
USB to I²C Bridging with Microchip USB 3.1 Gen 1 Hubs

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INTRODUCTION

The USB to I²C bridging feature gives system designers using Microchip hubs expanded system control and potential BOM reduction. The use of a separate USB to I²C device is no longer required and a downstream USB port is not lost as occurs when a standalone USB to I²C device is implemented. This feature is available on the Microchip USB5734 and USB58xx/USB59xx USB3.1 Gen 1 Hubs.

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

- Configure I²C Pass-Through Interface
- I²C Write
- I²C Read

SECTIONS

[Section 1.0, General Information](#)

[Section 2.0, Part Number Specific Information](#)

[Section 3.0, Protouch2 DLL Implementation](#)

[Section 4.0, Manual Implementation](#)

REFERENCES

Consult the following documents for details on the specific parts referred to in this document.

- *Microchip USB5734 Data Sheet*
- *Microchip USB5806 Data Sheet*
- *Microchip USB5816 Data Sheet*
- *Microchip USB5826 Data Sheet*
- *Microchip USB5906 Data Sheet*
- *Microchip USB5916 Data Sheet*
- *Microchip USB5926 Data Sheet*
- *Microchip AN1903 Configuration Options for the USB5734 and USB5744*
- *Microchip AN2316 Configuration Options for the USB58xx and USB59xx*

1.0 GENERAL INFORMATION

Microchip hub 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 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
USB5734	4-Port USB3.1 Gen 1 Hub	Enabled by default
USB5806	6-Port USB3.1 Gen1 Hub	Enabled by default
USB5816	6-Port USB3.1 Gen1 Hub with Type-C™ Support on 1 Downstream Port	Enabled by default
USB5826	6-Port USB3.1 Gen1 Hub with Type-C Support on 2 Downstream Ports	Enabled by default
USB5906	6-Port USB3.1 Gen1 Hub with Type-C Support on the Upstream Port	Enabled by default
USB5916	6-Port USB3.1 Gen1 Hub with Type-C Support on the Upstream Port and 1 Downstream Port	Enabled by default
USB5926	6-Port USB3.1 Gen1 Hub with Type-C Support on the Upstream Port and 2 Downstream Ports	Enabled by default

The Hub Feature Controller is a USB2.0 WinUSB class device connected to an extra internal USB port in the hub. For example, in a four port hub, the Hub Controller is connected to port 5 of the USB2.0 portion of the hub. The Product ID (PID) for the Hub Controller is 0x2740. All bridging commands are addressed to the Hub Controller, not the Hub.

