ELIMINATION OF IMAGE BLOCKING PROBLEM FOR SINGLE TUNER IDTV APPLICATIONS

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İZMİR

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We have read the thesis entitled **“ELIMINATION OF IMAGE BLOCKING PROBLEM FOR SINGLE TUNER IDTV APPLICATIONS”** completed by **Emre YENİGÜN** under supervision of **ASSOC. PROF. DR. UĞUR ÇAM** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ABSTRACT

In this thesis, the LCD TV (liquid crystal display television) and IDTV (integrated digital television) technologies were presented. For the single tuner IDTV application, a specific dijital image blocking problem was solved.

In the single tuner IDTV application, a single hybrid tuner is used and the IF (intermediate frequency) output signals of the tuner are divided by two, as analog side (LCD-TV main board) IF input signals and digital side (digital module card) IF input signals. The digital module card is used for IF demodulating and MPEG (moving pictures expert group standard) decoding. The analog IF demodulating process is made in LCD TV main board. The hybrid tuner is located on that main board. The IF output of the tuner is carried to the digital module card by a cable. To distribute the IF output of the hybrid tuner to analog side and digital side and to use an IF cable for carrying the IF signal to the digital module card, impair the IF signal shape.

In this thesis, the image blocking problem was solved. The source of the problem was found as impedance mismatching and IF signal impairing. The new high frequency emitter follower circuits were designed for solving this problem. The BF799 high frequency transistor was used for this high frequency circuit application.

Keywords : LCD TV, IDTV, image blocking problem, IF demodulating, MPEG decoding, hybrid tuner, IF cable, IF signal impairing, impedance mismatching, BF799 high frequency transistor.

TEK TUNERLİ IDTV UYGULAMALARI İÇİN GÖRÜNTÜ BLOKLANMA PROBLEMİNİN GİDERİLMESİ

ÖZ

Bu tezde, LCD TV (sıvı kristal görüntülü televizyon) ve IDTV (entegre sayısal televizyon) teknolojileri sunulmuştur. Tek tunerli IDTV uygulaması için, özel bir sayısal görüntü bloklanma problemi çözülmüştür.

Tek tunerli IDTV uygulamasında, tek bir karma tuner kullanılmakta ve tunerin IF (orta frekans) çıkış sinyalleri, analog taraf (LCD TV anakart) IF giriş sinyalleri ve sayısal taraf (sayısal modül kartı) IF giriş sinyalleri olarak ikiye bölünmektedir. Sayısal modül kartı, IF kipçözme ve MPEG (hareketli görüntü uzmanları birliği standartı) kodçözme için kullanılmaktadır. Analog IF kipçözme işlemi, LCD TV anakartında yapılmaktadır. Karma tuner bu anakart üzerinde bulunmaktadır. Tunerin IF çıkışı, sayısal modül kartına bir kablo ile taşınmaktadır. Karma tunerin IF çıkışını analog ve sayısal tarafa dağıtmak ve IF sinyalini sayısal modül kartına taşımak için bir IF kablosu kullanmak, IF sinyalini bozmaktadır.

Bu tezde, sayısal görüntü bloklanma problemi çözülmüştür. Problemin kaynağı empedans uyumsuzluğu ve IF sinyal zayıflaması olarak tespit edilmiştir. Problem çözümü için yeni yüksek frekanslı emetör sürücü devreleri tasarlanmıştır. Yüksek frekans devre uygulaması için BF799 yüksek frekans transistörü kullanılmıştır.

Anahtar sözcükler : LCD TV, IDTV, saysal görüntü bloklanma problemi, IF kipçözme, MPEG kodçözme, karma ayarlayıcı, IF kablosu, IF sinyal zayıflaması, empedans uyumsuzluğu, BF799 yüksek frekans transistör.

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CHAPTER ONE
INTRODUCTION

Most existing terrestrial television transmissions are broadcast as analogue signals where the signal quality can be reduced due to location, obstacles, or interference from other sources (such as overhead electric cables). To receive the best possible signal, a rooftop antenna is required. Satellite television uses an external dish to receive its data, however, these signals are affected by weather conditions and pollution in the earth's atmosphere. Although cable television suffers little of the signal loss experienced by terresterial and satellite television services, existing cable television services are restricted in the number of channels they can offer.

Digital television will ultimately replace the existing analogue systems and bring far more than significantly improved video and audio signal quality to television viewers. Digital television allows much more information (i.e. channels) to be transmitted and uses a new broadcasting technology to transmit services in binary format. Each channel is compressed and converted into a digital data stream using the Moving Pictures Experts Group (MPEG-2) compression algorithms. This type of digital compression packs at least five times as many channels into a given distribution network bandwidth. MPEG only transmits the parts of a picture that changes from one frame to the next, rather than sending a completely new frame, thus reducing the amount of data that needs to be sent in order to reconstruct the original picture. Because the space needed for a digital channel is less than that for an analogue channel several digital signals can be transmitted side-by-side in the space previously occupied by a single analogue channel. Atmospheric interference has little or no effect on a digital signal as digital television receives high quality signals as binary coded data at the receiver with little loss of information.

Digital television produces sharper images than traditional analogue television and includes digital surround sound. Some service providers even have High Definition Television (HDTV) (depending on the standard adopted) and wide-screen programs. However, potentially the most interesting and exciting feature is that digital transmission creates the potential for interactive services. In combination with a return channel, digital television will be able to offer viewers a variety of enhanced and interactive services, from interactive soap operas to a high speed internet over the air by combining TV with the Internet. Possible services include: an electronic program guide (EPG), video-on-demand (VOD), personal video recorder (PVR), pay-per-view, multi-camera-angle sporting events, home billing, home shopping, games, TV chat, digital Teletext, digital subtitles, etc (Peng, 2002).

At the single tuner digital television application, one tuner is used for analogue and digital broadcasting. That type of tuner is called as hybrid tuner. A hybrid tuner has one tuner that can be configured to act as an analog tuner or a digital tuner. Switching in between the systems is fairly easy, but can not be done "on the fly" (TV Tuner Card, 2008). At that application, digital broadcast content is carried to the digital module card by a cable. The length of that cable create a image blocking problem for the digital channels.

In that thesis, the source of the image blocking problem was found at the digital channels. That problem was analyzed in Micronas Netherlands Test Laboratories.

Impedance mismatching creates the signal power differences between tuner output IF and IDTV module board input IF. That mismatching affects the signal shape at the analog and digital IF side because of the parallel IF and IF cable application. The emitter follower circuits were used for the impedance matching and the isolation of analog IF signal from the digital IF signal. That circuit was implemented to our IDTV project and that project was produced at the Vestel company.

CHAPTER TWO
INTEGRATED DIGITAL TELEVISION (IDTV)

An Integrated Digital Television ("IDTV" or "iDTV") set is a television set with a built in digital tuner, be it for DVB-T, DVB-S, DVB-C, ATSC or ISDB. Most of them also allow reception of analogue signals (PAL, SÉCAM or NTSC). They do away with the need for a set top box for converting those signals for reception on a television.

Most IDTVs do not inherently support pay TV, and as a result many are fitted with Common Interface slots to allow the use of a conditional access module. They may also include support for other features of a digital television "platform", such as an interactive television engine and support for some form of return channel. A small number of IDTVs include a PVR, which removes the need for an external PVR, possibly requiring its own digital set-top box (Integrated Digital Television, 2008).

2.1 TV Signals

The sound to the microphone is continuously converted to electrical signals for transport. However, to transport a scene requires capturing a picture in time, dividing the picture into a matrix of many tiny picture elements. Each picture element must be sampled one at a time producing a voltage output that represents a level between black and white.

The picture elements are sampled in an orderly sequence as your would read the page of a book. The scanning process starts in the upper left, scans straight across to the right side, and quickly resets back to the left just below the initial starting point. The process repeats scanning many lines horizontally until reaching the bottom right of the picture. The process then resets moving vertically to the top right to begin scanning a new picture.

During the scanning process each picture element outputs an electrical voltage relative to the level of light ranging form black to white. The voltage output is blanked and sync pulses are added when resetting from the right to left and bottom to top.

The scanning process in the television receiver follows the same order to recreate the image on the television screen. The electrical voltage representing the black and white levels of the original scene is applied to the TV. The voltage varies its beam conduction changing the light output from the picture elements on face of the TV. This process recreates the original scanned picture image.

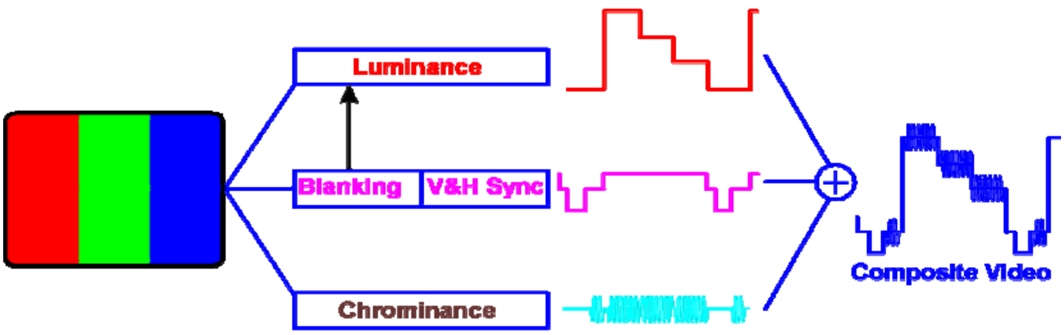

Figure 2.1 A composite video signal includes luminance information, color information, sync pulses.

The picture scanning process is fast. Each horizontal scan line (including retrace) occurs in just 63.5 microseconds (15.734 Hz). One complete vertical scan field from top to bottom, including 262.5 horizontal scan lines, is completed in $1/60^{th}$ of a second. While one scan is enough to reproduce a scene, higher resolution, or picture detail, is produced by combining two scanned fields in an interlaced fashion to complete a picture or frame.

The black-to-white information of the composite video signal is retained by the relationship of the voltage levels defining the video and blanking/sync. Levels are defined relative to a standard 1VPP signal with negative sync polarity terminated with 75 ohms. The picture voltage ranges approximately 714 mV and the sync pulse range approximately -286 mV. These levels may also be defined with an IRE unit of measurement created by the Institute of Radio Engineers. Zero to one hundred IRE represents the video voltages while 0 to –40 IRE represents sync level voltages.

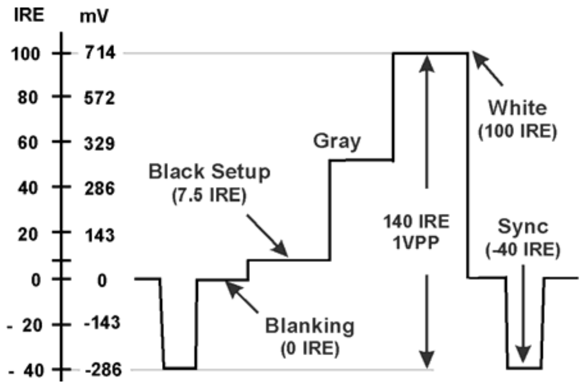

Figure 2.2 A 1VPP negative sync composite video signal is measured in mV or IRE units.

The black-to-white voltages of the composite video vary in both amplitude and frequency. While audio frequencies range from 20-20 KHz or cycles-per-second, video ranges in frequency from DC (0 Hz) to 4.2 MHz. To understand video frequencies consider a single horizontal scan line from left to right. For a dark, white or constant light level the voltage remains at a constant DC level. Now consider the video frequency of a picture with the left side black and the right half white, as illustrated in Figure 2.3. The video signal forms a square wave with a video frequency of approximately 19 kHz. A total of 106 black to white voltage variations across the screen relate to approximately 2 MHz while 159 interruptions relate to approximately 3 MHz. The higher the frequency the more it relates to the detail or resolution of the scene.

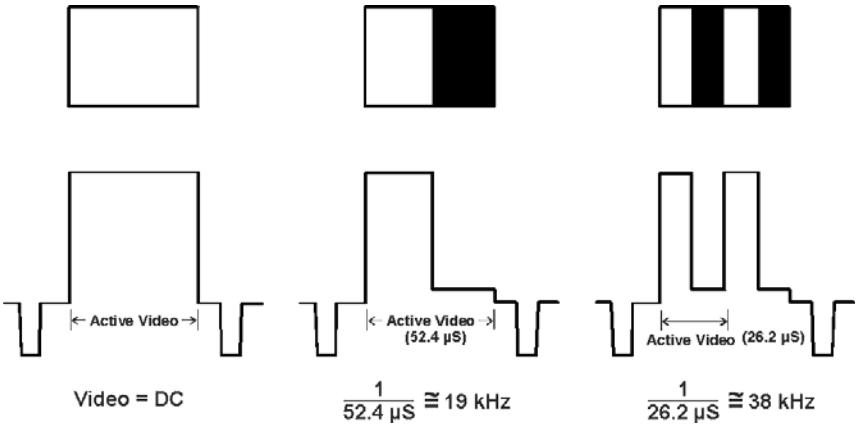

Figure 2.3 The changing video voltages from black to white create video frequencies from 0 - 4.2 MHz.

2.1.1 Chroma Encoding

Color in the composite video signal begins when the camera filters out the electrical voltages of the individual red, green and blue light of the scene. These individual voltages is what a television receiver recovers and applies to the red, green and blue electron guns of the color picture tube or CRT to recreate the color image. Since it is not practical or possible in the bandwidth provided to transmit separately three-color signals, an encoding scheme was devised. The encoding scheme also permits black and white television receivers to function normally.

The encoding process mixes the red, green and blue video signal voltages to form three signals: the luminance or Y signal, plus two color mixture or difference signals called R-Y or I, and B-Y or Q. The TV receiver uses the Y or luminance mixture to recover the black and white picture information to produce the image brightness. The color mixtures are used to recover the separate red, green and blue electrical voltage to produce proper color saturation and color tint.

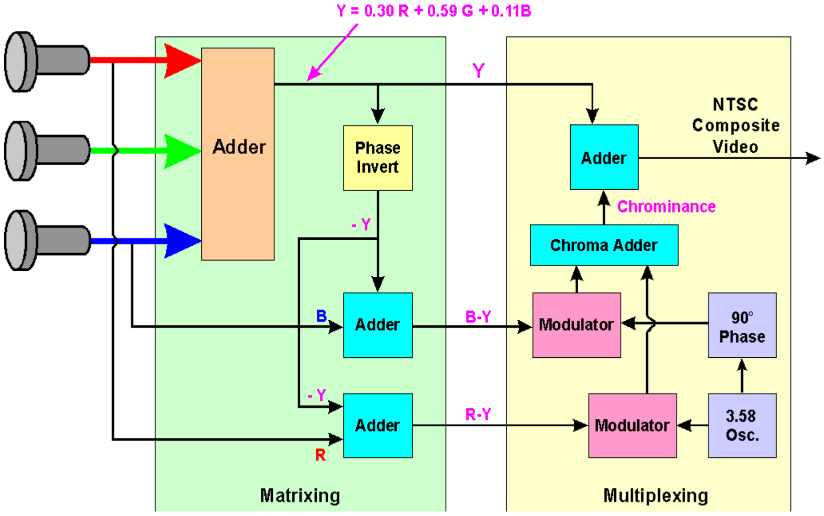

Figure 2.4 To produce NTSC color requires red, green, blue matrixing and multiplexing to a 3.58 MHz subcarrier.

