

Direct Toner Printed Circuits

What if they gave a revolution and nobody came? There is a ridiculously simple and a decades-old process for quickly and cheaply making higher quality printed circuit board prototypes. In minutes and for pennies, even on your kitchen table. Using no darkroom, zero photo work, and few exotic supplies.

The only tiny gotcha is that not all of the bits and pieces have yet gotten put together into a single coherent and easy-to-use pile. If you are the type of *Midnight Engineer* who, instead of using the white or black keys, likes to play in the cracks, then this opportunity is for you.

I call this process *The Direct Toner Printed Circuit Method*. Figure one shows details. But first, a review of...

The Old Way

A printed circuit, of course, is that flat thing that all the electronic bugs sit on. The purpose of a printed circuit board is to support and interconnect most of the individual components and integrated circuit bugs.

Traditionally, most printed circuit prototypes are usually made by an exotic and painful multi-step process. You will first create an accurate oversize electronic artwork for your circuit and lettering patterns. This gets done at a 2:1 for commercial products or 4:1 for the military. You'll then photoreduce into a dense *litho* negative.

After that, you can use the litho negative to cut a silk screen and then screen an *etch resistant* onto a thin sheet of fiberglass or other insulator that has a thin copper foil bonded to one or both of its sides. You then eat away the copper by using a warm and usually sprayed etchant such as sodium persulfate. In several minutes, all of the copper not protected by the resist dissolves, leaving you with your circuit and connector patterns. The finishing operations usually come next. Such as drilling, solder masking, silk screening ink callouts or plating connectors.

For more precise needs, a liquid or a dry film photo resist first gets applied to the printed circuit board and then is exposed directly through your litho negative. During the development, portions of the photoresist will harden and others will wash away, leaving you with a resist pattern on the board. The photo method boards can be predrilled if plated-through holes are needed.

My favorite source for classic printed circuit materials, etchants, and and such in small quantities is Kepro. Two leading silk screen suppliers are those *Advance Process* and *Southern Sign* folks. Ads for products appear in such free industry trade journals as *Electronic Packaging*, *Circuits*

Manufacturing, or in the *Surface Mount Technology* mag.

A pc service house typically charges \$100 or even more for five identical prototype boards. Delivery could take the better part of a month unless you pay a stiff premium. But except for a few details that need improved on, you can do the same thing in minutes for pennies by using...

The Direct Toner Method

There are two little known secrets behind the direct toner method. The first secret is that laser printer toner makes an excellent etch resist. Which really is not all that surprising, since toner has polyethylene in it.

In the late 1960's, Xerox foisted off some unbelievably klutzy archaic first generation copier trade-ins onto some rather gullible aerospace firms as pc prototyping systems. Your bare boards became electrostatically charged in a pattern as set by a positive fixed 2:1 artwork. The boards got heated, leaving a fused etch-ready toner pattern.

While incredibly cumbersome, the machines did work. Or at least well enough to prove that properly fused toner put on a well cleaned board made a great etch resist.

The second big secret is that most *PostScript* speaking laser printers can directly produce acceptable quality 1:1 printed circuit artwork to reasonable accuracies. That *PostScript* language can also instantly convert between 1:1, 2:1, or 4:1 formats, and do so as positive or negative, frontwards or reversed. With no photo work at all.

In addition, *PostScript* can easily pretend it is a plotter by use of a *HPGL* emulator. Thus, *PostScript* printers are *totally* compatible with *all* the previous plotter-oriented pc layout software. But, all you really need for a circuit layout with *PostScript* is a plain old word processor.

