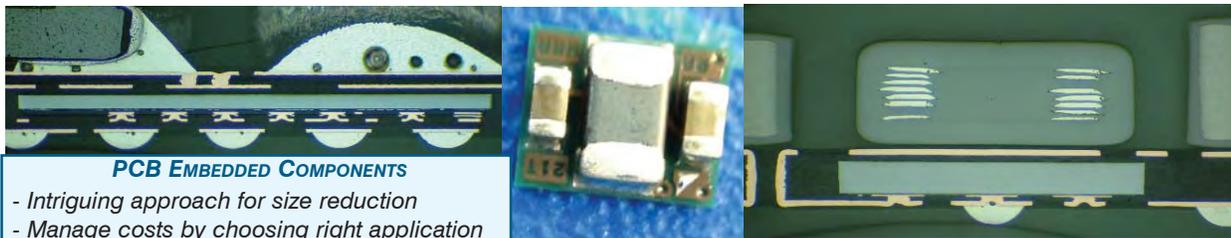


THE PRISMARк WIRELESS TECHNOLOGY REPORT

A Quarterly Market and Technology Analysis of RF Wireless Systems,
Modules and Components from 100MHz to 100GHz

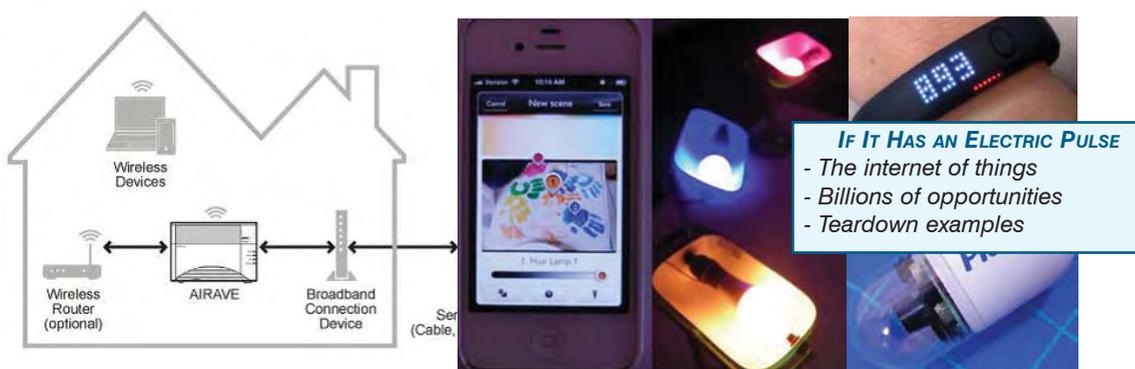
MARCH 2013



PCB EMBEDDED COMPONENTS

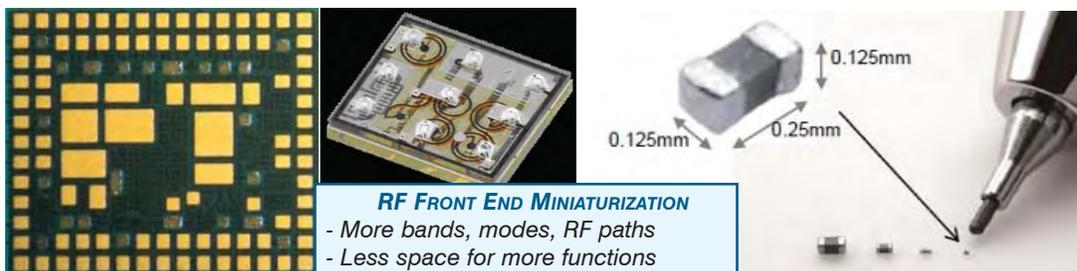
- Intriguing approach for size reduction
- Manage costs by choosing right application
- Examples from AT&S and TDK-EPC

Photo source: Prismark/Binghamton University



IF IT HAS AN ELECTRIC PULSE

- The internet of things
- Billions of opportunities
- Teardown examples



RF FRONT END MINIATURIZATION

- More bands, modes, RF paths
- Less space for more functions
- Discussion of options to reduce size

A valuable source of competitive intelligence and trend analysis for technology and business development executives. Targeted at wireless systems designers, RF semiconductor houses, board and package assemblers, as well as their component suppliers.



