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WT41-E

DATA SHEET

Tuesday, 08 October 2013

Version 1.4

VERSION HISTORY

Version	Comment
1.0	Release
1.1	Power vs supply voltage figure added
1.2	Typo corrections
1.3	Certification information updated
1.31	Absolute maximum supply voltage 3.7V
1.32	NCC certification info added. HCI30 removed from the ordering information list.
1.33	NCC labeling info added in Chinese
1.34	Duplicate spurious emissions table removed
1.4	MSL information added

TABLE OF CONTENTS

DESCRIPTION

WT41-E is a long range class 1, Bluetooth® 2.1 + EDR module. WT41-E is a highly integrated and sophisticated Bluetooth® module, containing all the necessary elements from Bluetooth® radio and a fully implemented protocol stack. Therefore WT41-E provides an ideal solution for developers who want to integrate Bluetooth® wireless technology into their design with limited knowledge of Bluetooth® and RF technologies. WT41-E is optimized for long range applications and since it contains a RF power amplifier, low noise amplifier and a u.fi connector for an external 2 dBi dipole antenna. With 115 dB radio budget WT41-E can reach over 1 km range in line off sight.

By default WT41-E module is equipped with powerful and easy-to-use iWRAP firmware. iWRAP enables users to access Bluetooth® functionality with simple ASCII commands delivered to the module over serial interface - it's just like a Bluetooth® modem.

APPLICATIONS:

- Hand held terminals
- Industrial devices
- Point-of-Sale systems
- PCs
- Personal Digital Assistants (PDAs)
- Computer Accessories
- Access Points
- Automotive Diagnostics Units

FEATURES:

- Fully Qualified Bluetooth v2.1 + EDR end product
- CE qualified
- Modular certification for FCC, IC and KCC
- MIC Japan compatibility fully tested with ARIB STD-T66
- TX power : 19 dBm
- RX sensitivity : -92 dBm
- Higly efficient chip antenna, U.FL connector or RF pin
- Class 1, range up to 800 meters
- Industrial temperature range from -40°C to +85°C
- RoHS Compliant
- USB interface (USB 2.0 compatible)
- UART with bypass mode
- 6 x GPIO
- 1 x 8-bit AIO
- Support for 802.11 Coexistence
- Integrated iWRAP™ Bluetooth stack or HCI firmware

1 Ordering Information

WT41-E-HCI

Firmware

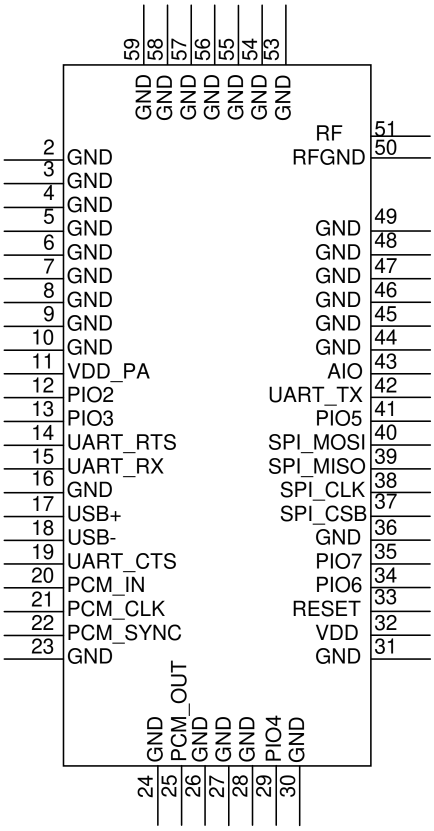
HCI	=	HCI firmware (Bluetooth 2.0 + EDR)
HCI21	=	HCI firmware (Bluetooth 2.1 + EDR)
AI	=	iWRAP 2.2.0
AI3	=	iWRAP 3.0.0
AI4	=	iWRAP 4.0.0
C	=	Custom*

HW version

E	=	u.fl connector

Product series

2 Pinout and Terminal Description



Pins 1 and 52 (GND) are not connected and have been removed

Figure 1: WT41-E pin out

	PIN NUMBER	PAD TYPE	DESCRIPTION
NC	1, 52	Not connected	Pins 1 and 52 (GND) have been removed from the module.
RESET	33	Input, weak internal pull-up	Active low reset. Keep low for >5 ms to cause a reset
GND	2-10, 16, 23,24,26-28, 30, 31,36,44-49, 53-59	GND	GND
RF	51	RF output	RF output for WT41-N. For WT41-A and WT41-E this pin is not connected
RFGND	50	GND	RF ground. Connected to GND internally to the module.
VDD_PA	11	Supply voltage	Supply voltage for the RF power amplifier and the low noise amplifier of the module
VDD	32	Supply voltage	Supply voltage for BC4 and the flash memory

