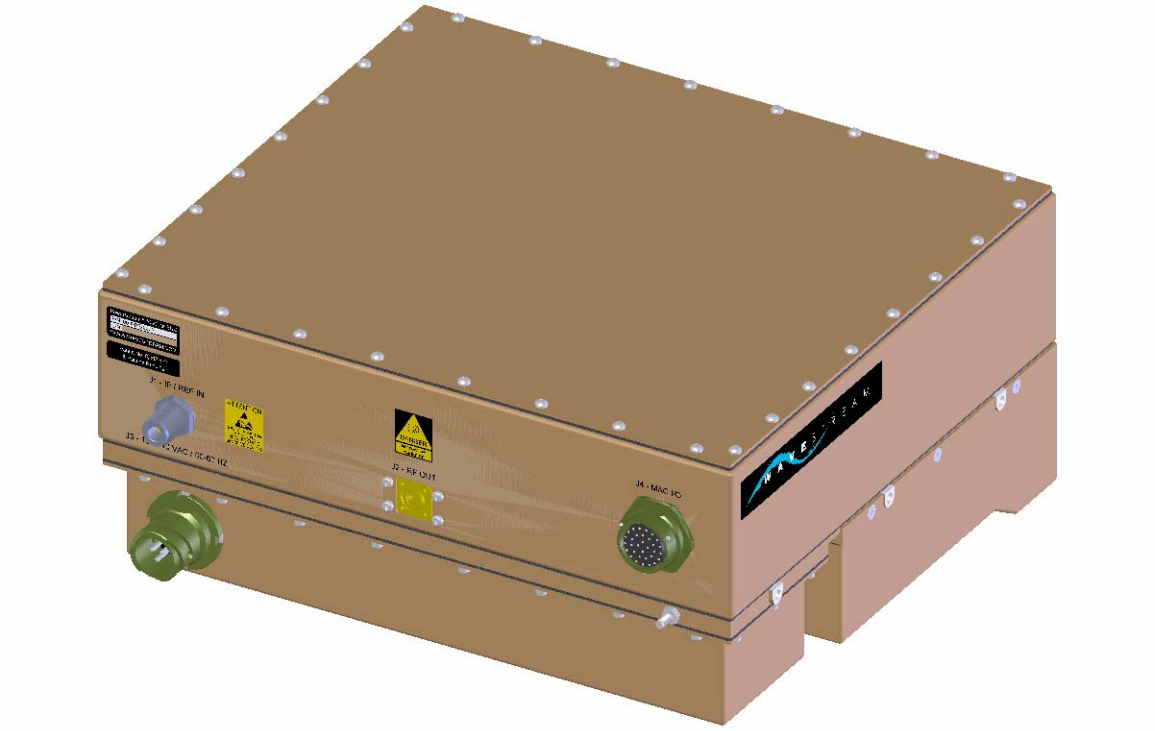
50 Watt

Ka-band

Grid Amplifier™

BUC

User Manual



About This Handbook

This document describes Wavestream's 50 Watt Ka-band Grid Amplifier™ Block Upconverter (BUC) herein referred to as "the Unit".

Updated documentation may be available on our website at www.wavestream.com or from Wavestream's sales group sales@wavestream.com.

This User Manual covers installation and configuration of the 50W Ka-band Grid Amplifier BUC, models JNB-KAM050-HS00 and JNB-KAM050HE00. Separate manuals cover other Wavestream products.

Notices

Wavestream document 90-005-0003

The information provided in this User Manual is being provided by Wavestream Corporation as a service to our customers. Although every effort has been made to verify the completeness and accuracy of the information contained in this manual, due to the highly technical nature of the material, and the dynamic nature of the satellite communications, Wavestream cannot be responsible for any errors and omissions.

CONTENTS

1 INTRODUCTION

This User Manual provides information and instructions for installation and operation of Wavestream equipment.

This User Manual is intended for use by trained field technicians or system engineers responsible for satellite networks.

Updates to this User Manual may be published. Access current versions of this and other Wavestream documentation by contacting sales@wavestream.com

This section includes:

- Introduction
- Warranty information on the Wavestream equipment.
- Instructions for getting technical support for Wavestream equipment.

This User Manual is for the Wavestream GBE-300310-50-NW-AC, a Ka-Band Grid Amplifier Block Up Converter (BUC), herein referred to as "the Unit". The Unit receives an L-Band input (1000-2000MHz) and transmits a 50 Watt Ka-Band output (30.0-31.0GHz).

The Unit comes in a single weatherized housing rated for indoor or outdoor use. It has an N-Type input and a WR28 waveguide output, a 120VAC Power input and a Monitor and Control connector. The Monitor and Control functions allow the user to enable and disable the internal amplifiers without shutting off the power supplies as well as to monitor the status of the Unit.

Warranty

The Wavestream warranty is defined in the Terms and Conditions of Sale that accompanied the quotation and purchase order. In the event that the Unit needs to be returned to Wavestream for repair, contact your customer service representative at Wavestream. If you purchased this Unit from a distributor, follow the distributor's RMA process.

The warranty does not apply to any defect, failure or damage caused by improper use or inadequate or improper maintenance and care.

Not withstanding the Warranty defined in the Terms and Conditions of Sale, Wavestream is not obliged to furnish service under this warranty:

- to repair damage resulting from attempts by personnel other than Wavestream to repair, or service the product
- to repair any damage or malfunction caused by the use of non-standard ancillary equipment
- to service a product that has been modified or integrated with other products if this modification has not been approved previously in writing by Wavestream

OPENING OR REMOVING ANY COMPONENT OR SEALED AREA (WITH THE EXCEPTION OF THE FAN ASSEMBLY) WILL IMMEDIATELY VOID THE WARRANTY

Technical Support

In the event you need technical information or operation support beyond the scope of this User Manual, contact Wavestream support at support@wavestream.com.

Equipment Service

Under all circumstances, contact Wavestream or your distributor for service.

A replacement fan assembly can be purchased from Wavestream.

With the exception of replacing the fans, do not attempt to service the equipment yourself.

Safety Tip: Opening or removing the cover of the Unit may expose you to dangerous voltages, high power RF energy or other hazards as well as void your warranty.

Notice

For the proper operation of this equipment and/or all parts thereof, the instructions in this guide must be strictly and explicitly followed. All of the contents of this guide must be fully read and understood prior to operating any of the equipment or parts thereof.

Failure to completely read and fully understand and follow all of the contents of this guide prior to operating this equipment, or parts thereof, may result in damage to the equipment or parts, and to any persons operating the same.

Wavestream does not assume any liability arising out of the application or use of any products, component parts, circuits, software, or firmware described herein. Wavestream further does not convey any license under its patent, trademark, copyright or common-law rights nor the similar rights of others. Wavestream further reserves the right to make any changes in any products, or parts thereof, described herein without notice.

Caution: This equipment generates, uses, and radiates radio frequency energy. This can present a safety hazard if not handled safely per the precautions identified in Section 2.

2 SAFETY

This Unit contains delicate electronics, electrical components and high radiated RF power. Follow all safety precautions in this section when the Unit is in operation.

Carefully read and follow all safety, use, and operating instructions before operating the Unit. Retain these instructions for future reference.