FIGURE 1-1: MICROCHIP HUB CONTROLLER EXAMPLE

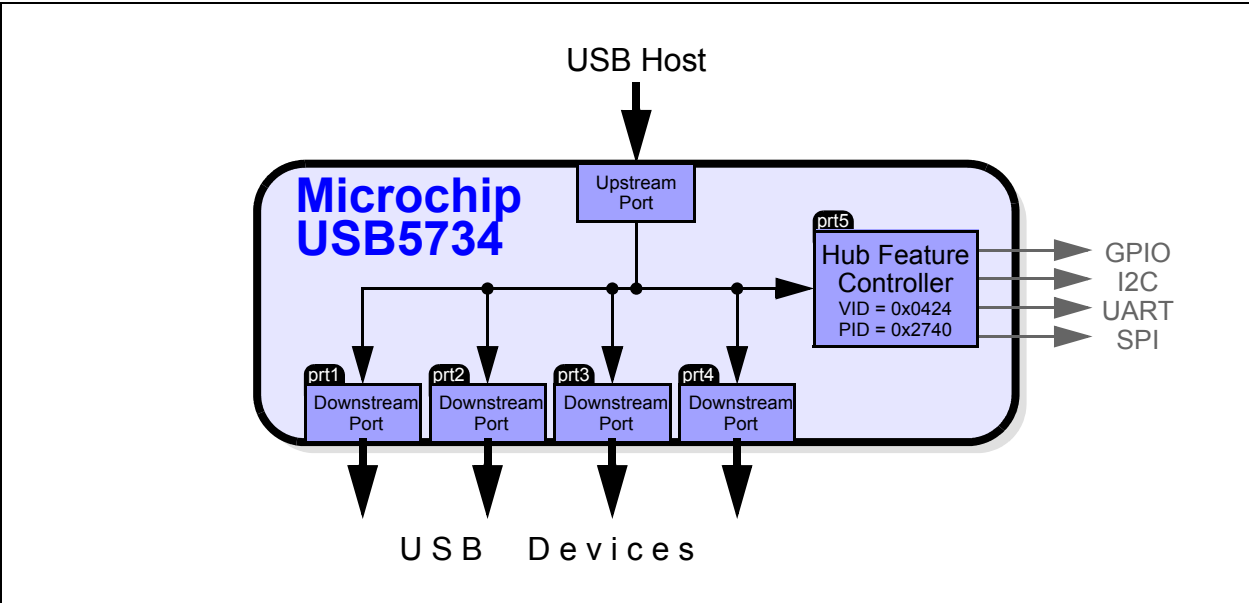
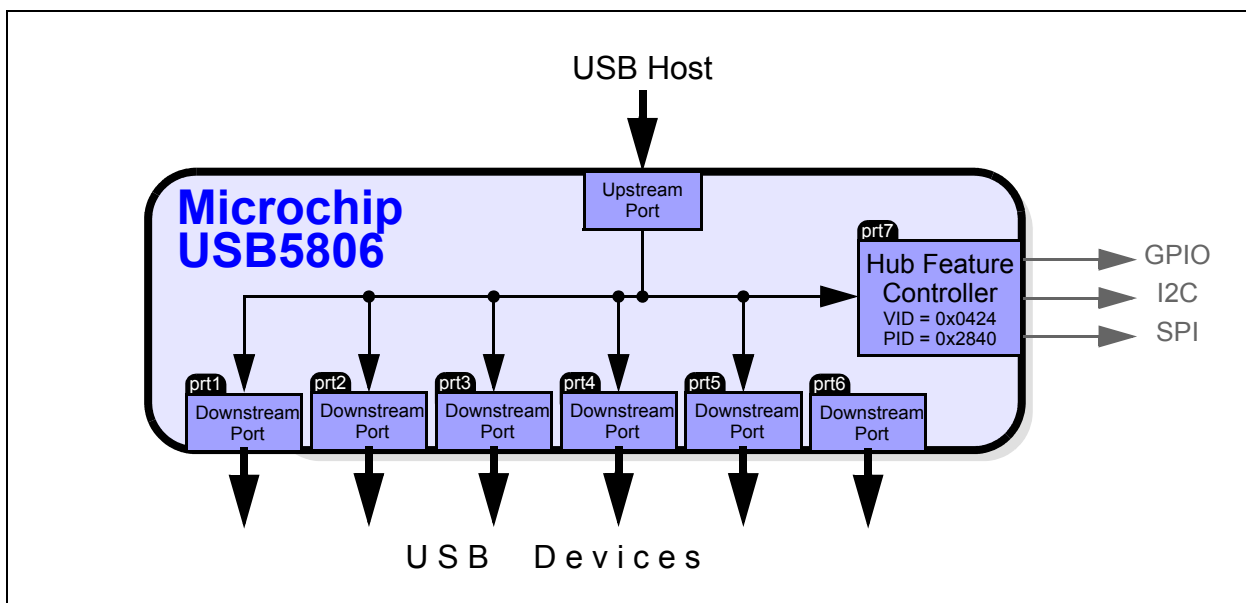


FIGURE 1-2: MICROCHIP HUB CONTROLLER EXAMPLE



1.1 I²C Bridging Commands

The following I²C Functions are supported:

- I2C Write
- I2C Read

1.1.1 I²C WRITE

The I²C interface works as a complete pass-through. This means that the host must properly arrange data payloads in the appropriate I²C compatible format and bit order, including the I²C slave device address. Up to 255 Bytes of data payload may be sent per I²C write command sequence.

