Flex Radio
2025 Product Review

Michael Walker VA3MW
Customer Education

FlexRadio
Find Everywhere

AGENDA

- About me
- Who is FlexRadio?
- What is an SDR?
- Why FlexRadio?
- The new FLEX-8000 Series
- The New Maestro
- PGXL / TGXL Integration
- Software Roadmap
- Q&A

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About Me

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Who is FlexRadio?

- Started in 2003; based in Austin, TX
- HF Software defined radio (SDR) pioneers
- Worldwide installed base >>30k

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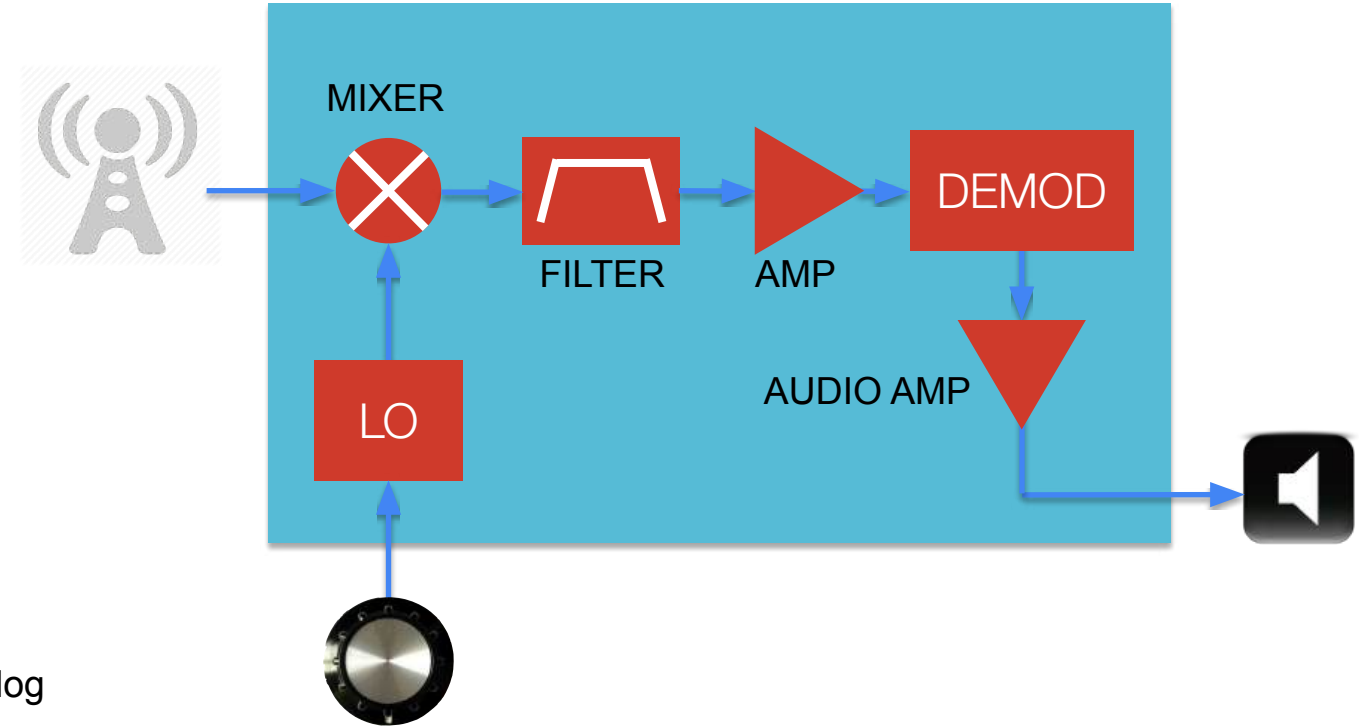
What is an SDR?
(not this)



Analog

Digital

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Analog Drawbacks

- Demodulation and Modulation require separate circuits for every mode of operation
- New modulations cannot be added after design
- Bandwidth of output typically restricted
- Multiple heterodyne stages result in distortion
- Phase noise
- Image rejection
- Selectivity
- Unable to scale

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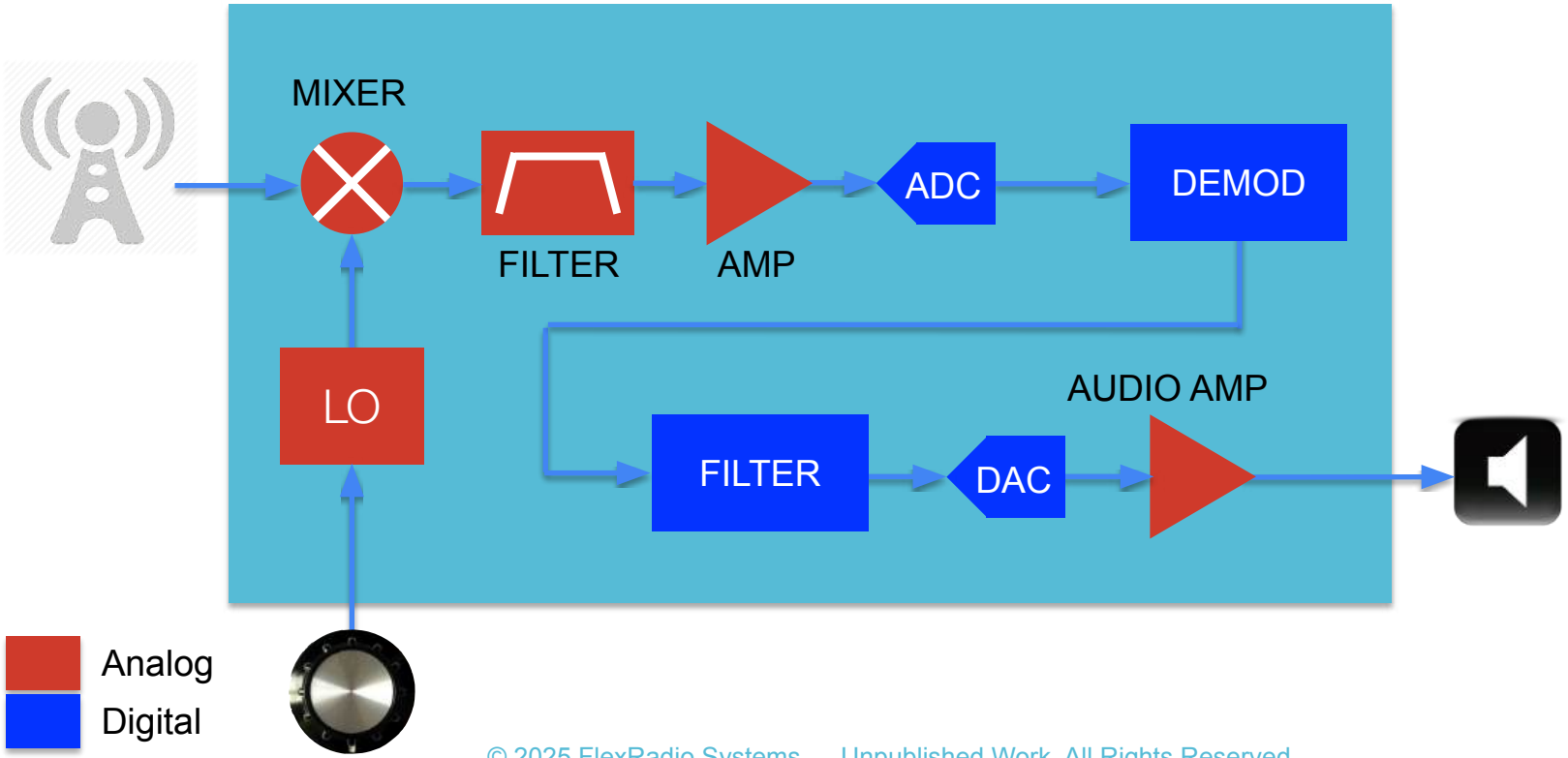
Some would call this an SDR…

(no, it is a hybrid)



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Digital baseband

- Software modes
- Dynamic filtering (bandwidths, type)
- Multiple receivers in narrow bandwidth (say 24-48kHz) [limited use]
- Scales
- Not limited to 1 user at 1 time
- More economical to build
- Works very well in crowded conditions

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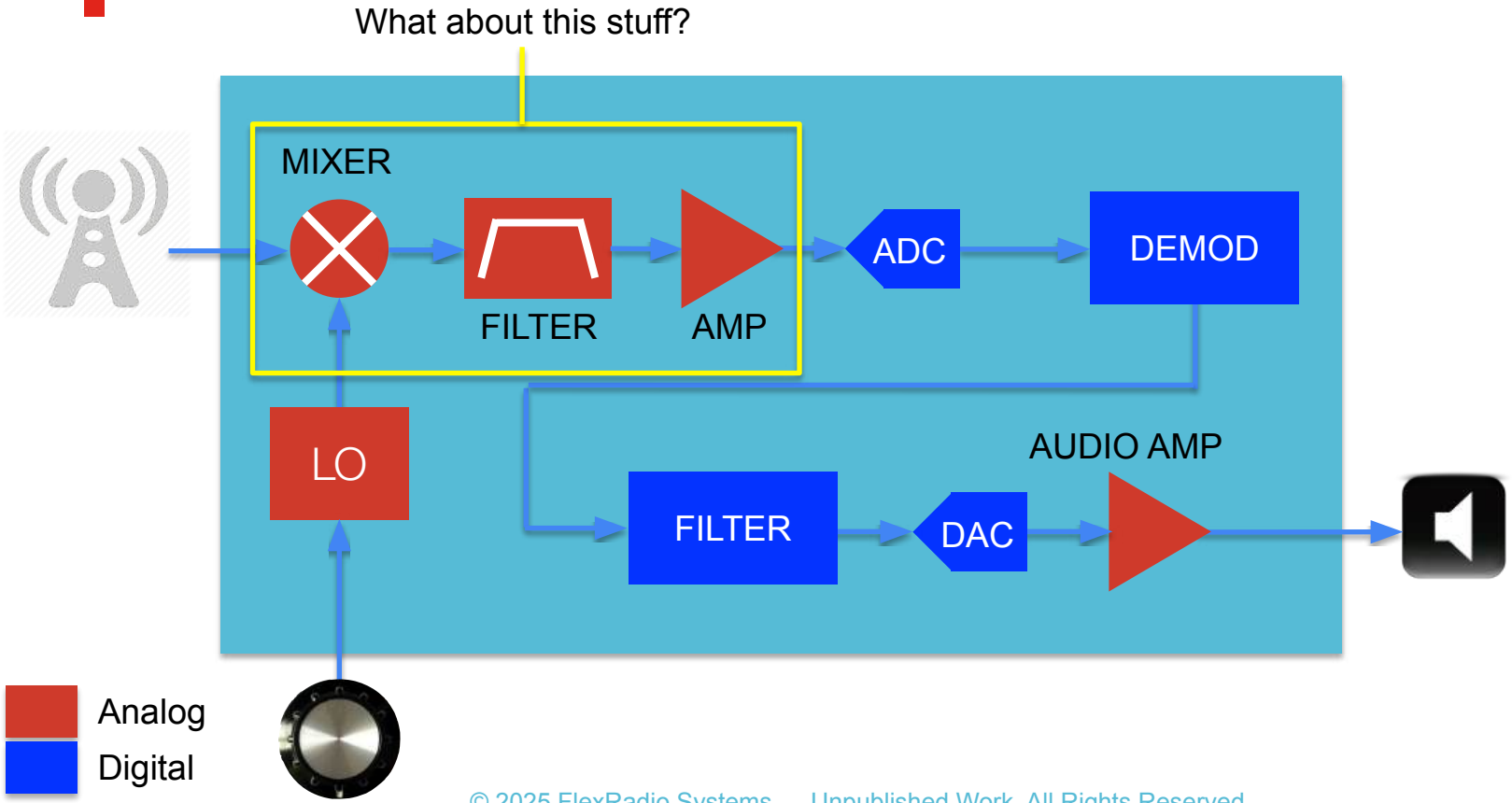
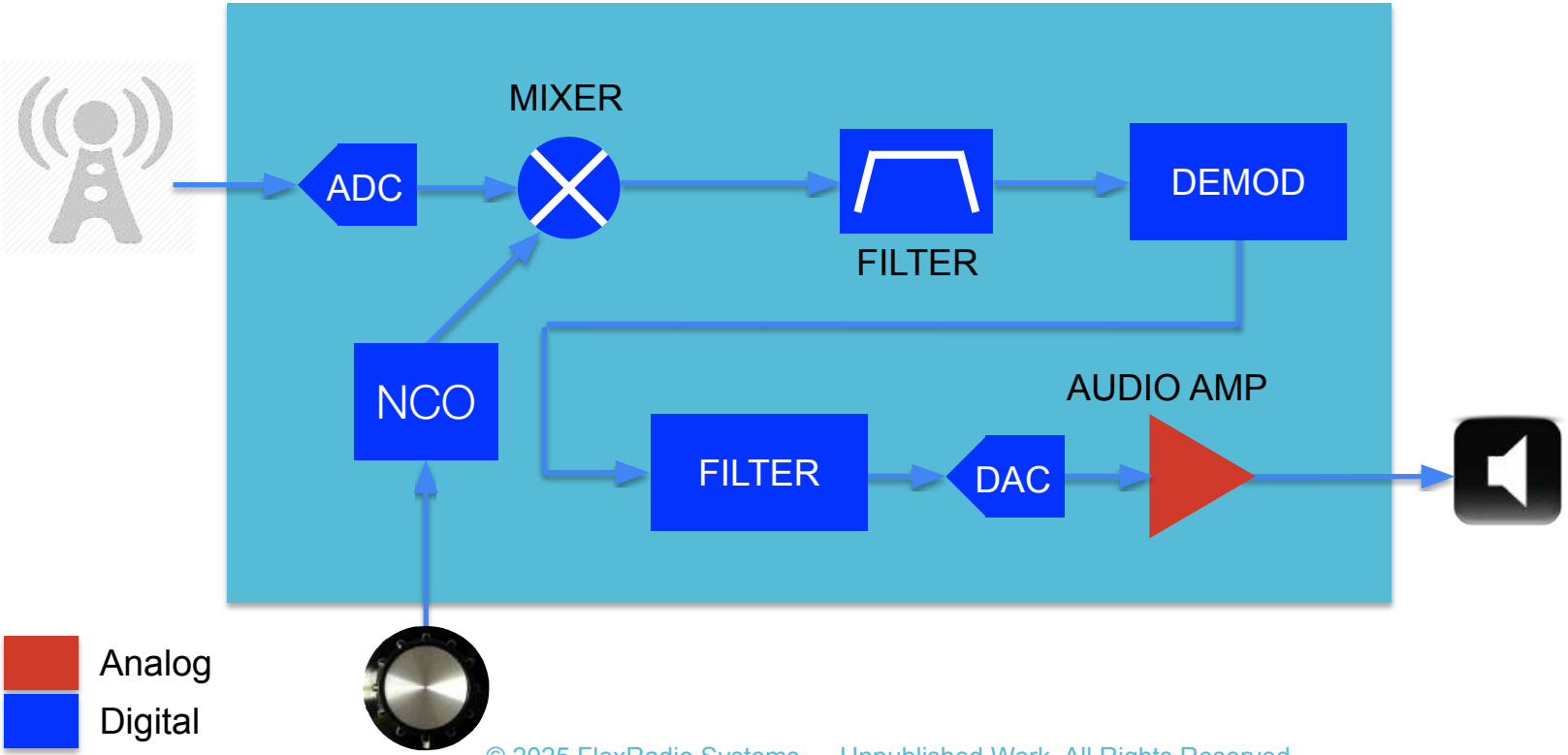
Can we do more?



