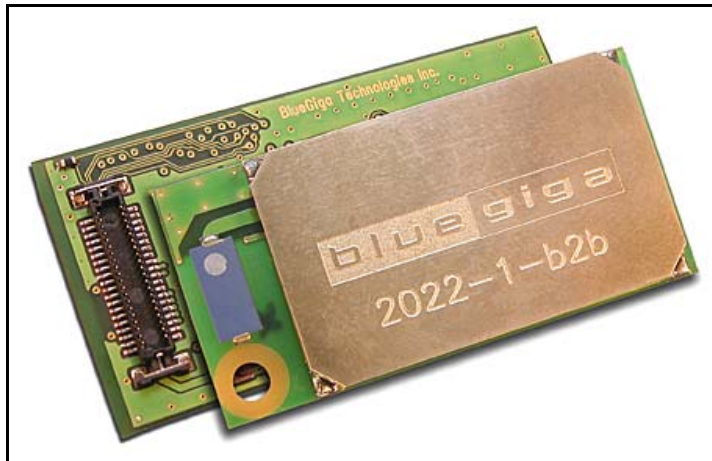# WRAP THOR 2022-1-B2B
BLUETOOTH MODULE

USER'S MANUAL (V 1.0)

WRAP THOR 2022-1-B2B

TABLE OF CONTENTS

1 OVERVIEW

1.1 FEATURE SUMMARY

The summary of the technical features are listed below.

- Wireless communication module corresponding to Bluetooth Specification V1.1.
- Bluetooth Class 1 device. Supports 100 m link range.
- Compact package size (25.6 * 14 * 2.5 mm).
- Up to 7 ACL connections and up to 3 SCO connections.
- UART interface with programmable baud rate.
- GPIO control.
- SPI
- 13-bit PCM interface.
- Built-in link controller and Link Manager Protocol.
- Command interface options.
  - WRAP THOR ASCII Interface™ using UART.
  - HCI using UART / USB.
- Built-in flash memory and system clock.
- Support for Virtual Machine applications inside the module.

1.2 TARGET APPLICATIONS

The target applications are telemetry, telematics, M2M applications, industrial instruments, sensors, and devices, hand-held devices, network appliances, embedded Linux systems, professional transportation systems, lifestyle electronics, cable replacement, Symbian phone accessories.

1.3 USE OF THE ASCII-INTERFACE

This is described separately in the ASCII-Interface manual.

2 BLOCK DIAGRAMS

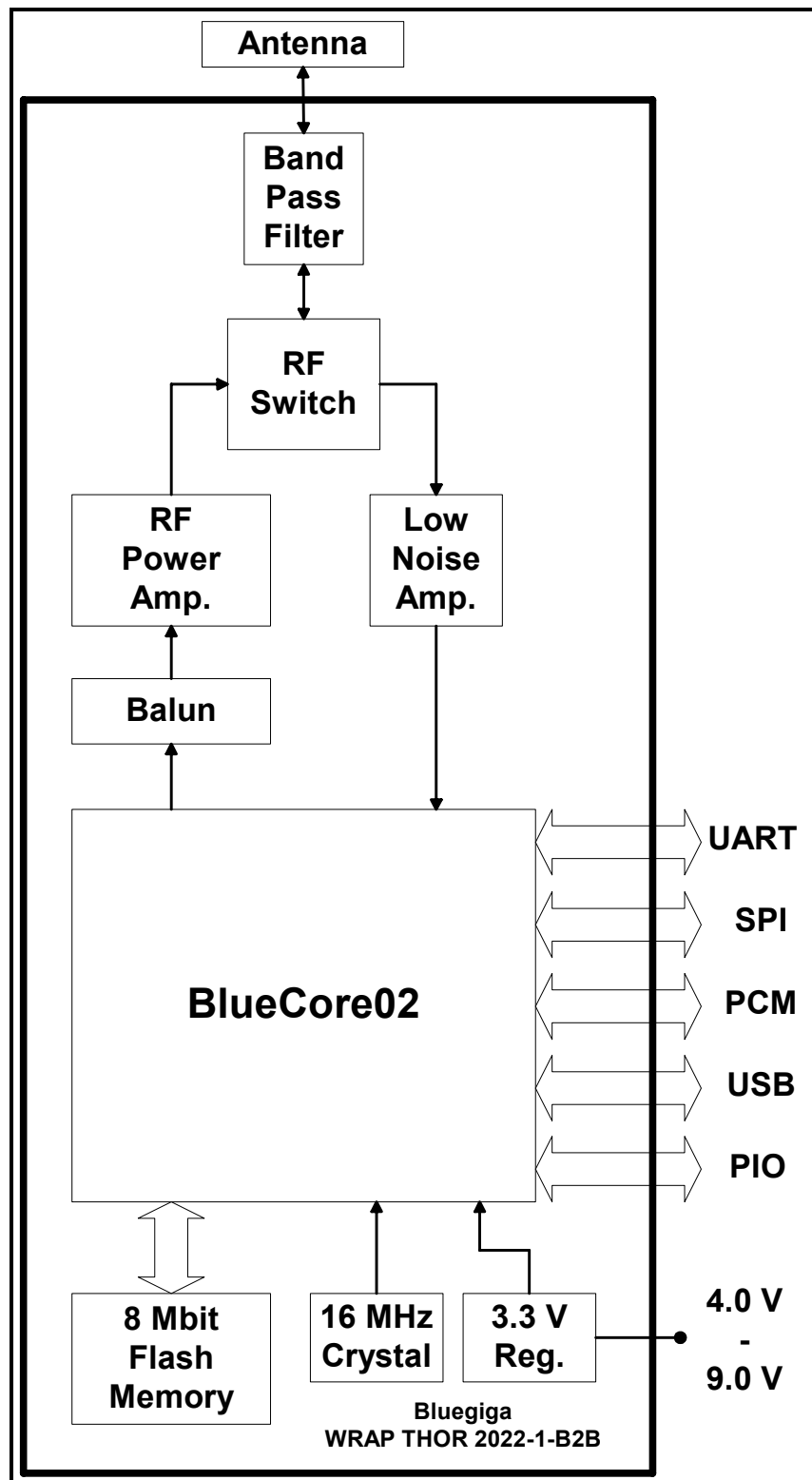### 2.1 BLOCK DIAGRAM OF WRAP THOR 2022-1-B2B

Figure 1: Block diagram of WRAP THOR 2022-1-B2B

3 COMMON PHYSICAL LAYER SPECIFICATIONS

The common physical layer specifications are shown in the table below.

	Item	Specification
1	Operating Frequency	2400 MHz to 2483.5 MHz (In the ISM-Band)
2	Carrier Spacing	1.0 MHz
3	Channels	79
4	Duplexing	TDD
5	Symbol Rate	1 Mbps
6	TX Modulation Polarity	Binary one: Positive frequency deviation
		Binary zero: Negative frequency deviation
7	RX Data Out Polarity	F_C + dF: "H"
		F_C - dF: "L"

Table 1: Common physical layer specifications

4 GENERAL SPECIFICATIONS

The general specifications are show in the table below.

	Item	Specification
1	Supply voltage	
	WRAP THOR 2022-1-B2B	Pin 40: 3.3 V ± 0.1 V regulated voltage. (Noise < 10 mV$_{P-P}$.) Pin 39: 4.0 V … 9.0 V unregulated voltage.
2	Supply current	
	WRAP THOR 2022-1-B2B	Maximum current in TX mode: 160 mA. Maximum current in RX mode: 60 mA.
3	Frequency range	2400 MHz … 2483.5 MHz. (ISM-Band.)
4	Guard band	2 MHz < F < 3.5 MHz. (Europe, Japan, USA.)
5	Carrier frequency	2402 MHz … 2480 MHz. F = 2402 + k MHz; k = 0 … 78.
6	Modulation method	GFSK, 1 Mbps, 0.5 Gaussian.
7	Hopping	1600 hops/s, 1 MHz channel space.
8	Maximum data rate	Asynchronous, 723.2 kbps / 57.6 kbps. Synchronous: 433,9 kbps/433.9kbps.
9	Receiving signal range	-82 to -20 dBm. (Typical.)
10	Receiver IF frequency	1.5 MHz. (Center frequency.)
11	Transmission power	Minimum: -18 … -16 dBm. Maximum +14 … +17 dBm. (Class 1 device with 6 power control levels.)
12	RF input impedance	50 Ω.
13	Baseband crystal OSC	16 MHz.
14	Output interfaces	6 GPIO, PCM, SPI, UART, USB.
15	Operation temperature	273 K … 328 K. (0 ºC … + 55 ºC).
16	Storage temperature	233 K … 358 K. (- 40 ºC … + 85 ºC.)
17	Compliance	Bluetooth specification, version 1.1.
18	USB specification	USB specification, version 1.1.

Table 2: General specifications

5 RADIO FREQUENCY CHARACTERISTICS

5.1 TRANSMITTER CHARACTERISTICS

The transmitter characteristics have been measured according to the test purposes of the Bluetooth test specification. The details of the initial condition and the test procedure may be found from the document mentioned above. The transmitter characteristics are show in the table below.

