



FORAX™ - DAS USER GUIDE



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FORAX – Distributed Antenna System – 102400-0003

Comprising:

102440-1001 RA - HP Antenna Interface Unit
102420-1002 RB - Optical Interface Module

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INTRODUCTION

Syntonics believes you will be pleased with your new FORAX-DAS (Fiber Optic Remote Antenna eXtension for Distributed Antenna Systems) RF-over-fiber communications system. Depending on the configuration you have ordered, your FORAX DAS system support up to 10 radios operating in the band 470.5 MHz – 697.5 MHz Transmit and 614 MHz– 722 MHz receive using single-mode optical fibers for distribution up to 12 remote locations. (Optionally, Multi-Mode fiber can be supported with distance limitations, contact Syntonics for details.) FORAX provides an all-analog optical link that can transport RF signal with any modulation type over a fiber optic cable. Instead of using heavy, short, power-dissipating coaxial cables, one coaxial cable per radio, FORAX uses a single long, lightweight, and secure fiber optic cable to connect all the radios. Features and benefits of this RF-over-fiber technology include:

Long Connections	<ul style="list-style-type: none"> Radio and its antenna can be located up to 10 km apart using single mode optical fiber— and further by special order (500 meters using Multi-Mode Fiber)
Easy Routing	<ul style="list-style-type: none"> RF signals are carried on lightweight, flexible, rugged, optical cables Multiple radios can be carried on a single fiber optic cable Geographic diversity in RF signal routing becomes easy Separate TX and RX antennas can be implemented with conventional radios that have one half-duplex antenna port
All frequencies, all modulations	<ul style="list-style-type: none"> FORAX-RP modules cover 470.5-697.5 MHz Tx (614 -722 MHz Rx) FORAX-RP modules handle a variety of communications waveforms
EMP/EMI Immunity	<ul style="list-style-type: none"> Lightning, electromagnetic pulses, or RF interference cannot propagate over, or influence the signals on, optical fiber cables Radio equipment is opto-isolated from antenna

Since developing FORAX in early 2004, Syntonics has continued to improve and expand the capability of the FORAX product line. RF-over-fiber is intrinsically a reliable technology and FORAX has been deployed since 2004 in many installations including military mission-critical operations.

The following sections of this guide describe basic FORAX-DAS configuration and capabilities, site preparation, system installation, system operation, specifications, customer support, and warranties.

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1. SYSTEM DESCRIPTION

Fiber Optic Radio Antenna eXtension (FORAX) connects multiple radios to multiple remote antennas using optical fibers in place of coaxial cable. The FORAX Distributed Antenna System (DAS) consists of an Optical Interface Chassis (OIC) housing up to 6 Dual Channel Optical Interface Modulus (OIMs) Syntonics Part Number 102420-1002 RB, and Antenna Interface Unit (AIU) chassis Syntonics Part Number 102440-1001 RA connected with optical fibers as shown in Figure 1-1.

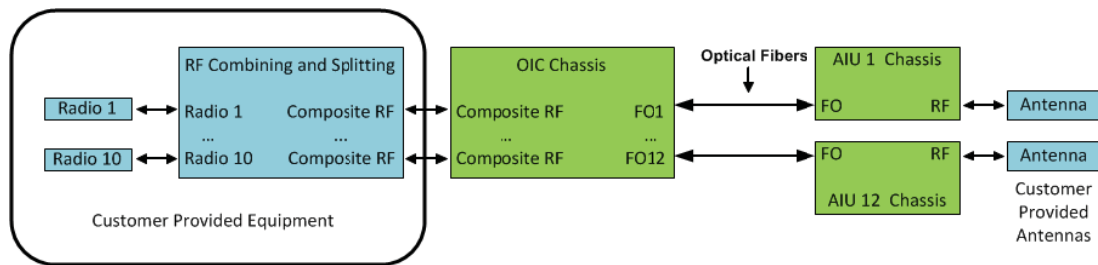


Figure 1-1. FORAX-DAS System Architecture

1.1. Optical Interface Unit

The OIU chassis as shown front and rear in Figure 1-3 contains up to six Optical Interface Modules (OIM), two Combiner Modules, and two Power Supply Modules. Each OIM can accommodate two fiber optic connections to an Antenna Interface Unit (AIU). The status of each OIM-to-AIU link is indicated by a Control Panel Module (CPM) attached to the front of the OIU. The CPM indicates the health of the fiber optic link, as well as proper input and output RF levels. Each OIM also has an indicator on the rear of the chassis for each fiber optic link.

