4RF

Aprisa FE

Product Description

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Disclaimer

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RoHS and WEEE Compliance

The Aprisa FE is fully compliant with the European Commission's RoHS (Restriction of Certain Hazardous Substances in Electrical and Electronic Equipment) and WEEE (Waste Electrical and Electronic Equipment) environmental directives.

Restriction of hazardous substances (RoHS)

The RoHS Directive prohibits the sale in the European Union of electronic equipment containing these hazardous substances: lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs).

4RF has worked with its component suppliers to ensure compliance with the RoHS Directive which came into effect on the 1st July 2006.

End-of-life recycling programme (WEEE)

The WEEE Directive concerns the recovery, reuse, and recycling of electronic and electrical equipment. Under the Directive, used equipment must be marked, collected separately, and disposed of properly.

4RF has instigated a programme to manage the reuse, recycling, and recovery of waste in an environmentally safe manner using processes that comply with the WEEE Directive (EU Waste Electrical and Electronic Equipment 2002/96/EC).

4RF invites questions from customers and partners on its environmental programmes and compliance with the European Commission's Directives (sales@4RF.com).

Compliance General

The Aprisa FE radio predominantly operates within frequency bands that require a site license be issued by the radio regulatory authority with jurisdiction over the territory in which the equipment is being operated.

It is the responsibility of the user, before operating the equipment, to ensure that where required the appropriate license has been granted and all conditions attendant to that license have been met.

Changes or modifications not approved by the party responsible for compliance could void the user's authority to operate the equipment.

Equipment authorizations sought by 4RF are based on the Aprisa FE radio equipment being installed at a fixed restricted access location and operated in point-to-point mode within the environmental profile defined by EN 300 019, Class 3.4. Operation outside these criteria may invalidate the authorizations and / or license conditions.

The term 'Radio' with reference to the Aprisa FE User Manual, is a generic term for one end station of a point-to-point Aprisa FE link and does not confer any rights to connect to any public network or to operate the equipment within any territory.

Compliance European Telecommunications Standards Institute

The Aprisa FE radio is designed to comply with the European Telecommunications Standards Institute (ETSI) specifications as follows:

	12.5 kHz. 25 kHz and 50 kHz Channel
Radio performance	EN 300 113-2, EN 302-561
EMC	EN 301 489 Parts 1 & 5
Environmental	EN 300 019, Class 3.4 Ingress Protection code IP51
Safety	EN 60950-1:2006

Frequency band	**Channel size**	**Power input**	**Notified body**
135-175 MHz	12.5 kHz, 25 kHz, 50 kHz	12 VDC	
320-400 MHz	12.5 kHz, 20 kHz, 25 kHz, 50 kHz	12 VDC	
400-470 MHz	12.5 kHz, 20 kHz, 25 kHz, 50 kHz	12 VDC	
450-520 MHz	12.5 kHz, 25 kHz, 50 kHz	12 VDC	

Compliance Federal Communications Commission

The Aprisa FE radio is designed to comply with the Federal Communications Commission (FCC) specifications as follows:

Radio	47CFR part 24, part 90 and part 101 Private Land Mobile Radio Services
EMC	47CFR part 15 Radio Frequency Devices, EN 301 489 Parts 1 & 4
Environmental	EN 300 019, Class 3.4 Ingress Protection code IP51
Safety	EN 60950-1:2006

Frequency Band *	**Channel size**	**Power input**	**Authorization**	**FCC ID**
135-175 MHz	12.5 kHz, 25 kHz	12 VDC	Part 90	Pending
400-470 MHz	12.5 kHz, 25 kHz, 50 kHz	12 VDC	Part 90	UIPSQ400M131
450-520 MHz	12.5 kHz, 25 kHz	12 VDC	Part 90	UIPSQ450M140
896-902 MHz	50 kHz	12 VDC	Part 24	UIPSQ896M141
928-960 MHz	12.5 kHz, 25 kHz, 50 kHz	12 VDC	Part 24,Part 90 and Part 101	UIPSQ928M141

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

* The Frequency Band it is not an indication of the exact frequencies approved by FCC.

Compliance Industry Canada

The Aprisa FE radio is designed to comply with Industry Canada (IC) specifications as follows:

Radio	RSS-119 / RSS-134
EMC	This Class A digital apparatus complies with Canadian standard ICES-003. Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.
Environmental	EN 300 019, Class 3.4 Ingress Protection code IP51
Safety	EN 60950-1:2006

Frequency Band *	**Channel size**	**Power input**	**Authorization**	**IC ID**
135-175 MHz	12.5 kHz, 25 kHz	12 VDC	RSS-119	Pending
400-470 MHz	12.5 kHz, 25 kHz, 50 kHz	12 VDC	RSS-119	6772A-SQ400M131
896-902 MHz	50 kHz	12 VDC	RSS-134	6772A-SQ896M141
928-960 MHz	12.5 kHz, 25 kHz, 50 kHz	12 VDC	RSS-119 and RSS-134	6772A-SQ928M141

* The Frequency Band it is not an indication of the exact frequencies approved by IC.

RF Exposure Warning

WARNING:

The installer and / or user of Aprisa FE radios shall ensure that a separation distance as given in the following table is maintained between the main axis of the terminal's antenna and the body of the user or nearby persons.

Minimum separation distances given are based on the maximum values of the following methodologies:

1. Maximum Permissible Exposure non-occupational limit (B or general public) of 47 CFR 1.1310 and the methodology of FCC's OST/OET Bulletin number 65.
2. Reference levels as given in Annex III, European Directive on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC). These distances will ensure indirect compliance with the requirements of EN 50385:2002.

Frequency (MHz)	Maximum Power (dBm) Note 1	Maximum Antenna Gain (dBi)	Minimum Separation Distance (m)
135	+ 37	15	2.5
175	+ 37	15	2.5
215	+ 37	15	2.5
240	+ 37	15	2.5
320	+ 37	15	2.5
400	+ 37	15	2.5
450	+ 37	15	2.5
470	+ 37	15	2.5
520	+ 37	15	2.5
896	+ 37	28	7.5
902	+ 37	28	7.5
928	+ 37	28	7.5
960	+ 37	28	7.5

Note 1: The Peak Envelope Power (PEP) at maximum set power level is +41 dBm.

Contents

1. Introduction

The 4RF Aprisa FE Radio

The 4RF Aprisa FE is a point-to-point digital radio providing secure narrowband wireless data connectivity for low capacity backhaul for SCADA, DMR infrastructure, telemetry and applications.

The radio link carries Ethernet data between the local and remote radios.

Product Overview

Network Coverage and Capacity

The Aprisa FE has a typical link range of up to 120 km, however, geographic features, such as hills, mountains, trees and foliage, or other path obstructions, such as buildings, will limit radio coverage. Additionally, geography may reduce network capacity at the edge of the network where errors may occur and require retransmission. However, the Aprisa FE uses 10W output power and Forward Error Correction (FEC) which greatly improves the sensitivity and system gain performance of the radio resulting in less retries and minimal reduction in capacity.

Ultimately, the overall performance of any radio link will be defined by a range of factors including the RF output power, the modulation used and its related receiver sensitivity and the geographic location.

Product Features

Functions

- Point-to-Point (PTP) operation
- Licensed frequency bands:

VHF 135	135-175 MHz
UHF 320	320-400 MHz
UHF 400	400-470 MHz
UHF 450	450-520 MHz
UHF 896	896-902 MHz
UHF 928	928-960 MHz

- Channel sizes – software selectable:
  - 12.5 kHz
  - 20 kHz
  - 25 kHz
  - 50 kHz
- Adaptive Coding Modulation (ACM): QPSK to 64 QAM
- Full duplex RF operation
- Ethernet data interface
- Data encryption and authentication using 128,192 and 256 bit AES and CCM security standards
- IEEE 802.1Q VLAN support with single and double VLAN tagged and add/remove VLAN manipulation to adapt to the appropriate RTU / PLCs
- QoS supports using IEEE 802.1p VLAN priority bits to prioritize and handle the VLAN / traffic types
- QoS per port (Ethernet, management)
- L2/3/4 filtering for security and avoiding narrow band radio network overload
- L3 Router mode with standard static IP route for simple routing network integration
- L2 Bridge mode with VLAN aware for standard Industrial LAN integration
- Ethernet header and IP/TCP / UDP ROCH header compression to increase the narrow band radio capacity
- Ethernet payload compression to increase the narrow band radio capacity
- SuperVisor web management support for element and sub-network (base-repeater-remotes) management
- SNMPv1/2/3 & encryption MIB supports for 4RF SNMP manager or third party SNMP agent network management
- SNMPv3 context addressing for compressed SNMP access to remote stations
- SNTP for accurate wide radio network time and date
- Transparent to all common SCADA protocols; e.g. Modbus, IEC 60870-5-101/104, DNP3 or similar
- Complies with international standards, including ETSI, FCC, IC, EMC, safety and environmental standards

Security

The Aprisa FE provides security features to implement the key recommendations for industrial control systems. The security provided builds upon the best in class from multiple standards bodies, including:

- IEC/TR 62443 (TC65) 'Industrial Communications Networks – Network and System Security'
- IEC/TS 62351 (TC57) 'Power System Control and Associated Communications – Data and Communication Security'
- FIPS PUB 197, NIST SP 800-38C, IETF RFC3394, RFC3610 and IEEE P1711/P1689/P1685

The security features implemented are:

- Data encryption

  Counter Mode Encryption (CTR) using Advanced Encryption Standard (AES) 128, 192, 256 bit, based on FIPS PUB 197 AES encryption (using Rijndael version 3.0)

- Data authentication

  NIST SP 800-38C Cipher Block Chaining Message Authentication Code (CBC-MAC) based on RFC 3610 using Advanced Encryption Standard (AES)

- Data payload security

  CCM Counter with CBC-MAC integrity (NIST special publication 800-38C)

- Secured management interface protects configuration
- L2 / L3 / L4 Address filtering enables traffic source authorization
- Proprietary physical layer protocol and modified MAC layer protocol based on standardized IEEE 802.15.4
- Licensed radio spectrum provides recourse against interference
- SNMPv3 with Encryption for NMS secure access
- Secure USB software upgrade
- Key Encryption Key (KEK) based on RFC 3394, for secure Over The Air Re-keying (OTAR) of encryption keys
- User privilege allows the accessibility control of the different radio network users and the user permissions

Performance

- Long distance operation
- High transmit power
- Low noise receiver
- Forward Error Correction
- Electronic tuning over the frequency band
- Thermal management for high power over a wide temperature range

Usability

- Configuration / diagnostics via front panel Management Port USB interface, Ethernet interface
- Built-in webserver SuperVisor with full configuration, diagnostics and monitoring functionality, including remote radio configuration / diagnostics over the radio link
- LED display for on-site diagnostics
- Dedicated alarm port
- Software upgrade and diagnostic reporting via the host port USB flash drive
- Over-the-air software distribution and upgrades
- Rack shelf mounting

System Gain vs FEC Coding

This table shows the relationship between modulation, FEC coding, system gain, capacity and coverage.

