$$

② Frame rate.

Sol:

$$\text{Frame rate} = \boxed{400\text{ k frames/s}}$$

(c) Duration of frame?

Sol:

$$\text{Frame duration} = \frac{1}{\text{Frame rate}} = \frac{1}{400,000} = \boxed{2.5 \mu\text{s}}$$

(d) Data rate?

Sol:

$$\begin{aligned} \text{Data rate} &= \overset{\text{rate}}{400,000 \frac{\text{frames}}{\text{s}}} \times \overset{\text{size}}{7 \frac{\text{bits}}{\text{frame}}} \\ &= \boxed{2.8 \text{ Mbps}} \end{aligned}$$

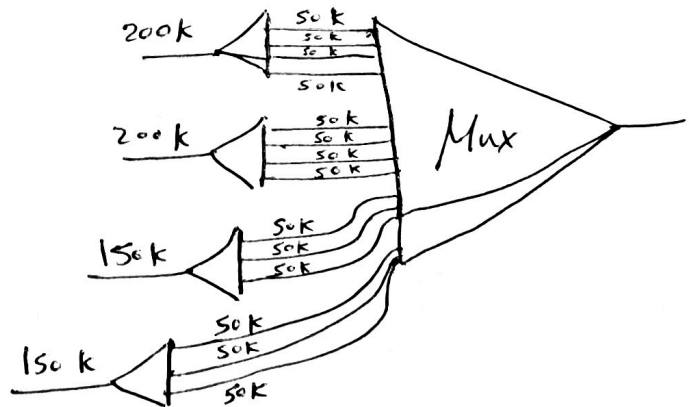
⇒ P6-8: 4 channels, two with bit rate 200 Kbps, and two with bit rate 150 Kbps, are to be multiplexed using multiple-slot TDM with no syn. bit.

(a) Size of a frame in bits?

Sol:

⇒ Divide all of them into 50 Kbps lines.

⇒ Frame size = 14 bits.



(b) Frame rate?

Sol: → 14 input lines of 50K, one bit from each per frame.

$$\therefore \text{Frame rate} = \boxed{50 \text{ kbps}}$$

© Duration of frame ?

Sol:

$$\text{Frame duration} = \frac{1}{\text{frame rate}} = \frac{1}{50k} = \boxed{20 \mu s}$$

④ data rate ?

Sol:

$$\text{Data rate} = 50k \times 14 = \boxed{700 \text{ kbps}}$$

⇒ P6-9: Two channels, one with a bit rate of 190 kbps & another with bit rate of 180 kbps. using pulse-stuffing TDM & no syn. bits

① Size frame in bits ?

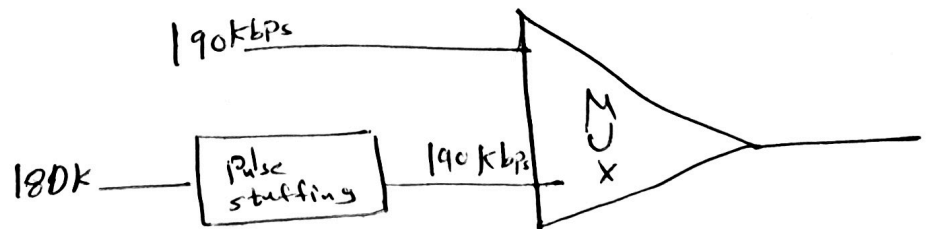
Sol:

④ extra bits نقص
في معدل البت
لأنه bit rate

⇒ we need to add extra bits to make both its bit rates = 190 kbps.

Now, we have two sources, each 190 kbps.

④ data unit وحدة
في طرف آخر
one bit



$$\boxed{\text{Frame size} = 2 \text{ bits}}$$

#

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(b) frame rate ?

SS:

$$\text{Frame rate} = 190 \text{ frames/s}$$

(c) duration of a frame ?

SS:

$$\text{Frame duration} = \frac{1}{\text{frame rate}} = \frac{1}{190 \text{ k}} = \boxed{5.26 \mu\text{s}}$$

(d) data rate ?

SS:

$$\text{Data rate} = 190 \text{ k} \times 2 = \boxed{380 \text{ kbps}}$$

$\Rightarrow$ P6-10 : T-1 line :

(a) duration of a frame ?

SS:

$\rightarrow$ T-1 line sends 8000 frames/s.

$$\rightarrow \text{Frame duration} = \frac{1}{8000} = \boxed{125 \mu\text{s}}$$

(b) overhead (number of extra bits per second) ?

SS:

$\rightarrow$ Each frame carries one extra bit.

$$\therefore \text{Overhead} = 8000 \times 1 = \boxed{8 \text{ kbps}}$$

⇒ P 6.11: Show the contents of the five output for a Sync. TDM multiplexer that combines four sources sending the

Following characters. Note that the characters are sent in the same order that they typed. The third source is silent.

