Don Lancaster's

Tech Musings

Pendulum accelerometers
Servo and feedback books
Log file 404 error extractor
How to listen in on bat nav
Using synchros and selsyns

May, 2000

I just picked up some interesting 1970's military accelerometers. They consist of a fist-sized mag damped pendulum coupled to a syncro transmitter. These do seem to offer sub-g sensitivities.

Yeah, solid state accelerometers from *Analog Devices* (check out their ADXL05 in particular) or *Motorola* or others are getting fairly cheap, stable, and quite sensitive. But these older mechanical beasties might still lead you to lots of interesting robot nav, physics demos, racing car apps, or even mil collectibles.

With mods, they might also make dandy inclinometers or levels. Figure one shows us a typical photo. More details on these are now posted to my *www.tinaja.com/bargms01.html*

All of which reminded me that it is way past time for us to look at…

Servos, Selsyns, and Friends

A lot of the stuff we routinely do with cheap electronics these days at one time had to be handled by special and expensive mechanical devices. A *servo* is any system that uses position or other *feedback* to gain accuracy.

The feedback of most closed loop systems improves precision but does so with price and stability problems. Usually, some position or velocity or whatever is measured and compared against your current goal, generating an *error signal*. The servo then seeks to minimize (or *null out*) errors.

A *servomechanism* is a servo that involves mechanical motion of some sort. A *servomotor* is just any motor or mechanical actuator which can be run in either direction and can also be safely stalled in any position.

A *selsyn* is a system that consists of two or more motor-like devices that are intended to control or sense shaft positions. These might be true servo closed loop devices. Or they may simply work open loop.

Selsyns played a major role in all WWII ships and aircraft for position control. They still do see use for ham antenna sensors, for rugged industrial needs, or to measure wind speed and direction. Useful sources for selsyn parts are *Fair Radio*, *Servo Systems* or *C & H Sales*.

Figure two shows a typical selsyn setup. A *synchro transmitter* consists of a three phase rotary transformer. The single phase rotor is driven from a 400 cycle (aircraft) or a 60 cycle (ship or land) source.

Three sensing windings physically spaced 120 degrees around the stator output three sinewaves whose values are related to the shaft angle.

A second device can be connected backwards across your three outputs. Its shaft will automatically *follow* the input shaft position. Thus a pair of synchros could send any mechanical position or speed from one location to another distant one.

Do note that this type of selsyn is really open loop. The input shaft has to do enough work to overcome all friction, electrical losses, and output shaft load inertia. So, your input shaft is loaded somewhat. Normally when you are only powering a meter pointer, this is no big deal. Other types of output selsyns will apply feedback for flap, rudder, or other serious tail twisting capabilities.

Related devices include *control transmitters* (to pick up improved accuracy), *differential transmitters* (to add or subtract two shaft angles), or *receivers* (handy for shaft position displays). A *synchro resolver* does the calculations needed to find an angle's X and Y components.

Fancier selsynn combinations can do amazingly sophisticated analog trig calculations or similar tasks.

