CmpE242 Spring 2022

1

Jan 26 (Wed) First Day of the Class.

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Office Hours: M.W. 4:30-5:30 P.M.

Textbooks + References:

No Textbook, however CPU Datasheets Are employed as a Base Line Reference, and serves as a textbook.

1. ARM11 CPU Datasheet, from Samsung & SCH Document for the development Board.

2. NVDA Jetson NANO Developer Kit. Reference Source for people using NANO as a target platform. System-on-module Document. (Not Used that much in this class). Design Guide As 2nd primary Ref. for Jetson NANO.

3. BroadCom Pie. BCM2835 (CPU Datasheet).

Selection of Target platform for this Course.

a. NVDA Jetson NANO
b. BroadCom Pie
c. SamSung ARM CPU
d. NXP i8

Note: Select your target platform from the options a – d. (Consider Nvidia Jetson NANO).

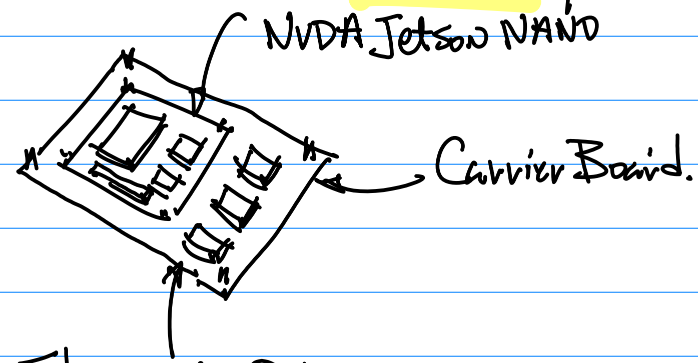
Programming Languages: { C/C++, python

O.S. Support: Linux.

Rich I/O I/F Support.

Requirements for the Course:

1. Design/Build A State-of-the-Art Prototype System; Each Person will have to have one individual system.



2 Form 4 person team, Work on Homework, Project, However All Coding, Report etc have to be complished individually, no Code, Report, Project etc. Can be Shared.

Grading:

1. Midterm Exam, Close Book / Close Notes 30%. Prototype System will be needed to Answer Design Questions, and to execute programs. Need to take photos of the prototype.

2. Final Exam, Similar Format, 40%. Prototype System is a Part of the Exam.

3. Homework, Projects. 30%. 1st Project During the 1st Half of the Semester. 2nd Project By Team Project, @ End of the Semester, Requires PPT Presentation & Live Demo.

Announcement in Class, in Written form Both in the Lecture Notes and ON SJSU Canvas.

Late Projects/Homework 1 pt Penalty.

Jan 31 (Monday)

Today's Topic: Bill of Material & Prototype System.

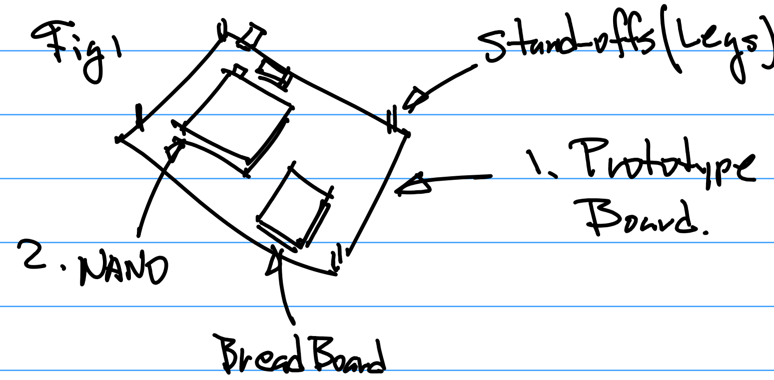
Target platform to Consider for your Prototype:

- Nvidia Jetson NANO, 2GB
- Broadcom Pie 3B+, 4.

Note: Jetson NANO is Better And more powerful with Almost the Same cost.

Bill of Material for Prototype System

Fig 1



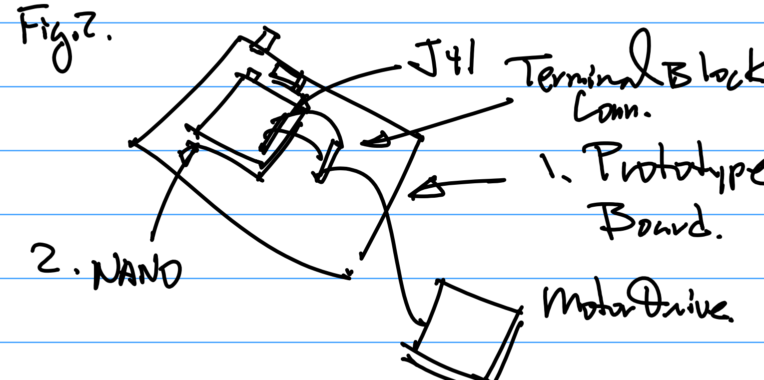
Note: a. Adequate size to host CPU-module (NVDA Jetson NANO) 16 × 11½ Cm.

b. Power Circuit.

c. Stepper motor Drive

Note: For Simple Testing Purpose, you can Choose to use Non-professional Grade Drive, Or Use professional Grade Stepper Motor Drive. (Robotics, CNC, 3D Printer Additive Manufacturing), Size of the Drive can be same Size of your CPU Module

Fig. 2.



Prefab "Through Holes" with Coating for Soldering.

Stand-offs (Legs)

Components for:

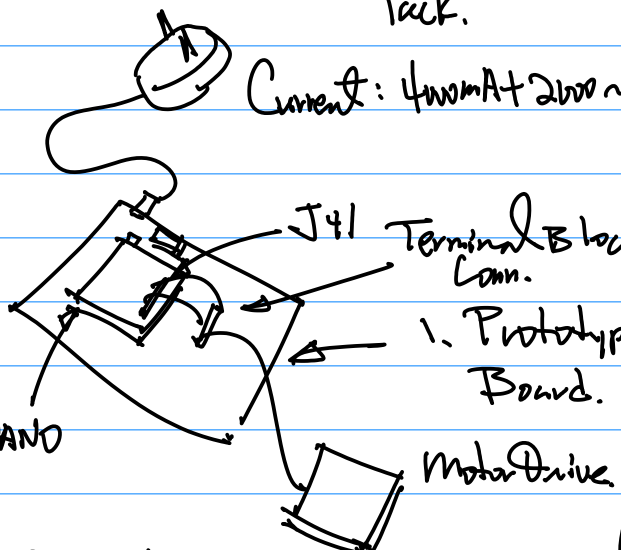
External Power Unit

GPIO Testing Circuit

External Power Unit { Option 1: Wall-Mount Adapter
Option 2: Batter Pack.

