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TMMB SYSTEM L COMPATIBILITY WITH DTT IN THE SUB-700 MHZ BAND

ITU-R WP6A WORKSHOP 08TH MARCH 2024
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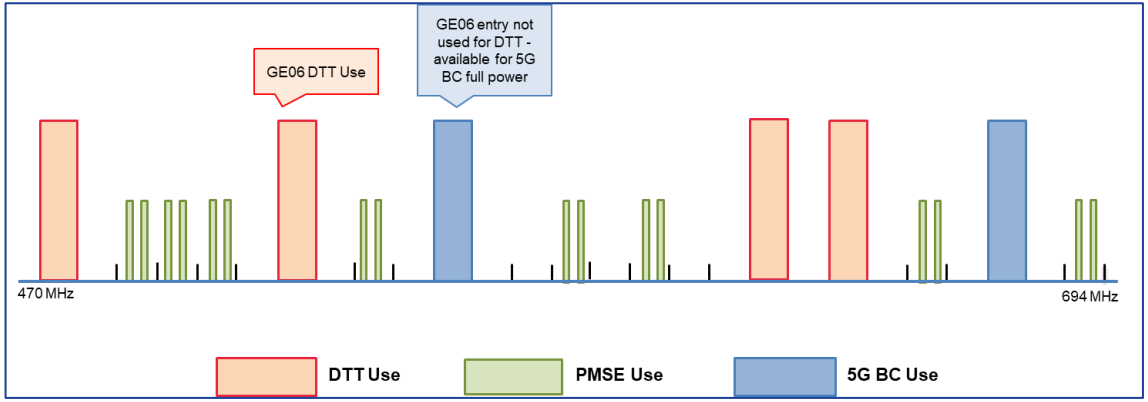
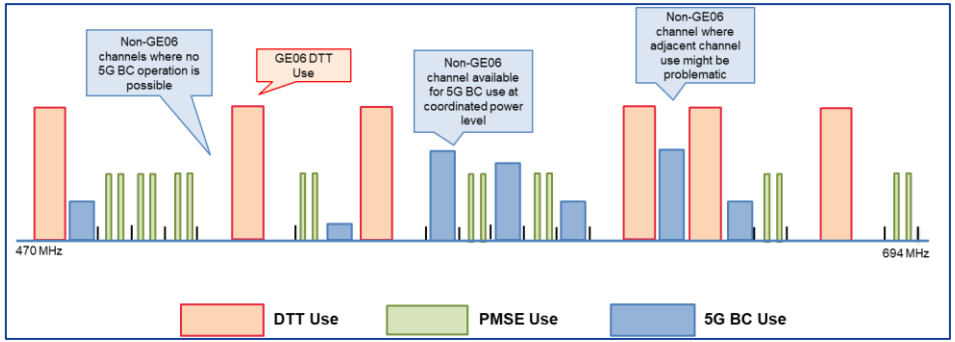
DTTB use of 470-694 MHz in Region 1

- The GE06 Agreement and Plan regulates the use of the 470-694 MHz band for DVB-T
  - The envelop concept allows other systems with same RF characteristics (e.g. DVB-T2)
- 5G Broadcast is an OFDM signal with similar DTTB RF characteristics
  - Transmit power, antenna patterns, bandwidths
  - HPHT, MPMT, LPLT
  - SFN and MFN
- The questions we tried to answer:
  - How can 5G Broadcast transmissions be introduced in the sub-700 MHz band ?
  - What is needed from the 5G Broadcast system designers to facilitate its implementation in the sub-700 MHz band ?

