CASCADE SYSTEM MODULES OPERATION GUIDE

The English version takes precedence over any translated versions.

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DOCUMENT CONTROL

This document has been produced, verified and controlled in accordance with Quality Management System requirements.

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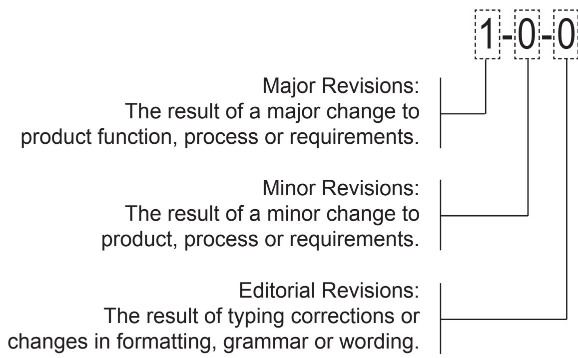
DOCUMENT REVISION DEFINITION

Documentation uses a three-level revision system. Each element of the revision number signifies the scope of change as described in the diagram below.



Three-level revision numbers start at 1-0-0 for the first release. The appropriate element of the revision number is incremented by 1 for each subsequent revision, causing any digits to the right to be reset to 0.

For example:
If the current revision = 2-1-1 Then the next major revision = 3-0-0
If the current revision = 4-3-1 Then the next minor revision = 4-4-0
If the current revision = 3-2-2 Then the next editorial revision = 3-2-3

Document revision history is provided at the back of the document.

NOTE

The user's authority to operate this equipment could be revoked through any changes or modifications not expressly approved by Codan Limited.

The design of this equipment is subject to change due to continuous development. This equipment may incorporate minor changes in detail from the information contained in this manual.

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

RF Exposure Warning

Exposure to radio frequency (RF) energy has been identified as a potential environmental factor that must be considered before a radio transmitter can be authorized or licensed. The FCC and IC have therefore developed maximum permissible exposure (MPE) limits for field strength and power density, listed in FCC 47 CFR § 1.1310 and IC RSS-102 Issue 5 Sect 4. The FCC has furthermore determined that determination of compliance with these exposure limits, and preparation of an Environmental Assessment (EA) if the limits are exceeded, is necessary only for facilities, operations and transmitters that fall into certain risk categories, listed in FCC 47 CFR § 1.1307 (b), Table 1. All other facilities, operations and transmitters are categorically excluded from making such studies or preparing an EA, except as indicated in FCC 47 CFR §§ 1.1307 (c) and (d).

KDB 447198 D01 General RF Exposure Guidance v06 and IC RSS-102 Issue 5 provide assistance in determining whether a proposed or existing transmitting facility, operation or device complies with RF exposure limits. In accordance with KDB 447198 , FCC 47 CFR § 1.1307 (b) and RSS-102 Issue 5 Sect 2.5, the Codan Radio Communications transmitter manufactured in Canada is categorically excluded from routine evaluation or preparing an EA for RF emissions and this exclusion is sufficient basis for assuming compliance with FCC/IC MPE limits. This exclusion is subject to the limits specified in FCC 47 CFR §§ 1.1307 (b), 1.1310 and IC RSS-102 Issue 5 Sect 4. Codan Radio Communications has no reason to believe that the excluded transmitter encompasses exceptional characteristics that could cause non-compliance.

Notes:

- The FCC and IC's exposure guidelines constitute exposure limits, not emission limits. They are relevant to locations that are accessible to workers or members of the public. Such access can be restricted or controlled by appropriate means (i.e., fences, warning signs and others).
- The FCC and IC's limits apply cumulatively to all sources of RF emissions affecting a given site. Sites exceeding these limits are subject to an EA and must provide test reports indicating compliance.

RF Safety Guidelines and Information

Base and Repeater radio transmitters are designed to generate and radiate RF energy by means of an external antenna, typically mounted at a significant height above ground to provide adequate signal coverage. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that permitted for successful communication. The following antenna installation guidelines must be adhered to in order to ensure RF exposure compliance:

Non-building-mounted Antennas:

- Height above ground level to lowest point of antenna ≥ 10 m
- Power ≤ 1000 W ERP (1640 W EIRP)

Building-mounted Antennas:

Power ≤ 1000 W ERP (1640 W EIRP)

The following RF Safety Guidelines should be observed when working in or around transmitter sites:

- Do not work on or around any transmitting antenna while RF power is applied.
- Before working on an antenna, disable the appropriate transmitter and ensure a “DO NOT USE” or similar sign is placed on or near the PTT or key-up control.
- Assume all antennas are active unless specifically indicated otherwise.
- Never operate a transmitter with the cover removed.
- Ensure all personnel entering a transmitter site have electromagnetic energy awareness training.

For more information on RF energy exposure and compliance, please refer to the following:

1. FCC Code of Regulations; 47 CFR §§ 1.1307 and 1.1310
2. KDB 447198 D01 General RF Exposure Guidance v06
3. https://www.fcc.gov/general/radio-frequency-safety-0
4. IC RSS-102 Issue 5, “Radio Frequency Exposure Compliance of Radio Communication Apparatus”

RF Maximum Permissible Exposure (MPE)

Exhibit Requirements for Installations in the United States of America

FCC Part 1, Section 1.1307 table 1- Transmitters, Facilities and Operations Subject to Routine Environmental Evaluation states the following for Part 90 Devices:

- Part 90 devices Non-building-mounted antennas: height above ground level to lowest point of antenna <10 m and power >1000 W ERP (1640 W EIRP). Building-mounted antennas: power >1000 W ERP (1640 W EIRP).

Another way of wording this is that Part 90 devices are not Subject to Routine Environmental Evaluation when the antenna is installed at 10Meters or higher and operating total power level of all channels is less than 1640 Watts EIRP.

As an example, a 125W transmitter with a 10dB gain antenna with a low loss cable would translate into 1,000 Watts EIRP in the envelope lobe. If it is mounted 10 Meters or higher above where people could be walking, you have a safe installation and do not have to perform MPE calculations for safe distance.

No antenna is supplied with this unit. Some suggested antennas are:

- Manufacturer: Sinclair Model: SC225 Gain: 0 dBd (2.15 dBi)
- Manufacturer: Sinclair Model: SC233 Gain: 3 dBd (5.15 dBi)
- Manufacturer: Sinclair Model: SD114 Gain: 7.5 dBd (9.65 dBi)

If the antenna is lower than 10Meters then you need to verify that your installation is at a safe distance for Exposure to the General Population.

For United States installations, you must ensure that your installation complies with the Maximum Permissible Exposure (MPE) requirements for general population that are specified under FCC Part 1 Section 1.1310 Table 1.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	$*900/f^2$	6
30-300	61.4	0.163	1.0	6
300-1,500			f/300	6
1,500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	$*180/f^2$	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

For US Installations, the maximum power density resulting from the composite Effective Isotopic Radiated Power (EIRP) from the antenna connected to this equipment must be limited to the maximum permissible exposure as stated below:

- **Power density limit for the band 152 to 174MHz** = 0.2 mW/cm^2

MPE and Safe Distance Calculations for USA Installations

This Power Density value is determined by the combination of RF output, cable loss, antenna gain, and distance from the antenna when energized.

The MPE calculation for US installations is expressed as follows:

- **Power Density Pd (mW/cm^2)** = $\left(\frac{\text{[illegible]}}{\text{[illegible]} * \text{[illegible]} * \text{[illegible]}^{\text{[illegible]}}}\right)$

Where

- **d** = distance from the antenna expressed in cm.
- **EIRP expressed in mW** = $10^{\left(\frac{[\text{[illegible]} (\text{[illegible]}) + \text{[illegible]} (\text{[illegible]}) - \text{[illegible]} (\text{[illegible]})]}{10}\right)}$
- **Tx Power (dBm)** = 10*log[Tx Power (mW)]

As an example, with the transmitter running at 125 watts output into an antenna with a gain of 10 dBi using a short cable with 0dB loss, to verify if 650cm (6.5meters) is a safe distance from the antenna to ensure exposure compliance of 0.2mW/cm^2:

1) 125 Watts Tx Power = 51dBm

2) EIRP (mW) = $10^{\left(\frac{[\text{[illegible]} (50\text{[illegible]}) + \text{[illegible]} (10\text{[illegible]}) - \text{[illegible]} (0\text{[illegible]})]}{10}\right)} = 10^{\left(\frac{60}{10}\right)}$ = 1,000,000mW

3) Pd (mW/cm2) = $\left(\frac{EIRP}{4*\pi*d^2}\right) = \left(\frac{1,000,000}{4*\text{[illegible]}*650^2}\right) = \left(\frac{1,000,000}{5,309,291}\right)$ = 0.19 mW/cm^2

- 6.5 meters (21.125 Feet) is a safe distance for US installations when using a 10dBi Antenna.

