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## USB-to-I<sup>2</sup>C Bridging with USB7002, USB7050, USB7051, and USB7052 Hubs

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### INTRODUCTION

The USB-to-I<sup>2</sup>C bridging feature gives system designers using Microchip hubs expanded system control and potential BOM reduction. The use of a separate USB-to-I<sup>2</sup>C device is no longer required and a downstream USB port is not lost as occurs when a standalone USB-to-I<sup>2</sup>C device is implemented. This feature is available on the Microchip USB7002, USB7050, USB7051, and USB7052 hubs.

Commands may be sent from the USB Host to the internal Hub Feature Controller (HFC) device in the Microchip hub to perform the following functions:

- Configure I<sup>2</sup>C Pass-Through Interface
- I<sup>2</sup>C Write
- I<sup>2</sup>C Read

### Sections

[General Information](#)

[Part Number-Specific Information](#)

[MPLAB<sup>®</sup> Connect Configuration](#)

[Manual Implementation](#)

[Examples](#)

### References

Consult the following documents for details on the specific parts referred to in this application note:

- *Microchip USB7002 Data Sheet*
- *Microchip USB7050 Data Sheet*
- *Microchip USB7051 Data Sheet*
- *Microchip USB7052 Data Sheet*

GENERAL INFORMATION

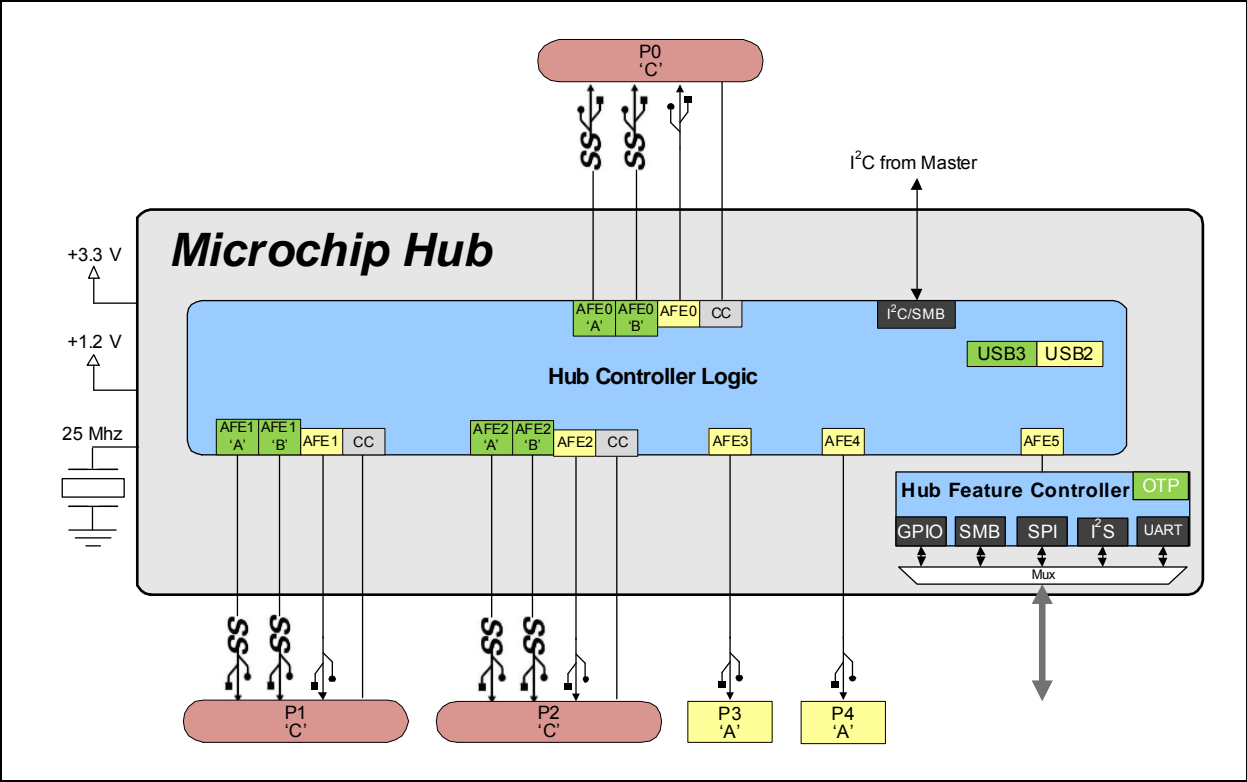
The USB Bridging features in Microchip hubs work via Host commands sent to a Hub Feature Controller embedded within the hub located on an additional internal USB port. In order for the bridging features to work correctly, this internal Hub Feature Controller must be enabled by default. Table 1 provides details on the default Hub Feature Controller settings by device.

