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Characteristics of Evolving Electromagnetic Environment with ECN800 parameters and Cable Network Equipment

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Integrated broadband cable telecommunication networks (CABLE).

Modal verbs terminology

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1 Scope

The present document describes the current and evolving electromagnetic environment following introduction of new radio services in the digital dividend UHF frequency band from 790 MHz to 862 MHz. It compares and contrasts relevant parameters against the current and evolving cable network equipment parameters defined by adopted European Norms.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] CEPT Report 30: "The identification of common and minimal (least restrictive) technical conditions for 790 - 862 MHz for the digital dividend in the European Union", November 2009.

[i.2] CEPT Report 31: "Frequency (channelling) arrangements for the 790-862 MHz band", November 2009.

[i.3] CENELEC EN 50083-2:2012: "Cable networks for television signals, sound signals and interactive services - Part 2: Electromagnetic compatibility for equipment".

[i.4] CENELEC EN 50083-8:2013: "Cable networks for television signals, sound signals and interactive services - Part 8: Electromagnetic compatibility for networks".

[i.5] CENELEC EN 50117: "Coaxial Cables".

[i.6] CENELEC EN 55013:2013: "Sound and television broadcast receivers and associated equipment - Radio disturbance characteristics - Limits and methods of measurement".

[i.7] CENELEC EN 55020:2007/A11:2011: "Sound and television broadcast receivers and associated equipment - Immunity characteristics - Limits and methods of measurement".

[i.8] CENELEC EN 55022:2010/AC:2011: "Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement".

[i.9] CENELEC EN 55024:2010/A1:2015: "Information technology equipment - Immunity characteristics - Limits and methods of measurement".

[i.10] CENELEC EN 61000-4-3:2006/A1:2008/A2:2010: "Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test".

[i.11] ETSI EN 300 429 (V1.2.1) (04-1998): "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems".

[i.12] ETSI TR 103 288: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Report of the CENELEC/ETSI Joint Working Group in response to the EC letter ENTRP/F5/DP/MM/entr.f5.(2013)43164 to the ESOs".

[i.13] Recommendation ITU-R F.1336 (02-2014): "Reference radiation patterns of omnidirectional, sectoral and other antennas for the fixed and mobile service for use in sharing studies in the frequency range from 400 MHz to about 70 GHz".

[i.14] G531/01077/09: "Measurement Report: Immunity of integrated TV receivers, settop boxes and data-modems connected to broadband cable and TV networks against radiation from LTE user equipment", January 2010, Federal Network Agency Germany.

[i.15] "NorDig Unified Requirements for Integrated Receiver Decoders for use in cable, satellite, terrestrial and IP-based networks", August 2014.

NOTE: Available at http://www.nordig.org/specifications.

[i.16] D-Book 8: "Digital Terrestrial Television Requirements for Interoperability", March 2015, Digital Television Group (DTG).

[i.17] ECC/DEC/(09)03: "ECC Decision of 30 October 2009 on harmonised conditions for mobile/fixed communications networks (MFCN) operating in the band 790 - 862 MHz", October 2009.

[i.18] Commission Decision 2010/267/EU: "Commission Decision of 6 May 2010 on harmonised technical conditions of use in the 790-862 MHz frequency band for terrestrial systems capable of providing electronic communications services in the European Union", May 2010.

[i.19] CEPT ERC Recommendation 74-01: " Unwanted emissions in the spurious domain", January 2011.

[i.20] Recommendation ITU-R P.1546-5: "Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz", September 2013.

