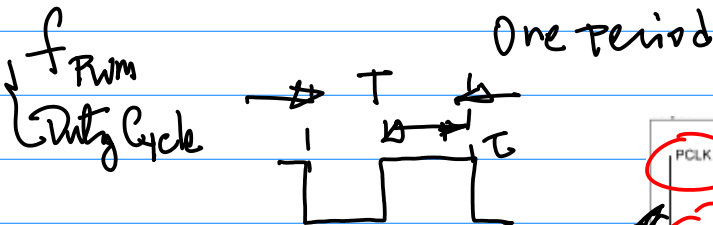March 16 (Wed)

Topics: 1° PWM Architecture/Hardware
Aspect — Waveforms,
Timing Diagrams, SPRs
2° LSM 303 Sensor I2C

Example: PWM Discussion.

f_{PWM}
{ Duty Cycle

One Period

T ← → τ

Duty Cycle = $\frac{\tau}{T}$ ... (1).

Square Wave: D.C. = 50%.

Architectural Aspects:

📄 2021F-105-#0-cpu-arm11-2018S-29-...

6410X_UM

P1106

32
PWM TIMER

This chapter describes the functions and usage of PV
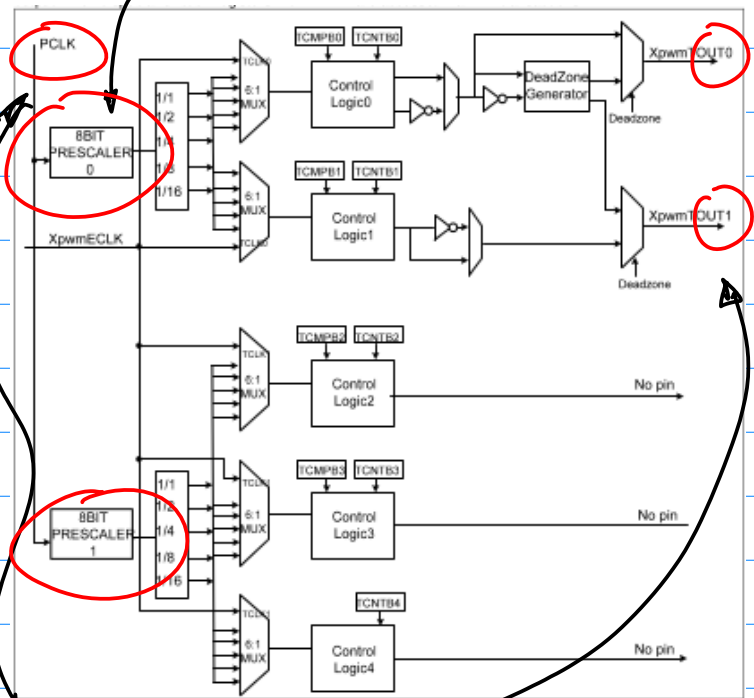
C. Prescaler for f_{PWM} Config
8 bit

P1107

Figure 32-1. PWMTIMER Clock Tree Diagram

a. Input: PCLK peripheral clock.
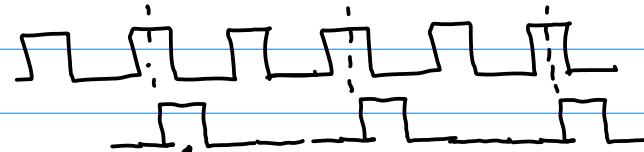$\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, ...$, of the System Clock
b. Output (2 outputs)

d. Special Purpose Registers

{ CONF (Configuration Register)
CNT (Control — "Count")
CMP (Comparision)

→ define f_{PWM} & Duty Cycle.

Note: Background on Counters.

