DRAWING BOARD

Video scrambling.

ROBERT GROSSBLATT

Looking at a line of video on an oscilloscope or waveform monitor can be a real eye pener. As we discuss the various ictors involved in video scramling, you'll need a good undertanding of video to follow along. ou'll also need some equipment to iew the waveform, other than on a V set. For a good background on ideo, get your hands on the series f Drawing Board columns I did on ideo from January to November 990. You'll probably be able to find hem in your library if you don't have he back issues.

The starting point for any wouldpe unscrambler (hereinafter reerred to as "us") is that scramblers hereinafter referred to as "them") start out with a signal that's exactly the one we want to wind up with. Video originates in the clear, gets messed up one way or another by them, and is sent to us. Our job is simply to undo what they've spent a lot of money doing.

You don't have to be a rocket scientist to mess up video—that is true both aesthetically and scientifically. The hard part is to do it in such a way that you can put it back together again. This means that there has to be a rigorous approach—almost a mathematical one—to tearing the signal apart.

Take a look at—and get intimately familiar with—the typical line of video shown in Fig. 1. While most of the time on the line is devoted to the picture area, it's the control area where the real work is done. The signal in the picture area determines what you'll be seeing on the screen but the stuff in the control area is what tells your TV where to put the picture and how it's supposed to appear.

The control area is blown up in Fig. 2, and the information in it is a graphed function of time and voltage. By the way, most video people like to talk about "units of video" rather than voltage for the same reason that audio people like to talk about decibels rather than voltage.

When the NTSC video standard was established, the two most basic decisions made were that it would range from 0 to 1 volt peak-to-peak, and that one voltage range would be reserved for picture and one would be reserved for control. As we go through our discussion on scrambled video, I'll talk sometimes about video in terms of IRE units and other times about voltage. The two are directly related as shown on the Y axis of Fig. 2.

The bottom line of the picture is 0 IRE units which is about 0.3 volts up the IRE scale. That point is important because it's both the defined level for black video (no picture on the screen) and the upper limit for any control signals. (There's a slight ambiguity here when you examine the colorburst but we'll get to that later.) For the moment, we can consider everything above 0.3 volts as picture and everything below that as non-picture.

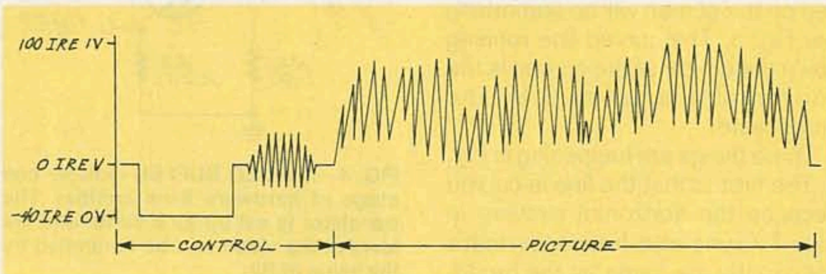

FIG. 1—TYPICAL LINE OF VIDEO. Most of the line is devoted to the picture area, but it's the control area that we're interested in.

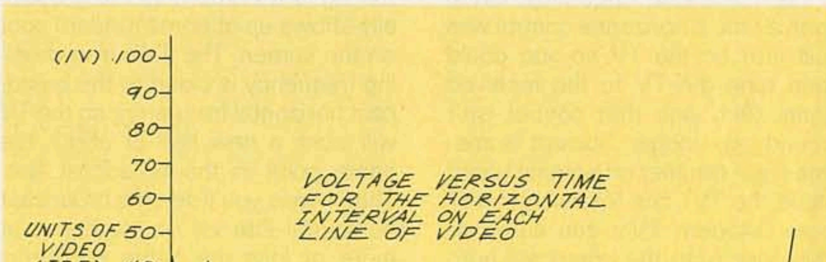

FIG. 2—THE CONTROL AREA. The NTSC video standard says that the signal can range from 0 to 1 volt peak-to-peak.

That signal definition is the basis for most of the hardware in every NTSC-compatible TV ever made. Your TV contains circuitry that expects control information to be below 0.3 volts and picture information from 0.3 to 1 volt. That's important because it is the starting point for scramblers; when you get rid of some of the control information, a standard TV can't display the picture. Remember that the horizontal sync pulse defines the end (or, depending on your point of view, the beginning) of a line of video. If the TV doesn't see it, it won't know how to display the line on the screen, and the result will be that the TV will end one line and start another one at some random point on the screen.

The freewheeling retrace frequency of the TV will come close to the one sent by the broadcaster, but it won't match exactly. What you'll see on the screen will be something like Fig. 3. The curved line running down the center of the screen is the horizontal interval sent by the broadcaster.

