Don Lancaster's

Hardware Hacker

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Epoxy encapsulation myths
Nichrome & resistance wire
Semiconductor suppliers III
FCC part 68 phone interface
Copy protection absurdities

History often repeats itself. First as a tragedy and then as a farce. It sure amazes me how many hardware hackers and software types refuse to learn from the past.

For instance, over a decade ago, the Apple II community conclusively proved beyond a shadow of a doubt that *copy protection does not work*.

Never did and never will.

Neither do the hardware dongles or similar add-ons. Yet many IBM and PC compatible folks are hell-bent on wasting new time, dollars, and energy reproving this fundamental truth to themselves. You will find only three known effects of copy protection: (A) It hacks off and inconveniences your legitimate users, sending them all to unlocked competitive products; (B) It diverts time and energy that is best spent improving and updating your code; And, of course, (C) Any copy protection dramatically *increases* the number of the bootleg copies of your product that get circulated.

The reason for C is simple. Copy protection *always* attracts attention to itself, causing scads of ultra-creative people to devote countless hours of time and energy towards cracking the secrets of your product.

Your bottom line is this: Undoing copy protection is *fun*! Not only is it challenging fun, it is by far the fastest and most cost effective way to learn machine language programming. And one of the best and the cheapest high quality learning experiences you will find anywhere ever.

Not to mention offering positively superb entertainment value.

On most hardware offerings, even grinding a part number off the key integrated circuit will have the exact opposite of the intended effect: All this does is cause lots of high energy people to puzzle out what the chip is and where to get one. The universal hacker popularity for that BA1404 stereo FM broadcaster can be directly traced to one firm stupidly grinding off one too many part numbers.

By far the most absurd notion on hardware copy protection to recently resurrect itself is to…

Pot it in epoxy!

I simply can't believe the number of calls and letters I've gotten on this lately. Back in the late 1950's, it was conclusively seen that potting your circuits in epoxy in no manner offers any design secrecy whatsoever. In fact, epoxy potting will *always* have the exact opposite effect.

First, any reasonably good design engineer could select a "black box" approach and carefully look at the inputs and the outputs of the circuit. From the circuit's size, cost, and from being aware of trade journals, data books, distributor's catalogs, and ap notes, they can easily come up with three or four methods to provide the same function.

At least one of which will end up far cheaper, better, and more creative than yours.

Second, it's a real trivial matter to X-ray any potted project. Free even, if it is a small module and you visit a reasonably curious dentist.

Third, most of the epoxy sources also supply *epoxy strippers*. These cheaply, rapidly, and conveniently dissolve out the potting compound, so it can be quickly washed away.

Fourth, epoxy could have several disruptive effects on your circuits. It changes the heat distribution and the operating temperatures. It can subtly

MATERIAL	RESISTIVITY measured in μΩ-cm	RESISTIVITY as compared to copper
Aluminum	2.8	1.64
Brass	7.0	4.07
Constantan	44.1	25.60
Copper	1.7	1.00
German Silver	33.0	19.18
Gold	2.4	1.42
Invar	81.0	47.00
Iron	10.0	5.81
Lead	22.0	12.79
Magnesium	4.6	2.67
Molybdenum	5.7	3.31
Music wire	11.8	6.86
Monel	42.0	24.40
Nichrome	150.0	87.20
Nickel	7.8	4.53
Platinum	10.0	5.81
Silver	1.6	0.95
Tantalum	15.5	9.01
Tin	11.5	6.69
Tungsten	5.5	3.20
Zinc	5.7	3.34

Fig. 1 – THE RESISTIVITY FOR ANY MATERIAL gets defined as the face-to-face electrical resistance of a unit cube. Here are several resistivity values for some of the more popular metals and alloys.

