BISM2™ Bluetooth Version 2.0 Serial Module

User Guide
Version 2.2

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Embedded Wireless Solutions Support Center: http://ews-support.lairdtech.com
Americas: +1-800-492-2320
Europe: +44-1628-858-940
Asia: +852-2923-0610
www.lairdtech.com/bluetooth

REVISION HISTORY

Revision	Date	Description	Approved By
1.0		Initial Release	Jonathan Kaye
2.0	29 July 2103	Converted to Laird formatting	Sue White
2.1	31 Oct 2013	Updated maximum multipoint connections (from 7 to 3)	Jonathan Kaye
2.2	16 Jan 2014	Separated manual into two documents: User Guide and Hardware Integration Guide	Sue White

CONTENTS

1 General Description

Laird's BISM2 Bluetooth Serial Module is a fully integrated and qualified Class 1 Bluetooth solution designed for the lowest integration cost and ownership for designers wishing to incorporate Bluetooth functionality into their products. The module is qualified to Bluetooth Version 2.0.

The BISM2 Bluetooth Serial Module is one of the most compact complete Bluetooth solutions, making it ideal to integrate into handheld devices. Another version of the BISM2 module is available that retains the same board size, mounting holes, and connector as the previous Bluetooth module from Laird, allowing users to access the improved radio performance and functionality without the need for any PCB modifications.

The BISM2 module is based on Cambridge Silicon Radio's BlueCore 04 chipset. The module contains all of the hardware and firmware for a complete Bluetooth solution, requiring no further components. The module has an integrated, high performance antenna which is matched with the Bluetooth RF and baseband circuitry. The firmware integrated into the BC04 chipset implements the higher layer Bluetooth protocol stack, up to and including the Generic Access Profile (GAP), Service Discovery Profile (SDAP), Serial Port Profile (SPP), Dial Up Networking (DUN) profile, Headset Profile (HSP), Hands Free Profile (HFP), File Transfer Profile (FTP) and Audio Gateway. A virtual processor within the BC04 implements an AT command processor. This interfaces to the host system over a straight forward serial port using an extensive range of AT commands. The AT command set abstracts the Bluetooth protocol from the host application, saving many months of programming and integration time. It provides extremely short integration times for data-oriented cable replacement and voice applications. A low cost development system is available for fast product evaluation and development.

An alternative version of firmware is available that provides multi-point programming support.

The module can be configured so that it can attach to a 'dumb' terminal or attach to a PC or PDA for cable replacement applications.

In addition to the Bluetooth functionality, The BISM2 module provides access to 9 General I/O lines and 2 analogue input and output lines. These can be configured to provide connection to simple devices, such as switches or LEDs, without requiring any external processing. Both the GPIO and ADC lines can be accessed either via the wired host UART connection, or remotely over the Bluetooth link.

The BISM2 module is supplied in a small form factor PCB (22.0 mm x 34.0 mm x 7.6 mm), that connects to a main PCB using a 40-way Hirose connector. The interface is compatible with the BISM1 module. The module includes a high sensitivity, high gain antenna which provides excellent range. Typical open field performance provides ranges of over 250 metres at transmit powers of 4 mW.

Support is provided for low power modes that make the BISM2 particularly applicable to battery powered installations.

The BISM2 module is lead-free, RoHS compliant, and supports an industrial temperature range of -40°C to +85° C.

1.1 Applications

- POS equipment
- Medical equipment
- Telematics
- Voice applications
- Industrial automation
- Automotive applications

2 INTEGRATED FIRMWARE

2.1 General

The BISM2 is designed to provide the fastest route to market for designers who wish to use Bluetooth to wirelessly enable their products. To this end, Laird has implemented a wide range of AT commands that control all of the standard Bluetooth tasks. These remove the complexity of Bluetooth from the design engineer and allow the wireless link to be controlled by means of a simple set of commands.

For applications where multiple concurrent live connections need to be maintained a variant of firmware is available which is specifically targeted at multipoint operation.

