VGA TO TV CONVERTER

BY

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DEDICATION

I dedicate this work to GOD Almighty and to my lovely parents Mr & Mrs. E.A. Okoli who facilitated my admission into this University and who have been with me throughout my time, which has brought me to this time of my final year project. May his grace and love which he/they have granted me never cease in my life in Jesus name (Amen).

DECLARATION

I Okoli .A. Chidozie declare that this work was done by me and has never been presented elsewhere for the award of a degree. All information obtained from published and unpublished works have been acknowledged. I hereby relinquish the copyright to the Federal University of Technology, Minna.

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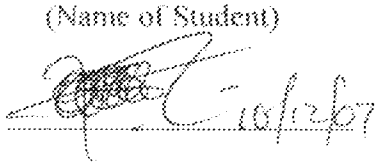

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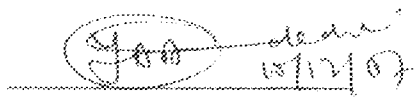

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ABSTRACT

The project design is a VGA to TV converter. The purpose of this project is to create a converter which makes it possible for the use of computers in homes and many business meeting rooms since nearly all homes and many business meeting rooms have a TV.

The core of this project is the circuit which is responsible for matching the VGA horizontal sync frequency to TV frequency and matching the VGA display frame rate of 60-70 Hz to TV fame rate of 50-60 Hz thereby, converting non-interlaced VGA picture to interlaced format for TV and VGA picture signals to RGB+Sync, PAL/NTSC composite video or S-video formats. The VGA drivers also help in the matching and conversion of the VGA signals to TV format by digitizing the whole VGA picture from the systems' internal memory and sending it out at a speed suitable for TV.

The achievement on the design of this project is the ability to use little amount of money to design and construct a valuable project called VGA to TV converter, that creates an avenue for the use of systems in almost every home and business meeting rooms. The usefulness of this designed project cannot be over-emphasized.

TABLE OF CONTENTS

LIST OF FIGURES / PLATES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

This project is aimed at designing and constructing a VGA- (Video Graphics Array) -to- TV converter which connects VGA card to TV through a Scart connector. The scart connector is a standard 21 pin AV connector which can be found practically in all modern TVs and VCRs made for European market. SCART connector is a standard interface for combining audio, composite video, RGB video and some control signals to one connector. The connector standardizes the pin outs and signal levels, but does not demand that all equipments have to implement every function. In some cases is would be nice to be able to display VGA picture on the large TV screen. The method used in the circuit maximizes the picture quality and resolution shown in TV screen. The design is based on the idea that the RGB signal can be routed directly to the TV so that RGB to composite video conversion in the converter and composite video to RGB conversion inside the TV are avoided.

The design is based around a TTL chip with four XOR ports, 2 resistors, 2 capacitors with other components such as A/D Converter, D/A Converter, Analogue Video Encoder. The TTL chip was logical because VGA sync signals are TTL level signals. The sync signal combiner has a system to adjust to different sync polarities so that it always makes correct composite sync signals. RGB to Composite video format is the signal format needed by TV input.

1.1 HISTORICAL BACKGROUND

1.1.1 HISTORY OF VGA

VGA was introduced on IBM'S ps/2 line in 1987 and quickly made the earlier CGA and EGA display interfaces obsolete, which were actually digital, but with lower resolution. The standard resolutions are 640x480, 800x600, 1024x768, 1280x1024 and 1600x1200, the latter three being the most commonly used. For example, 1024x768 means there are 1,024 columns and 768 rows of pixels on screen. The higher the resolution, the more material is viewable on screen, however, a high resolution on a small screen makes text very small. In a short time, non-IBM vendors boosted the base resolution and colors to so-called "super vga" over the years, resolution have been extended way beyond the original specification.

VGA may refer only to the original VGA resolution of 640x480 and 16 colors. This base resolution is only used when booting the pc in safe mode and may also be the maximum resolution for small screens on handheld devices. VGA uses an analogue monitor, and PC display adapter's to output analogue signals.

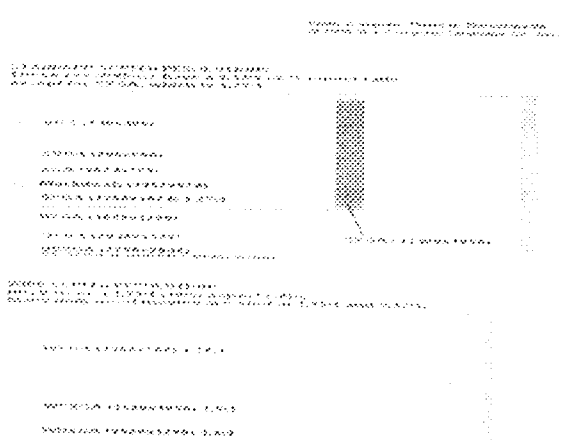

Plate 1.1 VGA standard screen resolutions

1.1.2 HISTORY OF TELEVISION

In 1873 the Scottish scientist James Clerk Maxwell predicted the existence of the electromagnetic waves that make it possible to transmit ordinary television broadcasts. Also in 1873 the English scientist Willoughby Smith and his assistant Joseph May noticed that the electrical conductivity of the element selenium changes when light falls on it. This property, known as photoconductivity, is used in the Videocon television camera tube. In 1888 the German physicist Wilhelm Hallwachs noticed that certain substances emit electrons when exposed to light. This effect, called photoemission, was applied to the image-orthicon television camera tube. Although several methods of changing light into electric current were discovered, it was some time before the methods were applied to the construction of a television system. The main problem was that the currents produced were weak and no effective method of amplifying them was known. Then, in 1906, the American engineer Lee De Forest patented the triode vacuum tube. By 1920 the tube had been improved to the point where it could be used to amplify electric currents for television

