NATIONAL COMMUNICATIONS AUTHORITY

MINIMUM REQUIREMENTS FOR RECEPTION OF DIGITAL TERRESTRIAL AND SATELLITE TELEVISION SERVICES FROM THE NATIONAL DIGITAL TELEVISION NETWORK

v1.0

December 2019

1 VERSION OF THE DOCUMENT

Date	Version	Comments
December, 2019	1.0	First official publication

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3 REFERENCES

The following referenced documents are indispensable for the application of this document. Information on currently valid national and international standards can be obtained from the Ghana Standards Authority.

[1] **ETSI EN 302 755 V.1.4.1**, Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2);

[2] **ETSI TS 101 162 V1.5.1**, Digital Video Broadcasting (DVB); Allocation of identifiers and codes for Digital Video Broadcasting (DVB) systems;

[3] **ETSI TS 102 773 1.3.1,** Digital Video Broadcasting (DVB); Modulator Interface (T2-MI) for a second generation digital terrestrial television broadcasting system (DVB-T2);

[4] **ETSI TS 102 831 V1.2.1**, Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2);

[5] **ETSI TS 102 992 V1.1.1**, Digital Video Broadcasting (DVB); Structure and modulation of optional transmitter signatures (T2-TX-SIG) for use with the DVB-T2 second generation digital terrestrial television broadcasting system;

[6] **ETSI EN 300 468 V1.13.1**, Specification for Service Information (SI) in DVB systems;

[7] **ETSI TS 101 211 V1.11.1**, Digital Video Broadcasting (DVB); Guidelines on implementation and usage of Service Information (SI);

[8] **ETSI EN 300 472 V1.3.1**, Digital Video Broadcasting (DVB); Specification for conveying ITU-R System B Teletext in DVB bitstreams;

[9] **ETSI EN 300 743 V1.4.1**, Digital Video Broadcasting (DVB); Subtitling systems;

[10] **ETSI TS 102 006 V1.3.2**, Digital Video Broadcasting (DVB); Specification for System Software Update in DVB Systems;

[11] **ETSI TS 101 154 V1.11.1**, Digital Video Broadcasting (DVB); Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream;

[12] **ISO/IEC 14496-1:2010/Amd 1:2010**, Synchronization and multiplexing of video and audio;

[13] **ISO/IEC 14496-3:2009/Amd 1:2009**, *Coding of audio-visual objects;*

[14] **ISO/IEC 14496-10:2012** Advanced video coding (AVC);

[15] **ETSI TS 102 366 V1.2.1**, Digital Audio Compression (AC-3, E-AC-3) Standard

[16] **ITU-R BT.624-4 (1990)**, Characteristics of television systems.

[17] **ETSI TS 102 796 V.1.1.1,** Hybrid Broadcast Broadband TV (HbbTV)

[18] **CI Plus Specification V.1.3(2011)**, Content Security Extensions to the Common Interface

[19] **Nordig Unified V2.4** NorDig Unified Requirements for Integrated Receiver Decoders for use in cable, satellite, terrestrial and IP-based networks

[20] ETSI EN 302 307 v1.2.1, Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)

4 LIST OF ABBREVIATIONS AND SYMBOLS

AC-3	Audio coding 3 (Dolby Digital)
AD	audio description
AFC	automatic frequency control
AFD	active format descriptor
AFNOR	Association Francaise de Normalisation
AM	Audience Measurement
API	Application Programming Interface
ARC	Audio Return Channel of an HDMI input
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
CAS	Conditional Access System
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
DAF	Digital Access Fee
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
DRM	Digital Rights Management
DSB	Double Side Band
DSM-CC	Digital Storage Media Command and Control
DTT	digital terrestrial television
DTH	Direct To Home

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-S2	Second Generation Digital Video Broadcasting - Satellite
DVB-T2	Second generation digital terrestrial television broadcasting system
DVB-T	DVB-Terrestrial
E-AC3	Enhanced audio coding 3 (Dolby Digital Plus)
E-EDID	Enhanced Extended Display Identification Data
EBU	European Broadcasting Union
ECCA	European Cable Communications Association
ECL	Euro Cable Labs, 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
OTT	Over The Top
PAL	phase alternating line
PAPR	Peak-to-Average-Power Ratio
PAT	Program Association Table
PCM	pulse code modulation
PCR	Programme Clock Reference
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
PVOD	Push Video On Demand
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
VAS	Value Added Services
VCR	video cassette recorder
VHF	very high frequency
VHS	Video Home System
VOD	Video On Demand
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)

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7 INTRODUCTION

7.1 Background

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.

The Ministry of Communications (MoC) is the agency of Government responsible for policy formulation for electronic communications. The MoC is leading the national efforts towards the completion of a transition from analogue to digital terrestrial television in conformance with the Geneva, 2006 (GE06) Agreement of the International Telecommunications Union (ITU). The GE06 Agreement requires a transition of television broadcasting services in the frequency band 174–230 MHz (VHF Band III) from analogue to digital technology by 17 June 2020 and those in the bands 470–582 MHz (UHF Band IV) and 582– 862 MHz (UHF V) by 17 June 2015. It is anticipated that the analogue TV network will be switched off by the Fourth Quarter of 2020.

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.

7.1.1 Minimum Receiver Specifications

The Ghana Standards Authority (GSA), the statutory body responsible for the development and promulgation of Ghana Standards, published Ghana Standard, GS 1099 in 2014 which sets out the Minimum Technical Specification of Digital Terrestrial Television (DTT) receivers in Ghana. The NCA, pursuant to its mandate under Section 3(a) of the National Communications Authority Act, 2008, Act 769, established a conformance regime to enforce conformance to the minimum

specifications.

In 2018, the Ghana Standards Authority commenced a review of GS1099 to include additional features and introduce minimum requirements for Direct-To-Home (DTH) satellite Receivers for Free to Air Television Reception in Ghana. This specification was published in 2019 as GS1099:2019: Ghana Minimum Technical Specifications of Digitial Terrestrial Television (DTT) & Direct-to-Home (DTH) Receivers for Free-to-Air Television Reception.

