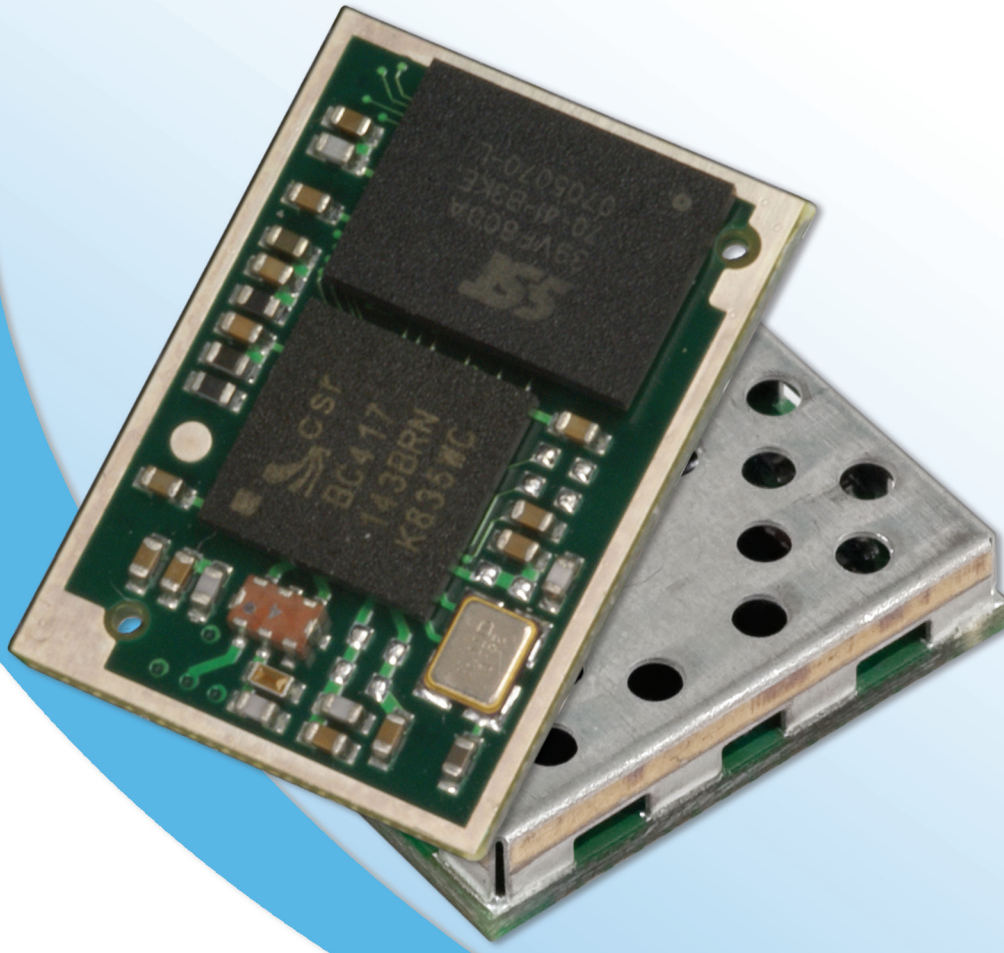
BTM410/411 DATA MODULE

USER MANUAL

Version 1.0



Laird TECHNOLOGIES®

Innovative **Technology** for a **Connected** World

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REVISION HISTORY

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Revision	Description
Version 1.0	06/22/10 - Initial Release Version

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BTM410/411

Bluetooth® AT Data Module

OVERVIEW AND KEY FEATURES

The BTM410 and BTM411 Bluetooth® modules from Laird Technologies have been designed to meet the needs of developers who wish to add robust, short range Bluetooth data connectivity to their products. They are based on the market leading Cambridge Silicon Radio BC04 chipset, providing exceptionally low power consumption with outstanding range. They support the latest Bluetooth® Version 2.1 Specification, providing the important advantage of Secure Simple Pairing, which improves security and enhances the ease of use for end customers.

With physical sizes as small as 12.5 x 18.0mm and best of class, low-power operation, these modules are the ideal choice for applications where designers need both performance and minimum size. For maximum flexibility in systems integration, the modules are designed to support a separate power supply for I/O.

To aid product development and integration, Laird Technologies has integrated a complete Bluetooth protocol stack within the modules, including support for the Bluetooth Serial Port Profile. The modules are fully qualified as Bluetooth End Products, allowing designers to integrate them within their own products with no further Bluetooth Qualification. They can then list and promote their products on the Bluetooth website free of charge.

Future releases include support for the Bluetooth Health Device Profile, making this module the ideal choice for manufacturers who are developing Continua Health Alliance compliant devices.

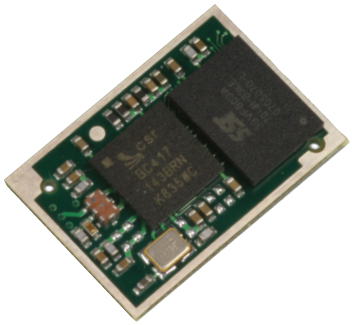
A comprehensive AT command interface is included, which simplifies firmware integration. Combined with a low cost developers kit, this ensures that the choice of Laird Technologies Bluetooth modules guarantees the fastest route to market.

FEATURES AND BENEFITS

- Bluetooth® v2.1+EDR
- Adaptive Frequency Hopping to cope with interference from other wireless devices
- Secure Simple Pairing support
- External or internal antenna options
- Comprehensive AT interface for simple programming
- Bluetooth® END Product Qualified
- Compact size
- Class 2 output – 4dBm
- Low power operation
- UART interface
- PCM and SCO for external codec
- GPIO lines under AT control
- Support for Serial Port Profile
- Support for Health Device Profile (later release)
- Wi-Fi co-existence

APPLICATION AREAS

- Embedded Devices
- Phone Accessories
- Security Devices
- Medical and Wellness Devices
- Automotive Applications
- Bluetooth® Advertising
- ePOS



SPECIFICATIONS

Categories	Feature	Implementation
Wireless Specification	Bluetooth®	Version 2.1+EDR
	Transmit Class	Class 2
	Frequency	2.402 – 2.480 GHz
	Channels	79 channels Frequency Hopping Adaptive Frequency Hopping
	Max Transmit Power	+4 dBm at antenna pad – BTM410 +4 dBmi from integrated antenna – BTM411
	Min Transmit Power	-27 dBm at antenna pad – BTM410 -27 dBmi from integrated antenna – BTM411
	Receive Sensitivity	-84dBm
	Range	30m
	Data Transfer Rate	Up to 300 kbps
Antenna Modes	External Antenna	50 Ohm matched SMT pad – BTM410
	Integrated Antenna (option)	+0dBi multilayer ceramic – BTM411
UART Interface	Serial Interface	RS-232 bi-directional for commands and data 16550 compatible
	Baud Rate	Configurable from 1,200 to 921,600bps Non-standard baud rates supported
	Bits	8
	Parity	Odd, even, none
	Stop bits	1 or 2
	Default Serial parameters	9600,n,8,1
	Levels	Set by VDD_USB input
	Modem Control	DTR, DSR, DCD, RI, RTS, CTS
General Purpose Interface	I/O	8 general purpose I/O pins
Audio	Support	1 PCM channel @ 64kbps
	SCO Channels	Support SCO and eSCO
	PCM Interface	Configurable as master or slave 8 bit A-law 8 bit µ-law 13 bit linear PCM Clock available when in slave mode
Protocols and Firmware	Bluetooth Stack	V2.1 compliant. Fully integrated.
	Profiles	GAP (Generic Access Profile) SDP (Service Discovery Profile) SPP (Serial Port Profile) HDP (Health Device Profile) – future release
	Firmware Upgrade	Available over UART
	Connection Modes	Point to point (cable replacement)

SPECIFICATIONS

Categories	Feature	Implementation
Command Interface	AT Instructions set	Comprehensive control of connection and module operation S Registers for non-volatile storage of parameters
Current Consumption	Data Transfer	Typically 32mA
	Low Power Sniff Mode	Less than 2.5mA
Supply Voltage	Supply	3.0V – 3.3V DC
	I/O	1.7V – 3.3V DC (independent of Supply)
	USB & UART	1.7V – 3.6V DC (independent of Supply)
Coexistence / Compatibility	WLAN (802.11)	2-wire and 3-wire hardware coexistence schemes supported
Connections	Interface	Surface Mount Pads
	External Antenna (BTM410)	Pad for 50 Ohm antenna
Physical	Dimensions	12.5mm x 18.0 x 3.4mm BTM410 12.5mm x 24.0mm x 3.4mm BTM411
	Weight	3 grams
Environmental	Operating Temperature	-30°C to +85°C
	Storage Temperature	-40°C to +85°C
Approvals	Bluetooth	Qualified as an END product
	FCC	Limited Modular Approval (BTM410) Full Modular Approval (BTM411)
	CE & R&TTE	Meets CE and R&TTE requirements
Miscellaneous	Lead free	Lead-free and RoHS compliant
	Warranty	12 Months
Development Tools	Development Kit	Development board and software tools DVK-BTM410 Dev Kit with BTM410 module fitted DVK-BTM411 Dev Kit with BTM411 module fitted

SPECIFICATIONS

Pin	Signal	Description	Voltage Specification
1	Unused		
2	GND		
3	UART_CTS	Clear to Send I/P	VUSB
4	UART_RXD	Receive data I/P	VUSB
5	UART_RTS	Request to Send O/P	VUSB
6	UART_TXD	Transmit data O/P	VUSB
7	GND		
8	SPI_CSB	SPI bus chip select I/P	VIO
9	SPI_MISO	SPI bus serial O/P	VIO
10	SPI_MOSI	SPI bus serial I/P	VIO
11	SPI_CLK	SPI bus clock I/P	VIO
12	VDD_USB	USB & UART supply voltage	
13	VDD_IO	I/O supply voltage	
14	VDD_IN	Main supply voltage	
15	GND		
16	PCM_IN	PCM clock I/P	VIO
17	PCM_SYNC	PCM sync I/P	VIO
18	PCM_CLK	PCM clock I/P	VIO
19	PCM_OUT	PCM Data O/P	VIO
20	RESET	Module reset I/P	See note 2
21	GPIO5	I/O for host	VIO
22	GPIO2 / UART_DCD	I/O for host	VIO
23	GND		
24	Unused		
25	Unused		See note 3
26	Unused		See note 3
27	Unused		See note 3
28	GND		See note 3
29	ANT (BTM410)	Antenna connection (50 ohm matched)	See note 3
30	GND		See note 3
31	Unused		See note 3
32	Unused		See note 3
33	Unused		See note 3
34	Unused		See note 3
35	Unused		See note 3
36	Unused		See note 3
37	Unused		See note 3
38	Unused		
39	Unused		
40	Unused		
41	GND		
42	GPIO1 / UART_RI	I/O for host	VIO
43	GPIO9 /UART_ DTR	I/O for host	VIO
44	GPIO10 / UART_DSR	I/O for host	VIO
45	GND		
46	D-	Not used for AT module variants	VUSB
47	D+	Not used for AT module variants	VUSB
48	GPIO7	I/O for host	VIO
49	GPIO6	I/O for host	VIO
50	GPIO4	I/O for host	VIO

Note: 1. Unused pins may have internal connections and must not be connected.
2. Reset input is active low. Input is pulled up to VDD_IN via 22k. Minimum reset pulse width is 5ms.
3. Pins 25-37 should be left not connected on modules with integrated antenna (BTM411, BTM421 and BTM431)

OPERATING PARAMETERS

OPERATING PARAMETERS

Recommended Operating Conditions		
OPERATING CONDITION	MIN	MAX
VDD_USB (USB compatibility not required)	1.7	3.6
VDD_USB (USB compatibility required)	3.1	3.6
VDD_IO	1.7	3.3
VDD_IN	3.0	3.3

VOLTAGE SPECIFICATIONS

Logic Levels (VUSB)			
INPUT VOLTAGE LEVELS	MIN	TYP	MAX
V_{ih}	0.7VDD_USB		
V_{il} 2.7<VDD_USB<3.0	-0.4		+0.8
1.7<VDD_USB<1.9	-0.4		+0.4
OUTPUT VOLTAGE LEVELS (1.7<VDD_USB<1.9)			
V_{oh} (Iout = -4mA)	VDD_USB – 0.4		
V_{ol} (Iout = 4mA)			0.4
OUTPUT VOLTAGE LEVELS (2.7<VDD_USB<3.0)			
V_{oh} (Iout = -4mA)	VDD_USB – 0.2		
V_{ol} (Iout = 4mA)			0.2

Note: VDD_USB must be connected to power the USB and UART interfaces.

Logic Levels (VIO)			
INPUT VOLTAGE LEVELS	MIN	TYP	MAX
V_{ih}	0.7VDD_IO		
V_{il} 2.7<VDD_IO<3.0	-0.4		+0.8
1.7<VDD_IO<1.9	-0.4		+0.4
OUTPUT VOLTAGE LEVELS (1.7 < VDD_IO < 1.9)			
V_{oh} (Iout = -4mA)	VDD_IO – 0.4		
V_{ol} (Iout = 4mA)			0.4
OUTPUT VOLTAGE LEVELS (2.7 < VDD_IO < 3.0)			
V_{oh} (Iout = -4mA)	VDD_IO – 0.2		
V_{ol} (Iout = 4mA)			0.2

AT COMMAND SET REFERENCE

INTRODUCTION

This document describes the protocol used to control and configure the BTM Bluetooth device.

The protocol is similar to the industry standard Hayes AT protocol used in telephony modems which is appropriate for cable replacement scenarios, as both types of devices are connection oriented.

Just like telephony modems, Laird Technologies' devices power up in an unconnected state and will only respond via the serial interface. In this state the device will not even respond to Bluetooth Inquiries. Then, just like controlling a modem, the host can issue AT commands which map to various Bluetooth activities. The configuration of the device can be saved, so that on a subsequent power up the device is discoverable or automatically connects.

The device has a serial interface which can be configured for baud rates from 1200 up to 921600 (default setting is 9600) and an RF communications end point. The latter has a concept of connected and unconnected modes and the former will have a concept of command and data modes. This leads to the matrix of states shown below.

	RF Unconnected	RF Connected
Local Command Mode	OK	OK
Remote Command Mode	ILLEGAL	OK
Data Mode	ILLEGAL	OK

The combinations, 'Data and RF Unconnected Mode' and 'Remote Command and RF Unconnected Mode' do not make sense and will be ignored.

Navigation between these states is done using the AT commands which are described in detail in subsequent sections.

AT COMMAND SET REFERENCE

GLOSSARY OF TERMS

		Description
A2DP	:	Advanced Audio Distribution Profile
ACL	:	Asynchronous Connection-Oriented Link
ADC	:	Analogue to Digital Converter
AGHFP	:	Audio Gateway Hands-Free Profile
AT	:	Command prefix, 'Attention'
AVRCP	:	Audio/Video Remote Control Profile
BISM	:	Bluetooth Intelligent Serial Module
CoD	:	Class Of Device (also referred to as "device class")
Codec	:	Device capable of encoding / decoding an analogue / digital signal
DAC	:	Digital to Analogue Converter
DSP	:	Digital Signal Processor
DUN	:	Dial-Up Network Profile
EIR	:	Extended Inquiry Response
eSCO	:	Enhanced Synchronous Connection Oriented Link (used for Audio)
FTP	:	File Transfer Profile
GOEP	:	Generic Object Access Exchange Profile
GPIO	:	General Purpose Input Output
HF	:	Hands-free Role of Hands-free Profile ("Hands-free Unit")
HFG	:	Audio Gateway Role of Hands-free Profile ("Hands-free Gateway")
HFP	:	Hands Free Profile
HID	:	Human Interface Device Profile
HS	:	Headset Role of Headset Profile ("Headset")
HSG	:	Audio Gateway Role of Headset Profile ("Headset Gateway")
HSP	:	Headset Profile
I/O (IO)	:	Input/Output
Mic	:	Microphone
MITM	:	Man In The Middle
OPP	:	Object Push Profile
PBAP	:	Phone Book Access Profile
PT	:	PASS THROUGH Command
PWM	:	Pulse Width Modulation
SBC	:	Sub Band Codec
SCO	:	Synchronous Connection Oriented Link (used for Audio)
SLC	:	Service Level Connection
SPP	:	Serial Port Profile
SSO	:	Serial Stream Oriented
SSP	:	Secure Simple Pairing
SUI	:	SUBUNIT INFO Command
Sxxx	:	S-Register No. xxx
TDL	:	Trusted Device List
UART	:	Universal Asynchronous Receiver / Transmitter
UI	:	UNIT INFO Command

AT COMMAND SET REFERENCE

OVERVIEW OF THE BTM PRODUCT FAMILY

BTM410 / BTM411	
Chipset	CSR BC4-Ext
Bluetooth version	2.1
Features	SSP, EIR, SCO (1), eSCO (1)
Profiles	SPP

(1) external codec required

BTM510 / BTM511	
Chipset	CSR BC5MM-Ext
Bluetooth version	2.1
Features	SSP, EIR, SCO, eSCO
Profiles	SPP, A2DP, AVRCP,HSP,HFP,DUN(DT)

BTM520 / BTM521	
Chipset	CSR BC5MM-Ext
Bluetooth version	2.1
Features	SSP, EIR, SCO, eSCO
Profiles	SPP, A2DP, AVRCP,HSP,HFP,DUN(DT)

AT COMMAND SET REFERENCE

BTM - AT COMMAND SET

This section describes the AT Command Set for a BTM module. This section is structured in functional groups of AT commands, related to module configuration, Bluetooth profiles, hardware units and miscellaneous purposes.

Assumptions

1. All commands are terminated by the carriage return character 0x0D, which is represented by the string <cr> in descriptions below this cannot be changed.
2. All responses from the BTM device have carriage return and linefeed characters preceding and appending the response. These dual character sequences have the values 0x0D and 0x0A respectively and shall be represented by the string <cr,lf>.
3. All Bluetooth addresses are represented by a fixed 12 digit hexadecimal string, case insensitive.
4. All Bluetooth Device Class codes are represented by a fixed 6 digit hexadecimal string, case insensitive.
5. All profile specific commands are identified by the prefix shown in Table 3.1

Profile	Term	AT-Command Prefix
Serial Port Profile	SPP	AT+SP…

Table 3.1: AT Command prefix for profiles

Command Syntax

The following syntax is employed throughout this document to describe optional or mandatory parameters for AT commands.

<bd_addr>	A 12 character Bluetooth address consisting of ASCII characters '0' to '9', 'A' to 'F' and 'a' to 'f'.
<devclass>	A 6 character Bluetooth device class consisting of ASCII characters '0' to '9', 'A' to 'F' and 'a' to 'f'.
N	A positive integer value.
M	An integer value which could be positive or negative, which can be entered as a decimal value or in hexadecimal if preceded by the '$' character. E.g. the value 1234 can also be entered as $4D2
<string>	A string delimited by double quotes. E.g. "Hello World". The " character MUST be supplied as delimiters.
<uuid>	A 4 character UUID number consisting of ASCII characters '0' to '9', 'A' to 'F' and 'a' to 'f'.

General AT Commands

1. AT

   Used to check the module is available.

   Response: <cr,lf>OK<cr,lf>

2. ATEn{Enable/Disable Echo}

   This command enables or disables the echo of characters to the screen. A valid parameter value will be written to S Register 506.

   E0 … Disable echo.
   E1 … Enable echo.

   All other values of n will generate an error.

