NATIONAL COMMUNICATIONS AUTHORITY

MINIMUM REQUIREMENTS FOR RECEIVERS OF FREE TO AIR DIGITAL TERRESTRIAL TELEVISION (DTT) IN GHANA

v1.0

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List of Abbreviations and symbols

AC-3	Audio coding 3(Dolby Digital used for 5.1 multichannel digital audio)
AD	audio description
AFC	automatic frequency control
AFD	active format descriptor
AFNOR	Association Francaise de Normalisation
API	Application Programming Interface
BAT	bouquet association table
BCD	Binary Coded Decimal
BDR	Broadcast Discovery Record (part of SD&S)
BER	bit error rate
BOOTP	Bootstrap Protocol
bslbf	bit string, left bit first
bw	bandwidth
C/(N+I)	ratio of carrier to noise plus interference
C/N	carrier to noise ratio
CATV	Community Antenna Television
CEA	Consumer Electronics Association (North American Association)
CENELEC	Comité Européen de Normalisation Electrotechnique
CI	Common Interface

CID	Content Identifier descriptor
CIF	Common Intermediate Format
COFDM	coded orthogonal frequency division multiplexing
CPU	central processing unit
CRC	cyclic redundancy check
CRID	Content Reference Identifier
CSO	Composite Second Order
CTB	Composite Triple Beat
CVBS	composite video baseband signal
D/A	Digital-to-Analogue converter
DAD	Default Authority Descriptor
DAVIC	Digital Audio-Visual Council
dBFS	dB Full Scale
DBMC	Digital Broadcasting Migration Committee
DDS	Display definition segment
DDWG	Digital Display Working Group
DECT	Digital Enhanced Cordless Telecommunications
DHCP	Dynamic Host Configuration Protocol
DSB	Double Side Band
DSM-CC	Digital Storage Media Command and Control
DTT	digital terrestrial television
DVB	Digital Video Broadcasting
DVB-C	Digital Video Broadcasting – Cable
DVB-CAM	CA-module that complies with the DVB Common Interface specification
DVB-data	Digital Video Broadcasting – Data Broadcasting
DVB-MHP	Digital Video Broadcasting – Multimedia Home Platform
DVB-S	Digital Video Broadcasting – Satellite
DVB-T2	Second generation digital terrestrial televison broadcasting system
DVB-T	DVB-Terrestrial
E-AC3	Enhanced audio coding 3
E-EDID	Enhanced Extended Display Identification Data
EBU	European Broadcasting Union
ECCA	European Cable Communications Association
ECL	EuroCableLabs, technical cell of ECCA
EEPROM	electrically erasable programmable read-only memory
EICTA	European Information & Communications Technology Industry

	Association
EIT	event information table
EITf	Event Information Table, following table/section of EITp/f
EITp	Event Information Table, present table/section of EITp/f
EITp/f	Event Information Table, present/following tables
EITsch	Event Information Table, schedule tables
EPG	electronic program guide
EPT	effective protection target
ESG	Event Schedule Guide (without any API)
FEC	forward error correction
FEF	Future Extension Frame
FFT	fast Fourier transform
FTA	free to air
GAP	Generic Access Protocol
GOP	Group Of Pictures
GS	Generic Stream
HD	High Definition
HDCP	High-bandwidth Digital Content Protection
HDMI	High-Definition Multimedia Interface
HDTV	High Definition Television
HE-AAC V2	High Efficiency Advanced Audio Coding
HbbTV	Hybrid Broadcast Broadband TV
HTTP	HyperText Transfer Protocol
IDTV	integrated Digital TV
IEC	International Electrotechnical Commission
IEEE	Institute for Electrical and Electronic Engineers
IEFT	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IMI	Instant Metadata Identifier
INA	Interactive Network Adapter
IP	Internet Protocol
IRD	Integrated Receiver
ISO	International Organisation for Standardisation
JTC	Joint Technical Committee
LCD	Logical Channel Descriptor

LCN	logical channel number
MAC	Medium Access Control
MER	Modulation Error Ratio
MFN	multi-frequency network
MHP	Multi Media Home Platform
MPEG	moving picture experts group
MPTS	Multi Programme Transport Stream
MTU	Maximum Transfer Unit
NEC	Nippon Electric Company
NEM	Network Element Management
NF	noise figure
NIC	Network Interface Card
NICAM	Near Instantaneous Companded Audio Multiplex
NIT	network information table
NT	Network Termination in general
NVOD	Near Video On Demand
NVRAM	non-volatile random access memory
OSD	On Screen Display
PAL	phase alternating line
PAPR	Peak-to-Average-Power Ratio
PAT	Program Association Table
PCM	pulse code modulation
PCR	Programme Clock Referance
PID	Packet Identifier
PIN	personal identification number
PLP	Physical Layer Pipe
PMT	Program Map Table
PTS	Presentation Time Stamp
PSI	Program Specific Information
PSTN	Public Switched Telephone Network
PVR	Personal Video Recorder, (same as PDR, Personal Digital Recorder, or DVR)
QAM	quadrature amplitude modulation
QCIF	Quarter Common Intermediate Format
QEF	quasi error free
QoS	Quality of Service

QPSK	quaternary phase shift keying
R	code rate
r.m.s.	root mean square
RCA	Radio Corporation of America
RCU	remote control unit
RF	Radio Frequency
RF	radio frequency
RFC	Request For Comments
RGB	red/green/blue
RoO	Rules of Operation
ROT	Rotated Constellation
rpchof	remainder polynomial coefficients, highest order first
RS	Reed-Solomon
RST	running status table
RTCP	Real-Time Transport Control Protocol
RTP	Real-Time Transport Protocol
RTSP	Real Time Streaming Protocol
SAP	Session Announcement Protocol
SD	Standard Definition
SD&S	Service Discovery and Selection
SDT	service description table
SDTV	Standard Definition Television
SFN	single frequency network
SI	service information
SMATV	Satellite Master Antenna Television
SNTP	Simple Network Time Protocol
S/PDIF	Sony/Phillips digital interface
SPTS	Single Programme Transport Stream
SSU	system software update
ST	Stuffing Table
STB	set-top box
SW	Software
TCP	Transmission Control Protocol
TDT	time and date table
TFS	Time Frequency Slicing
TFTP	Tunnelling File Transfer Protocol

TOT	time offset table
TPS	transmission parameter signalling
TR	Tone Reservation
TS	Transport Stream
Tu	Useful symbol time
TV	television
UHF	ultra-high frequency
uimsbf	unsigned integer most significant bit first
UTC	Universal Time, Co-ordinated
VCR	video cassette recorder
VHF	very high frequency
VHS	Video Home System
VoIP	Voice over IP
VPN	Virtual Private Network
VSB	Vestigial SideBand
xDSL	x Digital Subscriber Line
XML	Extensible Markup Language
YUV	a signal defined as colour space, luminance (Y) and colour difference (U/V)

Introduction

The NATIONAL COMMUNICATIONS AUTHORITY (NCA) is mandated by Section 2 of the Electronic Communications Act, 2008, Act 775 to regulate the radio spectrum designated or allocated for use by broadcasting organisations and providers of broadcasting services in accordance with the standards and requirements of the International Telecommunications Union and its Radio Regulations as agreed to or adopted by the Republic. In furtherance of carrying out this function the law mandates the Authority to determine technical and other standards and issue guidelines for the operation of broadcasting organisations and bodies providing broadcasting services.

In pursuance of the above mandate, the National Communications Authority in conformance to the Geneva, 2006 (GE06) Agreement is carrying out a transition of television broadcasting services in the frequency bands 174–230 MHz (VHF Band III), 470–582 MHz (UHF Band IV) 582–862 MHz (UHF V) from analogue to digital technology.

Digital terrestrial television (DTT) offers improved spectrum efficiency compared to analogue TV. It also offers enhanced video and audio quality, interactivity, as well as increased programme choices.

DTT transmissions in Ghana will be based on DVB-T2 (EN 302 755) and MPEG-4 coding. Radio frequency allocated for television broadcasting in Ghana are Bands 174–230 MHz (VHF) and 470–862MHz (UHF). Initially the DTT service will be available in parallel with the existing analogue network (i.e. simulcast period), but it is anticipated that the analogue TV network will be switched off starting from December 2014.

The Authority is mandated by Section 3(a) of the National Communications Authority Act, 2008, Act 769 to establish and monitor the implementation of national communications standards and ensure compliance accordingly. The Authority has therefore adopted the following standards for Digital Terrestrial Television (DTT) in Ghana:

> a. Transmission standard   - **ETSI EN 302 755 popularly called DVB-T2**

b. Compression technology – **ISO/IEC 14496 Advanced Video Coding (AVC)/MPEG-4 (part 10), High Efficiency Advanced Audio Coding (HE-AAC)**

c. Format: **Standard Definition (SD). High Definition (HD) is optional for STBs but mandatory for iDTVs.**

d. Optional Application Programming Interface (API) for additional and interactive services - **ETSI TS 102 796, Hybrid Broadcast Broadband TV (HbbTV)**

During the digital television transition, viewers would require TV sets with the capability of receiving digital television signals transmitted according to the standards above.
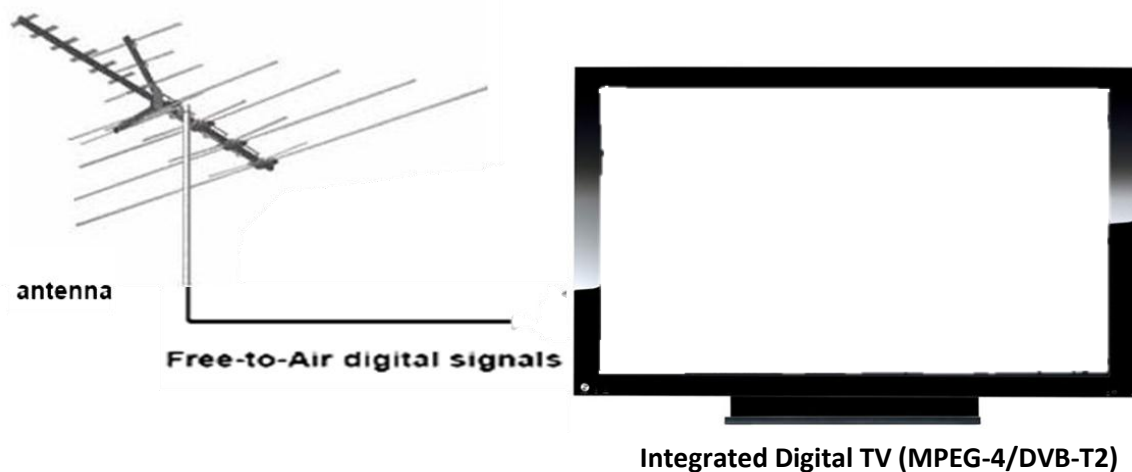