For both applications a comprehensive range of windows based software is available to speed up the design process. A low cost development kit is also available that can be used for prototyping both cable replacement and multipoint applications.

2.2 Profiles

Bluetooth has been designed to accommodate a very wide range of wireless applications. To enable these different applications the Bluetooth SIG (Special Interest Group) has defined a series of different profiles that define the way in which Bluetooth devices communicate with each other and perform basic functions. These provide a base line of interoperability for specific application scenarios, upon which more complex user applications can be developed.

There are over 30 different profiles, many of which have been developed for specific applications. The BISM2 firmware is provided with support for the profiles that are most commonly required for cable replacement applications.

The current profiles support includes:

- GAP Generic Access Profile. The base connection profile upon which others are based.
- SDP: Service Discovery Profile. The profile to find other Bluetooth devices and the services they support.
- SPP: Serial Port Profile. Emulation of a serial cable for cable replacement applications.
- DUN: Dial-Up Networking. Profile support for connection to an external PSTN, GSM, GPRS or VPN connection.
- Audio Gateway. The base element for Headset and Handsfree profile. A portion of these profiles must be implemented within the host system.
- HSP: Headset Profile. Supports early implementations of headsets. Now largely replaced by the:
  - HFP Hands-free profile, which provide more control over the headset operation.
- FTP File Transfer Profile (full client support).

For other profile support, please contact Laird at wireless.support@lairdtech.com.

2.3 AT Overview

The AT command set is well known by engineers and was developed to aid the integration of PSTN modems. It provides simple high level commands for complex functions that can easily be incorporated into programs or used within programming scripts.

Laird has used this familiar concept and extended it to Bluetooth to simplify the integration of Bluetooth for product designers. Rather than having to understand the many stages of setting up a Bluetooth connection or function, a single AT command is all that is required.

For example, to connect to a Bluetooth device with an address 00809844EA13, send the following string to the UART of the BISM2 module.

```
ATD00809844EA13
```

The module will attempt to make a connection and return connect 00809844ea13,1101) or (NO CARRIER), depending on whether the connection was successful.

The scope of the AT command set developed by Laird is such that most Bluetooth functionality can be covered, greatly reducing development time.

To provide additional functionality a range of "S" registers has been implemented. These allow program settings to be stored to control the BISM2 function and also give access to configuring and reading ports and status registers within the BISM2.

Full details of the AT command set are provided in the Blu2i AT Command Reference Manual.

2.3.1 AT Features at a Glance

2.3.1.1 General

- Configure two modules to automatically connect and transfer data, audio or a combination of data and audio when both devices are powered. The peer device does not have to be another Intelligent Serial module. It is possible to implement auto connect with a Bluetooth enabled mobile phone.
- Automatically re-connect devices when a connection is dropped.
- Remotely access the AT parser of the remote unit from a master device to perform Over The Air (OTA) configuration.
- Configure the module to enter a state on power up and after a period of time change to another state automatically. This allows units to be placed in the discoverable state for a limited time period.
- Read and write to GPIO lines
- Read the ADC channels
- Get fast GPIO and ADC status through an inquiry response (patent pending)

2.3.1.2 Audio

- Set up audio connections
- Enable / disable Auto Answer for incoming connections

2.3.1.3 UART

- Change the baud rate from 1200 to 921,600 baud.
- Use the DSR line to drop connections
- Flexible configuration as either DTE or DCE
- Change escape sequence character
- Change the number of Stop bits and Parity
- Enable or disable echoes

2.3.1.4 Security

- Enable Authentication by requiring a PIN code for incoming AND / OR outgoing connections
- Enable data to be encrypted over the air for incoming AND / OR outgoing connections. The module can be configured to be:
  - non-connectable and non-discoverable
  - non-connectable but discoverable
  - connectable but non-discoverable
  - connectable and discoverable

- Automatically store Paired devices in a trusted device database in the flash memory

2.3.1.5 Bluetooth

- Set the module to be a master or slave
- Make a Bluetooth connection to a specified device
- Perform a full inquiry for other Bluetooth devices
- Query a remote device to check if a service is offered
- Fetch the friendly name of a remote device
- Increase or decrease the delay before the master abandons a connection attempt
- Change the device class code
- Set the device's friendly name
- Change the Inquiry scan time
- Change number of returned devices from an inquiry scan
- Obtain the RSSI value for a connection

2.3.1.6 Power Management

- Decrease or increase the output power to suit your connection range
- Configure the modules to work in Sniff and other low power modes.

