Telecommunications Authority of Trinidad and Tobago

This document may be cited as

Broadcasting Technical Quality of Service Standards: Subscription and Free-to-Air Television Broadcasting Services in Trinidad and Tobago

(First round)

July 2017

TATT Ref: 2/3/56

Maintenance History		
Date	**Change Details**	**Version**
07 July 2017	Consultative document for first round of public consultation	0.1

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1. Introduction

Since its establishment in 2004, the Telecommunications Authority of Trinidad and Tobago (hereafter called "the Authority") has sought to guarantee consumers good quality services through policy and industry guidelines, while at the same time imposing on concessionaires the lightest possible burden in relation to testing and compliance.

Section 45 (2) Part V of the Telecommunications Act, Chap. 47.31 empowers the Authority to "identify, adopt or establish technical standards". In fulfilling this mandate, while taking account of technological advances and best practices in the television industry, the Authority proposes to update its quality standards for Subscription and Free-to-Air (FTA) television services.

1.1 Rationale

The Authority's Consumer Rights and Obligations Policy (CROP) (2014) safeguards consumers in the telecommunications and broadcasting sectors by ensuring high standards for customer service and consumer-related Quality of Service (QoS). However, the CROP currently does not include consumer-related technical QoS standards for subscription and FTA television broadcasting services.

This document serves to establish standards that are currently not captured in the CROP document, and provides a much needed update to the broadcasting technical QoS indicators referenced in Schedule F of a type 5 concession, under which subscription broadcasters are authorized.

The technical quality indicators, specified in the current concession, do not facilitate accurate measurement of the QoS delivered to consumers or a verification of consumers' complaints of broadcasting services. Additionally, as both subscription and FTA television are transitioning from analog to digital broadcasting, QoS indicators are needed for digital services.

1.2 Purpose

This document recommends technical QoS standards for Subscription and FTA television broadcasting services. The recommended technical QoS standards are to be used in measuring and gathering data for addressing consumer complaints and ensuring compliance with QoS obligations by subscription and FTA television providers. Moreover, standards for digital cable signal leakage are now being articulated, whereas formerly only analog standards were available.

The recommended technical standards in this document are based on the current technical environment of subscription and FTA television broadcasting services in Trinidad and Tobago. In proposing technical QoS standards, the Authority sought guidance from organizations, such as other regulators and standardization bodies, involved in the development, testing and monitoring of QoS parameters for subscription and FTA networks and services.

1.3 Objective

This document recommends a series of technical quality standards for the following:

a) Subscription TV Services:
    i. QAM-based digital cable systems;
    ii. Non-QAM digital cable systems;
        - IPTV Technical Standards
    iii. Analog cable systems (RF signals transmitted through coaxial cables); and
    iv. Digital and analog cable systems signal leakage.

b) Free To Air' TV Services:
    i. Analog Free-to-Air QoS; and
    ii. Digital Free-to-Air QoS.

1.4 Supporting Framework

This document is a subset of the CROP and therefore should not be regarded in isolation of the CROP. CROP safeguards consumers' interests and ensures high standards of consumer-related service quality which comprises both customer service indicators and technical QoS indicators that directly affect the consumer.

In keeping with the intent of CROP, this document focuses exclusively on the reliability of service enjoyed by consumers. The document specifies consumer-related and technical QoS indicators, for subscription and FTA services, and specifies nominal service requirements.

1.5 Review Cycle

As the broadcasting sector grows and develops, there is need to revise and update these quality standards to ensure that standards for subscription and FTA services are relevant and current. As such, these standards will be modified, as the Authority deems necessary, subsequent to consultation with all stakeholders, including the general public.

Questions or concerns regarding the maintenance of this framework may be directed to the Authority via e-mail to info@tatt.org.tt.

1.6 Consultation Process

In accordance with its *Procedures for Consultation in the Telecommunications Sector of Trinidad and Tobago (2010)*, the Authority will seek the views and opinions of the general public and other stakeholders regarding the proposals made herein. Consideration will be given to comments and recommendations made during the consultation process, and the document will be revised accordingly.

This document will be made available for public consultation for a four (4) week period according to the Authority's procedures. Comments should be submitted to consultation@tatt.org.tt or mailed to:

Telecommunications Authority of Trinidad and Tobago

#5, Eighth Avenue Extension, off Twelfth Street,

Barataria, Republic of Trinidad and Tobago

1.7 Other Relevant Documents

In addition to the information received from Trinidad and Tobago broadcasting industry stakeholders, the following documents make provisions which were helpful in finalizing these proposed QoS standards for subscription and FTA television services:

- *Consumer Rights and Obligations Policy – Consumer and Customer Quality of Service Standards for the Telecommunications and Broadcasting Sector of Trinidad and Tobago* (ver. 1.0, 2014);
- *Authorization Framework for the Telecommunications and Broadcasting Sectors of Trinidad and Tobago* (ver. 0.5, 2005);
- *Concession for the Operation of a Public Telecommunications Network and/or Provision of Public Telecommunications and/or Broadcasting Services*; and
- *Equipment Standardization Framework* (ver. 1.0, 2008).

