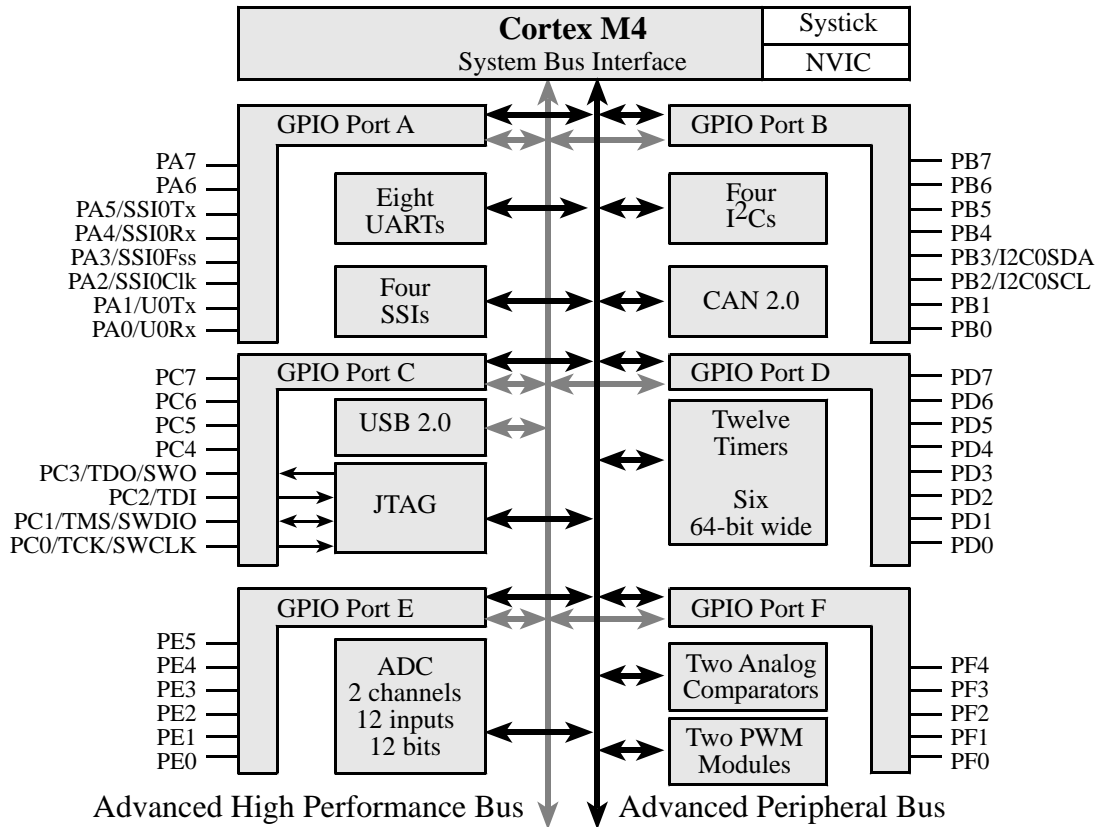


EE445L Laboratory Manual

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In Case of Emergency Dial 911

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This laboratory assignment accompanies the book, Embedded Systems: Real-Time Interfacing to ARM Cortex M Microcontrollers, ISBN-13: 978-1463590154, by Jonathan W. Valvano, copyright © 2015.

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Parts you may need on long term checkout from the lab checkout

- 3 – Bypass capacitors (any value 0.01 to 0.22uF)
- 3 – Switches that plug into a protoboard,
- 1 – 32-ohm speaker or similar (Labs 3, 5)
- 1 – PN2222 (Lab 3)
- 1 – TIP120 NPN Darlington motor driver (Lab 10)
- 1 – 1N914 snubber diode (Lab 10)
- 1 – DC motor with tachometer (4-wire, 5V) (Lab 10)
- 1 – 30k, 50k, or 100k NTC thermistor (Lab 9)

I. Introduction to EE445L Laboratory

I.1. Grading Policies (Labs 7, 8, 11 have different grading policies)

Groups will consist of exactly two students. Lab partners have separate checkout grades⁺, but share the preparation^{*}, report^{*}, software quality^{*}, and late penalty grades^{*}. For each lab assignment, there are a number of preparation tasks that must be completed before the laboratory period. The following activities occur in this order at the beginning of lab, you turn in your preparation, the TA will give a short lab lecture, the TA will check your preparation, and if possible the TA will return the preparation to you.