2.4 Multipoint Firmware

For multipoint operation, the same hardware can be loaded with multipoint software. Whereas the firmware for single point 'AT' communication only allows one connection to be active at any one time, using multipoint firmware allows a number of simultaneous connections to be made and maintained. It also allows connections to multiple profiles to one or more devices. Multipoint firmware should be seen as a concept of channels instead of slave connections.

When operating in Bluetooth multipoint mode, the resources and bandwidth of a Bluetooth master device are shared amongst the different connected devices. This has an impact on the maximum throughput to any one device. If multiple device connections are maintained it also impacts on the memory resources and device database within the Bluetooth stack. Designers should be aware of these restrictions when using multipoint configurations. In most cases better latency and power consumption can be achieved by polling or fast data transfer rather than by maintaining concurrent connections.

In general, multipoint connections are viable for up to three connections, but other connection schemes become appropriate if a greater number of devices are being deployed.

2.5 OTA (Over the Air) Configuration

When the BISM2 has its remote AT parser enabled, its settings can be remotely controlled by a master unit (see register S536). This places the slave unit's AT parser in remote mode providing over the air configuration. This mode is of use for remote sensor applications, where no host processor is required to control the slave Bluetooth unit.

2.6 Boot Modes

The module has the capability of booting into 1 of 7 modes. Currently only Boot Mode 1 is supported.

Boot Mode 1 is default and gives functionality equivalent to the BISM1 module.

These modes will specify different PSKEY settings to allow for different basic operation. Please contact Laird for further information.

3 Low Power Modes

The current drain from the Vcc power input line is dependent on various factors. The three most significant factors are the voltage level at Vcc, UART baud rate and the operating mode.

The hardware specification for the blu2i module allows for a voltage range of 3.6 to 7.0v at Vcc. Tests have shown that there is no significant difference in current draw when Vcc is 5 or 6V.

The UART baud rate has a bearing on power drain because as is normal for digital electronics, the power requirements increase linearly with increasing clocking frequencies. Hence higher baud rates result in a higher current drain.

Finally with regards to operating mode the significant modes are; idle, waiting for a connection, inquiring, initiating a connection and connected. With connected mode, it is also relevant to differentiate between no data being transferred and when data is being transferred at the maximum rate possible.

The operating mode can best be described by stating the AT commands required to enter that mode. In addition, there are certain S Registers which have a direct impact on power consumption, which are described next.

The blu2i module has a single LED which can be configured to display connection status. Tests have shown that this LED can consume up to 5.3mA which is more than double the current draw when in Idle mode. S Register 534 can be used to completely disable this indicator.

S Registers 508 to 511, which specify the page and inquiry scan intervals and windows, can be used to adjust the average current drain when in discoverable and or connectable modes. Registers 508 and 509 specify the interval and window for page scans and registers 510 and 511 specify the interval and window for inquiry scans. Register pairs 508/509 and 510/511 describe duty cycles when the blu2i module goes into scan modes. It is while scanning that the highest current draw occurs. The average current draw is determined by simple arithmetic using the values stored in the 508/509 and 510/511 register pairs.

The current drain while waiting for a connection or discoverable mode is about 30 times higher than in idle mode. This is when the page/inquiry scan duty cycle is 100%. These modes give the quickest response to a page or inquiry request from a remote peer.

It is possible to reduce the duty cycle down to as low as 0.5% at the expense of response time. The response time can be specified via S Registers 508 and 510 for page and inquiry respectively, where the worst case response time can be as high as 2.5 seconds. Then the duty cycle can be varied by changing the value of S Registers 509 and 511 appropriately.

