UDC 621.397: 535:6

NORMATIVE SUPPORT OF EFFICIENT INTRODUCTION AND FURTHER PROGRESS OF DIGITAL TELEVISION AND MULTIMEDIA BROADCASTING TECHNOLOGIES

GOFAIZEN O.V, BALIAR V.B, PYLIAVSKYI V.V

O.S. Popov Odessa national academy of telecommunications
Kuznechna st., 1, Odessa, 65029, Ukraine
SE "Ukrainian scientific-research institute of radio and television",
Bunin st., 1, Odessa, 65026, Ukraine
oleg.gofaizen@gmail.com, balyar.vb@onat.edu.ua, v.pilyavskiy@ukr.net

НОРМАТИВНЕ ЗАБЕЗПЕЧЕННЯ ЕФЕКТИВНОГО ВПРОВАДЖЕННЯ Й ПОДАЛЬШОГО ПРОГРЕСУ ТЕХНОЛОГІЙ ЦИФРОВОГО ТЕЛЕВІЗІЙНОГО ТА МУЛЬТИМЕДІЙНОГО МОВЛЕННЯ

ГОФАЙЗЕН О.В., БАЛЯР В.Б., ПИЛЯВСЬКИЙ В.В.

Одеська національна академія зв'язку ім. О.С. Попова
вул. Кузнечна, 1, Одеса, 65029, Україна
ДП «Український науково-дослідний інститут радіо і телебачення»
вул. Буніна, 31, Одеса, 65026, Україна
oleg.gofaizen@gmail.com, balyar.vb@onat.edu.ua, v.pilyavskiy@ukr.net

НОРМАТИВНОЕ ОБЕСПЕЧЕНИЕ ЭФФЕКТИВНОГО ВНЕДРЕНИЯ ДАЛЬНЕЙШЕГО ПРОГРЕССА ТЕХНОЛОГИЙ ЦИФРОВОГО ТЕЛЕВИЗИОННОГО И МУЛЬТИМЕДИЙНОГО ВЕЩАНИЯ

ГОФАЙЗЕН О.В., БАЛЯР В.Б., ПИЛЯВСКИЙ В.В.

Одесская национальная академия связи им. А.С. Попова
ул. Кузнечная, 1, Одесса, 65029, Украина
ГП «Украинский научно-исследовательский институт радио и телевидения»
ул. Бунина, 31 Одесса, 65026, Украина
oleg.gofaizen@gmail.com, balyar.vb@onat.edu.ua, v.pilyavskiy@ukr.net

Abstract. *The transition to digital television broadcasting and further progress of digital systems and technologies in the terrestrial environment continues worldwide. An important part of this transition is the introduction of new, efficient technologies and relative national and international standardization. In addition, for achieving the successful transition it is required to take into account the experience of implementation in countries that have already implemented digital broadcasting on economic, technical, social and other sides. This defines actual tasks in the general problem of introduction of digital terrestrial television and multimedia broadcasting. For consideration of main aspects series of standards, reports and other normative and technical documents will be analyzed - and it may take a long time. Certain solutions to assist technical professionals and/or the Administrations wishing to introduce digital broadcasting and realize further progress, in obtaining of systematic and actual information on the latest broadcasting technologies and experience of the technical implementation is the use of ITU Handbooks and Reports on digital broadcasting that are developed with this purpose. Active participants of development such international documents as part of activity in Study Group 6 "Broadcasting services" of Radio communication Sector of International Telecommunication Union (ITU-R) are the authors of this publication, on behalf of the Administration of Ukraine. This report presents information on the current results of the authors activity towards the development and publication of international ITU-R documents on technical implementation of digital terrestrial TV broadcasting, television colorimetry and measurements in digital broadcasting path. The main tasks of further improvement of the documents are presented. Publication of the documents will help technical specialists and administrations to define solutions on the implementation and further progress of digital television and multimedia broadcasting systems.*

Key words: digital television broadcasting, television colorimetry, implementation, digital television path, measurement, colour appearance

