NEXT Lab

Semiconductor Development Group

NXM1012/1013

High Sensitivity 16-CH
Capacitive Touch Switch

General Description

The NXM1012/1013 are a auto calibration High sensitivity 16 channel Capacitive touch switch. It includes 2 oscillator and frequency shift detector.
It has very strong immunity against external noise or noisy environment with high performance Analog circuit and Adaptive Digital algorithm

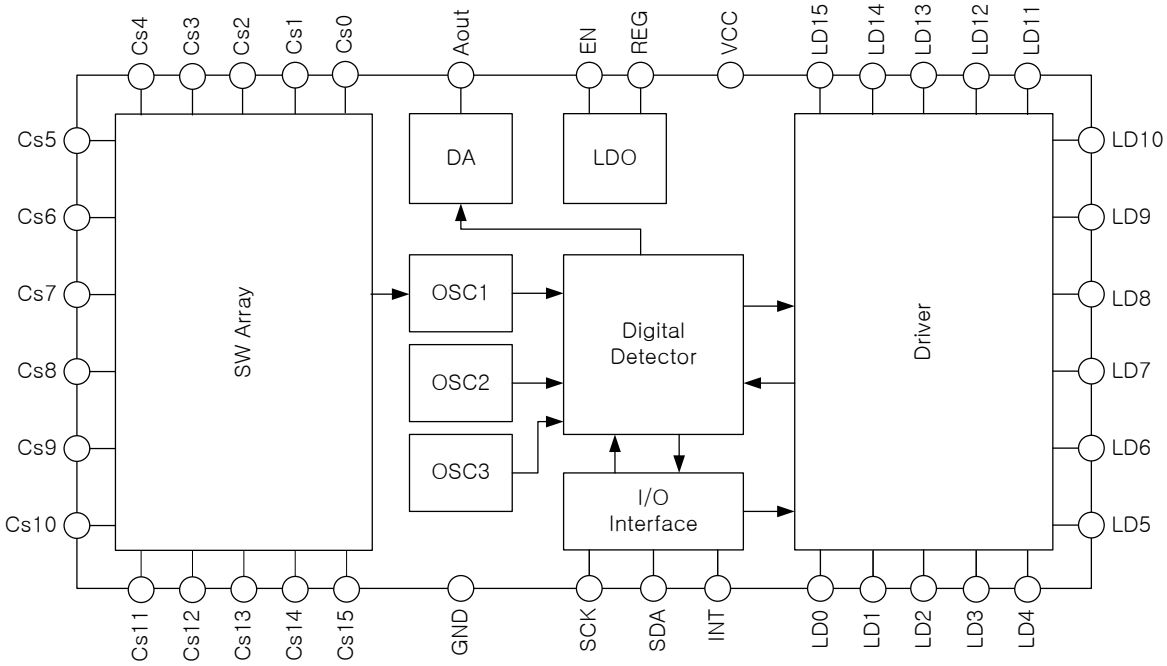
Feature

- Supply voltage : 1.6V ~ 3.6V
- Embedded Simple LDO
- Embedded POR and Enable External Reset control
- Direct 4Mode LED Display
- 4level LED Dimming
- I/O Interface : Parallel / IIC / Aout
- Single/Multi option
- Operation mode selectable
  Auto mode : BF mode ↔ BS mode / BF mode ↔ Sleep Mode
  Direct mode (with MCU) : BF mode / BS mode / Sleep 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
- 2 Custom bits at IIC Bus
- A few external parts
- Auto digital calibration
- Package : 32-QFN(NXM1013 @ Non-Parallel Output) & 40-QFN(NXM1012)

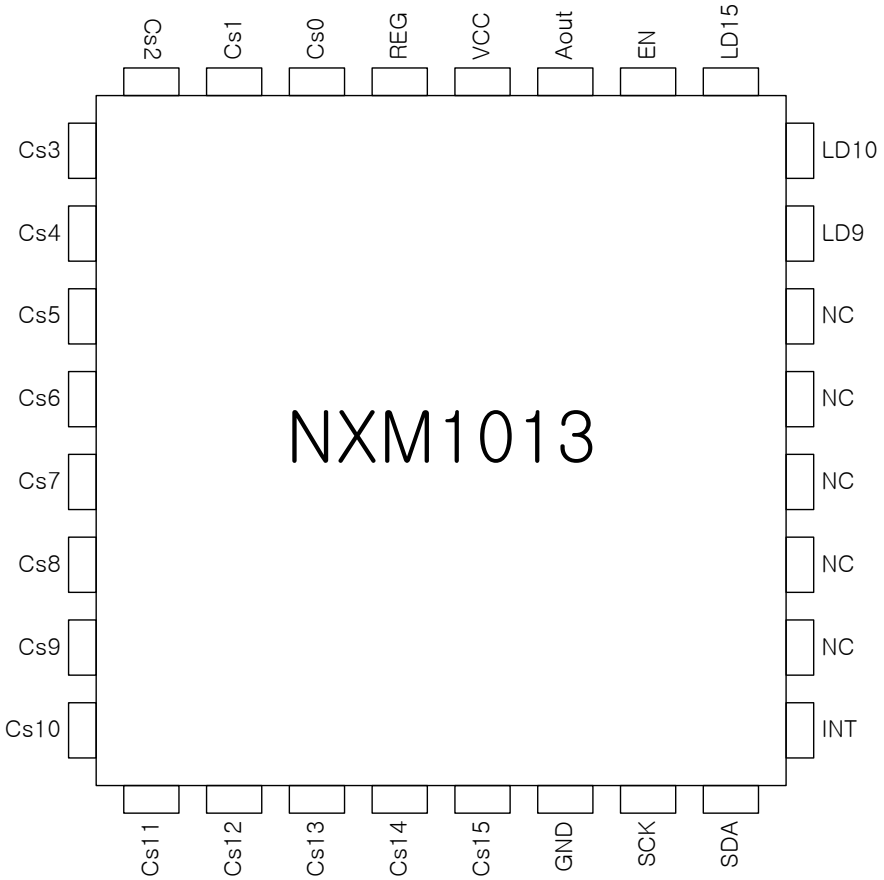
Application

- Mobile application
- Mini/Micro Audio system
- Membrane Switch replacement
- Sealed control panel
- Door key
- Flat TV

