THE WEST RAND AMATEUR RADIO CLUB

July 2005
Volume 5, Issue 12

ANODE

Inside this issue:

Editor's Comments

July 2005

The Anode is NOT a virus!
I got an email from a recipient the other day stating that his email client or server had removed the Anode as it was a pdf from his email. Could I send it to him again. Sorry to say I cannot do such a silly thing as send it again. Only to have it removed by his email program or server. Its entirely up to you to correctly set up your email receiving system. If you want to catch up on previous issues of Anode, buy the Anode Compendium from the club at the next meeting.

The last issue for the "year" Issue 12 Volume 5
I generally arrange my articles in Word before putting them into the MS Publisher article for generation. This means that afterwards I cannot check for duplicate articles, search for articles or even find reference articles. Well this must stop. We are going to use a more modern tool to generate the Anode in future. The articles will be placed into Rich Text Format documents and translated into XML. The xml documents will then be translated into an HTML or TEXT output which will come to you as an email. This will be more efficient as it will

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Precision VXO for Crystal Characterization & Matching

The Precision VXO (PVXO) and its matching Crystal Test Fixture (CTF) were created to provide a low cost means of evaluating the characteristics of crystals and a means of measuring their series resonant frequency. With this information, one can then build very low cost, high performance, crystal filters for receivers and transmitters. The PVXO was kitted by the NJ QRP Club, but has since sold out those units. However, photos of that unit are available on this page for completeness.

The schematic diagram for the PVXO. A detailed description of what this circuit is and how it works can be found in the Atlanticon 2002 paper entitled "Simplified Tools and Methods for Measuring Crystals" whose link is at the bottom of this page.

The circuitry shown above is transformed to a working instrument using Manhattan-style construction. The front panel contains the frequency control potentiometer, inductance switches, and the output BNC connector.

Additional details of the construction looking at the backside of the PVXO. When it was in this form, the frequency was read out on an external counter.

Later on in the development of the instrument,

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Special points of interest:

- Contact details on back page (updated)
- New email address for Anode and ZS6WR. See back page

Editors Comments & News

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only transfer the text to your email client. The pictures will come from a web-site as you open and read the email. The whole thing then can be saved as a complete web page onto your hard disk for later (offline) reading. The overall size of this 'download' will be much smaller than an equivalent pdf.

This will take place next issue, the first for the 'New Year'. If you have any objections to this, please email me.

Time and Frequency Standards (in SA).

No more ZUO. So here is an article on using a GPS to synchronise a frequency standard. Possibly future articles will cover the use of local television signals to synchronise a frequency standard and thereby a clock for use in a portable environment.

Ham-comp

The Ham-Comp notes continued with a presentation on memory at the 'Bring & Fix' meeting last Monday. The section 'Memory' will be added to the project notes. We covered from the original memory on the PC motherboard up to 72 pin memory modules.

The next Saturday Ham-comp meeting will be the afternoon of the 16th at 13:00.

