

CMPE240 Spring 22

Jan 26 (Wed)

Today's Topics: Introduction

& Organizational meeting.

Harry Li, Ph.D.

Green Sheet: On-Line from github

<https://github.com/hualili/CMPE240-Adv-Microprocessors>

hualili / CMPE240-Adv-Microprocessors Public

Code Issues 1 Pull requests Actions Projects Wiki

master 1 branch 0 tags

hualili Add files via upload

2018F Add files via upload

1769 patch.zip Add files via upload

2022S-112-project-Lecture-Reflection-Handouts.pdf

2022S-100-accessible_CMPE240-HarryLi.pdf CMSIS_CORE_LPC17xx.tar.gz

Naming convention: Year + Semester + ID + Name of the Doc.

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Office Hours: Mondays & Wednesdays
4:30 - 5:30 PM.

Office hours Zoom link: Join Zoom Meeting

[https://us04web.zoom.us/j/9841607683?
pwd=UIA3aEk1TnV4bjNLQk5CQkw0dDk4UT09](https://us04web.zoom.us/j/9841607683?pwd=UIA3aEk1TnV4bjNLQk5CQkw0dDk4UT09)

Meeting ID: 984 160 7683 Passcode:
121092

TextBooks + Ref

1.

No text Book, But NXP CPU Datasheet
is utilized as a Base Line Ref

2. SCH Design of the CPU module.

FR5 (Rev.D.)

Prototype Board: Each person will
Build his/her Prototype System.

Team work is encouraged, form 4 people
team for this Class. However all the
work has to be done individually.

Grading: Midterm 30%

Format: Written Exam But

Need to have prototype ready to execute
programs, And get photos of your
Prototype Board.

Final Exam: 40%, Similar format as
the midterm.

Homework / Projects Counts Another 30%.

Written Announcement on WhiteBoard
(Lecture Notes) And SJSU CANVAS.

Late Project submission will have 1 pt.

Penalty per each Lecture Day.

Introduction.

1. Bill of material for LFC17ba
Prototype Board Design.

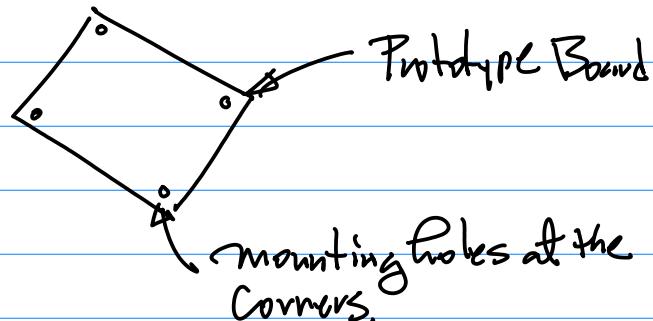
Jan 31 (Monday)

Today's Topic: Introduction.

Prototype System.

Task 1. Form 4 Person Team

Work Together throughout the entire Semester. By this Wednesday.



Stand-offs: (Legs) for the Board.

Prototype System.

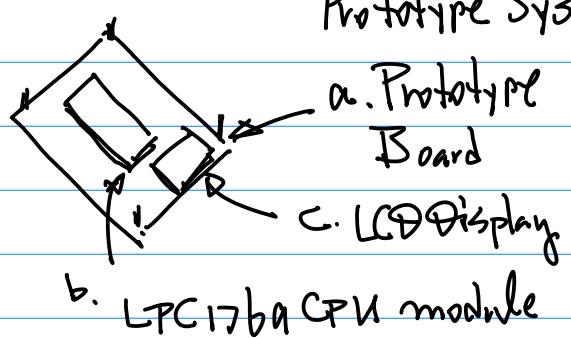


Fig. 1

Note: a. Adequate Size

Not Too big, to host LPC1769

module & LCD Display module, plus "Glue" logic.

"Glue Logic" GPIO Circuit as a part of the "Glue"

Ethernet Connector, RJ45, in the future for possible networking Applications, TCP/IP, micro-Web Server.

4" x 3" Or Similar Size.

16 cm x 11 1/2 cm.



Fig. 2 CPU
Digi-Key, or mouser Electronics

CPU: Cortex M3

c. LCD Display module

SPI (Serial Peripheral Interface)

Software Driver function(s) are provided/Accesible

- LPC 1769
 - Color TFT LCD display
- Resolution : 128x160,
Pixel Depth: 18-bit (262,144) colors
- Controller: ST7735
Interface: SPI interface

LCD Pins

LPC1769 Pins

From the class github

LCD module

- 2021F-113-LCD-TFT (ThinFilmTransistor).jpg
- 2021F-114-display-NEC-3P5-LCD-68775.pdf

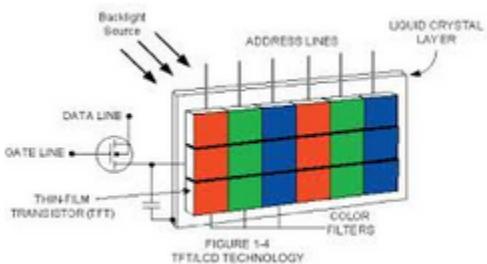


Fig.3

Components for:

Power Unit Design Need

GPIO (General Purpose I/O)

LPC1769 is powered with 3 options.

Option 1: USB Cable Connection to provide power from the host (PC) to LPC1769 CPU module.

for Debugging / Testing Purpose But not for Deployment

Option 2: External Power to the prototype System. To Allow you Deployment of the Prototype System. → Mandatory, By

the last project, each prototype will have to be deployed with External Power.

7.5V ~ 9V DC @
1500 mA ~ 4000 mA

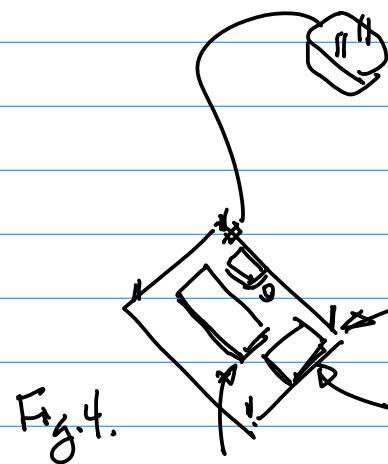


Fig.4.

Prototype System.

a. Prototype Board

c. LCD Display

b. LPC1769 CPU module

Build Option 2 Power Unit Circuit is required now, Before the first Project.

Components for the Power Unit

① Wall-mount Adapter.

Spec. 7.5 ~ 9VDC

1500 mA ~ 4000 mA.

