CPI ModuMAX SSPA Systems

C, X, and Ku-Bands

ModuMAX SSPAs are completely modular RF amplifier systems

Output powers of up to 1500 watts in C Band, 1250 watts in X-Band (configured for Multi Carrier Operation — Low PIM), or 800 watts in Ku-Band. Patented technology utilizes hot-swappable, plug-in RF modules, power supplies, and electronic assemblies to maximize performance and minimize downtime.

CPI ModuMAX SSPA series:
high power, fully redundant, patented technology

True High-Power HOT-SWAP Modular System

- Switchless redundancy
- No switching, no external hot standby required

Configurable Power Levels

- N+X redundancy in a single system
- Configure operating RF power level as required for application and mission

Extremely Low MTTR

- Less than 3 minutes for module replacement

Full Diagnostics

Intelligent, Ultra-High Efficiency Power Supply System

Single Module Failure Compensation Feature

FEATURES:

- Modular architecture
- Three year all-inclusive warranty
- Worldwide service
- Proven reliability

POWER AND FREQUENCIES:

- **C-Band**
  - 3000 watts
  - 1500 watts
  - 1000 watts
  - 800 watts
- **X-Band**
  - 2200 watts
  - 1250 watts
  - 700 watts
- **Ku-Band**
  - 1500 watts
  - 800 watts
  - 500 watts
  - 350 watts

CPI Communications & Power Industries

www.cpii.com/satcom

Introduction

Satellite communications providers face significant risk when the link to a satellite is disrupted. Critical applications go offline, customers lose confidence, and revenue is lost as providers scramble to recover the link. Thus, most satellite earth stations employ brute-force redundancy, i.e. two of everything, to reduce the risk, but at significant cost and increased complexity. When the final amplifier stage was a single tube and thus a single point failure, having a second amplifier immediately available was a pragmatic solution. However, with the demonstrated viability and practicality of solid state amplifiers, non-brute-force redundancy solutions offer significant cost and performance advantages.

Built-in Redundancy

Solid-state power amplifiers (SSPAs) consist of multiple transistors in parallel, and consequently contain built-in redundancy. Utilizing multiple parallel RF modules, power supplies and cooling fans, CPI ModuMAX SSPAs are extremely reliable and fault-tolerant. With the ModuMAX series, one fault-tolerant SSPA can replace two conventionally designed high power amplifiers yielding significant installation savings and reduced operating costs.

Due to its internal architecture and unique operating features such as single-module failure compensation and configurable power, ModuMAX is designed to eliminate the need for a redundant, stand-by unit in most applications.

RF Plug-In Modules

The RF plug-in modules are conveniently accessible from the front panel. Summary module status is visually indicated by a multicolor indicator on each module with detailed information available at the control panel display and via remote M&C.

Failure of a single module causes a drop of approximately 1.2 dB in output power without the momentary loss of signal caused by redundant switchover systems. Defective RF modules can be hot-swapped while the SSPA continues to operate. Since they contain only a fraction of the RF power transistors in the SSPA, spare RF modules are affordable.

Easy to Operate and Maintain

ModuMAX SSPAs are designed to be easy to operate and maintain. All features can be fully remote controlled through standard RS-232/-422/-485 and network interfaces. For quick and easy manual access, the most commonly used controls are located on the front panel.

Most maintenance can be performed safely while the SSPA continues to operate. Any of the eight fans in the air-cooling system can be easily removed and replaced, without ever taking the SSPA off-line. Even the power supply modules are redundant and hot swappable.

Configurable Power

ModuMAX SSPAs combine the RF output power from eight identical, fully interchangeable RF plug-in modules (16 in a phase-combined system) to obtain the rated power capacity. These modules can be individually turned on or off via either local or remote control. Installations can exploit this feature to reduce prime power consumption during times when the required RF output power is lower than the maximum linear power capacity of the amplifier. This ability to adjust the number of enabled RF modules to match the output power requirement is called configurable power.

Additionally, the amplifier modules can also be employed in an N+X redundancy configuration where, in the event of a fault occurring in the online modules, the available spare modules can be brought on line rapidly via M&C.

Configurable power is implemented by determining the minimum number of modules that must be enabled to provide the required RF output power. Any modules not needed to support the system traffic load are deactivated, either locally or via one of the remote interfaces. When the system is operating, the remote M&C system monitors the ModuMAX for faults. If the M&C system detects a fault in an enabled amplifier module, it immediately enables one of the deactivated modules to compensate for the loss.