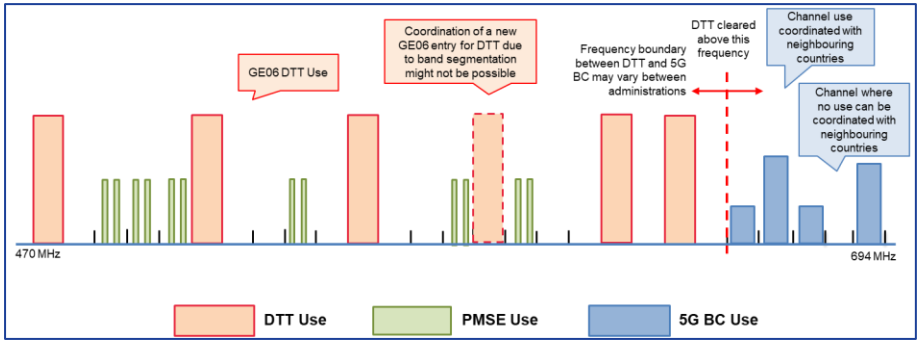
Scenarios for introduction in the sub-700 MHz band



Scenario 1: Use of coordinated GE06 DTTB entries by 5G Broadcast



Scenario 2: Interleaved use in GE06



Scenario 3: Band segmentation

Use of GE06 DTTB entries by 5G Broadcast - compatibility

- CONDITION: The 5G Broadcast signal needs to respect the technical parameters of the DTTB entry (envelop concept)
- Co-channel case:
  - No compatibility issue but the coverage area of 5G Broadcast might not be the same as the DTTB entry depending on system parameters and network configurations used
- Adjacent channel case:
  - **Impact on DTTB** - hole punching if sites not co-sited and different antennas. Solutions:
    - Appropriate antenna patterns and power design from 5G Broadcast to avoid interference to DTTB
    - Appropriate filtering of 5G Broadcast transmitter
    - In some cases, notch filters in antenna feeder at DTTB reception
  - **Impact on 5G Broadcast receivers** - large power differences of signals received (ACS issue). Solutions:
    - Co-siting 5G Broadcast and DTTB transmitters
    - Adding notch filters in 5G Broadcast receivers - feasible but impractical

Interleaved use by 5G Broadcast of spectrum between GE06 entries - compatibility

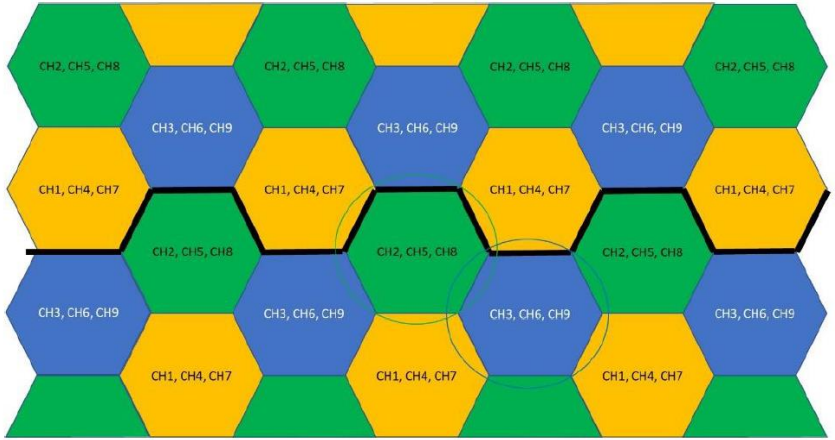
- CONDITION: The 5G Broadcast signal should not interfere to the existing DTTB entries and should be compatible with DTTB in neighbouring countries
- Co-channel case:
  - Reduction of power of HPHT sites compared to DTTB or/and antenna changes
  - Selection of robust 5G Broadcast mode
  - Addition of sites to improve coverage
- Adjacent channel case (similar to previous scenario):
  - **Impact on DTTB** - hole punching if sites not co-sited and different antennas. Solutions:
    - Appropriate antenna patterns and power design from 5G Broadcast to avoid interference to DTTB
    - Appropriate filtering of 5G Broadcast transmitter
    - In some cases, notch filters in antenna feeder at DTTB reception
  - **Impact on 5G Broadcast receivers** - large power differences of signals received (ACS issue). Solutions:
    - Co-siting 5G Broadcast and DTTB transmitters
    - Adding notch filters in 5G Broadcast receivers - feasible but impractical