- Maximum FEC coding results in the highest system gain, the best coverage but the least capacity
- Minimum FEC coding results in lower system gain, lower coverage but higher capacity
- No FEC coding results in the lowest system gain, the lowest coverage but the highest capacity

This table defines the modulation order based on gross capacity:

Modulation	FEC Coding	Capacity
QPSK (High Gain)	Max Coded FEC	Minimum
QPSK (Low Gain)	Min Coded FEC	
16QAM (High Gain)	Max Coded FEC	
QPSK	No FEC	
16QAM (Low Gain)	Min Coded FEC	
16QAM	No FEC	
64QAM (High Gain)	Max Coded FEC	
64QAM (Low Gain)	Min Coded FEC	Maximum

This table defines the modulation order based on receiver sensitivity:

Modulation	FEC Coding	Coverage
QPSK (High Gain)	Max Coded FEC	Maximum
QPSK (Low Gain)	Min Coded FEC	
16QAM (High Gain)	Max Coded FEC	
QPSK	No FEC	
16QAM (Low Gain)	Min Coded FEC	
64QAM (High Gain)	Max Coded FEC	
16QAM	No FEC	
64QAM (Low Gain)	Min Coded FEC	Minimum

Architecture

The Aprisa FE Architecture is based around a layered TCP/IP protocol stack:

- Physical
  Proprietary wireless
  Ethernet interface
- Link
  Proprietary wireless
  VLAN aware Ethernet bridge
- Network
  Standard IP
  Proprietary automatic radio routing table population algorithm
- Transport
  TCP, UDP
- Application
  HTTPS web management access with proprietary management application software including management of remote radio over the radio link
  SNMPv1/2/3 for network management application software

Interfaces

Antenna Interface

- N type 50 ohm, female connector

Ethernet Interface

- 4 ports 10/100 base-T Ethernet layer 2 switch using RJ45

  Used for Ethernet user traffic and radio sub-network management.

USB Interfaces

- 1 x Management port using USB micro type B connector

  Used for product configuration with the Command Line Interface (CLI).
- 1 x Host port using USB standard type A connector

  Used for software upgrade and diagnostic reporting.

Protect Interface

- 1x Protect interface port

  Used for the Protected Station operation (future option).

Alarms Interface

- 1x Alarm port using RJ45 connector

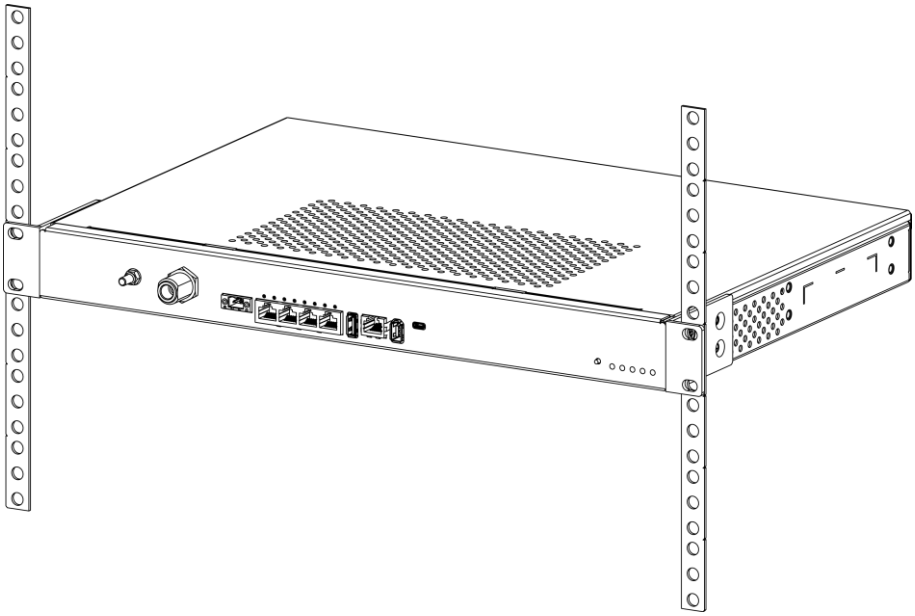
  Used to provide 2 x hardware alarm inputs and 2 x hardware alarm outputs

Mounting

The Aprisa FE is designed to be rack mounted in a standard 19” rack.

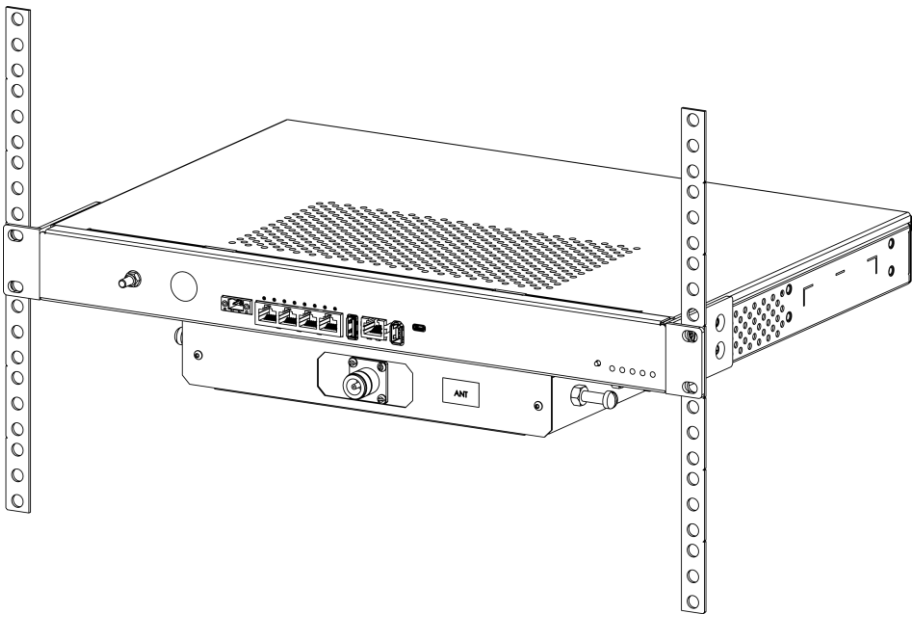
Internal Duplexer

When the duplexer mounts internally, the space required is 1U.



External Duplexer

When the duplexer mounts externally, the rack space required is 2U.



2. Product Options

Chassis Options

300 mm Chassis Depth – Internal Duplexer

The standard Aprisa FE chassis has a depth of 300 mm and can accommodate some duplexer types.

The following products are supplied in a 300 mm depth chassis with the duplexer mounted internally:

Part Number	Frequency Band	Internal Duplexer
APFE-N896-SSC-G1-30-ENAA	896-902 MHz	Minimum split 9.0 MHz Passband 1.5 MHz
APFE-N896-SSC-G2-30-ENAA	896-902 MHz	Minimum split 9.0 MHz Passband 1.0 MHz
APFE-N928-SSC-G2-30-ENAA	928-960 MHz	Minimum split 9.0 MHz Passband 1.0 MHz

300 mm Chassis Depth – External Duplexer

The following products are supplied in a 300 mm depth chassis but with the duplexer mounted externally:

Part Number	Frequency Band	External Duplexer
APFE-N135-SSC-N0-30-ENAA	135-175 MHz	Minimum split 4.6 MHz Passband 0.5 MHz
APFE-N320-SSC-A1-30-ENAA	320-400 MHz	Minimum split 5.0 MHz Passband 0.5 MHz
APFE-N400-SSC-B1-30-ENAA	400-470 MHz	Minimum split 5.0 MHz Passband 0.5 MHz
APFE-N450-SSC-M0-30-ENAA	450-520 MHz	Minimum split 5.0 MHz Passband 0.5 MHz

440 mm Chassis Depth – Internal Duplexer Only

The full depth Aprisa FE chassis has a depth of 440 mm and can accommodate some duplexer types.

The following products are supplied in a 440 mm depth chassis with the duplexer mounted internally:

Part Number	Frequency Band	Internal Duplexer
APFE-N320-SSC-A1-44-ENAA	320-400 MHz	Minimum split 5.0 MHz Passband 0.5 MHz
APFE-N400-SSC-B1-44-ENAA	400-470 MHz	Minimum split 5.0 MHz Passband 0.5 MHz

Protected Station

The Aprisa FE Protected Station is fully monitored hot-standby and fully hot-swappable product providing radio and user interface protection for Aprisa FE radios. The RF ports and interface ports from the active radio are switched to the standby radio if there is a failure in the active radio.

All interfaces (RF, data, etc.) are continually monitored on both the active and standby radio to ensure correct operation. The standby radio can be replaced without impacting traffic flow on the active radio.

The Aprisa FE Protected Station can operate as a local or remote station.

The protection behaviour and switching criteria between the active and standby radios is identical for the two configurations.

Each radio is configured with its own unique IP and MAC address and the address of the partner radio.

On power-up, the primary radio will assume the active role and the secondary radio will assume the standby role. If, for some reason, only one radio is powered on it will automatically assume the active role.

The Aprisa FE Protected Station is a future development.

Protected Ports

The protected ports are located on the protected station front panel. Switching occurs between the active radio ports and the standby radio ports based on the switching criteria described below.

The protected ports include:

- Antenna ports ANT/TX and RX
- Ethernet ports

Operation

In hot-standby normal operation, the active radio carries all Ethernet traffic over the radio link and the standby radio transmit is on with its transmitter connected to an internal load. Both radios are continually monitored for correct operation including the transmitter and receiver and alarms are raised if an event occurs.

The active radio sends regular ‘keep alive’ messages to the standby radio to indicate it is operating correctly. In the event of a failure on the active radio, the RF link and user interface traffic is automatically switched to the standby radio.

The failed radio can then be replaced in the field without interrupting user traffic.

3. Specifications

RF Specifications

Blocking (desensitization), intermodulation, spurious response rejection, and adjacent channel selectivity values determined according to the methods introduced in V1.7.1 of ETSI standards EN 300 113-1.

Frequency Bands

ETSI Compliant

Broadcast Band	Frequency Band	Frequency Tuning Range	Synthesizer Step Size
UHF	320 MHz	320-400 MHz	6.250 kHz

ETSI / FCC / IC Compliant

Broadcast Band	Frequency Band	Frequency Tuning Range	Synthesizer Step Size
VHF	135 MHz (1)	135-175 MHz	2.5 kHz
UHF	400 MHz	400-470 MHz	6.250 kHz

ETSI / FCC Compliant

Broadcast Band	Frequency Band	Frequency Tuning Range	Synthesizer Step Size
UHF	450 MHz	450-520 MHz	6.250 kHz

FCC / IC Compliant

Broadcast Band	Frequency Band	Frequency Tuning Range	Synthesizer Step Size
UHF	896 MHz	896-902 MHz	6.250 kHz
UHF	928 MHz	928-960 MHz	6.250 kHz

Note 1: Please consult 4RF for availability.

The Frequency Tuning Range is not an indication of the exact frequencies approved by FCC / IC.

