ANOMALOUS PROPAGATION

Newsletter: **The Midwest VHF/UHF Society**

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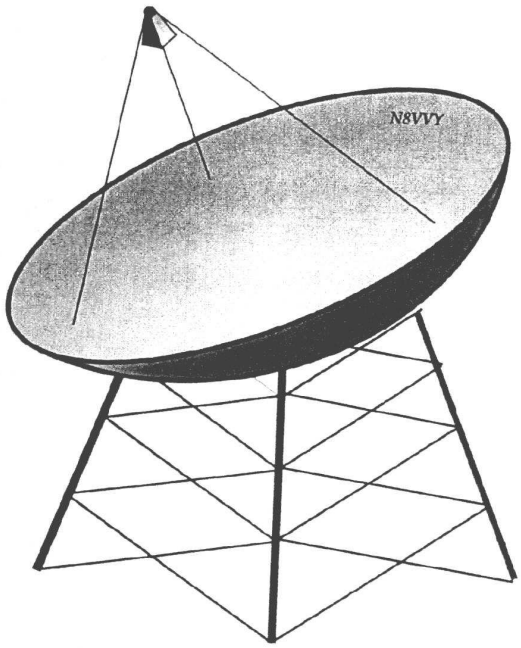

Annual Society membership is $ 12.00. Please make checks payable to Gerd Schrick

MIDWEST VHF-UHF SOCIETY

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Mtg Fri 28th of Oct. (6:30PM) MCL Cafeteria on 4485 Far Hills Av (Rt. 48) in Kettering. Going South from Dayton drive past the Town and Country Shopping Center on your left. At the next light turn right, then left into a small shopping center. MCL is at the end on the right

Contents

Upcoming Events

AMSAT Symposium 4,5,6 November –San Jose, CA

Ft. Wayne, In Hamfest - 19/20 November

AMSAT Symposium (from the AMSAT Bulletin Board)

Time is quickly approaching for the upcoming AMSAT Symposium to be held November 4-6. This year's Symposium marks the 50th anniversary of the launch of the first amateur radio satellite into space. The Symposium is being held in San Jose, CA which is the home of Project OSCAR, the organization that built amateur radio's first satellite. As part of our commemoration, the ARRL is bringing an OSCAR 1 prototype which has been refurbished to help highlight this significant milestone. Our banquet speaker, Lance Ginner, K6GSJ was a member of the team that built OSCAR 1; he subsequently was involved with a number of follow-on amateur radio satellite projects. Lance's presentation promises to be a fascinating look at the early days of amateur radio in space as well as perhaps some lessons learned.

De N8ZM Oct. 2011

Good grief it is the middle of October already! Before you know it, it will be Thanksgiving, then Christmas, the New Years (Yeah, I know this isn't news to any of you. I'm just showing off). So, we need to work on the schedule for our next few MVUS meetings. As I recall, we agreed on the day after Thanksgiving for November, but I am not sure what we decided about December. The 4th Friday is the 23rd, the day before Christmas Eve, which just might mean that EVERYONE is out shopping and partying, which might mean a big crowd at the MCL. OR did we decide on following Friday, the 30th, on the theory that it is New Years Eve is the following night, so only a few folks would be out getting an early start? I'm sure some one of you remembers.

The annual Fall FMT will be on November 9th, at around 9 PM to 10 PM. Our own Mike, W8RKO, will again be in the middle of things, putting a very accurate signal on from his QTH. I suspect that N8UR will be trying to find some way to make some measurements from down Atlanta way, even though he does not yet have all of his frequency standards and receivers back up yet. He might have to settle for using a mere ICOM 746!

Speaking of John, he stopped by for dinner with a bunch of MVUS folks last week, and was truly gratified that so many of you took the time to join him for dinner. HE was on his way home from a 3 week vacation at his place on Beaver Island in upper Lake Michigan, where he managed to get a 43 ft. vertical installed so that he can play on the HF bands from up there. On his next trip he plans to install the radials. Knowing John, it is a neat and well-executed setup.

The 1296 Beacon antenna is now hooked up to a coax, and W8RKO has been working on a temporary setup just to see how well it gets out from 800' AGL. That puts it at about 1700' ASML, which is pretty decent. Let us know if you hear it!

