SA4103 Induction Voice Coil Motor Driver

1 Features

- I2C Interface (Fast Mode+), support 1.8V level
- Power Down (<1uA)
- I2C Slave Address : user define bits (2LSB)
  - Default : 0001100
  - 00011XX R/W (multiple addresses)
- Built-in Sensor coil driver and Amplifier
- Built-in H_SYNC pin to avoid image interference
- PID Controller
  Control signal : Digital input (12 bits)
- NVRAM
  Store Time (Max) : 30ms
  Free access : 19bytes (address 0xDD ~ 0xEF)
  (address 0xFE~0xFF is for only NVRAM setting.)
- Operating Temperature Range : -20℃ to 80℃
- 10-Ball WLCSP Package With 0.4mm Pitch
- Size : 0.8mm x 2.238 mm

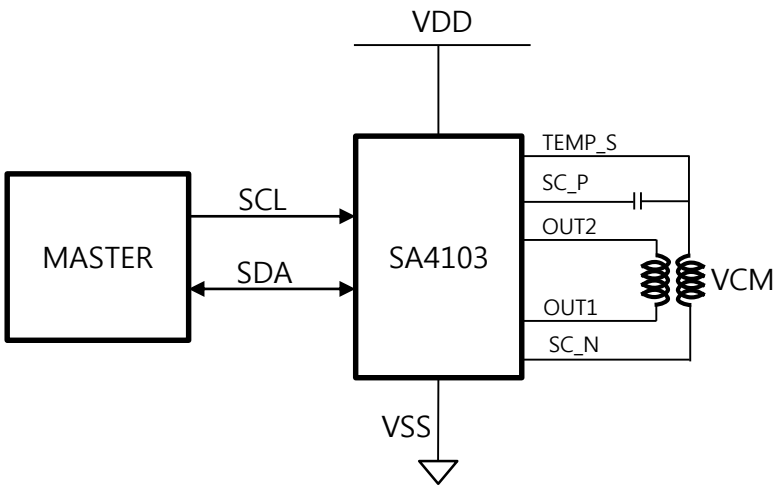
2 Application

- Cell Phone Auto Focus
- Digital Still Camera Auto Focus
- Security Cameras
- Web and PC Cameras

3 Description

The SA4103 is induction voice coil motor driver for camera auto focus. SA4103 also has an internal oscillator, PID controller and current control circuit which can be controlled through I2C interface by external micro controller.

Simplified Schematic



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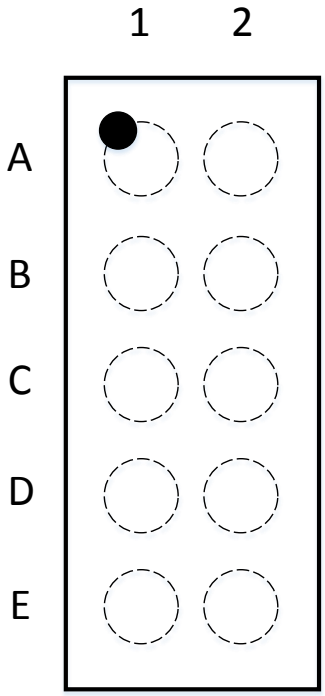
4 Pin Configuration and Functions



Bumps down view

Pin Functions

No.	PIN	I/O/P	DESCRIPTION	OFF STATUS
A1	OUT2	O	Driver output2	Unknown
A2	OUT1	O	Driver output1	Unknown
B1	VDD	P	Input power supply	Power
B2	VSS	G	Ground	Ground
C1	TEMP_S	I	Measure the temperature of sense coil	Unknown
C2	SCL	I	I2C clock	Hi-Z
D1	SC_P	O	Sensor Coil output P	Unknown
D2	SDA	I/O	I2C data	Hi-Z
E1	SC_N	O	Sensor Coil output N	Unknown
E2	H_SYNC	I	Sync for image sensor	Unknown

5 Specifications

5.1 Absolute Maximum Ratings

SYMBOL	PARAMETER	MIN	MAX	UNIT
VDD	Power Supply Voltage	-0.3	4	V
Vin	Input Voltage	-0.3	VDD	V
Vout	Output Voltage	-0.3	VDD	V
V_{HBM}	Static Discharge (HBM)		2	kV
V_{MM}	Static Discharge (MM)		200	V
Tj	Junction Temperature	-40	175	℃

+ Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
Note 1: All voltage values are with respect to VSS.