No warm-up time is required; the amplifier modules become functional immediately upon enabling.

Configurable power allows prime power consumption to be significantly reduced by deactivating modules while still meeting the system RF power requirements. While power consumption is approximately proportional to the number of enabled modules, RF output capacity decays as shown in the following table.

RF Power Drop per Module Loss

Single ModuMAX		Phase-Combined ModuMAX System			
Loss of n Modules	RF Power Drop (dB)	Loss of n Modules	RF Power Drop (dB)	Loss of n Modules	RF Power Drop (dB)
1	1.16	1	0.56	9	7.18
2	2.50	2	1.16	10	8.52
3	4.08	3	1.80	11	10.10
4	6.02	4	2.50	12	12.04
5	8.52	5	3.25	13	14.54
6	12.04	6	4.08	14	18.06
7	18.06	7	5.00	15	24.08
—	—	8	6.02	—	—

Phase-Combined Systems

A pair of ModuMAX SSPAs can be phase combined in a single 45 RU rack utilizing a fixed (hybrid) or variable phase combining (VPC) system. The VPC system affords flexibility to configure the system for operation using either ModuMAX SSPA individually (single mode), or using both simultaneously (phase-combined mode) to nearly double the system output power. A phase-combined ModuMAX system has a total of 16 RF modules (8 in each of 2 RF units); with 16 modules, one failed module causes only about 0.6 dB drop in output power.

Power

For lower power systems, operating power is supplied by four identical plug-in power supply modules in a rack-mount chassis; higher output systems require six modules (two PS chassis) per RF unit for full redundancy. If a module fails, the remaining ones can supply 100% of the required load current and the defective module can be hot-swapped without interruption.

ModuMAX SSPAs can be connected to 120/208 VAC or 230/400 VAC three-phase sources, or to single-phase 180–264 VAC, supporting installation worldwide.

