Don Lancaster's
Tech Musings

October, 1996

I recently got a helpline call from someone who strongly feels they have once and for all solved the cellular phone fraud problem. By use of his elegant system software modification. The question was how to profitably market the concept.

Well, maybe. Maybe not.

Without a closer look, the chances are that this caller's simple solution would only further escalate the cell wars a notch. If it did not have any obvious or hidden flaws.

But that's not the problem.

The problem is that certain things can be sold by small scale startups or independent individuals. While some can not. It seems to me there's three key questions you should ask:

Are you an industry insider? Do you aggressively subscribe to *all* the field's trade journals, read its books, attend its shows, and network with its experts? Do you thoroughly grok the fundamental technical and marketing principle of the industry?

If not, the odds are overwhelming that you're developing a non-solution to a non-problem. You probably do not possess the skills or the tools to even understand the *real* problem, let alone correct it. And that the gotchas here are certain to git ya.

Does the field welcome innovation? Areas that are highly regulated, have complex infrastructure, are controlled from a solidly entrenched oligopoly. Areas where major changes have to happen for your concept to fly. Fields lawyers have eaten for lunch. Any and all of these are not reasonable places for you to be spending your time and effort.

Can you sell six of them? Your best concepts are those you can sell to real people. Who have real wallets in their back pocket. Having real VISA cards in them. If you cannot sell a few of your designs to your friends, there is no way you will ever sell lots of them to your enemies.

Some ferinstances: If reasonably priced, your improved laptop battery would be instantly gobbled up as a sure fire winner. But that very same battery technology for an electric car is pretty near certain to get ruthlessly stomped upon.

A new personal airplane design is *guaranteed* to bankrupt you. Every time. But a variant sold as a quarter sized R/C model kit could be a very popular product. Especially when it doubles as a video platform.

Or more to the point: A snap-on accessory that an end user can attach to their phone to eliminate cellular fraud is workable. But fundamental changes in the cellular standards and distribution are not.

At least not for most small scale startups or outside individuals.

Yeah, it's real difficult not to get excited about a new concept. Long ago, I've had low pressure pneumatic robotics gobble up all sorts of time and resources. My magic sinewave development is currently using as much as twenty hours a day.

Thus, it is real hard to focus on stuff that is technically challenging *and* still marketable by a small scale startup. But asking these fundamental questions ahead of time can save you lots of hours and grief.

And lets you focus your time and energy in better directions.

Much more on all this in my *Case Against Patents* package. And also in WHEN2PAT.PDF on *www.tinaja.com* And, of course, also in my *Incredible Secret Money Machine*.

Digital Filter Intro

Most books on digital filters seem excessively and unnecessarily arcane to me. Let's try a totally different and off-the-wall approach instead.

A *filter* is just some frequency selective network. Designed to favor certain frequencies over the others. Usually to isolate a desired signal or to improve the signal-to-noise ratio of a system. The *treble* control on your hifi is a *lowpass filter.* A *bass* control is a *highpass filter.* AM radio tuning uses a *bandpass filter.*

Traditional filters were built with capacitors and inductors. Many of these have long ago gotten replaced with *active filters*. Combinations of resistors, capacitors, and opamps that exactly fake inductors. But without needing any real coils. More details in my *Active Filter Cookbook.*