1.8 Abbreviations

64 QAM	Quadrature Amplitude Modulation with 64 constellation points
256 QAM	Quadrature Amplitude Modulation with 256 constellation points
AM	Amplitude Modulation
ATSC	Advanced Television Systems Committee
Cable	Cable Television Systems
C/N	Carrier to Noise Ratio
dB	Decibel - a logarithmic value of a ratio
dBc	Decibels relative to carrier amplitude
dBm	Decibels relative to one milliwatt
dBmV	Decibels relative to one millivolt across a given impedance (75 ohms in North American cable systems)
DOCSIS	Data Over Cable Service Interface Specifications
DSG	DOCSIS Set-top Gateway
HDTV	High Definition Television
HRC	Harmonically Related Carrier
IRC	Incrementally Related Carrier
kbps	kilobits per second- bits per second in thousands
kHz	kiloHertz - cycles per second, in thousands
MAC	Media Access Control
Mbps	Megabits per second- bits per second in millions
MER	Modulation Error Ratio
MHz	MegaHertz - cycles per second in millions
mV	millivolt – thousandths of a volt
p-p	Peak to peak
RMS	Root Mean Square
SDTV	Standard Definition Television
STB	Set Top Box
SI	Service/System Information

1.9 Definitions

Amplitude Modulation-Vestigial Sideband (AM-VSB) - used to broadcast analog NTSC video signals (SCTE 40, 2011).

Asynchronous Transfer Mode (ATM) - a switching and transport protocol that allows data, voice, and video to be carried over a single physical network (SCTE 40, 2011).

Audio-Visual services - include analog and digital broadcast, on-demand services, premium, tiered and other video services.

Bit Error Rate (BER) - the percentage of bits with errors divided by the total number of bits that have been transmitted, received or processed over a given time period

Carrier - an RF signal used to carry information (video, audio and data) by some modulation scheme (SCTE 40, 2011).

Composite Video - a baseband representation of a video signal containing luminance and chrominance information (SCTE 40, 2011).

Carrier-to-Interference ratio (CIR) - the ratio of the power in the RF carrier to the power of the interference signal.

Composite Triple Beat (CTB) - a third order distortion caused by mixing three carriers (A+B-C) that fall on the fundamental of a carrier (SCTE 40, 2011).

Composite Second Order (CSO) - the sum effect of all second order distortion products (SCTE 40, 2011).

Demarcation Point - typically a point at (or about) twelve inches outside of where the cable wire enters the subscriber's premises (FCC Rules 47 CFR Section 76.5).

Digital Television (DTV) - a general term for the digital coding and transmission of an Audio / Video Program (SCTE 40, 2011).

Downstream - transmission from the headend to the terminal device (SCTE 40, 2011).

Drop Cable - a coaxial cable from a subscriber tap to the Demarcation Point (SCTE 40, 2011).

Forward Application Transport Channel (FAT) - a data channel carried from the headend to the terminal device in a modulated channel at a rate of 26.97 or 38.81 Mbps (SCTE 40, 2011).

Forward Data Channel (FDC) - a data channel carried from the headend to the terminal device in a modulated channel at a rate of 1.544 to 3.088 Mbps (SCTE 40, 2011).

Headend - the control center of a cable television system, where incoming signals are amplified, converted, processed, and combined into a common cable, along with any locally originated programming, for transmission to subscribers (SCTE 40, 2011).

Hum Modulation of Carrier - the peak-to-peak magnitude of the amplitude distortion relative to the radio frequency (RF) carrier signal level due to the fundamental and low-order harmonics of the power-supply frequency.

Intermediate Frequency (IF) - a signal processing stage between RF and baseband (SCTE 40, 2011).

Moving Picture Experts Group (MPEG) - an international standards-setting group, working to develop standards for compressed full-motion video, audio, and other associated information (SCTE 40, 2011).

Noise - an undesired or unintended element of a signal (SCTE 40, 2011).

Out-of-Band (OOB) - the OOB channels provide communication channels between the network and the terminal (SCTE 40, 2011).

Quadrature Amplitude Modulation (QAM) - a radio frequency modulation scheme that combines phase and amplitude modulation (ANSI/SCTE, 2007).

Quadrature Phase Shift Keying (QPSK) - a signalling and modulation scheme in which an RF carrier is phase shifted to signal digital data (SCTE 40, 2011).

Reverse Data Channel (RDC) - a data channel transmitted from the terminal device to the headend in a modulated channel at a rate of 0.256 to 3.088 Mbps (SCTE 40, 2011).

Reed-Solomon - a coding method that adds parity symbols to a data packet thereby providing a forward error correction capability (SCTE 40, 2011).

Radio Frequency (RF) - used to describe the part of the electromagnetic frequency spectrum that is used to transmit video, audio, and data over the air or via coaxial cable (SCTE 40, 2011).

Signal Quality Margin Test - a fast and simple pass/fail measurement that can provide an indication of the digital service quality at various nodes in the cable distribution network.

Signal-to-Noise ratio (SNR or S/N) - used to quantify how much a signal has been corrupted by noise.

Slope - Is caused by 'SKIN EFFECT', wherein signal attenuation increases with frequency of the channel.

Society of Motion Picture and Television Engineers (SMPTE) - a standard organization devoted to advancing theory and application in motion imaging, including film, television, video, computer imaging, and telecommunications (SCTE 40, 2011).

