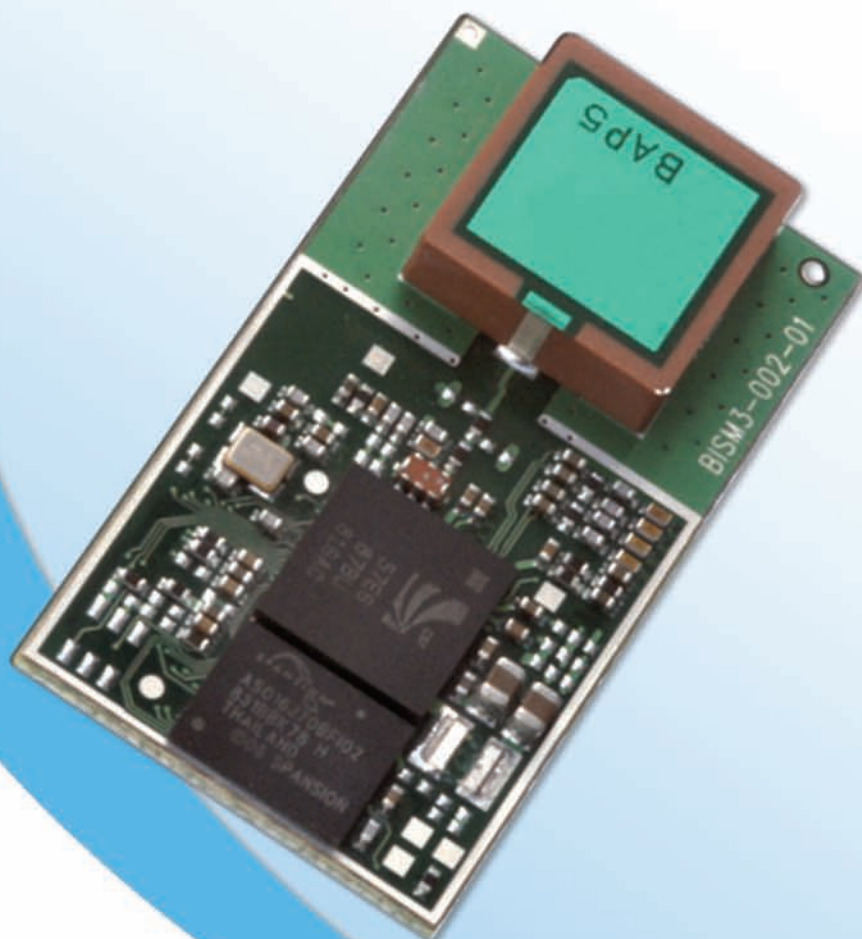


BTM520/521 MULTIMEDIA MODULE

USER MANUAL



Laird
TECHNOLOGIES®

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

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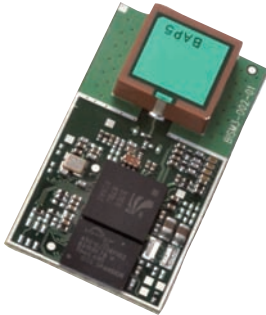
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**OVERVIEW AND
KEY FEATURES**

The BTM520 and BTM521 are the most advanced low power, multimedia Bluetooth modules on the market. They have been designed by Laird Technologies to meet the needs of developers who require the ultimate Bluetooth audio performance and flexibility, along with fast time to market. The modules include everything needed for a fully qualified and functional Bluetooth multimedia application. As well as providing best in class radio performance, range and power consumption, they support all of the functionality to run Cambridge Silicon Radio's Road Tunes and Blue Tunes development environments. They support the latest Bluetooth Version 2.1+EDR Specification, providing the important advantage of Secure Simple Pairing, which improves security and enhances the ease of use for end customers. The BTM521, with an integrated high performance multilayer ceramic antenna can achieve open field ranges in excess of 300 metres.

The modules include a 16 bit stereo codec and microphone input to support both stereo and mono applications, with the ability to drive 16 Ω stereo speakers. They also contain all of the necessary audio filtration and biasing components, so that the module only requires the addition of speakers, microphone and push buttons to make a complete implementation.

The modules contain a full, integrated Bluetooth stack along with SPP, HFP 1.5, HSP, AVRCP and A2DP profiles, all of which have been qualified, so that no further Bluetooth qualification is required. For users with more complex applications, additional profiles will be available for file transfer, object exchange, dial up networking, messaging and phone book control. Future support also includes the Health Device Profile, making this the ideal module for development of Continua compliant medical devices. Because these modules are pre-qualified, customers using these modules can list and promote their products on the Bluetooth website free of charge.

The BTM520 and BTM 521 modules include an embedded 32 bit, 64 MIPS DSP core within the BC05, which is integrated with the Bluetooth functionality and which allows designers to add significant product enhancements. These include features such as echo cancellation, noise reduction and audio enhancement using additional soft codecs. 16Mb of flash memory is available within the module, so that complex functionality can be included. DSP routines are licensable from a number of specialist partners. Typical applications for these modules include Bluetooth headsets, Bluetooth stereo headsets, VoIP phones, automotive products, wireless audio links and medical / healthcare devices.

To speed product development and integration, Laird Technologies has developed a comprehensive AT command interface, which simplifies application development and includes support for audio and headset functionality. Combined with a low cost developer's kit, this ensures that the choice of Laird Technologies Bluetooth modules guarantees the fastest route to market.

BTM520/521

Bluetooth® Multimedia Plus Module

OVERVIEW AND KEY FEATURES

FEATURES

- Fully featured Bluetooth multimedia module
- Supports CSR Road Tunes and Blue Tunes applications
- Bluetooth v2.1+EDR
- Supports mono and stereo headset applications
- Adaptive Frequency Hopping to cope with interference from other wireless devices
- 32bit Kalimba DSP for enhanced audio applications
- Support for Secure Simple Pairing
- External or internal antenna options
- HSP, HFP, A2DP and AVRCP audio profiles
- Future support for OBEX, DUN, FTP, HDP profiles for additional functionality
- 16 bit stereo codec and microphone input
- Integrated audio amplifiers for driving 16Ω speakers
- Comprehensive AT interface for simple programming
- Bluetooth END Product Qualified
- Compact Size
- Class 1 output – 8dBm (typical)
- Low power operation
- Wi-Fi Coexistence Hardware Support

APPLICATION AREAS

- High Quality Stereo Headsets
- Mono Voice Headsets
- Hands-free devices
- Wireless Audio Cable Replacement
- MP3 and music players
- Medical and Healthcare Devices
- Phone Accessories
- VoIP products
- Cordless Headsets
- Aftermarket Automotive Applications

SPECIFICATIONS

CATEGORIES	FEATURE	IMPLEMENTATION
Wireless Specification	Standards Supported	Bluetooth® v2.1 + EDR
	Transmit Class	Class 1
	Frequency	2.402 – 2.480 GHz
	Channels	79 channels Frequency Hopping Adaptive Frequency Hopping
	Max Transmit Power	+6 dBm (typical) @ antenna pad – BTM520 +8 dBm (typical) from integrated antenna – BTM521 (provisional)
	Min Transmit Power	-27 dBm @ antenna pad – BTM520 -27 dBm from integrated antenna – BTM521 (provisional)
	Receive Sensitivity	Better than -86 dBm
	Data Transfer rate	Up to 300kbps
	Range	> 300 metres free space (Data)
Antenna Modes	External Antenna	50 Ohm U.FL – BTM520
	Integrated Antenna	+2dBi multilayer ceramic – BTM521
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	1.7 - 3.6V CMOS (independent of Vcc)
	Modem Control	RTS, CTS DTR, DSR, DCD, RI [†]
General Purpose Interface	I/O	13 general purpose I/O pins [†]
	ADC	2 x ADC
	I ² S	Stereo Audio Digital Interface Bus
	PCM	Shared with I ² S
	SPDIF	Shared with I ² S
	LED	Two dedicated
Audio	Codec	Integrated stereo codec with -95dB SNR for DAC
	Amplifiers	Direct drive for 16Ω speakers On board filters
	Microphone	Input with bias for low noise microphone On board filters
	Sample Rates (DAC & ADC)	8, 11.025, 16, 22.05, 32 & 44.1kHz
Protocols & Firmware	Bluetooth® Stack	V2.1 compliant. Fully integrated.
	Profiles	GAP (Generic Access Profile) SDP (Service Discovery Profile) SPP (Serial Port Profile) HSP HFP – Audio Gateway and Handsfree A2DP – Source and Sink AVRCP – Target and Controller SCO/eSCO FTP Client (future release) DI (future release) GOEP (future release) PBAP (future release) MAP (future release) HDP (future release)
	Protocols	RFCOMM AVCTP AVDTP OBEX (future release) MCAP (future release)
	Firmware Upgrade	Available over UART

SPECIFICATIONS

CATEGORIES	FEATURE	IMPLEMENTATION
Command Interface	AT Instruction set	Comprehensive control of connection and module operation, including extensions for Audio control. Direct mapping of GPIO to audio functions, e.g. Play, Volume, etc. S Registers for non-volatile storage of parameters
	Additional Support	All I/O available for CSR Road Tunes and Blue Tunes applications
DSP	Kalimba DSP	Integrated in BC05 32bit, 64MIPS, 16Mbps Flash Memory (shared)
	Applications	Available from partners
Current Consumption	Data Transfer	Typically < 70mA (including speaker drive)
	Low Power Sniff Mode	Less than 1.5mA
Supply Voltage	Supply	3.0V – 4.2V DC
	I/O	1.7V – 3.6V DC
Coexistence / Compatibility	WLAN (802.11)	2, 3 and 5-wire hardware coexistence schemes supported
Connections	External Antenna (option)	Pad for 50 Ohm antenna – BTM520
	Interface	Surface Mount Pads
Physical	Dimensions	20.0mm x 36.0mm x 4.9mm
	Weight	3 grams
Environmental	Operating Temperature	-30°C to +70°C
	Storage Temperature	-40°C to +85°C
Approvals	Bluetooth®	Qualified as an END product
	FCC	Meets FCC requirements Modular Approval
	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

†Modem control pins and GPIO are shared

SPECIFICATIONS **PIN OUT**

PIN	SIGNAL	DESCRIPTION	VOLTAGE SPECIFICATION
1	PCM_IN	PCM Data I/P	VPADS
2	PCM_OUT	PCM Data O/P	VPADS
3	PCM_SYNC	PCM Sync I/P	VPADS
4	PCM_CLK	PCM CLK I/P	VPADS
5	GND		
6	SPI_MOSI	SPI bus serial I/P	VPADS
7	SPI_CSB	SPI bus chip select I/P	VPADS
8	SPI_MISO	SPI bus serial O/P	VPADS
9	SPI_CLK	SPI bus clock I/P	VPADS
10	LED_EXT1	Host I/O	Open Drain
11	LED_EXT0	Host I/O	Open Drain
12	GPIO_1/RX_ENABLE		VIO
13	GPIO_2/TX_ENABLE		VIO
14	GND		
15	VDD_PADS	VPADS supply	
16	VDD_PIO	VIO supply	
17	VDD_IN	Main supply	
18	GND		
19	AUDIO_GND		
20	SPKR_B_P	Speaker, channel B+ (right) – Note 3	
21	SPKR_B_N	Speaker, channel B- (right) – Note 3	
22	SPKR_A_P	Speaker, channel A+ (left) – Note 3	
23	SPKR_A_N	Speaker, channel A- (left) – Note 3	
24	MIC_BIAS	Microphone bias – Note 4	
25	MIC_BN_C	Microphone, channel B- (right) – Note 4	
26	MIC_BP_C	Microphone, channel B+ (right) – Note 4	
27	MIC_AP_C	Microphone, channel A+ (left) – Note 4	
28	MIC_AN_C	Microphone, channel A- (left) – Note 4	
29	Unused		
30	Unused		
31	Unused		
32	Unused		
33	Unused		
34	Unused		
35	Unused		
36	Unused		
37	Unused		
38	Unused		
39	Unused		
40	Unused		
41	Unused		
42	Unused		
43	Unused		
44	Unused		
45	Unused		
46	Unused		
47	Unused		
48	Unused		
49	Unused		
50	Unused		
51	Unused		
52	Unused		
53	Unused		
54	Unused		

SPECIFICATIONS **PIN OUT (continued)**

PIN	SIGNAL	DESCRIPTION	VOLTAGE SPECIFICATION
55	Unused		
56	Unused		
57	Unused		
58	GPIO_4		VIO
59	GPIO_12	Host I/O	VPADS
60	AUX_DAC		VIO
61	GPIO_5	Host I/O	VIO
62	GPIO_6/BT_STATE/ BT_PRIORITY	Host I/O / BT Co-existence	VPADS
63	GPIO_8/RF_ACTIVE	Host I/O / BT Co-existence	VPADS
64	GPIO_13	Host I/O	VPADS
65	GPIO_10	Host I/O	VPADS
66	GND		
67	AIO1	ADC Input, 10 bit 0-1.5V input range	
68	DSR	Host I/O	VPADS
69	GPIO_9/DTR	Host I/O	VPADS
70	AIO0	ADC Input, 10 bit 0-1.5V input range	
71	DCD	Host I/O	VPADS
72	GPIO_11	Host I/O	VPADS
73	RI	Host I/O	VPADS
74	GPIO_7/WLAN_ACTIVE	Host I/O / BT Co-existence	VPADS
75	GND		
76	USB_D-		VUSB
77	USB_D+		VUSB
78	GPIO_3		VIO
79	VDD_USB	VUSB supply	
80	VREGENABLE_H	Main regulator enable – pull high for correct operation	
81	GND		
82	UART_RTS	Request to Send O/P	VUSB
83	UART_CTS	Clear to Send I/P	VUSB
84	UART_TX	Transmit data O/P	VUSB
85	UART_RX	Receive data I/P	VUSB
86	Reset	Module reset I/P (active low) – Note 1	VPADS

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	3.6
VDD_PADS	1.7	3.6
VDD_IN	3.0	3.3

VOLTAGE SPECIFICATIONS

LOGIC LEVELS (VUSB)			
Input Voltage Levels	Min	Typ	Max
V_{ih}	0.625VDD_USB		VDD_USB+0.3
V_{il}	-0.3		0.25VDD_USB
Output Voltage Levels			
V_{oh} (Iout = -4mA)	0.75VDD_USB		VDD_USB
V_{ol} (Iout = 4mA)	0		0.125

LOGIC LEVELS (VIO)			
Input Voltage Levels	Min	Typ	Max
V_{ih}	0.625VDD_IO		VDD_IO+0.3
V_{il}	-0.3		0.25VDD_IO
Output Voltage Levels			
V_{oh} (Iout = -4mA)	0.75VDD_IO		VDD_IO
V_{ol} (Iout = 4mA)	0		0.125

LOGIC LEVELS (VPADS)			
Input Voltage Levels	Min	Typ	Max
V_{ih}	0.625VDD_PADS		VDD_PADS+0.3
V_{il}	-0.3		0.25VDD_PADS
Output Voltage Levels			
V_{oh} (Iout = -4mA)	0.75VDD_PADS		VDD_PADS
V_{ol} (Iout = 4mA)	0		0.125

LOGIC LEVELS (VUSB – USB TERMINALS D+, D-)			
Input Voltage Levels	Min	Typ	Max
V_{ih}	0.7VDD_USB		
V_{il}			0.3VDD_USB
Output Voltage Levels (to correctly terminated USB cable)			
V_{oh}	2.8		VDD_USB
V_{ol}	0		0.2

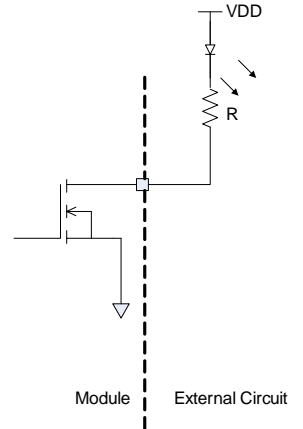
OPERATING PARAMETERS

- Note:
1. Reset input is active low. Input is pulled up to VDD_PADS via 22k. Minimum reset pulse width is 5ms.
 2. LED drive pins are open drain outputs and hence the external circuit to the right should be used.

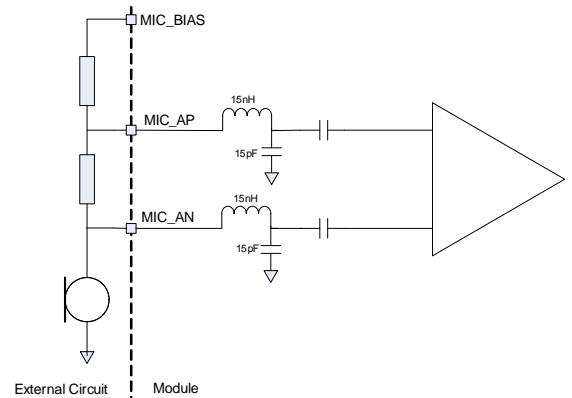
The voltage on the module pad should be maintained below 0.5V in which case the R_{on} of the FET is around 20Ω . Provided that this condition is met, then the current flowing through the diode is:

$$I_{led} = \frac{VDD - V_F}{R + 20} \quad \text{Where } V_F \text{ is the forward bias voltage of the LED.}$$

3. The speaker output is capable of driving loads with a minimum impedance of 16Ω directly.
4. The audio inputs can operate in either line input mode or microphone mode. The input circuit has a two stage amplifier – the first stage provides a fixed 24dB gain and the second a variable gain of between -3dB and 18dB. If an input gain of less than 24dB is selected, then the first stage is switched out and the module is operating in line input mode.

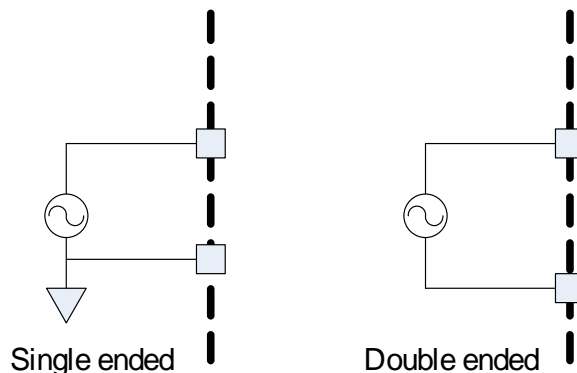


When operating in microphone mode the microphone should be biased as follows:



The input impedance on the microphone inputs (in microphone mode) is typically $6k\Omega$. In order to maintain the regulation on the MIC_BIAS pin, the current drawn must be in the range $0.2 - 1.23mA$. If the resistor draws less current than this, then an additional resistor to ground must be added to pre-load the microphone output. The audio input is designed for use with inputs of between $1\mu A$ and $10\mu A$ at 94dB SPL. If the biasing resistors are set to $1k\Omega$, this implies a microphone with a sensitivity in the range -40dBV to -60dBV.

When operating in line input mode, the input can be connected directly to the module input pins in either single or double ended configuration as follows:



**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

BTM520/521

Bluetooth® Multimedia Plus Module

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**

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. The AT command set description refers to firmware version 14.1.1.0. Firmware version can be checked by AT+I3 (short) or AT+I333 (full). Please also have a look the firmware release notes for this version.

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 six 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...
Advanced Audio Distribution Profile	A2DP	AT+AP...
Audio/Video Remote Control Profile	AVRCP	AT+AV...
Headset Profile	HSP	AT+HS...
Hands-Free Profile	HFP	AT+HF...
Dial-Up Network Profile	DUN	AT+DU...

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 six 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 four 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 six digit hexadecimal number derived as per "Bluetooth Assigned Numbers" [8].

The 24 bits are made of four 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 six bits is interpreted differently based on the Major Device Class stored in the next five bits.
Bits 8-12:	Major Device Class: five bits, refer to Figure 1 and Table 3 in "Bluetooth Assigned Numbers" [8].
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" [8].

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 [9]. 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. AT+515=<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 six 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 19 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 six digit device class code or a two digit major device class. If it is not specified, the value is taken from S register 516.

When <devclass> is six hexadecimal characters long, it specifies an AND mask which is used to filter inquiry responses. When <devclass> is two 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 sped 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.

Although it is very convenient to have the friendly name displayed in the inquiry response, this option can significantly reduce the performance of the inquiry process. Especially in areas with a large number of discoverable Bluetooth devices it might become nearly impossible to find a particular device.

An optimal solution would be a first inquiry scan without friendly name and <dev_class> filter. In a second run, the friendly name is queried by AT+BTF<BdAddr> for each device found.

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

Inquiry Response Format

<cr,lf>OK<cr,lf>

S register 330 is not referenced.

**AT COMMAND SET
REFERENCE****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.

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 two 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	<ul style="list-style-type: none"> • MITM protection (MITM = "Man in the Middle" attack) • Encryption • User interaction 	High security
Level 2	<ul style="list-style-type: none"> • No MITM protection • Encryption 	Medium Security

**AT COMMAND SET
REFERENCE**

Security Level	Characteristics	Comment
Level 1	<ul style="list-style-type: none"> • No MITM protection • (No) Encryption (1) • Minimal user interaction 	Low Security
Level 0	<ul style="list-style-type: none"> • 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.

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 six digit decimal number.
1	Display yes no	The device has the capability to display or communicate a six digit decimal number and 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).
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.

**AT COMMAND SET
REFERENCE****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 six digit passkey displayed by remote device	Representing keyboard input

Table 3.5: SSP Input commands**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 25.

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 89.
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

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,>OK<cr,>

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,>OK<cr,>

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 2.3, page 89). 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 three characters. This restriction results from the maximum AT command length which is 34 (query by AT+I15). The difference of 5 is caused by "ATX" (three characters) and the enclosing quotation marks (two 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 three 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 three characters. This restriction results from the maximum AT command length which is 34 (query by AT+I15). The difference of 5 is caused by "ATX" (three characters) and the enclosing quotation marks (two 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 three 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, page 28 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 three character escape sequence starting with '\'. For example, the embedded <cr><lf> sequence would be sent as the six 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,>OK<cr,>

**AT COMMAND SET
REFERENCE****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>000000000000

<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 SPP 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>000000000000

<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 page 26 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 Technologies 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>

AT COMMAND SET
REFERENCE

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

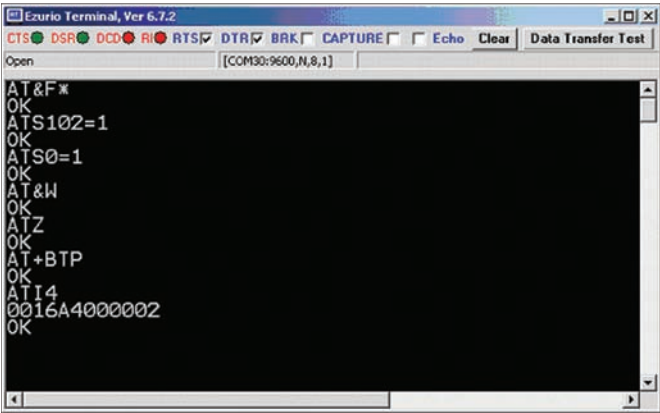


Figure 3.3 SPP example – Preparation of Device B

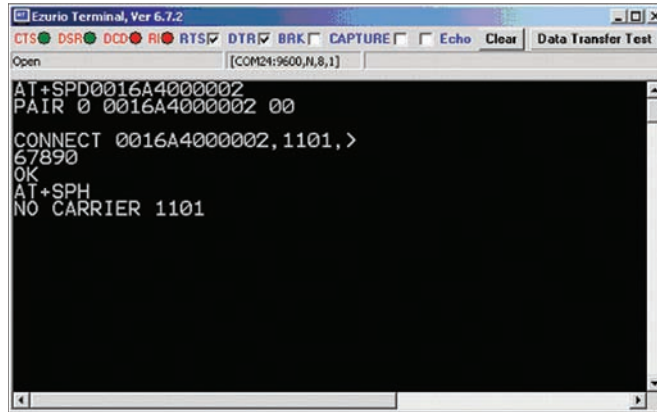
**AT COMMAND SET
REFERENCE**

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

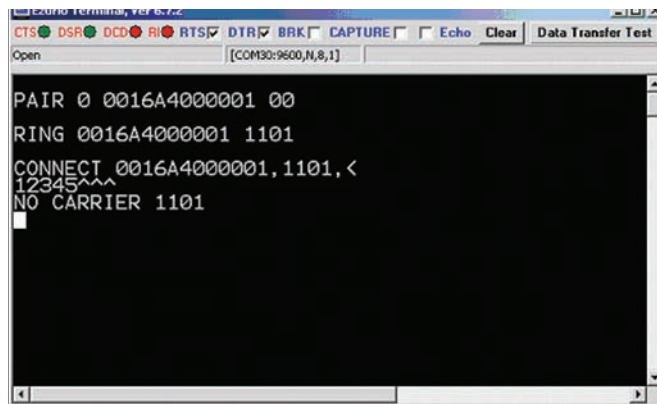


Figure 3.5: SPP example Device B - incoming connection, receiving data, disconnection

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 two 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 $S0 \neq 0$ and $S100 \neq 0$ 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 $S0 \neq 0$ and $S100 \neq 0$ 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

3. A2DP (Advanced Audio Distribution Profile)

The “Advanced Audio Distribution Profile” is used for unidirectional transmission of high quality audio streams between two Bluetooth devices. A2DP must be enabled by setting S 102 to a value of 128. Also, an A2DP role must be assigned to a BTM module, either source or sink. After this has been done, the settings need to be stored by AT&W followed by ATZ.

