TIME CODED DISTRIBUTION VIA BROADCASTING STATIONS

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ABSTRACT

The distribution of standard time signals via AM and FM broadcasting stations presents the distinct advantages to offer a wide area coverage and to allow the use of inexpensive receivers, but the signals are radiated a limited number of times per day, are not usually available during the night and no full and automatic synchronization of a remote clock is possible.
As an attempt to overcome some of these problems, a time coded signal, with a complete date information, is diffused by the IEN, via the national broadcasting networks in Italy.
These signals are radiated by some 120 AM and about 3000 FM and TV transmitters around the country.
In such a way, a time-ordered system with an accuracy of a couple of milliseconds is easily achieved.

INTRODUCTION

A national metrological Laboratory has to satisfy the requirements of many classes of users; it is also sometimes noticeable the tendency to concentrate the efforts on the primary metrology or on the most accurate or precise comparison systems, disregarding consequently the "low-precision" dissemination.

(1) The work was performed when the author was at IEN.

The aim of this paper is to illustrate how some of the latter problems are solved at the Istituto Elettrotecnico Nazionale (IEN), the Laboratory entrusted with the Time and frequency metrology in Italy.

In the following section some news is given about the so-called low-accuracy users and the requirements thereof. The third section deals with some dissemination systems all using the radio and television broadcasting stations, whereas the fourth section is devoted to a new time-code service introduced in the Country. Finally, in the last section some applications of the new code are outlined.

Medium to Low-Accuracy Users and their requirements

The larger set of the end-users of a national time and frequency dissemination service seems to be interested in knowing the time with accuracies between 1 s and 1 ms, and the frequency with a relative accuracy between 10^{-6} and 10^{-9}.

Some data about the classes of users and their requirements are to be found in a CCIR report (ref. 1), that is based on an enquiry performed by the National Bureau of Standards.

A similar analysis, albeit not so wide, was performed in Italy, only among technical and scientific users, giving similar results. But it turned out that for these users the most stringent requirements were not on the accuracy but in the format and the general characteristics of the signal that should:

- provide a complete date information,
- allow the use of automatic systems,
- be available on continuous basis, in order to avoid a local clock and,
- be available everywhere in the Country an adequate and stable signal-to-noise ratio.

In designing a new dissemination system, one is moreover confronted with some CCIR Recommendations (ref. 2) asking to use, as far as possible, the existing radio facilities, for obvious spectrum conservation reasons. On this line, some services (ref. 3) or proposals (ref. 4) were illustrated in recent years.

Some frequency and time dissemination systems via the broadcasting stations

In Italy there is one broadcasting Authority, the Radio Audizioni Italiane (RAI), with a network of microwave links connecting the major Studios, located in Rome, with all the AM, FM and TV broadcasting transmitters.

The standard time signals of the IEN are sent via a radio link to the above mentioned Studios to be hence distributed to the various transmitters.

At the moment about 120 AM transmitters operating in the MF bands and 3500 FM or TV transmitters operating in the VHF and UHF bands are linked to a common time source.

The standard time and frequency services via the RAI broadcasting transmitters are listed in Table I; some more services are under study or development.

As regards the standard Time signals, service 1 is a time signal, depicted in fig. 1, and distributed since the year 1942; this signal is radiated about 30 times per day. Service 2 is the new time code signal, to be described in what follows and attached to service 1. For the standard frequency dissemination, service 3 consists in the frequency stabilization of the carrier of an AM transmitter, located in North Italy and covering with its surface wave great part of the country during the day. The carrier at 900 kHz is obtained by synthesis from a rubidium standard and the corrections thereof are printed as a daily value, in a monthly instalment appearing on the review "Alta Frequenza".

The RAI, service 4, sends a standard frequency subcarrier at $16\frac{2}{3}$ kHz along the microwave links serving the FM transmitters.

This subcarrier is used in order to stabilize the frequency of the AM transmitters and to practice the so-called "precision frequency offset" between the carriers of some co-channel TV transmitters. The subcarrier can be easily extracted from any FM receiver and can be used in a number of well known techniques.

