TIME DISSEMINATION IN THE HYDRO QUEBEC NETWORK

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ABSTRACT

The ever increasing complexity of electrical networks combined with the increasing cost of power losses during a network failure has led public utilities to become equipped with more powerful and precise tools for pinpointing the causes of such a fault. Hydro Quebec has developped and is now using a time dissemination system which uses a modified IRIG B code transmitted on its own telecommunication network. The reasons for using such a system and the way it was carried out are discrete.

INTRODUCTION

After a fault occurs on a network it is at times difficult to reconstitute the chain of events without a means of precisely dating each one of these events. In fact when the fault is straightforward (the fall of a transmission line or bursting of a transformer) the cause and thus the remedy is easy to establish. In a lot of cases however the situation is not nearly so clear which leaves the analyst with a series of events which all took place within a few seconds or less (opening of a circuit breaker, alternator trigger off etc.) without him being able to determine precisely the cause or origin of these events.

The precise dating of each event has proved to be an effective tool in eliminating any doubt in those cases. Indeed the fact of being able to reconstitute the order of events allows to recover the origin and thus the cause of trouble to be pinpointed.

In practice each transport substation must therefore have the same time everywhere. The accuracy required is in the order of 1 ms or better.

Several tests with WWVB have proven that such exact timing could not be obtained, not to mention the fact that in the north east of Quebec and in Labrador the VLF station Rugby (united Kingdom) interferes with that of WWVB.

HYDRO QUEBEC IRIG B SYSTEM

Hydro-Quebec has thus decided to synchronise its clocks using an IRIG B code transmitted on its own telephone network.

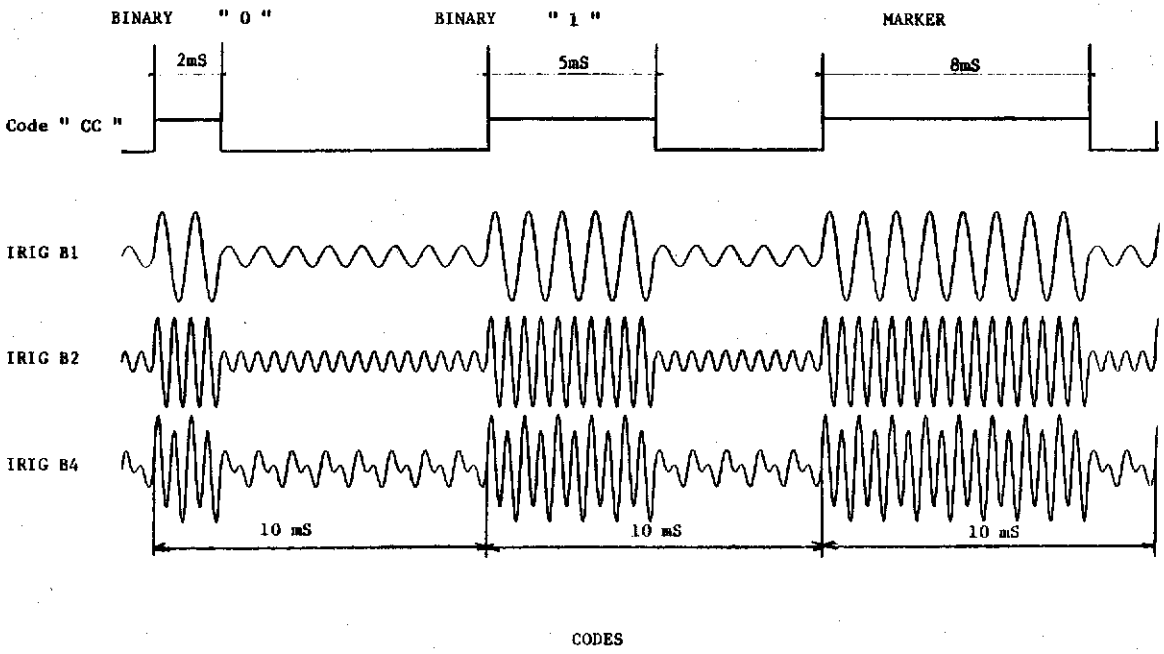


FIGURE 1

At first a 2 KHz carrier (Figure 1) (IRIG B2) was used in order to obtain a spectrum better centered within the telephonic band (300 Hz - 3 KHz). Closed loop measurements (go and return on the same telephone channel) have shown an excellent stability with this system (variations of less than 100 µs over 728 miles - Montreal Churchill). However measurements between two points (go only) have shown that it is impossible to use such a method directly. In fact it was noticed that the phase of the 2 KHz signal varied in a random fashion giving a variation of ± 500 µs of the local hour as compared to the master clock and worse yet, that a normal decoder could not read the code about 20% of the time.

