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LinkStar

LinkStar-STX3-PC104 ICD

SZ-LinkStarSTX3PC104-ICDv01100

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1 Overview

This document describes the physical, electrical, and functional characteristics of the *LinkStar-STX3-PC104* radio system (**Figure 1**). The information contained in this document is intended to provide the end user with the necessary technical information required to use the *LinkStar-STX3-PC104* in a custom application.

The *LinkStar-STX3-PC104* provides opportunities to integrate satellite connectivity into products used for vehicle and asset tracking, remote data reporting and data logger reporting that have limited size requirements. Integrated computer, GPS, plus low power consumption and the small size of the STX3 module itself make the *LinkStar-STX3-PC104* radio system a highly efficient device ready for integration in a wide variety of applications.

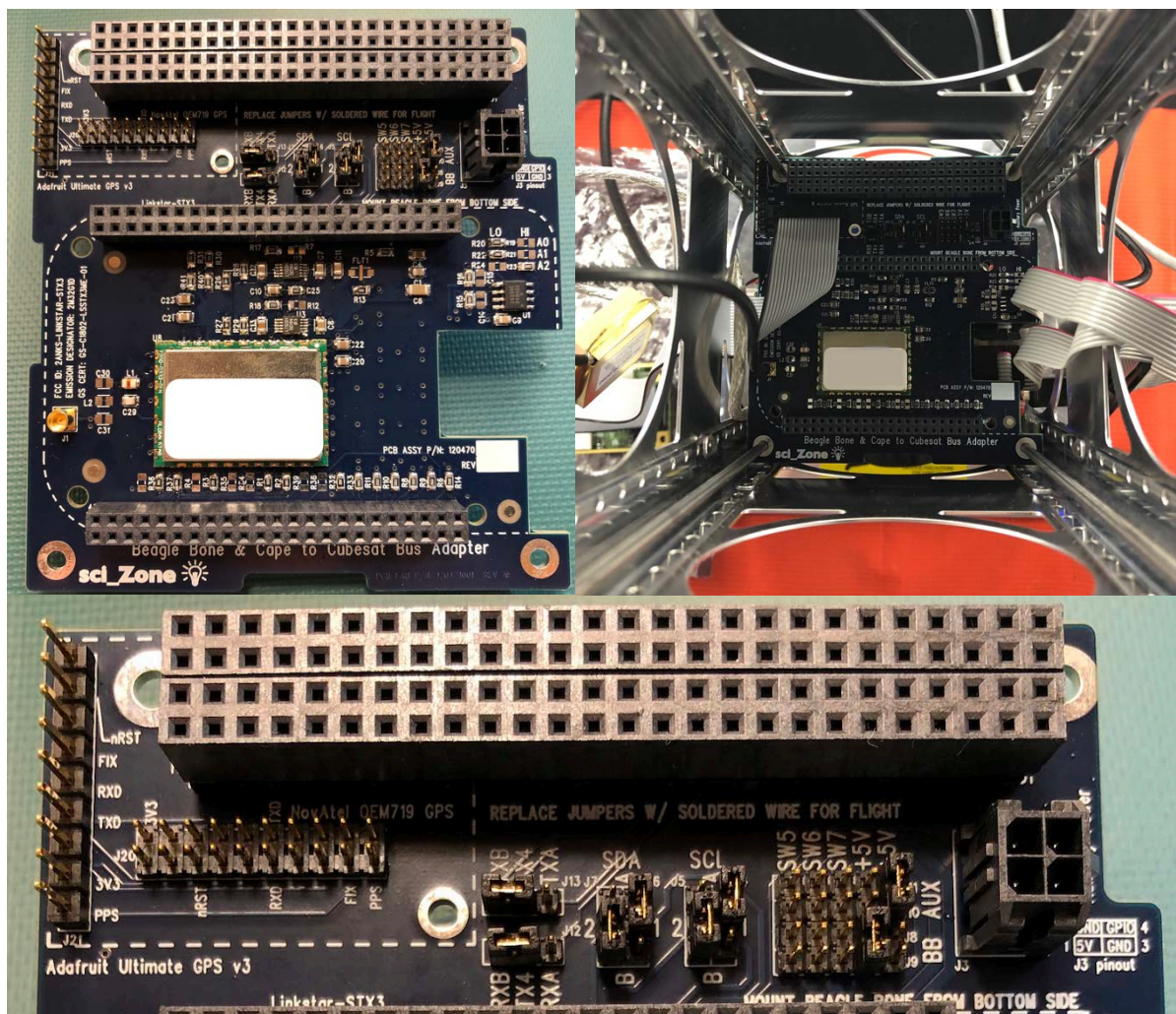


Figure 1. The *LinkStar-STX3* Radio System, Top View (Left) and Cubesat Integration (Right) and close of the Cubesat bus interface, J3 auxiliary interface, J21 GPS connectors and jumpers to link the BeagleBone Black and J3 to the Cubesat bus.

2 Functionality

The *LinkStar-STX3-PC104* operates on the *Globalstar*TM LEO satellite network. LEO (Low Earth Orbit) means that there are a number of satellites in low earth orbit that constantly orbit the planet and can communicate with *Globalstar*TM based devices that are within range of its current position.

Since the satellite position is constantly changing, simplex devices will transmit with no knowledge of any of the satellites locations; one or more satellites may receive the transmission. These satellites will then relay the message to the nearest satellite gateway as shown in **Figure 2**. Once received by the satellite gateway, the simplex message will be delivered to the simplex gateway where redundant messages are discarded and the data from the message is sent to *sci_Zone* and our web based interface to view the data.

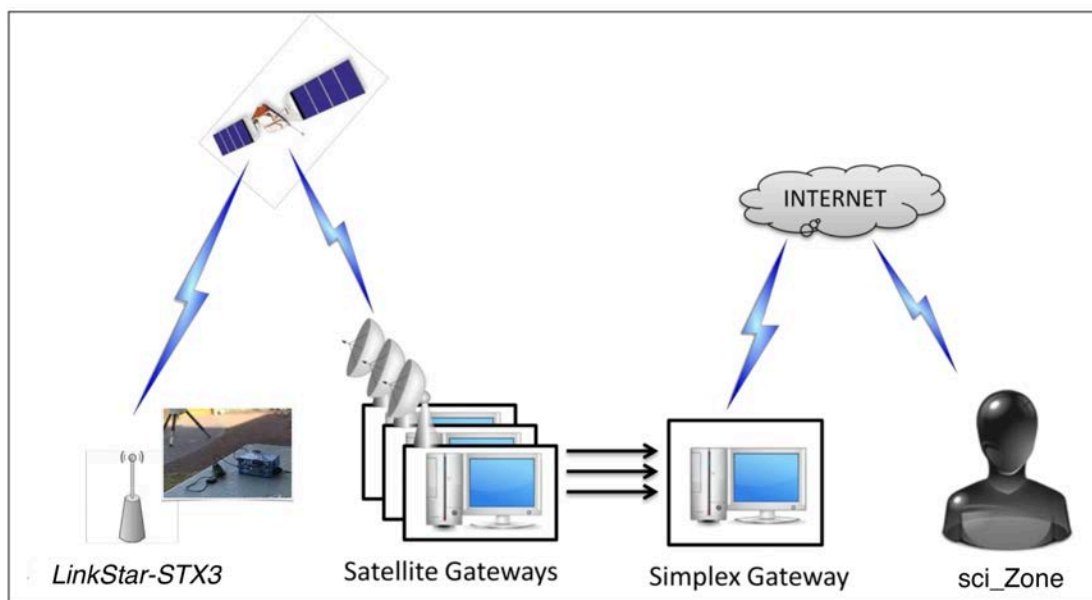


Figure 2. Simplex Messaging.

Messages are composed of 1 or more 9-byte payloads. The *LinkStar-STX3* can only transmit 9-byte on-air messages, so user payloads greater than 9 bytes will require multiple on-air packets to be transmitted for each user payload. See Figure 3.