Channel Sizes

ETSI Compliant

320 / 400 MHz Bands

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
12.5 kHz	60.0 kbit/s	40.0 kbit/s	20.0 kbit/s	
20 kHz	84.0 kbit/s	56.0 kbit/s	28.0 kbit/s	
25 kHz	120.0 kbit/s	80.0 kbit/s	40.0 kbit/s	
50 kHz	216.0 kbit/s	144.0 kbit/s	72.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	52.0 kbit/s	23.1 kbit/s	11.6 kbit/s	
20 kHz	72.7 kbit/s	32.4 kbit/s	16.2 kbit/s	
25 kHz	103.9 kbit/s	46.2 kbit/s	23.1 kbit/s	
50 kHz	187.1 kbit/s	83.2 kbit/s	41.6 kbit/s	

Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	45.6 kbit/s	17.3 kbit/s	8.7 kbit/s	
20 kHz	63.8 kbit/s	24.2 kbit/s	12.1 kbit/s	
25 kHz	91.2 kbit/s	34.6 kbit/s	17.3 kbit/s	
50 kHz	164.2 kbit/s	62.4 kbit/s	31.2 kbit/s	

450 MHz Band

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
12.5 kHz	60.0 kbit/s	40.0 kbit/s	20.0 kbit/s	
25 kHz	120.0 kbit/s	80.0 kbit/s	40.0 kbit/s	
50 kHz	216.0 kbit/s	144.0 kbit/s	72.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	52.0 kbit/s	23.1 kbit/s	11.6 kbit/s	
25 kHz	103.9 kbit/s	46.2 kbit/s	23.1 kbit/s	
50 kHz	187.1 kbit/s	83.2 kbit/s	41.6 kbit/s	

Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	45.6 kbit/s	17.3 kbit/s	8.7 kbit/s	
25 kHz	91.2 kbit/s	34.6 kbit/s	17.3 kbit/s	
50 kHz	164.2 kbit/s	62.4 kbit/s	31.2 kbit/s	

FCC Compliant

400 MHz Band

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
12.5 kHz	54.0 kbit/s	36.0 kbit/s	18.0 kbit/s	
25 kHz	96.0 kbit/s	64.0 kbit/s	32.0 kbit/s	
50 kHz	216.0 kbit/s	144.0 kbit/s	72.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	46.8 kbit/s	20.8 kbit/s	10.4 kbit/s	
25 kHz	83.1 kbit/s	37.0 kbit/s	18.5 kbit/s	
50 kHz	187.1 kbit/s	83.2 kbit/s	41.6 kbit/s	

Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	41.0 kbit/s	15.6 kbit/s	7.8 kbit/s	
25 kHz	73.0 kbit/s	27.7 kbit/s	13.9 kbit/s	
50 kHz	164.2 kbit/s	62.4 kbit/s	31.2 kbit/s	

450 MHz Band

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
12.5 kHz	54.0 kbit/s	36.0 kbit/s	18.0 kbit/s	
25 kHz	96.0 kbit/s	64.0 kbit/s	32.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	46.8 kbit/s	20.8 kbit/s	10.4 kbit/s	
25 kHz	83.1 kbit/s	37.0 kbit/s	18.5 kbit/s	

Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	41.0 kbit/s	15.6 kbit/s	7.8 kbit/s	
25 kHz	73.0 kbit/s	27.7 kbit/s	13.9 kbit/s	

896 MHz Band

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
50 kHz	216.0 kbit/s	144.0 kbit/s	72.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
50 kHz	187.1 kbit/s	83.2 kbit/s	41.6 kbit/s	

Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
50 kHz	164.2 kbit/s	62.4 kbit/s	31.2 kbit/s	

928 MHz Band

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
12.5 kHz	60.0 kbit/s	40.0 kbit/s	20.0 kbit/s	
25 kHz	96.0 kbit/s	64.0 kbit/s	32.0 kbit/s	
50 kHz	216.0 kbit/s	144.0 kbit/s	72.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	52.0 kbit/s	23.1 kbit/s	11.6 kbit/s	
25 kHz	83.1 kbit/s	37.0 kbit/s	18.5 kbit/s	
50 kHz	187.1 kbit/s	83.2 kbit/s	41.6 kbit/s	

Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	45.6 kbit/s	17.3 kbit/s	8.7 kbit/s	
25 kHz	73.0 kbit/s	27.7 kbit/s	13.9 kbit/s	
50 kHz	164.2 kbit/s	62.4 kbit/s	31.2 kbit/s	

IC Compliant

400 MHz Band

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
12.5 kHz	54.0 kbit/s	36.0 kbit/s	18.0 kbit/s	
25 kHz	96.0 kbit/s	64.0 kbit/s	32.0 kbit/s	
50 kHz	216.0 kbit/s	144.0 kbit/s	72.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
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12.5 kHz	46.8 kbit/s	20.8 kbit/s	10.4 kbit/s	
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Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
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25 kHz	73.0 kbit/s	27.7 kbit/s	13.9 kbit/s	
50 kHz	164.2 kbit/s	62.4 kbit/s	31.2 kbit/s	

896 MHz Band

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
50 kHz	216.0 kbit/s	144.0 kbit/s	72.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
50 kHz	187.1 kbit/s	83.2 kbit/s	41.6 kbit/s	

Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
50 kHz	164.2 kbit/s	62.4 kbit/s	31.2 kbit/s	

928 MHz Band

No Forward Error Correction

Channel Size	Gross Radio Capacity			
	64 QAM	16 QAM	QPSK	
12.5 kHz	54.0 kbit/s	36.0 kbit/s	18.0 kbit/s	
25 kHz	96.0 kbit/s	64.0 kbit/s	32.0 kbit/s	
50 kHz	216.0 kbit/s	144.0 kbit/s	72.0 kbit/s	

Minimum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	46.8 kbit/s	20.8 kbit/s	10.4 kbit/s	
25 kHz	83.1 kbit/s	37.0 kbit/s	18.5 kbit/s	
50 kHz	187.1 kbit/s	83.2 kbit/s	41.6 kbit/s	

Maximum Coded Forward Error Correction

Channel Size	Gross Radio Capacity less FEC			
	64 QAM	16 QAM	QPSK	
12.5 kHz	41.0 kbit/s	15.6 kbit/s	7.8 kbit/s	
25 kHz	73.0 kbit/s	27.7 kbit/s	13.9 kbit/s	
50 kHz	164.2 kbit/s	62.4 kbit/s	31.2 kbit/s	

Receiver

Receiver Sensitivity

			12.5 kHz	25 kHz	50 kHz
BER < 10^{-2}	64 QAM	Max coded FEC	-104 dBm	-100 dBm	-97 dBm
BER < 10^{-2}	64 QAM	Min coded FEC	-103 dBm	-99 dBm	-96 dBm
BER < 10^{-2}	64 QAM	No FEC	-101 dBm	-97 dBm	-94 dBm
BER < 10^{-2}	16 QAM	Max coded FEC	-111 dBm	-108 dBm	-105 dBm
BER < 10^{-2}	16 QAM	Min coded FEC	-110 dBm	-107 dBm	-104 dBm
BER < 10^{-2}	16 QAM	No FEC	-107 dBm	-104 dBm	-101 dBm
BER < 10^{-2}	QPSK	Max coded FEC	-116 dBm	-113 dBm	-110 dBm
BER < 10^{-2}	QPSK	Min coded FEC	-115 dBm	-112 dBm	-109 dBm
BER < 10^{-2}	QPSK	No FEC	-113 dBm	-110 dBm	-107 dBm
BER < 10^{-6}	64 QAM	Max coded FEC	-101 dBm	-97 dBm	-94 dBm
BER < 10^{-6}	64 QAM	Min coded FEC	-99 dBm	-95 dBm	-92 dBm
BER < 10^{-6}	64 QAM	No FEC	-94 dBm	-90 dBm	-87 dBm
BER < 10^{-6}	16 QAM	Max coded FEC	-108 dBm	-105 dBm	-102 dBm
BER < 10^{-6}	16 QAM	Min coded FEC	-106 dBm	-103 dBm	-100 dBm
BER < 10^{-6}	16 QAM	No FEC	-100 dBm	-97 dBm	-94 dBm
BER < 10^{-6}	QPSK	Max coded FEC	-113 dBm	-110 dBm	-107 dBm
BER < 10^{-6}	QPSK	Min coded FEC	-111 dBm	-108 dBm	-105 dBm
BER < 10^{-6}	QPSK	No FEC	-106 dBm	-103 dBm	-100 dBm

Adjacent Channel Selectivity

		12.5 kHz	25 kHz	50 kHz
Adjacent channel selectivity		> -45 dBm	> -35 dBm	> -35 dBm
BER < 10^{-2}	64 QAM	> 43 dB	> 53 dB	> 53 dB
BER < 10^{-2}	16 QAM	> 43 dB	> 53 dB	> 53 dB
BER < 10^{-2}	QPSK	> 48 dB	> 58 dB	> 58 dB

Co-Channel Rejection

		12.5 kHz	25 kHz	50 kHz
BER < 10^{-2}	64 QAM	> -23 dB	> -23 dB	> -23 dB
BER < 10^{-2}	16 QAM	> -19 dB	> -19 dB	> -19 dB
BER < 10^{-2}	QPSK	> -12 dB	> -12 dB	> -12 dB

Intermodulation Response Rejection

		12.5 kHz	25 kHz	50 kHz
Intermodulation response rejection		> -33 dBm	> -33 dBm	> -33 dBm
BER < 10^{-2}	64 QAM	> 55 dB	> 55 dB	> 55 dB
BER < 10^{-2}	16 QAM	> 55 dB	> 55 dB	> 55 dB
BER < 10^{-2}	QPSK	> 60 dB	> 60 dB	> 60 dB

Blocking or Desensitization

		12.5 kHz	25 kHz	50 kHz
Blocking or desensitization		> -15 dBm	> -15 dBm	> -15 dBm
BER < 10^{-2}	64 QAM	> 73 dB	> 73 dB	> 73 dB
BER < 10^{-2}	16 QAM	> 73 dB	> 73 dB	> 73 dB
BER < 10^{-2}	QPSK	> 78 dB	> 78 dB	> 78 dB

Spurious Response Rejection

		12.5 kHz	25 kHz	50 kHz
Spurious response rejection		> -30 dBm	> -30 dBm	> -30 dBm
BER < 10^{-2}	64 QAM	> 58 dB	> 58 dB	> 58 dB
BER < 10^{-2}	16 QAM	> 58 dB	> 58 dB	> 58 dB
BER < 10^{-2}	QPSK	> 63 dB	> 63 dB	> 63 dB

Receiver Spurious Radiation

	12.5 kHz	25 kHz	50 kHz
Receiver spurious radiation	> -57 dBm	> -57 dBm	> -57 dBm

Transmitter

Average Power output Note: The Peak Envelope Power (PEP) at maximum set power level is +41 dBm.	64 QAM	0.01 to 1.6 W (+10 to +32 dBm, in 1 dB steps)
	16 QAM	0.01 to 2.0 W (+10 to +33 dBm, in 1 dB steps)
	QPSK	0.01 to 3.2 W (+10 to +35 dBm, in 1 dB steps)

Note: The Aprisa FE transmitter contains power amplifier protection which allows the antenna to be disconnected from the antenna port without product damage.

Adjacent channel power	< - 60 dBc
Transient adjacent channel power	< - 60 dBc
Spurious emissions	< - 37 dBm
Attack time	< 1.5 ms
Release time	< 0.5 ms
Data turnaround time	< 2 ms
Frequency stability	± 1.0 ppm
Frequency aging	< 1 ppm / annum

Modem

Forward Error Correction	Variable length concatenated Reed Solomon plus convolutional code
Adaptive Burst Support	Adaptive FEC Adaptive Coding Modulation

Data Payload Security

Data payload security	CCM* Counter with CBC-MAC
Data encryption	Counter Mode Encryption (CTR) using Advanced Encryption Standard (AES) 128, 192 or 256
Data authentication	Cipher Block Chaining Message Authentication Code (CBC-MAC) using Advanced Encryption Standard (AES) 128, 192 or 256

Interface Specifications

Ethernet Interface

The Aprisa FE radio features an integrated 10Base-T/100Base-TX layer-2 Ethernet switch.

To simplify network setup, each port supports auto-negotiation and auto-sensing MDI/MDIX. Operators can select from the following preset modes:

- Auto negotiate
- 10Base-T half or full duplex
- 100Base-TX half or full duplex

The Ethernet ports are IEEE 802.3-compatible. The L2 Bridge (Switch) is IEEE 802.1d/q/p compatible, and supports VLANs and VLAN manipulation of add/remove VLANs.