In 2019, the Government of Ghana revised its policy on the transition from analogue to digital television. The new policy introduced a Digital Access Fee (DAF) to replace the existing TV licensing fee for TV receivers imposed by the Television Licensing Decree, 1966, (N.L.C.D. 89). The Policy also requires that Conditional Access (CA) and middleware technology should be employed for the collection of DAF. The additional features are necessary to support the robust and secure collection of Digital Access Fee (DAF) and support the future provision of value added services (VAS) such as Audience Measurement (AM), Internet Protocol (IP) Hybrid functionality i.e. Over the Top (OTT) Video on Demand (VOD) services and an Electronic Program Guide (EPG). This Policy decision will require that Free-to-Air services are encrypted and made available only to viewers who have paid the DAF. Consequently, the receivers for DTT and DTH services delivered via the National Digital Television Network built by the Government of Ghana shall require the appropriate CA and middleware in order to function properly.

This document therefore sets forth, the requirements for receivers intended to receive terrestrial or satellite television programmes delivered via the National Digital Television Network in Ghana. Private Pay TV operators may employ their own conditional access systems for their Pay TV services as they are already doing.

This document applies to Set-top-boxes (STBs). 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.

7.1.2 DTT STBs

During the digital television transition, 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.

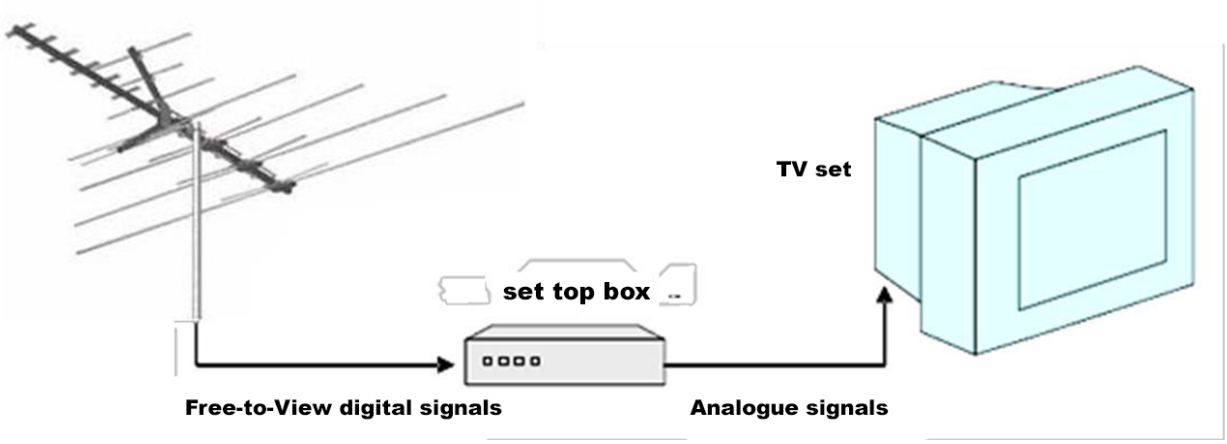

Figure 1: Reception of DTT signals using analogue TV Set and a set top box

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. Viewers using DVB-T2/MPEG-4 integreated digital TV sets without the conditional access module specified in this document may not be able to receive programmes from the National Digital Television Network and would also need a set-top box.

7.1.3 DTH STBs

Viewers who are in areas where receiving DTT signals are not available would need an STB capable of receiving the DTH service.

The requirements are identical to those for DTT, except that a DTH STB and satellite dish are required.

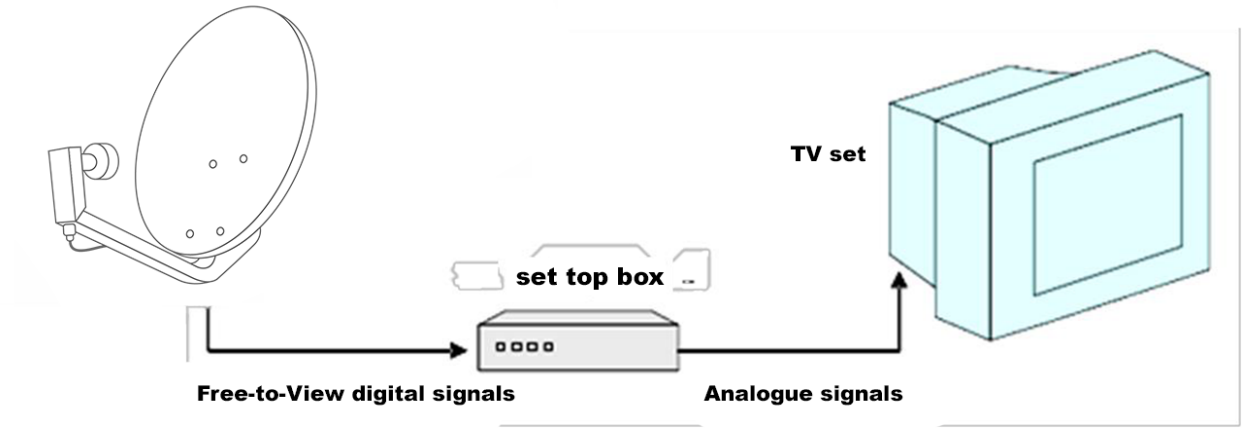

Figure 2: Reception of DTH TV signals using analogue TV Set and a set top box

7.1.4 Conformance Regime

The National Communications Authority shall publish a revised conformance regime for the enforcement of TV receiver specifications in Ghana.

8 SCOPE

This standard sets out the minimum technical requirements for high definition STB receivers for free-to-view DTT/DTH television services in Ghana delivered from the National Digital Television Network.

Compliance to this standard is mandatory for free-to-view DTT/DTH receivers expected to receive services in Ghana delivered from the National Digital Television Network established by the Government of Ghana.

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

All High Definition (HD) functionalities shall be mandatory for all DTT/DTH Receivers.

The standard concerns:

(a) Broadcasters;
(b) Broadcasting signal distributors;
(c) STB manufacturers;
(d) TV and STB dealers and sellers;
(e) TV installers;
(f) General public.

9 DEFINITIONS

For the purposes of this document, the following definitions are used.

8.1 The term "**STB'** or '**STB receiver**' in this document refers to a set top box that the consumer purchases in order to use free-to-view DTT/DTH services in Ghana.

