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Spec Title: IMPLEMENTING AN 8-BIT ASYNCHRONOUS  
INTERFACE WITH FX2LP(TM) - AN6077

Sunset Owner: Rama Sai Krishna Vakkantula (KSKV)

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## Implementing an 8-bit Asynchronous Interface with FX2LP™

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### Abstract

AN6077 discusses how to configure the general programmable interface (GPIF) and slave FIFOs of the EZ-USB FX2LP™ to implement an 8-bit asynchronous interface. The GPIF is a programmable 8- or 16-bit parallel interface that reduces system costs by providing a glueless interface between the EZ-USB FX2LP and different types of external peripherals.

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### Introduction

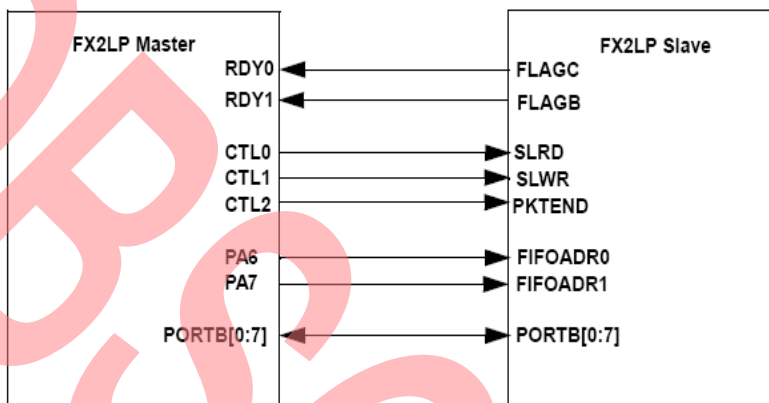
The GPIF allows the EZ-USB FX2LP to perform local bus mastering to external peripherals implementing a wide variety of protocols. For example, EIDE/ATAPI, printer parallel port (IEEE P1284), Utopia, and other interfaces are supported using the GPIF block of the EZ-USB FX2LP. In this example, it masters the slave FIFO interface of another EZ-USB FX2LP. This implementation uses the GPIF Designer (a utility Cypress provides to create GPIF waveform descriptors) to design the application-specific physical layer. The firmware is based on the Cypress EZ-USB FX2LP firmware 'frameworks'. A hardware setup of two back-to-back EZ-USB FX2LP boards is also used, one acting as a master and another as a slave. Familiarity with the EZ-USB FX2LP development kit, examples and documentation on the development kit CD-ROM, and chapters 9 (EZ-USB FX2LP Slave FIFOs) and 10 (GPIF) of the EZ-USB FX2LP Technical Reference Manual is assumed.

The objective of this application note is to:

- Demonstrate a glueless interface to an 8-bit peripheral data bus (the FIFO of a slave EZ-USB FX2LP).
- Use EZ-USB FX2LP to transfer data to and from the peripheral (slave EZ-USB FX2LP) and the USB host.

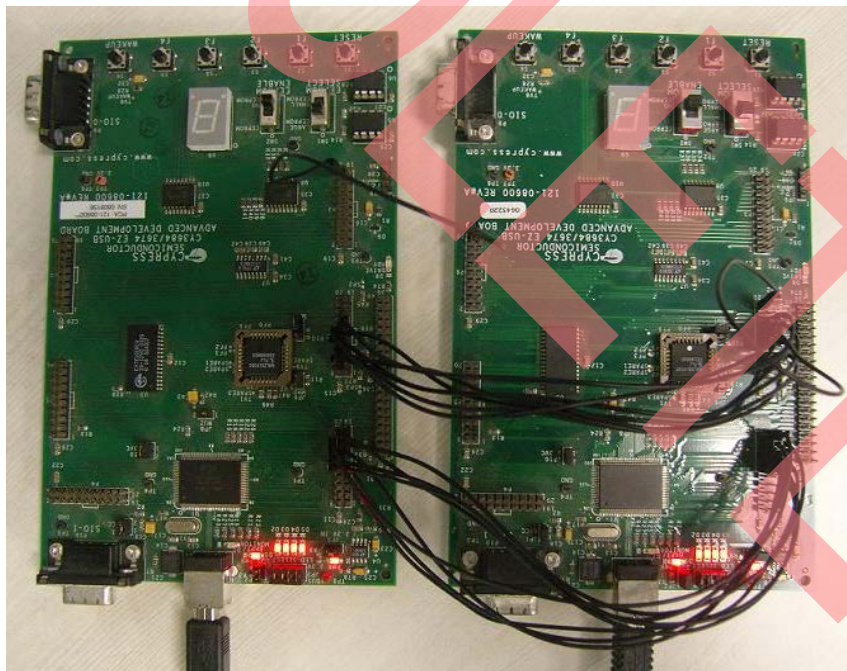
This application note discusses the necessary hardware connections, internal register settings, and 8051 firmware implemented to execute data transactions over the interface and across the USB bus.

Figure 1. Hardware Connection Diagram



## Hardware Setup

The following figure shows the back to back setup that is used for implementing this 8-bit asynchronous interface



## GPIF Master Pin Descriptions

This section discusses GPIF pin names, descriptions, and their uses.

### RDYn Inputs

RDY[5:0] are 'ready' inputs that can be sampled and allow a transaction to wait (inserting wait states), continue, or repeat until the signal is at the appropriate level. This implementation uses RDY0 and RDY1 to control data flow.

RDY0 is tied to FLAGC (EP2 empty flag) of the slave and RDY1 is tied to FLAGB (EP6 Full Flag) of the slave.

Other RDY inputs may be used in the application for additional debug status information.

### CTLx Outputs

CTL[5:0] are programmable control outputs that are used as strobes, read/write lines, or other outputs.

CTL0, CTL1 and CTL2 are used in this application.

CTL0 is tied to SLRD of the slave.

CTL1 is tied to SLWR of the slave.

CTL2 is tied to PKTEND of the slave.

### FD[0:7]

This implementation has an 8-bit data bus. PORTB[0:7] serves as the data bus on both the master and the slave.

### PORTA[6:7]

PA6 and PA7 are tied to FIFOADR0 and FIFOADR1 of the slave. These are used to drive the address of the FIFO being accessed by the master.

## Slave FIFO Pin Descriptions

The slave FIFO pin names, descriptions, and their uses are discussed in this section.

### SLRD

SLRD is the Slave Read line for the FIFO. SLRD acts as the read strobe for the slave. CTL0 of the master provides the strobe.

### SLWR

SLWR is the Slave Write line for the FIFO. SLWR acts as the write strobe for the slave. CTL1 of the master provides the strobe.