No	Item	Min	Typ	Max	Unit	Bluetooth test purpose
1	Output power.	+12	+16	+18	dBm	TRM/CA/01/C. (NTC, ETC.)
2	Power density.			20	dBm	TRM/CA/02/C. (ETC.)
3	Frequency range.	2400		2483.5	MHz	TRM/CA/04/C. (NTC, ETC.)
4	-20 dB band width.			1.0	MHz	TRM/CA/05/C. (NTC, ETC.)
5	Adjacent channel power.					TRM/CA/06/C. (NTC, ETC.)
	$\mid M - N \mid = 2$.			-20	dBm	
	$\mid M - N \mid \geq 3$.			-40	dBm	
6	Modulation characteristics.					TRM/CA/07/C. (NTC, ETC.)
	$\Delta F1_{AVG}$.	140		175	kHz	
	$\Delta F2_{MAX}$. (99.9 %.)	115			kHz	
	$\Delta F2_{AVG}/\Delta F1_{AVG}$.	0.8			-	
7	Initial carrier frequency tolerance.	-75	0	75	kHz	TRM/CA/08/C. (NTC, ETC.)
8	Carrier frequency drift.					
	DH1.	-25		+25	kHz	
	DH3.	-40		+40	kHz	TRM/CA/09/C. (NTC, ETC.)
	DH5.	-40		+40	kHz	
	Drift rate.			20000	Hz	
9	Out-of-band spurious emissions.					
	Operation mode.					
	30 MHz … 1 GHz.			-36	dBm	
	1 GHz … 12.75 GHz.			-30	dBm	
	1.8 GHz … 1.9 GHz.			-47	dBm	
	5.15 GHz … 5.3 GHz.			-47	dBm	TRC/CA/01/C. (NTC.)
	Idle mode.					
	30 MHz … 1 GHz.			-57	dBm	
	1 GHz … 12.75 GHz.			-47	dBm	
	1.8 GHz … 1.9 GHz.			-47	dBm	
	5.15 GHz … 5.3 GHz.			-47	dBm	

Table 3: Transmitter characteristics

NTC: Normal Test Condition. Nominal power supply voltage (V_{DD} = 3.3 V) and nominal operating temperature (T_{NOM} = 298 K = 25 ºC).

ETC: Extreme Test Condition. Extreme power supply voltages (V_{DD} = 3.3 V ± 0.1 V) and extreme operating temperatures (T_{MIN} = 253 K = 0 ºC, T_{MAX} = 328 K = 55 ºC) in all combinations.

5.2 RECEIVER CHARACTERISTICS

The receiver characteristics have been measured according to the test purposes of the Bluetooth test specification. The details of the initial condition and the test procedure may be found from the document mentioned above. The receiver characteristics are show in the table below.

No	Item	Min	Typ	Max	Unit	Bluetooth test purpose
1	Sensitivity. Single slot packets.	-87	-82	-75	dBm	RCV/CA/01/C. (NTC, ETC.)
2	Sensitivity. Multi-slot packets.	-87	-82	-75	dBm	RCV/CA/02/C. (NTC, ETC.)
3	C/I performance.					RCV/CA/03/C. (NTC.)
	C/I_{0MHz}. (Co-Channel)	11			dB	
	C/I_{1MHz}.	0			dB	
	C/I_{2MHz}.	-30			dB	
	$C/I_{3\geq MHz}$.	-40			dB	
	C/I_{IMAGE}.	-9			dB	
	$C/I_{IMAGE+1MHz}$.	-20			dB	
4	Blocking performance.					RCV/CA/04/C. (NTC.)
	30 MHz…2000 MHz.	-10			dBm	
	2000 MHz…2400 MHz.	-27			dBm	
	2500 MHz…3000 MHz.	-27			dBm	
	3000 MHz…12.75 GHz.	-10			dBm	
5	Intermodulation performance.	-39			dBm	RCV/CA/05/C. (NTC.)
6	+1 MHz			4	dB	
	+2 MHz			-30	dB	
	>+3 MHz			-40	dB	
	Image frequency			-6	dB	
	Adjacent (1 MHz) to in-band image			-16	dB	
7	Maximum input level.			-20	dBm	RCV/CA/06/C. (NTC.)

Table 4: Receiver characteristics

NTC: Normal Test Condition. Nominal power supply voltage (V_{DD} = 3.3 V) and nominal operating temperature (T_{NOM} = 298 K = 25 ºC).

ETC: Extreme Test Condition. Extreme power supply voltages (V_{DD} = 3.3 V ± 0.1 V) and extreme operating temperatures (T_{MIN} = 253 K = 0 ºC, T_{MAX} = 328 K = 55 ºC) in all combinations.

6 PIN DESCRIPTION

6.1 PIN DESCRIPTION OF WRAP 2022-1-B2B

The pin description of WRAP 2022-1-B2B is shown in the table below.

No	Pin name	I/O	Description
1	RESET_IN	I	Reset if high. (Internal 1 Kohm pull-down resistor.)
2	NC	-	Not connected.
3	PIO (2)	I/O	Programmable I/O lines.
4	NC	-	Not connected.
5	PIO (3)	I/O	Programmable I/O lines.
6	PIO (4)	I/O	Programmable I/O lines.
7	PIO (6)	I/O	Programmable I/O lines.
8	PIO (5)	I/O	Programmable I/O lines.
9	PIO (7)	I/O	Programmable I/O lines.
10	NC	-	Not connected.
11	NC	-	Not connected.
12	NC	-	Not connected.
13	NC	-	Not connected.
14	NC	-	Not connected.
15	NC	-	Not connected.
16	NC	-	Not connected.
17	GND	GND	Ground.
18	GND	GND	Ground.
19	PCM_SYNC	I/O	Synchronous data strobe (pull-down).
20	PCM_CLK	I/O	Synchronous data clock (pull-down).
21	PCM_IN	I	Synchronous 8 kbps data in (pull-down).
22	PCM_OUT	O	Synchronous 8 kbps data out (pull-down).
23	NC	-	Not connected.
24	NC	-	Not connected.
25	NC	-	Not connected.
26	NC	-	Not connected.
27	SPI_MOSI	I	Synchronous Serial Interface data input (pull down).
28	SPI_CLK	I	Synchronous Serial Interface Clock (pull down).
29	SPI_CSB	I	Chip select for synchronous serial interface (pull-up). Active low.
30	SPI_MISO	O	Synchronous Serial Interface data output (strong pull-down).
31	UART_CTS	I	Asynchronous serial data CTS (pull-up). Active low.
32	USB_D-	A	USB data minus.
33	UART_RST	O	Asynchronous serial data RTS (pull-up). Active low.
34	USB_D+	A	USB data plus.
35	UART_TX	O	Asynchronous serial data out.
36	UART_RX	I	Asynchronous serial data.
37	GND	GND	Ground.
38	GND	GND	Ground.
39	5V0	VDD	Power supply connection. (Unregulated power input.)
40	3V3	VDD	Power supply connection. (Regulated power input.)

Table 5: Pin configuration

List of abreviations: Analog (A), Input (I), Output (O), Ground (GND), Radio Frequency port (RF).

Notes: Voltage level of input (I), output (O) and input/output (I/O) pins is 3.3 V.

7 MECHANICS

7.1 PHYSICAL OUTLOOK OF WRAP 2022-1-B2B

The physical outlook of WRAP THOR 2022-1-B2B is shown in the image below.
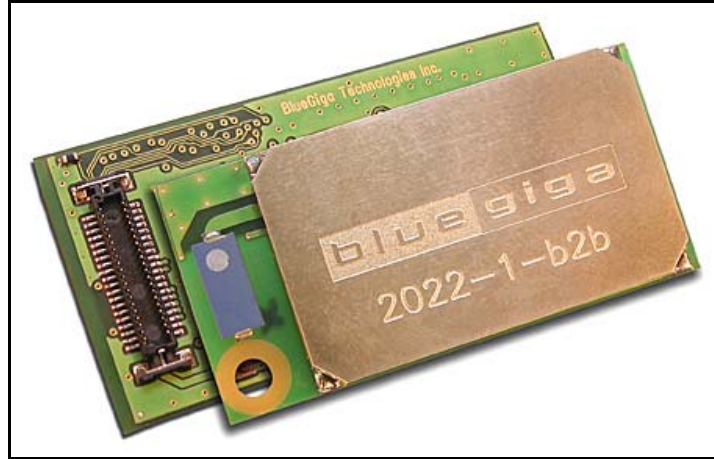

