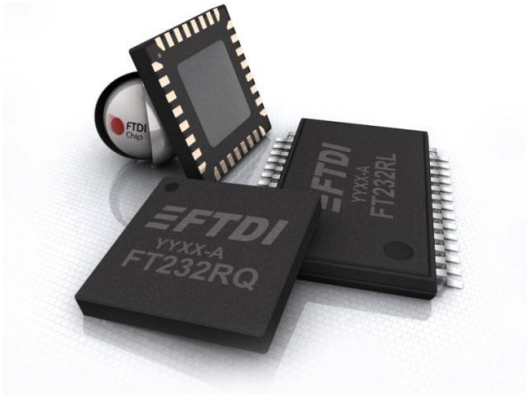
Future Technology Devices International Ltd.

FT232R USB UART IC



The FT232R is a USB to serial UART interface with the following advanced features:

- Single chip USB to asynchronous serial data transfer interface.
- Entire USB protocol handled on the chip. No USB specific firmware programming required.
- Fully integrated 1024 bit EEPROM storing device descriptors and CBUS I/O configuration.
- Fully integrated USB termination resistors.
- Fully integrated clock generation with no external crystal required plus optional clock output selection enabling a glue-less interface to external MCU or FPGA.
- Data transfer rates from 300 baud to 3 Mbaud (RS422, RS485, RS232) at TTL levels.
- 128 byte receive buffer and 256 byte transmit buffer utilising buffer smoothing technology to allow for high data throughput.
- FTDI's royalty-free Virtual Com Port (VCP) and Direct (D2XX) drivers eliminate the requirement for USB driver development in most cases.
- Unique USB FTDIChip-ID™ feature.
- Configurable CBUS I/O pins.
- Transmit and receive LED drive signals.
- UART interface support for 7 or 8 data bits, 1 or 2 stop bits and odd / even / mark / space / no parity
- FIFO receive and transmit buffers for high data throughput.
- Synchronous and asynchronous bit bang interface options with RD# and WR# strobes.
- Device supplied pre-programmed with unique USB serial number.
- Supports bus powered, self powered and high-power bus powered USB configurations.
- Integrated +3.3V level converter for USB I/O.
- Integrated level converter on UART and CBUS for interfacing to between +1.8V and +5V logic.
- True 5V/3.3V/2.8V/1.8V CMOS drive output and TTL input.
- Configurable I/O pin output drive strength.
- Integrated power-on-reset circuit.
- Fully integrated AVCC supply filtering - no external filtering required.
- UART signal inversion option.
- +3.3V (using external oscillator) to +5.25V (internal oscillator) Single Supply Operation.
- Low operating and USB suspend current.
- Low USB bandwidth consumption.
- UHCI/OHCI/EHCI host controller compatible.
- USB 2.0 Full Speed compatible.
- -40°C to 85°C extended operating temperature range.
- Available in compact Pb-free 28 Pin SSOP and QFN-32 packages (both RoHS compliant).

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1 Typical Applications

- USB to RS232/RS422/RS485 Converters
- Upgrading Legacy Peripherals to USB
- Cellular and Cordless Phone USB data transfer cables and interfaces
- Interfacing MCU/PLD/FPGA based designs to USB
- USB Audio and Low Bandwidth Video data transfer
- PDA to USB data transfer
- USB Smart Card Readers
- USB Instrumentation
- USB Industrial Control
- USB MP3 Player Interface
- USB FLASH Card Reader and Writers
- Set Top Box PC - USB interface
- USB Digital Camera Interface
- USB Hardware Modems
- USB Wireless Modems
- USB Bar Code Readers
- USB Software and Hardware Encryption Dongles

1.1 Driver Support

Royalty free VIRTUAL COM PORT (VCP) DRIVERS for...

- Windows 98, 98SE, ME, 2000, Server 2003, XP and Server 2008
- Windows 7 32,64-bit
- Windows XP and XP 64-bit
- Windows Vista and Vista 64-bit
- Windows XP Embedded
- Windows CE 4.2, 5.0 and 6.0
- Mac OS 8/9, OS-X
- Linux 2.4 and greater

Royalty free D2XX *Direct* Drivers (USB Drivers + DLL S/W Interface)

- Windows 98, 98SE, ME, 2000, Server 2003, XP and Server 2008
- Windows 7 32,64-bit
- Windows XP and XP 64-bit
- Windows Vista and Vista 64-bit
- Windows XP Embedded
- Windows CE 4.2, 5.0 and 6.0
- Linux 2.4 and greater

The drivers listed above are all available to download for free from FTDI website (www.ftdichip.com). Various 3rd party drivers are also available for other operating systems - see FTDI website (www.ftdichip.com) for details.

For driver installation, please refer to http://www.ftdichip.com/Documents/InstallGuides.htm

1.2 Part Numbers

Part Number	Package
FT232RQ-xxxx	32 Pin QFN
FT232RL-xxxx	28 Pin SSOP

Note: Packing codes for xxxx is:

- Reel: Taped and Reel, (SSOP is 2,000pcs per reel, QFN is 6,000pcs per reel).
- Tube: Tube packing, 47pcs per tube (SSOP only)
- Tray: Tray packing, 490pcs per tray (QFN only)

For example: FT232RQ-Reel is 6,000pcs taped and reel packing

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1.3 USB Compliant

The FT232R is fully compliant with the USB 2.0 specification and has been given the USB-IF Test-ID (TID) 40680004.



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2 FT232R Block Diagram

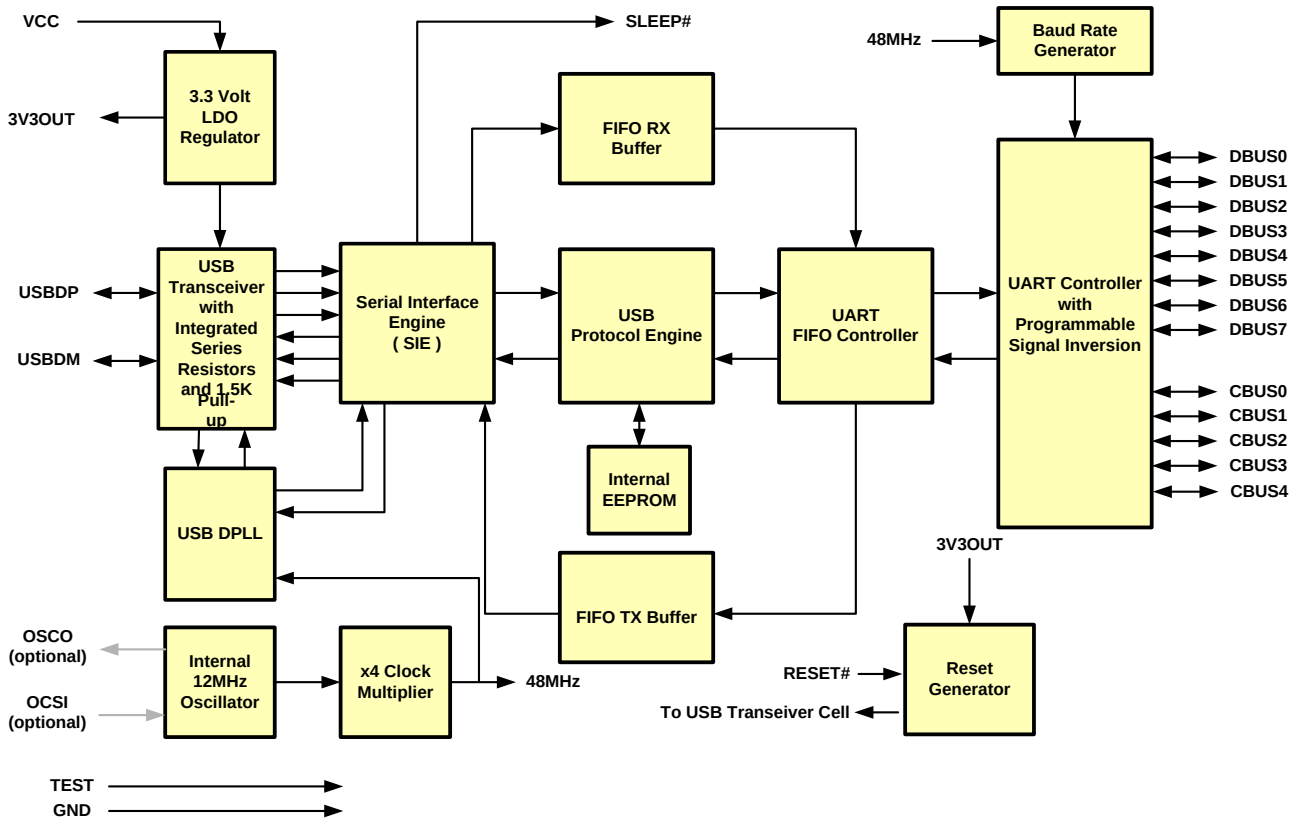


Figure 2.1 FT232R Block Diagram

For a description of each function please refer to Section 4.

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3 Device Pin Out and Signal Description

3.1 28-LD SSOP Package

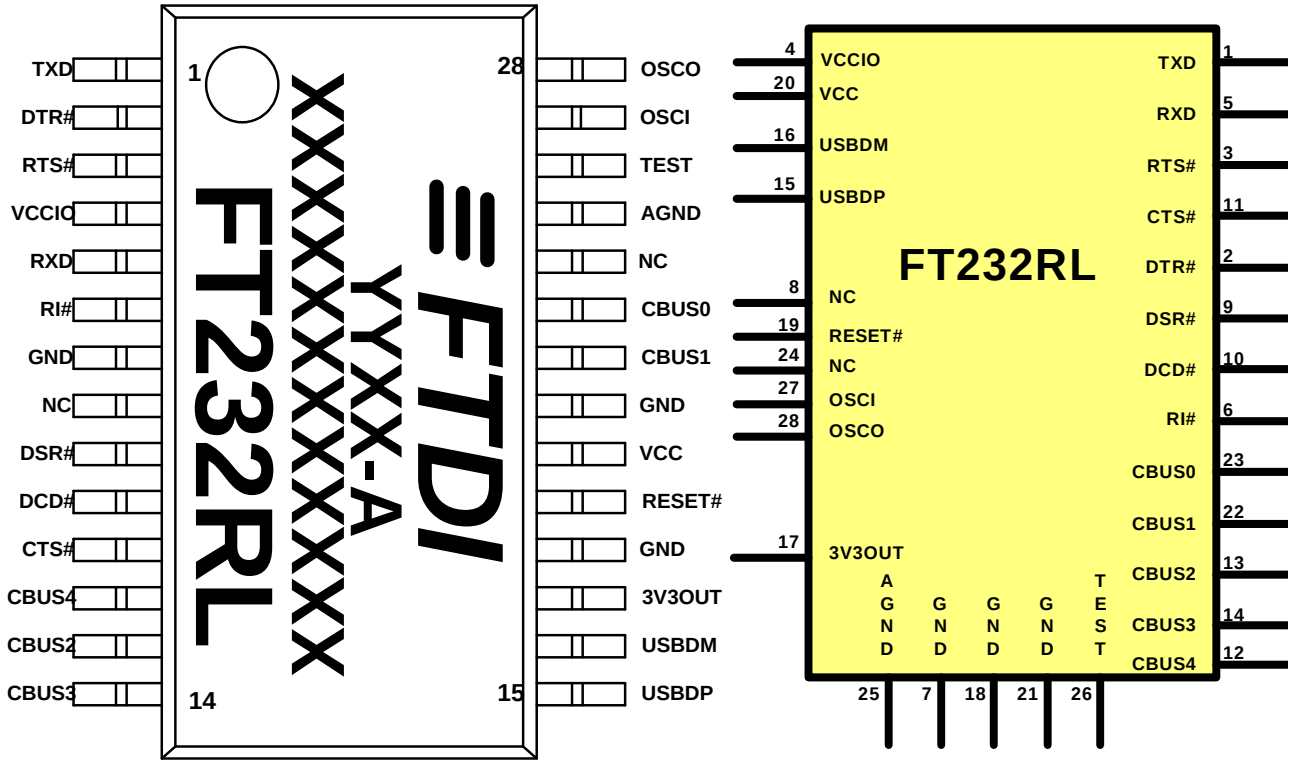


Figure 3.1 SSOP Package Pin Out and Schematic Symbol

3.2 SSOP Package Pin Out Description

Note: The convention used throughout this document for active low signals is the signal name followed by a #

Pin No.	Name	Type	Description
15	USBDP	I/O	USB Data Signal Plus, incorporating internal series resistor and 1.5kΩ pull up resistor to 3.3V.
16	USBDM	I/O	USB Data Signal Minus, incorporating internal series resistor.

