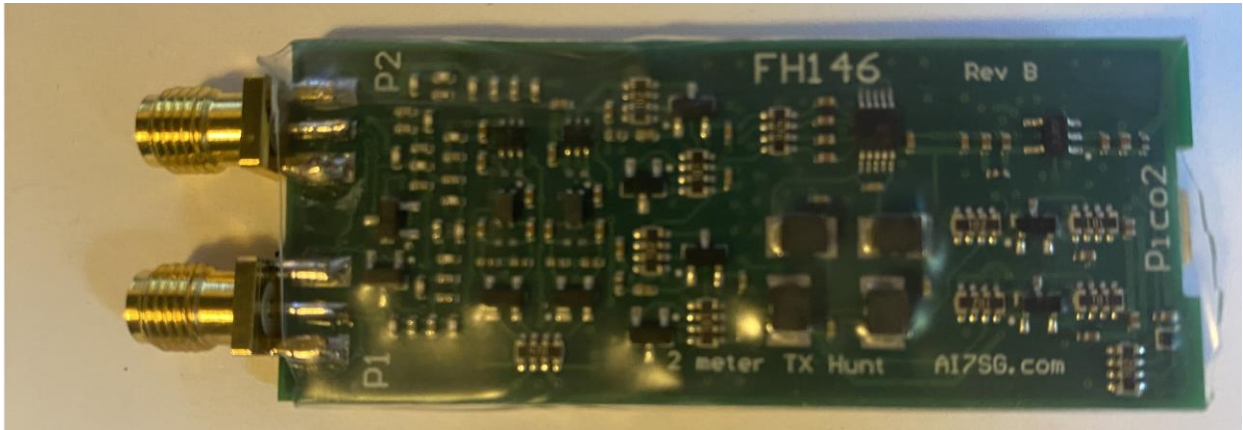


FH146 User Guide

Low-Cost Dual Channel Angle of Arrival Direction Finding System for Amateur Radio Transmitter Hunts on 2 meters



Introduction	2
In the Box	2
Assembly	3
Programming.....	3
Software	4
Device Setup dialog box	5
Quick Start	6
Using Pitch, Roll, and Yaw to set up magnetic compass	7
Transmitter hunting	8
FCC	9
Disclaimer – NO WARRANTY	10
Appendix A: Emission Data, FH146 Rev B	10
Conducted to Antenna, direct connect.....	11
Radiated Emissions @ 1m, normalized to 10m	12

Introduction

The FH146 is a dual channel receiver specifically designed for amateur radio transmitter hunts on 2 meters. Where most hunters rely on directional antennas and signal strength, the FH146 enables true angle of arrival lines of bearing by analyzing the phase of the radio waves arriving at two antennas vs. the antenna spacing. The FH146 is designed to gently transition into compression, giving a good line of bearing from 6 dB above the noise floor, all the way up to 10 milliwatts of received power (about 10 feet from a 2-watt transmitter)

To avoid damage, keep antennas at least 2 meters from a 1-watt transmitter, further for stronger transmitters

Included is a compass to give the absolute direction of the transmitter, rather than just a direction relative to the user.

The FH146 is designed to operate well from 144-148 MHz, but can be tuned from 136-163 MHz with a performance penalty. The Pico2 may not be as stable above 150 MHz.

In the Box

- FH146 dual channel mixer board
- Pico 2 microcontroller board (no header)
- Clear shrink wrap tube (serves as the housing without hiding the circuit boards)

Assembly

Requires soldering iron, solder, and clamp-on ferrites. Warning: soldering irons are hot and can cause serious burns. Some solders contain lead, a toxic metal.

Requires a USB 2.0 micro-B cable (not included). Emission data collected with Ferrite beads on USB and SMA cables, and may be required to reduce clock emissions to FCC limits.

Requires two antennas, not included. Creativity here is encouraged!

