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A Novel Approach for Implementing MPEG-4 Technology for Set Top Boxes

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Abstract

MPEG-4 is the latest technology in Set Top Box (STB) world. MPEG-4 uses DVB-S2 (Digital Video Broadcasting – Satellite version 2) technique. DVB-S2, which offers a 30% improvement in bandwidth efficiency, will enable broadcasters to offer more HD channels, with better performance, than anywhere else on the planet. STB is any electronic device designed to produce output on a conventional television set (on top of which it nominally sits) and connected to some other communications channels such as telephone, ISDN, optical fiber or cable. The STB usually runs software to allow the user to interact with the programs shown on the television.

In increasing numbers, consumers are switching from analog to digital TV reception. They're looking for more channels, clearer and more reliable pictures and if they can get it lower costs. To meet this growing demand and to keep prices down, manufacturers of MPEG-4 compliant IRDs (Integrated Receiver/Decoders; or, simply, "set-top boxes") are ramping up their production lines while doing everything possible to keep manufacturing costs to a minimum. A critical component in keeping these costs down is the speed and efficiency with which these units can be tested on the production line [4].

STB can make it possible to receive TV signals, connect to networks, play games via a game console browse networks including the Internet, interact with electronic program guide, virtual channels, electronic storefronts and walled gardens, send e-mail, and video conference.

Keywords: MPEG-4, DVB-S2, Audio-Video coding.

Introduction

Digitally broadcast TV services are now well established in markets in many countries. Many of these services have adopted the DVB-S2 specifications which have become a world-wide standard. The cost of digital receivers for DVB-S2 services is still predictably high. The costs have not noticeably reduced yet because of three main factors. First, the volumes have not reached really high levels (DSS in the USA is an exception), second because it takes time for the lowest cost implementations to be identified and developed and third because the manufacturing margins.

New generations of receivers are being developed and manufactured which are bringing both lower costs and increased functionality. This paper takes a look at solutions being deployed in DVB-S2 receivers so far and what can be expected in the near future in terms of cost reduction techniques and new functionalities. Digital Set-Top-Box is a video/ audio subsystem that supports digital/analog video broadcasting (cable, satellite, terrestrial), broadband connection, personal video recording (PVR), VoIP, interactive internet, and wireless connectivity.

Different types of STB

1. Broadcast TV Set-Top Boxes
2. Enhanced TV set-top boxes
3. Advanced Set-Top
4. Sidecar
5. Hybrid Digital Cable Box

Specifications

- **Processor**
  240 MHZ CPU

- **Memory**
  32MB SDRAM

- **Boot-Flash**
  2 MB NOR Flash
  Extensible up to 4MB

- **Front-end module**
  DVB-S2-C: 44-870 MHZ EN 300 429
  Compliant cable NIM
  DVB-S2-S: 950-2150 MHZ EN 300 421
  Compliant satellite NIM

- **Smartcard Interface**
  1 Smartcard Reader, ISO-7816 Compliant

- **Transport De-multiplexer and De-scrambler**
  Single transport stream input. 32 PID

Filters and 32 x 8 section filters DVB-S2 De-scrambling

o. **Video Decoder**
Single decode of MPEG-2 and MPEG-4
Streams MP@ML

o. **Audio Decoder**
MPEG-1 Layer 1 and 2, MPEG-4

o. **Video Interfaces**
CVBS (coax) Video output

o. **Audio Interfaces**
L-R Analog audio out

o. **Front Panel**
3 keys for channel changing and Stand by function. Two LEDs for Diagnosis

o. **IR Remote**
Support for RC6/RC5/NXP Protocol Based IR remote control

Features

1. MPEG-4 SD Video decoding
2. MPEG-1 layer1 , 2 & MPEG-4 Audio decoding
3. DVB-S2 Standard EPG
4. Channel management with favorite
5. Channels and parental locks
6. Fully functional IR remote control
7. Smartcard interface for CAS
8. Diagnostic LEDs
9. 2D OSD engine for graphics and Menus

STB Block Diagram

DVB-S2 integrated receiver decoder

The IRD receives and decodes the broadcast TV services. It tunes to the required channel, extracts and decodes the selected data, checks the access rights of the user and outputs picture, sound or other services as needed.