*CONSULTANTS TO THE ELECTRONICS INDUSTRY
BUSINESS OPPORTUNITY FROM TECHNOLOGY AND
MARKET CHANGES*

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THE PRISMARK WIRELESS TECHNOLOGY REPORT – March 2013

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Same old story: while it is mostly calm on the surface, hidden dangers lurk underneath. For only the third time in its history, mobile phone unit shipments declined in 2012, although only just barely. The strong and ongoing shift to smartphones is having a remarkable impact on the market shares of handset designers and their supply base. We look at these market shares and comment on likely changes in the year ahead.....	2
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The RF front end continues to be under pressure to reduce its footprint, while at the same time the number of frequency bands and modes that must be supported is increasing. New architectures, such as receive diversity, MIMO, and carrier aggregation are adding further pressure to find technologies that reduce the size of the RF front end. The latest developments are discussed, together with options of further miniaturization in the near future.....	9
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Billions of devices are already connected to the Internet, and many billions more are expected to come online. Increasingly, these devices use wireless links, either because that enables the application, improves it, or simply presents the easiest route to deployment. Either way, it presents a great opportunity for suppliers of wireless chipsets, filters, antennas, modules, and other components.....	21
4.0 PCB EMBEDDED COMPONENTS	
The embedding of active or passive components into the dielectric layers of a printed circuit board is not a new idea. In fact, initial volume production started in 2005, and perhaps earlier, although usually for one-off design wins. Apart from a well-controlled embedding process, the key to success of PCB embedding is to pick the right application so that the yield and cost is competitive. The industry is now at that point, as some of the latest design wins show....	40

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PCB EMBEDDED COMPONENTS

The image shows a close-up of a PCB with a component embedded in it. The component is a square die with a grid of pads. The PCB is green and has a white solder mask. The component is mounted on a copper pad. The image is a close-up of the component and the PCB.

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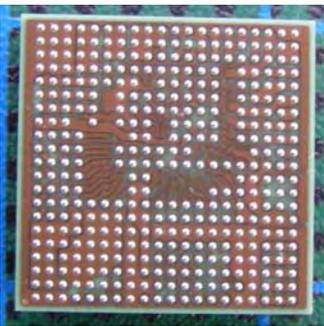
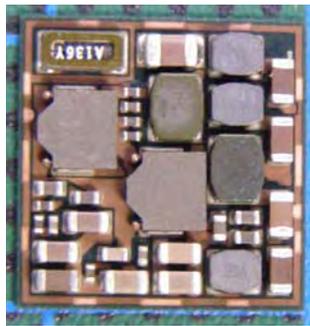
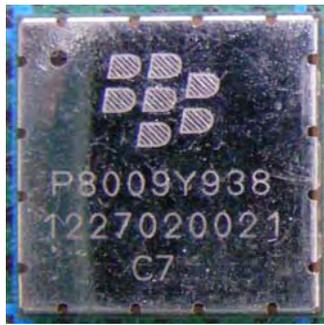
TDK SESUB

TDK is a global supplier of electronic components, with R&D and manufacturing facilities in Japan, Asia, Europe and America. The company has developed core competencies that range from materials and process technology, to simulation, production and device and module technologies. In the following PCB embedding example, TDK designed the module, embedded the die and assembled the module.

TDK has developed its own proprietary PCB embedding technology, called SESUB—Silicon Embedded in SUBstrate. One of the first high volume products to use this technology is a power management module used in some versions of the new BlackBerry Z10. The power management module can be used for Qualcomm Snapdragon, TI OMAP4, and NVIDIA TEGRA chipsets with different firmware. It is based on two MAXIM die, the MAX8955E power manager and the MAXQ6831 16-bit RISC controller, that are embedded into the PCB of the module. The module measures 11 mm x 11 mm x 1.63mm—a reduction of 60% compared to a discrete PCB layout—and uses 380 LGA pads at 0.5mm as the external interconnect.