1. Solder the Pico 2 to the back of the FH146. Align carefully with 2 solder joints before soldering the rest of the pins.
2. Solder on the SMA connectors, if not already done, ensuring they are flush with the PCB and centered.
3. (optional) Slide assembly into heat shrink tube, shrink with a heat gun on the lowest effective heat setting. Trim before, during, and/or after to ensure SMA and USB connectors are accessible.
4. Place clamp-on ferrite beads on USB and SMA lines, mounted close to the FH146, for best performance and lowest Pico2 clock leakage.

Programming

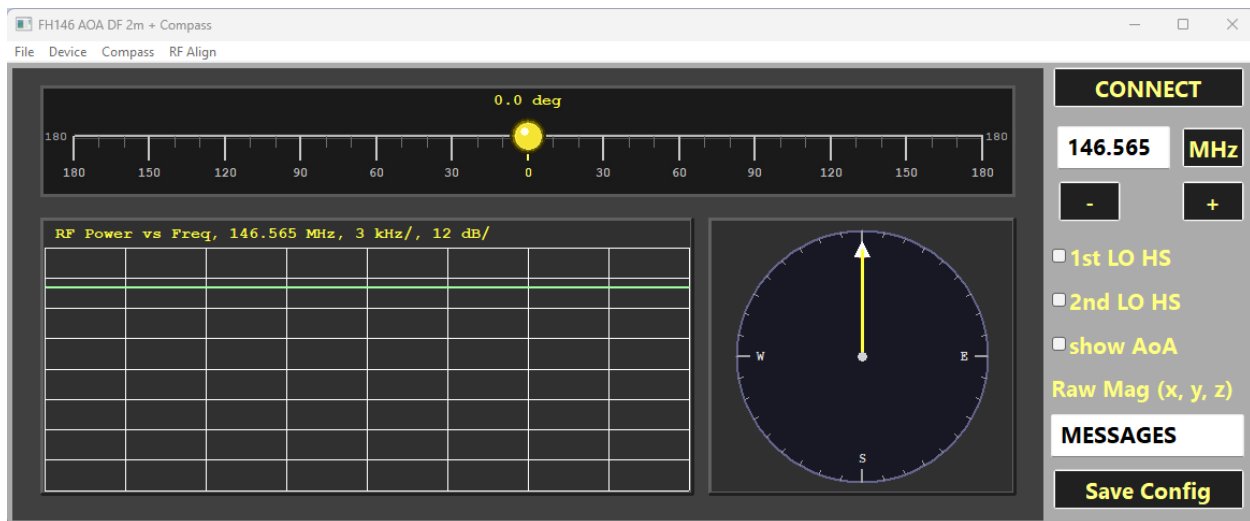
1. Download the latest firmware from github.com/jcrookswy/DF2m (.uf2 file extension)
2. Plug the assembled FH146 into your PC or laptop. It should show up like a thumb drive.
3. Drag the .uf2 file onto this new drive. The drive should disappear.
4. Using the Windows “Device Manager”, look under COM/LPT to identify which COM port it installed as. If it is COM1-9, proceed. For COM10 or greater, reassign it to a single digit port number.

Software

The software can be downloaded from github.com/jcrookswy/DF2m and is meant to run on a relatively inexpensive laptop (think i3 processor).

Look for FH146 DF2m.zip. Download it and extract into the folder of your choice.

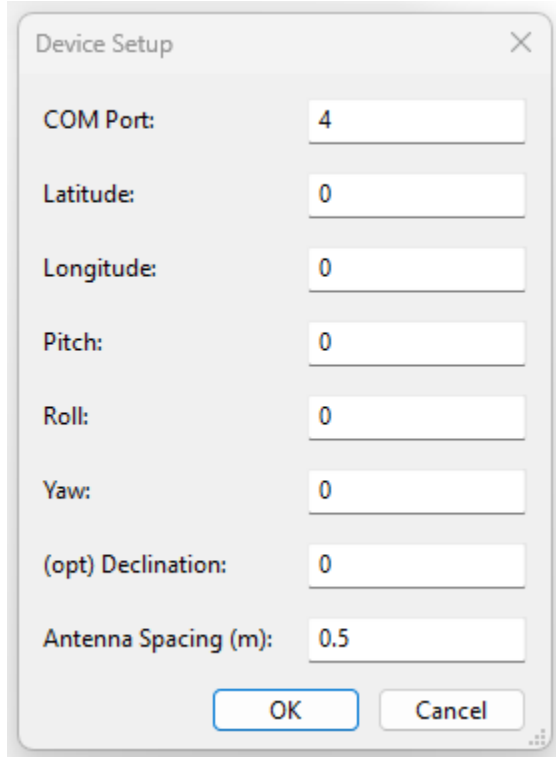
The software uses Intel's Integrated Performance Primitives, which means it requires x86/x64 architecture (sorry ARM fans!).