An incoming A2DP connection request is accepted automatically if a valid link key for the paging device exists. If no link key is available, Secure Simple Pairing (SSP, BT2.1) or legacy pairing (BT2.0 or earlier) is carried out, depending on the Bluetooth version of the paging device.

After an A2DP connection has been established, the module remains in AT Command mode. S Register 531 is ignored for A2DP connections.

Version 1.2 of A2DP is supported.

The A2DP service record contains an optional field which indicates the A2DP supported features of a device. This feature field can be set by S312 for a sink and by S313 for a source. Please refer to Table 3.16 for details.

Table 3.17 gives an overview on supported A2DP features on a BTM device.

Table 3.12 lists supported A2DP codec types.

A2DP Feature	Support in SRC (Audio Source)		Support in SNK (Audio Sink)	
	Spec.	BTM5xx	Spec.	BTM5xx
1. Audio Streaming	M	Yes	M	Yes

M: mandatory

Table 3.11: A2DP Supported Features on BTM5xx

A2DP Codec Type	Support in SRC (Audio Source)		Support in SNK (Audio Sink)	
	Spec.	BTM5xx	Spec.	BTM5xx
1. SBC	M	Yes	M	Yes
2. MPEG-1,2 Audio	O	No	O	No
3. MPEG-2,4 AAC	O	No	O	No
4. ATRAC family	O	No	O	No

M: mandatory

O: optional

Table 3.12: A2DP Supported Codec Types on BTM5xx

**AT COMMAND SET
REFERENCE****3.1 A2DP Example 1**

This section gives an example of an A2DP connection between a Laird Technologies BTM device as Audio Sink (wireless speaker/ wireless headphones) and a PC with a built in Bluetooth device and Toshiba Bluetooth Stack 2.1 as Audio Source.

The PC must support A2DP. If it is a different stack the procedure should be similar and follow the steps of:

- 1.) Device discovery
- 2.) Device Selection
- 3.) Pairing
- 4.) Connection establishment (e.g., initiated by PC)

If you have a Bluetooth 2.0 or earlier stack on your PC, legacy pairing with PIN will occur. In that case use AT+BTK=<PIN> to enter the PIN on the BTM device.

The BTM5xx device is assumed to be connected to a terminal program, e.g., Ezurio Terminal on a PC. The sequence of AT commands and the instructions for the PC side are listed in Table 3.13. Figure 3.6 through to Figure 3.11 show appropriate screenshots.

Phase	Dev.	AT Command	Comment
Preparation	BTM5xx	AT&F*	Restore factory default settings A2DP profile is enabled per default in S102 Audio Sink role is enabled per default in S300
		ATS515=\$040400	Set A2DP device class
		ATS512=4	Make device connectable and discoverable (permanent setting)
		AT&W	Store settings
		ATZ	Reset
Preparation / Connection setup	PC	n/a	1.) Open "Bluetooth Settings" from the taskbar icon - Figure 3.6
			2.) Click on "New Connection" - Figure 3.6
			3.) Click Next (Discover BT Devices) - Figure 3.7
			4.) Select "Laird BTMM..." if not listed: click "Refresh" - Figure 3.8
			5.) Click "Yes" on "Allow this Device to connect?" - Figure 3.9
			6.) Connection is initiated by PC - Figure 3.10
			7.) Open a player (e.g., Windows Media Player) to play some music
			8.) Connect a Headphone/Speaker to the Audio Output of the BTM device
Connected	BTM5xx	n/a	Troubleshooting: If nothing can be heard, verify that a Bluetooth Audio Device has appeared in the Device Manager - Figure 3.1. Also check that the Bluetooth Audio Device is selected as speaker in your player application. Sometimes a player needs to be closed and restarted in order to send its audio output to a new speaker device (which is the Bluetooth Audio Device here).
		AT+GOU	Music can be heard on the speakers/headphones
		AT+GOD	Increment volume (audio output gain) by one
		AT+APH	Decrement volume (audio output gain) by one
		AT+APH	Response "NO CARRIER 110D": disconnection confirmed

Table 3.13: A2DP Example 1 Command Sequence

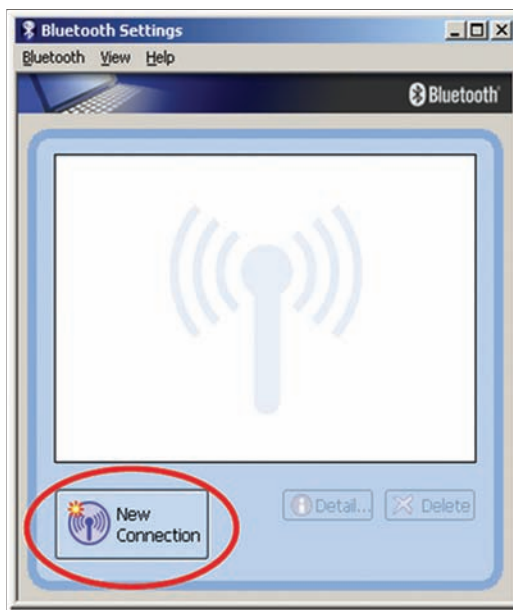
**AT COMMAND SET
REFERENCE**

Figure 3.6: A2DP example 1 – PC Bluetooth settings

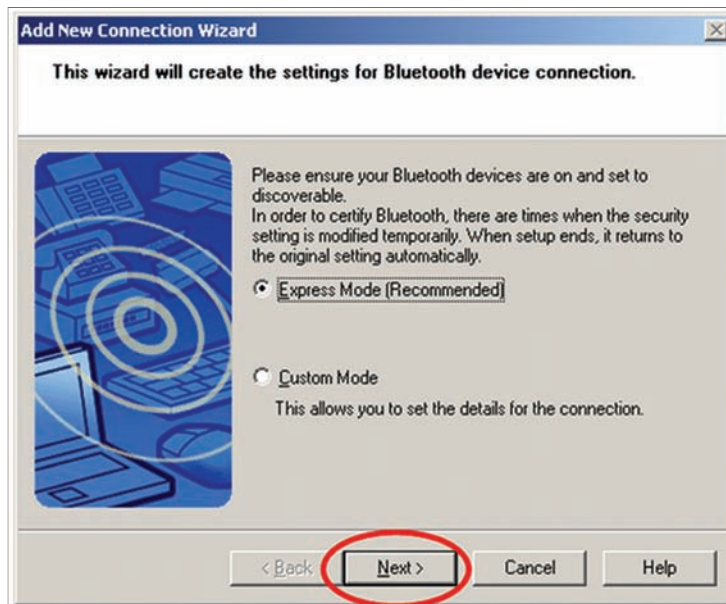


Figure 3.7: A2DP example 1 – Start discovery of Bluetooth devices

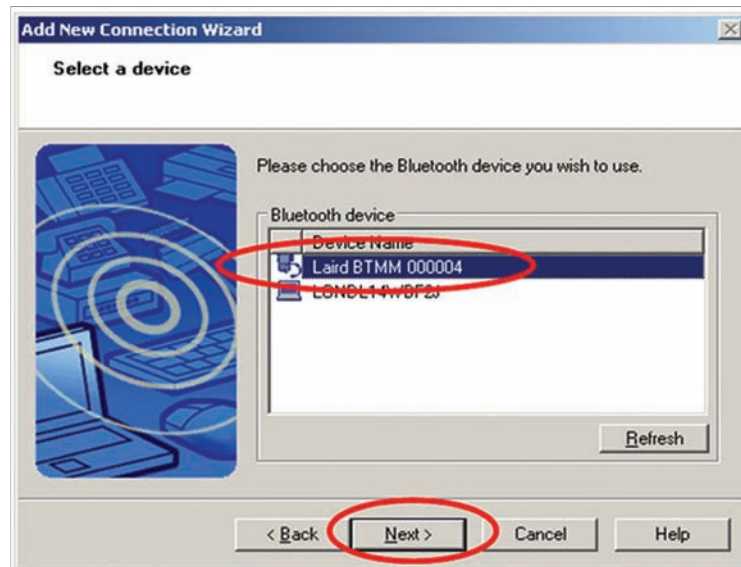
**AT COMMAND SET
REFERENCE**

Figure 3.8: A2DP example 1 – Select Bluetooth device (Click “Refresh” if Laird BTMM is not listed)



Figure 3.9: A2DP example 1 – Confirm pairing (here: Secure Simple Pairing, no PIN required)



Figure 3.10: A2DP example 1: Connection established

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REFERENCE

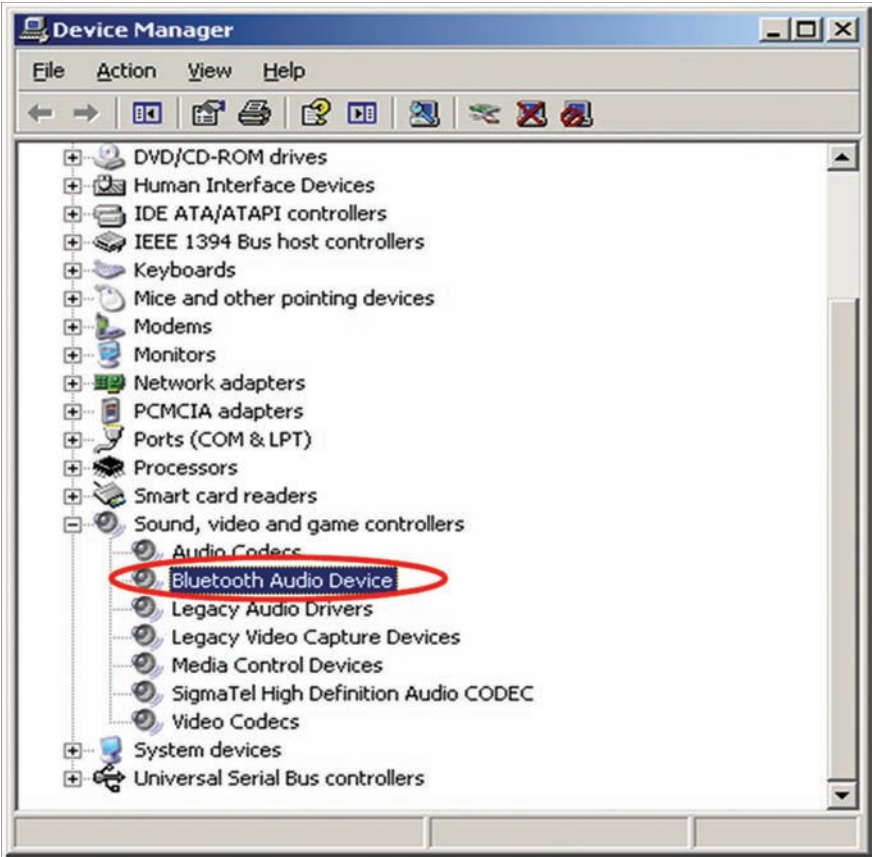


Figure 3.11: A2DP example 1: New Bluetooth Audio Device in the Device Manager

3.2 A2DP Example 2

This section gives an example of an A2DP connection between a Laird Technologies BTM5xx device (A) as Audio Sink (wireless speaker/ wireless headphones) and another Laird Technologies BTM5xx device (B) as Audio source.

Both BTM5xx devices are assumed to be connected via UART to a terminal program, e.g., Ezurio Terminal on a PC. The required instructions along with the sequence of AT commands are listed in Table 3.14. Figure 3.12 to Figure 3.15 show appropriate screenshots.

Phase	Dev.	AT Command	Comment
Preparation	ext. audio equipm.		1.) Connect an audio source (e.g. MP3 player) to the stereo audio input (line in) of Device B 2.) Connect a headphone or a speaker to the stereo audio output (line out) of device A
Preparation	A	AT&F*	Restore factory default settings A2DP profile is enabled per default in S102 Audio Sink role is enabled per default in S300
		ATS515=\$040400	Set A2DP device class (Sink)
		ATS512=4	Make device connectable and discoverable (permanent setting)
		AT&W	Store settings
		ATZ	Reset
		ATI4	Query Bluetooth device address of Dev. A <BdAddr_DevA>

**AT COMMAND SET
REFERENCE**

Phase	Dev.	AT Command	Comment
Preparation	B	AT&F*	Restore factory default settings A2DP profile is enabled per default in S102
		ATS300=2	Enable Audio Source role
		ATS515=\$080400	Set A2DP device class (source)
		AT&W	Store settings
		ATZ	Reset
		Initiate Connection	B
Connected			
Play music from the audio source Music should be audible on the headphones/speakers. If not: check audio output of the audio source (e.g., connect headphones directly to audio source for a test)			
Adjust Volume	A	AT+GOU	Increment volume (audio output gain) by one
		AT+GOD	Decrement volume (audio output gain) by one
	B	AT+GIU	Increment volume (audio input gain) by one
		AT+GID	Decrement volume (audio input gain) by one
		Note: the audio input gain (A2DP source) is a critical setting because the optimal setting cannot be verified by objective means by the module itself.	
Disconnect	A/B	AT+APH	Response "NO CARRIER 110D": disconnection confirmed

Table 3.14: A2DP Example 2 Command Sequence and Instructions

```

Ezurio Terminal, Ver 6.7.2
CTS DSR DCD RI RTS DTR BRK CAPTURE Echo Clear Data Transfer Test
Open [COM4:9600,N,8,1]
AT&F*
OK
ATS515=$040400
OK
ATS512=4
OK
AT&W
OK
ATZ
OK
ATI4
0016A4000004
OK

```

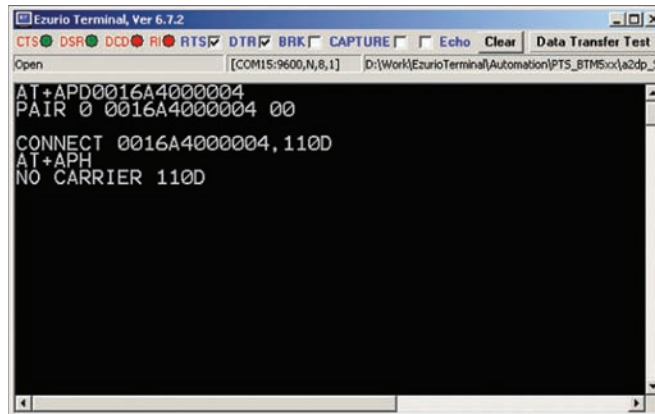
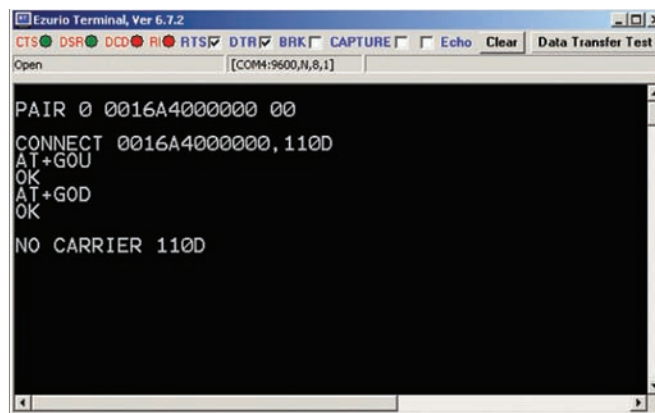
Figure 3.12: A2DP Example 2 – Preparation of Device A (Sink)

```

Ezurio Terminal, Ver 6.7.2
CTS DSR DCD RI RTS DTR BRK CAPTURE Echo Clear Data Transfer Test
Open [COM15:9600,N,8,1]
AT&F*
OK
ATS300=2
OK
ATS515=$080400
OK
AT&W
OK
ATZ
OK

```

Figure 3.13: A2DP Example 2 – Preparation of Device B (Source)

**AT COMMAND SET
REFERENCE****Figure 3.14: A2DP Example 2 –Initiate and Release Connection from Device B (Source)****Figure 3.15: A2DP Example 2 – Accepting Connection and Volume Adjustment Device A (Sink)****3.3 Enable A2DP**

The advanced audio distribution profile (A2DP) is enabled by issuing `ATS102=128`. After verifying that a role has been set (`S300 != 0`) the S registers must be saved by `AT&W`. Finally issue `ATZ` to make the new settings effective. If the A2DP flag in `S102 (0x80)` is not set after `ATZ` although it was set and saved before `ATZ`, then `S300` was = 0 at boot time, which is invalid for A2DP.

3.4 Select A2DP Role

The A2DP role is selected by S register 300 as follows:

- 0 – no role selected
- 1 – A2DP Sink (default)
- 2 – A2DP Source

The setting must be saved by `AT&W` and becomes effective on next power cycle (`ATZ`).

CAUTION: If `S 300=0` at boot time (no role selected) and the A2DP flag (`0x80`) is set in `S102`, the A2DP flag will be cleared automatically because A2DP cannot be enabled without a role selected.

**AT COMMAND SET
REFERENCE****4. Set A2DP Device Class**

AT+SS15=\$<device_class_{hex}>; AT&W; ATZ

For compliance with the A2DP specification, [2] (and hence for successful interoperability to other devices) it is required to set up a valid device class code. The default device class code of a BTM device is 0x001F00 which is invalid for the A2DP profile.

The A2DP specification [2] mandates the following requirements for the device class of an A2DP device:

1. Mandatory to set the 'Rendering' bit for the SNK and the 'Capturing' bit for the SRC in the Service Class field.
2. Recommended to set 'Audio/Video' as Major Device class both for the SNK and the SRC.
3. Select the appropriate Minor Device class as defined in the Bluetooth Assigned Numbers [8].

There is a tool available on the internet for creating a particular device class code: refer to [9].

With the assumptions above (Major Device class = Audio/Video), Table 8 in [8] gives the complete list of codes for the minor device class. If you are not sure about the minor device class, use the row marked with n/a for the minor device (e.g., 0x040400 for sink or 0x080400 for source).

Table 3.15 gives some examples of device class codes for A2DP devices.

Device Class Code	Major Service	Major Device	Minor Device	A2DP Role
0x040400	Rendering	Audio/Video	n/a	Sink
0x040414	Rendering	Audio/Video	Loudspeaker	Sink
0x040418	Rendering	Audio/Video	Headphones	Sink
0x04041C	Rendering	Audio/Video	Portable Audio	Sink
0x040420	Rendering	Audio/Video	Car audio	Sink
0x080400	Capturing	Audio/Video	n/a	Source
0x080410	Capturing	Audio/Video	Microphone	Source
0x080428	Capturing	Audio/Video	HiFi Audio Device	Source

Table 3.15: A2DP device class code – examples

The device class is written to the module using AT+SS15=\$<device_class_{hex}> where <device_class_{hex}> is the 6 character device class code without leading "0x". Use subsequent AT&W and ATZ for the new value to become effective. Please also refer to page 15, section 4.

4.1 Initiate A2DP Connection

AT+APD<bd_addr_{hex}>

Initiate A2DP connection to Bluetooth address <bd_addr_{hex}>. The remote device must support the complementary role to the local device. If link keys are missing in one or both devices, pairing will either occur automatically or pairing is required to be initiated by AT+BTW<bd_addr_{hex}>. This depends on various factors like the combination of local and remote IO capabilities or the Bluetooth version of the remote device.

Response:

<cr><lf>PAIR 0 <bd_addr> 00<cr><lf> (first time only, auto pairing without MITM authent.)

<cr><lf>CONNECT <bd_addr>,110D,><cr><lf>

Or:

<cr><lf>NO CARRIER 110D<cr><lf> (not successful)

**AT COMMAND SET
REFERENCE****4.2 Output Gain Settings – A2DP Sink****AT+GOU / AT+GOD**

AT+GOU – Increment audio output gain (volume).

AT+GOD – Decrement audio output gain (volume).

Response:

<cr><lf>OK<cr><lf>

<cr><lf>ERROR 57<cr><lf> – Maximum gain level reached

<cr><lf>ERROR 58<cr><lf> – Minimum gain level reached

The output gain level can be set directly using S register 589. Alternatively, S register 689 can be used to set the required overall output gain in dBr multiplied by 10. Please refer to section 1, page 80.

4.3 Input Gain Settings – A2DP Source**AT+GIU / AT+GID**

AT+GIU – Increment audio input gain.

AT+GID – Decrement audio input gain.

Response:

<cr><lf>OK<cr><lf>

<cr><lf>ERROR 57<cr><lf> – Maximum gain level reached

<cr><lf>ERROR 58<cr><lf> – Minimum gain level reached

The input gain level can be set directly using S register 590. Alternatively, S register 690 can be used to set the required overall input gain in dBr multiplied by 10. Please refer to section 1, page 80.

4.4 Release A2DP Connection**AT+APH / ATH110D**

Release an A2DP connection by AT+APH. Alternatively, ATH110D can be used. (110D presents the UUID for the A2DP profile). Please refer to section 4, page 90.

4.5 Supported Features – A2DP Sink**S312**

Use S Register 312 to set the A2DP sink supported features that will be advertised in the A2DP service record. Refer to Table 3.16. The S register needs to be saved (AT&W) and the module needs to be power cycled (ATZ) for a new value to become effective.

4.6 Supported Features – A2DP Source**S313**

Use S Register 313 to set the A2DP source supported features that will be advertised in the A2DP service record. Refer to Table 3.16. The S register needs to be saved (AT&W) and the module needs to be power cycled (ATZ) for a new value to become effective.

Task	AT-Command / SRegister	Comment
Enable A2DP profile	S102	128 = A2DP, Error 46 if A2DP role has not been set (see S300) Needs subsequent AT&W and ATZ to become effective
Set A2DP role	S300 [0..2]	0 = feature not set 1 = A2DP Sink (default) 2 = A2DP Source Needs subsequent AT&W and ATZ to become effective

**AT COMMAND SET
REFERENCE**

Task	AT-Command / SRegister	Comment
Initiate outgoing A2DP connection	AT+APD<bd_addr>	Response if accepted: "CONNECT 0123456789012,110D,>" Response if rejected: "NO CARRIER 110D"
Close only A2DP connection	"AT+APH" or "ATH110D"	Response: "NO CARRIER 110D" if connection has existed and S329=0 "NO CARRIER" if connection has not existed and S329=0
Close all connections	ATH*	Response: "NO CARRIER <profileUUID>" for each profile that was previously connected (see section 4, page 90)
Set gain level	S589 [0..22], default = 15	Set codec output gain level (applies to sink)
	S590 [0..22], default = 15	Set codec input gain level (applies to source)
Set overall gain (dBr * 10)	S689 [-450..215]	Set codec output gain in dBr * 10 (applies to sink), default = 0
	S690 [-450..215]	Set codec input gain in dBr * 10 (applies to source), default = 0
Increment Gain	AT+GOU	Increment codec output gain by 1 step in gain table (refer to section 1, page 80)
	AT+GIU	Increment codec input gain by 1 step in gain table (refer to section 1, page 80)
Decrement Gain	AT+GOD	Decrement codec output gain by 1 step in gain table (refer to section 1, page 80)
	AT+GID	Decrement codec input gain by 1 step in gain table (refer to section 1, page 80)
Set A2DP Sink supported features bit mask	S312 [1..15]	Bitmask - sink supported features: Bit 0 = Headphone (default) Bit 1 = Speaker Bit 2 = Recorder Bit 3 = Amplifier Subsequent AT&W plus ATZ required for a new value to become effective
Set A2DP Source supported features bit mask	S313 [1..15]	Bitmask - source supported features: Bit 0 = Player (default) Bit 1 = Microphone Bit 2 = Tuner Bit 3 = Mixer Subsequent AT&W plus ATZ required for a new value to become effective

Table 3.16: A2DP – S Registers and AT-Commands

**AT COMMAND SET
REFERENCE****5 AVRCP (Audio Video Remote Control Profile)**

The "Audio/Video Remote Control Profile" is used to remotely control audio or video streaming devices. A device must be defined as either control (CT) or target (TG). Furthermore, one of four categories (Player/Recorder, Monitor/Amplifier, Tuner, Menu) must be assigned to a device.