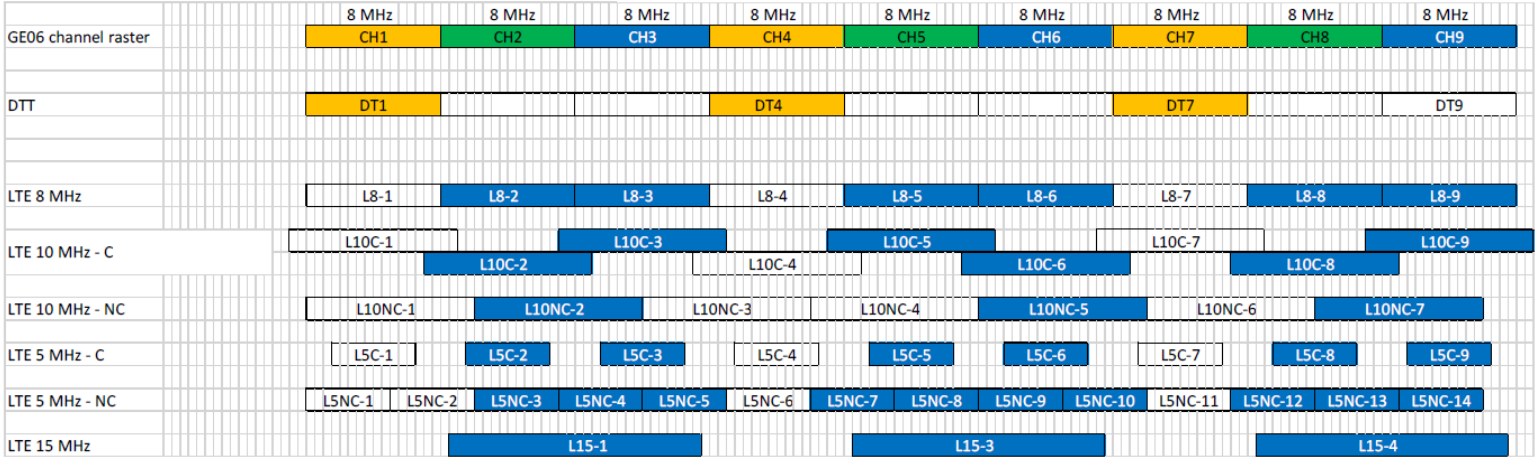
Band segmentation for 5G Broadcast - compatibility

- CONDITION: The 5G Broadcast use of the segmented band would need to coexist with the existing DTTB entries in neighbouring countries
- Co-channel case:
  - If 5G Broadcast uses an existing GE06 entry, same as scenario 1: possible coverage reduction
  - If 5G Broadcast uses interleaved spectrum, same as scenario 2:
    - Reduction of power of HPHT sites compared to DTTB or/and antenna changes
    - Selection of robust 5G Broadcast mode
    - Addition of sites to improve coverage
- Adjacent channel case (similar to LTE in 800 MHz band):
  - **Impact on DTTB** - Solutions:
    - Out-of-band filtering of 5G Broadcast transmitter, in particular if not co-sited
    - In some cases, notch filters in antenna feeder at DTTB reception
  - **Impact on 5G Broadcast receivers** - large power differences of signals received (ACS issue). Solutions:
    - Adding a filter in 5G Broadcast receivers to block all DTTB below the segmented band
    - Adding 5G Broadcast sites to improve signal to interference ratio