Precision VXO for Crystal Characterization & Matching

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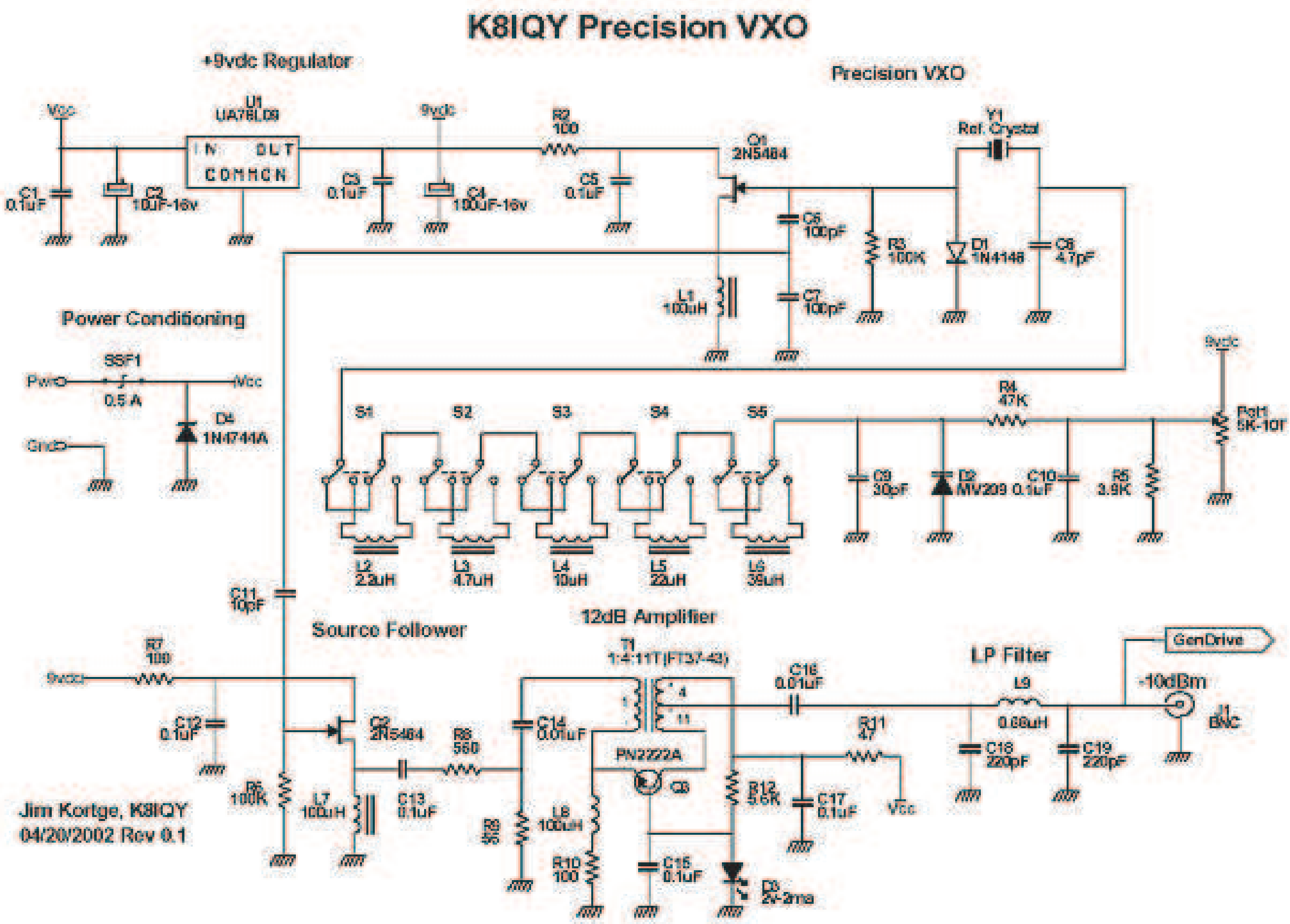
the Arizona QRP Club offered their inexpensive "Stinger Singer" CW frequency readout designed by Dan Tayloe, N7VE. This module was added and the instrument could now read out the frequency to which it was set. A SPST push button switch was added to the front panel to control the module.

Suitable visual readouts can be obtained from the AADE and KD1JV web sites.



The NJ QRP Club sold 100 of the PVXO kits during 2002 and 2003. This picture shows what the finished kit looked like. Included were all components, case, and templates for doing the lettered covers.

This kit was relatively expensive to produce due to the cost of the components, especially the precision 10 turn pot, five switches, and case, and therefore didn't sell very well. However, those that bought them got a real deal considering the capabilities of the unit.

This is a spectrum plot of the PVXO with a 4.9152 MHz crystal running in the unit. The harmonics decrease as the frequency of the crystal being used increases, and the output frequency moves closer to the cut-off frequency of the output low pass filter.

The schematic diagram of the

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Precision VXO for Crystal Characterization & Matching

