Boulder Amateur Television Club

TV Repeater's REPEATER

April, 2023
issue #127

BATVC web site: www.kh6htv.com

ATN web site: www.atn-tv.com

Jim Andrews, KH6HTV, editor - kh6htv@arrl.net www.kh6htv.com

A Low Phase Noise Frequency Synthesizer

Jim, KH6HTV

This past fall and winter, we have discussed in this newsletter several frequency synthesizers for use as Local Oscillators (LO) for microwave projects. All of them have fallen short in the area of excessive phase noise which severely compromised the sensitivity when they were used as the LO in a microwave down-converter. For digital TV, the key parameter was "What was the weakest DVB-T signal we could receive?"

For this article, I am focusing on LOs for the 23 cm band. For back-ground, I refer the reader to our ATV newsletter for November, 2022, issue #116, pages 9-13. The table on page 12 compared various 23 cm down-converters for DVB-T Sensitivity. The winner was the KH6HTV Video, model 23-7 which came in at -99 dBm. I have decided to share with our readers the design of it's LO.

The design of the 23-7 consisted of a pre-amp feeding a Mini-Circuits ADE-25MH double-balanced mixer, followed by a 500 MHz low-pass filter for the IF output. The pre-amp was basically the KH6HTV Video model 23-LNA with a second stage of amplification added. It's key performance specs. were: 28 dB gain, 1.1 dB noise figure and 130 MHz -3 dB band-width. The mixer required +13 dBm (±3dB) LO drive. It's typical conversion loss was -7 to -8 dB. Thus, the overall conversion gain of the down-converter was about 20 dB.

The schematic diagram for my LO design is shown on the following page. It's key components are a free-running VCO, U1 and a low frequency PLL synthesizer IC, U5. The VCO is from Z-Communications (***www.zcomm.com***) It is their model V585ME35. It's key specs. for my purposes were tuning range 0.9 to 1.4 GHz, (*note: I also used it in my model 23-8, 23 cm FM-TV modulator*), +6 dBm nom. rf power, and +8 Vdc supply voltage. I should note that back in 2012-13 when I designed these products, I also tried to use a VCO from Mini-Circuits, but gave up on it due to excessive phase noise.

The PLL frequency synthesizer I used was a CMOS, Motorola MC145151P2. It is a part dating back to the 1980s. Why did I use it ? Well the bottom line is I am an old (age 81), analog engineer, not digital, and always had issues trying to deal with micro-processors, etc. All of the present day frequency synthesizers have a serial input programming port and really need a separate micro-processor computer, such as an Arduino, to provide them with the programming command on an IC2 buss. I plead ignorance of how to do it. Tried, but not successful. So, I went back to what I know how to do. A much simpler, synthesizer chip with parallel BCD input programming lines. Hence the giant, domino sized, IC I used, the MC145151P2. Thus on the schematic diagram, you will note a large array of programming diodes shown connected to the programming lines on U5.

The MC145151 includes it's own on-board crystal oscillator circuit. It is intended for a nominal input frequency of the order of 20 MHz. For my desired LO frequency in the 1 GHz range, I used external pre-scalers of divide by 64 to get down to 20 MHz area. Then using an 8 MHz crystal, the LSB for frequency programming became 250 kHz. The LO programming lines thus became: 1024, 512, 256, 128, 64, 32, 16, 8, 4, 2, 1, 1/2 & 1/4 MHz. Diodes to ground were connected to the unused lines. Active lines were left open. The programming diode circuit shown allows a selection of three possible LO frequencies via a three position, front panel toggle switch.

Good frequency synthesizer design guide-lines from the 1980s recommended using an attenuator and buffer amplifier on the output of the VCO. This then isolated the VCO from any possible load changes which could cause pulling of the frequency. Following this guide-line I put a 6 dB pad directly on the output of the VCO. I followed it with a broad-band MMIC, U2, which had 20 dB gain and +20 dBm max. output power. Because +20 dBm was too much power for the Mini-Circuits mixer, I then attenuated it again with a 5 dB pad down to +15 dBm for the LO drive to the mixer. As part of this 5 dB pad, I made a voltage divider, R8 & R12, to further attenuate to -5 dBm the LO signal I feed to the first pre-scaler, U3. The pre-scaler divide by 64 consists of two, ECL divide by 8 pre-scalers, U3 & U4. They are Motorola MC12026A.