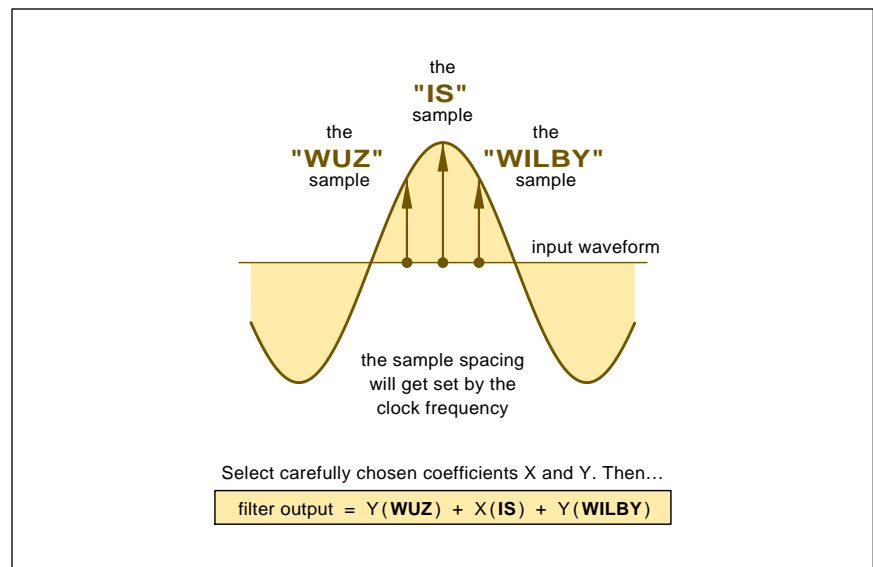Instead, a *digital filter* takes an existing pile of numbers. It then runs

Fig. 1 – THE "TRISAMP" is a useful building block. One which can let you understand, design, test, debug, and apply digital filters.

the registers get stacked as
deep as required for the
input word size in use

sample clock

filter input

the **"WILBY"** sample

the **"IS"** sample

the **"WUZ"** sample

Y coeff input
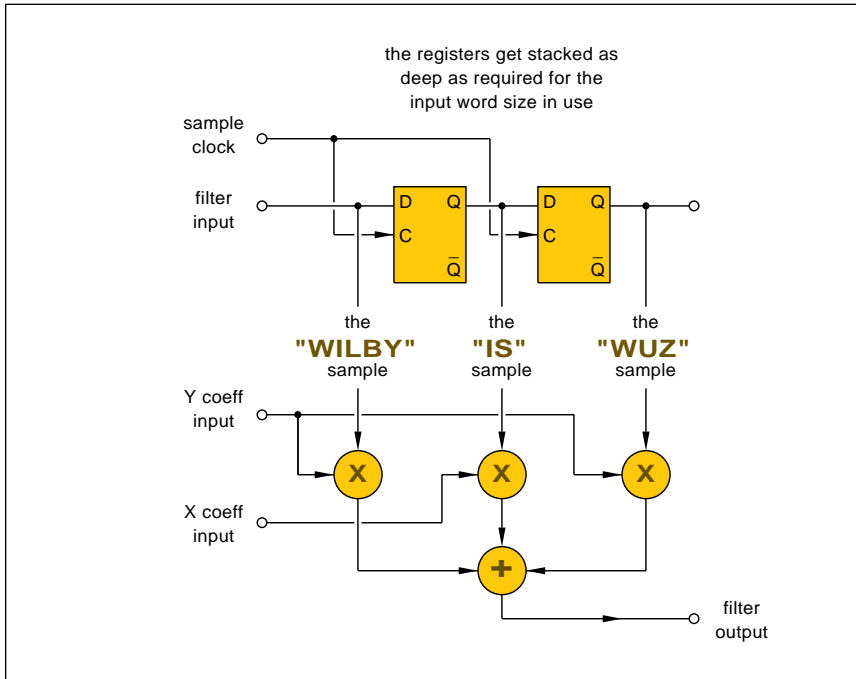
X coeff input

filter output

Fig. 2 – DIGITAL FILTERS can be much more powerful than analog ones because they can look both forward and backward in time. The need for a time machine gets avoided by using the shift register scheme shown here.

multiply-and-add calculations upon those numbers to create a new pile of numbers. The behavior of the new pile of numbers will hopefully be "better" in some way or another.

For instance, a stream of digital video can become digitally highpass filtered to improve its sharpness. Or lowpass filtered for softening. Or to eliminate slanted "jaggies".

