

HARDWARE HACKER

Remote controls
Infrared receivers
A new A/D converter
New data book resources
Analog computer interfacing

Remote controls and a great A/D converter!

DON LANCASTER

WE WILL START OUT WITH OUR USUAL reminder that this is your column and that you can get both technical help and off-the-wall networking by calling the Guru himself per the "Need Help?" box. The best calling times are during weekdays, 8-5, mountain standard time.

Also as is usual, I have gathered pretty near every source mentioned here into a common "Names and Numbers" table. Several of those addresses are where you go to get more info or to follow up on any specific product.

Let us see. I have now found yet another low-cost source for those data-access arrangement telephone transformers that we looked at last month. Do check out the Tamura model *TTC-142*. They're available for under a dollar in very large quantities.

The developments in superconductivity continue at an astonishing pace. By switching to materials made of aluminum, barium, and the thallium used in rat poison, the critical temperatures have now been raised another 30 degrees to 120 Kelvin. Which is now halfway up to dry-ice temperature.

NEED HELP?

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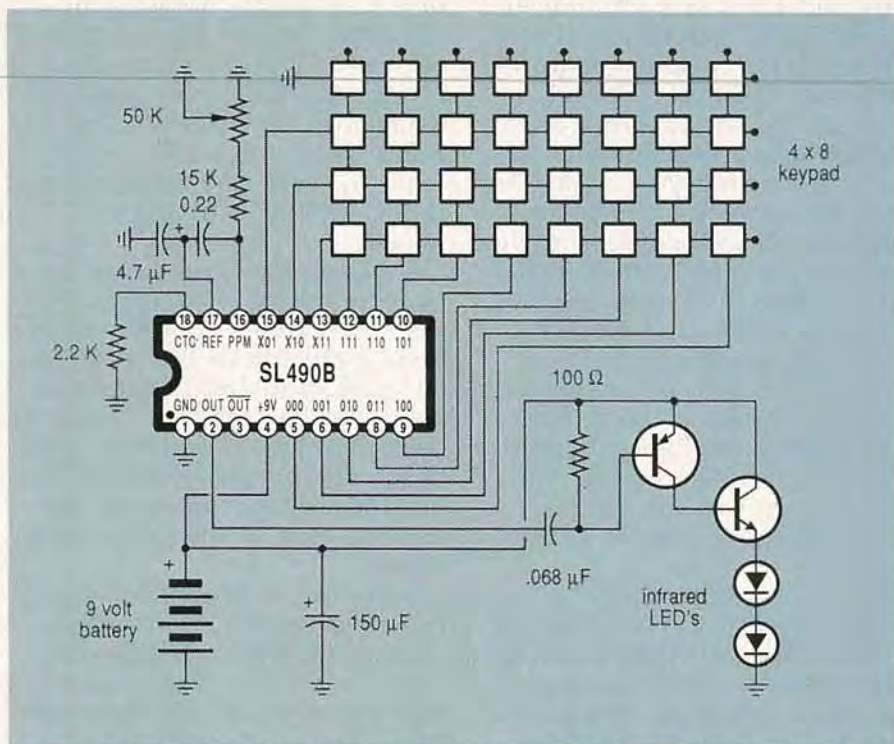


FIG. 1—A HANDHELD REMOTE-CONTROL transmitter can send up to 32 different commands. Each command outputs a repeating code of six brief light pulses.

The new materials are also much cheaper and more stable. It does remain to be seen whether their current densities will end up high enough for real-world uses.

One very good source of most superconductor info is *Science* magazine, which is published by the American Association for the Advancement of Science, and is available at most larger libraries. Those 120-K superconductors are detailed in the February 16 issue.

There's also a very interesting tutorial on free-electron lasers in the March 4, 1988 *Science*; and the first details on what probably is the final elusive proof to Fermat's last

theorem (a classic and infuriatingly subtle math problem) are found in their March 18 copy.

Onward and upward...

Remote controls

There sure is a lot of help-line interest lately in remote-control circuits. All you **Radio-Electronics** hackers are now trying to remote-control everything from HO-gauge trains through hi-fi audio, home entertainment, to commanding an amazing assortment of robotics, aides for the handicapped, on up to industrial-process controls and even full-size racing cars.

It turns out that there is no "best" or even a "standard" way of handling any remote-control problem, nor is there one single circuit that will do all things for all people. It depends on what you are remote-controlling over what channel, how reliable the control has to be, how many others are using the same channel, the amount of security required, the available power, what types of outputs you need, etc...