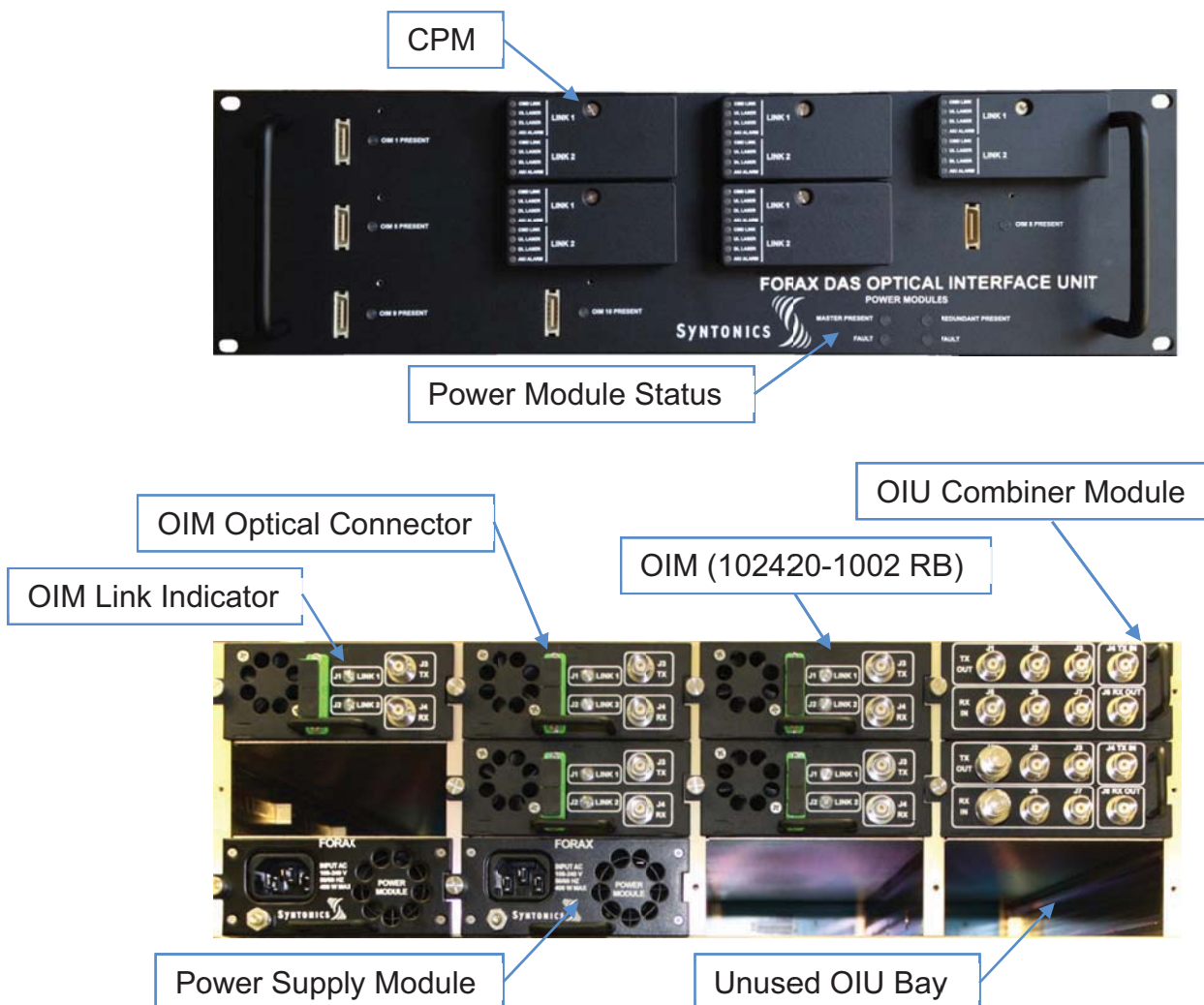


Figure 1-2. OIM Features

1.2. Antenna Interface Unit

Similarly, the AIU chassis is shown in Figure 1-4. The AIU RF connector may be connected directly to an appropriate antenna. Indicators on the front panel provide a simple status of the fiber optic communication link, RF status, and power.

