

## Objective

This example demonstrates the UART transmit and receive operation in PSoC® 6 MCU using low level APIs. This is done using polling, ISR, and DMA methods.

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## Overview

This example contains three sub-examples that implement a UART using: polling, ISR, or DMA to manage the UART. Each sub-example uses low level UART APIs and echoes what is received on the UART serial terminal. The UART\_Low\_Level\_Polling example polls repeatedly. The UART\_Low\_Level\_User\_ISR example uses a user interrupt. The UART\_Low\_Level\_DMA example uses DMA functions.

## Requirements

**Tool:** [PSoC Creator™ 4.2](#)

**Programming Language:** C (ARM® GCC 5.4-2016-q2-update, ARM MDK 5.22)

**Associated Parts:** All [PSoC 6 MCU](#) parts

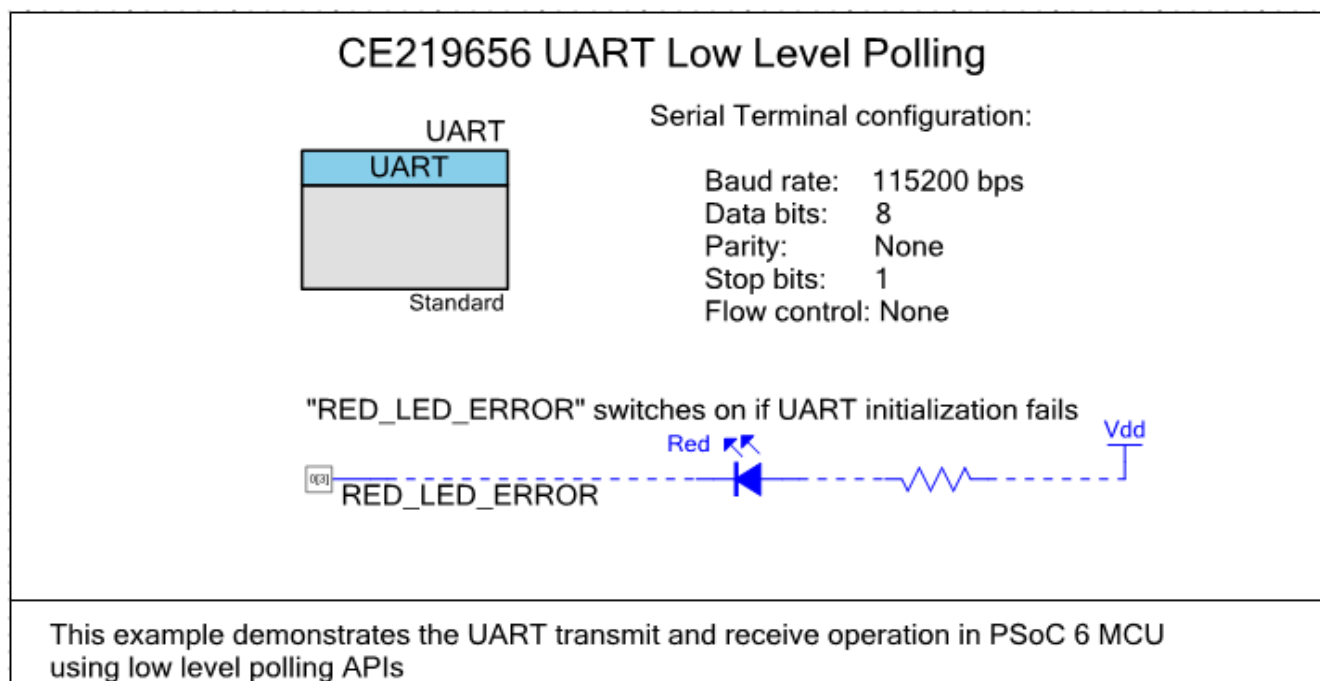
**Related Hardware:** [CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit](#)

## Design

### UART\_Low\_Level\_Polling

The UART\_Low\_Level\_Polling design shown in [Figure 1](#) has a UART (SCB\_UART\_PDL) Component configured for TX+RX mode at 115200 bps baud rate, 8N1.