### SLOE

In this implementation SLOE is tied to SLRD.

### FD[0:7]

This is Port B, which is configured as the 8-bit data bus. If the WORDWIDE bit of the *IFCONFIG* register is set, then port D is configured to be FD[8:15]. This implementation has an 8-bit interface.

### FLAGA/FLAGB/FLAGC/FLAGD

FLAGC is used to indicate the state of 'emptiness' of the endpoint 2 FIFO of the slave. FLAGB is used to indicate the state of 'fullness' of the endpoint 6 FIFO of the slave.

FLAGA and FLAGD are not used in this implementation.

### FIFOADR[0:1]

The master selects one of the four slave FIFOs using the FIFOADR pins, and then drives the 8-bit FIFO data using the SLRD (Slave Read) and SLWR (Slave Write) signals.

### PKTEND

PKTEND is used to dispatch a short (less than the maximum packet size) IN packet to the USB. In this implementation, it is tied to CTL2 of the master EZ-USB FX2LP.

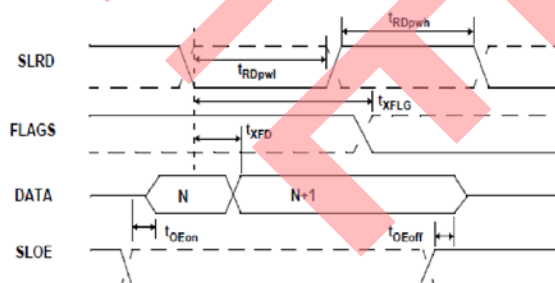
## Creating GPIF Waveforms

This section describes the parameters to create a waveform and includes figures for graphical clarity. Example code is also included. GPIF Designer tool can be downloaded from the <http://www.cypress.com>

Once downloaded and installed in PC, it can be run from **Start > All Programs > Cypress > USB > GPIF Designer**. More information regarding GPIF Designer can be found with the "Help" tab present on the tool.

### FIFORD

When creating the FIFORD waveform the following timing parameters must be met:



$t_{RD_{pwl}}$	-SLRD pulse width LOW = 50 ns (minimum)
$t_{RD_{pwh}}$	-SLRD pulse width HIGH = 50 ns (minimum)
$t_{XFLG}$	-SLRD to FLAGS output propagation delay = 70 ns (maximum)
$t_{XFD}$	-SLRD to FIFO data output propagation delay = 15 ns (maximum)
$t_{OE_{on}}$	-SLOE Turn on to FIFO data valid = 10.5 ns (maximum)
$t_{OE_{off}}$	-SLOE Turn off to FIFO data hold = 10.5 ns (maximum)

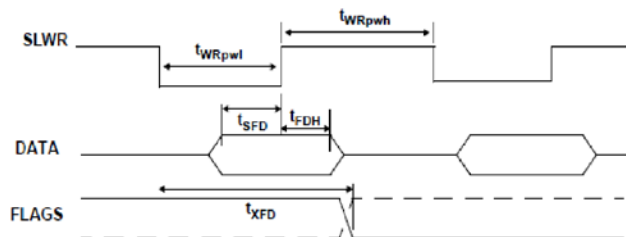
This results in the following sequence:

<b>s0</b>	Sample the empty flag of the peripheral. If the peripheral is 'not empty', proceed to s1 else go to s6 where an interrupt is triggered and the waveform is aborted.
<b>s1</b>	Assert the SLRD strobe and wait for three cycles to meet the $t_{RD_{pwl}}$ parameter.
<b>s2</b>	Sample the data bus.
<b>s3</b>	Branch to IDLE.

Figure 2 shows the GPIF Designer view of the FIFO read waveform.

## FIFOWR

When creating the FIFOWR waveform the following timing parameters must be met:



$t_{WR_{pwl}}$	- SLWR pulse width LOW = 50 ns (minimum)
$t_{WR_{pwh}}$	- SLWR pulse width HIGH = 50 ns (minimum)
$t_{SFD}$	- SLWR to FIFO DATA setup time= 10 ns (minimum)
$t_{FDH}$	- FIFO DATA to SLWR hold time = 10 ns (minimum)
$t_{XFD}$	- SLWR to FLAGS output propagation delay = 70 ns (maximum)

This results in the following sequence:

<b>s0</b>	Sample the full flag of the peripheral. If the peripheral is 'not full', proceed to s1, otherwise proceed to s6 to trigger an interrupt and abort the GPIF waveform.
<b>s1</b>	Assert the SLWR strobe and drive the data bus and wait for three cycles to meet the $t_{WR_{pwl}}$ parameter.
<b>s2</b>	Deassert the SLWR and increment the FIFO pointer.
<b>s3</b>	Branch to IDLE.

Figure 3 shows the GPIF Designer view of the FIFO Write waveform. Figure 4 and Figure 5 on page 6 show the view of the GPIF waveforms in the *gpif.c* file. This is the same as is seen in the GPIF Tool utility.