Fig.3

Current: 4000mA+2000~4000mA



Note: Adaptor To Provide Power Current Not just to the Target platform, But also to the entire Board

NANO Target Requires 4A (4000mA) Current for Peak Computing, On top of it, you will need to consider providing Adequate Current for Glue Logic, for Sensor I/F (LSM303), for Stepper Motor Drive. ①

Note: IC DC Regulator is Needed.

Make sure DC Regulator IC Can Handle Adequate Current

Consider 7805 as an example. Only 1500mA is allowed, No good

information

-voltage integrated-circuit voltage regulators is designed for a wide range of
include on-card regulation for elimination of noise and distribution problems ass
tion. Each of these regulators can deliver up to 1.5 A of output current.
thermal-shutdown features of these regulators essentially make them immune

(7805 Datasheet)

Note: Some power regulator will have Output voltage Drop.

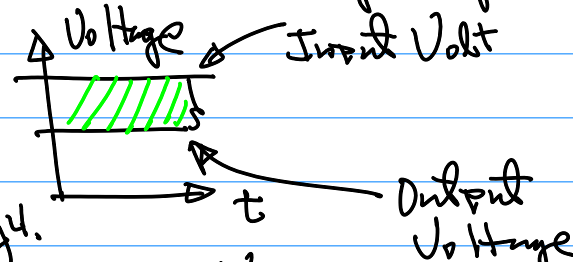
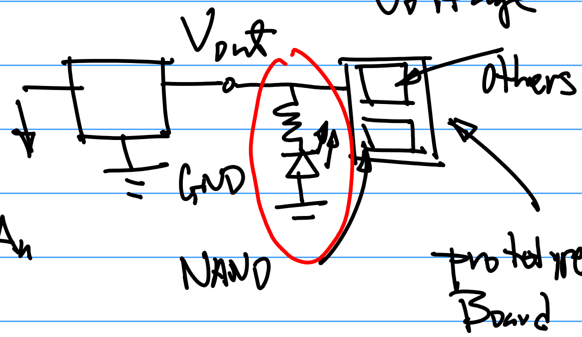


Fig4.



② Red LED, $V_{LED} \simeq 1.2V$, $I_{LED} \simeq 10mA$

③ Assorted Resistors (A few hundred of Ohms to A few Mega Ohms)

Caps. for Noise Reduction. for IC Regulator Compensation).

④ Right Angle DC Connector.

Right Angle

GPIO Testing
- Input
  - "0"s
  - "1"s
- Output
  - "0"s
  - "1"s

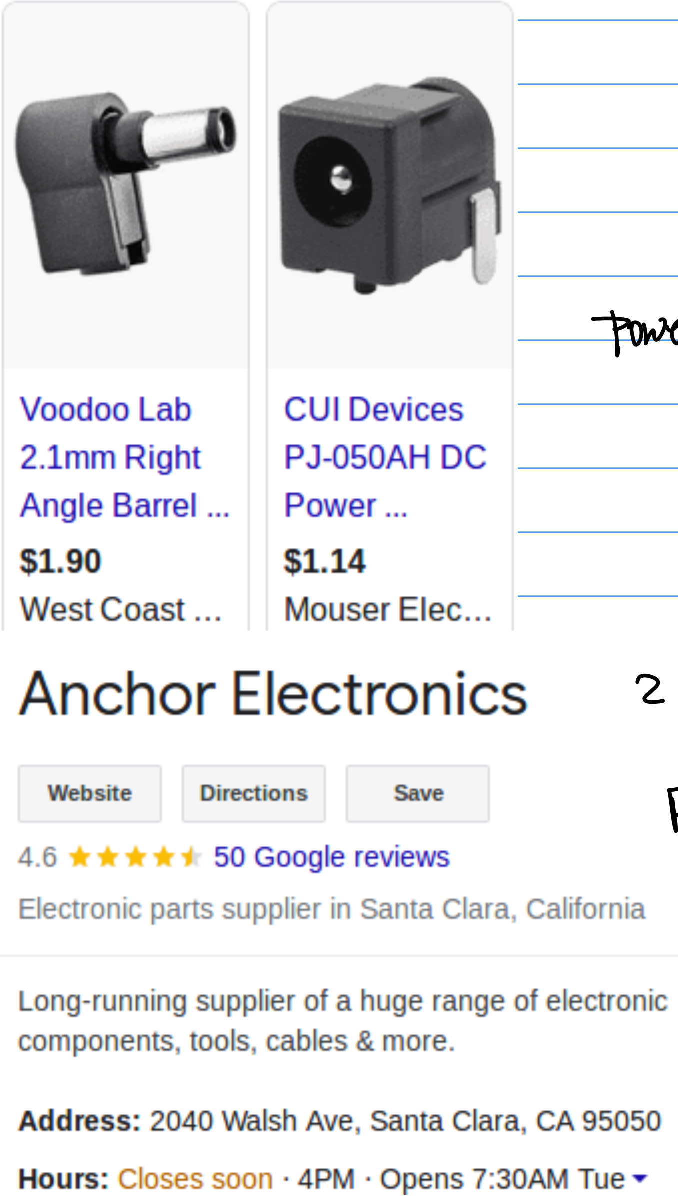


Fig.5

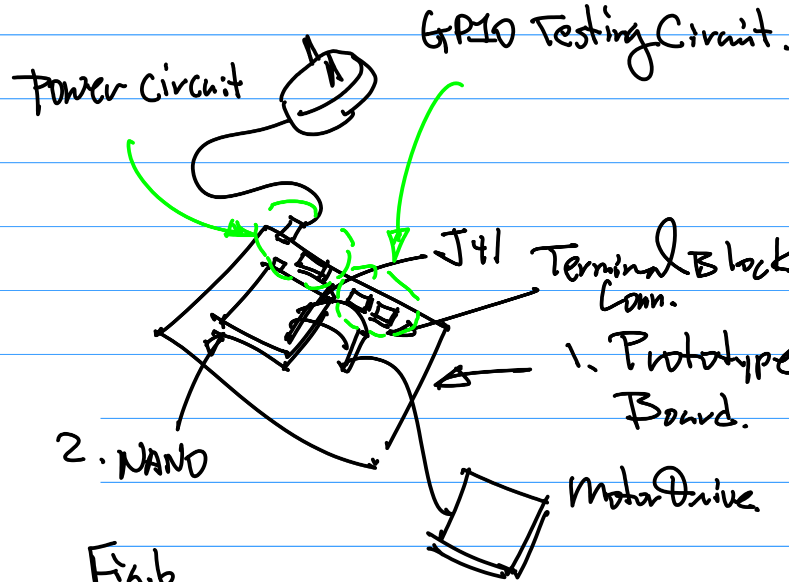
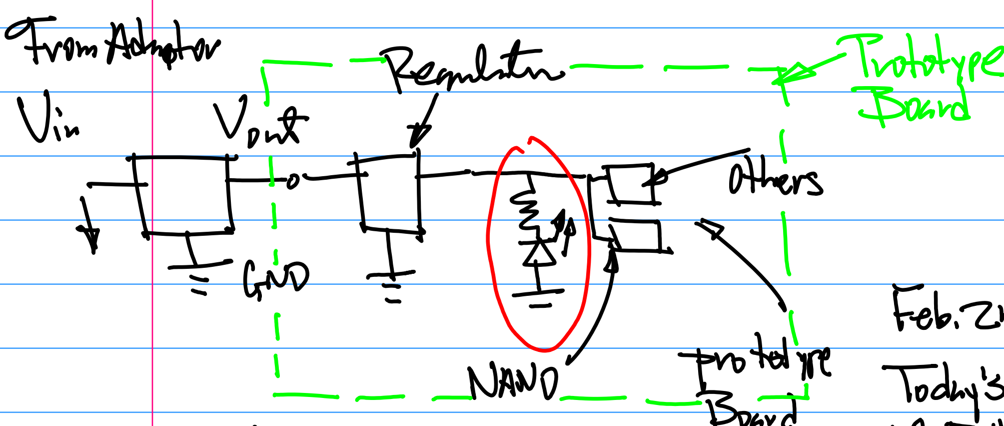