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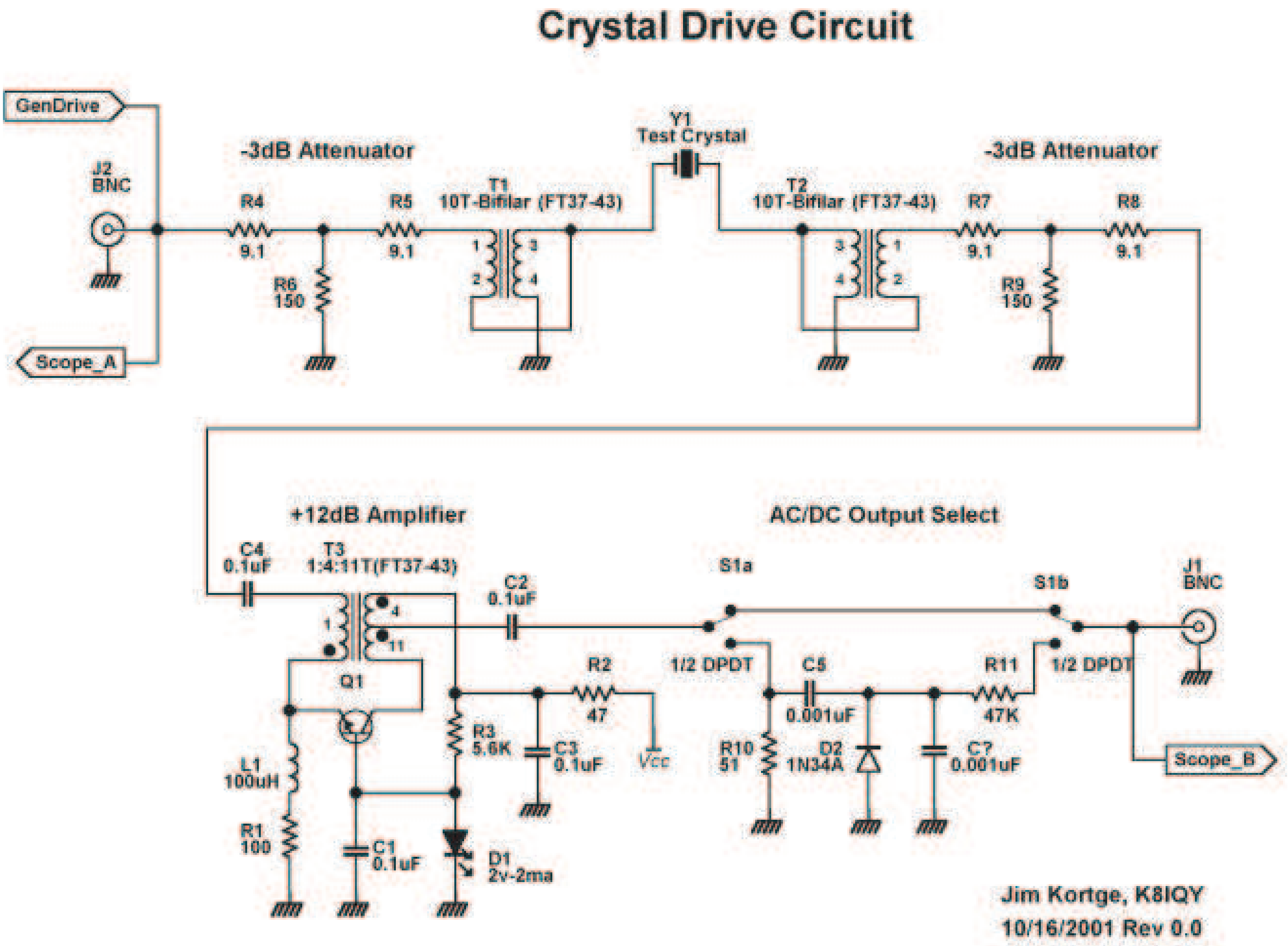
Crystal Test Fixture (CTF) which is used in conjunction with the PVXO. This circuit provides the required drive level to the crystal being tested, as well as approximately matching the impedance the crystal under test. Data produced when using the two instruments together let one determine the characteristics of a crystal family, and then match units for subsequent use as crystal filter elements.

The Crystal Test Fixture was also built using Manhattan-style construction methods. Shown in the photo is the 25 Ohm cermet potentiometer used to determine the equivalent series resistance (ESR) of a crystal. The PVXO drive connects to the left BNC connector, and the external detector to the right BNC connector.



Crystal Test Fixture side view. The DPDT switch selects either an RF probe, or output directly from the RF amplifier to accommodate differing readout instruments.

One of the more interesting (at least to me) measurements made with the PVXO and CTF was to demonstrate the effects of grounding the case of a crystal under test. As can be plainly seen, the series resonant frequency is unchanged, but the parallel resonant frequency changes about 1.5 KHz (higher) when the case is grounded. The obvious implication is that the performance of a crystal filter is also changed on its high side by moving that slope farther out from the passband.