5.2 Recommended Operating Conditions

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
VDD	Power Supply Voltage	2.65	2.8	3.6	V
Vin	Input Voltage	0		VDD	V
Vout	Output Voltage	0		VDD	V
TA	Operating ambient temperature	-20		80	℃

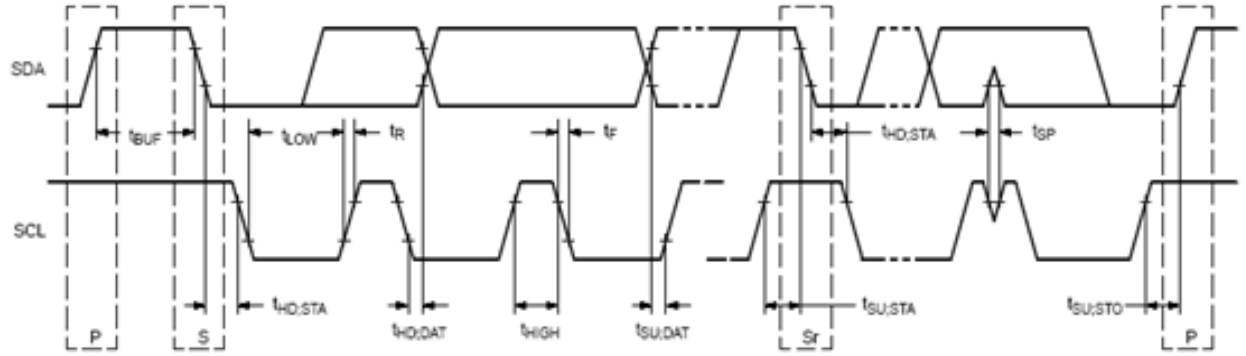
5.3 Electrical Characteristics

PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
Supply Current	Sleep Mode	Sleep	-1		+1	uA
	Standby Mode	Driver Disabled		7	10	mA
	Active Mode (Note2)	Normal Operating (Coil Current is 0mA)		15		mA
Maximum Output Current			95	100		mA
Low Level Input Voltage					VDD*0.3	V
High Level Input Voltage			VDD*0.7			V
Power On Time					10	ms
NVRAM Store Time					30	ms

Note2: Include coil & position sensing & temperature sensing current.
Dependent on sensing duty cycle & sensing period.

5.4 Data Transmission Timing Requirements

PARAMETER	Symbol	CONDITIONS	MIN	MAX	UNIT
Output Low Level (SDA)	V_{OL}	IOL = 4mA		0.5	V
SCLK Operating Frequency	f_{SCLK}			1000	kHz
Stop and Start Condition	t_{BUF}		0.5		us
Hold Time After Repeated Start Conditions	$t_{HD;STA}$		0.25		us
SCLK Clock Low Period	t_{LOW}		0.5		us
SCLK Clock High Period	t_{HIGH}		0.4		us
Repeated Start Condition Setup Time	$t_{SU;STA}$		0.25		us
Data Hold Time	$t_{HD;DAT}$		0	0.9	us
Data Setup Time	$t_{SU;DAT}$		100		ns
Clock/Data Fall Time	t_F			300	ns
Clock/Data Rise Time	t_R			300	ns
Stop Condition Setup Time	$t_{SU;STO}$		0.25		us



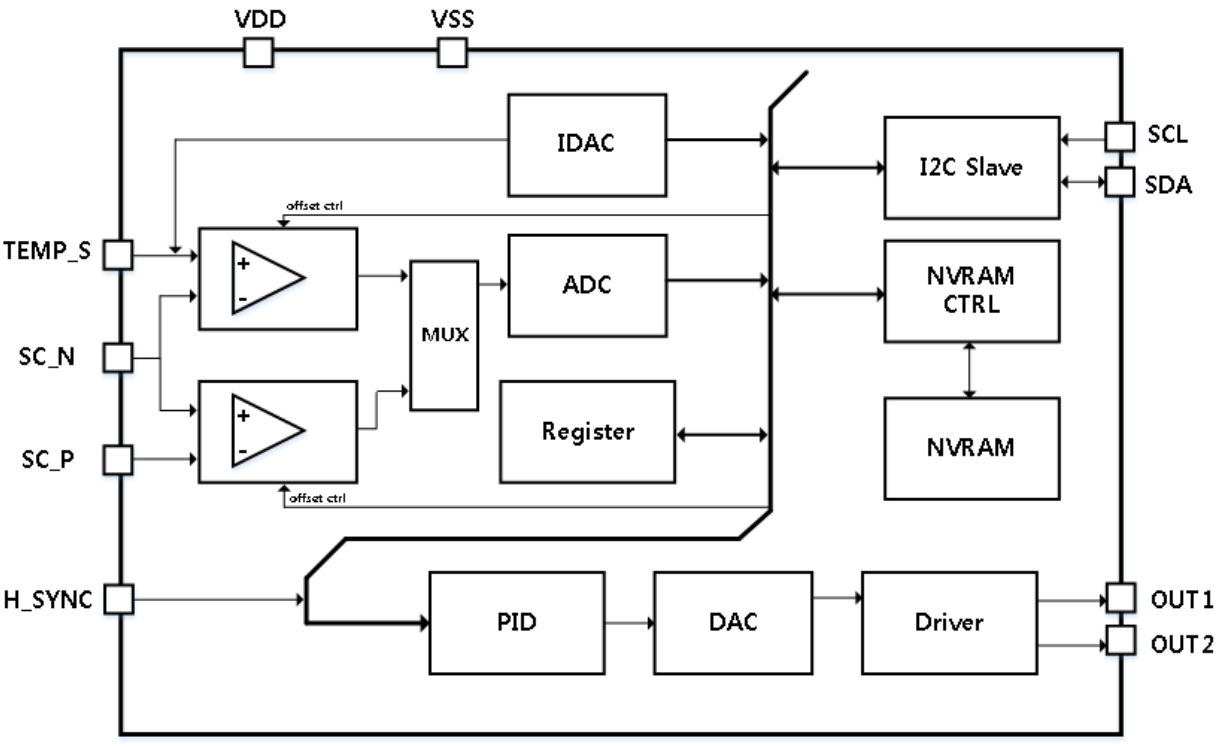
6 Detailed Description

6.1 Overview

The SA4103 is intended for high performance autofocus in camera modules. The device is used to control the current in the voice coil motor (VCM). The VCM current and thus the lens position can be controlled via the I2C interface and an auto focus function can be implemented.

