Why it is Imperative for the FCC to Impose an Interoperability Condition if it Approves the AT&T-Qualcomm Transaction

Vulcan Wireless

November 28, 2011

Recommended FCC Action: The AT&T-Qualcomm license transfer should require interoperability as a condition but also allow AT&T to proceed with its current deployment plans in the short term

- *After the transaction closes, any mobile device offered by AT&T that operates on paired Lower 700 MHz band spectrum must operate on all Lower 700 MHz band paired spectrum. This condition only applies to new devices, beginning as early as 6 months after the transaction closes and fully implemented two years following the close of the transaction*

FCC Must Take Action Now

- The lack of interoperable equipment and 4G mobile devices for the Lower 700 MHz A Block is a major impediment to deployment in the band
- The FCC can, and must, take action immediately to solve this problem
  - The transaction creates new interference obstacles for lower A Block licensees, threatens their ability to achieve interoperability, and could enable AT&T to circumvent the FCC's roaming decisions
- There are no technical- or cost-based impediments to imposing an interoperability condition on this transaction, as demonstrated by a recent technical study
- An interoperability condition is most appropriate at this time to quickly restore a competitive environment and reduce the threat of impediments to A Block deployment at the lowest possible cost

The FCC Needs to Require a Simple Condition to Curtail Manipulation and Compensate for the Absence of the Traditional Balance of Market Forces in the Band Plan Process

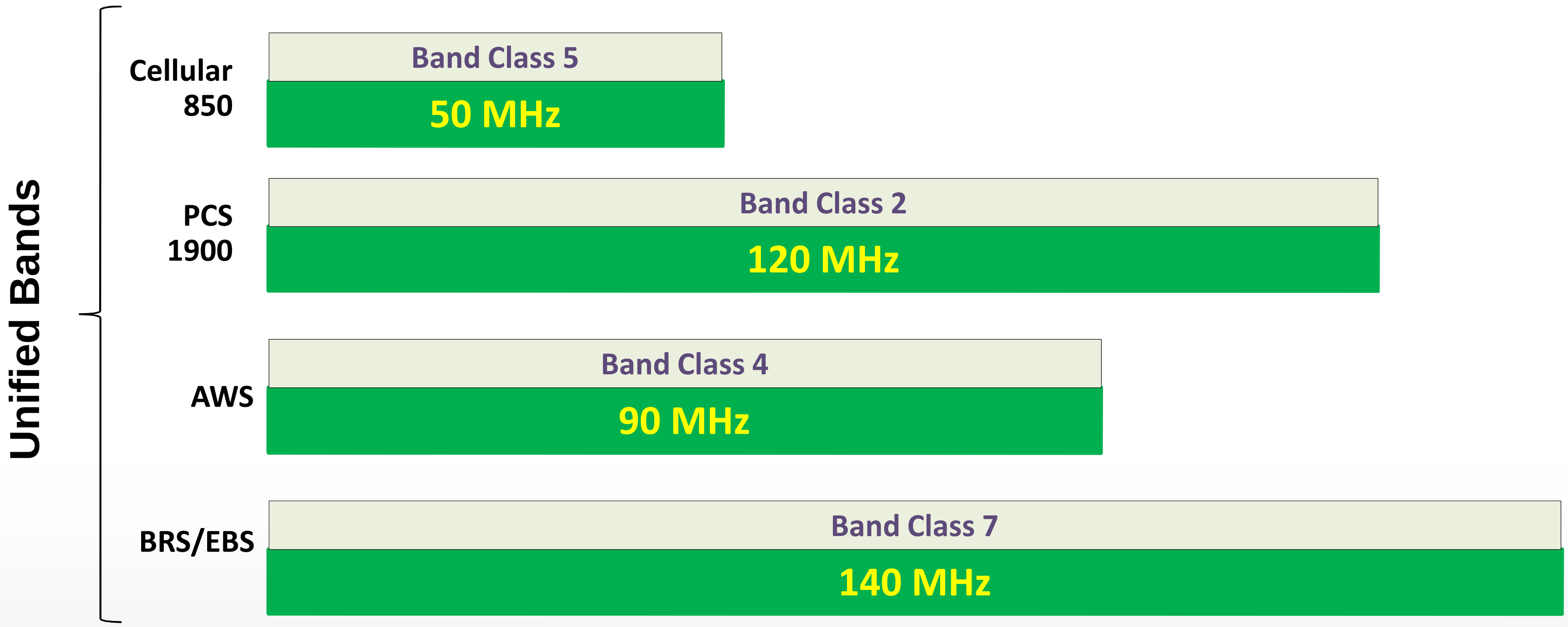
- For standards bodies to work, multiple wireless carriers need to be present to allow for the creation of interoperable band classes and provide the necessary economies of scale and access to technology
- Neither standards bodies nor markets work when there is only one wireless carrier in the market influencing the band plan process
- The 3GPP process is predicated on market force collaboration, but the unanticipated problem is that only one wireless carrier dominated the Lower 700 MHz band plan process
- Predatory tactics were allowed to influence the band class creation in the standards body process leading to unprecedented and unanticipated marketplace manipulation
- AT&T's dominance of the band plan process thwarts efficiencies that benefit consumers, vendors, and licensees
- Requiring interoperability will compensate for the lack of traditional market forces and rebalance the band plan process

Background

- Following the DTV transition, the US led the world in awarding 700 MHz spectrum for 4G, providing an early deployment of the spectrum relative to other countries
  - This early awarding of 700 MHz spectrum led to unprecedented and unanticipated manipulation of the existing Lower 700 MHz band plan, slicing up 700 MHz spectrum in unnecessary and harmful ways to suit the business goals of AT&T versus the technology goals traditionally used in establishing a band plan
  - The AT&T-Qualcomm acquisition magnifies AT&T's market power in the Lower 700 MHz band and increases its ability to exert undue influence within the 3GPP process to the detriment of other Lower 700 MHz band licensees, consumers, & FCC policy

Vulcan Wireless

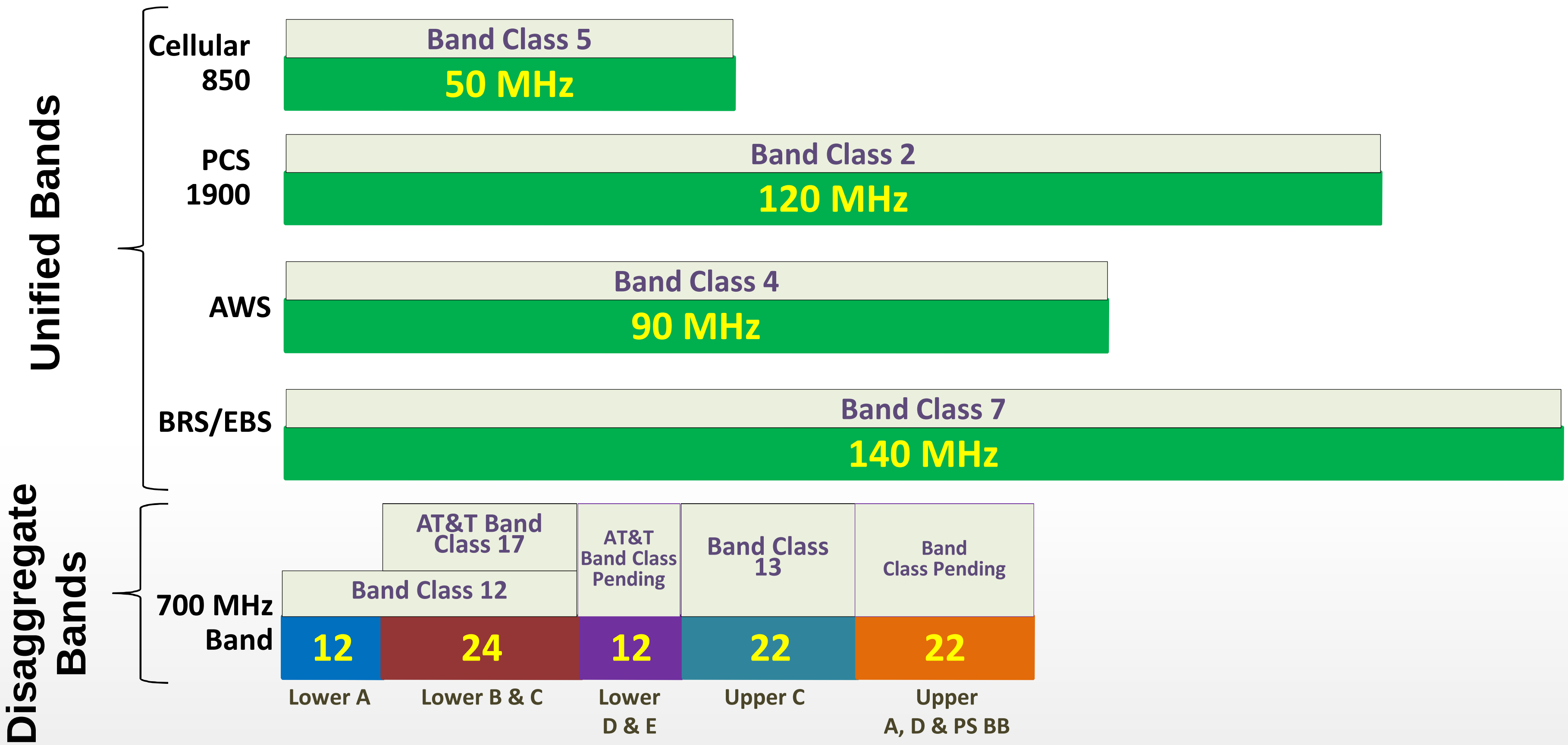
Wireless Frequencies & 3GPP Band Classes