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Precision VXO for Crystal Characterization & Matching

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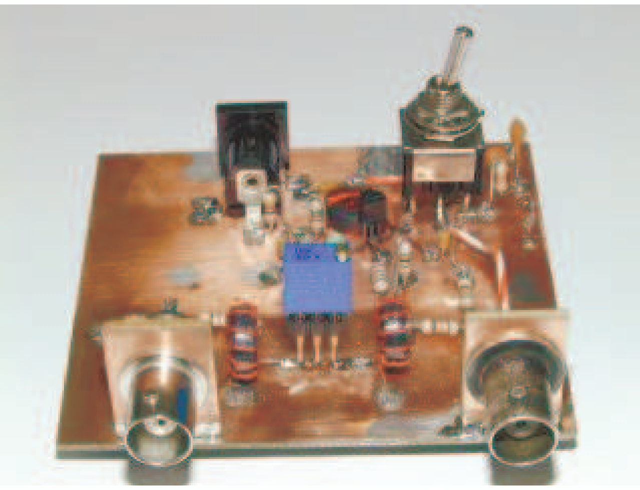
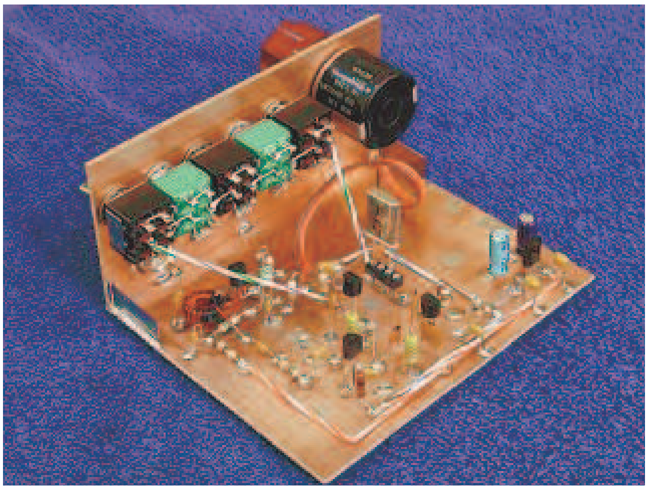
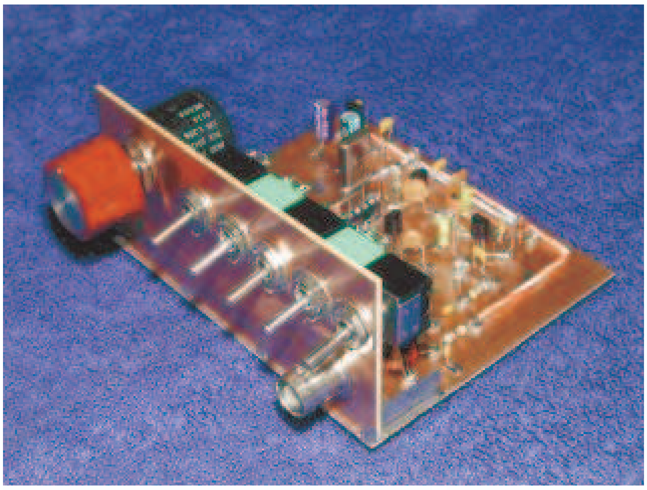
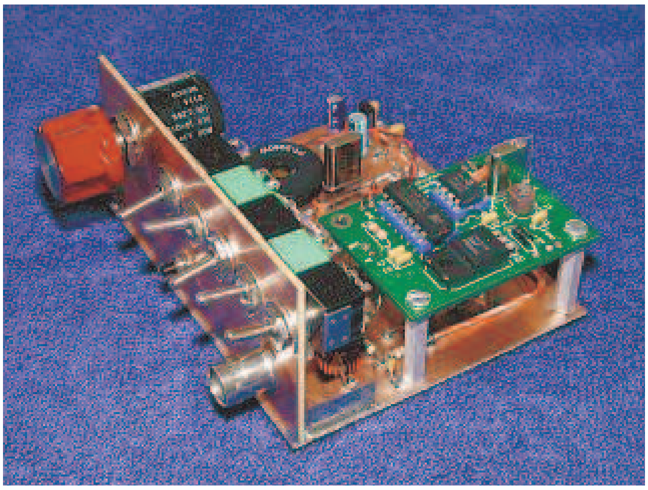
My Atlanticon 2002 paper entitled "Simplified Tools and Methods for Measuring Crystals" can be downloaded here. The file is in .PDF format, is 1 Mb in size, and describes how to use the PVXO and CTF combo to characterize a set of crystals, and then match them for use in a crystal filter. It does not tell you how to design the filter. That task is best done using the "Filter" program, free from the AADE web site.