   Response: <cr,lf>OK<cr,lf>

   Or

   Response: <cr,lf>ERROR nn<cr,lf>

AT COMMAND SET REFERENCE

3. ATZ<n> {Hardware Reset and emerge into boot mode 'n'}

   Forces the device through a hardware reset which means it will eventually come alive in the local command and unconnected mode. This allows changes to the non-volatile memory to take effect. The module will issue an OK response after the reset is complete and it is ready to receive commands once again.

   ATZ and ATZ0 signify reset and emerge into the current boot mode (see command ATI14). ATZ1 to ATZ4 instructs the module to reset and then emerge into the appropriate boot mode. Note that S Register 103 specifies the boot mode from cold.

   Boot modes are required to configure some low level device settings which cannot be configured by S registers and AT commands. Currently there are predefined settings defining the PCM data format to be used with certain codec ICs (applies mainly to BC04).

   Response after reset: <cr,lf>OK<cr,lf>

4. AT+BTC<devclass$_{hex}$> {Set Device Class Code Temporarily}

   This command is used to set the device class code which will be sent in subsequent inquiry responses. It can be read back using the AT+BTC? Command, as described below.

   <devclass> is a 6 digit hexadecimal number derived as per "Bluetooth Assigned Numbers" [3].

   The 24 bits are made of 4 fields briefly described as follows (bit 0 corresponds to the least significant bit):-

Bits 0-1:	Format Type. This field currently only has a value of 00 (i.e. format type 1)
Bits 2-7:	Minor Device Class: The value of these 6 bits is interpreted differently based on the Major Device Class stored in the next 5 bits.
Bits 8-12:	Major Device Class: 5 bits, refer to Figure 1 and Table 3 in "Bluetooth Assigned Numbers" [3]
Bits 13-23:	Major Service Class: 11 bit field, used as a mask to define service classes, refer to Figure 1 and Table 2 in "Bluetooth Assigned Numbers" [3]

   Laird Technologies devices do not map to any predefined Major Service Class or Major Device Class and so the default devclass as shipped is 001F00, which means no Major Service Class and "Unclassified" Major Device class.

   Other examples of device class codes are follows:

Code (Hexadecimal)	Name	Major Service	Major Device	Minor Device
0x001F00	Unclassified	None	Unclassified	n/a
0x200404	Headset	Audio	Audio	Headset

   There is a tool available in the internet for creating a particular device class code: refer to [4].
   A device class set by AT+BTC becomes visible immediately but will be lost on next power cycle.

   Response: <cr,lf>OK<cr,lf>

   Or for an invalid <devclass> value (usually a value which is not 6 hexadecimal characters long):

   Response: <cr,lf>ERROR 08<cr,lf>

5. ATS515=<devclass$_{hex}$> {Set Device Class Code Permanently}

   S Register 515 is used to set the device class code permanently. Use AT&W to save the setting to non-volatile memory. The new value will become visible on next power cycle which can be initiated by ATZ. Refer to number 4 for more information about the device class code.

   Response: <cr,lf>OK<cr,lf>

6. AT+BTC? {Read Device Class Code}

   This command is used to read the current device class code.

   Response: <cr,lf>123456

   <cr,lf>OK<cr,lf>

AT COMMAND SET REFERENCE

7. AT+BTF="<string>" {Set Friendly Name Temporarily}

   This sets the friendly name of this device as seen by other devices. The new name becomes immediately visible. Any name set by this command will be lost on next power cycle.

   Please refer to S register 593 (Table 4.1) too.

   Response: <cr,lf>OK<cr,lf>

8. AT+BTN="<string>" {Set Friendly Name Permanently}

   This sets the default friendly name of this device as seen by other devices. It will be stored in non-volatile memory. The new name will become visible to other devices on next power cycle. Use AT+BTF to make the name visible immediately. Use AT+BTN? To read it back. An empty string ("") will delete the string from non-volatile memory which will force the default name to be used which is "Laird BTM 789012". The digits in the default friendly name represent the last 6 digits of the local Bluetooth address.

   Please refer to S register 593 (Table 4.1) too. If a new value of S593 needs to be retained permanently, save it to non-volatile memory by "AT&W".

   Response: <cr,lf>OK<cr,lf>

9. AT+BTN? {Read Friendly Name from Non-volatile Memory}

   Read the default friendly name from non-volatile memory.

   Response: <cr,lf>"My Friendly Name"<cr,lf>

   <cr,lf>OK<cr,lf>

10. AT+BTF<bd_addr> {Get Remote Friendly Name}

    This command gets the remote friendly name of the peer specified.

    Response: <cr,lf><bd_addr>,"Friendly Name"

    <cr,lf>OK<cr,lf>

11. AT+BTP {Make Device Discoverable and Connectable }

    Make the device discoverable and connectable and wait for a connection from any device.

    The setting remains valid until next reset or power cycle (unless not changed by any other AT command subsequently). For permanent discoverable/connectable settings, please refer to S Register 512.

    Response: <cr,lf>OK<cr,lf>

12. AT+BTQ {Make Device Discoverable}

    Make the device discoverable but not connectable. Being discoverable implies that this device will respond to inquiries from other devices (inquiry scans enabled).

    The setting remains valid until next reset or power cycle (unless not changed by any other AT command subsequently). For permanent discoverable/connectable settings, please refer to S Register 512.

    Use AT+BTX to make the device not discoverable.

    Response: <cr,lf>OK<cr,lf>

13. AT+BTG {Make Device Connectable}

    Make the device connectable but not discoverable and wait for a connection from any device.

    The setting remains valid until next reset or power cycle (unless not changed by any other AT command subsequently). For permanent discoverable/connectable settings, please refer to S Register 512.

    Response: <cr,lf>OK<cr,lf>

AT COMMAND SET REFERENCE

14. AT+BTV<bd_addr>,<uuid> {SDP Query for Service }

    This command is used to interrogate the SDP database of the peer device <bd_addr> for the service <uuid>. It results in an ACL connection and then an SDP transaction.

    If the <uuid> service is present then

    Response: <cr,lf>0

    <cr,lf>OK<cr,lf>

    If the <uuid> service is not present then

    Response: <cr,lf>1

    <cr,lf>OK<cr,lf>

    If the device < bd_addr > cannot be reached, or is in non-connectable mode then

    Response: <cr,lf>2

    <cr,lf>OK<cr,lf>

    If the SDP database is corrupt or invalid then

    Response: <cr,lf>3

    <cr,lf>OK<cr,lf>

    If the device is not in idle mode then

    Response: <cr,lf>4

    <cr,lf>OK<cr,lf>

    and in this case, the command AT+BTX may put the device into the correct idle mode.

15. ATIn {Information}

    This will return the information about the Laird Technologies device and its status. Please refer to Table 4.2 (Appendix) for a complete list of supported ATIn parameters.

    For recognized values of n:

    Response: <cr,lf>As Appropriate<cr,lf>OK<cr,lf>

    For unrecognized values of n.

    Response: <cr,lf>Laird Technologies Inc, UK, (c)2009<cr,lf>

AT Commands for S Registers

As with modems, the Bluetooth module employs a concept of registers which are used to store parameters, such as escape sequence character, inquiry delay time etc.

For a list of general S registers please refer to page 17 and Table 4.1.

S registers associated with a particular profile or specific functions, are described in the appropriate profile section of this document.

The following AT commands allow the manipulation of S registers.

1. ATSn=m {Set S Register}

   The value part 'm' can be entered as decimal or hexadecimal. A hexadecimal value is specified via a '$' leading character. For example $1234 is a hexadecimal number.

   When S register values are changed, the changes are not stored in non-volatile memory UNTIL the AT&W command is used. Note that AT&W does not affect S registers 520 to 525 or 1000 to 1010 as they are updated in non-volatile memory when the command is received.

2. ATSn? {Read S Register Value}

   This will return the current value of register n.

   For recognized values of n

   Response: <cr,lf>As Appropriate<cr,lf>OK<cr,lf>

   For unrecognized values of n

   Response: <cr,lf>ERROR nn<cr,lf>

AT COMMAND SET REFERENCE

3. ATSn=? {Read S Register – Valid Range}

   This will return the valid range of values for register n.

   For recognized values of n

   Response: <cr,lf>Sn:(nnnn..mmmm)<cr,lf>OK<cr,lf>

   For unrecognized values of n

   Response: <cr,lf>ERROR nn<cr,lf>

4. AT&Fn {Set S Register Defaults}

   This command will only work when the device is in local command and unconnected mode. Depending on the value of 'n' it installs S Register values appropriate for various power modes, ranging from minimum power consumption to maximum.

   Legal values of 'n' are as per the following table. All other values of n will generate a syntax error response. If 'n' is not specified then a default value of 0 is assumed where the baud rate is NOT changed.

&F0 (Default)	Medium power consumption, UART baud rate unchanged
&F1	Minimum power consumption, UART baud rate set to 9600
&F2	Minimum power consumption, UART baud rate set to 38400
&F3	Minimum power consumption, UART baud rate set to 115200
&F4	Medium power consumption, UART baud rate set to 115200
&F5	Maximum power consumption, UART baud rate set to 115200

   The new values are NOT updated in non-volatile memory until the AT&W command is sent to the device.

   Response: <cr,lf>OK<cr,lf>

   Or

   Response: <cr,lf>ERROR nn<cr,lf>

5. AT&F* {Clear Non-volatile Memory}

   The AT&F* variant of the command installs values in S registers as per command AT&F4 and then all other user parameters in non-volatile memory are erased. This means that the trusted device database is cleared, and so are parameters related to the following commands: AT+BTR, AT+BTN, AT+BTS.

   Response: <cr,lf>OK<cr,lf>

   Or

   Response: <cr,lf>ERROR nn<cr,lf>

6. AT&F+ {Clear Non-volatile Memory}

   This command erases all user parameters in non-volatile memory except S Registers 520 to 525. This means that the trusted device database is cleared, and so are parameters related to the following commands: AT+BTR, AT+BTN, AT+BTS.

   Response: <cr,lf>OK<cr,lf>

   Or

   Response: <cr,lf>ERROR nn<cr,lf>

7. AT&W {Write S Registers to Non-volatile Memory}

   Writes current S Register values to non-volatile memory so that they are retained over a power cycle.

   Response: <cr,lf>OK<cr,lf>

   Or

   Response: <cr,lf>ERROR nn<cr,lf>

AT COMMAND SET REFERENCE

General S Registers

Please refer to Appendix, Table 4.1 for a list of supported S Registers.

The main purpose of S Registers is to make the device configuration persistent. All S Registers can be saved to non-volatile memory by AT&W.

In some cases, an AT command and an S register exist for one and the same setting. In the majority of those cases the AT command's setting will be lost on next power cycle whereas the S register can be saved and is still available after power cycle. This rule applies to many but not to all of those cases.

AT Commands for Inquiry

1. AT+BTI<devclass> { Inquire}

   This will make the device perform an inquiry for delay seconds and max number of unique responses, where delay is defined by S register 517 and max is specified by S register 518.

   The <devclass> is an optional parameter where the value specifies either a 6 digit device class code or a 2 digit major device class. If it is not specified, the value is taken from S register 516.

   When <devclass> is 6 hexadecimal characters long, it specifies an AND mask which is used to filter inquiry responses. When <devclass> is 2 hexadecimal characters long, it forces the inquiry to filter responses to devices that match their major device class code to this value – which can only be in the range 00 to 1F.

   The response format to AT+BTI is defined by S Register 330 by bitmask. This is device address, device class, friendly name, receiver strength indicator and extended inquiry data. Please refer to Figure 3.1 and Table 3.2.

   For S330=1:

   Response: <cr,lf>12346789012

   <cr,lf>12345678914

   <cr,lf>OK<cr,lf>

   A Bluetooth inquiry process is such that for a single inquiry request a device could respond many times. To ensure that an address is sent to the host only once for a particular AT+BTI, an array of addresses is created at the start of each AT+BTI and is filled as responses come in. This array of addresses is stored in dynamic memory and as such if the memory allocation fails then the inquiry procedure is aborted and in that case an error response is sent to the host. To clarify, a single AT+BTI will never return the same Bluetooth address more than once, but as long as the responding device is active, all AT+BTI commands will always return it.

   As the inquiry process is driven by randomness, it is not guaranteed that each discoverable device is always found on the first attempt. Sometimes more than one inquiry processes might be necessary to find a particular device. The probability also depends on the inquiry scanning intervals of the device being searched for.

   The inquiry process can be speed up if the friendly name is not required (flag not set in S330) as part of the inquiry response or if a <dev_class> filter is used.

Bit	7	6	5	4	3	2	1	0
	Reserved for future usage			EIRD	RSSI	FN	COD	ADR
Default	0	0	0	0	0	0	0	1

Figure 3.1: S Register 330 controlling inquiry response format

Field	Description
0 – ADR	1 – display Bluetooth device address on inquiry result 0 – do not display Bluetooth device address on inquiry result; if any further bit is set, a comma is inserted as separator
1 – COD	1 – display class of device on inquiry result 0 – do not display class of device on inquiry result; if any further bit is set, a comma is inserted as separator
2 – FN	1 – display friendly name on inquiry result 0 – do not display friendly name on inquiry result; if any further bit is set, a comma is inserted as separator
3 – RSSI	1 – display RSSI value on inquiry result 0 – do not display RSSI value on inquiry result; if any further bit is set, a comma is inserted as separator
4 – EIRD	1 – display eird on inquiry result 0 – do not display eird on inquiry result

Table 3.2: Field Descriptions for S Register 330

AT COMMAND SET REFERENCE

Inquiry Response format

The format of an inquiry result will be:

<cr,lf><bd_addr>,<dev_class>,<friendly_name>,<rssi>,<eir_data><cr,lf>

<bd_addr> = 12 digit, hexadecimal;

<dev_class> = 6 digit, hexadecimal;

<friendly_name> = printable ASCII character, enclosed by ' " '

<rssi> = signed 2 digits decimal

<eir_data> = printable ASCII character whenever possible, otherwise a byte is displayed as ¬2 digit hexadecimal with preceding '\', enclosed by ' " '

For example the data block 01 41 42 43 44 02 03 45 46 04 0A 0D will be presented as "\01ABCD\02\03456\04\0A\0D"

No validation is performed on incoming EIR data.

If a higher significant flag is set and a lower significant bit is not set in S 330, for each disabled item a comma is printed.

Example: S330 = 9 (ADDR enabled, COD and FN disabled, RSSI enabled)

Inquiry Response:

<cr,lf>123456789012,,,-54

<cr,lf>123456789014,,,-54

<cr,lf>OK<cr,lf>

2. AT+BTIV<devclass>{ Inquire }

   As per AT+BTI but the response comprises for all inquiry responses:

   1. the Bluetooth device address
   2. device class code

   S register 330 is not referenced.

3. AT+BTIN<devclass> { Inquire }

   As per AT+BTI but the response comprises for all inquiry responses:

   1. the Bluetooth device address
   2. device class code
   3. friendly name

   S register 330 is not referenced.

4. AT+BTIR<devclass>{ Inquire }

   As per AT+BTI but the response comprises for all inquiry responses:

   1. the Bluetooth device address
   2. device class code
   3. friendly name
   4. rssi (receiver signal strength indicator)

   S register 330 is not referenced.

5. AT+BTIE<devclass>{ Inquire }

   As per AT+BTI but the response comprises for all inquiry responses:

   1. the Bluetooth device address
   2. device class code
   3. friendly name
   4. rssi (receiver signal strength indicator)
   5. extended inquiry data

   S register 330 is not referenced.

AT COMMAND SET REFERENCE

6. AT+BTE="<EIR-Data>" {Set up outgoing EIR Data}

   This command sets up outgoing EIR (extended inquiry response) data.

   Format: <EIR-Data> = printable ASCII character whenever possible, otherwise a 2 digit hexadecimal with preceding '\' presenting one byte. Please note that the given data is written to baseband as it is (raw data) and no checks on the data format is performed. Hence, the user is responsible for writing data that corresponds to the extended inquiry response data format as described in the Bluetooth Specification Version 2.1 + EDR [1], vol3, Part C – Generic Access Profile, 8 Extended Inquiry Response Data Format (page 1305 in the .pdf-file).

   Response: <cr,lf>OK<cr,lf>

7. AT+BTE? {Query outgoing EIR Data}

   This command prints the outgoing EIR data that is currently set up

   Response:

   <cr,lf>

   <EIR-Data>

   <cr,lf>OK<cr,lf>

Secure Simple Pairing (SSP)

Secure Simple Pairing (SSP) has been introduced since Bluetooth 2.1 + EDR. It aims to increase the security provided by a Bluetooth link whilst making the pairing process more user friendly.

There are white papers about SSP available through the internet (provided by the Bluetooth SIG and other companies), explaining the mechanisms and backgrounds of SSP. They can be found by searching the internet for e.g. "Bluetooth Secure Simple Pairing". Please familiarize with those documents to get a better understanding of SSP and the following settings.

1. Security Level (S320)

   The security level is defined in the BT2.1+EDR specification [1], vol3, Generic Access Profile (Table 5.7). There are 4 Levels providing different levels of security:

Security Level	Characteristics	Comment
Level 3	• MITM protection (MITM = "Man in the Middle" attack) • Encryption • User interaction	High security
Level 2	• No MITM protection • Encryption	Medium Security
Level 1	• No MITM protection • (No) Encryption (1) • Minimal user interaction	Low Security
Level 0	• No MITM protection • No Encryption • Minimal user interaction	Permitted only for service discovery

(1) Although encryption is not necessary for security level 1, encryption will always be enabled because this specification mandates encryption for all services other than SDP (service discovery).

Table 3.3: Security Levels

   The security level is defined by S Register 320 and is referenced at boot time only. Hence the register must be saved by "AT&W " and the module must be power cycled (or "ATZ") subsequently.

   S320 = 3 will overwrite the setting of S Register 322 (enable MITM).

   The security level will remain the same until next power cycle and is valid for all profiles and services of the module. For SDP (service discovery profile), security level 0 is always assigned internally.

AT COMMAND SET REFERENCE

2. IO-Capability (S321)

S-Register 321 defines the IO-capability of the device. The setting is used for IO-capability negotiations prior to SSP in order to identify whether the IO-capabilities of both devices are sufficient for MITM protection (if required). Table 3.4 lists possible values.

S321	IO-Capability	Comment
0	Display only	The device has the capability to display or communicate a 6 digit decimal number.
1	Display yes no	The device has the capability to display or communicate a 6 digit decimal number and at least two buttons that can be easily mapped to 'yes' and 'no' or a mechanism where-by the user can indicate either 'yes' or 'no' (e.g. pressing a button within a certain time limit)
2	Keyboard only	The device has a numeric keyboard that can input numbers '0' through '9' and a confirmation. The device has also at least two buttons that can be easily mapped to 'yes' and 'no' or a mechanism whereby the user can indicate either 'yes' or 'no' (e.g. pressing a button within a certain time limit)
3	No input no output	The device does not have the ability to indicate 'yes' or 'no', and the device does not have the ability to display or communicate a 6 digit decimal number.
4	Reject IO-Cap requests	IO-capability requests prior to SSP are rejected.

Table 3.4: IO capabilities

3. Force Man-In-The-Middle Protection (MITM, S322)

Protection against MITM-attacks can be enabled by S332. This S-Register only applies if the security level (S320) is less than 3. In case of security level (S320) = 3, MITM protection is always enabled and this S 322 is ignored.

A new value written to S322 applies immediately. No power cycle is required.

A link key created with MITM protection is named "authenticated link key".

A link key created without MITM protection is named "unauthenticated link key".