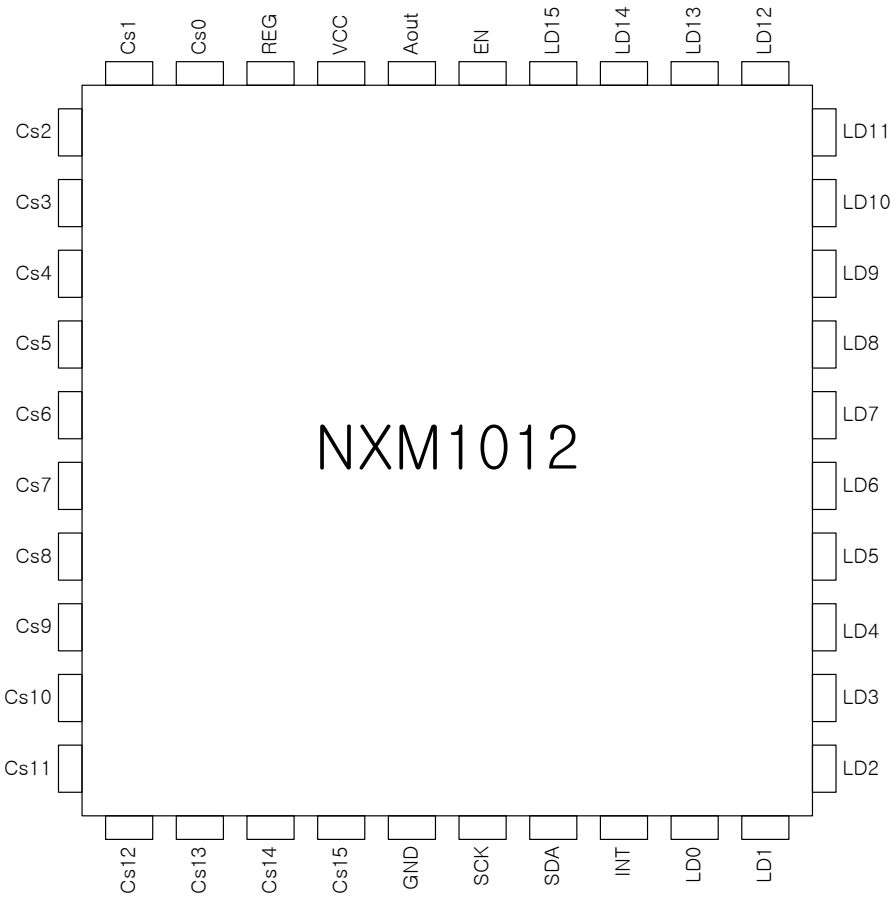
Block Diagram



Terminal assignment (32QFN)



Terminal assignment (40QFN)



Pin description (32QFN,NXM1013)

Pin Name	Pin No.	I/O	Description
CS3	1	I	Channel 3 Capacitor sensor input
CS4	2	I	Channel 4 Capacitor sensor input
CS5	3	I	Channel 5 Capacitor sensor input
CS6	4	I	Channel 6 Capacitor sensor input
CS7	5	I	Channel 7 Capacitor sensor input
CS8	6	I	Channel 8 Capacitor sensor input
CS9	7	I	Channel 9 Capacitor sensor input
CS10	8	I	Channel 10 Capacitor sensor input
CS11	9	I	Channel 11 Capacitor sensor input
CS12	10	I	Channel 12 Capacitor sensor input
CS13	11	I	Channel 13 Capacitor sensor input
CS14	12	I	Channel 14 Capacitor sensor input
CS15	13	I	Channel 15 Capacitor sensor input
GND	14	S	Ground

SCK	15	I	Serial Clock Line
SDA	16	I/O	Serial data
INT	17	O	Interrupt
NC	18	-	Not Assigned Pin
NC	19	-	Not Assigned Pin
NC	20	-	Not Assigned Pin
NC	21	-	Not Assigned Pin
NC	22	-	Not Assigned Pin
LD9	23	I/O	Channel 9 Output / Custom bit 0
LD10	24	I/O	Channel 14 Output / Custom bit 1
LD15	25	I/O	Channel 15 Output / Option Setting Pin
EN	26	I	Enable Pin
Aout	27	O	DA output
VCC	28	S	Power Supply
REG	29	O	Regulator output
CS0	30	I	Channel 0 Capacitor sensor input
CS1	31	I	Channel 1 Capacitor sensor input
CS2	32	I	Channel 2 Capacitor sensor input

Pin description (40QFN,NXM1012)

Pin Name	Pin No.	I/O	Description
CS2	1	I	Channel 2 Capacitor sensor input
CS3	2	I	Channel 3 Capacitor sensor input
CS4	3	I	Channel 4 Capacitor sensor input
CS5	4	I	Channel 5 Capacitor sensor input
CS6	5	I	Channel 6 Capacitor sensor input
CS7	6	I	Channel 7 Capacitor sensor input
CS8	7	I	Channel 8 Capacitor sensor input
CS9	8	I	Channel 9 Capacitor sensor input
CS10	9	I	Channel 10 Capacitor sensor input
CS11	10	I	Channel 11 Capacitor sensor input
CS12	11	I	Channel 12 Capacitor sensor input
CS13	12	I	Channel 13 Capacitor sensor input
CS14	13	I	Channel 14 Capacitor sensor input
CS15	14	I	Channel 15 Capacitor sensor input
GND	15	S	Ground

SCK	16	I	Serial Clock Line
SDA	17	I/O	Serial data
INT	18	O	Interrupt
LD0	19	O	Channel 0 Output
LD1	20	O	Channel 1 Output
LD2	21	O	Channel 2 Output
LD3	22	O	Channel 3 Output
LD4	23	O	Channel 4 Output
LD5	24	O	Channel 5 Output
LD6	25	O	Channel 6 Output
LD7	26	O	Channel 7 Output
LD8	27	O	Channel 8 Output
LD9	28	O	Channel 9 Output
LD10	29	O	Channel 10 Output
LD11	30	O	Channel 11 Output
LD12	31	O	Channel 12 Output
LD13	32	O	Channel 13 Output
LD14	33	O	Channel 14 Output
LD15	34	O	Channel 15 Output
EN	35	I	Enable Pin
Aout	36	O	DA output
VCC	37	S	Power Supply
REG	38	O	Regulator output
CS0	39	I	Channel 0 Capacitor sensor input
CS1	40	I	Channel 1 Capacitor sensor input

Electro-static Discharge (ESD)

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

Maximum Absolute ratings

Parameter	Symbol	Value	Unit
Supply Voltage	Vccmax	-0.3 ~ 3.6	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

Electrical Characteristics

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

Characteristics	Symbo	Condition	Value			Unit
			min	typ	max	
Operating voltage range	VDD	-	1.6	-	3.6	V
Current Consumption	Idd	BF Mode	-	160	-	uA
		BS Mode	-	60	-	
		Sleep Mode	-	4.0	-	
Sense Oscillation Frequency	Fs	Any Vdd voltage	-	4.0	-	MHz
Open Collector output maximum sink current	Isink	Vout=0.4V Default setting	-	10	-	mA
Minimum Detective capacitance Difference	△C	-	-	-	0.01	pF
Self calibration time	Tcall	After system reset	-	25.6	-	ms
Burst Sense Oscillation Period	Tp	BF Mode	-	6.4	-	ms
		BS Mode	-	20.0	-	
		Sleep Mode	-	1000	-	
Response Time 1	Tr1	BF Mode	-	25.6	-	ms
Response Time 2	Tr2	BS Mode	-	80.0	-	ms

Application Note

- Parameter setting

NXM1012/1013 Provide many customer functions.