Figure 2. FIFO Read Waveform in GPIF Designer

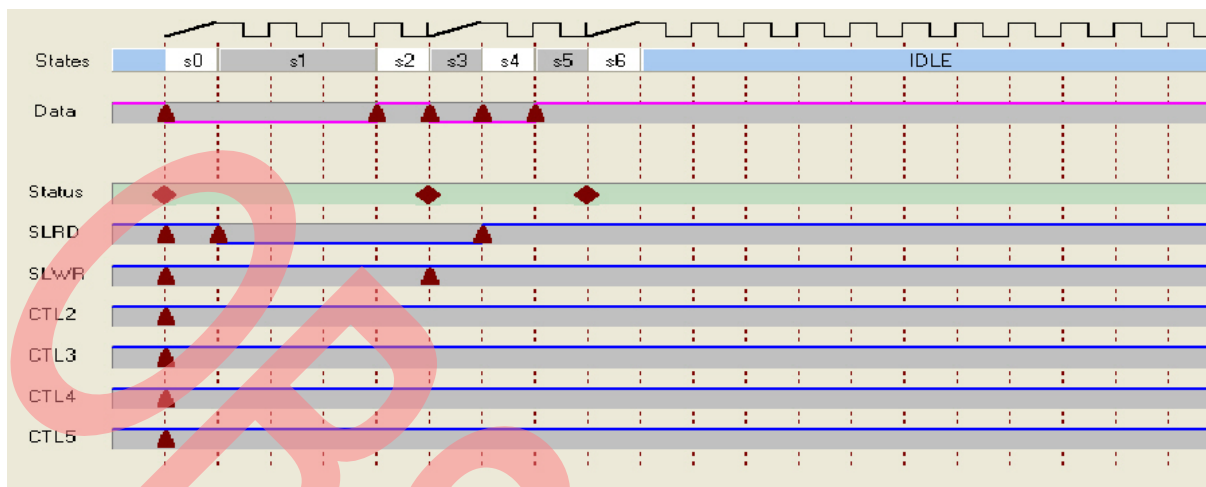


Figure 3. FIFO Write Waveform in GPIF Designer

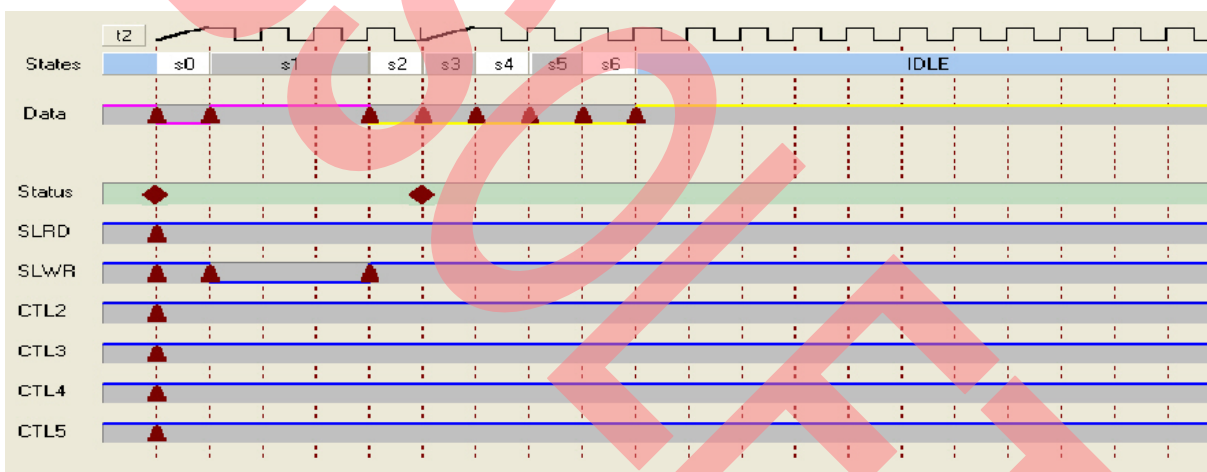




Figure 4. FIFO Read Waveform in gpif.c

```
// GPIF Waveform 2: FIFO Rea
//
// Interval      0      1      2      3      4      5      6      Idle (7)
//
// AddrMode Same Val Same Val Same Val Same Val Same Val Same Val Same Val
// DataMode NO Data NO Data Activate NO Data NO Data Activate Activate
// NextData SameData SameData SameData SameData SameData SameData SameData
// Int Trig No Int No Int No Int No Int No Int No Int Trig Int
// IF/Wait IF Wait 3 Wait 1 IF Wait 1 Wait 1 IF
// Term A S_Empty RDY2 RDY2
// LFunc AND AND
// Term B S_Empty RDY2 RDY2
// Branch1 Then 1 ThenIdle Then 6
// Branch0 Else 6 ElseIdle Else 6
// Re-Exec No No No
// Sngl/CRC Default Default Default Default Default Default Default
// SLRD 1 0 0 0 1 1 1 1
// SLWR 1 1 1 1 1 1 1 1
// CTL2 1 1 1 1 1 1 1 1
// CTL3 1 1 1 1 1 1 1 1
// CTL4 1 1 1 1 1 1 1 1
// CTL5 1 1 1 1 1 1 1 1
//
```

Figure 5. FIFO Wire Waveform in gpif.c

```
// GPIF Waveform 3: FIFO Wr1
//
// Interval      0      1      2      3      4      5      6      Idle (7)
//
// AddrMode Same Val Same Val Same Val Same Val Same Val Same Val Same Val
// DataMode NO Data Activate NO Data NO Data NO Data NO Data NO Data
// NextData SameData SameData NextData SameData SameData SameData SameData
// Int Trig No Int No Int No Int No Int No Int No Int No Int
// IF/Wait IF Wait 3 Wait 1 IF Wait 1 Wait 1 Wait 1
// Term A S_Full RDY2 RDY2
// LFunc AND AND
// Term B S_Full RDY2 RDY2
// Branch1 Then 1 ThenIdle ThenIdle
// Branch0 Else 0 ElseIdle ElseIdle
// Re-Exec No No No
// Sngl/CRC Default Default Default Default Default Default Default
// SLRD 1 1 1 1 1 1 1 1
// SLWR 1 0 1 1 1 1 1 1
// CTL2 1 1 1 1 1 1 1 1
// CTL3 1 1 1 1 1 1 1 1
// CTL4 1 1 1 1 1 1 1 1
// CTL5 1 1 1 1 1 1 1 1
//
```

## 8051 Firmware Programming (Master)

This section describes how to configure the 8051 to support the interface on the master side (register settings and others) and discusses the firmware implemented to perform data transactions over the local bus and the USB. The complete code listing is provided at the end of this document.

### Firmware Architecture

The firmware is designed to handle USB INs and OUTs arbitrarily (for example, the direction of transfer is not favored).

It is also fairly deterministic in its approach and is 'event-driven' by the following key conditions:

#### OUTs (FIFO Writes)

- Endpoint 2 OUT has data
- Peripheral interface not busy (GPIF IDLE)
- Slave interface FIFO not full

#### INs (FIFO Reads)

- Peripheral interface not busy (GPIF IDLE)
- Slave Interface FIFO not empty
- Endpoint 6 IN available not full

Because the GPIF is a shared resource between FIFO reads and writes, the peripheral interface status is always checked before committing the GPIF to launch any form of physical bus transactions.



The firmware is optimized for 512-byte FIFO reads and writes with other mechanisms in place to handle short packets (1–511 bytes). The firmware uses the AUTO mode for both IN and OUT transfers. This means that the maximum size (512 bytes) packets are committed automatically from the peripheral domain to the USB domain for OUT transfers. For IN transfers, they are

committed from USB to the peripheral domain. The 8051 is not involved in committing packets. Short packets are handled by the master strobing the PKTEND of the slave. In this implementation, the PKTEND of the slave is tied to CTL2 of the master. Therefore, the GPIFIDLECTL register is written to strobe PKTEND.