Version 1.0 of AVRCP is supported.

The AVRCP specification [3] adopts the AV/C Digital Interface Command Set (AV/C command set, defined by the 1394 Trade Association) device model and control message format. In this device model a remote control target consists of one or more subunits. At least the subunit "PANEL" must exist. Remote control commands are passed to a subunit with the "PASS THROUGH" command. A BTM device, configured as target will support one PANEL-subunit.

Table 3.17 gives an overview on supported AVRCP features on a BTM device.

AVRCP Feature	Support in CT (Control)		Support in TG (Target)	
	Spec.	BTM5xx	Spec.	BTM5xx
1. Connection establishment for control	M	Yes	O	Yes
2. Release connection for control	M	Yes	M	Yes
3. Sending UNIT INFO command	O	Yes	X	No
4. Receiving UNIT INFO command	X	No	M	Yes
5. Sending SUBUNIT INFO command	O	(1)	X	No
6. Receiving SUBUNIT INFO command	X	No	M	Yes
7. Sending VENDOR DEPENDENT command	O	No	X	No
8. Receiving VENDOR DEPENDENT command	X	No	O	No
9. Sending PASS THROUGH command	M	Yes	X	No
10. Receiving PASS THROUGH command	X	No	M	Yes

M: mandatory
O: optional
X: excluded
(1) incomplete

Table 3.17: AVRCP Supported Features on BTM5xx

5.1 AVRCP Example 1

This section gives an example of an AVRCP connection between a Laird Technologies BTM5xx device as AVRCP Controller and a PC with a built in Bluetooth device and Toshiba Bluetooth Stack 2.1 as AVRCP Target.

For any other Bluetooth Stack with AVRCP (target role) support, the setup should follow the steps of:

1. Identifying Bluetooth Device Address of PC
2. Enabling AV Remote Control Service
3. Selecting player and/or setup display of incoming remote control commands

The BTM5xx device is assumed to be connected to a terminal program, e.g., Ezurio Terminal on a PC. The sequence of AT commands and the instructions for the PC side are listed in Table 3.18. Figure 3.16 to Figure 3.21 show appropriate screenshots.

This example can be combined with the A2DP Example 1 (Section 3.1, page 36). Then the AVRCP connection should be initiated after A2DP is connected.

**AT COMMAND SET
REFERENCE**

Phase	Dev.	AT Command	Comment
Preparation	BTM5xx	AT&F*	Restore factory default settings AVRCP profile is enabled per default in S102 AVRCP Control role is enabled per default in S301
		ATZ	Reset
Preparation	PC	n/a	1.) Select "Options..." from the Bluetooth icon in the taskbar (Figure 3.16)
			2.) Identify the PC's Bluetooth Address <BdAddr_PC> in the "General" tab of Bluetooth Options (Figure 3.16)
			3.) Make sure that "AV Remote Control Service is enabled" (Figure 3.16)
			4.) Go to "Other" tab of Bluetooth Options and Click Button "AV Player..." (Figure 3.17)
			5.) Select "TopRight" at the "Display Position" dropdown menu (Figure 3.17)
			6.) Close each window by clicking "OK"
Initiate Connection	BTM5xx	AT+AVD<BdAddr_PC>	Response: (Figure 3.19) "CONNECT <BdAddr_PC>,110E,>" (AVRCP connected)
Connected, send remote control commands	BTM5xx	AT+AVC44	Send "Play" (Figure 3.20, Figure 3.21) Response: "OK" - command accepted "AVPTC 0,44,0" -confirmation received from PC "AVPTC 0,44,1" -confirmation received from PC Reception of command should be displayed in top-right corner of PC screen (Figure 3.21), Player should start playing.
		AT+AVC46	Send "Pause" (Figure 3.20, Figure 3.21) Response: "OK" - command accepted "AVPTC 0,46,0" -confirmation received from PC "AVPTC 0,46,1" -confirmation received from PC Reception of command should be displayed in top-right corner of PC screen (Figure 3.21), Player should pause.
		AT+AVC45	Send "Stop" (Figure 3.21) Response: "OK" - command accepted "AVPTC 0,45,0" -confirmation received from PC "AVPTC 0,45,1" -confirmation received from PC
Disconnect	BTM5xx	AT+AVH	Response: (Figure 3.20) "NO CARRIER 110E" (disconnection confirmed)

Table 3.18: AVRCP Example 1 Command Sequence

AT COMMAND SET REFERENCE

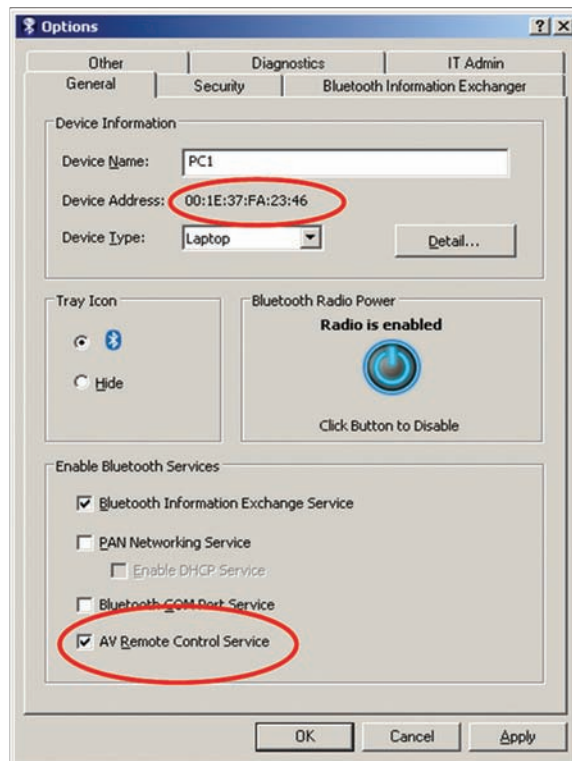


Figure 3.16: AVRCP Example 1 – Bluetooth Address of PC and AV Remote Control Service

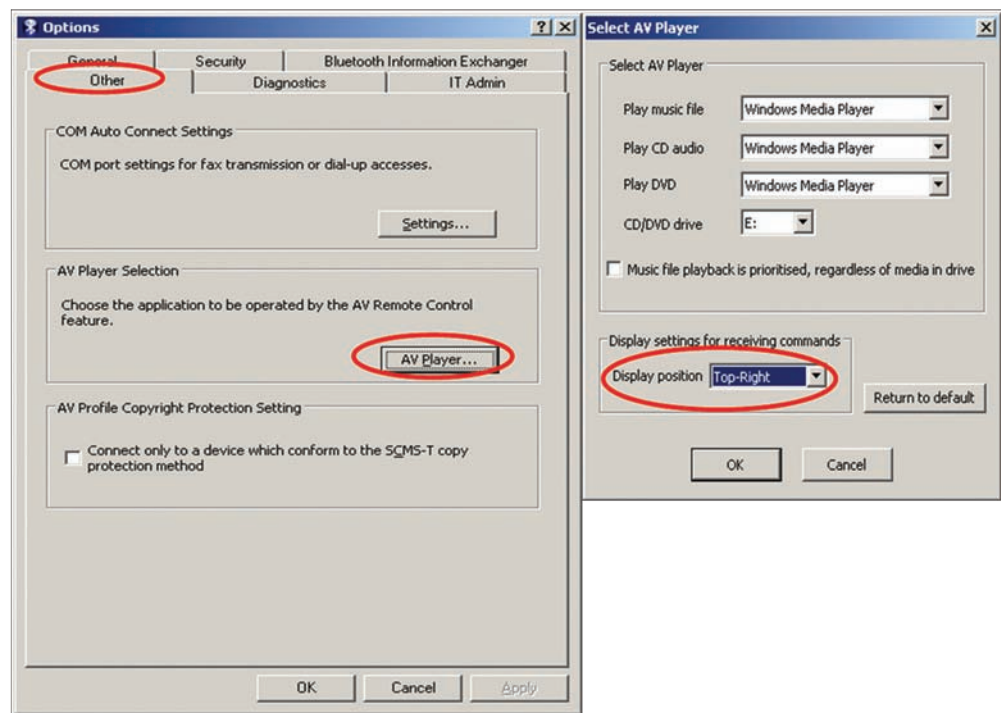


Figure 3.17: AVRCP Example 1 – Player Selection and Receiving Commands Display Setup

AT COMMAND SET REFERENCE

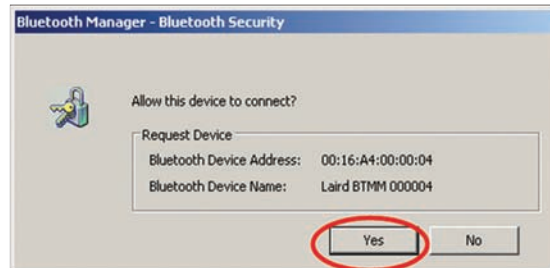


Figure 3.18: AVRCP Example 1 – Secure simple pairing dialogue

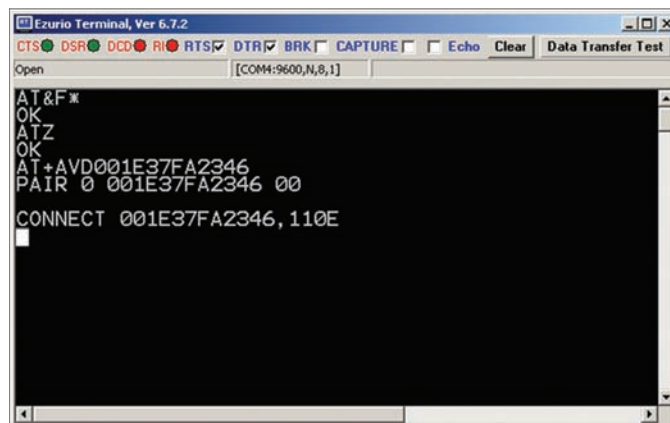


Figure 3.19: AVRCP Example 1 – BTM5xx Preparation and Connection Setup

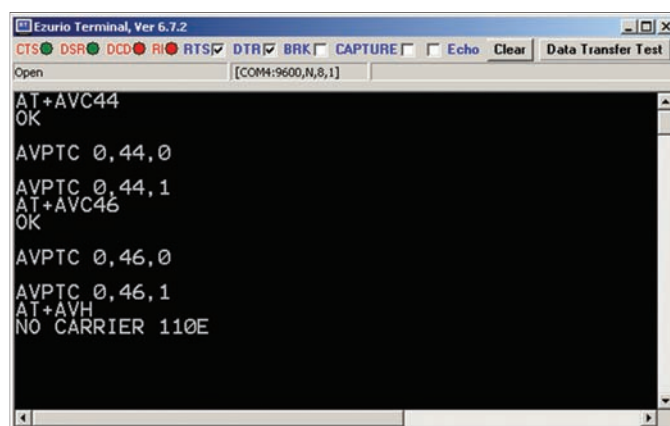


Figure 3.20: AVRCP Example 1 – BTM5xx Sending Commands and Connection Release



Figure 3.21: AVRCP Example 1 – Incoming AVRCP commands (top-right corner of screen)

**AT COMMAND SET
REFERENCE****5.2 AVRCP - Control (CT) and Target (TG)**

This section describes AT Commands and S registers which are common to BTM5xx AVRCP Controller role and AVRCP Target role.

5.2.1 Initiate AVRCP Connection

AT+AVD<bd_addr_{hex}>

Initiate AVRCP control connection to Bluetooth address <bd_addr_{hex}>. The module must be configured as AVRCP Control by S register 301 = 1. Furthermore, a category must be selected in S register 302.

Response: <cr,lf>CONNECT 123456789012,110E,><cr,lf>

Or: <cr,lf>NO CARRIER 110E<cr,lf>

Or: <cr,lf>ERROR 47<cr,lf>

Or: <cr,lf>ERROR 48<cr,lf>

After an AVRCP connection has been established, the module remains in AT command mode. S Register 531 is ignored for AVRCP connections.

5.2.2 Release AVRCP Control Connection

AT+AVH

Release AVRCP control connection.

Response <cr,lf>NO CARRIER 110E<cr,lf>

5.3 AVRCP - Control (CT)

This section describes AT Commands and S registers when BTM5xx is configured as an AVRCP Controller (S301=1).

5.3.1 Send UNIT INFO Request

AT+AVU

Send a Unit Info request to a connected AVRCP target.

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

On command completion:

<cr,lf>AVUR <n>,<unit_id_{hex}>,<unit_type_{hex}>,<company_id_{hex}><cr,lf>

<n> = status_{dec}: 0 – success

1 – fail

4 – timeout

If <n> is greater than zero (unsuccessful outcome), <unit_type_{hex}> and <company_id_{hex}> will not be sent. Examples for unsuccessful response are:

<cr,lf>AVUR 1<cr,lf> or

<cr,lf>AVUR 4<cr,lf>

For unit_type see Table 3.21: AV/C Unit/Subunit Types.

5.3.2 Send SUBUNIT INFO Request (Incomplete*)

AT+AVS<page_{dec}>

Send a Subunit Info request to a connected AVRCP target.

Response: <cr,lf>OK<cr,lf> (immediately)

And: <cr,lf>AVSR <n>,<page_{dec}>,<pagedata_{hex}> <cr,lf> (after command completion)

<n> = status_{dec}: 0 – success

1 – fail

4 – timeout

<page_{dec}> : requested page [0..31]

<pagedata_{hex}>: 1st word of requested page

**AT COMMAND SET
REFERENCE**

If <n> is greater than zero (unsuccessful outcome), <page_{dec}> and <pagedata_{hex}> will not be sent. Examples for unsuccessful response are:

<cr,<lf>AVSR 1<cr,<lf> or

<cr,<lf>AVSR 4<cr,<lf>

*) incomplete because only the first word of the requested page is being displayed in the AVSR asynchronous message

5.3.3 Send Remote Control Command

AT+AVC<operation_id_{hex}>,<button_state>

Send a remote control command to a connected AVRCP target. Internally, a PASS THROUGH command is created and sent to the PANEL subunit of the AVRCP target.

<operation_id_{hex}> is the value for the actual remote control command. Valid values are specified in Table 3.20. Some Operation IDs can be replaced by mnemonics, see Table 3.20.

<button_state> represents "Button pushed" (=0) or "Button released" (=1) If <button_state> is not specified, two PASS THROUGH commands, each with button_state=0 and button_state=1, will be created and being sent consecutively.

The "OK" response is sent immediately on receipt of AT+AVC command. On command completion, an unsolicited message will be sent to the host in the form "AVPTC <n>, <bd_addr>, <button_state>". AVPTC means "AVRcp Pass Through Confirmation".

Parameter n indicates the command's status:

'n'=0: successful, command confirmation received from target

'n'=1: timeout, target has not sent confirmation within the specified maximum time

'n'=2: all other unsuccessful outcomes

Parameters:

<operation_id_{hex}> (mandatory): see Table 3.20

<button_state> (optional) : '0' - Button pushed

'1' - Button released

Response: <cr,<lf>OK<cr,<lf> (immediately)

And: <cr,<lf>AVPTC <n>,<operation_id_{hex}>,<button_state><cr,<lf>

(after command completion)

If status n indicates an unsuccessful outcome, <operation_id_{hex}> and <button_state> are omitted.

5.4 AVRCP – Target (TG)

This section describes AT Commands and S registers when BTM5xx is configured as an AVRCP Target (S301=2). In this mode, BTM5xx supports one subunit PANEL (see [3]).

5.4.1 Incoming AVRCP Connection Request

An incoming AVRCP connection request is accepted automatically if a valid link key for the paging device exists. If no link key is available, Secure Simple Pairing (SSP, BT2.1) or legacy pairing (BT2.0 or earlier) is carried out, depending on the Bluetooth Version of the paging device.

After an AVRCP connection has been established, the module remains in AT command mode. S Register 531 is ignored for AVRCP connections.

5.4.2 UNIT INFO Response

It is mandatory to respond to a UNIT INFO command if configured as AVRCP target. Required response parameters are IEEE Company ID and a Unit Type.

The IEEE Company ID is a 24 bit integer which can be set via S Register 303.

The response is sent automatically with the company ID as per S303 and a fixed unit type of 0x09 ("Panel").

AT COMMAND SET REFERENCE

5.4.3 SUBUNIT INFO Response

It is mandatory to respond to a SUBUNIT INFO command if configured as AVRCP target. Required response parameters are Subunit type and MaxSubUnitId.

The response is sent automatically with a fixed value of 0x09 ("Panel") for parameter Subunit type and a fixed value of 0x00 for parameter MaxSubUnitId (only one subunit exists, which is panel).

5.4.4 PASS THROUGH Indication

An incoming PASS THROUGH command will be indicated by an unsolicited message.

AVPTI <subunit_id_{hex}>,<operation_id_{hex}>,<button_state>

For subunit_id_{hex} see Table 3.21. For operation_id_{hex} see Table 3.20.

<button_state>: '0' is Button pushed

'1' is Button released

5.4.5 PASS THROUGH Response

AT+AVR<avrc_response_type_{hex}>

If S register 310 == 0, a Pass Through (PT) response is required from the host. The response is sent using the command:

AT+AVR<avrc_response_type_{dec}>

Parameter:

<avrc_response_type_{dec}>: see Table 3.22, write-value.

If S register 310 == 1, a Pass Through response is sent automatically with an <avrc_response_type> defined by S register 311. In this case, the host is not required to respond.

Task	AT-Command / S Register	Comment
Enable AVRCP profile	S102	256 = AVRCP, Error 47 if AVRCP role has not been set (see S301); Error 48 if S301== 2 and Category has not been set (see S302) Needs subsequent AT&W and ATZ to become effective
Set AVRCP role	S301 [0..2]	0 = disabled 1 = Control "CT" (default) 2 = Target "TG" Needs subsequent AT&W and ATZ to become effective
Set AVRCP category	S302 [0..4]	0 = Feature disabled (default) 1 = Player/Recorder 2 = Monitor/Amplifier 3 = Tuner 4 = Menu Needs subsequent AT&W and ATZ to become effective
Initiate outgoing AVRCP control connection	AT+AVD<bd_addr>	Response if accepted: "CONNECT 0123456789012,110E,>" Response if rejected: "NO CARRIER 110E"
Close only AVRCP connection	"AT+AVH" or "ATH110E"	Response: "NO CARRIER 110E" if connection has existed and S329=0 "NO CARRIER" if connection has not existed and S329=0

AT COMMAND SET
REFERENCE

Task	AT-Command / S Register	Comment
Close all connections	ATH*	Response: "NO CARRIER <profileUUID>" for each profile that was previously connected (see section 4, page 90)
Send remote control command (Control)	AT+AVC<operation_id _{hex} >,<state>	<operation_id _{hex} >: see Table 3.20 <state> (optional): '0' Button pushed '1' Button released Response on command completion: "AVPTC <n>,<operation_id _{hex} >,<state>"
Send a Unit Info request (Control)	AT+AVU	Response on command completion: "AVUR <n>,<unit_id _{hex} >,<unit_type _{hex} >,<company_id _{hex} >" Successful if <n> = 0
Send a Subunit Info request (Control)	AT+AVS (incomplete*)	Response on command completion: "AVSR <n>,<page _{dec} >,<pagedata _{hex} > <cr,lf>" Successful if <n> = 0 *) only first word of the pagedata is being displayed in the AVSR response message
Set Company Id (Target)	S303 [0..0xFFFFF]	IEEE Company ID, 24bit hexadecimal, Required for UNIT INFO Response in AVRCP target mode, default value is 0xFFFFF.
Enable Unit Info Response (Target)	S305 [0..1]	0 – reject incoming Unit Info Requests 1 – accept incoming Unit Info Requests and send response automatically (default) with Company ID as per S303 and unit type = 0x09 ("Panel", fixed)
Enable Subunit Info Response (Target)	S306 [0..1]	0 – reject incoming Subunit Info Requests 1 – accept incoming Subunit Info Requests and send response automatically (default) with Subunit type = 0x09 ("Panel", fixed) and MaxSubUnitId = 0x00 (fixed)
Configure PASS THROUGH (PT) Response (Target)	S310 [0..1]	1 = Enable automatic PT-response, response type is read from S311, (default) 0 = Host is required to respond to PT-Indication, see 'AT+PTR'
Set automatic PT response type (Target)	S311 [0.. 7]	This value is queried for automatic PT-Response, see Table 3.22 Default value is "accepted" 1w/ 9r Note: if this value is set to "reject" (2w/10r), then incoming Pass Through commands are not forwarded to the host processor (no AVPTI message is sent to the host.)
Respond to incoming Pass Through command (Target)	AT+AVR<avrc_response_type _{hex} >	<avrc_response_type _{hex} >: see Table 3.22 If S 310 == 1, response from host is not required.

Table 3.19: AVRCP – S Registers and AT Commands

**AT COMMAND SET
REFERENCE**

Command	Operation ID
Select	0x00
Up	0x01
Down	0x02
Left	0x03
Right	0x04
Right up	0x05
Right down	0x06
Left up	0x07
Left down	0x08
Root menu	0x09
Setup menu	0x0A
Contents menu	0x0B
Favourite menu	0x0C
Exit	0x0D
0	0x20
1	0x21
2	0x22
3	0x23
4	0x24
5	0x25
6	0x26
7	0x27
8	0x28
9	0x29
Dot	0x2A
Enter	0x2B
Clear	0x2C
Channel up	0x30
Channel down	0x31
Sound select	0x32
Input select	0x33
Display information	0x34
Help	0x35
Page up	0x36
Page down	0x37
Power	0x40
Volume up	0x41
Volume down	0x42
Mute	0x43
Play	0x44
Stop	0x45
Pause	0x46
Record	0x47
Rewind	0x48
Fast forward	0x49
Eject	0x4A
Forward	0x4B
Backward	0x4C
Angle	0x50
Sub picture	0x51
F1	0x71
F2	0x72
F3	0x73
F4	0x74
F5	0x75
Vendor unique	0x7e

Table 3.20: AVRCP – Operation IDs for Remote Control Commands

AT COMMAND SET REFERENCE

Unit / Subunit Type	Value
Monitor	0x00
Audio	0x01
Printer	0x02
Disc	0x03
Tape recorder player	0x04
Tuner	0x05
CA	0x06
Camera	0x07
Reserved	0x08
Panel	0x09
Bulletin board	0x0A
Camera storage	0x0B
Vendor unique	0x1C
Reserved for all	0x1D
Extended	0x1E
Unit	0x1F

Table 3.21: AV/C Unit/Subunit Types

AVRC Response Type	Read-Value (S311, sent in response)	Write-Value (S311) or AT+AVR<parameter>
Not implemented	8	0
Accepted	9	1
Rejected (note: incoming pass through commands (AVPTI) will not be displayed to the host if this is the value of S311)	10	2
In transition	11	3
Stable	12	4
Changed	13	5
Interim	15	6
Bad profile	16	7

Table 3.22: AVRC Response Types

Message	Comment
CONNECT 123456789012,110E,>	Outgoing AVRCP connection established '123456789012' – bd_addr of peer device '110E' – UUID indicating AVRCP
CONNECT 123456789012,110E,<	Incoming AVRCP connection established '123456789012' – bd_addr of peer device '110E' – UUID indicating AVRCP
NO CARRIER 110E	AVRCP connection rejected or closed
NO CARRIER	All Connections closed
AVUR 0<n>,<unit_id>,<unit_type _{hex} > <company_id _{hex} >	Successful response to AT+AVU (UNIT INFO Request), indicates completion of command <unit_id _{hex} >: Unit ID <unit_type>: see Table 3.21 <company_id>: IEEE Company ID
AVUR <n> (n>0)	Unsuccessful response to AT+AVU (UNIT INFO Request), indicates completion of command <n> = status _{dec} : 1 – fail 4 – timeout

AT COMMAND SET
REFERENCE

Message	Comment
AVSR 0,<page _{dec} >,<pagedata _{hex} >	Successful response to AT+AVS (SUBUNIT INFO Request), indicates completion of command <page _{dec} > : requested page [0..31] <pagedata _{hex} > : 1st word of requested page
AVSR <n> (n>0)	Unsuccessful response to AT+AVS (SUBUNIT INFO Request), indicates completion of command <n> = status _{dec} : 1 – fail 4 – timeout
AVPTI <subunit_id _{hex} >,<operation_id _{hex} >,<state>	Indication of incoming Pass Through command <subunit_id _{hex} >: subunit id <operation_id _{hex} >: see Table 3.20 <state>: '0' – Button pushed '1' – Button released
AVPTC <n>,<operation_id _{hex} >,<state>	Confirmation of AT+AVC (Control Command Request) <n> = status _{dec} : 0 – success 1 – fail 4 – timeout 7 – operation not supported any value in range [1..9] - not successful <operation_id _{hex} >: see Table 3.20 <state>: '0' – Button pushed '1' – Button released

Table 3.23: AVRCP Unsolicited Messages

5.5 AVRCP GPIO Mapping

GPIOs can be mapped to AVRCP Commands (operations) with GPIO Configuration Registers S 651 to 663. If Function mapping is enabled (FME=1), and if a valid av_operation_id (see Table 3.20) is assigned to a GPIO and if the module is configured as AVRCP Control (S 301), a rising edge causes the appropriate command request to be sent to the connected AVRCP target as if AT+AVC was issued with <state>=0 (Button pushed). A trailing edge on this GPIO will cause the same command to be sent with <state>=1 (Button released).