8.2 The term '**Receiver'** or '**DTT receiver**' or '**DTH receiver'** in this document refers to an STB that the consumer purchases in order to use free-to-view DTT/DTH services in Ghana

8.3 The term "**shall**" indicates that a requirement is mandatory.

8.4 The term "**should**" indicates that a requirement is highly recommended, but not mandatory.

8.5 The term "**may**" indicates that a requirement is optional.

8.6 The term "Audio Description" refers to an ancillary service primarily provided for the visually impaired that provides a spoken description of the video component of a service;

8.7 The term "**Digital Terrestrial Television"** or **"DTT"** refers to Terrestrial delivery of digital transmissions in the UHF/VHF frequency bands using the DVB-T2 standard as set out in [1];

8.8 The term "**Direct To Home"**, or **"DTH"** refers to Satellite delivery of digital transmissions using the DVB-S2 standard as set out in [20];

8.9 The term **"Free-to-View"** or **"FTV"** refers to a digital TV service which is provided free-of-charge without any form of continual subscription but is nevertheless encrypted;

8.10 The term **"Multiplex"** or **"MUX"** refers to Group of digital terrestrial television or audio program channels or data services that are combined together into one output signal for broadcast;

8.11 The term **"Private Data Stream"** refers to a DVB data stream designed for a specific application which is ignored by other DVB decoders that are not designed to use the data;

8.12 The term **"Analogue Systems"** refers to legacy analogue TV. The Analogue System used in Ghana is PAL B/G;

8.13 The term **"Conditional Access System",** or **"CAS"** refers to the protection of TV content by requiring certain criteria to be met before granting access to the content;

8.14 The term **"Middleware Client"** refers to the runtime environment for the Middleware Application and support for additional broadcast and IP data services;

8.15 The term **"Middleware Application"** refers to a downloadable application which renders the user interface, provides the EPG, interactive services, Push VOD and audience measurement.

8.16 The term **"Value-Added Service"**, or **"VAS"** refers to a service over and above those offered by DVB which create additional consumer opportunities to receive content for entertainment, information or education.

10 PERFORMANCE REQUIREMENTS (Common DTT/DTH)

Table 1 indicates some of the major hardware and firmware functions in the Receiver. Detailed requirements are specified in the appropriate performance requirement.

Table 1: Main hardware/firmware functions for the Receiver

Video Profiles	
MPEG-4 AVC HP@L3 SDTV	M
MPEG-4 AVC HP@L4 HDTV	M
Audio decoding/processing	
MPEG-1 Layer II (Musicam)	O
E-AC3, including down-mix to stereo	O
E-AC3 (E-AC3 converted to AC3) digital output	O
HE-AAC V2 Level 4 digital output and converted to either AC-3 or DTS	O
HE-AAC V2 Level 4 down mix to stereo	M
Subtitling	
DVB (SDTV) subtitling	M
DVB (HDTV) subtitling support for DDS	O
API	
DVB HbbTV	O
Security	
Verimatrix VCAS 4.3.3 (Ultra Security)	M
Smart Card Reader	M
Middleware	
Verimatrix Middleware Client	M
Verimatrix Middleware Application	M
Value Added Services[1]	
DAF Collection	M
Audience Measurement	M
PVOD	M
Connected Services	M
Interfaces	

[1] This is not an exhaustive list of all Value Added Services which manufacturers may wish to build into their product but simply lists those features which are mandatory within this Specification

DVB-T2/S2 front end	M
UHF re-modulator	O
RF female input connector	M
RF male output connector	O
Analogue SD video output	M
HDMI output	M
HDMI ARC	O
S/PDIF output	O
Analogue audio left output	M
Analogue audio right output	M
12V DC input	M
100 – 250V AC, 50Hz (±2%)	O

10.1 DEMULTIPLEXING AND DECODING

10.1.1 Support of MPEG-4

The STB decoder shall support H.264 level 3, as defined in [14], decoding for standard definition display.

The transport stream shall comply with [12], and the video profile level shall be Main profile level 3 in accordance with [14].

Receivers shall support the following minimum set of resolutions and frame rates:

Table 2: Video Decoder — resolutions and frame rates

Resolution	Frame Rate	Scanning	Aspect Ratio	Profile
720 × 576	25	Interlaced	4:3 or 16:9	AVC HP@L3
1280 × 720	50	Progressive	16:9	AVC HP@L4
1440 × 1 080	25	Interlaced	16:9	AVC HP@L4
1920 × 1 080	25	Interlaced	16:9	AVC HP@L4
1920 × 1 080	25	Progressive	16:9	AVC HP@L4

10.1.1.1 *Video*

Video decoding shall be in accordance with 10.1.1. Receivers shall down convert HD content on SD outputs.

10.1.1.1.1 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 720x576i (25fps) in 4:3 frame aspect ratio or 16:9 frame aspect ratio video with colours according to the standards listed in Table 3.

Table 3: 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.

10.1.1.1.2 Aspect Ratio

The 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 **[11]**.

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

The STB 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 STB Receiver should select the display mode providing the best possible video quality. This is to avoid the STB 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 STB 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.

10.1.1.1.3 *Support of still pictures*

The 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.

10.1.1.2 Output for STBs

If the STB decoder uses a re-modulator, all Analog Systems, listed in section 8.12, modulated SD video and audio signal shall be presented as prescribed in section 10.2 on a connector as defined in section 10.14.

The STB decoder shall also provide a composite (CVBS) video output on a RCA socket as defined in section 10.14. The composite video signal levels shall be in accordance with ISO / IEC 61938. For HD services, the decoder shall derive a down-converted version for output via this interface as described in section 10.1.1.1.1. The decoder shall provide a single HDMI output for HD content.

10.1.2 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.

10.1.2.1 *General*

The Receiver shall support decoding of HE-AAC v1 Level 4 and HE-AAC v2 Level 4 in accordance with [13] and [11].

The Dynamic Range Control tool as defined in Section 6.4.3 of [11] and the MPEG4 Audio ancillary Data as defined in Annex C.5 of [11] shall be supported with the exception of Presentation Mode as defined in C.5.4 of [11]. The support of Presentation Modes as defined in C.5.4 of [11] shall be optional.

Receivers shall support decoding of HE-AAC v2 Level 4 bit streams. Receivers should support conversion of HE-AAC v2 Level 4 streams to either an AC-3 or DTS bit stream for output via S/PDIF or HDMI ARC. Pass through of the HE-AAC v2 Level 4 bit stream over S/PDIF or HDMI ARC may be supported.

