PCB-4000

1+1 Phase Combiner
Installation and Operation Manual

IMPORTANT NOTE: The information contained in this document supersedes all previously published information regarding this product. Product specifications are subject to change without prior notice.

Part Number MN/PCB4000.IOM   Revision 1

PCB-4000

1+1 Phase Combiner
Installation and Operation Manual

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Revision 1
April 29, 2010

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PREFACE

About this Manual

This manual provides installation and operation information for the Comtech EF Data PCB-4000 1+1 Phase Combiner. This is a technical document intended for earth station engineers, technicians, and operators responsible for the operation and maintenance of the PCB-4000.

Comtech EF Data has reviewed this manual thoroughly in order to provide an easy-to-use guide to your equipment. All statements, technical information, and recommendations in this manual and in any guides or related documents are believed reliable, but the accuracy and completeness thereof are not guaranteed or warranted, and they are not intended to be, nor should they be understood to be, representations or warranties concerning the products described. Further, Comtech EF Data reserves the right to make changes in the specifications of the products described in this manual at any time without notice and without obligation to notify any person of such changes.

Revision 1 of this manual represents a complete rewrite in which all content has been updated in its entirety and re-ordered to conform to current Comtech EF Data Technical Publications standards and practices.

If you have any questions regarding your equipment or the information in this manual, please contact the Comtech EF Data Customer Support Department.

Reporting Comments or Suggestions Concerning this Manual

Comments and suggestions regarding the content and design of this manual are appreciated. To submit comments, please contact the Comtech EF Data Technical Publications Department:

TechnicalPublications@comtechefdata.com

Conventions and References

Cautions and Warnings

WARNING *indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.*

CAUTION *indicates a hazardous situation that, if not avoided, may result in minor or moderate injury.* **CAUTION** *may also be used to indicate other unsafe practices or risks of property damage.*

IMPORTANT *or* **NOTE** *indicates information critical for proper equipment function, or a statement that is associated with the task being performed.*

Recommended Standard Designations

Recommended Standard (RS) Designations have been superseded by the new designation of the Electronic Industries Association (EIA). References to the old designations are shown only when depicting actual text displayed on the screen of the unit (RS-232, RS-485, etc.). All other references in the manual will be shown with the EIA designations.

Trademarks

Other product names mentioned in this manual may be trademarks or registered trademarks of their respective companies and are hereby acknowledged.

Metric Conversion

Metric conversion information is located on the inside back cover of this manual. This information is provided to assist the operator in cross-referencing non-metric to metric conversions.

Electrical Safety Notice

This equipment has been designed to minimize exposure of personnel to hazards. For further information, contact the Comtech EF Data Customer Support Department.

The operators and technicians must:

- Know how to work around, with, and on high voltage equipment.
- Exercise every precaution to ensure personnel safety.
- Exercise extreme care when working near high voltages.
- Be familiar with the warnings presented in this manual.

Double pole / neutral fusing is used on the prime power supply input.

Warranty Policy

Comtech EF Data products are warranted against defects in material and workmanship for a specific period from the date of shipment, and this period varies by product. In most cases, the warranty period is two years. During the warranty period, Comtech EF Data will, at its option, repair or replace products that prove to be defective. Repairs are warranted for the remainder of the original warranty or a 90 day extended warranty, whichever is longer. Contact Comtech EF Data for the warranty period specific to the product purchased.

For equipment under warranty, the owner is responsible for freight to Comtech EF Data and all related customs, taxes, tariffs, insurance, etc. Comtech EF Data is responsible for the freight charges only for return of the equipment from the factory to the owner. Comtech EF Data will return the equipment by the same method (i.e., Air, Express, Surface) as the equipment was sent to Comtech EF Data.

All equipment returned for warranty repair must have a valid RMA number issued prior to return and be marked clearly on the return packaging. Comtech EF Data strongly recommends all equipment be returned in its original packaging.

Comtech EF Data Corporation's obligations under this warranty are limited to repair or replacement of failed parts, and the return shipment to the buyer of the repaired or replaced parts.

Limitations of Warranty

The warranty does not apply to any part of a product that has been installed, altered, repaired, or misused in any way that, in the opinion of Comtech EF Data Corporation, would affect the reliability or detracts from the performance of any part of the product, or is damaged as the result of use in a way or with equipment that had not been previously approved by Comtech EF Data Corporation.

The warranty does not apply to any product or parts thereof where the serial number or the serial number of any of its parts has been altered, defaced, or removed.

The warranty does not cover damage or loss incurred in transportation of the product.

The warranty does not cover replacement or repair necessitated by loss or damage from any cause beyond the control of Comtech EF Data Corporation, such as lightning or other natural and weather related events or wartime environments.

The warranty does not cover any labor involved in the removal and or reinstallation of warranted equipment or parts on site, or any labor required to diagnose the necessity for repair or replacement.

The warranty excludes any responsibility by Comtech EF Data Corporation for incidental or consequential damages arising from the use of the equipment or products, or for any inability to use them either separate from or in combination with any other equipment or products.

A fixed charge established for each product will be imposed for all equipment returned for warranty repair where Comtech EF Data Corporation cannot identify the cause of the reported failure.

Exclusive Remedies

Comtech EF Data Corporation's warranty, as stated is in lieu of all other warranties, expressed, implied, or statutory, including those of merchantability and fitness for a particular purpose. The buyer shall pass on to any purchaser, lessee, or other user of Comtech EF Data Corporation's products, the aforementioned warranty, and shall indemnify and hold harmless Comtech EF Data Corporation from any claims or liability of such purchaser, lessee, or user based upon allegations that the buyer, its agents, or employees have made additional warranties or representations as to product preference or use.

The remedies provided herein are the buyer's sole and exclusive remedies. Comtech EF Data shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

Customer Support

Refer to p.ix in this Preface for information regarding this product's Warranty Policy.

Contact the Comtech EF Data Customer Support Department for:

- Product support or training

- Reporting comments or suggestions concerning manuals

- Information on upgrading or returning a product

A Customer Support representative may be reached at:

> Comtech EF Data
> Attention: Customer Support Department
> 2114 West 7th Street
> Tempe, Arizona 85281 USA
>
> 480.333.2200 (Main Comtech EF Data number)
> 480.333.4357 (Customer Support Desk)
> 480.333.2161 FAX

To return a Comtech EF Data product (in-warranty and out-of-warranty) for repair or replacement:

- **Contact** the Comtech EF Data Customer Support Department. Be prepared to supply the Customer Support representative with the model number, serial number, and a description of the problem.

- **Request** a Return Material Authorization (RMA) number from the Comtech EF Data Customer Support representative.

- **Pack** the product in its original shipping carton/packaging to ensure that the product is not damaged during shipping.

- **Ship** the product back to Comtech EF Data. (Shipping charges should be prepaid.)

Online Customer Support

An **RMA number request** can be requested electronically by contacting the Customer Support Department through the online support page at **www.comtechefdata.com/support.asp**:

- **Click** on the "Service" hyperlink, then read the "Return Material Authorization" section for detailed instructions on our return procedures.

- **Click** on the "RMA Request Form" hyperlink, then fill out the form completely before sending.

- **Send e-mail** to the Customer Support Department at **service@comtechefdata.com**.

Notes:

Chapter 1. INTRODUCTION

1.1   Overview

Phase combining is a traditional technique that cost effectively increases the available output power of an amplifier system. The PCB-4000 1+1 Phase Combiner (**Figure 1-1**), together with two **S**olid **S**tate **P**ower **A**mplifiers (SSPAs), form a complete 1+1 phase combined system that doubles the available output power. The PCB-4000 also features a "soft fail" configuration; i.e., if one SSPA experiences a failure, the total output power will only be reduced by 3 dB, rather than 6 dB.

Figure 1-1. Comtech EF Data PCB-4000 1+1 Phase Combiner Control Box (PCCB)

1.2   Functional Description

The PCB-4000 is available in either a X-Band version (CEFD P/N PL/11285-1) or C-Band version (CEFD P/N PL-0000330). The box may be provided as an item in an overall assembly kit, or as a subassembly kit item. For application examples, see **Appendix A. ASSEMBLY KITS**.
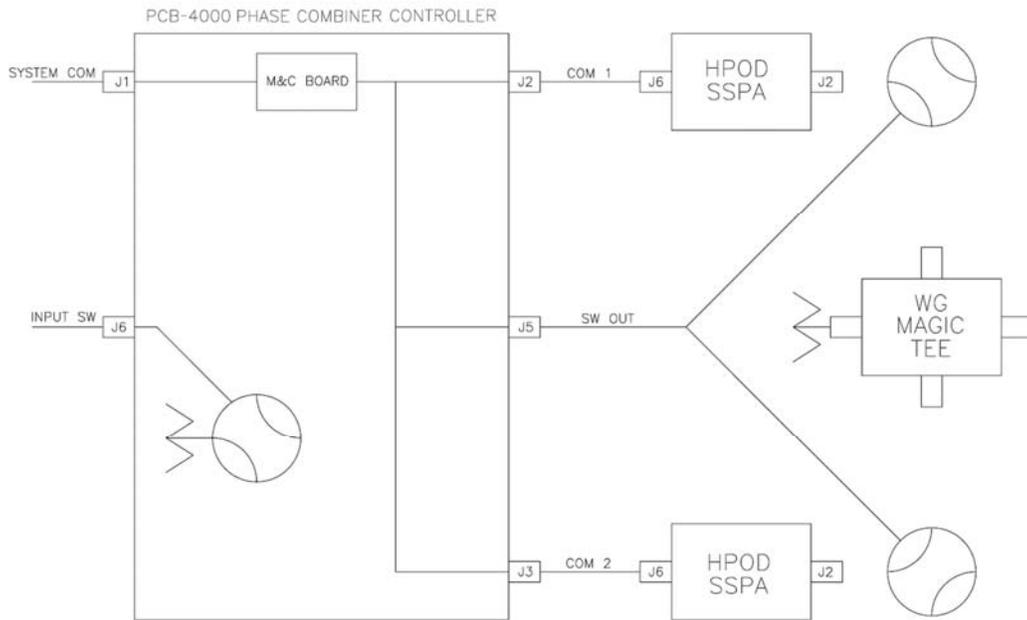
Monitor & Control (M&C) System Interconnect
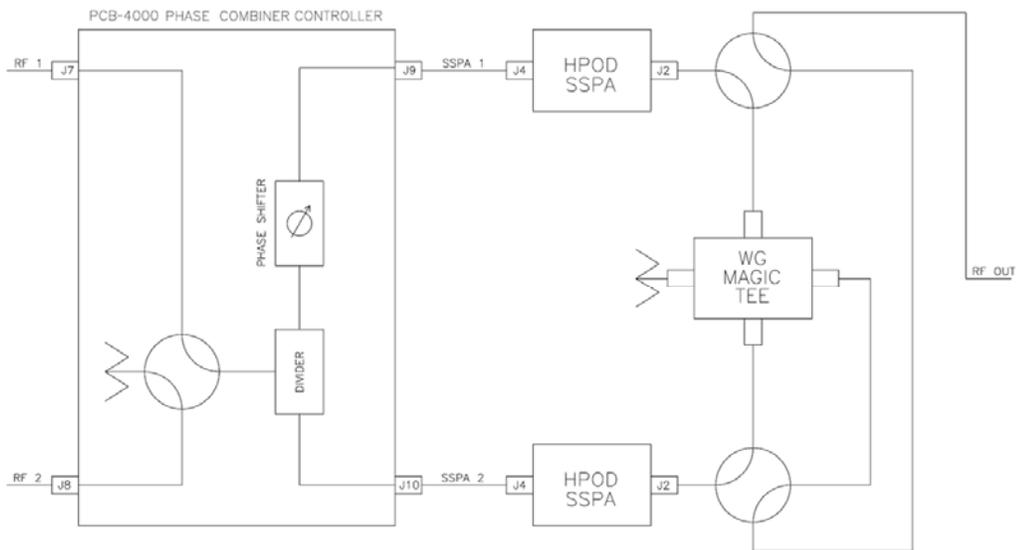
RF System Interconnect

Figure 1-2. Comtech EF Data 1+1 Phase Combined System Block Diagrams

Figure 1-2 provides block diagrams depicting the major components of the 1:1 phase combined system. (These diagrams employ Comtech EF Data HPODs – High Powered Outdoor Amplifiers – as the designated SSPAs.)

The PCB-4000 1+1 Phase Combiner Control Box (PCCB) contains a microprocessor-based M&C circuit board to control the system. Interconnection is as follows:

- The PCCB communicates with each SSPA via control cables that are attached from the PCCB J2 and J3 connectors to each SSPA.

- It is also through this connection that the PCCB receives it prime power to operate. A +24V signal from each SSPA is diode OR'ed to provide redundant operating power for the PCCB.

- Control of the waveguide switches is accomplished via a "Y" cable at the J5 connector. The user communicates with the control box via the J1 System Comm connector.

Note: In order to avoid ambiguities, all communication to each SSPA is also accomplished via the control box M&C.

The PCCB provides a weatherized housing for the necessary input RF components. System interconnection is as follows::

- An input RF redundancy switch, controlled via the J6 connector, selects which RF path is directed to the output.

- The output RF signal is fed into an in-phase divider, which equally splits the signal in phase and amplitude to the **SSPA 1 OUT J9** and **SSPA 2 OUT J10** output connectors.

  o The RF path to the **SSPA 1 OUT J9** output connector contains a manually adjustable phase shifter; this phase shifter is used to equalize the phase difference of each SSPA signal path to achieve maximum system output power. It is accessible via a small cover panel. This critical component is factory set and should only be adjusted, if needs arise, by carefully following an appropriate alignment procedure – refer to **Chapter 3. OPERATION AND ADJUSTMENT PROCEDURES** for further information.

  o The RF path to the **SSPA 2 OUT J10** output connector contains a length of coaxial cable that is factory manufactured to provide equal phase length paths from the RF input to each PCCB output when the adjustable phase shifter is set to its midpoint. This provides a maximum adjustable phase range.

  There are also several isolators inside the PCCB that maintain good system **V**oltage **S**tanding **W**ave **R**atio (VSWR). The user should not alter any RF cable inside (or outside) this box that is part of the RF signal path.

- The RF signals from the PCCB are fed to the RF input of the respective SSPA via a set of phase matched cables. Again, the phase length (and matching) of these cables is essential to system operation and no substitutes should be used. The routing should not be such to cause extreme bends.

- The output waveguide combining system consists of balanced waveguide lengths, two waveguide transfer switches, a "Magic-Tee" combiner with termination, and couplers for test and alignment.

1.3   Theory of Operation

As mentioned previously, phase combining is a common technique to increase the available output power of an amplifier system. Referring back to the **Figure 1-2** system block diagrams, when two signals of equal phase and amplitude are fed into the "Magic-Tee" combiner, the individual power of each SSPA is summed at the output port and cancelled in the termination port.

In real systems, the phase and amplitude of the two signals are never exactly equal, so there is a small amount of power that is absorbed by the load termination. This terminated port is sometimes referred to as the "wasted" power port. In practice, however, it is possible to keep phase and amplitude imbalances at low enough levels such that overall combining losses are only in the 0.2 to 0.5 dB range.

Figure 1-3 shows the effects of phase imbalance on the power combining efficiency.
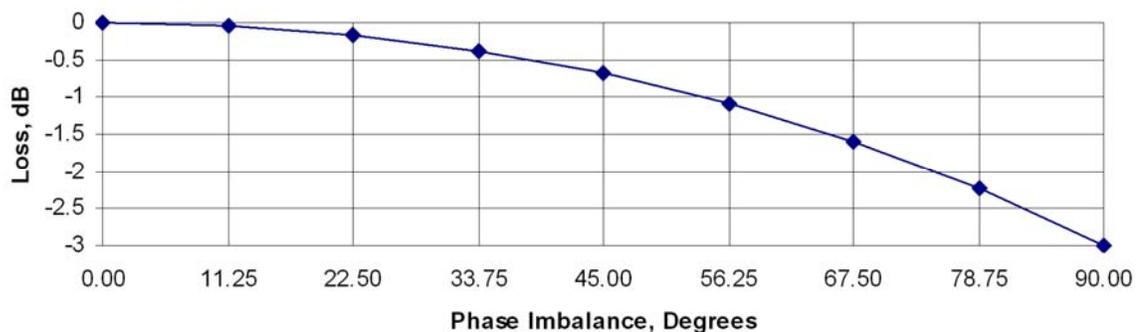
Figure 1-3. Combining Loss vs. Phase Imbalance Summary of Specifications

1.3.1   Phase and Gain Equalization

Naturally, two separate amplifiers are likely to have different phase and gain characteristics. The PCB-4000 1+1 system is designed such that the phase difference between the two amplifier paths is compensated by adjusting the phase shifter in the Phase Combiner Control Box. This is done at the factory for the full amplifier bandwidth and should not normally require further adjustment in the field unless an amplifier has been replaced. (See alignment procedure).