There are brief periods of time where there is no satellite in range of the simplex transmitters due to obstructions and/or satellite coverage geometry. Since a simplex device has no way of knowing if a transmitted message has been successfully received, the *LinkStar-STX3* device is designed to send multiple (redundant) transmissions for each message being sent over the *Globalstar*TM network. The default value for the number of redundant transmissions per message is three. This means that each message sent to the *LinkStar-STX3* will be transmitted three times. Each transmission will contain the exact same data payload. The redundant transmissions of each message will be sent on a randomized 5-minute nominal interval – a range of intervals can be set via the *QuickSAT/VMS* interface.

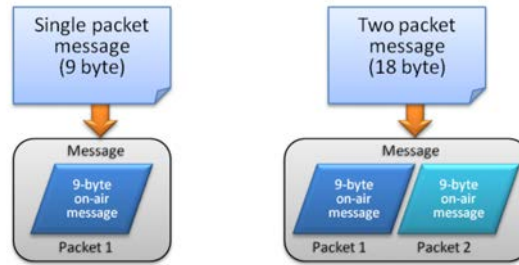


Figure 3. Messages Packets.

The transmission sequence for a single-packet message using the default setting of three redundant transmissions is shown in Figure 4.

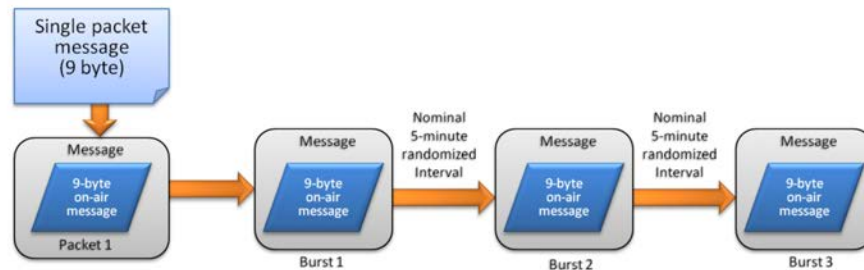


Figure 4. Redundant 9-byte message packet.

The transmission sequence for a two-packet message using the default setting of 3 redundant transmissions is shown in Figure 5.

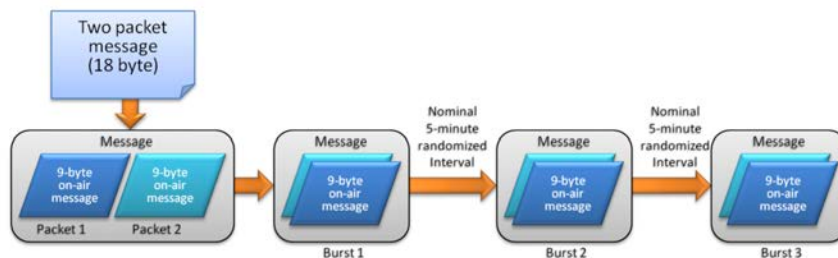


Figure 5. Redundant 18-byte message packet.

For normal conditions where the transmitter has an open view of the sky, this will result in a better than 99% chance that the message will be received.

2.1 GPS Interface

Unless the *LinkStar-STX3-PC104* is used in space, the unit must be connected to a GPS at all times in order to communicate. This is to provide location services which will automatically set the channel on the *LinkStar-STX3-PC104*.

NOTE: If the GPS is removed from the *LinkStar-STX3-PC104 radio system* while on the ground all communication services will be stopped, unless the *LinkStar-STX3-PC104 radio system* is in **SPACE** mode. This mode can only be set if authorized by *sci_Zone*.

3 Mechanical Interfaces

The *LinkStar-STX3-PC104* radio system consists of the *STX3 PC104* board with the STX3 radio and connectors, jumpers and stacking headers, the STX3 antenna, the Industrial *BeagleBone Black* (Rev C) computer, and GPS and GPS antenna. The *BeagleBone Black* is mounted underneath the *STX3 PC104* board. The GPS is mounted either on the *STX3 PC104* board (the *Adafruit Ultimate GPS*) or mounted separately and connected via a ribbon cable (the *NovAtel OEM719*). In the case of the *Adafruit Ultimate GPS* the antenna is integrated with the GPS; the antenna for the *NovAtel OEM719* is mounted separately.

NOTE: The *LinkStar-STX3-PC104* radio system can be used without the *BeagleBone Black*, however the for the radio to function an alternative computer must be used that will adhere to the *BeagleBone Black* to *STX3 PC104* board connections, operates with the *Debian Operating System* (v9.5), and must have the *QuickSAT/VMS* software installed.

3.1 Dimensions and Mass

Table 3-1. Mechanical dimensions and mass

Dimension	Value	Unit
Width	90.17	mm
Length	95.89	mm
Height - Tallest top side component	8.1	mm
Height - PCB Thickness	1.6	mm
Height - Tallest bottom side component	4.7	mm
System Mass	63	g

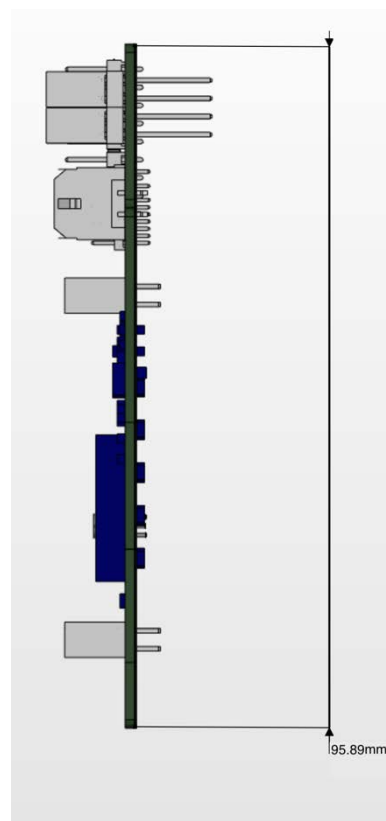
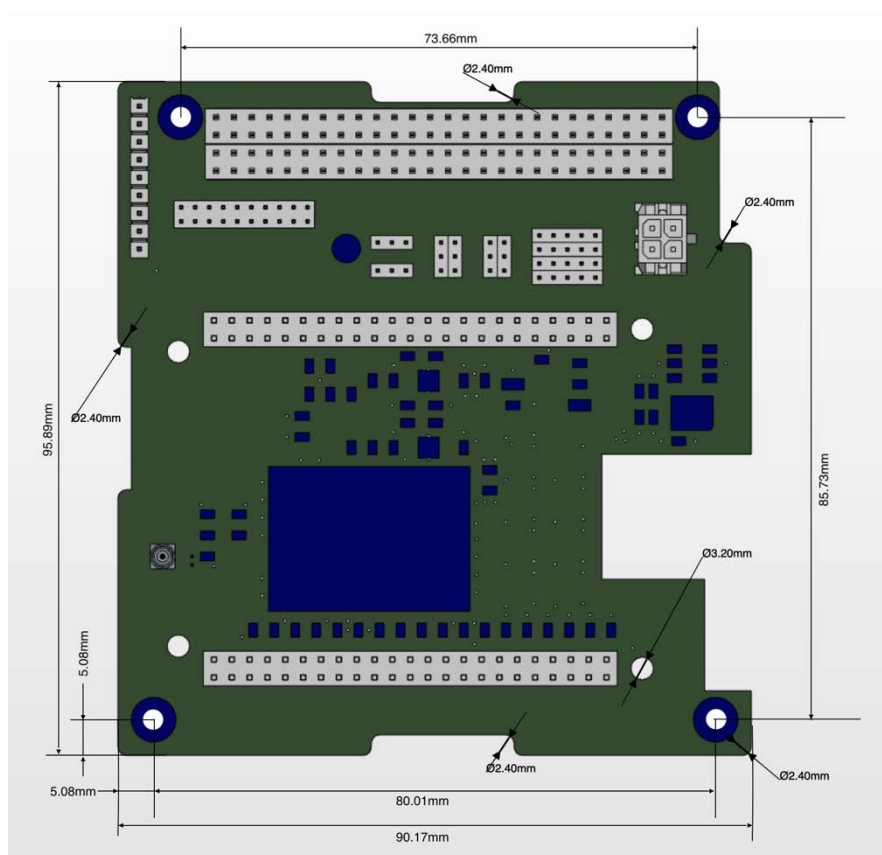
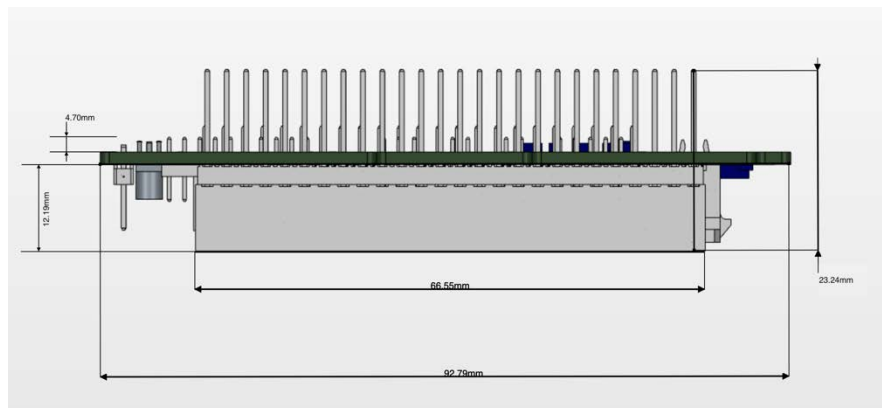