All function is selectable by Serial interface

And when Stand alone applications without controller,

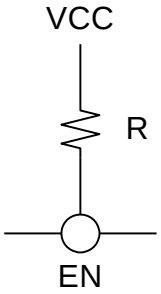
The Customer parameter can be selected by external parts(in 40 QFN).

- Power Sequence

When NXM1012/1013 is supplied with VCC initially, there is a possibility of malfunction because of unstable power supply(VCC). We recommend that you should soft-reset NXM1012 after setting sensitivity and operation mode. Reset Command is ADD:10h, Data:04h and Reset clear command is ADD:10h, Data:00h.

- Stand alone applications

(All customer parameter is re-settable by Serial interface,
even if the parameter was set by external parts.
When you connect parallel output (LD0 to LD15) to u-com,
You should use normal Input of u-com to set parameter
by external parts normally.)



* Sensitivity setting

NXM1012/1013 detect external resister between VCC and EN when power on,
And according to the resister value,
The capacitance detect sensitivity is determined.
See below table.

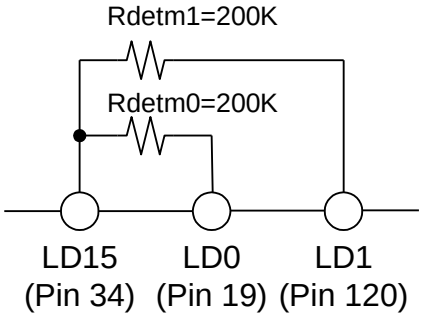
Resister Value	<10K	20K	30K	40K	50K	60K	70K	80K <
Sensitivity Level	1	2	3	4	5	6	7	8
Decription	← High Sensitivity							Low Sensitivity →

When Sensitivity level 4,

10mm*10mm Sense pad is detectable 5mm acrylic isolation.

* Internal detect mode (Frequency) setting

NXM1012/1013 has 4 internal system frequency, f1, f2, f3 and f4. f4 is the fasted and f1 is the slowest. And the Internal detect mode (Frequency) is selectable by resister addition like left figure.



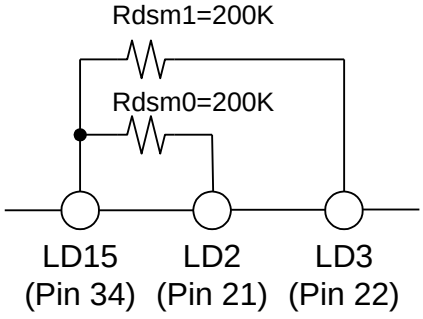
Rdetm1	Rdetm0	Detect mode
0	0	about fixed f3
0	1	about fixed f4
1	0	f3 and f4 rotation
1	1	Full rotation

(If there be resister then 1, None resister then 0)

The default value (None resister) is fixed f3 operation.

* Display mode setting

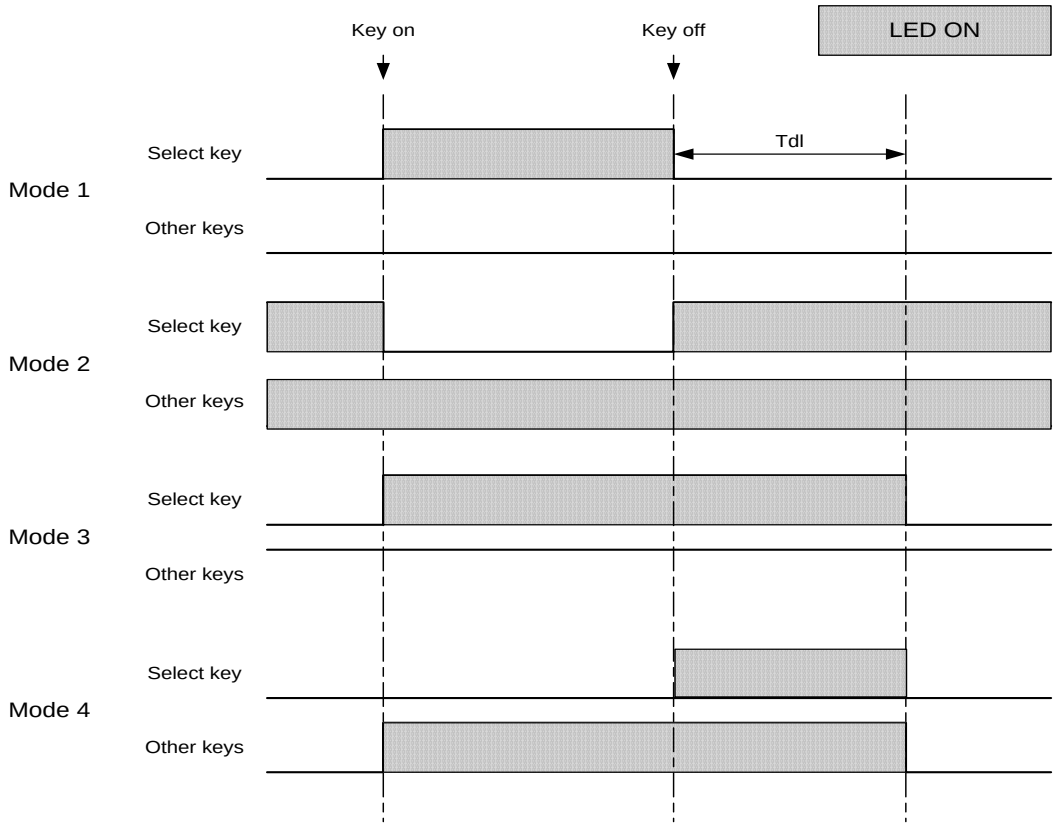
NXM1012/1013 has 4 Display modes,
Which are "Select key on mode", "All on and select key off mode"
"Select key on and delayed off mode", "Key select all on & select key off and delayed All off mode"



The display mode is
selectable by resister addition like left figure.
(If there be resister then 1, None resister then 0)

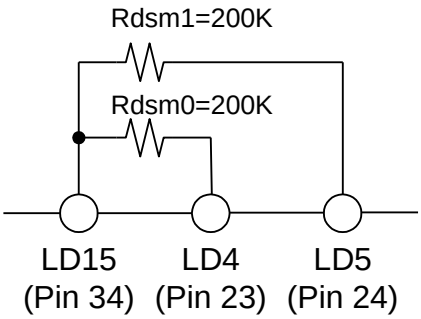
Rdsm1	Rdsm0	Display mode
0	0	Mode 1
0	1	Mode 2
1	0	Mode 3
1	1	Mode 4

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



* Detect speed setting

NXM1012/1013 has 3 Detect speed modes,
When stand alone application, 2 mode is provided
One is FS mode, other is SL mode,



The display speed is
selectable by resister addition like left figure.
(If there be resister then 1, None resister then 0)

Rdsm1	Rdsm0	Operation mode
0	0	FS mode (BS ←→ BF)
0	1	BF mode always
1	0	SL mode (Sleep ←→ BF)
1	1	NU

If FS mode, NXM1012/1013 stay BS mode, and key detect, it is changed BF mode.
And SL mode, NXM1012//1013 stay Sleep mode, and key detect, It is changed BF mode.
At any mode, if Key is detected within 4sec after last key released,
the mode is not changed.
In other word, after 4sec from Key released, it is return BS mode (when FS mode),
or Sleep mode (when SL mode)
If BF mode is selected by controller, (It can't be selected in Stand-alone application)
The NXM1012/1013 operates BF mode always
※ There are 3 mode of operation depending the current consumption.