3 Symbols and abbreviations

3.1 Symbols

For the purposes of the present document, the following symbols apply:

d	Distance
dB	Decibel
dB(µV)	Decibel with reference to 1 µV
dB(µV/m)	Decibel with reference to 1 µV/m
dBm	Decibel with reference to 1 mW
E	Electrical Field Strength
m	Meter
Mbit/s	Megabit per second
MHz	Megahertz
ms	Millisecond
mW	Milliwatt
P	Power
V/m	Volt per Meter
W	Watt

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP	Third Generation Partnership Project
AM	Amplitude Modulation
APT	Asia-Pacific Telecommunity
ASMG	Arab Spectrum Management Group
ATU	African Telecommunications Union
BEM	Block Edge Mask
BS	Base Station
BTS	Base Transmitter Station

CATV	Community (Cable) Antenna Television
CEN	European Committee for Standardization
CEPT	European Conference of Postal and Telecommunications Administrations
CISPR	International Special Committee on Radio Interference
CITEL	Inter-American Telecommunication Commission
CPE	Customer Premises Equipment
DIN	German Industrial Norm
DKE	German Electrotechnical Commission
DL	DownLink
DTT	Digital Terrestrial Television
DVB	Digital Video Broadcasting
DVB-C	Digital Video Broadcasting - Cable
DVB-T	Digital Video Broadcasting - Terrestrial
ECC	Electronics Communications Committee (CEPT)
ECN	Electronic Communications Network
EIRP	Equivalent Isotropic Radiated Power
EMC	ElectroMagnetic Compatibility
EN	European Norm
ERC	European Radiocommunications Committee
ERP	Effective Radiated Power
ESO	European Standards Organization
EU	European Union
FDD	Frequency Division Duplex
FM	Frequency Modulation
FTTx	Fiber-To-The-x
GSM	Global System for Mobile Communication
HFC	Hybrid Fiber-Coax
IEC	International Electrotechnical Commission
IF	Intermediate Frequency
ITU	International Telecommunications Union
JTG	Joint Task Group
JWG	Joint Working Group
LTE	Long-Term Evolution
MFCN	Mobile/Fixed Communication Network
MNO	Mobile Network Operator
PAL	Phase Alternating Line
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RX	Receiver
SDO	Standards Developing Organizations
SIR	Signal-to-Interference Ratio
SMS	Short Message Service
STB	Set-Top Box
TC	Technical Committee
TDD	Time Division Duplex
TRP	Total Radiated Power
TV	TeleVision
TX	Transmitter
UE	User Equipment
UHF	Ultra High Frequency
UL	Uplink
UMTS	Universal Mobile Telecommunications System
VCR	Video Cassette Recorder
WG	Working Group
WRC	World Radio Conference

4 General principles of HFC and LTE co-existence

4.1 Technical considerations

4.1.1 Radio frequency usage

For many decades the UHF spectrum between 470 MHz and 862 MHz was used for terrestrial and cable broadcast TV distribution. It was decided to use 8 MHz channels in the UHF spectrum. The relevant portion of the channel raster is displayed in Figure 1. The same frequency spectrum is used by terrestrial broadcasting over the air as well as by RF cable systems in a wired network. Co-existence is enabled by establishing a set of standards defining appropriate requirements for the separation of the wired transmission from its electromagnetic environment.

With the more efficient usage of the spectrum by digital television, the terrestrial service portfolio can be maintained by using fewer frequency resources. The parts of the spectrum becoming available for alternative use are known as the Digital Dividend. Resulting from the decisions of the ITU World Radiocommunication Conference (WRC) 2007 with regard to the future usage of the Digital Dividend many European countries are in the course of or have completed the reorganization of the relevant spectrum. Decisions by CEPT e.g. on the allotted bandplan in the 800 MHz band were taken with the aim to minimize impact on the Customer Premises Equipment (CPE). The idea was that a base transmitter station was expected to not have an impact to the disturbance situation to the same extent as UE.

For example, the German government decided to make available the frequency range from 790 MHz to 862 MHz for mobile broadband Internet in Germany while the usage for terrestrial broadcasting services ceases. The main difference resulting for the electromagnetic environment compared to the previous usage by broadcast services is the presence of radio signals in up- and downlink in close proximity to broadcasting CPE. Previously, there were no transmitters close to TV sets or other CPE like cable modems, VCRs or set-top boxes.