The device connects to a video processor or image sensor through a standard I2C interface which supports up to 1-Mbit/s data rate. The digital interface supports IO levels from 1.8V to 3.3V.

6.2 Function Block Diagram



6.3 Device Functional Modes

6.3.1 Mode of Operation

Sleep If the device will enter sleep mode when power down register is high. default is Active mode.

Standby The device is in standby mode when power on.

Active In active mode VCM driver output is enabled all the time resulting in higher power consumption.

6.4 Programming

6.4.1 I2C Bus Operation

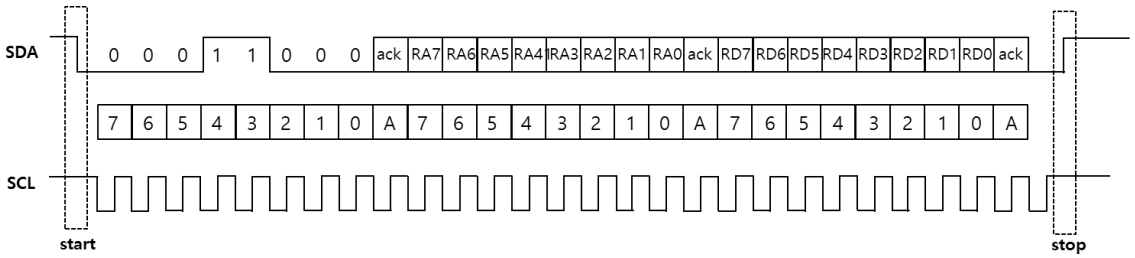
The SA4103 hosts a slave I2C interface that supports data rates up to 1 Mbit/s and auto-increment addressing and is compliant to I2C standard 4.0.

Register Write

A register is written by first sending the command byte, with the device address and read/write set to "0"(write). Then a register address byte is sent, which selects which register is to be written (RA7-RA0 below).

Finally, the data byte is sent, which is latched into the addressed register when complete.

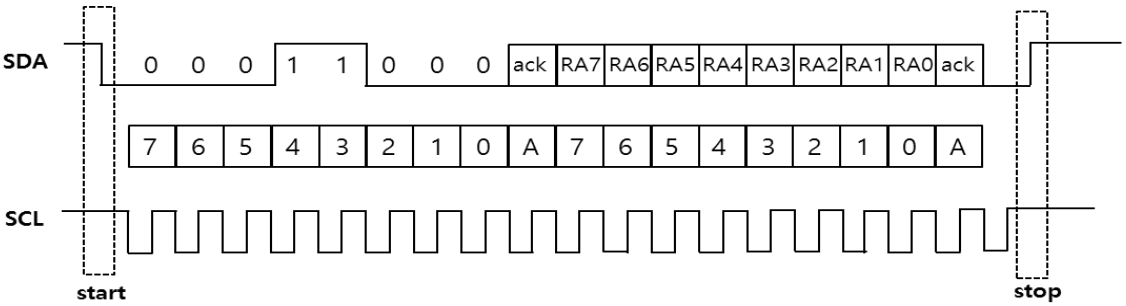
Note that additional writes may be performed without sending a stop; in this case the register address will automatically increment and the following 8-bit register will be written.



Register Read

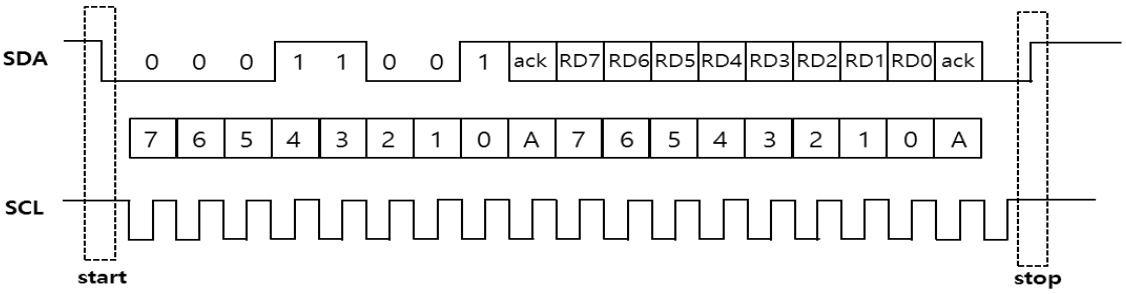
A register is read by first sending the command byte, with the device address and read/write set to "0"(write).