General	Interface	RJ45 x 2 (Integrated 2-port switch)
	Cabling	CAT-5/6 UTP, supports auto MDIX (Standard Ethernet)
	Maximum line length	100 metres on cat-5 or better
	Bandwidth allocation	The Ethernet capacity maximum is determined by the available radio link capacity.
	Maximum transmission unit	Option setting of 1522 or 1536 octets
	Address table size	1024 MAC addresses
	Ethernet mode	10Base-T or 100Base-TX Full duplex or half duplex (Auto-negotiating and auto-sensing)
Diagnostics	Left Green LED	Off: no Ethernet signal received On: Ethernet signal received
	Right Green LED	Off: Indicates no data traffic present on the interface Flashing: Indicates data traffic present on the interface

Note: Do not connect Power over Ethernet (PoE) connections to the Aprisa FE Ethernet ports as this will damage the port.

Hardware Alarms Interface

The hardware alarms interface supports two alarm inputs and two alarms outputs.

Alarm Inputs

The alarm connector provides two hardware alarm inputs for alarm transmission to the other radios in the network.

Interface	RJ45 connector
Detector type	Non-isolated ground referenced voltage detector
Detection voltage - on	> +10 VDC
Detection voltage - off	< +4 VDC
Maximum applied input voltage	30 VDC
Maximum input current limit	10 mA

Alarm Outputs

The alarm connector provides two hardware alarm outputs for alarm reception from other radios in the network.

Interface	RJ45 connector
Output type	Non-isolated ground referenced open collector output
Maximum applied voltage	30 VDC
Maximum drive current	100 mA
Overload protection	Thermally resettable fuse

Protect Interface

The Protect interface is used to connect the radios to the protection switch within a Protected Station. It is not a customer interface.

Protection Switch Specifications

The Aprisa FE Protected Station is a future development.

Power Specifications

Power Supply

Aprisa FE Radio

Nominal voltage	+13.8 VDC (negative earth)
Absolute input voltage range	+10 to +30 VDC
Maximum power input	35 W
Connector	Molex 2 pin male screw fitting 39526-4002

Aprisa FE Protected Station

The Aprisa FE Protected Station is a future development.

Power Consumption

Note: The radio power consumption is very dependent on transmitter power, the type of traffic and network activity.

Aprisa FE Radio

Mode	Power Consumption (10 W radio with 4-CPFSK modulation)
Transmit / Receive	< 35 W for 10 W transmit power
	< 25.0 W for 1 W transmit power
Receive only	< 7 W

Aprisa FE Protected Station

The Aprisa FE Protected Station is a future development.

Power Dissipation

Aprisa FE Radio

Transmit Power	Power Dissipation (10 W radio with 4-CPFSK modulation)
10 W transmit power	< 25 W
1 W transmit power	< 24 W

Aprisa FE Protected Station

The Aprisa FE Protected Station is a future development.

General Specifications

Environmental

Operating temperature range	-40 to +60˚ C (-40 to +140˚ F)
Storage temperature range	-40 to +80˚ C (-40 to +176˚ F)
Operating humidity	Maximum 95% non-condensing
Acoustic noise emission	No audible noise emission

Mechanical

Aprisa FE Radio

Dimensions	Width 434 mm (17.1”) Depth 300 mm (11.8”) and 440 mm (17.3”) Height 44.45 mm (1.75”)
Weight	5.0 kg (11.3 lbs) (dependent on duplexer type)
Colour	Matt black
Mounting	Rack mount 19” 1U high (internal duplexer)

Aprisa FE Protected Station

The Aprisa FE Protected Station is a future development.

Compliance

ETSI

Radio	EN 300 113-2
EMI / EMC	EN 301 489 Parts 1 & 5
Safety	EN 60950-1:2006
Environmental	ETS 300 019 Class 3.4 Ingress Protection code IP51

FCC

Radio	47CFR part 24, part 90 and part 101 Private Land Mobile Radio Services
EMC	47CFR part 15 Radio Frequency Devices, EN 301 489 Parts 1 & 4
Safety	EN 60950-1:2006
Environmental	ETS 300 019 Class 3.4 Ingress Protection code IP51

IC

Radio	RSS-119 / RSS-134
EMC	This Class A digital apparatus complies with Canadian standard ICES-003. Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.
Safety	EN 60950-1:2006
Environmental	ETS 300 019 Class 3.4 Ingress Protection code IP51

4. Management

SuperVisor

The Aprisa FE contains an embedded web server application (SuperVisor) to enable element management with any major web browser (such as Mozilla Firefox or Microsoft® Internet Explorer).

SuperVisor enables operators to configure and manage the local radio and remote radio over the radio link.

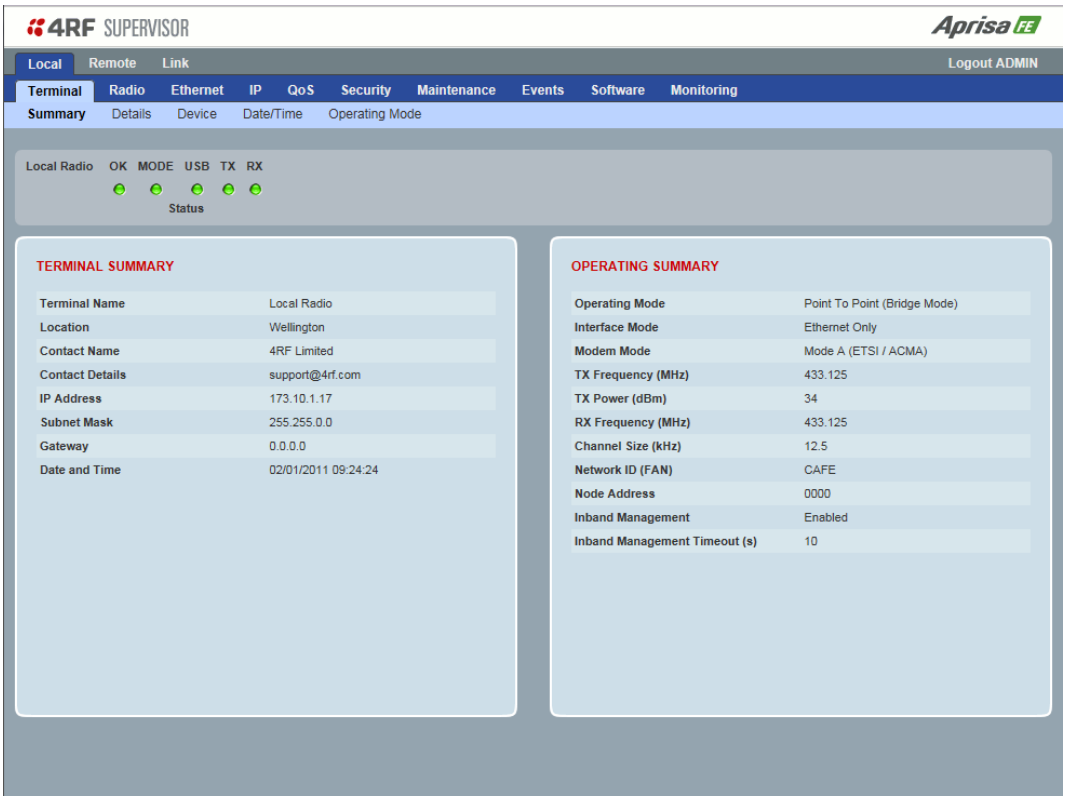
The key features of SuperVisor are:

- Full element management, configuration and diagnostics
- Manage the local and remote radio (remote management)
- Managed link software distribution and upgrades
- Performance and alarm monitoring of the link, including RSSI, alarm states, time-stamped events, etc.
- View and set standard radio configuration parameters including frequencies, transmit power, and Ethernet port settings
- Set and view security parameters
- User management
- Operates over a secure HTTPS session

The following are three examples of SuperVisor screens:

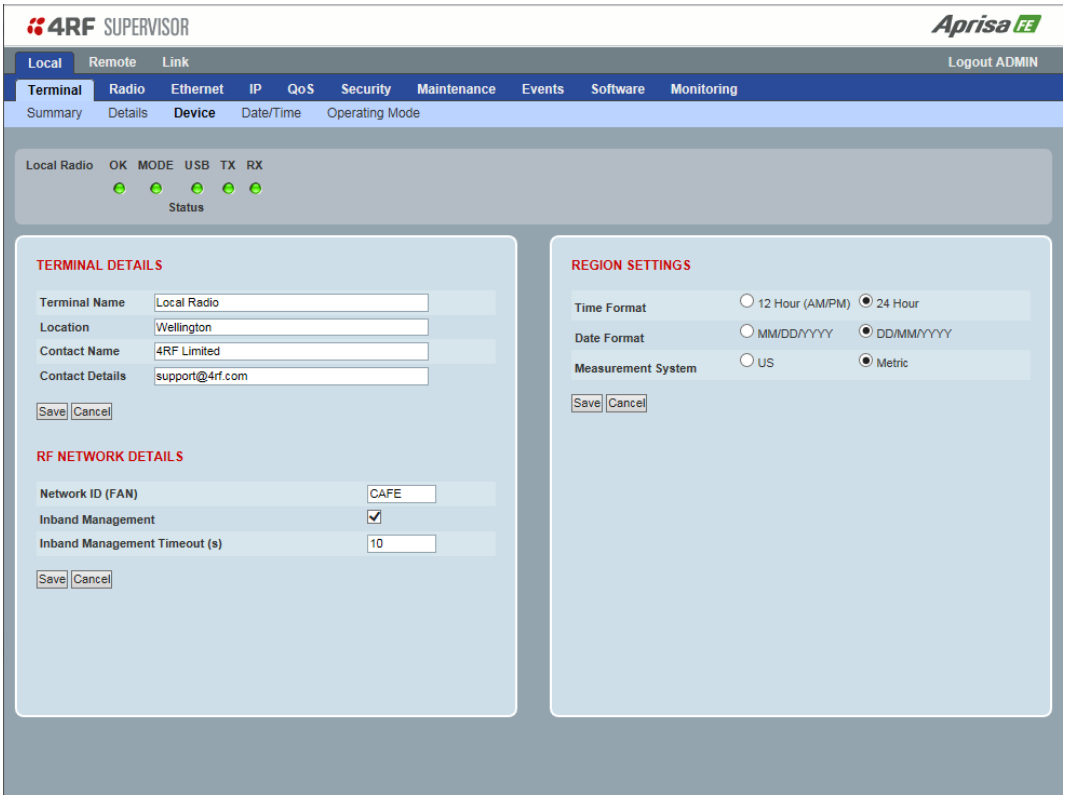
Viewing the Aprisa FE Terminal Settings

The SuperVisor software enables operators to view the terminal settings:



Configuring the Aprisa FE Terminal Details

The SuperVisor software enables operators to set the terminal details including Terminal Name, Location, Contact Name and Contact Details with a maximum of 40 characters.