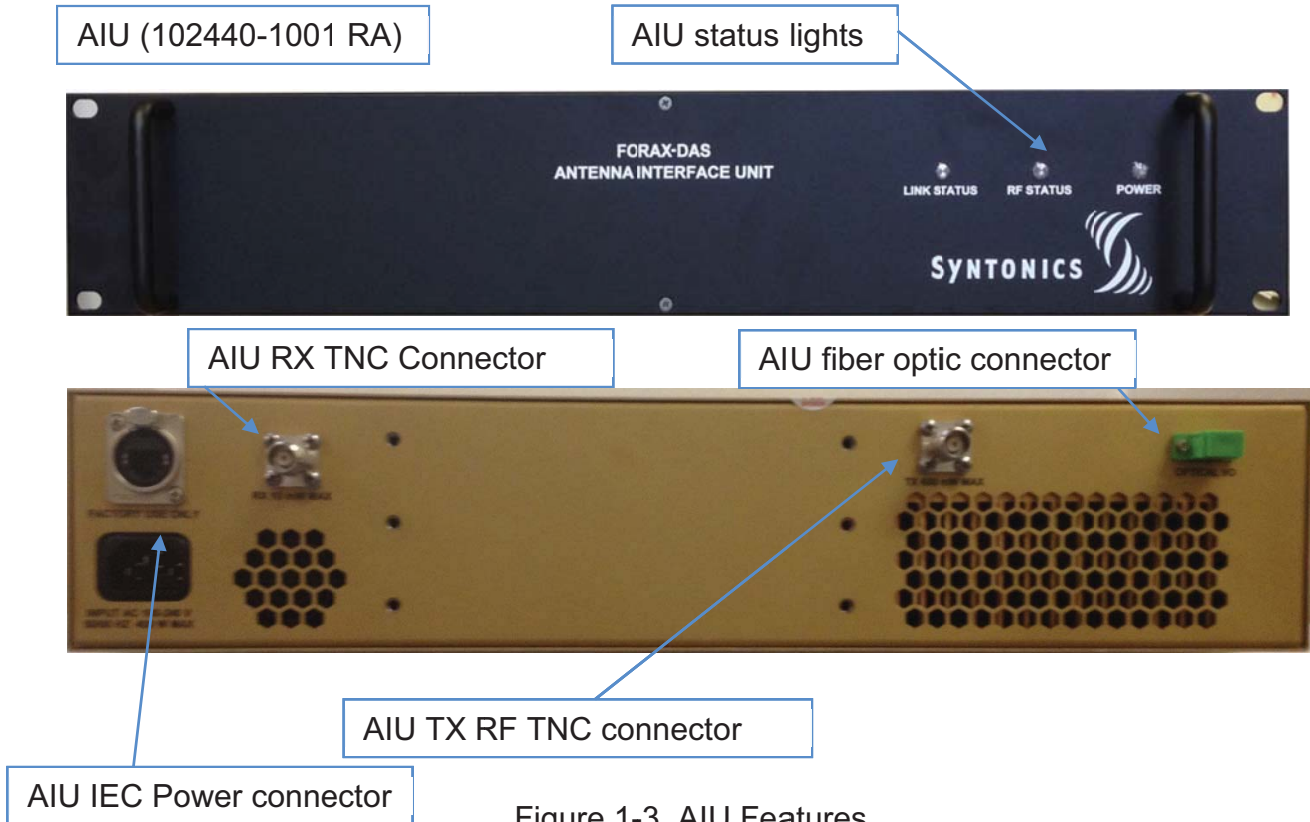


Figure 1-3. AIU Features

The following section describes the standard FORAX-RP link available.

1.3. RF Links

FORAX-DAS links support transmission in the band 470.5 – 697.5MHz while simultaneously receiving in the band 614 – 722 MHz providing RF transport over optical fiber as shown in Figure 1-4.

