QST

ARRL The National Association for Amateur Radio®

March 2021

Apache Labs ANAN-7000DLE MKII HF and 6-Meter SDR Transceiver with i7 CPU

Product Review

Apache Labs ANAN-7000DLE MKII HF and 6-Meter SDR Transceiver with i7 CPU

Reviewed by Terry Glagowski, W1TR
w1tr@arrl.net

The ANAN-7000DLE MKII is a newer entry in the family of software-defined radio (SDR) transceiver offerings from Apache Labs. We reviewed the ANAN-100D in the October 2015 issue of *QST*, and the ANAN-8000DLE in the April and November 2018 issues.

Many hams are used to a traditional self-contained transceiver into which you connect power, an antenna, a microphone, a key, and other accessories, and you are on the air. They are not comfortable with using a separate personal computer to run SDR software that controls the radio. Apache Labs addressed that concern by offering versions of the ANAN-7000DLE MKII with a PC module built into the radio chassis. This internal PC eliminates the requirement for a separate computer, but the user supplies a monitor, a keyboard, and a mouse. The internal PC can be networked with other computers on a local area network (LAN), so that data can be exchanged, and the SDR can also be controlled by an external computer if desired.

The Apache ANAN series radios have always used open-source firmware and software. Microsoft Windows has been the dominant operating system, but versions for Linux are also available. We'll discuss the software later in this review.

There are some hardware changes for the ANAN-7000DLE MKII compared to previous ANAN transceivers. The version with the built-in CPU has a cabinet that is 5 × 15 × 13 inches, midway between the size of the '100D and the 8000DLE. The unit without the built-in CPU has a cabinet size similar to the '100D, which is about is 3.5 × 10.5 × 9 inches. The fan is quieter than my '100D, and the fan controller allows for an external fan for better cooling.

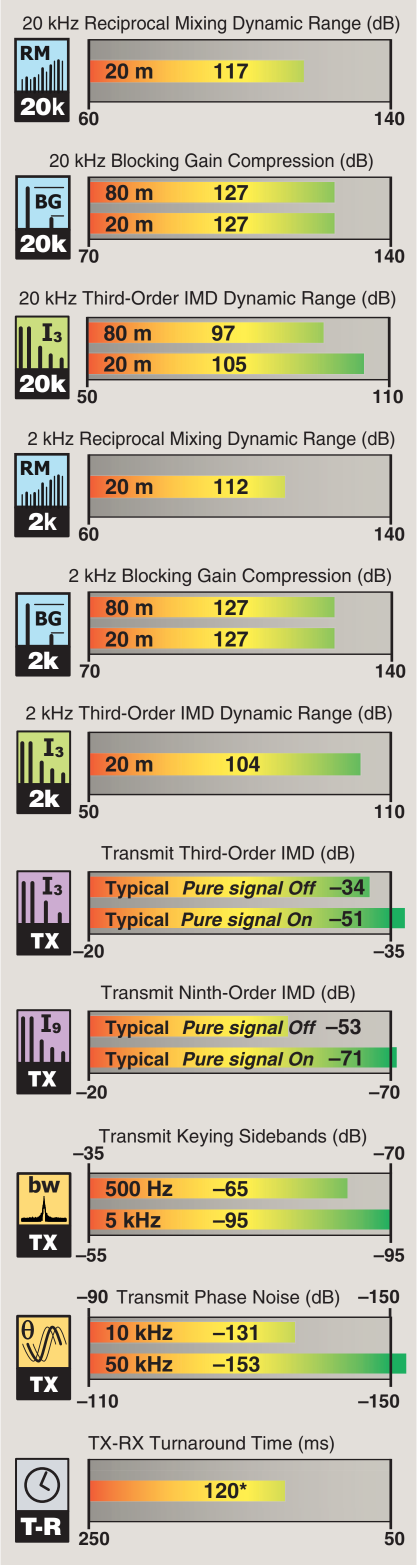
System Overview

The review transceiver includes the optional i7 PC module (CPU). It's an Intel NUC8i7BE embedded computer with 8 MB RAM and a 128 GB solid-state drive (SSD) running the 64-bit version of Microsoft Windows 10 Home. This device has Wi-Fi and Bluetooth built in. Apache Labs also offers the 7000DLE MKII with an internal i5 PC module, or no internal PC module.

Bottom Line

The Apache Labs ANAN-7000DLE MKII features improved hardware and software compared to previous models and can be equipped with an internal PC module, which eliminates the need for a separate PC to run the control software. Receiver performance is very good, and the Pure Signal predistortion feature provides an exceptionally clean SSB signal.

ANAN-7000DLE MKII Key Measurements Summary



KEY: QS2103-PR151

Randomizer and Dither features enabled during receiver measurements.

*SSB mode, AGC Fast

Table 1
Apache Labs ANAN-7000DLE MKII, serial number 7000DLEMKII0006

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: Receive, 9 kHz – 61.44 MHz. Transmit, not specified.	Receive, 0.03 – 61.440 MHz;* 160 – 6 meter amateur bands.
Power requirement: Transmit, 30 A; receive, 3 A at 13.8 V dc.	Transmit, 17 A (typical) at maximum power output; 6.0 A (typical) at minimum power output. Receive, 2.6 A. Power off, <2 mA.
Modes of operation: SSB, CW, AM, FM, digital, RTTY.	As specified.
Receiver	**Receiver Dynamic Testing****
Noise floor: Not specified.	Noise floor (MDS), 500 Hz bandwidth: 0.137 MHz –127 dBm 0.475 MHz –128 dBm 1.0 MHz –130 dBm 3.5 MHz –132 dBm 14 MHz –132 dBm 50 MHz –141 dBm
Noise figure: Not specified.	14 MHz, 15 dB; 50 MHz, 6 dB.
Spectral sensitivity: Not specified.	Panadapter: 14 MHz, –137 dBm, 50 MHz, –143 dBm. Waterfall: 14 MHz, –147 dBm, 50 MHz, –153 dBm.
AM sensitivity: Not specified.	10 dB (S+N)/N, 1 kHz tone, 30% modulation, 6 kHz BW: 1.0 MHz 2.23 µV 3.88 MHz 1.80 µV 29.0 MHz 5.07 µV 50.4 MHz 0.59 µV
FM sensitivity: Not specified.	29 MHz, 0.70 µV; 52 MHz, 0.22 µV.
ADC overload level: Not specified.	HF, –5 dBm; 50 MHz, –19 dBm.
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range, 500 Hz bandwidth: *20 kHz offset* *5/2 kHz offset* 3.5 MHz 127 dB 127/127 dB 14 MHz 127 dB 127/127 dB 50 MHz 119 dB 119/119 dB
Reciprocal mixing dynamic range: Not specified.	14 MHz, 20/5/2 kHz offset: 117/115/112 dB.

