adc
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Preliminary Datasheet

AD1008

High Sensitivity 8-Ch Capacitive Touch Switch

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Rev 0.3

JAN. 29, 2013

History

Rev. 0.1 DEC. 4, 2012	1st version released.
Rev. 0.2 JAN. 29, 2012	2st version released.

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1 Descriptions and Features

1.1 General Description

AD1008는 자동 보정기능을 가진 고감도 8channel touch switch이다.
2개의 oscillator와 주파수 조정 검출기를 가지고 있다. 고성능 Analog circuit 와 Digital algorithm을 적용하여, 외부 소음 또는 열악한 환경에 강한 내성이 있다.

1.2 Features

- Supply voltage : 1.6V ~ 3.6V
- Embedded Simple LDO
- Embedded POR and Enable External Reset control
- Parallel, 3-Line/I^2C Interface auto detectable
- Direct 4Mode LED Display
- 4level LED Dimming
- I/O Interface: Parallel / I^2C / Aout
- Single/Multi option
- Operation mode selectable
  Detect speed mode (with MCU) :
  Active mode / Lowe power mode / Sleep mode
  Auto mode :
  Lower power mode ↔ Active mode / Sleep Mode ↔ Active mode
- Enable Individual adjustment each channel sensitivity: 1of 8 Mode
- Very low frequency Harmonic Noise elimination
- Fixed frequency oscillation at any supply voltage
- Very low current consumption
- 1 Custom bits at I^2C Bus
- Few external parts
- Auto digital calibration
- Package: 24-QFN

1.3 Application

- Mobile applications.
- Mini/Micro Audio systems.
- Membrane Switch replacement.
- Sealed control panel.
- Door key.
- Flat TVs.

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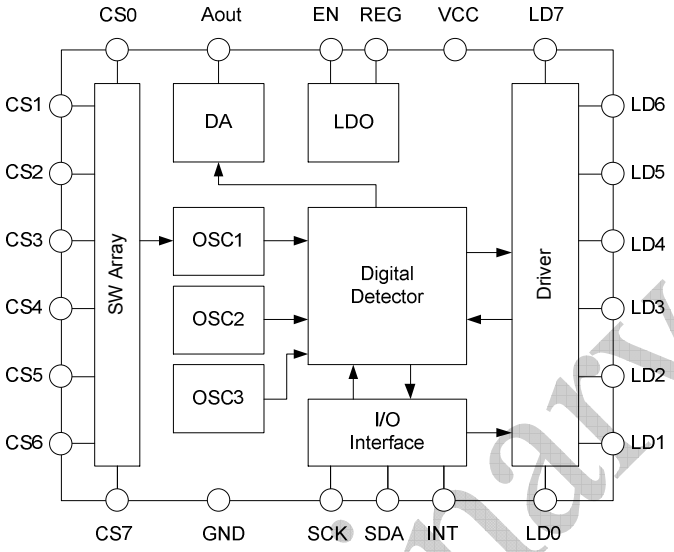
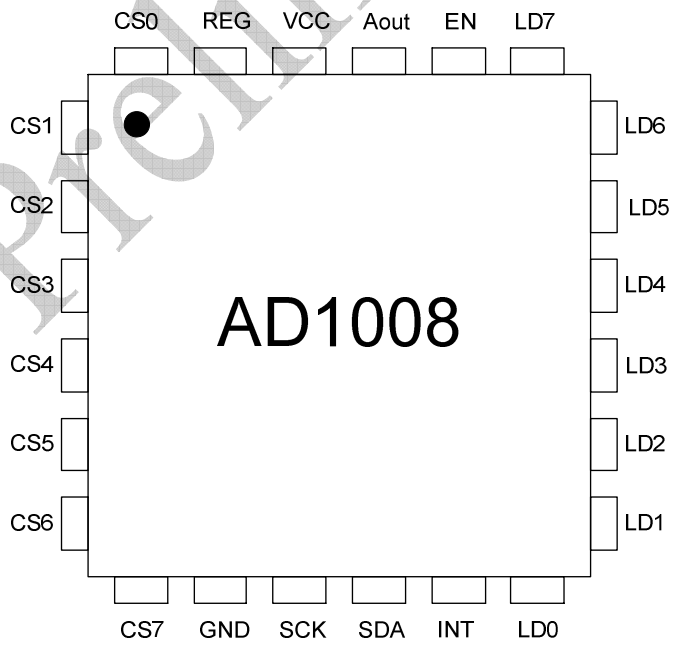
2 Block Diagram & Pin Descriptions

2.1 Block Diagram

Figure 2-1 AD1008 Block Diagram



2.2 Pin Diagram (24QFN)



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2.3 Pin Definition(24QFP)

Table 2-1 AD1008 Pin Definitions

No.	*Pin Name*	*Description.*	*I/O*
1	Cs1	Channel 1 Capacitor sensor input	I
2	Cs2	Channel 2 Capacitor sensor input	I
3	Cs3	Channel 3 Capacitor sensor input	I
4	Cs4	Channel 4 Capacitor sensor input	I
5	Cs5	Channel 5 Capacitor sensor input	I
6	Cs6	Channel 6 Capacitor sensor input	I
7	Cs7	Channel 7 Capacitor sensor input	I
8	GND	Ground	Supply
9	SCK	Serial Clock Line	I
10	SDA	Serial Data	I/O
11	INT	Interrupt	O
12	LD0	Channel 0 Output	O
13	LD1	Channel 1 Output	O
14	LD2	Channel 2 Output	O
15	LD3	Channel 3 Output	O
16	LD4	Channel 4 Output	O
17	LD5	Channel 5 Output	O
18	LD6	Channel 6 Output	O
19	LD7	Channel 7 Output	O
20	EN	Enable(Sensitivity set input when stand alone)	I
21	Aout	DA output	O
22	VCC	Power Supply	Supply
23	REG	Regulator output	O
24	Cs0	Channel 0 Capacitor sensor input	I

2.4 Electro-static Discharge (ESD)

Table 2-2 AD1008 Electro-static Discharge.

