

DIGITAL COMMUNICATIONS

Lecture (5-1): TDM - Tutorial

Example 1:

The following signals are sampled each at its Nyquist rate and multiplexed and transmitted by using TDM:

S1(t) bandlimited to 1.8 KHz

S2(t) bandlimited to 3.6 KHz

S3(t) bandlimited to 0.6 KHz

S4(t) bandlimited to 0.6 KHz

S5(t) bandlimited to 0.6 KHz

Solution:

number of pieces

Fs for S1(t) = $2 \cdot f_{\max} = 2 \cdot 1.8 = 3.6 \text{ KS/sec}$ 3

Fs for S2(t) = $2 \cdot f_{\max} = 2 \cdot 3.6 = 7.2 \text{ KS/sec}$ 6

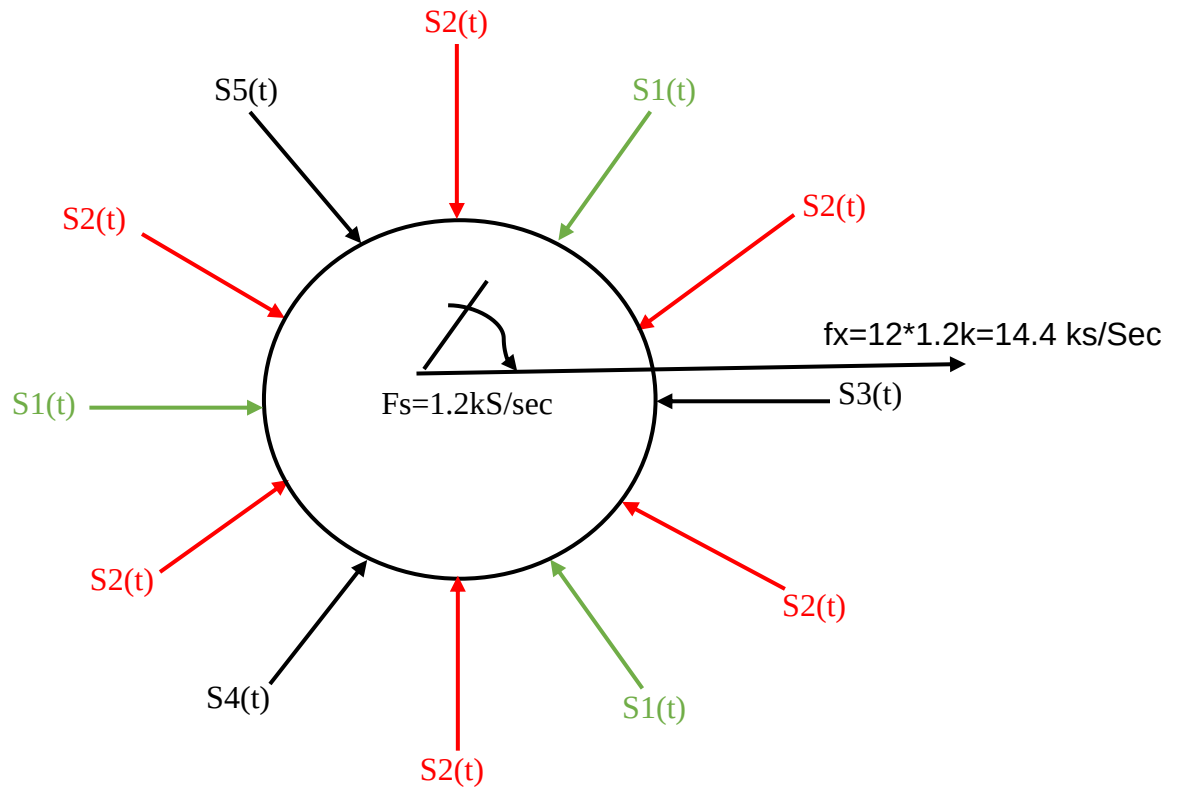
Fs for S3(t) = $2 \cdot f_{\max} = 2 \cdot 0.6 = 1.2 \text{ KS/sec}$ 1