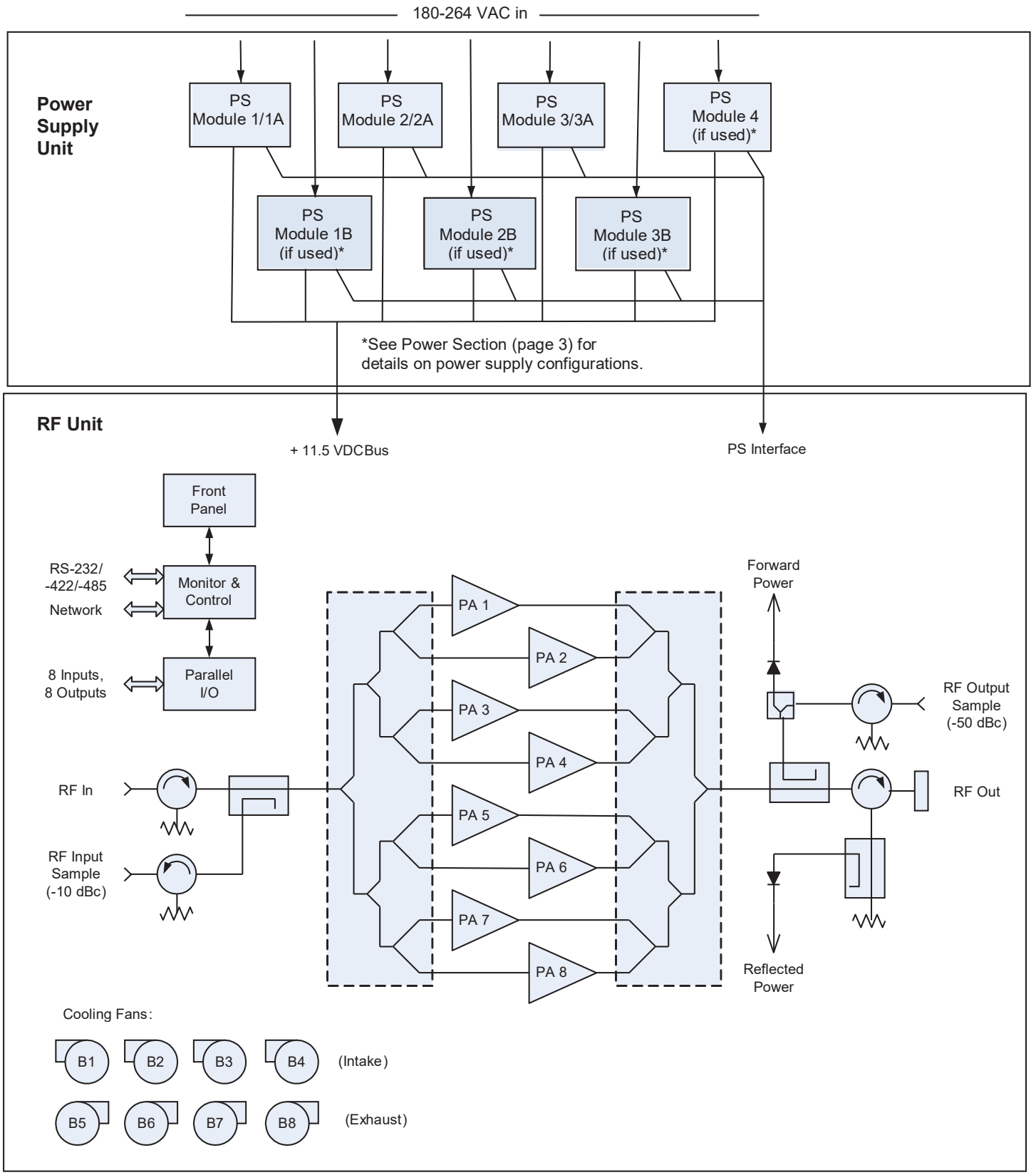
Cooling System

ModuMAX also incorporates redundancy into its integral forced-air cooling system. Sufficient cooling margin is built into the design to tolerate the loss of one cooling fan. Fans are monitored for rotational speed, and failure of a fan is indicated on the control panel display. In the event of a fan failure, the SSPA can continue to operate until a replace-ment is installed. The air cooling system utilizes separate rear panel air intake and exhaust ducts and can be vented either outdoors or into the room.

Global EMC and Safety Compatibility

ModuMAX SSPA systems are certified to applicable EU EMI/EMC and safety standards.

Ref. Des.	Function	Connector Type	Mating Connector	Comment
RF Unit				
J1	RF Input	Type N Female	Type N Male	
J2	RF Output	CPR137G/CPR112G/WR75G Waveguide	CPR137/CPR112/WR75 Flange	C-/X-/Ku-Band
J3	DC In	Bus Bars	Ring Terminals	Supplied
J4	Serial I/O	9-pos D, Female	9-pos D, Male	Supplied
J5	Parallel I/O	37-pos D, Male	37-pos D, Female	Supplied
J7	System Interface	15-pos D, Male	15-pos D, Female	Used with optional maintenance switch
J9	PS Interface	9-pos D, Male	9-pos D, Female	Supplied
J10	RF Input Sample	Type N Female	Type N Male	On front panel
J11	RF Output Sample	Type N Female	Type N Male	On front panel
A15	Network Interface	RJ-45 Receptacle	RJ-45 Plug	Ethernet 10 Base T
Power Supply Unit				
+12 V, RTN	DC Output	Bus Bars	Cable Lugs	Supplied
TB1, TB2	AC Input	Terminal Block	Wires	
J4	Remote	9-pos D, Female	9-pos D, Male	Supplied
J5	Status	9-pos D, Male	9-pos D, Female	Supplied
J6	Sync	RJ-45	RJ-45	Supplied, if used
J7	Sense	9-pos D, Female	9-pos D, Male	Supplied


180-264 VAC in
Power Supply Unit
PS Module 1/1A
PS Module 2/2A
PS Module 3/3A
PS Module 4 (if used)*
PS Module 1B (if used)*
PS Module 2B (if used)*
PS Module 3B (if used)*
*See Power Section (page 3) for details on power supply configurations.
RF Unit
+ 11.5 VDC Bus
PS Interface
Front Panel
RS-232/ -422/-485 Network
Monitor & Control
8 Inputs, 8 Outputs
Parallel I/O
RF In
RF Input Sample (-10 dBc)
PA 1
PA 2
PA 3
PA 4
PA 5
PA 6
PA 7
PA 8
Forward Power
Reflected Power
RF Output Sample (-50 dBc)
RF Out
Cooling Fans:
B1
B2
B3
B4
(Intake)
B5
B6
B7
B8
(Exhaust)