Pin	*Mode*	*Value*	*Unit*
Input pin	HBM	8000	V
	MM	500	V
Other pins	HBM	2000	V
	MM	200	V

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3 Characteristic

3.1 Maximum Absolute ratings

Maximum Absolute ratings

Parameter	*Symbol*	*Value*	*Unit*
Supply Voltage	Vccmax	-0.3~6.0	V
Maximum Pin Voltage(Normal)	Vpnmax	-0.3~Vdd+0.3	V
Maximum Pin Voltage(Open Collector)	Vpomax	-0.3~3.6	V
Storage temperature	Tstg	-45~150	℃
Operating temperature	Topr	-40~85	℃
Power Dissipation	Pdmax	800	mW

3.2 Electrical Characteristics

VCC=3.3V. Ta=25.0℃ Unless otherwise noted

Characteristics	*Symbol*	*Condition*	*Value*			*Unit*
			min	*typ*	*max*	
Operating voltage range	VDD	-	1.6	-	3.6	V
Current Consumption	Idd	Active Mode Low power Mode Sleep Mode	-	85 20 3.0	- - -	uA
Sense Oscillation Frequency	Fast mode	Any Vdd Voltage	-	4.0	-	MHz
Open Collector Output Maximum sink current	Isink	Vout=0.4V Default setting	-	10	-	mA
Minimum Detective Capacitance Difference	ΔC	-	-	-	0.01	pF
Self calibration time	Tcall	After system reset	-	25.6	-	ms
Burst Sense Oscillation Period	Tp	Active Mode Low Power Mode Sleep Mode	- - -	3.2 24.0 1000	-	ms
Response Time 1	Tr1	Active Mode	-	12.8	-	ms
Response Time 2	Tr2	Low Power Mode	-	96.0		ms

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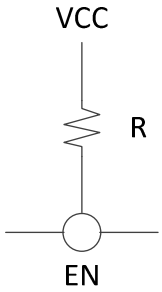
4 Application Note

4.1 Parameter Setting

AD1008는 고객에게 다양한 기능들을 제공한다. 모든 기능은 Serial interface으로 선택 할 수 있다. 그리고 controller를 사용하지 않고, 단독으로 동작 할 경우, Customer parameter는 외부 part들에 의해 선택된다.

4.2 Standalone applications



만약 parameter가 외부 part에의해 설정되었더라도, 모든 customer parameter는 Serial interface로 재 설정이 가능하다.

4.2.1 Sensitivity setting

AD1008는 Power on하는 순간에 VCC와 EN사이의 외부 저항을 검출한다. 그리고 저항 값에 따라 정전용량 감도는 결정된다.
(자세한 사항은 아래 table을 참조)

Register Value	<10K	20K	30K	40K	50K	60K	70K	80K<
Sensitivity Level	1	2	3	4	5	6	7	8
Description	←High Sensitivity					Low Sensitivity→		

감도가 4일 경우, 10mm*10mm sense pad는 5mm acrylic isolation을 검출할 수 있다.

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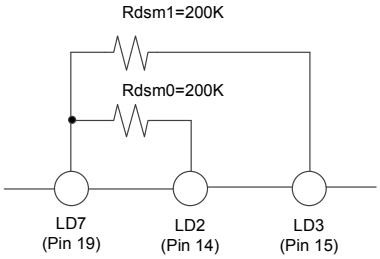
4.2.2 Internal detect mode(Frequency) setting

AD1008는 f1, f2, f3, 그리고 f4로 4개의 내부 system frequency가 있다. F4는 가장 빠르고, F1 은 제일 느리다. 그리고 내부 detect mode (Frequency)는 다음 그림과 같이 추가 저항으로 선택 할 수 있다. Default value(None register)는 f3 동작으로 고정된다.
(저항이 있으면 1이고, 없으면 0이다)

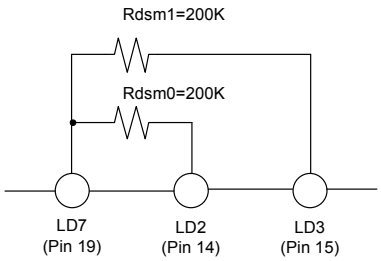


Internal detect mode setting

Rdetm1	*Rdetm0*	*Detect mode*
0	0	about fixed f3
0	1	about fixed f4
1	0	f3 and f4 rotation
1	1	Full rotation

4.2.3 Display mode setting

AD1008는 4가지 LED display mode 가있다. “Select key on mode”, “All on and select key off mode”, “Select key on and delayed off mode”, “ Key select all on & select key off and delayed All off mode” 이다.
Display mode는 다음 그림과 같이 저항을 추가하여 선택 할 수 있다.
(저항이 있으면 1이고, 없으면 0이다.)