Figure 1: Reception of Free to Air digital signals using integrated digital TV set

Viewers whose TV sets are able to receive only analogue signals will need to use special digital adapters, i.e. set-top boxes, which have the primary function of converting digital input to analogue output signals.
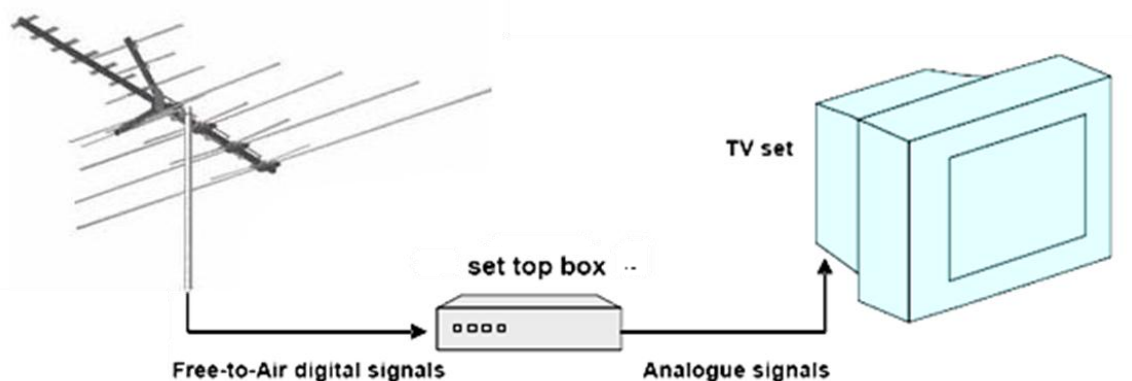

Figure 2: Reception of Digital TV signals using analogue TV Set and a set top box

Viewers who may have integrated digital sets based on DVB-T/MPEG-2 or DVB-T/MPEG 4 standard would not be conforming to the Ghana standard (DVB-T2/MPEG-4) and would also need a standard set-top box.

In accordance with Section 5(c) of the National Communications Authority Act, 2008, Act 769 the Authority shall take the necessary steps to protect consumers from sub-standard products. In this regard, the Authority shall apply its mandate under Section 66 of the Electronic Communications Act, 2008, Act 775 to certify terminal equipment of public electronic communications network.

In pursuance of this mandate, the Authority requires that all digital terrestrial television receivers (set-top boxes and integrated digital television sets) sold on the Ghanaian market to conform to the minimum receiver standard published herein. To enforce this requirement, a conformance regime (described in a separate document) shall require all STBs and integrated digital TV sets sold in Ghana to pass a conformance test to be certified. A logo, known as the 'digital Ghana thumb' (see Figure 3), has been developed as a certification mark to help consumers and retailers through switchover in Ghana.

The 'digital Ghana thumb' logo shall be featured in marketing campaigns related to the transition from analogue to digital broadcasting, and consumers of Digital Terrestrial Television (DTT) services shall be told to "look for the logo" when buying digital TV equipment. The logo is designed to identify digital TV products and digital TV services that have been tested and found to conform to Ghana's technical specifications.

Figure 3: Digital Ghana Thumb Logo indicating conformance of STBs to Ghana's minimum requirements

With immediate effect**, there shall be no manufacture, assembly, importation, marketing, or sale of <u>a set-top box (STB) for Digital Terrestrial Television</u> which does not conform to the requirements specified in this document.**

The objective of this document is to ensure a DTT receiver which will provide good quality video and sound for the viewer and to ensure the lowest possible cost for the free-to-air receiver. This document therefore sets requirements for a free-to-air DTT receiver which will result in a low cost, low maintenance unit providing basic functionality, i.e. demodulating the DVB-T/DVB-T2 signal and decoding the MPEG-2/MPEG-4 programme broadcasts and an Electronic Program Guide (EPG) providing details of the available services.

The Ghana DTT receiver standard is based on DVB-T2/MPEG-4. Since DVB-T2 is backward compatible with DVB-T (whether MPEG 2 or MPEG 4), it would be able to receive existing SDTV transmissions from Skyy Digital and Cable Gold which are based on DVB-T/MPEG-2 and DVB-T/MPEG-4 respectively. However, these services are expected to be upgraded to DVB-T2/MPEG-4 **by analogue switch-off**. Ghana Broadcasting Corporation (GBC) which is currently carrying out a Pilot DTT service based on DVB-T/MPEG-4 shall carry out its nationwide DTT service in DVB-T2/MPEG-4.

Requirements in this specification may be assigned to STB or to iDTV or to STB&iDTV according to section 1.3; 1.4 and 1.5 of this document. If not mentioned the requirement applies to both: STB receiver and iDTV receiver. **All the requirements of this document are mandatory unless it is specifically mentioned as optional**. Where the document is silent on a specific feature, the feature is regarded as being optional. The inclusion of optional features can be seen as part of the marketing strategy of the manufacturer.

Although this document sets out requirements for free-to-air DTT Receivers, receivers promoted by **Pay TV operators shall ensure compliance** to these requirements.

The requirements of the [TV Licensing Decree, 1966, NLCD 89](#) shall apply to the manufacture, assembly, importation, dealership, sale, hiring and/or repair of Digital Terrestrial Television receivers. In addition, data shall be collected on STBs in a bid to build a database of the ownership of TVs to which STBs would be connected.

1. Scope

1.1 This standard sets out the minimum technical requirements for a standard and high definition receiver for free-to-air digital terrestrial television in Ghana.

1.2 The term "Receiver" or "DTT receiver" in this document refers to a set top box (STB), an integrated television set (iDTV) and any other device that the consumer purchases in order to use DTT services in Ghana.

1.3 The term "STB' or 'STB receiver' in this document refers to a set top box (STB) that the consumer purchases in order to use DTT services in Ghana.

1.4 The term "iDTV' or 'iDTV receiver' or in this document refers to an integrated digital TV set (iDTV) that the consumer purchases in order to use DTT services in Ghana.

1.5 Compliance to this standard is mandatory for all set-top boxes and television sets and any receiver that shall be sold in Ghana for the purpose of receiving DTT services.

1.6 The standard specifies which functionalities are mandatory and those which are optional.

1.7 All Standard Definition (SD) functionalities shall be mandatory for all DTT Receivers.

1.8 High Definition (HD) functionalities are mandatory for iDTVs but optional for STBs.

1.9 The standard concerns:
  (a) broadcasters,
  (b) broadcasting signal distributors,
  (c) TV and set-top box manufacturers,
  (d) TV and set-top box dealers and sellers,
  (e) TV installers,
  (f) General public

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from the Ghana Standards Authority (GSA), Standards Division.

- ETSI EN 302 755, *Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)*

- ETSI EN 300 744, *Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television*

- ETSI EN 300 743, *Digital Video Broadcasting (DVB); Subtitling systems.*

- ETSI EN 300 472, *Digital Video Broadcasting (DVB); Specification for conveying ITU-R System B Teletext in DVB bitstreams.*

- ETSI EN 300 468, *Specification for Service Information (SI) in DVB systems*

- ETSI TR 101 211, *Digital Video Broadcasting (DVB); Guidelines on implementation and usage of Service Information (SI).*

- ETSI TS 101 154, *Digital Video Broadcasting (DVB); Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream.*

- ETSI TS 102 006, *Digital Video Broadcasting (DVB); Specification for System Software Update in DVB Systems.*

- ETSI TS 102 366, *Digital Audio Compression (AC-3, E-AC-3) Standard*

- IEC 60728-5, *Cabled networks for television signals, sound signals and interactive services – Part 5: Headend equipment.*

- ISO/IEC 61938, *Audio, video and audiovisual systems – Interconnections and matching values – Preferred matching values of analogue signals.*

- ISO/IEC 13522-5, *Information technology – Coding of multimedia and hypermedia information – Part 5: Support for base-level interactive applications.*

- ISO/IEC 13818-7, *Information technology – Generic coding of moving pictures and associated audio information – Part 7: Advanced Audio Coding (AAC).*

- ISO/IEC 14496-3, *Information technology – Coding of audio-visual objects – Part 3: Audio.*

- ISO/IEC 14496-10, *Information technology – Coding of audio-visual objects – Part 10: Advanced video coding.*

- ISO/IEC 13818-1, *Information technology – Generic coding of moving pictures and associated audio information: Systems.*

- [ITU-R BT.624-4](), *Characteristics of television systems.*

3. Definitions

For the purposes of this document, the following definitions.

3.1 Audio Description

Ancillary service primarily provided for the visually impaired that provides a spoken description of the video component of a service

3.2 Digital Terrestrial Television (DTT)

Terrestrial delivery of digital transmissions in the UHF/VHF frequency bands using the DVB-T2 standard as set out in ETSI EN 302755

3.3 Free-to-Air

Service which is broadcast unencrypted or in the clear and capable of being received without payment of subscription fees

3.4 Multiplex (mux)

Group of digital terrestrial television or audio programme channels or data services that are combined together into one output signal for broadcast

3.5 Private Data Stream

DVB data stream designed for a specific application which is ignored by other DVB decoders that are not designed to use the data

4. Performance requirements

Table 1 indicates some of the major hardware and firmware functions in the DTT receiver.

Detailed requirements are specified in the appropriate performance requirement.

Table 1: Main hardware/firmware functions for the various IRD configurations

	STB	iDTV
Video decoding/processing		
MPEG-2 MP@ML SDTV video	–	–
MPEG-4 AVC HP@L3 SDTV	M	M
MPEG-4 AVC HP@L4 HDTV	O	M
Audio decoding/processing		

	STB	iDTV
E-AC3, including down-mix to stereo	O	M
E-AC3 (E-AC3 converted to AC3) digital output	O	M
HE-AAC V2(Mono or stereo audio pairs)	M	M
Subtitling		
DVB (SDTV) subtitling	M	M
API		
DVB HbbTV	O	O
Interfaces		
DVB-T front end	–	–
DVB-T2 front end	M	M
UHF re-modulator	O	–
RF female input connector	M	M
RF male output connector	M	–
Analogue SD video output	M	–
HDMI output	O	–
HDMI input	–	M
Analogue audio left output	M	–
Analogue audio right output	M	–
12V DC input	M	–
100 – 250V AC	M	M

M = Mandatory; O = Optional

4.1 Spectrum and DTT modulation and coding

4.1.1   Spectrum

The Receiver shall operate within the VHF and UHF television broadcasting bands as shown in Table 2.

