

WT41-A / WT41-N

DATA SHEET

Thursday, 17 March 2011

Version 1.31

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VERSION HISTORY

| Version | Comment |
|---------|---|
| 0.1 | First draft |
| 0.2 | Description and product codes added |
| 0.21 | Dimensions updated, layout guide added, UART and USB chapters added |
| 0.22 | Pin descriptions, PCM, USB, UART, SPI |
| 0.3 | Physical dimensions corrected |
| 0.31 | Product codes corrected |
| 0.32 | Recommendation for a power-up reset circuitry added to chapter 10 |
| 0.4 | Pins 1 and 52 (GND) removed. Dimensions updated, recommended land pattern added |
| 0.5 | Certification information added |
| 0.6 | Physical dimensions and recommended PCB land pattern updated |
| 0.7 | Figure 5 recommended land pattern corrected |
| 1.0 | Radio and antenna characteristics, layout guide for WT41-N |
| 1.1 | Japan certification info added |
| 1.2 | FCC RF radiation exposure statement updated |
| 1.3 | Layout guide updated |
| 1.31 | VDD added to table 1 |

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DESCRIPTION

WT41 is a long range class 1, Bluetooth® 2.1 + EDR module. WT41 is a highly integrated and sophisticated Bluetooth® module, containing all the necessary elements from Bluetooth® radio to antenna and a fully implemented protocol stack. Therefore WT41 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 is optimized for long range applications and since it contains a RF power amplifier, low noise amplifier and a highly efficient chip antenna. With 115 dB radio budget WT41 can reach over 1 km range in line of sight.

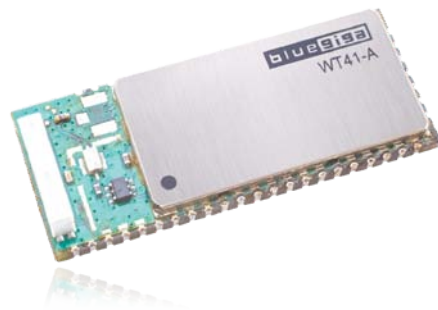
By default WT41 module is equipped with powerful and easy-to-use iWRAP firmware. iWRAP enables users to access Bluetooth® functionality with simple ASCII commands delivered to the module over serial interface - it's just like a Bluetooth® modem.

APPLICATIONS:

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

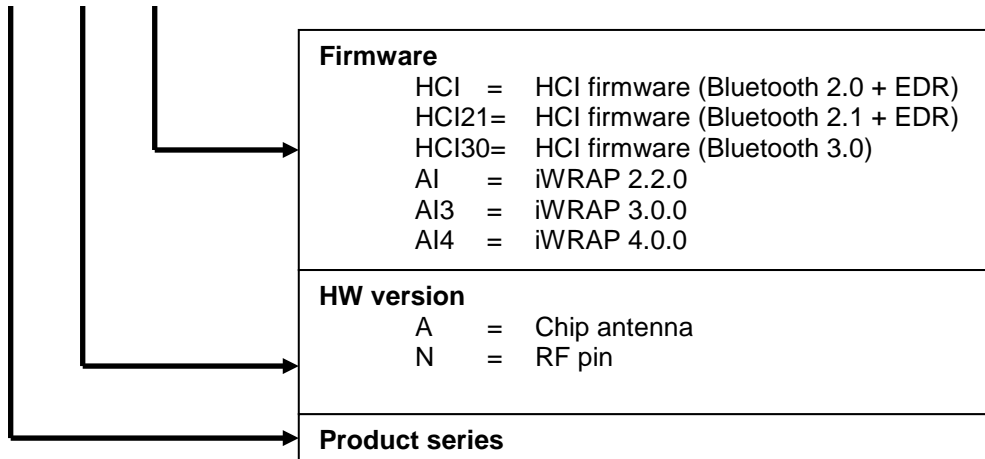
FEATURES:

- Fully Qualified Bluetooth v2.1 + EDR end product, CE and FCC and IC
- TX power : 19 dBm
- RX sensitivity : -92 dBm
- Highly 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-A-HCI



2 Pinout and Terminal Description

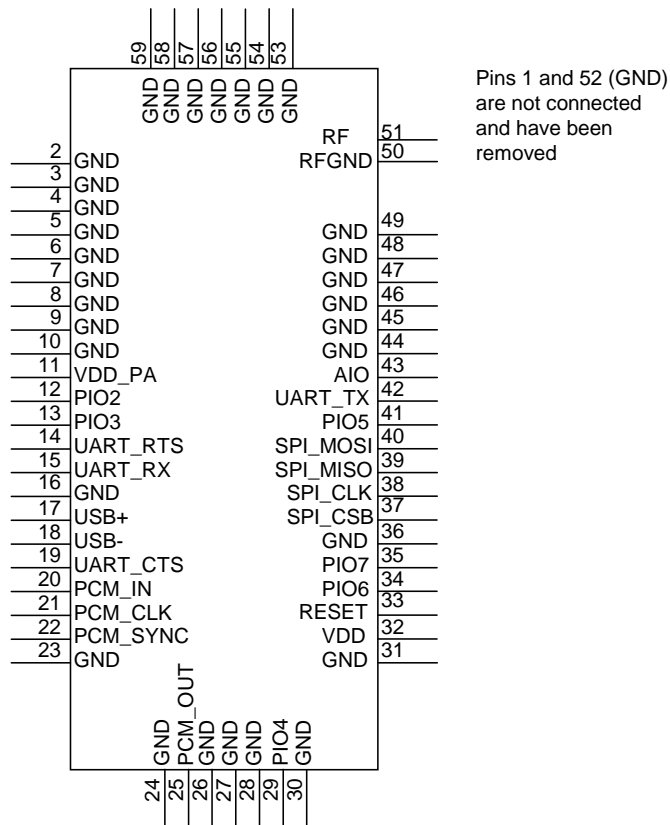


Figure 1: WT41 pin out

| | 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, programmable strength internal pull-down/pull-up | Programmable input/output line |
| PIO[3] | 13 | Bi-directional, programmable strength internal pull-down/pull-up | Programmable input/output line |
| PIO[4] | 29 | Bi-directional, programmable strength internal pull-down/pull-up | Programmable input/output line |
| PIO[5] | 41 | Bi-directional, programmable strength internal pull-down/pull-up | Programmable input/output line |
| PIO[6] | 34 | Bi-directional, programmable strength internal pull-down/pull-up | Programmable input/output line |
| PIO[7] | 35 | Bi-directional, programmable strength internal pull-down/pull-up | Programmable input/output line |
| AIO[1] | 43 | Bi-directional | Programmable analog input/output line |

Table 2: GPIO Terminal Descriptions

| SPI 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 | 3.6 | 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 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 | | | 4 | - | dB |
| RF power variation over supply voltage range (*) | | | 1.5 | - | dB |
| RF power variation over BT band | 0.1 | 1 | 2 | - | dB |
| RF power control range (*) | -10 | | 19 | | |
| 20dB band width for modulated carrier | | 942 | | 1000 | kHz |
| ACP (1) | F = F ₀ ± 2MHz | | -20 | -20 | |
| | F = F ₀ ± 3MHz | | -40 | -40 | |
| | F = F ₀ > 3MHz | | -40 | -40 | |
| Drift rate | | 7 | | +/-25 | kHz |
| ΔF_{1avg} | | 169 | | 140<175 | kHz |
| ΔF_{1max} | | 161 | | 140<175 | kHz |
| $\Delta F_{2avg} / \Delta F_{1avg}$ | | 1.1 | | >=0.8 | |

Table 9: Transmitter performance for BDR

3.4 Radiated Spurious Emissions

Measured from WT41 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-A

| Standard | | Min (AVG / PEAK) | Typ (AVG / PEAK) | Max (AVG / PEAK) | Limit by the Standard (AVG / PEAK) | Unit |
|--|---------------------------------|------------------|------------------|------------------|------------------------------------|--------|
| FCC part 15 transmitter spurious emissions | 2nd harmonic | | <48/55 | 50/56 | 54 / 74 | dBuV/m |
| | 3rd harmonic | | <48/51 | 48/52 | 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 2400 MHz (conducted) | | -50 | | -20 | dBc |
| | Band edge 3483.5MHz (conducted) | | -58 | | -20 | dBc |
| ETSI EN 300 328 transmitter spurious emissions | Band edge 2400MHz | | -39 | -36 | -30 | dBm |
| | 2nd harmonic | | | | -30 | dBm |
| | 3rd harmonic | | | | -30 | dBm |
| ETSI EN 300 328 receiver spurious | (2400 - 2479) MHz | | | | -47 | dBm |
| | (1600 - 1653) MHz | | | | -47 | dBm |

Table 11: Radiated spurious emission for WT41-N

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 12: Receiver sensitivity

3.6 Current Consumption

| Operation 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 13: Current consumption

3.7 Antenna Performance and Radiation Patterns

Antenna performance measured from the module as a standalone and as mounted to the evaluation board.

