HARDWARE HACKER

The Apple II GS; solar pumps; low-cost EPROM erasing; D/A conversion . . . more

By Don Lancaster

Be sure to get yourself a copy of the August 8, 1986 issue of *Science* magazine. You'll find a major paper here on neuron computing by J.J. Hopefield and D.W. Tank. This is bound to become one of the key "horses mouth" source documents of this exciting new field that we looked at a few columns back.

Speaking of other publications, it seems I got the phone number wrong twice for *Speleonics*. Hopefully, it is correct in this month's Names and Numbers box.

Quite a few of you have asked for more information on the "other" underground radio, the one that involves piracy broadcasts, satellite unscrambling, and such. This is one area I just haven't gotten into very much, but I hear there is a magazine called. *A.C.E.* that is published by the *Association of Clandestine Radio Enthusiasts.*

There's also our sister publication, *Popular Communications*, that gives lots more details on this sort of thing. Finally, there apparently is a satellite descrambling hotline available at (305) 771-0575.

And now for this month's feature attractions . . . .

What's the word on the new Apple II GS?

In a word—fantastic!

Publishing deadlines being what they are, I have only had a limited amount of hands-on time on this machine so far. What you have here is a drop-it-in board swap for an Apple IIe that instantly up grades the computer to full 16-bit, 65C816-based computing power, while maintaining nearly full compatability with most existing Apple software. You still have lots of slots like in a IIe. Like in a IIc, all of the stuff that used to need slots is now on-board, including two serial interfaces, a real-time clock, video firmware, the mouse interface, *Apple talk*, and support for as many as 128 disk drives, each of which can potentially handle media up to 4 gigabytes (!) in size.

You'll find three operating modes. There's the "slow" emulation mode that tries to behave *exactly* like the earlier II + or IIc. There's a "fast" emulation mode that speeds up Applesoft programs by a factor of 2.5 times. Finally, there is the new "native" mode that gives full 16-bit computing power, complete with desk tops, toolboxes, windows, *Quickdraw* graphics tools, and more.

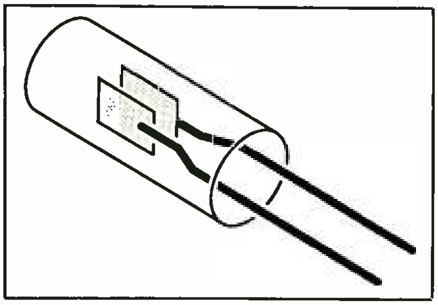

Fig. 1. JKL's new BF727 ultraviolet lamp for inexpensive EPROM erasing.

There are major improvements in the existing graphics, plus two new full color graphics modes that are every bit as good as anything available elsewhere. An optional sound card instantly converts the II GS into an absolutely stunning studio-quality music, speech, or special sound effects synthesizer. Up to 32 fully poly phonic oscillators can be combined in as many as eight stereo channels, all with their own private 64K RAM memory.

While there is "only" 256K of main RAM on-board, a plug-in socket lets you easily and cheaply expand to 4 mega bytes of directly addressable RAM. You can also add another 4 megabytes per slot of slot-based RAM, to bring memory total beyond 32 megabytes. The expansion socket just needs RAM chips, since all of the refresh and address multiplexing is handled by the main board in the computer.

ROM is also expandable.

There are lots of new features, too. The new monitor does full 65C816 assembly, disassembly, tracing, and debugging. It also includes the SANE floating-point numerics set, with up to 80-bit precision.

A new front desk bus is supported by a second microprocessor. This is sort of a party line for input mice, keyboards, keypads, trackballs, graphics tablets, whatever. The keyboard itself is configurable into nearly two dozen different languages and layouts, including Dvorak. Internal character sets are available for most major languages everywhere in the world.

Things are a mite hectic around here just now, but as soon as I get some real hands-on time with my machine, I'll give you a full report. In the meantime, you can use our Hardware Hacker help line as a II GS hotline.

I need a very cheap EPROM eraser

How does $6 sound? Read on.