The N8ZM team missed out on working the September ARRL VHF contest due to the fact that our new shack was not quite ready fro prime time when the contest rolled around. However, we have been making great progress on getting it ready for January, thanks to N8IDS, WB8TDG, KB8ZR, and W8PLZ. It is now wired, painted outside, insulated inside, and the coaxes have been run. A little bit of work to get the operating positions in place and the 'last mile' of coax to the radios and we will be cooking'. Look for us in January, unless there is 3' of snow or a blizzard going on.

Speaking of VHF contests, in the ARRL June test, even though we logged our best score ever from our location, we still could not break into the nationwide Top Ten. We have been there in the September and January tests, but June has always eluded us. The propagation is always so good for everyone, and the activity seems to be generally higher, so we have quite a bit more competition to deal with. But we won't give up!

As we approach the end of the year, it is a good opportunity to check to see that your MVUS dues are paid up. Sure, it costs less to e-mail Anom Prop to most of you, but we still have to print and snail mail a few copies each month to mail out to those who prefer paper, and also to have for promotional purposes. MVUS is one of the least expensive radio clubs you can belong and we have a great time together. There aren't any egos or politics, so everything is very low-key. Maybe that isn't for everyone, but we enjoy it. SO, if you like the sort of environment where you can share fun and ideas, and ask questions without being made to feel stupid, join us! We'd enjoy having you as part of the group.

See you at the MCL on the 28th! Tom, N8ZM

Transponder News By Gerd, WB8IFM

As you can imagine I have been busy with repairing the house and rebuilding the tower and antennas destroyed by the May storm. Finally the house repairs are done. And now, after 6 months, the tower is back up, however, to a "moderate" height of just 80 feet. (hi) Now I start with the rotor, mast and various beam antennas and a couple of wire inverted Vs. Hope the wx plays along!

Mike, W8RKO, ran into Bruce, W7BAS, who was offering affordable microwave oscillators at the Hamvention. For the frequencies we were looking for Bruce had to work on and modify his design, but as of 2 weeks ago, we have a brand new synthesized 2838 MHz Lo for our transponder and are eager to put it to use. We hope to report about it next month. **You find an article from Bruce on page 7.**

This and That 10-11

There were two more! That is to our Aug 27 picnic: the xyls of Randy, W8ART, and Gerry, W8GDT. That brings the total number to 19. Sorry about the lapse. Ed.

Falling from the Sky. Tracking stations will typically witness the uncontrolled return of at least one piece of space debris every day; and on average, one intact defunct spacecraft or old rocket body will come back into the atmosphere every week. Something the size of UARS (schoolbus) is seen perhaps once a year. Much larger objects such as space station cargo ships return from orbit several times a year, but they are equipped with thrusters capable of guiding their dive into a remote part of the Southern Ocean. [BBC- 9-24-11]

American Men Can't Cook. By and large, American Men can't cook. I blame the fact that they did not join the Boy Scouts. When you learn to cook your breakfast over a fire, you become a man, or at least take a significant step toward becoming one. [Alton Brown]

Stock Market. I never liked the stock market-to me it's Vegas without any of the fun parts, the girls in bikinis. [George Clooney]

1939 3el-Beam, Boom and Coax. The three-element well-known factory-built kit consisted of copper-plated steel tubing elements. The necessary wooden cross members and mounting insulators were supplied in the kit along with an 8-ohm concentric cable to feed the array. [F.Claude Moore, W9HLF, from "Rotary Beam" in Radio, March 1939]

Discipline. And respect for adults is a very important requirement for a child in order to learn in school or elsewhere. Sergei Rachmaninoff's musical talent was obvious, but when his parents split young Sergei failed his yearly exam at the St. Petersburg conservatory. He went to Moscow and was lucky to study with the stern disciplinarian Nikolay Zverev. Among other measures the daily 6AM wake-up to practice redeemed the young man. [Christopher Chaffee, WSU]

1950s Ham Radio. Even a well-built ham radio station looks to the lay person like a table full of radio chassis awaiting repair. [Von Tramp, Braunschweiger Zeitung 2-25-1954]

Stop and Go. Certainly sounds like a garbage truck problem. A company in Florida uses hydraulic power that absorbs the braking energy and then applies it for starting up. That sure is an ideal solution to "low mileage" which is improved by 45%. But there is a problem:" Customers are saying the system is too quiet." It seems that residents are used to hearing the garbage trucks coming from a block or two away, and tend to drag out their trash at the last moment. With the Parker series hydraulic hybrid systems installed, they oftentimes never hear the trucks—then call to complain that the trucks never came down their street (when, in fact, they had). [Electronic Design, 9-2011]

Planned Obsolescence. (Remember that term? I first came across it when I wanted to repair a plain radio and found on the back a sign which said: "No serviceable parts inside". ED) I had one typewriter for 50 *years*, but I've bought *seven computers* in six *years*. I suppose that's why Bill Gates is rich and *Underwood* is out of business. [Andy Rooney]

Solar System. 99% of its mass is in the sun, all the planets with their moons, the asteroids and all other objects orbiting the sun are just 1%.