4. Disable Legacy Pairing (S323)

If the remote device is a legacy device (BT2.0 or earlier), legacy pairing with usage of PIN codes will be initiated. Legacy Pairing can be disabled by S-Register 323 = 1. Then pairing with legacy devices will always fail.

5. SSP Timeout (S324)

The SSP timeout [s] is defined by S-Register 324. The timeout must be at least 60s to meet the BT specification requirements [1]. This time is required to be sufficient for the user to compare or read and input a 6 digit number. A time of 90 seconds is recommended which is the default value.

6. SSP Input Commands

Table 3.5 lists all AT commands related to SSP input operations.

AT Command	Operation	Comment
AT+BTBY	Accept pairing request	Representing 'yes' input
AT+BTBN	Reject pairing request	Representing 'no' input
AT+BTB012345	Enter 6 digit passkey displayed by remote device	Representing keyboard input

Table 3.5: SSP Input commands

AT COMMAND SET REFERENCE

7. AT+BTW<bd_addr> {Initiate SSP}

   This command initiates secure simple pairing (dedicated bonding) with a device whose Bluetooth address is <bd_addr>. The correct term for this command's action with respect to the Bluetooth specification 2.1+EDR [1] is "Dedicated Bonding".

   Dedicated bonding means the exchange of link keys (pairing) without creating a connection to a particular profile or service immediately.

   The remote device must be a Bluetooth 2.1 device, otherwise (BT2.0 or earlier) legacy pairing will occur automatically if S323=0. For legacy pairing please refer to page 23.

   The "OK" response is sent immediately on receipt of the AT+BTW command. Depending on the combination of IO-capabilities of both devices, one of the asynchronous messages from Table 3.7 might appear during the pairing process. Please refer to that table for the required actions.

   On pairing completion, an unsolicited message in the form PAIR n <bd_addr> will be sent to the host.

8. S Registers for Secure Simple Pairing

   The following table lists all S Registers for Secure Simple Pairing. For the registers' details please refer to their descriptions above.

Register	Default	Range	Comment
S320	2	1..3	Security Level: see [1], vol3, Generic Access Profile - Table 5.7 needs subsequent 'AT&W' and power cycle to take effect value = 3 overwrites S322
S321	1	0..4	Set IO capability: 0 – display only 1 – display yes no 2 – keyboard only 3 – no input no output 4 – reject IO-cap requests
S322	0	0..1	Force man-in-the-middle-protection (MITM): 0 – disabled 1 – enabled referenced only if security level (S320) < 3
S323	0	0..1	Disable legacy (pre-BT2.1) Pairing: 0 – legacy pairing enabled 1 – legacy pairing disabled
S324	90	1..255	Secure Simple Pairing timeout in s This value must be at least 60 in order to meet the recommendation of BT2.1 specification

Table 3.6: S-Registers for Secure Simple Pairing (SSP)

AT COMMAND SET REFERENCE

9. Asynchronous SSP Messages

Table 3.7 lists asynchronous messages which occur if MITM is enabled. The actually sent message depends on the combination of the IO capabilities of both ends. The combination of IO capabilities of both devices can also be insufficient for MITM protection. In that case the pairing will fail (PAIR 2 <BdAddr>). Please refer Table 5.6 in BT2.1+EDR specification [1], vol3, Generic Access Profile for sufficient combinations of IO-capabilities for MITM (=authenticated link key).

Message	Action / Comment
PAIR ? <BdAddr>,"<friendlyname>",<Passkey> Example: PAIR ? 0016A4000002,"Laird BTM 000002",863611	Passkey compare request: Expecting the user to compare the passkey displayed on both ends and to confirm a match by "AT+BTBY" at both ends or reject by "AT+BTBN" if passkey does not match
PASSKEY ? <BdAddr>,"<friendlyname>" Example: PASSKEY ? 0016A4000001,"Laird BTM 000001"	Passkey request: Expecting the user to enter the passkey displayed by the remote device. Use AT+BTB<passkey>, example: AT+BTB012345 *see(1) below
PAIR N <BdAddr>,"<friendlyname>",<Passkey> Example: PASSKEY N 0016A4000002,"Laird BTM 000002",164585	Passkey notification: Display BdAddr, friendly name and passkey to user; Expecting the user to enter the passkey from this message at the remote device's numeric keyboard.
PAIR 0 <BdAddr> <nn>	Successfully paired with device of <BdAddr>. <nn> (optional) indicates the status of automatic storage to trusted device list. Value 0 = success; Settings controlled by S325 to S328. Please refer to section 2.3, page 37
PAIR 1 <BdAddr>	Pairing timeout
PAIR 2 <BdAddr>	Pairing failed
PAIR 3 <BdAddr>	Pairing failed (too many repeat attempts)
PAIR 4 <BdAddr>	Pairing rejected by remote device
PAIR 5 <BdAddr>	Pairing failed (unit keys not supported)
PAIR 6 <BdAddr>	Pairing failed (SSP not supported)
PAIR 7 <BdAddr>	Pairing failed (already busy with pairing)
(1) If both devices have a "KeyboardOnly" capability, no pass key can be displayed. In that case, the user is required to invent and enter the identical 6 digit numeric passkey at both ends.	

Table 3.7: Asynchronous messages for SSP

10. Known SSP Issues

a.) General Bonding (automatic pairing on link setup if devices have not been paired previously) does not work with legacy devices (BT2.0 and earlier). If the remote device is BT2.0 or earlier, initiate dedicated bonding (AT+BTW<BdAddr>) prior to connection establishment.

b.) Outgoing General Bonding (automatic pairing on link setup if devices have not been paired previously) with MITM does not work with two BTM devices, because any UART input on the initiating device is not accepted until the link has been established. Workaround: initiate dedicated bonding (AT+BTW<BdAddr>) prior to connection establishment.

c.) If the link key of previously paired devices is not available any more in the remote device but still available in the trusted device list (TDL) of the local device (query by AT+BTT?), pairing will fail. In that case remove the device address from the local TDL using AT+BTD<BdAddr> and reinitiate pairing from the local device (AT+BTW<Bd_addr>).

AT COMMAND SET REFERENCE

AT Commands for Legacy Pairing

1. AT+BTW<bd_addr> {Initiate Pairing}

   Provided the remote device is a Bluetooth 2.0 device or earlier and legacy pairing is not disabled (S323 = 0), this command is used to initiate legacy pairing with the device with <bd_addr>. Legacy pairing refers to the mechanism of entering an identical PIN key on both ends.

   If the PIN is required (if not set earlier by AT+BTK="<PIN>"), asynchronous indications will be sent to the host in the form PIN? <bd_addr> where the address confirms the device with which the pairing is to be performed. To supply a PIN, use the AT+BTK command.

   For a successful pairing, the link key is stored in a volatile cache which is overwritten every time a new pairing is initiated using this command. If S register 325=1, the link key is automatically saved to the non-volatile trusted device list. Otherwise (S325=0) the link key can be added to the trusted device list by AT+BTT. Please refer to below under AT Commands managing Trusted Devices for further AT commands related to trusted device list.

   The "OK" response is sent immediately on receipt of the AT+BTW command. On pairing completion, an unsolicited message will be sent to the host which will be in the form PAIR n <bd_addr>.

   If AT+BTI or AT+BTP or AT+BTG or AT+BTQ or ATD is issued between the AT+BTW command and the subsequent PAIR asynchronous response, then an ERROR response will be sent to those commands as the device is not in a mode from where such commands can be actioned.

   Response: <cr,lf>OK<cr,lf>

2. AT+BTK="<string>" {Set Passkey}

   This command is used to provide a PIN passkey. The PIN is stored in non-volatile memory for future use. If this command is used as response to a "PIN? 12345678" asynchronous message, the PIN provided by this command will not be stored in non-volatile memory.

   Specifying an empty string deletes the PIN from the non-volatile memory. The string length must be in the range 0 to 8, otherwise an error will be returned.

   Response: <cr,lf>OK<cr,lf>

3. Legacy Pairing – Asynchronous Messages

   PIN?

   This response is sent to the host during a pairing negotiation.

   The fully qualified string is PIN? 012345678901 where 012345678901 is the Bluetooth address of the peer device. In response, the host must supply a pin code which is entered using the AT+BTK command.

   If the peer does not supply the address in the message exchange, then the address is specified as 000000000000 – and the pairing will proceed as normal.

   PAIR n <bd_addr>

   This response is sent to the host on termination of a pairing process. If pairing was successful then 'n' = 0, if a timeout occurred then 'n'=1 and for all other unsuccessful outcomes the value will be 2. The parameter <bd_addr> is the address of the peer device if available.

   PAIR 0 <bd_addr> MM

   This response is sent to the host on termination of a successful pairing process. The optional MM is sent only if the according S Register 325..328 is set to 1 to automatically save the link key (see Section 2, pg 37) The value MM indicates the result of the save operation and a value of 00 implies success, otherwise the value corresponds to an error code.

AT COMMAND SET REFERENCE

AT Commands Managing Trusted Devices

1. AT+BTT? {List Trusted Device}

   This command is used to list the contents of the trusted device database. The link key is NOT displayed so the response is as shown below. If the list is empty then just the OK response is sent otherwise an OK is used to terminate the list. Use the command ATI6 to read the maximum size of the trusted device database.

   Response: <cr,lf>12346789012

   <cr,lf>12345678913

   <cr,lf>12345678914

   <cr,lf>OK<cr,lf>

2. AT+BTT {Add Trusted Device}

   This command is used to store the cached link key in the non-volatile database. If the database is full it will respond with an ERROR. If the device is already in the database, then the key is replaced. If the link key cache is empty, that is, a pairing has not been performed since the device was powered, then the response will be an ERROR.

   Response: <cr,lf>OK<cr,lf>

   Or

   Response: <cr,lf>ERROR<cr,lf>

3. AT+BTD<bd_addr>{Remove Trusted Device}

   This command is used to remove the specified device from the list of trusted devices in the non-volatile database. If the device is not in the database then the response will still be an OK.

   Response: <cr,lf>OK<cr,lf>

4. AT+BTD* {Remove All Trusted Devices}

   This command is used to remove all devices from the trusted device list (TDL) in the non-volatile database. No confirmation will be asked for. So beware!!!

   WARNING: If you make a connection, the link key gets cached in the underlying stack. So if you subsequently delete the key using AT+BTD* and immediately request a connection to the same device, then the connection will be established. To ensure this does not happen, send ATZ after the AT+BTD*.

   Response: <cr,lf>OK<cr,lf>

5. AT+BTW? {List Cached Trusted Device}

   This command is used to list the cached trusted device.

   Response: <cr,lf>12346789012

   <cr,lf>OK<cr,lf>

   If the cache is empty the response is as follows.

   Response: <cr,lf>OK<cr,lf>

AT Commands for Serial Stream Oriented Profiles (SSO)

The Serial Port Profile (SSP) and the Dial-up Networking Profile (DUN) belong to the group of Serial Stream Oriented profiles (SSO).

When activated, an SSO profile claims one UART for its data stream and assumes all data at the UART to be transmitted over or received from RF 1:1. Hence, as there is only one UART available on a BTM device, the UART is not available for other profiles, services or module control purposes.

One approach of managing data and control over UART is to configure local command mode with S531=3. In this mode, incoming RF data is presented by the asynchronous message RX<string>. Outgoing data is sent by ATX<string> or ATY<string>.

With this approach it is possible to manage several non-SSO connections (e.g. A2DP, AVRCP) and at maximum one SSO connection (SSP or DUN). An attempt to connect a second SSO profile while already one SSO connected will result in Error 65.

Any incoming connection request to an SSO profile will be rejected if one SSO is already connected.

The following section describes AT- commands related to SSO-profiles

AT COMMAND SET REFERENCE

1. ATX"<string>" {Send Data in Local Command and Connected Mode}

   This command is used to send data to the remote device when in local command and connected mode.

   The parameter <string> is any string not more than 29 characters long whereby a non printable character (\hh, see below) counts 3 characters. This restriction results from the maximum AT command length which is 34 (query by ATI15). The difference of 5 is caused by "ATX" (3 characters) and the enclosing quotation marks (2 characters).

   If the maximum string length is exceeded, ERROR 05 (syntax error) will occur.

   If a non-visual character is to be sent then insert the escape sequence \hh where hh are two hexadecimal digits. The 3 character sequence \hh will be converted into a single byte before transmission to the peer.

   Response: <cr,lf>OK<cr,lf>

   Or

   <cr,lf>ERROR 05<cr,lf> (e.g. <string> too long)

2. ATY"<string>" {Send Data in Local Command and Connected Mode}

   This command is similar to ATX in syntax and functionality, except that the string is only copied to the output rf buffer. Only when an empty string is presented, all pending data in the output rf buffer will be flushed out.

   The parameter <string> is any string not more than 29 characters long whereby a non printable character (\hh, see below) counts 3 characters. This restriction results from the maximum AT command length which is 34 (query by ATI15). The difference of 5 is caused by "ATX" (3 characters) and the enclosing quotation marks (2 characters).

   If the maximum string length is exceeded, ERROR 05 (syntax error) will occur.

   If a non-visual character is to be sent then insert the escape sequence \hh where hh are two hexadecimal digits. The 3 character sequence \hh will be converted into a single byte before transmission to the peer.

   Response: <cr,lf>OK<cr,lf>

   Or

   <cr,lf>ERROR 05<cr,lf> (e.g. <string> too long)

3. ^^^ {Enter Local Command Mode}

   When in data and connected mode and when S 507 is set to 0 or 1, the host can force the device into a command and connected mode so that AT Commands can be issued to the device. The character in this escape sequence is specified in the S2 register, so it can be changed. In addition, the escape sequence guard time is specified by S Register 12. By default the guard time is set to 100 milliseconds.

   Leaving data mode by "^^^" has a severe penalty on data throughput, because each incoming character needs to be checked for '^' with respect to the guard time.

   Alternatively, a de-assertion of the DTR/DSR line can be used as the only trigger to leave data mode (S507=2). This gives a significant higher data throughput because data is passed directly between UART and RF without character checking. Please refer to Section 6, pg. 26 for more information.

   In modems this escape sequence is usually "+++". "^^^" is specified to avoid confusion when the module is providing access to a modem.

   Response: <cr,lf>OK<cr,lf>

4. !!!{Enter Remote Command Mode}

   When in data and connected mode, the host can force the remote device into a command and connected mode so that AT Commands can be issued to the device remotely. The escape sequence guard time is specified by S Register 12 and is the same as per the ^^^ escape sequence. By default the guard time is set to 100 milliseconds. The remote device issues ATO as normal to return to data mode (Refer to 5). For this command to be effective S Register 536 must be set to 1.

   Response: <cr,lf>OK<cr,lf>

AT COMMAND SET REFERENCE

5. ATO {Enter Data Mode} (letter 'o')

   Return to data mode. Assume that the module is in data mode after OK is received. Responds with an error if there is no Bluetooth SSO connection.

   Response:

   <cr,lf> CONNECT 123456789012,<<cr,lf> (if it was an incoming connection)

   <cr,lf> CONNECT 123456789012,><cr,lf> (if it was an outgoing connection)

   Or

   Response: <cr,lf>ERROR nn<cr,lf>

6. Dropping SSO Connections

   In a conventional telephony modem, a call is normally terminated by first sending a +++ character sequence enveloped by an escape sequence guard time (of the order of 100 to 1000 milliseconds) to enter local command and connected mode and then the ATH command.

   Laird Technologies BTM devices provide a variety of ways of dropping a connection. One method is similar to the above, but instead a ^^^ character sequence is used. This is to eliminate ambiguity when a data call is in progress via a mobile phone which was established using the mobile phone's Bluetooth AT modem. The second method involves the host dropping the DTR (DSR from the module's viewpoint) handshaking line.

   Being able to drop a connection using the escape sequence ^^^ has a severe penalty on data throughput. In fact, the data rate is of the order of 85kbps instead of about 300kbps. To cater for this performance hit, the device's connection drop capability is configurable to be in one of two modes.

   One mode allows for a connection to be dropped using either method, and the other mode allows for a connection drop using the DTR method only. By default, the device is in the former mode. This mode is selected using the S507 register (Appendix, Table 4.1).

   To reiterate, the escape sequence is as follows:-

   <Guard time><Esc Chr><Guard time><Esc Chr><Guard time><Esc Chr><Guard time>

   This means that even when a file transfer is occurring and it happens to be full of <Esc Chr> characters then it is not going to drop into command mode because, when transferring a file it is going to happen as fast as possible and so the inter character gap is going to be significantly shorter than the <Guard time>.

   The <Esc Chr> character can be changed via the S2 register and the <Guard time> interval can be specified via the S12 register (Appendix, Table 4.1).

7. SSO - Asynchronous Messages

   RX<string>

   This response is sent to the host when the unit is in online-command mode and S Register 531 is set to 3 and data arrives from a peer.

   If the data from the string contains non-visual characters (for example ASCII 0 to 31 and ASCII 128 to 255), then those characters are translated into a 3 character escape sequence starting with '\'. For example the embedded <cr><lf> sequence would be sent as the 6 character string \0D\0A.

   If the data contains the character '"' then it is sent as \22.

   If the data contains the character '\' then it is sent as \5C

AT COMMAND SET REFERENCE

8. SSO – S Registers

The following table lists S registers for SSO profiles.

Register	Default	Range	Description
S2	94	32..126	Escape sequence character. It is not '+' by default as a Bluetooth serial link can be used to connect to a mobile phone which exposes an AT command set, which will in turn use '+' as default. So if both used '+' there will be confusion. 94 is the character '^'.
S12	100	40..5000	Escape sequence guard time in milliseconds, with a granularity of 20ms. New values are rounded down to the nearest 20ms multiple
S507	0	0..2	When set to 0, a connection can be dropped using ^^^ escape sequence only and the state of DSR line is ignored. When set to 1 a connection can be dropped using EITHER the ^^^ escape sequence OR the DSR handshaking line. When set to 2, a connection can only be dropped using a deassertion of DSR. Mode 2 provides for the highest data transfer rate. If the status of the DSR line is to be conveyed to the remote device as a low bandwidth signal then this register MUST be set to 0, otherwise a deassertion of DSR will be seen as a request to drop the Bluetooth connection. This register affects S Register 536 – see details of 536
S531	0	0..4	Specifies the mode on connection establishment. 0 = Normal, that data is exchanged between UART and RF 1 = LOCAL_COMMAND. UART input is parsed by the AT interpreter and RF data is discarded 2 = REMOTE_COMMAND. RF input is parsed by the AT interpreter and UART data is discarded. If S Reg 536 is not 1 then this register cannot be set to 2 and an ERROR will be returned 3 = LOCAL_COMMAND. UART input is parsed by the AT interpreter and incoming RF data is sent to the host using the RX<string> asynchronous response. 4 = LOCAL_COMMAND and on the rf side, the gpio is automatically sent when there is a change in input (digital I/O cable replacement mode).
S536	0	0..1	When set to 1, a remote device can 'capture' the AT parser of this unit by it sending this module an escape "!!!" sequence. The inter character timing is set via S Register 12. If S Register 507 is >= 2, then reading this register will always return 0 and writing 1 will result in ERROR 33.

Table 3.8: S Registers for SSO profiles

AT Commands for a Selected Peer Device

This section describes AT commands to make the BTM Bluetooth device connectable for one particular remote device only or to connect to a particular remote device on reset or on power cycle automatically.

1. AT+BTP<bd_addr> {Make Device Discoverable and Selectively Connectable}

Make the BTM device discoverable (for all devices) and connectable for the device with the Bluetooth address <bd_addr> only. Connection requests from any other devices will be rejected.

If <bd_addr> is 000000000000 then incoming connections are accepted from any device, as per AT+BTP without an address.