After a study it was discovered that this problem was related to the use of SSB in the FDM microwave system.

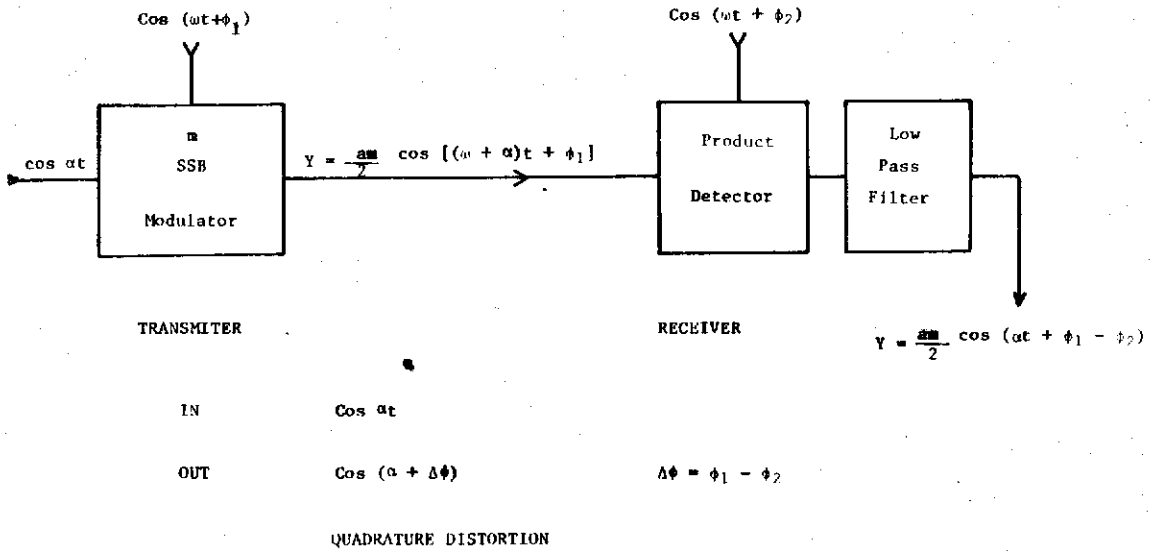
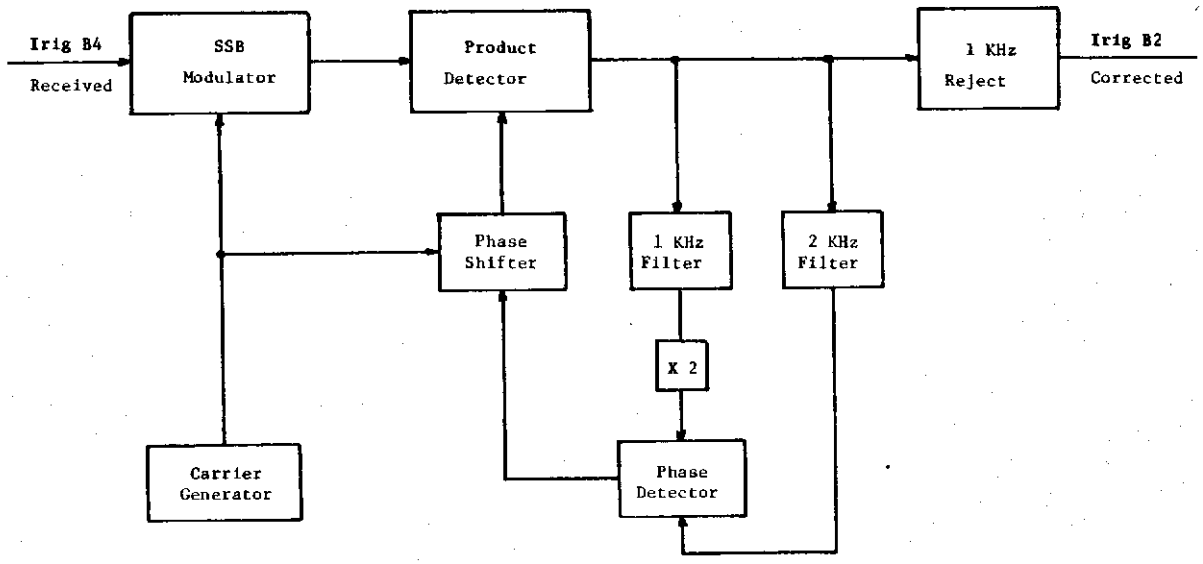