MATERIAL	10 gauge	20 gauge	30 gauge	40 gauge
Aluminum	2	17	169	1720
Brass	4	41	419	4260
Constantan	26	260	2640	26,800
Copper	1	10	103	1050
German Silver	19	194	1970	20,100
Gold	1	14	141	1480
Invar	47	477	4850	49,300
Iron	6	59	598	6080
Lead	13	130	1320	13,400
Magnesium	3	27	275	2800
Molybdenum	3	34	341	3470
Music wire	7	70	706	7180
Monel	24	247	2451	25,600
Nichrome	65	659	6750	70,240
Nickel	5	46	467	4750
Platinum	6	59	598	6080
Silver	1	10	98	991
Tantalum	9	91	928	9430
Tin	7	68	688	7002
Tungsten	3	32	330	3350
Zinc	3	33	344	3450

Values in milliohms per foot ~or~ Ohms per 1000 feet.

Fig. 2 – SOME TYPICAL RESISTANCE VALUES for different materials and wire gauges.

detune polystyrene capacitors. Its weight shifts mechanical resonances to more destructive frequencies.

Fifth, a very little known fact: The ferrite rf beads used on typical high frequency analog circuits *must* be able to change their size slightly or they will not work properly. The high frequency energy gets absorbed by a magnetostriction that in turn converts to heat. Locking ferrite beads in an epoxy can alter their response.

Used with care, there are times and places where the epoxy potting is an appropriate technique. Especially for water resistance or use in hazardous environments. But epoxy potting for copy protection just does not work.

Getting "Nichrome" wire

I've gotten several calls and letters recently wanting hacker sources for "Nichrome" wire. I'll show you some sources and alternates in just a bit. But please note that "Nichrome" is one particular brand of one particular formulation of what is more properly called *resistance wire*.

Most often, you'll want all of your electrical or electronic wires to be very efficient. And wasting as little energy and producing as little heat as possible. But there are other times and places when you want to cause a wire to intentionally generate heat or create a specific voltage drop.

Obvious examples include toasters, electric blankets, hot wire plastic or foam cutters, laminating machines, space heaters, soldering irons, motor starters, thermal relays, refrigerator defrosters, or for dummy transmitter loads. Some non-obvious places for carefully controlled resistance in wire format include current meter shunts and sensors that turn your printer on whenever you power your computer.

Most elements, alloys, and other materials group themselves into four types. *Conductors* can pass electricity fairly easily and have low resistances. Conductors can include both ordinary wire and resistance wire.

Semiconductors offer a moderately high resistance to electrical currents, with silicon and germanium being the most obvious examples. *Insulators* offer very high resistance to electrical current. Rubber, glass, plastics, and ceramics are typical insulators.

And, finally, the *Superconductors* can offer zero resistance to electrical currents. But all superconductors are restricted to exotic formulations and special conditions under extremely low temperatures. You'll find more on superconductors in the *Hardware Hacker II* reprints.

Take a one centimeter cube of any element, alloy, or material. Next, you apply a voltage from full face to the opposite full face. Then measure the current. By Ohm's Law, the ratio of the voltage to current determines the *resistance* of the cube. But we have a special name for the resistance of a unit cube. This is the *resistivity*, and is shown by ρ, the Greek letter *rho*.

The resistance of a wire increases with its length and will decrease in proportion to its area. The metric resistivity units are Ohm-centimeters^2 per centimeter, or Ohm-centimeters. I'll use a wondrously oddball unit of *microOhm-centimeters* (μΩ-cm) here so our numbers look nicer.

Resistivity values let us compare materials *independent of their actual sizes*. Some popular resistivity values are shown in figure one, while figure two shows you how much resistance you can expect for various wire sizes of selected materials.

The lowest resistivity of common elements or alloys is silver, checking in at 1.6 μΩ-cm. But silver is fairly rare and readily tarnishes, and the commodity price of silver changes all over the lot. So, silver isn't used too much except for RFI suppression and exotic military stuff.

Copper, of course, is the universal best choice in a conductor. It has a resistivity of a mere 1.7 μΩ-cm. Only five percent worse than silver.