The user interface consists of the following parts:

- Menu, including File, Device, Compass and RF Align sub-menus
- The Bearing indicator, top.
- The spectrum plot, lower left. Note that it is 12 dB per vertical division, 2 full S units, so there is a wide range of powers it can display.
- The compass / bearing plot, lower right
- Control Panel, Right

Device Setup dialog box



Device Setup dialog box showing the following fields and values:

Field	Value
COM Port:	4
Latitude:	0
Longitude:	0
Pitch:	0
Roll:	0
Yaw:	0
(opt) Declination:	0
Antenna Spacing (m):	0.5

Buttons: OK, Cancel

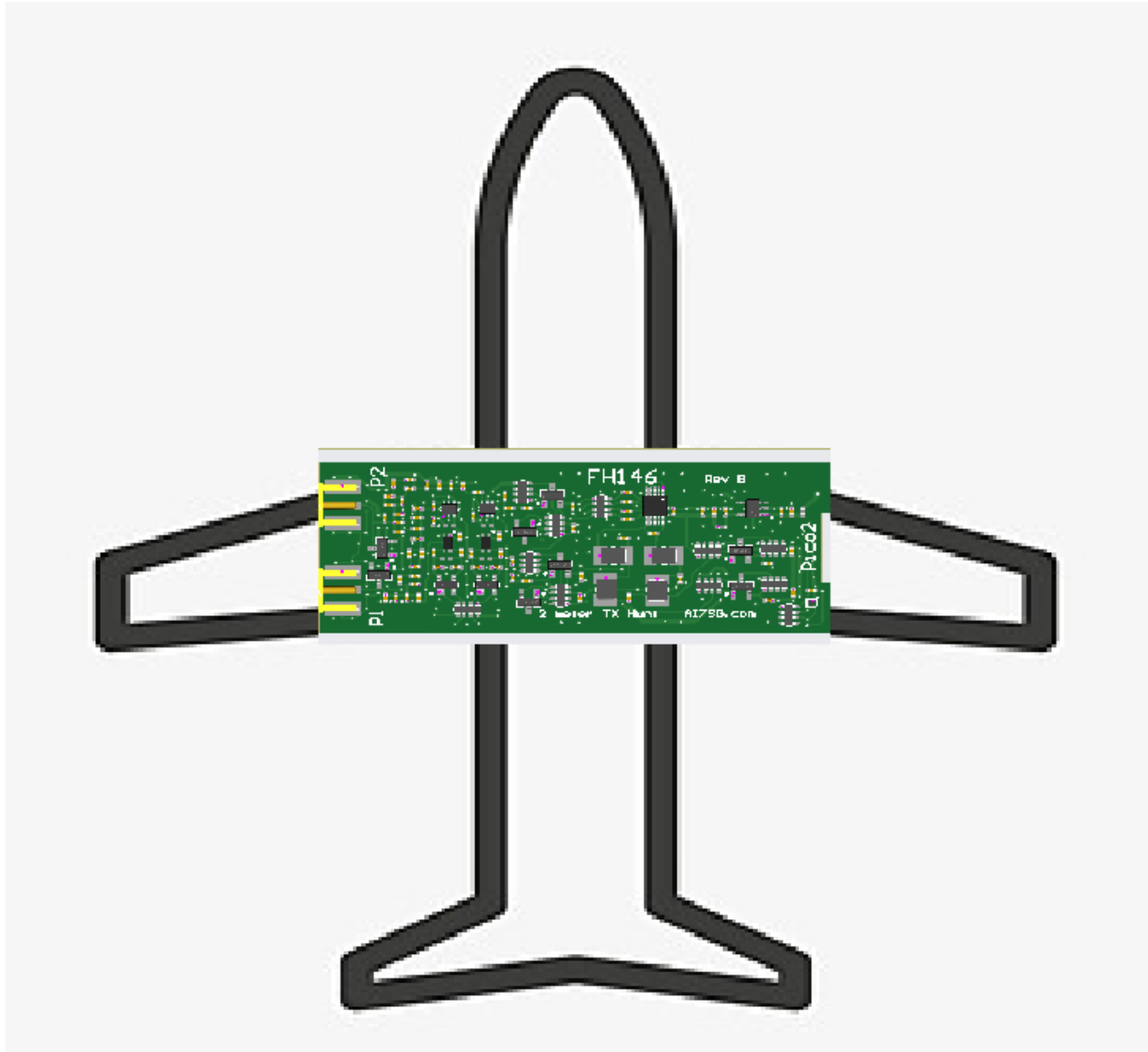
Quick Start

1. Copy the DF2m software into the folder of your choice.
2. You may need to Disable Smart App Control (SAC), as this is an unsigned homebrew application. You can review the source code and compile it yourself if you prefer!
3. Launch the software. Under Compass→ Device Setup, enter the COM port, and click SAVE CONFIG.
4. Click “Connect”. You should see everything updating.
5. Calibrate the compass, by aligning it for minimum X value (maximum Negative), maximum X value, repeat min/max for Y and Z axis. This allows the software to calibrate out the magnetometer and circuit’s offset. The readout for the raw magnetometer readings is near the lower right corner of the user interface.