The minimum safe distance, from a radiating structure using different Gain Antennas"

- For the Band 152 to 174MHz with 2dBi Gain Antenna: d (safe distance) = 2.6 m
- For the Band 152 to 174MHz with 6dBi Gain Antenna: d (safe distance) = 4.0 m
- For the Band 152 to 174MHz with 10dBi Gain Antenna: d (safe distance) = 6.5 m

RF Maximum Permissible Exposure (MPE)

Exhibit Requirements for Installations in Canada

No antenna is supplied with this unit. Some suggested antennas are:

- Manufacturer: Sinclair Model: SC225 Gain: 0 dBd (2.15 dBi)
- Manufacturer: Sinclair Model: SC233 Gain: 3 dBd (5.15 dBi)
- Manufacturer: Sinclair Model: SD114 Gain: 7.5 dBd (9.65 dBi)

For Canada installations, you must ensure that your installation complies with the Maximum Permissible Exposure (MPE) requirements for general population that are specified under RSS-102 Section 4 Table 4.

Table 4: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
$0.003\text{-}10^{21}$	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142\ f^{0.3417}$	$0.008335\ f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158\ f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

MPE and Safe Distance Calculations for Canada Installations

For Canada installations, the maximum power density resulting from the composite Effective Isotopic Radiated Power (EIRP) from the antenna connected to this equipment must be limited to the maximum permissible exposure as stated below:

- **Power density limit for the band 152 to 174MHz** = 1.291 W/m²

The MPE calculation for US is expressed as follows:

- **Power Density Pd (W/m²)** = [illegible] / ([illegible]*[illegible]*[illegible])

Where

- **d** = distance from the antenna expressed in meters (m).
- **EIRP expressed in Watts (W)** = 10^([[illegible] ([illegible]) + [illegible] ([illegible]) − [illegible] ([illegible])] / 10)
- **Tx Power (dBW)** = 10*log[Tx Power (W)]

As an example, with the transmitter running at 125 watts output into an antenna with a gain of 10 dBi using a short cable with 0dB loss, to verify if 7.5meters is a safe distance from the antenna to ensure exposure compliance of 1.21W/m^2:

4) 125 Watts Tx Power = 20.97dBW

5) EIRP (W) = 10^([[illegible] (20[illegible]) + [illegible] (10[illegible]) − [illegible] (0[illegible])] / 10) = $10^{(\frac{30}{10})}$ = 1,000W

6) Pd (W/m2) = $\left(\frac{EIRP}{4*\pi*d^2}\right) = \left(\frac{1,000}{4*[illegible]*8.5^2}\right) = \left(\frac{1,000}{907.9}\right)$ = 1.11 W/m^2

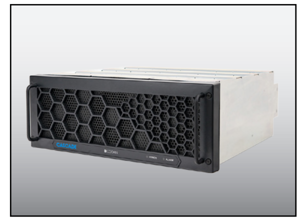
- 8.5 meters is a safe distance for Canada installations when using a 10dBi gain antenna.

When installing the antenna, the above relationship should be used to ensure the combination of power, antenna gain, and distance is such that the maximum permissible power density is not exceeded. Different combinations of output power and antenna gain will result in different minimum safe distances.

The minimum safe distance, from a radiating structure using different Gain Antennas"

- For the Band 152 to 174MHz with 2dBi Gain Antenna: d (safe distance) = 3.5 m
- For the Band 152 to 174MHz with 6dBi Gain Antenna: d (safe distance) = 5.5 m
- For the Band 152 to 174MHz with 10dBi Gain Antenna: d (safe distance) = 8.5 m

Contents



GENERAL INFORMATION

INTRODUCTION

The CASCADE product continues the Codan Radio Communications tradition of module-based products, where module capability expands into systems capability. CASCADE comes in a compact rack form factor of 19-inch width and 4U height, providing the flexibility of a mix of transceivers / power amplifier pairs; six receivers only or a mix of modules. From a transmitting point of view, CASCADE offers up to two 125-watt power amplifier / transceiver pairs capable of not only P25 Phase I, but also LSM and P25 Phase II.

This guide covers operation information for the CASCADE System subrack and front panel, and includes details on individual modules: DC-DC Power Supply, VHF Power Amplifier and VHF Transceiver.

BASE STATION / REPEATER SPECIFICATIONS

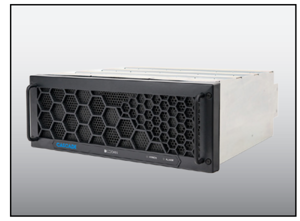
RECEIVER (RX)	
FCC Frequency Band:	150.8 to 173.4 MHz
IC Frequency Band:	148 to 174 MHz
Channel Spacing:	12.5 kHz
Channel Step Size:	1.25 kHz
Blocking Rejection:	≥ 100 dB
Frequency Switching Range:	Full Band
Reference Sensitivity (12 dB SINAD & 5% BER):	≤ -120 dBm
Adjacent Channel Rejection:	≥ 60 dB
Conducted Spurious Output Power (Analog):	≤ -95 dBm (9 kHz to 1 GHz)
Intermodulation Rejection:	≥ 80 dB
Hum & Noise Ratio:	*N/A
L.O. Frequency Stability:	≤ ± 0.5 ppm
Audio Distortion (Analog):	*N/A (≤ 2%)
Audio Output Level (600 Ω Balanced):	*N/A

TRANSMITTER (TX)	
FCC Frequency Band:	150.8 to 173.4 MHz
IC Frequency Band:	148 to 174 MHz
Channel Spacing:	12.5 kHz
Channel Step Size:	1.25 kHz
Frequency Switching Range:	Full Band
RF Output Power:	10 to 125W; 1W steps, adjustable
Duty Cycle:	100%
Undesired Emissions (Conducted Spurious):	≤ -90 dBc
Undesired Emissions (Adjacent Channel Power Ratio):	≥ 67 dB
Intermodulation Attenuation:	≥ 70 dB
FM Hum & Noise Ratio:	*N/A (≥ 45 dB Analog)
Carrier Frequency Stability:	≤ ± 0.5 ppm
Audio Distortion (Analog):	*N/A (≤ 2%)
VSWR Protection:	Any (with fold-back)
Emission Designators:	8K10F1D, 8K10F1E, 8K10F1W, 8K10F7W, 8K70D1D, 8K70D1E, 8K70D1W, 8K70D7W,9K80D7D, 9K80D7E, 9K80D7W, 11K0F3E

GENERAL SPECIFICATIONS:

Standby Current:	≤ 300 mA @ -48 VDC (no fan)		
Transmit Current:	≤ 7.25A @ -48 VDC (@ 125W with fans)		
Operating Temperature:	-30 to +60°C		
Dimensions (4RU):	**Width:**	**Height:**	**Depth:**
	48.3 cm / 19 in	17.6 cm / 6.95 in	50.2 cm / 19.8 in
Weight:	20.1 kg / 44.3 lbs [1 channel] 25.9 kg / 57.1 lbs [2 channel]		

* **CASCADE is not equipped with an analog audio input or output.**
Values noted are typical.
Equipment descriptions and specifications are subject to change without notice or obligation.



SAFETY INFORMATION

IMPORTANT SAFETY WARNINGS

To reduce the risk of personal injury and property damage, exercise caution and look for and comply with the safety symbols shown below.

STOP SIGN

When this symbol is shown, **DO NOT** continue until the safety items identified have been noted and addressed. Ignoring this reminder violates Codan standards of design for the product and will most likely result in severe personal injury or equipment damage.

CAUTION SIGN

When this symbol is shown, exercise caution and read the information carefully. If the corresponding procedure or information is not performed or applied correctly, the equipment may fail or performance may be compromised and personal safety could also be compromised.

NOTE:

When this symbol is shown, the selected information will add clarity to a procedure or provide additional information that will enhance the equipment performance.