Count By 2

Expand this to A counter for Both
integer Number & Fractional Number
(in General) → f_{PWM} (for interger Only)
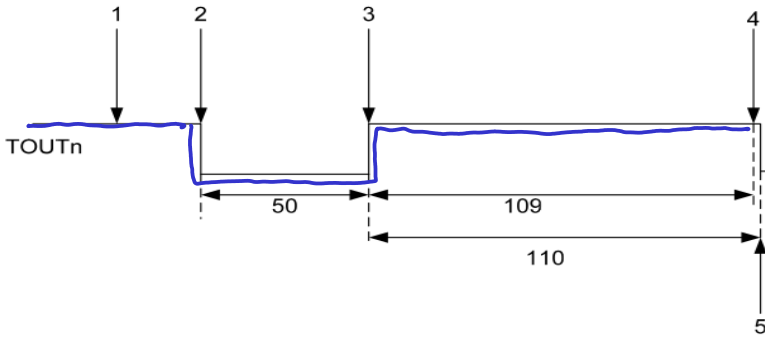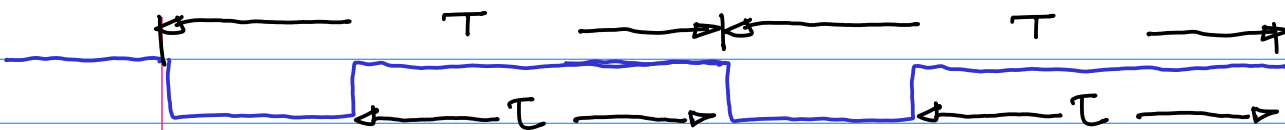then, use Another Counter to get Duty Cycle.

TOUTn

50   109

110

Figure 32-2. Simple Example of PWM Cycle Block Diagram

T T
τ τ

$$T = 1/f_{PWM} \cdots (2), \quad f_{PWM} = \frac{PCLK}{(Prescaler+1)DIV} \cdots (3)$$

Frequency = PCLK / ({prescaler value + 1}) / {divider value}

$$Suppose \ PCLK = \frac{1}{4}(System\ Clock) = \frac{1}{4}(800 \times 10^6)$$

$$= 200 \times 10^6$$

Defined By Special Purpose
Register.

Design Guidelines for PWM:

① CNT (TCNTBϕ) Define f_{PWM} ③ CONF Configuration
COUNTRY   Register.
Count   Timer   Buffer ϕ for PWMϕ Defines f_{PWM}

② CmP (TCmPBϕ) Defines Duty Cycle
Comparision

Example: Suppose PCLK = 500×10^6 (mHz),   Find the Counts for TCNTBϕ
   Suppose to Drive A Stepper $\frac{PCLK}{N} = f_{PWM} \cdots (4)$
   Motor f_{PWM} = 2KHz = 2×10^3

$\dfrac{PCLK}{N} = f_{PWM}$, Substitute the design Requirements into it.

$\dfrac{500\times10^6}{N} = 2\times10^3$,

$\therefore N = \dfrac{500\times10^6}{2\times10^3} = 250\times10^3$

Verify if TCNTB0 can hold up to that Number

PP 1117

32.4 SPECIAL FUNCTION REGISTERS

32.4.1 REGISTER MAP

Register	Offset	R/W	Descrip
TCFG0	0x7F006000	R/W	Timer Configuration Registe two 8-bit Prescaler and Dea
TCFG1	0x7F006004	R/W	Timer Configuration Registe and DMA Mode Select Bit
TCON	0x7F006008	R/W	Timer Control Register
TCNTB0	0x7F00600C	R/W	Timer 0 Count Buffer Regis
TCMPB0	0x7F006010	R/W	Timer 0 Compare Buffer Re
TCNTO0	0x7F006014	R	Timer 0 Count Observation
TCNTB1	0x7F006018	R/W	Timer 1 Count Buffer Regis

2^{32}

32.4.1.4 TCNTB0 (Timer0 Counter Register)

Register	Offset	R/W	
TCNTB0	0x7F00600C	R/W	Timer 0 Count I

Conclusion: 5-Steps operation of PWM. Can be described as (1) Count By N with Eqn (4), PP3. , And deposit
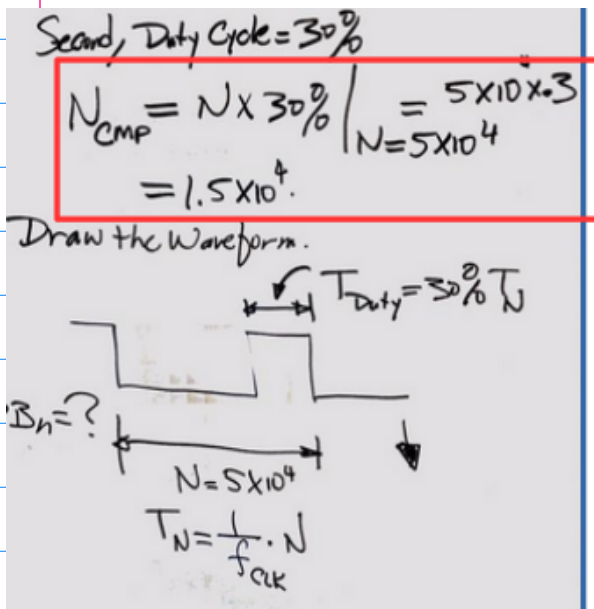
N into TCNTB0; (2) Deposit Count M into TCMPB0, where $M = (D.C.) \times N$ ... (5)

