AN2001

USB to UART Bridging with Microchip USB 2.0 Hubs

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INTRODUCTION

The USB to UART bridging feature of Microchip's USB 2.0 hubs provides system designers with expanded system control and potential BOM reductions. When using this feature, a separate USB to UART device is no longer required and a downstream USB port is not lost, as occurs when a standalone USB to UART device is implemented. This feature is available on the Microchip USB2534, USB2533, USB2532, USB4604, and USB4624 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:

- Set UART Interface Baud Rate
- UART Write
- UART Read

Sections

References

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

- *USB2534 Data Sheet*
- *USB2533 Data Sheet*
- *USB2532 Data Sheet*
- *USB4604 Data Sheet*
- *USB4624 Data Sheet*
- *AN 26.18 Configuration of the USB253x / USB3x13 / USB46x4*

1.0 GENERAL INFORMATION

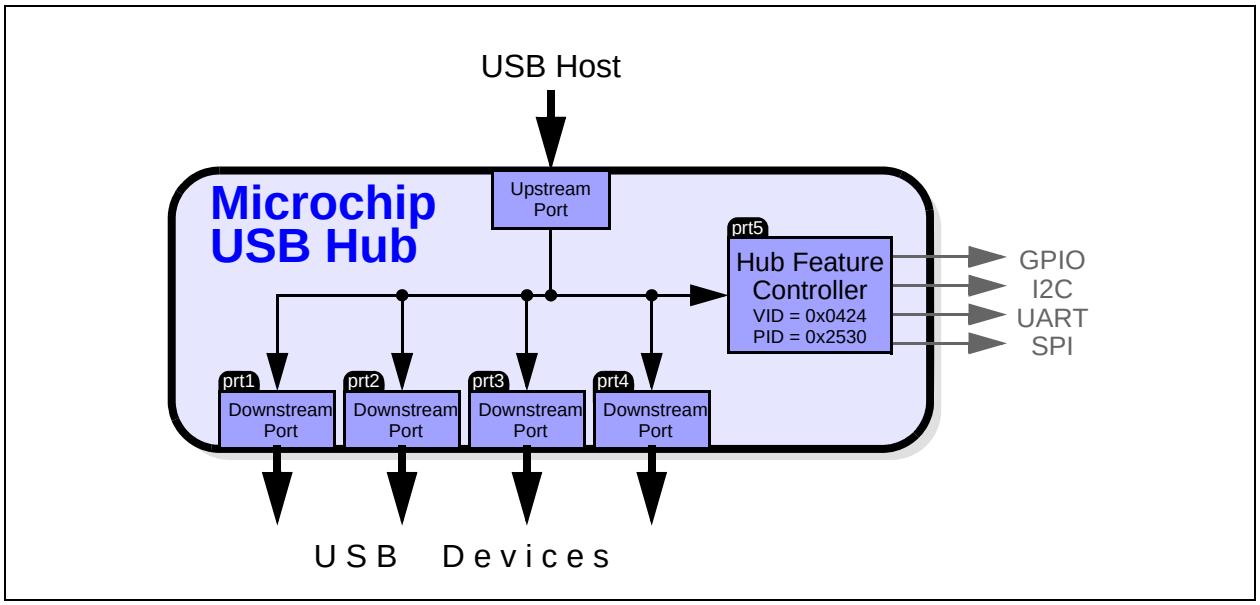
Microchip's USB hub bridging features operate via host commands sent to a Hub Feature Controller embedded within the device, located on an additional internal USB port. In order for the bridging features to work correctly, this internal Hub Feature Controller must be enabled by default. Table 1 provides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

TABLE 1: DEFAULT SETTINGS FOR HUB FEATURE CONTROLLER ENABLE

Part Number	Part Summary	Hub Controller Default Setting
USB2532	2-Port USB2.0 Hub	Disabled (enable via config)
USB2533	3-Port USB2.0 Hub	Disabled (enable via config)
USB2534	4-Port USB2.0 Hub	Disabled (enable via config)
USB4604-1080	4-Port USB2.0 Hub (USB or HSIC Upstream)	Enabled
USB4604-1070	4-Port USB2.0 Hub (USB or HSIC Upstream)	Disabled (order 1080 SKU)
USB464-1080	4-Port USB2.0 Hub (USB or HSIC Upstream / 2 Downstream HSIC Ports)	Enabled
USB4624-1070	4-Port USB2.0 Hub (USB or HSIC Upstream / 2 Downstream HSIC Ports)	Disabled (order 1080 SKU)

The Hub Feature Controller is connected to an extra internal port in the hub. For example, in a hub with hour ports enabled, the Hub Feature Controller is connected to port 5. The Product ID (PID) for the Hub Feature Controller is 0x2530. All bridging commands are addressed to the Hub Feature Controller, not the Hub.