1.1.2 I²C READ

The I²C interface works as a complete pass-through. This means that the host must properly arrange data payloads in the appropriate I²C compatible format and bit order, including the I²C slave device address. Up to 255 Bytes of data payload may be sent per I²C write command sequence.

1.2 I²C Interface Setup Requirements

1.2.1 USB5734

The I²C interface operates at 62.5kHz clock speed by default.

The USB5734 hub must be placed in either Modes 1, 2, 3, or 6 with the I2C_SLV_CFG[1:0] pins left unconnected (no pull-up/down resistors). Modes 4 and 5 do not support the I²C bridging interface.

When set in configuration modes 1, 2, 3, or 6, the PROG_FUNC4 pin becomes SMCLK, and the PROG_FUNC5 pin becomes SMDAT. Ensure that pull-up resistors are present on both SMCLK and SMDAT lines (10 kΩ is recommended).

1.2.2 USB58XX/USB59XX

The I²C interface operates at 62.5kHz clock speed by default.

The USB58xx/USB59xx hub must be placed in CONFIG1 mode via the CFG_STRAP pin. When set in configuration CONFIG1 mode, the SMCLK and SMDAT pins become the I²C interface for use with USB to I²C bridging.

2.0 PART NUMBER SPECIFIC INFORMATION

2.1 Part Summary

The following tables display the I²C interface pins by part number.

2.2 USB5734

TABLE 2: USB5734 I2C INTERFACE PINS

Pin #	Name	Notes
1	CFG_STRAP	This pin is sampled at power on to enter one of the 6 modes of operation. The I ² C Bridge only operates with modes 1, 2, 3, and 6. The following pull-up/down resistor must be present to enter one of these modes: 200 k Ω Pull-Down: Configuration 1 - Mixed Mode 200 k Ω Pull-Up: Configuration 2 - FlexConnect Mode 10 k Ω Pull-Down: Configuration 3 - Speed Indicator Mode 10 Ω Pull-Up: Configuration 6 - Full UART Mode
42	SPI_CLK/(I2C_SLV_CFG0)	I2C_SLV_CFG0 strap is sampled at power on and it must have no pull-up/down resistors detected at power on to enter I ² C Bridge mode.
43	SPI_DO/(I2C_SLV_CFG1)	I2C_SLV_CFG1 strap is sampled at power on and it must have no pull-up/down resistors detected at power on to enter I ² C Bridge mode.
46	PROG_FUNC4/(SMDAT)	Data pin of the I ² C Bridge. Must have an external pull-up resistor to 3.3V present.
47	PROG_FUNC5/(SMCLK)	Clock pin of the I ² C Bridge. Must have an external pull-up resistor to 3.3V present.

2.3 USB58xx/USB59xx

TABLE 3: USB58XX/USB59XX I2C INTERFACE PINS

Pin #	Name	Notes
20	CFG_STRAP	This pin is sampled at power on to enter one of the 6 modes of operation. The I ² C Bridge only operates with mode 1 (CONFIG1)
74	SMBDATA/GPIO6	Data pin of the I ² C Bridge. Must have an external pull-up resistor to 3.3V present.
75	SMBCLK/GPIO8	Clock pin of the I ² C Bridge. Must have an external pull-up resistor to 3.3V present.

3.0 PROTOUCH2 DLL IMPLEMENTATION

The simplest method for implementing the USB to I2C bridging functions is to use the publicly available ProTouch2 DLL library. The PT2 DLL library is available for Windows operating systems. Visit the product page for any of the hubs listed in this document on microchip.com to download the ProTouch2 package for the desired Operating System. Using the libraries available in the SDK, the bridging features can be implemented in C-code.

The DLL package contains the following:

- ProTouch2 DLL User Guide: Detailed description of how to use the DLL and call each function
- ProTouch2 Release notes:
- Library Files:
 - For Windows: A “.dll” and a “.lib” file
- Example code

3.1 Commands included in the SDK

- **MchpUsbl2CSetConfig:** Setup the I2C interface (such as clock speed).
- **MchpUsbl2CRead:** Read up to 255 Bytes of data from an I2C slave device.
- **MchpUsbl2CWrite:** Write up to 255 Bytes of data to an I2C slave device.
- **MchpUsbl2CTransfer:** Read and write from an I2C slave device.