The setting remains valid until next reset or power cycle (unless not changed by any other AT command subsequently). For permanent discoverable/connectable settings, please refer to S Register 512 and AT+BTM<bd_addr>

Response: <cr,lf>OK<cr,lf>

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2. AT+BTG<bd_addr>{Make Device Selectively Connectable Only}

   Make the BTM device connectable for the device with the Bluetooth address <bd_addr> only. Connection requests from any other devices will be rejected.

   If the specified address is 000000000000 then incoming connections are accepted from any device, is as per AT+BTP without an address.

   The BTM device is not discoverable.

   The setting remains valid until next reset or power cycle (unless not changed by any other AT command subsequently). For permanent discoverable/connectable settings, please refer to S Register 512 and AT+BTM<bd_addr>

   Response: <cr,lf>OK<cr,lf>

3. AT+BTM<bd_addr> {Set Incoming Peer Address}

   This command is used to store a peer address for incoming connections in non-volatile memory. Only the device with Bluetooth address <bd_addr> will be permitted to make a connection to the BTM device. Connection requests from other devices will be rejected.

   The new setting applies immediately and will retain over a power cycle (unless not changed by any other AT command subsequently).

   When S register 512 = 3, 4, 6 or 7 then the BTM device will wait for an incoming connection from the peer address specified. If <bd_addr> is 000000000000, then incoming connections from any devices are permitted.

   Response: <cr,lf>OK<cr,lf>

4. AT+BTM {Delete Incoming Peer Address}

   This command is used to delete the peer address previously stored using AT+BTM<bd_addr>.

   If the BTM device was connectable for the selected device before this command, it will be connectable for any device immediately after this command.

   Response: <cr,lf>OK<cr,lf>

5. AT+BTM? {Read Incoming Peer Address}

   This command is used to display the peer address stored in non-volatile memory, used to put the module in pure cable replacement mode.

   Response: <cr,lf>12346789012

   <cr,lf>OK<cr,lf>

   If the location is empty the response is as follows.

   Response: <cr,lf>00000000000

   <cr,lf>OK<cr,lf>

6. AT+BTR<bd_addr> {Set Outgoing Peer Address}

   This command is used to store a peer address for outbound connections in non-volatile memory.

   This command is used to set up a module in pure cable replacement mode. If S register 512 = 1 and the peer address is NOT 000000000000, then it will periodically (time specified via S register 505) attempt to connect to the peer address specified. In this circumstance all data from the host are buffered in the receive buffer, until a Bluetooth connection is established with the peer device and it then sends the buffer across. This means that if the peer device is not in the vicinity and will never be there and S507=1 or 2, the device effectively becomes useless, as in this circumstance the module is not listening for commands arriving on the UART.

   In this circumstance, a recovery is possible by one of two methods. The first method assumes that the DTR from the host is connected to the DSR line of the module and S507=1. The second method assumes that this connection is absent and S507=1 or 2.

   In the first method it is enough to deassert the DTR line from the host and that will abort the autoconnect cycle. No "OK" is sent in response. Hence it is up to the host to send a character regularly (e.g. one per second) until the BTM device echoes all buffered characters to the host (provided echo is enabled). Once the BTM device echoes characters it is in command mode.

AT COMMAND SET REFERENCE

The second method is initiated by resetting the device and then ensuring that the text string "AT+BT&BISM&<cr>" is sent (where <cr> is the carriage return character). There is special code which looks out for this magic command and terminates the autoconnect cycle if it sees it and confirms to the host of that fact by sending an "OK" response.

Response: <cr,lf>OK<cr,lf>

7. AT+BTR {Delete Outgoing Peer Address}

   This command is used to delete the peer address previously stored using AT+BTR<bd_addr>.
   Response: <cr,lf>OK<cr,lf>

8 AT+BTR? {Read Outgoing Peer Address}
This command is used to display the peer address stored in non-volatile memory, used to put the device in pure cable replacement mode.
Response: <cr,lf>12346789012
<cr,lf>OK<cr,lf>
If the location is empty the response is as follows.
Response: <cr,lf>00000000000
<cr,lf>OK<cr,lf>

Bluetooth Profiles

This section covers S-Registers and AT-Commands that are related to supported Bluetooth Profiles on BTM.

1. Profile Activation

   In order to activate available profiles and advertise them to potential client devices, S-Register 102 is used. Per default, only SPP is activated (value=1). Other supported profiles can be activated by setting the appropriate Flag in S-Register 102. Once S-Register 102 has been written, the changed value needs to be saved to non-volatile memory ("AT&W") and subsequently a reset ("ATZ") or power cycle is required. Please note that "AT&W" saves the content of all S Registers to non-volatile memory.

2. SPP (Serial Port Profile)

   The serial port profile (SPP) is used for serial data transmission with a remote device in both directions. It behaves like a wireless replacement for a serial cable.

   SSP belongs to the group of serial stream oriented profiles (SSO) so please refer to pg. 24 too.

   In order to use SPP, the profile must be enabled in S102 (value=1). If it was not enabled earlier, set the S register accordingly and issue AT&W followed by ATZ.

   2.1 SPP example

   This section gives an example on how an SPP connection between two Laird BTM devices can be established. It is assumed that two devices A and B are connected to a terminal program e.g. Ezurio Terminal on a PC. The example sequence of AT commands is listed in Table 3.9. Figure 3.2 through to Figure 3.5 are presenting appropriate screenshots with Ezurio Terminal.

Phase	Dev.	AT Command	Comment
Preparation	A	AT&F*	Restore factory default settings
		ATS102=1	Enable Serial Port Profile (SPP)
		AT&W	Store settings
		ATZ	Reset
Preparation	B	AT&F*	Restore factory default settings
		ATS102=1	Enable Serial Port Profile (SPP)
		ATS0=1	Automatic response after one "RING"
		AT&W	Store settings
		ATZ	Reset
		AT+BTP	Make device temporary connectable and discoverable
		ATI4	Query Bluetooth device address of local device <BdAddr_DevB>

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Phase	Dev.	AT Command	Comment
Initiate connection	A	AT+SPD<BdAddr_DevB>	Initiate SPP connection from device A to device B. Asynchronous messages: "PAIR 0…" (pairing successful, A and B) "RING…" (B only) "CONNECT…" (connected, A and B)
Connected	A,B	<data>	Any character entered on one end is displayed at the other end.
Enter command mode	A or B	^^^	Response "OK" : Command mode confirmed, now AT commands are expected at the UART; UART data from host is not sent across to remote device
Disconnect		AT+SPH	Response "NO CARRIER…" (A and B): disconnection confirmed

Table 3.9: SPP Example Command Sequence

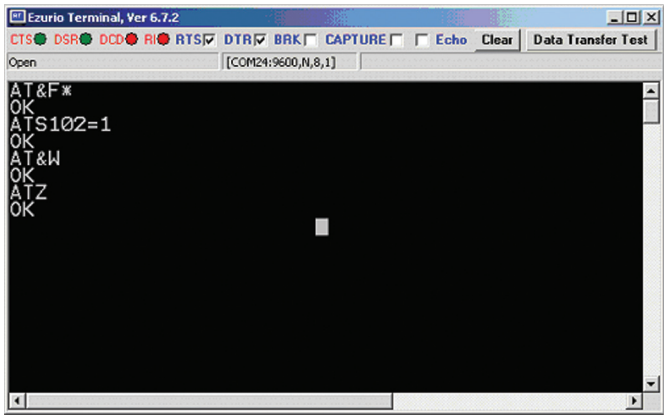


Figure 3.2: SPP example - Preparation of Device A

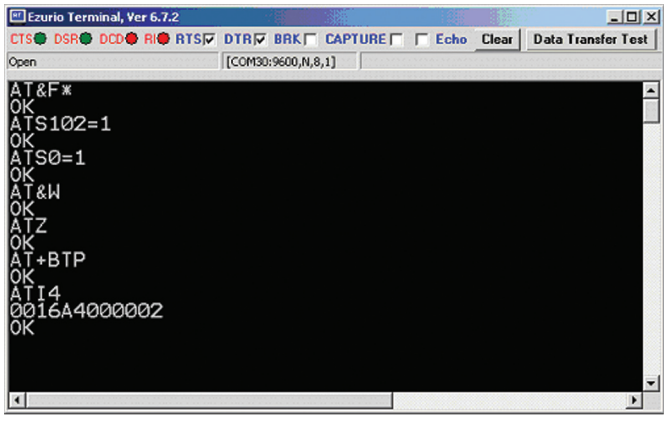


Figure 3.3 SPP example – Preparation of Device B

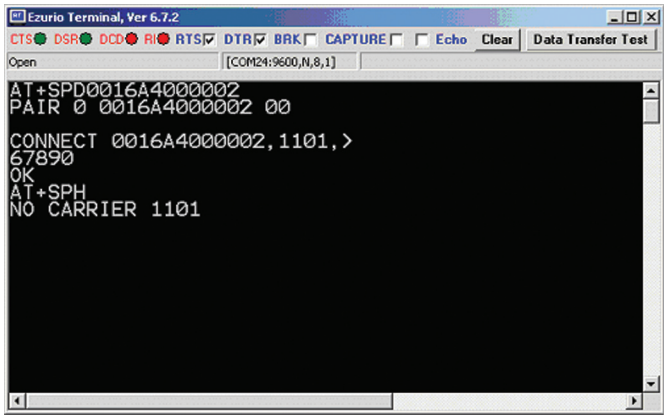


Figure 3.4: SPP example Device A - initiate connection, receiving data, command mode, disconnect

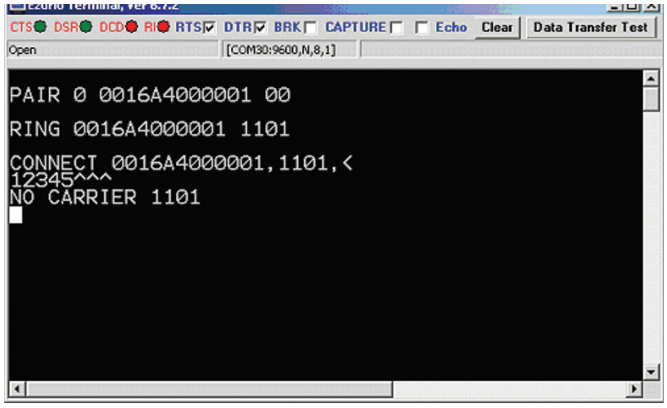


Figure 3.5: SPP example Device B - incoming connection, receiving data, disconnection

2.2 ATA {Accept Incoming SPP Connection Request}

Accept an incoming connection, which is indicated by the unsolicited string <cr,lf>RING 123456789012<cr,lf> every second. 123456789012 is the Bluetooth address of the connecting device.

Response: <cr,lf>CONNECT 123456789012,1101,<<cr,lf>

2.3 AT+SPD<bd_addr> {Make Outgoing SPP Connection}

Initiate an SPP connection to device with Bluetooth address <bd_addr> and SPP profile. The timeout is specified by S register 505.

For backward compatibility, the following command fulfils the same purpose: ATD<bd_addr>.

Response: <cr,lf>CONNECT 123456789012,1101,><cr,lf>

Or <cr,lf>NO CARRIER<cr,lf>

Due to a known issue in the Bluetooth RFCOMM stack, it is not possible to make more than 65525 outgoing connections in a single power up session. Therefore if that number is exceeded, then the connection attempt will fail with the following response:-

Response: <cr,lf>CALL LIMIT

Or <cr,lf>NO CARRIER<cr,lf>

In that case, issuing an ATZ to reset the device will reset the count to 0 and more connections are possible.

AT COMMAND SET REFERENCE

2.4 AT+SPDL {Remake Connection}

Make a SPP connection with the same device as that specified in the most recent AT+SPD command. An error will be returned if the 'L' modifier is specified AND a Bluetooth address.

For backward compatibility, the following command fulfils the same purpose: ATDL

Response: <cr,lf>CONNECT 123456789012,><cr,lf>

Or <cr,lf>NO CARRIER<cr,lf>

2.5 AT+SPDR {Make SPP Connection to Peer Specified in AT+BTR}

Make a SPP connection with the device address specified in the most recent AT+BTR command. An error will be returned if the 'R' modifier is specified AND a Bluetooth address.

For backward compatibility, the following command fulfils the same purpose: ATDR

Response: <cr,lf>CONNECT 123456789012,><cr,lf>

Or <cr,lf>NO CARRIER<cr,lf>

2.6 AT+SPH {Drop SPP Connection}

Drop an existing SPP connection or reject an incoming connection indicated by unsolicited RING messages.

For backward compatibility, the following command fulfils the same purpose: ATH

Response: <cr,lf>NO CARRIER<cr,lf>

2.7 SPP – Incoming Connections

The Laird Technologies BTM device can be configured using the AT+BTP or AT+BTG command so that it will scan for incoming connections from other Bluetooth devices. It can also be configured via S Register 512 to be in this mode by default on power up.

When the lower layers detect an SPP connection request, a RING 123456789012 string is sent to the host every second. The command ATA is used to accept the connection and ATH to reject the request.

On connection, if the S0 Register is >=0 then confirmation to the host is in the form:-

CONNECT 123456789012,1101,<

When S0 register is -1, neither RING nor CONNECT is sent to the host and the connection is silently accepted.

If the S 100 register is non-zero, then after the ring indications specified by this register have been sent to the host, and the host has failed to accept or reject the incoming connection, then an automatic 'hangup' is initiated.

2.8 SPP – Asynchronous Messages

RING

This string is sent to the host when a remote device is initiating a serial port connection. The fully qualified string is in the form RING 012345678901 where 012345678901 is a 12 digit hexadecimal number which corresponds to the remote device's Bluetooth address. This response is sent to the host every 2 seconds until the host either accepts the connection using the ATA command or rejects it using the ATH command.

CONNECT 123456789012,1101,<

An SPP connection has with Bluetooth device 123456789012 has been established successfully. The connection was initiated by the remote device (incoming).

CONNECT 123456789012,1101,>

An SPP connection has with Bluetooth device 123456789012 has been established successfully. The connection was initiated by the local device (outgoing).

AT COMMAND SET REFERENCE

2.9 SPP – S Registers

S Registers for SPP are summarized in Table 3.10.

Register	Default	Range	Description
S0	0	-1..15	Number of RING indication before automatically answering an incoming connection. A value of 0 disables autoanswer. If -1, then autoanswer on one RING and do NOT send RING/CONNECT response to the host. This emulates a serial cable replacement situation Setting values >= 0, resets S Register 504 to 0 and <0 forces 504 to 1. If S0 <> 0 and S100 <> 0 then S0 must be < S100. If a value is entered which violates this rule, then ERROR 29 is sent in response. If S504 =1 then this register will return -1, regardless of the actual value stored in non-volatile memory.
S100	15	0..15	Number of RING indications before an auto disconnection is initiated. A value of 0 disables this feature. If S0 <> 0 and S100 <> 0 then S0 must be < S100. If a value is entered which violates this rule, then ERROR 29 is sent in response.

Table 3.10: S Registers for SPP

Hardware Units (BTM410 / 411)

This section covers S-Registers and AT-Commands that are related to hardware units of a BTM410 or BTM411 device. For this section, please also refer to the bluecore data sheet [5] for further information.

1. Codec Gain

   The BTM410/411 can operate with an external PCM codec. Laird provides a number of different codec evaluation boards designed for use with the BTM410/411 development kit. For example the ACC-05 is a codec evaluation board based around the Winbond W681360 codec [6]. The platform provides flexible support for different codec formats (μ-law, A-law and 13 bit linear). If 13 bit linear format is chosen, then the 13 bit sample will be transmitted over the PCM interface as the MS 13 bits of a 16 bit word. The LS 3 bits may be used to control the output gain of the codec (for example on the Winbond W681360) and the AT software allows this output gain setting to be controlled using s-register 589 as described in Table 3.11.

2. Hardware Units - S Registers

   Table 3.11 below gives an overview on S Registers for hardware units except GPIO. For GPIO Registers please refer to Table 3.13: GPIO S Registers

Register	Default	Range	Description
S589	8	0..8	External codec output gain

Table 3.11: S Registers for Hardware Units

AT COMMAND SET REFERENCE

3. GPIO

On a BTM410/411 device a number of digital I/Os can be used for general purposes. Each GPIO will be assigned to an S-Register (S651 to S663) which will be capable of both GPIO configuration (config mode) as well as single pin read/write access (r/w mode). The bitmask of the I/O pin for direct read/write access will be 0x01. All configuration flags are allocated to higher value bits. A bitmask for the I/O pin will be applied to if S-Register 650 is set to 1. This will enable the user to access a GPIO-Pin directly by reading/writing 0 or 1. If the GPIO shall be configured, S650 must be set to 0 in order to obtain access to the GPIO configuration flags.

All logical GPIO lines can be read/written in one atomic step by new S-Register 670 at any time.

Some GPIOs can have an alternative function assigned. If the alternative function is enabled, the appropriate I/O Pin is not available as GPIO any more. Handshaking functions are generally enabled per default. Wi-Fi coexistence functions are currently not used. But if they should be used or required in the future, the appropriate function cannot be moved to another I/O Pin. Hence it should be considered that no other user function is assigned to an I/O Pin if the coexistence functions are required. The following table lists all GPIOs and their alternative functions.

GPIO Pin (BTM410/411)	Alternative Function	
	Handshaking	Wi-Fi Coexistence
GPIO1	RI	-
GPIO2	DCD	-
GPIO3	-	BT_Priority / Ch_Clk
GPIO4	-	BT_Active / BT_ State
GPIO5	-	Wlan_Active
GPIO6	-	Rf_Active
GPIO7	DTR	-
GPIO8	DSR	-

GPIO - Alternative Functions BTM410/411

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Reserved												FME	INV	DIR	PS
Default	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3.6: GPIO configuration register

AT COMMAND SET REFERENCE

Field	Description
0 – PS	I/O Pin State – returns the current state of the I/O pin (0/1) when read A write affects the I/0 pin directly if DIR=1 and FME=0
1 – DIR	Direction – controls if the I/O pin is an input or an output 0 input 1 output
2 – INV	Inversion – controls if the I/O pin is inverted or not. Applies to both pin directions (read and write). 0 not inverted 1 inverted
3 – FME	Function Mapping Enable – Enables function mapping of the pin. A function mapping code must be set in GPIO configuration register [8:15]. The pin will carry out the assigned operation and is not accessible anymore as GPIO. 0 disable function mapping 1 enable function mapping
[4:15]	Reserved

Table 3.12: GPIO Configuration Register Field Descriptions

Register	GPIO	Default	Range	Comment
S650		0	0..1	Mode for GPIO Config Registers: 0 = no mask; 1 = enable i/o pin state Mask
S651	GPIO1	0x0000	0..0xFFFF	GPIO Configuration Registers S650 must be set to 0 to enable configuration access Controls Pin State, Pin Direction, Pin Inversion, Function Mapping Enable, Function Mapping Select and Function Mapping Code / av_operation_id. See Table 3.12: GPIO Configuration Register Field Descriptions
S652	GPIO2			
S653	GPIO3			
S654	GPIO4			
S655	GPIO5			
S656	GPIO6			
S657	GPIO7			
S658	GPIO8			
S670	GPIO1..8	0x0000	0..0xFF	Read/Write all GPIOs in one atomic step (Write operation only affects GPIOs configured as outputs) 0x0001: GPIO1 0x0002: GPIO2 0x0004: GPIO3 0x0008: GPIO4 0x0010: GPIO5 0x0020: GPIO6 0x0040: GPIO7 0x0080: GPIO8

Table 3.13: GPIO S Registers

AT COMMAND SET REFERENCE

Miscellaneous

1. SCO / eSCO Audio Link

BTM modules provide an AT command to establish an SCO / eSCO audio connection between a pair of BTM modules (or BISM2). This enables the user to create bidirectional audio links independently from a particular Bluetooth profile. The only prerequisite is the existence of a Rfcomm link (serial port profile) between the modules. If this link doesn't exist, it can be created using AT+SPD<BdAddr>. Please refer to pg. 29.