Transport Stream (TS) - MPEG-2 transport stream (ISO/IEC 13818-1[14]).

Terminal Device (cable set-top box) - is a TV interface device that serves, as its primary function, to connect a cable system to a TV broadcast receiver or other subscriber premise equipment.

Upstream - transmission from the terminal device to the headend (SCTE 40, 2011).

1.10 Compliance Notation

"SHALL"	The concessionaire is required to fully comply with the standard as specified.
"SHALL NOT"	The item is an absolute prohibition of this standard as specified.
"SHOULD"	There may exist valid reasons in particular circumstances to ignore this standard, but the full implications are to be understood and the case carefully considered before choosing.
"SHOULD NOT"	There may exist valid reasons in particular circumstances when the stated condition is acceptable or even useful, but the full implications are to be understood and the case carefully considered before implementing any conditions described in this standard.
"MAY"	This item is optional. One concessionaire may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

2. Quality Requirements for Subscription Service

In keeping with its statutory mandate to identify, adopt or establish preferred technical standards that take account of changes in technology, the Authority proposes to adopt new and improved technical standards for subscription broadcasting service. Subsection 2.1, 2.2 and 2.3 define the technical quality standards associated with a QAM-based digital cable system, non-QAM (IP television) digital cable system and analog cable system respectively. These standards shall be used to ensure that subscription broadcasters in Trinidad and Tobago satisfy their quality requirements as defined in a type 5 concession.

2.1 QAM-based Digital Cable Systems Technical Standards

The majority of digital signals today is being delivered digitally via quadrature amplitude modulation (QAM) over hybrid fiber-coax (HFC) cable plant (FCC NPRM 2012). Therefore, the Authority proposes to adopt the Society of Cable Telecommunications Engineers (SCTE) 40 2011 Digital Cable Network Interface Standards (SCTE 40 2011) for QAM-based digital cable systems and shall conduct tests that assess compliance with these standards.

The SCTE 40 2011 standard is also adopted by other Region 2 Administrations such as the Federal Communications Commission (FCC) and provides the best means of ensuring that consumers are receiving a good quality signal. The Authority intends to incorporate this standard into schedule F of a type 5 concession for the quality requirements of a QAM-based digital cable system.

By selecting an existing industry-developed standard that is already followed by QAM-based digital cable operators, the Authority is placing little to no additional burden on cable operators. The SCTE 40 2011 standard provides the metrics for compliance; however, only those quality indicators treating with the delivery of digital video signals shall be tested by the Authority for compliance. Quality indicators for the upstream or downstream of data performance shall not be tested for compliance.

Purpose

This standard defines the characteristics and normative specifications for the digital network interface between a cable television system and commercially available digital cable products that are used to access multi-channel television programming.

Measurement Method

The Trilithic 860 DSPi instrument or other suitable test instruments capable of measuring the technical characteristics of a QAM-based digital cable system shall be used to take all field measurements. The Forward Application Transport (FAT) digital signal power shall be measured as the average signal power in a 6 MHz channel.

Threshold and Standards

The minimum signal quality for QAM-based digital cable system shall comply with the SCTE 40 2011 standard that has received American National Standards Institute (ANSI) approval (ANSI/SCTE 2011). This standard describes the basic technical operational characteristics of digital cable systems using QAM, including such characteristics as relative channel power, carrier-to-noise ratios, and adjacent-channel characteristics. See Appendix 1 for the technical standards for QAM-based digital cable systems.

Compliance with these technical standards shall be tested:

1. The channel-specific standards for normal video channels contained in the FAT table (see table 10, appendix 1) shall be tested only on a subset of channels; and
2. The nominal power levels (see table 11, appendix 1) and the adjacent channel levels (see table 12, appendix 1) shall be tested across every QAM channel on the system.

2.2 Non-QAM Cable Systems and Qualitative Signal Quality

Non-QAM systems such as the VDSL, ADSL2+ systems do not possess uniform characteristics. Therefore, the proposed SCTE 40 2011 Digital Cable Network Interface Standards for QAM-based digital systems is not relevant to non-QAM systems, nor are there presently established industry standards or guidance for the testing and measurement of each particular new technology.

In Trinidad and Tobago, non-QAM digital cable systems are fewer in number than QAM/HFC systems, and primarily utilize Internet Protocol (IP) delivery over either fiber-optic cable or DSL-based transmission over twisted-pair copper wires.

2.2.1 IPTV Systems Technical Standards

Internet Protocol Television (IPTV) refers to the delivery of digital subscription television over an IP-based network that is managed to support the required level of QoS, quality of experience (QoE), security, interactivity, and reliability. IPTV is delivered via Set Top Boxes (STB) and other devices to television sets or other displays, in standard and high-definition formats, at a quality that is discernible from free to air broadcast television.

QoE is defined in ITU-T Recommendation G.1080 as the overall acceptability of an application or service, as perceived subjectively by the end-user. Good QoE is reliant upon error-free delivery of packet data without retransmission and is built on the foundation of good QoS. QoE testing on an IPTV network must encompass both service and transmission layers for the most accurate result.