➢ **Every historical mobile wireless band class in the US has a unified band plan.** Traditionally, vendors came together in 3GPP to establish a single band class across individual spectrum allocations as a common technical foundation for all service providers within the band, driving economies of scale and interoperability.

➢ **Unified Band Plans have contributed significantly to ecosystem development, industry growth and consumer choice.** Without a common band plan, consumers can never switch carriers with a phone and data roaming is not possible.

Wireless Frequencies & 3GPP Band Classes



- **With 700 MHz, the 3GPP process has been unduly influenced to force disaggregation**

The unique use of 700 MHz frequencies exclusively in the US has given AT&T (a dominant 700 MHz spectrum holders) excessive influence, as there are no large international carriers using the same spectrum. This has led to unprecedented band class fragmentation and delays, slower ecosystem development and less consumer choice.

Activity Timeline for 700 MHz Band Class Pre- and Post- Auction 73

Dec 2007 (prior to auction) Only Band Class 12 is before 3GPP. Heading into Auction 73, there was no indication that there would not be interoperability. Prior to the auction, the focus had been on Band Class 12.

March 2008 Auction closes

April 2008 Motorola submits paper to 3GPP proposing Band Class 17 – eliminates lower band interoperability and covers B and C Blocks predominantly owned by AT&T

June 2008 Ericsson questions reason for fracturing the band into separate band classes; Ericsson removes objections after AT&T supports Band Class 17 **"which goes against economies of scale and may lead to market fragmentation"**

September 2008 3GPP ratifies Band Class 17 – Ericsson objections silenced

December 2010 3GPP ratifies Band Class 12 with 1 MHz guard band - It has taken a long time for the marginalized A-Block licensees to get vendors to develop devices for its stand-alone band class. By the end of this year, both VZW and AT&T will have deployed 700 MHz spectrum to their customers, while the A-Block licensees are still waiting for a workable prototype.

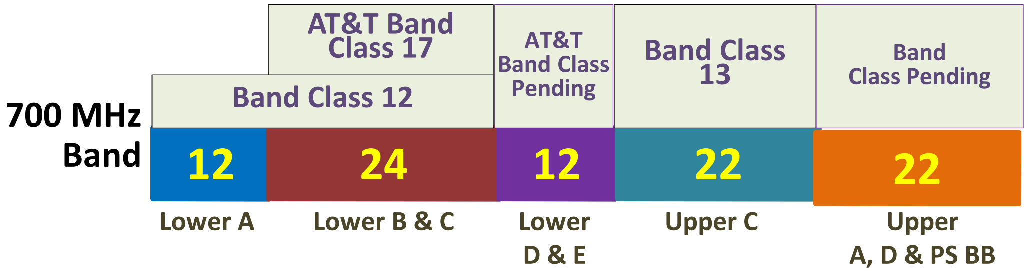
November 2011 AT&T requests that an additional 1 MHz of guard band be provided by Band Class 12 to protect spectrum being acquired from Qualcomm

Post-merger, AT&T would control approximately 75% of the spectrum in the Lower 700 MHz band. AT&T effectively dictates to the vendor community in the lower 700 MHz band.

700 MHz Band Class Manipulation Benefited AT&T but Derailed and Corrupted Lower 700 MHz Interoperability Efforts, Created Global Backlash, and Thwarted A Block 4G Deployments

ITU & 3GPP Mission: "Adopting international standards to ensure seamless global communications and interoperability for next-generation networks (NGN)" – ***this was not done***

- Normally major global wireless carriers such as Orange, Vodafone, China Mobile , among others, are involved at the outset in standard-setting for key spectrum bands – ***this was not done***
- Carriers always make the necessary technical compromises to ensure ecosystem interoperability – ***this was not done***
- Since the US led in awarding 700 MHz licenses, AT&T, with its captive vendor community found itself in an unusual position to drive standards only for the AT&T-owned spectrum bands, often without even providing traditional and necessary technical data to support asserted needs – ***this needs to be corrected***
- Global analysts and global wireless carriers alike cite the lack of 700 MHz interoperability standards as a key issue and new non-US global standards are being developed as a result [*e.g.*, Asia-Pacific Telecommunity (namely, the APT band plan)] – ***this needs to be corrected***



The Problem: The unique nature of the 700 MHz band (with no matching international allocation) and market consolidation have led to a skewed 3GPP process, which has resulted in:

1: Fractured and disaggregated spectrum
2: A captive vendor community
3: Isolated/orphaned spectrum holders
4: Harm to competition and consumers

Pro-Consumer and Pro-Competition FCC Policies Have Been Circumvented and the Recent FCC Roaming Order Rendered Useless

- The April 2011 FCC Workshop on Interoperability revealed that primarily business reasons, more so than technical reasons, drove 700 MHz band plan fragmentation
- The acquisition of D & E Block licenses by AT&T removes a key part of the technical reasons used in 3GPP to originally rationalize the need to develop its own separate Band Class 17
- If AT&T is allowed to hide behind the claim that its mobile devices do not interoperate with other 700 MHz spectrum, then FCC policy goals will continue to be circumvented and the roaming order will be eviscerated
- Without FCC action now, before the network is built and deployed, the opportunity to correct the situation may become forever lost

The AT&T-Qualcomm License Transfer Would Exacerbate the Interoperability Problems in the Lower 700 MHz Band

- The AT&T-Qualcomm acquisition, if approved, would magnify AT&T's market power in the Lower 700 MHz band and increase its ability to exert undue influence within the 3GPP process to the detriment of other Lower 700 MHz band licensees.
- The acquisition would specifically threaten interoperability by increasing the potential for significant interference across the Lower 700 MHz band.
  - For example, AT&T has argued that adjacent and other transmissions in or around 700 MHz caused interference concerns and required the creation of Band Class 17. But these concerns apparently do not apply to AT&T itself, which is now suggesting that it does not and will not cause interference to others, including by using the adjacent D & E Blocks.
  - **Nonetheless, there has already been a request at 3GPP to reduce the usable bandwidth for Band Class 12 licensees. This AT&T influenced request comes even before their acquisition is completed**
  - **AT&T's public submissions to the FCC never revealed that its use of the D Block spectrum would require other licensees to reduce their use of spectrum to create guard band for AT&T's purposes**
  - Without an interoperability requirement, AT&T at any time would be able to introduce new system requirements that cause interference to, preclude interoperability with, and introduce additional costs for, other Lower 700 MHz band licensees.
- Moreover, if the acquisition is approved, AT&T will have no incentive to cooperate with Lower Band licensees on *any* issues that may arise in the Lower 700 MHz Band, as it will function as a separate ecosystem. This will further threaten interoperability.
- Without interoperability, there will be no roaming across the Lower 700 MHz band and there will be a greater risk of exclusive handset arrangements, both of which will hinder competition and create islands of incompatibility – especially in the Lower 700 MHz A Block.
- The FCC should not approve the proposed license transfer without transaction-specific conditions to remedy these related interoperability concerns.