The logical level of a GPIO can be inverted by setting the appropriate flag “INV” in the appropriate GPIO configuration register.

If configured as AVRCP Target, the direction flag (DIR) in the GPIO Configuration Register must be set to 1 in order to indicate received commands at a digital output. A write operation to a GPIO will not have any effect if that GPIO is mapped to AVRCP.

The level inversion Flag INV of the GPIO Configuration Register also applies in target mode.

Restrictions can apply if certain GPIOs will be reserved for other functions in future, e.g. coexistence supporting functionality.

Please refer to Table 3.44 and section 8.1 on page 87.

6. HSP (Headset Profile)

The “Headset Profile” provides full-duplex audio capability combined with minimal device control commands. Audio bandwidth is limited and deemed to be sufficient for, e.g., voice links. Table 3.24 lists the feature requirements of the HSP specification [4] and the level of support by BTM5xx.

Version 1.2 of the Headset Profile specification is supported.

In most cases it will be preferred to use the more advanced Hands-Free Profile (HFP).

HSP defines the role of the headset (HS) and the role of the audio gateway (AG) which are both supported on BTM5xx. They are enabled by setting the appropriate flag in S-Register 102 (plus subsequent “AT&W” and “atz”).

An HSP connection can be in one of two states: ACL connected or audio connected. The ACL is initiated by either HS or AG. The audio connection (a SCO link) shall always be initiated and released by the AG.

A host processor is required, using AT commands to control the BTM5xx module (hosted operation mode).

An AT command beginning with AT+HS... indicates affiliation to the Headset role of HSP.

An AT command beginning with AT+HSG... indicates affiliation to the Audio Gateway role of HSP.

**AT COMMAND SET
REFERENCE**

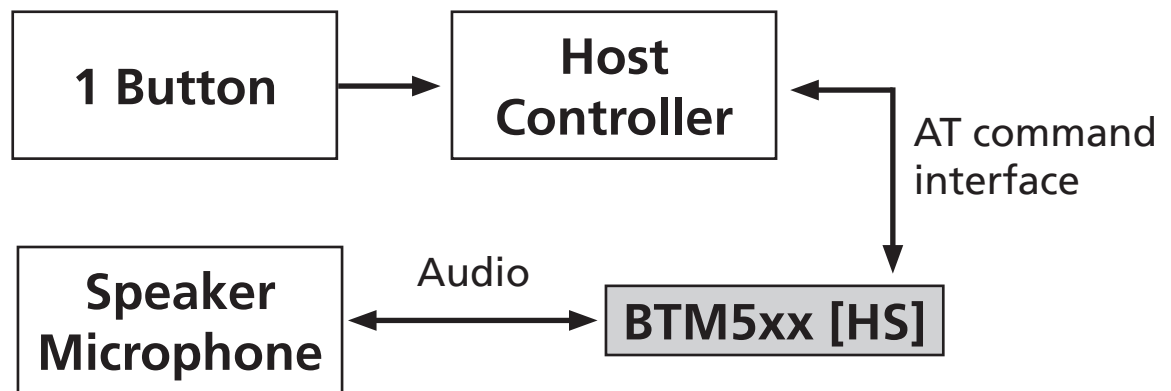
HSP Feature	Support in HS		Support in AG	
	Specification	BTM5xx	Specification	BTM5xx
1. Incoming audio connection	M	Yes	M	Yes
2. Outgoing audio connection	M	Yes	O	Yes
3. Audio connection transfer	M	Yes	M	Yes
4. Remote audio volume control	O	(1)	O	(1)

M: mandatory
O: optional
(1) Supported planned for future firmware release

Table 3.24: Headset Profile supported features on BTM5xx**6.1 Headset role (HS)**

Headset role is activated by setting flag 0x02 in S102 plus "AT&W" plus "ATZ".

Figure 3.22 shows a block diagram of a headset and how a BTM5xx module would be integrated in hosted operation mode.

**Figure 3.22 Headset block diagram****6.1.1 Initiate ACL connection from HS**

AT+HSD<bd_addr_{hex}>

Initiate ACL connection from local headset instance to remote device with <bd_addr_{hex}>. The remote device must support the audio gateway role (AG) of the headset profile (HSP).

Response: <cr,lf>CONNECT 123456789012,1112,><cr,lf>

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

Or: <cr,lf>ERROR 59<cr,lf>

Or: <cr,lf>ERROR 63<cr,lf>

After an ACL connection has been established, the module remains in AT command mode. S Register 531 is ignored for HSP connections. An audio connection should be established within short time. The command is "AT+HSB".

6.1.2 Send "AT+CKPD=200"

AT+HSB

Send "AT+CKPD=200" to connected audio gateway. This indicates a user initiated action to the gateway, e.g., a button press. Depending on the current audio connection state, the audio gateway will establish or release the audio connection subsequently. Please refer to Table 3.25.

**AT COMMAND SET
REFERENCE**

Connection status	Outcome of AT+HSB ("AT+CKPD=200")
ACL connected (ATI63=1)	Audio link will be initiated by AG Referred to as "Audio Connection Transfer from AG to HS" in HSPv1.2
Audio connected (ATI63=2)	Audio link and ACL should be released by the AG, actual outcome depends on AG

Table 3.25: Outcome of "AT+HSB"**6.1.3 Release Connection from Headset****AT+HSH**

Release connection from local Headset instance. Audio connection will be released if existing, ACL will be released anyway.

A connection release, initiated by the Headset, is not defined in the Headset Profile specification [4]. A profile compliant disconnection is initiated from Headset by sending "AT+CKPD=200" (use "AT+HSB") to the audio gateway.

This command was introduced for the sake of completeness and should be used for testing purposes only.

Response:

On audio disconnection (optional): <cr,<lf>HS"AU0"<cr,<lf>

On ACL disconnection: <cr,<lf>NO CARRIER 1108<cr,<lf>

6.1.4 Headset status**ATI63**

Returns the status of the Headset (HSP) instance:

0 = not connected

1 = ACL connected

2 = Audio connected

6.1.5 Headset asynchronous messages**CONNECT <bd_addr_{hex}>,<uuid_{hex}>[,<dir>]**

An ACL connection to headset has been established.

<bd_addr_{hex}> : Bluetooth address of headset device

<uuid_{hex}> : "1108" if it was an incoming connection
: "1112" if it was an outgoing connection.

<dir> : "<">"<">"<">"<">" optionally indicates the direction (incoming/outgoing), please refer to S331 and section 6, page 92.

HS"RING"

HS has received a "RING" indication from the connected audio gateway. HS is expected to respond with "AT+CKPD=200" (see "AT+HSB").

HS"AU1"

Audio connection (SCO) has been established (= "audio on").

HS"AU0"

Audio connection (SCO) has been released (= "audio off").

NO CARRIER 1108

ACL connection to local HS-instance has been released. Please note section 6, page 92.

**AT COMMAND SET
REFERENCE**

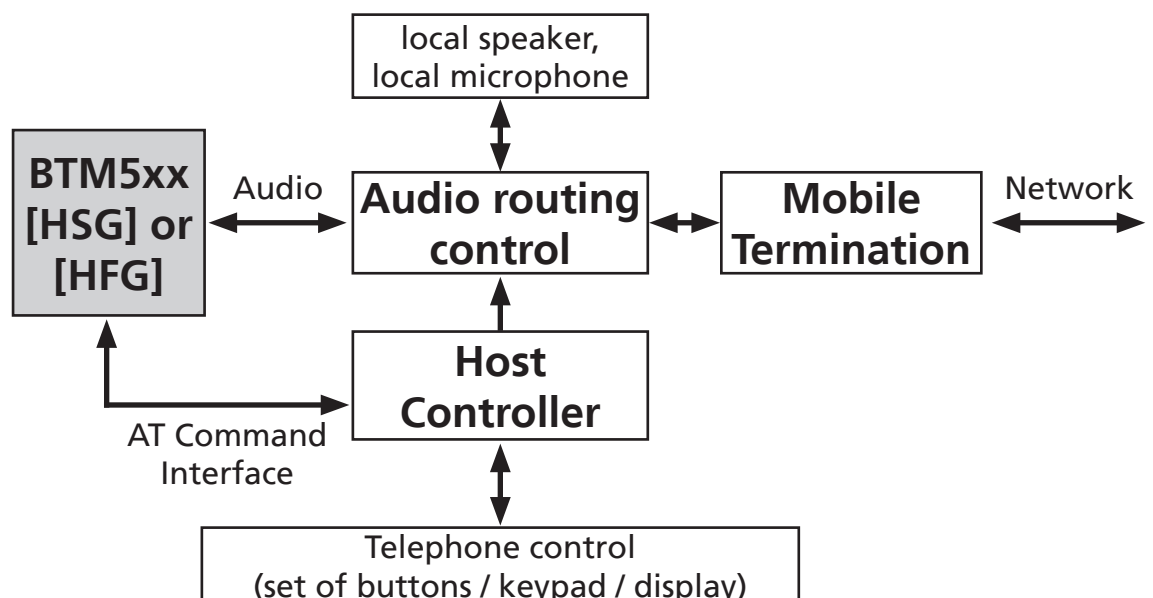
6.1.6 Headset summary

Task	AT-Command / S Register	Comment
Enable HSP-HS role	S102	0x02 = HS role of HSP (bitmask), needs subsequent "AT&W" and "atz" to activate
Initiate ACL from headset	AT+HSD<bd_addr _{hex} >	Responses: successful: "CONNECT 123456789012,1112,>" failed: "NO CARRIER" profile disabled: "ERROR 59" incorrect state: "ERROR 63"
Send "Button pressed" (HS)	AT+HSB	Sends "AT+CPKD=200" to the connected gateway
Disconnect from HS	AT+HSH / ATH1108 / ATH*	For test purposes only, because disconnection initiated by HS other than sending "AT+CPKD=200" to gateway is not defined in HSP specification.
Enable "ATH" for HS	S332	Enable HS disconnection "ATH1108" and "ATH*" <ul style="list-style-type: none"> 0 = disabled (default) 1 = enable Should only be enabled for test purposes, because disconnection initiated by HS other than sending "AT+CPKD=200" to gateway is not defined in HSP specification.
Inquire HS status	ATI63	0 = not connected 1 = ACL connected 2 = Audio connected

Table 3.26: Headset role (HSP) – Summary of S Registers and AT Commands

6.2 Audio gateway role (AG-HSP / HSG)

Audio gateway role (for HSP) is activated by setting flag 0x08 in S102 plus "AT&W" plus "atz".
Figure 3.23 outlines a block diagram of an audio gateway with a BTM5xx in hosted operation mode.

**Figure 3.23 Audio Gateway block diagram**

**AT COMMAND SET
REFERENCE****6.2.1 Initiate ACL Connection from AG (HSP)****AT+HSGD<bd_addr_{hex}>**

Initiate ACL connection from local headset-gateway instance to remote device with <bd_addr_{hex}>. The remote device must support the headset role (HS) of the headset profile (HSP).

Response: <cr,lf>CONNECT 123456789012,1108,><cr,lf>

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

Or: <cr,lf>ERROR 59<cr,lf>

Or: <cr,lf>ERROR 63<cr,lf>

After an ACL connection has been established, the module remains in AT command mode. S Register 531 is ignored for HSP connections.

If S-Register 345=1, the audio gateway will alert the headset immediately by sending "RING" or by performing the in-band ringing procedure (depending on S Register 346) and wait for the response "AT+CKPD=200".

If S-Register 345=0, an incoming call must be signaled to the HS manually by issuing "AT+HSGC". This will either send the "RING" message to the HS or perform the in-band ringing procedure and wait for "AT+CKPD=200" to be received from the HS.

In the case the headset does not respond, it is the host's responsibility to terminate the connection by "AT+HSGH".

6.2.2 Alert HS by Sending "RING" Message or In-Band Ringing**AT+HSGC**

When in "ACL connected" state, the command "AT+HSGC" alerts the HS either by sending "RING" (if S346=0) or by in-band ringing (if S346=1). In the latter the AG is assumed to create an in-band ringtone which is audible on the HS through the SCO connection. The in-band ringtone is not created by BTM5xx itself. It is required to be created by the external circuit and to be connected to the BTM5xx analogue audio input.

In-band ringing is indicated by "ATI64" returning 6. Alerting using the "RING" message is indicated by "ATI64" returning 5.

In both cases the response "AT+CKDP=200" ("Button pressed") is expected from the HS.

6.2.3 Cancel an Ongoing Alert Process**AT+HSGCH**

When the HSG is alerting the HS (ATI64 = 5 / 6) this state can be cancelled by "AT+HSGCH". If in-band ringing was active (ATI64 = 6) , the audio connection will be released.

6.2.4 Release Audio from HSG Side/Transfer Audio from HS to HSG**AT+HSGR**

When in "audio connected" state, the AG can transfer the audio connection from the headset to itself with "AT+HSGR". This results in the release of the audio connection whereas the ACL connection is retained. In "ACL connected" state, the headset (HS) is able to transfer the audio connection back to the HS by sending "AT+CKPD=200".

6.2.5 Initiate Audio from HSG Side/Transfer Audio from HSG to HS**AT+HSGA**

When in "ACL connected" state, the AG can transfer the audio connection from itself to the headset by "AT+HSGA". This results in the establishment of a SCO based audio connection.

6.2.6 Connection Release from AG**AT+HSGH**

Release existing connection to a HS. If the HS is alerted, alerting will be cancelled. If an audio connection exists it will be released first. ACL will be released in either case.

Response:

On audio disconnection (optional): <cr,lf>HSG "AU0"<cr,lf>

On SLC disconnection: <cr,lf>NO CARRIER 1112<cr,lf>

**AT COMMAND SET
REFERENCE****6.2.7 Enable Automatic Alerting on SLC Establishment****S345**

S-Register 345 enables automatic alerting on ACL establishment. It contains a bitmask where bit0 corresponds to outgoing ACL connections and bit1 corresponds to incoming ACL connections.

If automatic alerting is disabled (S345=0), it can be initiated manually by "AT+HSGC".

6.2.8 Enable In-Band Ringing**S346**

In-band ringing is enabled by S-Register 346 (value =1). If disabled (S346=0), the "RING" message is send instead to alert the HS.

6.2.9 Enable Automatic SLC Release**S347**

If the HSG is in "audio connected" state and the HS initiates an audio release by "AT+CKPD=200" ("Button pressed"), the ACL will be released too if S-Register 347 = 1. If S347=0, it is up to the user to release the ACL manually by "AT+HSGH" or retain the ACL by doing nothing.

6.2.10 AG Status**ATI64**

Returns the status of the Audio Gateway (HSP) instance:

0 = not connected

1 = ACL connected

2 = Audio connected

5 = Alerting HS by sending "RING"

6 = Alerting HS by in-band ringing

6.2.11 AG Asynchronous Messages

CONNECT <bd_addr_{hex}>,<uuid_{hex}>[,<dir>]

An ACL connection to headset has been established.

<bd_addr_{hex}> : Bluetooth address of headset device

<uuid_{hex}> : "1112" if it was an incoming connection
: "1108" if it was an outgoing connection.

<dir> : "<"/"/"/"/"O" optionally indicates the direction (incoming/outgoing), please refer to S331 and section 6, page 92.

HSG"AU1"

Audio connection (SCO) has been established (= "audio on").

HSG"AU0"

Audio connection (SCO) has been released (= "audio off").

HSG"B"

"AT+CKPD=200" ("Button pressed") was received from HS.

HSG"VGSn"

"AT+VGS=n" with was received from HS (speaker gain setting). The valid range for n is 0..15.

HSG"VGMn"

"AT+VGM=n" with was received from HS (microphone gain setting). The valid range for n is 0..15.

NO CARRIER 1112

ACL connection to local AG-instance has been released. Please note section 6, page 92, too.

AT COMMAND SET
REFERENCE

6.2.12 AG - HSP Summary (HSG)

Task	AT-Command / S Register	Comment
Enable HSP-AG role	S102	0x08 = AG role of HSP (bitmask), needs subsequent "AT&W" and "atz" to activate
Initiate SLC from AG (HSP)	AT+HSGD<bd_ad-dr _{hex} >	Responses: successful: "CONNECT 123456789012,1108,>" failed: "NO CARRIER" wrong state: "ERROR 63" profile disabled: "ERROR 59"
Alert HS by RING or in-band ringing	AT+HSGC	An existing SLC is required. RING / in-band-ringing is controlled by S346. Automatic alerting can be configured using S345.
Cancel alerting before answered by HS	AT+HSGCH	HSG must be in alerting state (ATI64=5 or =6) HSG will stop sending RING-message or release audio (in-band ringing)
Initiate audio / Transfer audio from AG to HS	AT+HSGA	An existing SLC is required
Release audio connection / Transfer audio from HS to AG	AT+HSGR	Response: successful: "OK" and "HSG"AU0" wrong state: "ERROR 63" profile/role disabled: "ERROR 59"
Release audio and SLC from AG	AT+HSGH or ATH1112 or ATH*	Response: successful: NO CARRIER 1112 (AG(HSP) was connected previously) wrong state: "ERROR 63" profile/role disabled: "ERROR 59"
Enable automatic alerting on ACL establishment	S345	0 = disable auto alerting 1 = auto alerting on outgoing ACL established 2 = auto alerting on incoming ACL established 3 = auto alerting on outgoing and incoming ACL established
Enable in-band ringing	S346	0 = disable in-band ringing 1 = enable in-band ringing
Enable automatic ACL release	S347	0 =disable 1 = ACL will be released automatically when audio was released by the HS.
Inquire AG status	ATI64	0 = not connected 1 = ACL connected 2 = Audio connected 5 = Ringing (ACL connected) 6 = In-band ringing (Audio connected)

Table 3.27: Audio gateway role (HSP) – Summary of S Registers and AT Commands

**AT COMMAND SET
REFERENCE****7. HFP (Hands-Free Profile)**

The Hands-free profile (HFP) defines how two devices supporting HFP shall interact with each other on a point-to-point basis. The use case for HFP is a hands-free unit that is connected wirelessly to an audio gateway. The audio gateway is typically a cellular phone. The hands-free unit acts as audio input and audio output of the cellular phone and allows to control typical telephony functions to be performed without access to the actual phone.

A BTM5xx module is required to be controlled by a host processor using AT commands (hosted operation mode). BTM5xx HFP implementation supports both Hands-free role and Audio gateway role.

An AT command beginning with AT+HF... indicates affiliation to Hands-free role of HFP.

An AT command beginning with AT+HFG... indicates affiliation to Audio Gateway role of HFP.

Version 1.5 of the hands-free profile is supported [5].

Table 3.28 below shows the feature requirements for this profile and the level of support on BTM5xx. It is highly recommended to download the profile specification [5] in order to understand the procedures related to a certain AT command. For quick navigation, references to [5] are given in this section which follow the syntax:

#<Feature>_<Section>

With:

<Feature> = HFP feature no. in Table 3.28 and Table 3.1 of [5]

<Section> = Appropriate Section in [5]

Example: #3_4.12

feature no. = 3, section = 4.12

HFP Feature	Support in HF		Support in AG	
	Specification	BTM5xx	Specification	BTM5xx
1. Connection management	M	Yes	M	Yes
2. Phone status information	M	Yes	M	Yes
3. Audio Connection handling	M	Yes	M	Yes
4. Accept an incoming voice call	M	Yes	M	Yes
5. Reject an incoming voice call	M	Yes	O	Yes
6. Terminate a call	M	Yes	M	Yes
7. Audio Connection transfer during an ongoing call	M	Yes	M	Yes
8. Place a call with a phone number supplied by the HF	O	Yes	M	Yes
9. Place a call using memory dialing	O	Yes	M	Yes
10. Place a call to the last number dialed	O	Yes	M	Yes
11. Call waiting notification	O	Yes	M	Yes
12. Three way calling	O	(2)	O	(2)
13. Calling Line Identification (CLI)	O	Yes	M	Yes
14. Echo cancellation (EC) and noise reduction (NR)	O	(5)	O	(5)
15. Voice recognition activation	O	(5)	O	(5)
16. Attach a Phone number to a voice tag	O	(5)	O	(5)
17. Ability to transmit DTMF codes	O	(5)	M	(4)
18. Remote audio volume control	O	(1)	O	(1)
19. Respond and Hold	O	(2)	O	(2)
20. Subscriber Number Information	O	Yes	M	Yes
21a. Enhanced Call Status	O	(2)	M	Yes
21b. Enhanced Call Controls	O	(2)	O	(2)

M: mandatory

O: optional

(1) support planned for future AT firmware release

(2) support planned for future AT firmware release, but with low priority

(3) not planned to be supported for future AT firmware

(4) service level signalization only

(5) support for service level signalization only planned for future AT firmware release

Table 3.28: Hands-free Profile supported features on BTM5xx

**AT COMMAND SET
REFERENCE****7.1 Hands-Free Unit Role (HF)**

Hands-free role is activated by setting flag 0x10 in S102 plus "AT&W" plus "atz". Figure 3.24 outlines a block diagram with a BTM5xx in hosted operation mode.

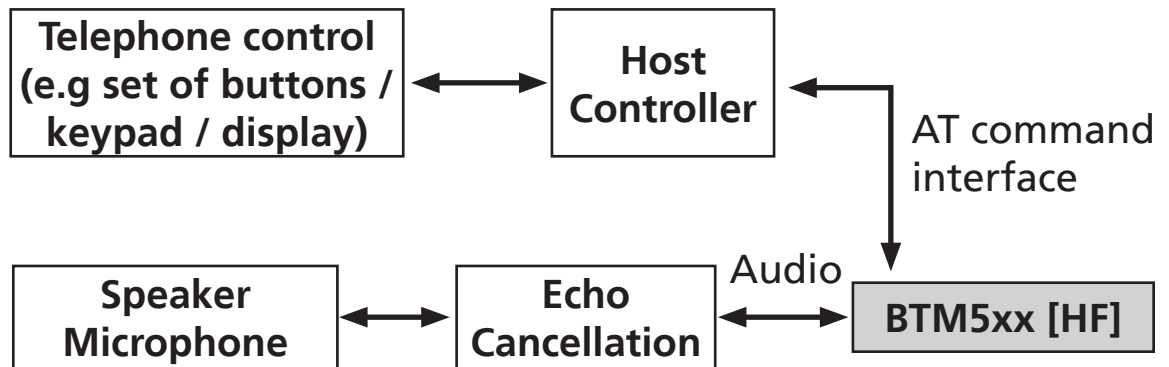


Figure 3.24 Hands-free unit block diagram

7.1.1 Initiate Service Level Connection (SLC) from HF (#1_4.2)

AT+HFD<bd_addr_{hex}>

Initiate service level connection (SLC) from local hands-free instance to remote device with <bd_addr_{hex}>. The remote device must support the audio gateway role (AG) of the Hands-free profile (HFP).