Receivers should support decoding of E-AC-3 elementary streams. Receivers should also support conversion of E-AC-3 elementary streams to an AC-3 bitstream for output via HDMI and S/PDIF. 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.

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.

10.1.2.2 Bit Rate

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

10.1.2.3 Sampling Frequency

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

10.1.2.4 Audio Description

Receivers shall be capable to simultaneously decode the main program and an associated audio description stream both encoded with HE-AAC. The associated audio description stream shall contain only a mono signal and shall use the same sampling frequency as the main program. The mixing of the two streams shall be done according to ETSI TS 101 154 Annex E.

Receivers should be capable of simultaneously decoding two different programme elements (Main Audio and Audio Description) carried in two separate E-AC-3 elementary streams. 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.

10.1.2.4.1 Sampling frequency

The Audio Description HD decoder should 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.

10.1.2.4.2 Substream support

Enhanced AC-3_Descriptor substreamN_flag shall always be set to 0b0.

10.1.2.4.3 Mixing metadata

The Audio Description HD decoder should 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.

10.1.2.4.4 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.

10.1.2.5 Mono-audio for STB Receivers

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.

10.1.2.6 Audio Outputs

10.1.2.6.1 HDMI outputs

The Receiver shall include an HDMI output, as described in section 10.14, and the following audio-specific requirements shall be implemented:

a) 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 HE-AAC decoding, the Receiver may output the HE-AAC elementary stream directly to the HDMI sink device.
c) If the HDMI sink device indicates support for E-AC-3 decoding, the Receiver may output the E-AC-3 elementary stream directly to the HDMI sink device.
d) If the HDMI sink device does not indicate support for HE-AAC decoding, but supports AC-3 or DTS decoding, the Receiver may convert the HE-AAC bit stream to an AC-3 or DTS bit stream prior to HDMI output.
e) If the HDMI sink device does not indicate support for E-AC-3 decoding, but supports AC-3 decoding, the Receiver may convert the E-AC-3 elementary stream to an AC-3 bitstream prior to HDMI output.
f) If the sink device does not indicate support for either HE-AAC, AC-3 or E-AC-3 decoding, or the user has selected “stereo” output via the on screen menu, the Receiver may decode the elementary stream to stereo PCM prior to HDMI output.

10.1.2.6.2 HDMI inputs with ARC output

If reading E-EDID of the HDMI sink device is supported then the following audio-specific requirements should be implemented:

a) If the HDMI sink device indicates support for HE-AAC decoding, the Receiver may output the HE-AAC elementary stream directly to the HDMI sink device over the ARC
b) If the HDMI sink device indicates support for E-AC-3 decoding, the Receiver may output the E-AC-3 elementary stream directly to the HDMI sink device over the ARC
c) If the HDMI sink device does not indicate support for HE-AAC decoding, but supports AC-3 or DTS decoding, the Receiver may convert the HE-AAC bit stream to an AC-3 or DTS bit stream prior to the transport over HDMI ARC
d) If the HDMI sink device does not indicate support for E-AC-3 decoding, but supports AC-3 decoding, the Receiver may convert the E-AC-3 elementary stream to an AC-3 bit stream prior to the transport over HDMI ARC
e) If the sink device does not indicate support for either HE-AAC, AC-3 or E-AC-3 decoding, or the user has selected “stereo” output via the on screen menu, the Receiver may decode the elementary stream to stereo PCM prior to transport over HDMI ARC.

If reading E-EDID of the HDMI sink device is not supported then the following audio-specific requirements shall be implemented:

a) Convert the E-AC-3 elementary stream to AC-3 prior to HDMI ARC output. (optional)

b) Convert the HE-AAC bit stream to either AC-3 or DTS prior to HDMI ARC output. (optional)
c) Pass through the HE-AAC bit stream on HDMI ARC output. (optional)
d) If the user has selected “stereo” output via the on screen menu, the Receiver shall decode the elementary stream to stereo PCM prior to HDMI ARC output.

10.1.2.6.3 S/PDIF Audio outputs

The Receiver may include an S/PDIF output, as described in section 10.14 and the following requirements shall be implemented:
a) Convert the E-AC-3 elementary stream to AC-3 prior to S/PDIF output. (optional)
b) Pass through the HE-AAC bit stream. (optional)
c) If the user has selected “stereo” output via the on screen menu, the HD receiver shall decode the elementary stream to stereo PCM prior to S/PDIF output.

The Receiver may include an S/PDIF output, as described in section 10.14 and the following requirements shall be implemented:
a) Convert the E-AC-3 elementary stream to AC-3 prior to S/PDIF output. (optional)
b) Convert the HE-AAC bit stream to either AC-3 or DTS prior to S/PDIF output. (optional)
c) Pass through the HE-AAC bit stream. (optional)
d) If the user has selected “stereo” output via the on- screen menu, the Receiver shall decode the elementary stream to stereo PCM prior to S/PDIF output.

10.1.2.6.4 Analogue audio outputs

The Receiver shall include an analogue audio output, as described in section 10.14 and decode the audio elementary stream prior to analogue audio output.

10.2 UHF re-modulator

Receivers may provide a UHF re-modulated output for use with Analog Systems, listed in section 8.12, and it shall:

a) modulate the decoded baseband signal onto Analog Systems, listed in section 8.12, in accordance with [16], 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 Analog Systems, listed in section 8.12, 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 4): 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.

If the Receiver provides a UHF re-modulator, 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.

10.3 RECEIVER SECURITY

Receiver security shall be provided by Verimatrix CAS with the following requirements:

VCAS 4.3.3 (Ultra Security)

Verimatrix VCAS provides content security features on the STB receiver and incorporates conditional access (CA) and rights management to protect broadcast TV services and Push VOD content.

A Smart Card reader with external card slot is required. Smart Cards are not intended to be used except as a remedial solution in the event of a security breach of the cardless CAS.

10.4 MIDDLEWARE CLIENT AND APPLICATION

Receiver shall integrate the following software components in addition to the manufacturer software stack:

Verimatrix Middleware Client version 8.12.47 or later
Verimatrix Middleware Application version 7.110.13.1 or later

10.5 SECURE SOFTWARE UPDATES

10.5.1 Support for Downloads

Receiver shall support over-the-air downloads of authorized software. Receiver shall support the Verimatrix secure loader to prevent unauthorized software downloads.