Table 1: Supply and RF Terminal Descriptions

PIO PORT	PIN NUMBER	PAD TYPE	DESCRIPTION
PIO[2]	12	Bi-directional, programmamble strength internal pull-down/pull-up	Programmamble input/output line
PIO[3]	13	Bi-directional, programmamble strength internal pull-down/pull-up	Programmamble input/output line
PIO[4]	29	Bi-directional, programmamble strength internal pull-down/pull-up	Programmamble input/output line
PIO[5]	41	Bi-directional, programmamble strength internal pull-down/pull-up	Programmamble input/output line
PIO[6]	34	Bi-directional, programmamble strength internal pull-down/pull-up	Programmamble input/output line
PIO[7]	35	Bi-directional, programmamble strength internal pull-down/pull-up	Programmamble input/output line
AIO[1]	43	Bi-directional	Programmamble analog input/output line

Table 2: GPIO Terminal Descriptions

PCM INTERFACE	PIN NUMBER	PAD TYPE	DESCRIPTION
PCM_OUT	25	CMOS output, tri-state, weak internal pull-down	Synchronous data output
PCM_IN	20	CMOS input, weak internal pull-down	Synchronous data input
PCM_SYNC	22	Bi-directional, weak internal pull-down	Synchronous data sync
PCM_CLK	21	Bi-directional, weak internal pull-down	Synchronous data clock

Table 3: PCM Terminal Descriptions

UART Interfaces	PIN NUMBER	PAD TYPE	DESCRIPTION
UART_TX	42	CMOS output, tri-state, with weak internal pull-up	UART data output, active high
UART_RTS#	14	CMOS output, tri-state, with weak internal pull-up	UART request to send, active low
UART_RX	15	CMOS input, tri-state, with weak internal pull-down	UART data input, active high
UART_CTS#	19	CMOS input, tri-state, with weak internal pull-down	UART clear to send, active low

Table 4: UART Terminal Descriptions

USB Interfaces	PIN NUMBER	PAD TYPE	DESCRIPTION
USB+	17	Bidirectional	USB data plus with selectable internal 1.5k pull-up resistor
USB-	18	Bidirectional	USB data minus

Table 5: USB Terminal Descriptions

SPI INTERFACE	PIN NUMBER	PAD TYPE	DESCRIPTION
SPI_MOSI	40	CMOS input with weak internal pull-down	SPI data input
SPI_CS#	37	CMOS input with weak internal pull-up	Chip select for Serial Peripheral Interface, active low
SPI_CLK	38	CMOS input with weak internal pull-down	SPI clock
SPI_MISO	39	CMOS output, tristate, with weak internal pull down	SPI data output

Table 6: Terminal Descriptions

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

Rating	Min	Max	Unit
Storage Temperature	-40	85	°C
VDD_PA, VDD	-0.4	3.7	V
Other Terminal Voltages	VSS-0.4	VDD+0.4	V

Table 7: Absolute Maximum Ratings

3.2 Recommended Operating Conditions

Rating	Min	Max	Unit
Operating Temperature Range	-40	85	°C
VDD_PA, VDD *)	3.0	3.6	V

*) VDD_PA has an effect on the RF output power.