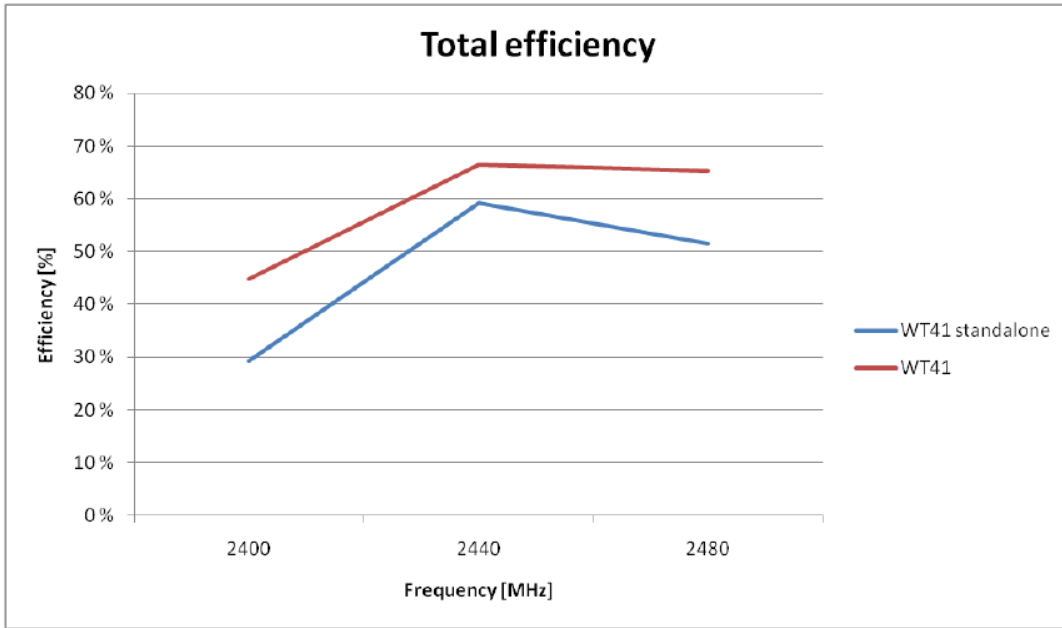


Table 14: Total efficiency of the chip antenna

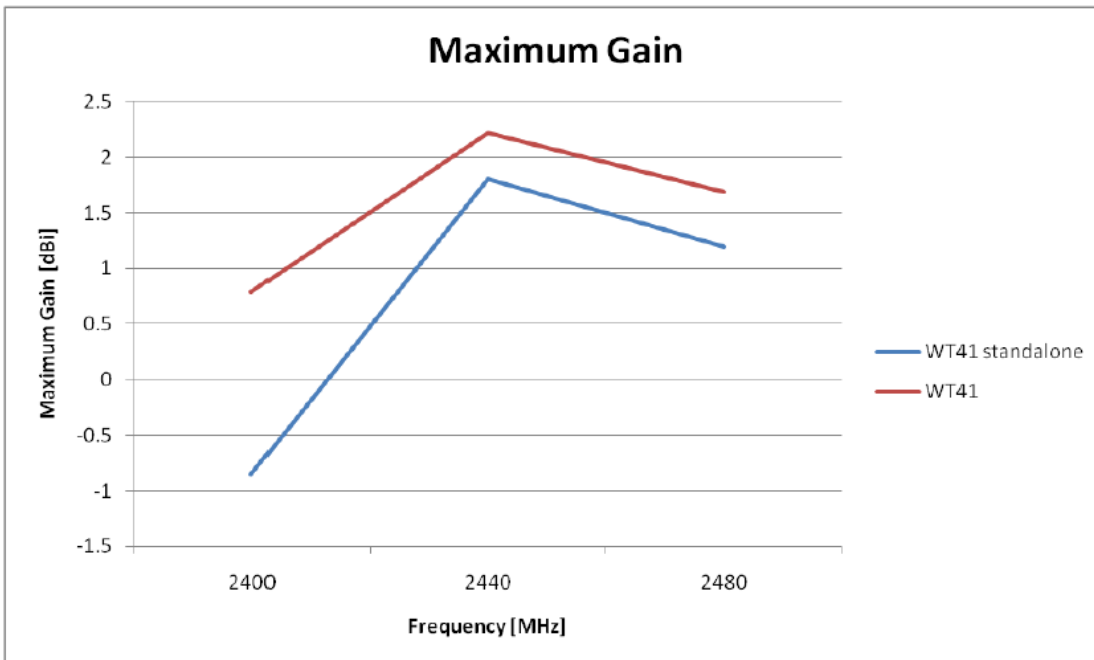
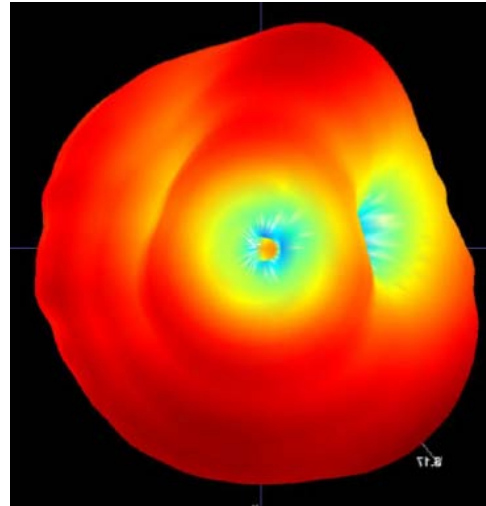
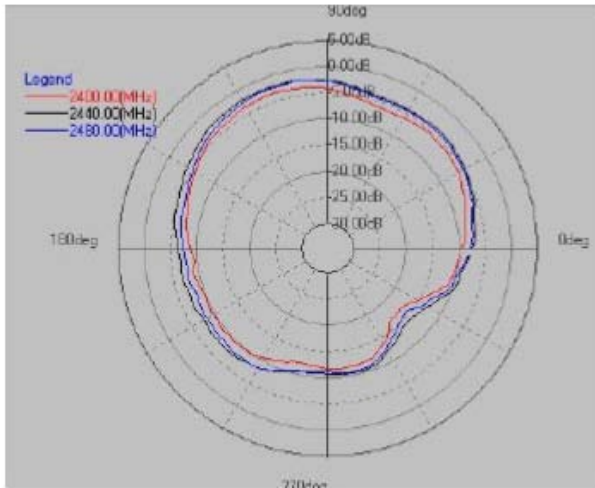
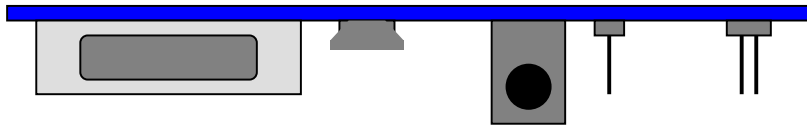
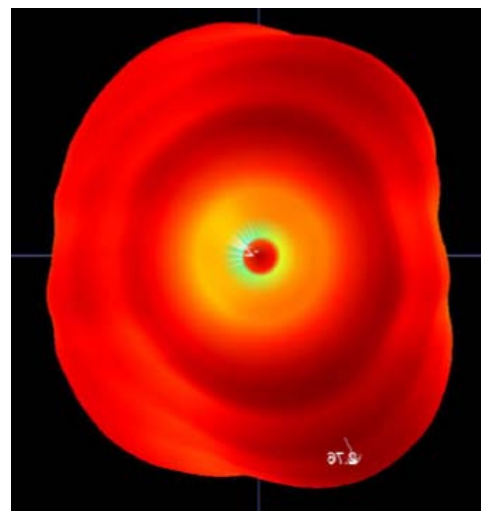
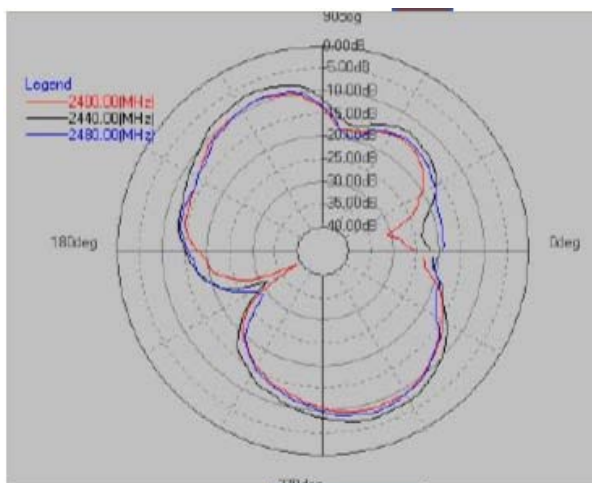
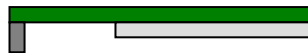


Table 15: Peak gain of the chip antenna

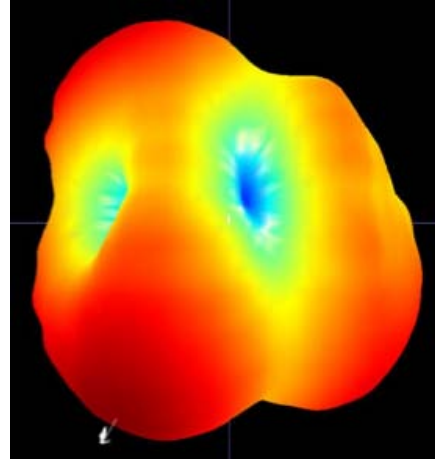
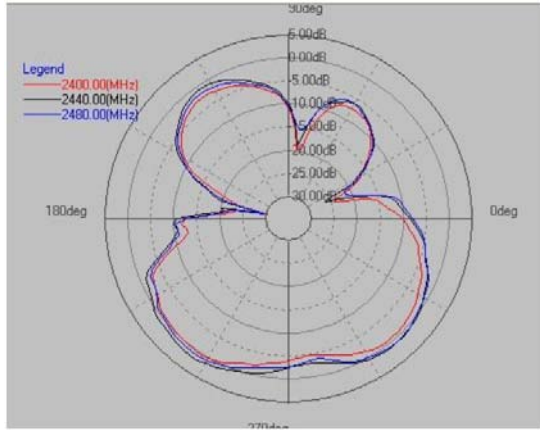
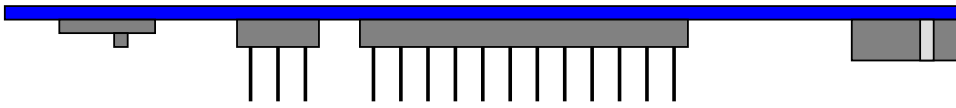
WT41 Evaluation Board