Figure 1. The UART\_Low\_Level\_Polling Example Schematic



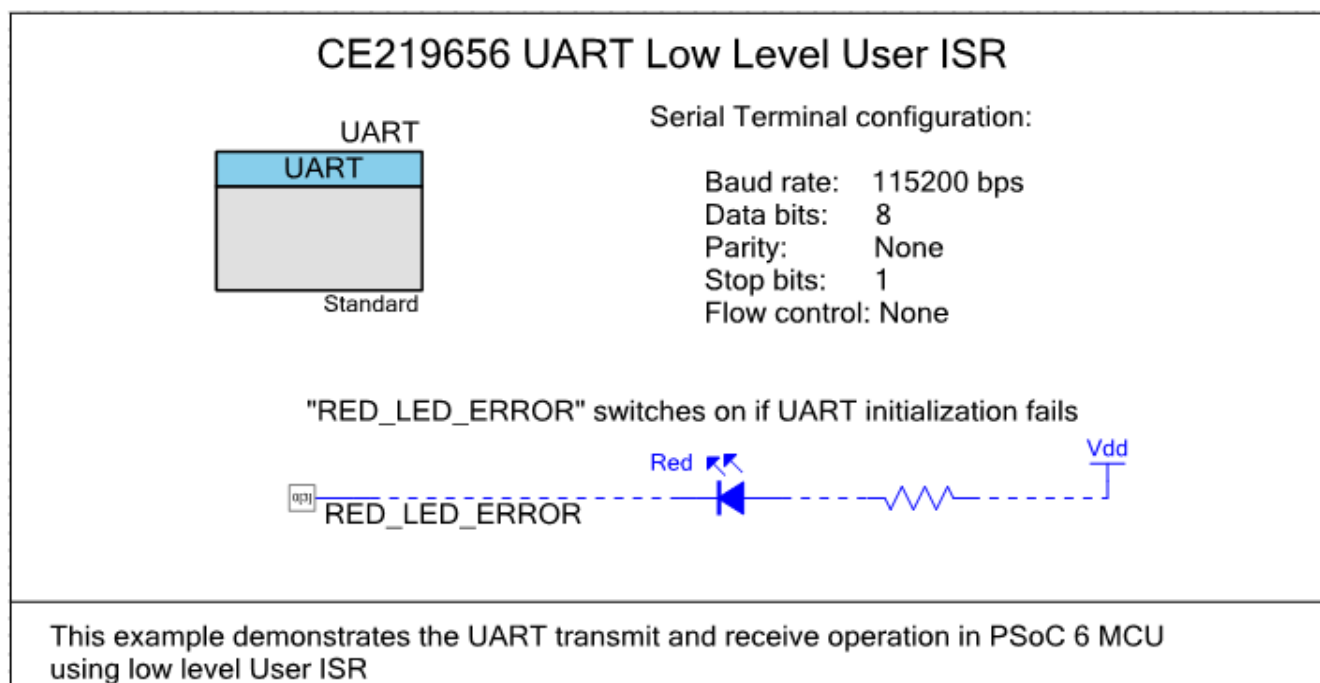
The UART\_Low\_Level\_Polling example firmware performs the following functions:

1. Turns OFF the RED\_LED\_ERROR.
2. Configures the UART Component.
3. Turns ON the RED\_LED\_ERROR if the UART Component initialization fails, then stays in an infinite loop.
4. Uses the UART to send a text header to the serial terminal.
5. Uses the low-level UART API to retransmit whatever the user types on the console.

## UART\_Low\_Level\_User\_ISR

Figure 2 shows the UART\_Low\_Level\_User\_ISR design. This design has a UART (SCB\_UART\_PDL) Component configured for TX+RX mode at 115200 bps baud rate, 8N1, and Interrupt mode: Internal.

Figure 2. The UART\_Low\_Level\_User\_ISR Example Schematic



The UART\_Low\_Level\_User\_ISR example firmware performs the following functions in main:

1. Turns OFF the RED\_LED\_ERROR.
2. Configures the UART Component.
3. Turns ON the RED\_LED\_ERROR if the UART Component initialization fails, then stays in an infinite loop.
4. Uses the UART to send a text header to the serial terminal.
5. Configures the UART interrupt with ISR\_UART as interrupt handler and enables UART interrupt.
6. Waits in an infinite loop for "UART RX FIFO not empty" interrupt.