At first glance, aluminum appears almost as good as copper, having a conductivity only 64 percent worse. In theory, the thicker but cheaper and

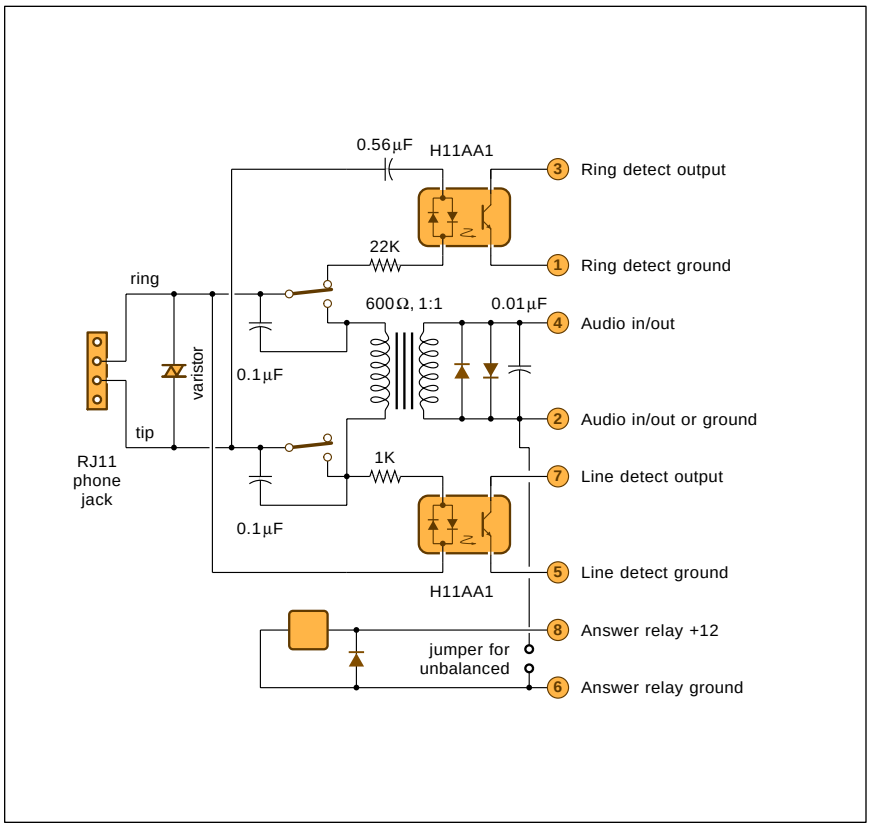

Fig. 3 – THE CIRCUITWERKES MPC-2 is a FCC Part 68 telephone interface that offers a "pass through" type approval for your own hacker projects.

lighter aluminum conductors could be substituted.

But aluminum has a pair of nasty habits which include electrochemical decomposition and the building up of sapphire hard (literally!) tough oxide coatings. Making a solid connection to an aluminum wire is not a trivial task. Several decades ago, a bunch of house trailers burned up after some abortive attempts at trying to perfect aluminum wiring.

Most of the other popular elements and alloys have resistivities that are moderately higher than copper. But a magic alloy of 61 percent nickel, 24 percent iron, and 15 percent chrome provides a resistivity over fifty times higher than copper. When combined with its other useful properties, this *Nichrome* alloy makes an outstanding resistance wire.

Figure two shows you how much resistance to expect for various wire sizes for each of these materials. A foot of 20 gauge Nichrome wire has a resistance of 0.659 ohms. The same alloy in 30 gauge provides around 6.75 ohms total.

Resistance wire gets measured in ohms per thousand feet. Or you may prefer its equivalent of milliohms per foot. Naturally, resistance wire works just like any other resistor, obeying Ohm's law and the usual…

$$P = E^2/R$$

power relations. A watt of electricity is, of course, a watt of heat. And a BTU of heat equals 17.58 watts. So you can easily calculate the amount of heat you should generate. As a reminder, a BTU or *British Thermal Unit* is the amount of heat needed to raise the temperature of one pound of water by one degree Farenheit.