Figure 1: Outlook of WRAP THOR 2022-1-B2B

7.2 MECHANICAL DRAWING OF WRAP THOR 2022-1-B2B

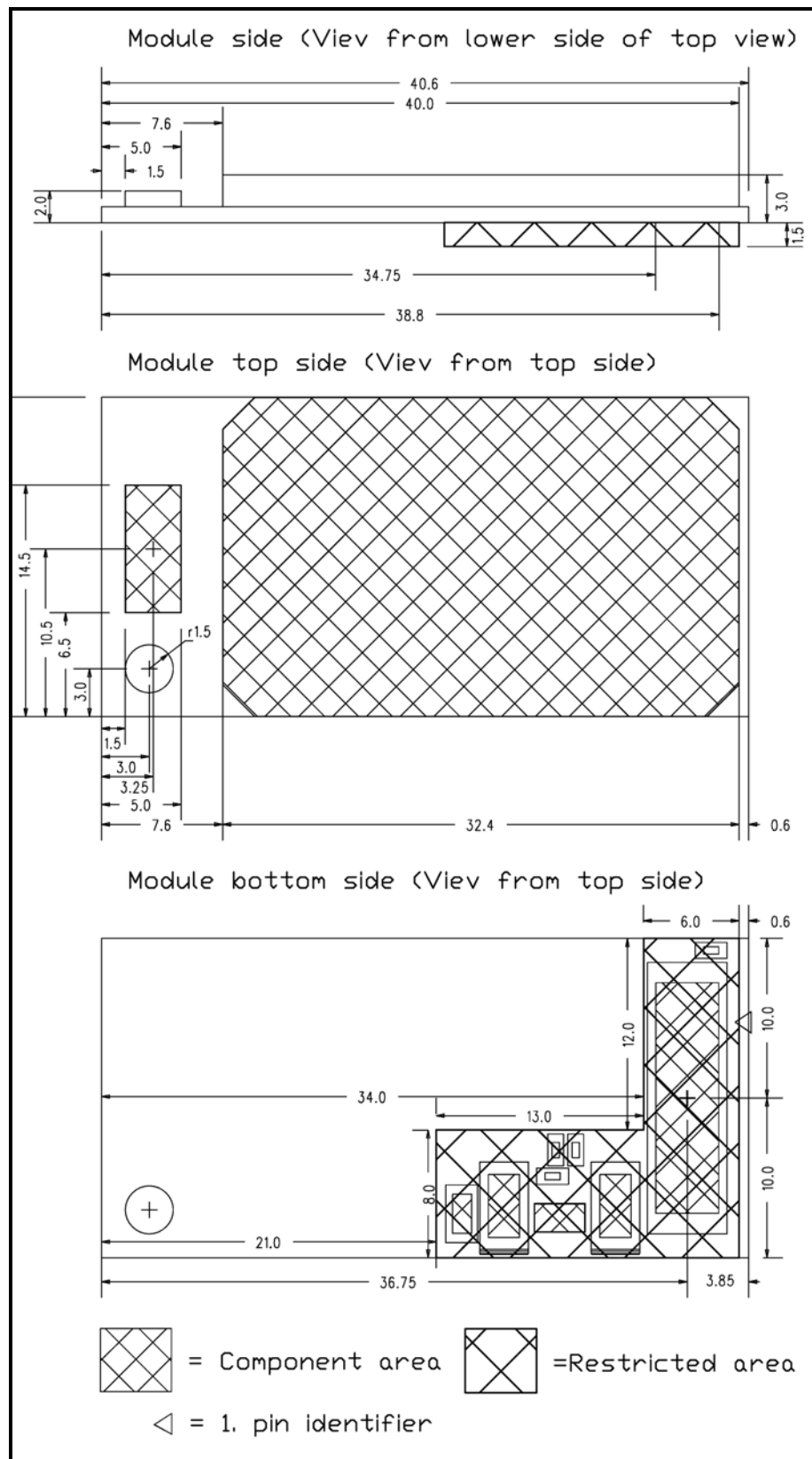The mechanical drawing of WRAP THOR 2022-1-B2B is shown in the figure below.

Figure 2: Mechanical drawing of WRAP THOR 2022-1-B2B

7.3 RECOMMENDED LAND PATTERN OF WRAP THOR 2022-1-B2B

WRAP THOR 2022-1-B2B module utilize AMP 4-353512-0 connector. The opposite connector for the application board is AMP 4-353515-0. The recommended land pattern of WRAP THOR 2022-1-B2B opposite connector and the module positioning is shown in the figure below.
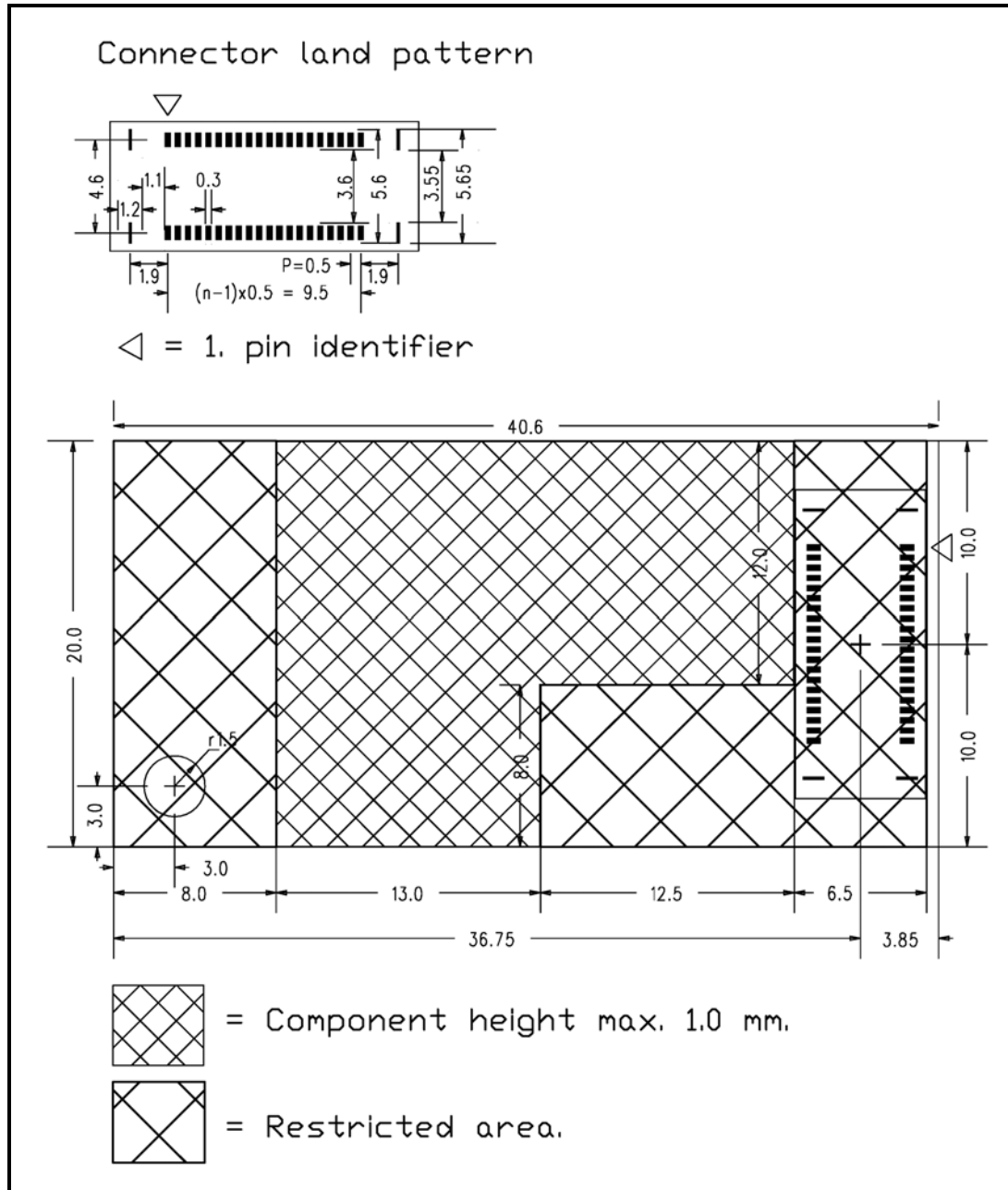

Figure 3: Recommended land pattern of WRAP THOR 2022-1-B2B

7.4

8   BLUETOOTH SOFTWARE STACKS

WRAP THOR 2022-1 is supplied with Bluetooth stack firmware which runs on the internal RISC
microcontroller. This is compliant with the Bluetooth specification v1.1.
The WRAP THOR 2022-1 software architecture allows Bluetooth processing overheads to be
shared in different ways between the internal RISC microcontroller and the host processor. The
upper layers of the Bluetooth stack (above HCI) can be run either on-chip or on the host processor.

Running the upper stack on WRAP THOR 2022-1 reduces (or eliminates, in the case of a virtual
machine (VM) application) the need for host-side software and processing time. Running the upper
layers on the host processor allows greater flexibility.
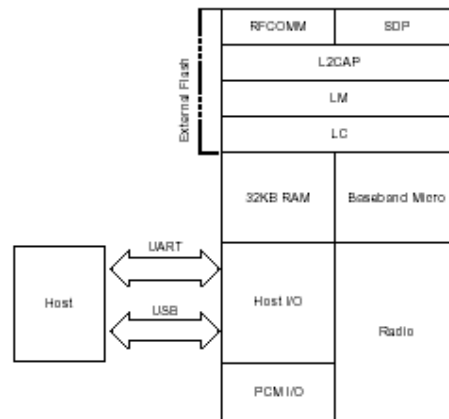
8.1   RFCOMM STACK

Figure 4: RFCOMM stack

In this version of the firmware the upper layers of the Bluetooth stack up to RFCOMM are run on-chip. This reduces host-side software and hardware requirements at the expense of some of the power and flexibility of the HCI only stack.
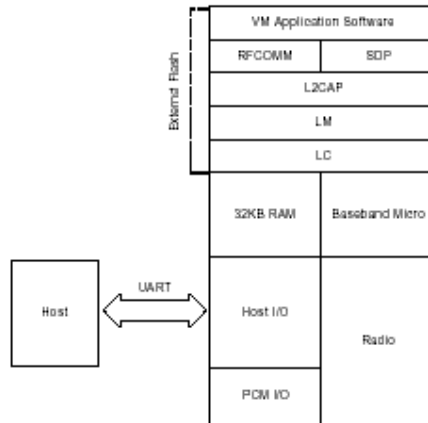
8.2   VIRTUAL MACHINE STACK

Figure 5: Virtual Machine

This version of the stack firmware requires no host processor. All software layers, including application software, run on the internal RISC processor in a protected user software execution environment known as a Virtual Machine (VM).