Direct Sampling SDR



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What is an NCO

In this diagram, the **NCO** stands for **Numerically Controlled Oscillator**. It is a key component in software-defined radios (SDRs) and digital signal processing (DSP). This is all in the digital domain.

Function of the NCO:

1. **Frequency Translation**:
   The NCO generates a digital signal at a precise frequency. This signal is used to shift the frequency of the incoming digitized signal to baseband (zero frequency) or another intermediate frequency (IF).
2. **Local Oscillator in Mixing**:
   The NCO's output is fed into the **mixer**, where it multiplies with the incoming signal from the ADC. This shifts the frequency of the input signal for further processing, such as filtering and demodulation.
3. **Precision and Stability**:
   Being digital, the NCO provides highly stable and precise frequency generation compared to traditional analog oscillators.

In summary, the NCO in this diagram is responsible for generating the reference signal that enables frequency translation, a critical step in the signal processing chain of SDRs.

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Direct Sampling

- Minimal distortion (convert to digital quickly)
- N-receivers
- With FFT, spectrum views on entire “band”
- High dynamic range
- Extreme flexibility through reprogrammability
- BUT
  - Challenging to design
  - Completely different engineering team

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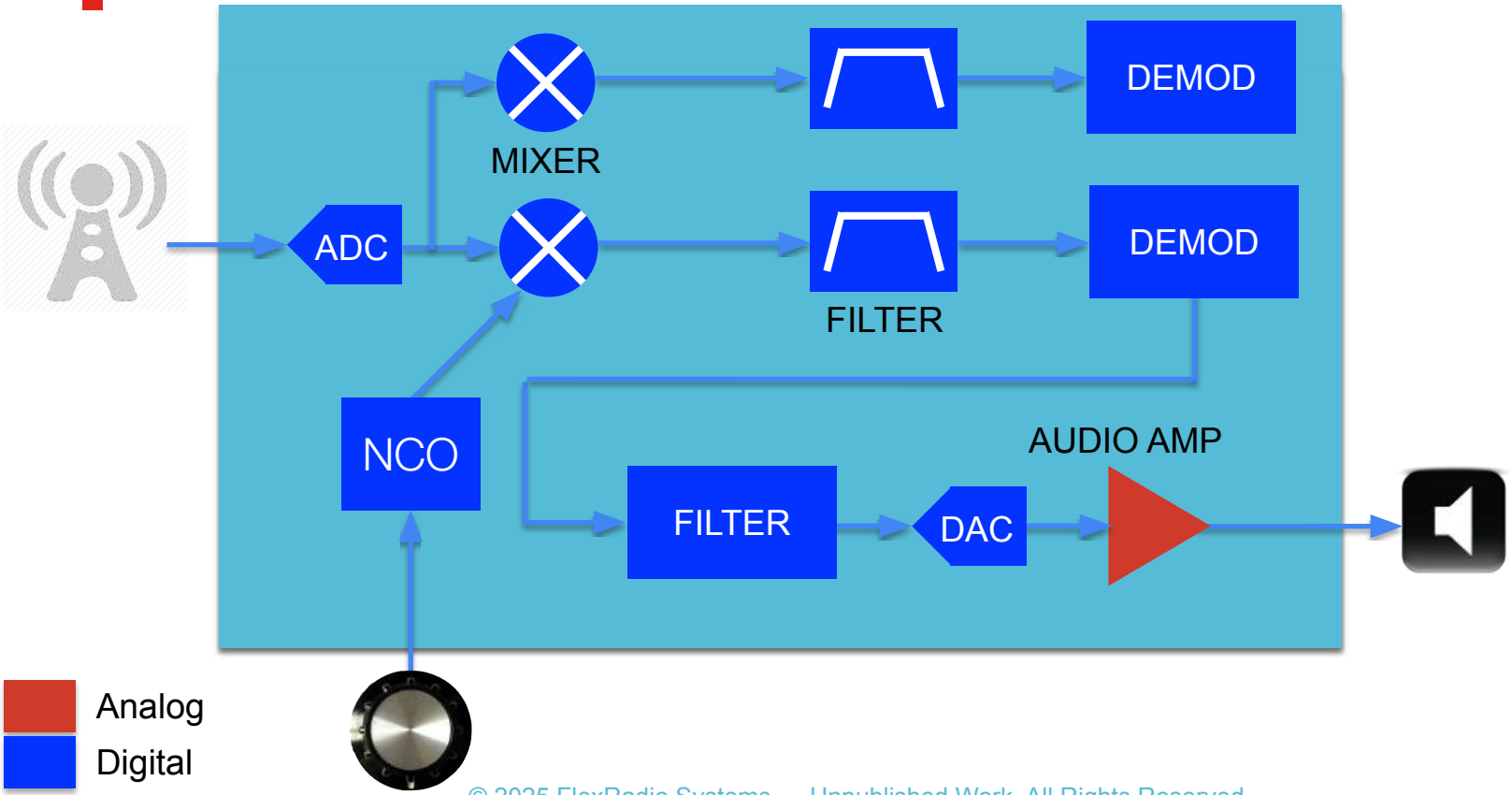
Direct Sampling SDR



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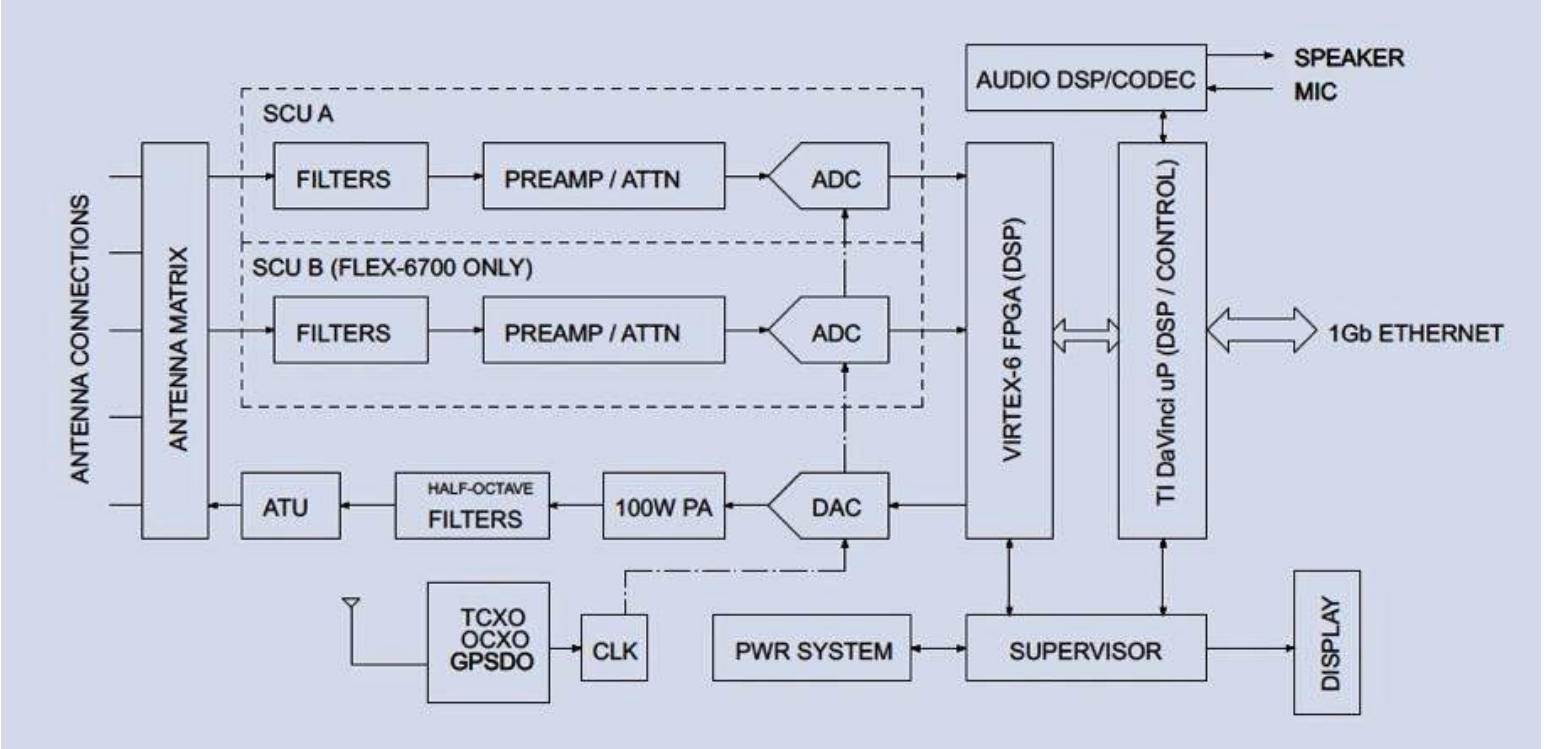
FlexRadio FLEX-6/8000 Series