Fs for S4(t) = $2 \cdot f_{\max} = 2 \cdot 0.6 = 1.2 \text{ KS/sec}$ 1

Fs for S5(t) = $2 \cdot f_{\max} = 2 \cdot 0.6 = 1.2 \text{ KS/sec}$ 1

The sum of pieces = 12

$12/3=4$, $12/6=2$, $12/1=12$



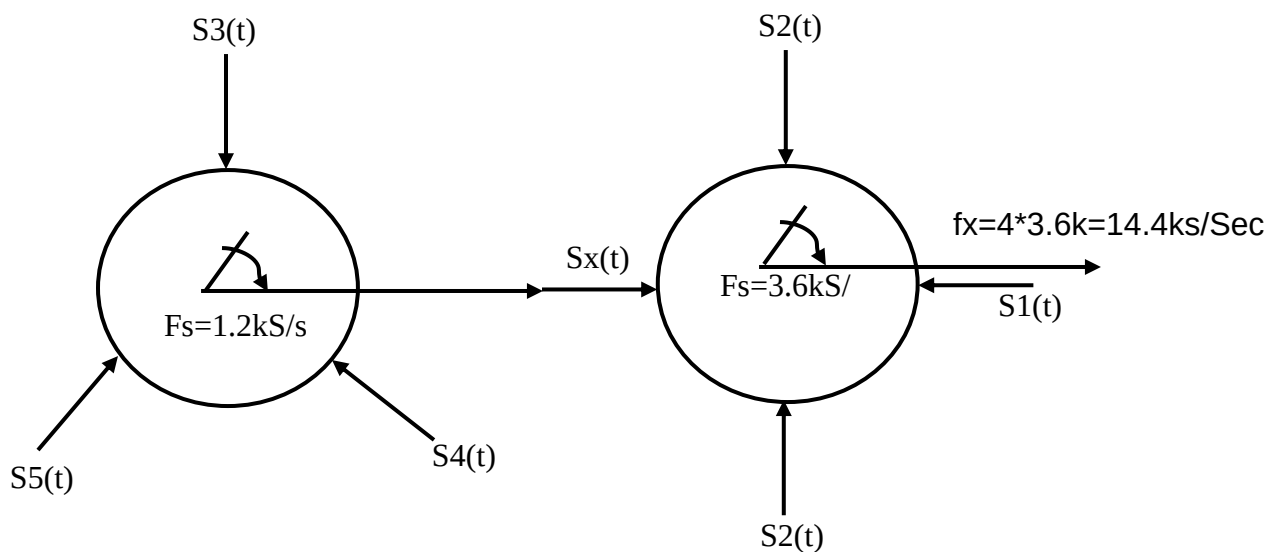
$$T_s = 1/1.2$$

$$T_x = (1/1.2)/12 = 1/14.4 \text{ msec}$$

$$F_x = 14.4 \text{ K S/sec}$$

$$BW = \frac{1}{2} f_x = \frac{1}{2} * 14.4 = 7.2 \text{ KHz}$$

Other solution:



$$T_s = 1/3.6$$

$$T_x = (1/3.6)/4 = 1/14.4 \text{ msec}$$

$$F_x = 14.4 \text{ K S/sec} \quad (\text{Or} \quad F_x = F_s * \text{number of pieces} = 3.6 * 4 = 14.4 \text{ KS/sec})$$

$$BW = \frac{1}{2} f_x = \frac{1}{2} * 14.4 = 7.2 \text{ KHz}$$

Example 2:

The following signals are sampled each at its Nyquist rate and multiplexed and transmitted by using TDM:

$S_1(t)$ bandlimited to 4.8 KHz

$S_2(t)$ bandlimited to 2.4 KHz

$S_3(t)$ bandlimited to 0.6 KHz

$S_4(t)$ bandlimited to 0.6 KHz

$S_5(t)$ bandlimited to 0.6 KHz

$S_6(t)$ bandlimited to 0.6 KHz

Solution:

number of pieces

$$F_s \text{ for } S_1(t) = 2 * f_{\max} = 2 * 4.8 = 9.6 \text{ KS/sec} \quad 8$$

$$F_s \text{ for } S_2(t) = 2 * f_{\max} = 2 * 2.4 = 4.8 \text{ KS/sec} \quad 4$$

$$F_s \text{ for } S_3(t) = 2 * f_{\max} = 2 * 0.6 = 1.2 \text{ KS/sec} \quad 1$$