The encoding process combines 30% red, 59% green and 11% blue to produce luminance (Y). It mixes 60% red, 28% of green's complementary color magenta, and 32% of blue's complementary color yellow to produce an I signal. Mixing 21% red, 52% magenta and, 31% blue forms the Q signal. The color mixtures are then converted to a single chroma signal and placed onto a 3.58 MHz sub-carrier by a multiplexing process.

The multiplexing stage converts the two color mixtures, either the I (R-Y) or Q (B-Y) to a chroma signal subcarrier at 3.579545 MHz (3.58MHz). In the multiplexing process two balanced AM modulators convert the I and Q signals to frequency sidebands of 3.58MHz. Phase shifting of 90 degrees puts the Q signals in quadrature with the I signal sidebands. The sideband frequencies are added to the luminance and output as the composite video signal.

To reproduce color requires chroma frequencies from zero to approximately 1.3 MHz for the I signal and zero to .5 MHz for the Q signal. These color signals are converted to signals ranging from approximately 2.28 MHz to 4.08 MHz in the composite video signal and co-exist with the luminance frequencies from 0-4.2MHz.

For the chroma and luminance frequencies to occupy the same frequencies and co-exist on the same wire is attributed to interleaving. For signals and harmonics of the signals to interleave, the color subcarrier was chosen to be an odd multiple of one-half the horizontal scan frequency. The luminance signals exist as signal energy that falls in the gaps of signal energy produced by the chroma sidebands.

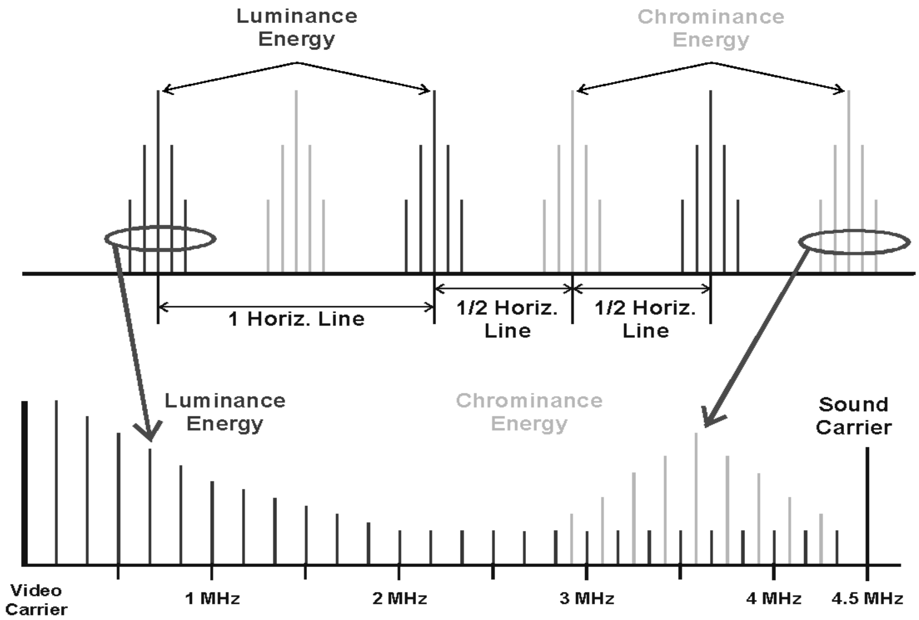

Figure 2.5 Interleaving permits luminance and chroma signals to co-exit in the same frequency band.

2.1.2 NTSC Standards

The standards that define the NTSC color composite video signal were established over 40 years ago by a group of industry leaders who formed the National Television System Committee (NTSC). Table 2.1 summarizes the NTSC composite video signal standards. The frequencies have an intricate and purposeful relationship. The vertical field frequency is exactly 59.94 Hz and the horizontal line frequency is 15,734.26 Hz. These are exact sub-multiples of the chosen color subcarrier 3.5795454 MHz.

Table 2.1 NTSC standards

NTSC STANDARDS
Horizontal Scan Frequency 15,734.26Hz
Vertical Scan Frequency 59.94 Hz
Color subcarrier frequency 3.579545 MHz
Lines per frame 525
Lines per field 262.5
Frames per second 30
Fields per second 60
Fields per frame 2
Video bandwidth 4.2 MHz
Aspect ratio 4:3
Video signal Am modulation
Video modulation negative
Audio signal FM modulation
RF channel bandwidth 6 MHz

2.1.3 TV-RF Signals

TV broadcast or cable distribution requires the composite video and audio signals be contained in a 6 MHz bandwidth RF channel. Modulators are used to convert the composite video and audio signals to RF carriers. A RF video carrier is used to carry the composite video including luminance, color and sync information. A second RF carrier is used for the audio signal information. Both carriers are part of a 6 MHz RF channel.

The video carrier is amplitude modulated (AM) by the composite video signal using negative sync modulation. This means the sync tips produce maximum carrier amplitude (0% modulation) and the white peaks produce minimum carrier amplitude (87.5% modulation). The relationship of the video signal and resulting amplitude modulated RF carrier is shown in Figure 2.6.

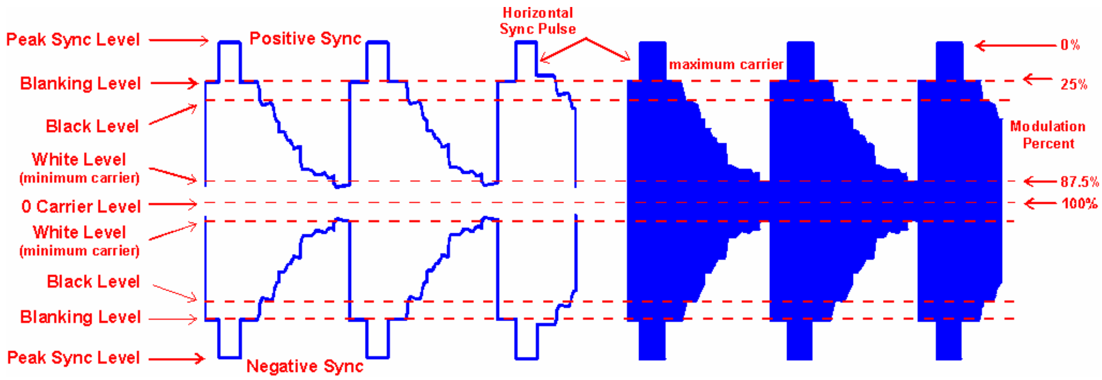

Figure 2.6 The composite video signal amplitude modulates the video RF carrier

The audio carrier is frequency modulated (FM) by the composite audio signal, which may include multi-television sound signals (MTS). The RF carrier is deviated from its resting frequency by +/- 25 kHz producing sidebands ranging from approximately 0-200 kHz above and below the carrier.

The video modulation is AM vestigial sideband. Full sideband modulation produces sideband frequencies above and below the RF carrier frequency ranging from 0-4.2MHz. The upper and lower sidebands would equally contain the full 4.2MHz luminance and chroma signal information covering over 8 MHz bandwidth. Vestigial sideband operation limits the lower sideband to approximately .75MHz below the carrier frequency and permits the full 4.2MHz above the carrier frequency.

All RF-TV channels have a designated 6MHz bandwidth containing the separate video and audio RF carriers. Sidebands above and below the carrier frequencies contain the video and audio signal information. In the RF channel the video carrier is positioned 1.25MHz above the lower edge of the channel. The color subcarrier is positioned 3.58 MHz above the video carrier. The FM modulated audio carrier is positioned 4.5 MHz above the video carrier.

TV or cable channel 3 has a 6 MHz bandwidth from 60-66 MHz. The video carrier is positioned at 61.25 MHz with lower sidebands limited to –1.25MHz and upper sidebands extending +4.2 MHz above the carrier (65.45MHz). The color subcarrier is positioned +3.58MHz from the video carrier (64.83MHz). The I color sidebands extend 1.3 MHz below the color subcarrier frequency and the I and Q color sidebands extend +.5 MHz above this frequency. The audio carrier is positioned +4.5MHz above the video carrier or at 65.75MHz (Kropuenske, 1995).

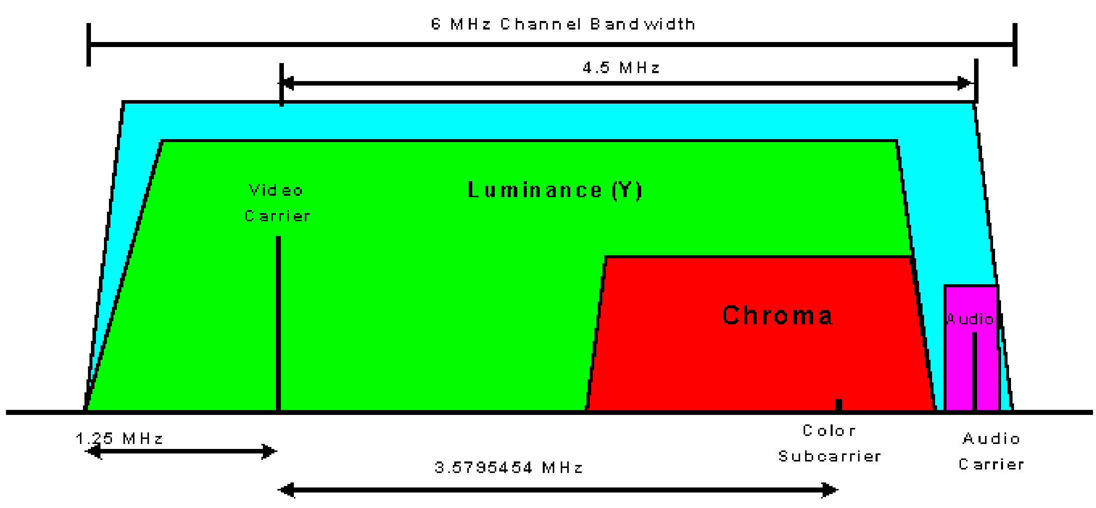

Figure 2.7 The spectrum of luminance, color, audio signals within a RF-TV channel

2.2 Digital Television Standards

Several different digital television standards are emerging from different world regions. The three main standards bodies include Digital Video Broadcasting (DVB), Advanced Television Systems Committee (ATSC), and Integrated Services Digital Broadcasting (ISDB). Table 2.2 presents a summary of the key parameters from the three resulting digital television standards. All proposed digital television systems use MPEG-2 technology for video and audio coding and for multiplexing to achieve an adequate throughput of the vast amounts of data required by HDTV or Standard Definition Television (SDTV).

Table 2.2 Comparation of parameters in different standards

Standard	System type	Video coding	Audio coding	Modulation scheme	Channel bandwidth	Bit rate (Mbps)	Adopted countries
DVB	DVB-S	MPEG-2	MPEG-2/1 digital sound	QPSK	8 MHz	38	All European countries, Australia, New Zealand, Russia, etc.
	DVB-T			QPSK/QAM/OFDM		24 15 (Mobile)	
	DVB-C			QAM		38	
ATSC	ATSC-T	MPEG-2	AC-3	8 VSB	6 MHz	19.28	North America, South Korea, Taiwan, Mexico, Argentina, etc.
	ATSC-C					38.57	
ISDB	ISDB-S	MPEG-2	MPEG-2 AAC	TC8PSK/QPSK/BPSK	34.5 MHz	52	Japan
	ISDB-T			DQPSK/QAM	5.6 MHz	21.47 4.06 (Mobile)	
	ISDB-C			64QAM	6 MHz	31.644	

All European countries have agreed to adopt the DVB standard as DVB is one of the leading standard bodies in digital television. It has defined a satellite transmission Standard (DVB-S), which is used by several satellite operators around the world. The DVB has also defined cable (DVB-C), terrestrial broadcast services (DVB-T) and Multimedia Home Platform (MHP) standards for receivers.

The DVB is based on SDTV and employs the MPEG-2 video compression and MPEG-2 or MPEG-1 digital sound. Only stereo sound will be transmitted initially however, at a later stage the system can be upgraded to multi-channel surround sound. Available screen aspect ratios include 4:3, 16:9 (wide-screen), and 2.21:1 (HDTV mode is optional). The DVB provides no direct compatibility between HDTV and STDV modes, which means that if HDTV transmissions are broadcast, they cannot be received on standard receivers.

High-definition pictures are to be simulcast alongside standard-definition pictures and future receivers will convert interlaced transmissions into a 625, or 1250, progressive format. The screen luminance resolution is 1920 x 1080 for both 25 Hz and 30 Hz HDTV. The screen resolution mode at a frequency of 30 Hz SDTV ranges from 720 x 480, 640 x 480, 544 x 480, 480 x 480, 352 x 480 to 352 x 240. The screen luminance resolution modes at a frequency of 25 Hz SDTV have 720 x 576, 544 x 576, 480 x 576, 352 x 576 to 352 x 288. In addition, DVB sets a common standard for encryption but broadcasters are free to use a conditional access system of their own choice to control de-encryption in response to payment.

The ATSC standard has been universally adopted in North America. ATSC is a U.S. organization that defines standards for terrestrial digital broadcasting and cable distribution. The ATSC standard is based on computer display standards that call for pictures to be transmitted at a rate of 24, 30, or 60 Hz to match cinema projection standards (24 frames per second) and 60 field /30 frame National Television Standards Committee (NTSC) analogue TV system. The Digital Audio Compression (AC-3) standard was selected for the audio source encoding and the MPEG-2 standard for the video encoding. ATSC includes digital HDTV, SDTV, data broadcasting, multi-channel surround-sound audio, and satellite directto-home broadcasting components. ATSC resolution ranges from 1920 x 1080, 1280 x 720, 704 x 480 to 640 x 480 with screen aspect ratios that include 16:9 (wide-screen) and 4:3 modes. The ISDB standard has been adopted as Japan's own unique national standard [4]. The technical standards for digital broadcasting in Japan are grouped as the ISDB Family. It consists of ISDB-S (Satellite) for satellite broadcasting, ISDB-C (Cable) for cable TV networks, ISDB-T (Terrestrial) and ISDB-TSB (Terrestrial Sound Broadcasting) for terrestrial broadcasting. They were developed as the Japanese specification in order to provide flexibility, expandability, and commonality between multimedia broadcasting services using each network.

The ISDB standard combines the functionality of a personal computer and video recorder and allows the inclusion of SDTV and HDTV. This standard also uses MPEG-2 for video and audio coding as well as data multiplexing. The MPEG-2

AAC (Advanced Audio Coding) is employed as the audio coding system. ISDB employs MPEG-2 MP@HL (Main profile at high level) for 1080i and 720p, MP@H14 for 480p, and MP@ML (Main profile at main level) for 480i, respectively.

2.3 Digital Broadcasting System

2.3.1 Broadcaster Head-End System

The broadcaster is responsible for producing MPEG-2 transport streams that contain several television programs. These transport streams need to be delivered error-free to the transmitters (i.e., terrestrial towers) or Microwave Multipoint Distribution Services (MMDS); satellite up-links and cable head-ends. These transport streams have no protection against error, which can cause serious effects, therefore error correction and channel coding (or modulation) is necessary before the signals are passed to the transmitters. Video and audio encoders are responsible for compressing and encoding the video and audio signals. One or more of the following are fed into the MPEG-2 multiplexer: video and audio elementary streams generated from these encoders; private data; service information (SI); conditional access (CA) control and synchronization information. Within the MPEG-2 multiplexer an initial packetization of the video and audio elementary streams is performed to produce Packetized Elementary Stream (PES) packets. Then, transport packets are generated from the PES packets and finally a transport stream is formed by multiplexing the transport packets with additional data from DVB-SI, CA control, and synchronization information. Private data is a data stream, whose content is not specified by MPEG, which may be used to carry digital Teletext; program subtitles; data; additional service information specific to a particular network and commands intended to control modulation and network distribution equipment, etc.