EPROMs, short for erasable and programmable read only memories, are ideal hacker components in that you can reprogram them over and over again. To

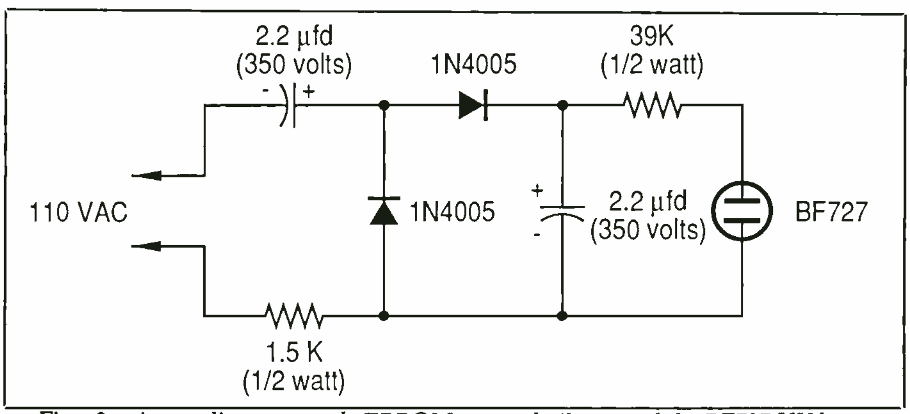

Fig. 2. An ac-line-operated EPROM eraser built around the BF727 UV lamp.

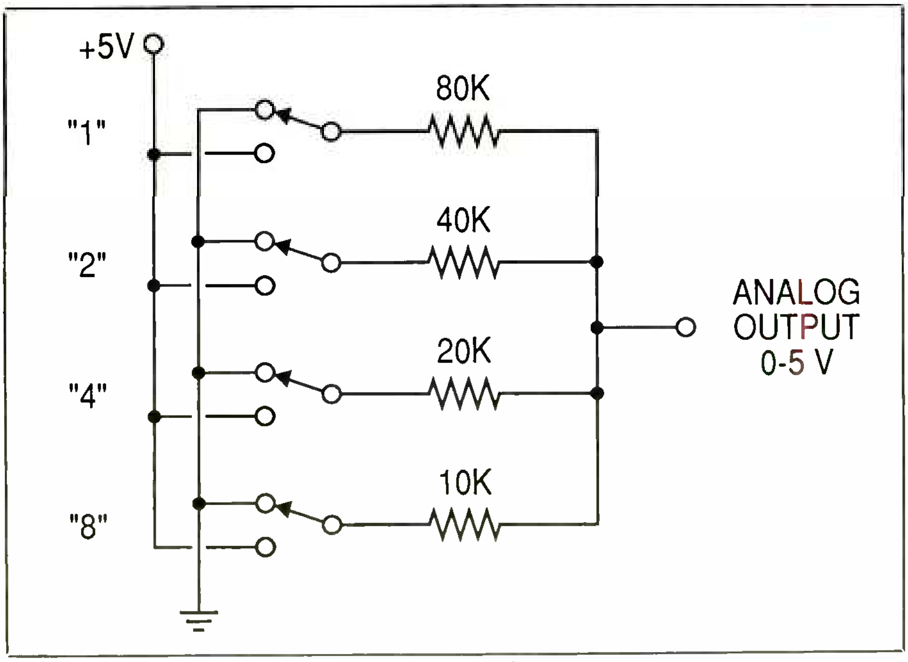

Fig. 3. A "manual" D/A converter.

erase an EPROM, you have to expose it to very strong ultraviolet light that has a very short wavelength of 2532 Angstroms. This wavelength is far shorter than most UV "poster" lamps, rockhound lamps, or germicidal types; so a very special lamp is needed.

Up to now, you had two ways to erase an EPROM. You could leave it out in strong sunlight for a week, or you could buy a special high-intensity, short-wavelength EPROM eraser at a cost of $80 or more. Many hackers felt this was too high a price to pay for just an occasional erasure.