Hardware Hacking. In my experience, it's easier to hack a piece of hardware you have around the house than to hack a software application on your PC. Why? When you obtain a piece of hardware, like a toaster, you can open it up to see what is inside and how it works. With most commercial software, you are stuck with only the executable file and no source code that shows the inner workings. [Scott Fullam, ED 6-21-04]

Going Ons. Trying to determine what is going on in the world by reading newspapers is like trying to tell the time by watching the second hand of a clock. [Ben Hecht]

People. When dealing with people, remember you are not dealing with creatures of logic, but with creatures of emotion, creatures bristling with prejudice and motivated by pride and vanity. [Dale Carnegie]

Software. Most software is overblown in ambition and size doesn't seem to matter. To judge I use the "engineering approach: compare what goes in to what comes out. Lets see: this page right here, as it is typed as a "word" document is 25kB large. Saved as RTF (rich text format) the file is only 10kB and undistinguishable from "word". On step further, saved as TXT (text), the file is only 5 kB, still perfectly readable but does not have the nice formatted look you see on this page. [Gerd, WB8IFM]

1296 Beacon

By Mike, W8RKO

I have been delayed getting the temporary beacon in place but should be able to before the end of October. To test the installation I will be temporarily using an FT 817 to drive a DEMI 1296 transverter. The transverter runs 25-watts on 1296 however the line losses going up to 800-feet will drop the power to approximately 2-watts at the antenna. The antenna is a halo design and horizontally polarized.

The CW ID sends: "W8KSE/B EM79RU 800 feet AGL 2 watt" then key down for about ten seconds. The sequence repeats. The proposed frequency for the beacon is 1296.080 MHz. Send reception reports to w8rko@arrl.net

ARRL Frequency Measuring Test 40- / 80-m

By Mike, W8RKO

Once again the club will participate in the ARRL FMT. We are the eastern transmitter running under the club call W8KSE. The transmissions take place from my QTH (W8RKO) in Centerville, Ohio. The details are in the November issue of QST. The test will start at 22:15 EST with Connie, K5CM starting the initial 3-minute call up on 40-meters. This will be followed by a 2-minute key down period. K5CM will send an ending announcement at 22:20 and turn transmission over to me.I will start at 22:25 EST with a 3-minute call up, 2-minute keydown, and 3-minute end announcement. W6OQI will follow the same sequence starting at 22:35 EST.

The FMT then repeats on 80-meters with K5CM starting at 22:45 EST, W8KSE at 22:55 EST, and W6OQI at 23:05 EST. The 40 meter frequency will be approximately 7055 KHz, 80 meters approximately 3579 KHz. All of us should be within 200-Hz of each other. Your job is to measure the frequency of each of us on both bands to at least a tenth of a herz. Submit your results via the website http://www.b4h.net/fmt/fmtentry.php. For reference the April results are at http://www.b4h.net/fmt/fmtresults201104.php. Additional information on FMT techniques can be found on Connie's website: http://www.k5cm.com.

My FMT station consists of PST Synthesizers locked to a 10-MHz GPS reference. They set the transmit frequency for 40 and 80 meters. The output of the Synthesizers are the input to the driver stage of two TS-520 Kenwood transceivers. We only use the driver and PA of the Kenwoods. One is tuned for 80 meters and the other 40 meters. The output is 100-watts on each band. The antenna for 80 meters is a 1/4-wave wire vertical suspended off of my tower. The 40 meter antenna is an inverted-V with the center at 60-feet. CW keying is accomplished by an RF switch connected between the Syntesizers and the TS-520's. The surface mount switch is driven by a .NET program running under Windows XP. The call-up, key down, and end announcement are automated. Once I click the "GO" button I sit back and watch the show.

