Satellite Communication

Single Channel Per Carrier

Single Channel Per Carrier (SCPC)

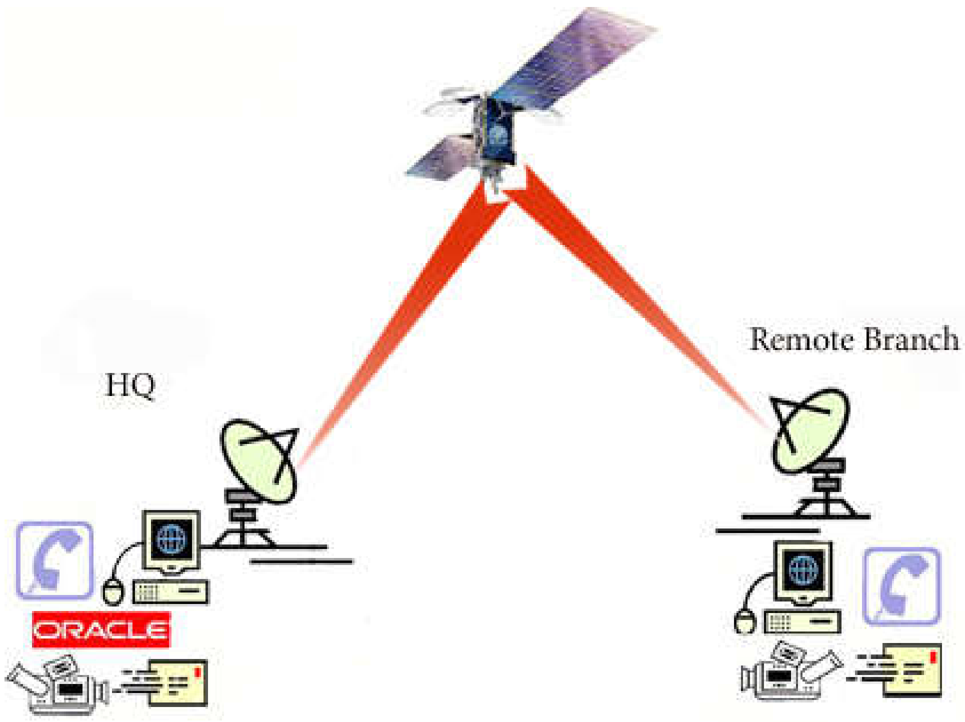
- SCPC is a satellite system that employs a separate carrier for each channel, as opposed to frequency division multiplexing that combines many channels on a single carrier.

- This technology enables companies and organizations to establish their own private network to connect sites into a single network with high reliable performance with very low latency.

SCPC Advantages

- Dedicated Space segment for the company traffic.
- Support All Servers.
- Hubless Connection A to B (No HUB involved)
- Unlimited Traffic
- No internet involve

SCPC (cont.)



SCPC (cont.)

- SCPC is widely used term in satellite communication.
- The satellite transponder will have some bandwidth and it is divided into number of carriers considering bandwidth across each carrier.
- For example C band satellite having total bandwidth of 500MHz is divided among many transponders having 36MHz bandwidth. Each transponder's band is used to carry information in the form of voice or data. This voice or data lines are called as channel.
- In this SCPC system, MUX can be configured for various bit rates as per channel and also data/voice can be configured.

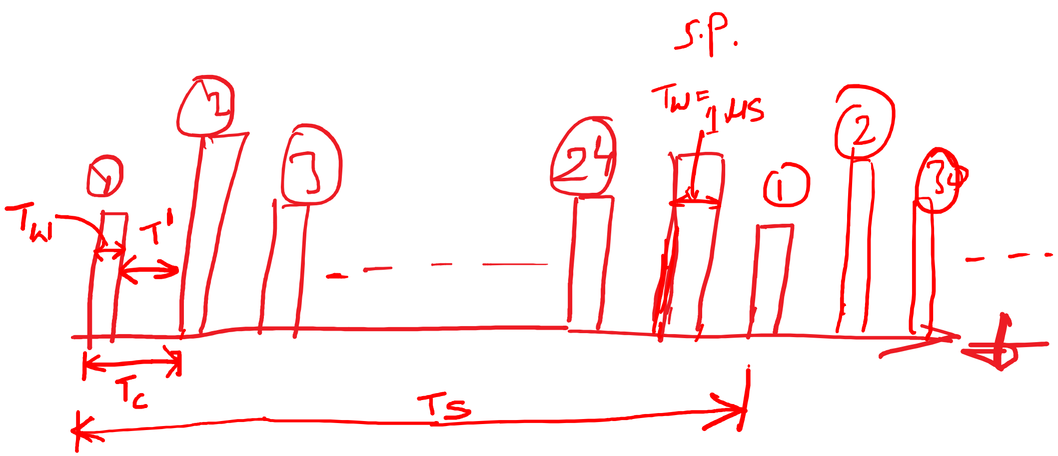
SCPC (cont.)

