Transport Stream Generator and Player for Digital Terrestrial Television ISDB-Tb

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Abstract— The current paper introduces software, named Celina, that integrates the three ISDB-Tb standard functional blocks: Source coding block, multiplex block and transmission coding block. Celina allows to generate the MPEG-2 Transport Stream and transmit it by controlling the modulator DekTec DTU-215 functionalities. Therefore, users can manipulate transmission parameters and can broadcast the Transport Stream previously generated through a Radio Frequency channel.

The first stage of the project uses bit level operations which perform the audio and video coding. The EWBS descriptor and the ISDB-Tb program-specific information tables are generated and implemented during the multiplex block. The second stage of the project handles a dynamic-link library, developed on C++, which utilize the most important DTU-215 modulator features. All of this features are embed in an easy- to-manage, scalable, Java graphic interface application.

Key Words— ENCODER, ISDB-TB, MODULATOR, MUX, TRANSPORT STREAM, GRAPHIC USER INTERFACE.

I. INTRODUCTION

DTT (*Digital Terrestrial Television*) is the combination of technological solutions that afford transmission and reception of motion pictures, sound and data in a stream of digital signals through a network of terrestrial repeaters. On March 26th, 2010 Ecuador adopted the Brazilian-Japanese standard ISDB-Tb (*International System Digital Broadcasting, Terrestrial, Brazilian version*) as the official standard for digital terrestrial television. Currently, cities like Quito and Guayaquil are broadcasting testing signals using this digital technology.

Because of features like the One-Segment service embedded into the same bandwidth, high reliability of the fixed/mobile reception, robustness against the multi-path effect and EWBS (*Emergency Warning Broadcast System*) used for disasters prevention makes ISDB-Tb a system with better performance than similar standards. ISDB-Tb technical structure is composed by three functional blocks which are: (1) Source coding block, (2) Multiplex block, and (3) Transmission coding block. This subsystems are shown at figure 1.

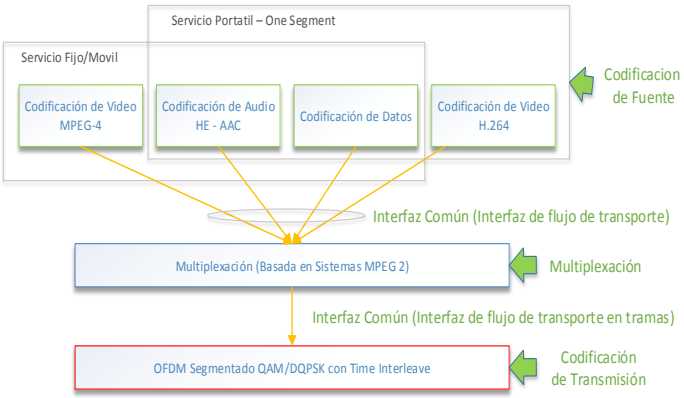

Fig. 1 ISDB-Tb Standard Estructure

The ISDB-Tb source coding block stablishes that fixed reception services use MPEG-4 and one-segment services uses H.264 as the compression method. Audio compression, both fixed and mobile, is defined by the HE-ACC method.

In the multiplex block, like the Japanese standard, the video, audio and data content are multiplexed in a single TS (*Transport Stream*). Transport Stream is a standard container format for transmission and storage of audio, video, and Program and System Information Protocol (PSIP) associated to the MPEG-2 ISO/IEC 13818-1 standard [1]. There are several professional tools in the market that generate Transport Streams and manipulate packets. For example, Open Caster, which is an open-source software [2], has been used to test DTT signals and research projects thanks to the ISDB-Tb adaptation developed by LIFIA[1] at the Universidad Nacional de la Plata [3].

The transmission coding block stablishes the coding, modulation and techniques to decrease impulsive noise, attenuation and interference effects. This block afford to broadcast within a robust signal the generated TS. By using a digital signal, broadcast errors can be corrected and a best picture quality like HD (*High Definition*) can be used [4].

[1] Research lab that offers technological transference and IT services to national a international communities

As other commercial solutions, Celina is a new multiplexer designed to generate and control digital television signals using DekTec[2] devices. Celina was developed by the ESPETV research group at the Universidad de la Fuerzas Armadas - ESPE. Celina is a multiplatform tool, which its current version was developed to work over Windows Operating System.