Follow this link to see the characteristics of several common computer crystals that have been used in some of my homebrew rigs. These parameters were obtained using the PVXO and CTF instruments shown above, and the procedures detailed in the 2002 Atlanticon paper.



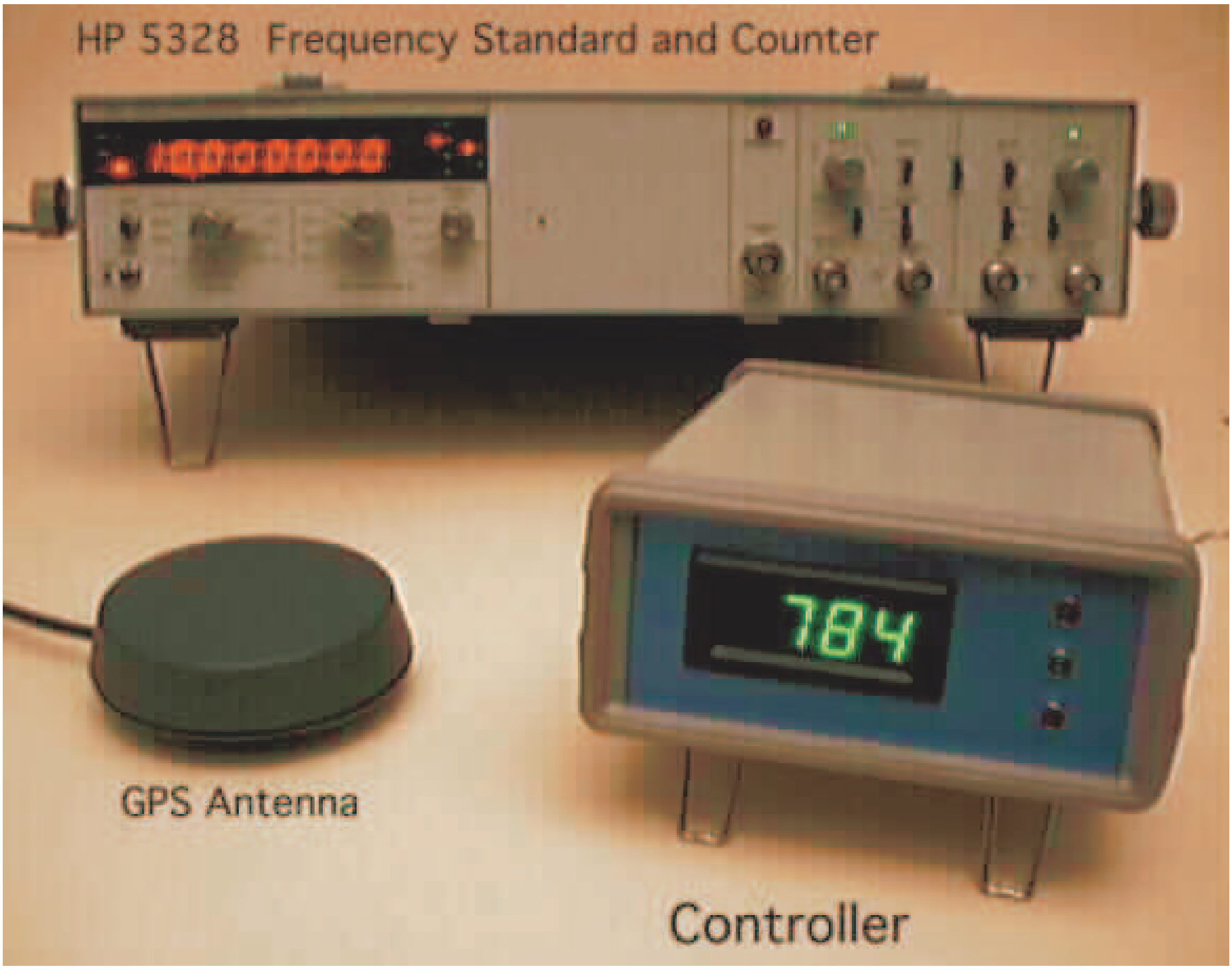






Brooks Shera's GPS-Controlled Frequency Standard

Several years ago I became interested in detecting weak extraterrestrial radio signals. This interest may sound slightly bizarre, but let me assure you that there are valid scientific reasons for it. This activity is greatly benefited if a stable and accurate frequency reference is available. The best I had was a WW II surplus BC-221, a unit designed to check the Army's tank transmitters. It was a marvel in its day, but a little lacking for my present purposes.



