# MEASURING METHODS AND EQUIPMENTS FOR DATA PACKET BROADCASTING

Joseph J. BLINEAU

Centre Commun d'Études de Télévision et Télécommunications
2, rue de la Mabilais – BP 1266 – 35013 Rennes Cédex
FRANCE

## ABSTRACT

Introduction to and description of new services using D.P.B. (Data Packet Broadcasting) on the TV channel. Definition of some parameters specific to the data signal and methods of measuring them.

Considered as an analog signal, the data signal can be examined as a video signal. However, due to its specific structure, it can be broken down in the time domain into a series of elementary intervals inside which the signal shape is perfectly determined at point of origin.

From a digital point of view, the data signal can be described as a bit sequence. Its quality is then measurable by parameters linked to binary states, the lowest level of information being the bit.

Some equipments required for both analog and digital measurements will be described.

## 1 – DIDON – DATA PACKET BROADCASTING SYSTEM

### 1 – 1 – Introduction

All the new services for social communications, which are under study and will use the television broadcasting networks as a support, have one feature in common : they use data signals. For this purpose a D.P.B. system (DIDON* system) [1] has been defined and studied at the CCETT laboratories in Rennes (France). This system allows to use the T.V. networks in their current design to broadcast data signals in addition to the conventional television service. These networks, which have been developed to transmit an analog signal, allows an immediate a coverage of almost the whole population.

This system can be used in two different ways :

- First : during analog programs : some of the lines of the field blanking interval are free, and are available for data broadcasting.
- Second : outside of the normal program hours, or on networks providing a great number of channels, such as cable distribution or satellite broadcasting, almost all the lines of the T.V. frame can be used for data broadcasting.

### 1 – 2 – The system design

The fundamental choices governing the design of the D.P.B. system are based upon two considerations :

- The set up of the system take advantage of existing networks.
- The system is to be used by different kinds of services.

*DIDON is an acronym for DIffusion de DONnées (= D.P.B.).

The consequences of these considerations on the design of the system are now examined.

#### 1 – 2 – 1 – Requirements for compatibility with existing standards and equipments

The ressource available for the data broadcasting system must be investigated from two points of view : time and frequency spectrum.

– time : the examination of a television signal shows that certain time intervals are not used by either the picture signal or the synchronization signal. These intervals consist of a number of line time slots in the field blanking interval.

Our purpose is to standardize the use of these line time slots and to extend this technique to all television signal free lines while television programs are not beeing broadcast. Therefore the available ressource is discontinuous (composed of free line time slots) and time-dependent (according to the use of the T.V. channel). The system designed, on such a principle, is therefore asynchronous.

– Frequency spectrum : though the active time of the video signal line is about the same in all the commonly used standards, the spectral bandwidth allocated to the video signal may be very different depending on these standards. To design a system edaptable to any value of this parameter, the data signal spectrum must be chosen in accordance with the video bandwith. This means that the bit duration may not be the same for all television standards. Therefore the system must allow an arbitrary slicing of data flows.

#### 1 – 2 – 2 – Use of the system by different services

Different kinds of services are already under investigation and others will certainly be imagined in the future. To preserve the possibility of being used by all these services, the system design must take into account the following two points :

– Differences in the nature of the services : to avoid any limitation the system must be transparent.

– Simultaneity of the services : the system must provide multiple access.

#### 1 – 2 – 3 – The fundamental choices for the design of the system

Let's sum up the above conclusions, the system must :
- be asynchronous,
- allow arbitrary slicing of the data flows,
- be transparent,
- provide multiple access.

Data packet multiplexing organization satisfies all these requirements. The basic sequence of operations is the following : assembly of the packet from the data source, the labelling of the packet according to data origin, the broadcasting of the packet within the video signal and the selection of the packet by the receiving equipment. The packet is made out of two parts : the header and the data block. Photos n° 1 and n° 2 give an example of a data packet and the detail of its header.

