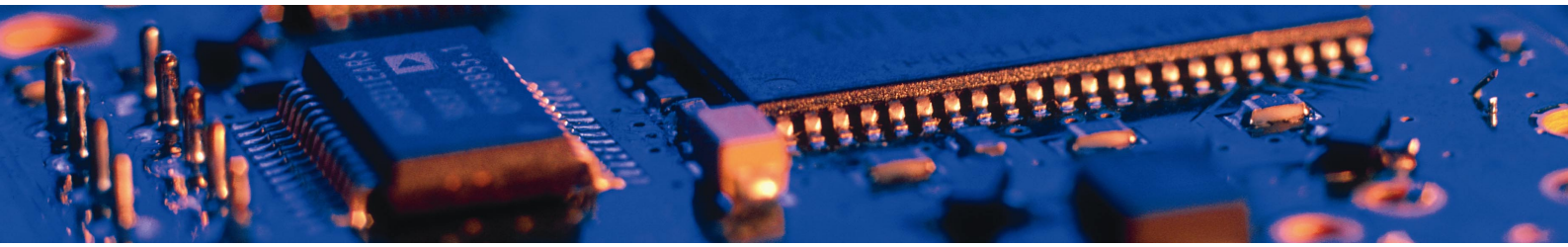

Bluetooth IO Module

Version 3

The Bluetooth IO Module implements wireless IO functionality on the standard Serial Port Adapter hardware. The Bluetooth IO Module supports up to 12 IO pins.

connectBlue

Bluetooth IO Module

Functional description and AT Commands specification

Release: 0704

Document version: 3.7

Document number: cBProduct-0608-01 (7)

Printed in Sweden.

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Contents

Chapter 1

Introduction

This document describes the functionality of the Bluetooth IO Module, hereafter referred to as BT IO. The BT IO is a variant of the standard SPA that implements wireless IO functionality. The IO functionality is implemented using the GPIO pins already available on the standard SPA and a simple protocol on top of the Bluetooth Serial Port Profile (SPP). Much of the functionality remains the same as for the standard SPA but additionally to this it is possible to use some of the connectors as inputs or outputs. The BT IO firmware is available for the following products:

- cB-OEMSPA310
- cB-OEMSPA311
- cB-OEMSPA331
- cB-OEMSPA312
- cB-OEMSPA332

Please note that not all of the products above support all 12 IO pins. See Table 1 for details on what pins that are available for each product.

1.1 Related Documents

- The **Serial Port Adapter AT Commands** document, contains a description of the AT commands supported in the standard Serial Port Adapter. It also contains information on how to use the AT commands to create Bluetooth applications. The command line format and data types used for the AT commands are defined in this document.
- **OEM Serial Port Adapter Electrical & Mechanical Datasheet**

Chapter 2

Functional description

The BT IO is a variant of the standard SPA that implements wireless IO functionality. Most of the functionality remains the same as for the standard SPA but additionally to this it is possible to use some of the connectors on the SPA as inputs or outputs.

The basic functionality is simple: when in data mode, pins configured as inputs are sampled and the status is transferred to a remote device using a protocol on top of the Bluetooth Serial Port Profile. On the remote device the corresponding output pins are set. The status of the pins is only transferred to the remote device when changed. A schematic picture of the functionality is seen in Figure 1. The protocol is described in Chapter 6.

A device may be configured with both input and output pins. The escape sequence and AT mode work the same way as for the standard SPA.

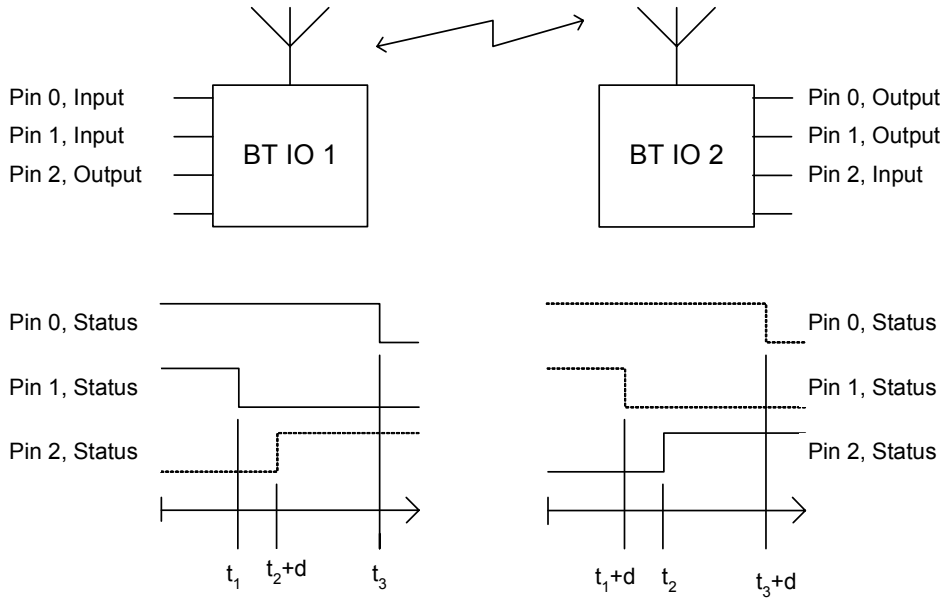


Figure 1 describes the basic functionality of the BT IO. The status on IO pins on an SPA is transferred to corresponding output pins on a remote SPA. There is a short delay (d) from that the Input is changed until the output on the remote side is set.

