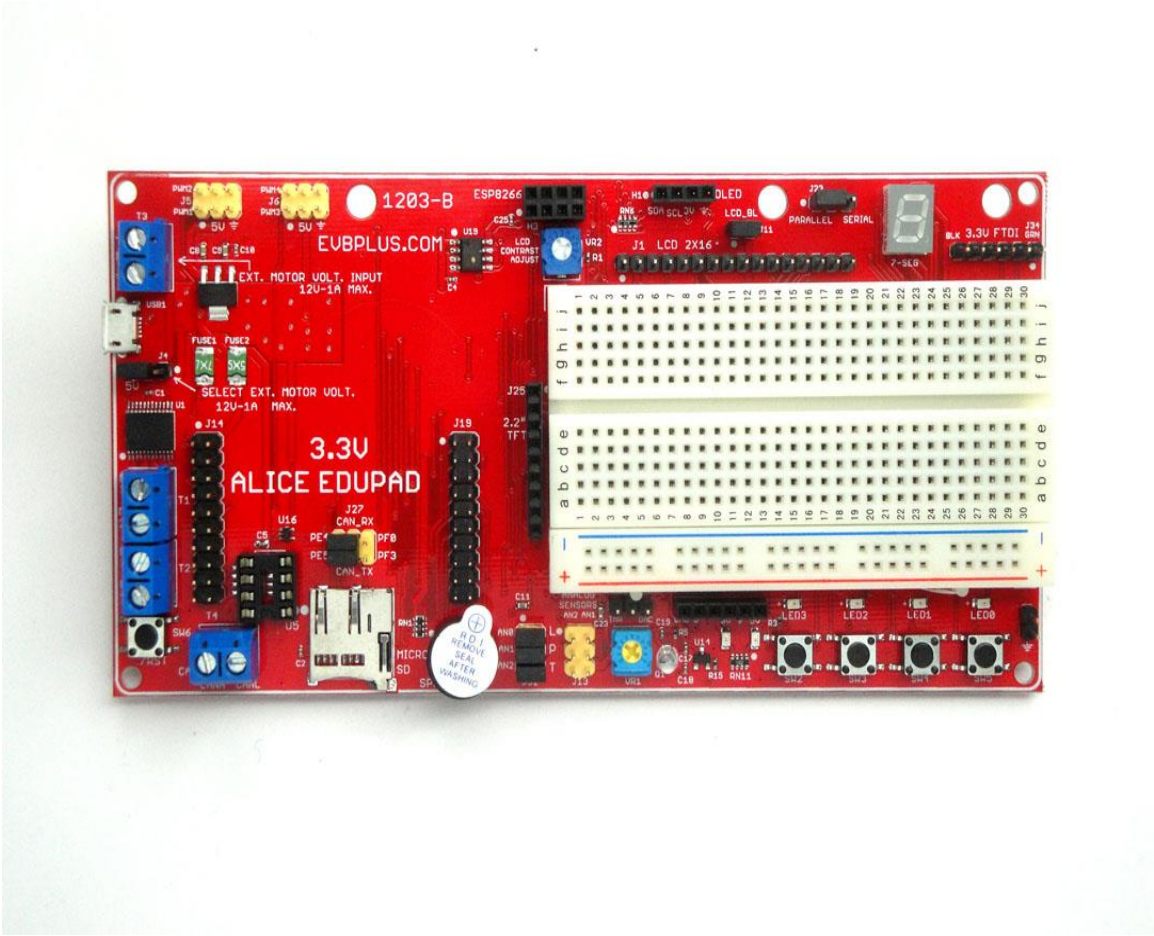
Alice EduPad for Tiva or MSP432 TI ARM Launchpad

User's Guide

Version 1.02 08/23/2017



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Chapter 1. Overview

1.1 Welcome

Thank you very much for purchasing our Alice EduPad trainer for the Tiva or MSP432 Launchpad. The Alice EduPad trainer is a low-cost, feature-packed universal training board for the Tiva TM4C123G or MSP432 TI ARM Launchpads. It incorporates onboard peripherals that will make this board an ideal trainer for EE and ECE courses in universities around the world.

For engineers, it is a convenient prototype system suitable for designers who want to rapidly develop and prototype ARM controller applications. For students, it not only can be used as a general trainer for freshman and sophomore but also as a versatile platform for senior projects as well. The features of the Alice EduPad trainer create a new potential for students at every level.