Then a register address byte is sent (RA7-RA0 below), which selects which register is to be read.



Following the register selection, another command byte is sent, again addressing the device, but with the read/write bit set to "1" (read). Then the data from the addressed register is read.

Note that additional reads may be performed without sending a stop; in this case the register address will automatically increment and the following 8-bit register will be read.



6.5 Register Map

ADDRESS (HEX)	NAME	DEFAULT	DESCRIPTION
00	POSITION_MSB	0000 0000	Target Position
01	POSITION_LSB	0000 0000	
02	CONT1	0100 0000	Mode Setting
03	CONT2	0000 0000	NVRAM Write Cmd / Chip ID
04	CURPOS_MSB	0000 0000	Current Position
05	CURPOS_LSB	0000 0000	
06~7F	RESERVED	0000 0000	Do not write

ADDRESS (HEX)	NAME	DEFAULT	DESCRIPTION
80	KP_MSB	0000 0000	PID Coefficient
81	KP_LSB	0000 0000	
82	KI_MSB	0000 0000	
83	KI_LSB	0000 0000	
84	KI_N_MSB	0000 0000	
85	KI_N_LSB	0000 0000	
86	KI_P_MSB	0000 0000	
87	KI_P_LSB	0000 0000	
88	KD_MSB	0000 0000	
89	KD_LSB	0000 0000	
8A	KD_N_MSB	0000 0000	
8B	KD_N_LSB	0000 0000	
8C	KL_MSB	0000 0000	
8D	KL_LSB	0000 0000	
8E	PRE_LOOPGAIN	0000 0000	
8F	LOOPTIME	0000 0000	
90	LOOP_BOUND_MSB	0000 0000	
91	LOOPGAIN_MSB	0000 0000	
92	LOOPGAIN_LSB	0000 0000	
93	LOOP_OFFSET_MSB	0000 0000	
94	LOOP_OFFSET_LSB	0000 0000	
95	DIV	0000 0000	
96	ERROR_LIMIT	0000 0000	
97	IIR1_A0_MSB	0000 0000	IIR Filter1 Coefficient
98	IIR1_A0_LSB	0000 0000	
99	IIR1_A1_MSB	0000 0000	
9A	IIR1_A1_LSB	0000 0000	
9B	IIR1_A2_MSB	0000 0000	
9C	IIR1_A2_LSB	0000 0000	
9D	IIR1_B0_MSB	0000 0000	

ADDRESS (HEX)	NAME	DEFAULT	DESCRIPTION
9E	IIR1_B0_LSB	0000 0000	IIR Filter1 Coefficient
9F	IIR1_B1_MSB	0000 0000	
A0	IIR1_B1_LSB	0000 0000	
A1	IIR1_B2_MSB	0000 0000	
A2	IIR1_B2_LSB	0000 0000	
A3	IIR2_A0_MSB	0000 0000	IIR Filter2 Coefficient
A4	IIR2_A0_LSB	0000 0000	
A5	IIR2_A1_MSB	0000 0000	
A6	IIR2_A1_LSB	0000 0000	
A7	IIR2_A2_MSB	0000 0000	
A8	IIR2_A2_LSB	0000 0000	
A9	IIR2_B0_MSB	0000 0000	
AA	IIR2_B0_LSB	0000 0000	
AB	IIR2_B1_MSB	0000 0000	
AC	IIR2_B1_LSB	0000 0000	
AD	IIR2_B2_MSB	0000 0000	
AE	IIR2_B2_LSB	0000 0000	
AF	IIR_SPL_TIME	0000 0000	IIR Filter Sampling control
B0~DB	Reserved	0000 0000	Reserved

ADDRESS (HEX)	NAME	DEFAULT	DESCRIPTION
DA	ADC_MIN_MSB	0000 0000	Function Enable
DB	ADC_MIN_LSB	0000 0000	
DC	ADC_MAX_LSB	0000 0000	
DD~EF	User memory	0000 0000	User memory
F0~FF	Reserved	0000 0000	Reserved

6.5.1 POSITION (Address – 0x00 ~ 0x01)

Target Position (12bit digitalized control signal)

DATA BIT	D7	D6	D5	D4	D3	D2	D1	D0
0x00	TARPOS[11:4]							
0x01	TARPOS[3:0]				RESERVED			

6.5.2 CONT1 (Address – 0x02)

Mode Setting

DATA BIT	D7	D6	D5	D4	D3	D2	D1	D0
0x02	-	OUTDIS	SLEEP	RESERVED				CALEXE

1) OUTDIS : Output Disable (0 : Servo Enable)
2) SLEEP : 1 Sleep Mode
3) CALEXE : 1 Calibration Mode

6.5.3 CONT2 (Address – 0x03)

NVRAM Control And Chip ID

DATA BIT	D7	D6	D5	D4	D3	D2	D1	D0
0x03 Write	RESERVED			MLOAD	RESERVED			MSTORE
0x03 Read	VER ID[3:0]				DEV ID[3:0]			

1) MLOAD : NVRAM Recall
2) MSTORE : NVRAM Store
3) VER ID and DEV ID: Chip ID (def. : 0x03)