Fig.6

Input Testing:
1. Toggle s/w.
2. Assorted Resistors
(10 Ohms ~ A few Hundred Ohms)

Output Testing:
1. Color LED (Red, yellow, Green)
2. Assorted Resistors.

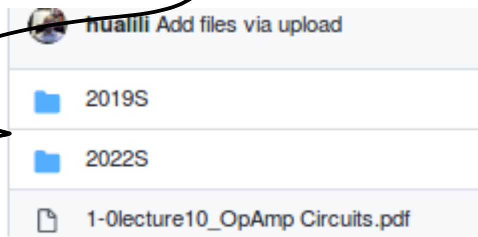


Components for GPIO Testing.

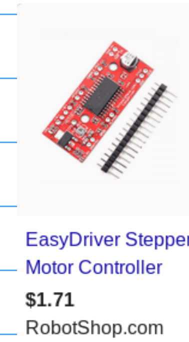
Feb. 2nd (Wed)

Today's Topics:
1° Bill of material (Continuation)
2° Prototype System Design.

Class github



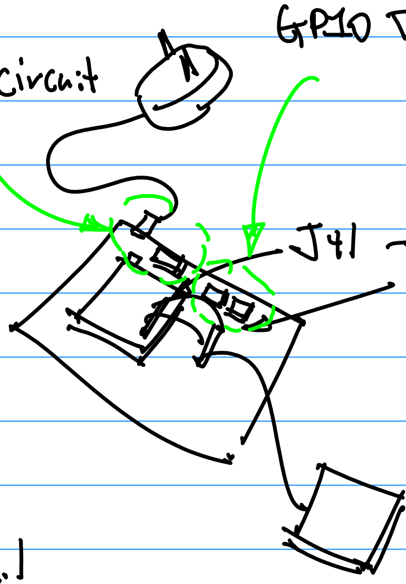
Option B for the motor drive "Easy Drive" a. ~1000mA.



Example: Bill of material for PID Controllers (Stepper motor etc).

GPIO Testing Circuit.

Power Circuit



J41

Terminal Block Conn.

Motor Drive

Fig. 1

Ref. for Stepper motor Drive

https://github.com/hualili/CMPE244

PID Controller (P: Proportional, I: Integral, D: Derivative)

For CNC, 3D Printer, for Self-Driving Robot

Motor Drive for Stepper motors.

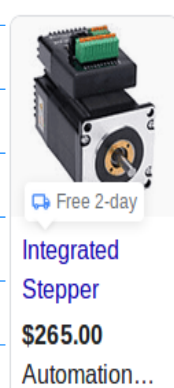
Option A. Professional Drive

Option B.

TB6600 4.5A CNC Single-Axis For LDR-40B

Stepper Motor Controller 1 15 USD

https://www.amazon.com/gp/product/B01DIK5IRI/ref=oh_aui_detailpage_o02_s00?ie=UTF8&psc=1



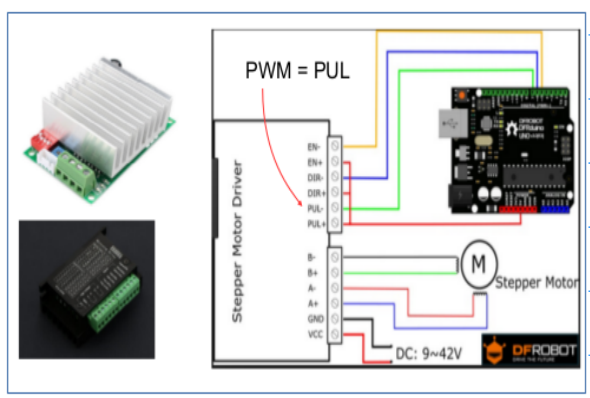


Fig. 2

~$15–$40

Note: Specs for Option A: a. 4.5A. (2500mA ~3000mA for this Class & Beyond) b. TB66xx (IC Chip Provides Adequate Power)

Bill of material (motor)

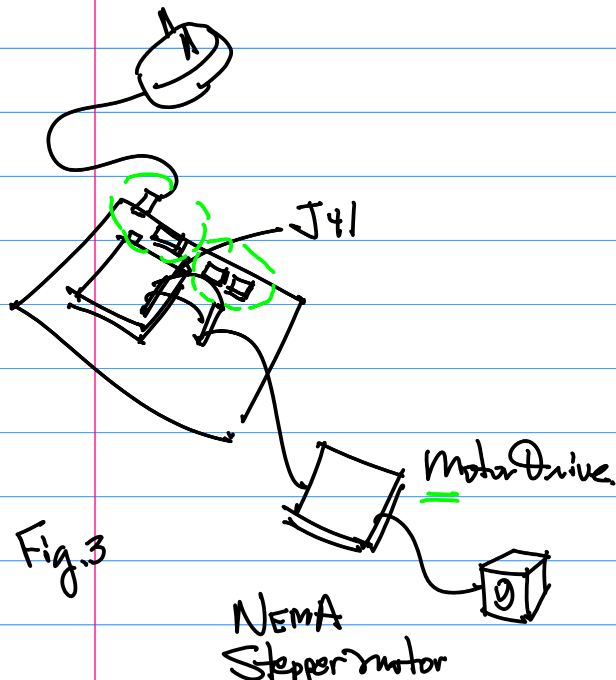


Fig.3

Buying LSM303 module

Bill of material (IOT Applications
Analog Sensor I/F)

ADC module
(Analog/Digital Conversion)

I2C
SPI (Serial peripheral Interface)

Adafruit 1018
Acceleration Sensor
$17.95
Mouser Electronics

Adafruit Industries
LLC 1085 ADS1115
$14.95
Digi-Key

Adafruit Industries
LLC 4648 PCF8591
$6.50
Digi-Key

https://www.anaheimautomation.com/marketing/stepper/stepper-motors.php?gclid=EAIaIQobChMIqsaW3pbi9QIV-R6tBh1QBAFsEAAYAiAAEgIhx_D_BwE

Stepper motor
- NEMA-17
$14.00
Adafruit Ind…

Fig4.