So a project began. The goal was to produce an inexpensive, but highly accurate, frequency standard by synchronizing a local crystal (or Rb) oscillator to the GPS atomic clocks. The project was started in the Spring of 1997 and a prototype was designed and operating in the late Fall of that year. Several months of experimentation and testing resulted in a design that produces a frequency accuracy better than one part in 10 to the 11. The cost of the device, exclusive of a commercial GPS receiver and a local oscillator, is less than $75.

Synchronization is accomplished by measuring the phase difference between the local oscillator and the 1 pulse-per-second timing signals from a commercial GPS receiver. The circuit computes and generates a control voltage that varies the frequency of the local oscillator so as to keep the phase difference constant -- a phase-locked loop.

The main challenges of the de-

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Brooks Shera's GPS-Controlled Frequency Standard

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sign result from (1) the large discrepancy in frequency between the local oscillator (typically 5 MHz) and the 1 PPS GPS signals, (2) the need to suppress the random jitter in the timing of the GPS signals (SA) purposely introduced by the DoD (note: early in 2000 the DoD discontinued this purposeful degradation of the GPS signals and the accuracy of the frequency standard improved considerably), and (3) the requirement that the controller be adaptable to oscillators with widely different stabilities.

The project has been described in an article that appears in the July '98 issue of the amateur radio journal, QST. Most of the information presented here is the result of ongoing experimentation and testing that was done after the article was submitted.

Important Information for Builders of the Controller

A nice printed circuit board ($21.50) is available from A & A Engineering, Anaheim, CA (714) 952-2114, their webpage has ordering information and a photo of the PCB.

Construction and Setup Notes (last revised June 11, 2001):

Notes
Some Questions and Answers (last revised June 11, 2001): Q&A

PC software to convert the controller's ASCII output for easy plotting with a spreadsheet, including the source code and some hints, courtesy of Gary Sanders, WB0BZR, gsanders1@bigfoot.com: gpslog.zip (62 Kbytes). An updated version handles both PIC code vsn 1.29 and 1.33 output formats gpslog3.zip (12 Kbytes) . Download both files if you don't have the instructions included in the original version. The PIC source code for a single chip frequency divider that takes a 10 MHz input and produces 9 square wave outputs - one for each frequency decade from 100 kHz to 0.001 Hz (1000 s period), courtesy of Tom Van Baak, tvb@leapsecond.com: PIC16C84 frequency divider code (zip format, 4 K bytes)

To see an application of the gps frequency standard and some photos of beautiful units built by Richard Ewing (KO7N) and Jimmy Oldaker (W7CQ) look at their EME webpage.

Another fine example of a completed gps frequency standard can be found at the G3RUH webpage of James Miller. In addition to photos of the handsome unit James constructed he provides a very useful manual (63kb). James took an HP Z3801A gps-disciplined standard (often available on eBay) and discarded everything but the high quality ovenized (hmm! Americanization. Ed) 10 MHz HP10811 crystal oscillator unit and the power supply module. He then built his frequency standard using a Rockwell 12-channel gps receiver and the PIC-based controller described here. The G3RUH webpage also describes many of James projects and articles, including his famous and widely duplicated G3RUH 9600 baud Packet Radio Modem.

Below is a picture of the controller together with a GPS antenna and, in the background, a 20 year old HP frequency standard that is locked to the GPS atomic clocks by the controller. The result is a frequency standard that is perhaps 1000 times more accurate than when HP manufactured it.

The digital meter on the front panel of the controller shows the voltage that is being applied to the oscillator in the HP 5328 to discipline it on to the frequency of the GPS atomic standards. The controller also provides an ASCII data stream that can be monitored and recorded to watch the operation of the system.