ARRL Lab Two-Tone IMD Testing (500 Hz bandwidth)

Band	*Spacing*	*Measured IMD Level*	*Measured Input Level*	*IMD DR****
3.5 MHz	20 kHz	–132 dBm	–35 dBm	97 dB
		–97 dBm	–10 dBm	
14 MHz	20 kHz	–132 dBm	–27 dBm	105 dB
		–97 dBm	–10 dBm	
14 MHz	5 kHz	–132 dBm	–28 dBm	104 dB
		–97 dBm	–10 dBm	
14 MHz	2 kHz	–132 dBm	–28 dBm	104 dB
		–97 dBm	–10 dBm	
50 MHz	20 kHz	–141 dBm	–46 dBm	95 dB
		–97 dBm	–31 dBm	

Manufacturer's Specifications	Measured in the ARRL Lab
Second-order intercept point: Not specified.	14 MHz, +87 dBm; 21 MHz, + 87 dBm; 50 MHz, +17 dBm.
DSP noise reduction: Not specified.	NR1, 10 dB.
FM adjacent channel rejection: Not specified.	29 MHz, 79 dB; 52 MHz, 72 dB.
FM two-tone, third-order dynamic range: Not specified.	20 kHz spacing, 29 MHz, 51 dB; 52 MHz, 72 dB.† 10 MHz spacing: 29 MHz, 104 dB; 52 MHz, 111 dB.
Squelch sensitivity: Not specified.	29 MHz, 0.28 µV; 52 MHz, 0.09 µV.
Notch filter depth: Not specified.	Auto-notch, >60 dB. Attack time, 1 second (single tone and two tones).
S-meter sensitivity: Not specified.	S-9 signal, 14 MHz, 50.1 µV; 50 MHz, 10 µV (after calibration). Scaling, 6 dB/S-unit.
IF/audio response: Not specified.	Range at –6 dB points:‡ CW (500 Hz BW): 305 – 898 Hz; Equivalent Rectangular BW: 493 Hz; SSB (2.4 kHz BW): 101 – 2594 Hz; AM (6 kHz BW): 11 – 2982 Hz.
Receive processing delay time: Not specified.	57 ms at transceiver rear speaker jacks.
Transmitter	**Transmitter Dynamic Testing**
Power output: 100 W SSB, CW, FM, digital; 1 – 30 W AM.	SSB, CW, FM, AM, digital, as specified for 1.8 – 30 MHz. 0 – 100 W SSB, CW, FM, digital; 0 – 32 W AM. At 54 MHz, 56 W maximum output.
Spurious-signal and harmonic suppression: >43 dB (HF); 60 dB (50 MHz).	HF, 71 dB typical; worst case, 66 dB (20 m); 50 MHz, 69 dB. Complies with FCC emission requirements.
SSB carrier suppression: >80 dB.	>70 dB.
Undesired sideband suppression: >80 dB.	>70 dB.
Third-order intermodulation distortion (IMD) products: Not specified.	3rd/5th/7th/9th order IMD products 100 W PEP RF output, Pure Signal off: –34/–38/–44/–53 dB (HF typical) –27/–38/–39/–50 dB (worst case, 15 m) 100 W PEP RF output, Pure Signal on –51/–62/–67/–71 dB (HF typical) –31/–55/–52/–58 dB (worst case, 10 m) At 50 W PEP RF output, 14 MHz: –35/–39/–50/–58 dB (Pure Signal off) –57/–64/–70/–73 dB (Pure Signal on) At 50 MHz, 100 W PEP RF output: –30/–37/–42/–53 dB (Pure Signal off) –34/–49/–53/–65 dB (Pure Signal on)
CW keyer speed range: Not specified.	1 to 48 WPM, iambic mode B.
CW keying characteristics: Not specified.	See Figures A and B.
Transmit-receive turnaround time (PTT release to 50% audio output): Not specified.	S-9 signal, AGC fast, SSB: 120 ms; CW, full break-in: 90 ms
Receive-transmit turnaround time (TX delay): Not specified.	SSB, 114 ms; FM, 62 ms (29 MHz), 60 ms (52 MHz).
Transmit phase noise: Not specified.	See Figure C.
RF output lag time versus amplifier key line open: Not specified.	0 ms (default settings).

Size (height, width, depth, with protrusions): 5.1 × 15.3 × 14.4 inches. Weight, 22 lbs.

Second-order intercept points were determined using S-5 reference.

*Reception is possible below 30 kHz, at a noise floor >1 µV.

**Randomizer and dither features enabled during noise floor and dynamic range measurements.

***Third-order IMD dynamic range measurements in a laboratory environment. Measurements shown represent the best case.

†Measurement is phase noise limited to the value indicated.

‡Default values; bandwidth is adjustable via DSP.

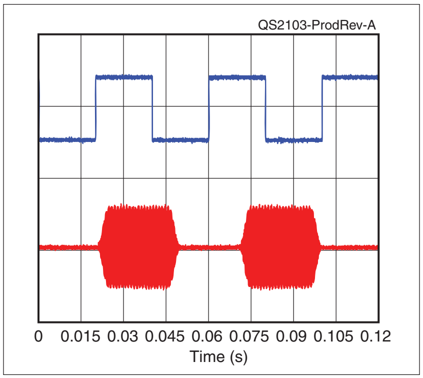


Figure A — CW keying waveform for the ANAN-7000DLE MKII shows the first two dits in full-break-in (QSK) mode using external keying. Equivalent keying speed is 48 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. (Note that the first key closure starts at the left edge of the figure.) Horizontal divisions are 10 ms. The transceiver was being operated at 100 W output on the 14 MHz band. As explained in the "Lab Notes" sidebar, at the normal test speed of 60 WPM, the RF output keying waveform could not keep up with the external keying device.