Antenna Data

Areas of typical antennas

Isotropic	$1/4\pi \times \lambda^2$	$= .08\ \lambda^2$
Small Dipole	$3/8\pi \times \lambda^2$	$= .12\ \lambda^2$
$\lambda/2$ Dipole		$= .13\ \lambda^2$
Parabolic (surface)		$= .54$ S
Long Horn		$= .81$ S (opening)
Max Gain Horn		$= .45$ S (fixed length)

$A=G\cdot\lambda^2/4\pi$

(A=receive aperture, G=gain as a number, λ= wavelength)

Broadcast stations use ERP (effective radiated power) to indicate how strong they are. Hams use transmitter output power and antenna gain to indicate how much they are radiating. At the same time, antenna gain also supports reception. But a much better measure for receive is to use the aperture or "capture area" of the antenna. This is often equal or close to the physical dimensions of the antenna and therefore a lot easier to visualize. The table on the left gives you some ideas for a few typical antennas. To mention just one thing: a small (shortened) dipole has almost the same aperture (gain) as a full size dipole. Feeding this shorter dipole would require some matching circuit.

HR Publicity (Ed)

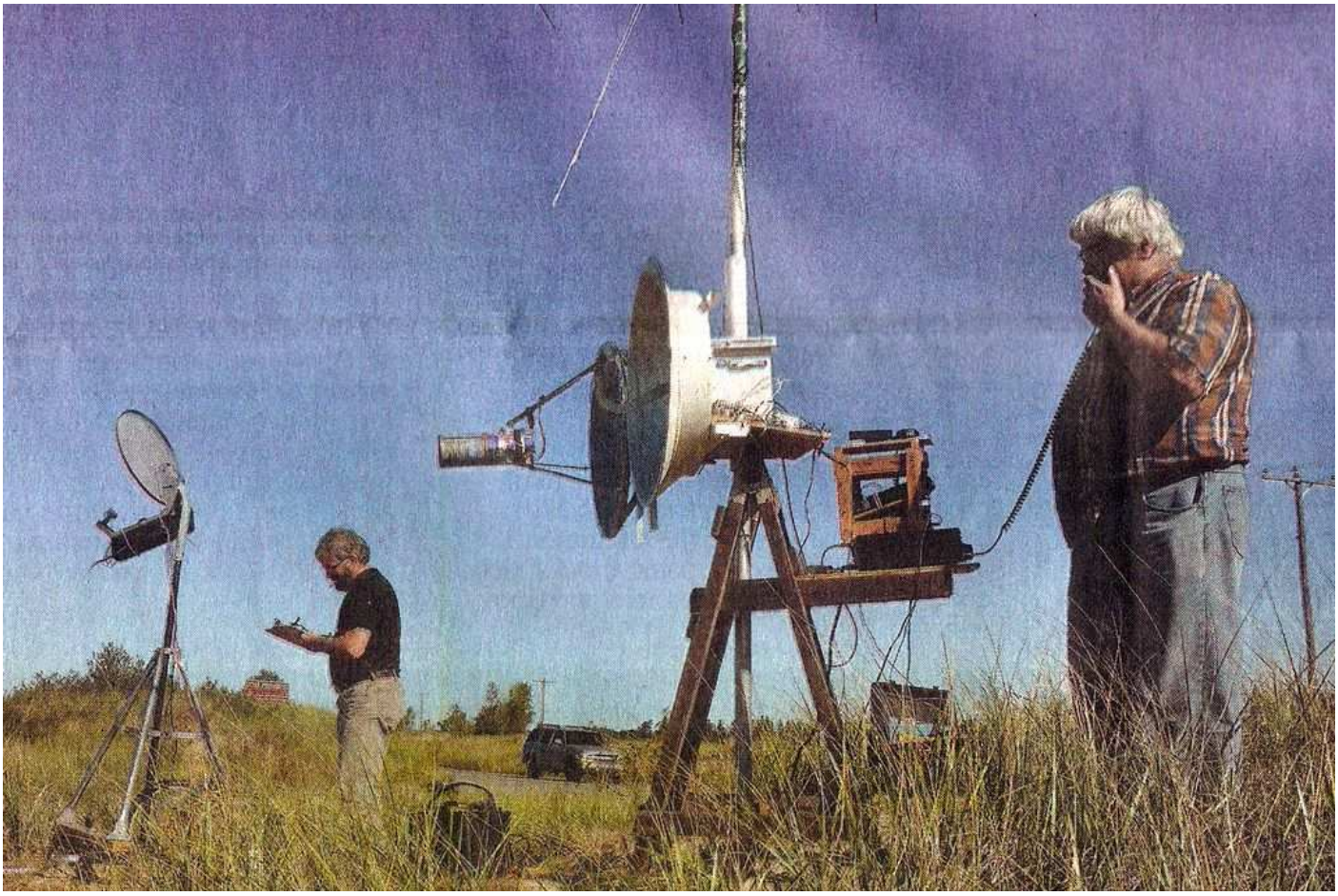
Lloyd, NE8i, and his cohorts get out with their rovers any chance they get: on these activity days or on contests. The stay close to the great lakes and set up in public places that are frequented by tourists and sightseers. So naturally they get onlookers and sometimes these are emboldened to approach and ask questions. That is a chance to demonstrate Hamradio to the public and collect Brownie points.