A SCO/eSCO link is intended for bidirectional transmission of speech. The sampling rate is fixed to 8 kHz, meaning a usable bandwidth of 3.5 kHz.

For SCO there are 3 packet types defined in the Bluetooth specification [1]: HV1, HV2, HV3. Each of them occupies one slot. They differ in the level of bit error checking. It is recommended to enable all three packet types for SCO links. This will pass the final decision down to the baseband. There is no retransmission of erroneous SCO packets.

For eSCO and basic data rate, there are 3 packet types defined in the Bluetooth specification [1]: EV3, EV4, EV5. EV3 occupies one slot, EV4 and EV5 can occupy up to three slots each. They differ in the level of bit error checking. It is recommended to enable all three packet types for eSCO links. This will pass the final decision down to the baseband. eSCO packets involve a CRC code and retransmission of erroneous eSCO packets.

Packet types and link types (SCO or eSCO) are negotiated on link setup. A BTM can accept either incoming SCO or eSCO links (S register 584), but not both SCO and eSCO at one time. If the initiating side requests an unsupported link type, the audio link will fail. The initiating BTM module is supposed to request the remaining link type in that case.

Table 3.14 lists all AT commands and S-Registers for SCO/eSCO links.

Task	AT-Command/S-Register	Comment
Initiate SCO link	AT+BTAx	x = packet type bitmask, recommended value = 7 1 = HV1 2 = HV2 4 = HV3
Initiate eSCO link	AT+BTA100x	x = packet type bitmask, recommended value = 7 1 = EV3 2 = EV4 4 = EV5
Release SCO/eSCO link	AT+BTA0 / AT+BTA	
Initiate SCO/eSCO link	AT+BTA8	Link type (SCO/eSCO) and packet types defined by S584.
Enable either SCO or eSCO for incoming requests and for AT+BTA8	S584 [0..1]	0 = SCO (HV1,HV2,HV3) enabled 1 = eSCO (EV3,EV4,EV5) enabled Only one link type can be enabled at one time.
Initiate SCO/eSCO link automatically on each SPP link	S532 [0..7]	The recommended value to enable this feature is 7. Value = bitmask for packet type. The link type (SCO/eSCO) is defined by S584. 0 : Feature disabled 1 : HV1 (S584=0) or EV3 (S584=1) 2 : HV2 (S584=0) or EV4 (S584=1) 4 : HV3 (S584=0) or EV5 (S584=1)

Table 3.14: SCO/eSCO AT-commands and S-Registers

AT COMMAND SET REFERENCE

1.1 SCO / eSCO Asynchronous Messages

The following asynchronous messages apply to SCO/eSCO connections

AUDIO ON (SCO)

This response is sent to the host when a SCO channel has been established.

AUDIO ON (eSCO)

This response is sent to the host when a eSCO channel has been established.

AUDIO OFF

This response is sent to the host when an existing SCO/eSCO channel has been closed.

AUDIO FAIL

This response is sent to the host when a SCO channel setup fails. This might be caused by the fact that the peer only accepts eSCO connections but a SCO connection was requested or vice versa. Please try to initiate the SCO connection with the remaining link type.

2. Link Key Management

On a BTM device, link keys are managed by the AT firmware. Appropriate AT commands are described on page 23. There is a range of S Registers defining the behavior of automatic link key storage on incoming/outgoing and dedicated/general bonding.

2.1 Dedicated Bonding

In BT2.1 specification, "dedicated bonding" is defined as the exchange of link keys between two devices without the intention of establishing a connection immediately.

Dedicated bonding is initiated by "AT+BTW<BdAddr>" (initiation of pairing).

2.2 General Bonding

In BT2.1 specification, "general bonding" is defined as the exchange of link keys between two devices with the intention of establishing a connection immediately. This is the case if a device tries to connect to another device without existing link key. Hence, pairing (authentication and exchange of link keys) is initiated automatically prior to the connection.

General bonding is initiated by a connection requesting AT command if there is no link key for the peer device existing. Such AT commands are:

"AT+SPD<BdAddr>", "AT+APD<BdAddr>", "AT+AVD<BdAddr>", "AT+HSD<BdAddr>", "AT+HSGD<BdAddr>", "AT+HFD<BdAddr>", "AT+HFGD<BdAddr>", "AT+DUD<BdAddr>"

2.3 Automatic Storage of Link Keys

Four S Registers define the automatic storage of link keys in the trusted device list, depending on incoming/outgoing and general/dedicated bonding. Please see Table 3.15.

Task	S-Register	Comment
Automatic link key storage on dedicated bonding outgoing (DBO)	S325 [0..1]	0 = do not store (cache only) 1 = store automatically (default) identical with S538
Automatic link key storage on general bonding outgoing (GBO)	S326 [0..1]	0 = do not store (cache only) 1 = store automatically (default)
Automatic link key storage on dedicated bonding incoming (DBI)	S327 [0..1]	0 = do not store (cache only) 1 = store automatically (default)
Automatic link key storage on general bonding incoming (GBI)	S328 [0..1]	0 = do not store (cache only) 1 = store automatically (default)

Table 3.15: Automatic storage of link keys

3. Profile Connection Status

The connection status of a profile can be queried by an ATI-Command. This might be helpful in order to decide whether to disconnect all connected profiles (via ATH*) or a certain one. For details please see Table 3.16.

AT COMMAND SET REFERENCE

Task	AT-Command	Comment
Get connection status of SPP	ATI60	0 = not connected 1 = connected (local command mode) 2 = connected (remote command mode) identical with ATI9
Get connection status of A2DP	ATI61	0 = not connected 1 = connected
Get connection status of AVRCP	ATI62	0 = not connected 1 = connected
Get connection status of HSP-Headset	ATI63	0 = not connected 1 = ACL connected 2 = audio connected
Get connection status of HSP-AG	ATI64	0 = not connected 1 = ACL connected 2 = audio connected
Get connection status of HFP-HF	ATI65	0 = not connected 1 = SLC connected 2 = audio connected 3 = in call, SLC 4 = in call, audio
Get connection status of HFP-AG	ATI66	0 = not connected 1 = SLC connected 2 = Audio connected 3 = in call - SLC 4 = in call – audio
Get connection status of DUN	ATI67	0 = not connected 1 = connected

Table 3.16: Profile connection status

4. Disconnecting Profiles

   A connection to a profile can be released by “ATH<Profile-UUID>”. For A2DP and AVRCP this means a second way of disconnecting

   The response on a disconnect command is usually “NO CARRIER <profileUUID>” if a connection has existed and S329=0. If no connection has existed and S329=0, no profileUUID is appended.

   If all connections are to be released, ATH* may be used. Please see Table 3.17.

AT COMMAND SET REFERENCE

Task	AT-Command	Comment
Disconnect SPP	ATH1101 or AT+SPH or ATH	Single "ATH" retained for backward compatibility, response "NO CARRIER" or "NO CARRIER 1101" depending on S329 and if a SPP connection has existed previously
Disconnect A2DP	ATH110D or AT+APH	If A2DP connection released: response = "NO CARRIER 110D"; If no A2DP connection has existed: response = "NO CARRIER"
Disconnect AVRCP	ATH110E or AT+AVH	If AVRCP connection released: response = "NO CARRIER 110E"; If no AVRCP connection has existed: response = "NO CARRIER"
Disconnect HSG	ATH1112 or AT+HSGH	If AG(HSP) connection released: response = "NO CARRIER 1112"; If no HSP connection has existed: response = "NO CARRIER"
Disconnect HS	ATH1108 or AT+HSH	Must be enabled by S332 because it would result in a behavior not defined in HSP specification. If HS(HSP) connection released: response = "NO CARRIER 1108"; If no HSP connection has existed: response = "NO CARRIER"
Disconnect HFG	ATH111F or AT+HFGH	If AG(HFP) connection released: response = "NO CARRIER 111F"; If no HSP connection has existed: response = "NO CARRIER"
Disconnect HF	ATH111E or AT+HFH	If HF(HFP) connection released: response = "NO CARRIER 111E"; If no HSP connection has existed: response = "NO CARRIER"
Disconnect all profiles listed in this table	ATH*	Response: "NO CARRIER <ProfileUUID>" for each previously connected profile or "NO CARRIER" if no existing connection found or HS connected but S332=0

Table 3.17: Profile release commands

5. Legacy Response Format (BISM2)

   Some BISM2 responses have been slightly changed on BTM modules in order to provide enhanced functionality. If required, a BISM2 compatible response format can be enabled by S Register 329. Table 3.19 shows the implications of enabled/disabled legacy response format.

Task	S-Register	Comment
Enable legacy response format (BISM2 compatible)	S329 [0..1]	0 = disabled (default) 1 = enabled

Table 3.18: Enabling/Disabling legacy response format

Command	Legacy response format enabled (S329=1)	Legacy response format disabled (S329=0)
"AT+SPH";"ATH1101"	Response = "NO CARRIER"	If SPP was connected, response = "NO CARRIER 1101" If SPP was not connected, response = "NO CARRIER"
"AT+APH";"ATH110D"	Response = "NO CARRIER"	If A2DP was connected, response = "NO CARRIER 110D" If A2DP was not connected, response = "NO CARRIER"
"AT+AVH";"ATH110E"	Response = "NO CARRIER"	If AVRCP was connected, response = "NO CARRIER 110E" If AVRCP was not connected, response = "NO CARRIER"
"AT+HSH";"ATH1108"	Response = "NO CARRIER"	If HS instance was connected, response = "NO CARRIER 110E" If HS instance was not connected, response = "NO CARRIER"
"AT+HSGH";"ATH1112"	Response = "NO CARRIER"	If HSG instance was connected, response = "NO CARRIER 1112" If HSG instance was not connected, response = "NO CARRIER"

AT COMMAND SET REFERENCE

Command	Legacy response format enabled (S329=1)	Legacy response format disabled (S329=0)
"AT+HFH";"ATH111E"	Response = "NO CARRIER"	If HF instance was connected, response = "NO CARRIER 111E" If HF instance was not connected, response = "NO CARRIER"
"AT+HFGH";"ATH111F"	Response = "NO CARRIER"	If HFG instance was connected, response = "NO CARRIER 111F" If HFG instance was not connected, response = "NO CARRIER"
"AT+DUH";"ATH1103"	Response = "NO CARRIER"	If DUN was connected, response = "NO CARRIER 1103" If DUN was not connected, response = "NO CARRIER"

Table 3.19: Implications of S329

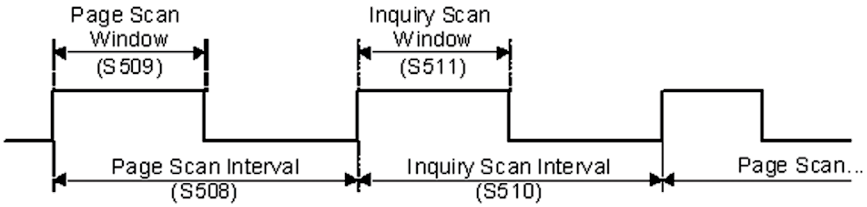
6. Page Scan / Inquiry Scan Interval and Window

Page scanning means being connectable. Inquiry scanning means being discoverable. With the following S registers the power consumption of the BTM can be influenced. However, lower power consumption means longer connection establishment time and longer time until a BTM is discovered by other devices.

The page scan window defines the time for the module to look out for incoming connection requests (paging). The inquiry scan window defines the time for the module to look out for incoming inquiry requests (device discovery). If the module is both connectable and discoverable (512=4 or AT+BTP issued), it will mutually do page scanning and inquiry scanning as shown in Figure 3.7. If connectable only, the module will perform page scanning only (repeatedly) and if discoverable only, then the module will perform page scanning only.

S register 508 defines the page scan interval in ms, range is [11..2250].

S register 509 defines the page scan window in ms, range is [11..2250].



S register 510 defines the inquiry scan interval in ms, range is [11..2250].

S register 511 defines the inquiry scan window in ms, range is [11..2250].

Figure 3.7: Page and Inquiry Scan Intervals and Windows

7. Sniff Mode

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 optimize 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 on slave side. In general, a slave draws about 5 times the current of a master. 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.

AT COMMAND SET REFERENCE

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 M-N 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 BTM 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.

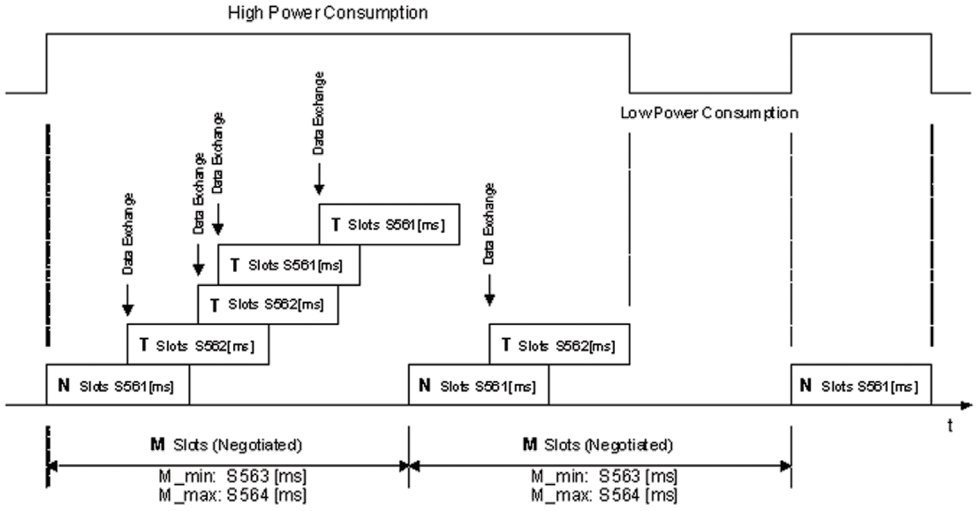


Figure 3.8: Sniff Mode Example

8. Maximum RF-Tx Power Level

   The maximum RF transmit power level for all operation states (inquiring / connecting / in connection) is controlled by S541 / S542.

9. Manufacturing Info String

   A string with manufacturing information can be retrieved by "ATI200".

10. Bluetooth Version

    The Bluetooth version can be queried by "ATI18".

11. Legacy Issues (BT2.0)

    There are some special cases if a legacy device (BT2.0 or earlier, e.g.BISM2) requests a connection to a BTM device (BT2.1).

    General bonding does not work if initiated by the legacy device. Instead, the legacy device must initiate dedicated bonding first (=pairing, BISM2: "AT+BTW<BdAddr>"). After successful pairing, the connection can be initiated by the legacy device (BISM2: "ATD<BdAddr>").

AT COMMAND SET REFERENCE

12. Factory Default UART Baud Rate

BTM devices are capable of operating at a very wide range of baud rates. S Registers 520 and 521 allow the baud rate to be set.

As long as the equation BAUDRATE * 0.004096 produces an integer value, then there will be 0% error in clocking for that baud rate.

So it is possible to set a baud rate that a PC cannot cope with, and in that circumstance it is virtually impossible to communicate with it.

To cater for this circumstance, the BTM device will come out of reset using 9600,N,8,1 comms settings for exactly 750 milliseconds and then revert to the communication parameters as per the S Registers.

If the host sends the string !<BISM>!<cr> where <cr> is the carriage return character within that 750ms period, then the module will remain at 9600,N,8,1 and will also configure itself using factory default S Register values.

If connected to a PC using Ezurio Terminal, the module can be reset to the factory default baud rate as follows:

Right click in the Ezurio Terminal window → Factory Default → Via BREAK/CMD @ 9600

(Tested with version 6.7.2 of Ezurio Terminal)

13. RI dependent Start-up Mode

The UART_RI line can be configured as an input and on power up its state can be used to force the device into one of two modes, defining discoverability and connectability state. See description for S Registers 565 to 569 inclusive for more details.

For example, the feature could allow a device to make an outgoing connection if RI is in one state, and be ready for an incoming connection in the other.

14. Reset via BREAK

The module can be reset by sending a BREAK signal. A BREAK signal exists when the module's UART_RX input is in a non-idle state (0v) for more than 125 milliseconds.

Ezurio Terminal provides a BREAK capability which can be used to reset a connected BTM device by ticking and un-ticking the BRK field, see Figure 3.9.

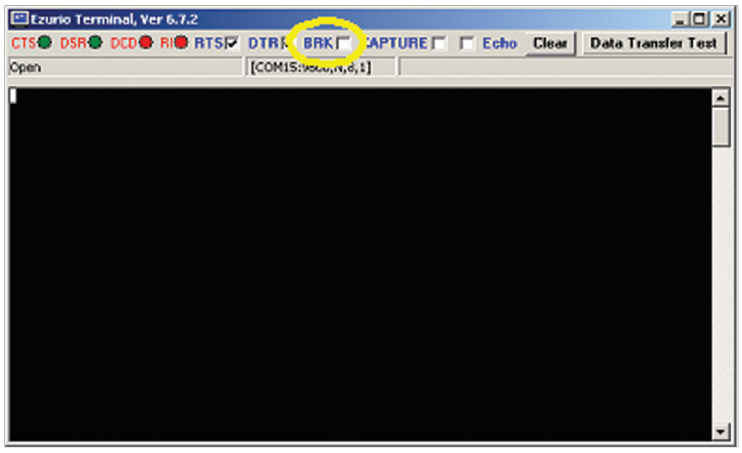


Figure 3.9: BREAK capability in Ezurio Terminal

15. Append Bluetooth Address to Friendly name

If S Reg 593 is set to 1, then the last 6 hex digits of the Bluetooth address are automatically appended to the friendly name. This allows multiple devices with the same name in a neighbourhood to be differentiated.

AT COMMAND SET REFERENCE

Appendix

General S Registers

The following table lists all general S Registers. Please not that this is not a complete listing of S Registers. Additional S registers, associated with a certain profile or feature are described in the appropriate section above.

