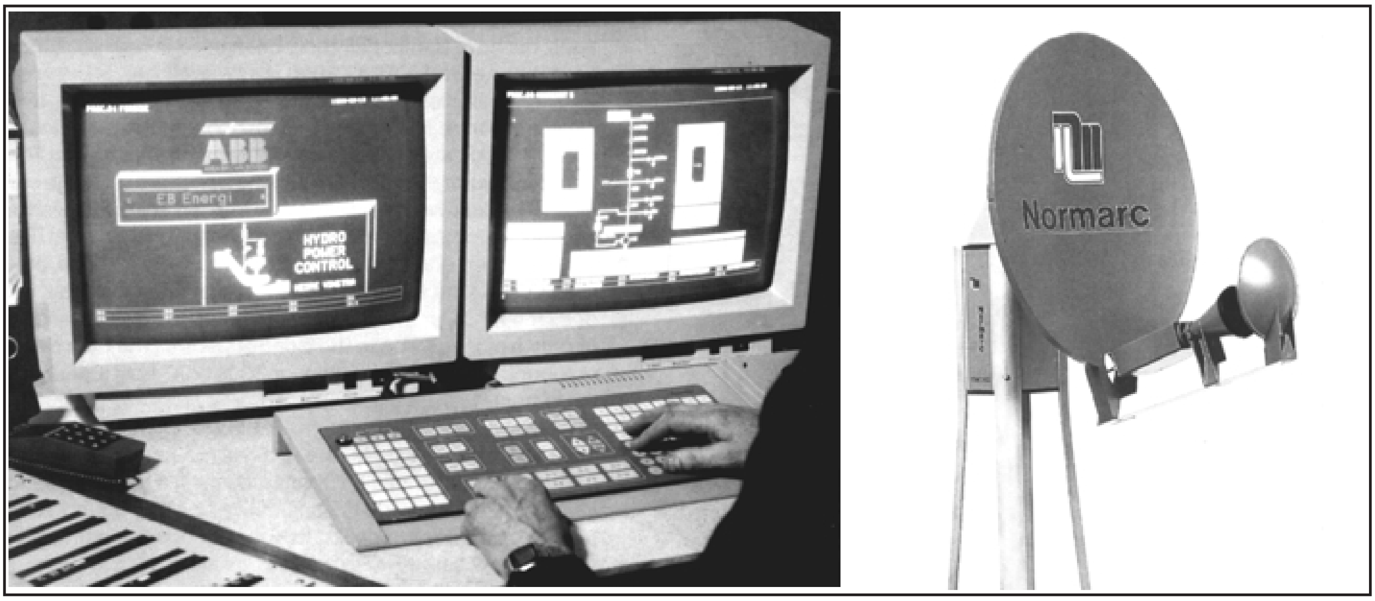
Detecting unwanted modulation of a data communication system clock



Background

A manufacturer of telemetry and satellite data communication equipment suspected severe noise on the 10 MHz system clock signal, during the final design phase of a new product.

Frequency measurements using a normal frequency counter showed that the average clock frequency was stable and correct, when measured over 0.1 s, 1 s or 10 s. But for very short measuring times, the display value varied more than expected.

The clock was checked with a spectrum analyzer, that could not reveal any major disturbing frequencies ("sidebands").

Measurement problem

The immediate measurement problem was to characterize and quantify this clock instability (=the frequency variations) to verify whether it would harm the performance of the product. The second task was to find the source of interference and eliminate its influence.

This was indeed a tough task. The traditional measuring tools, like traditional counters, oscilloscopes, spectrum analyzers etc. did not have the capabilities needed.

Time was running and the dead-time for the final design release was coming closer. In the right moment however, a CNT-81 timer/counter/analyzer was made available for the design group.

Measurement set-up

The noisy 10 MHz clock signal was connected to input A of a CNT-81, which was connected to a PC running TimeView™. The CNT-81 was set to frequency measurements, using default settings.

A free-running data capture of 4096 frequency measurements was made, and a frequency vs time graph was instantly displayed, see figure 1. The frequency samples were taken approx. every 200 μs, and each frequency value had a resolution of 7 digits.

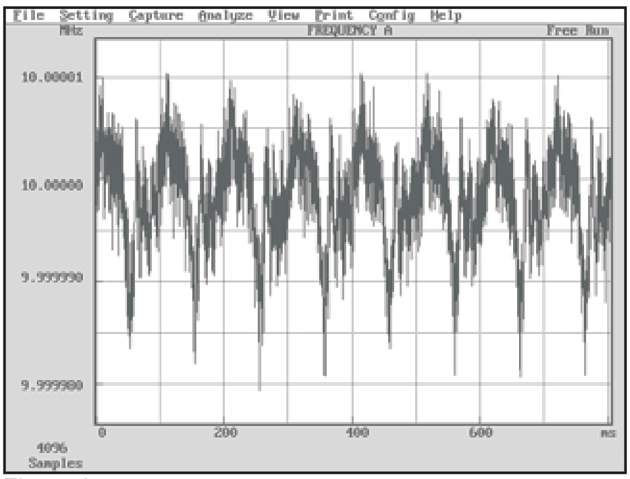


Figure 1 *Periodic frequency deviations of the system clock is shown in the frequency vs time graph*

Frequency vs time graph gives first clue

The frequency vs time graph in figure 1 shows periodic frequency variations on the 10 MHz clock frequency. These variations have the shape of a “distorted triangular or sawtooth wave”.

