

Datasheet and Textbook Reading Guide for CprE 288

General-Purpose Input/Output (GPIO) on the TM4C Microcontroller

Chapter 10 of the Tiva TM4C microcontroller datasheet, General-Purpose Input/Outputs (GPIOs), covers the details of how GPIO works on our platform. Additionally, chapters 2, 4, and 7 of the Bai textbook have sections that help explain important aspects of this part of the datasheet. To help you work through this information, here is a reading guide to reduce your reading from over 50 pages of the datasheet to about 15 pages (i.e., for the GPIO Module). You may want to bookmark pages, sections, figures and tables for easy reference.

Readings about the TM4C Memory Map

- 1) Datasheet Section 2.4 Memory Model and Table 2-4 Memory Map
- 2) Bai textbook Chapters 2 and 6. Sections in these chapters describe the memory map used for the TM4C123G microcontroller. GPIO registers, along with other memory-mapped peripheral devices, occupy a specific range in the memory space. Each register has a unique address.
 - a) Section 2.3.1 (Figure 2.10), section 2.6.2 (Table 2.5), section 6.3 (Figure 6.14)
- 3) tm4c123gh6pm.h header file: See the addresses used in the Register Definition macros. Compare these addresses with the peripheral device range in the memory map.
- 4) Valvano and Yerraballi Embedded Systems book, section 2.7, Address Space,
http://users.ece.utexas.edu/~valvano/Volume1/E-Book/C2_FundamentalConcepts.htm

Readings about the GPIO Module

- 1) Datasheet Chapter 10 (~15 pages)
 - a) Skip: Sections 10.2.4 Commit Control, 10.2.6 Identification, Table 10-5
 - b) In section 10.5, Register Descriptions, only read about the following important registers. The register macro names shown below are defined for our platform in the tm4c123gh6pm.h header file, where X denotes the ports A-F. Keep in mind our platform uses the APB bus addresses.
 - i) Register 1: GPIO Data (GPIO_PORTX_DATA_R)
 - ii) Register 2: GPIO Direction (GPIO_PORTX_DIR_R)
 - iii) Register 10: GPIO Alternate Function Select (GPIO_PORTX_AFSEL_R)
 - iv) Register 18: GPIO Digital Enable (GPIO_PORTX_DEN_R)
 - v) Register 21: GPIO Analog Mode Select (GPIO_PORTX_AMSEL_R)
 - vi) Register 22: GPIO Port Control (GPIO_PORTA_PCTL_R)
 - c) In section 5.5, Registers Descriptions
 - i) Register 60: General-Purpose Input/Output Run Mode Clock Gating Control (SYSCTL_RCGCGPIO_R)
 - d) In section 23.4, see Table 23-5: GPIO Pins and Alternate Functions. This is the same table as in the Bai textbook: Table 7.1 and Table 2.6

- 2) Bai textbook Chapters 2, 4, and 7. Sections in these chapters elaborate on the content of datasheet Chapter 10. Read though these as needed to help you understand the datasheet.
 - a) Sections 2.6.1, 2.6.2.3, 2.6.3: GPIO (~6.5 pages). Read sections except as noted below:
 - i) Light read of section 2.6.3.1, The System Clock
 - ii) Skip sections 2.6.3.3.4 – 5, Commit and Interrupt Control Registers
 - iii) In section 2.6.3.3.6, Pad Control Registers, skip GPIODR2R – GPIOSLR (start with GPIODEN)
 - iv) Skip section 2.6.3.3.7, Identification Registers
 - b) Sections 4.5.7.1 – 4.5.7.2.4 (notice the register information in the figures), and section 4.5.7.2.5.3 (Figure 4.33: DRAModel.c sample code) (~6.5 pages).

