



九齊科技股份有限公司
Nyquest Technology Co., Ltd.

DATA SHEET

NY9T Series

4-bit MCU with LED Controller and Capacitive Touch of Low Stand-by Current

Version 1.3

Aug. 31, 2016

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Revision History

Version	Date	Description	Modified Page
1.0	2015/05/29	Formal release.	-
1.1	2015/08/20	<ol style="list-style-type: none"> 1. Modify PWM-IO description. 2. Update DC characteristics. 3. Update NY9T016A die pad diagram. 4. Update ordering information of package. 	<p style="text-align: center;">4, 6, 9</p> <p style="text-align: center;">19</p> <p style="text-align: center;">25</p> <p style="text-align: center;">26</p>
1.2	2015/11/17	<ol style="list-style-type: none"> 1. Modify the recommended R_{ADJ} value. 2. Modify NY9T001A die pad diagram. 3. Add package dimension information. 4. Modify ordering information. 	<p style="text-align: center;">18</p> <p style="text-align: center;">23</p> <p style="text-align: center;">26, 27, 28</p> <p style="text-align: center;">28</p>
1.3	2016/08/31	<ol style="list-style-type: none"> 1. Add CDC, PWM Frame Rate and Hysteresis description. 2. Modify V_{REG} capacitor value and R_{ADJ} description. 3. Add CDC pin description and the IC body with this function. 4. Add 4KHz and 66KHz of LED PWM Frame Rate. 5. Add Enlarge Scan Time. 6. Modify recommended R_{ADJ} value. 7. Add Touch-Key Hysteresis Level. 8. Add CDC parameter to DC Characteristics. 9. Add notice of PCB layout for R_{ADJ}. 	<p style="text-align: center;">4, 6</p> <p style="text-align: center;">7</p> <p style="text-align: center;">9, 10, 12, 14</p> <p style="text-align: center;">14</p> <p style="text-align: center;">17</p> <p style="text-align: center;">19</p> <p style="text-align: center;">19</p> <p style="text-align: center;">20</p> <p style="text-align: center;">23</p>

1. 概述

NY9T系列產品為單晶片CMOS的4位元微控制器，提供LED控制處理器與電容式觸摸感應功能。使用RISC精簡指令集架構，共有45條指令，大多數指令都是1個時序即可完成，可以很方便的以程式控制來完成不同的應用。利用+/-1%精準的400kHz內阻震盪，可以不需外加震盪電阻。另外，還內建一個RC16K模式以降低耗電，並提供待機模式(Halt mode)，可大幅度的節省功耗。

內建最多 8 通道的 PWM-IO LED 輸出，提供 4 種類比輸出電流，搭配數位 256 階的硬體 PWM 電流控制，可控制 LED 不同的亮度。還提供恆流輸出選項，讓使用者不用加上外部限流電阻就可保護 LED。藉由九齊的軟體開發工具“Q-Visio”，使用者在互動界面上可輕鬆、快速編寫 LED 閃法。

觸摸按鍵功能可以取代機械開關與按鍵，NY9T系列提供1至16個觸摸按鍵。內建的LDO穩壓器可以讓觸摸感應器提供穩定的電容式感應，自動判別算法可針對一定厚度範圍內的非導電材料來偵測不同形狀和大小的觸摸按鍵，而分時觸摸按鍵掃描也可有效的減少耗電。藉由九齊創新的開發軟體“Q-Touch”可開發不同的觸摸應用。

2. 功能

- 寬廣的工作電壓：2.0V ~ 6.0V。
- 4-bit RISC 精簡指令集架構的微控制器，共有45條指令。
- 共有4個母體，最大母體的ROM容量為16Kx10-bit，程式和資料共用同一塊ROM。

IC Type	I/O	ROM (bits)	RAM (bits)	Touch-Key	PWM-IO	*LED Brightness Level
NY9T001A	4	4K x 10	48 x 4	1	3	256
NY9T004A	8	8K x 10	48 x 4	4	4	256
NY9T008A	16	12K x 10	96 x 4	8	8	256
NY9T016A	24	16K x 10	96 x 4	16	8	256