ANAHEIM AUTOMATION

Selection GuideLine:

1. Digital Interface Protocol (CPU and ADC Interface);

SPI: 50+ mbps, I2C: 2~4 mbps

Bill of Material (Sensors) for PID

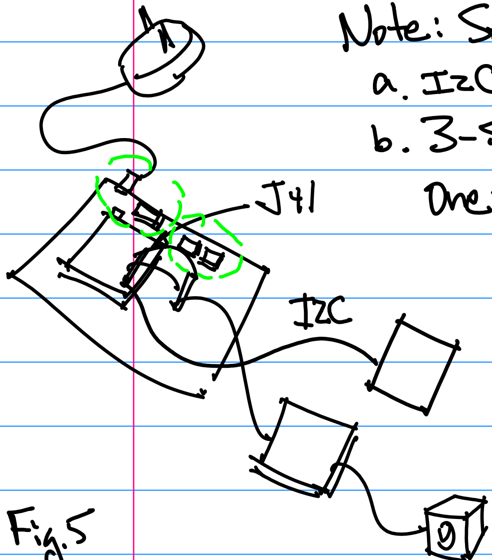
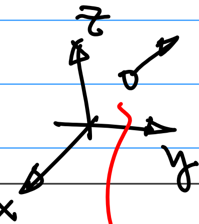


Fig.5

Note: Sensor LSM303
a. I2C Sensor Interface;
b. 3-sensing units in
One package



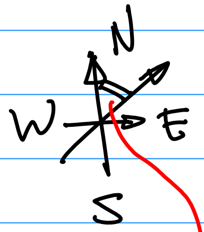


Fig.6

LSM303

LSM303DLHC

life.augmented

Ultra-compact high-performance eCompass module:
3D accelerometer and 3D magnetometer

Datasheet - production data

② ①

including Temperature
Sensing (the 3rd one)

Selection Guideline (Continued)

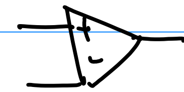
2. Sample Rate:
   500KSPS or 1 MSPS (million Samples per Second)

3. Quantization Level of ADC.
   Bits per Sample. 8~10 bit Resolution minimum;

Nyquist Sampling Theorem.

$$f_{sample} \geq 2 f_{max} \quad \ldots (1)$$

Note: Optional Component —— OpAmp.
Operational Amplifier



Single OpAmp.

Or LM358
(Quad OpAmps in One Package).

Homework: One A week from Today. (Feb.9) 11:59pm

1. Identify your target platform, And provide A screen Capture or photo of its Expansion connector. with Table of pin Assignment;
2. Create A table of Bill of material Based on Lecture Discussion.
3. Submission: A pdf file with Naming: First_Last_SID_Target_242.pdf.
   Submission to CANVAS.

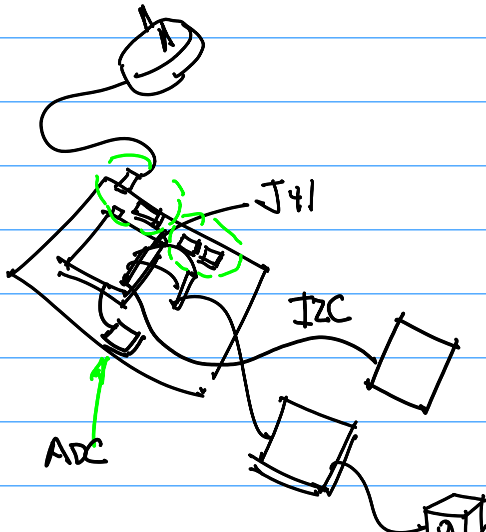
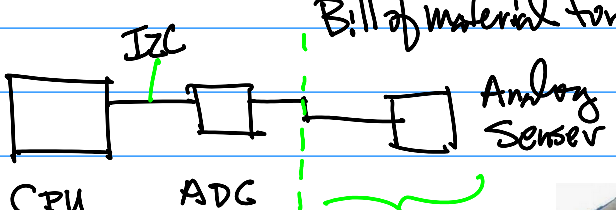


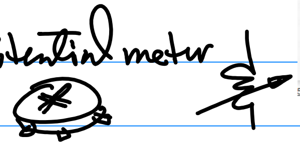
Fig.7

Feb 7 (Mon)
Today's Topics:
1° Bring Up the target platform.
2° GPIO Testing, e.g., "Hello, the world".

Bill of material for ADC.



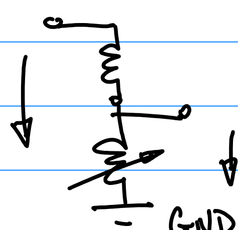
Potential meter



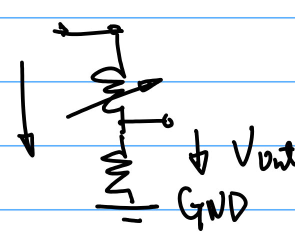

5k Potential meter. | Download ...

Target Platforms { a. Jetson NANO
b. Pie3B+/4.

Fig.8



OR



Note: Base Line Reference
Samsung ARM11.

Ref. CPU Datasheet of Samsung ARM-11 is on the Class github. (CMPE244)

2021F-105-#0-cpu-arm11-2018S-29-...

PPT for Today's Lecture

Example: Bring Up The target Platform, NANO.

Note: Visit Nvidia Developer Site, And sign up As a developer

Pre-requisites:

1° Developer Account;

2° Linux O.S. (Kernel Source Distribution) for Device Driver Development & Kernel Source Optimization;

3° Down Load Pre-Compiled, Pre-Built Kernel Image to SD Card And

4° Target Board, Jetson NANO 2GB OR 4GB.

Step 1. Down Load Pre-Build Kernel Image

Step 1. Down load SD card OS image from Nvidia to your host machine, laptop, the zipped file size is 6.1G, unzip it to get OS image, e.g., *.img file, ref:

https://developer.nvidia.com/embedded/learn/get-started-jetson-nano-devkit#write

Step 2. Down Load "Ethcher" Software tool, then execute this tool to write the Down Loaded Pre-Built Kernel O.S. to your SD Card.

