

Notes on Video Conversion

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Preface

Author and Copyright

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DISCLAIMER

Interconnecting a video source and display device that are not compatible can potentially result in expensive damage to either or both pieces of equipment. While this isn't that likely with just a bit of care, it cannot be ruled out.

We will not be responsible for damage to equipment, your ego, blown parts, county wide power outages, spontaneously generated mini (or larger) black holes, planetary disruptions, or personal injury that may result from the use of this material.

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Introduction

Scope and Purpose of This Document

Questions relating to various aspects of converting one video format (like PC SVGA) to another (like NTSC) are very common.

Most of the articles in this document have been compiled over the last two years based on replies from myself and others to postings on the USENET newsgroups comp.sys.ibm.pc.hardware.video and those of the sci.electronics hierarchy. I apologize if your response is not here - it could have been that I missed the posting and will welcome contributions.

As always, comments, suggestions, and corrections are welcome.

Note: in this document, the terms 'VGA' and 'SVGA' are used somewhat interchangeably. However, strictly speaking:

- VGA refers to the basic original IBM VGA standard of 640 x 480 at 60 Hz.
- SVGA refers to scan rates greater than and including the basic VGA rate.

Commercial Solutions

A number of companies offer adapters to handle many of the problems discussed below. They may advertise in the backs of electronics/hobbyist magazines (many are not exactly large companies!) or turn up with a Web search. Here is one:

- [Gonbes Technology Co., Ltd.](#). They also seem to specifically support conversion to enable many types of industrial manufacturing/automation equipment to use modern video monitors.

I have absolutely no affiliation with this company nor do I have any first hand knowledge of their products.

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TV (NTSC/PAL) to RGB

Watching TV on a VGA/SVGA Monitor

Depending on the monitor, you may need a lot of electronics. VGA uses a 31.47 kHz horizontal scanning frequency - twice NTSC.

1. If it is auto-scan and goes down to 15 kHz horizontal, then you need an NTSC to RGB converter. There are chips from companies like Sony, Signetics, and others that will do this without too much pain.
2. If it will not sync at 15.734 kHz, you will need a real time digital scan converter consisting of a video digitizer and a full frame buffer with suitably fast I/O, For the special case of basic VGA, a subset of this called a line doubler or scan doubler will also work but there are some

problems with this approach. See the section: [What is a Scan Doubler?](#).

For PAL (625/50) the relevant resolution is closer to 800x600.

There are boards for your PC that will take NTSC/PAL and put it into a window.

There are also stand-alone boxes that will allow you to view NTSC/PAL on a VGA computer monitors. One example is the [Z64 V-Box](#). I have no idea how well it performs. However, from the specs, it would appear to have a limited color resolution (only Y:U:V 4:2:2) so while adequate for some games, it may display annoying contours for continuous tone images. And since it only generates a resolution of 640x460, there may be serious artifacts when driving a higher resolution flat panel display.

What you may find in the end is that your \$150 TV gives you a better picture.

(The following from: Stan Rohrer)

For cards as well that take NTSC and put it into a window on your PO:

Check in the PC mail-order catalogs and your local PC parts outlets. There are a number of TV boards and frame grabber boards that do what you want. Prices start (I think) around \$150. Professional level conversion boxes soar above there somewhere.

I've just started investigating such devices. PC Zone (800-258-2088 for orders/catalog) and MicroWarehouse (800-367-7080) carry Computer Eyes and TelevEyes by Digital Vision. Prices here range from \$300 to \$600 with the highest reported to include genlock and overlay capability.

PC Zone has an AITech TV board for \$150. I don't know if it will take NTSC video input or not. One of the guys I work with just bought an (unknown brand) TV board that takes NTSC but he doesn't have it installed yet.

SCART to VGA

This will only be possible without a lot of work if the VGA compatible monitor or video projector can sync at the PAL (or whatever) scan rate. If so, this may be possible with just a special cable. If available, use an oscilloscope to confirm that your equipment produces the relevant signals (not all SCART connectors have all the signals). See the document: [Pinouts for Various Connectors in Real Life\(tm\)](#) for the SCART pinouts.

While VGA usually expects separate H and V sync - it looks like SCART has them only in combined (composite) form but many monitors and video projectors will accept either.

(From: Someone who wishes to remain anonymous.)

I just bought a box that lets me view PAL/NTSC output from a VCR or DVD player on an old (but big) VGA monitor I had spare.

It's called the Gamars V-box. Inside it has a Philips SAA7111 and an Averlogic AL250 IC. Inputs are composite video and S-video, autodetecting PAL or NTSC. Output is VGA.

The quality is great. The only problem is that playing an NTSC disc in my PAL DVD player causes the DVD player to output PAL at 60 Hz. This fools the V-box into engaging NTSC mode, which results in a black and white picture.

The box was inexpensive, about \$40 or so. Cheap importer: [Golden Shop VGA Box Page](#).

(From: Mike Deane.)

I have played with the V-Box unit, and it's pretty good considering it = wasn't really meant for converting monitors into TVs. However, it only = produces 640 x 480 resolution, which is not so great if you were = planning to use a 1024x768 TFT display with it. The screen syncs up OK, = but cannot do a decent job of multiplying up the resolution, so the = result is fairly nasty.

TV to Fixed Frequency Monitor

The hardware needed to watch TV on a typical high resolution fixed frequency monitor would cost more than a nice large TV. In two words, forget it! In addition to decoding the NTSC/PAL to RGB, the scan rates are SO different that the only hope would be to build a full blown scan converter.

TV to MGA

"How hard would it be to make my amber Hercules monitor display the output from my VCR? the VCR has a RCA video output and a coaxial RF output and I want to use the monitor as an orange TV."

This is almost certainly not worth the effort as the monitor accepts TTL (2 bits) and can display at most 4 gray (well, amber) levels without extensive modifications. In addition, the scan rates differ substantially between NTSC or PAL and the Hercules standard. As noted below and elsewhere in this document, a CGA monitor with a composite video input would be a better choice.

(From: Jerry Penner (jpenner@sentex.net).)

You want to connect a Herc Mono TTL monitor to a composite video signal? Can you say 'Big Waste of Time and Effort'? If you want a black and orange or black and green TV screen, connect your RCA video output on your VCR to the input of a composite CGA monitor. These monitors were used on Sanyo MBC computers, and early Apple clones as well as some XT's. Colour composite CGA monitors used to be used on C-64 and Vic-20 computers. Their usefulness as TV/game monitors is legendary, and you'll be lucky to find a used one for under CDN\$80.

TV to CGA

"I have a RGB CGA monitor and would like to use it to display a composite or S-video signal from a VCR. I was wondering if anyone knows how to accomplish this or knows of any economical products that will be able to do this. Any info on S-video pinouts would also be greatly appreciated."

Is it strictly CGA? If so, that is TTL and you can forget about displaying VCR S-video without extensive and not worth-it modifications. Some CGA monitors have composite inputs or analog RGB inputs. With analog RGB inputs, you need an NTSC to RGB converter. These can be built with a single chip and some discrete components. There are probably converter boxes available as well. If it accepts composite, then just use the normal video out from your VCR. S-video won't gain you anything unless the monitor has separate Y and C inputs as well. If all it has is S-video in, then you can combine the Y and C signals with a resistor and capacitor. See the section: [S-Video to Composite](#).