This section includes:

- Safety considerations for use of the Unit.

Safety Precautions

Use safety precautions when working at or near the Unit as described in these sections.

Warning: Shock Hazard

Do not open the equipment. High voltages are present under the lid of the Unit. Service is only to be performed by Wavestream.

With the exception of the fan assembly, the Unit contains no user serviceable parts. Do not attempt to service this product yourself. Any attempt to do so voids any and all warranties.

Warning: High Power RF Hazard

Do not operate unless the RF output waveguide flange is properly connected to the rest of the system or to a high power load. **The unit emits high power RF energy which could be harmful to the human body.**

When operating the equipment, never place personnel or any object in front of or near the output waveguide opening.

Caution: Electrostatic Sensitive Devices

Be aware that there are devices in the Unit that are easily damaged by ESD. Take standard ESD precautions when handling the Unit.

When operating the Unit, observe these precautions:

Follow the connection procedure described in this manual in Section 4, entitled "Install the Unit".	Do not apply power to the Unit until the Unit is appropriately connected to the feed and antenna system or a high power load. **The Unit radiates high energy RF.**
Avoid Water and Moisture on Connectors	The IF input, Power, M&C connections should be tightly connected and sealed against outside moisture using good commercial practice and UV-rated materials. Care should be taken on the installation of an "O" ring for the WR28 waveguide connection to prevent contaminants from entering the interface and to avoid pinching of the gasket.

Provide Adequate Ventilation	Since the Unit uses forced air convection for cooling, it relies on proper ventilation to ensure reliable operation. The Unit draws air in from the front side (face with connectors on it) and exhausts air to the back side. ***THE VENTILATION MUST NOT BE BLOCKED*** To avoid overheating and ensure that the ventilation slots are not blocked, place the Unit at least 2 inches from any object that could obstruct air flow. If the Unit is placed in a closed area, such as a building or radome, ensure that proper ventilation is provided and that the air temperature does not exceed the maximum rated temperature.
Use the Correct Power Source 	To prevent damage to the Unit, ensure that the applied AC power is within the range of 90-264VAC.
Route Power Cords Safely	Route power cords so that they are not walked on or pinched. Pay particular attention to cords and connections at the plugs, receptacles, and the point where they exit from the Unit and attach to other equipment. Do not place any items on or against power cords.

Protect Against Lightning and Power Surges	To protect against voltage surges and built-up static charges, install the Unit with appropriate grounding methods in compliance with grounding standards for electrical and radio equipment according to the electrical codes in the country of installation. To ensure continuous and undisturbed unit operation from primary power line anomalies, use an Uninterruptible Power Source (UPS) with your Unit.
Do not penetrate the Unit	Touching internal parts in the Unit is dangerous to both you and the Unit. Never put any object through slots or openings, as this could result in touching dangerous voltage points, short-circuiting parts, electric shock, fire or electro-static discharge (ESD). If an object were to fall into the Unit, unplug the unit, as serious damage could occur to the unit.

3 SYSTEM DESCRIPTION

Wavestream's patented Spatial Power Advantage™ delivers RF power in a small and light package. Our patented technology delivers the highest efficiency in the industry resulting in significantly streamlined thermal designs and high MTBF.

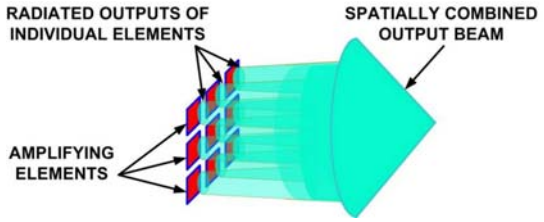
This section includes:

- A brief primer on Wavestream's unique spatial power combining technology.
- Interface descriptions including pin out and mating connector information
- For more information visit Wavestream's website: www.wavestream.com

SPATIAL POWER COMBINING

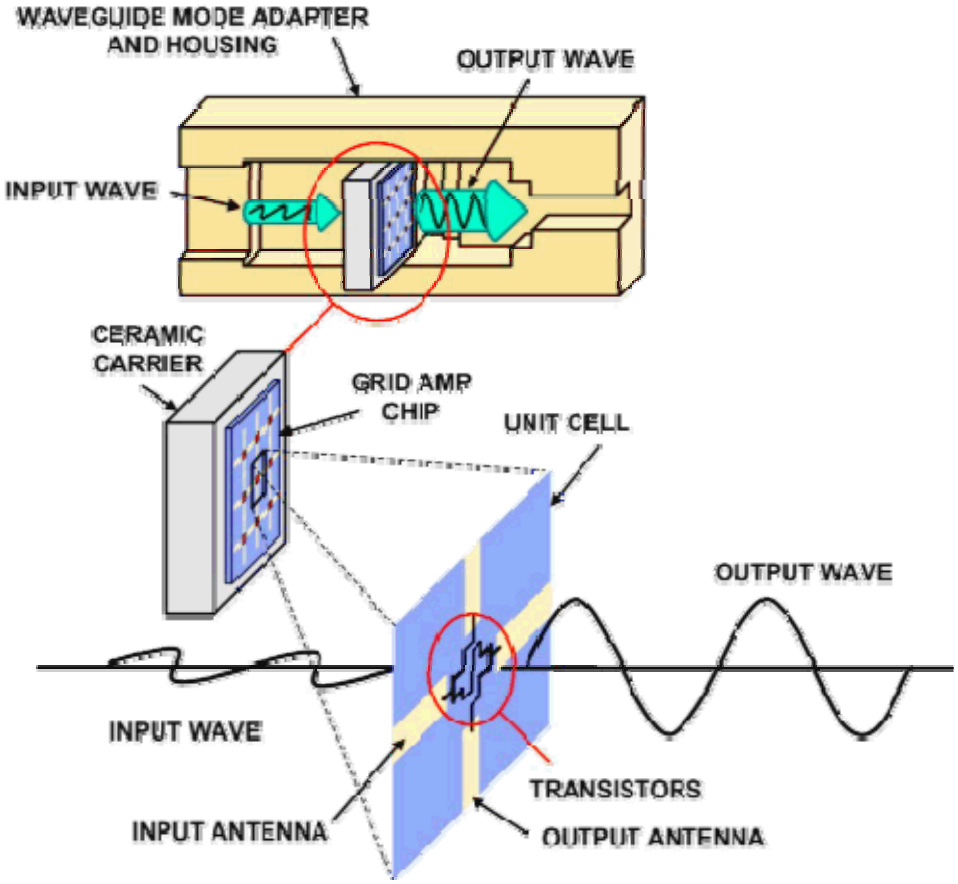
How Grid Amplifiers™ Work

The spatially power combined Grid Amplifier employs a fundamentally different technique for combining the outputs of the transistors. Rather than combining in multiple stages and increasing loss and size with each combining stage, all transistor outputs are combined in a single stage, minimizing the loss and size of the combining network. Many amplifying elements are used to synchronously amplify the input signal, and their outputs are combined in free space for very high combining efficiency.