The user may write custom application code to run on the BlueCore VM using BlueLaM software development kit (SDK) supplied with the BlueLab and Casira development kits, available separately from CSR. This code will then execute alongside the main BlueCore firmware. The user is able to make calls to the BlueCore firmware for various operations.

The execution environment is structured so the user application does not adversely affect the main software
routines, thus ensuring that the Bluetooth stack software component does not need re-qualification when the
application is changed.

Using the VM and the BlueLab SDK the user is able to develop applications such as a cordless headset or other profiles without the requirement of a host controller. BlueLab is supplied with example code including a full implementation of the headset profile.

Note:
Sample applications to control PIO lines can also be written with BlueLab SDK and the VM for the HCI stack.

9 UART INTERFACE

WRAP THOR 2022-1 Universal Asynchronous Receiver Transmitter (UART) interface provides a simple mechanism for communicating with other serial devices using the RS232 standard (1).
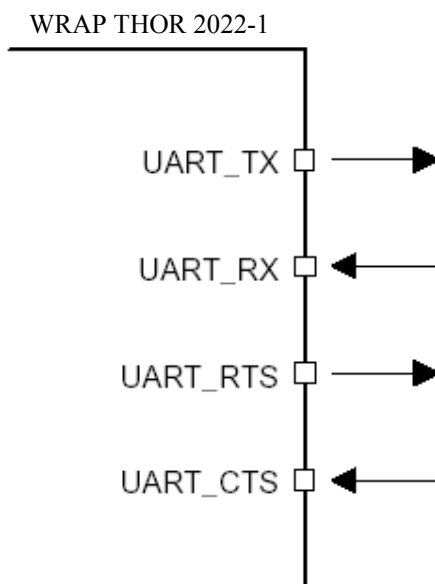
WRAP THOR 2022-1

Figure 6: Universal Asynchronous Receiver

Four signals are used to implement the UART function, as shown in Figure 5. When WRAP THOR 2022-1 is connected to another digital device, UART_RX and UART_TX transfer data between the two devices. The remaining two signals, UART_CTS and UART_RTS, can be used to implement RS232 hardware flow control where both are active low indicators. All UART connections are implemented using CMOS technology and have signalling levels of 0V and VDD_PADS.

UART configuration parameters, such as Baud rate and packet format, are set using WRAP THOR 2022-1 software.

Notes:

In order to communicate with the UART at its maximum data rate using a standard PC, an accelerated serial port adapter card is required for the PC.
(1) Uses RS232 protocol but voltage levels are 0V to VDD_PADS, (requires external RS232 transceiver IC)

Parameter		Possible Values
Baud Rate	Minimum	1200 Baud (·2%Error)
		9600 Baud (·1%Error)
	Maximum	1.5MBaud (·4%Error)
Flow Control		RTS/CTS or None
Parity		None, Odd or Even
Number of Stop Bits		1 or 2
Bits per channel		8

Table 6: Possible UART Settings

The UART interface is capable of resetting WRAP THOR 2022-1 upon reception of a break signal. A Break is identified by a continuous logic low on the UART_RX terminal, as shown in figure 9.16. If tBRK is longer than the value, defined by the Persistent Store Key PSKEY_HOST_IO_UART_RESET_TIMEOUT, (0x1a4), a reset will occur. This feature allows a host to initialise the system to a known state. Also, WRAP THOR 2022-1 can emit a Break character that may be used to wake the Host.
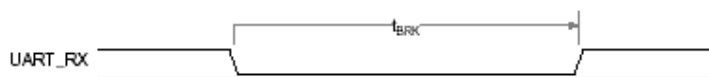

Figure 7: Break signal

Note:
The DFU boot-loader must be loaded into the Flash device before the UART or USB interfaces can be used.
This initial Flash programming can be done via the serial peripheral interface. Table 9.10 shows a list of commonly used Baud rates and their associated values for the Persistent Store Key PSKEY_UART_BAUD_RATE (0x204). There is no requirement to use these standard values any Baud rate within the supported range (see Table 9.8) can be set in the Persistent Store Key according to the following formula.

$$\text{Baud Rate} = \frac{\text{PSKEY\_UART\_BAUD\_RATE}}{0.004096}$$

Baud Rate	Persistent Store Value		Error
	Hex	Dec	
1200	0x0005	5	1.73%
2400	0x000a	10	1.73%
4800	0x0014	20	1.73%
9600	0x0027	39	-0.82%
19200	0x004f	79	0.45%
38400	0x009d	157	-0.18%
57600	0x00ec	236	0.03%
76800	0x013b	315	0.14%
115200	0x01d8	472	0.03%
230400	0x03b0	944	0.03%
460800	0x075f	1887	-0.02%
921600	0x0ebf	3775	0.00%
1382400	0x161e	5662	-0.01%

Table 7: Standard Baud Rates

10 USB INTERFACE

WRAP THOR 2022-1 USB devices contain a full-speed (12Mbits/s) USB interface, capable of driving a USB cable directly. No external USB transceiver is required. The device operates as a USB peripheral, responding to requests from a master host controller such as a PC. Both the OHCI and the UHCI standards are supported. The set of USB endpoints implemented behave as specified in the USB section of the Bluetooth specification v1.1 and v1.2 part H2.

As USB is a master-slave orientated system, WRAP THOR 2022-1 only supports USB slave operation.

10.1 USB DATA CONNECTIONS

The USB data lines emerge as pins USB_D+ and USB_D- on the package. These terminals are connected to the internal USB I/O buffers of WRAP THOR 2022-1 and therefore have a low output impedance. To match the connection to the characteristic impedance of the USB cable, series resistors must be connected to both
USB_D+ and USB_D-.

10.2 USB PULL-UP RESISTOR

WRAP THOR 2022-1 features an internal USB pull-up resistor. This pulls the USB_D+ pin weakly high when WRAP THOR 2022-1 is ready to enumerate. It signals to the PC that it is a full-speed (12Mbit/s) USB device.

The USB internal pull-up is implemented as a current source, and is compliant with 7.1.5 of the USB specification v1.1. The internal pull-up pulls USB D+ high to at least 2.8V when loaded with a 15Kohm-5% pull-down resistor (in the hub/host) when VDD_PADS=3.1V). This presents a thevenin resistance to the host of at least 900 ohms. Alternatively, an external 1.5Kohm pull-up resistor can be placed between a PIO line and D+ on the USB cable. The firmware must be alerted to which mode is used by setting Persistent Store Key PSKEY_USB_PIO_PULLUP (0x2d0) appropriately. The default setting uses the internal pull_up resistor.

10.3 POWER SUPPLY

The minimum output high voltage for USB data lines is 2.8V. To safely meet the USB specification, the voltage on terminals must be an absolute minimum of 3.1V. CSR recommends 3.3V for optimal USB signal quality.

10.4 SELF-POWERED MODE

In self-powered mode, the circuit is powered from its own power supply and not from the VBUS (5V) line of the USB cable. It draws only a small leakage current (below 0.5mA) from VBUS on the USB cable. This is the easier mode for which to design for, as the design is not limited by the power that can be drawn from the USB hub or root port. However, it requires that VBUS be connected to WRAP THOR 2022-1 via a resistor network (Rvb1 and Rvb2), so WRAP THOR 2022-1 can detect when VBUS is powered up. WRAP THOR 2022-1 will not pull USB_D+ high when VBUS is off.
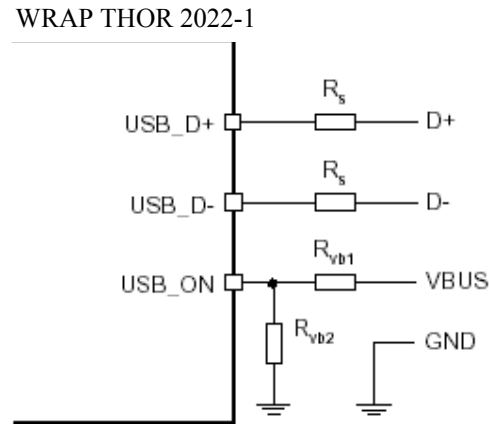
Figure 8: Connections to WRAP THOR 2022-1 for Self-Powered Mode

The terminal marked USB_ON can be any free PIO pin. The PIO pin selected must be registered by setting PSKEY_USB_PIO_VBUS (0x2d1) to the corresponding pin number.