JKL components has just introduced a brand new BF727-UV2 miniature ultraviolet lamp that sells for only $5. Its spectrum has been optomized specifically for erasing EPROMs. A drawing of this lamp is shown in Fig. 1, its simple 110-volt ac drive circuit in Fig. 2. Ultraviolet light comes out the side of the lamp, between the two parallel plates.

The Fig. 2 driver circuit is basically a voltage doubler and current limiter. The lamp fires at 300 volts and runs at an *externally* limited operating current of 1 milliampere. Be sure to use very high quality 350-volt capacitors if you build this circuit.

There are some gotchas. The intensity of the BF727-UV2 is far lower than the $80 erasers. The good news is that you don't have to be quite as careful with your visual interlocks as you did with the higher-intensity lamps. Keep in mind that high intensity UV light can easily cause permanent blindness. For this reason I still would not recommend looking directly at the JKL lamp, except for the briefest possible time.

The bad news is that it takes overnight to erase an EPROM. And that's running at higher-than-normal current with a concentrating reflector. Still, you can easily build a small "snap-on" eraser and actually erase an EPROM while it is still in the original circuit. This is something the larger erasers cannot handle at all.

Let us know the best design you come up with for a clip-on eraser.

Any new breakthroughs in solar energy?

Jim Allen of the *Solarjack* company has come up with a genuine breakthrough in solar energy economics. And he has done so with a product that has been thoroughly field tested.

Windmills have traditionally been used in remote areas of the arid southwest for pumping water for livestock and game. But windmills are costly to service, and they perform poorly because of erratic winds and dropping water tables. On the other hand, solar-powered pumps have simply been too expensive to use in these locations. Why? Because each solar array had to drive a costly inverter and a bank of expensive and hard-to-maintain batteries. Worse yet, the efficiency of the inversion and storage processes gets so low that you lose all the way around.

Jim got to thinking that solar energy would make a lot more sense if you could throw away the inverter and the batteries, getting rid of both their cost and their inefficiency. Now, in a water pumping operation, you have one goal and one goal only. You want to put as much water into the tank as you can, and do so as efficiently as possible.

So, Jim reasoned that he would design the pump to fit the sunshine, rather than using inverters and batteries to make the sunshine fit the pump. What he came up with is a new variable displacement pump mechanism. When the sun is shining brightly, the pump makes long strokes and lifts lots of water. When the sun shines a little, the pump makes short strokes and lifts less water. At night the pump makes zero strokes and does not lift anything.

What about clouds? Jim put a hefty flywheel on the pump so it can coast through brief cloudy periods. A small, simple, and very efficient CMOS microcontroller monitors flywheel speed, and, every now and then, adjusts pump displacement to exactly match the available energy coming in from up there.

A small secondary motor with a worm screw drive is used to adjust the stroke.

Thanks to the flywheel, the pump runs at an optimum and nearly constant speed, so long as any power at all is coming out of the panel.

I am particularly proud of all this, because Jim is one of my students. And he is successfully doing some extremely high-tech things in a distinctly low-tech part of the country.

Give him a call if you want any more details.

How do D/A converters work?

D/A, or digital-to-analog, converters convert digital numbers into nearly continuously varying output signals. In general, D/A converters are a lot simpler and cheaper than the A/D converters we looked at last month.

The three most important parameters of a D/A converter are its cost, its resolution, and its settling time. The resolution of a D/A converter is the number of output steps you get. In turn, this is related to the number of input bits the converter can handle. For instance, an 8-bit converter will give 256 output levels, a 12-bit converter will give 4096 levels, and a 16-bit converter will give 65,536 different output levels. Settling time is the time it takes for a change in the input digital code to produce an output that is very near the final desired analog level.

Let's look at some circuits.

Figure 3 is a very simple 4-bit manual D/A converter. The 1, 2, 4 and 8 switches are respectively summed with their 80K, 40K, 20K and 10K resistance values, producing an output voltage with 16 discrete steps. Note that the larger resistance values provide lower current increments.