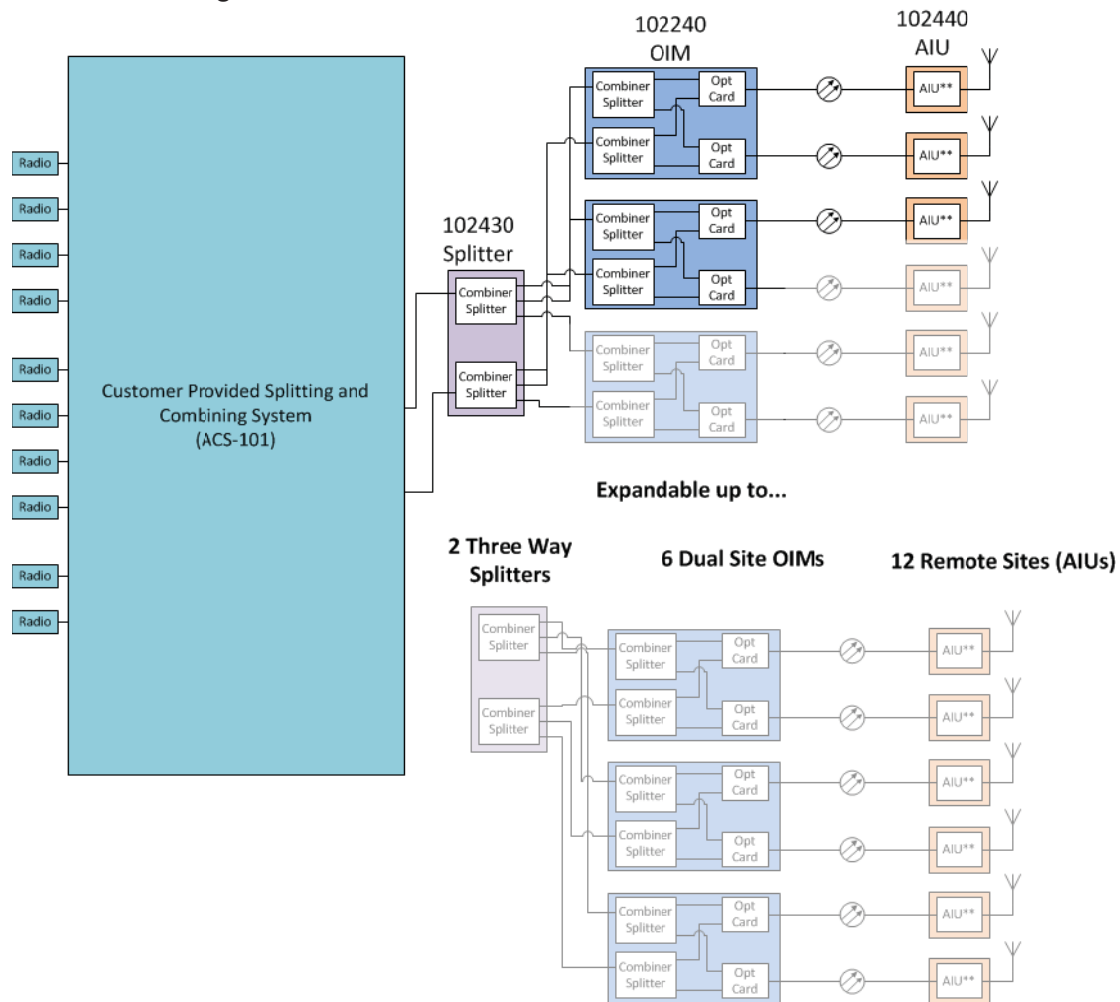


Figure 1-4. RF Block Diagram

FORAX-DAS RF links are setup to support a variety of antennas including leaky coaxial cable (LCX) antennas such that the mobile radio units can select an appropriate Rx/Tx frequency for communication with any radio within the array of base station radios. Inversely, any base station radio can select an appropriate Rx/Tx frequency for communication with a mobile radio.

2. BASIC SYSTEM INSTALLATION

2.1. Site Preparation

Site preparation is the single most important factor in the ease of installation and proper operation of the FORAX-DAS system. The following paragraphs outline the minimum requirements for a trouble-free installation.

2.2. Fiber Optic Cabling

A single-mode optical fiber is required for each FORAX-DAS channel. The maximum allowable optical loss between the OIM and AIU is 5 dB optical for full performance link operation.

All optical connections in the link cannot generate combined optical reflections greater than -50 dB optical. Large optical reflections can degrade FORAX-DAS performance in two ways. First, the reflections generate feedback into the lasers causing optical power oscillations which modulate noise onto the RF signal. In order to mitigate the effect of single large reflections, each laser in the FORAX system is equipped with an internal isolator as well as a secondary external isolator. Secondly, reflective connections can result in an unstable oscillatory mode within the optical fiber. This mode results in a significantly elevated RF noise floor which drastically reduces receive sensitivity. In extreme cases, the noise floor can become sufficiently elevated that the RF detector in the AIU is tripped, resulting in degraded system performance.

Sytonics recommends optically aligned Angled Physical Contact (APC) connectors throughout the entire fiber installation. APC connections provide the best defense against poorly terminated fibers and reflections. At a minimum APC connectors must be used to connect to the OIM and AIU. Any patch cable that transitions from APC to Physical Contact (PC/UPC) connectors should be longer than 30 meters in order to minimize reflections.

NOTE:

Sytonics recommends the fewest possible APC patch connections between the OIM and AIU in order to minimize optical losses and optical reflections.

The most common cause of unacceptably high optical loss is dirty fiber connectors. A single dirty connector can cause optical losses greater than the entire loss budget for the link. For this reason, great care should be taken to thoroughly clean all fiber connectors in accordance with manufacturer recommendations each time the connectors are mated.

NOTE:

Never clean optical connectors carrying light with a wet cleaning product. Optical power levels as low as +15 dBm (32 mW) may cause explosive ignition of cleaning materials.

The total optical loss for each fiber should be measured prior to FORAX-DAS installation. An estimate for the expected losses in a high quality fiber installation can be calculated as:

$$\text{Optical Loss (dB optical)} = (0.002 * \text{length of fiber (m)}) + (0.5 * \# \text{ of patch connections})$$

Measured optical losses exceeding this estimate should be investigated and fixed to ensure proper operation of the FORAX system.

2.2.1. Power

The universal power modules operate from any 90-240 VAC, 50-60 Hz power source. The maximum total power requirement for a FORAX-RP OIU chassis is a function of the number of links. A single Power Supply Module can provide sufficient power to run all devices in a fully populated OIU chassis. In normal operation with redundant power supplies, current is shared across the load by both the master and redundant power modules; therefore, if both power supplies are installed and healthy, the advertised power consumption of the load is cut in half for each power module (beyond the idle power required by the power supply itself). The total AC power requirement in Watts is calculated as follows:

$$\text{OIU: Max Total Power (W)} = 54 + (\# \text{ of links} * 10)$$

For maximum protection against power and lightning surges, Sytonics recommends protecting the system with an Uninterruptible Power Supply. At a minimum, the system should be protected with a high quality surge/lightning suppressor.