The graph below highlights one of the challenges mentioned above - the jitter in gps timing. The data for the plot were collected from the ASCII port of the controller using it only as a phase meter. The controller inputs were the 1 pps timing ticks from a Motorola Oncore gps receiver and the 10 MHz signal from a Efratom FRK-L Rubidium frequency standard. Each dot represents the time (phase) difference be-

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Brooks Shera's GPS-Controlled Frequency Standard

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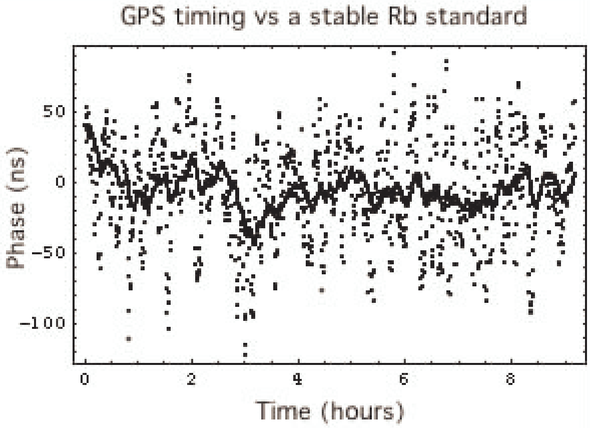
tween the two signals averaged over 30 seconds. The rms jitter is 36 nanoseconds (ns) and excursions of 100 ns or more are evident. If we force our local oscillator to follow these short-term gps phase fluctuations its potential frequency accuracy will be greatly reduced.



Averaging over a longer period than 30 s helps somewhat (the solid line on the graph is an exponential average of the 30-sec data over about 15 minutes), but large phase fluctuations lasting more than an hour are still evident. The origin of these long term variations is unknown (to me). They may be due partly to errors in the orbital periods of the gps satellites, transitions from one satellite to the next as they pass in and out of view, receiver time scale adjustments, and ionospheric effects. The residual shorter term fluctuations are probably due to SA (note: these data was taken before SA was turned off).

Whatever the cause of the jitter, a long integration time is needed to reduce it. My controller has switches that allow the user to select any of 7 filtering time constants - from a few minutes up to many hours. The longest times are probably only suitable for disciplining a very stable oscillator, such a Rb standard or a quartz crystal in a double oven.

The filter in the controller is an active second-order PI type, implemented as a 40-bit digital IIR filter programmed into an 8-bit PIC microprocessor (just in case you wanted to know). Much of the design time I devoted to this project was spent creating the software.

In addition to the microprocessor, the controller contains a few other IC's to measure the phase and to generate the control voltage. The phase-measuring circuit uses a 24 MHz xtal chip, a 16-bit binary counter, and a shift register. Its measurement accuracy is about 3 ns for a 30 sec averaging time. An 18-bit DAC generates the feedback control voltage under command of the CPU. The IC's are all available from DigiKey and other sources. A programmed PIC is available from the author (or you can program your own with my binary code file). A PC board ($21.50) is available from A & A Engineering, Anaheim, CA (714) 952-2114, their webpage has ordering information and a photo.

To see a closeup of the prototype controller circuit board, click here (size is about 2.5" by 5):" circuit board (84K bytes)

To see the Rb frequency standard I used, click here: Rb freq. standard (32K bytes)

Some results: GPS control of an inexpensive surplus Crystal Frequency Standard

This graph shows the control voltage that was applied by the controller to lock an Austron 1250A crystal frequency standard to the frequency of the GPS atomic standards (for convenience, I have converted the steering voltage to frequency units). The surplus 1250A had been sealed in its original packing since it was manufactured in 1987. The 50 hour graph shows that the correction needed becomes more and more negative as the 1250A tries to drift upward in frequency. Fortunately, the drift rate seems to be decreasing and there are no discontinuous jumps in the oscillator frequency. To see an expanded graph that shows the GPS jitter more clearly, click on the 50 hour plot. The filter algorithm in the controller has reduced the jitter from 36 ns to about 1