10.5 BUS-POWERED MODE

In bus-powered mode the application circuit draws its current from the 5V VBUS supply on the USB cable.
WRAP THOR 2022-1 negotiates with the PC during the USB enumeration stage about power consumption.

For Class 2 Bluetooth applications, CSR recommends that the regulator used to derive 3.3V from VBUS is rated at 100mA average current and should be able to handle peaks of 120mA without foldback or limiting. In bus-powered mode, WRAP THOR 2022-1 requests 100mA during enumeration.

For Class 1 Bluetooth applications, the USB power descriptor should be altered to reflect the amount of power required. This is accomplished by setting the Persistent Store Key PSKEY_USB_MAX_POWER (0x2c6). This is higher than for a Class 2 application due to the extra current drawn by the Transmit RF PA.

When selecting a regulator, be aware that VBUS may go as low as 4.4V. The inrush current (when charging reservoir and supply decoupling capacitors) is limited by the USB specification (see USB 1.1 specification, section 7.2.4.1). Some applications may require soft-start circuitry to limit inrush current if more than 10pF is present between VBUS and GND.

The 5V VBUS line emerging from a PC is often electrically noisy. As well as regulation down to 3.3V and 1.8V, applications should include careful filtering of the 5V line to attenuate noise that is above the voltage regulator's bandwidth. Excessive noise on the 1.8V supply to the analogue supply pins of WRAP THOR 2022-1 will result in reduced receive sensitivity and a distorted transmit signal.

10.6 SUSPEND CURRENT

USB devices that run off VBUS must be able to enter a suspended state, whereby they consume less that 0.5mA from VBUS. The voltage regulator circuit itself should draw only a small quiescent current (typically less than 100 mA) to ensure adherence to the suspend-current requirement of the

USB specification. This is not normally a problem with modern regulators. Ensure that external LEDs and/or amplifiers can be turned off by WRAP THOR 2022-1. The entire circuit must be able to enter the suspend mode.
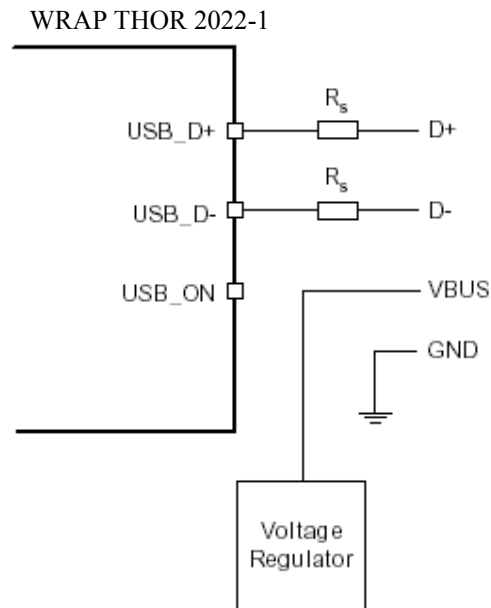
WRAP THOR 2022-1

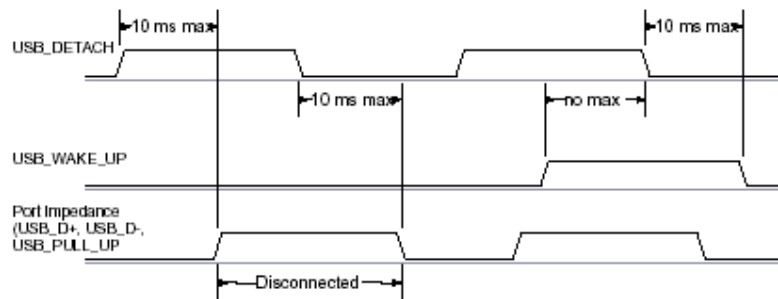**Figure 9: Connections to WRAP THOR 2022-1 for Bus-Powered Mode**

Figure 10: USB_DETACH and USB_WAKE_UP Signal

10.7 DETACH AND WAKE_UP SIGNALLING

WRAP THOR 2022-1 can provide out-of-band signalling to a host controller by using the dedicated control lines called 'USB_DETACH' and 'USB_WAKE_UP'. These are outside the USB specification (no wires exist for them inside the USB cable), but can be useful when embedding WRAP THOR 2022-1 into a circuit where no external USB is visible to the user. Both control lines are shared with PIO pins and can be assigned to any PIO pin by setting the Persistent Store Keys PSKEY_USB_PIO_DETACH (0x2ce) and PSKEY_USB_PIO_WAKEUP (0x2cf) to the selected PIO number).

USB_DETACH, is an input which, when asserted high, causes WRAP THOR 2022-1 to put USB_D- and USB_D+ in a high-impedance state and to 1.5kY pull-up resistor on USB_D+. This detaches the device from the bus and is logically equivalent to unplugging the device. When USB_DETACH is taken low, WRAP THOR 2022-1 will connect back to USB and await enumeration by the USB host.

USB_WAKE_UP, is an active high output (used only when USB_DETACH is active) to wake up the host and allow USB communication to recommence. It replaces the function of the software USB WAKE_UP message (which runs over the USB cable proper), and cannot be sent while WRAP THOR 2022-1 is effectively disconnected from the bus.

10.8 USB DRIVER

A USB Bluetooth device driver is required to provide a software interface between WRAP THOR 2022-1 and Bluetooth applications running on the host.

10.9 USB 1.1 COMPLIANCE

WRAP THOR 2022-1 is qualified to the USB specification v1.1, details of which are available from http://www.usb.org. The specification contains valuable information on aspects such as PCB track impedance, supply inrush current and product labeling.

Although WRAP THOR 2022-1 meets the USB specification, CSR cannot guarantee that an application circuit designed around the chip is USB compliant. The choice of application circuit, component choice and PCB layout all affect USB signal quality and electrical characteristics. The information in this document is intended as a guide and should be read in association with the USB specification, with particular attention being given to Chapter 7. Independent USB qualification must be sought before an application is deemed USB compliant and can bear the USB logo. Such qualification can be obtained from a USB plugfest or from an independent USB test house.

Terminals USB_D+ and USB_D- adhere to the USB specification 1.1 (Chapter 7) electrical requirements.
For ac and dc specifications for terminals USB_DETACH, USB_WAKE_UP, USB_PULL_UP and USB_ON, refer to section 9.10 PIO specification.

10.10 USB 2.0 COMPATIBILITY

WRAP THOR 2022-1 is compatible with USB specification 2.0 masters; under these circumstances the two ends agree the mutually acceptable rate of 12Mbits/s according to the USB 2.0 specification.

11 SERIAL PERIPHERAL INTERFACE

WRAP THOR 2022-1 uses 16-bit data and 16-bit address during serial peripheral interface transactions. Such transactions will occur whether the internal processor is running or is stopped. This section details the
considerations required when interfacing to WRAP THOR 2022-1 via the four dedicated serial peripheral interface terminals. Data may be written or read one word at a time or the auto-increment feature may be used to access blocks.

11.1 INSTRUCTION CYCLE

Before WRAP THOR 2022-1 can be addressed, SPI_CSB must be taken low (SPI_CSB = 0).

Data on SPI_MOSI is then clocked into WRAP THOR 2022-1 on the rising edge of the clock line SPI_CLK.

When reading, WRAP THOR 2022-1 will reply to the Master on MISO (the data being valid on the falling edge of the SPI_CLK). The Master provides the clocking.

11.2 SINGLE-CYCLE OPERATION

After a serial peripheral interface transaction completes, the Master toggles SPI_CLK with SPI_CSB high to
initiate a new transaction. SPI_CSB must be high for at least two SPI_CLK cycles.

11.3 MULTI-SLAVE OPERATION

WRAP THOR 2022-1 should not be connected in a multi-slave arrangement by simple parallel connection of slave MISO lines. When WRAP THOR 2022-1 is deselected (SPI_CSB = 1), the SPI_MISO line does not float. Instead, WRAP THOR 2022-1 outputs 0 if the processor is running or 1 if it is stopped.

11.4 WRITING TO WRAP THOR 2022-1

To write to WRAP THOR 2022-1, the 8-bit write command (00000010) is sent first (C[7:0]) followed by a 16-bit address (A[15:0]). After that, 16-bits of data (D[15:0]) are sent.

11.5 AUTO-INCREMENT OPERATION

Sending a command word and the address of a register every time it is to be read or written can be a significant overhead, especially when large amounts of data are to be transferred. To overcome this WRAP THOR 2022-1 offers increased data transfer efficiency via an auto-increment operation. During operation, WRAP THOR 2022-1 increments the address automatically. Only the data is transmitted or received over the serial peripheral interface. WRAP THOR 2022-1 keeps the previous command word.