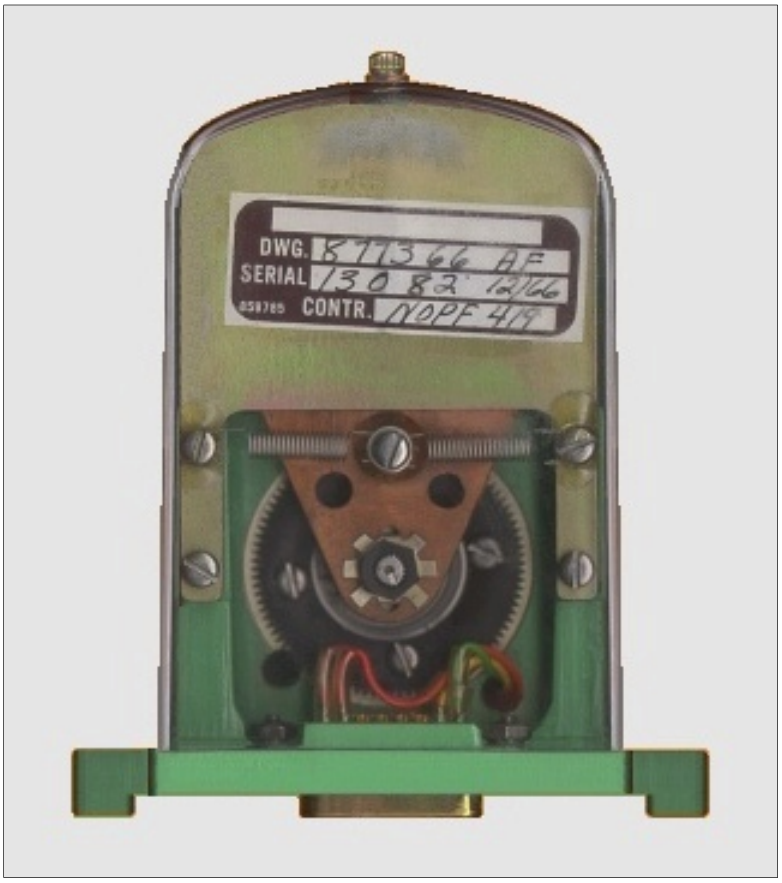

Fig. 1 – AN OLDER MILITARY ACCELEROMETER that makes use of a pendulum coupled to a synchro transmitter.

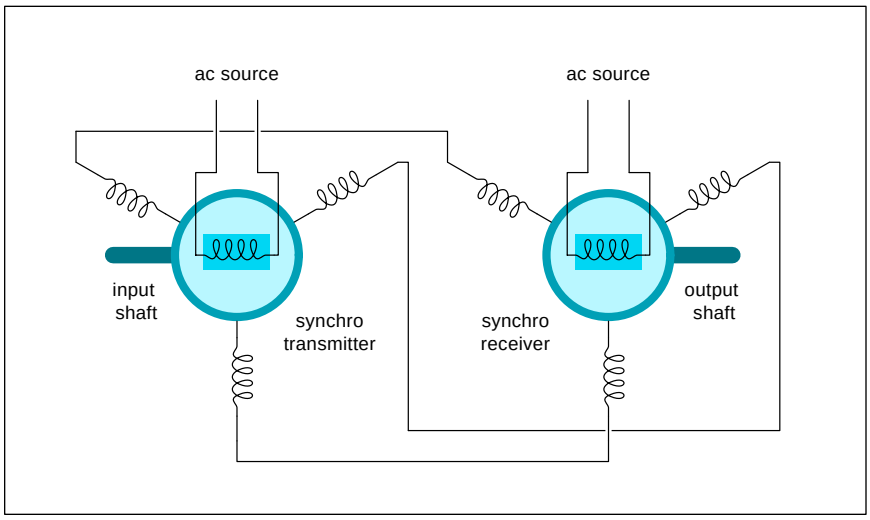

Fig. 2 – A SELSYN SYSTEM consists of a synchro transmitter and a synchro receiver. The output shaft position follows the input.

Fig. 3 – SYNCHRO TRANSMITTER used to sense shaft position.

A useful synchro application guide tutorial is available at *www.litton-ps.com/DataSheetList.htm*

Figure three shows us a standard synchro transmitter. Older sizes are usually measured in tenths of an inch. Thus a "size eight" selsyn is 0.8 inches in diameter while the "size fourteen" safely clears an inch and a half space.

Let me know if you need any of these to play with.

Dealing With 400 Hertz

Military and other aircraft selected 400 Hertz as an operating frequency because the size and weight (and thus the horsepower per pound) are much better than the usual 60 Hertz utility power. The short transmission range of higher frequencies is not a factor in most airborne apps.

Working 400 cycle power used to be a pain, but these days a PIC, some coils, and a few power semis easily generates it. Mechanical "dynamotor" 60 Hertz to 400 Hertz converters are readily available as military surplus at *www.tinaja.com/barg01.html* .