Spatial Power Combining of Many Elements in a Single Combining Stage

The PowerStream Grid Amplifier is powered by Wavestream's Grid Amplifier chip which consists of an array of several hundred transistors which together form an in-waveguide amplifier as shown in the diagram below:



PowerStream™ Grid Amplifier™ using Patented Spatial Power Combining

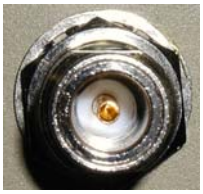
Wavestream's Grid Amplifier architecture provides significant advantages over traditional SSPAs which use microstrip or waveguide combining. All the MMIC amplifier outputs are combined in a single stage of combining in air, making the amplifier highly efficient. Furthermore the signal never traverses a bond wire, removing a key single point of failure found in traditional amplifiers.

INTERFACES

The Unit has the following interfaces:

"IF / REF IN" CONNECTOR (J1)

- The "IF / REF IN" Connector is a Type N female connector.



Type N Connector

- The Unit requires that the L-Band (1000-2000MHz) Input and a 10MHz reference are multiplexed into the "IF IN / REF IN" Connector. Most modems are configured to provide the required multiplexed signal and reference. This multiplexing can be performed using a bias tee and a separate reference source if unavailable from the modem.

"RF OUT" CONNECTOR (J2)

- The "RF OUT" Connector is a WR28 waveguide flange.

WR28 flange

- When operating, the Unit will output up to 50 Watts of RF power at Ka-Band (30.0-31.0GHz). To make a water-tight connection, the mating WR28 flange should have an O-Ring groove and the appropriate O-Ring ought to be inserted prior to mating this interface.

"120VAC IN" CONNECTOR (J3)

- The "120VAC IN" Connector is a 3-Pin Circular Connector. This is an ITT Cannon part with part number CB7-16-10PS. Its mating connector (part number CB6E16-10SS) has been supplied with the Unit.

ITT Cannon P/N: CB7-16-10PS

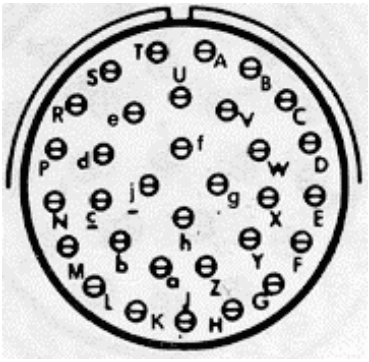
- The Unit is powered from this connector. At peak output power, the Unit will not draw more than 6.5 Amps.

PRIME POWER INTERFACE PINOUT:

Pin#	Signal Name	Pin Description
A	PRIME PWR	+120VAC Line
B	PRIME RTN	+120VAC Neutral
C	GND	Ground

MONITOR AND CONTROL INTERFACE (J4)

- The "M&C" Connector is a 32-Pin Circular Connector. This is an ITT Cannon part with part number KPT07A18-32S. Its mating connector (part number KPT06U18-32P) has been supplied with the Unit.



ITT Cannon P/N: KPT07A18-32S

- The Unit uses this connector as a serial RS-485 interface.

MONITOR AND CONTROL INTERFACE PINOUT:

Pin #	Signal Name	Pin Description
Pin A:	STDBY_TX*_1	Safety Interlock1 – Unit will not turn on if not grounded.
Pin B:	STDBY_TX*_2	Safety Interlock2 – Unit will not turn on if not grounded.
Pin C:	OVERTEMP	High if “Over Temperature” event is occurring
Pin D:	OVERRIDE	Battle Short (Active High) High = Battle Short active
Pin E:	RESERVED	n/a
Pin F:	REF_LOCK_DSCRT	Reports acquisition of reference signal and upconverter has locked (active HI)
Pin G:	no connect	n/a
Pin H:	no connect	n/a
Pin J:	RF_FWD_PWR	Analog Output Voltage Proportional to RF Forward Output Power
Pin K:	GND	Logic Gnd
Pin L:	RS_485-RX+	Serial Communication Channel
Pin M:	RS_485-RX-	Serial Communication Channel
Pin N:	RS_485-TX+	Serial Communication Channel
Pin P:	RS_485-TX-	Serial Communication Channel
Pin R:	RESERVED1	n/a
Pin S:	RESERVED2	n/a
Pin T:	GND	Logic Gnd
Pin U:	no connect	n/a
Pin V:	no connect	n/a
Pin W:	no connect	n/a
Pin X:	no connect	n/a
Pin Y:	no connect	n/a
Pin Z:	no connect	n/a
Pin a:	no connect	n/a
Pin b:	no connect	n/a
Pin c:	no connect	n/a
Pin d:	no connect	n/a
Pin e:	no connect	n/a
Pin f:	no connect	n/a
Pin g:	no connect	n/a
Pin h:	no connect	n/a
Pin j:	GND	Logic Gnd

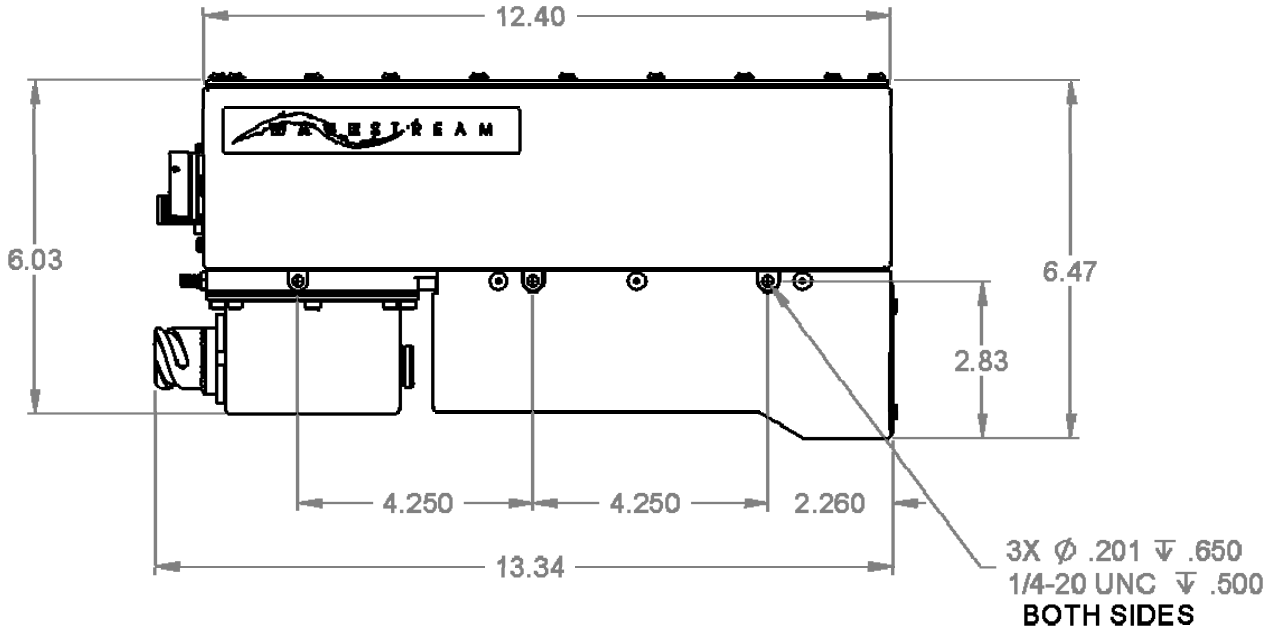
The default SABUS address of the unit is 0x30(hex).