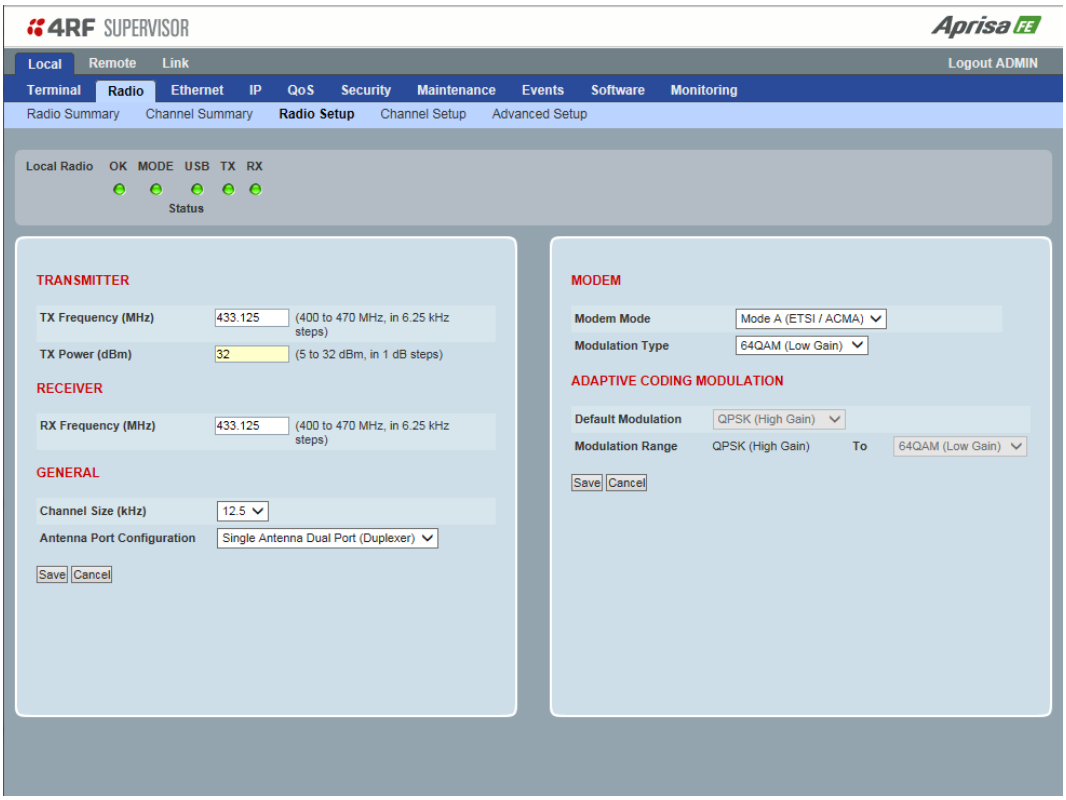


Configuring the Aprisa FE RF Network Details

The SuperVisor software enables operators to set the RF Network Details including:

Network ID	Sets the network ID of the radio. Both the local and remote radio must be set to the same network ID Four hex chars
Inband Management	Enables inband management of the remote radio
Inband Management Timeout (sec)	Sets the inband management timeout period

Configuring the Aprisa FE Radio Settings



The SuperVisor software enables operators to set the radio settings including:

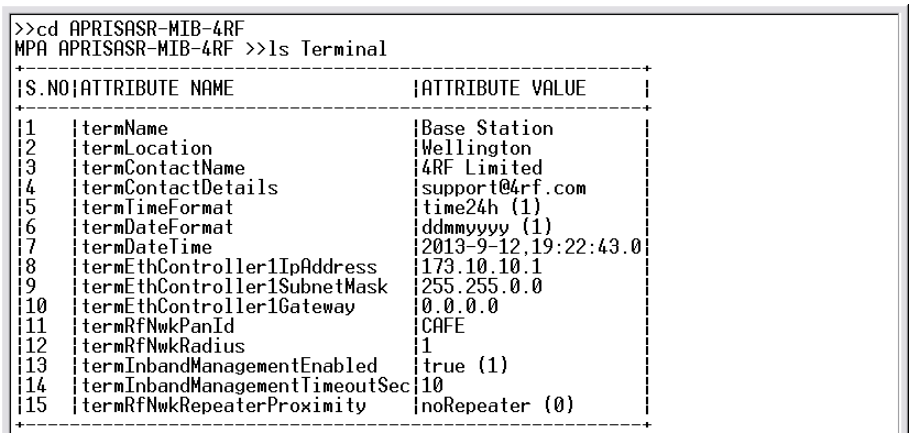
TX Frequency	Sets the transmit frequency in MHz
TX Power	Sets the transmit Power in dBm
RX Frequency	Sets the receive frequency in MHz
Channel Size	Sets the channel size 12.5 kHz, 25 kHz or 50 kHz (depending on variant)
Antenna Port Configuration	Sets the antenna port configuration to single / dual antenna and single / dual port
Modem Mode	Sets the modem / compliance for the radio
Modulation Type	Sets the ACM or fixed Modulation Type for the radio
Modulation Range	Sets the upper limit that the Adaptive Code Modulation can automatically adjust up to

Command Line Interface

The Aprisa FE has a Command Line Interface (CLI) which provides basic product setup and configuration.

This interface can be accessed via an Ethernet Port (RJ45) or the Management Port (USB micro type B).

The Terminal menu is shown in the following picture:



SNMP

In addition to web-based management (SuperVisor) and the Command Line Interface, the Aprisa SR network can also be managed using the Simple Network Management Protocol (SNMP agent). MIB files are supplied which can be used by a dedicated SNMP Manager, such as Castle Rock's network management system, to support effective and flexible network monitoring and diagnostics.

Alternatively, the user can use its own 3rd party NMS SNMP agent to manage the FE radio network.

For communication between the SNMP manager and the radio, Access Controls and Community strings must be set up as described in the Aprisa FE User Manual.

LED Display Panel

The Aprisa FE has an LED Display panel which provides on-site alarms / diagnostics without the need for PC.

Normal Operation

In normal radio operation, the LEDs indicate the following conditions:

	OK	MODE	USB	TX	RX
Flashing Red		*Radio has not registered*			
Solid Red	*Alarm present with severity Critical, Major and Minor*			*TX path fail*	*RX path fail*
Flashing Orange		*Diagnostics Function Active* *OTA Firmware Distribution*	*Management traffic on the USB MGMT port*		
Solid Orange	*Alarm present with Warning Severity*		*Device detect on the USB host port (momentary)*		
Flashing Green	*Software Upgrade Successful*	*Stand-by radio in protected station*	*Tx / Rx Data on the USB host port*	*RF path TX is active*	*RF path RX is active*
Solid Green	*Power on and functions OK and no alarms*	*Processor Block is OK* *or active radio in protected station*	*USB interface OK*	*Tx path OK*	*Rx path OK*

LED Colour	Severity
Green	No alarm – information only
Orange	Warning alarm
Red	Critical, major or minor alarm

Single Radio Software Upgrade

During a radio software upgrade, the LEDs indicate the following conditions:

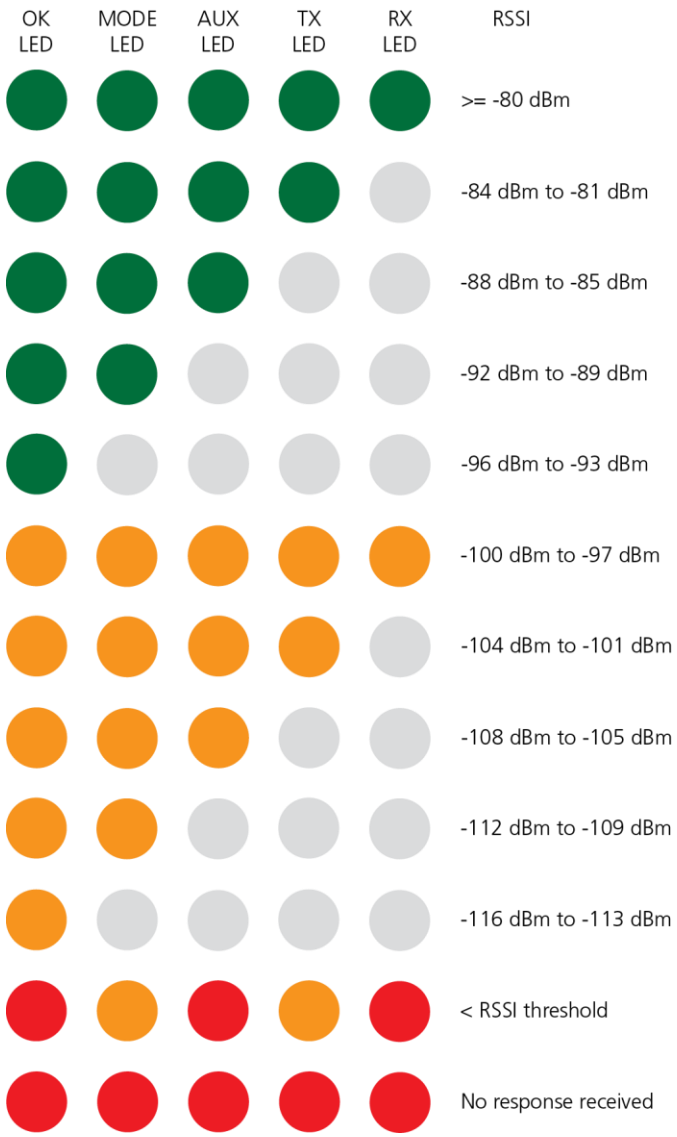
- Software upgrade started - the OK LED flashes orange
- Software upgrade progress indicated by running USB to MODE LEDs
- Software upgrade completed successfully - the OK LED flashes green
- Software upgrade failed - any LED flashing red during the upgrade

Link Software Upgrade

During a link software upgrade, the MODE LED flashes orange on the local radio and the remote radio.

Test Mode

In Test Mode, the LED Display panel presents a real time visual display of the RSSI. This can be used to adjust the antenna for optimum signal strength.



5. Applications

The Aprisa FE is a low cost, IP based, low capacity up to 50 kHz narrow band point-to-point product in the VHF, UHF, 900 MHz licensed bands targeted for the LMR, DMR (digital mobile radio), SCADA and utility low capacity linking and backhaul application. The product supports the transition to IP connectivity and security as standard base operation. The Aprisa FE is part of the 4RF point-to-point product portfolio.

This section describes sample Aprisa FE point-to-point radio applications. The following applications are described:

- General purpose basic point-to-point (PTP) application
- DMR (Digital Mobile Radio) backhaul applications
- SCADA backhaul applications
- SCADA linking - top of the hill SCADA linking applications

Basic point-to-point application

The Aprisa FE point-to-point link is used to connect any low capacity Ethernet/IP sites using full duplex. VHF/UHF and 900 MHz frequency bands are used for long distance connectivity. The full duplex low capacity linking can be in the range of 20 kbit/s to 240 kbit/s using 12.5, 25 or 50 kHz channel sizes.

The local Aprisa FE receives Ethernet frames from site A and transmits them to remote Aprisa FE which forwards the Ethernet frames to site B. On the same time, the remote Aprisa FE receives Ethernet frames from site B and transmits them to local Aprisa FE which forward the Ethernet frames to site A, performing a full duplex operation across the Aprisa FE point-to-point link.

Both the local and remote Aprisa FE radios use a directional yagi antenna to provide higher gain and long distance point-to-point connection.