Figure 6. STX3 PC104 Board Dimensions – Part 1.

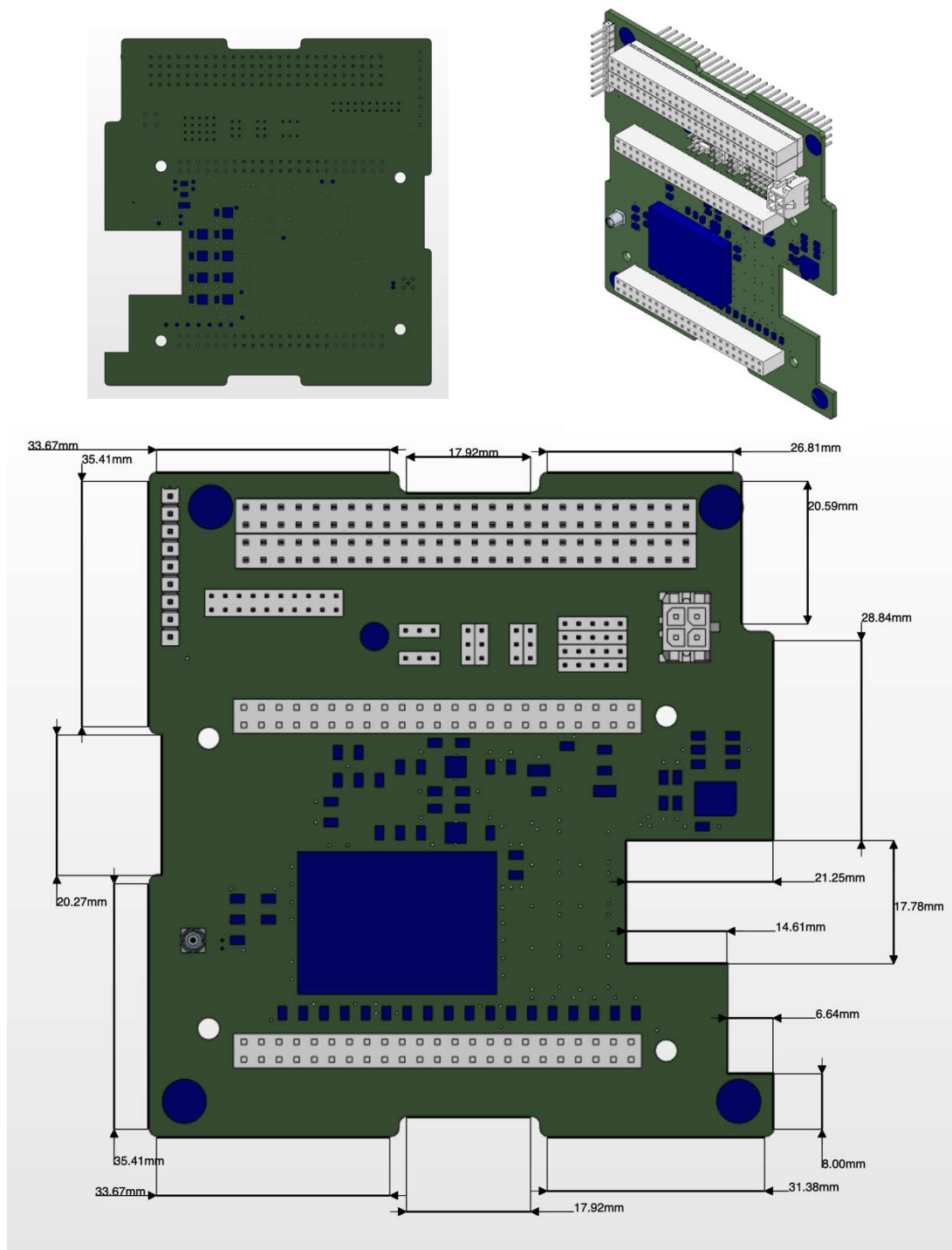


Figure 7. STX3 PC104 Board Dimensions — Part 2.

