FlexRadio

Aurora User Guide

AU-510 / AU-510M / AU-520 / AU-520M Transceivers

Revision

Rev. 0.1

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Contents

Chapter 1

Introduction to Aurora

1.1 What is Aurora?

FlexRadio has developed a new HF transceiver with a 500W output on 160-10m HF bands (200W on 6m). This radio does not use a legacy RF exciter followed by a linear amplifier. Instead, it uses a transmitter that employs Polar Modulation (PM). With PM, the radio still generates traditional SSB, CW, FT-8, RTTY, and all the standard on-air signals.

A 500-watt transceiver with an integrated automatic antenna tuner (ATU) in a single unit offers a few clear advantages, especially for seasoned operators who value simplicity and efficiency. First, it reduces the need for interconnecting multiple devices, which cuts down on cabling, potential RFI issues, and the complexity of station setup. The integrated transmitter and ATU are designed to work in harmony, offering faster tuning and better protection. Another big plus is the space-saving aspect—ideal for both compact home stations and portable setups where minimizing gear is a priority.

Aurora provides significant benefits over transceivers with linear amplifiers. By enabling the use of a high efficiency Class D PA, Aurora yields significant power savings, generates less heat, resulting in the need for a much smaller heat sink, which also reduces size and weight; fewer components than legacy radio and amplifier combination.

By adopting the proven architecture of the FLEX-6000 and FLEX-8000 series and maintaining compatibility with SmartSDR, Aurora offers a familiar yet powerful upgrade path for today's FlexRadio operators.

1.2 Why Aurora?

1.2.1 Transmitter Efficiency

The Aurora transmitter achieves approximately 80% efficiency, compared to 40-60% for traditional linear amplifiers. This means:

- **6x reduction in heat generation** - A 500W transmitter fits in the space of a traditional 100W amplifier
- **Lower operating costs** - Less electricity required to generate the same output power
- **Reduced cooling requirements** - Smaller heat sinks, quieter fans
- **Improved reliability** - Less thermal stress on components

1.2.2 Compact, Integrated Design

Aurora combines everything you need in one package:

- 500W transmitter
- Internal AC to DC power supply (100-240VAC auto-sensing)
- Automatic antenna tuner (3:1 SWR capability)

- Full FLEX-8000 series receiver performance

The result is an 18-pound (8 kg) transceiver that delivers 500W output with an integrated power supply and ATU.

1.2.3 Familiar Operation

Aurora runs SmartSDR, the same software used by FLEX-6000 and FLEX-8000 series radios. Existing FlexRadio operators will find a familiar interface with Aurora-specific enhancements for monitoring transmitter performance.

1.3 Aurora Model Overview

Aurora is available in four models:

Model	Description
AU-510	Single SCU (FLEX-8400 platform), 2 receivers, no display
AU-510M	Single SCU with Maestro 8” touchscreen display
AU-520	Dual SCU (FLEX-8600 platform), 4 receivers, no display
AU-520M	Dual SCU with Maestro 8” touchscreen display

All models include SmartSignal™ (adaptive predistortion), integrated ATU, and full SmartLink remote operation capability.

1.4 Key Differences from Traditional Radios

1. **SWR Sensitivity** - Aurora is more sensitive to SWR mismatches. The internal ATU should be used for non-resonant antennas.
2. **AC Power Only** - Aurora requires 80-264 VAC input. DC operation is not supported.
3. **External Amplifiers** - Using external amplifiers is strongly discouraged due to the 500W output level.
4. **APD Required** - SmartSignal™ (adaptive predistortion) should remain enabled at all times for optimal signal quality.

Chapter 2

Quick Start Guide

To ensure reliable operation, it's important to understand how Aurora manages SWR, tuning, and adaptive processing. The following notes highlight key differences from previous Flex models and provide essential guidance for new owners.

2.1 Powering On the Aurora

The Aurora utilizes a 110/220 VAC (60 or 50 Hz) auto-sensing internal power supply. Connect the IEC power cable from the connector on the radio to your AC wall outlet. Please note that a master power switch is integrated into the power connector, and it **must be turned on** before the radio will boot.

2.2 SWR Sensitivity

Aurora is more sensitive to SWR and manages it differently from other FlexRadio models.

- Output power will begin to reduce automatically (SWR foldback) when SWR exceeds 1.7:1
- Transmission will stop, and a fault will be set if SWR exceeds 2.5:1

> **Warning**
>
> **SWR Protection**
> The Aurora's SWR protection is more aggressive than traditional radios. Always ensure your antenna system is properly matched before operating at full power.

2.3 Use with an External Linear Power Amplifier

> **Caution**
>
> **NOT RECOMMENDED**
> It is **STRONGLY DISCOURAGED** to use an external linear amplifier with Aurora. Most linear amplifiers are designed to accept no more than 100 watts of drive. Connecting one to Aurora's 500-watt output will almost certainly result in damage to the external amplifier and will constitute a violation of your warranty.

2.4 Using an External Tuner

When using an external tuner, set the TUNE Power slider to 3% or less.

- This disables internal fault limits, allowing the external tuner to complete its tuning process

- Setting the TUNE Power to 4% or higher can cause faults during tuning

2.5 APD (Adaptive Predistortion)

Aurora relies on APD to maintain optimal transmit signal quality.

- APD should remain enabled at all times
- Do not disable APD during normal operation

> **Note**
>
> **SmartSignal™**
> APD is part of FlexRadio's SmartSignal™ technology, which continuously monitors and corrects the transmitted signal for optimal linearity.

2.6 Internal ATU (Automatic Tuning Unit)

The internal ATU is rated for full-power operation up to 3:1 SWR.

- It may be able to tune higher SWR loads, but it is not rated for full power beyond 3:1
- When operating above 3:1 SWR, reduce output power to prevent faults or damage

2.7 Quick Reference

Parameter	Specification
Input Voltage	80-264 VAC (auto-sensing)
Maximum Power (HF)	500W
Maximum Power (6m)	200W
SWR Foldback Begins	1.7:1
SWR Fault Threshold	2.5:1
ATU Rated SWR	3:1
Weight	18 lbs (8 kg)

2.8 First Steps

1. **Unpack and inspect** the radio for shipping damage
2. **Connect AC power** using the provided IEC cable
3. **Turn on the master power switch** on the rear panel
4. **Connect your antenna** to one of the TX-capable antenna ports
5. **Start SmartSDR** and connect to your Aurora radio
6. **Enable the ATU** if using a non-resonant antenna
7. **Begin operating** at reduced power until you verify antenna match

Chapter 3

Model Comparison

3.1 Aurora Series Overview

Aurora is available in four models, based on the proven FLEX-8000 series architecture. The AU-510 models are built on the FLEX-8400 platform, while the AU-520 models are built on the FLEX-8600 platform.

3.2 Model Differences

3.2.1 AU-510 vs AU-520

The fundamental difference between the AU-510 and AU-520 is the number of Spectral Capture Units (SCUs):

AU-510 (FLEX-8400 Platform)

- One internal Spectral Capture Unit (SCU)
- Two UHF connectors for full-power TX/RX operation (500W), one RX-only antenna port, and one transverter port (max +10 dBm)
- Two internal receivers
- 30 dB band pass filters
- Can place receivers on one antenna at a time

AU-520 (FLEX-8600 Platform)

- Two Spectral Capture Units (SCUs)
- Two UHF connectors for full-power TX/RX operation (500W), two RX-only antenna ports, and two transverter ports (max +10 dBm)
- Four internal receivers
- Can place receivers on either of two antennas simultaneously
- 7th Order competition-grade preselectors
- Contest band filters (> 50 dB rejection)
- True Diversity Reception
- SO2R Ready

3.2.2 Standard vs M Models

The “M” suffix indicates Maestro integration:

- **AU-510 / AU-520** - No built-in display; requires external client (SmartSDR Windows, Mac, or iOS)
- **AU-510M / AU-520M** - Includes 8” 1920×1200 IPS touchscreen with full Maestro front panel controls