- **Equipment Modification** – DO NOT modify any parts on this equipment. Contact Codan Radio Communications Service Department.
- **Radiation from Radio Frequency (RF)** – DO NOT touch the antenna when using the Transmitter. Always follow RF Safety Guidelines.
- **Exploding Hazard** – DO NOT operate the CASCADE equipment if flammable gas or gas fumes are present.
- **RF Burn Hazard** – DO NOT touch the output connector in an open circuit condition while transmitting. The amplifier RF output connector may produce risk of RF burns if operated with the output connector in an open-circuit condition. The power amplifier should always be operated with the specified load and connectors.
- **Personal Safety** – DO NOT operate or perform maintenance on the system without direct authority from Codan Radio Communications. Comply with all material handling regulations as many components are heavy and moving or lifting could cause physical injury.
- **Airflow Restriction** – DO NOT cover or restrict the cooling fans or vents; overheating can occur and cause serious damage.
- **Equipment Damage** – DO NOT lift the subrack by the front panel handles. The handles are not designed to bear the full weight of the subrack and fitted modules.
- **Hot Surface Hazard** – The Power Amplifier surface temperature may exceed safe touch temperatures when operated under high-power and/or high-ambient temperature conditions.
- **Shock Hazard** – Protect all CASCADE equipment from the possibility of lightning strikes and contact from any unspecified external power source.

Assembled subrack and modules weigh over 40 pounds (18+ kilograms). A two-person lift may be required.

SUBRACK AND FRONT PANEL SAFETY

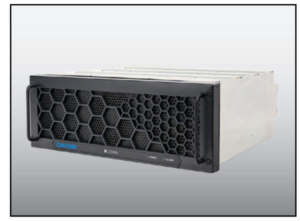
- A qualified service person is required to access the front panel area, even with equipment energized
- An unqualified user should not remove the front panel as no access is required to this area for any routine operation of the system
- The CASCADE subrack and modules should be well ventilated and free from high humidity and excess dust and dirt

Front Panel Installed – User Access

Hazard	Description
Heat Hazard	• Recirculated air may be hot in some scenarios • Handles may remain hot after exposure to high ambient air temperature within specifications
Mechanical	Improperly secured front panel may fall on operator
Radiation	Acoustic noise level may be hazardous, especially in multi-rack configurations

Front Panel Assembly Removed – Qualified Personnel

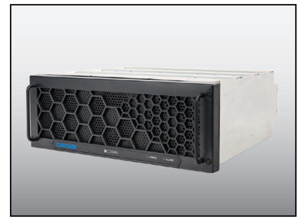
Hazard	Description
Energy Hazard	• All PSU +48V outputs and connected FIB circuits can source hazardous energy levels • PSU–PA power harness may remain energized at hazardous energy levels after disconnection from PSU side (PA input capacitor charge)
Heat Hazard	• TRx front panel may become hot under continuous operation • PA front panel and heatsink fins may become hot under continuous or intermittent operation • All metalwork may remain at hazardous temperature following prolonged high ambient conditions
Mechanical	• Rough edges are present on the subrack; lacerations are possible while adding or removing modules and connectors. • Operator may crush finger between rackframe and module handle when inserting leftmost or rightmost TRx module



REGULATORY INFORMATION

This product complies with the following safety regulations:

- FCC Title 47 – Part 22
- FCC Regulation §15.21
- ANSI C63.4-2014
- IC RSS-GEN, Sec 8.3
- IC RSS-102
- RSS-119 Issue 12
- FCC Title 47 – Part 15
- FCC Title 47 – Part 90
- FCC Regulation §15.19
- FCC Regulation §15.105
- ICES-003
- IC RSS-GEN, Sec 8.4



SYSTEM SETUP

The modules and full CASCADE subrack are very heavy. Use extreme caution when moving or lifting. Comply with all material handling regulations.

UNPACK THE SUBRACK

The CASCADE subrack ships from the factory with the modules installed, based on specific customer configurations. Unpacking procedures require two people (skilled in material handling procedures) to unpack and move the filled subrack.

MODULE CONFIGURATIONS

The following images identify the modules and their positioning in the subrack (see Figures 1–3).

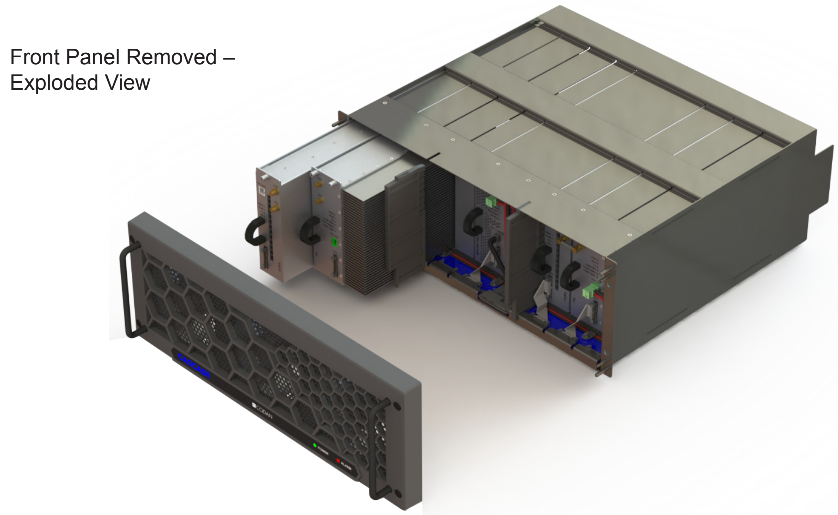


FIGURE 1: Complete CASCADE System

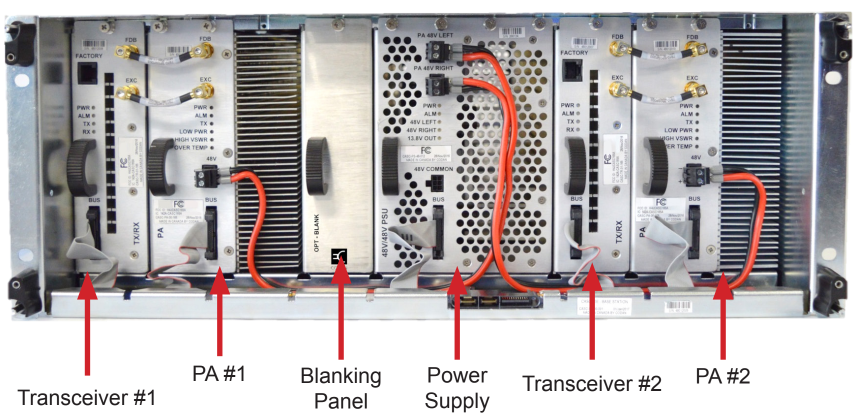


FIGURE 2: CASCADE System – Front View Two Channels Option

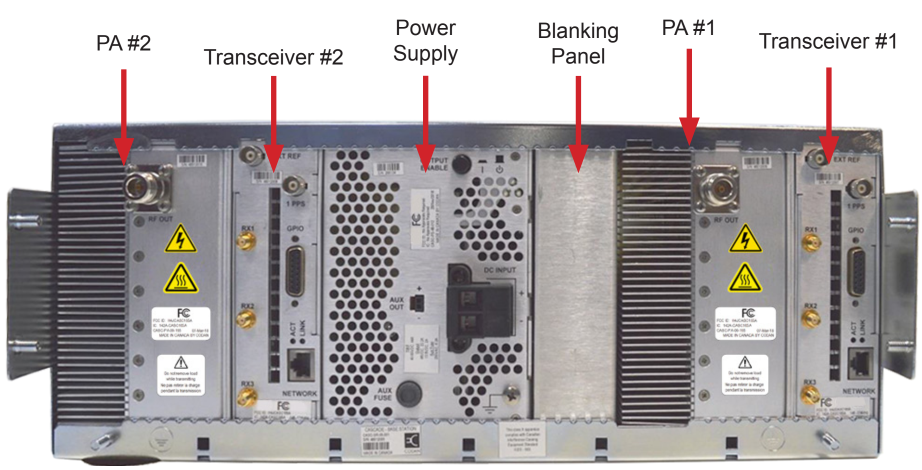
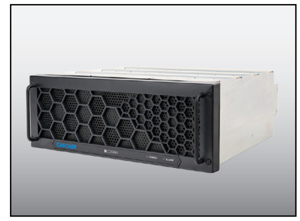


FIGURE 3: CASCADE System – Rear View Two Channels Option

CASCADE WEB GUI

CASCADE Web GUI is an innovative user interface for the CASCADE system. The GUI has many unique features including:

- Full remote access to the Cascade system – no need be preset at the radio site
- Remote access uses standard IT infrastructure – no need for adding communication infrastructure
- Most common Web browsers gives full access to the system – no need to install User Interface software.
- Access restrictions are implemented by using Login and Password protection
- Communication protocols are secure and encrypted
- Single User Interface let user manage multiple transceivers at one time
- Multiple features of the User Interface enables, but is not limited to:
    - Configuring receivers and transmitters
    - Managing users and passwords
    - Updating firmware and software
    - Saving and loading system configurations
    - Monitoring the system"s real time status
    - Performing basic PTT and BER tests



CASCADE THEORY OF OPERATION

The CASCADE product is capable of acting as an RF repeater or base station with up to two “Simultaneous Receive Channels” and up to two 125W “Simultaneous Transmit Channels”.