Parameter	Notes	Specification
Frequency Range (1)	C-band, Standard (MPCD-) C-band, Extended (MPCM-) C-band, INSAT (MPCL-) X-band, Std (MPXB-) Ku-band, Std (MPKM-) Ku-band, Ext (MPKO-) Ku-band, INSAT (MPKJ-)	5.850 to 6.425 GHz 5.850 to 6.725 GHz 6.725 to 7.025 GHz 7.900 to 8.400 GHz 14.00 to 14.50 GHz 13.75 to 14.50 GHz 12.75 to 13.25 GHz
Gain, at Maximum Setting	C-band, X-band and Ku-band	70 dB min. to 75 dB max. 65 dB min. to 70 dB max.
Gain vs. Temperature	0 to 50° C	±0.75 max., ±0.5 typical
Gain Adjustment Range	Digital	20 dB min. in 0.1 dB steps
Gain Flatness		±1.0 dB over the full band; ±0.3 dB over any 40 MHz
Saturated / P1dB Output Power	1500 W C-band 1000 W C-band (D-band) 800 W C-band (D & M bnd) 1250 W X-band 700 W X-band 800 W Ku-band 500 W Ku-band 350 W Ku-band	+62.0 dBm typ. (1500 W) / +61.3 dBm min. (1384 W) +60.0 dBm typ. (1000 W) / +59.5 dBm min. (900 W) +59.0 dBm typ. (800 W) / +58.5 dBm min. (708 W) +61.0 dBm typ. (1250 W) / +60.3 dBm min. (1072 W) +58.5 dBm typ. (700 W) / +58.0 dBm min. (620 W) +59.0 dBm typ. (800 W) / +58.0 dBm min. (630 W) +57.0 dBm typ. (500 W) / +56.2 dBm min. (400 W) +55.5 dBm typ. (350 W) / +54.8 dBm min. (300 W)
Two Tone Intermodulation		-25 dBc max.. at 3 dB backoff from P1dB (-30 dBc typical)
Residual Noise, C-Band	5.850 - 6.425 GHz 3.4 - 4.2 GHz	-70 dBW/4 kHz max. -160 dBW/4 kHz max.
Residual Noise, Ku-Band	14.0 – 14.5 GHz	-70 dBW/4 kHz max.
Group Delay	Linear Parabolic Ripple	0.03 ns/MHz 0.003 ns/MHz^2 1.0 ns peak to peak
AM/PM Conversion		3.5°/dB max. at P1dB output power (2.5°/dB typical)
Second Harmonic		-60 dBc max. at P1dB output power
Spurious		-70 dBc max. at P1dB output power
VSWR		1.3:1 max, input and output, 1.2:1 typical
Sample Ports	Input Output	-10 dBc typical -50 dBc typical
Power Requirements	Single or 3-phase	180 to 264 VAC, 47 to 63 Hz
Power Consumption	1500 W C-band 1000 W C-band (D-band) 800 W C-band 1250 W X-band 700 W X-band 800 W Ku-band 500 W Ku-band 350 W Ku-band	7.0 kW typ; 9.3 kW max. (2) 5.0 kW typ; 7.5 kW max. (2) 4.9 kW typ; 6.5 kW max. (2) 7.0 kW typ; 9.0 kW max. (2) 4.9 kW typ; 6.5 kW max. (2) 7.0 kW typ; 9.3 kW max. (2) 5.4 kW typ; 7.2 kW max. (2) 5.4 kW typ; 7.2 kW max. (2)
Cooling System	Forced Air	Volumetric Air Flow - RF Unit: 400 CFM typical PS Unit: 125 CFM max., 75 CFM typical
Operating Temperature	Ambient/Inlet air	1500 W C, 1250 W X, 800 W Ku: 0°C to +45°C All other power levels: 0°C to +50°C
Storage Temperature	Non-operating	-45°C to +85°C
Relative Humidity		95% non-condensing
Altitude Derating	10,000 ft (3000 m) max.	Derate 2°C per 1000 ft (300 m)
Dimensions	RF Unit (13 RU panel height) Pwr Supply (3 RU Panel ht.)(3)	19.0" W x 22.72"H x 27.38" D; 483 mm W x 577 mm H x 695 mm D 19.0" W x 5.22" H x 23.42" D; 483 mm W x 133 mm H x 595 mm D
Weight	RF Unit Power Supply	253 lbs (115 kg) 53 lbs (24 kg)

(1) Consult factory for non-standard frequency bands.
(2) Cold start at 0°C and saturated output.
(3) 1500 W C-Band, 1250 W X-Band, and 800 W Ku-Band systems require two Power Supply Units.