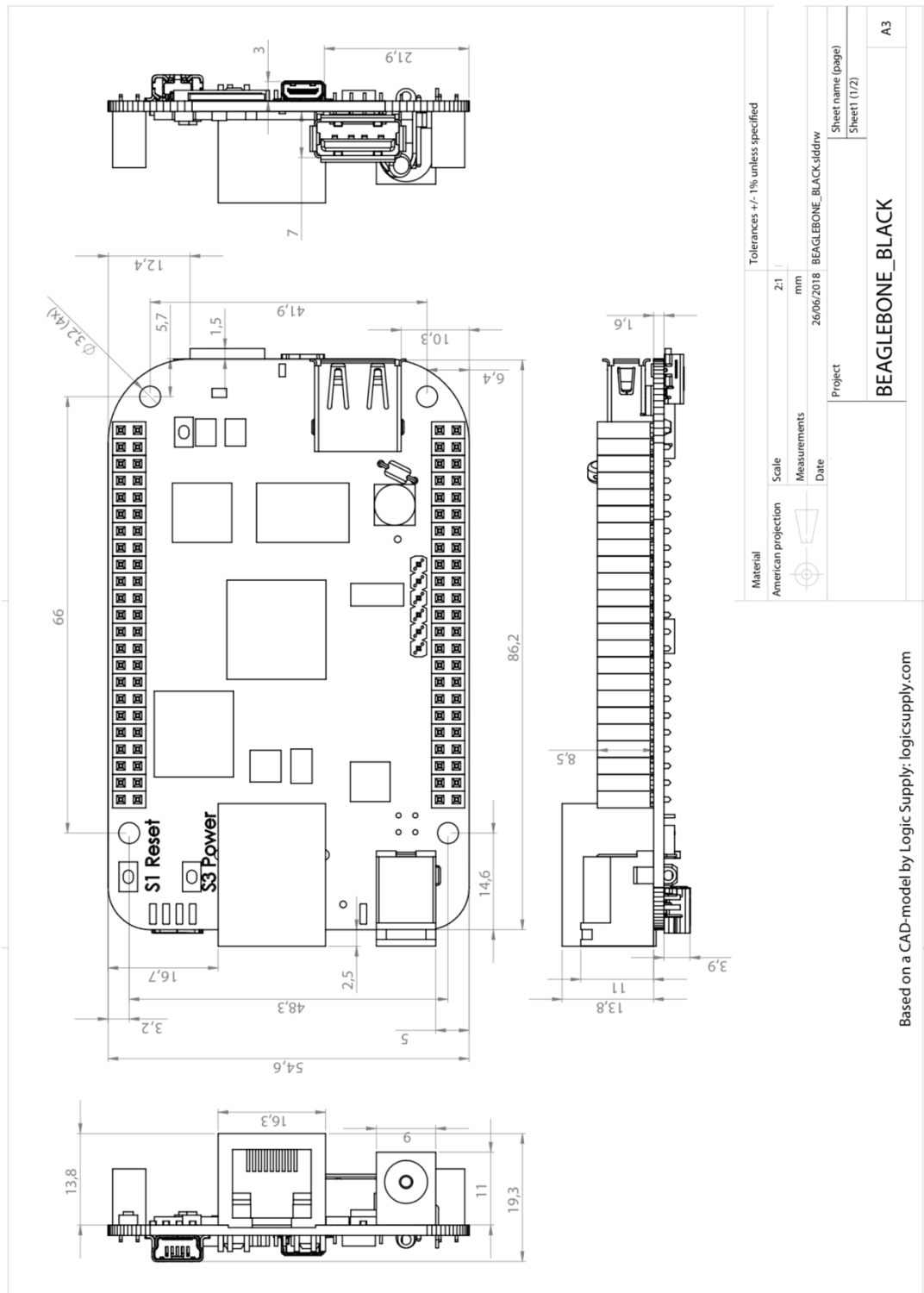


Figure 8. BeagleBone Black Dimensions.

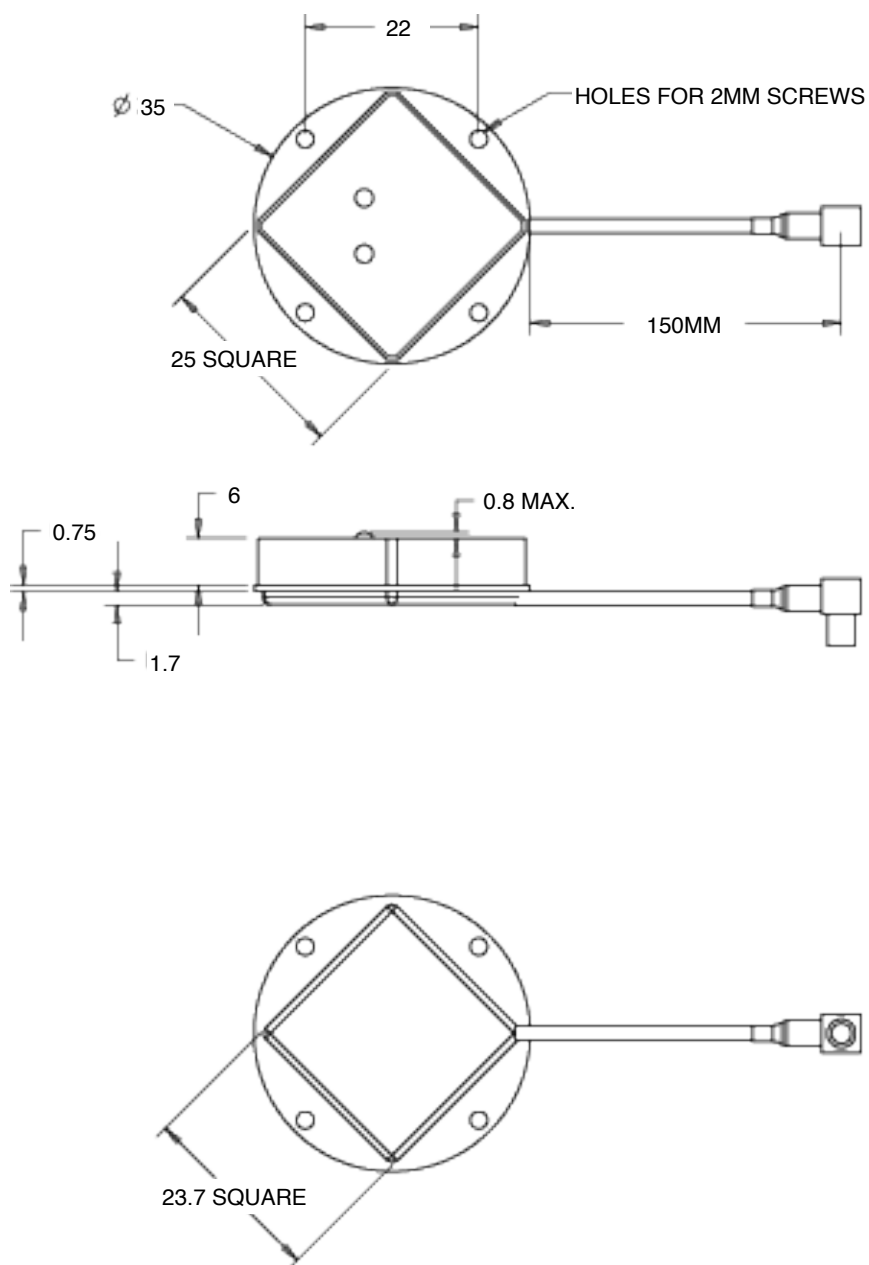


Figure 9. TW1500 Antenna Dimensions for the LinkStar-STX3.

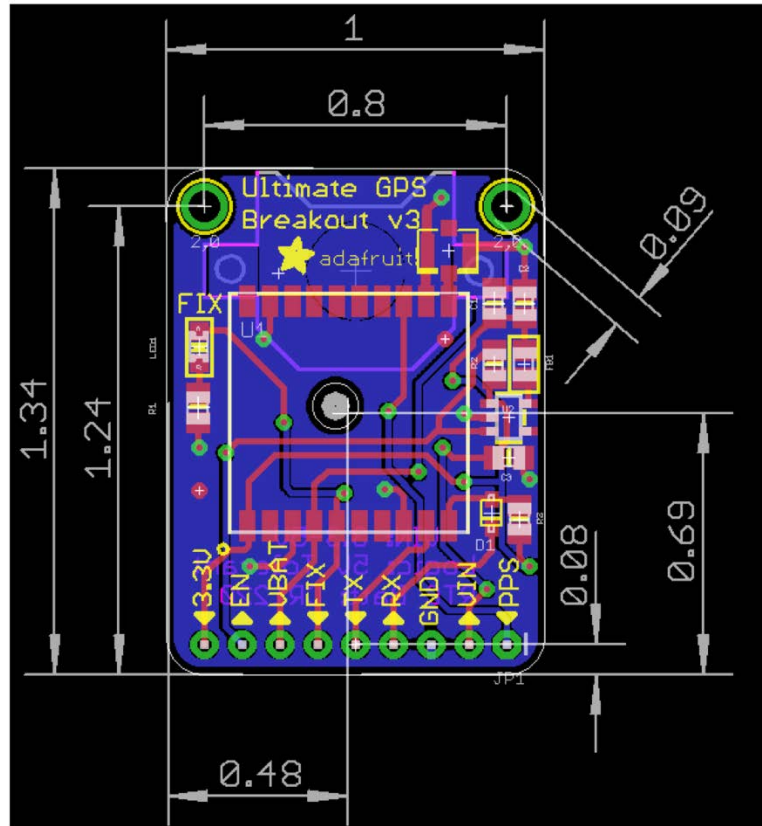


Figure 10. AdaFruit Ultimate GPS Dimensions (© Adafruit Industries) — used on ground versions of the LinkStar-STX3-PC104 ONLY. The AdaFruit Ultimate GPS CANNOT be used in space.