10.5.2 Over-the-air Updates

Over-the-air updates shall use the DVB System Software Update mechanism (DVB-SSU Enhanced profile) specified in [10]. Enhanced profile is used to benefit from the additional STB targeting capabilities. All receivers must parse the UNT stream to identify correct downloads.

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 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.

Receiver shall be supplied with the download mode enabled, such that any updates issued after the production date will immediately be recognized.

10.6 SUBTITLING

The Receiver shall be capable of displaying subtitles for the hearing impaired in accordance with [9].
The Receiver 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.

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 may 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 subtitle or 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 and supported by the receiver.

10.7 MEMORY

The STB shall have a minimum memory capacity as necessary to deliver the mandatory features, typically:

a) 128Mbytes Flash memory,
b) 256 Mbytes RAM.

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

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

The memory specification has been chosen to allow for the lowest component price whilst also being capable of delivering the mandated functionality, 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.

10.8 GRAPHICS CAPABILITIES

A minimum of two OSD graphics planes should be supported on the STB receiver. OSD graphics from the Middleware Application shall be rendered to one OSD graphics plane. DVB subtitles shall be rendered into a separate hardware graphics plane that can support 8bpp pixel data as a minimum.

Subtitles are always positioned directly in front of the video plane behind the main graphics.
The OSD graphics layer for the Middleware Application shall have a resolution of 1280 x 720. The OSD graphics layer for the Middleware Application shall support 32 bpp ARGB8888 colour space.

The underlying graphics stack shall scale the OSD graphics plane to match the following HDMI output resolutions:

768 x 576
1280 x 720
1920 x 1080i

The underlying graphics stack shall scale the OSD graphics plane to 720 x 576 for analogue output.

10.9 STANDBY OPERATION

10.9.1 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.

10.9.2 Active standby operation

In case it is not possible to provide a passive standby with the power requirements in section 10.10.4(c), the Receiver shall provide an active standby state.

After selecting standby the STB receiver may remain in active standby for 5 min before switching to passive standby. The middleware application may extend the active standby period for longer or switch between passive and active standby where it is required to do so to meet the VAS requirements e.g. Push VOD download.

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

10.9.3 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) Receiver Off to Service display: a maximum of 40s;
b) Active Standby to Service display: a maximum of 5s;
c) Passive Standby to Service display: a maximum of 40s.

10.9.4 Power consumption for STBs

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.

10.10 STB LED indications

The STB receiver shall have one bi-colour on the front panel indicating power status and IR function flash.

10.11 Front Panel Controls

The following controls shall be provided on the front panel of STB receiver:

- Program selector P+ and P−;
- Standby/On.

10.12 IP Networking

The Receiver must support IPv4, ICMP, IGMPv3, TCP and UDP.

The IP network stack must support filtering, prioritisation and measurement of traffic based on protocol, source, destination and originating process.

The Receiver must support DHCP and manual configuration of network interfaces, the following parameters must be configurable:
IP Address
Subnet mask
Default gateway
DNS Server Address

The IP stack must be capable of handling a throughput of at least three concurrent 10 Mb/s TCP sessions. The IP stack must be able to handle an encrypted TLS session with a throughput of 8 Mb/s (RC4) or 4Mb/s (AES128) without significant impact on the functionality of other functions.
The STB receiver shall support streaming on demand video using the following protocols:

Protocol Containers

HTTP Progressive Download MPEG-2 SPTS, MP4

Adaptive bitrate streaming over HTTP MPEG-2 SPTS, MP4

Live streaming using UDP MPEG-2 SPTS

The Receiver shall support background downloading of content via IP. Content download shall be performed as an HTTP or HTTPS GET.

The Receiver shall support MPEG-1 layer III audio elementary streams.

10.13 Connectors

The following connectors shall be used:

a) An RF input female connector that complies with IEC 61169-2 or IEC 611969-24 (type F).
b) An RF output male connector that complies with IEC 61169-2 or IEC 611969-24 (type F) for STB receiver.
c) UHF re-modulated output [optional].
d) Colour-coded RCA sockets for composite (CVBS) video and stereo audio output, or 3.5mm jack with suitable RCA terminated cable supplied.
e) 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.
f) 2 USB 2.0 ports via a USB type A jack Each port should be USB2.0 or USB2.0 compatible. Data write performance to the mass storage device should be at least 15Mb/s. Data read performance from the mass storage device should be at least 12Mb/s. Data read/write performance to the WiFi adapter should be at least 300Mb/s. [mandatory].
g) HDMI output – type A [mandatory]
h) S/PDIF output [optional]
i) The use of a C8 AC power inlet in accordance with IEC 60320-1 for the power supply built into the Receiver.

10.14 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.
d) Normative voltage and frequency.

The above items a, b &c shall also be available in the software of the Receiver.

11 PERFORMANCE REQUIREMENTS (DTT)

11.1 SPECTRUM AND DTT MODULATION AND CODING

11.1.1 Spectrum

The Receiver shall operate within the VHF and UHF television broadcasting bands as shown in Table 4.

Table 4*: Mandatory Frequency Bands*

	Band	Frequency Range	Bandwidth	Centre Freq.	Requirement
VHF	VHF III	174 – 230 MHz	7 MHz	7 MHz	**Mandatory**
	VHF III	174 – 230 MHz	8 MHz	8 MHz	**Mandatory**
UHF	UHF IV	470 – 582 MHz	8 MHz	8 MHz	**Mandatory**
	UHF V	582 – 862 MHz	8 MHz	8 MHz	**Mandatory**

The receiver shall scan the 7MHz Centre frequency (E.g. 177.5, 184.5, 191.5, 198.5, 205.5, 212.5, 219.5 & 226.5) for 7 MHz bandwidth in VHF Band III.

The receiver shall scan the 8MHz Centre frequency (E.g.474.0, 482.0, 490.0, 498.0, 506.0, 514.0, 522.0) for 8 MHz bandwidth in UHF Bands IV & V.

11.2 DTT modulation and Coding

The receiver shall support the different mode of operation referenced in the standard [1]. 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 [1].