As the switches are flipped, the output will go to the level set by the switch combinations. Since there are four switches, this is a 4-bit converter. There are 16 possible combinations for the four switches, so we get 16 possible output levels from 0 to 5 volts. Intermediate levels will be 0.333 volt each. Thus, level 1 will be a third of a volt, level 2 will be two-thirds and so on.

Let's add some improvements in our "neuron-like" D/A converter shown in Fig. 4. Those 1-2-4-8 resistor ratios and currents can cause problems when lots of accuracy is needed. Instead, we've shown an R/2R network that needs only two resistor values and lets each switch always handle the same current. We have also summed the analog current to the *virtual ground* of a CMOS inverter connected as an op amp, rather than trying to sum output voltage. This gives a faster settling time and a lower output impedance.

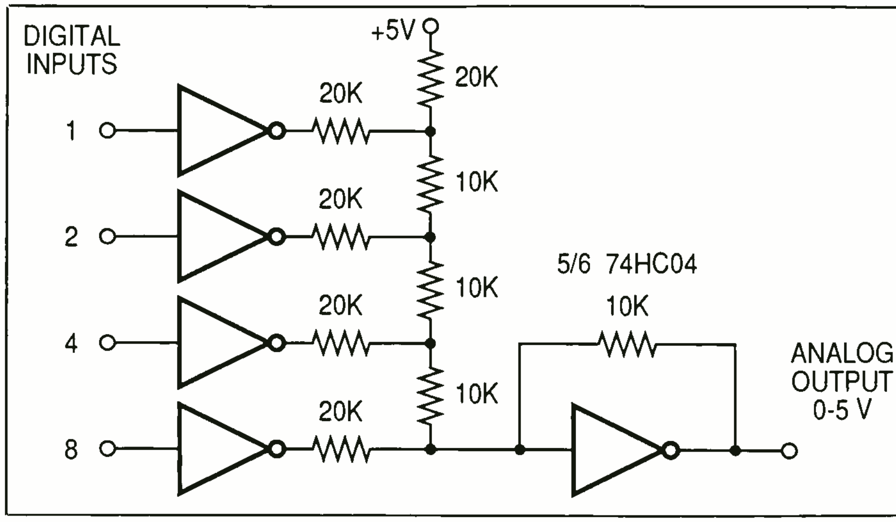

Fig. 4. A "neuron-like" D/A converter that uses R/2R summing.

In real-world D/A converters, you usually use input latches, and clock them at a specified rate.

Let's throw some more terms at you. A "monotonic" D/A converter guarantees that each successive digital value will produce a progressively higher output voltage. This can become sticky in high-resolution converters that must work over a wide temperature range.

A De-glitched converter has some steps taken to make sure that there are no unacceptable output spikes following a change of digital input. This becomes

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very important in video applications, where any glitches at all will produce horrible screen results. An essential first step at de-glitching a high-speed D/A converter is to make sure the turn-on and turn-off times of the input latches are identical. This is not trivial. A second method of de-glitching is to catch the analog output only at known "data-valid" times, and hold this result until the next known data-valid time.

Normally, a D/A converter is driven from a precision voltage reference, rather than from the power supply. This prevents any glitches in the supply from getting into the output. In general, Schottky TTL circuits make very poor D/A converters since they sit there "muttering" to themselves, rather than saturating to ground or the positive supply as does CMOS.

Some D/A converters will let you input any voltage you want, and then will output the product of that input and the digital word. These are called "multiplying" D/A converters. One important use is as digitally controlled attenuators for audio and video applications.

If you are allowed to input only a positive voltage to a multiplying converter, you have a one-quadrant circuit. If you can input either positive or negative analog values, you have a "two-quadrant" converter. Finally, if you can input either positive or negative analog values, as well as negative or positive digital values (by using a suitable code), you end up with a "four-quadrant" multiplying converter.

Multi-quadrant converters are considerably more expensive and complex than the one-quadrant versions. Pricing of D/A converters starts from under a dollar each.