I have a Magnavox CM8762-074T RGB Color Monitor which accepts both CGA TTL and NTSC color composite video inputs. Locating monitors of this type may be an alternative to video format conversion. These may be available for next to nothing as the owners have upgraded and are often

not interested in (or aware of) their present utility. They are often of relatively high quality and display a very nice picture since their original intended resolution is similar to that of NTSC. I use the Magnavox CM8762-074T for testing of VCRs and other baseband video sources.

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PC VGA/SVGA to/from TTL

VGA to TTL (MGA, CGA, EGA)

Both the signal format and scan rates are incompatible. Therefore, simple conversion between analog VGA/SVGA and any of the TTL formats - Mono, CGA, and EGA - is generally not realistically possible.

Some (mostly older high-end) monitors will accept multiple input types like VGA, EGA, and composite. Some examples are: Mitsubishi AUM1371/81, Tatung CM1495, Princeton Ultra-14, and NEC MultiSync. These can select between VGA and EGA input (either a switch or cable) and the Mitsubishi (at least) will also accept composite (NTSC) video.

VGA to CGA1

The following applies with minor changes (scan rates, number of bits) to MGA, CGA, EGA, and most other TTL video signal formats as well.

"I am trying to use an old Sony monitor, (PVM-1342Q), which only accepts a CGA video signal through a 9 pin connector. My output is SVGA via a HD15 pin connector. Any suggestions on pin assignments or existing converters to do the job?"

Assuming the monitor is actually CGA, it is probably not worth it. CGA is TTL and SVGA is analog - you would need a converter and then only end up with CGA's 8 colors or whatever.

The scan rates differ by a significant factor. If you can program your VGA card for the monitor's horizontal scan rate (around 15.734 Hz - similar to NTSC in the case of CGA), then the remaining problem is converting from analog to TTL. This will require some high speed comparators and logic.

VGA to CGA 2

For the general case of desiring to drive a true CGA-TTL monitor from a VGA card, there are three options:

1. Replace the monitor with a VGA monitor.
2. Replace the video card with a CGA card if you can find one.
3. Completely redesign the CGA monitor to accept the VGA scan rate and analog video input. Neither of these is easy or necessarily even possible and the resolution of the CRT may be inadequate in any case.

If the monitor accepts analog RGB, it may be possible to program you VGA card to put out the CGA (15.734 kHz) horizontal scan rate to be compatible with a CGA monitor of this type. Your hardware and software may or may not support this easily or at all.

If it's a true CGA monitor, there simply is no practical way to use it with a VGA card. Period. If it's one of the original multisyncs that happens to work with CGA, then there's some hope. However, these weren't so common: Sony 1302, Mitsubishi AUM1381 or Diamond Scan, plus a few others). In this case, you just need the proper cable and the appropriate switch settings for the monitor.

VGA to CGA 3

"We are trying to upgrade our print servers and have a lot of CGA monitors and a lot of PS2 computers with VGA cards. We don't need more than 2 colors (mono) but when we make an adapter to connect the R to R, G to G, B to B, H to H, V to V, Ground to Ground and the rest NC we don't really get what is wanted.

Well, what happens is that the display is quite acceptable other than the fact that there are two of everything on the screen indicating timing problems. Covering the right side of the screen with a sheet of paper works to cure the problem but a more acceptable solution is needed.

Adjustments to the monitor frequency, width, phase, H-hold, etc. don't help."

This is not surprising as the horizontal scan rates for VGA and CGA differ by about a factor of two. This is much too large change for the monitor to accommodate.

Note that CGA outputs TTL level signals (0 to 3-5V) and VGA outputs analog levels (.7 V p-p). Therefore, what you have done may not work in any case if the monitor expects strictly a TTL input. However, your monitor must be compatible with the VGA levels.

The monitor would have to sync at double its normal scan rate for the picture to properly fill the screen. First, it would be difficult to modify the monitor for such a substantial change in horizontal scan rate. Second, and more importantly, any such change could compromise the safety - stressing the monitor's circuitry - increasing the risk of failure and the possible fire hazard. Therefore, I would not recommend even making the attempt unless you are quite knowledgeable in the design of monitor deflection circuits and power supplies.

One other option other than replacing the video card or the monitor would be to determine if your PC is capable of putting out CGA scan rate video. Many video cards do have this capability not so much for CGA as for NTSC/PAL compatibility. However, some programming or use of special video drivers (software) may be required.

Alternatively, you may be able to find an inexpensive card that would be able to provide the correct timing or even some old CGA cards that no one wants anymore. Also, monochrome video rates are 18.43 kHz. If you can find some MGA cards, you may be able to tweak the monitor that far.

Actually, for your intended application, painting over one half of the screen isn't such a bad idea. :-)

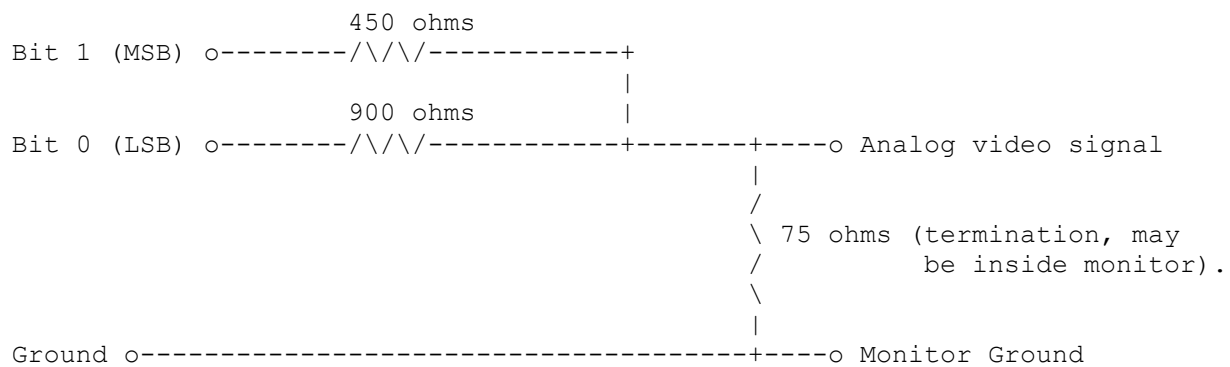
TTL to VGA/Analog

This requires matching the scan rates and implementing a suitable digital to analog converter to take the TTL data and produce analog signals.

A scan converter can be used on the analog signals once they are generated to adapt the video to your monitor. However, I don't know if scan converters with suitable input and/or output capabilities exist.

The digital to analog conversion can be done with a few resistors if you are not terribly fussy about

the quality. For example, the following circuit should be able to generate a reasonable VGA signal from a 2 bit input (e.g., MGA or one of the EGA color channels):



This assumes the H and V sync are separate signals. If this is not the case, these will need to be combined into this signal (at least one of the channels) as well.

I have not tested this circuit. Using low value pullups on the TTL signals (say 220 ohms) should help improve the high level consistency.