A rack ground strap may be connected to the #10 ground lug on the power modules. If both power modules are present in the chassis, one ground connection should provide an adequate chassis ground for any application.

2.2.2. Rack

FORAX-DAS equipment is designed to be compatible with standard two- and four-post equipment racks. The FORAX-DAS chassis may be installed on sliding or fixed rails; however, Sytonics recommends that the 3U and larger chassis be installed on shelves.

The OIU and AIU chassis should be installed in a rack location that provides sufficient air flow for cooling and ensures that ambient temperature does not exceed 40°C during system operation. Because of heat generated by the AIU HPA, Sytonics recommends mounting of the AIU chassis at least 1U away from other equipment in order to insure adequate cooling.

NOTE:

Except for power supply cooling which is drawn in through ventilation holes in the rear, air flows into the chassis at the top and bottom front and is discharged out at the rear ventilation holes. Free airflow is required for proper system operation.

2.2.3. RF Lightning Protection

The FORAX-DAS AIU includes a moderate amount of surge protection; however, it is unlikely to survive a near or direct lightning strike. Where appropriate, Sytonics recommends that each AIU be protected by a high quality RF lightning protection system.

2.2.4. Co-site Interference

To mitigate co-site interference, each FORAX-DAS AIU may be fitted with an external, passive bandpass filter to operate in a specific portions of the frequency band. At a minimum, the FORAX-DAS antenna installation should be designed with significant RF isolation between transmitters and receivers such that in-band RF signals from other transmitters do not exceed -30 dBm at the input to the AIU.

Sytonics Applications Engineers can help with customer filter specifications if desired.

2.3. FORAX-DAS Installation

The FORAX-RP system is easily installed in a properly prepared site by taking the following steps.

- A. Mount each OIU and AIU chassis securely in a two or four post rack using slides or shelves. The customer provided RF combining and splitting equipment and OIU must be adjacently mounted due to interconnected cable assemblies.

NOTE:

The chassis and modules are designed for infrequent removal and replacement. Care should be taken during installation of a module to keep the module aligned to the slot to prevent binding. If binding occurs, realign the module until it slides freely.



Figure 2-1. 1U OIU Chassis with All Modules Partially Inserted

- B. Connect the customer provided RF Splitting and combining equipment to the OIU with the appropriate interconnect cable assemblies as defined by Table 2-1. Ensure sufficient cable assembly stress relief between units.

Customer provided RF splitting & combining Equipment	OIU Combiner/Splitter 1	OIU Combiner Splitter 2
TX Output 1	J4 TX In	-
RX Input 1	J8 RX Out	-
TX Output 2	-	J4 TX In
RX Input 2	-	J8 RX Out

Table 2-1. FORAX-DAS - OIU connections

- C. Connect each OIU, and AIU ground post to the rack earth ground.
- D. Connect the rack earth ground to one of the OIU PM/HPM ground posts.
- E. Carefully remove the protective caps on the OIU/AIU fiber optic connectors and mate to single-mode APC fiber optic cable.

NOTE:

It is imperative to keep the fiber connectors as clean as possible to minimize RF link losses. ALL fiber connectors should be cleaned with a ferrule end-face cleaner (CLETOP or an equivalent) each time they are mated. When fiber connectors are not in use, the provided covers should be installed to prevent dirt intrusion.

- F. Set the base station radio for each link to the operating frequency and correct output power. The FORAX DAS System has been designed to deliver the correct RF signal level to the OIM with the configuration and cabling provided. Deviating from the delivered hardware configuration (including the attenuator fixed to the input of the OIU Splitter) will significantly degrade performance.
- G. **Deviations from the delivered configuration that result in carrier levels in excess of -10 dBm per base station radio being presented to the OIM TX Input will result in emissions in violation of FCC Regulations.**
- H. Apply power to OIU, and AIU as appropriate. Verify the following:
- GREEN** Power Module Present lights are illuminated for each installed power supply. Power Module fault indicator lights are not illuminated.
 - BLUE** Module Present lights are illuminated for each installed OIU without a CPM, and **GREEN** Module present lights are illuminated for each installed AIM.
 - GREEN** CMD LINK, UL LASER, DL LASER and AIU ALARM lights are illuminated for each installed OIU/AIM link with a CPM.
- I. Connect an RF power meter and load to each AIU. Verify the transmit power of each AIU.
- J. Once output power has been verified, connect the AIU to the antenna or secondary high power amplifier using a high quality coax cable.

Upon completion of these steps, the FORAX-DAS system will be ready for service.

2.4. Module Replacement

All OIU modules are hot-swappable and may be removed and replaced without disrupting the operation of the other modules.