However, the other day our friends hit the jackpot when a (nosey) newspaper reporter stopped by to ask questions and even took some pictures.. Here is the write up:

Hello, Wisconsin

By Steve Begnoche
Ludington Daily News

Lloyd Ellsworth, (NE8i) of traverse City, foreground, and James French, (W8ISS) of Lincoln Park set up battery-operated, homemade microwave radio systems on top of a bluff at the first curve in Ludington State Park Saturday morning in order to communicate with other amateur radio operators in Wisconsin and Chicago. Ellsworth said people often wrongly think microwave signals can only go a few miles, but they were communicating successfully with operators in Wisconsin and were preparing to contact others in Chicago. He noted they're federally licensed and that as they play around building and using the equipment they learn a lot.



On the left, James, W8ISS, and on the right Lloyd, NE8i.
Ludington State Park, Lake Michigan across from Chicago

The W7BAS Synthesizer

Bruce Shurtz W7BAS 10/19/2011

The following is a description of the W7BAS Synthesizer or MicroSynth. First off let me preface that the development of this unit is not wholly my original design, but rather an expansion on the work and experimentation of Mike Reed KD7TS first and foremost. A few years back I was in search of a programmable L.O. for a transverter I was building. I ran across KD7TS on the radio one afternoon and he suggested I check out his webpage. That was the start of it all and it's been a learning experience ever since. With that said, I would like to thank KD7TS for his inspiration; guidance and technical expertise in helping me create this unit.

Functional Description

The heart of the W7BAS MicroSynth is the synthesizer chip (U2) from SiLabs, the Si4112/4133. The unit contains a wealth of features, is easy to program with a PIC and functions well, even a bit outside of its datasheet specs. The unit offers IF and dual RF outputs, self-tuning VCO's, R & N dividers, power down and lock detect features all in a nice 6 X 9mm SMT 24-pin package. This chip has been in production for several years and is tried and tested. In Fig 1 is a photo of the MicroSynth unit.

On the left-hand side of the board is the PIC chip, a 16F688. This is used to hold the data to be programmed into the registers of the synth chip. To the right of the PIC chip is the Si4112 chip itself. For all of my designs I use the Si4112 model at this time. The Si4112 contains only an IF VCO which will tune from ~500 MHz to a bit over 1300 MHz. This output can also be divided by 2, 4 or 8. This gives a range of ~62 MHz to above 1300 MHz output. The chip like all PLL's also has an update rate that needs to be considered. The update rate determines the minimum step size of frequencies that can be programmed into and subsequently output from the synthesizer. Note, in most cases a higher update rate equals lower phase noise.

The update rate of the Si4112 can be set to a value between 10 kHz – 1 MHz. I have found that setting the update rate to lower than 50 KHz starts to compromise the phase noise in a negative way. This is not to say a phase update rate of 20khz can't be used for say a beacon, it means the added noise will really compromise the receiving end of a transverter. It is best to use steps of no less than 100 KHz when using the unit as an LO in a transverter. This keeps the phase noise at better than -80dbc in most cases.

Below the PIC and Si4112 chips is the power supply section. The left regulator is a 3.3v version and the other is a 5v unit. To the right of the 7805 regulator is the on-board 14.4Mhz Meiden TCXO reference oscillator. This little TCXO is phenomenal! It is steady as a rock, frequency adjustable via a trimmer, runs on 5v and has a phase noise of >-100dbc! All for $0.32 in quantity from PyroJoe via E-bay. Directly above the TCXO is an input line for an external reference, such as a 10 MHz GPSDO or Rubidium etc…

At the top right of the board resides the RF amplification and filtering for the unit. I use a Sirenza SGA2186 or SGA2486 for the output amp. The SGA's are 2.5v devices and there is biasing on the board. The Si4112 outputs around -4dbm standard. This varies a db or two with programmed frequency. When combined with one of the Sirenza MMIC's I can achieve anything from ~0 to +10dbm output. The filtering I use is the LFCN series from Minicircuits. These are great little (1206 size) LPF's and only cost a few bucks. Keep in mind; one could also use discrete L/C components to do the filtering, as KD7TS does on his units. This saves a fair amount of cash. For ease of build/duplication I chose the LFCN's.