<u>Responsibility</u>	<u>grade</u>
Attendance Attendance is an important part of EE445L. All students must attend all lab sections.	5 ⁺
Preparation Preparation, is a submission on Canvas, includes your software, which is due at the start of lab. The software should be typed into the computer and compiled with no syntax errors. Preparation does not usually involve running and debugging, but it should not be handwritten. Preparation also includes hardware circuit diagrams, which are also due at the start of lab. Handwritten diagrams are acceptable for the prep, but diagrams in the report must be generated using a CAD package. Hardware diagrams include chip numbers, pin numbers, resistor/capacitor types and tolerances, connections to computer. You are responsible for the procurement of all necessary parts before lab starts. As part of the preparation, hardware circuits but not necessarily built or debugged. See specific instructions for each lab.	15 [*]
Software Quality (see the section on software style guidelines later on in the lab manual) Documentation, comments, choice of good variable and function names Proper style, organization, modular structure, ease of understanding	20 [*]
Report (10) Final hardware circuit diagrams (must be generated using a CAD program) (15) Results, performance/data graphs (handwritten/scanned drawings are OK) Reports will be due 11:59pm of the assigned day, submitted as a pdf.	25 [*]

Checkout, demonstration to TA

Performance, correctness of the program function	20*
Interface to the human operator, menus, error messages	
Oral understanding of engineering tradeoffs	15+
Both students must be present, together, during checkout	

Penalty 2 points per day, up to two days, for late checkout

No late checkout after two days

Late Report

-5/day*

100+

Total

If a TA other than yours checks out your lab, please email your TA specifying the time, date, lab number and the other TA's name. Also, please follow up with both TAs to make sure you got credit for the lab. Please include the following information at the beginning of each of your software files:

- 1) **Students' names**
- 2) **TA name**
- 3) **Date of last change**
- 4) **Lab assignment number**
- 5) **Purpose of the software module**
- 6) **Hardware configuration**

I.2. SAFETY REGULATIONS:*IN CASE OF EMERGENCY DIAL 911 or 512-471-4441*

Since there will be times when students will work other than the regularly scheduled lab sections, it is necessary that certain regulations be observed for the convenience and safety of all. Since the possibility of lethal shock exists in those circuits utilizing low potentials, the following should always be observed:

1. Working alone in a lab room is not permitted.
2. Working after regular hours without written permission is not permitted.
3. Work benches must be clear of all coats, knapsacks and extraneous materials. Coat racks are desired for those desiring this convenience. Otherwise all materials must be stored under the work area or out of the way.
4. Shoes must be worn in the lab at all times. Shoes represent a significant protection against electrical shock.
5. Smoking, food and beverages (e.g., coffee) are not permitted anywhere in the lab area.

IN CASE OF INJURY OR SHOCK:

Turn off power, do not move the injured. Start artificial respiration if breathing has stopped. Have someone else call 911 or 512-471-4441 if CPR is needed.

IN CASE OF FIRE:

Turn off the power, call 911 or 512-471-4441, fight fire with available extinguisher, have someone clear the building.

I.3. LAB PROCEDURES AND POLICIES

FIRST LAB: There are no labs during the week that classes begin. Go to the regularly scheduled lab the week following the week classes begin. During this time, you will be introduced to the lab equipment. You will also be instructed on lab procedures and grading policy. If you missed your regularly scheduled lab, attend one of the other lab periods. Note that attending a lab session for which you are not registered is not permitted except during the first week of classes.

LAB PARTNERS: Every student is required to have a lab partner. You will perform all labs with a partner. Students choose their own lab partners during the first week.

LAB EQUIPMENT USAGE: Lab hours are posted in the laboratory. There are no sign-up sheets, but cooperation is expected. If you start debugging on a station, you may stay as long as you like, with three exceptions:

- You must leave when the second floor labs are closed for the day;
- You must leave during the first half-hour of the other regularly scheduled lab periods;

You may not leave the station unattended for more than 15 minutes.

If you would like to use a station that has been left unattended for more than 15 minutes:

- 1) Carefully disconnect the hardware and eject any USB disks;
- 2) Do not save any software files;
- 3) Return all materials (hardware, disks, paper) to the front desk;
- 4) Leave a note on the station with your name and time;
- 5) Write a note to the TA describing exact times listing what you turned in.

LAB LECTURE: The purpose of the lab lecture is to provide necessary information to complete the lab. The scope of the lectures will be material relevant to the lab. The lecture will be conducted during the first 15 minutes of each lab session.

LAB PREPARATION: Lab preparation must be performed prior to the regularly scheduled lab period. All software must be written, edited and designed before coming to the lab. Hardware must be designed down to the pin numbers. Label all resistance and capacitance values and types. For example, 1k Ω 5% carbon, or 0.01 μ F 5% ceramic. In this way, the lab period may be spent in debugging your system with the TA's help. The preparation is due at the start of the lab. Preparation includes gathering all the physical components required to perform the lab.