FIGURE 1: MICROCHIP HUB FEATURE CONTROLLER BLOCK DIAGRAM



1.1 UART Bridging Commands

The following UART Functions are supported:

- Set UART Baud Rate
- UART Write
- UART Read

1.1.1 SET UART BAUD RATE

The UART baud rate may adjusted via a bridging command. The suggested standard baud rate values are 600Hz, 1.2kHz, 2.4kHz, 4.8kHz, 9.6kHz, 19.2kHz, 38.4kHz, 57.6kHz, or 115.2kHz.

1.1.2 UART WRITE

Transfer up to 64 Bytes of data through the UART serial port to a connected serial peripheral.

1.1.3 UART READ

Synchronously receive up to 64 Bytes of data through the UART serial port from a connected serial peripheral.

2.0 PART NUMBER SPECIFIC INFORMATION

2.1 Part Summary

The following tables display the UART interface pins by part number as well as any notes on those pins.

2.2 USB2532

TABLE 2: USB2532 UART INTERFACE PINS

Pin #	Name	Notes
19	UART_RX	-
21	UART_TX	-

2.3 USB2533

TABLE 3: USB2533 UART INTERFACE PINS

Pin #	Name	Notes
19	UART_RX/OCS3_N	This pin is shared with the USB port 3 over-current input. To use as the UART_RX pins, you must do one of the following additional configurations: • Disable USB Port 3 and disable OCS3_N source (register 3C28h) • Set over-current sense to ganged mode (register 3006h) and disable OCS3_N source (register 3C28h)
21	UART_TX	-

2.4 USB2534

TABLE 4: USB2534 UART INTERFACE PINS

Pin #	Name	Notes
19	UART_RX/OCS3_N	This pin is shared with the USB port 3 over-current input. To use as the UART_RX pins, you must do one of the following additional configurations: • Disable USB Port 3 and disable OCS3_N source (register 3C28h) • Set over-current sense to ganged mode (register 3006h) and disable OCS3_N source (register 3C28h)
21	UART_TX/OCS4_N	This pin is shared with the USB port 4 over-current input. To use as the UART_RX pins, you must do one of the following additional configurations: • Disable USB Port 4 and disable OCS4_N source (register 3C2Ch) • Set over-current sense to ganged mode (register 3006h) and disable OCS3_N source (register 3C2Ch)

2.5 USB4604 and USB4624

TABLE 5: USB4604 AND USB4624 I2C INTERFACE PINS

Pin #	Name	Notes
28	UART_RX/OCS3_N	This pin is shared with the USB port 3 over-current input. To use as the UART_RX pins, you must do one of the following additional configurations: • Disable USB Port 3 and disable OCS3_N source (register 3C28h) • Set over-current sense to ganged mode (register 3006h) and disable OCS3_N source (register 3C28h)
30	UART_RX/OCS4_N	This pin is shared with the USB port 4 over-current input. To use as the UART_RX pins, you must do one of the following additional configurations: • Disable USB Port 4 and disable OCS4_N source (register 3C2Ch) • Set over-current sense to ganged mode (register 3006h) and disable OCS3_N source (register 3C2Ch)

3.0 SDK IMPLEMENTATION

The simplest method for implementing the USB to UART bridging functions is to use the publicly available USB2530 SDK (Software Development Kit). The SDK is available for Windows and Linux operating systems. Visit the product page for any of the hubs listed in this document on microchip.com to download the SDK package for the desired Operating System. Using the libraries available in the SDK, the bridging features can be implemented in C-code.