Other resistance wire parameters do include the tensile strength, the temperature coefficient of resistance, and the temperature coefficient of expansion. The resistance tempco gets important fast in such things as meter shunts. The expansion tempco becomes crucial when you are going through some ceramic seal. Should the wire and the ceramic expand at

SEMICONDUCTOR RESOURCES, PART III

OKI Semiconductor
785 N Mary Avenue
Sunnyvale, CA 94086
(800) 832-6654

Panasonic
1 Panasonic Way
Secaucus, NJ 07094
(201) 348-7000

Plessey Semiconductor
PO Box 660017
Scotts Valley, CA 95067
(408) 438-2900

Raytheon Semiconductor
350 Ellis Street
Mountain View, CA 94039
(415) 968-9211

Rockwell International
4311 Jamboree Road, box C
Newport Beach, CA 92658
(714) 833-4600

ROHM Corporation
3034 Owen Drive
Antioch, TN 37013
(615) 641-2020

Samsung Semiconductor
3725 North First Street
San Jose, CA 95134
(408) 435-5400

Sanyo
80 Commerce Drive
Allendale, NJ 07401
(201) 825-8080

SEEQ Technology
47131 Bayside Pkwy
Fremont, CA 94537
(510) 226-7400

Seiko Instruments
2990 West Lomita Blvd
Torrance, CA 90505
(310) 517-7770

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

Sharp Electronics
10 Sharp Plaza
Mahwah, NJ 07430
(201) 529-8757

Siemens Components
2191 Laurelwood Road
Santa Clara, CA 95054
(408) 980-4568

Sierra Semiconductor
2075 N Capitol Avenue
San Jose, CA 95132
(408) 263-9300

Signetics
811 East Arques Avenue
Sunnyvale, CA 94088
(800) 227-1817

Silicon General
11861 Western Avenue
Garden Grove, CA 92641
(714) 898-8121

Siliconix
2201 Laurelwood Road
Santa Clara, CA 95054
(800) 554-5565

Sony Corporation
10833 Valley View Street
Cypress, CA 90630
(714) 220-9100

Standard Microsystems
80 Arkay Drive
Hauppauge, NY 11787
(516) 273-3100

Stanford Telecommunications
2421 Mission College Blvd
Santa Clara, CA 95056
(408) 748-1010

Tektronix
PO Box 500
Beaverton, OR 97077
(800) 835-9433

Teledyne Components
1300 Terra Bella Avenue
Mountain View, CA 94043
(415) 968-9241

Teltone
22121 20th Avenue SE
Bothel, WA 98021
(800) 426-3926

Teccor Electronics
1801 Hurd Drive
Irving, TX 75038
(214) 580-1515

Texas Instruments
PO Box 401560
Dallas, TX 75240
(800) 336-5236

Toshiba America
9775 Toledo Way
Irvine, CA 92718
(714) 455-2000

Unitrode Integrated Circuits
7 Continental Blvd
Merrimack, NH 03054
(603) 424-2410

Western Design Center
2166 East Brown Road
Mesa, AZ 85213
(602) 962-4545

Xicor
1511 Buckeye Drive
Milpitas, CA 95035
(408) 432-8888

Zilog
210 Hacienda Avenue
Campbell, CA 95008
(408) 370-8000

different rates, you can self destruct at high temperatures.

The fastest and simplest way to get some Nichrome wire to play with is to gently crush up a surplus power resistor in a vise and unwind the wire. Different sizes offer different lengths and gauges of wire. Resistance wire often ends up available surplus at bargain prices, especially at *Fair Radio Sales*. *American Science and Surplus* also offers cheap resistance wires. Originally used as refrigerator defroster elements.

