PTTI APPLICATIONS AT HYDRO-QUÉBEC

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ABSTRACT

As a power utility, Hydro-Québec used the PTTI techniques. The time dissemination system in the Hydro-Québec Network (11th PTTI) is now installed in several points.

We have since built a portable clock using a rubidium standard and associated circuitry (a microprocessor IRIG B reader-generator, time interval counter, time accumulator etc.) which are necessary for our measurement. The article describes the apparatus and the experimental results obtained.

We have also used GOES synchronized clocks for making precise voltage angle measurement on the Hydro-Québec Network. Some modifications have been made on a commercial unit. Applications and results will be presented.

I INTRODUCTION

As a Power Utility, Hydro-Québec should use all facilities available to reduce outage probabilities. We are presently working on two main PTTI applications: time dissemination for event recording purposes and angle measurement of a 60 Hz voltage.

The first one was described in more detail at the last PTTI (1). We show here the development and construction of a portable clock to make time delay calibrations. The second one is an application of a GOES synchronized clock. We present the whys, hows and problems encountered in this case.

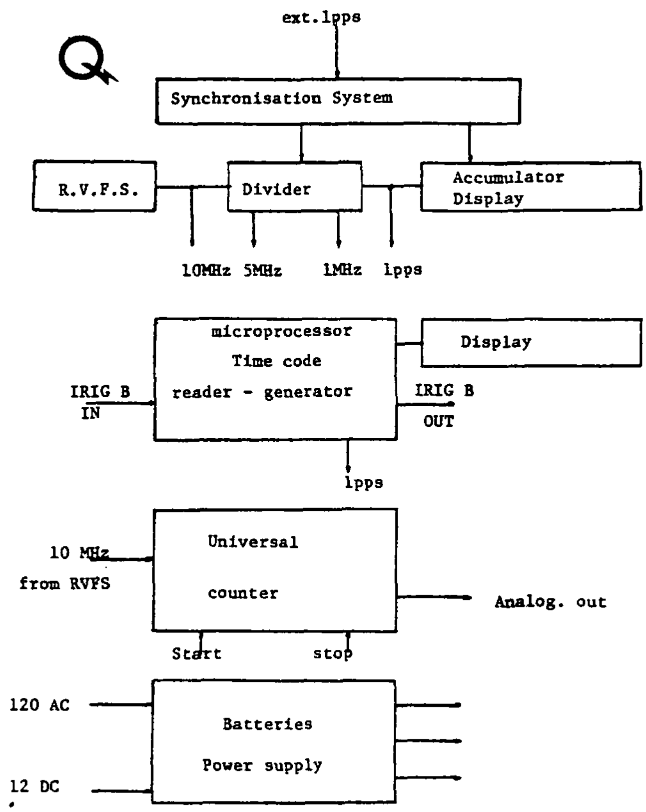
II TIME DISSEMINATION

Actually, from a master clock, we disseminate time code to most of the main power stations of the Hydro-Québec network. The code is used in each place to put a date on each event's recording. The precision required is 1 ms. To calibrate the propagation delays between the master clock and the remote ones we have built a portable clock called HM2.

The characteristics of the clock are:
- Weight 32 kg
- Dimensions: 9" x 16" x 20"
- Rubidium vapor frequency standard
- IRIG B decoder-generator
- Universal counter (frequency-time delay) with analog output
- 24 hours autonomy on batteries
- 110 VAC and 12 VDC input.

The block diagram is shown in Figure 1. Only the clock part (excluding the display) runs on battery during travel. The divider is synchronized by an external 1 pps source.

The time code reader has an 1 pps output, so an operator can receive a time code in a power station, check the value of the transmitted date and measure the delay between the internal 1 pps of the clock and the one decoded from the time code using the universal counter. Figure 2 gives a typical recording.

