DIDON : A data broadcasting system

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In order to provide a transmission support common to new social communication services now under study at the C.C.E.T.T., a new data packet broadcasting system compatible with television signal broadcasting network has been developed and is currently being tested. Based on the use of all or of a part of the lines of the video signal, DIDON provides transmission capacity of up to 4 Meb/s. The data packet multiplexing organization that has been used guarantees characteristics of transparency and multiple access. Field tests are currently being carried to determine the reception conditions and zones of coverage in relation to those provided by television. It is thus possible to attain, without infrastructure development, a digital broadcasting capacity providing a new dimension in the field of data communication.

1. Introduction

Television systems were devised at a time when the problem of overloading the radioelectric spectrum was much less acute than it is at present. Thus, the standardization of video signals and of radio broadcasting systems exhibit characteristics which we would now view as constituting a waste of resources. There are "holes" in the time scale and in the frequency spectrum, which, from the point of view of modern technology, are not necessary for the correct reproduction of the audio-visual message.

Since the need to transmit data, particularly in the area of social communications, will surely continue to increase, there has been evident interest in the creation of systems that take advantage of these holes, whether expressed in microseconds or in kilohertz. The only restriction involved is that of not disrupting existing television service; if the norms used to construct television signal broadcasting equipment are accepted, we have available to us, without infrastructure development, a nationwide network able to transmit, as we shall see, a sizeable data flow.

Such a network, once operational, will be in great demand. As a consequence, wise management will be necessary to avoid the undisciplined type of usage that would constitude a new source of resource waste.

2. The context of DIDON's development

Before continuing further, and without providing a course in television technology, it is probably useful to review several points. A television signal is made up of an image signal, termed video, and a sound signal. These two signals are broadcast simultaneously by two different modulated carriers, in amplitude for the image signal and in amplitude or frequency for the sound signal. The video signal is made up of a synchronization signal used by television sets for horizontal and vertical controls and of the image signal itself. In fact, the television image is composed of a number of lines.

The only "holes" with which we are concerned here and which are used by DIDON are those situated in the time scale.

More precisely, we are concerned with the free line time slots. These time intervals are situated at the level of the vertical synchronization signal and correspond to the period of time during which the cathode tube spot returns to the top of the screen for a new pass.

The idea of using these lines is not new. Test signals used to monitor channel broadcast quality have been making use of these lines for several years. More recently, numeric data transmissions have been carried on these lines but in specific, and therefore limited, applications.

Our goal in constructing DIDON has been to build a data broacasting system that uses the available resource to its fullest extent and one that is user-independent. Our fundamental choices have, in consequence, been guided by the ideas, common to classic data transmission networks, of transparency and multiple access. One consequence is that, while during regular television transmission hours the system must make do with only a few lines of the field blanking interval, the system is capable, outside these hours, of utilizing all lines and thereby providing substantially greater transmission capacity.

The significance of this "full channel" functioning should not be underestimated. While first suggested by the simple fact that the television networks function only about 50% of the time, additional points have confirmed our interest in this possibility.

The first such point is the planned discontinuation of 819-lines programs, thus freeing the frequency bands these programs are using currently. While no decision has as yet been made regarding the reassignment of these bands, it is certainly conceivable that they will be used for social communication service. In this case, DIDON would have a privileged field of application.

The second such point was the adoption in Geneva in February 1977 of a frequency plan for direct satellite broadcasting putting five new television channels at the disposal of different countries. Assuming mixed data/television use, DIDON could play a major role in the system.

Finally, there is great interest, particularly in North America, in cable broadcasting. Cable television systems provide a major number of channels; certain of these channels could be entirely devoted to data transmission. Moreover, the advent of bidirectional television transmission could, in combination with DIDON, help solve problems involved in the local transmission of computer-assisted instructional systems.

3. New social communication systems

In a preceding section we employed the term "new social communication services". What are these services now being added to conventional television ? They can be classified into two types, depending on whether they are linked to a television program or not.

3-1. Two services of the first type are currently the object of research at the C.C.E.T.T.; the first such service is a program delivery service allowing remote control of cassette recorders to tape and store television programs in the viewer's absence; the second is a scrambled television service.