Display mode setting

Rdsm1	*Rdsm0*	*Display mode*
0	0	Mode 1
0	1	Mode 2
1	0	Mode 3
1	1	Mode 4

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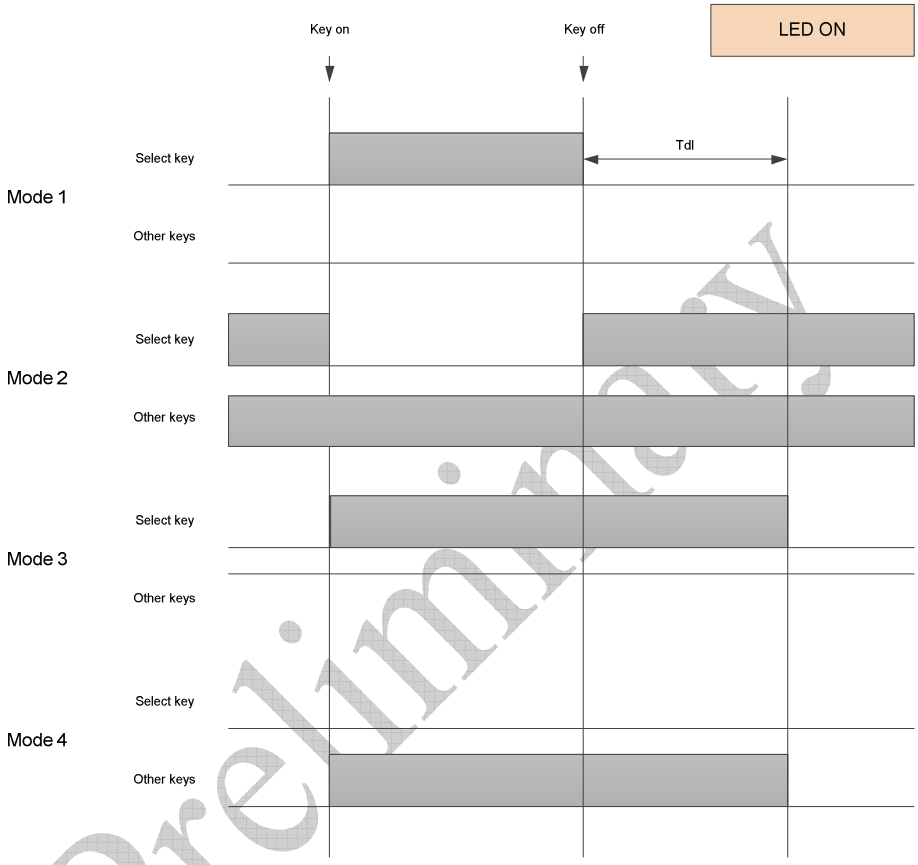
Display mode

Mode	Display mode
Mode 1	Select key on mode
Mode 2	All on and select key off mode
Mode 3	Select key on and delayed off mode
Mode 4	Select key off & other keys all On and delayed All off mode



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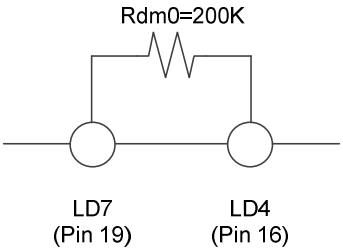
4.2.4 Detect Speed Setting

AD1008는 3가지 speed mode가 있으며, stand alone 일 경우 2가지 mode 를 제공한다. 하나는 Fast mode, 다른 한 개는 Slow mode이다.
Display speed는 다음 그림과 같이 저항을 추가 하여 선택 할 수 있다. (저항이 있으면 1, 없으면 0이다.)



Detect Speed Setting

Rdm0	*Detect speed mode*
0	Fast mode (Low power mode←→ Active mode)
1	Slow mode (Sleep mode ←→ Active mode)

- Fast mode: AD1008는 Low power mode 상태에서 key가 인식되면, Active mode로 변경.
- Slow mode: AD1008이 Sleep mode 상태에서, key가 인식되면, 그것은 Active mode로 변경.
- 어떠한 mode에서든, 마지막 key입력 후, Key가 4초이내 검출 된다면, mode는 변경되지 않는다.
- Key가 입력된 후 4초후에는 Fast mode인 경우는 Low power mode로 복귀하고, Slow mode 일 경우 Sleep mode로 복귀한다.
- Controller에 의해 Active mode가 선택되면(Stand alone 응용에서는 선택할 수 없다), AD1008는 항상 Active mode로 동작 한다.

전류 소비에 따라 3가지 동작 mode로 구분할 수 있다.

- High mode는 항상 active mode로 동작한다. 전류 소비는 많지만, key인식 시간은 짧다.
- Fast mode는 기본적으로 Low power mode로 동작한다. Key 검출 후 동작 mode는 Active mode로 변경 된다. 전류 소비는 High mode보다 적다.
- Slow mode는 기본적으로 Sleep mode로 동작한다. Key 인식 후 동작 mode는 Active mode로 변경된다. (전류 소비는 가장 적다.)
  이들 key scan mode의 주기는 각각 다르다. (6page. 참조)

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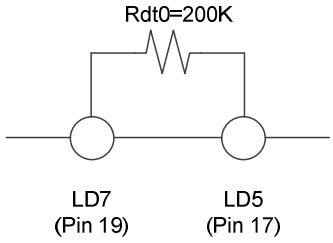
4.2.5 Display Delay time setting

Key 동작 후 지연된 display(Display mode 2 & 4)일 경우, delay time(Tdl)을 설정 할 수 있다.
Delay time은 다음 그림과 같이 저항으로 설정 할 수 있다.
(저항이 있으면 1, 없으면 0이다.)