- PM/HPM removal: Disconnect AC power cable and ground strap, loosen locking screw, slide module out of chassis.
- OIM removal: Loosen locking screw, Slide module approximately 1 inch to remove power, disconnect RF and optical cables, slide module out of chassis.
- CPM removal: Loosen locking screw, Remove CPM from chassis. The link will retain the last settings until a CPM is reinstalled.

NOTE:

Do not disconnect Fiber Optic or RF cables from modules while under power. Either disconnect AC power from the entire chassis, or pull module partially out of chassis to remove power.

3. FORAX-DAS OPERATION

The FORAX-DAS system is designed to operate autonomously with minimal user configuration required. As shown in Figure 3-1, each link module installed in an OIU will be indicated by a **BLUE** Module Present LED on the front panel. Additionally, the PM(s) and HPM(s) internally monitor status and failure will be indicated by a **RED** Fault LED. RF and fiber optic link status for each OIM are indicated by the CPM LEDs on the front and redundant LEDs on the rear panel of each OIM.

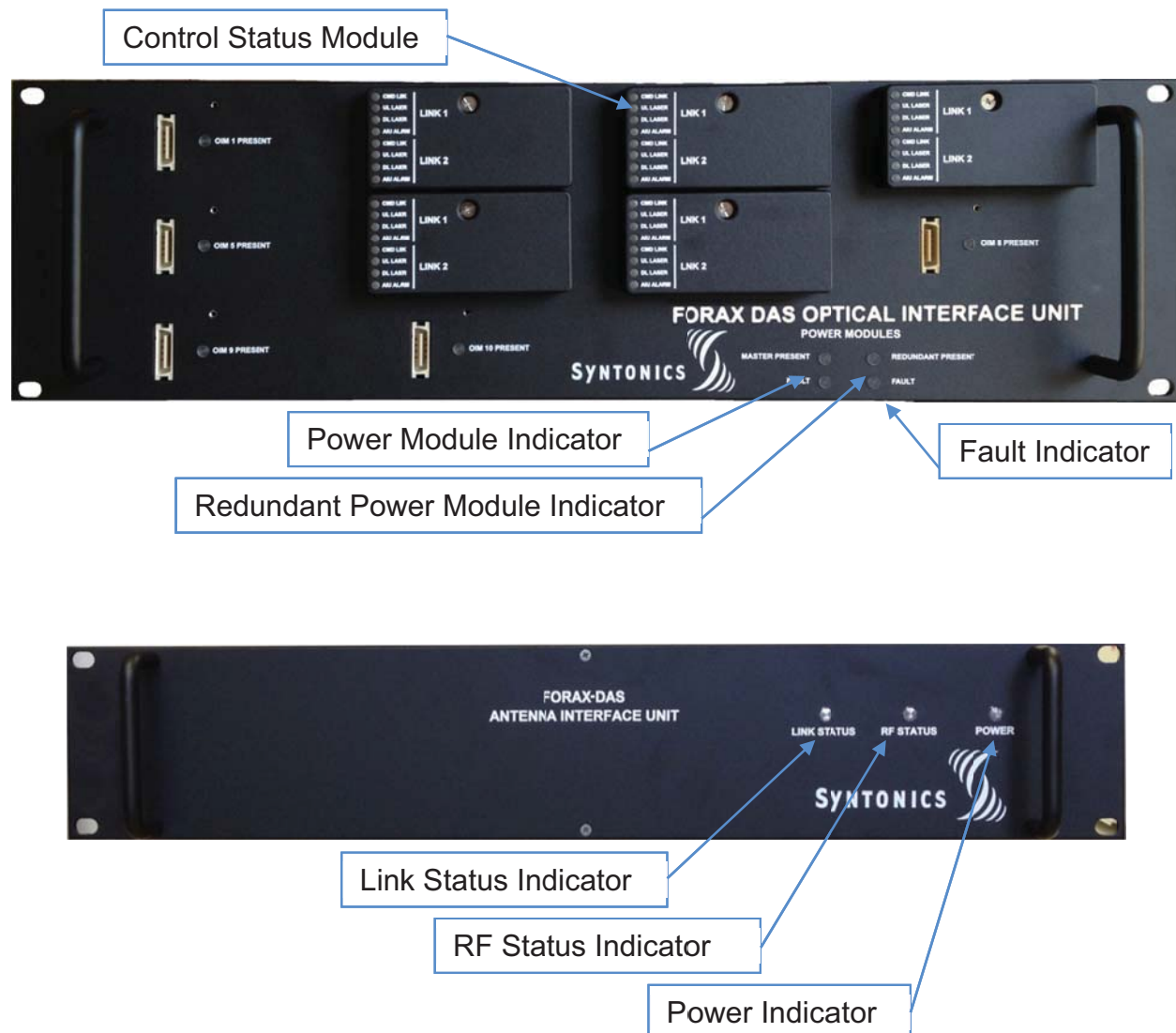


Figure 3-1. OIU and AIU Status Indicators

The CPM is shown in Figure 3-2. Status indicators are displayed as **GREEN**, **AMBER**, or **RED**, control indicators are displayed in **BLUE**. A summary of status indicators and control indicators follows:

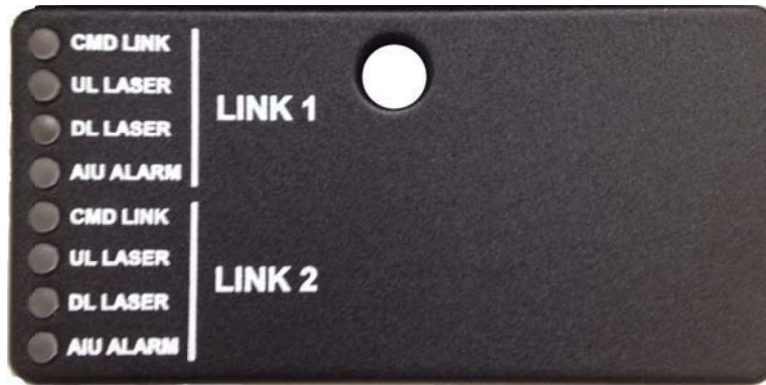


Figure 3-2. CPM Status Indicators and Controls

3.1. Status Indicators

- **CMD LINK:**
 - GREEN:** OIM/AIU command link functioning properly
 - AMBER:** OIM to AIU link degraded/non-op
 - RED:** AIU not reporting status
- **UL LASER:**
 - GREEN:** Light amplitude good
 - AMBER:** Light amplitude marginal
 - AMBER:** (Blinking) No AIU Communication
 - RED:** Light amplitude low
- **DL LASER:**
 - GREEN:** Light amplitude good
 - AMBER:** Light amplitude marginal
 - RED:** Light amplitude low
- **AIU ALARM:**
 - AMBER:** AIU Temperature at Warning Threshold
 - RED:** AIU Transmit FAILURE

NOTE: The AIU contains an HPA and active temperature monitoring and control software. Under normal operating conditions, the AIU ALARM light should be **OFF** but may be **AMBER** during high ambient temperature conditions. The system will continue to operate normally in this situation but air flow through the system should be confirmed to avoid the possibility of extended high temperature operation damaging the HPA.

Although it is not recommended to overheat the HPA, if it occurs, the HPA is protected from thermal damage by first reducing power, then turning off output completely. Once cooled down, the HPA should return to normal function.

3.2. Transmit Duty Cycle

FORAX-DAS links are designed to operate continuously at a 100% transmit duty cycle.

3.3. Maintenance

FORAX-RP systems are designed for continuous long-term operation, and do not require any scheduled maintenance.

3.4. Declaration of Conformity

This product is in conformance with Part 15 of the FCC Rules and Regulations for Information Technology Equipment. Operation of this product is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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4. SPECIFICATIONS

Tables 4-1 and 4-2 list specifications for the FORAX-DAS System.

Table 4-1. FORAX-DAS System General Specifications

Maximum Optical Cable Loss	5 dB
Maximum Optical Reflectance	-50 dB
Fiber optic connector type	Single-mode, FC/APC
RF connector type	AIU TNC-type female OIU BNC female
Power connector type	IEC C13
Power requirements	Input Voltage: 90-240 VAC, 50-60 Hz OIU Power: 100 W Max AIU Power: 250 W Max (each)
Operating temperature	+10 C to +40 C
Storage temperature	-40 C to +80 C
Case Size (WxHxD)	1U, 19 x 1.75 x 20 in 2U, 19 x 3.50 x 20 in 3U, 19 x 5.25 x 20 in
Weight	OIU: 15 lb AIU: 15 lb
Laser Data	Class 1 Laser Product Optical Fiber Communication System, Service Group 1 Maximum Power 10 mW Wavelength 1310, 1550 nm Complies with 21 CFR 1040.10 and 1040.11

Table 4-2. FORAX-RP System Radio Link Specifications

System	Inbound (RX) gain	10 dB nominal
System	Outbound gain	0 ± 2 dB
System	Input Power per carrier	17 dBm
AIU	Input P1dB	+38 dBm
AIU	Input 2 tone IP3	+48 dBm
AIU	Nominal Output Power	17 dBm
AIU	Minimum Signal (50 dB C/N ₀ @ Radio)	-105 dBm
AIU	Receive Input P1dB	-20 dBm
AIU	Receive Input 2 tone IP3	-10 dBm
AIU	Minimum Antenna Return Loss	8 dB

5. CUSTOMER SUPPORT

Sytonics strives to provide outstanding support to our customers. The FORAX system is designed for long service life and operational reliability. Most of the issues Sytonics encounters are with fiber optic cabling and RF co-site interference. Because of our experience with several types of installations, many issues with the FORAX system can be resolved quickly with a short telephone or email conversation.

Sytonics Technical Service Support Operations can be reached at 1-410-884-0500 between 9 a.m. and 5 p.m. EST, Monday through Friday, excluding holidays.

