VE6HQ 23cm Solid State Amplifier

I rejoined the active amateur radio community after nearly a 50 years absence. In the late 1970's operating as VE6RI, I had conducted a series of exciting 432 mHz experiments using over the horizon tropospheric scatter propagation between Edmonton and Calgary. I wanted to renew this excitement, however soon realized technology has changed from the 4CX250B vacuum tube coaxial resonate cavity that I had constructed in the 1970's.

I embarked on a process to build a modern solid-state amplifier for 23 cm (1296 MHz) amplifier using the available and low-cost technology

The amplifier was to be driven by a SDR transceiver that produced approximately 1 milliwatt (0 dBm) of RF drive power. My objective was to amplify the transmit signal power level to about 10 watts (40 dBm).

Principle parts included a solid-state amplifier, 24-volt DC power supply, heat sink, and cooling fan. All the parts were purchased through the usual "online' sources with total cost approximately $100.

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A photograph of completed 23 cm amplifier is shown as Figure 1.

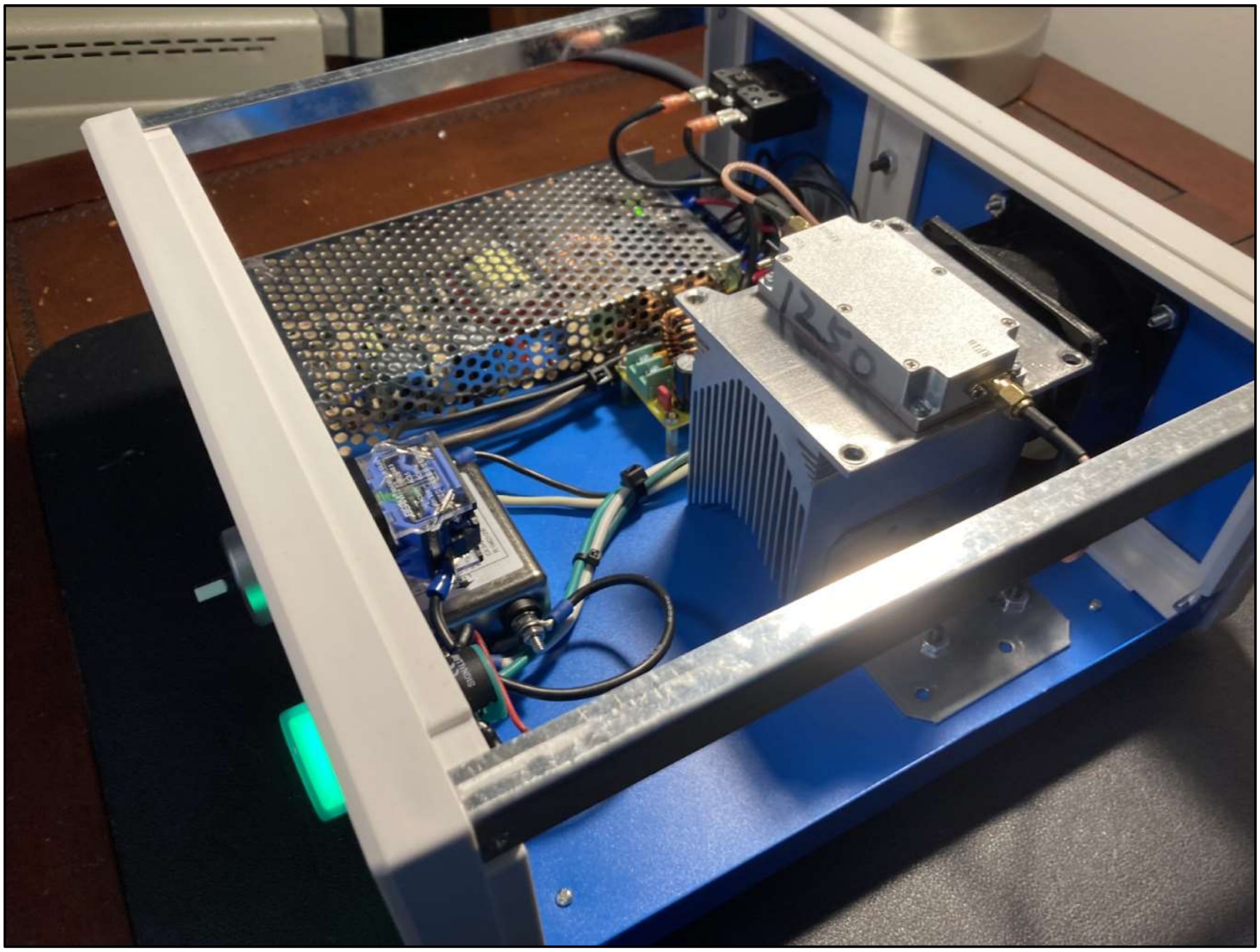

Figure 1 VE6HQ 23 cm 10-Watt RF Amplifier

The 23 cm amplifier project was based upon assembly of available subassembly components. This method provided a time and cost-effective approach to the project.