The Solution

Recommended FCC Action: The AT&T-Qualcomm license transfer should require interoperability as a condition but also allow AT&T to proceed with its current deployment plans in the short term

- The lack of interoperable equipment and 4G mobile devices for the Lower 700 MHz A Block is a major impediment to deployment in the band
- The FCC can, and must, take action immediately to solve this problem
  - The transaction creates new interference obstacles for lower A-Block licensees, threatens their ability to achieve interoperability, and could enable AT&T to circumvent the FCC's roaming decisions
- There are no technical- or cost-based impediments to imposing an interoperability condition on this transaction, as demonstrated by a recent technical study
- An interoperability restriction is most appropriate at this time to quickly restore a competitive environment and reduce the threat of impediments to A Block deployment at the lowest possible cost

After the transaction closes, any mobile device offered by AT&T that operates on paired Lower 700 MHz band spectrum must operate on <u>all</u> Lower 700 MHz band paired spectrum. This condition only applies to new devices, beginning as early as 6 months after the transaction closes and fully implemented two years following the close of the transaction

FCC Action Will Help to Accelerate Other US 4G Deployments and Address Global Backlash

- ***Mike Byrne, Chair of the European Commission's Radio Spectrum Policy Group and a Commissioner at the Commission for Communications Regulation (ComReg) said***: "Cooperation between Europe and the Americas is increasingly important to ensure that spectrum is being used wisely and countries are able to recover from the economic slump. An inward-looking approach results in increased fragmentation and higher prices for products and services that have to be tailored to each region."

- ***Sebastian Cabello, Director of GSMA's regional office in Latin America, said***: "GSMA members want harmonized frequencies, which drive scale and adoption of wireless services. Mr. Cabello noted that one drawback of the U.S. plan is the difficulty in device interoperability between sub-bands."

Benefits of the Proposed Condition

Not onerous

- Allows AT&T to transition to this solution over time
- No stranded investment because no impact on current handset sales
- New phones are constantly developed and deployed

A solution that will evolve as mobile wireless services evolve

- Does not force AT&T into a single configuration, but imposes a service condition
- Allows AT&T to innovate and develop new handsets just as in other mobile bands (which all have a uniform band class)
- Ensures that Band Class 12 licensees can get devices, and that roaming is technically possible across the Lower 700 MHz band

Interference is not an impediment to interoperability

- The FCC workshop demonstrated that there is no technical barrier to interoperability – only business decisions prevent it
- Post-transaction there are no significant technical differences between Band Class 12 (Lower A, B, & C Blocks) vs. Band Class 17 (Lower B & C)
- Band Class 12 could be substituted for Band Class 17 without impacting the number of bands on a chip

Extensive Study Demonstrates that There Are No Technical Impediments to Lower 700 MHz Interoperability

- A consortium of several 700 MHz A Block license holders* funded a "real world" study by conducting a variety of tests and collaborative engineering analyses/evaluations regarding the underlying assumptions originally put forth regarding the need for a separate Band Class 17 in the Lower 700 MHz band that has precluded interoperability
- The study included a combination of in-market field environmental measurements along with device lab bench testing of AT&T4G devices
- The study included field measurements in Atlanta, a market with a high power E Block system (50 kW), AT&T Lower B and C Block LTE system, Verizon Upper C Block LTE system, a high power Channel 51 broadcaster and an LPTV broadcaster. Also included in the test were AT&T LTE 4G devices.

*The consortium members include: Vulcan Wireless, King Street Wireless, Cavalier Wireless, Continuum 700, Cox Wireless, C Spire and MetroPCS.

700 MHz Study Objectives

- Provide "Real World" hard engineering data that specifically addresses and quantifies previously submitted general claims that has led to confusion regarding the impact of interference in the lower 700 MHz band
- Quantify answers to questions: If AT&T were to use Band Class 12 versus Band Class 17, would AT&T experience any increased levels of interference, degraded service or increases in handset costs?
  - Are the fundamental assumptions used to support AT&T's adoption/creation of a separate Band Class 17 technically necessary or marketplace motivated?
- How does the AT&T acquisition of D and E Block licenses affect the need for Band Class 17 ?
  - Has the main rationale originally used to rationalize the creation of Band Class 17 been technically eliminated with this acquisition
  - Could the acquisition of these licenses impact interoperability among other license holders in the lower 700 MHz band

Summary of 700 MHz Study Findings

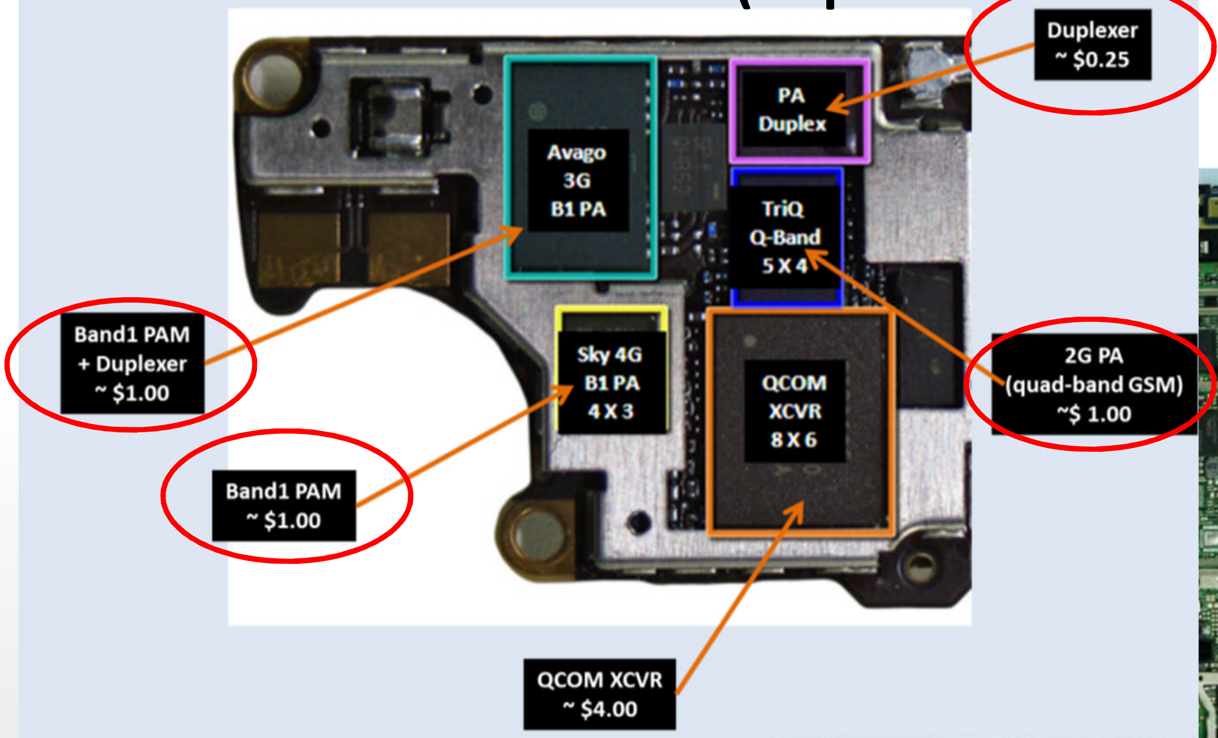
- Band Class 17 B and C Blocks already suffer greater interference threats from each other than what would be introduced from a unified Lower 700 MHz Band Class that includes the Lower A Block. Neither high power E Block transmissions nor Channel 51 transmissions create an increased interference threat; in fact, the interference threat is lower.
  - AT&T LTE devices currently receive and successfully manage greater levels of interference from within the B and C Blocks than need to be accounted for by unifying the Lower 700 MHz paired bands
  - Concerns and claims made about reverse intermodulation distortion interference are unfounded

- Unsubstantiated concerns and claims about the potential increase in cost or size of devices are inaccurate and misstated as testing shows the BOM costs will remain virtually unchanged.

