The FT245BQ is the lead free version of the 2nd generation of FTDI's popular USB FIFO I.C. This device not only adds extra functionality to its FT8U245AM predecessor and reduces external component count, but also maintains a high degree of pin compatibility with the original, making it easy to upgrade or cost reduce existing designs as well as increasing the potential for using the device in new application areas.

1.0 Features

HARDWARE FEATURES

- Single Chip USB ⇔ Parallel FIFO bi-directional Data Transfer
- Transfer Data rate to 1M Byte / Sec - D2XX Drivers
- Transfer Data rate to 300 Kilobyte / Sec - VCP Drivers
- Simple to interface to MCU / PLD/ FPGA logic with a 4 wire handshake interface
- Entire USB protocol handled on-chip… no USB-specific firmware programming required
- FTDI's royalty-free VCP and D2XX drivers eliminate the requirement for USB driver development in most cases.
- 384 Byte FIFO Tx buffer / 128 Byte FIFO Rx Buffer for high data throughput.
- New Send Immediate support via SI Pin for optimised data throughput.
- Support for USB Suspend / Resume through PWREN# and WAKEUP pins.
- Support for high power USB Bus powered devices through PWREN# pin
- Adjustable RX buffer timeout
- In-built support for event characters
- Integrated level converter on FIFO and control signals for interfacing to 5V and 3.3V logic
- Integrated 3.3V regulator for USB IO
- Integrated Power-On-Reset circuit
- Integrated 6MHz – 48Mhz clock multiplier PLL
- USB Bulk or Isochronous data transfer modes
- New Bit-Bang Mode allows the data bus to be used as an 8 bit general purpose IO Port without the need for MCU or other support logic.
- 4.35V to 5.25V single supply operation
- UHCI / OHCI / EHCI host controller compatible
- USB 1.1 and USB 2.0 compatible
- USB VID, PID , Serial Number and Product Description strings in external EEPROM
- EEPROM programmable on-board via USB
- Compact 5 x 5 mm Lead free RoHS compliant QFN32 package

VIRTUAL COM PORT (VCP) DRIVERS for

- Windows 98 and Windows 98 SE
- Windows 2000 / ME / Server 2003 / XP
- Windows XP 64 Bit
- Windows XP Embedded
- Windows CE 4.2
- MAC OS-8 and OS-9
- MAC OS-X
- Linux 2.40 and greater

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

- Windows 98 and Windows 98 SE
- Windows 2000 / ME / Server 2003 / XP
- Windows XP 64 Bit
- Windows XP Embedded
- Windows CE 4.2
- Linux 2.4 and Greater

APPLICATION AREAS

- Easy MCU / PLD / FPGA interface to USB
- Upgrading Legacy Peripheral Designs to USB
- USB Instrumentation
- USB Industrial Control
- USB Audio and Low Bandwidth Video data transfer
- PDA ⇔ USB data transfer
- USB MP3 Player Interface
- USB FLASH Card Reader / Writers
- Set Top Box (S.T.B.) PC - USB interface
- USB Digital Camera Interface
- USB Hardware Modems
- USB Wireless Modems

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1.1 General Description

The FT245BQ provides an easy cost-effective method of transferring data to / from a peripheral and a host P.C. at up to 8 Million bits (1 Megabyte) per second. Its simple, FIFO-like design makes it easy to interface to any microcontroller or microprocessor via IO ports.

To send data from the peripheral to the host computer, simply write the byte-wide data into the module when TXE# is low. If the (384-byte) transmit buffer fills up or is busy storing the previously written byte, the device keeps TXE# high in order to stop further data from being written until some of the FIFO data has been transferred over USB to the host. TXE# goes high after every byte written.

When the host sends data to the peripheral over USB, the device will take RXF# low to let the peripheral know that at least one byte of data is available. The peripheral can read a data byte every time RXF# goes low. RXF# goes high after every byte read.

By using FTDI's virtual COM port drivers, the peripheral looks like a standard COM port to the application software. Commands to set the baud rate are ignored - the device always transfers data at its fastest rate regardless of the application's baud-rate setting. Alternatively, FTDI's D2XX drivers allow application software to access the device "directly" through a published DLL based API. Details of the current VCP and D2XX driver can be found on FTDI's web site (http://www.ftdichip.com)

2.0 Enhancements

This section summarises the enhancements of the 2nd generation device compared to its FT8U245AM predecessor. For further details, consult the device pin-out description and functional descriptions.

- **Integrated Power-On-Reset (POR) Circuit**
  The device now incorporates an internal POR function. The existing RESET# pin is maintained in order to allow external logic to reset the device where required, however for many applications this pin can now be either left N/C or hard wired to VCC. In addition, a new reset output pin (RSTOUT#) is provided in order to allow the new POR circuit to provide a stable reset to external MCU and other devices. RSTOUT# was the TEST pin on the previous generation of devices.

- **Integrated RCCLK Circuit**
  In the previous devices, an external RC circuit was required to ensure that the oscillator and clock multiplier PLL frequency was stable prior to enabling the clock internal to the device. This circuit is now embedded on-chip – the pin assigned to this function is now designated as the TEST pin and should be tied to GND for normal operation.

- **Integrated Level Converter on FIFO interface and control signals**
  The previous devices would drive the FIFO and control signals at 5V CMOS logic levels. The new device has a separate VCCIO pin allowing the device to directly interface to 3.3V and other logic families without the need for external level converter I.C.'s

- **Power Management control for USB Bus Powered, high current devices**
  A new PWREN# signal is provided which can be used to directly drive a transistor or P-Channel MOSFET in applications where power switching of external circuitry is required. A new EEPROM based option makes the device pull gently down its FIFO interface lines when the power is shut off (PWREN# is High). In this mode, any residual voltage on external circuitry is bled to GND when

power is removed thus ensuring that external circuitry controlled by PWREN# resets reliably when power is restored. PWREN# can also be used by external circuitry to determine when USB is in suspend mode (PWREN# goes high).

- **Send Immediate / WakeUp (SI / WU) signal**
  The new Send Immediate / WakeUp signal combines two functions on a single pin. If USB is in suspend mode (and remote wakeup is enabled in the EEPROM), strobing this pin low will cause the device to request a resume from suspend (WakeUp) on the USB Bus. Normally, this can be used to wake up the Host PC. During normal operation, if this pin is strobed low any data in the device RX buffer will be sent out over USB on the next Bulk-IN request from the drivers regardless of the packet size. This can be used to optimise USB transfer speed for some applications.

- **Lower Suspend Current**
  Integration of RCCLK within the device and internal design improvements reduce the suspend current of the FT245BQ to under 100uA typical (excluding the 1.5K pull-up on USBDP) in USB suspend mode. This allows greater margin for peripherals to meet the USB Suspend current limit of 500uA.

- **Support for USB Isochronous Transfers**
  Whilst USB Bulk transfer is usually the best choice for data transfer, the scheduling time of the data is not guaranteed. For applications where scheduling latency takes priority over data integrity such as transferring audio and low bandwidth video data, the new device now offers an option of USB Isochronous transfer via an option bit in the EEPROM.
- **Programmable FIFO TX Buffer Timeout**
  In the previous device, the TX buffer timeout used to flush remaining data from the TX buffer was fixed at 16ms timeout. This timeout is now programmable over USB in 1ms increments from 1ms to 255ms, thus allowing the device to be better optimised for protocols requiring faster response times from short data packets.

- **Relaxed VCC Decoupling**
  The 2nd generation devices now incorporate a level of on-chip VCC decoupling. Though this does not eliminate the need for external decoupling capacitors, it significantly improves the ease of PCB design requirements to meet FCC, CE and other EMI related specifications.

- **Bit Bang Mode**
  The 2nd generation device has a new option referred to as “Bit Bang” mode. In Bit Bang mode, the eight FIFO data lines can be switched between FIFO interface mode and an 8-bit Parallel IO 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 prescaler of the FT232BQ device). As well as allowing the device to be used stand-alone as a general purpose IO controller for example controlling lights, relays and switches, some other interesting possibilities exist. For instance, it may be possible to connect the device to an SRAM configurable FPGA as supplied by vendors such as Altera and Xilinx. The FPGA device would normally be un-configured (i.e. have no defined function) at power-up. Application software on the PC could use Bit Bang Mode to download configuration data to the FPGA which would define its hardware function, then after the FPGA device is configured the FT245BQ can switch back into FIFO interface mode to allow the programmed FPGA device to communicate with the PC over USB. This approach allows a customer to create a “generic” USB peripheral who’s hardware function can be defined under control of the application software. The FPGA based hardware can be easily upgraded

or totally changed simply by changing the FPGA configuration data file. Application notes, software and development modules for this application area will be available from FTDI and other 3rd party developers.

- **Less External Support Components**

  As well as eliminating the RCCLK RC network, and for most applications the need for an external reset circuit, we have also eliminated the requirement for a 100K pull-up on EECS to select 6MHz operation. When the FT245BQ is being used without the configuration EEPROM, EECS, EESK and EEDATA can now be left n/c. For circuits requiring a long reset time (where the device is reset externally using a reset generator I.C., or reset is controlled by the IO port of a MCU, FPGA or ASIC device) an external transistor circuit is no longer required as the 1.5K pull-up resistor on USBDP can be wired to the RSTOUT# pin instead of to 3.3V. Note : RSTOUT# drives out at 3.3V level, not at 5V VCC level. This is the preferred configuration for new designs.

- **Extended EEPROM Support**

  The previous generation of devices only supported EEPROM of type 93C46 (64 x 16 bit). The new devices will also work with EEPROM type 93C56 (128 x 16 bit) and 93C66 (256 x 16 bit). The extra space is not used by the device, however it is available for use by other external MCU / logic whilst the FT245BQ is being held in reset.