### Pseudocode for Master OUT

```
if GPIF is IDLE
    if there is a packet in EP2 OUT
        if the peripheral is not FULL
            trigger the GPIF Write Transaction
            // handle short packet
            if the transaction count < 512
                if GPIF is IDLE
                    strobe PKTEND
                else
                    // do nothing; wait for GPIF to be done
            else
                // do nothing; packet is not short packet
        else
            // do nothing; peripheral is FULL
    else
        // do nothing; no data is available to transfer
    else
        // do nothing; GPIF is not IDLE
```

### Pseudocode for Master IN

```
if the GPIF is IDLE
    if the peripheral is not empty
        if EP6 IN is not full
            trigger the GPIF Read transaction
            if packet is short packet
                commit the packet by writing INPKTEND
            else
                //do nothing; packet is not short
        else
            //do nothing; EP6 IN is full
    else
        //do nothing; the peripheral does not have data to transfer
    else
        //do nothing; GPIF is busy
```

### Expanded Master OUT Code

```
if( GPIFTRIG & 0x80 )
{
    // DONE=1, when GPIF is "idle"
    // check if there is a packet in the peripheral domain (EP2OUT)
    if( EP24FIFOFLGS & 0x02 )
    {
        // EF=1 when buffer "empty", for example, no more data to transfer
```

```

    }
    else
    {
// EF=0, when slave fifo is "not empty"
// the cpu passed the packet to the peripheral domain (AUTO OUT)
// check if peripheral "not full"
        if( GPIFREADYSTAT & 0x02 )
        {
// RDY1=1, when peripheral is "not" FULL (tied to peripheral "full" flag)
// drive FIFOADDR lines
            OEA = 0xC0;
            IOA = 0x80;

            xFIFOTC_OUT = ( ( EP2FIFOBCH << 8 ) + EP2FIFOBCL );

// setup GPIF transaction count
            SYNCDELAY;
            EP2GPIFTCH = EP2FIFOBCH;
            SYNCDELAY;
            EP2GPIFTCL = EP2FIFOBCL;

// trigger FIFO write transaction(s)
            SYNCDELAY;
            GPIFTRIG = GPIFTRIGWR | GPIF_EP2;

// once master (GPIF) drains OUT packet, it (re)arms to usb domain
// this path is always auto, meaning core handles it

            if( xFIFOTC_OUT < enum_pkt_size )
            {
// handle short packet to peripheral
// wait for the transaction to terminate naturally
                while( !( GPIFTRIG & 0x80 ) )
                {

                    ; // poll GPIFTRIG.7, DONE bit
                }

// signal short packet to peripheral here
// in this implementation CTL2 is tied to PKTEND of slave strobe PKTEND of slave

                GPIFIDLECTL |= 0x04;
                GPIFIDLECTL &= 0xFB;
                GPIFIDLECTL |= 0x04;
            }
            else
            {

```

```
// was max packet size
// let transaction terminate naturally
}
```

```
    }
    else
    {
// RDY1=0, when peripheral is FULL
    }
}
else
{
// DONE=0 when GPIF is "not" IDLE
}
```

### Expanded Master IN Code

```
// is the GPIF idle
if( GPIFTRIG & 0x80 )
{
// check if peripheral is "not empty"
if( GPIFREADYSTAT & 0x01 )
{
// RDY0=1, when peripheral is "not empty"
// drive FIFOADDR lines
OEA = 0xC0;
IOA = 0x00;
if( EP68FIFOFLGS & 0x01 )
{
// EP6FF=1, when fifo "full"
}
else
{
// EP6FF=0, when fifo "not full", for example, buffer available
// setup GPIF transaction count
SYNCDELAY;
EP6GPIFTCH = 0x02;
SYNCDELAY;
EP6GPIFTCL = 0x00;
// trigger FIFO read transaction(s), using SFR
SYNCDELAY;
GPIFTRIG = GPIFTRIGRD | GPIF_EP6;
// wait for transaction to terminate naturally
SYNCDELAY;
while( !( GPIFTRIG & 0x80 ) )
{
; // poll GPIFTRIG.7, DONE bit
}
```

```

    }

// AUTOOUT=1, core handles transfers
// cpu is not in the data path however, cpu is responsible for committing "short packets"

    xFIFOTC_IN = ( ( EP6FIFOBCH << 8 ) + EP6FIFOBCL );
if( xFIFOTC_IN < enum_pkt_size )
{
// handle short packet from peripheral
    SYNCDELAY;
    INPKTEND = 0x06;
// w/skip=0;commit however many bytes in packet.
    SYNCDELAY;
}
else
{
// core commits packet via EPxAUTOINLENH/L
}

else
{
// master has all the data the peripheral sent
}
}
else
{
// peripheral interface busy
}
}

```

## Firmware for the Slave

Since the slave works only in AUTO mode, there is no code required for data transfer to and from the master, except for the initialization of registers and specifying the EP6AUTOINLEN registers.

## Summary

This application note describes how to set up the GPIF to transfer data over an 8-bit asynchronous interface (to the slave FIFO of another EZ-USB FX2LP). It includes hardware setup, creating GPIF waveforms, and writing the 8051 code that arbitrarily handles both USB INs and OUTs.

This application note is centered on a specific back-to-back board setup with two EZ-USB FX2LP boards. However, many concepts and insights conveyed

in this document can be applied to and used as a basic framework for mainstream applications.

## References

For more information on GPIF, refer to the following documents available on our website:

- [FX2LP GPIF Master-Slave FIFO Back-to-Back Setup](#): This contains an example project which implements the code explained in the above document without using flow control.
- [Manual Mode Operation of EZ-USB FX2LP™ in GPIF and Slave FIFO Configuration](#)
- [EZ-USB FX2 GPIF Primer](#)
- [Interfacing SRAM with FX2LP over GPIF](#)