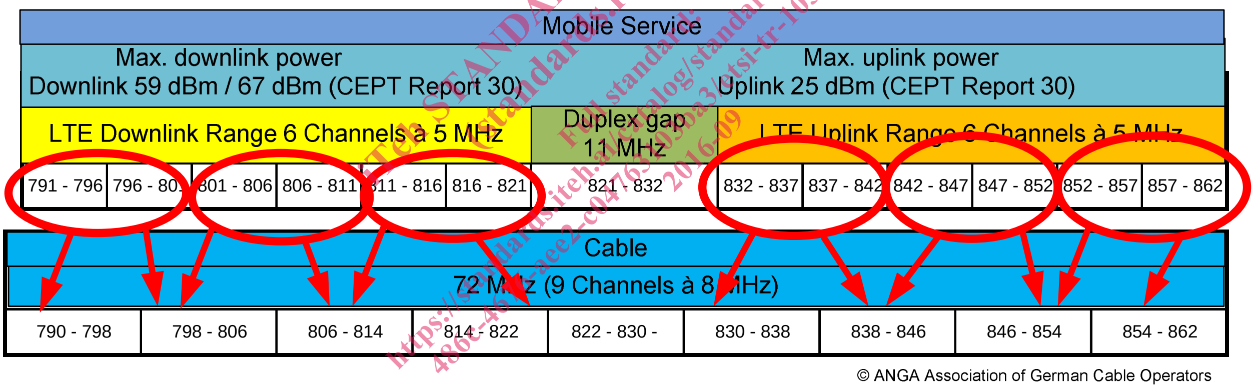


Figure 1: Co-Channel situation with the frequency assignment for new mobile services against the broadcast UHF channel raster

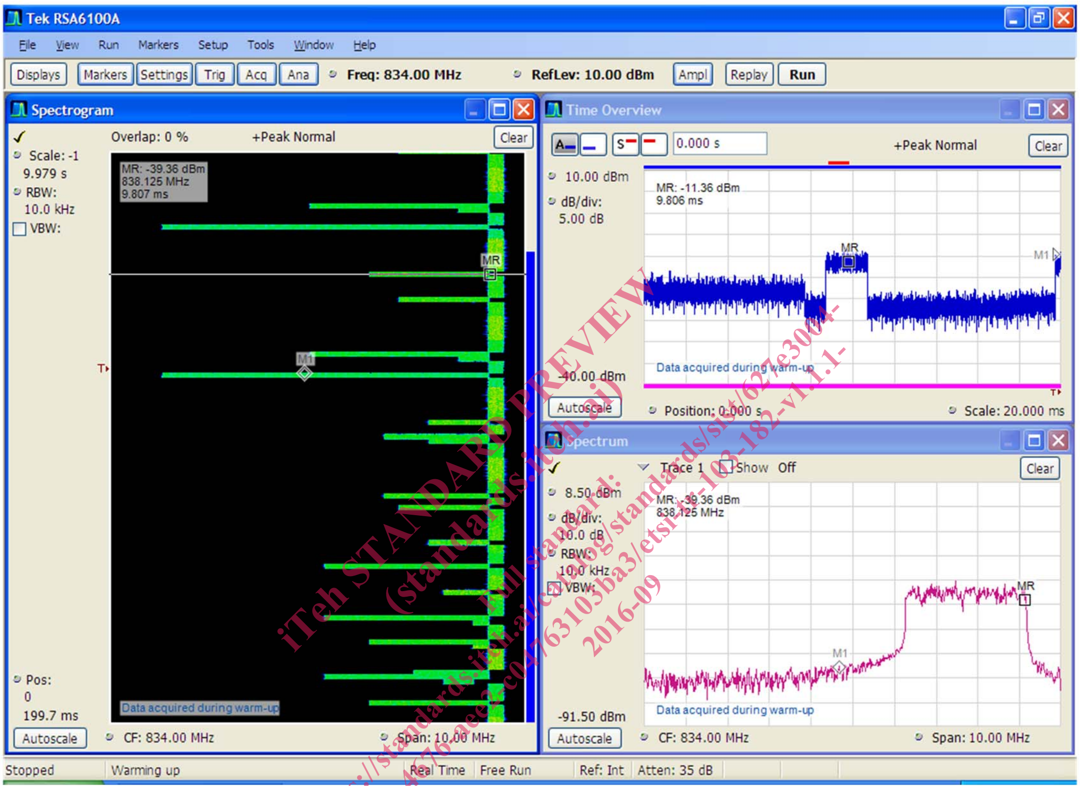
4.1.2 Reference signals for assessing co-existence