For additional details on how to use the SDK to implement USB to I²C bridging, download the ProTouch2 package and read the User's Manual.

4.0 MANUAL IMPLEMENTATION

The USB to I²C 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 ProTouch2 DLL.

The details of the I²C pass-through control packets are shown below. All USB to I²C 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 port 5 of a 4 port hub).

4.1 I²C Control Flags

Both the Read and Write commands have a special control flag parameter which is defined below:

TABLE 4-1: USB SETUP COMMAND

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 ² C command.
0	SEND_STOP	If asserted, send a STOP condition as the last step of this command.

4.2 I²C Write Command

This command is used to send data to an I²C peripheral connected to the USB hub. Both the I²C control flags (defined in [Section 4.1, "I²C Control Flags"](#)) and the I²C slave address are bundled into the wValue field.

TABLE 4-2: 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 ² C Control Flags (See Section 4.1, "I²C Control Flags") LSB (YY): I ² C Slave device address
wIndex	0x0000	Reserved
wLength	0xNN	N Bytes of data to be send in the data stage (in the OUT EP0 control transfer packets)

4.2.1 I²C WRITE USB TRANSACTION SEQUENCE

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

Data Phase: 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, transfer was a success. If an IN-STALL packet is sent from Hub Feature Controller, there was an error during transfer, likely due to missing ACK from the I²C slave.

4.3 I²C Read Command

This command is used to read data from an I²C peripheral connected to the USB hub. Both the I²C control flags (defined in [Section 4.1, "I²C Control Flags"](#)) and the I²C slave address are bundled into the wValue field.

TABLE 4-3: USB SETUP COMMAND

Setup Parameter	Value	Description
bmRequestType	0x41	Vendor specific command, Host-to-device data transfer
bRequest	0x72	Register read command: CMD_I2C_READ
wValue	0xXXYY	MSB (XX): I ² C Control Flags (See Section 4.1, "I²C Control Flags") LSB (YY): I ² C Slave device address
wIndex	0x0000	Reserved

TABLE 4-3: USB SETUP COMMAND

Setup Parameter	Value	Description
wLength	0xNN	N Bytes of data to be send in the data stage (in the OUT EP0 control transfer packets)

4.3.1 I²C READ USB TRANSACTION SEQUENCE

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

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

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

5.0 EXAMPLES

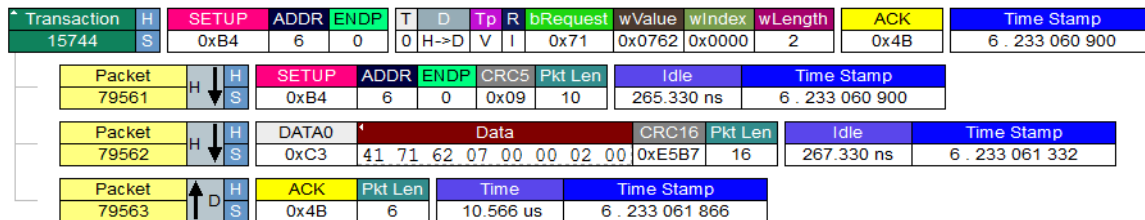
5.1 Send an I²C Write to an attached Device

- Command Phase (SETUP Transaction):** Send the following SETUP Register Read Command to Endpoint 0 of the Hub Feature Controller to send an I²C Write command to the attached I²C device with the I²C Address as defined in the wValue field:

TABLE 5-1: I²C WRITE SETUP PACKET EXAMPLE

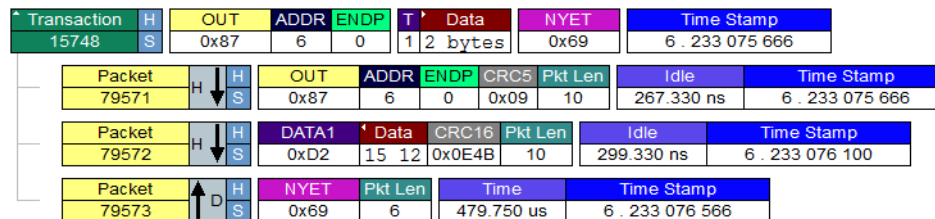
Field	Value	Note
bmRequestType	0x41	-
bRequest	0x71	-
wValue	0x0762	I ² C Control Flag 0x07, I ² C Address 0x62 (0110 0010b)
wIndex	0x0000	-
wLength	0x0002	2 Bytes of Data (Register Address + 1 Byte of Data)