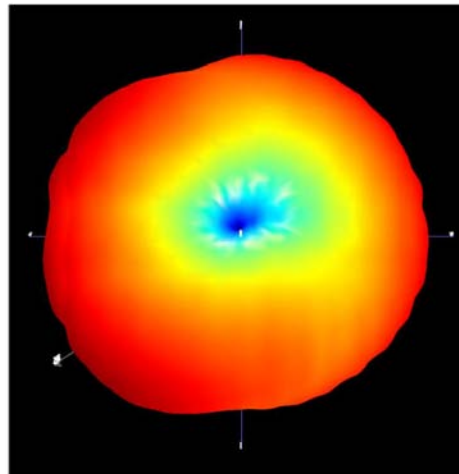
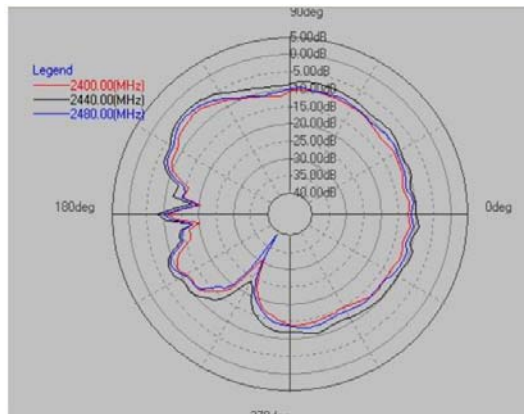
WT41 stand alone

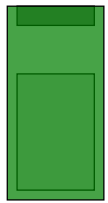
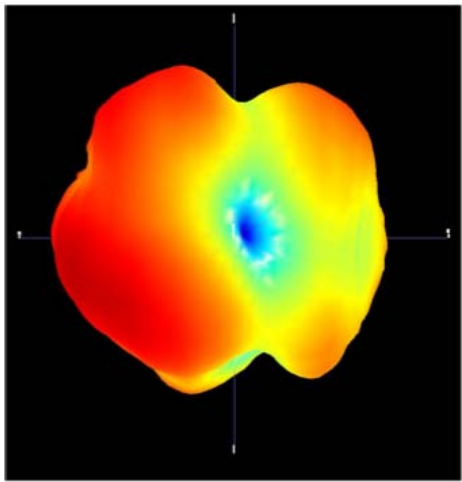
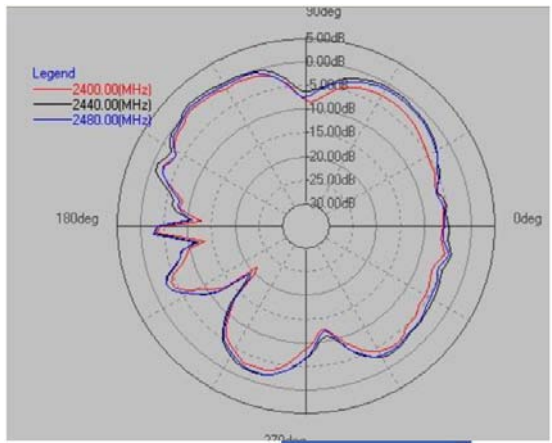
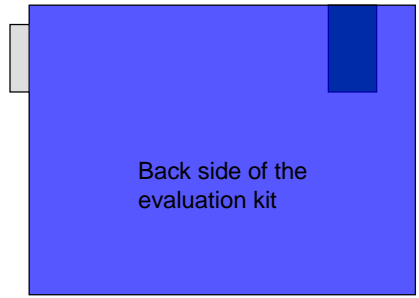


WT41 Evaluation Board

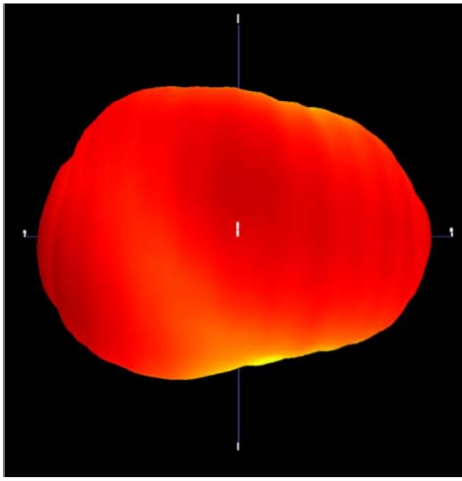
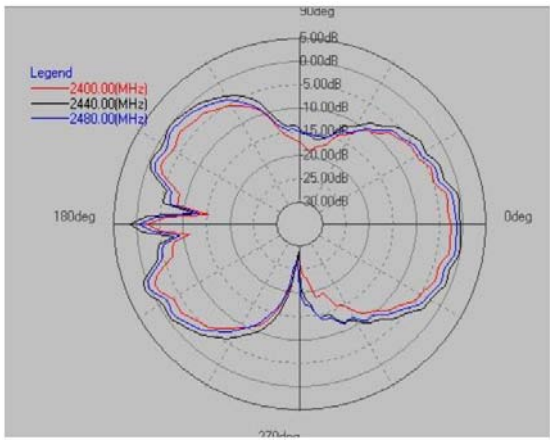


WT41 stand alone





Back side of WT41-A



4 Physical Dimensions

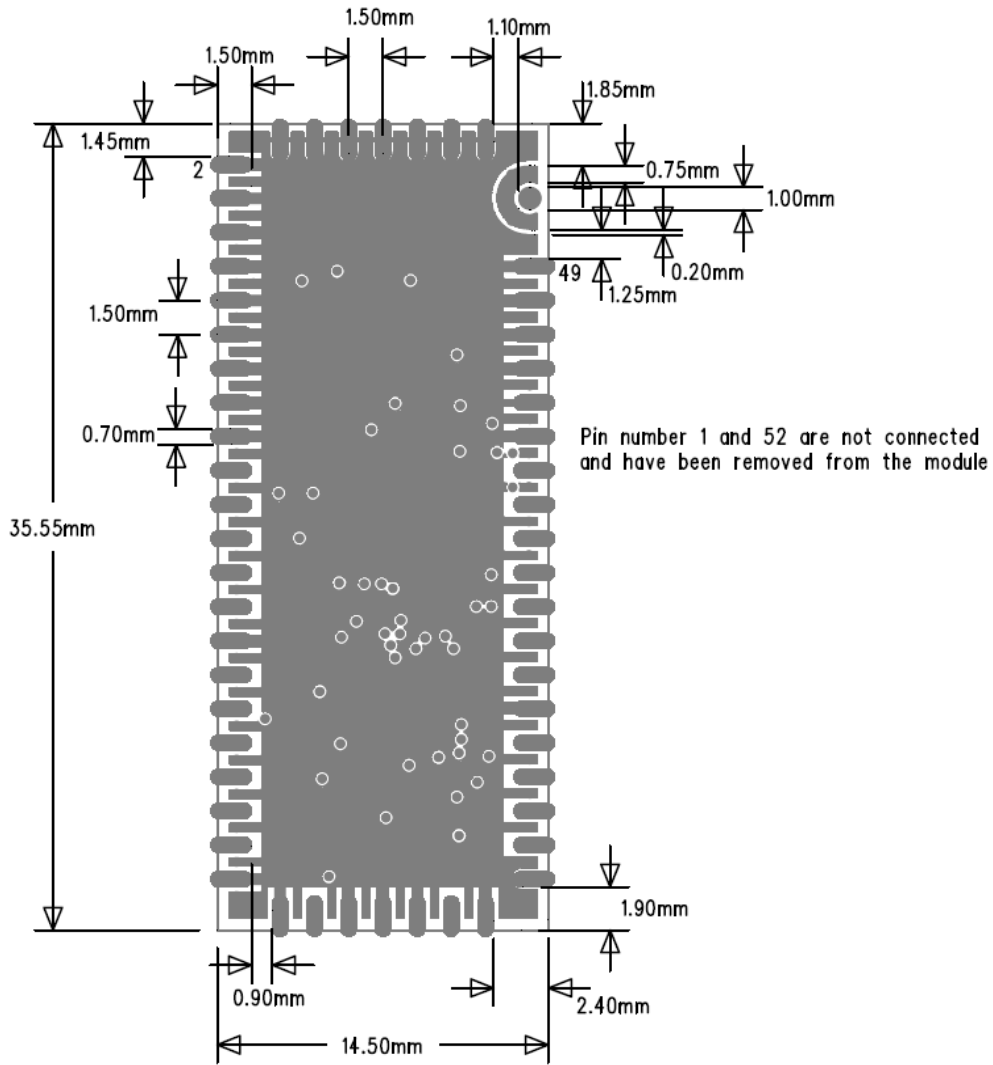


Figure 2: Physical dimensions (top view)