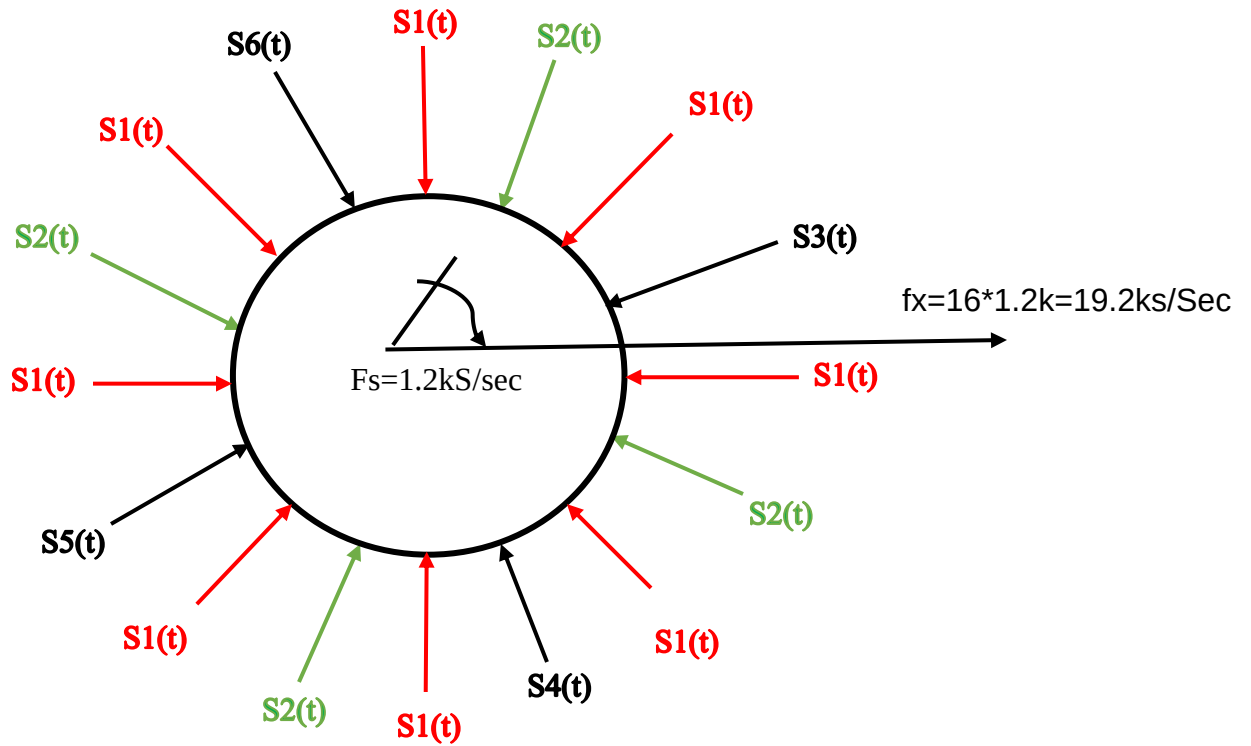
$$F_s \text{ for } S_4(t) = 2 * f_{\max} = 2 * 0.6 = 1.2 \text{ KS/sec} \quad 1$$

$$F_s \text{ for } S_5(t) = 2 * f_{\max} = 2 * 0.6 = 1.2 \text{ KS/sec} \quad 1$$

$$F_s \text{ for } S_6(t) = 2 * f_{\max} = 2 * 0.6 = 1.2 \text{ KS/sec} \quad 1$$