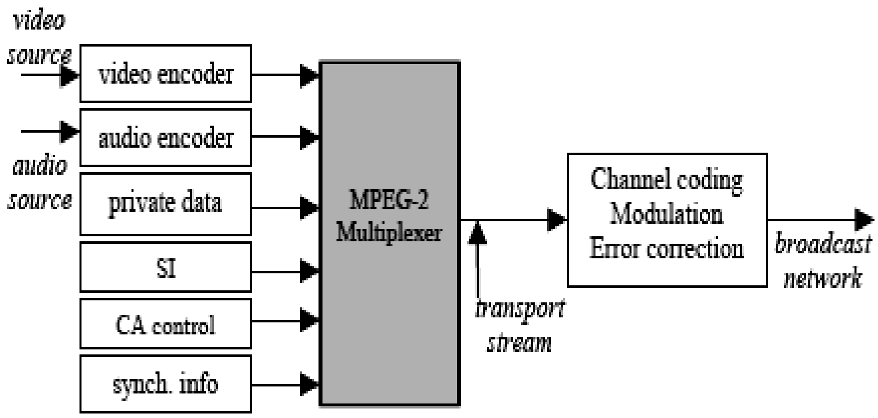

Figure 2.8 Main components of broadcaster high-end system.

Service information is also added to the broadcast stream to allow program tuning and selection and, once acquired, is stored in the SI database. DVB-SI includes four Program Specific Information (PSI) tables: Program Association Table (PAT); Program Map Table (PMT); Network Information Table (NIT) and Conditional Access Table (CAT). It also contains seven additional tables: Bouquet Association Table (BAT); Service Description Table (SDT); Event Information Table (EIT); Running Status Table (RST); Time and Date Table (TDT); Time Offset Table (TOT) and Stuffing Table (ST). PSI tables provide information to facilitate automatic configuration of the receiver; enable demultiplexing and decode the various program streams within the multiplex. The additional tables provide identification of services and events carried in different multiplexes. SI data is conveyed as packets that have unique PIDs and these packets must be included periodically in every transport stream. The PAT always has a PID of 0, and the CAT a PID of 1. The demultiplexer must determine all of the remaining PIDs by assessing the appropriate table.

Synchronization of the decoding and presentation processes for audio and video at the receiver is a particularly important aspect of a real time, software based, multiplexer. Consequently, a system of time stamps is specified to ensure that related elementary streams are replayed with the correct synchronization at the decoder. CA support is provided for the control of scrambling (i.e., for conditional access), which may be applied to one or more of the elementary streams.

The transport stream from the MPEG-2 Multiplexer is raw-serial binary data and is unsuitable for transmission for a variety of reasons. For example, runs of identical bits cause Direct Current (DC) offsets and lack a bit clock meaning that there is no control of the spectrum and that the bandwidth required is too great. Therefore, channel coding and modulation techniques are required. The purpose of channel coding is to increase the robustness and reliability of the digital information that is being transmitted over a noisy channel. In order to further increase robustness appropriate error correction is added to the transmitted data. The objective of modulation is to shift the message signal to the appropriate frequency therefore increasing the data transfer rate and making it suitable for transmission.

2.3.2 Receiver

Figure 2.2 shows a signal flow diagram for the main building blocks in a set-top box receiver. The Radio Frequency (RF) interface is connected to the incoming modulated signal. The tuner/demodulator block performs channel (frequency) selection, demodulation and error correction of the incoming MPEG-2 signal. The tuner module is capable for accessing Quadrature Amplitude Modulation (QAM), Orthogonal Frequency Division Multiplex (OFDM), and Quaternary Phase Shift Keying (QPSK) network modulated data. The baseband output signal from the tuner is forwarded to the demodulator whose function is to sample the analogue signal and convert it to a digital bit-stream. Once the bit-stream has been recovered it is checked for errors and forwarded to the demultiplexer and the output from the tuner/demodulator block is an MPEG-2 transport stream.

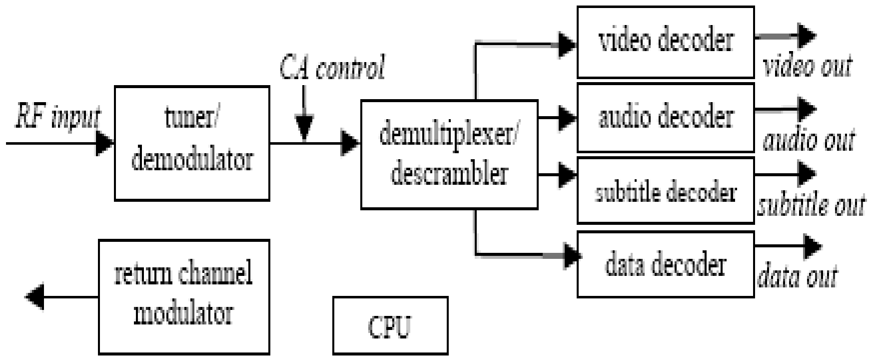

Figure 2.9 Block diagram of digital television receiver side

The demultiplexer block synchronizes with the transport stream coming from the tuner/demodulator (or CA module) and selects the appropriate audio, video and/or private data elementary streams, according to the service selections made by the viewer. The demultiplexer block also contains circuits for descrambling of services subject to CA data in conjunction with a smart card. The CA module is an external plug-in CA, which is attached via the Common Interface. MPEG-2 uses an identifier (i.e., PID) to distinguish a packet as containing a particular format (i.e., audio, video, or data). The audio and video decoders complete processes for presentation (e.g., de-packetization, decompression, synchronization with related services, etc.). The subtitle decoder is used to decode and present the program subtitle data using the On Screen Display (OSD) buffer, while the data decoder is responsible for decoding system or private data (e.g., digital Teletext, SI, etc.). Subtitle and data decoders can be separate hardware modules or software.

The Central Processing Unit (CPU) is a microprocessor and the key system component in a digital television. It manages all the internal units and attached external plug-in units and its functions include initializing various hardware components; processing a range of Internet and interactive services; monitoring and managing hardware interrupts; fetching data and instructions from memory and running related programs, etc (Peng, 2002).

2.3.3 COFDM (Coded Orthogonal Division Multiplexing)

The basic idea of the COFDM comes from the observation of the impairment occurring during the Terrestrial channel propagation. The response of the channel is not identical for each of its frequency sub-bands: due to the sum of received carriers (main + echoes), no energy or more than the one transmitted is sometimes received. To overcome this problem, the first mechanism is to spread the data to transmit over a large number of closely spaced frequency sub-bands. Then, as some data will be lost during the terrestrial propagation, to reconstruct them in the receiver, the data flows are encoded (i.e. : protected) before transmission.

The “Coded” and “Frequency Division Multiplex” abbreviations come from these two clean and simple concepts.

The characteristics of the transmission channel are not constant in the time domain. But, during a short interval of time, the terrestrial channel propagation characteristics are stable. Accordingly, as shown in Figure 2.10, the COFDM implements a partitioning of the terrestrial transmission channel both in the time domain and in the frequency domain, to organise the RF channel as a set of narrow “ frequency subbands” and as a set of small contiguous “time segments”.

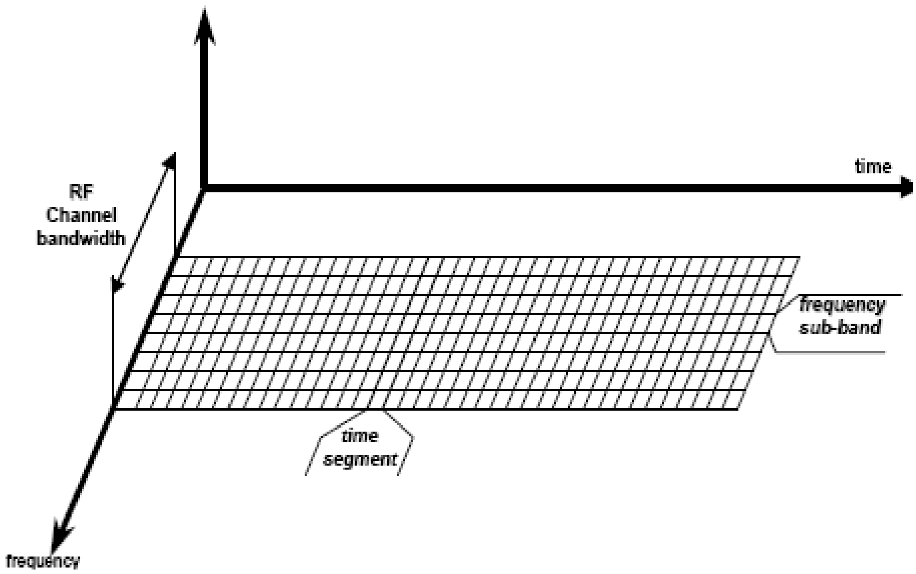

Figure 2.10 DVB-T channel partitioning

Inside each time-segment, named OFDM symbol, one sub-carrier supply each frequency sub-band. To avoid inter-carrier interference, the inter-carrier spacing is set to be equal to the inverse of the symbol duration: then sub-carriers are “orthogonal”.

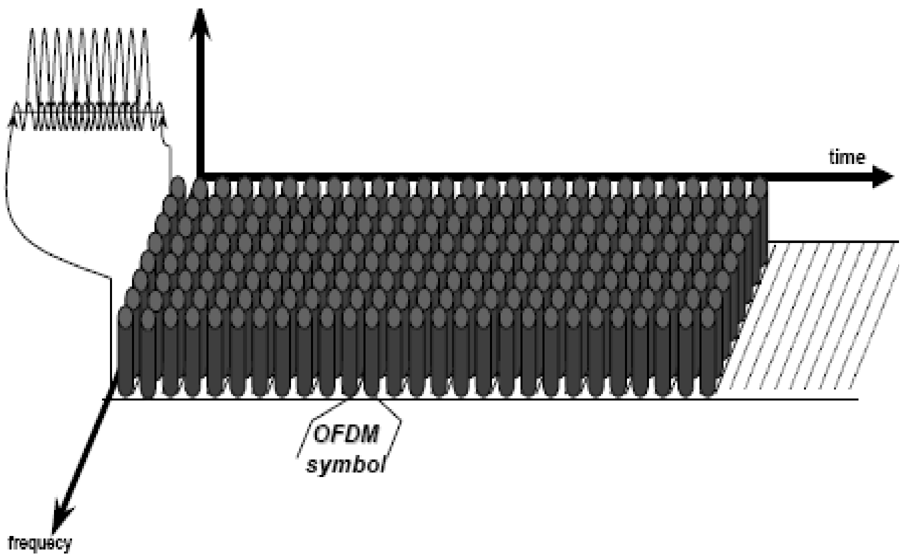

Figure 2.11 Sub-carriers insertion

To demodulate properly the signal, the receivers have to sample it during the useful period of the OFDM symbol (not during the guard interval). Accordingly, a time window has to be accurately placed in regard to the instant where each OFDM symbol occurs on air. The DVB-T system uses « pilot » sub-carriers, regularly spread in the transmission channel, as synchronisation markers. This is illustrated in the following Figure 2.12.

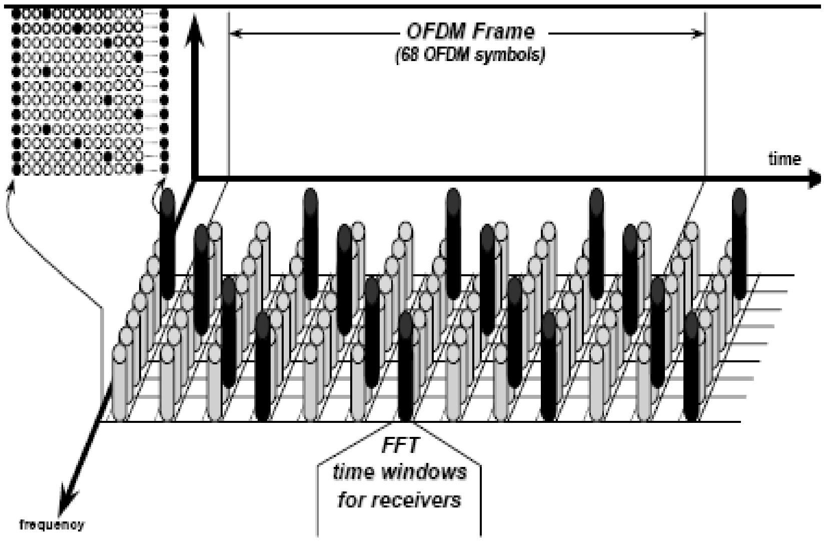

Figure 2.12 Synchronisation markers

These different features (channel partitioning, data encoding, guard interval and synchronisation markers insertions) constitute the basic characteristics of the COFDM modulation. Unfortunately, most of these features imply a lost of the channel payload or a reduction of its useful bitrate. A contrario, they provide channel robustness. Playing with such parameters allow to manage various trade-off between "Bitrate & robustness". To give as much liberty as possible to the broadcasters, then to adapt the terrestrial transmission to each specific situation, the DVB-T standard has defined a range of value for these parameters : their combinations constitute the DVB-T modes.

The COFDM modulation spreads the transmitted data in the time & frequency domains, after protecting data bits by convolutional coding. As the frequency fading occurs on adjacent frequency sub-bands, contiguous data bits are spread over distant sub-carriers inside each OFDM symbol. This feature, known as frequency interleaving, is illustrated in Figure 2.13.

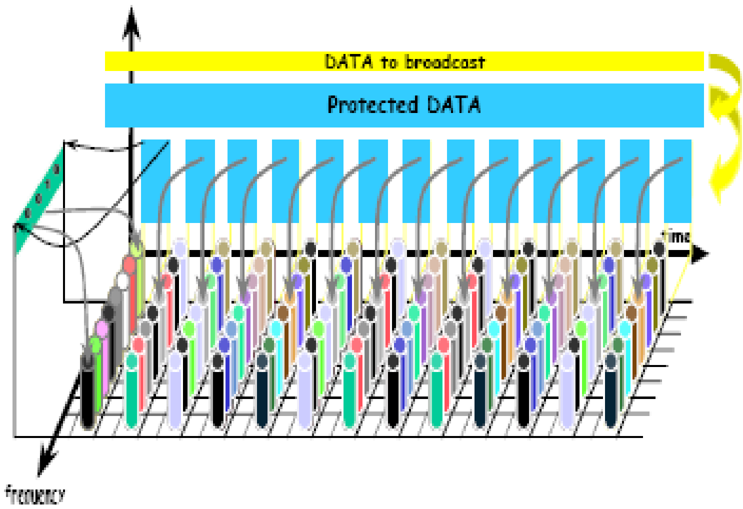

Figure 2.13 MAP data on OFDM signals

To map data onto OFDM symbols means to individually modulate each sub-carrier according to one of the three basic DVB-T complex constellations. The DVB-T's regular constellations are shown in Figure 2.14.