## Code Listing for Master Side

```
#pragma NOIV // Do not generate interrupt vectors
#include "fx2.h"
#include "fx2regs.h"
#include "fx2sdly.h" // SYNCDELAY macro

extern BOOL GotSUD; // Received setup data flag
extern BOOL Sleep;
extern BOOL Rwuen;
extern BOOL Selfpwr;

BYTE Configuration; // Current configuration
BYTE AlternateSetting; // Alternate settings

// proto's from "gpif.c"
void GpifInit( void );

// 512 for high speed, 64 for full speed
static WORD enum_pkt_size = 0x0000;

// when set firmware running in TD_Poll( ); handles data transfers
BOOL td_poll_handles_transfers = 1;

// when set cpu is out of the data path
BOOL endp_auto_mode_enabled = 1;

//-----
// Task Dispatcher hooks
// The following hooks are called by the task dispatcher.
//-----
void TD_Init( void )
{ // Called once at startup

    CPUCS = 0x10; // CLKSPD[1:0]=10, for 48 MHz operation
                  // CLKOE=0, don't drive CLKOUT

    GpifInit( ); // init GPIF engine via GPIFTool output file

    // Registers which require a synchronization delay, see section 15.14
    // FIFORESET FIFOPINPOLAR
    // INPKTEND OUTPKTEND
    // EPxBCH:L REVCTL
    // GPIFTCB3 GPIFTCB2
    // GPIFTCB1 GPIFTCB0
    // EPxFIFOPFH:L EPxAUTOINLENH:L
    // EPxFIFOCFG EPxGPIFFLGSEL
    // PINFLAGSxx EPxFIFOIRQ
    // EPxFIFOIE GPIFIRQ
    // GPIFIE GPIFADRH:L
    // UDMACRCH:L EPxGPIFTRIG
    // GPIFTRIG

    SYNCDELAY; // see TRM section 15.14
```

```

REVCTL = 0x02;                // REVCTL.1=1;

SYNCDELAY;
EP2CFG = 0xA0;                // BUF[1:0]=00 for 4x buffering

// EP6 512 BULK IN 4x
SYNCDELAY;
EP6CFG = 0xE0;                // BUF[1:0]=00 for 4x buffering

// EP4 and EP8 are not used in this implementation
SYNCDELAY;                    //
EP4CFG = 0x20;                // clear valid bit
SYNCDELAY;                    //
EP8CFG = 0x60;                // clear valid bit

SYNCDELAY;                    //
FIFORESET = 0x80;             // activate NAK-ALL to avoid race conditions
SYNCDELAY;                    //
FIFORESET = 0x82;             // reset, FIFO 2
SYNCDELAY;                    //
FIFORESET = 0x84;             // reset, FIFO 4
SYNCDELAY;                    //
FIFORESET = 0x86;             // reset, FIFO 6
SYNCDELAY;                    //
FIFORESET = 0x88;             // reset, FIFO 8
SYNCDELAY;                    //
FIFORESET = 0x00;             // deactivate NAK-ALL

// 8-bit bus (WORDWIDE=0)
SYNCDELAY;
EP2FIFOCFG = 0x00;
SYNCDELAY;
EP6FIFOCFG = 0x0C;

SYNCDELAY;
EP2BCL = 0x00;                // arm first buffer
SYNCDELAY;                    //
EP2BCL = 0x00;                // arm second buffer
SYNCDELAY;                    //
EP2BCL = 0x00;                // arm third buffer
SYNCDELAY;                    //
EP2BCL = 0x00;                // arm fourth buffer
SYNCDELAY;

SYNCDELAY;
OUTPKTEND = 0x02;
SYNCDELAY;
OUTPKTEND = 0x02;
SYNCDELAY;
OUTPKTEND = 0x02;
SYNCDELAY;
OUTPKTEND = 0x02;
SYNCDELAY;

SYNCDELAY;                    //
  
```

```

EP2FIFOCFG = 0x10;
SYNCDelay;

// IN endp's come up in the cpu/peripheral domain

// setup INT4 as internal source for GPIF interrupts
// using INT4CLR (SFR), automatically enabled
INTSETUP |= 0x03; // Enable INT4 FIFO/GPIF Autovectoring
SYNCDelay; // used here as "delay"
EXIF &= ~0x40; // just in case one was pending.
SYNCDelay; // used here as "delay"
GPIFIRQ = 0x02;
SYNCDelay; //
GPIFIE = 0x02; // Enable GPIFWF interrupt
SYNCDelay; //
EIE |= 0x04; // Enable INT4 ISR, EIE.2(EIEX4=1)
}

#define GPIFTRIGWR 0
#define GPIFTRIGRD 4

#define GPIF_EP2 0
#define GPIF_EP4 1
#define GPIF_EP6 2
#define GPIF_EP8 3

void TD_Poll( void )
{ // Called repeatedly while the device is idle
  static WORD xFIFOTC_OUT = 0x0000;
  static WORD xFIFOTC_IN = 0x0000;

  // Registers which require a synchronization delay, see section 15.14
  // FIFORESET FIFOPINPOLAR
  // INPKTEND OUTPKTEND
  // EPxBCH:L REVCTL
  // GPIFTCB3 GPIFTCB2
  // GPIFTCB1 GPIFTCB0
  // EPxFIFOPFH:L EPxAUTOINLENH:L
  // EPxFIFOCFG EPxGPIFFLGSEL
  // PINFLAGSxx EPxFIFOIRQ
  // EPxFIFOIE GPIFIRQ
  // GPIFIE GPIFADRH:L
  // UDMACRCH:L EPxGPIFTRIG
  // GPIFTRIG

  OEA = 0xC0;
  IOA = 0x80;

  if( td_poll_handles_transfers )
  {
    // Handle OUT data
  }
}

```



```

// is the peripheral interface idle

if( GPIFTRIG & 0x80 )
{
    // DONE=1, when GPIF is "idle"

    // check if there is a packet in the peripheral domain (EP2OUT)
    if( EP24FIFOFLGS & 0x02 )
    {
        // EF=1 when buffer "empty", for example, no more data to transfer
    }
    else
    {
        // EF=0, when slave fifo is "not empty"
        // the cpu passed the packet to the peripheral domain (AUTO OUT)

        // check if peripheral "not full"
        if( GPIFREADYSTAT & 0x02 )
        {
            // RDY1=1, when peripheral is "not" FULL (tied to peripheral "full" flag)
            // drive FIFOADDR lines
            OEA = 0xC0;
            IOA = 0x80;

            xFIFOTC_OUT = ( ( EP2FIFOBCH << 8 ) + EP2FIFOBCL );

            // setup GPIF transaction count
            SYNCDELAY;
            EP2GPIFTCH = EP2FIFOBCH;
            SYNCDELAY;
            EP2GPIFTCL = EP2FIFOBCL;

            // trigger FIFO write transaction(s), using SFR

            SYNCDELAY;
            GPIFTRIG = GPIFTRIGWR | GPIF_EP2;

            // once master (GPIF) drains OUT packet, it (re)arms to usb domain
            // this path is always auto, meaning core handles it

            if( xFIFOTC_OUT < enum_pkt_size )
            {
                // handle short packet to peripheral

                // wait for the transaction to terminate naturally
                while( !( GPIFTRIG & 0x80 ) )
                {
                    ; // poll GPIFTRIG.7, DONE bit...
                }

                // signal short packet to peripheral here
                // in this implementation CTL2 is tied to PKTEND of slave
                // strobe PKTEND of slave
            }
        }
    }
}