Or Battery Pack.



Fig.5

② Red LED indicator, to Show Power is on/off.

$V_{LED} \approx 1.2 \text{ VDC}$; $8 \text{~} 10 \text{ mA}$

③ Power Regulation IC 7805, or 1117.

Fig 6



STMicroelect
L7805CV ...

\$0.63
Digi-Key

Note: 78xx family
7812, 7805 etc.

- 3-Terminal Regulators
 - Output Current up to 1.5 A
 - Internal Thermal-Overload Protection
- KC (TO-220) PACKAGE (TOP VIEW)

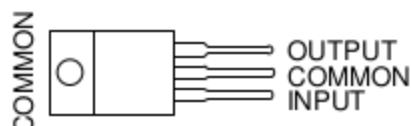
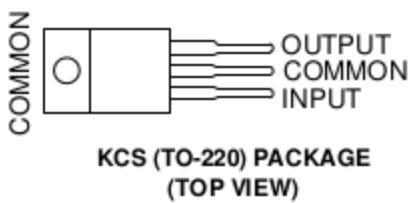


Fig. 9.

Lecture Notes is 2022S-101n
in the class github.

2022S-101-accessible_CMPE240-HarryLi.pdf

2022S-101-Notes-2022-01-26.pdf

μ A7800 SERIES POSITIVE-VOLTAGE REGULATORS

SLVS056J – MAY 1976 – REVISED MAY 2003

(4) Right Angle (plng) Connector



Kobiconn
151-7620E-E DC
\$1.14
Mouser Electronics

(5) Assorted Resistors (A few hundred ohms to a few Mega Ohms).

(6) Compensating Caps.

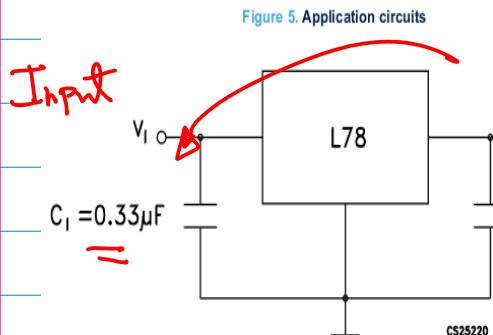


Fig. 7

Components for GPIO

Use GPIO "Hello, the world"
for Debugging | Input { "0"s
| Output { "1"s
} }
} }
} }
} }

Feb and (Wed)

Today's Topics:

1° Bill of Material

2° CPU Datasheet, Architecture

options for the target platform.

(LTC1769)

Note for STmicro
the Caps Required are
Z.

a. NVIDIA (Nvidia) Jetson NANO

Caution: Device Driver Programming
in U.S. Kernel Space.

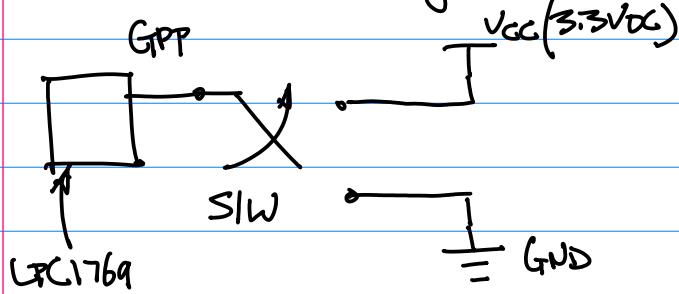
5% Bonus: Implementation at
Registers/Hardware Level, LCD

Fig. 8

LCD has to the Same SPI I/F
for NAB & LPC1769.

GPP I/O Output Testing.

Example: GPIO I/O Testing Circuit



GPP: General Purpose Port,
Same as GPIO.

Fig 1.

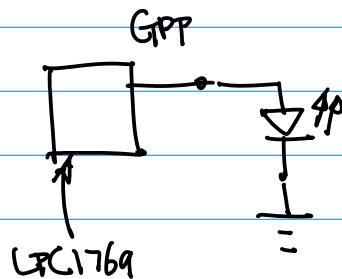
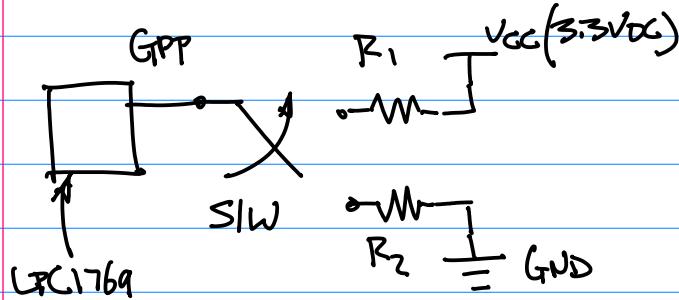
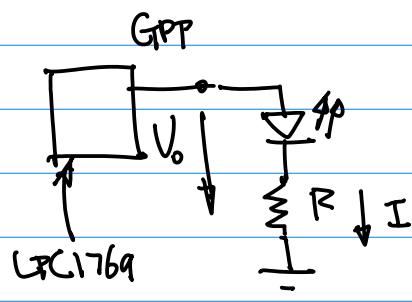


Fig 2



Better Design.

Fig 6.

Consider Resistor Value Calculation

$$V_{CC} = 3.3VDC, V_{out} = 3.3VDC \\ (\text{GPP})$$

Select Resistor Value to Regulate
the Amount of Current $\sim 10mA$

$$\text{Hence, } R_{1,2} = \frac{V_{CC}}{10mA} = \frac{3.3}{10 \times 10^{-3}} \\ = 3.3 \times 10^2 \Omega.$$

Calculation of the Resistor

$$V_o = V_{LED} + IR$$

... (1)

$$V_{LED} \approx 1.2V, I = 10mA, V_o = 3.3V \\ (\text{CMOS})$$

Substitute the

above Conditions into Eqn(1),

$$3.3 = 1.2 + R \times 10 \times 10^{-3}$$

$$R = \frac{2.1}{10^{-3}} = 2.1 \times 10^2 = 210 \Omega$$

Note: please use right size of the
prototype wire
 $26 \sim 30 \text{ AWG}$.



Striveday™ 26 AWG 100ft
amazon.com



Wire - 200m 30AWG Blue

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Note: Optional — Right Angle

RJ-45 Connector: (8 pos)
(Female)



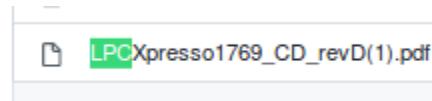
Modular Jack
8P8C PCB ...