The DC tuning voltage output from the MC145151 synthesizer, U5, comes out from pin 4 and drives the V_{tune} port of the VCO, U1. However, this must first pass through a low-pass filter network to control the PLL loop band-width. This is provided by the multi-stage, R-C network R16-R20 and C15-C19. It is agumented with a DC voltage storage circuit consisting of Q1 and C-18.

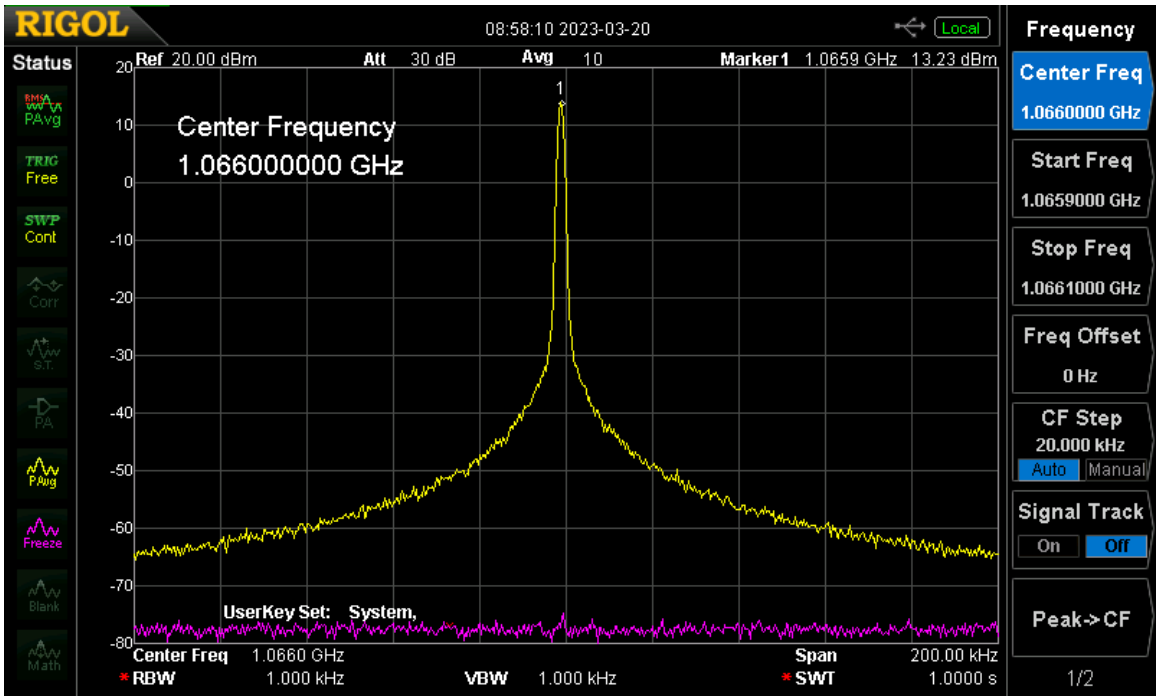
The final circuit shown on the schematic diagram is a driver for a front panel indicator LED to show when the LO circuit is phase-locked. The LED glows red when out of lock and green when locked. The entire LO circuit is powered via a +9 Vdc voltage regulator.

Performance ? --- As I mentioned earlier, this LO design gave me the best 23cm, DVB-T receiver performance of all LOs tested. I have just built a couple more of the 23-7 Down-Converters using the