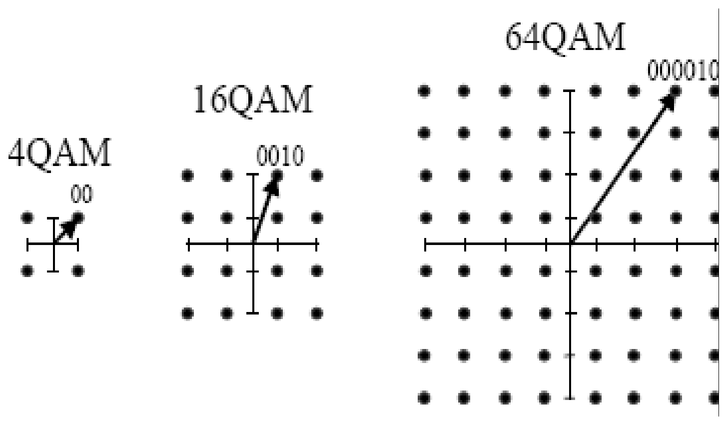

Figure 2.14 Basic DVB-T constellations

Depending on the constellation chosen, 2 bits (4QAM), 4 bits (16QAM) or 8 bits (64QAM) are carried at a time on each sub-carrier. But each constellation has a dedicated robustness, in regard to the minimum C/N tolerated for viable demodulation : roughly, 4QAM is 4 to 5 times more tolerant to noise, than 64QAM (Faria, 2000).

CHAPTER THREE
SINGLE TUNER IDTV APPLICATION

In the single tuner IDTV application, an hybrid tuner, a TV main board and IDTV module board were used. The IF signal of digital part was carried by a cable. That structure brought some problems. Most important problems are impedance matching, cable losses, cable impedance effect. In this chapter, the block diagram of single tuner IDTV structure, types of tuners, SAW filters, IF cable type were mentioned.

3.1 Tuners

The missions of tuner are strengthening poor signals, selecting designated stations and converting signals with all information that carried to named as intermission frequency which is lower frequency (38.9 MHz analogue signal center frequency, 36.1 MHz digital signal center frequency); the selected signals have modulated audio and video carrier frequencies. The CVBS signal has 48.25-863.25 MHz frequency that is modulated with RF; comes from antenna to tuner.

Out of the many incoming signals the television tuner picks out one channel's frequency and outputs encoded audio and video information into a fixed frequency. The tuner always outputs in the same frequency, often called the intermediate frequency. It is only the picture information encoded in that frequency that changes. So, if the user selects channel 2, the picture encoded in the electromagnetic waves corresponding to channel 2 is picked and encoded by the tuner using the intermediate frequency.

The TV tuner has a channel selector to move up and down the spectrum of incoming frequencies. Because the tuner always outputs the same, its output signal can be amplified easily. So, the signal is large enough to be processed. Figure 3.1 shows the blocks of the TV tuner.

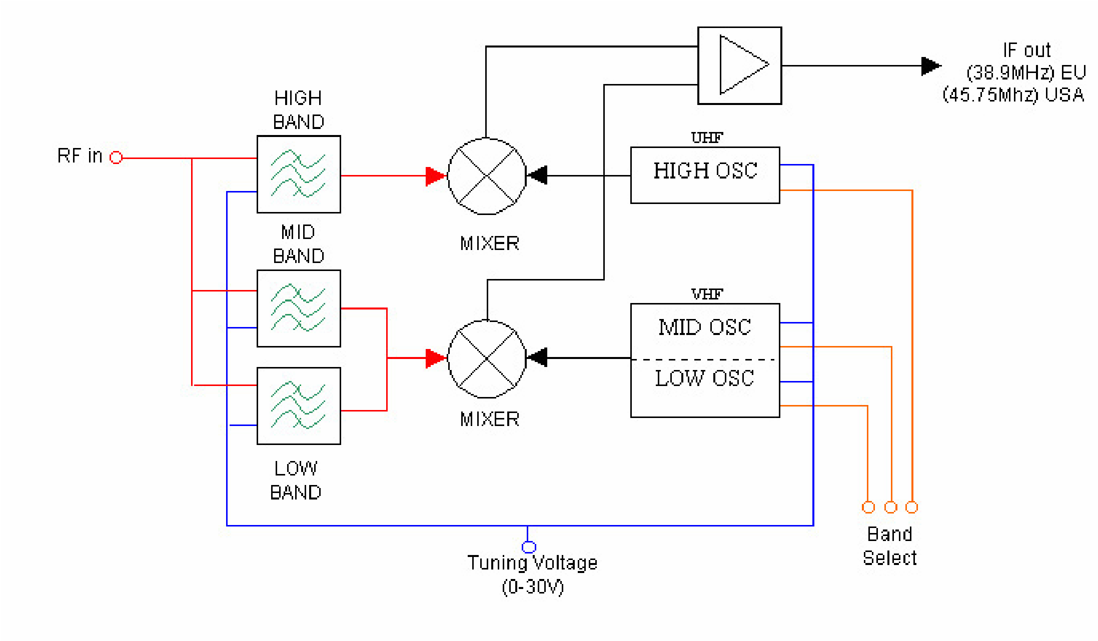

Figure 3.1 Internal blocks of a TV tuner

Output of the tuner is seen in Figure3.2. This is IF version of transmitted RF signal. In receiver systems incoming signals at different frequencies are filtered and down converted to a fix lower frequency. In TV systems tuner does it. Thus rest of the circuit (demodulator, fitler etc.) is designed according to this special frequency level. In Figure3.2, windowed part in the upper window is zoomed to the lower side.

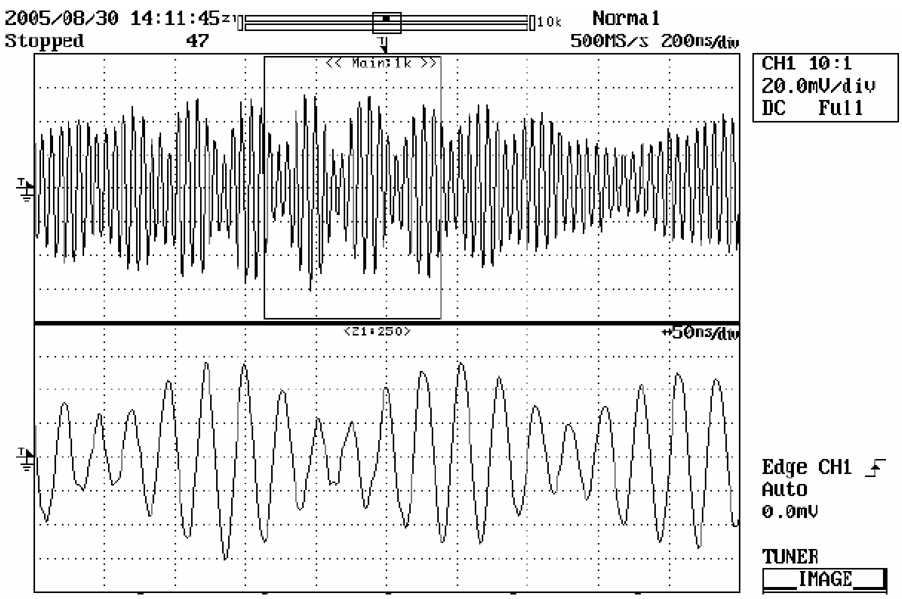

Figure 3.2 Tuner output

3.1.1 Types of Tuners

TV tuners are available in a number of different interfaces: as PCI-bus expansion card, PCIe (PCI Express) bus or USB devices. In addition, some video cards double as TV tuners, notably the ATI All-In-Wonder series. The card contains a receiver, tuner, demodulator, and an analog-to-digital converter for analog TV. There are currently four kinds of tuner card on the market.

Analog TV tuners are suitable for real-time viewing but ideally requiring some sort of compression if it is to be recorded. More expensive models encode the signal to Motion JPEG or MPEG, relieving the main CPU of this load. Many cards also have analog input (composite video or S-Video) and many also provide FM radio reception.

At the digital TV tuners, digital TV is broadcast as an MPEG-2 stream, so no encoder is necessary; instead, the digital cards either provide the whole MPEG transport stream or extract the individual (audio and video) elementary streams.

The hybrid tuners have one tuner that can be configured to act as an analog tuner or a digital tuner. Switching in between the systems is fairly easy, but can not be done "on the fly". The card operates as a digital tuner or an analog tuner until reconfigured.

Combo tuners are similar to the hybrid tuners, except there are 2 separate tuners on the card. One can watch analog while recording digital, or vice versa. The card operated as an analog tuner and a digital tuner. The advantages over 2 separate cards are cost and utilization of expansion slots in the computer. As many regions around the world convert from analog to digital broadcasts, these tuners are gaining popularity (TV Tuner Card, 2008).

3.2 SAW Filters

Advantages of *SAW Filter* technology include compact packages, low shape factors, superior linear phase characteristics, rejection qualities, and the relatively stable performance over temperatures. Many other advantages are derived from the physical structure of SAW Filters which allow for extremely robust and reliable designs that remain stable in the field/application. Additionally, the inherent design and wafer processing techniques of Saw Filters provide for a repeatable device in both low and high volume production.

Surface Accoustic Wave (SAW) fundamentals provide for a piezoelectric material that converts an incoming electromagnetic signal into an acoustic signal, and vice versa. In its most basic form, a SAW filter consists of a polished piezoelectric substrate with a deposit of two transducers with interdigital arrays of thin electrodes. The electrodes making up the arrays alternate polarities so that when an RF signal voltage is applied across them, a surface wave is then generated. In designing a SAW Filter, the overall frequency response characteristics are determined by deriving two impulse responses for the two transducers whose transforms are added together in dB. The surface of a piezoelectric substrate is then etched with the two impulse responses.

Generally, a SAW Filter manufacturer will offer their most popular devices as standards creating a reference for Engineers to design from. Typically, and especially true in the RF SAW Filter category, a standard device is available for most common applications. However, for applications requiring parameters that are not currently considered industry standards, Oscilent is uniquely equipped to offer design and development services at comparatively lower costs than our competitors.

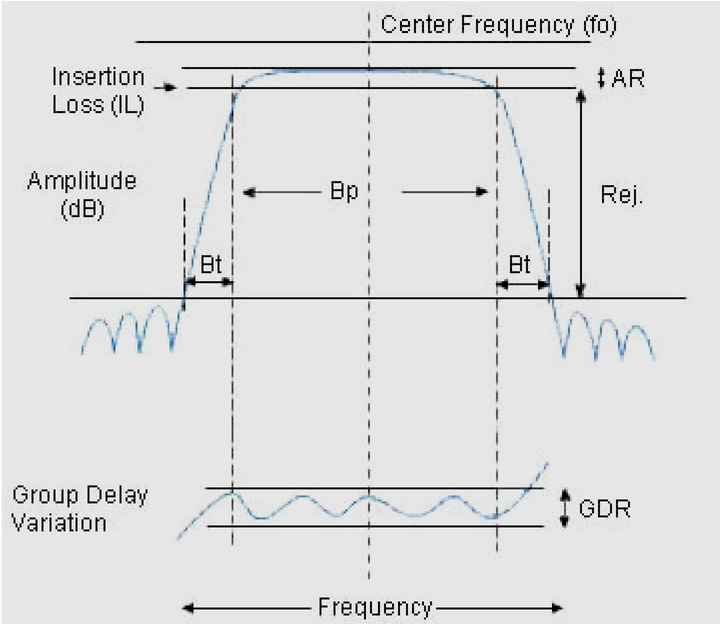

Figure 3.3 Ideal SAW filter characteristic.

Simply stated, the Passband Width (Bp) will pass a signal occupying a specific frequency band, and reject others falling outside the band. From a SAW Filter design perspective, the first parameter to consider is the Fractional Bandwidth (Bp/Fo) because of the influence on the substrate material to be used in the design. The substrate material influences many parameters, most importantly the Temperature Stability specifications.

The Amplitude Ripple (AR) is a measure (dB) of the variation, or differential value, of attenuation in the passband of a filter, typically a SAW Filter will be specified as having a Typical and Maximum allowable value.

From a mathematical perspective measured in time, the Group Delay (GDR) of a SAW Filter is the first differential value of time for phase frequency of phase changing (variation) in pass band. Otherwise, the Group Delay can be referenced as the slope of the Phase vs. Frequency Curve. In simple terms, the Group Delay represents the time it takes for the signal to pass through the SAW Filter.

All ranges of the SAW Filter not including the Passband. The Rejection (REJ) can also be referred to as the Rejection Range, or Stop Band. We can refer to this as the range in which the Relative Attenuation is larger than the specified Rejection side. With proper material selection and design, Rejection of 50dB, or greater, is possible within a wide selection of fractional bandwidths and shape factors.

Advances in SAW Filter design techniques routinely allow for a design incorporating a specification of under 10dB Insertion Loss (IL) , however, the minimum attainable Insertion Loss is generally influenced by the Fractional Bandwidth and the influences of this ratio on the applicable substrate material. The Insertion Loss value will generally increase when approaching the fractional bandwidth limit of a substrate material. For instance, a Fractional Bandwidth value of 8% will generally produce lower Insertion Loss than a Fractional Bandwidth value of 30% using the same substrate material (Oscilent Corporation., 2001).

Output of saw filter is seen Figure3.4. Voltage level is very low. This signal then goes to demodulator. Demodulator specs are given so that this signal must be about 60-100μV.

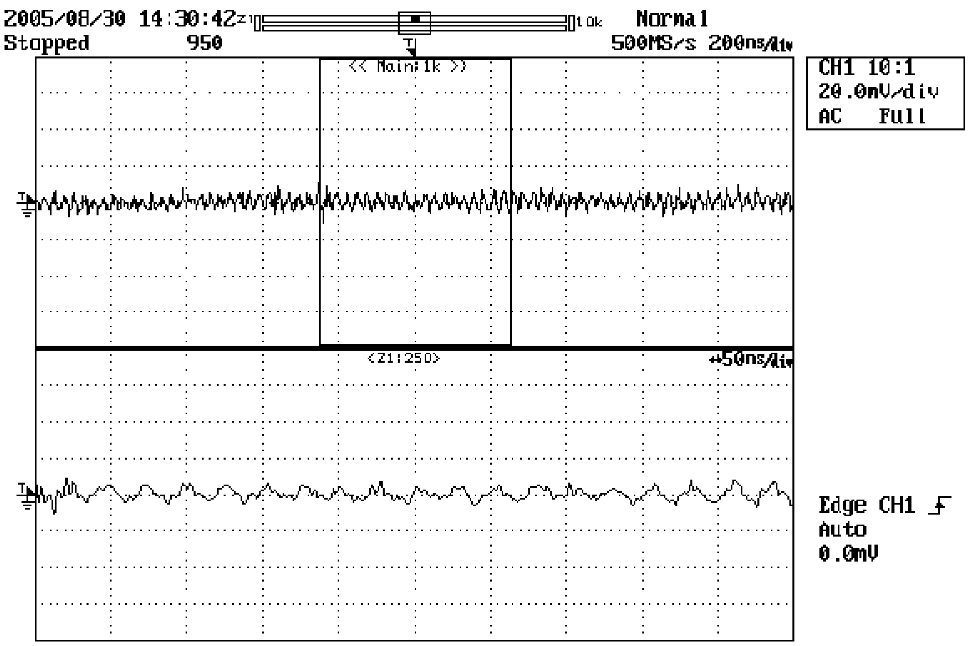

Figure 3.4 SAW filter output (video IF).