In the design of an IPTV network, QoS and QoE are vital pointers in determining whether subscribers will receive an end product of acceptable quality. QoS involves the totality of a telecommunication service that bears on its ability to satisfy stated and implied needs of the user of the service. Good QoS standards improve the likelihood that high QoE expectations will be met.

The quality parameters of an IPTV network are defined at different layers of the network. There are a number of objective parameters of service performance, such as encoding bit rate, packet loss, delay

and bandwidth availability, that affect the overall QoE of customers. The relation between QoE and QoS performance metrics is estimated empirically. Once identified, the QoE/QoS relationship can be used in two ways:

a) Given a QoS measurement, in principle, the expected QoE for a user can be, with appropriate assumptions, predicted; and

b) Given a target QoE for a user, in principle, the net required service layer performance can be, with appropriate assumptions, deduced.

In keeping with the QoE/QoS relationship, the Authority proposes to adopt the International Telecommunication Union – Telecommunication (ITU-T) Recommendation G.1080 for testing and monitoring the QoE of an IPTV video service. Recommendation ITU-T G.1080 defines the QoE requirements from an end-user perspective and is agnostic to network deployment architectures and transport protocols. The recommended minimum transport layer standards for satisfactory QoS and QoE for MPEG-2 and MPEG-4 encoded Standard Definition Television (SDTV) and High Definition Television (HDTV) IPTV video services are listed in Tables 1, 2, 3, 4 and 5 respectively. Standards are for the IP flows containing video streams only. The requirement for network performance of broadcast SDTV applications listed in Table 2 and 3 also applies to video on demand (VoD) and premium content services.

Purpose

The recommended technical standards for digital video signal transmitted over an IPTV Network are designed to ensure the appropriate service quality is delivered. This recommendation addresses the QoE targets and expresses QoE requirements in the context of parameters such as bit rate or packet loss rate.

Measurement Method

The Agilent – IPTV Testing instrument or other suitable test instruments capable of measuring the parameters outlined in Tables 1, 2, 3, 4 and 5 shall be used to conduct all quality tests.

Thresholds and Standards

The process of determining the QoE and/or QoS performance targets depends on a number of issues, such as the compression coding scheme to be used for the service, content characteristics, content

provider requirements, and customer satisfaction. The following assumptions were made when establishing technical standards for IPTV:

- MPEG transport stream for generic coding of moving picture;
- H.262 and H.264 4 codec for SDTV and HDTV respectively;
- No or minimal loss concealment (tolerable loss rates may be higher depending on degree and quality of STB loss concealment);
- Standards are end-to-end, from headend encoder output to any application-layer protection mechanisms at the customer's premises; and
- Standards are for the IP flows containing video streams only; IP streams for other applications may have different performance requirements.

The technical standards for testing and monitoring the video signal quality transported across an IP network shall not exceed the ranges specified in Tables 1, 2, 3, 4 and 5. These values are all based on assumptions made above (e.g. MPEG compression coding) and are not applicable to all possible IPTV Systems.

Table 1- Video Service Control Plane Technical Standards (Source: SCTE 40 2011)

User Action	Description	Maximum Recommended Delay
User interface actions	Electronic Program Guide (EPG) scrolling. Video on Demand (VoD) remote control button push to onscreen indication that command was received	200 ms
Channel Zapping	Zapping delay is defined as the time between pushing the remote control button and the first stable channel is displayed on the TV	<=2 seconds
System start-up time	Time from STB power on to channel availability	10 seconds

Table 2 - Minimum level of Transport Layer performance for satisfactory QoE for H.262/MPEG-2 encoded SDTV Services

Transport Stream bit rate (Mbps)	Latency (Delay)	Jitter	Maximum duration of a single error	Corresponding Loss Period in IP packets	Loss Distance	Corresponding Average IP Video Stream Packet Loss Rate
3.0	<200 ms	<50 ms	<= 16 ms	<6 IP packets	<=1 error event per hour	<= 5.85×10^{-06}
3.75				<7 IP packets		
5.0				<9 IP packets		

Table 3 - Minimum level of Transport Layer performance for satisfactory QoE for H.264/MPEG-4[1] encoded SDTV Services

Transport Stream bit rate (Mbps)	Latency (Delay)	Jitter	Maximum duration of a single error	Corresponding Loss Period in IP packets	Loss Distance	Corresponding Average IP Video Stream Packet Loss Rate
1.75	<200 ms	<50 ms	<= 16 ms	<4 IP packets	<=1 error event per hour	<= 6.68×10^{-06}
2.0				<5 IP packets		<= 7.31×10^{-06}
2.5				<5 IP packets		<= 5.85×10^{-06}
3.0				<6 IP packets		<= 5.85×10^{-06}

[1] MPEG-4 is one of the latest (audio and video) compression method, designed especially for low-bandwidth video/audio encoding purposes.