Step 2. Write the image to your microSD card by following the instructions from Nvidia, first you will need to down load the writer software "ethcher" to your host machine from this site:

(2.1) for Linux host, Download, install, and launch Etcher.

https://www.balena.io/etcher/

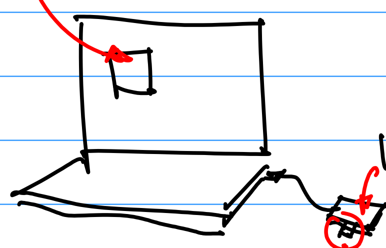


Fig 1.

Step 3. Took SD Card from the Reader, Insert the Card into the USB Slot of the target platform, then Power-On the System. Then follow the steps during the Booting to initialize & Configure the System, such as user Name, Password, Time Zone Setup etc.

Example: To prepare GPIO Testing. (To Be Assigned as Homework)

Hardware Aspect:

Step 1. Identify the Expansion Connector &

Pin Assignment.
From NVIDA Developer Site to find Connector Information

J41 Connector

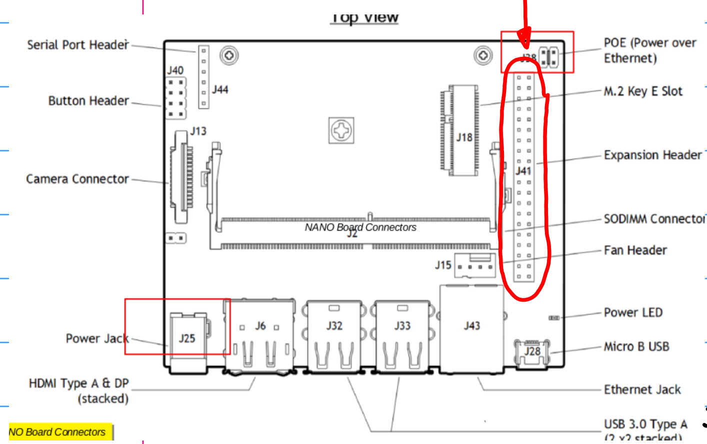


Fig.2

Table 1. Pin Assignment/Connectivity Table

CPU Pin/Connector	Description	Note
GPIO79/J41-12	GPIO Input	
GPIO78/J41-40	GPIO Output	
GND/J41-6	GND	

Step3.
Design Schematics

Step2. Establish Pin Assignment/
Connectivity Table

Pin Assignment { GND: Common GND
GPIO: { GPIO79/pin12
GPIO78/pin40

Sysfs GPIO	Name	Pin	Pin	Name	Sysfs GPIO
	3.3 VDC Power	1	2	5.0 VDC Power	
	I2C_2_SDA I2C Bus 1	3	4	5.0 VDC Power	
	I2C_2_SCL I2C Bus 1	5	6	GND	
gpio216	AUDIO_MCLK	7	8	UART_2_TX /dev/ttyTHS1	
	GND	9	10	UART_2_RX /dev/ttyTHS1	
gpio50	UART_2_RTS	11	12	I2S_4_SCLK	gpio79
gpio14	SPI_2_SCK	13	14	GND	
gpio194	LCD_TE	15	16	SPI_2_CS1	gpio232
	3.3 VDC Power	17	18	SPI_2_CS0	gpio15
gpio16	SPI_1_MOSI	19	20	GND	
gpio17	SPI_1_MISO	21	22	SPI_2_MISO	gpio13
gpio18	SPI_1_SCK	23	24	SPI_1_CS0	gpio19
	GND	25	26	SPI_1_CS1	gpio20

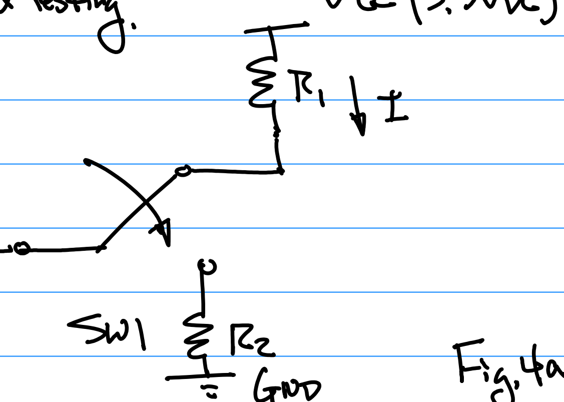
	GND	25	26	SPI_1_CS1	gpio20
	I2C_1_SDA I2C Bus 0	27	28	I2C_1_SCL I2C Bus 0	
gpio149	CAM_AF_EN	29	30	GND	
gpio200	GPIO_PZ0	31	32	LCD_BL_PWM	gpio168
gpio38	GPIO_PE6	33	34	GND	
gpio76	I2S_4_LRCK	35	36	UART_2_CTS	gpio51
gpio12	SPI_2_MOSI	37	38	I2S_4_SDIN	gpio7
	GND	39	40	I2S_4_SDOUT	gpio78

i, Ph.D.

Fig.3

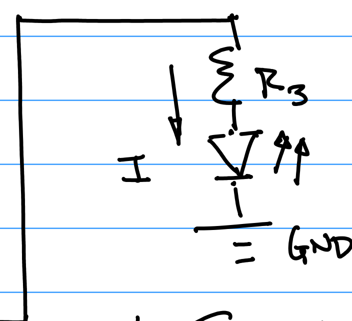
Sysfs GPIO	Name	Pin	Pin	Name	Sysfs GPIO
	3.3 VDC *Power*	1	2	5.0 VDC *Power*	
	I2C_2_SDA *I2C Bus 1*	3	4	5.0 VDC *Power*	
	I2C_2_SCL *I2C Bus 1*	5	6	GND	
gpio216	AUDIO_MCLK	7	8	UART_2_TX */dev/ttyTHS1*	
	GND	9	10	UART_2_RX */dev/ttyTHS1*	
gpio50	UART_2_RTS	11	12	I2S_4_SCLK	gpio79
gpio14	SPI_2_SCK	13	14	GND	
gpio194	LCD_TE	15	16	SPI_2_CS1	gpio232
	3.3 VDC *Power*	17	18	SPI_2_CS0	gpio15
gpio16	SPI_1_MOSI	19	20	GND	
gpio17	SPI_1_MISO	21	22	SPI_2_MISO	gpio13
gpio18	SPI_1_SCK	23	24	SPI_1_CS0	gpio19
	GND	25	26	SPI_1_CS1	gpio20
	I2C_1_SDA *I2C Bus 0*	27	28	I2C_1_SCL *I2C Bus 0*	
gpio149	CAM_AF_EN	29	30	GND	
gpio200	GPIO_PZ0	31	32	LCD_BL_PWM	gpio168
gpio38	GPIO_PE6	33	34	GND	
gpio76	I2S_4_LRCK	35	36	UART_2_CTS	gpio51
gpio12	SPI_2_MOSI	37	38	I2S_4_SDIN	gpio77
	GND	39	40	I2S_4_SDOUT	gpio78

Input Testing.