While the broadcast signals used in terrestrial and cable networks are well defined and exhibit fairly stable characteristics over time, LTE signals are highly variable and practical experience is still limited. Therefore, it is essential to define a set of reference signals that can be used consistently when assessing co-existence between LTE and cable. The reference signals should reflect specific characteristics of actual LTE transmissions as close as possible. In the present document, LTE UE uplink signals are considered when uploading and when idle. The focus on UE generated signals is following the principle as described in the previous Clause that the UE is expected to be the major source of potential disturbance.

The structures of the RF signals as they are transmitted by LTE UEs are shown in the figures 2 and 3. The highly variable nature of the signal is depicted by choosing two operational modes (i.e. upload and idle) that are resulting in significantly different signal shapes and spectral distribution of transmit power. The figures show the signal format in the time as well as in the frequency domain. These signal structures were used for the common measurements in Kolberg, Germany [i.14]. Participants from the German regulator BNetzA, mobile operators, cable operators and TV manufacturers agreed on the definition of the reference signals. The group used a 10 MHz UE (i.e. mobile terminal) signal.

Figure 2 shows the UE signal measured with a real time spectrum analyser. The shown signal is a multicarrier signal with a bandwidth of 10 MHz. The spectrogram (left portion of Figure 2) shows an actual capture of a LTE UE signal over 200 ms (y-Axis). Transmit power encoded in colours (blue - low power; red - high power) is distributed across time and frequency. The occupied Resource Blocks (unit of scheduling) are clearly visible across the frequency axis (x-Axis). The UE signal occupies different parts of the channel over time during a transmission.

The signal definition is based on a capture of a 2 Mbit/s upload from a UE in a live LTE 800 network. For the measurement campaign this signal was mapped for the use with a commercially available programmable LTE signal generator. Table 1 shows the statistical evaluation of the recorded LTE signal (2 Mbit/s upload) which was used in Figure 2. The widest allocation of Resource Blocks occupies 8,25 MHz but is only used 3 % of the time. This is despite the fact that the signal is configured for a 10 MHz channel.