11.3 RADIO FREQUENCY

11.3.1 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 302 755. It shall be capable of receiving transmissions broadcast with any allowable combination of modulation and transmission parameters as shown in Table 5:

Table 5*: Modulation and transmission parameters*

	ETSI EN 302 755
Constellation	**QPSK, 16-QAM, 64-QAM, 256-QAM; both rotated and non-rotated**
Code Rate	**1/2, 3/5, 2/3, 3/4, 4/5, 5/6**
Guard Interval	**1/128, 1/32, 1/16, Tu19/256, Tu/8, Tu19/128, Tu/4**

Transmission mode	**1K, 2K, 4K, 8K normal and extended, 16K normal and extended, 32K normal and extended**
Pilot pattern	**PP1, PP2, PP3, PP4, PP5, PP6, PP7**
SISO/ MISO	**both to be supported**
PAPR	**No PAPR used, ACE-PAPR only used, TR-PAPR only used, ACE and TR PAPR are used;**
FEC Frame length	**64800, 16200**
Input Mode	**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	**Optional**
Time Frequency Slicing (TFS)	**Optional**
Normal Mode or High Efficiency Mode	**Both Modes to be Supported**
FEF and Auxiliary streams	**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.**
DVB-T2 Lite	**Optional**
Scrambling of L1 post signalling	**L1_POST_SCRAMBLED Support is Mandatory**

Table 6*: A limited set of DVB-T2 modes for performance requirements*

1	2	3	4	5	6
Identifier	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
Band	VHF III 7MHz SFN	UHF IV/V 8MHz SFN	VHF III 7MHz SFN	UHF IV/V 8MHz MFN	VHF III 7MHz MFN
Transmission Mode	32K extended	32K extended	32K normal	32K extended	32K normal
Constellation	256 QAM ROT	256 QAM ROT	256 QAM ROT	256 QAM ROT	256 QAM ROT
Code rate	3/4	2/3	2/3	3/4	3/4
Guard Interval	1/8 448us	19/256 266us	19/256 304us	1/128 28us	1/128 32us
Pilot Pattern	PP2	PP4	PP4	PP7	PP7
PAPR	TR-PAPR	TR-PAPR	TR-PAPR	TR-PAPR	TR-PAPR
System Characterization (SISO/MISO)	SISO	SISO	SISO	SISO	SISO
FEC Frame Length	64800	64800	64800	64800	64800
Input Mode	Single PLP	Single PLP	Single PLP	Single PLP	Single PLP
TFS	No	No	No	No	No
Normal Mode (NM) / High Efficiency Mode (HEM)	HEM	HEM	HEM	HEM	HEM

1	2	3	4	5	6
Identifier	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
Band	VHF III 7MHz SFN	UHF IV/V 8MHz SFN	VHF III 7MHz SFN	UHF IV/V 8MHz MFN	VHF III 7MHz MFN
FEF	Not used	Not used	Not used	Not used	Not used
Auxiliary streams	Not used	Not used	Not used	Not used	Not used
L1 Modulation	64 QAM	64 QAM	64 QAM	64 QAM	64 QAM
TIME_IL_LENGTH	3	3	2	3	3
TIME_IL_TYPE	0	0	0	0	0
Frame_Interval (I_JUMP)	1	1	1	1	1
Lf (no of symbols/frame)	60	62	42	60	60
No. of FEC blocks per interleaving frame	185	200	132	200	195
Bitrates (Mbits/s)	**37.12**	**36.15**	**30.81**	**44.79**	**38.21**

Table 7: Performance Requirements for the limited set of DVB-T2 modes

	Identifier	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
	Band	UHF IV/V 8MHz SFN	UHF IV/V 8MHz 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	20.4	21.7	21.7
2.0	C/N Performance on 0dB echo channel (dB)	27.9	24.6	24.6	26.6	26.6
3.0	Minimum receiver signal input levels on Gaussian channel (dBm)	-76.2	-78.7	-79.3	-77.4	-78.0
4.0	Minimum receiver signal input levels on 0dB echo channel	-71.2	-74.5	-75.1	-72.5	-73.1
5.0	Receiver noise	6.0	6.0	6.0	6.0	6.0

	Identifier Band	Mode 1 UHF IV/V 8MHz SFN	Mode 2 UHF IV/V 8MHz SFN	Mode 3 VHF III 7MHz SFN	Mode 4 UHF IV/V 8MHz MFN	Mode 5 VHF III 7MHz MFN
	figure on Gaussian channel (dB)					
6.0	Maximum receiver signal input levels (dBm)	-35.0	-35.0	-35.0	-35.0	-35.0
7.0	**Immunity to "digital" signals in Other Channels**					
	Digital ACI N+/-1 C/I (dB)	28.0	28.0	28	28.0	28
	Digital ACI other channels C/I (dB)	38.0	38.0	38.0	38.0	38.0
8.0	**Immunity to Co-Channel Interference from Analogue TV Signals**					
	PAL B/G & SECAM-K CCI C/I (dB)	7.0	5.0	5.0	7.0	7.0

	Identifier	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
	Band	UHF IV/V 8MHz SFN	UHF IV/V 8MHz SFN	VHF III 7MHz SFN	UHF IV/V 8MHz MFN	VHF III 7MHz MFN
9.0	**Immunity to Adjacent Channel Interference From Analogue TV Signals**					
	PAL B/G & SECAM-K ACI C/I N+/-1 (dB)	33.0	33.0	33.0 Note 4	33.0	33.0 Note 4
	PAL B/G & SECAM-K ACI other channels C/I (dB)	40.0	40.0	40.0	40.0	40.0
10.0	Performance in Time-Varying Channels 10Hz doppler (5Hz after AFC) 20µs 0dB echo	3 dB	3 dB	3 dB	3 dB	3 dB
11.0	Synchronisation for varying echo power levels in SFN (dB)	31.0	28.1	28.1	31.0	31.0
12.0	C/(N+I) Performance in Single Frequency Networks for more	27.9	24.6	24.6	26.6	26.6

	Identifier	Mode 1		Mode 2		Mode 3		Mode 4		Mode 5	
	Band	UHF IV/V 8MHz SFN		UHF IV/V 8MHz SFN		VHF III 7MHz SFN		UHF IV/V 8MHz MFN		VHF III	7MHz MFN
	than one echo (dB)										
13.0	C/(N+I) Performance in Single Frequency Networks inside the guard interval (dB)	27.9		24.6		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)
		-532	-12.0	See Note 2		See Note 3		-133	-11.5	-152	-11.5
		-525	-11.5					-120	-11.0	-130	-11.0
		-510	-10.5					-90	-9.5	-100	-9.5
		-490	-9.0					-60	-7.0	-70	-7.0
		-475	-7.5					-30	-2.0	-50	-4.5
		-448	-2.0	-266	-2.0	-304	-2.0	-28	-2.0	-32	-2.0
		448	-2.0	266	-2.0	304	-2.0	28	-2.0	32	-2.0

Identifier	Mode 1		Mode 2	Mode 3	Mode 4		Mode 5	
Band	UHF IV/V 8MHz SFN		UHF IV/V 8MHz SFN	VHF III 7MHz SFN	UHF IV/V 8MHz MFN		VHF III	7MHz MFN
	475	-7.5	See Note 2	See Note 3	30	-2.0	50	-4.5
	490	-9.0			60	-7.0	70	-7.0
	510	-10.5			90	-9.5	100	-9.5
	525	-11.5			120	-11.0	130	-11.0
	532	-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.