Plus and Minus

There are bunches of advantages to digital filters. First and foremost, a well designed digital filter is always "correct" and never needs "tuning". A digital filter might easily be adjusted by using software. Over an incredibly wide range. They can often be swept without any nasty transients.

Or changed entirely.

Special circuitry could be totally eliminated if the digital filtering gets done inside a stock microprocessor. Or a DSP digital signal processor.

Best of all, the digital filter can do certain tasks that end up difficult or impossible when using classic analog designs. Mostly because the digital filter could travel both *forward* and *backward* in time! Where a capacitor or inductor cannot react to currents or voltages yet to happen.

Examples here include *brick wall* filters with extremely sharp cutoffs. Or *linear phase* filters that attenuate a waveform's harmonics without any time shifting distortion.

There are also disadvantages and limitations to digital filters. While a lot simpler than some may have you believe, these have been rather hard to understand in the past.

You do already have to have your pile of numbers before you can filter them. Thus, A/D and D/A conversion might be needed in your system.

There is a really ugly property of digital filters called *aliasing*. If you sample any waveform less than *twice* per cycle, you might "fold over" and generate lower frequency noise and artifacts. Very rarely, aliasing can be a valuable tool. One that lets you do digital mixing, downsampling, or a downconversion. But far more often, aliasing is a major nusiance that *must* be dealt with by prefiltering.

sample clock frequency = 72.00

X = 1.00 Y = 0.00

X = 0.50 Y = - 0.25

X = 0.14 Y = 0.43

X = 0.33 Y = 0.33
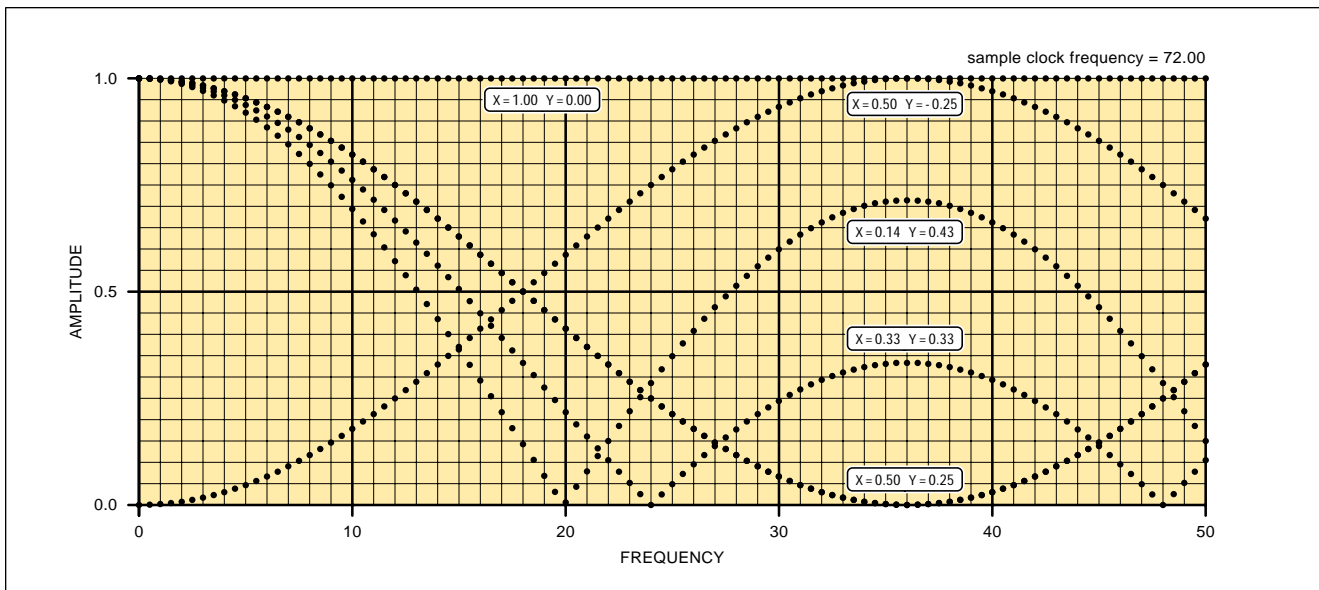
X = 0.50 Y = 0.25

AMPLITUDE

FREQUENCY

Fig. 3 – HOW A TRISAMP'S FREQUENCY RESPONSE varies when its X and Y coefficients are changed.