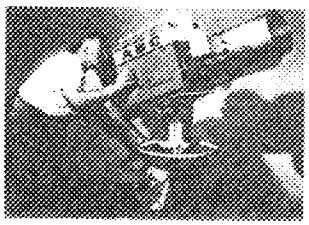

Plate 1.2 Early television camera

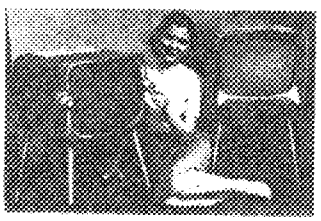

Plate 1.3Television set in the 1950's

The scientific principles on which television is based were discovered in the course of basic research. The first practical television system began operating in the 1940s. Television is a system of sending and receiving pictures and sound by means of

electronic signals transmitted through wires and optical fibres or by electromagnetic radiation.

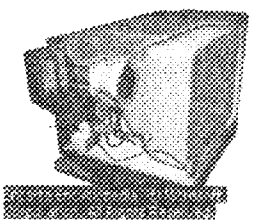

Plate 1.4 The inside view of a TV set

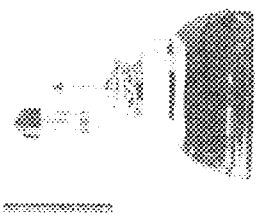

Plate 1.5 CRT (Cathode Ray tube)

These signals are usually broadcast from a central source, a television station, to reception devices such as television sets in homes or relay stations such as those used by cable television service providers. Television is the most widespread form of communication in the world. Though most people will never meet the leader of a country, travel to the moon, or participate in a war, they can observe these experiences through the images on their television. Television has a variety of applications in society, business, and science. The most common use of television is as a source of information and entertainment for viewers in their homes.

1.2 WHY BACK TO TV DISPLAY?

There are many reasons why there are needs to connect PC to TV:

- Programs like Power Point and Harvard Graphics made it easy for anyone to create good presentations
- Today's TVs are better than old TVs
- TVs are generally bigger than computer monitors and give bigger picture
- Nearly every home and many business meeting rooms have a TV

4. Converter technology (both hardware and software) has improved

VGA to TV converters are also needed by computer professionals who make computer animation and computer educational video tapes. The makes for small web browsing computers need techniques for efficient VGA to TV conversion to be able to use inexpensive standard PC graphics technology on their products.

1.3 AIM AND OBJECTIVES

1.3.1 AIM

The aim of this project is to design and construct a scart converter that connects VGA card to TV with SCART connector

1.3.2 OBJECTIVES

- Match VGA horizontal sync frequency to TV sync frequency
- Match the VGA display frame rate (60 or 70 Hz) to TV frame rate (50 or 60 Hz)
- Convert non-interlaced VGA picture to interlace format for TV
- Convert VGA picture signals to RGB+Sync, PAL/NTSC composite video or S-video formats

CHAPTER 2

LITERATURE REVIEW

TELEVISION is a Greek word originated in the 20th century from the words *tele* (an instrument for operating over long distances) *& vision* (ability to see, imagine) [1]. Television is a system for converting visual images with sound into electrical signals, transmitting them by radio or other means, and displaying them electronically on a screen.

SCART *(Syndicat des constructeurs des appareils Radio receptors et Television)* is an acronym from France in the 1980's which is a 21 pin connector used in modern European TV's to connect video equipments [1] ,this connector was named by the committee which designed the connector.

VGA meaning Video Graphics Array is the display standard for the PC, VGA may refer to the 15-pin VGA socket on a PC in general in order to contrast it with a digital DVI socket for flat panels [1].

Naturally the computer graphics (VGA) and normal broadcast television (NTSC, PAL or SECAM standard) are very incompatible with each other. With suitable conversion it is possible to show VGA picture on TV screen with somewhat degraded quality. This conversion can be done with some external hardware or the conversion hardware can be built into the graphics cards (PC graphics cards with TV output option).

Normal video signals you watch on TV screen are generally in composite video or RF (antenna). The picture signal sent out by PC graphics cards (VGA, SuperVGA and newer cards) is analogue RGB signal with separate sync signals. The picture resolutions vary between the computer (typically from 640x480 well above 1024x768) and the broadcast television (nominally 525 or 625 lines in Y direction is signal, somewhat less visible, resolution in X direction not absolutely defined, usually effective X resolution between 300-600 pixels). The picture format used in broadcast TV is interlaced but computer uses non-interlaced video. Also, the picture format sync rates are different. The HSYNC rate of TV is 15625 Hz (for PAL and SECAM standards) or 15750 Hz (for NTSC standard). The VSYNC rate is 50 Hz (for PAL and SECAM) or 60 Hz (for NTSC). Original VGA used around 31 KHz HSYNC rate and 60-70 Hz frame rate. Nowadays typical values are HSYNC=30-65 KHz and VSYNC=50-120 Hz [2].