Table 8: Recommended Operating Conditions

3.3 PIO Current Sink and Source Capability

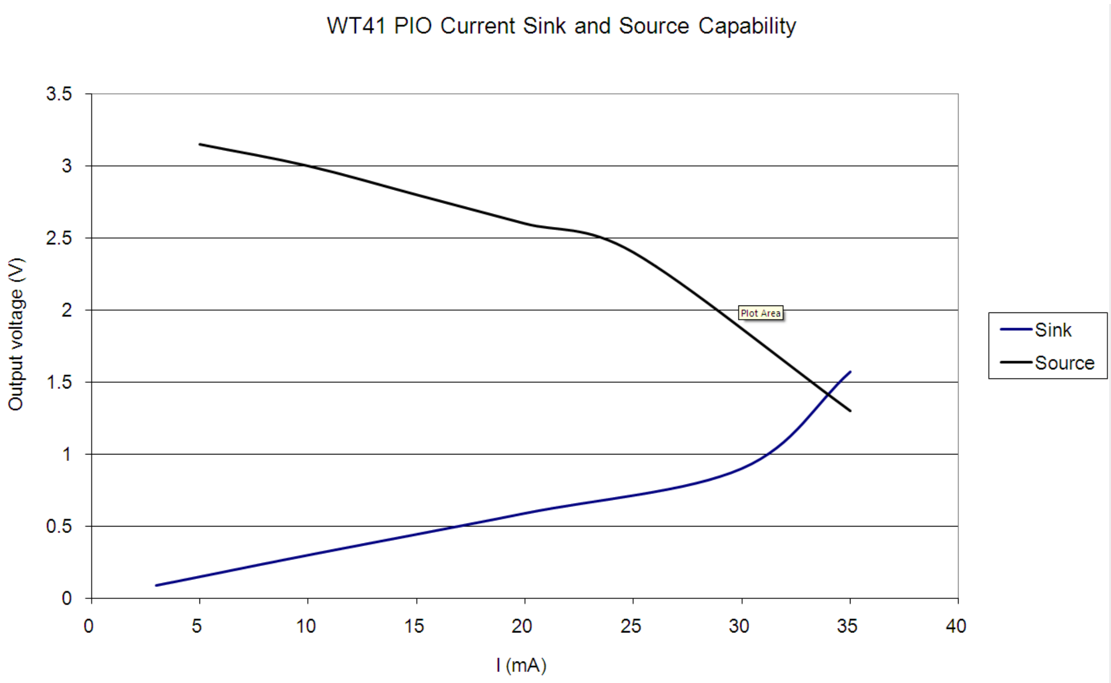


Figure 2: WT41-E PIO Current Drive Capability

3.4 Transmitter Performance For BDR

Antenna gain 2.3dBi taken into account

RF Characetristics, VDD = 3.3V @ room temperature unless otherwise specified		Min	Typ	Max	Bluetooth Specification	Unit
maximum RF Transmit Power		17	19	20	20	dBm
RF power variation over temperature range				1	-	dB
RF power variation over supply voltage range (*				2	-	dB
RF power variation over BT band		0.1	0.5	2	-	dB
RF power control range (*		-10		19		
20dB band width for modulated carrier			942		1000	kHz
ACP (1	$F = F_0 \pm 2MHz$			-20	-20	
	$F = F_0 \pm 3MHz$			-40	-40	
	$F = F_0 > 3MHz$			-40	-40	
Drift rate			7		+/-25	kHz
ΔF_{1avg}			169		140<175	kHz
$\Delta F1_{max}$			161		140<175	kHz
$\Delta F_{2avg} / \Delta F_{1avg}$			1.1		>=0.8	

Table 9: Transmitter performance for BDR

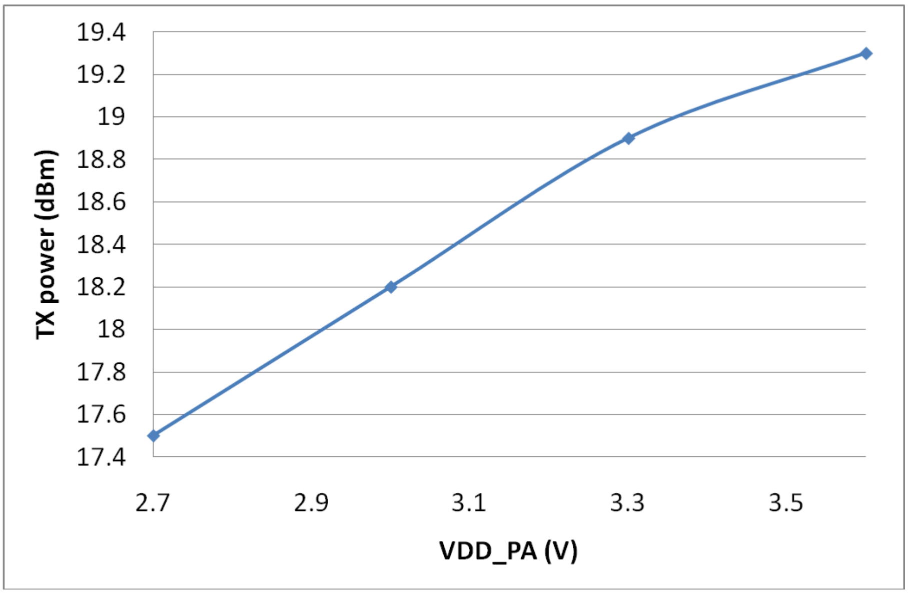


Figure 3: Typical TX power as a function of VDD_PA

3.4.1 Radiated Spurious Emissions

Measured from WT41-E evaluation board

Standard	Band / Frequency	Min (AVG / PEAK)	Typ (AVG / PEAK)	Max (AVG / PEAK)	Limit by the Standard (AVG / PEAK)	Unit
FCC part 15 transmitter spurious emissions	2nd harmonic		52	54/58	54 / 74	dBuV/m
	3rd harmonic		51	54/58	54 / 74	dBuV/m
	Band edge 2390MHz		50/60	52/63	54 / 74	dBuV/m
	Band edge 2483.5MHz		52/65	54/67	54 / 74	dBuV/m
	Band edge 2400MHz (conducted)		-50		-20	dBc
	Band edge 2483.5MHz (conducted)		-58		-20	dBc
ETSI EN 300 328 transmitter spurious emissions	Band edge 2400MHz		-39	-36	-30	dBm
	2nd harmonic		-41		-30	dBm
	3rd harmonic		-41		-30	dBm
ETSI EN 300 328 receiver spurious	(2400 - 2479) MHz		-		-47	dBm
	(1600 - 1653) MHz		-52		-47	dBm

Table 10: Radiated spurious emission for WT41-E

3.5 Receiver Performance

Antenna gain not taken into account

RF characteristis, VDD = 3.3V, room temperature (**	Packet type	Min	Typ	Max	Bluetooth Specification	Unit
Sensitivity for 0.1% BER	DH1		-92		-70	dBm
	DH3		-92			dBm
	DH5		-91			dBm
	2-DH1		-94			dBm
	2-DH3		-93			dBm
	2-DH5		-93			dBm
	3-DH1		-88			dBm
	3-DH3		-85			dBm
	3-DH5		-84			dBm
Sensitivity variation over temperature range			TBD			