Please note that the Tiva or MSP432 Launchpad and USB cable are not included with your purchase of the Alice EduPad trainer.

The micro USB cable comes with your Launchpad purchase from TI on line store. https://store.ti.com/Tiva-C-LaunchPad.aspx It sells for $12.99. They usually have it in stock. Other distributors, like Mouser and Digi-key, all have it, but the price may be a little higher.

The external power supply is not needed for your normal use, it's only needed when in standalone operation without a PC. The DC jack uses a Micro USB connector. Most of the smart phone chargers except iPhone have a 5V output with a micro USB connector, they can be used as the external power supply.

Warning:
The Tiva and MSP432 Launchpads don't have a built-in reverse-polarity-protection diode. If you are going to experience H-Bridge with an external high voltage motor (>5V), please make sure that the high voltage (>5V) cannot be touched the 5V supply, or it may damage the USB port of your laptop, or even your whole laptop.

1.2 Tiva and MSP432 Launchpad features:

The Tiva Launchpad is a low cost evaluation platform for ARM Cortex-M4F microcontrollers made by TI. It has many features. The main features of the Tiva Launchpad are listed below:

- Powerful 32-bit TM4C123GH6PM microcontroller
- 256K bytes of flash memory
- 32K bytes of RAM
- 80 MHz system clock
- On board in-circuit debugger
- USB on-the-go
- Motor control PWM
- RGB LED
- Two user switches
- TivaWare software libraries
- Standard Booster Pack interface

TI MSP432 ARM Launchpad features:

The TI MSP432 Launchpad is a low cost evaluation platform for ARM Cortex-M4F microcontrollers made by TI. It has many features, the main features of the TI MSP432 Launchpad are listed below:

- Low-power, high performance MSP432P401R MCU
  48MHz 32-bit ARM Cortex M4F with Floating Point Unit and DSP acceleration
  Power consumption: 80uA/MHz active and 660nA RTC standby operation
  Analog: 24Ch 14-bit differential 1MSPS SAR ADC, Two Comparators
  Digital: Advanced Encryption (AES256) Accelerator, CRC, DMA, HW MPY32
  Memory: 256KB Flash, 64KB RAM
  Timers: 4 x16-bit, and 2 x 32-bit
  Communication: Up to 4 I2C, 8 SPI, 4 UART
- 40 pin BoosterPack Connector, and support for 20 pin BoosterPacks
- Onboard XDS-110ET emulator featuring EnergyTrace+ Technology
- 2 buttons and 2 LEDs for User Interaction
- Back-channel UART via USB to PC

1.3 Alice EduPad hardware features:

The Alice EduPad board includes the following features for teaching ARM courses:

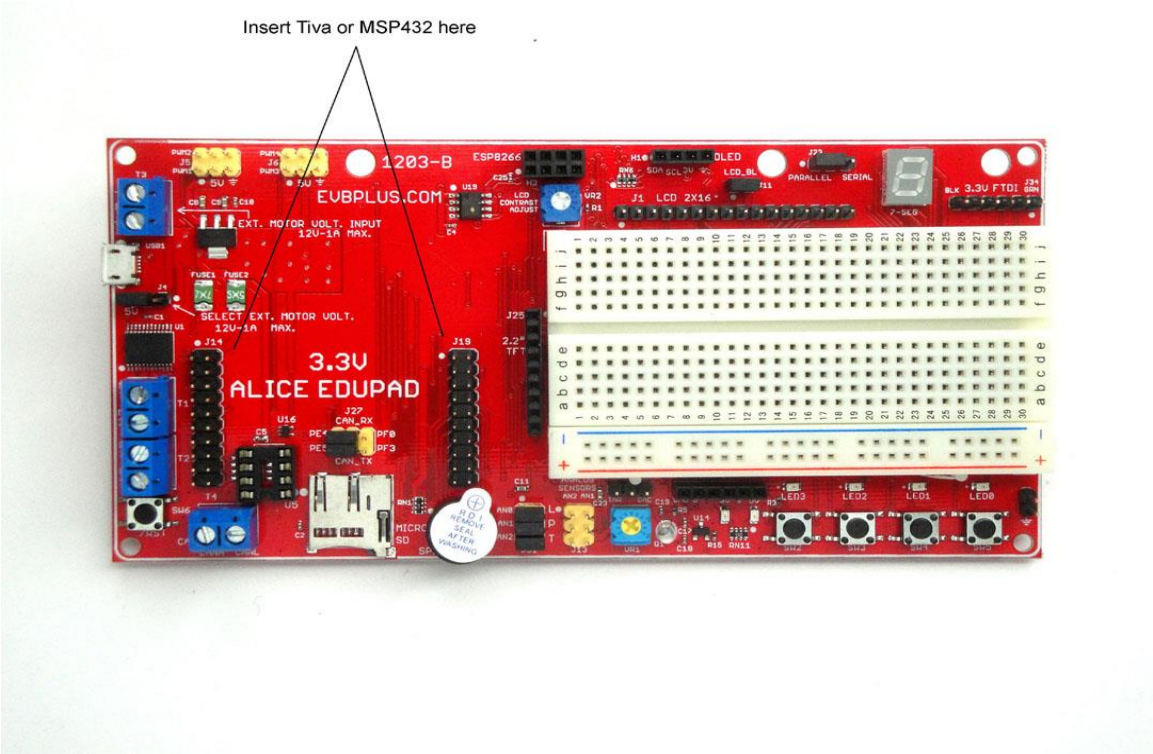
1. Four user LEDs
2. Four pushbutton switches
3. Four Servo controls or relay outputs
4. Speaker.
5. 7-segment display
6. 16x2 LCD header, 4-bit parallel or serial interface
7. 0.96”, 128x64 OLED header
8. 2.2” TFT QVGA display header
9. ESP8266 WiFi applications
10. Light sensor
11. Temperature sensor
12. Potentiometer for analog input
13. 12-bit DAC
14. Dual H-Bridge for controlling 2 DC motors or one stepper motor
15. Two analog sensor inputs
16. MicroSD memory card slot
17. Solderless breadboard included
18. PC board size is 6.25" X 3.1”

Chapter 2. Software development

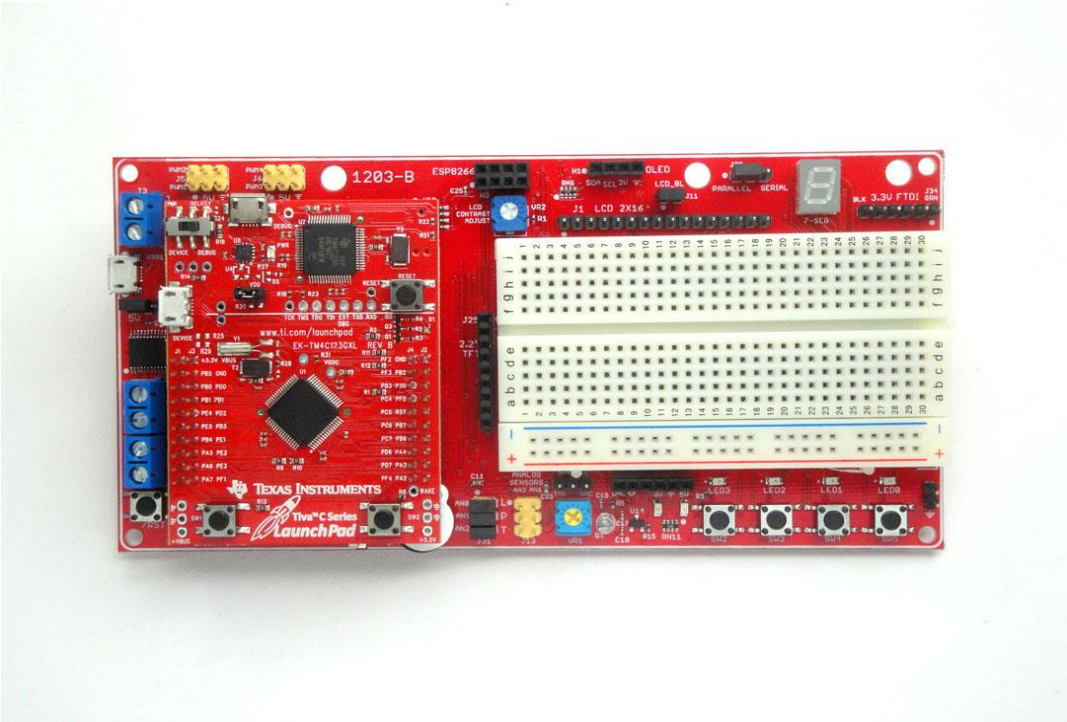
It is recommended that you become familiar with the software development tools for Tiva Launchpad before working with the Alice EduPad.
So the software development on the Alice EduPad is a two-step process.
1, Work on the Tiva Launchpad standalone and familiarize with its software development. Don't plug the Tiva Launchpad onto the Alice EduPad until you feel comfortable writing a small test program because it's easier to test a small program on the Tiva Launchpad standalone.