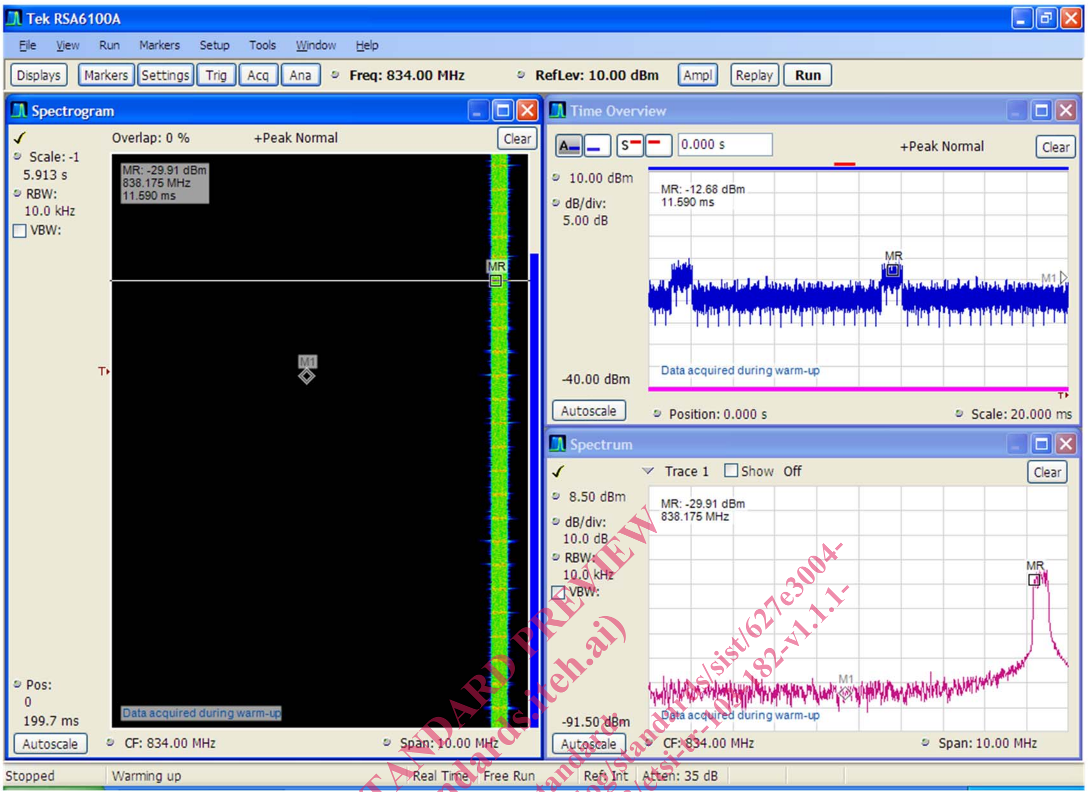
NOTE: Time span of spectrogram is 200 ms.

Figure 2: LTE signal (2 Mbit/s upload, generated by signal generator)

Table 1: Statistics of a LTE signal (2 Mbit/s upload) recorded at a live LTE 800 network

Time resolution:	1 ms	Counts	Probability
Total frames:		200	100,0 %
Width > 1:		37	18,5 %
Block width 0:	0,36 MHz	163	81,5 %
Block width 1:	1,00 MHz	6	3,0 %
Block width 2:	2,10 MHz	3	1,5 %
Block width 3:	3,20 MHz	6	3,0 %
Block width 4:	4,40 MHz	3	1,5 %
Block width 5:	5,00 MHz	7	3,5 %
Block width 6:	5,70 MHz	6	3,0 %
Block width 7:	7,10 MHz	0	0,0 %
Block width 8:	8,25 MHz	6	3,0 %

Figure 3 shows a mapped version of a real measured idle signal which is used in live LTE 800 networks. Only a small number of resource blocks is used for the transmission of management information in idle mode. The signal captured in a live LTE 800 network was mapped for the use with a commercially available programmable LTE signal generator.



NOTE: Time span of the spectrogram is 200 ms.

Figure 3: LTE signal (idle mode with control channel only)

4.2 Scheme of Harmonised Standards

HFC networks and their components are developed against international standards, Harmonised European standards and other European standards. The most relevant aspect for this report is the electromagnetic compatibility. Figure 4 depicts a high-level view on the architecture of current cable networks and identifies the European Harmonised Standards and the portions of the network they apply to as well as the modulation and channel coding given by ETSI EN 300 429 [i.11].