Table 2: Mandatory Frequency Bands

1	2	3	4	5
	Band	**Frequency**	**Channel**	**Requirement**

		Range	Spacing	
VHF	VHF III	174 – 230 MHz	7 MHz	Mandatory
UHF	UHF IV	470-582 MHz	8 MHz	Mandatory
	UHF V	582-862 MHz	8 MHz	Mandatory

4.1.2   DTT modulation and coding

The receiver shall support the 8K mode of operation referenced in the DVB-T standard ETSI EN 300 744. The decoder shall be capable of achieving full specified performance with any of the combinations of modulation (QPSK/16QAM/64QAM), forward error correction coding and guard interval as specified in ETSI EN 300 744.

The receiver shall support the 16K and 32 K modes as well as the normal and extended carrier modes as defined in ETSI EN 302 755. The decoder shall be capable of achieving full specified performance with any of the combinations of modulation (QPSK/16QAM/64QAM/256QAM), forward error correction coding and guard interval as specified in ETSI EN 302 755.

The decoder shall be capable of achieving full specified performance with any of the modes of operation defined for DVB-T2 in ETSI EN 302 755.

4.2 Radio frequency

4.2.1   DTT tuner/demodulator

The receiver shall be provided with a single DTT tuner/demodulator for the reception of signals from terrestrial transmitters broadcasting in accordance with ETSI EN 300 744 (for DVB-T) and ETSI EN 302 755 (for DVB-T2). It shall be capable of receiving transmissions broadcast with any allowable combination of modulation and transmission parameters, as follows:

Table 3: Modulation and transmission parameters

	DVB-T	DVB-T2
Constellation	QPSK, 16-QAM, 64-QAM	QPSK, 16-QAM, 64-QAM, 256-QAM; both rotated and non-rotated
Code Rate	1/2, 2/3, 3/4, 5/6, 7/8	1/2, 3/5, 2/3, 3/4, 4/5, 5/6
Guard Interval	Tu/32, Tu/16, Tu/8, Tu/4	Tu/128, Tu/32, Tu/16, Tu19/256, Tu/8, Tu19/128, Tu/4
Transmission	2K, 8K	1K, 2K, 4K, 8K normal and extended,

	DVB-T	DVB-T2
mode		16K normal and extended, 32K normal and extended
Pilot pattern	N/A	PP1, PP2, PP3, PP4, PP5, PP6, PP7
SISO/ MISO	N/A	both to be supported
PAPR	N/A	No PAPR used, ACE-PAPR only used, TR-PAPR only used, ACE and TR PAPR are used;
FEC Frame length	N/A	64800, 16200
Input Mode	N/A	Mode A (single PLP) or Input Mode B (Multiple PLPs – Common PLP, Type 1 and 2 up to the maximum allowed figure 255). The Decoder shall automatically detect which mode is being used.
Single RF frequency	N/A	Optional
Time Frequency Slicing (TFS)	N/A	Optional
Normal Mode or High Efficiency Mode	N/A	Both Modes to be Supported
FEF and Auxiliary streams	N/A	DTT receiver does not require to demodulate or decode content of FEF parts and auxiliary streams but the existence of FEF and or auxiliary streams shall not cause the Receiver to malfunction.

Table 4: A limited set of DVB-T2 modes for performance requirements

1	2	3	4	5	6	7
Identifier	**Mode 1**	**Mode 2**	**Mode 3**	**Mode 4**	**Mode 5**	**Mode 6**
Band	**UHF IV/V 8MHz SFN**	**UHF IV/V 8MHz SFN**	**VHF III 7MHz SFN**	**VHF III 7MHz SFN**	**UHF IV/V 8MHz MFN**	**VHF III 7MHz MFN**
Transmission Mode	32K extended	32K extended	32K normal	32K normal	32K extended	32K normal
Constellation	256 QAM ROT	256 QAM ROT	256 QAM ROT	256 QAM ROT	256 QAM ROT	256 QAM ROT
Code rate	3/4	2/3	3/4	2/3	3/4	3/4
Guard Interval	1/8 448us	19/256 266us	1/8 512us	19/256 304us	1/128 28us	1/128 32us
Pilot Pattern	PP2	PP4	PP2	PP4	PP7	PP7
PAPR	TR-PAPR	TR-PAPR	TR-PAPR	TR-PAPR	TR-PAPR	TR-PAPR
System Characterization (SISO/MISO)	SISO	SISO	SISO	SISO	SISO	SISO
FEC Frame Length	64800	64800	64800	64800	64800	64800
Input Mode	Single PLP	Single PLP	Single PLP	Single PLP	Single PLP	Single PLP
TFS	No	No	No	No	No	No
Normal Mode (NM) / High Efficiency Mode (HEM)	HEM	HEM	HEM	HEM	HEM	HEM
FEF	Not used	Not used	Not used	Not used	Not used	Not used
Auxiliary streams	Not used	Not used	Not used	Not used	Not used	Not used
L1 Modulation	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM
TIME_IL_LENGTH	3	3	2	2	3	3
TIME_IL_TYPE	0	0	0	0	0	0
Frame_Interval (I_JUMP)	1	1	1	1	1	1
Lf (no of symbols/frame)	60	62	44	42	60	60
No. of FEC blocks per interleaving frame	185	200	132	132	200	195
Bitrates (Mbits/s)	**37.12**	**36.15**	**31.59**	**30.81**	**44.79**	**38.21**

Table 5: Performance Requirements for the limited set of DVB-T2 modes

	Identifier	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
	Band	UHF IV/V 8MHz SFN	UHF IV/V 8MHz SFN	VHF III 7MHz SFN	VHF III 7MHz SFN	UHF IV/V 8MHz MFN	VHF III 7MHz MFN
Section		Performance					
1.0	C/N Performance on Gaussian channel (dB)	22.9	20.4	22.9	20.4	21.7	21.7
2.0	C/N Performance on 0dB echo channel (dB)	27.9	24.6	27.9	24.6	26.6	26.6
3.0	Minimum receiver signal input levels on Gaussian channel (dBm)	-76.2	-78.7	-76.8	-79.3	-77.4	-78.0
4.0	Minimum receiver signal input levels on 0dB echo channel	-71.2	-74.5	-71.8	-75.1	-72.5	-73.1
5.0	Receiver noise figure on Gaussian channel (dB)	6.0	6.0	6.0	6.0	6.0	6.0
6.0	Maximum receiver signal input levels (dBm)	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0
	Immunity to "digital" signals in Other Channels						
	Digital ACI N+/-1 C/I	28.0	28.0	28	28	28.0	28

	Identifier	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6
	Band	UHF IV/V 8MHz SFN	UHF IV/V 8MHz SFN	VHF III 7MHz SFN	VHF III 7MHz SFN	UHF IV/V 8MHz MFN	VHF III 7MHz MFN
Section		Performance					
7.0	(dB)						
	Digital ACI N+/-2 C/I (dB)	38.0	38.0	38.0	38.0	38.0	38.0
	Digital ACI N+9 C/I (dB)	28.0	28.0	28.0	28.0	28.0	28.0
8.0	Immunity to Co-Channel Interference from Analogue TV Signals						
	PAL B/G CGI C/I (dB)	7.0	5.0	7.0	5.0	7.0	7.0
9.0	Immunity to Adjacent Channel Interference From Analogue TV Signals						
	PAL B/G AGI C/I N+/-1 (dB)	33.0	33.0	33.0 [Note 4]	33.0 [Note 4]	33.0	33.0
	PAL B/G AGI C/I N+/-2 (dB)	44.0	44.0	44.0	44.0	44.0	44.0
	PAL B/G AGI C/I N+9 (dB)	44.0	44.0	44.0	44.0	44.0	44.0
10.0	Performance in Time-Varying Channels 10Hz doppler (5Hz after	3 dB	3 dB	3 dB	3 dB	3 dB	3 dB

	Identifier	Mode 1		Mode 2		Mode 3		Mode 4		Mode 5		Mode 6	
	Band	UHF IV/V 8MHz SFN		UHF IV/V 8MHz SFN		VHF III 7MHz SFN		VHF III 7MHz SFN		UHF IV/V 8MHz MFN		VHF III 7MHz MFN	
Section	**Performance**												
	AFC) 20µs 0dB echo												
11.0	Synchronisation for varying echo power levels in SFN (dB)	31.0		28.1		31.0		28.1		31.0		31.0	
12.0	C/(N+I) Performance in Single Frequency Networks for more than one echo (dB)	27.9		24.6		27.9		24.6		26.6		26.6	
13.0	C/(N+I) Performance in Single Frequency Networks inside the guard interval (dB)	27.9		24.6		27.9		24.6		26.6		26.6	

14.0 C/(N+I) Performance in Single Frequency Networks outside the guard interval (dB)	Delay (µs)	Echo level (dBc)	Delay (µs)	Echo level (dBc)	Delay (µs)	Echo level (dBc)	Delay (µs)	Echo level (dBc)	Delay (µs)	Echo level (dBc)	Delay (µs)	Echo level (dBc)
	-532	-12.0			-608	-12.0			-133	-11.5	-152	-11.5
	-525	-11.5			-600	-11.5			-120	-11.0	-130	-11.0
	-510	-10.5	See Note 2		-580	-10.5	See Note 3		-90	-9.5	-100	-9.5
	-490	-9.0			-560	-9.0			-60	-7.0	-70	-7.0
	-475	-7.5			-540	-7.0			-30	-2.0	-50	-4.5
	-448	-2.0	-266	-2.0	-512	-2.0	-304	-2.0	-28	-2.0	-32	-2.0
	448	-2.0	266	-2.0	512	-2.0	304	-2.0	28	-2.0	32	-2.0
	475	-7.5			540	-7.0			30	-2.0	50	-4.5
	490	-9.0	See Note 2		560	-9.0	See Note 3		60	-7.0	70	-7.0
	510	-10.5			580	-10.5			90	-9.5	100	-9.5

	Identifier	Mode 1		Mode 2		Mode 3		Mode 4		Mode 5		Mode 6	
	Band	UHF IV/V 8MHz SFN		UHF IV/V 8MHz SFN		VHF III 7MHz SFN		VHF III 7MHz SFN		UHF IV/V 8MHz MFN		VHF III 7MHz MFN	
Section	Performance												
		525	-11.5			600	-11.5			120	-11.0	130	-11.0
		532	-12.0			608	-12.0			133	-11.5	152	-11.5

Notes:
1. The performance requirement is based on 30 seconds error free video.
2. There is no allowance for an echo outside the guard interval for 8MHz 19/256 PP4 due to the 19/256 guard interval (266us) being very close to the Nyquist limit for PP4 (298.67us). This specification defines the maximum delay for an echo outside the guard interval to be 57/64*Nyquist which is equal to the guard interval of 266usec for 19/256 PP4.
3. There is no allowance for an echo outside the guard interval for 7MHz 19/256 PP4 due to the 19/256 guard interval (304us) being very close to the Nyquist limit for PP4 (341.3us). This specification defines the maximum delay for an echo outside the guard interval to be 57/64*Nyquist which is equal to the guard interval of 304usec for 19/256 PP4.
4. When there is a PAL-B with NICAM N-1 interference in 7MHz channels, the DVB-T2 signal in channel N must have a frequency offset of at least +166 KHz.