2.1 Data Mode

In data mode the functionality of the serial interface is the same as for the normal SPA. All data received on the serial interface is transferred to a remote device and all data received over the Bluetooth link is written on the serial interface.

Additionally, if a Bluetooth IO packet is received over air it is not only forwarded to the serial port but also the IO pins are set accordingly. This means that it is

possible to control the outputs or monitor the inputs of a remote BT IO, using any Bluetooth device that implements the Serial Port Profile. Data received on the Bluetooth link that does not match the packets defined by the BT IO protocol is ignored by the IO driver and only sent on the serial port. For details see Chapter 6.

Also, if a Bluetooth IO packet is received on the serial interface, it is not only forwarded to the Bluetooth link but also the IO pins are set accordingly. This means that it is also possible to control the outputs or monitor the inputs, of a local BT IO as well as a remote.

When the status of pins configured as inputs are changed, the BTIO generates status events. The status events are sent both on serial interface and on the Bluetooth link. The inputs are only sampled when in data mode. The inputs are not sampled in AT-mode.

The connection scheme defined in AT*ADWDRP works just the same as in the standard SPA. If configured as “connect on data”, then the device will try to connect as soon as the sampling of the inputs is started and data is being generated. Please refer to the AT Command Specification for details on how to configure the SPA using AT commands.

2.2 Sample period

The sample period, of the input pins, is configurable. The default value is 10ms. The shortest period supported is 2ms.

2.3 Filter

The IO also implements simple filter functionality for avoiding glitches. The filter is configurable. See chapter 7.1 for details.

2.4 Node Id

To support multipoint applications using Wireless Multidrop™ it is possible to give a BTIO an id. The id is set using the AT*AMIO command. How the id is used is described in the specification on the BTIO protocol.

2.5 Default values

The default values for the output pins are configurable. The default values are used when:

- No connection exists
- Device is in AT mode

When the default value is changed using the AT*AMIO command, the status of all pins are set immediately.

2.6 Select Peer On Name functionality

The Bluetooth IO implements a feature that makes it possible to connect to another device with a specific name. This is very useful when the Bluetooth IO is not connected to a host but still need to connect to different devices. For example when used in a simple remote control application. How to configure and use ”The Select Peer On Name” functionality is described in detail in the AT*ADWDRP and AT*AMIO commands.

The “Select Peer On Name” functionality is very similar to the “Connect to Name” functionality. The difference is that the “Select Peer On Name” sequence is triggered for example when a button is pressed compared to the “Connect to Name” which is always run at reset. Also the “Select Peer On Name” will store the remote peer in the persistent memory while a device connected to using “Connect to Name” is not remembered after a reset of the device.

Chapter 3

IO pins

3.1 Available IO pins

The table below lists all available IO pins and their location. Notice that the IO pins need different design solutions (see the last column in the table). Please refer to the Electrical and Mechanical Data sheet for details on the connectors and electrical characteristics.

IO	Normal SPA functionality	Connector	Voltage domain	Design guide (See section 3.2)
0	Red	J1, J2 pin11	3V	Standard 3V IO pins
1	Switch-0	J1, J2 pin12	1.8V	IO-1 pin
2	Green/ Switch-1	J1, J2 pin13	3V	Not available as IO. See E&M datasheet
3	Blue	J1, J2 pin14	3V	Not available as IO. See E&M datasheet
4	UART_CTS	J1, J2 pin15	3V	Standard 3V IO pins
5	UART TXD	J1, J2 pin16	3V	Not available as IO. See E&M datasheet
6	UART_RTS	J1, J2 pin17	3V	Standard 3V IO pins
7	UART RXD	J1, J2 pin18	3V	Not available as IO. See E&M datasheet
8	UART_DTR	J1, J2 pin19	3V	Standard 3V IO pins
9	UART_DSR	J1, J2 pin 20	3V	Standard 3V IO pins
10	Serial Select 0	J3 pin9	1.8V	IO-10 / IO-11 pins**
11	Serial Select 1	J3 pin10	1.8V	IO-10 / IO-11 pins**
12	Reserved	J3 pin15	1.8V	Standard 1.8V IO pins*
13	Reserved	J3 pin16	1.8V	Standard 1.8V IO pins*
14	Reserved	J3 pin17	1.8V	Standard 1.8V IO pins*
15	Reserved	J3 pin18	1.8V	Standard 1.8V IO pins*

*) Not available on cB-OEMSPA310

**) Not available on cB-OEMSPA310, cB-OEMSPA312 or cB-OEMSPA332

Table 1 list the available IO pins. Please note that not all of the IO pins are available on all of the products.

3.2 Design guide

All figures in this chapter show how to use the pins of the OEMSPA as either inputs or outputs. The left side of the figures describes the OEMSPA while the

right side describes the host system to which the OEMSPA is connected. The dotted line marks the outer bound of the OEMSPA.

