

PRELIMINARY

# ModuMAX GaN SSPA Systems

## *Ku Band*

ModuMAX SSPAs using GaN based amplifiers are completely modular RF amplifier systems offering output power of up to 3 kilowatts in Ku-Band. Patented technology utilizes hot-swappable, plug-in RF modules, power supplies, and electronic assemblies to maximize performance and minimize downtime in SATCOM systems. An advanced interface and control system allows unprecedented remote access and operation.

- **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**

### Single-Thread SSPAs

*Ku-Band*

1100 Watts

1900 Watts

### Phase-Combined System

*Ku-Band*

3000 Watts



*A revolutionary concept in solid-state power amplifiers, the ModuMAX series eliminates the need for a spare power amplifier or for redundant switchover networks in many satellite earth station applications.*

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SATCOM Technologies

**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 fault tolerance. Using multiple parallel RF modules, power supplies and cooling fans, General Dynamics 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.

The RF modules, cooling fans, power supply modules, control systems and interface card are redundant and hot swappable. All routine maintenance can be performed safely while the SSPA continues to operate. There are no cables to remove and reinstall. Since the RF module is fully calibrated at the factory and there is no removal and reinstallation of RF cabling, there is no need to re-phase the system when a module is replaced. The ModuMAX system is designed to eliminate the need for highly skilled technicians. Most required maintenance activity is accomplished without tools.

**RF Plug-In Modules**

The RF plug-in modules are conveniently accessible from the front panel. Removal of the module requires no cables to be disconnected and reconnected. 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. An RF

module 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.

**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 be deployed 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	—	—

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### 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 10/100 Base T Ethernet protocol network interfaces. The system is fully operational over a secure Web based interface with all functions duplicated via a front panel touch screen interface. Both interfaces are completely user configurable for maximum security and flexibility.

### 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.

### Global EMC and Safety Compatibility

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

### Power

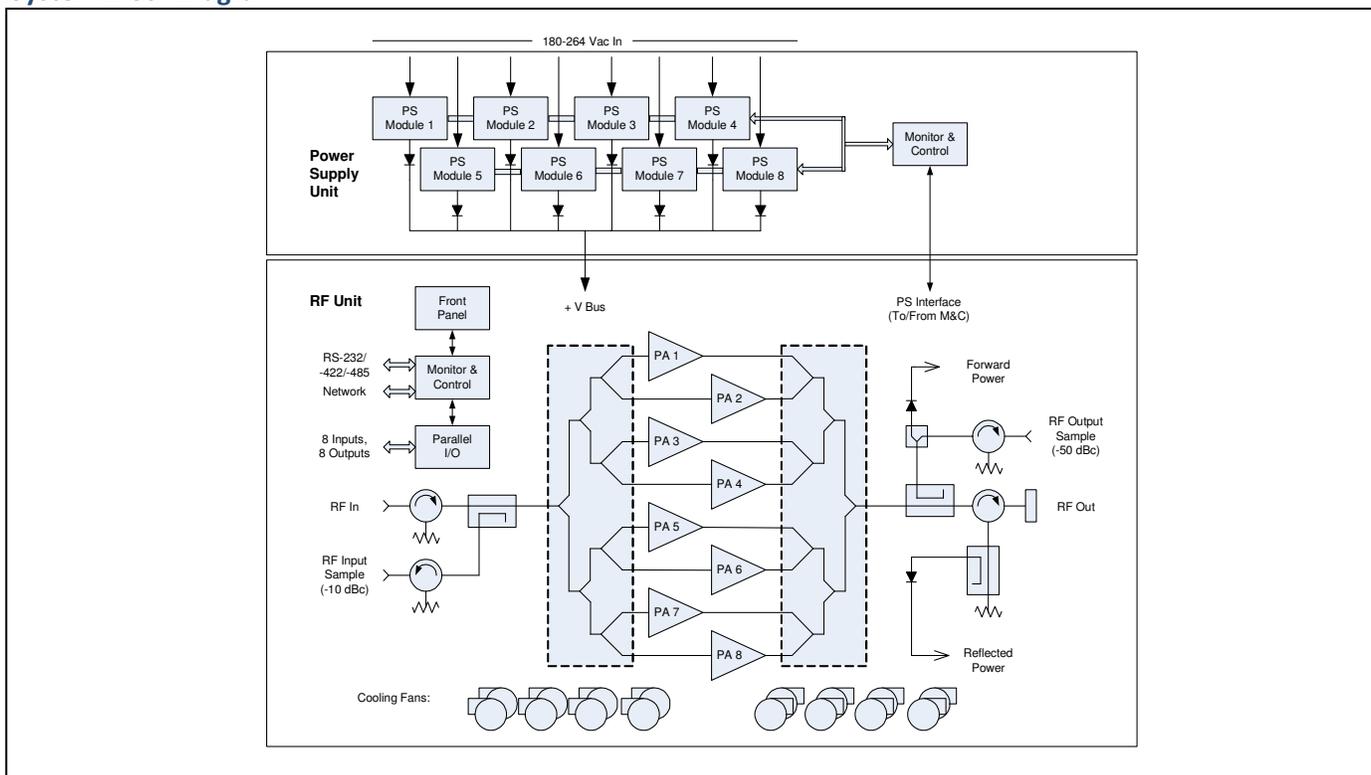
Power is supplied by up to eight identical plug-in power supply modules in a rack-mount chassis. If a module fails, the remaining ones can supply 100% of the required load current and the defective module can be hot-swapped without interruption.