- As it is imperative from SCPC concept that only single channel is occupying the carrier all the time, hence it is not an efficient system in the use of satellite resource (i.e. carrier for FDMA access assignment). Hence VOX feature is enabled to save power, which will only enable RF when voice activity is detected.

- SCPC is mainly useful for defense applications requiring dedicated connection from one end to the other with encryption always enabled.

Problem:

- 24 voice signals are sampled uniformly and then time division multiplexed each sample has a duration of 1 μsec and is same as that of synchronization pulse. The highest frequency component of each voice signal is 3.4 KHz. Assuming the sampling rate of 8 KHz. Find the spacing between two successive pulses of TDM signal?



$$T' = T_c - T_W$$

$$\frac{1}{f_s} = T_s \qquad f_s \rightarrow 8\,KHz$$

$$= \frac{T_s}{M+1} - T_W \qquad T_W \rightarrow 1\,\mu sec \qquad M \rightarrow 24$$

$$= \frac{1/8K}{24+1} - 1\mu$$

$$= 4\ \mu sec.$$

Lecture 3

FDMA Capacity estimation for equal size carriers

1. Find Maximum $EIRP_{max}$ or Total $(C/No)_T$ from link transmission equation

2. Find individual carrier $EIRP_i$ or $(C/No)_i$

$$EIRP_i = \left(\frac{C}{N_0}\right)_i - \frac{G}{T} + Losses + k \quad in\ dB$$

or

$$\left(\frac{C}{N_0}\right)_i = EIRP_i + \frac{G}{T} - Losses - k \quad in\ dB$$

3. Estimate number of carriers possible from power requirement

$$10\log(n_p) = EIRP_{\max} - EIRP_i \quad \text{or} \quad 10\log(n_p) = \left\{\left(\frac{C}{N_0}\right)_T - \left(\frac{C}{N_o}\right)_i\right\}$$

Numerical value of n_p should be rounded to next lowest integer

4. Find bandwidth available for all carriers B_a.

5. Find noise bandwidth for individual carrier with modulation, filter roll off and guard band

B_i = *[(bit rate / Spectral efficiency factor of modulation) x (1 + filter roll off factor)] x (1 + guard band factor)*

6. Calculate number of carriers from bandwidth requirement

$$n_b = \frac{B_a}{B_i}$$

B_a = available bandwidth
B_i = noise bandwidth of *i-th* carrier

Numerical value of n_b should be rounded to next lowest integer

Capacity is n_p *or* n_b whichever is lower

Link is called power limited if n_p is lower

Problem:

From each station, 24 terrestrial channels are multiplexed in TDM to transmit as one carrier with QPSK modulation, Bit rate of 1.544 Mbps, 20% filter roll off factor and 20% guard band factor.

Required C/N per carrier is 5.5 dB.

Total C/No the link can support for a full transponder operation is 81 dBHz. For one transponder find,

a. number of FDMA carriers

b. total number of terrestrial channels that can be transmitted.

$B_i = 10 \log [(1.544 \times 10^6 / 2) \times (1+0.2)] \times [1+0.2]$
$= 10\log(1.112 \text{ MHz}) = 60.46 \text{ dBHz}$

$No = N/B$, $C/No = (C/N) \times B$, or $C/No = C/N + B$ in dB

$(C/N_0)_i = (C/N)_i + B_i = 5.5 + 60.46 = 65.96 \text{ dBHz}$

Number of carriers in the transponder
$= [(C/No)_t - (C/No)_i]$
$= 81 - 65.96 = 15.04 \text{ dB} = 31.91 \sim 31$ carriers

Number of channels in full transponder
= no. of TDM channels per carrier x number of carriers
= 24 x 31 = 744 channels

Problem:
A 36 MHz transponder has maximum EIRP of 50 dBw and has multiple carriers.