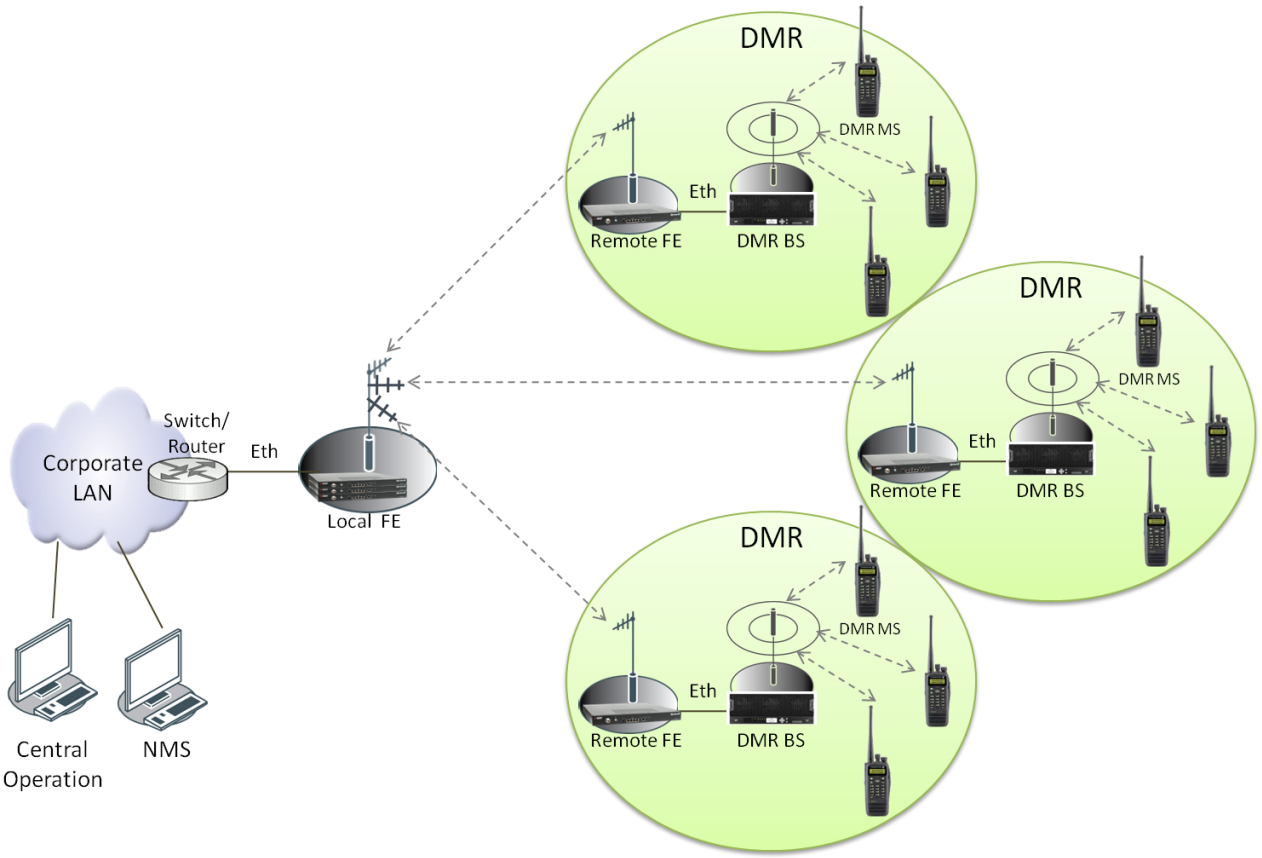
DMR (Digital Mobile Radio) backhaul applications

DMR Tier II comprises licensed conventional radio systems, mobiles and hand portables operating in PMR frequency bands 30 to 1000 MHz. The ETSI DMR Tier II standard is targeted at users who need advanced voice and integrated IP data services in licensed bands.

DMR is a two-way radio used by large organization / enterprise and uses 12.5 KHz (6.25 equivalent-6.25e) 9.6 kbit/s gross rate covers a 2-slot TDMA channel (effective net up to ~3 kbit/s, each). DMR tier II mainly supports voice and IP data (and text messaging, GPS and other in DMR tier III) services.

DMR is used in variety of organization application, such as Public (government) administration, public works, manufacturing facilities, transportation, campus and hospitality such as resorts and schools, construction sites, energy/utility companies and public safety organizations.

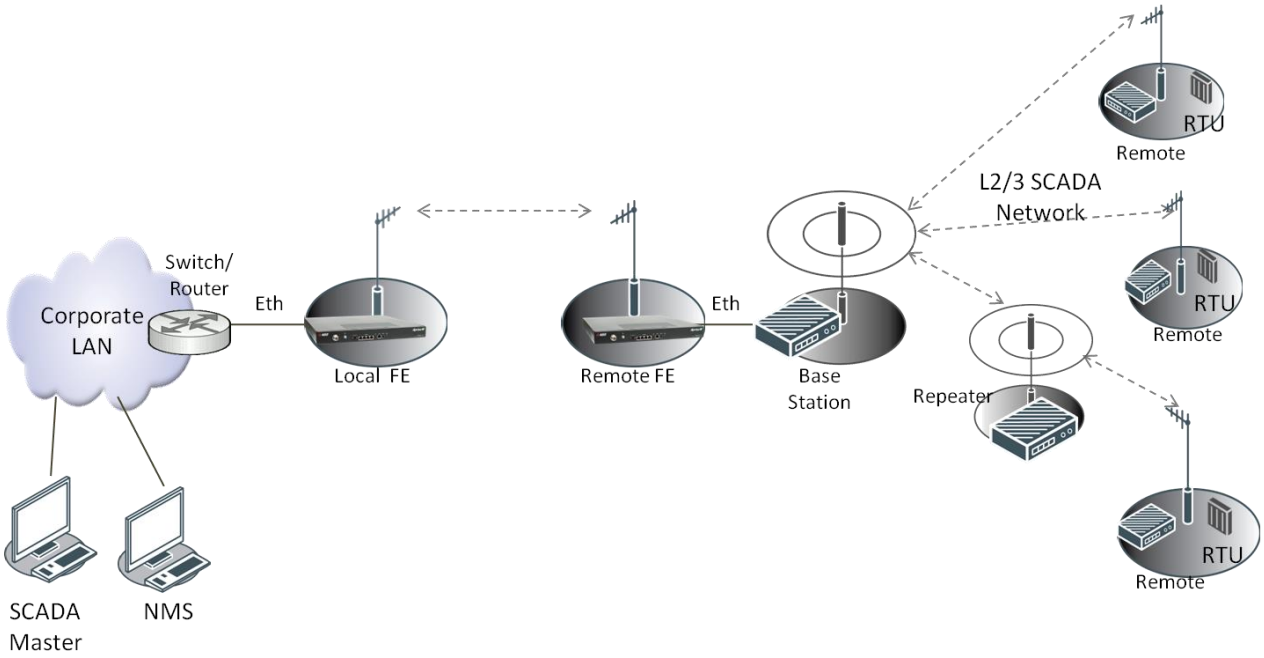
The Aprisa FE full duplex point-to-point link can be used to backhaul multiple DMR sites (see figure) and connect them to the organization headquarters central operation, aggregating multiple DMR base stations which in effects aggregates multiple DMR mobile station users.



SCADA backhaul applications

In a remote SCADA operated site (see figure) which is far from the industrial corporate operation centre SCADA master, an Aprisa FE can be used as the SCADA network backhauling solution.

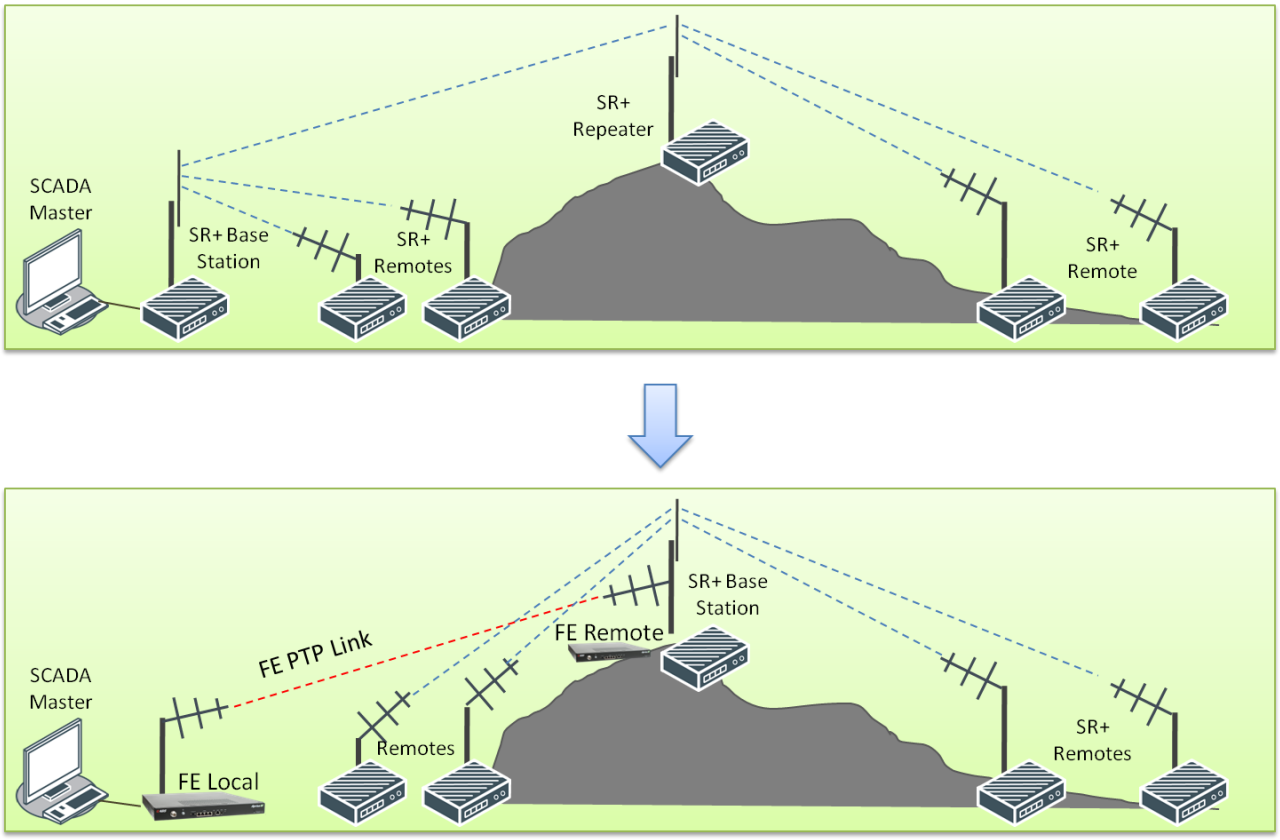
The Aprisa FE full duplex point-to-point link can be used to backhaul the SCADA network remote site and connect the SCADA base station radio network to the SCADA master in the operational centre.



SCADA linking - top of the hill SCADA linking applications

In a point-to-multipoint (PMP) SCADA radio network, a remote station might not be in the range of the base station radio signal coverage, due to terrain signal fading caused by mountains and hills (see figure). To extend the base station coverage and overcome the hill top fading, a repeater radio station is used (see top figure). However, a repeater in a narrow bandwidth capacity PMP network degrades network throughput and latency performance.

In a SCADA application where latency and throughput are important to protect critical infrastructure, a change in topology is required (see bottom figure) to eliminate the need for a repeater station by replacing the top of the hill repeater with base station radio, having direct connection of all the remote stations to the base station without the need for repeater station. The Aprisa FE full duplex point-to-point link can be used for linking the top of the hill base station radio to the SCADA master in the industrial corporate SCADA operational centre.



6. Product Architecture

Product Operation

There are two components to the wireless interface: the Physical Layer (PHY), the Network Layer. These two layers are required to transport data across the wireless channel in the point-to-point configuration.

Physical Layer

The Aprisa FE PHY uses two frequency full duplex transmission mode with separate transmit and receive antenna connection to operate with external duplexers.

The Aprisa FE is a packet based radio. Data is sent over the wireless channel in discrete packets / frames, separated in time. The PHY demodulates data within these packets with coherent detection.