```

```

    GPIFIDLECTL |= 0x04;
    GPIFIDLECTL &= 0xFB;
    GPIFIDLECTL |= 0x04;

    }
    else
    {
        // was max packet size
        // let transaction terminate naturally
    }

    }
    else
    {
        // RDY1=0, when peripheral is FULL
    }
  }
}
else
{
    // DONE=0 when GPIF is "not" IDLE
}

// Handle IN data

// is the GPIF idle
if( GPIFTRIG & 0x80 )
{
    // check if peripheral is "not empty"
    if( GPIFREADYSTAT & 0x01 )
    {
        // RDY0=1, when peripheral is "not empty"
        // drive FIFOADDR lines
        OEA = 0xC0;
        IOA = 0x00;

        if( EP68FIFOFLGS & 0x01 )
        {
            // EP6FF=1, when fifo "full"
        }
        else
        {
            // EP6FF=0, when fifo "not full", for example, buffer available

            // setup GPIF transaction count
            SYNCDELAY;
            EP6GPIFTCH = 0x02;
            SYNCDELAY;
            EP6GPIFTCL = 0x00;

            // trigger FIFO read transaction(s), using SFR

            SYNCDELAY;

```

```

    GPIFTRIG = GPIFTRIGRD | GPIF_EP6;

    // wait for the transaction to terminate naturally
    SYNCDELAY;
    while( !( GPIFTRIG & 0x80 ) )
    {
        ; // poll GPIFTRIG.7, DONE bit
    }

    // AUTOOUT=1, core handles transfers
    // cpu is not in the data path
    // however, cpu is responsible for committing "short packets"

    xFIFOTC_IN = ( ( EP6FIFOBCH << 8 ) + EP6FIFOBCL );

    if( xFIFOTC_IN < enum_pkt_size )
    {
        // handle short packet from peripheral
        SYNCDELAY;
        INPKTEND = 0x06; // w/skip=0;commit however many bytes in packet.
        SYNCDELAY;
    }
    else
    {
        // core commits packet via EPxAUTOINLENH/L registers
    }
}
else
{
    // master has all the data the peripheral sent
}
}
else
{
    // peripheral interface busy
}
}

}

BOOL TD_Suspend( void )
{ // Called before the device goes into suspend mode
  return( TRUE );
}

BOOL TD_Resume( void )
{ // Called after the device resumes
  return( TRUE );
}

//-----

```

```
// Device Request hooks
// The following hooks are called by the end point 0 device request parser.
//-----
BOOL DR_GetDescriptor( void )
{
    return( TRUE );
}

BOOL DR_SetConfiguration( void )
{ // Called when a Set Configuration command is received

    if( EZUSB_HIGHSPEED( ) )
    { // FX2LP in high speed mode
        SYNCDELAY;
        EP6AUTOINLENH = 0x02; // set core AUTO commit len = 512 bytes
        SYNCDELAY;
        EP6AUTOINLENL = 0x00;
        SYNCDELAY;
        enum_pkt_size = 512; // max. pkt. size = 512 bytes
    }
    else
    { // FX2LP in full speed mode
        SYNCDELAY;
        EP6AUTOINLENH = 0x00; // set core AUTO commit len = 64 bytes
        SYNCDELAY;
        EP6AUTOINLENL = 0x40;
        SYNCDELAY;
        enum_pkt_size = 64; // max. pkt. size = 64 bytes
    }

    Configuration = SETUPDAT[ 2 ];
    return( TRUE ); // Handled by user code
}

BOOL DR_GetConfiguration( void )
{ // Called when a Get Configuration command is received
    EPOBUF[ 0 ] = Configuration;
    EPOBCH = 0;
    EPOBCL = 1;
    return(TRUE); // Handled by user code
}

BOOL DR_SetInterface( void )
{ // Called when a Set Interface command is received
    AlternateSetting = SETUPDAT[ 2 ];
    return( TRUE ); // Handled by user code
}

BOOL DR_GetInterface( void )
{ // Called when a Set Interface command is received
    EPOBUF[ 0 ] = AlternateSetting;
    EPOBCH = 0;
    EPOBCL = 1;
    return( TRUE ); // Handled by user code
}
```

```

BOOL DR_GetStatus( void )
{
    return( TRUE );
}

BOOL DR_ClearFeature( void )
{
    return( TRUE );
}

BOOL DR_SetFeature( void )
{
    return( TRUE );
}

//-----
// USB Interrupt Handlers
// The following functions are called by the USB interrupt jump table.
//-----

// Setup Data Available Interrupt Handler
void ISR_Sudav( void ) interrupt 0
{
    GotSUD = TRUE;          // Set flag
    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmSUDAV;       // Clear SUDAV IRQ
}

// Setup Token Interrupt Handler
void ISR_Sutok( void ) interrupt 0
{
    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmSUTOK;       // Clear SUTOK IRQ
}

void ISR_Sof( void ) interrupt 0
{
    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmSOF;         // Clear SOF IRQ
}

void ISR_Ures( void ) interrupt 0
{
    if ( EZUSB_HIGHSPEED( ) )
    {
        pConfigDscr = pHighSpeedConfigDscr;
        pOtherConfigDscr = pFullSpeedConfigDscr;
    }
    else
    {
        pConfigDscr = pFullSpeedConfigDscr;
        pOtherConfigDscr = pHighSpeedConfigDscr;
    }
}