Table 4 - Minimum Level Transport Layer performance for satisfactory QoE for H.262/MPEG-2 encoded HDTV Services

Transport Stream bit rate (Mbps)	Latency (Delay)	Jitter	Maximum duration of a single error	Corresponding Loss Period in IP packets	Loss Distance	Corresponding Average IP Video Stream Packet Loss Rate
15.0	<200 ms	<50 ms	<= 16 ms	<24 IP packets	<=1 error event per 4 hours	<= $1.17x10^{-06}$
17.0				<27 IP packets		<= $1.16x10^{-06}$
18.1				<29 IP packets		<= $1.17x10^{-06}$

Table 5 - Minimum Level Transport Layer performance for satisfactory QoE for H.264/MPEG-4 encoded HDTV Services

Transport Stream bit rate (Mbps)	Latency (Delay)	Jitter	Maximum duration of a single error	Corresponding Loss Period in IP packets	Loss Distance	Corresponding Average IP Video Stream Packet Loss Rate
8.0	<200 ms	<50 ms	<= 16 ms	<14 IP packets	<=1 error event per 4 hours	<= $1.28x10^{-06}$
10.0				<17 IP packets		<= $1.24x10^{-06}$
12.0				<20 IP packets		<= $1.22x10^{-06}$

2.2.2 Treatment of other Non-QAM Digital Cable Systems

The Authority recognizes that there are no established industry QoS standards or guidance for the testing and measurement of each particular new technology in the subscription television industry. Therefore, digital cable systems distributing signals on conventional coaxial or hybrid fiber-coaxial cable and which, because of their basic design, cannot comply with one or more of the technical standards set forth in section 2.1 and 2.2.1, may be permitted to operate upon the Authority's approval on a case-by-case basis. To obtain the Authority's approval, cable operators must submit to the Authority its own proof-of-performance plan for ensuring subscribers receive good quality signals.

2.3 Analog Cable Systems Technical Standards

The Authority proposes to adopt the latest version of the Federal Communications Commission (FCC) Cable Rules Part 76.605 Technical Standards (2014) for analog NTSC or similar video downstream cable television service. This standard requires that analog cable television systems transmit signals to subscriber equipment on frequencies in accordance with the "Cable Television Channel Identification Plan, CEA-542-D" (SCTE 204 2014).

Purpose

To upgrade existing technical standards and ensure that analog cable television providers are providing a good quality signal to subscribers.

Measurement Method

The Trilithic 860 DSPi instrument or other suitable test instruments capable of measuring the parameters outlined in Table 6 and Table 7 shall be used to take all measurements.

Threshold and Standards

The requirements in Table 6 apply to the performance of a cable television system as measured at any subscriber terminal with a matched impedance at the termination point or at the output of the modulation or processing equipment (generally the headend) of the cable television and are applicable to each NTSC or similar video downstream subscriber television channel in the system.

The technical standards for an analog NTSC or similar video downstream cable television channel in the system shall not exceed the ranges prescribed in Tables 6 and 7.

Table 6 - Analog Cable Systems Technical Standards

TECHNICAL STANDARDS	
Television standard	NTSC
Channel bandwidth	6.0 MHz per channel
Channel configuration	Standard 4.5 MHz video/audio: audio 15-17 dB below carrier
Minimum signal level at TV	2 dBmV across 75-ohm termination at the channel input
Minimum Carrier/Noise	30 dBc (below carrier)
Permissible variation of visual carrier level	a) Over 24 hours 12 dB max b) Between two adjacent 3 dB max channels c) Between any two channels 12 dB max
Frequency response (each channel)	+ 2 dB from 0.75 kHz to 4 kHz above visual carrier level
Aural frequency deviation	25 kHz
Signal to intermodulation ratio	45 dB min
Radiation level	< 15 uV/m at 30 metres
Line amplifier voltage	60 Vac max
Prohibited Frequencies	No cable television system may utilize a frequency at power levels equal to or exceed 10 microwatts within 100 kHz plus tolerance of the emergency aircraft locator frequency 121.5 MHz or within 50 kHz plus tolerance of the distress signal frequencies 156.8 MHz and 243.0 MHz

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For each NTSC or similar video downstream cable television channel in the system:

1. (i) The cable television channels delivered to the subscriber's terminal shall be capable of being received and displayed by TV broadcast receivers used for the off-the-air reception of TV broadcast signals;
   (ii) Cable television systems shall transmit signals to subscriber premises equipment on frequencies in accordance with the channel allocation plan set forth in CEA-542-C: "Standard: Cable Television Channel Identification Plan,".

2. The centre frequency of the aural carrier must be 4.5 MHz ± 5 kHz above the frequency of the visual carrier at the output of the modulating or processing equipment of a cable television system, and at the subscriber terminal.

3. (1) The visual signal level across a terminating impedance which correctly matches the internal impedance of the cable system as viewed from the subscriber terminal shall:
   a) not be less than 1 millivolt across an internal impedance at 75 ohms (0 dBmV); and
   b) as measured at the end of a 30 metre (100 foot) cable drop that is connected to the subscriber tap, it shall not be less than 1.41 millivolts across an internal impedance of 75 ohms (+ 3 dBmV).

   (2) At other impedance values, the minimum visual signal level as viewed from the subscriber terminal, shall be the square root of 0.0133 (Z) millivolts and, as measured at the end of 30 metre cable drop that is connected to the subscriber tap shall be 2 times the square root 0.00662 (Z) millivolts, where 'Z' is the appropriate impedance value.