3-2. As far as services of the second type are concerned, the C.C.E.T.T. has focused its attention on services leading to the display of a non-analog picture, i.e one constructed by the reception equipment on the basis of codes received. These services are:

- a teletext service leading to the display on a television screen of a picture composed of alphanumeric or simple graphic symbols.

- an audiography service where the television set displays a slow-moving picture accompanied by an audio commentary.

- a broadcast facsimile service using paper to provide a very high resolution picture.

The common characteristic of these services is that they are based on digital data broadcasting designed to be received simultaneously by a large number of users. DIDON was conceived to resolve the problem of their multiplexing in a television channel. Let us now look at the technical characteristics of the system.

4. Resource available

4-1. In the time scale: as we have seen, the available resource is made up of free line time intervals, thus being discontinuous and dependent on time (i.e. whether a television program is being broadcast or not).

4-2. In the frequency spectrum: while the active duration of a video signal line is approximately the same in all commonly used television standards, the width of the spectrum band allocated to the video signal varies in different broadcasting standards. It is thus essential that the system be adaptable to any value of this parameter. Indeed, the data signal spectrum must be in close relation to the width of the video band. Thus bit duration may not be the same for all television standards and the amount of information inserted in a quantum of transmission capacity (a TV signal line) may not be constant from one standard to another. Therefore, the system must allow for arbitrary slicing in the data flow.

4-3. The nature of the resource that has just been defined, together with the transparency and multiple access requirements, has led us to choose a data-packet multiplexing organization where each packet occupies the active duration of a line of video signal.

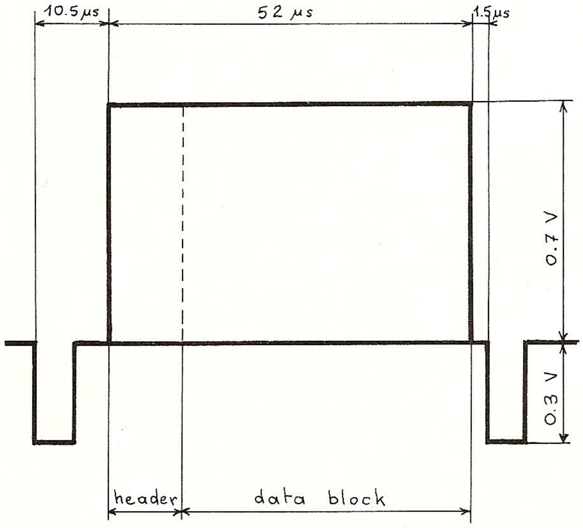


FIG. 1 : A packet

Each packet broadcast contains the information that allows the terminal to which it has been sent to recognize it. All along the transmission chain, the sequence of operations is as follows: assembly of data into packets, labelling the packets as a function of the origin of the data contained in the packet, broadcasting of packets, selection of the packets by the receiving equipment.

5. Data packet description

The coding system used is the NRZ (non-return to zero). As we have seen, the maximum size of the packet depends on the television system. For standard L, the standard that is used in France, the packet size is 40 octets, made up of 8 header octets and a data block of 32 octets.

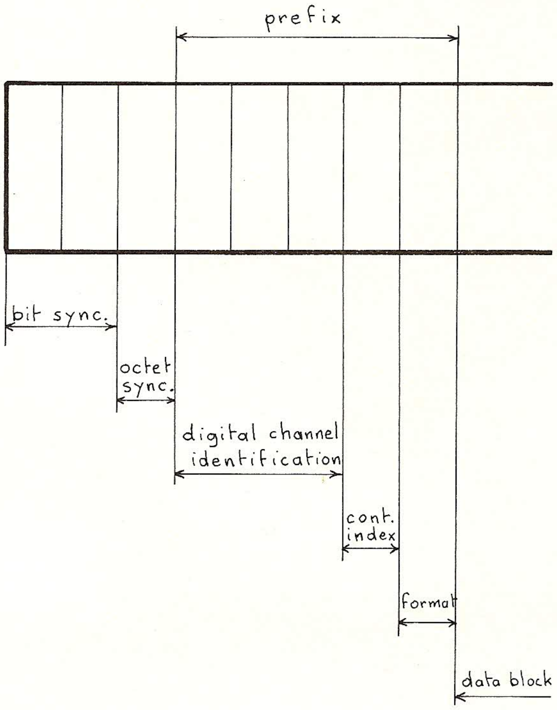


FIG. 2 : The packet header

Let us provide a description of the header based on the use made of it on reception. This operation can be described by a three-level structure:

- the bit level which consists of the resynchronization of the receiver bit frequency oscillator. A clock run-in sequence composed of alternating logical 1 and 0 is used for this purpose.