(3) The Down Counting will decrement TCNTB0's count by 1 at a time, And a Comparison is made to TCMPB0, if matched, then trigger the Output to "1", Down Counting continues till the Count in TCNTB0 = 0 One period is reached. Then Repeat this process.

Example: Suppose CLK = 50 MHz. Design Implementation Technique to produce $f_{PWM} = 1000 Hz$, to Drive Stepper motor Controller, in addition, Duty Cycle is 30%.

Feb. 21. 2/.

Find: (1) $TCNTB_n = ?$; (2) Find TCMP

S) First. find the Counts N Based on the given condition.

$\left. \dfrac{50\times10^6}{N} = f_{PWM}, \right\}$ ... (1)

$N = \dfrac{50\times10^6}{1\times10^3} = 5\times10^4 \rightarrow$ Hex $\Big|_{f_{PWM}=1000}$

TCMPBn

$TCNTn$

Second, Duty Cycle = 30%

$$N_{cmp} = N \times 30\% \Big|_{N = 5 \times 10^4} = 5 \times 10^4 \times .3$$

$$= 1.5 \times 10^4.$$

Draw the Waveform.

$T_{Duty} = 30\% \, T_N$

$B_n = ?$

$N = 5 \times 10^4$

$$T_N = \frac{1}{f_{CLK}} \cdot N$$

March 21 (monday)

Midterm on 23rd (Wed).

1 hr. Exam, + 15 min.

Review on Midterm.

3 Questions.

1. A question on Basic Concepts.
   1. CPU Architecture
      32 Bit Architecture
   a. Memory Map. Banks,
   b. GPP/IO Peripheral Controller.
   c. SPRs. Naming, functions.
      GPxCON, GPxDAT
      Tech. Spec ⟶ Binary Pattern
   d. ARM 11 Reference, Code
      User Space, Kernel Space
   e. Target Platform, NAND,

Software Side ⟶ { O.S. distribution.
Tool Chain,
menu config. }

f. SPRs in Driver Code.
   GPIO user program.
   { fd = open(" ⟶ ");
     ↳ Path/Driver
     ioctl ( ); }
   Kernel Space Program Sample
   GPECON, etc ⟶ CPU
                     Datasheet

g. GPIO Testing. { I/P Testing
                    O/P Testing.

Ref:
⟶ 2022S-101-notes-cmpe242-3-14.pdf

PP.9   CKT ⟶ Pin Selection

          gpio 79 (Pin 12)
          gpio 78 (Pin 40)

2.
Question(s) on PIO Controller Design.
   { Hardware   { Motor Drive
     Software   GPP/PWM }

Motor Drive Pin Connection Requirements
Sch., Connectivity Table.

"Demo" Live Execution of
your program.
   i. Board is Ready. Take
   a photo of your Board During
   the exam.
   ii. Stepper motor / motor Drive
And the Prototype Board
Work together, Take a photo,
Screen Capture of Program
execution.

Motor Operation, Micro Steps,
Angular Displacement.

Target Platform. Hardware
Configuration to access device
driver, such as GPIO, PWM
or I2C.

3. Theoretical Aspects of the
PID Controller Design.
   a.   PID Block Diagram.
   P~, PI~, PD, ... etc.
   D(erivative Controller) Short
                Future.
   I(ntegration Controller) history

  b. Computation. Forward Difference,
Backward Difference,
Central Difference.   Kernels,
Computation.

Integration Controller. history
Back N Steps.

  C. Sensor Interface Hardware I2C
    I/F.

  LSM303 I2C Based Sensor.

Example: An Application of
LSM303

vehicle, "skipping"
may occur

Actual Path
Desired Path
Angular error
Lateral error
Reference trajectory
Actual trajectory

Fig 1.