The SDK package contains the following:

- User's Guide: Detail description of how to use the SDK and call each function
- Release Notes:
- Library Files:
  - For Windows: A ".dll" and a ".lib" file
  - For Linux: a ".cpp" file that can be built into a ".a" file
- Example code

3.1 Commands included in the SDK

- **MchpUsbUartSetConfig:** Sets the baud rate of the UART interface.
- **MchpUsbUartWrite:** Transfer data through serial port to a connected serial peripheral.
- **MchpUsbUARTRead:** Transfer data through serial port from a connected serial peripheral.

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

4.0 MANUAL IMPLEMENTATION

The USB to UART 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 or Linux host system and cannot use the SDK.

The details of the UART pass-through control packets are shown below.

4.1 Enable UART Pass-Through Interface Command

The follow SETUP packet command will initialize the interface and perform the following:

- Reset UART transmission and reception pointers to 0
- Reset reception error status to 0
- Initialize UART interface with 9600 baud rate, 8 bit mode, timer 1 as baud generator
- Enable asynchronous UART reception

TABLE 6: USB SETUP COMMAND

Setup Parameter	Value	Description
bmRequestType	0x41	Vendor specific command, Host-to-device data transfer
bRequest	0x2A	UART_PASSTHRU_ENTER
wValue	0x20	Enables UART pass through control flag
wIndex	0x0000	Reserved
wLength	0x00	No data stage

4.2 Configure UART Interface

The follow SETUP packet command can be used to change the baud rate of the UART interface.

TABLE 7: USB SETUP COMMAND

Setup Parameter	Value	Description
bmRequestType	0x41	Vendor specific command, Host-to-device data transfer
bRequest	0x40	UART_SET_REGISTERS
wValue	0x00	Reserved
wIndex	0x0000	Reserved
wLength	0x06	Size of UART_REGS structure

The UART_REGS structure is defined as:

TABLE 8: USB SETUP COMMAND

Setup Parameter	Value	Description
Reserved	0x01	Reserved, always 0x01
byBD	0x00 or 0x01	BD baud configuration byte
bySMOD	0x00 or 0x01	SMOD baud configuration byte
byTH1	0x00 - 0xFF	Timer 1 reload value (used only when byBD=0x00)
wS0REL	0x0000-0xFFFF	S0REL register value (used only when byBD=0x01)

There are two sets of formulas that may be used to configure the UART interface into a desired baud rate setting. Using these two sets of formulas, you must calculate and find the best result (lowest error) and set byBD and bySMOD accordingly.

When byBD= 0x00 & bySMOD = 0x01, byTH1 will be used:

- **byTH1** = 256 - ((2)(60,000,000)) / (384*desired_baud_rate)
- **actual_baud_rate** = (2*60,000,000)/(384*(256-TH1))
- **Error** = 100*((actual_baud_rate - desired_baud_rate) / (desired_baud_rate))

When byBD= 0x01 & bySMOD = 0x00, by wS0REL will be used:

- **byS0REL** = 1024 - ((60,000,000 / (64*desired_baud_rate))
- **actual_baud_rate** = (60,000,000) / (64 * (1024 - S0REL))
- **Error** = 100*((actual_baud_rate - desired_baud_rate) / (desired_baud_rate))

4.2.1 BAUD RATE CONFIGURATION CALCULATION EXAMPLE:

If the desired baud rate is 115,200, then using the two sets of formulas gives the following results:

Assuming byBD= 0x00 & bySMOD = 0x01:

- **byTH1** = 256 - ((2)(60,000,000)) / (384*115,200) = 256 - 2 = 254
- **actual_baud_rate** = (2*60,000,000)/(384*(256-254)) = 156,250
- **Error** = 100*((156,250- 115,200) / (115,200)) = 35%

Assuming byBD= 0x01 & bySMOD = 0x00:

- **byS0REL** = 1024 - ((60,000,000 / (64*115,200)) = 1024 - 8 = 1,016
- **actual_baud_rate** = (60,000,000) / (64 * (1024 - 1,016)) = 117,187
- Error = 100*((117,187 - 115,200) / (115,200)) = 1%

After comparing the two Error results above, parameters byBD = 0x01, bySMOD = 0x00, and byS0REL = 0x03F8 (1,016) should be selected due to the significantly lower error calculation.

4.3 UART Write Command

This command is used to send data to a UART peripheral connected to the USB hub.

