The Golden Age of Mobile Wireless

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ABSTRACT
The wireless industry is experiencing a period of rapid change due to an explosion of mobile wireless data traffic. This increase is spurring deployment of additional frequency bands and modes which in turn drives RF front-end (RFFE) content. This paper addresses effects of this data demand stimulus and explores additional opportunities for RFFE component vendors.

INTRODUCTION

For those who can withstand the expectation of constant and predictable cost reduction, our industry has entered a new age of prosperity driven by the explosive growth of mobile wireless data traffic. Figure 1 highlights this ramp where data traffic is nearly doubling per year [1].

Figure 1 – Forecast of mobile wireless data traffic

Worth noting is the predominance of laptops and netbooks in the data traffic. Far outstripping their volume growth are smartphones which are growing at a 19% CAGR according to Deutsche Bank as shown in Figure 2 [2]. In the future with video applications such as Apple’s FaceTime and Google’s YouTube, the smartphone traffic could drive the wireless data traffic yet higher.

Figure 2 – Forecast of smartphone shipments
[Source: Deutsche Bank]

Advancing signal modulation schemes to higher orders and closer to the Shannon limit is no longer sufficient to meet this rising tide of bits in the ether. The only recourse for Operators are adding frequency spectrum, increasing spatial reuse through smaller cells and MIMO, and improving RF performance in the mobile devices. This in turn provides opportunities to RF component providers in increased content as well as new technical challenges on which they can differentiate.

ADDING SPECTRUM

At the behest of President Obama, the FCC recently studied the capacity of the existing spectrum to meet the rapidly increasing data demand. Figure 3 shows their stark finding of a shortfall of 300 MHz in bandwidth by 2014. This spectrum is not available in one slice but rather in many small segments due to legacy allocations, which have traditionally been very difficult to displace. Recall the digital TV conversion process, which released 700 MHz spectrum. Studies of this reallocation began in the late ‘90s and will see the first widespread operation in 2011.
The deficit in spectrum is not limited to the USA; this has resulted in 22 FDD bands and 9 TDD bands being defined in the latest release of the 3GPP standard with the expectation that more bands will be identified in the future. If fully supported in a device, this would require 40 different configurations of mode/band operation. This highlights the complexity driven by the fragmentation of the spectrum by country, and requires the supply chain to be able to support many different device configurations. While it is unlikely that mobile wireless devices will support all band and modes, they will face a dramatic increase in the number of bands deployed per device as shown in figure 4 [4].

Smartphones today already commonly ship with eight bands of operation (4xGSM+4xUMTS) and this number is expected to continue to rise with additional HSPA and LTE spectrum deployment.

This increase in the amount of spectrum supported by the mobile wireless device is causing rapid increase in the total address market for RF Front-End (RFFE) components. Figure 5 shows all segments growing with the market size surpassing $5B in 2014.
This approach of simply adding additional power amplifiers, dupplexers and switch throws is not expected to continue as the industry is seeking more integrated solutions which provide cost, performance, and form-factor improvements. Figure 7 shows an alternative implementation that provides for scalability to larger numbers of supported modes and bands.

Figure 7 – Scalable multimode, multiband RFFE Architecture

Noteworthy in this block diagram is the transition to multi-band power amplifiers (PAs) and the RFFE tuner. The multiband PAs reduce the number of PAs required to support the growing number of bands, but this comes at the expense of performance due to the mode switches and wider bandwidth supported by the PA. The tuner can offset this performance degradation by actively matching the antenna and RFFE for optimal performance. The tuner is optimized for very wide-band performance, which is important for full-duplex systems with wide spacing between TX and RX frequencies like WCDMA and LTE. By employing a coupled resonator topology widely used in band-pass filters and impedance-matching networks, this reconfigurable matching network provides wide impedance coverage in the operating bands of 698 – 960 MHz and 1710 – 2170 MHz. Insertion loss (IL) and return loss (RL) performance at 50Ω demonstrate excellent broadband coverage shown in Figure 8. The broad Smith Chart coverage shown in Figure 9 demonstrates the RFFE tuner’s capability to effectively match a wide range of antenna impedances to 50 Ω.

Figure 8 - Measured Return Loss and Insertion Loss

Additionally, the antenna characteristic can be actively tuned for improved performance. Figure 10 shows measured results where the handset antenna has been tuned using a Peregrine DTC (digitally tunable capacitor) device. The green shading indicates the delta in performance between the tunable and fixed antenna designs with up to 9 dB performance improvement at the lower side of Band V.

Figure 9 - Measured Smith Chart Coverage points that can be matched back to 50Ω

Figure 11 – Tunable vs. fixed antenna efficiency

[Source: Ethertronics]

The gains in performance due to the tuner equate to gains in spectral efficiency by optimizing the terminal’s performance for its current operating mode. Figure 11 shows the achievable spectral efficiency gains vs. signal-to-noise ratio of the connection.
Here a 7 dB improvement in SNR effectively doubles the capacity of the network. This could effectively cut the required spectrum deployment per the FCCs calculation from 300MHz down to 150MHz.

Capacity is also being increased through the utilization of spatial diversity to create separate data streams, commonly referred to as MIMO (multiple-input, multiple-output). To accomplish this, duplicate RFFE must implement for each RF I/O. For full 2x2 MIMO, this would mean duplicating the RFFE shown in figure 6 or 7. If only 1x2 MIMO is implemented, then a simple receive-only RFFE can be implemented as shown in figure 12.

Due to the form factor constraints of mobile wireless devices, antenna tuning is also expected to be needed on the diversity antenna to realize the increase in data capacity.

**CONCLUSIONS**

The growth of data centric services is driving the need for additional bandwidth leading to the proliferation of frequency bands and the need for improvements in spectral efficiency. These requirements increase the performance requirements and complexity of the RF front-end and offer significant opportunities for those that can meet the challenges.

**REFERENCES**