FIGURE 5-1: I²C WRITE SETUP TRANSACTION EXAMPLE



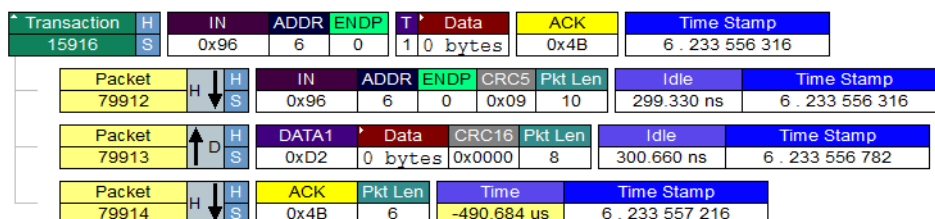
- Data Phase (OUT Transaction):** Host sends an OUT packet followed by the data bytes of length wLength starting from the specified address after receiving an IN packet. In this instance, register 0x12 is being written to register 0x15 (Data = 0x15, 0x12). Hub Feature Controller responds with a NYET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

FIGURE 5-2: I²C WRITE IN TRANSACTION EXAMPLE



- 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.

FIGURE 5-3: I²C WRITE OUT TRANSACTION EXAMPLE



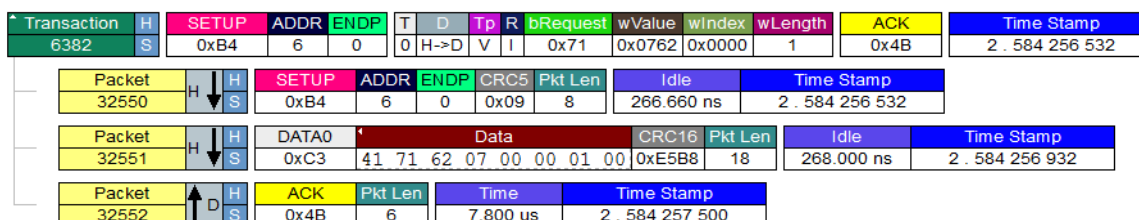
5.2 Send an I²C Read to an Attached Device

1. **Command Phase 1 (SETUP Transaction 1):** Send the following SETUP Register Read Command to Endpoint 0 of the Hub Feature Controller to prepare the I²C device to return data.

TABLE 5-2: I²C READ SETUP COMMAND 1 EXAMPLE

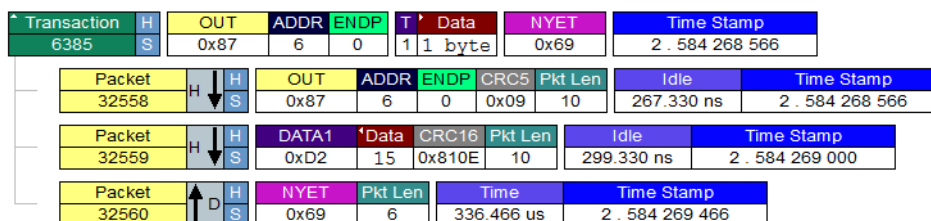
Setup Parameter	Value	Note
bmRequestType	0x41	-
bRequest	0x71	-
wValue	0x0762	Control Flag = 0x07, I ² C Address = 0x62 (01100010b)
wIndex	0x0000	-
wLength	0x0001	-

