ECEN 3360
Digital Design Lab #6
Using the LDMA for LEUART transmit
Spring 2019

Objective: This assignment's goal is to realize energy savings by offloading the highest energy consuming peripheral, the CPU, from sending bytes of data to the LEUART to transmit to the BLE module. While the Direct Memory Access, DMA, is occurring, the processor should be in the lowest energy sleep mode, EM2.

Note: This assignment will begin with the completed Lab 5 assignment.

Lab 6 Due: Sunday April 14th, 2019

Lab 6 Instructions:

1. Make any changes required to Lab 5, Reading Commands from the LEUART. Please work with the Instructing Team to get your code working to Lab 5.

2. To better match the energy measurements from your project to the expect results, all projects must enable HFXO to wake up and run after coming out of sleep energy modes. The following line of code should be added in your cmu.c function after all the calls to initialize the HFXO oscillator.
    a. **CMU_HFXOAutostartEnable**(true, true, true);

3. LETIMER0 should be set to the following conditions at startup / reset.
    a. Si7021 temperature read period = 3.0 seconds
    b. No LED heart beat requirement

4. Initialize/program the Pearl Gecko LEUART to work down into EM2 energy mode
    a. Enable the LEUART for both transmit and receive
    b. Set the energy mode to the lowest energy level that will allow the LEUART to receive data
    c. You must <u>not</u> enable Loop Back

5. Configure, initialize the Pearl Gecko LDMA, Linked Direct Memory Access, peripheral.
    a. This assignment will be focusing on LEUART data transmission which will require the LDMA interrupts to be enabled to indicate when the last byte of data has been sent from the output buffer to the LEUART->TXDATA register.

6. Implement a function to set up the structures required for the LDMA transmission.

a. Input arguments should be the output data string and total number of bytes to transfer via DMA
b. Source will be an output buffer from memory
    i. What will be the address increment size of the source, memory buffer?
    ii. Please refer to the LDMA chapter in the Pearl Gecko Reference Manual
c. Destination will be the LEUART0->TXDATA buffer
    i. What will be the address increment size of the destination, LEUART0->TXDATA?
    ii. Please refer to the LDMA chapter in the Pearl Gecko Reference Manual
d. There are predefined structures that you can use for the different descriptor modes in the Pearl Gecko HAL documentation.
    i. Which one should you use for this assignment?
        1. LDMA_DESCRIPTOR_SINGLE_M2M_BYTE
        2. LDMA_DESCRIPTOR_SINGLE_M2M_HALFWORD
        3. LDMA_DESCRIPTOR_SINGLE_M2M_WORD
        4. LDMA_DESCRIPTOR_SINGLE_P2M_BYTE
        5. LDMA_DESCRIPTOR_SINGLE_M2P_BYTE
        6. LDMA_DESCRIPTOR_SINGLE_P2P_BYTE
e. There are predefined structures for the LDMA configuration as well
    i. Which one should you use for this assignment?
        1. LDMA_TRANSFER_CFG_PERIPHERAL
        2. LDMA_TRANSFER_CFG_PERIPHERAL_LOOP
        3. LDMA_TRANSFER_CFG_MEMORY
        4. LDMA_TRANSFER_CFG_MEMORY_LOOP

7. A helpful example can be found at Silicon Labs Git Hub:
    a. https://github.com/SiliconLabs/peripheral_examples/blob/public/usart/spi_dma_master/src/main_s1_pg1_efr.c

8. To enable DMA from the LEUART down into EM2 mode, you will need to properly enable this function in the LEUART0 peripheral
    a. Refer to section 17.3.10 DMA Support in the Pearl Gecko Reference manual
    b. You can enable this functionality by writing directly to the LEUART0 register or use the proper HAL emlib routine

9. With the DMA descriptor and configuration functions created, you must assign a DMA channel # for this DMA operation
    a. No specific number is required

10. The above sets up the basic data structures and peripheral to enable the DMA to occur. Now it is time to set up you code in your program.
    a. You will replace the code to transmit the temperature data string to the BLE UART with a DMA transfer

b. As you did in Lab 4b, you must create an output string that contains the ASCI-II characters to transmit and the total number of bytes to transfer to the LEUART

11. The basic procedure to use the DMA to transmit is the following:
    a. Call the descriptor/configuration function to configure the descriptor data structure and configure the DMA transfer operation with the desired output buffer string and total bytes to DMA
    b. Enable the LEUART0 to support DMA in low energy modes
    c. Block sleep mode to the lowest energy mode that the LEUART can support DMA transfers
    d. Call the function to start the DMA, LDMA_StartTransfer
        i. Please refer to the Pearl Gecko HAL documentation for additional details
    e. Upon the last byte transferred, the LDMA will generate an interrupt
        i. If your system could go down into EM3 after the DMA transmission is completed, you cannot allow that to occur until the last byte of data has completed its transmission out of the LEUART0
        ii. Use this interrupt to enable the LEUART0 TXC interrupt to notify you that the last byte has been transmitted
        iii. Disable the LEUART0 to support DMA in low energy modes
    f. Upon LEUART0 TXC interrupt, you now know that all bytes of the DMA have been completed and sent out of the LEUART0
        i. Unblock sleep mode to the lowest energy mode that the LEUART can support DMA transfers

12. The Pearl Gecko should be in sleep mode during the DMA transfers, reducing the energy expenditures of transmitting the temperature from the Pearl Gecko to the BLE module.

13. The Pearl Gecko should be able to receive and transmit data from the BLE module simultaneously

Deliverables:

1. Project code exported to Canvas for grading
2. Energy Profiler screen shot of the DMA transfer of the temperature from the Pearl Gecko to the BLE module
3. Lab 6 worksheet to be completed in Canvas

4. Deductions:
    a. Magic numbers - 3 pts
    b. Not unique files per peripheral - 3 pts
    c. No comments before each function documenting its function, input arguments, and outputs returned - 3 pts
    d. No acknowledgement of IP - 2 pts
5. Late Submission:

a. Due date to Monday the 15th at 11:59pm - 5 pts
b. Tuesday the 16th thru Wednesday, April 17th, at 11:59pm - 10 pts
c. After April 17th - 15 pts

6. If code does not work, corresponding Quiz questions will be marked as 0 if answered correctly.