11.3.2 Tuning

11.3.2.1 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.

11.3.2.2 Automatic Tuning

The DTT receiver shall be capable of performing automatic tuning over the frequency ranges indicated in Table 4: Mandatory Frequency Bands, 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 section 11.3.1).

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.

11.3.3 Response to changes in modulation

The DTT receiver shall recover from changes in modulation parameters and output an error free TS. This shall take less than one second for any change.

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-signaling change

11.3.4 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 4.

11.3.5 Time Interleaving

The DTT receiver shall at least include time interleaving capability corresponding to the maximum time interleaving according to **[1]**, i.e. $2^{19}+2^{15}$ OFDM cells for a data PLP and its common PLP together.

11.4SERVICE INFORMATION (SI) AND PROGRAM-SPECIFIC INFORMATION (PSI)

11.4.1 Service information tables

The general implementation of SI and PSI shall be in accordance with [6] and [7].

The DTT receiver shall be able to process the PSI/SI tables. The following “Actual” tables shall be Mandatory:- NIT, SDT, EIT, TDT.

AIT shall be mandatory for receivers that support Interactivity. EIT shall be mandatory for "Other" transport streams.

11.4.2 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.

11.4.3 Channel Order and Numbering

The Middleware UI / application manages LCNs and the presentation of services using broadcast data provided by the platform operator.

11.4.3.1 Regional Broadcast Management

The middleware application manages regional broadcasts based on information that the platform provides.

11.4.3.2 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.

11.4.3.3 EIT present/following, actual/other

EIT present/following (Now and Next) and actual/other information shall be broadcast,

including extended event information, for services carried in all DTT transport streams, i.e. EIT present/following and actual/other including genre tables, parental control and series descriptor.

The middleware is responsible for decoding EIT information. The middleware application is responsible for displaying EIT information within the UI.

11.4.3.4 Time exclusive services

The DTT receiver may 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 may display a notification screen (the Placeholder) which will typically provide the service name and its hours of operation.

The decoder should 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.

11.5POWER SUPPLY

The STB receiver shall be supplied complete with 100-250 V AC to 12V DC power supply unit where the nominal frequency shall be 50Hz with a fluctuation range between ±2%.

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 under voltage, frequency variations 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.

12 PERFORMANCE REQUIREMENTS (DTH)

12.1SPECTRUM AND DTH MODULATION AND CODING

12.1.1 Spectrum

DTH services in Ghana will be provided on Ku-Band (12-18 GHz)

12.1.2 DTH modulation and Coding

The receiver shall support the different modes of operation referenced in the standard [20]. The decoder shall be capable of achieving full specified performance with any of the combinations of modulation (QPSK/8PSK/16APSK/32APSK) and forward error correction coding as specified in [20].

12.2RADIO FREQUENCY

12.2.1 DTH Tuner/demodulator

The receiver shall be provided with a single DTH tuner/demodulator for the reception of signals from satellite transmitters broadcasting in accordance with ETSI EN 302 307. It shall be capable of receiving transmissions broadcast with any allowable combination of modulation and transmission parameters as shown in Table 8:

Table 8: Modulation and transmission parameters

	ETSI EN 302 307
Constellation	**QPSK 8PSK 16APSK 32APSK**
Code Rate	**1/4, 2/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9**
FEC	**LDPC + BCH 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 6/7, 8/9, 9/10**

12.2.2 LNB Control

The tuner shall be capable of controlling an external Low Noise Block (LNB) as follows:

	LNB Control
Vertical Polarity	**13V DC**
Horizontal Polarity	**18V DC**
22KHz tone control	**22kHz ±0.4kHz (0.8V ± 0.2V)**

12.2.3 Intermediate Frequency

The tuner shall be able to tune Intermediate Frequencies (IF, as output from the Low Noise Block) in the range 950 – 2150MHz generated as follows:

LNB Control Voltage	Tone	Polarization	Intermediate Frequency
13 V	0	Vertical	950 – 1950 MHz
18 V	0	Horizontal	950 – 1950 MHz
13 V	22 kHz	Vertical	1100 – 2150 MHz
18 V	22 kHz	Horizontal	1100 – 2150 MHz

12.2.4 DiSEqC

Digital Satellite Equipment Control (DiSEqC) protocol level 1.1 shall be supported to facilitate switching satellite sources.

12.2.5 Tuning

The tuning process shall be automatic and managed by the middleware utilizing pre-loaded tuning tables to locate the correct satellite, frequencies, transponders and associated parameters (e.g. symbol rates and DiSEqC).

Automatic tuning shall proceed automatically on first-time install with appropriate on-screen display of progress or failure (with on-screen assistance if errors occur).

It shall be possible for the pre-loaded tuning tables to be updated by broadcast to enable planned changes to satellites.

The middleware shall provide for a manual method of locating the service in the event of an un-planned change such as satellite failure.

12.2.6 Response to changes in modulation

The DTT receiver shall recover from changes in modulation parameters and output an error free TS. This shall take less than one second for any change.

12.3POWER SUPPLY

The STB receiver shall be supplied complete with 100-250 V AC to 12V DC power supply unit where the nominal frequency shall be 50Hz with a fluctuation range between ±2%.

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 under voltage, frequency variations and reversed polarity shall be incorporated.

The power supply must provide the necessary outputs to support LNB (section 12.2.2) and DiSEqC (section 12.2.4) external equipment.

13 MIDDLEWARE APPLICATIONS

Middleware applications are implemented by the Middleware Client and Middleware Application.