Standard 3V IO pins

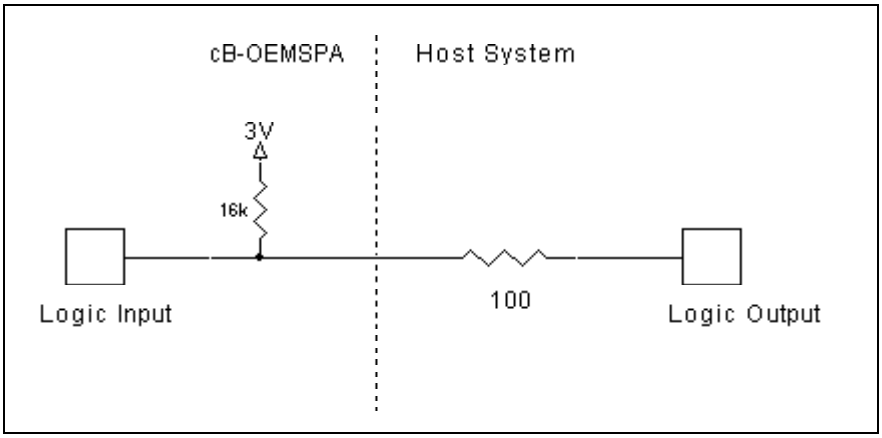


Figure 2 - Recommended design when using 3V IO pins as input.

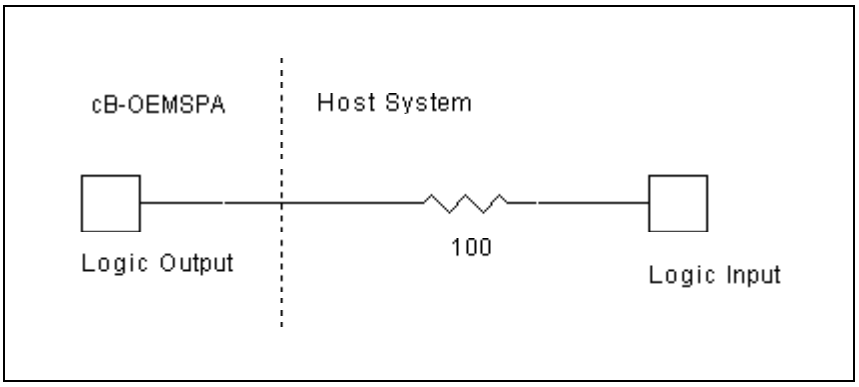


Figure 3 - Recommended design when using 3V IO pins as output.

Standard 1.8V IO pins

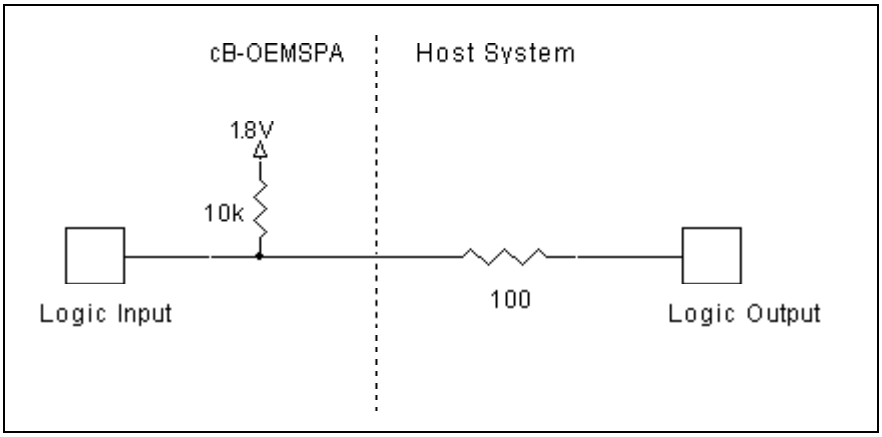


Figure 4 - Recommended design when using 1.8V IO pins as input.

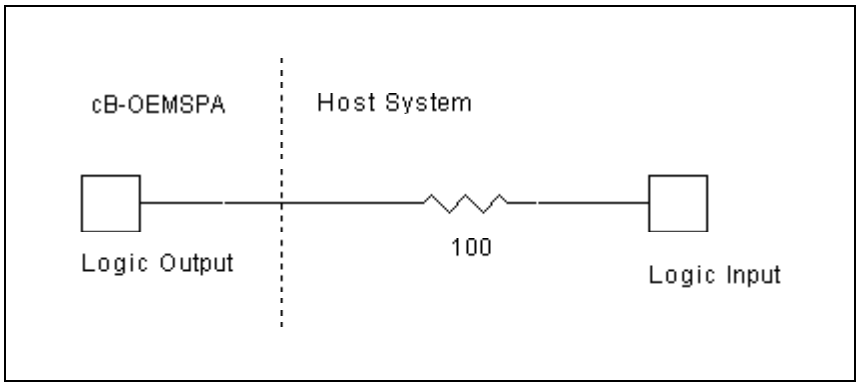


Figure 5 - Recommended design when using 1.8V IO pins as output.

IO-1 pin

The IO-1 pin has an Schottky diode in series, which need to be considered.