4. The visual signal level on each channel as measured at the end of 30 metre cable drop that is connected to the subscriber tap shall not vary more than 8 dB within any six-month interval, and shall be maintained within:
   a) 3 dB of the visual signal level of any visual carrier within a 6 MHz nominal frequency separation;
   b) 10 dB of the visual signal level on any other channel on a cable television system of up to 300 MHz of a cable distribution system upper frequency limit, with a 1 dB increase for each additional 100 MHz of cable distribution system upper frequency limit (for example, 11 dB for a system at 301-400MHz, 12 dB for a system at 401-500 MHz, etc); and
   c) A maximum level such that signals degradation due to overload in the subscriber's receiver or terminal does not occur.

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5. The root means square (RMS) voltage of the aural signal shall be maintained between 10 and 20 dB below the associated visual signal level and shall be met at the subscriber terminal and at the output of the modulating and processing equipment (generally the headend).
   (2) For subscriber terminals that use equipment which modulates and demodulate the signal (e.g., baseband converters), the RMS voltage of the aural signal shall be maintained between 6.5 and 17 dB below the associated visual level at the subscriber terminal.

6. The amplitude characteristic shall be within a range of ±2 dB from 0.75 MHz to 5.0 MHz above the lower boundary frequency of the cable television channel, referenced to the average of the highest and lowest amplitudes within these frequency boundaries. The amplitude characteristic shall be measured at the subscriber terminal.

7. The ratio of RF visual signal level to the system noise shall not be less than 43 dB, however good engineering practice targets end-of-line analog TV channel CNR in the 46 to 49 dB range.

8. The ratio of visual signal level to the RMS amplitude of any coherent disturbances such as intermodulation products, second and the third order distortions or discrete-frequency interfering signals not operating on proper offset assignments shall be as follows:
   a) The ratio of the visual signal level to coherent disturbances shall not be less than 51 dB for non-coherent channel cable television systems, when measured with modulated carriers and time averaged; and
   b) The ratio of the visual signal level to coherent disturbances which are frequency coincident with the visual carrier, shall not be less 47 dB for coherent channel cable systems, when measured with modulated carriers and time averaged.

9. The terminal isolation provided to each subscriber terminal:
   a) Shall not be less than 18 dB. In lieu of periodic testing, the cable operator may use specifications provided by the manufacturer for the terminal isolation equipment to meet this standard; and
   b) Shall be sufficient to prevent reflections caused by open-circuited or short-circuited subscriber terminals from producing visible picture impairments at any other subscriber terminal.

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10. The peak-to-peak variation in visual signal level caused by undesired low-frequency disturbances (HUM or repetitive transients) generated within the system, or by inadequate low-frequency response, shall not exceed 3% of the visual signal level. Measurements made on a single channel using a single unmodulated carrier may be used to demonstrate compliance with this standard at each test location.

11. The following requirements apply to the performance of the cable television system as measured at the output of the modulating or processing equipment (generally the headend) of the system:
    a) The chrominance-luminance delay inequality (or chrome delay) which is the change in delay time of the chrominance component of the signal relative to the luminance component, shall be within 170 nanoseconds;
    b) The differential gain for the colour subcarrier of the television signal, which is measured as the difference in amplitude between the largest and smallest segments of the chrominance signal (divided by the largest and express as a percent), shall not exceed ± 20%; and
    c) The differential phase for the colour subcarrier of the television signal which is measured as the largest phase difference in degrees between each segment of the chrominance signal and reference segment (the segment at the blanking level of 0 IRE), shall not exceed ±10 degrees.
    Note: All measurement is taken at the headend.
12. Transit delay from headend to most distant customer shall be less than 0.800 ms (typically much less)

FREQUENCY BANDS

13. (1) For operation in the frequency bands 108-137 and 225-400 MHz the standards relating to Signaling Leakage Performance Criteria and Frequency Separation Standards are applicable to all subscriber television systems transmitting carriers or other signal components carried at an average power level equal to or greater than 10^{-4} watts across a 25 kHz bandwidth in any 160 microsecond period at any point in the cable distribution system in the frequency bands 108-137 and 225-400 MHz for any purpose.
    (2) Before transmitting any carrier or other signal component with an average power level across a 25 Hz bandwidth in any 160 microsecond time period equal to or greater than 10^{-4} watts at any point in the subscriber television distribution system on any new

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frequency or frequencies the aeronautical radio frequency bands the licensee is to notify the Commission

FREQUENCY SEPARATION STANDARDS

All subscriber television systems which operate in the frequency bands 108-137 and 225-400 MHz shall comply with the following frequency separation standards:

1. In the aeronautical radio communication bands 108-137, 225-328.6 and 335.4-400 MHz, the frequency of all carrier signals or signal components carried at an average power level equal to or greater than 10-4 watts in a 25 kHz bandwidth in any 160 microsecond period shall operate at frequencies offset from certain frequencies which may be used by aeronautical radio services and the aeronautical frequencies from which offsets shall be maintained are those frequencies which are within one of the aforementioned aeronautical bands, and when expressed in MHz and divided by 0.025 yield an integer, the offset meeting one of the following criteria:
    a) all such cable carriers or signal components shall be offset by 12.5 kHz with a frequency tolerance of ± 5 Hz; or
    b) the fundamental frequency from which the carrier frequencies are derived by multiplication by an integer number which shall be 6.0003 MHz with a tolerance of ± 1Hz Harmonically Related Carrier (HRC) comb generators only.

