HARDWARE HACKER

Stroke graphics, temperature-measurement circuits & stunning new graphics materials

By Don Lancaster

We will start off with our usual reminder that this is your column and that you can get technical help on most any topic per the "Need Help?" box.

Many of our newer readers have been asking about the artwork you see here. Everything, including *all* schematics, isometric sketches, tech illustrations, etc. is done *solely* with the AppleWriter word processor running on an Apple IIe and then printed camera-ready and slightly oversize on a Laserwriter printer.

An exciting new language called *Postscript* makes it all happen, helped along by some utilities I put together on my own. No digitizers or scanners of any type are used.

I've got a free demo pack on all this that I'll be most happy to send to you when you call or write. Some of it is now even in *full color*, straight out of a stock Laserwriter!

And now . . . .

What are the differences between stroke and raster scan video?

There have been several calls from *Modern Electronics* hackers who have picked up bargain priced surplus "XY" color RGB video monitors and have asked if I would please show them a simple interface circuit usable for personal computer text input. Well, yew jest caint get there from here, no way, nosiree, nohow.

Why?

At one time, long ago and far away, there were two fundamentally different ways of presenting data on a video screen.

The method you probably know about is called "raster scan" graphics, and is shown in Fig. 1. With raster scan graphics, the video screen is constantly "painted," going rapidly to the right and slowly downward, creating a *raster* of *scan* lines. When a particular dot on the screen is to be lit a particular color, the guns in the CRT display tube are activated, producing a spot. Sequential spot patterns then produce dot-matrix text characters or graphic video images.

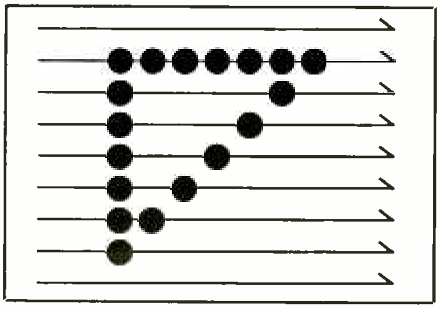

Fig. 1. Raster scan graphics.

Raster scanning, or course, is used in all newer video games, in all television broadcasts, and in all personal computers.

The alternative to raster scanning is called "stoke graphics," and is shown in Fig. 2. With stroke graphics, each and every object to be put on the screen is drawn one at a time, in sequence. Instead of the horizonatal and vertical oscillators used in raster scanning, there is just a pair of deflection amplifiers. Data from a "display list" is D/A converted and routed to the deflection amplifiers. Each object on the screen is drawn one line at a time.

Stroke graphics is particularly good at showing diagonal lines of open and chunky objects, such as various sized asteroids, tumbling in different directions all at once on a predominantly black background.

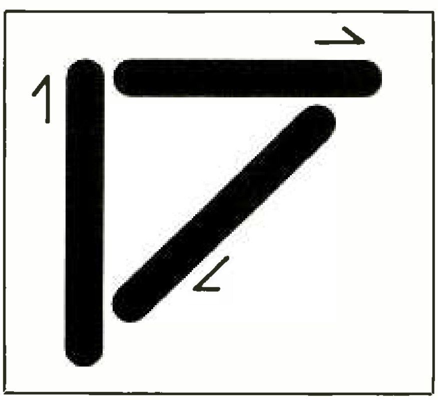

Fig. 2. Stroke graphics.

The early advantages of stroke graphics were that you needed incredibly little digital memory and you never put the CRT electron beam any place you did not really want an image.

But there were some overwhelming gotchas that killed stroke graphics a decade ago, except in plotters, military stuff and certain arcade video games that were able to uniquely exploit this type of display.

The first major disadvantage is that text is extremely difficult to show, especially in nice-looking fonts. The second is that flicker can get ridiculously bad if you try to put too many objects on the screen at once. The third is that large solid-color objects, or colored backgrounds are just not feasible.