Анотація *- Перехід на повністю цифрове телевізійне мовлення в наземному середовищі й подальший прогрес цифрових систем і технологій триває по всьому світу. Важливою складовою такого переходу є впровадження новітніх ефективних технологій, їх національна та міжнародна стандартизація. Окрім того, для успішного переходу має бути враховано досвід впровадження в країнах, що вже розпочали цифрове мовлення, з економічної, технічної, соціальної та інших сторін. Цим визначено актуальні задачі в рамках загальної проблеми впровадження цифрового наземного телевізійного та мультимедійного мовлення. Для урахування всіх основних аспектів має бути проаналізовано низку стандартів, звітів та інших нормативних й технічних документів – й це може зайняти досить багато часу. Певним рішенням, що допоможе технічним спеціалістам та/або Адміністраціям зв'язку країн, що бажають впроваджувати цифрове мовлення й реалізувати подальший прогрес, отримати систематизовану та сучасну інформацію щодо новітніх технологій мовлення й досвіду технічної реалізації є використання міжнародних Довідників та Звітів МСЕ з цифрового мовлення, що їх розробляють саме з цією метою. Активними учасниками розробки таких міжнародних документів в рамках діяльності в Дослідній комісії 6 «Служби мовлення» Сектора радіозв'язку Міжнародного союзу електрозв'язку (МСЕ-Р) є автори цієї публікації, що діють за дорученням Адміністрації зв'язку України. В роботі представлено інформацію щодо поточних результатів діяльності авторів в напрямку розроблення та видання міжнародних документів МСЕ-Р стосовно технічної реалізації систем цифрового наземного ТВ мовлення, телевізійної колориметрії й вимірювань в тракті цифрового мовлення. Представлено основні завдання щодо подальшого вдосконалення та доповнення документів. Видання документів буде сприяти спеціалістам та адміністраціям в прийнятті рішень щодо впровадження та подальшого прогресу систем цифрового телевізійного та мультимедійного мовлення.*

Ключові слова: цифрове телевізійне мовлення, впровадження, тракт цифрового телебачення, вимірювання, телевізійна колориметрія, кольоросприйняття.

Аннотация *- Переход на полностью цифровое телевизионное вещание и дальнейший прогресс цифровых систем и технологий в наземной среде продолжается по всему миру. Важной составляющей такого перехода является внедрение новейших эффективных технологий, их национальная и международная стандартизация. Кроме того, для успешного перехода должен быть учтён опыт внедрения в странах, которые уже внедрили цифровое вещание, с экономической, технической, социальной и других сторон. Этим определяются актуальные задачи в рамках общей проблемы внедрения цифрового наземного телевизионного и мультимедийного вещания. Для учёта всех основных аспектов должен быть проанализирован ряд стандартов, отчётов и других нормативных и технических документов - и это может занять достаточно много времени. Определённым решением, которое поможет техническим специалистам и/или Администрациям связи стран, желающим внедрять цифровое вещание и реализовывать дальнейший прогресс, получать систематизированную и современную информацию о новейших технологиях вещания и опыте технической реализации является использование международных Справочников и Отчётов МСЕ в направлении цифрового вещания, разрабатываемых именно с этой целью. Активными участниками разработки таких международных документов в рамках деятельности в Исследовательской комиссии 6 «Службы вещания» Сектора радиосвязи Международного союза электросвязи (МСЭ-Р) являются авторы этой публикации, действующие по поручению Администрации связи Украины. В работе представлена информация, касающаяся текущих результатов деятельности авторов в направлении разработки и издания международных документов МСЭ-Р по технической реализации системы цифрового наземного ТВ вещания, телевизионной колориметрии и методах измерений в тракте цифрового вещания. Представлены основные задачи, которые были поставлены относительно совершенствования и дополнения документов. Издание документов будет содействовать специалистам в принятии решений по внедрению и дальнейшему прогрессу систем цифрового телевизионного и мультимедийного вещания.*

Ключові слова: цифровое телевизионное вещание, внедрение, тракт цифрового телевидения, измерения, телевизионная колориметрия, цветовосприятие.

INTRODUCTION

In recent years, the authors are prepared numerous contributions submitted by Administration of Ukraine to Study Group 6 ITU-R and its Working Parties 6A, 6B, 6C. These contributions were supported on international level and included in numerous international documents. This article presents the results of development of three documents by SG 6 and its WPs 6A and 6C with active participation of authors that are considered as the significant developments up to now.