6. You will need to rotate pitch, roll, AND yaw to find the true extreme values, within 10 counts or so, if you want the compass to work well. Or add some smarter 3-D rotation math to the source code, recompile and send me a copy.
7. Build 2 antennas and mount them to your laptop about 1 meter apart. Or come up with a more clever antenna solution.

8. Tell the software how the FH146 is mounted using pitch, roll, and yaw. This should allow the compass to make good measurements in any orientation.
9. Generate a test signal, e.g. from a friend keying up their 2m radio on lowest power.
10. Enter the frequency into the control panel, then click "MHz".
11. Position the signal directly in front of your antenna system, then from the menu select RF Align→ Zero This works best in an open-air environment, free of large metal reflectors like cars or fences, as multipath can alter the angle of arrival quite a bit.
12. Point antenna 30 degrees left, then right. If the indicator moves the wrong direction, click RF Align→Flip.
13. Fill out the rest of the "Device Setup" form, including latitude / longitude, and magnetic declination at your location, if known
14. SAVE CONFIG so you don't have to repeat the process.

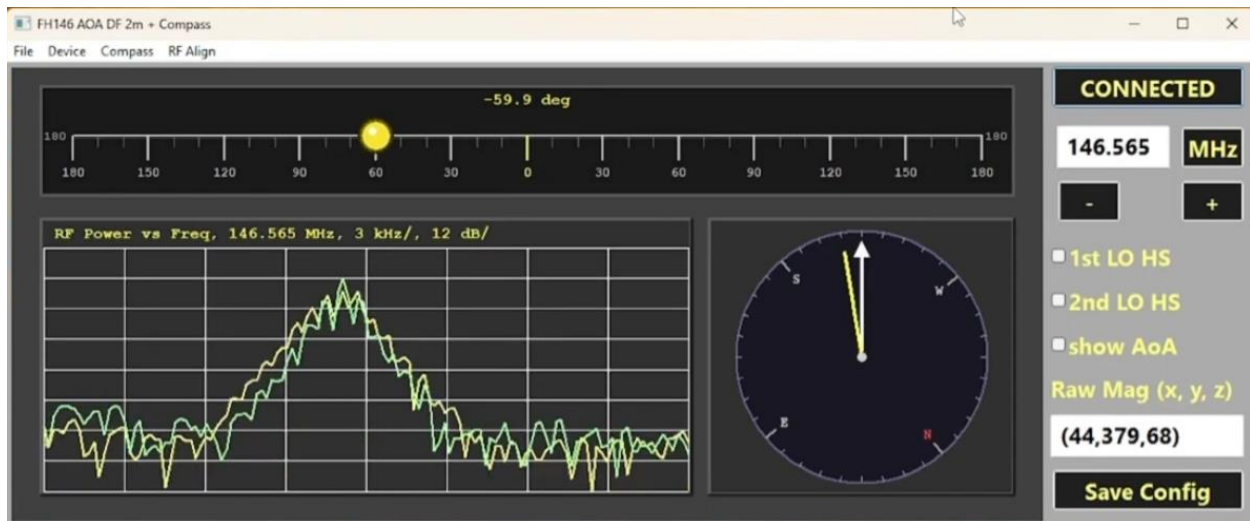
Using Pitch, Roll, and Yaw to set up magnetic compass