The amplifier gain difference is automatically compensated for by the PCCB Monitor and Control System. Upon power up, the M&C reads the gain of each individual amplifier as calibrated at the factory, and automatically attenuates the amplifier with the most gain so as to be equal with the lower gain unit. For example, if SSPA #1 had a factory gain calibration setting of 76 dB, and SSPA #2 had a factory gain calibration setting of 73 dB, the M&C system would automatically set the attenuation setting of SSPA#1 to 3 dB to equalize the system gain. Although not generally needed or recommended, a user input gain offset setting is also provided for system fine tuning. For operation and alignment information, refer to **Chapter 3. OPERATION AND ADJUSTMENT PROCEDURES**.

Note that, due to the power divider and cable losses, the overall gain of the system will be less than the individual gain of each amplifier. Please refer to the system test data sheet for actual system gain.

1.3.2   System Attenuation

The PCB-4000 makes it easy to adjust the overall system gain. The user inputs the requested attenuation setting and the PCB-4000 automatically adjusts the gain of each SSPA accordingly, resulting in the desired attenuation value while maintaining optimum power combining conditions.

The SSPAs included in the system are calibrated over a range 10 dB beyond specification (30 dB vs 20 dB). As explained above, a portion of the 30 dB range is required for gain equalization. Therefore, the maximum allowable attenuation in a 1+1 system is software limited to 24 dB, but still exceeds system specifications.

1.3.3   Soft Fail Protection

In the event of a failure of one of the SSPAs, the PCB-4000 controls the waveguide switches such that the good unit's power is routed around the "Magic-Tee" combiner directly to the output port. This results in only a 3 dB power loss, or "soft failure". Without the waveguide switches, a failure in one unit would result in a 6 dB power loss.

1.4   Dimensional Envelope

Note: All dimensions are in English units; metric units are shown in parentheses. This figure is typical for the PL-0000330 C-Band and PL/11285-1 X-Band versions of the PCB-4000.
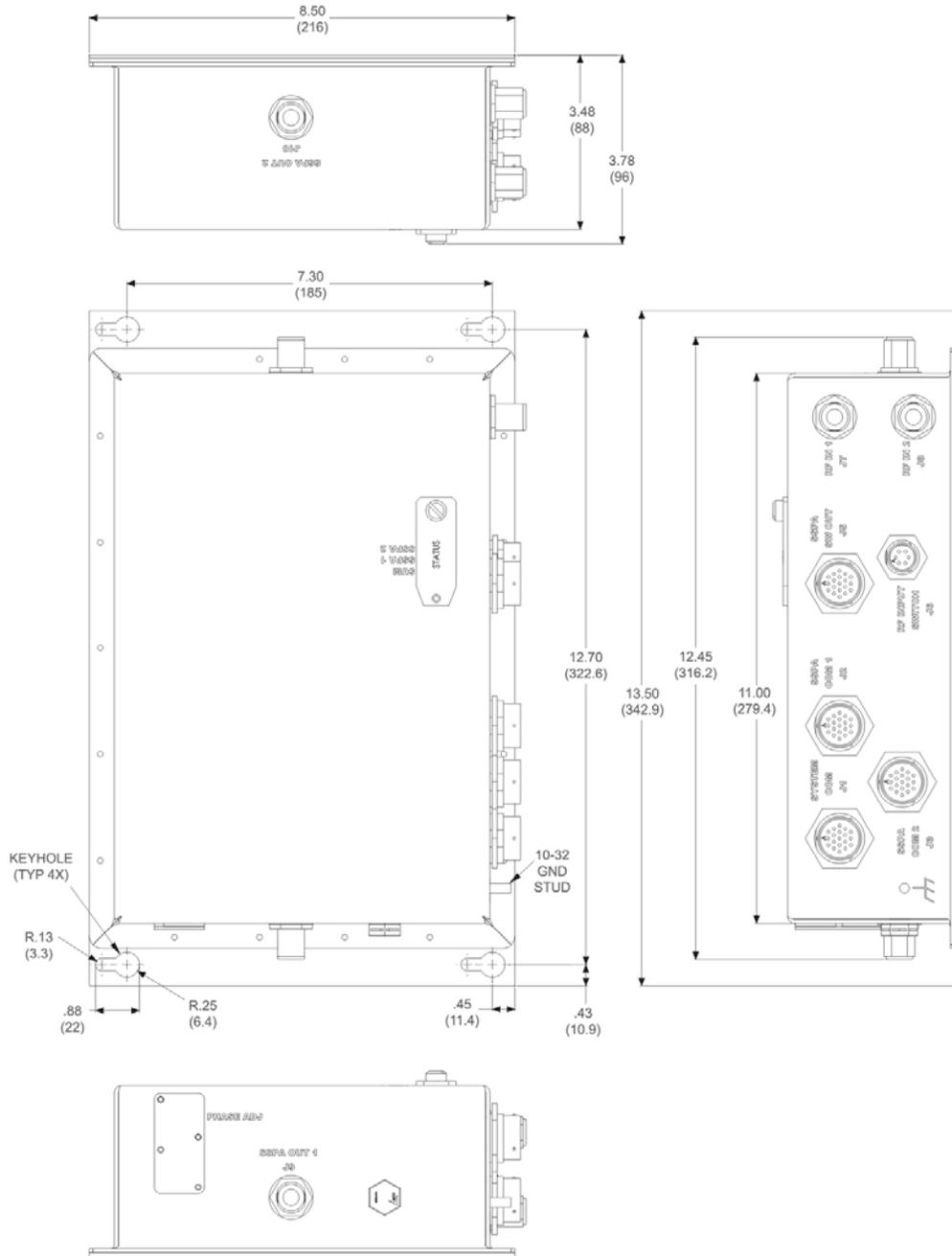
Figure 1-4. PCB-4000 Dimensional Envelope

Chapter 2. EXTERNAL CONNECTORS

2.1　Overview

This chapter summarizes the connectors provided for all necessary external connections between the PCB-4000 1+1 Phase Combiner and other equipment. **Table 2-1** on the next page summarizes the connectors provided on the PCB-4000, grouped according to service function.

PCCB Front View

PCCB Left Side View　　　　　**PCCB Right Side View**
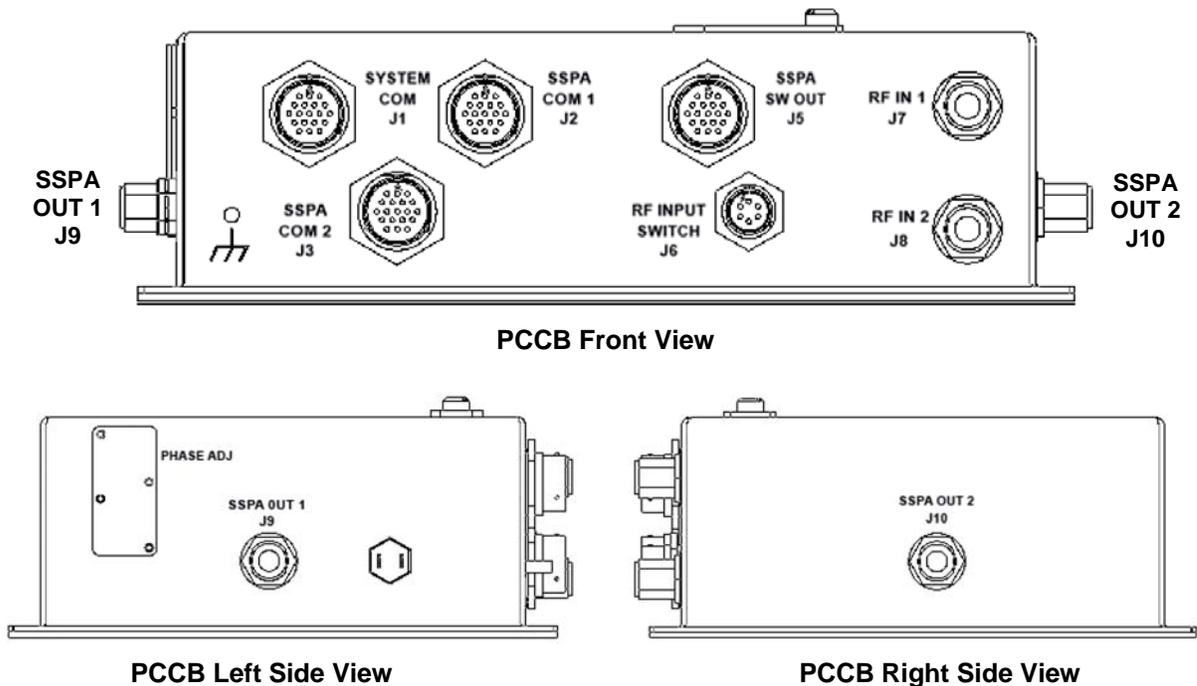
Figure 2-1. PCB-4000 External Connectors

Basic installation and operational information is provided in **Chapter 3. OPERATION AND ADJUSTMENT PROCEDURES** and **Appendix A. ASSEMBLY KITS.** For a detailed overview on the PCB-4000's operability (via remote M&C commands and queries), refer to **Appendix B. REMOTE CONTROL**.

Table 2-1. PCB-4000 External Connectors

Connector Group (Chapter Sect.)	Name / Ref Des	Connector Type	Function
M&C (Sect. 2.2)	SYSTEM COM J1	19-pin Circular Connector	Customer EIA-232/485 and discrete interface
	SSPA COM 1 J2	19-pin Circular Connector	Connects to SSPAs
	SSPA COM 2 J3		
	SSPA SW OUT J5	19-pin Circular Connector	Connects to both waveguide switches
	RF INPUT SWITCH J6	6-pin Circular Connector	Drive input, selects either RF IN 1 or RF IN 2
RF (Sect. 2.3)	RF IN 1 J7	Type 'N'	RF Inputs to PCCB
	RF IN 2 J8		
	SSPA OUT 1 J9	Type 'N'	RF Outputs to SSPAs
	SSPA OUT 2 J10		
Power/Ground (Sect 2.4)	AC	Pin 'R' on SSPA COM 1 J1, SSPA COM 2 J3	See Sect. 2.4.1 for AC power provision note
	Ground	#10-32 stud	Common Chassis Ground

 IMPORTANT

To maintain compliance with the European EMC Directive (EN55022, EN50082-1) properly shielded cables are required for data I/O.

2.2 Monitor and Control (M&C) Interface Connectors

Note: All M&C connectors are found on the front panel of the PCCB box.

2.2.1 SYSTEM COM J1 Connector

The **SYSTEM COM J1** connector is a 19-pin circular connector, type MS3112E14-19S. It serves as the primary input between the user and the PCCB for controlling and monitoring both SSPAs. Its pinout specification is provided in **Table 2-2**.

Mating connector: ITT Cannon MS3116J14-19P
(CEFD P/N CN/MS3116J14-19P)

Table 2-2. Connector J1 Pinouts

Pin #	Signal Function	Signal Name / Description
A	RS485_+RX	Customer communications interface
B	RS485_-RX	Customer communications interface
C	RS485_+TX	Customer communications interface
D	RS485_-TX	Customer communications interface
E	RS232_RD	Customer communications interface
F	Spare	Reserved for future use
G	RS232_TD	Customer communications interface
H	System Fault NO	When there is a summary fault in the PCB-4000, this pin (NO) will be tied to the Fault Common pin.
J	System Fault NC	When there is not a summary fault in the PCB-4000, this pin (NC) will be tied to the Fault Common pin.
K	Fault Common	
L	SSPA 1 Fault NO	When there is a fault with SSPA 1, this pin (NO) will be tied to the Fault Common pin.
M	SSPA 1 Fault NC	When there is not a fault with SSPA 1, this pin (NC) will be tied to the Fault Common pin.
N	Ground	
P	SSPA 2 Fault NO	When there is a fault with SSPA 2, this pin (NO) will be tied to the Fault Common pin.
R	SSPA 2 Fault NC	When there is not a fault with SSPA 2, this pin (NC) will be tied to the Fault Common pin.
S	System Mute	SSPA will be muted if this pin is grounded
T	SSPA 3 Fault NO	(**NOTE**: This pin is reserved for use with 1:2 systems only.)
U	SSPA 3 Fault NC	(**NOTE**: This pin is reserved for use with 1:2 systems only.)
V	Ground	GND

2.2.2   SSPA COM 1 J2, SSPA COM 2 J3 Connectors

The **SSPA COM 1 J2** and **SSPA COM 2 J3** connectors are 19-pin circular connectors, type MS3112E14-19S. Each serves as the primary input/output interface between the PCCB and its specified SSPA. The typical pinout specification is provided in **Table 2-3**.

Typical mating connector: ITT Cannon MS3116J14-19P
                             (CEFD P/N CN/MS3116J14-19P)

Table 2-3. Connector J2, J3 Pinouts

Pin #	Signal Function	Signal Name / Description	Direction
A	NC		
B	NC		
C	NC		
D	NC		
E	RS232_RD	Provides for Comm between PCB and SSPA	Input
F	NC		
G	RS232_TD	Provides for Comm between PCB and SSPA	Output
H	Switch Inhibit Output	Provides a hardware mute input to SSPA with switch fault	Output
J	NC		
K	Ground	GND	
L	SUMFLT_NO	Monitors SSPA summary fault relay	Input
M	NC		
N	Ground	GND	
P	ONLINE_STATUS	Used by PCB for online status indication	Input
R	+24V	Bias voltage from SSPA	Input
S	Mute Control	Allow for customer inhibit. Tied to Pin S of System Comm (J1) connector	
T	NC		
U	NC		
V	NC		

2.2.3   SSPA SW OUT J5 Connector

The **SSPA SW OUT J5** connector is a 19-pin circular connector, type MS3112E14-19S. It connects, via a "Y" cable, to the SSPA #1 and SSPA #2 waveguide switches. Its pinout specification is provided in **Table 2-4**.

Mating connector: ITT Cannon MS3116J14-19P
                        (CEFD P/N CN/MS3116J14-19P)

Table 2-4. Connector J5 Pinouts

Pin #	Signal Function	Signal Name / Description	Direction
A	Pos1, SW1 Drive		Output
B	Ground	GND	
C	POS2, SW1, Drive		Output
D	POS1, SW1, Indicator		Input
E	Ground	GND	
F	POS2, SW1, Indicator		Input
G	NC		
H	POS1, SW2, Drive		Output
J	Ground	GND	
K	POS2, SW2, Drive		Output
L	POS1, SW2, Indicator		Input
M	Ground	GND	
N	POS2, SW2, Indicator		Input
P	NC		
R	NC		
S	NC		
T	NC		
U	NC		
V	NC		

2.2.4   RF INPUT SWITCH J6 Connector

The PCCB contains a built-in selector switch, a latching 28 VDC coaxial unit. The position of this switch is selected by the **RF INPUT SWITCH J6** – a 6-pin circular connector (CEFD P/N CN/MS-PT07M6PC). Its pinout specification is provided in **Table 2-5**.

Mating connector: ITT Cannon MS3116J10-6S
(CEFD P/N CN/MS3116J10-6S)

Table 2-5. Connector J6 Pinouts

Pin #	Signal Function	Signal Name / Description	Direction
A	POS1, Drive		Input
B	Ground	GND	
C	POS2, Drive		Input
D	POS1, Indicator		Output
E	Ground	GND	
F	POS2, Indicator		Output

2.3   RF Interface Connectors

2.3.1   RF IN 1 J7, RF IN 2 J8 Connectors

The **RF IN 1 J7** and **RF IN 2 J8** connectors are Type 'N' female connectors, each serving as an RF signal input interface to the PCCB. Note the following:

- The **RF IN 1 J7** input is selected when the RF INPUT SWITCH J6's "**POS1**" Signal Function is activated.

- The **RF IN 2 J8** input is selected when the RF INPUT SWITCH J6's "**POS2**" Signal Function is activated.

2.3.2   SSPA OUT 1 J9 Connector

The **SSPA OUT J10** connector, located on the left side panel of the PCCB, is a Type 'N' female connector. It provides the RF signal output from the PCCB to SSPA #1.

2.3.3   SSPA OUT 2 J10 Connector

SSPA OUT 2
J10
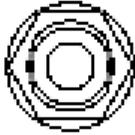
The **SSPA OUT 2 J10** connector, located on the right side panel of the PCCB, is a Type 'N' female connector. It provides the RF signal output from the PCCB to SSPA #2.

2.4   Power and Ground Interfaces

2.4.1   AC Power

The PCB-4000 derives its power from the SSPAs. Each SSPA provides a +24V signal line via cables interconnecting the SSPAs to the SSPA COM 1 J2 and SSPA COM 2 J3 connectors (Pin 'R' – see **Table 2-3** in **Sect. 2.2.2**). These two signals are "diode OR'ed" to provide redundancy.

Note: Although the PCB-4000 box will turn on and function when only one SSPA is powered on, the system will not provide optimum output power unless *both* of the SSPAs are powered on.

2.4.2   Ground Connector

A #10-32 stud is provided on the front panel of the PCCB for connecting a common chassis ground among equipment.