3.3 Complete Specifications Comparison

Feature	AU-510	AU-510M	AU-520	AU-520M
Transmitter Power	1–500W HF, 1–200W 6m	1–500W HF, 1–200W 6m	1–500W HF, 1–200W 6m	1–500W HF, 1–200W 6m
Efficiency (Peak)	Up to 80%	Up to 80%	Up to 80%	Up to 80%
Spectral Capture Units (SCUs)	1	1	2	2
Slice Receivers / Panadapters	2 / 2	2 / 2	4 / 4	4 / 4
DAX IQ / Audio Channels	2 / 2	2 / 2	4 / 4	4 / 4
RX Antenna Ports	1	1	2	2
Transverter Ports (0 - +10dBm)	1	1	2	2
RMDR (1 kHz / 2 kHz)	110 / 115 dB	110 / 115 dB	110 / 115 dB	110 / 115 dB
Dynamic Range	> 145 dB	> 145 dB	> 155 dB	> 155 dB
Preselectors	3rd Order	3rd Order	7th Order	7th Order
Contest Band Filters	—	—	> 50 dB rejection	> 50 dB rejection
True Diversity Reception	—	—	Yes	Yes
Receive Frequency Coverage	30 kHz–54 MHz	30 kHz–54 MHz	30 kHz–54 MHz	30 kHz–54 MHz
Transmit Frequency Coverage	Amateur Bands, 160m–6m	Amateur Bands, 160m–6m	Amateur Bands, 160m–6m	Amateur Bands, 160m–6m
Spectrum Bandwidth (Max)	7 MHz	7 MHz	14 MHz	14 MHz
Spectrum Resolution (Max)	5.85 Hz/px	5.85 Hz/px	1.46 Hz/px	1.46 Hz/px
Full Duplex	Yes	Yes	Yes	Yes
Display	None	8” 1920×1200 IPS Touchscreen	None	8” 1920×1200 IPS Touchscreen
Maestro Front Panel	No	Yes	No	Yes
SmartSignal™ (Adaptive Predistortion)	Yes	Yes	Yes	Yes
CESSB (RF Compression)	Yes	Yes	Yes	Yes
MultiFlex (Dual Client Support)	Yes	Yes	Yes	Yes
Integrated Tuner	Yes	Yes	Yes	Yes
Integrated Power Supply	Yes	Yes	Yes	Yes
Remote Operation (SmartLink)	Yes	Yes	Yes	Yes

Feature	AU-510	AU-510M	AU-520	AU-520M
External Display Support (HDMI)	—	Yes	—	Yes
GNSS / GPSDO Support	Yes / Optional	Yes / Optional	Yes / Optional	Yes / Optional
SO2R Ready	—	—	Yes	Yes
Power Input	80–264VAC	80–264VAC	80–264VAC	80–264VAC
Dimensions (H × W × D)	6.74” × 14” × 13.25”	6.74” × 14” × 13.25”	6.74” × 14” × 13.25”	6.74” × 14” × 13.25”

3.4 Common Features Across All Models

All Aurora models include:

- **500W output** on HF bands (160-10m)
- **200W output** on 6 meters
- **SmartSignal™ (APD)** adaptive predistortion
- **Integrated ATU** rated for 3:1 SWR
- **Internal AC power supply** (80-264VAC auto-sensing)
- **SmartLink** remote operation capability
- **MultiFLEX** dual client support
- **Full SmartSDR compatibility**
- **Transverter support**

Chapter 4

Polar Modulation

4.1 Introduction to Polar Modulation

Polar modulation is a highly efficient signal transmission technique that separates a radio frequency (RF) signal into two fundamental components: amplitude (envelope) and phase (angle) components, allowing each to be amplified independently and more efficiently.

Unlike legacy linear amplification methods, which require power-hungry and heat-intensive amplifiers to preserve signal integrity, polar modulation can provide the drive needed for a high efficiency Class D amplifier.

Originally proposed in the 1950s by Leonard Kahn through his Envelope Elimination and Restoration (EER) technique, polar modulation has seen renewed interest with modern digital signal processing (DSP) capabilities.

It enables cleaner, smaller, and more energy-efficient transmitters than legacy linear amplifier designs.

4.2 How It Works

Traditional linear amplifiers process the complete RF signal (amplitude and phase combined) through a single amplification chain. This requires the amplifier to operate in a linear region, which is inherently inefficient.

Polar modulation takes a different approach:

1. **Signal Separation** - The RF signal is decomposed into its polar components:
   - **Envelope (Amplitude)** - The varying amplitude of the signal
   - **Phase (Angle)** - The instantaneous phase of the carrier
2. **Independent Processing** - Each component is processed separately:
   - The phase component drives a highly efficient switching amplifier
   - The envelope component modulates the power supply of the switching amplifier
3. **Recombination** - The original signal is reconstructed at the output by combining the phase-modulated carrier with the envelope modulation

4.3 The Polar Explorer Transmitter

Aurora uses FlexRadio's Polar Explorer transmitter technology. This transmitter is highly efficient because it replaces legacy linear amplification with switch-mode amplification—specifically Class D amplifiers—and leverages digital signal processing (DSP) to separate and handle the signal's envelope (amplitude) and phase components independently.

4.3.1 Key Advantages

- **High Efficiency** - Up to 80% efficiency compared to 40-60% for linear amplifiers

- **Reduced Heat** - 6x reduction in waste heat generation
- **Compact Size** - 500W capability in the footprint of a 100W linear amplifier
- **Lower Weight** - Complete 500W station weighs only 18 pounds

4.4 Why Can't Aurora Be Used as an External Amplifier?

A common question is whether the Aurora transmitter technology can be used with other radios. Unfortunately, it cannot.

The Polar Explorer technology that Aurora is built upon requires inputs not of low-level composite RF like a legacy amplifier, but of an RF carrier and an envelope waveform. No radios on the market output these components, expecting an external transmitter that uses polar modulation.

The Aurora transmitter must be tightly integrated with the host transceiver. Therefore, this technology is available only as a FlexRadio integrated transceiver.

4.5 Comparison: Polar Modulation vs Linear Amplification

Characteristic	Polar Modulation	Linear Amplification
Efficiency	Up to 80%	40-60% typical
Heat Generation	Low	High
Power Supply Requirements	Lower	Higher
Size/Weight	Compact	Large/Heavy
Complexity	High (digital processing)	Moderate
Integration	Requires tight integration	Standalone possible

4.6 Historical Background

The concept of polar modulation dates back to Leonard Kahn's work in the 1950s on Envelope Elimination and Restoration (EER). However, practical implementation was challenging with the analog technology of the era.

Modern digital signal processing has made polar modulation practical by enabling:

- Precise separation of envelope and phase components
- Real-time compensation for non-linearities
- Adaptive predistortion (SmartSignal™/APD)
- Tight timing synchronization between components

FlexRadio's implementation brings polar modulation to amateur radio for the first time in a production transceiver.

Chapter 5

SmartSignal™ (APD)

5.1 What is SmartSignal™?

SmartSignal™ is FlexRadio's implementation of Adaptive Predistortion (APD), a technology that ensures optimal transmit signal quality. It is included with all Aurora models and is essential for proper operation of the polar modulation transmitter.

5.2 SmartSignal™ and Aurora

SmartSignal™ is particularly important for Aurora's polar modulation architecture. Because the transmitter operates differently from traditional linear amplifiers, APD helps ensure:

- Optimal signal quality across all modes
- Proper handling of amplitude variations
- Compliance with spectral purity requirements

> **Warning**
>
> **APD Must Remain Enabled**
> APD should remain enabled at all times during normal Aurora operation. Disabling APD can result in degraded signal quality and is not recommended.

5.3 Configuration

In SmartSDR, the APD/SmartSignal™ controls are the same as for FLEX-8000 series radios. For Aurora:

- APD is permanently enabled for normal operation

5.4 Benefits of SmartSignal™

Benefit	Description
Improved Linearity	Reduces intermodulation distortion
Cleaner Signal	Minimizes splatter on adjacent frequencies
Consistent Performance	Maintains quality across temperature variations and antenna loading
Automatic Adaptation	No manual adjustment required

Chapter 6

System Block Diagram

6.1 Aurora Architecture Overview

Aurora combines the proven FLEX-8000 series receiver architecture with FlexRadio's Polar Explorer transmitter technology.