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 replacement is installed. The air cooling system comprises separate rear panel air intake and exhaust ducts and can be vented either outdoors or into the room.

### System Block Diagram



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## Single-Thread SSPA Specifications

Parameter	Notes	Min.	Nom./Typ. <sup>(1)</sup>	Max.	Units
Frequency Range	Ku-Band, Extended	13.75		14.50	GHz
Gain, at Maximum Setting	Ku-Band	65		70	dB
Gain vs. Temperature	0 to 50 °C		±0.5	±0.75	dB
Gain Adjust Range	Digital, 0.1 dB steps	20			dB
Gain Flatness	Full band Per 40 MHz			±1.0	dB
				±0.3	dB
Saturated Power Output	1100 W Ku-Band		+60.4 (1100)		dBm (W)
	1900 W Ku-Band		+62.8 (1900)		dBm (W)
	3000 W Ku-Band <sup>(2)</sup>		+64.6 (3000)		dBm (W)
Linear Output Power	1100 W Ku-Band	+57.4 (550)			dBm (W)
	1900 W Ku-Band	+59.8 (950)			dBm (W)
	3000 W Ku-Band <sup>(2)</sup>	+61.6 (1500)			dBm (W)
Two-Tone Intermodulation	At rated linear power		-30	-25	dBc
Residual Noise, Ku-Band	13.75–14.5 GHz			-70	dBW/4 kHz
Group Delay	Linear			0.03	ns/MHz
	Parabolic			0.003	ns/MHz <sup>2</sup>
	Ripple			1.0	ns p-p
AM/PM Conversion	At rated linear power		2.5	3.5	°/dB
Second Harmonic	At rated linear power			-60	dBc
Spurious	At rated linear power			-70	dBc
VSWR	Input, Output		1.2:1	1.3:1	
Sample Ports	Input/Output		-10/-50		dBc
Power Requirements (single or 3-phase)	Voltage	180		264	Vac
	Frequency	47		63	Hz
	Power factor		0.98		
Power Requirements (single or 3-phase)	Power, 1100 W Ku-Band		11		kVA
	Power, 1900 W Ku-Band		19		kVA
	Power, 3000 W Ku-Band		30		kVA
Cooling System			Forced air		
Operating Temperature °C	Ambient/inlet air	0		+50	°C
Storage Temperature	Non-operating	-45		+85	°C
Relative Humidity	Non-condensing			95	%
Altitude Derating	10,000 ft (3000 m) max.		Derate 2 °C per 1000 ft (300 m)		
Size <sup>(3)</sup>	RF Unit (16 U panel ht.)		19.0 W x 27.97 H x 33.13 D		inches
			483 W x 710 H x 842 D		mm
Weight <sup>(3)</sup>	Power Supply (4 U ht.)		19.0 W x 6.97 H x 30.67 D		inches
			483 W x 177 H x 779 D		mm
Weight <sup>(3)</sup>	RF Unit		400 (182)		lb (kg)
	Power Supply		100 (45)		lb (kg)