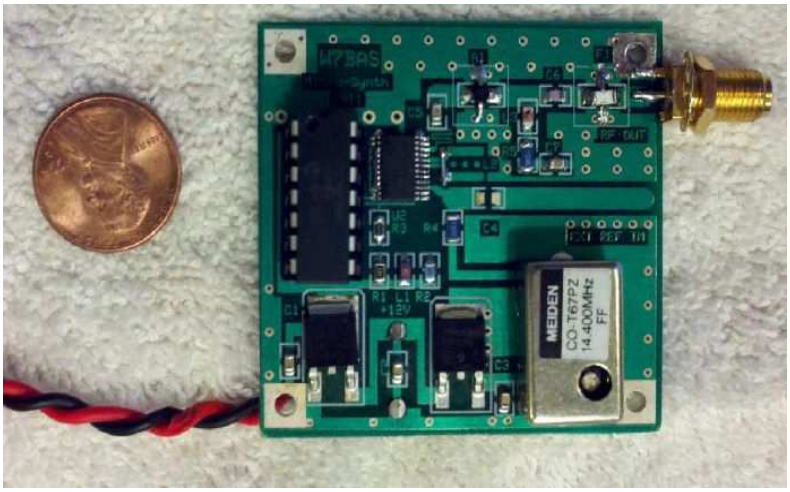


Fig. 1

Programming and Tuning

In order to generate an output frequency the Si4112 needs some information. The first thing it needs to know is, "what is the approximate frequency you like it generate"? I say "approximate" because we need to tell the chip where to tune its VCO. The Si4112 has a very complex self tuning algorithm, and as such it only needs the user to set the VCO "close"; (5%-10% of output frequency), and the self tuning algorithm will do the rest on its own. To set the VCO "center" frequency requires only the tuning of an on-board stripline inductor. L2 is one half of a tank circuit, (the other half (C) is in the chip) that tunes the VCO. An inductance of ~2nh to 10nh will cover a range of ~550 MHz to 1000 MHz. By shorting the leads as they come out of the Si4112 package the VCO will tune as high as 1300 MHz reliably. Well above what the datasheet states. One quirk I have found with the units is that they will always reliably lock if the VCO is set lower than the final output frequency, but that the units will frequently fail to lock if the VCO is set higher than the final output frequency. I have found this to be the case more often than not. The datasheet advises "within 5% +/-"The inductor tuning requires the user place a short across L2 to provide the needed inductance.

Once the VCO is centered the Si4112 needs to know what exact frequency you want to output. Let's say 720 MHz. To come up with an output of 720 MHz the Si4112 is going to need to do some math. The formula for an output frequency is:

Fout = N/R*Reference Frequency.

N & R are numbers. N can be anything from 0-65535 and R can be anything from 0 to 8191.