The Aprisa FE PHY provides carrier, symbol and frame synchronization predominantly through the use of preambles. This preamble prefixes all packets sent over the wireless channel which enables fast Synchronization.

Adaptive Coding Modulation

The Aprisa FE provides Adaptive Coding Modulation (ACM) which maximizes the use of the RF path to provide the highest radio capacity available.

ACM automatically adjusts the modulation coding and FEC code rate in both directions of transmission over the defined modulation range based on the signal quality.

When the RF path is healthy (no fading), modulation coding is increased and the FEC code rate is decreased to maximize the data capacity.

If the RF path quality degrades, modulation coding is decreased and the FEC code rate is increased for maximum robustness to maintain path connectivity.

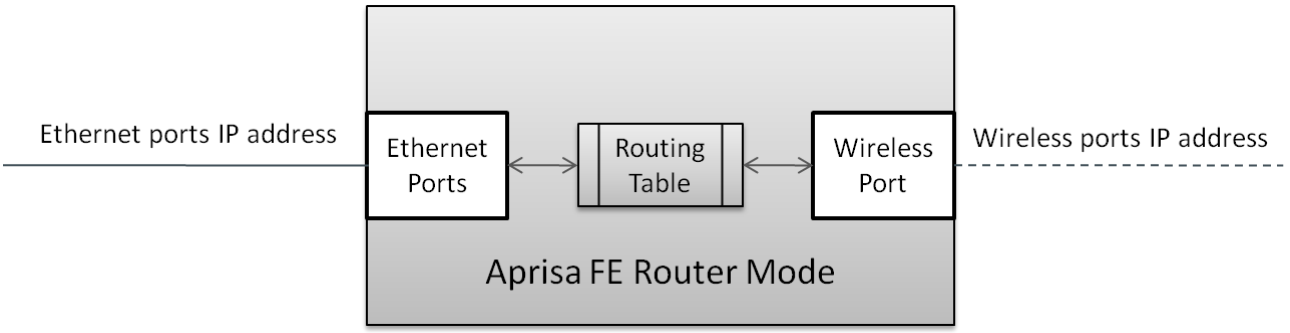
Network Layer

Packet Routing

Aprisa FE is a standard static IP router which routes and forwards IP packet based on standard IP address and routing table decisions.

Aprisa FE router mode (see figure below), enables the routing of IP packets within the Aprisa FE wireless network and in and out to the external router / IP RTUs devices connected to the Aprisa FE wired Ethernet ports.

Within the Aprisa FE Router mode, each incoming Ethernet packet on the Ethernet port is stripped from its Ethernet header to reveal the IP packet and to route the IP packet based on its routing table. If the destination IP address is on a device connected to the remote FE, the packet is then forwarded to the wireless ports and transmitted in a PTP wireless packet to remote radio. The appropriate remote then routes the IP packet and forwards it based on its routing table to the appropriate Ethernet port, encapsulating the appropriate next hop MAC header and forwarding it to the IP device for further packet processing.



Static IP Router

The Aprisa FE works in the point-to-point (PTP) network as a standard static IP router with the Ethernet and wireless / radio as interfaces.

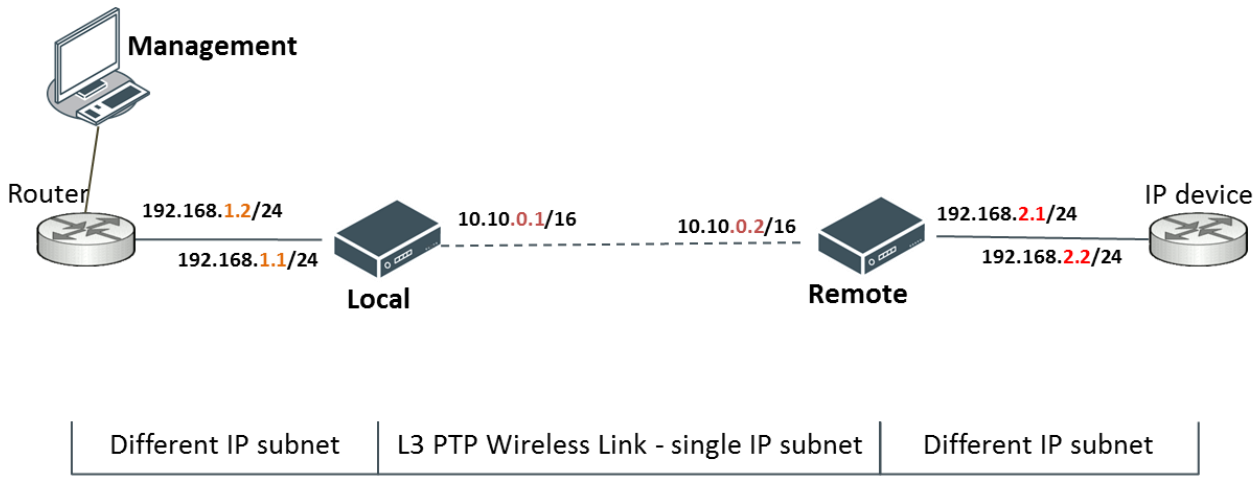
The Aprisa FE static router is semi-automated operation, where the routing table is automatically created in the local radio and populated with routes to the remote radio during the registration process and vice versa, where the routing table is automatically created in the remote radio and populated with routes to local radio during the registration process. Updates occur when the remote radio is disconnected for any reason, with the routing table updated in a controlled fashion.

Also, in decommission operation, the local radio routing tables is completely flushed allowing an automatic rebuild. This avoids the user manually inserting / removing of multiple static routes to build / change the routes in the network which might be tedious and introduce significant human error. The Aprisa FE works as a static IP router without using any routing protocol and therefore does not have the overhead of routing protocol for better utilization of the narrow bandwidth PTP link.

In addition to the semi-automated routes, the user can manually add / remove routes in the routing table for the radio interface, Ethernet Interface and for routers which are connected to the radio network.

The Aprisa FE supports IP gateway connections to other networks. Thus, a configurable IP address default gateway can be set using a static route in the routing table with a destination IP address of 0.0.0.0. It is used by the router when an IP address does not match any other routes in the routing table.

The Aprisa FE sub-netting rules distinguish between the wireless interface and the remote Ethernet interface. The PTP link is set on a single IP subnet, while each Aprisa FE remote's Ethernet interface is set to a different subnet network.



Static IP Router – Human Error Free

To ensure correct operation, the Aprisa FE router local radio alerts when one (or more) of the devices is not configured for router mode or a duplicated IP is detected when manually inserted and etc.

When the user changes the local radio IP address / subnet, the local radio sends an ARP unsolicited announcement message and the remote radio auto-update its routing table accordingly. This also allows the router that is connected to the local radio to update its next hop IP address and its routing table.

When the user changes the remote radio IP address / subnet, a re-registration process in the local radio then auto-updates its routing table accordingly.

Bridge Mode with VLAN Aware

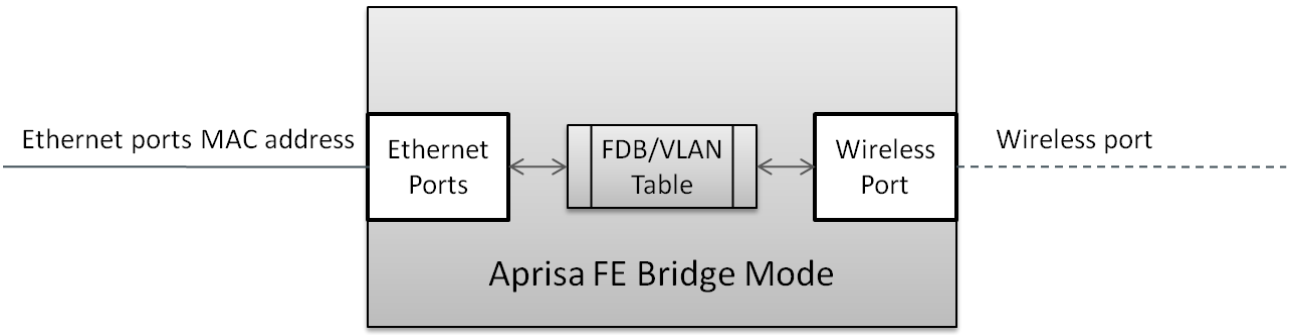
Ethernet VLAN Bridge / Switch Overview

The Aprisa FE in Bridge mode of operation is a standard Ethernet Bridge based on IEEE 802.1d or VLAN Bridge based on IEEE 802.1q/p which forward / switch Ethernet packet based on standard MAC addresses and VLANs using FDB (forwarding database) table decisions. VLAN is short for Virtual LAN and is a virtual separate network, within its own broadcast domain, but across the same physical network.

VLANs offer several important benefits such as improved network performance, increased security and simplified network management.

The Aprisa FE Bridge mode (see figure below), is the default mode of operation and it enables the switching / bridging of Ethernet VLAN tagged or untagged packets within the Aprisa FE PTP wireless network and in and out to the external Industrial LAN network and RTUs devices connected to the Aprisa FE wired Ethernet ports. Within the Aprisa FE Bridge mode, each incoming Ethernet packet is inspected for the destination MAC address (and VLAN) and looks up its FDB table for information on where to send the specific Ethernet frame. If the FDB table doesn't have any information on that specific MAC address, it will flood the Ethernet frame out to all ports in the broadcast domain and when using VLAN, the broadcast domain is narrowed to the specific VLAN used in the packet (i.e. broadcast will be done only to the ports which configured with that specific VLAN).

The FDB table is used to store the MAC addresses that have been learnt and the ports associated with that MAC address. If destination MAC address is a bridge device, the packet is then forwarded to the wireless ports and transmitted in a PTP wireless packet to the remote radio. The appropriate remote then switches the Ethernet packet and forwards it based on its FDB table (base on MAC or VLAN & MAC) to the appropriate Ethernet port to the bridge device for further packet processing.



VLAN Bridge Mode Description

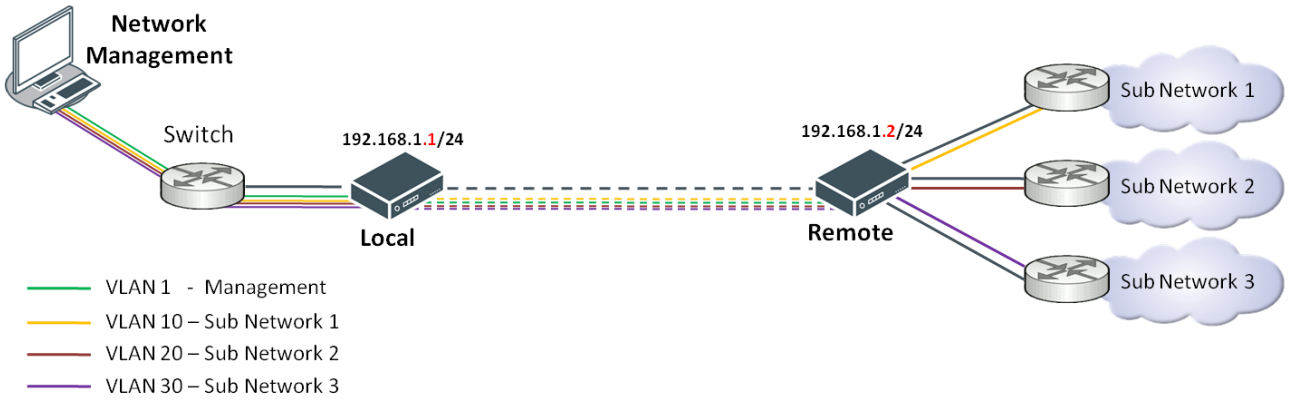
General – Aprisa FE VLAN Bridge

Aprisa FE works in the point-to-point (PTP) network as a standard VLAN bridge with the Ethernet and wireless / radio as interfaces.