TI supplies an application to program the Tiva Launchpad. It is called LM Flash Programmer. The instructions to program the Tiva Launchpad are listed on the Tiva Launchpad user's guide.
http://www.ti.com/lit/ug/spmu296/spmu296.pdf page 14. But you need a toolchain to create an image for the flash programmer.

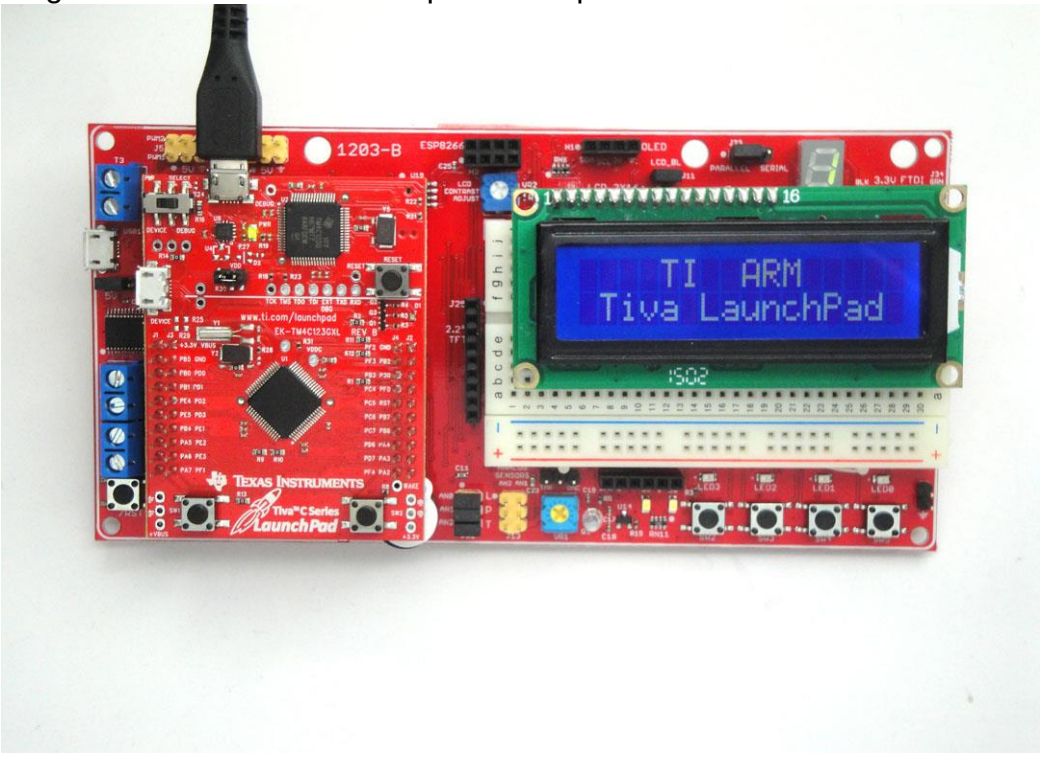
2. Insert the Tiva or MSP432 Launchpad into the Alice EduPad's J14 and J19.



The Tiva on the Alice EduPad



Plug in a USB cable from the top to develop code



TI listed three major IDE's for Tiva software development:

- Keil MDK-ARM
- IAR Embedded Workbench
- Code Composer Studio

Since Keil was acquired by ARM, for an EE or an ECE course, the Keil seems to be more popular.

Professor Mazidi and Professor Chen have chosen the Keil IDE and wrote a textbook for the Tiva Launchpad. Professor Mazidi is a highly regarded author of many textbooks for embedded systems, and Professor Chen is an ARM controller software expert who wrote and tested all C and Energia sample programs for the Alice EduBase and the Alice EduPad. We are very grateful for their hard work.