$\underset{\overrightarrow{P_A}}{\alpha}$: from LSM303
: is measurable

$\overrightarrow{P_A}$ X
α } Displacement
Due to Error
$\overrightarrow{P_D}$
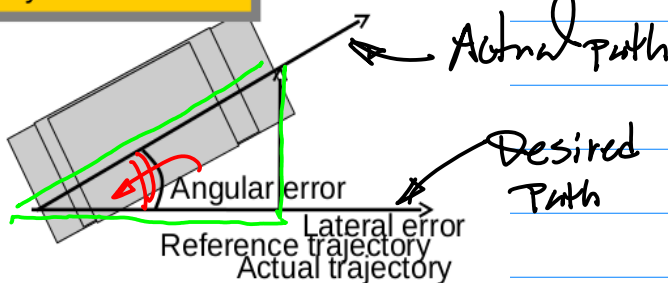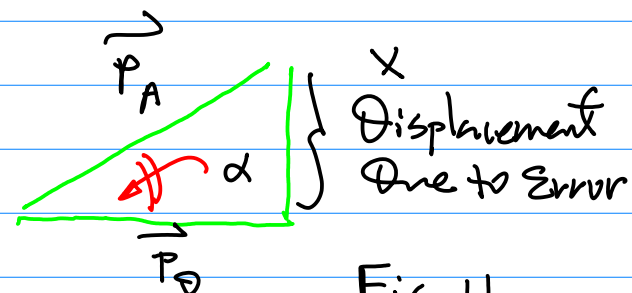
Fig. 1b

CmpE242   March 21, 22

Find $\|\vec{P_A}\|$ is defined by PWM Driven Stepper motor action.

Fig. 3.

X
Displacement Due to Error

$\vec{P_A}$ α

$\vec{P_D}$
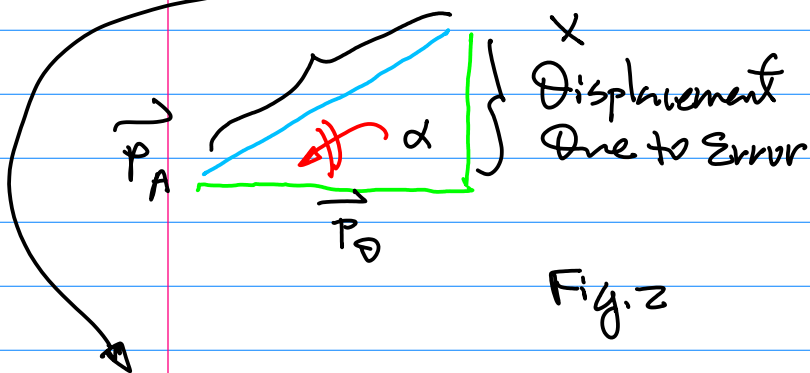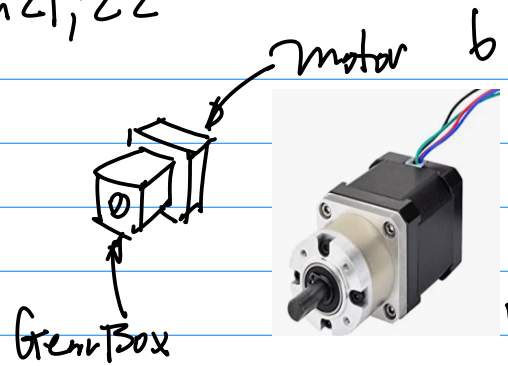
Fig. 2

STEPPERONLINE Nema 17 Geared Stepper Motor Gear Ratio 5:1 3D Printer Extruder Motor DIY CNC Robotics
Visit the STEPPERONLINE Store
★★★★★ ∨   25 ratings
Amazon's Choice in 3D Printer Motors by STEPPERONLINE
$40.05