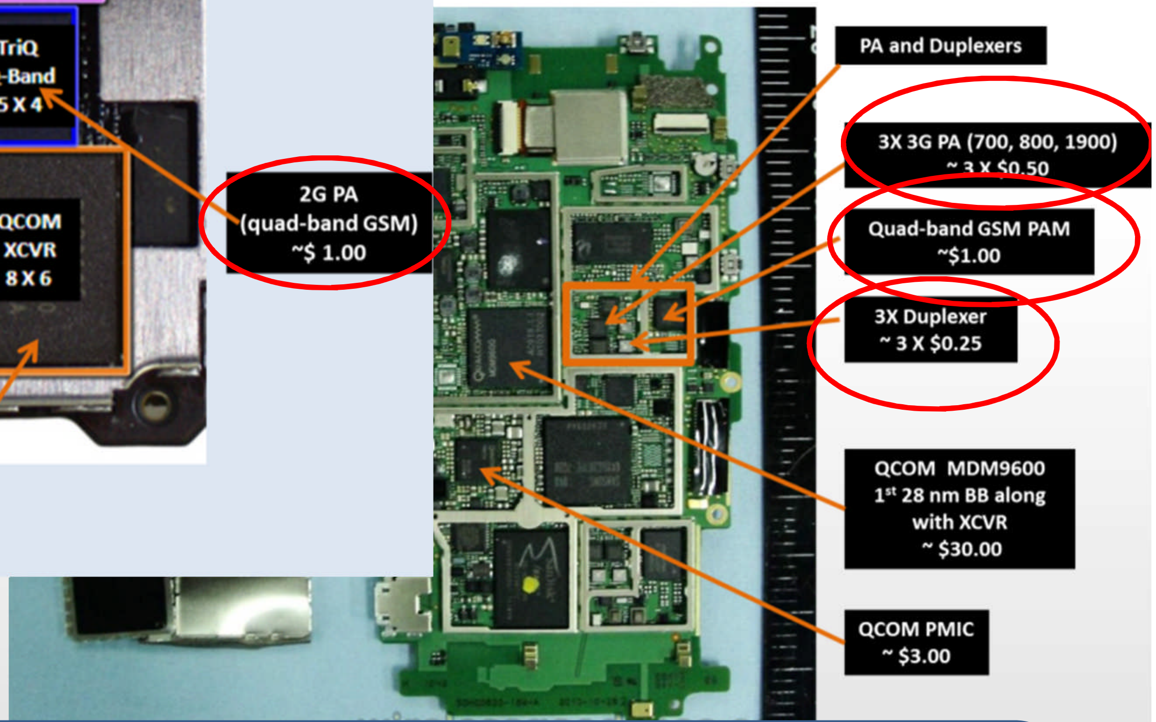
No Cost Increases Anticipated in Either Apple or Android Bill of Materials

(Impact of Band Class 12)

iPhone 4S

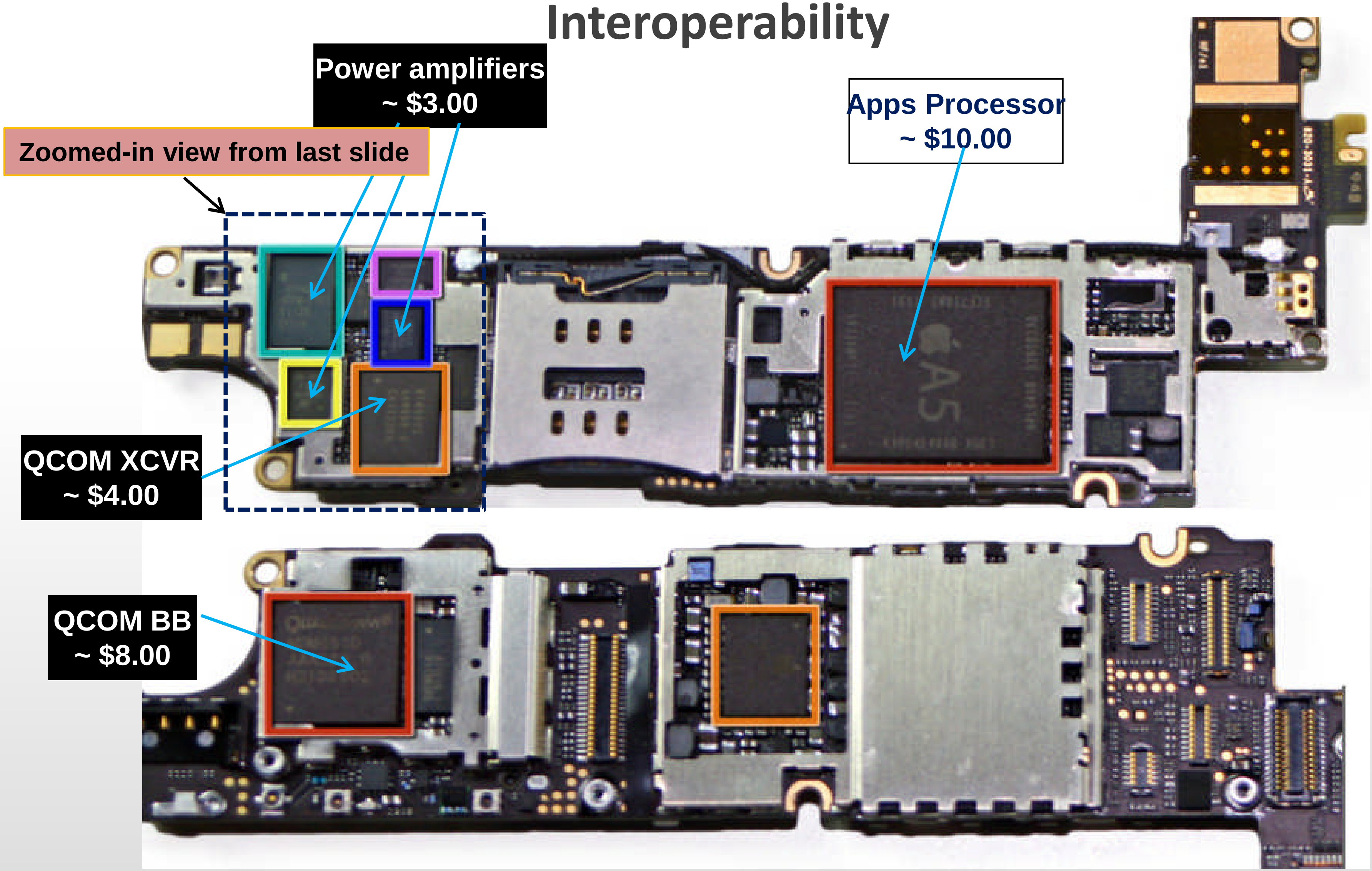


HTC Thunderbolt



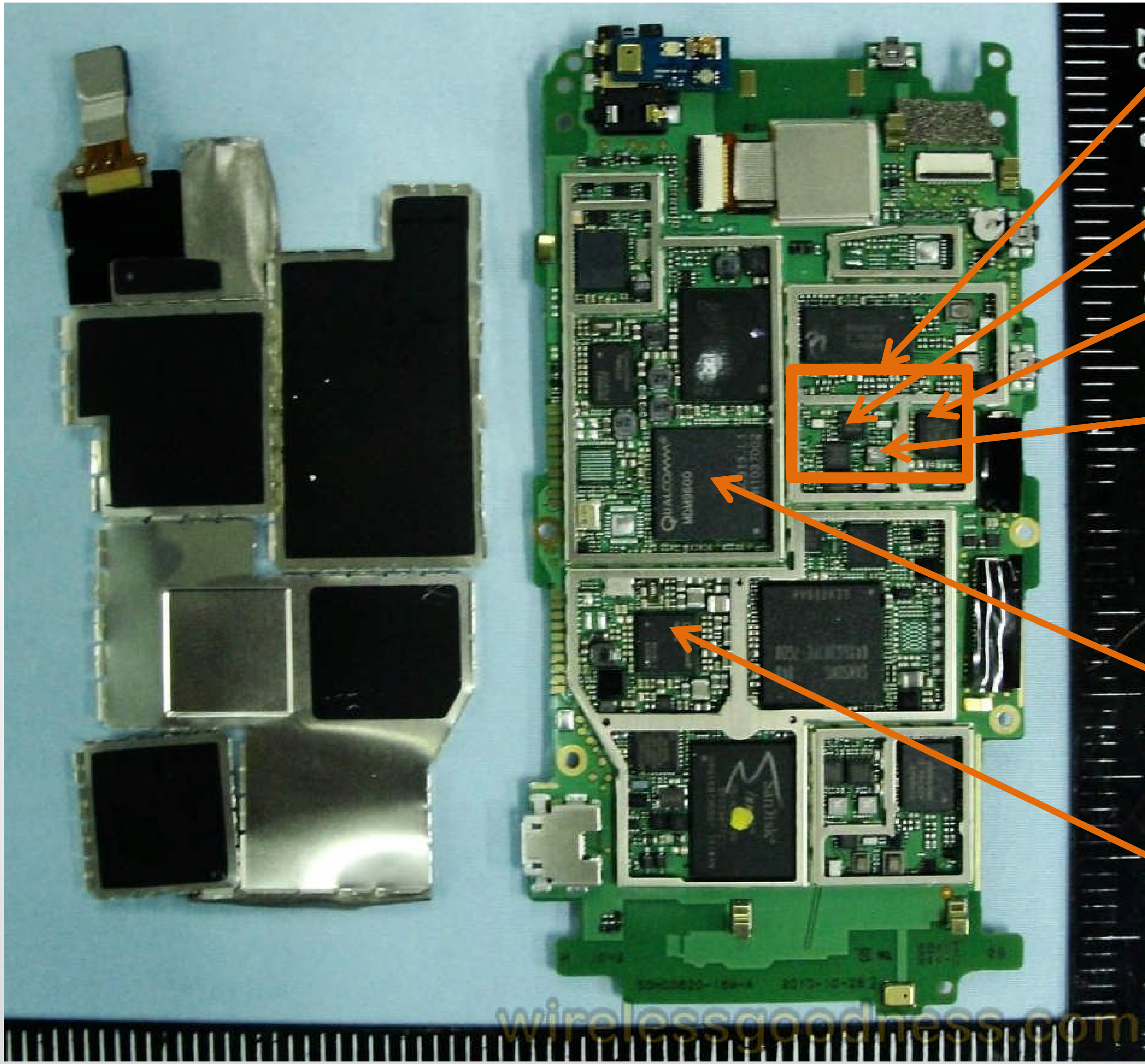
Device Performance indicates that no changes are required except to simply broaden the duplexer to cover Lower A, B and C Blocks. However, if new filter (and potentially new Power Amplifier Module) components are required, similar BOMs component prices are all < $1 and, in quantity, have no cost impact.

