# Operations Manual,
# 5RU Rack Mountable SSPA

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# Indoor RM SSPAs, General Information

Teledyne Paradise Datacom
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# Introduction

This section provides the general information for the Teledyne Paradise Datacom Indoor Rack Mount Solid State Power Amplifier (SSPA) Chassis. This includes a description of the unit and safety precautions for operation of the unit.

# Description

The Teledyne Paradise Datacom family of Indoor SSPA Chassis includes the 3RU (rack unit), 5RU and 7RU configurations. Generally, the larger the rack space used, the higher the RF output power. See Table 1.

**Table 1: Indoor Rack Mount SSPA Configurations**

| Chassis Type | Band Availability | Width | Height | Depth | Weight (typical) |
|---|---|---|---|---|---|
| 3RU | S, C, X, Ku | 19.00 in. [483 mm] | 5.22 in. [133 mm] | 25.25 in. [641 mm] | 85 lbs. [38.5 kg] |
| 5RU | S, C, X, Ku | 19.00 in. [483 mm] | 8.75 in. [222 mm] | 30.25 in. [768 mm] | 150 lbs. [68 kg] |
| 7RU | C, X, Ku | 19.00 in. [483 mm] | 12.22 in. [310 mm] | 30.00 in. [762 mm] | 160 lbs. [72.5 kg] |

These units are available with Gallium Arsenide (GaAs) or Gallium Nitride (GaN) RF modules. GaN amplifiers utilize innovative linearization techniques that produce linear output power with the same efficiency as tube based amplifier systems. S-Band units are only available with GaN RF modules.

## 3RU SSPA Chassis

The 3RU chassis was specially designed to accommodate applications where rack space is at a premium. At only 3RU in height, this SSPA Chassis is perfect for use in Satellite News Gathering or flyaway applications. See Section 2 of the 3RU manual for details.

## 5RU SSPA Chassis

The 5RU chassis is available with one of the highest power densities in the industry, with up to 2kW of output power in S-Band, 1.6kW in C and X-Band, and 1kW in Ku-Band. See Section 2 of the 5RU manual for details.

## 7RU SSPA Chassis

The 7RU chassis offers redundant RF power in a single unit. The 7RU chassis features four (4) RF modules, which can be accessed from the front panel. With Auto Gain enabled, a failure of a single RF module will not adversely affect amplifier performance. The RF modules are hot-swappable, and can be removed from the chassis without taking the amplifier offline. See the **Removable Module** description in the Unit Description section of the 7RU manual for details.

## Rack Mount SSPA Features

All indoor rack mount SSPAs use a separate 1RU power supply chassis, which includes up to four power supply modules. The power supply has one more module than is necessary to operate the amplifier, resulting in N+1 redundancy for the power source.

A rich feature set has been maintained for all chassis configurations. For field maintainability, this chassis features:

- Front and rear panel removable fan trays;
- Front panel removable power supply modules;
- Rear panel removable controller card assembly;
- RF output sample port (Front panel for 3RU/5RU; Rear panel for 7RU).

The indoor RM SSPA chassis includes a wide array of standard interfaces:

- Front Panel Local Interface and Status Indicators
- RS232/RS485 (4-wire) Serial Communication (with either Windows-based M&C or third-party M&C drivers available)
- Ethernet Port (SNMP, UDP Serial Programming, Web Browser Interface)
- Parallel I/O (Form C Contact Outputs, Opto Isolated Inputs)

The chassis' microprocessor monitors various voltages, currents and temperatures within the unit for a full fault analysis. The user also may select additional faults related to the RF output level, an optional reflected RF power level and operating temperature.

An internal attenuator allows up to 20.0 dB of attenuation to be applied to the RF signal. Temperature compensation limits the amplifier's output response from varying significantly over the operating temperature. Also, the system contains input and output sample ports.

# Specifications

Refer to the SSPA's specification sheet for complete specifications. The latest revision of the specification sheet is available on the Teledyne Paradise Datacom web site: www.paradisedata.com.