The compass is oriented on the PCB such that pitch, roll, and yaw are relative to this orientation:



Enter the pitch, roll, and yaw fields, to describe how the board is mounted. Be sure to get the sign correct! Please note that, especially at higher latitudes, even a few degrees of tilt can affect the readings quite a bit.

Transmitter hunting



Once your system is calibrated, you are ready to hunt for transmitters. You must enter the correct frequency. If it looks like there is interference from another transmitter, you can change the “1st LO HS” (first local oscillator injected high side, above the RF frequency, when checked) and “2nd LO HS” to isolate the signal. You can track using the default phase difference of arrival if you like, but it will track the actual bearing better if you check “show AoA” (show Angle of Arrival, not phase difference of arrival).

FCC

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Disclaimer – NO WARRANTY

This software, firmware, hardware designs, and all associated materials are provided "as is," without warranty of any kind, express or implied, including but not limited to the warranties of merchantability, fitness for a particular purpose, and non-infringement. In no event shall AI7SG or any contributors be liable for any claim, damages, or other liability — whether in an action of contract, tort, or otherwise — arising from, out of, or in connection with the software, firmware, hardware, or the use or other dealings therein.

This includes, but is not limited to, any damage to computer hardware, laptops, peripheral devices, radio equipment, or data loss resulting from the installation, construction, operation, or malfunction of this software, firmware, or hardware.

The FH146 hardware and any derived designs are provided for amateur radio experimentation purposes only. The user assumes full responsibility for correct construction, safe operation, and compliance with all applicable regulations.

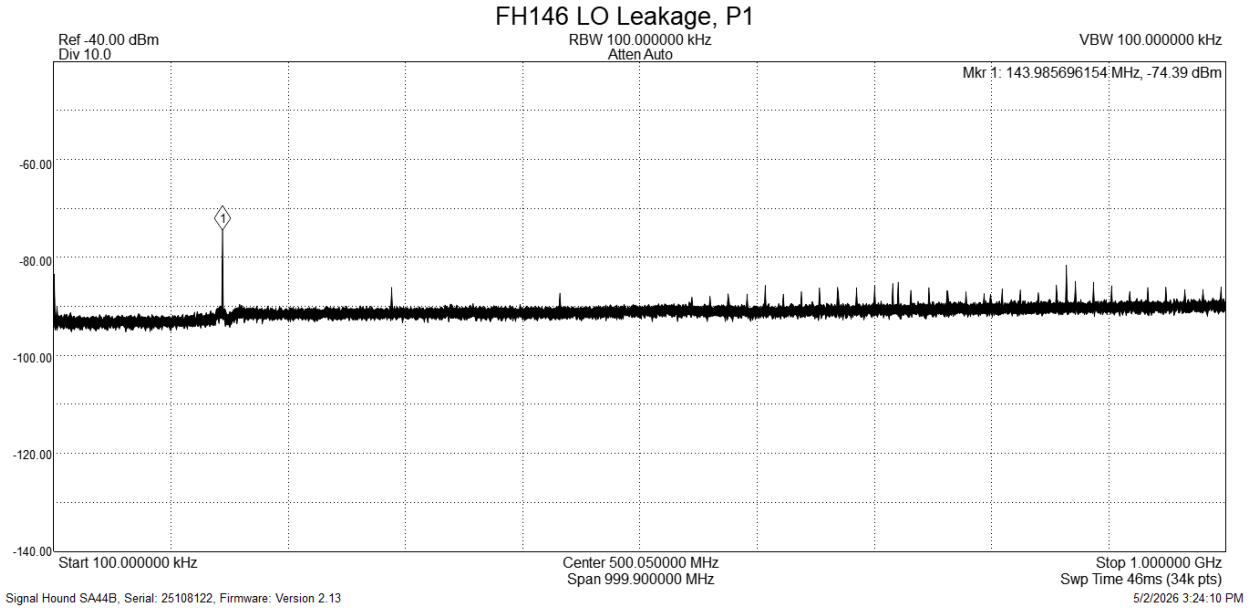
Use of this software and hardware is entirely at your own risk.