CGA to VGA

There are two problems:

- CGA is TTL; VGA is analog. Relatively simple circuitry can deal convert the TTL levels into the .7 or so V signal.
- CGA scan rate is approximately 15.75 kHz; VGA is 31.4 kHz. Therefore, unless the VGA monitor can scan at the lower rate (some early multiscan monitors like the Mitsubishi AUM1371/81/91 can do this), a scan doubler will be needed. See the section: [What is a Scan Doubler?](#).

In general, where only 1 (or a few) of these are needed, locating true CGA monitors at used computer stores or thrift shops is definitely the easier way to go!

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VGA to Analog RGB

Note that in some cases, no actual hardware is needed - the video adapter may be programmed to do what you want either using existing or special driver software or at a low level by directing controlling the video chipset:

(From: Jack Schidt (jack@wintel.net).)

Most questions regarding changing or using VGA signals in non-standard (PC) methods, is answerable only by consulting either:

1. Graphics adapter manufacturer (if known) of the VGA adapter, or integrated motherboard. They may have the information you need.

2. Graphics chip manufacturer. They will have programming information or books you can read to change the device programming. NTSC mode set commands are sometimes on the graphics chip mfg's Website or BBS.

However, this is not always simple!

If you are lucky, you can reach an apps engineer in either case who has knowledge of your requirements, and has the means to supply you a solution. Otherwise, you need to write a short assembly language program to stuff the VGA controller registers with the correct parameters for what you are trying to do.

VGA to Fixed Frequency Monitor (3, 4, or 5 BNC Connectors)

Questions about this specific problem are among the most common as low cost fixed frequency monitors become available when their workstation hosts are decommissioned due to the march of progress.

You will have to obtain the specs to have any idea of whether what you want to do is possible. These are very often high resolution with a typical horizontal scan rate of 64 kHz.

There are several issues:

- Video compatibility - here is the one area where you are likely fine - your monitor is probably compatible with VGA analog video levels - .7 V p-p.
- Scan rate - your horizontal and vertical refresh rate. I would expect that the monitor is not auto-scan and probably not compatible with VGA or SVGA. Please check the specs if you have them or post a message so that someone else can identify it. You need to know its horizontal and vertical scan frequency range.

If it is fixed frequency, you will be able to use it only in your high resolution (probably) applications. Booting the PC will require a normal VGA monitor for the messages to be seen.

Assuming you are willing to use something else to boot and only run at a single resolution, then the last hurdle is sync:

- Sync. You have 5, 4, or 3 BNC (coax) connectors on the back of the monitor.
 - 5 BNC connectors - this means that you likely have separate horizontal and vertical (H and V) sync inputs - just what your VGA card wants. In this case, as far as sync is concerned at least, all you need is a VGA-to-5 BNC cable.
 - 4 BNC connectors - this means that your monitor requires composite sync. The H and V sync signals must be combined into one TTL level signal. Some cards like those from ATI will probably drive it with just a VGA to 4 BNC cable since they can be programmed to generate composite sync with no additional hardware. (Actually, get a VGA to 5 BNC - you just won't use one of the syncs and this may come in handy at a later time).

You need to determine what its expected H and V rates are to see if they fall within the range of the video card. Some internal twiddling may be possible depending on the monitor. Also, the software size adjustment in the ATI Install program also affects rates so that adds another couple of degrees of freedom.

If you need to combine the H and V sync, a TTL gate, single transistor circuit, or sometimes just a couple of resistors will do it.

For example, if you are able to program your video card for negative sync polarity, then an AND gate (which will act as an OR for negative logic) should do it. For positive sync polarity, a NOR gate or NPN transistor will work. It is also possible to build an auto-polarity switching circuit to accommodate any combination of positive and negative sync polarities. In some cases, just using a resistor in series with each sync line will be enough.

- o 3 BNC Connectors - these monitors need what is known as 'sync-on-green'. This will require some circuitry to combine the H+V+video into one signal. The circuitry is quite simple if you are electronically handy. Commercial boxes to do this are also available.

(From: Exar (exar@aol.com).)

For any type of video converters call ALTINEX, INC. in California 714-524-5400 they make a device that will combine sync, separate sync, put it on Green, shift image left or right. Product name is DA1910SX. I have several of them for my PC, MAC SGI and SUN.

See the documents: "Fixed Frequency Monitor FAQ" and "Sync-On-Green PC Video FAQ" for details.

Some monitors have the required circuitry to accept separate sync internally that is not brought out for a particular model. In this case, some careful exploration may reveal hidden treasures.

So, check your scan rate. If that is not compatible, then you will need a new display board anyway. If it is compatible, then you will just need the sync combiner. Then there is the problem of booting DOS or Windows - these usually want 640x400 at boot.

There are video cards designed for just this purpose. Whether the investment is worth it compared with a new PC compatible monitor is questionable IMO.

See the document: [Notes on Approaches to Using Fixed Frequency Monitors on PCs](#) for additional information and names of companies who manufacture the special video adapters.

VGA to Apple RGB

"Is there any way to modify an Apple 12-inch RGB color monitor so that it can display 640x480 (instead of 512x384)?

Has anyone ever managed to do this? Any opinions on whether or not it is possible?"

I assume you want VGA resolution - 31.4 kHz horizontal.

This would require changing the horizontal scan rate by a large amount and is unlikely to be easily accomplished without extensive modifications to the monitor's circuitry. This should not even be attempted unless you are knowledgeable in the design of monitor deflection circuits and power supplies.

For other Apple (MacIntosh) monitors, see the section: [VGA to Fixed Frequency Monitor \(3, 4, or 5 BNC Connectors\)](#) as most of these run at a fixed frequency. For example, the Mac II rate is 35.0 kHz

H and 66.67 Hz V.

VGA to Mac (Monitor) Conversion

I have no idea of what this gadget actually does but it may be worth checking out:

(From: James Willcox (jwillcox@spitfire.net).)

Boca makes an adapter. I have one and it works fine. It has little switches on it to select resolution and refresh rate.

VGA to Sun/Sony GDM1960

(From: Flupke ut Warns (P.O.Langemeijer@student.utwente.nl).)

The most important thing is to get the sync pin(s) connected and the horizontal scan rate as close to the required value.

(From Paul Langemeijer).

If you have a GDM-1960, you can make an even easier modification to the monitor. A thing I might add to the problem of the sync-on-green, is the 'modifying' of your monitor. Well actually it isn't that hard. If you remove some of the panels (the one near the connectors with the monitor turned off!), I found holes for two more BNC connectors. You can put them in, attach a bridge and put in two resistors (the holes for these are obvious, the numbers are above them). And you've got a 5-BNC monitor (and it works). You should use 75 Ohm resistors and the monitor syncs perfectly at 1024*768 at 85 Hz (Standard VESA videomode).

(From: Pascal Specht (specht@roguewave.fr).)

I'm now running the GDM-1960 from my DECstation 5000 on my PC.

I found an even easier way (if you can live without the three VIDEO OUT BNC's). Simply reuse two of them for H and V-sync - No resistors, no holes to bore. This applies to my Digital GDM-1960 D3. Simply follow up the cables going from these 'video out' BNC's and take them off at the other end. Put these ends now into the obvious holes for the two predesigned places intended to take in the missing BNC connectors. Add the bridge to make the HSync connected. That's it. It perfectly works on my nVidia RIVA 128 with 1024x768 at 85 Hz, but also 1280x1024 at 60 Hz.