- the octet level which allows reassembly of the data into octets for further processing. For this purpose, the third header octet is searched by successive bit shifting until a reference configuration of 8 bits is obtained. Careful choice of this framing code assures synchronization even when an error bit is present.

- the packet level which assures the processing of the information contained in the prefix of each packet, to select the data transmitted by one of the sources on a given digital channel. The prefix octets are Hamming codes containing four information bits and four protection bits, and thus providing a single error correcting possibility. The first three octets are used for digital channel identification. The fourth is a continuity index used to verify that no packet has been lost between this one and the preceding one.

The fifth octet is a format octet used to specify the size of the data block.

6. System performance

6-1. Necessity of quality controls: television has been with us for 40 years and has long since reached a level of technical maturity; the stages that have marked its evolution have never reversed the basic principles on which it was constructed. For most television viewers product quality is excellent, providing an image and a sound comparable in quality to that seen and heard with other audio-visual media such as movies, slide projectors, record players, etc.

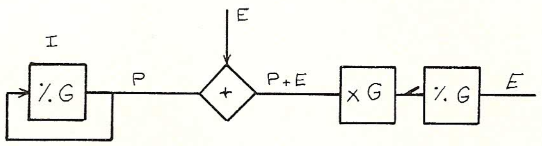
The proposed new services do not have forty years at their disposal in which to gradually improve the quality of their product. In spite of the burden presented by the introduction of digital transmission on systems previously designed and maximized to provide sound and an animated image, the DIDON system must provide a service whose quality, for the vast majority of users, is comparable to the quality of current television service. The public would not accept a product inferior in quality to that which it currently enjoys.

Thus the necessity of quality controls appears evident, controls used prior to the final installation of the system in order to forsee, in so far as is possible, the geographic zones, called service zones, where reception will be of sufficiently high quality for a sizable proportion of the population. As a corollary, and in case the initial results are not entirely satisfactory, it may be necessary either to conduct laboratory studies to improve equipment before it is launched in the marketplace or to modify some quality criteria of the existing network in order to make the network more suited to the broadcasting of two different types of services.

Any consideration of quality problems, particularly those involving images, complex structures in which the adaptive apparatus of the human eye plays a role, must find a satisfactory method to deal with the difficulty of measurement, i.e. the quantitative evaluation of a phenomenon that is partly subjective.

In this case, moreover, quality measurement is further complicated by the variety of new services using the same transmission network. It therefore seems wise to first characterize the quality of the common trunk that makes up the DIDON broadcasting system rather than concentrating on a particular service. The characterization of the DIDON system is facilitated by the digital nature of the information transmitted. Since the signals are nothing other than a series of bits, it is simple to quantify quality by calculating the ratio of the number of erroneously received bits to the number of received bits; this ratio is the bit error rate, familiar to specialists in the field of digital transmission. We have introduced a second measurement parameter, the bit loss rate, that is the ratio of the number of non-received bits to the number of bits sent. This second measurement is made necessary by the one-way transmission structure which involves a risk of loss of information, (essentially in the form of packets), and which means that it is impossible to request that a lost packet be resent.

Our final problem was the choice of the kind of data to be used in measuring the error and loss rates. We wished to dissociate the evaluation of the broadcast network quality from the nature of the data that it would transmit. The test data thus should be universal and of a sufficiently complex structure as to cover the gamut of possible uses.



I : init sequence

G : generator polynomial

P : pseudo-random sequences

E : error polynomial

$$P = I / G$$

$$(P + E) \times G = I + E\,G$$

FIG. 3 : Use of pseudo-random sequences

Pseudo-random bit sequences were chosen to meet these requirements. Laboratory studies, either purely theoretical simulations or experimental in nature, allow observation of the behavior of a given new service related to error and loss rates.