So why not just throw a couple of horizontal and vertical oscillators on a stroke system and pretend it is a raster scan display? After all, a couple of 555 timers shouldn't be all that complex, should it? This sounds simple enough, but there is a problem in the comparative writing rates between raster and stroke systems. A normal resolution raster scan graphics system has to sweep from left to right across the screen in something like 60 microseconds. On a 10" raster, this converts to a 6-microsecond-per-inch sweep rate. The surplus arcade monitors being sold today have a sweep rate around 0.04 microseconds per inch, which is 150 times too slow! The flicker would be unbelievably bad, as the screen would get updated a maximum of once every 2 seconds or so, rather than the 60 fields per second needed for a flicker-free display.

Well you say, why not just soup up the stroke monitor's XY deflection amplifiers and give them a little better frequency response? Would that work?

Once again, the answer is: no way! Raster scan sweeping is extremely energy efficient, since the deflection current used to sweep from center to right is saved, reversed, and then used again to sweep from left to center. Unless you get very tricky, the high-frequency linear deflection amplifiers you would need for fast-raster-rate stroke graphics would

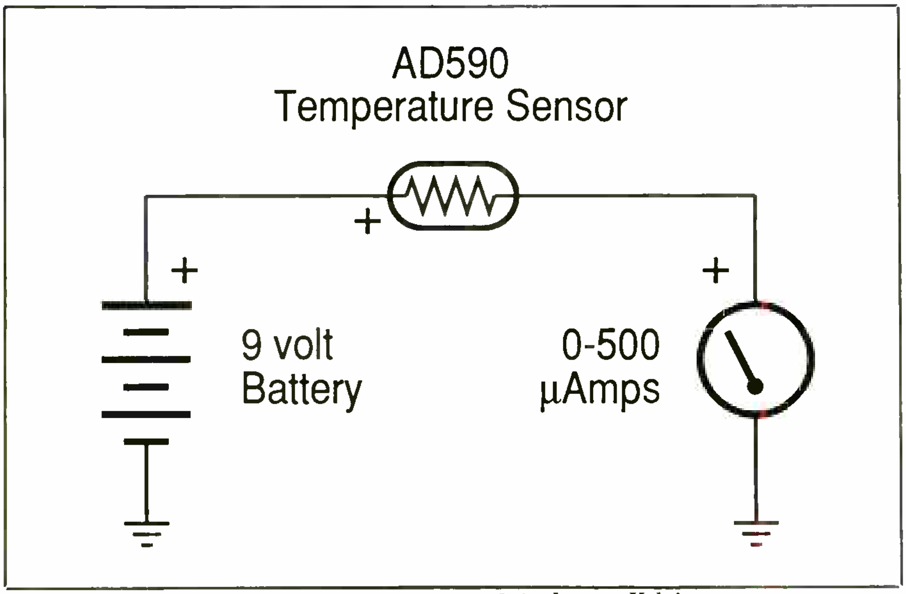

Fig. 3. Simple thermometer reads in degrees Kelvin.

have to handle several kilowatts of power for a large color display!

The bottom line? Thse surplus XY monitors are real parts bargains and they let you do all sorts of interesting but highly specialized video game simulations. But they are absolutely and totally unsuitable for displaying stock text and video from any personal computers.

How can I electronically measure temperature

There are lots of different ways to measure temperature, depending on the range being measured, the type of output wanted, and the accuracy needed.

Traditional thermometers are based upon the thermal expansion of some material. Liquid columns of mercury or alcohol are used in everyday thermometers. A very thin capillary tube is used to "amplify" the apparent expansion.

Another important temperature transducer is the bimetallic strip. In a bimetallic strip, two metals or alloys with different expansion coefficients are bonded together. As the temperature changes, one metal or alloy expands faster than the other, and the strip will bend or coil. This is how your usual home heating thermostat works. Alternatively, you can form a snap-action disk out of bimetallic material, giving you the switching thermostat you will find in an electric skillet or a coffee maker.

Measurement of extremely high temperatures takes special techniques. An older way to measure the temperature of a furnace or a kiln is with an "optical pyrometer." This is simply a wire that is heated. You visually compare the wire color against the furnace color, and adjust a dial until they match. You then read the equivalent temperature off the calibrated dial.