One big supplier of new resistance wire is *MWS Wire Industries*. Their equivalent to "Nichrome" is known as MWS-675. They also offer two dozen other variations. Their MWS-875 provides even higher resistivity with better tempcos for both resistance and expansion. This alloy uses chrome, aluminum, and iron, with traces of added carbon and silicon. It is also slightly lighter in weight.

By the way, other trade names for *Nichrome* are *Trophet C*, *Alloy C*, *HAI-NiCr60*, *Chromel C*, *Nikrothal 6*, and *Electroloy*.

For this month's contest, just tell me about a new or unusual hacker use for resistance wire. There'll be all of the normal *Incredible Secret Money Machine II* book prizes, along with an all expense paid (FOB Thatcher, AZ) *tinaja quest* for two going to the best submission of all.

As usual, send your written entries to me here at *Synergetics* and not to **Electronics Now** editorial.

A hacker's part 68 telephone interface

In several past columns, we have looked at the FCC *part 68 Interfaces*. These are required any time you want to put voice, music, caller id data, or modem tones on or off of the phone line. The key component needed is just a fancy transformer with a high isolation voltage rating, a very good balance, and the ability to accept dc primary current.

There are lots of dollars, time, and effort needed to get an interface FCC type approved. And *it is now illegal to make any connection to the phone line without going through an FCC approved Part 68 interface*. At least in the US.

Several firms now offer "pass thru"

interfaces that you can include within your own circuits to get an instant and automatic type approval. The two major suppliers are now *Cermetek* and *Dallas Semiconductor*. Sadly, their pricing has been too high for most hacker uses.

A startup outfit by the name of *CircuitWerkes* is now offering a new and hacker friendly Part 68 interface at a user acceptable price of $29.95. And yes, it offers a full type approval pass thru. Subject only to a few easy rules that involve component spacing, labels, docs, and mods.

Figure three shows you the circuit.

A small relay decides the *on-hook* and the *off-hook* states. To "sieze" or "answer" the line, you apply 12 volts dc to the relay, providing 60 mils.

The ring detector circuit is active only when on hook. This consists of a optoisolator that responds to the high ac ringing voltage, typically 140 volts at a frequency of 28 to 40 Hertz. The output of the ring detector is an open collector. You'll have to provide both an external pullup resistor and a filter capacitor to ground. Suitable values are 12 K and 5 microfarads.

The main data path is active both on and off hook. This dual feature is needed for a caller id compatibility. When you are on hook, the data path is capacitor coupled.

When off hook, the data path gets dc coupled through the transformer primary. A second optoisolator in parallel with the primary acts as a line current detector. The line current gets detected by monitoring your dc *voltage* drop across the primary.

The line current detection lets you know when your calling party hangs up. This optoisolator also offers open collector output. A pullup resistor is also required here.

The main data path is just a special transformer with two clipping diodes to limit your maximum applied audio. A jumper option allows you to select a balanced or single ended 600 ohm source/sink for your audio.

Typically, your computer will first monitor the ring detector. After a ring, it siezes the line and optionally grabs the caller id tones. Then it will send or receive your voice or data. Finally, you can hang up by dropping out the relay. Either by detecting the absence of line current or by hanging up on purpose.

As a second contest for this month, just tell me about a new or unusual application for a hacker legal Part 68 interface project.

Much more info on those caller id applications appears in a dozen files on my *Guru's Lair* website.

More semiconductor resources

We will wrap up our continuing listing of the major semiconductor houses in a third and final sidebar.

This month, we will cover *OKI* up through *Zilog*. I've tried to zero in on those suppliers of the greatest hacker interest. Let me know if I missed any of your favorites.

A complete list will appear in the *Hardware Hacker IV* reprints.

As we have seen before, your best bet here is to request a short form catalog, the price list, and a literature directory. Be absolutely sure to use professionally sounding phone calls or your own custom PostScript laser letterhead. A ball-point-pen on tablet paper flat out won't hack it. Much more on finding and using tech info are in my newly revised *Incredible Secret Money Machine II*.