A rule: *Input signals to a digital filter must get prefiltered so that zero energy exists above one-half of your sample frequency!*

Unless you have some really good reason to be doing otherwise.

The *dynamic range* of any digital filter is limited by several factors. These include your input and output *word sizes*, *truncation errors* and any *roundoff errors*.

Because you are often adding up very small differences between large values, the *internal* word size usually has to be much larger than that of the input or output.

Thus, digital filters are much more suited to larger input signals than to very small ones.

Simpler digital filters apply integer math or *fixed point* arithmetic. These are faster and easier to implement but have reduced dynamic range.

Exotic digital filters can use a full *floating point* processing for all their math. While more accurate, floating point filters often run much slower. Either restricting the maximum input frequency. Or forcing you to move to *non real time* applications.

Finally, if your filter only works with a small number of samples, you might get into some ugly *windowing* problems. Sort of the same as that difference between the transient and steady state responses on a classic

```
%  PostScript triple cascaded trisamp digital filter designer v 2.04

%  Copyright c 1996 by Don Lancaster and Synergetics, Box 809, Thatcher, AZ
%  85552 (520) 428-4073 http://www.tinaja.com  All commercial rights and all
%  electronic media rights are fully reserved. Reposting is expressly forbidden.

%  For best results, improve with Guru Gonzo PostScript utilities. Enhanced and
%  fully annotated version available as TRISAMP.PS on www.tinaja.com

% draw a graph:
110 350 translate 8 dup scale 0.03 setlinewidth 1 setlinecap gsave 0 0 moveto 51 {0 0
moveto 0 20 rlineto 1 0 translate} repeat stroke grestore gsave 0 0 moveto 21 {0 0
moveto 50 0 rlineto 0 1 translate} repeat stroke grestore 0.12  setlinewidth gsave 3 {
-0.5 0 moveto 50.5 0 rlineto 0 10 translate} repeat stroke grestore gsave 6 { 0 -0.5
moveto 0 20.5 rlineto 10 0 translate} repeat stroke grestore

/dot { newpath 0.150 0 360 arc fill } def      % dot utility

/tripletrisamp {0 0.5 50 {/freq exch store 180 freq mul sampfreq 2 div div cos coeffB mul
2 mul coeffA add /firsthold exch store firsthold abs 20 mul freq exch dot 180 freq mul
sampfreq 2 div div cos coeffD mul 2 mul coeffC add /secondhold exch store secondhold
abs 20 mul freq exch dot 180 freq mul sampfreq 2 div div cos coeffF mul 2 mul coeffE
add coeffC coeffD 2 mul add div /thirdhold exch store thirdhold abs 20 mul freq exch dot
firsthold secondhold mul thirdhold mul abs 20 mul freq exch dot} for} def

%  ///// demo - remove or alter before reuse. /////

/sampfreq 72 def                         % set sample clock frequency

/coeffA 2.0 4 div def                     % center of first trisamp
/coeffB 1.0 4 div def                     % pair
/coeffC 1.0 3 div def                     % center of second trisamp
/coeffD 1.0 3 div def                     % pair
/coeffE 1.0 7 div def                     % center of third trisamp
/coeffF 3.0 7 div def                     % pair

tripletrisamp showpage quit               % do it and flaunt it
```

Fig. 5 – POSTSCRIPT TRIPLE TRISAMP exploration utility can easily make you an instant digital filter design expert. This code is easily expanded.

analog network. Softening the edges of a window or making sure that the edges happen where they don't cause problems are two possible cures.