The UART\_Low\_Level\_User\_ISR example firmware performs the following functions in ISR\_UART:

1. If the interrupt cause is "UART RX FIFO not empty", it clears the interrupt, gets the received character from the terminal, and echoes the character to the terminal.
2. If the interrupt cause is not "UART RX FIFO not empty", it turns ON the RED\_LED\_ERROR and stays in an infinite loop.

## UART\_Low\_Level\_DMA

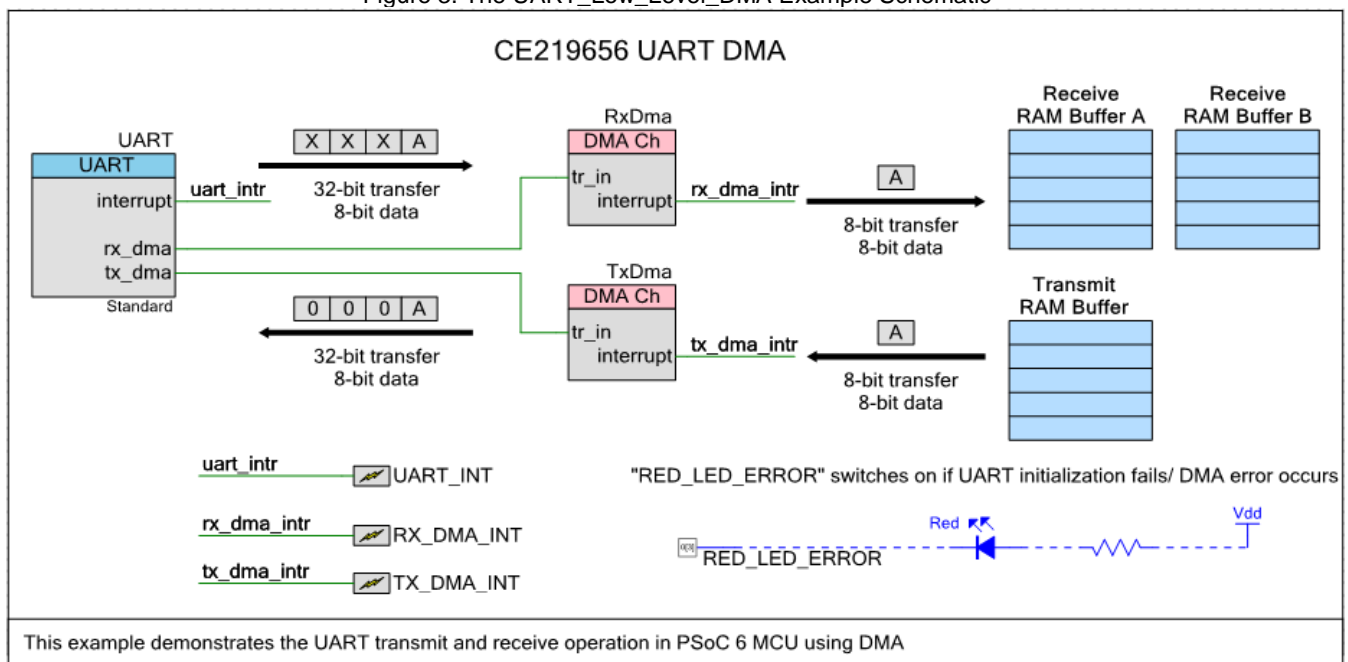
The UART\_Low\_Level\_DMA design shown in Figure 3 has a UART (SCB\_UART\_PDL) Component configured for TX+RX mode at 115200 bps baud rate, 8N1.

The rx\_dma and tx\_dma interrupt outputs are enabled in the Component configuration. The RxDma Component handles data transfer in the receive direction. The RxDma has two descriptors in the chain. These two descriptors are configured such that the source buffer becomes ping pong in the receive direction to provide firmware time to pull the data out of one or the other buffer. Each descriptor is configured to transfer a single element in byte mode. The TxDma Component handles data transfer in the transmit direction. The TxDma has only one descriptor, configured to transfer a single element in byte mode.

The UART\_INT (System Interrupt) Component is configured to handle UART error interrupts - RX FIFO Overflow, RX FIFO Underflow, and TX FIFO Overflow. RX\_DMA\_INT (System Interrupt) Component is configured to handle UART rx\_dma interrupt. TX\_DMA\_INT (System Interrupt) Component is configured to handle UART tx\_dma interrupt.

The RED\_LED\_ERROR indicates UART initialization failure status or DMA error status.