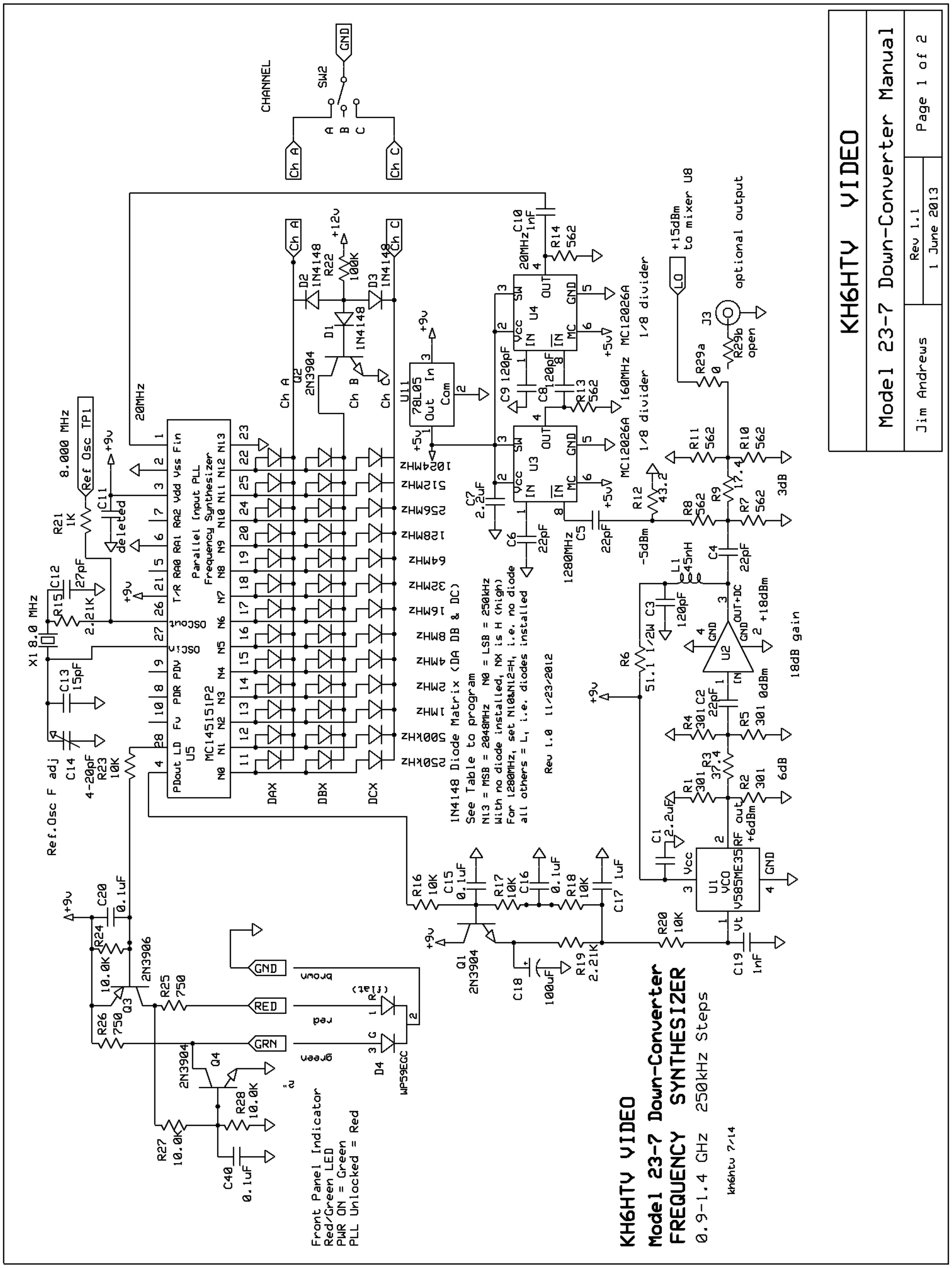
two extra MC145151s I got from Steve. I built them because I recently needed to buy the VCOs and the PLL synthesizer to build a 23cm FM-TV Modulator (model 23-8) for the Dayton, Ohio ATV repeater. So I decided to go ahead and use them in the down-converter. Build one for myself and the other for possible re-sale.