6-2. Problems encountered in data broadcasting and results obtained: one general characteristic of a data transport network is the presence of vulnerability stretching from the point of data transmission to the point of reception. The situation of the DIDON network in this regard is particularly vulnerable. First, its physical support is the television broadcasting network which was not designed for data transmission; moreover, the broadcasting equipment utilizing high voltage at high frequency, distorts the data signal when it is sent. Since DIDON involves a broadcasting network using air-borne radio-electric propagation, the signal is further disrupted as, for example, through reflection echoes on obstacles. Finally, the reception equipment, which must be designed to reach a wide public at a reasonable price, produces further distortions in the data packet.

Since our goal is to reach the largest possible segment of the population with the best possible quality, a series of field observations in different conditions have been carried out to evaluate the situation. Our first area of interest was the problem posed by mountainous zones, both because this geographical situation arises frequently in Europe and because the problems involved here are clearly more acute than they are elsewhere. We have found that the signal distortions that lead to a poor error rate have two primary causes that are both frequent and characteristic of these regions:

- successive distortions produced by emission equipment; the mountainous terrain necessitates the use of a large number of small, linked repeaters. This situation is in contrast to that of a flat region where, as a general rule, one powerful transmitter covers a wide surface areas. Clearly, this multiplicity of equipment creates more distortions.

- distortions produced during propagation; these are primarily those created by the presence of multiple echoes on the mountainsides. The fact that these reflections produce "ghosts" on the television screen is well-known; their effect is no less significant for DIDON.

In spite of these difficulties, on the basis of field test data, we estimate that 90 % of the population would have a maximum error rate of 10^{-4} , a value considered tolerable for forseeable services.

Nonetheless, some users might wish to improve this rate through the use of error-correcting codes; therefore, we have investigated the distribution of these errors over the course of time. It is apparent that the vast majority of errors are simple ones (83 % of the cases), with double errors appearing in only 8 % of the cases. In addition, we have found that, in general, (80 % of the case), a single bit was incorrect in a data packet. These results suggest simple error correction procedures that would involve only a slight loss of useful flow.

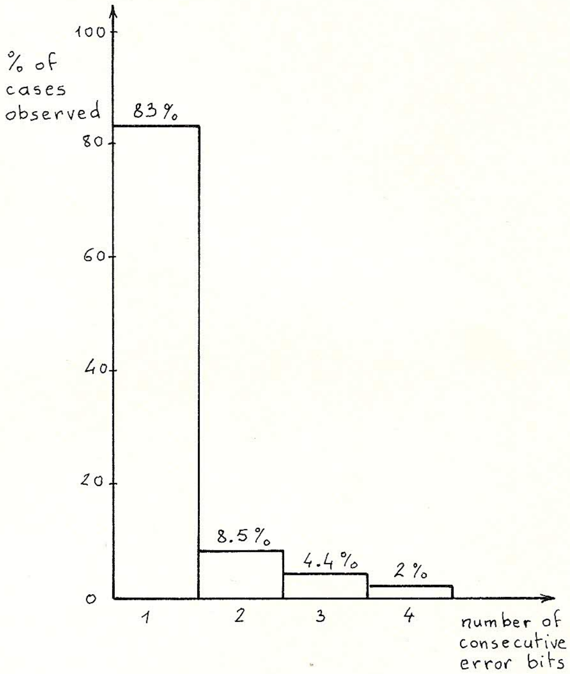


FIG. 4 :Length of observed errors

We then turned our attention to urban areas, since their significance in measures of reception is also great, due largely to the percentage of the population that inhabits these areas. In France, the Paris metropolitan region alone contains some 10 million people, in other words, 20 % of the national population. Reception conditions are often unfavorable. Large concrete and steel buildings constitue obstacles to wave propagation. In addition, the use of communal rather than individual aerials produces further impairments.

The test data show that the proportion of the urban population benefiting from adequate service would be similar to that in the mountainous areas, with about 85 % having a maximum error rate of 10^{-4} .

The most frequent causes of impairment are the inadequacies of aerials, a situation where cost is an important factor, and the problems created by large buildings which reflect or block signals.