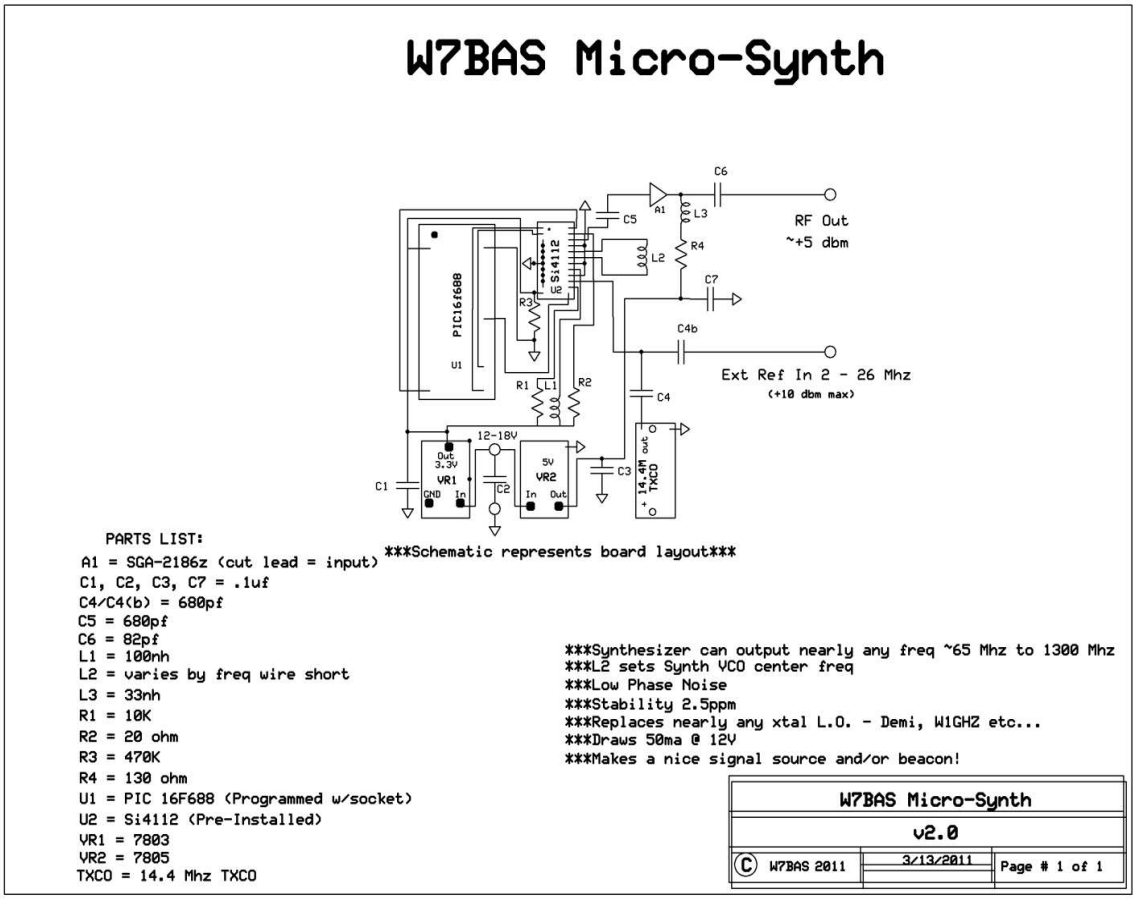
The rest is math. N (3600) / R (72) * Ref (14.4) = 720 MHz with an update rate of 200 kHz.

If you make R 144 you get 720 MHz with an update rate of 100 kHz. Remember, update rate = step size and vice-versa.

All of the above is written in pic code and stored on the 16f688 PIC.

Now that we have the MicroSynth generating a 720 MHz signal, the rest is just amplification and filtering/multiplication.

I have built customer units as high in frequency as 2838 MHz (946*3) and my own units to 3900 MHz with good results. This required an additional MMIC and LFCN filter. The result was the MicroSynth2. This unit offers up to +20dbm output 60-1300 MHz and up +10dbm output from 1300-3900 MHz. All harmonics/spurs are better than -35dbc down. Phase noise (using the on-board TCXO) is better than -80dbc in most cases. Stability of the 14.4 TCXO is spec'd to 2.5ppm but it is closer to 1ppm after 5 min warm up. Using an external GPSDO or Rubidium will produce even better phase noise. The units run off of 8-15VDC with the MicroSynth drawing ~ 50ma and the MicroSynth2 drawing ~100ma. If the user desires to use an external reference source than the TCXO is removed/left off from the board and a 0805 coupling cap in the Ext Ref line is installed.



DCC 2011 – Baltimore, Maryland

by John Ackermann N8UR

The 30th annual Digital Communications Conference jointly sponsored by ARRL and TAPR was held in Baltimore on Sep. 16 – 18. This year's DCC had about 100 attendees and the talks covered a wide range.

Here are some presentations that I thought were particularly interesting to VHF/UHF types:

- John Hansen (W2FS) has developed a Bluetooth wireless serial cable emulator that can be used for a number of applications. John is the designer/provider of the TNC-X packet radio node controller, and his primary objective was to allow a computer to interface to the TNC-X without a physical cable, but the module he used can be used for lots of other short-distance serial communications requirements.
- Howard Long (G6LVB) designed the FunCube – a low cost SDR that covers from 64 to 1700 MHz, interfaces to the PC via USB, and is entirely built into a USB dongle. Howard described how he went from his original design to building and shipping over a thousand units worldwide.
- David Rowe (VK5DGR) described work on the low-data-rate voice coder/decoder he has been working on, CODEC 2. This is really important work as CODEC 2 is believed to be patent-free and thus will be available for amateurs to experiment with as open source software. CODEC 2 is core technology that will open the door for amateur digital voice systems that don't require proprietary hardware.
- Charles Brain (G4DUO) and Ken Konechy (W6HHC) gave a presentation (remotely via the net) on a low cost exciter for digital television. This could be a breakthrough because current hardware to generate DTV signals is very expensive.