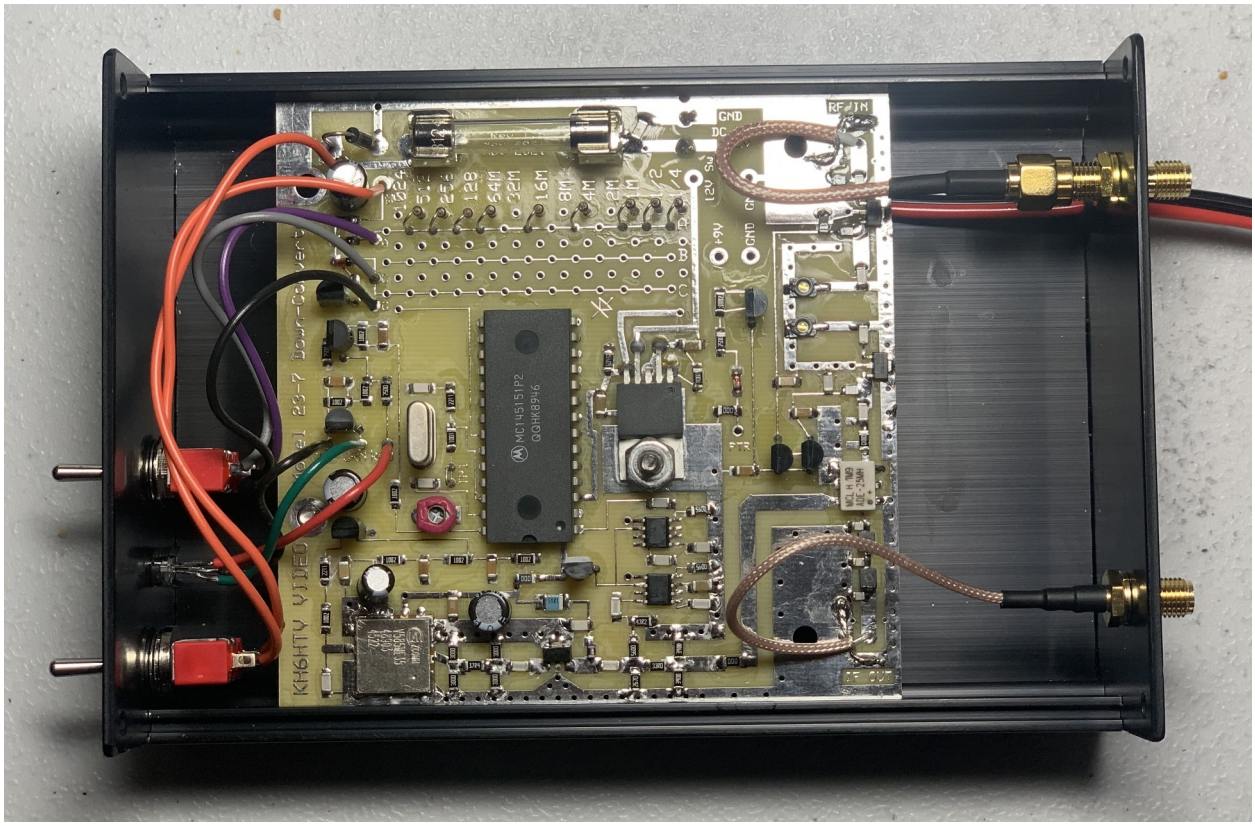
I set up the down-converters for an LO frequency of 1066 MHz (1024+32+8+2). This LO thus down-converts the 23 cm band bottom end 1240-1246 MHz, ARRL ATV channel 1, down to broadcast TV channel 7, 174-180 MHz, etc. The below photo shows the excellant phase noise performance. No spurious synthesizer artifacts were found, even on a wider band scan. Likewise an even narrower span with a 100 Hz band-width showed nothing else.

Availablity & Cost of Components? --- The VCO from Z-Comm is still available. They cost $25 each. However, Z-Com requires a minimum purchase of five pieces. With shipping, buying 5 of them will set you back about $140. The MC145151 is now an obsolete part and no longer available from normal electronics distributors, such as Digi-Key, Mouser, etc. You need to do a Google search to find them from small companies specializing in obsolete semiconductors. Expect to pay about $10 each, but oftentimes with large up front processing charges, and/or minimum purchase requirements. Fortunately, recently when I needed some, another ATVer, Steve, WA0TQG, dug through his junk box and found three of them for me. The ECL dividers, MC12026A, are still available. I recently found them at Arrow for about $2 each. Building the entire 23 cm down-converter was a bit costly. Total parts cost came to about $225. The enclosure from LMB alone cost about $90.



LO phase noise measurement: center frequency = 1066 MHz, span = 200 kHz, 10dB/div & 20kHz/div, 1 kHz resolution band-width. The magenta trace shows the spectrum analyzer noise floor. Pout = +14.5dBm at 1066 MHz.


KH6HTV VIDEO
Model 23-7 Down-Converter Manual
Page 1 of 2
Rev 1.1
1 June 2013
Jim Andrews
KH6HTV VIDEO
Model 23-7 Down-Converter
FREQUENCY SYNTHESIZER
0.9-1.4 GHz 250kHz Steps
kh6htv 7/14
1N4148 Diode Matrix (DA DB & DC)
See Table to program
N13 = MSB = 2048MHz N0 = LSB = 250kHz
With no diode installed, NX is H (high)
For 1280MHz, set N10&N12=H, i.e. no diode
all others = L, i.e. diodes installed
Rev 1.0 11/23/2012
Front Panel Indicator
Red/Green LED
PWR ON = Green
PLL Unlocked = Red
CHANNEL
SW2
MC145151P2
U5
Parallel Input PLL
Frequency Synthesizer
U1
VCO
V585ME35
U2
18dB gain
MC12026A
1/8 divider
78L05
U11
+15dBm
to mixer U8
optional output
Ref Osc TP1
8.000 MHz
Ref.Osc F adj