Some applications may be supported by future releases of the Middleware Application to meet these service requirements.

13.1 ELECTRONIC PROGRAM GUIDE (EPG)

Receiver middleware shall receive an EPG broadcast in DVB EIT schedule tables.

The middleware application shall render the EPG on screen according to the UI specification. Through the UI, the user shall be able to browse TV listings and perform associated functions such as setting reminders and recordings.

The middleware shall continuously obtain the EPG except during passive standby. This ensures it is immediately available and up to date when the user interacts with it.

13.2 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) derived from the EITschedule 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.

13.3 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.

13.4 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.

13.5 LANGUAGES AND FONTS

The Languages and Fonts as described in section Annex A.2 shall be supported if received as any string in SI/PSI.

13.6 Digital Access Fee Collection

This feature is enabled by the use of CA protection on all channels and a back end system that requires the user to register and pay the fee via a non-STB based payment mechanism. The Middleware Application will provide the necessary user interface to implement this feature.

13.7 On-screen banner advertising

This feature will provide for display of graphical banner messages within the UI which can be used to inform users of new services, features, programs or other platform related content. Banners can have associated key presses to 'click through' to full-screen pages displaying additional text and graphic content. The Middleware Application will provide the necessary capability to render scheduled banners within the UI.

13.8 Interactive Broadcast Services

This feature will provide access to a number of articles containing a mix of text and images to inform the users of local and national issues in areas such as Government, Health, Police etc. The Middleware Application will provide the necessary user interface to implement this feature.

13.9 Push VOD and PVR

The Receiver will support USB mass storage to provide PVR and Push VOD functionality (each rendered by the Middleware Application).

The Receiver will be capable of creating disk partitions to allow different areas of storage for PVR and Push VOD.

The Receiver should have the capability to detect approved USB Mass Storage devices and reject the use of non-approved devices.

The Receiver should manage the prioritisation of record events by using a common priority parameter attached to events associated with both PVR and PushVOD functionality.

The Receiver will support PVR functionality with bookings and scheduled recordings being set by the user. Record conflicts arising at the time of booking will be managed by the Middleware Application.

The Receiver should support Push VOD functionality based on DVB delivery of VOD assets. The Receiver shall support this functionality by recording VOD assets to the USB mass storage device.

The Receiver should support the necessary PVR and Push VOD recording functionality to recommence recordings after a power cycle to compensate for power outages.

The PushVOD feature enables the STB to receive and store video assets and associated metadata (titles, synopsis, cover art) from special DTV services and broadcast data. The Middleware Application will provide the necessary user interface to implement this feature.

13.10 Connected Services

For areas where good Internet access is available, the Receiver will allow access to connected services via an Ethernet, Wi-Fi or 3G/4G connection using a USB dongle. These services are rendered through the Middleware Application, they may include:

- Information Services
- Video on Demand
- Live OTT Video

14 USER INTERFACE

The User Interface (UI) is completely dependent and managed by the Middleware application.

A common user interface will be used by all receivers and implemented as part of the common middleware application. Using a common user interface ensures a consistent user experience, operation and feature set for all consumers and simplifies support and marketing.

The UI limits the available feature set adjustment on first install to simplify the 'user experience' and guide them through the registration process. Once complete, the 'user' can access the services menu option to adjust settings as normal.

The Common User Interface is defined in the Ghana Common User Interface Specification

15 REMOTE CONTROL UNIT (RCU)

15.1 MINIMUM FUNCTIONALITY

15.1.1 Protocol

Each 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.

15.1.2 Infrared receiver frequency

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

15.1.3 Keys and layout

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;
g) control the on-screen cursor (up, down, left, right);
h) exit from the menu and information structure;
i) select the next service up or down (P+ and P−);
j) increase or decrease the audio level;
k) adjust the audio level to zero (mute) and restore back to previous setting;
l) display and suppress subtitles;
m) toggle between normal and standby operation;
n) toggle between television and radio services (for STB only);
o) provide a short cut to interactive services and overlay text. (optional)
p) navigate between UI screen using the colour buttons

The RCU may implement all the keys in accordance with the HbbTV profile as defined in **[17]**.

15.1.4 Operation

15.1.4.1 *Response Time*

The design of the 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.

15.1.4.2 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.

15.1.4.3 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.

15.2ALTERNATIVE 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).

15.3 RELIABILITY

15.3.1 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.

15.3.2 Environmental

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

15.3.3 PACKAGING

The RCU shall be included in the same shipping carton as the 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.

16 COMPLIANCE

16.1 HEALTH AND SAFETY

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

16.2 ELECTROMAGNETIC COMPATIBILITY (EMC)

The Receiver and all accessories shall comply with the following standards: Emissions: CISPR 13 or EN55013, Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement

16.3 PERFORMANCE

Compliance of the 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.

17 ACCESSORIES

The Receiver shall be supplied with the following accessories:

- **Mains cord set**, of length at least 1.5 m and incorporates a plug and an appliance connector as defined in section 10.14
- **Composite (CVBS) video/stereo audio cable**, of length at least 1.5 m, terminated with RCA

connectors (only for STB).

- **Remote control unit (RCU)** that complies with the requirements in section 15, together with "AA" or "AAA" sized batteries.
- **User manual** in English, French and Portuguese languages, at least.
- **Quick guide** (in English, French and Portuguese languages, at least), 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.

18 PACKAGING

The Receiver shall be securely packaged to protect it against possible damage during transit.

The packaging shall contain all the accessories set out in section 17, 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.

19 E-WASTE DISPOSAL

The means of disposal for the Receiver (E-waste) shall be indicated, in accordance with National guidelines whenever applicable.

20 ANNEX A: COUNTRY SPECIFIC INFORMATION

1. DVB IDENTIFIERS

Country	DVB ID Requirement				
	Original Network Description		**Original Network (ONID)**	**ID**	**Network ID**
Ghana	Ghana DTT		0x2120		0x3001 - 0x3100

2. LANGUAGES AND FONTS

Country	ETSI EN 300 468 V1.13.1.	
	Language	**Character Code Table**
Ghana	English	00 - Latin alphabet

3. PLUGS & APPLIANCE CONNECTORS

It is required that the receiver is supplied with one or more of the following connector types:-

Country	Plug / Socket Connector Type
Ghana	Type G British BS-1363