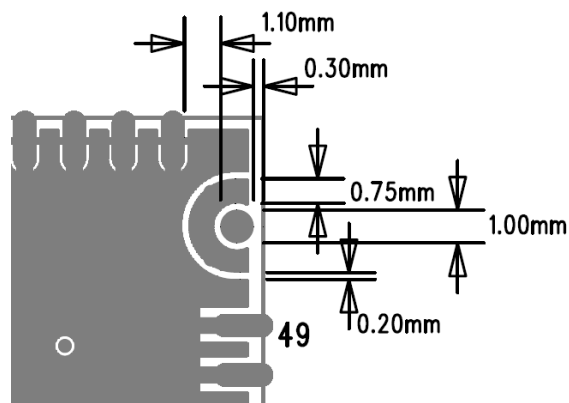


Figure 3: Dimensions for the RF pin (top view)

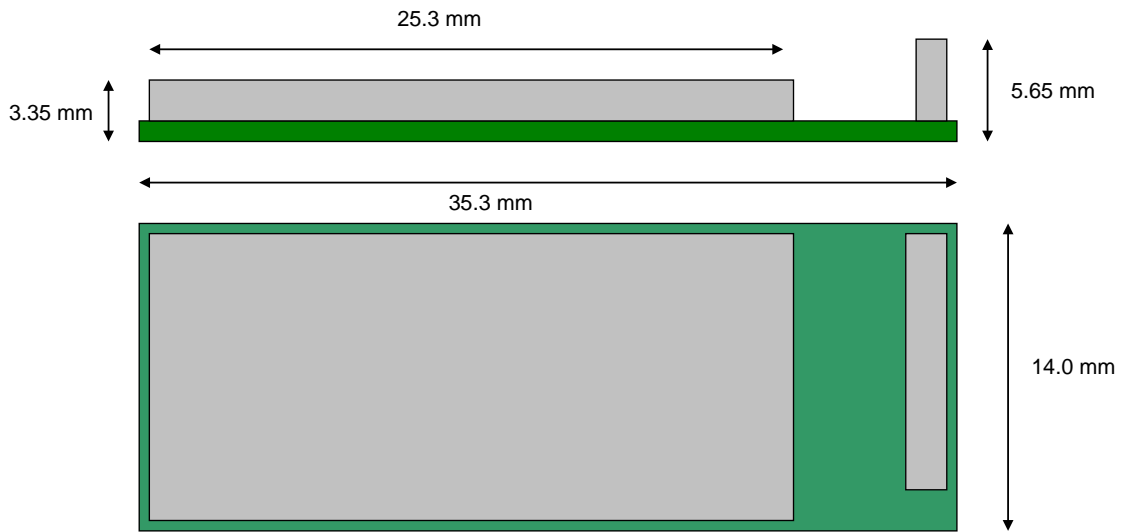


Figure 4: Dimensions of WT41

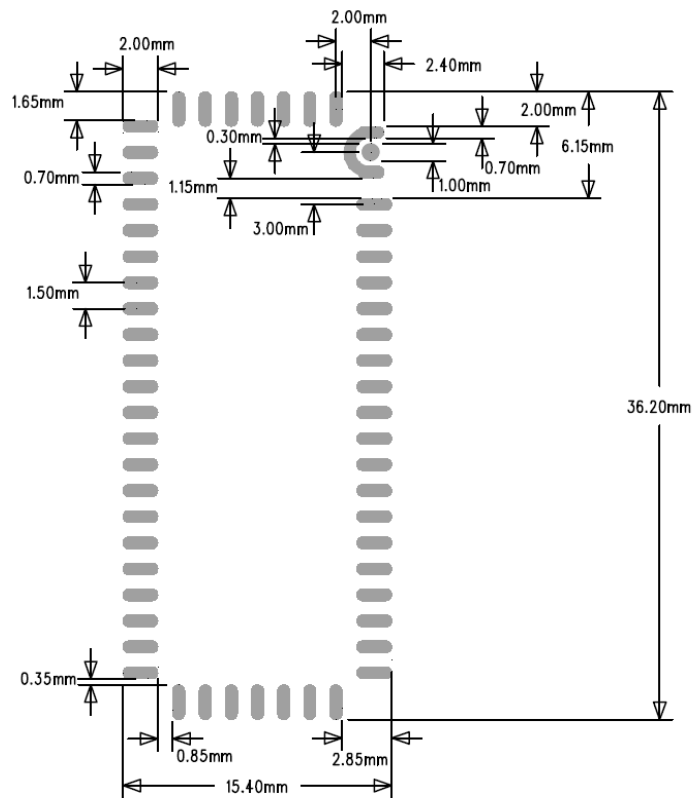


Figure 5: Recommended land pattern

5 Layout Guidelines

5.1 WT41-A

WT41-A should be mounted directly over a solid GND plane. The best performance can be achieved when placing the module to the left corner or to a middle edge of the mother board, as shown in the figure below. Components can be mounted directly under the module and the antenna. The antenna is extremely robust for environment in close proximity to the antenna. Any dielectric material has minor effect on the resonant frequency of the antenna. Metal objects with physical height less than 2 mm can be placed freely anywhere around the module within the area of the mother board without significantly effecting on the radiation characteristics. It is important to place the module to the edge of the mother board and not to place metal objects in front of the antenna.

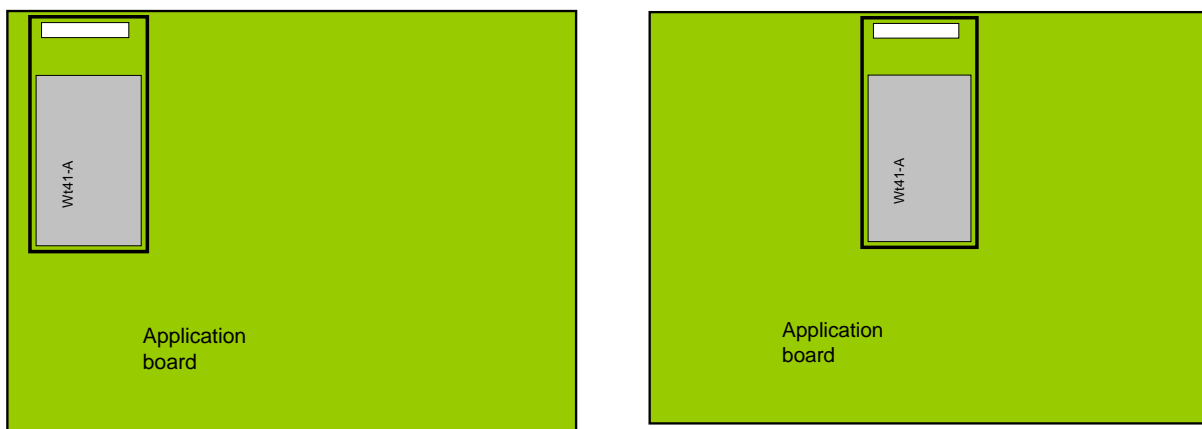


Figure 6: Recommended positions for WT41-A

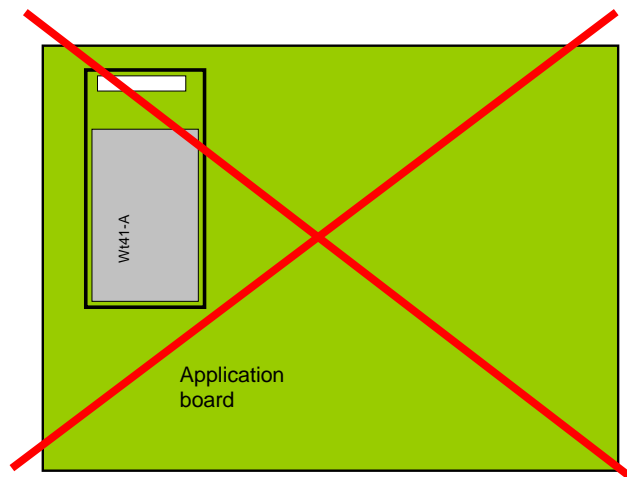


Figure 7: Do not place the module so that the GND plane reaches in front of the antenna

5.2 WT41-N

5.2.1 Layout for WT41-N with u.fl connector close to RF pin

If the trace from the RF pin to u.fl connector is very short there is no need to use impedance controlled trace. Figure 6 shows an example layout where the u.fl connector is placed right next to the RF pin.

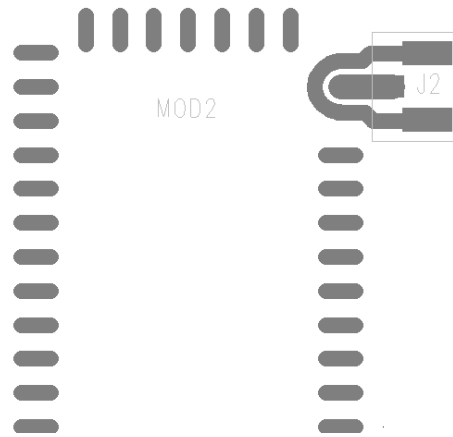


Figure 8: Layout of WT41-N with U.FL connector placed next to the RF pin

5.2.2 Layout for WT41-N with 50 ohm trace from RF pin to a SMA connector

Use 50 ohm transmission line to trace the signal from RF pin to an external RF connector. Figure 6 shows a layout example for WT41-N with an external SMA connector.