HANDBOOK ON TECHNICAL IMPLEMENTATION OF DIGITAL TERRESTRIAL TELEVISION BROADCASTING

The decision to prepare a Handbook was taken at a meeting of the Working Party 6A in Geneva, 24-31 October 2008 [1, 2]. Drafting of international ITU-R Handbook on the technical implementation of digital terrestrial TV broadcasting (DTTB) was carried out by international expert

group of the Working Party 6A, whose members were the authors of this article together with leading experts in this field Christoph Dosch (Germany), Stephen Ripley (UK), Roger Bunch (Australia), Walid Sami (European Union of Broadcasters), Jean-Jacques Guitot (France), Andoni Perez de Lema (Spain), Alexandre Kholod (Switzerland), Kyung-Mee Kim (Korea), Larry Olson and Joseph Flaherty (USA), Yukihiro Nishida and Shuji Hirakawa (Japan), Alina Karwowska-Lamparska (Poland), Eli Sofer (Israel), Vittorio Baroncini (Italy) peter Dare (company Sony), Zhiping Xia (company ABS), Alberto Morello (company RAI), Anne-Lise Thieblemont (company Qualcomm), Pan Changyong (University of Tsinghua, China).

Handbook on the technical implementation of networks and systems of digital terrestrial television broadcasting is the second handbook on digital broadcasting developed by the ITU-R, but it covers all the latest trends, concepts and technologies that have appeared since 2002. This project that implemented by the Working Party 6A includes research results, inclusive which are made in Ukraine as well as and authors initiatives on further introduction and further progress of digital broadcasting.

Handbook covers the important introduction issues of modern digital terrestrial television broadcasting systems, including the introduction of technologies for forming and transmission of signals from both traditional TV programs and additional services that extend the use of standard services to the use of interactive applications or to applications with advanced functionality. Such functionality allows not only to get additional services, but also allows for people with disabilities to overcome technological and other barriers that separate them from getting the information in conventional manner. In addition, modern television has absorbed many of the capabilities of other, already familiar applications for viewers, such as the Internet, applications with 2D/3D graphics, entertainment and e-commerce. This made it possible not to lose their audience, and in some cases, even to expand. Technologies such as 3DTV, UHD, HDR, immersive audio technologies, and others make it possible to keep television at the forefront of information and television technologies.

The purpose of the Handbook development is to assist on technical and operational issues, such as networks and systems, the quality of sound and image and quality of transmission, as well as other issues of interest in terms of the introduction of digital terrestrial television broadcasting (from multimedia systems to UHDTV) in different countries. The Handbook considers the progress and convergence technologies, different environments for production, primary and secondary distribution of broadcast programs, as well as experience in providing quality service for DTTB and other important issues.

The main tasks of drafting the Handbook was following: provisions relating to the introduction of digital terrestrial (such as ATSC, DVB, ISDB, DTMB and others) television systems and multimedia broadcasting (DVB-H, DVB-T2 Lite, T-DMB, DVB-SH, ATSC-M/H, etc.) systems with reception on the handheld terminals. The Handbook, if possible, had to be able to stay actual during change of broadcasting technology, the convergence of broadcast and non-broadcast applications. Handbook was planned to include, if possible, information on options and technical implementation of digital terrestrial broadcasting networks. Handbook was aimed to include, if possible, information regarding the availability of standards, ITU-R Recommendations and Reports.

The concept of the handbook is structured so that the reader, getting into the appropriate section, can get not only the general concept of technology and the basic information on the relevant

issue, but also get information on the relevant regulatory support, including ITU-R Study Questions, Recommendations and Reports, ETSI, ATSC, ARIB, ISO / IEC and others. Such a concept allows using the Handbook not only as an information map, but also provides an opportunity to choose one or another technical or other solution in the field of digital terrestrial broadcasting for Administrations facing a corresponding problem. As for technical issues covered by the Handbook, they can all be divided into three main groups – issues of digital terrestrial television and multimedia broadcasting system, network issues and formation of television signal in terms of using the terrestrial environment for delivering relevant content to studio or during outside broadcasting.