# Inspection

When the unit is received, an initial inspection should be completed. First ensure that the shipping container is not damaged. If it is, have a representative from the shipping company present when the container is opened. Perform a visual inspection of the equipment to make sure that all items on the packing list are enclosed. If any damage has occurred or if items are missing, contact:

Teledyne Paradise Datacom
328 Innovation Blvd., Suite 100
State College, PA 16803 USA
Phone: +1 (814) 238-3450
Fax: +1 (814) 238-3829

# Rack Mounting and Installation

The SSPA Chassis is designed to fit in a standard 19" (483 mm) wide EIA rack. Optional rack slides are available, which will ship with the unit.

If Teledyne Paradise Datacom is supplying the equipment cabinet along with a system, a portion of the rack slides may be secured to each SSPA chassis at the factory.

Install the rack slides into the equipment cabinet using the rack slide manufacturer's recommended installation instructions.

Extend the sliding section of the rack slide from the cabinet until it locks into place. See Figure 1.

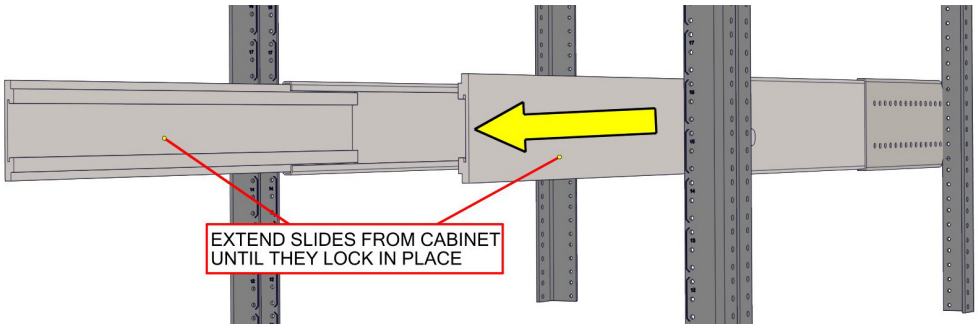


**Figure 1: Extend Rack Slide from Cabinet**

Insert the rack slide section attached to the SSPA into the sliding section. See Figure 2.

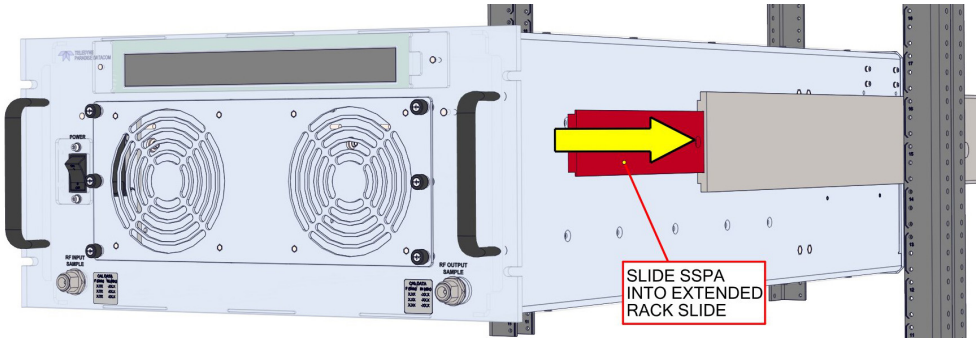


**Figure 2: Install SSPA into Rack Slide (5RU SSPA Shown)**

Release the locking mechanism on the sliding section, and push the SSPA into the cabinet. Secure the front panel to the cabinet rails. See Figure 3. Hardware may not be included if Teledyne Paradise Datacom is not supplying the equipment cabinet.