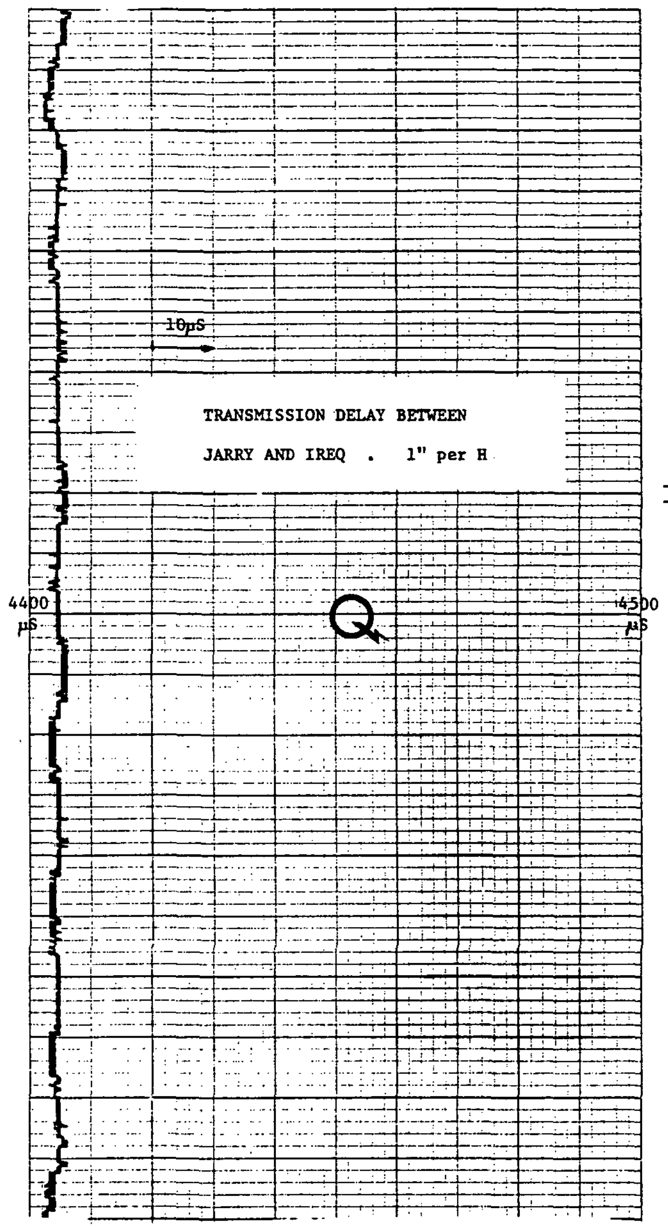


HM2 BLOC DIAGRAM

FIG. 1

One could use HM2 as code generator to send a time code to other apparatus in order to check them.

The portable clock will also be used to calibrate in the field Xtal oscillators with the help of a frequency comparator. This is useful for stationary apparatus or for precise setting of running oscillators. We



Transmission time delay record using HM2

FIG. 2

also plan to use the portable clock as backup of the main frequency standard at the master station because in case of failure it can take some months to repair it.

III 60 Hz VOLTAGE ANGLE OF A TRANSMISSION LINE

3.1 Definition-interest

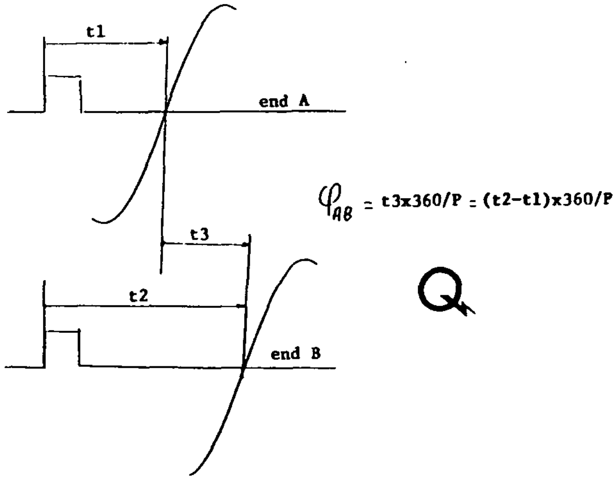
The 60 Hz voltage angle is the phase angle between the two voltages which exist at the ends of a transmission line. Roughly the angle depends on the load of the line, the length of the line, and the number of lines used in parallel between two points.