```

```
}

EZUSB_IRQ_CLEAR( );
USBIRQ = bmURES;      // Clear URES IRQ
}

void ISR_Susp( void ) interrupt 0
{
    Sleep = TRUE;
    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmSUSP;
}

void ISR_Highspeed( void ) interrupt 0
{
    if ( EZUSB_HIGHSPEED( ) )
    {
        pConfigDscr = pHighSpeedConfigDscr;
        pOtherConfigDscr = pFullSpeedConfigDscr;
    }
    else
    {
        pConfigDscr = pFullSpeedConfigDscr;
        pOtherConfigDscr = pHighSpeedConfigDscr;
    }

    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmHSGRANT;
}

void ISR_Ep0ack( void ) interrupt 0
{
}

void ISR_Stub( void ) interrupt 0
{
}

void ISR_Ep0in( void ) interrupt 0
{
}

void ISR_Ep0out( void ) interrupt 0
{
}

void ISR_Eplin( void ) interrupt 0
{
}

void ISR_Eplout( void ) interrupt 0
{
}

void ISR_Ep2inout( void ) interrupt 0
{
}

void ISR_Ep4inout( void ) interrupt 0
{
}

void ISR_Ep6inout( void ) interrupt 0
```

```
{
}
void ISR_Ep8inout( void ) interrupt 0
{
}
void ISR_Ibn( void ) interrupt 0
{
}
void ISR_Ep0pingnak( void ) interrupt 0
{
}
void ISR_Ep1pingnak( void ) interrupt 0
{
}
void ISR_Ep2pingnak( void ) interrupt 0
{
}
void ISR_Ep4pingnak( void ) interrupt 0
{
}
void ISR_Ep6pingnak( void ) interrupt 0
{
}
void ISR_Ep8pingnak( void ) interrupt 0
{
}
void ISR_Errorlimit( void ) interrupt 0
{
}
void ISR_Ep2piderror( void ) interrupt 0
{
}
void ISR_Ep4piderror( void ) interrupt 0
{
}
void ISR_Ep6piderror( void ) interrupt 0
{
}
void ISR_Ep8piderror( void ) interrupt 0
{
}
void ISR_Ep2pflag( void ) interrupt 0
{
}
void ISR_Ep4pflag( void ) interrupt 0
{
}
void ISR_Ep6pflag( void ) interrupt 0
{
}
void ISR_Ep8pflag( void ) interrupt 0
{
}
void ISR_Ep2eflag( void ) interrupt 0
{
}
```



```

}
void ISR_Ep4eflag( void ) interrupt 0
{
}
void ISR_Ep6eflag( void ) interrupt 0
{
}
void ISR_Ep8eflag( void ) interrupt 0
{
}
void ISR_Ep2fflag( void ) interrupt 0
{
}
void ISR_Ep4fflag( void ) interrupt 0
{
}
void ISR_Ep6fflag( void ) interrupt 0
{
}
void ISR_Ep8fflag( void ) interrupt 0
{
}
void ISR_GpifComplete( void ) interrupt 0
{
}
void ISR_GpifWaveform( void ) interrupt 0
{ // FIFORD WF detected peripheral prematurely empty (less than max. pkt. size)

    GPIFABORT = 0xFF;           // abort to handle shortpkt
    INPKTEND = 0x06;
    SYNCDELAY;
    EXIF &= ~0x40;
    INT4CLR = 0xFF;           // automatically enabled at POR
    SYNCDELAY;
}

```

## Code Listing for the Slave Side

```

#pragma NOIV           // Do not generate interrupt vectors
#include "fx2.h"
#include "fx2regs.h"
#include "fx2sdly.h"    // SYNCDELAY macro

extern BOOL GotSUD;     // Received setup data flag
extern BOOL Sleep;
extern BOOL Rwuen;
extern BOOL Selfpwr;

BYTE Configuration;    // Current configuration
BYTE AlternateSetting; // Alternate settings

```

```
//-----
// Task Dispatcher hooks
// The following hooks are called by the task dispatcher.
//-----
void TD_Init( void )
{ // Called once at startup

  CPUCS = 0x10; // CLKSPD[1:0]=10, for 48 MHz operation
  SYNCDELAY;
  REVCTL=0x02;

  IFCONFIG = 0xCB;
  // IFCLKSRC=1 , FIFOs executes on internal clk source
  // x MHz=1 , 48 MHz internal clk rate
  // IFCLKOE=0 , Don't drive IFCLK pin signal at 48 MHz
  // IFCLKPOL=0 , Don't invert IFCLK pin signal from internal clk
  // ASYNC=1 , master samples asynchronous
  // GSTATE=0 , Don't drive GPIF states out on PORTE[2:0], debug WF
  // IFCFG[1:0]=11, FX2 in slave FIFO mode

  // Registers which require a synchronization delay, see section 15.14
  // FIFORESET FIFOPINPOLAR
  // INPKTEND OUTPKTEND
  // EPxBCH:L REVCTL
  // GPIFTCB3 GPIFTCB2
  // GPIFTCB1 GPIFTCB0
  // EPxFIFOPFH:L EPxAUTOINLENH:L
  // EPxFIFOCFG EPxGPIFFLGSEL
  // PINFLAGSxx EPxFIFOIRQ
  // EPxFIFOIE GPIFIRQ
  // GPIFIE GPIFADRH:L
  // UDMACRCH:L EPxGPIFTRIG
  // GPIFTRIG
```

```

SYNCDELAY;

FIFORESET = 0x80;           // activate NAK-ALL to avoid race conditions
SYNCDELAY;                 // see TRM section 15.14
FIFORESET = 0x82;           // reset, FIFO 2
SYNCDELAY;                 //
FIFORESET = 0x84;           // reset, FIFO 4
SYNCDELAY;                 //
FIFORESET = 0x86;           // reset, FIFO 6
SYNCDELAY;                 //
FIFORESET = 0x88;           // reset, FIFO 8
SYNCDELAY;                 //
FIFORESET = 0x00;           // deactivate NAK-ALL

SYNCDELAY;
PINFLAGSAB = 0xEF;          // FLAGA - fixed EP8FF, FLAGB - fixed EP6FF
SYNCDELAY;
PINFLAGSCD = 0x98;          // FLAGC - fixed EP2EF, FLAGD - fixed EP4EF
SYNCDELAY;
PORTACFG |= 0x80;           // FLAGD, set alt. func. of PA7 pin
SYNCDELAY;
FIFOPINPOLAR = 0x00;        // all signals active low
SYNCDELAY;

EP2CFG = 0xA0;
SYNCDELAY;
EP6CFG = 0xE0;

// EP4 and EP8 are not used in this implementation
SYNCDELAY;                 //
EP4CFG = 0x20;              // clear valid bit
SYNCDELAY;                 //
EP8CFG = 0x60;              // clear valid bit

// handle the case where we were already in AUTO mode
EP2FIFOCFG = 0x00;          // AUTOOUT=0, WORDWIDE=0
SYNCDELAY;

SYNCDELAY;                 //

```

```

EP2BCL = 0x00;           // arm first buffer
SYNCDELAY;              //
EP2BCL = 0x00;           // arm second buffer
SYNCDELAY;              //
EP2BCL = 0x00;           // arm third buffer
SYNCDELAY;              //
EP2BCL = 0x00;           // arm fourth buffer
SYNCDELAY;              //

SYNCDELAY;
OUTPKTEND = 0x02;
SYNCDELAY;
OUTPKTEND = 0x02;
SYNCDELAY;
OUTPKTEND = 0x02;
SYNCDELAY;
OUTPKTEND = 0x02;
SYNCDELAY;

EP2FIFOCFG = 0x10;       // AUTOOUT=1, WORDWIDE=0
SYNCDELAY;

EP6FIFOCFG = 0x0C;       // AUTOIN=1, ZEROLENIN=1, WORDWIDE=0
SYNCDELAY;
}

void TD_Poll( void )
{ // Called repeatedly while the device is idle

    // nothing to do;slave fifo's are in AUTO mode

}

BOOL TD_Suspend( void )
{ // Called before the device goes into suspend mode
    return( TRUE );
}