Response:

SLC established: <cr,<lf>CONNECT 123456789012,111F,><cr,<lf>

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

Or: <cr,<lf>ERROR 59<cr,<lf>

Or: <cr,<lf>ERROR 63<cr,<lf>

After a SLC connection has been established, the module remains in AT command mode. S Register 531 is ignored for HFP connections.

7.1.2 Initiate Audio Connection from HF (#3_4.11)

AT+HFA

Initiate audio connection from local Hands-free instance. An existing service level connection is required.

Response:

Audio on: <cr,<lf>HF"AU1"<cr,<lf>

7.1.3 Release Audio Connection from HF (#3_4.12)

AT+HFR

Release audio connection only. The service level connection will be retained.

Response:

Audio off: <cr,<lf>HF"AU0"<cr,<lf>

7.1.4 Release Entire Connection from HF (#1_4.3)

AT+HFH

Release connection from local Hands-free instance. Audio connection will be released if existing, SLC will be released anyway.

Response:

On audio disconnection: <cr,<lf>HF"AU0"<cr,<lf> (only if audio connection exists)

On SLC disconnection: <cr,<lf>NO CARRIER 111E<cr,<lf>

**AT COMMAND SET
REFERENCE****7.1.5 Answer Incoming Call from HF (#4_4.13)****AT+HFCA**

Answer an incoming call. "ATA" will be sent to the AG. In return, the audio gateway shall update its "+CIEV" indicators ("call=1" and "callsetup=0") and send appropriate messages to the HF. Upon receipt of a "+CIEV" message, HF will notify its host by a "HFI<indicator>,<value>" message. Please refer to section 7.1.15 on page 66.

7.1.6 Reject Incoming Call from HF/Terminate Call from HF (#5_4.14;#6_4.15)**AT+HFCH**

Reject incoming call / terminate ongoing call. "AT+CHUP" will be sent to the AG. In return, the audio gateway shall update its indicator "call"=0 and send the appropriate "+CIEV" message to the HF. HF will notify its host by a "HFI<indicator>,<value>" message. Please refer to section 7.1.15 on page 66.

7.1.7 Place Call with Number Provided by HF (#8_4.18)**AT+HFC"nnn"**

Initiate a new call from HF to the number specified by the number string "nnn". This command will send "ATDnnn" to the audio gateway.

7.1.8 Memory Dialing from the HF (#9_4.19)**AT+HFCM"mmm"**

Initiate a new call from HF to the number stored in memory location "mmm" of the AG. This command will send "ATD>mmm" to the audio gateway.

7.1.9 Re-Dial Last Number from HF (#10_4.20)**AT+HFCL**

Initiate a new call from HF to the number last dialed by AG. "AT+BLDN" will be sent to the AG. In return, the audio gateway shall update its indicator "callsetup"=2 and send the appropriate "+CIEV" message to the HF. HF will notify its host by a "HFI<indicator>,<value>" message. Please refer to section 7.1.15 on page 66.

7.1.10 Enable Caller Line Identification Presentation – CLIP (#13_4.23)

The CLIP feature is enabled by setting Bit 2 (value=4) in the HF supported features S register 581. Subsequent AT&W and ATZ is required to take effect. If this bit is set at boot time, the following actions are carried out automatically:

1. The according flag is set in the HF service record.
2. The according flag is set in the BRSF-message on Service Level Connection establishment
3. The SLC message "AT+CLIP=1" is sent automatically once the SLC is established

Response to action no. 3 will be indicated by either HF"CLIP,OK" or HF"CLIP,ERROR" after the "CONNECT..." message.

7.1.11 Enable Call Waiting Notification – CCWA (#11_4.21)

The CCWA feature is enabled by setting Bit 1 (value=2) in the HF supported features S register 581. Subsequent AT&W and ATZ is required to take effect. If this bit is set at boot time, the following actions are carried out automatically:

1. The according flag is set in the HF service record.
2. The according flag is set in the BRSF-message on Service Level Connection establishment
3. The SLC message "AT+CCWA=1" is sent automatically once the SLC is established

Response to action no. 3 will be indicated by either HF"CCWA,OK" or HF"CCWA,ERROR" after the "CONNECT..." message.

**AT COMMAND SET
REFERENCE****7.1.12 Query Subscriber Number from HFG (#20_4.30)****AT+HFS?**

Query subscriber numbers from HFG. "AT+CNUM" is sent to the HFG. HFG will send the subscriber number information, indicated on the HF by HF"+CNUM,,,". An "OK" will be sent by HFG on termination, indicated on HF by the asynchronous message HF"CNUM,OK". If the HFG does not support this feature, it should send ERROR, indicated on HF as HF"CNUM,ERROR". Refer to section 7.1.17 on page 66.

Response:

<cr><lf>OK<cr><lf> (immediately, BTM accepting command)

and one of the following:

<cr><lf>HF"+CNUM:<number>,<type>,<service>"<cr><lf> (refer to section 3.2.7.1.17)

<cr><lf>HF"CNUM,OK"<cr><lf>

or

<cr><lf>HFX"<SLC_message>"<cr><lf> (original SLC response from HF gateway, but response format not compliant to HFP specification)

<cr><lf>HF"CNUM,OK"<cr><lf>

or

<cr><lf>HF"CNUM,ERROR"<cr><lf> (feature not supported by HF-gateway)

or

Nothing, if the HF-gateway is ignoring this query for any reason

7.1.13 Query Operator Selection (#2_4.8)**AT+HFO?**

Query operator selection from HFG. "AT+COPS?" is sent to the HFG. HFG will send the operator selection information, indicated on the HF by HF"+COPS,,,". An "OK" will be sent by HFG on termination, indicated on HF by the asynchronous message HF"COPS,OK". If the HFG does not support this feature, it should send ERROR, indicated on HF as HF"COPS,ERROR". Refer to section 7.1.17 on page 66.

Response:

<cr><lf>OK<cr><lf> (immediately, BTM accepting command)

And one of the following:

<cr><lf>HF"+COPS:<mode>,<operator_size>,<operator>"<cr><lf>
(refer to section 7.1.17 on page 66)

<cr><lf>HF"COPS,OK"<cr><lf>

or:

<cr><lf>HF"COPS,ERROR"<cr><lf>

7.1.14 Enable Extended Error Codes in HFG – CMEE (#2_4.9)**AT+HFE1**

Enable operator selection from HFG. "AT+CMEE=1" is sent to the HFG. HFG will respond with "OK", indicated at the HF by HF"CMEE,OK" or "ERROR" indicated at the HF by HF"CMEE,ERROR"

Response:

<cr><lf>OK<cr><lf> (immediately, BTM accepting command)

And one of the following:

<cr><lf>HF"CMEE,OK"<cr><lf> (confirmation from HFG)

or:

<cr><lf>HF"CMEE,ERROR"<cr><lf> (error, e.g. not supported by HFG)

AT COMMAND SET REFERENCE

7.1.15 "+CIEV" Indicators Received from AG (#2)

HFI<indicator_string>,<val> (S333=1, default)

HFI<indicator_id>,<val> (S333=0)

Inform the HF-host about a "+CIEV" indicator message received from the connected audio gateway. S-Register 333 enables verbose mode for HFI indicators. Possible indicators are listed in Table 3.29.

" +CIEV" Audio Gateway Indicator	HFI indicator_string (S333=1)	HFI indicator_id (S333=0)	Section in HFP spec. [5]
Service	"service"	1	4.4
Call	"call"	2	All call related sections
Call Setup	"callsetup"	3	
Call held	"callheld"	4	
Signal	"signal"	5	4.5
Roam	"roam"	6	4.6
Battery Charge	"battchg"	7	4.7

Table 3.29: +CIEV indicators in HFI message

7.1.16 Hands-Free Status

ATI65

Returns the status of the Hands-free (HFP) instance:

0 = not connected

1 = SLC connected

2 = Audio connected

3 = In call, SLC connected

4 = In call, audio connected

5 = In call setup (incoming/dialling/alerting), SLC connected

6 = In call setup (incoming/dialling/alerting), audio connected

7.1.17 Hands-Free Asynchronous Messages

CONNECT <bd_addr_{hex}>,<uuid_{hex}>[,<dir>]

A Service level connection to headset has been established and initialized.

<bd_addr_{hex}> : Bluetooth address of headset device

<uuid_{hex}> : "111E" if it is an incoming connection
"111F" if it is an outgoing connection.

<dir> : "</"/"/"1"/"0" optionally indicates the direction (incoming/outgoing), please refer to S331 and section 6, page 92

HF"RING"

HF has received a "RING" indication from the connected audio gateway. HF is expected to respond with "ATA" (answer, see "AT+HFCA") or "AT+CHUP" (see "AT+HFCH").

HF"ERROR"

HF has received "ERROR" from the connected audio gateway. This can be due to a request for memory dialling with invalid memory location (AT+HFC>"mmm") or due to a request to redial the last number (AT+HFDL) but there is no last number available in the AG.

HF"AU1"

Audio connection (SCO) has been established (= "audio on").

HF"AU0"

Audio connection (SCO) has been released (= "audio off").

HF"CLIP,OK"

HFG has replied with OK to reception of "AT+CLIP=1" or "AT+CLIP=0".

**AT COMMAND SET
REFERENCE****HF"CLIP,ERROR"**

HFG has replied with ERROR to reception of "AT+CLIP<...>".

HF"+CLIP,n,m,1234567"

A "calling line identification notification" (+CLIP:"1234567",<type>) has been received from the HFG. This message is sent by the HFG on incoming calls together with HF"RING". The HFG and telephone network must support this feature and the according flag (Bit 2) in the HF supported features S register 581 must be set at boot time.

n = type of number (derived from the <type> in SLC message, not the original value):

- 0 – unknown
- 1 – international number
- 2 – national number
- 3 – network specific number
- 4 – dedicated access, short code

m = length of caller number (number of characters)

1234567 = caller number

HF"CCWA,OK"

HFG has replied with OK to reception of "AT+CCWA=1" or "AT+CCWA=0".

HF"CCWA,ERROR"

HFG has replied with ERROR to reception of "AT+CCWA<...>".

HF"+CNUM:'1234567',ttt,s"

Response to a AT+CNUM request received from HFG:

1234567 – phone number in format specified by ttt

ttt – specifies the format of the phone number provided, and can be one of the following values:

- values 128-143: The phone number format may be a national or international format, and may contain prefix and/or escape digits. No changes on the number presentation are required.
- values 144-159: The phone number format is an international number, including country code prefix. If the plus sign ("+") is not included as part of the number and shall be added by the HFG as needed.
- values 160-175: National number. No prefix nor escape digits included.

s – Indicates which service this phone number relates to. Shall be either 4 (voice) or 5 (fax).

HF"+BSIR:0"

HFG has disabled In-Band Ring tone capability ("BSIR:0" was received on SLC)

HF"+BSIR:1"

HFG has enabled In-Band Ring tone capability ("BSIR:1" was received on SLC)

HF"CNUM,OK"

HFG has replied with OK to reception of AT+CNUM (subscriber number information query).

HF"CNUM,ERROR"

HFG has replied with ERROR to reception of AT+CNUM (subscriber number information query). A reason might be that this feature is not supported by the HFG.

HF"+COPS:m,ss,Operator"

Response to a AT+COPS? request received from HFG:

m – contains the current mode and contains no information with regard to the name of the operator.

ss – size of the operator name in characters

Operator – the name of the network operator in alphanumeric format

HF"COPS,OK"

HFG has replied with OK to reception of "AT+COPS?".

AT COMMAND SET REFERENCE

HF"COPS,ERROR"

HFG has replied with "ERROR" to reception of "AT+COPS".

HF"CMEE,OK"

HFG has replied with OK to reception of "AT+CMEE=1".

HF"CMEE,ERROR"

HFG has replied with "ERROR" to reception of "AT+CMEE=1".

HFI<...>

Indicator (+CIEV...) from audio gateway was received. Refer to section 7.1.15 on page 66.

NO CARRIER 111E

Service level connection to local HF-instance has been released. Please note section 6, page 92, too.

7.1.18 Hands-free summary

Task	AT-Command / S Register	Comment
Enable HFP-HF role	S102	0x10 = HF role of HFP (bitmask), needs subsequent "AT&W" and "ATZ" to activate
Initiate SLC from HF	AT+HFD<bd_ad-dr _{hex} >	Responses: successful: "CONNECT 123456789012,111F,>" failed: "NO CARRIER" profile disabled: "ERROR 59" incorrect state: "ERROR 63"
Initiate audio connection from HF	AT+HFA	Responses: HF"AU1"
Release audio only from HF / Transfer Audio to AG	AT+HFR	Responses: HF"AU0"
Initiate call with number provided by HF	AT+HFC"nnn"	"nnn" = number string
Initiate call with number provided by memory of AG	AT+HFCM"mmm"	"mmm" = memory location in AG of number requested to dial
Initiate call to last dialled number	AT+HFCL	Response: HFI"callsetup",2 – confirmation, call is being set up OR: HFG"ERROR" - last dialled number not available in AG
Disconnect SLC from HF (and audio if exists)	AT+HFH / ATH111E / ATH*	Please note section 4, page 90 and section 6, page 92
Enable verbose indicators	S333	0 – display indicator ID only in HFI.. asynchronous message (refer to Section 7.1.15 on page 66) 1 – display indicator string in HFI... asynchronous message (refer to Section 7.1.15 on page 66)
Set HF supported features	S581	Bitmask Bit 1 – call waiting notification capability Bit 2 – CLIP presentation capability Other options are not supported by the current firmware
Inquire HF status	ATI65	0 = not connected 1 = SLC connected 2 = Audio connected 3 = in call - SLC 4 = in call - audio

Table 3.30: Hands-free role (HFP) – Summary of S Registers and AT Commands

**AT COMMAND SET
REFERENCE****7.2 Audio Gateway Role (AG-HFP / HFG)**

Audio gateway role is activated by setting flag 0x40 in S102 plus "AT&W" plus "atz". Please refer to Figure 3.23 (page 58) for a block diagram of an audio gateway with a BTM5xx in hosted operation mode.

Table 3.28 shows the feature requirements for this profile and the level of support on BTM5xx. It is highly recommended to download the profile specification [5] in order to understand the procedures related to a certain AT command. For quick navigation, references to [5] are given in this section which follow the syntax:

#<Feature>_<Section>

With:

<Feature> = HFP feature no. in Table 3.28 and Table 3.1 of [5]

<Section> = Appropriate Section in [5]

Example: #3_4.12

feature no. = 3, section = 4.12

7.2.1 Initiate Service Level Connection (SLC) from AG (#1_4.2)

AT+HFGD<bd_addr_{hex}>

Initiate service level connection (SLC) from local audio gateway instance to remote device with <bd_addr_{hex}>. The remote device must support the Hands-free role (HF) of the Hands-free profile (HFP).

Response:

SLC established: <cr,lf>CONNECT 123456789012,111E,><cr,lf>

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

Or: <cr,lf>ERROR 59<cr,lf>

Or: <cr,lf>ERROR 63<cr,lf>

After an SLC connection has been established, the module remains in AT command mode. S Register 531 is ignored for HFP connections.

7.2.2 Initiate Audio Connection from AG (#3_4.11)

AT+HFGA

Initiate audio connection from local audio gateway instance. An existing service level connection is required.

Response:

Audio on: <cr,lf>HFG "AU1" <cr,lf>

This command is not permitted to be issued in a call setup state (incoming / dialling / alerting, ATI66 = 5 or 6) and will return with ERROR 63 in that case.

7.2.3 Release Audio Connection from AG (#3_4.12)

AT+HFGR

Release audio connection only. The service level connection will be retained.

Response:

Audio off: <cr,lf>HFG "AU0" <cr,lf>

This command is not permitted to be issued in a call setup state (incoming / dialling / alerting, ATI66 = 5 or 6) and will return with ERROR 63 in that case.

**AT COMMAND SET
REFERENCE****7.2.4 Release Entire Connection from AG (#1_4.3)****AT+HFGH**

Release connection from local audio gateway instance. An ongoing call will be terminated and a audio connection will be released if existing, SLC will be released anyway.

Response:

On audio disconnection: <cr,lf>HFG"AU0"<cr,lf> (only if audio connected)

On SLC disconnection: <cr,lf>NO CARRIER 111F<cr,lf>

This command is not permitted to be issued in a call setup state (incoming / dialling / alerting, ATI66 = 5 or 6) and will return with ERROR 63 in that case.

Please also refer to Section 6, page 92.

7.2.5 Signal Incoming Call from AG to HF (#4_4.13)**AT+HFGC"<number_string>",<type_{dec}>**

Signal an incoming call by sending "RING" and "+CLIP:"<number_string>",<type_{dec}>" to HF periodically. The <number_string> field represents the phone number of the ringing party. The type field specifies the format of the phone number provided, and can be one of the following values:

- values 128-143: The phone number format may be a national or international format, and may contain prefix and/or escape digits. No changes on the number presentation are required.
- values 144-159: The phone number format is an international number, including the country code prefix. If the plus sign ("+") is not included as part of the number and shall be added by the AG as needed.
- values 160-175: National number. No prefix nor escape digits included.

Please refer to the Hands-free Profile Specification [5].

The HF is now expected to answer or to reject the call. Optionally, an incoming call can be answered or rejected at the AG side.

7.2.6 Signal "call answered at AG" to HF (#4_4.13.3)**AT+HFGCA**

If no call is active (check with AT+HFGC?, refer to section 7.2.16):

Signal from HFG to HF that an incoming call has been answered at the HFG. On the SLC the indicators "+CIEV:2,1" (call=1) and "+CIEV:3,0" (callsetup=0) are sent to the HF subsequently. The status of the incoming call is changed to active.

If one or more calls are active (check with AT+HFGC?, refer to section 7.2.16):

Signal from HFG to HF that all active calls are put on hold and the waiting call has been answered at the HFG. On the SLC the indicators "+CIEV:3,0" (callsetup=0) and "+CIEV:4,1" (callheld=1) are sent to the HF subsequently. The status of the active call(s) is changed to held and the status of the waiting call is changed to active.

The states of all current calls can be checked by AT+HFGC?

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

7.2.7 Signal Outgoing Call Status from AG to HF (#8_4.18; #9_4.19; #10_4.20)**AT+HFGC1["<number_string>",<type_{dec}>]**

This command shall be used as successful response to a HF initiated call, indicated by one of the following asynchronous messages:

- HFG"Dnnn" (dial number <nnn> given by HF-unit)
- HFG"D>nnn" (dial from AG memory location nnn)
- HFG"L" (redial last number)

"OK" is sent as successful response to the HF's request.

Signal an outgoing call status by sending "+CIEV:3,2" (callsetup=2) indicator to HF. If an audio connection is not present yet, it will be initiated.

**AT COMMAND SET
REFERENCE**

A call record with status = dialling is created and can be checked by AT+HFGC?.

The optional parameters <number_string> and <type> will be stored in the call record. Their format is described in section 7.2.5.

For HFG "Dnnn", AT+HFGC1 this is the only possible response the HFG can issue. If the HFG wants to cancel the HF's call request, it shall issue AT+HFGC1 first, followed by AT+HFGCH which will then terminate the call process.

AT+HFGC2

Signal to HF that remote party was reached and is being alerted during an outgoing call setup procedure. "+CIEV:3,3" (callsetup=3) indicator is sent to HF. If the wireless network does not provide an indication of alerting the remote party, the AG may not send this indication.

AT+HFGC3

Signal to HF that remote party has answered the call. "+CIEV:2,1" (call=1) and "+CIEV:3,0" (callsetup=0) indicators is sent to HF subsequently.

AT+HFGC4["<number_string>",<typedec>]

This command shall be used if a call is initiated at the HFG and not at the HF.

"OK" is not sent to the HF (in contrast to HFGC1).

Signal an outgoing call status by sending "+CIEV:3,2" (callsetup=2) indicator to HF. If an audio connection is not present yet, it will be initiated.

A call record with status = dialling is created and can be checked by AT+HFGC?.

The optional parameters <number_string> and <type> will be stored in the call record. Their format is described in section 7.2.5.

7.2.8 Signal termination or rejection of a call from AG to HF (#6_4.15)**AT+HFGCH**

Terminate or reject all calls in one of the following states: active, incoming, waiting, dialling, alerting. And signal termination of a call by sending "+CIEV:2,0" (call=0) indicator to HF.

If a call in state incoming / waiting is ongoing, this command means it is rejected. If a call in state dialling / alerting is ongoing, this would then indicate the interruption / cancellation of the ongoing call setup procedure for any reason (including rejection of an outgoing call by the remote party).

According to the call status of the terminated or rejected call, HFG "T" or HFG "R" is sent to the host.

AT+HFGCHL

Terminate all calls in status "held". And signal termination of a call by sending "+CIEV:4,0" (callheld=0) indicator to HF. The appropriate call record is deleted.

7.2.9 Sending AG Indicators to HF (" +CIEV..." , #2)**AT+HFGI<indicator_id_{dec}>,<value_{dec}>**

Send an AG indicator to HF in the form "+CIEV:<indicator_id>,<value>"

Table 3.31 lists possible indicators and their value range.

If there is no SLC existing and indicator "Service" is set (AT+HFGI1,n), the value is stored in volatile memory in order to be presented during a future SLC initialization procedure.

For all other indicators, this command is valid only if a SLC exists.

AT+HFGI should only be used with indicator IDs 1 (service), 5 (network signal strength), 6 (roam) and 7 (battery charge level).

For call management purposes the appropriate AT+HFGCx command should be used. They will send call related indicators (call, call setup, call held) automatically.

**AT COMMAND SET
REFERENCE**

Indicator name	indicator_id	Range of value	Section in HFP spec. [5]
Service	1	0..1	4.4
Call	2	0..1	All call related sections
Call setup	3	0..3	All call related sections
Call held	4	0..2	All call related sections
Signal	5	0..5	4.5
Roam	6	0..1	4.6
Battery Charge	7	0..5	4.7

Table 3.31: AG indicators for "AT+HFGI.."**7.2.10 Send Operator String to HF ("COPS...", #2_4.8)****AT+HFGO"<operator_string>"**

Send network operator string to HF by "+COPS:0,0,"<operator_string>" on SLC. This command shall be used to respond to a "AT+COPS?" request, indicated by the asynchronous message HFG"OP?".

7.2.11 Change In-band ring tone setting when SLC exists (#4_4.13.4)**AT+HFGBO / AT+HFGB1**

As a prerequisite for this command, the in-band ring flag (0x08) must have been set in S596 (HFG supported features) at boot time and a service level connection to the HF shall be established.

Use AT+HFGBO to indicate to the HF that the HFG will not provide in-band ring tones subsequently. "+BSIR:0" is sent over the SLC.

Use AT+HFGB1 to indicate to the HF that the HFG will provide in-band ring tones subsequently. "+BSIR:1" is sent over the SLC.

The BTM module does not create ring tones itself. The actual ringtone signal would have to be provided by an external circuit and would have to be injected to the analogue audio input port of the BTM module.

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

Or: <cr,<lf>ERROR 68<cr,<lf> If no SLC present

Or: <cr,<lf>ERROR 69<cr,<lf> If in-band ring flag was not set in the HFG supported features (S596) at boot time.

7.2.12 Send "ERROR" or "+CME ERROR..." to HF**AT+HFGE<cme_code>**

Send "ERROR" to HF if no <cme_code> is given. Required as optional response to HFG"D>nnn" an HFG"L".

If the optional <cme_code> is appended and if extended AG error result codes were enabled by HF (stored internally), the appropriate extended error result code in the form of +CME ERROR: <cme_code> is sent to HF.

If <cme_code> is appended but extended error codes have not been enabled by HF, <cme_code> is ignored and only "ERROR" is sent to HF.