TABLE 9: USB SETUP COMMAND

Setup Parameter	Value	Description
bmRequestType	0x41	Vendor specific command, Host-to-device data transfer
bRequest	0x41	UART write command: UART_DATA_PC_TO_DEVICE
wValue	0x00	Reserved
wIndex	0x0000	Reserved
wLength	0xNN	Data length of data to be sent (0x01 - 0x40 are possible values)

The maximum amount of data that can be sent from one USB command is 64 Bytes by specifying wLength = 0x40.

4.3.1 UART WRITE USB TRANSACTION SEQUENCE:

1. SETUP PACKET (Host > Hub): To prepare UART interface for data.
2. DATA (Host > Hub): Data payload of length wLength is sent from host to hub.
3. STATUS (Hub > Host): If an IN-Zero Length Packet is sent from hub, transfer was a success. If an IN-STALL packet is sent from hub, there was an error during transfer.

4.4 UART Read Command

This command is used to read data from a UART peripheral connected to the USB hub.

TABLE 10: USB SETUP COMMAND

Setup Parameter	Value	Description
bmRequestType	0xC1	Vendor specific command, Device-to-host data transfer
bRequest	0x42	UART write command: UART_DATA_DEVICE_TO_PC
wValue	0x00	Reserved
wIndex	0x0000	Reserved
wLength	0xNN	Data length of data to be read (0x01 - 0x40 are possible values)

The maximum amount of data that can be read from one USB command is 64 Bytes by specifying wLength = 0x40. The last byte received will always be the status code of the UART reception as shown below:

- 0x00 - No error
- 0x00 - Buffer overrun (data received was more than what the FIFO receiver buffer could hold)

The error code always returns the reception status between last UART_DATA_DEVICE_TO_PC command and the current command.

4.4.1 UART WRITE USB TRANSACTION SEQUENCE:

4. SETUP PACKET (Host > Hub): To prepare UART interface for data.
5. DATA (Hub > Host): Data payload of length wLength is sent from host to hub.
6. STATUS (Host > Hub): An IN-Zero Length Packet is sent from host to complete the data read.

4.5 Disable UART Pass-Through Interface Command

The follow SETUP packet command is required to disable the UART pass-through interface. Note that there is no data phase to this USB transaction.

TABLE 11: USB SETUP COMMAND

Setup Parameter	Value	Description
bmRequestType	0x41	Vendor specific command, Host-to-device data transfer
bRequest	0x2B	UART_PASSTHRU_EXIT
wValue	0x20	Disables UART pass through control flag
wIndex	0x0000	Reserved
wLength	0x00	Reserved

5.0 EXAMPLES

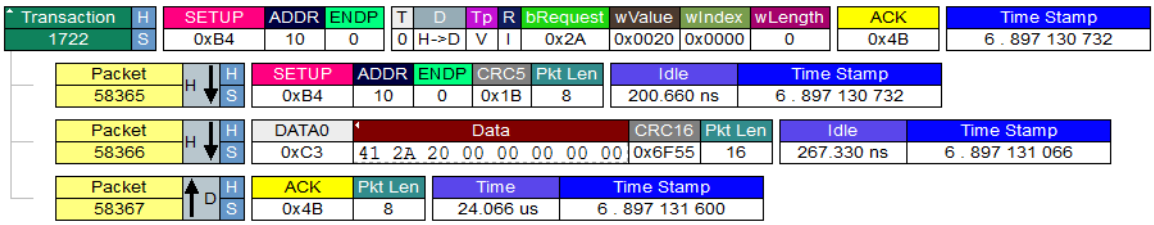
5.1 Enable and Configure the UART Interface for 115,200 Baud Rate

1. Send a command to the Hub Feature Controller to enable the UART pass through interface:

TABLE 12: EXAMPLE ENABLE UART PASS THROUGH SETUP PACKET

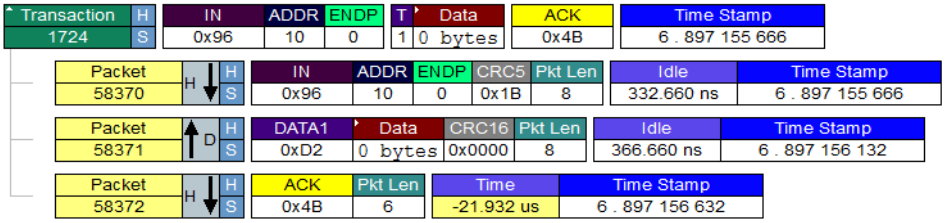
Field	Value	Note
bmRequestType	0x41	Vendor specific command, Host-to-device data transfer
bRequest	0x2A	UART_PASSTHRU_ENTER
wValue	0x20	Enables UART pass through control flag
wIndex	0x0000	
wLength	0x0000	

FIGURE 2: EXAMPLE ENABLE UART PASS THROUGH SETUP TRANSACTION



2. **Status (IN Transaction):** The host sends an IN packet to the Hub Feature Controller, to which the Hub Feature controller replies with a zero data length packet. The host ACKs to complete the bridging command.