Table 3.1 USB Interface Group

Pin No.	Name	Type	Description
4	VCCIO	PWR	+1.8V to +5.25V supply to the UART Interface and CBUS group pins (1...3, 5, 6, 9...14, 22, 23). In USB bus powered designs connect this pin to 3V3OUT pin to drive out at +3.3V levels, or connect to VCC to drive out at 5V CMOS level. This pin can also be supplied with an external +1.8V to +2.8V supply in order to drive outputs at lower levels. It should be noted that in this case this supply should originate from the same source as the supply to VCC. This means that in bus powered designs a regulator which is supplied by the +5V on the USB bus should be used.
7, 18, 21	GND	PWR	Device ground supply pins

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Pin No.	Name	Type	Description
17	3V3OUT	Output	+3.3V output from integrated LDO regulator. This pin should be decoupled to ground using a 100nF capacitor. The main use of this pin is to provide the internal +3.3V supply to the USB transceiver cell and the internal 1.5kΩ pull up resistor on USBDP. Up to 50mA can be drawn from this pin to power external logic if required. This pin can also be used to supply the VCCIO pin.
20	VCC	PWR	+3.3V to +5.25V supply to the device core. (see Note 1)
25	AGND	PWR	Device analogue ground supply for internal clock multiplier

Table 3.2 Power and Ground Group

Pin No.	Name	Type	Description
8, 24	NC	NC	No internal connection
19	RESET#	Input	Active low reset pin. This can be used by an external device to reset the FT232R. If not required can be left unconnected, or pulled up to VCC.
26	TEST	Input	Puts the device into IC test mode. Must be tied to GND for normal operation, otherwise the device will appear to fail.
27	OSCI	Input	Input 12MHz Oscillator Cell. Optional – Can be left unconnected for normal operation. (see Note 2)
28	OSCO	Output	Output from 12MHZ Oscillator Cell. Optional – Can be left unconnected for normal operation if internal Oscillator is used. (see Note 2)

Table 3.3 Miscellaneous Signal Group

Pin No.	Name	Type	Description
1	TXD	Output	Transmit Asynchronous Data Output.
2	DTR#	Output	Data Terminal Ready Control Output / Handshake Signal.
3	RTS#	Output	Request to Send Control Output / Handshake Signal.
5	RXD	Input	Receiving Asynchronous Data Input.
6	RI#	Input	Ring Indicator Control Input. When remote wake up is enabled in the internal EEPROM taking RI# low (20ms active low pulse) can be used to resume the PC USB host controller from suspend.
9	DSR#	Input	Data Set Ready Control Input / Handshake Signal.
10	DCD#	Input	Data Carrier Detect Control Input.
11	CTS#	Input	Clear To Send Control Input / Handshake Signal.
12	CBUS4	I/O	Configurable CBUS output only Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is SLEEP#. See CBUS Signal Options, Table 3.9.
13	CBUS2	I/O	Configurable CBUS I/O Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is TXDEN. See CBUS Signal Options, Table 3.9.

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Pin No.	Name	Type	Description
14	CBUS3	I/O	Configurable CBUS I/O Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is PWREN#. See CBUS Signal Options, Table 3.9. PWREN# should be used with a 10kΩ resistor pull up.
22	CBUS1	I/O	Configurable CBUS I/O Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is RXLED#. See CBUS Signal Options, Table 3.9.
23	CBUS0	I/O	Configurable CBUS I/O Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is TXLED#. See CBUS Signal Options, Table 3.9.

Table 3.4 UART Interface and CUSB Group (see note 3)

Notes:

1. The minimum operating voltage VCC must be +4.0V (could use VBUS=+5V) when using the internal clock generator. Operation at +3.3V is possible using an external crystal oscillator.
2. For details on how to use an external crystal, ceramic resonator, or oscillator with the FT232R, please refer Section 7.6
3. When used in Input Mode, the input pins are pulled to VCCIO via internal 200kΩ resistors. These pins can be programmed to gently pull low during USB suspend (PWREN# = "1") by setting an option in the internal EEPROM.

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3.3 QFN-32 Package

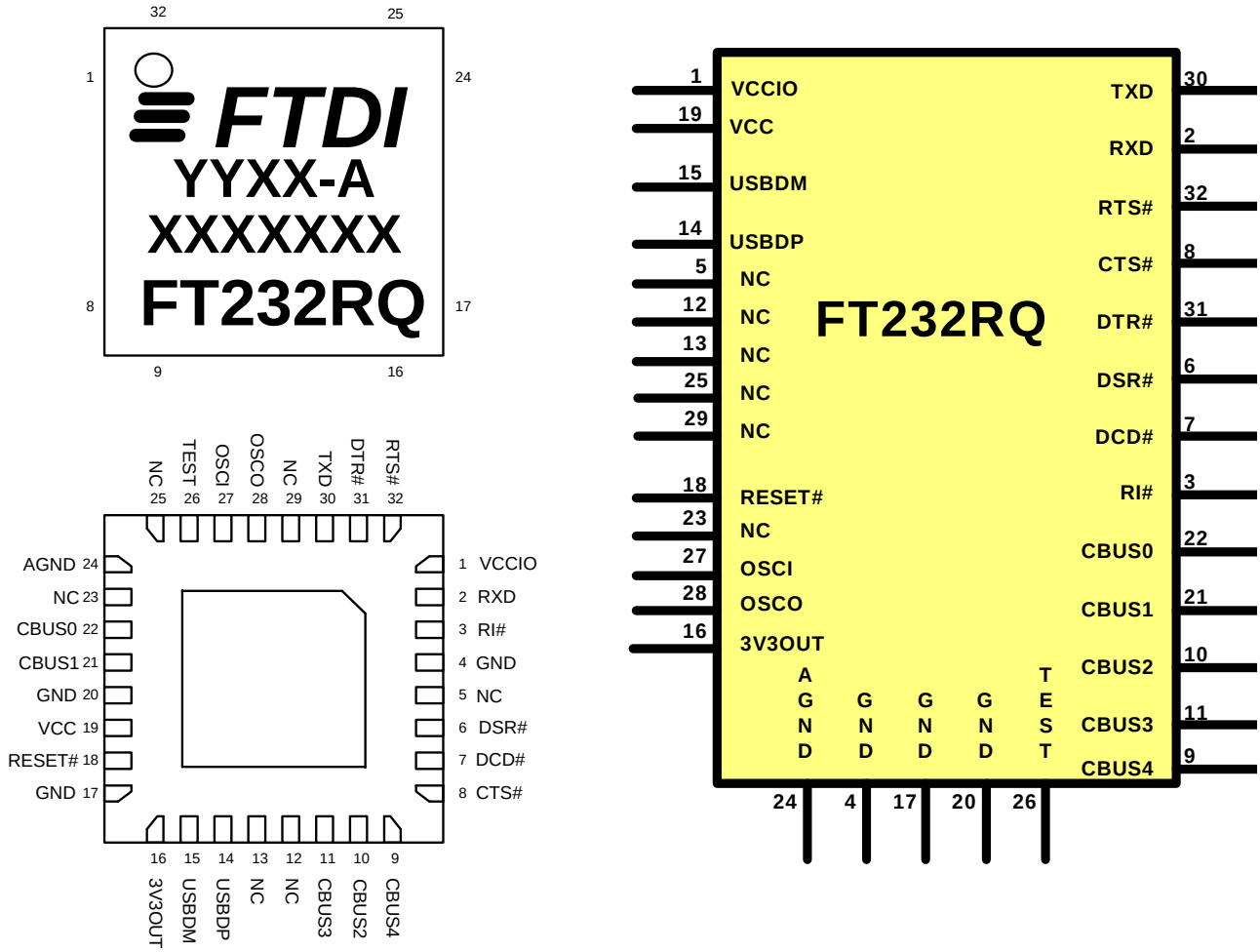


Figure 3.2 QFN-32 Package Pin Out and schematic symbol

3.4 QFN-32 Package Signal Description

Pin No.	Name	Type	Description
14	USBDP	I/O	USB Data Signal Plus, incorporating internal series resistor and 1.5kΩ pull up resistor to +3.3V.
15	USBDM	I/O	USB Data Signal Minus, incorporating internal series resistor.

Table 3.5 USB Interface Group

Pin No.	Name	Type	Description
1	VCCIO	PWR	+1.8V to +5.25V supply for the UART Interface and CBUS group pins (2, 3, 6,7,8,9,10 11, 21, 22, 30,31,32). In USB bus powered designs connect this pin to 3V3OUT to drive out at +3.3V levels, or connect to VCC to drive out at +5V CMOS level. This pin can also be supplied with an external +1.8V to +2.8V supply in order to drive out at lower levels. It should be noted that in this case this supply should originate from the same source as the supply to VCC. This means that in bus powered designs a regulator which is supplied by the +5V on the USB bus should be used.
4, 17, 20	GND	PWR	Device ground supply pins.

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Pin No.	Name	Type	Description
16	3V3OUT	Output	+3.3V output from integrated LDO regulator. This pin should be decoupled to ground using a 100nF capacitor. The purpose of this output is to provide the internal +3.3V supply to the USB transceiver cell and the internal 1.5kΩ pull up resistor on USBDP. Up to 50mA can be drawn from this pin to power external logic if required. This pin can also be used to supply the VCCIO pin.
19	VCC	PWR	+3.3V to +5.25V supply to the device core. (See Note 1).
24	AGND	PWR	Device analogue ground supply for internal clock multiplier.

Table 3.6 Power and Ground Group

Pin No.	Name	Type	Description
5, 12, 13, 23, 25, 29	NC	NC	No internal connection. Do not connect.
18	RESET#	Input	Active low reset. Can be used by an external device to reset the FT232R. If not required can be left unconnected, or pulled up to VCC.
26	TEST	Input	Puts the device into IC test mode. Must be tied to GND for normal operation, otherwise the device will appear to fail.
27	OSCI	Input	Input 12MHz Oscillator Cell. Optional – Can be left unconnected for normal operation. (See Note 2).
28	OSCO	Output	Output from 12MHZ Oscillator Cell. Optional – Can be left unconnected for normal operation if internal Oscillator is used. (See Note 2).

Table 3.7 Miscellaneous Signal Group

Pin No.	Name	Type	Description
30	TXD	Output	Transmit Asynchronous Data Output.
31	DTR#	Output	Data Terminal Ready Control Output / Handshake Signal.
32	RTS#	Output	Request to Send Control Output / Handshake Signal.
2	RXD	Input	Receiving Asynchronous Data Input.
3	RI#	Input	Ring Indicator Control Input. When remote wake up is enabled in the internal EEPROM taking RI# low (20ms active low pulse) can be used to resume the PC USB host controller from suspend.
6	DSR#	Input	Data Set Ready Control Input / Handshake Signal.
7	DCD#	Input	Data Carrier Detect Control Input.
8	CTS#	Input	Clear To Send Control Input / Handshake Signal.
9	CBUS4	I/O	Configurable CBUS output only Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is SLEEP#. See CBUS Signal Options, Table 3.9.
10	CBUS2	I/O	Configurable CBUS I/O Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is TXDEN. See CBUS Signal Options, Table 3.9.

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Pin No.	Name	Type	Description
11	CBUS3	I/O	Configurable CBUS I/O Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is PWREN#. See CBUS Signal Options, Table 3.9. PWREN# should be used with a 10kΩ resistor pull up.
21	CBUS1	I/O	Configurable CBUS I/O Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is RXLED#. See CBUS Signal Options, Table 3.9.
22	CBUS0	I/O	Configurable CBUS I/O Pin. Function of this pin is configured in the device internal EEPROM. Factory default configuration is TXLED#. See CBUS Signal Options, Table 3.9.

Table 3.8 UART Interface and CBUS Group (see note 3)

Notes:

1. The minimum operating voltage VCC must be +4.0V (could use VBUS=+5V) when using the internal clock generator. Operation at +3.3V is possible using an external crystal oscillator.
2. For details on how to use an external crystal, ceramic resonator, or oscillator with the FT232R, please refer to Section 7.6.
3. When used in Input Mode, the input pins are pulled to VCCIO via internal 200kΩ resistors. These pins can be programmed to gently pull low during USB suspend (PWREN# = "1") by setting an option in the internal EEPROM.

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3.5 CBUS Signal Options

The following options can be configured on the CBUS I/O pins. CBUS signal options are common to both package versions of the FT232R. These options can be configured in the internal EEPROM using the software utility FT_PPROG or MPROG, which can be downloaded from the FTDI Utilities (www.ftdichip.com). The default configuration is described in Section 8.