2.1 THEORETICAL BACKGROUND

All video monitors now have retraced blanking that is shorter than the blanking from the camera. This means that the signal which the monitor can display contains all of the information from the camera. However, most video monitors, unlike computer displays, are set up to overscan so that some of the image goes off the edge of the tube. The method used in the circuit maximizes the picture quality and resolution shown in TV screen. The method does not make it possible to have any kind of flicker removing filtering. The advantages of the design are simplicity and superior image resolution compared to many commercial designs.

Theoretically the drivers which use those methods should work with every PC graphics card which claims VGA card compatibility. Unfortunately in real life the situation is not this good. The problem is that common accelerated PC graphics cards are typically and internally very different from the original VGA hardware and the original VGA card register functions are only emulated using some special hardware. The chipset makers usually claim 100% VGA compatibility, but they have only implemented part of the VGA functionality right (the most often needed part). If all the rarely needed special video clocking modes are not implemented correctly the drivers don't work correctly. Sometimes all of those functions are implemented to the graphics card chipset VGA emulation but some of the registers have access controls (which give or deny access to some timing registers), so that if access is not granted to those registers then the driver does not work correctly (the access control is graphics chipset specific feature) [2].

2.1.1 TECHNIQUES FOR CONNECTING VGA CARD TO TELEVISION

In some cases it would be nice to be able to display VGA picture in the large TV screen. There are commercial adapters for this purpose, but they tend to be quite expensive and the picture quality in less expensive ones leaves much to desire. One of the reasons why the picture after conversion looks bad is that the commercial units convert VGA signal to composite video which has quite severe bandwidth limitations. My design is based on the idea that the RGB signal can be routed directly to the TV so that RGB to composite video conversion in the converter and composite video to RGB conversion inside the TV are avoided. In this way the picture quality is better and the converter is

simpler. The disadvantage of this is that your TV must have EURO-AV/SCART connector with RGB inputs to be usable with this circuit. You can't use this adapter to record VGA picture to VCR directly because VCR needs always composite video signal. Remember that the timing signals in the video signal you are making must be exactly right or otherwise you might get sync problems, poor colors or no colors at all [2].

2.1.2 VGA TO TV CONVERSION TECHNIQUES

There are four basic ways for which VGA to TV (Scart) conversions are done:

1. MAKE VGA TO SEND OUT TV FREQUENCY SIGNALS

This technique has been used in the cheapest VGA to TV gaming adapters like ADS Technology Game Zapper (not manufactured anymore) and Boffin Multimedia VIP 50 (also discontinued). The product consists of VGA to TV adapter box and the drivers. The drivers set the VGA card to generate signals at normal TV frequencies. The adapter box takes the RGB signals from VGA card monitor output and converts them to composite video signal. The advantage of this design is that the electronics is cheap and the products can be made cheap. The disadvantages are possible compatibility problems with some VGA cards and programs. Typically the drivers support only DOS programs. In high resolution modes one problem is the flickering caused by interlacing. It is not possible to use VGA monitor and TV display at the same time [3].

2. ONE TV SCANLINE MEMORY BUFFER

This technique started on the idea that VGA screen at 640x480 resolutions is non-interlaced picture 60 Hz refresh rate and horizontal scan frequency of 2xNTSC horizontal scan frequency. The converter needed to convert this to interlaced TV signals has to do the following things:

- Store first odd number scan line shown in VGA screen
- Send out the stored can line at half speed and encode it to NTSC video signal
- Store next odd scan line to buffer

Using this method the whole picture is converted to TV screen. When all odd lines are handled in one picture, the even number scan lines are handled in the same way on next round. This method gives out nice interlaced NTSC TV picture from 640x480 VGA screen. The converter handles 640x480 graphics nicely without any drivers and it is possible to have your VGA monitor showing the same picture at the same time.

To be able to show other VGA resolutions nicely a driver is needed to set all VGA modes to 60 Hz refresh rate (the driver makes VGA card to add blank scan lines to the beginning and end of the picture to make it 480 line picture).

When conversion is needed for PAL TV, a driver is needed which sets all VGA modes to 50 Hz operation. The horizontal scan rate for PAL output is still made by halving the VGA horizontal scan rate, which gives a little bit too high horizontal scan rate for output

PAL signal. This problem usually messes up the colors in many products (for proper PAL signal decoding the horizontal scan rate must be very accurately right in conjunction with the color subcarrier frequency).

The electronics itself become quite complicated. A typical circuit which connects to VGA monitor output needs fast A/D converters for digitizing incoming video signal, small memory buffer for storing those signals and digital PAL/NTSC encoder. Because the basic conversion needs quite much electronics, the manufacturers have typically added a flicker reducing circuits to their products. Flicker reduction circuit stores few scan lines information and interpolate between those scan lines to get rid of some of the flickering. There are some special IC's in the market which can do all this [3].