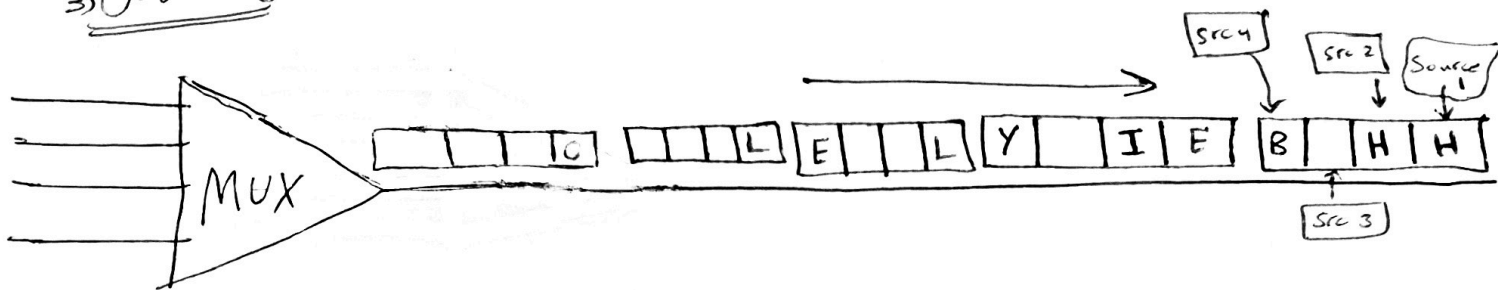
(a) Source 1 message: HELLO

⑥ Source 2 message: HI .

© Source 3 message:

④ Source 4 message: BYE.

3) Solution:

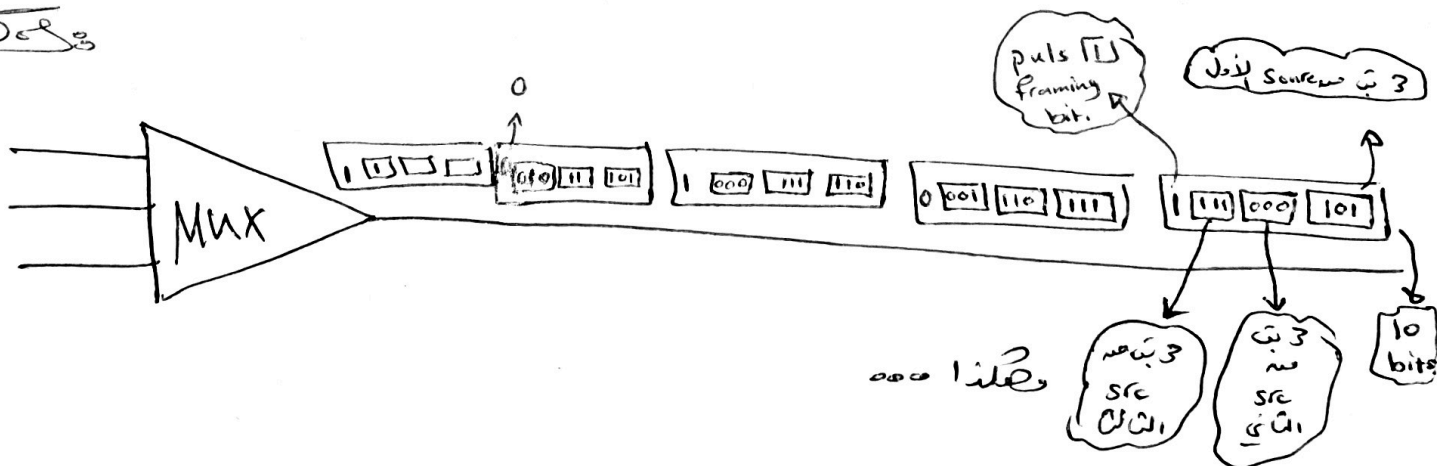


⇒ P6.12 : Sync. TDM system. Each output slot is only 10 bits long (3 bits taken from each input plus 1 framing bit).

→ What is the output stream?