Auto-increment mode is invoked by keeping SPI_CSB low after the last bit of a read or write operation, while providing an extra 16 clock cycles. If the previous command was a write, continuous 16-bit words of data may then be written to the WRAP THOR 2022-1 without the need to send the address or command word. Similarly, if the previous command was a read, then data may be read. T[15:0] are not returned after the first read, just D[15:0].
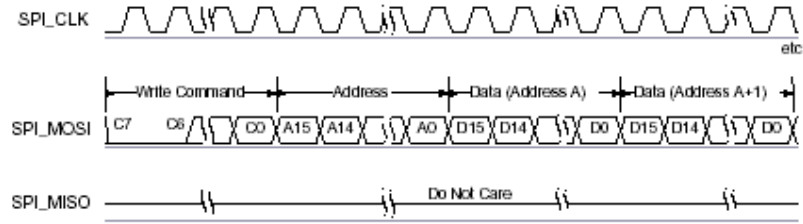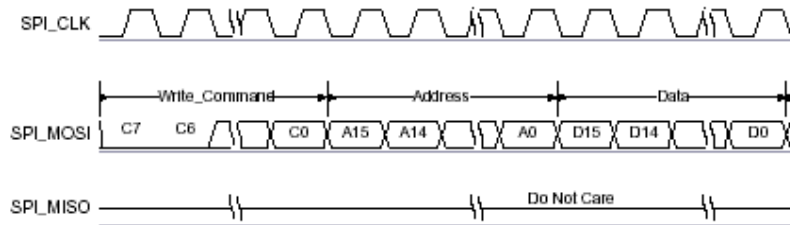
Figure 11: Example Auto-Increment Operation
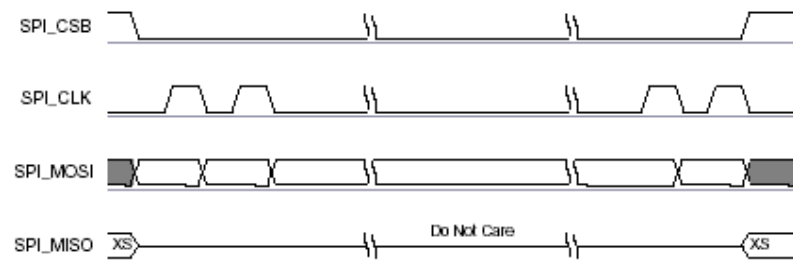

Figure 12: Write Operation A

Figure 13: Write Operation B

11.6 READING FROM WRAP THOR 2022-1

Reading from WRAP THOR 2022-1 is similar to writing to it. An 8-bit read command (00000011) is sent first, followed by the address of the location to be read. WRAP THOR 2022-1 then outputs the 16-bit contents of the location on MISO with a check-word during T[15:0] and data during bits D[15:0].

The check-word is composed of {command, address [15:8]}. The check-word may be used to confirm a read operation to a memory location. This overcomes the problems encountered with typical serial peripheral interface slaves, whereby it is impossible to determine whether the data returned by a read operation is valid data or the result of the slave device not responding.
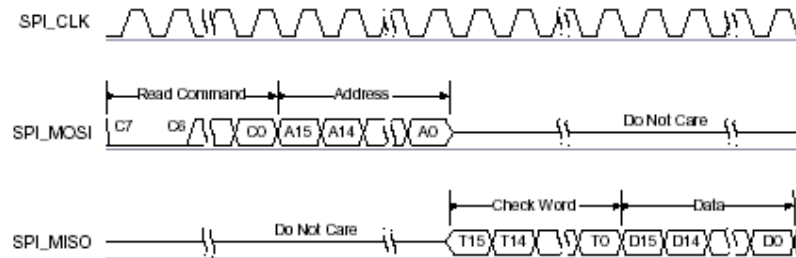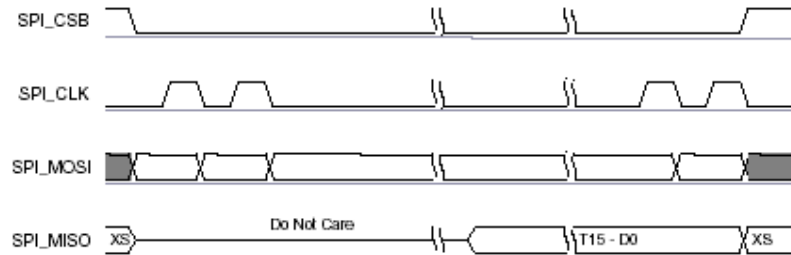
Figure 14: Read Operation A

Figure 15: Read Operation B

12 PCM

Pulse Code Modulation (PCM) is the standard method used to digitise human voice patterns for transmission over digital communication channels. Through its PCM interface, WRAP THOR 2022-1 has hardware support for continual transmission and reception of PCM data, thus reducing processor overhead for wireless headset applications. WRAP THOR 2022-1 offers a bi-directional digital audio interface that routes directly into the baseband layer of the on-chip firmware. It does not pass through the HCI protocol layer.

Hardware on WRAP THOR 2022-1 allows the data to be sent to and received from a SCO connection.

Up to three SCO connections can be supported by the PCM interface at any one time.(1)

WRAP THOR 2022-1 can operate as the PCM interface Master generating an output clock of 128, 256 or 512kHz. When configured as PCM interface slave it can operate with an input clock up to 2048kHz. WRAP THOR 2022-1 is compatible with a variety of clock formats, including Long Frame Sync, Short Frame Sync and GCI timing environments.

It supports 13 or 16-bit linear, 8-bit o-law or A-law companded sample formats at 8ksamples/s and can receive and transmit on any selection of three of the first four slots following PCM_SYNC. The PCM configuration options are enabled by setting the Persistent Store Key PS KEY_PCM_CONFIG (0x1b3).

WRAP THOR 2022-1 interfaces directly to PCM audio devices includes the following:
. Qualcomm MSM 3000 series and MSM 5000 series CDMA baseband devices
. OKI MSM7705 four channel A-law and o-law CODEC
. Motorola MC145481 8-bit A-law and"o-law CODEC
. Motorola MC145483 13-bit linear CODEC
WRAP THOR 2022-1 is also compatible with the Motorola SSITM interface

Note:
(1) Subject to firmware support, contact CSR for current status.

12.1 PCM INTERFACE MASTER/SLAVE

When configured as the Master of the PCM interface, WRAP THOR 2022-1 generates PCM_CLK and
PCM_SYNC.

WRAP THOR 2022-1

PCM_OUT

PCM_IN

PCM_CLK   128/256/512kHz
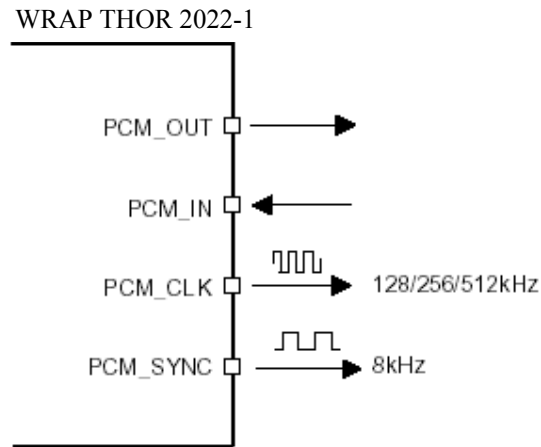
PCM_SYNC   8kHz

Figure 16: WRAP THOR 2022-1 as PCM Interface Master

When configured as the Slave of the PCM interface, WRAP THOR 2022-1 accepts PCM_CLK rates up to
2048kHz.

WRAP THOR 2022-1

PCM_OUT

PCM_IN

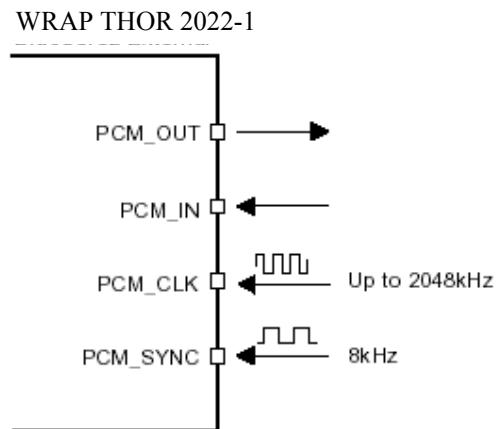PCM_CLK   Up to 2048kHz

PCM_SYNC   8kHz

Figure 17: WRAP THOR 2022-1 as PCM Interface Slave

Note:
A minimum of 3 clock cycles needs to be applied before a SCO is established

Long Frame Sync
Long Frame Sync is the name given to a clocking format that controls the transfer of PCM data words or
samples. In Long Frame Sync, the rising edge of PCM_SYNC indicates the start of the PCM word. When
WRAP THOR 2022-1 is configured as PCM Master, generating PCM_SYNC and PCM_CLK, then
PCM_SYNC is 8-bits long. When WRAP THOR 2022-1 is configured as PCM Slave, PCM_SYNC
may be from two consecutive falling edges of PCM_CLK to half the PCM_SYNC rate (i.e., 62.5os)
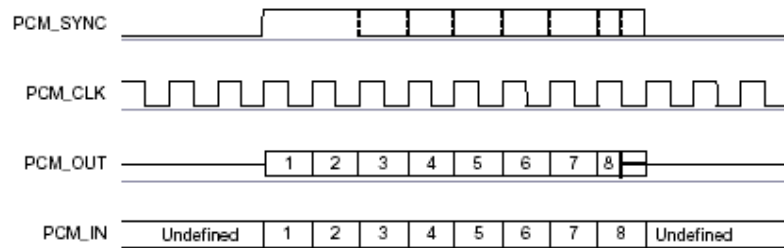long.

