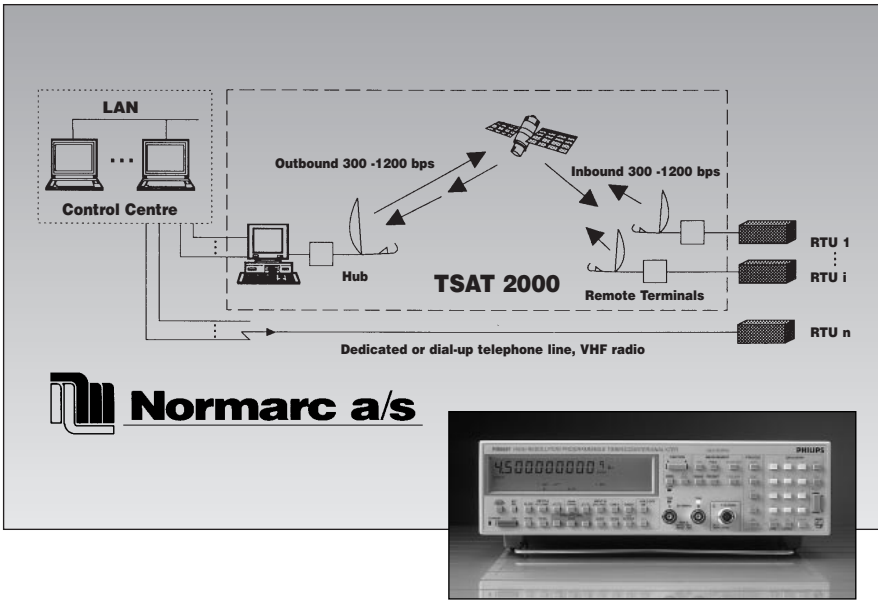
FLUKE®

Viewing Frequency Shift Keying (FSK) Signals

PM 6681 Timer / Counter / Analyzer with TimeView™ Software

Application Note



Background
Normarc a/s (Oslo, Norway) makes communications equipment for telemetry and data transfer via satellite. Their systems permit many kinds of remote monitoring and control functions, such as data transfer of road traffic information from various sensors (intensity, temperature, carbon monoxide–concentration in tunnels etc) or control of e.g. traffic signals.

For data communication, Normarc uses a HF–carrier frequency, with a 300–1200 bps FSK–modulation.The carrier frequency used is 70 MHz modulated with a small frequency shift every 3 ms. Four discrete frequencies are used for data coding, each separated approximately 300 Hz. The frequency transitions are filtered via a gaussian filter to avoid the sharp frequency changes that would otherwise generate harmonics and cause the signal to occupy more valuable bandwidth than desired. Due to this filtering, the frequency transitions are smooth, less distinct, but bandwidth "waste" is reduced. This Application Note describes how the PM 6681 timer/counter coupled with TimeView PC–based software from Fluke solved a tough Frequency Shift Keying (FSK) measurement problem for Normarc.

The measurement problem
The measurement problem was to identify and view the small frequency shifts on the 70 MHz carrier, and verify that the four discrete frequencies used were at 300 Hz intervals.
Viewing a 70,000,000 Hz carrier and simultaneously track rapidly changing 300 Hz shifts is a very tough measurement task. Before the introduction of the Fluke PM 6681 it required extremely expensive tools. In fact, before PM 6681 and TimeView was demonstrated the first time, the engineers at Normarc had not yet been able to view the dynamic signal in the frequency vs time domain at all.
So in summary, the measurement problem could be simply stated: "Sample the frequency fast enough to be able to view all frequency shifts, and do every individual measurement with very high resolution".

Resolution requirements
The required resolution of each frequency measurement was $1x10^{-7}$, or 7 Hz for the 70 MHz carrier. To reliably follow all frequency shifts, at least two frequency samples per modulation clock cycle must be made. At 300 bps, the modulation clock has a period of approx 3.3 ms, which means that 1 sample every 1.6 ms is required.

The PM 6681 and TimeView were set up for free–running data capture and the measuring time for each frequency sample was set to 1 ms. All other settings were the TimeView defaults with the PM 6681. A 1 ms measuring time gives a $5x10^{-8}$ resolution (3.5 Hz) and a sample rate of one measurement every 1.1 ms, well

inside the requirements. The result is shown in Figure 1.