TABLE 1: DEFAULT SETTINGS FOR THE HUB FEATURE CONTROLLER ENABLE

Part Number	Part Summary	Hub Feature Controller Default Setting
USB7002	4-Port USB3.1G1 hub – 2xUSB-C w/cc pin i/f, 2xType A DFP (2.0), No PD	Enabled by default
USB7050	4-Port USB3.1G1 hub – 2xUSB-C w/ UPD350, 2xType A DFP (2.0/3.1), PD FW	Enabled by default
USB7051	4-Port USB3.1G1 hub – 2xUSB-C w/ cc pin/350, 2xType A DFP (2.0/3.1), PD FW	Enabled by default
USB7052	4-Port USB3.1G1 hub – 2xUSB-C w/ cc pin i/f, 2xType A DFP (2.0/3.1), PD FW	Enabled by default

The Hub Feature Controller is a USB 2.0 WinUSB class device connected to an internal USB 2.0 port in the hub. For example, in a four-port hub, the Hub Controller is connected to port 6 of the USB 2.0 portion of the hub. The Product ID (PID) for the Hub Controller is 0x7040. All bridging commands are addressed to the Hub Controller and not the Hub. (See Figure 1.)

FIGURE 1: MICROCHIP HUB CONTROLLER EXAMPLE



## I<sup>2</sup>C Bridging Commands

The following I<sup>2</sup>C functions are supported:

- [I2C Write](#)
- [I2C Read](#)

### I<sup>2</sup>C WRITE

The I<sup>2</sup>C interface works as a complete pass-through. This means that the Host must properly arrange data payloads in the appropriate I<sup>2</sup>C-compatible format and bit order, including the I<sup>2</sup>C slave device address. Up to 255 bytes of data payload may be sent per I<sup>2</sup>C Write command sequence.

### I<sup>2</sup>C READ

The I<sup>2</sup>C interface works as a complete pass-through. This means that the Host must properly arrange data payloads in the appropriate I<sup>2</sup>C-compatible format and bit order, including the I<sup>2</sup>C slave device address. Up to 255 bytes of data payload may be sent per I<sup>2</sup>C Write command sequence.

## I<sup>2</sup>C Interface Setup Requirements

The I<sup>2</sup>C interface operates at 100 kHz clock speed by default. Refer to [Clock Configuration](#) for other supported speeds.

The I<sup>2</sup>C interface is supported in all configuration options.

## PART NUMBER-SPECIFIC INFORMATION

### Part Summary

Table 2 to Table 5 display the I<sup>2</sup>C interface pins by part number.

**TABLE 2: USB7002 I<sup>2</sup>C INTERFACE PINS**

Option 1 I <sup>2</sup> C		Option 2 I <sup>2</sup> C	
MSTR_I2C_CLK	PF18	MSTR_I2C_CLK	PF30
MSTR_I2C_DATA	PF19	MSTR_I2C_DATA	PF31

**Note 1:** Configuration Options 3 and 4 do not support I<sup>2</sup>C Bridging.

**TABLE 3: USB7050 I<sup>2</sup>C INTERFACE PINS**

Option 1 I <sup>2</sup> C		Option 2 I <sup>2</sup> C		Option 3 UART		Option 5	
MSTR_I2C_CLK	PF18	MSTR_I2C_CLK	PF30	MSTR_I2C_CLK	PF10	MSTR_I2C_CLK	PF10
MSTR_I2C_DATA	PF19	MSTR_I2C_DATA	PF31	MSTR_I2C_DATA	PF11	MSTR_I2C_DATA	PF11

**Note 1:** Configuration Option 4 does not support I<sup>2</sup>C Bridging.

**TABLE 4: USB7051 I<sup>2</sup>C INTERFACE PINS**

Option 1 I <sup>2</sup> C		Option 2 I <sup>2</sup> C		Option 3 UART		Option 4 FLEX	
MSTR_I2C_CLK	PF18	MSTR_I2C_CLK	PF30	MSTR_I2C_CLK	PF10	MSTR_I2C_CLK	PF10
MSTR_I2C_DATA	PF19	MSTR_I2C_DATA	PF31	MSTR_I2C_DATA	PF11	MSTR_I2C_DATA	PF11