GROUND STUD

- Located between connectors J3 and J4 is a ground stud which is screwed into the main body of the Unit. This should be used to ground the Unit to the rest of the system.

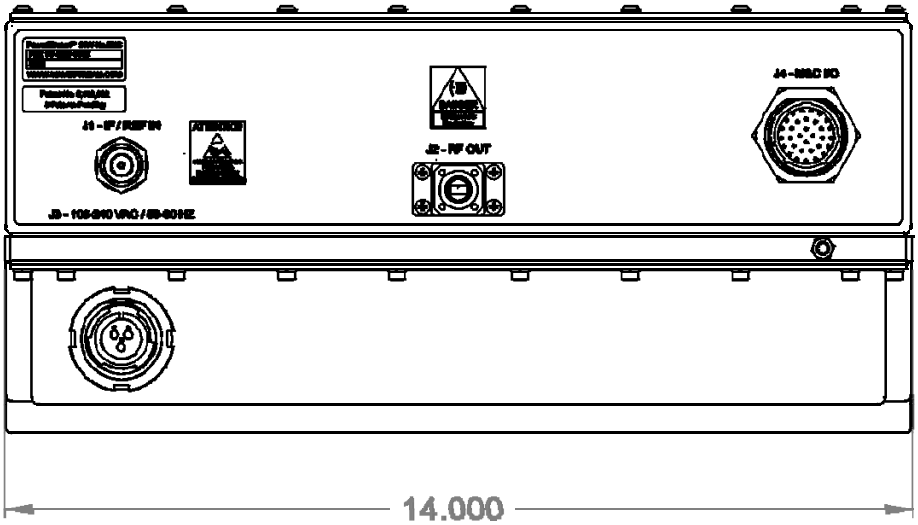
MOUNTING INTERFACE

- The Unit is designed to mount to a plate via the 2 sets of 3 ¼-20 bolt holes located on each side of the Unit. The plate should be designed to be capable of carrying the weight of the Unit. That plate is the typically attached to a feed arm or other platform. No conductive cooling is assumed. Therefore, the function of the Unit's mounting interface is simply to enable meeting the system vibration and shock requirements.