The CASCADE product is comprised of the following:

- A Subrack which houses all of the CASCADE Components (see Figure 4)
- A Power Supply, either AC to DC or DC to DC which supplies electrical power to all the modules
- Up to two RF Transceiver modules
- Up to two RF Power Amplifier modules
- A Front Panel which contains cooling fans and control circuitry
- A Front Interface Board which handles all the module to module communication

CAUTION

DO NOT LIFT the system by these handles. The handles are designed to remove and install the front panel, not to bear weight.

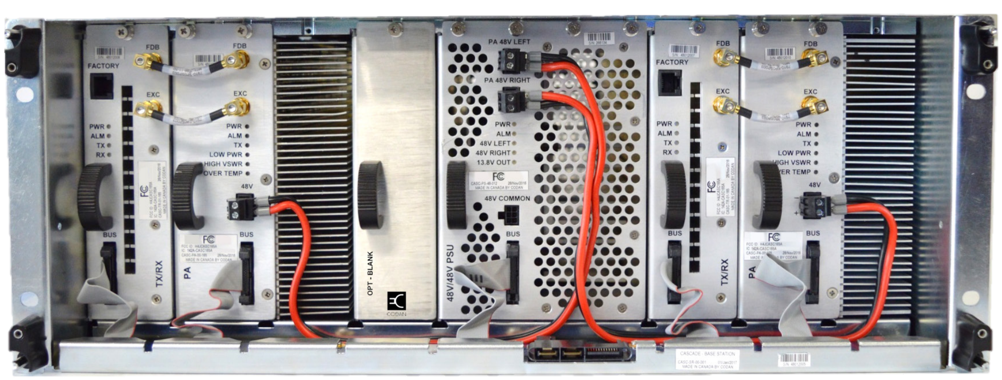
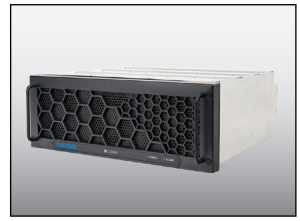


FIGURE 4: CASCADE Front Panel and Installed Modules

CAUTION

The CASCADE system requires adequate ventilation and ALL vents must be kept clear. The cooling fans will only work when the front panel is properly in place. Cooling airflow moves from the front of the unit to the rear of the subrack so the airflow must not be restricted in any way.



CASCADE POWER SUPPLY

INTRODUCTION

The power supply (PSU) is a DC-DC converter providing a low noise output with an ultra-high efficiency above 94.5%. It delivers up to 2x16.7A output current with 48V output voltage and is capable of operating from -30°C to 60°C. See Figure 5 for images of the CASCADE power supply.

The power supply is designed to provide sufficient power for a full CASCADE subrack containing two transceivers, two 125W power amplifiers, three fans and an option slot. The PSU can also be used in other configuration requiring less current, for example, a multiple receiver configuration (up to six transceivers).

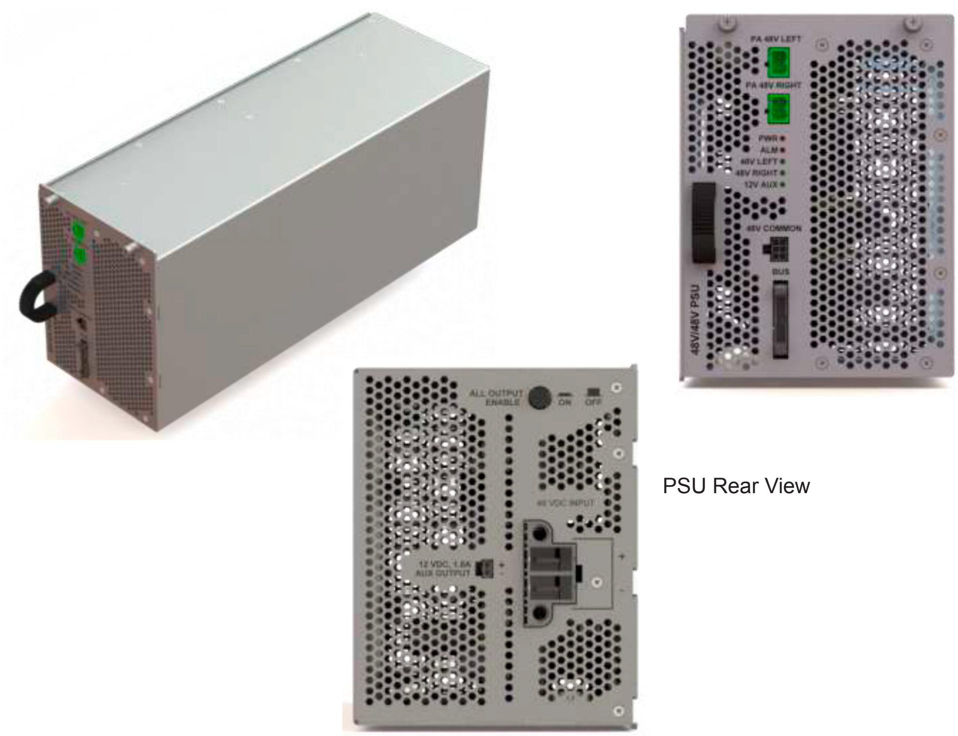


FIGURE 5: Power Supply – Side Front and Rear Views

INSTALLATION

The PSU slides in the 5th slot from the left of the CASCADE subrack (see Figure 6). The PSU is fastened with four Phillips screws in the front.

FIGURE 6: PSU Installed in Subrack

POWER CONNECTIONS

The power supply is NOT protected against reverse polarity and may get damaged, overheat and/or cause fire if not connected properly. The metal enclosure is labeled showing the positive and the negative polarity.

The PSU requires a DC power source providing a voltage between the operational ranges specified in the product specifications. The connector MUST BE CONNECTED WITH THE RIGHT POLARITY.

A ground connection is required on the back of the PSU using an M5 x 12 screw already installed (see Figure 7).

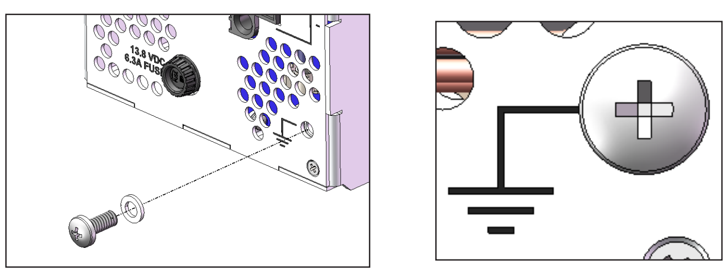


FIGURE 7: Ground Connection – Screw Installed

A 13.8V auxiliary connection is also located on the back of the enclosure. The connection polarity is labeled on the back of the enclosure (see Figure 8).

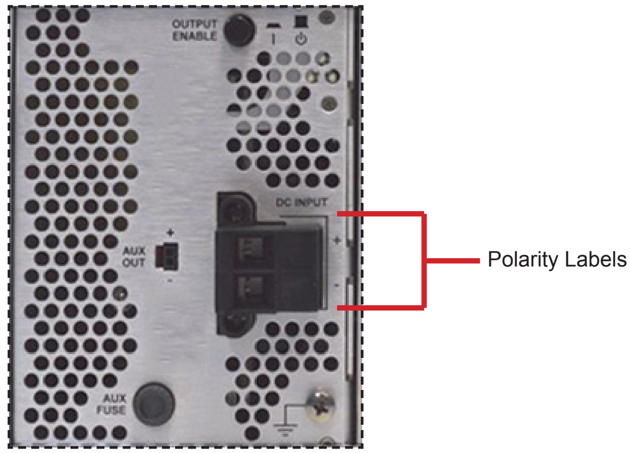


FIGURE 8: Power Supply Rear Panel – Connection Polarity

On the front the power supply are four connectors (see Figure 9). The top two connectors are intended for connection to the two power amplifiers. The six-pin **48V Common** connection must be connected to the Front Interface Board (FIB) using the appropriate cable.

The last connector on the front bottom is used to communicate with the other CASCADE components The connector uses a ribbon cable and is connected to the FIB in the connector (J5).