3. MANY SCANLINE CONVERTERS WITH SCALING

This technique needs that the VGA card screen refresh rate is set as the same refresh rate of the TV fields, i.e.50 Hz for PAL and 60 Hz for NTSC. This techniques work basically in the same way as the method 2 described above. The difference is that the conversion can be done even if the VGA horizontal sync rate is not exactly twice the TV horizontal rate. For example if there are 3 VGA graphics scan lines for every TV scan line time the converter scaling IC takes the graphics of those scan lines and scale those to one TV scan line which is sent to the TV. The number of computer screen scan lines for TV scan line might not even have to be an integer. The details of how many computer scan lines are used to make one TV scan line are programmed to the converter and scalar IC. The

converter electronics must have enough memory to handle the data of fed VGA scan lines (at least for computer graphics input scan lines and for output scan line to TV). This technique is used in some PC graphics cards which have TV output options in them. When the TV output is needed the graphics card must be set to suitable mode which has the right horizontal and vertical scan rates and then the converter/scalar IC is programmed to do the conversion in the way which gives right TV picture [4].

4. FULL FRAME CONVERTERS

This is the most expensive class of VGA to TV converters which have one big advantage: you don't need to load any drivers to your computers to be able to use them and you can use your computer monitor at the same time with TV. The converter is just a box which you plug between your VGA card output and TV. The box does all the conversion from the VGA signal to high quality video signal.

The circuit works using a technique where one part of the circuit constantly digitizes the VGA picture at the rate the VGA card sends it to a frame buffer inside the converter. Another part of the circuit reads the data from the frame buffer at the speed the TV wants and outputs it to TV. The principle is quite simple, but the problem is that the converter needs easily megabytes of high speed memory to be able to store a whole VGA screen frame to the converter memory. These type converters are very useful in showing windows presentations on TV screen. The disadvantage of this type of converters is their problem in reproducing animations: the picture looks always "jerky" on TV even if it is

smooth on computer monitor. This problem is caused by the frame rate conversion done by the converter and there is no way to avoid this problem in this converter type. Some expensive converters use motion estimation algorithms to make the movement smoother but the problem in those is that they are computationally very expensive (needs expensive special hardware) and many of the algorithms add up other type of artifacts to some type of video material (these algorithms are not foolproof) [4].

2.1.3 WHAT NEEDS TO BE DONE WHEN CONNECTING VGA TO TV

Connecting VGA picture to TV does not seem to be an easy task because VGA and TV use different picture scan rates and resolutions.

Table 1 Frequencies of VGA card mode

Vert. Res.	Horiz Freq	H Sync Polarity	Vert Freq	V Sync Polarity
350 lines 400 lines 480 lines	31.5 kHz 31.5 kHz 31.5 kHz	pos neg neg	70.07 Hz 70.07 Hz 59.95 Hz	neg pos neg

Those frequencies are used in standard VGA cards. Higher frequencies are used in higher resolutions and when totally flicker free display is needed. You are sure to get the frequencies above when you set your monitor type to standard VGA in your graphics card configuration. The frequencies should be something to suit your TV set.

Table 2.1 Frequencies of TV modes

TV System	total lines	Horiz. freq.	Vertical freq.	Color freq.
NTSC (US)	525 lines	15.734 kHz	59.94 Hz	3.579 MHz
PAL (Europe)	625 lines	15.625 kHz	50.00 Hz	4.433 MHz
SECAM (France)	625 lines	15.625 kHz	50.00 Hz	4.4 MHz

- NTSC stands for National Television Standards Committee
- PAL stands for Phase Alternate Line
- SECAM stands for Sequentiell Couleur A' Memoire

Many modern televisions in Europe accept only PAL standard color video signals, but they have no problem in handling the frequencies of NTSC (US) system if the picture is fed to them through SCART connector RGB pins. The picture in both systems is originally interlaced, but TV sets also accept non-interlaced pictures but you loose half of the vertical resolution.

2.1.4 DIFFERENT PICTURE FORMATS OF TV AND COMPUTER DISPLAYS

All video monitors now have retrace blanking (the interval that the CRT electron beam is shut off for retrace) that is shorter than the blanking from the camera. This means that the signal which the monitor can display contains all of the information from he camera. However most video monitors, unlike computer displays, are set up to overscan so that some of the image goes off the edge of the tube [5].

2.2 HOW TO DO THE CONVERSION

There are two ways of doing the scan rate conversion. First idea is to make a device which digitizes the whole VGA picture to its internal memory and sends it out at the speed which is suitable for TV. This is how it is done in expensive commercial units. The advantage of this system is that this works with every software and computer which outputs VGA signal just by plugging the unit to VGA card. Normal VGA monitor can be used with this type of adapter at the same time with the TV. The disadvantage is that this kind of circuit becomes complex and expensive. There is another disadvantage: you can't get smooth movement to the TV screen. Something which seems to move smoothly in the VGA screen does not move smoothly in TV screen because the frame rate conversion makes movements "jerky". Because of those disadvantages this method is only suitable for showing business graphics, not interactive action games.

Another way to generate scan rates suitable for TV is to program VGA card to put out picture at the TV scan rates. VGA card is quite freely programmable video card and this kind of programming can be done quite well even using standard VGA card (some SuperVGA chipset has advanced functions for making interfacing to TV easier). For this purpose you need the suitable software to set the scanning frequencies of VGA card to suit the TV you are using. The disadvantage of this is that you need suitable software driver and the driver must be loaded every time you use VGA to TV converter. The advantage of this approach is that the hardware becomes simple and inexpensive. Because the frame rate is converted directly on the VGA card, the graphic programs

which sync themselves to VGA screen refresh sync to this new setup and output smoothly to the TV screen [6].