3.3 Single Tuner IDTV Block Diagram

Figure 3.5 shows a single tuner IDTV application block diagram. A hybrid tuner was used for reception of the TV RF signals. At the output of the tuner, IF lines are parallel. One of the IF lines goes to the analog side, other IF line goes to the digital side (IDTV module side) of the TV. Two SAW filters were used at that application. Types of the SAW filters are X6966. Tuner type is hybrid. IF cable length was chosen as 25cm. That length causes the impedance matching problems and signal shape distortions. That mismatching creates a distortion at IF frequency band shape. Therefore, some image blocks occurs at the video frame.

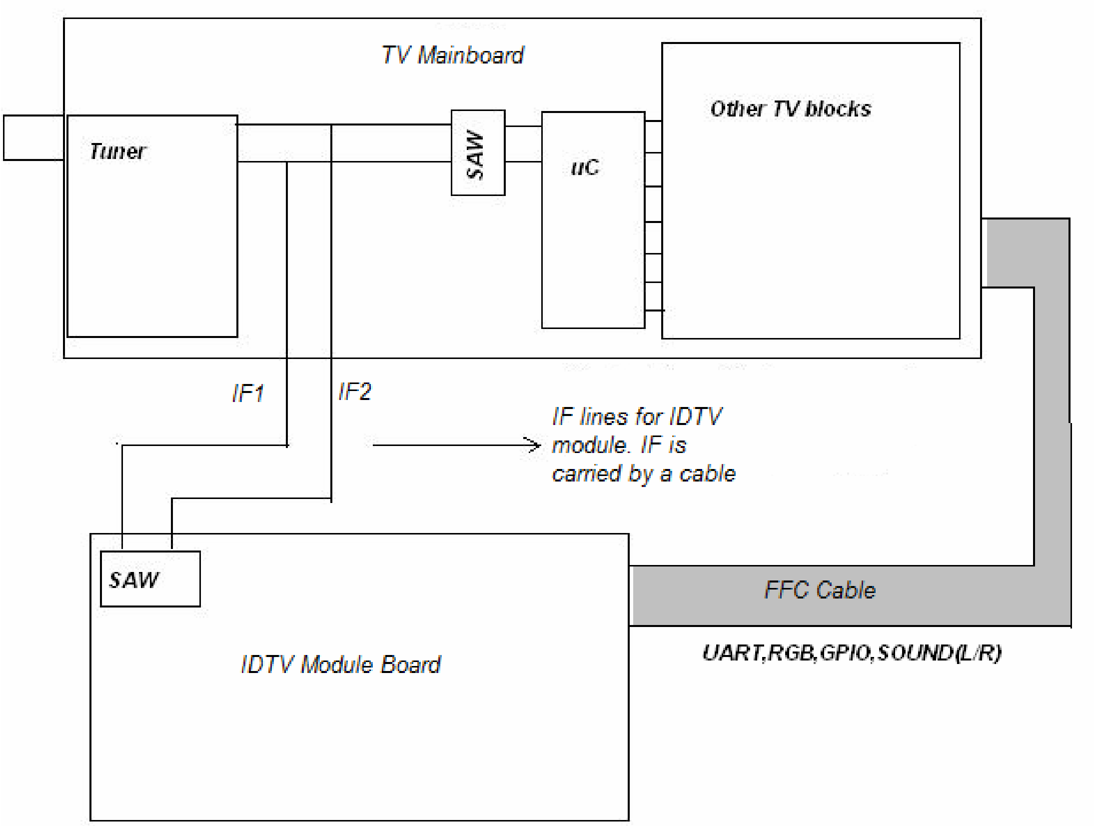

Figure 3.5 Single tuner IDTV block diagram.

CHAPTER FOUR
IMAGE BLOCKING PROBLEM AND SOLUTION

4.1 Image Blocking Problem

Due to the IF cable length, a digital blocking problem was observed. The equivalent circuit of the IF cable is given at Figure 4.1.

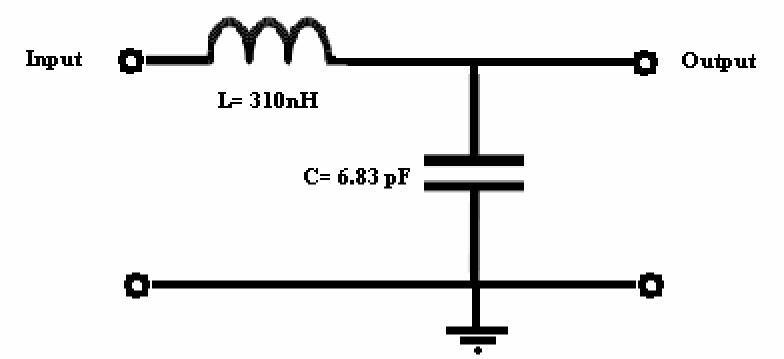

Figure 4.1 IF cable equivalent circuit.

Impedance mismatching creates the signal power differences between tuner output IF and IDTV module board input IF. That mismatching affects the IF signal shape because of the parallel IF and If cable application. The emitter follower circuits were used for the impedance matching and for the isolation of analog IF signal from the digital IF signal (like a buffer application). The BF799 high frequency transistors were used at that emitter follower circuit. Table 4.1 shows the hfe values of the 500MHz BF799 NPN transistor (Infenion Technologies, 2003).

Table 4.1 Hfe values of the BF799 NPN transistor

DC Current Gain	Min. (hfe)	Typ. (hfe)	Max. (hfe)
Ic = 5mA	35	95	-
Ic = 20mA	40	100	250

4.1.1 Emitter Followers

The emitter follower is used to provide current gain and impedance matching applications. The input to this circuit is applied to the base, while the output is taken from the emitter. The voltage gain is always less than ”1” and the output voltage is in phase with the input voltage. Since the output follows the input, this amplifier is referred to as the emitter follower rather than the common collector amplifier.

DC analysis for the emitter follower is similar to the common emitter amplifier that we have been with.

The base voltage is achieved using a voltage divider as before and the base voltage is found as:

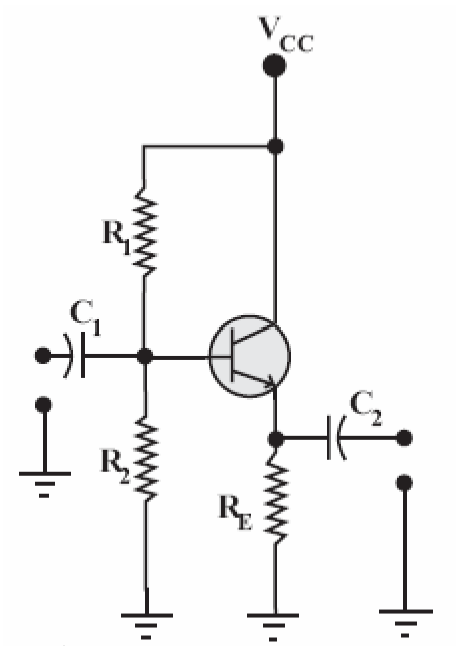

Figure 4.2 Emitter follower circuit.

$$V_B = \frac{R2}{R1+R2} V_{CC} \tag{4.1}$$

The emitter voltage is found exactly as:

$$V_E = V_B - 0.7V \qquad (4.2)$$

The emiter current is:

$$I_E = \frac{V_E}{R_E} \qquad (4.3)$$

V_{CEQ} is found as:

$$V_{CEQ} = V_{CC} - V_E \qquad (4.4)$$

The DC load line is found in a similar fashion as:

$$I_C = \frac{V_{CC}}{R_E} \qquad (4.5)$$

$$V_{CE(off)} = V_{CC} \qquad (4.6)$$

Find both ends of the line, plot them, then connect them with a straight line. The circuit to the right is calculated and plotted on the graph to the left.

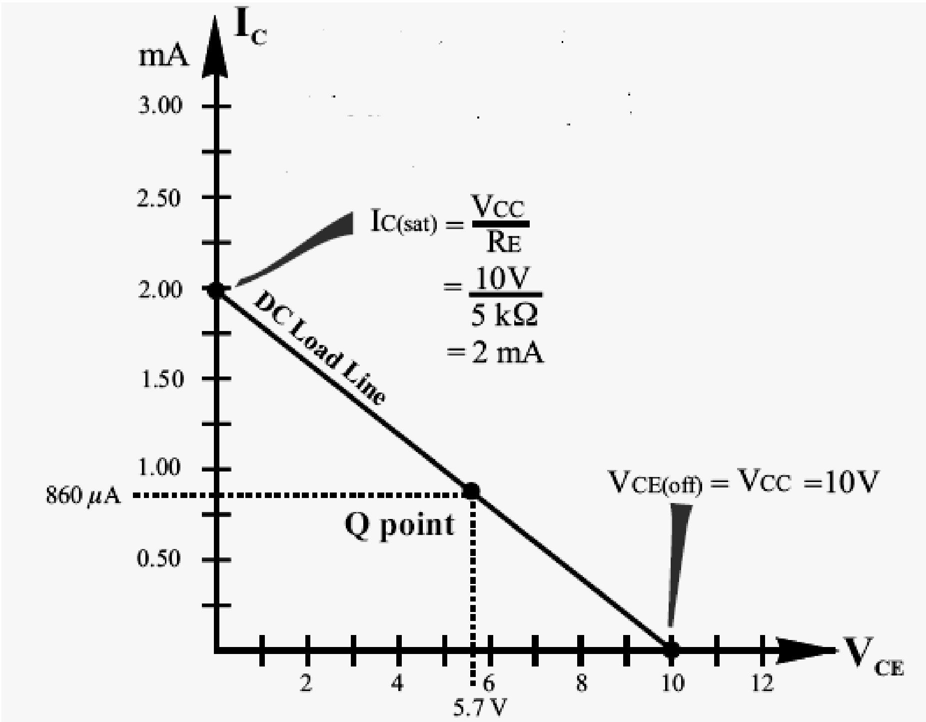

Figure 4.3 DC load line.

A typical emitter follower is shown in circuit a. The load is capacitively coupled to the emitter.

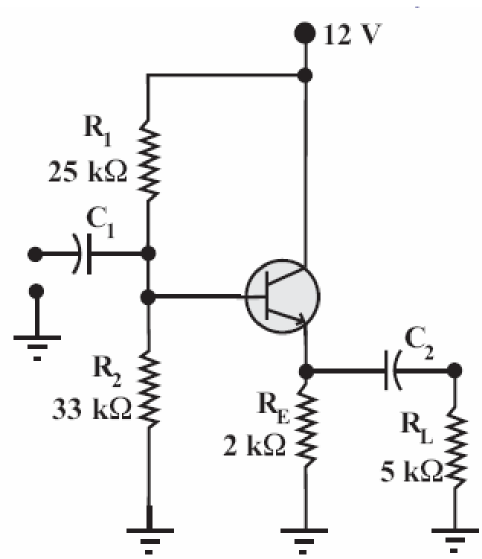

Figure 4.4 Circuit a.

At circuit b, it is the AC equivalent circuit. Here, the total equivalent AC emitter resistance is r_E , and is found as:

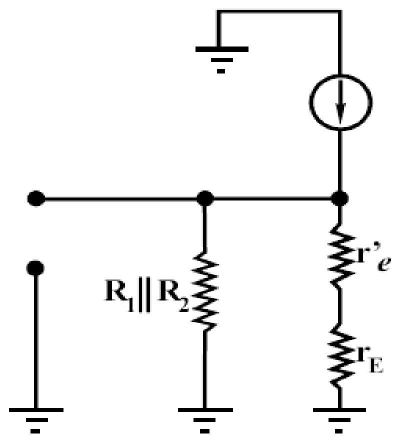

Figure 4.5 Circuit b.

$r_E = R_E \,||\, R_L$ (4.7)

At circuit c, the input signal is applied to both the input circuit (R1 || R2) and the output circuit.

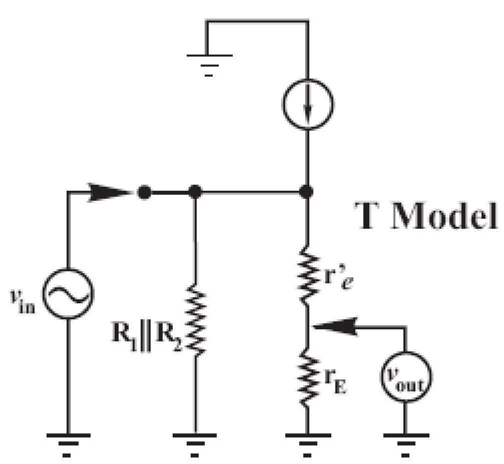

Figure 4.6 Circuit c.

Voltage gain of the circuit as:

$$A_V = \frac{r_E}{(r_e' + r_E)} \tag{4.8}$$

In most practical cases r_e' is very small when compared to the value of r_E. When this is true, the gain can be approximated as:

$$A_V \cong 1 (\text{when } r_E >> r_e') \tag{4.9}$$

The current gain of the emitter follower is found as:

$$A_i = h_{fc} . \frac{Z_{in} . r_E}{Z_{base} . R_L} \tag{4.10}$$

The current gain of the emitter follower is significantly lower than the current gain of the transistor. The relationship is due to the current divisions that occur in both the input and output circuits. This is similar to the low current gain situation with the C.E. amplifier.

In the equation 4.10, we have used h_{fc} in place of h_{fe}. We are assuming that h_{fc} is approximately equal to h_{fe}. The subscript "c" merely indicates that the parameter applies to the emitter follower (common collector) rather than the common emitter amplifier. The exact equation for h_{fc} is:

$$h_{fc} = h_{fe} + 1 \tag{4.11}$$

The input impedance of the emitter follower is found as the parallel equivalent resistance of the base resistors and the transistor input impedance.

$$Z_{in} = R_1 || R_2 || Z_{base} \tag{4.12}$$

The base input impedance is:

$$Z_{base} = h_{fc}.(r_e' + r_E) \tag{4.13}$$

The output impedance is the impedance that the circuit presents to its load. When a load is connected to the circuit, the output impedance of the circuit acts as the source impedance for that load.

Since the emitter follower is often used in impedance matching applications, the output impedance becomes important.

One main function of the emitter follower is to match the source impedance to the load impedance to improve power transfer from the source to the load.

The formula for output impedance is given as:

$$Z_{out} = R_E \,||\, \left(r_e'.\frac{R_{in}'}{h_{fc}} \right) \tag{4.14}$$

In some impedance matching considerations, it is important to have an input impedance that is as high as possible. Figure 4.7 shows an emitter follower using emitter feedback. A comparable circuit using voltage divider bias is shown in Figure 4.8.

Figure 4.7 will have a much higher input impedance than Figure 4.8.

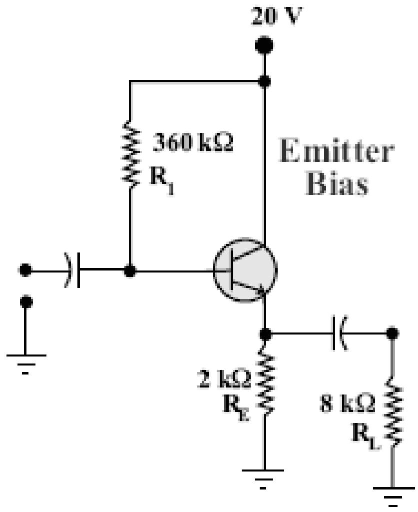

Figure 4.7 Emitter feedback application.

