



LTE APT 700MHz Device White Paper

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1. Executive Summary

LTE is the fastest developing mobile communication technology and rapid expansion globally is continuing in 2013. By May 2013, 175 commercial networks have been deployed in 70 countries and 424 operators across 126 countries are currently investing in LTE. The total number of LTE subscribers will exceed 100 million in 2013 H2, 5 times increased year to year. (Source: GSA Evolution to LTE report).

LTE provides the solution to operators who are increasingly challenged by the explosive growth in mobile data traffic. The primary drive towards LTE is the requirement for more capacity, performance management and improved efficiencies to lower the unit cost of delivering traffic. LTE supports a full IP-based network and harmonization with other radio access technologies. It enables a single unifying global standard for even higher scale economies and simplifying roaming.

Due to the expansion of mobile technology, mobile-data traffic will continue to grow significantly, expecting to increase 12 times by 2018, driven mainly by video demand. This fast growing mobile data demand places great pressure on spectrum resources. Figure 1 shows the trend. (Source: Ericsson 2013)

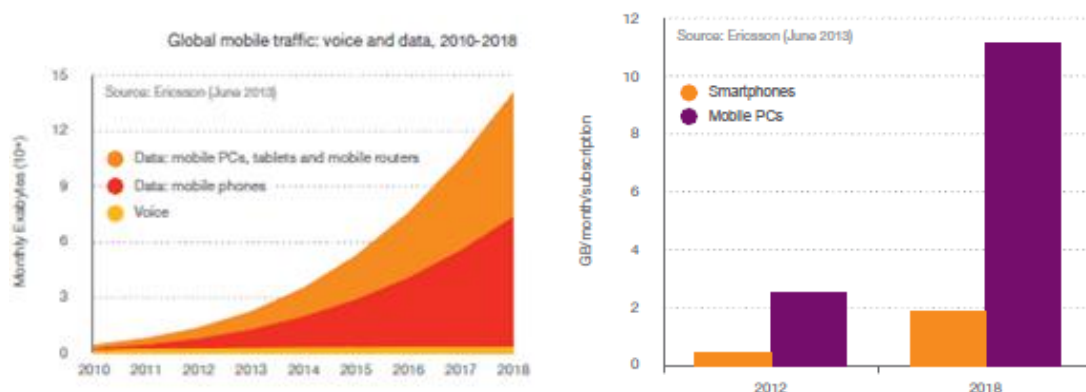


Figure 1: Mobile data traffic

Allocation of the 700MHz band (this is commonly referred to as Digital Dividend) to mobile communication is one of the key solutions for meeting the mobile data explosion challenge.

The APT 700 MHz band plan has the opportunity to be the most highly harmonized, nearly worldwide band for mobile broadband. The resulting economies of scale for APT band plan-compliant devices are expected to be massive, with corresponding economic, consumer and societal benefits.

ZTE believes APT700 terminals will be available in the market starting from Q4 2013.

2. LTE APT 700MHz Overview

2.1 3GPP APT700 Band Definition

3GPP defines two bands for APT700 MHz band plan (698-806 MHz), including band 28 and band 44, this is shown in table 1. The APT band plan has been designed to enable the most efficient use of available 700MHz spectrum. 3GPP divides the band into contiguous blocks of the frequency, the TDD band 44 includes 100 MHz of continuous spectrum, while the FDD band 28 has one 45 MHz for uplink and another 45 MHz for downlink.

Table 1 3GPP Band Definition for APT700

3GPP band	Duplex	Uplink Frequency	Downlink frequency
28	FDD	703 – 748 MHz	758 – 803 MHz
44	TDD	703 – 803 MHz	703 – 803 MHz

The low-frequency nature of 700MHz means the mobile signal can travel relatively longer distances, which is ideal for improving the services offered to customers in rural and regional areas.