II. VIDEO AND AUDIO COMPRESSION

Audio and video compression is achieved using FFMPEG[3]. FFMPEG is open-source software that permits to record, encode and stream audio and video files. Furthermore, it can work over several operating systems using a command line interface. In the current project, the Java application uses a Runtime class and generates a *.bat* file for Windows in order to execute the commands that FFPMEG requires.

In the GUI *(Graphic User Interface)* developed, the Input tab allows to select the *.mp4*, *.avi* or *.mov* file that will be encoded. Subsequently, the video and audio encoder, as well as video resolution, aspect ratio and audio channel is selected. The Input tab is shown at the figure 2.

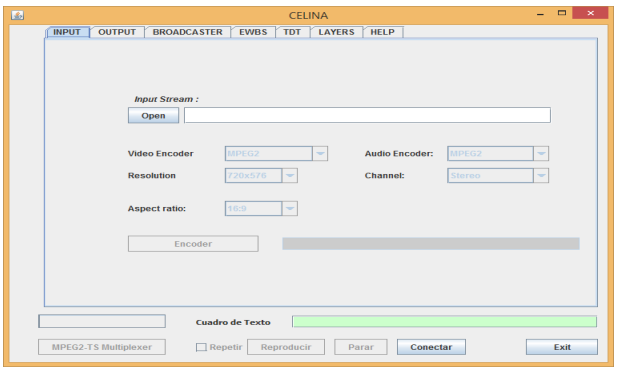

Fig. 2 Audio and video encoding interface

According to the selected configuration, a *.bat* file is generated within the FFMPEG instructions that will create the temporary file *out.ts*. A instruction generated is shown below.

```
#!/bin/sh
ffmpeg -i '/Users/ESPETV/Desktop/prueba.mp4' -vcodec mpeg2video -s 720x576 -r 30 -b 5000k -aspect 16:9 -acodec mp2 -ac 2 -ab 128000 -ar 48000 -muxrate 29.958294M -f mpegts out.ts
```

where:

- -vcodec mpeg2video -s 720x576 -r 25 -b 5000k -aspect 16:9 identifies that MEPG2 is used as the video encoder with a 720x576 resolution, 30 frames per second, 5 Mbps transfer rate and 16x9 ratio aspect. CELINA was configured to support 1920x1080 or 1280x720 reslution with a transfer rate of 10 Mbps for HD signals, 720x480 or 640x480 resolution with a transfer rate of 5 Mbps for SD *(Standard Definition)* signals and 320x180 or 320x240 with 300kbps for LD *(Low Definition)* signals.
- -acodec mp2 -ac 2 -ab 128000 -ar 48000 stablishes MPEG2 as audio encoder, with stereo channel (1 mono, 2 estéreo) and a transfer rate of 128 kbps and 48kHz.
- -muxrate 29.958294M -f mpegts out.ts determines that a TS named *out.ts* is generated. This TS has a transfer rate of 29,95Mps with null packets as the ISDB-T standard requires [4].

The generated file *out.ts* has TS packets of 188 bytes each. This packets contain the audio and video PES (*Packetized Elementary Stream*) that are used to generate the data stream according to the ISDB-Tb system [4].

III. PSI/SI TABLES AND SERVICES GENERATION

The PSI/SI (*Program Specific Information* / *Service Information*) data permits the receiver to identify and correctly decode the different services that make up the TS. The temporary file *out.ts* has the PAT (*Program Association Table*) table that associates the included programs into the TS. Also contains the PMT (*Program Map Table*) table that links the video and audio elements. Additionally, the *out.ts* file include the PCR (*Program Clock Reference*) table that controls the video and audio synchronization. All this tables are related with their own PID (*Packet Identifier*), which is represented with a 13-bits number. The *out.ts* file can be played by specific programs like VLC. However, it does not contain the required ISDB-Tb format.

In addition, Celina includes a TS analyzer that obtains the PIDs of audio, video and PMT from the PAT data, and it shows them in the GUI as decimal numbers like figure 3 displays.