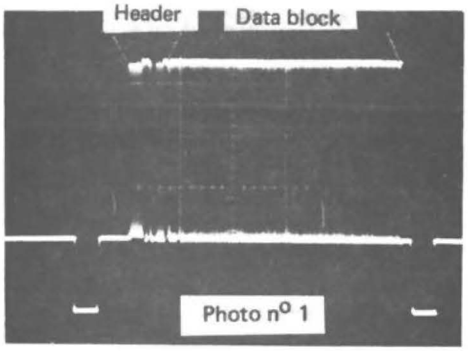



Photo n° 1

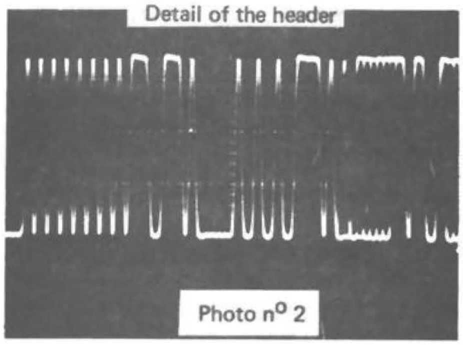



Photo n° 2

1 – 3 – Description of the techniques implemented

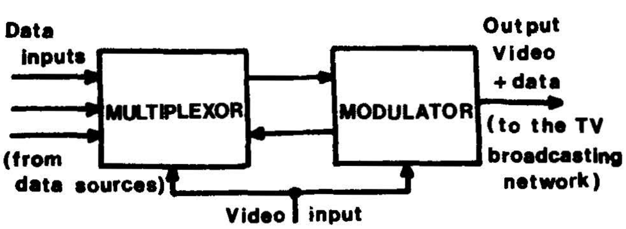
They consist of the transmission techniques and the receiving techniques.

1 – 3 – 1 – Transmission techniques

The transmission techniques are those used at a given point of the television broadcasting network to insert the data into the video signal. The basic technique is T.D.M.A. (time - division - multiple - access) at two levels :

– multiplexing of packets generated by different sources
– multiplexing of these packets within the video signal, using the free line time slots.

The first operation, which is a digital multiplexing, is carried out by the part of the equipement named the multiplexor. The second, which is an analog operation, is performed by the modulator (figure 1).



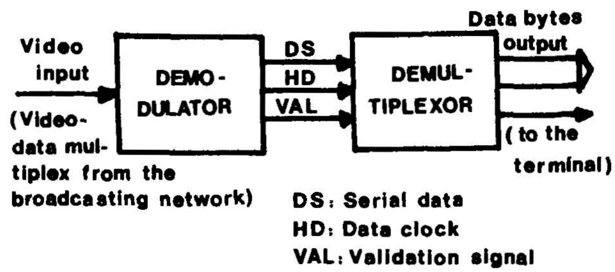

– Figure 1 –

1 – 3 – 2 – Reception techniques

The reception is the extraction, from the possibly impaired video-data multiplex, of the data carried on a digital channel. This operation is performed by the two parts of the receiving equipment (figure 2) :

– the demodulator, which determinates a slicing level, and delivers the data signal, to the next circuit, with a correctly phased clock, and a validation signal.

– the demultiplexor which, after having taken care of the synchronization byte, processes the header information in order to select the data carried by a digital channel (the link created by the D.P.B. network between a data source and a terminal) and to deliver them to the terminal.