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Figure 2 shows a photograph of the RF pallet sourced from the internet supplier. The vendor supplied specifications are listed below.

Figure 2 23cm RF Amplifier

- Operating frequency: 1200-1320MHz (1268)
- Output power: 13W (41dBm@24V, RFin=5dBm (3mW))
- Operating voltage: 20-28V (24V recommended)
- Operating current: 1.7A (depending on the supply voltage)
- System impedance: 50 Ohm
- External dimensions: 76*40*16.5mm (without connector)
- Product weight: 95g
- Connector type: SMA female head (external screw inner hole)

Figure 2 shows a photograph of the power supply section of the RF amplifier. A 24 volt, (5 amp rated) switching power supply was used to supply DC power to the amplifier module. It is well known that the switching power supplies tend to create significant high frequency noise and transients. To suppress these undesired artifacts, I installed a DC filter and capacitor between the supply voltage output and the amplifier. Testing with an oscilloscope showed no detectable noise following the addition of these filter components.

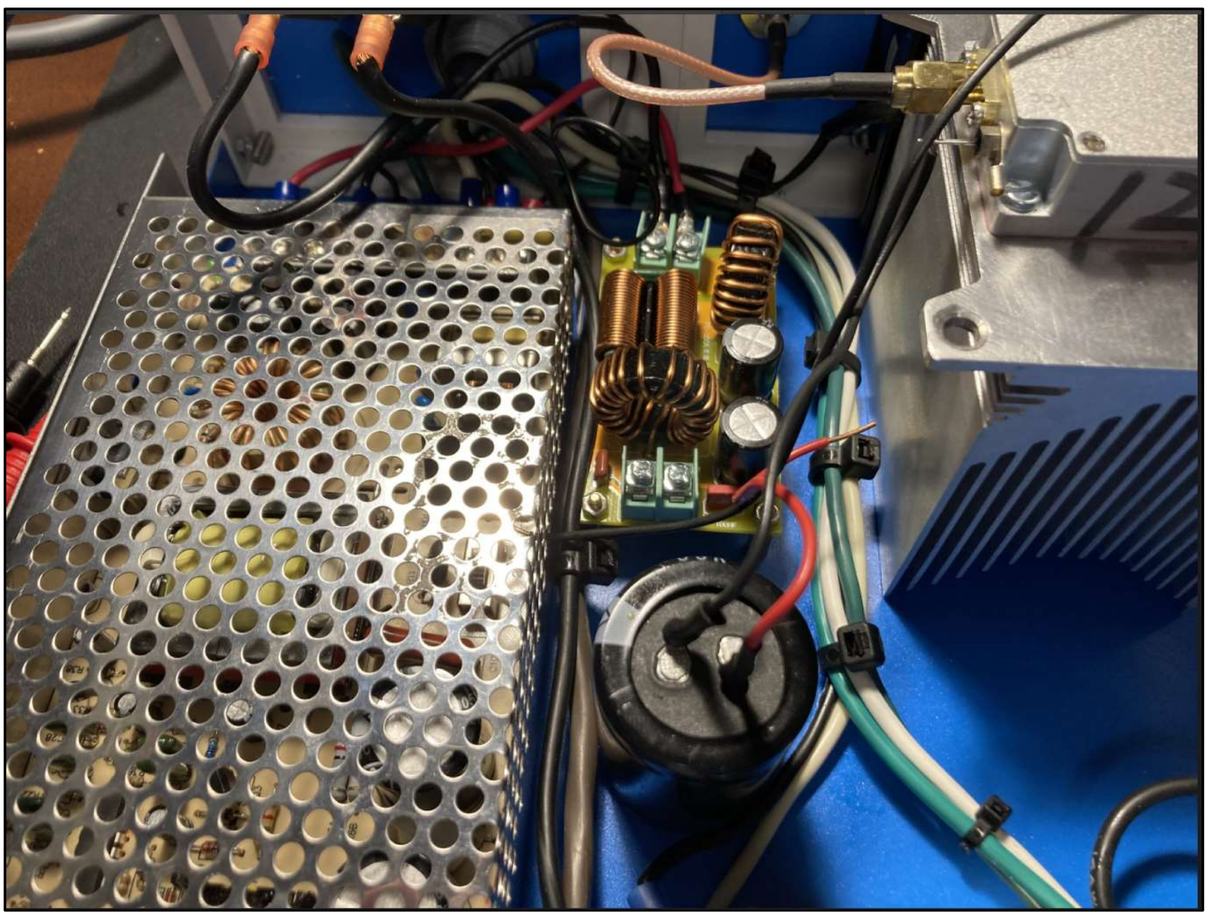

Figure 3 Power Supply Section

Adequate power and cooling are mandatory to ensure reliable operation for any RF amplifier. I installed a large heatsink to the RF module using high quality thermal compound. In addition, a fan was installed within the chassis to directly cool the heatsink with forced air. Figure 4 illustrates the rear panel chassis assembly complete with RF input / output BNC connectors and fan.

Electrical and mechanical construction followed best practices including proper wiring, circuit breaker installation and parts layout.

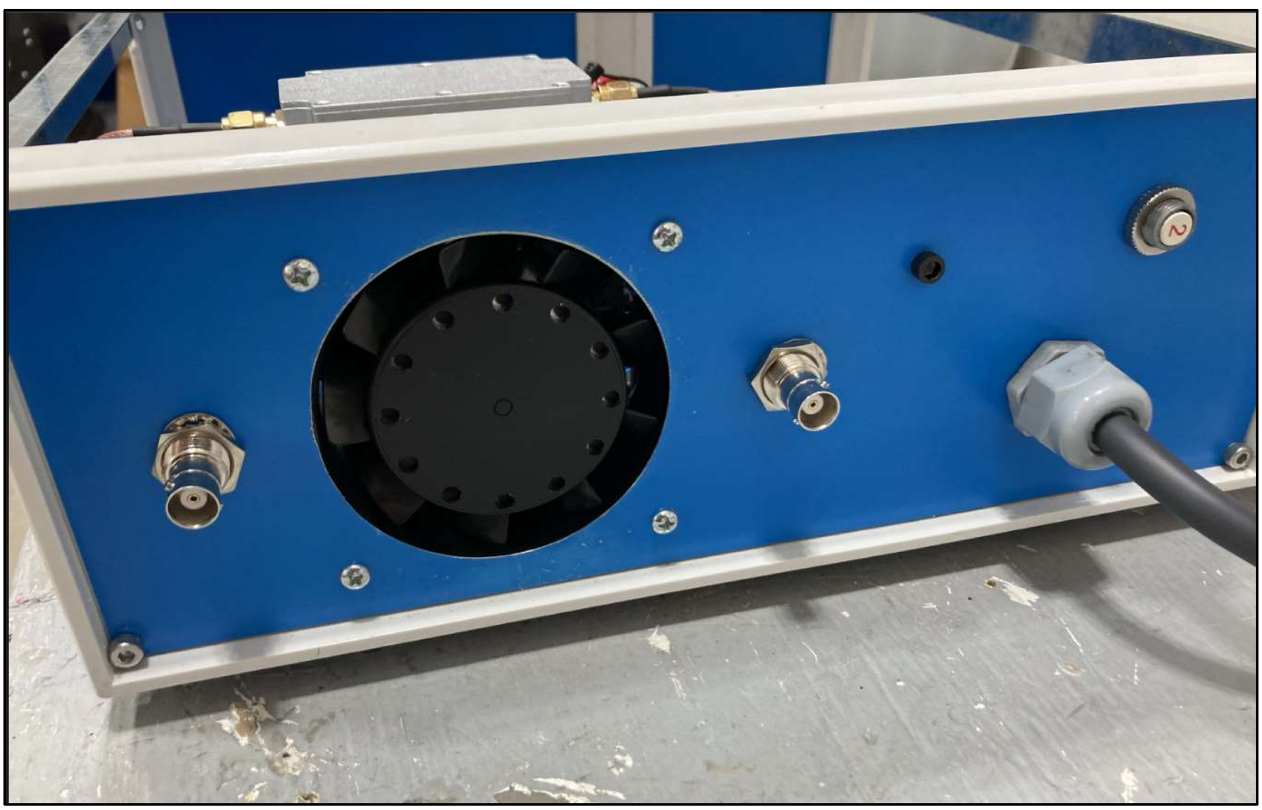

Figure 4 Rear Panel

Bench testing of the 23 cm RF amplifier and SDR transceiver combination was an important part of this project. During all tests, RF power was terminated in a 25-watt RF dummy load.