FIGURE 3: EXAMPLE ENABLE UART PASS THROUGH IN TRANSACTION

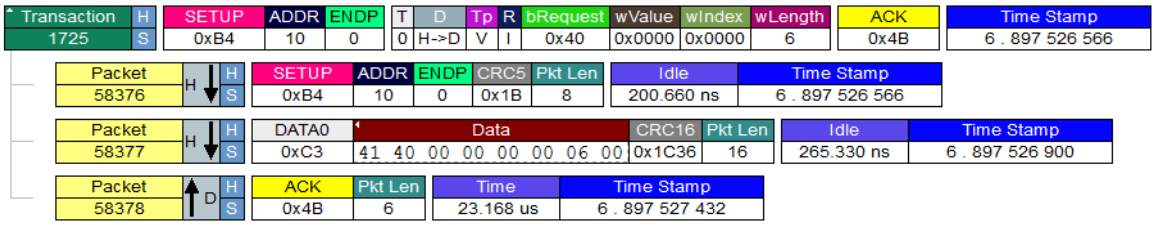


3. Send a command to the Hub Feature Controller to enable the UART pass through interface:

TABLE 13: EXAMPLE CONFIGURE UART PASS THROUGH SETUP PACKET

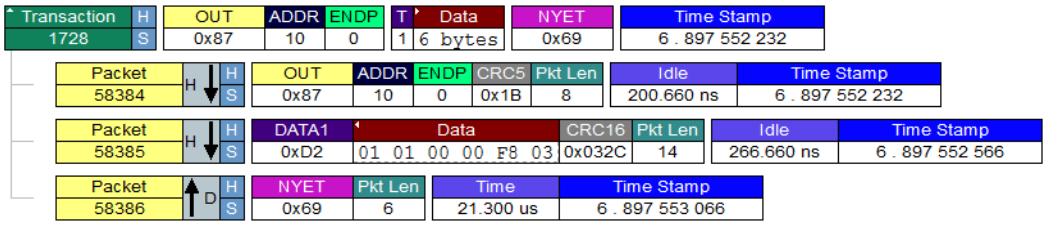
Field	Value	Note
bmRequestType	0x41	Vendor specific command, Host-to-device data transfer
bRequest	0x40	UART_SET_REGISTERS
wValue	0x00	
wIndex	0x0000	
wLength	0x06	Size of UART_REGS structure

FIGURE 4: EXAMPLE CONFIGURE UART PASS THROUGH SETUP TRANSACTION



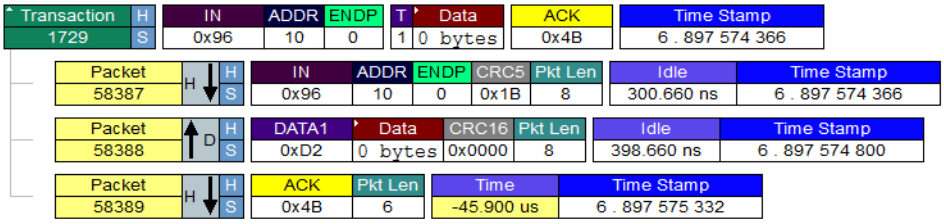
4. **Data (OUT Transaction):** The host sends an OUT packet to the Hub Feature Controller containing the UART REGS data necessary to configure the UART baud rate to 115,200. This data is 0x01, 0x01, 0x00, 0x00, 0xF8, 0x03. See **Section 4.2.1 “Baud Rate Configuration Calculation Example:”** for the derivation of this data.

FIGURE 5: EXAMPLE CONFIGURE UART PASS THROUGH OUT TRANSACTION



5. **Status (IN Transaction):** The host sends an IN packet to the Hub Feature Controller to which it responds with a zero length data transaction. The host completes the transaction with an ACK.