A more modern way to measure high temperatures is with an infrared sensor. These are sort of like photocells, except they respond in the infrared region to radiation from any hot body. They have the big advantage of being able to remotely measure any hot source. Unfortunately, infrared sensors become quite expensive and cumbersome when you try to accurately measure lower temperatures with them.

Today, there are at least six popular ways of measuring everyday temperatures electronically. These include the crystal oscillator, the thermocouple, the thermistor, the p-n junction, the silicon transducer, and the bulk silicon resistor. Of these, the crystal oscillator method is by far the most precise and has by far the best resolution. It can resolve down to 0.001 degree or better. On the other hand, this method is very expensive.

Most quartz crystals are carefully cut at just the right angle to minimize frequency variations over temperature. You can instead carefully pick your crystal cut to purposely get a strong and linear frequency variation. By hetrodyning the output frequency against a stable source, you get an audio tone that can be measured. *Hewlett-Packard* is one source of instruments of this type.

Any two dissimilar metals that contact each other will generate a voltage that is proportional to temperature. This is the principle behind the thermocouple.

Thermocouples are used in industry to measure a wide range of temperatures. One popular thermocouple is called a "type J" and is made from copper contacting the alloy constantan. The output from this arrangement is only 50 microvolts per degree C or so. Thus, you have to use precision differential instrument amplifiers to get useful results. You also have to figure out where to connect the other end of the constantan wire, for this connection will also generate a voltage that is in series with the one you are trying to measure. Traditionally, the other connection was made in an ice bath, so you would get the relative temperature difference between the two thermocouple junctions. These days, however, a precision voltage reference is often used to replace the ice bath.

You have to be very careful when connecting thermocouples, for even solder to copper has a 3-microvolt per degree C thermal voltage.

Many different thermocouple systems are available from *Omega Engineering*. They also have a fat and free *Temperature Measurement Handbook and Encyclopedia* that you can send for.

Thermistors are compounds of silicon carbide and other materials that exhibit a very strong change of resistance versus temperature. By first calibrating a thermistor and then measuring its resistance you can measure temperature.

While you get something that is very easy to measure as an output, thermistors tend to be be nonlinear. Sometimes, several thermistors and resistors are placed in a single package to give more linearity and accuracy. Self-heating effects must be carefully watched in thermistors, or they will mask the real temperature.

Yellow Springs Instruments is a leading source of thermistors and probes. In general, thermistors are an older technology that is being rapidly replaced by the silicon transducers and silicon resistors.

For quick and dirty temperature measurement, just use the base-emitter junction of any old silicon transistor—or stack a bunch of them up. Each junction changes by 2.2 millivolts per degree centigrade over a fairly wide temperature range. Diodes should also work just fine. Unfortunately, this output voltage sits on top of a 0.6-volt device-dependent offset; so it is best used for limited accuracy or for "set-point" uses where you want to turn a switch on or off at a fixed and easily calibrated temperature.

This silicon junction effect is carefully linearized and calibrated in the silicon temperature transducer. What you have is a miniature integrated circuit that uses a current mirror to route the internal current between a pair of carefully matched silicon junctions. The differential mirroring is adjusted so that an extremely linear and reproducible output current of 10 microvolts per degree Kelvin results.