Notes:

Notes:

Chapter 3. OPERATION AND ADJUSTMENT PROCEDURES

IMPORTANT

Before attempting any of the procedures featured in this chapter, the user is strongly advised to read **Chapter 1. INTRODUCTION** *to become familiar with system terminology and Theory of Operation, and* **Chapter 2. EXTERNAL CONNECTORS** *to become familiar with the PCCB's connectors and their functionality.*

3.1 Overview

As indicated in **Chapter 1. INTRODUCTION**, the PCB-4000 1+1 Phase Combiner system is aligned at the factory using a network analyzer. As this technique facilitates easy adjustment and setting of the phase shifter for optimum output power combining over the full amplifier bandwidth, *alignment in the field is generally not required and the user is strongly cautioned against making unneeded adjustments*. The user need only to assemble the 1+1 phase combined system – an example is shown on the next page in **Figure 3-1** – and complete all required cable connections (**Figure 3-2**).

However, if an amplifier or other critical system component (e.g., the PCB-4000 unit) is replaced, the procedures provided in this chapter explain the steps necessary to restore proper system operation. A verification procedure is also furnished for the user who simply wants to confirm that the system is working properly.

IMPORTANT

It is recommended that only qualified personnel familiar with high-power amplifiers, test equipment, and phase combined systems attempt these procedures.

3.2   System Installation and Cable Connections

Figure 3-1 shows an example of the PCB-4000 deployed in a typical 1+1 phase combined system (see **Appendix A. ASSEMBLY KITS** for details on band-specific system applications). Take note of the callouts in this figure, as they will be referenced in the procedures that follow in this chapter. **Figure 3-2** summarizes the cabling required from the PCCB to other components of the system.
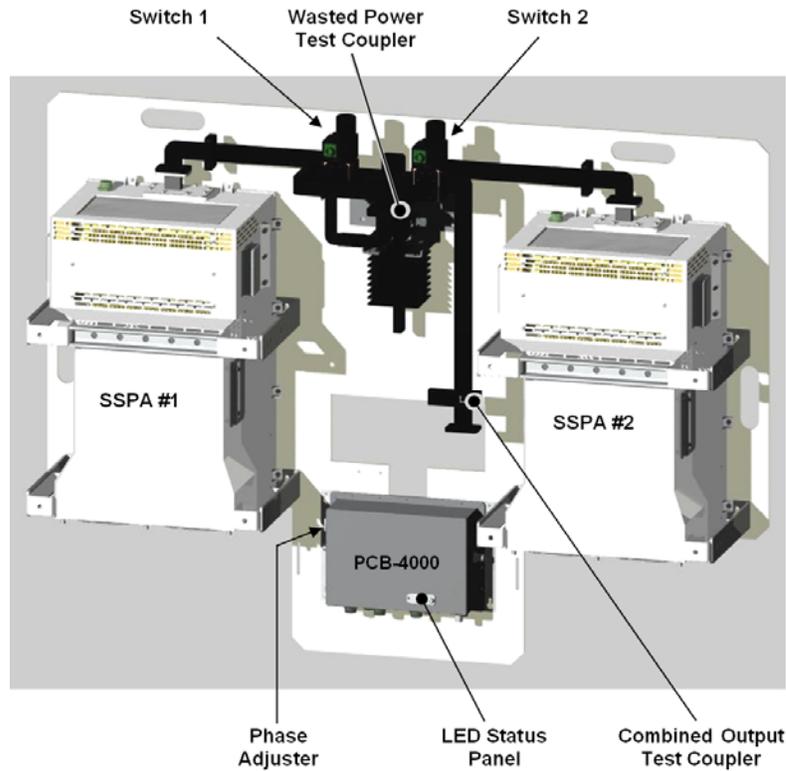
Figure 3-1. PCB-4000 1+1 Phase Combined System Assembly Example
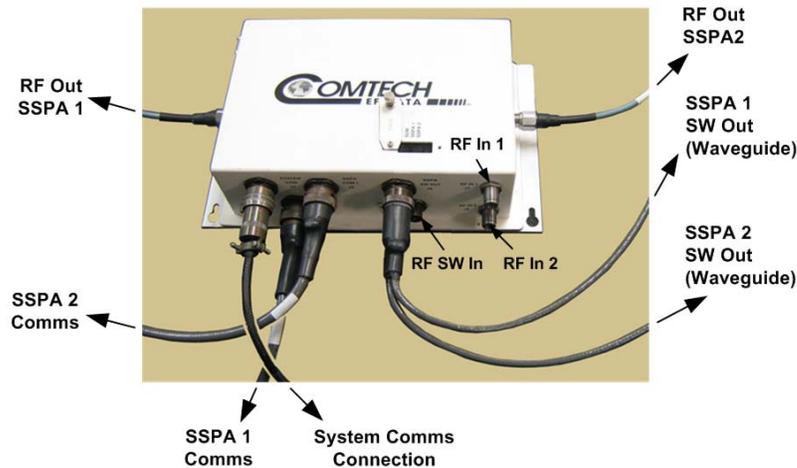
Figure 3-2. PCB-4000 1+1 Phase Combined System Cable Connections

3.2.1 Installation

Referring to **Figure 3-1** and **Figure 3-2**, observe the following:

Step	Procedure
1	Install the SSPAs in their respective positions as detailed in the factory datasheet and in accordance with **Figure 3-1**. This means that the specific serial numbered SSPA that was aligned in Position 1 at the factory must also now be installed in Position 1; the same applies to the SSPA in Position 2. Labels are provided to help ensure correct installation. It is suggested that any mounting hardware used in the installation process not be fully tightened until the entire system is installed.
2	Attach the Waveguide (WG) combining network to the mounting structure and to each SSPA. For assembly details, refer to **Appendix A. ASSEMBLY KITS**. Take care to install the provided waveguide gaskets at each SSPA output. It may be necessary to slightly adjust each SSPA to prevent undue stress on the waveguide structure. Tighten all hardware when proper alignment is achieved.
3	Assemble the PCB-4000 Phase Combiner Control Box (PCCB) to the mounting structure.
4	Install the Type 'N' RF Phase Matched Coaxial Cables (CEFD P/N CA/RF11872-1) as shown in **Figure 3-1**. Each cable is labeled according to its destination SSPA: o Connect the cable labeled '**SSPA1**' from the PCCB Type 'N' port labeled '**SSPA OUT 1 J9**' to the RF Input port on **SSPA #1**. o Repeat this task for the cable labeled '**SSPA2**', connecting it between the PCCB Type 'N' port labeled '**SSPA OUT 1 J10**' and the RF Input port on **SSPA #2**. **IMPORTANT** *Ensure the RF cabling is installed correctly, as any "cross" connections will cause system malfunction.*
5	Install the "COM" Cable (CEFD P/N CA/WR11966-2) between each of the following PCCB connectors and their corresponding SSPA "**COM**" ports: o (PCCB) **SSPA COM 1 J2** to **SSPA #1**. o (PCCB) **SSPA COM 2 J3** to **SSPA #2**.
6	Install a Waveguide (WG) Switch Control "Y" Cable (CEFD P/N CA/WR12013-1) between the PCCB connector labeled '**SSPA SW Out J5**' (**Figure 3-2**) and the two waveguide switches as shown in **Figure 3-1**. Pay particular attention to ensure that the ends labeled '**SW1**' and '**SW2**' are respectively connected to Waveguide Switch #1 and Waveguide Switch #2.
7	Install the user-provided RF Input Switch control cable (if applicable) to the PCCB connector labeled '**RF INPUT SWITCH J6**'.
8	Properly terminate the waveguide system output port, review all cables for proper connections, and ensure that all mounting hardware is tightened.

3.3   Initial System Setup and Verification

For this section, it is assumed that the system has been assembled, all cables have been connected, and that the output port is terminated in a broad-band high power load as depicted in the block diagram in **Figure 1-2**. If the system is in operation and only verification is desired, refer to **Section 3.5**.

Overall system performance may be verified by measuring the ratio of the transmitted power to that of the power being dissipated by the "dummy" load. If necessary, the gain and amplitude balance will be adjusted.

Observe the following:

Step	Procedure
1	In the normal 1+1 phase combiner mode, the **RED=X** remote command setting should be set to **1**. This can be verified by querying the system (refer to **Appendix B. REMOTE CONTROL**).
2	A. Attach a power meter to the Combined Output Power Test Coupler (refer to **Figure 3-1**). B. Apply a low level signal at center frequency; making sure the output signal (at the system output port –not the coupled port) will be at least 10 dB below Prated. C. Measure the output power and include the coupler correction factor.
3	A. Attach a power meter to the Load or "Wasted" Power Test Coupler (refer to **Figure 3-1**). B. Measure the power and include coupler correction factor.
4	If the Load or "Wasted" power level is 15-20 dB below the transmitted power, the system is operating correctly. **Note:** If the ratio is below 10 dB, proceed to the gain and phase alignment procedures that follow in this chapter.
5	A. Slowly increase the input power until the desired operating output power is achieved. B. Again, verify the appropriate ratio of the transmitted to dissipated power.
6	If desired, the above steps can be repeated at different frequencies to verify proper full bandwidth operation.

3.3.1 LED Status Operation

The PCB-4000 1+1 Phase Combiner features four
Light-Emitting Diode (LED) indicators – three
are operational, with the fourth reserved for future
applications. Each LED provides the user with
visual cues to the operational, online, and offline
status of the system.

Figure 3-3 illustrates the location of the LED
indicators. Located on the top of the PCB-4000
enclosure under a pivoting protective plate, the
LEDs may be viewed by loosening the captive
screw that keeps the plate in place; the user can
then swing the plate away to reveal the LED
display window.
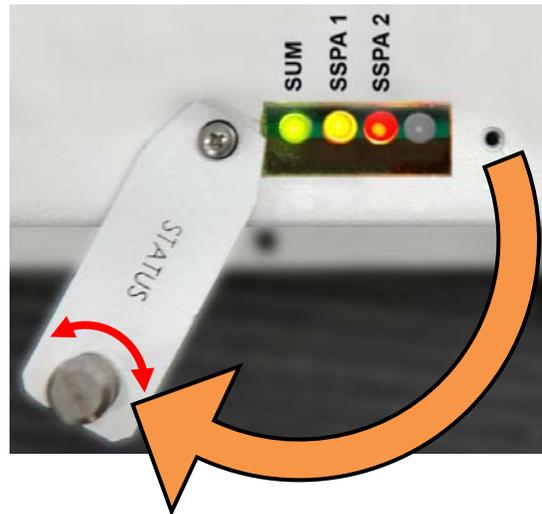
Figure 3-3. PCB-4000 LED Status Panel

The behavior of the LEDs, as they appear under varying operational conditions, is as follows:

LED	Color / Behavior		Description
SUM (LED 1)	Green		Phase Combiner has no summary fault.
	Red (blinking)		A switch fault has occurred.
	Red (constant)		A Summary Fault has occurred.
SSPA 1 (LED 2) **-or-** **SSPA 2 (LED 3)**	Phase-Combine mode (RED=1)	Green (constant)	SSPA is unfaulted, unmuted and online.
		Orange (constant)	SSPA is unfaulted but muted, and online.
		Red (blinking)	SSPA is faulted and has gone offline.
		Red (constant)	SSPA is faulted but online.
	Non Phase-Combine mode (RED=0)	Green (constant)	SSPA is unfaulted, unmuted and online.
		Green (blinking)	SSPA is unfaulted, unmuted and offline.
		Orange (constant)	SSPA is unfaulted but muted, and online.
		Orange (blinking)	SSPA is unfaulted but muted, and offline.
		Red (constant	SSPA is faulted but online.
		Red (blinking)	SSPA is faulted and has gone offline.
(LED 4)	*Inoperable* (always dark), reserved for future use		

3.4   Gain or Amplitude Balance Verification and Alignment

> **IMPORTANT**
>
> ***This procedure is generally not necessary if all parameters of Section 3.3 have been met.***

As a result of the configuration of the waveguide switches in a 1+1 system, it is possible to measure the individual gain of each SSPA path by switching each SSPA individually to the output load.

For this procedure, it is assumed that the output port is terminated and data will be taken using the test port couplers.

Observe the following:

Step	Procedure
1	A. Attach a power meter to the Combined Output Power Test Coupler (refer to **Figure 3-1**). B. Apply a low level signal at center frequency, making sure the output signal will be at least 10 dB below Prated.
2	To measure only the individual gain of SSPA#1, SSPA#2 must by *bypassed* by changing the state of the waveguide switches via remote control (for detailed remote command and query information, see **Appendix B. REMOTE CONTROL**): A. Execute remote command **RED=0**; B. Execute remote command **BYP=2**. The output of SSPA#1 will be sent to the system output, while SSPA#2 will be muted and directed to the "wasted" port.
3	Record the amplitude or gain level of SSPA#1.
4	Execute remote command **BYP=1** to measure the individual gain of SSPA#2. This time, the output of SSPA#2 will be sent to the system output, while SSPA#1 will be muted and directed to the "wasted" port.
5	Record the amplitude or gain level of SSPA#2.
6	Compare the levels of the two paths. Typically the gains of each SSPA will be within ± 1 dB at center frequency. If the above test is performed at other frequencies, it is reasonable to assume that the gain difference may be greater.

3.5   Amplitude Alignment *(as necessary)*

Even if the difference of each individual SSPA path is greater than ±1 dB, amplitude adjustment may not be necessary if all parameters of **Section 3.3** have been met. However, if these parameters have *not* been met, then fine tuning adjustment is advisable.

Note: If the system is to be used in a narrow frequency range, the user may also wish to optimize the gain balance over this narrow range.

Observe the following:

Step	Procedure
1	If Steps **1** through **6** in **Section 3.4** have not been completed, perform them ***now***.
2	Again, insure the input signal is at center frequency and that the output power level is approximately Prated -10 dB.
3	Alternately toggle between remote commands **BYP=1** and **BYP=2** to measure the gains of each SSPA path. Note which path has the greater amount of gain.
4	Use the **AOF** (user amplitude offset) remote command/query to equalize the gain between the 2 paths. For example, if SSPA 1 has 2 dB excess gain: A. Query the offset of SSPA 1 using remote query **AOF?1**. The unit should respond with a gain offset ranging between 0 and 6. Record this value, then add 2 dB. For this example, assume SSPA 1 responded with 1 dB. Adding 2 dB of required additional offset to the existing 1 dB of offset results in 3 dB of required offset. B. Now send remote command **AOF=1,3.00**.
5	Proceed to the phase alignment procedure (**Section 3.6**) if anything has been changed or altered that may affect the phase alignment. Otherwise, verify proper operation via the LED Indicators as per **Section 3.3.1**.

3.6   Phase Alignment

! **IMPORTANT** *As the system is aligned at the factory, this step should generally not be necessary unless it has been required to replace one of the SSPAs or other critical path components. Make sure that all parameters of Section 3.3 have been met before performing this adjustment.*

For this procedure, it is assumed that the system has been installed and that the output port is terminated in a broad-band high power load.

Overall system performance is verified by measuring the ratio of the transmitted power to that of the power being dissipated by the "dummy" load. If necessary, the phase balance may be adjusted by trimming the phase shifter, which is located inside the PCCB box and accessible via a secured cover labeled **PHASE ADJ** on the left side of the box.
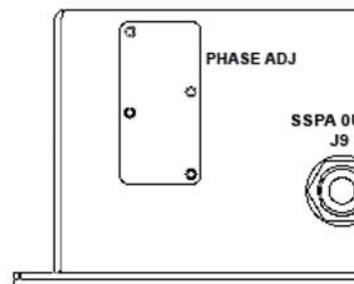
Figure 3-4. PHASE ADJ Panel

Observe the following:

Step	Procedure
1	Ensure the system is set to 1+1 phase combined mode by issuing remote command **RED=1** (refer to **Appendix B. REMOTE CONTROL**).
2	A. Attach a power meter to the Combined Output Power Test Coupler (refer to **Figure 3-1**). B. Apply a low level signal at center frequency, making sure the output signal (at the system output port –not the coupled port) will be at least 10 dB below Prated. C. Measure the output power and include the coupler correction factor.
3	A. Attach a power meter to the Load or "Wasted" Power Test Coupler (refer to **Figure 3-1**). B. Measure the power and include coupler correction factor.
4	If the Load or "Wasted" power level is 15-20 dB below the transmitted power, the system is operating correctly. If the ratio is below 10-15 dB, proceed to the align the phase shifter by: A. Remove the **PHASE ADJ** cover panel (refer to **Figure 3-4**) located on the left side of the PCCB box. B. Utilizing the supplied socket and screwdriver, first loosen the phase shifter lock nut. C. Slowly adjust the phase shifter by turning the screwdriver. The system is aligned at the operating frequency when the transmitted to "wasted" power ratio is maximized. If it is not possible to simultaneously view the transmitted and "wasted" power, it is recommended to minimize the "wasted" power. Generally, the "wasted" power reading will be more sensitive to phase shifter adjustments.
5	A. Slowly increase the input power until the desired operating output power is achieved. B. Again, verify the appropriate ratio of the transmitted to dissipated power.
6	Verify that the system works over the full bandwidth by injecting a signal at the start and stop frequencies as well. The ratio of the transmitted to "wasted" power should be 15-20 dB, but is not likely to be as good as it was at the adjustment (center) frequency. If acceptable full bandwidth performance is not measured, it may be necessary to repeat **Steps 2** through **5** for the start, stop, and center frequencies – realizing that optimum performance at any one particular frequency must be sacrificed slightly to achieve full bandwidth operation.
7	Make sure the lock nut on the phase shifter is tightly secured by using the supplied socket, then replace the cover panel.