4.2.2   Tuning

4.2.2.1 General

The Decoder shall ignore all services originating from any non-DTT sources, such as DVB-H services, to avoid consumer confusion. Portable/handheld receivers should not ignore DVB-H services.

4.2.2.2 Automatic tuning

The DTT receiver shall be capable of performing automatic tuning over the frequency ranges indicated in Table 2, to find all the multiplexes and services received in the complete frequency range. The Receiver shall automatically detect which mode is being used (Refer to Table 3). It shall also be able to interpret and respond to tuning parameters found in the SI/PSI (e.g. within the network information table (NIT)).

When receiving a DVB-T2 signal with Multiple PLP (i.e. Mode B), the Receiver shall analyse and interrogate the SI information per PLP.

The decoder shall display a given service only once in the service list (so avoiding duplicates of the same service), even if this service (i.e. same path comprising original network identifier, transport stream identifier and service identifier) is received from more than one transmitter. In such a case, the service emanating from the transmission with the highest quality (as defined by signal strength and signal quality) shall be the one chosen to be entered into the service list.

4.2.2.3 Manual tuning

In addition to automatic tuning, the Receiver decoder shall be capable of performing manual tuning where the channel number or frequency (or both) is entered by the viewer. The decoder shall tune to the channel entered by the viewer, search all available DTT modes, add any new services and replace existing services in the service list.

The decoder shall display a given service only once in the service list (so avoiding duplicates of the same service), even if this service (i.e. same path comprising original network identifier, transport stream identifier and service identifier) is received from more than one transmitter. In such a case, the service emanating from the transmission with the highest quality (as defined by signal strength and signal quality) shall be the one chosen to be entered into the service list.

4.2.3 Response to changes in modulation

The DTT receiver should recover from changes in modulation parameters and output an error free TS. This should take less than one second for any change. The DTT receiver should be able to detect a change of modulation parameters signalled in the TPS data of the DVB-T signal, in order to reduce the recovery time.

The DTT receiver decoder tuned to a DVB-T2 transmission shall automatically recover from changes in P1, L1 pre-signalling data and L1 post signalling. An error-free TS shall be available within five seconds for any P1 and/or L1 pre-signalling change. An error-free TS shall be output within five seconds for any L1 post-signalling FEF change and within two seconds for any other L1 post-signalling change.

4.2.4 Bypass support for STB

The path from RF input to RF output shall allow RF bypass independently of the operational or stand-by status of the STB decoder, so that connected equipment (e.g. a TV set) can continue to operate.

The RF bypass gain shall be in the range −1 dB to +3 dB over the frequency ranges in Table 2.

4.2.5 UHF re-modulator for STBs

4.2.5.1 If the STB decoder provides a UHF re-modulated output for use with a PAL TV receiver it shall:

a)   modulate the decoded baseband signal onto PAL-G in accordance with ITU-R BT.624-4, except that dual side bands shall be allowed;

b)   have a peak signal level of 3 mV nominal across 75 Ω (−39 dBm);

c)   have a return loss at the output of less than 6 dB;

d)   be tunable from 470 MHz to 862 MHz;

e)   be preset at the factory to channel 63;

f)   support PAL mono audio output, with a volume control;

g)   have an audio FM deviation of 40 kHz ± 5 kHz at −12 dB full-scale transmitter output setting (equivalent to +6 dBm studio sound level);

h)   have a vision to sound carrier ratio of 16 dB ± 4 dB;

i)   produce spurious output levels that do not exceed:

1)   in band (as in Table 2): 12 dBµV max.;

2)   out of band (30 MHz to 1 GHz, excluding in-band above):   43 dBµV max.;

j)   with the "RF out" terminated in 75 Ω, exhibit an output voltage leakage to the "RF in" terminal of 36 dBµV max.

4.2.5.2 If the STB decoder provides a UHF re-modulater, the RF output shall be combined with an RF bypass facility that provides feeds for analogue TVs and VCRs. The second-order intermodulation at the RF output, measured in accordance with IEC 60728-5 with 85 dBµV input, shall be equal to or lower than −60 dBc.

4.2.6   Time Interleaving

The DTT receiver shall at least include time interleaving capability corresponding to the maximum time interleaving according to ETSI EN 302 755, i.e. $2^{19}+2^{15}$ OFDM cells for a data PLP and its common PLP together.

4.3 Demultiplexing and decoding

4.3.1   Support of MPEG-4

The STB decoder shall support MPEG-4 AVC/H.264 level 3 decoding for standard definition display.

iDTV receivers shall support MPEG-4 AVC/H.264 level 4 decoding for standard definition and high definition display.

The transport stream shall comply with ISO/IEC 13818-1, and the video profile level shall be Main profile level 3 in accordance with ISO/IEC 14496-10.

The DTT receiver shall support standard definition video resolution of 720×576.

The DTT receivers supporting HD shall support the following minimum set of resolutions and frame rates:

Table 6:   Video Decoder — resolutions and frame rates

Resolution	Frame Rate	Scanning	Aspect Ratio	Profile

Resolution	Frame Rate	Scanning	Aspect Ratio	Profile
720 × 576	25	Interlaced	4:3 or 16:9	AVC HP@L3
1 280 × 720	50	Progressive	16:9	AVC HP@L4
1 440 × 1 080	25	Interlaced	16:9	AVC HP@L4
1 920 × 1 080	25	Interlaced	16:9	AVC HP@L4
1 920 × 1 080	25	Progressive	16:9	AVC HP@L4

4.3.2   Video

Video decoding shall be in accordance with 4.3.1. For STBs supporting HD, the DTT receiver shall provide a HD output and a down-converted SD output.

4.3.2.1 STB decoder down-conversion of High Definition Video for Standard Definition output

For RF-PAL and CVBS outputs, the decoded HD video shall be down-converted by the SD Format Converter to SD resolution for output via these outputs. Down-conversion of pictures shall be implemented, from any of the incoming encoded HD full screen luminance resolution values (1920x1080, 1440x1080, and 1280x720) to SD resolution (720x576).

When down-converting any 1:1 pixel aspect ratio format (i.e. 1280x720 or 1920x1080) in the Decoder Composition Output to 720x576 resolution, the target shall be 702x576 pixels to be centered in the 720x576 grid with nine black pixels inserted as the start of the 720 pixel active line and nine pixels inserted as the end of the 720 pixel active line. The Down-converted HD video shall be displayed as 16:9 letter box on 4:3 displays. (Allowing centre cut would limit the safe area to 4:3 for HD production, hence not an allowed display option).

The SD Format Converter should apply appropriate re-interlacing (field mode integration re-interlacing). It shall process and output 720x576i25 in 4:3 frame aspect ratio or 16:9 frame aspect ratio video with colours according to the standards listed in

Table 7.

Table 7: Video Decoder — colour frame aspect ratio

Active composition resolution in the "Decoder Composition Output" (Horizontal x Vertical)	Documentation for appropriate Colour Processing	Comments
720x576	ITU-R BT.1700 (replaces ITU-R BT.470 System B, G)	Note that 576 lines in both interlaced scan (576i) and progressive scan (576p) shall be processed and output with equal colour parameters.

4.3.2.2 Aspect Ratio

The DTT receiver shall support both 16:9 (widescreen) and 4:3 picture format changes, including support for the correct aspect ratio and use of the active format descriptor (AFD) as defined in ETR 101 154.

For the HD output, the Receiver shall be able to use the EDID information provided by the display to automatically determine the Receiver output.

The DTT receiver shall provide an "Original Format" option, i.e. to output the same format as received if supported by the display, as indicated by the EDID information. If the received format is not supported, the Receiver should select the display mode providing the best possible video quality. This is to avoid the Receiver output to go black, if there is a mismatch between received format and display capabilities.

It shall also be possible to manually set the default output format from the Receiver to a fixed format.

For the down-converted SD format, the STB decoder shall support manual selection of the required aspect ratio.

For SD video and down converted HD video the combination of coded frame aspect ratio information plus the use of the AFD, embedded by the MPEG encoder into the video sequence header, shall provide the viewer with the following options:

a)   **16:9 material on 4:3 displays**. The decoder shall provide the following viewer options:

1)   display the material as a 16:9 letterbox within a 4:3 frame; or

2)   perform a 4:3 centre cut-out on the originating material and present this full-frame within the 4:3 display. In this case the decoder shall support 'pan and scan' operation;

b)   **4:3 material on 16:9 displays**. The decoder shall provide "pillarboxing" of 4:3 material into a 16:9 frame, in order to maintain the correct aspect ratio of the originating material.

4.3.2.3 Support of still pictures

The DTT receiver shall be able to decode and display still pictures (frame), i.e. a video sequence that contains a single intra-coded picture. Such a video bit stream will cause the buffer to under-flow. In this situation, while the decoding process shall continue to examine the buffer, the display process associated with the decoder shall repeat the previously decoded picture until the normal operation of the buffer can resume.

4.3.2.4 Outputs for STBs

If the STB decoder uses a re-modulator, a PAL-B/G modulated SD video and audio signal shall be presented as prescribed in 4.2.5.1 on a connector as defined in 4.11.3.

The STB decoder shall also provide a composite (CVBS) video output on a RCA socket as defined in 4.11.3. The composite video signal levels shall be in accordance with ISO / IEC 61938. For decoders supporting HD, the decoder shall derive a down-converted version for output via this interface as described in 4.3.2. The decoder shall provide a single HDMI output for HD content.

4.3.3   Audio

The STB Receiver shall support the possibility to adjust the audio-delay on the S/PDIF output (if available) up to 250 ms and it should be adjustable in 10 ms steps, as the STB Receiver may have several different user set-ups, resulting in different a/v delays; e.g. the STB Receiver may be connected to several types of external audio-amplifiers and the STB Receiver may be connected to several types of external screens.