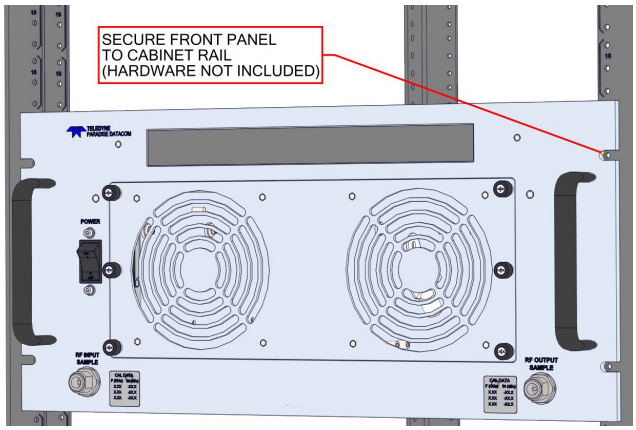


**Figure 3: Slide SSPA into Cabinet; Secure to Cabinet Rails**

## Installation Notes

When installing the SSPA, make sure to use the lifting handles on the front and back of the chassis. Do not lift by the waveguide flange or other connectors.

At least two persons, or a mechanical lift, should be available to set the amplifier into place.

# Shipment

To protect the SSPA Chassis during shipment, use high quality commercial packing methods. When possible, use the original shipping container and its materials. Reliable commercial packing and shipping companies have facilities and materials to adequately repack the instrument.

# Safety Considerations

Potential safety hazards exist unless proper precautions are observed when working with this unit. To ensure safe operation, the user must follow the information, cautions and warnings provided in this manual as well as the warning labels placed on the unit itself.

## High Voltage Hazards

High Voltage, for the purpose of this section, is any voltage in excess of 30V. Voltages above this value can be hazardous and even lethal under certain circumstances. Care should be taken when working with devices that operate at high voltage.

**⚠ All probes and tools that contact the equipment should be properly insulated to prevent the operator from coming in contact with the voltage.**

**⚠ The work area should be secure and free from nonessential items.**

**⚠ Operators should never work alone on high voltage devices. There should always be another person present in the same work area to assist in the event of an emergency.**

**⚠ Operators should be familiar with procedures to employ in the event of an emergency, i.e., remove all power, CPR, etc.**

**⚠ An AC powered unit will have 115 VAC or 230 VAC entering through the AC power connector. Caution is required when working near this connector, the AC circuit breaker, or the internal power supply.**

## High Current Hazards

Many high power devices are capable of producing large surges of current. This is true at all voltages, but needs to be emphasized for low voltage devices. Low voltage devices provide security from high voltage hazards, but also require higher current to provide the same power. High current can cause severe injury from burns and explosion. The following precautions should be taken on devices capable of discharging high current:

**⚠ Remove all conductive personal items (rings, watches, medals, etc.)**

**⚠ The work area should be secure and free of non-essential items.**

**⚠ Wear safety glasses and protective clothing.**

**⚠ Operators should never work alone on high risk devices. There should always be another person present in the same area to assist in the event of an emergency.**

⚠ **Operators should be familiar with procedures to employ in the event of an emergency, i.e., remove all power, CPR, etc.**

Large DC currents are generated to operate the RF Module inside of the enclosure. Extreme caution is required when the enclosure is open and the amplifier is operating. Do not touch any of the connections on the RF modules when the amplifier is operating. Current in excess of 60 Amperes may exist on any one connector.

## RF Transmission Hazards

RF transmissions at high power levels may cause eyesight damage and skin burns. Prolonged exposure to high levels of RF energy has been linked to a variety of health issues. Please use the following precautions with high levels of RF power.