Table 11: Receiver sensitivity

3.6 Current Consumption

Opearation mode	Peak (mA)	AVG (mA)
Stand-by, page mode 0	-	2.1
TX 3DH5	100.5	77.6
TX 2DH5	99.3	77.6
TX 3DH3	98.1	71.1
TX 2DH3	98.1	71.2
TX 2DH1	98.7	51.6
TX DH5	164	120
TX DH1	166	67.3
RX	56.8	52.6
Deep sleep		0.36
Inquiry	169.3	58.7

Table 12: Current consumption

3.7 Antenna Specification

WT41-E is designed and qualified to be used with a 2.14 dBi dipole antenna. Any dipole antenna with the same or less gain can be used with WT41-E as far as the technical information of the antenna is provided for Bluegiga for approval. Any antenna approved by Bluegiga can be used with WT41-E without additional applications to FCC or IC. Table 19 on page 42 lists the antennas pre-approved by Bluegiga. Using an antenna of a different type (i.e. different radiation pattern) or higher gain will require a permissive change for the certifications. Please contact support@bluegiga.com for details

4 Physical Dimensions

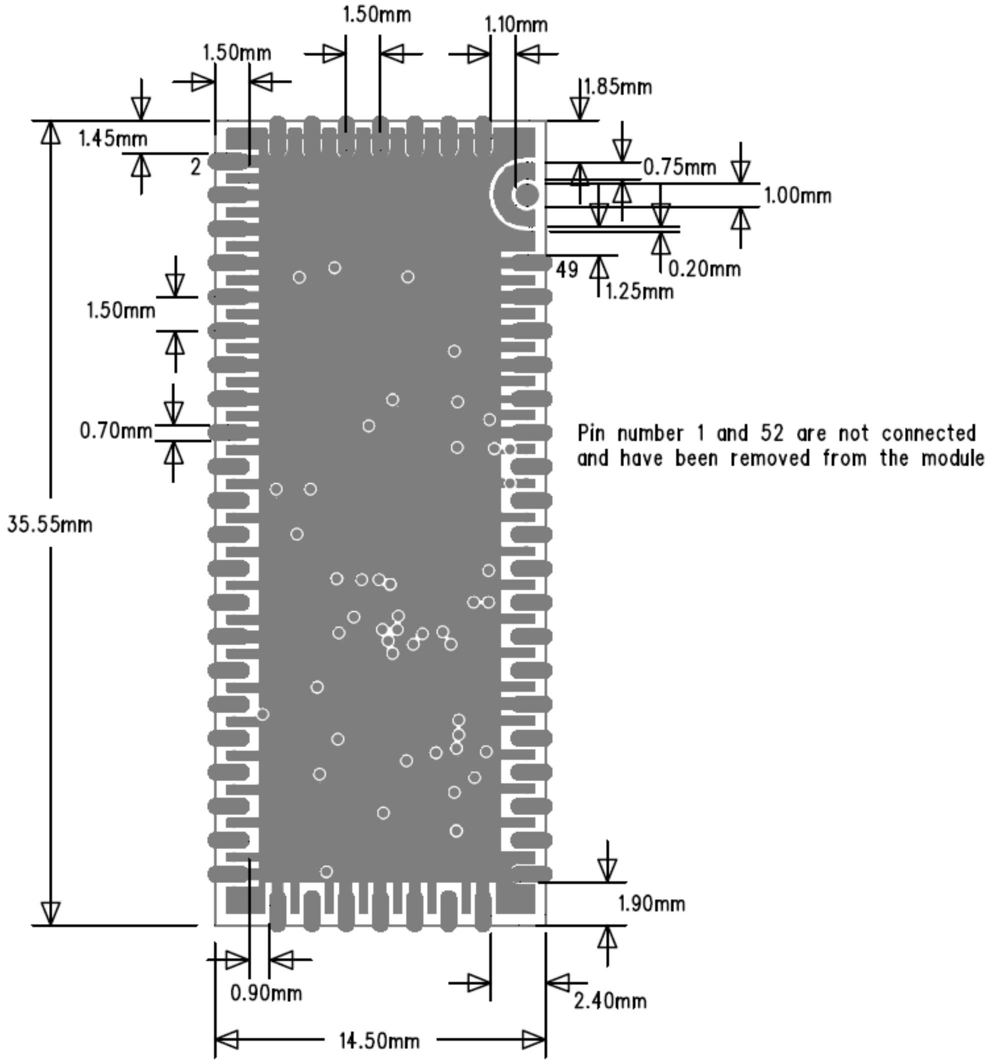


Figure 4: Physical dimensions (top view)

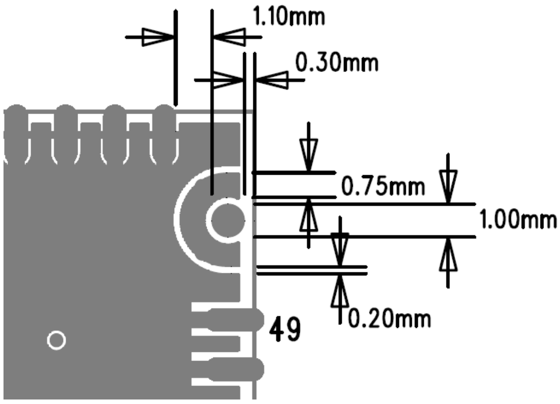


Figure 5: Dimensions for the RF pin (top view)