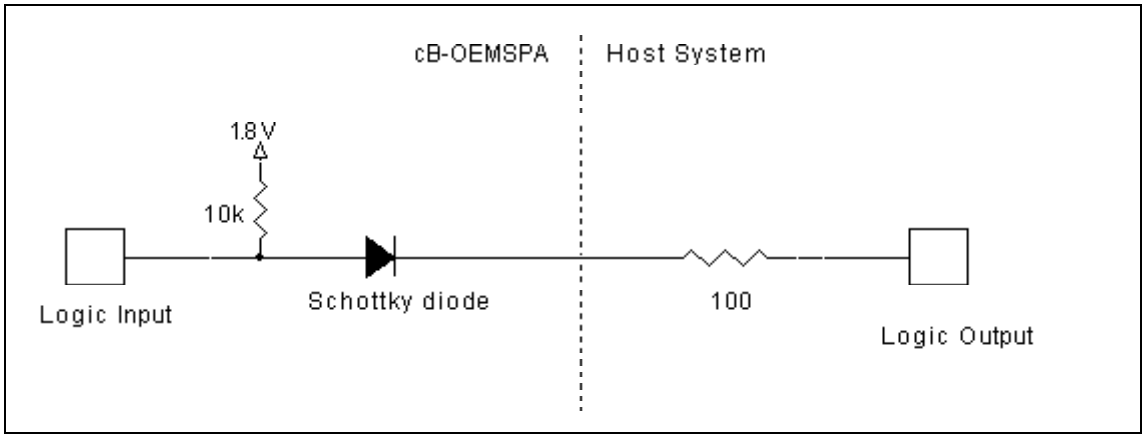


Figure 6 – Recommended design when using IO-1 as input. The series diode makes it possible to use either 1.8V or 3V signal levels.

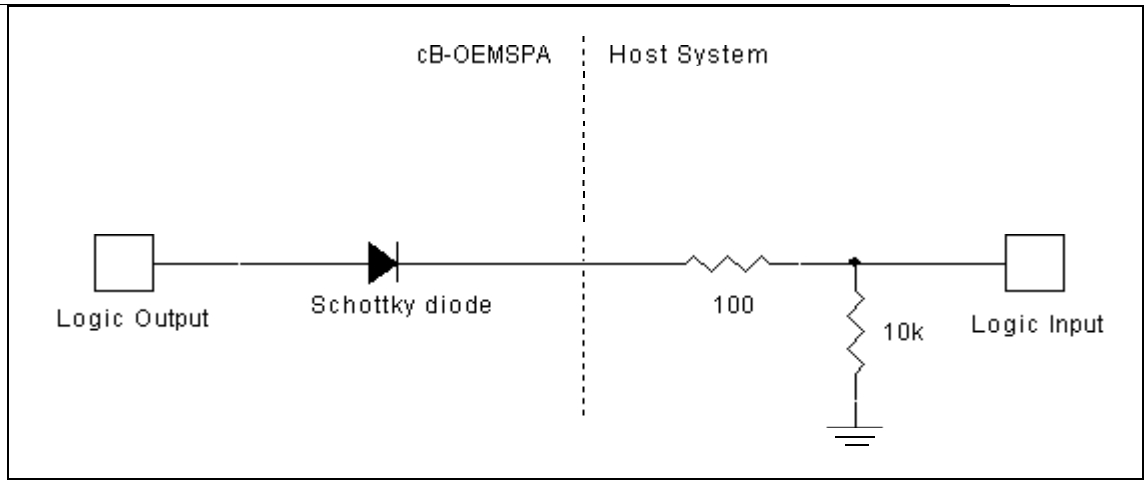


Figure 7 - Recommended design when using IO-1 as output. The series diode makes it necessary to add an external pull-down to define a low state.

IO-10 / IO-11 pins

IO-10 and IO-11 has an additional pull-up to 3V.

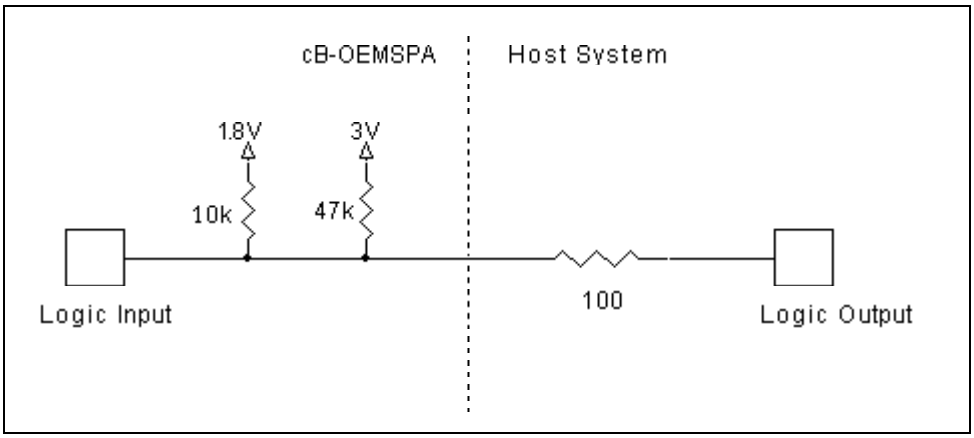


Figure 8 - Recommended design when using IO-10 and IO-11 as input.