Voltage angle is the most important parameter of a power system network. Until now, it was only calculated. Its direct measurement gives a lot of information on the behavior of the power system network. Its recordings during fault can be used in postmortem studies of the network, or used to adjust or correct the theoretical model.

3.2 Measurement procedures

Points of measurement are far away from each other (hundreds of km) and most of the attempts to code and send voltage waveforms from one point to the other failed due to transmission time delay variations of the same order of the thing to be measured (1° at 60 Hz equals 40 µs).

So we (2) and others (3) in the past have done some experiments using two (or more) local references at 60,000 Hz synchronized together. Then one can measure and code the local (or absolute) voltage angle and send those values to a central station which now may calculate the voltage angle by substraction. Figure 3 illustrates this method.



Method of measurement

FIG. 3

Using this concept we built a system with the following objectives in mind:

- fully automatic system
- 24 hour operation every day of the year
- accuracy of measurement better than 1° at 60 Hz (≈ 40 μs)
- 30 measurements per second.

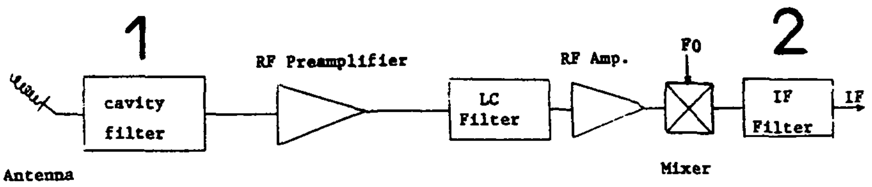
Using the GOES time code to synchronize the 60,000 Hz reference has created some problems.

3.3 Problems in using GOES time code-Hydro-Québec's improvements

GOES time code is in an experimental phase. From time to time data are wrong or absent. Or there is a change in the satellite used, so the helix antennas are in the wrong direction.

GOES frequency is not exclusive: so there are several radio interferences due to mobile radio and the only commercial clock available with automatic correction of time delay propagation has a lack of selectivity which perturbs its operation during RFI.

We made two modifications of the clock (Figure 4)



Hydro-Québec's improvement of the GOES synchronized clock

FIG. 4

1) We added a cavity filter to limit RF band pass and possible saturation of the RF preamplifies

2) We changed the IF quartz filter. The original one gives 40 to 45 dB of ultimate rejection, the new one gives 75 to 80 dB of rejection limited mainly by the printed circuit on which it is installed.

By comparison a typical mobile radio has over 90 dB of rejection.

In severe environment the unmodified clock synchronized only during the night (no or few users of mobile radio) but remains totally unsynchronized during the day (except on weekends). The modified model remains synchronized during the day. In other environments (few mobile radio) the improved model makes less errors than the unmodified one. Figure 5 shows typical results of the modified one (in favorable environments) and Figure 6 typical errors when we remove the cavity (but improved filter in place). We don't have recordings of the original clock, but, errors are more numerous.