Appendix A: Emission Data, FH146 Rev B

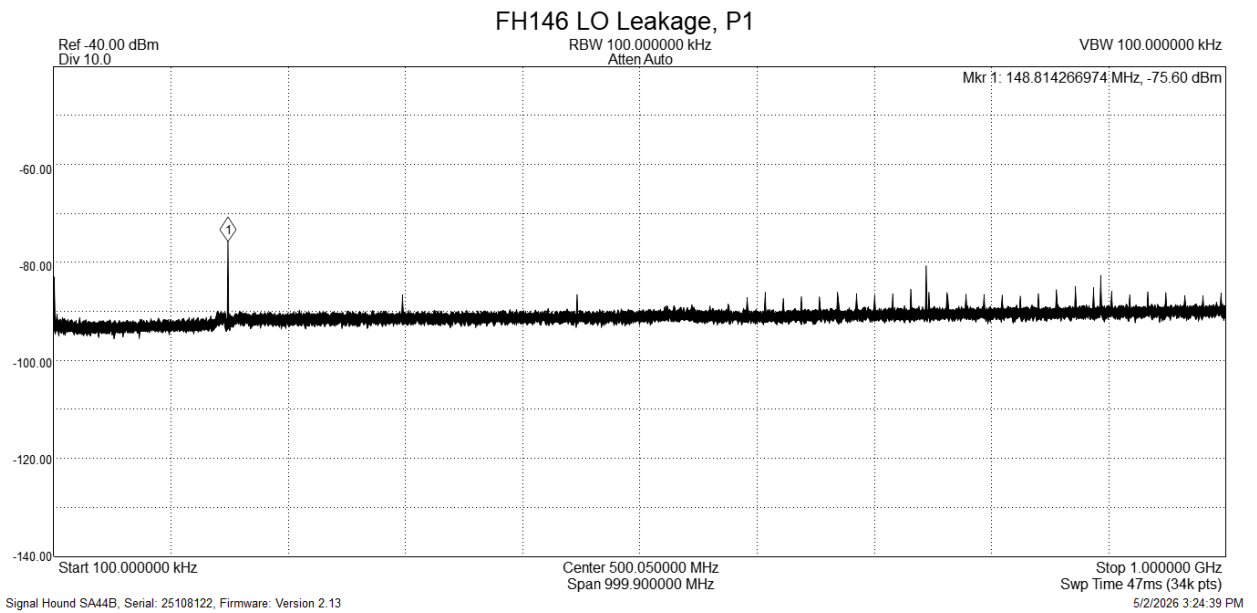
Conducted to Antenna, direct connect



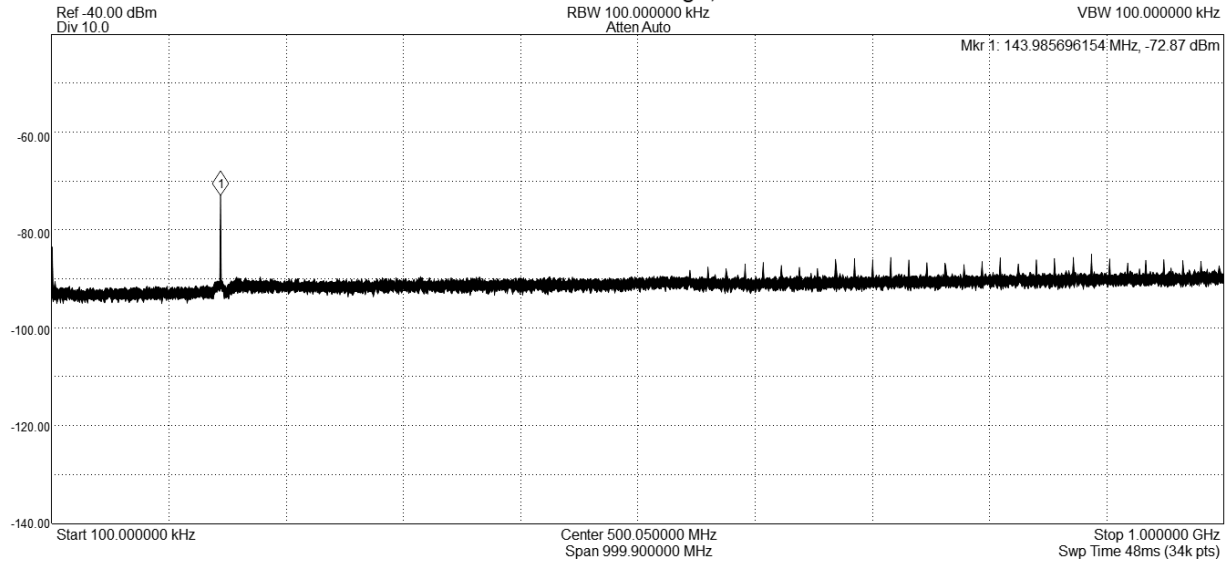