\$0.69
PEconnecto...

1. Exercise: Bring your Prototype Board together w/LPC1769 CPU module to the next Class.

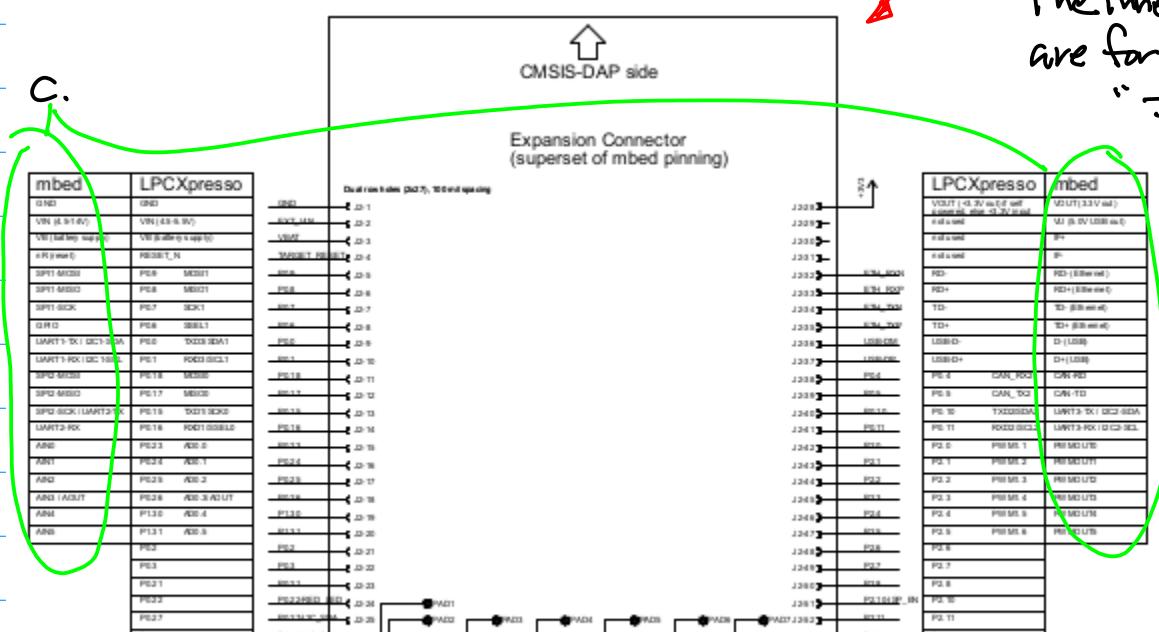
2. Form 4-Person Team, have a Coordinator, And report your team formation By next Class.

Example: LPC1769 CPU module Schematics



a. CPU module and Schematics in b.
c. LPC1768 mbed.

b. The inner tables are for 1769.
"I/O Rich"

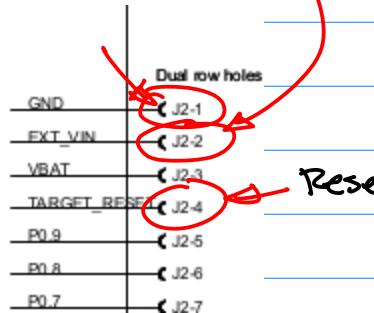


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Exercise: How many GPIO pins?
(for LPC1767 module)

Example: Power Input to LPC1769

LPCXpresso	
GND	
VIN (4.5-5.5V)	
VBAT	
RESET_N	circled
P0.9	MOSI1
P0.8	MISO1
P0.7	SCK1



Note: Enumeration of the Connector
pins → the first pin is
marked as "1".

Note: physical mapping of the pin
to Actual module ;

Note: Reset pin — provide
Access to this pin in your
Prototype design.

CPU Datasheet from github / ~lcmpe244

2021F-107-lpc-cpu-UM10360.pdf

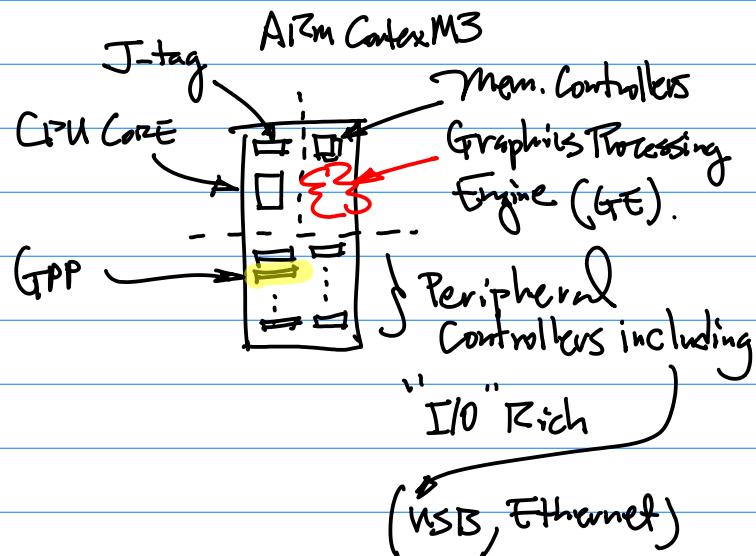
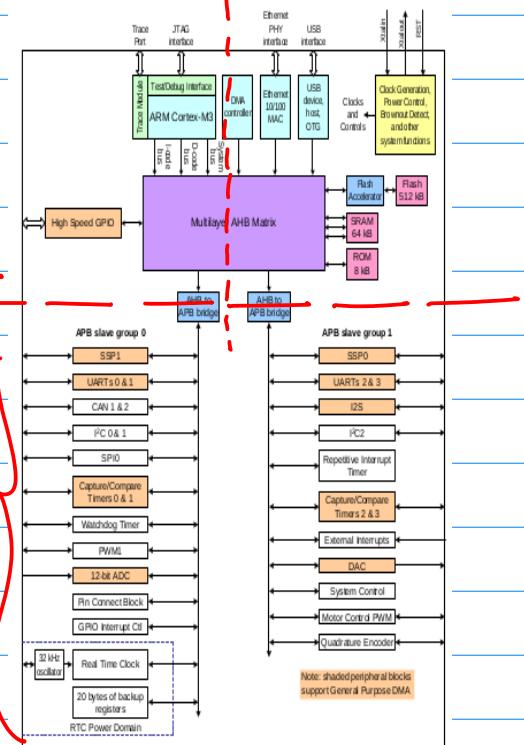
Feb 7 (Monday).