- **USB 2.0 (full speed option)**

  A new EEPROM based option allows the FT245BQ to return a USB 2.0 device descriptor as opposed to USB 1.1. Note : The device would be a USB 2.0 Full Speed device (12Mb/s) as opposed to a USB 2.0 High Speed device (480Mb/s).

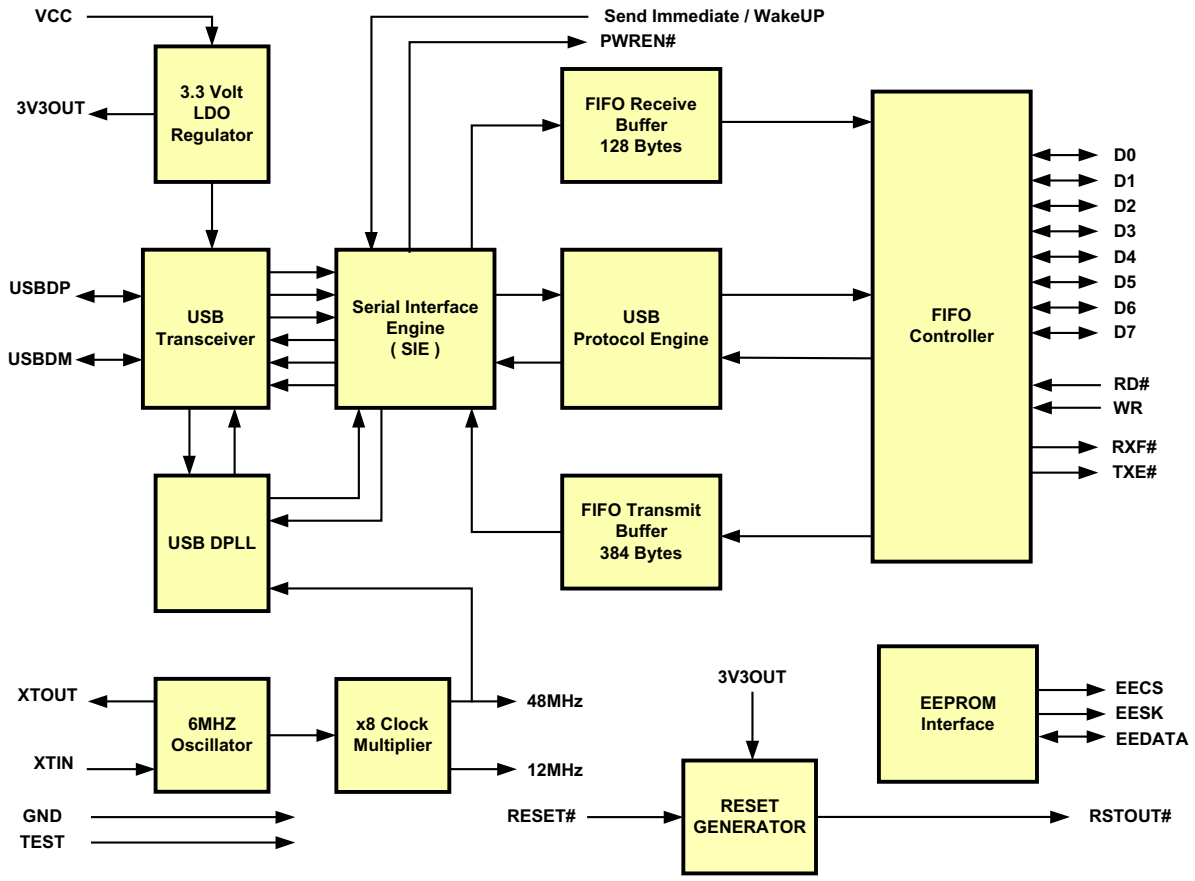
- **Multiple Device Support without EEPROM**

  When no EEPROM (or a blank or invalid EEPROM) is attached to the device, the FT245BQ no longer gives a serial number as part of its USB descriptor. This allows multiple devices to be simultaneously connected to the same PC. However, we still highly recommend that EEPROM is used, as without serial numbers a device can only be identified by which hub port in the USB tree it is connected to which can change if the end user re-plugs the device into a different USB port.

- **EEREQ# / EEGNT#**

  These (FT8U245AM) pins are no longer supported on the FT245BQ device. They have been replaced with the new SI / WU and PWREN# signals respectively.

3.0 Block Diagram (simplified)



3.1 Functional Block Descriptions

- **3.3V LDO Regulator**

  The 3.3V LDO Regulator generates the 3.3 volt 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 RSTOUT# pin. The main function of this block is to power the USB Transceiver and the Reset Generator Cells rather than to power external logic. However, external circuitry requiring 3.3V nominal at a current of not greater than 5mA could also draw its power from the 3V3OUT pin if required.

- **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 3.3 volt level slew rate control signalling, whilst a differential receiver and two single ended receivers provide USB data in, SEO and USB Reset condition detection.

- **USB DPLL**

  The USB DPLL cell locks on to the incoming NRZI USB data and provides separate recovered clock and data signals to the SIE block.

- **6MHz Oscillator**

  The 6MHz Oscillator cell generates a 6MHz reference clock input to the x8 Clock multiplier from an external 6MHz crystal or ceramic resonator.

- **x8 Clock Multiplier**

  The x8 Clock Multiplier takes the 6MHz input from the Oscillator cell and generates a 12MHz reference clock for the SIE, USB Protocol Engine and FIFO controller blocks. It also generates a 48MHz reference clock for the USB DPLL.

- **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 to the USB 2.0 specification, it performs bit stuffing / un-stuffing and CRC5 / CRC16 generation / checking 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 (Chapter 9) requests generated by the USB host controller and the commands for controlling the functional parameters of the FIFO.

- **FIFO Receive Buffer (128 bytes)**
  Data sent from the USB Host to the FIFO via the USB data out endpoint is stored in the FIFO Receive Buffer and is removed from the buffer by reading the FIFO contents using RD#.

- **FIFO Transmit Buffer (384 bytes)**
  Data written into the FIFO using WR# is stored in the FIFO Transmit Buffer. The Host removes Data from the FIFO Transmit Data by sending a USB request for data from the device data in endpoint.

- **FIFO Controller**
  The FIFO Controller handles the transfer of data between the external FIFO interface pins and the FIFO Transmit and Receive buffers.

- **RESET Generator**
  The Reset Generator Cell provides a reliable power-on reset to the device internal circuitry on power up. An additional RESET# input and RSTOUT# output are provided to allow other devices to reset the FT245BQ, or the FT245BQ to reset other devices respectively. During reset, RSTOUT# is driven low, otherwise it drives out at the 3.3V provided by the onboard regulator. RSTOUT# can be used to control the 1.5K pull-up on USBDP directly where delayed USB enumeration is required. RSTOUT# will be low for approximately 5ms after VCC has risen above 3.5V AND the device oscillator is running AND RESET# is high. RESET# should be tied to VCC unless it is a requirement to reset the device from external logic or an external reset generator I.C.

- **EEPROM Interface**
  Though the FT245BQ will work without the optional EEPROM, an external 93C46 (93C56 or 93C66) EEPROM can be used to customise the USB VID, PID, Serial Number, Product Description Strings and Power Descriptor value of the FT245BQ for OEM applications. Other parameters controlled by the EEPROM include Remote Wake Up, Isochronous Transfer Mode, Soft Pull Down on Power-Off and USB 2.0 descriptor modes.
  The EEPROM should be a 16 bit wide configuration such as a MicroChip 93LC46B or equivalent capable of a 1Mb/s clock rate at VCC = 4.35V to 5.25V. The EEPROM is programmable-on board over USB using a utility available from FTDI's web site (http://www.ftdichip.com). This allows a blank part to be soldered onto the PCB and programmed as part of the manufacturing and test process.
  If no EEPROM is connected (or the EEPROM is blank), the FT245BQ will use its built-in default VID, PID Product Description and Power Descriptor Value. In this case, the device will not have a serial number as part of the USB descriptor.

4.0 Device Pin-Out

Figure 1
Pin-Out
(QFN32 Package)