You can purchase their books at Amazon.
https://www.amazon.com/Tiva-ARM-Programming-Embedded-Systems/dp/0997925922/ref=sr_1_6?ie=UTF8&qid=1503622303

https://www.amazon.com/MSP432-Programming-Embedded-Systems-books/dp/0997925914/ref=sr_1_2?s=books&ie=UTF8&qid=1474025605&sr=1-2&keywords=MSP432+ARM+Book+Mazidi+and+Naimi

Sample programs are available at Professor Mazidi's web site:

http://www.microdigitaled.com/EduPad/EduPad.htm

Chapter 3. On-line resources

Tiva Launchpad user's guide including schematic:
http://www.ti.com/lit/ug/spmu296/spmu296.pdf

How to download and install Keil and How to Create a C Project in Keil and sample programs:
http://www.microdigitaled.com/ARM/TI_ARM_books.htm
This book can be used with Alice EduPad.

Getting started with Tiva Launchpad:
http://processors.wiki.ti.com/index.php/Getting_Started_with_the_TIVA%E2%84%A2_C_Series_TM4C123G_LaunchPad

Tiva Launchpad workshop workbook:
http://software-dl.ti.com/trainingTTO/trainingTTO_public_sw/GSW-TM4C123G-LaunchPad/TM4C123G_LaunchPad_Workshop_Workbook.pdf

If you have any technical questions regarding the Tiva Launchpad, you can post a message at The Tiva forum. Many TI engineers are active on the forum to answer your question.
http://e2e.ti.com/support/microcontrollers/tiva_arm/default.aspx

If you have any question regarding the Alice EduPad hardware and need a tech support call us at 1-630 283-0321 or email your question to evbplus @ gmail.com

Chapter 4: Hardware Descriptions

The circuit is designed in such way that the value of all resistors and capacitors are not critical.

4.1 LEDs:

Each pin of the PB0-PB3 is connected to an LED. In order to turn on an LED, you need to program the corresponding port B pin as output and set it high.

4.2 Push button switches:

The PD0-PD3 are connected to the 4 push buttons.

4.3 Light sensor (AN0)

The light sensor (a TEMP4452 or equivalent) is connected to the PE1 (AIN2) of the ADC port.

4.4 Potentiometer (AN1)

The 5K potentiometer VR2 is connected to the PE2 (AIN1) of the ADC port

4.5 Temperature sensor (AN2)

The temperature sensor (LM45 or equivalent) is connected to the PE5 (AIN8) of the ADC port

4.6 Speaker

The speaker is a 5V audio magnetic transducer and it's driven by the PC4 by a timer or software or by the DAC output from U17 (MCP4725). The signal source of the speaker is selected by jumper J24.

4.7 Serial EEPROM

A small serial EEPROM (24LC02) is provided for experimenting with I2C communication.

4.8 UART communication

When PB0 and PB1 are not used for the Lab assignment #1 (see above paragraph #4.1 and #4.2) or not used for driving the onboard H-Bridge, they can be used as a UART.

The UART can be used by user's application programs. It supports direct 3.3V digital signal interface with other boards, or use a USB to a 3.3V serial adapter (FTDI cable) for interfacing with a PC.

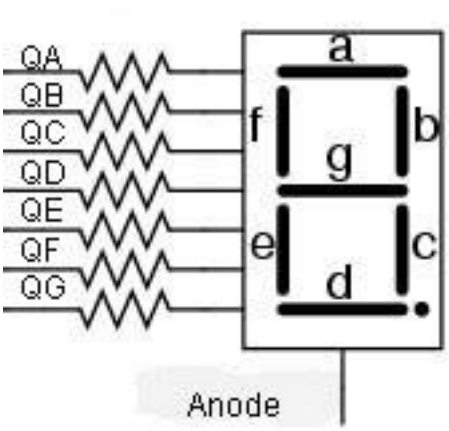
4.9 7-Segment LED display

The type of the 7-segment LED display on the Alice EduPad is called common anode, all cathodes are driven individually by an output pin and the anode is connected to the 5V supply.

Before sending a number to a 7-segment LED display, the number must be converted to its corresponding 7-segment code depending on how the 7-segment display is connected to an output port.