6.2 Block Diagram

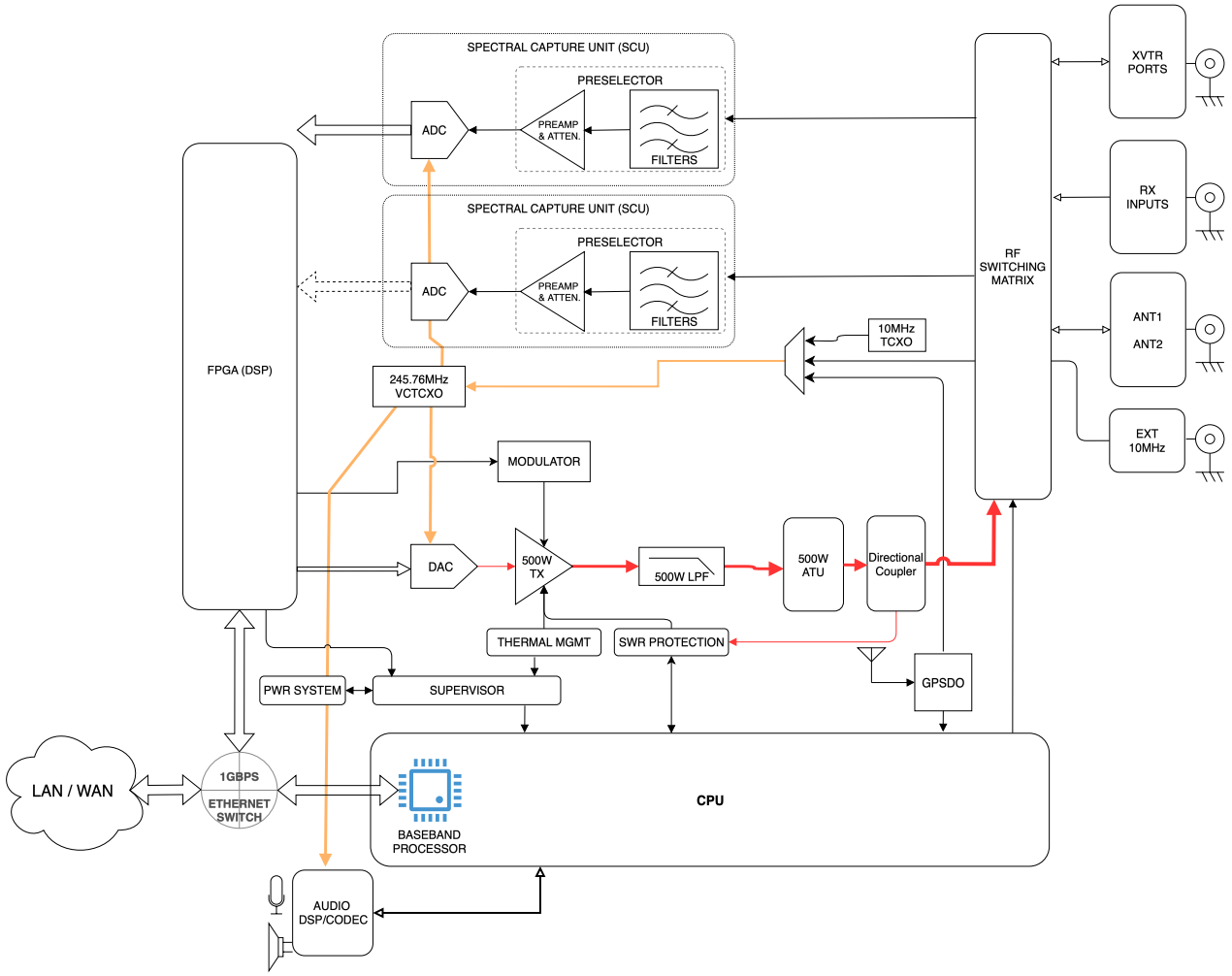

Figure 6.1: Aurora Block Diagram

6.3 Major Subsystems

6.3.1 Receiver Section

Aurora uses the same Spectral Capture Unit (SCU) technology as the FLEX-8000 series:

- **AU-510/AU-510M** - Single SCU (FLEX-8400 architecture)
- **AU-520/AU-520M** - Dual SCU (FLEX-8600 architecture)

Each SCU provides:

- Wide-band digital sampling
- Real-time spectrum processing
- Multiple independent slice receivers
- Panadapter/waterfall displays

6.3.2 Transmitter Section

The Polar Explorer transmitter includes:

- **Envelope/Phase Separator** - DSP-based decomposition of the modulated signal
- **Phase Path** - High-efficiency switching amplifier for the phase component
- **Envelope Modulator** - Controls PA supply voltage to restore amplitude
- **Output Stage** - Final amplification and filtering
- **SmartSignal™ (APD)** - Adaptive predistortion for linearity

6.3.3 Low-Pass Filter (LPF) Section

The LPF board provides:

- Band-specific harmonic filtering
- Forward/reverse power sensing
- Return loss detection
- SWR measurement

6.3.4 Automatic Antenna Tuner (ATU)

The integrated ATU provides:

- Automatic impedance matching
- 3:1 SWR matching capability
- L-network topology
- Fast tuning algorithm

6.3.5 Power Supply

The internal AC power supply features:

- Auto-sensing input (80-264 VAC)
- High-efficiency conversion
- Multiple regulated outputs
- Integrated protection circuits

6.4 Signal Flow

6.4.1 Transmit Path

1. Audio/digital input processed by DSP
2. Signal separated into envelope and phase components
3. Phase component amplified by switching PA
4. Envelope modulates PA supply voltage
5. Combined signal passes through LPF
6. ATU matches antenna impedance
7. RF output to antenna

6.4.2 Receive Path

1. Antenna signal through preselector
2. ADC digitizes RF directly
3. DSP extracts slice receiver bandwidth
4. Audio/data output to client

6.5 Protection Systems

Aurora includes multiple protection circuits:

Protection	Function
SWR Foldback	Reduces power above 1.7:1 SWR
SWR Fault	Stops TX above 2.5:1 SWR
Overcurrent	Protects PA from excessive current
Overtemperature	Thermal shutdown protection
Mod Fault	Monitors modulator health
Load Resistance	Detects improper load conditions
Return Loss	Fast hardware protection

Chapter 7

Specifications

7.1 General Specifications

Parameter	Specification
Receive Frequency Coverage	30 kHz – 54 MHz
Transmit Frequency Coverage	Amateur Bands, 160m–6m
Operating Modes	SSB, CW, AM, SAM, FM, RTTY, Digital
Dimensions (H × W × D)	6.74” × 14” × 13.25” (171 × 356 × 337 mm)
Weight	18 lbs (8 kg)
Power Input	80–264 VAC, 47-63 Hz (auto-sensing)
Power Factor	> 0.94

7.2 Transmitter Specifications

Parameter	Specification
Output Power (HF)	1–500 W (160m–10m)
Output Power (6m)	1–200 W
Efficiency	Up to 80% (peak)
Duty Cycle	ICAS (25-50%) rated
Output Impedance	50 Ω nominal
Harmonic Suppression	≤ -60 dBc
AM Output Power	125W HF, 50W 6m

7.3 SWR and Protection

Parameter	Specification
SWR Foldback Threshold	1.7:1
SWR Fault Threshold	2.5:1
ATU Matching Range	Up to 3:1 SWR

Parameter	Specification

7.4 Receiver Specifications

7.4.1 AU-510 / AU-510M

Parameter	Specification
Spectral Capture Units	1
Slice Receivers	2
Panadapters	2
RX Antenna Ports	1
Transverter Ports	1 (0 to +10 dBm)
Transverter IF Coverage	100 kHz – 54 MHz
ADC Resolution / Sample Rate	16-bit / 122.88 Msps
RMDR	110 dB (1 kHz), 115 dB (2 kHz)
Dynamic Range	> 145 dB
Preselectors	3rd Order
DAX IQ / Audio Channels	2 / 2

7.4.2 AU-520 / AU-520M

Parameter	Specification
Spectral Capture Units	2
Slice Receivers	4
Panadapters	4
RX Antenna Ports	2
Transverter Ports	2 (0 to +10 dBm)
Transverter IF Coverage	100 kHz – 54 MHz
ADC Resolution / Sample Rate	16-bit / 122.88 Msps
RMDR	110 dB (1 kHz), 115 dB (2 kHz)
Dynamic Range	> 155 dB
Preselectors	7th Order (Competition-grade)
Contest Band Filters	> 50 dB rejection
DAX IQ / Audio Channels	4 / 4
True Diversity Reception	Yes

7.5 Antenna Connections

7.5.1 AU-510 / AU-510M

Port	Function
ANT1	TX/RX (500W capable)
ANT2	TX/RX (500W capable)
RX1	RX only
XVTR	Transverter (0 to +10 dBm)

7.5.2 AU-520 / AU-520M

Port	Function
ANT1	TX/RX (500W capable)
ANT2	TX/RX (500W capable)
RX1	RX only
RX2	RX only
XVTR1	Transverter (0 to +10 dBm)
XVTR2	Transverter (0 to +10 dBm)