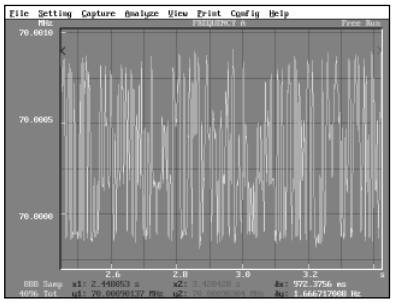


Figure 1 The frequency vs time graph of a FSK-signal (4-shifted frequency levels)

Analyzing the frequency vs time graph

The frequency vs time graph in Figure 1 shows that the frequency values are concentrated around four different frequency levels. This is more clearly seen when the TimeView presentation mode is changed from "lines" to "dots", so the individual measured value pairs [f(t), t] are not interconnected with lines, as shown in Figure 2.

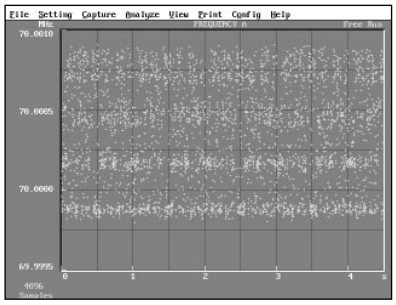


Figure 2 The frequency values from Figure 1 shown as non-interconnected "dots"

But how are these four frequency levels distributed? From Figure 1 or Figure 2 it may be difficult to actually quantify the "frequency density", that is how often the signal is at one or the other frequency level. TimeView can give a thorough answer to that too.

A closer look at the four shifted frequencies

By using the TimeView statistics analysis mode, the frequency distribution histogram verifies that the frequency samples can be grouped into four "frequency clusters", shown in Figure 3.

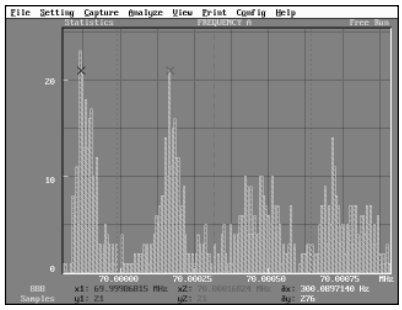


Figure 3 The distribution of the frequency samples obtained from Figure 1

By moving the two cursors to the center of each cluster, the mean value of each cluster can be read. Also the field "ax=300.08 Hz" indicates the frequency difference between the cursors.

Analyzing individual clusters

The histogram can also be used to verify the fitness of the gaussian filter. Too little filtering, and you are wasting bandwidth. Too much will cause the clusters to overlap too much and data may be wrongly interpreted.
A measure of the filter characteristics is found by analyzing the distribution in each cluster. For Normarc, the standard deviation must be well below 150 Hz to assure a good communication. Figure 4 shows, a zoom-in of the first (=lowest frequency) cluster. As can be seen in the greyed box in the upper right corner, the calculated standard deviation for this cluster is 24.4 Hz.

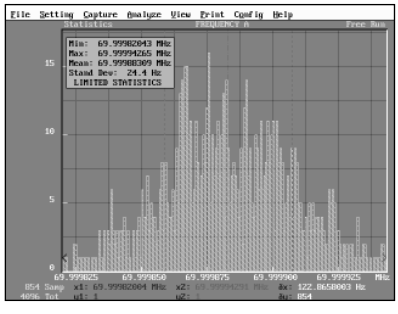


Figure 4 The distribution of frequencies in the first cluster only

Instrument requirements

To be able to make this frequency versus time measurement with the required sampling rate and resolution, you must combine both a very high resolution and a very high measurement speed in the same instrument. The PM 6681 offers both the highest resolution and the highest measurement speed available in any timer/counter today. Of course, this type of measurement can not be handled by oscilloscopes or spectrum analyzers. The strength of those instruments is to measure amplitude variations over time, not frequency variations over time.
Not even all expensive dedicated modulation domain analyzers will do this measurement with the required resolution, e.g. the 53310A from Hewlett-Packard would fall short, because of insufficient resolution ($2x10^{-7}$ for 1 ms measuring time instead of the required $1x10^{-7}$). However, the PM 6681 and TimeView Software give you measuring power and precision needed to meet these challenging requirements.

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