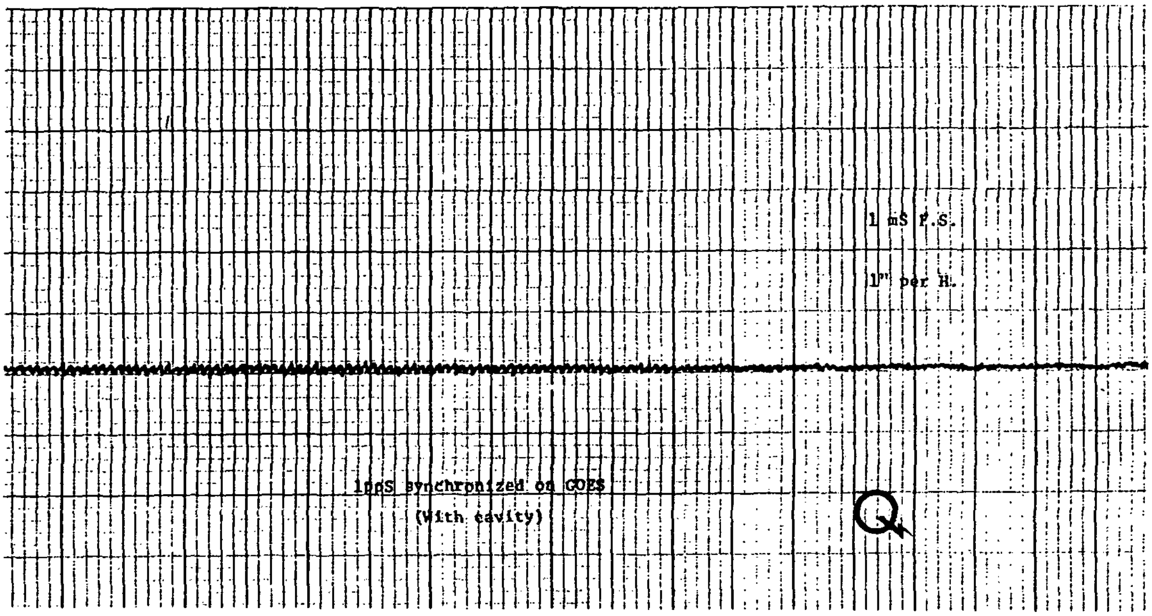


FIG. 5