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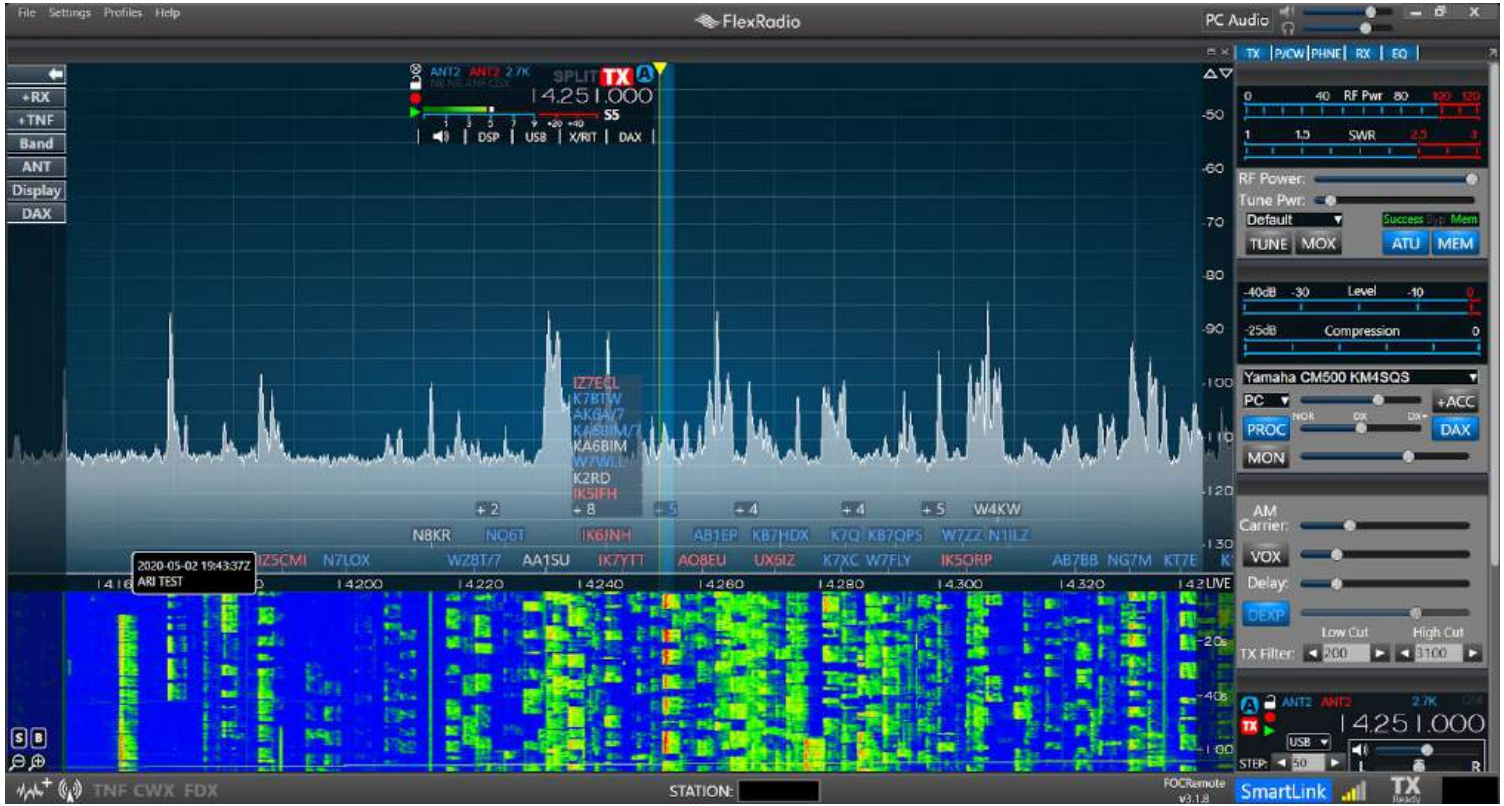
Examples



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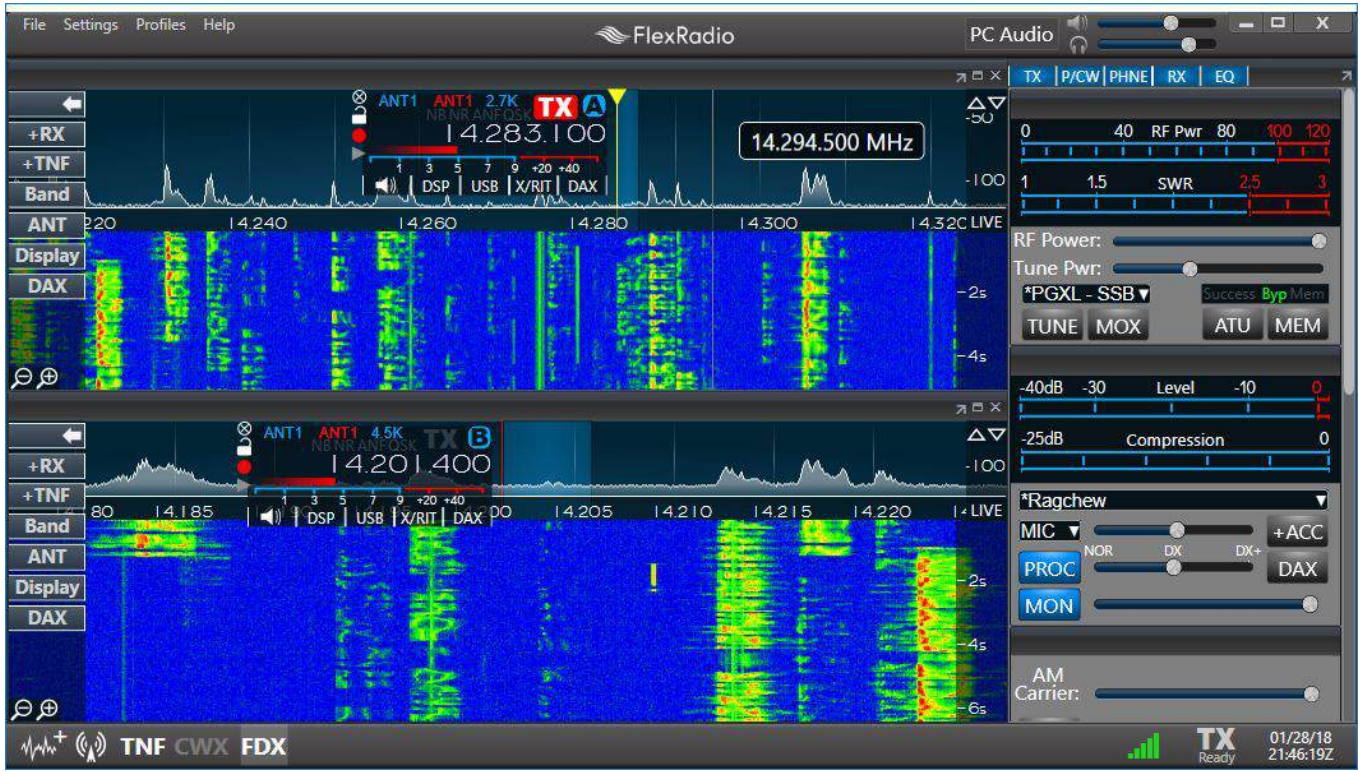
Examples



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Why FlexRadio?

- There are a lot of HF radios on the market
- All are different, offering different capabilities, some unique
- Why should you consider FlexRadio for your next HF radio?

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Best Remote Capability

- SmartSDR built from the ground up to be remotable
- SmartSDR for Windows uses remote API, even locally
- Optimized to allow full capabilities over virtually any bandwidth network

- Unique cloud-based broker connects operator and radio
  - Without getting in the way (broker only)
- Low latency
- Multiple users

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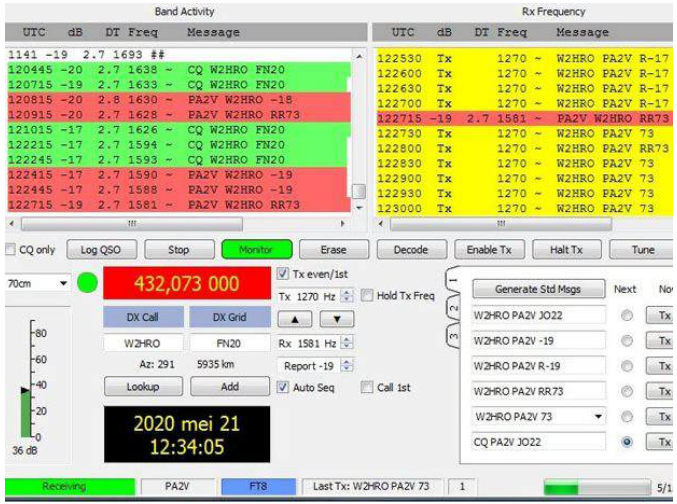
Multiple Receivers

- Direct sampling architecture means all receivers are as good as the “primary”
- Entry-level FLEX-8400 ships with two receivers
- FLEX-8600 ships with four receivers
- Allows monitoring multiple bands of FT4, FT8, etc. simultaneously (Slice Master: easy button)
- Receivers can be placed anywhere in the spectrum (no limits)
- All receivers have independent audio & control channels



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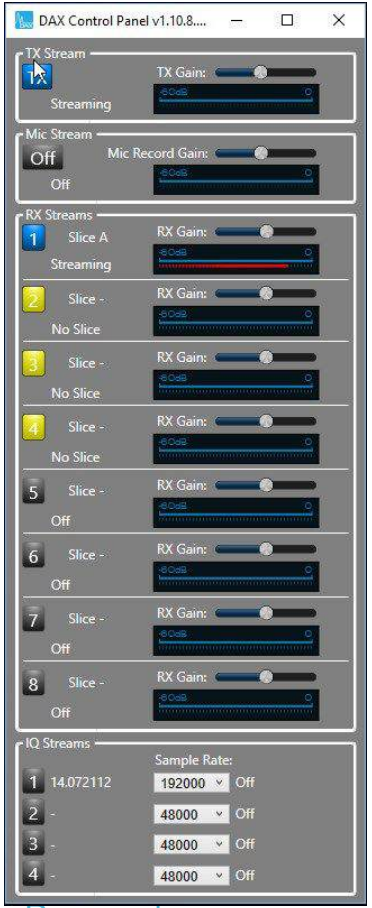
Digital Audio eXchange (DAX)

- Every receiver in a FLEX has an independent DAX audio channel
- Appears on Windows/Mac as a virtual audio in/out
- Allows simultaneous operation of multiple channels
- In addition, multiple WIDEBAND DAX channels for Skimmers, etc.
- ALL delivered on the same Ethernet cable



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Ethernet Control & Audio

- Competitive radios have serial ports
- All Audio (DAX), Wideband data (DAX IQ) and control (CAT or SmartSDR API) flow over a single Ethernet cable
- Different computers can connect to and operate your radio simultaneously
- FLEX radios are enabled for remote Internet use, right out of the box (no additional interfaces to purchase)

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Typical Remote Bandwidth

Resource	Bandwidth, Mbps
Streaming Audio from Receiver	0.07 - 0.20
Panadapter, 1fps	0.07
Panadapter, 30fps	1.966
DAX stream, 24kbps	1.690
DAX stream, 192kbps	13.517
2 panadapter + audio + DAX	16.894

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SO2R / Full Duplex

- Full Duplex operation built in — radio can transmit and receive at the same time
- Many competitors use the some of the same electronics for RX/TX and cannot do this
- Allows aforementioned multiple FT4, FT8 operation
- Also enables a complete SO2R station in a single radio include Audio management (OTRSP)

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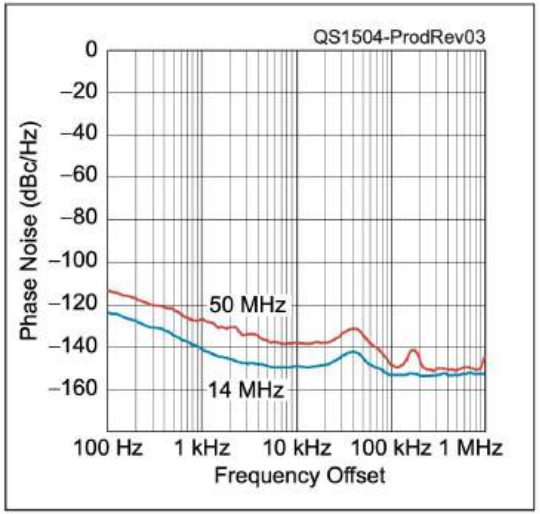
Industry-leading Phase Noise

- Ultra-low phase noise allows for nearby operators
- Multiple FlexRadios can be operated in close proximity, even at 1500W
- Significantly reduces issues with interference from nearby operators
- Important for: Field Day, DXpeditions, Contest stations, etc.



