HAM RADIO

By Joseph J. Carr, K4IPV

Using Digital Frequency Counters

Federal Communications Commission regulations don't require hams to know their exact operating frequency (at least not in most cases), but they do require that we observe the edge of the band (or sub-band if you are not an Extra Class licensee) in which we are operating. Therefore, we need to be able to measure the operating frequency of our transmitters when we work close to the edge of the dial—the dial frequency on the rig is not always accurate (in fact, it is rarely accurate unless the unit has a built-in frequency counter).

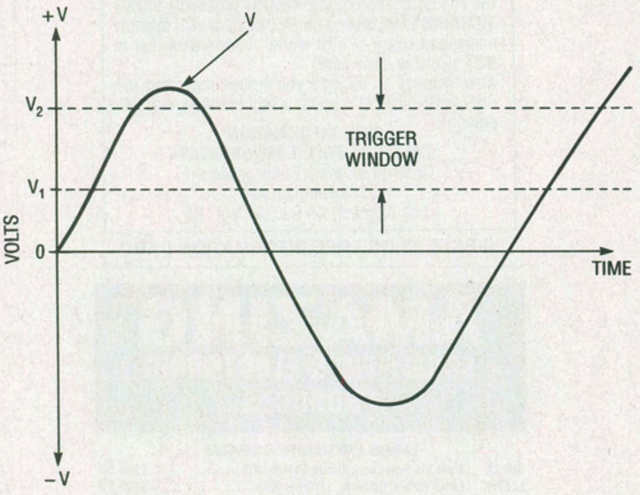

Fig. 1. Here's the input signal/trigger window for a properly functioning counter. The trigger window limits are V_1 and V_2. To trigger properly, the input signal must first cross V_1 in a positive-going direction, and then cross V_2 in a negative-going direction.

FREQUENCY MEASUREMENTS

There are many different ways to measure frequency, but digital-frequency counters are the current "best way" to measure the operating frequency of a radio transmitter. Once the exclusive play-toy of well-financed (with strong a emphasis on the word financed) two-way radio shops, engineering laboratories, industrial-production testers and government-lab technicians were the only people who could afford such instruments. But today, most amateurs who can afford an HF ham rig can also afford a decent digital-frequency counter.

Why are such instruments so popular? Perhaps it's because of their ease of operation. Just press the microphone button (or the telegraph key) and the operating frequency of your transmitter pops up on the digital display for all to see. What could be simpler? But, if it's so simple, then why do we frequently get the wrong answer? In fact, when the answer is wrong, it's so ridiculously wrong that a child could see the error.

Why does that happen? Perhaps, just perhaps, digital-frequency counters (DFC's) are—dare we commit heresy—not perfect. In fact, digital-frequency counters are far from perfect, especially the simpler, low-cost types. But understanding the sources of counter errors can keep you from making mistakes.

ERROR SOURCES

Erroneous readings result because the input circuit of a digital-frequency counter is a triggered circuit. Such circuits contain built-in hysteresis over a certain trigger window that conditions the signal. The input signal must cross two thresholds, in the right order, only once per cycle. Figure 1 shows the basic scenario. The input signal is a semi-AC waveform that has both positive and negative excursions with little or no DC-offset component.

The trigger window limits are V_1 and V_2, and are set by the design of the counter (some counters have adjustable trigger windows). To trigger properly, the input signal must first cross V_1 in a positive-going direction, and then cross V_2 in a negative-going direction, so the counter can trigger properly.

But what if the input signal either fails to cross both trigger window limits, or if it crosses too many times per cycle (as when the signal is noisy)? Consider the signal in Fig. 2, for example. That signal is a sine wave with severe harmonic distortion. The signal crosses the trigger thresholds (V_1 and V_2) twice per cycle (at points A, B, C, and D), so it would be erroneously read as twice the frequency of the actual input signal.

OTHER PROBLEM SOURCES

Figure 3 shows the output from an older RF signal generator that has a problem. The signal amplitude is highly irregular, and offers plenty of opportunity for the signal to cross the threshold limits many times per cycle. When that photograph was taken from my oscilloscope, the signal generator was set to 600-kHz CW, but the digital-frequency counter read (in sequence) 690, 1214, 420, and 2,202 during the time it took for the Polaroid film to develop (about 45 seconds). Who could believe that reading.

Figures 4 and 5 illustrate another type of problem. Figure 4 shows the square-wave output of an audio-range function generator, which, when applied to my DFC, generated a read out

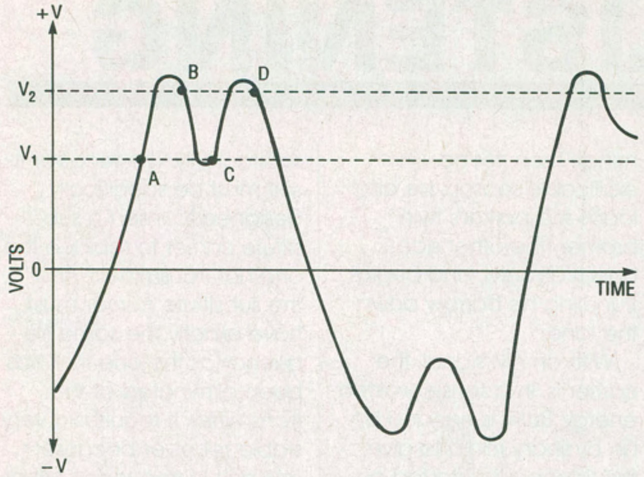

Fig. 2. If the input signal crosses the trigger window too many times per cycle (as this harmonically-distorted signal does), the counter is triggered twice for each input cycle, and therefore gives a reading that's twice the frequency of the actual input signal.