7.2.13 Subscriber Number Records ("CNUM...", #20_4.30)**AT+HFGS="<number_string>",<type>,<service>**

This command adds a subscriber number record to the HFG. The subscriber number is the telephone number of the HFG. It is allowed to have more than one subscriber numbers. All subscriber numbers available should be stored in the HFG immediately after power up of the system. As soon as an SLC to a HF device is established, the HF can query the HFG's subscriber numbers at any time by sending "AT+CNUM" to the HFG on the SLC. The subscriber number records existing at that time will be sent to the HF automatically then. Subscriber number records are stored in volatile memory. Hence they are lost on reset or power cycle. At maximum 4 subscriber number records are allowed.

**AT COMMAND SET
REFERENCE**

<number_string> = subscriber number string, characters allowed: 0123456789*#+ABDCTP!W@

<type> = specifies the format of <number_string> provided, can be one of the following values:

- values 128-143: The phone number format may be a national or international format, and may contain prefix and/or escape digits. No changes on the number presentation are required.
- values 144-159: The phone number format is an international number, including the country code prefix. If the plus sign ("+") is not included as part of the number and shall be added by the AG as needed.
- values 160-175: National number. No prefix nor escape digits included.

<service> = service of this subscriber number, permitted values:

4 – voice

5 – fax

Response:

<cr><lf>OK<cr><lf> command valid, record added

OR:

<cr><lf>ERROR 05<cr><lf> syntax or value range error

OR:

<cr><lf>ERROR 67<cr><lf> maximum number of subscriber number records reached

AT+HFGS?

This command returns a list of currently available subscriber number records which would be sent to the HF-unit on request ("AT+CNUM" issued by HF on the SLC).

Response:

For each subscriber number record (if at least one is available):

<cr><lf>[<index>]"<number_string>",<type>,<service><cr><lf>

And finally:

<cr><lf>OK<cr><lf> command finished

With:

<index> = current index of the record, required as parameter n for AT+HFGSD<n>

<number_string> = subscriber number string

<type> = specifies the format of <number_string>, refer to "AT+HFGS=..." above

<service> = service of this subscriber number:

4 – voice

5 – fax

AT+HFGSD

Delete all subscriber number records in the HFG.

Response:

<cr><lf>OK<cr><lf>

AT+HFGSD<n>

Delete subscriber number record with index <n> in the HFG. <n> refers to the index that is displayed on HFGS?. <n> is assumed to be one digit. The index is not fixed to a record. If there are higher numbered indexes than the one deleted, the remaining records will get a new index assigned dynamically on HFGS?.

Response:

<cr><lf>OK<cr><lf>

Or:

<cr><lf>ERROR 66<cr><lf> record with requested index <n> not available

Or:

<cr><lf>ERROR 05<cr><lf> syntax error

**AT COMMAND SET
REFERENCE****7.2.14 HFG – Call Waiting Notification (“+CCWA...”, #11_4.21, #12_4.22.1)**

Call waiting notification is a mandatory feature for the HFG and is therefore supported on the BTM510/511. If call waiting notification was enabled by the HF (#11_4.21) and when a call is waiting (incoming call whilst call is active), the call waiting notification “+CCWA...” and the appropriate call setup indicator “+CIEV: callsetup=1” are sent automatically as specified in section 4.22.1 of the HFP specification [5].

7.2.15 HFG status**ATI66**

Returns the status of the HFG instance:

0 = not connected

1 = SLC connected

2 = Audio connected

3 = In call, SLC connected

4 = In call, audio connected

5 = In call setup (incoming/dialling/alerting), SLC connected

6 = In call setup (incoming/dialling/alerting), audio connected

8 = In call, no SLC

7.2.16 HFG Call Records

The HFG maintains call records for all calls. Even when no HF is attached to the HFG (no SLC existing), the HFG needs to be aware of all ongoing calls in order to send the correct HFP indicators as soon as an HF connects.

Also, it is mandatory for the HFG to respond to a current call list request, issued by the HF (AT+CLCC, #21a_4.31.1). The HFG queries its internal list of current calls and replies automatically to AT+CLCC.

The list of current calls is displayed to the host by AT+HFGC?. The state of a call record is changed by AT commands beginning with “AT+HFGC...” .

AT+HFGC?

List all current calls.

Response for each call record (if existing, verbose mode controlled by S354):

```
<cr,<lf>[<idx>],<dir>,<call_status>,<call_mode>,<fmultiparty>,<br>,<number_string>,<number_type>
```

With:

idx : unique index of call, 1 digit

dir : 0 ('>') for outgoing, 1 ('<') for incoming call

call_status :

0 = active

1 = held

2 = dialling (outgoing)

3 = alerting (outgoing)

4 = incoming (incoming and ringing)

5 = waiting (incoming and waiting whilst another call is active)

call_mode :

0 = voice

1 = data

2 = fax

fmultiparty :

0 = call is point to point ('p')

1 = call is part of multiparty ('m')

number_string : calling or called line identification presentation string, refer to section 7.2.5.

number_type : number type for CLIP, refer to section 7.2.5.

**AT COMMAND SET
REFERENCE**

Response at the end of list:

<cr,<lf>OK<cr,<lf>

S354 – Enable/disable verbose presentation of call records

S register 354 controls verbose presentation of call records (AT+HFGC?)

Value 0 = non-verbose mode (default)

Value 1 = verbose mode

Verbose mode gives better understanding of call states and call records in a human readable style whereas non-verbose mode is the preferred mode for a host microcontroller.

7.2.17 Call status vs. HFG status

Table 3.32 maps the call states to HFG states. For more information about call states refer to section 7.2.16. For more information about HFG status refer to section 7.2.15.

Call status (AT+HFGC?)	HFG status, SLC (ATI66)	HFG status, no SLC (ATI66)
Incoming (ringing)	5/6	8
Dialling	5/6	8
Alerting	5/6	8
Active, waiting	5/6	8
Alerting	3/4	8
Held	3	8

Table 3.32: Mapping of call status and HFG status

7.2.18 Audio Gateway (HFP) - Asynchronous Messages

CONNECT <bd_addr_{hex}>,<uuid_{hex}>[,<dir>]

A Service level connection to headset has been established and initialized.

<bd_addr_{hex}> : Bluetooth address of headset device

<uuid_{hex}> : "111F" if it is an incoming connection
"111E" if it is an outgoing connection.

<dir> : "<"/">"/"I"/"O"" optionally indicates the direction (incoming/outgoing), please refer to S331 and section 6, page 92.

HFG"VGS<n>"

Speaker gain setting message was received from HF (" +VGS:<n>") with n = gain [0..15].

HFG"VGM<n>"

Microphone gain setting message was received from HF (" +VGM:<n>") with n = gain [0..15].

HFG"AU1"

Audio connection (SCO) has been established (= "audio on").

HFG"AU0"

Audio connection (SCO) has been released (= "audio off").

HFG"C"

A call has been established and is ongoing.

HFG"T"

A call has been terminated.

HFG"R"

Incoming call was rejected by HF.

HFG"OP?"

Request for network operator string ("AT+COPS?") received from HF. AG is expected to reply with "+COPS:0,0,<operator_string>" on SLC. Use AT+HFGO"<operator_string>".

**AT COMMAND SET
REFERENCE****HFG"Dnnn"**

Request from HF to place an outgoing call to phone number provided by HF with <nnn> = number string. The AG is expected to confirm the outgoing call with the command AT+HFGC1.

HFG"D>nnn"

Request from HF to place an outgoing call using memory dialling with <nnn> = memory location. The AG is expected to either confirm the outgoing call with the command AT+HFGC1 or to respond with AT+HFGE if the memory location is invalid.

HFG"L"

Request from HF to place an outgoing call using the last number dialled. The AG is expected to either confirm the outgoing call with the command AT+HFGC1 or to respond with AT+HFGE if the last number dialled is not available.

HFG"Mn"

Request from HF to generate DTMF code <n> towards the telephony network.

HFG"NREC0"

Request from HF to disable noise reduction and echo cancellation. This message will only appear if noise reduction/echo cancellation was enabled in S596 at boot time (Bit1). The HFG is supposed to disable noise reduction and echo cancellation and respond with an OK. If noise reduction / echo cancellation was not enabled at boot time, no message will be displayed and "ERROR" will be sent to the HF silently.

HFG"CLIP1"

Request to activate caller line identification notification in the AG.

HFG"CCWA1"

Request to activate call waiting notification in the AG.

HFG"CMEE1"

Request to activate extended AG error result codes in the form +CME ERROR: <err>.

NO CARRIER 111F

Service level connection to local HFG-instance has been released. Please note section 6, page 92.

7.2.19 AG - HFP summary (HFG)

Task	AT-Command / S Register	Comment
Enable HFP-AG role	S102	0x40 = AG role of HFP (bitmask), needs subsequent "AT&W" and "ATZ" to activate
Initiate SLC from HFG	AT+HFGD<bd_addr _{hex} >	Responses: Successful: "CONNECT 123456789012,111F,>" failed: "NO CARRIER" profile disabled: "ERROR 59" incorrect state: "ERROR 63"
Initiate audio connection from AG / Transfer Audio from AG to HF	AT+HFGA	Response: HFG "AU1" not permitted during call setup state (incoming/ dialling/alerting), ERROR 63 is returned in that case
Release audio only from AG / Transfer Audio from HF to AG	AT+HFGR	Response: HFG "AU0" not permitted during call setup state (incoming/ dialling/alerting), ERROR 63 is returned in that case
Disconnect SLC from HFG (and audio if exists)	AT+HFGH / ATH111F / ATH*	Please note section 7.2.4 not permitted during call setup state (incoming/ dialling/alerting), ERROR 63 is returned in that case
Signal incoming call to HF	AT+HFGC"<number_ string>",<type _{dec} >"	Sends "RING" and "+CLIP: <number_string>,<type>" to HF <type> must be in range 128..175 Refer to section 7.2.5 on page 70
Signal incoming call answered at HFG to HF	AT+HFGCA	Sends "+CIEV:2,1" (call=1) and "+CIEV:3,0" (callset- up=0) over SLC. Refer to section 7.2.6 on page 70

AT COMMAND SET
REFERENCE

Task	AT-Command / S Register	Comment
Signal outgoing call status to HF, update call record	AT+HFGC1["<number_string>",<typedec>]	Outgoing call is being initiated by AG as result of a HF request . Use this AT command as positive confirmation of: HFG"Dnnn" or (1) HFG"D>mmm" or (2) HFG"L" (2) "OK" is sent to the HF. A call record in state "dialling" is created. <number_string> and <type> are optional and will be stored in the call record if given. <type> must be in range 128..175 Refer to section 7.2.5
	AT+HFGC2	Outgoing call: Remote party has been reached and is being alerted; may not be used if the telephone network does not provide this information; state of call record is changed to "alerting".
	AT+HFGC3	Outgoing call: Remote party has answered the call; state of call record is changed to "active".
	AT+HFGC4["<number_string>",<typedec>]	Outgoing call: use if a call is initiated on the HFG and was not requested by HF. "OK" is not sent to the HF. A call record in state "dialling" is created. <number_string> and <type> are optional and will be stored in the call record if given. <type> must be in range 128..175 Refer to section 7.2.5
Signal termination of a call or a call setup procedure to HF	AT+HFGCH	Command also used to inform HF about remote rejection of outgoing call
Release all held calls	AT+HFGCHL	Release was initiated either locally or remotely
Query list of current calls of HFG	AT+HFGC?	Returns the list of current calls
Enable/disable verbose mode for call record presentation	S354 [0..1]	Value: 0 =non-verbose mode for AT+HFGC? (default) 1 = verbose mode for AT+HFGC?
Send AG indicator status to HF (+CIEV...)	AT+HFGI<indicator_iddec>,<valuedec>	For <indicator_id> and <value> see Table 3.31 . Command is recommended to be used only with indicator IDs 1(service), 5 (signal), 6 (roam) and 7(battery charge level). For all other indicators (2-call, 3-call setup, 4-call held), the appropriate call managing AT commands are recommended to be used. These commands send the indicators automatically.
Send network operator string to HF	AT+HFGO"<operator_string>"	Command used to respond to HFG"OP?"
Send error to HF	AT+HFGE	Sends "ERROR" to HF. Needed on HFG"D>mmm" if memory location is invalid or on HFG"L" if last dialed number not available.
Send extended error result code to HF	AT+HFGE<cme_codedec>	" +CME ERROR: <cme_codedec>" is sent to HF if HF did enable this feature earlier. Otherwise a simple "ERROR" is sent to HF.
Disable / Enable In-Band ring tone	AT+HFGBO/1	" +BSIR:0" or " +BSIR:1" is sent to HF. SLC must exist and Bit 3 of S596 (HFG supported features) must have been set at boot time. Ringtone signal must be provided by external circuit.

**AT COMMAND SET
REFERENCE**

Task	AT-Command / S Register	Comment
Set HFG supported features	S596	Bitmask Bit 0 – three way calling Bit 1 – echo cancellation and/or noise reduction function Bit 2 – voice recognition function Bit 3 – In-band ring tone capability Bit 4 – Attach a number to voice tag Bit 5 – Ability to reject call Bit 6 – Enhanced call status Bit 7 – Enhanced call control Bit 8 – Extended Error Result Codes Note: Bit 0...Bit 4 of these settings are advertised in the Service Record of the HFG. The default value is 0x68 which means Bit 3, Bit 5 and Bit 6 set. After a new value was set, the commands "AT+BTW" and "ATZ" are required for the new value to become effective. Make sure that Bit 6 is always set because this is a mandatory feature for HFP1.5 – AG.
Inquire HFG status	ATI66	0 = not connected 1 = SLC connected 2 = Audio connected 3 = in call – SLC 4 = in call – audio 5 = call setup: ringing (incoming call) / dialling or alerting (outgoing call) – SLC 6 = call setup: ringing (incoming call) / dialling or alerting (outgoing call) – audio 8 = in call but no SLC

(1) AT+HFGC1 is the only possible response to HFG"Dnnn". If the HFG wants to reject this call attempt from the HF, it must issue AT+HFGC1 first and subsequently AT+HFGCH.

(2) HFG"D>mmm" and HFG"L" can alternatively be responded to with HFGE to confirm that the requested operation was not successful (i.e. memory location invalid or last dialled number not available).

Table 3.33: AG-HFP (HFG) – Summary of S Registers and AT Commands**8. DUN (Dial-Up Networking Profile)**

The Dial-up networking profile (DUN,[6]) defines protocols and procedures for the dial-up networking use case. Scenarios are the usage of a wireless modem or a cellular phone for dial-up Internet connections or the usage of a wireless modem or cellular phone to receive data calls by a PC.

There are two roles defined:

- 1.) Gateway (GW)-This device provides access to the public network (e.g., cellular phone or modem), and is not supported on BTM.
- 2.) Data Terminal (DT)-This device uses the dial-up services of the Gateway (e.g., PC), and is supported on BTM.

In order to map these roles to the conventional modem structure, the Gateway is referred to as Data Circuit Endpoint (DCE), and the Data Terminal is referred to as Data Terminal Endpoint (DTE).

A BTM module is required to be controlled by a host processor using AT commands (hosted operation mode). BTM DUN implementation supports DT role only.

The DUN profile belongs to the group of serial stream oriented profiles (SSO). The appropriate implications and restrictions are described on page 24.

An AT command beginning with AT+DU... indicates affiliation to the DUN profile.

**AT COMMAND SET
REFERENCE**

Service	Support in DT		Support in GW	
	Specification	BTM	Specification	BTM
1. Data call without audio feedback	M	Yes	M	No
2. Data call with audio feedback	O	No	O	No
3. Fax services without audio feedback	N/A	No	N/A	No
4. Fax services with audio feedback	N/A	No	N/A	No
5. Voice call	N/A	No	N/A	No

M: mandatory
O: optional
N/A: not applicable

8.1 Profile Activation

DUN profile is activated by setting flag 0x04 in S102 plus "AT&W" plus "ATZ".

8.2 Initiate DUN Connection

AT+DUD<bd_addr_{hex}>

Initiate ACL connection to remote device with <bd_addr_{hex}>. The remote device must support the DUN profile (HSP).

Response: <cr,lf>CONNECT 123456789012,1103,><cr,lf>

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

Or: <cr,lf>ERROR 59<cr,lf>

Or: <cr,lf>ERROR 63<cr,lf>

Or: <cr,lf> ERROR 65<cr,lf>

After an DUN connection has been established, the module changes its mode to the mode defined by S Register 531. The recommended value is S531=0 for a DUN connection (=default). Before initiating a DUN connection, S507 must be set to 2 (ats507=2). This will cause the module to escape from connected mode to command mode by toggling DSR line only. An escape sequence of "^^^" is not compliant with the DUN specification. S507=2 also configures the module for high data throughput.

Once the Bluetooth connection is established all data arriving at the UART is transferred to the gateway, hence any AT commands will be transferred directly to the gateway. Now the host can e.g. dial in to the internet provider by "ATD123456" as if directly connected to a serial modem.

8.2.1 Release DUN Connection

AT+DUH

The module must be in command mode so that AT-commands will be parsed. If the module is in data mode (S531=0, S507=2), toggle DSR line to change into command mode. <cr><lf>OK <cr><lf> will be sent to the host to confirm that that module is in command mode. Toggling DSR means to de-assert (deactivate) and assert (activate) the DSR line within a time specified by S519 which is 500 ms per default. Hence DSR needs to be asserted at the time of AT+DUD<BdAdd>, if data mode with S531=0 and S507=2 or S507=1 is configured.

DSR asserted means a voltage level of logic 0 (0.0 V) at the module pin, because the UART level shifter inverts the signal. Accordingly, DSR de-asserted means a voltage level of logic 1 (3.3 V) at the module pin.

Response:

On Bluetooth disconnection: <cr,lf>NO CARRIER 1103<cr,lf>

**AT COMMAND SET
REFERENCE**

Task	AT-Command / S Register	Comment
Enable DUN profile	S102	0x04 = DUN (bitmask), needs subsequent "AT&W" and "ATZ" to activate
Set up escape mode via DSR, high throughput	ATS507=2	Needs subsequent "AT&W" if desired as permanent setting
Initiate DUN connection	AT+DUD<bd_addr _{hex} >	Responses: successful: "CONNECT 123456789012,1103,>" failed: "NO CARRIER" profile disabled: "ERROR 59" incorrect state: "ERROR 63"
Release DUN connection	AT+DUH	Responses: successful: "NO CARRIER 1103" profile disabled: "ERROR 59" incorrect state: "ERROR 63"

Table 3.34: DUN – Summary of S Registers and AT Commands**Hardware Units (BTM520 / 521)**

This section covers S-Registers and AT-Commands that are related to hardware units of a BTM520 or BTM521 device. For this section, please also refer to the bluecore data sheet [10] for more detailed information.

1. Audio Loopback Mode

For testing purposes, an audio loopback mode is available. In mode=1 audio input (ADC) and audio output (DAC) are connected directly. In mode = 2, the stereo audio input signal is fed through the Kalimba DSP with running SBC codec (encoder, decoder) and is directed back to the audio stereo output. Audio Loopback Mode is controlled with the new AT Command "AT+BTL".

Task	AT-Command / SRegister	Comment
Set audio loopback mode	AT+BTL<Mode>	Mode: 0 = off 1 = on, ADC -> DAC 2 = on, ADC -> DSP -> DAC
Set sampling rate for Audio Loopback Mode	S419 [0..6], default=6	0 = 8 kHz 1 = 11.025 kHz 2 = 16 kHz 3 = 22.050 kHz 4 = 24 kHz 5 = 32 kHz 6 = 44.1 kHz

Table 3.39: Audio Loopback AT-commands and S-Registers**2. Codec Gain**

Analogue input and output gains (Input Amplifier, Output Amplifier, Figure 3.25) can be set to one of 23 steps called "Gain Level". To each gain level, an overall gain (dBr) is assigned, according to Table 3.40. The overall gain is formed by an analogue and a digital component as outlined in Table 3.40. Gain values can be specified either as gain level or as overall gain by separate S Registers. Please note that a pair of such S-Registers always updates the other corresponding S-Register (e.g., S589 – S689 and S590 – S690).

For S689 and S690, the overall gain (dBr) must be entered multiplied by 10. If the input value doesn't match a gain table entry, the nearest possible value is set. The actually set value can be checked by reading back S689/S690. The value of S689/S690 is printed out multiplied by 10 in order to avoid non integer numbers.

The command class "AT+G..." enables incremental and decremental gain settings. The increment/decrement command corresponds to one row up/down in the gain table (Table 3.40). The Gain level registers S589/S689 and S590/S690 are not affected by increment/decrement commands. Instead, the current gain level is cached and can be retrieved by "AT+G(I|O)?". There are two further commands to restore the cached gain level from S589/S590 ("AT+G(I|O)R") and to save the currently cached gain level to S589/S590 ("AT+G(I|O)S").

AT COMMAND SET
REFERENCE

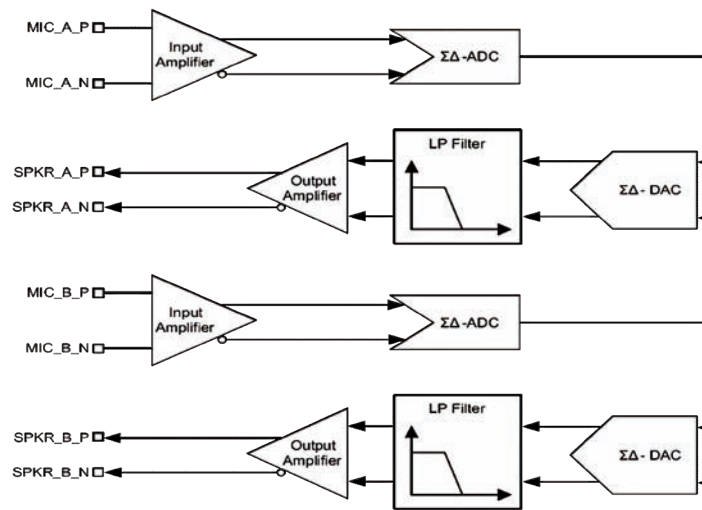


Figure 3.27: Stereo Audio Codec Block Diagram

Output Gain Level or Input Gain Level S589 or S590	Overall Gain (dBr) S689 or S690	Digital Component	Analogue Component
22	+21.5	7	7
21	+18.0	6	7
20	+15.5	5	7
19	+12.0	4	7
18	+9.5	3	7
17	+6.0	2	7
16	+3.5	1	7
15	0	0	7
14	-3.0	0	6
13	-6.0	0	5
12	-9.0	0	4
11	-12.0	0	3
10	-15.0	0	2
9	-18.0	0	1
8	-21.0	0	0
7	-23.5	15	0
6	-27.0	14	0
5	-29.5	13	0
4	-33.0	12	0
3	-35.5	11	0
2	-39.0	10	0
1	-41.5	9	0
0	-45.0	8	0

Table 3.40: Gain Table

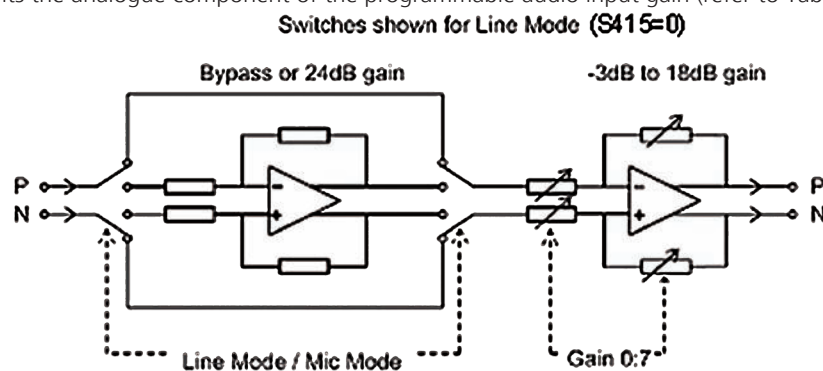
AT COMMAND SET
REFERENCE

Task	AT-Command / SRegister	Comment
Set output gain level	S589 [0..22], default=15	See Gain Table; S689 is affected, too
Set output overall gain (dBr)	S689 [-450..+215], default=0	See Gain Table; value must be entered (and is returned) multiplied by 10; S589 is affected, too
Set input gain level	S590 [0..22], default=15	See Gain Table; S690 is affected, too
Set input overall gain (dBr)	S690 [-450..+215], default=0	See Gain Table; value must be entered (and is returned) multiplied by 10; S590 is affected, too
Increment current output gain level	AT+GOU	Error 57 shall appear if maximum gain level reached
Decrement current output gain level	AT+GOD	Error 58 shall appear if minimum gain level reached
Query current output gain level	AT+GO?	
Restore current output gain level from S589	AT+GOR	
Save current output gain level to S589	AT+GOS	
Increment current input gain level	AT+GIU	Error 57 shall appear if maximum gain level reached
Decrement current input gain level	AT+GID	Error 58 shall appear if minimum gain level reached
Query current input gain level	AT+GI?	
Restore current input gain level from S590	AT+GIR	
Save current input gain level to S590	AT+GIS	

Table 3.41: Gain Settings AT commands and S-Registers

3. Mic Input Gain

A microphone preamplifier that adds an extra 24dB to input gain, is controlled by S-Register 415. The microphone amplifier is enabled by ATS415=1 and disabled by ATS415=0. Refer to Table 3.43. The first amplifier in Figure 3.26 represents the microphone preamplifier and the second amplifier represents the analogue component of the programmable audio input gain (refer to Table 3.35).