And this is a perfect way to apply my new *magic sinewave* techniques you will find described in detail at m y *www.tinaja.com/magsn01.html*

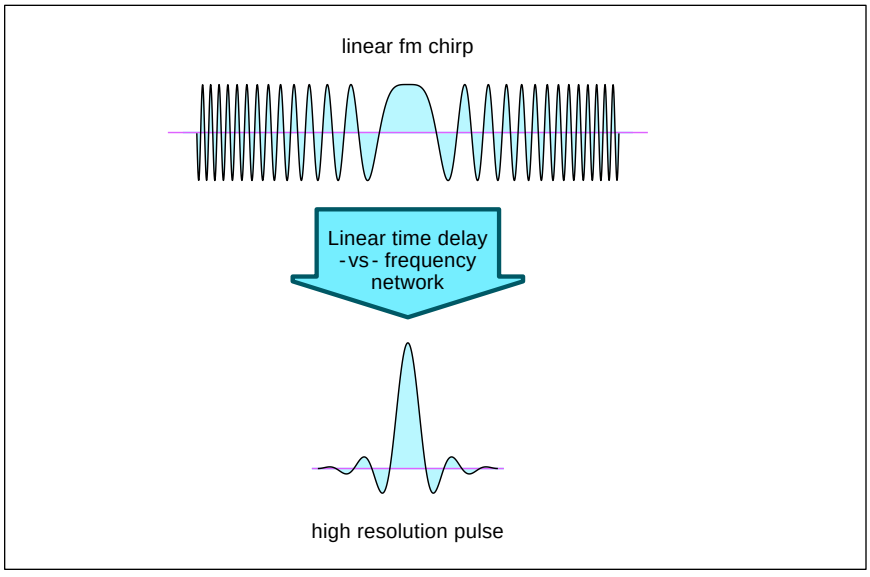

Fig. 4 – A BAT'S CHIRP uses this sophisticated Fourier Transform scheme to dramatically improve its nav resolution.

Can you run a 400 cycle device at 60 Hertz? If you one-on-one try this, smoke and fire are certain to result. The lower winding inductance draws much higher current at a set voltage, saturates the iron, and burns up.

Do not ever plug any 400 cycle device into the same voltage 60 cycle power line!

But there is a sneaky workaround that few folks have picked up on. Uh, flux density is the name of the game. A 400 cycle device will usually run just fine on 60 Hertz *if* you lower the voltage to 60/400ths or 0.15. The same current will produce the same magnetic flux, and the beast should remain happy.

Naturally, the power and speed of a motor will be miniscule if you try this. But possibly still useful.

400 Hertz iron is often cheap.

Thankfully, in the case of a selsyn transmitter, these days you can use higher impedance *electronic* loads you route to a PIC or whatever. A 12 or 15 volt 60 Hertz ac supply should work just fine.

Thus, selsyn synchro transmitters may still be able to hold their own against encoders or whatever for some experimental uses. Especially wind speed and position or for ham antenna sensing. And just may offer cost and reliability advantages.

Servo and Feeback Books

Selsyns may seem dated, but servo and feedback concepts definitely are not. With this in mind, I've gathered

together some of the better books on this subject for you as our resource sidebar. More details on these titles at *www.tinaja.com/amlink01.html*

Listening to Bats

Bats make use of utterly amazing ultrasonic sonar systems. Their *echo location* gets used both in a low res mode for navigation and in high res to chow down on flying bugs.

Considering the weight, the power, resolution, and efficiency, a typical bat nav system is some *eleven orders of magnitude* better than the best of military radar systems.

Eons ago, the bats discovered the *chirp* secret to high resolution radar. Namely that a long swept frequency sinewave could get collapsed into the narrow pulses needed for high res distance measurements. Collapsing can be done by taking the *Fourier* transform of the swept return signal. But the bat more than likely uses an acoustical delay network having a linear time versus frequency delay characteristic.

Per figure four.

Intuitively, sending any swept FM sinewave into a linear time delay vs frequency network stalls the higher frequency parts more than the lower ones, so they all "pile up" on top of each other and form a narrow pulse. Mathematically, you have done the frequency domain to time domain conversion through *Fourier*, *Wavelet*, or some similar transformation.

Your sweep rates and frequencies depend on the species and whether the bat is in travel or chow mode. But typical sweep limits might be 20 to 40 or 30 to 60 kilohertz with rep rates going as high as 200 per second.