7.6 Spectrum / Waterfall Display

7.6.1 AU-510 / AU-510M

Parameter	Specification
Maximum Bandwidth	5 kHz – 7 MHz
Maximum Resolution	5.85 Hz/pixel

7.6.2 AU-520 / AU-520M

Parameter	Specification
Maximum Bandwidth	5 kHz – 14 MHz
Maximum Resolution	1.46 Hz/pixel

7.7 Display (M Models)

Parameter	Specification
Screen Size	8 inches
Resolution	1920 × 1200
Type	IPS Touchscreen
HDMI Output	Yes (M models only)

7.8 Environmental

Parameter	Specification
Operating Temperature	0°C to +50°C
Storage Temperature	-20°C to +70°C
Humidity	Up to 95% non-condensing

7.9 Features Summary

Feature	AU-510	AU-510M	AU-520	AU-520M
SmartSignal™ (APD)	Yes	Yes	Yes	Yes
CESSB	Yes	Yes	Yes	Yes
MultiFLEX	Yes	Yes	Yes	Yes
Integrated ATU	Yes	Yes	Yes	Yes
Internal PSU	Yes	Yes	Yes	Yes
SmartLink	Yes	Yes	Yes	Yes
GNSS Support	Yes	Yes	Yes	Yes
GPSDO	Optional	Optional	Optional	Optional
Full Duplex	Yes	Yes	Yes	Yes
SO2R Ready	No	No	Yes	Yes
Maestro Display	No	Yes	No	Yes

Chapter 8

Efficiency & Thermal Management

8.1 Understanding Efficiency

Aurora achieves approximately 80% transmitter efficiency, compared to 40-60% for traditional linear amplifiers.

8.1.1 The Math of Efficiency

Efficiency matters more than the percentage difference suggests. Consider these examples:

Traditional 100W Transmitter (40% efficient)

- Input power required: 100W ÷ 0.40 = 250W
- Heat generated: 250W - 100W = **150W of waste heat**

Aurora 100W Output (80% efficient)

- Input power required: 100W ÷ 0.80 = 125W
- Heat generated: 125W - 100W = **25W of waste heat**

The 80% efficient transmitter generates only **17% of the heat** of the 40% efficient amplifier—a **6x reduction** in heat generation.

This lower heat output allows a 500W transmitter to fit in the space of a traditional 100W linear amplifier.

8.1.2 Full Power Comparison

Configuration	Output	Efficiency	Input Power	Heat Generated
Traditional 100W radio	100W	40%	250W	150W
Traditional 100W + 500W amp	500W	40%	1,250W	750W
Aurora	**500W**	**80%**	**625W**	**125W**

Aurora generates only 125W of heat to produce 500W of output—compared to 750W+ of heat from a traditional configuration.

8.2 Thermal Management

8.2.1 Reduced Cooling Requirements

With less heat being generated, Aurora's cooling requirements are reduced compared to traditional high-power transmitters:

- Smaller internal heat sink
- Quieter cooling fans
- No external cooling required

The radio includes active cooling with variable-speed fans.

8.2.2 Shack Environment

Less waste heat means your shack stays cooler. This is especially important for:

- Smaller or poorly ventilated rooms
- Summer operation
- Portable/field operations
- Reduced air conditioning costs

8.2.3 Operating Temperature

Condition	Specification
Normal heatsink temperature	< 35°C
Temperature fault threshold	70°C heatsink

8.2.4 Temperature Monitoring

Aurora provides PA temperature monitoring through SmartSDR:

- Real-time temperature display in the Aurora panel
- Automatic power reduction if temperature rises
- Thermal fault protection prevents damage

8.3 Digital Mode Operation

Aurora is rated for Intermittent Commercial and Amateur Service (ICAS) at 50% duty cycle. At 50% duty cycle, full power FT8, RTTY, and other digital modes are supported. We recommend not exceeding 5 minutes continuous key-down at full power.

- Monitor temperature and follow duty-cycle recommendations for optimal lifespan

> **Tip**
>
> **Digital Mode Best Practices**
> While Aurora can handle sustained digital mode operation, monitoring PA temperature during extended high-duty-cycle sessions is recommended. The SmartSDR Aurora panel provides real-time temperature readings.

8.4 Power Savings

The efficiency advantages translate directly to operating cost savings:

Scenario	Traditional 500W	Aurora 500W	Savings
Input power (full output)	~1,250W	~625W	50%
Heat to dissipate	~750W	~125W	83%
Generator fuel consumption	Baseline	50% less	50%
Solar panel requirements	Baseline	50% less	50%

For portable operators using generators or solar power, Aurora's efficiency can cut fuel consumption or panel requirements in half while still delivering full 500W output.

Chapter 9

Feature Overview

9.1 SmartLink Remote Operation

Aurora models are built on the same remote platform as all FLEX-8000 radios. SmartLink enables full remote operation over the internet:

- Operate your Aurora from anywhere with internet access
- Same experience as local operation
- Secure connection through FlexRadio's SmartLink servers
- Compatible with SmartSDR for Windows, Mac, and iOS

9.2 MultiFLEX Dual Client Support

All Aurora radios support MultiFLEX, allowing two operators to use the radio simultaneously:

- Two independent clients can connect
- Each operator gets their own slice receivers
- Shared access to transmitter
- Ideal for contesting or training

9.3 SmartSignal™ (Adaptive Predistortion)

SmartSignal™ is included with all Aurora models and ensures optimal transmit signal quality:

- Continuous monitoring and correction
- Maintains spectral purity
- Essential for polar modulation architecture
- Always enabled during normal operation

9.4 CESSB (RF Compression)

Controlled Envelope Single Sideband (CESSB) provides increased talk power without the drawbacks of traditional speech processing:

- Up to 3 dB effective power increase
- Maintains clean signal
- Works with SmartSignal™ for optimal results

9.5 Integrated Automatic Tuner

All Aurora models include a built-in ATU:

- Matches loads up to 3:1 SWR
- Fast tuning algorithm
- Full power rated
- Memory for previously tuned frequencies

9.6 Transverter Support

Aurora supports transverters for operation on bands beyond HF/6m:

Model	Transverter Ports	Output Level
AU-510/510M	1	0 to +10 dBm
AU-520/520M	2	0 to +10 dBm

Transverters attach to the XVTR ports in the same fashion as FLEX-6000 and FLEX-8000 series radios.

9.7 GNSS and GPSDO Support

All Aurora models support GNSS (Global Navigation Satellite System):

- GPS timing reference
- Optional GPSDO (GPS Disciplined Oscillator) for frequency accuracy
- Automatic time synchronization

9.8 Full Duplex Operation

Aurora supports full duplex (FDX) mode for:

- Satellite operation
- Transverter applications
- Simultaneous TX and RX on different frequencies

9.9 Network Features

Feature	Description
Gigabit Ethernet	High-speed network connection
SmartLink	Remote operation over internet
MultiFLEX	Dual client support
API Access	Full FlexRadio API support

9.10 Audio Features

Feature	Description
DAX	Used for computer-driven messages and digital operation
Multiple TX profiles	Save and recall microphone settings
Built-in EQ	Transmit and receive equalization
VOX	Voice-operated transmit

9.11 M Model Exclusive Features

The AU-510M and AU-520M add:

Feature	Description
8” Touchscreen	1920×1200 IPS display
Maestro Controls	Full front panel knobs and buttons
HDMI Output	Connect external display
Standalone Operation	No external client required
Aurora Boot Screen	Custom startup display

9.12 SO2R Capability (AU-520/520M)

The dual-SCU AU-520 models are SO2R (Single Operator, Two Radios) ready:

- Operate two independent receivers simultaneously
- Competition-grade preselectors
- Four slice receivers
- Full contest capability

9.13 What Aurora Does NOT Support

For clarity, Aurora has the following limitations:

Feature	Status	Reason
DC power input	Not supported	Requires AC (80-264V)
External amplifier	Not recommended	500W output would damage most amps
MARS/SHARES	Transmit not supported	Transmit limited to amateur bands
Trade-in program	Not available	At this time

Chapter 10

Power Requirements

10.1 AC Power Input

Aurora includes an internal auto-sensing AC power supply that accepts a wide range of input voltages:

Parameter	Specification
Input Voltage Range	80–264 VAC
Input Frequency	47-63 Hz
Power Factor	> 0.94
Connector	IEC C14
Maximum Power Consumption	~700W at full output

The power supply automatically senses the input voltage—no manual switching required. This means Aurora can operate on:

- 120V outlets (North America, Japan)
- 230V outlets (Europe, Australia, most of world)
- Generator power (as long as it's within voltage range)

> **Note**
>
> **Full Power on 120V**
> Unlike some high-power equipment that requires 240V for full output, Aurora can deliver its full 500W on any voltage within the 80-264V range. Operators with only 120VAC line voltage can still achieve 100% of maximum output.