Microphone Mode input impedance = 6kΩ

Line mode input impedance = 6kΩ to 30kΩ

Figure 3.26: ADC Analogue Amplifier Block Diagram

**AT COMMAND SET
REFERENCE****4. Mic Bias**

Mic Bias is enabled by S-Register 416 : 1=enable, 0=disable.

Mic Bias Current is controlled by S-Register 417 as outlined in Table 3.37.

Mic Bias Voltage is controlled by S-Register 418 as shown in Table 3.38.

These settings apply only if the audio subunit is activated (e.g., while in audio loopback mode/while in SCO connection/while in A2DP connection). Otherwise, S416 to S418 will not have any effect.

S Register 417	Mic Bias Current Output [mA]
0	0.237 - 0.394
1	0.296 - 0.492
2	0.354 - 0.589
3	0.412 - 0.687
4	0.471 - 0.785
5	0.530 - 0.883
6	0.589 - 0.980
7	0.647 - 1.078
8	0.706 - 1.176
9	0.764 - 1.273
10	0.823 - 1.371
11	0.882 - 1.469
12	0.940 - 1.566
13	0.998 - 1.664
14	1.057 - 1.762
15	1.116 - 1.859

Table 3.37: Mic Bias Current Output – S417

S Register 418	Mic Bias Voltage Output [V]
0	1.61 - 1.80
1	1.65 - 1.86
2	1.71 - 1.93
3	1.76 - 1.98
4	1.84 - 2.06
5	1.89 - 2.14
6	1.97 - 2.23
7	2.04 - 2.32
8	2.18 - 2.46
9	2.27 - 2.58
10	2.39 - 2.72
11	2.50 - 2.87
12	2.70 - 3.09
13	2.85 - 3.29
14	3.07 - 3.56
15	3.28 - 3.84

Table 3.38: Mic Bias Voltage Output – S418

**AT COMMAND SET
REFERENCE****5. Auxiliary DAC**

The auxiliary DAC is enabled with S-Register 730.

The DAC output level is set by S-Register 731.

6. LED

The module provides two dedicated output pins for LEDs (LED0, LED1). The following modes are supported: LED_OFF, LED_ON, LED_PWM and LED_PULSE.

In LED_PWM mode, the parameters "Duty Cycle" and "PWM Period" can be specified via S-Registers. This enables either to dim the brightness of an LED (PWM Period=0) or to specify blinking with defined on-time in a defined period (PWM Period > blinking visible for the eye).

In LED_PULSE mode, the brightness of an LED is modulated. Modulation speed is defined by parameter "Pulse Rate" and maximum brightness is defined by parameter "Duty Cycle".

Task	AT-Command / SRegister	Comment
Set LED 0 mode	S335 [0..3], default=0	Mode: 0 = LED_OFF 1 = LED_ON 2 = LED_PWM 3 = LED_PULSE
Set LED 1 mode	S340 [0..3], default=0	
Set LED 0 Duty Cycle	S336 [0..4095], default = 2048	
Set LED 1 Duty Cycle	S341 [0..4095], default = 2048	
Set LED 0 PWM Period	S337 [0..15], default = 0	referenced if LED mode = LED_PWM
Set LED 1 PWM Period	S342 [0..15], default = 0	
Set LED 0 Pulse Rate	S338 [0..15], default = 0	referenced if LED mode = LED_PULSE
Set LED 1 Pulse Rate	S343 [0..15], default = 0	

Table 3.39: LED S-Registers**7. Hardware Units - S Registers**

Table 3.40 below gives an overview on S Registers for hardware units except GPIO. For GPIO Registers please refer to Table 3.43.

Register	Default	Range	Description
S415	0	0..1	Enable Microphone Input Gain, adds extra 24dB to input gain
S416	0	0..1	Enable MicBias
S417	0	0..15	Set MicBiasCurrent (refer to Table 3.37)
S418	0	0..15	Set MicBiasVoltage (refer to Table 3.38)
S419	6	0..6	Set sampling rate for Audio Loopback: 0 = 8 kHz 1 = 11.025 kHz 2 = 16 kHz 3 = 22.050 kHz 4 = 24 kHz 5 = 32 kHz 6 = 44.1 kHz
S589	15	0..22	Codec output gain level (index of gain table)
S590	15	0..22	Codec input gain level (index of gain table)
S689	0	-450..215	Set codec output gain in dBr * 10 (applies to sink), default = 0
S690	0	-450..215	Set codec input gain in dBr * 10 (applies to source), default = 0
S335	0	0..3	Set LED0 mode 0 = LED_OFF 1 = LED_ON 2 = LED_PWM 3 = LED_PULSE

**AT COMMAND SET
REFERENCE**

Register	Default	Range	Description
S336	2048	0..4095	Set LED 0 Duty Cycle, referenced if LED mode = LED_PWM or LED_PULSE
S337	0	0..15	Set LED 0 PWM Period, referenced if LED mode = LED_PWM
S338	5	0..15	Set LED 0 Pulse Rate, referenced if LED mode = LED_PULSE
S340	0	0..3	Set LED1 mode 0 = LED_OFF 1 = LED_ON 2 = LED_PWM 3 = LED_PULSE
S341	2048	0..4095	Set LED 1 Duty Cycle, referenced if LED mode = LED_PWM or LED_PULSE
S342	0	0..15	Set LED 1 PWM Period, referenced if LED mode = LED_PWM
S343	5	0..15	Set LED 1 Pulse Rate, referenced if LED mode = LED_PULSE
S730	0	0..1	Enable Auxiliary DAC
S731	0	0..255	Set Auxiliary DAC Level

Table 3.40: S Registers for Hardware Units**8. GPIO**

On a BTM520/521 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 new 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	Alternative Function	
	Handshaking	Wi-Fi Coexistence
GPIO1	-	RxEnable
GPIO2	-	TxEnable
GPIO3	-	-
GPIO4	-	-
GPIO5	-	-
GPIO6	-	BT_State/BT_Priority
GPIO7	-	Wlan_Active
GPIO8	-	-
GPIO9	DTR	-
GPIO10	-	-
GPIO11	-	-
GPIO12	-	-
GPIO13	-	-

Table 3.41: GPIO - Alternative Functions

**AT COMMAND SET
REFERENCE**

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Function mapping code / av_operation_id								Reserved			FMS	FME	INV	DIR	PS
Default	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3.27: GPIO configuration register

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/O 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 or an av_operation_id 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 – FMS	Function Mapping Select – Selects if a Function Mapping Code (see Table 3.44) or an av_operation_id (see Table 3.20) is set in GPIO configuration register [8:15]. Valid only if FME=1. 0 select Function Mapping Code (Table 3.44) 1 select av_operation_id (Table 3.20)
[5:7]	Reserved
[8:15] function mapping code / av_operation_id	A Function Mapping Code (FMC, Table 3.44) or an av_operation_id (Table 3.20) is set in this bit field. The pin is mapped to a profile specific function (A2DP,HFP) or to an AVRCP remote control operation and will carry out the assigned operation. A mapped function does not affect any other flag of the GPIO configuration register. So, e.g. DIR and INV must be set manually according to the selected function and hardware requirements. Valid only if FME=1. FMS selects function mapping code or av_operation_id. See also section 8.1 on pg.84 “Profile specific GPIO function mapping” And section 5.5 on pg. 55 “AVRCP GPIO Mapping”

Table 3.42: GPIO Configuration Register Field Descriptions

**AT COMMAND SET
REFERENCE**

Register	GPIO	Default	Range	Comment
S650		0	0..1	Mode for GPIO Configuration 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 Error! Reference source not found.
S652	GPIO2			
S653	GPIO3			
S654	GPIO4			
S655	GPIO5			
S656	GPIO6			
S657	GPIO7			
S658	GPIO8			
S659	GPIO9			
S660	GPIO10			
S661	GPIO11			
S662	GPIO12			
S663	GPIO13			
S670	GPIO1..13	0x0000	0..0x1FFF	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 0x0100: GPIO9 0x0200: GPIO10 0x0400: GPIO11 0x0800: GPIO12 0x1000: GPIO13

Table 3.43: GPIO S-Registers**8.1 Profile specific GPIO function mapping**

In some Bluetooth Profiles it makes sense to map GPIOs to certain functions, e.g. Volume Up/Down (HFP/A2DP), answer call (HFP), reject call (HFP) etc. Therefore, new S registers 651 to 663 will be introduced, corresponding to GPIO1 to GPIO13. If a function mapping code is set to one of those registers and function mapping enabled (FME=1), the appropriate Pin will carry out the assigned function and will not be available anymore as GPIO.

The logical level of a GPIO can be inverted by setting the appropriate INV-flag of the appropriate GPIO Configuration Register.

Restrictions can apply if certain GPIOs will be reserved for other functions in future, e.g., Wi-Fi coexistence signalling.

Function Mapping Code	Value	Comment
Volume Up	0x01	A2DP,HFP: adjust volume locally
Volume Down	0x02	A2DP,HFP: adjust volume locally
Mute	0x03	A2DP,HFP
Answer Incoming Call	0x04	HFP
Reject Call or Hang Up	0x05	HFP
Reject Call	0x06	HFP
Hang Up	0x07	HFP

Table 3.44: GPIO Function Mapping Codes

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 section 2, page 31.

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 three 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 three 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 3.45 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 3.45: 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 26. 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 an 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 3.46.

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 3.46: Automatic storage of link keys

**AT COMMAND SET
REFERENCE****3. Profile Connection Status**

The connection status of a profile can be queried by an AT-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 3.47.

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 3.47: 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 3.48.

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"

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Task	AT-Command	Comment
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 3.48: 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 3.50 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 3.49: 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"

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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 3.50: Implications of S329**6. UUIDs in "CONNECT"/"NO CARRIER" messages**

In profiles where functionality and command set differs between both possible roles (asynchronous profiles), role indicating UUIDs are used in the "CONNECT" and "NO CARRIER" messages. HSP and HFP are asynchronous profiles.

A2DP and AVRCP are treated as synchronous profiles because only one profile instance with one role selected can be initialized currently. Therefore a common UUID is used indicating the profile only but not the role.

In a message "CONNECT <bd_addrhex>,<UUID>", UUID is the profile/role the connection is made to. Hence for an outgoing connection, UUID indicates the remote device's profile/role. If it is an incoming connection, UUID indicates the local device's profile/role UUID. Hence, role indicating UUIDs presented in a "CONNECT" message will be equal on both ends of a connected pair.

In a message "NO CARRIER <UUID>", UUID represents the local profile/role UUID. Hence for an asynchronous profile, role-indicating UUIDs will differ on both ends of a previously connected pair.

Table 3.51 Gives an overview of currently used UUIDs on BTM devices.

UUID (hex)	Profile/Role	Role indication	Comment
1101	SPP	No	Synchronous profile
1108	HSP – HS	Yes	Headset role (Headset profile)
110D	A2DP	No	Common UUID for source and sink role
110E	AVRCP	No	Common UUID for controller and target role
1112	HSP – AG	Yes	Audio gateway role (Headset profile)
111E	HFP – HF	Yes	Hands-free role (Hands-free profile)
111F	HFP – AG	Yes	Audio gateway role (Hands-free profile)

Table 3.51: UUIDs used in BTM5xx CONNECT/NO CARRIER messages

There is an option to append a direction indicator to a connect message. This enables the host to distinguish an incoming connection from an outgoing connection based on the "CONNECT" message. The direction indicator only applies to role indicating UUIDs and if S329=0. The direction indicator is configured by S register 331, please refer to Table 3.52

S331	Meaning	Example	
		Incoming connection	Outgoing connection
0	Disabled	CONNECT 0123456789AB,1108	CONNECT 0123456789AB,1108
1	Character style, 'I' or 'O'	CONNECT 0123456789AB,1108,I	CONNECT 0123456789AB,1108,O
2 (default)	Symbol style, '<' or '>'	CONNECT 0123456789AB,1108,<	CONNECT 0123456789AB,1108,>

Table 3.52: Examples for direction indication in "CONNECT" messages

**AT COMMAND SET
REFERENCE****7. UUIDs in service records of HSP**

This section provides some background information on UUIDs and their usage in service record of the Headset profile.

In the “Bluetooth Assigned Numbers” document [8] in the table “Service classes”, there are three UUIDs assigned for the HSP:

Mnemonic	UUID size	UUID	Profile [Ref #5]
HSP	uuid16	0x1108	See Headset Profile, Bluetooth SIG
Headset - AG	uuid16	0x1112	See Headset Profile, Bluetooth SIG
Headset - HS		0x1131	Bluetooth Headset Profile, Bluetooth SIG

Table 3.53: Bluetooth Assigned Numbers for HSP

In the service record for HSP 1.2 - Headset role ([4], page 21), the following values are assigned:

Item	Value	UUID
ServiceClass0	“Headset”	0x1131
Profile0	“Headset Profile”	0x1108

Table 3.54: Selected items of HSP - headset role service record

In the service record for HSP 1.2 – Audio gateway role ([4], page 22), the following values are assigned:

Item	Value	UUID
ServiceClass0	“Headset Audio Gateway”	0x1112
Profile0	“Headset Profile”	0x1108

Table 3.55: Selected items of HSP - audio gateway role service record

The tables above show that UUID 0x1108 identifies the Headset profile whereas the role is explicitly identified by the ServiceClass0 UUID (0x1131=HS / 0x1112=HSG).

Although UUID 0x1108 appears in the service records of both Headset unit AND Audio Gateway, 0x1108 is still used as identifier for the Headset role in CONNECT and NO CARRIER messages on BTM520/521.

In HSP1.0 - headset role, 0x1108 was assigned to both ServiceClass0 and Profile0, i.e. it appeared twice in the service record of a HS-unit and once in the service record of the audio gateway.

Predecessors of the BTM520/521 (e.g. BISM2) have used 0x1108 as identifier for the Headset role. This was inherited on BTM520/521 and is the reason why 0x1108 is still used in BTM520/521 “CONNECT” and “NO CARRIER” messages.

The logically correct UUID for the HS-role would be 0x1131.

When using the AT+BTIV<BdAddr>,UUID_{hex} to query UUIDs of a remote device in order to determine supported profile and roles, the user must be aware of the circumstances described here. (E.g. do not assume the remote device supports the headset role if UUID 0x1108 was found in the service records but still check for 0x1112)

8. 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 (S12=4 or AT+BTP issued), it will mutually do page scanning and inquiry scanning as shown in Figure 3 28. If connectable only, the module will perform page scanning only (repeatedly) and if discoverable only, then the module will perform page scanning only.

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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].

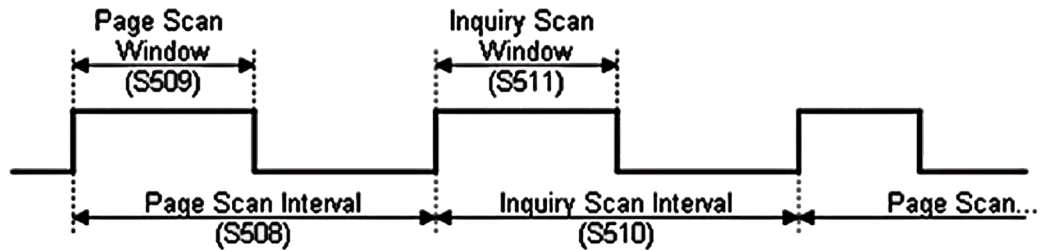


Figure 3.28: Page and Inquiry Scan Intervals and Windows

9. 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 five 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 was solved by having a mode called Sniff, with appropriate lower layer negotiating protocol.

Sniff mode during connection is basically an agreement between the slave and its master that data packets will only be exchanged for N timeslots every M slots. The slave can then assume that it will never be contacted during 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.

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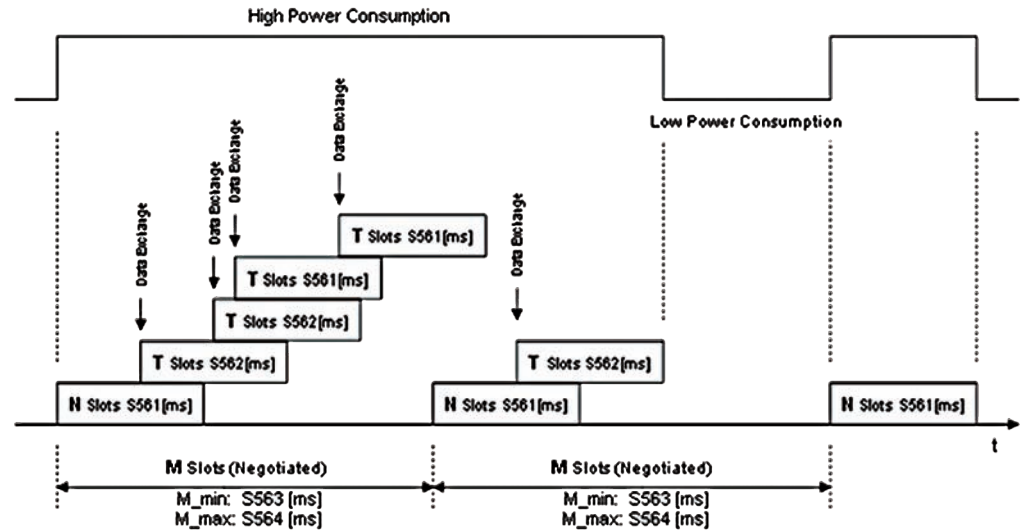


Figure 3.29: Sniff Mode Example

10. Maximum RF-Tx Power Level

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

11. Manufacturing Info String

A string with manufacturing information can be retrieved by "AT1200".

12. Bluetooth version

The Bluetooth version can be queried by "AT118".

13. 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>").

14. 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 $\text{BAUDRATE} * 0.004096$ 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)

**AT COMMAND SET
REFERENCE****15. 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.

16. 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 3.30.

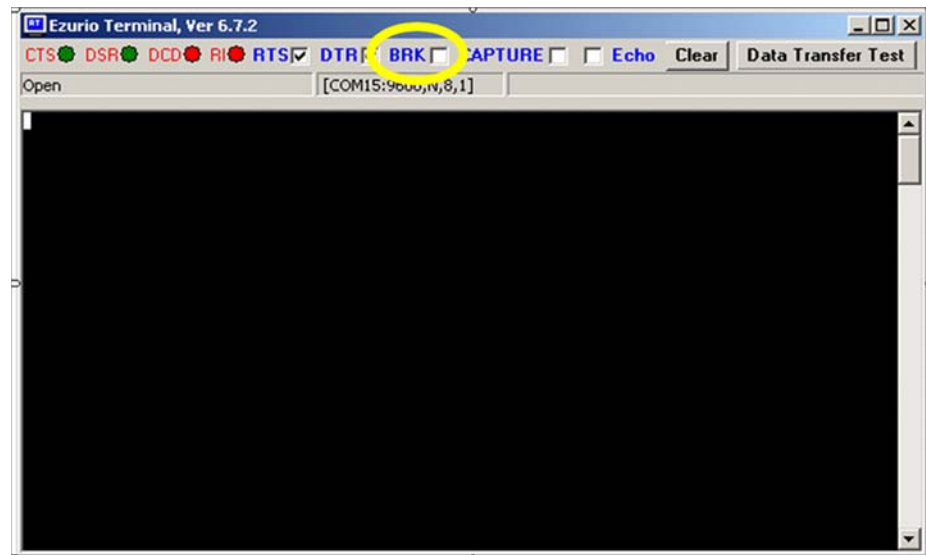


Figure 3.30: BREAK capability in Ezurio Terminal

17. Append Bluetooth Address to Friendly Name

If S Reg 593 is set to 1, then the last six 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 note 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
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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 messages 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 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.
S508	640	11..2550	Page Scan Interval in milliseconds. Minimum is 11.25ms so 10/11ms will give 11.25ms, refer to Section 7, page. 93.
S509	160	11..2550	Page Scan Window in milliseconds. Minimum is 11.25ms so 10/11ms will give 11.25ms, refer to Section 7, page. 93.
S510	640	11..2550	Inquiry Scan Interval in milliseconds. Minimum is 11.25ms so 10/11ms will give 11.25ms, refer to Section 7, page. 93.
S511	160	11..2550	Inquiry Scan Window in milliseconds. Minimum is 11.25ms so 10/11ms will give 11.25ms, refer to Section 7, page. 93.

**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

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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: 1200,2400,4800,9600,19200,28800,38400,57600,115200. 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 used 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 13, page. 95 "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 S541 because 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	<p>This register specifies in each 4 bit nibble, how the DTR, DCD, RI output pins are controlled when in a Bluetooth connection</p> <p>Nibble 0..3 specifies the source for DTR</p> <p>4..7 specifies the source for DCD</p> <p>8..11 specifies the source for RI</p> <p>Each nibble can take the following value:</p> <p>0 Do NOT touch the I/O</p> <p>1 Always deassert</p> <p>2 Always assert</p> <p>3 If RTC bit in CONTROL_IND is 1 then assert otherwise deassert</p> <p>4 If RTR bit in CONTROL_IND is 1 then assert otherwise deassert</p> <p>5 If DV bit in CONTROL_IND is 1 then assert otherwise deassert</p> <p>6 If IC bit in CONTROL_IND is 1 then assert otherwise deassert</p> <p>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.</p>
S553	\$0201	\$0..\$fff	<p>This register specifies in each 4 bit nibble, how the DTR,DCD,RI output pins are controlled when NOT in a Bluetooth connection</p> <p>Nibble 0..3 specifies the source for DTR</p> <p>4..7 specifies the source for DCD</p> <p>8..11 specifies the source for RI</p> <p>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.</p> <p>Each nibble can take the following value:</p> <p>0 Always deassert</p> <p>1 Always assert</p> <p>2 Assert if RING is being sent to the host</p>
S554	0	0..900	<p>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)</p> <p>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.</p>
S555	1	1..7	<p>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).</p> <p>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, S Reg 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.</p>
S558	0	0..1	<p>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.</p>
S559	0	0..3	<p>This specifies a mask. When Bit 0 is 1, the response word "ERROR" is replaced by "BTERR" and "OK" is replaced by "ok".</p> <p>When Bit 1 is 1, then error responses do not include the error number and instead the error number can be retrieved using AT+I12.</p>

**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 9, page 94 and Figure 3.29.
S562	0	0..1000	Sniff Timeout Time in units of milliseconds. 0 means disable. See Section 9, page 94 and Figure 3.29.
S563	0	0..1000	Sniff Minimum Interval in units of milliseconds. 0 means disable. See Section 9, page 94 and Figure 3.29.
S564	0	0..1000	Sniff Maximum Interval in units of milliseconds. 0 means disable. See Section 9, page 94 and Figure 3.29.
S565	0	0..1	If set to 1, RI (Ring Indicate) line is configured as an input and forces the start-up mode (S Reg 512) and post-timeout on Start-up mode (S Reg 555) 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 S Reg 554 instead of mode defined in S Reg 555.
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 S Reg 554 instead of mode defined in S Reg 555.
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 six 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: 0 = not connected 1 = SLC connected 2 = Audio connected 3 = in call - SLC 4 = in call – audio
ATI66	HFG 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
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)

**AT COMMAND SET
REFERENCE**

Error	Description
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
66	Index of subscriber number record too large
67	Maximum number of subscriber number records reached
68	No SLC exists for AT+HFGBO/1
69	In-band ringing was not enabled in HFG supported features (S596, 0x08) at boot time
70	Invalid number type, must be in range 128 <= number type <= 175
71	Maximum number of calls reached
72	Call state issue
73	A second waiting call is not is not allowed
74	No call held
75	Invalid index <idx>

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] "Advanced Audio Distribution Profile Specification" Rev. V12, 16/04/2007
<http://www.bluetooth.com/Bluetooth/Technology/Works/A2DP.htm>
(link at bottom of page "Need more? View the Advanced Audio Distribution Profile (A2DP) 1.2")
- [3] "Audio/Video Remote Control Profile" Revision 1.0 22/05/2003
<http://www.bluetooth.com/Bluetooth/Technology/Building/Specifications/>
(click on "Audio/Video Remote Control Profile 1.0")
<http://www.bluetooth.com/Bluetooth/Technology/Works/AVRCP.htm>
(alternative, but only revision 1.3 of the AVRCP spec is available, therefore go to link at bottom of page "Need more? View the Audio/Video Remote Control Profile (AVRCP) 1.3")
- [4] "Headset Profile" Revision V12r00, 18/12/2008
<http://www.bluetooth.com/Bluetooth/Technology/Works/HSP.htm>
(link at the bottom of page "Need more? View the Headset Profile (HSP)")
- [5] "Hands-free Profile 1.5" Revision V10r00, 25/11/2005
<http://www.bluetooth.com/Bluetooth/Technology/Works/HFP.htm>
(link at the bottom of page "Need more? View the Hands-Free Profile (HFP) 1.5")
- [6] "Dial-Up Networking Profile" Version 1.1
<http://www.bluetooth.com/Bluetooth/Technology/Works/DUN.htm>
(link at the bottom of page "Need more? View the Dial-up Networking Profile (DUN)")
- [7] "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)")
- [8] "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"
- [9] 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 [8] anyway.
- [10] "Bluecore 5-Multimedia External" Data Sheet, Cambridge Silicon Radio (CSR)
<http://www.csrsupport.com> (log in or new account required)
- [11] "Bluecore 4 External" Data Sheet, Cambridge Silicon Radio (CSR)
<http://www.csrsupport.com> (log in or new account required)

**FCC REGULATORY
STATEMENTS****BTM520 FCC and Industry Canada Statements**

The end 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 in 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.