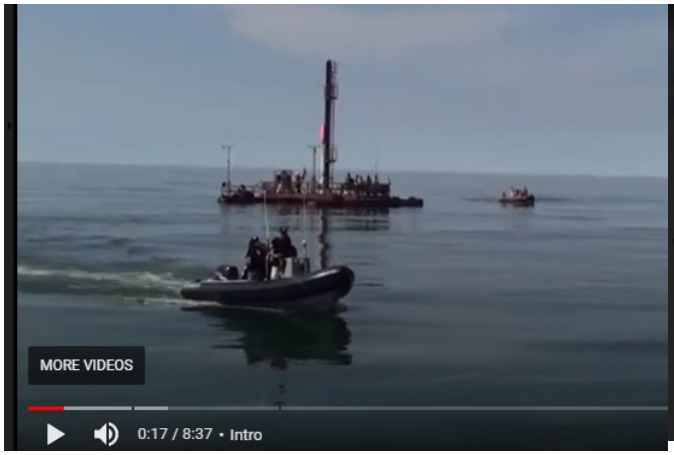
Interior View of the KH6HTV model 23-7 Down-Converter. The silver square package in the lower left is the VCO. The large domino size 24 pin DIP IC is the MC145151P2. The programming diode array is in the top center. The white package on the right is the mixer. The RF input is the top right SMA. The 23 cm LNA is in the upper right. The IF output is the bottom right SMA.

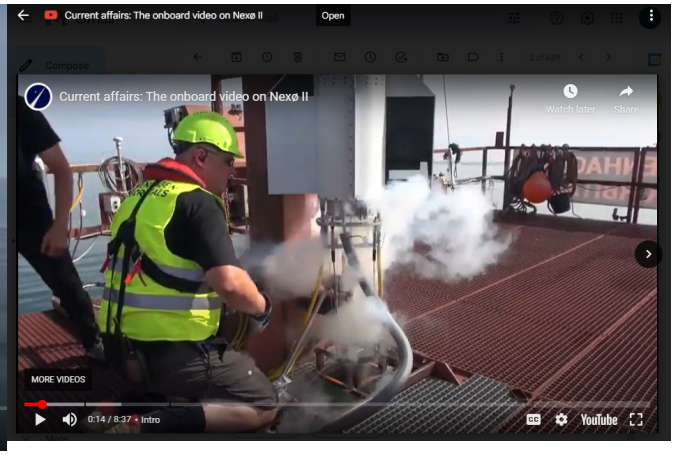
73 de Jim, KH6HTV, Boulder, Colorado

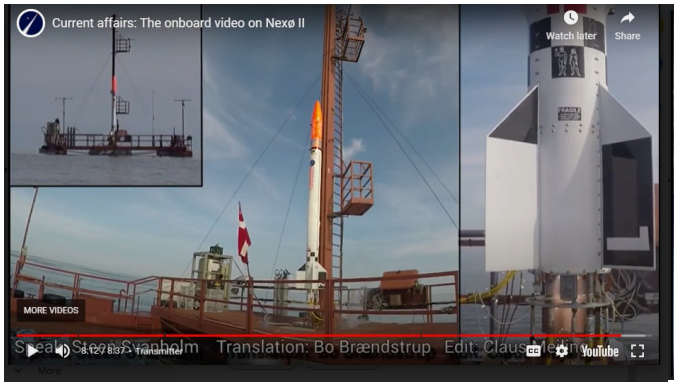
GREAT MATERIAL for a DVB-T Lecture

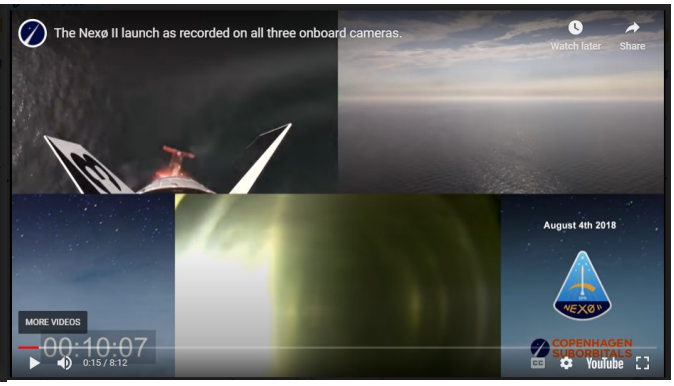
Have you been asked to give a talk to your local ham club about our modern day, digital ATV ? If so, you are probably wondering where to find some good material for your Power-Point slides. Well here is the place to go --- ***www.k0dvb.org*** Matt, K0DVB (guess his call sign gives away his interest !) prepared a great training class for the Boulder, Colorado ARES back in 2018. It was presented in two sessions, complete with hands-on training with BCARES digital ATV gear. At ***https://k0dvb.org/television/atv-training/*** you will find .pdf files for Matt's part 1 and part 2 of his DVB-T Training. Part 2 is especially useful for other groups wishing to learn a lot more about the internal workings of DVB-T. Part 1 was more oriented towards BCARES, ATV operations.