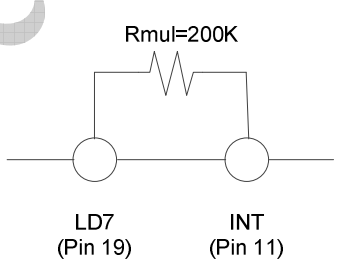


Display Delay time setting

Rdt0	*Delay time*
0	2 sec
1	4 sec

4.2.6 Single/Multi setting

AD1008는 2가지 mode가 있다.
Single mode 는 첫 번째로 눌려진 한 개의 key를 선택하는 mode이고, multi mode 는 모든 key를 검출 한다.
Sing/Multi mode는 다음 그림과 같이 저항을 추가하여 선택 할 수 있다.
(저항이 있으면 1, 없으면 0이다.)



Single/Multi setting

Rmul0	*Mode*
0	Single mode
1	Multi mode

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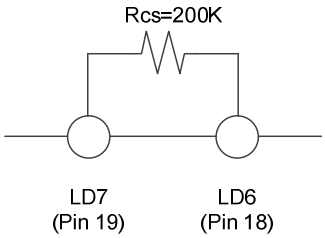
4.3 Register Map in serial setting

Write Slave address 는 “100111C0”b이다. C는 custom bit이다.
다음 그림과 같이 저항을 추가 하여 설정 할 수 있다
(저항이 있으면 1, 없으면 0이다.)



Register Map in serial setting

Rcs	*I2C Slave address (write)*
0	b"10011100"
1	b"10011110"

Register Map1

Sub address	*Data [7:0]*							
0X00						MTsng	DRTmd	OPRmd[1:0]
0X01					OPRled[1:0]		ILED[2:0]	
0X02						OSCmd[1:0]		ONtm[1:0]
0X03		1ch-Sensitivity [2:0]					2ch-Sensitivity [2:0]	
0X04		3ch-Sensitivity [2:0]					4ch-Sensitivity [2:0]	
0X05		5ch-Sensitivity [2:0]					6ch-Sensitivity [2:0]	
0X06		7ch-Sensitivity [2:0]					8ch-Sensitivity [2:0]	
0X08	8-CH Output Data[7:0](Read-Only)							

Register는 INT(PIN11)가 High일 때 읽을 수 있다.

MTsng : Single or Multi option

Value	*Operation*
0	Single mode
1	Multi mode

DRTmd & OPRmd[1:0] : Operating mode

DRTmd	*OPRmd1*	*OPRmd0*	*Operation*
0	0	0	Active mode always
0	0	1	Fast mode (Low power mode ←→ Active mode)
0	1	0	Slow mode (Sleep ←→ Active mode)
0	1	1	NU
1	0	0	Active mode always
1	0	1	Low power mode always
1	1	0	Sleep mode always
1	1	1	NU

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OPRled[1:0] : LED Display setting

OPRled1	*OPRled0*	*Operation*
0	0	Select key on mode
0	1	All on and select key off mode
1	0	Select key on and delayed off mode
1	1	Select key off & other keys all On and delayed All off mode

ILED[2:0] : LED Dimming

ILEDX	*ILEDX*	*ILEDX*	*Operation*
0	0	0	ILED = Level 0
0	0	1	ILED = Level 1
0	1	1	ILED = Level 2
1	1	1	ILED = Level 3

OSCmd[1:0] : Detect mode (Frequency) setting

OSCmd1	*OSCmd0*	*Operation*
0	0	about fixed f3
0	1	about fixed f4
1	0	f3 and f4 rotation
1	1	Full rotation

Rotation Mode(2'b10 & 2'b11)는 5level 감도까지 사용 할 수 있다.

ONtm[1:0] : Display Delay time setting

ONtm1	*Ontm0*	*Operation*
0	0	about 1 sec
0	1	about 2 sec
1	0	about 3 sec
1	1	about 4 sec

Sensitivity [2:0] : Each channel sensitivity setting

D2	*D1*	*D0*	*Sensitivity*	*Operation*
0	0	0	Level 1	High Sensitivity
0	0	1	Level 2	
0	1	0	Level 3	
0	1	1	Level 4	Detectable 10mm*10mm PAD in 5mm acrylic isolation.
1	0	0	Level 5	
1	0	1	Level 6	
1	1	0	Level 7	
1	1	1	Level 8	Low sensitivity

"AD1008"은 Rotation Mode 일 때, 민감도 5~8level까지 사용할 수 있다. (OSCmd==10b, 11b)