The sum of pieces= 16

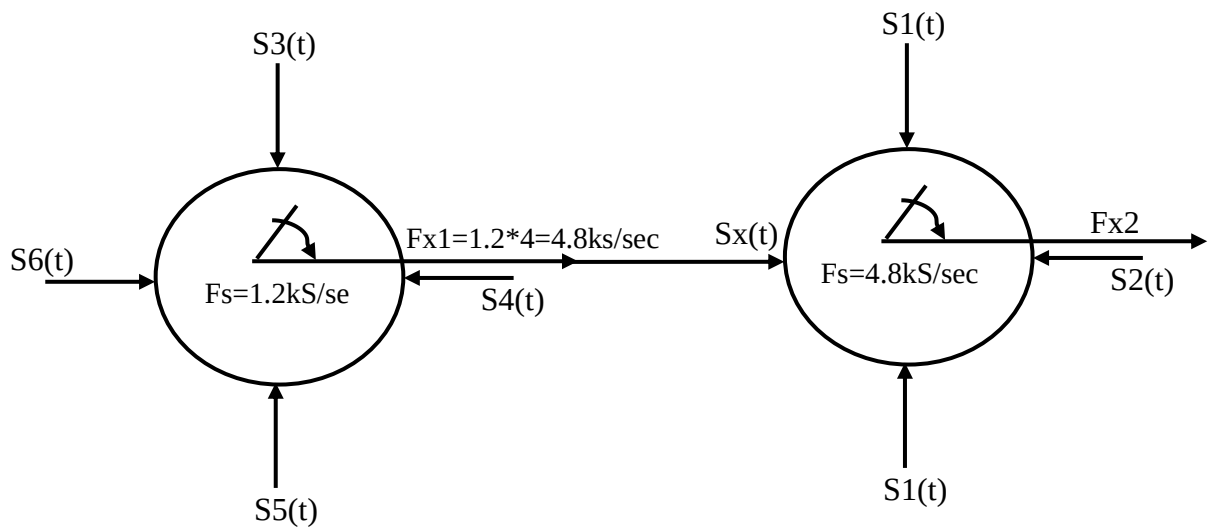
$16/8=2$, $16/4=4$, $16/1=16$



$F_x = F_s * \text{number of pieces} = 1.2 * 19 = 19.2 \text{ KS/sec}$

$BW = \frac{1}{2} f_x = \frac{1}{2} * 19.2 = 9.6 \text{ KHz}$

Other solution



$$F_{x2} = 4.8 * 4 = 19.2 \text{ KS/sec}$$

$$BW = \frac{1}{2} f_{x2} = \frac{1}{2} * 19.2 = 9.6 \text{ KHz}$$

Example 3:

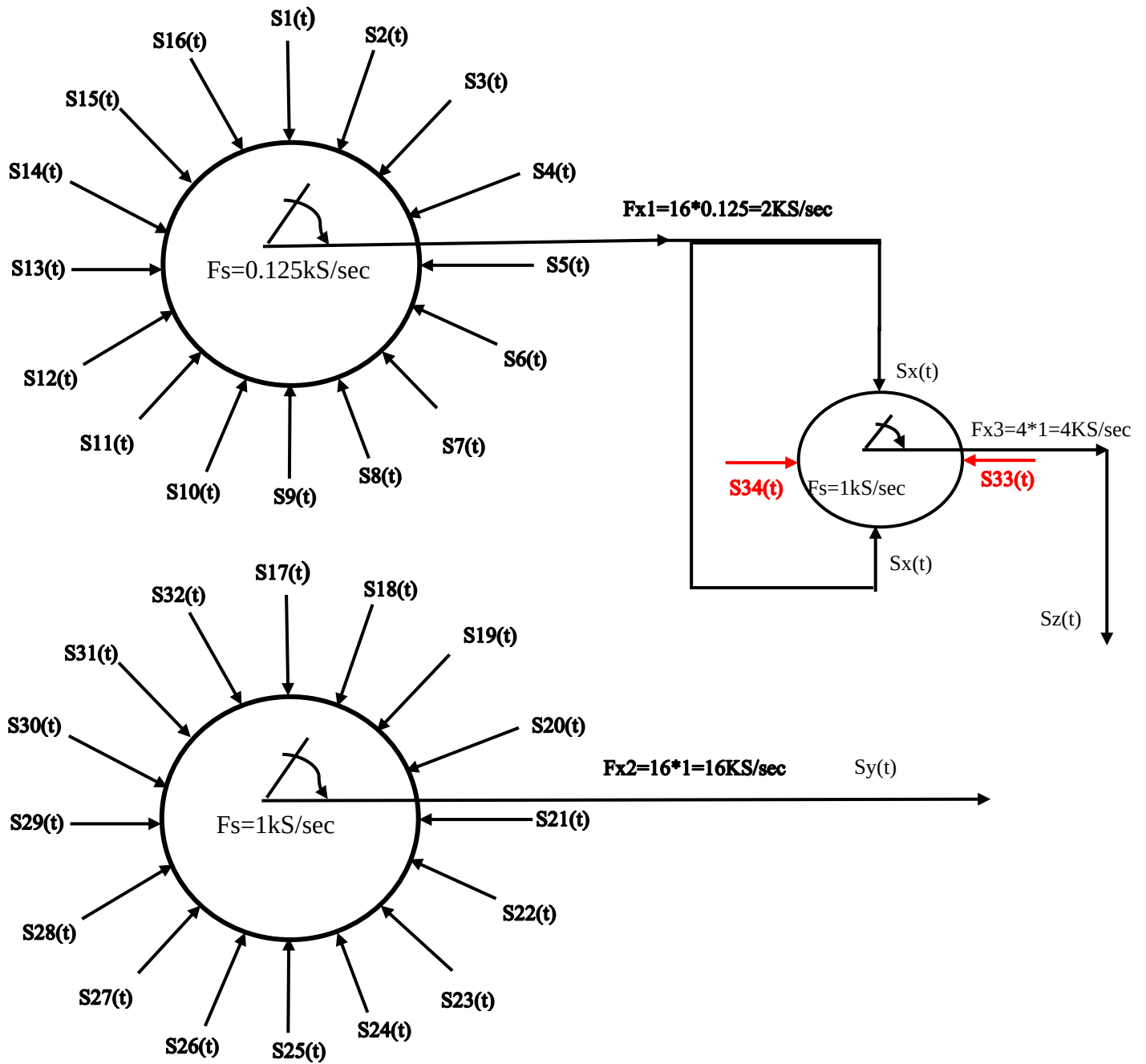
The following 36 channels are to be multiplexed using TDM:

- 1 channel sampled at 8KHz
- 1 channel sampled at 4KHz
- 18 channel sampled at 1KHz
- 16 channel sampled at 0.125KHz

Solution:

First, we notice that every channel was sampled which mean that the above frequencies given are F_s .

To solve this example, we have 16 channels sampled at 0.125KHz will sub-commutation firstly.

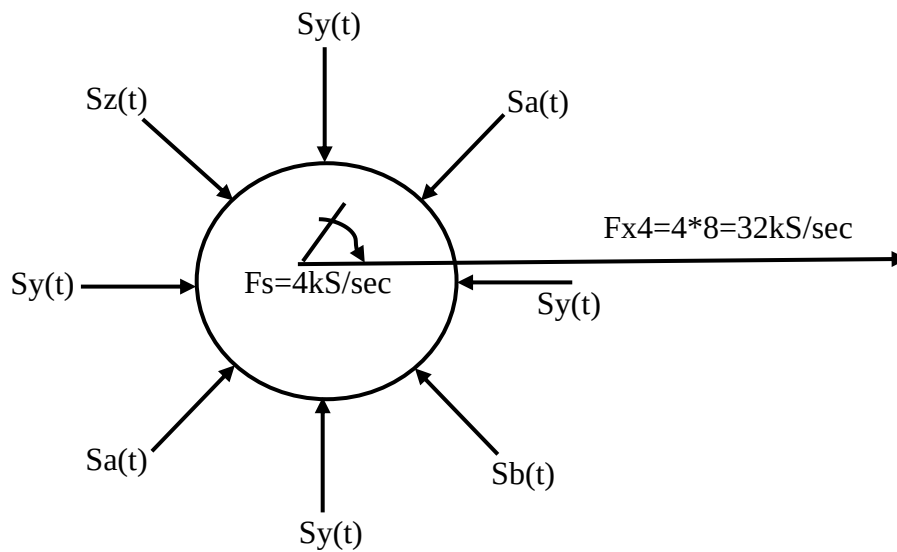


If we looking at the remaining signals and the produced signals from the above TDM system we have:

		number of pieces
1	channel sampled at 8KHz [Sa(t)]	2
1	channel sampled at 4KHz [Sb(t)]	1
1	channel sampled at 16KHz [Sy(t)]	4
1	channel sampled at 4KHz [Sz(t)]	1

The sum of pieces = 8

$$8/2=4, 8/1=8, 8/4=2$$



$$BW = \frac{1}{2} f_x 4 = \frac{1}{2} * 32 = 16 \text{ KHz}$$

If the above example was modified to be, Design TDM system to transmit these channels:

- 1 channel sampled at 8KHz
- 18 channel sampled at 1KHz
- 16 channel sampled at 0.125KHz

The solution would be the as the first part of the previous example, the difference would be in the second part:

	number of pieces
1 channel sampled at 8KHz [Sa(t)]	2
1 channel sampled at 16KHz [Sy(t)]	4
1 channel sampled at 4KHz [Sz(t)]	1

The sum of pieces = 7

We notice that the summation of pieces divisible with remainder. To solve this problem, we add an additional channel which called ground (GND) to the other channels so the sum of pieces =8

	number of pieces
1 channel sampled at 8KHz [Sa(t)]	2
1 channel sampled at 16KHz [Sy(t)]	4
1 channel sampled at 4KHz [Sz(t)]	1
1 channel GND	1

The sum of pieces = 8