FIGURE 6: EXAMPLE CONFIGURE UART PASS THROUGH IN TRANSACTION



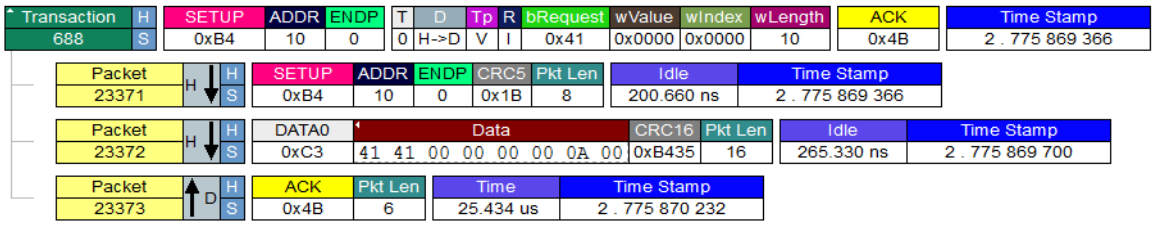
5.2 Send 10 Bytes of data to an attached UART Device

1. **Command Phase 1 (SETUP Transaction 1):** This example shows how to perform a UART write of 10 bytes to an attached UART device. Send the following SETUP Register Read Command to Endpoint 0 of the Hub Feature Controller to begin the UART write feature.

TABLE 14: EXAMPLE UART WRITE SETUP PACKET

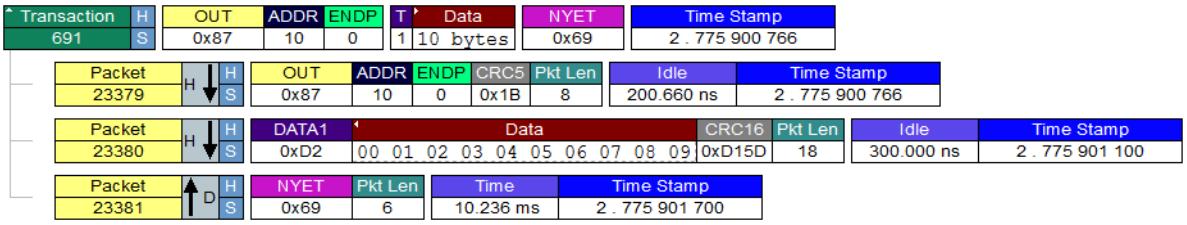
Field	Value	Note
bmRequestType	0x41	Vendor specific command, Host-to-device data transfer
bRequest	0x41	UART_DATA_PC_TO_DEVICE
wValue	0x0000	
wIndex	0x0000	
wLength	0x000A	10 byte data length

FIGURE 7: EXAMPLE UART WRITE SETUP TRANSACTION



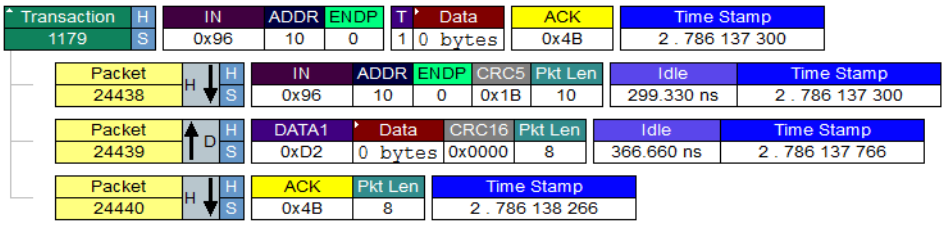
2. **Data Phase 1 (OUT Transaction 1):** Host sends an OUT packet followed by a 10 byte data payload. In this example, the data payload is 0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, x07, 0x08, x09. The Hub Feature Controller responds with a NYET after receiving the data.

FIGURE 8: EXAMPLE UART WRITE OUT TRANSACTION



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. The host ACKs to complete the bridging command.

FIGURE 9: EXAMPLE UART WRITE IN TRANSACTION



APPENDIX A: APPLICATION NOTE REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision Level & Date	Section/Figure/Entry	Correction
DS00002001A (09-01-15)	All	Initial release.

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
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