FIGURE 5-4: I²C READ SETUP TRANSACTION 1 EXAMPLE



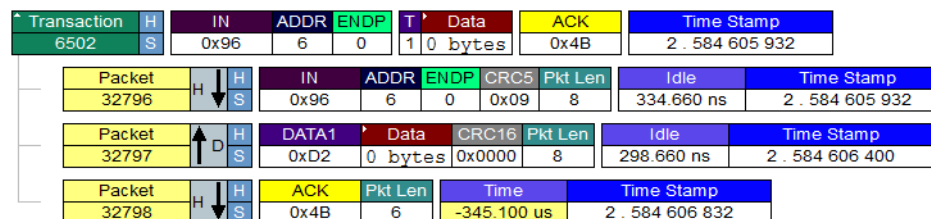
2. **Data Phase 1 (OUT Transaction 1):** Host sends an OUT packet followed by the data. The data in this instance is 0x15. Hub Feature Controller responds with a NYET.

FIGURE 5-5: I²C 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.

FIGURE 5-6: I²C 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.

TABLE 5-3: I²C READ SETUP COMMAND 2 EXAMPLE

Setup Parameter	Value	Note
bmRequestType	0x41	-
bRequest	0x71	-
wValue	0x0762	Control Flag = 0x07, I ² C Address = 0x63 (01100011b)
wIndex	0x0000	-
wLength	0x0001	-

FIGURE 5-7: I²C READ SETUP TRANSACTION 2 EXAMPLE

Transaction	H	SETUP	ADDR	ENDP	T	D	TP	R	bRequest	wValue	wIndex	wLength	ACK	Time Stamp
6503	S	0xB4	6	0	0	D→H	V	I	0x72	0x0763	0x0000	1	0x4B	2 . 584 765 500

Packet	H	SETUP	ADDR	ENDP	CRC5	Pkt Len	Idle	Time Stamp
32800	H	0xB4	6	0	0x09	10	265.330 ns	2 . 584 765 500

Packet	H	DATA0	Data				CRC16	Pkt Len	Idle	Time Stamp
32801	H	0xC3	C1 72 63 07 00 00 01 00				0xB935	16	267.330 ns	2 . 584 765 932

Packet	D	ACK	Pkt Len	Time	Time Stamp
32802	D	0x4B	6	331.900 us	2 . 584 766 466

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

FIGURE 5-8: I²C READ IN TRANSACTION 2 EXAMPLE

Transaction	H	IN	ADDR	ENDP	T	Data	ACK	Time Stamp
6621	S	0x96	6	0	1	1 byte	0x4B	2 . 585 098 366
Packet 33040	H	IN	ADDR	ENDP	CRC5	Pkt Len	Idle	Time Stamp
	H	0x96	6	0	0x09	10	299.330 ns	2 . 585 098 366
Packet 33041	D	DATA1	Data	CRC16	Pkt Len	Idle	Time Stamp	
	D	0xD2	12	0x034D	10	267.330 ns	2 . 585 098 832	
Packet 33042	H	ACK	Pkt Len	Time	Time Stamp			
	H	0x4B	8	2.366 us	2 . 585 099 266			

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.

FIGURE 5-9: I²C READ OUT TRANSACTION 2 EXAMPLE

Transaction	H	OUT	ADDR	ENDP	T	Data	ACK	Time Stamp
6623	S	0x87	6	0	1	0 bytes	0x4B	2 . 585 103 700
Packet 33045	H	OUT	ADDR	ENDP	CRC5	Pkt Len	Idle	Time Stamp
	H	0x87	6	0	0x09	10	265.330 ns	2 . 585 103 700
Packet 33046	H	DATA1	Data	CRC16	Pkt Len	Idle	Time Stamp	
	H	0xD2	0 bytes	0x0000	8	300.660 ns	2 . 585 104 132	
Packet 33047	D	ACK	Pkt Len	Time	Time Stamp			
	D	0x4B	6	-334.334 us	2 . 585 104 566			

APPENDIX A: APPLICATION NOTE REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision Level & Date	Section/Figure/ Entry	Correction
DS00001998B (12-07-16)	All	Fixed references to <i>AN2316 Configuration Options for the USB58xx and USB59xx</i> throughout.
		Trademark and Sales Listing pages updated.
		Updated minor formatting and grammar issues throughout.
DS00001998A (09-10-15)	All	Initial release.

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