Digital signals are fed to the IRD in the same way as for analogue TV signals so in the case of satellite transmission an outdoor unit, comprising dish and low noise block (LNB), is required to receive the signals and convert them to a suitable intermediate frequency (IF).

Architecture of the IRD

The main functional blocks of the digital STB, as shown in the example architecture of Fig. 4.1, can be grouped into the main sub-systems of front-end, conditional access, MPEG decoding, output signal encoding and control.

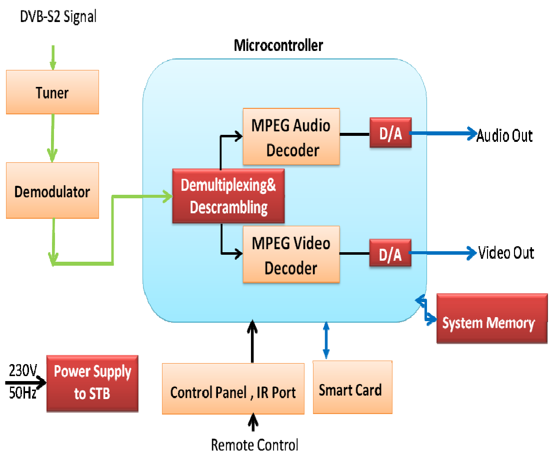

Figure 4.1: Block diagram of Set Top Box.

Front-End

The front-end converts the RF input to the MPEG Transport Stream meeting the DVB-S2 specifications for channel coding and modulation for satellite or cable transmission. The tuner accepts input from satellite typically from 950 MHz to 1250 MHz, with a normal channel bandwidth of 7 MHz, and converts to a suitable IF. The Demodulator carries out separation of I and Q signals, QAM demodulation, equalization with a digital filter followed by symbol to byte mapping. The FEC performs the Reed Solomon error correction, removes the energy dispersal and outputs the MPEG transport stream.

Conditional Access Sub-system

The conditional access (CA) system uses scrambling and encryption to control user access to the broadcast services. Transport stream packets, containing video, audio or data transmitted are scrambled using the DVB-S2 scrambling system. Selected packets of the transport stream are descrambled in the STB synchronized by control words or keys under the control of a security module e.g. Smart Card. The security module also decrypts the control words which are transmitted in an encrypted form and stores personal user data [2].

The CA elements consist of descrambler, some demultiplexing functions to enable decoding of conditional access data in the transport stream, the security module and the means to communicate between the security module and the STB. These functions may be located together in a self-contained module or they may be contained in devices embedded in the STB as shown in the example in Fig. 4.2.

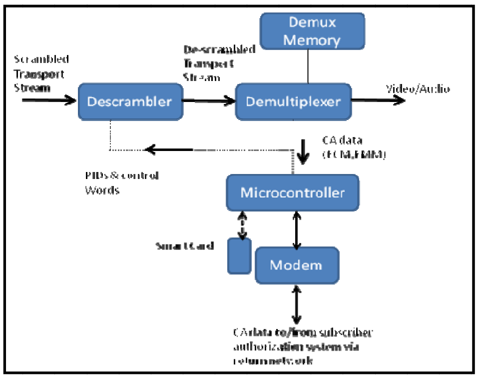

Figure 4.2: Conditional Access Elements.

Transport packets are selected in the Descrambler using their packet identification number (PID) and descrambled if the scrambling control bits in the packet header indicate they are scrambled. The Microcontroller provides the PID numbers and correct control words supplied by the Smart Card. Entitlement control messages (ECM) and entitlement management messages (EMM) or other CA data carried in the transport stream is extracted by the Demultiplexer and passed to the Smart Card. Decoded control words are reretурned to the descrambler to enable the descrambling process to be synchronized.

MPEG Decoding and On-Screen Display

The MPEG decoder consists of the system layer decoding (Demultiplexer) and the source decoding (video and audio decoding). Early STBs implement these in three separate devices plus memory and support circuitry as in the example of Fig. 4.3.