4.3.3.1 General

The DTT receiver shall support decoding of HE-AAC v1L2 and HE-AAC v2L2 in accordance with ISO/IEC 14496-3 and ISO/IEC 13818-7. The use of HE-AAC v1L2 and HE-AAC v2L2 shall primarily be for mono or stereo video services and/or radio services.

HD Receivers shall support decoding of E-AC-3 elementary streams. HD Receivers shall also support conversion of E-AC-3 elementary streams to an AC-3 bitstream for output via HDMI (only STB) and SPDIF.   If this option is supported, the decoding and conversion of an E-AC-3 elementary stream shall conform to the requirements defined in ETSI TS 102 366 including annex E, and the following constraints. Support for decoding MPEG-1 Layer II (Musicam) is optional. The decoder shall use the ISO 639 language descriptors to determine languages of audio service elements, handle dynamic changes and present audio service information.

4.3.3.2 Audio mode

HD Receivers shall be capable of decoding the first independent substream of an E-AC-3 elementary stream (independent substream 0) containing up to 5.1 channels of audio. HD Receivers shall implement E-AC-3 decoding functionality that is capable of outputting at least 2-channels of decoded PCM. HD Receivers shall support down-mixing of E-AC-3 streams that contain more than 2 channels of audio.

4.3.3.3 Bit rate

HD Receivers shall support decoding of E-AC-3 elementary streams encoded at bit rates of up to 3 024 kbit/s.

4.3.3.4 Sampling frequency

HD Receivers shall support decoding of E-AC-3 elementary streams encoded at a sample rate of 48 kHz.

4.3.3.5 Substream support

HD Receivers shall be able to accept E-AC-3 elementary streams that contain more than one substream. HD Receivers shall be capable of decoding independent substream 0. Support for decoding of additional dependent substreams is optional.

4.3.3.6 Audio Description

HD Receivers shall be capable of simultaneously decoding two different programme elements (Main Audio and Audio Description) carried either in two separate E-AC-3 elementary streams. HD Receivers shall, in addition to the decoding requirements specified in sections 4.3.3.2 through 4.3.3.5, implement Audio Description decoding with the following capabilities.

4.3.3.6.1   Audio mode

The Audio Description HD decoder may be capable of decoding a single independent substream from an E-AC-3 elementary stream containing up to 5.1 channels of audio. The Audio Description HD decoder may be capable of outputting at least 2-channels of decoded

PCM. The Audio Description HD decoder may support downmixing of E-AC-3 streams that contain more than 2 channels of audio.

4.3.3.6.2 Sampling frequency

The Audio Description HD decoder shall support decoding of E-AC-3 sub streams and elementary streams encoded at a sample rate of 48 kHz. If the sample rate of the Audio Description service does not match the sample rate of the Main Audio service, the HD receiver may decode only the Main Audio service.

4.3.3.6.3 Substream support

The Audio Description HD decoder shall support decoding of a single independent substream. Substream id values of 0, 1, 2 and 3 shall be supported. HD Receivers may be able to select a single independent substream from an E-AC-3 elementary stream that contains multiple independent substreams and route this single substream to the Audio Description decoder. HD Receivers may support Audio Description services delivered within the same E-AC-3 bitstream as the Main Audio service, and delivered using a separate E-AC-3 elementary stream carried in a separate PID within the broadcast transport stream.

4.3.3.6.4 Mixing metadata

The Audio Description HD decoder shall support extraction of mixing metadata from the E-AC-3 bitstream and delivery of this mixing metadata to an audio mixing component within the receiver. The AD_Descriptor, if present, shall be ignored.

4.3.3.6.5 Audio Description synchronization requirements.

If audio access units from two audio services which are to be simultaneously decoded have identical values of PTS indicated in their corresponding PES headers, then the corresponding audio access units shall be presented to the audio decoder for simultaneous synchronous decoding. Synchronous decoding means that for corresponding audio frames (access units), corresponding audio samples are presented at the identical time.

If the PTS values do not match (indicating that the audio encoding was not frame synchronous) then the audio frames (access units) of the main audio service may be presented to the audio decoder for decoding and presentation at the time indicated by the PTS. An audio description service, which is being simultaneously decoded, may have its audio frames (access units), which are in closest time alignment (as indicated by the PTS) to those of the main service being decoded, presented to the audio decoder for simultaneous decoding. In this case the associated service may be reproduced out of sync by as much as 1/2 of a video frame.

4.3.3.7 Mono-audio for STBs

There shall be a configurable option in the On-screen Menu to replace the analogue Stereo Left signal output via one of the RCA sockets with a derived analogue Mono feed.

4.3.3.8 Audio Outputs

4.3.3.8.1 HDMI outputs

STB receiver may include an HDMI output, as described in section 4.11.3, and the following audio-specific requirements shall be implemented:

a) STB receivers shall determine the audio decoding capability of a connected HDMI sink device by reading the E-EDID structure of the sink device.

b) If the HDMI sink device indicates support for E-AC-3 decoding, the STB receiver may output the E-AC-3 elementary stream directly to the HDMI sink device

c) If the HDMI sink device does not indicate support for E-AC-3 decoding, but supports AC-3 decoding, the STB receiver may convert the E-AC-3 elementary stream to an AC-3 bitstream prior to HDMI output

d) If the sink device does not indicate support for either AC-3 or E-AC-3 decoding, or the user has selected "stereo" output via the on screen menu, the STB receiver may decode the elementary stream to stereo PCM prior to HDMI output.

4.3.3.8.2 S/PDIF Audio outputs

STB receiver may include an S/PDIF output, as described in section 4.11.3 and the following requirements shall be implemented:

a) Convert the E-AC-3 elementary stream to AC-3 prior to S/PDIF output.

b) If the user has selected "stereo" output via the on screen menu, the STB receiver shall decode the elementary stream to stereo PCM prior to S/PDIF output

4.3.3.8.3 Analogue audio outputs

STB receiver shall include an analogue audio output, as described in section 4.11.3 and decode the audio elementary stream prior to analogue audio output.

4.4 Subtitling

The DTT receiver shall be capable of displaying subtitles for the hearing impaired in accordance with ETSI EN 300 743. The decoder shall be capable of overlaying the subtitle

text on the picture. The subtitles for the hearing impaired may differ from the normal subtitles by the amount of text displayed per second, which is controlled by the broadcasted content.

The Receiver shall be capable of displaying subtitles in English and major languages spoken in Ghana including those listed in Table 8:

Table 8: ISO 639 codes for some languages spoken in Ghana

Language	ISO-639 Language code		
	639-1	**639-2**	**639-3**
Akan	ak	aka	
Ewe	ee	Ewe	
Ga		Gaa	
Nzema		Nzi	
Hausa	ha	hau	
Dagbani			dag

The Receiver shall provide the option of Enabling or Disabling the displaying of subtitles. When enabled, subtitles will automatically be displayed. When disabled, the decoder shall allow manual selection from the available list of broadcasted subtitle services. The Receiver shall allow the user to configure the preferred first and second language subtitle services, which will be automatically displayed when available. Should neither be available, the first available subtitle language shall be presented. The decoder shall provide the option of disabling the language presented, or of selecting another available language.

The presence of subtitle services shall be indicated by a subtitle icon on the Now and Next Banner. When the languages button is selected on the remote control unit, the list of available subtitle languages shall be displayed and the user can select his preference.

The Receiver shall be capable of displaying subtitling and interactive graphics simultaneously, where available.

4.5 Teletext

Teletext services shall be provided in accordance with ETSI EN 300 472.

4.6 Service information (SI) and program-specific information (PSI)

4.6.1 Service information tables

The general implementation of SI and PSI shall be in accordance with ETSI EN 300 744 and ETSI EN 300 468.

The DTT receiver shall be able to process the PSI/SI tables including the Mandatory and Optional PSI/SI tables, both for the "Actual" and for "Other" transport streams.

4.6.2 Networks and bouquets

It is anticipated that bouquets will be allocated on a regional basis. Services will be broadcast on both a national and regional basis with the SI tables containing information on all events. The DTT receiver shall use the Logical Channel Numbering functionality to construct accurate Now and Next information for the region identified on the appropriate menu screen.

4.6.2.1 *Logical Channel Number Descriptor*

LCN information shall be broadcasted via a privately defined LCN descriptor as outlined below. This descriptor shall be broadcasted in the TS Loop of the NIT on all multiplexes.

```
logical_channel_descriptor() {
        descriptor_tag                              8 (uimsbf)
        descriptor_length                           8 (uimsbf)
        for (i=0;i<number_of_services;i++){
                service_id                          16 (uimsbf)
                visible_service_flag                1  (bslbf)
                reserved                            5  (bslbf)
                logical_channel_number              10 (uimsbf)
        }
}
```

descriptor_tag*:* this shall be assigned the value 0x83

visible_service_flag: 1: visible 0: Not Visible

reserved: all reserved bits shall be set to 1. The receiver shall ignore these bits.

service_id: DVB defined service id.