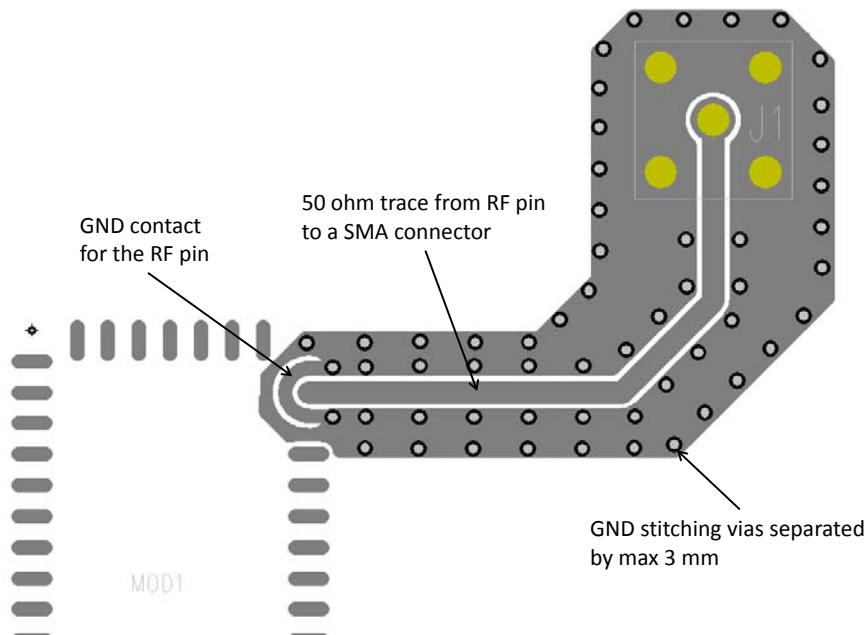


Figure 9: Example RF trace for WT41-N

A transmission line impedance calculator, such as TX-Line made by AWR, can be used to approximate the dimensions for the 50 ohm transmission line. Figure 7 shows an example for two different 50 ohm transmission lines.

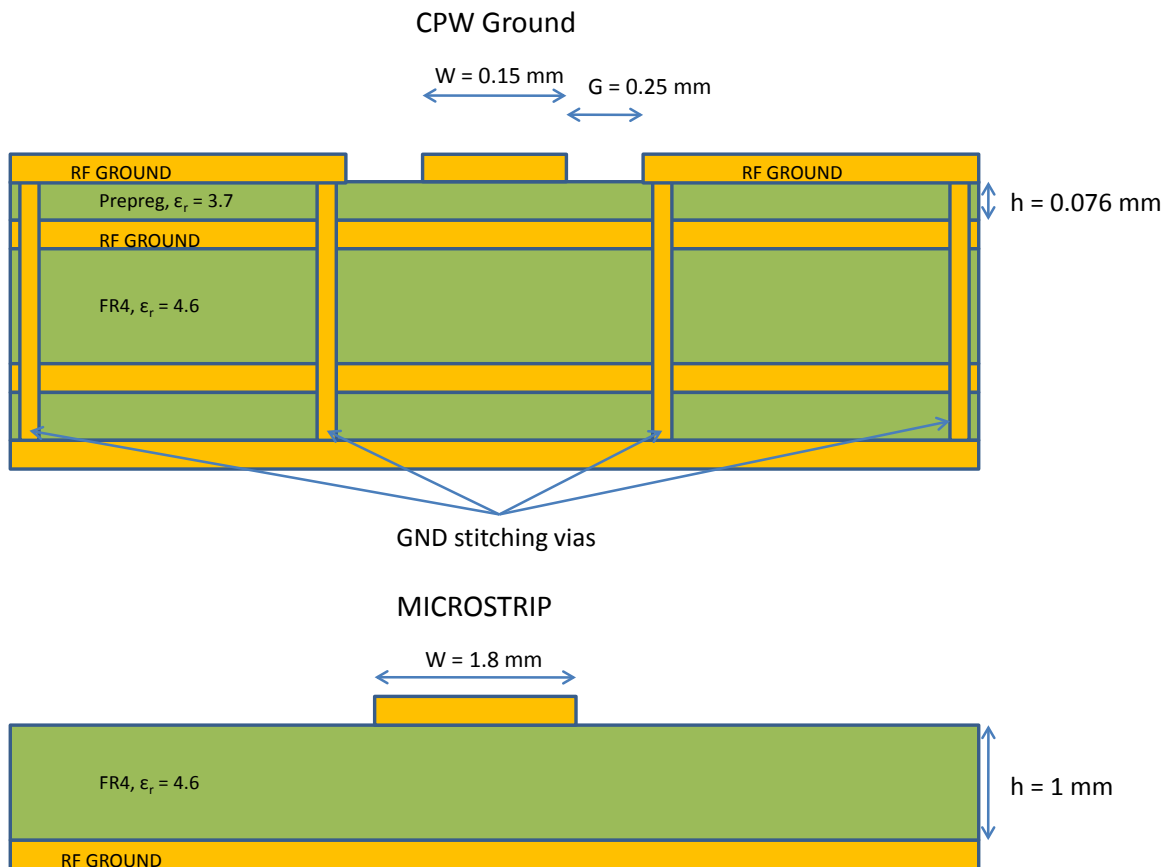


Figure 10: Example cross section of two different 50 ohm transmission line

6 UART Interface

This is a standard UART interface for communicating with other serial devices. WT41 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 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 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 16: Possible UART Settings

The UART interface is capable of resetting WT41 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 XXX. If t_{BRK} 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 can emit a break character that may be used to wake the host.

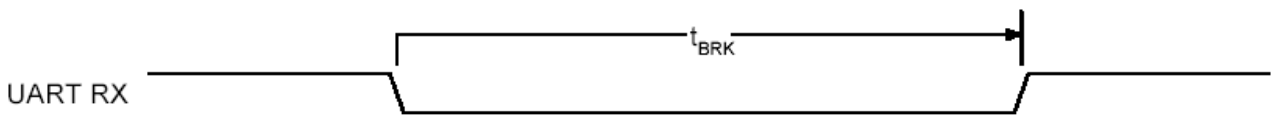


Figure 11: Break Signal

Table XXX 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 XXX

$$\text{Data Rate} = \frac{\text{PSKEY_UART_BAUDRATE}}{0.004096}$$

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 17: Standard Data Rates

6.1 UART Bypass

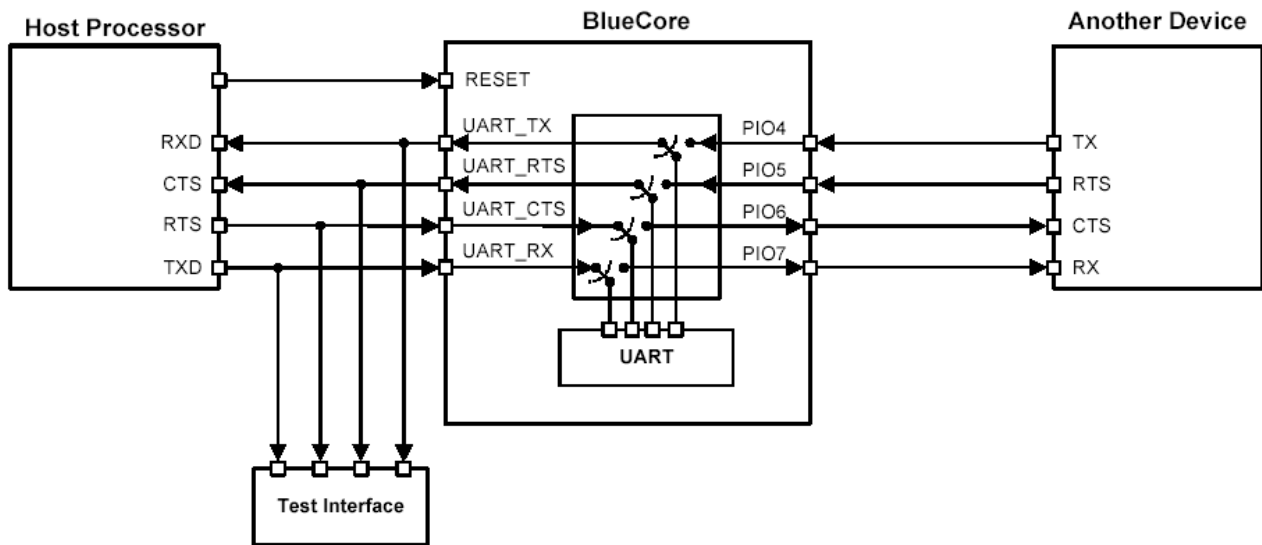


Figure 12: UART Bypass Architecture

6.2 UART Configuration While Reset is Active

The UART interface for WT41 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 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 XXX indicates. Once the bypass mode has been invoked, WT41 will enter the Deep Sleep state indefinitely.

In order to re-establish communication with WT41, 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 (12Mbps/s) USB interface for communicating with other compatible digital devices. WT41 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 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 features an internal USB pull-up resistor. This pulls the USB_DP pin weakly high when WT41 is ready to enumerate. It signals to the PC that it is a full speed (12Mbps/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 via a resistor network (Rvb1 and Rvb2), so WT41 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.

