EE319K Introduction to Embedded Systems EE319K will continue the bottom-up educational approach, started in BME303 and EE306. The overall educational objective is to allow students to discover how the computer interacts with its environment. It will provide hands-on experiences of how an embedded system could be used to solve EE problems. The focus will be understanding and analysis rather than design. The analog to digital converter (ADC) and digital to analog converter (DAC) are the chosen mechanism to bridge the CE and EE worlds. EE concepts include Ohms Law, LED voltage/current, resistance measurement, and stepper motor control. CE concepts include I/O device drivers, debugging, stacks, FIFO queues, local variables and interrupts. You may use, edit, run or distribute these files as long as the copyright notices within the files remain. No specific warranty exists concerning the accuracy or reliability of these examples. I think they work, but history has shown, sometimes I can be wrong.

Syllabus for EE319K Introduction to Microcontrollers

EE319K E-Book : Has reading material, interactive tools and instructor videos UT.6.01x Embedded Systems - Shape The World

Send comments to: Jonathan W. Valvano Go to **Lab Material** **Lecture examples** **Old Exams** **Data sheets** **Home Page** **Pictures of TAs**
Embedded Systems: Introduction to ARM Cortex-M Microcontrollers (Volume 1), ISBN: 978-1477508992 Available from Amazon Available from CreateSpace
To download all LM3S1968 software ValvanoWare_1968.zip (For use with LM3S1968)
To download all TM4C123/LM4F123 software **EE319K_ware.exe** (EE319K Spring 2014, includes DLLs which will automatically install)

Keil Debugger Issue: Keil real-board debugger used to work, now it quits immediately **Window8KeilDebuggerFix.htm**

Lectures (we are having trouble with the website, if you cannot see a file because of permissions, try clearing cookies), Spring 2014 lectures will be posted as we create them.
PowerPoint lectures written by Professors Ramesh Yerraballi, Andreas Gerstlauer, Bill Bard, and Jonathan Valvano

Lec1.ppt WS_01.doc	Introduction, microcontroller, binary, digital logic, Ohm's Law TM4C123, Flowcharts, Design Cycle TM4C123, embedded systems, Thumb-2
Lec2.ppt WS_02.doc NOTGate-asm.zip Rand100_4F120asm.zip	Data flow graphs, call graphs, numbers Debugging, design of a microcontroller-based NOT gate Fixed-point, condition codes, errors, dropout, overflow, truncation, roundoff
Lec3.ppt WS_03.doc	Assembly syntax Functions, logic operations Parallel I/O Switches and LED interfaces
Lec4.ppt WS_04.doc NOTGate-C.zip Primes.zip	I/O Abstraction, software design, branches Carry and overflow bits
Lec5.ppt WS_05.doc ParamPassingASM.zip ParameterPassing_4F120.zip FunctionalDebugging.zip	Functions, ARM Architecture Procedure Call Standard (AAPCS), parameter passing, call by value, call by reference, arrays, indexing, functional debugging Code for parameter passing examples from the slides, book and more Parameter passing example (in C) Functional debugging code from slides
Lec6.ppt WS_06.doc	SysTick, and review for Exam1
Lec7.ppt WS_07.doc	PLL, Array access, Abstraction, finite state machines, linked structures, introduction to I/O synchronization
Lec8.ppt WS_08.doc ModularProgramming.zip	I/O synchronization, Thread synchronization, fundamentals of interrupts, Periodic interrupts with SysTick, DAC, sound generation. Modular programming in C
Lec9.ppt WS_09.doc LocalVariablesASM.zip	Local variables, LCD interface, blind cycle, fixed-point
Lec10.ppt WS_10.doc	ADC fundamentals, Nyquist Theorem ADC Programming
Lec11.ppt WS_11.doc	Fixed-point, Data acquisition system, Lab 8
Lec12.ppt WS_12.doc	FIFO Queues UART

Lec13.ppt WS_13.doc Lec13_UART.zip	2-D array, structures, Timer2A periodic interrupt, Kentec display, sounds Project illustrating the use of struct
~~Lec14.ppt~~	~~Floating Point (floating point will not be on the final exam)~~ ~~Security (security will not be on the final exam)~~
Lec15.ppt	Review

Starter files http://users.ece.utexas.edu/~valvano/arm/

Lab/homework materials (**to do ** or **old** means not done yet)