Today's Topics 1° CPU Datasheet
+ Schematics ; 2° Hardware

Design for the Prototype System.

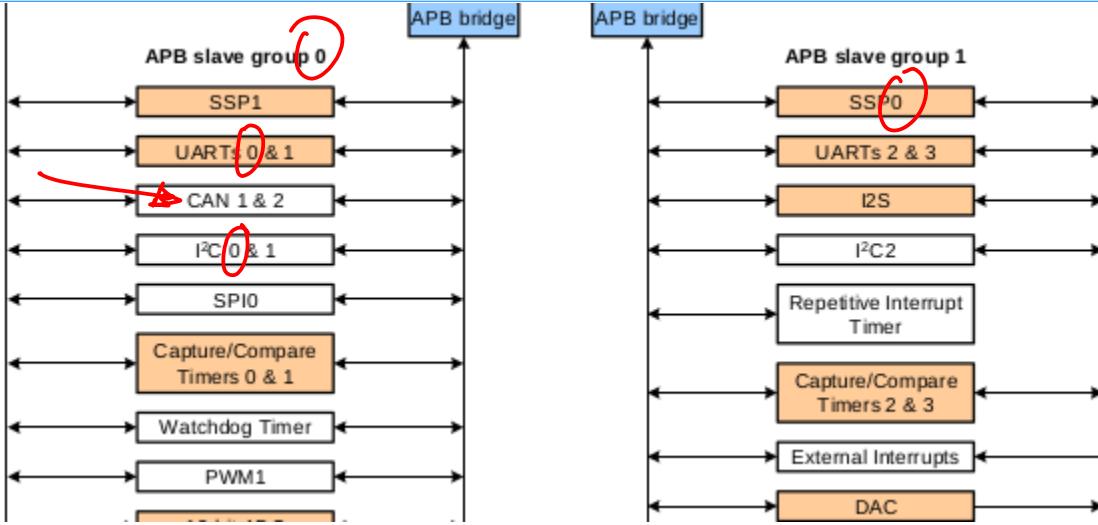
Example: Build "Hello, the world" for
the prototype system.

Step 1. CPU Architecture, PP.9 ≠ 12



Select GPP (General Purpose Port) to Build
GPIO I/O to Realize "Hello, the world"
function. (with Input Testing / Output Testing
Circuit)

Note: Peripheral Controllers

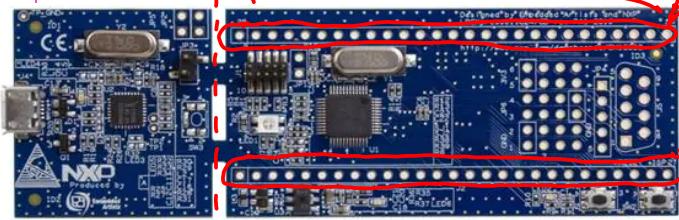


Step 2: Map the GPP to its physical Board, e.g., CPU module.
Hence, we need schematics.

from the Class github.

a. from the schematics,
identify the first
pin, e.g., J2-1

Do the same of your physical
CPU module. J2 connector
CPU module



Interface to the host

LPCXpresso

GND	J2-1
VIN (4.5-5.5V)	J2-2
VB (battery supply)	J2-3
RESET_N	J2-4
P0.9	J2-5
P0.8	J2-6
P0.7	J2-7
P0.6	J2-8
P0.0	J2-9
P0.1	J2-10
P0.18	J2-11
P0.17	J2-12
P0.15	J2-13
P0.16	J2-14
P0.23	J2-15
P0.24	J2-16
P0.25	J2-17
P0.26	J2-18
P1.30	J2-19
P1.31	J2-20
P0.2	J2-21
P0.3	J2-22
P0.21	J2-23
P0.22	J2-24
P0.27	J2-25
P0.28	J2-26
P2.13	J2-27

Dual row holes (2x27), 1:

a.

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Step 3. Select 2 GPIO pins

One for Input Testing Circuit, P0.2 Input, P0.3 Output Table 1.

The other for Output Testing Circuit.

Connectivity & Pin Assignment Table
3 col. format

P0.26	AD0.3/AOUT
P1.30	AD0.4
P1.31	AD0.5
P0.2	
P0.3	
P0.21	
P0.22	
P0.27	
P0.28	
P2.13	

Connector Pin

CPU/Connector Pin	Description	Notes
P0.2/J2-21	GPIO Input	
P0.3/J2-22	GPIO Output	

GPIO pins, CPU Naming.

CPU Datasheet for General Purpose Port

TP117

pin. For other functions, the direction is controlled automatically.

Table 80. Pin function select register 0 (PINSEL0 - address 0x4002 C000) bit description

PINSEL0	Pin name	Function when 00	Function when 01	Function when 10	Function when 11	Reset value
1:0	P0.0	GPIO Port 0.0	RD1	TXD3	SDA1	00
3:2	P0.1	GPIO Port 0.1	TD1	RXD3	SCL1	00
5:4	P0.2	GPIO Port 0.2	TXD0	AD0.7	Reserved	00
7:6	P0.3	GPIO Port 0.3	RXD0	AD0.6	Reserved	00
9:8	P0.4	GPIO Port 0.4	I2SRX_CLK	RD2	CAP2.0	00
11:10	P0.5	GPIO Port 0.5	I2SRX_WS	TD2	CAP2.1	00
13:12	P0.6	GPIO Port 0.6	I2SRX_SDA	SSEL1	MAT2.0	00
15:14	P0.7	GPIO Port 0.7	I2STX_CLK	SCK1	MAT2.1	00

