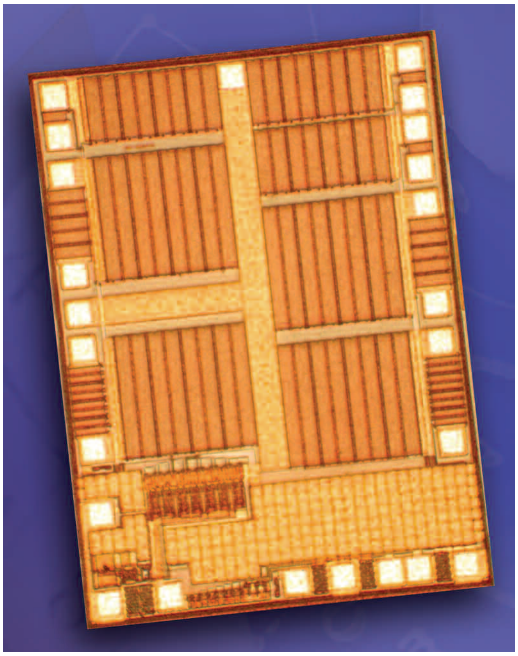
Microwave Journal



An Ultra-linear SP7T Handset Antenna Switch for GSM/PCS/EDGE/WCDMA Applications

Industry standards bodies — such as the 3GPP Standards organization governing global cellular networks such as GSM, PCS, EDGE and WCDMA — are traditionally chartered to create a stable business environment for advancing technology in a competitive market. These industry standards — as simple as the pitch of a PCB or as influential as the premise of Moore's Law — offer suppliers an equal opportunity to compete, and provides an industry the best chance to grow and prosper. Additionally, industry standards enable well-defined product roadmaps, which in turn set clear objectives for rapid technology advancement using focused resources. Without achievable directives, an industry stagnates as misaligned resources and product roadmaps reach a dead-end.

The cellular phone industry enjoyed well-defined guidelines for performance and mechanical footprint during the transition from analog to Second Generation (2G and 2.5G) standards. Today's 3G environment, however, is more complicated. The market continues to grow, however through consolidation now fewer companies compete for a larger share of the integrated design.

At the "RF front end" of the cellular handset, the antenna switch module (ASM) and power amplifier (PA) module have advanced on a steep learning curve due to the well defined expectations of handset manufacturers. The initial ASMs supported a single frequency band and were 5.5 × 10 mm. Today's ASMs — 81 percent smaller than their predecessors — are tasked to support four bands with significantly better RF performance, and to fit in 3.2 mm^2. Complexity is at an all time high, and the learning curve has hit an inflection point. The number of variations and the lack of GSM/WCDMA architectural, functional and mechanical standards has stalled advancement. As well, the number of frequency bands and the aggressive technical requirements of the multi-mode, multi-band GSM/WCDMA

PEREGRINE SEMICONDUCTOR CORP.
San Diego, CA

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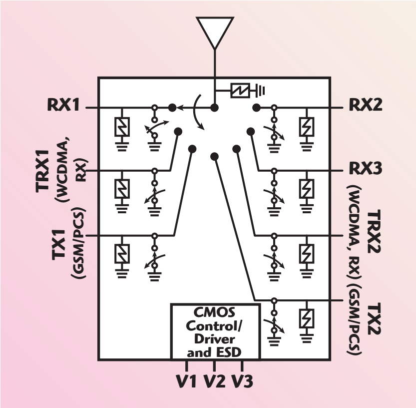
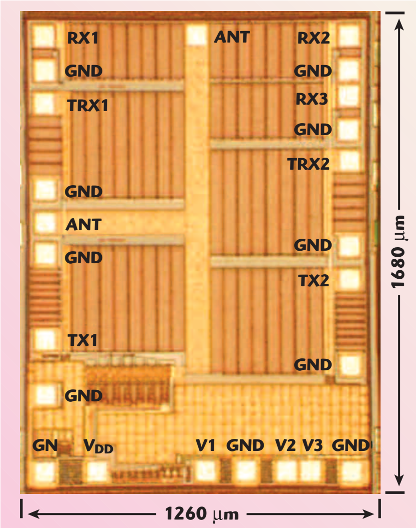


▲ *Fig. 1 The PE42671 SP7T switch.*



▲ *Fig. 2 PE42671 die top view.*

handset have overcome the limits of traditional RFIC technologies such as GaAs. Most critically affected by these ultra-high performance specs are the antenna and the RF switch. The antenna must effectively radiate from 800 to 2200 MHz, a daunting task given the miniscule area allowed for the antenna. The RF switch must be capable of switching up to eight paths of high power RF signals with low insertion loss, high isolation and exceptional linearity.