FIGURE 2

If we split the IRIG B signal in a Fourier Series, each component follows the equations of Figure 2. If $\Delta\phi$ is the phase difference between the two local oscillators of the FDM transmitter and receiver, the component will have a phase shift equal to $\Delta\phi$. The resultant from all these components gives a signal which can be deformed, inverted etc.

It was noticed that in a going and returning signal the error in the going signal is almost exactly corrected by the return error; thus the idea originated of simulating a return locally. For that purpose it was necessary to add a 1 KHz pilot to the IRIG B2 code which is in phase with the 2 KHz carrier of the B2 code giving IRIG B4 code (Figure 1).

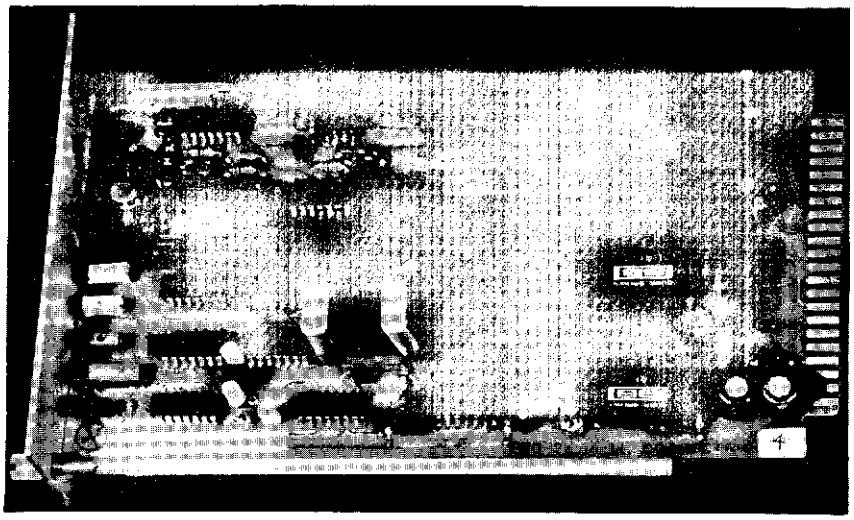
If locally at the arrival we split the signal by filtering its 1 KHz and 2 KHz components, each one will have a phase error of $\Delta\phi$. By multiplying the 1 KHz component we obtain a 2 KHz signal with a phase error of 2 $\Delta\phi$ which there locally shows a phase difference $\Delta\phi$ between the two 2 KHz signals.