3.7   System Online and Transmitting

For this procedure, it is assumed that the system has been installed and that access to the system output port is unavailable due to current system traffic. To check for proper operation, the difference in power being transmitted *versus* the power being dissipated in the load termination should be measured and compared.

Observe the following:

Step	Procedure
1	A. Attach a power meter to the Combined System Output Power Test Coupler (refer to **Figure 3-1**). B. Measure the output power and include coupler correction factor.
2	A. Attach a power meter to the Load or "Wasted" Power Test Coupler (refer to **Figure 3-1**). B. Measure the power and include coupler correction factor, including the coupler correction factor.
3	The Load or "Wasted" power level should be 15-20 dB below the power being transmitted to the antenna.

Notes:

Notes:

Chapter 4. FLASH UPGRADING

4.1   Overview

This chapter provides procedural information for upgrading the firmware for the Comtech EF Data PCB-4000 1+1 Phase Combiner. This chapter assumes that the user has familiarity with Microsoft Windows-based operating systems.

4.2   Flash Updating via Internet

The PCB-4000 uses 'Flash memory' technology internally; this makes firmware upgrading very simple, and updates can now be sent via the Internet (**Figure 4-1**), via E-mail, or on CD. The complete upgrading process is summarized as follows:

- New firmware update for upgrading the PCB-4000 is transferred to a user provided PC intended for Monitor and Control (M&C) of the PCB-4000 system.

- By simply connecting the PCB-4000 to an available serial port on the user-provided PC, the upgrade can then be performed without opening the PCB-4000.

- Once the firmware update is extracted from the transferred archive file, the upgrade process is executed via use of a utility program, **FLSHCSAT.exe**.

Figure 4-1. Flash Update via Internet

4.2.1   Firmware File Transfer Procedure

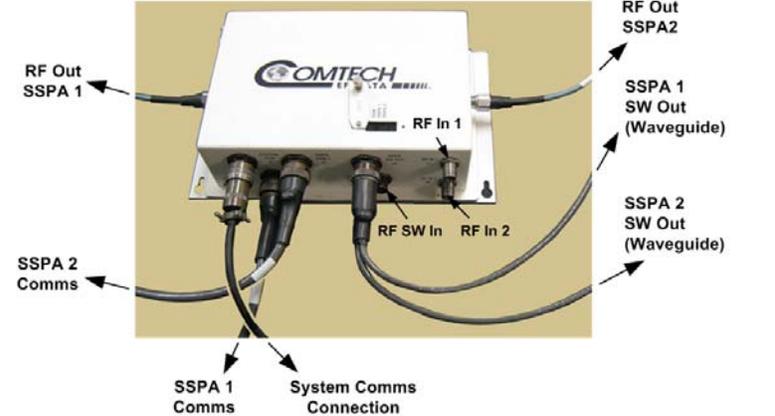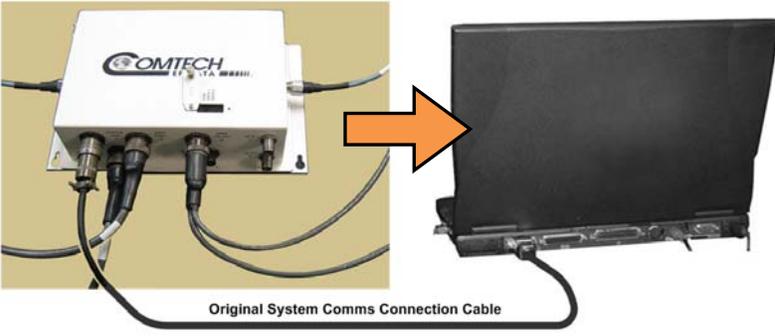| Step	Procedure
1	**Identify** the reflashable product, firmware number, and version for download. **Via serial remote control**, the firmware number, versions, and revision level can be queried as follows: **<0/FRW?**
2	**Create** a temporary directory (folder) on the PC: **Windows**: Select **File → New → Folder** and rename the "New Folder" to "temp" or another unused name. A "*c:\temp*" folder should now exist. **Note:** The **c:** is the drive letter used in this example. Any valid, writable drive letter can be used. *CMD prompt:* At the command prompt (c:\>) type "**MD temp**" or "**mkdir temp**" without quotes (**MD** and **mkdir** stand for *make directory*). A "*c:\temp*" subdirectory should now exist, where **c:** is the drive letter used in the example.

3	**Download** the correct firmware file to this temporary folder. As shown in **Figure 4-1**:
	
	    a) **Go online** to: www.comtechefdata.com;
	    b) **Click on:** *Support* tab;
	    c) **Click on:** *Software Downloads* drop-down *or* hyperlink from *Support* page;
	    d) **Click on:** *Download Flash and Software Update Files* icon;
	    e) **Click on: Flash and Software Update Files / Select a Product Line***: Transceivers* hyperlink;
	    f) **Under the MBT-4000/B heading, select** the *PCB4000 (1+1 Phase Combiner)* product hyperlink;
	    g) **Select** the appropriate firmware hyperlink for download.
	
	About Firmware Numbers, File Versions, and Formats: The flashable files on the download server are organized by product prefix; Depending on the product for which it is intended, the filename may designate the firmware number (verify that the correct firmware number is known – see **Step 1**); revision letter, if applicable; release version; and release date.
	
	The naming convention for the PCB-4000 Base Unit firmware is **FW11411-1x.CCC** (where 'x'denotes the firmware revision letter).
	
	Note: The current version firmware release is provided. If applicable, a minimum of one version prior to the current release is also available. *Be sure to identify and download the desired version.*
	
	The downloadable files are stored in two formats: *.exe (self-extracting) and *.zip (compressed). Some firewalls will not allow the downloading of *.exe files. In this case, download the *.zip file instead.
	
	For additional help with "zipped" file types, refer to *PKZIP for Windows*, *WinZip*, or *ZipCentral* help files. *PKZIP for DOS* is not supported due to file naming conventions.

4	**Extract** the files to the temporary folder on the PC, PC, then **verify** the success of the file extraction using the *dir* command. At least four files should be extracted:
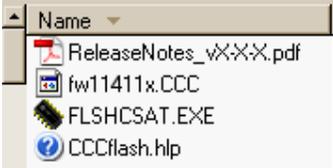	
	    • **ReleaseNotes_vX-X-X.pdf**: Where "X-X-X" denotes the firmware version number.
	    • **fw11411x.CCC:** Firmware file, where "x" denotes the firmware revision letter.
	    • **FLSHCSAT.EXE:** CEFD Flash Upload Utility Program.
	    • **CCCflash.hlp:** FLSHCSAT Help File.
	
	If these four files are available as indicated here, proceed to the next section to perform the flash upgrade.

4.3   Flash Upgrade Procedure

Step	Procedure	
1	Locate and identify the PCB-4000 1+1 Phase Combiner System. The illustration to the right serves to identify the key cable connections at the PCCB for a typical system.	
2	Ensure that the PCCB is connected to a user-provided Windows-based PC.	
	NOTE: If needed, the CA/WR12243-1 System Programming Cable is available from Comtech EF Data. Contact CEFD Customer Support for ordering information.	
3	Double-click **FLSHCAT.EXE** (filename or icon) to execute the flash upload utility.	

Step	Procedure	
4	Front the FLSHCAT dialogue box, select the pertinent serial port used for communication between the PC and the PCCB. (In this example, as noted at 'A', COM1 has been selected.)	
5	Do **not** select a Baud Rate (noted at 'B') other than the default selection of 38400, unless otherwise instructed by Comtech EF Data Technical Support.	
6	Click on '**Software Upload**' as noted at 'C'.	
7	Select the firmware file for upload. Click '**Choose File**' then, once the *Select a File Name* dialogue box opens, use the window on the right to navigate to the desired folder. Finally, double-click on the firmware file from the window on the left.	
8	Prior to continuing the upload process, the PCB-4000 system must be powered off by disconnecting the **SSPA COM 1 J2 and SSPA COM 2 J3 connector** cables. Once this is done, click '**Start Upload**'.	
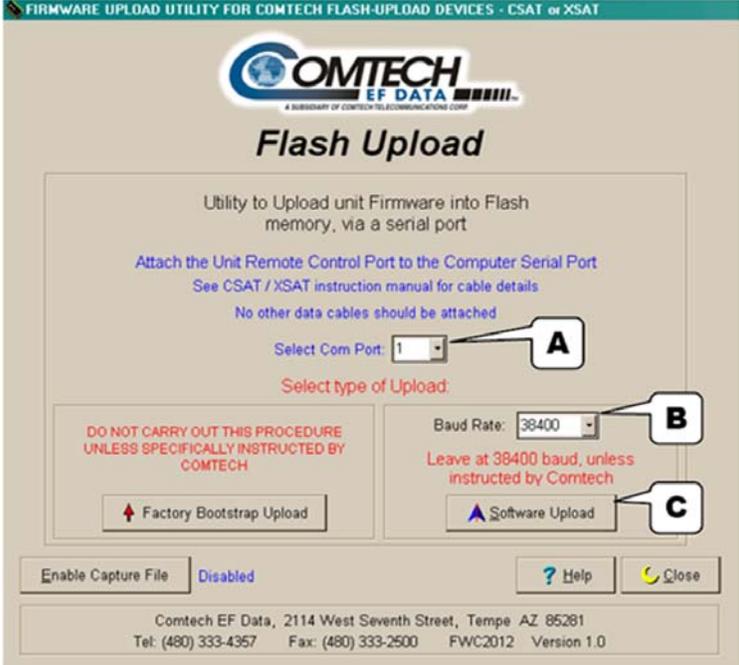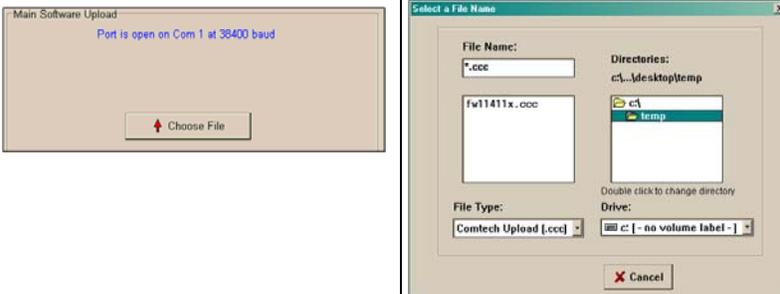
Step	Procedure		
9	When prompted, reconnect the **SSPA COM 1 J2** and **SSPA COM 2 J3** connector cables.	Main Software Upload — Upload will be 854 blocks, about 1 minute — POWER UP THE UNIT, NOW	
10	Once communications have been established between the PC and PCCB, the upload will take place – *do not interrupt this upload process*.	Main Software Upload — Upload will be 854 blocks, about 1 minute — Sending block 263 of 854... — 30% — DO NOT INTERRUPT UPLOAD	
	Note: If the upload is not successful for any reason – e.g., the communications cable is not physically connected, the wrong COM port is specified, the user inadvertently interrupted the upload, etc. – the user may troubleshoot the setup as needed, then click on '**Repeat Upload**' or '**Go Back to Start**' to resume or retry the upload process.	Main Software Upload — Upload will be 854 blocks, about 1 minute — Timed out waiting for response	
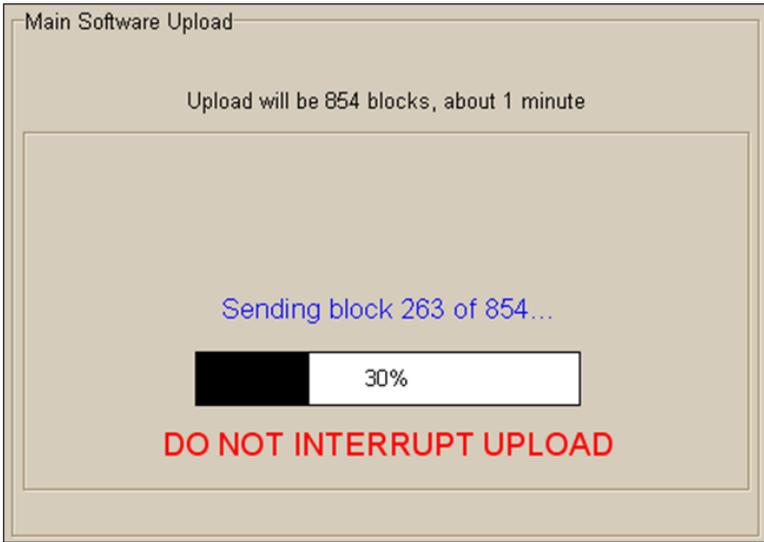
Step	Procedure	
11	Upon successful completion of the upload, the user may click on '**Go Back to Start**' (if, for example, more than one PCB-4000 1+1 Phase Combined System requires upgrade) or '**Close**' (to exit the FLSHCAT program).	
12	If needed, disconnect the System Programming Cable (CEFD P/N CA/WR12243-1) and reconnect the original System Communications connection cable.	
13	The LEDs on the top of the PCCB may illuminate GREEN (unmuted), ORANGE (muted), or RED (faulted) to indicate the current status of the PCCB, SSPA1, and SSPA2 operations. Refer to **Chapter 3. OPERATION AND ADJUSTMENT PROCEDURES** for more information on these operational states for the PCB-4000.	
The upgrade process has been successfully completed.		
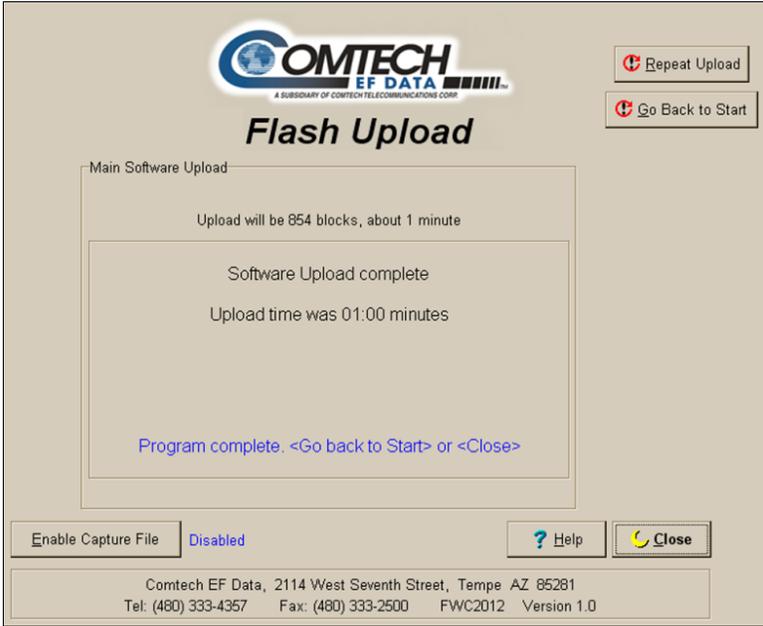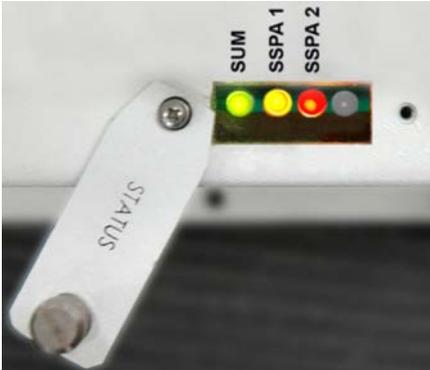
Appendix A. ASSEMBLY KITS

A.1   Overview

This appendix outlines the Comtech EF Data accessory and assembly kits that satisfy installation requirements for A PCB-4000 1+1 Phase Combined System – an example is shown at right:
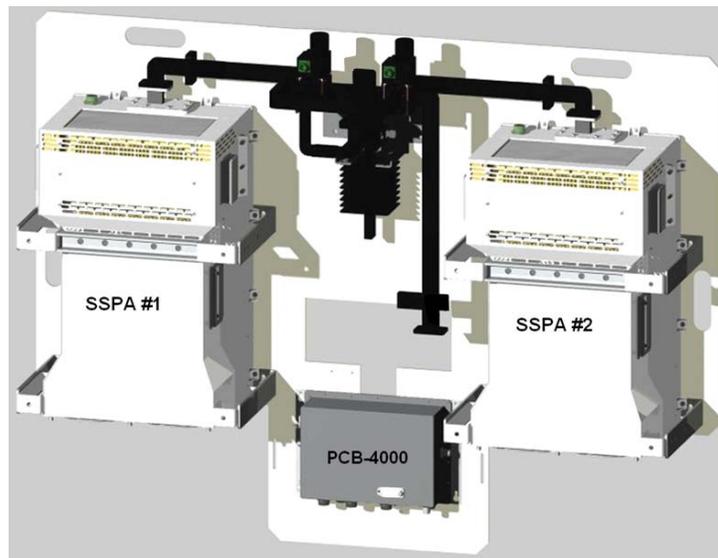
FIGURE	TABLE (BOM)	CEFD Part No.	Description
A-1	N/A	PL/12319-1	Universal Pole Mounting Kit
A-2	N/A	PL/11285-1	1+1 Phase Combiner Box, X-Band (p/o KT/11344-1)
		PL-0000330	1+1 Phase Combiner Box, C-Band (p/o KT-0000056)
A-3	A-1	KT/11344-1	Combined 1:1 X-Band Assembly Kit – HPOD
A-4	A-2	KT/11387-1	Redundant 1:1 X-Band Waveguide / Switch Kit
A-5	A-3	KT-0000055	Combined 1:1 C-Band Top Assembly Kit – HPOD
A-6	A-4	KT-0000017	Unistrut Mounting Kit
A-7	A-5	KT/12300-1	HPOD Mouting Kit
A-8	A-6	KT-0000054	C-Band Waveguide / Switch Kit – HPOD

Note: As the model of the SSPA pair deployed within a 1+1 Phase Combined System may vary, the illustrations provided herein intentionally omit the depiction of any installed SSPA pair.