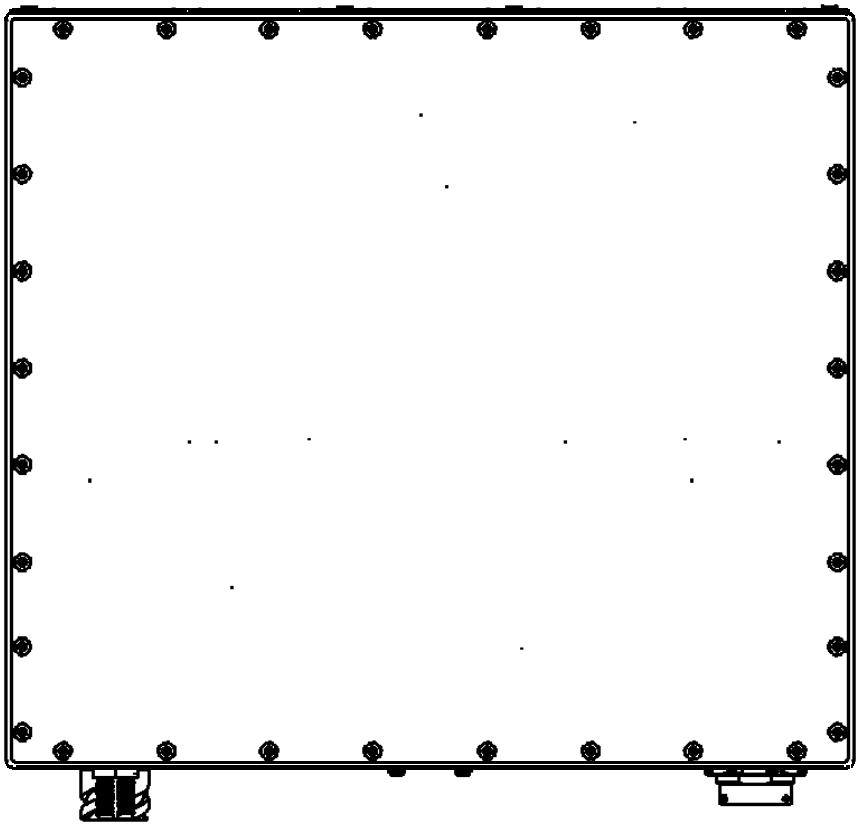


MOUNTING HOLE PATTERN

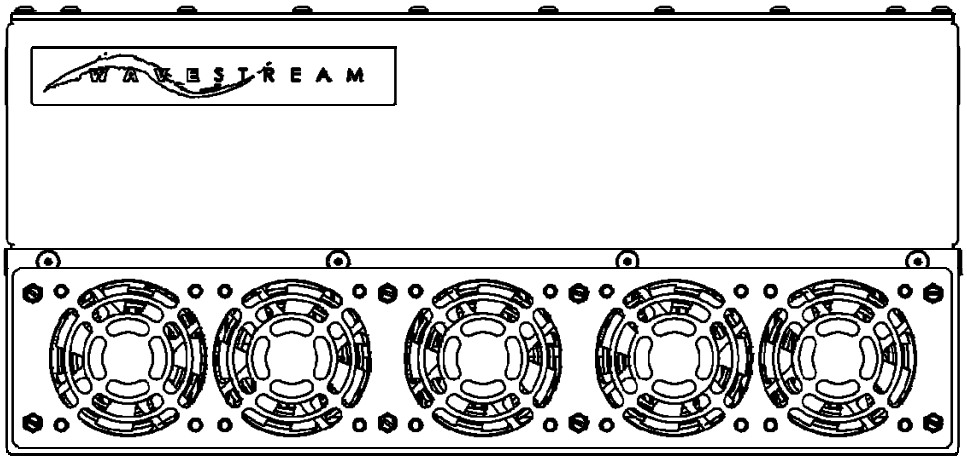
OUTLINE DRAWINGS



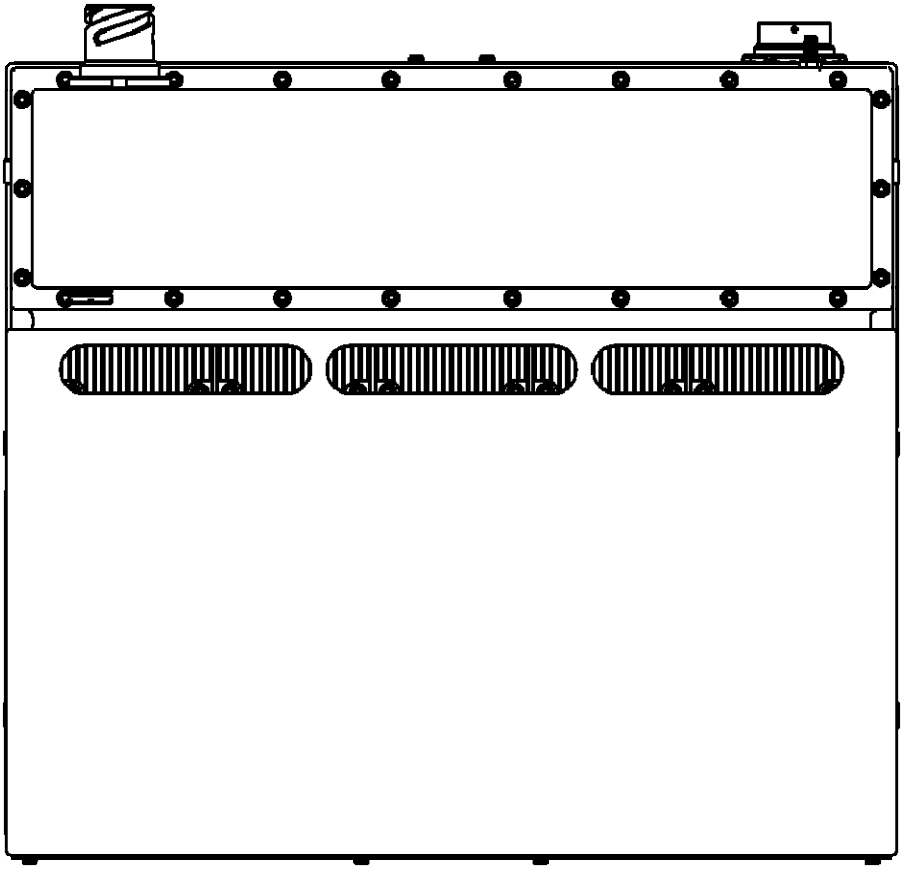
Outline Drawing 1: FRONT VIEW



Outline Drawing 2: TOP VIEW



Outline Drawing 3: REAR VIEW



Outline Drawing 4: BOTTOM VIEW

ADDITIONAL INFORMATION

- The Fans: The Unit cools itself with fans. These fans are weatherized to handle an extreme environment that includes heavy spray. They will shut off when the temperature of the Unit is below 10°C. The fans are the only serviceable part in the Unit. To replace the fan assembly, see Section 7.
- Cable Construction: If the M&C cable is greater than 6 feet, it is recommended that multi-conductor shielded cable be used to reduce noise pickup. Shield should be connected to the case. The Ground Stud on the chassis can be used for this purpose.

4 CONNECTING AND CONFIGURING THE UNIT

This document assumes the user has a working knowledge of satellite communications and RF systems.

This section includes:

- General step-by-step installation instructions.
- Detailed information on the Unit's interfaces.

The experienced satellite professional will find this Unit to have standard interfaces and straightforward installation. However, proper system engineering, including a detailed link budget, should be performed to guarantee proper operation and conformance to standards and regulations.

UNPACK THE UNIT:

Keep the shipping box and all packing materials for future use including return of the Unit for repair.

Check the unit for any visible damage. If the unit appears to be damaged, contact Wavestream or your distributor.

Make a note of date, location and serial number of the unit. This information may be useful in the future.

ACCESSORIES:

The Unit is shipped with the following accessories to aid in installation:

- Mating Connector to Prime Power Connector, J3
  - ITTC P/N: CB6E16-10SS
- Mating Connector to "M&C" Connector, J4
  - ITTC P/N: KPT06U18-32P

INSPECT INTERFACES

Inspect the WR28 waveguide. Remove the cover or tape that may be there to protect that interface. Remove any foreign objects such as packing material that might be in or around the waveguide opening.

Inspect the Prime Power pins to make sure they are not damaged. Make sure the connector has not been damaged.

Inspect the Monitor and Control connector to make sure it is not damaged. Check to verify that there is no debris in any of the sockets.

Inspect the N-Type Connector to verify that it is not damaged.

PERFORM CONTINUITY CHECK ON THE CABLES

Even if cables have been made in advance, it is important to use an ohm meter to perform a continuity check on each of the individual wires. Incorrect wiring could permanently damage the unit.

Pin-out tables for each connector are included in Section 3 – System Description.

INSTALL THE UNIT

Proceed with the installation according to standard practice.

Mount the Unit using the mounting holes described in Section 3.

Ground the Unit by attaching ground strap between system chassis and Ground Stud.

Bolt the feed to the WR28 flange. For a weather-tight seal, be sure to install an O-Ring in the groove in the feed's WR28 waveguide flange and properly torque down the screws on this interface. Make sure to keep the "O" ring clean and to not pinch the ring when installing the Unit on the feed.

Connect the M&C cable to the M&C Connector (J4).

IMPORTANT: The minimum wires in the M&C cable required to turn on the Unit are:

- the 4 RS-485 wires (Pins L,M,N&P) need to be connected to a controller
- BOTH Safety Interlocks (Pins A&B) need to be tied to any of the ground pins (Pins K, T, or j)

The default SABUS address of the Unit is 0x30(hex).

Connect the IF input to the N-type connector (J1).

The final connection is the AC power cord. One end of this cord shall be connected to the AC Connector (J3) on the Unit. The other end needs to be plugged into either a generator or into an isolation transformer. Please see the important note pertaining to this in Section 2, entitled “Use the Correct Power Source“.

NOTE: Do not energize the unit until the unit is completely installed on the feed and antenna**. The unit emits high power RF energy which could be harmful to the human body.**

5 TROUBLESHOOTING

TBS

6 TECHNICAL SPECIFICATIONS

This section provides detailed technical specifications for the Unit.

This section includes:

- Performance specifications for the Unit

SPECIFICATIONS FOR GBE-300310-50-NW-AC

50 Watt Ka-Band Grid Amplifier Block Upconverter

RF OUTPUT

Transmit Frequency	30.0-31.0 GHz
RF Port Connector	WR-28
RF Output VSWR	1.25:1 max
Saturated Output Power	> 47 dBm
Rated Linear Output Power (power at which all other RF specifications are met)	44 dBm
Small Signal Gain	60 dB nominal
Intermodulation Level below total power of two equal carriers, at linear Rated Output Power	-25 dBc
Spectral Regrowth at linear Rated Power at 1.0x symbol rate offset for OQPSK modulation, and at 1.5x symbol rate offset for QPSK modulation	-30 dBc
Receive Band Noise In 20.2 – 21.2 GHz band	-100 dBm/Hz
Output Transmit Spurious	-55 dBc
AM/PM Conversion	2 deg/dB

Phase Noise	-32 dBC at 10 Hz offset -62 dBC at 100 Hz offset -72 dBC at 1 KHz offset -82 dBC at 10 kHz offset -92 dBC at 100 kHz offset -102 dBC at 1 MHz offset -112 dBC at 10 MHz offset -112 dBC at 100 MHz offset

IF INPUT

IF Frequency	1000-2000 MHz
IF Port Connector	Type N Female
IF Input Impedance	50 Ohm
Frequency Reference	10 MHz on IFL, 0dBm +/- 5dBm

INTERFACES

AC Connector	3-Pin Male - ITT Cannon CB7-16-10PS (mating CB6E16-10SS)
Monitor and Control Connector	32-Pin Female - ITT Cannon KPT07A18-32S (mating KPT06U18-32P)
M&C Serial Interface	RS-485
Power Control	30 dB min; 0.25 db steps

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature	-40°C to +60°C
Non-Operating Temperature	-50°C to +70°C
Operating Relative Humidity	100% Condensing
Shock	10g, 11ms half sine
Vibration	MIL-STD-810E, method 514-4
Humidity	100% Condensing

MECHANICAL SPECIFICATIONS

Size	14” W x 6.5” H x 12” L
Weight	33.8 lbs

POWER SPECIFICATIONS

AC Power	90-264 VAC, 50-60 Hz
AC Prime Draw	6A max at rated linear output power

7 MAINTENANCE

This section explains proper maintenance of the Unit.