For APT700, the coverage area is about 4 times larger than LTE2.6GHz with better indoor penetration, 45% improvement in cell-edge throughput and 40%~50% site reduction compared to LTE 1.8GHz. Reduction of extra base stations results in quick delivery of LTE to market and lower TCO for the Operator

2.2 APT 700 Band Ecosystem

Adoption of the APT700 MHz band plan by a growing number of countries across the APAC and Latin America regions confirms the strong momentum and represents a major opportunity for global spectrum harmonization for LTE systems.

The APT band plan has become a multi-regionally harmonized spectrum band that will provide a coherent ecosystem for LTE devices. Most Asian countries have already opted for the APT band; there is a strong evidence of a rising regional consensus among the vast majority of Latin American countries. European's "second" digital dividend plan implies that it will be compatible with the APT 700MHz band plan. All facts indicate that the APT 700 MHz band is becoming one of the most harmonized bands in the world. This also brings the close-to-global roaming opportunities for APT 700MHz devices.

The wide adoption of APT 700 band will lead to economies of scale which will in turn strengthen the APT700 ecosystem and lead to better pricing for APT 700MHz terminals.

In May 2013, Telstra announced it has successfully secured licences in the 700 MHz band and 2.5 GHz band in the spectrum auction held by the Australian Communications and Media Authority (ACMA). The licences are for a contiguous 2x20 MHz block of spectrum in the 700 MHz band. The spectrum licences have a term of 15 years. Telstra CEO David Thodey said the auction result was a significant outcome for Telstra customers as it would help ensure the company remained at the forefront of mobile connectivity and continue to deliver a superior mobile experience for customers.

2.3 APT 700 Terminal Foreground

The LTE ecosystem to date has grown strongly and according to a GSA report, 821 LTE user devices were announced by March 2013, operating in various FDD and TDD frequency bands including 261 smart phones, 256 routers including personal hotspots, 123 dongles etc.

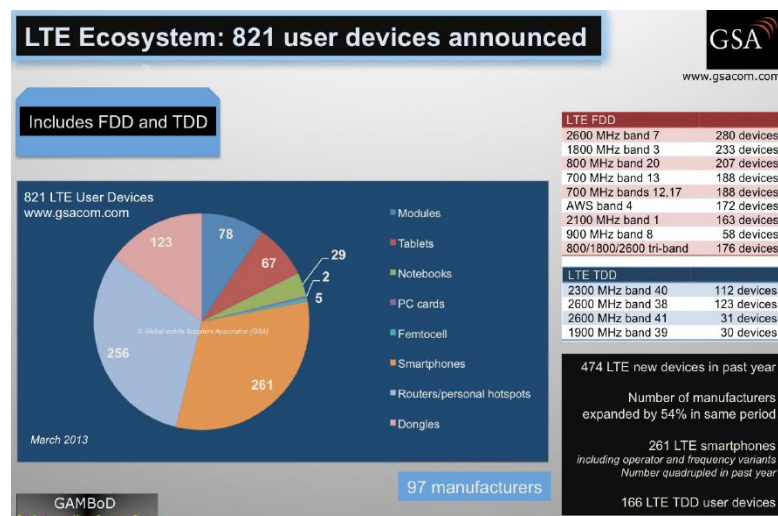


Figure 2: LTE terminals ecosystem (Source: GSA report)

Whilst there are no APT 700 spectrum devices so far, the emerging international demand combined with the following description of the chipsets, antenna and RF solutions suitable for integration of the APT700 band into handsets shows that there are few barriers to wide spread integration this band.

3. LTE APT 700 Terminals Design

Compared with 2G/3G standards, LTE has over 40 frequency bands definitions and each country has different band combination requirements for LTE/3G/2G, therefore

multi-band and multi-mode are major challenges for LTE terminal design.

Figure 3 shows the structures of LTE dongle and Wi-Fi hotspot router. The basic communication sub-system includes baseband modem chipset, RF chipset, power management chipset, RF front-end and antenna.