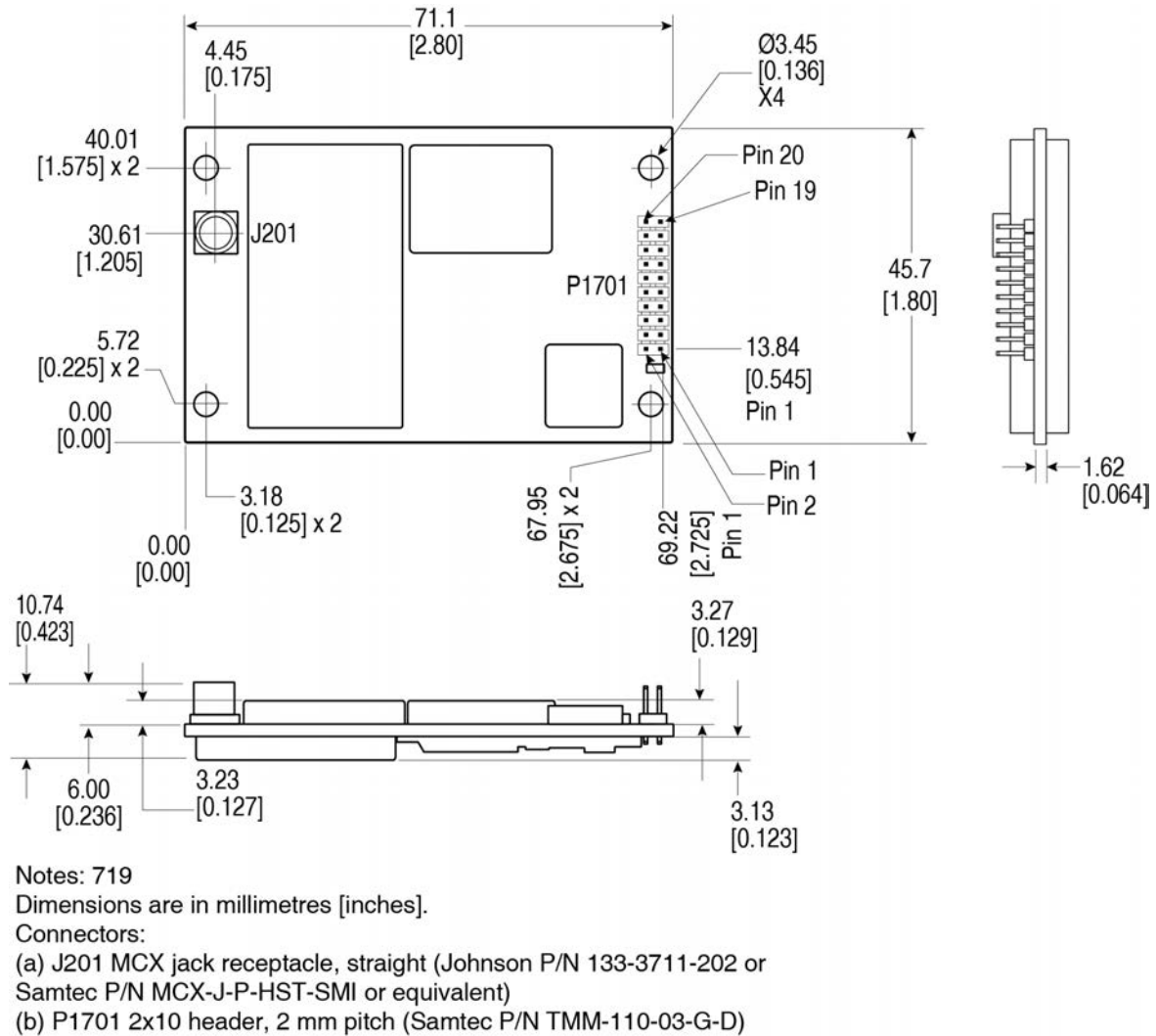


Figure 11. Dimensions of the NovAtel OEM719 GPS (©NovAtel).

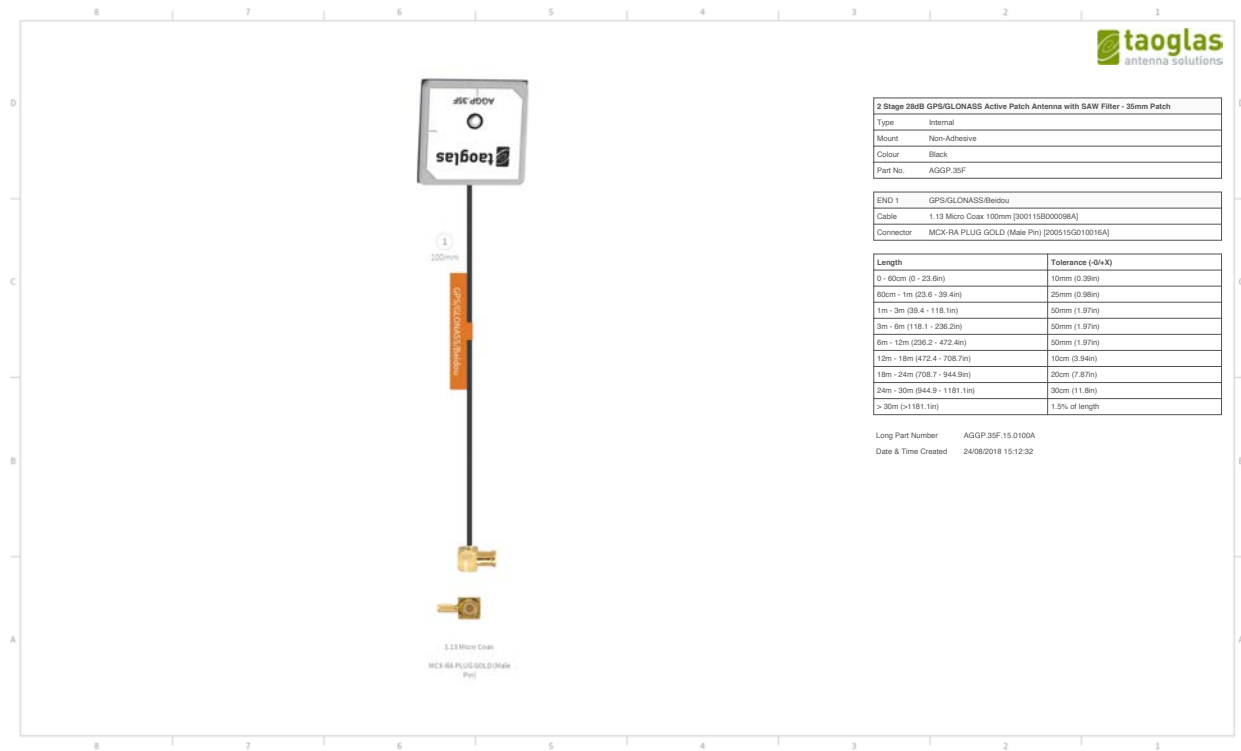


Figure 12. Dimensions of the Taoglas AGGP.35F.15.0100A GPS Antenna (©Taoglas) for the NovAtel OEM719 GPS.