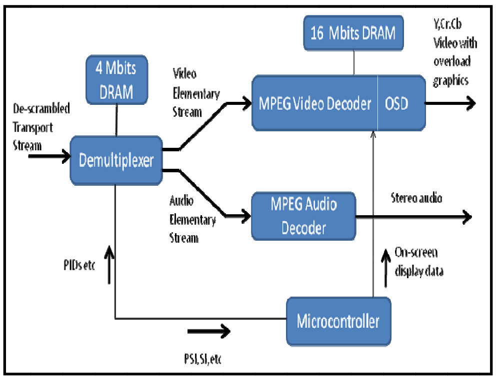

Figure 4.3: MPEG Decoder.

The transport stream contains programs with elementary streams of video and audio and other data such as PSI, SI, CA information, teletext, etc. The Demultiplexer performs selection and separation of the required streams employing hardware filters where necessary ignoring the streams not required. The video and audio elementary streams are decoded in their respective decoders and data is passed to the Microcontroller. Video and audio decoding requires decompression in hardware due to the complexity and speed necessary to perform the de-compression. More recent STBs use integrated devices which have combined the video and audio decoding into one device (except for the video memory).

The MPEG video decoder usually has other functions integrated into it for reasons of efficiency. Two of these important functions are aspect ratio conversion and the on-screen display (OSD). Aspect ratio conversion is needed for conversion of 16:9 to 4:3 aspect ratio images, however the necessary interpolation filters are also used to convert from the coded image format to the display format when they differ.

Data and OSD data, as shown in Table 1- Video Decoder Memory Usage, required a complete 3 frames of storage for the previous, next and currently decoded frames as shown. However improved designs have reduced this to between 2.5 and 2.8 frames which have enabled combined video and audio MPEG decoders to squeeze all their storage into 16 Mbits.

Output Signal Encoding

The video encoder performs encoding of the video output of the MPEG-4 decoder (digital Y**,** Cr, Cb format) to composite (PAL, SECAM or NTSC) and matrixing to R, G, B components. These signals are converted to analogue following which teletext signals are re-inserted in the composite signals if required.

Control

The Microcontroller implements the software (applications, library functions, communications, operating system and the hardware device drivers), sets up the devices in the STB and controls the VO ports. It is likely to be a 16 or 32 bit device e.g. Motorola 68K family. [1] The IRD requires memory for storage of the application code, operating code, working data and configuration data requiring a typical combination of 0.5 Mbyte RAM,1 Mbyte ROM (FLASH allows upgrading) and 2-8Kbytes Non-Volatile RAM (EEPROM).The **U0** ports of the STB typically include a serial data interface (RS232) for asynchronous data connection to PC, a parallel data interface (IEEE1284) for higher speed asynchronous data connection to PC/printer, modem return channel for asynchronous data connection to remote device (e.g. a PSTN modem with speeds of 1200 or 2400 baud) and IR receiver for the remote commander.

Flow Chart

Main Program flow chart

Fig. 5.1 shows main program flow chart of microcontroller. It shows overall flow of microcontroller operation.