**TABLE 5: USB7052 I<sup>2</sup>C INTERFACE PINS**

Option 1 I <sup>2</sup> C		Option 2 I <sup>2</sup> C	
MSTR_I2C_CLK	PF30	MSTR_I2C_CLK	PF30
MSTR_I2C_DATA	PF31	MSTR_I2C_DATA	PF31

## MPLAB<sup>®</sup> CONNECT CONFIGURATION

The simplest method for implementing the USB-to-I<sup>2</sup>C Bridging functions is to use the publicly available MPLABCC DLL library. The MPLABConnect.dll library is available for Windows operating systems. Visit the product page on microchip.com for any of the hubs listed in this document and to download the MPLABCC package for Windows. Using the libraries available in the SDK, the bridging features can be implemented in C code.

The DLL package contains the following:

- MPLABCC Release Notes
- Library files:
  - For Windows: A .dll
- Example code

### Commands included in the SDK

- MchpUsbl2CSetConfig: This sets up the I<sup>2</sup>C interface (such as clock speed).
- MchpUsbl2CReadRead: This reads up to 255 bytes of data from an I<sup>2</sup>C slave device.
- MchpUsbl2CWrite: This writes up to 255 bytes of data to an I<sup>2</sup>C slave device.
- MchpUsbl2CTransfer: This reads and writes from an I<sup>2</sup>C slave device.

For additional details on how to use the SDK to implement USB to I<sup>2</sup>C bridging, download the MPLABCC package.

## MANUAL IMPLEMENTATION

The USB-to-I<sup>2</sup>C Bridging features may be implemented at the lowest level if you have the ability to build USB packets. This approach is required if you are not using a Windows Host system and cannot use the MPLABCC DLL.

The details of the I<sup>2</sup>C pass-through control packets are shown below. All USB to I<sup>2</sup>C bridging commands must be sent directly to Endpoint 0 of the Hub Feature Controller connected to the last downstream port of the Microchip hub (i.e. located on the port 5 of a 4 port hub).

### I<sup>2</sup>C Enter Pass-Through Command

The I<sup>2</sup>C Enter Pass-Through command is required to enable the I<sup>2</sup>C bridge. This command only needs to be issued one time for every reset/power cycle. The I<sup>2</sup>C clock frequency is also configured within the wValue of this command. (See [Clock Configuration](#) for details on the possible values.)

### I<sup>2</sup>C Control Flags

Both the read and write commands have a special control flag parameter which is defined as show in [Table 6](#).

**TABLE 6: I<sup>2</sup>C CONTROL FLAGS**

Bits	Control	Usage
2-7	Reserved	N/A
2	SEND_NACK	If asserted, NACK the last byte in the transfer.
1	SEND_START	If asserted, send a Start condition as the first step in the I <sup>2</sup> C command.
0	SEND_STOP	If asserted, send a Stop condition as the last step of this command.

### I<sup>2</sup>C Write Command

This command is used to send data to an I<sup>2</sup>C peripheral connected to the USB hub. Both the I<sup>2</sup>C Control flags (defined in [I<sup>2</sup>C Control Flags](#)) and the I<sup>2</sup>C slave address are bundled into the wValue field. See [Table 7](#) for more details on the command.

**TABLE 7: USB SETUP COMMAND**

SETUP Parameter	Value	Description
bmRequestType	0x41	Vendor-specific command; Host-to-device data transfer
bRequest	0x71	Register read command: CMD_I2C_WRITE
wValue	0xXXYY	MSB (XX): I <sup>2</sup> C Control flags (See <a href="#">I<sup>2</sup>C Control Flags</a> .) LSB (YY): I <sup>2</sup> C Slave device address
wIndex	0x0000	Reserved
wLength	0xNN	N bytes of data to be sent in the data stage (in the OUT EP0 control transfer packets)

## I<sup>2</sup>C WRITE USB TRANSACTION SEQUENCE

**Command Phase:** The Hub Feature Controller receives the setup packet with the parameters specified above.

**Data Phase:** The Host sends multiple EP0 OUT packets of 64 bytes each with a total length of N bytes.

**Status Phase:** If an IN-Zero Length Packet is sent from Hub Feature Controller, it would mean that the transfer was a success. If an IN-STALL packet is sent from Hub Feature Controller, there was an error during the transfer, likely due to missing ACK from the I<sup>2</sup>C slave.