CBUS Signal Option	Available On CBUS Pin	Description
TXDEN	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	Enable transmit data for RS485
PWREN#	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	Output is low after the device has been configured by USB, then high during USB suspend mode. This output can be used to control power to external logic P-Channel logic level MOSFET switch. Enable the interface pull-down option when using the PWREN# in this way.*
TXLED#	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	Transmit data LED drive – pulses low when transmitting data via USB. See Section 7.5 for more details.
RXLED#	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	Receive data LED drive – pulses low when receiving data via USB. See Section 7.5 for more details.
TX&RXLED#	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	LED drive – pulses low when transmitting or receiving data via USB. See Section 7.5 for more details.
SLEEP#	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	Goes low during USB suspend mode. Typically used to power down an external TTL to RS232 level converter IC in USB to RS232 converter designs.
CLK48	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	48MHz Clock output.**
CLK24	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	24 MHz Clock output.**
CLK12	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	12 MHz Clock output.**
CLK6	CBUS0, CBUS1, CBUS2, CBUS3, CBUS4	6 MHz Clock output.**
CBitBangI/O	CBUS0, CBUS1, CBUS2, CBUS3	CBUS bit bang mode option. Allows up to 4 of the CBUS pins to be used as general purpose I/O. Configured individually for CBUS0, CBUS1, CBUS2 and CBUS3 in the internal EEPROM. A separate application note, AN232R-01, available from FTDI website (www.ftdichip.com) describes in more detail how to use CBUS bit bang mode.
BitBangWRn	CBUS0, CBUS1, CBUS2, CBUS3	Synchronous and asynchronous bit bang mode WR# strobe output.
BitBangRDn	CBUS0, CBUS1, CBUS2, CBUS3	Synchronous and asynchronous bit bang mode RD# strobe output.

Table 3.9 CBUS Configuration Control

* PWREN# must be used with a 10kΩ resistor pull up.

**When in USB suspend mode the outputs clocks are also suspended.

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4 Function Description

The FT232R is a USB to serial UART interface device which simplifies USB to serial designs and reduces external component count by fully integrating an external EEPROM, USB termination resistors and an integrated clock circuit which requires no external crystal, into the device. It has been designed to operate efficiently with a USB host controller by using as little as possible of the total USB bandwidth available.

4.1 Key Features

Functional Integration. Fully integrated EEPROM, USB termination resistors, clock generation, AVCC filtering, POR and LDO regulator.

Configurable CBUS I/O Pin Options. The fully integrated EEPROM allows configuration of the Control Bus (CBUS) functionality, signal inversion and drive strength selection. There are 5 configurable CBUS I/O pins. These configurable options are

1. **TXDEN** - transmit enable for RS485 designs.
2. **PWREN#** - Power control for high power, bus powered designs.
3. **TXLED#** - for pulsing an LED upon transmission of data.
4. **RXLED#** - for pulsing an LED upon receiving data.
5. **TX&RXLED#** - which will pulse an LED upon transmission OR reception of data**.**
6. **SLEEP#** - indicates that the device going into USB suspend mode.
7. **CLK48 / CLK24 / CLK12 / CLK6** - 48MHz, 24MHz, 12MHz, and 6MHz clock output signal options.

The CBUS pins can also be individually configured as GPIO pins, similar to asynchronous bit bang mode. It is possible to use this mode while the UART interface is being used, thus providing up to 4 general purpose I/O pins which are available during normal operation. An application note, AN232R-01, available from FTDI website (www.ftdichip.com) describes this feature.

The CBUS lines can be configured with any one of these output options by setting bits in the internal EEPROM. The device is supplied with the most commonly used pin definitions pre-programmed - see Section 8 for details.

Asynchronous Bit Bang Mode with RD# and WR# Strobes. The FT232R supports FTDI's previous chip generation bit-bang mode. In bit-bang mode, the eight UART lines can be switched from the regular interface mode to an 8-bit general purpose I/O port. Data packets can be sent to the device and they will be sequentially sent to the interface at a rate controlled by an internal timer (equivalent to the baud rate pre-scaler). With the FT232R device this mode has been enhanced by outputting the internal RD# and WR# strobes signals which can be used to allow external logic to be clocked by accesses to the bit-bang I/O bus. This option will be described more fully in a separate application note available from FTDI website (www.ftdichip.com).

Synchronous Bit Bang Mode. The FT232R supports synchronous bit bang mode. This mode differs from asynchronous bit bang mode in that the interface pins are only read when the device is written to. This makes it easier for the controlling program to measure the response to an output stimulus as the data returned is synchronous to the output data. An application note, AN232R-01, available from FTDI website (www.ftdichip.com) describes this feature.

FTDIChip-ID™. The FT232R also includes the new FTDIChip-ID™ security dongle feature. This FTDIChip-ID™ feature allows a unique number to be burnt into each device during manufacture. This number cannot be reprogrammed. This number is only readable over USB and forms a basis of a security dongle which can be used to protect any customer application software being copied. This allows the possibility of using the FT232R in a dongle for software licensing. Further to this, a renewable license scheme can be implemented based on the FTDIChip-ID™ number when encrypted with other information. This encrypted number can be stored in the user area of the FT232R internal EEPROM, and can be decrypted, then compared with the protected FTDIChip-ID™ to verify that a license is valid. Web based applications can be used to maintain product licensing this way. An application note, AN232R-02, available from FTDI website (www.ftdichip.com) describes this feature.

The FT232R is capable of operating at a voltage supply between +3.3V and +5V with a nominal operational mode current of 15mA and a nominal USB suspend mode current of 70µA. This allows greater margin for peripheral designs to meet the USB suspend mode current limit of 2.5mA. An integrated level converter within the UART interface allows the FT232R to interface to UART logic running at +1.8V, 2.5V, +3.3V or +5V.

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4.2 Functional Block Descriptions

The following paragraphs detail each function within the FT232R. Please refer to the block diagram shown in Figure 2.1

Internal EEPROM. The internal EEPROM in the FT232R is used to store USB Vendor ID (VID), Product ID (PID), device serial number, product description string and various other USB configuration descriptors. The internal EEPROM is also used to configure the CBUS pin functions. The FT232R is supplied with the internal EEPROM pre-programmed as described in Section 8. A user area of the internal EEPROM is available to system designers to allow storing additional data. The internal EEPROM descriptors can be programmed in circuit, over USB without any additional voltage requirement. It can be programmed using the FTDI utility software called MPROG, which can be downloaded from FTDI Utilities on the FTDI website (www.ftdichip.com).

+3.3V LDO Regulator. The +3.3V LDO regulator generates the +3.3V reference voltage for driving the USB transceiver cell output buffers. It requires an external decoupling capacitor to be attached to the 3V3OUT regulator output pin. It also provides +3.3V power to the 1.5kΩ internal pull up resistor on USBDP. The main function of the LDO is to power the USB Transceiver and the Reset Generator Cells rather than to power external logic. However, it can be used to supply external circuitry requiring a +3.3V nominal supply with a maximum current of 50mA.

USB Transceiver. The USB Transceiver Cell provides the USB 1.1 / USB 2.0 full-speed physical interface to the USB cable. The output drivers provide +3.3V level slew rate control signalling, whilst a differential input receiver and two single ended input receivers provide USB data in, Single-Ended-0 (SE0) and USB reset detection conditions respectfully. This function also incorporates the internal USB series termination resistors on the USB data lines and a 1.5kΩ pull up resistor on USBDP.

USB DPLL. The USB DPLL cell locks on to the incoming NRZI USB data and generates recovered clock and data signals for the Serial Interface Engine (SIE) block.

Internal 12MHz Oscillator - The Internal 12MHz Oscillator cell generates a 12MHz reference clock. This provides an input to the x4 Clock Multiplier function. The 12MHz Oscillator is also used as the reference clock for the SIE, USB Protocol Engine and UART FIFO controller blocks.

Clock Multiplier / Divider. The Clock Multiplier / Divider takes the 12MHz input from the Internal Oscillator function and generates the 48MHz, 24MHz, 12MHz and 6MHz reference clock signals. The 48Mz clock reference is used by the USB DPLL and the Baud Rate Generator blocks.

Serial Interface Engine (SIE). The Serial Interface Engine (SIE) block performs the parallel to serial and serial to parallel conversion of the USB data. In accordance with the USB 2.0 specification, it performs bit stuffing/un-stuffing and CRC5/CRC16 generation. It also checks the CRC on the USB data stream.

USB Protocol Engine. The USB Protocol Engine manages the data stream from the device USB control endpoint. It handles the low level USB protocol requests generated by the USB host controller and the commands for controlling the functional parameters of the UART in accordance with the USB 2.0 specification chapter 9.

FIFO RX Buffer (128 bytes). Data sent from the USB host controller to the UART via the USB data OUT endpoint is stored in the FIFO RX (receive) buffer. Data is removed from the buffer to the UART transmit register under control of the UART FIFO controller. (Rx relative to the USB interface).

FIFO TX Buffer (256 bytes). Data from the UART receive register is stored in the TX buffer. The USB host controller removes data from the FIFO TX Buffer by sending a USB request for data from the device data IN endpoint. (Tx relative to the USB interface).

UART FIFO Controller. The UART FIFO controller handles the transfer of data between the FIFO RX and TX buffers and the UART transmit and receive registers.

UART Controller with Programmable Signal Inversion and High Drive. Together with the UART FIFO Controller the UART Controller handles the transfer of data between the FIFO RX and FIFO TX buffers and the UART transmit and receive registers. It performs asynchronous 7 or 8 bit parallel to serial and serial to parallel conversion of the data on the RS232 (or RS422 or RS485) interface.

Control signals supported by UART mode include RTS, CTS, DSR, DTR, DCD and RI. The UART Controller also provides a transmitter enable control signal pin option (TXDEN) to assist with interfacing to RS485 transceivers. RTS/CTS, DSR/DTR and XON / XOFF handshaking options are also supported. Handshaking is handled in hardware to ensure fast response times. The UART interface also supports the RS232 BREAK setting and detection conditions.

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Additionally, the UART signals can each be individually inverted and have a configurable high drive strength capability. Both these features are configurable in the EEPROM.

Baud Rate Generator - The Baud Rate Generator provides a 16x clock input to the UART Controller from the 48MHz reference clock. It consists of a 14 bit pre-scaler and 3 register bits which provide fine tuning of the baud rate (used to divide by a number plus a fraction or "sub-integer"). This determines the baud rate of the UART, which is programmable from 183 baud to 3 Mbaud.

The FT232R supports all standard baud rates and non-standard baud rates from 183 Baud up to 3 Mbaud. Achievable non-standard baud rates are calculated as follows -

Baud Rate = 3000000 / (n + *x*)

where 'n' can be any integer between 2 and 16,384 (= 2^{14}) and '*x*' can be a sub-integer of the value 0, 0.125, 0.25, 0.375, 0.5, 0.625, 0.75, or 0.875. When n = 1, *x* = 0, i.e. baud rate divisors with values between 1 and 2 are not possible.

This gives achievable baud rates in the range 183.1 baud to 3,000,000 baud. When a non-standard baud rate is required simply pass the required baud rate value to the driver as normal, and the FTDI driver will calculate the required divisor, and set the baud rate. See FTDI application note AN232B-05 on the FTDI website (www.ftdichip.com) for more details.

RESET Generator - The integrated Reset Generator Cell provides a reliable power-on reset to the device internal circuitry at power up. The RESET# input pin allows an external device to reset the FT232R.

RESET# can be tied to VCC or left unconnected if not being used.

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5 Devices Characteristics and Ratings

5.1 Absolute Maximum Ratings

The absolute maximum ratings for the FT232R devices are as follows. These are in accordance with the Absolute Maximum Rating System (IEC 60134). Exceeding these may cause permanent damage to the device.

Parameter	Value	Unit
Storage Temperature	-65°C to 150°C	Degrees C
Floor Life (Out of Bag) At Factory Ambient (30°C / 60% Relative Humidity)	168 Hours (IPC/JEDEC J-STD-033A MSL Level 3 Compliant)*	Hours
Ambient Temperature (Power Applied)	-40°C to 85°C	Degrees C
MTTF FT232RL	11162037	hours
MTTF FT232RQ	4464815	hours
VCC Supply Voltage	-0.5 to +6.00	V
DC Input Voltage – USBDP and USBDM	-0.5 to +3.8	V
DC Input Voltage – High Impedance Bidirectionals	-0.5 to + (VCC +0.5)	V
DC Input Voltage – All Other Inputs	-0.5 to + (VCC +0.5)	V
DC Output Current – Outputs	24	mA
DC Output Current – Low Impedance Bidirectionals	24	mA
Power Dissipation (VCC = 5.25V)	500	mW

Table 5.1 Absolute Maximum Ratings

* If devices are stored out of the packaging beyond this time limit the devices should be baked before use. The devices should be ramped up to a temperature of +125°C and baked for up to 17 hours.