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Continuous Improvement

- FlexRadio continually enhances SmartSDR
- Features added are available for free or a nominal upgrade price
- FLEX-6700/6500/6300 owners from a decade ago are still receiving upgrades.
- Significant upgrades have been $199 in the past (two) so a total investment of ~$400 for all the new features over a decade

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FlexRadio: the Next Generation

- The FLEX-6000 was introduced in 2012, a dozen years ago
- Updates through the years:
  - 2014 — DAX and DAXIQ, Waterfall, SAM, TNF, Quick record/playback, downward expander, speech processor, FM, remote in LAN, etc.
  - 2015 — WAN remote, Maestro, API released, FlexADP developer program, etc.
  - 2016 — Wideband noise blanker (WNB), RTTY mode, Full duplex, SO2R in a box, DAX autoTX
  - 2017 —Lots of API applications, iPhone/iPad support,

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FlexRadio: the Next Generation

- Updates through the years:
  - 2017 —SmartLink, Lots of API applications, iPhone/iPad support, CAT Control Panel, OTRSP support, hardware serial ports, Native Winkeyer support, etc.
  - 2018 — N1MM streaming panadapter, M-Series radios, FLEX-64/6600, Contest preselectors, MARS/SHARES @entry level, HDMI output, pop-out panadapters, quick-split, custom panadapter color, etc.
  - 2019 — multiFLEX, zoom-to-band, segment, integrated spots, band settings panel, etc.

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FlexRadio: the Next Generation

- Updates through the years:
  - 2020—2023 — SmartControl mode, iPad/iPhone FT8, PGXL integration, COVID/supply chain turmoil …, designing new products…

… and now…

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Next Generation Radio: FLEX-8000 Series

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FLEX-8000 Models

	8400	8400M	8600	8600M
RX/Pan	2/2	2/2	4/4	4/4
Pan Width	7MHz	7MHz	14MHz	14MHz
SCU	1	1	2	2
SO2R			✅	✅
RX Presel	✅	✅	✅✅	✅✅
ATU	⭕	⭕	✅	✅
GNSS	✅	✅	✅	✅
GPSDO	⭕	⭕	⭕	⭕
MARS	⭕	⭕	⭕	⭕
Displ/Knob		✅		✅

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Next Generation Radio: FLEX-8000 Series

Feature	Benefit
Built on the successful FLEX-64/6600 base architecture and chassis	Customer familiarity
Enhanced performance (~4x CPU; ~2x FPGA)	Opens door to many new applications and capabilities (roadmap discussion)
Enhanced M-Series performance based on successful Maestro-C (~2x display performance)	Opens door to many new applications and capabilities
Integrated GNSS receiver with external Antenna included	Radio always on frequency
Optional, more capable GPSDO with 10MHz output; higher performance	10MHz can feed other shack equipment; suitable for more demanding environments

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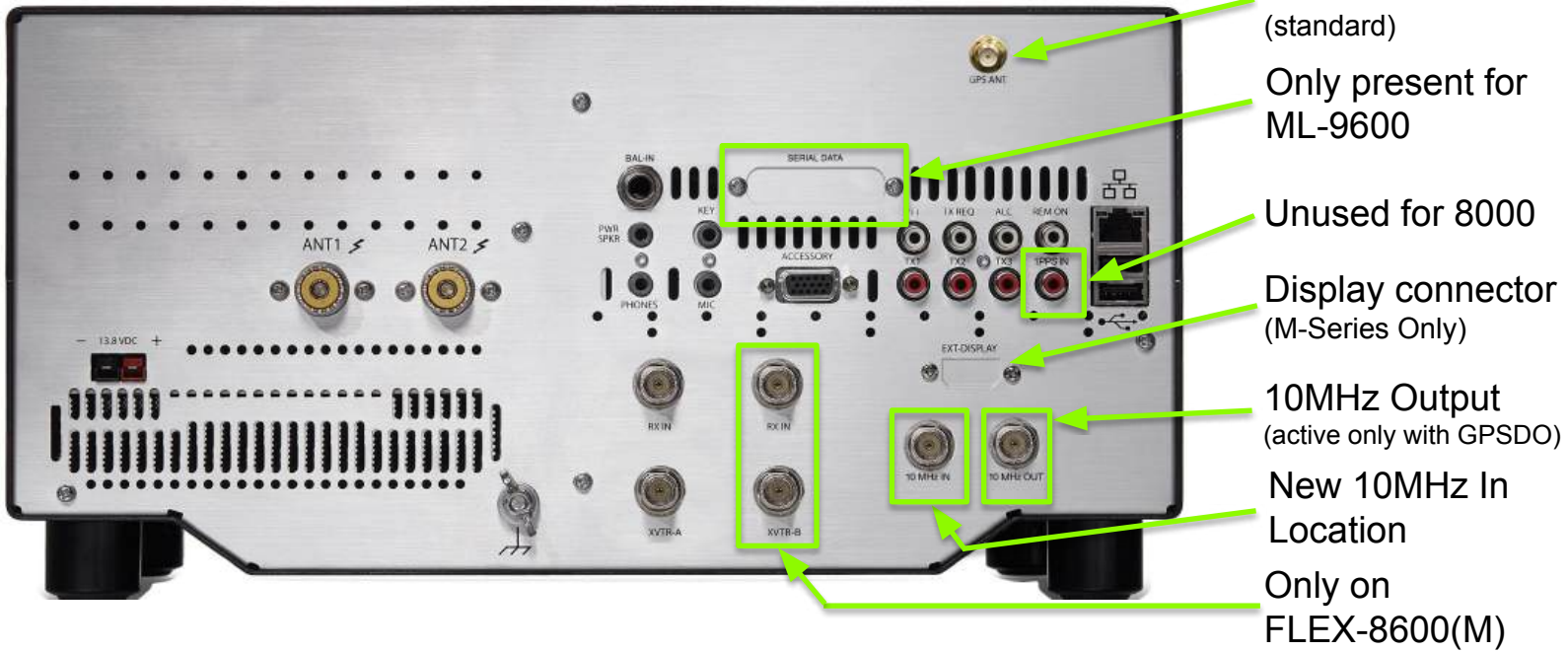
Next Generation Radio: FLEX-8000 Series



GNSS Antenna
(standard)

Only present for
ML-9600

Unused for 8000

Display connector
(M-Series Only)

10MHz Output
(active only with GPSDO)

New 10MHz In
Location

Only on
FLEX-8600(M)

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Internal GNSS Receiver

- 32-channel, multi-system capable
- TTFF (cold) < 35s
- SBAS = WAAS, EGNOS, GAGAN & MSAS

	GPS	GLONASS	Galileo	QZSS	SBAS
Country					
Signal	L1C/A	L1OF	E1B/E1C	L1C/A, L1S	L1C/A
Channels	12	10	8	4, 2	2
Tracking	-162dBm	-158dBm	-136dBm	-136/4dBm	-130dBm

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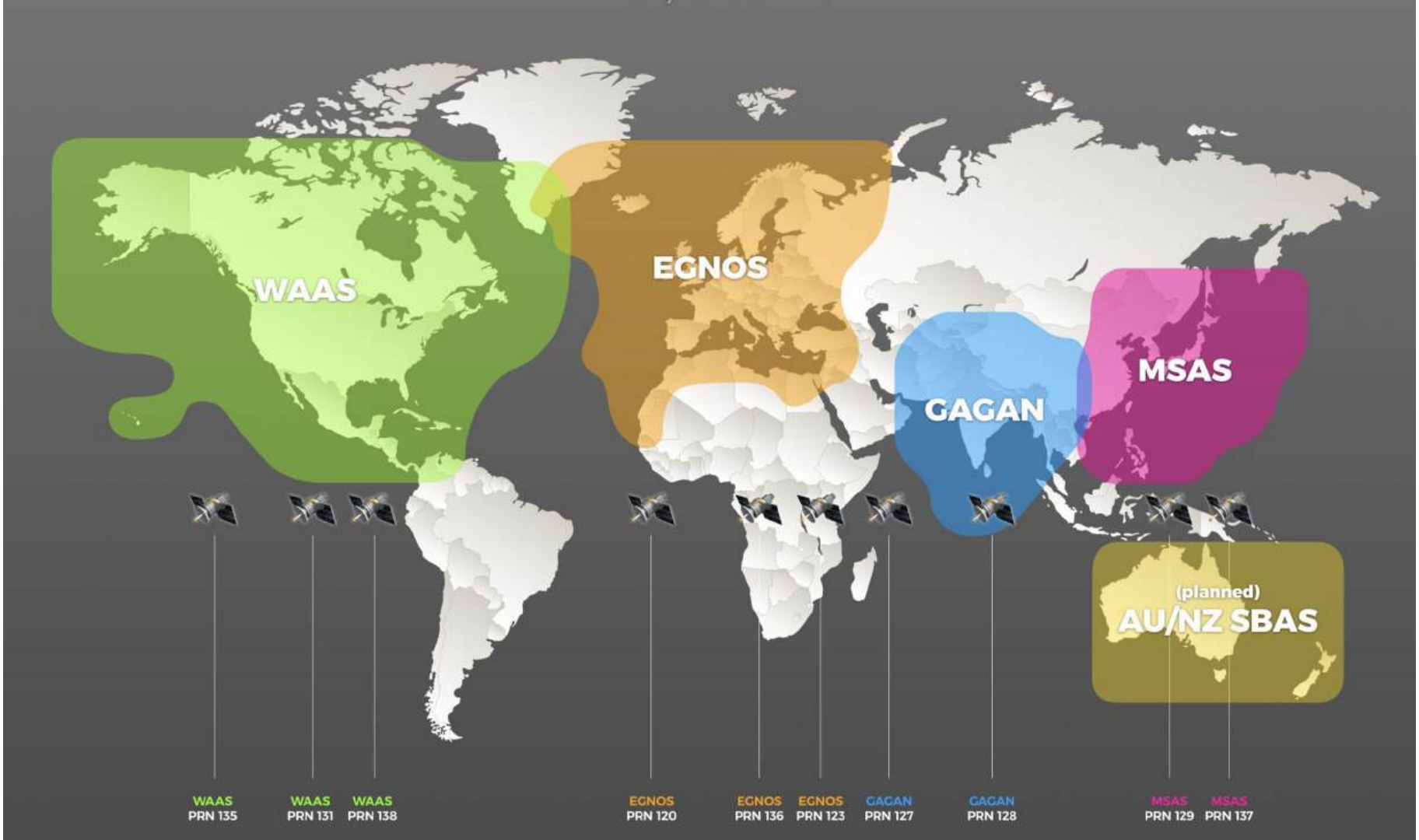
WAAS
EGNOS
GAGAN
MSAS
(planned)
AU/NZ SBAS
WAAS PRN 135
WAAS PRN 131
WAAS PRN 138
EGNOS PRN 120
EGNOS PRN 136
EGNOS PRN 123
GAGAN PRN 127
GAGAN PRN 128
MSAS PRN 129
MSAS PRN 137

The New Maestro!

- Significantly Improved WiFi Capability
  - Better antenna (MIMO)
  - WiFi 6 compatible
- Significantly Improved CW sidetone
- Internally rechargeable battery option — ~8 hours of run time!
- New power indication/switch matches M-Series Radios
- New pseudo-differential MIC connection
- HD Display Output — use external monitor with the Maestro
- Integrated mic/headphone connector (CTIA standard)
- 24VDC allows rapid charging
- Use it ANYWHERE!

The New Maestro!