2. In the aeronautical radio navigation bands 108-118 and 328.6-335.4 MHz, the frequency of all carrier signals or signal components carrier at an average power level equal to or greater than 10^{-4} watts in a 25 kHz bandwidth in any 160 microsecond period shall be offset by 25 Hz with a tolerance of ±5 Hz and the aeronautical radio navigation frequencies from which offsets shall be maintained are as follows –
    a) within the aeronautical band 108 - 118 MHz when expressed in MHz and divided by 0.025 yields even integer; and
    b) within the band 328.6 - 335.4MHz.

NOTE: The Harmonically Related Carrier (HRC) system shall meet the requirement in the 328.5 - 335.4 MHz navigation glide path band, those incrementally Related Carriers (IC) system with comb generator reference frequencies set at certain odd multiples equal to or greater than 3 times the 0.0125 MHz aeronautical communications band offset (for example 6n ± 1.250 ± 0.0375 MHz may also meet the 25 kHz offset requirement in the navigation glide path band)

(*Source*: Federal Communications Commission (FCC). Cable Rules Standards, 2000)

Under certain circumstances, a coaxial cable plant can “leak” and interfere with over-the-air users of spectrum. With exception to the general provision requiring measurements to be made at subscriber terminals, and without regard to the type of signal carried by the cable television systems, signal leakage from a cable television system shall be limited as specified in Table 7.

Table 7 - Cable Systems Signal Leakage Standards

Frequencies	Signal leakage limit	Distance in meters (m)
Analog signals less than and including 54 MHz, and over 216 MHz	15 µV/M	30
Analog signals Over 54 up to and including 216 MHz:	20 µV/M	3
Digital signals less than and including 54 MHz, and over 216 MHz	13.1 µV/M	30
Digital signals Over 54 up to and including 216 MHz:	2.4 µV/M	3

(*Source*: Federal Communications Commission (FCC). Cable Rules Standards, 2000)

3. Free-to-Air Television Technical Standards

Over-the-air tuners allow users to watch live, Free-to-Air (FTA) analog or digital TV channels. The signal is captured by an antenna, transmitted via coaxial cable, and then received by an over-the-air tuner, which converts the signal to USB output. This section outlines the technical quality standards associated with a digital and analog Free-To-Air (FTA) television network.

3.1 Digital Free-to-Air Technical Standards

Digital FTA television is an advanced broadcasting technology that enables superior audio-visual quality and more interactive services. Two broadcasting formats are supported by this technology, namely SDTV and HDTV. The Authority proposes to adopt Advanced Television Systems Committee (ATSC) broadcasting standards for digital FTA television service in Trinidad and Tobago. These quality standards are outlined in Table 8 and shall be used for testing an ATSC network for QoS.

Purpose

These standards shall be used for monitoring and enforcement of the quality of a digital FTA television service.

Measurement Method

The Promax TV Explorer HD ATSC instrument or other suitable test instruments capable of measuring the parameters outlined in Table 8 shall be used to conduct all quality tests.

Threshold and Standards

The technical standards of a digital FTA television service shall not exceed the ranges specified in Table 8.

Table 8 - Digital FTA QoS Threshold and Standards for ATSC Networks

QUALITY INDICATORS	DESCRIPTION	STANDARDS
Outlet Signal Level (RxLev)	Signal Level is measured assuming that power spectral density is uniform throughout channel bandwidth	60 – 70 dBµV
Carrier to Noise (C/N) Ratio	Out-channel measurement. Noise level is measured at $f_{noise} = f_{tuning} \pm ½ *$ Channel BW. To measure it correctly the digital channel must be tuned to its centre frequency	≥ 26 dB
Modulation Error Rate (MER)	Modulation error ratio with noise margin indication	≥ 25 dB
VBER	BER (Bit error rate) measurement for the digital signal after error correction (BER after Viterbi)	$< 2x10^{-7}$
SER	Measuring the number of erroneous segments divided by the total segments received	≥ 20 dB

3.2 Analog Free-to-Air Technical Standards

The Authority recognizes that there are various quality standards, quoted in product specifications and the literature, to measure the quality of an analog FTA video signal after its transmission. However, the essential technical standards for testing the quality of an analog FTA video signal are specified in Table 9.

Purpose

These standards shall be used for quality testing, monitoring and enforcement of an analog FTA television service.

Measurement Method

The Trilithic 860 DSPi instrument or other suitable test instruments capable of measuring the parameters outlined in Table 9 shall be used to conduct all QoS tests.

Threshold and Standards

The QoS indicators of an analog FTA television service shall not exceed the ranges specified in Table 9.