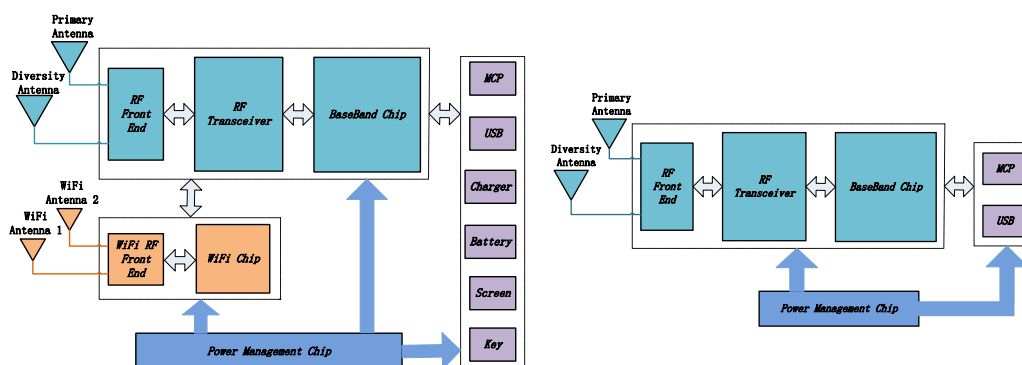


Figure 3: LTE Wi-Fi hotspot router and dongle architecture

3.1 Multi-band RF Design

APT 700 band terminal devices will be derived from existing designs that include operation in multiple bands and formats. Multi-band support in a single wireless terminal brings many benefits to the operator.

With the technology improvement made in the existing LTE devices, nowadays most of the RF chips can support multi-band technology. Multi-bands support requires a wideband antenna, duplexer for high band and low band, more switch ports and more components for each band. All of which have introduced extra design challenges for the already over-crowded PCB.

Thanks to the advances made in technology and components, industry has introduced new components to handle these challenges, such as the MMPA (multi-mode multi-band power amplifier) and FEM (front end module). Terminal vendors can support more and more bands in device and device size is getting smaller.

In Feb 2013, Qualcomm announced the new RF transceiver chip, the WTR1625L. This chip will support carrier aggregation with a significant expansion in the number of active RF bands. The WTR1625L can accommodate all cellular modes, 2G, 3G and 4G/LTE frequency bands and band combinations that are either deployed or in commercial planning globally.

3.2 Antenna Design

In LTE terminal design area, the MIMO antenna is one of the most important components.

Antenna design for the APT 700 MHz band is a challenge because of the wavelength of 700MHz signals. The efficiency of an antenna depends directly on its size and the space available in a mobile device. Smartphone and tablet products are getting smaller and slimmer, this trend leaves less space to accommodate the antenna. To maintain the antenna efficiency for the co-existence of multiple bands within the same terminal, the antenna design needs to be carefully tuned to ensure the performance for the multiple operating bands.

To maintain the LTE terminals performance, some of the key areas of antenna design are:

- High isolation between main and diversity antennas.
- Performance gap between main and diversity antenna.
- Envelope correlation coefficient.

The challenge in the design of antennas drives the industry to improve technologies or designs that is benefitting the LTE ecosystem. Some of the technologies adopted by terminals are:

- High isolation antenna: This new antenna can achieve high isolation by improvement in the ground plane. APT700 band is a low frequency band, and the wavelength is much larger than in 1800MHz band. The distance between the two antennas is limited by the available space on the PCB and cannot guarantee sufficient isolation. New technology can help improve this issue.
- Antenna active tuner: This technology can make the antenna work on a wider band. Antenna matching circuit can be adjusted dynamically based on the different working frequency. This technology can especially improve the antenna efficiency for high band and low band.

All the advances made in technology and components will benefit the APT 700MHz ecosystem as well.

3.3 Power Consumption and Management

Power consumption and management become increasingly important due to the facts below:

- Mobile terminals are getting smaller and slimmer which limits the size and capacity of the battery, while the screen is getting bigger.
- Lithium-ion battery technology updates slowly.
- Broadband data rates continue to increase.