– Figure 2 –

## 2 – MEASUREMENTS NECESSITY AND OBJECTIVES

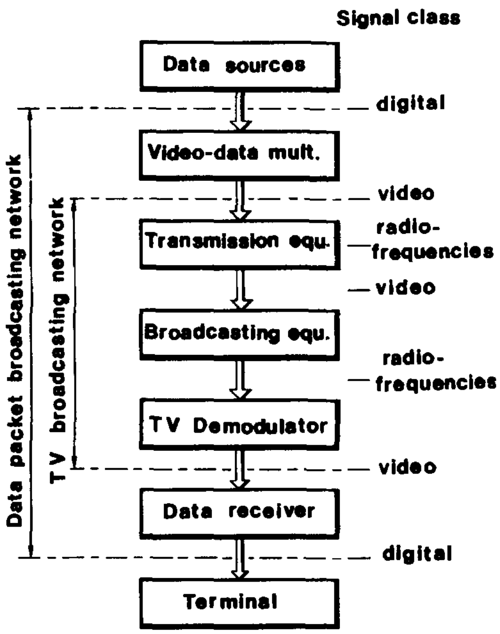
The video data multiplex signal can be impaired, at emission, during broadcasting, or at reception. The introduction and the development of services using data broadcasting necessitates the specification of equipment quality and the determination of the area inside which the reception of data is expected to be correct. To achieve these objectives, specific parameters must be defined and methods of measuring these parameters must be set up. The specificity of data broadcasting methods implies the study and development of new measuring equipments.

Although the parameters, currently used for the picture analog signal and measured with the I.T.S. (insertion test signals), can be taken into account to characterize the broadcasting network, it is necessary to use, in addition, new parameters which are specific to the data signal.

Figure 3 shows the structure of the data packet broadcasting network. It creates digital channels between data sources and receiving terminals. This network includes the TV broadcasting network (it was designed to be fully compatible with the existing standards and equipments) ; it implies, in addition, a transmission equipment (the video-data multiplexor) and a receiving equipment.

One of the measurements objectives is to define the quality of the data broadcasting network, statistically, as it is usually done for the TV broadcasting network. These measurements are made during field trials [2].

A second objective is to caracterize the performance of each equipment of the data broadcasting network with respect to the data signal. The equipments under test may be specific (data receiving equipment) or included in the TV broadcasting network (transmitter or TV demodulator for example).




– Figure 3 –

## 3 – CHARACTERIZATION OF THE VIDEO CHANNEL – PARAMETERS

Before examining in detail the specific characteristics of the data signal, it is interesting to recall the impairments due to the TV channel which can affect the video signal, and to determine the most important parameters with respect to the data signal.

The TV channel is the source of impairments which can be classified in two parts :

– intersymbol interferences due to linear (amplitude and phase) and non linear distorsions,

– addition of noise to the useful signal, which increases the effect of the distorsions.

The effects of these distorsions on the TV picture quality are now well known. Several parameters can be measured by using I.T.S. signals built up to characterize the most sensitive distorsions with respect to the TV picture quality (taking into account vision physiology).

The experiments have shown that some of them, especially the 2T pulse and the noise measurement line, are useful to characterize the effects of the video channel impairments on the data signal.

## 4 – CHARACTERIZATION OF THE DATA SIGNAL – PARAMETERS

As a part of the video data multiplex, the data signal can be considered as a particular case of the video signal ; however, its particular structure allows a precise characterization. Inside a data packet, this signal can be split up into time intervals inside which the shape of the signal is perfectly determined at the emission level. The superposition, on an oscilloscope screen, of the shape of the data signal during the successive time intervals, gives what we call an «eye pattern». This diagram provides an idea of the data signal quality, independently on the last part of the network : the receiving equipment.

From an other point of view, the data signal, contrarily to the picture signal, carries a digital, and therefore very easily exprimable, information. Thus its quality can be measured by parameters which can be directly interpreted as specifying the quality of digital channels.

### 4 – 1 – Analog characterization – Parameters

The analog characterization of the data signal quality is appreciated from the eye pattern. This diagram is generally drawn on an oscilloscope screen, but other means of display such as a plotter can be used.