The issues covered in the first information group (more general, first information group is included in Volume II) relate to the requirements and general concepts of terrestrial television broadcasting, as well as strategies and directions for further development. A significant part of the information group is devoted to issues of digital terrestrial and multimedia television broadcasting systems of first and second generations (DVB, ATSC, ISDB, China DTV series of standards), modern TV applications (including interactive applications and platforms (HbbTV, Hybridcast, etc.) and aspects of convergence with non-broadcast technologies), conditional access and protection of TV content from unlicensed use and others. Also are considered important issues of the quality of television content with the definition of requirements for the broadcasting signal and quality assessment methods with an indication of the corresponding normative base, as well as issues of digital terrestrial TV receivers with the definition of requirements for functional and hardware features, middleware. Special attention is paid to the issues of accessibility for people with disabilities and other groups of people with special needs with the definition of concepts and technical solutions that was already implemented and that is in process of implementation. In detail, Volume II includes the following sections:

– system level in digital television systems;

– digital terrestrial television broadcasting systems;

– terrestrial multimedia broadcasting systems;

– hybrid terrestrial/satellite multimedia broadcasting system;

– the convergence of broadcast and non-broadcast technologies;

– interactive television;

– conditional access and content protection in digital television broadcasting;

– baseband signal quality;

– receivers of digital terrestrial television broadcasting;

– aspects of digital broadcasting services to persons with disabilities.

Network issues of the second information group (also, mainly referred as Volume I) cover current issues of building of digital terrestrial television broadcasting networks, planning and coordinating the use of frequency resource (principles and features of planning, coordination procedures, sharing of the frequency range and protection of the broadcasting service, etc.) with the definition of the relevant normative base, basic principles and related software. So, Volume I includes the following sections:

– aspects of digital terrestrial television broadcasting;

– strategy of the introduction of digital broadcasting;

– frequency and technical requirements for terrestrial broadcasting networks;

– terrestrial networks implementation and issues of frequency planning of the broadcasting network for digital terrestrial television broadcasting;

– coordination procedures for the use of the frequency resource of digital terrestrial television broadcasting networks;

– the system quality of operation in digital terrestrial television broadcasting;

– satellite assistance in digital terrestrial television broadcasting.

Questions of outside broadcasting, outside production and contribution of broadcast signal to the studio through a terrestrial channel are considered in the third information group (Volume III). The information contains information about the requirements for electronic news gathering systems at the level of content formation and the level of transmission for the delivery of SDTV, HDTV and UHDTV television signals, as well as the frequency requirements for TV production systems that are used within the fixed and mobile services.

At the October meeting of the WP 6A in June 2016 it was decided to publish the draft Handbook as International Handbook. The handbook consists of 15 chapters and contains 318 pages.. Modern television broadcasting technologies are becoming more and more complex. Therefore, for the introduction of digital terrestrial television broadcasting, it's effective technical implementation, as well as the provision of new services and the provision of high quality television broadcasting, a kind of roadmap on technology is needed, highlighting their features and characteristics. These are the main aim and goal of this Handbook.

Considering that currently television technologies are in next cycle of development (HDR broadcasting, 8K television systems, MPEG-H immersive systems and other new technologies) and introduction in everyday broadcasting, in near future new edition is required.

At the October meeting of the WP 6A in June 2016 it was decided to publish the draft international Handbook. Now the Handbook is published in ITU database [3].

REPORT ITU-R ON MEASUREMENTS FOR DIGITAL TERRESTRIAL TELEVISION BROADCASTING SYSTEMS

During the introduction of digital broadcasting the problem of delivery of audiovisual content with the required level of quality with limited frequency resources under various distortions are appearing. In this connection, there is the problem of determining the possible technical solutions for quality control of the operation of digital broadcasting and defining a set of parameters used to assess the distortion of the signal. In digital broadcasting systems the important component of successful performing of all such tasks on its implementation and maintenance is quality control of functioning end-to-end chain of broadcasting system. Lack of control of the system performance can lead to the fact that the quality of the system as a whole will be degraded to an unacceptable level.

Considering mentioned above and understanding the importance of measurements during deployment and technical operation of digital terrestrial television broadcasting, it was proposed to start international standardization in this field. Development of such document was initiated by Ukraine experts according to the tasks of Questions ITU-R 109/6 and ITU-R 124/6.