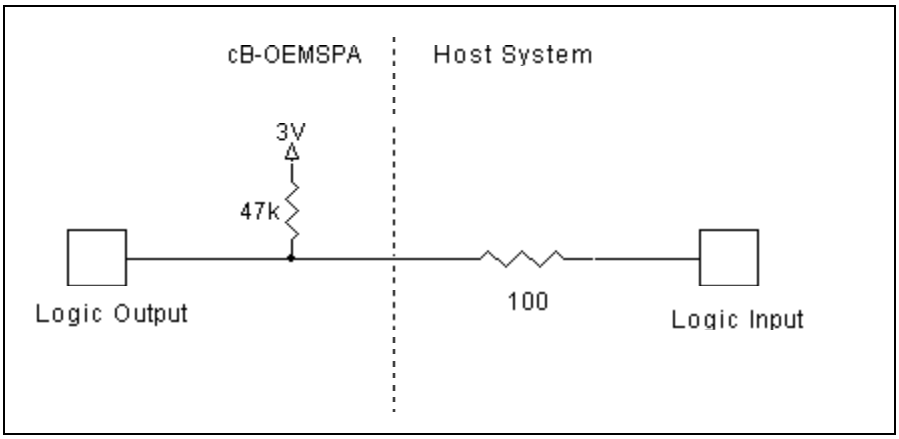


Figure 9 - Recommended design when using IO-10 and IO-11 as output.

Chapter 4

Differences to standard Serial Port Adapter

For the BT IO most of the connectors are used as IOs. Functionality in the standard SPA that requires these pins has been removed from the BT IO. The following functionality is changed compared to the standard SPA:

UART RTS/CTS signalling

UART flow control is not supported (AT*AMRS). UART RTS/CTS pins are controlled as any other IO pins on the module.

UART DTR/DSR signalling

UART DTR/DSR signalling is not supported (AT*AMDS). UART DTR/DSR are controlled as any other IO pins on the module.

Button functionality

No button functionality is supported. Switch-0 and Switch-1 are controlled as any other IO pins on the module.

Only logical level UART communication

Serial Select lines are used as IOs. This means that only logical level UART signalling is supported.

Limited LED functionality

The red LED is used as IO. The blue and green LEDs are working the same way as for the standard SPA. In the standard SPA an attempt to connect to a remote device is indicated with a purple colour (red and blue LEDs). In the BT IO this is instead indicated with a steady blue colour, which is the same indication as for a connection.

Low Power Mode

The Bluetooth IO can be configured to use stop mode to save power. The functionality is the same as in sleep mode (default) except that a host have to wake up the device before sending data on the serial interface. The method of waking up the device is different compared to the standard SPA. In the standard SPA, the DSR pin is used to wake up the device. For the Bluetooth IO the DSR pin is used as any other IO. Instead the pin, which shall be used to wake up the de-

vice, is configurable. The wake up pin is set in the command AT*AMIO, see chapter 7.2.

The Bluetooth IO will not enter stop mode until 10 seconds after start or when in AT-mode.

Note that when the BT IO is operating in stop mode, a host system only have to wake up the BT IO when it needs to send data on the serial interface. If the serial interface is not used or only used for configuration within 10s after a reset, no wake up pin is needed.

Restoring Serial Settings

Switch-1, which is used to restore the serial settings on the standard SPA is used as an IO on the Bluetooth IO. This means that it is not possible to restore the serial settings using any buttons.

If you lose what serial settings that is configured for a device you have to change FW back to standard SPA FW and mount the device on the standard SPA development board. It is now possible to restore the serial settings using switch-1. Change the FW back to Bluetooth IO FW and then you will be back in business. The whole procedure will take a couple of minutes.

Link Supervision Timeout

The link supervision time out is set to 200ms for the Bluetooth IO. This means that the device will detect a link loss within 200ms and restore all outputs to default values. The link supervision is 2 seconds for the standard SPA and typically 30 seconds for a Bluetooth implementation on a PC.

Toolbox

The Bluetooth IO can be configured using the AT Command toolbox. Using the toolbox makes it much easier to test the IO functionality compared to using “raw” AT commands since the tool calculates the different bit masks. The toolbox is available on the CD that come with the Bluetooth IO Development Kit and is also available for download at www.connectblue.se.

Chapter 5

Optimization

To minimize the delays in a BTIO application there are two configurations that can be changed:

To minimize the delay introduced by the Bluetooth connection, configure the BTIO with link policy 10,0 (Quality of Service and DM1 packets only). This is done using the AT*AMLP command.

To minimize the delay introduced by the sampling, set the sampling interval to 2ms. This is the shortest sampling interval supported. The default sample period is 10ms. Also set the filter constant to 1 (default).

Chapter 6

Protocol

The IO status is communicated between devices using a simple protocol. Additionally, a host may also perform read and write requests.

All packets start with a start field and a packet identity field. The Node id is used to identify a BTIO in a Wireless Multidrop scenario. It is possible to address a unique BTIO (Node Id of 0 to 254) or to send broadcasts (Node Id of 255) to all connected BTIOs. The last byte of the packet is an 8-bit checksum.

Start	Packet id	Node id	N bytes data	Check sum

Byte 0 Byte 1 . . .

The start byte is 0xA5. The checksum is calculated as the unsigned sum of all bytes in the packet except for the checksum itself.