There are also No Cost Impediments to Lower 700 MHz Interoperability



Device Component Bill of Materials for iPhone 4S

Device Component Bill of Materials for HTC Thunderbolt



PA and

3X 3G PA (700, 800, 1900)
~ 3 X $0.50

Quad-band GSM
PAM

3X Duplexer
~ 3 X $0.25

QCOM MDM9600
1st 28 nm BB along
with XCVR
~ $30.00

QCOM
PMIC
~ $3.00

Interoperability is Clearly in the Public Interest

Prerequisite to Competition. An interoperability requirement will ensure that AT&T and Verizon, which will hold the vast majority of Lower 700 MHz spectrum and disproportionate influence over the vendor ecosystem, will not hold the vendor community captive, to the detriment of A Block licensees.

Prerequisite to Data Roaming. Without an interoperability requirement, AT&T can easily use the standards body process to render the FCC's new data roaming requirements technically infeasible.

911 and Public Safety Interoperability. Some 911 calls could fail without an interoperability requirement. The 700 MHz spectrum provides a different footprint than other bands currently used for mobile. In a geographic (likely rural) location only served by a 700 MHz footprint, it is possible that a phone operating on the Lower 700 MHz A Block could only reach a Lower 700 MHz B and C Block tower but not be able to communicate due to differing standards or a lack of interoperability. In addition, commercial interoperability should offer cost savings for public safety.

Jobs and Deployment. Smaller wireless carriers and new entrants hold all of the A Block licenses beyond the top 25 markets, which are held by VZW. Whether they are competitive providers or the only provider, A Block licensees bring jobs and economic opportunities to their communities. The President's broadband deployment goal of reaching 98% of Americans cannot be met without the participation of all wireless carriers.

Less $ Needed for USF Subsidy in Rural Areas. The cost needed to serve these areas will only go up and ultimately be paid for through USF.

More $ at Future Auctions/Diversity. A major reason for the success of recent auctions is multiple bidders. Multiple bidders/entrants provide an opportunity for marketplace diversity and auction competition. These entities will not bid if they can simply be driven out of the marketplace through standards bodies practices. The overall pool of auctions monies will be reduced and the larger carriers will see less competition for markets, further reducing revenues.

3GPP TSG-RAN WG4 meeting #61 **R4-115759**
San Francisco, California, USA, 14-18 November, 2011

Source: Ericsson, ST-Ericsson

Title: Co-existence/co-location between LTE Downlink FDD 716-728 MHz and Band 17, 12

Agenda item: 8.3.1

Document for: Approval

1 Introduction

LTE downlink FDD 716-728 MHz was approved in [1]. LTE downlink FDD 716-728 MHz is allocated at 0 MHz distance from Band 12/17 UL. Co-existence/co-location between these bands needs to be considered.

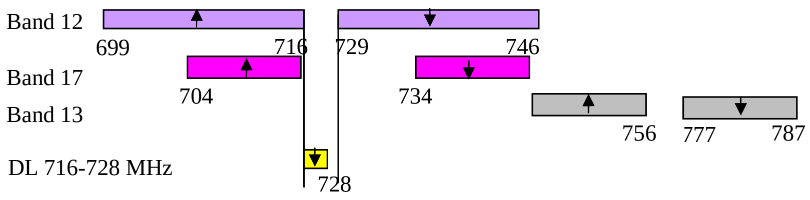


Figure 1. 3GPP spectrum allocation in together with DL 716-728 MHz

2 Discussion

2.1. BS co-existence/co-location

The same operator is expected to deploy in both LTE DL FDD 716-728 MHz and Band 12/17. Therefore BS co-location (instead of co-existence) can be considered the most realistic scenario.

To be able to protect Band 12/17 UL against a LTE DL 716-728 MHz BS with 46 dBm transmit power, an attenuation of about 80 dB is needed in case of co-located BSs, considering that ACS is the applicable requirement for Band 12/17 at 716 MHz, which defines a blocker of -52dBm for 6dB degradation. Here, we assume 1 dB degradation at the receiver band of Band 12/17. Such rejection level will require certain frequency separation between the bands or performance degradation at Band 12/17 UL highest edge. Band 12/17 is 17/12 MHz wide, which means that the largest LTE carrier which can be fit is 15/10 MHz. Assuming that this carrier is allocated in the middle of Band 12/17, degradation could be allowed at Band 12/17 UL highest edge.

LTE DL FDD 716-728 MHz needs to protect Band 12/17 UL according to the co-location spurious emission requirements stated in TS 36.104, -96 dBm/100kHz at 716 MHz, if co-location is declared. The filter needs to attenuate the signal by 80 dB considering ACLR=45dB at the adjacent channel. LTE DL FDD is composed by two blocks, Block D (716-722 MHz) and E (722-728 MHz), which are 6 MHz wide each. It is then possible to allocate 2x5 MHz LTE carriers as well as 1x10 MHz carriers. In those regions on which just Block D has been allocated for mobile communications, the carrier could be put at the highest edge, i.e. 717-722 MHz. In case of regions, where both block D+E are allocated, the carrier could occupy 718-728 MHz, increasing the frequency separation towards Band 12/17 UL.

Figure 2 shows simulations for LTE DL FDD 716-728 MHz assuming co-location with Band 12 and allowing less protection at the highest edge of Band 12 UL. 20 dB rejection is also considered at 10 MHz from the highest operating band edge of LTE DL FDD to be able to decrease emissions on the spurious emissions domain according to TS 36.104. LTE DL FDD arrangement is defined as 716-728 MHz, while real deployment scenarios allow an increase of the guard between Band 12 UL and LTE DL FDD by at least 1 MHz. Thus, filter simulations are shown with a 716-728 MHz and 717-728 MHz passband. Simulations are not optimized since they intend to show the effect of the frequency separation between Band 12 UL and LTE DL FDD 716-728 MHz. We can observe that the number of poles needed for LTE DL FDD 716-728 MHz with 716-728 MHz passband is 12 and 10 for a 716-728 MHz and 717-728 MHz passband, respectively. The Q value is in case of 716-728 MHz passband (Q=17000) is about 2.4 times the one for 717-728 MHz passband (Q=7000)