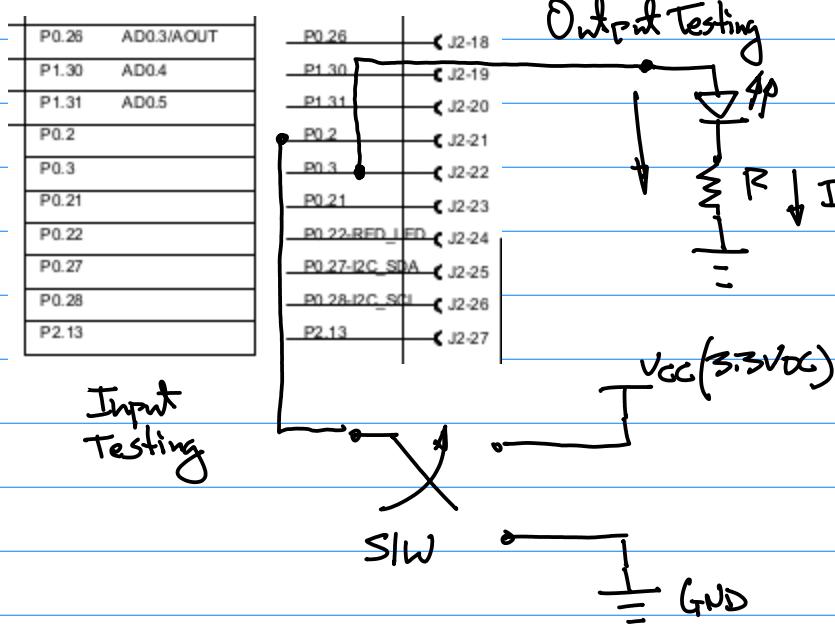
PINSEL0 Special Purpose Register

$$\text{PINSEL0}[5:4] = \begin{cases} 00 & \text{GPIO} \\ 01 & \text{TX} \\ 10 & \text{ADC} \\ 11 & \text{Not used.} \end{cases}$$

2 bits @ Bit 4 & 5

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PP14.

Framework: The A week from today
(Feb 14).

1° Draw Schematic Design for
GPIO Testing.

2° Take a photo of your prototype
Board. To Capture the work-in-progress

3° Combine 1° & 2° into One Pdf,
then Zip it. Submit your
Work online to SJSU CANVAS.

Consider GPU Architecture Discussion.

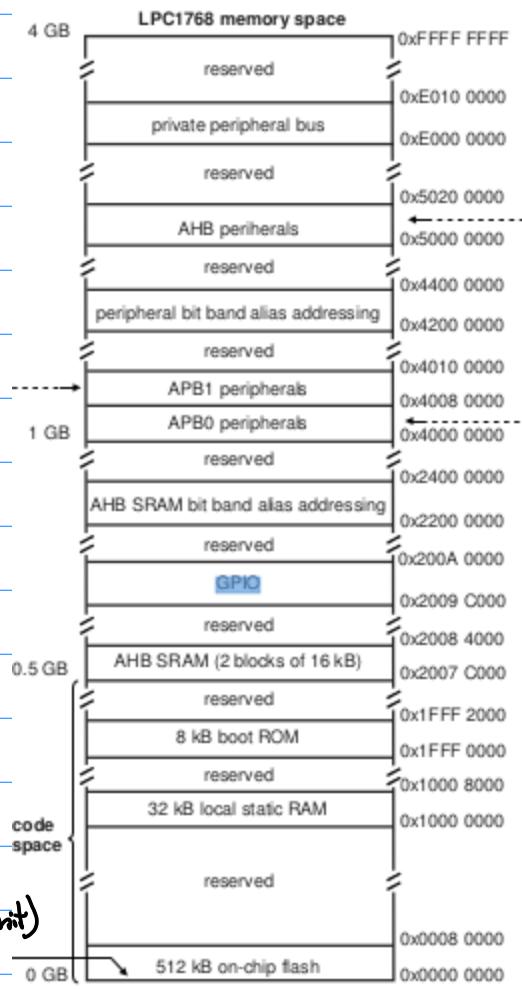
Example: GPU Block Diagram →

Memory Map.

1. 32 Bit Architecture

ALU (Arithmetic Logic Unit)
R.F. (Register files),
Bus System, Data ~, Addr. ~

Bank of Registers, 32 bit
32 bit

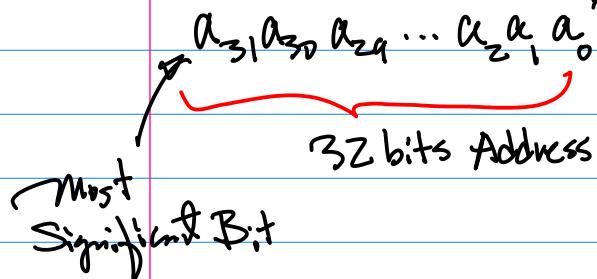


Cmpe240 Spring 22

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2. Addr. Bus 32 Bit.

Least Significant bit (Little Endian)



"Little Endian" v.s. "Big Endian"

Step 2

To set up the IDE Development Environment to match your target platform.

Feb 9 (Wed) Today's Topics :

- 1° CPU Architecture ;
- 2° MCU Xpresso, IDE, GPIO Testing Program.

Example: Compilation & Build

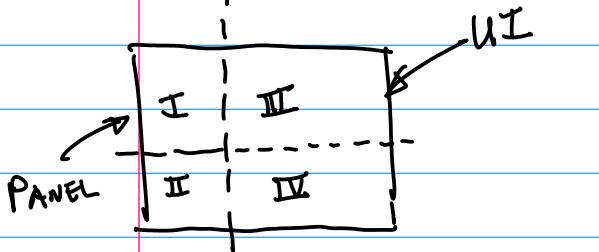
First Firmware Program for GPIO I/O Testing.

Note: Visit NXP website, Sign up to become a Developer.

Download MCU Xpresso.

Version 11.3.0

Start your JDE XPRESSO.



Project Panel (I):

Import LPC1769 patch from Z4D Class github.

1769 patch.zip

on11.10.Guidelines for Devs

Step 3

2018S-11-GPIO-2015-1-30.zip

Import GPIO Project (Sample code) for your Homework.

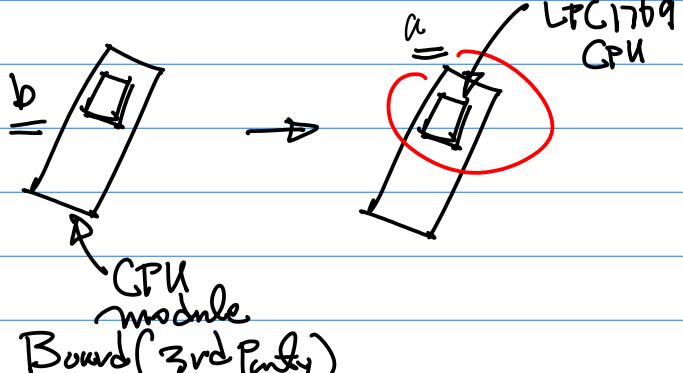
Step 4. Build & Execute GPIO Sample Project

Highlight GPIO Project at the Project Panel → Move to

Quickstart Panel, click on "Build" to Build it.

Step 2

To set up the IDE Development Environment to match your target platform.



Go to "Quickstart" → Panel to Import LPC1769 Patch, And projects

Note: There are several projects, pre-tested for your references purpose, including C/C++, SRI, etc.