10.2 No DC Operation

> **Warning**
>
> **DC Power Not Supported**
> Aurora **cannot** operate from 13.8V DC or any other DC voltage. You must use 80-264 VAC as the supply voltage.

This is because Aurora's internal power supply is specifically designed for AC input to power the polar modulation transmitter architecture.

10.3 Master Power Switch

The AC power connector on the rear panel includes an integrated master power switch. This switch **must be turned on** before the radio will boot.

10.4 Power Consumption

Operating Mode	Approximate Power Consumption
Standby	~50W
Receive	~75W
Transmit (100W output)	~175W
Transmit (500W output)	~700W

10.5 Comparison to Traditional Configurations

Aurora's efficiency provides significant power savings compared to traditional radio + amplifier configurations:

Configuration	Power Required for 500W Output
Traditional 100W radio + external 500W amp	1,250–1,500W
Aurora	**~700W**

This represents a **50%+ reduction** in power consumption.

10.6 Portable and Off-Grid Operation

For portable operations using generators or solar power:

10.6.1 Generator Requirements

- Minimum recommended capacity: 1,000W (for full power operation)
- Smaller generators can be used at reduced power output
- Clean sine wave output recommended

10.6.2 Solar Power

Aurora can operate from an inverter connected to a battery/solar system:

- Pure sine wave inverter required
- Minimum 1,000W inverter for full power
- Monitor battery capacity for sustained operation

> **Tip**
>
> **Fuel Savings**
> Because Aurora requires only ~700W for 500W output (compared to ~1,500W for traditional setups), generator fuel consumption can be reduced by more than 50%.

10.7 Electrical Safety

- Use a properly grounded AC outlet
- The IEC power cord should be rated for the expected current
- Ensure adequate circuit capacity (15A minimum on 120V)
- Consider a surge protector or UPS for sensitive electronics protection

10.8 Power-Up Sequence

1. Connect IEC power cable to Aurora and wall outlet
2. Turn on the master power switch (rear panel)
3. Press the front panel power button
4. Aurora will boot automatically
5. Wait for SmartSDR connection to complete
6. Radio is ready for operation

Chapter 11

SWR Management

11.1 Aurora's SWR Sensitivity

Aurora is more sensitive to SWR and manages it differently from other FlexRadio models. The polar modulation transmitter architecture requires tighter impedance control than traditional linear amplifiers.

11.2 SWR Thresholds

SWR Level	Behavior
< 1.7:1	Full power operation
1.7:1 - 2.5:1	Automatic power foldback (reduced output)
> 2.5:1	Transmission stops, fault condition set

11.2.1 SWR Foldback

When SWR exceeds 1.7:1, Aurora automatically reduces output power to protect the transmitter. This is called "SWR foldback."

- Foldback is automatic and immediate
- Output power decreases as SWR increases
- Full power resumes when SWR returns below threshold
- No operator intervention required

11.2.2 SWR Fault

If SWR exceeds 2.5:1, Aurora will:

1. Immediately stop transmission
2. Set a PA fault condition
3. Report the fault to SmartSDR

Fault automatically clears when SWR returns to acceptable level; no operator action required.

11.3 Why Aurora is More Sensitive

Traditional linear amplifiers can tolerate higher SWR with graceful degradation. Aurora's polar modulation architecture has different requirements:

- The modulator output impedance is optimized for 50Ω

- Impedance mismatches affect both efficiency and linearity
- Protection circuits are more aggressive to prevent damage

11.4 Using the Internal ATU

The internal ATU is your first line of defense against SWR issues:

- Rated for matching loads up to 3:1 SWR
- Should be engaged for any non-resonant antenna
- Provides impedance transformation to present 50Ω to the transmitter

> **Tip**
>
> **ATU Best Practice**
> Enable the ATU whenever operating with antennas that are not precisely resonant on the operating frequency.

11.4.1 ATU Limitations

While the ATU can tune higher SWR loads, it is only rated for full power up to 3:1 SWR:

Antenna SWR	ATU Status	Power Rating
< 3:1	Tuned	Full power (500W)
> 3:1	May tune	Reduce power

When operating above 3:1 SWR, reduce output power to prevent faults or damage.

11.5 Best Practices

11.5.1 Before Operating

1. **Check antenna SWR** at reduced power before going to full power
2. **Enable the ATU** if SWR is above 1.5:1
3. **Tune the ATU** on each band before operating

11.5.2 During Operation

1. **Monitor SWR** in SmartSDR
2. **Reduce power** if SWR rises unexpectedly
3. **Investigate** any sudden SWR changes (may indicate antenna problem)

11.5.3 Troubleshooting High SWR

Symptom	Possible Cause	Solution
High SWR on all bands	Feedline problem	Check coax connections and cable

Symptom	Possible Cause	Solution
High SWR on one band	Antenna not resonant	Use ATU or adjust antenna
SWR changes during TX	Arcing or loose connection	Inspect antenna system
Sudden SWR increase	Weather, antenna damage	Investigate physical antenna

11.6 SWR Display in SmartSDR

SmartSDR displays SWR in the Aurora panel:

- Scale shows SWR values
- Red above 1.7:1 indicating foldback region
- Real-time updates during transmission

Chapter 12

ATU Operation

12.1 Internal ATU Overview

All Aurora models include an integrated Automatic Antenna Tuner (ATU). The ATU matches antenna impedances up to 3:1 SWR to present an optimal 50Ω load to the transmitter.

12.2 ATU Specifications

Parameter	Specification
Matching Range	Up to 3:1 SWR
Power Rating	500W (at matched SWR)
Topology	L-network
Memory	Stores tuned frequencies

12.3 When to Use the ATU

Enable the ATU when:

- Operating with non-resonant antennas
- Band edges where SWR may be higher
- Using multi-band antennas
- Antenna SWR exceeds 1.5:1

The core Aurora technology is more sensitive to impedance mismatches than a linear amplifier. As a result, use of the integrated tuner will be required for any non-resonant antennas.

12.4 ATU Operation in SmartSDR

12.4.1 Enabling the ATU

1. Click the **ATU** button in SmartSDR
2. The ATU will engage

12.4.2 Tuning Process

1. Select your operating frequency
2. Click **TUNE** to initiate tuning

3. ATU transmits a low-power carrier
4. Tuning completes automatically
5. Memory stores the tuned settings

12.4.3 ATU Memory

The ATU remembers tuned settings for each frequency/antenna combination:

- Fast recall when returning to a frequency
- No re-tuning required for memorized frequencies

12.5 Power Limitations

The ATU is rated for full power up to 3:1 SWR. For higher SWR loads:

Antenna SWR	Recommendation
Up to 3:1	Full power with ATU
3:1 to 5:1	May tune, reduce power
Above 5:1	ATU may not match, use external tuner

> **Warning**
>
> **High SWR Operation**
> When operating above 3:1 SWR, reduce output power to prevent faults or damage, even if the ATU successfully tunes.

12.6 Using an External Tuner

An external ATU can be used instead of or in addition to the internal ATU:

12.6.1 Requirements

- External tuner must handle at least 500W
- Use high-quality, properly rated components
- Ensure proper grounding

12.6.2 Configuration

When using an external tuner, set the **TUNE Power slider to 3% or less**:

- This disables internal fault limits
- Allows the external tuner to complete its tuning process
- Setting TUNE Power to 4% or higher can cause faults during tuning

> **Note**
>
> **Why Low Tune Power?**
> At low power levels (3% or below), Aurora disables certain protection circuits that would otherwise fault during the tuning process when SWR temporarily exceeds normal limits.

12.6.3 Tuning Procedure with External Tuner

1. Set TUNE Power to 3% or less
2. Reduce RF Power to minimum
3. Disable the internal ATU by pressing ATU and/or MEM so they are grey (inactive)
4. Initiate tune on external tuner
5. Allow external tuner to complete matching
6. Return TUNE Power to normal setting
7. Gradually increase RF Power

> **Warning**
>
> **External Tuner Auto-Tuning**
> Make sure the external tuner is prevented (by internal settings) from automatically tuning at high power levels, which may damage the tuner.