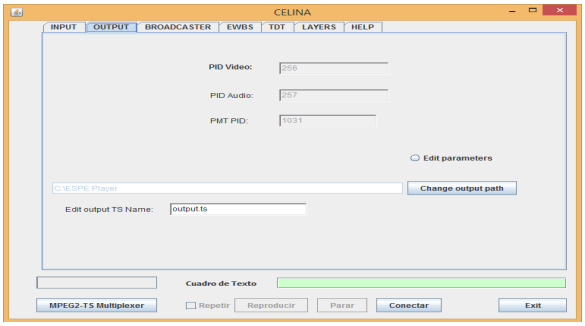

Fig. 3 PMT, audio and video PIDs from the out.ts file.

The new PID values can be used to restructure the PAT, PMT, PCR and every audio and video TS packet according to the ABNT NBR 15603-1 specification [4].

The provider name is a variable that can be entered by the user through the Broadcaster tab, using the Broadcaster Name option as figure 4 shows. In addition, in the same figure it can

[2] Company that designs and manufacture PC cards, USB/IP devices and software for the digital television professional market.

[3] http://www.ffmepg.org

be observed that the user has the option to include the Network Name, TS Name and Virtual Channel. The Virtual Channel option is important because broadcasters can transmit on any other frequency and maintain the same channel number as their current analog channel.

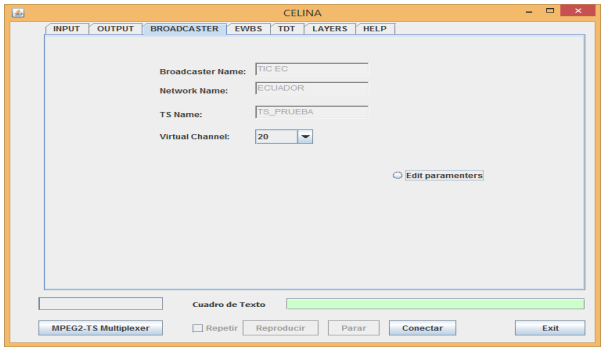

Fig. 4 BROADCASTER Menu.

The EWBS tab can active the EWBS emergency system by configuring the12-bits area code that modifies the PMT data and includes the emergency descriptor [5]. As figure 5 shows, Celina suggests the 0x0A3D or 2621 code by default. This code is the global area for Brazil and it is used because it was configured in the receivers used for lab testing. The emergency signal was configured to be activated after the first quarter of the video has passed.

The MPEG2-TS Multiplexer button generates a ready to transmit TS for both standards ISDB-T and ISDB-Tb. The temporary file *out.ts* stays in memory for new configurations until a new file is loaded or the program is closed.

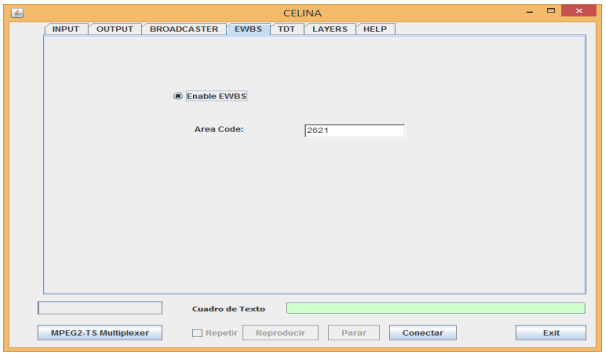

Fig. 5 EWBS Menu.

IV. DEKTEC MODULATOR

The DTU-215 DekTec modulator and the DTAPI (*DekTec Application Programing Interface*) are used for the transmission coding block. DTAPI enables application programs to access the functions of DekTec Devices at a higher level of abstraction than would be possible using direct device-driver calls [8]. The DTAPI is a collection of C++ classes, each representing a generic hardware function that afford the use of several digital television standards as well as other DekTec devices. Celina only uses those classes and variables that are compatible with the ISDB-Tb standard and the DTU-215 modulator.

The development of the DTU-215 modulator control platform consists of two parts: a DLL (*Dynamic Link Library*) developed on C++ that uses the DTAPI functions, and a Java application that includes the C++ DLL, the TS generation part and an easy-to-use GUI. The figure 6 shows the different layers of abstraction used on the current project. The two higher layers were developed in Celina.