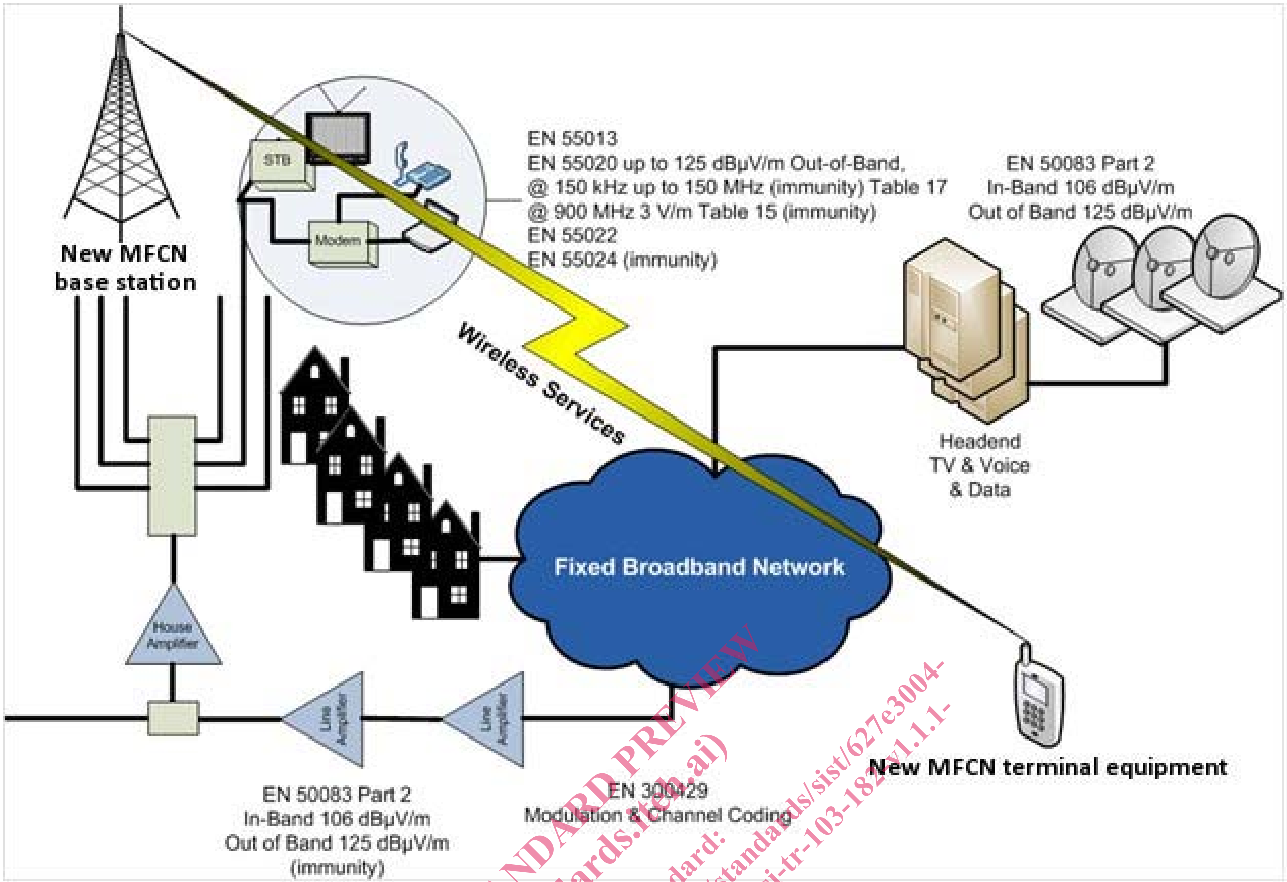


Figure 4: Relevant standards for emission of and immunity against electromagnetic field strength in HFC networks and attached equipment

Standards play a key role in establishing interoperability among devices but also in addressing regulatory and co-existence requirements. Particularly in the area of radio frequency co-existence and electromagnetic compatibility (EMC) a complex structure of various organizations on international and European level has evolved with the goal to appropriately take into account all relevant interests. In many cases, the establishment of joint activities (e.g. Joint Working Groups between CENELEC and ETSI) has been necessary in order to efficiently align various interests and develop technical deliverables. Figure 5 depicts the relation between international and European organizations when defining the electromagnetic environment. It is influenced by both, users of the radio frequency spectrum in free space as well as operators of RF modulated signals guided in wires.