C-Band

MPC□6□□M

5.850-6.425 GHz = D	800 W = 800 1000 W = 1000 1500 W = 1500
5.850-6.725 GHz = M	800 W = 800 1500 W = 1500
6.725-7.025 GHz = L	1500 W = 1500

X-Band

MPX□8□□M

7.90-8.40 GHz = B	700 W = 700 1250 W = 1250

Ku-Band

MPK□14□□M

14.00-14.50 GHz = M	350 W = 350 500 W = 500 800 W = 800
13.75-14.50 GHz = O	350 W = 350 500 W = 500 800 W = 800
12.75-13.25 GHz = J	800 W = 800

Each SSPA system includes an RF Unit, a Power Supply Unit or Units, interconnecting cables, mating connectors, rack slides, and mounting hardware. All features described in this specification are included as standard equipment.

Option Kits (Order separately):

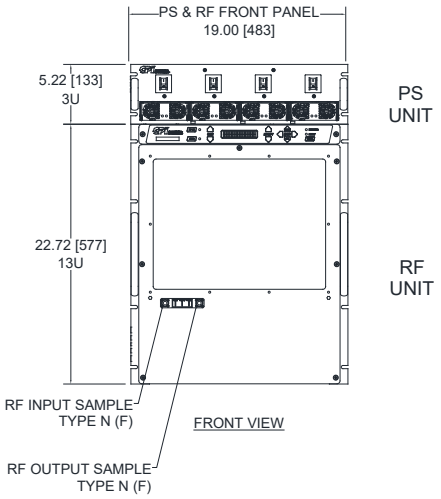
- **45 RU Rack Cabinet (standard).** See also Rack Cabinet Integration Kits.
- **Rack Cabinet Integration Kits:** Includes cabling and waveguide needed to complete installation of one or two SSPAs into a standard 45 RU rack cabinet.

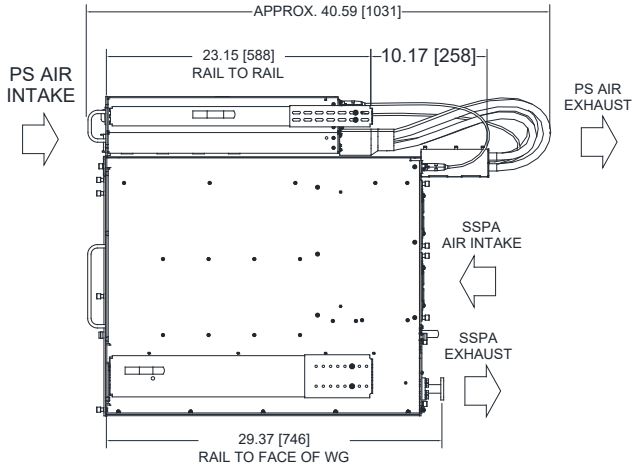
  Qty. 1 SSPA: Integrate (1) SSPA into a standard rack cabinet, with top-panel system interfaces for primary AC power, RF input, RF output, network, serial I/O, parallel I/O.

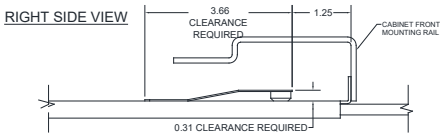
  Qty 2 SSPAs: Integrate (2) single-thread SSPAs into a standard rack cabinet with top-panel interfaces.
- **Spares Kit A:** Includes (1) RF Unit plug-in Module, (1) Power Supply plug-in Module, and (1) RF Unit Fan Assembly.
- **Spares Kit B:** Includes Spares Kit A plus (1) RF Unit Logic PCB, (1) Power Supply Capacitor PCB, (1) RF Unit Parallel I/O PCB, (1) RF Unit NIC PCB, (1) RF Unit Front Panel assembly, (2) RF Module Flexible Cable assemblies.
- **Maintenance Switch Kit:** Antenna/Dummy Load switch and high power RF termination for one SSPA.
- **Air Intake Duct Kit:** Duct transition for one RF Unit chassis rear panel air inlet to 10" diameter (252 mm) circular duct.
- **Air Exhaust Duct Kit:** Duct transition for one RF Unit chassis rear panel outlet to 8" diameter (203 mm) circular duct.
- **Phase Combining Kit:** Variable phase combiner assembly and interconnection to (2) identical SSPAs to provide nominally twice the RF power output. (Both SSPAs must be installed in one rack cabinet; cabinet is not included in the Phase Combining Kit.)

  Combined system maximum saturated power:
  - C-band 3000 W (2x 1500 W);
  - X-band 2200 W (2x 1250 W);
  - Ku-band 1500 W (2x 800 W).

