The radio frequency (RF) front-end of the mobile phone has always been subject to various constraints, notably because of the kind of functions and applications that have become necessities. Consumers believe that phones should have cameras, music, high-speed internet, etc. in the slimmest, most attractive packages possible, with multi-band, multi-mode support.

Combining the aforementioned with Bluetooth, WiFi, and WiMAX makes the front-end highly complex. This demand directly translates into highly challenging design issues for front-end designers, who need to be constantly in sync with market demands.

Discrete or modularisation?

With the ever-increasing and varying consumer demand, board space in the front end has come under severe constraints, with a large number of functions needing to be accommodated in the limited space available. This has created the need for modules or integrated solutions, providing a superior balance between cost, form factor, and performance.

The front end has already seen the advantages of integration, beginning with the introduction of the antenna switch module (ASM), which was later integrated with surface acoustic wave (SAW) filters, to form the front-end module (FEM), which greatly simplified front-end design.

This chart gives an indication of the different ways in which integration has been adopted in the front end, and does not necessarily represent the flow of the signal between the various components.

A recent trend in the market has been the implementation of transmit modules, integrating the power amplifier (PA), the switch, and the low pass filter (LPF) functions, further simplifying the design and reducing the need for designers to interact with various RF component manufacturers across the supply chain. This module has been very well received in the market, especially in the 2G and 2.5G front ends, supporting standards such as GSM, GPRS, and EDGE.

As the mobile handset moves toward multi-band and multi-mode support, the use of discrete components in the front end is being debated. WCDMA phones accounted for 10% of the total handset shipped in 2006, and Frost & Sullivan expects this market to experience strong growth in the future.

WCDMA phones are backwards-compatible with GSM, GPRS, and EDGE, requiring a minimum of seven switching paths between the antenna and the different PA modules, which has opened up the market for discrete switches. The market is expected to move toward integration in the future. However, with the kind of band diversity in WCDMA (nine different bands and different regions of the world using different bands), the idea of a discrete switch enabling this scenario is highly appealing.

With the PA evolving to support an increasing number of bands and multiple modes in cases such as WCDMA, it appears very convenient to have a discrete PA, and not necessarily as part of the transmit module. However, either way, companies with expertise in PAs will not be affected by the change in market trends, as most of them have the ability to integrate the PA into the transmit module.

Transceiver manufacturers have also made significant contributions to reductions in component count by eliminating the intermediate frequency (IF) stages by the adoption of zero IF receivers. They have also further eased space constraints by eliminating the SAW filtering components in the transmit side with the introduction of low-noise transmitter architectures in GSM and in some EDGE devices.

New receiver architectures are attempting to remove the inter-stage filters on the receive side in WCDMA and further reductions in board space consumption seems to be possible. The elimination of these filters is subject to modifications in duplexer capabilities. With an increasing number of handset manufacturers opting for single-chip transceivers that integrate the baseband, the trend toward higher levels of integration is gaining momentum.

To have all the RF components, including the transceiver and the baseband, on a single chip would be ideal for a handset manufacturer; however, this idea is expected to face several constraints. To realise such a design would warrant the need for a system-on-a-chip (SoC)-type design, but the components such as the PA and the transceiver are based on different technologies. The PA is dominated by gallium arsenide (GaAs) and the transceiver is designed in complementary metal-oxide semiconductor (CMOS).

This makes it almost impossible to realise this design. To overcome this obstacle, some companies have designed the PA in CMOS, which has not been much of a success, largely due to the fact that the CMOS PA has come up against issues such as the inability to meet industry performance specifications, a large number of passives, a larger size and differences in packaging type.

All these factors weigh against integrating the PA with the transceiver, making it much more sensible to integrate the PA with the switch and the filtering devices in the front end to form a highly integrated FEM.

Conclusion

The question still lingers - does the future lie with integrated modules or will the front end be enabled by discrete components? While discrete components tend to provide a stopgap solution for highly complex front-ends, the future of the RF front-end ultimately lies in integration, with a higher level of integration expected in the future.

Until the market moves toward a totally integrated module in the front-end, discrete components such as the RF switch will act as an interim solution to tackle front-end complexity. Thus, the front-end will be a mix of integrated and discrete components, till the market completely adopts these integrated modules.

Contact Patrick Cairns, Frost & Sullivan, Tel 021 680-3274, patrick.cairns@frost.com