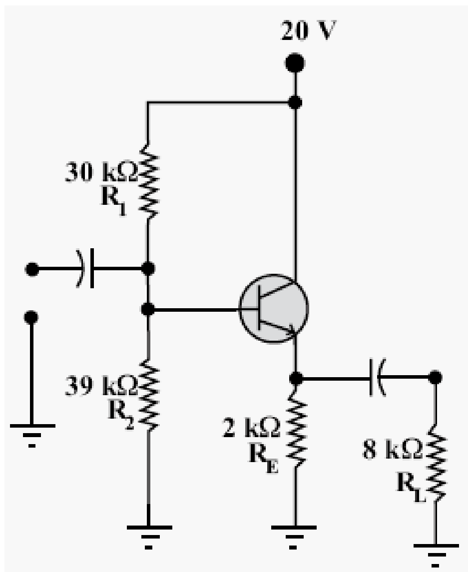

Figure 4.8 Voltage divider bias application.

For Figure 4.8;

$$Z_{in} = R_1 \| R_2 \| Z_{base} \tag{4.15}$$

But, for Figure 4.7;

$$Z_{in} = R_1 \| Z_{base} \tag{4.16}$$

Maximum power is transferred to a load when the source and load impedances are equal. The circuit below is an example of the emitter follower being used as a buffer.

A buffer is a circuit that is used for impedance matching that aids the transfer of power from the source to the load.

In the circuit shown below, the relatively high input impedance and the relatively low output impedance of the circuit.

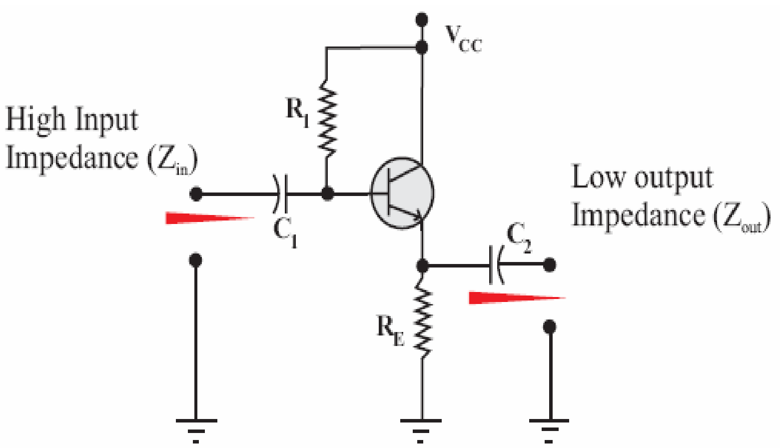

Figure 4.9 Input and output impedances of an emitter follower.

In the circuit shown in Figure 4.10 shows a source with a high impedance, connected to a load with a low impedance. In this case, only a small amount of the source power will be delivered to the load. Most of the power will be developed across its own internal resistance & will be lost.

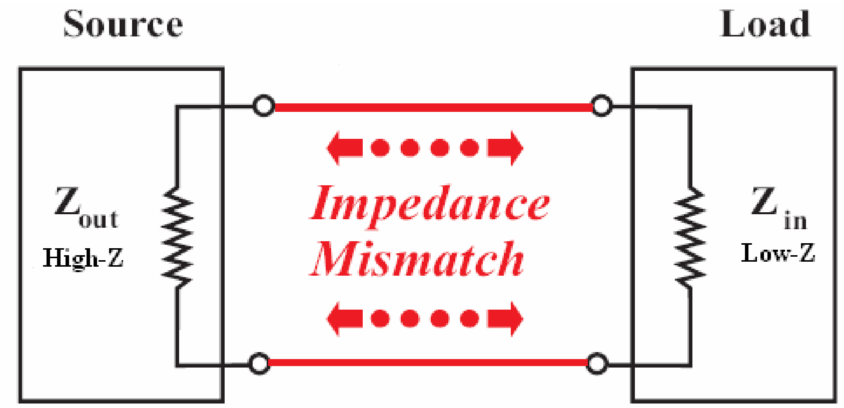

Figure 4.10 Impedance mismatch condition.

Figure 4.11 shows an emitter follower inserted between the same source and load. Here, the source impedance closely matches the input impedance of the amplifier, providing an improvement of power transfer from the source to the amplifier. The same is true at the output, since the output impedance of the amplifier matches the load. The end result is that the maximum power has been transferred from the original source to the original load (Sedra, A., & Smith, K. , 1982).

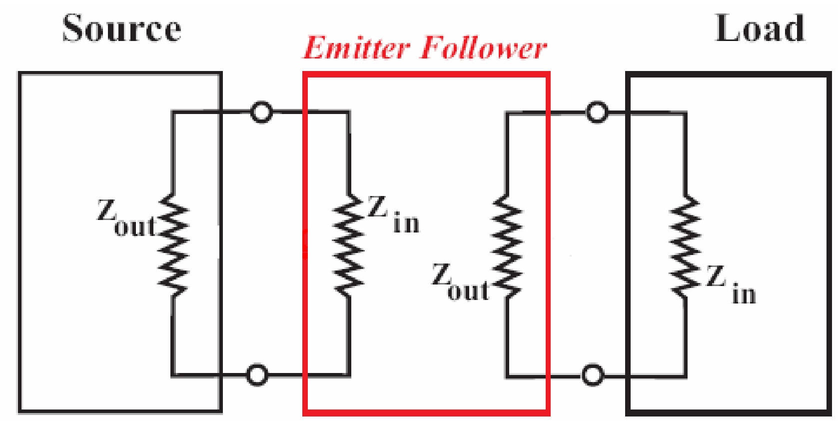

Figure 4.11 Impedance matching with emitter follower.

4.1.2 The New Circuit Design for Digital Blocking Problem

Two pieces of X6966 SAW filters were used at this project. One of these was used for analog side. Other SAW filter was used for digital side. A distortion was observed at the digital IF lines because of impedance matching problem. Some measurements were taken and designed an emitter follower circuit for IDTV IF lines.

We analyzed the IF block at four steps that includes;

- Only one SAW filter (analogue side and IF cable were neglected).
- Two parallel SAW filters (IF cable was neglected).
- Two parallel SAW filters and IF cable.
- Two parallel SAW filters, IF cable and emitter follower buffer.

Figure 4.12 shows a simple block diagram for the first case. That case is basic. IF cable and parallel analog SAW filter were neglected. SAW filter input waveform has no distortion.

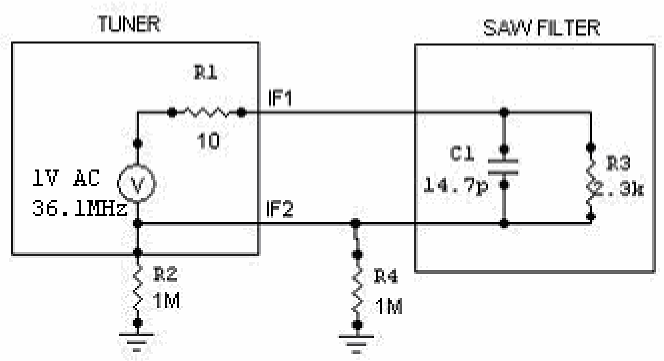

Figure 4.12 IF block without analog SAW filter and IF cable.

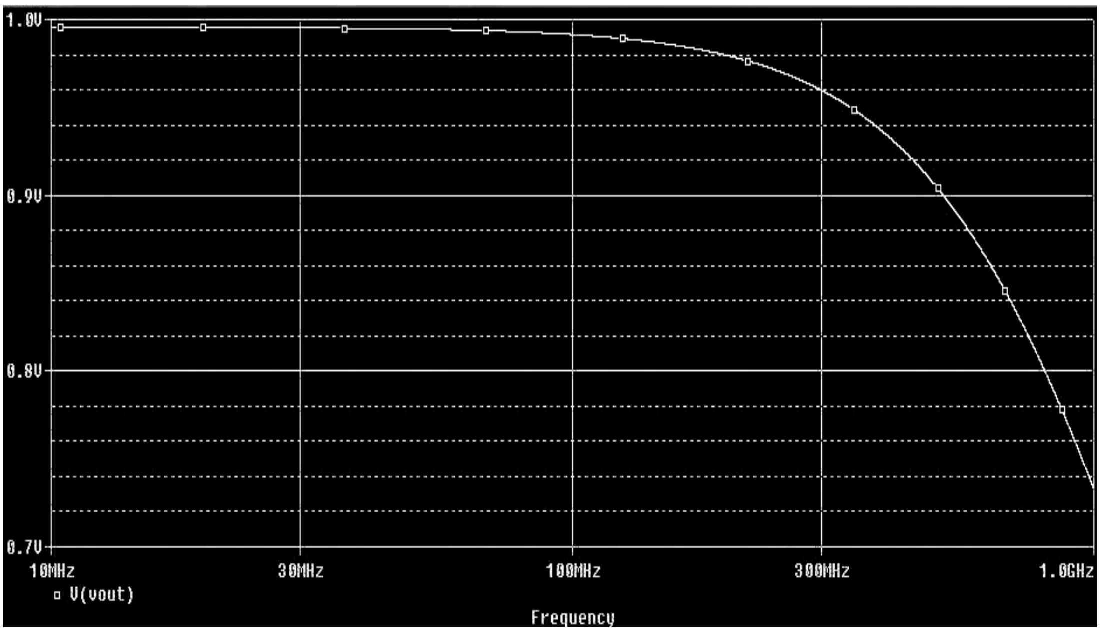

Figure 4.13 SAW filter input signal waveform at the frequency domain (Condition 1).

Figure 4.14 represents step 2. In that step, analog and digital SAW filters are parallel.

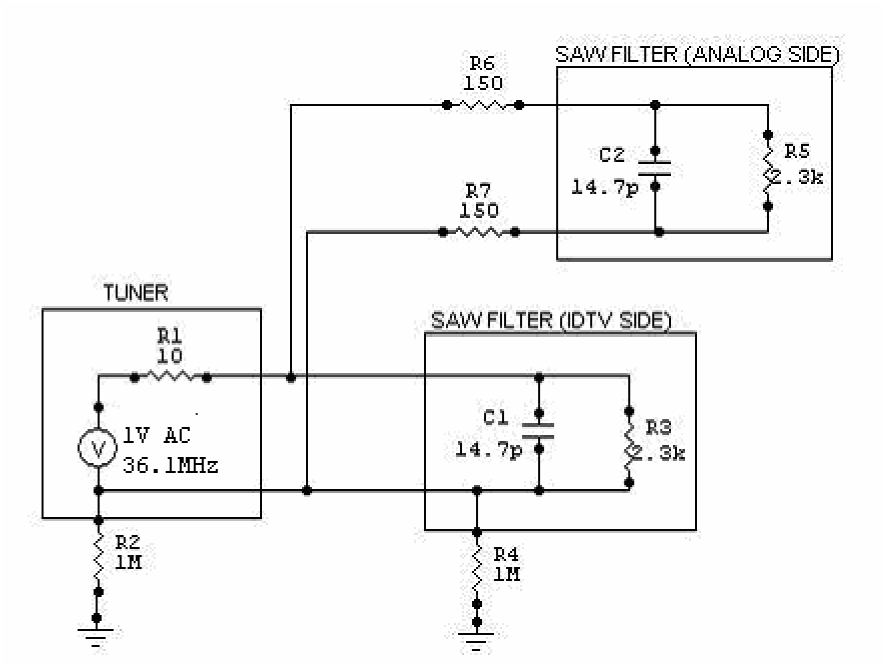

Figure 4.14 IF block with two parallel SAW filters.

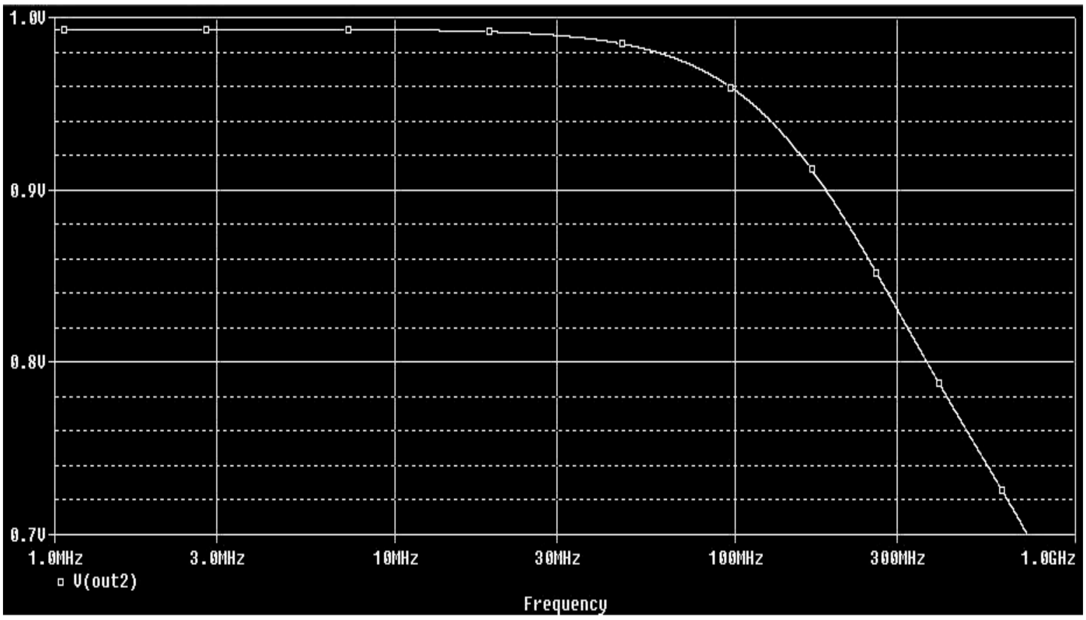

Figure 4.15 SAW filter input signal waveform at the frequency domain (Condition 2).

In the single tuner IDTV application, IF cable was required. Because, IDTV module board was located at the corner of the LCD panel. Therefore, IF signals were carried by a cable. Figure 4.16 shows that block and Figure 4.17 and 4.18 show the distortion at the end of the band.