This section includes:

- Procedure for replacing the fan assembly.

FAN ASSEMBLY REPLACEMENT PROCEDURE

The fan assembly is designed to be field replaceable. A replacement can be obtained by contacting Wavestream.

TOOLS REQUIRED

Flathead screwdriver

PROCEDURE

Turn off the power to the Unit.

For safety reasons, remove the cable attached the AC Connector (J3).

Unscrew the 8 flathead captive screws that hold the fan assembly in place. (See Outline Drawing 3: Rear View in Section 3).

Carefully pull the fan assembly out of the Unit.

Twist to remove the power connector.

With the replacement fan assembly in hand, carefully connect the fans' power connector.

Insert fan assembly into place.

Screw in the 8 flathead captive screws.

Reconnect the Unit's power cable to the AC Connector (J3).

8 SERIAL M&C PROTOCOL

This section describes the Serial Monitor and Control protocol.

This section includes:

- Electrical Specifications for the RS-485 serial interface
- Command and Response packet structures
- General Description of the SAbus Protocol

Introduction

Typically, monitor and control of the Unit will be integrated into a comprehensive Graphical User Interface (GUI). This section provides general information on the electrical specifications, command structures and SAbus protocol to help users understand the general interface. The user should consult Wavestream for specific information for software development.

Wavestream has developed a Test GUI to assist in the integration, test and qualification of the Unit. Refer to the document “Wavestream 50W Grid Amplifier BUC Serial Test GUI.doc” for details.

Packet Structure:

Dec	Hex	Abr.	Character Name	Notes
02	0x02	STX	Start of Text	
03	0x03	ETX	End of Text	
06	0x06	ACK	Acknowledge	

21	0x15	NAK	Negative Acknowledge	
	0x30 to 0x39		Address	One byte, typically in the range 0x30 to 0x39, but can be any value other than STX, ETX, ACK or NAK. Must match the value configured into the M&C unit or the message is ignored
	0x30 to 0xF0		Command	One byte, typically in range 0x30 to 0xF0, but can be any value other than STX, ETX, ACK, or NAK
			Data	Up to 570 bytes of ASCII characters
			Checksum	One byte containing the XOR of all previous bytes including STX and ETX
			Echo Address	
			Echo Command	

Response to Errors:

- If the address does not match, the M&C will not respond.
- If the checksum is invalid, the M&C will not respond.

ASCII Encoding of Binary Data:

All binary data sent and received by the M&C unit is encoded into ASCII characters. If a communication protocol allows unrestricted binary data, it is impossible to designate a unique start, stop, ack or nak byte. Since the data payload of a packet can contain bytes of any value, you are never sure if a byte is a control code, or part of the payload. If a communication is corrupted, and the receiver loses track of where it is in a message, there is no reliable way to guarantee resynchronization. In the worst case, depending on the data payload, the communication might never recover synchronization.

By following this rule, the start, stop, ack, and nak codes are guaranteed to never be present in the data payload.

All binary data is encoded in hex ASCII in Intel byte order. Intel byte order is also known as little endian, since the list significant byte is first in memory.

So if a 16-bit word contains the binary value 0x12AB, it will be stored in memory as AB12, and converted to the ASCII string “AB12”.

Master Slave Communication:

All communication is initiated by the Master. The M&C will never initiate a communication, it will only respond.

Communication hardware is 4-wire RS-485. The signals have termination resistors. The Unit should be the only one in the circuit or in a multi-drop configuration, it must be the last one in the chain.

The M&C receiver is always active. The transmitter is activated when a reply is being sent and then deactivated. This allows for the possibility of multiple units existing in parallel.

Each M&C unit is assigned the Address = 0x02. It will only respond to messages sent to this address.

Combined Status Message:

The M&C reposts the entire status of the amplifier in a single communication.

Separate messages are not currently provided to get individual pieces of information.

The command

CMD_GET_STATUS = 0x40 is used.

Status Message Definition:

The most convenient way to use the data definitions is to use the C or C++ programming language on an Intel architecture machine.

The structures and bit-fields can be used directly. The structures are packed using byte alignment. Most compilers default to WORD, DWORD or larder alignment. The compiler must be configured to pack these structures correctly.

The directive

#pragma pack(1) works for Microsoft Visual C++ V6.0

For users of other languages, here is the status message in generic terms:

Commands:

Command	Hex	Notes
CMD_GET_UNIT_ID	0x30	Returns the Unit ID in ASCII Since the Unit ID is an ASCII string it is returned directly it is not further converted to hex like the binary data Unit ID consist of Model Number followed by Firmware Version Total Bytes: 24 ASCII characters + 1 byte for null terminator = 25 bytes
CMD_GET_SERIAL_NUMBER	0x31	Returns the Serial Number in ASCII Since the Serial Number is an ASCII string, it is returned directly, it is not further converted to hex like the binary data Total Bytes: 24 ASCII characters + 1 byte for null terminator = 25 bytes
CMD_SET_ADDRESS	0x34	Sets the address of the Unit on the serial bus. By default the Unit ships from the factory with address 0x30 (hex).
CMD_GET_STATUS	0x40	Returns the status of the amplifier in hex ASCII format
CMD_GET_RAW_STATUS	0x41	Returns the raw values from the various sensors (temperature, voltage) in the Unit. For example, temperatures are reported in Status in degrees C. The raw value will be reported as it is read from device without conversion.
CMD_ENABLE_TRANSMITTER	0x50	Sets the TransmitSoftEnable bit This will enable the transmitter if it is not in Fault mode and the two Enable lines are Low Response if successful, ACK with the string “OK”

CMD_DISABLE_TRANSMITTER	0x51	Clears the TransmitSoftEnable bit This will disable the transmitter uniless the Override line is high Response of successful, ACK with the string "OK"
CMD_SET_ATTENUATION	0x52	Sets attenuation to a user specified 16 bit value which translates to 0.25 dB steps. Response of successful, ACK with the string "OK"
CMD_RESET_FAULT_MODE	0x66	Resets the Fault Mode condition.

SAbus - GENERAL INFORMATION

INTRODUCTION

The SAbus is an interface designed explicitly as an economical method of providing complex remote monitor and control capability in satellite earth station equipment. Although it requires a limited degree of intelligence in each earth station component, the SAbus provides comprehensive monitor and control capability and a degree of flexibility not available in customized systems solutions.

Electrically, the SAbus is compatible with EIA RS-422 or RS-485. The RS-422/485 interface is a unipolar, balanced, 5-volt serial interface designed to connect equipment which must exchange data over considerable distances with high-noise immunity and high speed. Standard IC drivers and receivers are available for RS-422/485 that convert to and from TTL logic levels. The SAbus subset of RS-422/485 allows up to 63 devices to be connected in parallel with up to 4000 feet between any master and group of slaves.