Watch this windowing detail or it will nail you every time.

Trisamp Building Blocks

My approach in the *Active Filter Cookbook* was to use a basic analog building block called a *second order section*. No matter how exotic your
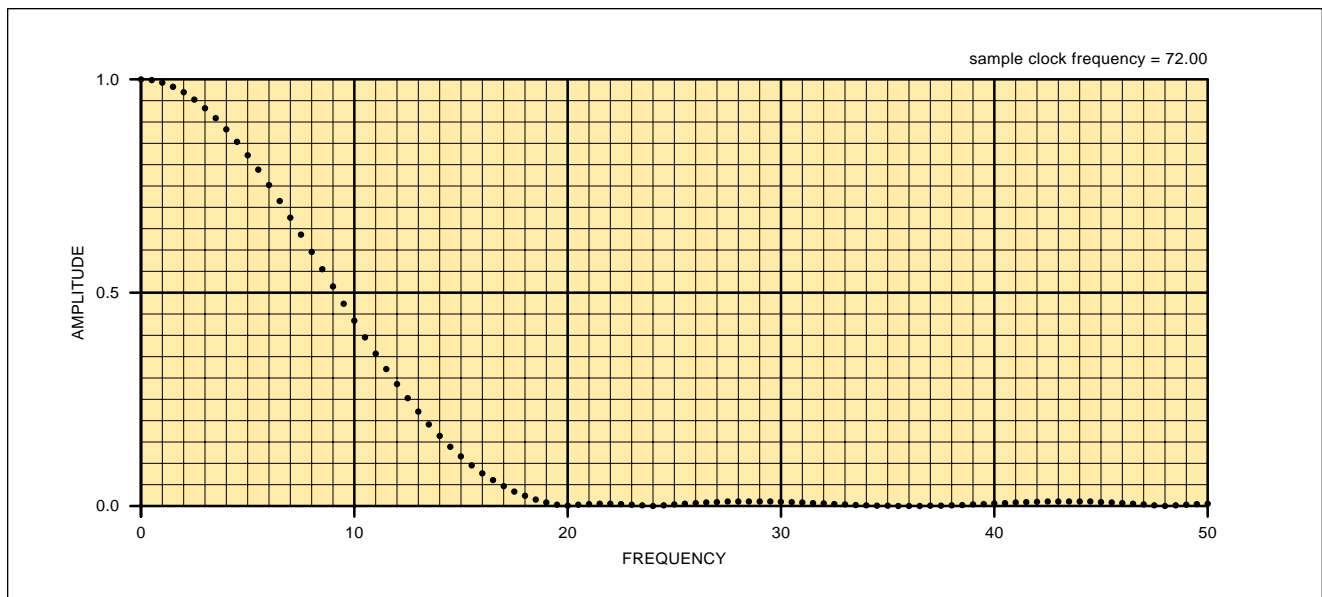

Fig. 4 – A LOWPASS FILTER built by cascading three trisamps. This is a "distortionless" or linear phase filter that is extremely difficult to build using older analog techniques. To simplify your final design, ordinary algebra easily reduces three cascaded trisamps into a single seven sample "septsamp". Additional samples improve response shape.

filter response, all you really ended up with was a pile of these cascaded sections. And each section only had two possible adjustments: The *cutoff frequency* and its *damping*.

Let's try something similar here. As figure one shows us, I'll call our basic building block a *trisamp*. Just as you can use and cascade second order analog sections, you can use and cascade trisamps.

A trisamp gathers in three samples of a waveform. Which I will call *wuz*, *is*, and *wilby*. It then scales them and adds them all together by using this fairly simple rule…

$$output = Y(was) + X(is) + Y(wilby)$$

Since a digital filter is a linear type of thingy, *it should not matter what frequency or what phase we use for our analysis*. Thus, we can apply just one frequency at a time to determine our overall response. And arbitrarily pick an *is* phase of 90 degrees.