Note: If not the first time, then Click on "Clean" to Clean it.

Step5 Flash/Writes to FLASH

Memory, then executing the Program Step by Step (or Execute the entire program).

Note: For Debugging, you will need to make sure the JDE Setting is for "Semi-Host", e.g. your host Laptop will be allowed communication to the Board During Debugging process. However, when doing deployment, choose "host" settings instead in the Board Configuration.

Homework: (Due 1½ weeks from Today)

Feb21, Monday 11:59 pm.

1. Build A Prototype System for GPIO Testing, Interrupt Testing.

2. Provide Schematic Drawing.
Use the tool of your preference.

3. Take a photo showing LED on And Entire System (Prototype + Host with USB Link)

4. Provide modify C code as a Separate file.

5. Put Everything into One pdf Except C code.

6. Zip the Submission, use Naming convention

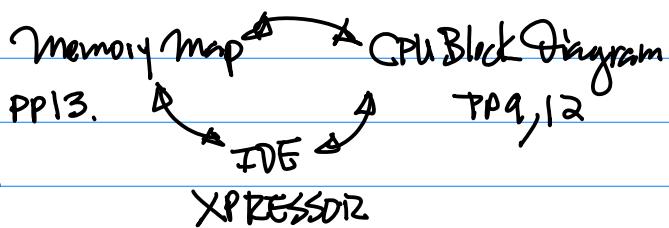
7. First Name - Last Name - SID - GPIO.ZIP
Submit to CANVAS.

Feb14 (Monday)

Today's Topics: 1° CPU Architecture

Base Reference: CPU Datasheet
from the class github/fkualili/cmpe240

Z02/F-17 ~



Examples: Continuation of the Theoretical Discussion

1. CPU Core, Cortex M3.

ARM CPU Belongs RISC.

Reduced Instruction Set Computer

General Design Guidelines

{ Uniformity

Regularity

Orthogonality

2. 32 Bit Architecture

Bus System (Address, Data, Control)
32 bits
R.F. (Register File)
32 bits

T.C.F.
BANK of Registers
32 bits

General Purpose

Registers : Those Registers that can Participate Any Meaningful Arithmetic/Logic Operations

Special Purpose

Registers : With Special Dedicated Functions, such as init/Config of Peripheral Controller.

ALU, 32 bits

(Arithmetic/Logic Unit).

3. Memory Map.

Question : How many individual memory address are there for 32 Bit Architecture?

$$2^{32} = 2^2 \cdot 2^{10} \cdot 2^{10} \cdot 2^{10} = 4 \text{ G}$$

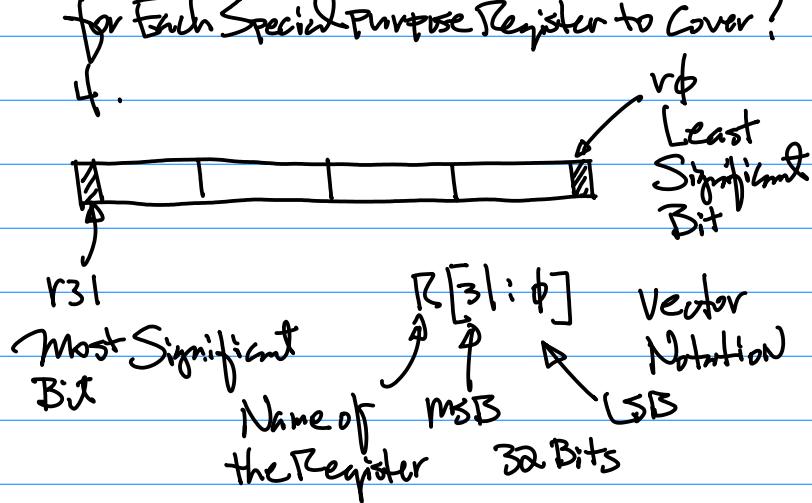
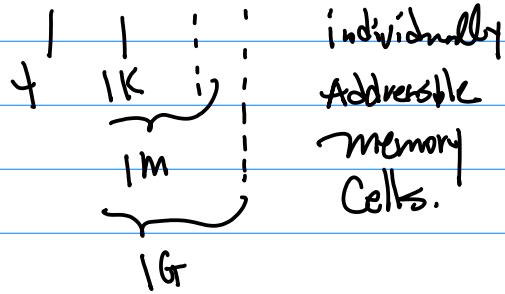


Fig. 1

4. Byte Addressable Machine

Those Machines whose Smallest memory cell with an unique address is a Single Byte.

1. Byte Addressable Machine

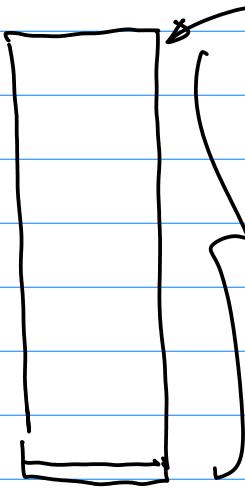
Question : What is the unit for the memory cells mentioned

Above in Question 1? A Byte.

Therefore, 32 bit Architecture \rightarrow 4 G Bytes

0x0000-0000

1st mem. cell



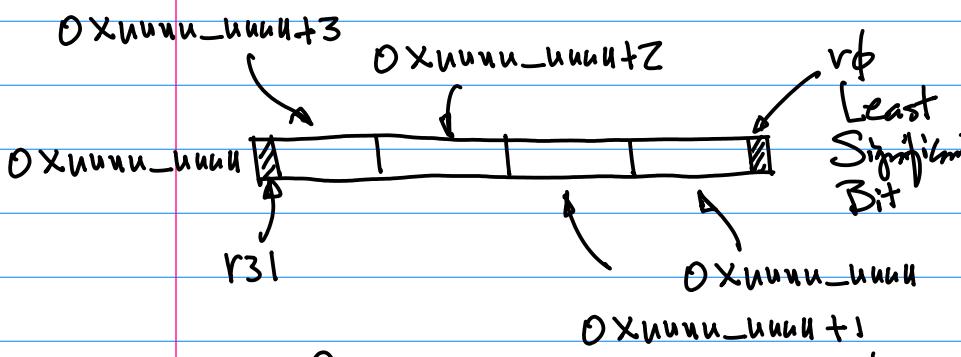
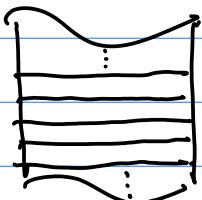
$$2^{32} = 4 \text{ G (Bytes)}$$

Fig. 2

5. Power-up Address : ~ when the CPU is Powered up, it fetches the 1st executable

1st Executable instruction from this memory location.