For example, if S Register 508 and 510 are both set to 1000ms and S Register 509 and 511 are both set to 11ms then the duty cycle is reduced to 1%, this means that average current drain at 5.0v will be 2% of 65mA plus the normal idle mode current, that is, it is as low as 2.75mA. However, in this case, it can take up to 1 second to establish a connection.

The connected state current consumption while a master or slave can be considerably reduced by enabling Sniff mode, described in detail in the next section.

		mA
Current per LED (when fitted)	3.6 V	3.20
	5.0 V	5.30

3.1 Low Power Modes using Sniff

Bluetooth connections are master/slave in nature. A master sends packets and a slave has to acknowledge that packet in the next timeslot. Timeslots in Bluetooth are 625 microseconds wide. This implies that a master

will always know when packets will be sent and received, which further means it is able to optimise power usage by switching on power hungry circuitry only when needed.

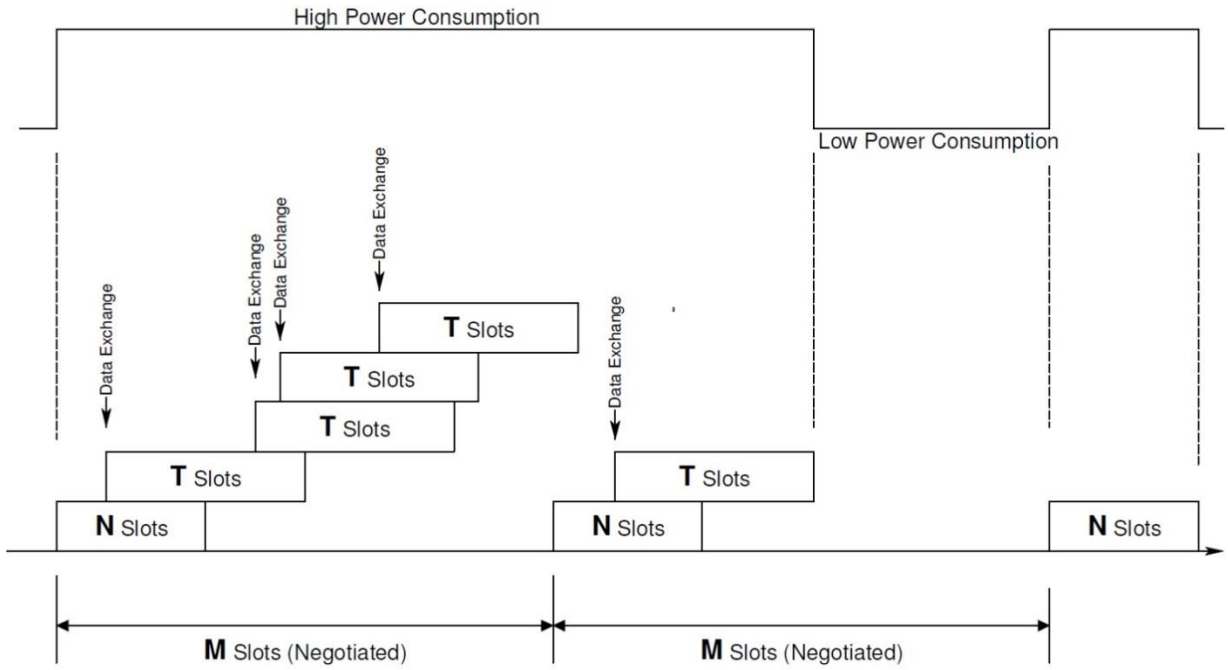
A slave on the other hand does NOT have prior knowledge of when a packet will be received and has to assume that a packet will be received from a master on every receive slot. This means that it has to leave its receiving circuitry on for most of the receive slot duration. The result of this is high power consumption as illustrated in the power table in Section 4.1, where a slave with no data transmission still consumes around 31mA whereas a master consumes only 6 mA.

This problem was identified very early in the evolution of Bluetooth (especially since headsets spend all their time as a slave in a Bluetooth connection) and it was solved by having a mode called Sniff, with appropriate lower layer negotiating protocol.