2.2.1 PROBLEMS IN WRITING THE VGA TO TV DRIVER

Normal VGA register set allows you to make some limited changes to the VGA timing and normally VGA card has the necessary clock control registers to divide the pixel clock rate by two to make the horizontal scan rate to match the TV scan rate. Some fine tuning has to be also done to make the sync signal and border size to match the ones needed by TV.

If the horizontal sync frequency is halved then this means that the vertical sync frequency becomes also half of the original, which is not what we need. Because normal TV uses interlaced display with field rate of about same as VGA card (60 Hz field for NTSC TV and VGA uses 60 Hz frame rate in 480 line modes), the card has make it so that it sends only half of the scan lines to TV at every field. In every VGA card it is possible to leave out every other scan line, which makes the screen visible on TV, although some resolution in lost. Some modern SuperVGA chipsets have option for turning on interlacing, which usually gives better results, although you must write a specific driver for every chipset to support those chipset specific functions.

If the horizontal refresh rate is not suitable after leaving scan lines out or turning the interlacing on, some other modifications to VGA registers are needed. The vertical refresh rate is determined by the horizontal scan rate and total number of scan lines in one

field (visible lines + border + sync signal). So by changing the size of the borders it is possible to adjust the vertical refresh rate (increasing border scan lines will decrease refresh rate) [7].

2.2.2 PROBLEMS WITH SUPERVGA MODES

SuperVGA modes are more problematic than standard VGA modes. When S-VGA graphics cards were introduced in the late 1980's, there were no industry standards. Each graphics chip manufacturer independently produced new modes and hardware to implement them. Software vendors were forced to implement vendor specific code to take advantage of S-VGA modes. Nowadays many biggest graphics card chip makers have tried minimizing changes to the S-VGA implementation in order to maintain compatibility with existing software.

However, the dynamic nature of the PC industry forces change. Windows, OS/2 and other GUI environments have caused S-VGA cards to be phased out in favor of accelerator cards. There has also been a widespread adoption of the VESA VBE standard for S-VGA programming in the DOS environment. Both trends allow programmers to access graphics hardware through device independent API's which have greatly reduced the need to maintain backwards compatibility at the hardware level. Unfortunately VESA VBE does not help much in writing the VGA to TV drivers because changing the refresh rates still needs access to the VGA registers directly (and quite often chipset specific features also). Many manufacturers nowadays implement VBE functions through the

accelerator hardware rather than through the 8 bit VGA hardware. The benefit is higher performance and greater access to memory. However, S-VGA software which relies on reading or "tweaking" VGA registers (like those VGA to TV driver) may fail.

CHAPTER 3

CIRCUIT DESIGN

It is basically a circuit which takes VGA signals and converts it to RGB + composite sync signal which can be fed to TV via SCART connector. VGA card picture components RED, GREEN and BLUE are already at the correct voltage level (0.7Vpp) and has correct impedance (75 ohm) for direct connection to corresponding inputs in the TV. What needs to be done is to combine separate horizontal and vertical sync signal from VGA card to one composite sync signal which is feed to TV video in pin in SCART connector. This sync signal conversion is done by the electronics in the circuit. The circuit has also sends correct level signal to the TV RGB input enabling control pin in the SCART connector (pin 16).

3.1 HOW THE CIRCUIT WORKS

This circuit is designed for converting normal VGA signals standard RGB signals and composite sync signal. The circuit is quite simple, because RGB signal output from VGA card is already standard 0.7Vpp to 75 ohm load. RGB+composite video format is the signal format needed by the TV input. Besides, that format conversion special drivers is needed to set the VGA card to suitable refresh rate for normal TV. For sync signals there is a circuit which combines horizontal and vertical sync signals to from composite sync signals. The circuit is simply based on one TTL chip with four XOR ports, two resistors and two capacitors. TTL chip was logical choice because VGA sync signals are

TTL level signals. The sync signal combiner has a system to adjust to different sync polarities so that it always makes correct composite sync signals. VGA card uses different sync signal polarities to tell the monitor which resolution is used. This circuit adjusts to sync signal polarity changes in less than 200 milliseconds, which is faster than setting time of a normal VGA monitor in the display mode change. The circuit needs well regulates +5V (+/-5%) power supply and takes about 120 mA current

3.2 DESIGN COMPONENTS

The components for this design were best choice based on their functionality and purpose most especially the TTL chip 74LS86 which signals corresponds to VGA sync signal which are already TTL level signals.

3.2.1 MAIN CIRCUIT

U_1 74LS86 (74HC86 or 74HCT86 can also be used)

C_1 22 microfarads 16V electrolytic capacitor

C_2 use 47 uF 16V electrolytic for more reliable operation (22 uF listed in the schematic can cause problems in some cases)

R_1, R_2, R_3, R_4, R_5 2.2 k ohm, 1/4 W

R_6, R_7, R_9 47 ohm, 1/2 W

R_8 120 ohm, 1/2 W

T_1, T_2 BC546B (2N2222 should also work but note the different pin out)

P_1 15 pin SUB-D connector (DE-15)

3.2.2 OUTPUT CONNECTOR:

21 pin EURO/SCART connector

3.2.3 WIRING:

Red, Green, Blue and Composite Sync lines should be wired using 75 ohm coaxial cable for best picture quality, but can be replaced with normal shielded wire.