The Aprisa FE is a standard IEEE 802.1q VLAN bridge, where the FDB table is created by the bridge learning / aging process. New MACs are learnt and the FDB table updated. Unused MACs are aged out and flushed automatically after aging period.

VLANs are statically configured by the user on the ports where a Virtual LAN is required across the PTP radio link. VLAN management can be used to manage with external NMS all the Aprisa FE devices on the radio network, and is automatically created with a VLAN ID = 1 default value. The VLAN ID can be changed by the user later on.

Each device in the Aprisa FE bridge is identified by its own IP address, as shown in the figure.



L2 VLAN PTP Wireless Link (with single IP subnet for management)

VLANs – Single, Double and Trunk VLAN ports

Aprisa FE supports single VLAN (CVLAN), double VLAN (SVLAN) and trunk VLAN.

A single VLAN can be used to segregate traffic type.

A double VLAN can be used to distinguish between different Aprisa FE PTP links, where the outer SVLAN is used to identify the link and the CVLAN is used to identify the traffic type. In this case, a double tagged VLAN will be forwarded across the Industrial LAN network and switched based on the SVLAN to the appropriate Aprisa FE PTP link. When packet enters the Aprisa FE PTP link, the SVLAN will be stripped off (removed) and the forwarding will be done based on the CVLAN, so only a single VLAN will pass through over the radio network and double VLAN will be valid on the borders of the PTP link.

Trunk VLAN is also supported by the Aprisa FE where the user can configure multiple VLANs on a specific Ethernet port and PTP link, creating a trunk VLAN port.

VLAN Manipulation – Add / Remove VLAN Tags

In order to support double VLAN and different device types connected to the Aprisa FE e.g. switches, RTUs, etc, which can be VLAN tagged or untagged / plain Ethernet devices, add / remove VLAN manipulation is required.

In an Aprisa FE VLAN tagged network, a remote Aprisa FE connected to a plain switch without VLAN support, will remove (strip-off) the VLAN tag from the packet before sending it to the switch. On the other direction, when the switch is sending an untagged packet, the Aprisa FE will add (append) an appropriate user pre-configure VLAN tag before sending it over the air to the local radio.

QoS using VLAN

VLANs carry 3 priority bits (PCP field) in the VLAN tag allowing prioritization of VLAN tagged traffic types with 8 levels of priority (where 7 is the highest priority and 0 is the lowest priority). The Aprisa FE supports QoS (Quality of Service) where the priority bits in the VLAN tagged frame are evaluated and mapped to four priority levels and four queues supported by the Aprisa FE radio. Packets in the queues are then scheduled out in a strict priority fashion for transmission over-the-air as per the priority level from high to low.

Avoiding Narrow Band Radio Traffic Overloading

The Aprisa FE supports mechanisms to prevent narrowband radio network overload:

1. L3/L4 Filtering

The L3 filtering can be used to block undesired traffic from being transferred on the narrow band channel, occupying the channel and risking the SCADA critical traffic. L3/4 filtering has the ability to block a known IP address and applications using TCP/IP or UDP/IP protocols with multiple filtering rules. The L3 (/L4) filter can block/forward (discard/process) a specific IP address and a range of IP addresses. Each IP addressing filtering rule set can also be set to filter a L4 TCP or UDP port/s which in most cases relates to specific applications as per IANA official and unofficial well-known ports. For example, filter and block E-mail SMTP or TFTP protocol as undesired traffic over the PTP radio link. The user can block a specific or range of IP port addresses, examples SMTP (Simple Mail Transfer Protocol) TCP port 25 or TFTP (Simple Trivial File Transfer Protocol) UDP port 69.

2. L2 Address Filtering

L2 Filtering (Bridge Mode) provides the ability to filter radio link traffic based on specified Layer 2 MAC addresses. Destination MAC (DA) addresses and a Source MAC (SA) addresses and protocol type (ARP, VLAN, IPv4, IPv6 or Any type) that meet the filtering criteria will be transmitted over the radio link. Traffic that does not meet the filtering criteria will not be transmitted over the radio link.

3. L2 Port VLANs Ingress Filtering and QoS

Double VLAN (Bridge Mode)

Double VLAN is used to distinguish/segregate between different PTP radio links. Traffic with double VLANs which are not destined to a PTP link will be discarded on the ingress of the radio link, avoiding the overload of the radio PTP link.

Single VLAN (Bridge Mode)

Single VLAN is used to distinguish/segregate between different traffic types assigned by the user in its industrial corporate LAN. In order to avoid the overload of the radio link, traffic with single VLANs which are not destined to a specific radio network will be discarded on the Ethernet ingress port of the radio link. All single VLANs which set and are eligible will be transmitted over the radio link.

QoS using 802.1p priority bits (Bridge Mode)

The priority bits can be used in the VLAN tagged frames to prioritized critical mission traffic and ensure critical traffic transmission relative to any other unimportant traffic. In this case, traffic based on VLAN priority (priority 0 to 7) enters one of the four priority queues of the Aprisa FE (Very High, High, Medium and Low). Traffic leaves the queues (to the radio network) from highest priority to lowest in a strict priority fashion.

4. Ethernet port QoS

The Aprisa FE supports ‘Ethernet Per Port Prioritization’. Each Ethernet port can be assigned a priority and traffic shall be prioritized accordingly. This is quite useful in networks where customers do not use VLANs or cannot use 802.1p prioritization.

5. Ethernet Data and Management Priority and Background Bulk Data Transfer Rate

Alternatively to VLAN priority, users can control the Ethernet traffic priority vs management priority and rate in order to control the traffic load of the radio network, where important and high priority data will pass-through first. The user can set the use of the Ethernet Data Priority, which controls the priority of the Ethernet customer traffic relative to the management traffic and can be set to one of the four queues. The Ethernet Management Priority controls the priority of the Ethernet management traffic relative to Ethernet customer traffic and can be set to one of the four queues. The Background Bulk Data Transfer Rate sets the data transfer rate (high, medium, low) for large amounts of management data.

6. Ethernet Packet Time to Live

Another aspect of avoiding overload radio network is the Ethernet packet TTL, which is used to prevent old, redundant packets being transmitted through the radio link. This sets the time an Ethernet packet is allowed to live in the system before being dropped if it cannot be transmitted over the air.

7. Robust Header Compression (ROHC) and Payload Compression

Aprisa FE supports ROHC v2 (Robust Header Compression v2 RFC4995, RFC5225, RFC4996, RFC3843, RFC4815). ROHC v2 is a standard way to compress IP, UDP and TCP headers and this significantly increases IP traffic throughput especially in narrow band network.

Aprisa FE supports payload compression. A Lempel–Ziv (LZ) algorithm is used to efficiently compress up to 50% traffic with high percentage of repetitive strings. Ethernet / IP payload traffic is compressed.

Product Architecture

The following are the key components of the Aprisa FE design:

Dual high performance ΣΔ fractional-N synthesizers to allow for full duplex operation

- Wideband design electronically tunes over entire band
- Proven low noise and spurious technology with over 50dB of SNR easily achieved

Power amplifier linearity

- Unique temperature compensated pre-distortion system improves the efficiency and linearity of the entire transmitter chain for non-constant envelope modulation systems
- Simple IQ modulation line up reduces part count and improves MTBF
- No mixing stages so no spurious responses present at the transmitter output

Digital control loops used for controlling power amplifier current and transmit output power, allows for faster ramping and settling times with less error

- Tx turn-on time limited primarily by PA ramping
- Robust, closed-loop power control – fast, accurate power ramp up and down

Highly rugged N-Channel RF Power LDMOS transistors for the power amplifier

- High efficiency (>50% PAE at 10W)
- Very low thermal resistance (1.0°C/W)

Direct IQ down-conversion

- Excellent Intermodulation distortion characteristics as channel filter can be placed directly after the mixer without impacting noise figure
- Digital channel filtering allows for multiple bandwidths with the same hardware
- Low parts count and no crystal filters help to keep receiver performance extremely stable over temperature

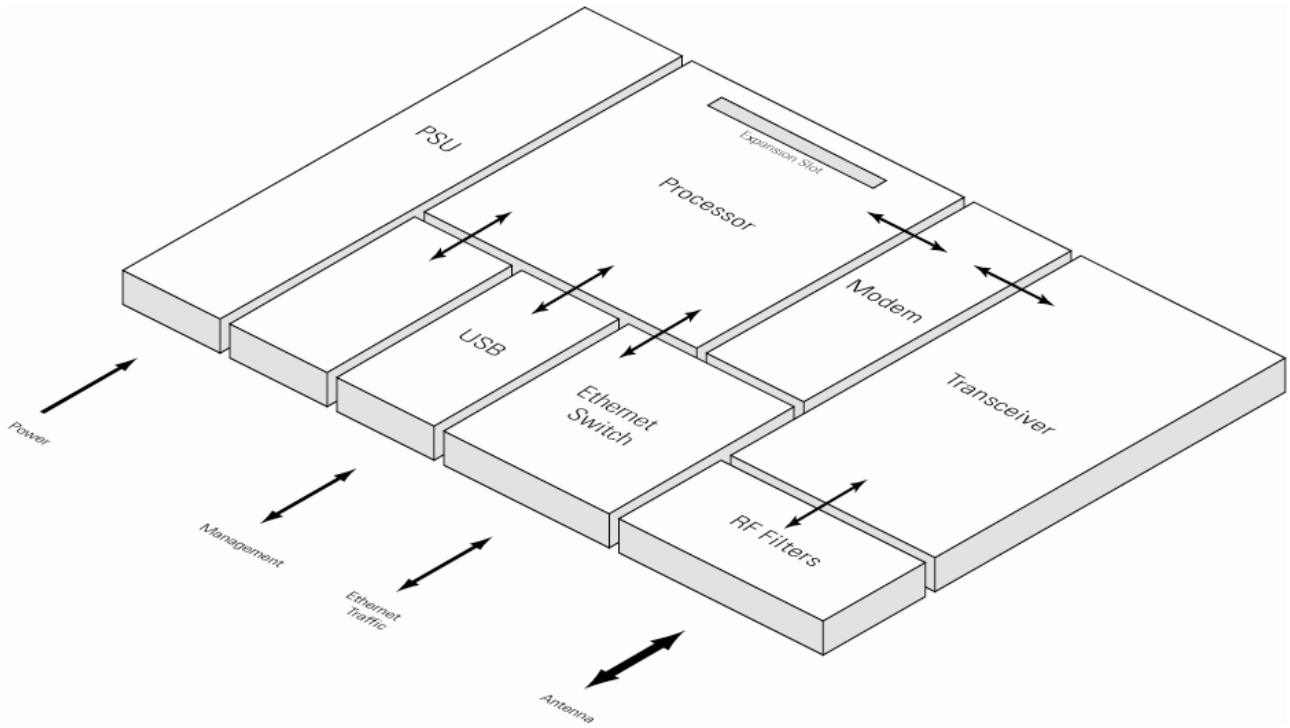
Integrated heat sink

- Limits number of mechanical interfaces
- Fin design optimized for natural convection

Monitoring and software control

- Temperature control loop shuts down the transmitter when the temperature exceeds continuous operation at 70°C
- Monitoring of RSSI and PA current to ensure the RF hardware is functioning to specification

Aprisa FE Radio Block Diagram



7. Contact Us

For further information or assistance, please contact Customer Support or your local 4RF representative.

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