In addition to his presentation on CODEC 2, David Rowe was the speaker at the banquet dinner on Saturday evening. This, for me, was the high point of the show even though it wasn't directly related to ham radio. David is a telecom engineer who has done work for non-profit organizations in developing nations. His current work is with the Village Telco Project, which has developed a very low cost system using simple hardware and open source software. It's intended to provide a wireless telephone system that can be installed in remote areas that don't have wired telephone service, and where cellular phones may be available but are too expensive for many people to afford (David described how there are many countries where the cell companies and governments have colluded to make cellular coverage ubiquitous but so expensive that a call can cost most of a typical worker's daily wages).

The hardware is basically a Wi-Fi access point running voice-over-IP software with an interface to an ordinary telephone. It's cleverly named the "Mesh Potato" because it uses "mesh" (ad hoc) networking so no towers are required; each station acts as a repeater for its neighbors and the routing dynamically changes as stations come and go. Local calls happen entirely via Wi-Fi, and long-distance calls can be handled through a base station that has a connection to the Internet.

Each hardware unit costs less than $100 and the idea is for local entrepreneurs to install and operate the system as a business. The first wide-scale implementation is in Dili in the new nation of East Timor, and David described the difficulties of working in a war-ravaged and unstable area. Take a look at the Village Telco Project – http://villagetelco.org – it's really a fascinating story.

Conversion Chart! By Gerd, WB8IFM

Building my new Tower using old and new parts, a had to do a lot of calculations often converting "metric" to the "inch" and it is easy to get confused. So a chart is a great help. I have had this chart, reproduced on the back page, since 1978 right at my workbench in the basement. It is the "National Bureau of Standards Miscellaneous Publication 286". Mine is compliments of Boker's Inc. from Minnesota and has the 1978 calendar on the back. The one on the back page is from Benson Metals, Inc. also from Minnesota. This one is available on the Web!

BENSON METALS INC.

1300 Sibley Memorial Highway
P.O. Box 800 • Mendota, MN 55150
(612) 452-8556 • FAX (612) 452-9743

DECIMAL and MILLIMETER EQUIVALENTS

	DECIMALS	MILLIMETERS
1/64	0.015625	0.397
1/32	.03125	0.794
3/64	.046875	1.191
1/16	.0625	1.588
5/64	.078125	1.984
3/32	.09375	2.381
7/64	.109375	2.778
1/8	.1250	3.175
9/64	.140625	3.572
5/32	.15625	3.969
11/64	.171875	4.366
3/16	.1875	4.762
13/64	.203125	5.159
7/32	.21875	5.556
15/64	.234375	5.953
1/4	.2500	6.350
17/64	.265625	6.747
9/32	.28125	7.144
19/64	.296875	7.541
5/16	.3125	7.938
21/64	.328125	8.334
11/32	.34375	8.731
23/64	.359375	9.128
3/8	.3750	9.525
25/64	.390625	9.922
13/32	.40625	10.319
27/64	.421875	10.716
7/16	.4375	11.112
29/64	.453125	11.509
15/32	.46875	11.906
31/64	.484375	12.303
1/2	.5	12.700

	DECIMALS	MILLIMETERS
33/64	0.515625	13.097
17/32	.53125	13.494
35/64	.546875	13.891
9/16	.5625	14.288
37/64	.578125	14.684
19/32	.59375	15.081
39/64	.609375	15.478
5/8	.625	15.875
41/64	.640625	16.272
21/32	.65625	16.669
43/64	.671875	17.066
11/16	.6875	17.462
45/64	.703125	17.859
23/32	.71875	18.256
47/64	.734375	18.653
3/4	.75	19.050
49/64	.765625	19.447
25/32	.78125	19.844
51/64	.796875	20.241
13/16	.8125	20.638
53/64	.828125	21.034
27/32	.84375	21.431
55/64	.859375	21.828
7/8	.875	22.225
57/64	.890625	22.622
29/32	.90625	23.019
59/64	.921875	23.416
15/16	.9375	23.812
61/64	.953125	24.209
31/32	.96875	24.606
63/64	.984375	25.003
1	1.000	25.400

1 mm = .03937"

.001" = .0254 mm

National Bureau of Standards Miscellaneous Publication 286