3.2.4 POWER SUPPLY COMPONENTS

7805 regulator chip

100 uF electrolytic 25V

10 uF electrolytic 16V

100 nF polyester or ceramic condensator

Wall adapter which outputs 8-18V DC and 150 mA or more current

Connector for connecting wall adaptor to circuit

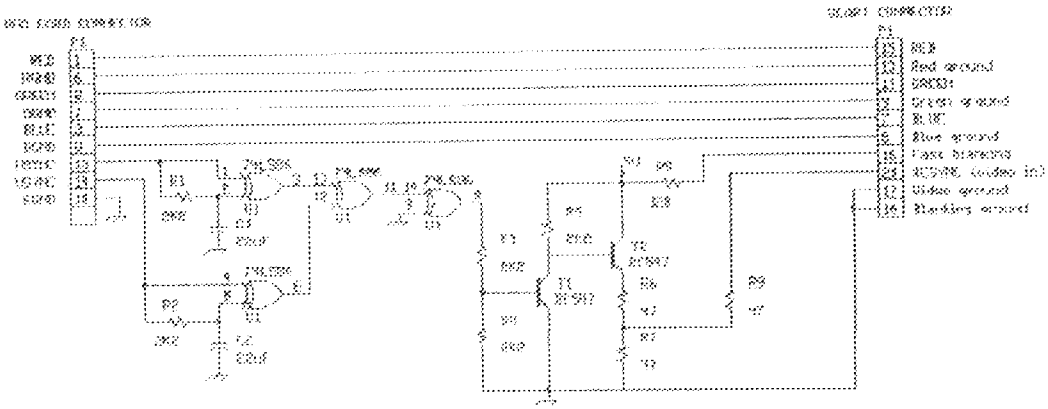

Fig 3.1 Circuit layout of the Wiring

CHAPTER 4

CONSTRUCTION

4.1 BUILDING THE CIRCUIT

VGA to TV converter is quite easy to build if you have some experience in building electronic circuits. The electronics of the circuits can be easily built to a small piece of Vero board and no special circuit board is needed. Remember to add power feed to the chip U1. It has not been marked to the schematic. U1 has ground at pin 7 and +5V power input at pin 14. The circuit needs well-stabilized power +5V power source (actual voltage can be in 4.75V to 5.25V range). The circuit takes less than 150 mA current, so you don't need a large power supply. If you don't have anything suitable available, you can always use a small general purpose wall transformer and a small +5V voltage regulation circuit. If your computer graphics card is VESA DDC compliant, it might have +5V available at VGA connector pin 9 (the standard have option that VGA card can have +5V at pin 9, but it does not necessarily have to have this). You can test easily if your computer has this +5V output using multimeter. VGA connector, SCART connector and other connectors must be fitted outside this circuit board. Remember that the SCART connector pin outs in the circuit diagrams are according the pin out used in TV end. If you should your circuit so that it has male SCART connector which goes directly to TV everything works as planned. If you want that your circuit has female connector and you use some ready-made SCART wire you must remember tow things. you have to use a wire which has all pins connected and the SCART interconnection cables switch pins 19 and 20 inside the

cable (those cables swap all audio and video incoming/out coming wires). For best signal quality all of the wiring should be made of 75 ohm coaxial cable (thin antenna wire) for best image quality just like in any video circuit. Because TV is not very high resolution display, the wire type does not matter much if the wire is only few meters long. I have successfully used shielded twisted pair computer cable for the connections (one pair takes one signal and one ground line). Use well shielded cable, because poorly shielded video cable can generate quite an amount of radio interference.

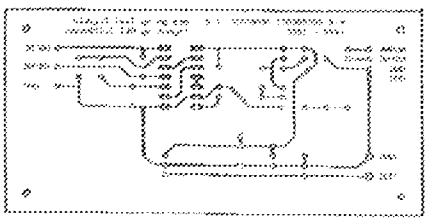

Fig 4.1 copper traces viewed from component side

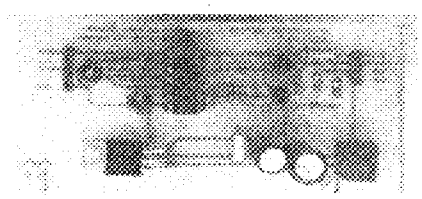

Plate 4.1 component layout picture

4.2 TESTING

4.2.1 DRIVER TESTING PROCEDURE

- Load the VGA to TV driver. Put it to the TV mode (most drivers go to TV disolat mode when loaded)
- If your monitor looses sync, then continue testing. If you still see the picture on regular VGA monitor the driver did not work correctly (NOTE: The picture might

still be visible after driver loading on some old multisync monitors capable of syncing to 15 kHz horizontal rate).

- Disconnect the monitor.
- Connect the ground of your measuring equipment input to the PC case.
- Connect the measuring equipment signal input to VGA HSYNC pin (pin 13). You should be able to measure around 15.6-15.8 kHz frequency or around 63-64 microsecond times between the sync pulses. If you get a higher frequency then the driver did not work correctly.
- Connect the measuring equipment signal input to VGA VSYNC pin (pin 14). You should be able to measure around 50 or 60 Hz frequency (time between sync pulses around 20 or 16.6 milliseconds).
- If everything went nicely to here, then at least this one graphics mode is expected to work with VGA to TV converter circuit. This simple measurement does not 100% guarantee that everything is correct, but gives quite good confidence. You can trust also other screen modes using the same measurement methods.