Because there are not enough I/O pins available, the Alice EduPad incorporates an HCT595 shift register to drive the cathodes. When a cathode is low, the corresponding LED segment lights up.

By convention, the 7segments are called segment A, B, C, D, E, F and G. Their locations in the



display are shown below:

The segment A, B, C, D, E, F, G and Decimal Point are driven by QA, QB, QC, QD, QE, QF, QG, and QH, respectively. The hex value of the segment code is shown in the following table:

Number	DP	G	F	E	D	C	B	A	Hex Value
1	0	0	0	0	0	1	1	0	0x06
2	0	1	0	1	1	0	1	1	0x5B
3	0	1	0	0	1	1	1	1	0x4F
4	0	1	1	0	0	1	1	0	0x66

The above table only lists #1 to #4, it's not difficult to figure out the other numbers once you know how #1 to #4 are created. To display the number 1 on the 7-segment display, you normally send 0x06 to the HCT595. Since this has a common anode, you need to invert the 0x06 before sending data out to the HCT595. You could invert the number and send 0xF9 to the HCT595 or you could use the C operator and send ~0x06.

4.10 LCD display

4.10.1. Serial interface LCD: (the jumper is placed on the 2 right-hand pins of J23)

The Alice EduPad incorporates an HCT595 shift register (U6) to control the LCD display. The chip select for the HCT595 is PC6 of the Tiva.

The U6 outputs QA-QH as the control and data bits D0-D1, D4-D7 for the LCD.

The pinouts of J1 are as follows:

Pin 1	GND	
Pin 2	VCC (5V)	
Pin 3	Connect to GND via the VR1 for contrast adjustment	
Pin 4	QA (D0)	RS pin for LCD module
Pin 5	GND	Write only for LCD module
Pin 6	QB (D1)	EN pin for LCD module
Pin 7	Not used	
Pin 8	Not used	
Pin 9	Not used	
Pin 10	Mot used	
Pin 11	QE (D4)	DB4 pin for LCD module
Pin 12	QF (D5)	DB5 pin for LCD module
Pin 13	QG (D6)	DB6 pin for LCD module
Pin 14	GH (D7)	DB7 pin for LCD module
Pin 15	Via a 100 Ohm resistor to VCC	LED backlight for LCD module
Pin 16	Backlight ground	EN/DIS for LED back light

The HCT595 is connected to the LCD controller with QE ~ QH to DB4 ~ DB7,
QA to RS, QB to enable. The QC and QD are not used.

The LCD module is hardwired for write-only operation.

4.10.2. Parallel interface LCD: (the jumper is placed on the 2 left-hand pins of J23)

The Alice EduPad also incorporates a parallel interface for the LCD, the COL0-COL3 (PA2-PA5) are connected to the D4-D7 of LCD via an HCT245 buffer (U18). The control pins are PE0 for LCD R/S and PC6 for LCD EN.

4.11 Digital-to-Analog Converters (DAC)

The MCP4725, a 12-bit I2C DAC is installed for learning I2C communication. It converts a digital binary code to an analog signal so a program can generate different waveforms from the DAC.

The DAC's analog output is provided on the J32, labeled as DAC. One way of testing the DAC driver is to connect the DAC output to an ADC input, so a user can send a binary code to the DAC and read the code back from the ADC.

4.12 H-Bridge

The H-bridge driver TB6612FNG is similar to the SN754410N, but has MOSFET output. It's much more efficient than the SN754410N, especially for controlling low voltage motors. The control software is the same for both IC's. It can control two DC motors or one stepper motor.

It takes two pins (PB0 and PB1) to control motor direction, one must be set at high, the other one must be set at low. If PB0 is high and PB1 is low the motor will turn clockwise, then if PB0 is low and PB1 is high the motor will turn count clockwise. If both PB0 and PB1 are set at the same state, the motor stops.

A DC motor is connected to the terminals labeled with M1 and M2, If the motor is turned in the opposite direction from what you expect, just swap the motor connections on the M1 and M2, you don't need to change your software.

The motors to be used to test your software should be small, low current and low voltage DC motors, like under 12V and 300mA.

The third pin is the PWM input for receiving different pulse widths to vary the motor speed. It is driven by pin PF3 of the Tiva Launchpad. The sample program is available on Professor Mazidi's web site.