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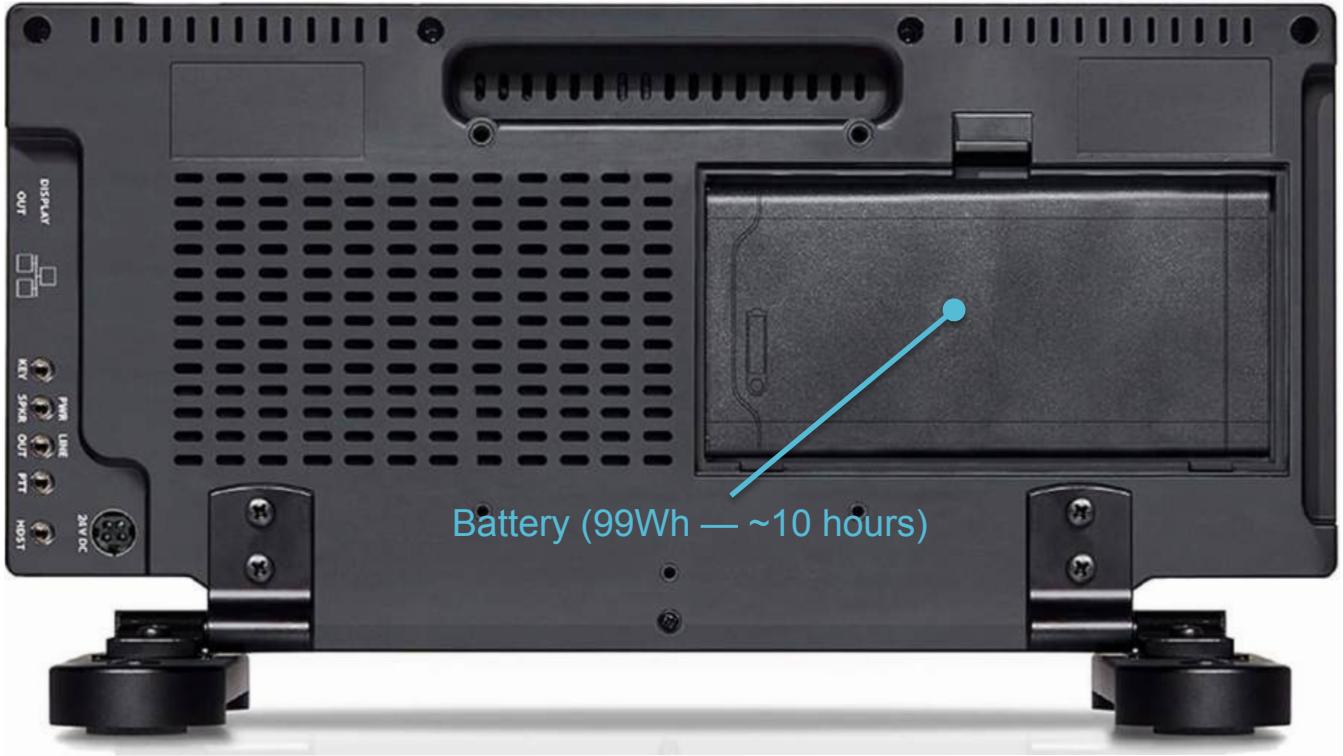
The New Maestro!



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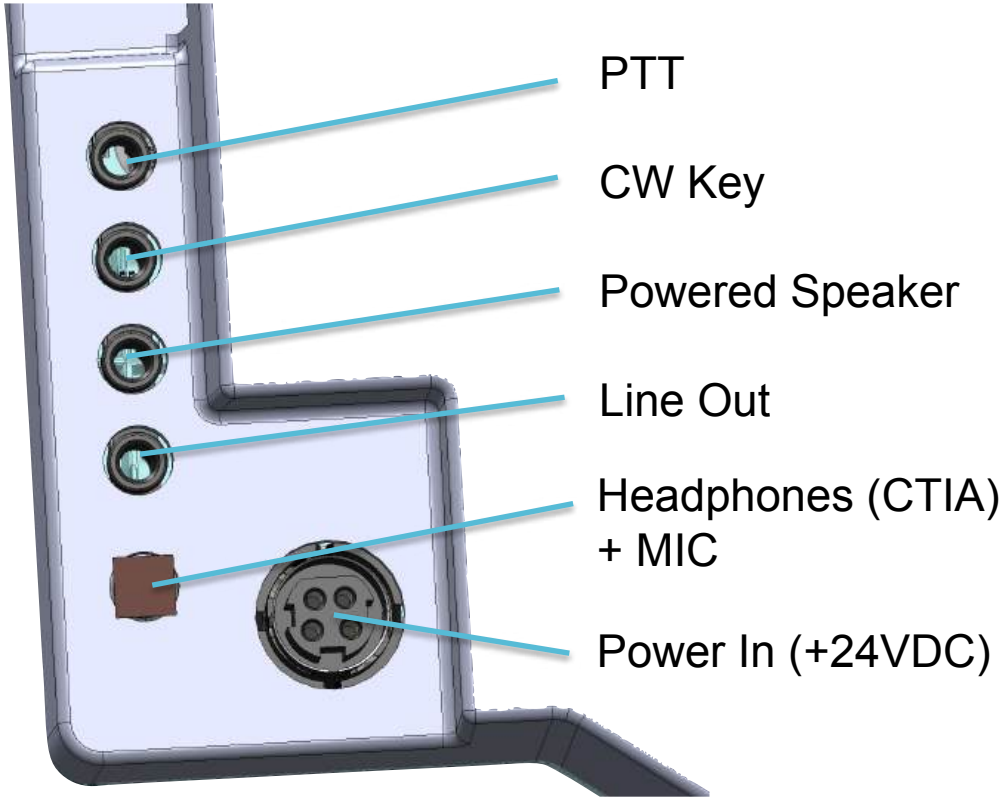
Maestro Rev C



Maestro Rev C

- 60W Single bay fast charger
- Longer cycle life
- Faster charging
- Simple operation – Plug and Play
- Automatic recognition and calibration of smart battery learned capacity
- External power supply for worldwide use
- Country specific AC input cables available

Maestro Rev C - MSRP

	Pricing
Maestro	$1599
Battery (99Wh)	$215
Single Rapid Charger (60W)	$160
Dual Charger (2x30W)	$260

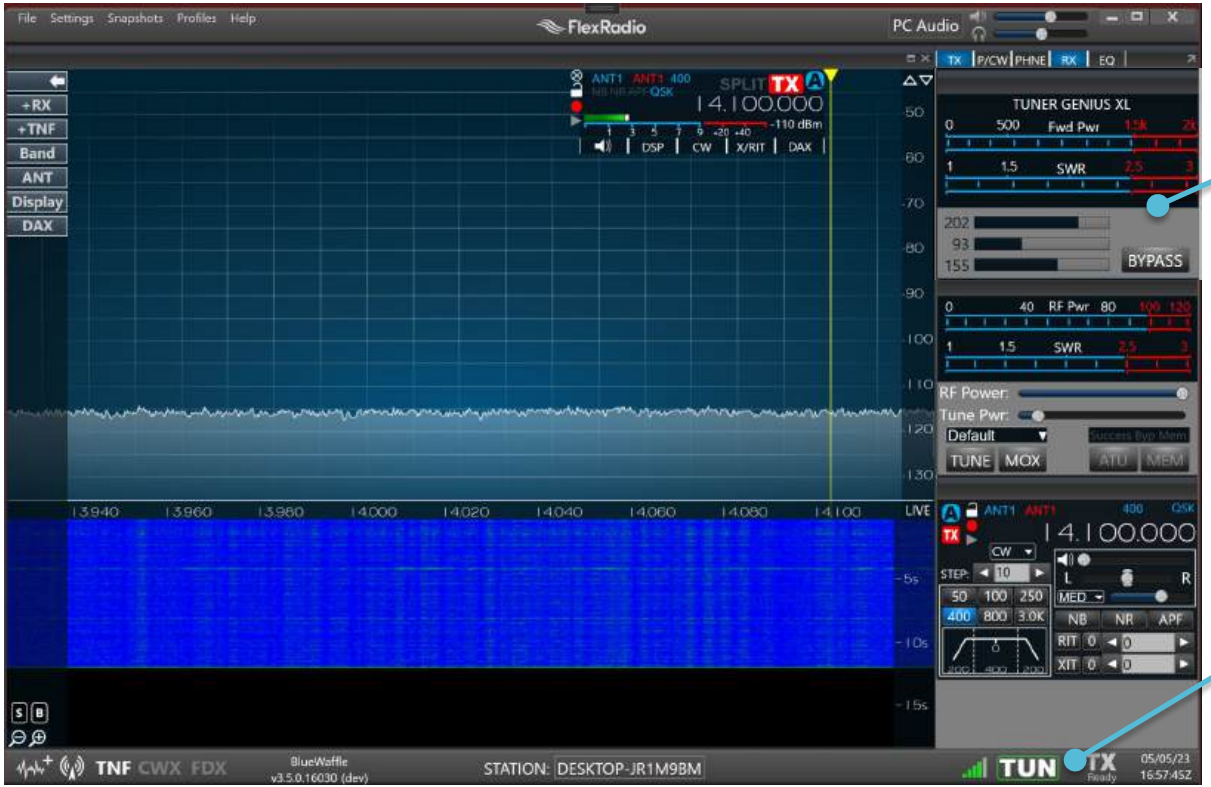
Future SmartSDR Features

- v3.8.19 (6000 + 8000)
  - Squelch for all voice modes
- Future
  - TGXL / PGXL integration with SmartSDR
  - Analog meters
  - USB cable pass thru

PGXL / TGXL Integration

- PGXL is FlexRadio's 1500W HF PA designed 4O3A
- TGXL is FlexRadio's 1500W HF Tuner designed with 4O3A
- Today, there are separate control apps for each

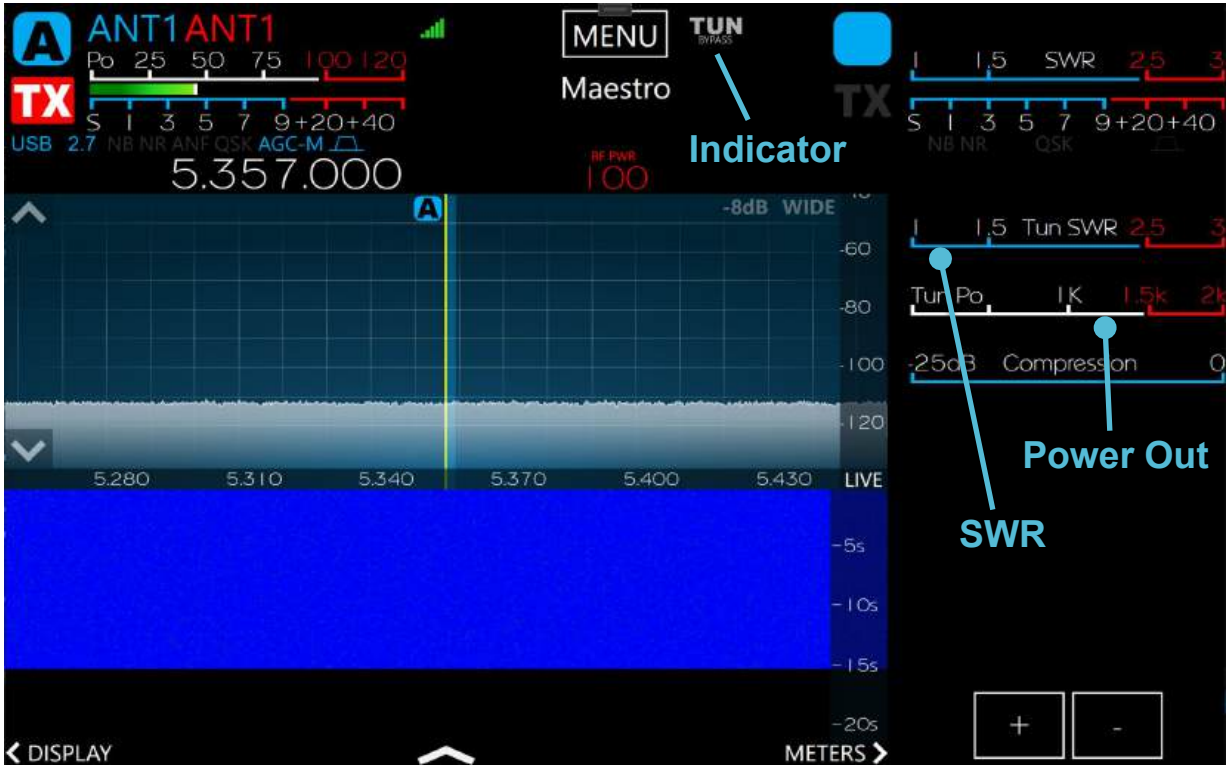
PGXL / TGXL Integration (SmartSDR)