Figure 3. The UART\_Low\_Level\_DMA Example Schematic



The UART\_Low\_Level\_DMA example firmware performs the following functions in main:

1. Configures RxDma:
  - a. Initializes the RxDma\_Descriptor\_1 with source address as UART RX FIFO and destination address as RxDmaUartBufferA SRAM buffer
  - b. Initializes the RxDma\_Descriptor\_2 with source address as UART RX FIFO and destination address as RxDmaUartBufferB SRAM buffer
  - c. Initializes the rx\_dma interrupt with RxDmaComplete as interrupt handler and enables rx\_dma interrupt
  - d. Enables the RxDma channel
2. Configures TxDma:
  - a. Initializes the TxDma\_Descriptor\_1 with source address as RxDmaUartBufferA SRAM buffer and destination address as UART TX FIFO. Note that the TxDma\_Descriptor\_1 source address ping pongs between RxDmaUartBufferA and RxDmaUartBufferB during data transfer
  - b. Initializes the tx\_dma interrupt with TxDmaComplete as interrupt handler and enables tx\_dma interrupt
  - c. Enables the TxDma channel

3. Initializes and enables the UART error interrupts
4. Switch OFF the RED\_LED\_ERROR
5. Configures the UART Component
6. Switches on the RED\_LED\_ERROR if the UART Component initialization fails and stays in an infinite loop
7. Uses the UART to send a text header into the serial terminal
8. Enables the global interrupts
9. Waits in an infinite loop for any of the rx\_dma interrupt, tx\_dma interrupt, or UART error interrupt.

### Design Considerations

This code example is designed to run on CY8CKIT-062-BLE with the PSoC 6 MCU device. To port the design to other PSoC 6 MCU family devices and kits, you must change the target device in Device Selector, and change the pin assignments in the **cydwr** settings. For single-core PSoC 6 MCU devices, port the code from *main\_cm4.c* to *main.c* file as CM0+ CPU is not used in this code example.

### Hardware Setup

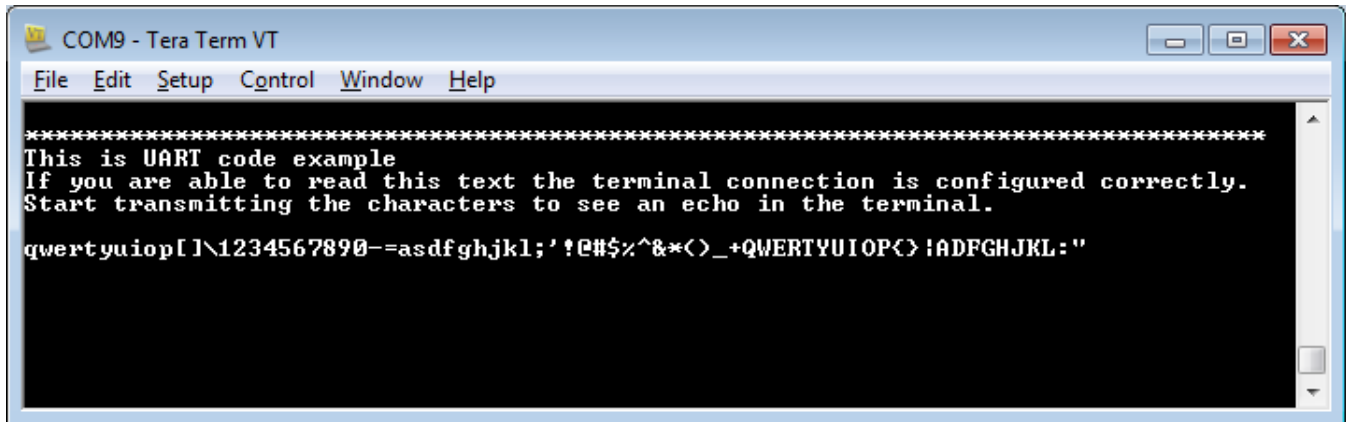
The code example works with the default settings on the CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit. If the settings are different from the default values, see the “Selection Switches” table in the [kit guide](#) to reset to the default settings.