## I<sup>2</sup>C Read Command

This command is used to read data from an I<sup>2</sup>C peripheral connected to the USB hub. Both the I<sup>2</sup>C Control flags (defined in [I2C Control Flags](#)) and the I<sup>2</sup>C slave address are bundled into the wValue field. (See [Table 8](#).)

**TABLE 8: USB SETUP COMMAND**

SETUP Parameter	Value	Description
bmRequestType	0xC1	Vendor-specific command; Device-to-Host data transfer
bRequest	0x72	Register read command: CMD_I2C_READ
wValue	0xXXYY	MSB (XX): I <sup>2</sup> C Control flags (See <a href="#">I2C Control Flags</a> .) LSB (YY): I <sup>2</sup> C Slave device address
wIndex	0x0000	Reserved
wLength	0xNN	N bytes of data to be sent in the data stage (in the OUT EP0 control transfer packets)

## I<sup>2</sup>C READ USB TRANSACTION SEQUENCE

**Command Phase:** The Hub Feature Controller receives the SETUP packet with the parameters specified above.

**Data Phase:** The Hub Feature Controller sends Multiple EP0 IN packets of 64 bytes each with a total length of N bytes.

**Status Phase:** The Host sends an OUT-Zero Length ACK packet to acknowledge receipt of data.

## EXAMPLES

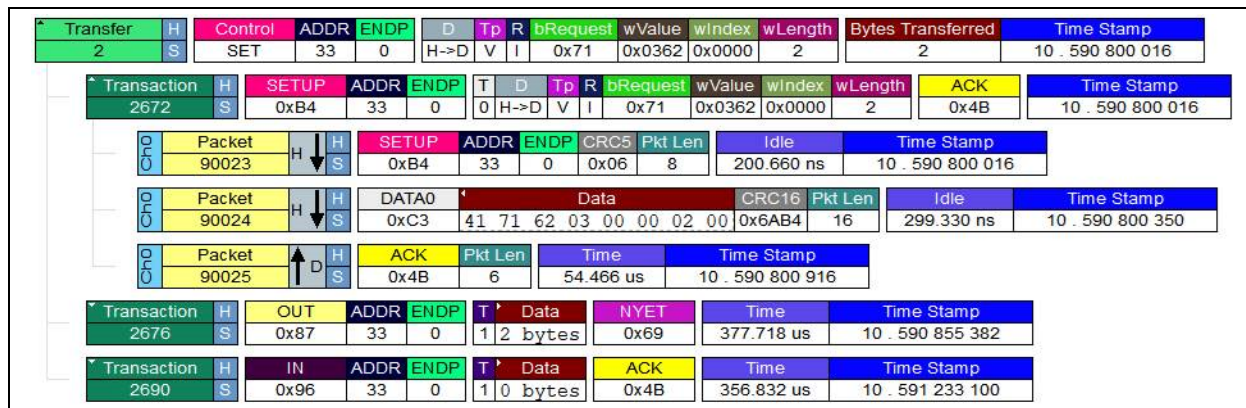
### Send an I<sup>2</sup>C Write to an Attached Device

1. **Command Phase (SETUP Transaction):** I<sup>2</sup>C Address 0x61: Write a value of 0x12 to Register 0x15. Send the following SETUP Register Read Command to Endpoint 0 of the Hub Feature Controller to send an I<sup>2</sup>C Write command to the attached I<sup>2</sup>C device with the I<sup>2</sup>C Address as defined in the wValue field. (See [Table 9](#) and [Figure 2](#).)