An SDR transceiver (Pluto Plus SDR) was used as an RF signal source with GPSDO oscillator frequency stability control. A separate SDR receiver (RSPDuo) was used to inspect all signals using spectrum analysis software.

Output RF power was measured for both the SDR transceiver and SDR-amplifier combination as a function of SDR drive power. Figure 5 and 6 illustrate the data obtained from the power level measurements. The SDR transceiver exhibits fairly linear response of output power versus drive level. In contrast, the 23 cm amplifier shows a P1dB compression point at a drivel level of 90 (39 dBm output power).

This non-linear response in not unexpected, as thus I tend to rollback much of the published specifications for electronic equipment that is available from the common low-cost vendor commercial sites available today.

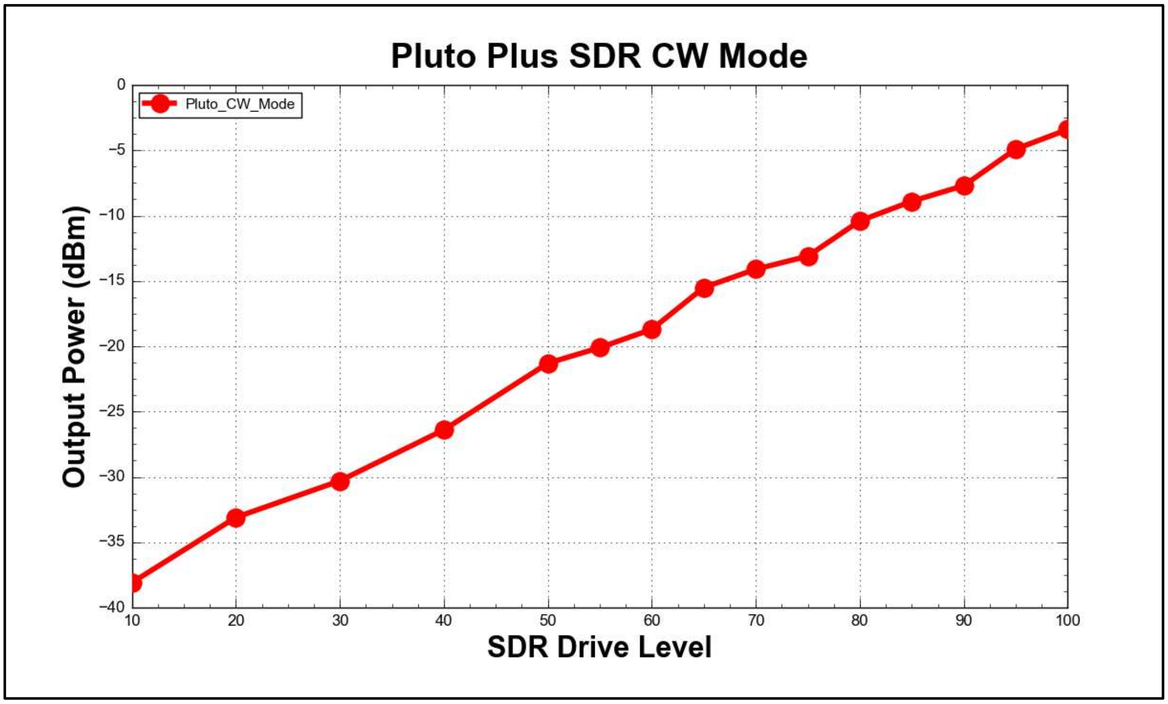

Figure 5 SDR Output Power

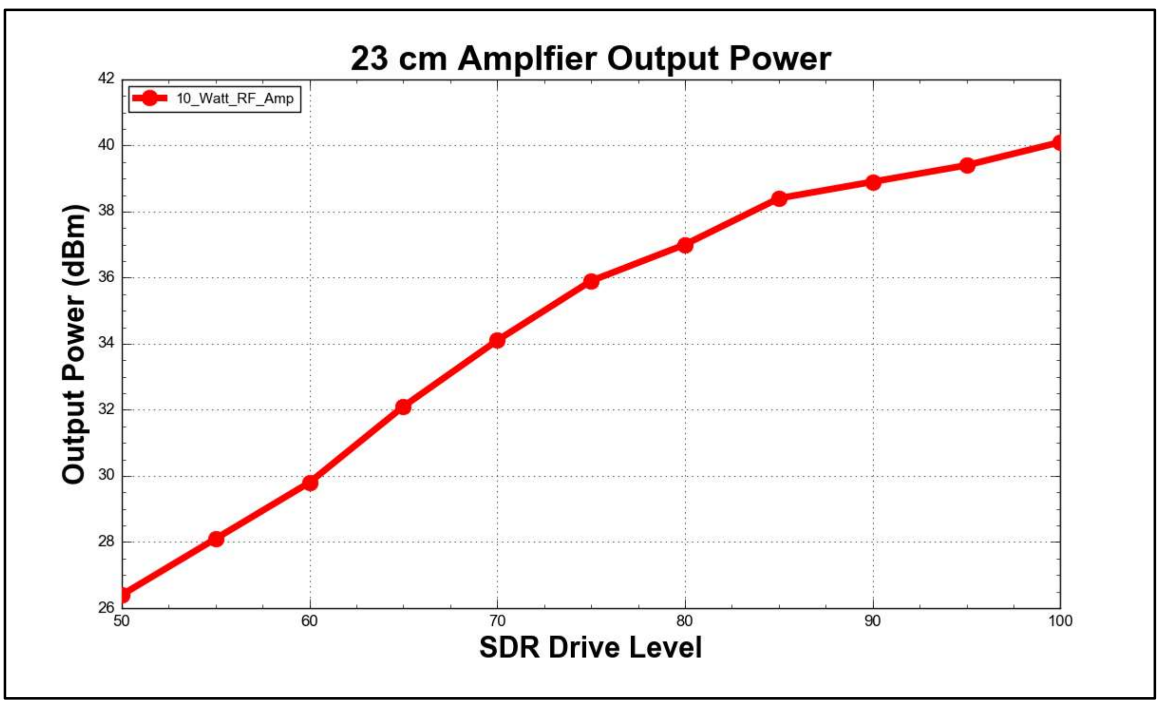

Figure 6 23 cm Amplifier Output Power

Intermodulation distortion (**IMD**) tests were conducted using the two-tone modulation method. In this case two tones (700 Hz and 1900 Hz) where applied to the SDR transceiver configured in upper side band (USB) mode. The IMD results for the SDR transceiver are illustrated as Figure 7. IMD products approximately -47 dBc were measured using a drivel level of 90.

The measured very low IMD products are exceptional for this SDR device, however they are known to increase with out-of-range drive level and ALC settings.