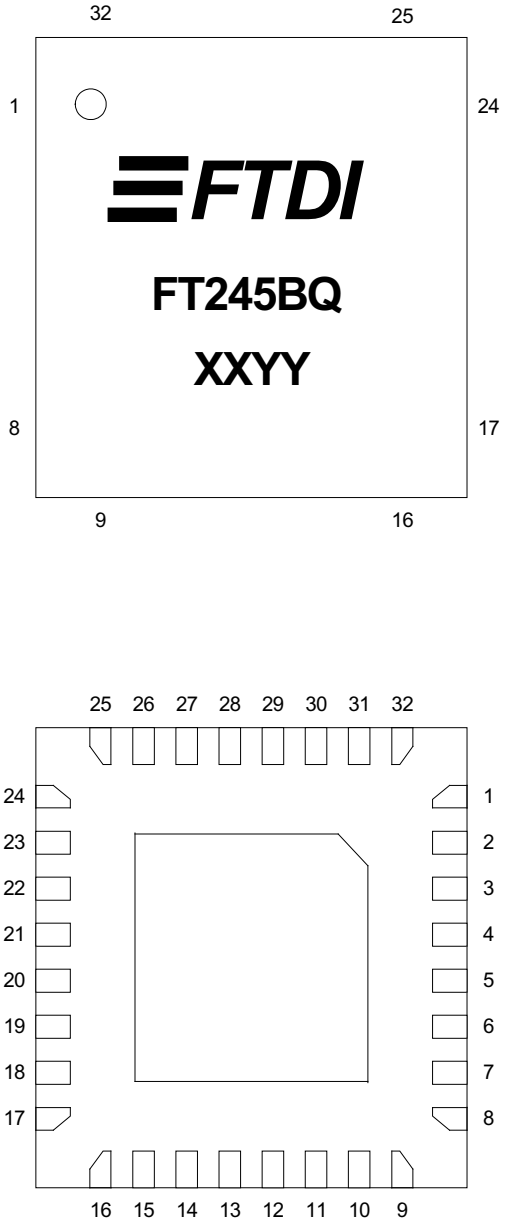
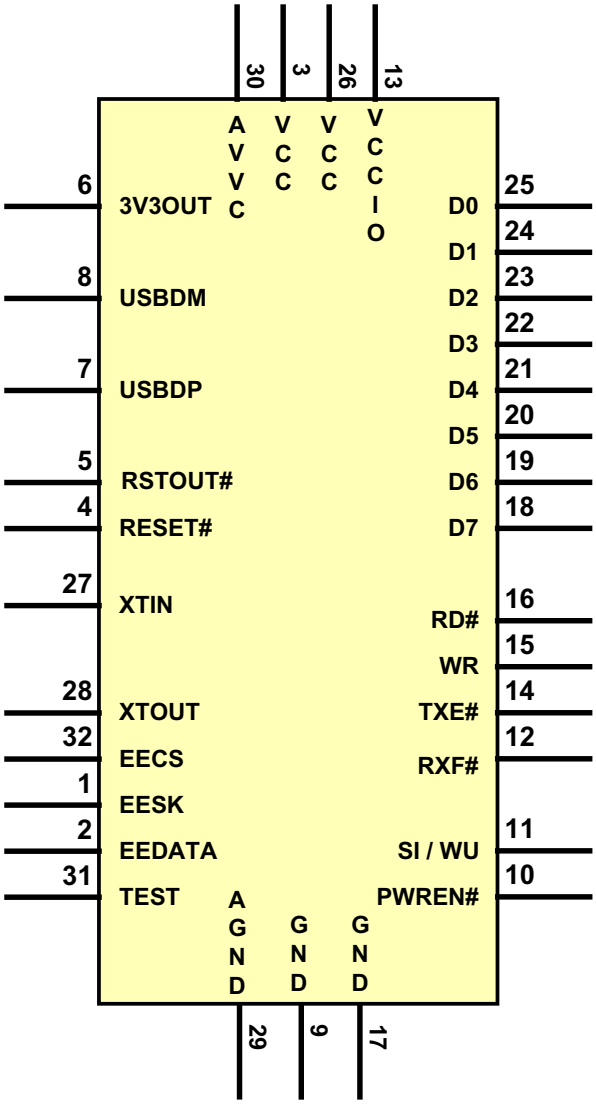


Figure 2
Pin-Out
(Schematic Symbol)



4.1 Signal Descriptions

Table 1 - FT245BQ - PINOUT DESCRIPTION

FIFO DATA BUS GROUP (*** Note 1)

Pin#	Signal	Type	Description
25	DO	I/O	FIFO Data Bus Bit 0
24	D1	I/O	FIFO Data Bus Bit 1
23	D2	I/O	FIFO Data Bus Bit 2
22	D3	I/O	FIFO Data Bus Bit 3
21	D4	I/O	FIFO Data Bus Bit 4
20	D5	I/O	FIFO Data Bus Bit 5
19	D6	I/O	FIFO Data Bus Bit 6
18	D7	I/O	FIFO Data Bus Bit 7

FIFO CONTROL INTERFACE GROUP

Pin#	Signal	Type	Description
16	RD#	IN	Enables Current FIFO Data Byte on D0..D7 when low. Fetches the next FIFO Data Byte (if available) from the Receive FIFO Buffer when RD# goes from low to high. *** Note 1
15	WR	IN	Writes the Data Byte on the D0..D7 into the Transmit FIFO Buffer when WR goes from high to low. *** Note 1
14	TXE#	OUT	When high, do not write data into the FIFO. When low, data can be written into the FIFO by strobing WR high then low. *** Note 2
12	RXF#	OUT	When high, do not read data from the FIFO. When low, there is data available in the FIFO which can be read by strobing RD# low then high again *** Note 2

USB INTERFACE GROUP

Pin#	Signal	Type	Description
7	USBDP	I/O	USB Data Signal Plus (Requires 1.5K pull-up to 3V3OUT or RSTOUT#)
8	USBDM	I/O	USB Data Signal Minus

EEPROM INTERFACE GROUP

Pin#	Signal	Type	Description
32	EECS	I/O	EEPROM – Chip Select. For 48MHz operation pull EECS to GND using a 10K resistor. For 6MHz operation no resistor is required. *** Note 3
1	EESK	OUT	Clock signal to EEPROM. Adding a 10K pull down resistor onto EESK will cause the FT245BQ to use USB Product ID 6005 (hex) instead of 6001 (hex). All of the other USB device descriptors are unchanged. *** Note 3
2	EEDATA	I/O	EEPROM – Data I/O Connect directly to Data-In of the EEPROM and to Data-Out of the EEPROM via a 2.2K resistor. Also pull Data-Out of the EEPROM to VCC via a 10K resistor for correct operation. *** Note 3

POWER CONTROL GROUP

Pin#	Signal	Type	Description
10	PWREN#	OUT	Goes Low after the device is configured via USB, then high during USB suspend. Can be used to control power to external logic using a P-Channel Logic Level MOSFET switch. Enable the Interface Pull-Down Option in EEPROM when using the PWREN# pin in this way.
11	SI / WU	IN	The Send Immediate / WakeUp signal combines two functions on a single pin. If USB is in suspend mode (PWREN# = 1) and remote wakeup is enabled in the EEPROM , strobing this pin low will cause the device to request a resume on the USB Bus. Normally, this can be used to wake up the Host PC. During normal operation (PWREN# = 0), if this pin is strobed low any data in the device TX buffer will be sent out over USB on the next Bulk-IN request from the drivers regardless of the pending packet size. This can be used to optimise USB transfer speed for some applications. Tie this pin to VCCIO if not used.

MISCELLANEOUS SIGNAL GROUP

Pin#	Signal	Type	Description
4	RESET#	IN	Can be used by an external device to reset the FT245BQ. If not required, tie to VCC.
5	RSTOUT#	OUT	Output of the internal Reset Generator. Stays high impedance for ~ 5ms after VCC > 3.5V and the internal clock starts up, then clamps its output to the 3.3V output of the internal regulator. Taking RESET# low will also force RSTOUT# to drive low. RSTOUT# is NOT affected by a USB Bus Reset.
27	XTIN	IN	Input to 6MHz Crystal Oscillator Cell. This pin can also be driven by an external 6MHz clock if required. Note : Switching threshold of this pin is VCC/2, so if driving from an external source, the source must be driving at 5V CMOS level or a.c. coupled to centre around VCC/2.
28	XTOUT	OUT	Output from 6MHz Crystal Oscillator Cell. XTOUT stops oscillating during USB suspend, so take care if using this signal to clock external logic.
31	TEST	IN	Puts device in I.C. test mode – must be tied to GND for normal operation.

POWER AND GND GROUP

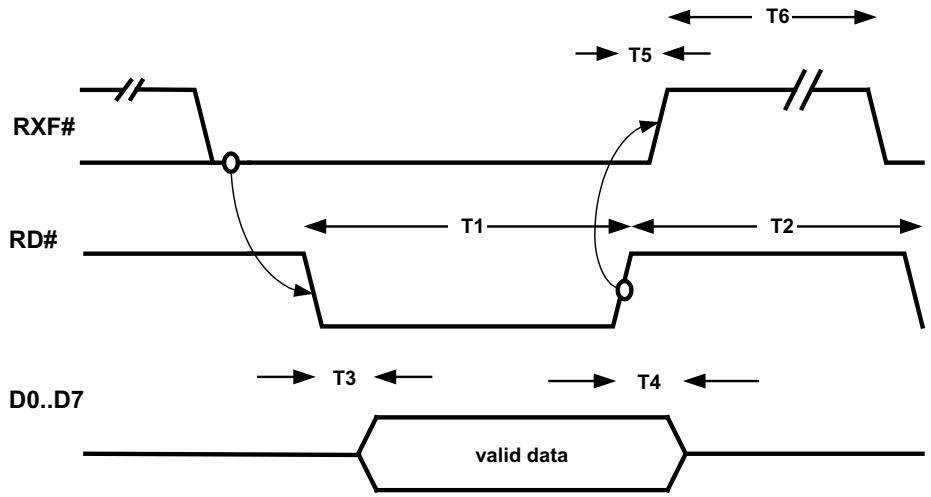
Pin#	Signal	Type	Description
6	3V3OUT	OUT	3.3 volt Output from the integrated L.D.O. regulator This pin should be decoupled to GND using a 33nF ceramic capacitor in close proximity to the device pin. Its prime purpose is to provide the internal 3.3V supply to the USB transceiver cell and the RSTOUT# pin. A small amount of current (<= 5mA) can be drawn from this pin to power external 3.3V logic if required.
3,26	VCC	PWR	+4.35 volt to +5.25 volt VCC to the device core, LDO and none-FIFO interface pins.
13	VCCIO	PWR	+3.0 volt to +5.25 volt VCC to the FIFO interface pins 10..12, 14..16 and 18..25. When interfacing with 3.3V external logic in a bus powered design connect VCCIO to a 3.3V supply generated from the USB bus. When interfacing with 3.3V external logic in a self powered design connect VCCIO to the 3.3V supply of the external logic. Otherwise connect to VCC to drive out at 5V CMOS level.
9,17	GND	PWR	Device - Ground Supply Pins
30	AVCC	PWR	Device - Analog Power Supply for the internal x8 clock multiplier
29	AGND	PWR	Device - Analog Ground Supply for the internal x8 clock multiplier

Note 1 : In Input Mode, these pins are pulled to VCCIO via internal 200K resistors. These can be programmed to gently pull low during USB suspend (PWREN# = “1”) by setting this option in the EEPROM.