The new code

With reference to fig. 2 the new coded signal is sent along with the previous time signal at the second 52, and consists of an Audio-Frequency-Shift-Keying 1248+ code, whose characteristics are depicted in fig. 3, along with a sample information. The format and the AFSK frequencies were the result of a trade off between the time allotted (not more than one second), the information to be transmitted (32 bits), the bandwidths that are available on the AM receivers, the pleasantness to the ear, the compatibility with some existing decoders of the previous time signal, and so on. In order to enhance the "smoothness" of the signal, no phase jumps occur in the switching between the two frequencies.

In fig. 3, the presence of two "parity bits" at positions 16 and 31 can be noticed; the possibility to decode only one part of information, e.g. hours and minutes, is thus given. The bit at position 15 tells whether the "day-light saving time" is used in the Country or not.

Fig. 4 shows the set-up of the clocks and related instrumentation used in order to generate and to monitor the new service, whereas in fig. 5 a general view of the time-scale room is given.

As regards the decoding of the signal a number of approaches can be followed. In some receivers-decoders developed at the IEN Laboratories the following criteria were followed for the time signal of fig. 1: check of the frequency, of the length of the pulses, of the length of intervals, of the blank at second 59. For the new coded signal (fig. 3), tests are performed on: frequency, identification pulses, total number of pulses, parity checks.

For the date code, a correct decoding was observed with a signal-to-noise ratio of 8 dB in simulated tests performed by the addition of white noise to the signal. It must be taken into account that the BCD code can immediately follow speech or music, no silent interval being insured before the code. On the other hand at the output of a typical FM receiver the S/N ratio exceeds usually 40 dB.

Final remarks

Between the abovementioned requirements for a general-purpose time signal, the code described provides the date information, suits the automatic decoders, allows a good coverage of the Country, but fails the round-the-clock availability.

Consequently the receiver-decoder must be fitted, with one of the inexpensive quartz-clock modules now available.

The quality of the quartz depends obviously on the allowed departure of the local clock at the end of the maximum interval in which no time signals are radiated. One of the receiver-decoders available on the market not only sets the clock but tells how to correct the frequency of the local clock whenever the number of corrections exceeds a preset value. In other options, the drift of the local standard can be removed via a servo; after a few days of operation, the error is of the order of a few units of 10^{-9}.

As regards the time dissemination, the precision is of the order of one-two milliseconds. The propagation delay depends on the path of the signal, between Turin-Rome and the interested transmitters. These delays reach a maximum of about 15 ms and are fairly constant, since in the radio links carrying the voice programs no reroutings are usually performed. For some applications, such as the study of the dynamic behaviour of the power network, the propagation delays were measured with a portable clock within one millisecond.

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TABLE I

Service	RAI stations	Type of service	Availability
1	all AM, FM, TV transmitters	time signal + voice announc.	30 times/day
2	all AM, FM, TV transmitters	date code	30 times/day
3	one AM station	stabilized carrier	continuous
4	all the FM stations	standard sub-carrier	18 hours/day