Now, For A Special purpose Register illustrated Below, it occupies 4 Bytes in a memory block



A Special Purpose Register covers 4 Address, Suppose the smallest Addr. is x , then, we have

$x+1, x+2, x+3$ 3 Additional

Addr. for the Special Purpose Register

b. Divide memory map into 8 Equal Banks.

$$2^{32} / 8 = 2^{32} / 2^3 = 2^{29} = 2^9 \cdot 2^{20} = \\ 512 \text{M (Byte)} \quad 1 \text{M}$$

the size for Each Memory Bank.

Feb 16 (Wed)

Topics: 1° CPU Architecture Discussion
2° Prep. for the Project of Building
3D G.P.U (Graphics Processing)

Example: Continuation of our Previous Discussion.

1. Eight Equal Banks

a. 1st Bank: BANK0
Last Bank: BANK7

b. BANK0 holds the power up Address \rightarrow Boot Process
 \downarrow
Boot Sequence

0x0000_0000

c. a_3, a_2, a_1 (3 Consecutive Bits to define each Mem. Bank)

Question: which 3 bits from the Addr. Bus Does one need to uniquely define Each Mem. Bank?

3 most Significant Bits $\rightarrow a_3, a_2, a_1$

$a_3, a_2, a_1, \phi, \phi, \phi, \phi, \dots, \phi, \phi, \phi$

Don't Cares

d. Defining Starting Addr. for Each Mem. Bank

$a_{31} \ a_{30} \ a_{29} \ | \ a_{28} \ a_{27} \ \dots \ a_1 \ a_0$

$0 \ 0 \ 0 \ | \ 0 \ 0 \ \dots \ 0 \ 0$

$0 \ 0 \ 1 \ | \ 0$

$0 \ 1 \ 0 \ | \ 0$

\vdots

$1 \ 1 \ 1 \ | \ 0 \ 0 \ \dots \ 0 \ 0$

BANK0 (1st)

BANK1 (2nd)

BANK2 (3rd)

Starting Address

0x0000_0000

0x2000_0000

0x4000_0000

BANK7 (8th)

0x8000_0000

Example: Find memory Bank which holds (a) SPI Port
(b) GPP Port?

Sol: (Option 1). From GPU Datasheet,
Memory map.

GPID Block Starting Addr.
0x2009_C000 ;

Option 2: (more in-depth information)

GPP Peripheral controller \rightarrow

Special Purpose Registers \rightarrow Configuration
DR Control Register
 \rightarrow To Config And Init

Addr. of the Register

\leftarrow
GPP Peripheral Controller

FIDIR (Fast I/O Direction defining

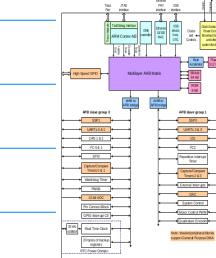
Register, e.g.: Define Input/Output
Direction)

2nd Memory Bank starting Addr: 0x2000_0000

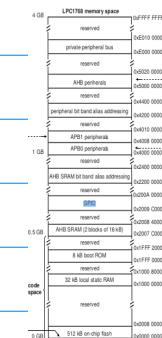
3rd " " " " " : 0x4000_0000

Therefore GPP port is within Bank 1 (2nd Bank)

GPU
Architecture
Block Diagram



\rightarrow memory map



IDE Xpresso

Fig. 1

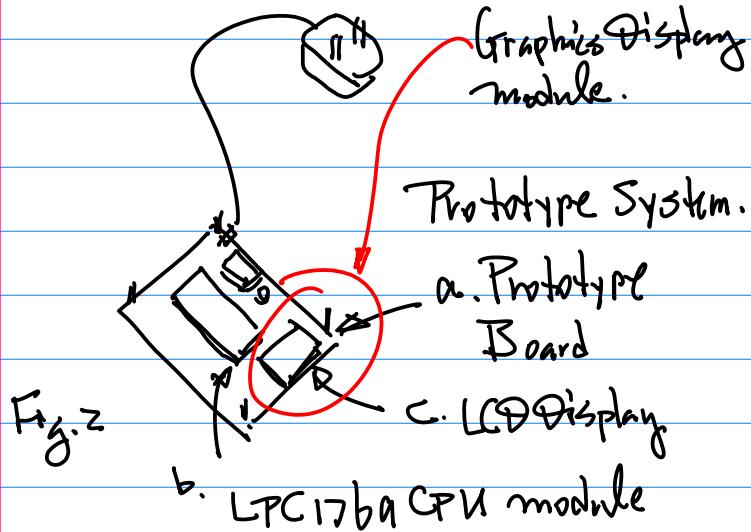
Consider 2D Graphics Engine Design.

Phase I: Design & Realize
Display Function By Hardware-Software Co-Design.

Phase II: 2D Vector Graphics Processing Engine.

Phase I Design / Implement

Graphics Display module



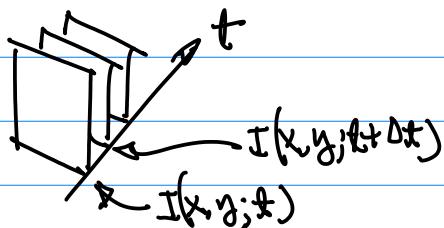
1024x768 Comparable to TZOP.
Color Image 24 bits for Each pixel
"pixel Depth"
bpp (Bits per pixel)
30 FPS (Frames per Second)
To find Bit Rate (Total Bits per Second)
 $1024 \times 768 \times 24 \times 30$

(PP.3)

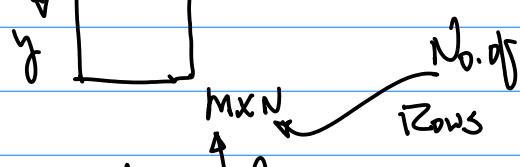
Design Guideline:

1° SPI Interface (Serial Peripheral Interface) to provide Adequate Bit Rate. $50 \text{ mbps} \approx 100 \text{ Mbps}$

Example: Suppose we have to display a video/graphics,
(Pixel graphics)



Resolution: $M \times N$ (0,0) Fig. 3



TZOP, 1080p High Resolution

Feb 21 Monday

Note: 1° Next Lecture, Feb 23rd,
Show & Tell, Inspection of your Prototype Board (One person on Board).
2° Form 4 Person Team, Update the Status.