Note 2: During device reset, these pins are tri-state but pulled up to VCCIO via internal 200K resistors.

Note 3: During device reset, these pins are tri-state but pulled up to VCC via internal 200K resistors.

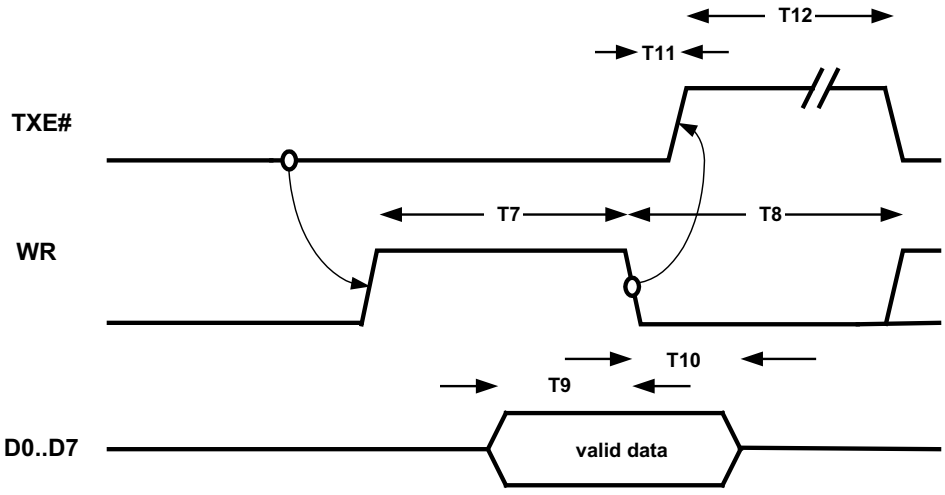
FT245BQ TIMING DIAGRAM – FIFO READ CYCLE



Time	Description	Min	Max	Unit
T1	RD Active Pulse Width	50		ns
T2	RD to RD Pre-Charge Time	50 + T6		ns
T3	RD Active to Valid Data *** **Note 4**	20	50	ns
T4	Valid Data Hold Time from RD Inactive *** **Note 4**	0		ns
T5	RD Inactive to RXF#	0	25	ns
T6	RXF inactive after RD cycle	80		ns

*** **Note 4** - Load 30 pF

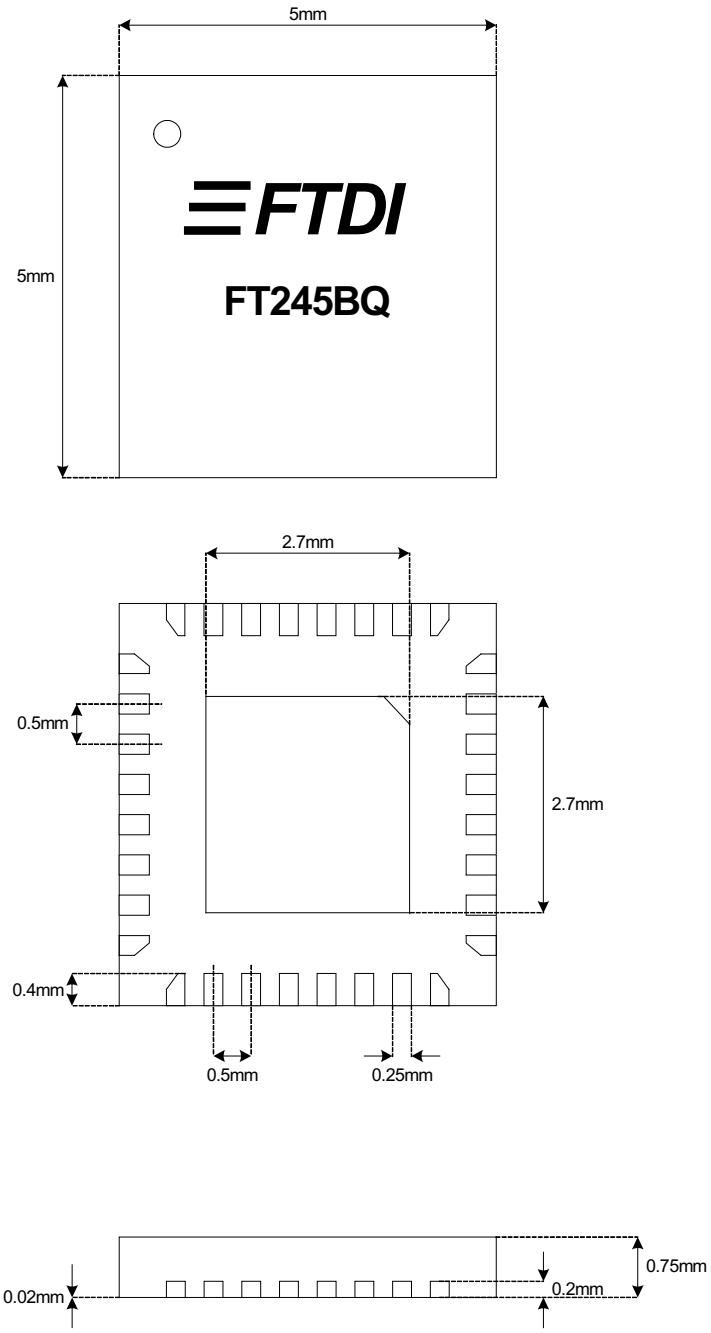
FT245BQ TIMING DIAGRAM – FIFO WRITE CYCLE



Time	Description	Min	Max	Unit
T7	WR Active Pulse Width	50		ns
T8	WR to WR Pre-Charge Time	50		ns
T9	Data Setup Time before WR inactive	20		ns
T10	Data Hold Time from WR inactive	0		ns
T11	WR Inactive to TXE#	5	25	ns
T12	TXE inactive after WR cycle	80		ns

5.0 Package Outline

Figure 3 – QFN32 Package Dimensions



The FT245BQ is supplied in a lead (Pb) free, leadless QFN package. This package has a 5 mm x 5 mm body with no protruding pins, and is ideal for projects where package area is critical. In the above drawing all dimensions are in millimetres. Note that there are two date code formats used - XXYY = Date Code where XX = 1 or 2 digit year number, YY = 2 digit week number); or XYY-1 where X = 1 digit year number, YY = 2 digit week number. The FT245BQ is fully compliant with the European Union RoHS directive.

A lead (Pb) free LQFP package version of the device is also available, part number FT245BL.

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6.0 Absolute Maximum Ratings

These are the absolute maximum ratings for the FT245BQ device in accordance with the Absolute Maximum Rating System (IEC 60134). Exceeding these may cause permanent damage to the device.

Parameter	Value	Units
Storage Temperature	–65°C to + 150°C	Degrees C
Floor Life (Out of Bag) at Factory Ambient (30°C/60% Relative Humidity)	192 Hours (Level 3 Compliant) **Note 5	
Ambient Temperature (Power Applied)	0°C to + 70°C	Degrees C
M.T.B.F. (at 35°C)	247484 Hours ≈ 28 Years	
VCC Supply Voltage	-0.5 to +6.00	V
D.C. Input Voltage - USBDP and USBDM	-0.5 to +3.8	V
D.C. Input Voltage - High Impedance Bidirectionals	-0.5 to +(Vcc +0.5)	V
D.C. 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
Electrostatic Discharge Voltage (Human Body Model) (I < 1uA)	+/- 3000	V
Latch Up Current (Vi = +/- 10V maximum, for 10 ms)	+/-200	mA

*** **Note 5** - *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 110°C and baked for 8 to 10 hours.*

6.1 D.C. Characteristics

DC Characteristics (Ambient Temperature = 0 to 70°C)

Operating Voltage and Current

Parameter	Description	Min	Typ	Max	Units	Conditions
Vcc1	VCC Operating Supply Voltage	4.35	5.0	5.25	V	
Vcc2	VCCIO Operating Supply Voltage	3.0	-	5.25	V	
Icc1	Operating Supply Current	-	25	-	mA	Normal Operation
Icc2	Operating Supply Current	-	100	200	uA	USB Suspend *** **Note 6**

***Note 6** – *Supply current excludes the 200uA nominal drawn by the external pull-up resistor on USBDP.*

FIFO Data / Control Bus IO Pin Characteristics (VCCIO = 5.0V)

Parameter	Description	Min	Typ	Max	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 = 2 mA
Vin	Input Switching Threshold	1.3	1.6	1.9	V	*** **Note 7**
VHys	Input Switching Hysteresis	50	55	60	mV	

FIFO Data / Control Bus IO Pin Characteristics (VCCIO = 3V to 3.6V)

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	2.2	2.7	3.2	V	I source = 2mA
Vol	Output Voltage Low	0.3	0.4	0.5	V	I sink = 4 mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	*** **Note 7**
VHys	Input Switching Hysteresis	20	25	30	mV	

***Note 7** – *Inputs or IO Pins in Input Mode have an internal 200K pull-up resistor to VCCIO.*

XTIN / XTOUT Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	4.0	-	5.0	V	Fosc = 6MHz
Vol	Output Voltage Low	0.1	-	1.0	V	Fosc = 6MHz
Vin	Input Switching Threshold	1.8	2.5	3.2	V	

RESET#, TEST, EECS, EESK, EEDATA, IO Pin Characteristics

Parameter	Description	Min	Typ	Max	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 = 2 mA
Vin	Input Switching Threshold	1.3	1.6	1.9	V	*** **Note 8**
VHys	Input Switching Hysteresis	50	55	60	mV	

***Note 8** – *EECS, EESK and EEDATA pins have an internal 200K pull-up resistor to VCC*

RSTOUT Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	3.0	-	3.6	V	I source = 2mA
Vol	Output Voltage Low	0.3	-	0.6	V	I sink = 2 mA