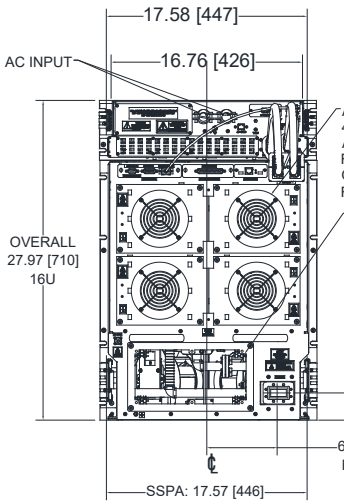
Outline Drawing, Typical C- Band SSPA (X- and Ku-Band are similar)







RACK SLIDE
CLEARANCE DETAIL



REAR VIEW

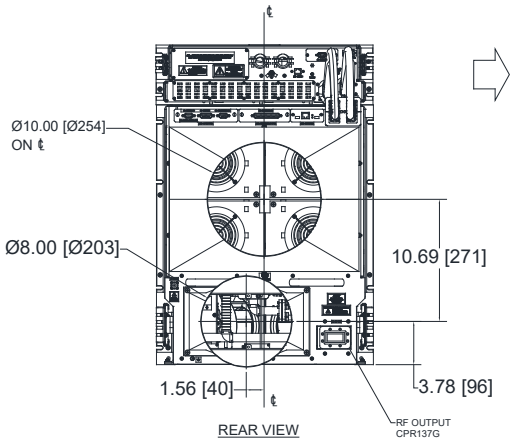
AIR INTAKE:
4 FANS REQUIRE CLEAN, FILTERED AIR OR ROOM AIR. VOLUMETRIC FLOW RATE IS 400 CFM (0.189 m^3/s). OPTIONAL DUCT TRANSISTION AVAILABLE FOR 10" (250 mm) DIAMETER DUCT.

AIR EXHAUST:
VOLUMETRIC FLOW RATE IS 400 CFM (0.189 m^3/s). OPTIONAL DUCT TRANSITION AVAILABLE FOR 8" (200 mm) DIAMETER DUCT.

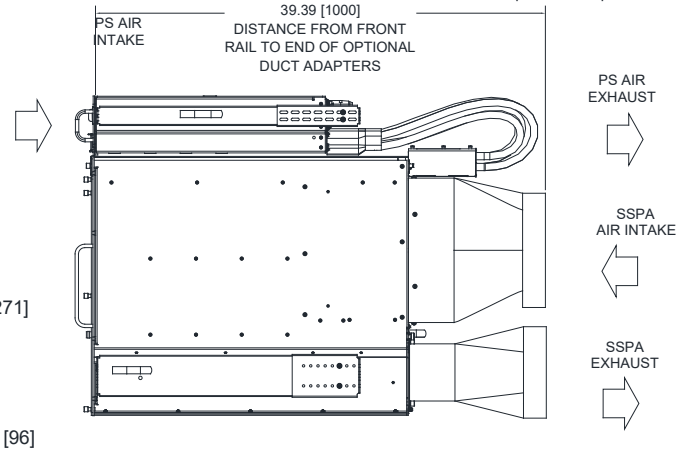
FAN NOISE:
SOUND PRESSURE LEVEL (SPL) @ 1 m IS 70 dBA (FRONT OF SSPA) AND 80 dBA (REAR OF SSPA).

EXTERNAL DUCT APPLICATION NOTES

1. MAXIMUM INTAKE DUCT SYSTEM:
   (1) 90° 10" diameter swept bend (no sharp corners); 10 ft (3050 mm) of 10" diameter rigid duct;
   -OR-
   5ft (1525 mm) of 10" diameter STRAIGHT run of flexible duct;
2. MAXIMUM EXHAUST DUCT SYSTEM:
   (2) 90° 8" diameter swept bends (no sharp corners); 10 ft (3050 mm) of 8" diameter rigid duct;
   -OR-
   5 ft (1525 mm) of 8" diameter STRAIGHT run of flexible duct; Exhaust louver or screen with minimum free area of 50 sq. inches.
3. If an intake duct is used in conjunction with an exhaust duct, use a maximum of (1) 90° 8" diameter swept bend in the exhaust duct.
4. The SSPA fans will not overcome the additional airflow resistance added by any dust filter. If filters are used, add an assist blower to overcome the filter's pressure drop.



REAR VIEW



RIGHT SIDE VIEW

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For more detailed information, please refer to the corresponding CPI technical description if one has been published, or contact CPI. Specifications may change without notice as a result of additional data or product refinement. Please contact CPI before using this information for system design.