A.2   Universal Pole Mounting Kit (PL/12319-1)

STRUT SHOWN FOR
REFERENCE ONLY
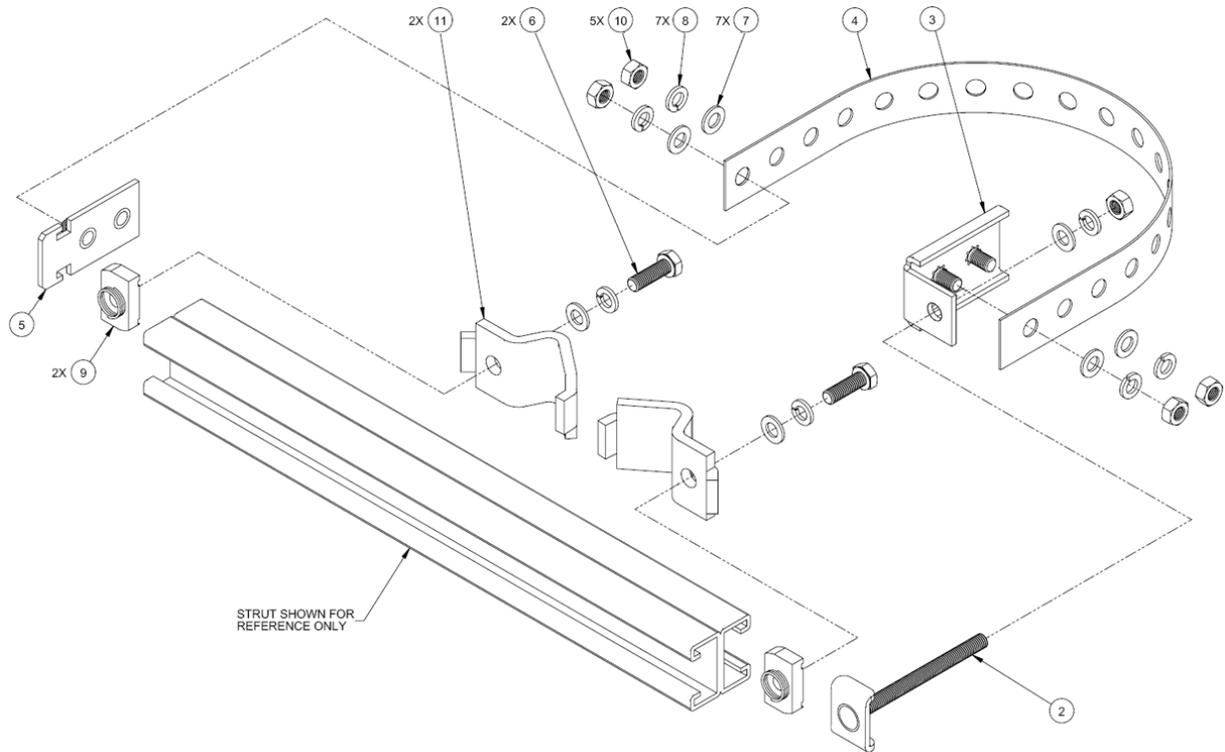
PL/12319-1 Universal Pole Mounting Kit			
Item No.	QTY	CEFD Part No.	Description
1	N/A	(FP-0000134)	Unistrut, Dual Channel (SHOWN FOR CLARITY ONLY, P/O CEFD KT-0000017 MOUNTING KIT)
2	1	FP/BR0072	Bracket, Strap Tensioner
3	1	FP/BR0070	Bracket, Strap Termination
4	1	FP/BR0071	Bracket, 1-1/4 Strap (TRIM TO REQUIRED LENGTH)
5	1	FP/BR0069	Bracket, Strap, Fixed
6	2	HW/M8X1.25X25HEXSS	Bolt, Hex head, M8X1.25X25, SS
7	7	HW/M8FLATSS	Washer, Flat, M8 SS, METRIC
8	7	HW/M8LOCKSS	Washer, Split Lock, M8, SS, METRIC
9	2	HW/M8SPRINGNUT	Spring Nut, M8X1.25
10	5	HW/M8X1.25MMHEXNUTSS	Nut, Hex M8X1.25X16MM, SS
11	2	HW/PIPEBLOCK	Pipe Block

Figure A-1. Universal Pole Mounting Kit PL/12319-1

A.3   PCB-4000 Phase Combiner Box in Assemblies

The PCB-4000 1+1 Phase Combiner standalone unit is available in either a X-Band version (CEFD P/N PL/11285-1) or C-Band version (CEFD P/N PL-0000330). The box may be provided as part of an overall assembly; for example, the X-Band standalone unit is provided as part of CEFD 1:1 Combined X-Band Assembly Kit KT/11344-1 (see **Sect. A.4.1**) or as a subassembly item – as shown here in **Figure A-2** in C-Band Box/Bracket kit KT-0000056, which is provided in 1:1 Combined C-Band Assembly Kit KT-0000055 (see **Sect. A.5.1**).
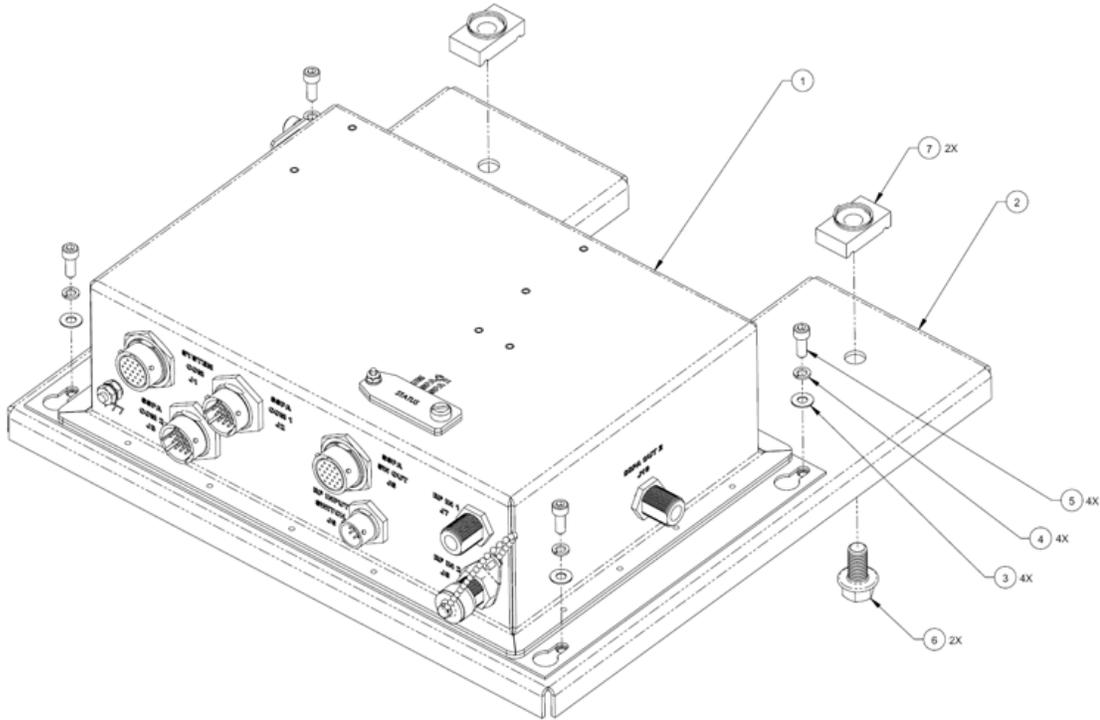
KT-0000056 Phase Combiner Box and Bracket Kit (as used in KT-0000055, Figure A-5)			
Item No.	QTY	CEFD Part No.	Description
1	1	PL-0000330	1+1 Phase Combiner Box, C-Band
2	1	FP-0000237	Bracket, Mounting, Phase Combiner Box
3	4	HW/10-FLT	Washer, Flat, SS
4	4	HW/10-SPLIT	Washer, Split Lock, SS
5	4	HW10-32x1/2SH	Bolt, Socket Head, SS
6	2	HW-0000070	Screw, Hex, Serrated Flange Head, SS

Figure A-2. PCB-4000 Phase Combiner Box and Bracket Kit (CEFD P/N KT-0000056)

A.4   PCB-4000 X-Band Unit (PL/11285-1) Assemblies

A.4.1   Combined 1:1 X-Band Assembly Kit – HPOD (KT/11344-1)

Table A-1. Kit KT/11344-1 BOM

Item No.	QTY	CEFD Part No.	Description
KT/11344-1 (as per Figure A-3 on next page)			
3	1	FP/WG11306-1	Waveguide, 90 Degrees Bend with Coupler
4	4	FP/WG11307-1	Waveguide, Transition CPRG-112 to CPRG-137
5	3	SW/WG-HAGS	Switch, WR112G, +24V
6	1	RF/ADAP-112-N	RF, Magic Tee, Coupler, 7.9 – 8.4 GHz
7	2	FP/WG11300-1	Waveguide, 90 Degrees E Bend CPRG-112
8	3	FP/WG11301-1	Waveguide, 90 Degrees CPRG –112
9	2	FP/WG11308-1	Waveguide, 90 Degrees, H Bend, CPRG-112
10	1	FP/WG11310-1	Waveguide, Combiner, CPRG-112
11	1	RF/X-TERM850W	PNQ, RF, Termination. Load 850W
13	15	GA/CPR112-R-F-C	Gasket, Round, Full-Thickness
14	1	PL/11285-1	Top Assy, Combiner Box
15	1	FP/WG1309-1	Waveguide, E Bend SW-to-SW, CPRG-112
20	A/R	HW/8-32HEXNUT	Nut, Hex
21	A/R	HW/8-FLT	Washer, Flat
22	A/R	HW/8-SPLIT	Washer, Lock
23	A/R	HW/8-32X1/2SHCS	Screw, Socket Head Cap
24	A/R	HW/8-32X7/8SHCS	Screw, Socket Head Cap
25	A/R	HW/SEM6 32X3/8PH	Screw, Phil Pan Head
31	1	RF/ADAP-112-N	Adapter, RF, CPRG112 to "N"
32	1	RF/CG-112/137INN	Crossguide Coupler, 40 dB
50	1	FP/BR11311-1	Bracket, Sw and Load MTG
51	1	FP/BR11670-1	Bracket, LNA's 1:1 and Combiner Sys
53	1	FP/BR11375-1	Bracket. Load, XSAT
54	4	RF/N-TERM50M1	50 Ω, 1W DC-8GHz

Note: A/R = As Required
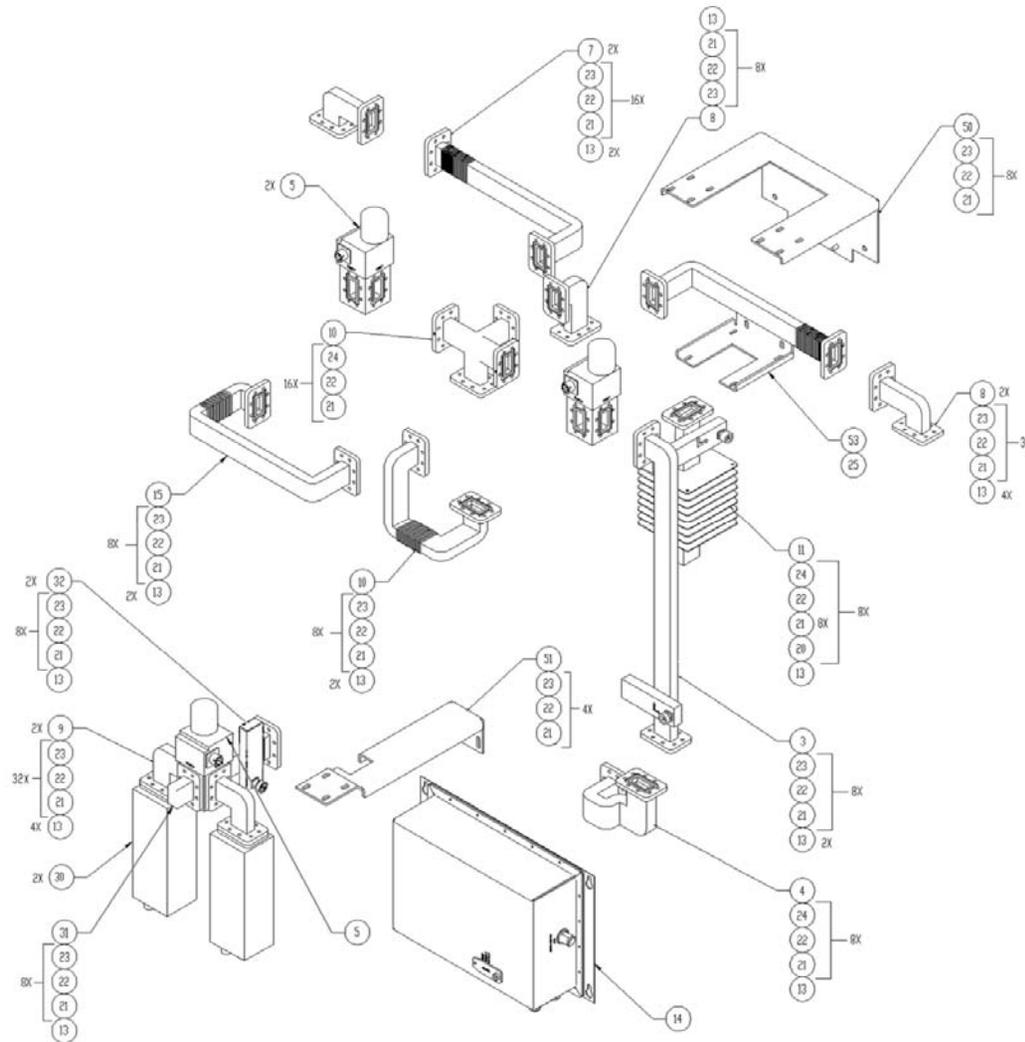
Figure A-3. Combined 1:1 X-Band Assembly Kit – HPOD (CEFD P/N KT/11344-1)

A.4.2   Redundant 1:1 X-Band Waveguide / Switch Kit – ODPA (KT/11387-1)

Table A-2. Kit KT/11387-1 BOM

Redundant 1:1 X-Band Waveguide / Switch Kit KT/11387-1 (as per Figure A-4 on next page)			
Item No.	QTY	CEFD Part No.	Description
3	1	RF/CG-112/137INN	Crossguide Coupler, 40 dB, Type N Connector, 137-112
4	1	FP/WG11671-1	Waveguide, 1:1 Filter to TX
5	2	SW/WG-HAGS	Switch, WR112G, +24V, Sealed, Standard Thread, Cold Temperature Rating
7	2	FP/WG11305-1	Waveguide, 90 Degree H-Bend Transition
8	2	FP/WG11301-1	Waveguide, 90 Degree, CPRG-112
9	3	FP/WG11308-1	Waveguide, 90 Degree, H-Bend, CPRG-112
11	1	RF/X-TERM850W	Termination, Load, 850 Watt, CPRG112, with Crossguide Coupler, 40 dB
13	14	GA/CPR112-R-F-C	Gasket, Round, CPR112, Full Thickness,
20	A/R	HW/8-32HEXNUT	Nut, Hex 8-32
21	A/R	HW/8-FLT	Washer, Flat SS
22	A/R	HW/8-SPLIT	Washer, Split SS
23	A/R	HW/8-32X1/2SHCS	Screw, Socket Cap
24	A/R	HW/8-32X7/8SHCS	Screw, Socket Head Cap, SS
25	A/R	HW/SEM632X3/8PH	Screw, Square Cone Pan Head Phillips SS
31	1	RF/ADAP-112-N	Adapter, CPRG112 to "N"
32	1	RF/CG-112/137INN	Coupler, Crossguide 40 dB N Type Connector
55	4	RF/N-TERM50M1	RF, 50Ω 1Watt. DC-8 GHz, Type N Male