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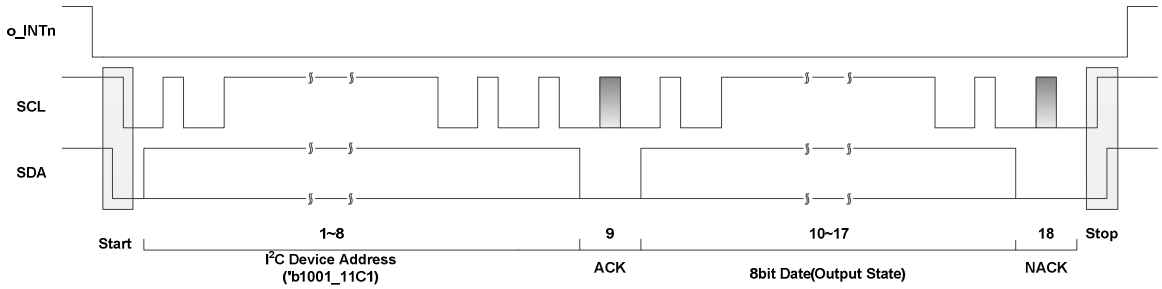
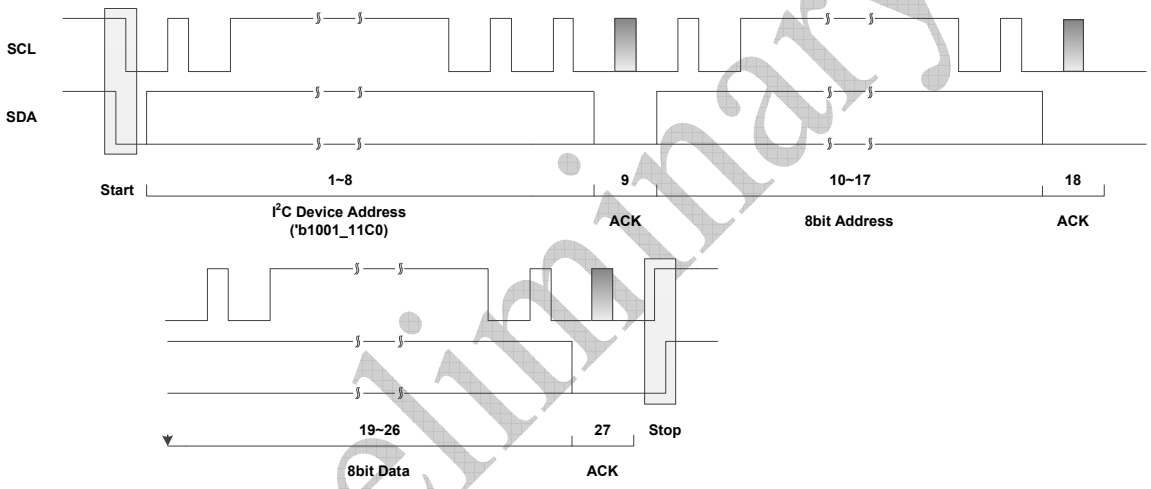
Read Detect key

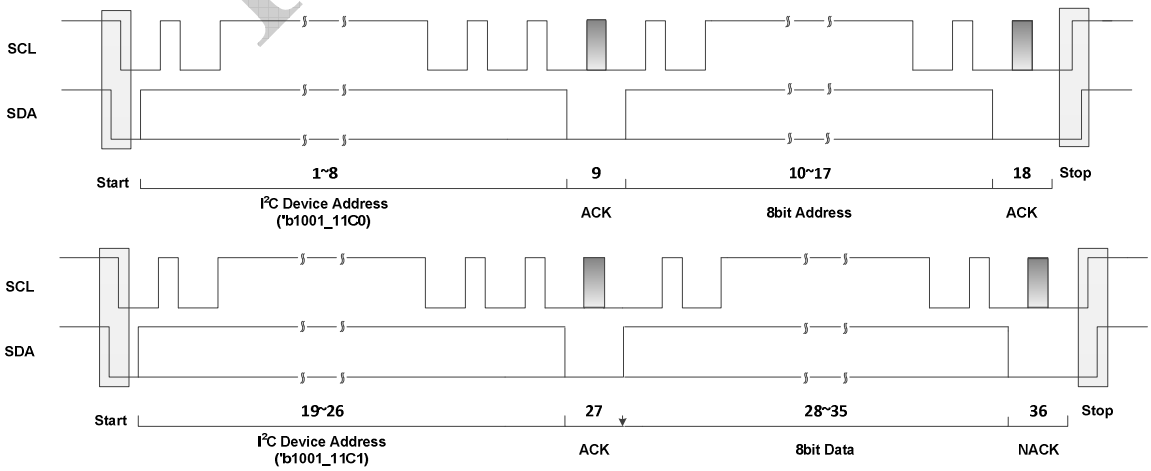


The slave address is b"100111C1". (C is custom bit)