You cannot directly hear most of a bat's chirp, because of its ultrasonic frequencies and wide bandwidths. Instead, one of a number of sneaky schemes can be used to listen in.

One of the simplest is pick up the bat's chirp with an ultrasonic alarm transducer. You then amplify and limit the signal and divide it down with a CMOS binary counter such as a 4040. The hard limiting removes many subtleties of the signal, but still lets you determine the presence and possibly the species of the bat.

The *hetrodyne* methods can also get used where you'll downconvert the bat's signal to the audio range where you can listen to it. A fancier newer scheme known as *time dilation* works even better. You sample every 16th chirp signal and feed it to a dual port memory. You then read out the signal at a 1/16th rate, converting it to audio. While retaining all the full amplitude details.

A great Tony Messina construction project on a simple divider-style bat detector can be gotten at *pw1.netcom.com/~t-rex/BatDetector.html*

Other technical bat resources are at *life.csu.edu.au/batcall/abs/links.htm*

Your classic method of showing a bat's chirp is with a *sonograph*. An early pioneer in this field was *Kay Elemetrics*. Still found, of all places, at *www.kayelemetrics.com*. Their *DSP Sonograph Model 5500-1* seems to be an industry standard.

Besides listining to bats, various counting and monitoring schemes are often put to use. They might involve anything from clickety-clack manual counters to the most elaborate of 3-D multi-target image processing.

Bat guano analysis can tell you a lot about pollution, climate, and other environmental changes as well. I am sometimes involved in an annual trek to Arizona's Falcon Creek Bat Cave to sample each year's guano deposits and return them for lab analysis.

WARNING: Before getting into this by yourself, be certain to read up on *histoplasmosis*.

Cough. Gag.

Much more about Fourier and correllation appears in MUSE90.PDF and HACK54.PDF. More on CMOS counters and such can be found in my *CMOS Cookbook*.

The best place to go for accurate bat info is *BCI*, an acronym for *Bat Conservation International*. You can visit the website at *www.batcon.org*

For some really strange reasons, bat enthuasiasts and cavers tend to go together. Maybe it is because they both sleep upside down. Thus, the *National Speleological Society* up at *www.caves.org* also has all sorts of

```
% POSTSCRIPT "404" ERROR EXTRACTOR/REPORTER
% ==========================
% Copyright c 2000 by Don Lancaster and Syenrgetics, Box 809, Thatcher, AZ, 85552
% (520) 428-4073 don@tinaja.com Web site: http://www.tinaja.com
% Consulting services available per http://www.tinaja.com/info01.html

% All commercial rights and all electronic media rights fully reserved.
% Personal use permitted provided header and entire file remains intact.
% Linking welcome. Reposting expressly forbidden.

% This PostScript-as-language routine reads an ISP log file and extracts all
% "404" or FILE NOT FOUND entries into a separate analysis file.

% To use this program, enter the full path sourcefile and target file names
% and keyphrase below and resave. Then distill the file.

% Note that a NO FILE PRODUCED message is normal and expected.

% IMPORTANT: Be sure to use "\\" when you mean "\" in any PostScript string!

/sourcefilename (C:\\medocs\\logfile.txt) def      % sourcefile
/targetfilename (C:\\medocs\\e404file.txt) def    % output file
/searchphrase (- 404) def                         % term to filter on
/workstring 2000 string def                       % string holds analysis line
/ws {writefile exch writestring} def              % create output file object
/addtooutfile {ws (\n) ws} def                    % add line to output file
/endoutfile {(\n\n) ws                            % close file when done
     writefile closefile} def

% checkline tests to see if a dash followed by a space and a 404 is present...
/checkline {dup searchphrase search {pop pop pop addtooutfile}{pop pop} ifelse}  def

% /startoutfile creates an output file object...
/startoutfile {targetfilename (w+) file /writefile exch def(\n\nLines containing ) ws
searchphrase ws ( in document ) ws sourcefilename ws (:\n\n) ws} def

% Main loop reads one logfile line at a time for processing...
/grabphrase {sourcefilename (r) file /workfile exch def startoutfile
{mark workfile workstring readline {checkline}{exit} ifelse
cleartomark} loop endoutfile pop} def

grabphrase                                        % This actually does it

%% EOF
```

Fig. 5 – POSTSCRIPT CODE to extract 404 log error messages.