For a single frequency sinewave input, your output should be a *scaled* amplitude clone of your input. The output will be larger or smaller than the input. Depending on the values and signs of X and Y. And upon the *ratio* of your input frequency to the sample rate clock.

The X and Y values are known as *coefficients*. While you could select different coefficients for *was* and *wilby*, this would add or remove time delay to your response.

Forcing the coefficients for *was* and *wilby* to *always be identical* can give you the class of "distortionless" filters known as *linear phase* filters. These are especially significant for data comm applications. And can be extremely difficult to do when using the older and more traditional analog design methods.

Which leaves dealing with…

Negative Time?

So how do you find out who *wilby* is without a time travel machine?

Simply look *one stage previous* in that shift register scheme of figure two! Or access *one sample address earlier* in a memory data bank. Sorta the same way any vertically delayed scope lets you look at the waveform edge you have just triggered on.

Let's look at the responses we can expect from a trisamp as we vary its coefficients and the input frequency. Naturally, I prefer to use the superb *PostScript* general purpose computer language for this. I will use 72 clock samples per fundamental cycle.

Figure three shows you several trisamp responses. Positive Y values result in lowpass shapes and negative Y values result in bandpass shapes. Also in general, the overall peak gain gets set by the absolute value sum of X and Y. Gains near unity are often used to keep the results from getting too large or disappearing entirely.

Ferinstance, a Y value of zero and an X value of one simply copies the peak value to the output. For a flat or an *all pass* response.

Consider Y = 0.25 and X = 0.50. At low frequencies, *wuz*, *is*, and *wilby* are nearly on top of each other, so

they pretty much sum to 1.0 and give us nearly unity gain.

But at the frequency whose time period equals exactly 36 clock cycles, an interesting result happens. *Wuz* and *Wilby* end up on negative cycle peaks and *is* sits on a positive cycle peak. *They sum to zero!*

Other X and Y coefficients create the shapes shown. By themselves, these shapes may be interesting. But they aren't all that useful. So, to get useful response shapes, you *cascade* your trisamps.

Figure four shows you a highly desirable linear phase low pass filter made by cascading the three trisamps shown. Note the excellent stopband response. And the modest droop in the passband is fairly typical of linear phase filters. Most importantly, there is *zero* excess phase shift to higher frequency harmonics. This property is very important in telecomm filters and for wave analysis.

Yes, you can easily regraph this in semilog frequency-vs-decibels for a more traditional appearing classic response plot. Among other features, this replot would make the stopband zeros more obvious.

Actually, nobody really cascades trisamps. Go on through some simple algebra, and you can quickly prove that any two cascaded trisamps are the same as a *five* coefficient filter. And three cascaded trisamps are the same as a *seven* coefficient filter. So you apply a *pentsamp* or a *septsamp* instead. All digital filtering amounts to is finding the right coefficients to use for the result you are after.

Figure five shows you PostScript code to do a seven coefficient filter made from three cascaded trisamps. You could easily use this routine to explore fancier digital filter response shapes on your own. Just modify the