USB IO Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
UVoh	IO Pins Static Output (High)	2.8		3.6	V	RI = 1.5K to 3V3Out (D+) RI = 15K to GND (D-)
UVol	IO Pins Static Output (Low)	0		0.3	V	RI = 1.5K to 3V3Out (D+) RI = 15K 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	29		44	Ohm	*** **Note 9**

Note 9 – *Driver Output Impedance includes the external 27R series resistors on USBDP and USBDM pins.*

7.0 Device Configuration Examples

7.1 Oscillator Configurations

Figure 4
3 Pin Ceramic Resonator Configuration

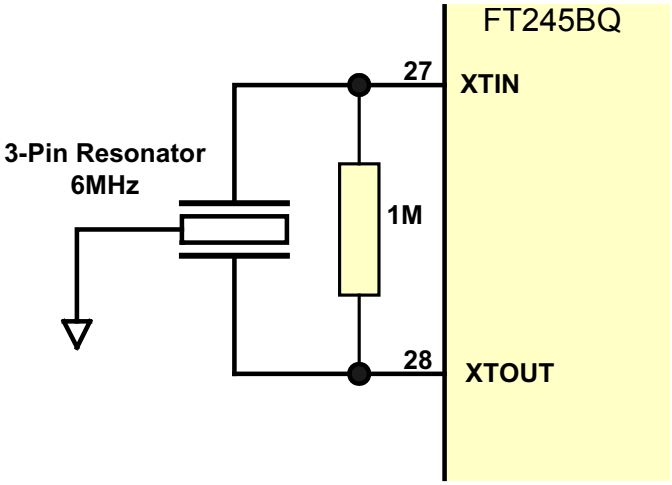


Figure 5
Crystal or 2-Pin Ceramic Resonator Configuration

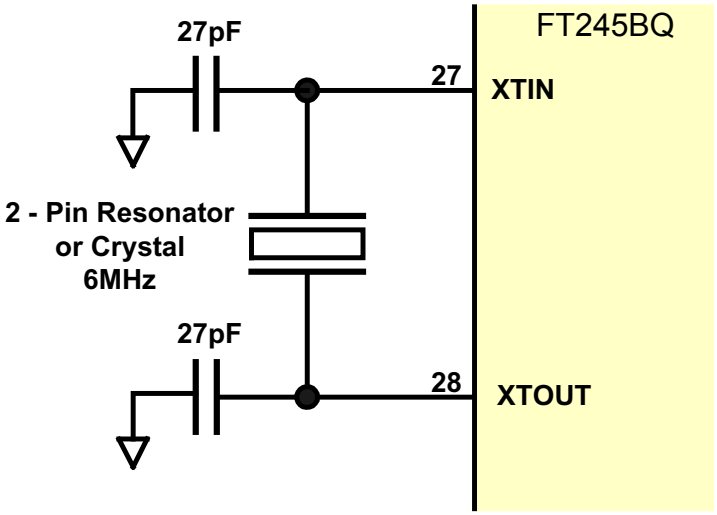


Figure 4 illustrates how to use the FT245BQ with a 3-Pin Ceramic Resonator. A suitable part would be a ceramic resonator from Murata's CERALOCK range. (Murata Part Number CSTCR6M00G15), or equivalent. 3-Pin ceramic resonators have the load capacitors built into the resonator so no external loading capacitors are required. This makes for an economical configuration. The accuracy of this Murata ceramic resonator is +/- 0.1% and it is specifically designed for USB full speed applications. A 1 MOhm loading resistor across XTIN and XTOUT is recommended in order to guarantee this level of accuracy.

Other ceramic resonators with a lesser degree of accuracy (typically +/- 0.5%) are technically outwith the USB specification, but it has been calculated that using such a device will work satisfactorily in practice with a FT245BQ design.

Figure 5 illustrates how to use the FT245BQ with a 6MHz Crystal or 2-Pin Ceramic Resonator. In this case, these devices do not have in-built loading capacitors so these have to be added between XTIN, XTOUT and GND as shown. A value of 27pF is shown as the capacitor in the example – this will be good for many crystals and some resonators but do select the value based on the manufacturers recommendations wherever possible. If using a crystal, use a parallel cut type. If using a resonator, see the previous note on frequency accuracy.

7.2 EEPROM Configuration

Figure 6
EEPROM Configuration

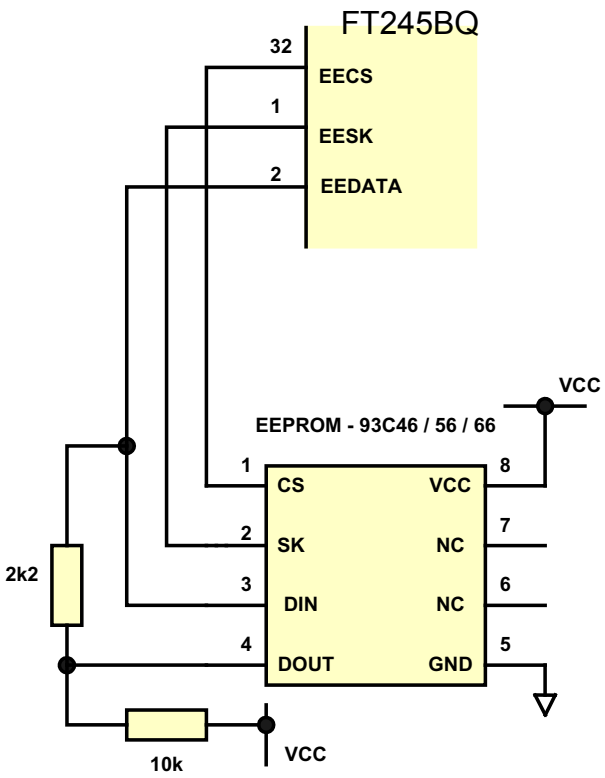


Figure 6 illustrates how to connect the FT245BQ to the 93C46 (93C56 or 93C66) EEPROM. EECS (pin 32) is directly connected to the chip select (CS) pin of the EEPROM. EESK (pin 1) is directly connected to the clock (SK) pin of the EEPROM. EEDATA (pin 2) is directly connected to the Data In (Din) pin of the EEPROM. There is a potential condition whereby both the Data Output (Dout) of the EEPROM can drive out at the same time as the EEDATA pin of the FT245BQ. To prevent potential data clash in this situation, the Dout of the EEPROM is connected to EEDATA of the FT245BQ via a 2.2 K resistor.

Following a power-on reset or a USB reset, the FT245BQ will scan the EEPROM to find out a) if an EEPROM is attached to the Device and b) if the data in the device is valid. If both of these are the case, then the FT245BQ will use the data in the EEPROM, otherwise it will use its built-in default values. When a valid command is issued to the EEPROM from the FT245BQ, the EEPROM will acknowledge the command by pulling its Dout pin low. In order to check for this condition, it is necessary to pull Dout high using a 10K resistor. If the command acknowledge doesn't happen then EEDATA will be pulled high by the 10K resistor during this part of the cycle and the device will detect an invalid command or no EEPROM present.

There are two varieties of these EEPROM's on the market – one is configured as being 16 bits wide, the other is configured as being 8 bits wide. These are available from many sources such as Microchip, ST Micro, ISSI etc. The FT245BQ requires EEPROM's with a 16-bit wide configuration such as the Microchip 93LC46B device. The EEPROM must be capable of reading data at a 1Mb clock rate at a supply voltage of 4.35V to 5.25V. Most available parts are capable of this.

Check the manufacturers data sheet to find out how to connect pins 6 and 7 of the EEPROM. Some devices specify these as no-connect, others use them for selecting 8 / 16 bit mode or for test functions. Some other parts have their pinout rotated by 90° so please select the required part and its options carefully.

It is possible to "share" the EEPROM between the FT245BQ and another external device such as an MCU. However, this can only be done when the FT245BQ is in its reset condition as it tri-states its EEPROM interface at that time. A typical configuration would use four bits of an MCU IO Port. One bit would be used to hold the FT245BQ reset (using RESET#) on power-up, the other three would connect to the EECS, EESK and EEDATA pins of the FT245BQ in order to read / write data to the EEPROM at this time. Once the MCU has read / written the EEPROM, it would take RESET# high to allow the FT245BQ to configure itself and enumerate over USB.