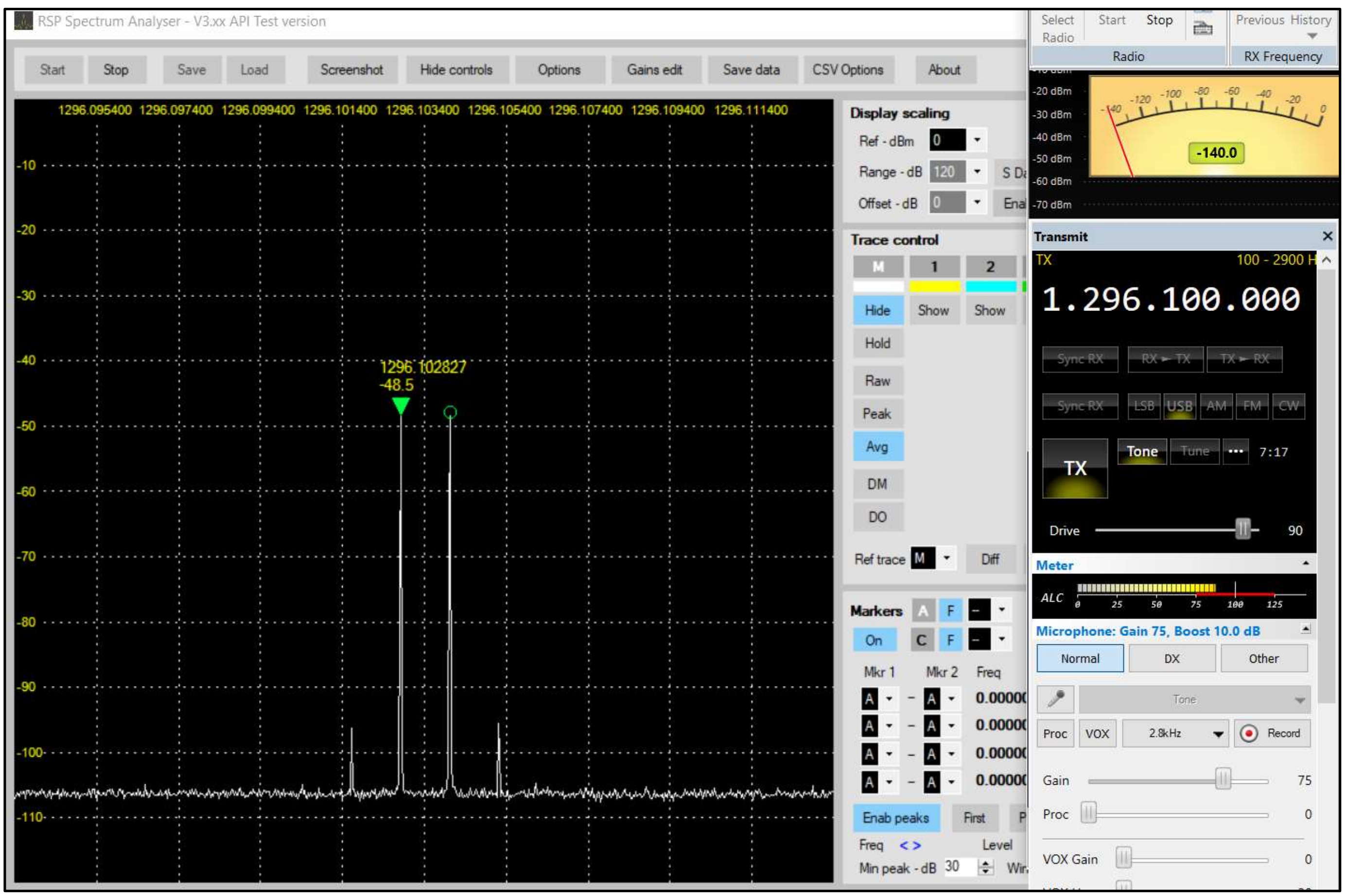

Figure 7 Two Tone IMD Test Data SDR Transceiver

Intermodulation distortion (**IMD**) tests were repeated using the 23 cm amplifier driven by the SDR transceiver. Figure 8 shows the significant increase in magnitude and number of IMD products. The increase of distortion products was not unexpected. The RF module operates in Class C mode and thus in a non-linear device. Operation of the RF amplifier for DW, FM and Digital Modes (i.e. FT8) would provide compliant "*on air*" performance. However, SSB operation should be avoided as the amplifier would likely create in band interference to adjacent RF signals.