To maximize the battery life, industry has been working on different areas to reduce the power consumption. Typically, CPU, Network radio interface and display are the three primary sources of power consumption, significant efforts have been made to optimize power consumption in these areas:

- 28nm chipset process technology: 28nm is becoming the mainstream in LTE chipsets. Compared with previous 45nm technology, 28nm process technology reduces PCB area and power consumption significantly.
- Power Amplifier (PA) efficiency: PA efficiency improvement is the key to improving the thermal footprint and battery efficiency. Envelope Tracking (ET) technology benefits terminals by providing significant reduction in PA max. power heat. Testing results show ET can reduce overall thermal footprint and RF power consumption significantly. By reducing power and heat dissipation, it enables the terminal vendors to design thinner smart phones with longer battery life.
- LTE connected mode DRX(CDRX): Connected Mode Discontinuous Reception (CDRX) is a feature introduced in Release 8 of 3GPP. Connected state DRX cyclically wakes up and shuts down the receiver circuits in order to save energy, this is shown in figure 4(Source: Nokia Siemens Networks: More battery life with LTE connected state DRX) . CDRX saves energy significantly in all scenarios, including web browsing, video streaming, and back ground data applications.

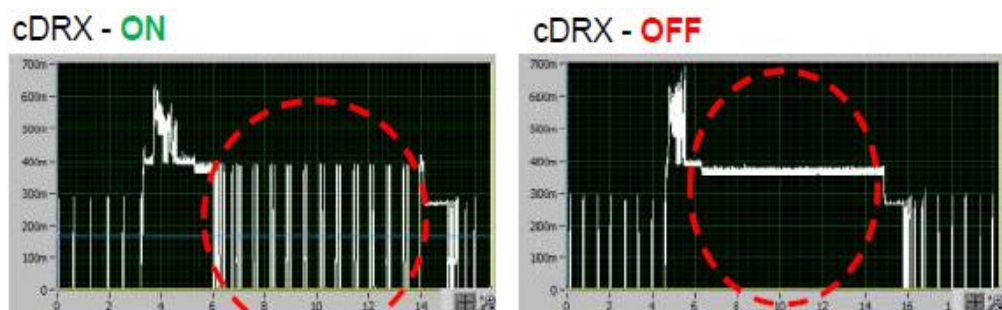


Figure 4: LTE connected mode DRX

- CABC (Content Adaptive Backlight Control): In a typical mobile design, the screen can consume as much as 50% of the total power. The power consumption is largely due to brightness; the brighter the screen, the higher the power consumed. The side effect of reducing brightness is it will decrease the viewable ability of the screen and reduces the user experience. CABC (Content Adaptive Backlight Control) is one of the screen power saving technologies, CABC adjust backlight brightness dynamically based on the analysis of the image to be displayed in the screen.

Over all, the technology progress made in existing LTE terminals will help extend the battery life of forthcoming LTE APT 700MHz terminals.

3.4 Carrier Aggregation

Carrier Aggregation is the core LTE-Advanced feature published in Release 10 of the 3GPP LTE standards. Massive increases in LTE subscriptions are driving bandwidth demand for additional LTE capacity. Carrier aggregation improves spectrum utilization.

For the existing LTE operators, carrier aggregation on APT 700 band with existing launched LTE frequencies(for example carrier aggregation between LTE 1800 band and APT 700MHz) is a reasonable choice to improve peak user data rates, increase average data rates, reduce latency and provide better load. Operators are looking at LTE-A CAT 6 or CAT 7 deployment based on carrier aggregation between APT 700 band and other frequencies.

Carrier Aggregation (CA) is the core technology of LTE-Advanced. It is the unique way to expand the radio bandwidth in the 3GPP standard. Figure 5 shows three modes of Carrier Aggregation.