Corrector Bloc Schematic

FIGURE 3

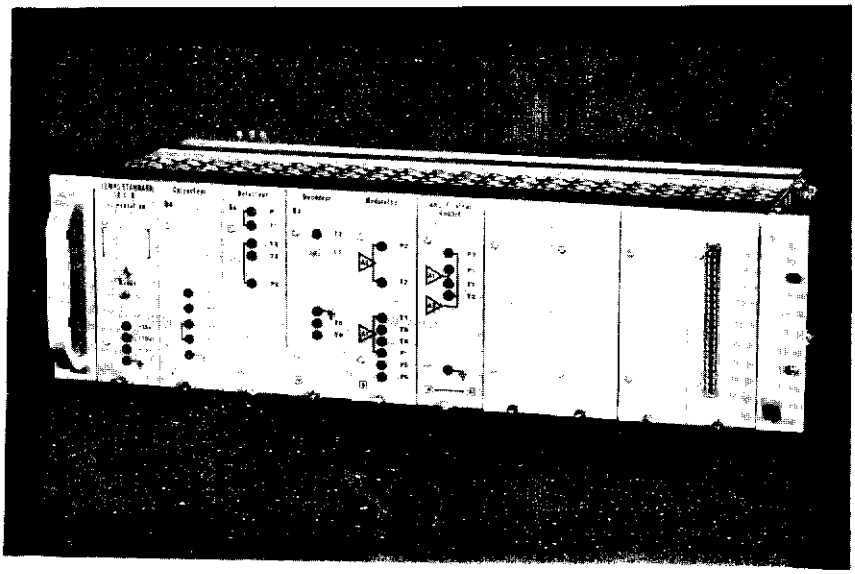
This particularity allows a corrector to be developped as seen on the Figures 3 and 4. This apparatus introduces the error - $\Delta\phi$ which now gives us a convenient signal.



Corrector

FIGURE 4

The reconstitution of an IRIG B1 signal (carrier at 1 KHz) is then assured by its allied circuitry (Figure 5).



Local Distributor

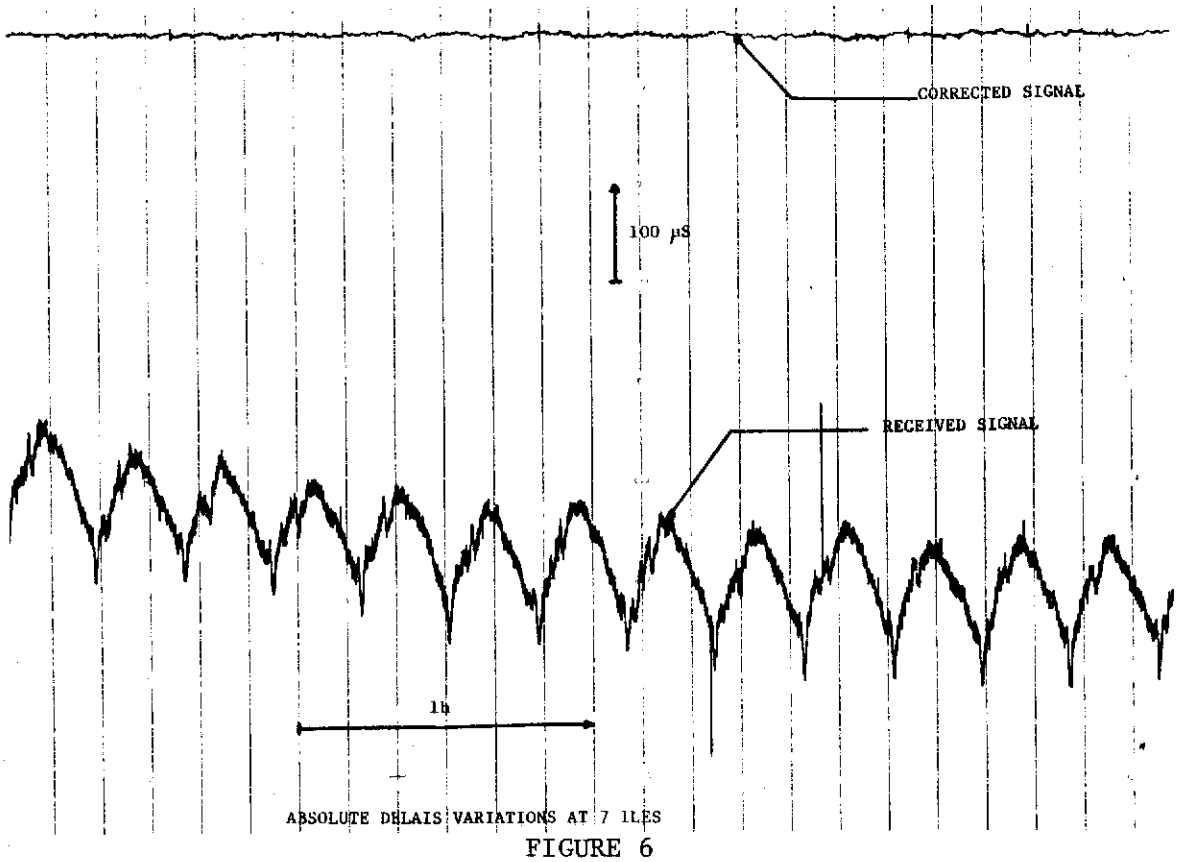
FIGURE 5

The apparatus also incorporates protection at its input and output which is necessary inside a high voltage substation.