The different packets are:

- *Status Event*: Generated by a BTIO node when the status of one or more input pin has changed. It is transferred both over air and on the serial line.
- *Read Request*: Sent by a host to read the input pins of a BTIO node. The packet can be sent both over air and on the serial line. The BTIO node will respond with a status event.
- *Write Request:* Sent by the host to change the output pin(s) of a BTIO node. The packet can be sent both over air and on the serial line.

The rest of this chapter describes the different packets in the protocol.

6.1 Status Event (Id = 0x01)

When in Data mode, a status event is generated when the status of any of the input pins are changed. The value field specifies the status of the pins and the valid mask field specifies which pins that are valid. All pins configured as inputs will be valid. The Node id field will be set to the Node Id of the device generating the packet.

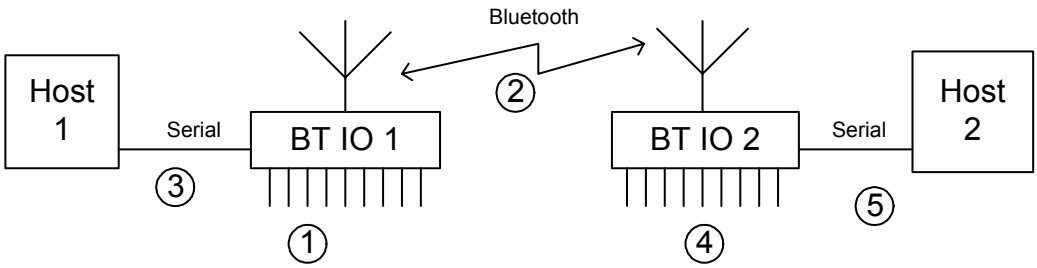
A Bluetooth IO device that receives this packet will update the status of the output pins. All pins marked as valid will be set to their corresponding value. Invalid pins are ignored. Note that the Node Id field is ignored when a Status Event is received.

The protocol supports 16 pins. Note that some of the pins are not mapped on any physical pin (see chapter 3.1).

0xA5	0x01	Node Id	Value MSB	Value LSB	Mask MSB	Mask LSB	Check sum

Byte	Description
0	Start field. Value 0xA5
1	Packet identity field. Value 0x01
2	Node id field. The node id of the sender. The node id is configured using the AT*AMIO command.
3	Value MSB. The status of pin 8 to 15.
4	Value LSB. The status of pin 0 to 7.
5	Valid mask MSB. Valid status for pin 8 to 15. 1 means that the status is valid. 0 means that the status shall be ignored.
6	Valid mask LSB. Valid status for pin 0 to 7. 1 means that the status is valid. 0 means that the status shall be ignored.
7	Checksum. The checksum is calculated as the unsigned sum of all bytes in the packet except for the checksum itself

Example scenario



1. Any of the input pins changes its state.
2. A status event is sent to the remote device on the Bluetooth interface.
3. A status event is sent on the serial interface
4. Output pins on the remote device is set according to the status event. Note that pins configured as inputs on BT IO device 1 must be configured as outputs on the BT IO device 2, otherwise the pin status is ignored.
5. The status event is written to the serial interface.

Note that no host devices are required in the above scenario.

The BT IO 2 device could be replaced with any Bluetooth device supporting the SPP profile. Then of course changes in inputs on BT IO 1 device will not result in changes of outputs in a remote device, but host 2 could monitor the status of the pins on BT IO device 1.

6.2 Read Request (Id = 0x02)

This packet specifies a request by the host to read the status of a BT IO node. Hence, when a node receives a Read Request with a matching Node id it will respond with a Status event (see chapter 6.1). If the Node Id is not matching then the packet is ignored.

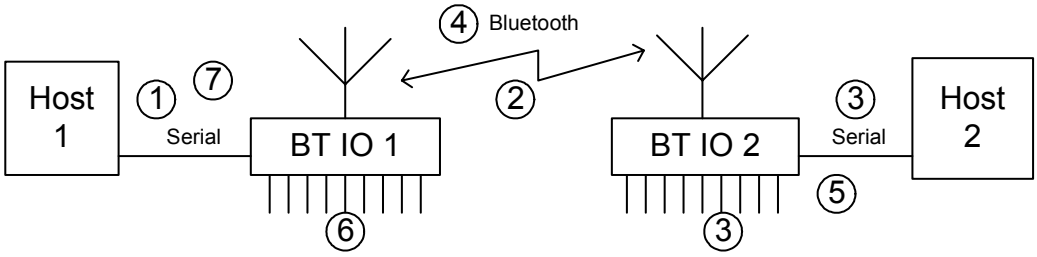
The Node Id field is matching if it is the same as the Node Id of the device or indicates broadcast.

Note that a BT IO device will never issue a read request itself.

0xA5	0x02	Node Id	Check sum

Byte	Description
0	Start field. Value 0xA5
1	Packet identity field. Value 0x02
2	Node id field. The id of the node that shall be read. Use 0xFF for broadcast.
3	Checksum. The checksum is calculated as the unsigned sum of all bytes in the packet except for the checksum itself.