The other half of the H-bridge driver is controlled by PB3, PB2 for direction and PF2 for PWM. The outputs are M3 and M4. Combining M1, M2, M3, and M4, the H-bridge driver can be used to drive a bipolar or unipolar stepper motor.

4.13 CAN

CAN interface is provided, but the CAN transceiver is not installed. If you are interested in CAN programming, place a MCP2551 into the 8-pin DIP socket. The J27 selects one of CAN ports, PE4 and PE5, or PF0 and PF3. Two jumpers on the J27 must be placed horizontally.

4.14 TFT

J25 is for a common 2.2" TFT QVGA display with SPI interface. The pinouts are listed below:

Pin1	5V	
Pin2	Ground	
Pin3	Chip select	PC6
Pin4	Reset	
Pin5	R/S	PE0
Pin6	MOSI	PB7
Pin7	SCLK	PB4
Pin8	Backlight	
Pin9	MISO	PB6

4.15 OLED

H1 is used for an OLED with I2C interface. The connections are:

Pin1	SDA (PA7)
Pin2	SCL (PA6)
Pin3	3.3V
Pin4	Ground

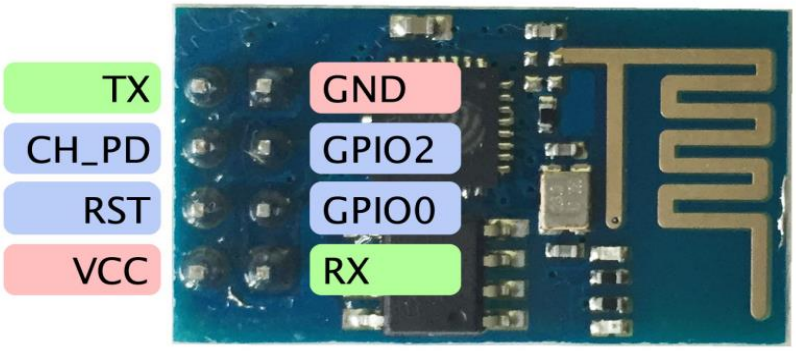
4.16 SD-Card

The SD-Card slot uses SPI interface. The pinouts are listed below:

Chip select	PC5
MOSI	PB7
SCLK	PB4
MISO	PB6

4.17 ESP8266 (ESP-01 module)

The purpose of including the ESP8266 is to bring WiFi capability into students' projects. The ESP8266 is controlled by Tiva or MSP432 launchpad via AT commands in serial communication.



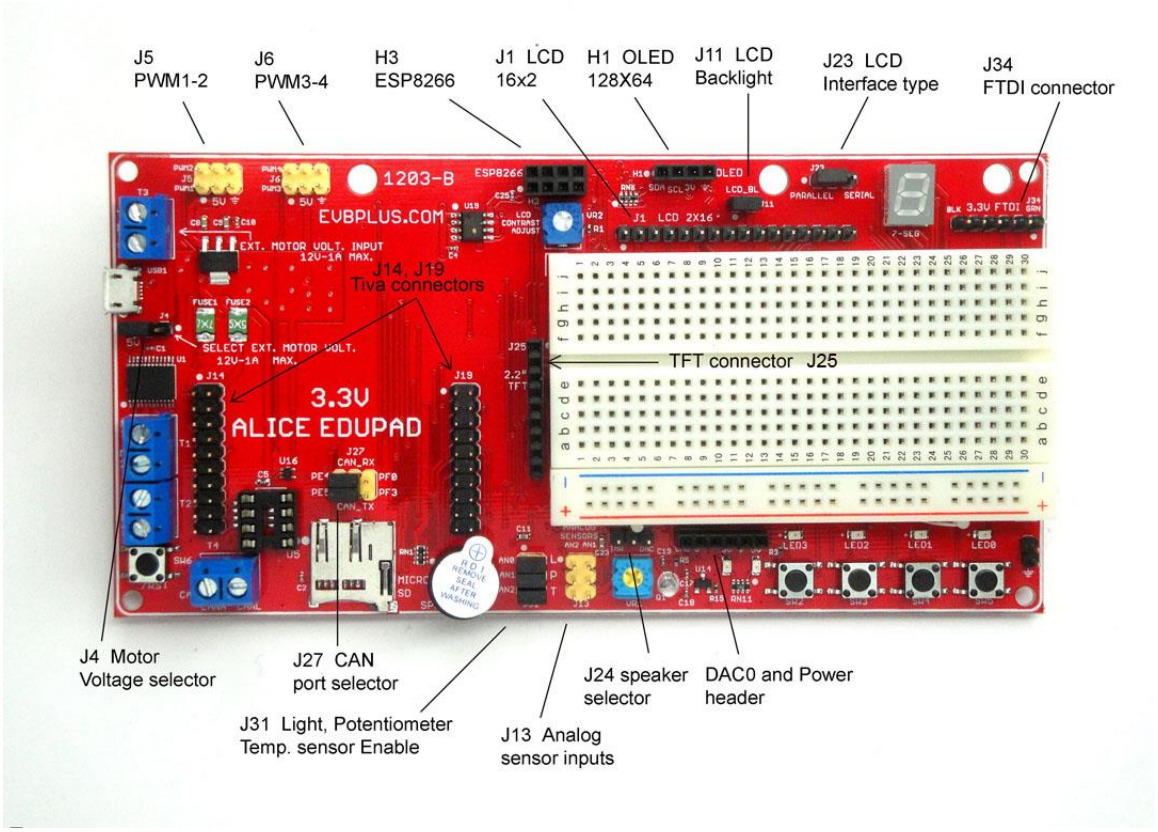
	Pin Name	Connect to		Pin Name	Connect to
1	TX	RX (LED0) of Tiva	2	GND	GND pf Tiva
3	CH_PD	3.3V	4	GPIO2	Pull up via a 10K
5	RST	/Reset of Tiva	6	GPIO0	Open (internal pull up)
7	VCC	3.3V	8	RX	TX (LED1) of Tiva