Two kinds of diagrams can be obtained, linked to the horizontal sweeping :

– a «Y» pattern (figure 4), if he horizontal sweeping is linear with respect to the time,

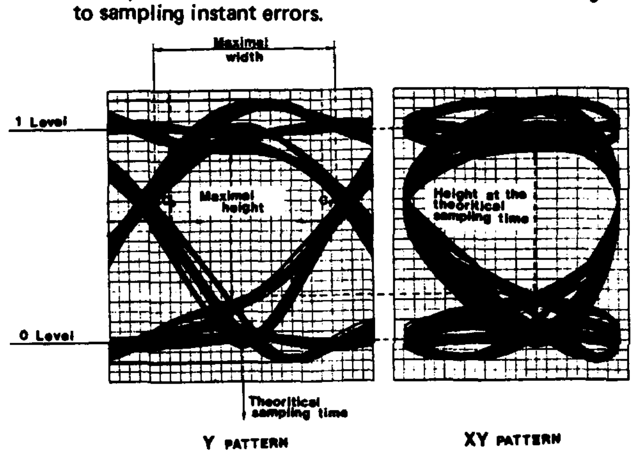
– an «XY» pattern (figure 4) if the horizontal sweeping is a signal made of an alternate suite of 1 and 0 transmitted on the same network as the data signal. The pattern is a LISSAJOUS diagram.

The interpretation of the eye pattern is linked to the way the data receiver's demodulator works : it determinates a slicing level to distinguish logical 1 and 0 status, and a sampling time to memorize a bit value.

The two most important parameters which can be measured on the eye diagram, are linked to these operations :

– the eye-height, which is the aperture at the sampling instant expressed in percentage of the difference between the steady-state «1» and «0» levels.

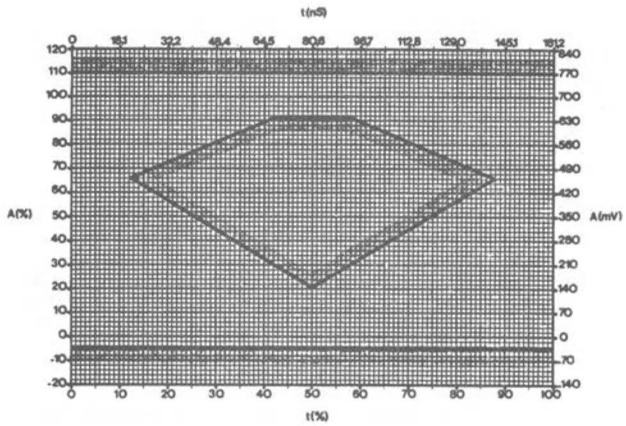
– the eye-width : indicates the sensitiveness of data signal to sampling instant errors.




– Figure 4 –

Some other parameters characterize the corruption of the data signal by the elements of the broadcasting network.

However, the different parameters which can be measured on the eye pattern are not directly, individually, linked to the quality of the received data signal, because the functioning of the receiving equipment is more or less corrupted by each of the analog distorsions of the data signal. On the other hand, each element of the broadcasting network is the source of impairments, which are not sufficient, individually to corrupt the digital signal (which can be regenerated). It is the reason why it is useful (particularly to test a specific equipment of the network such as transmitter [3] or TV demodulator) to draw a frame of the eye diagram. An example of such a frame is given on figure 5. This frame has been established by computer [4] for the test of a TV transmitter in L standard (positive modulation). This diagram is asymetric because of the non linear quadrature distorsions due to an envelope detection demodulator usually used for transmitter testing. The value of the bit frequency is 6.203125 MHz as used in France.




— Figure 5 —

4 — 2 — Digital characterization — Parameters

As we have seen above, parameters which can be directly interpreted and easily measured to specify digital channel quality must be defined.

The impairment of the analog signal, due to network distorsions, generates, when it is sufficiently important, errors on the data stream in the packets. Generally, these errors will appear with the same probability in the two parts of the packet: the header and the data-block. However, in the digital multiplex, these errors have a different effect according as they are located in the prefix or in the data block.