- NY9T001A – Touch-Key: PA0, PWM-IO: PE0~PE2.
- NY9T004A – Touch-Key: PA0~PA3, PWM-IO: PE0~PE3.
- NY9T008A – Touch-Key: PA0~PA3, PB0~PB3, PWM-IO: PE0~PE3, PF0~PF3.
- NY9T016A – Touch-Key: PA0~PA3, PB0~PB3, PC0~PC3, PD0~PD3, PWM-IO: PE0~PE3, PF0~PF3.

- 最大母體的RAM為 96x4-bit，分成2頁，每頁48x4-bit。
- 400KHz 指令頻率。
- 精準的400KHz內阻振盪。(+/- 1%)
- 提供RC16K模式可降低耗電。(+/- 30%)
- 提供待機模式(Halt mode)，可節省功耗，靜態電流(Isb)小於1uA。
- 掃描觸摸按鍵時的待機電流非常低，可減少耗電。
- 提供低壓復位(LVR=1.8V)，看門狗計時(WDT)，I/O復位功能(External Reset)。

- 最多有24根彈性的I/O腳，可設定為：一般I/O、PWM-I/O 輸出 或 Touch-Key 輸入。
- General purpose I/O的輸入與輸出由暫存器控制。選擇輸入時，使用者可以選擇：輸入無下拉電阻 (Floating)、弱輸入下拉電阻(Weak Pull-Low Resistor) 或 強輸入下拉電阻(Strong Pull-Low Resistor)。選擇輸出時，使用者可選擇：CMOS輸出 或 一般電流開漏輸出(Open Drain with Normal Sink Current)。
- 最多有 8 通道同的 PWM-I/O 輸出(PE0~3 與 PF0~3)，PWM-I/O 腳位和一般 I/O 共用。每個輸出腳還可以有三種輸出選擇：大灌電流輸出(Large Sink Current)、定灌電流輸出(恆流, Constant Sink Current, CSC) 或 拉電流輸出(Drive Current)。
- PE0~3 和 PF0~3 輸出電流選項：
 - a. 大灌電流輸出：4 種電流 100%、83%、50% 或 33%。
 - b. 定灌電流輸出：4 種電流 100%、83%、50% 或 33%。
 - c. 拉電流輸出：只有一種 100% 電流，部分 IC 在 PE1 與 PE2 提供定拉電流輸出(CDC)。
- PWM-I/O 搭配軟體控制，最多有 256 階 LED 亮度，LED 的更新率(frame rate)為 128Hz、4KHz 或 66KHz。
- 最多有 16 個觸摸鍵：PA0~3、PB0~3、PC0~3 和 PD0~3，皆和一般 I/O 共用。
- 觸摸按鍵可選擇 同時多個按鍵偵測 或 單一按鍵偵測功能。(光罩選擇)
- 觸摸感應的硬體自動校正功能可隨時提供精準的觸摸按鍵偵測以避免環境改變。
- 可設定 任一觸摸按鍵 或 特定觸摸按鍵(Key1/PA0) 來喚醒 IC。(光罩選擇)
- 2 種觸摸按鍵掃描模式：一般模式(Normal mode) 或 慢速模式(Slow mode)，可由軟體選擇。在一般模式時，會進行依序掃描，可以減少按鍵偵測時間，但比較耗電。而在慢速模式時，會進行分時掃描，可以減少耗電但需要較長的喚醒時間。
- 4 種觸摸按鍵反應時間(Debounce Time)，可以用來避免雜訊干擾。(光罩選擇)
- 2 種觸摸遲滯選擇，小遲滯窗口或大遲滯窗口。(光罩選擇)
- 2 種靈敏度模式：預設模式(Preset mode) 與 自訂模式(Custom mode)。(光罩選擇)
- 8 階靈敏度控制，可經由軟體或外部 R_{ADJ} 電阻來調整。
- 內建 LDO 穩壓器(2.1V)，以提供穩定的電源來避免靈敏度異常導致偵測錯誤。