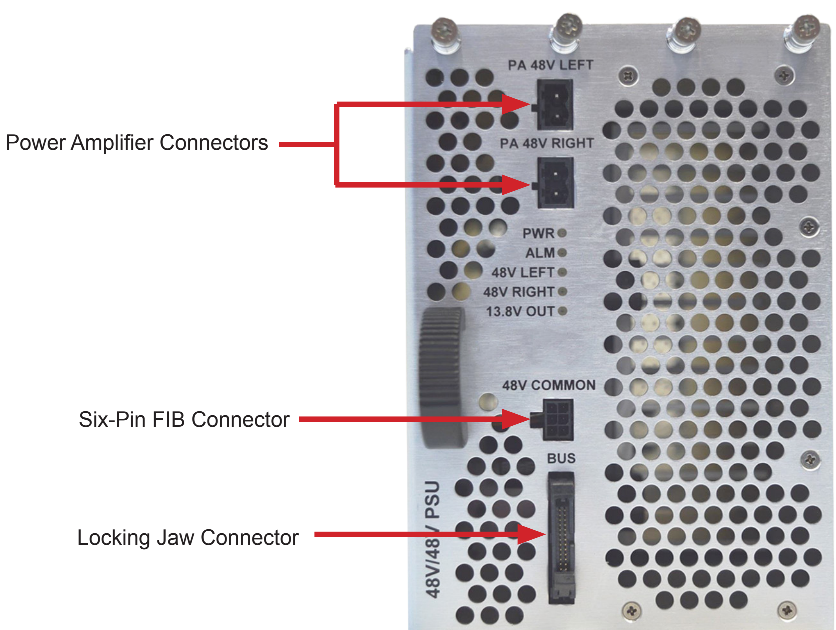


FIGURE 9: Power Supply Front panel Connectors

THEORY OF OPERATION

The PSU is designed to offer a stable, low noise, output signal of 48V. The main components are the two bricks converting the input voltage into 48V. Mounted on the mainboard (DC-DC -48V to 48V Isolated PSU) these bricks are designed for telecommunication purposes and provide the isolation required for CASCADE operation. An auxiliary board (-48V to 13.8V Isolated AUX) is also attached to the mainboard providing a 13.8V output voltage for external use.

The PSU is designed to be used in a CASCADE subrack with the fan assembly running. The PSU is not designed to be used as a standalone unit because it requires cooling for normal operations.

Input Filter

The input filter is used to limit the conducted emissions of the power supply and offer filtering for noise coming in or out of the PSU.

Temperature Sensors

For temperature monitoring, sensors (U11 and U12)—located close to the bricks—are monitoring the 48V board temperature and sending the exact temperature to the microcontroller (U10). The microcontroller in turn sends the measurements to the other components of the CASCADE via the FIB connection to control the fan speed.

For over-heating, three levels of protection are included:

1. **Software Protection** – if the temperature is too high, the CASCADE fan control system will automatically increase the fan speed to lower the internal temperature of the PSU.
2. **Pre-set Temperature Protection** – from the bricks themselves.
3. **Thermostats** – (48V: Q2, Q4 / 13.8V: Q2) connected to the On/Off connection and at a factory preset temperature of 95°C. These thermostats turn the converter OFF if the board temperature is higher than the preset temperature.

Voltage and Current Measurement

For the 48V right and left and the 13.8V, the current and voltage is measured independently and the information is transmitted to the microcontroller. The microcontroller is comparing the levels within its preset nominal levels and enables the corresponding LED in the front of the enclosure. In case of errors, the alarm light will be ON and the corresponding output LED will be OFF.

Auxiliary Voltages

For the digital section of the 48V board, three different voltage levels are required:

- 5.6V (U15)
- 5V (U9)
- 3.3V (U16)

The voltage converters receive an input from the DIG_Vcircuit powered by either the auxiliary 48V coming out of U2, U5 or the 13.8V.

Microcontroller (U10)

The power supply's logic is only used to report its state, including: voltages, currents and temperature to the other components of the CASCADE. The microcontroller receives input from different sections of the PSU and can activate LED lights in the front of the unit and transmit this information via the FIB.

Alarms and Status

Five LED lights on the front of the enclosure provide the basic information about the power supply status. These LEDs include:

- Power Light (PWR)
- Alarm Light (ALM)
- 48V Left Status (48V LEFT)
- 48V Right Status (48V RIGHT)
- 13.8V Status (13.8V OUT)

Two signals: IOG_48V_LEFT and IOG_48V_RIGHT are also used to monitor the status of each DC-DC Converter brick.

Operation

To operate the power supply, an output enable button located in the back of the enclosure turns the device's output ON (see Figure 10).

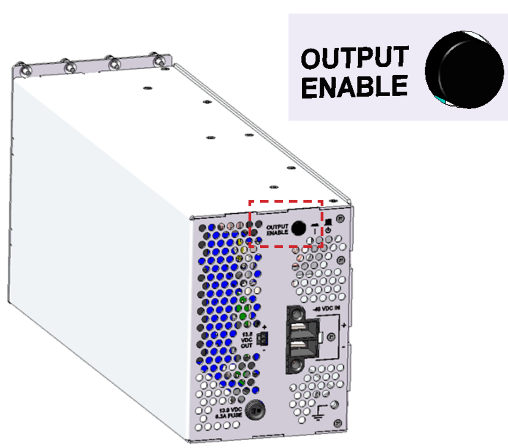


FIGURE 10: Output Enable Button Location

Protection

DC-DC -48V to 48V Isolated PSU Board

Input

Name	Fuse Type	Location
48V Right	40A, 250V Fast-Acting (F5)	Inside the enclosure
48V Left	40A, 250V Fast-Acting (F2)	Inside the enclosure

Output

Name	Type	Location
48V_L_FP	3.75A, Resettable (F5) (Section 5.3)	Inside the enclosure
48V_R_FP	3.75A, Resettable (F3) (Section 5.3)	Inside the enclosure
48V_C_FP	3.75A, Resettable (F4) (Section 5.3)	Inside the enclosure
+48V_L	Internal. Foldback, then hiccup past 17.6A	In U2[1]
+48V_R	Internal. Foldback, then hiccup past 17.6A	In U2[1]

[1] Refer to the PSU block diagram in the CASCADE Power Supply section for details.

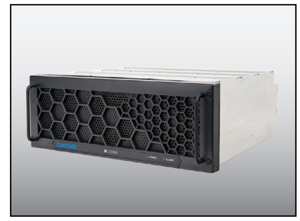
-48V to 13.8V Isolated AUX PSU

Input

Fuse	Type	Location
48V	2A, 250V Fast-Acting (F3)	Inside the enclosure

Output

Fuse	Type	Location
13.8V	2A, 250V Fast-Acting (F1)	Inside the enclosure



CASCADE TRANSCEIVER

INTRODUCTION

The CASCADE Transceiver (TRx) is a full duplex software controlled radio (see Figure 11) and is comprised of:

- An **RF PCB** that contains the Transmit, Receive and Clock Distributions sections
- A **Digital PCB** that contains the user interfaces and a single board computer which acts as the brains of the CASCADE product

FIGURE 11: Transceiver Module

RECEIVER THEORY OF OPERATION

The CASCADE Receiver is a standard superheterodyne architecture. It can demodulate Analog FM and Digital C4FM (P25 Phase I) modulation and is composed of four main sections:

- RF Front End
- IF Filtering and Amplification
- Analog RF to Digital Conversion
- LO Synthesis

The **RF Front End** includes all the receiver circuitry from the antenna input to the mixer. This includes a bandpass filter, an LNA and a second bandpass filter used for *image rejection*.

The first bandpass filter is wide band over the entire switching range of the receiver. It blocks any strong out-of-band interfering signals from entering the receiver. The LNA provides the first stage amplification and increases the sensitivity of the receiver. The image-reject filter also helps to block the out-of-band interfering signal as well as eliminate any image frequency response of the receiver.

The **IF Filtering and Amplification** stage includes a mixer, crystal filters, an LNA and some automatic gain control circuitry (AGC).

The AGC Circuitry protects the components from being overdriven by a high-level signal. The mixer down-converts the incoming RF signals from the front end to a lower intermediate frequency (IF) which is then filtered by highly selective crystal filters and amplified again by the IF LNA. This decreases the noise floor and increases the sensitivity of the receiver. The crystal filters also help provide excellent in-band, off-channel filtering.