SOME SERVO AND FEEDBACK BOOKS

Analytic Feedback System Design (Peter Dorato)
Automatic Control:The Power of Feedback (T. Djaferis)
Control System Design Guide (George Ellis)
Control System Dynamics (Robert Clark)
D.C. Motors Speed Control Servo Systems… (R. Greene)
Design of control systems for DC drives (A. Buxbaum)
Feedback Control of Dynamic Systems (Gene Franklin)
Feedback Control Systems (Charles Phillips)
Force and Touch Feedback for Virtual Reality (G. Burdea)
Introduction To Feedback Control Systems (Pericles Emanuel)
Introduction to Servomechanism System Design (W. Humphrey)
Modern Control Systems (Richard Dorf)
Nonlinear and Optimal Control Systems (Thomas Vincent)
Principles of Process and Servo Control (D. Senko)
Quantitative Feedback Theory (Constantine H. Houpis)
Schaum's Outline of Feedback and Control Systems (Schaums)
Synchro and Resolver Conversion (Georffrey Boyes)

For more book details, see ***www.tinaja.com/amlink01.html***

info and bat related activities. Local chapters of the NSS are often called *grottos*. A typical state will have a dozen or more.

Avoiding 404's

Preventing website errors can be a thankless and never-ending task. We saw last month how there is a great freebie *Dr. HTML* web service up at *www.imageware.com/RxHTML* or by way of my home page HTML button at *www.tinaja.com*. This is great for checking everything from links to spelling to programming syntax. We also saw how to extend this service to Acrobat .PDF files.

A 404 or *File Not Found* Error is any file you cannot provide on your website. Some of these will be plain old mistakes visitors have made. Or snooping attempts to hunt for porn or to deduce your site structure. Others might be admin related. Ferinstance, the way my ISP has the site search set up, unnecessary errors are reported. The search succeeds and the visitor is happy, but the error is mysteriously generated anyway.

A third source of errors are your own mistakes that may be difficult or impractical to repair. Such as an url mention in some newsgroup or on a printed page. Or a misquote.

But the final error sources are your own mistakes which you can correct. These you must ruthlessly stomp out when and as you find out about them. You find your errors by reading the raw log files that your ISP should be providing you. Note that most stats software only does error summaries instead of the needed details.

Errors can be found by searching the log files for a "- 404". Of special interest is their *referral* info in the same line. This tells you where your visitor came from. When they arrived from another of your pages, you've got a great clue to exactly when and where the error came down.

A reasonable goal should be to keep your 404 error rate under *one half of one percent.*

Our PostScript-as-language code for this month reads your log file, extracts the useful parts of each 404 error line and reports them back to you. This can be a convenient way to improve your web stats.

NEED HELP?

Phone or email all your US Tech Musings questions to:

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Box 809-EN
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(520) 428-4073

US email: *don@tinaja.com*
Web page: *www.tinaja.com*

Details in figure five.

You should first enter a PostScript program into a word processor or editor and then modify it for your intended use. You then save the file *as a standard ASCII textfile*. The file is then sent to Acrobat Distiller or GhostScript. Extracted output error lists are reported onscreen in the log file and are saved as separate files for later analysis and correction.

More on PostScript-as-langage in *www.tinaja.com/post01.html*

New Tech Lit

MicroSoft has recently upgraded their already outstanting *TerraServer* site. Topo maps have gotten newly added to their aerial photos. They are also in the process of adding bunches of new photo coverage to one meter accuracy. You can find all this up at *www.terraserver.microsoft.com* Or just click on the AERIAL button up at my *www.tinaja.com*

A monster "my database is bigger than yours" feud seems to be going on between the terraserver folks and the online IBM patent resource up at *patent.womplex.ibm.com* Uh, both of these clearly seem to be moving up well into terabyte territory.