1. GENERAL DESCRIPTION

The NY9T series IC is a powerful 4-bit micro-controller based LED control processor with capacitive touch sensing function. The RISC MCU architecture is very easy to program and control, and various applications can be easily implemented. There are total 45 instructions, and most of them are executed in one cycle. Through the accurate 400kHz internal oscillation of +/- 1% tolerance, an external resistor is not required. Furthermore, a RC16K mode is designed to save power consumption and a HALT is to minimize the power.

There are maximum 8 channels of PWM-IO LED output. PWM-IO output can provide 4 kinds of analog output current cooperating with 256-level hardware digital current control to drive LED with different brightness. The optional constant current is provided to protect LED, and it's not necessary to add the external current-limit resistor. The interactive software-developing tool of "Q-Visio" is user-friendly and quick for LED pattern programming.

The Touch-Key function can replace the mechanical switch or button. Multiple Touch-Keys is from 1 touch key up to 16 touch keys. A built-in LDO regulator for touch sensor can provide a stable capacitive sensing design for touch application. The auto distinguishing methodology supports the diversity key pattern in a thickness range of non-conductive dielectric material, and time sharing Touch-Key scan also reduces the power consumption. An innovative software tool "Q-Touch" is provided to develop the different touch applications.

2. FEATURES

- Wide operating voltage range: 2.0V to 6.0V.
- 4-bit RISC type micro-controller with 45 instructions.
- There are 4 bodies. 16Kx10-bit ROM is the maximum. Program and LED data share the same ROM space.

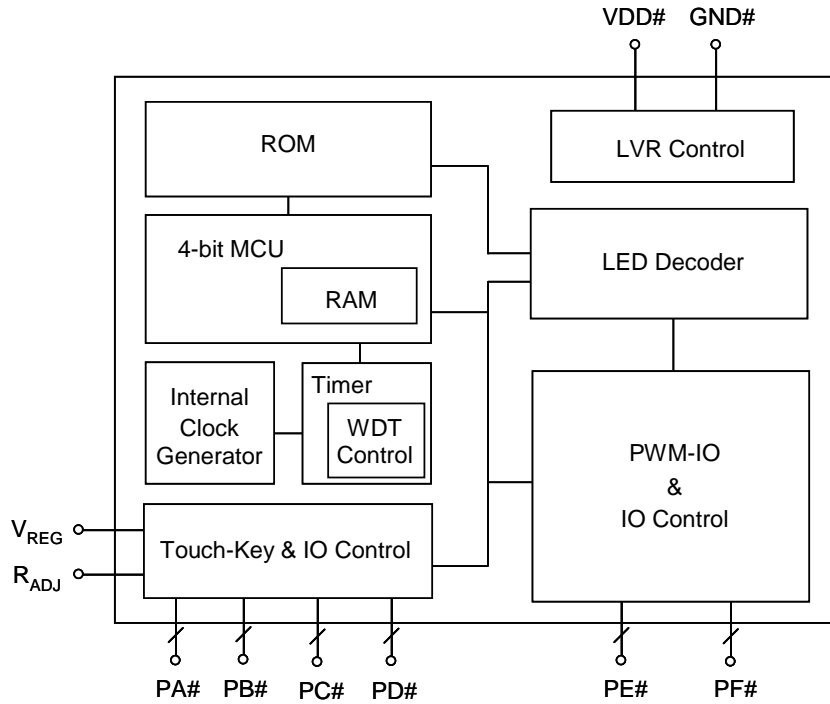
IC Type	I/O	ROM (bits)	RAM (bits)	Touch-Key	PWM-IO	*LED Brightness Level
NY9T001A	4	4K x 10	48 x 4	1	3	256
NY9T004A	8	8K x 10	48 x 4	4	4	256
NY9T008A	16	12K x 10	96 x 4	8	8	256
NY9T016A	24	16K x 10	96 x 4	16	8	256