Note: A/R = As Required
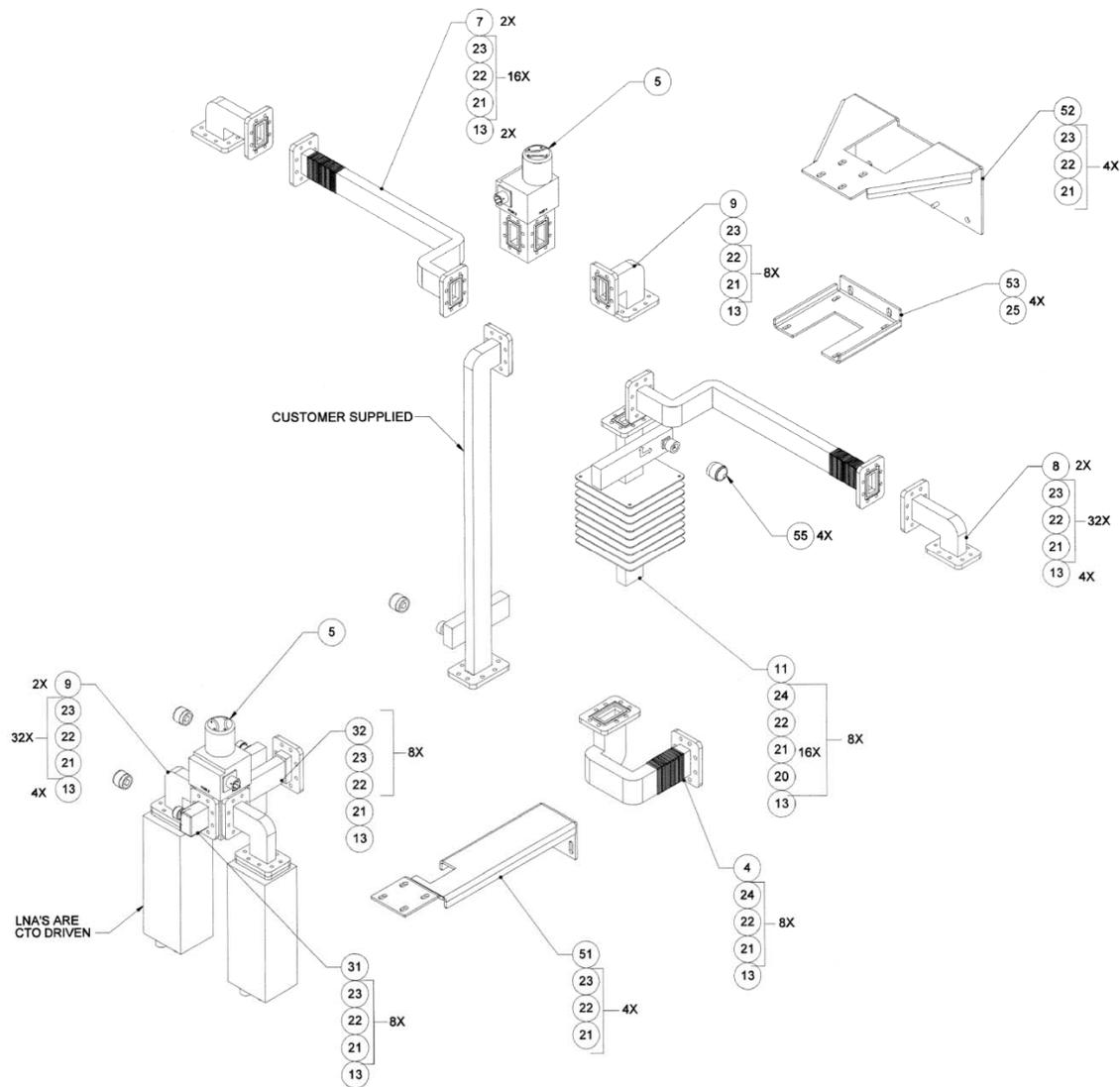
Figure A-4. Redundant 1:1 X-Band Assembly Kit – ODPA (CEFD P/N KT/11387)

A.5   PCB-4000 C-Band Unit (PL-0000330) Assemblies

A.5.1   Combined 1:1 C-Band Top Assembly Kit – HPOD (KT-0000055)

Table A-3. Kit KT-0000055 BOM

KT-0000055 (as per Figure A-5 on next page)			
Item No.	QTY	CEFD Part No.	Description
1	1	KT-0000017	1:2 Unistrut Mounting Kit (see **Figure A-6**, **Sect. A.5.1.1**)
2	2	KT/12300-1	HPOD Mounting Bracket Kit (See **Figure A-7**, **Sect. A.5.1.2**)
3	1	KT-0000056	C-Band Phase Combiner Box and Bracket Kit (see **Figure A-1**, **Sect. A.2**)
4	1	KT-0000054	C-Band 1:1 HPOD Waveguide and Switch Kit (see **Figure A-8, Sect. A.5.1.3**)
N/A	2	CA/RF11872-1*	Cable Assembly, Ku-Band RF IN
N/A	2	CA/WR11966-1*	Cable Assembly, SSPA to Combiner Box
N/A	1	CA/WR12013-1*	Cable Assembly, Switches, Combined System

*Note: Refer to **Chapter 4. FLASH UPGRADING** for information on the cable connections
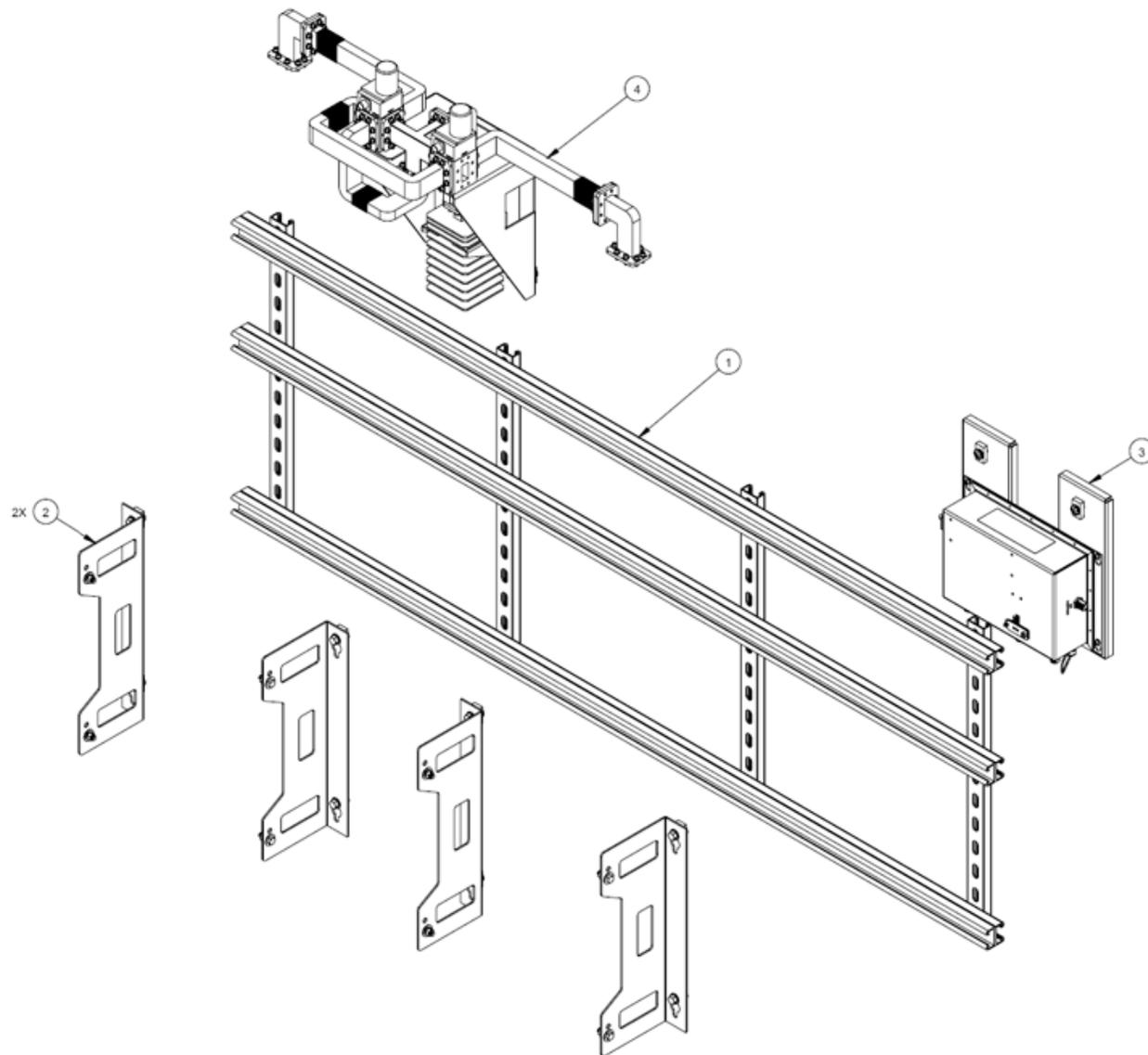
Figure A-5. Combined 1:1 C-Band Top Assembly Kit – HPOD (CEFD P/N KT-0000055)

A.5.1.1   Unistrut Mounting Kit (KT-0000017)

Table A-4. Kit KT-0000017 BOM

Unistrut Mounting Kit KT-0000017 (as per Figure A-6 on next page)			
Item No.	**QTY**	**CEFD Part No.**	**Description**
1	3	FP-0000134	Unistrut, Dual Channel, 74.13" LG
2	4	FP/BR11932-1	Bracket, Unistrut, SS, 26.25" LG
4	12	HW/3/8SPRINGNUT	Sping Nut, 3/8-16, Short Spring, SS
5	12	HW-0000069	Washer, Flat, Thick, 3/8, SS
6	12	HW/3/8-SPLIT	Washer, Lock, Split, 3/8, SS
7	12	HW./3/8-16X1BLT	Bolt, Hex Head, 3/8 x 1" LG, SS
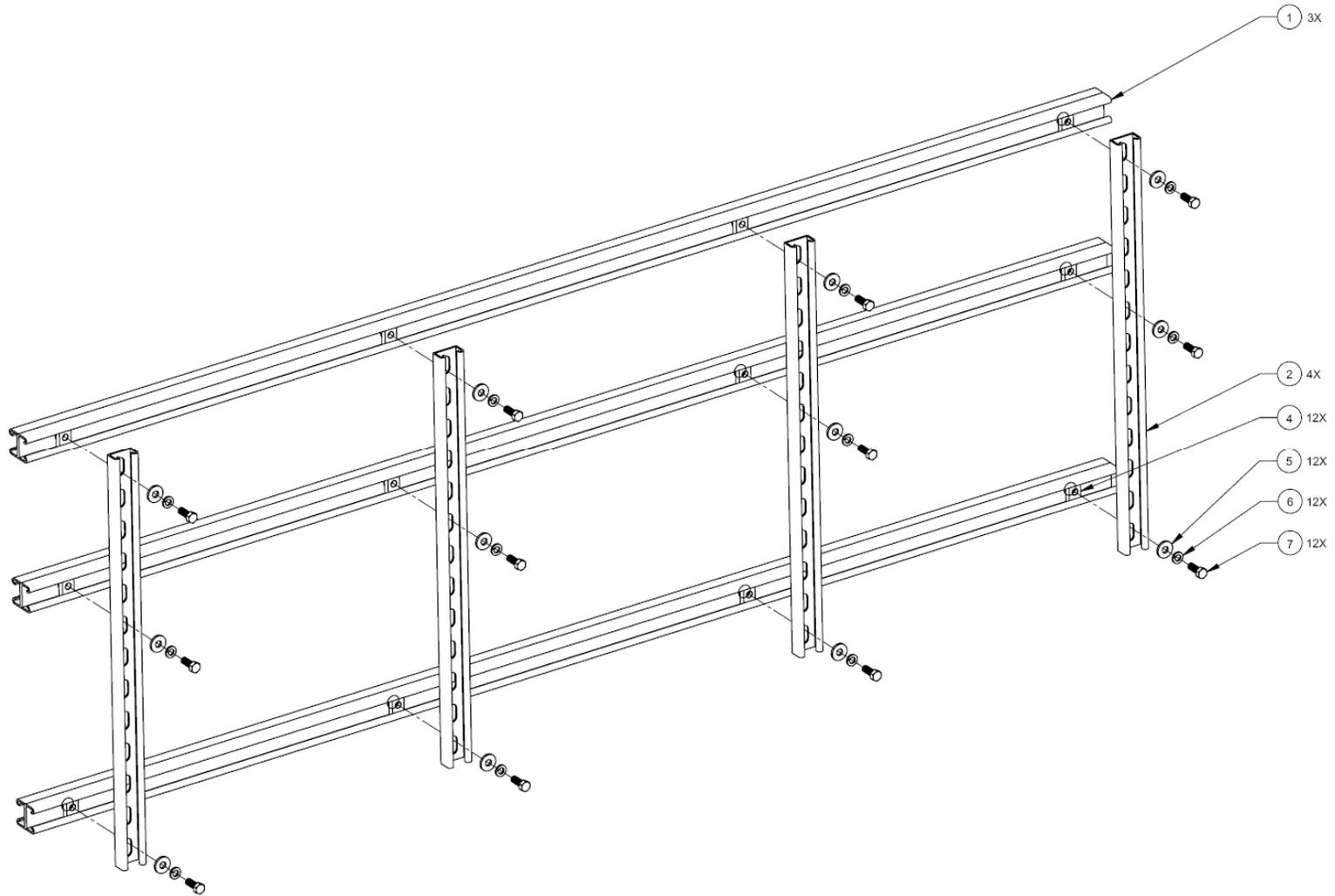
Figure A-6. Unistrut Mounting Kit (CEFD P/N KT-0000017)

A.5.1.2   HPOD Mounting Bracket Kit (KT/12300-1)

Table A-5. Kit KT/12300-1 BOM

HPOD Mounting Bracket Kit KT/12300-1 (as per Figure A-7 on next page)			
Item No.	**QTY**	**CEFD Part No.**	**Description**
1	2	FP/BR12239-1	Bracket, Unistrut
2	4	HW/3/8SPRINGNUT	Spring Nut, 3/8-16, Short Spring, SS
3	4	HW/3/8-FLT	Washer, Flat, 3/8
4	4	HW/3/8-SPLIT	Washer, Lock, Split, 3/8, SS
5	4	HW/3/8-16X1BLT	Bolt, Hex Head, 3/8-16 x 1" LG, SS
6	4	HW/5/16-18HEXNT	Nut, Hex, 5/16-18
7	8	HW/5/16-Flat	Washer, Flat, 5/16
8	4	HW/5/16-SPLIT	Washer, Lock, Split, 5/16, SS
9	4	HW/5/16-18X1BLT	Bolt, Hex Head, 5/16-18 x 1" LG, SS
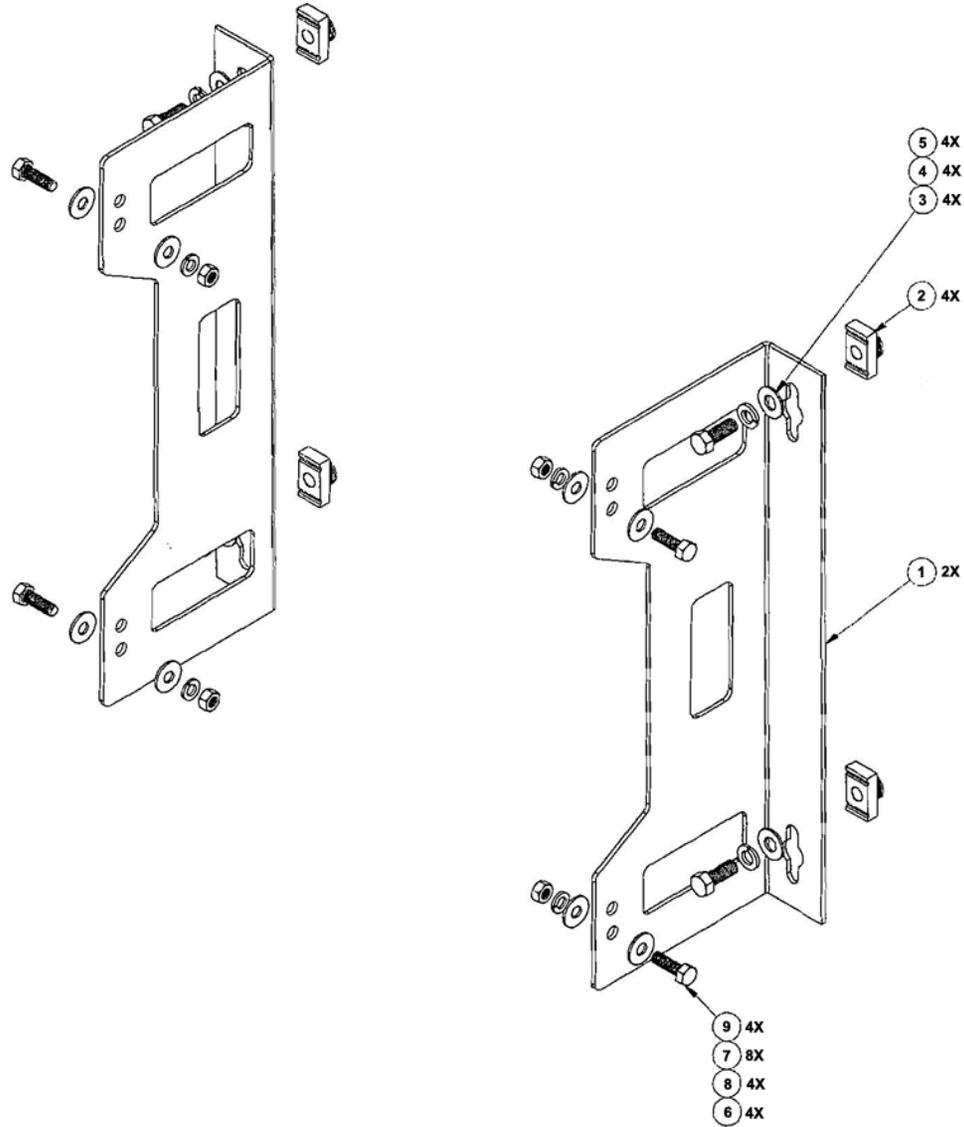
Figure A-7. HPOD Mounting Bracket Kit (CEFD P/N KT/12300-1)