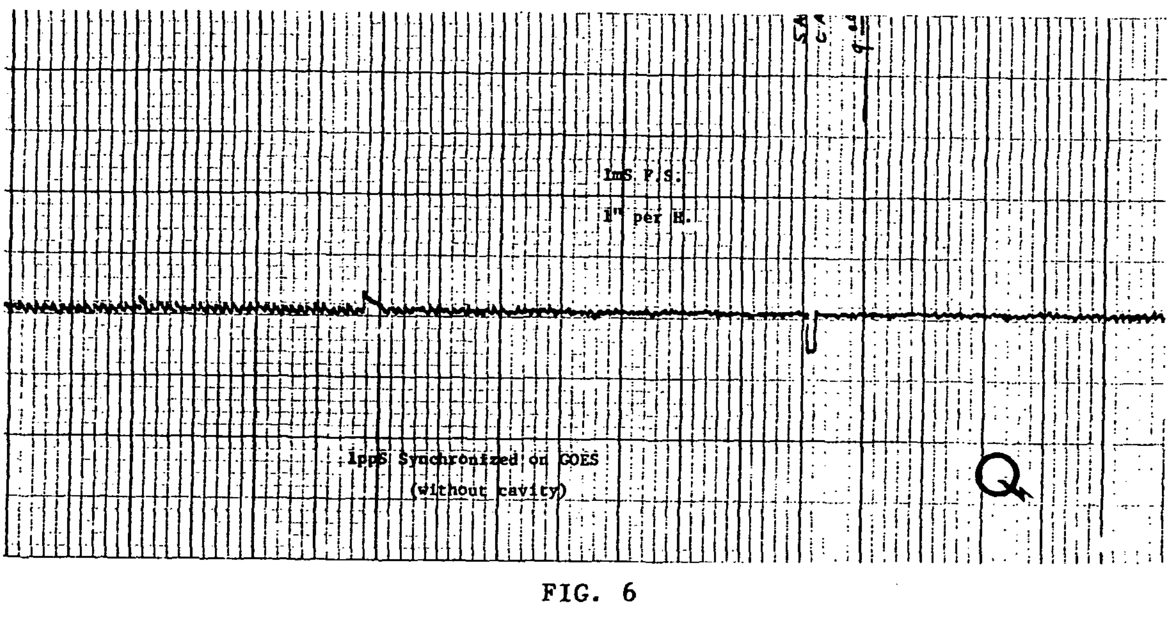
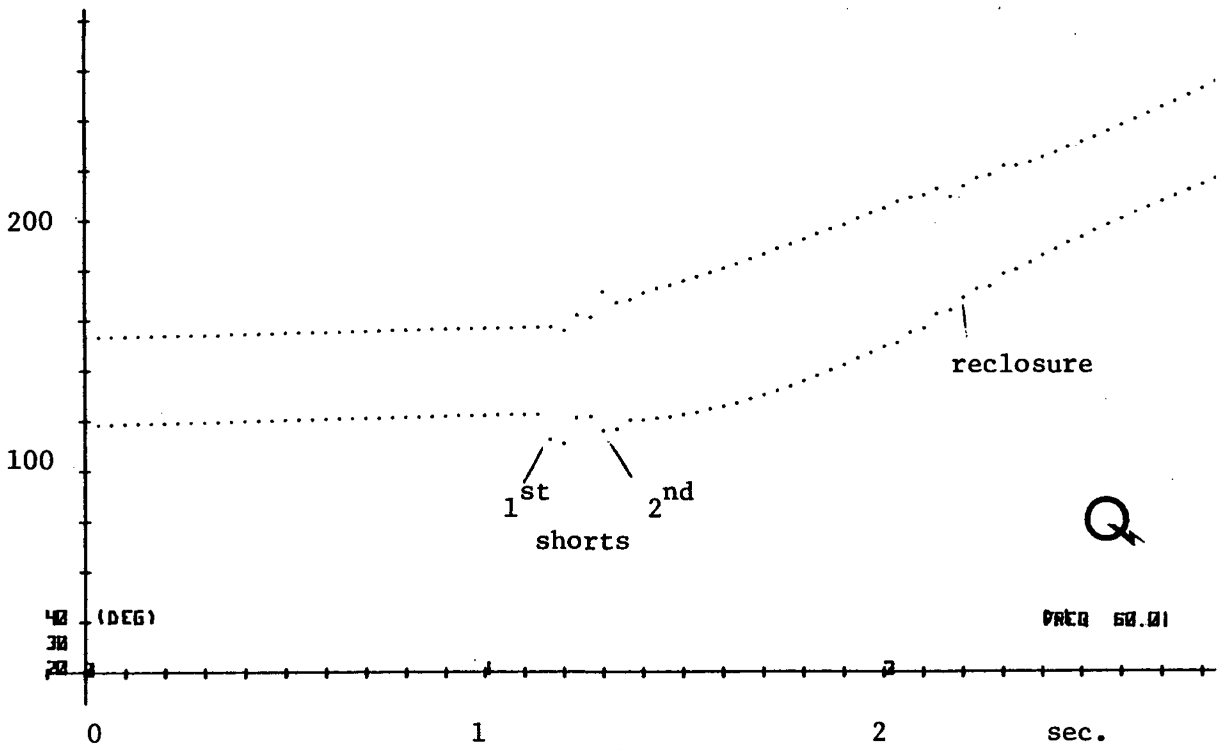