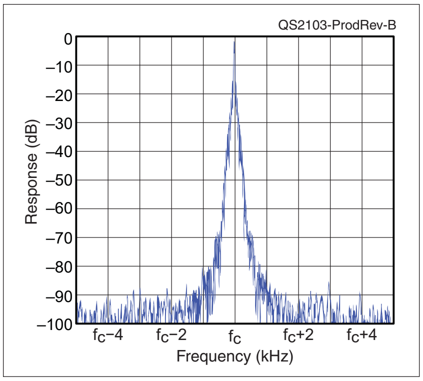


Figure B — The spectral display of the ANAN-7000DLE MKII transmitter is shown during keying sideband testing. Equivalent keying speed is 48 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 100 W PEP output on the 14 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

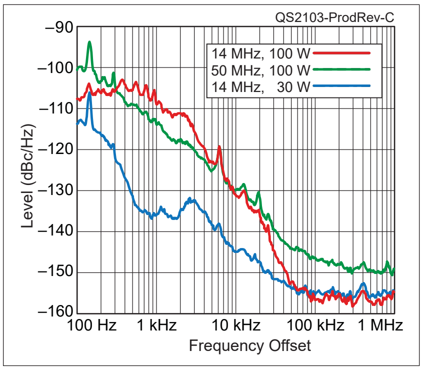


Figure C — The spectral display of the ANAN-7000DLE transmitter output is shown during phase-noise testing. Power output is 100 W on the 14 MHz band (red trace), 30 W on the 14 MHz band (blue trace), and 100 W on the 50 MHz band (green trace). The carrier, off the left edge of the plot, is not shown. This plot shows composite transmitted noise 100 Hz to 1 MHz from the carrier. The reference level is –90 dBc/Hz, and the vertical scale is 10 dB per division.

Lab Notes: Apache Labs ANAN-7000DLE MKII

Bob Allison, WB1GCM

Initial testing of the Apache Labs ANAN-7000DLE MKII showed higher-than-anticipated transmit IMD on the 17- through 10-meter amateur bands, even with the Pure Signal function enabled. We returned the radio to the US service center, where they determined that four inductors in the low-pass filter sections for the affected bands required smaller cores. The replacements were installed in our unit, and all further units employ these new parts.

With the revised inductors, the review radio's transmit IMD improved dramatically. A good benchmark for reasonable third/fifth/seventh/ninth-order IMD products is 30/40/50/60 dB below PEP output. With Pure Signal enabled, the ANAN-7000DLE MKII typically measured 51/62/67/71 dB below PEP. This translates to very low transmitted distortion products and a clean, narrow signal that offers more elbow room for others operating near the transmit frequency.

During initial testing, we also found that the review radio did not comply with FCC spectral purity requirements because of a spurious emission when transmitting on the 6-meter band. This problem was fixed with the release of the Protocol 2 (*Thetis/Metis*) software and firmware.

Other transmit performance parameters are favorable, with reasonably low transmit phase noise and a nicely shaped CW waveform with narrow CW bandwidth. Like the ANAN-8000DLE reviewed previously, the maximum external keying speed of the transmitter is 48 WPM. Any higher speeds will result in character shortening.

The lowest of the three dynamic ranges in the review radio at 2 kHz spacing was two-tone, third-order IMD at 104 dB. This places the ANAN-7000DLE MKII in the top tier of performance. The only parameter that might cause an issue is two-tone, second-order IMD when operating on the 6-meter band. There is a small chance of phantom signals when two strong signals are present at the antenna jack, with the sum of the two frequencies falling somewhere in the 6-meter band.

Turnaround times (receive-to-transmit and transmit-to-receive) are about average for SDR transceivers. Receive processing delay time (the time between when a signal arrives at the antenna jack when it is heard in the speaker) is shorter than expected. At 57 milliseconds, it is faster than some of the other SDRs we have measured.

As the review was wrapping up, the 7000DLE MKII developed a heat-related problem with the video display using the internal i7 PC, although we could still control the radio using an external PC. We sent the radio for repair, and replacement of defective RAM fixed the problem.

A word of caution: prior to testing, I discovered the transmit inhibit function in the setup menu did not inhibit the transmitter. In the Lab, that can result in transmitting at high power into sensitive test equipment.

The unit comes with the software needed to run the SDR already installed, so the unit is ready to use out of the box. As tested here, *Thetis* software version 2.7.0 and *Metis* firmware version 2.0 have been installed. *Thetis/Metis* is also known as Protocol 2 and is the latest generation firmware and software available for the Apache Labs ANAN series SDR transceivers.

I was a little skeptical that 128 GB is sufficient storage, but with two SDR software versions and many third-party ham radio and MARS (Military Affiliate Radio System) applications loaded, my usage is 48 GB. There should be plenty of room for word processing, spreadsheet, and other applications, but anything with a very large database might be a challenge. Because the unit has the capability of Wi-Fi and ethernet LAN connections, external storage is always available.

The Apache Labs ANAN series radios, including the ANAN-7000DLE MKII, have the following major subsystems:

1) The mechanical and electrical chassis, including a heatsink and fans, with provisions for external fans.

2) The RF board containing the analog parts of the receiver and transmitter, the power amplifier, and the filters. The new RF board in the 7000DLE MKII offers better receiver dynamic range and better transmit Pure Signal (pre-distortion) support than previous hardware. (Pure Signal significantly improves the transmitted IMD products, as discussed in the "Lab Notes" sidebar.)

3) The digital board with a field programmable gate array (FPGA) to perform all the direct upconversion/downconversion (DUC/DDC) and digital signal processing (DSP) functions. In the 7000DLE MKII, it is an Orion II board.

4) The SDR firmware for the digital board (*Metis*).

5) The SDR software for the personal computer (*Thetis*).

Apache Labs manufactures the transceiver hardware, but open-source developers create the firmware and software, which is freely available for anyone to use or adapt. The firmware is specific to the digital board used in the transceiver, with versions called Hermes, Angelia, Orion, and so on. The software is common to all the ANAN series transceivers. This article will focus on improvements in the hardware with the ANAN-7000DLE MKII and the Protocol 2 software/firmware.