Support can also be reached by email at Customer.Service@SytonicsCorp.com. Email inquiries should be acknowledged within one business day.

After a brief description of the problem a Sytonics representative will give instructions for troubleshooting and where to find the part number and serial number of your product.

The part and serial numbers will be used to determine if your product qualifies for warranty service under the terms of the limited warranty (see section 6). Items under warranty will be supported free of charge. For items out of warranty, Sytonics will provide a not-to-exceed time and materials estimate to repair the item.

If the problem cannot be resolved with the equipment in place, Technical Service Support Operations will issue a Return Material Authorization (RMA) number. The item to be returned shall be packaged appropriately for safe shipment and the RMA number should be marked on the outside of the package, and sent prepaid, insured. The repaired or replaced item will be returned at Sytonics' expense.

For installations that require the highest reliability and little operational disruption, Sytonics recommends that our customers purchase spare modules. Once a problem has been isolated to an individual link or power module, the module can be quickly swapped out without disrupting the operation of rest of the system.

6. LIMITED HARDWARE WARRANTY

Syntronics warranty obligations are limited to the terms set forth below:

6.1. Limited Warranty

SYNTHONICS warrants this hardware product against defects in materials and workmanship, under normal use and service, for a period of one (1) year from the date of receipt by the Purchaser.

If the Purchaser discovers a defect within the warranty period, SYNTHONICS will repair the product with either new or refurbished replacement parts at no charge. If SYNTHONICS is unable to restore the product to good working order, SYNTHONICS will, at its option, replace or refund the purchase price of the product. All products that are replaced will become the property of SYNTHONICS. Any replaced or repaired product is warranted for the remainder of the initial warranty period or ninety days, whichever is longer. SYNTHONICS shall not be responsible for any software, firmware, information or memory data of the Purchaser contained in, stored on, or integrated with any products for system components returned to SYNTHONICS pursuant to any warranty.

6.2. Return Procedures

To obtain service under this warranty within the established period, the Purchaser must:

Call SYNTHONICS Technical Service Support Operations at 1-410-884-0500 between 9 a.m. and 5 p.m. EST, Monday through Friday, excluding holidays.

To insure that your product qualifies for return to factory warranty service, you will be asked to provide the model and serial number of your product, the date of original purchase, and the Purchaser's name, address, and phone number.

Products returned to SYNTHONICS' Technical Service Support Operations must be pre-authorized by SYNTHONICS with a Return Material Authorization (RMA) number marked on the outside of the package, and sent prepaid, insured, and packaged appropriately for safe shipment. The repaired or replaced item will be shipped to the Purchaser at SYNTHONICS' expense.

6.3. Applicability

This warranty applies only to hardware products (including internal components) supplied by SYNTHONICS that can be identified by the "SYNTHONICS" trademark, trade name, or logo affixed to them. Any warranty on external third-party hardware installed by SYNTHONICS with this product is provided by the hardware vendor, not SYNTHONICS. This warranty applies to all SYNTHONICS products and third party products included in each purchase. This warranty does not apply to damage caused by accident, abuse, misuse, improper installation or testing, misapplication, service performed by a third party other than SYNTHONICS, or any other cause beyond the range of the intended use, or by fire, lightning, or other hazard; if the product has been modified without the

written permission of SYNTONICS; or if any SYNTONICS serial number has been removed or defaced.

6.4. Limitations of Remedies and Damages

IN NO EVENT WILL SYNTONICS, ITS PARENT OR SUBSIDIARIES OR ANY OF THE LICENSORS, DIRECTORS, OFFICERS, EMPLOYEES OR AFFILIATES OF ANY OF THE FOREGOING BE LIABLE TO THE PURCHASER FOR ANY CONSEQUENTIAL, INCIDENTAL, INDIRECT OR SPECIAL DAMAGES WHATSOEVER (INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS OF BUSINESS PROFITS, BUSINESS INTERRUPTION, LOSS OF BUSINESS INFORMATION AND THE LIKE,) WHETHER FORESEEABLE OR UNFORESEEABLE, ARISING OUT OF THE USE OF OR INABILITY TO USE THE SOFTWARE OR ACCOMPANYING WRITTEN MATERIAL, REGARDLESS OF THE BASIS OF THE CLAIM AND EVEN IF SYNTONICS OR A SYNTONICS REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGE. SYNTONICS LIABILITY TO THE PURCHASER FOR DIRECT DAMAGES FOR ANY CAUSE WHATSOEVER, AND REGARDLESS OF THE FORM OF THE ACTION, WILL BE LIMITED TO THE ACTUAL PURCHASE PAID FOR THE PRODUCT.

Some states do not allow the exclusion or limitation of incidental or consequential damages or exclusion of implied warranties, so the above limitations or exclusions may not apply to the Purchaser. This warranty gives the Purchaser specific legal rights, and the Purchaser may also have other rights that vary from state to state.

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