Example scenario



1. The host sends a read request to BT IO device 1. The read request has node id set to node id of BTIO 2.
2. The BT IO 1 device forwards all data that it receives on its serial interface to the Bluetooth interface.
3. The BT IO 2 device reads its inputs and also forwards the read request to the serial interface.
4. The BT IO 2 device sends a status event with information on the status of all inputs pins to the BT IO 1 device.
5. The BT IO 2 device sends a status event with information on the status of all inputs pins on the serial interface.
6. The BT IO 1 sets its outputs according to the status event.
7. The status event is written to the serial interface.

In the above scenario the BT IO 1 device could be replaced with any bluetooth device supporting the SPP profile. Also Host 2 is not required.

If the read request is a broadcast (node id 0xFF) then BTIO 1 will respond with a status event as well.

6.3 Write Request (Id = 0x03)

A host may write this packet to change the output pins on a BT IO device.

Hence, when a device receives a Write Request with a matching Node id it will set its outputs to the values defined in the packet. If the Node Id is not matching then the packet is ignored.

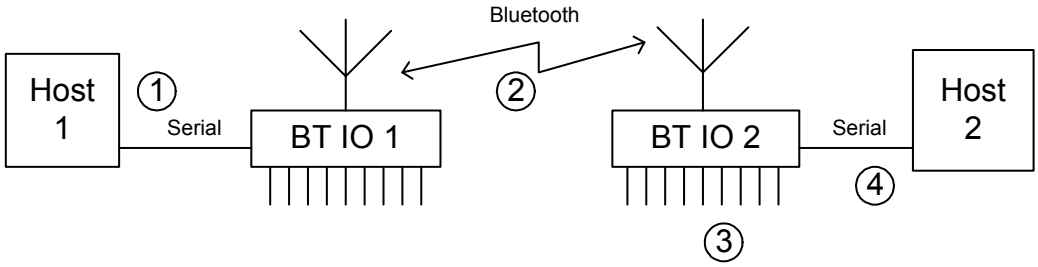
The Node Id field is matching if it is the same as the Node Id of the device or indicates broadcast.

Note that a BT IO device will never issue a write request itself.

0xA5	0x03	Node Id	Value MSB	Value LSB	Mask MSB	Mask LSB	Check sum

Byte	Description
0	Start field. Value 0xA5
1	Packet identity field. Value 0x03
2	Node id field. The id of the node that shall set its outputs. Use 0xFF for broadcast.
3	Value MSB. The output status of pin 8 to 15.
4	Value LSB. The output status of pin 0 to 7.
5	Valid mask MSB. Valid status for pin 8 to 15. 1 means that the status is valid. 0 means that the status shall be ignored.
6	Valid mask LSB. Valid status for pin 0 to 7. 1 means that the status is valid. 0 means that the status shall be ignored.
7	Checksum. The checksum is calculated as the unsigned sum of all bytes in the packet except for the checksum itself.

Example scenario



1. Host 1 sends a write request to the BT IO 1 device. The node id is set to the node id of BT IO 2.
2. The write request is sent to the remote device.
3. The BT IO 2 device sets its outputs according to the write request.
4. The BT IO 2 device writes the write request to the serial interface.

If the write request is a broadcast (node id 0xFF) then BTIO 1 will respond with a status event as well.

In the above scenario the BT IO 1 device could be replaced with any bluetooth device supporting the SPP profile. Also Host 2 is not required.

Chapter 7

AT Commands Reference

7.1 Changes in the standard AT Commands

Read_Default_Remote_Peer (AT*ADRDRP=)

AT Command	Description
AT*ADRDRP=< peer_id ><CR>	This command reads the Bluetooth device address and device name of the selected default remote peer (peer id).

Command Parameters	Type	Value
peer_id	integer	The peer ID can be between 0 and the value written by the Write_No_Of_Peers command –1 or read by the Read_No_Of_Peers command –1.

Responses	Description
<CR><LF>*ADRDRP:<bd_addr>,<connect_scheme>, <update_remote_peer_on_incoming>, <device_name><CR><LF>OK<CR><LF>	Successful response.
<CR><LF>ERROR<CR><LF>	Error response.

Response Parameters	Type	Value
bd_addr	Bd_Addr	Bluetooth device address of the default remote peer.

connect_scheme	integer	This parameter is a bit field. Bit 0 is the least significant bit. Each bit is defined as follows: Bit 0: Connect on data Try to connect to default remote peer on data traffic. Bit 1: Always connected Always try to be connected to the default remote peer when in data mode. Bit 2: Connect on external signal Try to connect to default remote peer on external signal. The external signal is implementation specific, e.g. some Serial Port Adapters might have a button. Bit 3: Connect to name On reset, try to connect to a device with the name given by the <device_name> parameter. The <device_name> may specify a part of, or the full name of the remote device. The SPA will at reset perform an inquiry followed by name requests on devices found during inquiry until a matching device is found. If no matching device is found the SPA will stop this procedure and operate as normal. If a matching device is found, the SPA will try to connect to this device. If no matching device is found, this is seen as an LED error indication. Bit 4: Select remote peer on name On activity on an io pin specified by AT*AMIO, try to connect to a device with the name given by the <device_name> parameter. The <device_name> may specify a part of, or the full name of the remote device. The SPA will perform an inquiry followed by name requests on devices found during inquiry until a matching device is found. If one matching device is found, the SPA will try to connect to this device. If the connection succeeds then the new device will be saved as default remote peer. If two or more devices are found, then the SPA will not connect to any of them. The inquiry and name discovery procedure will be performed at –32dBm. This means that only devices within a close range will respond to the inquiry. Bit 5-15: Reserved for future use. *Advanced:* Bit 16-23: Always connected period This field can be used to define the period for connection attempts for always connected (Bit 1 set). If not set or set to 0 then the default period 10s is used. Time in seconds. Bit 24-31: Page timeout The page timeout. This field defines for how long the module tries to connect to the remote device. The time is defined in units of 80ms. For example, to set the page time out to 1,040s choose the value 0x0D. If not set or set to 0 then the default page timeout 5,12s is used.
update_remote_peer_on_incoming	enumerator	1: Every time a remote device connects to the selected DefaultServerProfile, update the remote peer device address to the device address of the connecting device. The new remote peer device address will be stored in the startup database. Only one of all the remote peers can use this feature. 0: Do not update the remote peer device address on incoming connections.
device_name	string	Maximum 240 characters.