Sniff mode during connection is basically an agreement between the slave and its master that data packets will only be exchanged for N timeslots every M slots. The slave can then assume that it will never be contacted during N-M slots, and so can switch its power hungry circuitry off. The specification goes further by also specifying a third parameter called 'timeout' (T) which specifies 'extra' timeslots that the slave will agree to listen for after receiving a valid data packet. Put another way, if a data packet is received by the slave, then it knows that it MUST carry on listening for at least T more slots. If within that T slot time period another data packet is received, then the timer is restarted. This mechanism ensures low power consumption when there is no data transfer – at the expense of latency. When there is a lot of data to be transferred, it acts as if sniff mode were not enabled.

It is stated above that during sniff mode, a slave listens for N slots every M slots. The Bluetooth specification states that a master can have up to 7 slaves attached to it with all slaves having requested varying sniff parameters. It may therefore be impossible to guarantee that each slave gets the M parameter it requested. In light of this, the protocol for enabling sniff mode specifies that a requesting peer specify the M parameter as a minimum and maximum value. This will allow the master to interleave the sniff modes for all slaves attached.

For this reason, the sniff parameters are specified in the BISM2 module via four S registers. S Register 561 is used to specify 'N', S Register 562 is used to specify 'T' and S Registers 563/564 are used to specify minimum 'M' and maximum 'M' respectively. Although the specification defines these parameters in terms of timeslots, the S register values have to be specified in units of milliseconds and the firmware does the necessary translation to timeslots.



4 Application Examples

4.1 RS232 Modem Signals

Just as a telephony modem has control and status lines, the blu2i module also provides for 6 control and status lines as per the table below. The direction column is as seen from the module's viewpoint.

Direction	Function
IN or OUT *	CI also known as RI (Ring Indicate)
IN or OUT *	DCD (Data Carrier Detect)
IN	DSR (Data Set Ready)
OUT	DTR (Data Terminal Ready)
IN	CTS (Clear To Send)
OUT	RTS (Request To Send)
* Configurable with S register 552	

The first four lines are under program control. These use four of the GPIO pins and are mapped to I/O as per the table below. The last two are under control of the UART driver and their functionality is always enabled.

Direction	Connector Pin Label	Function
IN/OUT	GPIO1	General Purpose I/O
IN/OUT	GPIO2	General Purpose I/O
IN/OUT	UART_RI	Input/Output from module
IN/OUT	UART_DCD	Input/Output from module
IN	UART_DSR	Input to module
IN/OUT	GIPO3/ UART_DTR	General Purpose I/O (or DTR functionality)
IN/OUT	GPIO4/ LED	General Purpose I/O (LED)
IN/OUT	GPIO5	General Purpose I/O
IN/OUT	GPIO6	General Purpose I/O
IN/OUT	GPIO7	General Purpose I/O
IN/OUT	GPIO8	General Purpose I/O

Note: PIO4 (DSR) is used by the blu2i module to sense that the host is connected, and is intricately linked with connections. For outgoing calls, if this line is not asserted then an error is indicated. Similarly for AT+BTP and AT+BTG.
While in a call, for appropriate modes, a de-assertion means fall into command state. If the deassertion exists for longer than the period specified in S Register 519 then the connection is dropped as if an ATH command was received.

PIO2 (RI), is normally de-asserted. When an incoming connection is detected it will be asserted, until the connection is either answered or rejected using ATA and ATH respectively. See S Registers 552 & 553 for more details

PIO3 (DCD) will be de-asserted when the device is in the unconnected state. Asserted when a connection is active. See S Registers 552 and 553 for more details.

PIO5 is either used as GPIO or driven as UART_DTR. When the unit is configured in pure host mode, this pin is forced into UART_DTR and is asserted when there is a Bluetooth connection.

GPIO Pins 1 to 8 are available for general purpose use.