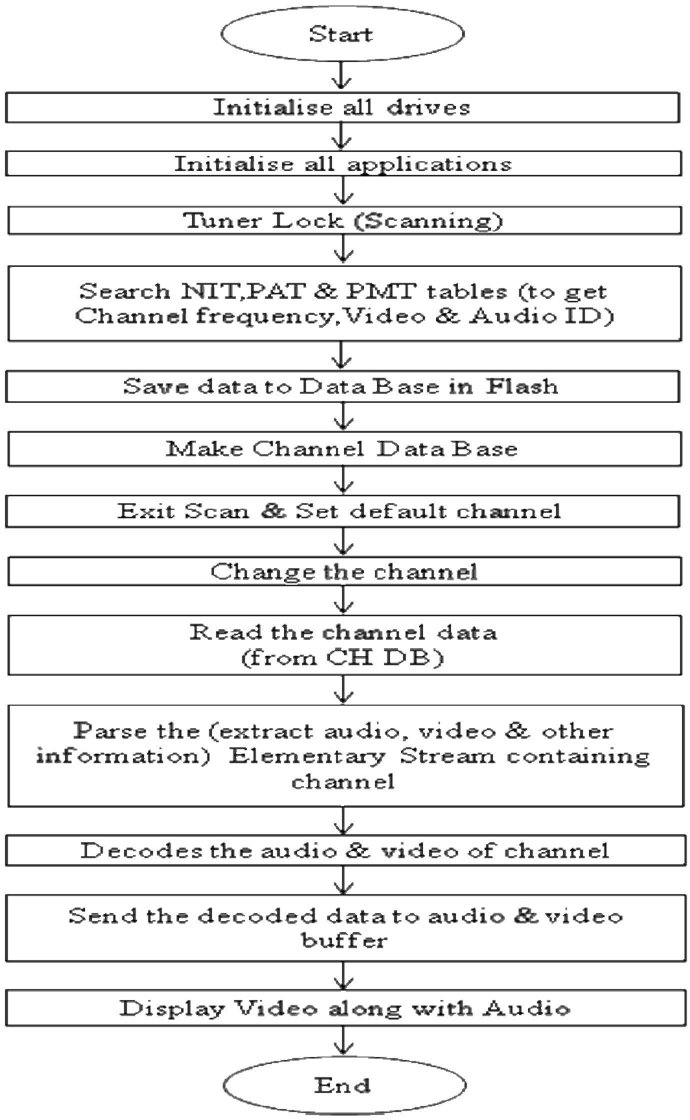

Figure 5.1: Main program flow chart.

Hardware and Software Requirements

Some of the first STBs are designed with a 'closed' software environment with no easily accessible application interface. The software maybe stored in conventional ROM in the STB so it cannot be upgraded after manufacture resulting in fixed functionality and limited life. The use of reprogrammable ROM such as Flash allows upgrading over the transmission path, through a return channel PSTN modem or other means e.g. via the serial port. This restricts the flexibility and requires duplicated memory to support the upgrade process. To be more flexible the system needs to be able to introduce new applications without replacing the complete software by dynamic linking of new applications or application modules. This allows new services to be supported by STBs in the field. Fig. 6.1 shows architecture to achieve this.

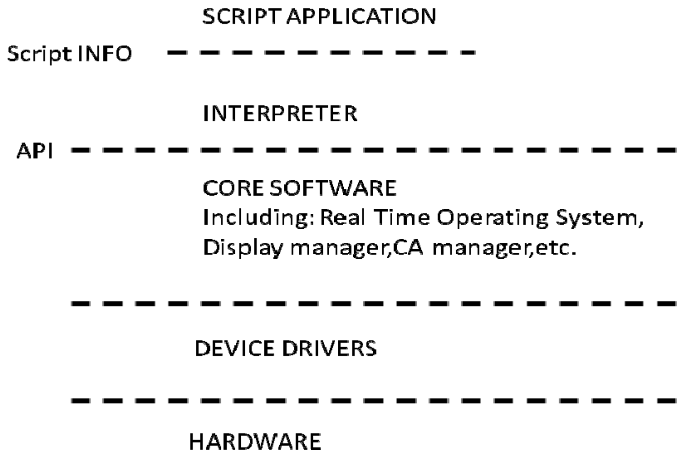

Figure 6.1: Download Software Architecture.

The application provides the high level control of the STB e.g. simple channel selection program, electronic program guide or sophisticated interactive software. This is supported by the core software which provides the main software processes such as the Display manager and CA manager running with a real time operating system. The core controls the hardware through device drivers. An application programming interface (API) is defined which provides a software interface allowing new application software to be introduced without replacing the layers of software below the interface. In addition, an interpreter provides a means to run script-like applications which don't have to be compiled into the machine language of the STB. However the use of Flash memory still provides the capability to upgrade the lowers layers if necessary. The use of the API also means that the scripting language can be upgraded allowing new features or enhancements to be added, again without replacing the complete STB software. The API as shown needs to support a range of functions in the STB such as presentation of text and objects to the Display, tuning and selection of programs, video and audio functions, user command input, conditional access functions, remote communications.