From picture 1 you can clearly see the periodic variation of the clock frequency, and you can roughly estimate the time between frequency “maxima” to approx. 100 ms. The difference between maximum and mininum clock frequency can be estimated to approx 30 Hz.

Distribution histogram quantifies clock frequency variations

To get a better quantative estimate, the statistical analysis in TimeView was used.

Figure 2 shows how all individual frequency measurements are distributed. The “fact box” shows maximum and minimum frequencies, along with a mean frequency of 9 999 998.2 Hz. Thus the mean (average) value is close to the nominal 10 MHz; only 1.8 Hz away. This is also the result shown on a frequency counter, measuring over a longer period.

However, the graphical distribution histogram itself gives a better picture of the clock instability. The diagram cursors in figure 2 shows that the difference between highest and lowest frequency is 31.14 Hz (“δx=31.14... Hz” under the diagram).

FFT-diagram finds disturbance source

So far it was found that the clock frequency is unstable, has an accurate mean frequency (1.8 Hz offset) but a ±15 Hz periodic deviation.

The question to ask now is “what is the source for this periodic frequency variations, in other words *modulation*.

By applying FFT-analysis, figure 3, the diagram cursors show that the modulation source has a dominating frequency of approx 10 Hz (9.8 Hz). Since another circuitry in the design had a switching frequency of approx. 10 Hz, the source for the clock instability was found very quickly, now when the designers knew were to look. This clock modulation interference was thereafter fixed in a short time.

Conclusion

The CNT-81 plus TimeView is an excellent, accurate and fast tool to quantify clock stability and detect unintentional modulation of high stable clock systems, for example in data communications.

Traditional instruments, that might be considered by unaware persons, are a.o. traditional counters, oscilloscopes or spectrum analyzers. None of these alternatives can detect 1.5 ppm frequency variations (±15 Hz deviation on a 10 MHz carrier), occuring many times per second. Nor are they able to find the 10 Hz modulation source.

Note that not even normal, expensive spectrum analyzers can detect such small frequency modulations To resolve frequency components within a few Hz around the 10 MHz peak, puts extremely high demands on narrow-band filtering. This small frequency deviation is however very easy to see with TimeView, according to picture 1.

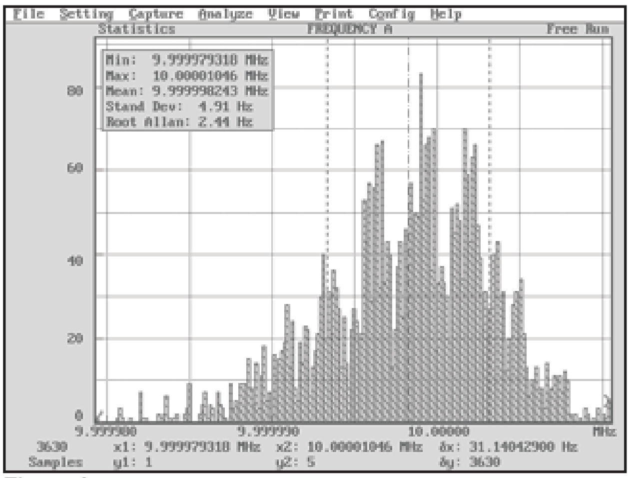


Figure 2 *The 31 Hz deviation is found in the distribution histogram*

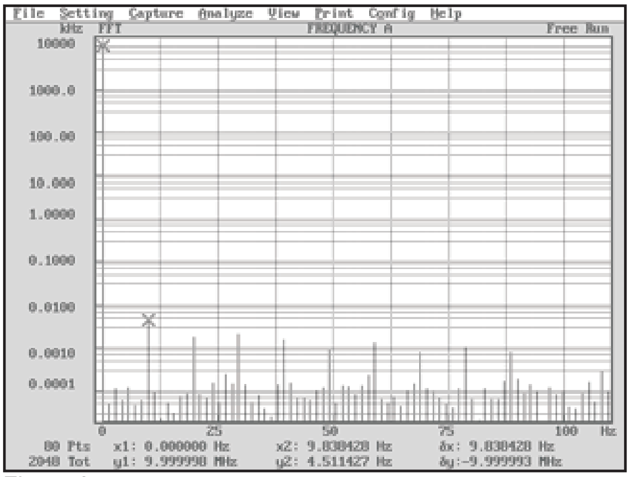


Figure 3 *The 9.8 Hz modulation is measured via the FFT-function*

pendulum