More Feed-Back on ATV from Near Space Flights (balloons & rockets):



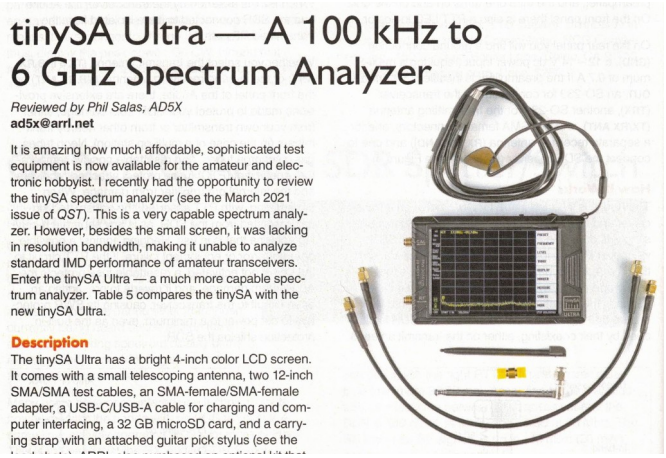






from **Claudio, I2NDT**, Dalmine, Italia --- "Hi Jim -- A small contribution to the discussion: "**Flying ATV**". It's not a balloon but a rocket, completely homemade by a group of amateurs in Denmark: "Copenhagen Suborbitals". In this video ***https://www.youtube.com/watch?v=HCwzDWxjHyU***
Alexandru Csete (who is also OZ9AEC) shows the system to be installed onboard the Nexø II rocket. They used a HackRF One! The rocket was launched in 2018 and here is the video received by the ground station from the 3 onboard cameras:
https://www.youtube.com/watch?v=WEqLsWczTPM
You can find a more detailed speech given by Alexandru during a public debriefing event after the successful launch here:
https://www.youtube.com/watch?v=8uylDBCjJyw
Alexandru Csete OZ9AEC (https://oz9aec.net/about), besides being a professional engineer in the space industry, is also the author of two well known software: Gpredict and Gqrx SDR.

best 73 de I2NDT, Claudio web sites: ***https://digilander.libero.it/i2ndt/***
& ***https://digilander.libero.it/i2ndt/grabber/grabber-compendium.htm***

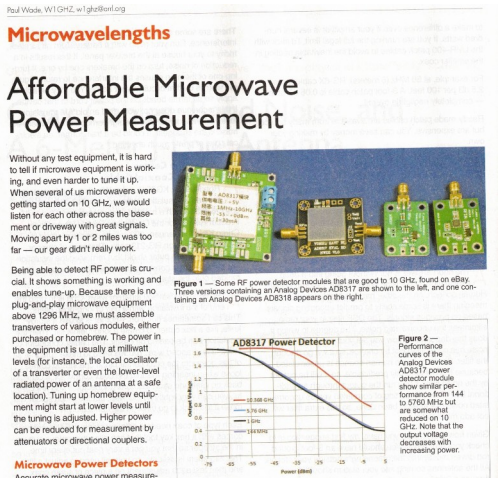


tinySA Ultra — A 100 kHz to 6 GHz Spectrum Analyzer

Reviewed by Phil Salas, AD5X
ad5x@arrl.net

It is amazing how much affordable, sophisticated test equipment is now available for the amateur and electronic hobbyist. I recently had the opportunity to review the tinySA spectrum analyzer (see the March 2021 issue of *QST*). This is a very capable spectrum analyzer. However, besides the small screen, it was lacking in resolution bandwidth, making it unable to analyze standard IMD performance of amateur transceivers. Enter the tinySA Ultra — a much more capable spectrum analyzer. Table 5 compares the tinySA with the new tinySA Ultra.