FF mode operates always on the BS mode. Although it consumes current much, key detection time is the shortest.

FS mode operates normally on the BS mode. After detecting key, operation mode is converted to the BF mode. Current consumption is smaller the FF mode.

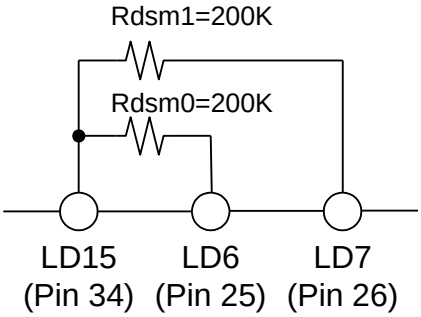
SL mode operates normally Sleep mode. After detecting key, operation mode is converted to the BF mode. Current consumption is the smallest.

There are 3 mode of key scan mode, key scan period is different each other(refer 4p)

* Display Delay time setting

When Delayed display after key action (Display mode 2 & 4) It can be setting delay time (Tdl). The delay time is selectable by resister addition like left figure.

(If there be resister then 1, None resister then 0)



Rdsm1	Rdsm0	Display Time
0	0	about 1 sec
0	1	about 2 sec
1	0	about 3 sec
1	1	about 4 sec

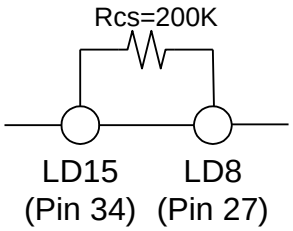
* Stuck release setting

There is option to release stuck status in stand-alone mode only.

This option is not applied in u-com application.

This option is selectable by resister addition like left figure.

(If there be resister then 1, None resister then 0)



Rdsm0	Mode
0	Disable
1	Enable

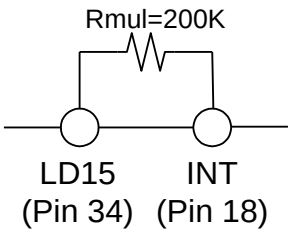
* Single/Multi setting

There is 2 mode in NXM1012/1013,

Single mode is only first 1 select mode, multi mode is detect key all select mode.

The Single/Multi mode is selectable by resister addition like left figure.

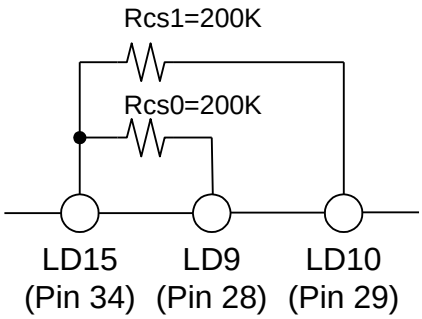
(If there be resister then 1, None resister then 0)



Rmul0	Mode
0	Single mode
1	Multi mode

- Register Map in serial setting

  * Write slave address is b"10011$C_1C_0$0" (C is custom bit)



It is selectable by resister addition like left figure.
(If there be resister then 1, None resister then 0)

Rcs1	Rcs0	IIC Slave address (write)
0	0	b"10011000"
0	1	b"10011010"
1	0	b"10011100"
1	1	b"10011110"

* Register Map

Sub address	Data [7:0]						
0X00				Stren	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]		
0X07		9ch-Sensitivity [2:0]			10ch-Sensitivity [2:0]		
0X08		11ch-Sensitivity [2:0]			12ch-Sensitivity [2:0]		
0x09		13ch-Sensitivity [2:0]			14ch-Sensitivity [2:0]		
0x0A		15ch-Sensitivity [2:0]			16ch-Sensitivity [2:0]		
0X0B	Led Data[7:0]						
0x0C	Led Data[15:8]						
0x0D	16-CH Output Data[7:0](Read-Only)						
0x0E	16-CH Output Data[15:8](Read-Only)						
0X10		NPADD[2:0]			SRST	NPEN	FTEN

* Stren : Stuck Release Enable

Value	Operation
0	Disable
1	Enable

* 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	BF mode always
0	0	1	FS mode (BS ←→ BF)
0	1	0	SL mode (Sleep ←→ BF)
0	1	1	NU
1	0	0	BF mode always
1	0	1	BS mode always
1	1	0	Sleep mode always
1	1	1	NU

* 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 = 4mA
0	0	1	ILED = 8mA
0	1	1	ILED = 12mA
1	1	1	ILED = 16mA

* 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) is enable to use up to 5 level of sensitivity

* 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

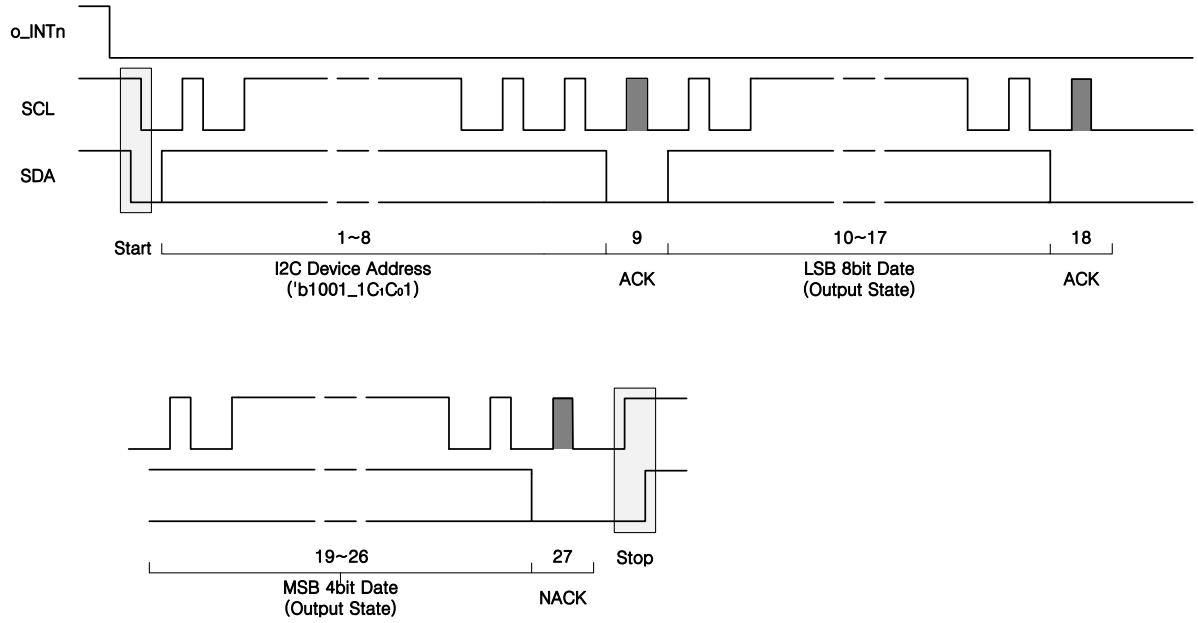
※ Above area is Sensitivity level that M1012 operates normally on Rotation Mode (OSCmd==2b10,2b11)