12.7 Internal vs External Tuner Comparison

Feature	Internal ATU	External ATU
Convenience	Integrated, automatic	Requires manual setup
Matching Range	Up to 3:1	Varies by model (typically higher)
Power Rating	500W	Varies by model
Loss	Minimal	Depends on tuner quality
Cost	Included	Additional purchase

12.8 Troubleshooting ATU Issues

Issue	Possible Cause	Solution
ATU won't tune	SWR too high	Check antenna, try external tuner
ATU tunes slowly	Marginal SWR	Verify antenna system
Fault during tune	TUNE Power too high	Reduce TUNE Power to 3% or less
Poor match after tune	ATU at limits	Reduce power or use external tuner

12.9 ATU and Antenna Selection

The ATU works with the antenna selection system:

- Select the appropriate TX antenna port
- ATU memory is per-antenna
- Different antennas may have different stored tuning solutions

Chapter 13

Digital Modes

13.1 Digital Mode Compatibility

Aurora is fully compatible with digital modes including:

- FT8 / FT4
- RTTY
- PSK31 / PSK63
- JS8Call
- WSPR
- SSTV
- Other digital modes

13.2 Duty Cycle Considerations

Aurora transceivers are rated for Intermittent Commercial and Amateur Service (ICAS), which is 25-50% duty cycle. Digital modes vary significantly in their duty cycle requirements:

Mode	Typical Duty Cycle	Notes
FT8	50%	15-second TX cycles
FT4	50%	7.5-second TX cycles
RTTY	100% during TX	Continuous carrier
PSK31	Variable	Depends on typing speed
WSPR	Low	2-minute TX every 10+ minutes

13.3 Maximum Power for Digital Modes

For normal digital mode operation:

Condition	Recommended Power
FT8/FT4 casual operation	Up to 500W
Extended FT8 contesting	Monitor temperature, reduce if needed
RTTY contesting	Monitor temperature, may need reduced power
WSPR	Low power by design

13.4 Thermal Considerations

During sustained digital mode operation:

1. **Monitor PA temperature** in the SmartSDR Aurora panel
2. **Allow cooling** between long transmit periods if temperature rises
3. **Reduce power** if temperature approaches limits

> **Tip**
>
> **Temperature Monitoring**
> The Aurora panel in SmartSDR displays real-time PA temperature. Normal operating temperature is below 35°C. The thermal fault threshold is 70°C.

13.5 Audio Configuration

For digital modes, configure your audio routing:

13.5.1 DAX (Digital Audio Exchange)

Use DAX for routing audio between Aurora and digital mode software:

1. Enable DAX in SmartSDR
2. Configure your digital mode software to use DAX audio devices
3. Set appropriate audio levels

13.5.2 TX Audio Levels

- Start with low drive levels
- Monitor ALC to ensure it's not compressing — if the ALC meter is deflecting, the audio input level is too high and the radio is reducing gain to protect the transmitter, which degrades signal quality
- Increase gradually to desired power output
- Watch for over-driving (flat-topped signals)

13.6 SmartSignal™ and Digital Modes

SmartSignal™ (APD) remains important for digital modes:

- Ensures clean transmitted signal
- Reduces IMD products
- Maintains spectral purity
- Should always remain enabled

13.7 PTT and Timing

For digital modes, configure PTT appropriately:

Method	Use Case
VOX	Simple setup, may have timing issues

Method	Use Case
CAT PTT	Precise timing control
Hardware PTT	Most reliable for high-speed modes

13.7.1 PTT Delay Considerations

Some digital modes (like FT8) are timing-sensitive:

- Ensure PTT lead time is sufficient for Aurora to key up
- Account for any CAT command latency
- Test timing before operating

13.8 RTTY-Specific Notes

RTTY is a 100% duty cycle mode during transmission:

- Aurora can handle extended RTTY operation
- Monitor temperature during contests
- Consider reduced power for multi-hour sessions
- Ensure adequate cooling around the radio

13.9 Best Practices

1. **Start at reduced power** until you verify proper operation
2. **Monitor temperature** during extended operation
3. **Use proper audio levels** to avoid over-driving
4. **Keep APD enabled** for optimal signal quality
5. **Verify SWR** before digital mode operation
6. **Use the ATU** if needed for your antenna

13.10 Comparison to Traditional 500W Stations

A traditional 100W radio + 500W amplifier combination generates significantly more heat during digital mode operation. Aurora's 80% efficiency means:

- Less heat generation for the same output power
- More sustainable high-duty-cycle operation
- Reduced cooling requirements
- Lower power consumption

Chapter 14

SmartSDR GUI Changes for Aurora

14.1 Overview

SmartSDR includes Aurora-specific interface changes to display transmitter status and provide control over Aurora-unique features. The integration is similar to that used for the PGXL amplifier, adapted for Aurora's polar modulation architecture.

14.2 Aurora Status Panel

A permanent panel is added at the top of the control panels when connected to an Aurora radio. This panel includes:

14.2.1 Aurora Logo

A stylized Aurora logo appears at the top of the panel for easy identification.

14.2.2 Meters Display

The panel displays four meters:

Meter	Scale	Notes
RF Power	0-600W	Blue to 500W, red 500-600W
SWR	Standard scale	Red above 2.0:1
Efficiency	0-100%	All blue scale
PA Temperature	30-100°C	Red at high end

14.2.3 Meter Visibility Options

The Efficiency and PA Temperature meters can be optionally hidden or displayed through the Settings menu.

14.3 Panel Controls

14.3.1 AU Button

The Aurora-specific widget can be toggled on/off with the "AU" button in the top bar of the TX panel.

14.4 Radio Identification

14.4.1 Bottom Bar

The radio model number appears appended to the software version number on the bottom bar, in the same font as the version number.

14.4.2 Settings Menu and Radio Chooser

Images in the Settings menu and radio chooser dialogs are updated to show the Aurora models:

- AU-510
- AU-510M
- AU-520
- AU-520M

14.5 APD Integration

SmartSignal™ (APD) integration is the same as for FLEX-8000 radios, with one important difference:

- For normal Aurora operation, APD controls are disabled (permanently set to ON)

> **Note**
>
> **APD Always On**
> APD is essential for Aurora's polar modulation architecture. The GUI disables the ability to turn it off during normal operation.

14.6 Amplifier Tab

Because the PGXL external amplifier is not compatible with Aurora (and not recommended), the AMP tab does not appear when connected to an Aurora radio.

14.7 M Model Boot Screen

Aurora M-model radios (AU-510M, AU-520M) display an Aurora-specific boot screen during startup.

14.8 New Meters

Aurora provides additional meter data not available on other FlexRadio models:

Meter	API Name	Description
PA Fault Status	PASTAT	PA high voltage fault status bits
PA Efficiency	PAEFF	Real-time transmitter efficiency (%)
PA Temperature	PATEMP	PA temperature in °C

These meters are accessible through the SmartSDR interface and API.

14.9 Configurable Power Level

The GUI reflects Aurora's 500W capability:

- Power slider ranges from 0–100%, representing percent of maximum power for the band (500W HF / 200W 6m)
- Power meters scale appropriately
- Settings reflect the higher power capability

14.10 SWR Display

SWR display reflects Aurora's tighter SWR requirements:

- Visual indication changes at Aurora-specific thresholds
- Color coding alerts operator to potential issues
- Real-time feedback during transmission

14.11 Settings Changes

Aurora-specific settings include:

- ATU configuration
- Tune power settings
- Temperature display options
- Aurora panel visibility

14.12 Firmware Requirements

Aurora GUI features require SmartSDR version 4.x or later with Aurora support enabled. Ensure your SmartSDR installation is up to date when operating Aurora radios.

Chapter 15

API Extensions for Aurora

15.1 Overview

The FlexRadio API has been extended to support Aurora radios. This document describes the changes and additions for developers and integrators.

15.2 New Radio Models

Aurora radios report the following new model values in discovery packets:

- `AURORA-510`
- `AURORA-520`
- `AURORA-510M`
- `AURORA-520M`

15.2.1 Discovery Packet Example

```
discovery_protocol_version=...
    model=<AURORA-510|AURORA-510M|AURORA-520|AURORA-520M> ...
```

Clients should recognize these model strings to enable Aurora-specific features.