6.5.4 CURPOS (Address – 0x04 ~ 0x05)

Current Position (12bit AD Sensor signal)

DATA BIT	D7	D6	D5	D4	D3	D2	D1	D0
0x04	CURPOS[11:4]							
0x05	CURPOS[3:0]				RESERVED			

6.5.5 PID Coefficient (Address – 0x80 ~ 0x96)

KP, KL, KI, KI_N, KI_P, KD, KD_N, LOOPGAIN, DIV etc. setting

DATA BIT	D7	D6	D5	D4	D3	D2	D1	D0
0x80	KP[15:8]							
---	---							
0x96	ERROR_LIMIT[7:0]							

6.5.6 IIR1 FILTER Coefficient (Address – 0x97 ~ 0xA2)

IIR1 A0, A1, A2, B0, B1, B2 setting

DATA BIT	D7	D6	D5	D4	D3	D2	D1	D0
0x97	IIR1_EN	IIR1_A0[14:8]						
---	---							
0xA2	IIR1_B2[7:0]							

6.5.7 IIR2 FILTER Coefficient (Address – 0xA3 ~ 0xAF)

IIR2 A0, A1, A2, B0, B1, B2 setting

DATA BIT	D7	D6	D5	D4	D3	D2	D1	D0
0xA3	IIR2_EN	IIR2_A0[14:8]						
---	---							
0xAF	IIR1_SPL_TIME[3:0]				IIR2_SPL_TIME[3:0]			

6.5.8 Calibration (Address – 0xDA ~ 0xDC)

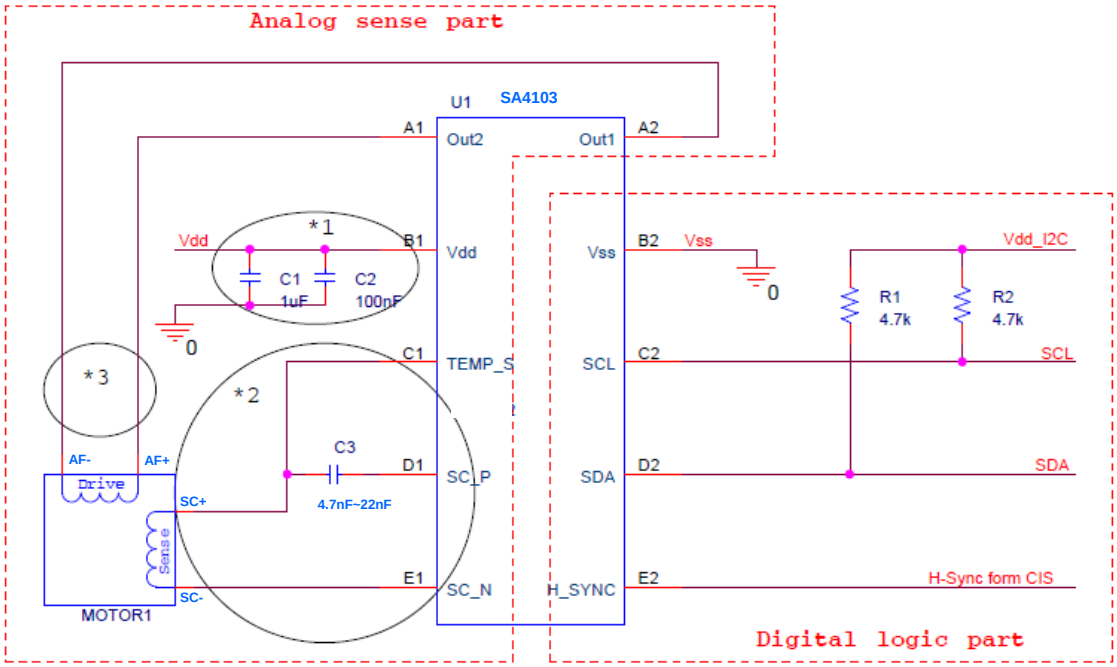
adc_min	adc value of bottom position of actuator – auto save during calibration
adc_max	adc value of top position of actuator – auto save during calibration

map_target = adc_min + (pi_target * (adc_max-adc_min)) / 4096

DATA BIT	D7	D6	D5	D4	D3	D2	D1	D0
0xDA	adc_min[11:4]							
0xDB	adc_min[3:0]				adc_max[11:8]			
0xDC	adc_max[7:0]							

7 Application

7.1 Typical Application



*1. Place components of C1, C2 and C3 as close as possible to the IC.
Smaller the temperature variation of C3, the better. If possible, we recommend COG type.