* SRst : Soft Reset

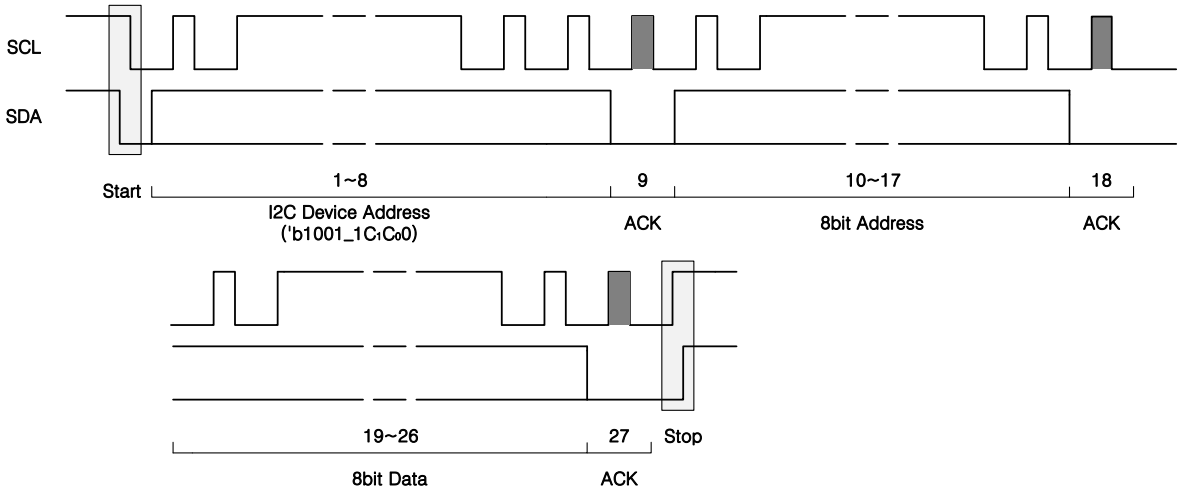
Value	Operation
0	Normal status
1	Soft Reset status

* Read Detect key

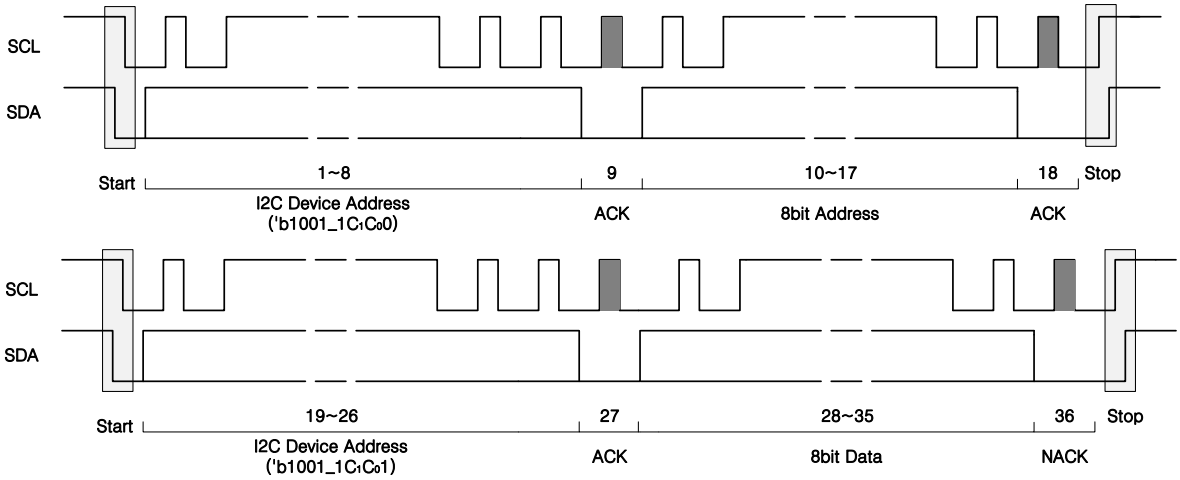
The slave address is b"10011$C_1C_0$1" (C is custom bit)



* Write Register Data through I2c Interface



* Read Register Data through I2c Interface



* Read DAout

If there is ADC in u-com,

It is enable data communication with only 1 line.

This pin is support that operation.

NXM1012/1013 has simple DAC and out different voltage according to pushed key.

Of course this function is operated only in Single mode.

When all keys are released, Aout = VCC,

and if some key is pushed, the voltage of Aout is like below

CS0	CS1	CS2	CS3	CS4	CS5	CS6	CS7
GND	1/16*VCC	2/16*VCC	3/16*VCC	4/16*VCC	5/16*VCC	6/16*VCC	7/16*VCC
CS8	CS9	CS10	CS11	CS12	CS13	CS14	CS15
8/16*VCC	9/16*VCC	10/16*VCC	11/16*VCC	12/16*VCC	13/16*VCC	14/16*VCC	15/16*VCC

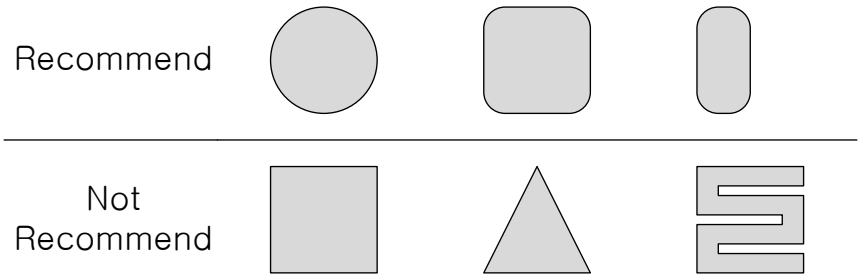
Maximum Falling Transition Time(Tfmax) = 20us