Figure 5 shows a simple circuit of an older low-cost microprocessor-compatible D/A converter. Important suppliers of sanely priced D/A converters include *Analog Devices* and *Texas Instruments*.

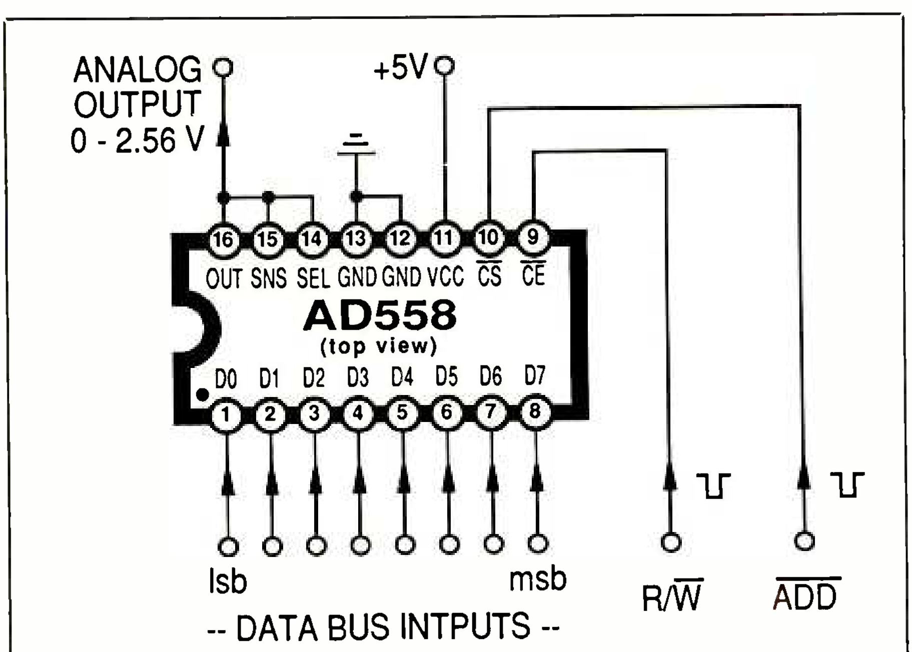

Fig. 5. A simple microprocessor-driven D/A converter circuit.

What's new in tech lit?

Lots of good technical stuff has shown up in the mail lately. The *Intersil Application Handbook* has lots of goodies on data acquisition and A/D conversion in it. From *SGS* came an L-296 switching regulator evaluation kit that's free if you send a request on letterhead. The kit includes the circuit board and two chips needed for a 4-amp, 5- to 40-volt dc step-down switching regulator. You still have to wind your own coil, though.

Two distributor catalogs came from *Newark*, a complete "old-line" electronics distributor, and from *Mouser*, with mostly foreign components at outstanding prices. A surplus catalog that came from *Marlin Jones* offers super-cheap pricing on ultrasonics, lasers, digital displays, robotics, steppers, and such.

From *Texas Instruments* came a new LSI Logic Data Book. Intriguing new devices include a memory mapper, barrel shifter, read-back latches, shaft encoder interfaces, and nearly 200 pages of application notes.

Finally, from *AESAR* came another catalog of exotic metals and elements at exotic prices. For some strange reason, none of these exotic metals houses offer 6-inch plutonium spheres. I guess it's because this particular product would give you an unfair advantage in lawn bowling.

Where can I learn the fundamentals of machine-language programming?

Check into my *Micro Cookbook* Volumes I and II. While they are particularly useful for the 6502 microprocessor, things are presented in such a way as to apply to any 8- or 16-bit microprocessor of your choice. I have a few copies in stock if you want one of them.

I also have expanded and revised my "free stuff" list, so be sure to get a copy. As always, this is your column, and you can get technical help by calling or writing per the Need Help? box. We are way behind on answering letters right now, so you'll get the best response with a telephone call. **ME**

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:

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