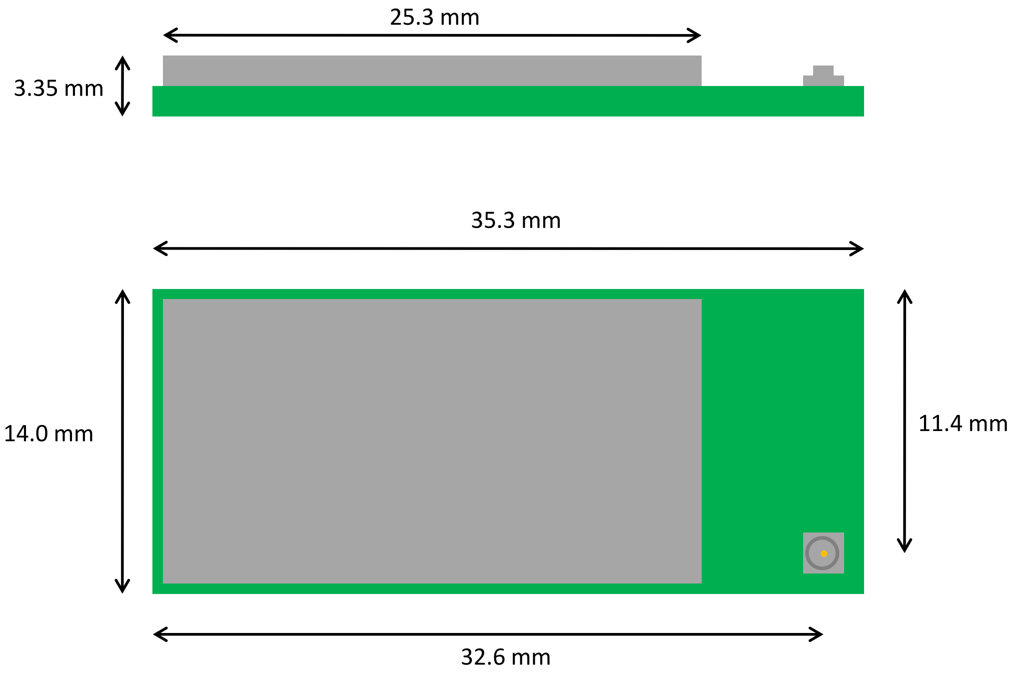


Figure 6: Dimensions of WT41-E

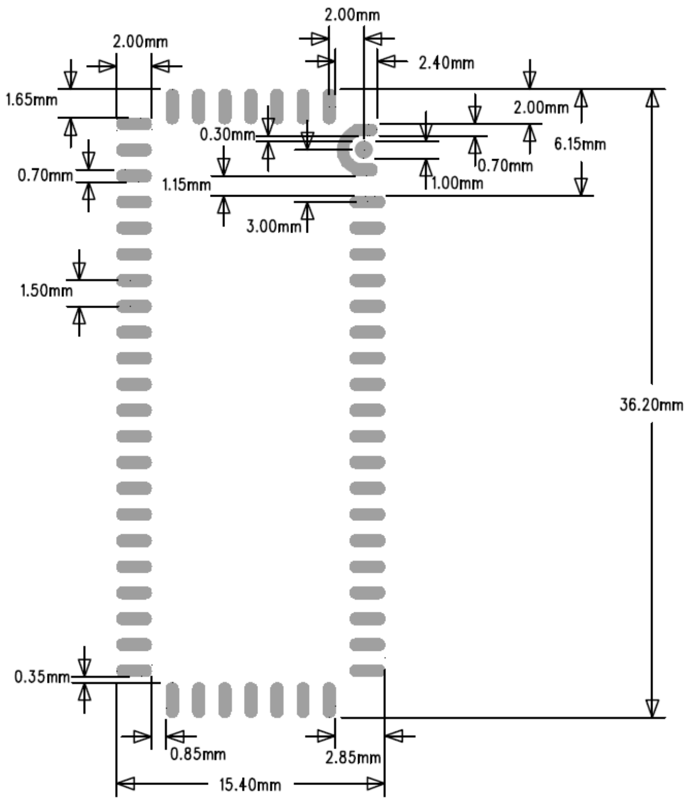


Figure 7: Recommended land pattern

5 Layout Guidelines

Use good layout practices to avoid excessive noise coupling to supply voltage traces or sensitive analog signal traces, such as analog audio signals. If using overlapping ground planes use stitching vias separated by max 3 mm to avoid emission from the edges of the PCB. Connect all the GND pins directly to a solid GND plane and make sure that there is a low impedance path for the return current following the signal and supply traces all the way from start to the end.

A good practice is to dedicate one of the inner layers to a solid GND plane and one of the inner layers to supply voltage planes and traces and route all the signals on top and bottom layers of the PCB. This arrangement will make sure that any return current follows the forward current as close as possible and any loops are minimized.