```

```
BOOL TD_Resume( void )
{ // Called after the device resumes
    return( TRUE );
}

//-----
// Device Request hooks
// The following hooks are called by the end point 0 device request parser.
//-----
BOOL DR_GetDescriptor( void )
{
    return( TRUE );
}

BOOL DR_SetConfiguration( void )
{ // Called when a Set Configuration command is received

    if( EZUSB_HIGHSPEED( ) )
    { // FX2LP in high speed mode
        EP6AUTOINLENH = 0x02;
        SYNCDELAY;
    // set core AUTO commit len = 512 bytes
        SYNCDELAY;
        EP6AUTOINLENL = 0x00;
        SYNCDELAY;

    }
    else
    { // FX2LP in full speed mode
        EP6AUTOINLENH = 0x00;
        SYNCDELAY;
    // set core AUTO commit len = 64 bytes
        SYNCDELAY;
        EP6AUTOINLENL = 0x40;
        SYNCDELAY;
    }

    Configuration = SETUPDAT[ 2 ];
}
```

```
    return( TRUE );          // Handled by user code
}

BOOL DR_GetConfiguration( void )
{ // Called when a Get Configuration command is received
    EPOBUF[ 0 ] = Configuration;
    EPOBCH = 0;
    EPOBCL = 1;
    return(TRUE);           // Handled by user code
}

BOOL DR_SetInterface( void )
{ // Called when a Set Interface command is received
    AlternateSetting = SETUPDAT[ 2 ];
    return( TRUE );        // Handled by user code
}

BOOL DR_GetInterface( void )
{ // Called when a Set Interface command is received
    EPOBUF[ 0 ] = AlternateSetting;
    EPOBCH = 0;
    EPOBCL = 1;
    return( TRUE );        // Handled by user code
}

BOOL DR_GetStatus( void )
{
    return( TRUE );
}

BOOL DR_ClearFeature( void )
{
    return( TRUE );
}

BOOL DR_SetFeature( void )
{
    return( TRUE );
}
```

```

}

BOOL DR_VendorCmnd( void )
{
    return( TRUE );
}

//-----
// USB Interrupt Handlers
// The following functions are called by the USB interrupt jump table.
//-----

// Setup Data Available Interrupt Handler
void ISR_Sudav( void ) interrupt 0
{
    GotSUD = TRUE;          // Set flag
    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmSUDAV;       // Clear SUDAV IRQ
}

// Setup Token Interrupt Handler
void ISR_Sutok( void ) interrupt 0
{
    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmSUTOK;       // Clear SUTOK IRQ
}

void ISR_Sof( void ) interrupt 0
{
    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmSOF;         // Clear SOF IRQ
}

void ISR_Ures( void ) interrupt 0
{
    if ( EZUSB_HIGHSPEED( ) )
    {
        pConfigDscr = pHighSpeedConfigDscr;
    }
}

```



```
pOtherConfigDscr = pFullSpeedConfigDscr;
}
else
{
    pConfigDscr = pFullSpeedConfigDscr;
    pOtherConfigDscr = pHighSpeedConfigDscr;
}

EZUSB_IRQ_CLEAR( );
USBIRQ = bmURES; // Clear URES IRQ
}

void ISR_Susp( void ) interrupt 0
{
    Sleep = TRUE;
    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmSUSP;
}

void ISR_Highspeed( void ) interrupt 0
{
    if ( EZUSB_HIGHSPEED( ) )
    {
        pConfigDscr = pHighSpeedConfigDscr;
        pOtherConfigDscr = pFullSpeedConfigDscr;
    }
    else
    {
        pConfigDscr = pFullSpeedConfigDscr;
        pOtherConfigDscr = pHighSpeedConfigDscr;
    }

    EZUSB_IRQ_CLEAR( );
    USBIRQ = bmHSGRANT;
}

void ISR_Ep0ack( void ) interrupt 0
{
}
```

```
void ISR_Stub( void ) interrupt 0
{
}

void ISR_Ep0in( void ) interrupt 0
{
}

void ISR_Ep0out( void ) interrupt 0
{
}

void ISR_Ep1in( void ) interrupt 0
{
}

void ISR_Ep1out( void ) interrupt 0
{
}

void ISR_Ep2inout( void ) interrupt 0
{
}

void ISR_Ep4inout( void ) interrupt 0
{
}

void ISR_Ep6inout( void ) interrupt 0
{
}

void ISR_Ep8inout( void ) interrupt 0
{
}

void ISR_Ibn( void ) interrupt 0
{
}

void ISR_Ep0pingnak( void ) interrupt 0
{
}

void ISR_Ep1pingnak( void ) interrupt 0
{
}

void ISR_Ep2pingnak( void ) interrupt 0
{
}
```

```
}  
void ISR_Ep4pingnak( void ) interrupt 0  
{  
}  
void ISR_Ep6pingnak( void ) interrupt 0  
{  
}  
void ISR_Ep8pingnak( void ) interrupt 0  
{  
}  
void ISR_Errorlimit( void ) interrupt 0  
{  
}  
void ISR_Ep2piderror( void ) interrupt 0  
{  
}  
void ISR_Ep4piderror( void ) interrupt 0  
{  
}  
void ISR_Ep6piderror( void ) interrupt 0  
{  
}  
void ISR_Ep8piderror( void ) interrupt 0  
{  
}  
void ISR_Ep2pflag( void ) interrupt 0  
{  
}  
void ISR_Ep4pflag( void ) interrupt 0  
{  
}  
void ISR_Ep6pflag( void ) interrupt 0  
{  
}  
void ISR_Ep8pflag( void ) interrupt 0  
{  
}  
void ISR_Ep2eflag( void ) interrupt 0
```

```
{
}
void ISR_Ep4eflag( void ) interrupt 0
{
}
void ISR_Ep6eflag( void ) interrupt 0
{
}
void ISR_Ep8eflag( void ) interrupt 0
{
}
void ISR_Ep2fflag( void ) interrupt 0
{
}
void ISR_Ep4fflag( void ) interrupt 0
{
}
void ISR_Ep6fflag( void ) interrupt 0
{
}
void ISR_Ep8fflag( void ) interrupt 0
{
}
void ISR_GpifComplete( void ) interrupt 0
{
}
void ISR_GpifWaveform( void ) interrupt 0
{
}
```

## Document History

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	2225095	AVF	03/19/2008	Reviewed the existing app note. Added spec number and new disclaimer; updated copyright.
*A	3032334	CPPK	09/16/2010	Added <a href="#">References</a> section. Removed reference to getting free samples.
*B	3102637	RSKV	12/06/2010	Added Figure under Hardware Setup heading. Updated as per application note template.
*C	3507666	RSKV	01/31/2012	Converted from FrameMaker to Word Updated to latest template.
*D	4284857	RSKV	02/18/2014	Obsolete document.

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