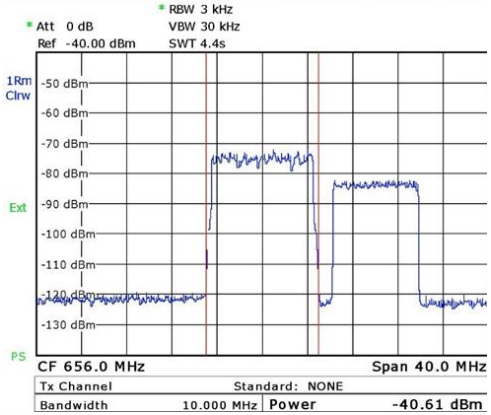
The bandwidth of the 5G Broadcast signal

- GE06 Plan is based on an 8 MHz channel raster. But initially 5G Broadcast was specified for 5, 10, 15 MHz
- An assessment of different band plans was made for 5G Broadcast introduction as per GE06 entries: the potential total bandwidth and power reduction compared to DTT entry

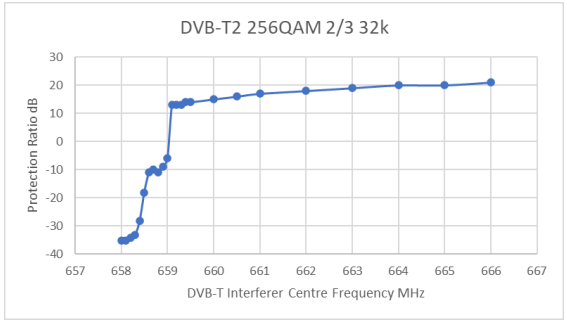


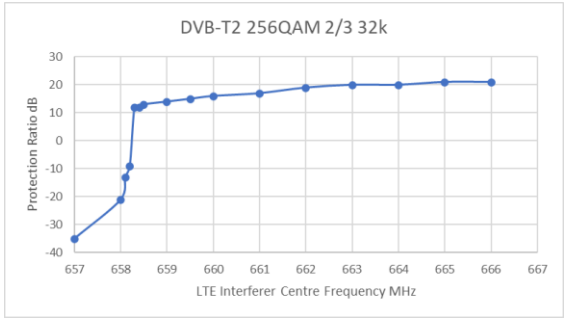


Measurements of adjacent and overlapping channels Protection Ratios



Example of LTE signal at -10 MHz
(No overlap with the wanted DVB service)





PR (Protection Ratio) values
function of the DVB-T or LTE interferer centre frequency

Effects of overlapping Interference to DVB signals from LTE and DVB are similar.

- Main differences are due to the effective bandwidth of the signals, DVB-T (or T2) and LTE.

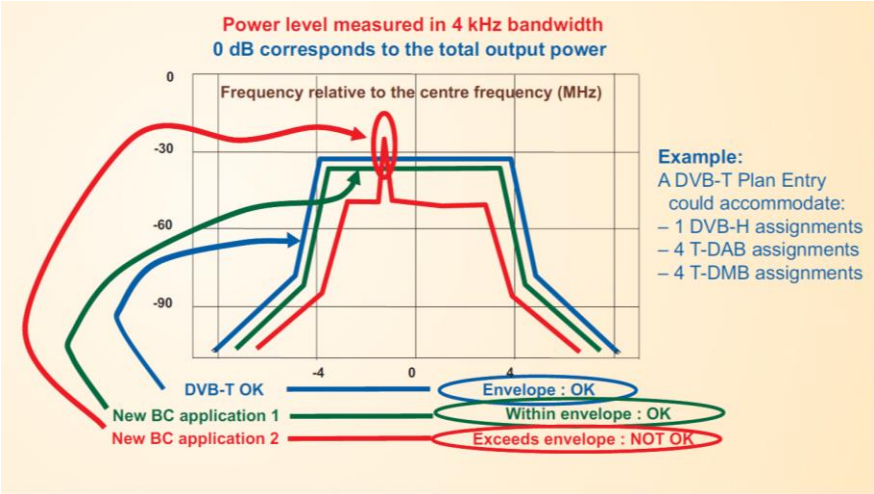
When the overlap is:

- 1 MHz (*), PR is becoming relevant and depends on the bandwidths involved.
- 2 MHz, PR is already greater than 10 dB (typical value 12 dB). This is a condition impractical to use.
- At full overlap, PR is of the order of the Co-Channel PR.