4 Electrical Interfaces

There are six primary sets of electrical connections on the *LinkStar-STX3-PC104* radio system which include (Figure 13):

- P8 and P9: *BeagleBone Black* interface
- H1 and H2: Cubesat Bus Interface
- J1: MMCX Female Antenna Connector
- J3: Generic Connection for radios and other devices
- J4 – J13: Jumpers for the interface between the Cubesat Bus and the *BeagleBone Black*
- J21: GPS Interface for both the Adafruit Ultimate GPS and the NovAtel OEM719

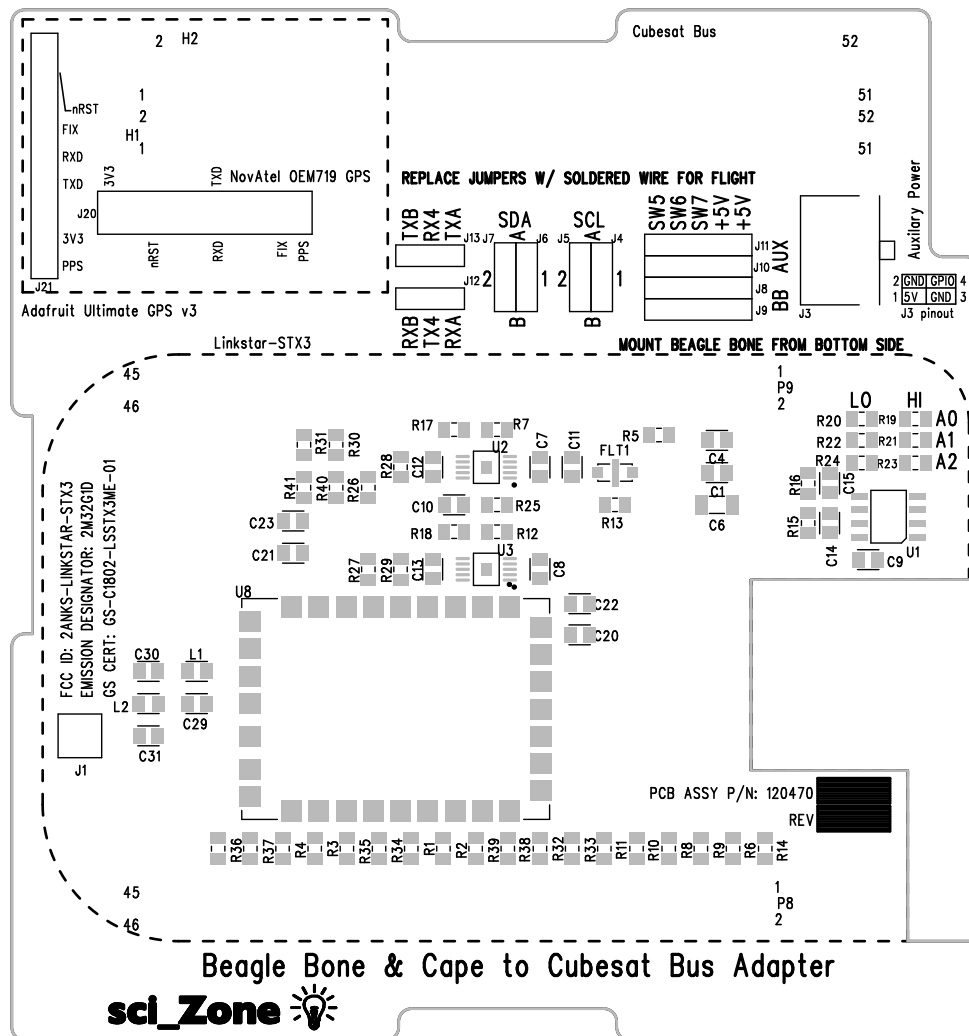


Figure 13. LinkStar STX3 board labeling with connectors shown.

4.1 P8 and P9, BeagleBone Black Interface

The *LinkStar STX3 PC104* board is stacked on top of the *BeagleBone Black (BBB)* header, however other “capes” can be stacked on top of the *LinkStar STX3* board P8 and P9 headers or between the *BBB* and the *LinkStar STX3 PC104* board (Figure 14).

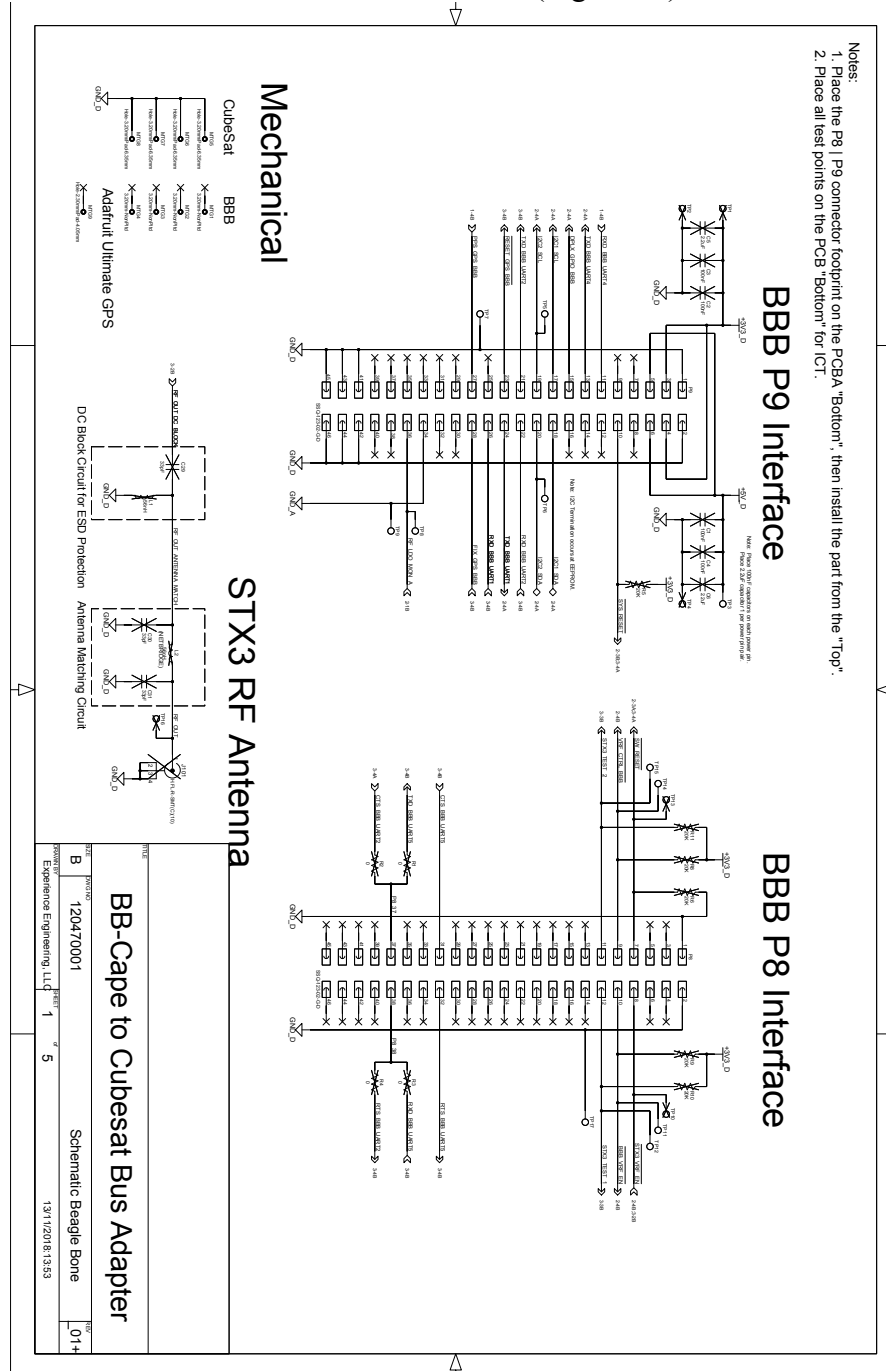


Table 4-1. BeagleBone Black (BBB) P8 pin connections used by the LinkStar STX3 PC104 board. Areas in red are RESERVED.

P8		
PIN	NAME	NOTES
P8_1	GND	
P8_2	GND	
P8_7	TIMER4	
P8_8	TIMER7	
P8_9	TIMER5	
P8_10	TIMER6	
P8_11	GPIO1_13	
P8_12	GPIO1_12	
P8_14	GPIO1_26	
P8_31	UART5_CTSN	
P8_32	UART5_RTSN	
P8_37	UART5_TXD	Used by the STX3
P8_38	UART5_RXD	Used by the STX3

Table 4-1 and Table 4-2 present the pinouts P8 and P9 used by the *Linkstar STX3 PC104* board. The BBB can be connected to the Cubesat bus using the jumpers provided on the *LinkStar STX3 PC104 board* to provide power to the BBB and auxiliary port, and data links via serial and I2C connections (Table 4-3 and Table 4-4).