The **Analog RF to Digital Conversion** is handled by an integrated circuit. The IF frequency is downmixed to another lower 2nd IF frequency which is directly sampled with a sigma-delta ADC and converted to a digital baseband signal. This digital signal then passes through two FIR filters before it is sent off to the single board computer on the digital PCB for more signal processing.

Two stages of **LO Syntheses** happen in this receive chain.
The **1st LO** is a programmable frac-n synthesizer. This LO feeds directly into the mixer in the “IF” section and is used in the RF-to-IF down conversion process. The LO’s ability to be programed to any required frequency over the entire receiver band is what allows this receiver to be software programmable to any receiver channel by the user without having to do any manual tuning.

The **2nd LO** is generated in the “clock distribution” section of the RF PCB. It feeds directly into the integrated circuit that handles the digital downmixed conversion discussed above. It is used in the process of converting the main IF frequency to the second lower IF frequency.

TRANSMITTER THEORY OF OPERATION

The transmitter portion of the CASCADE transceiver is a linearized amplifier capable of the following modulation schemes:

- Narrowband Analog FM (12.5kHz channel)
- P25 Phase 1 (C4FM)
- LSM (CQPSK)
- P25 Phase 2 (π/4-HDQPSK)

To facilitate these different modulation schemes, the transmitter is comprised of the following sections:

- Baseband processing
- Cascaded local oscillator synthesis
- RF amplification
- Cartesian feedback linearization

The baseband processing converts the digital data into analog I/Q signals to drive the RF chain. The I and Q signals contain the modulation information that is used by the Cartesian feedback linearization to modulate the cascaded local oscillators and generate the final RF output.

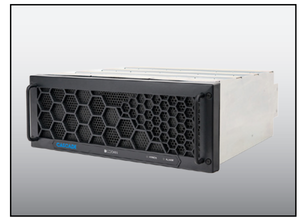
Two high performance RF synthesizers are used to generate the local oscillator for the transmitter. These synthesizers are cascaded together to allow for easy integer boundary spur steering. The first oscillator is used as a tunable reference for the second oscillator which generates the RF LO at twice the RF output frequency.

The output of the RF LO is differential; the signal is kept at a high level to maintain the high phase noise performance of the synthesizer and is then attenuated to a level that is acceptable to that of the Cartesian feedback linearizer.

Cartesian Loop

The Cartesian Loop is an analog linearization technique. Analog I and Q signals are used to modulate a local oscillator to generate the RF output. A portion of this output power is fed back into the CMX998 (Cartesian feedback loop transmitter IC) and downmixed to baseband.

This baseband signal consists of the original transmitted signal plus any non linearities associated with the external circuitry. The baseband signal from the feedback port is subtracted from the original input signal to get an inversion of the non linearities which is then added to the original input signal to compensate for the non-linearities in the external circuitry.



CASCADE POWER AMPLIFIER

DO NOT install or service the CASCADE Power Amplifier.
Contact Codan Radio Communications.

INTRODUCTION

The CASCADE Power Amplifier (PA is designed to operate in the CASCADE subrack (see Figure 12). The PA provides variable gain (35dB nominal) enabling 1W adjustable power steps amplifying an input signal to a nominal output level between 40dBm and 51dBm. A scaled sample of the output is provided as a control to enable the use of the amplifier in a Cartesian linearization loop. Fault conditions are monitored and reported to the control unit, as well as indicated by LEDs on the front panel.

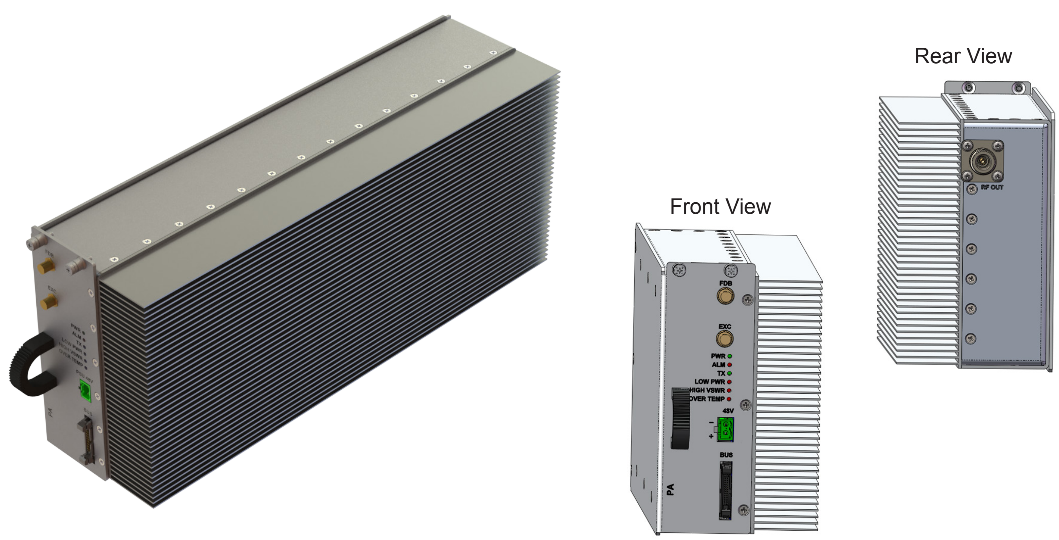


FIGURE 12: Power Amplifier Module

INSTALLATION

One or two power amplifiers can be inserted into the CASCADE subrack. The power amplifier is fastened with two Phillips screws at the front of the subrack (see Figure 13).

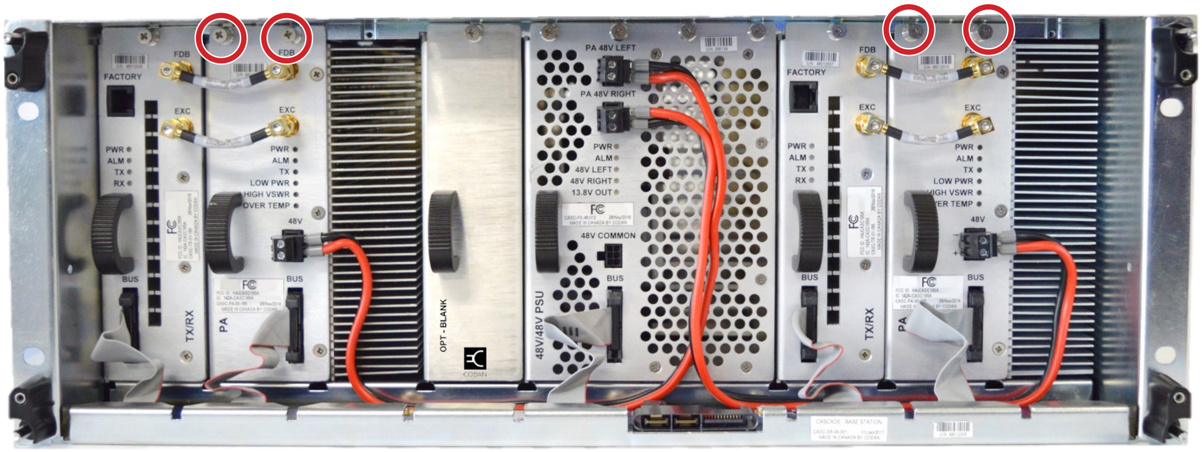


FIGURE 13: Power Amplifier Subrack Locations

CONNECTIONS

The PA requires DC power from the 48V PSU which is supplied to the front of the PA. The ribbon cable connector on the bottom front is used to communicate with the other components of the CASCADE system. The input and sampled output signals are connected to the transceiver units via short cables with SMA connectors. The output is delivered via a Type-N female connector at the back.

THEORY OF OPERATION

The PA is designed to amplify an input signal with modulation characteristics that produce a spectrum with a 5dB peak to average ratio with high fidelity when operated in a Cartesian loop. A further requirement is that the output should be variable in 1W steps from 40dBm (10W) to 51dBm (125W) nominal. This is accomplished by internal variable attenuators in the amplification path as well as in the sampled output path setting up the appropriate power window for the Cartesian loop controlled from the transceiver module.

The output voltage standing wave ratio (VSWR) is monitored, as well as the heatsink temperature. Protective action is taken under severe thermal and VSWR, as well as fault conditions by the control system.

Digital Control Board

The function of the digital control board is to provide all the management and control functions for the PA, generate the supply voltages for the 40dBm stage and manage the communication with the rest of the CASCADE subsystem.

40dBm Stage

The 40dBm stage takes the input signal and amplifies it to the level needed for the 53dBm stage to further amplify it to the required power setting. This stage also controls the attenuators in the amplification and feedback paths for the proper operation of the Cartesian loop in conjunction with the digital control board.