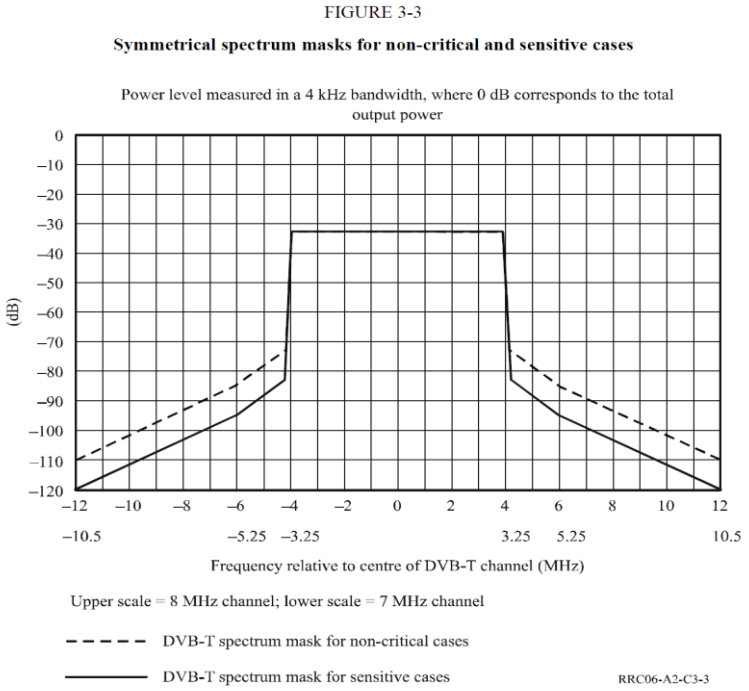
(*) Centre Frequencies are 658/657 and 666 MHz respectively

Compliance with GE06 provisions

1. The GE06 envelop concept:



2. The DTT Spectrum Mask:



› **Signals larger than 8 MHz would require a power reduction (e.g. more than 40 dB in the whole of a 10 MHz 5G Broadcast signal)**

The bandwidth of the 5G Broadcast signal

- 5 and 8 MHz signals can be implemented with minimum constraints, 8 MHz being more spectrum efficient
- 10 MHz signal would have several constraints:
  - Power reduction to protect DTT in the adjacent channel (between 26 to 44 dB in most cases)
  - Non-compliance with GE06 provisions, coordination with neighboring countries on a case-by-case would be required
  - Interference from DTT in adjacent channel
- 15 MHz signal (capacity advantage) would have several constraints:
  - Limited availability of two contiguous 8 MHz channels in a given area
  - The position of the 15 MHz channels would need to be flexible to use contiguous 8 MHz channels where available
  - Non-compliance with GE06 provisions, coordination with neighboring countries on a case-by-case basis would be required

Latest 3GPP work on 5G Broadcast

1. 6, 7, 8 MHz bandwidths added to the standard (3GPP Release 17):
   - ETSI TS 103 720 V1.2.1 (2023-06) – '*5G Broadcast System for linear TV and radio services; LTE based 5G terrestrial broadcast system*'
2. Band plans below 700 MHz agreed (to be included in Release 18):

Table 5.5-1 E-UTRA frequency bands

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive	Duplex Mode
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
107	N/A	612 MHz – 652 MHz	SDO (NOTE 11)
108	N/A	470 MHz – 698 MHz	SDO (NOTE 11)
NOTE 11: This band is restricted to LTE based 5G terrestrial broadcast operation.			