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5.2 DC Characteristics

DC Characteristics (Ambient Temperature = -40°C to +85°C)

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCC1	VCC Operating Supply Voltage	4.0	---	5.25	V	Using Internal Oscillator
VCC1	VCC Operating Supply Voltage	3.3	---	5.25	V	Using External Crystal
VCC2	VCCIO Operating Supply Voltage	1.8	---	5.25	V	
Icc1	Operating Supply Current	---	15	---	mA	Normal Operation
Icc2	Operating Supply Current	50	70	100	µA	USB Suspend
3V3	3.3v regulator output	3.0	3.3	3.6	V	

Table 5.2 Operating Voltage and Current

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	3.2	4.1	4.9	V	I source = 2mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 2mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	**
VHys	Input Switching Hysteresis	20	25	30	mV	**

Table 5.3 UART and CBUS I/O Pin Characteristics (VCCIO = +5.0V, Standard Drive Level)

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	2.2	2.7	3.2	V	I source = 1mA
Vol	Output Voltage Low	0.3	0.4	0.5	V	I sink = 2mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	**
VHys	Input Switching Hysteresis	20	25	30	mV	**

Table 5.4 UART and CBUS I/O Pin Characteristics (VCCIO = +3.3V, Standard Drive Level)

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Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	2.1	2.6	2.8	V	I source = 1mA
Vol	Output Voltage Low	0.3	0.4	0.5	V	I sink = 2mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	**
VHys	Input Switching Hysteresis	20	25	30	mV	**

Table 5.5 UART and CBUS I/O Pin Characteristics (VCCIO = +2.8V, Standard Drive Level)

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	1.32	1.62	1.8	V	I source = 0.2mA
Vol	Output Voltage Low	0.06	0.1	0.18	V	I sink = 0.5mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	**
VHys	Input Switching Hysteresis	20	25	30	mV	**

Table 5.6 UART and CBUS I/O Pin Characteristics (VCCIO = +1.8V, Standard Drive Level)

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	3.2	4.1	4.9	V	I source = 6mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 6mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	**
VHys	Input Switching Hysteresis	20	25	30	mV	**

Table 5.7 UART and CBUS I/O Pin Characteristics (VCCIO = +5.0V, High Drive Level)

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	2.2	2.8	3.2	V	I source = 3mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 8mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	**
VHys	Input Switching Hysteresis	20	25	30	mV	**

Table 5.8 UART and CBUS I/O Pin Characteristics (VCCIO = +3.3V, High Drive Level)

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Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	2.1	2.6	2.8	V	I source = 3mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 8mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	**
VHys	Input Switching Hysteresis	20	25	30	mV	**

Table 5.9 UART and CBUS I/O Pin Characteristics (VCCIO = +2.8V, High Drive Level)

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	1.35	1.67	1.8	V	I source = 0.4mA
Vol	Output Voltage Low	0.12	0.18	0.35	V	I sink = 3mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	**
VHys	Input Switching Hysteresis	20	25	30	mV	**

Table 5.10 UART and CBUS I/O Pin Characteristics (VCCIO = +1.8V, High Drive Level)

** Only input pins have an internal 200KΩ pull-up resistor to VCCIO

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Vin	Input Switching Threshold	1.3	1.6	1.9	V	
VHys	Input Switching Hysteresis	50	55	60	mV	

Table 5.11 RESET# and TEST Pin Characteristics

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Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
UVoh	I/O Pins Static Output (High)	2.8		3.6	V	RI = 1.5kΩ to 3V3OUT (D+) RI = 15KΩ to GND (D-)
UVol	I/O Pins Static Output (Low)	0		0.3	V	RI = 1.5kΩ to 3V3OUT (D+) RI = 15kΩ to GND (D-)
UVse	Single Ended Rx Threshold	0.8		2.0	V	
UCom	Differential Common Mode	0.8		2.5	V	
UVDif	Differential Input Sensitivity	0.2			V	
UDrvZ	Driver Output Impedance	26	29	44	Ohms	See Note 1

Table 5.12 USB I/O Pin (USBDP, USBDM) Characteristics

5.3 EEPROM Reliability Characteristics

The internal 1024 Bit EEPROM has the following reliability characteristics:

Parameter	Value	Unit
Data Retention	10	Years
Read / Write Cycle	10,000	Cycles

Table 5.13 EEPROM Characteristics

5.4 Internal Clock Characteristics

The internal Clock Oscillator has the following characteristics:

Parameter	Value			Unit
	Minimum	Typical	Maximum	
Frequency of Operation (see Note 1)	11.98	12.00	12.02	MHz
Clock Period	83.19	83.33	83.47	ns
Duty Cycle	45	50	55	%

Table 5.14 Internal Clock Characteristics

Note 1: Equivalent to +/-1667ppm

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Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	2.1	2.8	3.2	V	I source = 3mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 8mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	

Table 5.15 OSCI, OSCO Pin Characteristics – see Note 1

Note1: When supplied, the FT232R is configured to use its internal clock oscillator. These characteristics only apply when an external oscillator or crystal is used.

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6 USB Power Configurations

The following sections illustrate possible USB power configurations for the FT232R. The illustrations have omitted pin numbers for ease of understanding since the pins differ between the FT232RL and FT232RQ package options.

All USB power configurations illustrated apply to both package options for the FT232R device. Please refer to Section 3 for the package option pin-out and signal descriptions.

6.1 USB Bus Powered Configuration

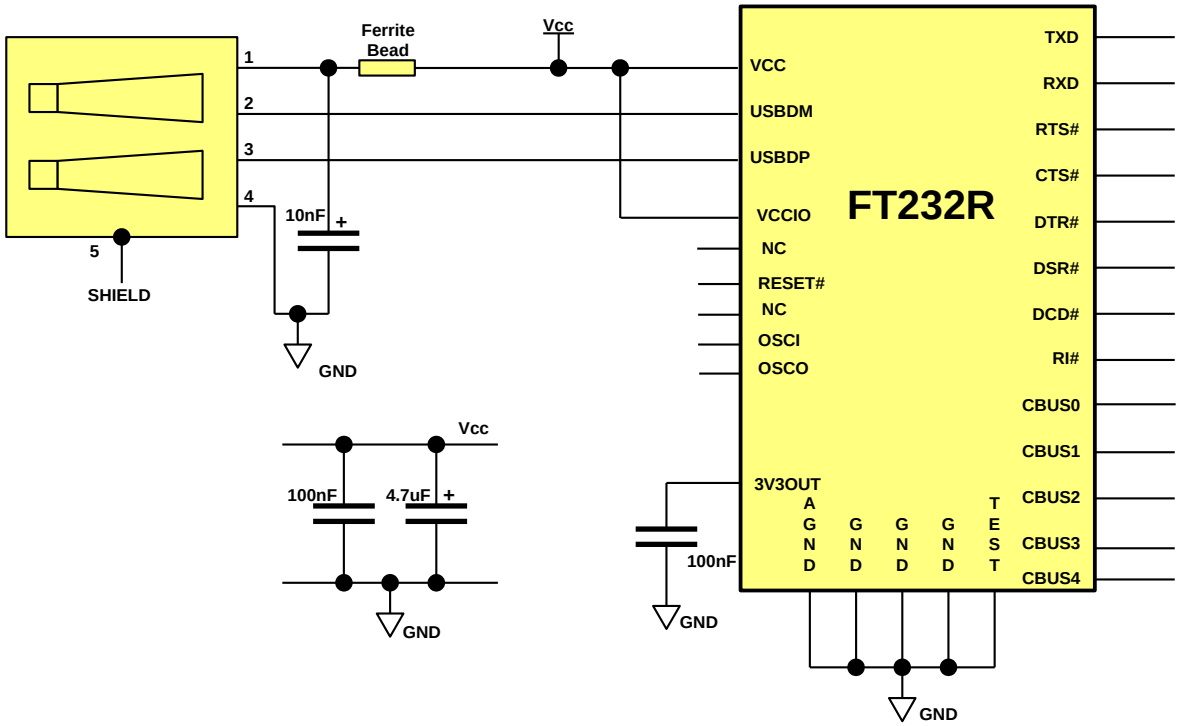


Figure 6.1 Bus Powered Configuration

Figure 6.1 Illustrates the FT232R in a typical USB bus powered design configuration. A USB bus powered device gets its power from the USB bus. Basic rules for USB bus power devices are as follows –

i) On plug-in to USB, the device should draw no more current than 100mA.
ii) In USB Suspend mode the device should draw no more than 2.5mA.
iii) A bus powered high power USB device (one that draws more than 100mA) should use one of the CBUS pins configured as PWREN# and use it to keep the current below 100mA on plug-in and 2.5mA on USB suspend.
iv) A device that consumes more than 100mA cannot be plugged into a USB bus powered hub.
v) No device can draw more than 500mA from the USB bus.

The power descriptors in the internal EEPROM of the FT232R should be programmed to match the current drawn by the device.

A ferrite bead is connected in series with the USB power supply to reduce EMI noise from the FT232R and associated circuitry being radiated down the USB cable to the USB host. The value of the Ferrite Bead depends on the total current drawn by the application. A suitable range of Ferrite Beads is available from Steward (www.steward.com), for example Steward Part # MI0805K400R-10.

Note: If using PWREN# (available using the CBUS) the pin should be pulled to VCCIO using a 10kΩ resistor.

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6.2 Self Powered Configuration

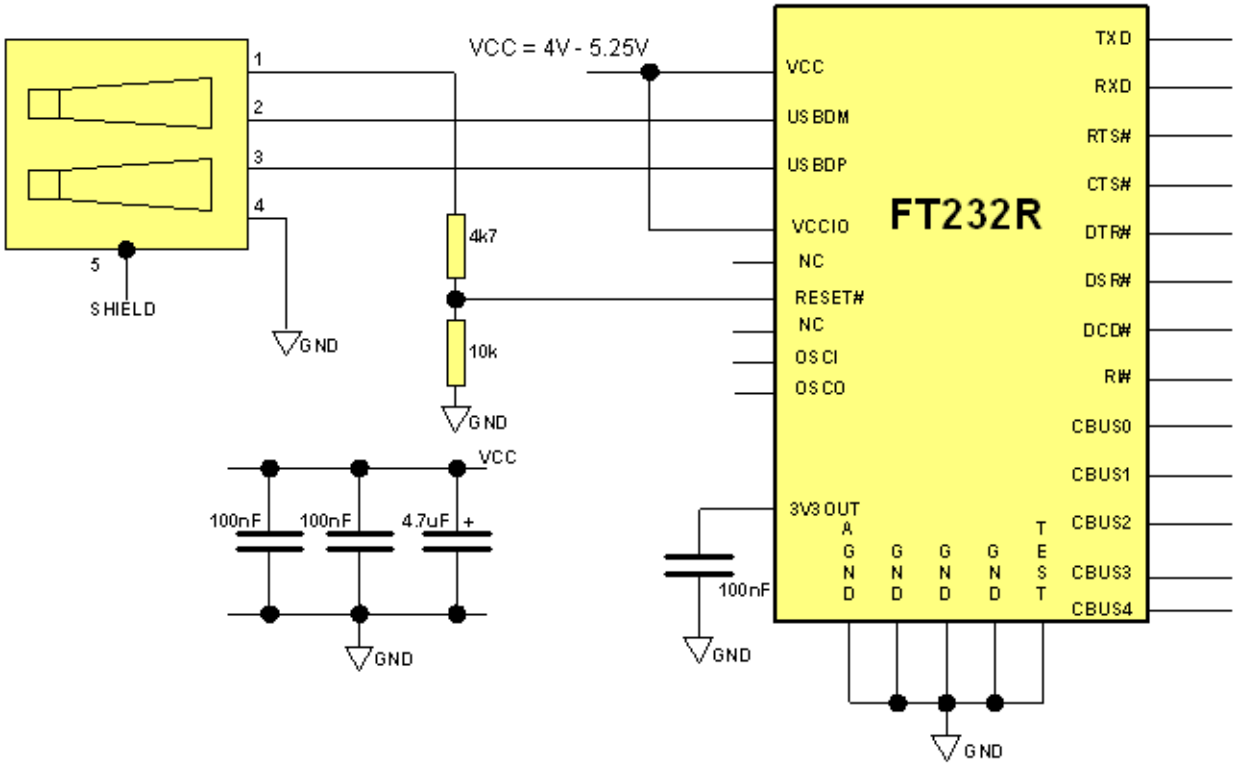


Figure 6.2 Self Powered Configuration

Figure 6.2 illustrates the FT232R in a typical USB self powered configuration. A USB self powered device gets its power from its own power supply, VCC, and does not draw current from the USB bus. The basic rules for USB self powered devices are as follows –

i) A self powered device should not force current down the USB bus when the USB host or hub controller is powered down.
ii) A self powered device can use as much current as it needs during normal operation and USB suspend as it has its own power supply.
iii) A self powered device can be used with any USB host, a bus powered USB hub or a self powered USB hub.

The power descriptor in the internal EEPROM of the FT232R should be programmed to a value of zero (self powered).

In order to comply with the first requirement above, the USB bus power (pin 1) is used to control the RESET# pin of the FT232R device. When the USB host or hub is powered up an internal 1.5kΩ resistor on USBDP is pulled up to +3.3V (generated using the 4K7 and 10k resistor network), thus identifying the device as a full speed device to the USB host or hub. When the USB host or hub is powered off, RESET# will be low and the FT232R is held in reset. Since RESET# is low, the internal 1.5kΩ resistor is not pulled up to any power supply (hub or host is powered down), so no current flows down USBDP via the 1.5kΩ pull-up resistor. Failure to do this may cause some USB host or hub controllers to power up erratically.

Figure 6.2 illustrates a self powered design which has a +4V to +5.25V supply.