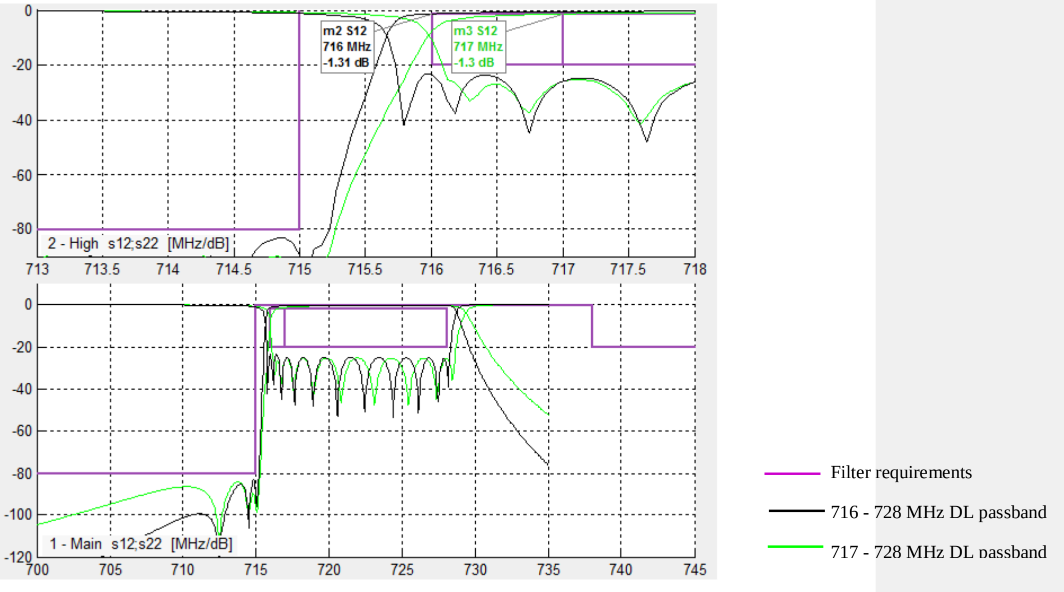


Figure 2. LTE DL FDD 716-728 MHz

Band 12 is 17 MHz wide while LTE DL FDD 716-728 MHz is 12 MHz. Due to the larger passband, the filter will be more challenging for a co-location scenario which requires 80 dB attenuation at 716 MHz or alternatively 717 MHz, if a real deployment case is considered. Certain IL degradation can also be allowed at the highest edge of band 12 UL, i.e. 699-715 MHz passband, taking into account the current deployment scenario.

2.1. UE co-existence

The coexistence between LTE Downlink FDD 716-728 MHz and Band 12 DL has been considered earlier but in a different context with a MediaFLO broadcast interferer in Block D and possibly also Block E. To facilitate UE coexistence, a 1 MHz guard and an additional in-band blocking requirements were introduced to protect Band 12 DL against broadcast interferers.

For the LTE Downlink FDD 716-728 MHz, coexistence with Band 12 is an UL-DL and the 1 MHz guard has only marginal effect on protected adjacent band. However, the DL-only band is used for carrier aggregation and supporting a Secondary CC. The Primary CC with the associated uplink is assigned in an operating band well separated from Band 12 in frequency, e.g. Band 2 or Band 4. Hence, if the Secondary CC is harmfully interfered by a close-by Band 12 UE, the Primary CC will still supply throughput. The CQI reported on the Primary CC will then show low values for the interfered Secondary CC and data (or higher-layer retransmissions) can be scheduled on the primary CC.

3 Conclusion

BS-BS co-location between LTE DL FDD 716-728 MHz and Band 12 requires challenging filters. However, this can be facilitated by considering a real deployment scenario on which carriers in Band 12 UL are allocated below 715 MHz and above 717 MHz in LTE DL FDD 716-728 MHz. In this way, guard band between UL and DL is increased.

3 Proposal

It is proposed to study the possibility of considering LTE Downlink FDD 76-728 MHz frequency arrangement as 717-728 MHz to improve BS-BS co-location/co-existence while not impacting real deployment scenarios. It is also proposed to add the following TP into the TR for LTE Downlink FDD 716-728 MHz [2]

References

[1] RP-110710, “Revised WID for New Band LTE Downlink FDD 716-728 MHz”, AT&T

[2] R4-113902, “New TR new Band 716-728MHz v0.0.1”, AT&T

TEXT PROPOSAL:

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6 List of band specific issues for <Work item name>

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- *<UTRA issues>*
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- *<E-UTRA issues>*
  - *<Issue 3>*
  - *…*
- *<MSR issues>*
  - *<Issue 4>*
  - *…*

List of general issues, UTRA, E-UTRA and/or MSR issues (if there is not any issue for a specific requirement, the same requirement as for the existing bands in the current 3GPP specifications will apply to the new band). The list serves as a summary of issues and should not contain any discussion of the solution to the issues. Further details, analysis, solutions and resulting requirements should be documented in the respective clause (7, 8, 9 and/or 10).

This chapter should consider for example co-existence studies with other 3GPP bands and other adjacent services, UE REFSENS and A-MPR.

This chapter should be filled in first place in order to have a clear picture of all issues which need further study and should be updated when new issues are found

7 General issues

This chapter is needed if is there is any general issue to solve (e.g. co-existence). Otherwise, it can be omitted. BS and UE issues should be treated separately.

General issues refer to common issues between E-UTRA, UTRA and/or MSR.

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7.1 Co-existence/co-location between LTE DL 716-728 MHz and Band 12/17

7.1.1. BS-BS co-existence/co-location

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The same operator is expected to deploy in both LTE DL FDD 716-728 MHz and Band 12/17. Therefore BS co-location (instead of co-existence) can be considered the most realistic scenario.

To be able to protect Band 12/17 UL against a LTE DL 716-728 MHz when the BS are co-located requires an attenuation of about 80 dB, assuming a BS with 46 dBm transmit power. Band 12/17 is 17/12 MHz wide, which means that the largest LTE carrier which can be fit is 15/10 MHz. Assuming that this carrier is allocated in the middle of Band 12/17, degradation could be allowed at Band 12/17 UL highest edge.

LTE DL FDD 716-728 MHz needs to protect Band 12/17 UL according to the co-location spurious emission requirement in TS 36.104, for which 80 dB attenuation is needed at the RF filter, assuming ACLR=45dB at the adjacent channel. LTE DL FDD is composed by two blocks, Block D (716-721 MHz) and E (722-728 MHz), which are 6 MHz wide each. It is then possible to allocate 2x5 MHz LTE carriers as well as 1x10 MHz carriers. In those regions on which just Block D has been allocated for mobile communications, the carrier could be put at the highest edge, i.e. 717-722 MHz. In case of regions, where both block D+E are allocated, the carrier could occupy 718-728 MHz, increasing the frequency separation towards Band 12/17 UL.

Figure 7.1-1 shows simulations for LTE DL FDD 716-728 MHz assuming co-location with Band 12 and allowing less protection at the highest edge of Band 12 UL. 20 dB rejection is also considered at 10 MHz from the highest operating band edge of LTE DL FDD to be able to decrease emissions in the spurious emissions domain according to TS 36.104. The filter simulations are shown with a 716-728 MHz and 717-728 MHz passband based on the LTE DL FDD 716-728 MHz arrangement and real deployment scenario, respectively. Simulations are not optimized since they intend to show the effect of the frequency. We can observe that the number of poles needed for LTE DL FDD 716-728 MHz with 716-728 MHz passband is 12and 10 for a 716-728 MHz and 717-728 MHz passband, respectively. The Q value is in case of 716-728 MHz passband (Q=17000) is about 2.4 times the one for 717-728 MHz passband (Q=7000)

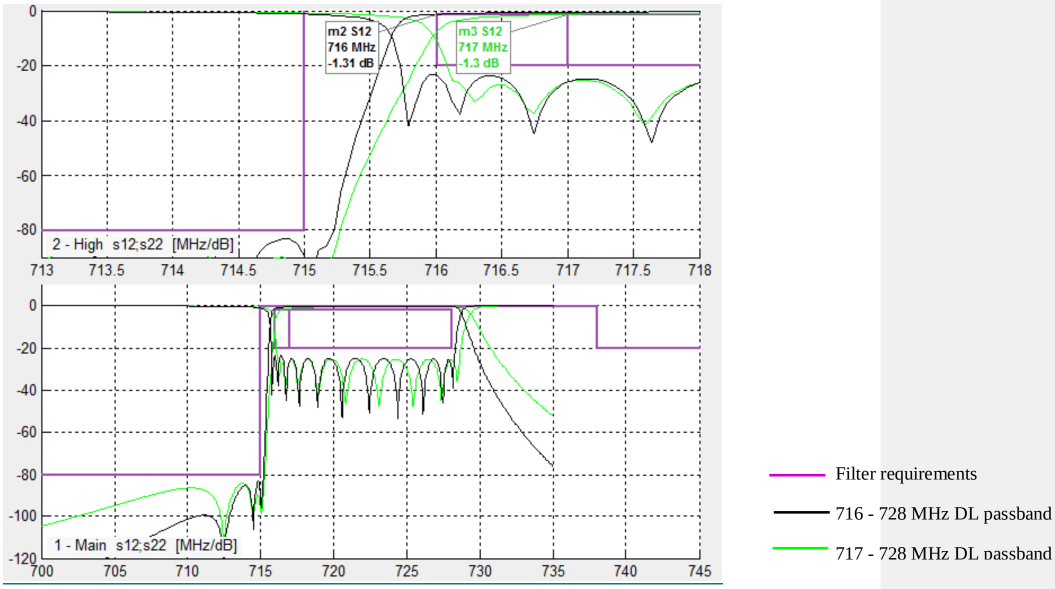

Figure 7.1-1, LTE DL FDD 716-728 MHz

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Band 12 has a wider passband than LTE DL FDD 716-728 MHz, thus the filter will be more challenging for this co-location scenario which requires 80 dB attenuation at 716 MHz or alternatively 717 MHz, if a real deployment case is considered. Certain IL degradation can also be allowed at the highest edge of band 12 UL, i.e. 699-715 MHz passband, taking into account the current deployment scenario.