Results and Discussions

1. Serial communication problem between Extender & CPU: Serial communication rectified by using USB cable instead of co-axial cable for better compatibility with the system CPU
2. Unsuitable environment condition (e.g. Temperature, Dust): The performances of Smart Card get affected due to surrounding temp. This resulted in incorrect sensing of Smart Card and display of massage like Invalid Smart Card. To overcome this problem the suitable work environment was created (like closed room with Dust free environment).
3. Video signal generating failure

The last-end wave of CVBS Output is same as fig. 7.1. (The below picture shows 75 Ohm lode status to TV when you gauge RCA wave)

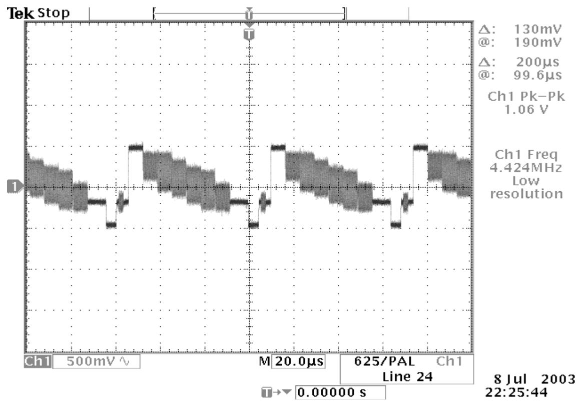

Figure 7.1: CVBS output waveform.

CVBS Output is normal but in case the last-end wave is distorted or the range of it is below 1Vdc ± 0.1. It is also observed that wrong value of Resistor & Capacitor in output buffer circuit causing failure in video signal generation.

To solve this problem I have added a check point at output buffer circuit for checking polarity & value of Resistor & Capacitor.

No Screen Display

TS Signal is input to microcontroller when tuner locks channel as shown in fig. 7.2.

As per my observation & study this problem was occurred due to dry soldering at demodulator power supply & reset pin (as per fig.7.3).

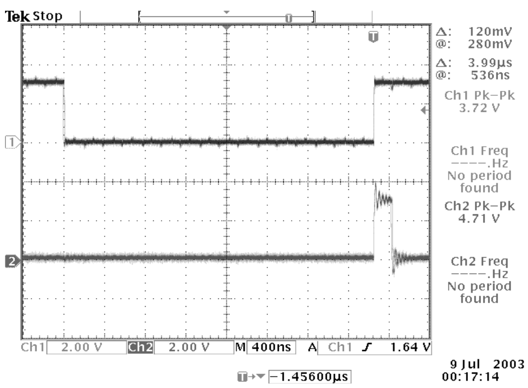

Figure 7.2: Signal TS_EN (VALID).

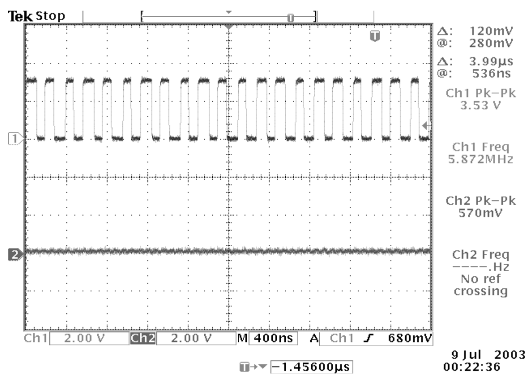

Figure 7.3: Signal waveform for TS CLK & ERROR.

Above problem solved by setting proper melting temperature of solder bath.

Applications

1. Digital signal transmission
2. Interactive broadcasting using a return channel [3]
3. For Internet broad band access
4. Satellite radio

Future Developments

The growth of bandwidth and broadband content services is driving functionality and indeed the prominence of the set-top box in the living room, so future developments of STB carries more important. The objectives of integration are to minimize packaging costs, reduce pin count, minimize total silicon areas and achieve architectural efficiencies. In turn the silicon integration leads to other cost reducing benefits in the product such as smaller/less complex PCBs, lower power consumption leading to cheaper power supply design, lower manufacturing costs (less devices to handle, simpler testing) and higher reliability.

Integration of receiver functions started, for example, with the combining of MPEG video and audio decoding, and the integration of the digital part of the front-end into one device. Further silicon integration can be achieved by integrating the DVB-S2 descrambler with the Demultiplexer and the Microcontroller (using a RISC core). An alternative is to create a complete MPEG sub-system but leave the Microcontroller separate.

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