Note:

1. When the FT232R is in reset, the UART interface I/O pins are tri-stated. Input pins have internal 200kΩ pull-up resistors to VCCIO, so they will gently pull high unless driven by some external logic.
2. When using internal FT232R oscillator the VCC supply voltage range must be +4.0V to 5.25V.
3. When using external oscillator the VCC supply voltage range must be +3.3V to 5.25V
   Any design which interfaces to +3.3 V or +1.8V would be having a +3.3V or +1.8V supply to VCCIO.

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6.3 USB Bus Powered with Power Switching Configuration

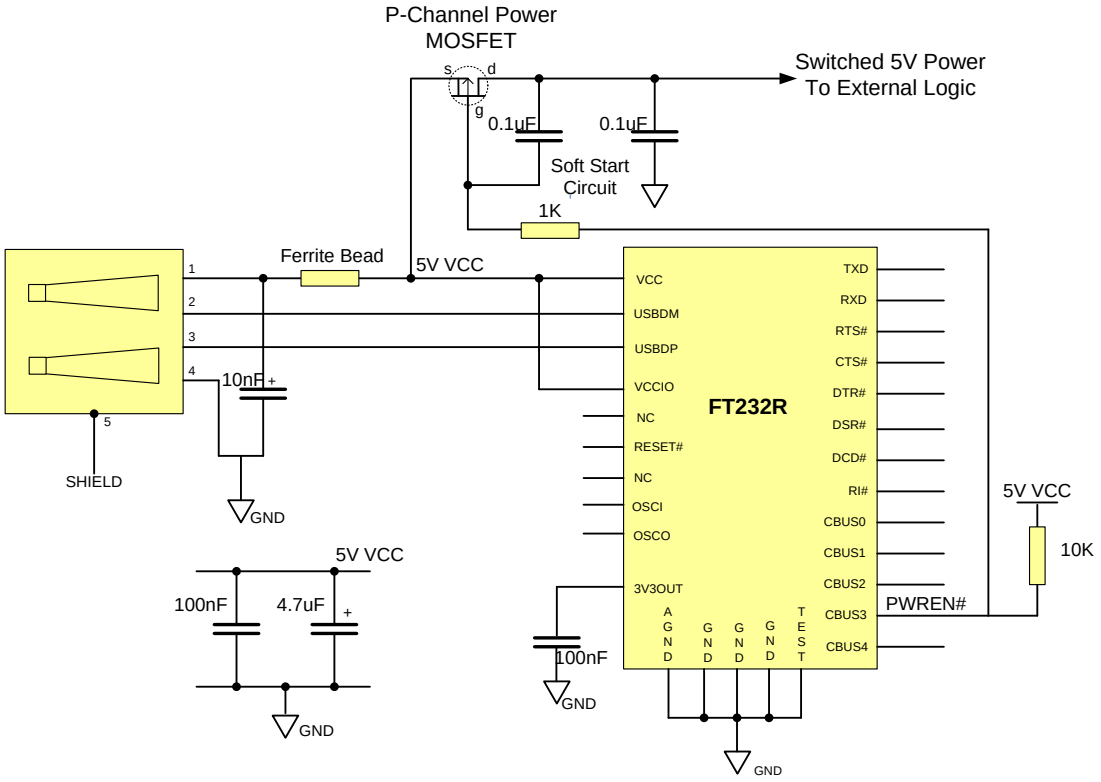


Figure 6.3 Bus Powered with Power Switching Configuration

A requirement of USB bus powered applications, is when in USB suspend mode, the application draws a total current of less than 2.5mA. This requirement includes external logic. Some external logic has the ability to power itself down into a low current state by monitoring the PWREN# signal. For external logic that cannot power itself down in this way, the FT232R provides a simple but effective method of turning off power during the USB suspend mode.

Figure 6.3 shows an example of using a discrete P-Channel MOSFET to control the power to external logic. A suitable device to do this is an International Rectifier (www.irf.com) IRLML6402, or equivalent. It is recommended that a "soft start" circuit consisting of a 1kΩ series resistor and a 0.1µF capacitor is used to limit the current surge when the MOSFET turns on. Without the soft start circuit it is possible that the transient power surge, caused when the MOSFET switches on, will reset the FT232R or the USB host/hub controller. The soft start circuit example shown in Figure 6.3 powers up with a slew rate of approximaely12.5V/ms. Thus supply voltage to external logic transitions from GND to +5V in approximately 400 microseconds.

As an alternative to the MOSFET, a dedicated power switch IC with inbuilt "soft-start" can be used. A suitable power switch IC for such an application is the Micrel (www.micrel.com) MIC2025-2BM or equivalent.

With power switching controlled designs the following should be noted:

i) The external logic to which the power is being switched should have its own reset circuitry to automatically reset the logic when power is re-applied when moving out of suspend mode.

ii) Set the Pull-down on Suspend option in the internal FT232R EEPROM.

iii) One of the CBUS Pins should be configured as PWREN# in the internal FT232R EEPROM, and used to switch the power supply to the external circuitry. This should be pulled high through a 10 kΩ resistor.

iv) For USB high-power bus powered applications (one that consumes greater than 100mA, and up to 500mA of current from the USB bus), the power consumption of the application must be set in the Max Power field in the internal FT232R EEPROM. A high-power bus powered application uses the descriptor in the internal FT232R EEPROM to inform the system of its power requirements.

v) PWREN# gets its VCC from VCCIO. For designs using 3V3 logic, ensure VCCIO is not powered down using the external logic. In this case use the +3V3OUT.

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6.4 USB Bus Powered with Selectable External Logic Supply

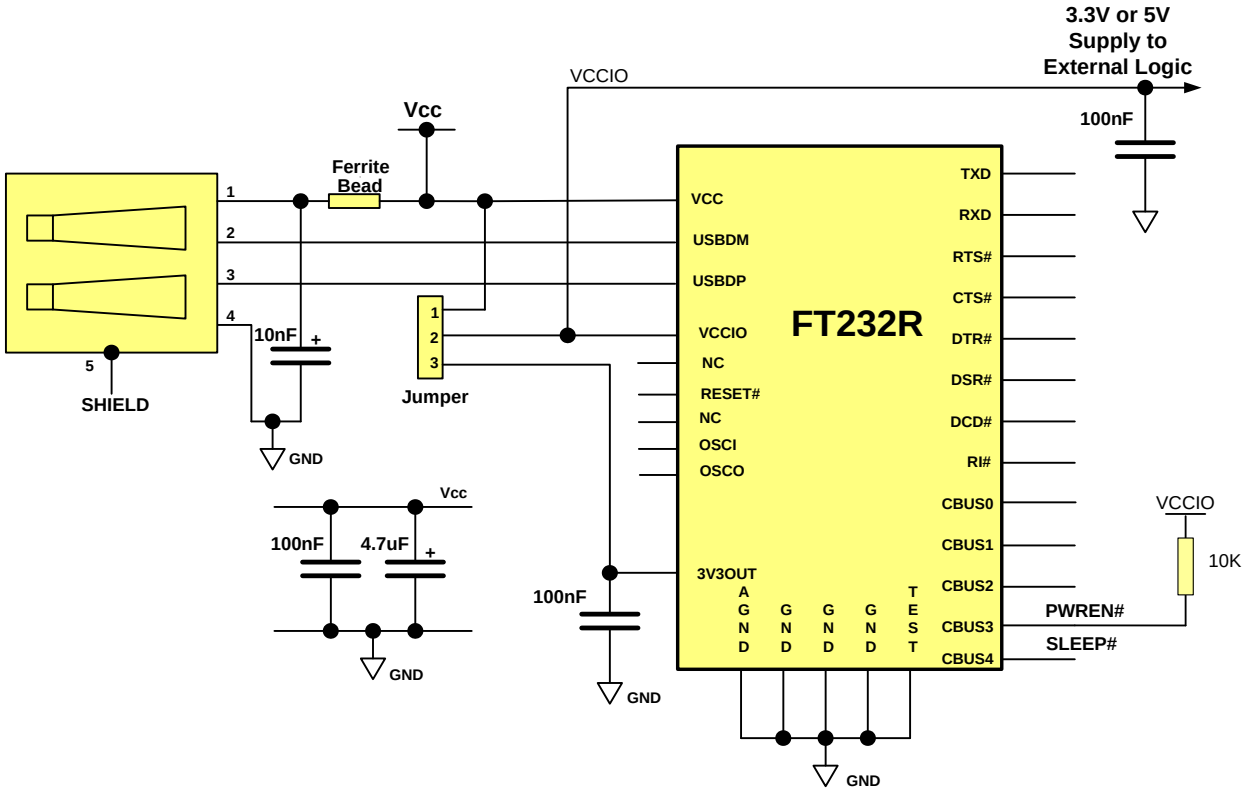


Figure 6.4 USB Bus Powered with +3.3V or +5V External Logic Power Supply

Figure 6.4 illustrates a USB bus power application with selectable external logic supply. The external logic can be selected between +3.3V and +5V using the jumper switch. This jumper is used to allow the FT232R to be interfaced with a +3.3V or +5V logic devices. The VCCIO pin is either supplied with +5V from the USB bus (jumper pins1 and 2 connected), or from the +3.3V output from the FT232R 3V3OUT pin (jumper pins 2 and 3 connected). The supply to VCCIO is also used to supply external logic.

With bus powered applications, the following should be noted:

i) To comply with the 2.5mA current supply limit during USB suspend mode, PWREN# or SLEEP# signals should be used to power down external logic in this mode. If this is not possible, use the configuration shown in Section 6.3.

ii) The maximum current sourced from the USB bus during normal operation should not exceed 100mA, otherwise a bus powered design with power switching (Section 6.3) should be used.

Another possible configuration could use a discrete low dropout (LDO) regulator which is supplied by the 5V on the USB bus to supply between +1.8V and +2.8V to the VCCIO pin and to the external logic. In this case VCC would be supplied with the +5V from the USB bus and the VCCIO would be supplied from the output of the LDO regulator. This results in the FT232R I/O pins driving out at between +1.8V and +2.8V logic levels.

For a USB bus powered application, it is important to consider the following when selecting the regulator:

i) The regulator must be capable of sustaining its output voltage with an input voltage of +4.35V. An Low Drop Out (LDO) regulator should be selected.

ii) The quiescent current of the regulator must be low enough to meet the total current requirement of <= 2.5mA during USB suspend mode.

A suitable series of LDO regulators that meets these requirements is the MicroChip/Telcom (www.microchip.com) TC55 series of devices. These devices can supply up to 250mA current and have a quiescent current of under 1µA.

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7 Application Examples

The following sections illustrate possible applications of the FT232R. The illustrations have omitted pin numbers for ease of understanding since the pins differ between the FT232RL and FT232RQ package options.

7.1 USB to RS232 Converter

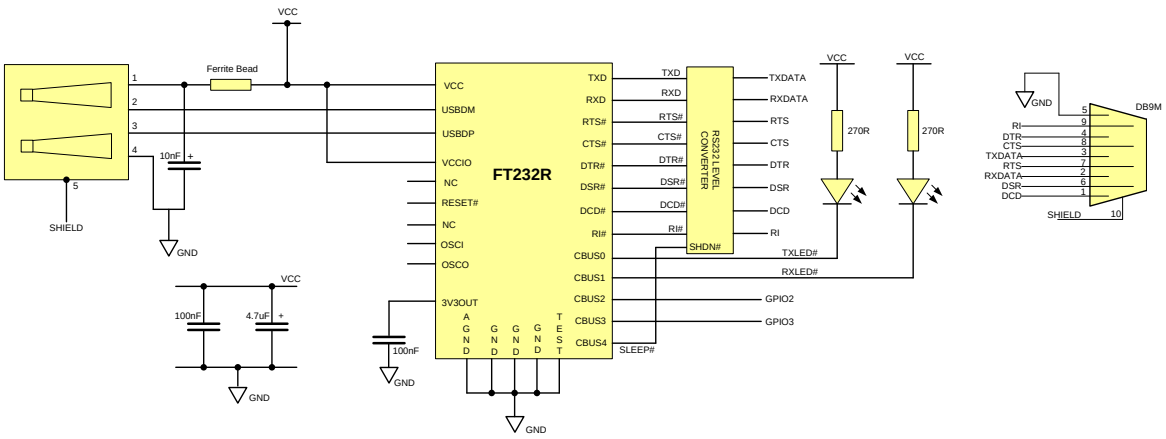


Figure 7.1 Application Example showing USB to RS232 Converter

An example of using the FT232R as a USB to RS232 converter is illustrated in Figure 7.1. In this application, a TTL to RS232 Level Converter IC is used on the serial UART interface of the FT232R to convert the TTL levels of the FT232R to RS232 levels. This level shift can be done using the popular "213" series of TTL to RS232 level converters. These "213" devices typically have 4 transmitters and 5 receivers in a 28-LD SSOP package and feature an in-built voltage converter to convert the +5V (nominal) VCC to the +/- 9 volts required by RS232. A useful feature of these devices is the SHDN# pin which can be used to power down the device to a low quiescent current during USB suspend mode.