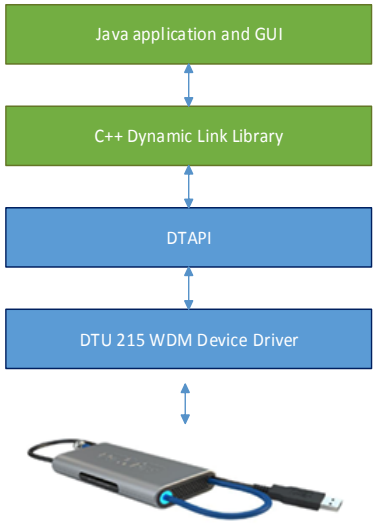

Fig. 6 Abstraction layers of CELINA

The Java application has 3 classes that permit to interact with the user, validate data and communicate with the DLL developed. Below there is a description of each class developed.

- IntegraJNI: It contains the variables and methods that are used in the DLL. This class only declares the native methods in Java; the implementation is done in the C++ DLL.
- ReproduccionVideo: It is a Runnable class that takes the previously configured and validated data, and used it to configure the transmission parameters and transmit the TS.
- TSGen: It is the main class that contains all the GUI objects and local methods. It uses the objects of the previously mentioned classes. In this class the generation of the TS is made.

Java and C++ integration was made using the JNI tool. JNI specifies the communication protocol between a Java code and an external native code written in other language. Celina uses JNI to connect the DLL with the Java application. This allow users to control the DekTec device using the GUI of the Java application.

The software development that controls the modulator was design to make the most of the DCTU-215 features. The DLL has 14 methods which made the logical connection,

configuration, transmission and other functionalities that permit to broadcast Transport Streams and Broadcast Transport Streams. Below it is listed several of the previously mentioned methods.

- String LeerError(): If there is any, it allows to read errors produced when a process has occur between the DTAPI and the modulator. C++ returns a *String* variable within the error message event.
- boolean AdjuntarTarjeta(): It permits to initialize the connection between the PC that host Celina and the modulator.
- boolean ConectarPuerto(): It permits to begin upper layer communication with the transmission port.
- boolean LimpiarBanderas(): It resets the internal error-control flags of the DTU-215 modulator.
- boolean Configuracion_Tx_TodoCapaA(boolean flag_TMCC, int[] valores_confg): It perform the transmission parameters configuration. It sends from Java to C++ an array of *int* variables that contain the required information of how the TS will be transmitted. The data that was sent, has a meaning according to its position in the array.
- boolean AbrirArchivo(String ts_path): It takes a *String* variable with the path and name of the TS and uses to open the file
- boolean InitTxParams(double frecuency, int size_pack, int nivelDbm): This method perform the configuration of the frequency where the TS will be transmitted, also it defines if the TS packets have 188 or 204 bytes in order to get them ready for the transmission.
- boolean ReproducirTs(int wrap): This method performs the transmission of the TS with the previously mentioned configuration. The only Java parameter send is an indicator that afford the wrap option.
- boolean PararTs(): It permits to stop the TS transmission
- boolean CerrarPrograma(): It performs the logical disconnection, reset the flags, erase any data in the buffer to end the communication with the DTU-215 modulator.
- int ValidarArchivoTS(): It permits to validate the selected file as a TS by checking its packet size.

V. RESULTS

To carry out the tests, the scenario consist of a Dell PC Core I5 1.7GHz with 4GB of RAM, which is connected to the USB cable of the Dektec DTU-215 modulator. The output port of the modulator is connected to a signal amplification device and then to a splitter which connects to the Agillent CXA Digital TV Analyzer and to a TV that contains the included ISDB-Tb decoder.

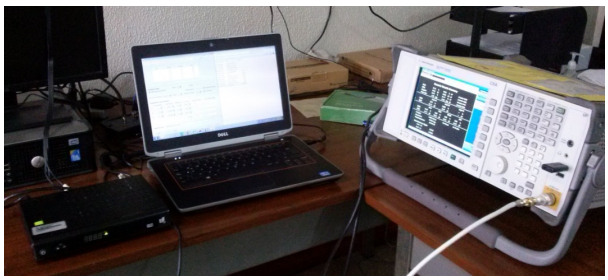

Fig. 7 Test scenario for transmission and reception of the ISDB-Tb signal

The TS generated, named *prueba.ts,* is transmitted by the Dektec DTU-215 modulator, through the physical channel number 30 on the 569,143 MHz frequency. The modulation parameters are configured, as well as the guard time, interleaving time, encoding and mode. Figure 8 shows the configuration of the previously mentioned parameters.