Let I = 10mA.

$R_1 = V_{cc}/I = 3.3/10\times10^{-3} = 330\Omega$, $R_2 = R_1$



$I \approx 10mA$

Note: Since NANO Output Current is small, so we choose not to use R_3.

Feb 9 (Wed) Topics:

1° Building GPIO Testing Capability on the target platform, Jetson NANO.

2° Kernel O.S. Sources plus toolchain

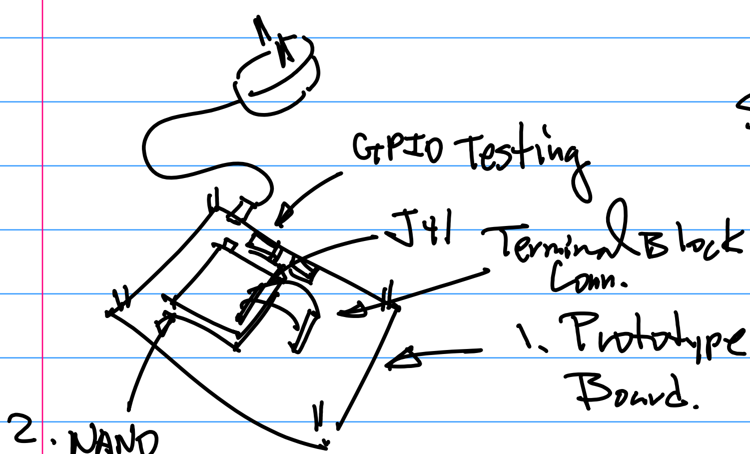
Example: Bring Up Your Target Board

Step 1. Build your prototype system with NANO Target Board mounted on it.

CMPE242 Feb9,22

Homework (Due A week from today) Feb16.

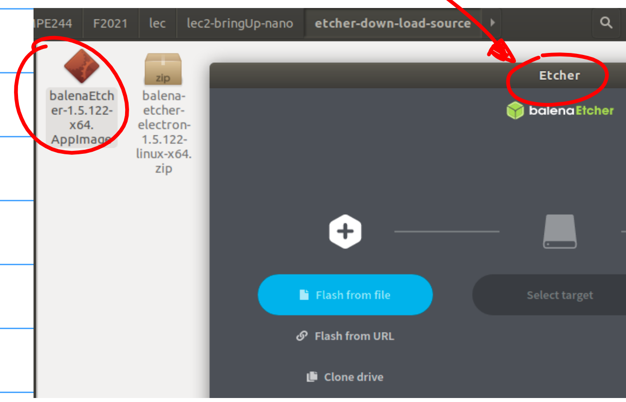
1. Prototype System with A Carrier Board 4"x3" OR Similar Size of your Choice;
2. GPIO Testing Circuit for Both Input/Output Testing (schematics)
3. Mount your NANO On the Carrier Board.



4. Take a photo of your System (with A Host connection)
5. Screen Capture from your Host machine, which shows NANO is running.
6. Put Photos plus Schematic into One PDF file, zip it, Submit to SJSU CANVAS.

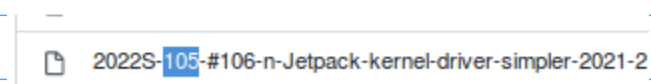
Step 2. Down Load Pre-Build Kernel

Image From NVDA Developer Site, And together with Flash Writing Software. "Etcher"



Step 3. Run "Etcher" program to Upload the O.S. Kernel Image to the target NANO Board.

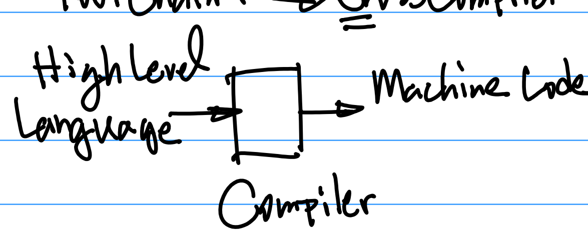
Note: Target Image for my Board is 2019.4 7 Due to my Applications in Deep Learning. For Embedded Class, we can use other/Latest Release



Jetpack from NVDA Consists of a. O.S. Kernel (Device Driver), b. GPU packages, c. OpenCV, d. DNN

O.S. (Operating Systems)

Tool Chain: → Cross Compiler



Step 4. Take SD Card to the target NANO, Boot (Power Up) the NANO, finish Configuration process, then Ready to go. (To create your Applications).

Example: O.S. Kernel Source Debugging, Device Driver Development

O.S. + Tool Chain for NANO

O.S. + Tool Chain for Samsung ARM11

Step 1. Down Load And Install Kernel Source, And Tool Chain.

Note: Purpose is to Optimize Kernel Image, Optimize/Develop/Debug Device Drivers.

\# make menuconfig

Software Tool for Kernel O.S. Compile + Build, And for Device Driver Development & Debugging.