Reduction Ratio, R_R
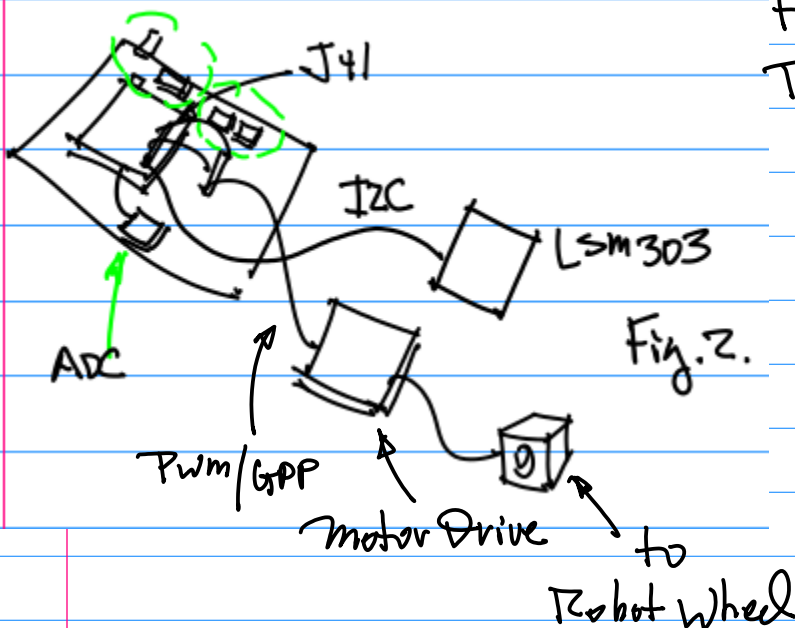
For the purpose of increasing the Torque.
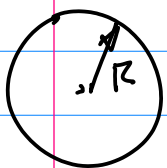

J41

I2C

LSM303

ADC

Fig. 2.

PWM/GPP

Motor Drive

to Robot Wheel

Fig. 4a, 4b With Reduction Ratio. Gear Box.

$.R$ the wheel of the Robot has the dimension R=100mm

Now, Let's take a look at the hardware of the motor Combo.

To find/Establish one-to-one
mapping Between the actual
Path and PWM Operation.

April 4 (monday)
Topics: 1° I2C Interface,
for LSM303 Sensor Integration.

Ref:

I2C Hardware Features
{ Protocol Definition
Coding Implementation

Hardware Features:
1. Pins { SDA: Bi-Directional
           Data Pin. (Signals
SCK: in Both Direction)
Serial Clock.