PHYSICAL SPECIFICATIONS

The SAbus interface uses only four data lines, circuit common, and shield. No hardware handshaking is used in the SAbus protocol. All SAbus devices can operate in electrical parallel with a single cable required to connect all devices controlled by a master. Figure 1 illustrates the connection of a master device and multiple slave devices.

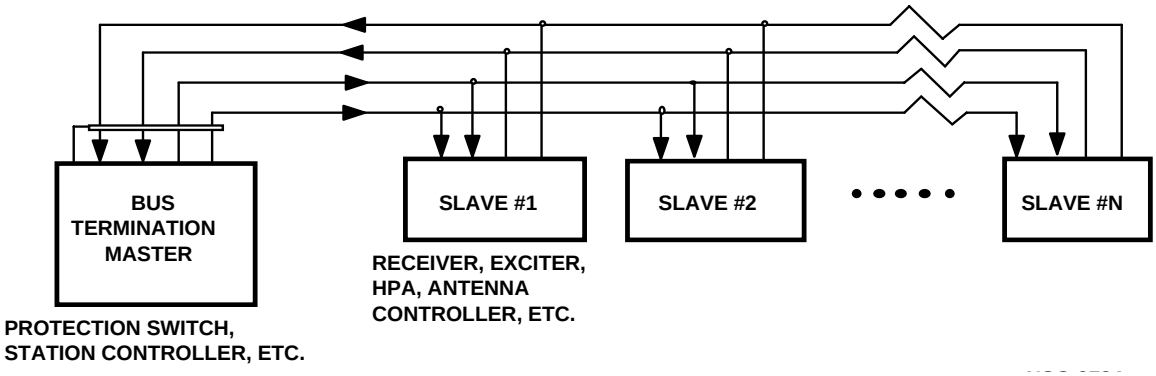


Figure 1. SAbus Master and Slaves

GENERAL SAbus INFORMATION

The following paragraphs provide general information pertaining to the SAbus. Detailed information pertaining to the SAbus interface command set follows this section.

SAbus Protocol

The SAbus interface is a multi-drop, balanced line, asynchronous, full-duplex communications link designed to interconnect equipment for remote control and switching applications. Products that are SAbus compatible can be linked together over a parallel-connected 4-wire circuit without regard to their particular function.

Each SAbus configuration can have one master and up to 63 slave devices (see Figures 2 and 3). Each slave device is internally configured to respond to a unique address. A master could be a protection switch, earth station controller, or any microcomputer or minicomputer that is electrically and operationally compatible with the SAbus. Since the electrical specifications are very similar to EIA standards RS-422/485 and RS-449, virtually any computer that meets these standards is capable of controlling remote devices over the SAbus.

Data Format

SAbus data format supports industry's standard asynchronous ASCII format with one start bit, eight data bits (7-bit ASCII with the 8th bit set to even parity), and one stop bit. The ASCII control character subset 00-1F (hex) are used for address, command, and data characters. The standard bus data rate via direct connect (up to 4000 feet) is 9600 baud; the data rate for devices connected to a master via modem is 1200 baud.

Message format and protocol over the SAbus is a derivative of IBM's binary synchronous communications protocol (BISYNC). The master station sends a command over the bus to all remote stations. The station whose address is contained in the second byte of the command message carries out the requested commands and then replies with a response message containing its own address and status information relating to its present condition. A remote station only sends a response following a command from the master containing its unique address. This prevents bus contention caused by more than one remote device communicating over the SAbus at the same time.

A remote device ignores all commands that contain parity or checksum errors, protocol errors, a wrong address, or message overrun errors. A remote device replies with a not-acknowledged (NAK) character if it receives an invalid command or data.

Message Format

Command messages (see Figure 2) begin with start-of-test (STX) byte followed by a remote address, a command byte, and multiple data bytes. The end-of-text (ETX) byte is sent following the last data byte and the message is terminated by a checksum character. Response messages are identical to command messages in format with the exception of the acknowledge (ACK) or not-acknowledged (NAK) character at the start of the message instead of STX. Figure 4 illustrates the format of the command and response message. A command or reply message may have a variable length up to a maximum of 132 bytes including delimiters and checksum. Although most currently implemented SAbus devices require no (or very few) data bytes, the capability for long messages is built into the protocol so that future applications requiring the transfer of large amounts of data can be accommodated. SAbus devices should observe the length of all messages, predefined by their communication protocol and NAK messages longer than permitted.

COMMAND MESSAGE:

STX	ADDRESS	COMMAND	D1	D2	Dn	Dn+1	ETX	CHKSUM

RESPONSE MESSAGE: COMMAND ACKNOWLEDGED

ACK	ADDRESS	COMMAND	D1	D	Dn	Dn+1	ETX	CHKSUM

RESPONSE MESSAGE: COMMAND NOT ACKNOWLEDGED-UNABLE TO EXECUTE OR INCORRECT COMMAND

NAK	ADDRESS	COMMAND	ETX	CHKSUM

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Figure 2. SAbus Message Format

Message Delimeters

A command message begins with STX (02 hex), the ASCII start-of-text character. A message-acknowledged reply begins with ACK (06 hex), the ASCII acknowledge control character; and a message-not-acknowledged reply begins with NAK (15 hex), the ASCII not-acknowledged control character. All messages end with the ETX (03 hex), the ASCII end-of-text control character, followed by the checksum byte.

Address Character

The device address must be valid ASCII printable character between "1" and "o", or 31 through 6F (hex); thus, 63 SAbus addresses are possible.

Command Character

The command (CMD) character immediately follows the device address and specifies one of a possible 80 different commands for a particular device. Values from 30 to 7F (hex) are allowed. Commands may be completely device dependent with the exception of command 30 (hex), which must cause a device to return its six-character device type and command 31 (hex) which is a status poll.

Command and Reply Data

A command or device reply may contain from 0 to 128 data characters and is restricted only to printable ASCII characters 20 through 7F (hex).

Check Character

The last character of any SAbus message is the check (CHK) character. This character is simply the bit-by-bit exclusive OR of all characters in the message starting with the STX character through the ETX character. This forms a longitudinal redundancy parity check over the entire message.

Message Timing

Different devices will require varying times to execute commands from a master. A receiver, for example, may be instructed to change frequency and may require up to a second for the synthesizer to lock. This should not prevent it from immediately acknowledging the command. The NAK or ACK reply does not signify that a function has actually taken place, but only that the message was received and understood. A status reply should indicate if a device is executing a time-consuming function.

A remote device must begin responding to a command within 100 milliseconds after receiving the last character of the command and no more than 10 milliseconds must pass between each character. If the remote device does not respond within this time, the master/controller should attempt to re-establish communication by re-polling this device at least once. Figure 3 shows a remote device SAbus state table and timing requirements.

At least a 10-bit time delay must be inserted between command messages in order to wake up a remote device. Once the device is awakened by data on the bus, it looks for STX followed by its address. If it does not see its own address, it ignores the rest of the message by going to sleep and remains in that state until the serial data line idles for at least 10-bit times or approximately 10 milliseconds.

All SAbus compatible devices must respond to a command 0 (30 hex), with 6 data bytes of ASCII characters in the following form:

ACK ADDR 30 D1 D2 D3 D4 D5 D6 ETX CHSUM

- where D1 through D4 are four ASCII characters representing the model number and D5 and D6 are two ASCII characters representing a software version number.