7.1.2. UE-UE co-existence

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UE co-existence between LTE FDD DL 716-728 MHz and Band 12 is an UL-DL and the 1 MHz guard has only marginal effect on protected adjacent band. However, the DL-only band is used for carrier aggregation and supporting a Secondary CC. The Primary CC with the associated uplink is assigned in an operating band well separated from Band 12 in frequency, e.g. Band 2 or Band 4. Hence, if the Secondary CC is harmfully interfered by a close-by Band 12 UE, the Primary CC will still supply throughput. The CQI reported on the Primary CC will then show low values for the interfered Secondary CC and data (or higher-layer retransmissions) can be scheduled on the primary CC.

7.1.3. Conclusion

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Conclusion: study the possibility of LTE Downlink FDD 716-728 MHz frequency arrangement as 717-728 MHz to improve BS-BS co-location/co-existence while not impacting real deployment scenarios. ~~<Issue 1>~~

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3GPP TSG-RAN WG4 (Radio) Meeting #60 R4-113985
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Title: BS to BS coexistence between Band 12/17 and additional new 716-728 downlink
Document for: Discussion

1. Introduction

The WI proposal to support the New Band LTE Downlink FDD 716-728 MHz was approved in RAN#50 [1]. And the revised WID was approved in RAN#51 [2]. One objective of the WIs is to specify the band-combinations specific Radio Frequency (RF) requirements for inter-band CA of Band 2, 4 or 5 plus additional new 716-728 downlink. Note that we will denote the additional new 716-728 downlink as Band A for convenience.

In this paper, we investigate the coexistence issue between Band 12/17 Base Station (BS) and Band A BS from the 3GPP requirements perspectives.

2. Discussion

The frequency ranges of the current Bands 12 and 17 uplink (UL) and downlink (DL) defined in the 3GPP standards [3] as well as the proposed DL-only Band A are shown in Figure 1 below.

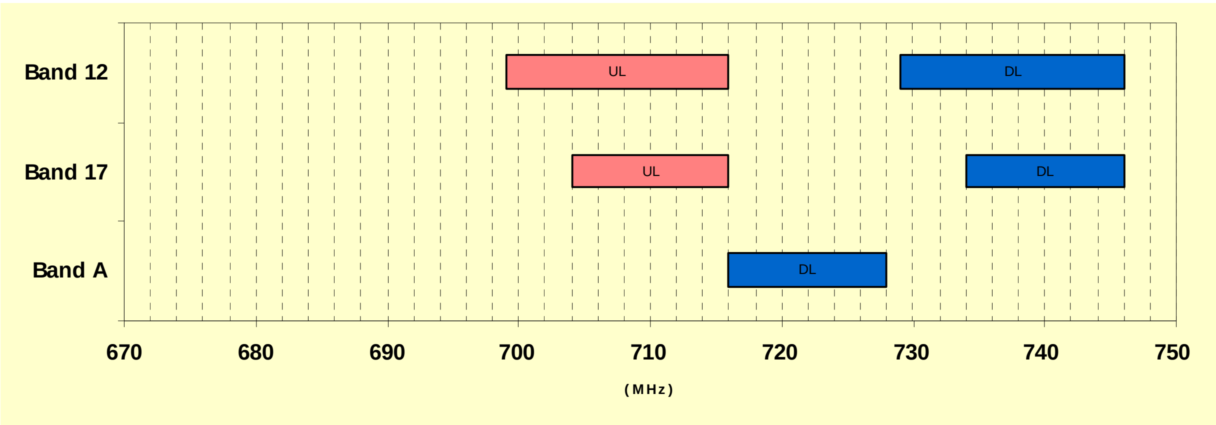

Figure 1: Frequency ranges of Bands 12, 17 and A

It can be seen from Figure 1 that the most challenging BS to BS coexistence issue is at 716 MHz where Band 12/17 UL is adjacent to Band A DL. To allow Band 12/17 BS to coexist (in the same geographical area) or co-locate with Band A BS, the operators should ensure the following:

- The Band A BS transmitter unwanted emissions received by the Band 12/17 BS do not cause unacceptable Band 12/17 BS receiver desensitization.
- The total Band A BS carrier power attenuated by the Band 12/17 BS receiver RF, IF and baseband filters do not result in the Band 12/17 BS receiver blocking.

2.1 Transmitter unwanted emissions

Currently, the BS spurious emissions limits for co-existence (in the same geographical area) with BS operating in other frequency bands is specified as -49 dBm/MHz in the UL frequency range of the operating band of the coexisted BS [3]. This requirement value is obtained assuming a 67 dB BS to BS minimum coupling loss (MCL) and a 0.8 dB victim BS receiver desensitization [4]. The calculation for 5 MHz and 10 MHz channel bandwidths is shown in Table 1 below.

Table 1: Calculation of spurious emission limits for BS coexistence

Thermal Noise power spectral density	dBm/Hz	-174	
BS noise figure	dB	5	
Channel bandwidth	MHz	5	10
Noise bandwidth	MHz	4.5	9
Receiver noise floor	dBm	-102.47	-99.46
BS Spurious emissions limits (co-existence)	dBm/MHz	-49	
BS-BS MCL (co-existence)	dB	67	
Receiver interference (co-existence)	dBm	-109.47	-106.46
Receiver interference + noise floor (co-existence)	dBm	-101.68	-98.67
Receiver sensitivity degradation (co-existence)	dBm	0.79	0.79

If we assume the out-of-band (OOB) emission from the power amplifier (PA) is designed to meet the -13 dBm/MHz specified in the Multi-Standard Radio (MSR) specification [4] so that the BS can also be used for UTRA operation, then the required rejection by the BS RF transmit (TX) filter to meet the -67 dBm/MHz emission limit will be (67 – 13 =) 54 dB.

Moreover, the BS spurious emissions limits for co-location with BS operating in other frequency bands is specified as -96 dBm/100 kHz in the UL frequency range of the operating band of the co-located BS [3]. This requirement value is obtained assuming a 30 dB BS to BS MCL and a 0.8 dB victim BS receiver desensitization [5]. The calculation for 5 MHz and 10 MHz channel bandwidths is shown in Table 2 below.

Table 2: Calculation of spurious emission limits for BS co-location

Thermal Noise power spectral density	dBm/Hz	-174	
BS noise figure	dB	5	
Channel bandwidth	MHz	5	10
Noise bandwidth	MHz	4.5	9
Receiver noise floor	dBm	-102.47	-99.46
BS Spurious emissions limits (co-location)	dBm/100kHz	-96	
BS-BS MCL (co-location)	dB	30	
Receiver interference (co-location)	dBm	-109.47	-106.46
Receiver interference + noise floor (co-location)	dBm	-101.68	-98.67
Receiver sensitivity degradation (co-location)	dBm	0.79	0.79

Again if we assume the OOB emission from the PA is designed to meet the -13 dBm/MHz specified in the MSR specification [4] so that the BS can also be used for UTRA operation, then the required rejection by the BS RF TX filter to meet the -96 dBm/100 kHz emission limit will be (96 – 10 – 13 =) 73 dB.

From the above discussion, it can be seen if the OOB emission from the PA is -13 dBm/MHz, then the Band A BS RF TX filter must provide 54 dB and 73 dB, respectively, to coexist (with 67 dB MCL) and co-locate (with 30 dB MCL) with Band 12/17 BS receiver. It is impractical to achieve these levels of rejection without any gap between the Band A DL and Band 12/17 UL. However, up to 4 MHz gap between the Band A DL and Band 12/17 UL could be obtained by putting the

UL carrier at the lower edge of the allocated frequency block and the DL carrier at the higher edge of the allocated frequency block. The carrier arrangement is shown in Table 3 below. Note that the unused frequency range at each edge inside the channel bandwidth (0.25 MHz and 0.5 MHz, respectively, for 5 MHz and 10 MHz channel bandwidth) are not included in Table 3.