Figure 8: Typical 4-layer PCB construction

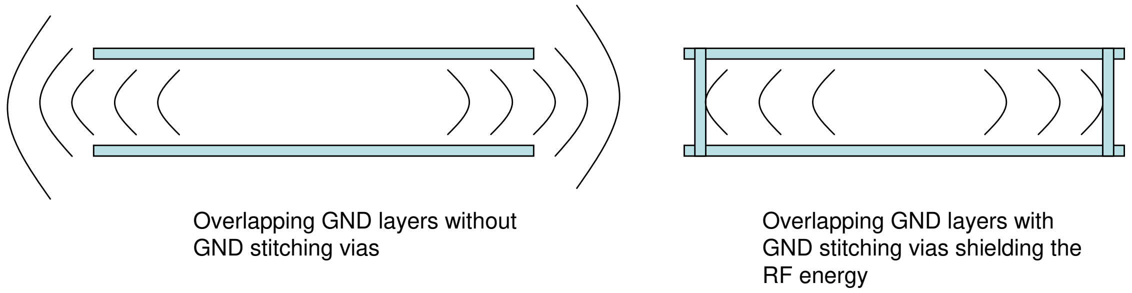


Figure 9: Use of stitching vias to avoid emissions from the edges of the PCB

6 UART Interface

This is a standard UART interface for communicating with other serial devices.WT41-E UART interface provides a simple mechanism for communicating with other serial devices using the RS232 protocol.

Four signals are used to implement the UART function. When WT41-E 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.

UART configuration parameters, such as data rate and packet format, are set using WT41-E software.

Note:

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.

Parameter	Possible Values	
Data Rate	Minimum	1200 bits/s (2%Error)
		9600 bits/s (1%Error)
	Maximum	3M bit/s (1%Error)
Flow Control	RTS/CTS or None	
Parity	None, Odd or Even	
Number of Stop Bits	1 or 2	
Bits per Channel	8	

Table 13: Possible UART Settings

The UART interface is capable of resetting WT41-E upon reception of a break signal. A break is identified by a continuous logic low (0V) on the UART_RX terminal, as shown in Figure 10. If tBRK is longer than the value, defined by 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, WT41-E can emit a break character that may be used to wake the host.

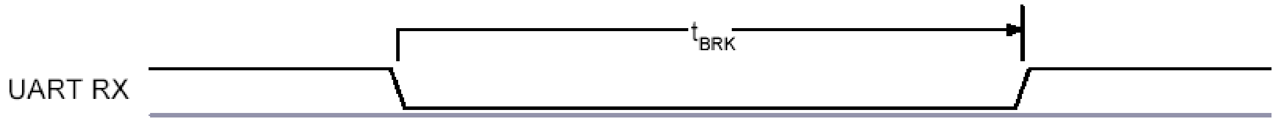


Figure 10: Break Signal

Table 17 shows a list of commonly used data rates and their associated values for PSKEY_UART_BAUD_RATE (0x204). There is no requirement to use these standard values. Any data rate within the supported range can be set in the PS Key according to the formula in Equation 1.

$$\text{Data Rate} = \frac{\text{PSKEY\_UART\_BAUDRATE}}{0.004096}$$

Equation 1: Data Rate

Data Rate (bits/s)	Persistent Store Value	Error	Dec
	Hex		
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%
1843200	0x1d7e	7550	0.00%
2764800	0x2c3d	11325	0.00%