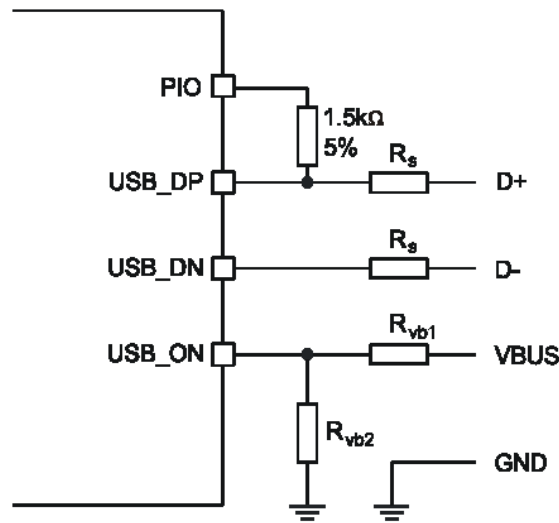


Figure 13: USB Connections for Self-Powered Mode

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 14: 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 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, 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 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 supply pins will result in reduced receiver sensitivity and a distorted RF transmit signal.

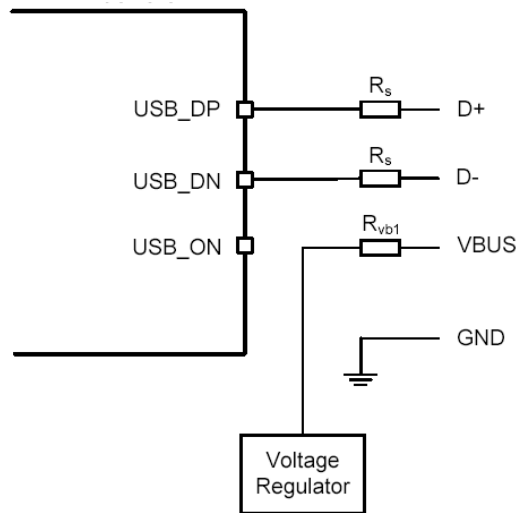


Figure 15: USB Connections for Bus-Powered Mode

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 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 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 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 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.

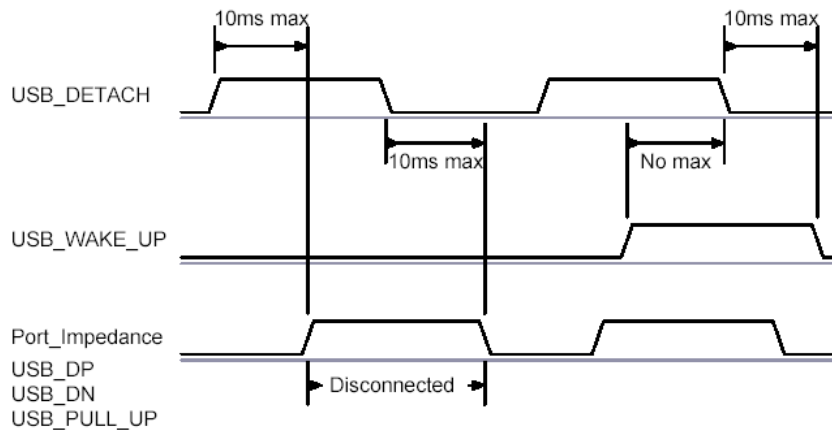


Figure 16: USB_Detach and USB_Wake_Up Signals

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 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.

8 Serial Peripheral Interface (SPI)

The SPI port can be used for system debugging. It can also be used for programming the Flash memory and setting the PSKEY configurations. WT41 uses 16-bit data and 16-bit address serial peripheral interface, where transactions may occur when the internal processor is running or is stopped. SPI interface is connected using the MOSI, MISO, CSB and CLK pins. Please, contact support@bluegiga.com for detailed information about the instruction cycle.

9 PCM Codec Interface

PCM is a standard method used to digitize audio (particularly voice) for transmission over digital communication channels. Through its PCM interface, WT41 has hardware support for continual transmission and reception of PCM data, thus reducing processor overhead for wireless headset applications. WT41 offers a bidirectional 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 WT41 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.

WT41 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. WT41 is compatible with a variety of clock formats, including Long Frame Sync, Short Frame Sync and GCI timing environments.

It supports 13-bit or 16-bit linear, 8-bit μ -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 PSKEY_PCM_CONFIG32.

WT41 interfaces directly to PCM audio devices.

NOTE: Analog audio lines are very sensitive to RF disturbance. Use good layout practices to ensure noise less audio. Make sure that the return path for the audio signals follows the forward current all the way as close as possible and use fully differential signals when possible. Do not compromise audio routing.

9.1 PCM Interface Master/Slave

When configured as the master of the PCM interface, WT41 generates PCM_CLK and PCM_SYNC.

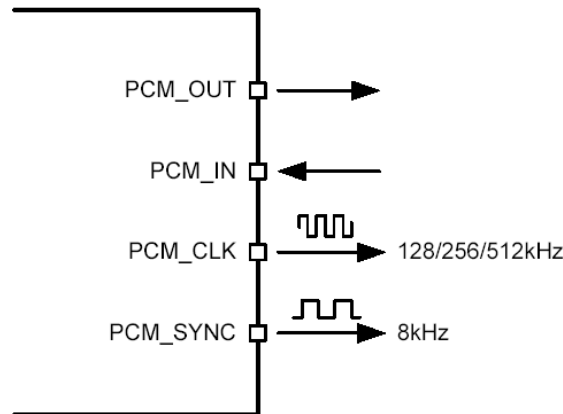


Figure 17: PCM Interface Master

When configured as the Slave of the PCM interface, WT41 accepts PCM_CLK rates up to 2048kHz.

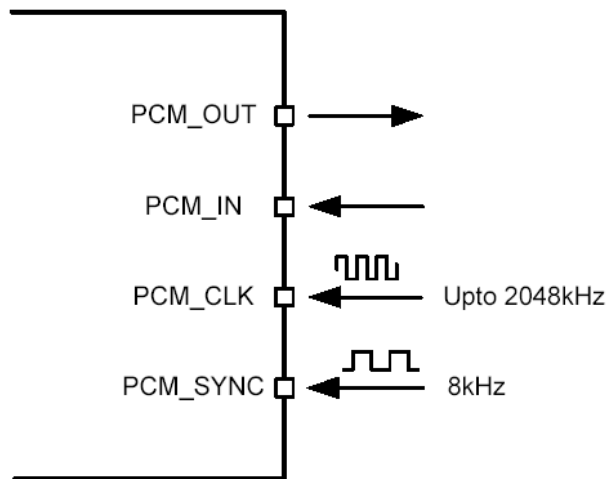


Figure 18: PCM Interface Slave

9.2 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 WT41 is configured as PCM master, generating PCM_SYNC and PCM_CLK, then PCM_SYNC is 8-bits long. When WT41 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., 62.5s long.

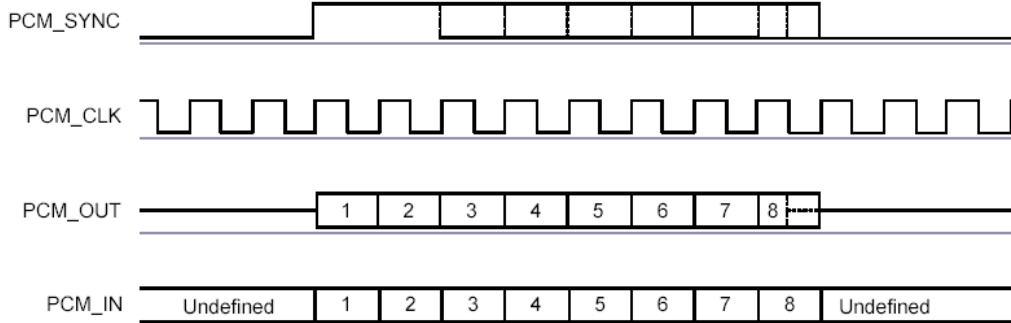


Figure 19: Long Frame Sync (Shown with 8-bit Companded Sample)

WT41 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.

9.3 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.

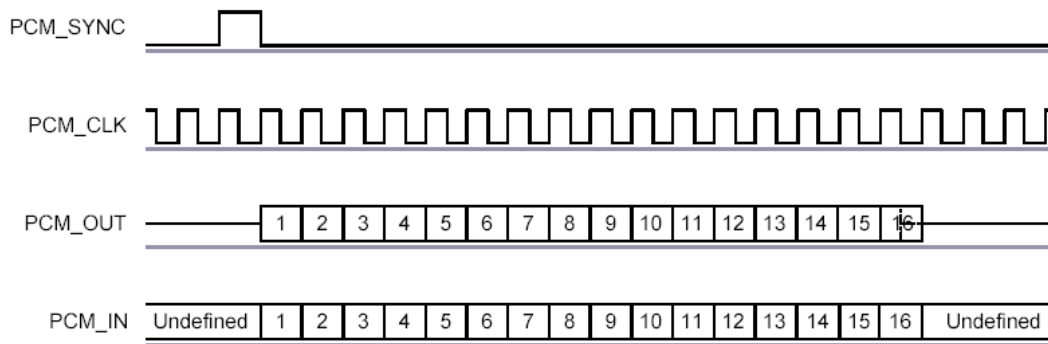


Figure 20: Short Frame Sync (Shown with 16-bit Sample)

As with Long Frame Sync, WT41 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.