VGA to Amiga 1024

From: jcaldwel@iquest.net (Mr. Caldwell)

It is a CGA frequency only monitor. It has an 8 pin analog jack on the back and may have a 5 pin ttl jack and ttl to analog converter inside for standard CGA, you can use a cable for the analog plug to a 9 pin d plug for MCGA and get 320 x 200 by 16 Million colors. Some IBM cards will put out the correct frequency and analog signal, most won't. I used an ATI Wonder VGA card that would work correctly *if* manually configured.

Otherwise you need a VGA to NTSC converter. See the section: [VGA to TV - NTSC or PAL](#) for more information.

VGA to SCART

SCART is basically an analog RGB + composite sync interface found mostly on PAL (and maybe other European standard) TVs but rarely on TVs in the U.S.

Signal conversion from VGA to SCART is straightforward - just a matter of generating composite sync and making the proper cable. However, it has the same problems as the others with respect scan rates unless you are running an O/S like Linux or an X-server - for the latter case, see: [X on TV](#).

Notes on VGA to RGB Conversion

See the document: [Approaches to Using Fixed Frequency Monitors on PCs](#) for an adapter using a programmable logic device to implement conversion from separate H and V sync to sync-on-green. Or, here is a solution using discrete logic:

(From: Jon Jenkins (jenkinsj@ozy.dec.com).)

I use standard 74HC DIP gates available from any electronics store. I use a 14 pin DIP socket originally so that I could change gate types (OR/XOR/AND) easily. 74HC86 (XOR) works just great with the VR320 (I am using it now can also use OR, don't understand why ??).

The VN10KM is a small signal N channel enhancement mode MOSFET also available from most electronics store.

If the video card you are using is a standard VGA output (I'm using a diamond stealth 64 VRAM):

- Pin 1: Red video
- Pin 2: Green video
- Pin 3: Blue video
- Pin 4: Monitor ID bit 2
- Pin 5: Ground
- Pin 6: Red return
- Pin 7: Green return
- Pin 8: Blue return
- Pin 9: NC
- Pin 10: Sync return
- Pin 11: Monitor ID bit 0
- Pin 12: Monitor Id bit 1
- Pin 13: H sync
- Pin 14: V sync
- Pin 15: NC

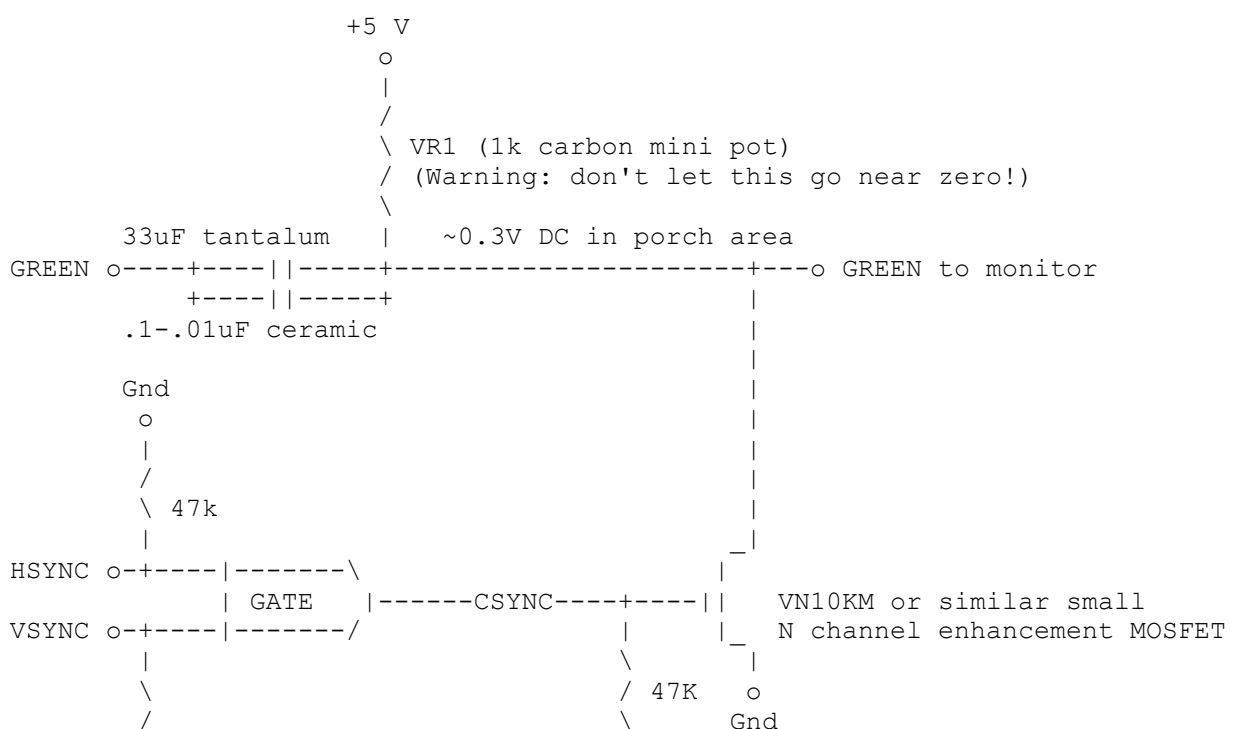
I join all the "returns" together with the ground on the small PCB and use that as a common ground for the RGB cable to the monitor. You can use separate if you want to but you should join the green return and sync returns together. I did find some small shadowing if I didn't group them all together.

Just a note, when you set up your video card in Windows (or Win95) set it to 1280x1024x72|66 or whatever is closest. I use a VR260 (1024x864) at 1027x768@66Hz (check with your manual DA or D4 are 72Hz) your VGA will not like this frequency so either disconnect it quickly or before you actually set the video card to this mode (i.e. put the OK as the active control in Windows and then connect the VR320 and hit return) My diamond setup gives me 10 seconds to do this adjustment When you exit you will probably have to select the 1280x1024 mode with your old VGA connected again and from then on every time you start Windows you will be able to view it in "big" colour mode. Note the vr320 will not work in DOS mode as it is not an auto-scan monitor so all you see when you boot up is garbage until Windows starts, I put "win" in my autoexec.bat file.

For FreeBSD/XF86 the lines are:

The circuit to do this is as follows:

1. You may be dealing with 135MHz square waves so there are lots of high frequency stuff around; use good RF practices.
2. The coupling capacitors are a safeguard to start with. I don't use them because they caused shadowing around sharp colour changes (the old RC effect).
3. Use the XOR gate first as a test but you may need other gates to actually get it working.
4. An oscilloscope will be handy for final adjustment.
5. Make the device is as close as possible to the video outlet on the VGA card.
6. Take the 5V from the PC power supply inside the box. I just hooked one of the spare connectors which I also use for an external fan (Pentiums being the heaters they are!). Make sure (check it again!!) (and again!!!) you don't get the 12V one!!
7. You must use a VN10KM or other small signal N-channel enhancement mode MOSFET. Others will not work!!