Version 4.0.10



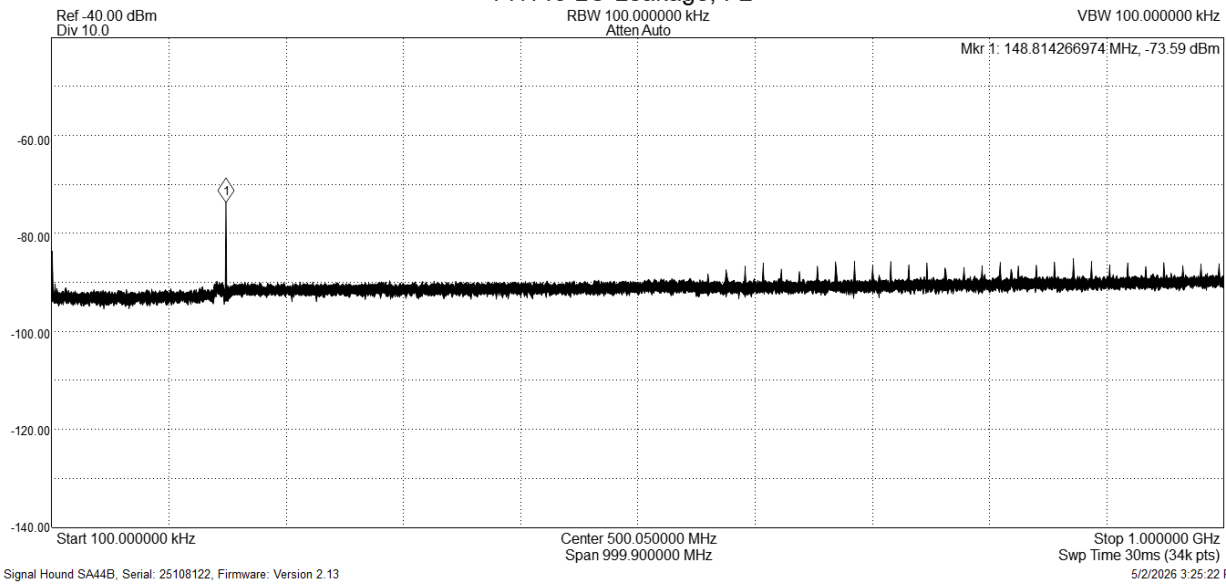
Version 4.0.10



FH146 LO Leakage, P2



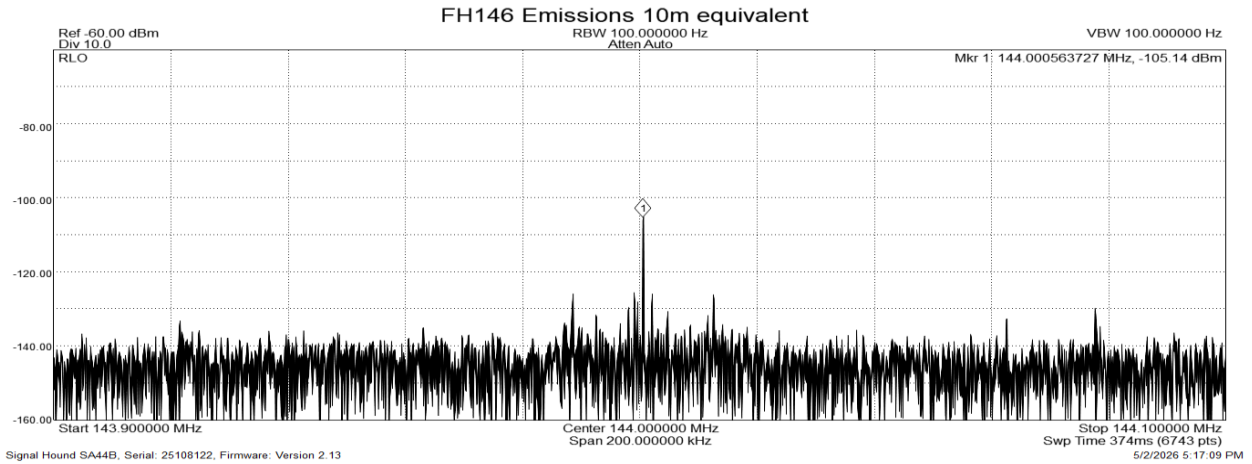