A suitable level shifting device is the Sipex SP213EHCA which is capable of RS232 communication at up to 500k baud. If a lower baud rate is acceptable, then several pin compatible alternatives are available such as the Sipex SP213ECA, the Maxim MAX213CAI and the Analogue Devices ADM213E, which are all suitable for communication at up to 115.2k baud. If a higher baud rate is required, the Maxim MAX3245CAI device is capable of RS232 communication rates up to 1Mbaud. Note that the MAX3245 is not pin compatible with the 213 series devices and that the SHDN pin on the MAX device is active high and should be connect to PWREN# pin instead of SLEEP# pin.

In example shown, the CBUS0 and CBUS1 have been configured as TXLED# and RXLED# and are being used to drive two LEDs.

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7.2 USB to RS485 Coverter

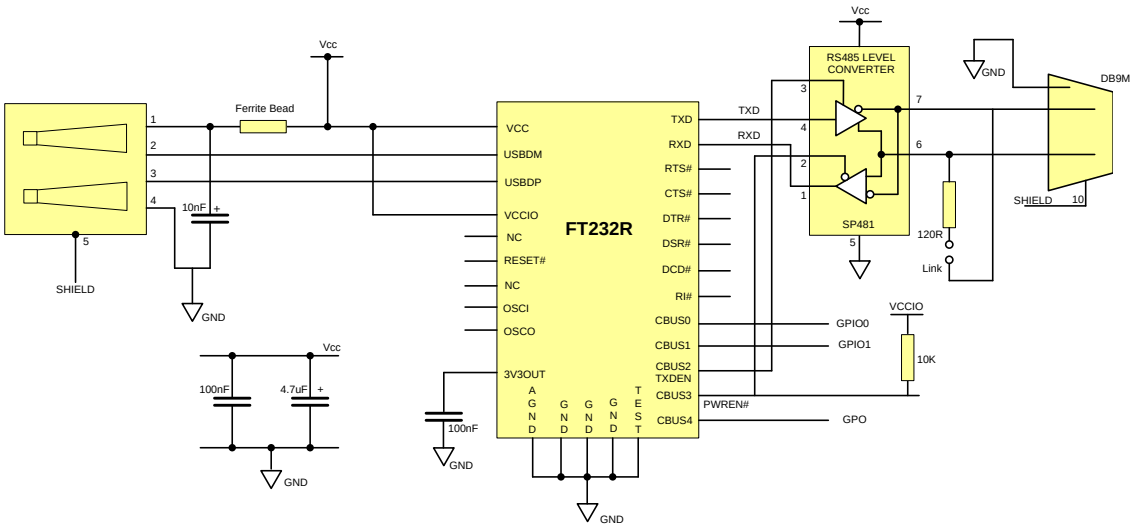


Figure 7.2 Application Example Showing USB to RS485 Converter

An example of using the FT232R as a USB to RS485 converter is shown in Figure 7.2. In this application, a TTL to RS485 level converter IC is used on the serial UART interface of the FT232R to convert the TTL levels of the FT232R to RS485 levels.

This example uses the Sipex SP481 device. Equivalent devices are available from Maxim and Analogue Devices. The SP481 is a RS485 device in a compact 8 pin SOP package. It has separate enables on both the transmitter and receiver. With RS485, the transmitter is only enabled when a character is being transmitted from the UART. The TXDEN signal CBUS pin option on the FT232R is provided for exactly this purpose and so the transmitter enable is wired to CBUS2 which has been configured as TXDEN. Similarly, CBUS3 has been configured as PWREN#. This signal is used to control the SP481's receiver enable. The receiver enable is active low, so it is wired to the PWREN# pin to disable the receiver when in USB suspend mode. CBUS2 = TXDEN and CBUS3 = PWREN# are the default device configurations of the FT232R pins.

RS485 is a multi-drop network; so many devices can communicate with each other over a two wire cable interface. The RS485 cable requires to be terminated at each end of the cable. A link (which provides the 120Ω termination) allows the cable to be terminated if the SP481 is physically positioned at either end of the cable.

In this example the data transmitted by the FT232R is also present on the receive path of the SP481.This is a common feature of RS485 and requires the application software to remove the transmitted data from the received data stream. With the FT232R it is possible to do this entirely in hardware by modifying the example shown in Figure 7.2 by logically OR'ing the FT232R TXDEN and the SP481 receiver output and connecting the output of the OR gate to the RXD of the FT232R.

Note that the TXDEN is activated 1 bit period before the start bit. TXDEN is deactivated at the same time as the stop bit. This is not configurable.

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7.3 USB to RS422 Converter

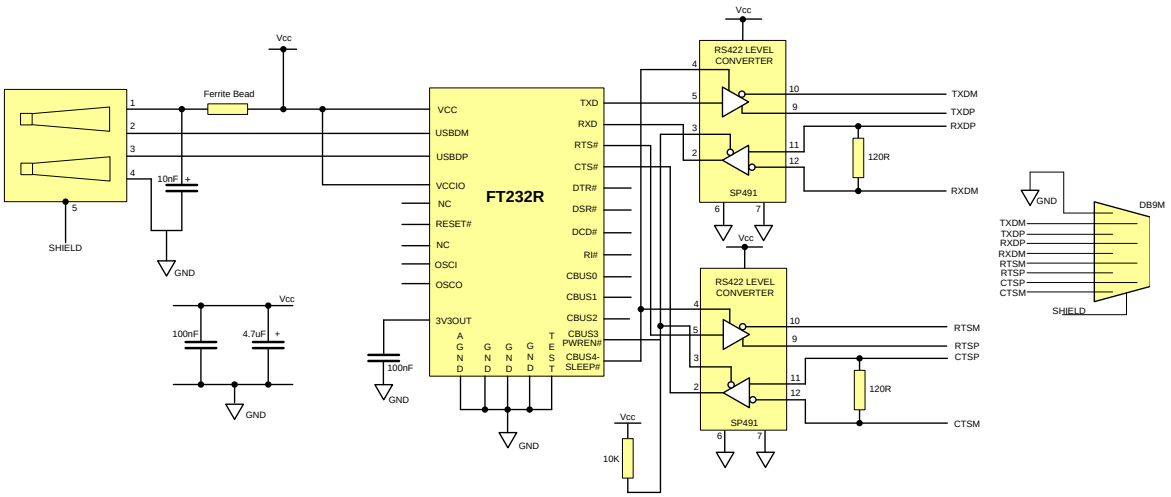


Figure 7.3 USB to RS422 Converter Configuration

An example of using the FT232R as a USB to RS422 converter is shown in Figure 7.3. In this application, two TTL to RS422 Level Converter ICs are used on the serial UART interface of the FT232R to convert the TTL levels of the FT232R to RS422 levels. There are many suitable level converter devices available. This example uses Sipex SP491 devices which have enables on both the transmitter and receiver. Since the SP491 transmitter enable is active high, it is connected to a CBUS pin in SLEEP# configuration. The SP491 receiver enable is active low and is therefore connected to a CBUS pin PWREN# configuration. This ensures that when both the SP491 transmitters and receivers are enabled then the device is active, and when the device is in USB suspend mode, the SP491 transmitters and receivers are disabled. If a similar application is used, but the design is USB BUS powered, it may be necessary to use a P-Channel logic level MOSFET (controlled by PWREN#) in the VCC line of the SP491 devices to ensure that the USB standby current of 2.5mA is met.

The SP491 is specified to transmit and receive data at a rate of up to 5 Mbaud. In this example the maximum data rate is limited to 3 Mbaud by the FT232R.

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7.4 USB to MCU UART Interface

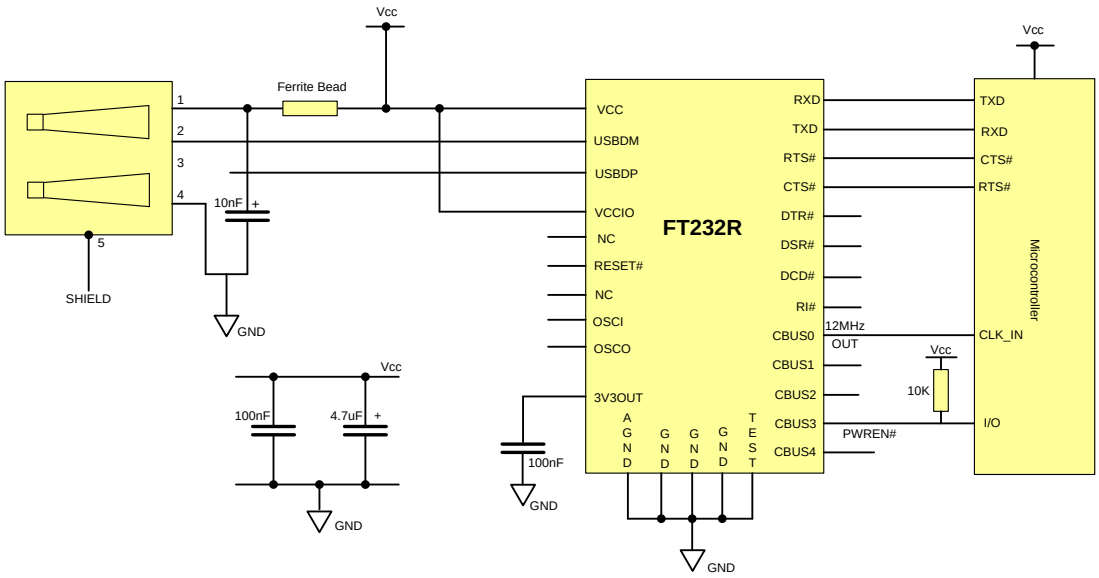


Figure 7.4 USB to MCU UART Interface

An example of using the FT232R as a USB to Microcontroller (MCU) UART interface is shown in Figure 7.4. In this application the FT232R uses TXD and RXD for transmission and reception of data, and RTS# / CTS# signals for hardware handshaking. Also in this example CBUS0 has been configured as a 12MHz output to clock the MCU.

Optionally, RI# could be connected to another I/O pin on the MCU and used to wake up the USB host controller from suspend mode. If the MCU is handling power management functions, then a CBUS pin can be configured as PWREN# and would also be connected to an I/O pin of the MCU.

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7.5 LED Interface

Any of the CBUS I/O pins can be configured to drive an LED. The FT232R has 3 configuration options for driving LEDs from the CBUS. These are TXLED#, RXLED#, and TX&RXLED#. Refer to Section 3.5 for configuration options.

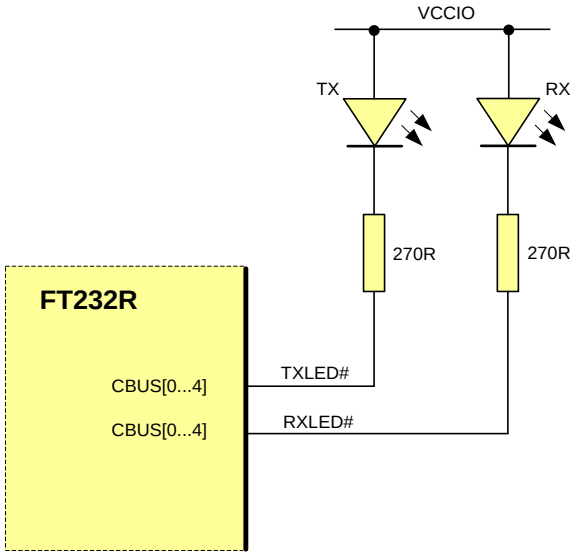


Figure 7.5 Dual LED Configuration

An example of using the FT232R to drive LEDs is shown in Figure 7.5. In this application one of the CBUS pins is used to indicate transmission of data (TXLED#) and another is used to indicate receiving data (RXLED#). When data is being transmitted or received the respective pins will drive from tri-state to low in order to provide indication on the LEDs of data transfer. A digital one-shot is used so that even a small percentage of data transfer is visible to the end user.

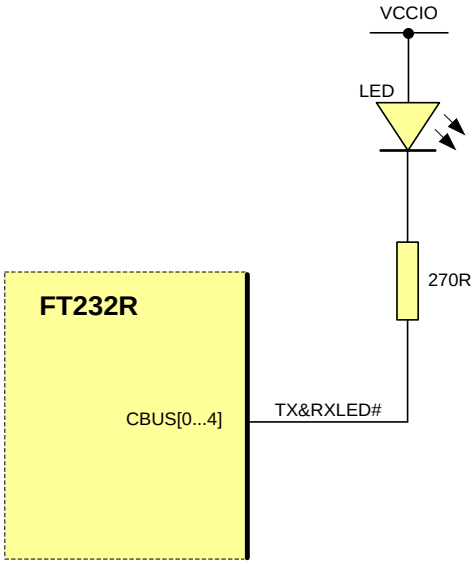


Figure 7.6 Single LED Configuration

Another example of using the FT232R to drive LEDs is shown in Figure 7.6. In this example one of the CBUS pins is used to indicate when data is being transmitted or received by the device (TX&RXLED). In this configuration the FT232R will drive only a single LED.