Hardware Installation

The ANAN-7000DLE MKII requires a user-supplied monitor (HDMI) and USB keyboard and mouse for operation with the internal PC module. I used a wireless keyboard/mouse for testing, but wired units will work fine too. A USB hub may be required if additional USB devices are used. It is too bad that a front-panel USB jack is not available for USB thumb drives, but a USB hub or extension cable will solve that.

The ANAN-7000DLE MKII front panel has stereo ¼-inch jacks for headphones, a CW key, and a microphone. The microphone jack tip and ring are configurable in software for audio or push-to-talk (PTT). Bias for an electret mic is also configurable in software. The microphone, headphone, and key jacks are mirrored on the rear panel with ⅛-inch phone jacks. Bluetooth capability opens the possibility of a wireless headset.

The rear panel (see Figure 1) is quite a bit busier. The radio requires 13.8 V dc at about 20 A, supplied via Anderson Powerpole connectors. (Note that the Powerpole orientation is backward compared to typical usage in the US.) There are BNC connectors for three antennas, a separate receive antenna, and a transverter input. The SMA connectors are for a 10 MHz reference input, a transverter output, and a Wi-Fi antenna (not supplied). There are also two ethernet jacks (SDR LAN and PC LAN), two USB-B and one USB-C ports, an HDMI jack for the monitor, speaker and audio input jacks, and PTT and CW key jacks. The speaker jacks are wired as balanced, tip to ring, with no ground to the sleeve. The embedded PC has a four-conductor headset connector for stereo audio out and monaural microphone in, similar to many laptop computers.

Figure 1 — The ANAN-7000DLE MKII's rear panel.

Controlling External Devices

Seven open-collector outputs available via the rear-panel DB-9 connector are configured using the transverters (XVTRS) and open collector (OC) setup tabs. The transverter local oscillator (LO) frequency offset and error can be programmed in, as well as the drive power required, and control of the transverter output and internal power amplifier. With external transverters connected and configured, your ANAN transceiver can act like a single transceiver from HF through VHF/UHF/microwaves.

The open collector outputs can be used for switching antennas, filters, and other external equipment. With one-hot wiring, seven different options can be selected or deselected. With binary decoding, up to 128 options can be selected. The latest *Thetis* software has separate setup forms for HF, VHF, and SWL bands.

Hardware Knobs, Sliders, and Buttons

The *Thetis* software has a configuration interface to use MIDI devices, such as the Hercules DJ controller series to make knobs, tuning wheels, sliders, and buttons available for those who prefer traditional front-panel controls. As a longtime ANAN SDR owner, I find a hardware controller very helpful for tuning frequency and for setting AF gain, AGC, and drive levels. Over the years, I have become more accustomed to using the on-screen controls for most everything else.

Network Installation

A number of network connection possibilities exist with this system. An air-gapped (standalone) system can be implemented, but wired and Wi-Fi connections to a local area network can be set up as well. The ANAN-7000DLE MKII can also be controlled by an external PC instead of the internal embedded PC, just like the other ANAN transceivers.

An air-gapped system with no connection to the outside world is of interest to Military Auxiliary Radio System (MARS) operators who may need additional security from internet intruders. A USB drive would be needed to install additional software or transfer files.

The 7000DLE internal PC can be connected to a LAN (and the internet) via Wi-Fi, and it can be accessed by other equipment if necessary. The computer would have two IP addresses, Automatic Private IP Addressing (APIPA) for the radio and computer ethernet, and a DHCP or static address for the Wi-Fi router. Use of Wi-Fi requires an external SMA antenna (not supplied, but readily available). If security is a concern, Wi-Fi can be set up temporarily to facilitate software installation and updates, and then disabled to maintain air gap.

Bandwidth may be limited with Wi-Fi, but the 7000DLE can be hardwired to a router via the rear-panel ethernet jack. The radio and/or the computer can be set up with DHCP or static IP addresses as needed. It is possible to control the radio with an external computer instead of the internal CPU in the radio chassis with this arrangement. The external computer would be plugged into the ethernet switch along with the internal CPU and the radio.

The Software

The Apache Labs ANAN-7000DLE MKII comes with operating software and firmware already installed and configured, so further installation is not required. Because updates are made frequently, it's highly recommended that you check for the latest release online at **github.com/TAPR/OpenHPSDR-PowerSDR/releases**. Protocol 1 is the *PowerSDR OpenHPSDR mRX* software. Protocol 2 is for the latest *Thetis* software and *Metis* firmware, which we used for this review.

The display and controls for *Thetis* have not changed much from *PowerSDR OpenHPSDR mRX* software (see Figure 2). There are the usual panadapter/panafall/spectrum display, frequency and mode fields, and buttons and slider controls that drive the behavior of the unit. There are a number of setup tabs to configure less-often-used settings and controls. The main setup screen is shown in Figure 3, and details may be found in the user manual available online.

The signal display shown in Figure 4 is set up as a *panafall*, a combination of panadapter and waterfall, for both receivers. The panadapter shows the current spectrum occupancy, while the waterfall shows the spectrum occupancy over the last few seconds.

The frequency display shows both receivers, along with the transmit frequency when in split mode. It is possible to tune the radio by clicking on the pan-


Thetis v2.7.0 (3/1/20) MW0LGE (a3) -- W1TR / AFA1DI

VFO A 28.475 000 10M SSB

VFO B 13.963 500 Out of Band

RX1 Meter -97 dBm

RX2 Meter -122 dBm

Master AF: 25

RX1 AF: 50

RX2 AF: 50

AGC Gain: 112

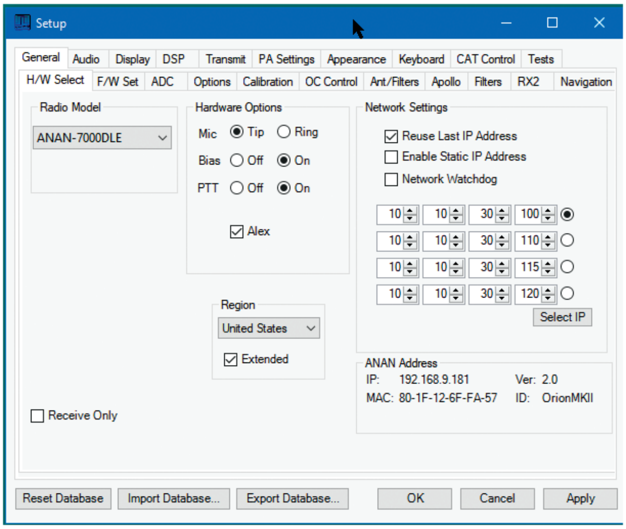
Drive: 50

SQL: -150

Transmit Profile: MARS SSB

1018 x 721 25% 13.4V 0.1A 01:48:07 utc Thu 6 Aug 2020 21:48:07 loc

Figure 2 — The main operating screen for the *Thetis* software.



