RF from your Calculator

Your pocket calculator can save you sums, when you use it as an RF signal generator.

by Bob Baxter

☐ The virtues of portable electronic calculators are by now so well-known and their prices have dropped so low that the units are found almost everywhere. Many presently-available machines—especially those employing LED displays—can be used as quick troubleshooting aids in addition to performing their usual day-to-day calculating chores. Whenever you need a fast, convenient, and portable amplitude-modulated RF source for equipment checkout, your calculator can often fill the bill.

Here's why. Just about all battery-powered calculators emit strong, wideband RF signals which extend well up into the tens of megahertz. These signals are generated primarily as side-effects by the operation of two components of the calculator: the power supply's DC-to-DC converter and the multiplexed LED digital readout.

Not every calculator has a DC-to-DC converter. But those operating from two or three penlight or nicad cells usually do, using it to step the low battery voltage up to a higher level more suitable for operating the MOS ICs which do the arithmetic. The converter produces a harmonic-rich square-wave output at a fundamental frequency typically between 20 kHz and 100 kHz—but the harmonics extend well up into the megahertz region.

Even if your calculator is one of those without a DC-to-DC converter, it's still almost certain to use a multiplex system to drive the output digital display. Multiplexing means that each selected segment of the digital readout is rapidly turned on and off many times each second rather than staying on continuously. When this switching is done rapidly enough, the readout appears to stay on all the time because of the relatively slow response time of the human eye. Readout devices are multiplexed for two reasons. First, multiplexing drastically reduces the power required to operate the readout at any given *apparent* brightness level because the readout is actually on and drawing current for only a small percentage of the time. As a consequence, batteries last much longer. Secondly, multiplexing permits a great reduction in the total number of IC's needed to actuate the calculator's readout display with an attending cost reduction at the time of purchase.

With a standard calculator's seven-segment LED readout and anywhere from 8 to 12 display digits, the multiplexing frequency is typically around 100 kHz. When currents of 20 mA or so are abruptly switched on and off through the LED display segments, significant amounts of RF energy at multiples of the multiplexing frequency are generated. These harmonics may extend well into the tens of megahertz. In fact, this harmonic radiation is one of the main reasons there are so few AM clock radios with LED time displays on the market today. The standard AM broadcast band is almost totally obliterated if the receiver's RF sections are within a foot or so of the multiplexed readout display unless extensive shielding is employed. Fortunately, there are two more practical and less expensive solutions than shielding. The first is the addition of resistance-capacitance networks to slow the rise and fall times of the multiplex waveform—and consequently filter out most of the higher-order harmonics. The second method is to drive each display digit directly and not use multiplexing at all. This second technique is much more practical in a clock radio than in a calculator for two reasons. First, clock radio displays normally have considerably fewer digits than most calculators; hence, the circuit problem isn't nearly so complex. And secondly, with a clock operated from the AC power line, the problem of rapidly discharging the batteries unless the output is multiplexed is eliminated. National Semiconductor Corporation has recently introduced a clock chip with direct drive of all readout segments to eliminate RF interference. It was designed with clock radio applications in mind.

One of the many uses for your calculator other than calculating. Here it is being used to check a windshield antenna.

But now back to your calculator, which almost certainly is multiplexed and unfiltered and produces a rich harmonic output. Turn it on and slowly bring it near a standard AM radio which is tuned either to a weak station or between stations. You should hear a mixture of buzzes and tones as the calculator is brought within several inches of the radio or its antenna. These tones probably will shift in frequency if you key different numbers into the display.

Now that you've verified that your calculator is a portable, wideband, RF source, what can you use it for? Well, a number of applications are obvious. Anytime you need a quick check to see if the RF and IF stages of an AM receiver are working, your calculator can provide a test signal. Probably its handiest use, though, is in continuity testing antennas and connecting cables. Auto antennas and their accompanying cables and connectors are easily tested for opens and shorts by bringing the calculator near the antenna while monitoring the radio output. Perhaps the ultimate example of this technique you can perform in your automobile. Place a calculator near the windshield antenna of a late model General Motors car. In cases of poor or non-existent reception, one or both of the two thin antenna wires imbedded inside the glass may be broken. By carefully tracing the path of each individual wire, a break or faulty connection can be located when the radio's output changes abruptly.

And one final thought. Those of you with LED digital watches might experiment with them. The power is much lower, and the metal watch case provides a lot of shielding, but there just might be enough RF coming from the display to be useful. ■