The BTM520 module (u.fl connector) has been approved with the following two antennas:

Centurion WCR2400-IP04

Ezurio Acc-009 patch antenna assembly

Use of the BTM520 with any other antenna assembly will require additional testing to be performed in order to maintain FCC compliance.

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 than 20cm to the body. In the case where the BTM520 / 521 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: PI4520B" or "Contains FCC ID: PI4520B." Any similar wording that expresses the same meaning may be used.

DECLARATIONS OF COMPLIANCE**EU DECLARATION OF CONFORMITY**

Manufacturer:	Ezurio Ltd
Product:	BTM520, BTM521
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)

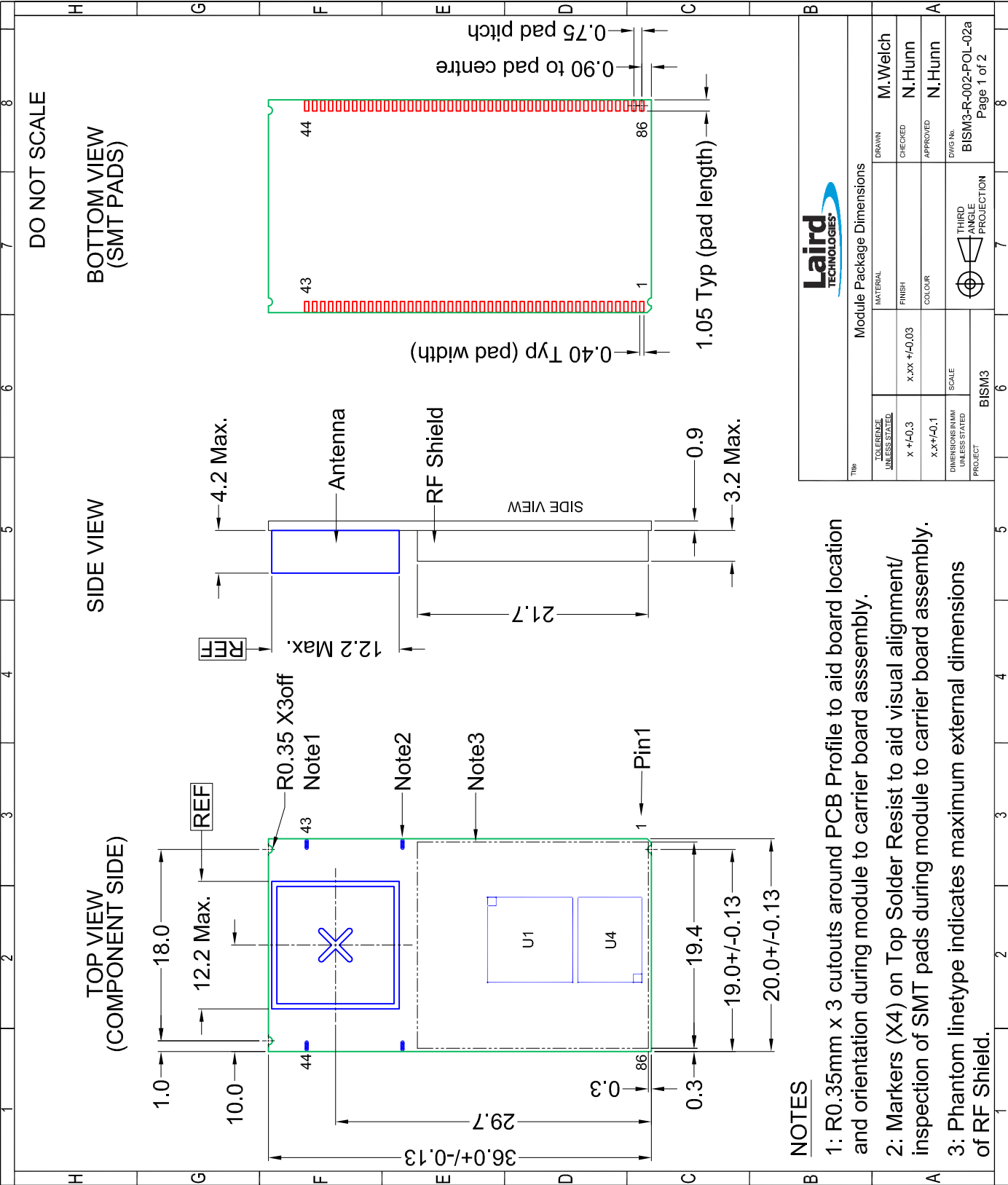
Declaration:

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:	November 2009
Name of Authorised Person:	Tim Wheatley, Director of Engineering
Signature:	

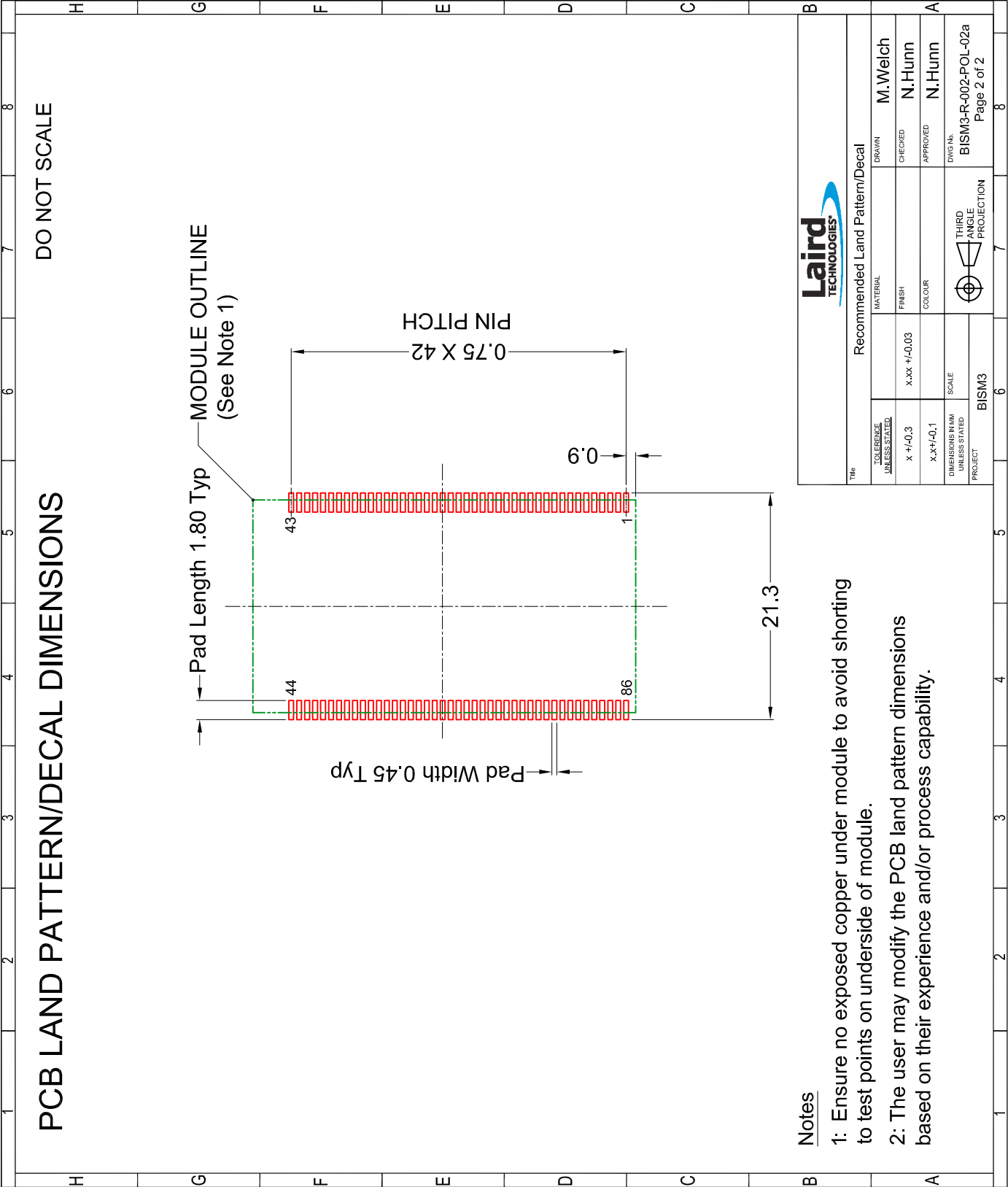
MECHANICAL
DRAWINGS

BTM520/521 Mechanical Diagrams

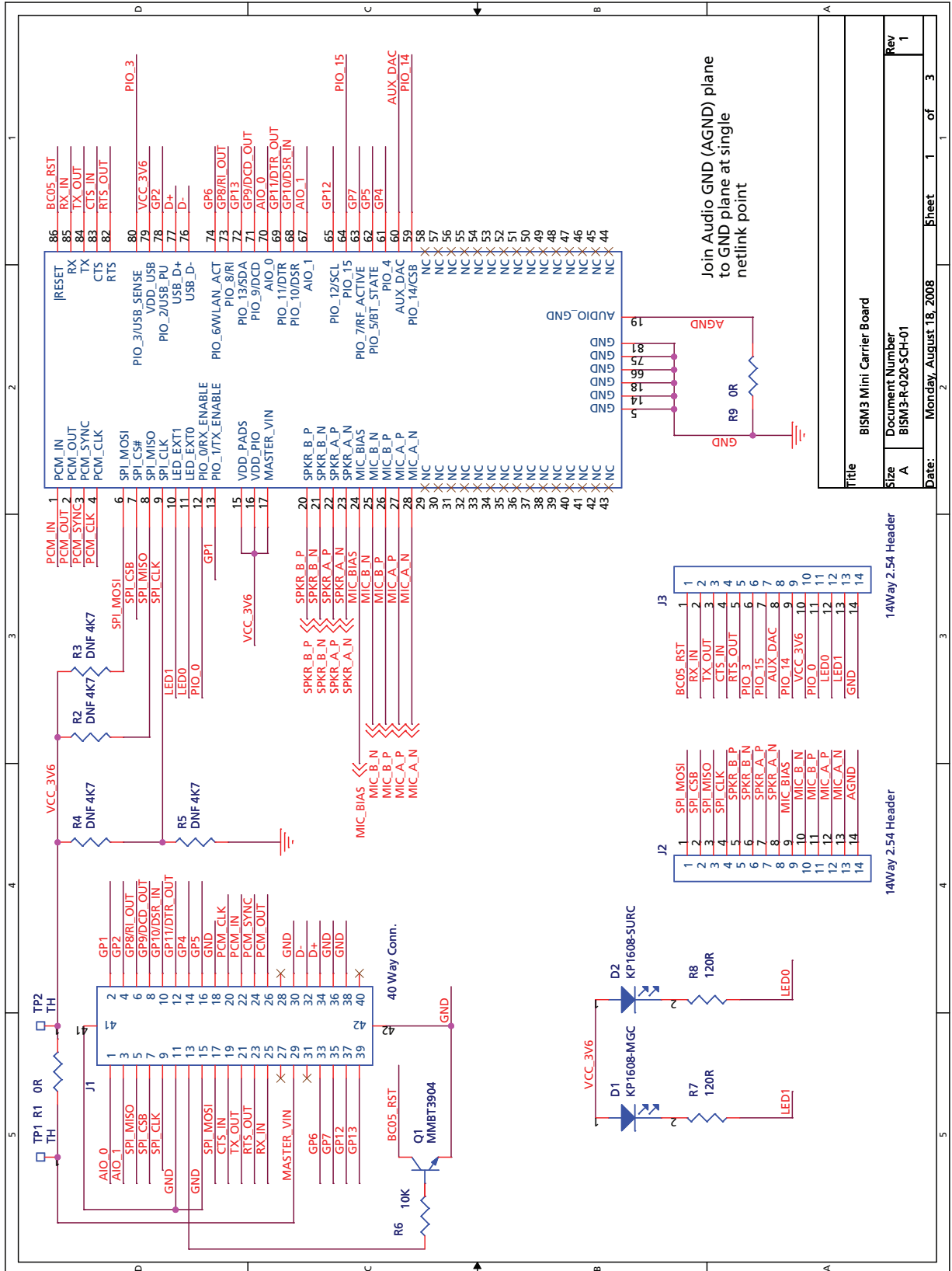


MECHANICAL
DRAWINGS

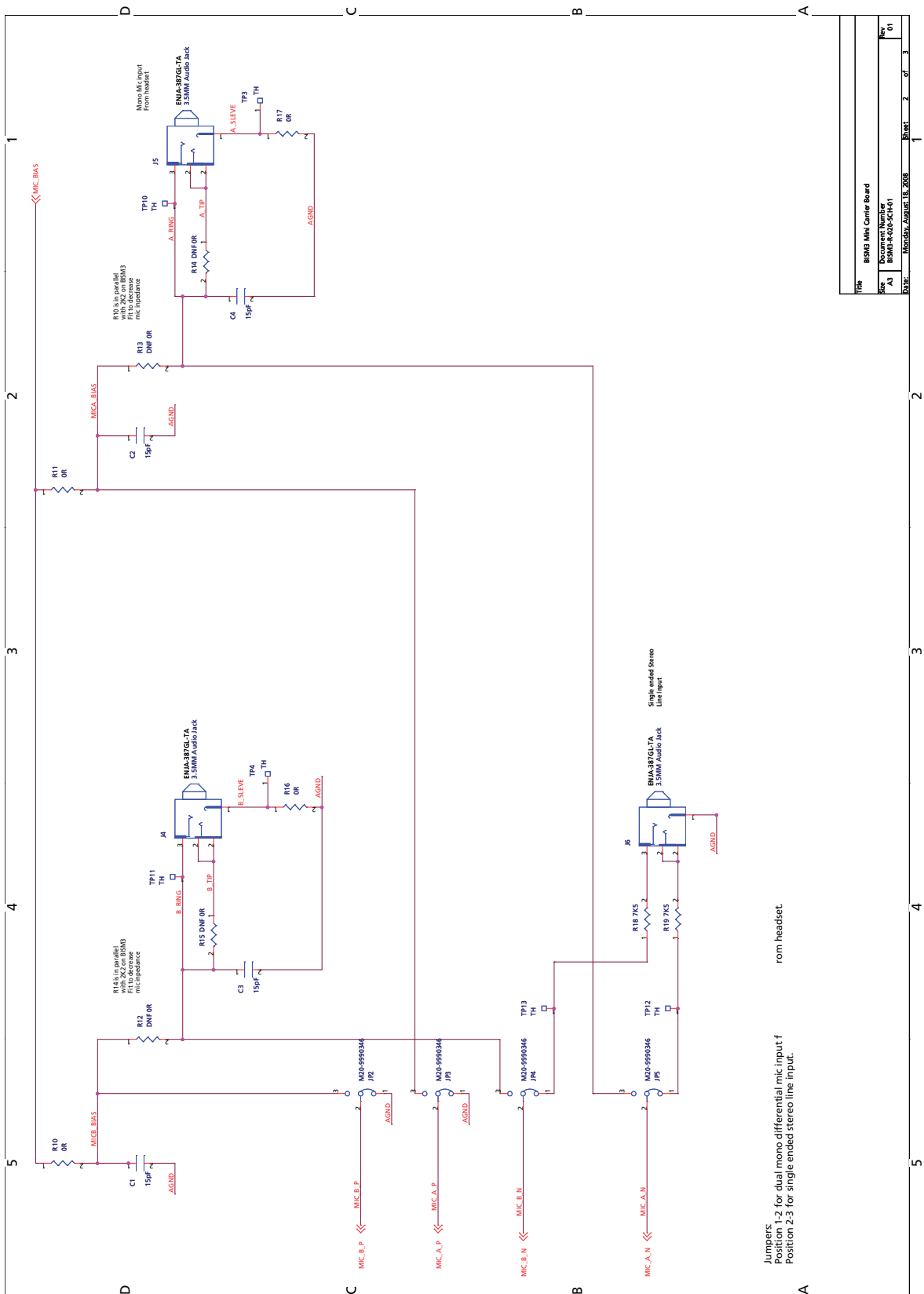
BTM520/521 Mechanical Diagrams



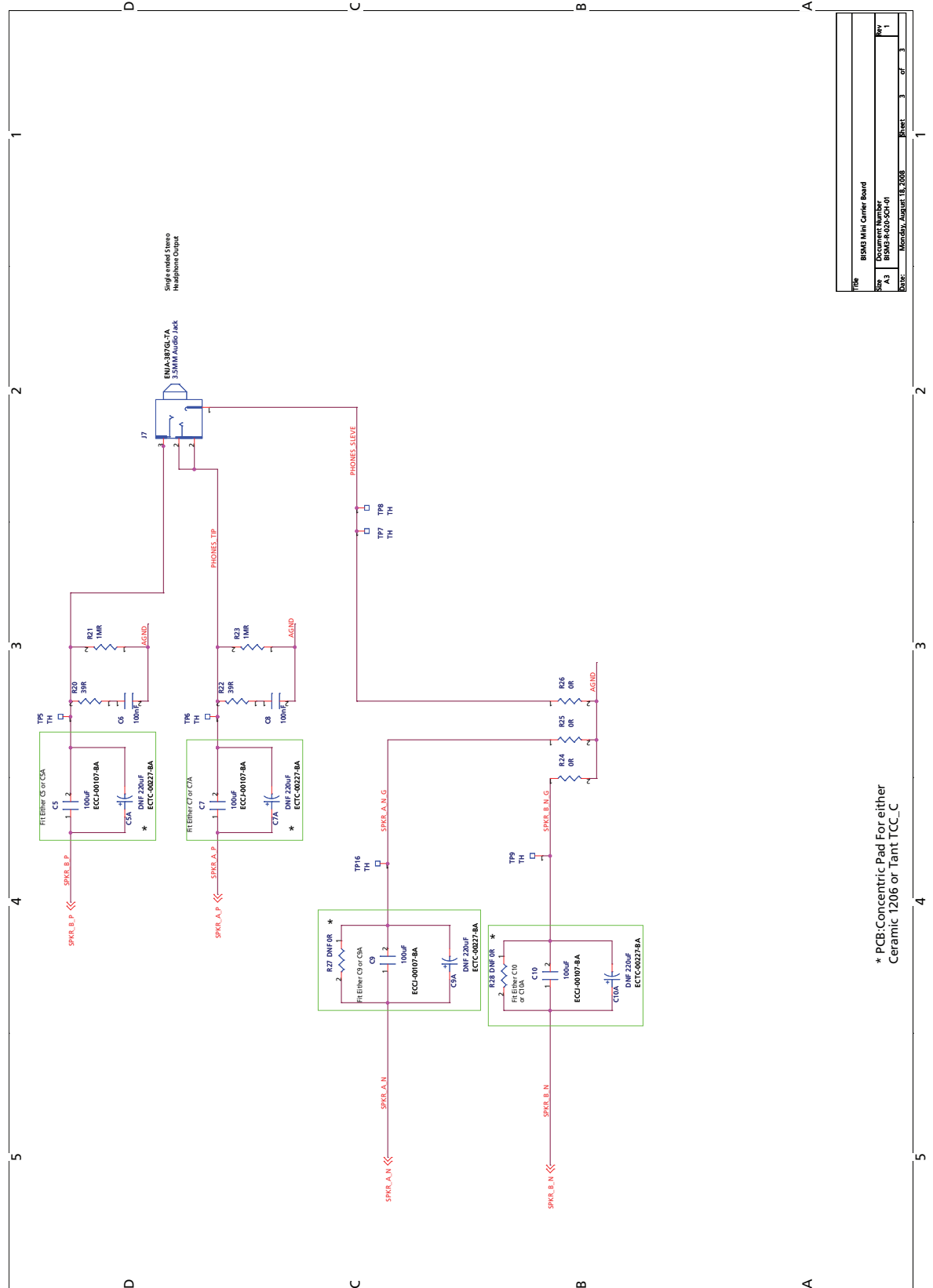
BTM520/521 Development Kit Schematic



BTM520/521 Development Kit Schematic



BTM520/521 Development Kit Schematic



* PCB:Concentric Pad For either Ceramic 1206 or Tant TCC_C

BTM520/521

Bluetooth® Multimedia Plus Module

ORDERING INFORMATION

ORDERING INFORMATION

BTM520	Bluetooth® Multimedia Plus Module (external antenna)
BTM521	Bluetooth® Multimedia Plus Module with integrated antenna
DVK-BTM520	Development Board with BTM520 soldered in place
DVK-BTM521	Development Board with BTM521 soldered in place

GENERAL COMMENTS

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

Refer to the schematic BTV-R-003.pdf for the Development Kit 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-BTM520-521 0310

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For a period of one (1) year from the date of purchase by the OEM customer, Laird Technologies warrants the OEM transceiver against defects in materials and workmanship. Laird Technologies will not honor this warranty (and this warranty will be automatically void) if there has been any (1) tampering, signs of tampering; 2) repair or attempt to repair by anyone other than an Laird Technologies authorized technician. This warranty does not cover and Laird Technologies will not be liable for, any damage or failure caused by misuse, abuse, acts of God, accidents, electrical irregularity, or other causes beyond Laird Technologies' control, or claim by other than the original purchaser. In no event shall Laird Technologies be responsible or liable for any damages arising: From the use of product; From the loss of use, revenue or profit of the product; or As a result of any event, circumstance, action, or abuse beyond the control of Laird Technologies, whether such damages be direct, indirect, consequential, special or otherwise and whether such damages are incurred by the person to whom this warranty extends or third party. If, after inspection, Laird Technologies' determines that there is a defect, Laird Technologies will repair or replace the OEM transceiver at their discretion. If the product is replaced, it may be a new or refurbished product.