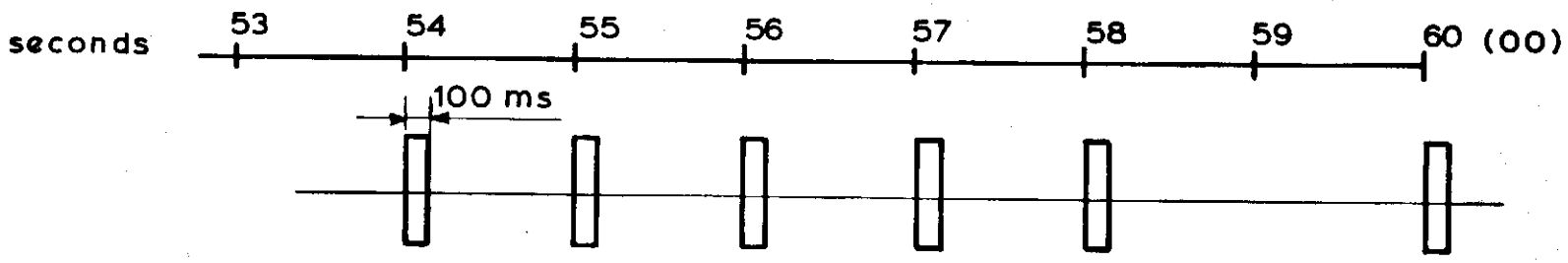


Figure 1. Time Schedule of the Old IEN Signal Radiated by the