Figure 18: Long Frame Sync (Shown with 8-bit Companded Sample)

WRAP THOR 2022-1 samples PCM_IN on the falling edge of PCM_CLK and transmits
PCM_OUT on the rising edge. PCM_OUT may be configured to be high impedance on the falling
edge of PCM_CLK in the LSB position or on the rising edge.

12.2 SHORT FRAME SYNC

In Short Frame Sync the falling edge of PCM_SYNC indicates the start of the PCM word.
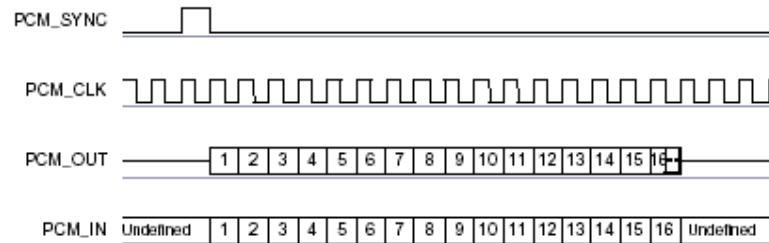PCM_SYNC is always one clock cycle long.

Figure 19: Short Frame Sync (Shown with 16-bit Sample)

As with Long Frame Sync, WRAP THOR 2022-1 samples PCM_IN on the falling edge of PCM_CLK and transmits PCM_OUT on the rising edge. PCM_OUT may be configured to be high impedance on the falling edge of PCM_CLK in the LSB position or on the rising edge.

12.3 MULTI-SLOT OPERATION

More than one SCO connection over the PCM interface is supported using multiple slots. Up to three SCO
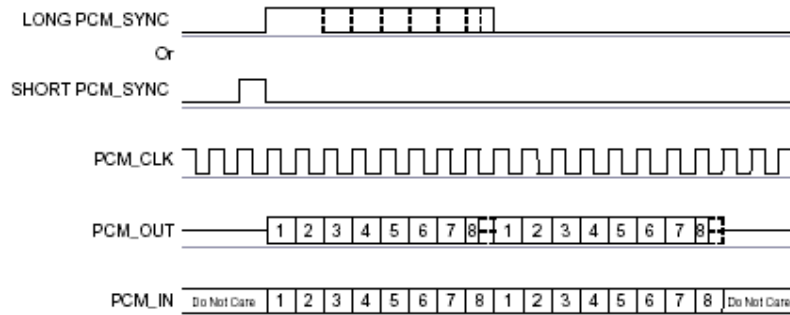connections can be carried over any of the first four slots.

Figure 20: Multi-slot Operation with Two Slots and 8-bit Companded Samples

12.4 GCI INTERFACE

WRAP THOR 2022-1 is compatible with the General Circuit Interface, a standard synchronous 2B+D ISDN timing interface. The two 64Kbps B channels can be accessed when this mode is configured. In the GCI interface two clock cycles are required for each bit of the voice sample. The voice sample format is 8-bit companded. As for the standard PCM interface up to 3 SCO connections can be carried over the first four slots.
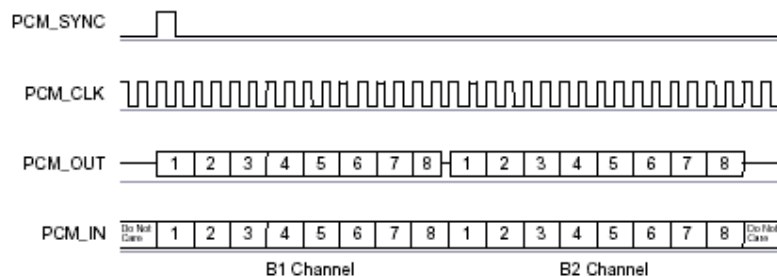

Figure 21: CGI Interface

The start of frame is indicated by PCM_SYNC and runs at 8kHz. With WRAP THOR 2022-1 in Slave mode, the frequency of PCM_CLK can be up to 4.096MHz. In order to configure the PCM interface to work in GCI mode it is necessary to set GCI_MODE bit in PSKEY_PCM_CONFIG32. The SAMPLE_FORMAT bits should be set to 0x0b01 to allow for the double clocking of each.

12.5 SLOTS AND SAMPLE FORMATS

WRAP THOR 2022-1 can receive and transmit on any selection of the first four slots following each sync pulse. Slot durations can be either 8 or 16 clock cycles. Durations of 8 clock cycles may only be used with 8-bit sample formats. Durations of 16 clocks may be used with 8, 13 or 16-bit sample formats.

WRAP THOR 2022-1 supports 13-bit linear, 16-bit linear and 8-bit o-law or A-law sample formats. The sample rate is 8ksamples/s. The bit order may be little or big endian. When 16-bit slots are used, the 3 or 8 unused bits in each slot may be filled with sign extension, padded with zeros or a programmable 3-bit audio attenuation compatible with some Motorola CODECs.
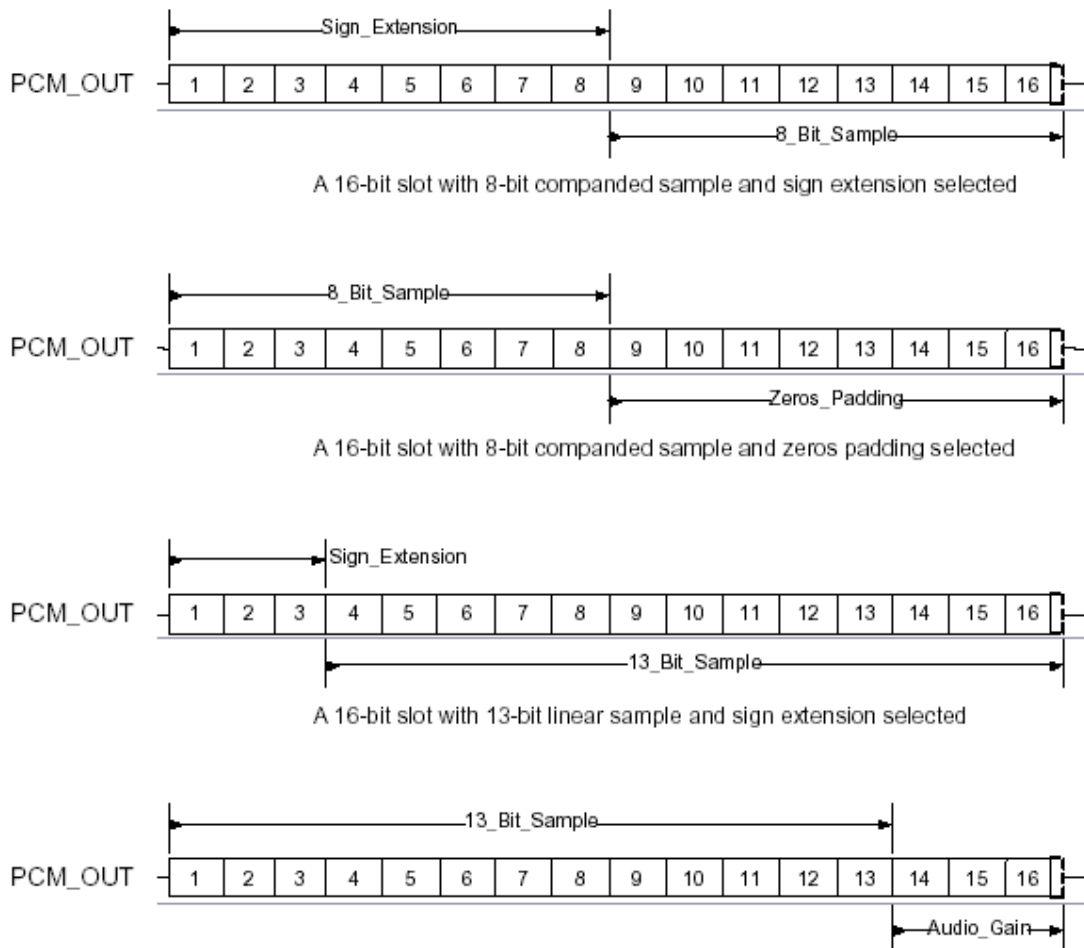

Figure 22: 16-bit Slot Length and Sample Formats

12.6 ADDITIONAL FEATURES

WRAP THOR 2022-1 has a mute facility that forces PCM_OUT to be 0. In Master mode, PCM_SYNC may also be forced to 0 while keeping PCM_CLK running (which some CODECS use to control power-down).