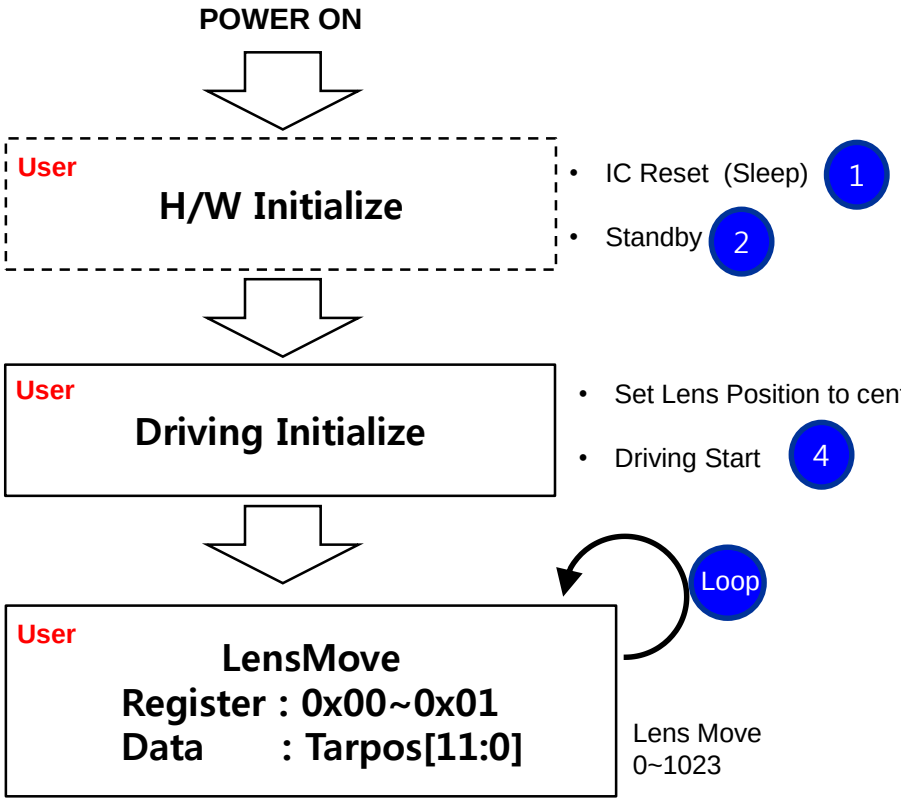
*2. The pattern should be as short as possible.
This signal line is a very sensitive signal and should not pass through any other signal line.
Make sure that there is sufficient distance between analog sensing lines (SC_P,SC_N) and analog driving lines (OUT1,OUT2).

*3. Since the drive pattern has a current of 100 mA or more, it is necessary to make the pattern thick enough.

* The analog sense part and the digital logic part must be separated.

* Power lines and ground lines should be thick enough.

7.2 Sequence of Power On



- **Example Code**

I2C Function..
(it's different depending on MCU.)

I2C_Read(BYTE byDevID, BYTE RegisterAddr, int nReadSize, BYTE* byData);
I2C_Write(BYTE byDevID, BYTE RegisterAddr, int nWriteSize, BYTE* byData);

```
void Mode_Sleep();
void Mode_Standby();
void Mode_Active();
void LensMove(int nInput) ;

void Initial (void)
{
    Mode_Sleep();
    Mode_Standby();
   LensMove( 1200 ) ;
   Mode_Active();
}
```

1 **IC Reset (Sleep Mode)**

2 **IC Standby (Standby Mode)**

3 **Set the lens position to the target when there is no current**

4 **Driving Start**
Write 0x00 to address 0x02

7.2 Sequence of Power On

```
#define SA4103_ID            0x18
#define SA4103_RUNCMD   0x02
#define SNA4103_TARGET  0x00

void Mode_Sleep()
{
   I2C_WriteByte(SA4103_ID, SA4103_RUNCMD, 0x60);
   Delay_ms(10);              //Wait 10ms
}
```

1 **IC Reset (Sleep Mode)**
Write 0x60 to address 0x02

```
void Mode_Standby();
{
   I2C_WriteByte(SA4103_ID, SA4103_RUNCMD, 0x40);
   Delay_ms(10);              // Wait 100ms
}
```

2 **IC Standby (Standby Mode)**
Write 0x40 to address 0x02

```
void Mode_Active()
{
   I2C_WriteByte(SA4103_ID, SA4103_RUNCMD, 0x00);
}
```

4 **Driving Start**
Write 0x00 to address 0x02

```
Void LensMove(int nInput)
{
   BYTE byData[2];
   int nScale ;

   byData[0] = BYTE( (nInput >> 4) & 0xFF );
   byData[1] = BYTE( (nInput << 4) & 0xF0) );
   I2C_Write (SA4103_ID, SNA4103_TARGET, 2, byData);
}
```

3 **Lens Move.**
I2C 2byte data Write to address 0x00, 0x01
byData[0] is written at address 0x00.
byData[1] is written at address 0x01.

7.2 Sequence of Power On

Lens Position Register

Register Addr : 0x00		
Bit	Name	Descript
7~0	Lens Position [11:4]	Position of the lens to be moved.