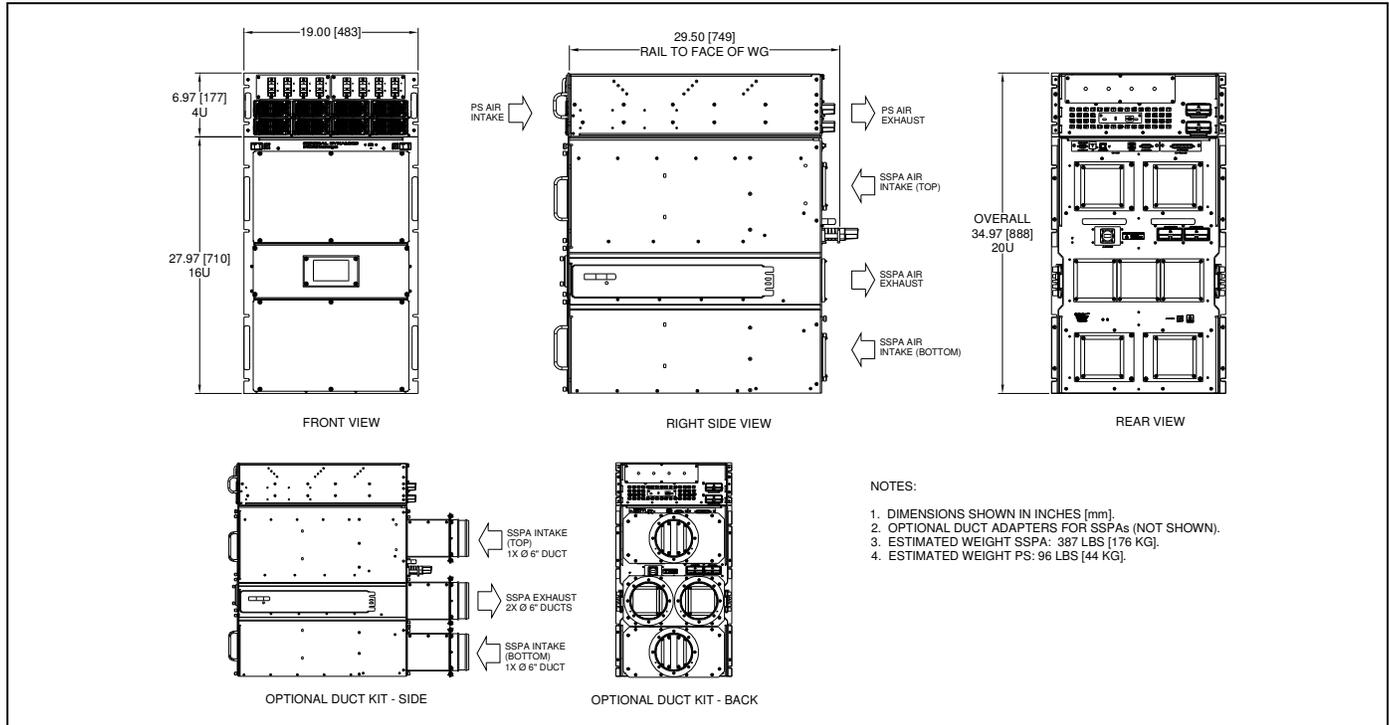
<sup>(1)</sup> When there is only one entry on a line, the Nom./Typ. column is a nominal value; otherwise it is a typical value. Typical values are intended to illustrate typical performance, but are not guaranteed.

<sup>(2)</sup> The 3000 W unit is a phase-combined system comprising (2) 1900 W ModuMAX SSPAs.