**TABLE 9: I<sup>2</sup>C WRITE SETUP PACKET EXAMPLE**

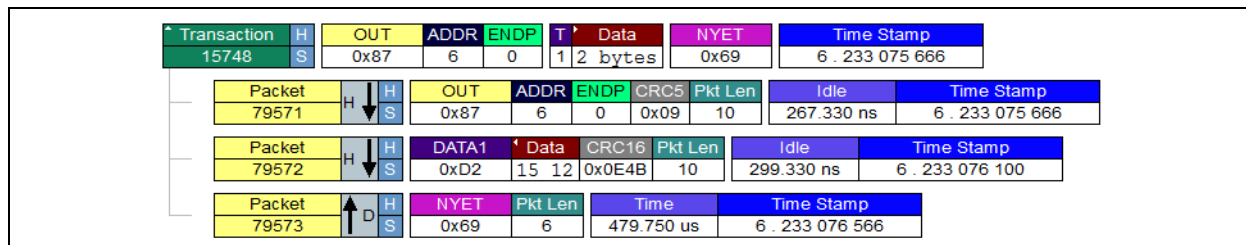
Field	Value	Note
bmRequestType	0x41	—
bRequest	0x71	—
wValue	0x0362	I <sup>2</sup> C Control flag 0x03, I <sup>2</sup> C Address 0x62 (0110 0010b)
wIndex	0x0000	—
wLength	0x0002	2 bytes of data (Register Address + 1 byte of data)

**FIGURE 2: I<sup>2</sup>C WRITE SETUP TRANSACTION EXAMPLE**



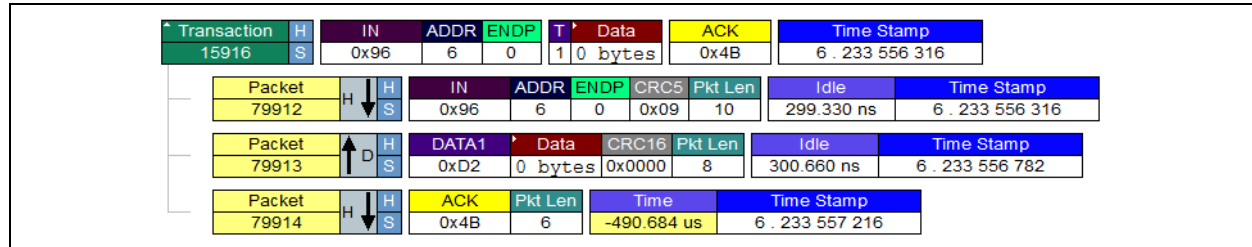
2. **Data Phase (OUT Transaction):** Host sends an OUT packet followed by the data bytes of length wLength starting from the specified address after receiving an IN packet. In this instance, Register 0x12 is being written to Register 0x15 (Data = 0x15, 0x12). Hub Feature Controller responds with a NYET after receiving the data. (See [Figure 3](#).)

**FIGURE 3: I<sup>2</sup>C WRITE IN TRANSACTION EXAMPLE**



3. **Status Phase (IN Transaction):** Host sends an IN packet to complete the USB Transfer. Hub Feature Controller responds with a zero-length data packet. The Host ACKs to complete the bridging command. (See [Figure 4](#).)



FIGURE 4: I<sup>2</sup>C WRITE OUT TRANSACTION EXAMPLE

## Send an I<sup>2</sup>C Read to an Attached Device

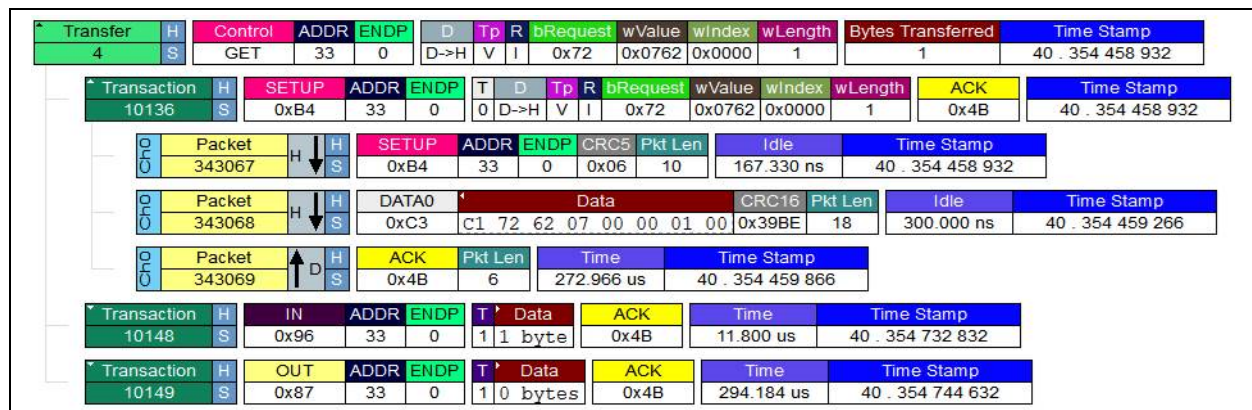
A read requires two operations:

- Transaction 1: Write the register to be read using I<sup>2</sup>C Write.
- Transaction 2: Read the register content(s), depending on length.