NAMES AND NUMBERS

American Inst Organbuilders
PO Box 130982
Houston TX 77219
(713) 529-2212

Clement Engineering
PO Box 1086
Severna Park MD 21146
(410) 268-6736

Compu-Mart
899 Presidential Ste 110
Richardson TX 75081
(800) 864-1155

Dukane Ultrasonics
2900 Sukane Drive
St Charles IL 60174
(708) 584-2300

Genesis Microchip
2111 Landings Drive
Mountain View CA 94043
(415) 428-4277

Harris Semiconductor
Box 883
Melbourne FL 32902
(407) 724-7000

ICT
2123 Ringwood Avenue
San Jose CA 95131
(408) 434-0678

Mitel
2321 Morena Blvd #M
San Diego CA 92110
(619) 276-3421

Qualcomm Inc
6455 Lusk Blvd
San Diego CA 92121
(619) 587-1121

Redmond Cable
15331 NE 90th Street
Redmond WA 98052
(206) 882-2009

Schott
3 Odell Plaza
Yonkers NY 10701
(914) 968-8900

Seagate
920 Disc Drive
Scotts Valley CA 95066
(408) 438-6550

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

Thomson CFS
40G Commerce Way
Totowa NJ 07511
(201) 812-9000

Wale Apparatus
400 Front Street
Hellertown PA 18055
(800) 334-WALE

Western Reserve Games
21651 Tungsten Road
Euclid OH 44117
(800) 531-1230

coefficients with your favorite word processor or editor. Then send it to *GhostScript* or route it to most any *PostScript* printer.

Lots more PostScript-as-language details are found on *www.tinaja.com* For an amazing range of applications, PostScript can completely blow away the more traditional general purpose computer languages.

Far more coefficients are normally chosen for fancier shapes. Typical hardware building block chips offer four coefficients each. These can get cascaded "wide" to handle twelve to sixteen or more coefficients. Or "deep" to handle the number of bits in a fixed point word.

Harris and *Qualcomm* are two big sources for these dedicated chips. But you can easily do the same thing with a PIC microprocessor.

I've been using digital filters as an important part of my *magic sinewave* research. Magic sinewaves are my brand new way for simplifying and dramatically improving the efficiency of such products as variable speed induction motor drives, solar panels, and electric cars. You can find a lot more about them and all their new research opportunities on my *Magic Sinewave* shelf you will find in the *www.tinaja.com* reference library.

5SiMX Hard Drives

As we saw a month or two ago, the *Hewlett-Packard* 5SiMX is an ideal mid-range PostScript laser printer. One well suited to Book-on-demand publishing. Its many features include genuine Adobe PostScript level II, 24 pages per minute print speed, a page flipping duplexer, 11x17 capability, refillable toner carts having excellent economics, 600 DPI resolution, photo halftone enhancements, and all the service manuals and parts readily available.

And, theoretically, a hard disk.

Scant few printer users appreciate how *absolutely crucial* a local hard disk is for a PostScript printer. *Apple* and *QMS* have had them for years.

First, your hard disk lets you store lots of fonts. Second, it lets you stash all of your Book-on-demand files so you'll never have to tie up a network resending them. That same storage lets you run unattended for overnight BOD publishing.

The same goes in spades for often used forms or patterns.

When a diskless PostScript printer is first turned on, all of those needed font bitmaps have to be laborously built up into a *font cache*. Your first few printouts (and anything "new" after that) will always be very slow.

A local hard disk instead saves a *font cache* for you. There is normally not any speed difference slowdown on your first few files.

Hard disks are also real useful for PostScript-as-language apps where they can serve as your primary I/O. They are also quite handy to log what is coming into your printer. To solve interface hassles. To convert formats. Or grab otherwise inaccessible data or commands.

Once you have used a PostScript printer that offers a hard disk, it is *unthinkable* to ever again so much as walk through the same room as a printer that lacks one.

Uh, the only tiny 5SiMX problem is that the HP disk drive has been undeliverable. Permanently so now, since HP has gone completely out of the hard drive business.

Well, it turns out you can easily substitute your own hard drive. For as little as $35. After you know and understand a few simple things.

Let's excerpt some key info from the *LaserJet 5SiMX Developer's Quick Reference Guide* from H-P…

"The standard 2-1/2 ATA/IDE disk drive interface is supported. (ATA stands for "AT Attachment", as in the IBM PC-AT bus. And IDE stands for *Intelligent Drive Electronics*). This printer is designed to allow these drives to be mounted directly to the formatter board."

"The disk drive attaches to four standoffs. It is electrically connected via a ribbon cable."