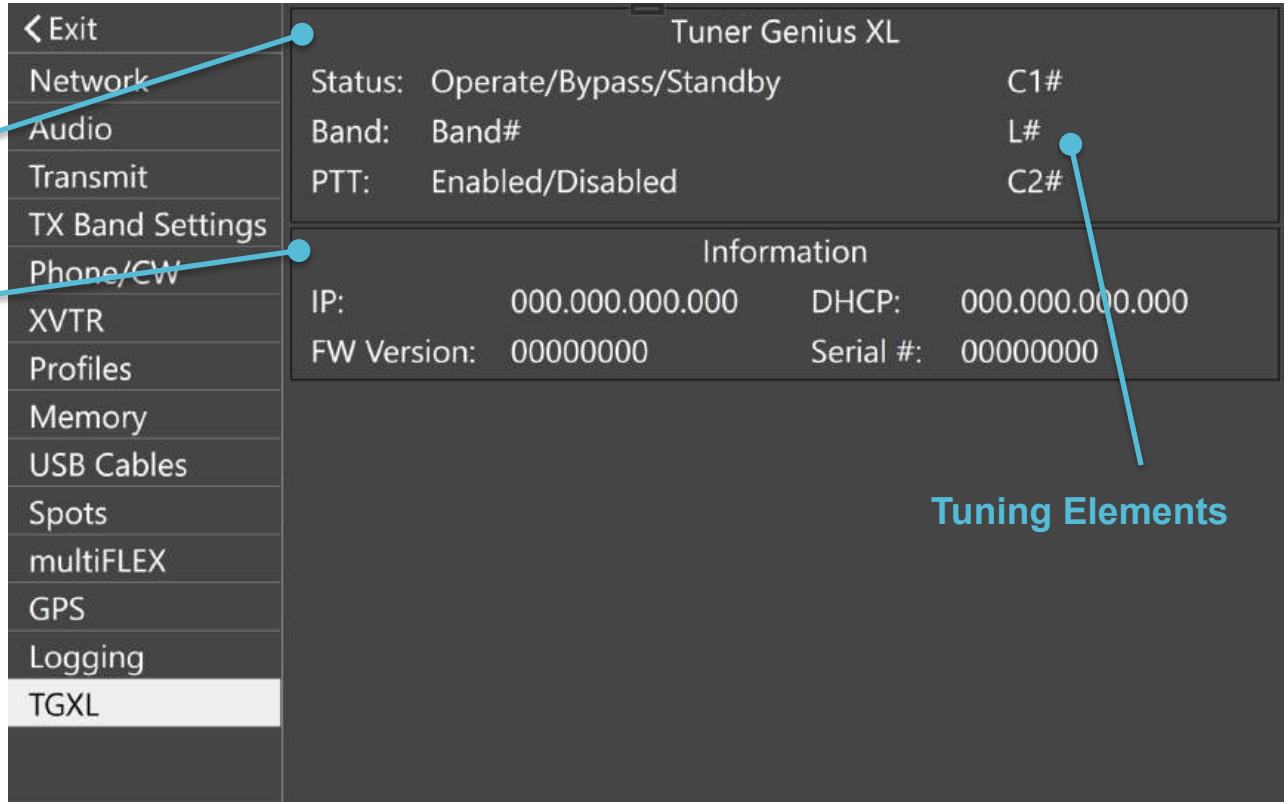
PGXL / TGXL Integration (SmartSDR)

- **Enabling/Bypass the TGXL**

PGXL / TGXL Integration (Maestro)



PGXL / TGXL Integration (Maestro)

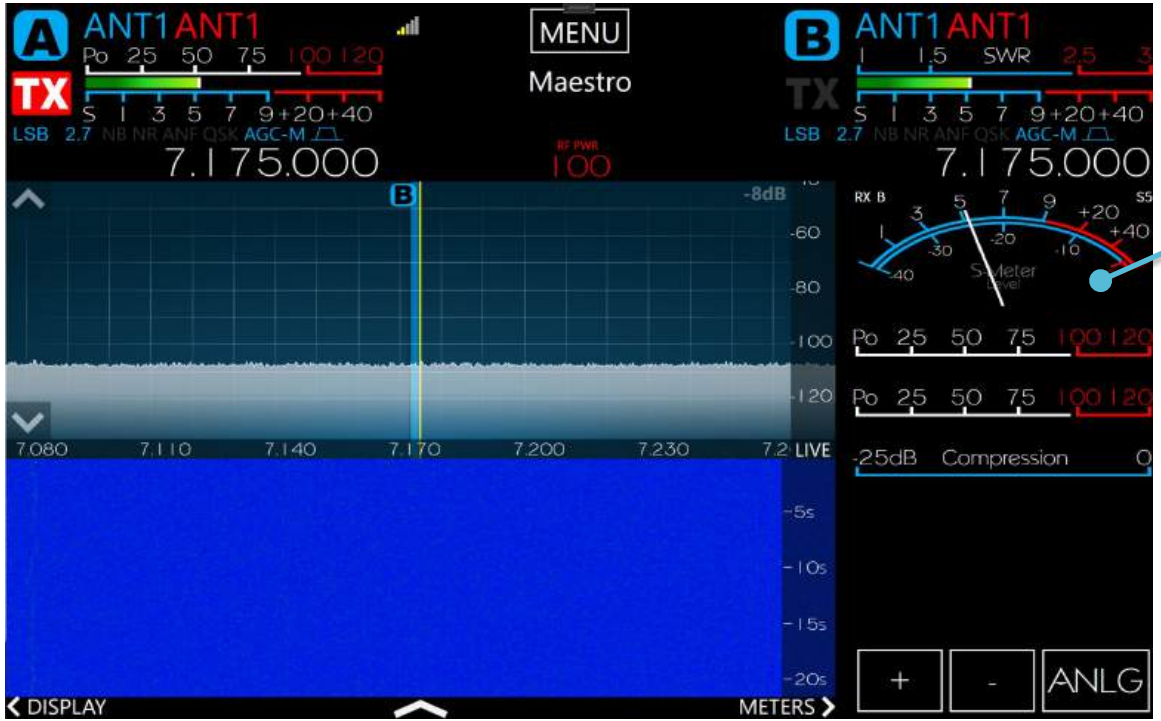


Metering Additions (SmartSDR)

- Analog meters in RX and TX
- TX function switchable with drop-down
- In RX meter indicates slice and power level in dBm or S-units

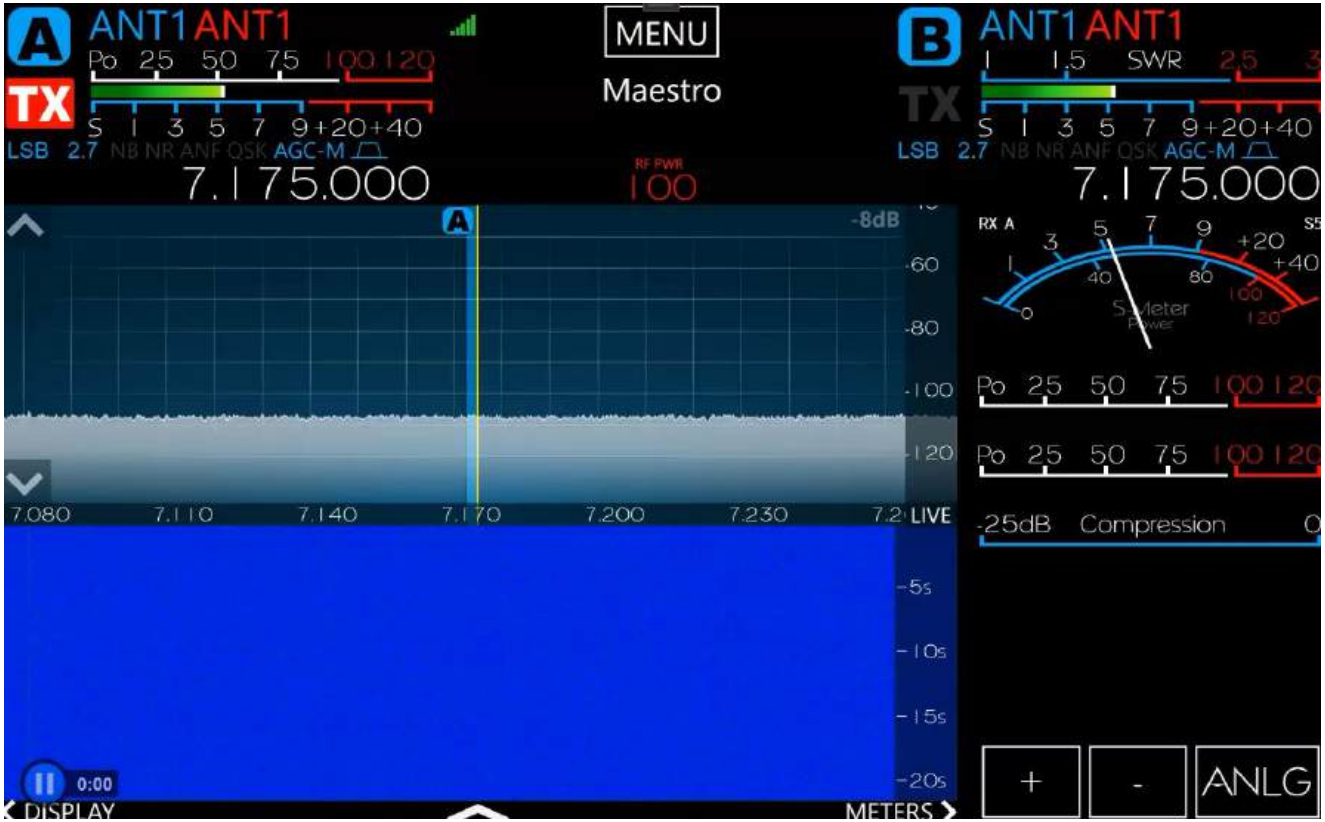
Metering Additions (SmartSDR)

Metering Additions (Maestro)



Analog Meter

Metering Additions (Maestro)




Innovation
Ahead

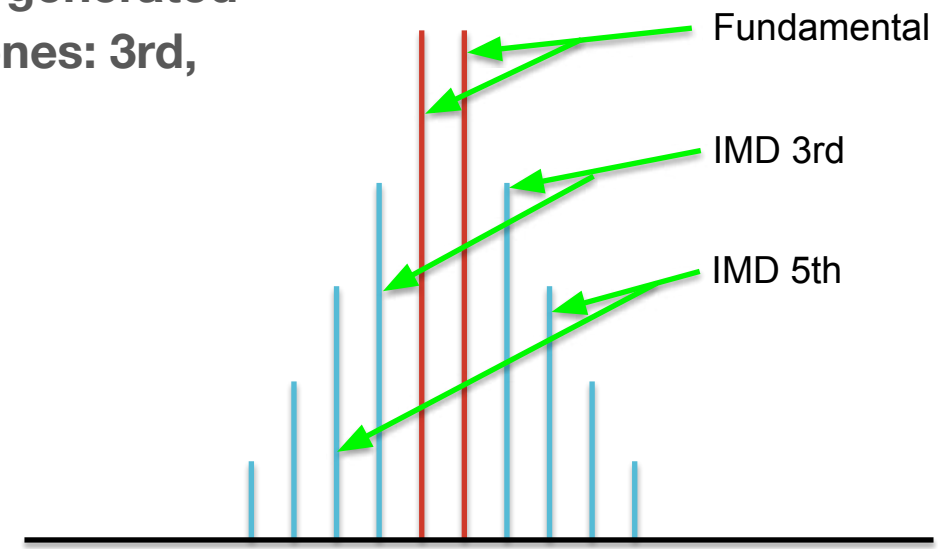
FLEX-8000 Software Roadmap

- With the extra capability, FlexRadio will add many new features over time
- Some new features will be hardware platform dependent (some not possible on the FLEX-6000)