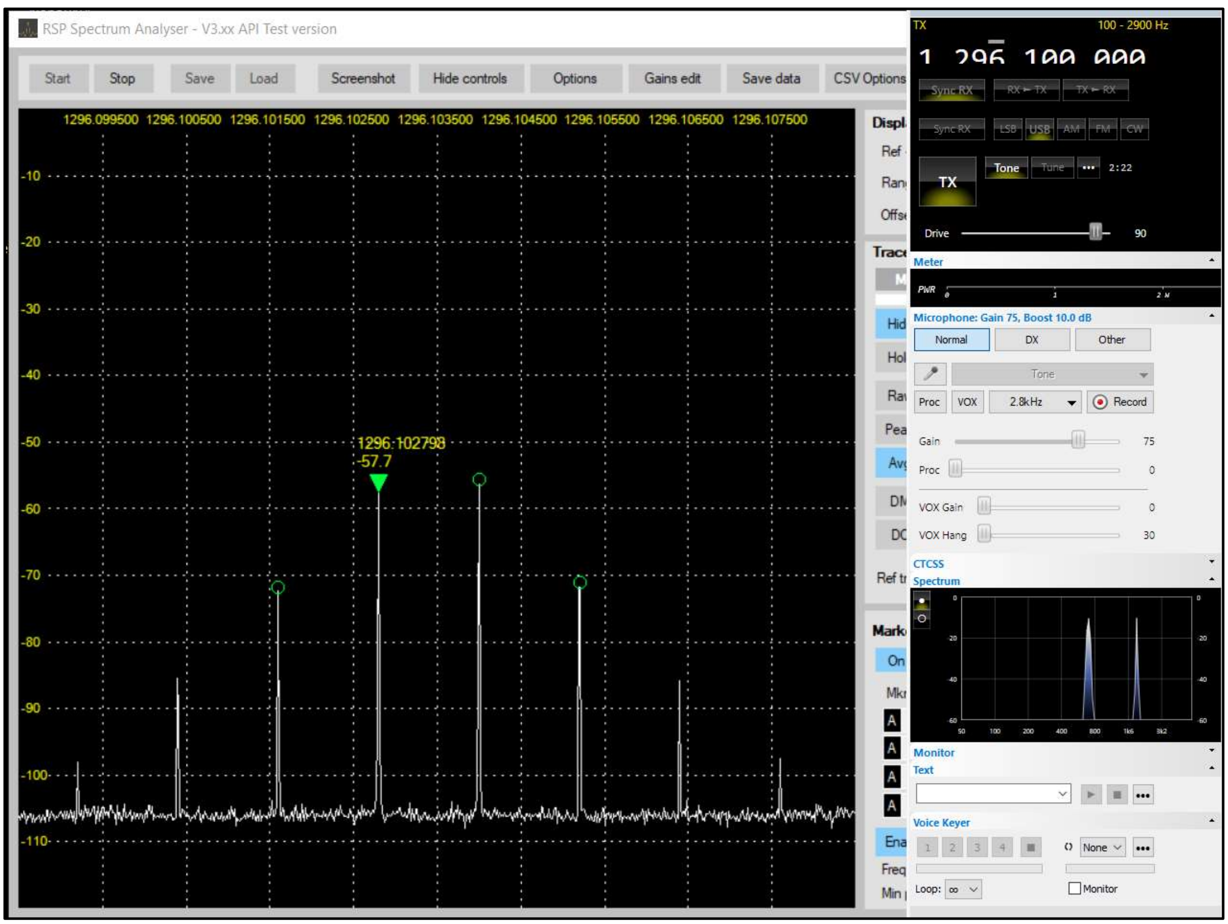

Figure 8 Two Tone IMD Test Data 23 cm Amplifier

About the Author

Don has pursued a lifelong interest in science and engineering beginning as a youth in western Canada. He received his first amateur radio license at the age of 15 while attending high school in Edmonton, Alberta, Canada.

Don continued this interest and graduated from the University of Alberta receiving a Bachelor Science in Electrical Engineering. During the last 41 years he has worked in the Energy Exploration industry in Canada, the United States, Europe, South America, the Middle East and the Far East.

His technical area of interest lead to publications of nuclear magnetic resonance applied to reservoir characterization. He was granted numerous US patents for developments of wireline pressure core technology. Don Westacott strongly considers training and technology transfer as an important part of his role within the E&P industry. Don accepted a role as guest lecturer at the Colorado School of Mines providing instruction to a new generation of petroleum engineering students. Don was honored to be the Distinguish Speaker at the Harvard University Energy Panel Arab Conference. During 2020, Don received the prestigious Hart Energy Innovators Award.

I was first amateur radio license was in 1967 as VE6ANW, a year later achieved the advanced certification as VE6RI. I initially pursued 20-meter DX working using the Drake R4B / T4XB / L4B equipment and a 3 element Yagi/Uda antenna at 70 feet. Soon after, I became interested in weak signal UHF propagation. Constructing of a "home brew" 70 cm radio system complete with 4CX250 linear amplifier based upon a novel resonant coaxial cavity design was completed. Three hundred (300) kilometer daily communications using over the horizon tropospheric scatter was achieved between his Edmonton QTH and VE6JX located in Calgary, Alberta.

After more than 50 years have passed, I have rejoined the amateur radio ranks and currently active on 20 meters and VHF / UHF bands. I was granted the KI5KGX call as an extra class USA amateur operator. Subsequently, we moved to Canada and I reinstated by Canadian amateur radio certificate and requested my current call VE6HQ.

Don and his wife Marilyn enjoy the success of their sons Matthew and Andrew.

During 2023, I presented a webinar on UHF Test Equipment, which may be found at:

https://vimeo.com/906428996)