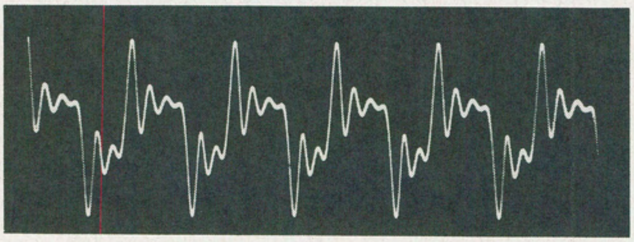

Fig. 3. Noisy or modulated signals (like this one taken from an old RF signal generator) cause unpredictable counts. Because of this signal's highly irregular amplitude, it offers plenty of opportunity to cross the threshold limits many times per cycle.

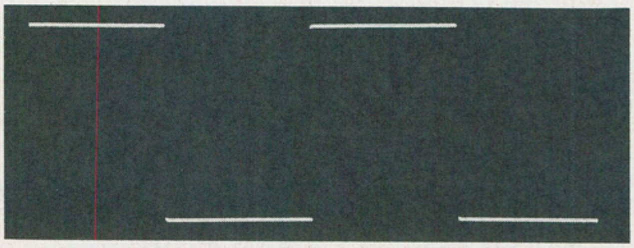

Fig. 4. This square-wave signal was applied to an oscilloscope and RF-frequency counter from an audio-range function generator.

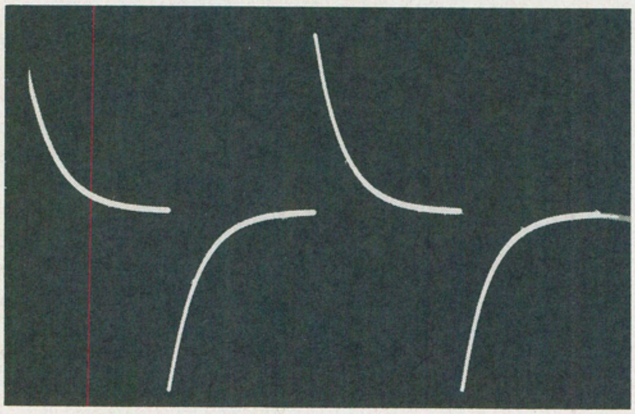

Fig. 5. When the square-wave signal in Fig. 4 was applied to an RF-frequency counter, which used capacitive coupling (to eliminate the DC component of the input signal), the signal was differentiated, creating two pulses for one, causing double counting.

that was exactly twice the actual input frequency. Here's why: My particular counter is designed principally as an RF counter, while the square wave's frequency was low audio. Since the input of the counter was capacitor coupled (to eliminate DC components on input signals), the square wave was differentiated, producing the signal shown in Fig. 5.

One thing that this discussion should tell you immediately is that the carrier frequency of modulated ham rigs cannot be properly measured with a simple DFC. Some sophisticated DFC's can strip off the modulation, but for most instruments, the modulation will foul up the reading. To combat that possibility, use a low-power output setting in CW mode in order to measure the frequency. Either that, or set the rig to AM and be very quiet while taking the reading. Single-side band (SSB) rigs may (but probably won't) produce enough carrier to trigger the counter. If not, then use the Carrier Injection control, if one is available.

Another problem seen on some counters is simple overload. The input-signal level will be quite high when the whip antenna on the DFC is extended full length, and placed near the transmitter antenna or dummy load (yes, dummy loads do leak some signal). If problems are seen, try reducing or increasing the signal to a point where proper triggering occurs. One can have both too little or too much signal, so be careful. Too much signal can burn out the front-end of the counter, so, again, be careful to follow the directions of the counter manufacturer.

It shouldn't be necessary to mention this, but many counters are burned up by one particularly dumb stunt, so I will: **Under no circumstance should the output of the transmitter be connected to the input of the counter**. Even a 30-watt mobile rig can burn out the counter's front-end in quick order. I actually saw that happen at a club display at an ARRL Atlantic Division Convention in the early 1960's (when DFC's cost $4,000 and up!). The guy connected the output of a Collins 32V2 HF ham transmitter directly to the high-impedance input of the counter. Sigh!..the DFC bellied up with a quick puff of smoke.

The only exception to the admonition to not connect the transmitter to a counter is the specific case where the counter is a through-line model. That type of instrument has a 50-ohm transmission-line section between an input and output jack so that the counter can be left connected in-line while the transmitter is operating. The actual signal for the DFC is taken from a small "gimmick" or coupling link that samples the signal. The actual, full-power signal is not applied to the counter input—only a small sampling of the total power level is used.

The digital frequency counter is probably the best way to measure frequency. It's certainly the easiest method, for the answer is usually unambiguous and needs no interpretation. And, when anomalous results occur, it is usually fairly easy to figure out what is happening, and deal with it.

Note: One easy way to examine the signal for such anomalies is to use an oscilloscope. Like digital counters, the costs of new scopes of more-than-basic capability are now quite low. Watch this column in the future for information on the oscilloscope and how it is used in ham radio. ■