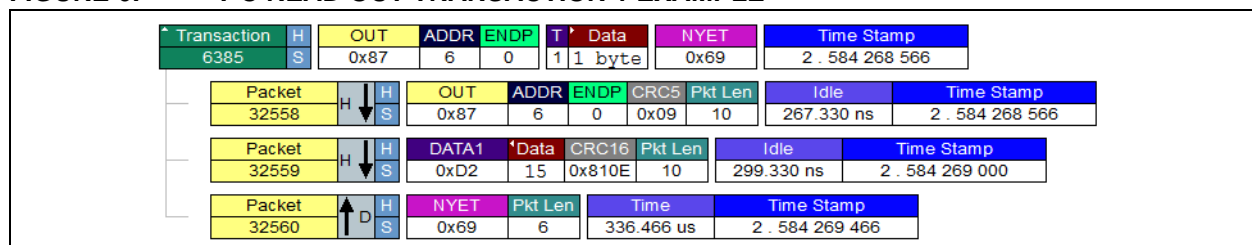
1. **Command Phase 1 (SETUP Transaction 1):** I<sup>2</sup>C Address 0x62: Read Register 0x15. Send the following SETUP Register Read Command in to Endpoint 0 of the Hub Feature Controller to prepare the I<sup>2</sup>C device to return data. (See Table 10 and Figure 5.)

TABLE 10: I<sup>2</sup>C READ SETUP COMMAND 1 EXAMPLE

Setup Parameter	Value	Note
bmRequestType	0xC1	—
bRequest	0x72	—
wValue	0x0762	Control flag = 0x07, I <sup>2</sup> C Address = 0x62 (01100010b)
wIndex	0x0000	—
wLength	0x0001	—

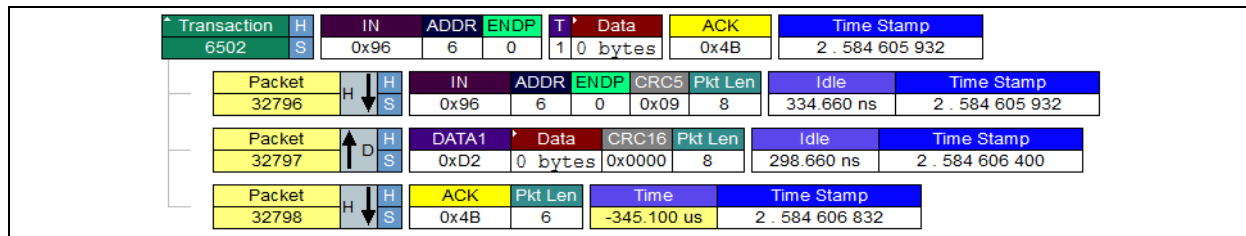
FIGURE 5: I<sup>2</sup>C READ SETUP TRANSACTION 1 EXAMPLE

2. **Data Phase 1 (OUT Transaction 1):** Host sends an OUT packet followed by the data. The data in this instance is 0x15. Hub Feature Controller responds with a NYET. (See Figure 6.)

FIGURE 6: I<sup>2</sup>C READ OUT TRANSACTION 1 EXAMPLE

3. **Status Phase 1 (IN Transaction 1):** Host sends an IN packet to complete the USB Transfer. Hub Feature Controller responds with a zero-length data packet. Host sends an ACK. (See Figure 7.)