Table 14: Standard Data Rates

6.1 UART Bypass

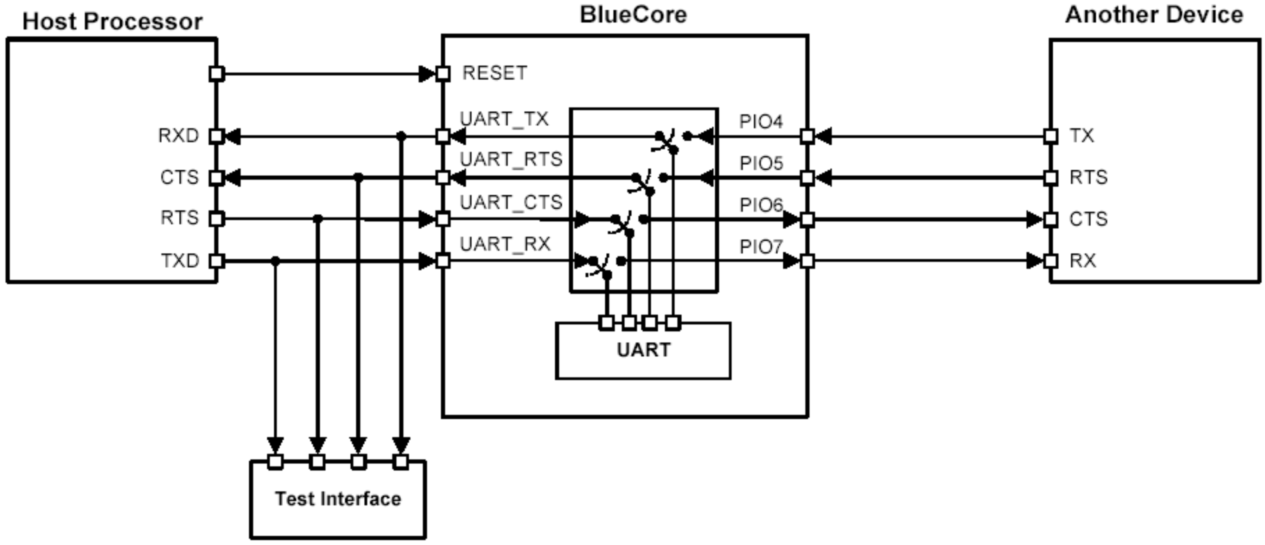


Figure 11: UART Bypass Architecture

6.2 UART Configuration While Reset is Active

The UART interface for WT41-E while the chip is being held in reset is tristate. This will allow the user to daisy chain devices onto the physical UART bus. The constraint on this method is that any devices connected to this bus must tristate when WT41-E reset is de-asserted and the firmware begins to run.

6.3 UART Bypass Mode

Alternatively, for devices that do not tristate the UART bus, the UART bypass mode on BlueCore4-External can be used. The default state of BlueCore4-External after reset is de-asserted; this is for the host UART bus to be connected to the BlueCore4-External UART, thereby allowing communication to BlueCore4-External via the UART. All UART bypass mode connections are implemented using CMOS technology and have signalling levels of 0V and VDD.

In order to apply the UART bypass mode, a BCCMD command will be issued to BlueCore4-External. Upon this issue, it will switch the bypass to PIO[7:4] as Figure 11 indicates. Once the bypass mode has been invoked, WT41-E will enter the Deep Sleep state indefinitely.

In order to re-establish communication with WT41-E, the chip must be reset so that the default configuration takes effect.

It is important for the host to ensure a clean Bluetooth disconnection of any active links before the bypass mode is invoked. Therefore, it is not possible to have active Bluetooth links while operating the bypass mode.

The current consumption for a device in UART bypass mode is equal to the values quoted for a device in standby mode.

7 USB Interface

This is a full speed (12Mbits/s) USB interface for communicating with other compatible digital devices. WT41-E acts as a USB peripheral, responding to requests from a master host controller such as a PC.

The USB interface is 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 can behave as specified in the USB section of the Bluetooth v2.1 + EDR specification or alternatively can appear as a set of endpoints appropriate to USB audio devices such as speakers.

As USB is a master/slave oriented system (in common with other USB peripherals), WT41-E only supports USB Slave operation.

7.1 USB Data Connections

The USB data lines emerge as pins USB_DP and USB_DN. These terminals are connected to the internal USB I/O buffers of the BlueCore4-External, therefore, have a low output impedance. To match the connection to the characteristic impedance of the USB cable, resistors must be placed in series with USB_DP/USB_DN and the cable.

7.2 USB Pull-Up resistor

WT41-E features an internal USB pull-up resistor. This pulls the USB_DP pin weakly high when WT41-E is ready to enumerate. It signals to the PC that it is a full speed (12Mbits/s) USB device.

The USB internal pull-up is implemented as a current source, and is compliant with section 7.1.5 of the USB specification v1.2. The internal pull-up pulls USB_DP high to at least 2.8V when loaded with a 15k 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. Alternatively, an external 1.5k 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 PSKEY_USB_PIO_PULLUP appropriately. The default setting uses the internal pull-up resistor.

7.3 USB Power Supply

The USB specification dictates that the minimum output high voltage for USB data lines is 2.8V. To safely meet the USB specification, the voltage on the VDD supply terminal must be an absolute minimum of 3.1V. Bluegiga recommends 3.3V for optimal USB signal quality.

7.4 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, 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 WT41-E via a resistor network (Rvb1 and Rvb2), so WT41-E can detect when VBUS is powered up. BlueCore4-External will not pull USB_DP high when VBUS is off.

Self-powered USB designs (powered from a battery or PSU) must ensure that a PIO line is allocated for USB pullup purposes. A 1.5k 5% pull-up resistor between USB_DP and the selected PIO line should be fitted to the design. Failure to fit this resistor may result in the design failing to be USB compliant in self-powered mode. The internal pull-up in BlueCore is only suitable for bus-powered USB devices, e.g., dongles.

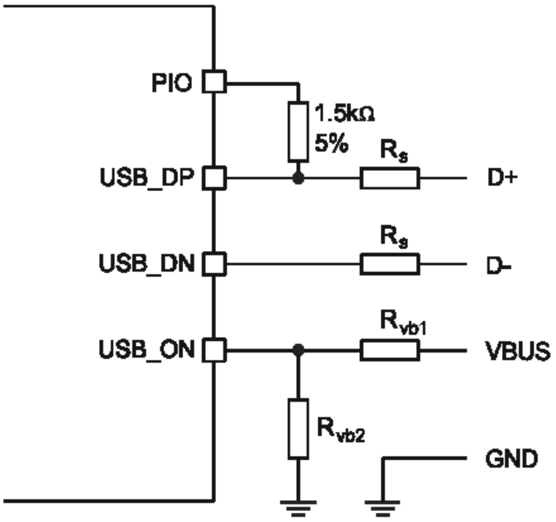


Figure 12: USB Connections for Self-Powered Mode

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

Identifier	Value	Function
R_s	27 nominal	Impedance matching to USB cable
R_{vb1}	22k 5%	VBUS ON sense divider
R_{vb2}	47k 5%	VBUS ON sense divider

Figure 13: USB Interface Component Values

7.5 Bus-Powered Mode

In bus-powered mode, the application circuit draws its current from the 5V VBUS supply on the USB cable. WT41-E negotiates with the PC during the USB enumeration stage about how much current it is allowed to consume. On power-up the device must not draw more than 100 mA but after being configured it can draw up to 500 mA.