15.3 New Meters

When the client subscribes to meters with `sub meter all`, two new meter quantities are provided for Aurora radios:

Meter	API Name	Description	Range	Units
PA Fault Status	PASTAT	PA high voltage fault status	0-256	bits
PA Efficiency	PAEFF	Transmitter efficiency	0-100	%

Additionally, PA Temperature (PATEMP) is now displayed with a dedicated visual meter on the Aurora panel (it was previously available but not prominently displayed on 8000 series).

15.3.1 Meter Status Examples

```
S7119F096|meter 7.src=RAD#7.num=7#7.nam=PASTAT#7.low=0.0#7.hi=256.0
    #7.desc=PA HV Fault Status#7.unit=bits#7.fps=10#
S7119F096|meter 8.src=TX-#8.num=6#8.nam=PAEFF#8.low=0.0#8.hi=100.0
    #8.desc=PA Efficiency#8.unit=dBm#8.fps=10#
S7119F096|meter 12.src=TX-#12.num=4#12.nam=PATEMP#12.low=0.0#12.hi=120.0
    #12.desc=PA Temperature#12.unit=degC#12.fps=0#
```

15.4 PA Fault Status Bits

The PASTAT meter provides fault status as a bit field:

Bit	Value	Fault Type	Description
0	0x01	Overcurrent	PA overcurrent detected
1	0x02	Load Resistance	Low load resistance fault
2	0x04	SWR	High SWR fault
3	0x08	Temperature	Thermal fault
4	0x10	Mod	Modulator fault
5	0x20	Return Loss	Hardware return loss fault
6	0x40	Load R (HW)	Hardware load resistance fault
7	0x80	Reserved	—

Multiple faults can occur simultaneously, resulting in multiple bits being set.

15.5 Configurable Power Level

Aurora radios report the internal PA power level in radio updates if the power level differs from the default 100W:

- Power meter scales update to reflect 500W (HF) or 200W (6m) capability
- Clients should scale power meter displays appropriately

15.6 External Amplifier Status

Aurora radios indicate that external amplifiers should not be used:

- PGXL amplifier integration is disabled
- AMP-related API features are not applicable
- Clients should not display amplifier controls

15.7 SWR Thresholds

Aurora uses different SWR thresholds than other FlexRadio models:

Threshold	Value	API Behavior
Foldback	1.7:1	Power reduction begins
Fault	2.5:1	TX stops, fault reported

Clients may wish to adjust SWR display color coding to reflect these thresholds.

15.8 APD Control

For Aurora radios:

- APD (SmartSignal™) should always be enabled
- Normal operation disables APD control (locked to ON)

15.9 API Compatibility

Aurora radios use the same API version as FLEX-8000 series with the extensions described above. Existing API integrations should:

1. Recognize new model strings
2. Handle new meter types
3. Adjust power and SWR scaling
4. Disable PGXL/amplifier features for Aurora models

15.10 Version Requirements

Aurora API extensions require:

- SmartSDR v4.x or later
- API protocol version supporting Aurora extensions

15.11 Developer Resources

For complete API documentation, refer to the FlexRadio API Documentation. The Aurora extensions build on the established API framework used by all FLEX-6000 and FLEX-8000 series radios.

Chapter 16

PA Faults

16.1 Introduction

Aurora includes comprehensive fault protection for the Overlord PA (Polar Explorer transmitter). This document describes each fault type, its causes, and troubleshooting approaches.

16.2 Fault Overview

There are six fault conditions detected by hardware or firmware in the Aurora PA. When any fault is detected, the PA enters a safe state:

1. **HV Disconnect** - Relay K6 opens, disconnecting high voltage from the modulator
2. **Modulator Clamp** - Modulator input forced to zero, output clamped to ground

16.3 Fault Status Bits

Faults are reported as a bit field in the PASTAT meter:

Bit	Code	Fault Type	Detection	Can Disable?
0	0x01	Overcurrent	Hardware	No
1	0x02	Load Resistance	Firmware	No (qualified)
2	0x04	SWR	Firmware	No (qualified)
3	0x08	Temperature	Firmware	No
4	0x10	Mod	Hardware	No
5	0x20	Return Loss	Hardware	Yes
6	0x40	Load R (HW)	Hardware	Yes

Multiple faults can occur simultaneously, resulting in multiple bits set (e.g., 0x24 = SWR + Return Loss faults).

16.4 Firmware-Detected Faults

Firmware faults are evaluated at 1 ms intervals (1000 times per second).

16.4.1 Load Resistance Fault (0x02)

Trigger Condition: Load resistance (Rload) drops below 4 ohms.

Calculation: Rload = Vpa / Ipa (PA voltage divided by PA current)

> **Note**
>
> **Internal Measurement**
> This refers to an internal load resistance measurement (Vpa/Ipa), not the antenna load resistance.

Normal Range:

- HF: 6–13.3Ω
- 6m: 10–25Ω

Qualification: Ignored when PA voltage (Vpa) < 20V, allowing tuner operations.

Causes:

- Improper load connected to PA output
- Hardware defects on the PA board
- Damaged components

16.4.2 SWR Fault (0x04)

Trigger Condition: SWR exceeds 2.5:1

Calculation: SWR computed from Return Loss value reported by LPF board.

Qualification: Ignored when PA voltage (Vpa) < 20V, allowing tuner operations.

Causes:

- Improper RF load at LPF output
- Antenna system problems
- ATU issues (if present)
- Cabling problems

Troubleshooting:

- Check antenna connections
- Verify coax cable integrity
- Inspect ATU if connected
- Check Return Loss and SWR values in monitoring

16.4.3 Temperature Fault (0x08)

Trigger Condition: Heatsink temperature > 70°C

Recovery: Wait for PA to cool down. No software clear available.

Causes:

- Extended high-duty-cycle operation
- Inadequate ventilation
- Ambient temperature too high
- Poor thermal contact (manufacturing defect)

16.5 Hardware-Detected Faults

Hardware faults trigger immediate protection in microseconds.

16.5.1 Overcurrent Fault (0x01)

Trigger Condition: Modulator current exceeds 12.5A

Detection: Hardware latch (U20) triggers safe state immediately.

Cannot be disabled.

Causes:

- Rload too low for commanded PA voltage
- Damaged PA FETs (Q1, Q2)

Troubleshooting:

- If fault persists during normal operation, FET damage should be suspected

16.5.2 Mod Fault (0x10)

Trigger Condition: Modulator switching devices (Q101, Q102) output a fault.

Possible causes within switching devices:

- Overcurrent
- Overtemperature
- Low supply voltage

Cannot be disabled.

Common Cause: Both Q101 and Q102 turned on simultaneously, shorting HV supply. This should not occur during normal operation but can happen if proper power-up sequence is not followed.

Recovery: Power cycle required.

16.5.3 Return Loss Fault (0x20)

Trigger Condition: Return loss < 7.35 dB (hardware fast detection)

Normal Range: > 11.73 dB

Qualification: PA voltage > 21V AND Forward power > 5W

Can be disabled for tuner operations.

Response Time: < 5 microseconds

Causes: Same as SWR fault (antenna/load problems)

16.5.4 Hardware Load R Fault (0x40)

Trigger Condition: Load resistance < 4 ohms (hardware detection)

Qualification: PA voltage > 21V

Can be disabled for tuner operations.

Response Time: Immediate hardware protection

Causes: Same as firmware Load Resistance fault

16.6 Fault Summary Table

Fault	Normal	Threshold	Qualifier
Overcurrent	< 12.5A	> 12.5A	None
Load R (FW)	6–13.3Ω (HF), 10–25Ω (6m)	< 4Ω	Vpa > 20V
SWR	< 1.7	> 2.5	Vpa > 20V
Temperature	Heatsink < 35°C	Heatsink > 70°C	None
Mod	See datasheet	See datasheet	None
Return Loss (HW)	> 11.73 dB	< 7.35 dB	Vpa > 21V AND Pfwd > 5W
Load R (HW)	6–13.3Ω (HF), 10–25Ω (6m)	< 4Ω	Vpa > 21V

16.7 Fault Recovery

When a fault occurs:

1. PA enters safe state automatically
2. Fault is reported to CPU with status bits
3. CPU displays fault information in SmartSDR
4. User must identify and clear the cause of the fault before resuming operation
5. CPU commands OLPA to re-enable high voltage

Most faults auto-clear once the underlying cause is resolved (e.g., SWR returns to acceptable levels, temperature drops below threshold). The Mod fault (0x10) is an exception — it requires a power cycle to recover.