HSYNC, VSYNC and CSYNC are grounded with 47k carbon resistors

Gate type=LS or HC types, HC preferred:

- OR: for -ve logic sync and no hsync during vsync.
- NAND: for +ve logic sync and no hsync during vsync.
- XOR: for -ve or +ve logic sync and hsync during vsync.

Capacitors are optional, I don't use them.

Use XOR gate with DEC monitors and as a first shot with others, then OR gate then NAND gate.

Get an oscilloscope and adjust porch levels to 0.3V and 0 level (sync level) to 0.0V

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VGA to TV - NTSC or PAL

"I am interested in converting a signal from my video card to a signal that can be taken into the video in on my vcr. I realize that it is not going to be easy. Still I would appreciate how to do it."

You are correct - this is not easy.

1. You need to convert RGB to NTSC or PAL - there are single chips for this. Try Sony, Philips, Motorola, and others. These will combine the R, G, B, Hsync, and Vsync into a single composite video signal using a minimum of additional components. The same part can usually do either NTSC or PAL by changing a jumper and possibly some of the external components.

For example:

(From: Brian B

"In the July 1996 issue of Electronics Now, a MC1377P (Motorola) is used to convert RGB to NTSC/PAL. The chip can be purchased through the Newark catalog. This chip is very easy to use and should make your circuit simple." (See the wiring instructions, below. --- sam.)

Some other possibilities may be: ADV7175/ADV7176, UPC1352 (ECG/NTE1416).

(From: Quick Fix (iradg@guru.nu).)

"The MC1377 is a 20 pin all-in-one chip. Connect the following: +12 VDC to pin 14 and ground to pin 15, composite sync to pin 2, RGB to pins 3, 4, and 5, respectively. Put a 3.58 MHz xtal between pins 17 and 18. Optional Y delay pin 6

to 8. Video output at pin 9. I have made and sold many of these.

2. You need to match the horizontal scan rate to NTSC (15.734 kHz) or PAL (15.625 kHz). Even basic VGA is roughly twice this - 31.4 kHz. If your video card can be programmed to put out interlaced NTSC or PAL rate video then this is easy. If not, it is more difficult. If you want to use any higher resolution than basic VGA (640x480) for a 60 Hz system or 800x600 for a 50 Hz system, it is a very non-trivial problem requiring a scan converter which includes a video A-D, full frame store, interpolator, readout timing, and video D-A. Unless you are an experienced digital and analog designer, you really really do not want to tackle this.

For the special case of VGA to NTSC or PAL, you may be able to get away with something less than a full blown scan converter. See the section: [What is a Scan Divider?](#)

You can also buy little boxes to do this. Quality is general not great as you are seriously limited by the NTSC/PAL standards. Even with S-video inputs to a TV or and S-VHS VCR played on a high-end TV, don't expect to be able to throw away your computer monitor!

Here's one link to check:

- [RAM Electronics Industries, Inc. SVGA to Video Adapter](#)

I have no idea of whether this devices works as advertised.

(From: Tomi Holger Engdahl.)

There is all sorts of information relevant to video at:

- [Epanorama Video Links](#)

There is collection of links to RGB to NTSC/PAL converter and other video chips at:

- [Epanorama Video Chips](#)

For more detail on this, check my circuit and related software at

- [VGA to TV Converter](#)

Probably the most complete VGA to TV conversion pages in the web can be found at:

- [Epanorama Video Conversion Links](#)

There you can find schematics, drivers, tips, ideas, documents, links to commercial products and much more. It does not have everything you need but it is a good start. Going to composite video or RF is more complicated as there are three composite video standard NTSC, PAL and SECAM in use in the world and there are also some small differences in modifications of those used in different countries) which is the reason why there are not much of this kind of project. VGA to TV conversion is not simple technology either (the circuit can be simple but there are quite many things to consider when designing such circuit).

Homebuilt circuit persons should take a look at:

"<http://www.epanorama.net/links/videocircuits.html#converters>">Epanorama Video Conversion Links

There you can find my design of VGA to TV converter which outputs RGBS signals suitable for TV SCART RGB input (I have also designed one with composite video output, but that's for a commercial application). At the same page you can find a PAL composite video output version of the circuit designed by Paulo Coelho.

For introduction to scan conversion, check

- <http://www.extron.com/>

Specifically:

- [Scan Conversion: Making the Video Connection](#)

Flickering is a problems always when yu do graphics to TV systems. The graphics material must be designed so that flicker is not noticeable or the scan converter box must include some kind of filtering to do the job.

NTSC/PAL system limit the bandwidth which makes picture to loose some details. The picture is usually even worse than that, because of the cheap video encoding chips used in many converters.

(From: Bill Sloman (sloman@sci.kun.nl).)

Try the Analog Devices AD721 and AD722. When I used the AD720, I had to add a National Semiconductor LM1881 sync separator, and black-level clamps on the red, green and blue inputs to get the right DC levels.

Check them out at [Analog Devices](#).

(From: Leon Heller (leon@lfheller.demon.co.uk).)

Raytheon has a chip which produces broadcast quality PAL/NTSC from VGA. I think that Harris does one, as well.

VGA to TV Converter Boxes, Adapters, and Boards

(From: Kevin Centanni (kpc@panix.com).)

There are a couple of VGA-to-TV converter boxes that also output an NTSC RGB signal. I own one from UMAX - I think it's called the TV-Mini. I bought it from Global Computer Supplies for about \$175. I also think that MicroWarehouse sells this product. There's a model sold by AVer also that has RGB out... but it's over \$300.

The UMAX TV-Mini is a small box that plugs into your VGA card... it also has a female VGA connector on it so you can display images on your computer monitor and television monitor at the same time. The TV-Mini is powered by the PC's keyboard connector. It has an RCA jack for composite NTSC, an S-Video jack for S-video output and a Mini-8-DIN for RGB output... if you go to UMAX's web page, they'll talk about how the TV-Mini comes with an RGB SCART cable (SCART is a strange looking connector that's used on many European televisions) - but it doesn't come with this cable.

I was able to build a small adapter cable with some parts from Digi-Key. The TV-Mini manual provides the Mini-9-DIN pinouts.

(From: Jerry G. (jerryg@total.net).)

I have played around with a few. The ones in the upper \$300 to \$400 are not too bad. You will get a reasonable picture. I found the cheap ones are extremely poor.

The best way to do it is with a video display card that has it built in. These cards are expensive because the scan rate must be changed. There is a lot of high speed ram and processing involved to do it right.

It is not a question of movement involved. It is a question of scan rate conversion that makes things complex. With this conversion there is the requirement of some complex quantizing to also convert the characters to match as well. In a lower priced card that I have seen good results is the ATI card with the NTSC output. I don't know the price of the card, but it is not cheap...! There is a Targa card that is excellent, but the price is too high unless you are in the business... But like I said, the higher the price, I found the pictures get better.

Also, the bandwidth for the fonts, and data coming through the conversion is extremely wide. It is wider than off of a conventional TV broadcast, or what comes out of a VCR. The TV set that you use must have a Video Component input, and be able to handle at least 600 lines resolution or better. If not, you will be cutting the performance of the signal right at the end! If your TV has S-Video capability, get the card with that option. It is better than using encoded NTSC or PAL. The S-Video mode keeps the color information separate for processing. This allows for a better signal to noise in the luminance signal, thus rendering cleaner pictures.