More on the patently absurd is up at *www.tinaja.com/patnt01.html*

From *Micro Linear*, a new CD on their integrated circuit line. Useful ap-notes are included on lamp ballast and intelligent battery management.

Freebie info on unique etching solutions and materials can be found at *www.10mb.com/zacryl/page2.html* Engineering links are provided here: *www.spacey.net/ldavis/frames.html* Hit the LEROY button on my home page at *www.tinaja.com*.

The SETI at home project has now shattered all records for the largest computing project of all time. It is now racking up over *one millenia per day* of computing time!

You are invited to become a participant by picking up details at *setiathome.ssl.berkeley.edu*

Our featured trade journals for this month: *BookTech*, *Print on Demand Business*, and *Digital Graphics*. All on lots of emerging and exciting new self-publishing opportunities. More at *www.tinaja.com/bod01.html*

State of the World 2000 is a "must read" from the *Worldwatch Institute*

NAMES AND NUMBERS

Adobe Acrobat
1585 Charleston Rd
Mountain View CA 94039
(800) 833-6687
www.adobe.com

Analog Devices
PO Box 9106
Norwood MA 02062
(800) 262-5643
www.analog.com

Bat Conservation Intl
PO Box 162603
Austin TX 78716
(800) 538-BATS
www.batcon.org

BookTech
401 N Broad St
Philadelphia PA 19108
(215) 238-5300
www.booktechmag.com

C&H Sales
PO Box 5356
Pasadena CA 91107
(800) 325-9465
aaaim.com/CandH/index.htm

Digital Graphics
2800 W Midway Blvd
Broomfield CO 80020
(303) 469-5730
www.nbm.com/digitalgraphics

Fair Radio Sales
Box 1105
Lima OH 45802
(419) 227-6573
www.fairradio.com

Kay Elemetrics
2 Bridgewater Lane
Lincoln Park NJ 07035
(973) 628-6200
www.kayelemetrics.com

Micro Linear
2092 Concourse Dr
San Jose CA 95131
(408) 433-5200
www.microlinear.com

Motorola
5005 E McDowell Rd
Phoenix AZ 85008
(800) 521-6274
www.motorola.com

Natl Speleological Soc
Cave Ave
Huntsville AL 35810
(205) 852-1300
www.caves.org

Print On Demand Business
445 Broad Hollow Rd
Melville NY 11747
(800) 308-6397
www.podb.com

Servo Systems
115 Main Rd Box 97
Montville NJ 07045
(800) 922-1103
www.servosystems.com

Synergetics
Box 809
Thatcher, AZ 85552
(520) 428-4073
www.tinaja.com

Valiant RayCrete
6005 Hughes St
San Diego CA 92115
(858) 679-2141
www.val-tech.com

Worldwatch Institute
1776 Massachusetts Ave NW
Washington DC 20036
(202) 452-1999
www.worldwatch.org

that is on energy, pollution, species survival, and population issues.

The secrets of designing your own USB universal serial bus products are in Jan Axelson's new *USB Complete* book. Other books in the series now include *Parallel Port Complete* and *Serial Port Complete*. More info is at *www.tinaja.com/amlink01.html*

RayCrete and *RayCrete* Marine by *Valiant Technologies* are two rather interesting new polyester materials claimed to be safer than epoxies. They can be used as a thick section glue, sealant, or filler.

This glop accepts a contact gloss from plastic forms, is reasonable in cost ($12 kits), stronger than many materials, bonds virtually anything to anything, and even sets underwater. Boat people can use these for repairs, and cavers to restore broken cave formations. See *www.val-tech.com*

To understand active filter design, be sure to check out my *Active Filter Cookbook*. See nearby *Synergetics* ad or *www.tinaja.com/synlib01.html*

Plus our usual reminder here that low cost consulting services are up at *www.tinaja.com/info01.html*.

Our latest buys on the bargains at *www.tinaja.com/barg01.html* include superb sweep and function generators and even a few mint classic cold war nuclear radiation calculators.

A fully hotlinked version of this column is up as file MUSE147.PDF Most of the mentioned items should appear in our *Names & Numbers* or *Servo Books* sidebars. ✦