Speed: ~ 4 mbps, ≤ 10 mbps

2. I2C Bus
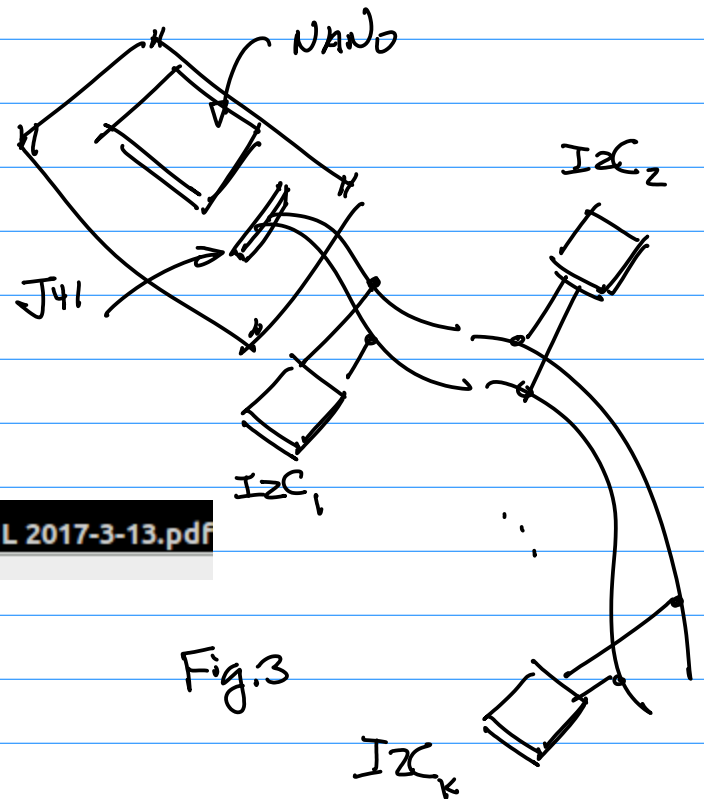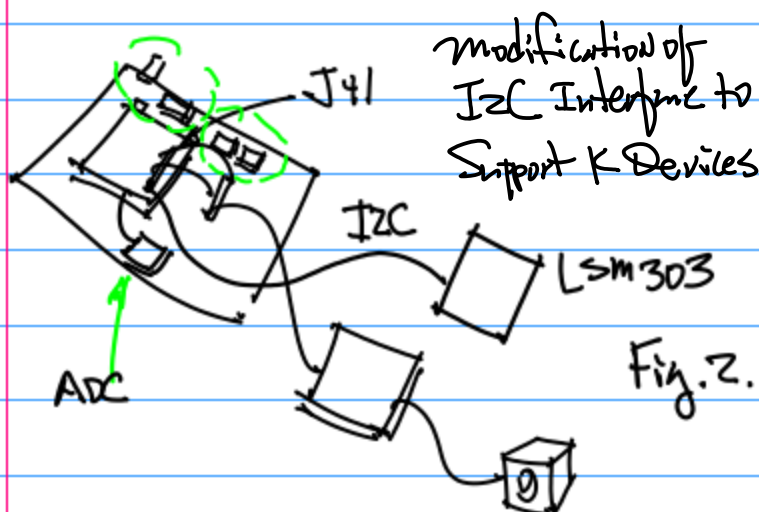

Fig. 3

Sub-Address: 7 bits, $2^7 = 128$ →
K=128 Devices, But in Real
Engineering Design, "FAN-IN", FAN-Out
(e.g. Adequate Electric Current)
have to be taken into Consideration.

Bus Communication { Master
                     Device
                   { Slave
                     Device(s)

NANO
I2C$_2$
J41
I2C$_1$
I2C$_K$

modification of
I2C Interface to
Support K Devices

J41
I2C
LSM303
ADC
Fig. 2.

Ref:

I2C Interface
(1) The transaction started through a START
(ST) signal, defined as a high-to-low on the
data line while the SCL line is held high.
(2) After ST, the next byte contains the slave
address (the first 7 bit), bit 8 for if the master
is receiving or transmitting data.
(3) When an address sent, each device
compares the first seven bits after ST. If they
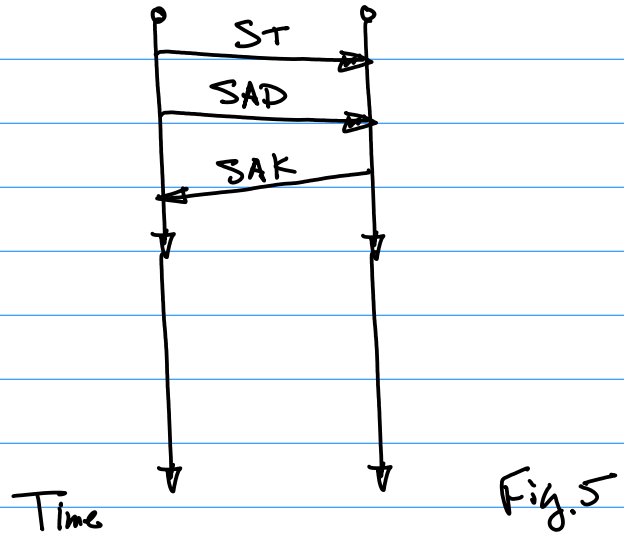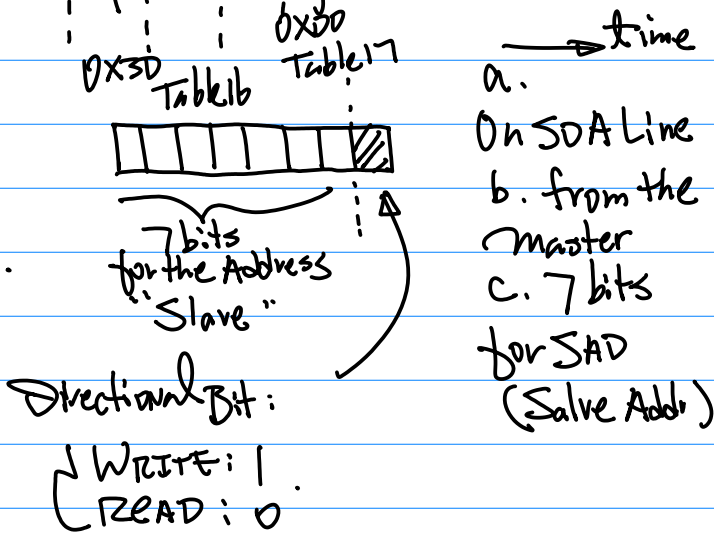match, the device is addressed.