Register	Deflt.	Range	Description
S2	94	32..126	Escape sequence character. It is not '+' by default as a Bluetooth® serial link can be used to connect to a mobile phone which exposes an AT command set, which will in turn use '+' as default. So if both used '+' there will be confusion. 0x5e is the character '^'.
S12	100	40..5000	Escape sequence guard time in milliseconds, with a granularity of 20ms. New values are rounded down to the nearest 20ms multiple
S101	$1101	$0..$ffff	UUID of default SPP based profile when not specified explicitly in the ATD command.
S102	Depending on module variant	Depending on supported profiles	Defines a set of bits masks for enabling profiles. Values can be ORed. A profile can be enabled only if it is supported by the BTM variant. Issue AT&W and ATZ in order to make the new setting effective 0x001 is Serial Port Profile 0x002 is Headset ("HS") 0x004 is DUN 0x008 is Audio Gateway (Headset, "HSG") 0x010 is Handsfree ("HF") 0x020 is OBEX FTP 0x040 is Audio Gateway (Handsfree, "HFG") 0x080 is A2DP 0x100 is AVRCP 0x200 is PBAP 0x400 is HID
S103	1	1..4	Boot Mode on cold boot Boot modes are required to configure some low level device settings which cannot be configured by S registers and AT commands. Currently there are predefined settings defining the PCM data format to be used with certain codec ICs (applies mainly to BC04). 1 – normal 2..4 – for future customization of the module
S325	1	0..1	Store link key automatically on dedicated bonding outgoing (DBO)
S326	1	0..1	Store link key automatically on general bonding outgoing (GBO)
S327	1	0..1	Store link key automatically on dedicated bonding incoming (DBI)
S328	1	0..1	Store link key automatically on general bonding incoming (GBI)
S329	0	0..1	Enable legacy (BISM2) response format
S330	1	1..31	Configure inquiry response of AT+BTI (Bitmask): 1 - show device address 2 - show class of device 4 - show friendly name 8 - show extended inquiry data Values can be ORed
S331	2	0..2	Direction indication style for "CONNECT" messages 0 – disabled 1 – character style: append 'I' to incoming and 'O' to outgoing CONNECT message, separated by a comma 2 – symbol style: append '<' to incoming and '>' to outgoing CONNECT message, separated by a comma applies only to role indicating UUID (e.g.HSP/HFP) and if S329=0

AT COMMAND SET REFERENCE

Register	Deflt.	Range	Description
S334	0	0..1	Enable Extended Sdp Error Codes 0 - disable 1 – enable
S504	0	0..1	Enable silent operation: Setting to 1 will force S0 to -1 and will suppress messages arising from connections or pairing. E.g. CONNECT, NO CARRIER, RING, PAIR etc. Suppressing connection based messaged allows the device to be configured in cable replacement mode
S505	10	2..120	Minimum delay before abandoning connection attempt as a master. Referenced by ATD. In units of seconds. See S Registers 530 and 543 also. Please note that as disconnection time can vary, this register only guarantees the minimum delay. Note that for invalid addresses specified in the ATD command, the "NO CARRIER" response will be immediate. See S register 560 for specifying disconnect max timeout
S506	0	0..1	Enable/Disable echoes. The ATEn command also affects this.
S507	0	0..2	When set to 0, a connection can be dropped using ^^^ escape sequence only and the state of DSR line is ignored. When set to 1 a connection can be dropped using EITHER the ^^^ escape sequence OR the DSR handshaking line. When set to 2, a connection can only dropped using a deassertion of DSR. Mode 2 provides for the highest data transfer rate. If the status of the DSR line is to be conveyed to the remote device as a low bandwidth signal then this register MUST be set to 0, otherwise a deassertion of DSR will be seen as a request to drop the Bluetooth® connection. This register affects S Register 536 – see details of 536
S508	640	11..2550	Page Scan Interval in milliseconds. Minimum is 11.25ms so 10/11ms will give 11.25ms, refer to Section 6, pg. 40.
S509	160	11..2550	Page Scan Window in milliseconds. Minimum is 11.25ms so 10/11ms will give 11.25ms, refer to Section 6, pg. 40.
S510	640	11..2550	Inquiry Scan Interval in milliseconds. Minimum is 11.25ms so 10/11ms will give 11.25ms, refer to Section 6, pg. 40.
S511	160	11..2550	Inquiry Scan Window in milliseconds. Minimum is 11.25ms so 10/11ms will give 11.25ms, refer to Section 6, pg. 40.

AT COMMAND SET REFERENCE

Register	Deflt.	Range	Description
S512	1	0..7	Specify power up state. When set to 0, AT+BTO is required to open the device for Bluetooth® activity. When set to 1, it proceeds to a state as if AT+BTO was entered. When set to 2, it will be discoverable only, similar to issuing AT+BTQ. When set to 3, it will be connectable but not discoverable e.g. AT+BTG When set to 4, it will be connectable and discoverable e.g. AT+BTP. When set to 5, it will be like 2, but all UART RX traffic is discarded in absence of a connection while DSR is asserted. If DSR is not asserted, then it behaves exactly as per mode 2. When set to 6, it will be like 3, but all UART RX traffic is discarded in absence of a connection while DSR is asserted. If DSR is not asserted, then it behaves exactly as per mode 3. When set to 7, it will be like 4, but all UART RX traffic is discarded in absence of a connection while DSR is asserted. If DSR is not asserted, then it behaves exactly as per mode 4. Note that by implication, a change to this can only be seen after a power cycle AND if AT&W is
S514	10	1..60	Pairing Timeout in seconds. This includes the time a host takes to supply the PIN number when PIN? Messages are indicated.
S515	$001F00	$000000.. $FFFFFF	Default Device Class Code. When queried, the value is always printed as a hexadecimal number. To change the device class of the module temporary and immediately without power cycle, use the command AT+BTC. To change the device class of the module permanently, write the new value to this S Register (ATS515=$<devclass$_{hex}$>), save the setting (AT&W) and initiate a power cycle (ATZ).
S516	$000000	0.. $2FFFFFF	Default Device Class filter to be used with AT+BTI when it is not explicitly specified. When queried the value is always printed as a hex number. The seventh most significant digit, can be 0,1 or 2, and is used to specify the type of device class filter. When 0, it specifies no filtering. When 1, it specifies an AND mask and all 24 bits are relevant When 2, it specifies a filter to look for devices with matching major device class which occupies a 5 bit field from bits 8 to 12 inclusive (assuming numbering starts at bit 0). All other 19 bits MUST be set to 0.
S517	20	2..61	Inquiry Length in units of seconds. This parameter is referenced by the AT+BTI command.
S518	8	0..255	Maximum number of responses from an inquiry request. This parameter is reference by the AT+BTI command. If this number is set too high, then AT+BTI will return ERROR 27. For a particular firmware revision, determine the effective maximum value by trial and error. That is, set to a high value, send AT+BTI and if ERROR 27 is returned, then retry with a smaller value. This effective max value will remain unchanged for that particular firmware build.
S519	500	100..3000	When S507>0, and in a connection, DSR can be used to change from data to command state by de-asserting the DSR line for less than the time specified in this register. This value is rounded down to the nearest 100ms

AT COMMAND SET REFERENCE

Register	Deflt.	Range	Description
S520	9600	1200.. ..115200	Change to a standard baud rate. The effect is immediate and in fact the OK will be sent at the new baud rate. Only one of the following baud rates are accepted: 1200,2400,4800,9600,19200,28 800,38400,57600,115200. If S register 525=1, then the maximum baud rate is limited to 115200
S521	9521	1200.. ..921600	Change baud rate to non-standard value. BTM modules support any baud rate. The only limitation is the integer arithmetic involved, which may adjust the applied rate slightly. If the internally computed baud rate is more than 2% offset from the desired input value, then an ERROR will be returned and the old baud rate will prevail. To inspect the actual baud rate, do ATS521? S521 should only be sued for non-standard baud rates. For standard baud rates use S520. The effect is immediate and in fact the OK will be sent at the new baud rate. If S Register 525=1, then the max baud rate is limited to 115200 In the event that a non-standard baud rate is requested, it is entirely possible that the host is not capable of generating such a baud rate. In this case the BTM device cannot be communicated with. If this happens, there is a procedure to recover from this situation which is described in section 12, pg. 42 "Factory Default UART Baud Rate".
S523	1	1..2	Number of Stop bits See S Register 526 for further information.
S524	0	0..2	Parity. 0=None, 1=Odd, 2=Even For the Go blue Activator variant of the module this register is read only. See S Register 526 for further information.
S525	0	0..1	Apply multiplier of 8 to baud rate internally. This is set to 0 (disabled) by default. If S Register 521 > 115200 then this register cannot be set to 1. See S Register 526 for further information.
S526	3	1..3	This register specifies a 2 bit mask used to qualify how S Registers 520 to 525 are actioned. If bit 0 is 1, the new communication parameters affect the UART immediately. If bit 1 is 1, the new communication parameters are stored in non-volatile memory So for example, to change communication parameters, but have them come into effect only after subsequent power cycles, then this register should be set to 2, and likewise to affect immediately and yet not have it persist over a power cycle, the value should be set to 1. Must be set before the baud rate change.
S530	1000	100..15000	Reconnect delay when configured as master in pure-cable-replacement mode. This value is rounded down to the nearest 100ms. See S Register 505 also.

AT COMMAND SET REFERENCE

Register	Deflt.	Range	Description
S531	0	0..4	Specifies the mode on connection establishment. 0 = Normal, that data is exchanged between UART and RF 1 = LOCAL_COMMAND. UART input is parsed by the AT interpreter and RF data is discarded 2 = REMOTE_COMMAND. RF input is parsed by the AT interpreter and UART data is discarded. If S Register 536 is not 1 then this register cannot be set to 2 and an ERROR will be returned 3 = LOCAL_COMMAND. UART input is parsed by the AT interpreter and incoming RF data is sent to the host using the RX<string> asynchronous response. 4 = LOCAL_COMMAND and on the rf side, the GPIO is automatically sent when there is a change in input. (digital I/O cable replacement mode)
S532	0	0..7	If non zero then on every connection, a SCO channel (audio) will be initiated. Bit 0 for HV1, Bit1 for HV2 and Bit2 for HV3. When the connection is lost, the SCO channel disappears along with it.
S535	20	0..41	Link Supervision Timeout. If units go out of range, then a NO CARRIER message will be sent to the host after the time specified here
S536	0	0..1	When set to 1, a remote device can 'capture' the AT parser of this unit by it sending this module an escape "!!!" sequence. The inter character timing is set via S Register 12. If S Register 507 is >= 2, then reading this register will always return 0 and writing 1 will result in ERROR 33.
S539	0	0..1	When set to 1, in idle mode (S512=1), UART Rx characters are discarded if DSR is de-asserted.
S541	20	-43..20	This sets the power level in dBm when inquiring or paging. Reading this register returns the value stored in non-volatile memory.
S542	4	-43..20	As per S541, however reading this register returns the current power level as set in the base band. The read can be different from S541because the actual power is set using a lookup table and the base band rounds down to the nearest value in the table.
S551	$3211	$0..$ffff	This register specifies in each 4 bit nibble, how the outgoing modem status bits to the remote peer gets its value. Bluetooth® allows for RTR, RTC, DV and IC bits to be exchanged over an RFCOMM connection. Nibble 0..3 specifies the source for RTC 4..7 specifies the source for RTR 8..11 specifies the source for DV (i.e. DCD) 12..15 specifies the source for IC (i.e. RI) Each nibble can take the following value:- 0 Always set to 0 1 Always set to 1 2 If DCD (pin 8 on module connector) is output then always 1 If DCD is input then 1 if DCD is asserted otherwise 0 3 If RI (pin 6) is output then always 0 If RI is input then 1 if RI is asserted otherwise 0 4 If DSR (pin 10) is asserted then 1 otherwise 0 In the event that a nibble specifies DSR as the source of its state, be aware that if, S Register 507 is anything other than 0, a de-assertion of DSR will cause the Bluetooth connection to be dropped. If bits 0..3 and 4..7 are set to 0, then some Bluetooth devices will use that as a signal to stop sending any data back.

AT COMMAND SET REFERENCE

Register	Deflt.	Range	Description
S552	$0122	$0..$fff	This register specifies in each 4 bit nibble, how the DTR, DCD, RI output pins are controlled when in a Bluetooth connection Nibble 0..3 specifies the source for DTR 4..7 specifies the source for DCD 8..11 specifies the source for RI Each nibble can take the following value:-\ 0 Do NOT touch the I/O 1 Always deassert 2 Always assert 3 If RTC bit in CONTROL_IND is 1 then assert otherwise deassert 4 If RTR bit in CONTROL_IND is 1 then assert otherwise deassert 5 If DV bit in CONTROL_IND is 1 then assert otherwise deassert 6 If IC bit in CONTROL_IND is 1 then assert otherwise deassert If this register is changed while in command and connected mode, then on going back online using the ATO command, the modem output lines will get refreshed.
S553	$0201	$0..$fff	This register specifies in each 4 bit nibble, how the DTR,DCD,RI output pins are controlled when NOT in a Bluetooth connection Nibble 0..3 specifies the source for DTR 4..7 specifies the source for DCD 8..11 specifies the source for RI In addition it also refers to S Register 552 to see if the relevant pin is an input or not to be touched. If the nibble in 552 is 0, then the relevant pin is an input. Each nibble can take the following value:- 0 Always deassert 1 Always assert 2 Assert if RING is being sent to the host
S554	0	0..900	Post Reset Window: If S Register 512>=2 and <=7 then this register specifies a time in seconds for which the device will stay in the S512 mode after power up or reset. On timeout, it will abort the discoverable and/or connectable and fall back into S512=1 mode, when it is deaf and dumb. (not connectable, not discoverable) Note that if AT+BTR has been used to specify a peer device, then on reverting to mode 1, it will attempt to make a connection to that peer device. A power cycle, reset via BREAK or ATZ is required to see the effects of change.
S555	1	1..7	If S Register 554 is nonzero, then after the post reset (defined by S554) window expires, the mode will revert to the mode specified in this register. This allows, for example, the device to be discoverable and connectable on power up (mode 4 or 7) and on window timer expiry to revert to connectable only (mode 3 or 6). A power cycle, reset via BREAK or ATZ is required to see effects of a change. In some firmware builds, S Registers 565 to 569 inclusive are visible, which allows the start-up mode to depend on the state of RI line (Setting S Reg 565 forces the RI pin to be configured as an input). For this feature to be active, SReg 565 should be set to 1. In that case, on start-up, if RI is asserted, then the start-up mode is defined by S Reg 568 and if de-asserted then S Reg 569.
S558	0	0..1	When 1, the following responses; “RING”, “NO CARRIER” and “CONNECT” are replaced by “BTIN”, “BTDOWN” and “BTUP” respectively. This will eliminate ambiguity when the module has a Bluetooth connection to an AT modem which also gives these responses.
S559	0	0..3	This specifies a mask. When Bit 0 is 1, the response word “ERROR” is replaced by “BTERR” and “OK” is replaced by “ok”. When Bit 1 is 1, then error responses do not include the error number and instead the error number can be retrieved using ATI12.

AT COMMAND SET REFERENCE

Register	Deflt.	Range	Description
S560	15	15..120	Disconnect timeout in seconds. This timer specifies how long to wait for confirmation from the peer device and/or the underlying stack that the connection has been successfully torn down. There can be instances where a confirmation does not arrive and so in this case this timer is used to 'close off' the procedure and put the state machine back into a proper mode for new operations. Time is specified with 15 seconds intervals.
S561	0	0..1000	Sniff Attempt Time in units of milliseconds. 0 means disable. See Section 7, pg. 40 and Figure 3.8.
S562	0	0..1000	Sniff Timeout Time in units of milliseconds. 0 means disable. See Section 7, pg. 40 and Figure 3.8.
S563	0	0..1000	Sniff Minimum Interval in units of milliseconds. 0 means disable. See Section 7, pg. 40 and Figure 3.8.
S564	0	0..1000	Sniff Maximum Interval in units of milliseconds. 0 means disable. See Section 7, pg. 40 and Figure 3.8.
S565	0	0..1	If set to 1, RI (Ring Indicate) line is configured as an input and forces the start-up mode (SReg512) and post-timeout on Start-up mode (SReg555) to be dependent on the state of RI. The RI conditional modes are defined by S Registers 566 to 569 inclusive.
S566	1	1..7	If S565=1, and RI is asserted then this is the mode the device will start up in.
S567	1	1..7	If S565=1, and RI is de-asserted then this is the mode the device will start up in.
S568	1	1..7	If S565=1, and RI is asserted then this is the mode the device will assume after the post-start-up timeout defined in SReg 554 instead of mode defined in SReg555
S569	1	1..7	If S565=1, and RI is de-asserted then this is the mode the device will assume after the post-start-up timeout defined in SReg 554 instead of mode defined in SReg555
S584	0	0..1	Enable/Disable eSCO
S588	0	0..1	After a disconnection, there will be a cold reset
S592	0	0..1	Set this to 1 to reduce the trusted device database to just 1 record when auto saving of pairing is enabled via S reg 538
S593	0	0..1	Automatically append last 6 digits of local Bluetooth address to the Friendly name which was set via AT+BTN or AT+BTF
S1001 to S1010	0	0..2^32	10 General Purpose 32 bit Registers for use by host. These are stored in non-volatile memory.

Table 4.1: BTM - General S Registers

AT COMMAND SET REFERENCE

ATI Commands

The following table lists all ATIn parameters supported by a BTM device. ATI commands provide general information about the BTM device and status information.

Commands	Information
ATI0	The product name/variant.
ATI1	The CSR firmware build number.
ATI2	The AT firmware build number. For internal use only.
ATI3	The AT firmware revision.
ATI4	A 12 digit hexadecimal number corresponding to the Bluetooth address of the BTM device.
ATI5	The manufacturer of this device.
ATI6	The maximum size of trusted device database.
ATI7	The manufacturer of the Bluetooth chipset.
ATI8	The chipset format.
ATI9	SPP connection status: 0=not connected 1=connected in local command mode 2=connected in remote command mode
ATI11	The reason why a "NO CARRIER" resulted in the most recent attempt at making an outgoing connection. Where the response values are as follows: 0 = No prior connection 1 = Connection timeout 2 = Connection attempt cancelled 3 = Normal disconnection 4 = Peer device has refused connection 5 = Service profile <uuid> requested not available on remote device 6 = Connection has failed 32 = ATH was entered 33 = Incoming connection aborted because too many rings 34 = Unexpected incoming connection 35 = Invalid address 36 = DSR is not asserted 37 = Call limit of 65531 connections has been reached 38 = Pairing in progress 39 = No link key 40 = Invalid link key 255 = Unknown Reason
ATI12	The last ERROR response number.
ATI13	The Sniff status is returned as follows:- Response: <cr,lf>a:b,c,d,e<cr,lf>OK<cr,lf> Where 'a' = 0 when not online and 1 when online and Sniff has been enabled, 'b' is the Sniff Attempt parameter, 'c' is the Sniff timeout parameter, 'd' is the minimum sniff interval and 'e' is the maximum sniff interval. All parameters 'b', 'c', 'd' and 'e' are given as Bluetooth slots which are 625 microseconds long converted from values of S Registers 561, 562, 563 and 564 respectively.
ATI14	The current boot mode
ATI15	The maximum length of an AT command, not including the terminating carriage return
ATI16	Codec Output Maximum Gain Range
ATI17	Codec Input Maximum Gain Range
ATI18	Bluetooth version
ATI19	Audio connection status: 0 = off, 1= on
ATI20	Returns the number of bytes pending to be sent in the rf buffer when a connection is up.
ATI33	Version number of Multipoint application (Note: ATI is provided for compatibility in multipoint mode, other AT commands are not available).