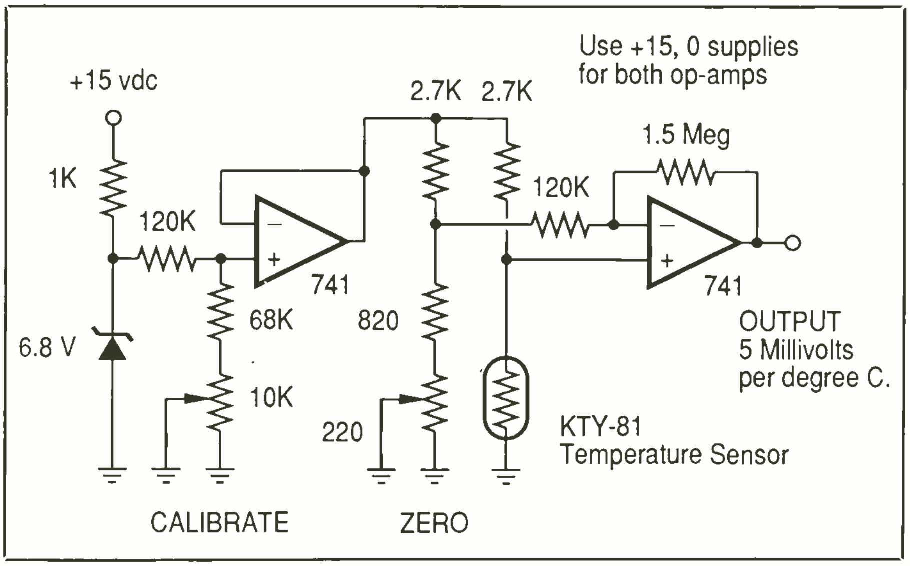

Fig. 4. This circuit gives 0-to-5-volt output for 0-to-100-degree C input.

The *Analog Devices* AD-590 is typical, and costs under $2.00. A similar part is available carded at *Radio Shack*. Since these devices produce a current output, they can be used over long distances. With a current output, all thermocouple effects in your wiring, plugs, and connectors magically go bye-bye.

The only little gotcha is that the output current is referenced to absolute zero, rather than zero degree centrigrade or to zero degree Fahrenheit. The typical output current is 273 microamperes at 0 °C and 373 microamperes at 100 °C. A pair of op amps usually have to be added to get a large output that is proportional to these everyday temperature scales. One op amp eliminates the 273-microvolt offset; the other amplifies and scales for either Fahrenheit or centrigrade use.

Finally, bulk silicon itself has a strong 0.7-percent per degree centrigrade temperature coefficient. You can just take a block of silicon, measure its resistance, and you are home free. The brand new *Amperex* KTY-81 sensors sell for as little as 21 cents each, are easily linearized with one resistor, and are accurate to a fraction of a degree.

These also need a pair of op amps to get linear operation over the Fahrenheit or centigrade scales. Free samples of the KTY81 series are available to letterhead requests.

In general, if you want to know a lot more about temperature sensors and sens-

NAMES AND NUMBERS

Amperex
Providence Pike
Slatersville, RI 02876
(401) 762-3800

Analog Devices
2 Technology Way
Norwood, MA 02062
(617) 329-4700

Control Engineering
1301 South Grove Avenue
Barrington, IL 60010
(312) 381-1840

Hewlett Packard
1820 Embarcadero Road
Palo Alto, CA 94303
(415) 857-8000

Measurement and Control
2994 West Liberty Avenue
Pittsburgh, PA 15216
(412) 343-9666

Omega Engineering
Box 4047
Stamford, CT 06907
(203) 359-1660

Omnicrom Systems
26111 Brush Avenue
Cleveland, OH 44132
(216) 289-6688

Yellow Springs Insts.
Box 279
Yellow Springs, OH 45387
(513) 767-7241

ing, check out *Measurements and Data* or *Control Engineering* magazines.

Show me some simple thermometer circuits

Figure 3 shows the AD 590 temperature transducer in a very simple circuit. The output meter directly measures degrees Kelvin, so 0 degree centrigrade will read as 273 microamperes, while 100 degrees centrigrade will read as 373 microamperes. To get to Fahrenheit, just relabel the meter scale.

Figure 4 shows how to use a KTY-81 silicon resistor to produce a 0-to-5-volt output for a 0-to-100-degree centigrade input. This dual op-amp circuit is typical of what you need to get from a sensor that is based on absolute zero to output everyday temperature scale values.

The 250-ohm pot is used to zero the 0-degree output. Then the 10k pot is used to set the 100-degree output to +5 volts. Most any old dual op amp could be substituted, as could a regulator for the zener diode. You might be able to cheat and use a 9-volt battery as well. Total cost should be well under $5.

