HARMONIC RADARS SEARCH FOR HIDDEN DEVICES

HARMONIC RADARS HAVE long held the promise of detecting devices at higher frequencies, although designing such systems involves tight control of internally generated harmonic and spurious signals. To aid in the detection of small, hidden electronic devices, researchers at the Sensor and Antenna Systems Group at the Informatics and Information Security Research Center of the Scientific and Technological Research Council of Turkey, Gebze, Turkey (www.tubitak.gov.tr), presented the design and implementation of a portable harmonic radar.

This radar boasts transmit capability from 1.95 to 2.05 GHz and a receive range from 3.90 to 6.15 GHz, with the capability to receive signals as high as third-order harmonics. The portable system features +32-dBm transmit power and −103-dBm receiver sensitivity. The harmonic radar system can discriminate semiconductor targets from corrosive metals, as well as detect a semiconductor target as small as 1.85 × 1.85 cm at a distance of more than 50 cm.

Harmonic radar systems are also referred to as nonlinear junction detectors (NLJDs). They have been designed for the purpose of hidden electronic devices in walls and furniture that might have been implanted for use as surveillance devices, or "bugs." An NLJD-based system is based on employing the nonlinearity of electronic devices because of the p-n junctions of their active devices, such as diodes and transistors. These semiconductor junctions will re-radiate received high-frequency energy at double or triple the frequency, and those harmonic frequencies can be received by a sensitive receiver operating in the proper frequency range.

Unfortunately, harmonic radars are particularly susceptible to false alarms from internal system harmonic leakage, corrosive or junction metals in the scanned area, and harmonic reflectors in the scanned area. The researchers developed their system to operate at multiple transmit frequencies to reduce the occurrence of false alarms. The harmonic radar system includes transmit and receive antennas, transmitter and receiver circuits, a 10-MHz oven-controlled crystal oscillator (OCXO), a digitizer, and a central processing unit (CPU) to run software and a graphical user interface (GUI) for the radar.

The transmit and receive circuit blocks were well isolated to reduce the effects of signal leakage. Transmit and receive filters also contribute a great deal to the excellent performance of the harmonic radar system, with the transmit filter helping to reduce the level of harmonics emitted by the transmitter and the receive filter, reducing the level of transmitted signals to the receiver. See "Getting the Bugs Out," *IEEE Microwave Magazine*, November 2015, p. 40.

DIFFERENTIATING MICROWAVE PHASE DETECTORS

COMPLEX MODULATION SCHEMES, along with many other high-frequency communications applications, require some form of phase detector to determine the phase and frequency of different and differential signals. Phase detectors have been available in many forms for many years, with phase-frequency detectors (PFDs) representing one of the more traditional and trusted components for detecting phase and frequency.

However, researchers at Universiti Kebangsaan Malaysia, Selangor, Malaysia (www.ukm.edu.my) recently presented their work on an effective alternative approach to reading phase and frequency. This takes the form of time-to-digital converters (TDCs), which can be fabricated with silicon digital complementary-metal-oxide-semiconductor (CMOS) integrated-circuit (IC) technology to achieve small component sizes at reasonable cost.

The authors focus on the use of TDCs in all-digital phase-locked loops (AD-PLLs) for stable, low-noise signal generation in modern communications systems. The use of this emerging digital phase-detection approach represents an abrupt departure from the analog phase-detection approaches that have long stabilized voltage-controlled oscillators (VCOs) and other frequency sources in PLL circuits. More mature digital phase detectors include logic-gate-based digital phase detectors and dynamic PFDs.

Since PFDs can operate in both linear and nonlinear modes, the choice of a PFD will depend a great deal on the application. Dead zones or blind spots can exist during the normal operation of a digital PFD with a dead zone, for example, representing a region where the phase differences between two signals fed to the input of the PFD cannot be detected due to the low sensitivity of the component. For a particular PLL design, the dead zone and blind-spot characteristics of a digital PFD must be carefully considered to minimize performance degradations for the PLL circuit.

Digital PFDs offer great promise for modern PLL circuits; although, as with any component technology, various tradeoffs must be weighed. These include the input voltage requirements, the maximum operating speed/frequency, the detector phase/frequency sensitivity, and the power dissipation. The article reviews the use of ADPFDs in high-frequency PLLs as well as in more exotic applications, including the measurement of time for less than one clock cycle. See "Investigating Phase Detectors," *IEEE Microwave Magazine*, December 2015, p. 56.