New tech lit

We have got some really exciting new publications for this month. The first is Dick Oliver's new *Nonlinear Nonsense*, a free quarterly newsletter on fractal modeling, chaos science, artifical life, and creative graphics. His 3-D fractal design software is also commercially offered.

Also free on professional request is the new *Spread Spectrum Handbook* from *Stanford Telecomm*. This is a dozen pages of ap-notes and useful references, along with bunches of data sheets for their high-end digital spread spectrum chips.

The *Scrambling News* has detailed insider information on the current tv video scrambling and descrambling methods. They also offer books full

NAMES AND NUMBERS

American Science & Surplus
601 Linden Place
Evanston, IL 60202
(708) 475-8440

Cermetek
1308 Borregas Avenue
Sunnyvale, CA 94089
(408) 752-5000

CircuitWerkes
6212 Southwest 8th Place
Gainesville, FL 32607
(904) 331-5999

Dallas Semiconductor
4401 Beltwood Pkwy South
Dallas, TX 75244
(214) 450-0400

Fair Radio Sales
PO Box 1105
Lima, OH 45802
(419) 227-6573

GEnie
401 N Washington Street
Rockville, MD 20850
(800) 638-9636

Lor'd Industries Limited
Box 156
Hancock, WI 54943
(715) 249-5611

MWS Wire Industries
31200 Cedar Valley Drive
Westlake Village, CA 91362
(818) 991-8553

Nonlinear Nonsense
Route 1 Box 5140
Morrisville, VT 05661
(802) 888-5275

Printer's Devil
PO Box 66
Harrison, ID 83833
(208) 689-3738

Satellite Watch News
6599 Commerce Court, #103
Gainesville, VA 22065
(703) 347-7926

Scrambling News
1552 Hertel Avenue
Buffalo, NY 14216
(716) 874-2088

SRS Encoder
PO Box 30668
Seattle, WA 98103
(206) 362-5267 [E-mail]

Stanford Telecomm
2421 Mission College Blvd
Santa Clara, CA 95054
(408) 748-1010

of schematics, mods and related tech info. A competing newsletter is the *Satellite Watch News*.

The *SRS Encoder* is a new monthly newsletter from the *Seattle Robotics Society*. Lots of regional info on great surplus buys here.

And Joe Singers *Printer's Devil* is a superb alternative publication on home printing and presswork. "A press in every home; a home in every press." Quarterly at a bargain $10 per year sub price.

Finally, the *New Age Alternatives Discount Catalog* is another resource for pseudoscience devices and info. Fascinating reading fer sure. This one is offered by *Lor'd Industries*.

We've previously seen that *High Energy Enterprises* and *Borderland Sciences* are additonal pseudoscience supply houses. It sould would be interesting to put together a master directory for all of these. Again, I feel they make some absolutely incredible reading. Some of the locals around here actually believe in all this stuff. And, amazingly, it does seem to work for them. Or so they claim.

For now, though, I'll stick with my "Looks like a duck, quacks like a duck" filter. Boy, a whole flock of 'em flew over that time.

Misquoting Sagan, extra-ordinary claims always demand extra-ordinary evidence. Most especially when any known physical laws are flagrantly violated. An independently testable and fully reproducible experiment is always the key you should watch for.

A reminder here that I have got reprints available for most of my columns. Both in *Book-on-demand* published hard copy and on line at *www.tinaja.com* Titles now include my *Ask the Guru*, *Hardware Hacker*, the *Blatant Opportunist*, *LaserWriter Secrets* and the new *Resource Bin*. Check my nearby *Synergetics* ad for more details.

As usual, I have gathered most of the mentioned resources together into both of our *Names and Numbers* and the *Semiconductor Manufacturer's III* sidebars. Do be sure to look here first. Also as usual, you can get tech help, consultant referrals, and lots of off-the-wall networking by calling my tech helpline.

Let's hear from you. There's some great new opportunities here. ✦

NEED HELP?

Phone or write all your US Tech Musings questions to:

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