Please note, that you will never get the same picture out of a TV video monitor as your computer monitor. They are based on very different processing and CRT design. There are VGA Monitor projectors on the market, and I would consider renting one for the casual use. It will certainly do a much better job. This is what I recommend and do for my clients. Don't even think about buying such a projector unless you have a lot of use for it. They are extremely expensive, and require periodic maintenance.

(From: E. Abel (EugeneA1@worldnet.att.net).)

I've used an ATI 3D Expression+ PC2TV. The S-Video output is not bad, although text is really not very crisp.

Surprisingly, the TV output from the Canopus Pure 3D card is much better. Text is actually readable. (this is on a 27" Sony trinitron TV.) The Canopus card uses a Chromtel chip to do the conversion.

Of course, at \$190 the card is a little pricy.

VGA to NTSC/PAL Chips

"I am trying to build a circuit to convert the RGB output of a video game to my large screen TV."

(From: Leon Heller (Leon@lfheller.demon.co.uk).)

If the game outputs VGA, Raytheon has a chip, the TMC2360, which converts it to broadcast quality PAL/NTSC video.

Another IC that does most of the required functions is the [Analog Devices](#) AD725 "RGB to NTSC/PAL Encoder".

(From: a-freak@freenet.de.)

A very nice IC is the TDA8501 which converts RGB or YUV to Y/C and FBAS signals, needs very few external parts and can be switched between NTSC and PAL with a single jumper. See [TDA8501 Datasheet](#) for more details.

Together with a sync processor like the TDA2579 and a colour decoder like the TDA4650 it gives a very simple color standard converter. Also the fast input switch allows one to build a very simple video genlock for home computers.

Questions and Answers on VGA to NTSC Considerations

This dialog resulted from the desire to construct a VGA to NTSC converter to output PC video to a TV or VCR.

"I managed to construct a VGA to RGB converter so far, so I'm almost halfway there, all I believe I need now is an RGB to NTSC converter circuit, although I was trying to avoid the cost of buying one they sell in the PC catalogs."

Can you program your video card to output 15,734 Hz H interlaced scan? If so, you will have a lot less hassle.

"I figure the odds are in my favor by creating one myself, and as far as I know, no harm could come to my computer by attempting it since the VGA/RGB is an output only and not an I/O. Now since I already managed to convert my VGA to RGB, hopefully you might be able to answer some specific questions for me?"

"Is there a minimum & maximum resolution for a TV, or does that depend on the size of the TV?"

If you mean resolvable spots on the TV screen, realistically, it is about half VGA horizontally and perhaps a little more than half vertically or about 320x300 give or take.

If you mean scan lines, that is pretty much fixed at 525 total interlaced 2:1 at 60/30 Hz (625 at 50/25 Hz for PAL 50 Hz systems) with about 420 (540) actually visible on a typical TV. TVs are not auto-scan - they are designed to run at a single scan rate.

Therefore, even displaying easily viewable VGA resolution will be tough. A TV with an S-video input may do somewhat better.

(Remember when you had at most 40 characters across on a Commodore?)

"Assuming the construction of this circuit would only allow a maximum output from my VGA card, what resolution would that be? 640x480 or 800x600? (I have no expectations of anything higher)"

As noted, for a regular TV, you can send it 640x480 but it will be somewhat fussy. 800x600 is really out of the question. A high quality TV-monitor might do VGA ok. The actual number of lines on a TV is, of course, only about 480 active with perhaps only 420 visible due to the CRT bezel. Unlike an auto-scan monitor, you don't get easy control of this and no control of the number of lines.

"Finally, taking into consideration the limitations of such a device, I only intend for this to be used for full motion video playback, as my current video capture card, as well as all other cards currently on the market, lack the ability to output the video back to the original source (i.e. a VCR or camcorder)."

Unfortunately, even expensive solutions are still limited by NTSC. However, since your playback is often at reduced resolution (e.g., MPEG) to begin with, this may be acceptable.

(From: FoulDragon (fouldragon@aol.com).)

I'll warn you: You can get a box that will make your PC display on a TV, but it will not be worth your while. We use them at our school, they cost from US \$100 and up, and the picture, even on a good TV is very poor. If you can afford one of those boxes, buy a used VGA [even monochrome] and use that as you will be much happier.

(From: Terry Lin (tlin@servtech.com).)

I find that with the ATI PC2TV, on a S-Video hookup on a Sony XBR, the image quality is pretty decent. The flicker removal makes even a full white screen easy to look at (provided you have the contrast turned down, which should be done on every set). I have seen what poor external boxes can do, they give me adaches with the flicker and blurriness. Just make sure your setup is right before evaluating the entire PC to TV monitor thing.

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VGA to Composite Video

Realize that no matter what you do, the quality you get on the TV/VCR is not going to be anywhere near what you see on the computer screen. You must keep this in mind when designing layouts, selecting text fonts and font sizes, etc. The new video cards with on-board NTSC/PAL output should be better than your average cheap converter but don't expect miracles.

"I need a bit of advice on converting VGA or SVGA to output suitable for a color composite monitor and/or a regular NTSC standard television. I have seen add on cards or outboard boxes that will convert VGA to standard TV but I am not sure if this will have the same effect on a Color Composite Monitor. You see I am wondering if it would be more cost effective to keep my old Apple Color Composite Monitor and buy the necessary hardware to convert VGA output from my IBM clone or to just go ahead and buy a bottom end 14" VGA monitor? Can I even get true 24 bit 800 x 600 color performance out of a TV or a color composite monitor?"

A color composite monitor may be somewhat better than a good TV but it is still limited by the NTSC standard - mainly horizontal resolution but color rendition as well. There is no way to get even basic VGA performance (640 x 480) from a TV or composite monitor.

You are much better off getting a bottom-end SVGA monitor for your PC. As noted, the resolution of a TV or composite monitor is not even good enough to do justice to VGA (640x480) when using the composite video input. Direct RGB can be better but the pitch of the CRT relatively coarse dot or slot mask or aperture grill is then likely to be the limiting factor. A composite monitor or TV will give you approximately 480-490 lines vertically but 10 to 15 percent of these may be hidden by the CRT bezel due to overscan. However, horizontal resolution is much worse. You will be lucky to get half the VGA resolution (300 to 350 lines). For SVGA, there is simply no way to display 800 x 600 without expensive scan conversion on such a tube and you will not be able to read text or display clear graphics. In addition, since the composite monitor or TV is interlaced, there will be annoying flicker of graphics with thin horizontal lines.

Save your pennies - prices for basic monitors are dropping. Your Apple monitor may work fine on

your VCR, however.

(From: Jerry Roush (roush_jerry@htc.honeywell.com).)

There is an "inexpensive" device available from JDR Microdevices that works fairly well, called the AVerKey (JDR part no. VGA-NTSC) They are about \$100. It also has S-video output.

VGA to Grayscale Composite Monitor

This will only work if you can program the video card to produce a compatible resolution and scan rate.