4.6.2.2 *Logical Channel Descriptor V2*

The LCN V2 privately defined descriptor may be broadcast. This descriptor contains additional information related to sorting of services depending on region. Receivers shall support this descriptor if broadcast.

descriptor_tag: This shall be 0x87 (decimal 135)

channel_list_id: This 8-bit id shall uniquely define the Logical Channel List for a particular region. This id shall be unique within the Original Network.

channel_list_name_length: This 8-bit field specifies the number of bytes that follow the channel_list_name_length field for describing characters of the name of the Channel List. The maximum length of the channel list name shall be 23 bytes.

char: This is an 8-bit field. A string of character fields specify the name of the channel list, the channel_list_name. (channel_list_name shall have a maximum length of 23 characters). Text information shall be coded using character table 00 as defined in Annex A of EN 300 468.

country_code: This 24-bit field identifies a country using the 3-character code as specified in ISO 3166. Each character is coded into 8-bits according to ISO 8859-1 and inserted in order into the 24-bit field. This shall be set to "GHA".

service_id: A service_id that belongs to the TS (i.e. services from transport streams not in the current loop shall not appear). One service may only be listed once in each channel list, but may belong to/be listed in more than one channel list.

visible_service_flag: 1: visible 0:Not Visible

reserved: All "reserved" bits shall be set to '1'. The receiver shall ignore these bits.

logic_channel_number: This is the broadcasters preferred Logical Channel Number for the service in question. Rules of operation are as per LCN Management section of this specification.

```
Logical_channel_v2_descriptor (){
        descriptor_tag                          8       Uimsbf
        descriptor_length                       8       Uimsbf
        for (i=0;i<N;i++){
                channel_list_id                 8       Uimsbf
                channel_list_name_length        8       Uimsbf
                for (i=0;i<N;i++) {
                        char                    8       Uimsbf
                }
                country_code                    24      Uimsbf
                descriptor_length               8       Uimsbf
                for (i=0;i<number_of_services;i++){
                        service_id              16      Uimsbf
                        visible_service_flag    1       Bslbf
                        reserved_future_use     5       Bslbf
                        logical_channel_number  10      Uimsbf
                }
        }
}
```

4.6.2.3   Channel Numbering

The Logical Channel Numbers shall be obtained from the LCN descriptor as outlined above.
The channel map shall be from 1-999 with valid LCN's being assigned in the range from 1-799 by the broadcaster. The details of the channel map are outlined below.
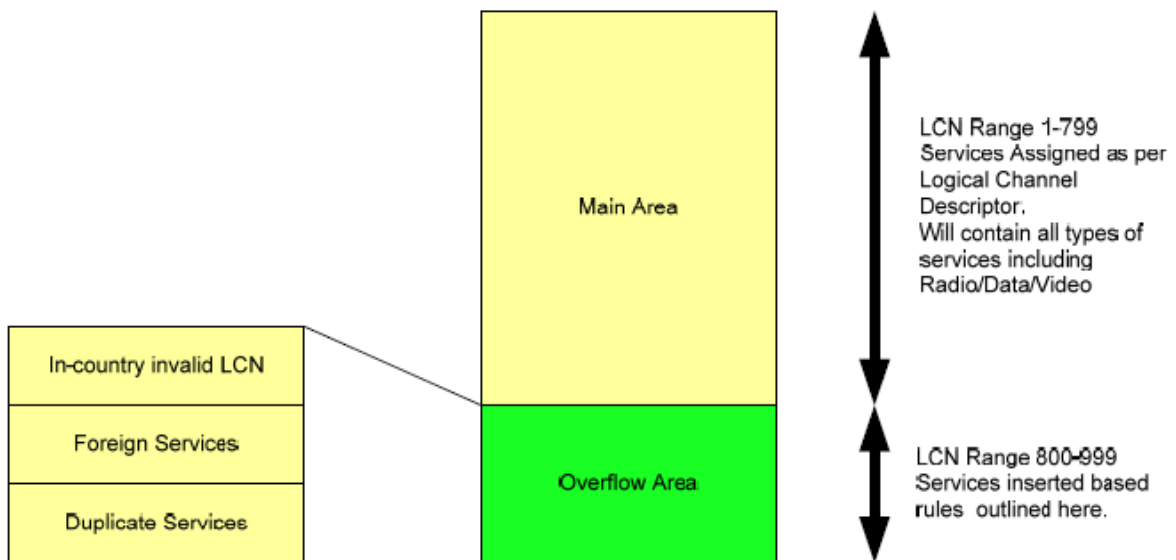

Figure 4: Channel Map when there is a Valid LCN Descriptor

Main Area: Services shall be ordered here according to the channel map as described by the Logical Channel Descriptor. If no valid Logical Channel Descriptor exists, please refer to the no logical channel descriptor section below.

Overflow area: Below is the list of different categories within the overflow area.

In country invalid LCN: Any service which has not been assigned a Logical Channel Number or has been assigned a number outside the valid range of 1-799, shall be placed in the overflow area. This section should only be used when there is a valid Logical Channel Descriptor within the network. Please refer to the no logical channel descriptor section below.

Foreign Services: Any service belonging to an original network other than the in country original network shall be placed in the overflow area.

Duplicate Services: If two or more unique services (unique DVB triplet) are assigned the same Logical Channel Number the service belonging to the multiplex with the best RF

quality shall be placed in the LCN assigned by the Logical Channel descriptor. All other services shall be placed in this category of the overflow area.

Receivers may implement their own ordering of services within the overflow area.

When no logical channel descriptor is found within the in country Original Network, all in country services shall be assigned Logical Channel Numbers in any order sequential from 1 onwards.
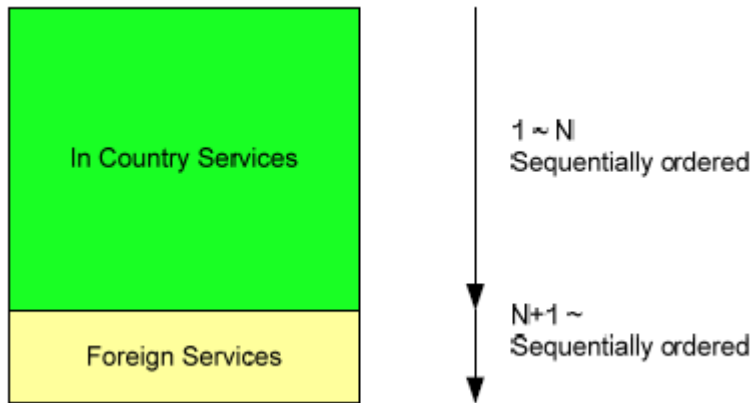

Figure 5: Illustration of Channel Map when LCN descriptor is not broadcasted

Services from the original network of foreign countries shall be placed immediately after the last in country service.
When there are duplicate services (same DVB triplet) only the service from the multiplex with the best RF quality shall be visible to the user, the duplicate shall not be assigned a logical channel number.

4.6.2.4   Regional Broadcast Management

A regional multiplex might contain one or more services which have events that differ from one region to another.
The receiver shall decode the Logical Channel Descriptor Version 2 as outlined above.

During initial install, all channel lists for the country selected by the user shall be collated by the receiver. Once the scan is complete, if there are more than 1 valid channel list, the user shall be given a method to select a preferred list. The wording of the selection items presented to the user shall include the 23 character string broadcasted in the descriptor.

The receiver shall then order the services based on the selected channel list.

4.6.3 Service configuration

The DTT receiver shall automatically detect configuration changes such as service information, modulation and frequency, as well as the adding or the deleting of services, and shall amend its operation accordingly without user intervention or disruption to services.

NOTE: It is anticipated that the DTT service will include a dynamic element in terms of the use of available bandwidth.

4.6.4 EIT present/following, actual/other

Only EIT present/following (Now and Next) information shall be broadcast, including extended event information, for services carried in all DTT transport streams, i.e. EIT present/following including genre tables, parental control and series descriptor.

4.6.5 Time exclusive services

The DTT receiver shall support the use of time exclusive services, i.e. where part of the multiplex capacity is used to support different services depending upon the time of the day. The services shall be shown within the relevant channel listings and users shall be able to select them as for normal services. During the time period when a service is not using the multiplex capacity (i.e. the service is inactive), the decoder shall display notification screen (the Placeholder) which will typically provide the service name and its hours of operation..

The decoder shall provide seamless transitions between active and inactive states so that the user experiences the replacement of the Placeholder screen with the active service, and vice versa.

4.7 Memory

4.7.1 The DTT receiver shall have a memory capacity of:
   a) 32 Mbytes Flash memory,

   b) 128 Mbytes RAM.

4.7.2 Settings and parameters, for example security-related data, shall be stored in non-volatile memory.

4.7.3 Manufacturers may emulate EEPROM in Flash in which case some parts of this data shall be enciphered in the NVRAM.

4.7.4 The memory specification has been chosen to allow for the lowest component price assuming the use of NAND Flash, but manufacturers are free to propose alternative technologies such as a hybrid solution making use of NOR and NAND Flash where these comply with the requirements of this standard.

4.8 Graphics capabilities

4.8.1   Resolution

The colour resolution shall be at least 16 bits (4:4:4:4) and the DTT receiver shall include a look-up table capable of storing a minimum of 256×24-bit RGB colour/transparency entries.

4.8.2   Multiple display planes

4.8.2.1 The DTT receiver shall have three display planes as given in 4.8.2.2 to 4.8.2.4, each with the capability of blending with active video. A minimum of 16 individual transparency levels shall be supported.

4.8.2.2 Graphics plane ("front" plane) that supports full screen On-screen display information. The sizing of the graphics display plane shall be a 4:3 aspect ratio, regardless of the video aspect ratio.

4.8.2.3 Video plane, that supports a full screen MPEG video stream or still image.

4.8.2.4 Background plane ("back" plane), that comprises a single-colour (24-bit RGB) background with a default setting of black.

4.9 Standby operation

4.9.1   Passive standby operation

Passive standby in STB receiver shall be provided and shall be the main standby mode, with the main CPU disabled but the RCU Rx function active and the re-modulator bypass active.

4.9.2 Active standby operation

In case it is not possible to provide a passive standby with the power requirements in 4.9.4 (c), the DTT receiver shall provide an active standby state.

After selecting standby the STB receiver shall remain in active standby for 5 min before switching to passive standby.

This mode shall support the downloading of data using DVB-SSU (including DTT receiver control information if this capability is installed) to the DTT receiver Flash memory.

4.9.3 Power-up times

The STB Receiver shall generate an on-screen message within 10s of the start of a reboot operation confirming that the decoder is powering up.

The following time limits shall apply to transitions in and out of standby operations:

   a) DTT receiver Off to Service display: a maximum of 20s;

   b) Active Standby to Service display: a maximum of 5s;

   c) Passive Standby to Service display: a maximum of 10s.

4.9.4 Power consumption

The STB together with its power supply shall have the following maximum power consumption:

   a) Normal Operation: 10 W;

   b) Standby (Active):   6 W;

   c) Standby (Passive):   3 W.

NOTE   These values will be reviewed to reduce energy consumption when technology permits.

4.10 Power supply

The receiver shall be supplied complete with 230 V a.c. to 12V d.c. power supply unit. The mains supply power unit may, at the discretion of the manufacturer be incorporated in the

receiver or alternatively be provided as an external module. Protection against overvoltage or undervoltage and reversed polarity shall be incorporated.

A DC power supply of +5 V capable of supplying a maximum current of 100 mA suitable for powering an external antenna amplifier shall be available on the input RF connector of STB. The DC power supply should not degrade the performance of the RF input. The DC power supply shall be protected against short circuits. It shall be possible to switch on or off the DC power supply via a selection in the menu structure. The default at first-time initialization and resetting to factory default shall be the DC supply switched off.

4.11 Interfaces

4.11.1 LED indications

4.11.1.1 Bi-colour LEDs
The STB receiver shall have a minimum of two bi-colour LEDs (LED #1 and LED #2) on the front panel.

The two LEDs shall be clearly distinguishable from each other either by their physical position (separation, left side LED and right side LED), or by means of a label.