Description
The tinySA Ultra has a bright 4-inch color LCD screen. It comes with a small telescoping antenna, two 12-inch SMA/SMA test cables, an SMA-female/SMA-female adapter, a USB-C/USB-A cable for charging and computer interfacing, a 32 GB microSD card, and a carrying strap with an attached guitar pick stylus (see the



Microwavelengths

Affordable Microwave Power Measurement

Without any test equipment, it is hard to tell if microwave equipment is working, and even harder to tune it up. When several of us microwavers were getting started on 10 GHz, we would listen for each other across the basement or driveway with great signals. Moving apart by 1 or 2 miles was too far — our gear didn't really work.

Being able to detect RF power is crucial. It shows something is working and enables tune-up. Because there is no plug-and-play microwave equipment above 1296 MHz, we must assemble transverters of various modules, either purchased or homebrew. The power in the equipment is usually at milliwatt levels (for instance, the local oscillator of a transverter or even the lower-level radiated power of an antenna at a safe location). Tuning up homebrew equipment might start at lower levels until the tuning is adjusted. Higher power can be reduced for measurement by attenuators or directional couplers.

Microwave Power Detectors

Figure 1 — Some RF power detector modules that are good to 10 GHz, found on eBay. Three versions containing an Analog Devices AD8317 are shown to the left, and one containing an Analog Devices AD8318 appears on the right.

AD8317 Power Detector

Figure 2 — Performance curves of the Analog Devices AD8317 power detector module show similar performance from 144 to 5760 MHz but are somewhat reduced on 10 GHz. Note that the output voltage decreases with increasing power.

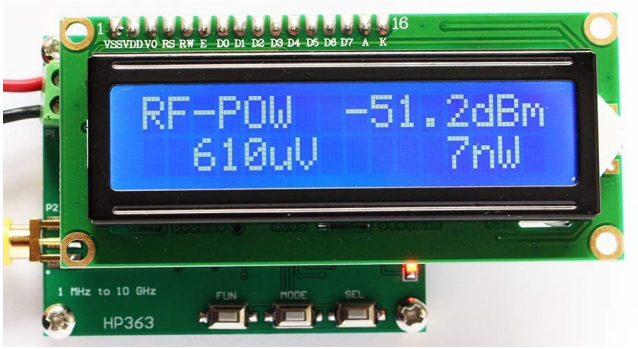
APRIL QST Articles of Interest

The April, 2023 issue of QST has a couple of articles of interest to microwave ATVers. They are about a couple of new, low cost test instruments which are useful in the microwave range. In the product review section, Phil, AD5X, reviewed the new "tinySA Ultra" spectrum analyzer. As opposed to the previous tinySA, this one is supposed to work out to 6 GHz. The Microwavelengths column by Paul, W1GHZ, discussed both the spectrum analyzer and also some low cost, rf power meters useable out to 10 GHz.

New Product Review:

AD-4317 RF Power Meter

One of the items discussed in Paul's, W1GHZ, column was an RF power meter based upon the Analog Devices AD8317. The various pc board versions Paul reviewed were very low cost and only contained the AD IC. Their output was a simple DC voltage which then needed to be measured and converted to dBm.



After reading Paul's article, I went on Amazon to find it and found what looked to be a bit more expensive, but also a more useful version shown here. It included a second pc board with a DVM, micro-computer and LCD display for readout of rf power in dBm, nano-Watts, and micro-Volts. Amazon's price was $60. The advertised specs. were: Frequency range = 1 MHz to 10 GHz. RF Power Range = -50dBm to 0dBm. So I purchased one for evaluation. So did it work? Yes. Was it accurate ? Yes & No.

I tested it over a frequency range from 100 kHz to 10.5 GHz and over an rf power range from -60dBm to 0dBm. I hit most of the various amateur radio bands. I used three different signal generators. For low frequencies, I used a 60 MHz function genator. For higher frequencies, I then used Analog Devices frequency synthisizers. First an AD-4350. For 5.8 & 10 GHz, I used an AD-5355. As my reference RF power standards, I used my Rigol DSA-815 spectrum analyzer for low frequencies. For high frequencies, I used my old reliable, HP-432A RF power meter with an HP-478A, thermistor RF

power head. I started all measurements at approximately 0dBm and then used a Mid-West Microwave rotary step attenuator to set all lower power levels in 1dB and 10dB step (0-69dB range). Only at 10 GHz, I was limited to a max. test power of -13dBm.

So, what did I discover ? First, the power curve Paul shows was confirmed. Yes, the AD device works over a power range of -50 to 0dBm. It shows compression at the high end as it approches 0dBm and expansion on the low end. The low end bottom number with no rf present is shown in the above photo. The "sweet" range in general is between -40 and -10 dBm where a 10 dB change in rf power level is reflected in approximately a 10 dB change in meter reading.