AT COMMAND SET REFERENCE

Commands	Information
ATI42	State information. Where the response values are as follows: 13 = NotOpen 14 = OpenIdle 15 = Ringing 16 = OnlineCommand 172 to 177 = waiting for connectable and/or discoverable where the lowest significant digit equates to the value stored in S Register 512 or 555. Note when n=16, ATI9 will return 1.
ATI60	SPP connection status: 0 = not connected, 1 = connected; identical with ATI9
ATI61	A2DP connection status: 0 = not connected, 1 = connected
ATI62	AVRCP connection status: 0 = not connected, 1 = connected
ATI63	HSP-Headset connection status: 0=not connected,1=ACL connected,2=audio connected
ATI64	HSP-Gateway connection status: 0=not connected,1=ACL connected,2=audio connected
ATI65	HF connection status:
ATI60	SPP connection status: 0 = not connected, 1 = connected; identical with ATI9
ATI61	A2DP connection status: 0 = not connected, 1 = connected
ATI62	AVRCP connection status: 0 = not connected, 1 = connected
ATI63	HSP-Headset connection status: 0=not connected,1=ACL connected,2=audio connected
ATI64	HSP-Gateway connection status: 0=not connected,1=ACL connected,2=audio connected
ATI65	HF connection status: 0 = not connected 1 = SLC connected 2 = Audio connected 3 = in call - SLC 4 = in call – audio
ATI67	DUN connection status: 0=not connected 1=connected in local command mode 2=connected in remote command mode
ATI101	The RSSI value in dBm. If a connection does NOT exist then a value of -32786 is returned. A value of 0 means the RSSI is within the golden range this is quite a large band, therefore RSSI is not always a useful indicator. Use ATI111 instead which returns the bit error rate.
ATI111	Returns LinkQual which in the CSR chipset is defined as BER (bit error rate). This returns a value which is the number of bits in error out of 1 million. Hence a value of 0 is best, and larger values are worse. As the value approaches 1000 (BER = 0.1%) it is an indication that the link is very bad and a large number of Bluetooth packets are being lost.
ATI200	Manufacturing data (e.g. module serial number, manufacturing date)
ATI333	Full AT firmware version number

Table 4.2: BTM ATI Commands

AT COMMAND SET REFERENCE

Error Responses

Error	Description
01	Register not recognized
02	Value for register is out of range
03	Incoming call NOT pending
04	No call to connect to. This error code has meaning for ATO only
05	Syntax Error
06	Empty String
06	Device Class could not be stored
08	Invalid Device Class Code
09	Invalid Bluetooth Address
10	Could not set Service or Friendly name
11	PS Store Write
12	PS Store Read
13	Not Idle
14	Incorrect Mode
15	Already Scanning
16	Pairing is already in progress
17	Not USED
18	Not USED
19	Not USED
20	Not safe to write to Non-volatile Store - Ongoing Bluetooth Connection
21	Link Key Cache is Empty
22	Link Key Database is Full
23	Malloc returned NULL - Resource Issue
24	Remote Address same as Local Address
25	Connection Setup Fail, DSR Not asserted
26	Unauthenticated licence
27	Max Responses (See S Register 518) too high. Memory allocation error
28	The length of Pin in AT+BTK is too long
29	Invalid Ring count specified for S Register 0 or 100. If S0<>0 and S100<>0 then S0 must be < S100
30	ADC Error
31	Analogue Value cannot be read as it is set for output
32	Analogue Value cannot be written as it is set for input
33	S Register Value is invalid
34	Both L and R modifier cannot be specified in ATD command
35	Invalid Major Device Class – valid value in range 0x00 to 0x1F inclusive
36	Pairing in progress – Command cannot be actioned – try again later
37	Invalid Sniff parameter specified. E.g. new Attempt value greater than MinInterval. Solution is to first increase MinInterval and re-enter the Attempt value.
38	Get Remote Friendly name Failed
39	Failed to change mode to Multipoint
40	7 Bit mode requires parity to be even or odd
41	Stream Error
42	Stream Pending Error

AT COMMAND SET REFERENCE

Error	Description
43	Unknown Audio Gateway Command
44	Busy, try later
45	Command or operation not allowed
46	No A2DP role has been set (see S register 300)
47	No AVRCP role has been set (see S register 301)
48	No AVRCP category has been set (see S register 302)
49	No AVRCP control connection
50	No A2DP or AVRCP connection currently incoming
51	Invalid operation ID (AVRCP)
52	Wrong AVRCP role
53	Command disabled by S-Register 310
54	No manufacturing information available
55	Audio resource error
56	Invalid UUID
57	Maximum gain level reached
58	Minimum gain level reached
59	Profile or role not enabled
60	Profile under construction
61	Unknown Headset command
62	Unknown Hands-free command
63	Incorrect state
64	Unknown DUN command
65	UART resource error

Table 4.3: BTM Error Responses

List of UUIDs

Table 4.4 gives a list of selected UUIDs. For a complete list refer to the "Assigned Numbers – Service Discovery (SDP)" document [3] by the Bluetooth SIG.

UUID	Mnemonic / Profile	Role
0x1101	Serial Port Profile (SPP)	-
0x1102	LAN access using PPP	-
0x1103	Dial-up Networking (DUN)	-
0x1105	OBEX Object Push	-
0x1106	OBEX File Transfer	-
0x1108	Headset Profile (HSP)	Headset
0x110A	A2DP	Audio Source
0x110B	A2DP	Audio Sink
0x110C	AVRCP	Remote Target
0x110D	A2DP	-
0x110E	AVRCP	-
0x110F	AVRCP	Remote Controller
0x1112	Headset Profile	Audio Gateway
0x111E	Hands-free Profile (HFP)	Hands-free unit
0x111F	Hands-free Profile (HFP)	Audio Gateway

Table 4.4: Selected UUIDs

AT COMMAND SET REFERENCE

References

[1] "Bluetooth Specification Version 2.1 + EDR [vol3]", 26 July 2007

http://www.bluetooth.com/Bluetooth/Technology/Building/Specifications/

(click on "Core Specification v2.1 + EDR")

[2] "Serial Port Profile" Specification

http://www.bluetooth.com/Bluetooth/Technology/Works/SPP.htm

(link at the bottom of page "Need more? View the Serial Port Profile (SPP)")

[3] "Bluetooth Assigned Numbers"

http://www.bluetooth.com/Bluetooth/Technology/Building/Specifications/

select "Items per page: ALL", go to end of page, there click on "Assigned Numbers – Baseband", for a complete list of Profile UUIDs: click on "Assigned Numbers – Service Discovery"

[4] Class of Device Generator: this link might be helpful for creating a particular CoD

http://bluetooth-pentest.narod.ru/software/bluetooth_class_of_device-service_generator.html

Caution: this tool allows selection of more than one minor device classes, so make sure that only one minor device class is select and verify the result with [3] anyway.

[5] "Bluecore 4 External" Data Sheet, Cambridge Silicon Radio (CSR)

http://www.csrsupport.com (log in or new account required)

[6] "Winbond 681360 Codec Board User Guide", Ezurio Application Note

FCC REGULATORY STATEMENTS

BTM410 FCC and Industry Canada Statements

The Final Equipment user manual must show the following statements:

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.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

To comply with the FCC RF exposure compliance requirements, this device and its antenna must not be co-located or operating to conjunction with any other antenna or transmitter.

Considerations for OEM integration:

This module has a limited modular approval. Approval with any other antenna configuration or layout other than that approved will necessitate additional radiated emission testing to be performed.

To inherit the modular approval, the antennas for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

This module was approved with the following antenna:

RF Solutions: ANT-24G-WHJ-SMA 0dBi

Operation of this module with any other antenna will require additional testing to be performed.

Co-location with other radio transmitting devices operating concurrently in the same band will require additional testing and certification.

Designers should note the distinction that the FCC makes regarding portable and mobile devices. Mobile devices are defined as products that are not used closer than 20cm to the human body, whereas portable devices can be used closer that 20cm to the body. In the case where the BTM410 module is used in a portable device, additional SAR testing must be performed on the complete product.

FCC Labelling requirement

If the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains Transmitter Module FCC ID: PI4410B" or "Contains FCC ID: PI4410B." Any similar wording that expresses the same meaning may be used.

BTM411 FCC and Industry Canada Statements

The user manual must show the following statements:

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.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

To comply with the FCC RF exposure compliance requirements, this device and its antenna must not be co-located or operating to conjunction with any other antenna or transmitter.

Considerations for OEM integration:

To inherit the modular approval, the antennas for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

Co-location with other radio transmitting devices operating concurrently in the same band will require additional testing and certification.

Designers should note the distinction that the FCC makes regarding portable and mobile devices. Mobile devices are defined as products that are not used closer than 20cm to the human body, whereas portable devices can be used closer that 20cm to the body. In the case where the BTM411 module is used in a portable device, additional SAR testing must be performed on the complete product.

FCC Labelling requirement

If the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains Transmitter Module FCC ID: PI4411B" or "Contains FCC ID: PI4411B." Any similar wording that expresses the same meaning may be used.

DECLARATIONS OF COMPLIANCE

EU DECLARATION OF CONFORMITY

Manufacturer:	Ezurio Ltd
Product:	BTM410
EU Directive:	RTTE 1995/5/EC
Conformity Assessment:	Annex IV

Reference standards used for presumption of conformity:

Article Number:	Requirement	Reference standard(s):
3.1a	Health and Safety	EN 60950-1:2006
3.1b	Protection requirements with respect to electromagnetic compatibility	EN 301 489-1 V1.8.1 EN 301 489-17 V2.1.1 Emissions: EN55022:2006/A1:2000/A2:2006(ClassB) Immunity: EN61000-4-2:1995/A1:1998/A2:2001 EN61000-4-3:2002/A1:2002
3.2	Means of the efficient use of the radio frequency spectrum	EN 300 328 V1.7.1 (2006-10)

Declaration:

We, Ezurio Ltd, declare under our sole responsibility that the essential radio test suites have been carried out and that the above product to which this declaration relates is in conformity with all the applicable essential requirements of Article 3 of the EU Directive 1995/5/EC, when used for its intended purpose.

Place of Issue:	Ezurio Ltd dba Laird Technologies Saturn House, Mercury Park Wooburn Green HP100HH, United Kingdom tel: +44 (0)1628 858 940 fax: +44 (0)1628 528 382
Date of Issue:	October 2009
Name of Authorised Person:	Tim Wheatley, Director of Engineering
Signature:	

DECLARATIONS OF COMPLIANCE

EU DECLARATION OF CONFORMITY

Manufacturer:	Ezurio Ltd
Product:	BTM411
EU Directive:	RTTE 1995/5/EC
Conformity Assessment:	Annex IV

Reference standards used for presumption of conformity:

Article Number:	Requirement	Reference standard(s):
3.1a	Health and Safety	EN 60950-1:2006
3.1b	Protection requirements with respect to electromagnetic compatibility	EN 301 489-1 V1.8.1 EN 301 489-17 V2.1.1 Emissions: EN55022:2006/A1:2000/A2:2006(ClassB) Immunity: EN61000-4-2:1995/A1:1998/A2:2001 EN61000-4-3:2002/A1:2002
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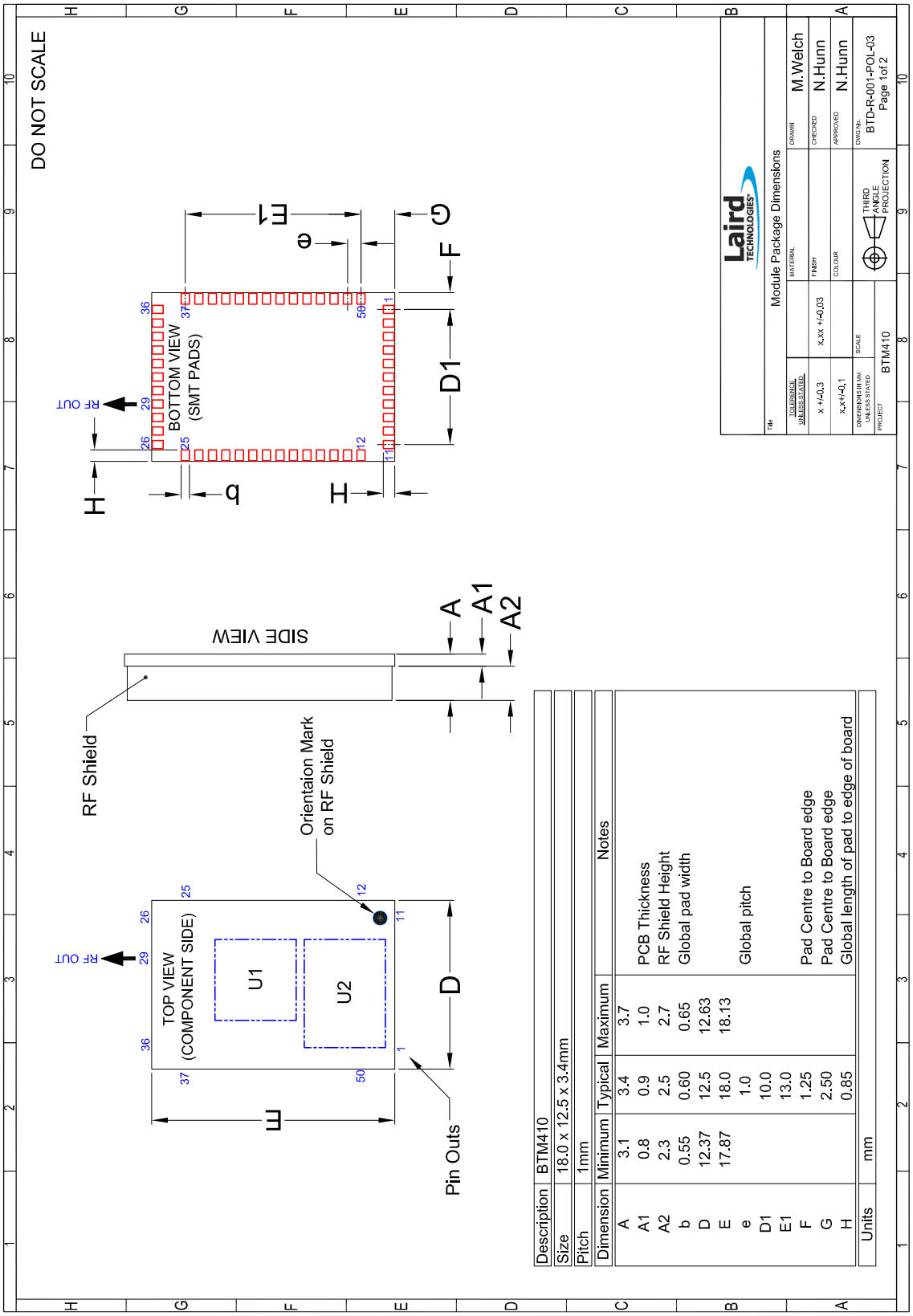
Date of Issue:	November 2009
Name of Authorised Person:	Tim Wheatley, Director of Engineering
Signature:	

MECHANICAL DRAWINGS

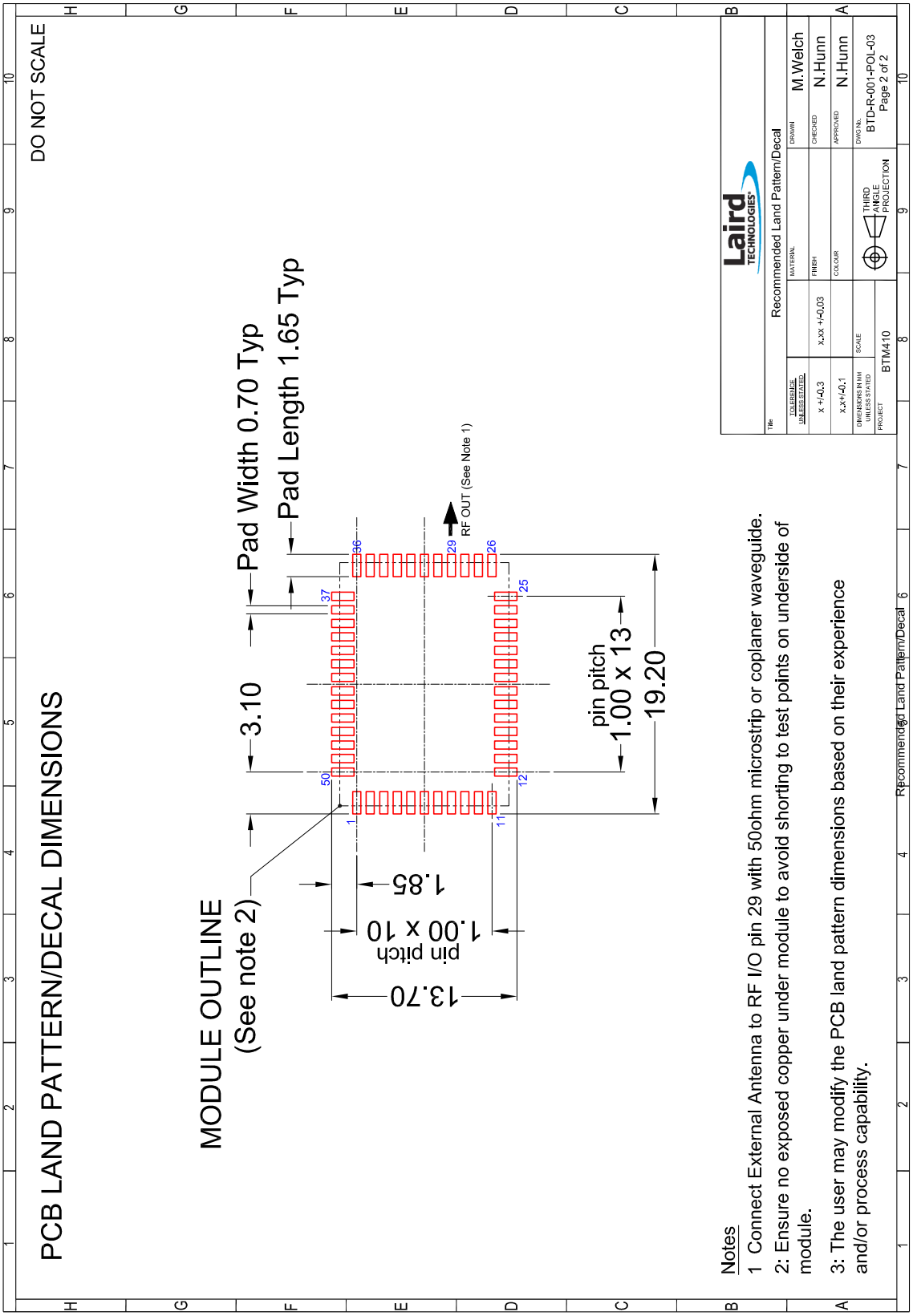
BTM410 Mechanical Details



Description	BTM410			
Size	18.0 x 12.5 x 3.4mm			
Pitch	1mm			
Dimension	Minimum	Typical	Maximum	Notes
A	3.1	3.4	3.7	
A1	0.8	0.9	1.0	PCB Thickness
A2	2.3	2.5	2.7	RF Shield Height
b	0.55	0.60	0.65	Global pad width
D	12.37	12.5	12.63	
E	17.87	18.0	18.13	
e		1.0		Global pitch
D1		10.0		
E1		13.0		
F		1.25		Pad Centre to Board edge
G		2.50		Pad Centre to Board edge
H		0.85		Global length of pad to edge of board
Units	mm			