A.5.1.3   C-Band Waveguide / Switch Kit – HPOD (KT-0000054)

Table A-6. Kit KT-0000054 BOM

KT-0000054 (as per Figure A-8 on next page)			
Item No.	QTY	CEFD Part No.	Description
1	1	FP-0000414	MOUNTING BRACKET, DUAL VERTICAL SWITCHES, CPR-137
2	4	HW/3/8SPRINGNUT	SPRINGNUT, 3/8-16, SHORT SPRING, SST (P3300)
3	4	HW/3/8-FLT	3/8 FLAT WASHER, SS
4	4	HW/3/8-SPLIT	3/8 SPLIT LOCK WASHER SS
5	4	HW/3/8-16X1BLT	3/8 - 16 HEX HEAD BOLT, 1.0 LONG, SS
6	1	FP-0000416	SUPPORT BRACKET, CPR-137 TERMINATION
7	2	HW/1/4-FLT	1/4 FLAT WASHER
8	2	HW/1/4-SPLIT	BIN, HW 1/4 SPLIT WASHER
9	2	HW/1/4-20X5/8SHCS	SCREW, 1/4-20 X 5/8 SHCS, SCREW, 1/4-20 X 5/8 SHCS, SS
10	2	SW/WGS28V-137S	SW WAVEGUIDE, CPR137, +28V SEALED
11	136	HW/10-FLT	#10 FLAT WASHER SS
12	128	HW/10-SPLIT	#10 SPLIT LOCK WASHER SS
13	64	HW/10-32X1/2SH	#10-32X1/2 SOCKET HEAD CAP SCREW SS
14	9	GA/CPR-137-R-H-C	GASKET, D SHAPE, CPR-137, HALF THICKNESS, CONDUCTIVE
15	1	HW-0000131	RF MAGIC TEE, COUPLER, 5.85-6.425 GHz, WR-137G, C-BAND, 4 WAY
16	56	HW/10-32X5/8SHC	#10-32 X 5/8 SOCKET HEAD CAP SCREW, SS
17	3	FP-0000410	WAVEGUIDE, CPRG-137, H-BEND ELBOW
18	9	GA/CPR137-R-F-C	GASKET, ROUND, CPR137, FULL THICKNESS, CONDUCTIVE
19	1	RF/CG-137-40-N	RF CROSSGUIDE, WR137, 40DB, N FEMALE, GROOVED
20	8	HW/10-32X3/4SH	#10-32X3/4 SOCKET HEAD CAP SCREW, SS
21	8	HW/10-32HEXNUT	#10-32 HEX NUT, SS
22	1	RF/C-TERM1000W	RF TERMINATION, LOAD, 1000 WATT, CPRG-137
23	1	FP-0000411	WAVEGUIDE, CPRG-137, SWITCH TO MAGIC TEE
24	1	FP-0000408	WAVEGUIDE, CPRG-137, SWITCH TO SWITCH
25	2	FP-0000409	WAVEGUIDE, CPRG-137, E-BEND ELBOW
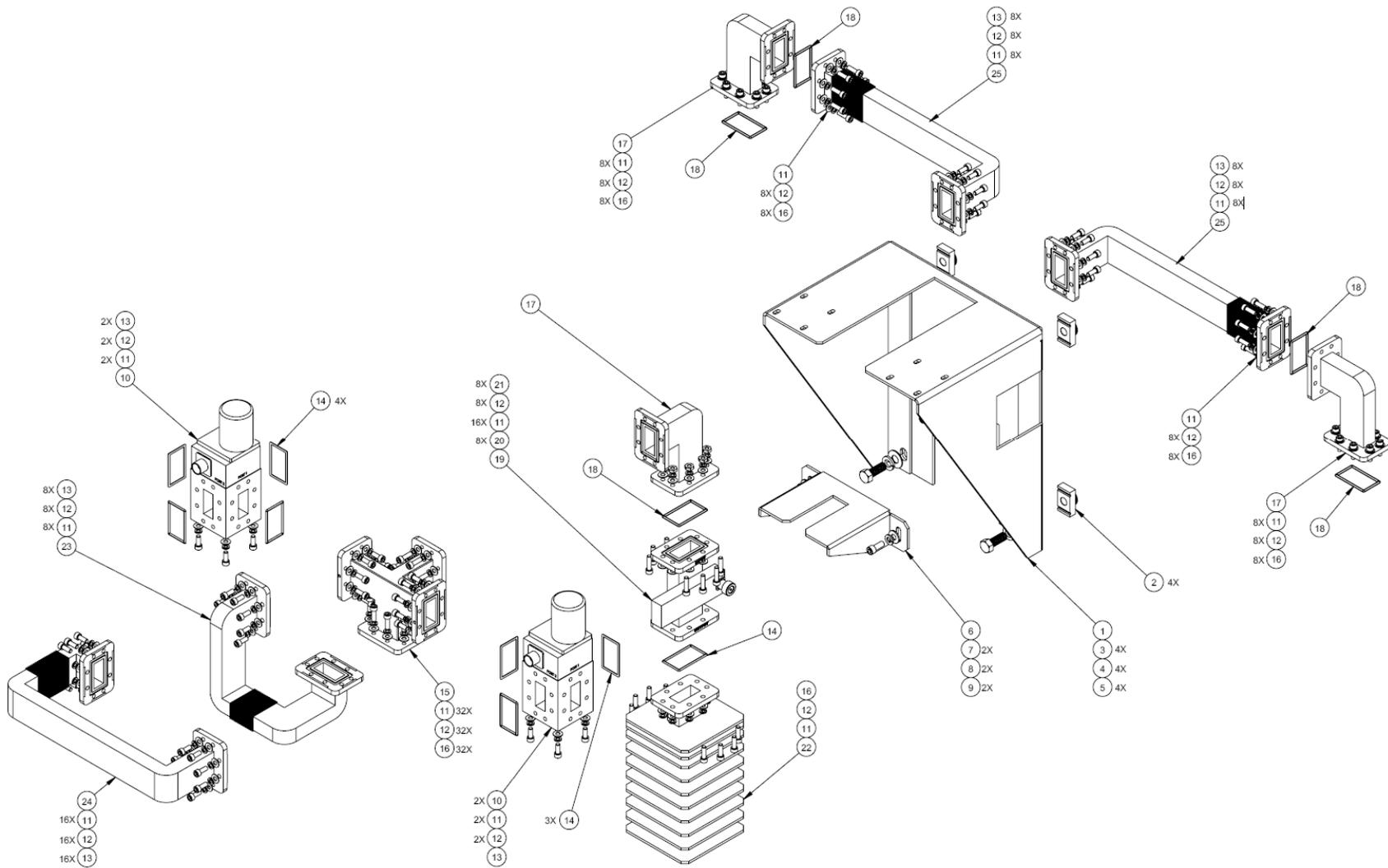
Figure A-8. C-Band Waveguide and Switch Kit – HPOD (CEFD P/N KT-0000054)

Notes:

Appendix B. REMOTE CONTROL

B.1   Overview

This appendix describes the protocol and message command set for remote monitor and control of the PCB-4000 1+1 Phase Combiner.

The electrical interface is either an EIA-485 multi-drop bus (for the control of many devices) or an EIA-232 connection (for the control of a single device), and data is transmitted in asynchronous serial form using ASCII characters. Control and status information is transmitted in packets of variable length, in accordance with the structure and protocol defined in later sections.

B.2   EIA-485

For applications where multiple devices are to be monitored and controlled, a full-duplex (or 4-wire plus ground) EIA-485 is preferred. Half-duplex (2-wire plus ground) EIA-485 is possible, but is not preferred. In full-duplex EIA-485 communications, there are two separate, isolated, independent, differential-mode twisted pairs, each handling serial data in different directions.

It is assumed that a 'Controller' device (a PC or dumb terminal) transmits data in a broadcast mode via one of the pairs. Many 'Target' devices are connected to this pair, and all simultaneously receive data from the Controller. The Controller is the only device with a line-driver connected to this pair – the Target devices have only line-receivers connected.

In the other direction, on the other pair each Target has a Tri-Stateable line driver connected, and the Controller has a line-receiver connected. All the line drivers are held in high-impedance mode until one (and only one) Target transmits back to the Controller. Each Target has a unique address, and each time the Controller transmits, the address of the intended recipient Target is included in a framed 'packet' of data. All of the Targets receive the packet, but only one (the intended) will reply. The Target enables its output line driver and transmits its return data packet back to the Controller in the other direction, on the physically separate pair.

EIA-485 (full duplex) summary:

- Two differential pairs – one pair for Controller-to-Target, one pair for Target-to-Controller.

- Controller-to-Target pair has one line driver (Controller), and all Targets have line-receivers.

- Target-to-Controller pair has one line receiver (Controller), and all Targets have Tri-State drivers.

B.3 EIA-232

This is a much simpler configuration in which the Controller device is connected directly to the Target via a two-wire-plus-ground connection. Controller-to-Target data is carried, via EIA-232 electrical levels, on one conductor, and Target-to-Controller data is carried in the other direction on the other conductor.

B.4 Basic Protocol

Whether in EIA-232 or EIA-485 mode, all data is transmitted as asynchronous serial characters, suitable for transmission and reception by a UART. The asynchronous character is fixed at 8-N-1 (8 data bits, no parity, one stop bit). Only two baud rates are supported: 9600 baud and 19200 baud.

All data is transmitted in framed packets. The host Controller is assumed a PC or ASCII dumb terminal that is in charge of the process of monitor and control. The Controller is the only device that is permitted to initiate, at will, the transmission of data. Targets are only permitted to transmit when they have been specifically instructed to do so by the Controller.

All bytes within a packet are printable ASCII characters, less than ASCII code 127. In this context, the Carriage Return and Line Feed characters are considered printable.

All messages from Controller-to-Target require a response – with one exception: This will be either to return data that has been requested by the Controller, or to acknowledge reception of an instruction to change the configuration of the Target. The exception to this is when the Controller broadcasts a message (such as Set Time/Date) using Address 0, when the Target is set to EIA-485 mode.

B.5   Packet Structure

Controller-to-Target						
Start of Packet	Target Address	Address Delimiter	Instruction Code	Code Qualifier	Optional Arguments	End of Packet
 ASCII code 60 (1 character)	 (4 characters)	/ ASCII code 47 (1 character)	 (3 characters)	= or ? ASCII codes 61 or 63 (1 character)	 (n characters)	Carriage Return ASCII code 13 (1 character)

Example: <0412/MUT=1{CR}

Target-to-Controller						
Start of Packet	Target Address	Address Delimiter	Instruction Code	Code Qualifier	Optional Arguments	End of Packet
> ASCII code 62 (1 character)	 (4 characters)	/ ASCII code 47 (1 character)	 (3 characters)	=, ?, !, or * ASCII codes 61, 63, 33, or 42 (1 character)	 (From 0 to n characters)	Carriage Return, Line Feed ASCII codes 13,10 (2 characters)

Example: >0412/MUT={CR}{LF}

B.5.1   Start Of Packet

Controller-to-Target: This is the character '<' (ASCII code 60).

Target-to-Controller: This is the character '>' (ASCII code 62).

Because this is used to provide a reliable indication of the start of packet, these two characters may not appear anywhere else within the body of the message.

B.5.2   Target (Base) Address

Up to 9,999 devices can be uniquely addressed. In both EIA-232 and EIA-485 applications, the permissible range of values is 1 to 9999. It is programmed into a Target unit using serial remote control.

> **IMPORTANT**
>
> *The Controller sends a packet with the address of a Target – the destination of the packet. When the Target responds, the address used is the same address, to indicate to the Controller the source of the packet. The Controller does not have its own address.*

B.5.2.1   Virtual Address

Virtual Address is a method that allows the user to access the SSPA via the PCCB using any communications software. Virtual Address is aupported in both EIA-232 and EIA-485 applications.

The following example depicts use of the virtual addressing scheme:

<123V1/MUT? *where:*

Base address = 123;

'V' = virtual address delimiter;

1 = virtual address of SSPA automatically set by the phase combiner box.

Notes:

1. Only three virtual commands can be used to program the individual SSPAs when in Phase Combined mode (RED=1):

   - CAA=
   - DAT=
   - TIM=

2. All virtual queries can be directed to the individual SSPAs in any mode.

3. The following virtual commands can NEVER be used to program the individual SSPAs:

   - MUT=
   - ATT=

B.5.3   Address Delimiter

This is the "forward slash" character '/' (ASCII code 47).

B.5.4   Instruction Code

This is a three-character alphabetic sequence that identifies the subject of the message. Wherever possible, the instruction codes have been chosen to have some significance. This aids in the readability of the message if seen in its raw ASCII form. Upper and lower case alphabetic characters (i.e., A-Z [ASCII codes 65-90], and a-z [ASCII codes 97-122]) may be used.

B.5.5   Instruction Code Qualifier

This is a single character, which further qualifies the preceding instruction code. Code Qualifiers obey the following rules:

1.   *From Controller-to-Target*, the only permitted values are:

Symbol	Definition
= **(ASCII code 61)**	'**=**' is used as the **assignment** operator, and is used to indicate that the parameter defined by the preceding byte should be set to the value of the argument(s) that follow it. **For example: MUT=1** would mean 'enable the Mute function.'
? **(ASCII code 63)**	'**?**' is used as the **query** operator, and is used to indicate that the Target should return the current value of the parameter defined by the preceding byte. **For example: MUT?** Would mean 'return the current state of the Mute function.'

2.   *From Target-to-Controller*, the only permitted values are:

Symbol	Definition
= **(ASCII code 61)**	The = code is used in two ways: First, if the Controller has sent a query code to a Target (**for example: MUT?** would mean 'return the current state of the Mute function'), the Target would then respond with **MUT=x**, where '**x**' represents the state in question (1 being 'enabled', 2 being 'disabled). Second, if the Controller sends an instruction to set a parameter to a particular value, then, providing the value sent in the argument is valid, the Target will acknowledge the message by replying with **MUT=** (with no message arguments).
? **(ASCII code 63)**	The **?** code is only used as follows: If the Controller sends an instruction to set a parameter to a particular value, then, if the value sent in the argument is not valid, the Target will acknowledge the message by replying (for example) with **MUT?** (with no message arguments). This indicates that there was an error in the argument of the message sent by the Controller.
! **(ASCII code 33)**	The **!** code is only used as follows: If the Controller sends an instruction code that the Target does not recognize, the Target will acknowledge the message by echoing the invalid instruction, followed by the ! character; for example, **XYZ!**
* **(ASCII code 42)**	The * code is only used as follows: If the Controller sends an instruction to set a parameter to a particular value, then, if the value sent in the argument is valid, but the target is in the wrong mode (e.g., Standby mode in Redundancy configuration) such that it will not permit that particular parameter to be changed at that time, the Target will acknowledge the message by replying (for example) with **MUT*** (with no message arguments).
# **ASCI code 35)**	The **#** code is only used as follows: If the controller sends an instruction code that the target cannot currently perform because of hardware resource issues, then the target will acknowledge the message by echoing the invalid instruction, followed by the # character; for example, **MUT#** (with no message arguments).

B.5.6   Optional Message Arguments

Arguments are not required for all messages. Arguments are ASCII codes for the characters 0 to 9 (ASCII codes 48 to 57), period (ASCII code 46) and comma (ASCII code 44).

B.5.7   End Of Packet

Controller-to-Target: This is the 'Carriage Return' character (ASCII code 13).