### Operation

1. Connect the CY8CKIT-062-BLE Kit or CY8CKIT-062 Kit to a USB port on your PC.
2. Open a serial port communication program such as Tera Term and select the corresponding COM port. Configure the terminal to match the UART: 115200 baud rate, 8N1, and Flow control – None. These settings must match the configuration of the PSoC Creator UART Component in the project.
3. Build and program the application into the CY8CKIT-062-BLE Kit or CY8CKIT-062 Kit. For more information on building a project or programming a device, see *PSoC Creator Help*.
4. Observe the UART example header message printed in the terminal window.
5. Type any character in the terminal window, and make sure that the same character is displayed in the terminal.

Figure 4 shows a snapshot of a sample UART terminal output.

Figure 4. UART Terminal Output



## Components

Table 1 lists the PSoC Creator Components used in all three sub-examples and the hardware resources used by each Component.

Table 1. PSoC Creator Components

Component	Instance Name	Hardware Resources
UART (SCB_UART_PDL)	UART	Single SCB peripheral block
General Purpose Input / Output (GPIO)	RED_LED_ERROR	One physical pin
Direct Memory Access (DMA_PDL)	RxDma, TxDma	Two DMA channels
System Interrupt (SysInt)	UART_INT, RX_DMA_INT, TX_DMA_INT	Three entries in the device interrupt vector table

## Parameter Settings

Non-default settings for each Component are outlined in red in the following figures.

Figure 5 shows the UART\_Low\_Level\_DMA example UART Component parameter settings.

Figure 5. UART\_Low\_Level\_DMA Example UART Component Parameter Settings

Configure 'SCB\_UART\_PDL'

Name:

Basic **Advanced** Pins Built-in

**DMA Triggers**

RX Output	<input checked="" type="checkbox"/>	f(x)
TX Output	<input checked="" type="checkbox"/>	f(x)

**Trigger Level**

RX FIFO Level	0u	f(x)
TX FIFO Level	127u	f(x)

**Interrupt Mode**

Interrupt	External	f(x)
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**RX Interrupt Sources**

RX FIFO not Empty	<input type="checkbox"/>	f(x)
RX FIFO Above Level	<input type="checkbox"/>	f(x)
RX FIFO Full	<input type="checkbox"/>	f(x)
RX FIFO Overflow	<input checked="" type="checkbox"/>	f(x)
RX FIFO Underflow	<input checked="" type="checkbox"/>	f(x)
RX Frame Error	<input type="checkbox"/>	f(x)
Break Detected	<input type="checkbox"/>	f(x)

**TX Interrupt Sources**

UART Done	<input type="checkbox"/>	f(x)
TX FIFO Empty	<input type="checkbox"/>	f(x)
TX FIFO Below Level	<input type="checkbox"/>	f(x)
TX FIFO not Full	<input type="checkbox"/>	f(x)
TX FIFO Overflow	<input checked="" type="checkbox"/>	f(x)
TX FIFO Underflow	<input type="checkbox"/>	f(x)

**Drop on Error**

Drop on Frame Error	<input type="checkbox"/>	f(x)
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**Break Width**

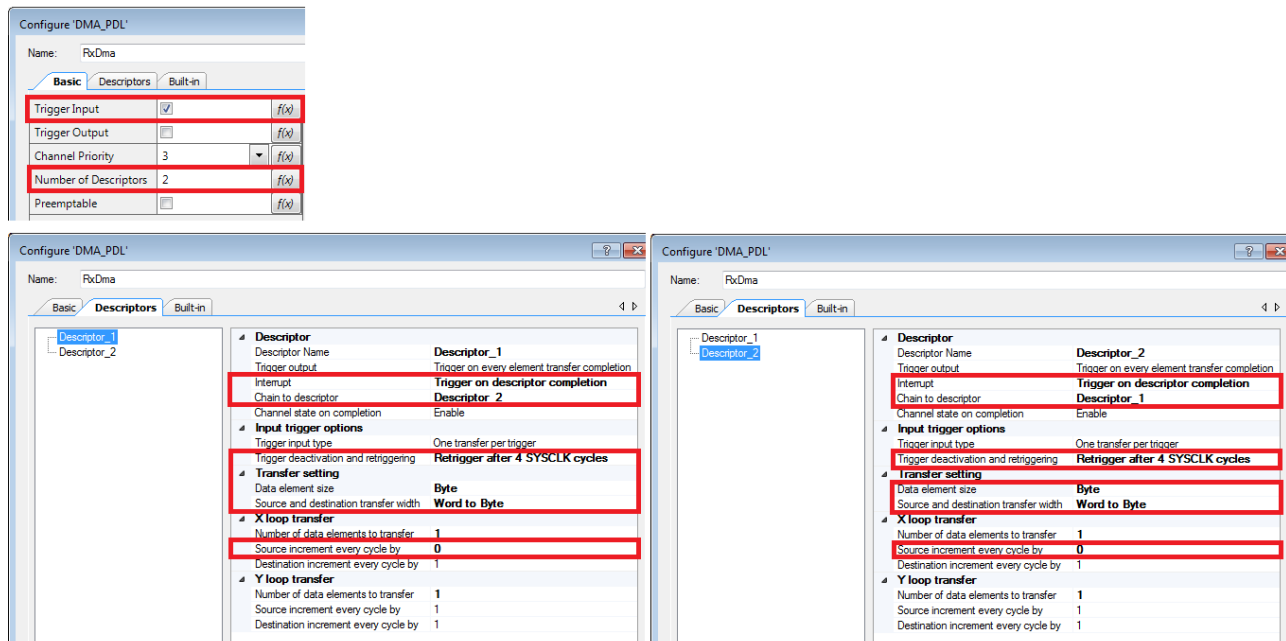
Break Signal Bits	11	f(x)
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**Flow Control**