⚠ **Always terminate the RF input and output connector prior to applying prime AC input power.**

⚠ **Never look directly into the RF output waveguide.**

⚠ **Maintain a suitable distance from the source of the transmission such that the power density is below recommended guidelines in ANSI/IEEE C95.1. The power density specified in ANSI/IEEE C95.1-1992 is 10 mW/cm2. These requirements adhere to OSHA Standard 1910.97.**

⚠ **When a safe distance is not practical, RF shielding should be used to achieve the recommended power density levels.**

## Electrical Discharge Hazards

An electric spark can not only create ESD reliability problems, it can also cause serious safety hazards. The following precautions should be followed when there is a risk of electrical discharge:

⚠ **Follow all ESD guidelines**

⚠ **Remove all flammable material and solvents from the area.**

⚠ **All probes and tools that contact the equipment should be properly insulated to prevent electrical discharge.**

⚠ **The work area should be secure and free from nonessential items.**

⚠ **Operators should never work alone on hazardous equipment. There should always be another person present in the same work area to assist in the event of an emergency.**

⚠ **Operators should be familiar with procedures to employ in the event of an emergency, i.e., remove all power, CPR, etc.**

## High Leakage Current

The equipment may have more than 3.5 mA leakage current. Make sure a connection to earth ground is present before applying prime power, and after removing prime power.

## High Potential for Waveguide Arcing

As with all systems which utilize high power signals within waveguide, the potential exists for an electric arc to form. To minimize this risk, Teledyne Paradise Datacom requires all waveguide be pressurized and dehydrated.

# Waveguide Pressurization/Dehydration

When working with high power amplifier systems that operate into waveguide, the inadvertent creation of arcs is always a concern. An arc in waveguide is the air discharge breakdown due to the ionization of the air molecules by electrons. This breakdown in waveguide occurs when the rate of electron production becomes greater than the loss of electrons to diffusion to the surrounding walls.

It is extremely difficult to precisely predict the power levels at which the breakdown occurs. It is dependent on a variety of factors but the primary factors are:

- Waveguide temperature and atmospheric pressure
- Components in the Waveguide Transmission System such as: Flanges, Bends, Tees, Combiners, Filters, Isolators, etc.
- Load VSWR presented to the amplifier.

When operating such a high power amplifier system it is imperative that the waveguide transmission system be dehydrated and pressurized. Operation with an automatic air dehydrator will provide dry pressurized air to ensure that condensation cannot form in the waveguide. Also the higher the pressure that can be maintained in the waveguide; the higher the power handling is in the waveguide system. Most commonly available air dehydrators are capable of providing pressures of 0.5 to 7.0 psig (25-362 mmHg).

At low power levels (uniform field distribution), low pressure can give good results. For non-uniform conditions, highly localized breakdown can occur. In this case the waveguide system will require much higher pressure. This occurs with bends, waveguide flange joints. If line currents flow across a small gap introduced by poor tolerances, flange mismatch, poorly soldered bends, field strengths in excess of that in the main line can occur in the gap. Pressurization with air or high dielectric gases can increase the power handling by factors of 10 to 100.

In High Power Amplifier systems an arc will travel from where it is ignited back to the amplifier. Typical arc travel speed is on the order of 20 ft/sec. Increasing the waveguide pressure can reduce the speed of arc travel. It is difficult to get an accurate calculation of the amount of pressurization needed, but it is a good practice to get as much pressure as your system can handle. All high power systems that meet the criteria of **Table 2** are pressure tested at the factory to 1.5 psig.

⚠ **Important! As a guide we recommend using the power levels in Table 2 as the threshold levels where special attention be given to dehydration and the overall simplification of waveguide system design.**

**Table 2: Recommended Output Power Thresholds**

| Satcom Band | Frequency Range | Amplifier Output Power | Waveguide |
|---|---|---|---|
| S Band | 1.7-2.6 GHz | > 10 kW | WR430 |
| C-Band | 5.7 - 6.7 GHz | > 2 kW | WR137 |
| X-Band | 7.9-8.4 GHz | > 1kW | WR112 |
| Ku-Band | 13.75-14.5 GHz | > 500W | WR75 |
| Ka-Band | 27-31 GHz | > 100W | WR28 |

It is a common misconception to look up the maximum theoretical power handling of a particular type of waveguide and assume that this is the maximum power handling. This may be the case for a straight waveguide tube with ideal terminations but these values must be significantly de-rated in practical systems. Phase combined amplifier systems can be particularly sensitive to the potential for waveguide arcing. This is due to the numerous bends, magic tees, multiple waveguide flange joints, and other waveguide components. **Table 3** shows the power handling capability of some popular waveguide components normalized to the waveguide power rating. From this table, we can see how a practical waveguide system's power handling will de-rate significantly.