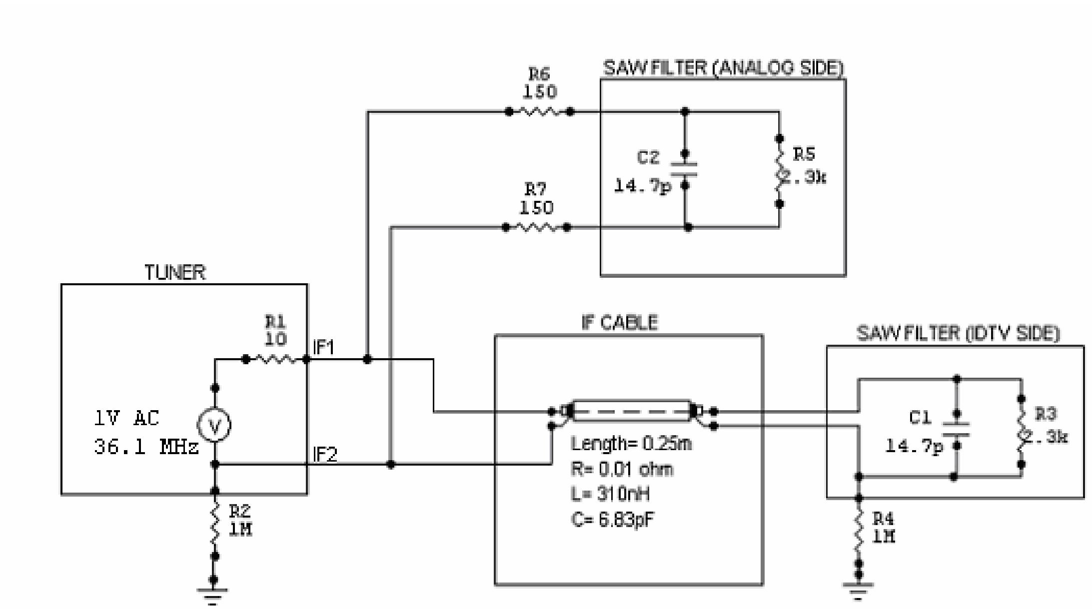

Figure 4.16 IF block with two SAW filters and IF cable.

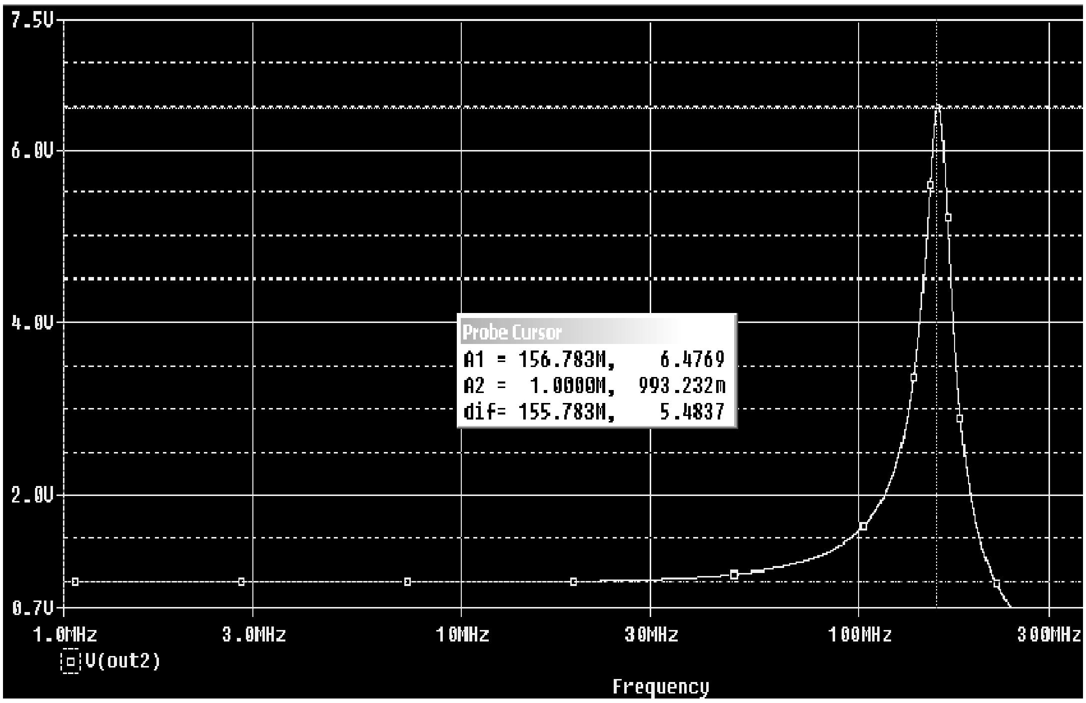

Figure 4.17 SAW filter input (IDTV side) has a peak at 156.783MHz.

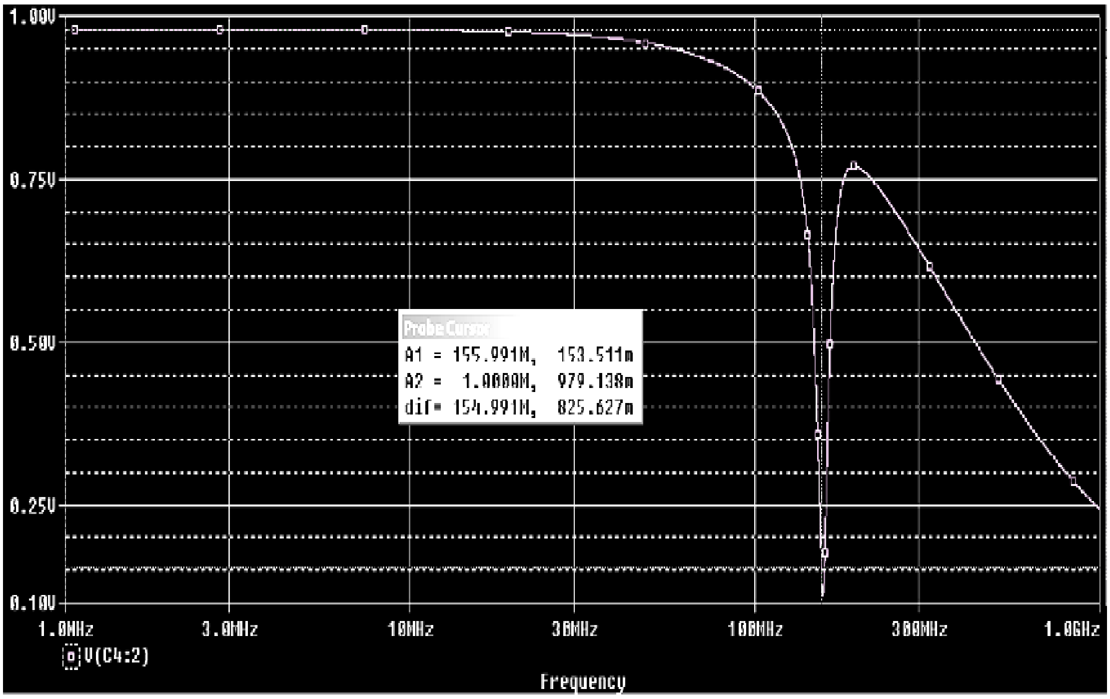

Figure 4.18 SAW filter input (analog side) has a peak at 155.991MHz.

Figure 4.17 and 4.18 show the undesired signal peaks. Therefore emitter follower buffers were added the output of the tuner. From formulas 4.12 and 4.14, emitter resistors and parallel base offset resistors were found. PCB lines and IF cable have the resistor values and emitter resistor value was changed according to this factors. The BF799 high frequency transistors were chosen for the design. The frequency range of this transistor is 0 Hz to 500 MHz. The problem was solved.

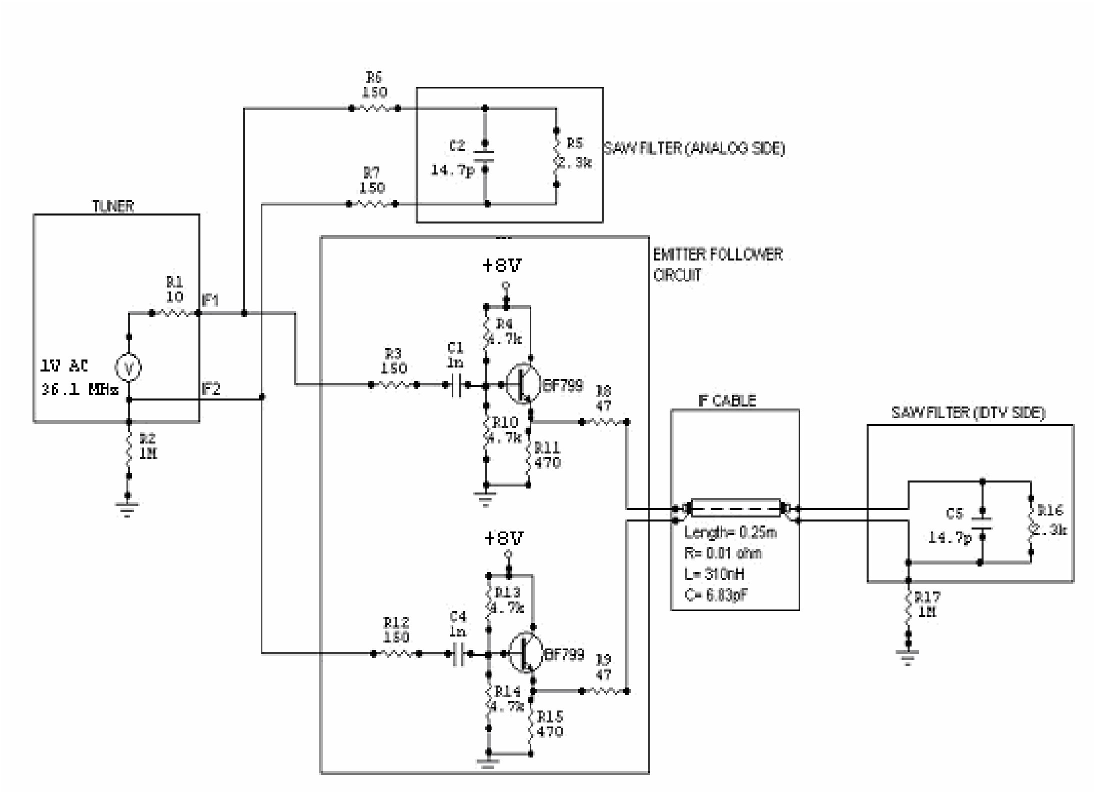

Figure 4.19 IF block with emitter follower circuit.

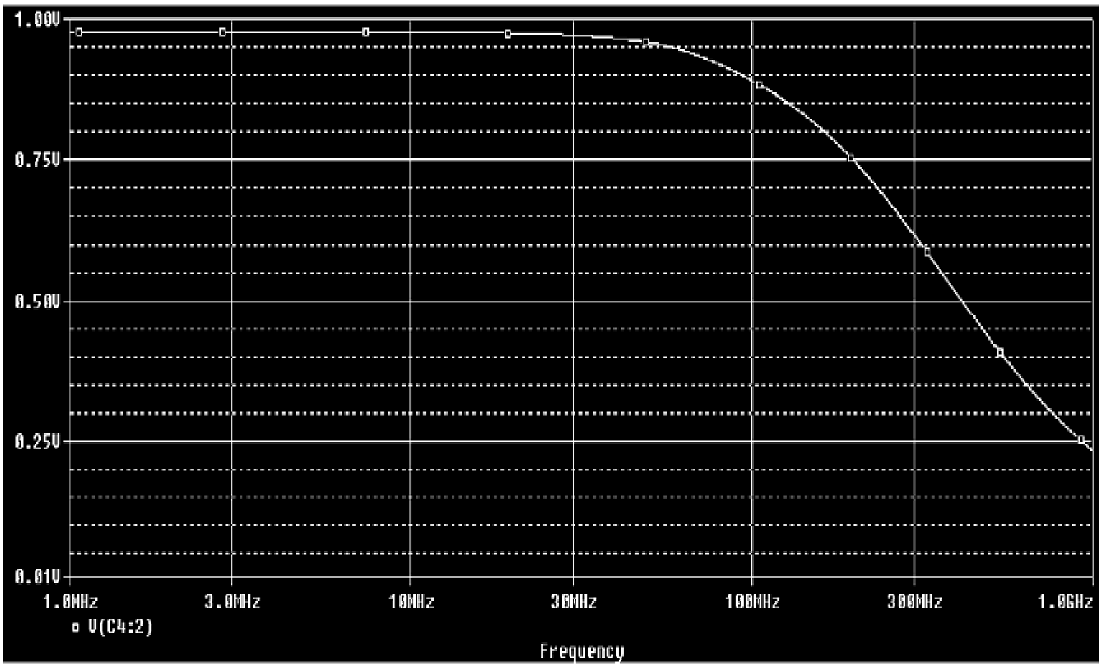

Figure 4.20 SAW filter input (digital side) has no peak.

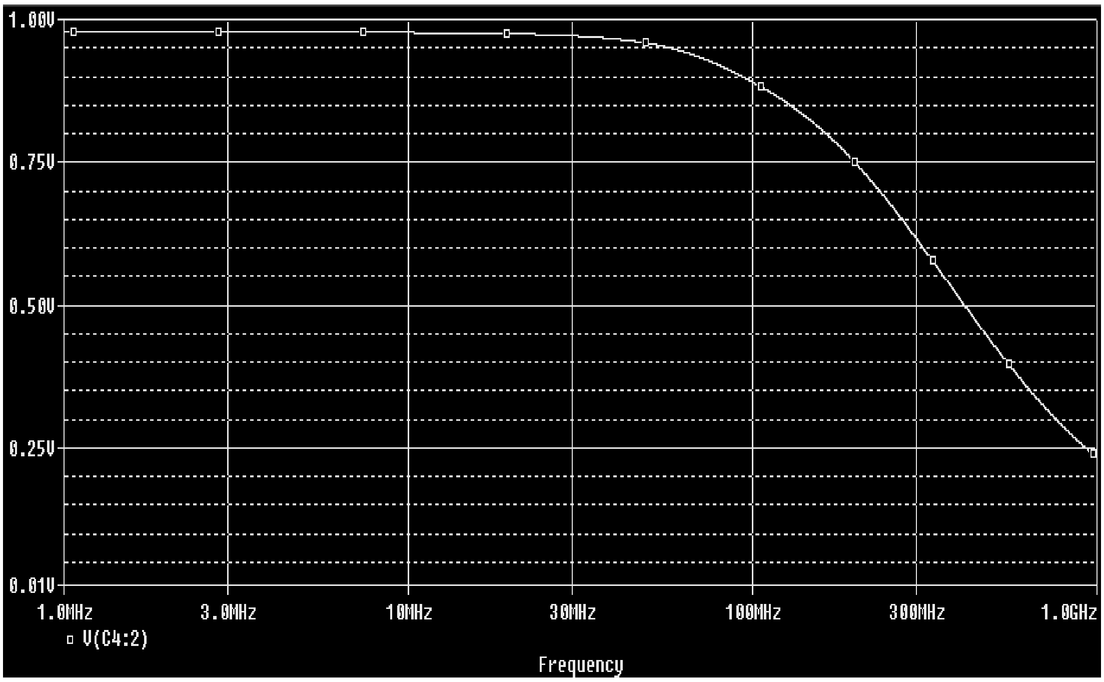

Figure 4.21 SAW filter input (analog side) has no peak.

4.1.3 Circuit Implementation for the Single Tuner IDTV Project

The new circuit was added to the IDTV products. The filtered +8V_IF was used voltage for the collector supplies of the high frequency (BF799) type transistors. Figure 4.22 shows our IDTV project schematics part which is produced in VESTEL production lines. The project name and main board type are secret.