12.7 PCM TIMING INFORMATION

PCM Master Timing

Symbol	Parameter	Min[2]	Typ	Max[2]	Unit
fmclk	PCM_CLK frequency	-	128 256 512	-	kHz
-	PCM_SYNC frequency	-	8		kHz
tmclkh [1]	PCM_CLK high	980	-	-	ns
tmclkl [1]	PCM_CLK low	730	-		ns
tdmclksynch	Delay time from PCM_CLK high to PCM_SYNC high	-	-	20	ns
tdmclkpout	Delay time from PCM_CLK high to valid PCM_OUT	-	-	20	ns
tdmclklsyncl	Delay time from PCM_CLK low to PCM_SYNC low (Long Frame Sync only)	-	-	20	ns
tdmclkhsyncl	Delay time from PCM_CLK high to PCM_SYNC low	-	-	20	ns
tdmclklpoutz	Delay time from PCM_CLK low to PCM_OUT high impedance	-	-	20	ns
tdmclkhpoutz	Delay time from PCM_CLK high to PCM_OUT high impedance	-	-	20	ns
tsupinclkl	Set-up time for PCM_IN valid to PCM_CLK low	30	-	-	ns
thpinclkl	Hold time for PCM_CLK low to PCM_IN invalid	30	-	-	ns
tr	Edge rise time (C$_l$ = 50 pf, 10-90 %)	-	-	15	ns
tf	Edge fall time (C$_l$ = 50 pf, 10-90 %)	-	-	15	ns

Note:
(1) Assumes normal system clock operation. Figures will vary during low power modes, when system clock
speeds are reduced.
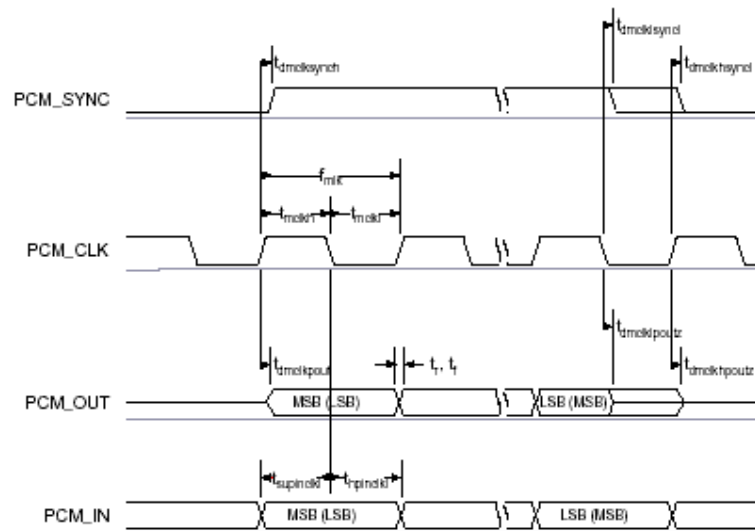(2) Valid for temperatures between -40°C and +105°C

Figure 23: PCM Master Timing

PCM Slave Timing

Symbol	Parameter	Min[1]	Typ	Max[1]	Unit
fsclk	PCM clock frequency (Slave mode: input)	64	-	2048	kHz
fsclk	PCM clock frequency (GCI mode)	128	-	4096	kHz
tsclkl	PCM_CLK low time	200	-	-	ns
tsclkh	PCM_CLK high time	200	-	-	ns
thsclksynch	Hold time from PCM_CLK low to PCM_SYNC high	30	-	-	ns
tsusclksynch	Set-up time for PCM_SYNC high to PCM_CLK low	30	-	-	ns
tdpout	Delay time from PCM_SYNC or PCM_CLK whichever is later, to valid PCM_OUT data (Long Frame Sync only)	-	-	20	ns
tdsclkhpout	Delay time from CLK high to PCM_OUT valid data	-	-	20	ns
tdpoutz	Delay time from PCM_SYNC or PCM_CLK low, whichever is later, to PCM_OUT data line high impedance	-	-	20	ns
tsupinsclkl	Set-up time for PCM_IN valid to CLK low	30	-	-	ns
thpinsclkl	Hold time for PCM_CLK low to PCM_IN invalid	30	-		ns
tr	Edge rise time (C$_l$ = 50 pF, 10-90 %)	-	-	15	ns
Tf	Edge fall time (C$_l$ = 50 pF, 10-90 %)	-	-	15	ns

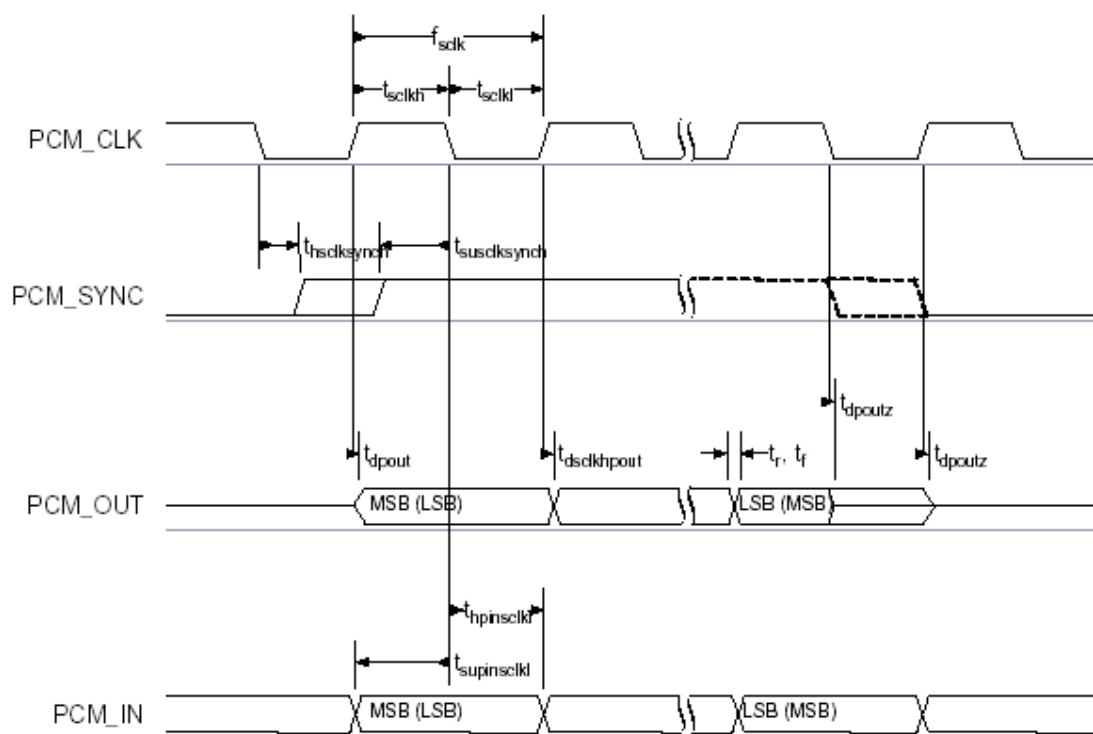(1) Valid for temperatures between -40°C and +105°C

Figure 24: PCM Slave Timing

13 PIO

The Parallel Input Output (PIO) Port is a general-purpose I/O interface to WRAP THOR 2022-1. The port consists of six programmable, bi-directional I/O lines, PIO[2:7].

Programmable I/O lines can be accessed either via an embedded application running on WRAP THOR 2022-1 or via private channel or manufacturer-specific HCI commands.

PIO[2]/USB_PULL_UP (1)
This is a multifunction terminal. The function depends on whether WRAP THOR 2022-1 is a USB or UART capable version. On UART versions, this terminal is a programmable I/O. On USB versions, it can drive a pull-up resistor on USB_D+. For application using external RAM this terminal may be programmed for chip select.

PIO[3]/USB_WAKE_UP (1)
This is a multifunction terminal. On UART versions of WRAP THOR 2022-1 this terminal is a programmable I/O. On USB versions, its function is selected by setting the Persistent Store Key PSKEY_USB_PIO_WAKEUP (0x2cf) either as a programmable I/O or as a USB_WAKE_UP function.

PIO[4]/USB_ON (1)
This is a multifunction terminal. On UART versions of WRAP THOR 2022-1 this terminal is a programmable I/O. On USB versions, the USB_ON function is also selectable (see USB Interface section 9.6).

PIO[5]/USB_DETACH (1)
This is a multifunction terminal. On UART versions of WRAP THOR 2022-1 this terminal is a programmable I/O. On USB versions, the USB_DETACH function is also selectable (see USB Interface section 9.6).

PIO[6]/CLK_REQ
This is multifunction terminal, its function is determined by Persistent Store Keys. Using PSKEY_CLOCK_REQUEST_ENABLE, (0x246) this terminal can be configured to be low when WRAP THOR 2022-1 is in deep sleep and high when a clock is required. The clock must be supplied within 4ms of the rising edge of PIO[6] to avoid losing timing accuracy in certain Bluetooth operating modes.

PIO[7]
Programmable I/O terminal.

Note:
(1) USB functions can be software mapped to any PIO terminal.

14 APPROVAL INFORMATION

Installation of the module

The module is intended only for installation inside equipment.

Bluetooth qualification

The Board-to-board module is *Bluetooth* qualified and listed as an end product. If not modified in any way, it is a complete *Bluetooth* entity, containing both functionality as well as the whole RF-part including the antenna.

This means: If the module is used without modification of any kind, it does not need any *Bluetooth* approval work.

If changes are made in the parameter set, added profiles or in the antenna design, it is required to be submitted to a BQB (*Bluetooth* Qualification Body) for evaluation on what needs to be tested.

CE marking

The B2B module carries the CE marking. The module has been submitted to the Notified Body No. 0682

FCC statement

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.

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Bluegiga Technologies may void the user's authority to operate the equipment.

FCC ID: QOQWRAO2022-1-B2B

Industry Canada

The Canadian registration number is:

IC: 5123A-20221B2B

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