But was it accurate in the "sweet" range ? Yes, and No. At low frequencies down to the measured 100 kHz (spec. was down to 1 MHz) and up to the 6 meter band (50 MHz) -- Yes, very good. At higher frequencies -- No !, you need to calibrate it against some known standards for significant offsets. Here briefly is what I found for my unit with the approximate error offsets: 150 MHz, -3.5dB error; 430 MHz, +2dB error; 900 MHz, +2dB error; 1270 MHz, +3.5dB error; 2.4 GHz, +6dB error; 5.8 GHz, +1dB error; 10 GHz, -7 to -11dB error; 10.5 GHz, -7 to -16dB error. Obviously on 3 cm (10 GHz) band it is only useful as an indicator of some rf being present, but not useful as a true measure of power.

73 de Jim, KH6HTV, Boulder, Colorado

W0BTV Details:

Inputs: 439.25 MHz, analog NTSC, VUSB-TV; 441MHz/6MHz BW, DVB-T & 1243 MHz/6MHz BW, DVB-T

Outputs: Channel 57 --- 423 MHz/6MHz BW, DVB-T, or optional 421.25 MHz, analog VUSB-TV. Also, secondary transmitter, FM-TV output on 5.905 GHz (24/7).

Operational details in AN-51a Technical details in AN-53a. Available at: ***https://kh6htv.com/application-notes/***

W0BTV ATV Net:

We hold a social ATV net on Thursday afternoon at 3 pm local Mountain time (22:00 UTC). The net typically runs for 1 to 1 1/2 hours. A DVD ham travelogue is usually played for about one hour before and 1/2 hour after the formal net. ATV nets are streamed live using the British Amateur TV Club's server, via: ***https://batc.org.uk/live/*** Select ***ab0my or n0ye***. We use the Boulder ARES (BCARES) 2 meter FM voice repeater for intercom. 146.760 MHz *(-600 kHz, 100 Hz PL tone required to access*).

Newsletter Details:

This is a free newsletter distributed electronically via e-mail to ATV hams. The distribution list has now grown to about 500. News and articles from other ATV groups are welcomed. Permission is granted to re-distribute it and also to re-print articles, as long as you acknowledge the source. All past issues are archived at: https://kh6htv.com/newsletter/

ATV HAM ADS

Free advertising space is offered here to ATV hams, ham clubs or ARES groups. List here amateur radio & TV gear For Sale - or - Want to Buy.

Goodies from Broadcast TV, ENG Truck -- For Sale: From Don, KB5KWV --- I have several things that were in a TV remote truck. They include a modulator where you can dial in the frequency, an up-converter to convert to microwave,(could not get the TWT amp), an encoder for digital modulation, and several other rack mount things that came out of the truck. Also some 440 and 900 ATV stuff.
Here is a list of what I have for sale
L3 communications up-converter
Tiernan TE3000 MP2 encoder
Teirnan TDR777 MP2 (IRO?)
LNR video exciter (set frequency, bandwidth, etc on front panel)
DX satellite receiver (set freq bandwidth, and 2 sub carrier with dial)
If interested, ---- Contact Darryl at DLE9480907 (at) aol.com
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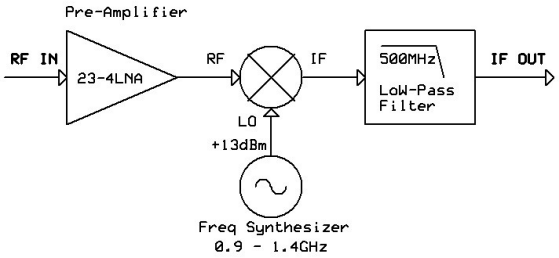
FOR SALE: 23cm Down-Converter, for more details, contact Jim, KH6HTV (kh6htv@yahoo.com)
price $450, includes shipping

Model 23-7
23 cm
DOWN - CONVERTER



The KH6HTV VIDEO Model 23-7 is a high performance, 23cm Down-Converter with 20 dB of conversion gain. The front end pre-amp is the same circuit as used in the model 23-LNA. It has a flat frequency response across the 23 cm band (1240-1300MHz) with a 1.2 dB noise figure. The double balanced Schottky diode mixer features a high level +14 dBm LO drive. The LO is provided by an easily re-programmable, frequency synthesizer. A three position, front panel toggle switch allows the selection of three pre-programmed LO frequencies.