FIG. 6

3.4 Results

Figures 7, 8, 9 show a typical recordings of local angle, voltage angle and frequency during short-circuits on two parallel lines, with automatic opening and reclosure.



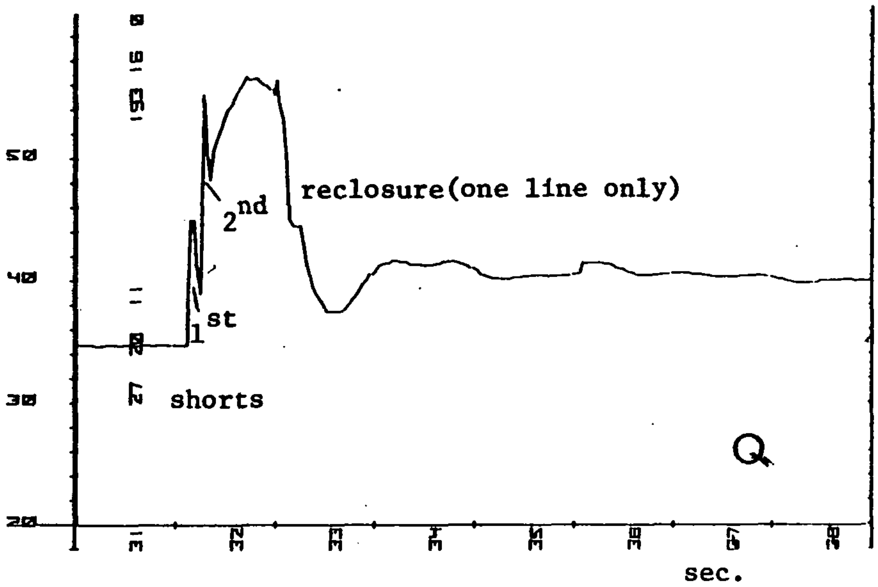
Local phase record

FIG. 7

[1] G. Misout, W. LeFrançois, L. LaRoche, "Time dissemination in the Hydro-Québec Network," 11th PTTI, P. 343.

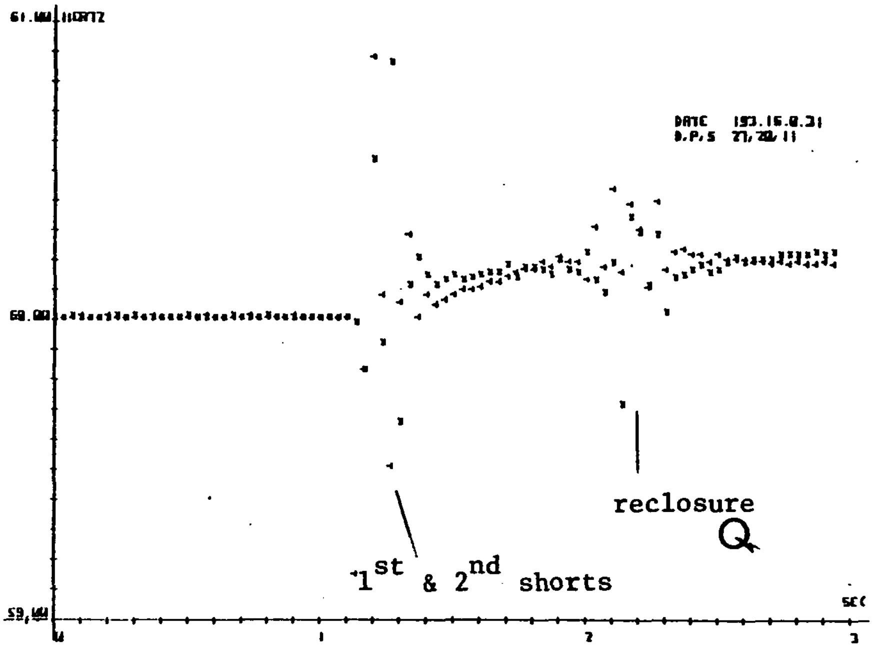
[2] G. Missout, P. Girard, "Measurement of bus voltage angle between Montreal and Sept Iles," IEEE Trans. on PAS-99, No. 2, pp.536, March/April 1980.

[3] G. Rovera, A. Schiavi, "La mésura a distanza dell angolo de fase dei vettori tensione nelle retielecttriche," Instuto Ellectrotechnico Nazionale Galileo Ferrarir, Vol. LVII, No. 1418-1421, 15-21, Sept. 74.



60 Hz voltage angle

FIG. 8



Frequencies of both extremeties of the line

FIG. 9

QUESTIONS AND ANSWERS

MR. DAVID HOWE, National Bureau of Standards

I am delighted that you are using the GOES experiment time code and it represents an important application of such dedication. However, you pointed out, it is an experimental system. What are your plans in the future for that system? Have you got any?

MR. MISSOUT:

There are some possible plans. First of all, we will try to find a new system of dissemination on the Hydro-Quebec microwave network to find the same accuracy as we have now.

Secondly, if this fails we may wait for a system like GPS which gives us more than one satellite. Because, actually, we use phase angle measurement for postmortem. But, it is possible to use automation. If you use the phase angle measurement for automatic control of the system, you have to be sure that it works.

So, actually each time we lose the satellite for whatever reason, the system doesn't work properly, and in fact, gives false measurements. So, we try to operate independently in our system; and secondly if it doesn't work we try your other system.