For more details on these two circuits, check out the "Silicon Temperature Sensors" ap note from *Amperex* and "Use of the AD590 Temperature Transducer in Remote Sensing" ap note from *Analog Devices*.

What is the new Omnicrom process?

I've just discovered a little-known graphic arts material called "Omnicrom." It has incredible hacker potential. What this material does is instantly convert *any* toner image from a copier or a laser printer into "real" printing in "real" ink, in any of 60 colors.

Figure 5 shows the details of this exciting new process. Toner basically consists of a mixture of black stuff and hot glue. When most people use toner, they are after the black image. But you can instead think of toner as a hot glue image that has been applied exactly when and where you want it.

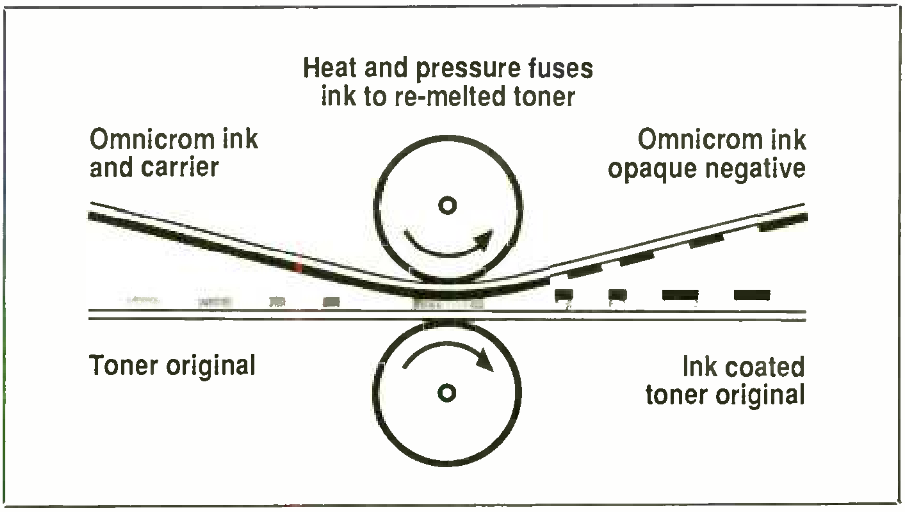

Fig. 5. How the Omnicrom color process works.

An Omnicrom sheet consists of real ink in stunning colors applied to a carrier. You place this sheet in contact with any toner original and apply heat and pressure. The heat and pressure remelts the toner and sticks the ink to it. At the same time, an opaque negative is produced on what remains of the Omnicrom sheet.

There are at least four ways to fuse the ink to your toner. The simplest is to use a laser printer, such as Apple's Laserwriter, and run the material through a second time while hand feeding a blank page.

You can experiment with most any copier that has a short and straight paper path that will accept heavier stock. Word has it that the next generation of copiers, particularly those by Minolta, will be set up to reliably handle this process.

If you do lots and lots of this sort of thing, you can buy a ridiculously overpriced $1300 fusion system directly from *Omnicrom*. Finally, you can easily build your own machine out of old copier parts or replacement components.

The sheets cost around 35 cents each, and their unimaged areas can be reused as often as you care to. Besides bright colors and metallics, there are golds, silvers, a pearl, black, and even a clear gloss.

What good is all this? First and foremost, laser printer users gain full color capability right here, right now, and at reasonable cost.

You can easily do many printed circuits from 2:1 artwork without needing a camera or a darkroom, at one-tenth the usual cost and hassle. All you need is a reducing copy machine. Same goes for panels, dialplates and the callouts for printed circuits. Any old copy from any old copy machine can now be made totally and truly black, any time you need a camera-ready image.

Several colors can go on one page by taping small pieces of Omnicrom over each color area. The best tape to use is *3M* Post-It Cover Up Tape from your local office supply.

Write or call, and I'll be most happy to send you some free Omnicrom samples to play with. This stuff is utterly and absolutely amazing. Let me know what new and mind-blowing uses you can come up with for this exciting new material. **ME**

NEED HELP?
Phone or write your **Hardware Hacker** questions directly to:

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