Italian Radio Company

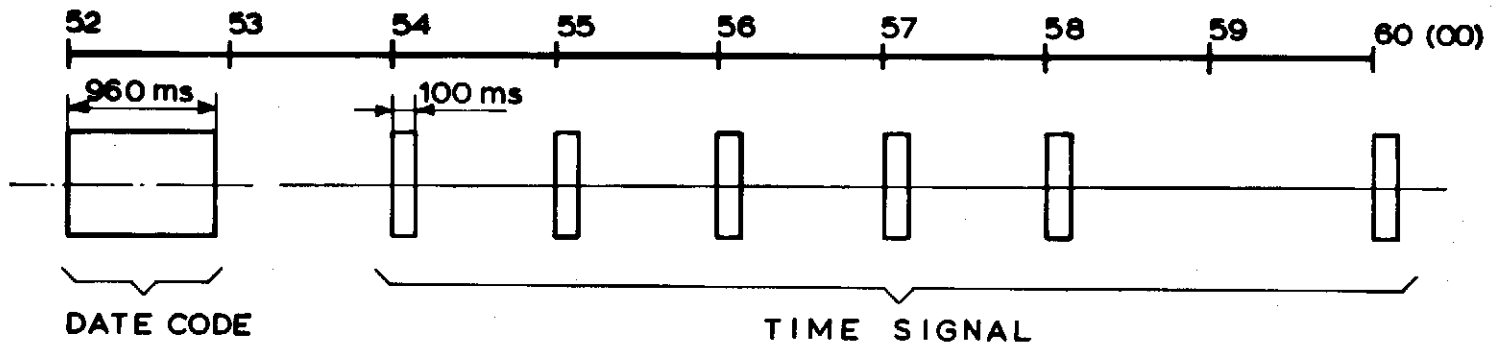
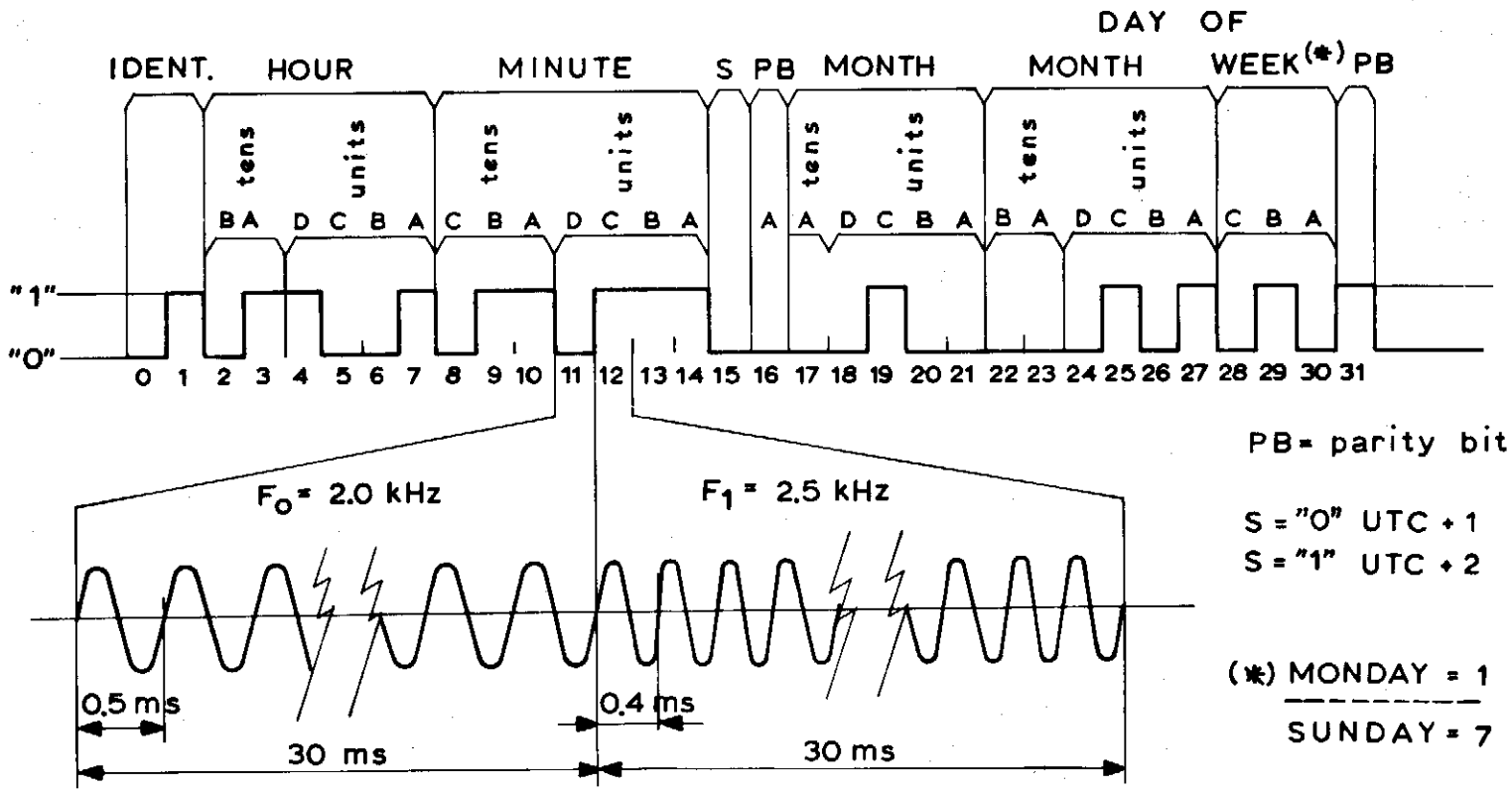