For WT41-E, the USB power descriptor should be altered to reflect the amount of power required. This is accomplished by setting 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. By default for WT41-E the setting is 300 mA.

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 the USB Specification. Some applications may require soft start circuitry to limit inrush current if more than 10uF 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 bandwidth. Excessive noise on WT41-E supply pins will result in reduced receiver sensitivity and a distorted RF transmit signal.

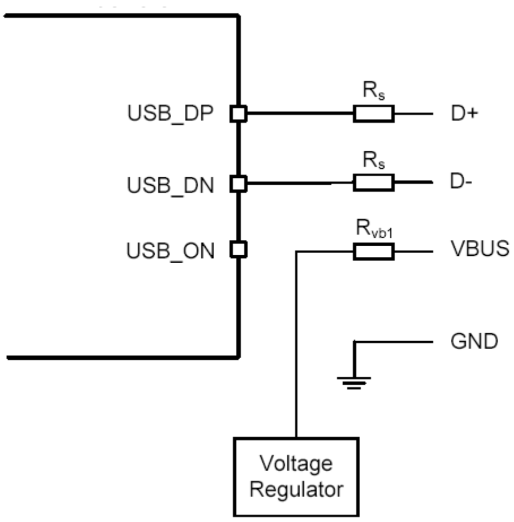


Figure 14: USB Connections for Bus-Powered Mode

7.6 USB Suspend Current

All USB devices must permit the USB controller to place them in a USB suspend mode. While in USB Suspend, bus-powered devices must not draw more than 2.5mA from USB VBUS (self-powered devices may draw more than 2.5mA from their own supply). This current draw requirement prevents operation of the radio by bus-powered devices during USB Suspend.

When computing suspend current, the current from VBUS through the bus pull-up and pull-down resistors must be included. The pull-up resistor at the device is 1.5 k. (nominal). The pull-down resistor at the hub is 14.25k. to 24.80k. The pull-up voltage is nominally 3.3V, which means that holding one of the signal lines high takes approximately 200uA, leaving only 2.3mA available from a 2.5mA budget. Ensure that external LEDs and/or amplifiers can be turned off by BlueCore4-External. The entire circuit must be able to enter the suspend mode.

7.7 USB Detach and Wake-Up Signaling

WT41-E can provide out-of-band signaling to a host controller by using the 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 WT41-E 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 PSKEY_USB_PIO_DETACH and PSKEY_USB_PIO_WAKEUP to the selected PIO number.

USB_DETACH is an input which, when asserted high, causes WT41-E to put USB_DN and USB_DP in high impedance state and turns off the pull-up resistor on DP. This detaches the device from the bus and is logically equivalent to unplugging the device. When USB_DETACH is taken low, WT41-E 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) and cannot be sent while BlueCore4-External is effectively disconnected from the bus.

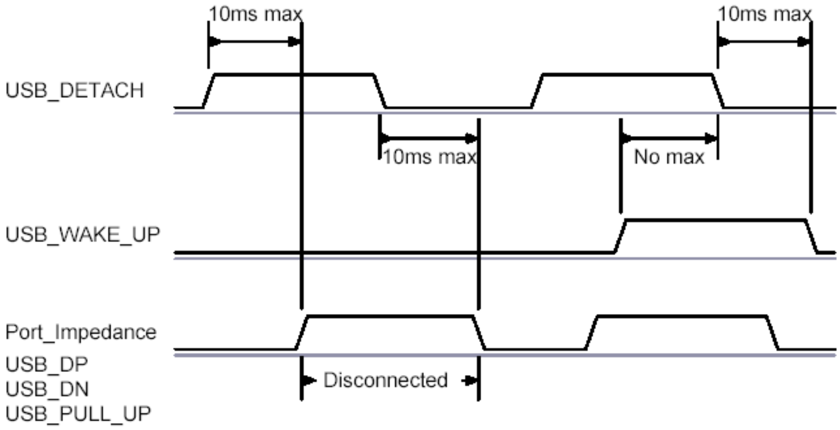


Figure 15: USB_Detach and USB_Wake_Up Signals

7.8 USB Driver

A USB Bluetooth device driver is required to provide a software interface between BlueCore4-External and Bluetooth software running on the host computer. Please, contact support@bluegiga.com for suitable drivers.

7.9 USB v2.0 Compliance and Compatibility

Although WT41-E meets the USB specification, CSR cannot guarantee that an application circuit designed around the module 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_DP and USB_DN adhere to the USB Specification v2.0 (Chapter 7) electrical requirements.

BlueCore4-External is compatible with USB v2.0 host controllers; under these circumstances the two ends agree the mutually acceptable rate of 12Mbits/s according to the USB v2.0 specification.