3. ACS and RefSens values agreed (to be included in 3GPP Release 18):

Table 7.5.1H-1: Adjacent channel selectivity for LTE based 5G terrestrial broadcast

Rx Parameter	Units	PMCH bandwidth		
		6 MHz	7 MHz	8 MHz
ACS	dB	[29.0]	[30.5]	[31.5]
NOTE: Values in this table apply only to UE implementations that relies on digital filtering according to the configured broadcast channel bandwidth				

Latest 3GPP work on 5G Broadcast

3. - cont. - ACS and RefSens values agreed (to be included in 3GPP Release 18):

Table 7.3.1H-1: Reference sensitivity for LTE based 5G terrestrial broadcast

Operating Band	PMCH bandwidth			Duplex Mode
	6 MHz (dBm)	7 MHz (dBm)	8 MHz (dBm)	
107	~~[~~-99.2~~]~~	~~[~~-98.5~~]~~	~~[~~-97.9~~]~~	SDO
108	~~[~~-99.2~~]~~	~~[~~-98.5~~]~~	~~[~~-97.9~~]~~	SDO

NOTE1: The signal power is specified per port
NOTE2: Values in this table apply only to UE implementations that relies on digital filtering according to the configured broadcast channel bandwidth

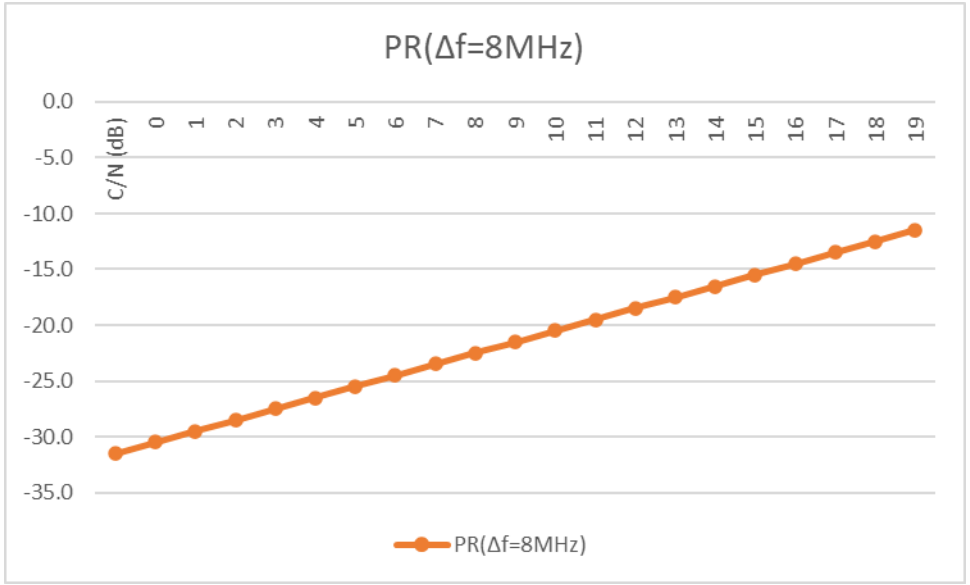
Adjacent channel PR calculation as per ACS and ACLR

Formula that relates ACS, ACLR and PR:

$$PR(\Delta f) = PR_0 + 10\log\left[10^{-\frac{ACS(\Delta f)}{10}} + 10^{-\frac{ACLR}{10}}\right] \quad (3)$$

If ACS=31.5 dB

And ACLR=61 dB



Conclusions

1. To introduce 5G Broadcast bellow 700 MHz in Region 1, reuse of coordinated GE06 DTTB frequencies when possible is the way to start with.
   - ✓ In case of non co-siting, need to apply mitigation techniques to reduce adjacent channel interference to DTTB: 5G Broadcast transmitter filtering, appropriate antenna design and power, notch filter at DTTB receiver
   - ✓ The 5G Broadcast receiver needs suitable RF characteristics to operate in the presence of high level adjacent DTTB signals in some areas – ACS value is in the standard. Mitigation techniques like co-siting are required to avoid hole punching.
2. An 8 MHz 5G Broadcast bandwidth has clear advantages to other channel bandwidths to be deployed within GE06 Plan.

MANY THANKS !

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