**FIGURE 7: I<sup>2</sup>C READ IN TRANSACTION 1 EXAMPLE**

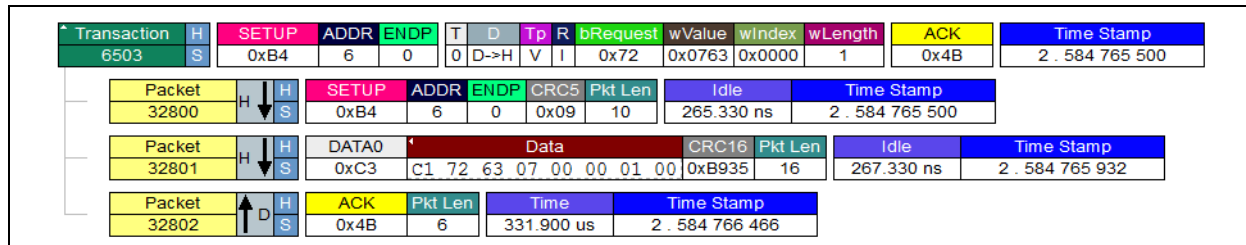


4. **Command Phase 2 (SETUP Transaction 2):** Send the following SETUP Register Read Command to Endpoint 0 of the Hub Feature Controller to retrieve the requested data. (See Table 11 and Figure 8.)

**TABLE 11: I<sup>2</sup>C READ SETUP COMMAND 2 EXAMPLE**

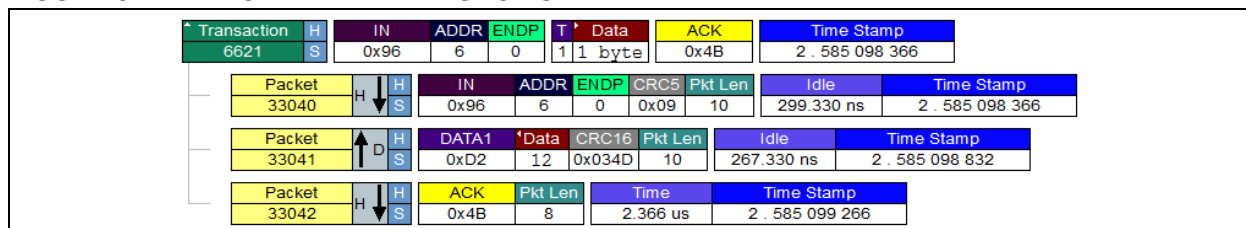
Setup Parameter	Value	Note
bmRequestType	0xC1	—
bRequest	0x71	—
wValue	0x0763	Control Flag = 0x07, I <sup>2</sup> C Address = 0x63 (01100011b)
wIndex	0x0000	—
wLength	0x0001	—

**FIGURE 8: I<sup>2</sup>C ADDRESS DATA PHASE BYTE 3 TRANSACTION 2 EXAMPLE**



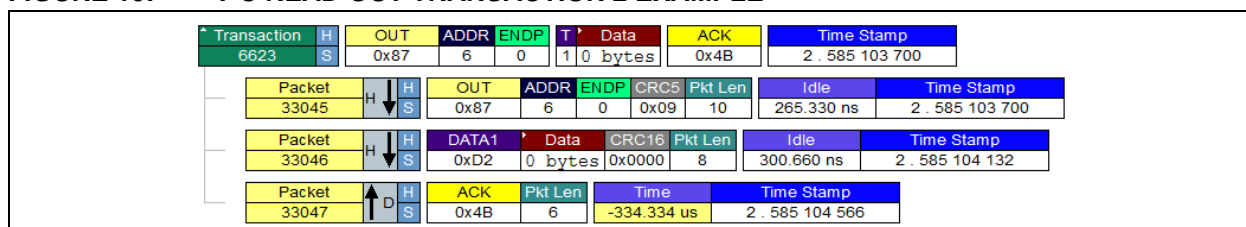
5. **Data Phase 2 (IN Transaction 2):** Host sends an IN packet, and Hub Feature Controller responds with the register contents (0x12). Host responds with an ACK. (See Figure 9.)

**FIGURE 9: I<sup>2</sup>C READ IN TRANSACTION 2 EXAMPLE**



6. **Status Phase 2 (OUT Transaction 2):** Host sends an OUT packet followed by a zero-data length packet. Hub Feature Controller responds with an ACK to complete the bridging command. (See Figure 10.)

**FIGURE 10: I<sup>2</sup>C READ OUT TRANSACTION 2 EXAMPLE**



## CLOCK CONFIGURATION

There is a register to control I<sup>2</sup>C clock frequency, named `bl2CInter128Delay` located at address `0xBFDD23410`. If the DLL API is used, register `bl2CInter128Delay` is written automatically. The value of `bl2CInter128Delay` is determined using this formula:

$$\text{bl2CInter128Delay} = 2 * (\text{Time period of the I2C bus clock in microseconds})$$

The default value is `0x14` for 100 kHz clock. A value of `0x5A` creates a delay of 900  $\mu\text{s}$ .