Note t_0 . t_1 t_2 t_3

Table 11. Transfer when master is writing one byte to slave, pp 20, datasheet

Master	ST	SAD + W		SUB		DATA		SP
Slave			SAK		SAK		SAK	

0X30
Table17

0X3D
Table16

Fig 4.

7 bits
for the Address
"Slave"

Directional Bit:
{ WRITE : 1 .
{ READ : 0

a.
On SDA Line
b. from the master
c. 7 bits
for SAD
(Salve Addr.)

→ time

Note : 1° ST Start
2° SAD Slave Address
3° SAK Slave Ack.

Question: SAD for LSM303
a.   b. SAD[7:1]
PP.20

Table 14.   SAD+Read/Write patterns

Command	SAD[7:1]	R/W	SAD+R/W
Read	0011001	1	00110011 (33h)
Write	0011001	0	00110010 (32h)

0011001X
3   (1) 0011 Read : 3
     (2) 0010 Write: 2

0X33   Read
0X32   Write
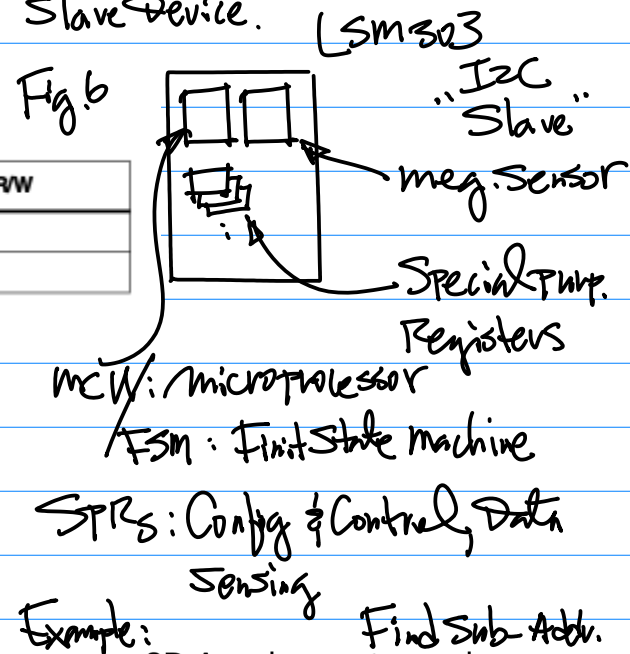
Note: Read Op is very often the 1st
One from the master. to get
Manufacturer's ID & Device ID etc.

Note: Space-Time Diagram.
→ Space   Spatial
Target (NAND) "Slave"
I2C master   LSM303

ST
SAD
SAK

Time   Fig.5

And on t_3 : SUB Sub-Slave-Addr.
to Address the unit inside the
Slave Device.   LSM303
                  "I2C"
Fig.6   "Slave"

meg. Sensor

Special Purp.
Registers

MCU: microprocessor
FSM : Finit State machine
SPRs : Config & Control, Data
                Sensing
Example :   Find Sub-Addr.

3D Accelerometer and
3D Magnetomete LMS303

Ref: Slide 7.   a. Sub-Addr. for
                         Magnetic Sensor

2. identify control register(s) for the right sensor
block with the sub-address to set data rate
(1) CRA_REG_M register (0x00) to set data rate

Control/Config Register's Address: 0X00
                            "SuB"
For Magnetic Sensor.

Table 16.   SAD

Command	SAD[6:0]	R/W	SAD+R/W
Read	0011110	1	00111101 (3Dh)
Write	0011110	0	00111100 (3Ch)

Table 17.   Register address map (continued)

Name	Slave address	Type	Register address		Default
			Hex	Binary	
TIME_LATENCY_A	Table 14	rw	3C	011 1100	00000000
TIME_WINDOW_A	Table 14	rw	3D	011 1101	00000000
Reserved (do not modify)	Table 14		3E-3F	--	--
CRA_REG_M	Table 16	rw	00	00000000	0001000
CRB_REG_M	Table 16	rw	01	00000001	0010000
MR_REG_M	Table 16	rw	02	00000010	00000011
OUT_X_H_M	Table 16	r	03	00000011	output

Example: Tech Spec.
   1° Read Angular Information / x-, y-, z-Acceleration
   2. Sample Rate (of Read) : 30 Hz
Find 1° Special Purpose Register Responsible
      to Perform Configuration.
   2° Find Binary Pattern to initialize
      the SPR.