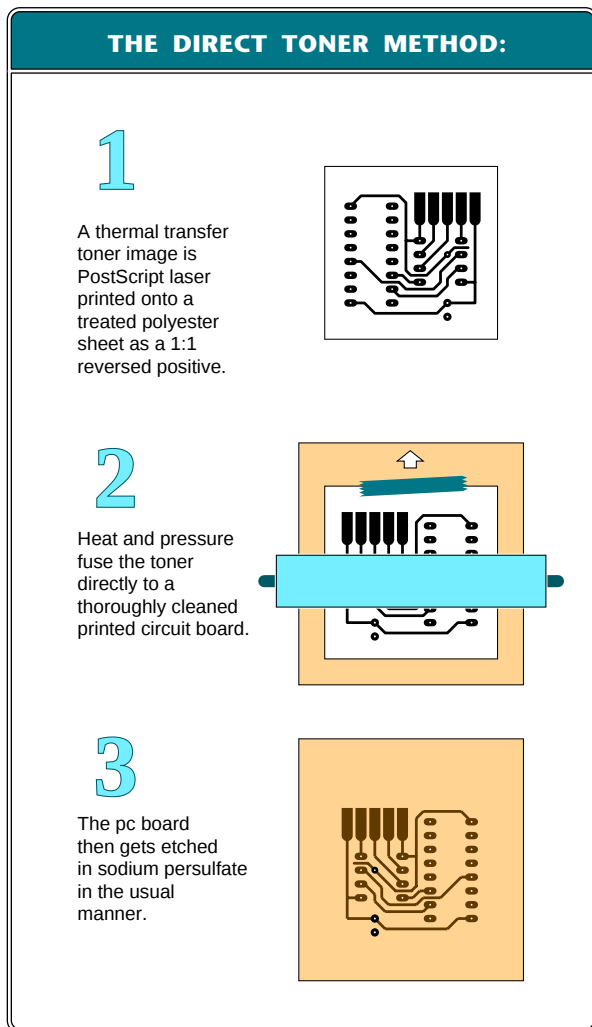
PostScript is also really great for downloading top quality pc artwork from the web.

For scads more on *PostScript*, see my *Synergetics* ad or drop in on my www.tinaja.com Or get those "red" and "blue" books from *Adobe Systems*. An early *PostScript* pc layout package is now included in my *PostScript Show and Tell* demo and test diskettes.

With the direct toner method, you first use *PostScript* to create a toner image on a transfer sheet. After that, you transfer the toner directly to a clean printed circuit board.

Finally, you do your etch. Spray or bubble at 120 degrees Fahrenheit is often best.

Thus, *PostScript* seems nearly ideal for generating toner patterns. And toner, once on your printed circuit board makes an excellent etch resist. Which leaves us with...



The Only Little Problem

The whole trick is to get the toner out of your PostScript printer and then reliably fused onto the printed circuit board. Every time, defect free.

While there's bits and pieces that sort of do the job, there are flat out too many variables to let you consistently get acceptable results.

It is unlikely that you'll be able to directly feed an actual circuit board into a stock or slightly modified laser printer in the near future. The copper conductors usually give the electrostatics fits, and those paper paths simply cannot handle thick rigid materials. So it looks like some transfer scheme will make a lot more sense.

What is needed instead is a fully integrated system of the printer, toner, transfer medium, bonding process, and annealing. In short, you want to get rid of surprises by making sure everything will work well together...

The printer – In the interests of sanity, it seems best to standardize on the Canon SX engine. This one is used in the Hewlett-Packard LaserJets, the Apple LaserWriters, and many of those great QMS machines. Simply letting your customers use "any old copier" is a near certain invitation for disaster and disappointment.

On those SX engines, it does seem like a good idea to temporarily use a "dry" fuser wiper pad before and during any actual transfer work. This leaves any silicon fuser oil residue out of your transfer process. With reasonable care, occasional use of a dry felt shouldn't harm the fuser.

The transfer medium – What you will require here is something that toner only loosely sticks to. Not too tight or it will not transfer fully to the pc board. And not too loose that it falls off. And, of course, dimensionally stable.

A product called TEC-200 film is sold by both Gateway Electronics and Meadowlake kinda works some of the time. This film appears to be a mylar with a silicone overcoat.

I've also had some luck using a Kapton film from Dupont that has the #136 high temperature mold release from Miller-Stevenson sprayed onto it. And it might end up that something really off the wall will work. Like the brand new Reynolds Wrap microwave paper, or possibly even a magician's water soluble paper.

The toners – It seems to me that the toner used has to be exactly matched to the transfer media. Stuff that nearly works does include a good grade of graphics toner from Don Thompson or Static Control Products.

But none of these products is a clear optimum. Once again, someone that can play with both toner formulations and compatible transfer materials will end up the big winner here. Reliability and reproducibility are the keys.

Two good sources for transfer sheet ideas are *Converting and Paper, Film, and Foil Converter* magazines.

UPDATE: Much better transfer products are available from DynaArt or Techniks.