Write Register Data through I2C Interface



Read Register Data through I2C Interface



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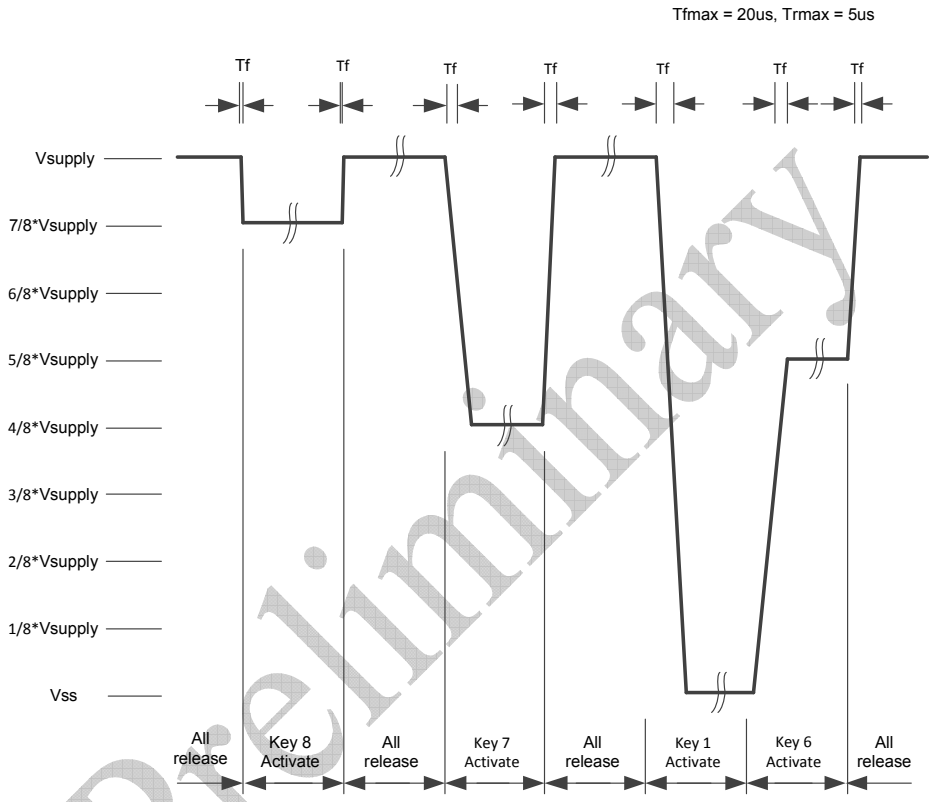
4.3.1 Read DAout(Pin23)

ADC 입력이 있는 MCU라면, 오직 1-line으로 data 통신이 가능하다.
이 pin은 다음과 같은 동작을 지원한다.
AD1008은 간단한 DAC가 있어, key 누름에 따라 다른 전압이 출력된다. 물론, 이 동작은 오직 sing mode에서만 지원 된다. Key가 release되었을 경우 Aout=Vsupply이고, 어떠한 key가 눌러지면, Aout의 전압은 아래와 같다.



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4.3.2 Layout Guidelines and best Practices

Layout Guidelines and best Practices

Sl. No.	*Category*	*Min*	*Max*	*Recommendations / Remarks*
1	Button Shape			Solid round pattern, Round with LED hole, rectangle with round corners
2	Button Size	2mm	20mm	Recommend : Minimum = 5mm
3	Button-Button spacing	0.1mm		Recommend : Minimum = 0.5mm
4	Button Ground Clearance	0.1mm	2mm	Recommend : Minimum = 0.5mm
5	Ground flood – top layer			Hatched ground 7 mil trace and 45 mill grid (15% filling)
6	Ground flood – bottom layer			Hatched ground 7 mil trace and 70 mil grid (10% filling)
7	Trace Length from Sensor pad to device pin			The length should be short as possible. Recommend : Length < 10cm
8	Trace Width	0.17mm	0.2mm	
9	Trace Routing			Traces should be routed on the non button side. If any non CapSense trace crosses CapSense trace, ensure that intersection is orthogonal.
10	Via Position for the sensors			Via should be placed near the edge of the button pad to reduce trace length thereby increasing sensitivity.
11	Via Hole Size for sensor traces			10 mil
12	Number of via on sensor trace	1	2	1
13	Cap Sense series resistor placement		10mm	Place Cap Sense series resistors close to the device for noise suppression. Cap sense resistors have highest priority, place them first.
14	Distance between Any Cap Sense trace to Ground	10mil	20mil	20mil
15	Device placement			Mount the Device on the layer opposite to button. The Cap Sense trace length between the Device and buttons should be minimum

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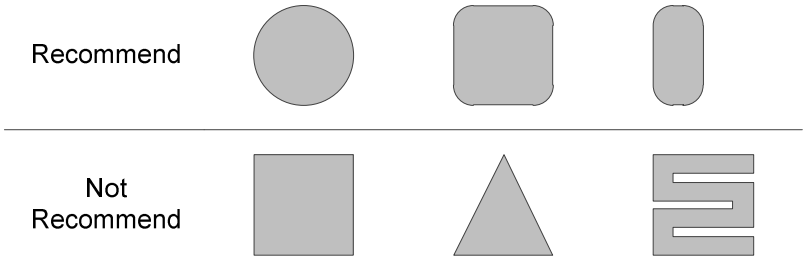
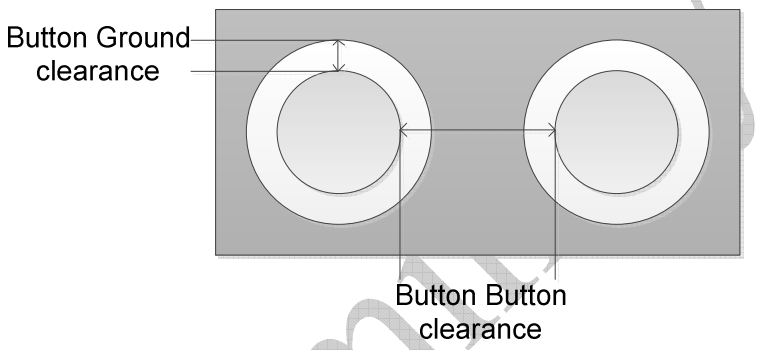
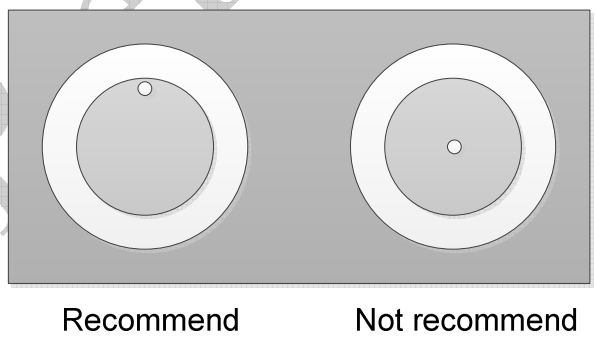
CapSence Button shapes