Target-to-Controller: This is the two-character sequence 'Carriage Return', 'Line Feed' (ASCII codes 13 and 10).

Both indicate the valid termination of a packet.

B.6   Remote Commands / Queries

Index Notes: Column 'C' = Command; **Column 'Q'** = Query; columns marked '**X**' designate instruction code as *Command only*, *Query only*, or *Command/Query*.

CODE	C	Q	PAGE	CODE	C	Q	PAGE	CODE	C	Q	PAGE	CODE	C	Q	PAGE
A				**D**				**R**				**T**			
AMP	X	X	B-7	DAT	X	X	B-9	RAS		X	B-10	TIM	X	X	B-12
AOF	X	X	B-7					RCS		X	B-10	TNA		X	B-12
ATT	X	X	B-7					RED	X	X	B-10				
AUX		X	B-7	**F**				RET		X	B-11				
				FRW		X	B-9	RMS		X	B-11				
B								RSN		X	B-11				
BYP	X	X	B-7					RUS		X	B-11				
				L											
C				LNA		X	B-9								
CAA	X		B-7					**S**							
CAS		X	B-8					SBR	X	X	B-11				
CCS		X	B-8	**M**				SFS		X	B-11				
CID	X	X	B-8	MUT	X	X	B-9	SPA	X	X	B-11				
CMS		X	B-8												
CUS		X	B-8												

Unless otherwise noted – In the tables that follow, these codes are used in the 'Response to Command' column (per Sect. B.5.6$_2$)

= Message ok   ? Received ok, but invalid arguments were found

* Message ok, but not permitted in current mode

Parameter Type	Command (Instruction Code and qualifier)	Command Valid for PCB or SSPA	Arguments for Command or Response to Query	Description of Arguments (Note that all arguments are ASCII numeric codes – i.e., ASCII codes between 48 and 57)	Response to Command (Target to Controller)	Query (Instruction Code and qualifier)	Query Valid for PCB or SSPA	Response to Query (Target to Controller)
RF Power Amplifier State	AMP=	PCB	1 byte, value of 0, 1	Command or Query Turns ON or OFF the SSPAs in the form AMP=x, where: 0 = Off 1 = On	AMP= AMP? AMP*	AMP?	ALL	AMP=x (see Description of Arguments for details)

Attenuation Offset	AOF=	PCB	7 bytes, alphanumeric	Command or Query
				Sets attenuation offset for specified SSPA
				Command: AOF=x,yy.yy where:
				   x=0 or 1 (SSPA number)
				   yy.yy=Attenuation offset
				Query: AOF?
				Example: AOF=1,01.50
				Note: AOF command will not take values greater than 6 dB)
					AOF=
					AOF?
					AOF*
						AOF?	PCB	AOF=x,yy.yy
								(see Description of Arguments for details)

Attenuation	ATT=	PCB	5 bytes, numerical	Command or Query. Valid attenuation level, in dB, at 0.25-dB step size as factory default. **Example:** ATT=12.25 **Note:** The attenuation range is limited to a maximum of 24 dB.	ATT= ATT? ATT*	ATT?	ALL	ATT=xx.xx (see Description of Arguments for details)
AUX Input Enable	AUX=	N/A	1 byte, value of 0, 1	Query only. Enables AUX input for SSPA mute <0001V1/AUX? **Where:** x is 0 (AUX Mute disabled) 1 (AUX Mute enabled)	AUX= AUX? AUX*	AUX?	SSPA	AUX=x (see Description of Arguments for details)

Bypass SSPA	BYP=	PCB	1 byte value of 0, 1 or 2	Command or Query
				Syntax:
				Command: BYP=a *where:*
				   a = 0 (No SSPA is bypassed)
				        1 (SSPA #1 is bypassed)
				        2 (SSPA #2 is bypassed)
				• Command bypasses the SSPA specified by argument.
				• Command works only in RED=0 mode.
				Query: BYP?
				• Query returns the number of the SSPA that is currently bypassed or offline.
				• Query works in any RED mode.
					BYP=
					BYP?
					BYP* (received ok but in the wrong RED mode)
						BYP?	PCB	BYP=a
								(see Description of Arguments for details)

Clear All Stored Alarms	CAA=	ALL	None	Command only Instructs the slave to clear all Stored Events. This command takes no arguments.	CAA=	N/A	N/A	N/A

Parameter Type	Command (Instruction Code and qualifier)	Command Valid for PCB or SSPA	Arguments for Command or Response to Query	Description of Arguments (Note that all arguments are ASCII numeric codes – i.e., ASCII codes between 48 and 57)	Response to Command (Target to Controller)	Query (Instruction Code and qualifier)	Query Valid for PCB or SSPA	Response to Query (Target to Controller)
Concise Alarm Status	N/A	N/A	11 bytes numerical with commas	Query only. Used to Query the Alarm status of the unit, response is comma delimited. **Example:** CMS=a,b,c,d,e,f,g'cr''lf' *where:* 　a thru k = 0 or 1, 0 = OK 1 = FT 　a = +24V Power Supply 　b = +5V Power Supply 　c = SSPA1 　d = SSPA2 　e = reserved 　f = SW1 Absent FLT 　g = SW2 Absent FLT	N/A	CAS?	ALL (Check SSPA manual for arguments returned from SSPA)	CAS=x….x (see Description of Arguments for details)
Concise Configuration Status	N/A	N/A	24 bytes numerical	Query only. Used to query the summarized version of RCS. **Example:** CCS=aa.aa,b,c,d,e,f,g,x'cr''lf' *where:* 　aa.aa = attenuation in dB 　b = RF power amplifier state 　c = mute state 　d = redundancy/phase combine mode 　e,f,g,x = SSPAs fault status (g is reserved (X))	N/A	CCS?	SSPA (per MBT manual)	CCS=x….x (see Description of Arguments for details)
Circuit Identification	CID=	PCB	24 bytes, alphanumeric	Command or Query Used to identify or name the unit or station. First line is limited to 24 characters. Second line is also limited to 24 characters. No carriage return between first line and second line.	CID= CID?	CID?	ALL	CID=x…x (see Description of Arguments for details)
Concise Maintenance Status	N/A	N/A	23 bytes numerical	Query only. Used to Query the Maintenance status of the unit in concise format. Response is comma delimited. **Example:** CMS=aaa.a,bbb.b,ccc.c,ddd.d'cr''lf' where: 　aaa.a = +24V Power Supply 　bbb.b = +5V Power Supply 　ccc.c = reserved (XXX.X) 　ddd.d = reserved (XXX.X)	N/A	CMS?	ALL (Check SSPA manual for arguments returned from SSPA)	CMS=x….x (see Description of Arguments for details)
Concise Utility Status	N/A	N/A	11 bytes alphanumeric	Query only. Used to Query the Maintenance status of the unit, response is comma delimited. **Example:** CUS=aaaa,bbbb'cr''lf' *where:* 　aaaa = Remote Unit Address 　bbbb = Remote Baud Rate	N/A	CUS?	ALL (Check SSPA manual for arguments returned from SSPA)	CUS=x….x (see Description of Arguments for details)

Parameter Type	Command (Instruction Code and qualifier)	Command Valid for PCB or SSPA	Arguments for Command or Response to Query	Description of Arguments (Note that all arguments are ASCII numeric codes – i.e., ASCII codes between 48 and 57)	Response to Command (Target to Controller)	Query (Instruction Code and qualifier)	Query Valid for PCB or SSPA	Response to Query (Target to Controller)
Set RTC(Real-Time-Clock) Date	DAT=	ALL	6 bytes, numerical	Command or Query. A command in the form **mmddyy**, where; dd = day of the month, between 01 and 31, mm = month of the year, between 01 and 12 and yy = year, between 00 and 99 (2000 to 2099) **Example:** DAT=042503 would be April 24, 2003	DAT= DAT? DAT*	DAT?	ALL	DAT=xx (see Description of Arguments for details)
Retreive Firmware Number	N/A	N/A		Query only Gets the Firmware Number of the unit. Bulk = FW/XXXXX M&C = FW/XXXXX FPGA = FW/XXXXX **Example:** FRW=FW12001'cr''lf'	N/A	FRW?	ALL	FRW=FWxxxxx

Retrieve next 5 unread Stored Alarms	N/A	N/A	145 bytes	Query only
				The unit returns the oldest 5 Stored Events which have not yet been read over the remote control.
				Reply format: **Sub-body{CR}Sub-body{CR}Sub-body{CR}Sub-body{CR}Sub-body, where Sub-body= YYYYYYYYYY ZZ mmddyy hhmmss**, *where:*
				YYYYYYYYYY being the fault description.
				ZZ being the alarm type.
				   FT = Fault
				   OK = Clear
				   IF = Information
				If there are no new events, the unit will reply with LNA*
					N/A	LNA?	SSPA	LNA=**YY..ss**
								(see Description of Arguments for details)

Mute State	MUT=	PCB	1 byte, value of 0,1	Command or Query. Mute the SSPAs, *where:* 0 = Disabled, 1 = Enabled 2 = Inhibit asserted (Query only) **Example:** MUT=1	MUT= MUT? MUT*	MUT?	ALL	MUT=x (see Description of Arguments for details)

Parameter Type	Command (Instruction Code and qualifier)	Command Valid for PCB or SSPA	Arguments for Command or Response to Query	Description of Arguments (Note that all arguments are ASCII numeric codes – i.e., ASCII codes between 48 and 57)	Response to Command (Target to Controller)	Query (Instruction Code and qualifier)	Query Valid for PCB or SSPA	Response to Query (Target to Controller)

Retrieve Alarm Status	N/A	N/A	53 bytes alphanumeric	Query only.
				Used to Query the Alarm status of the unit.
				Example: RAS='cr'
				  P24VT=OK'cr'
				  P5VLT=OK'cr'
				  SSPA1=OK'cr'
				  SSPA2=OK'cr'
				  XXXXX=OK'cr'
				  SW1FT=OK'cr'
				  SW2FT=OK''cr''lf'
				
				Note: XXXXX = reserved
					N/A	RAS?	ALL (Check SSPA manual for arguments returned from SSPA)	RAS=x....x (see Description of Arguments for details)

Retrieve Configuration Status	N/A	N/A	33 bytes alphanumeric	Query only.
				Used to Query the configuration status.
				Example: RCS='cr'
				  ATT=12.75'cr'
				  AMP=1'cr'
				  MUT=1'cr'
				  PCM=1,0'cr'
				  FLT=0,0,X'cr''lf' *where:*
				  ATT= attenuation in dB
				  AMP= RF power amplifier state, 0=OFF, 1=ON
				  MUT=RF mute state, 0=unmuted, 1=muted
				  PCM=Redundancy/Phase Combined mode,
				    0 = off
				    1 = 1:1 phase combine
				    2 = 1:2 phase combine (future)
				    3 = reserved
				    4 = reserved
				  FLT=X,Y,Z -> SSPAs fault state
				    X = SSPA#1 (1=faulted, 0=unfaulted)
				    Y = SSPA#2 (1=faulted, 0=unfaulted)
				    Z = reserved (X)
					N/A	RCS?	SSPA (per MBT manual)	RCS=x....x (see Description of Arguments for details)

Redundancy /Phase Combine Mode	RED=	PCB	1 byte, value of 0, 1,2,3	Command or Query
				Set the redundancy/phase combine mode.
				    0 = Off
				    1 = 1:1 Phase combined
				    2 = reserved
				    3 = reserved
				    4 = reserved
					RED=
					RED?
						RED?	PCB	RED=x (see Description of Arguments for details)

Parameter Type	Command (Instruction Code and qualifier)	Command Valid for PCB or SSPA	Arguments for Command or Response to Query	Description of Arguments (Note that all arguments are ASCII numeric codes – i.e., ASCII codes between 48 and 57)	Response to Command (Target to Controller)	Query (Instruction Code and qualifier)	Query Valid for PCB or SSPA	Response to Query (Target to Controller)
Retrieve Equipment Type	N/A	N/A	20 bytes, alphanumeric	Query only. The unit returns a string indicating the Model Number and the value of internal software revision installed. **Example:** Phase –Combine Ver. 1.1.16I	N/A	RET?	ALL	RET=x….x (see Description of Arguments for details)
Retrieve Maintenance Status	N/A	N/A	47 bytes, alphanumeric	Query only. Used to Query the maintenance status of the unit. 　　P24VT=024.1′cr′ 　　P05VT=015.2′cr′ 　　XXXXX=XXX.X′cr′ 　　XXXXX=XXX.X′cr′″lf′ **Note:** XXXXX = reserved	N/A	RMS?	ALL (Check SSPA manual for arguments returned from SSPA)	RMS=*x….x* (see Description of Arguments for details)
Serial Number	N/A	PCB	9 bytes, numerical 000000000 to 999999999	Query only. Used to Query the units 9 digit serial number. Slave returns its S/N, in the form **xxxxxxxxx**. **Example:** RSN=000000165	N/A	RSN?	ALL	RSN=xxxxxxxxx (see Description of Arguments for details)
Retrieve Utility Status	N/A	N/A	17 bytes alphanumeric	Query only. Used to Query the utility status of the unit **Example:** RUS=′cr′ 　　　ADR=0001′cr′ 　　　BDR=9600′cr′″lf′	N/A	RUS?	ALL (Check SSPA manual for arguments returned from SSPA)	RUS=x….x (see Description of Arguments for details)
Remote Baud Rate	SBR=	PCB	4 bytes,	Command or Query. Set remote baud rate as follows: 9600 = 9600 baud 19K2 = 19200 baud	SBR= SBR?	SBR?	PCB	SBR=xx (see Description of Arguments for details)
Summary Fault Status	N/A	N/A	1 byte, value of 0,1	Query only. Used to Query the status of the Summary Fault Relay. **Example:** SFS=0 *where:* 　　0 = OK 　　1 = FT	N/A	SFS?	SSPA	SFS=**x** (see Description of Arguments for details)
Remote Address	SPA=	PCB	4 byte, numerical	Command or Query. Set Physical Address-between 0001 to 9999. Resolution 0001 **Example:** SPA=0412	SPA= SPA?	SPA?	PCB	SPA=x (see Description of Arguments for details)

Parameter Type	Command (Instruction Code and qualifier)	Command Valid for PCB or SSPA	Arguments for Command or Response to Query	Description of Arguments (Note that all arguments are ASCII numeric codes – i.e., ASCII codes between 48 and 57)	Response to Command (Target to Controller)	Query (Instruction Code and qualifier)	Query Valid for PCB or SSPA	Response to Query (Target to Controller)
Set RTC Time	TIM=	ALL	6 bytes, numerical	Command or Query. A command in the form **hhmmss**, indicating the time from midnight, where hh = hours, between 00 and 23; mm = minutes, between 00 and 59, and ss = seconds, between 00 and 59 **Example:** TIM=231259 would be 23 hours, 12 minutes and 59 seconds past midnight.	TIM = TIM? TIM *	TIM?	ALL	TIM=xx (see Description of Arguments for details)
Retrieve Number of unread Stored Alarms	N/A	N/A	2 bytes, numerical	Query only. Returns the number of Stored Events which remain unread, in the form **xx**. **Example reply:** TNA=18	N/A	TNA?	SSPA	TNA=**xx** (see Description of Arguments for details)

METRIC CONVERSIONS

Units of Length

Unit	Centimeter	Inch	Foot	Yard	Mile	Meter	Kilometer	Millimeter
1 centimeter	—	0.3937	0.03281	0.01094	6.214×10^{-6}	0.01	—	—
1 inch	2.540	—	0.08333	0.2778	1.578×10^{-5}	0.254	—	25.4
1 foot	30.480	12.0	—	0.3333	1.893×10^{-4}	0.3048	—	—
1 yard	91.44	36.0	3.0	—	5.679×10^{-4}	0.9144	—	—
1 meter	100.0	39.37	3.281	1.094	6.214×10^{-4}	—	—	—
1 mile	1.609×10^{5}	6.336×10^{4}	5.280×10^{3}	1.760×10^{3}	—	1.609×10^{3}	1.609	—
1 mm	—	0.03937	—	—	—	—	—	—
1 kilometer	—	—	—	—	0.621	—	—	—

Temperature Conversions

Temperature	° Fahrenheit	° Centigrade
Water freezes	32	0
Water boils	212	100
Absolute 0	-459.69	-273.16

Formulas
° C = (F - 32) * 0.555
° F = (C * 1.8) + 32

Units of Weight

Unit	Gram	Ounce Avoirdupois	Ounce Troy	Pound Avoirdupois	Pound Troy	Kilogram
1 gram	—	0.03527	0.03215	0.002205	0.002679	0.001
1 oz. avoir.	28.35	—	0.9115	0.0625	0.07595	0.02835
1 oz. troy	31.10	1.097	—	0.06857	0.08333	0.03110
1 lb. avoir.	453.6	16.0	14.58	—	1.215	0.4536
1 lb. Troy	373.2	13.17	12.0	0.8229	—	0.3732
1 kilogram	1.0×10^{3}	35.27	32.15	2.205	2.679	—