To create a WCDMA/GSM handset that is spec compliant, handset manufacturers have been incorporating separate WCDMA and GSM radio sections in one case — not a strategy any handset manufacturer would want on its roadmap for long. So while the industry has set its sights high, it has struggled to find a solution, until now. At the European Microwave Conference (EuMC) in Paris, France, Nokia presented a paper addressing its quest to integrate into a single radio architecture.[1] The Peregrine PE42660 SP6T switch, designed in Peregrine's UltraCMOS™ process with HaRP™ technology, was identified as a high throw count switch that meets the linearity requirements defined by the 3GPP standard: an IP3 of +65 dBm. Typical SP6T/SP7T GaAs pHEMT switches have IP3 of only +57 dBm. And now, Peregrine's newest HaRP-enhanced PE42671 SP7T switch provides for dual WCDMA bands and a quad-band GSM radio to be connected to a single antenna, delivering an unprecedented +68 dBm IP3.

PE42671 – TRUE MULTI-BAND PERFORMANCE

The PE42671 SP7T switch integrates one or two WCDMA and three or four GSM frequency bands (see ***Figure 1***). Its four transmit ports with unprecedented linearity (IP3 = +68 dBm) allow for spec-compliant handsets and efficient front-end architectures. Beyond linearity, the PE42671 switch also provides significant design value over other technologies such as PIN diode and pHEMT configurations. Small size and versatile layout, as shown in ***Figure 2***, enable the application designer to use the PE42671 switch in extremely small RF modules. The SP7T switch is comprised of two transmit ports that can be used for GSM/PCS/EDGE, two transmit/receive ports that can be used for either WCDMA or as receive ports and three symmetric receive ports. On-chip CMOS decode logic facilitates three-pin low voltage CMOS control, while high ESD tolerance of 1500 V at all ports, no blocking capacitor requirements and on-chip SAW filter overvoltage protection devices make this device the ultimate in integration and ruggedness. The switch operates at 2.75 V over a frequency range of 100 to 3000 MHz and offers low transmit insertion loss of 0.60 dB at 900 MHz and 0.80 dB at 1900 MHz. Tx-Rx isolation is 47 dB at 900 MHz and 40 dB at 1900 MHz. Its input third-order intercept is +68 dBm at 50 Ω and its IMD3 is –111 dBm (with +20 dBm Tx and –15 dBm blocker signals).

STATE-OF-THE ART HARMONICS

Harmonic performance of the RF switch is a critical element of the antenna switch module. Typical switch technologies such as PIN diode and GaAs pHEMT provide only 6 dB of margin, requiring up to three or four design iterations to match the LTCC to the switch before hitting the specification. At the maximum operating power of +35 dBm, the HaRP-enhanced UltraCMOS switch delivers –50 dBm P3fo, which is 20 dB of margin to the GSM specification of –30 dBm. The second harmonic is fundamentally low in UltraCMOS technology because distortion is symmetric on positive and negative voltage swings. In the GSM system, this very low even-order distortion for the second harmonic is desirable because the second harmonic of the GSM transmit band falls in the DCS receive band. The less than –50 dBm second-harmonic performance allows for less noise transmitted in the DCS band and increased system capacity for the carrier.

ULTRACMOS PERFORMANCE ADVANTAGE

UltraCMOS is a standard CMOS processing technology, however as opposed to building devices on silicon, a conducting substrate, it places devices directly on top of a sapphire substrate. The perfectly insulating sapphire allows UltraCMOS to maintain all the positive attributes of bulk CMOS including low power operation, manufacturability, repeatability, scaling properties and IP block re-use, and to deliver the RF performance required for 3G applications and beyond.

Reference

1. T. Ranta, J. Ellä and H. Pohjonen, "Antenna Switch Linearity Requirements for GSM/WCDMA Mobile Phone Front-ends," *8th European Conference on Wireless Technology Proceedings*, Paris, France, Oct. 2005, pp. 23–26.

Peregrine Semiconductor Corp., San Diego, CA (858) 731-9400, www.psemi.com.