Button Layout Design



Recommended via-hole Placement



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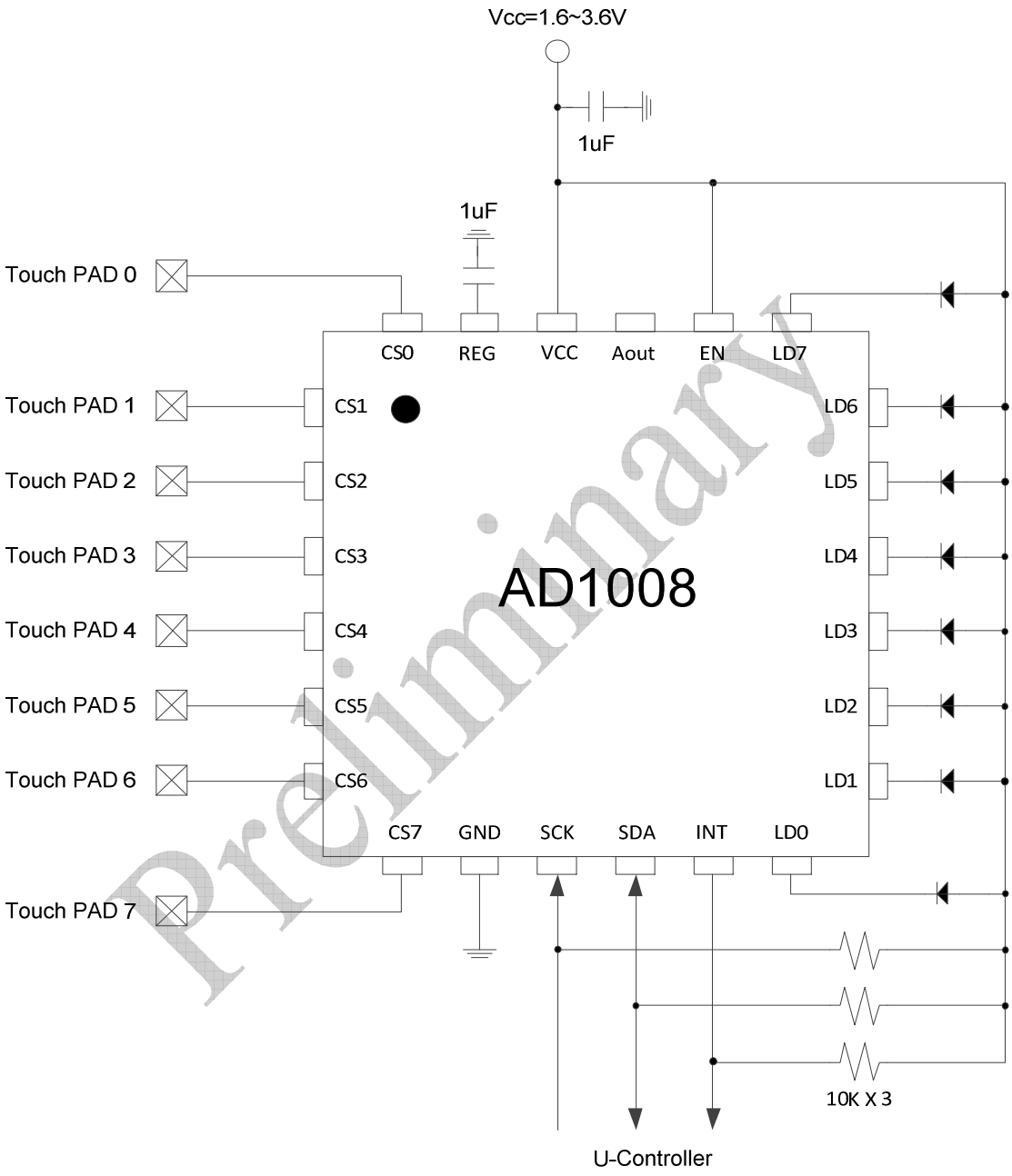
4.4 Application