Intermodulation Distortion (IMD)

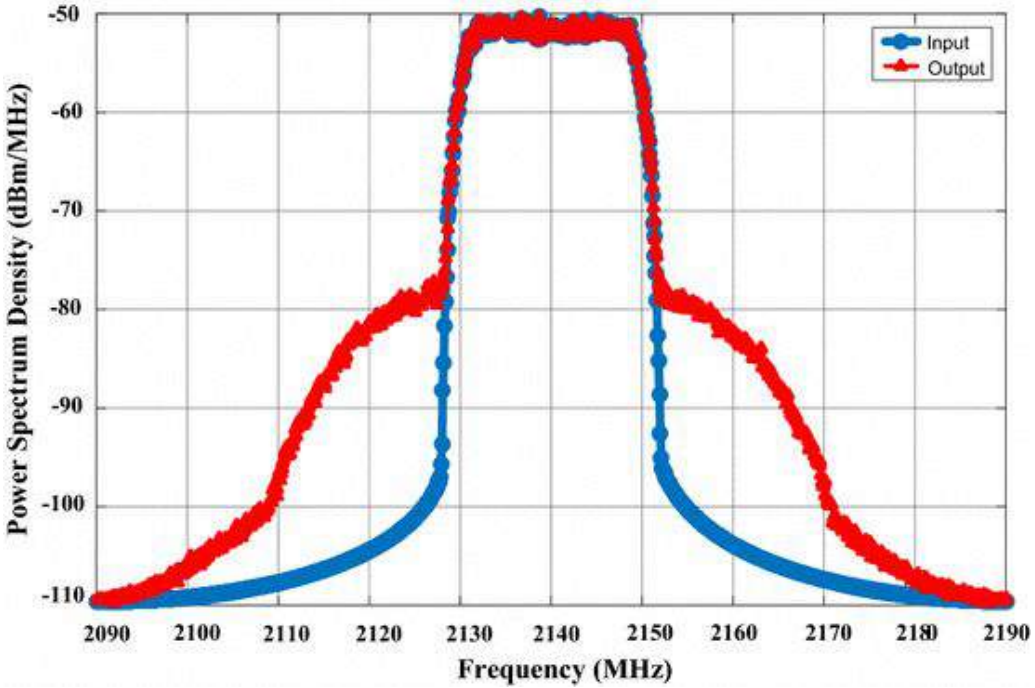
(also called spectral regrowth in broadcast/cellular)

- Caused by non-linearities in our “linear amplifiers”
- Occurs in any analog amplification stage, 100W, 1,500W, etc.
- Multiple “products” generated by relationship of tones: 3rd, 5th, 7th, etc.



Intermodulation Distortion (IMD)

(also called spectral regrowth in broadcast/cellular)



IMD: Why do we care?

- To be neighborly, polite — sharing the band
- Regulations:

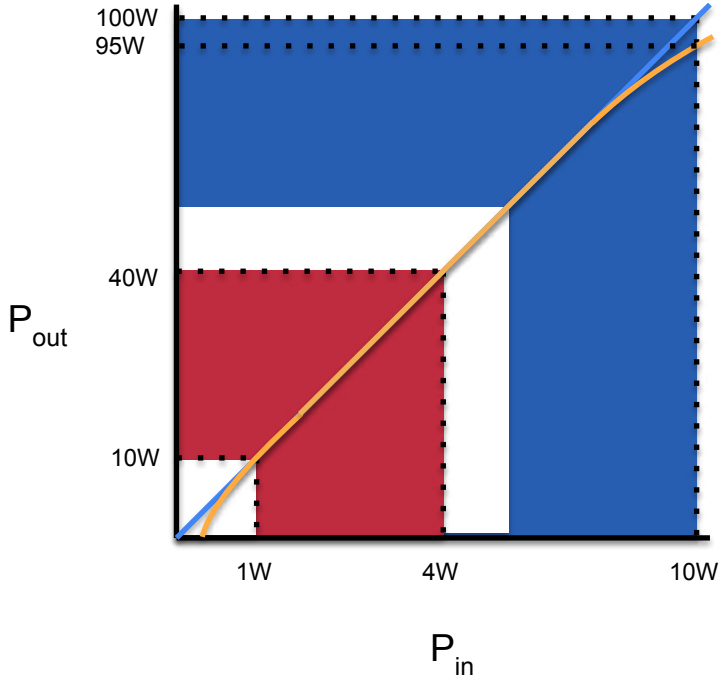
§ 97.307 Emission standards.

(c) All spurious emissions from a station transmitter must be reduced to the greatest extent practicable. If any spurious emission, including chassis or power line radiation, causes harmful interference to the reception of another radio station, the licensee of the interfering amateur station is required to take steps to eliminate the interference, in accordance with good engineering practice.

(d) …

How are our PA's not linear?

- Let's say: 10dB gain amp
- But our amp is not completely linear…
- This "compression" is completely normal
- Look at P1dB and P3dB specs for any amplifier…



IMD: How is it fixed?

- Running class A on oversized finals helps, but wastes heat and costs $ (think of buying a 1500W final for a 100W PA)
- What could we do if we *knew how* the signal would be distorted?
- Could we calculate a P_{in} level that gets us the correct P_{out} level?
- What if we looked at every sample and adjusted it so that the PA made the correct signal?
- This is called “pre-distortion” because we adjust before the distortion occurs

Pre-Distortion Types

- Different types of pre-distortion: STATIC, ADAPTIVE
- STATIC
  - Calibration must be manually performed
  - Correction based on this one test
  - Typically see ~8-15dB of benefit
- ADAPTIVE
  - Examines spectrum in real time (must support full duplex)
  - Adapts to changes: frequency, voltage, temperature, mode, etc.
  - Typically see ~15-25dB improvement

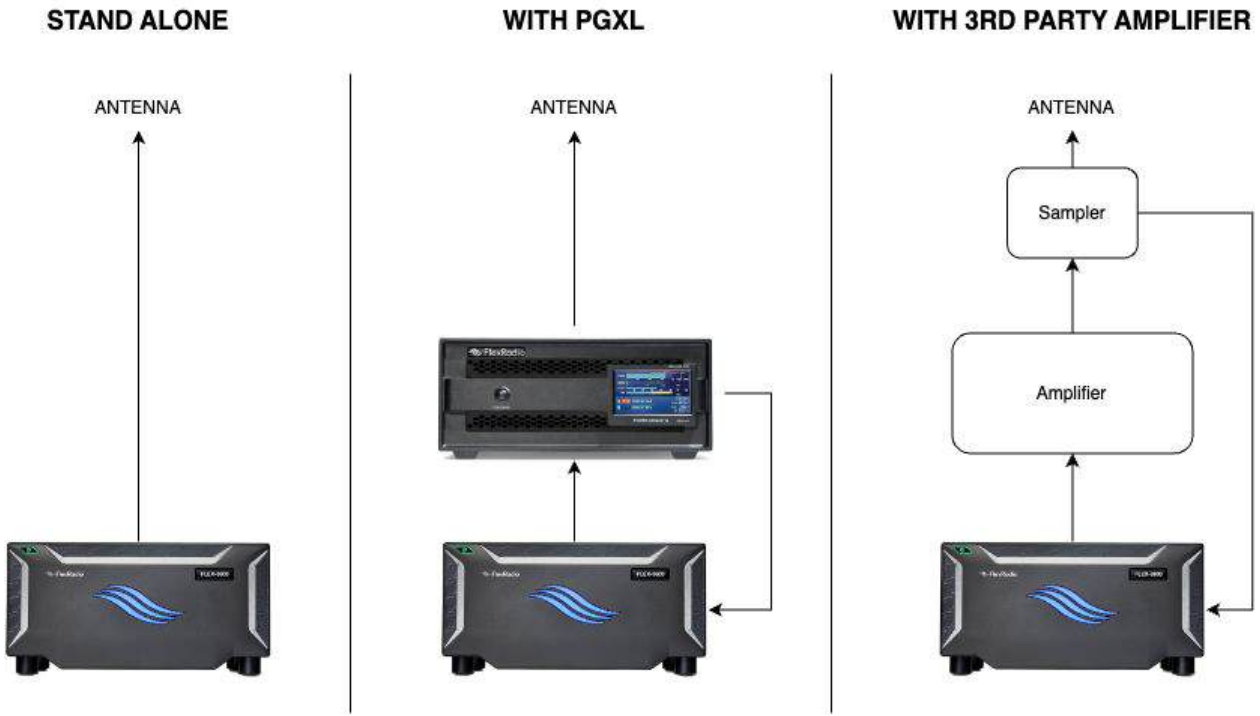
Adaptive Pre-Distortion (APD)

- FlexRadio is implementing ADAPTIVE PRE-DISTORTION
- Dynamically characterizes PA performance and builds correction model
- Applies correction model in real-time
- Currently working in the lab; will be available in later release (not at launch)
- Available on all FLEX-8000 series radios (included)
- Will it be available on the FLEX-6000 series radio?
    - We are investigating; will come after 8000 if economically feasible

Adaptive Pre-Distortion (APD)

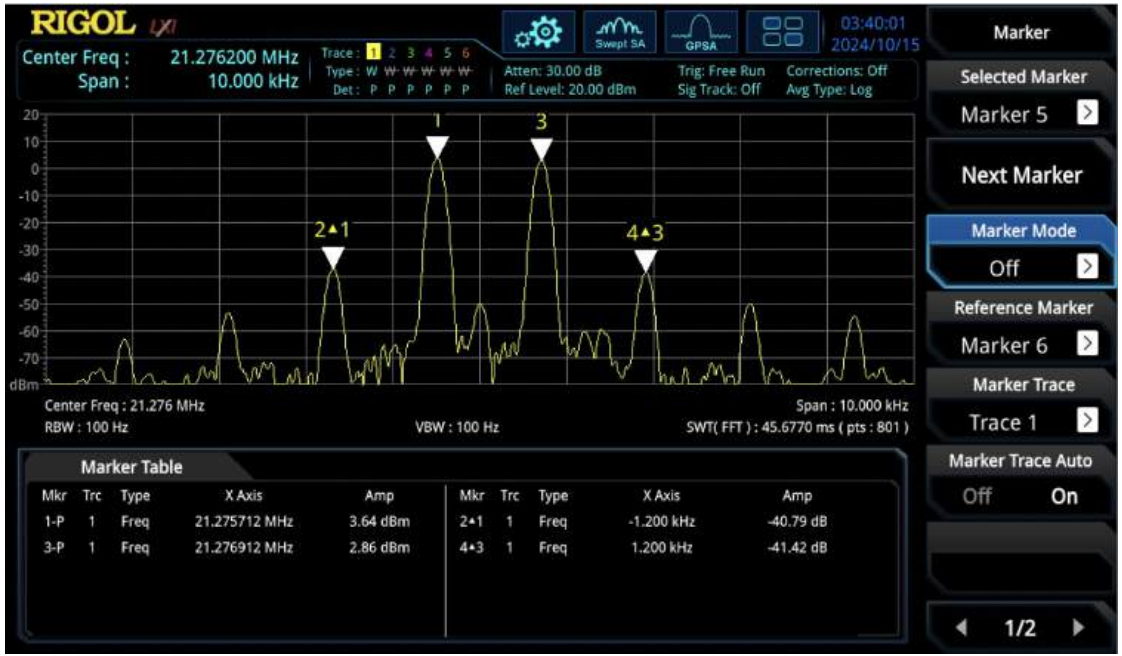
- Works with internal FLEX-8000 100W PA
  - Calibration occurs during every to every few transmissions and the adaptive model is updated
  - Model applied in real-time
- Works with any external PA using FlexRadio sampler
  - Sampler available at later date (upgrade option)
  - Assumes P_{out} <= 2kW
- PGXL has integrated, compliant sampler

Adaptive Pre-Distortion (APD)