7.3 USB Bus Powered and Self Powered Configuration

Figure 7
USB Bus Powered Configuration

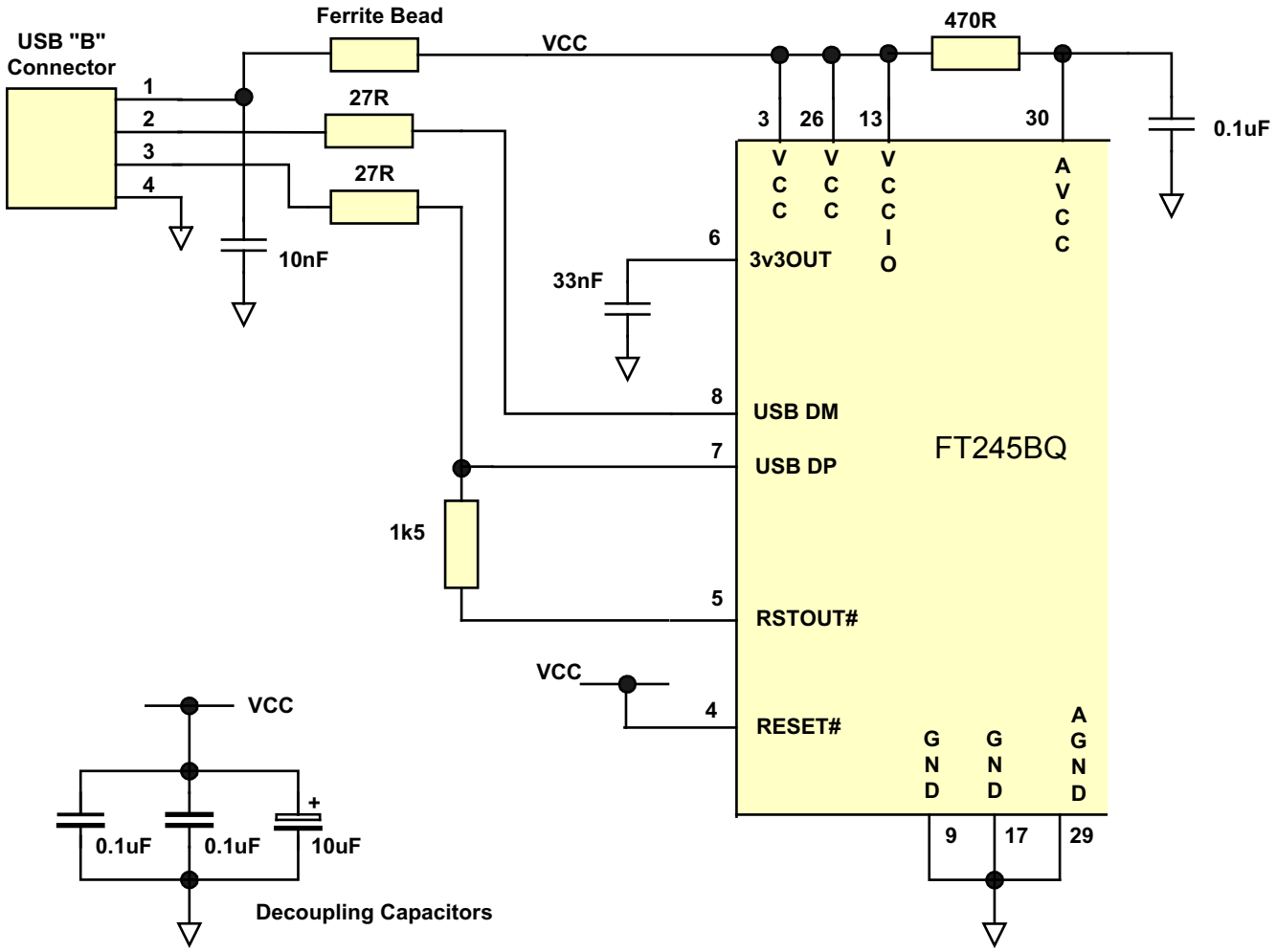


Figure 7 illustrates a typical USB bus powered configuration. A USB Bus Powered device gets its power from the USB bus. Basic rules for USB Bus power devices are as follows –

a) On plug-in, the device must draw no more than 100mA
b) On USB Suspend the device must draw no more than 500uA.
c) A Bus Powered High Power Device (one that draws more than 100mA) should use the PWREN# pin to keep the current below 100mA on plug-in and 500uA on USB suspend.
d) A device that consumes more than 100mA can not be plugged into a USB Bus Powered Hub
e) No device can draw more that 500mA from the USB Bus.

The power descriptor in the EEPROM should be programmed to match the current draw of the device.

A Ferrite Bead is connected in series with USB power to prevent noise from the device and associated circuitry (EMI) being radiated down the USB cable to the Host. The value of the Ferrite Bead depends on the total current required by the circuit – a suitable range of Ferrite Beads is available from Steward (www.steward.com) for example Steward Part # **MI0805K400R-00 also available as DigiKey Part #** 240-1035-1.

Figure 8
USB Self Powered Configuration

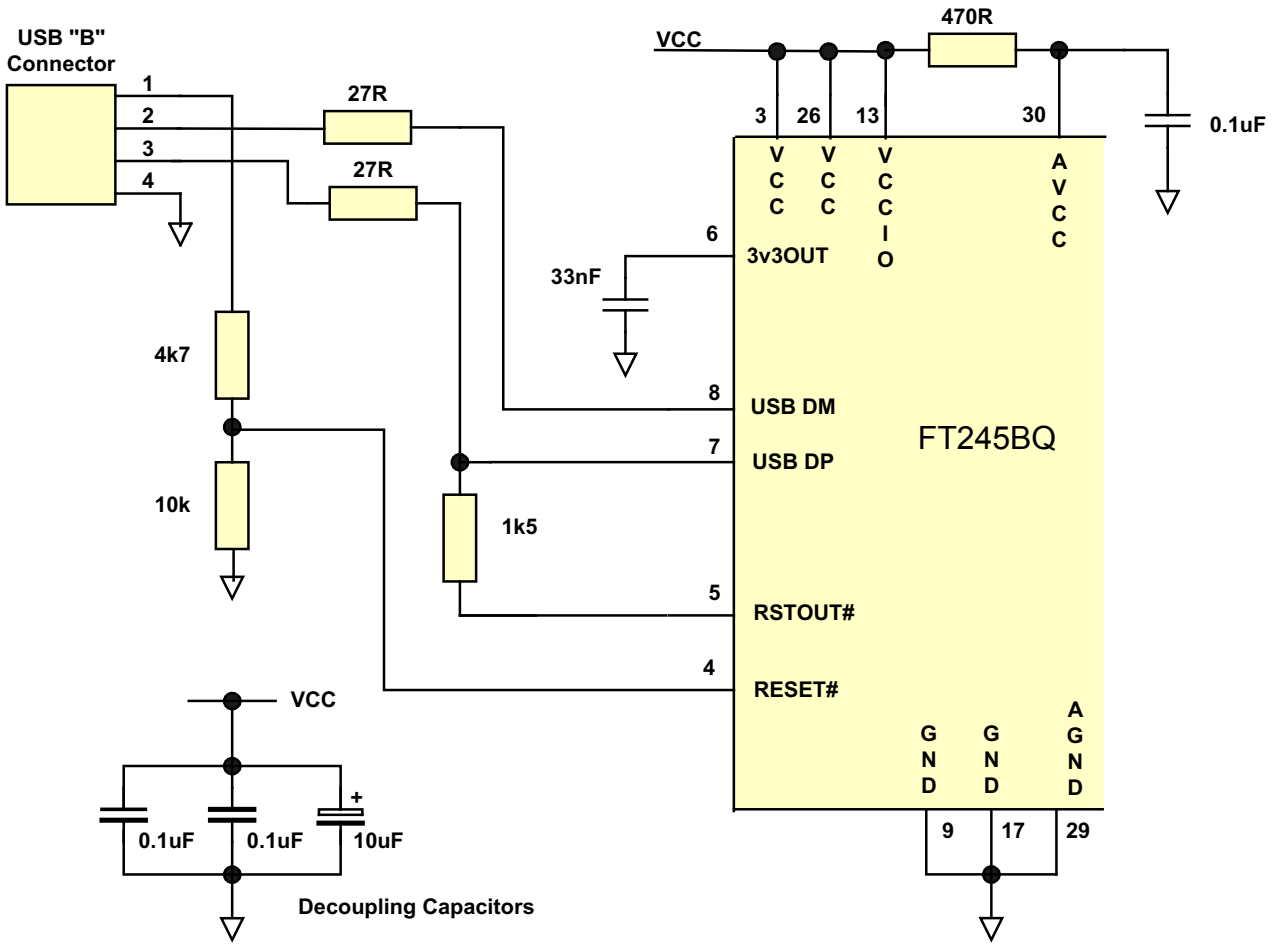


Figure 8 illustrates a typical USB self powered configuration. A USB Self Powered device gets its power from its own POWER SUPPLY and does not draw current from the USB bus. The basic rules for USB Self power devices are as follows –

a) A Self-Powered device should not force current down the USB bus when the USB Host or Hub Controller is powered down.

b) A Self Powered Device can take as much current as it likes during normal operation and USB suspend as it has its own POWER SUPPLY.

c) A Self Powered Device can be used with any USB Host and both Bus and Self Powered USB Hubs

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

To meet requirement a) the 1.5K pull-up resistor on USBDP is connected to RSTOUT# as per the bus-power circuit. However, the USB Bus Power is used to control the RESET# Pin of the FT245BQ device. When the USB Host or Hub is powered up RSTOUT# will pull the 1.5K resistor on USB DP to 3.3V, thus identifying the device as a full speed device to USB. When the USB Host or Hub power is off, RESET# will go low and the device will be held in reset. As RESET# is low, RSTOUT# will also be low, so no current will be forced down USBDP via the 1.5K pull-up resistor when the host or hub is powered down. Failure to do this may cause some USB host or hub controllers to power up erratically.

Note : When the FT245BQ is in reset, the FIFO interface pins all go tri-state. These pins have internal 200K pull-up resistors to VCCIO so they will gently pull high unless driven by some external logic.

