

# Measuring TDMA signal frequencies in digital cellular radio mobile telephones

## Application Note

It's a known fact that the quality of face-to-face communications depends primarily on the good alignment between the talker and the listener. This fact also applies, in a more measurable sense, to modern digital communication networks. Any misalignment between transmitter and receiver quickly reduces the quality of the transmitted messages.

Since their introduction some 40 years ago, frequency counters have been useful tools in adjusting and verifying the frequency alignment of all kinds of communication systems. The required accuracy with which this alignment needs to be performed depends on the communication system's channel spacing, the amount of information being transmitted in each channel, and the bandwidth allocated to each channel. Previously in most voice communication systems, each RF channel carried only one call at a time, and most crystal based frequency counters were able to measure transceiver performance with sufficient accuracy.

Today, more and more user demands place higher capacity requirements on communication systems. These increased capacity requirements are satisfied by either reducing each channel's bandwidth, reducing the channel-to-channel spacing (to fit more channels within the same overall bandwidth), or increasing the amount of information transmitted within each channel. All these



measures increase the performance and accuracy requirements of the communication system transceivers.

This application note focuses on a typical TDMA style digital cellular telephone system, like the North American Digital Cellular (NADC) or the Pacific Digital Cellular (PDC) systems. Alignment of these systems requires measurement resolution of 10 to 20 Hz when measuring the 800/900 MHz, or 1500 MHz signal from the mobile station. Analog communication systems usually use some kind of Frequency Division Duplex (FDD) mode, with either AM or FM

modulation. Digital systems also use a variety of modulation and access systems. For example, modern digital cellular radio systems commonly use Time Division Multiple Access (TDMA) with various multiplexing ratios, combined with complex modulation techniques such as Quadrature Phase Shift Keying (QPSK) or Frequency Shift Keying (FSK).

Because of the complexity and capacity of these transmission methods, accurate measurements of their CW frequencies are required, but cannot be performed in a simple and straightforward manner.

feature which is also available in the PM 6681. This is done by taking an average over a number of samples. If an average is taken of more than 50 samples, an additional digit is displayed. Besides increasing the frequency

signals. This feature eliminates the need for an external synchronization signal. This "SYNC DELAY" must be longer than the burst-on time, and shorter than the burst repetition time (see Fig.1). In the PM 6681, this time can be set in steps of 10 ns from 50 ns up to 1.3 s.

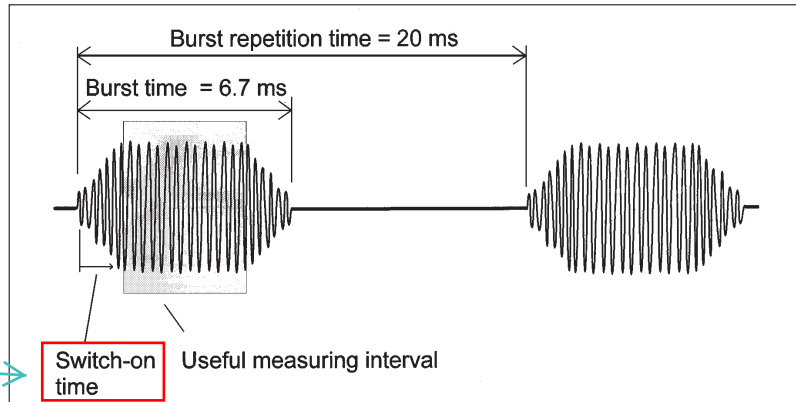


Figure 1 . Typical TDMA signal from a mobile station in the NADC system.

In the Cellular Base Station Transceiver, the TDMA timing has a signal burst-on time of 6.7 ms (see Fig.1). To achieve the required 10 Hz resolution in a sufficiently short measuring time, the measuring device (frequency counter) needs to be very fast and to have a very high resolution. An absolute resolution of 10 Hz in 900 MHz means a relative resolution of about 1 in  $10^8$ .

This presents no problem for Fluke's PM 6681, the highest resolution universal/timer/counter available today, which features a single-shot resolution of 50 ps, and which gives a relative resolution of  $5 \times 10^{-11}$  for frequency measurements over one second. When measuring on a single burst with 5 ms measuring time, the PM 6681 gives the required resolution of  $1 \times 10^{-8}$ . This means that just one single burst measurement is enough for the PM 6681 to achieve the required resolution of 10 Hz. Other counters would need to do down conversion to reach the same resolution.

If even higher resolution is required, the resolution of the measurement can be increased by using statistical averaging, a

measurement resolution, the ability to average many readings permits more characterization of the transceiver performance. In addition to the mean frequency value, the maximum, minimum, standard deviation and Allan variance of the frequency values in the burst can also be read.

To limit the transmission bandwidth of each burst transmission, the startup of the burst increases linearly over a short time (ramping time), during which false counts could be made. To overcome this problem, a short delay is needed between the start of the burst and the start of the measurement (start arming delay). To provide this delay, the PM 6681 features a built-in arming delay function, ranging from 200 ns to 1.6 s (in 100 ns increments). Other counters which lack this capability would need an external RF detector to generate an external arming signal (if possible), which would furthermore need to be delayed externally to obtain proper synchronization.

Finally the PM 6681 also features self-synchronization to facilitate very high resolution measurements in repetitive burst

To summarize then, in order for a counter to measure on TDMA signals in digital cellular radio, it must be able to synchronize on non-continuous signals (bursts). With its built-in self-synchronization, Fluke's PM 6681 can do this. A counter must have a delayable start of measurement; the PM 6681 can delay from 200 ns to 1.6 s in 100 ns steps. A counter must have high resolution; the PM 6681 has  $5 \times 10^{-11}$  in a second (or 8 digits in a few ms). Finally, a counter must be able to set a suitable measuring time for the burst; again this presents no problem for Fluke's PM 6681, which can set measuring times from 80 ns and up.

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