Trends in RF Design Technologies for Mobile Wireless Devices

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INTRODUCTION

We are obsessed with our technology. Most workers today rely on their mobile devices to keep them connected to their work and home. Mobile devices, from a myriad of suppliers, offer the ability to check email, stream content, and of course, to make purchases.

Wireless is fundamental to mobile device operation. Customers have come to expect seamless wireless coverage and the industry has responded with more base stations and access points in the places where we do business. Coverage and capacity demands are also increasing in the home. Sensors and controllers, cameras and TVs are becoming part of the wireless lexicon.

TRENDS

Connectivity starts with the WAN or WIFI solution. To increase the download speeds vendors and carriers are working to increase bit rates and maximize bandwidth usage.

In the US, the average user spends 67% of the time on an LTE network with an average download speed of 6.5 Mbps according the crowdsourcing application, Opensignal [1]. The average speed is a reflection of traffic load and carriers are looking to increase the bandwidth with LTE Advanced. By aggregating several carrier bands, peak data rate speeds of 300 Mbps in 40 MHz can be supported (LTE CAT 6) and bursty applications such as maps and Facebook can share bandwidth effectively [2].

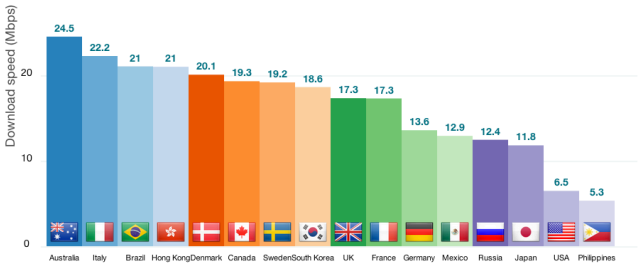

Figure 1. Average LTE download speed per country [1].

In 802.11ac, 256-QAM modulation schemes combined with 80 MHz 5 GHz channels push the per chain capacity to 433.3 Mbps (Figure 2). When multiple antenna streams are taken into account, the speed increases linearly. Future chipsets plan on using 160 MHz of bandwidth for further throughput improvement either by using a single 160 MHz spectrum block or by combining two noncontiguous 80 MHz blocks. LTE Advance and 802.11ac both support Multi-user MIMO, the technique to use several antennas to transmit multiple frames to unique clients simultaneously over the same spectrum.

Mobile devices operating these advanced standards typically utilize digital pre-distortion (DPD) techniques to linearize the power amplifier by taking into account the amplifier's gain and phase characteristics. Digital pre-distortion can improve the power amplifier's transmitter fidelity performance by 2-3 dB in 802.11n commercial chipsets but is limited to improving only internal silicon power amplifiers. For high-power external amplifiers, a highly efficient device is the foundation for reducing thermal impacts and increasing battery life in mobile devices.

Theoretical throughput for single Spatial Stream (in Mb/s)									
MCS index	Modulation type	Coding rate	20 MHz channels		40 MHz channels		80 MHz channels		160 MHz channels	
			800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI
0	BPSK	1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65
1	QPSK	1/2	13	14.4	27	30	58.5	65	117	130
2	QPSK	3/4	19.5	21.7	40.5	45	87.8	97.5	175.5	195
3	16-QAM	1/2	26	28.9	54	60	117	130	234	260
4	16-QAM	3/4	39	43.3	81	90	175.5	195	351	390
5	64-QAM	2/3	52	57.8	108	120	234	260	468	520
6	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5	526.5	585
7	64-QAM	5/6	65	72.2	135	150	292.5	325	585	650
8	256-QAM	3/4	78	86.7	162	180	351	390	702	780
9	256-QAM	5/6	N/A	N/A	180	200	390	433.3	780	866.7

Figure 2. 802.11ac rate table. Throughput increases linearly with the number of spatial streams.

In addition to the license-free 2.4 GHz and 5 GHz WIFI bands, the 60 GHz band offers additional capacity. The 802.11ad standard offers a maximum physical layer rate of 7 Gbps over a 2.16 GHz wide channel. 60 GHz can provide the ultimate wireless replacement, enabling ultra-high video transmission or providing wireless USB3 or PCIe 5 Gbps connections. 60 GHz systems also enable sub-millisecond link latency for fast-twitch gaming connections between the mobile device and the game console. Due to the small 5 mm wavelength at 60 GHz, phase antenna arrays are used steer the beam to increase antenna directivity and performance.

The biggest drawback of 60 GHz technologies is the limited range due to the roughly 20 dB higher path loss than 5 GHz [3]. The challenge to the design community is how

to overcome this degradation and improve the radiated output power and noise figure of 60 GHz systems while competitively designing for cost and battery life. Improving the link budget is imperative for this technology to gain traction in the commercial space.

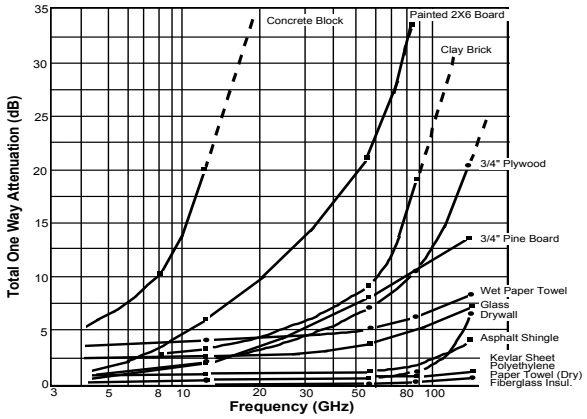

Figure 3. Attenuation through different mediums as a function of frequency [3].

Speed is important, but so is operating range and stability. Sensors, cameras, home appliances as well as heavy industrial equipment are also being attached to the Internet. Internet of Things (IOT) devices don't require high capacity, but require a higher level of system performance to ensure that their data gets to the host. Examples of IOT protocols include WIFI, BlueTooth and ZigBee. WIFI is used in familiar items like thermostats and smoke detectors that have larger batteries or AC power. BlueTooth Low-Energy (BTLE), with emphasis on low-power consumption is being targeted in for audio and wearable devices, while Zigbee, with meshing built in to its firmware stack, is currently being sold in lighting applications. Mobile devices will need the flexibility to work together with IOT devices making coexistence an essential part of the overall radio system design.

CONCLUSIONS

The wireless home and office continues to evolve. Several competing technologies are vying to provide Internet connectivity and the next level of machine-to-machine communication. Wireless designers have several challenges to deliver competitive low-cost devices to the market.

REFERENCES

[1] OpenSignal, http://opensignal.com/reports/state-of-lte-q1-2014 (2014).
[2] Qualcomm Product Brief, LTE Advanced—Evolving and expanding in to new frontiers (2014).
[3] Sheung Li, IEEE 802.11-07/2790r0 (2007).

ACRONYMS

LTE: Long Term Evolution
WAN: Wide Area Network
WIFI: Wireless Fideality
DPD: Digital Pre-Distortion
IOT: Internet Of Things
BTLE: BlueTooth Low Energy