NOTE: Pin connections highlighted in **red** in Table 4-1 and Table 4-2 are reserved and NOT to be used by any other device.

Refer to the *BeagleBone Black System Reference Manual, Revision C* for details of P8 and P9.

4.2 H1 and H2 Cubesat Bus Interface, Jumpers J4-13

The *LinkStar-STX3-PC104* is designed to interface and communicate through the Cubesat bus architecture. The cubesat bus can be used to provide switched and unswitched power to the BBB and the auxiliary port and allow for serial and I2C communications to and from the BBB. Table 4-3 and Table 4-4 present the cubesat pin connections used by the *LinkStar-STX3-PC104* system.

Jumpers are provided on the *LinkStar STX3 PC104* board to select which pins are connected between the BBB and the cubesat bus. Refer to Table 4-1 through Table 4-4 and Figure 13 and Figure 15 for details on how to configure the jumpers.

Table 4-2. BeagleBone Black (BBB) P9 pin connections used by the LinkStar STX3 board. Areas in red are RESERVED.

P9		
PIN	NAME	NOTES
P9_1	GND	
P9_2	GND	
P9_3	DC_3.3V	Used by the STX3
P9_4	DC_3.3V	Used by the GPS
P9_5	VDD_5V	
P9_6	VDD_5V	
P9_10	SYS_RESET	
P9_11	UART4_RXD	Use jumper on J12 to connect to either H33 (RS232_RXA) or H34 (RS232_RXB) to the Cubesat Bus
P9_13	UART4_TXD	Use jumper on J13 to connect to either H35 (RS232_TXA) or H36 (RS232_TXB) to the Cubesat Bus
P9_15	GPIO1_16	Used on J3 pin 4
P9_17	I2C1_SCL	Jumper on J4 and J5 to select either H1_43 (SCL_A) or H1_47 (SCL_B) to connect to the Cubesat Bus
P9_18	I2C1_SDA	Jumper on J6 and J7 to select either H1_41 (SDA_A) or H1_45 (SDA_B) to connect to the Cubesat Bus
P9_19	I2C2_SCL	Jumper on J4 and J5 to select either H1_43 (SCL_A) or H1_47 (SCL_B) to connect to the Cubesat Bus
P9_20	I2C2_SDA	Jumper on J6 and J7 to select either H1_41 (SDA_A) or H1_45 (SDA_B) to connect to the Cubesat Bus
P9_21	UART2_TXD	Used by the STX3
P9_22	UART2_RXD	Used by the STX3
P9_23	GPIO1_17	RESET GPS
P9_24	UART1_TXD	Used by the GPS
P9_26	UART1_RXD	Used by the GPS
P9_27	GPIO3_19	Used by the GPS
P9_28	SPI1_CS0	Used by the GPS
P9_34	AGND	Used by STX3 RF LDO MON A
P9_36	AIN5	Used by STX3 RF LDO MON A
P9_41	CLKOUT2	
P9_42	GPIO0_&	
P9_43	GND	
P9_44	GND	
P9_45	GND	
P9_46	GND	

Table 4-3. Cubesat Bus H1 pin connections used by the LinkStar STX3 Board.

H1		
PIN	NAME	NOTES
H1_33	RS232_RXA	Use jumper J12
H1_34	RS232_RXB	Use jumper J12
H1_35	RS232_TXA	Use jumper J13
H1_36	RS232_TXB	Use jumper J13
H1_41	SDA_A	Use Jumpers J6 or J7
H1_43	SCL_A	Use Jumpers J4 or J5
H1_45	SDA_B	Use Jumpers J6 or J7
H1_47	SCL_B	Use Jumpers J4 or J5

4.3 GPS Interface

The *LinkStar STX3* board is designed to support either the Adafruit Ultimate GPS Board or the NovAtel OEM719 GPS. Either GPS unit is connected through J21 as shown in Figure 16. Power is provided by the BBB to the GPS units. The NovAtel OEM719 can be turned off through software control to save power.

4.4 J3: Generic Connection for radios and other devices

The J3 connection (Figure 13) can be used to connect and power a range of radio systems and devices including the *LinkStar Duplex Series of radios*. The J3 connector is a Molex four position 3mm vertical plug, part number WM1784-ND, Molex / 43025-0400.

Jumpers can be used to select the source of power from the Cubesat bus (Table 4-4) – power is ONLY provided via the Cubesat bus.

4.5 J1: Antenna Connection

The TW1500 antenna (Figure 9) for the STX3 radio is connected to the *LinkStar STX3* board at J1 (Figure 13). The connector is an MMCX Right-Angle Male Connector.

Table 4-4. Cubesat Bus H2 pin connections used by the LinkStar STX3 Board.

H2		
PIN	NAME	NOTES
H2_9	GND	
H2_13	5V Switched	Switched 5V power SW5. Use connector J10/J11 for auxiliary power J3 or connector J8/J9 for BBB power.
H2_14	GND	
H2_15	5V Switched	Switched 5V power SW6. Use connector J10/J11 for auxiliary power J3 or connector J8/J9 for BBB power.
H2_16	5V Switched	Switched 5V power SW7. Use connector J10/J11 for auxiliary power J3 or connector J8/J9 for BBB power.
H2_17	GND	
H2_21	GND	
H2_22	GND	
H2_25	5V Bus	Unswitched 5V power. Use connector J10/J11 for auxiliary power J3 or connector J8/J9 for BBB power.
H2_26	5V Bus	Unswitched 5V power. Use connector J10/J11 for auxiliary power J3 or connector J8/J9 for BBB power.
H2_29	GND	
H2_30	GND	
H2_32	GND	
H2_47	GND	
H2_48	GND	

Table 4-5. J3 Connection.

J3		
PIN	NAME	NOTES
J3_1	5V	Use connector J10/J11 to select power source from the Cubesat Bus
J3_2	GND	
J3_3	GND	
J3_4	GPIO	GPIO1_16 on the BBB