Table 3: Possible gap between Band 12/17 UL and Band A DL

Band 12/17 frequency block (FCC allocation)	Band A frequency block (FCC allocation)	Band 12/17 UL carrier (MHz)	Band A carrier (MHz)	DL<->UL Gap (MHz)
C	D	710 – 715	717 – 722	2
C	D+E	710 – 715	718 – 728	3
B+C	D	704 – 714	717 – 722	3
B+C	D+E	704 – 714	718 – 728	4

With the at least 2 MHz (2.5 MHz including unused frequency inside the channel bandwidth) gap available by carrier arrangement as shown in Table 3 above, it could be feasible for the Band A BS RF TX filter to provide the required rejection to coexist or co-locate with Band 12/17 BS receiver, with small degradation in other aspects of the filter performance (e.g. insertion loss and modulation accuracy). However, the increase in cost, size, weight, and complexity of the filter still need to be considered. Other alternatives to achieve the same Band 12/17 BS receiver desensitization of 0.8 dB include reducing the OOB emission from the Band A PA and increasing the coupling loss (i.e. antenna isolation) from Band A BS TX antenna connector to Band 12/17 BS receive (RX) antenna connector.

2.2 Receiver blocking

Now we look at the Band 12/17 BS receiver blocking requirements in order to avoid receiver blocking by the Band A DL carrier power. Currently, the interfering signal power for the BS adjacent channel selectivity (ACS) requirement is specified as -52 dBm for a 6 dB victim BS receiver desensitization [3]. These requirement values mean that the minimum rejection by the Band 12/17 BS receiver IF and baseband filters on the adjacent channel interferer is 45.72 dB for 5 MHz channel bandwidth, as the BS RF filter cannot provide any rejection in the in-band frequency range. The calculation for 5 MHz channel bandwidth is shown in Table 4 below. Note that the calculation in Table 4 is also valid for 10 MHz channel bandwidth because the same reference measurement channel as for 5 MHz channel bandwidth is specified for the ACS requirement.

Table 4: Calculation of BS ACS requirement

Thermal Noise power spectral density	dBm/Hz	-174
BS noise figure	dB	5
Channel bandwidth	MHz	5
Noise bandwidth	MHz	4.5
Receiver noise floor	dBm	-102.47
Interfering signal power (ACS)	dBm	-52
Receiver sensitivity degradation (ACS)	dB	6
Allowed receiver interference (ACS)	dBm	-97.72
Required receiver filter rejection (ACS)	dBm	45.72

Moreover, the interfering signal power for the BS in-band general blocking requirement is specified as -43 dBm for a 6 dB victim BS receiver desensitization [3]. This interfering signal level is applied from the lower frequency of the BS receive band minus 20 MHz to the upper frequency of the BS receive band plus 20 MHz. These requirement values mean that the minimum rejection by the Band 12/17 BS receiver IF and baseband filters on the in-band interferer is 54.72 dB for 5 MHz channel bandwidth, as the BS RF filter cannot provide any rejection in this in-band frequency range. The calculation for 5 MHz channel bandwidth is shown in Table 5 below. Again the calculation in Table 5 is also valid for 10 MHz channel bandwidth because the same reference measurement channel as for 5 MHz channel bandwidth is specified for the in-band general blocking requirement.

Table 5: Calculation of BS in-band general blocking requirement

Thermal Noise power spectral density	dBm/Hz	-174
BS noise figure	dB	5
Channel bandwidth	MHz	5
Noise bandwidth	MHz	9.00
Receiver noise floor	dBm	-102.47
Interfering signal power (general blocking)	dBm	-43
Receiver sensitivity degradation (general blocking)	dB	6
Allowed receiver interference (general blocking)	dBm	-97.72
Required receiver filter rejection (general blocking)	dBm	54.72

Comparing the required receiver filter rejection levels in Tables 4 and 5, it can be seen that the BS receiver IF and baseband filters could provide (54.72 – 45.72 =) 9 dB more rejection when the interfering signal is 5 MHz further away from the wanted signal. This will mean 1.8 dB/MHz more rejection if we assume a constant slope in the filter transfer function within this frequency range.

On the other hand, the interfering signal power for BS blocking performance requirement when co-located with BS in other frequency bands is specified as 16 dBm for a 6 dB victim BS receiver desensitization [3]. Again this requirement value is obtained assuming a BS output power of 46 dBm and a 30 dB BS to BS MCL [5]. These requirement values mean that the minimum rejection by the BS receiver RF, IF and baseband filters on the co-located BS DL signal is 113.72 dB for 5 MHz channel bandwidth. The calculation for 5 MHz channel bandwidth is shown in Table 6 below. Again the calculation in Table 6 is also valid for 10 MHz channel bandwidth because the same reference measurement channel as for 5 MHz channel bandwidth is specified for co-location blocking requirement.

Table 6: Calculation of BS co-location blocking requirement

Thermal Noise power spectral density	dBm/Hz	-174
BS noise figure	dB	5
Channel bandwidth	MHz	5
Noise bandwidth	MHz	4.5
Receiver noise floor	dBm	-102.47
Interfering signal power (co-location blocking)	dBm	16
Receiver sensitivity degradation (co-location blocking)	dB	6
Allowed receiver interference (co-location blocking)	dBm	-97.72
Required receiver filter rejection (co-location blocking)	dBm	113.72

Now if we use the more conservative ACS rejection by the Band 12/17 BS receiver IF and baseband filters on the co-located BS A DL signal, then the required rejection by the Band 12/17 BS RF RX filter to meet the co-location blocking requirement will be (113.72 – 45.72 =) 68 dB. It is impractical to achieve this level of rejection without any gap between the Band 12/17 UL and Band A DL. However, as discussed above and shown in Table 3, up to 4 MHz gap between the Band 12/17 UL and Band A DL could be obtained by putting the UL carrier at the lower edge of the allocated frequency block and the DL carrier at the higher edge of the allocated frequency block.

With the at least 2 MHz (2.5 MHz including unused frequency inside the channel bandwidth) gap available by carrier arrangement as shown in Table 3 above, the Band 12/17 BS receiver IF and baseband filters should provide more rejection than ACS, and it could be feasible for the Band 12/17 BS RF RX filter to provide the required rejection to co-locate with Band A BS transmitter, with small degradation in other aspects of the filter performance (e.g. insertion loss). However, the increase in cost, size, weight, and complexity of the filter still need to be considered. Other alternatives to achieve the same Band 12/17 BS receiver desensitization of 6 dB include increasing the IF and baseband filter rejection of the Band 12/17 receiver and increasing the coupling loss (i.e. antenna isolation) from Band A BS TX antenna connector to Band 12/17 BS RX antenna connector. In order to maintain same Band 12/17 BS receiver desensitization of 0.8 dB based on Band A BS transmitter emissions, the 30 dB MCL derived from Band 12/17 BS RX co-location blocking requirement should be increased to 42 dB.

3. Conclusions

In this paper, we have investigated the coexistence issue between Band 12/17 BS and Band A BS from the 3GPP requirements perspectives. We have shown that with the at least 2 MHz (2.5 MHz including unused frequency inside the channel bandwidth) gap available by carrier arrangement, it could be feasible for the Band 12/17 BS RX RF filters and the Band A BS TX RF filters to provide the required rejection to co-exist/co-locate with each other, with small degradation in other aspects of the filter performance (e.g. insertion loss and modulation accuracy). However, the increase in cost, size, weight, and complexity of the filters still need to be considered. Other alternatives to achieve the Band 12/17 receiver desensitization of 0.8 dB include reducing the OOB emission from the Band A PA, increasing the IF and baseband filter rejection of the Band 12/17 receiver, and increasing the coupling loss (i.e. antenna isolation) from Band A BS TX antenna connector to Band 12/17 BS RX antenna connector. Therefore, if at least 2 MHz gap will be available by channel arrangement of the Band 12/17 UL and/or Band A DL carriers, then we can reuse the same coexistence / co-location requirements for Band A as the other frequency bands specified in the 3GPP standards.

References

[1] RP-110435, “Work Item Proposal: New Band LTE Downlink FDD 716-728 MHz”, AT&T.

[2] RP-110432, “Revised WID for New Band LTE Downlink FDD 716-728 MHz”, AT&T.

[3] 3GPP TS 36.104 v10.3.0, “Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception”.

[4] 3GPP TS 37.104 v10.3.0, “E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception”.

[5] 3GPP TS 25.942 v10.0.0, “Radio Frequency (RF) system scenarios”.