Radio Model: ANAN-7000DLE

Hardware Options
Mic ● Tip ○ Ring
Bias ○ Off ● On
PTT ○ Off ● On
☑ Alex

Region: United States
☑ Extended

Network Settings
☑ Reuse Last IP Address
☐ Enable Static IP Address
☐ Network Watchdog
10 10 30 100 ●
10 10 30 110 ○
10 10 30 115 ○
10 10 30 120 ○

ANAN Address
IP: 192.168.9.181 Ver: 2.0
MAC: 80-1F-12-6F-FA-57 ID: OrionMKII

☐ Receive Only

Figure 3 — The main setup screen for configuration of many hardware and software options.

adapter, using the mouse thumbwheel, or entering the frequency using the keyboard. You can drag the filter edges to change bandwidth.

The meter displays are very nice. The S-meter shows signal level in dBm as well as S-units (S-9 = –73 dBm, scaling is 6 dB per S-unit). I like the split power/SWR meter that shows forward power in watts and SWR simultaneously.

The Operational Status section of the main screen shows band, mode, DSP functions, levels, and other parameters. There is a mode specific section with controls relevant to the current emission mode. Memory channels can be given group and channel names.

Thetis DSP Features

The *Thetis* software offers a number of standard DSP features. The traditional noise reduction (NR) uses a standard algorithm. The advanced noise reduction algorithm (NR2) is really outstanding. It makes SSB sound like FM, and it plays well with digital modes, including FT8 and MIL-STD-188-M110a waveforms used in MARS.

The spectral noise blanker (SNB) causes signals to pop out of the background noise, while the automatic notch filter (ANF) effectively eliminates annoying heterodynes and carriers. The multi-notch filter (MNF) will attack multiple heterodynes. The CW audio peak filter (APF) offers additional filtering in the audio subsystem.

Audio equalizers are available for receive and transmit. Transmit bandwidth can be set up to 10 kHz for AM

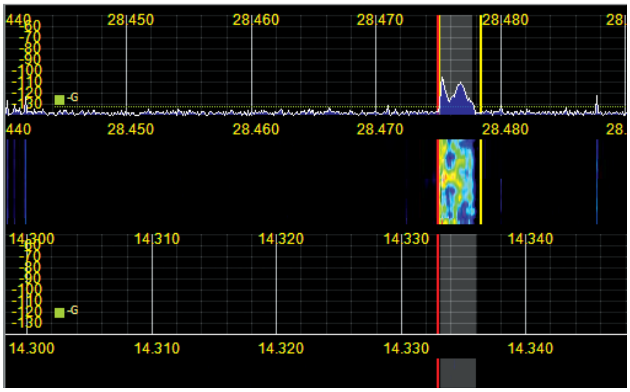


Figure 4 — A portion of the spectrum display in the panafall mode.

afficionados. The advanced continuous frequency compression (CFC) and controlled envelope single sideband (CESSB) processing features allow you to get that AM broadcast quality sound. Audio profiles can store settings for various activities, such as general conversation or contesting.

PowerSDR and *Thetis* have a feature where both VFOs are synchronized to the same frequency and phase locked. If receivers RX1 and RX2 are connected to separate analog-to-digital converters (ADCs) and each ADC is connected to a different antenna, the phase and amplitude of each receiver can be adjusted to enhance desired signals or to cancel unwanted noise and interference.

In *Thetis*, if you right-click on certain controls, you are directly vectored to the tab for settings related to that control. This is very handy for mic gain, VOX, compression, transmit audio profiles, and other frequently used settings.

Thetis offers a lot of flexibility for recording and playing back signals off the air, so you can show others what they sound like rather than having to describe it in words. There is a provision for setting up scheduled recordings as well, for one-time-only or periodic recordings of your favorite shortwave broadcast or ham radio net.

CW QSK Operation

When used with *Thetis* software, the ANAN-7000DLE MKII has full-break-in CW (QSK), which earlier units did not have. The CW QSK is a great step forward for the Apache Labs ANAN series and requires some trial and error setting up the AGC parameters to let the receiver recover from the transmit signal quickly enough. Transmit-receive switching uses relays, and clicking is clearly audible.

I had an issue with QSK operation because the monitor (which tracks the transmit signal) cannot be shut off to hear just the sidetone (which tracks the keyer paddle). As with other SDRs, there is a bit of latency — a slight delay — between the keyer paddle action and the transmitted signal, which is heard in the monitor. The delay is present even with low-latency filter settings. For some reason, you cannot disable the monitor (with latency) and only use the sidetone (no latency). I found it difficult to send without the proper audio feedback while using CW keyer paddles. If sending with keyer memories or a keyboard, this is not as important. I wish there were separate slider controls for monitor level and sidetone level, independent of the master AF gain.

On the Air

I had the luxury of spending quite a while using the ANAN-7000DLE MKII on the air. I used a wide variety of bands and modes, including many digital soundcard modes, such as PSK, RTTY, FT8, and MIL-STD-M110a. I got excellent signal and audio reports across the board.

The unit worked well on MARS frequencies, which are outside the normal ham bands. You need to use the **EXTENDED REGION** in the main setup tab to enable transmission on the MARS frequencies. (Watch the band edges if you operate with this feature enabled.)