"The Seagate ST9420AG is the disk that has been qualified to work in the LaserJet 5SiMx printer."

The developer's guide is available through *HP Developers*. My favorite source for custom cables is *Redmond Cable*. The oddball *2 millimeter* bulk ribbon cable and connectors are sold by *Digi-Key* or *Mouser*.

This is sometimes called a *mini-IDE* or "European" cable.

Bargain drives often show up in *Compu-Mart*, in *Computer Hot Line*, and similar publications. Note that non-Seagate drives may be larger and have different mounting holes. Older and larger 3-1/2 inch drives are most likely not worth your hassle. Besides needing excess supply current, their larger pinouts take a special adaptor.

The last three digits of the Seagate part number are apparently its size. Or, in this case 420 Megabytes.

Do be *extremely careful* when you experiment here on your own! Any crossed cable can destroy both your drive and the printer electronics. Do not attempt to interface a SCSI drive. Unless you know all about fancy and expensive IDE to SCSI conversions.

And, of course, *never hot swap an IDE drive!* Always turn power off.

On your PostScript software side, the drive is called *%disk0%*. Fonts usually go in a */fonts/* subdirectory. Although half a gig is vastly more storage than you are likely to need here, there's one curious limitation: You are only allowed *one thousand* different files on your drive.

Filenames can be one to a hundred characters long. Nulls, backslashes, percents, end-of-file, and spaces are disallowed characters.

Much more on BOD in general in my *Book-on-demand Publishing Kit*.

Navigation Resources

I just got a flyer from *Advanstar Communications* on their brand new bookstore. This one focuses on GPS *Global Positioning System* and GIS *Geographical Info System* texts.

Since its been a while, I thought we might summarize several of the better navigation info sources as this month's resource sidebar.

Start with the *Navtech Bookstore*. Then those shows and publications from the *Institute of Navigation*. Two important trade journals include *GPS World* and *ITS World*. The latter on *Intelligent Transportation Systems*.

And a reminder that *Trimble* has a great nav tutorial it calls *GPS – A guide to the Next Utility*. Hot links to several useful GPS and nav sources are found on *www.tinaja.com*

New Tech Lit

From *Thomson-CSF*, a new data book on their *CCD Image Sensing Products*. From *Mitel*, an analog and digital *Telecomm* data book.

That PC1802 *Stereo Enhancement Processor* chip from *ICT* uses 3-D psychoacoustics to "spread out" the apparent source of stereo sounds. A new GMVLD10 real time video line doubler integrated circuit is useful for de-interlacing.

From *Genesis Microchip*. Uses do include tv-to-monitor conversions and video walls.

That *MIM Module* from *Clement Engineering* can be useful for balloon telemetry and other remote sensing apps. Original jukebox manuals are sold by *Western Reserve Games*.

Some info on power ultrasonics appears in the *Waves* newsletter from *Dukane*. Bunches of traditional pipe organ building info gets sold by the *American Institute of Organbuilders*. Who do offer various newsletters and conferences.

Two unusual glass topics: Glass paints are newly available through *Wale Apparatus*. While *Foturan* is a new photo-etchable glass product line from the *Schott* folks.

That long unclaimed $10,000 prize for anybody able to convincingly demonstrate dowsing techniques to locate a buried water pipe has just been upsized to $640,000.00. Contact *www.randi.com* for details. More on pseudoscience bashing in general on *www.tinaja.com*

For more on the fundamentals of digital integrated circuits, read my *CMOS Cookbook* and *TTL Cookbook*. Either by themselves or as part of my bargain *Lancaster Classics Library*.

Per my nearby *Synergetics* ad.

As usual, many of the mentioned resources do appear in our *Names & Numbers* and *Navigation Resources* sidebars. A reminder that a no charge technical helpline is available per the *Need Help* box. Funding and time constraints strictly limit this service to US callers only.

Let's hear from you. ❖