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7.6 Using the External Oscillator

The FT232R defaults to operating using its own internal oscillator. This requires that the device is powered with VCC(min)=+4.0V. This supply voltage can be taken from the USB VBUS. Applications which require using an external oscillator, VCC= +3.3V, must do so in the following order:

1. When device powered for the very first time, it must have VCC > +4.0V. This supply is available from the USB VBUS supply = +5.0V.
2. The EEPROM must then be programmed to enable external oscillator. This EEPROM modification cannot be done using the FTDI programming utility, MPROG. The EEPROM can only be re-configured from a custom application. Please refer to the following applications note on how to do this:

   http://www.ftdichip.com/Documents/AppNotes/AN_100_Using_The_FT232_245R_With_External_Osc(FT_000067).pdf

3. The FT232R can then be powered from VCC=+3.3V and an external oscillator. This can be done using a link to switch the VCC supply.

The FT232R will fail to operate when the internal oscillator has been disabled, but no external oscillator has been connected.

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8 Internal EEPROM Configuration

Following a power-on reset or a USB reset the FT232R will scan its internal EEPROM and read the USB configuration descriptors stored there. The default factory programmed values of the internal EEPROM are shown in Table 8.1.

Parameter	Value	Notes
USB Vendor ID (VID)	0403h	FTDI default VID (hex)
USB Product UD (PID)	6001h	FTDI default PID (hex)
Serial Number Enabled?	Yes	
Serial Number	See Note	A unique serial number is generated and programmed into the EEPROM during device final test.
Pull down I/O Pins in USB Suspend	Disabled	Enabling this option will make the device pull down on the UART interface lines when in USB suspend mode (PWREN# is high).
Manufacturer Name	FTDI	
Product Description	FT232R USB UART	
Max Bus Power Current	90mA	
Power Source	Bus Powered	
Device Type	FT232R	
USB Version	0200	Returns USB 2.0 device description to the host. Note: The device is a USB 2.0 Full Speed device (12Mb/s) as opposed to a USB 2.0 High Speed device (480Mb/s).
Remote Wake Up	Enabled	Taking RI# low will wake up the USB host controller from suspend in approximately 20 ms.
High Current I/Os	Disabled	Enables the high drive level on the UART and CBUS I/O pins.
Load VCP Driver	Enabled	Makes the device load the VCP driver interface for the device.
CBUS0	TXLED#	Default configuration of CBUS0 – Transmit LED drive.
CBUS1	RXLED#	Default configuration of CBUS1 – Receive LED drive.
CBUS2	TXDEN	Default configuration of CBUS2 – Transmit data enable for RS485
CBUS3	PWREN#	Default configuration of CBUS3 – Power enable. Low after USB enumeration, high during USB suspend mode.

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Parameter	Value	Notes
CBUS4	SLEEP#	Default configuration of CBUS4 – Low during USB suspend mode.
Invert TXD	Disabled	Signal on this pin becomes TXD# if enable.
Invert RXD	Disabled	Signal on this pin becomes RXD# if enable.
Invert RTS#	Disabled	Signal on this pin becomes RTS if enable.
Invert CTS#	Disabled	Signal on this pin becomes CTS if enable.
Invert DTR#	Disabled	Signal on this pin becomes DTR if enable.
Invert DSR#	Disabled	Signal on this pin becomes DSR if enable.
Invert DCD#	Disabled	Signal on this pin becomes DCD if enable.
Invert RI#	Disabled	Signal on this pin becomes RI if enable.

Table 8.1 Default Internal EEPROM Configuration

The internal EEPROM in the FT232R can be programmed over USB using the FTDI utility program MPROG. MPROG can be downloaded from FTDI Utilities on the FTDI website (www.ftdichip.com). Version 2.8a or later is required for the FT232R chip. Users who do not have their own USB Vendor ID but who would like to use a unique Product ID in their design can apply to FTDI for a free block of unique PIDs. Contact FTDI support for this service.

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9 Package Parameters

The FT232R is available in two different packages. The FT232RL is the SSOP-28 option and the FT232RQ is the QFN-32 package option. The solder reflow profile for both packages is described in Section 9.5.

9.1 SSOP-28 Package Dimensions

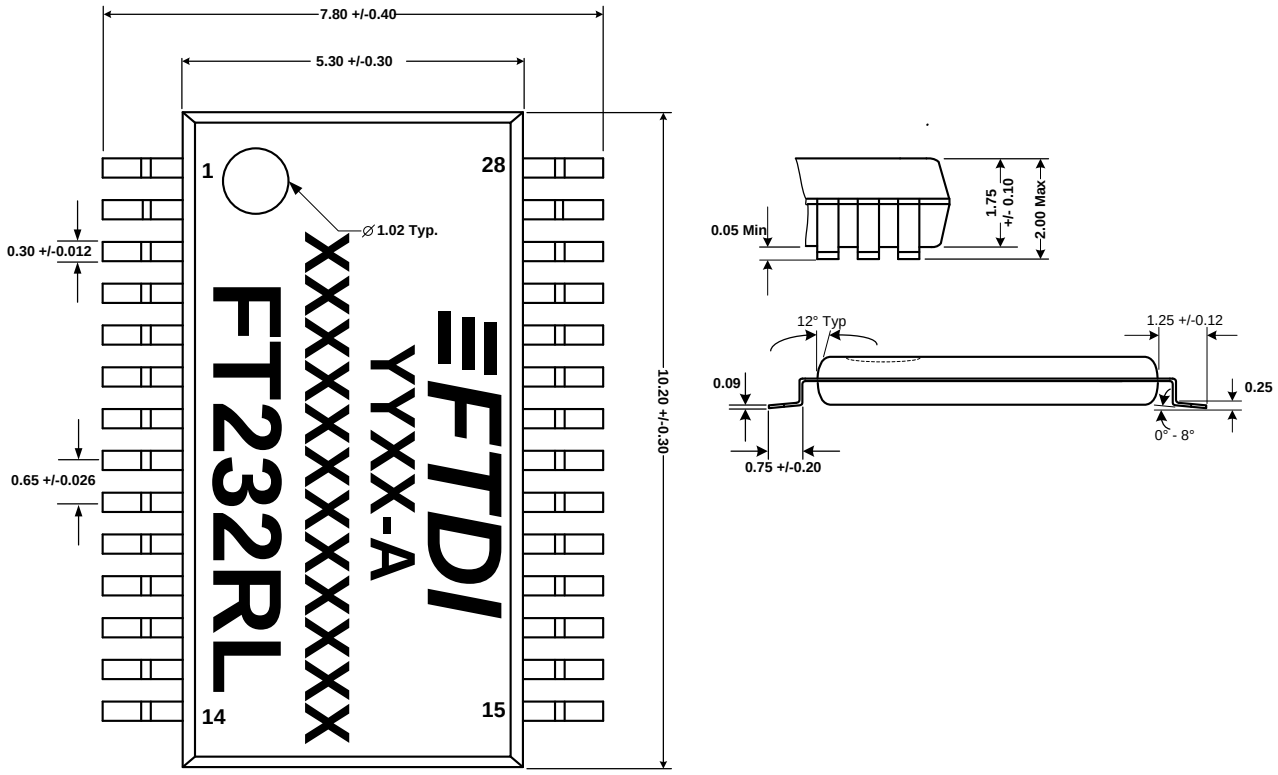


Figure 9.1 SSOP-28 Package Dimensions

The FT232RL is supplied in a RoHS compliant 28 pin SSOP package. The package is lead (Pb) free and uses a 'green' compound. The package is fully compliant with European Union directive 2002/95/EC.

This package is nominally 5.30mm x 10.20mm body (7.80mm x 10.20mm including pins). The pins are on a 0.65 mm pitch. The above mechanical drawing shows the SSOP-28 package.

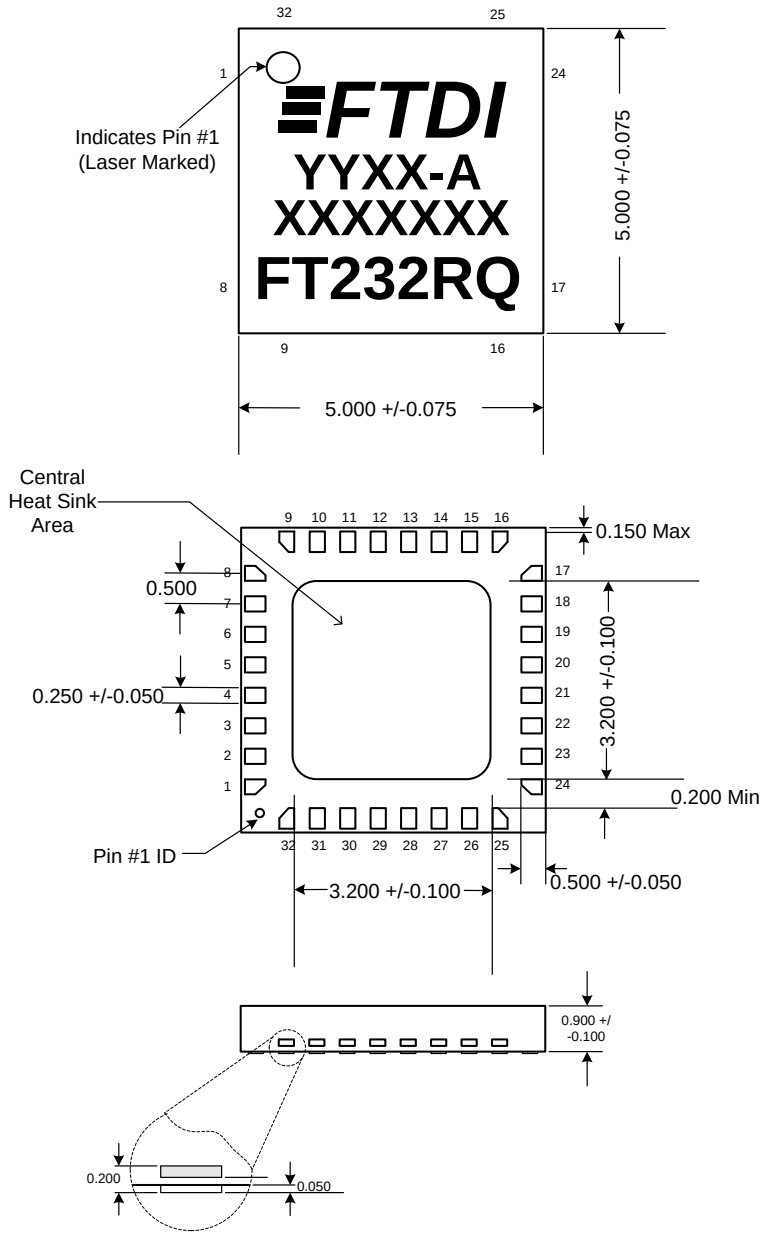
All dimensions are in millimetres.

The date code format is **YYXX** where XX = 2 digit week number, YY = 2 digit year number. This is followed by the revision number.

The code **XXXXXXXXXXXX** is the manufacturing LOT code. This only applies to devices manufactured after April 2009.

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9.2 QFN-32 Package Dimensions



Note: The pin #1 ID is connected internally to the device's central heat sink area . It is recommended to ground the central heat sink area of the device.

Dimensions in mm.

Figure 9.2 QFN-32 Package Dimensions

The FT232RQ is supplied in a RoHS compliant leadless QFN-32 package. The package is lead (Pb) free, and uses a 'green' compound. The package is fully compliant with European Union directive 2002/95/EC.

This package is nominally 5.00mm x 5.00mm. The solder pads are on a 0.50mm pitch. The above mechanical drawing shows the QFN-32 package. All dimensions are in millimetres.

The centre pad on the base of the FT232RQ is not internally connected, and can be left unconnected, or connected to ground (recommended).

The date code format is **YYXX** where XX = 2 digit week number, YY = 2 digit year number.

The code **XXXXXXX** is the manufacturing LOT code. This only applies to devices manufactured after April 2009.