The receiver is at least as sensitive as any of my other transceivers, and perhaps more sensitive on 6 meters. It receives better and copies digital transmissions better than any of my other transceivers. The laboratory results show that receiver performance is competitive, and the transmit IMD with Pure Signal enabled is second to none.

Conclusions

The Apache Labs ANAN-7000DLE MKII is the next refinement in a now mature SDR technology available from Apache Labs. I have an Apache Labs ANAN-100D that I acquired in 2014, and I can say the ANAN-7000DLE MKII is a noticeable improvement. This is a great radio. My only issue with it is the behavior of the sidetone and transmit monitor during QSK CW operation, as discussed.

Additional information and screen captures are available from **www.arrl.org/qst-in-depth**.

Manufacturer: Apache Labs Pty Ltd., 3 Pershing Way, Point Cook, VIC 3030, Australia; **www.apache-labs.com**. Available direct or from Ham Radio Outlet. Price: $4,295. With i5 CPU, $3,995. No CPU (Black Edition), $2,795.

tinySA — A Small Spectrum Analyzer

Reviewed by Phil Salas, AD5X
ad5x@arrl.net

Bottom Line

At about $50, the tinySA can put a surprisingly capable spectrum analyzer into the hands of many STEM students and home experimenters.

In recent years, a number of inexpensive RF test devices have come on the market. The latest is the tinySA, a small spectrum analyzer with a 2.8-inch, 320 × 240 pixel color touchscreen. This $49 spectrum analyzer was developed by Erik Kaashoek, PD0EK, and is manufactured and distributed by Hugen. The tinySA looks like the nanoVNA I reviewed in the May 2020 issue of *QST*.

Description

The tinySA comes in a nice box and includes a small telescoping antenna, two 8-inch SMA-to-SMA test cables, an SMA-female-to-SMA-female adapter, a USB cable for charging the internal battery and for computer interfacing, and a carrying strap with a guitar-pick stylus (see Figure 5). The spectrum analyzer

Figure 5 — The tinySA accessories.

has two inputs: a high-quality input covering 0.1 – 350 MHz, and a low-quality input that covers 240 – 960 MHz. Resolution bandwidth filters are manually selectable and automatically selectable from 2.6 kHz to 640 kHz for both input ranges. There is an accurate 0 – 31 dB input step attenuator for the 0.1 – 350 MHz input. The 240 – 960 MHz input has very limited image suppression, and its input attenuator is frequency dependent and varies from 25 – 40 dB.

As with any spectrum analyzer, to use this device, you will need some type of sampler or attenuator to reduce the signal to be measured to a very low level to avoid damaging the tinySA. The specified absolute maximum input level is +10 dBm (10 mW) with 0 dB of internal attenuation, and the maximum short-term input power is +20 dBm (100 mW) with 30 dB of internal attenuation. The specs also suggest keeping input power below –25 dBm for best measurement accuracy.

The tinySA has a built-in calibration signal generator for automatic self-test and low-frequency input range calibration. It can also be used as a signal generator for receiver alignment, with a sine wave output from 0.1 – 350 MHz, and a square wave output from 240 – 960 MHz. These output signals can be modulated for internal or external amplitude and frequency. You can even turn on a waterfall display to monitor a selected frequency range.

Finally, the tinySA can be connected to a computer for software updates. There is also computer interface software available that permits some screen captures, but this software was pretty minimal at the time of this review. The tinySA specifications are given in Table 2.

Table 2
tinySA Key Specifications

General Specifications

Manually selectable resolution bandwidth filters: 3, 10, 30, 100, 300, 600 kHz
Absolute power level accuracy after calibration: ±1 dB
Absolute maximum input level: +10 dBm with 0 dB internal attenuation
Maximum short term input power: +20 dBm with 30 dB internal attenuation
Suggested maximum input power: +5 dBm with internal attenuation in automatic mode
For best measurements keep input power below –25 dBm

Low-Frequency Input Specifications

Input frequency range: 100 kHz – 350 MHz (down to 10 kHz with reduced sensitivity)
1 dB compression point: +2 dBm with 0 dB internal attenuation
Lowest discernible signal when using 30 kHz resolution bandwidth: –102 dBm
Spur free dynamic range when using 30 kHz resolution bandwidth: 70 dB

Low-Frequency Signal Generator

Frequency range: 100 kHz to 350 MHz; selectable in 1 dB steps from –76 to –6 dBm
Sine wave output: Harmonics > –40 dBc
Modulation: AM, NBFM and WBFM, or slow sweep over selectable frequency span

High-Frequency Input Specifications

Input frequency range: 240 MHz to 960 MHz
Input impedance: Frequency dependent and deviates from 50 W
1 dB compression point: –6 dBm with no internal attenuation
Lowest discernible signal when using a resolution bandwidth of 30 kHz: –115 dBm
Spur free dynamic range when using a 30 kHz resolution bandwidth: 50 dB
Input attenuator: 25 – 40 dB, frequency dependent. Increases power level error ±10 dB
Note: Strong signals outside the 240 – 960 MHz range can cause distortion of signals

High-Frequency Signal Generator

Frequency range: 240 MHz to 960 MHz, in variable increments from –38 to +13 dBm
Modulation: NBFM and WBFM, or slow sweep over selectable frequency span

Reference Generator

Optional square wave output from **HIGH** SMA jack with –25 dBm fundamental
Frequency: 1, 2, 4, 10, 15, or 30 MHz.
See **www.arrl.org/qst-in-depth** for additional specifications.

Using the tinySA

I recommend joining the tinySA user group at **groups.io/g/tinysa**. Another important link is the tinySA wiki at **tinysa.org/wiki**. On this site, you can find a preliminary manual, firmware update information, and the Windows interface software.

Along the top side of the nanoVNA are a USB-C interface, a red charging LED indicator, an **ON/OFF** switch, a flashing blue operating LED, and a momentary rocker/pushbutton switch that's used for adjustments. Before using the tinySA for the first time, charge the unit with the supplied USB cable. The red charging LED turns off when the tinySA's battery is fully charged. Battery charge time is specified at 1 hour with a 500 mA minimum USB charger. A full charge provides about 2 hours of operation.