Write_Default_Remote_Peer (AT*ADWDRP=)

AT Command	Description
AT*ADWDRP=<peer_id>,<bd_addr>, <connect_scheme>, <update_remote_peer_on_incoming>, <device_name>, <store_in_startup_database><CR>	This command writes the Bluetooth device address, connect scheme and device name of the currently selected default remote peer.

Command Parameters	Type	Value
peer_id	integer	The peer ID can be between 0 and the value written by the Write_No_Of_Peers command –1 or read by the Read_No_Of_Peers command –1.
bd_addr	Bd_Addr	Bluetooth device address of the default remote peer.
connect_scheme	integer	See Read_Default_Remote_Peer.
update_remote_peer_on_incoming	enumerator	See Read_Default_Remote_Peer.
device_name	string	See Read_Default_Remote_Peer.
store_in_startup_database	enumerator	0: The setting will only be valid for the current power cycle. 1: The Serial Port Adapter will remember the setting between power cycles. The settings database in the Serial Port Adapter will be updated.

Responses	Description
<CR><LF>OK<CR><LF>	Successful response.
<CR><LF>ERROR<CR><LF>	Error response.

7.2 IO configuration AT Commands

Read_IO_Configuration (AT*AMIO?)

AT Command	Description
AT*AMIO?<CR>	Reads the IO configuration for the module.

Responses	Description
<CR><LF>*AMIO:<input_mask>, <output_mask>,<default_output>,<poll_period_in_ms>,<filter_constant>,<node_id>, < select_remote_peer_pin ><CR><LF>OK<CR><LF>	Successful response.
<CR><LF>ERROR<CR><LF>	Error response.

Result Parameters	Type	Value

input_mask	integer	Bit mask defining input pins. Acceptable range is 0x0000 to 0xFFFF. Note that the command support more pins than available on the current HW. Table 1defines which pins are supported. (Default value is 0)
output_mask	integer	Bit mask defining output pins. Acceptable range is 0x0000 to 0xFFFF. Note that the command support more pins than available on the current HW. Table 1 defines which pins are supported. (Default value is 0)
default_output	integer	Bit mask defining default values for pins configured as outputs. The pin is set to the default value when no Bluetooth connection exists or when in AT-mode. (Default value is 0) Example: To set the default value for pin 0 and pin 1 to 0 and for pin 2 and pin 3 to 1 use the value 12 (0x000C)
poll_period_in_ms	integer	Poll period in milliseconds. The poll period defines how often input pins are sampled. The shortest poll period supported is 2ms. (Default value is 10ms)
Filter_constant	integer	Constant defining how many identical samples of a pins status that is required before the status shall be considered changed. If all changes in status shall be reported to remote side and glitches is not a problem, then set this value to one. (Default value is 1) Example: Filter constant set to 2 and poll interval set to 2ms. When a pins status is changed then 2 identical samples taken after each other are required for the status to be considered changed. This means that a glitch shorter than 2ms is ignored.
node_id	integer	The Node id for the device. The Node id is part of all packets in the protocol defined in Chapter 6. (Default value is 0) 255 is reserved for broadcast.
select_remote_peer_pin	integer	Defines which pin that activates the “Select remote peer on name” sequence. This pin shall not be configured as input or output in the input or output mask. Note that the default remote peer must be configured as well. Set to –1 (default) if select peer on name shall not be used.
wake_up_pin	integer	Defines which pin that shall wake up the device from stop mode. Set to –1 (default) if no wake up pin is needed or stop mode is not used.

Write_IO_Configuration (AT*AMIO=)

AT Command	Description
AT*AMIO= <input_mask>, <output_mask>, <default_output>, <poll_period_in_ms>, <filter_constant>, <store_in_startup_database><CR>	Sets the IO configuration for the module.

Command Parameters	Type	Value

input_mask	integer	See Read_IO_Config.
Output_mask	integer	See Read_IO_Config.
Default_output	integer	See Read_IO_Config.
poll_period_in_ms	integer	See Read_IO_Config.
Filter_constant	integer	See Read_IO_Config.
node_id	integer	See Read_IO_Config.
select_remote_peer_pin	integer	See Read_IO_Config.
wake_up_pin	integer	See Read_IO_Config.

Responses	Description
<CR><LF>OK<CR><LF>	Successful response.
<CR><LF>ERROR<CR><LF>	Error response.