The popular carriers for remote control do include tones over the phone line; fiber optics; radio links including ham and CB; sonic and ultrasonic sound; both regular and infrared light; the AC power-line RF techniques; and all of those usual computer networks and serial ASCII data channels.

Most remote controls these days are digital, and often are computer controlled. Any analog or varying signals (such as audio or the flaps on a R/C model plane) are handled by some sort of digital communication scheme, perhaps by using either pulse position or duty-cycle modulation.

At any rate, I've just run into two outstanding free data books from a pair of widely different integrated-circuit manufacturers. They should keep you busy for several years' worth of remote-control hacking.

Start out with the bright green new *Integrated Circuit Solutions for Communications* product data book from MX-COM. Those people build specialized integrated circuits for both the telephone and radio communications trade. The typical single-quantity chip prices are in the \$10-25 range.

Some of their more interesting devices include the MX204 speech scrambler, their brand new MX403 selective calling transponder, the MX315 tone-controlled squelch circuit, and their MX205 digital tone-generator chip.

Then, check into that magenta *Satellite, Cable and TV Integrated Circuit Handbook* from Plessey.

There are many dozens of very interesting and low-cost circuits in that book. Once again, it will take years to fully explore all of the hacker potential of those unique chips.

As a ferinstance, we can start out

with the SL490-B remote-control transmitter shown in Fig. 1. The intended use is for a hand-held, battery-powered infrared remote-control transmitter, as are popular with TV sets and VCR's.

The same circuit can be used with ultrasonic transducers or most any other control channel.

A total of 32 commands are available that use a five-bit pulse position modulated code. When used with infrared diodes, pulse widths of 15 microseconds are also used. The five-bit word is sent out most significant bit first.

The timing period of a digital logic "1" varies with the application, but is usually made as long as possible. Otherwise, functions such as a TV volume control may change too fast to be usable. A digital logic "0" will always be 1.5 times the timing period for the logic "1," while the word-interval delay will be 3 times the "1" period.

Each of the command sequences consist of six pulses. The first is a start pulse. The second pulse is delayed by the "1" or the "0" time of the most significant command bit. The third pulse is delayed by the "1" or the "0" time of the next command bit, and so on. The six pulse groupings continue as long as the key is held down.

Note that no current limiting is provided for the infrared-light-emitting transmitting diode or diodes. It is thus very important that your circuit layout will discharge only a small portion of the 150 microfarad capacitor charge into the output LED per pulse, and that the supply voltage to the chip itself not drop in the process.

While most any infrared LED could be used, you'll more than likely get the best results with one or two high-power, high-brightness lamps, driven by a suitable pair of high-gain, and high pulse current transistors.

The infrared output power can be increased with a mirror or else a directional reflector.

Infrared receivers and decoders

There are a number of suitable decoder chips and circuits detailed in the Plessey handbook. They vary with whether you need analog outputs for volume controls or whatever, and on whether you are in a television-receiver or a computer environment.

Figure 2 shows us an infrared preamplifier circuit that should automatically convert the received infrared pulses into some noise-free digital pulses of just the correct amplitude for further processing. A two-chip receiver is normally used, with the preamplifier receiving and cleaning up the pulses, and the separate decoder converting all the receiver code bursts into actual output commands.

The data book does include a suggested circuit layout for their SL486 preamp. An infrared sensitive photodiode is used for the light receiver, while those capacitors provide bandpass filtering for good noise rejection.

The preamp circuit is normally placed inside a shielded case that has a plastic filter in front of it; the filter passes infrared but rejects room illumination.

This month, let's have us a double contest. Just dream up a new or unusual remote-control ap-

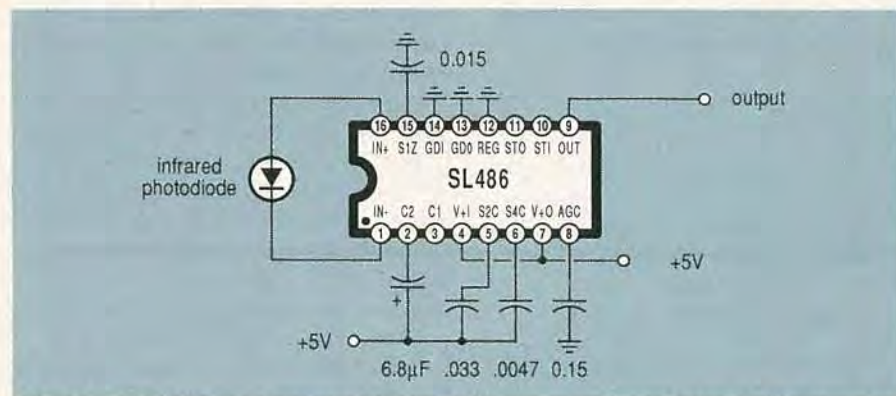


FIG. 2—AN INFRARED REMOTE-CONTROL preamplifier is usually required between your receiving photodiode and the final digital decoder circuitry.

