

# DMA - Memory to Memory transfer

## Objective

- Copy data from one memory block to another memory block using DMA controller
- Use implemented driver to compare the performance between DMA copy and CPU copy

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## Part 0: Read the DMA chapter

The first step is to familiarize yourself with the DMA peripheral. Read the LPC user manual multiple times before you start the assignment.

### UM10562

#### Chapter 35: LPC408x/407x General Purpose DMA controller

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User manual

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## 35.1 Basic configuration

The GPDMA is configured using the following registers:

1. Power: In the PCONP register ([Section 3.3.2.2](#)), set bit PCGPDMA.  
**Remark:** On reset, the GPDMA is disabled (PCGPDMA = 0).
  2. Clock: The GPDMA operates at the AHB bus rate, which is the same as the CPU clock rate (CCLK).
  3. Interrupts: Interrupts are enabled in the NVIC using the appropriate Interrupt Set Enable register.
  4. Programming: see [Section 35.6](#).
  5. Select the DMA channel alternate requests in the DMA channel request select register in the system control block. See [Section 3.3.7.7](#).
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## Part 1: Basic DMA driver

In this portion of the lab, you will implement GPDMA driver by choosing one of the DMA channels (0-7, preferably 7) for performing memory-to-memory copy between 2 arrays. You will be modifying DMA registers available in `lpc40xx.h`

```
#include <stdbool.h>

#include "lpc40xx.h"
#include "lpc_peripherals.h"

typedef enum {
    DMA__CHANNEL_0 = 0,
    DMA__CHANNEL_1,
    DMA__CHANNEL_2,
    DMA__CHANNEL_3,
    DMA__CHANNEL_4,
    DMA__CHANNEL_5,
    DMA__CHANNEL_6,
    DMA__CHANNEL_7,
} dma__channel_e;

LPC_GPDMACH_TypeDef *dma_channels[] = {LPC_GPDMA0, LPC_GPDMA1, LPC_GPDMA2, LPC_GPDMA3,
                                         LPC_GPDMA4, LPC_GPDMA5, LPC_GPDMA6, LPC_GPDMA7};

void dma_initialize(void) {
    // 1. Power on GPDMA peripheral; @see "lpc_peripherals.h"
    lpc_peripheral__turn_on_power_to(...); // Fill in the arguments
}

void dma_copy(dma__channel_e channel, const void *dest, void *source, uint32_t size_in_bytes);
// 2. Enable GPDMA - Set the Enable bit in Config register

// 3. Clear any pending interrupts on the channel to be used by writing to the IntTCClear
// and IntErrClear register. The previous channel operation might have left interrupt active
// 4. Write the source address into the CSrcAddr register.
dma_channels[channel]->CSrcAddr = (uint32_t)source;

// 5. Write the destination address into the DestAddr register.

// 6. Write the control information into the Control register in one instruction
```

```

// transfer size [11:0]
// source burst size [13:12]
// dest burst size [15:14]
// source transfer width [20:18]
// destination transfer width [23:21]
// source address increment [26]
// destination address increment [27]
// TCI enable
// Enable channel by setting enable bit for the channels CConfig register
// IMPORTANT:
// Poll for DMA completion here
}

bool check_memory_match(const void *src_addr, const void *dest_addr, size_t size) {
    // Write code to check the data of source and destination arrays
    // Hint: You may use memcmp()
}

int main(void) {
    const uint32_t array_len = ____; //specify a length (< 2^12)
    // Be aware that you only have 64K of RAM where stack memory begins
    // You can make these 'static uint32_t' or make them global to not use stack memory
    uint32_t src_array[array_len];
    uint32_t dest_array[array_len];
    // Initialize the source array items to some random numbers
    // Choose a free DMA channel with the priority needed.
    // DMA channel 0 has the highest priority and
    // DMA channel 7 the lowest priority
    dma__initialize();
    dma__copy(...);          // fill in the arguments

    const bool memory_matches = check_memory_match(...); // fill in the arguments
    while (true) {
    }
    return 1; // main() shall never return}

```

## Part 2: Compare Performance of various methods

Reuse code from [Part 1](#). Reference the code below to measure the time taken for DMA copy, programmatic copy and standard library function `memcpy()`

```
#include <string.h>

// Declare source and destination memory for the lab
static uint8_t memory_array_source[4096];
static uint8_t memory_array_destination[4096];
// Re-initialize the memory so they do not match
static void reset_memory(void) {
    for (size_t i = 0; i < sizeof(memory_array_source); i++) {
        memory_array_source[i] = i;
        memory_array_destination[i] = i + 1;
    }
}

// Copy memory using standard library memcpy()
static uint32_t memory_copy__memcpy(void) {
    const uint32_t start_time_us = sys_time__get_uptime_us();
    {
        memcpy(...); // TODO: Fill in the parameters
    }
    const uint32_t end_time_us = sys_time__get_uptime_us();

    return (end_time_us - start_time_us);
}

// Copy memory using the DMA
static uint32_t memory_copy__dma(void) {
    const uint32_t start_time_us = sys_time__get_uptime_us();
    {
        dma__copy(...); // TODO: Fill in the parameters
    }
    const uint32_t end_time_us = sys_time__get_uptime_us();

    return (end_time_us - start_time_us);
}
```

```

static uint32_t memory_copy__loop(void) {
    const uint32_t start_time_us = sys_time__get_uptime_us();
    {
        // TODO: Use a for loop
    }
    const uint32_t end_time_us = sys_time__get_uptime_us();

    return (end_time_us - start_time_us);
}

int main()
{
    dma__initialize(...);
    // Test 1:
    reset_memory();
    const uint32_t dma_us = memory_copy__dma();
    if (!check_memory_match(memory_array_source, memory_array_destination, sizeof(memory_array_source)))
        puts("ERROR: Memory copy did not work");
    }
    // TODO: Reset memory, then perform memory copy, and check if memory matches
    // Test 2:
    const uint32_t loop_us = memory_copy__loop();

    // Test 3:
    const uint32_t memcpy_us = memory_copy__memcpy();

    printf("DMA copy completed in: %lu microsec\n", dma_us);
    printf("For loop completed in: %lu microsec\n", loop_us);
    printf("memcpy completed in : %lu microsec\n", memcpy_us);

    while (true) {
    }
    return 1; // main() shall never return}

```

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## Requirements

- [Part 1](#) and [Part 2](#) must be completed and fully functional.
  - You are encouraged to ask questions for any line of code that is not well understood (or magical).
- Try changing source burst size and destination burst size bits to understand performance improvements
  - Note the time taken in each case and turn in the screenshots
- Should be able to make it work for any DMA channels(0-7) or array size
  - We may ask you to change the channel or array length and then recompile and re-flash your board to and prove it works

## What to turn in:

- Turn in the **screenshots** of terminal output for different burst size

**Extra Credit - Make program to choose DMA channels using onboard buttons and run DMA copy process**

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