Figure 9
Bus Powered Circuit with 3.3V logic drive / supply voltage

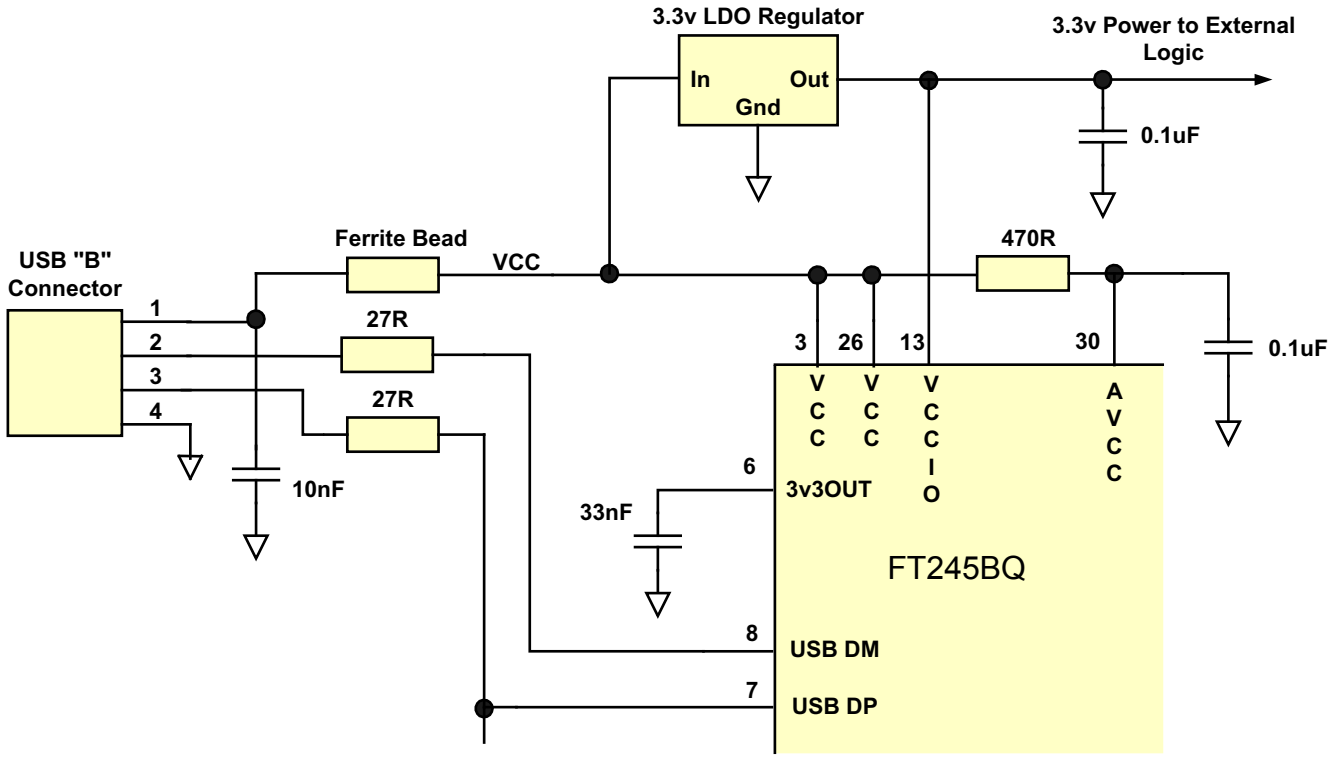


Figure 9 shows how to configure the FT245BQ to interface with a 3.3V logic device. In this example, a discrete 3.3V regulator is used to supply the 3.3V logic from the USB supply. VCCIO is connected to the output of the 3.3V regulator, which in turn will cause the FIFO interface IO pins to drive out at 3.3V level. For USB bus powered circuits some considerations have to be taken into account when selecting the regulator –

a) The regulator must be capable of sustaining its output voltage with an input voltage of 4.35 volts. A Low Drop Out (LDO) regulator must be selected.
b) The quiescent current of the regulator must be low in order to meet the USB suspend total current requirement of <= 500uA during USB suspend.

An example of a regulator family that meets these requirements is the MicroChip (Telcom) TC55 Series. These devices can supply up to 250mA current and have a quiescent current of under 1uA.

In some cases, where only a small amount of current is required (< 5mA) , it may be possible to use the in-built regulator of the FT245BQ to supply the 3.3V without any other components being required. In this case, connect VCCIO to the 3V3OUT pin of the FT245BQ.

Note : It should be emphasised that the 3.3V supply for VCCIO in a bus powered design with a 3.3V logic interface should come from an LDO which is supplied by USB bus, or from the 3V3OUT pin of the FT245BQ, and not from any other source.

Figure 10
Self Powered Circuit with 3.3 V logic drive / supply voltage

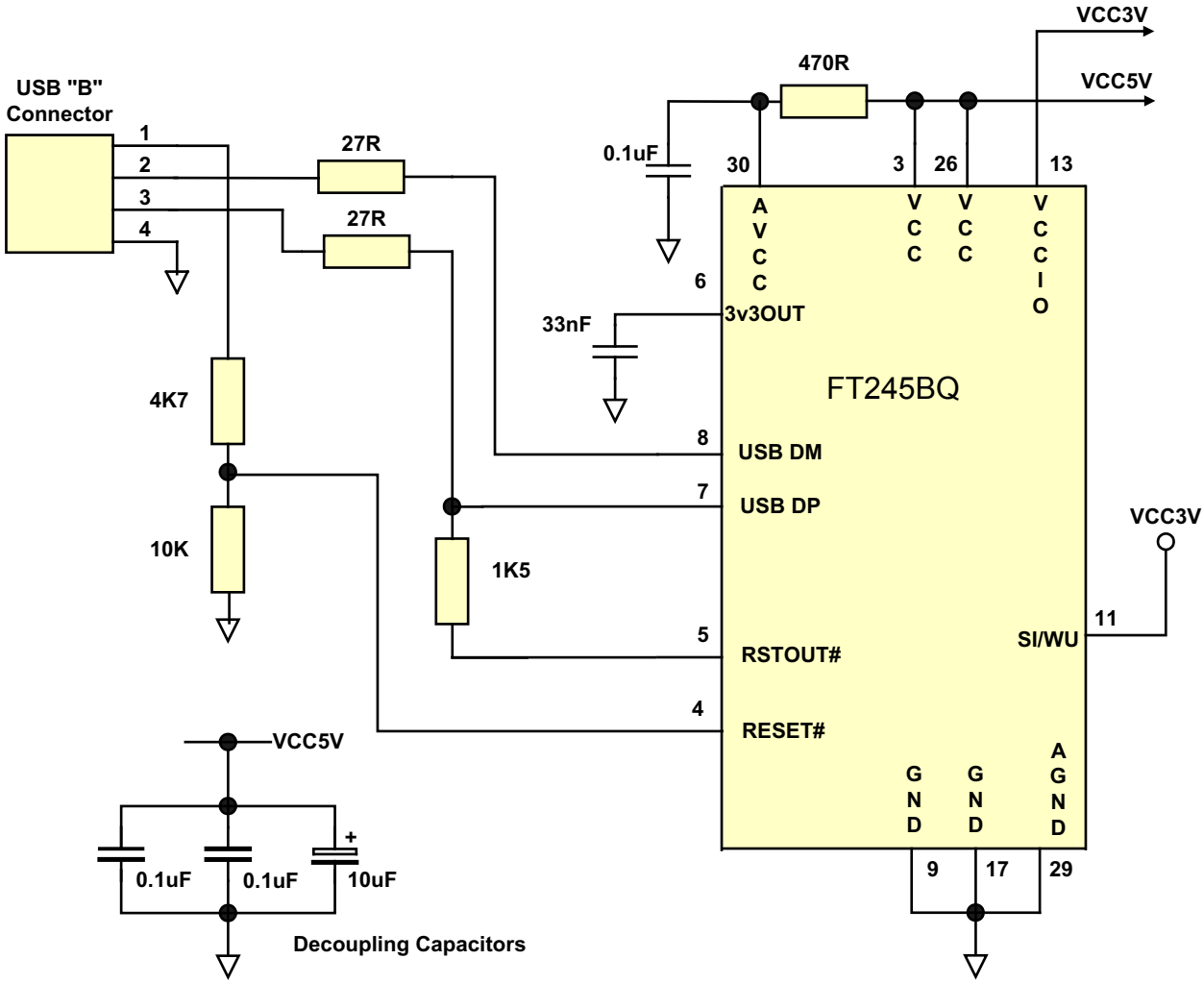
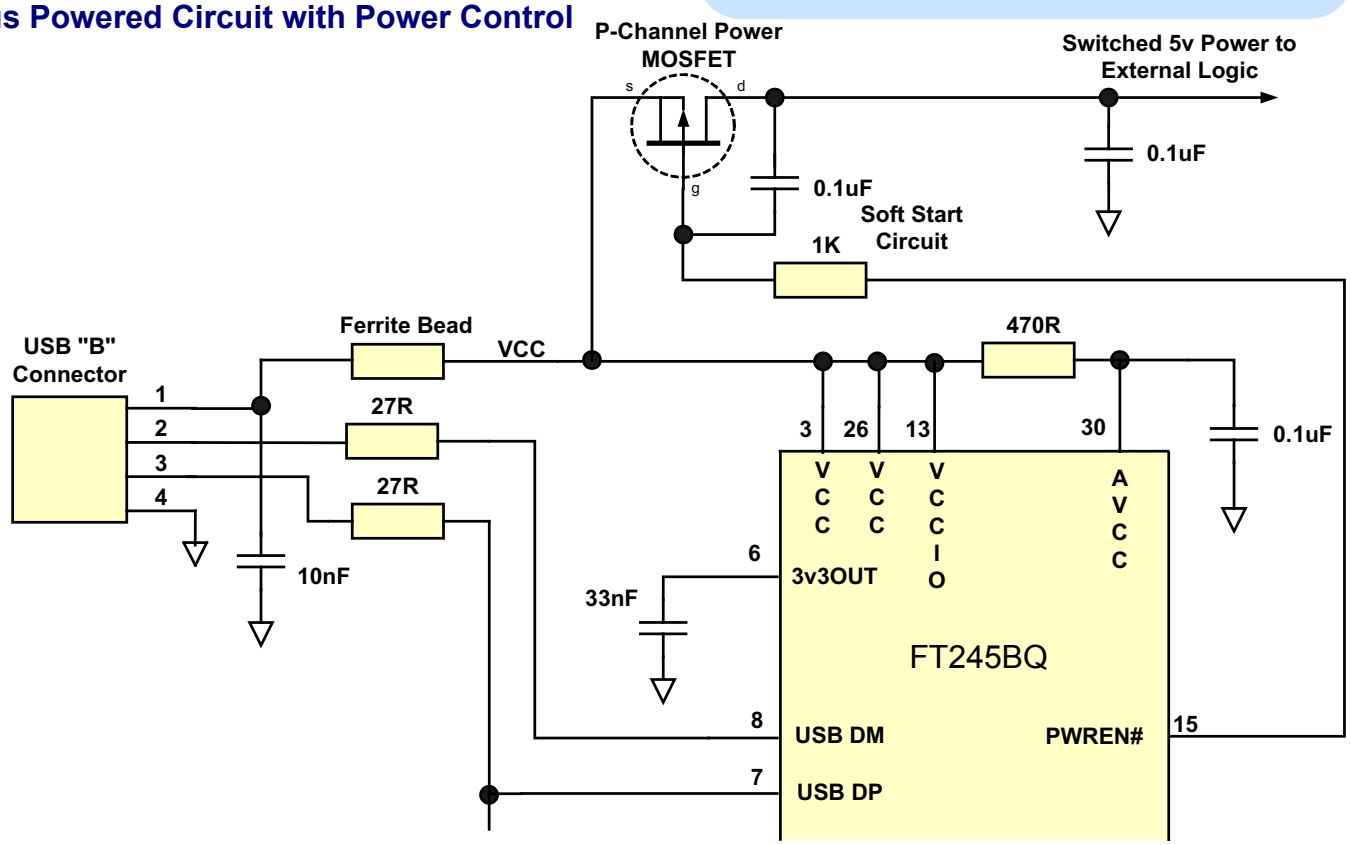