FH146 LO Leakage, P2



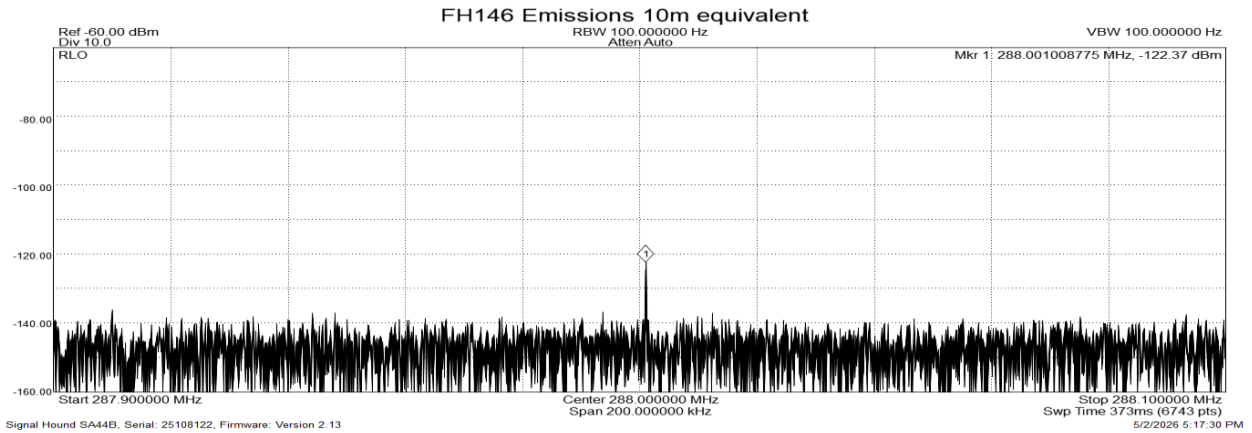
Radiated Emissions @ 1m, normalized to 10m



Version 4.0.10



Version 4.0.10



Version 4.0.10

