The Impact Of Smartphones On Discrete RF Components

By Rick Cory, Skyworks Solutions, Inc.

Was it only 20 years ago when:

- Almost all RF components were single-function, discrete devices?
- Almost all packaged RF components were available in any package style you wanted, as long as expensive metal-ceramic packages were what you wanted?
- Highly integrated, inexpensive RF integrated circuits (RFICs) were a futuristic concept?

The state of technology in electronics has advanced at an ever-increasing pace, and the RF/microwave segment of this market is no exception. We deal with this technology every day, and many of those who may read this article are directly involved in and responsible for these rapid changes. We are so immersed in these advances that sometimes we "cannot see the wood for the trees" (apologies to the 16th century English playwright John Heywood). If we take a step back for a moment and consider how far our industry has come in such a short time, we are challenged to avoid the feeling that we have a great deal in common with Washington Irving's classic character Rip Van Winkle.

Van Winkle was his village's likable ne'er-do-well, whose life spanned the late colonial and early republic periods of the United States. He went into the Catskill Mountains one day to hunt, although he was probably more motivated to avoid the glare and castigations from Dame Van Winkle, his wife, than he was to bring home something for dinner. While in the woods, he encountered and was bewitched by the ghost of Hendrick Hudson, whose magical liquor induced Rip to fall asleep for 20 years. When he awoke just where he had fallen asleep in the mountains, he had no idea how long he had been gone until he found his way back to his village, only to be stunned by how much the village, its inhabitants, and its culture had changed.

As seen in the 12/##/10 edition of the RF Globalnet (**www.rfglobalnet.com**) newsletter.

Not to mention the fact that he had fallen asleep as a subject of a British king and had awakened as a citizen of the new republic of the United States.

One is challenged to consider the state of RF components in today's smart phones and other appliances, such as tablet computers, and not feel empathy for Rip. Twenty years ago, discrete RF devices were almost exclusively large, expensive, single-function devices. For example, amplifier circuits consisted of discrete transistors, resistors, capacitors, and inductors that one could actually see without the aid of a magnifying glass or microscope! Today's smartphone RF amplifiers are almost all contained in multifunction integrated circuits or modules that also may perform such functions as RF switching, filtering, power detection, and provisions for automatic gain control — all in a package that is only 25% as large as in "the old days", and at a fraction of the price.

Solid-state, single-pole-ten-throw (SP10T) switches existed, but they were almost entirely built with discrete PIN diodes mounted in channelized, machined metal housings for the electronic countermeasures market. Now we see field-effect transistor (FET) SP10Ts, and switches with even higher throw counts, in tiny surface-mount packages for use between a single antenna and the various receivers (think GPS) and transceivers (think EDGE, GSM, WCDMA, LTE, Bluetooth, WLAN, etc.) that are contained within these handheld data terminals that are utilized more for always-connected Internet service, and only incidentally for voice communications.

Even though the smart appliance RFICs perform analog functions, there is an important similarity compared to the ubiquitous, strictly digital microprocessor — the capabilities of the RFICs developed for smart appliances have expanded exponentially, due to increased levels of integration, as compared to their predecessors, much like Moore's Law describes for the evolution of silicon digital circuits in which the number of transistors per die doubles approximately every two years.

Consider a simple transmit-receive, single-pole-double-throw (SPDT) RFIC switch. In its simplest form, the RFIC contains only two FETs. A version with improved RF isolation performance that is very widely used today contains a whopping four FETs: a series-shunt pair on the transmit side and its mirror image on the receive side of the switch. A recently introduced SP10T switch, which is housed in a single 3 x 3.8 mm package, comprises: a GaAs RF switch die with more than 40 FETs, a silicon decoder/driver die with several thousand FETs, and a third die that comprises a pair of passive low-pass filters to reduce harmonic emissions from the GSM power amplifiers, which drive two of the switch's input ports. We have evolved from feeling peacock-proud over a single-function IC whose active devices can be counted on one hand (with a finger to spare!), to regarding today's much more highly integrated, multi-function products as remarkable and valuable, but also as representations of an intermediate technological step to ever more capable products.

An important aspect of Moore's Law, as he initially described in 1965, relates manufacturing costs to the number of components per integrated circuit. He posited that there is an optimal number of devices per die that produces minimal manufacturing cost, and that this optimal number increases as integration technology improves. Fortunately, this principle applies equally well to RFICs, whether they are made with silicon or GaAs. The modern counterpart of our friend Mr. Van Winkle might be befuddled by the fact that even as the level of function of an RFIC for a smart phone has dramatically increased, its price has commensurately decreased.

In Irving's story, Rip happily lived to a ripe old age under the care of his daughter after adjusting to his new world and eventually embracing it. While it is decidedly more difficult to accurately predict our future than to report Rip's history, one prediction is a safe bet: In the domain of RF component technology advancement driven by the smartphone revolution, the best is yet to come — even more functionality in smaller packages at lower costs.

About the Author

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