Section 4.5.6.5, Naming Convention and Definition, is helpful and explains the C keyword *volatile*. For more information, consult C programming resources, or check out these articles:

"Introduction to the Volatile Keyword," by Nigel Jones, Embedded Systems Programming, July 2001: <http://www.embedded.com/electronics-blogs/beginner-s-corner/4023801/Introduction-to-the-Volatile-Keyword>

Wikipedia Article: [https://en.wikipedia.org/wiki/Volatile_\(computer_programming\)](https://en.wikipedia.org/wiki/Volatile_(computer_programming))
 - c) Sections 7.1, 7.2, 7.3, programming example in section 7.4 (Figure 7.7: DRAKeyPadPoll.c sample code) (~13 pages)

Note that the section 7.4 programming example uses a different version of the header file to reference the registers. We use a Register Definition header file like the one shown in Figure 5.10 that provides macros to access the registers. The other header file – which we don't use in lab – defines each peripheral with a structure pointer, and registers are accessed using the pointer operator (->). The structure version is used in this example and several others in the textbook (read it, but don't code with it).
- 3) tm4c123gh6pm.h header file: See the Register Definition macros for the GPIO port registers. Compare their addresses with the address information given in the datasheet register descriptions.

How To Search for Registers in the Datasheet

There are various ways to find information in the datasheet. Use the table of contents. Search the PDF document. Use the sidebar in a PDF viewer. This short video from the Valvano and Yerraballi supplemental text demonstrates this:

Valvano and Yerraballi, Video D6-0: Using the GPIO register datasheet,
<https://youtu.be/VI2vrRwzWio> (2 minutes)

Note: Refer to your own PDF copy of the Tiva TM4C123 datasheet -- open it separately in a PDF viewer to see the table of contents sidebar.

Ultimately, you need to have some part of the register name to look up or search for. You might find that in the Bai textbook, V&Y ES book, or the tm4c123gh6pm.h header file. Often, it works best to use just part of the register name. For example, I can search for "RCGC" in the header

file. That gives me the macro definition for SYSCTL_RCGCPGIO_R. Likewise in the datasheet, you'll get several matches when searching for "RCGC" and can browse through them to see what looks most useful for your purposes. Often, even if you don't get to the register description on the first match, there are hyperlinks in the datasheet that will take you there. Plus, after you find things a few times, you will begin to know where to look.

Supplemental Readings

Various sections from the book, Valvano and Yerraballi, Embedded Systems - Shape the World, <http://users.ece.utexas.edu/~valvano/Volume1/E-Book/>, cover information in a more tutorial and step-by-step manner. You are encouraged to browse the V&Y book and choose what might be helpful to spend time on.

- 1) Valvano and Yerraballi supplemental text:
 - a) Section 2.3: Introduction to Computers (Figures 2.8, 2.10), http://users.ece.utexas.edu/~valvano/Volume1/E-Book/C2_FundamentalConcepts.htm
 - b) Section 2.7: Address Space, http://users.ece.utexas.edu/~valvano/Volume1/E-Book/C2_FundamentalConcepts.htm
 - c) Chapter 6: Parallel I/O Ports, Embedded Systems - Shape the World, Sections 6.0 - 6.3 (through Interactive Tool 6.1), http://users.ece.utexas.edu/~valvano/Volume1/E-Book/C6_MicrocontrollerPorts.htm
 - d) Interactive exercise 6.1: http://users.ece.utexas.edu/~valvano/Volume1/E-Book/C6_Interactives.htm
 - e) Short videos available at Chapter 6 link or from YouTube, <https://www.youtube.com/playlist?list=PLyg2vmIzGxXH48Rq5HsilGdQxbAh0w4Di> (e.g., C6-1a, C6-1c, D6-0)
 - f) Video C6-2b: Friendly Code, via Chapter 6 link or from YouTube, <https://youtu.be/0LLD1kLFN-U> (explains setting and clearing specific I/O port bits using bitwise operations)
 - g) Section 10.3: Structures, http://users.ece.utexas.edu/~valvano/Volume1/E-Book/C10_FiniteStateMachines.htm