Errors located in the data block, affect only the data using the digital channel. Some redundancy can be added by concatenating a suffix to the data block allowing to correct one error per block.

Errors which appear in the packet header will cause, if they are not corrected, using the Hamming correction code implemented for the header bytes, the loss of the whole or of a part of the information carried by the data block of this packet.

Two parameters have been defined to specify the quality of digital channels :

— The bit error rate which is the ratio of the number of bits incorrectly received to the total number of bits received.

— The loss rate which is the ratio of the number of bits not received to the number of bits sent.

These two parameters are mean values computed from the observations. It may be interesting to complete these observations by the error and loss distributions. These informations will be very useful to set up error detection and correction procedures.

5 — MEASURING METHODS

5 — 1 — Measurements on the video channel

These measurements are well known, and do not need a special development. It is possible to find on the market a certain number of equipments allowing to measure all possible parameters on the I.T.S. and to display them or to print them on a ticket.

Some specific oscilloscope plug in units also exist which allow to select the appropriate horizontal and vertical calibrations in accordance with each measured parameters.

5 — 2 — Analog measurements on the data signal

As we have seen in § 4 - 1, our purpose is to draw the eye pattern. Whatever the method is, some precautions are required, concerning the drawing duration.

— Y pattern

The method consists in triggering an horizontal linear sweeping, inside the data block, in synchronism (with a constant delay) with the emission data clock. The data blocks examined, must contain all the possible configurations of the data bytes : pseudo-random sequences, also used for digital measurement, fulfill perfectly this condition.

Whatever the equipement is, the method has two successive steps :

- the selection of the TV lines carrying pseudo-random sequencies. This can be done in different ways, the better being to the use of a receiving equipment to select the digital channel subject to measurements.
- triggering of the linear sweeping, in synchronism with the data clock. This clock must be locally regenerated with a minimum of jitter.

— XY pattern

The first step is the same than above. The second requires a special synchronizing signal to be inserted at the emission level on the line preceding the pseudo-random sequence. This line, carrying a data signal of alternate «1» and «0», is delayed by the TV line duration, and used (without shaping) as horizontal sweeping signal. Practically, oscilloscopes have not a sufficient horizontal bandwidth and this method requires a sampling plug in unit.

5 — 3 — Digital measurements

5 — 3 — 1 — Principles

The method is as follows : information with a known structure is sent over a digital channel and differences with the original structure are analyzed at the receiving end. To be sure of obtaining valid results, the original reference information must cover the entire range of possible configurations which the transmitted information may take.

As the transmitter and receiver are generally distant, the original structure cannot be communicated to the receiver.

The structure of the reference information should be such that it can be regenerated locally by the receiver itself. Lastly, as we have seen, the reference information must be such that the two parameters specifying the quality of the digital channels can be readily apprehended.

Pseudo-random sequences meet these requirements.

5 — 3 — 2 — Properties of pseudo-random sequences

Given an integer n, a pseudo-random sequence will be a series of $2^n - 1$ bits having the following three properties :

a) If $q = 2^n - 1$, the sequence contains $\frac{q+1}{2}$ bits «1» and $\frac{q-1}{2}$ bits «0».

b) The autocorrelation function $\tau(d)$ of the sequence is constant and equal to :

$$\tau(d) = \frac{1}{q} \text{ if } d \neq 0 \text{ [mod q]}$$

c) The longest series of 1s is $\ell = n$ and there is only one such sequence.

For $\ell$ between 1 and $n - 1$, any series of 1s of length $\ell$ appears twice as frequently as a series of 1s of length $\ell + 1$.

These properties are typical of a series of bits taken at random, each having a probability of 1/2 of being a «1».