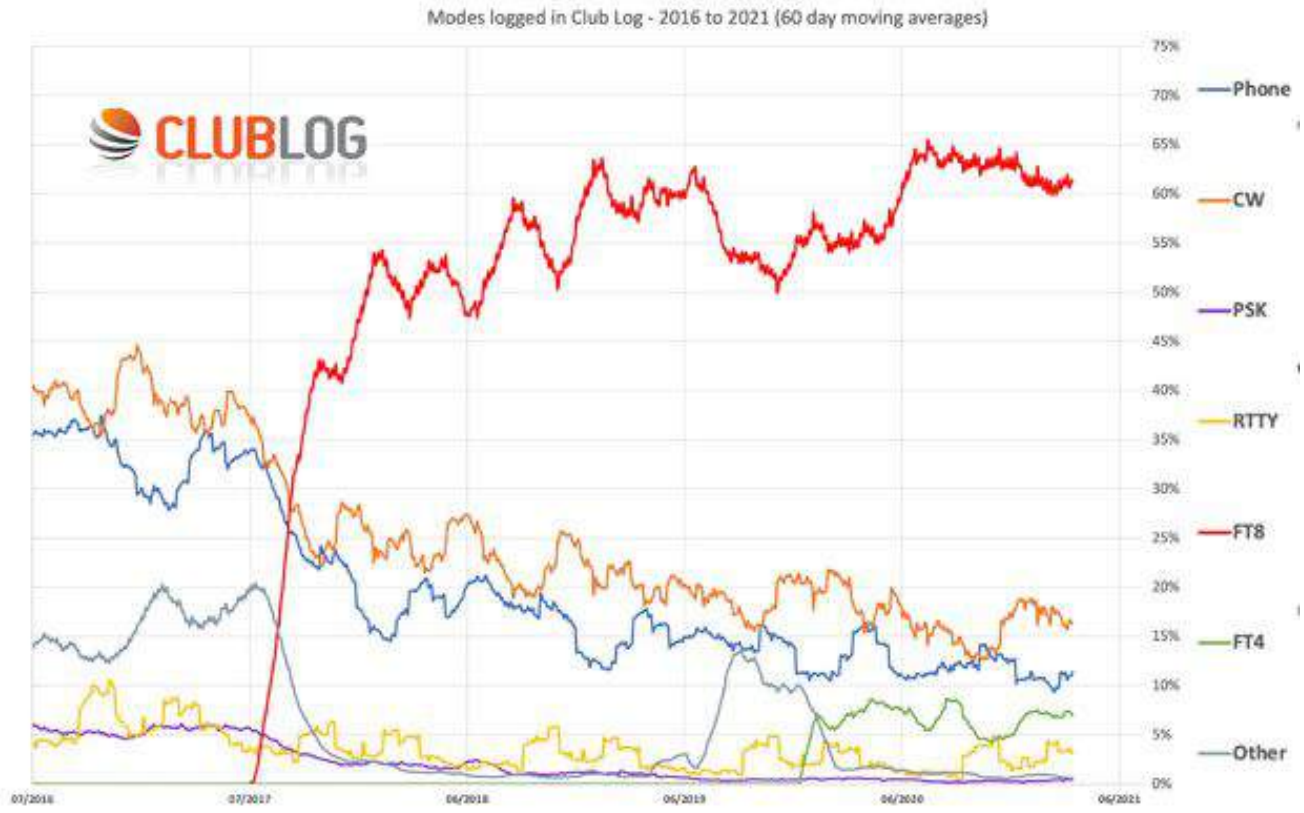


Adaptive Pre-Distortion (APD)

- **IMD Before: -33dBc**
- **IMD After: -41dBc**

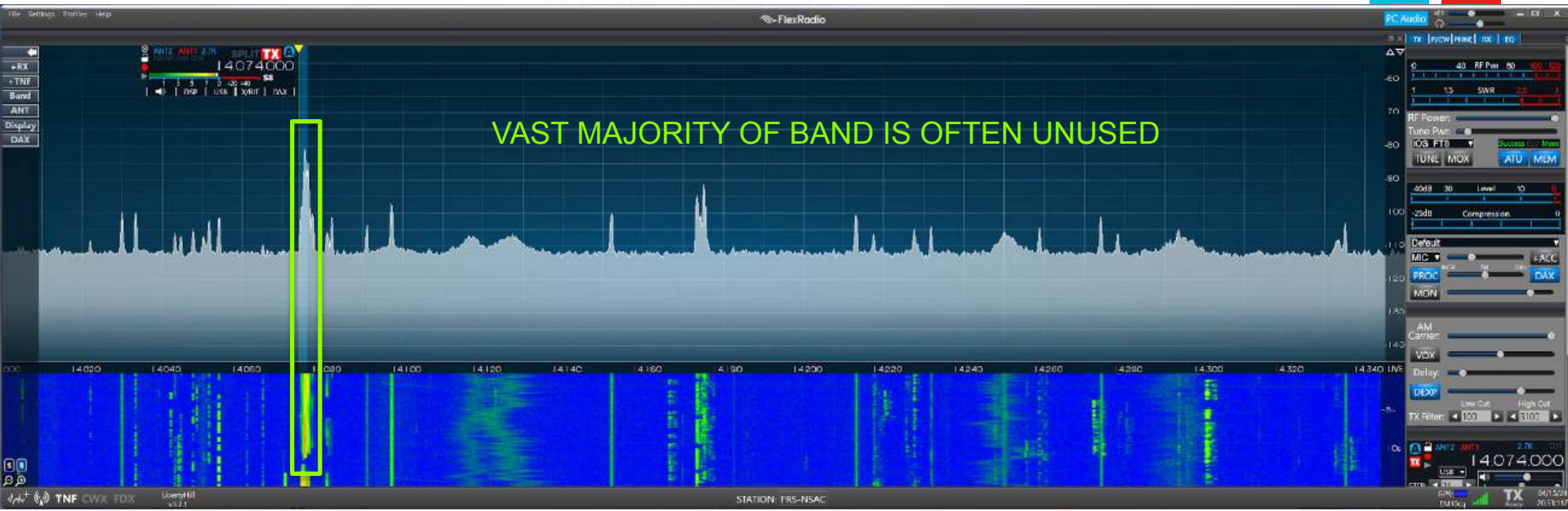


FT8: The most popular QSO mode



FT8: The Problem

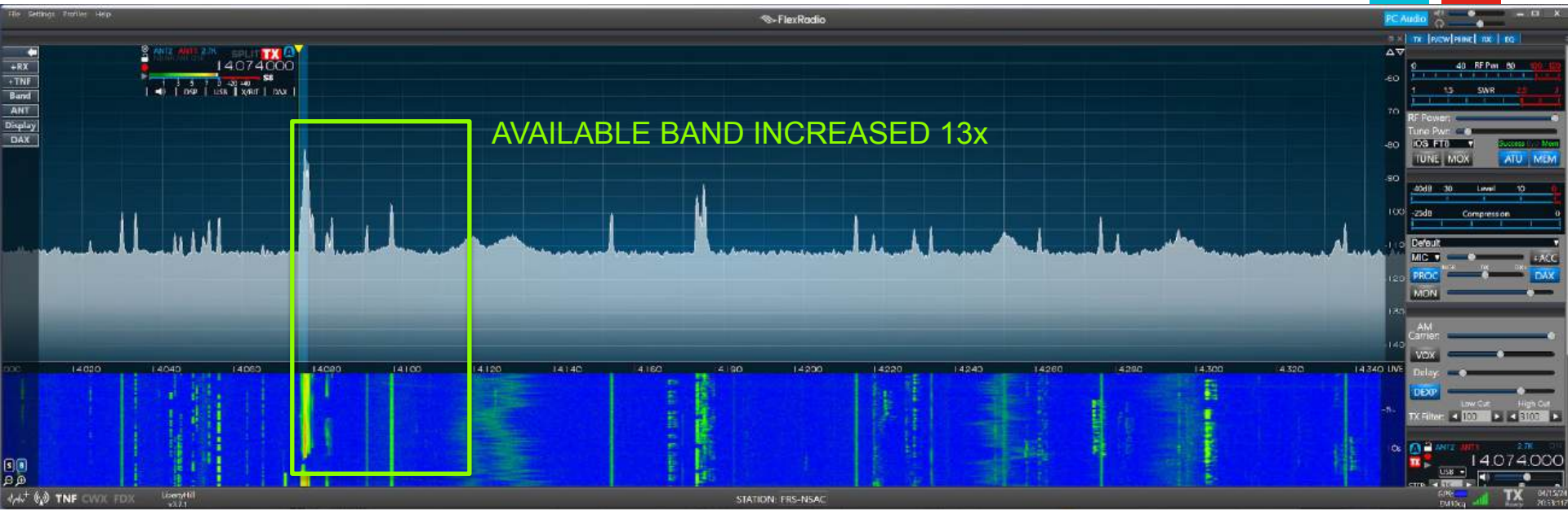
- Everyone scrunched into 3kHz of bandwidth



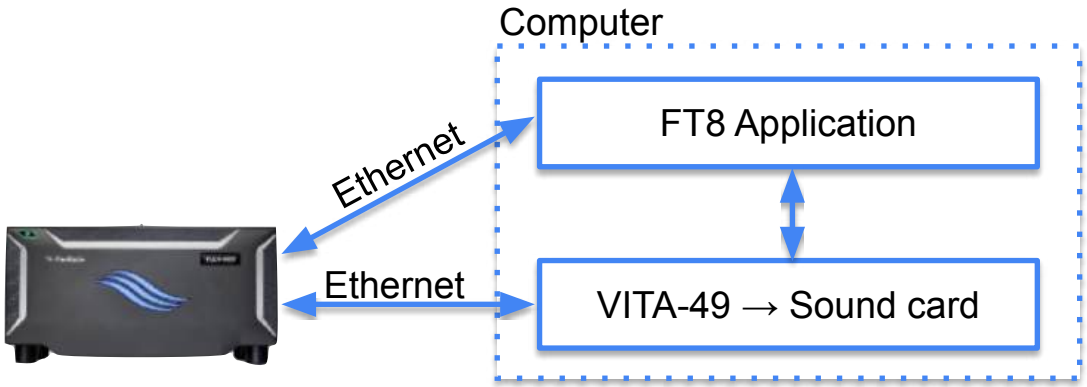
FT8 — The Solution: AMATEUR WIDEBAND

- Ability to transmit and receive over 40kHz of bandwidth
- Multiple carriers transmitted at once with single radio
- FT8 will move from a 3kHz window to a 40kHz window
- Multiple transmit channels to radio allow multiple carriers in band
- Radio ensures compliance with rules (each carrier must stay within a 3kHz segment of the allowable 40kHz space)
- FlexRadio working to make application code open source — other vendors can use if they make their radios compatible

FT8 — The Solution: WIDEBAND



FT8 — The Solution: AMATEUR WIDEBAND



- FlexRadio seeking developers to work on applications
- Interested, see steve@flex.radio

Spectrum Overview

- Visibility of all HF/6m amateur bands in single, unified panadapter
- Provides high situational awareness of bands
  - Easy to spot openings
  - DX stations moving between bands readily visible
  - Location of current receivers marked

Advanced Noise Reduction

- Additional noise reduction techniques and choices
- Uses additional processing power to achieve greater noise mitigation (improved NR, new NR capabilities, ANF, NB)

Integrated NTP Server

- Internal GNSS receiver is source for time standard
- Radio responds to NTP requests on local network
- Replaces remote NTP services for timing-critical applications like WSJT / FT8, etc.
- Provides NTP services without Internet access (during POTA operation, for example)

FLEX-8000 Pricing / Features

	8400	8400M	8600	8600M
RX/Pan	2/2	2/2	4/4	4/4
Pan Width	7MHz	7MHz	14MHz	14MHz
SCU	1	1	2	2
SO2R			✅	✅
RX Presel	✅	✅	✅✅	✅✅
ATU	⭕	⭕	✅	✅
GNSS	✅	✅	✅	✅
GPSDO	⭕	⭕	⭕	⭕
MARS	⭕	⭕	⭕	⭕
Displ/Knob		✅		✅
	$2,499	$3,649	$4,899	$5,899

FLEX-8000 Availability

- Now shipping to customers that put down deposit in May
- If you've ordered, please wait for us to contact you
- To purchase:
  - Deposit: $500
  - Email: andy@flexradio.com or sales@flex.radio and we will call back and get you set-up

Thanks for being a customer! Questions?

Find Everywhere