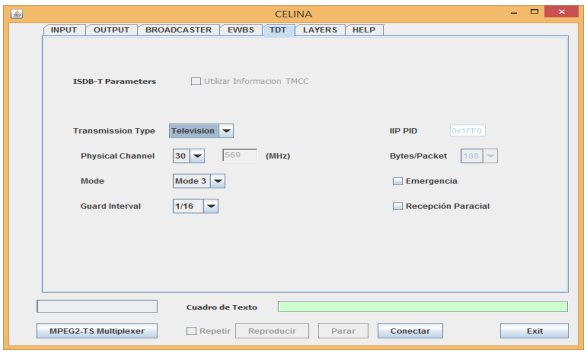

Fig. 8 Configuration of the transmission parameters

Once the signal is transmitted, Figure 9 shows the Transport Stream reception, the same that presented full synchronization without freezes, and the channel name “TIC EC”, in channel 30.1 can be seen, as it was configured.

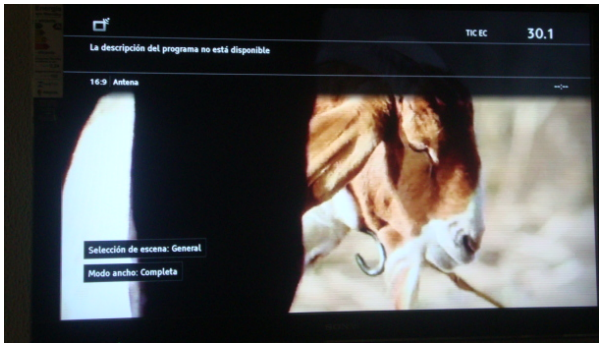

Fig. 9 Digital TV image reception

The Agillent analyzer verifies that the transmission signal is indeed the center frequency mentioned above, and the bandwidth of the channel is 6MHz as indicated by the ISDB-Tb standard.

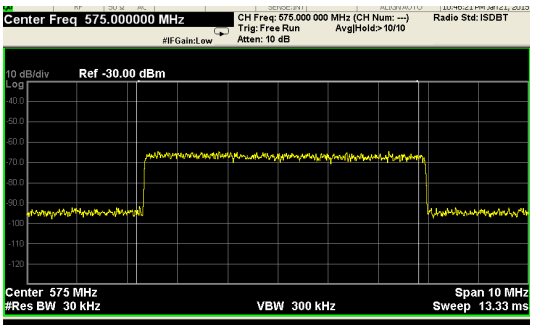

Fig. 10 Bandwidth transmission and Frequency verification

To test the emergency signal, a Japanese decoder, brand PIXELA[4], was connected. The bit of the emergency signal in the TMCC (*Transmission and Multiplexing Configuration Control*) of the modulator was activated, as shown in the Figure 11, there is the emergency signal activation.

Fig. 11 Reception of the emergency signal

Celina is a tool that allows the generation of a TS, including the encoding and multiplexing stage. It builds the PAT, PMT, PRC, SDT and NIT tables based on the Broadcasters' requirements. It includes the generation of the EWBS emergency signal, which activates audible alarms in decoders, as well as it turns on the decoders, based on established code in the program which must match the receiver.

Celina allows the transmission of the previously generated TS, considering that settings as: transmission frequency, channel bandwidth, service distribution in hierarchical layers, hierarchical layers modulation, etc. all comply the ISDBT-Tb standard applicable regulations.

Celina was designed as a training support tool. It works at the bit level, allowing a large number of configurations according to future requirements. For example, it increases the number of emergency codes or modifies tables' parameters presented with fixed values. In future versions, Celina will support the possibility of multiple programming, Ginga Applications data and the generation BTS integrated with ISDB-T and ISDB-Tb DekTec modulators.

[4] Peripheral PC hardware and multimedia software manufacturer

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