At the meeting of the Working Party 6A (September 26–30, 2011) the contribution of Ukraine with propositions on a new report on measurement methods for digital terrestrial television broadcasting (DTTB) systems containing

The draft report was developed by the Working Party 6A of SG 6 based on contributions of Ukraine and other member Administrations of the ITU-R and published in the ITU-R database. The report was developed based on the research results, which are made in Ukraine and authors initiatives for the further development of television metrology presented in the form of contributions to the Study Group (SG) 6 of Radiocommunication Sector of the International Telecommunication Union (ITU-R) from the name of the Communication Administration of Ukraine. The report covers the main metrology aspects of television broadcasting chains, in particular, methods of measurement of Radio Frequency (RF) path, in the baseband and at the network level for different systems of digital television broadcasting. Its publication will contribute to the progress of television metrology and its use in television broadcasting, and allow to implement an integrated quality monitoring of the system of digital TV broadcasting during of technical operation and to conduct further research at various levels for more operative evaluation of performance and fault detection in end-to-end DTTB path.

Draft Report became Report after it was published in the database of the Radiocommunication Sector of the International Telecommunication Union (ITU-R) as [4]. The report as a normative document systematically defining measurement methods in the path of digital TV broadcasting systems at all levels is unique in worldwide practice.

The structure of the report corresponds to the following:

1 Introduction: The introduction highlights the role of measurement during implementation and technical operation of digital terrestrial television broadcasting systems.

2 The principles of measurement and monitoring for digital terrestrial TV broadcasting: Basic principles and classification of measurement parameters for digital terrestrial television broadcasting are provided and the main principles and quality monitoring features of DTTB paths are highlighted.

3 Baseband measurements and analysis of MPEG-2 transport streams: Baseband measurement and analysis of MPEG-2 transport streams (TS) with a description of the common parameters for all existing DTTB systems (bit rate measurement, etc.) and some measurements specific to certain systems (for DVB, ATSC, ISDB, etc.) are provided. Also the minimum necessary set of measuring equipment to assess the quality of the DTTB system at level of MPEG-2 TS is provided.

4 Baseband measurement and analysis of non-MPEG streams: Baseband measurement and analysis for streams that do not belong to the MPEG streams (for example, GSE streams) are provided.

5 System measurement and analysis for digital terrestrial television broadcasting: This clause gives the details of common and specific measurements of DTTB characteristics (such as MER/EVM, amplitude and phase imbalance of I/Q components, phase noise, shoulder attenuation, etc.).

6 Network measurement and analysis for digital terrestrial television broadcasting: Measurements (general and specific) for the evaluation of network parameters (such as, for example, the network delay, specific measurements for SFN networks) as well as minimum set of measuring equipment are defined.

Also quantitative and qualitative characteristics assessments for terrestrial television broadcasting in the standards DVB-T/T2 were obtained, but the results were not included in the report due to limited volume. So it was published as separate articles.

Now the document is published as the Report ITU-R BT.2389 [4].

REPORT ITU-R ON TELEVISION COLORIMETRY

Development of International Report “"Elements of TV colorimetry” is based on studies performed in Ukraine and on authors initiatives in directions of the further development of TV colorimetry.

This Report covers a wide range of topics including ideal colorimetry and future predictions, and some conclusions. It should be noted that over a period of time these predictions and conclusions may have been overtaken by the passage of time, or other industry factors. Reference is also made to an ideal camera, in this context a virtual camera. The report covers main aspects of television colorimetry, including the main directions of further progress of television systems and related applications, as well as methods for evaluating the color transmission quality with taking into account conditions of observation of images.

In the sections of this Report, all these aspects, particularly, technical aspects correlated with colorimetry characteristics of TV and, to some extent, with other image systems, colour rendering quality aspects and aspects associated with the state-of-the-art of colour perception models, are considered.