Table 9 - Analog FTA QoS Threshold and Standards

QUALITY INDICATORS	DESCRIPTION	STANDARDS
RF Signal Power (RxLev)	Level measurement of the currently tuned carrier within the service area of a FTA broadcaster	≥ 60 dBµV at 30ft above ground level within the service area.
Aural frequency deviation	The amount of variation of a carrier frequency or center frequency from its assigned value	± 25 kHz
Carrier to Noise (C/N) Ratio	Ratio between the modulated signal power and the equivalent noise power for the same bandwidth (according to TV standard)	≥ 43 dB
FM Deviation	Measure the frequency peak deviation for any modulated analog carrier in FM	± 75 kHz
AM Hum Modulation	The peak-to-peak variation in visual signal level caused by undesired low-frequency disturbances (HUM or repetitive transients) generated within the system, or by an inadequate low-frequency response	≤ 3% of the visual signal level
Chroma / Luma Delay	Change in delay time of the chrominance component of the signal relative to the luminance component	Shall be within 170 ns
Differential phase	Nonlinear chroma phase as a function of luminance level. A change in the color saturation results	≤ ±10 degrees
Differential Gain	Nonlinear chroma gain as a function of luminance level. A change in hue results	≤ ± 20%

4. References

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Appendix1: Digital QAM-Based Technical Standards

The following tables are reprinted from ANSI/SCTE 40 2011 for convenience. The original versions of these tables can be found in the SCTE 40 2011 standards for digital cable systems.
http://www.scte.org/documents/pdf/standards/SCTE_40_2011.pdf

Table 10 - Analog and FAT Channel: RF Transmission Characteristics

1.	RF Channel Spacing	6 MHz
2.	RF Frequency Range	54 MHz to 1002 MHz, IRC/HRC/Standard Channel Plans
3.	Transit delay from headend to most distant customer	≤ 0.800 ms (typically much less)
4.	Carrier-to-noise-plus-interference ratio, C/(N+I), in a 6-MHz band where C/(N+I) includes the simultaneous presence of all additive impairments in the 6-MHz channel bandwidth including CTB, CSO, and other forms of discrete interference. The carrier, noise, and interference are all subject to any linear channel distortions (micro-reflections) present in the transmission path. C/N (analog channel)	Not less than 27 dB for 64 QAM; 33 dB for 256 QAM; 43 dB for AM-VSB analog
5.	CTB	Not greater than -53 dBc referenced to inband carrier levels for analog channels
6.	CSO	Not greater than -53 dBc referenced to inband carrier levels for analog channels
7.	Carrier-to-any other discrete interference (ingress)	Not greater than -53 dBc
8.	AM Hum Modulation	No greater than 3% p-p
9.	Group Delay Variation	≤ 0.37 µs/MHz across the 6-MHz channel
10.	Chroma / Luma Delay	≤ 170 ns (AM-VSB analog)

11.	Phase Noise	≤ -86 dBc/Hz @ 10 kHz offset (relative to the center of QAM signal spectrum)
12.	Maximum Amplitude Variation across the 6 MHz channel (digital channels) Maximum Amplitude Variation across the 6 MHz channel (analog channels)	≤ 6 dB p-p ≤ 4 dB p-p
13.	Bound for a single dominant micro-reflection	-10 dB at ≤ 0.5 µs -15 dB at ≤ 1.0 µs -20 dB at ≤ 1.5 µs -30 dB at ≤ 4.5 µs Micro-reflections longer than 4.5 microseconds are included under item 4 (of this table) as a contributor to the interference I in C/(N+I)). Micro-reflections, if present, shall not cause the channel Group Delay Variation and Maximum Amplitude Variation in 4.9 and 4.12 respectively to be exceeded
14.	Carrier level at the terminal input	64 QAM: -15 dBmV to + 15 dBmV 256 QAM: -12 dBmV to +15 dBmV Analog Visual Carrier (c): 0 dBmV to +15 dBmV Analog Aural Carrier: -10 dBc to –17 dBc

Table 11 - Nominal Relative Carrier Power Levels

Analog NTSC	0 dB (reference level)
256 QAM FAT	-5 ± 2 dB
QPSK FDC	-8 ± 5 dB
64 QAM FAT	-10 ± 2 dB

Table 12 - Adjacent Channel Characteristics

	Desired (D) Channel Modulation	*Undesired (U) Adjacent Channel Modulation*	*Worst Case D/U Ratio*
1	Analog NTSC	64 QAM	+2 dB
2	Analog NTSC	256 QAM	-3 dB
3	Analog NTSC	QPSK FDC	-3 dB
4	64 QAM FAT	Analog NTSC	-18 dB
5	64 QAM FAT	256 QAM	-15 dB
6	64 QAM FAT	QPSK FDC	-15 dB
7	256 QAM FAT	Analog NTSC	-13 dB
8	256 QAM FAT	64 QAM	-5 dB
9	256 QAM FAT	QPSK FDC	-10 dB
10	QPSK FDC	Analog NTSC	-19 dB
11	QPSK FDC	64 QAM	-11 dB

12	QPSK FDC	256 QAM	-16 dB
13	Analog NTSC	Analog NTSC	-3 dB
14	64 QAM FAT	64 QAM	-6 dB
15	256 QAM FAT	256 QAM	-6 dB
16	QPSK FDC	QPSK FDC	-6 dB

- *Independent of the D/U ratios, the C/(N+I) and the absolute signal levels shall meet the requirements for those parameters as described elsewhere in the specification*
- *Good engineering practice normally requires that only a single FDC channel be adjacent to a FAT channel*