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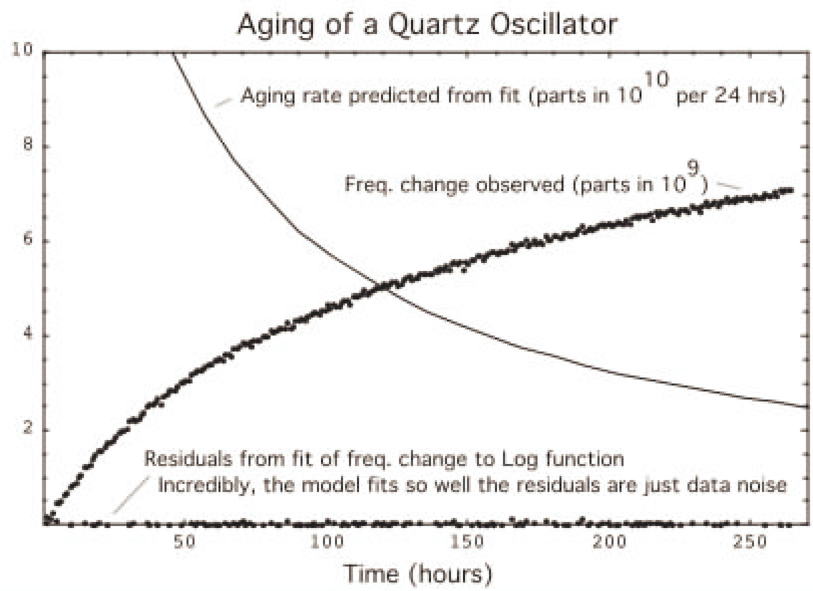
ns rms. The residual 1 ns jitter produces the spurious short-term frequency corrections of a few parts in 10 to the 11 that are evident in the expanded plot. As the crystal stabilizes, a longer filter time constant can be selected and the jitter will be reduced even further.



An Interesting Sidelight: Aging of a quartz oscillator

After the data for the graph above was obtained, I continued to record the ASCII output from the controller to see how the Austron 1250A frequency changed as time passed. The graph below shows the frequency change that that occurred over a period of about 11 days. The total change was about 7 parts in 10 to the 9th. If the aging is due to a single process, like desorption of gases from the surface of the quartz, then we might expect the aging to behave logarithmically, like a first-order chemical reaction. To check this idea, I fitted the data with a log function: delta F = K log(1+ t/T), where t is time, and K and T are parameters adjusted to fit the data. The result was MUCH better than I expected. The graph shows the residuals from the fit (the difference between the data and fit) and they are negligible. Since the fit was so good, I became more bold and used the fitted model to predict the aging rate that we can expect for the next year. This is a long time to extrapolate but the fit was so good I couldn't resist. The prediction says that after a year the aging should be less than 1 part in 10 to the 11th in a 24 hour period (to see the prediction, CLICK ON THE AGING PLOT). Frankly, I doubt if it will get this good. We'll see.

Update: after 3 weeks (June 15, '98) the aging of the Austron 1250A is still following the logarithmic prediction with essentially negligible residuals. I find this rather astounding. Click here to see the latest plot AgingAfterThreeWeeks The curves on the graph have the same labels as the one above.

Further update (Feb. '99): The current aging rate is 6 parts in 10 to the 12th in a 24 hour period. This is somewhat BETTER than the prediction that was made 8 months earlier and was consider to be optimistic!

More to come...

The binary software for the controller's PIC 16C73 microprocessor (version 1.29): gpscntrl.zip (3 K bytes)

The LATEST version of the binary software for the controller's PIC 16C73 microprocessor (version 1.33): gpscntrl_133.zip (3 K bytes)

I have received numerous requests for reprints of the QST article from folks that that do not have access to QST. To satisfy this need I have put an Acrobat PDF-format file of the article here QST_GPS.pdf (796 Kbytes) `http://www.rt66.com/~shera/QST_GPS.pdf`

If you find these results interesting and have comments or questions you can contact the author, Brooks Shera, W5OJM, at shera@rt66.com . I would be happy to hear from you.

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Bulletins (Sundays at …)
11h15 Start call in of stations
11h30 Main bulletin start

Frequencies
439.000MHz 7.6MHz split
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145,625 MHz (West Rand Repeater)
10,135 MHz (HF Relay)

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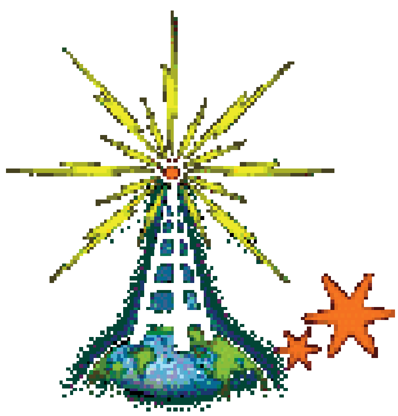
West Rand members - we need your input!

To make this the best ham radio magazine in South Africa we need your input. Please submit articles, comments, suggestions etc.

Please send plain text with no formatting to the email address below.

In July 2003, we re-published an Anode Compendium on CD. It has the issues from July 2000 until June this year. This included the new Adobe reader. It has been updated, check with the chairman for details.



We need your input! Email us articles, comments and suggestions please. john.brock@pixie.co.za