4.2.2 ADDING MONITOR ID SIGNALS

If you are planning to use the TV as the only monitor for the computer, you might want to add the monitor type identification function to this circuit. This can be easily added to circuit by connecting VGA connector pin 11 to pin 5 with piece of wire. In this way the VGA card gets color monitor ID from the VGA to TV adapter and you can boot your computer to color monitor mode when VGA to TV adapter is connected.

4.2.3 ADDING SOUNDS FROM COMPUTER TO TV OPTION

Other nice modification is to add computer sound to TV speakers' option. This can be done connecting soundcard right line level output to SCART connector pin 2, left line level output to SCART connector pin 6 and connect sound card audio ground to SCART connector pin 4. In this way the sound is nicely routed from soundcard to TV speakers.

It is a good idea to use well shielded cable for audio to prevent audio lines from picking high frequency noise from video signals going to TV.

4.2.4 USING FEMALE SCART CONNECTOR AS CIRCUIT OUTPUT

Sometimes you might want to build the circuit using female SCART connector which will fit nicely to plastic case and you can connect the circuit to TV using standard SCART interconnection cable. If you are planning to use female connector in the circuit and you use standard scart wire to connect it to TV you must remember the following things:

4. use a SCART cable which has all pins connected (all cables don't have RGB wires connected
4. standard RGB cable crosses all audio and video lines so that what is input in one end is connected to the output in another end

The necessary modification if you want to use female SCART connector is to connect the composite sync signal output to pin 19 instead of pin 20 (If you plan to use the sound option then you connect left channel to pin 3 and right channel to pin 1)

4.3 TROUBLESHOOTING

If the TV does not have SCART connector this circuit design can't work directly. There are possibilities of extending the circuit design to also work with TV composite video or RF inputs. These modifications have two bad things:

4. The circuit gets much more complicated
4. The picture quality will go much worse than what you get from SCART version

4.3.1 USING THE CIRCUIT WITH TV WHICH HAS COMPOSITE VIDEO INPUT

If you find out on external RGB to composite converter you can connect the SCART VGA to TV circuit to that converter and get nice composite video (or S-video) signal out of it which you can then feed to your TV.

If the TV uses PAL standard then you can build the VGA converter to outputs PAL composite video signal. The TV in composite video input mode is much more sensitive to the signal variations as in RGB mode. This might mean that you will not get any colors, flickering colors, wrong colors or bleeding colors with some of the VGA to TV driver

4.3.2 USING CIRCUIT WITH TVS WHICH HAVE ONLY RF ANTENNA INPUT

If your TV has only antenna input then you need to have a modulated composite video signal to be able to feed it to your TV. The modulated video signal is just composite video signal (PAL or NTSC standard depending on your TV) which is modulated to radio frequency carrier. The connection would be the following:

VGA -> composite video converter -> modulator -> TV RF input

- VGA card outputs RGB signal which goes to the converter circuit.
- Converter converts RGB from the VGA card to composite video signal (must match the composite video standard your TV uses).
- RF-modulator converts the composite video signal to the RF signal understood by TV antenna input. This modulator can be a ready made module or built from an electronics kit. It is also possible to use your VCR as an RF modulator by connecting the composite video to your VCR video input connector and tuning your TV to video channel (you might need to press some button in VCR to enable the composite video input in VCR).

4.4 COMMON PROBLEMS DURING TROUBLESHOOTING

PROBLEM 1: My TV and/or monitor picture looks like a scrambled cable broadcast

Your computer's resolution is set too high or you don't have correct driver loaded. The TV absolutely requires a 15625 Hz or 15750 Hz vertical sync frequency. Make the changes necessary so that your video card and driver will produce a usable signal. Check also that the circuit gives out usable composite sync signal.

PROBLEM 2: TV is not syncing to VGA picture at all

The problem can be either the driver or the circuit. Check the following thing to make sure that there is no driver problems:

- Check that the driver is loaded to the memory and TV mode is activated

- Check that the driver support the screen mode used
- Check that the driver works with you VGA card chipset
- Check that the driver give correct frequencies to your TV (select Pal or NTSC driver according the TV system used in your country)

Check that the TV is connected to AV channel where it takes the signal from SCART input. Check also that everything is plugged correctly. If this does not help, then you have to really start troubleshooting on the circuit board.

First thing to do is to check that the circuit get steady 5V (+-0.2V) operation voltage. The check that the sync signals HSYNC and VSYNC are coming from VGA card to circuit board. Check also that you see those signals at positive polarity at U1 pins 3 and 9. Then check that you see TTL level composite sync signal at U1 pin 11.

If this all is correct, the problem might be the sync output section built from resistors and transistors. It is very easy to make mistakes in here by connecting one transistor in the wrong way or something else similar simple mistake. Recheck the transistor circuit. That circuit should give around 1.2 S Vpp open circuit signal voltage at SCART pin 16.

PROBLEM 3: No picture at all in TV

Check that the TV is in AV channels and the drivers are correctly activated in computer. Check that the connections are made correctly and the circuit gets enough power. Make sure that there is +5V open circuit voltage visible at adapter SCART connector pin 16. Make sure also that R8 gets +5V power and has correct resistance value. If this is all correct, the do all the things mentioned in problem solving above.

PROBLEM 4: TV screen scrolls up/down

Check that your TV support the TV standard the driver is written to support. If you have PAL TV use PAL driver, and if you have NTSC TV use NTSC driver. NTSC drivers can work well in many modern PAL TVs, but not all.