Maximum Rising Transition Time(Trmax) = 5us

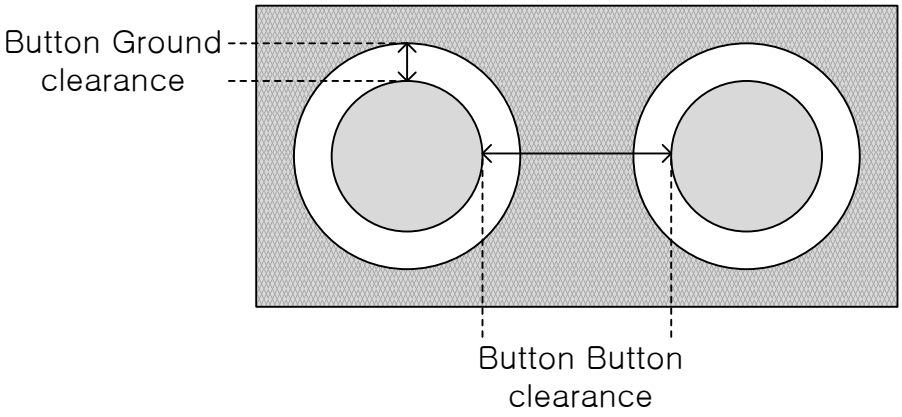
Layout Guidelines and best Practices

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

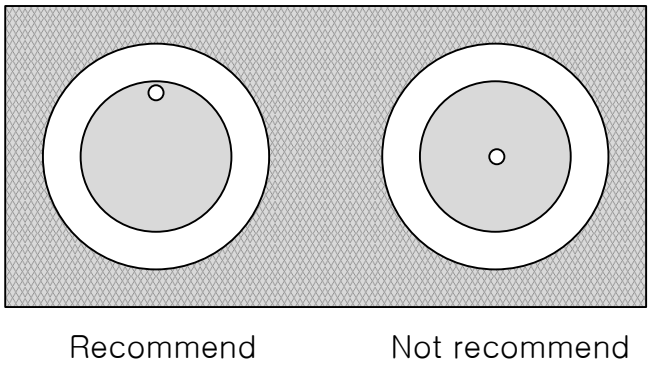
CapSence Button shapes



Button Layout Design

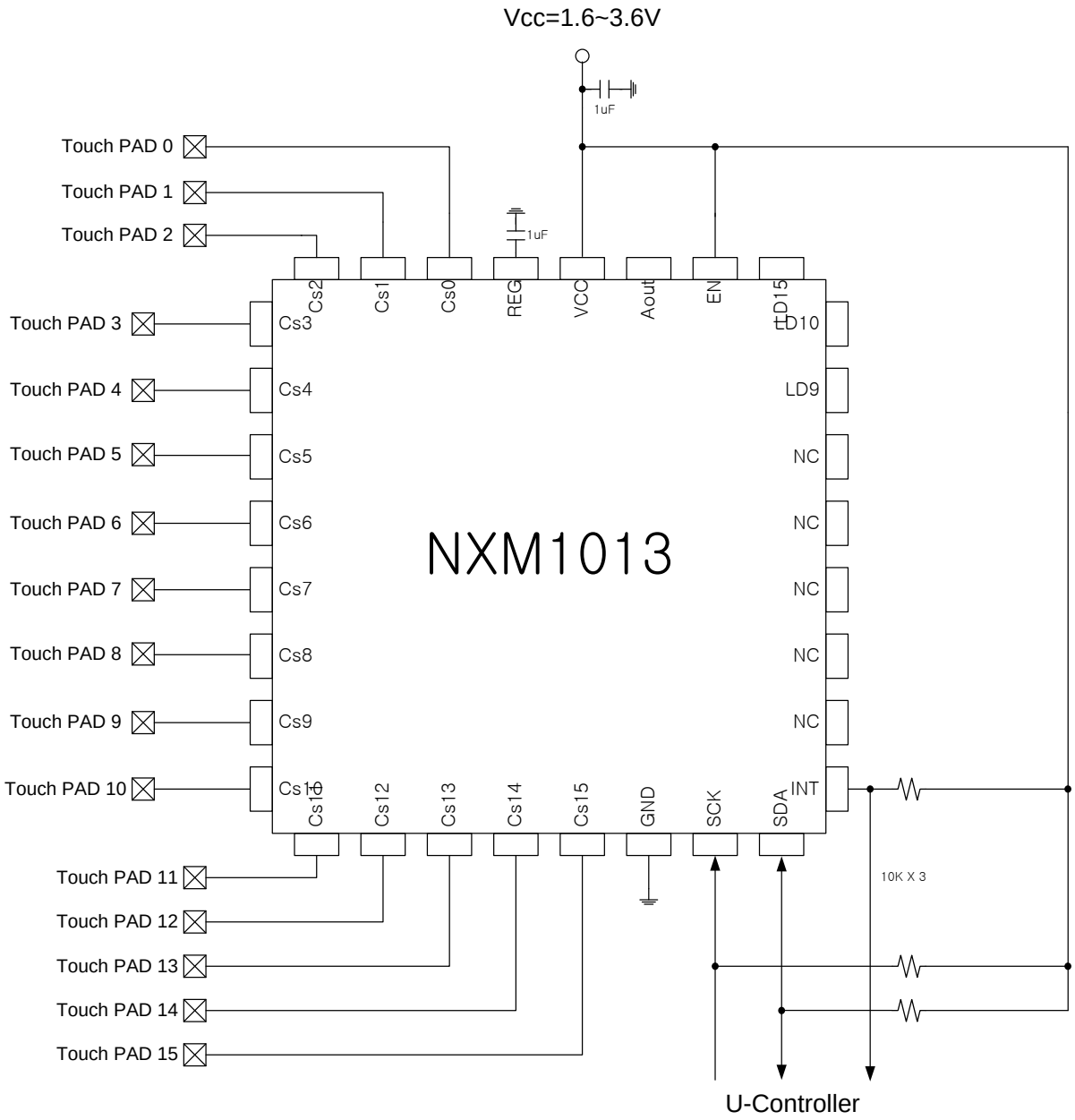


Recommended via-hole Placement



Application Circuit

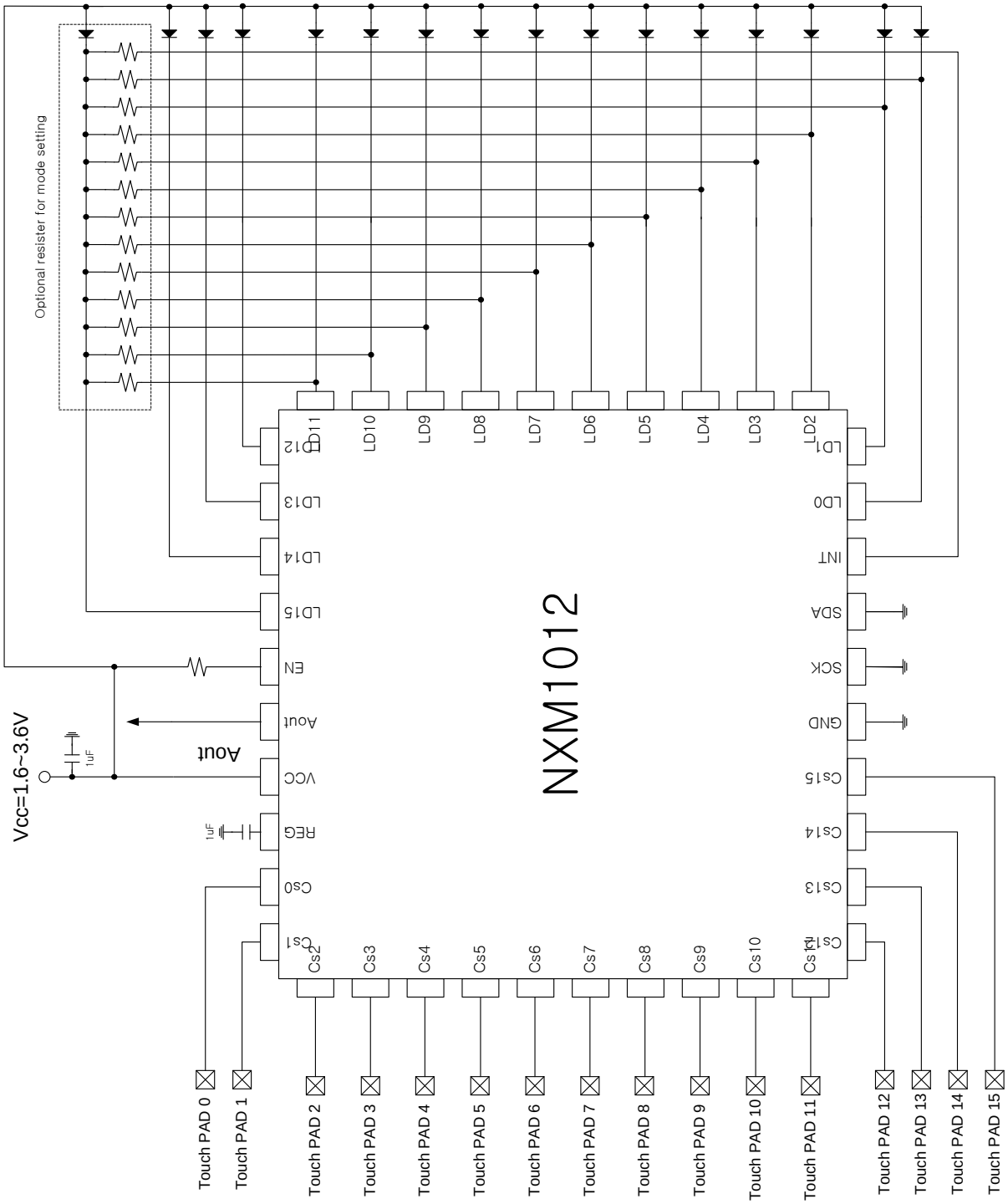
- With u-Controller (With IIC interface)