Receive station G/T is -10 dB/K, free space loss is 192 dB, misc. loss is 6.6. dB.

Each 10 KHz carrier needs 45 dBHz C/No.

Find number of carriers can be supported by the transponder.

Per carrier EIRP = C/No – G/T + Losses + k
= 45 - (-10) + 192 + 6.6 – 228.6 = 25 dBw

n_p in dB = Available EIRP – per carrier EIRP
= 50 – 25 = 25 dB = 316.22 ~ 316

Available bandwidth = 36 MHz = 75.56 dBHz
Per carrier bandwidth = 10 KHz = 40 dBHz

n_b in dB = Available bandwidth – bandwidth per carrier
= 75.56 – 40 = 35.56 dB = 3600

Number of carrier supported is 316

Problem:
Transponder bandwidth, EIRP are 36 MHz, 50 dBw
Receive G/T = 30 dB/K, Losses = 198.6 dB
Each carrier bandwidth = 1 MHz, C/No = 65 dBHz
Find number of carriers that can be supported.

Per carrier EIRP = 65 – 30 + 198.6 – 228.6 = 5 dBw

n_p = 50 – 5 = 45 dB = 31622.77 or 31622 carriers

n_b = 36 x 10^6 / 1 x 10^6 = 36 carriers

Transponder can support 36 carriers

Frame Efficiency of TDMA system can be estimated as,

$$\eta_f = \frac{number\ of\ useful\ bits}{number\ of\ possible\ bits} \times 100\%$$

$$= 1 - \frac{overhead\ bits}{total\ possible\ bit\ in\ a\ frame} \times 100\%$$

Total number of possible bits in a frame
= Frame time x TDMA transmission rate

Assume, in each frame,
Number of Ref. bursts = 2, Ref. burst = 576 bits,
Preamble for each user burst = 560 bits,
Guard time equivalent number of bits = 128 bits.
For 2 msec frame time and 95% frame efficiency, find number of user bursts that can be supported when TDMA transmission rate is 120 Mbps.

$$\eta_f = 1 - \frac{\textit{overhead bits}}{\textit{total possible bits in a frame}}$$

$$\begin{aligned} \textit{overhead bits} = {} & \textit{bits in reference bursts} \\ & + \textit{total preamble bits} \\ & + \textit{total guard time equivalent bits} \end{aligned}$$

$$0.95 = 1 - \frac{2 \times 576 + n \times 560 + (n+2)128}{0.002 \times 120 \times 10^6}$$

$$n = 15.3 \approx 15$$

Capacity estimation

$$Actual\ \ inf.\ rate\ \ in\ \ TDMA$$

$$= \left(\frac{Total\ number\ of\ bits\ in\ a\ frame - overhead\ bits\ in\ a\ frame}{frame\ time} \right)$$

$$= TDMA\ transmission\ rate - \left(\frac{overhead\ \ bits}{frame\ \ time} \right)$$

$$For\ all\ voice\ circuit\ case,$$

$$Number\ of\ voice\ channels\ = \frac{TDMA\ \ information\ \ rate}{\underline{voice\ \ channel\ \ bit\ \ rate}}$$

$= 64\,K\,bits$

In a TDMA system having each burst preamble = 560 bits, Reference burst size = 576 bits, no. of reference bursts = 2, Guard time = 128 bits, TDMA Transmission rate = 96.64 Mbps, voice channel rate = 64 Kbps. Find number of voice channels.

$$TDMA \quad \inf o\ rate,$$

$$R_i = 96.64 \times 10^6 - \left[\frac{2 \times 576 + 12 \times 560 + (12 + 2) \times 128}{0.002} \right]$$

$$= 91.808 \times 10^6 \quad bps$$

$$No.\ of\ voi\ ce\ Channel\ s = \left(\frac{R_i}{R_v} \right) = \frac{91.808 \times 10^6}{64 \times 10^3}$$

$$= 1434.5$$

$$= 1434\ channels$$