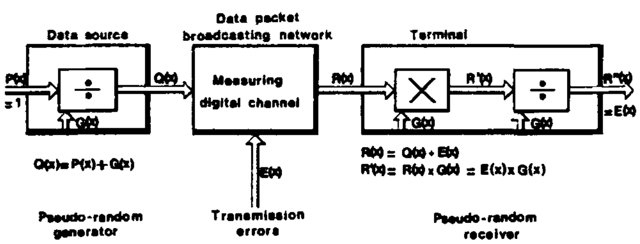
5 – 3 – 3 – Generation of pseudo-random sequences

Pseudo-random sequences are generated by feed-backed shift registers.

If we make the analogy between sequences of bits and a set of polynomials with modulo 2 addition, we express the pseudo-random sequence as the result of the division of a polynomial P by a polynomial G, called the generator polynomial. The polynomial P is expressed by the initial state of the positions of the shift register and G by the feed back coefficients.

If the register has n positions, the polynomial G must be chosen from the irreducible polynomials of degree n to make the resulting sequence of length $2^n - 1$.

5 – 3 – 4 – Measurement of the error rate (shown fig 5)




– Figure 6 –

The pseudo-random sequence is transmitted, using a measurement digital channel, and is received with errors which are expressed by a polynomial E(x) called the error polynomial.

The error number can be measured by counting the «1» coefficients from E(x).

The error rate can be deduced from the error number by the knowing of the measurement time and the useful bit rate of the measuring data channel, or by counting the number of received bits.

5 – 3 – 5 – Measurement of the loss rate

We have seen that the loss of information generally results from the loss of a whole data packet because of impairment of its header.

It is shown that in this case the operations described above lead, after a loss, to an error polynomial E(x) with an apparent error rate of 1/2. This is called a desynchronization.

This property is used to detect the loss of a packet. We may note that with a simple procedure we can resynchronize the process of extraction of the error polynomial automatically after each loss of information.

5 – 3 – 6 – Statistics on errors and losses

The method described above only allows to tally errors and losses and does not give any information on the event distribution. This information can be get by recording the error polynomial E(x) and certain packet header bytes (continuity index). These recordings are processed on a computer to get :

- the error and loss rates
- graphic results concerning loss and error distribution.

5 – 3 – 7 – Conclusion

The method chosen to measure the quality of the digital channels is simple and objective.

This method, using the error rate and the loss rate, provides an intrinsic channel quality specification without being necessary to take into account the type of information to be transmitted, which will depend on the user.

Due to the multi-access property of the D.P.B. system, a digital channel permanently dedicated to the broadcasting of pseudo-random measurement sequences can be used. Quality control can thus be carried out at any time and at any point without interrupting or interfering with data transmission on other channels.

## 6 – MEASURING EQUIPMENTS

Some equipments defined by our laboratories are under development and will soon be available ; they are :

– ENERTEC* n° 5547, which is an oscilloscope plug in unit allowing to draw the Y eye pattern. It also incorporates a digital part to count errors and losses and to calculate automatically error rate and loss rate.

– ENERTEC n° 5376 is a digital measuring equipment, having the same digital characteristics as the 5547.

Other equipments have been built and tested in our laboratories ; they are :

– an eye-meter, allowing to measure the eye-height, defined as the difference between the two slicing levels generating a given error rate.

– a TV-meter (patended) was designed to check the ability of TV demodulators to receive data signals. It draws an eye pattern on the TV screen.

* ENERTEC (Schlumberger subsidiary)
Département Instruments
5, rue Daguerre
42030 Saint Etienne (FRANCE)

BIBLIOGRAPHY

[1] CCETT RSI/T/02/79 DIDON : A data broadcasting system by Y. NOIREL, G. DUBLET.

[2] CCETT RSI/NT/13/15/80 The Data Packet Broadcasting system DIDON. Results of field trials.

[3] CCETT RSI/T/03/79 Television transmitters and data broadcasting by J.-C. VARDO.

[4] CCETT RSI/T/22/77 DIDON – Data Packet Broadcasting system. Theoretical model of a digital channel by J.-C. VARDO.