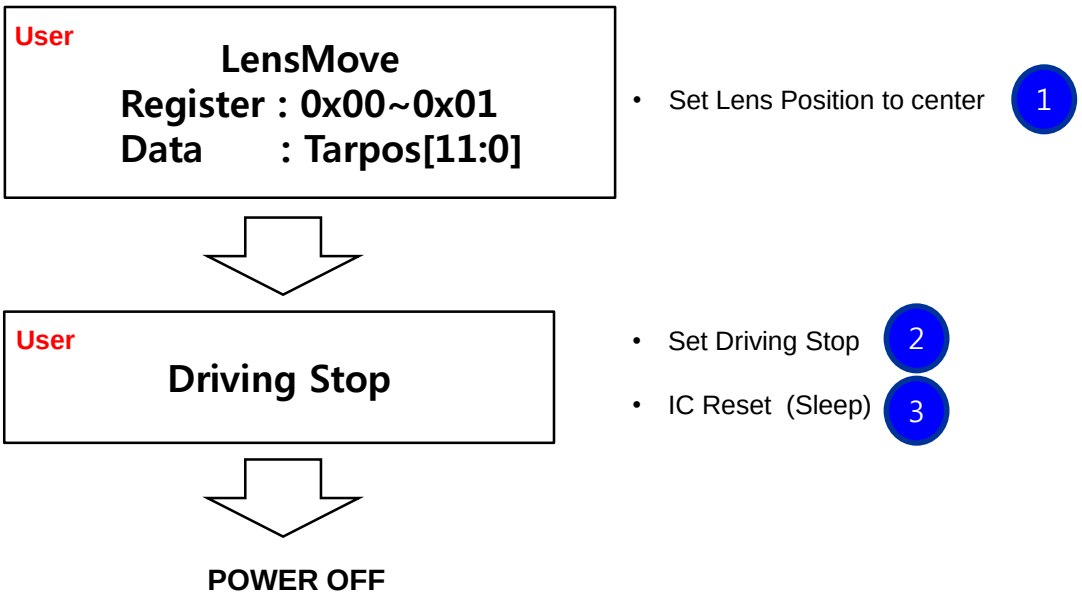
Register Addr : 0x01		
Bit	Name	Descript
7~4	Lens Position [3:0]	Position of the lens to be moved.
3~0	Not used	

When the second data (addr : 0x01) is written to I2C, the lens moves.

Mode Setting Register

Register Addr : 0x02		
Bit	Name	Descript
7	Reserved	Set 0
6	Output Disable	0: Actuator Drive On 1: Actuator Drive Off
5	Sleep	0: Normal Mode 1: Sleep Mode
4~0	Reserved	Always set 0

7.3 Sequence of Power Off



- **Example Code**

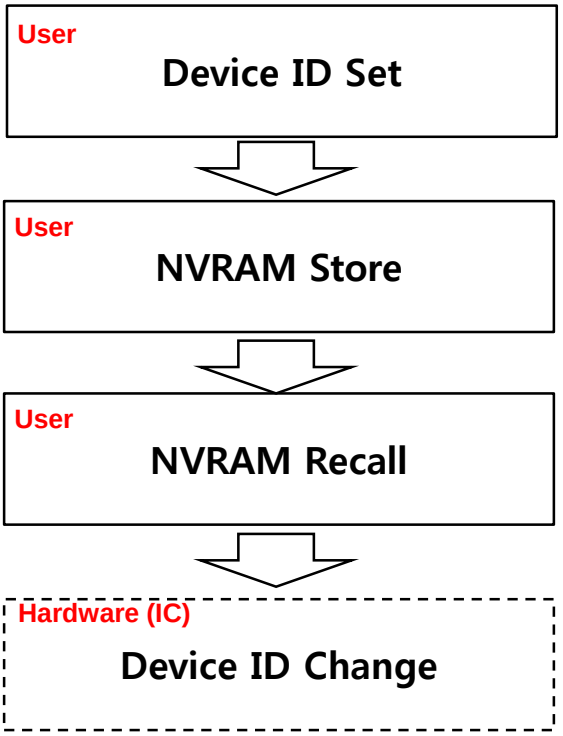
```
void PowerOff(void)
{
   LensMove( 1200 );
   Mode_Standby();
   Mode_Sleep();
}
```

1 **Set the lens position to the target when there is no current**

2 **Driving Stop**
Write 0x40 to address 0x02

3 **IC Reset**
Write 0x60 to address 0x02

7.4 Sequence of changing I2C device ID



I2C Master (User) Set up.
- Set device ID register

1

I2C Master (User) Set up.
- NVRAM Store Command

2

I2C Master (User) Set up.
- NVRAM Recall Command

3

It is automatically operated by hardware.

- **Example Code**

I2C Function..
(It's different depending on MCU.)

```
#define SA4103_ID_DEFAULT      0x18
#define SA4103_SWITCH1         0xD8
#define SA4103_NVRAM           0x03
```

I2C_Read(BYTE byDevID, BYTE RegisterAddr, int nReadSize, BYTE* byData);
I2C_Write(BYTE byDevID, BYTE RegisterAddr, int nWriteSize, BYTE* byData);

```
void I2C_SetSlaveAddr(BYTE bySlaveID)
{
   BYTE byData[1];
   BYTE bySlaveID_Reg;

   switch(bySlaveID)
   {
      case 0x18:  bySlaveID_Reg = 0x00; break;
      case 0x1A:  bySlaveID_Reg = 0x40; break;
      case 0x1C:  bySlaveID_Reg = 0x80; break;
      case 0x1E:  bySlaveID_Reg = 0xC0; break;
      default :   return;
   }
```