※ If NXM1012/1013 is single mode, unused input pins(CS input) should be connected to GND through capacitor 10pF.
(unused input pin capacitor value is 5pF larger than used input pin capacitor value)

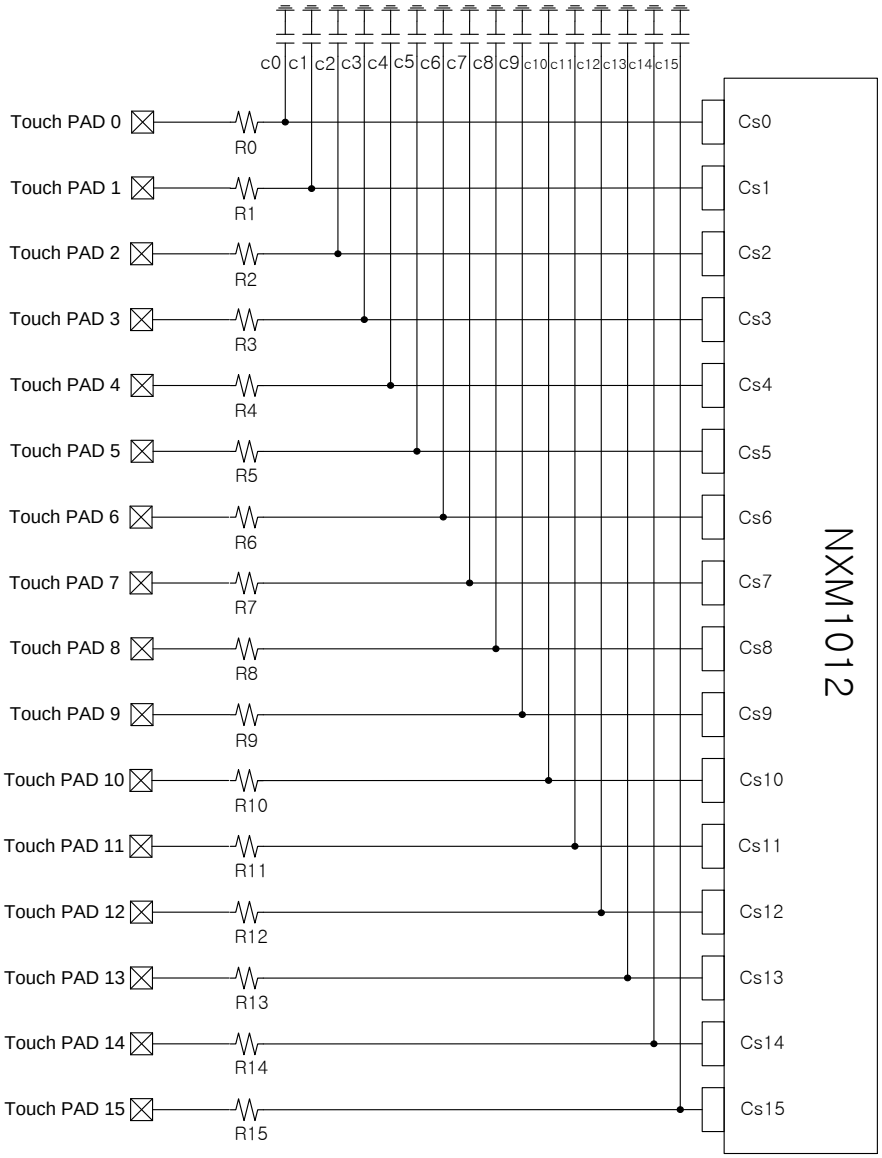
Application Circuit

- Stand alone (Using Aout or Parallel)



※ If NXM1012/1013 is single mode, unused input pins(CS input) should be connected to GND through capacitor 10pF.
(unused input pin capacitor value is 5pF larger than used input pin capacitor value)