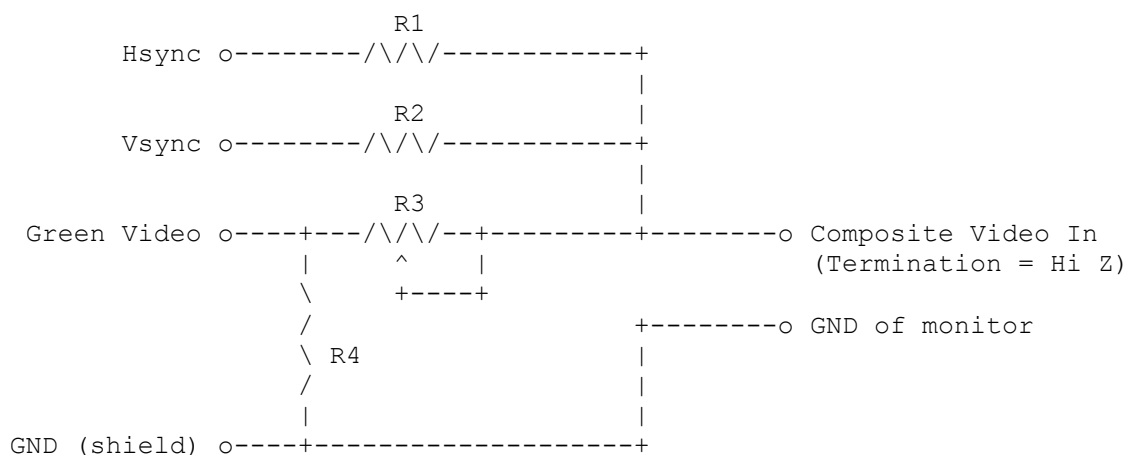
If you would like to experiment, here is a really simple circuit that may work well enough for combining Hsync, Vsync, and one of the VGA color signals, say green, into a composite video.

If the monitor sense lines on the VGA connector are tied MS1 (pin 12) = GND, MS0 (pin 11) = no connect, then some programs will default to monochrome and use a reasonable color map. I don't know how you will get a reasonable mapping to monochrome for the others.

All you will need are 4 resistors.

I am calling your connector on the monitor 'Composite Video In'.

- Hsync through 500-1K ohm (R1) to Composite Video In.
- Vsync through 500-1K ohm (R2) to Composite Video In.
- Green Video through 200 ohm (R3 - variable) to Composite Video In.
- Green Video side of R3 to Ground through an 82 ohm (R4) resistor.
- Tie this ground to the BNC or RCA connector ground.



It is essential that all this be built as close to the monitor as possible for best signal quality.

Set monitor video termination for Hi-Z. R4 provides the cable termination to minimize reflections and ghosting of the green video signal.

Set your video card for negative sync polarity.

You may need to tweak these values for best results. This will depend on your actual signals. The variable R3 may provide enough range for this.

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TV or Composite Video to RGB (Analog or Digital)

NTSC to CGA

"Does anyone know how to convert a video out signal into a signal usable by a CGA monitor (RGB + H and V sync)?"

If your CGA monitor is TTL, then it may not be possible, at least not without modifications to the monitor. You need to convert from NTSC to RGB. There are single chips (with a few external components) solutions to this. Try Sony, Philips/Signetics, and Analog Devices (I think) as well as others. These take NTSC (or PAL) and output RGB and sync. CGA is not analog (continuous range of video values). It is TTL with Red, Green, and Blue signals as well as a separate Intensity signal. Unless your CGA monitor can take analog video (.7 V p-p) inputs, you will still only be able to get 8 or 16 colors - not a normal TV picture. (And even for that, you will need external circuitry to convert the analog output of the decoder chip to TTL.)

However, some CGA monitors have internal NTSC composite inputs and in that case, it is simply a matter of flipping the appropriate switch.

Composite Video (NTSC/PAL) to RGB

Several companies provide single ship solutions requiring only the addition of a few discrete components to convert NTSC or PAL to RGB and H+V or C sync. Some have options for YIQ, S-Video, and other formats at the input or output in as well.

See: Epanorama Video chips and circuits page:

- [Epanorama Video Chips](#)

for an extensive list of video encoder, decoder, sync, and other chips with links to their datasheets. Also, check out the web sites or databooks of Sony, Philips, Brooktree, Motorola, Linear Technology, etc.

One example is the Motorola MC44011. (However, it would appear to not be a currently available part as of Summer, 2001, as I could not find it on either the Motorola or On-Semi Web sites).

This part can be used without an external delay line (for PAL to RGB) but a delay is recommended. The chip also provides an A/D sampling clock output for video digitizing applications.

(From: Julie Porter (Julie.Porter@efi.com).)

I was able to get my Sony PVM Monitor to successfully take a YC input on the RGB port. I used the MC44011 and it worked! However be advised. The MC44011 has just been announced for last buy this month! March of 1999. There are no other non digital solutions. The TDA3330 has been unavailable for some time. There is some additional information on my [Video Animation](#) Web site. I urge people to call Motorola and ask that this component, not be discontinued as there are many web references designs that use it. There are no substitutes. It should also be noted that if people are considering these designs then they should get the parts soon. The part will go out of production this fall (1999).

(From: Jeremy Todd (bulb@cix.compulink.co.uk).)

Sony makes at least two PAL decoder chips - CXA1621S and V7021.

It looks like you'd need a separate sync stripper (LM1881 or EL4581CN)

Brooktree's Bt812KHF is a much fancier thing for video processing and multimedia stuff.

From RS(UK) both the Sony chips are 10UKP each for 1 off's. The Bt812KHF is 107UKP!!

(From: Sam).

Also, some questions are along the lines of the following:

"I looked at several chip manufacturers. Most have extensive documentation on their chips in PDF format. Again, most of the chips currently available convert Y/C to digital RGB, and have a lot of extra brightness/sharpness control built in. Too complex- the simplest chip I came across was 18 pins and still required two dozen external components."

(From: Eugene (eugenek@istar.ca).)

The answer is: MC44011 by Motorola, cost \$28(Can). It requires some sort of a micro to program it (PIC or the like will do).

There is no external critical components except for a 14.318MHz crystal (found on any PC motherboard).

About the old TV single-chip decoders. This is not true, I've been working with those things for 15 years, and in 70-80s the decoders were much more complicated than they are now (each decoder, actually, requires a delay line (sometimes more than one) and a bunch of various filters). Yes, you had one chip and half a dozen of coils, trim-caps to tune (that required some equipment and knowledge).

Sorry, the chip I suggest has 44pins :-(but little hassle :-)

Watching TV on a PC Monitor - NTSC/PAL to VGA

Questions are along the lines of the following:

"I'm wondering whether I could use my NEC Multisync as a TV. Long ago I had a Mitsubishi Colour Monitor which could also be directly connected to the videorecorder. Sure, I could use cards in my PC like "WIN/TV", but then every time I want to look TV I have to switch on the PC as well.

Is there the possibility to convert a video to a VGA signal? My NEC has only a VGA input. Or: Are there any monitors available which have both inputs (like my old Mitsubishi)?"

"I have a VGA monitor That I want to use to watch TV. I want to be able to maybe build a box that will let me plug a vcr video out into the monitor. I do not want to spend tons of \$\$\$\$\$. Can anyone tell me if there is a way to do this??"