16.8 Tuner Operations

During tuner operations, some faults are disabled to allow impedance matching:

- Set TUNE Power to 3% or less
- This disables fault limits that would trigger during tuning
- SWR and Load R faults are ignored when Vpa < 20V

> **Warning**
>
> **TUNE Power Setting**
> Setting TUNE Power to 4% or higher can cause faults during tuning operations.

Chapter 17

Troubleshooting

17.1 Common Issues and Solutions

17.1.1 Power and Startup Issues

Symptom	Possible Cause	Solution
Radio won't power on	Master switch off	Turn on rear panel master switch
Radio won't power on	AC power issue	Verify AC outlet has power
Radio won't power on	Power cord issue	Check IEC cable connection
No network connection	Ethernet cable	Verify cable is connected and link lights active

17.1.2 SWR-Related Issues

Symptom	Possible Cause	Solution
High SWR on all bands	Feedline problem	Check coax connections and cable condition
High SWR on one band	Antenna not resonant	Use ATU or adjust antenna
SWR fault during operation	Antenna system issue	Check connections, reduce power, investigate antenna
SWR foldback (reduced power)	SWR > 1.7:1	Enable ATU or improve antenna match
Can't transmit, SWR fault	SWR > 2.5:1	Resolve antenna issue before operating

17.1.3 Tuner Issues

Symptom	Possible Cause	Solution
ATU won't tune	SWR too high	Check antenna, may need external tuner
Fault during tuning	TUNE Power too high	Set TUNE Power to 3% or less

Symptom	Possible Cause	Solution
External tuner causes faults	TUNE Power too high	Reduce TUNE Power for external tuner use
Poor match after ATU tune	At ATU limits	Reduce power or use external tuner

17.1.4 Temperature Issues

Symptom	Possible Cause	Solution
Temperature fault	Overheating	Ensure adequate ventilation, reduce duty cycle
Temperature rising quickly	High duty cycle	Allow cooling between transmissions
Temperature rising quickly	Blocked ventilation	Check for obstructions around radio
High idle temperature	Ambient temperature	Ensure room is adequately cooled

17.1.5 Transmit Issues

Symptom	Possible Cause	Solution
No RF output	TX antenna not selected	Verify TX antenna selection in SmartSDR
Low output power	SWR foldback active	Check and improve antenna SWR
Low output power	Power slider low	Verify power setting in SmartSDR
PA fault during TX	Multiple possible	Check PASTAT bits for specific fault
Poor audio reports	RF feedback	Check for RF feedback; ensure proper grounding and cable routing

17.1.6 Digital Mode Issues

Symptom	Possible Cause	Solution
Over-driven signal	Audio levels too high	Reduce DAX/audio input levels
Timing errors (FT8)	PTT delay	Adjust PTT lead time in software
Faults during digital	Temperature	Monitor temp, reduce power or duty cycle

17.2 PA Fault Troubleshooting

When a PA fault occurs, check the PASTAT bits to identify the specific fault:

Code	Fault	First Steps
0x01	Overcurrent	Check for short circuit, may indicate PA damage
0x02	Load Resistance	Check antenna and feedline
0x04	SWR	Verify antenna match, use ATU
0x08	Temperature	Allow cooling, improve ventilation
0x10	Mod	Power cycle radio, contact support if persistent
0x20	Return Loss	Check antenna system
0x40	Load R (HW)	Check antenna system

See PA Faults for detailed fault information.

17.3 SmartSDR Connection Issues

Symptom	Possible Cause	Solution
Radio not discovered	Network issue	Verify radio and PC on same network
Radio not discovered	Firewall blocking	Configure firewall for SmartSDR
Connection drops	Network instability	Check Ethernet cables and switches
SmartLink won't connect	Account issue	Verify SmartLink registration

17.4 When to Contact Support

Contact FlexRadio support if:

- PA faults persist after troubleshooting
- Mod fault occurs repeatedly
- Temperature faults occur under normal conditions
- Hardware damage is suspected
- Issues cannot be resolved with standard troubleshooting

17.5 Diagnostic Information

When contacting support, have ready:

- Radio model and serial number
- SmartSDR version
- Description of the issue

- PA fault codes (if applicable)
- Steps already tried
- Operating conditions when issue occurred

17.6 Preventive Maintenance

To avoid issues:

1. **Antenna System**
   - Regularly inspect connections
   - Check SWR periodically
   - Ensure proper grounding
2. **Environment**
   - Maintain adequate ventilation
   - Avoid extreme temperatures
   - Protect from moisture
3. **Operation**
   - Use ATU for non-resonant antennas
   - Monitor temperature during high-duty-cycle modes
   - Avoid external amplifiers
4. **Software**
   - Keep SmartSDR updated
   - Keep radio firmware current
   - Backup profiles and settings

Chapter 18

External Amplifiers

18.1 Important Warning

> **Caution**
>
> **External Amplifier Use NOT RECOMMENDED**
> It is **STRONGLY DISCOURAGED** to use an external linear amplifier with Aurora. Doing so may cause serious damage and void your warranty.

18.2 Why External Amplifiers Are Problematic

18.2.1 Aurora Output Power

Aurora produces up to **500 watts** of output power on HF bands. Most external linear amplifiers designed for amateur radio are built to accept no more than 100 watts of drive power.

18.2.2 The Risk

Connecting Aurora's 500-watt output to an external amplifier designed for 100W drive will:

1. **Damage the external amplifier** - Input circuits will be overwhelmed
2. **Potentially damage Aurora** - Reflected power and fault conditions
3. **Void warranties** - Both Aurora and amplifier warranties may be affected
4. **Create safety hazards** - Overstressed components may fail catastrophically

18.3 Common Questions

18.3.1 "Can I just reduce Aurora's power?"

While you could theoretically reduce Aurora's output to 100W or less, this approach:

- Wastes Aurora's capabilities
- Still risks accidental full-power keying
- Offers no advantage over using Aurora at full power directly

18.3.2 "What if my amplifier can handle 500W drive?"

Very few amateur amplifiers accept 500W input. Even those that do:

- Are designed for specific input impedance
- May have different timing requirements
- Offer minimal benefit given Aurora's already substantial output

18.3.3 "I want more than 500W output"

Legal considerations:

- US amateur maximum is 1,500W PEP
- Aurora at 500W is already substantial power
- The 3-4 dB gain from 500W to 1,500W is often not worth the complexity

Practical considerations:

- Traditional amplifiers with Aurora lose efficiency benefits
- Setup complexity increases significantly
- Additional equipment weight/cost

18.4 If You Must Use an External Amplifier

If you have a specific requirement for external amplification (rare situations):

1. **Verify amplifier specifications**
   - Confirm drive power rating
   - Check input impedance
   - Verify PTT/sequencing requirements
2. **Confirm bypass power handling**
   - The external amplifier must be able to handle 500 watts of RF power in bypass mode
   - Failure to confirm this can result in damage to the amplifier
   - Example: The PGXL can only handle 200 watts in bypass (confirmed by 4O3A); connecting Aurora's 500W output through a PGXL in bypass will damage the PGXL
3. **Use appropriate power level**
   - Set Aurora output well below amplifier maximum drive
   - Never exceed amplifier input power rating
4. **Implement proper sequencing**
   - Amplifier must key before Aurora transmits
   - Aurora must unkey before amplifier
5. **Monitor carefully**
   - Watch for reflected power
   - Monitor amplifier temperature
   - Be prepared for faults
6. **Understand warranty implications**
   - Damage from external amplifier use may not be covered
   - Document your configuration

18.5 Better Alternatives

Instead of external amplification, consider:

18.5.1 Antenna Improvements

- Better antenna = more effective than more power
- Gain antennas provide "free" dB
- Lower feedline loss improves efficiency

18.5.2 Operating Techniques

- 500W is substantial power for most situations
- Proper timing and calling techniques improve success
- Digital modes (FT8) work well at moderate power

18.5.3 Multiple Aurora Units

For multi-operator or SO2R operation:

- Second Aurora provides independent capability
- No interconnection complexity
- Full SmartSDR integration

18.6 Summary

Approach	Recommendation
External amplifier with Aurora	**Not recommended**
Aurora at full power (500W)	**Optimal for most uses**
Aurora at reduced power	Appropriate for QRP operation
Antenna improvements	Excellent complement to Aurora

Aurora is designed as a complete, integrated 500W station. External amplification adds complexity, risk, and minimal benefit while potentially causing serious equipment damage.