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9.3 QFN-32 Package Typical Pad Layout

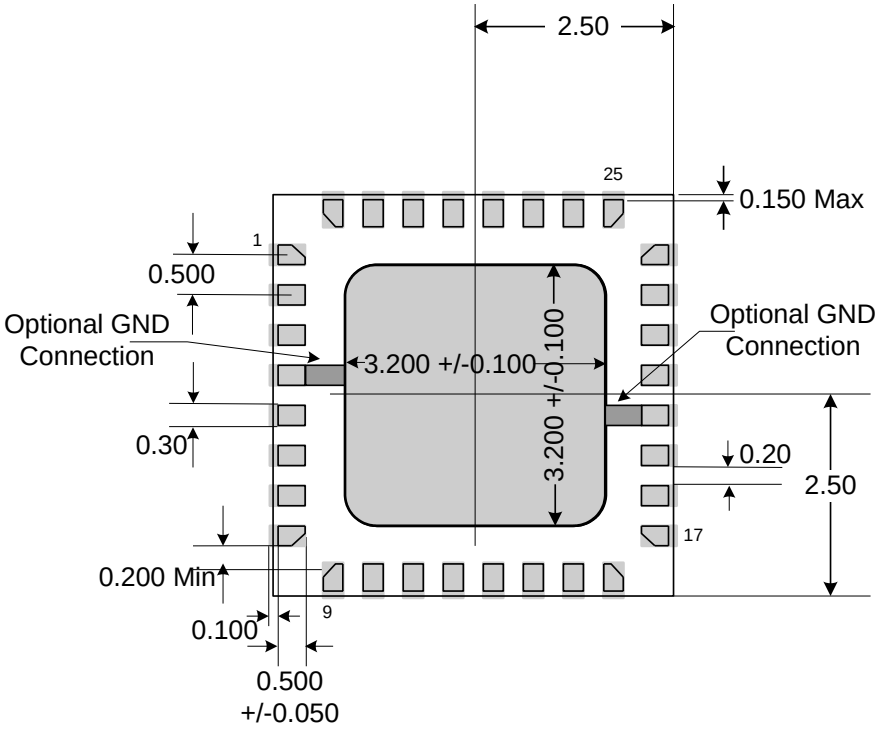


Figure 9.3 Typical Pad Layout for QFN-32 Package

9.4 QFN-32 Package Typical Solder Paste Diagram

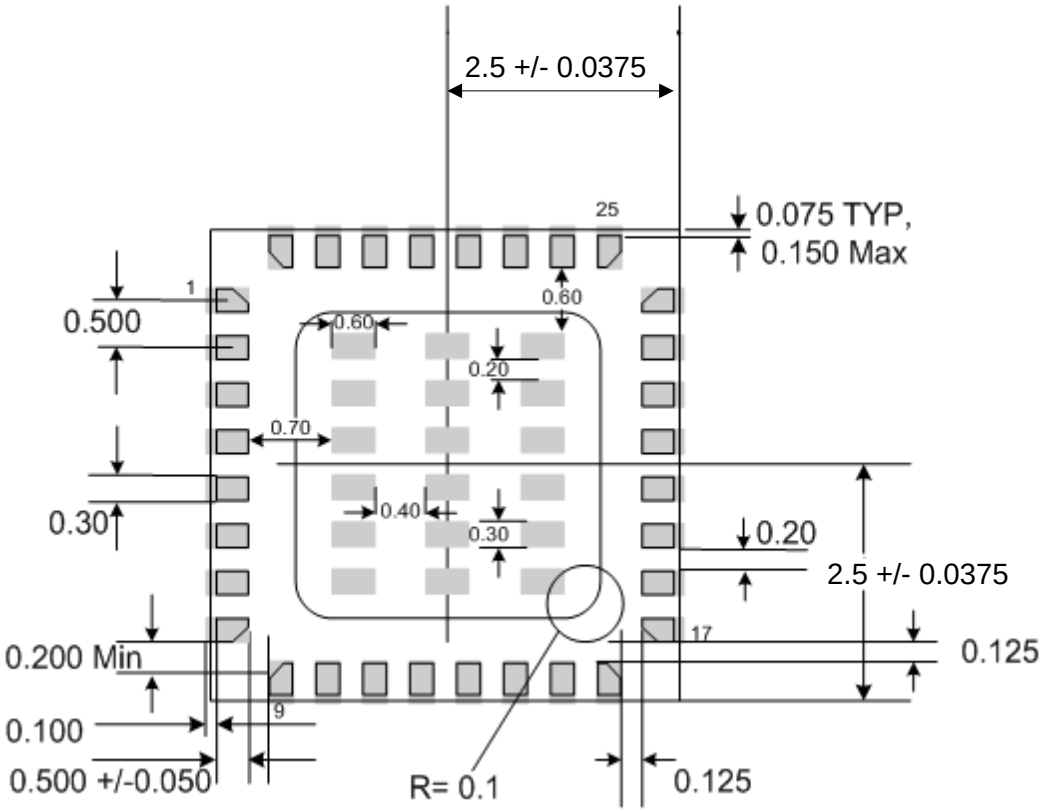


Figure 9.4 Typical Solder Paste Diagram for QFN-32 Package

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9.5 Solder Reflow Profile

The FT232R is supplied in Pb free 28 LD SSOP and QFN-32 packages. The recommended solder reflow profile for both package options is shown in Figure 9.5.

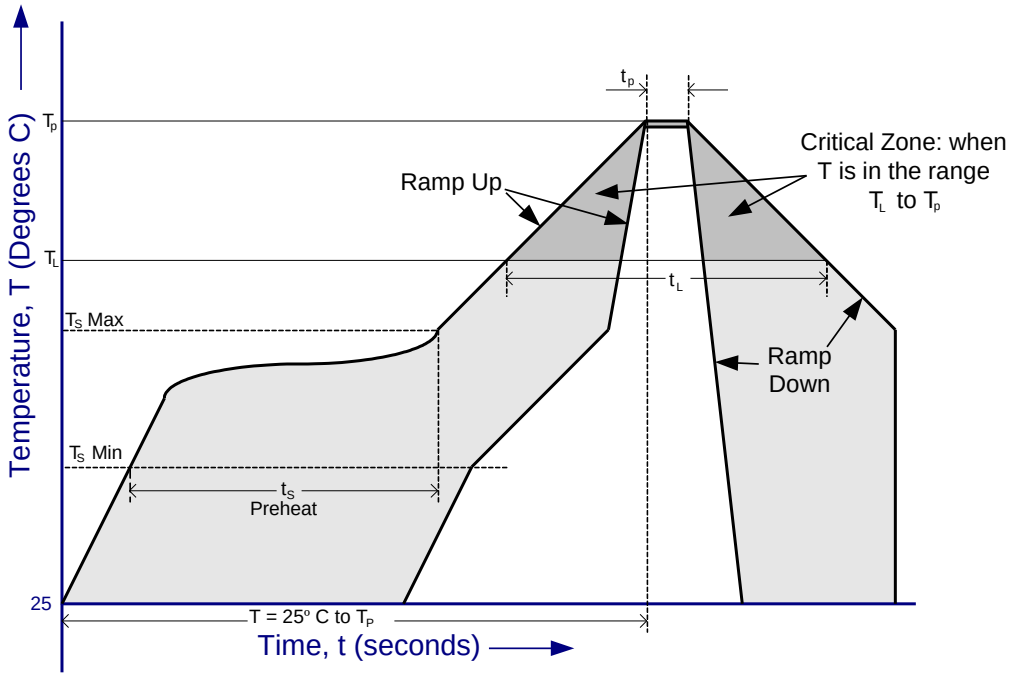


Figure 9.5 FT232R Solder Reflow Profile

The recommended values for the solder reflow profile are detailed in Table 9.1. Values are shown for both a completely Pb free solder process (i.e. the FT232R is used with Pb free solder), and for a non-Pb free solder process (i.e. the FT232R is used with non-Pb free solder).

Profile Feature	Pb Free Solder Process	Non-Pb Free Solder Process
Average Ramp Up Rate (T_s to T_p)	3°C / second Max.	3°C / Second Max.
Preheat - Temperature Min (T_s Min.) - Temperature Max (T_s Max.) - Time (t_s Min to t_s Max)	 150°C 200°C 60 to 120 seconds	 100°C 150°C 60 to 120 seconds
Time Maintained Above Critical Temperature T_L: - Temperature (T_L) - Time (t_L)	 217°C 60 to 150 seconds	 183°C 60 to 150 seconds
Peak Temperature (T_p)	260°C	240°C
Time within 5°C of actual Peak Temperature (t_p)	20 to 40 seconds	20 to 40 seconds
Ramp Down Rate	6°C / second Max.	6°C / second Max.
Time for T= 25°C to Peak Temperature, T_p	8 minutes Max.	6 minutes Max.

Table 9.1 Reflow Profile Parameter Values

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10 Contact Information

Head Office – Glasgow, UK

Future Technology Devices International Limited
Unit 1, 2 Seaward Place
Centurion Business Park
Glasgow, G41 1HH
United Kingdom
Tel: +44 (0) 141 429 2777
Fax: +44 (0) 141 429 2758

E-mail (Sales) sales1@ftdichip.com
E-mail (Support) support1@ftdichip.com
E-mail (General Enquiries) admin1@ftdichip.com
Web Site URL http://www.ftdichip.com
Web Shop URL http://www.ftdichip.com

Branch Office – Taipei, Taiwan

Future Technology Devices International Limited (Taiwan)
2F, No 516, Sec. 1 NeiHu Road
Taipei 114
Taiwan, R.O.C.
Tel: +886 (0) 2 8791 3570
Fax: +886 (0) 2 8791 3576

E-mail (Sales) tw.sales1@ftdichip.com
E-mail (Support) tw.support1@ftdichip.com
E-mail (General Enquiries) tw.admin1@ftdichip.com
Web Site URL http://www.ftdichip.com

Branch Office – Hillsboro, Oregon, USA

Future Technology Devices International Limited (USA)
7235 NW Evergreen Parkway, Suite 600
Hillsboro, OR 97123-5803
USA
Tel: +1 (503) 547 0988
Fax: +1 (503) 547 0987

E-Mail (Sales) us.sales@ftdichip.com
E-Mail (Support) us.admin@ftdichip.com
Web Site URL http://www.ftdichip.com

Branch Office – Shanghai, China

Future Technology Devices International Limited (China)
Room 408, 317 Xianxia Road,
ChangNing District,
ShangHai, China

Tel: +86 (21) 62351596
Fax: +86(21) 62351595

E-Mail (Sales): cn.sales@ftdichip.com
E-Mail (Support): cn.support@ftdichip.com
E-Mail (General Enquiries): cn.admin1@ftdichip.com

Web Site URL: http://www.ftdichip.com

Distributor and Sales Representatives

Please visit the Sales Network page of the FTDI Web site for the contact details of our distributor(s) and sales representative(s) in your country.

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Appendix A – References

Useful Application Notes

http://www.ftdichip.com/Documents/AppNotes/AN232R-01_FT232RBitBangModes.pdf

http://www.ftdichip.com/Documents/AppNotes/AN_107_AdvancedDriverOptions_AN_000073.pdf

http://www.ftdichip.com/Documents/AppNotes/AN232R-02_FT232RChipID.pdf

http://www.ftdichip.com/Documents/AppNotes/AN_121_FTDI_Device_EEPROM_User_Area_Usage.pdf

http://www.ftdichip.com/Documents/AppNotes/AN_120_Aliasing_VCP_Baud_Rates.pdf

http://www.ftdichip.com/Documents/AppNotes/AN_100_Using_The_FT232_245R_With_External_Osc(FT_000067).pdf

http://www.ftdichip.com/Resources/Utilities/AN_126_User_Guide_For_FT232_Factory%20test%20utility.pdf

http://www.ftdichip.com/Documents/AppNotes/AN232B-05_BaudRates.pdf

http://www.ftdichip.com/Documents/InstallGuides.htm

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Appendix C - Revision History

Version 0.90	Initial Datasheet Created	August 2005
Version 0.96	Revised Pre-release datasheet	October 2005
Version 1.00	Full datasheet released	December 2005
Version 1.02	Minor revisions to datasheet	December 2005
Version 1.03	Manufacturer ID added to default EEPROM configuration; Buffer sizes added	January 2006
Version 1.04	QFN-32 Pad layout and solder paste diagrams added	January 2006
Version 2.00	Reformatted, updated package info, added notes for 3.3V operation;	June 2008
	Part numbers, TID; added UART and CBUS characteristics for +1.8V;	
	Corrected RESET#; Added MTTF data;	
	Corrected the input switching threshold and input hysteresis values for VCCIO=5V	
Version 2.01	Corrected pin-out number in table3.2 for GND pin18.	
	Improved graphics on some Figures.	
	Add packing details. Changed USB suspend current spec from 500uA to 2.5mA	
	Corrected Figure 9.2 QFN dimensions.	August 2008
Version 2.02	Corrected Tape and Reel quantities.	
	Added comment "PWREN# should be used with a 10kΩ resistor pull up".	
	Replaced TXDEN# with TXDEN since it is active high in various places.	
	Added lot number to the device markings.	
	Added 3V3 regulator output tolerance.	
	Clarified VCC operation and added section headed "Using an external Oscillator"	
	Updated company contact information.	April 2009
Version 2.03	Corrected the RX/TX buffer definitions to be relative to the USB interface	June 2009
Version 2.04	Additional dimensions added to QFN solder profile	June 2009
Version 2.05	Modified package dimensions to 5.0 x 5.0 +/-0.075mm.	December 2009
	and Solder paste diagram to 2.50 x 2.50 +/-0.0375mm	
	Added Windows 7 32, 64 bit driver support	
	Added FT_PROG utility references	
	Added Appendix A-references	
	Figure 2.1 updated	
	Updated USB-IF TID for Rev B	
Version 2.06	Updated section 6.2, Figure 6.2 and the note,	May 2010
	Updated section 5.3, Table 5.13, EEPROM data retention time	
Version 2.07	Added USB Certification Logos	July 2010

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