NAMES AND NUMBERS

Alcoswitch

1551 Osgood Street
North Andover, MA 01845
(617) 685-4371

Crystal Semiconductor

2024 E St. Elmot Rd.
Austin, TX 78760
(512) 445-7222

Linear Technology

1630 McCarthy Blvd.
Milpitas, CA 95035
(408) 942-0810

Monolithic Memories

2175 Mission College Blvd.
Santa Clara, CA 95054
(800) 222-9323

MX-Com, Inc.

4800 Bethania Station Rd.
Winston-Salem, NC 27105
(919) 744-5050

Personal Engineering

Box 1821
Brookline, MA 02146
(617) 232-3652

Plessey Semiconductors

9 Parker
Irvine, CA 92718
(714) 472-0303

Recticon

345 Potero Avenue
Sunnyvale, CA 94086
(408) 738-4266

Science/AAAS

1333 H Street
NW Washington, DC 20005
(202) 326-6400

SGS-Thompson

1000 East Bell Road
Phoenix, AZ 85022
(602) 867-6100

Tamura

1150 Dominguez Street
Carson, CA 90746
(213) 638-1790

Texas Instruments

Box 5012
Dallas, TX 75265
(214) 995-3821

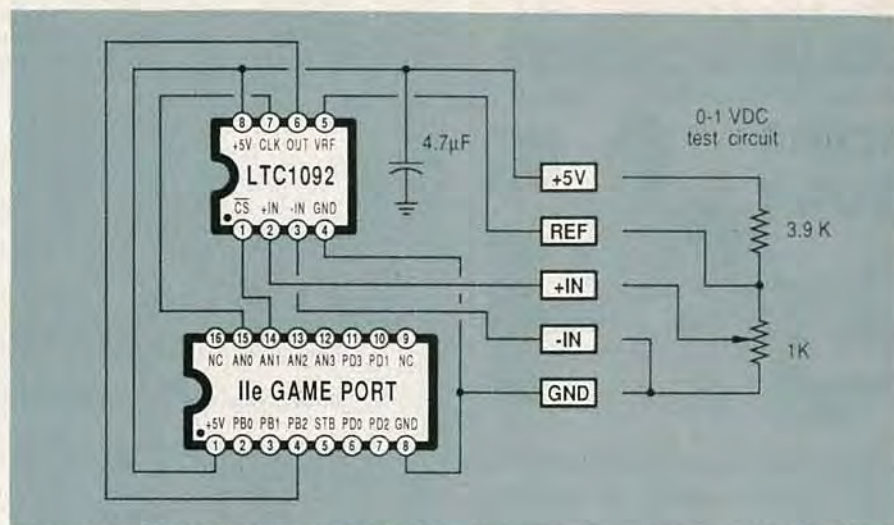


FIG. 3—THIS 10-BIT FLOATING POINT A/D CONVERTER is very easy to interface to an Apple IIe, IIgs, or any other personal computer or microprocessor.

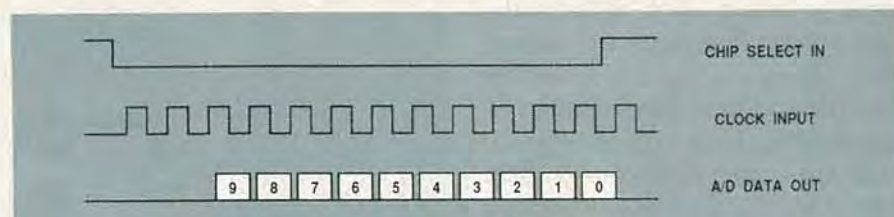


FIG. 4—TIMING WAVEFORMS USED WITH THE LTC1092. Your computer or other external timing inputs a chip select and thirteen clock pulses; the LTC1092 responds in turn with ten A/D serial data bits. The A/D conversion speed can be as fast as 45 kHz.

entries, and an all-expense-paid (FOB Thatcher, AZ.) tinaja quest to the best entry of all.