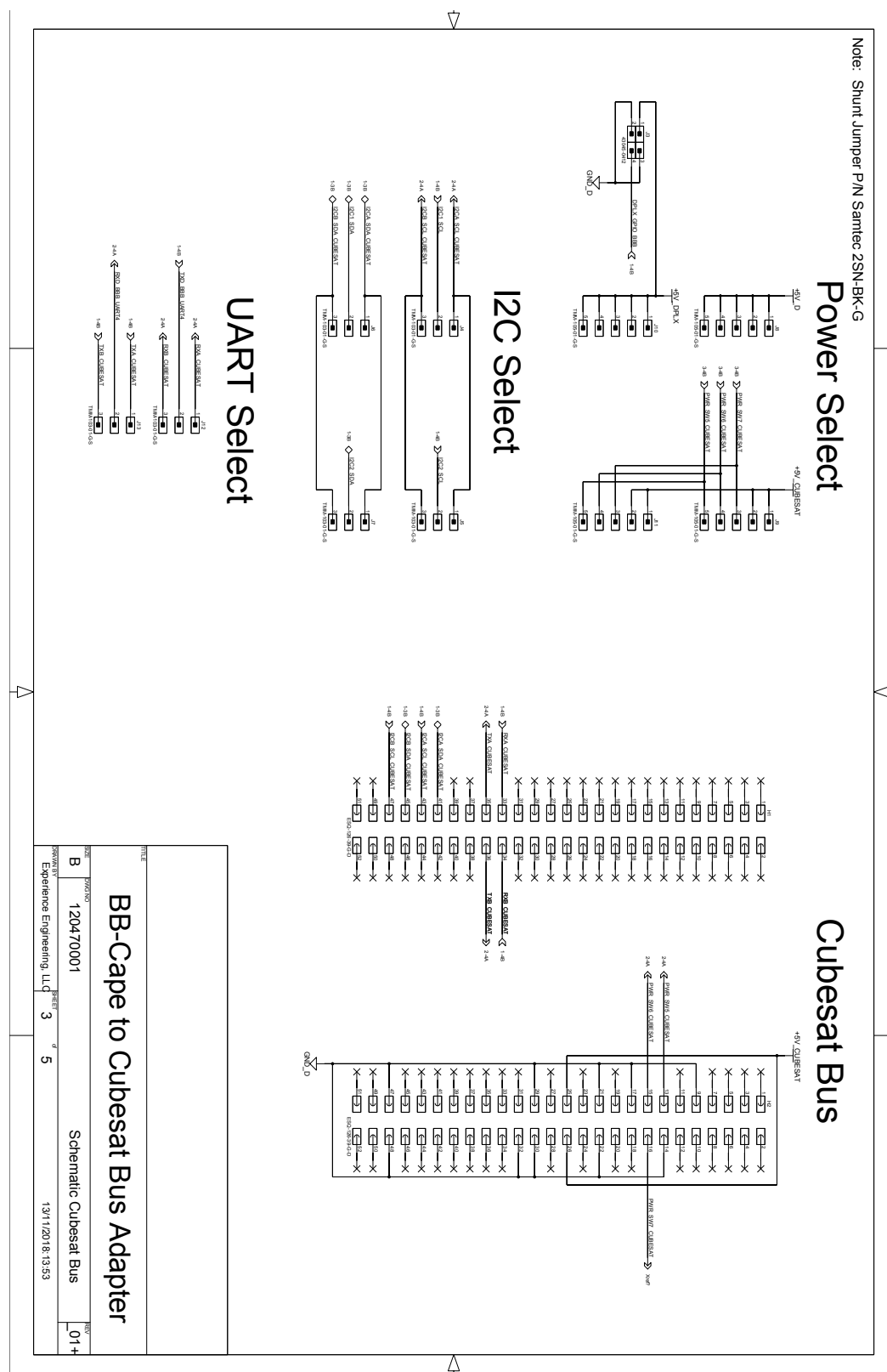


Figure 15. BeagleBone Black to Cubesat Bus Interface including referenced jumper connections.



5 Maximum Limits

5.1 Specifications

Parameter	Specification
Temperature Range — Operating	-40 C to +80 C
Temperature Range — Storage	-40 C to +85 C
Pressure — Operating	10 ⁻⁸ atm
Pressure — Storage	1 atm
Magnetic Field	±8.1 Gauss

5.2 Vibration and shock

The *LinkStar STX3* board and the *NovAtel OEM719* designed and manufactured to withstand vibration and shock with consideration to NASA GEVS.

The entire *LinkStar-STX3-PC104* will need to be tested for each unique configuration and application.

6 Handling and Storage

The *LinkStar-STX3-PC104* motherboard and *Industrial BeagleBone Black* computer, the combined units plus antenna, requires specific guidelines to be observed for handling, transportation and storage. These are stated below. Failure to follow these guidelines may result in damage to the units or degradation in performance.

6.1 Electrostatic Discharge (ESD) Protection

This system incorporates static sensitive devices and care should be taken during handling. Do not touch or handle the board without proper electrostatic protection in place. All work carried out on the system should be done in a static dissipative environment.

6.2 General Handling

The board is designed to be robust and withstand flight conditions. However, care must be taken when handling the device. Care should be taken not to drop the devices. All metal objects (including probes) should be kept clear of these headers.

Gloves should be worn when handling all flight hardware.

Flight hardware should only be removed from packaging in a class 100000 (or better) clean room environment.

6.3 Shipping and Storage

The devices are shipped in anti-static packaging enclosed in a hard protective case. This case should be used for storage. All hardware should be stored in anti-static packaging.

7 Regulatory Approval

The *LinkStar-STX3* module has received regulatory approvals for modular devices in the United States. Modular device approval allows the end user to place the STX3 module inside a finished product and not require regulatory testing for an intentional radiator (RF transmitter), provided no changes or modifications are made to the module circuitry. **Changes or modifications could void the user's authority to operate the equipment.** The end user must comply with all of the instructions provided by the *sci_Zone* and *Globalstar*, which indicate installation and/or operating conditions necessary for compliance. The integrator is still responsible for testing the end product for any additional compliance requirements required with this module installed (digital device emission, PC peripheral requirements, etc.) in the specific country that the end device will be marketed. For more information on regulatory compliance, refer to the specific country radio regulations in the following sections.

7.1 Radio Astronomy Site Avoidance

The end user device must comply with the requirements for Radio Astronomy Site avoidance as specified by the Globalstar National Science Foundation agreement of 2001. It must be compliant with CFR 25.213.

7.2 Regulatory Notices

The STX3 has received Federal Communications Commission authorization under FCC Rules Part 25 as a modular transmitter. Final installation must be in compliance with CFR 25.213 (see 7.1 above). The antenna installation and operating configurations of this transmitter must satisfy MPE categorical Exclusion Requirements of 2.1091.

The STX3 module will satisfy FCC modular transmitter requirements only when used with the antenna type specified in Appendix A. No power amplifiers may be used under the terms of this modular approval. It is permissible to use different antenna manufacturers provided the same antenna type that has similar inband and out-of-band radiation patterns and antenna gain (equal to or less than the antenna gain listed above) is used.

The module provides the Tallysman™ *TW2500* with 50cm cable with MMCX male connector for an external antenna connected via the *LinkStar-STX3-PC104* female MMCX connector. Other antennas connected via the MMCX connector cable of similar performance can be used. Use of any antenna other than those listed in Appendix A will require proof of compliance (peak gain).

This device has been designed to operate with the antenna listed in Appendix A, and having a maximum gain of 4.55 dB. Antennas not included in this list or having a gain greater than 4.55 dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms

The *LinkStar-STX3-PC104* radio system has been labeled with its own FCC ID number:

FCC ID: 2ANKS-LINKSTAR-STX3

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

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a commercial, industrial, aeronautical and space based installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment OFF and ON, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

WARNING: Changes or modifications not expressly approved by *sci_Zone, Inc* and *Globalstar* may render the device non-compliant to FCC and other regulatory body standards for operation and may void the user's authority to operate the equipment.

NOTICE: This equipment complies with the FCC RF Exposure Limits. A minimum of 20 centimeters (8 inches) separation between the device and the user and all other persons should be maintained.

AVIS: Cet équipement est conforme aux RSS-102 Limites d'exposition RF. Un minimum de 20 centimètres (8 pouces) entre l'appareil et l'utilisateur et toutes les autres personnes devrait être maintenue.

7.3 Warnings, Restrictions and Disclaimers

The *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* is an experimental and development system.

The *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* is for Feasibility Evaluation Only and testing, in Laboratory/Development and Outdoor Environments. The *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* with the *Industrial BeagleBone Black* is a flexible development product, and thus not a complete product. It is intended solely for use for preliminary feasibility evaluation in laboratory/development, test and field environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems including changing antennas and power supplies. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk you acknowledge, represent, and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the *LinkStar-STX3-ME* and *LinkStar-STX3-PC104*. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the *LinkStar-STX3-ME*, *LinkStar-STX3-PC104* and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. Since the *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* is a flexible product and not a completed product, it may not meet all applicable regulatory and safety compliance standards which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* will not result in any property damage, injury or death, even if the *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* should fail to perform as described or expected.

Certain Instructions. It is important to operate the e l e m e n t 1 4 BeagleBone Black Industrial within Supplier's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified BeagleBone ratings (including but not

limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact the Supplier representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the BeagleBone and/or interface electronics. Please consult the System Reference Manual prior to connecting any load to the BeagleBone output. If there is uncertainty as to the load specification, please contact the Supplier representative. During normal operation, some circuit components may have case temperatures greater than 60 C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the BeagleBone schematic located at the link in the BeagleBone System Reference Manual. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use the BeagleBone.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold the Suppliers, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the *LinkStar-STX3-ME* and *LinkStar-STX3-PC104* fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the Supplier's product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify Suppliers of such intent and enter into a separate Assurance and Indemnity Agreement.