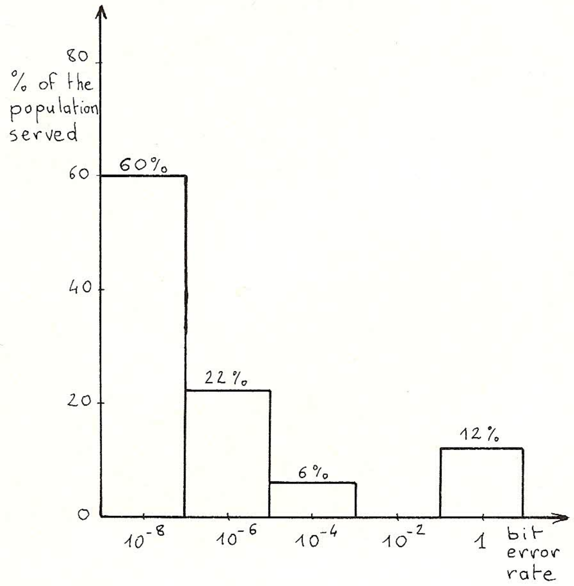


FIG. 5 :Distribution of error rate in urban population

A field test with a target other than zone coverage was carried out by the Swiss PTT using our equipments. Their test involved the effect of the choice of bit frequency on the error rate for the G broadcasting standard used in Switzerland as well as in most Western European countries. The results as shown in Figure 6, indicate that a careful choice of bit frequency allows adjustement to the system used.

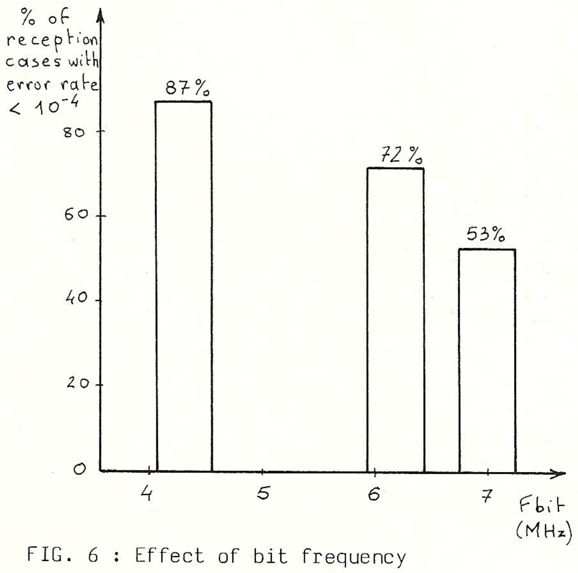


FIG. 6 : Effect of bit frequency

7. Conclusion

Field studies designed to evaluate potential reception of projected social communication services including a teletext service indicate that mountainous and urban areas pose the greatest problems to obtaining complete nationwide coverage. The results for these two areas can thus be considered as a "worst case" estimate of reality. We can assume that, given the current state of network infrastructure and equipment, a service of 10^{-4} quality could easily be provided for more than 85 % of the population.

Improvements in this figure become increasingly difficult to achieve as a 100% figure is approached. Nevertheless, progress is possible. On the reception end, manufacturers of television sets are likely to develop, in the years to come, improvements in demodulation systems to reduce distortion and echo suppression systems; such modifications will make the television set better suited to its new task. Improvements are also possible on the transmitting end.

Thus, in mountainous areas, more rigorous maintenance of transmitting equipment would have a beneficial effect on service quality. Unfortunately, in urban areas the problems of poor reception are more difficult to overcome. While improvements can theoretically be made by revising the established standards for group antenna installations, the usefullness of such measures is open to doubt, since only half the installations are in compliance with the current standards, cost is highly significant to the user, and verification of private installations by competent organizations is most difficult to achieve in a systematic fashion. Problems involved in propagation in an urban environment can only be resolved by setting up cable links serving affected buildings with reception antennas placed at uncongested sites. Several projects of this type have been successfully carried out in Paris when new construction blocked the signal to an entire neighborhood.

In spite of the difficulties involved, the results already obtained are remarkable and suggest that the system can be installed at the national level in the years to come.

The use of the existing television network means that the growth of the data broadcasting system can easily be adapted to increasing user needs.

The magnitude of the flows available (up to about 4 Meb/s) and the potential for national coverage add a new dimension to data communication.

The first public application will consist of a teletext service; TDF has announced that this service will be available in 1980.

8. Références

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