Performance for DSI Satellite System in Voice Applications

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Abstract: - In this paper, the performance of DSI TDMA satellite systems is carried out, where the TDMA network has a distributed control. The main parameter of performance is the probability that a speech spurt would be clipped for more than an specific time and speech activity factor. The DSI gain is also calculated in order to optimize the number of satellite and terrestrial channels.

Key-words: - Satellite, Multiple Access, TDMA, SCPC, DAMA, speech activity factor.

1 Introduction

The new techniques of digital transmission over digital satellite channels involve the use of natural pauses in conversation to increase the performance of the system. In that case, the channels occupied for a conversation can be assigned to other users if they do not generate information. The number of the potential users in this system is increased significantly [1], [4] [5].

In this paper, one of the most important techniques used to increased the utilization of the Time Division Multiple Access (TDMA) satellite networks is presented. The evaluation of the performance is based on the probability that the number of simultaneous speech spurts on the terrestrial channels with speech activity factor probability of a will equal or exceed the number of satellite channels [2] [3].

The section 2 is dedicated to TDMA Satellite Systems. The section 3 explains the Dynamic Assignment Multiple Access (DAMA). The Single Carrier Per Carrier (SCPC) DAMA satellite is presented in section 4. The Digital Speech Interpolation (DSI) is explained in section 5. The section 6 is dedicated to present the results of the work and the conclusions of the paper are presented in section 7.

2 TDMA Satellite Systems

The modern satellite systems involve the optimization of the resources, specially the number of available channels for up-link and down-link. In the Figure 1, a digital TDMA satellite network is illustrated.

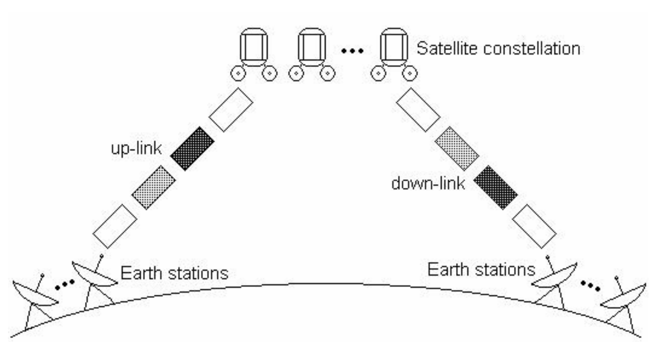

Fig. 1 TDMA satellite system.

The earth stations transmissions are shown like rectangles with a limited time duration. Each station transmits traffic burst in a periodic TDMA frame, where the period of the frame is equal to sample time for speech applications [7].

The Figure 2, shows a TDMA frame. It is important to emphasize the existence of two reference bursts (PR and SR), that are related to primary and secondary reference stations. These stations preserve the synchronization of the frame and their bursts do not contain traffic data.

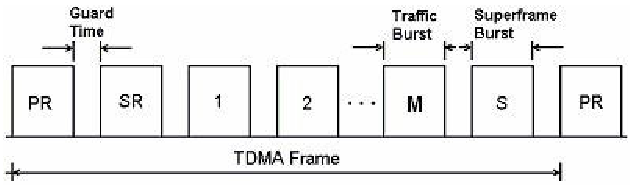

Fig. 2 TDMA frame.

There is a super frame burst (S) that marks the position of the frame in a set of frames named super frame. It is very common that the status of the frame is updated every super frame, then the position of the burst into the frame and the number of the users, can change in the beginning of the next super frame.

In a pre-assigned TDMA satellite system every traffic burst involves a earth station in the up-link (ETO) and its position is known in the TDMA frame.

In Figure 3 three ETO burst are shown, where ETD_i is the earth station in the down-link, M is the number of satellite channels and N is the number of terrestrial channels.