Three things are happening in Fig. 3. The first is that the line is curved because the horizontal circuitry in your TV runs at a frequency that's not exactly the same as the broadcast horizontal frequency. The TV can accept a certain amount of drift in the horizontal frequency. Once upon a time a horizontal control was built into on the TV so you could hand tune the TV to the received signal. Although that control isn't around any longer (except sometimes as a trimmer on a circuit board inside the TV), the tolerance is still there. Modern TV's can automatically lock onto the broadcast horizontal frequency so there's no reason for the horizontal control to be accessible.

The second thing that's happening is that the line is in the center of your screen. The reason for that is simple. The TV's horizontal circuit uses the received horizontal pulse as an instruction to move the beam back to the left side of the screen. Because the scrambled signal has anything but a recognizable horizontal sync pulse, the TV zips the line back to the left side of the screen whenever it reaches the right side.

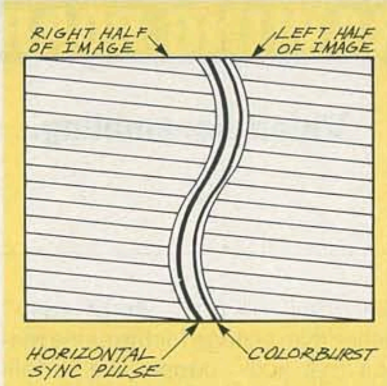

FIG. 3—A FREEWHEELING RETRACE won't match the frequency sent by the broadcaster. The curved line running down the center of the screen is the horizontal interval sent by the broadcaster.

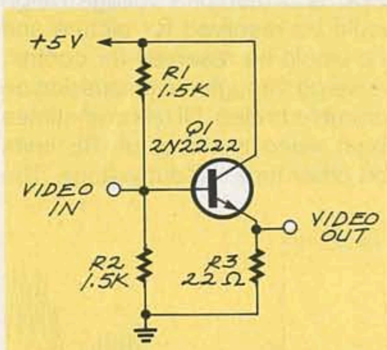

FIG. 4—A VIDEO BUFFER isolates one stage of hardware from another. The transistor is set up as a buffer and the level of the video can be controlled by the value of R2.

Because that has nothing to do with the signal it's receiving, the line usually shows up at some random spot on the screen. The TV's freewheeling frequency is close to the broadcast horizontal frequency, so the TV will start a new line at about the same point in the broadcast line. That means you'll see the broadcast horizontal interval on each line at more or less the same horizontal location on the screen. The result is a curved line down the screen.

The third thing happening on the TV screen is that the colors are messed up. Because the horizontal sync is missing, the TV circuitry isn't seeing the colorburst in the right place, so there's no reference for either the intensity or color of the picture. The TV then uses whatever it sees in the colorburst location as a reference for both the intensity and color of the image.

You can see now that by simply getting rid of horizontal sync, the resulting video signal will be completely messed up. The best way to appreciate that, and a good way to get into video hardware, is to build something to demonstrate how all this stuff really happens. That's right, our first piece of hardware is going to be something that will let you scramble video. And, as far as the law is concerned, I'm pretty sure that nobody's going to become very upset.

We'll need a source of real video. That can be anything from an NTSC generator to a line-level video signal from the back of a VCR. You'll also need a scope to look at the video waveform and a TV to look at the picture. You can do without the latter but the former is a must. I'm not going to beat you up any more about getting a scope, but if you don't have one, get one. If you don't get one, this series of columns, while informative, will be somewhat less than useful from a practical point of view.

To get started, because we're building circuitry that is going to use an external signal, the first thing we have to do is buffer it. That is done for two reasons. The first is that we have to be able to control the level seen by our video circuitry, and the second is so that a wiring error on the breadboard isn't going to send unpleasant voltages back to the signal generator or VCR. The results could be a bit nasty.

Video buffers are just like any other buffer—they're simple circuits that isolate one stage of hardware from another. Think of it as being like an electronic fuse. The easiest way to build a buffer is with a single transistor as shown in Fig. 4. The transistor is set up as a buffer, and the level of the video can be controlled by the value of R2. You can also put a potentiometer in series on the line feeding the video to the base of the transistor and trim the level that way.

Although the NTSC video standard calls for a signal that's 1-volt peak-to-peak, most VCR manufacturers don't strictly follow that standard when it comes to a video output signal. If you put the signal on a scope, you'll probably find that it's a bit higher than that. If that's the

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case, you should trim the level because the circuits we'll be building expect a 1-volt signal.

The only other thing to notice here—there just isn't much to the circuit at all—is that the video signal being fed to the base of the transistor is related to both positive voltage and ground through R1 and R2. The circuit is going to run on a regulated 5-volt supply; it must be steady because the level of the supply voltage is going to have an effect on the level of the video. Wire up the circuit shown in Fig. 4 and get the video source in place. When we get together next time we'll start designing some kind of circuit to screw up the signal. **R-E**