The transfer machine – Sorry, but an iron simply will not hack it. Heated power transfer rollers that can sharply and adjustably raise the temperature to the 340 degree range, hold for a second, and then sharply drop are needed.

Although Kroy Color or Omnicrom machines can do the job, they are outrageously overpriced. Low cost surplus variants are getting scarce.

While fairly cheap laminators are available through USI, these do use a heated plate instead of heated rollers and don't seem to get nearly hot enough.

Actually, a general purpose sanely priced and adjustable heated roller machine would have lots of different uses. Including both the traditional dry film and the new direct toner printed circuits, Kroy Color, general thick or thin laminating, and even Bakerizing. The latter is a zero cost and virtually unknown (despite my screaming it from the rooftops) process that makes toner shiny and durable.

The transfer process – Your actual transfer environment needs improved and standardized. The pc board must be three stages beyond clean. After a thorough and chemical cleaning that lets water flow in an unbroken stream across the board, a ten second or so pre-etch is recommended to give a "tooth" for the toner. Properly cleaned copper is not copper colored at all. It is instead a hot pink.

It seems like a good idea to preheat your copper clad at least up into the 160 degree range to prevent it acting like a giant heat sink and source of thermal shock.

Finally, some sort of post heating or annealing seems like a good idea. Too little and pinholes and rough edges might remain. Too much and you get blobbing. But just right,

DIRECT TONER SOURCES

Adobe Systems

1585 Charleston Road
Mountain View CA 94039
(800) 833-6687

Advance Process Supply

400 North Noble Street
Chicago, IL 60622
(312) 829-1400

Circuits Manufacturing

500 Howard Sreet
San Francisco, CA 94105
(415) 397-1881

Converting

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Morris Plains NJ 07950
(201) 292-5100

DuPont Riston

8 Pasteur Drive #100
Irvine CA 92713
(708) 635-8800

DynaArt Designs

4707 140th Avenue N #212
Clearwater FL 34622
(813) 524-1500

Electronic Packaging

1350 E. Touhy Avenue
Des Plaines, IL 60018
(312) 635-8800

Gateway Electronics

8123 Page Blvd.
St. Louis, MO 63130
(800) 669-5810

Kepron Circuit Systems

640 Scarlet Creet Blvd
St Louis MO 63122
(800) 325-3878

Kroy Color

14555 N. Hayden Road
Scottsdale AZ 85260
(602) 951-1593

Meadowlake

Box 497
Northport, NY 11768
(516) 757-3385

Miller-Stephenson

Box 950
Danbury, CT 06813
(203) 743-4447

Paper & Foil Converter

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Chicago IL 60606
(312) 726-2802

Southern Sign Supply

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Glen Burnie, MD 21061
(301) 768-8600

Static Control Components

3115 H Silver Drive
Sanford NC 27331
(800) 488-2424

Surface Mount Technology

17730 W. Peterson Road
Libertyville, IL 60048
(312) 362-8711

Synergetics

Box 809
Thatcher, AZ 85552
(520) 428-4073

Techniks Inc

45J Ringo Road
Ringoes NJ 08551
(908) 788-8249

Don Thompson

20650 Prairie Street
Chatsworth CA 91311
(800) 423-5400 X2537

USI

PO Box 644
Branford, CT 06405
(800) 243-4565

and the polyethylene should just barely remelt into a solid and a well-bonded mass. Possibly a final Bakerizing pass could also be of help here.

And so...

Well, there you have the essentials of the process. Toner makes great etch resist and PostScript makes setting up the resist patterns trivially easy. Which can lead to instant and nearly free printed circuit prototypes by just about anyone anywhere. But bunches of playing around still is required to optimize your toner, exchange media, and transfer.

Remember that your main goal must be to get consistent results by using standard laser printers and minimum cost transfer tools or machinery. A process that nearly anyone can afford and personally use. ♦

Microcomputer pioneer and guru Don Lancaster is the author of 35 books and countless articles. Don maintains a US technical helpline you'll find at (520) 428-4073, besides offering all his own books, reprints and consulting services.

Don has a free new catalog crammed full of his latest insider secrets waiting for you. Your best calling times are 8-5 weekdays, Mountain Standard Time.

Don is also the webmaster of www.tinaja.com You can also reach Don at Synergetics, Box 809, Thatcher, AZ 85552. Or you can use email via don@tinaja.com

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