"I have a HI-FI VHS that is attached to my stereo. Therefore, my audio needs are well

taken care of. I now need the video. I had to sell my TV a little while ago so I do not have a T.V. at this point. I have recently acquired a 20" monitor for my PC (DFI brand.) It has the RGB (red-green-blue) connectors on the back along with a Horizontal and Vertical cable connections. So I have a cable that plugs into my video board on my PC that turns into 5 connectors at the end that connects to the monitor."

"Does anyone have any information on viewing composite video on SVGA type monitors. I have a MAGNAVOX SVGA monitor and if possible I'd like to feed composite video from my VCR and Sony PSX and PANASONIC 3D0 to it. Rather than getting a Toshiba TIMM monitor there has to be some kind of blackbox that will allow someone to do this...Please send info to the address provided or post here."

It depends on your monitor:

1. The monitor needs to support the NTSC scan rate - 15,734 H, 60 V. Some NECs do (like the 3D) but others do not (like the 2A).
2. You need to convert NTSC to RGB. There are boxes on the market for this or if you are handy with electronics, single chips to do this. Check out Sony, Philips, Analog Devices, Motorola, and others for NTSC/PAL to RGB decoder chips.

For PAL (625/50) the relevant resolution is closer to 800x600.

If your PC monitor scans down to 15.734 kHz, then all you need to do is convert the line level NTSC composite to RGB and sync. Some older auto-scan monitors like the Mitsubishi AUM1381 even have a composite NTSC input jack. Conversion requires a single chip and a few discrete components. Commercial converter boxes are also available.

However, if it is a modern SVGA/auto-scan that does not go below 31.4 kHz, then it is a non-trivial problem requiring a video A/D, frame memory, readout electronics, video D/A, etc. This is called a scan converter and is not an afternoon project even for an experienced design engineer.

You can of course buy PC cards that will enable you to watch TV in a window on you PC.

There are also external boxes that will accept antenna/cable or NTSC/PAL composite input and drive a VGA monitor. One such unit is the 'Proview' (Proview Technology, Garden Grove, CA). This is reviewed in Popular Electronics, June, 1997. It appears to be quite capable with its own internal 181 channel tuner and IR remote control. It accepts both RF (antenna or cable) and composite inputs and can select between the video source or computer to drive the monitor (but does no processing of the computer's VGA signal - full screen only). With a suggested list price of \$119, the Proview could represent a cost effective alternative to a new TV if you have a VGA monitor sitting around collecting dust.

Another one can be found at:

- [AVerMedia](#)

(I have no personal experience with any of the above products --- sam).

In any case, a \$150 TV may actually produce a better picture. This is because the CRT/electronics in a computer monitor is optimized for focus at the expense of brightness. Therefore, sharpness may actually be excessive and brightness may be inadequate except under subdued lighting conditions (especially on a well worn monitor!).

(From: Helmut Weber (Helmut.Weber@hamburg.sc.philips.com).)

There are some companies that have boards ready, which you only have to buy and plug into your PC. Try:

- <http://www.miro.com>

(From someone else. --- sam).

"I want to display output of VCR on my computer monitor. Is there a video card that has Video In (such as RCA in)? Would you tell me which video cards they are? Or does anyone know any other way to display VCR out on a computer monitor? Or Is there a PC monitor exist that has RCA input jacks?"

(From: Todd McCormick (todd@galstar.com).)

There are lots of video cards that have video capture and real time display from RCA phono and S-Video inputs, Matrox Rainbow Runner (which requires a Matrox Millenium/Mystique 220/G200) or the upcoming Marvel, the ATI All-In-Wonder and it's decedents.....

There are several other cards that fill this bill. There are external devices that attach to your parallel ports, or USB port, or Firewire port which can also do this. Some of the older Diamond monitors also had video input as well as a computer input but they were quite expensive.

Comments on TV to VGA/SVGA Conversion

You need a lot more than cables. Here are some comments:

1. Your SVGA monitor must be able to sync down to 15,735 Hz Horizontal - the NTSC scan rate - this is CGA speed and few modern monitors go this low. You thus need a scan converter - not cheap.
2. You need to convert the composite video or S-video out from your VCR into separate RGB and possibly H and V sync. This means electronics not just wires.
3. You will need a good switchbox to select between the sources, you cannot just hook them together.
4. The quality of the TV video on your expensive SVGA monitor will likely be worse than on a \$150 TV due to the fine focus of the monitor and the possibly lower brightness. To put it simply, the monitor is too good for NTSC video.
5. Why tie up your computer system watching TV? The other alternative is to get one of those TV tuner and/or frame grabber cards for the PC.

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Video Standards Conversion

NTSC to PAL

"Does anyone know of a simple way to convert NTSC signals produced by American video equipment to UK PAL signals."

If you simply mean the color conversion, then a couple of chips will do it.

There are chips to do RGB to NTSC or PAL color encoding but not, as far as I know, scan conversion. For your needs, look into Sony, Philips, and Analog Devices, Motorola, and others.

See: Epanorama Video chips and circuits page:

- [Epanorama Video Chips](#)

for an extensive list of video encoder, decoder, sync, and other chips with links to their datasheets.

As has been pointed out, using the strict definition of NTSC to PAL as referring only to the color encoding, all you need is a couple of chips for NTSC to RGB and then RGB to PAL, maybe even a single chip. However, for the very common interpretation of NTSC to PAL (IMHO, maybe a little USA-biased) is with respect to US NTSC 525 line 60 Hz systems to PAL 625 50 Hz systems which is where the non-trivial part comes in.

If what you really mean is NTSC 525/60 Hz to PAL 625/50 Hz, it's not trivial.

- The horizontal and vertical scan rates differ 15734 vs. 15625.
- The number of lines/frame differ 525 vs. 625.
- The color encoding differs.

If you simply want to watch an NTSC tape on a PAL TV it may work but not with proper color if the vertical has a wide enough range to sync or you have a vertical hold control with enough range. If your intent is to put it into a VCR, you can safely forget it.

The usual way is to use a scan converter. Essentially, an NTSC color decoder/A-D feeds a frame buffer (approximately VGA size). The frame buffer is then read out at PAL rates and the necessary interpolation is performed using digital processing to go from 525 (480 or so active) to 625 (580 or so active) lines. The output is sent to a video DAC and then color encoded for the PAL system. Everything all happens in real-time.

Needless to say, this is not your basic hobbiest afternoon project.

Here are some additional comments:

(From: Clive Tobin (tobin@nwus.com).)

Conversion is not a trivial matter, involving interpolating scanning lines, changing the field rate, and changing the color encoding scheme. I am not aware of a simple chip set that will do it. There are several ways of doing it with bought equipment, listed in order of increasing price:

1. If you can stand to look at it on your computer instead of your TV, you can buy TV tuner cards with video input jacks, that will display NTSC on your VGA computer screen. I think I have seen these for around \$100.
2. Buy a multistandard TV, which are becoming increasingly popular and don't cost much more than single-standard ones. You would not need an NTSC tuner if it has a video input jack. (I don't know if your camera has an RF modulator as well as a video output.)