CTS	<input type="checkbox"/>	f(x)
RTS	<input type="checkbox"/>	f(x)

Figure 6 shows the UART\_Low\_Level\_DMA example RxDma Component parameter settings.

Figure 6. UART\_Low\_Level\_DMA Example RxDma Component Parameter Settings



Configure 'DMA\_PDL'

Name: RxDma

Basic Descriptors Built-in

Trigger Input ☒ f(x)

Trigger Output ☐ f(x)

Channel Priority 3 f(x)

Number of Descriptors 2 f(x)

Preemptible ☐ f(x)

Configure 'DMA\_PDL'

Name: RxDma

Basic Descriptors Built-in

Descriptor\_1

Descriptor Name Descriptor\_1

Trigger output Trigger on every element transfer completion

Interrupt **Trigger on descriptor completion**

Chain to descriptor Descriptor\_2

Channel state on completion Enable

Input trigger options

Trigger input type One transfer per trigger

Trigger deactivation and retriggering **Retrigger after 4 SYSCLK cycles**

Transfer setting

Data element size Byte

Source and destination transfer width **Word to Byte**

X loop transfer

Number of data elements to transfer 1

Source increment every cycle by 0

Destination increment every cycle by 1

Y loop transfer

Number of data elements to transfer 1

Source increment every cycle by 1

Destination increment every cycle by 1

Configure 'DMA\_PDL'