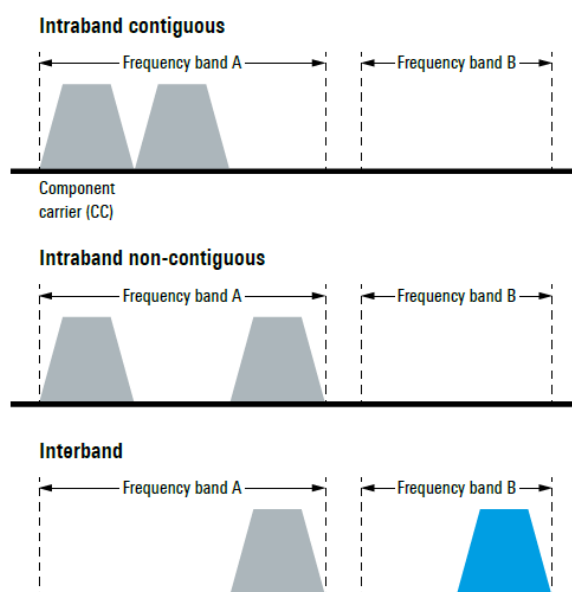


Figure 5: Three modes of carrier aggregation

The main challenges of carrier aggregation deployment are at UE side. CA requires many new resources, particularly in the UE. Handsets are required to support additional bands of operation. Additional bands will require additional front end and other components, all of which will affect device size, battery life and cost.

3.5 Voice over LTE and RCS/RCS-e

In the LTE radio and Evolved Packet Core (EPC) architecture, there is no circuit-switched domain to handle voice calls as with legacy 2G/3G.

There are a series of solutions current in use and there are roadmaps to deal with the evolution of networks until such time as LTE coverage is ubiquitous for voice over LTE:

- Circuit Switched Fallback (CSFB)
- Simultaneous Voice and LTE (SVLTE)
- Single Radio Voice Call Continuity (SRVCC)

In the transition phases of LTE deployment where both LTE and legacy networks will co-exist, Single Radio Voice Call Continuity (SRVCC) offers LTE/IMS-based voice service within the LTE coverage area and CS-based voice service outside the LTE coverage area. When moving out of the LTE coverage area, a user's voice must be passed smoothly from LTE to CS network, and network upgrade should be kept to a minimum. With SRVCC, an Enhanced MSC is employed alongside the MME in the LTE network and a Session Continuity Control Application Server (SCC AS) in the IMS network is used for handover between CS and IMS. In this way, voice call continuity between the IMS and CS domains can be maintained without the need to upgrade all existing MSCs.

SRVCC is specified in 3GPP TS 23.216. Figure 6 shows the simplified procedure for SRVCC for GERAN or UTRAN.