As always, send your entries directly to me, and not to the **Radio-Electronics** offices.

Paper designs are just fine; you do not have to build or test your entry to enter.

An amazing A/D converter

There's a new analog-to-digital (A/D) converter out that I have been really impressed with. It is called the *LTC1092* and is made by Linear Technology. Cost is around \$12.

The resolution is a big 10 bits, meaning that you can accurately and linearly slice an analog signal into 1024 pieces. It can run as fast as 50 kilohertz and includes its own internal sample and hold circuitry. Since the *LTC1092* is an 8-pin mini-DIP serial device, it is easy to interface to virtually any micro-computer or personal computer. And it all works off a single +5-volt power supply.

But, what I like best of all about that beast is that it uses a floating-

point reference-voltage scheme. By lowering the reference voltage, you can directly handle ridiculously smaller input signals. In fact, you should now be able to run a temperature transducer or even a pressure sensor directly into this chip without needing any fancy pre-amplification or signal conditioning.

Put another way, the chip can give you a 10-bit resolution over a 16-bit dynamic range, all at a tiny fraction of the cost of a "real" 16-bit A/D converter. All of which should enormously simplify hacking just about everything from postal scales to hot-tub controllers through stream gauges and audio frequency processing.

Figure 3 shows you a test circuit I worked up that can plug directly into the game-paddle port of an Apple IIe or IIgs. All the waveforms involved are shown in Fig. 4, while the machine-language driver and Applesoth controlling program appear in Fig. 5. Finally, Fig. 6 shows a possible PC layout.

You connect the chip to +5 volts and ground through the supply

plication, or an off-the-wall use for the upcoming A/D converter circuit of Fig. 3. There will be the usual Incredible Secret Money Machine prizes to the best twenty

1. To CREATE your machine language driver, get into BASIC.SYSTEM and then do a CALL -151. Then enter the following code in this order ...

```

300: 02 02 2C 5A C0 2C 58 C0 2C 59 C0 2C 58 C0 2C 59 <cr>
310: C0 2C 58 C0 2C 59 C0 A9 00 0E 63 C0 2A 2C 58 C0 <cr>
320: 2C 59 C0 0E 63 C0 2A 8D 01 03 2C 58 C0 2C 59 C0 <cr>
330: 0E 63 C0 2A 2C 58 C0 2C 59 C0 0E 63 C0 2A 2C 58 <cr>
340: C0 2C 59 C0 0E 63 C0 2A 2C 58 C0 2C 59 C0 0E 63 <cr>
350: C0 2A 2C 58 C0 2C 59 C0 0E 63 C0 2A 2C 58 C0 2C <cr>
360: 59 C0 0E 63 C0 2A 2C 58 C0 2C 59 C0 0E 63 C0 2A <cr>
370: 2C 58 C0 2C 59 C0 0E 63 C0 2A 8D 00 03 2C 5B C0 <cr>
380: 2C 58 C0 2C 59 C0 60 <cr>

```

```
BSAVE DRIVER.1092.1, AS300, LS87 <cr>
```

2. To ACCESS your machine language driver, use this BASIC program ...

```

100 PRINT CHR$(13); PRINT CHR$(04); PRINT "BLOAD DRIVER.1092.1"
200 CALL 770
300 PRINT PEEK (768) + 256 * PEEK (769)
400 GOTO 200

```

FIG. 5—THIS APPLE IIe/IIgs SOFTWARE DRIVER will let you directly interface a high-quality 10-bit A/D converter from your computer's game I/O connector.

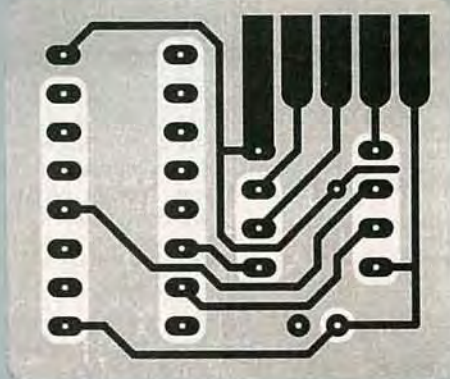


FIG. 6—ONE POSSIBLE PC LAYOUT for your converter. The ground plane on the component side is an absolute must! The view here is from the foil side.

pins. There are three pins on the input side called the + input, the - input, and the reference input. The voltage difference between the + input and the - input is compared against the reference. A zero or a negative difference gets you a zero output, while a difference equal to or greater than the reference gets you "all ones" or decimal "1023."