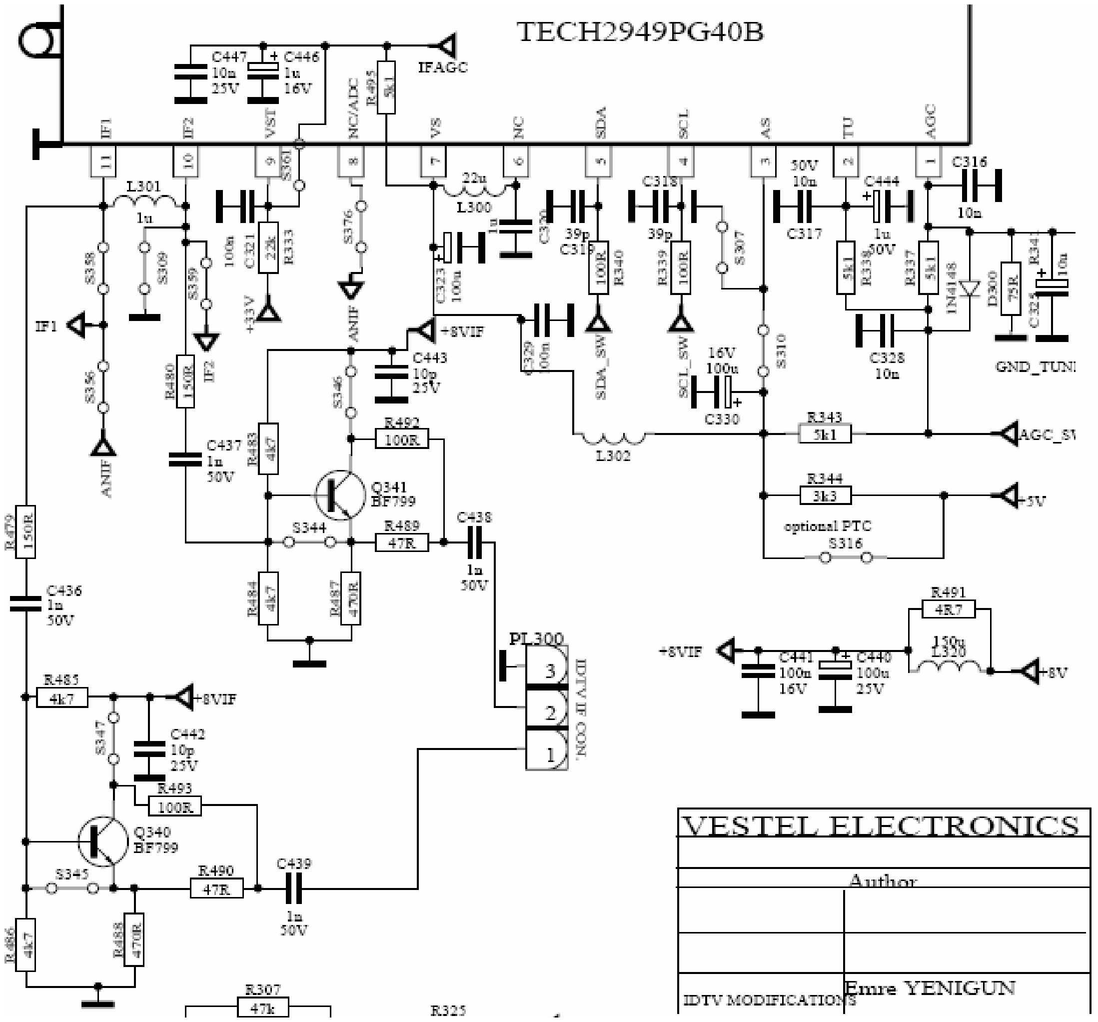

Figure 4.22 IDTV schematics which is produced at the company.

There is a single hybrid tuner at that schematic. Pin number 10 and 11 are the IF outputs of the tuner. PL300 connector is connected to the IF cable that goes to the

IDTV module card. IF1 and IF2 outputs are connected to analog side (main board SAW).

Before the emitter follower circuit digital image, there was the image blocking on the screen. Figure 4.23 shows this problem. At this figure, some digital block noises are seen. The IF signal level is week. Figure 4.24 and 4.25 shows our lab measurements for analog side and digital side SAW filter inputs for this problem. The signal shape distorted at 157.477MHz. According to the theory, if there is no impedance mismatching and max. power transfer problem, the signal shape must be flat at the frequency band. The distorted frequency value are same analog and digital side. Digital and analog IF signals were affected the other one. Therefore, high frequency buffer circuit was required.

Figure 4.23 Digital blocking problem and signal level.

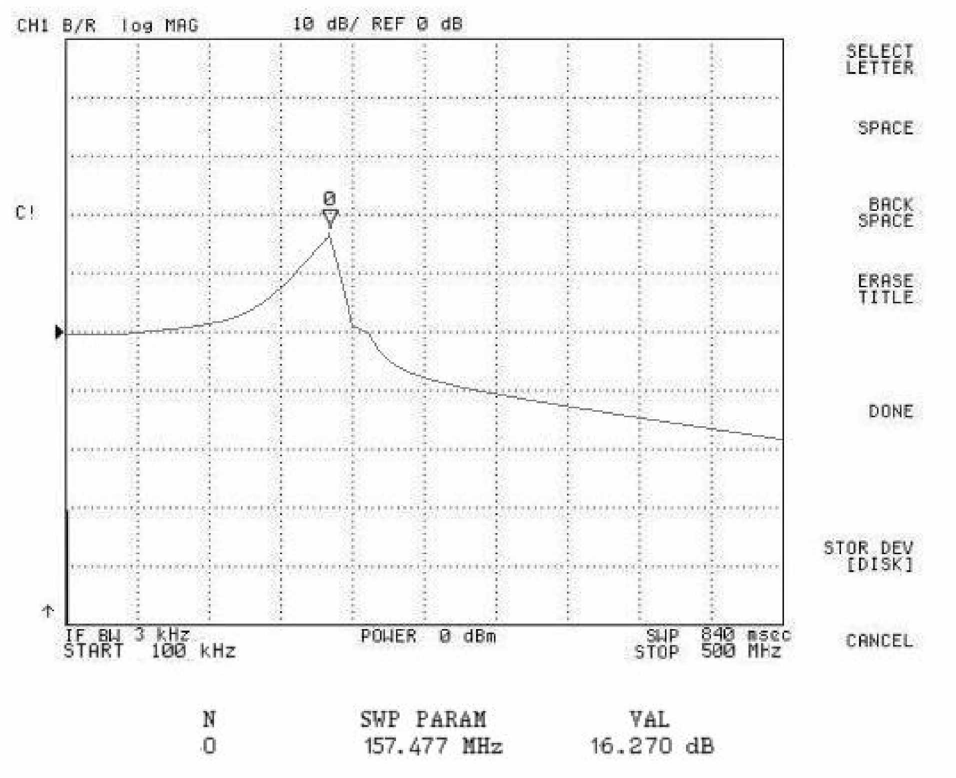

Figure 4.24 SAW filter input at the digital side before the new circuit design .

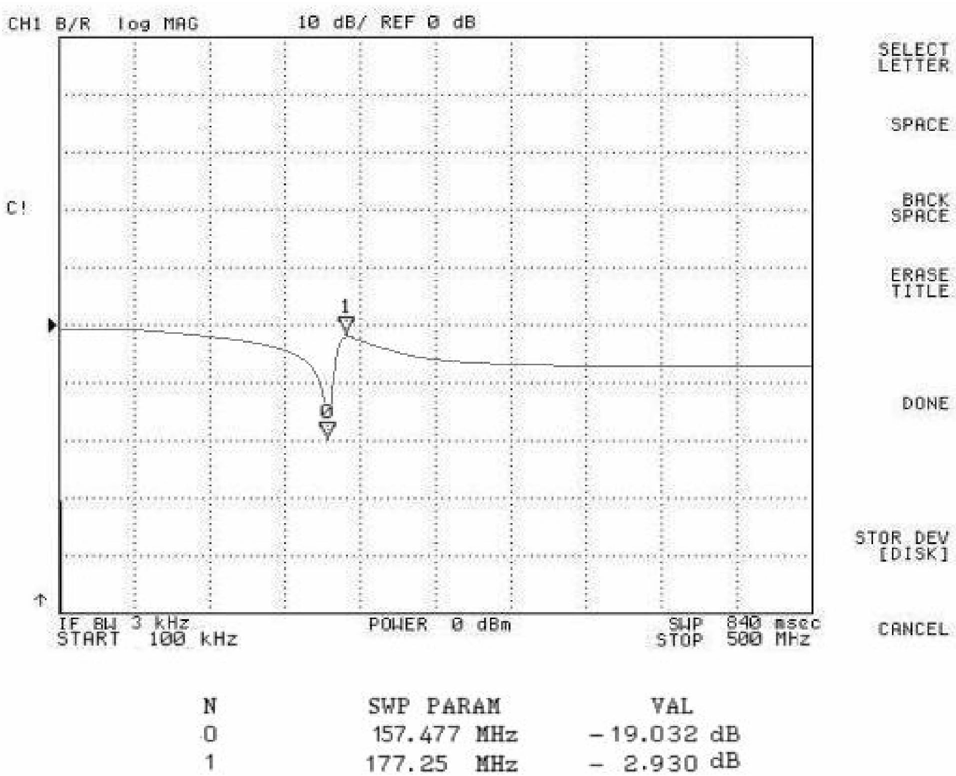

Figure 4.25 SAW filter input at the analog side before the new circuit design.

The new emitter follower circuits were designed. After this implementation, the image block noises are not visible. The IF signal level is strong. Figure 4.26 shows the digital image on the screen after this new circuit modification. SAW filter input signal shapes are same for digital and analog side. Figure 4.27 shows the SAW filter input for analog side and digital side.

Figure 4.26 Digital image after the new circuit design.

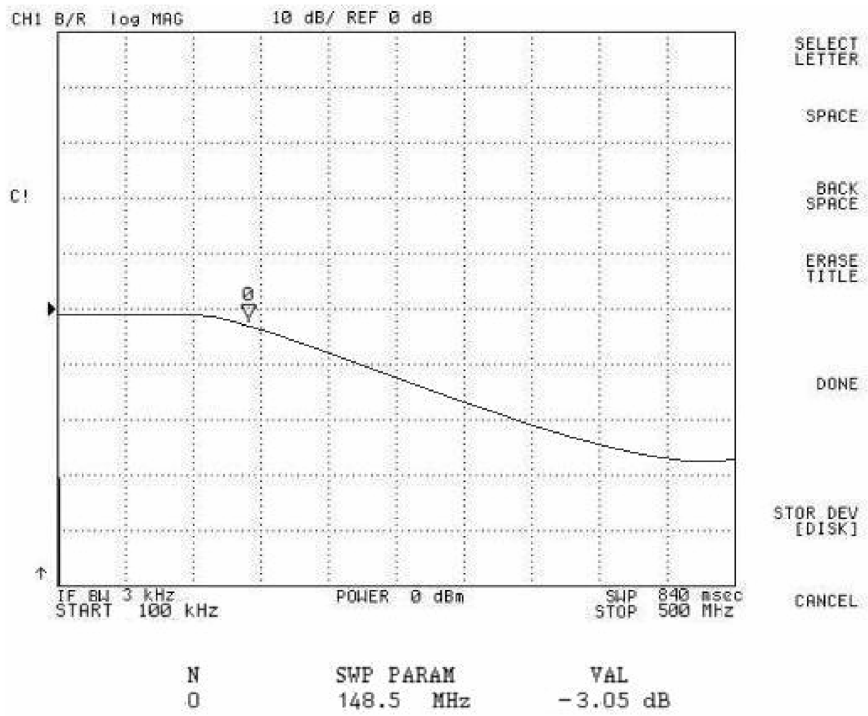

Figure 4.27 SAW filter inputs after the new circuit design.

Two layer PCB was used at that project. BF799 transistors and IF cable connector are close to the hybrid tuner. Figure 4.28 shows the PCB layout.

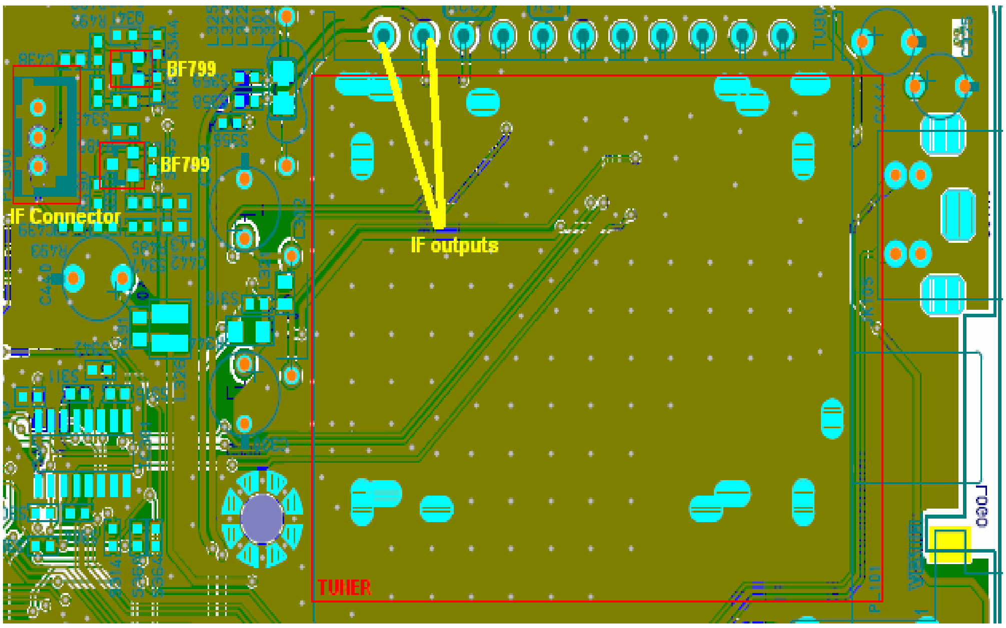

Figure 4.28 PCB Layout of the tuner, emitter follower and IF connector side.

CHAPTER FIVE
CONCLUSION

In this thesis, a special digital TV application was analyzed which includes LCD TV main board and external IDTV module card. IF output signals of the hybrid tuner were carried by a cable to the IDTV module board. Analog side IF signals were connected to the same IF lines as parallel. That application causes impedance mismatching and maximum power impairing problems which depends on the cable length and parallel IF application. That problem creates the image blocking problem. Sometimes, the some image parts was broken at the TV screen.

A new circuit was designed for IF lines impedance matching and maximum power transfer. The emitter follower solution was the best solution for the impedance matching, power transfer and isolation the digital IF signals from the analog IF signals.

Many transistors had some problems for high frequency circuit design. The BF799 special high frequency transistors were used for the overcoming from that problem. BF799 transistors could work 0 Hz to 500 MHz frequency range.

The main problem was solved with the high frequency emitter follower circuit design. The IDTV setups which included that new circuit were tested 100 times at the test group. The blocking problem was not visible at the screen. And the IDTV project was produced at the Vestel company.

In the future works, a new tuner types will be used as silicon tuner. That tuners like an silicon ic which include CMOS logics inside.

Digital COFDM and MPEG decoder integrated circuits will integrate to the main controller. Main controller will include 8051 microcontroller, audio and video processors, COFDM (digital IF demodulator), MPEG decoders (MPEG2 and MPEG4) and scaler-deinterlacer blocks. When that “single chip solution” will come to the TV market, the tuner IF signals will connect to the single chip by one way. External IDTV module board, IF cable, and parallel IF application terms will not be used. That single chips will have the digital part and analog part integrated circuits.

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