53dBm stage

This stage does the final amplification of the signal and also contains the directional couplers and associated circuitry for the monitoring of the output VSWR and for the sampled output feedback signal. An harmonic filter is also included in this board.

Isolator

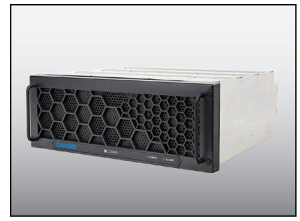
The isolator is integrated into the PA to provide additional protection against bad VSWR conditions.

Alarms and Status

Six LEDs on the front of the PA provide the basic information about the power amplifier status and potential fault conditions. These LEDs include DC power, alarm and transmit status indicators; and low power, high VSWR and over-temperature fault condition indicators.

Operation

The PA can only be operated as a module or as modules in the CASCADE subsystem. Standalone operation is not the purpose of this CASCADE module.

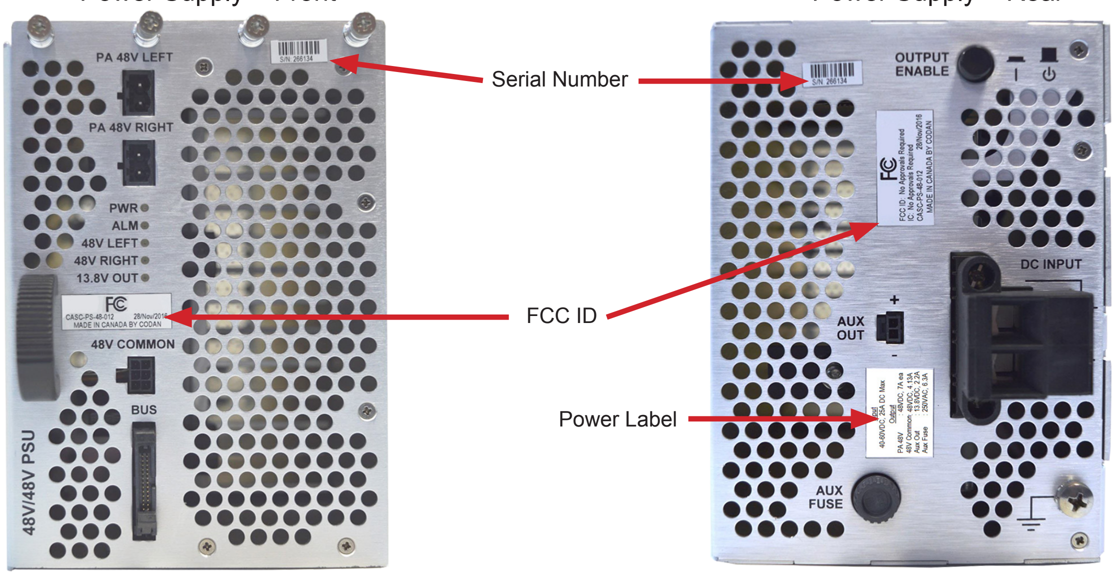


PRODUCT LABELING

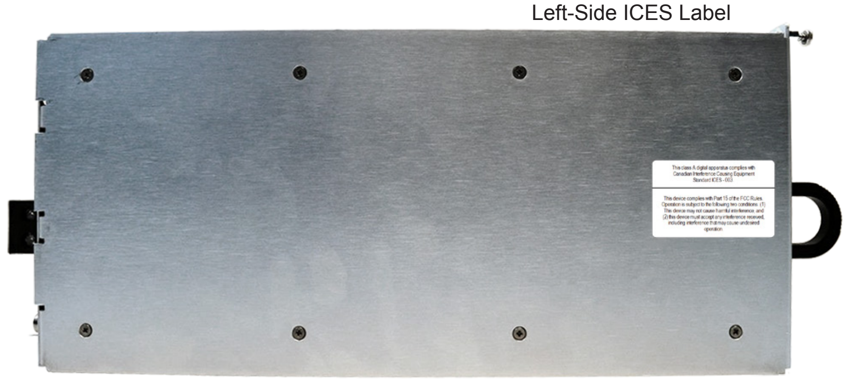
POWER SUPPLY LABELS

Power Supply – Front

Power Supply – Rear

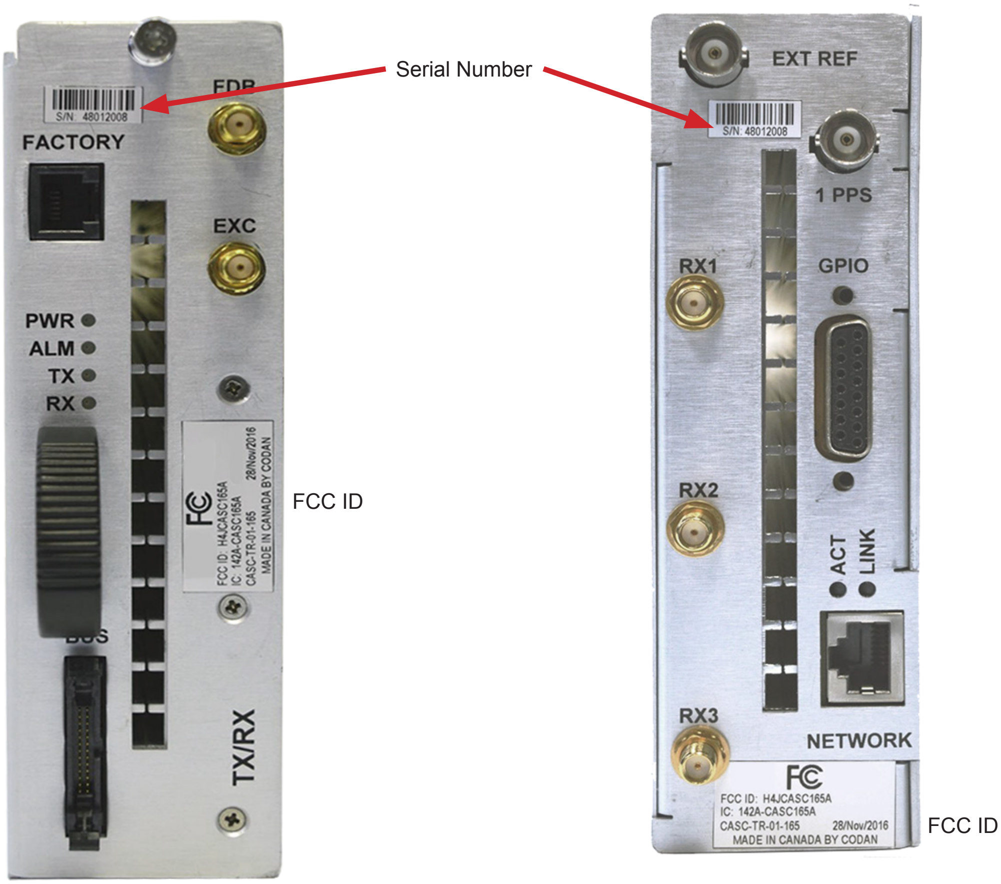


Left-Side ICES Label

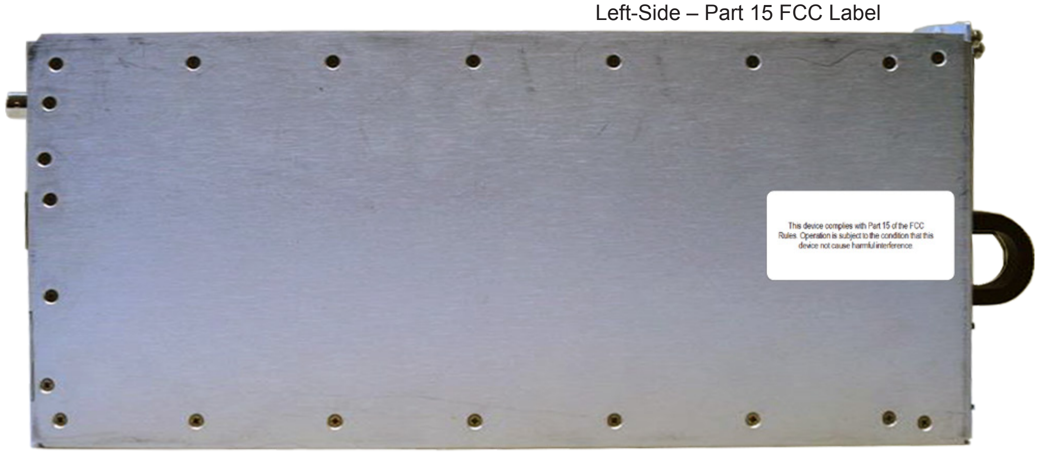


TRANSCEIVER LABELS

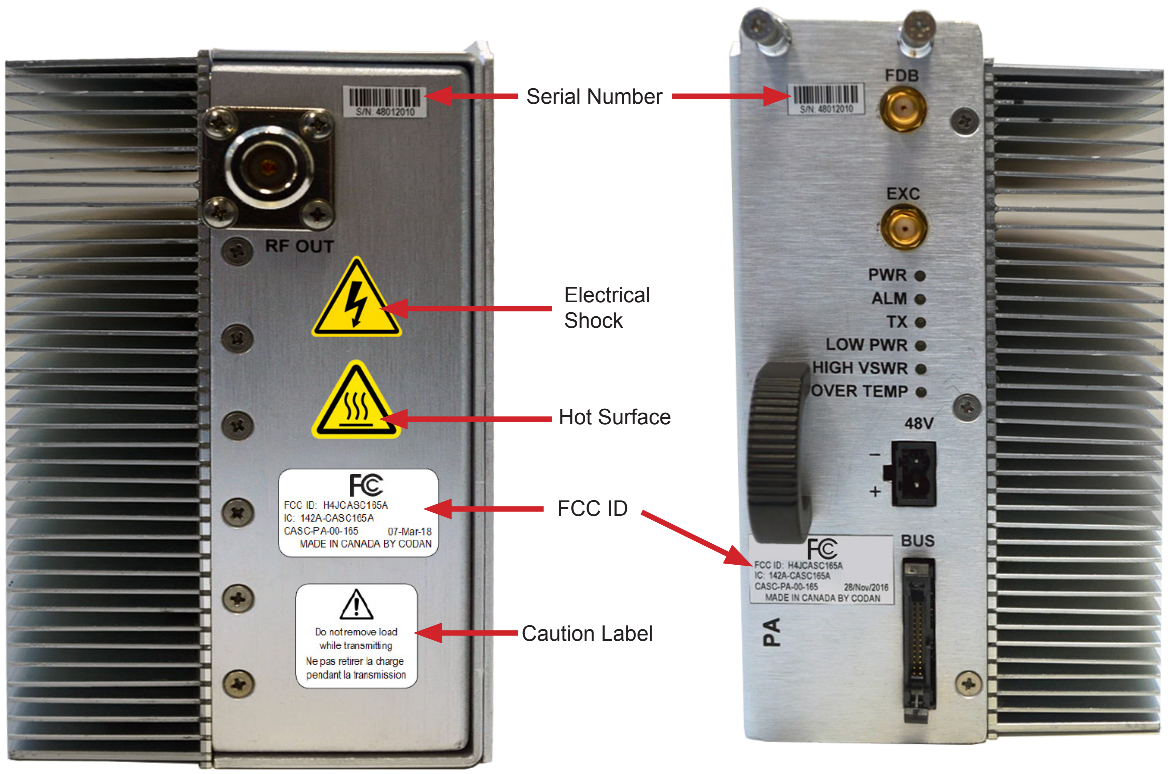
Transceiver – Front | Transceiver – Rear