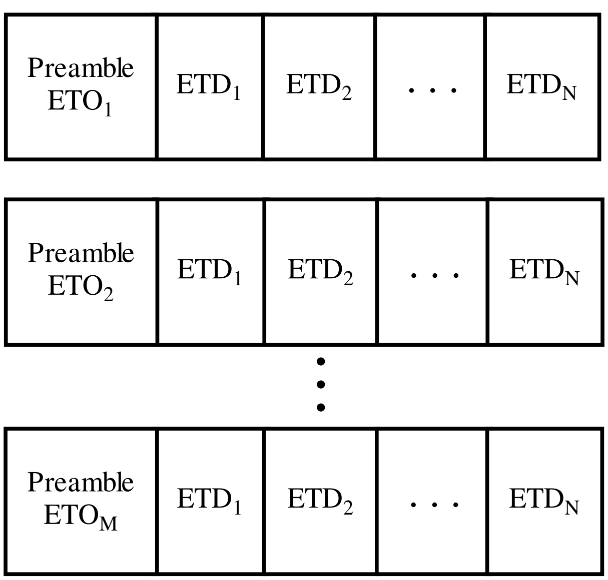

Fig. 3 TDMA frame.

The architecture illustrated in Figure 2 is very common in long-distance telephone systems. In this Figure the sub-bursts ETD_i have a limited number of channels, usually 24 (North-America) or 30 (Europe). Subsequently, it is possible that incoming call could not be assigned.

The probability that an arriving call will be blocked by finding all the channels busy is calculated by equation 1.

$$B(n,a)=\frac{a^n/n!}{\sum_{k=0}^{n}\left(a^k/k!\right)} \quad (1)$$

Where n is the number of channels; and, a is the traffic intensity.

3 DAMA in TDMA Satellite Systems

In any DAMA system the most important function is to allocate the capacity to set up a call. The method by which this function is handled illustrates the most significant difference between DAMA systems concepts: centralized control versus distributed control.

In the centralized DAMA system a master control station assumes the responsibility of assigning the available duplex circuits required to establish the communications between two traffic stations. In comparison, in a distributed control there is no a master station and the traffic stations assume equal control status as far as normal operation is concerned.

Both centralized and distributed control has several advantages and disadvantages, centralized control performs better where the capacity of terrestrial stations can vary, and its major disadvantage is that an outage at the master control station causes a total system failure. In distributed control systems the failure of one station does not affect the other stations, but its major disadvantage is that a large processing capability is required at each terrestrial or space station [6].

4 SCPC-DAMA System

One of the most important DAMA systems use the Single Carrier Per Carrier technique, specially where the network has 100 or more small remote stations [5] [6].

In SPADE systems there are two kinds of bursts, in Figure 4 the distribution of sub-bursts is illustrated.

Guard Time (5)	Carrier Recovery (49)	Bit Timming Recovery (40)	Unique Word (32)	Carrier Hangover (2)

Fig. 4 . Reference burst of the SPADE common signal channel

The other kind of bursts are the local data bursts, that are shown in Figure 5.

Guard Time (5)	Carrier Recovery (16)	Bit Timming Recovery (19)	Unique Word (20)	Message (48)	Parity Bits (18)	Carrier Hangover (2)

Fig. 5 . Local data burst of the SPADE common signaling channel

5 Digital Speech Interpolation

In a normal conversation there are many pauses between sentences, words and even syllables. Many measurements have demonstrated that the voice channel is occupied 40 % or less, then it is possible to transmit two telephone conversation in the same physical channel. This technique employed to optimize the utilization of the system is named Digital Speech Interpolation DSI. In this process *N* conversations are carried on *M* transmission channels, where *M*<*N*.

$$DSI_{gain} = \frac{N}{M} \qquad (2)$$

Then DSI operates by assigning a satellite channel only when a speech spurt is present. As a consequence of this, the efficiency of DSI increases if there are more terrestrial channels.

Frequently, there are not available channel for incoming conversations and it can result in a form of clipping of the initial portion of a speech spurt. It is not acceptable a speech clip longer than 50 ms in a high quality transmission. In order to have an acceptable performances that the probability of speech clipping equal to 50 ms o longer should be less than 0.02 or 2% [6].