7.4 Sequence of changing I2C slave address

```
I2C_Read(SA4103_ID_DEFAULT, SA4103_SWITCH1, 1, byData);

byData[0] = (byData[0]&0x3F) | bySlaveID_Reg;

I2C_Write(SA4103_ID_DEFAULT, SA4103_SWITCH1, 1, byData);
```
→ **Set Slave Address** (1)

```
byData[0] = 0x01;
I2C_Write(SA4103_ID_DEFAULT, SA4103_NVRAM, 1, byData);
```
→ **NVRAM Store** (2)

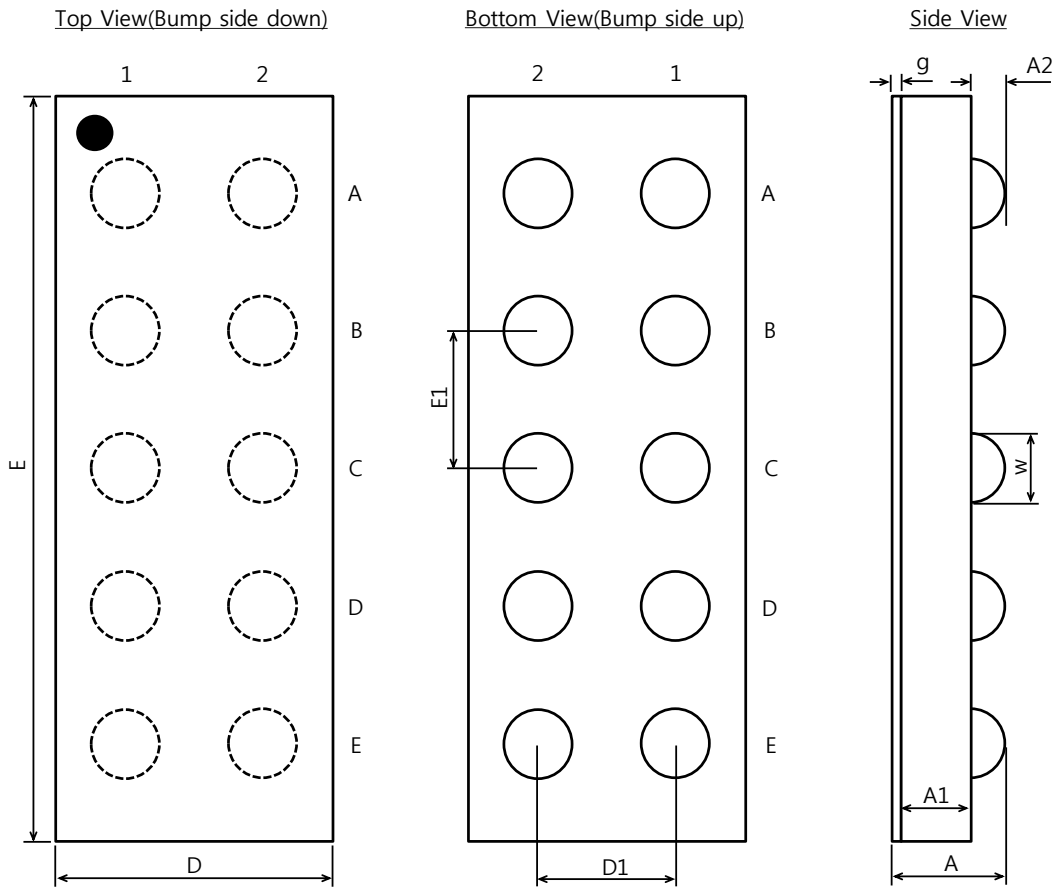
```
delay(50);
byData[0] = 0x10;
I2C_Write(SA4103_ID_DEFAULT, SA4103_NVRAM, 1, byData);
```
→ **NVRAM Recall** (3)

```
delay(20);
}
```

Register Addr : 0xD8		
Bit	Name	Descript
7~6	I2C_DEV	I2C Device ID 0: 0x18, 1: 0x1A, 2: 0x1C, 3: 0x1E
5	DAC_POL	DAC Polarity
4	ADC_POL	ADC Polarity
3	TC_POL	Temperature Sensor Polarity
2	SAMPLE_TM2_ON	ADC Sampling time2 Mode On
1	HSYNC_EDGE	HSYNC detect 0: Falling Edge, 1: Rising Edge
0	HSYNC_EN	HSYNC Input Enable

Register Addr : 0x03		
Bit	Name	Descript
7~5	Reserved	
4	NVR_RECALL	NVRAM Recall Command
3~1	Reserved	
0	NVR_STORE	NVRAM Store Command

8 PKG Dimension



Unit:mm

DIMENSION

Symbols	MIN	NOM	MAX	Note
A	0.271	0.300	0.329	± 0.029
A1	0.190	0.205	0.220	± 0.015
A2	0.059	0.070	0.081	± 0.011
D	0.770	0.800	0.830	± 0.030
E	2.208	2.238	2.268	± 0.030
D1		0.400		
E1		0.400		
g	0.022	0.025	0.028	± 0.003
w	0.170	0.200	0.230	± 0.030

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