Example: Continued from the previous Example.

$$1024 \times 768 \times 24 \times 30 = 2^x ?$$

$$1024 \times 768 \times 24 \times 30$$

$$\vdots \quad \vdots \quad \vdots \quad \vdots$$

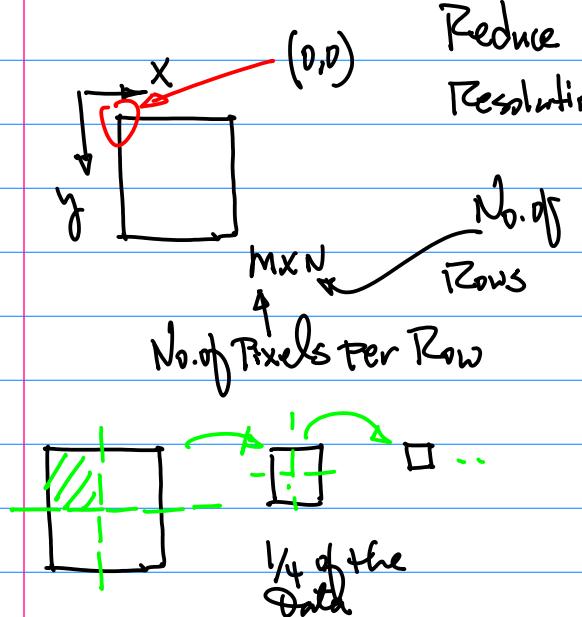
$$2^{10} \quad 2^{10} \quad 2^5 \quad 2^5 =$$

$$2^x = 2^{10} = 1024$$

$$2^x = 2^9 = 512 \quad 768$$

$$2^{10} \quad 2^{10} \quad 2^5 \quad 2^5$$

$$= \underbrace{1K \cdot 1K}_{1m} \quad \underbrace{1K}_{1K} = 1 \text{ Gbps}$$

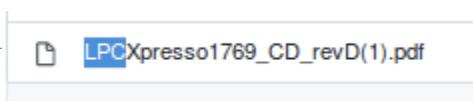


1. SPI Hardware Interface requires 4 pins, "3+1" pins
Names:
 Output pin MISO Master Output
 Input pin MOSI Slave Input
 Clock pin SCK ~ Input ~ DP
 plus "Enable" pin SSEL_X
 move than ONE SPI.

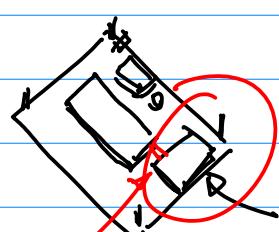
Table 1. SPI pin Assignment

Name	Pin CPU/Connector	Note
MOSI	P0.9 / J2-5	
MISO	P0.8 / J2-6	
SCK	P0.7 / J2-7	
SSEL	P0.6 / J2-8	

Example: Start SPI I/F Hardware
Discussion First.



LPCXpresso	
GND	
VIN (4.5-5.5V)	
VB (battery supply)	
RESET_N	
P0.9	MOSI1
P0.8	MISO1
P0.7	SCK1
P0.6	SSEL1
P0.0	TxD3/SDA1
P0.1	RxD3/SCL1
P0.18	MOSI0
P0.17	MISO0
P0.15	TxD1/SCK0
P0.16	RxD1/SSEL0
P0.23	AD0.0



SPI Interface

Fig. 1. Identify the Right Suitable LCD module.

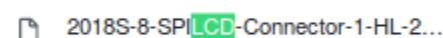
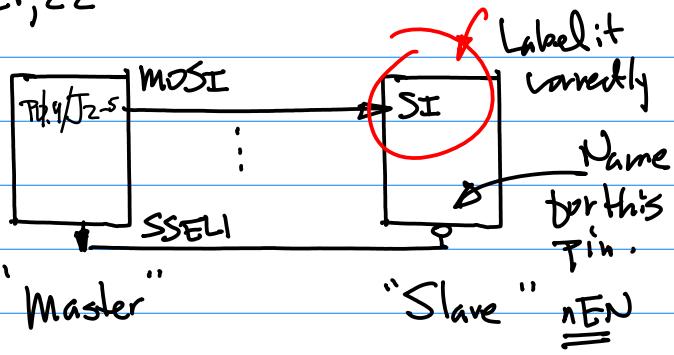
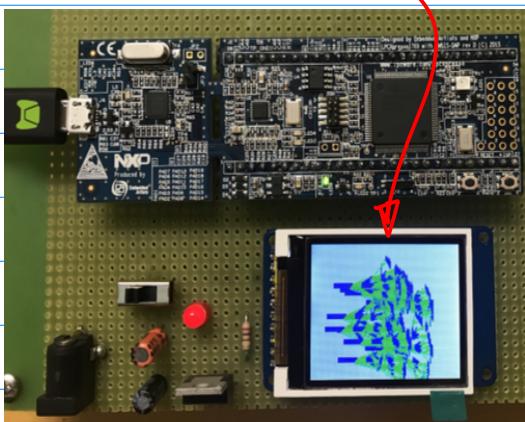


Fig. 2

CMPE240

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LCD Sample module



Pin Connectivity Table for Schematic Design.

2018S-9-SPILCD-Connector-1-HL-2..

LPC-1769		LCD
Label	Pin	
MOSI	P0.18	SDA
MISO	P0.17	MISO
SCK	P0.15	SCL
CS	P0.16	TFT CS
GPIO-DC (Data / command)	P0.21	AO
GPIO-Reset	P0.22	RST
3.3V		LED+
GND		LED-

Reference: CTI One Corporation

Note :

Bit Rate for 30 FPS, and

18 bit Pixel Depth

- LPC 1769

- Color TFT LCD display

Resolution: 128x160

Pixel Depth: 18-bit (262 144) colors

Controller: ST7735

Interface: SPI interface

The Base to Build
Connectivity Table for
LCD module

Exercise: Connectivity
Table for LCD, use
the following Table format

Name	Pin CPU/Connector	Note
SI	MOSI Pin 9/J2-5	Serial Input for LCD
	MISO Pin 8/J2-6	Pin Name
	SCK Pin 7/J2-7	Pin Number of the CPU module
	SSEL Pin 6/J2-8	provide Pin Number of the LCD module

Note 1. Defining which Device is "master",
which Device is a "Slave".

In our case, CPU (LPC1769) is a master

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Interface Signals on LCD (General
Guidelines)

{ SPI Signals
Control Backlight
Toggle Data/Command