The structure of the Report contains:

1 The introduction – highlights the state of current knowledge in the field of colour science and state of TV colorimetry and its current progress: General model of light-to-light television and related imaging systems. The model is presented for non-adaptive and adaptive and potential adaptive systems: colorimetric characteristics of television and related systems. Relationship between tristimulus values in XYZ colour space and in RGB signal space. Relationship between spectral reflectance of transmitted scene object and tristimulus values in RGB signal space. Comparison colour rendering of through light-to-light TV path for colorimetric parameters based on CIE-1931 and CIE-2006 colorimetry systems. Colorimetric characteristics of digital standard definition and high definition television systems. Colorimetric characteristics of ultra-high definition digital television systems. Multimedia systems colorimetric characteristics. Colorimetric characteristics of new video applications: Digital cinema systems and LSDI systems. Colorimetric characteristics of new video applications: Video production systems in multimedia environment. Characteristics of colorimetry systems for digital video coding systems

2 Colorimetric characteristics of professional and consumer displays. Colour appearance models: General requirements for colour appearance models. CIELUV Model. CIELAB Model

3 New Colour appearance models. CIECAM02 model. Modification of CIECAM02 by Luo et al. CAM02-UCS (a'_M, b'_M) chromaticity diagram. High-Luminance Colour Appearance Model

4 Colour difference estimation. Introductory notes. Colour difference metrics formulation for two possible approaches for uniform and non-uniform colour spaces. CIEDE2000 metric based on CIELAB colour appearance model

5 Image appearance and image difference models. Introductory notes. General formulations. S-CIELAB as a spatial extension of the CIELAB colour difference space

6 Image appearance models iCAM and MOM. iCAM model. MOM model. Problems and example of adaptive TV technologies implementation. The problems of adaptive systems realization and implementation. An example of adaptive technology implementation

7 Mobile applications. CIECAM02 for mobile applications. Illumination-adaptive colour reproduction system for mobile displays. Image Colour-Quality Modelling for Mobile LCDs

8 The values of spectral sensitivity characteristics of primary channels of TV cameras. Comparison colour rendering of through light-to-light TV path for colorimetric parameters based on CIE-1931 and CIE-2006 colorimetry systems. Spectral characteristics of the ideal UHDTV camera in terms of CIE 1931 and CIE 2006 colorimetry. valuation of colour distortion due to difference of view on the characteristics of the ideal UHDTV camera in terms of CIE 1931 and CIE 2006 colorimetry

9 Evaluation of colour rendering fidelity of the through light-to-light digital television system video path

10 Colour gamuts transmitted and reproduced by television and related systems. Conventional colour gamut and extended colour primaries triangle television systems. Digital cinema and LSDI applications

11 Possible criteria of colour reproduction quality evaluation. Approaches to evaluation. Evaluation criteria of colour reproduction quality. Test materials which may be used for the evaluation of colorimetric quality of reproduced images. Optimization of colour reproduction quality for natural objects. Possible approach to evaluation of colour rendering fidelity of the through light-to-light digital television system video path. The influence of observing conditions on colour reproduction quality assessment. Possible future of TV colorimetry. The tasks for further studies

The report is published in the database of Radiocommunication Sector International Telecommunication Union (ITU-R) as Report ITU-R BT.2380-1 [5].

Propositions for further improvement and amendment the Report are published in [6].

Its publication will contribute to further development of video technology from the standpoint of modern progress in colorimetry science.

CONCLUSION

Publication of mentioned above Handbook and Reports will help to solve problems on the implementation and further progress of digital terrestrial broadcasting technology based on generalized information that covers basic aspects of digital broadcasting systems developed and used in the world.

REFERENCES

1 Chairman, Working Party 6A. Report on the Meeting of Working Party 6A (Geneva, 24–31 October 2008) Document 6A/120-E, 8 December 2008

2 Annex 18 to Working Party 6A Chairman's Report. Establishment of a Rapporteur Group on development of a Handbook on digital television (DTV) implementation. Document 6A/TEMP/113, 1 June 2009

3 Handbook on Digital Terrestrial Television Broadcasting networks and systems implementation https://www.itu.int/pub/R-HDB-63-2016

4 Report ITU-R BT.2389 Guidelines on measurements for digital terrestrial television broadcasting systems.

5 Report ITU-R BT.2380-1 Television colorimetry elements

6 Gofaizen O.V., Pilyavskiy V.V. Modern progress of TV colorimetry. Proposals for revision Report ITU-R BT.2380 "Elements of Television Colorimetry" // Digital Technologies, № 20, 2016. P.102-106