4.2 Modem Signalling over Bluetooth

The RFCOMM protocol used in Bluetooth for implementing the serial port profile allows for the exchange of four modem signals. This information is contained in a special transparent message which contains bits identified as RTR, RTC, DV and IC which depending on the type of serial device being emulated maps to DTR or DSR, RTS, DCD and RI respectively. In addition, this message also includes the ability to convey a BREAK input from one end to the other.

To allow for the greatest flexibility and variability in how the modem control signals are used out in the real world, S Registers 551, 552 and 553 have been provided which allow for any of RTR,RTC,DV and IC to be mapped to any modem control/status line.

BREAK signal on Rx line

If the host sends a break signal of duration greater than 100ms, then the blu2i module is configured to treat that as a signal to perform a hardware reset.

This being the case it is not possible to convey a BREAK over Bluetooth to the peer device.

Reset

The module can be reset by the host without the need of any I/O using a BREAK signal. The module has been configured to reset when the RX line detects a break condition for durations greater than 100 milliseconds.

The Reset line has a fixed pull down resistor of 10k Ohm.

4.3 Pure Cable Replacement Mode

The module has the capability of being preset into a pure 5-wire data cable replacement mode. The 5 wires being RX, TX, CTS, RTS and GND. This mode requires no changes to a host application since the Bluetooth connection is automatically set up on power up. If the connection is lost the BISM2 module will constantly retry until the connection is reinstated.

By implication, two devices are needed to replace a cable. One device is pre-configured to always be a master and the other, a slave.

Assuming the Bluetooth address of the master to be <bdaddr_m> and that of the slave to be <bdaddr_s>, the master module is configured by sending it the following AT commands:

- AT&F*
- ATS512=1
- ATS504=1
- ATS507=2
- ATS530=2000
- AT&W
- AT+BTR<bdaddr_s>

The ATS507=2 setting puts the device in DSR drop mode only. This means that when the device needs to be reconfigured, deasserting the DSR line will ensure that the module responds quickly to AT commands. This further means that in standalone mode, the DSR input line MUST be asserted e.g. 0V in TTL signal mode.

The slave is configured by:

- AT&F*
- ATS512=4
- ATS0=-1
- AT&W
- AT+BTR<bdaddr_m>

Where <bdaddr_m> is optional. If it is not specified, then the slave unit will accept connections from any device. If specified then only connections from the device specified will be accepted.

If it is desired that the slave unit should not be discoverable (the master is by default not discoverable), then the configuration commands are:

- AT&F*
- ATS512=3
- ATS0=-1
- AT&W
- AT+BTR<bdaddr_m>

Where <bdaddr_m> is optional. If it is not specified, then the slave unit will accept connections from any device. If specified then only connections from the device specified will be accepted.

When the units are next power cycled, the slave unit will wait for the master to connect to it and the master will continually look for the slave. If a connection attempt fails, the master will wait for 2 seconds before

reattempting a connection. This 2 second delay can be varied by issuing it an ATS530 command with an appropriate value in the range 100 ms to 15000 ms.

Note: The DSR input to the module MUST be asserted for the auto connection to succeed. When operating at TTL levels a 0 V is seen as an assert state. When operating at RS232 levels and voltage greater than 3 V is seen as assert. It is usual to connect the DTR line of the host to the DSR line of this device.

4.4 Audio Cable (voice)

With a pair of these modules it is possible to replace a mono audio cable with two way traffic. That is, a setup where a microphone is connected to a speaker at the remote end and vice versa. So this mode effectively replaces two audio cables.

Assuming the Bluetooth address of the master to be <bdaddr_m> and that of the slave to be <bdaddr_s>, the master module is configured by sending it the following AT commands:

- AT&F*
- ATS512=1
- ATS504=1
- ATS530=2000
- ATS532=7
- AT&W
- AT+BTR<bdaddr_s>

And the slave is configured by:

- AT&F*
- ATS512=4
- ATS0=-1
- AT&W
- AT+BTR<bdaddr_m>

4.5 Modem Control and Status Signals

A serial port has DTR, DSR, RTS, CTS, DCD and RI control lines. RTS and CTS are locally controlled to prevent local buffer overflow.