LAB REPORT: Each lab report is bound separately. There is a **Deliverables** section that details the specific components required for that lab report. The lab report typically includes the following items:

- A) Objectives (1/2 page maximum)
- B) Hardware Design. Detailed hardware designs with pin numbers.
Generated using a CAD program like **PCB Artist**
Include all external devices used (chips, R's C's values and types)
Show connections to the microcontroller board.
- C) Software Design (no software printout in the report)
Draw figures illustrating the major data structures used,
A call-graph illustrating the modularity of the software components
Draw data-flow graph showing how data is processed
- D) Measurement Data
Whenever appropriate, enter data into MatLab or Excel, or take photographs of the screen. Include graphs and figures as specified in the assignment.
- E) Analysis and Discussion (answers to specific questions given in the assignment)

CHECKOUT: A rough draft of your hardware diagrams and your source code listings must be given to the TA before you demonstrate. If your experiment works, you will be assigned a good score on the performance part. The TA will ask the partners oral questions that test your "understanding" of the computer engineering concepts of the lab. The partners will answer separate questions and receive separate "understanding" grades. You must get your rough draft software listings signed and dated by a TA to prove that the lab was completed in a satisfactory manner. Late checkouts will result in lost points. **Your software files will be copied onto the TA's web space during checkout.**

I.5. Web sites

Electronic parts	http://www.jameco.com/
Electronic parts	http://www.digikey.com/
Electronic parts	http://www.mouser.com/
Surplus parts	http://www.bgmicro.com
Surplus parts	http://www.allelectronics.com
Sensors	http://www.sparkfun.com
robot parts	http://www.robotstore.com/
robot sensors	http://www.parallax.com/
robot parts	http://www.towerhobbies.com/
enclosures	http://www.pactecenclosures.com/

I.6. Legal Stuff

The opinions expressed in these notes do not necessarily reflect the opinions of the University, its management or its big time financial donors. Also, there shall be no bologna, Bevis, mustard, chewing the cables, free lunch, sob stories, running & screaming, whining, hitting, spitting, kicking, biting, or tag backs. Quit it or we're telling. (Enjoy the course.)

IO	Ain	0	1	2	3	4	5	6	7	8	9	14
PA0		Port	U0Rx							CANIRx		
PA1		Port	U0Tx							CANITx		
PA2		Port		SSI0Clk								
PA3		Port		SSI0Fss								
PA4		Port		SSI0Rx								
PA5		Port		SSI0Tx								
PA6		Port			I ₂ C1SCL		M1PWM2					
PA7		Port			I ₂ C1SDA		M1PWM3					
PB0	USB0ID	Port	UIRx						T2CCP0			
PB1	USB0VBUS	Port	UITx						T2CCP1			
PB2		Port			I ₂ C0SCL				T3CCP0			
PB3		Port			I ₂ C0SDA				T3CCP1			
PB4	Ain10	Port		SSI2Clk		M0PWM2			T1CCP0	CAN0Rx		
PB5	Ain11	Port		SSI2Fss		M0PWM3			T1CCP1	CAN0Tx		
PB6		Port		SSI2Rx		M0PWM0			T0CCP0			
PB7		Port		SSI2Tx		M0PWM1			T0CCP1			
PC4	C1-	Port	U4Rx	U1Rx		M0PWM6		IDX1	WT0CCP0	U1RTS		
PC5	C1+	Port	U4Tx	U1Tx		M0PWM7		PhA1	WT0CCP1	U1CTS		
PC6	C0+	Port	U3Rx					PhB1	WT1CCP0	USB0epen		
PC7	C0-	Port	U3Tx						WT1CCP1	USB0pflt		
PD0	Ain7	Port	SSI3Clk	SSI1Clk	I ₂ C3SCL	M0PWM6	M1PWM0		WT2CCP0			
PD1	Ain6	Port	SSI3Fss	SSI1Fss	I ₂ C3SDA	M0PWM7	M1PWM1		WT2CCP1			
PD2	Ain5	Port	SSI3Rx	SSI1Rx		M0Fault0			WT3CCP0	USB0epen		
PD3	Ain4	Port	SSI3Tx	SSI1Tx				IDX0	WT3CCP1	USB0pflt		
PD4	USB0DM	Port	U6Rx						WT4CCP0			
PD5	USB0DP	Port	U6Tx						WT4CCP1			
PD6		Port	U2Rx			M0Fault0		PhA0	WT5CCP0			
PD7		Port	U2Tx					PhB0	WT5CCP1	NMI		
PE0	Ain3	Port	U7Rx									
PE1	Ain2	Port	U7Tx									
PE2	Ain1	Port										
PE3	Ain0	Port										
PE4	Ain9	Port	U5Rx		I ₂ C2SCL	M0PWM4	M1PWM2			CAN0Rx		
PE5	Ain8	Port	U5Tx		I ₂ C2SDA	M0PWM5	M1PWM3			CAN0Tx		
PF0		Port	U1RTS	SSI1Rx	CAN0Rx		M1PWM4	PhA0	T0CCP0	NMI	C0o	
PF1		Port	U1CTS	SSI1Tx			M1PWM5	PhB0	T0CCP1		C1o	TRD1
PF2		Port		SSI1Clk		M0Fault0	M1PWM6		T1CCP0			TRD0
PF3		Port		SSI1Fss	CAN0Tx		M1PWM7		T1CCP1			TRCLK
PF4		Port					M1Fault0	IDX0	T2CCP0	USB0epen		

Table 2.7. PMCx bits in the GPIO_PORTx_PCTL_R register on the TM4C specify alternate functions. *PB1*, *PB0*, *PD4* and *PD5* are hardwired to the USB device. *PA0* and *PA1* are hardwired to the serial port. PWM is not available on LM4F120.