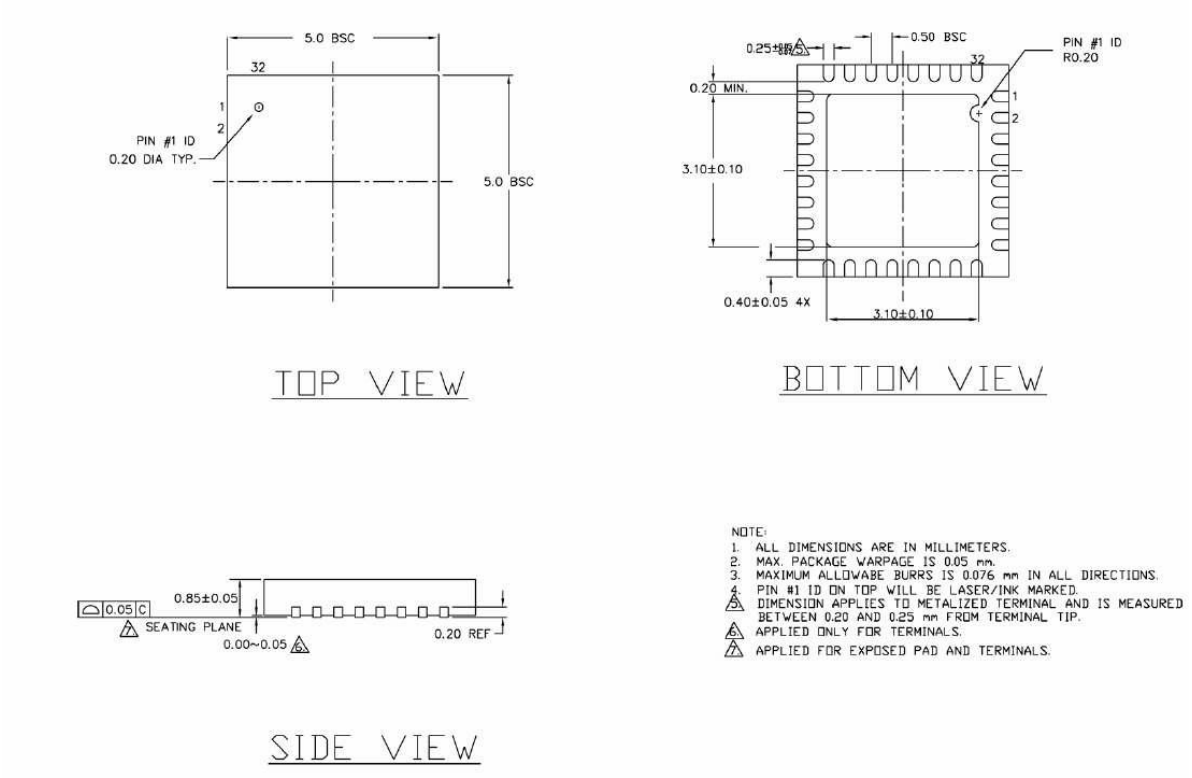
- Input CS connection for noise immunity



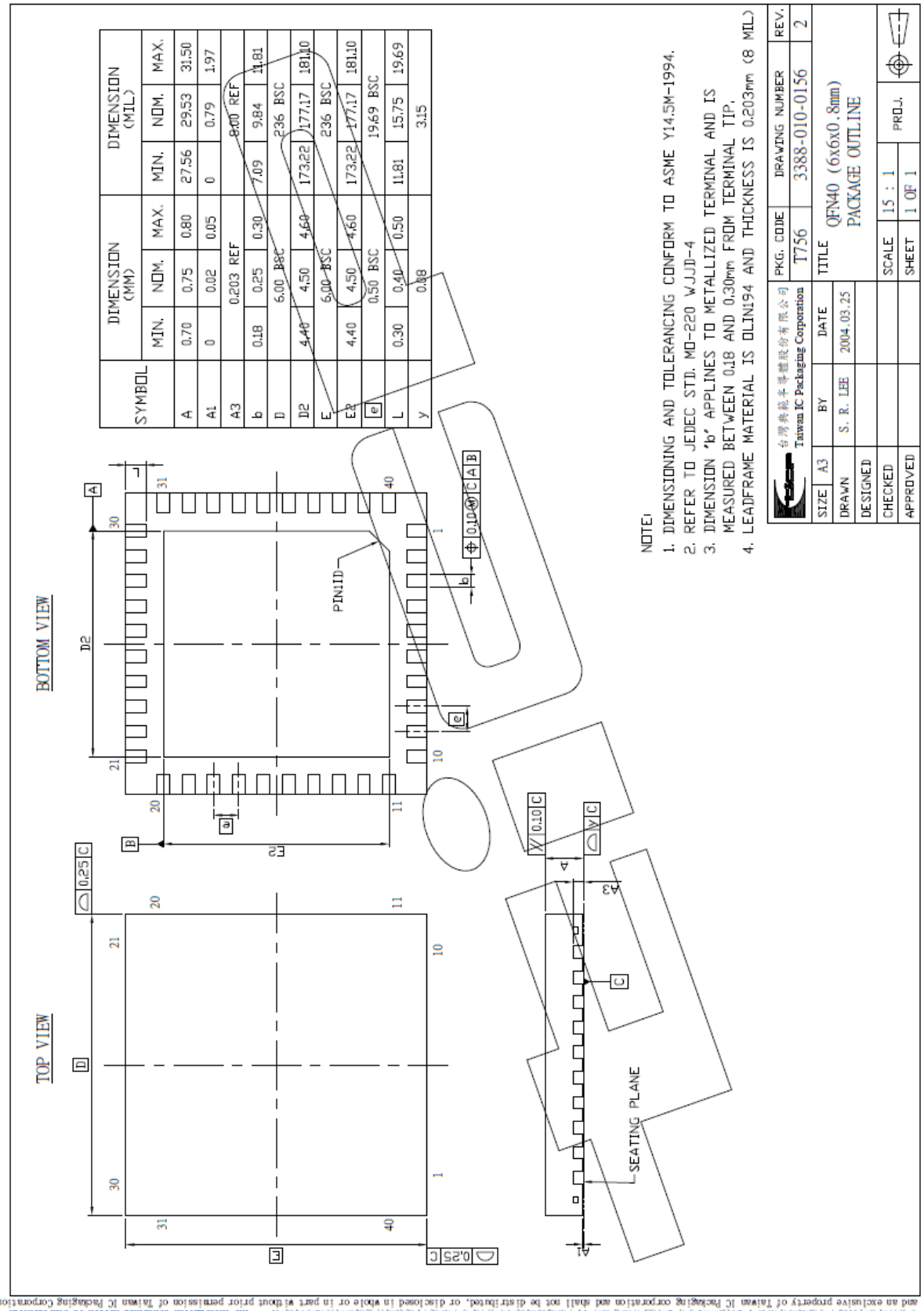
※ we recommend R0~R15 is from 1.6k to 2.4k and C0~C15 is less than 5pF.

※ R0~R15 and C0~C15 are not affected by noise , as closer to the chip.

Package Outline (32QFN, NXM1013)



Package Outline (40QFN, NXM1012)



SYMBOL	DIMENSION (MM) MIN.	NOM.	MAX.	DIMENSION (MIL) MIN.	NOM.	MAX.
A	0.70	0.75	0.80	27.56	29.53	31.50
A1	0	0.02	0.05	0	0.79	1.97
A3		0.203 REF			8.00 REF	
b	0.18	0.25	0.30	7.09	9.84	11.81
D		6.00 BSC			236 BSC	
D2	4.40	4.50	4.60	173.22	177.17	181.10
E		6.00 BSC			236 BSC	
E2	4.40	4.50	4.60	173.22	177.17	181.10
e		0.50 BSC			19.69 BSC	
L	0.30	0.40	0.50	11.81	15.75	19.69
y		0.08			3.15	