Link to download	Type	Description
EE319K_LabManualSp14.pdf EE319K_LabManualF13.pdf	pdf	Spring 2014 Lab manual (new 1/26) Fall 2013 Lab manual
Lab 1 grading sheet Lab 2 grading sheet Lab 3 grading sheet Lab 4 grading sheet Lab 5 grading sheet Lab 6 grading sheet Lab 7 grading sheet Lab 8 grading sheet old Lab 9 grading sheet old Lab 10 grading sheet old(certification)	pdf	Grading sheets If you are using PD0 or PD1 remove R9 and R10 from board
EE319Kkit.txt	text	List of components in the baggy each EE319K student receives
LabDemo SimpleProject_4F120asm.zip InputOutput_4F120asm.zip LaunchPadDLL.dll (new 9/12) Squarewaves_4F120asm.zip	pdf of instructions Random Num Switch in, LED output DLL to simulate Port F Toggles two Port F pins	Details of the first and second EE319K lab demonstrations
EE319KLab1.dll	Keil uVision project Lab 1 graders	Use this project to perform Lab 1. Put DLL in your Keil\ARM\BIN folder
EE319KLab2.dll	Keil uVision project	Use this project to perform Lab 2. It configures the logic analyzer within the simulator
EE319KLab3.dll	Keil uVision project	Use this project to perform Lab 3. It configures the logic analyzer within the simulator
EE319KLab4.dll	Keil uVision project	Use this project to perform Lab 4. It configures the grader within the simulator. You must export the symbols DataBuffer, TimeBuffer, DataPt, and TimePt for the grader to work
EE319KLab5.dll	Keil uVision project	Use this project to perform Lab 5. It configures the grader within the simulator. Eventually there will be a grader. If you wish to simulate Lab 5 you can set the debugger parameters to DLM.DLL -pLM3S3748 and remove the PLL code (it runs at 16 MHz), or use the settings DCM.DLL -pCM4 -dEE319KLab5. Alpha version has no grader. The EE319K lab grades are determined by the TA during checkout and not really a function of the score provided by the autograder.
EE319KLab6.dll	Keil uVision project	Use this project to perform Lab 6. Notice that this project has the main program in Lab6.c and four submodules. Each module has a header file (prototypes of public functions) and a code file (implementations in C). If you wish to simulate Lab 6 you can set the debugger parameters to DLM.DLL -pLM3S3748 and remove the PLL code (it runs at 16 MHz), or use the settings DCM.DLL -pCM4 -dEE319KLab6. Alpha version has no grader. The EE319K lab grades are determined by the TA during checkout and not really a function of the score provided by the autograder.
Lab 7 will not have a grader	Keil uVision project	Use this project to perform Lab 7. Low level graphics interface. The Nokia project is for Lab 7B
Lab 8 will not have a grader Slide pot data sheet		Uses the ADC to measure distance. You may use either display. Copy your LCD.s and print.s files from Lab 7 into this project.

Lab 9 starter will be your Lab 8 Lab 9 will not have a grader		Connected to microcontrollers such that data collected on one system are displayed on the other
Lab 10 will not have a grader YouTube video of superfinals Lab15_SpaceInvaders.zip (for the Nokia 5110)	Keil uVision project, BMP, JPG, WAV, XLSX, TXT, C	Use this project to perform Lab 10. Hand-held, arcade-style game. Runs on LM4F120/TM4C123 with Kentec display. Sights and sounds to build the game. There are three potential games to choose from: Connect Four, Space Invaders, and Pipe Dream
Porting_Project.pdf	pdf	Directions on how to port one uVision project into another
EE319K_LM3S1968_Artist.sch EE319K_TM4C123_artist.sch	PCB Artist Drawing file	This starter file has the LM3S1968 or the TM4C123/LM4F120 and all the external parts that we will be using in EE319K. You can get this free program at http://www.4pcb.com/ but be careful because downloading attempts to add junk (say no to all special offers like buzzdock, aspca, etc.)
Lab 10 video from Fall 2012 Lab10: WavConv.m (Matlab/Octave script to convert wav files into C declaration with 4-bit sound	YouTube video; Matlab/Ocatve script	To learn more about Game Engine design look at Chapter 15 of the E-book

LM4F120/TM4C123 Reference material

Keil uVision instructions for download and setup version 4.73 (do not install version 5)
How to install EE319K/EE445L/EE345M software on a Macintosh
CortexM_InstructionSet.pdf Assembly instruction set
CortexM4_TRM_r0p1.pdf Technical Reference Manual Cortex M4, Assembly instruction set
QuickReferenceCard.pdf ARM® and Thumb-2 Instruction Set Quick Reference Card
CreatingProject.pdf uVision4 instructions
tm4c123gh6pm.pdf Data sheet of microcontroller
tm4c123gh6pmErrata.pdf Known bugs of microcontroller
TM4C123_LaunchPadUsersManual.pdf Board information
lm4f120.s lm4f120h5qr.h Assembly/C files will all the port addresses for the microcontroller.
tm4c123gh6pm.s tm4c123gh6pm.h Assembly/C files will all the port addresses for the microcontroller.