This value will be multiplied by 10 in the firmware to have some buffer time in order not to miss any byte when operating at a lower speed, thereby ensuring data integrity.

The maximum value that can be programmed in `bl2CInter128Delay` is `0x63`.

(i.e a maximum of  $99 * 10 = 990 \mu\text{s}$  can be added as the maximum Inter-128Byte delay)

To configure the USB-I2C bridge for 40 kHz clock operation, it is only necessary to write a value of `0x32` to `bl2CInter128Delay` after any other I<sup>2</sup>C bridge setups have been made. The `bl2CInter128Delay` and Bus Frequency Control register values are provided for various supported clock frequencies in [Table 12](#).

The method for writing to registers (including `bl2CInter128Delay`) through the SMBus (slave) is explained in Section 2.4 of *AN2439 Configuration of the USB491x/USB492x/USB4715*. An example clock configuration is provided in the [Clock Configuration Example](#).

**TABLE 12: BUS FREQUENCY CONTROL AND B12CINTER128DELAY REGISTER VALUES FOR COMMON 12C CLOCK FREQUENCIES**

Frequency (kHz)	Bus Frequency Register Value (hex)	bl2CInter128Delay Value	
		Decimal	Hexadecimal
400	0A00	5	05
250	081B	8	08
200	1818	10	0A
100 (default)	3131	20	14
80	3D3E	25	19
50	6363	40	28
40	7C7C	50	32
25	C7C7	80	50
20	F9F9	100	64

### Clock Configuration Example

An example clock configuration for 40 kHz operation is provided below. (Refer to [Table 13](#) to [Table 16](#).)

1. Write `bl2CInter128Delay` located at `0xBFDD23410` with a value of `0x32` (40 kHz per [Table 12](#)).

**TABLE 13: CLOCK CONFIGURATION COMMAND 1 EXAMPLE**

Setup Parameter	Value	Note
<code>bmRequestType</code>	<code>0x40</code>	Host-to-device data transfer
<code>bRequest</code>	<code>0x03</code>	<code>CMD_MEMORY_WRITE</code>
<code>wValue</code>	<code>0x3410</code>	Least Significant 16-bits of memory address in little-endian format
<code>wIndex</code>	<code>0xBFDD2</code>	Most Significant 16-bits of memory address in little-endian format
<code>wLength</code>	<code>0x0001</code>	Number of data bytes to write

Data to be written: `0x32`

2. Enable I<sup>2</sup>C pass-through and set frequency.

**TABLE 14: CLOCK CONFIGURATION COMMAND 2 EXAMPLE**

Setup Parameter	Value	Note
bmRequestType	0x41	Host-to-device data transfer
bRequest	0x70	CMD_I2C_ENTER_PASSTHRU
wValue	0x7C7C	I <sup>2</sup> C Clock Frequency: 40 kHz
wIndex	0x0000	—
wLength	0x0000	—

3. Write the start address from which data needs to be read.

**TABLE 15: CLOCK CONFIGURATION COMMAND 3 EXAMPLE**

Setup Parameter	Value	Note
bmRequestType	0x41	Host-to-device data transfer
bRequest	0x71	CMD_I2C_WRITE
wValue	0x03A0	03: I <sup>2</sup> C Control flags (START, STOP) A0: Slave Address
wIndex	0x0000	—
wLength	0x0001	1 byte of data

Data to be written: 0x00

4. Read 2 bytes of data.

**TABLE 16: CLOCK CONFIGURATION COMMAND 4 EXAMPLE**

Setup Parameter	Value	Note
bmRequestType	0xC1	Host-to-device data transfer
bRequest	0x72	CMD_I2C_READ
wValue	0x07A1	07: I <sup>2</sup> C Control flags (NACK, START, STOP) A1: Slave Address
wIndex	0x0000	—
wLength	0x0002	2 bytes of data

## APPENDIX A: APPLICATION NOTE REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision Level & Date	Section/Figure/ Entry	Correction
DS00002754 (08-09-18)	All	Initial release

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