LED #1 shall be defined as the Power LED on the left-hand side.

LED #2 shall be defined as the Status LED on the right-hand side.

The colours of the Power LED shall be Red/Green.

The colours of the Status LED shall be Red/Green.

4.11.1.2 The Power LED — Red/Green
The Power LED indications shall be as follows:

Standby = Red;

Operate = Green;

Reception of RCU command = flashing single burst.

4.11.1.3 The Status LED — Red/Green

The Status LED indications in STB shall be as follows:

System boot/program search = flashing Green;

Normal operation = continuous Green;

Fault/no signal found = continuous Red;

Software download in progress = flashing Red.

4.11.2 Controls

The following controls shall be provided on the front panel of STB receiver. iDTV shall have the following controls at a place around the front panel that the user can operate easily:

- Program selector P+ and P−;

- Volume selector V+ and V−;

- Menu;

- Ok;

- Standby/On.

4.11.3   Connectors

The following connectors shall be used:

a) An RF input female connector that complies with IEC 61169-2.

b) An RF output male connector that complies with IEC 61169-2 for STB receiver.

c) Colour-coded RCA sockets for composite (CVBS) video and stereo audio [output for STB, input for iDTV].

d) A DC power jack of 9.5 mm in length, outside diameter (OD) of 5.5 mm, centre pin of 2.5 mm, and with the centre pin as +12 V and the outer contact as earth for STB receiver.

e) A USB 2,0 port via a USB type A jack [optional].

f) HDMI input - type A [optional for STB, mandatory for iDTV]

g) S/PDIF output [optional for STB, mandatory for iDTV]

h) The use of a C8 AC power inlet in accordance with IEC 60320-1 for the power supply built into the DTT receiver for STB receiver .

4.11.4 Identification

The decoder shall have an external label with the following information:

a) identification of the manufacturer or the supplier (or both);

b) model number of the decoder;

c) serial number of the decoder.

5. Applications

5.1 HbbTV interactive application environment

The DTT receiver may implement all mandatory requirements of **ETSI TS 102 796 V.1.1.1, Hybrid Broadcast Broadband TV (HbbTV)**.

5.2 Electronic Program Guide (EPG)

Receiver shall provide a programme guide. It is preferable that this uses data from the transmitted DVB EIT schedule tables. This is because these tables are continually updated by broadcasters to reflect schedule changes. If the source of the schedule data is EITschedule, acquisition shall be continuous and not dependent upon the reception of the first sections of any tables for acquisition to start. If a Receiver is unable to maintain continuous acquisition such that a section is missed, it should be acquired at the next available opportunity. Receiver shall concurrently acquire EIT schedule for all receivable services. When a receiver caches the EIT information, it should ensure that updates to the broadcast EIT tables are reflected in the cache within one cycle of the modified table. If an equivalent data source is used but is unavailable, the Receiver shall use EIT instead. An "equivalent data source" is defined to be a data source that provides sufficient information in a suitably timely manner to meet all of the mandatory requirements in this chapter.
The EPG display shall be available at all times (excluding standby) following initial acquisition.

5.2.1 EPG Scope and Accuracy

The Receiver shall display a minimum of 8 days of schedule data in the EPG (subject to the purging of data for past events by the receiver). This can be derived from the EITschedule information (recommended because of its accuracy) or from an alternative source providing an equivalent level of information. When possible, the accuracy of the EPG should be improved further by use of the EITp/f information.

Note: Broadcasters may delete some or all of the current day's past events during EITschedule updates. Consequently, Receiver should not rely on the information about past events in the broadcast schedule when displaying the EPG.

5.2.2 EPG Updating

When the user accesses the EPG, it shall be displayed regardless of the state of the receiver's schedule database (for example, database is partially populated in the minutes after power-on). In normal operation, the Receiver shall maintain the full EPG up to date and be able to display the full EPG within 10 seconds of selection. The Receiver shall display EPG information as soon as it is received without requiring user interaction to update the display.

5.2.3 EPG and Local time

The EPG shall always display events with the correct local time offset which applies at the time for which the event is billed.

By default, where present, the guidance text should be displayed as part of the programme guide, whenever the synopsis is displayed.

5.3 Secure downloads and updates

5.3.1 Support for downloads

The DTT receiver shall support over-the-air downloads of authorized software.

5.3.2 Over-the-air updates

Over-the-air updates shall use the DVB System Software Update mechanism (DVB-SSU Simple profile) specified in ETSI TS 102 006.

Each software release has a unique model or version reference which shall be used by the Receiver to establish whether it is to be downloaded. The DTT receiver shall only respond to updates that contain this unique identifier. In particular, the Receiver shall not respond to updates targeted at other Receiver models produced by the same manufacturer.

The system shall allow for separate test keys to enable laboratory and field trial tests of new software without affecting the in-field population of decoders.

Receiver shall be supplied with the download mode enabled, such that any updates issued after the production date will immediately be recognized and processed as part of the initial setting up operation.

6. User interface

6.1 Now and Next Banner

6.1.1 Operation

6.1.1.1 The DTT receiver shall be capable of displaying a banner message containing key information for the service and event currently accessed.

The banner shall contain the following minimum information where this is signalled in the SI. If the required information is not present in the SI the decoder shall leave the relevant field blank. The banner shall include:

a) the name and logical channel number of the current service,

b) the name of the current event,

c) the start and end times of the current event,

d) the parental control rating for the current event,

e) the name and start time of the following event,

f) the service options.

6.1.1.2 The DTT receiver shall be able to present the user with information on the present and following event on any channel. The Now and Next Banner shall present this information, allowing the user to navigate the present and following event information for each channel, to access the event description (that consists of a minimum of 300 characters for each event).

6.1.1.3 It shall also be possible to access extended event information by a single press of a key on the RCU whilst the Now and Next Banner is displayed or extended event information displays on Now and Next Banner information.

6.1.1.4 "Service options" refers to an indication of the presence of additional languages, subtitling, interactive services, audio description and other options associated with the current event. Subtitling, interactive service and audio description shall be selectable from the RCU and shall not require access to the menu screens.

6.1.2 Banner triggering

The Now and Next Banner display shall be triggered by a single press of a key on the RCU or the completion of a channel change operation. The banner shall not be triggered at event boundaries.

The banner shall be generated within less than 1 s of the trigger action. For STB receiver Now and Next Banner should have a configurable display time. The banner display time shall be controlled through a parameter field in the STB configuration menu screen.

6.2 On-screen Menu

6.2.1 Operation

6.2.1.1 General

The Main Menu shall provide access to functional features of the DTT receiver, through a structured and explicit organization of these features. Short cuts might be provided to access any of the features with a direct access from the RCU, in addition to the regular access from the menu.

6.2.1.2 Ability to modify menu contents

It shall be possible to modify the contents, structure and operation of the menu structure through the over-air update mechanism.

This shall include the addition of further options within existing pages and also the addition of further pages to the menu structure.

6.2.1.3 PIN access option

The DTT receiver shall provide the option of requiring the entry of a menu access PIN before displaying the parental control menu and allowing access to its option screens.

The operation of this function is defined in 6.5.

6.2.2 Main Menu screen

The Main Menu provides access to all configuration screens, including user preferences and installation. Installation screens are intended for infrequent access by the user, primarily at

initial installation and where manual updates are required. The following menu options are presented:

a) Languages
b) Installation;
c) display;
d) parental control

Each of these options shall link to a set of supplementary screens of information configuration options as defined in 6.2.2.1 to 6.2.2.7.

6.2.2.1 Languages

The languages option shall access a list of languages available for the program currently running, including, in a single list, audio options, subtitles options, and audio description.

Each language shall be accompanied by an icon defining the option as audio, subtitle, or audio description. The list shall include a minimum of two items: the default audio of the program, and "no subtitle". Pressing <OK> on any of the options shall activate it and close the list.

If available, the same list can be accessed with the language key on the RCU.

6.2.2.1.1 Language selection

Pull-down menus exist for each of the following, each containing specified language options:

1) Menu for controlling the language used in the menu screens;

2) Audio for configuring the preferred audio component;

3) Subtitles for configuring the preferred subtitling component.

In each case the default language shall be English original. It shall be possible to override the selected preferences for audio and subtitles by selections made from the languages list, for which information is extracted from the SI / EIT.

6.2.2.2 Installation
6.2.2.2.1   Country Selection
The DTT receiver shall display a country selection menu in which "Ghana" or "West Africa" shall be listed.

6.2.2.2.2   Channel scanning
Channel scanning shall cover the complete range of frequencies as in Table 2.

The following three options shall be available:

    a. a rescan of the required frequency range to locate and add new or changed services;

    b. the deletion of all stored settings and subsequent scan and storage of new ones;

    c. the scan of a single multiplex (manual search: entry of the channel number to be searched).

When the rescan option is selected, the default operation shall be to scan all applicable channels; however, there shall also be a manual option allowing the user to limit the scan to a specific channel.

Where the deletion option is selected, an on-screen warning shall be provided that this action will delete the currently saved channels.

During all scanning operations, the DTT receiver shall provide an indication of progress by displaying the number of the channel currently being scanned and the number of services located or indicate the percentage of the scanning progress. Where a multiplex is encountered, the decoder may display details of its name and network identification, together with the signal strength and quality.

Where more than one multiplex is found to contain the same services, the decoder shall prioritize the one that has the best signal strength and quality. The decoder shall ensure that there is no duplication of entries in the channel list.

6.2.2.2.3   TV settings
The TV settings in (a) to (c) shall be available.

    a) Aspect ratio

        1) 4:3

        2) 16:9

    b) Audio descriptor and audio settings

        1) Audio descriptor on/off,

        2) Audio volume offset,

        3) Audio Language.

    c) RF modulator (for STBs only)

It shall be possible to select the output UHF channel number of the RF modulator

6.2.2.2.4 Service updates

The service update screen shall contain details of the current software and hardware versions stored in the DTT receiver.

In addition, an indication of whether updates are available shall also be provided.

A Scan Update option shall allow the user to check for updates.

Where updates are available, an Initiate Update option shall allow the user to start the update process manually rather than wait for the normal update during standby operation.

6.2.2.2.5 System information and diagnostics

6.2.2.2.5.1 Diagnostics Screen

A diagnostics screen shall provide the following information:

a. hardware and software version numbers;

b. middleware and other resident application version numbers for STB only;

c. the received multiplex's indications of signal strength;

6.2.2.2.5.1.1 Signal strength and quality Indicators

A signal strength Indicator and a signal quality indicator shall be provided for as on screen display.