LM3S1968 Reference material

LM3S1968.pdf Data sheet
LM3S1968errata.pdf Known bugs
LM3S1968kit.pdf Evaluation kit, circuit diagram
lm3s1968.s This assembly file contain all the port addresses for the microcontroller.
SystemDesignGuidelines.pdf How to design embedded systems
LM3S1968pins.pdf Piece of paper between board and protoboard (print at 100%)
LM3S1968soldering.pdf How to solder pins on the kit
RiT_OLED_P1420_revision2.pdf OLED data sheet
Ifyoumessuptheboard.pdf How to reflash chip

Homework assignments (one page printouts turned in to TA at the start of class)

HW0.doc HW0.pdf Definitions and numbers, due in the lfirst class during the week of 9/2
HW1.doc HW1.pdf Circuits, Simple Assembly, due in the firstt class during the week of 2/3
HW2.doc HW2.pdf Assembly programming, Switch/LED interface, due in the first class during the week of 2/10
HW3.doc HW3.pdf Introduction to C, logical operations, due in the **first** class during the week of 2/17
HW4.doc HW4.pdf Old Exam 1 practice, Zyante Chapter 3,4, due on 2/20 at exam1 time.
HW5.doc HW5.pdf HW5_Exercise5_1.zip HW5_Exercise5_2.zip HW5_Assignment5_2.zip Zyante Chapters 4 and 5, due in the first class during the week of 3/3
HW6.doc HW6.pdf HW6_Assignment6_2.zip Zyante Chapters 5 and 6, Arrays, indexing, functional debugging, due **Wednesday/Thursday 3/19-20**
HW7.doc HW7.pdf Two easy practice Exam2s, due in the class **Wednesday/Thursday 3/26-27**
HW8.doc HW8.pdf Two harder practice Exam2s: Mode and BCD, due **Thursday 4/3 at the time of the exam**
HW9.doc HW9.pdf Zyante functions and pointers, due Monday/Tuesday 4/14-15
HW10.doc HW10.pdf Zyante structs and E-Book Game Desgin due Wednesday/Thursday 4/23-24
HW-Extra.doc HW-Extra.pdf *This is an optional homework that can be used to replace any missed homeworj and is due* Monday/Tuesday 4/21-22

Old Exams (old 9S12 exams)

Quiz1ASp11FunSize.pdf old Valvano exam converted to TM4C123
Quiz1ASp12FunSize.pdf old Valvano exam converted to TM4C123
Quiz1AF12.pdf Quiz1AF12sol.pdf This is Valvano exam
Exam1Practice1.pdf Exam1Practice1Sol.pdf This is Yerraballi exam to be presented Monday 9/30/2013 7:30pm by Saugata and Chinmaya
Exam1Practice2.pdf (I don't have solution to this one) This is Yerraballi exam to be presented Tuesday 9/30/2013 7:00pm
Exam1Practice3.pdf Exam1Practice3Sol.pdf This is a Gerstlauer exam
Exam1F13asol.pdf Exam1F13bsol.pdf Solutions to Fall 2013 exams

Exam2_Sum.zip Easy practice Exam2 involving strings and addition (HW7)
Exam2_Quad.zip Easy practice Exam2 involving arrays and multiplication (HW7)
Exam2_Mode.zip Hard practice Exam 2 involving strings and pointers (HW8) (60 min)
Exam2_Moore.zip Hard practice Exam 2 involving Port initialization and a Moore FSM (HW8) (60 min)
StringCompare.zip Easy practice Exam 2 involving ASCII strings
Exam2_Merge.zip Hard practice Exam 2 involving ASCII strings
Exam2_Sum32.zip Easy practice Exam 2 involving 32-bit numbers and overflow (35min)
Exam2thoughts.pdf Study guide for Exam 2
Exam2C_CalculusSpring2013.zip Practice Exam shown in class Monday and Tuesday
FinalSp12_1968.pdf Final exam from Spring 2012 converted to LM3S1968
FinalF12a.pdf FinalF12aSol.pdf Final exam Fall 2012
FinalSp13a.pdf FinalSp13aSol.pdf FinalS13.pdf S13Final.pdf Final exam Spring 2013
FinalF13.pdf FinalF13Sol.pdf Final exam Fall 2013
ReferenceMaterialForFinalF13.pdf Reference material for Fall 2013 final , Wed, Dec 11, 7-10pm, location: JGB 2.324

Major changes for spring 2014 EE319K

Code repository, such as SVN, starting with Lab 4
Implement both receiver and transmitter in Lab 9
More labs will have an autograding engine, put custom DLLs in the Keil\ARM\BIN folder

Last updated February 27, 2014 **Send comments to: Jonathan W. Valvano .**