9.4 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.

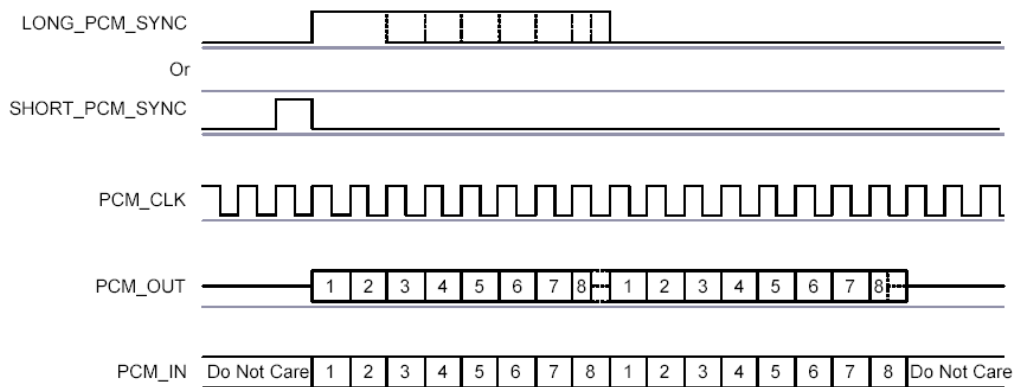


Figure 21: Multi-slot Operation with Two Slots and 8-bit Companded Samples

9.5 GCI Interface

WT41 is compatible with the GCI, a standard synchronous 2B+D ISDN timing interface. The two 64kbits/s B channels can be accessed when this mode is configured.

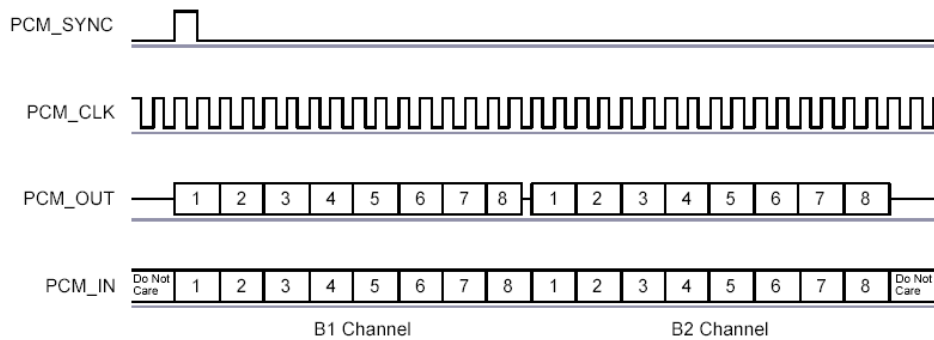


Figure 22: GCI Interface

The start of frame is indicated by the rising edge of PCM_SYNC and runs at 8kHz. With WT41 in Slave mode, the frequency of PCM_CLK can be up to 4.096MHz.

9.6 Slots and Sample Formats

WT41 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-bit, 13-bit or 16-bit sample formats.

WT41 supports 13-bit linear, 16-bit linear and 8-bit -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.

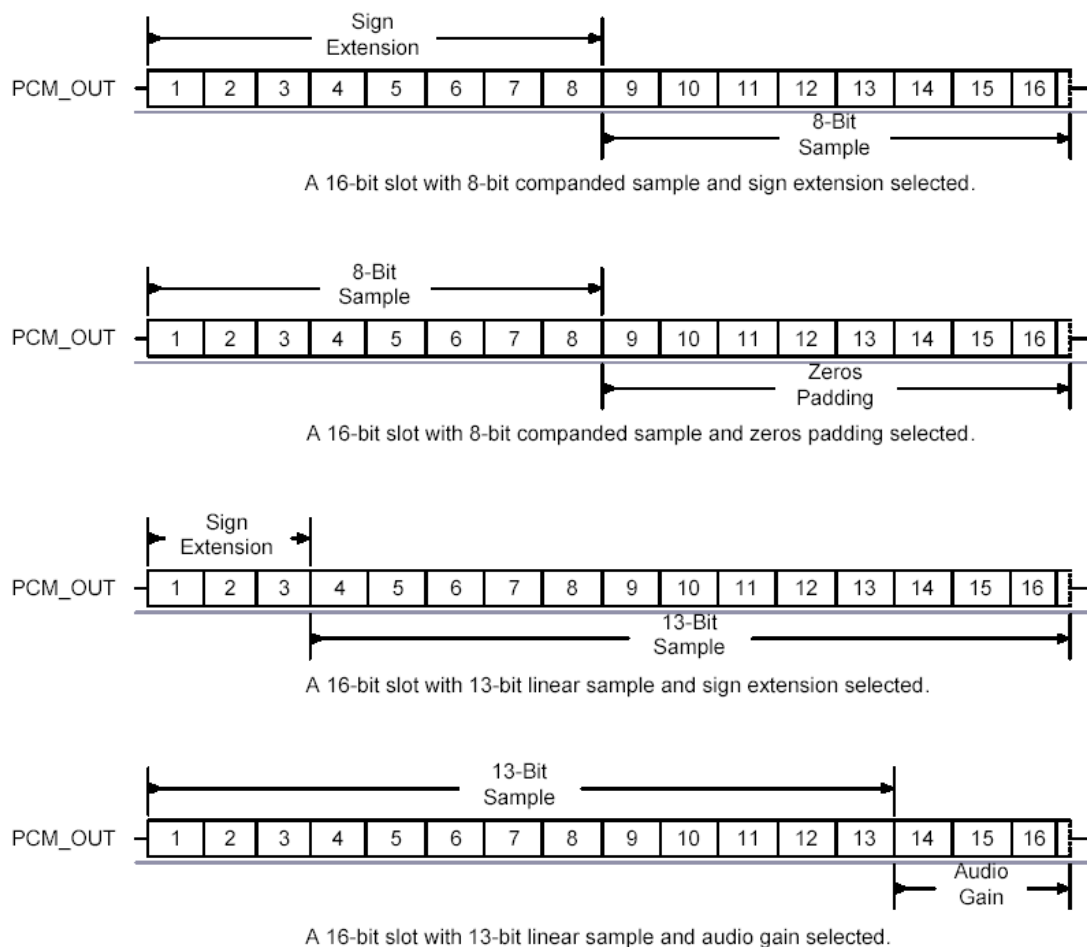


Figure 23: 16-bit Slot Length and Sample Formats

9.7 Additional Features

WT41 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.

9.8 PCM_CLK and PCM_SYNC Generation

WT41 has two methods of generating PCM_CLK and PCM_SYNC in master mode. The first is generating these signals by DDS from BlueCore4-External internal 4MHz clock. Using this mode limits PCM_CLK to 128, 256 or 512kHz and PCM_SYNC to 8kHz. The second is generating PCM_CLK and PCM_SYNC by DDS from an internal 48MHz clock (which allows a greater range of frequencies to be generated with low jitter but consumes more power). This second method is selected by setting bit 48M_PCM_CLK_GEN_EN in PSKEY_PCM_CONFIG32. When in this mode and with long frame sync, the length of PCM_SYNC can be either 8 or 16 cycles of PCM_CLK, determined by LONG_LENGTH_SYNC_EN in PSKEY_PCM_CONFIG32.

The Equation XXX describes PCM_CLK frequency when being generated using the internal 48MHz clock:

$$f = \frac{\text{CNT_RATE}}{\text{CNT_LIMIT}} \times 24\text{MHz}$$

Equation 2: PCM_CLK Frequency When Being Generated Using the Internal 48MHz Clock

The frequency of PCM_SYNC relative to PCM_CLK can be set using Equation XXX:

$$f = \frac{\text{PCM_CLK}}{\text{SYNC_LIMIT} \times 8}$$

Equation 3: PCM_SYNC Frequency Relative to PCM_CLK

CNT_RATE, CNT_LIMIT and SYNC_LIMIT are set using PSKEY_PCM_LOW_JITTER_CONFIG. As an example, to generate PCM_CLK at 512kHz with PCM_SYNC at 8kHz, set PSKEY_PCM_LOW_JITTER_CONFIG to 0x08080177.