Figure 10 is an example of a USB self powered design with 3.3V interface. In this case VCCIO is supplied by an external 3.3V supply in order to make the device IO pins drive out at 3.3V logic level, thus allowing it to be connected to a 3.3V MCU or other external logic. A USB self powered design uses its own power supplies, and does not draw any of its power from the USB bus. In such cases, no special care need be taken to meet the USB suspend current (0.5 mA) as the device does not get its power from the USB port.

As with bus powered 3.3V interface designs, in some cases, where only a small amount of current is required (<5mA), it may be possible to use the in-built regulator of the FT245BQ to supply the 3.3V without any other components being required. In this case, connect VCCIO to the 3v3OUT pin of the FT245BQ.

Note that if SI/WU is not being used it should be pulled up to VCCIO.

Figure 11
Bus Powered Circuit with Power Control



USB Bus powered circuits need to be able to power down in USB suspend mode in order to meet the <= 500uA total suspend current requirement (including external logic). Some external logic can power itself down into a low current state by monitoring the PWREN# pin. For external logic that cannot power itself down in that way, the FT245BQ provides a simple but effective way of turning off power to external circuitry during USB suspend.

Figure 11 shows how to use a discrete P-Channel Logic Level MOSFET to control the power to external logic circuits. A suitable device could be a Fairchild NDT456P, or International Rectifier IRLML6402, or equivalent. It is recommended that a “soft start” circuit consisting of a 1K series resistor and a 0.1 uF capacitor are used to limit the current surge when the MOSFET turns on. Without the soft start circuit there is a danger that the transient power surge of the MOSFET turning on will reset the FT245BQ, or the USB host / hub controller. The values used here allow attached circuitry to power up with a slew rate of ~12.5 V per millisecond, in other words the output voltage will transition from GND to 5 V in approximately 400 microseconds.

Alternatively, a dedicated power switch I.C. with inbuilt “soft-start” can be used instead of a MOSFET. A suitable power switch i.c. for such an application would be a Micrel (www.micrel.com) MIC2025-2BL or equivalent.

Please note the following points in connection with power controlled designs –

a) The logic to be controlled must have its own reset circuitry so that it will automatically reset itself when power is re-applied on coming out of suspend.
b) Set the Pull-down on Suspend option in the FT245BQ’s EEPROM.
c) For USB high-power bus powered device (one that consumes greater than 100 mA, and up to 500 mA of current from the USB bus), the power consumption of the device should be set in the max power field in the EEPROM. A high-power bus powered device must use this descriptor in the EEPROM to inform the system of its power requirements.
d) For 3.3V power controlled circuits VCCIO must not be powered down with the external circuitry (PWREN# gets its VCC supply from VCCIO). Either connect the power switch between the output of the 3.3V regulator and the external 3.3V logic OR if appropriate power VCCIO from the 3v3OUT pin of the FT245BQ.

Figure 12
Microprocessor Interface Example

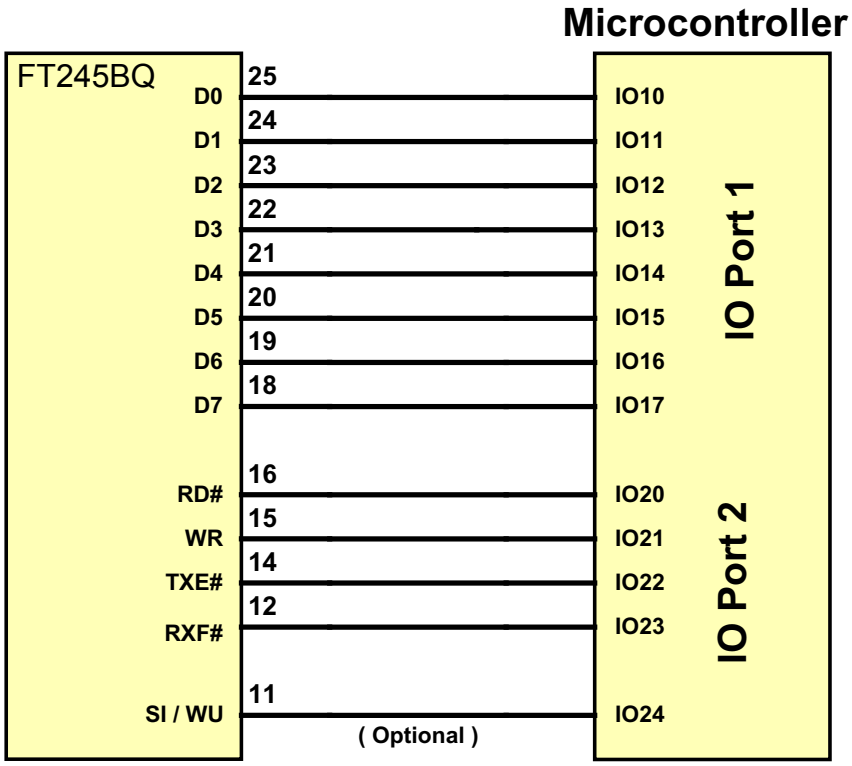


Figure 12 illustrates a typical interface between the FT245BQ and a MicroController (MCU). This examples uses two IO Ports of the MCU, one port (8 bits) to transfer data and the other port (4 / 5 bits) to monitor the TXE# and RXF# status bits and generate the RD# and WR strobes to the FT245BQ as required. Optionally, SI / WU can be connected to another IO pin if this function is required. If the SI / WU function is not required, tie this pin of the FT245BQ to VCCIO. If the MCU is handling power management functions, then PWREN# should also be connected to an IO pin of the MCU.

The 8 data bits of Port 1 can be shared with other peripherals when the MCU is not accessing the FT245BQ.

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8.0 Document Revision History

DS245B Version 1.0 – Initial document created 8th August 2002.

DS245B Version 1.1 – Updated 23 October 2003

- Pin and package naming made consistent throughout data sheet.
- Section 1.0 Corrected data transfer rate for VCP drivers.
- Section 1.0 Amended to reflect availability of Mac OS X drivers.
- Section 1.1 Description of behaviour of TXE# and RXF# amended.
- Section 3.1 Minor changes to functional block descriptions.
- Section 2.0 Compatible EEPROM configurations corrected.
- Section 4.1 SI/WU Pin description amended.
- Section 4.1 RSTOUT# Pin description amended.
- Section 4.1 EEPROM interface Pin descriptions amended.
- Section 4.1 Note 2 should have referred to VCCIO, not VCC.
- Section 4.1 FIFO timing diagram amended.
- Section 6.1 Minimum Operating supply voltage adjusted.
- Section 7.1 Updated recommended ceramic resonator part number and circuit configuration.
- Section 7.3 “USB Self Powered Configuration (1)” (original Figure 8) removed. Recommended circuit for USB self powered designs updated.
- Section 7.3 Self Powered Circuit with 3.3V logic drive / supply voltage added (new figure 8).
- Section 7.3 Figure 11 Bus powered circuit with power control updated to add soft start circuit on MOSFET. Circuit description amended.

DS245B Version 1.2 – Updated 20 November 2003.

- Section 6.1 FIFO Data control Bus IO pin characteristics amended
- Section 6.1 RESET#, TEST, EECS, EESK, and EEDATA pin characteristics amended.
- Section 6.1 RSTOUT# pin characteristics amended.

DS245B Version 1.3 – Updated 10 December 2003

- Section 5.0 Package drawing amended.
- Section 6.0 Floor Life / Relative Humidity specification added. ESD and Latch Up specifications amended.
- Section 7.1 Required accuracy of crystal / resonator corrected.

DS245B Version 1.4 – Updated 10 February 2004

- Grammar Corrections.
- Section 10.0 FTDI Address Updated
- Section 4.1 VCCIO Pin description ammended.

DS245B Version 1.5 – Updated March 2004

- Section 4.1 FIFO EESK Pin Description amended.
- Section 4.1 FIFO WR timings and diagram amended.
- Section 7.3 Figure 10 SI/WU Pin number corrected
- Section 7.3 Figure 11 PWREN# Pin number corrected

DS245B Version 1.6 – Updated February 2005

- Section 1 - Win CE VCP drivers now available
- Section 1 - D2XX drivers for Win CE and Linux now available
- Section 5 FT245BQ (lead free) and FT245BQ (lead free QFN package) now available

DS245B Version 1.7 – Updated December 2005

- Section 1 - Driver OS availabillity updated
- Section 6.1 - USB Data line absolute maximum rating added.

9.0 Disclaimer

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