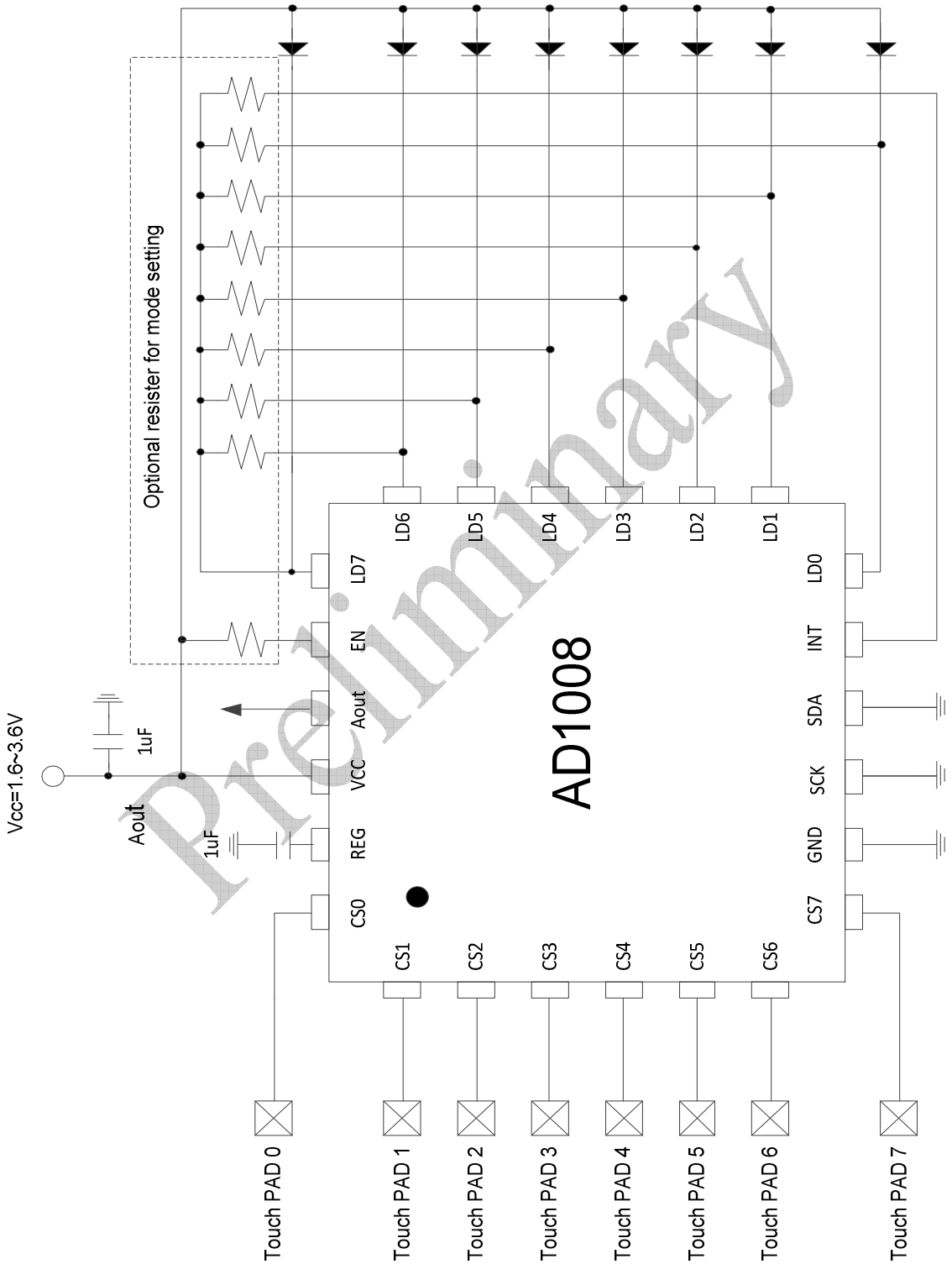
With u-Controller (With I2C interface)



Preliminary

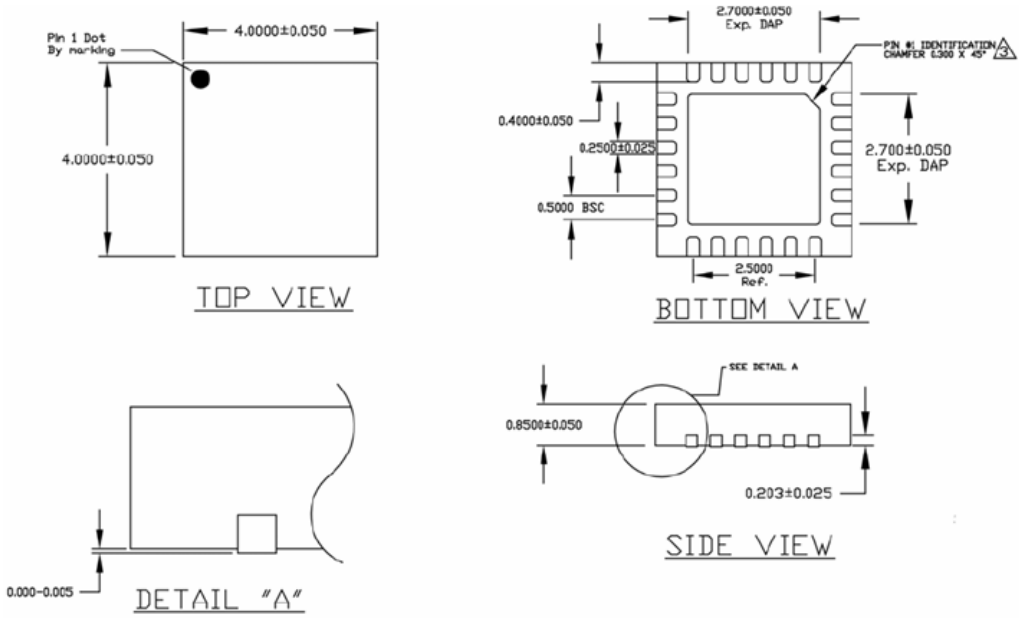
4.5 Application Circuit

Standalone (Using Aout or Parallel)



Preliminary

5 Package Outline(24QFN)



단위는 항상 millimeters(mm) 이다.

Pin#1은 identifier 상단표면에 존재해야 한다.

style pin 1 은 identifier 아래쪽 면에 있다. Identifier package를 이용하려면 다른 기능의 identifier package 또는 다른 기능의 package body 기능을 사용 해야 한다.

Preliminary