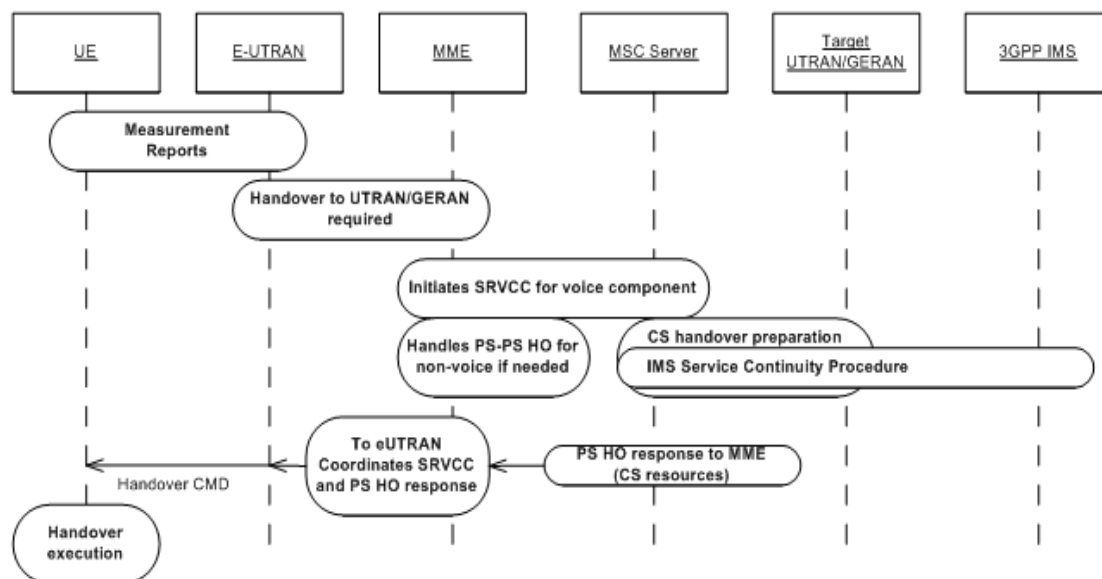


Figure 6: High level concepts for SRVCC from E-UTRAN to UTRAN/GERAN

Rich Communications Suite (RCS and RCS-e) services are defined by the GSM Association and other industry associations. RCS is targeting to change the way people communicate. It delivers an experience beyond voice and SMS by providing consumers instant messaging or chat, live video, file sharing and enhanced phonebook.

VoLTE/RCS provides an improvement in spectral efficiency and is needed to increase network capacity and allow for the re-farming of 3G spectrum in the future. Commercial VoLTE/RCS introduction is determined by device capabilities and availability. Other factors include network coverage, the existence and maturity of IMS core networks and commercial strategy.

Operators such as SK Telecom, LG U-Plus, AT&T and Verizon Wireless are either already operating or planning for VoLTE technology. On 25th February 2013, ZTE announced it had conducted a High Definition (HD) voice over LTE (VoLTE) call using enhanced Single Radio Voice Call Continuity (eSRVCC) for Hong Kong's leading mobile operator CSL, the success of this demonstration is an important milestone in the development of LTE voice services in the mobile industry.

4. Conclusions

The lower frequency of the APT 700 band means the mobile signal can travel relatively longer distances or further into buildings, which is ideal for customers in rural and regional areas as well as built up areas.

The emerging international alignment and support for the APT 700 band plan represents a major opportunity for global spectrum harmonization for LTE systems,

paving the way for ensuring the greatest economies of scale for devices and capacity for mobile broadband and for roaming.

The standardization carried out by 3GPP was strongly supported by key industry stakeholders and Telecommunication equipment vendors are working on the commercialization of APT 700 UE and network infrastructure to support this new band.

Terminals are important and an essential part of the LTE APT 700 ecosystem and with APT700 emerging as a mainstream spectrum in the APAC and Latin America regions the resulting potential user base points to significant opportunities for scale and wide spread adoption into handsets.

This white paper summarizes the technical challenges and solutions for the APT 700MHz terminal, such as antenna design, multi-band RF design, carrier aggregation and voice solutions.

APT 700 terminals will benefit from the whole existing LTE technology ecosystem. ZTE believes that APT 700 terminals will be commercially launched from Q4 2013.

5. Abbreviations

3GPP – Third Generation Partnership Project
APAC – Asia Pacific
APT – Asia-Pacific Telecommunity
CSFB– Circuit Switched Fallback
CA – Carrier Aggregation
CC – Component Carrier
CDMA – Code Division Multiple Access
DL – Downlink
ET – Envelope Tracking
FEM – Front End Module
GSA – The Global mobile Suppliers Association
GSM – Global System for Mobile communications
ID – Industrial Design
LTE – Long Term Evolution (evolved air interface based on OFDMA)
LTE-A – LTE Advanced
MHz – Megahertz
MMPA – Multi-mode Multi-band Power Amplifier
OTT – Over-the-top
PA – Power Amplifier
PCB –PCB Printed Circuit Board
RF – Radio Frequency
SRVCC – Single Radio Voice Call Continuity
SVLTE – Simultaneous Voice and LTE
UE – User Equipment
UMTS – Universal Mobile Telecommunications System
ZTE – ZTE Corporation

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