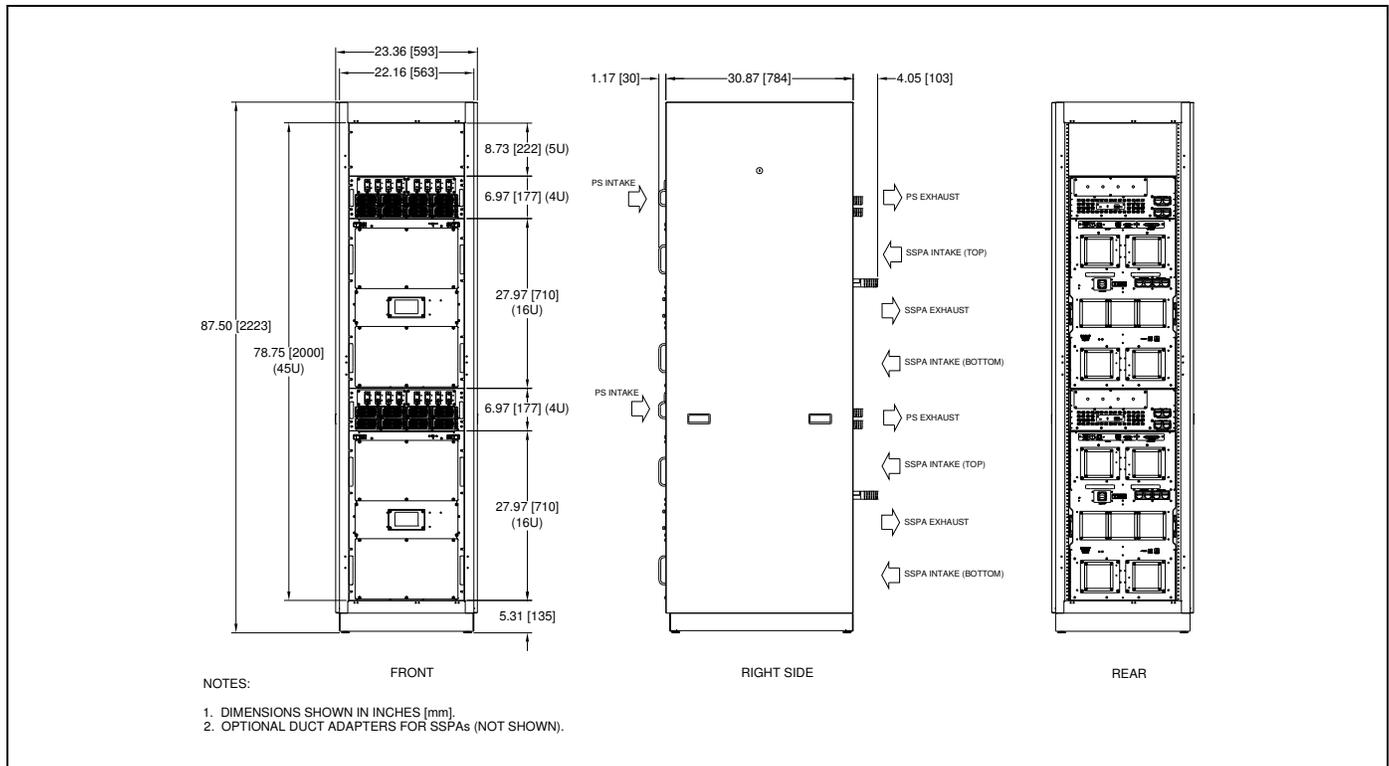
<sup>(3)</sup> Size and weight are given for a single ModuMAX SSPA (1100 W or 1900 W).

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## Outline Drawing, Single-Thread SSPA



## Outline Drawing, Dual SSPAs in one Rack Cabinet



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For more information about the ModuMAX series SSPAs, or to arrange for a demonstration unit, please send an email to [satcom@gd-ms.com](mailto:satcom@gd-ms.com).

General Dynamics SATCOM Technologies offers a diverse family of satellite and wireless communications products. Visit our website at <http://www.gdsatcom.com>.

### Other Products

- Solid-State Power Amplifiers and SSPA Systems
- Solid-State Power BUCs and SSPB Systems
- Low Noise Amplifiers and LNA Systems
- Low Noise Block Converters and LNB Systems
- Block Up and Block Down Converters
- Synthesized Converters
- Line Drive Amplifiers
- Power Supply Monitors
- Redundant Control Panels for SSPAs, SSPBs, and LNAs

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