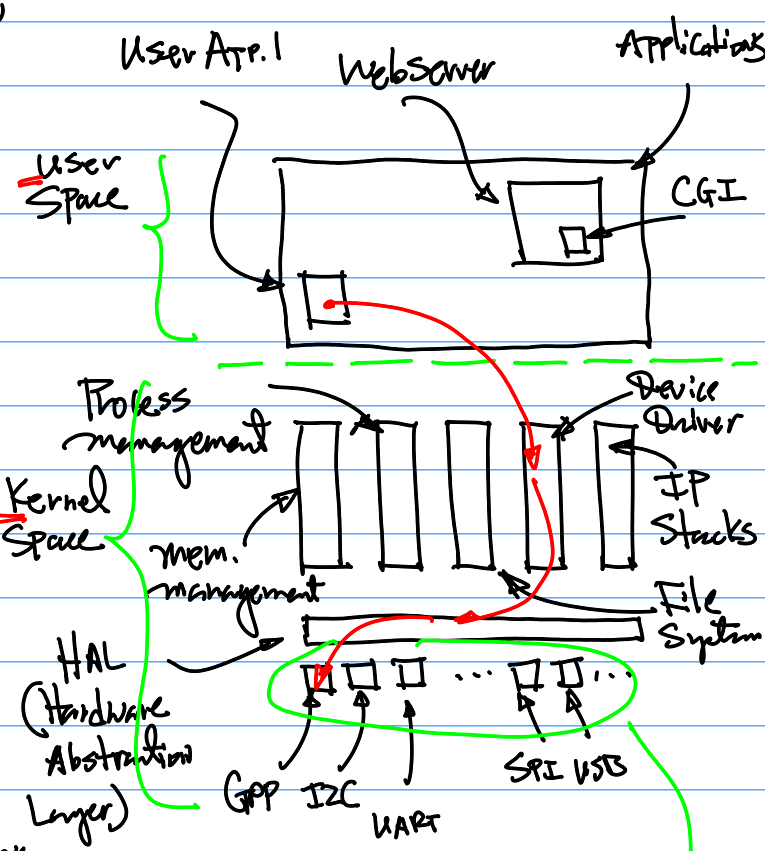
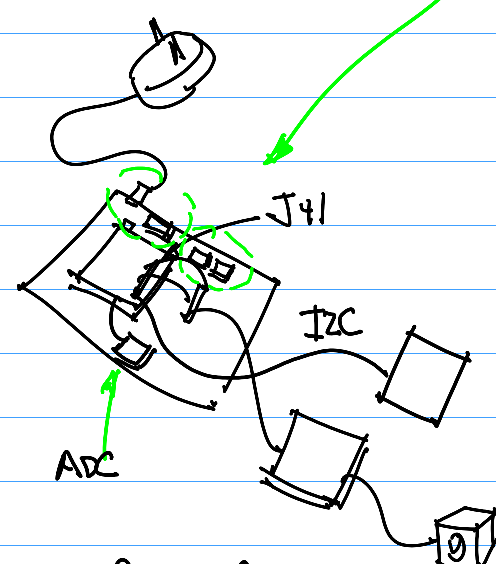


Fig. 1.



Note: CGI Common Gateway Interface

Older, But Widely Adopted Technology for I/O Devices Interfaces.

Feb 14 (Monday)

Topics: 1° Kernel Space Programming. Kernel Source Distribution, Tool Chains, Device Driver Development.

Example: Embedded Software Architecture

Objective: To Connect Kernel O.S., Devices Drivers to the Target NANO plus Carrier Board

Note: Software Architecture (Block Diagram) & Prototype System illustration (Fig.1) are required.

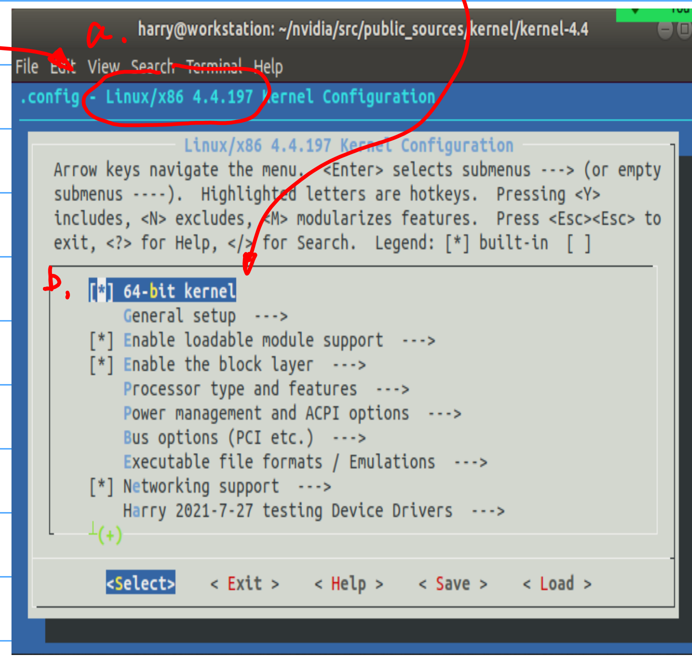
Example: Kernel Source Distribution & Tool Chain.

Download + Install O.S. Kernel Distribution (Pre-Build Image & Source Code Distribution) Together with the tool chain.

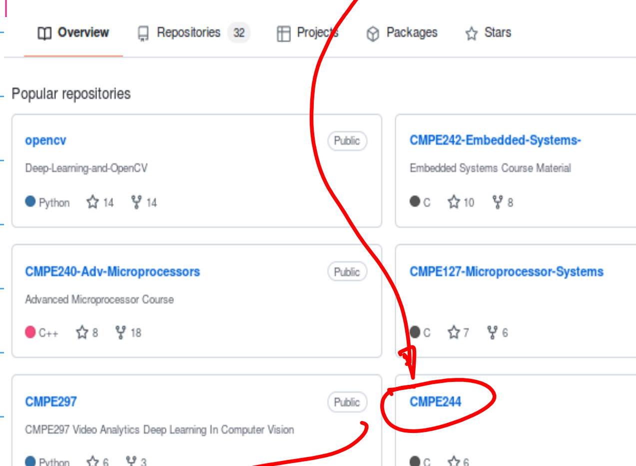
Target: NAND

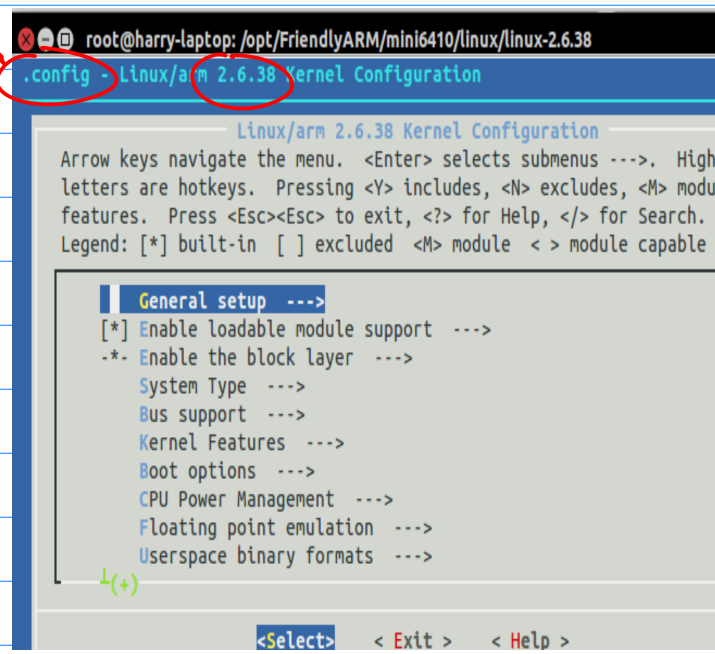
Reference platform: Samsung ARM11.

a. Version of the config b. Target



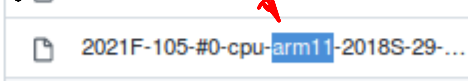
Now, for Samsung Target (ARM11)
a. Version of Config. for 32 bit ARM11.