PCB EMBEDDED COMPONENTS

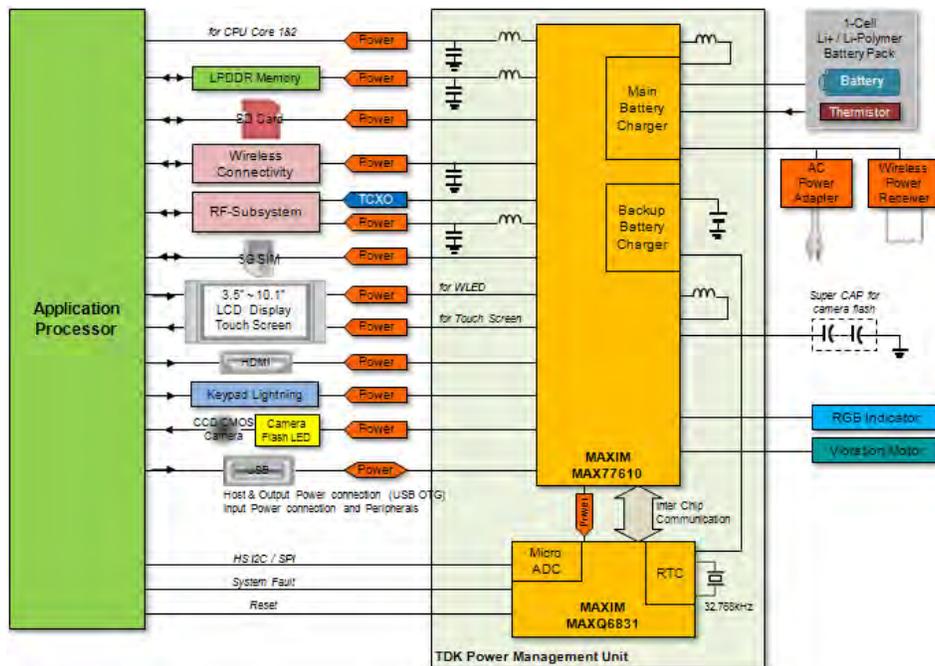
TDK POWER MANAGEMENT MODULE



5 x 4.4MHz Buck Converters	23 x High PSRR LDOs	1 x WLED Converter
Accurate Battery Fuel Gauge	Power Mgt State Machine	2 x Switch Mode Charger for Li+ / Li-Poly 1-Cell Battery
Camera Flash w/ Super CAP	MAX8955E PMIC & MAXQ6831 16bit RISC	RGB LED string Driver
Vibration Motor Driver		4x4 Keypad backlight LED Driver
SIM / RUM Level Translator	16ch / 12bits ADC	32kHz RTC Driver
128kFlash 8k RAM	HS I2C / SPI for Control	19.2/26MHz clock gen. w/ 5outputs

The module constitutes the smartphone’s main system power manager, as well as the system’s battery charger. Among others, it includes five 4.4MHz buck converters, twenty-three low-noise LDO (Low Drop Out) regulators, a real-time clock with 32kHz crystal, converter for the camera flash LED and LED for the display and touch screen. The following simplified block diagram shows the TDK power management module supporting the applications processor, wireless section, memory and other parts of the smartphone.

TDK POWER MANAGEMENT MODULE IN SMARTPHONE

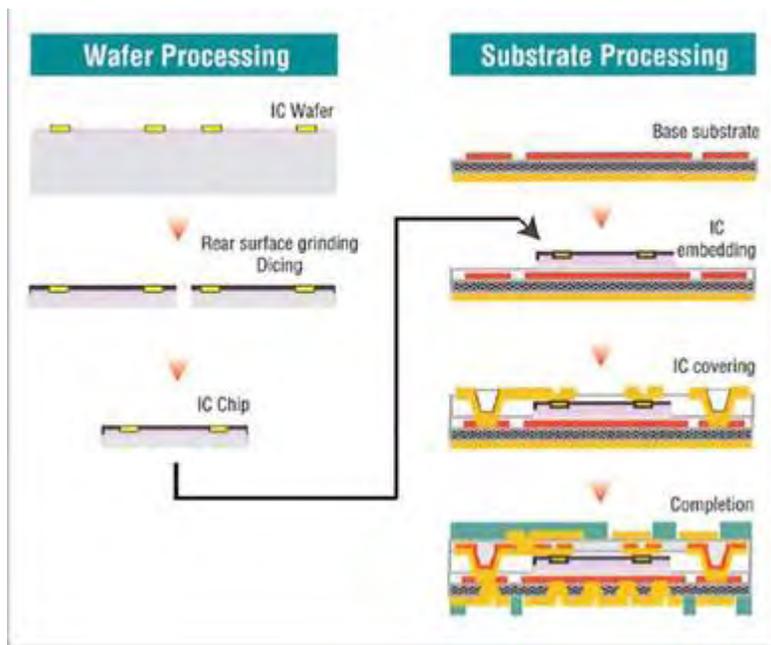


PCB EMBEDDED COMPONENTS

The TDK power management module was designed in cooperation with TDK, Maxim, and BlackBerry, whereby TDK buys the IC and is the module's product owner. In other cases, the customer provides the die and TDK embeds it. The die are delivered by Maxim as tested wafers with $4\mu\text{m}$ copper on the die pads to TDK. TDK then thins the wafers to $50\mu\text{m}$, singulates them, and embeds them using its SESUB process.

In the TDK's SESUB process, the die is first mounted face-up onto a two-layer PCB core. An additional copper foil is then laminated over the die and PCB core, forming an additional copper layer through which microvias can be formed to contact the die bond pads and the initial PCB core. This therefore creates the die interconnects and the side-to-side interconnects. The TDK SESUB process is ready for die with a minimum pitch of $80\mu\text{m}$ in volume production, and TDK is planning to introduce $50\mu\text{m}$ minimum pitch capability. The process flow is shown below.

TDK SESUB PROCESS FLOW



Since the copper layers that form the interconnects to the embedded die are defined photolithographically, they can have any shape. For example, for high current connections, the vias and traces can be larger, thus reducing resistance and improving performance. Thinner and wider traces and vias can be mixed in the same design for best optimization, but early collaboration between the IC designer and TDK is preferred.