**Table 3: De-rating of W/G Components Relative to Straight W/G**

| Waveguide Component | Relative Power Rating |
|---|---|
| H Plane Bend | 0.6 to 0.9 |
| E Plane Bend | 0.97 |
| 90-Degree Twist | 0.8 to 0.9 |
| Magic Tee | 0.80 |
| E-Plane Tee | 0.06 |
| H-Plane Tee | 0.80 |

| | |
|---|---|
| Cross Guide Coupler | 0.21 |

Most waveguide systems have many of these components integrated before reaching the antenna feed. It is not uncommon for a Satcom waveguide network to de-rate to 5% of the straight waveguide power rating.

The load VSWR also has an impact on the breakdown threshold in waveguide networks. Standing waves degrade the power handling of any transmission line network. The graph of **Figure 4** shows the rapid degradation of waveguide breakdown vs. load VSWR. The chart shows that for a 2.0:1 load VSWR, the breakdown potential will be half of what it would be with a perfectly matched load. This can degrade even more when high Q elements such as band pass filters are included in the waveguide network.

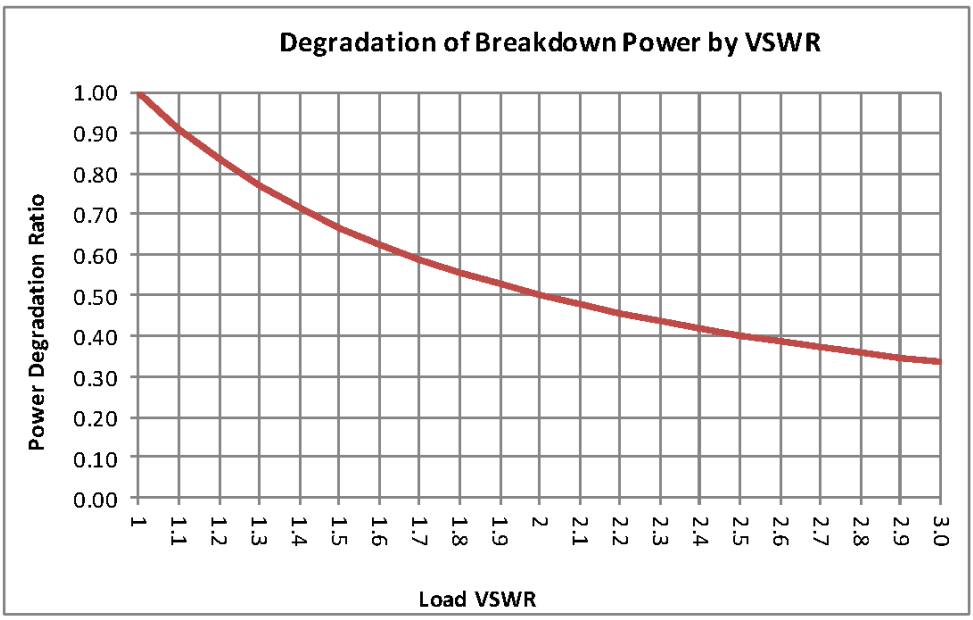


**Figure 4: Degradation of Breakdown Power by VSWR**

There are many factors to consider with high power amplifier systems in terms of the output waveguide network. Especially when using HPA systems with output power levels of **Table 2**, it is imperative to ensure that the output waveguide network is pristinely clean and dry. An appropriate dehydrator should be used with capability of achieving adequate pressure for the system's output power. Take extra precaution to make sure that any waveguide flange joints that are not already in place at the factory are properly cleaned, gasket fitted, and aligned. A properly designed and maintained waveguide network will ensure that no arcing can be supported and will provide many years of amplifier service life.

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