The probability that the number of simultaneous speech spurts on *N* terrestrial channels with speech activity factor probability of a will equal or exceed *M* satellite channels (*M*>*N*) is given by equation 3.

$$B(M,N,\alpha) = \sum_{x=M}^{N} \left\{ \frac{N!}{x!(N-x)!} \alpha^x (1-\alpha)^{N-x} \right\} \qquad (3)$$

In that case, the probability that a speech spurt will be clipped for more than T seconds is determined by equation 4. In that equation the result of cumulative binomial distribution allows to evaluate the performance in DSI systems.

$$B(M,N,\theta) = B[M,N,\alpha \exp(-T/L)] \qquad (4)$$

Where θ can be calculated by equation 5, and it represents an exponential speech spurt distribution.

$$\theta = \alpha \exp\left(\frac{-T}{L}\right) \qquad (5)$$

Where: L is the mean speech spurt duration.

The performance of this kind of system can be determined according to speech lost as result of the freeze-out of all *N* terrestrial channels in the network. This behavior can be calculated by equation 6.

$$b(x,N,\alpha) = \frac{N!}{x!(N-x)!} \alpha^x (1-\alpha)^{N-x} \qquad (5)$$

Where: *b* is the fraction of time that exactly $x<N$ terrestrial channels are active with an speech activity factor of α, and x-M of these terrestrial channels will incur speech loss whenever $x>M$.

6 Results

The most important parameter to evaluate the performance of this work is the percent of clipping that can be grater than a 50 ms. Because, in these conditions the quality of the system is extremely low. The DSI also gives a efficiency parameter of the network.

The performance of the TDMA satellite DSI system is plotted in Figure 5, where a 40 % speech activity factor was assumed for an average call duration of 90 seconds.

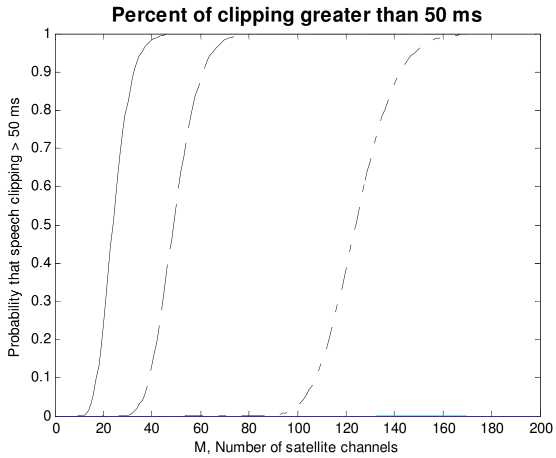

Fig. 6 . Percent of clipping greater than 50 ms

In Figure 6 three systems was simulated for 30, 60 and 240 terrestrial channels over a large number of satellite channels, respectively (left to right) in that figure.

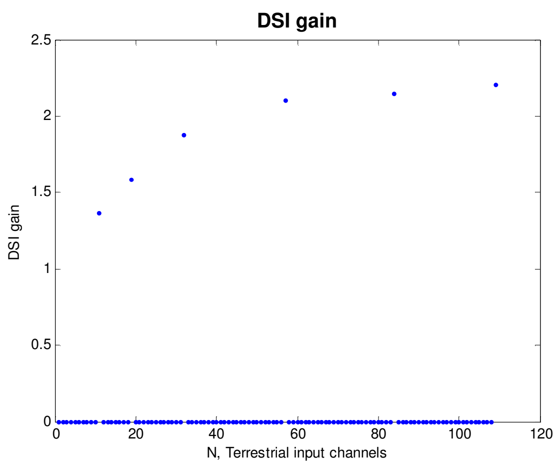

Fig. 7 . DSI gain for the simulated system.

The most important parameter to evaluate the performance in the described system is the DSI gain defined in equation 4. The Figure 7 illustrates the DSI in the simulated TDMA system shown in Figure 6.

7 Conclusions

This paper shows the performance of TDMA satellite system with digital speech interpolation (DSI) as a technique to improve the utilization of the network in long-distance telephone calls.

The main alternative to the solution proposed here is Time Assignment Speech Interpolation (TASI). The use of TASI is reduced as a consequence of several advantages of DSI in digital satellite communications using PCM for voice encoding and TDMA for satellite access. It is necessary to emphasize that the mean call duration has changed for data application in the PSTN, subsequently new measurements should be considered in data applications.

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