A sample program is downloadable from Professor Mazidi's web site
http://www.microdigitaled.com/EduPad/Tiva-EduPad/TI_Tiva_EDUPAD_Trainer.htm

4.18 All on-board headers:

J1 LCD connector for a 16x2 LCD
J4 Motor power source selector, jumper on left side for onboard 5V, on right for external power voltage, <12V, <1A.
J5 Two servo outputs, controlled by PF2 and PF3. Servos are supplied with 5V
J6 Two servo outputs, controlled by PF0 and PF1. Servos are supplied with 5V
J11 LCD backlight
J13 Analog sensor inputs and can be used for an IR distance sensor, such as GP2D12 or other analog or digital sensors
J14 Tiva main pin header 1
J19 Tiva main pin header 2
J23 LCD interface type select, serial or parallel
J24 Speaker source selector, Timer or DAC
J25 TFT display header
J27 CAN port select
J31 Light, potentiometer and temperature enable jumpers
J34 FTDI connector

H1 OLED
H3 ESP8266



4.19 I/O pin usage

Pin Name	Header name	I/O device(s)
PE1	J14-14, J31-1	AN0, Light sensor
PE2	J14-16, J31-3	AN1, Potentiometer
PE5	J14-11, J31-5	AN2, Temperature sensor
PF2	J19-1, J1-1	PWM1 for servo
PF3	J19-3, J1-2	PWM2 for servo
PF0	J19-8, J4-1	PWM3 for servo
PF1	J14-20, J4-2	PWM4 for servo
PC4	J19-7, J24-1	Speaker
PC5	J19-9	SD memory
PC6	J19-11, J25-3	LCD 16x2, TFT
PC7	J19-13	7-segment display
PE0	J19-6	TFT
PE4	J14-9	CAN_RX
PE5	J14-11	CAN_TX
PB0	J14-5, J34-3	LED0, H-Bridge, ESP8266
PB1	J14-7, J34-2	LED1, H-Bridge, ESP8266
PB2	J19-4	LED2, H-Bridge
PB3	J19-5	LED3, H-Bridge
PD0	J14-6	SW5, Pushbutton
PD1	J14-8	SW4, Pushbutton
PD2	J14-10	SW3, Pushbutton
PD3	J14-12	SW2, Pushbutton
PB4 (SPI-SCLK)	J14-13	7-segment display, LCD, TFT
PB6 (SPI-MISO)	J19-14	7-segment display, LCD, TFT
PB7 (SPI-MOSI)	J19-12	7-segment display, LCD, TFT
PA6 (I2C-SCL)	J14-17	EEPROM, OLED
PA7 (I2C-SDA)	J14-19	EEPROM, OLED