Name: RxDma

Basic Descriptors Built-in

Descriptor\_2

Descriptor Name Descriptor\_2

Trigger output Trigger on every element transfer completion

Interrupt **Trigger on descriptor completion**

Chain to descriptor Descriptor\_1

Channel state on completion Enable

Input trigger options

Trigger input type One transfer per trigger

Trigger deactivation and retriggering **Retrigger after 4 SYSCLK cycles**

Transfer setting

Data element size Byte

Source and destination transfer width **Word to Byte**

X loop transfer

Number of data elements to transfer 1

Source increment every cycle by 0

Destination increment every cycle by 1

Y loop transfer

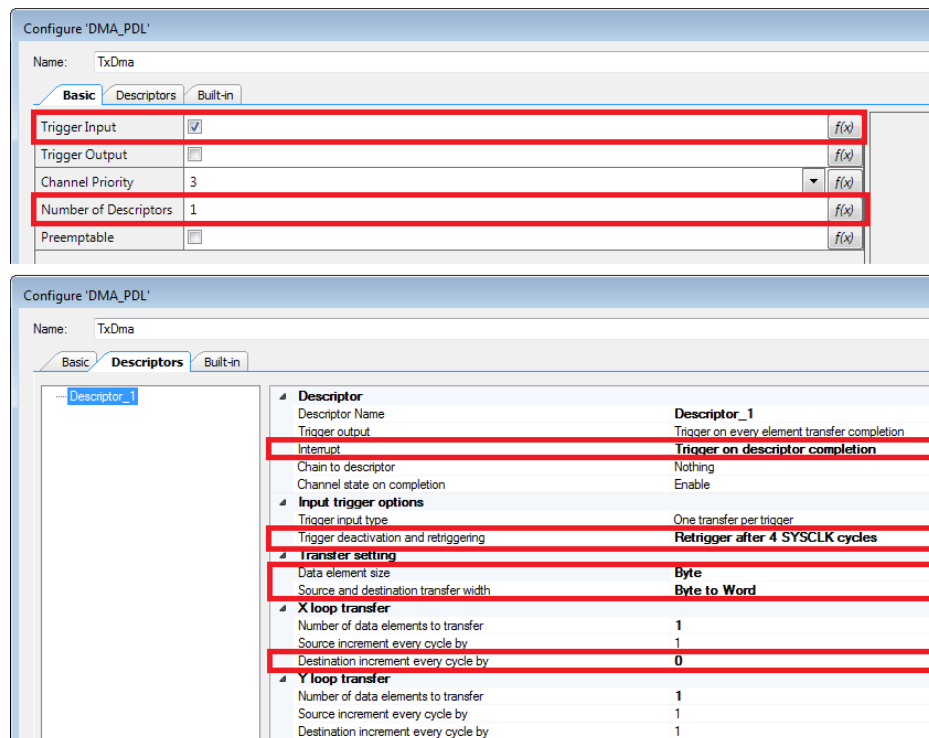
Number of data elements to transfer 1

Source increment every cycle by 1

Destination increment every cycle by 1

Figure 7 shows the UART\_Low\_Level\_DMA example TxDma Component parameter settings.

Figure 7. UART\_Low\_Level\_DMA Example TxDma Component Parameter Settings



Configure 'DMA\_PDL'

Name: TxDma

Basic Descriptors Built-in

Trigger Input ☒ f(x)

Trigger Output ☐ f(x)

Channel Priority 3 f(x)

Number of Descriptors 1 f(x)

Preemptible ☐ f(x)

Configure 'DMA\_PDL'

Name: TxDma

Basic Descriptors Built-in

Descriptor\_1

Descriptor Name Descriptor\_1

Trigger output Trigger on every element transfer completion

Interrupt **Trigger on descriptor completion**

Chain to descriptor Nothing

Channel state on completion Enable

Input trigger options

Trigger input type One transfer per trigger

Trigger deactivation and retriggering **Retrigger after 4 SYSCLK cycles**

Transfer setting

Data element size Byte

Source and destination transfer width **Byte to Word**

X loop transfer

Number of data elements to transfer 1

Source increment every cycle by 1

Destination increment every cycle by 0

Y loop transfer

Number of data elements to transfer 1

Source increment every cycle by 1

Destination increment every cycle by 1



## Design-Wide Resources

Table 2 shows the pin assignment for the code example.

Table 2. Pin Names and Location

Pin Name	Location
UART:rx	P5[0]
UART:tx	P5[1]
RED_LED_ERROR	P0[3]

## Related Documents

Table 3 lists all relevant application notes, code examples, knowledge base articles, device datasheets, and Component/user module datasheets.

Table 3. Related Documents

Application Notes	
<a href="#">AN210781</a> Getting Started with PSoC 6 MCU with Bluetooth Low Energy (BLE) Connectivity	Describes PSoC 63 with Bluetooth Low Energy (BLE) Connectivity and how to build your first PSoC Creator project
PSoC Creator Component Datasheets	
<a href="#">UART</a>	Supports UART communication
<a href="#">Direct Memory Access</a>	Supports up to 16 DMA channels
<a href="#">System Interrupt</a>	Interrupt vectoring and control
<a href="#">General-Purpose Input / Output</a>	Supports Analog, Digital I/O and Bidirectional signal types
Device Documentation	
<a href="#">PSoC 6 MCU: PSoC 63 with BLE Datasheet</a>	<a href="#">PSoC 6 MCU: PSoC 63 with BLE Architecture Technical Reference Manual</a>
Development Kit (DVK) Documentation	
<a href="#">CY8CKIT-062-BLE PSoC 6 BLE Pioneer Kit</a>	

## Document History

Document Title: CE219656 - PSoC 6 MCU UART using Low Level APIs

Document Number: 002-19656

Revision	ECN	Orig. of Change	Submission Date	Description of Change
*A	5856608	VJYA	08/23/2017	Initial public release
*B	6003214	VJYA	12/22/2017	Updated to latest PSoC Creator build and Fixed CDT#295974

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