In between, the output number is linear with the input voltage difference. For instance, a difference of one-half the reference will get you level 512 and so on. The + input and - input impedances are very high, while the reference input will look like a 7K load.

There are three pins on the out-

put side. The first is the chip select. Your computer or timing circuit brings it low at the start of a conversion cycle, holds it low for a complete conversion, and releases it back high again.

A second pin is called the clock. Your computer, or else an external timing circuit, delivers thirteen clock pulses during a conversion, first bringing the clock high and then returning it back low again. The clock frequency must be in the 10- to 500-kHz range.

That is a "successive approximation" type of register. Nicely, the clock-to-clock pulse spacing does not have to be constant, which greatly simplifies using software to generate clock pulses.

The analog input only has to be constant and present during the first 2½ clock cycles. That is called the acquisition time. The input reference is internally held for the remainder of the conversion interval. That can certainly eliminate the need for an external sample and hold circuit.

The *LTC1092* outputs data in the following way: One microsecond after the third clock pulse, the most significant bit (B9) is output. A microsecond after the fourth clock pulse, the next bit (B8) is output. That continues until all ten bits are output. It is up to your computer or your external interface circuit to catch those bits on the fly.

A/D controlling software

It is fastest to generate your clock pulses with add-on hardware, but the Apple *Ile* and *Iigs* can manipulate their game-port lines fast enough so that you can get over a 6-kHz conversion rate using nothing but machine-language software.

That is ridiculously faster than is needed for most hacker uses, particularly for such applications as recording temperatures.

Use of the BASIC language will, of course, slow you down bunches. One hundred or so conversions per second is typical for a simpler BASIC program.

Over on the game-paddle port, annunciator AN1 is used as the chip-select line and AN0 is used as the clock. Data is input on the PB2 line. The machine-language driver simply drops the chip-select low, outputs eleven clock pulses, and then returns the chip-select high.

Following the third through twelfth clock pulse, the received data is routed into two registers with the eight least significant binary bits ending up in location \$0300, or decimal 768. The two most significant binary bits end up in location 0301, or decimal 769.

In the simple example shown, the Applesloth program will do a 10-bit binary to decimal ASCII conversion for you and display it.

Oh yes. About that jitter.

A one-bit resolution with a one-volt reference ends up less than a millivolt. If any ground currents or any other type of noise gets into

your inputs or reference, it will be duly converted over into a 10-bit accurate result and cause your answers to bounce around a bit.

Extreme care must be used when shielding and guarding both the inputs and the reference, particularly if you are going to run with very low reference inputs. Printed-circuit boards and good shielding are a must. But that's what the black magic of analog circuit design is all about.

Yes, I have a source-code listing available on that. Let me know if you want a copy. Similarly, if you work up a driver for some other computer, send in a copy so we can share it with the others.

New tech info

Texas Instruments has a new and free *Advanced CMOS Logic Designers Handbook* out, but watch all the fine print. TI opted for non-standard chip pinouts and did some other rather bizarre things with this new high-speed logic family. They have also gone way overboard on laughingly arcane

and confoundingly obtuse new logic symbols.

There's a sequence of new *The Brighter Power* booklets available from SGS-Thompson. They include chips to handle Detroit's latest buzzword—high-side drivers. The high-side driver lets you ground the other side of a lamp, coil, solenoid, valve, or whatever. Yes, high-side driver chips are smart enough to shut themselves down on a short circuit, a current overload, high temperature, etc.

Other data books this month include the new *LCA Applications Handbook* from Monolithic Memories on hacker-programmable gate arrays; a *Smart Analog* data book from Crystal Semiconductor about their telephone chips and A/D converters; and a great book on *Analog Signal Processing Integrated Circuits* from Reticon.

There's a new trade journal out called *Personal Engineering* that you may want to try and qualify for. And Alcoswitch has a fat new catalog of all sorts of switches and similar hardware available.

Turning to my own products, if you are into the fundamentals of microprocessors and microcomputers, please check out my *Micro Cookbooks*, volumes I and II. I've got two new utility packages for those of you now using PostScript-speaking laser printers—one for hacker printed-circuit layouts and a second for creating two-point perspective drawings.

And, yes, we should soon have a complete set of *Hardware Hacker* reprints available, going all of the way back and including a master names and numbers section. Write or call if you are interested.

Let's hear from you....

R-E



Now do you agree that a voice-actuated garage-door opener doesn't make much sense?