I suggest that you not attach any large coaxial adapters directly to the tinySA's SMA connectors. Always use the sup-

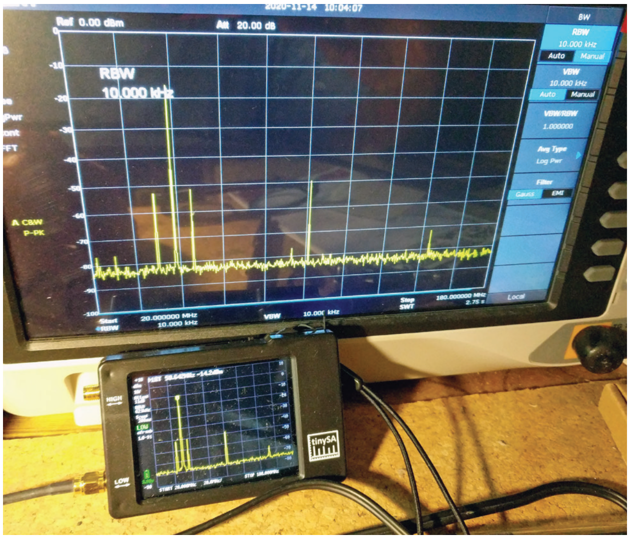


Figure 6 — The spectral output of a 6-meter transverter observed on the tinySA and a Siglent SSA3021X.

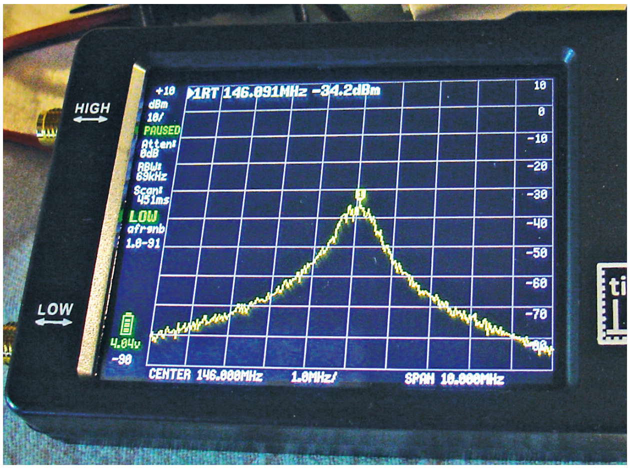


Figure 7 — A broadband noise source can be used to measure a filter's response.

plied 8-inch SMA-to-SMA cables. In order to interface with more common connectors, you can purchase SMA-to-N, SMA-to-SO-239, and SMA-to-BNC adapters — all readily available online. Further, because SMA connectors are specified for 500 mate/unmate operations, you may want to attach SMA-male-to-SMA-female adapters to the tinySA ports to protect the original SMA connectors.

Displaying Signals

I started by first connecting the supplied telescopic whip antenna to the 0.1 – 350 MHz input, as this is the default input and sweep range. It is interesting to see all the RF signals in this range. The 88 – 108 MHz broadcast spectrum is quite packed with visible signals — at least at my location. One default marker automatically finds the highest signal and reads out the signal's frequency and level (up to four markers are available). Touching the screen with your preferred stylus brings up the menu. While the tinySA screen is quite small, the supplied guitar pick stylus on the wrist strap works well. The rocker/pushbutton switch can also be used, especially for ease in moving the markers on the screen. But I prefer the touchscreen for the settings and menu selections.

When using the tinySA for the first time, the Self Test should be performed. This is accomplished by connecting the high and low connectors together with one of the supplied SMA cables. Click on the screen, select **CONFIG** and then **SELF TEST**. When these tests are complete, select **CONFIG**, **LEVEL CAL**, and then **CALIBRATE**. Once complete, this procedure results in measurement accuracy of 1 dB over the entire frequency range.

As I have a Siglent SSA3021X benchtop spectrum analyzer, I wanted to see how the tinySA compared. My first test involved a 28-to-50 MHz transverter with 10 W output. Figure 6 shows the transverter's output spectrum on both the tinySA and the SSA3021X up to the third harmonic of the transverter. Part 97 of the FCC rules requires that amateur radio transmitters from 30 – 225 MHz with a mean power of 25 W or less must attenuate any spurious emissions at least 40 dB below the mean power of the fundamental emission. As you can see in Figure 6, there is excellent agreement between the tinySA and the Siglent SSA3021X. Both devices show that the transverter's ±6 MHz spurs and the second harmonic (–37 dBc and –35 dBc, respectively) do not meet FCC requirements, and so this device requires an external band-pass filter of some sort to be used by US amateurs.

Another important test is the two-tone intermodulation distortion (IMD) performance of transmitters and amplifiers. Unfortunately, with the tinySA's minimum resolution bandwidth (RBW) of 2.7 kHz, it is impossible to display the desired spectral detail for the typical amateur SSB tests with audio tones of about 700 and 1900 Hz. (The ARRL Lab uses an RBW of 10 Hz when performing these tests.) I did look at a 10 kHz bandwidth AM signal at 50 MHz, where the 2.7 kHz resolution bandwidth does permit looking at the modulated spectrum and found that the tinySA did not properly display the AM signal. The sideband levels are incorrect, and the tinySA shows many other close-in sidebands that don't show up on the SSA3021X. (See **www.arrl.org/qst-in-depth** for a photo showing the comparison.)

Signal Generator

Next, I did some spot tests on the tinySA's signal generator output capability. I found the 0.1 – 350 MHz output to be a clean sine wave with harmonics greater than 50 dB down. Also, the output level tracked within 0.6 dB of the set level across the frequency range as measured with my calibrated Mini-Circuits power meter. As specified, the 240 – 960 MHz output is not a sine wave, and second and third harmonic outputs are about 10 – 12 dB down. The output level for this frequency range measured about 2 dB higher than the actual output setting.

Finally, I looked at the ability to tune filters with the tinySA. While the tinySA does not have a tracking generator, you can feed the output of an inexpensive broadband noise source (available from online auction sites) through the filter into the tinySA. Figure 7 is the tinySA display of a 2-meter band-pass filter's response with a broadband noise input.

You can also use a noise source and a directional coupler to measure return loss. Used Mini-Circuits ZFDC-series directional couplers are often available inexpensively from online auction sites. A block diagram and more information on performing this test are available from **www.arrl.org/qst-in-depth**.