Several measurements made in the Montreal region and between Montreal and 7 Island have shown the quality of the obtained results (Figure 6).

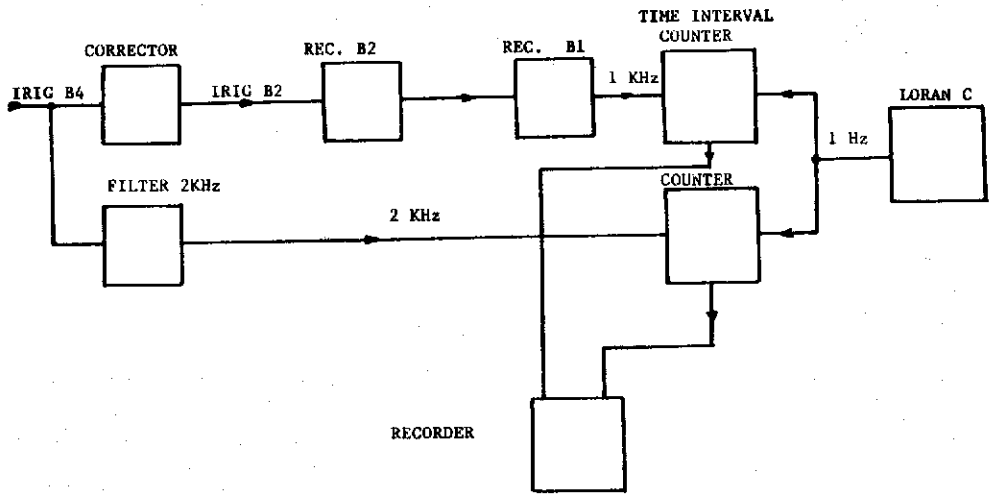
The method of measurements employed is shown on Figure 7.

The master clock used is a rubidium clock located in Montreal. The accuracy of the measuring clock is assured by a LORAN C receiver.



ABSOLUTE DELAIS VARIATIONS AT 7 ILES

FIGURE 6

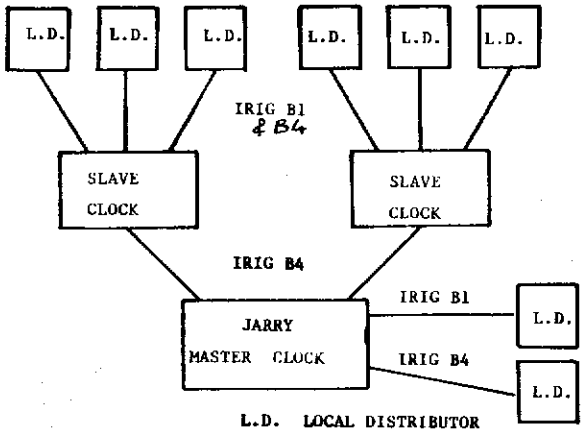


MEASUREMENT APPARATUS

FIGURE 7

Hydro-Quebec is presently installing a system based on a centralized master clock. A small number of slave clocks placed in some key areas of the network limits the number of necessary links by avoiding to join all the points to the master clock and also assures a permanent time code distribution in case of a link break between the master clock and a slave clock (Figure 8).

In Jarry Station we plan to have 3 clocks with an automatic Switch over based on a majority decision. One of the 3 clocks should be synchronized by GOES Satellite.



HYDRO QUEBEC TIME CODE GENERATION

FIGURE 8

QUESTIONS AND ANSWERS

DR. BARTHOLOMEW:

I would only observe that Hydro-Quebec, as a public utility, is not totally pre-occupied with fuel cost adjustments as some of our locals are.