If more than one command is required to obtain status information of device's functions that can cause setting of a change bit, then the device must implement a clear change bit command and this must be the only command which causes the change bit to be cleared. If several commands have to be executed in order to set all the information that can cause a change bit to be set, then multiple change bits may be used to reduce the bus traffic.

Wherever possible, SAbus numeric data should be sent encoded as ASCII data characters and only in cases where it cannot be avoided, numeric data should be sent in binary or BCD packed format. Status bits in data bytes (i.e., change bits, alarm bits, etc.) should occupy no more than four bits in the low-order nibble. The high-order nibble should be set to 03 to guarantee that the byte will contain a printable ASCII character.

The slave state diagram (see Figure 3) presents the required protocol implementation at the slave device that guarantees the proper transfer and processing of communication messages sent by a master/controller over SAbus.

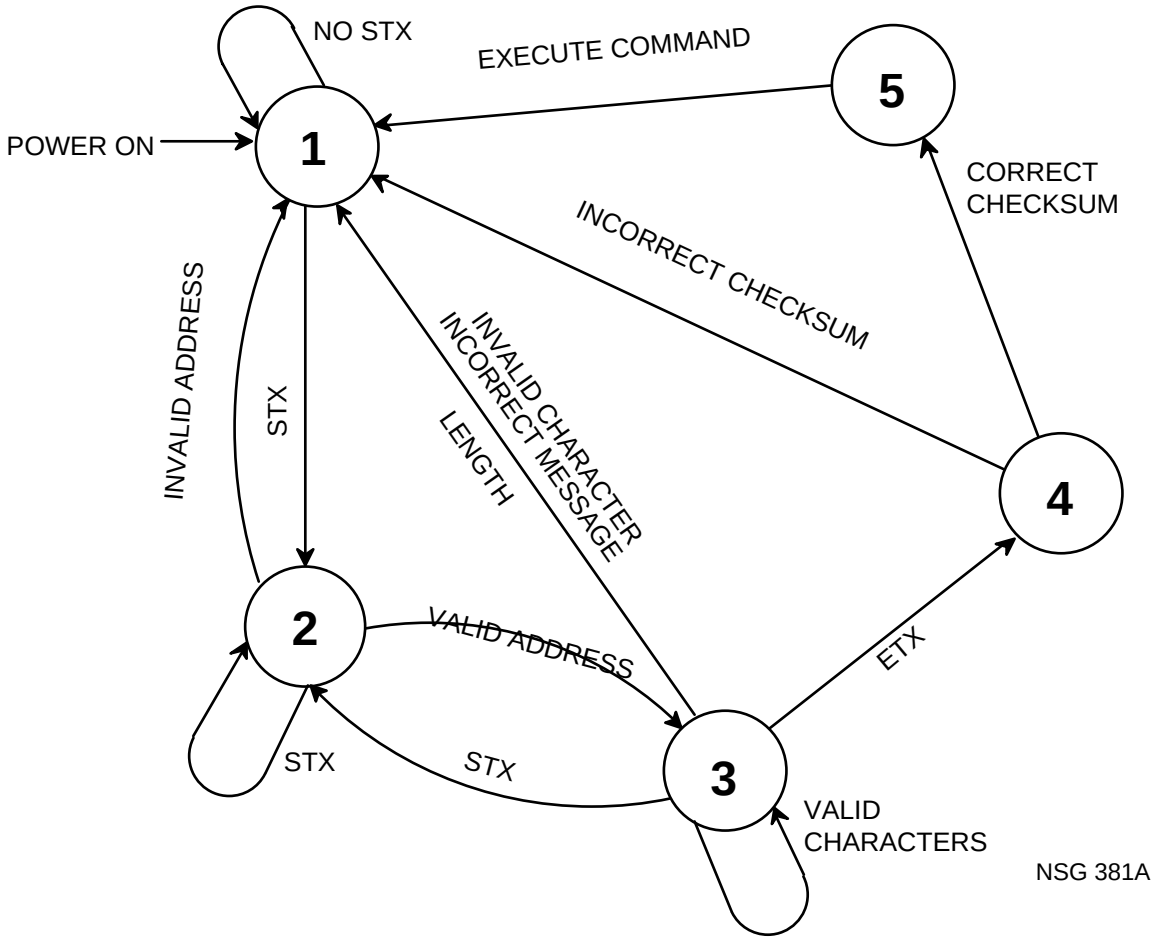

Figure 3. Slave State Diagram

State Diagram Notation

In Figure 3, each state that a device can assume is represented graphically as a circle. A single-digit number is used within the circle to identify the state. All permissible transitions between states are represented graphically by arrows between them. Each transition is qualified by a condition that must be true in order for the transition to occur. The device will remain in its current state if conditions which qualify transitions leading to other states are false or conditions that qualify pseudo-transitions are true. A pseudo-transition is a transition that occurs within the same state and is represented graphically by arrows leaving from and arriving at the same state. Table 1 describes mnemonics used to identify transitions in the state diagram.

Table 1. State Diagram Mnemonics

Mnemonic	Description
STX	Start-of-text ASCII control character, used as a header in SAbus command messages to identify the beginning of a new message.
ETX	End-of-text ASCII control character, used as a termination character in SAbus messages to identify the end of data.
Checksum	Longitudinal redundancy check (LRC) byte is the last byte in the SAbus message data block. The value of the LRC byte is the exclusive OR of all message bytes including the STX and the ETX bytes and is used to detect errors during transmission of data.

State 1 - Device Idle State

In State 1, a device is ready to receive a new message, and therefore, must complete any previous message reception. A device always powers on in State 1. A device will exit State 1 and enter State 2 (device addressed state) only if STX byte is received.

State 2 - Device Addressed State

In State 2, a device is waiting to receive the address byte, the second byte of the SAbus command message. A device will exit State 2 and enter:

1. State 3 (device data state) if received address byte equals a device's address.

2. State 1 (device idle state) if received address byte does not equal a device's address.

3. State 2 (remain in current state) if STX byte is received which may be the beginning of a new message data block.

State 3 - Device Data State

In State 3, a device is engaged in receiving the command and associated data bytes sent by a master/controller. A device will exit State 3 and enter:

1. State 4 (device data error state) if ETX byte is received signifying the end of data in the message.

2. State 1 (device idle state) if invalid command, or data character, or incorrect number of data bytes is received.

State 4 - Device Data Error State

In State 4, a device is waiting to receive a checksum byte which tests the transmitted message for errors. A device will exit state 4 and enter:

1. State 5 (command execute state) if a checksum byte is true (received LRC value of checksum byte equals LRC value computed by a device during message reception)

2. State 1 (device idle state) if a checksum byte is false (received LRC value of checksum byte does not equal LRC value computed by a device during message reception).

State 5 - Command Execute State

In State 5, a device, having completed a reception of SAbus message, executes a device's function specified by a command byte. A device will send and appropriate response message to a master/controller within 100 milliseconds after receiving the last character of the message. A device will always exit State 5 and enter State 1 - Device Idle State.

REV.	ECO NO.	REQUESTOR	BRIEF DESCRIPTION	DATE
X01	--	Gary Echo, Keith King	Initial Release	12/18/07