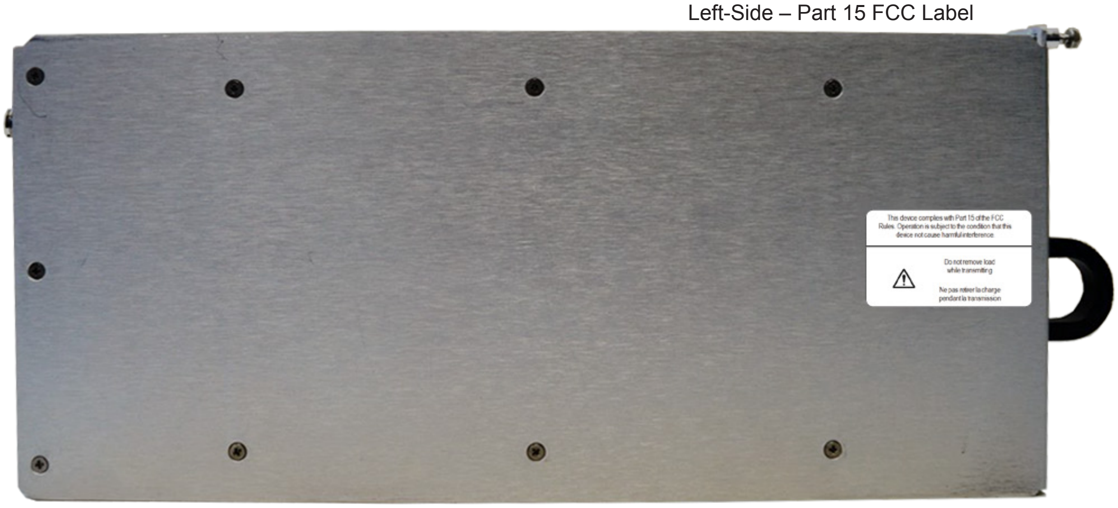
Left-Side – Part 15 FCC Label



POWER AMPLIFIER LABELS



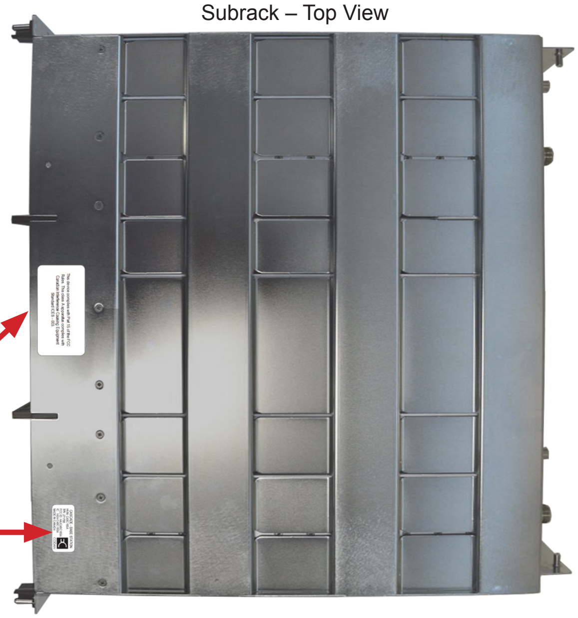
Left-Side – Part 15 FCC Label



FRONT PANEL AND SUBRACK LABELS

NOTE:
This warning label will be applied to the product before shipping.

Subrack – Top View



Class A – ICES

Product ID & Serial Number

Subrack – Rear View

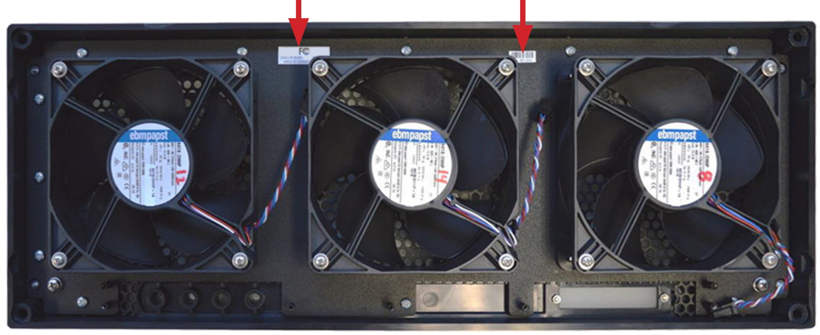
Product ID & Serial Number

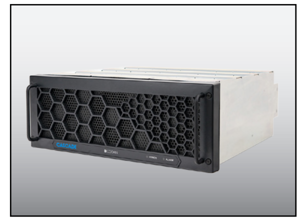
Class A – ICES

FCC ID

Serial Number

Front Panel – Rear View





GLOSSARY OF TERMS

AM	Amplitude Modulation
ANSI	American National Standards Institute
CAP	Compliance Assessment Program
CISPR	Comité International Spécial des Perturbations Radioélectriques International Special Committee on Radio Interference
EN	European Committee for Standardization
ETSI	European Telecommunications Standards Institute
EUT	Equipment Under Test
FCC	Federal Communications Commission
FM	Frequency Modulation
FP	Front Panel
HW	Hardware
IEC	International Electrotechnical Commission
IC	Industry Canada
LED	Light Emitting Diode
LSM	Linear Simulcast Modulation
MU	Measurement Uncertainty
PA	Power Amplifier
pk–pk	Peak to Peak
PSU	Power Supply
PTT	Push To Talk
VSWR	Voltage Standing Wave Ratio