CPU (ARM11) Datasheet

Class github



Development of Device Driver

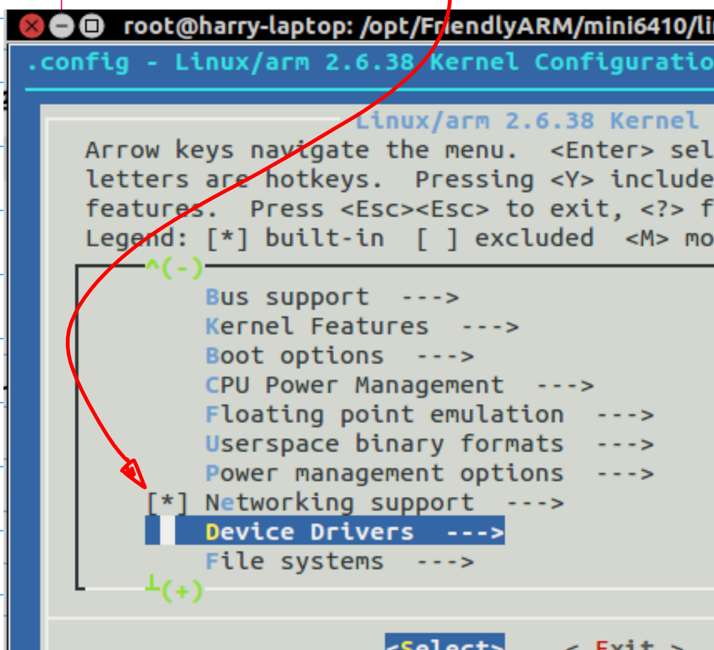
Step 1. Run menuconfig for kernel Configuration.

Go to your installation directory,
home\nvidia\...\source\kernel\...

Step 2. Locate Device Driver for GPIO I/F.

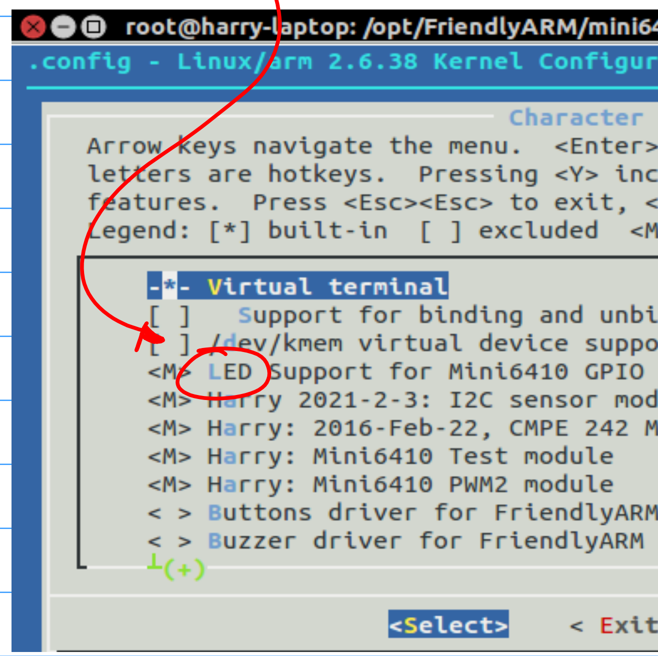
Note: I2C, SPI Are 2 Device Drivers plus PWM are Needed for 242.

Take Samsung As Example first.
Select Device Driver at the Root UI Option

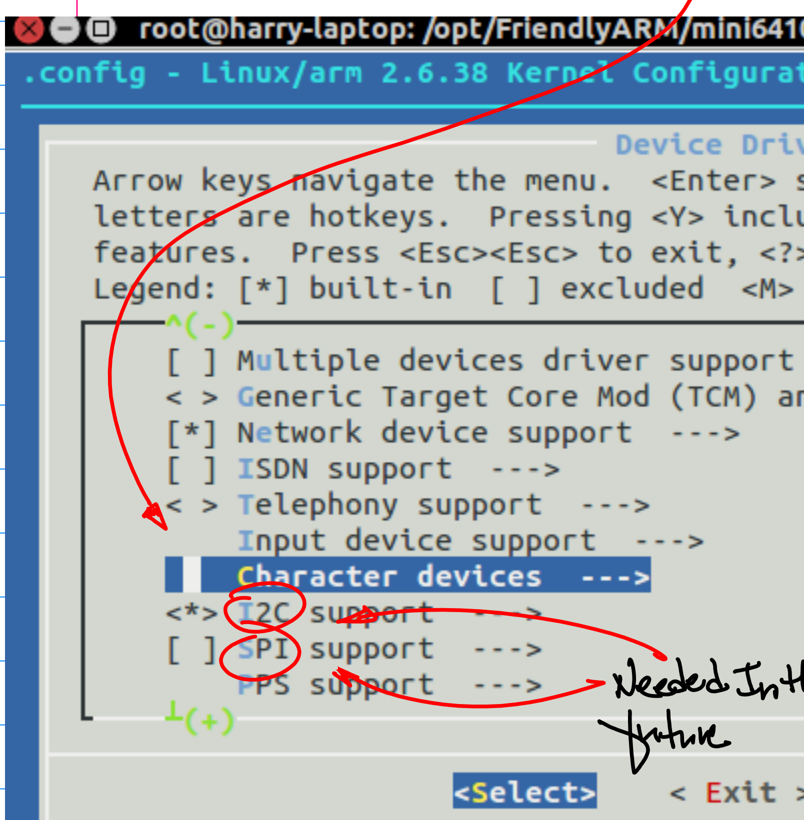


Brows till Reach the Device Driver You Need.

GPIO Testing with Device Driver "LED"



Step3. Select Char Device (Character)



Needed In the Future

Example: Now, Switch to menuconfig Version 4.4.197 for Jetson NANO, Look & Feel of the menuconfig is the Same.

Now, Let's Discuss NANO GPIO I/F with Utilization of Existing (Factory Level Release) Device Driver.

Homework

1. Write C/C++, OR Python Code to Perform GPIO Input/Output Testing, ON NANO. Make Sure use your GPIO Testing Circuit Designed in the Class;
2. Input Testing has to cover input "1"

And input "0" By Toggling the Switch;

3. Output Testing to Cover Output "1" & "0" to turn ON/off LED.

4. Photos of Execution of the Program:

a. Input "1" & "0" console print message.

b. Output "1" & "0", LED Light ON/OFF.

c. Entire System;

5. Source code, Binary (for C/C++) as well

6. Create One pdf for All photos, Zip to include Source code And/OR Binary

7. Submit zip file to CANVAS. By 23rd (Wed) 11:59 p.m.