The on the screen display or bar shall be colour coded to indicate in-tolerance, marginal and out-of-tolerance conditions. The display shall be supported by a text description or colour bar that indicates

a) signal OK or green colour bar,

b) signal marginal or yellow colour bar,

c) signal poor / too low or red colour bar

6.2.2.2.5.1.2 Signal Strength Indicator

The DTT receiver shall be provided with a signal strength indicator (SSI). The value for the SSI shall be referred to the RF signal input.

The absolute accuracy may be ±5 dB at RF signal input levels -80 dBm to -60 dBm and ±7 dB for RF signal input levels higher than -60 dBm. The relative accuracy should be ±3 dB between centre frequencies within one frequency band, e.g. VHF Band III or UHF Band IV/V, supported by the receiver.

Signal strength indicator shall have a relative value within a range from 0% to 100%.

The signal strength indicator shall be updated once per second.

6.2.2.2.5.1.3   Signal Quality Indicator

The DTT receiver shall be provided with a signal quality indicator (SQI). The value for the SQI shall be referred to the RF signal input for DVB-T signals and for DVB-T2 the value for the SQI should be referred to a PLP in the received signal at the RF signal input.

The absolute accuracy of the C/N value reported for DVB-T shall be of ±1dB for C/N values of 17 dB to 27 dB at the RF signal input.

For DVB-T2 the SQI should refer to a PLP in the received signal and its combination of C/N and BER before BCH where the signal quality is weighted by the received C/N. E.g. PLP without bit error before BCH should be weighted with C/N.

The signal quality indicator shall have a relative value within a range from 0% to 100% and with a resolution of 1%.

The signal quality indicator shall be updated once per second.

6.2.2.2.5.1.4   When a multiplex entry is selected, the following information shall be available from OSD screens:

   a) channel number;

   b) signal strength and average error rate according to 6.2.2.2.5.1.2;

   c) Transport stream ID;

   d) Original network ID;

   e) network ID;

   f) service ID

6.2.2.2.5.1.5   An additional text message shall indicate when parameters are out of tolerance, for example: "Low signal level" or "Poor quality signal" or no signal bar is displayed.

6.2.2.2.6   Factory reset

The DTT receiver shall include the provision for restoring the factory default settings in response to a user instruction.

This shall return the Receiver to the state in which it left the factory, with all locally stored data (for example, user preferences, PINs, channel lists, etc.) removed.

In STB only the factory reset function shall also be triggered by a defined sequence of key presses of the front panel buttons, i.e. without the need for an RCU.

6.2.2.3   Display
6.2.2.3.1   Now and Next Banner display time

There shall be a setting to control the duration that the Now and Next Banner is displayed in the STB receiver. Values for the display time options can be defined between 1 s and 10 s in increments of 1 second.

6.2.2.4   Parental control

Parental control parameters support the operation of parental control as described in 6.5. This includes the setting and resetting of PINs for both content access and access to the parental control settings, the activation of the parental control mode, and the setting of the age threshold.

6.3 Operation at first-time switch-on

The DTT receiver when shipped by the manufacturer shall not have any preset information stored in the NVRAM. When the decoder is switched on for the first time and it detects that the NVRAM is clear, a banner shall be displayed indicating that no preset information is present.

The following sequence of configuration screens shall be displayed:
   a) **Language** – the user shall be able to select the language. The language menu shall remain until a language has been selected. This language selection shall define the language of all subsequent menus.
   b) **Region selection** - the user shall be able to select the region (if provided).

c) **Aspect ratio (4:3 or 16:9**) - the user shall be able to select the aspect ratio (for STB only)

d) **Signal acquisition mode** - the user shall be able to select automatic scan or manual channel selection.

(i)   **Automatic scan** – if the user selects this option the full UHF and VHF band as defined in this specification is scanned. The sound channel shall be muted until such time as a valid program is presented.

In the Receiver at completion of the scanning, the following shall be displayed: **"Signal found".**

Subsequently the available program with the lowest program number shall be selected.

6.4 Time and date information

The DTT receiver shall use the time and date information carried in the relevant SI tables, to
provide an On-screen display in the following screens:
- Menu Page
- Now and Next Banner

6.5 Parental control

6.5.1   Operation

It shall be possible to apply parental control on individual events and complete channels. Parental control for individual channels shall be implemented as part of the channel store and preferences function.

Parental control function for an event or channel shall be controlled by the parental rating contained in the EPG (SI, EIT information). The DTT receiver shall suppress both video and audio if the parental rating is above the configuration threshold for the event.

Unblocking of a parentally blocked event shall be done through the entering of a parental pin. Once the event has been unblocked, it shall remain unblocked for the duration of the event. A change away from the channel and back again shall not require PIN re-entry within the timescale of that event.

When a higher rating is applied to an unblocked event the unblocked event shall be blocked and the user will be required to re-enter the parental pin.

Checking of parental control status and subsequent content suppression, if appropriate, shall apply across all state transitions, e.g. at switch on, coming out of standby, at channel change and at event boundaries.

Parental control pin shall be reset by performing a reset to factory settings.

The factory default setting shall be parental control disabled.

6.5.2   On-screen messages

If the user has enabled parental control and the rating of the current event is above the trigger level the DTT receiver shall request the entry of a 4-digit parental control PIN before allowing access to the event.

If an incorrect PIN is entered the decoder shall generate an error message and request re-entry.

During this period it shall be possible to select other services, put the Receiver into standby etc., but these actions shall not reset the timer and the error message shall be displayed whenever the user returns to that event.

6.5.3   Configuration

The Menu structure shall include provision for user configuration of parental control settings including the resetting of the PIN sequence, changing the PIN sequence and setting the minimum age trigger level.

Events higher than the parental rating selected by the user shall be blocked for viewing and allow viewing of content with a lower rating. In the absence of a parental rating for an event all content shall be parentally blocked. The factory default setting shall be parental control disabled.
The DTT receiver shall support ratings as defined in ETSI TR101 211, i.e. minimum age = rating + 3 years.

6.5.4   Operation with radio services

If a radio service is selected the DTT receiver shall display the relevant Now and Next banner once the service is acquired. The banner has the same functionalities and navigation opportunities as for TV channels. Optionally, if details event information is available, the banner shall not time out and shall remain on screen unless alternative content is signalled within SI, in which case the banner should time out as for a television service. The banner shall move over the screen automatically.

7. Remote control unit (RCU)

7.1 Minimum functionality

7.1.1 Protocol

Each DTT receiver shall be supplied with an RCU with which the full functionality of the device shall be operated.

The decoder shall use a standardized RCU protocol.

In the interest of interoperability, it is recommended that manufacturers use the NEC protocol for the RCU.

7.1.2 Infrared receiver frequency

The infrared carrier frequency for the RCU shall be 38 kHz.

7.1.3 Keys and layout

7.1.3.1 It shall be possible to perform the following functions by means of the RCU:

a) enter the program channel number by numeric keys;

b) access and navigate the menu structure;

c) access the Electronic Program Guide (Now and Next Banner and Event) and program information;

d) confirm an option selection;

e) control the on-screen cursor (up, down, left, right);

f) exit from the menu and information structure;

g) select the next service up or down (P+ and P−);

h) increase or decrease the audio level;

i) adjust the audio level to zero (mute) and restore back to previous setting;

j) display and suppress subtitles;

k) toggle between normal and standby operation;

l) toggle between television and radio services (for STB only);

m) provide a short cut to interactive services and overlay text.

7.1.3.2 The RCU may implement all the keys in accordance with the HbbTV profile (**ETSI TS 102 796 V.1.1.1**).

7.1.4   Operation

7.1.4.1 Response time

The design of the DTT receiver and the RCU operating system shall ensure a maximum time of 100 ms between the release of the key and the commencement of the specified response.

7.1.4.2 Channel entry

All television, radio and interactive services will be assigned a three-digit LCN. The RCU shall be configured for three-digit LCN operation.

7.1.4.3 N-key rollover

The design of the keypad and the RCU operating system shall prevent unintended repeated entries. This shall include a delay of 100 ms between the completion of a key press and the recognition of the next entry.

7.2 Alternative RCU design

It is recommended that manufacturers make available alternative RCUs for those with impaired vision or impaired manual dexterity (e.g. over-sized keys and character fonts, shaped keys).

7.3 Reliability

7.3.1   Robustness

The RCU shall be designed to withstand frequent usage; it shall have a robust case which is resistant to damage when being dropped onto hard surfaces.

7.3.2 Environmental

The RCU shall be designed to work in the same environmental conditions (i.e. ambient temperature and humidity) as the DTT receiver.

7.4 Packaging

The RCU shall be included in the same shipping carton as the DTT receiver. The internal packaging shall be sufficient to prevent any damage or scuffing to the RCU during transit. Batteries shall be provided separately and packaged to prevent accidental short circuiting during transit.

8. Compliance

8.1 Health and safety

The DTT receiver and all accessories shall comply with IEC 60065 *Audio, video and similar electronic apparatus – Safety requirements*.

8.2 Electromagnetic compatibility (EMC)

8.2.1   The DTT receiver and all accessories shall comply with the following standards:

   a) Emissions: CISPR 13, S*ound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement*

   b) Immunity: CISPR 20, *Sound and television broadcast receivers and associated equipment – Immunity characteristics – Limits and methods of measurement*

8.3 Performance

Compliance of the DTT receiver and the RCU with the performance requirements shall be tested using the relevant test methods which shall be defined as part of the conformance regime.

9. Accessories

9.1 The Receiver shall be supplied with the accessories given in 9.2 to 9.8.

9.2 **STB only:** 230 V a.c. to 12 V d.c. converter.

9.3 **Mains cord set**, of length at least 1.5 m and incorporates a plug and an appliance connector Type G British BS-1363.

9.4 **Composite (CVBS) video/stereo audio cable**, of length at least 1.5 m, terminated with RCA connectors (only for STB).

9.5 **Remote control unit (RCU)**, that complies with the requirements in clause 7, together with "AA" or "AAA" sized batteries.

9.6 **User manual** in English (Paper/Electronic).

9.7 **Quick guide** (in English), that contains a basic wiring diagram, which shows alternative connections for installations with and without a VCR, and with and without baseband (video and audio) input to the television display.

10. Packaging

10.1 The DTT receiver shall be securely packaged to protect it against possible damage during transit.

10.2 The packaging shall contain all the accessories set out in clause 9, and the following information which shall be visible on the outside of the packaging:
   a. the identification of the manufacturer;

   b. the model number of the decoder;

   c. the serial number of the decoder.

10.3 The means of disposal for the DTT receiver shall be indicated on the packaging and in the user manual.