The status of DTR, DRS, DCD and RI can be exchanged with the remote peer device. If for example, the DTR/DSR lines are to be exchanged between the two peers to simulate the performance of a physical cable, then it is possible to do so. Refer to the description for S Registers 551, 552 and 553 for more details.

Some serial implementations link CTS and RTS to remove the need for handshaking. Laird does not recommend linking CTS and RTS other than for testing and prototyping. If these pins are linked and the host sends data at the point that the Bluetooth serial module deasserts its RTS signal, then there is a significant risk that internal receive buffers will overflow which could lead to an internal processor crash. This will lead to a drop in connection and may require a power cycle to reset the module. Laird recommends that the correct CTS/RTS handshaking protocol be adhered to for proper operation.

4.6 Oscillator Output

The output from the high performance crystal oscillator (+ 10ppm) can be divided and output on one of the selected PIO lines, removing the need for a crystal on the customer's main pcb. The frequencies available are:

- 8 MHz

- 16 MHz
- 24 MHz
- 48 MHz

For more implementation details, please contact Laird's FAE team.

5 RELATED DOCUMENTS

The following BISM2 technical documents are also available from the Laird BISM2 product page under the Documentation tab:

- Product Brief
- TRBLU23 Hardware Integration Guide
- AT Command Set User Guide
- Development Kit User Guide
- Firmware Release Notes
- AT Commands Quick Start Guide
- Multipoint Firmware User Guide

- Bluetooth Core 2.0 Specification – www.bluetooth.org

The following downloads are also available from the Laird RM024 product page:

- Laird (EZURIO) Terminal v6.9.0.zip
- Laird UWTerminal Version 6.60.zip
- Laird MpBtHost v3.5.0.zip

6 DISCLAIMERS

LAIRD'S BLUETOOTH PRODUCTS ARE NOT AUTHORISED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE MANAGING DIRECTOR OF LAIRD LTD.

The definitions used herein are:

a) Life support devices or systems are devices which (1) are intended for surgical implant into the body, or (2) support or sustain life and whose failure to perform when properly used in accordance with the instructions for use provided in the labelling can reasonably be expected to result in a significant injury to the user.

b) A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness. Laird does not assume responsibility for use of any of the circuitry described, no circuit patent licenses are implied and Laird reserves the right at any time to change without notice said circuitry and specifications.

6.1 Data Sheet Status

Laird reserves the right to change the specification without notice in order to improve the design and supply the best possible product.

Please check with Laird for the most recent data before initiating or completing a design.

Where reference is made to related products from other suppliers, Laird takes no responsibility for the information, availability or performance of such products.

6.2 Warranty

Laird warrants that its products shall conform to Laird's published specifications and remain free from defects in materials and workmanship under normal, proper and intended use for a period of two (2) years from date of purchase, provided that proof of purchase be furnished with any returned equipment.

If during the warranty period any component part of the equipment becomes defective by reason of material or workmanship and Laird is immediately notified of such defect, Laird shall at its option supply a replacement part or request return of equipment, freight prepaid, to its designated facility for repair. In the event no trouble is found on products returned for repair, Laird reserves the right to charge the customer its standard published repair charge.

This warranty shall not apply to any products that have been subject to misuse, bending, twisting, neglect, alteration, improper installation, testing or unauthorized repair performed by anyone other than a Laird designated repair facility. Any non-warranty repairs or maintenance shall be at Laird's standard rates in effect at the time.

This warranty is in lieu of all other warranties, whether expressed, implied, or statutory, including but not limited to, implied warranties or merchantability and fitness for a particular purpose. In no event shall Laird be liable, whether in contract, in part, or on any other basis, for any damage sustained by its customers or any other person arising from or related to loss of use, failure or interruption in the operation of any products, or delay in maintenance, or for incidental, consequential, in direct, or special damages or liabilities, or for loss of revenue, loss of business, or other financial loss arising out of or in connection with the sale, lease, maintenance, use, performance, failure, or interruption of these products.