9.9 PCM Configuration

The PCM configuration is set using two PS Keys, PSKEY_PCM_CONFIG32 detailed in Table XXX and PSKEY_PCM_LOW_JITTER_CONFIG in Table XXX. The default for PSKEY_PCM_CONFIG32 is 0x00800000, i.e., first slot following sync is active, 13-bit linear voice format, long frame sync and interface master generating 256kHz PCM_CLK from 4MHz internal clock with no tri-state of PCM_OUT.

| Name | Bit position | Description |
|----------------------------|--------------|--|
| - | 0 | Set to 0 |
| SLAVE MODE EN | 1 | 0 selects Master mode with internal generation of PCM_CLK and PCM_SYNC. 1 selects Slave mode requiring externally generated PCM_CLK and PCM_SYNC. This should be set to 1 if 48M_PCM_CLK_GEN_EN (bit 11) is set. |
| SHORT SYNC EN | 2 | 0 selects long frame sync (rising edge indicates start of frame), 1 selects short frame sync (falling edge indicates start of frame). |
| - | 3 | Set to 0 |
| SIGN EXTENDED EN | 4 | 0 selects padding of 8 or 13-bit voice sample into a 16-bit slot by inserting extra LSBs, 1 selects sign extension. When padding is selected with 3-bit voice sample, the 3 padding bits are the audio gain setting; with 8-bit samples the 8 padding bits are zeroes. |
| LSB FIRST EN | 5 | 0 transmits and receives voice samples MSB first, 1 uses LSB first. |
| TX TRISTATE EN | 6 | 0 drives PCM_OUT continuously, 1 tri-states PCM_OUT immediately after the falling edge of PCM_CLK in the last bit of an active slot, assuming the next slot is not active. |
| TX TRISTATE RISING EDGE EN | 7 | 0 tristates PCM_OUT immediately after the falling edge of PCM_CLK in the last bit of an active slot, assuming the next slot is also not active. 1 tristates PCM_OUT after the rising edge of PCM_CLK. |
| SYNC SUPPRESS EN | 8 | 0 enables PCM_SYNC output when master, 1 suppresses PCM_SYNC whilst keeping PCM_CLK running. Some CODECS utilize this to enter a low power state. |
| GCI MODE EN | 9 | 1 enables GCI mode. |
| MUTE EN | 10 | 1 forces PCM_OUT to 0. |
| 48M PCM CLK GEN EN | 11 | 0 sets PCM_CLK and PCM_SYNC generation via DDS from internal 4 MHz clock, as for BlueCore4-External. 1 sets PCM_CLK and PCM_SYNC generation via DDS from internal 48 MHz clock. |
| LONG LENGTH SYNC EN | 12 | 0 sets PCM_SYNC length to 8 PCM_CLK cycles and 1 sets length to 16 PCM_CLK cycles. Only applies for long frame sync and with 48M_PCM_CLK_GEN_EN set to 1. |
| - | [20:16] | Set to 0b00000. |
| MASTER CLK RATE | [22:21] | Selects 128 (0b01), 256 (0b00), 512 (0b10) kHz PCM_CLK frequency when master and 48M_PCM_CLK_GEN_EN (bit 11) is low. |
| ACTIVE SLOT | [26:23] | Default is 0001. Ignored by firmware |
| SAMPLE_FORMAT | [28:27] | Selects between 13 (0b00), 16 (0b01), 8 (0b10) bit sample with 16 cycle slot duration 8 (0b11) bit sample 8 cycle slot duration. |

Table 18: PSKEY_PCM_CONFIG32 description

| Name | Bit position | Description |
|------------|--------------|---|
| CNT LIMIT | [12:0] | Sets PCM_CLK counter limit |
| CNT RATE | [23:16] | Sets PCM_CLK count rate. |
| SYNC LIMIT | [31:24] | Sets PCM_SYNC division relative to PCM_CLK. |

Table 19: PSKEY_PCM_LOW_JITTER_CONFIG Description

10 I/O Parallel Ports

Six lines of programmable bidirectional input/outputs (I/O) are provided. All the PIO lines are power from VDD.

PIO lines can be configured through software to have either weak or strong pull-ups or pull-downs. All PIO lines are configured as inputs with weak pull-downs at reset. Any of the PIO lines can be configured as interrupt request lines or as wake-up lines from sleep modes.

WT41 has a general purpose analogue interface pin AIO[1]. This is used to access internal circuitry and control signals. It may be configured to provide additional functionality.

Auxiliary functions available via AIO[1] include an 8-bit ADC and an 8-bit DAC. Typically the ADC is used for battery voltage measurement. Signals selectable at this pin include the band gap reference voltage and a variety of clock signals: 48, 24, 16, 8MHz and the XTAL clock frequency. When used with analogue signals, the voltage range is constrained by the analogue supply voltage internally to the module (1.8V). When configured to drive out digital level signals (e.g., clocks), the output voltage level is determined by VDD.

10.1 PIO Defaults

Bluegiga cannot guarantee that these terminal functions remain the same. Refer to the software release note for the implementation of these PIO lines, as they are firmware build-specific.

11 Reset

WT41 may be reset from several sources: RESET pin, power on reset, a UART break character or via software configured watchdog timer. The RESET pin is an active low reset and is internally filtered using the internal low frequency clock oscillator. A reset will be performed between 1.5 and 4.0ms following RESETB being active. It is recommended that RESET be applied for a period greater than 5ms.

The power on reset occurs when the VDD_CORE supply internally to the module falls below typically 1.5V and is released when VDD_CORE rises above typically 1.6V. At reset the digital I/O pins are set to inputs for bidirectional pins and outputs are tri-state.

The reset should be held active at power up until all the supply voltages have stabilized to ensure correct operation of the internal flash memory. Following figure shows an example of a simple power up reset circuit. Time constant of the RC circuitry is set so that the supply voltage is safely stabilized before the reset deactivates.

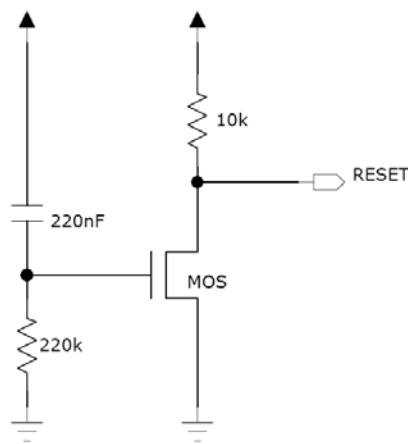


Figure 24: Example of a simple power on reset circuit.

11.1 Pin States on Reset

| PIN NAME | STATE |
|-----------------|--------------------------------------|
| PIO[7:2] | Input with weak pull-down |
| PCM_OUT | Tri-stated with weak pull-down |
| PCM_IN | Input with weak pull-down |
| PCM_SYNC | Input with weak pull-down |
| PCM_CLK | Input with weak pull-down |
| UART_TX | Output tristated with weak pull-up |
| UART_RX | Input with weak pull-down |
| UART_RTS | Output tristated with weak pull-up |
| UART_CTS | Input with weak pull-down |
| USB+ | Input with weak pull-down |
| USB- | Input with weak pull-down |
| SPI_CSB | Input with weak pull-down |
| SPI_CLK | Input with weak pull-down |
| SPI_MOSI | Input with weak pull-down |
| SPI_MISO | Output tristated with weak pull-down |
| AIO[1] | Output, driving low |

Table 20: Pin States on Reset

12 Certifications

WT41 is compliant to the following specifications.

12.1 Bluetooth

WT41 module is *Bluetooth* qualified and listed as a controller subsystem and it is Bluetooth compliant to the following profiles of the core spec version 2.1/2.1+EDR.

TBA

12.2 FCC

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.

FCC RF Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This transmitter is considered as mobile device and should not be used closer than 20 cm from a human body. To allow portable use in a known host class 2 permissive change is required. Please contact support@bluegiga.com for detailed information.

Note:

When using WT41-A or WT41-N the end product must display an exterior label with the following detail incorporated: "Contains Transmitter Module FCC ID: QOQWT41"

12.3CE

WT41 meets the requirements of the standards below and hence fulfills the requirements of EMC Directive 89/336/EEC as amended by Directives 92/31/EEC and 93/68/EEC within CE marking requirement.

- EMC (immunity only) EN 301 489-17 V.1.3.3 in accordance with EN 301 489-1 V1.8.1
- Radiated emissions EN 300 328 V1.7.1

12.4 Industry Canada (IC)

WT41 meets Industry Canada's procedural and specification requirements for certification.

Industry Canada ID: 5123A-BGTWT41

12.5 Japan

WT41-A is certified for Japanese market with certification number 2011093/01. The rated transmit power is 1mW/MHz without AFH (adaptive frequency hopping). Japan's regulations limit the maximum spectral power density to 3mW/MHz. When using AFH the number of active channels can be as low as 20 which will effectively increase the spectral power density. Thus when AFH is in use the transmit power must be decreased nominally to 13 dBm to meet Japan regulations.



Figure 25: Identification code for Japanese market

12.6 Qualified Antenna Types for WT41-N

This device has been designed to operate with the antennas listed below, and having a maximum gain of 2 dB. Antennas not included in this list or having a gain greater than 2 dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

| Qualified Antenna Types for WT41-N | |
|------------------------------------|--------------|
| Antenna Type | Maximum Gain |
| Dipole | 2.3 dBi |

Table 21: Qualified Antenna Types for WT41-N

Any antenna that is of the same type and of equal or less directional gain as listed in table 14 can be used without a need for retesting. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication. Using an antenna of a different type or gain more than 2.2 dBi will require additional testing for FCC, CE and IC. Please, contact support@bluegiga.com for more information.

13 Contact Information

Sales: sales@bluegiga.com

Technical support: support@bluegiga.com
<http://www.bluegiga.com/techforum/>

Orders: orders@bluegiga.com

Head Office / Finland:

Phone: +358-9-4355 060

Fax: +358-9-4355 0660

Street Address:

Sinikalliontie 5A

02630 ESPOO

FINLAND

Postal address:

P.O. BOX 120

02631 ESPOO

FINLAND

Sales Office / USA:

Phone: (781) 556-1039

Bluegiga Technologies, Inc.

99 Derby Street, Suite 200 Hingham, MA 02043