Final Thoughts

At a price of $50, you can certainly find some uses for the tinySA in your station. With an appropriate sampler or attenuators, it is great for looking at spurious and harmonic performance of transmitters, transverters, and amplifiers. It can help to find unknown signals at your location. It can be used as a signal source for receiver alignment. And finally, with some inexpensive additional components, it can be used for filter design. Check out the tinySA Wiki (**www.tinysa.org/wiki/**) for more details on this device.

The review unit was purchased from R&L Electronics (**www.randl.com**) for $49. Check the Where to Buy link at **www.tinysa.org** for vendors in other countries.

MFJ-2010 Off-Center-Fed Dipole Antenna

Reviewed by Steve Ford, WB8IMY
wb8imy@arrl.net

There are several ways to get multiband performance from an HF dipole antenna. You can break up the antenna (electrically speaking) with traps, add more wires in parallel, or just feed the dipole with balanced feed line, such as window line and a balanced antenna tuner.

The off-center-fed (OCF) dipole design takes a different approach. Instead of feeding the dipole at the center (where the impedance is approximately 70 Ω) the OCF dipole moves the feed point off center. By doing so, it is possible to find a point where the impedance can be matched to 50 Ω coaxial cable through a 4:1 current balun. When fed in this fashion, the antenna will provide a low SWR at the lowest design frequency, as well as at frequencies on several higher bands. So if all goes as planned, what was formerly a single-band dipole becomes a multiband dipole.

The MFJ-2010 is an OCF dipole designed for use on 40, 20, 10, and 6 meters. Built with #14 AWG stranded copper wire, it is 67 feet long and rated for 300 W PEP (150 W continuous).

Bottom Line

The MFJ-2010 off-center-fed dipole offers single-feed line operation on 40, 20, 10, and 6 meters at up to 300 W PEP (150 W continuous). Depending on your installation, an antenna tuner may be required for full-band coverage.

Installation and Tuning

The MFJ-2010 arrives preassembled. All you have to do is clip off the tie wraps and uncoil the wires (see Figure 8). The feed point balun is housed within a small, black ABS plastic enclosure with an SO-239 coaxial cable connector underneath (see Figure 9).

Figure 8 — The MFJ-2010, unpacked and ready to install.

Table 3
MFJ-2010 OCF Dipole in a Low-Height, Sloping Configuration

Frequency (MHz)	SWR	Frequency (MHz)	SWR
7.000	1.2:1	28.000	2:1
7.300	1.6:1	28.400	1.4:1
		29.700	1.9:1
14.000	1.8:1		
14.350	1.6:1	50.000	2.5:1
		50.500	1.9:1
		52.500	2.9:1

The end insulators are flat rectangles of flexible plastic, although they seemed remarkably strong.

The feed point is about 20 feet from one end of the antenna, which worked out well for me, because it meant the coax could drop directly to the cable entrance for my station without taking detours in various directions. An OCF dipole isn't necessarily designed for physical convenience like this, but sometimes the off-center arrangement comes in handy.

MFJ recommends installing the antenna with the feed point at a height of at least 35 feet. Because I didn't have two worthy supports, I was forced to use a sloping configuration, which placed the feed point at about 20 feet and the lower end of the antenna at only 8 feet above ground. The high end of the dipole was at 40 feet.

This is far from ideal for an OCF dipole. As a result, my initial SWR measurements indicated that the low-SWR points were beyond the high-frequency ends of several bands. The exception was 40 meters, where the lowest SWR was measured at 7.200 MHz.

I added 12 inches of wire to the lower end of the antenna — the end I could reach easily — and was pleasantly surprised to see the SWR drop to acceptable levels within each band (see Table 3). By "acceptable," I mean less than 3:1. That's low enough for any decent antenna tuner to handle, including the one in my transceiver. If you're feeding the MFJ-2010 with low-loss coax, any additional loss caused by the elevated SWR is inconsequential. It's likely that if I had been able to install the antenna horizontally, and at the recommended height, no length adjustments for SWR would have been necessary.

In OCF dipoles, the quality of the feed-point balun is critical for efficient performance, and to keep RF off the feed line. I often operate with 100% duty-cycle modes, such as RTTY with my 100 W transceiver, and I didn't encounter a problem.

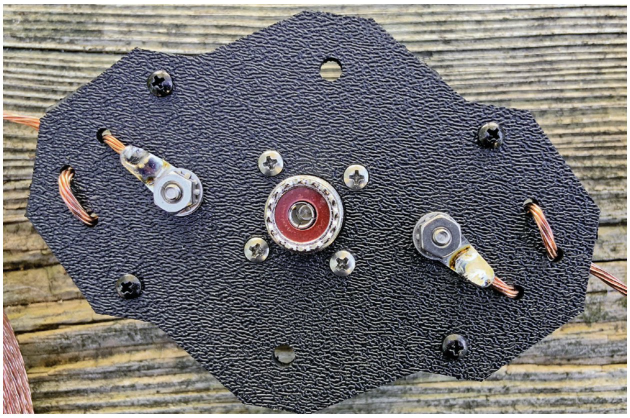


Figure 9 — The underside view of the feed point shows the balun assembly.

I ran initial tests with the WSPR digital mode and was pleased. The MFJ-2010 seemed to perform slightly better than the 40/20-meter dipole it replaced, but now I had 10- and 6-meter capability as well.

I used the antenna during the JARTS RTTY contest in October and was able to work any station I could hear. During the month, 6 meters opened for some weak contacts using FT8, and I managed to get several stations in the log without difficulty.

Just for fun, I attached my antenna analyzer to the feed line to see how the MFJ-2010 design responded to signals above 6 meters. I was surprised to discover that the antenna presented SWR below 2:1 across the entire 2-meter band. Because I was feeding the antenna with relatively small-diameter coax (LMR-240), the loss at this frequency was high, but the antenna was still usable. The addition of 2 meters may have been a side effect of my odd installation, but it was a nice bonus nonetheless.

Manufacturer: MFJ Enterprises, 300 Industrial Park Rd, Starkville, MS 39759; **www.mfjenterprises.com**. Price: $69.95