Figure 2. The New IEN Time Signal with a Complete Date Coded Information



DATE CODE AND DETAILS OF THE FSK MODULATION; THE DATE TRANSMITTED IS TUESDAY 5 APRIL, 19 HOURS 37 MINUTES, UTC+1

Figure 3. The Coded Information Seen in Details

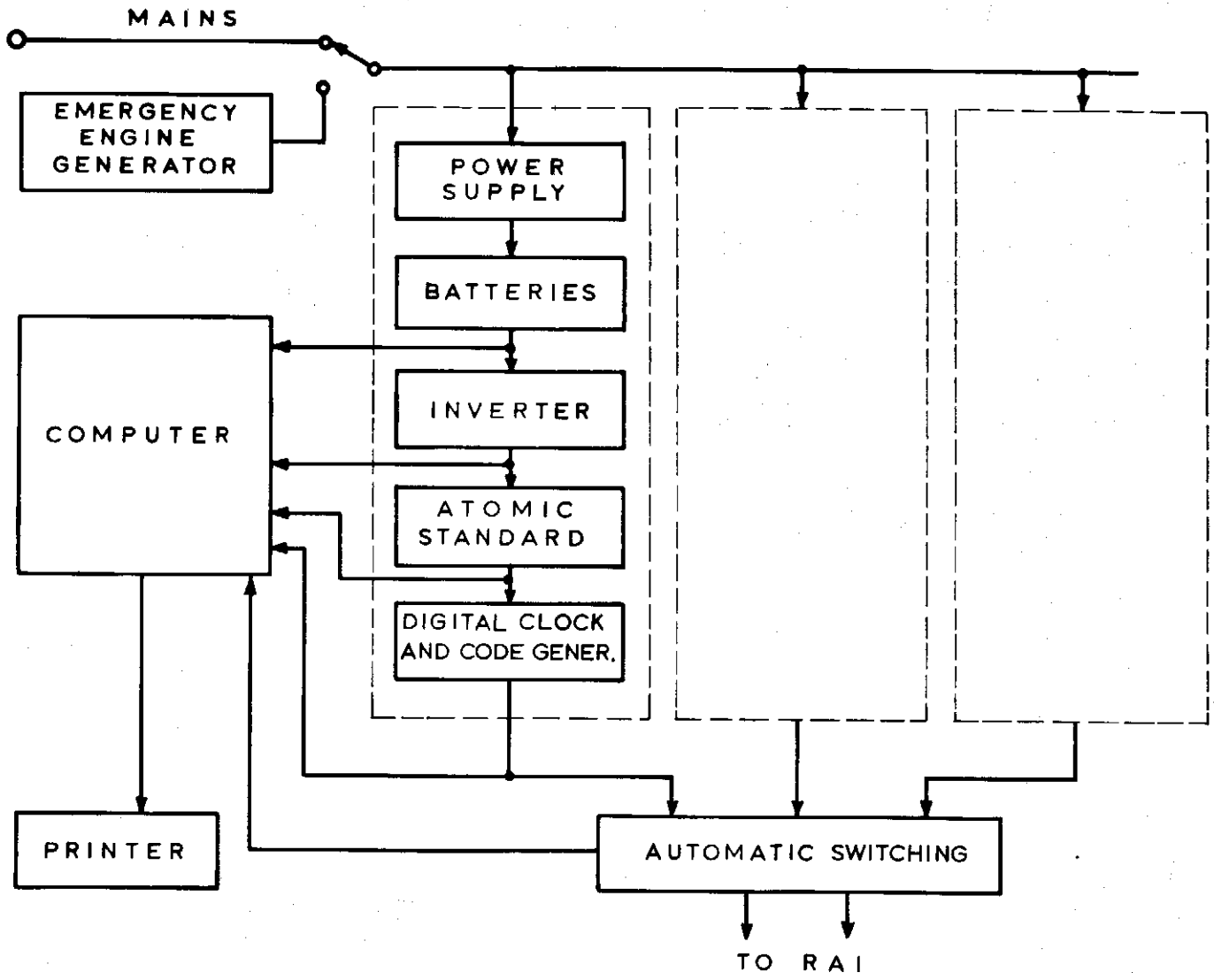


Figure 4. Equipment Set-Up Used to Generate and Control the New Coded Time Signal

Figure 5. View of the IEN New Time and Frequency Laboratory

QUESTIONS AND ANSWERS

DR. BARTHOLOMEW:

We are being very economical of our time. Does anybody have any questions for the professor? How big a demand are you having for that day of the week time code?

DR. LESCHIUTTA:

Yes. Just to give you an idea, we have received about, when we made an inquiry three years ago, about 2,000 different people asking the day of the week. Those are, it is funny, are coming from banks or from supermarkets, from very, very strange peoples.

I don't know the reason why they need exactly also the day of the week, but this happens. So we were asked especially to insert also this information.

QUESTION:

Could you give an estimate of how inexpensive and reliable you expect the timing equipment will be?

DR. LESCHIUTTA:

Yes. At the moment the equipment we are seeing is on the order of $1,500 dollars but this is development equipment. The problem is this one: you can buy a very inexpensive frequency modulation receiver, this is not the problem, $20 or $30 dollars, it depends upon the class of the receiver; or perhaps more, in the region of $200 dollars if you want a receiver with the sort of control on your selector. And the decoder itself is about 4-5 IC's, can be done, and the rest is the display. So I think that that kind can come out with the price on the order between $300 and $500 dollars, just to give you an idea.