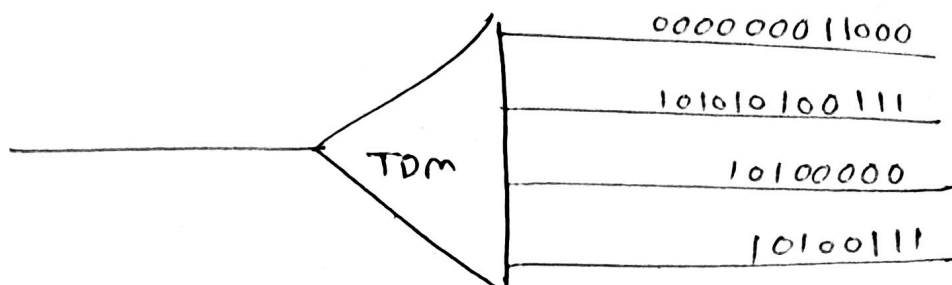
⑤ The bits arrive at the multiplexer as shown by the arrows.

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⇒ P 6-13 : demultiplexer in sync. TDM if input slot is 16 bits long (no framing bits), what is the bit stream in each output?

⇒ Sol :



⇒ P 6-14 :

Figure 6.23 :

What the overhead (number extra bits) :-

① In DS-1 service?

⇒ Sol :

$$1.544 \text{ Mbps} - (24 \times 64 \text{ kbps}) = 8 \text{ kbps}$$

$\uparrow$ In DS-1 $\downarrow$ From DS-0

② In DS-2 service?

⇒ Sol :

$$6.312 \text{ Mbps} - (4 \times 1.544 \text{ Mbps}) = 136 \text{ kbps}$$

$\downarrow$ In DS-2 $\downarrow$ From DS-1

③ In DS-3 service?

⇒ Sol :

$$44.376 \text{ M} - (7 \times 6.312 \text{ M}) = 192 \text{ kbps}$$

④ In DS-4 service?

⇒ Sol

$$247.176 \text{ M} - (6 \times 44.376 \text{ M}) = 7.92 \text{ Mbps}$$

⇒ P. 15 : minimum number of bits in a $PN^{\rightarrow \text{Pseudorandom noise}}$ sequence if use FHSS with channel BW of $B = 4\text{kHz}$ & $B_{ss} = 100\text{k}$?

⇒ Sol:

$$\text{The number of hops} = \frac{100\text{ k}}{4\text{ k}} = \boxed{16 \text{ cycles}}.$$

$$\text{So, we need } \log_2 25 \approx \boxed{5 \text{ bits}}.$$

⇒ P. 16 : FHSS system uses a 4 bit PN sequence.

IF bit rate of the PN is 64 bits per seconds.

① total possible channels?

⇒ Sol:

$$2^4 = \boxed{16} \text{ channels.}$$

② What the time needed to finish a complete cycle of PN ?

⇒ Sol:

$$\frac{64 \text{ bits/s}}{4 \times 16} = \boxed{1 \text{ s}}.$$

⇒ P6.17: pseudorandom generator uses the following formula to create a random series:

$$N_{i+1} = (5 + 7N_i) \bmod 17 - 1$$

→ In Which N_i defines the current random number and N_{i+1} defines the next random.

→ The term mod means the value of the remainder when dividing $(5 + 7N_i)$ by 17.

→ Show the sequence created by this generator to be used for spread spectrum.

Sol:

⇒ Random numbers: 11, 13, 10, 6, 12, 3, 8, 9 :

$$i=0, N_1 = \boxed{11}$$

$$i=1 \Rightarrow N_2 = (5 + 7 \times 11) \bmod 17 - 1 = \boxed{13}$$

$$i=2 \Rightarrow N_3 = (5 + 7 \times 13) \bmod 17 - 1 = \boxed{10}$$

$$i=3 \Rightarrow N_4 = (5 + 7 \times 10) \bmod 17 - 1 = \boxed{6}$$

$$i=4 \Rightarrow N_5 = (5 + 7 \times 6) \bmod 17 - 1 = \boxed{12}$$

$$i=5 \Rightarrow N_6 = (5 + 7 \times 12) \bmod 17 - 1 = \boxed{3}$$

$$i=6 \Rightarrow N_7 = (5 + 7 \times 3) \bmod 17 - 1 = \boxed{8}$$

$$i=7 \Rightarrow N_8 = (5 + 7 \times 8) \bmod 17 - 1 = \boxed{9}$$

$$i=8 \Rightarrow N_9 = (5 + 7 \times 9) \bmod 17 - 1 = \boxed{-1} \quad \dots (12)$$

القيمة
بالأسفل
في جوف
##

⇒ P6.18 :-

→ data rate = 10 Mbps.

→ How many 64-kbps voice channel
can be carried by this medium if we
use DSSS with the Barker sequence?

⇒ Sol :-

→ Barker chip is 11 bits, which mean that it
increases the bit rate (11) times.

→ Voice channel of 64 kbps needs → $11 \times 64k$
= 704 kbps

∴ bandpass channel can carry :

$$\frac{10 \text{ Mbps}}{704 \text{ kbps}} \approx \boxed{14 \text{ channels}}$$

* End of ch 6 *