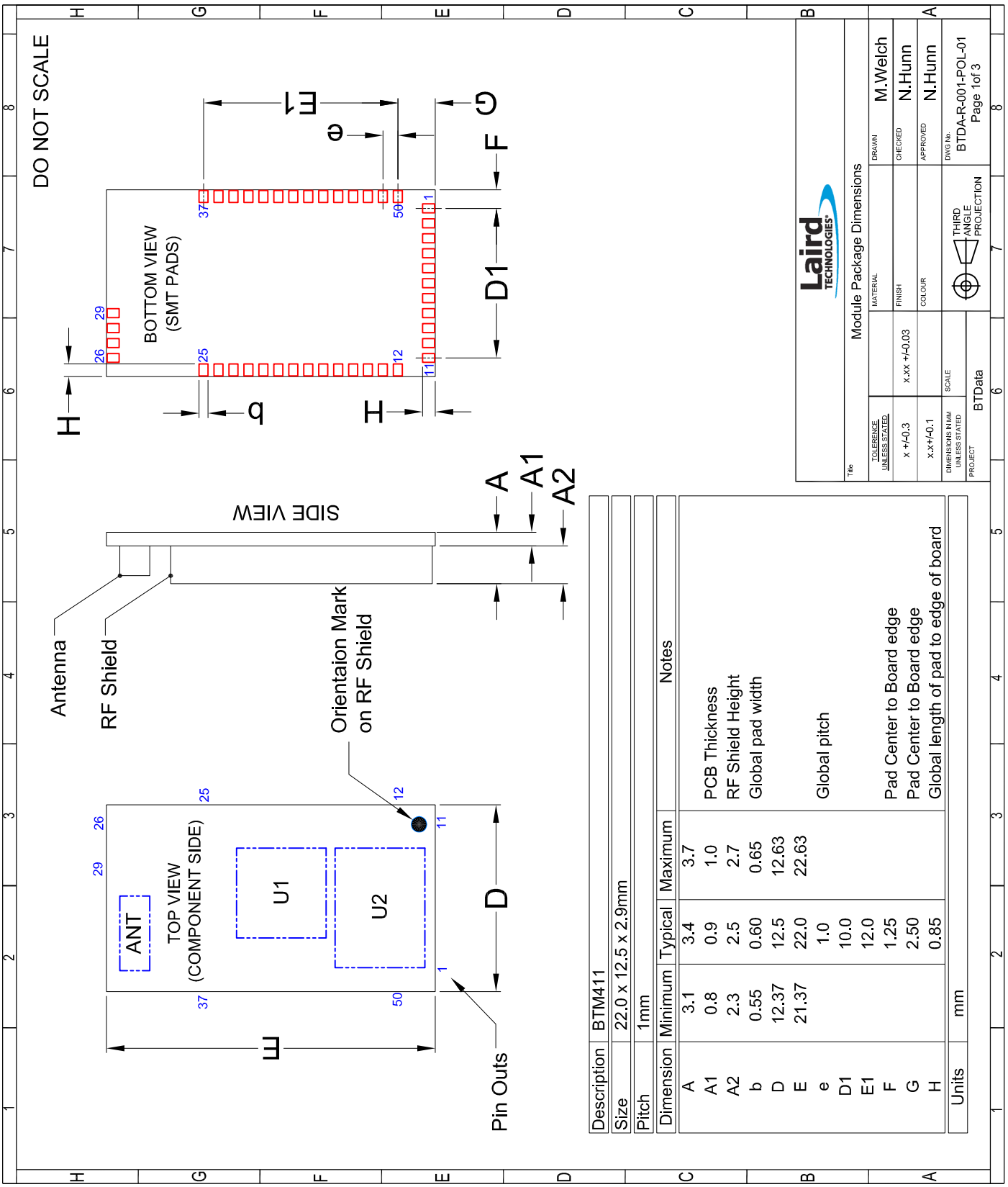
MECHANICAL DRAWINGS

BTM410 Mechanical Details



MECHANICAL DRAWINGS

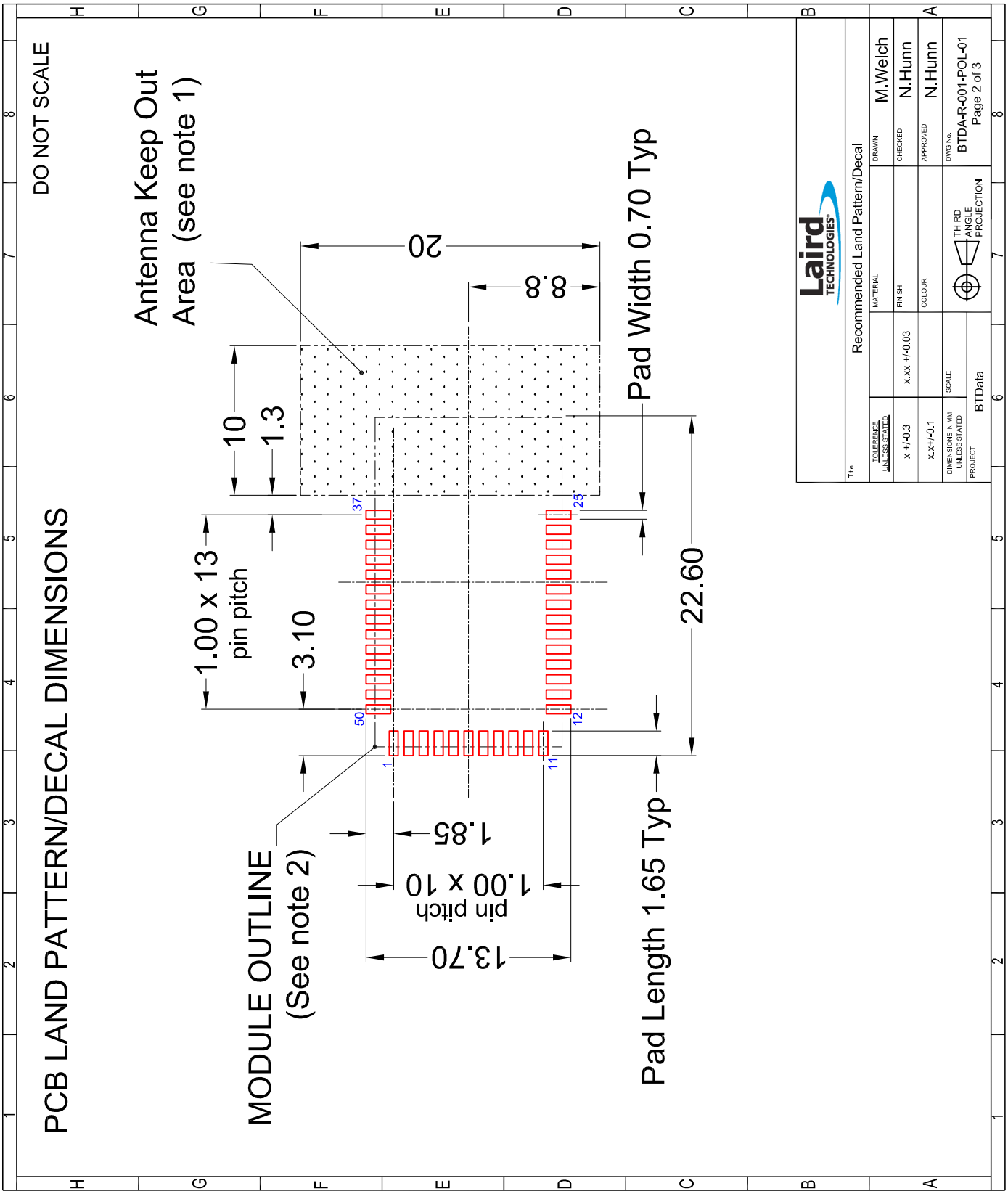
BTM411 Mechanical Details



Description	BTM411				
Size	22.0 x 12.5 x 2.9mm				
Pitch	1mm				
Dimension	Minimum	Typical	Maximum		Notes
A	3.1	3.4	3.7		
A1	0.8	0.9	1.0		PCB Thickness
A2	2.3	2.5	2.7		RF Shield Height
b	0.55	0.60	0.65		Global pad width
D	12.37	12.5	12.63		
E	21.37	22.0	22.63		
e		1.0			Global pitch
D1		10.0			
E1		12.0			
F		1.25			Pad Center to Board edge
G		2.50			Pad Center to Board edge
H		0.85			Global length of pad to edge of board
Units	mm				

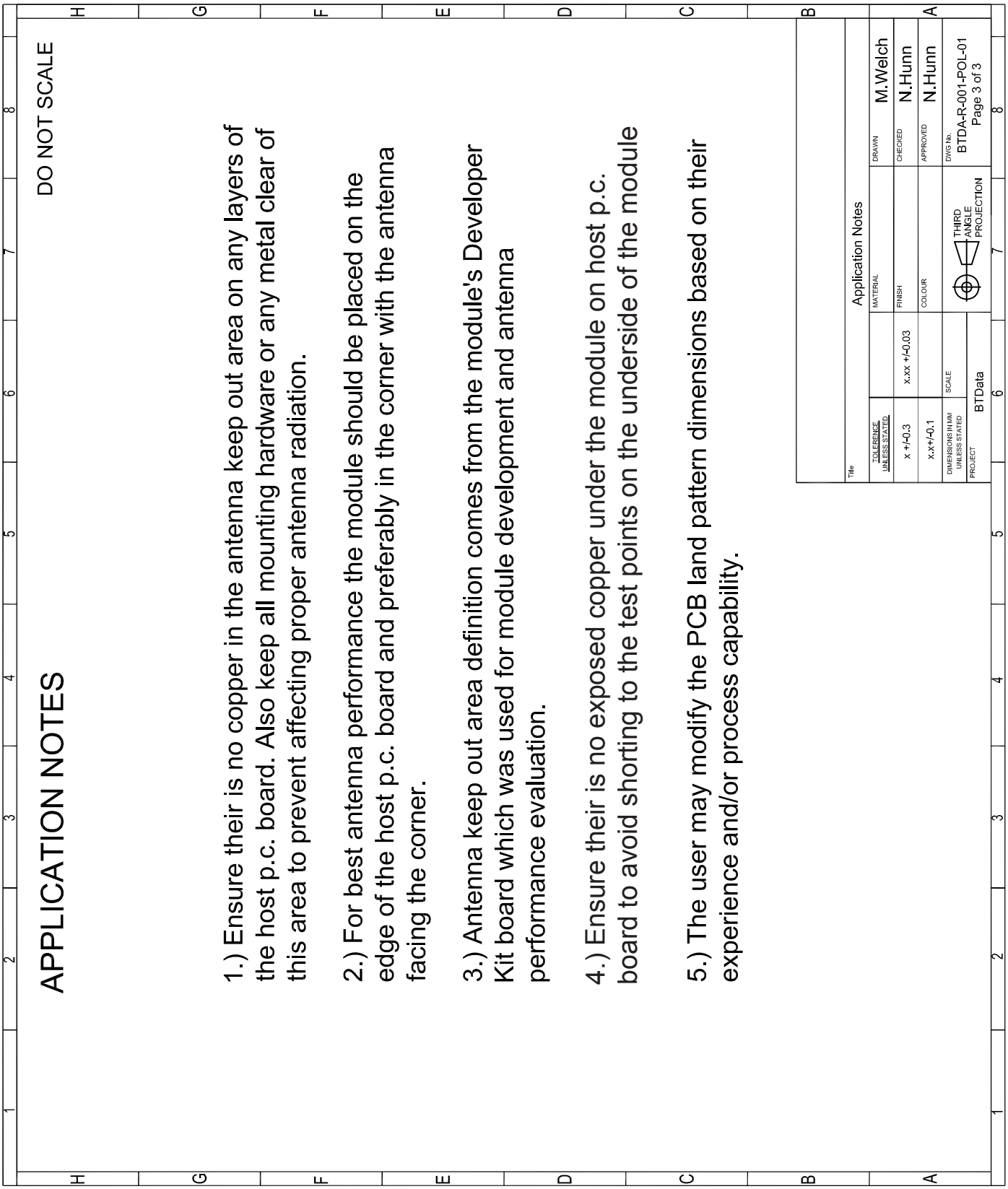
MECHANICAL DRAWINGS

BTM411 Mechanical Details



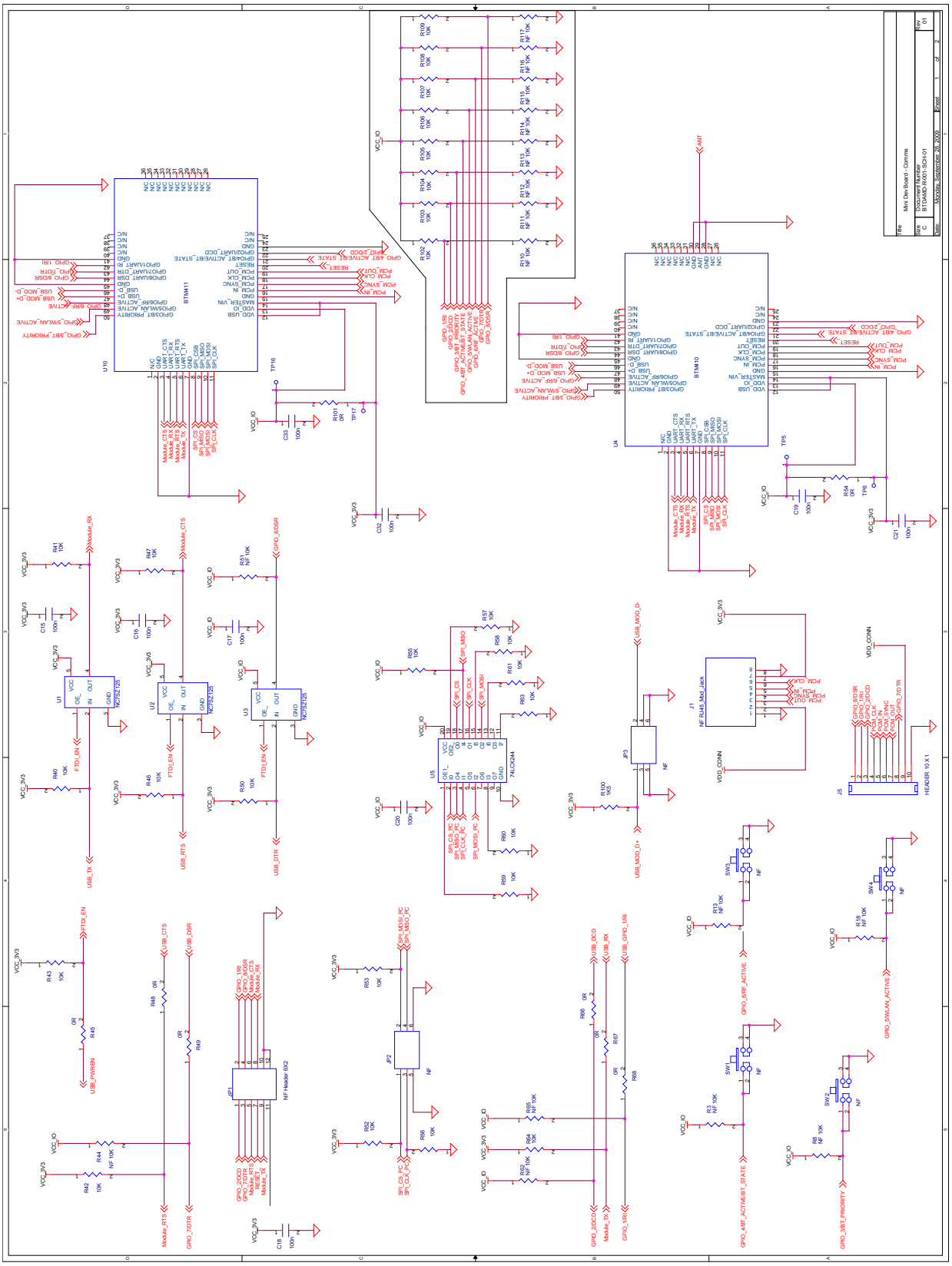
MECHANICAL DRAWINGS

BTM411 Mechanical Details



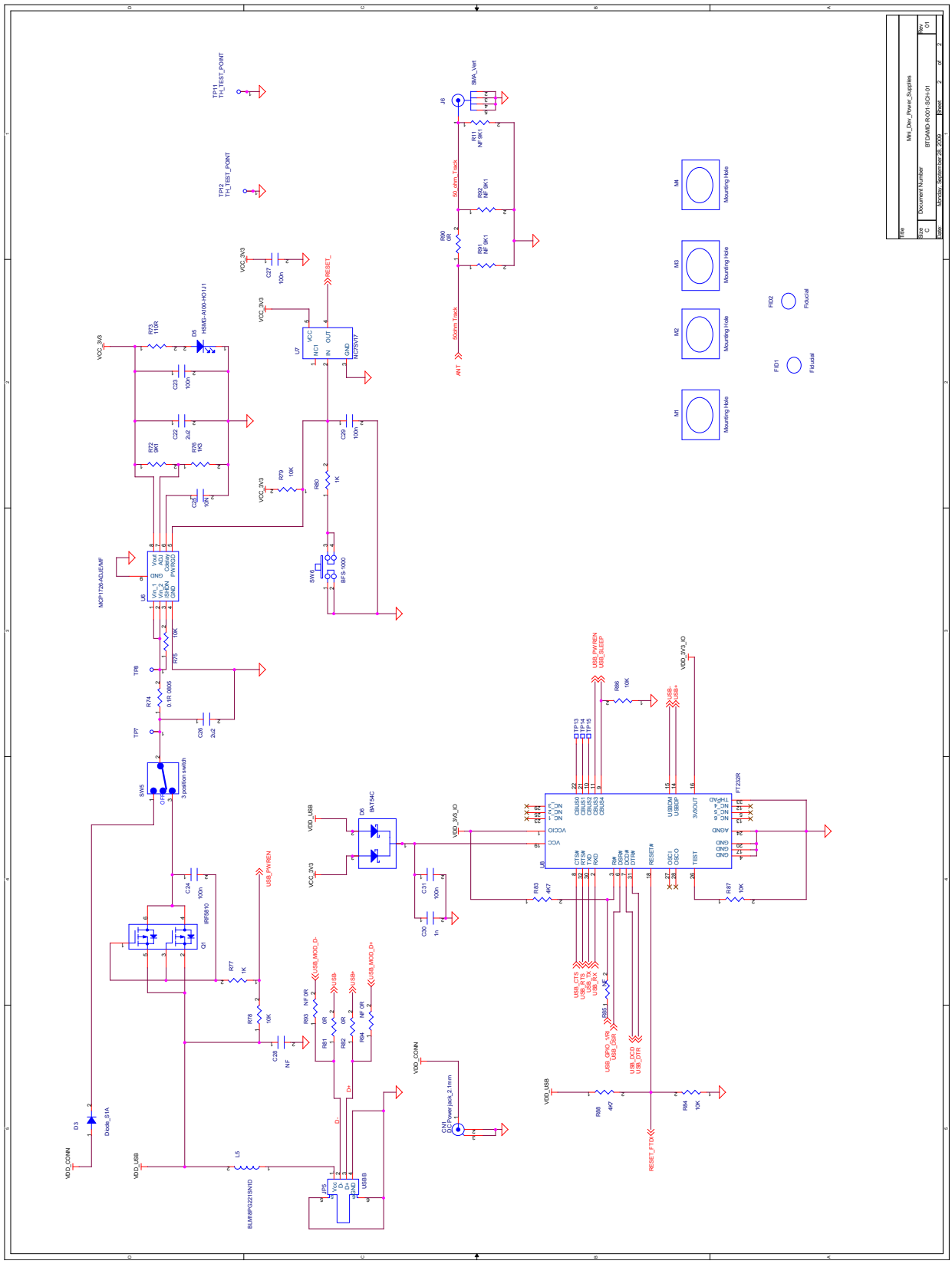
MECHANICAL DRAWINGS

Development Kit Schematic



MECHANICAL DRAWINGS

Development Kit Schematic



ORDERING INFORMATION

ORDERING INFORMATION

PART NUMBER	DESCRIPTION
BTM410	Bluetooth AT Data Module (external antenna)
BTM411	Bluetooth AT Data Module (with integrated antenna) Q1-2009
DVK – BTM410	Development board with BTM410 module soldered in place
DVK – BTM411	Development board with BTM411 module soldered in place Q2-2009

GENERAL COMMENTS

This is a preliminary datasheet. Please check with Laird Technologies for the latest information before commencing a design. If in doubt, ask.

Refer to the schematic BTDMD-R-001.pdf for the Development Kit on the following two pages for examples of typical pin connections. A pdf of the schematic can be downloaded from the product web page.

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LWS-UM-BTM410-411 0610