If the driver is correct, then you must check the hardware to make sure that the VSYNC signal goes well all the way from VGA card to the TV. First check that VSYNC signal goes to U1 pin 4. It goes through one XOR gate and you should see the VSYNC signal at positive polarity at U1 pin 6. Then the signal is mixed to HSYNC with the following gages, and finally you should see TTL level composite sync signal at U1 pin 11. Finally the signal goes through transistor amplifier circuit to CSYNC output.

PROBLEM 5: You see the picture "waving" or you see horizontal dark band scrolling over the picture

You have ground loop problem. Disconnect the TV from antenna network and all other equipments and try again. The problem should go away. If still problem, then check the ground connections in your cabling.

If you have a modern 100 Hz TV or some other digital video equipment then the problem might be that the TV just can't exactly sync to the signal from the VGA to TV converter because it can varies slight from the real TV broadcasts in some timing details. Try with another driver and check if this corrects the problem.

PROBLEM 6: Wrong colors

Check the wiring of RED, GREEN and BLUE signals. The might be short circuit or bad connection in one of those signal wires.

PROBLEM 7: TV shows only gray picture with only some faint details of the computer screen picture

This usually means that the sync signal part of the circuit works nicely, but there is problem in getting the RGB signal to the TV. Check that your TV settings are correct for receiving RGB signals from SCART connector (if your TV has two connectors check that you use the one which has RGB input capability). Check also that the circuit gives control voltage to the SCART pin 16. That voltage should be in 1.3V range when you have the circuit connected to TV.

PROBLEM 8: The edges of my screen are missing on the TV.

This is due to the over scan built into your TV's design. The edges of your picture ARE being projected onto the CRT, but behind the painted mask, so that you cannot see them. Try another driver because some drivers allow selecting between under scan and over scan mode

PROBLEM 9: The picture does not fill the complete TV screen

Normal TV and VGA screen resolutions are not the same. VGA screen has many resolutions and some of them fill more part of the TV screen than other. You can adjust the amount of the TV screen the computer picture fill only by changing the

computer resolution (if your TV can handle both PAL and NTSC frequencies you can also try to change the video mode). On horizontal direction some drivers have selection to select between under scan and over scan modes.

PROBLEM 10: Picture has ghosting or is blurred

There is problem in your wiring. You have used too long cable or cable type not suitable for high frequency video signals.

CHAPTER 5

CONCLUSION

The VGA to TV converter displays your VGA signals on TV with sound option i.e your sound output from your sound card also connects to the scart connector which gives the best picture quality you can get out of TV with no colour smearing

5.1 AREAS OF APPLICATION

Playing games on large screen

Games look usually nicer in larger screen. The circuit and driver work with very many DOS games.

PC based TV screen info systems

You can use an old PC and a large TV to create an info screen with changing pictures or scrolling texts. With PC you can easily create also interactive or otherwise nice info screens.

Computer TV integration

You can now browse web pages and view your MPEG files in you big TV screen instead of that small computer monitor you have. You can also try web browsing in your big TV (note: the picture will flicker quite much on this).

Interfacing to video studio equipment

If your video studio has equipments with RGB inputs, you can record high quality the computer graphics to video tape. Depending on the professional video equipment and your computer setup this simple circuit might work very well or you might get syncing problems.

Virtual reality display interfacing

Many homemade virtual reality head mounted displays (HMD) are built from old pocket TVs. If the LCD TV has RGB inputs somewhere inside the TV you can get computer graphics nicely to that small LCD screen.

REFERENCE

[1] Concise oxford English Dictionary 11e, Oxford University Press 2004.

[2] How to get your vga2tv converter to work, Tomi Engdahl < Tomi.Engdahl@iki.fi> June 2006.

[3] VGA to TV converter information, Tomi Engdahl < Tomi.Engdahl@iki.fi> August 2006

[4] VGA to TV converter, Paulo Sergio Coelho <then@delta hut fi> February 2007

[5] Steve Kitteisen, Info on the three colour TV systems , CCIR Report 624-4 / 1990

[6] Viewing TV video signal on VGA monitor, www howstuffworks .com/vga2tv html

[7] http //www tkk.fi/Misc/Electronics/circuits/vga2tv/converterdriver_tips.html

[8] http://www.tkk.fi/Misc/Electronics/circuits/vga2tv/vga2tv.html

[9] http://www.muia.com/~roberts/vidstd

[10] http://www.ee.surrey.ac.uk/Contrib/WorldTVconversion.html

[11] http //scib.igd.fhg.de/scib/tv/ccir/rep_624/read.html

[12] http://www.epanorama.net/links/videoconnector.html

[13] "VGA." Microsoft® Student 2007 [DVD]. Redmond, WA: Microsoft Corporation, 2006.

[14] The Computer Language Co.Ltd, Computer Desktop Encyclopedia, 2006

MODE OF OPERATION

Connect Adaptor to mains ie: wall socket
nnect VGA connector to VGA port on the CPU
OWER ON THE CPU

ONNECT the 21 pin Scart Connector to the AV Connector
t the back of the TV
une the TV to the AV channel for the Scart Connector
ie - AV1 or AV2 depending on TV make
TV doesn't have 21 pin Connector then use a 21 pin to
2 av pin Connector to connect to TV and follow same
teps 4 & 5.