- NY9T001A – Touch-Key: PA0, PWM-IO: PE0~PE2.
- NY9T004A – Touch-Key: PA0~PA3, PWM-IO: PE0~PE3.
- NY9T008A – Touch-Key: PA0~PA3, PB0~PB3, PWM-IO: PE0~PE3, PF0~PF3.
- NY9T016A – Touch-Key: PA0~PA3, PB0~PB3, PC0~PC3, PD0~PD3, PWM-IO: PE0~PE3, PF0~PF3.

- Maximum 96x4-bit RAM, divided into 2 pages.
- 400KHz instruction frequency.
- Precisely 400KHz oscillator with built-in resistor R_{osc} for operating mode. (+/- 1% tolerance)
- RC16K mode to save the power consumption. (+/- 30% tolerance)

- HALT mode to minimize power, less than 1uA standby current.
- Very low standby current for Touch-Key scan to reduce the power consumption.
- Low Voltage Reset (1.8V), Watch-Dog Reset and I/O Port reset are all supported to protect the system.
- Maximum 24 flexible I/Os with optional function: General purpose I/O, PWM-I/O output or Touch-Key input.
- General purpose I/O's direction is controlled by registers. For the input option, users can select one of three kinds of option: input without pull-low resistor (floating), input with weak pull-low resistor or input with strong pull-low resistor. For the output Port, users can select the CMOS output or Open Drain output with normal sink.
- Maximum 8-channel PWM-I/O output of PE0~3 and PF0~3 shared with I/Os. Each output has other 3 kinds of output option: large sink current, constant sink current (CSC) or drive current output.
- PE0~3 and PF0~3 output current option:
 - a. Large sink current: 4 kinds of current, 100%, 83%, 50%, 33%.
 - b. Constant sink current: 4 kinds of current, 100%, 83%, 50%, 33%.
 - c. Drive current: only 100% current and constant drive current (CDC) only for PE1 and PE2.
- Programmable PWM-I/O has maximum 256 levels LED brightness with software control. The LED frame rate can be selected from 128Hz, 4KHz and 66KHz.
- Maximum 16 Touch-Keys of PA0~3, PB0~3, PC0~3 and PD0~3 shared with I/Os.
- Touch-Key supports simultaneous multi-key or single-key touch function configured by option.
- Hardware Auto-Calibration function of Touch-Key is provided for touch accuracy to prevent the environment change.
- Touch-Key wake-up can be any key or specified key (Key1/PA0) configured by option.
- 2 kinds of scan modes for Touch-Key: normal mode and slow mode, selected by software programming. At normal mode, sequential scan can shorten the touch detecting time but more power consumed. Oppositely, at slow mode, time sharing scan can reduce power consumption but longer wake-up time.
- 4 kinds of debounce time for Touch-Key press/release detection configured by option in order to keep away from the noise interference.
- 2 kinds of hysteresis level: Small Hysteresis Level and Large Hysteresis Level for all Touch-Keys configured by option.
- 2 kinds of sensitivity mode: Preset mode and Custom mode for all Touch-Keys configured by option.
- 4 kinds of sensitivity levels can be selected by software programming or external R_{ADJ} resistor.
- Built-in LDO regulator (2.1V) for a stable power that avoids the abnormal sensitivity and false detection.

3. BLOCK DIAGRAM



4. PAD DESCRIPTION

Pad Name	ATTR.	Description
VDD#	Power	Positive power
GND#	Power	Negative power
V _{REG}	Power	Regulator input. Connect a 1000pF (102) cap to GND or keep floating.
PA0~3	I/O	Bit 0~3 for Port A
PB0~3	I/O	Bit 0~3 for Port B
PC0~3	I/O	Bit 0~3 for Port C
PD0~3	I/O	Bit 0~3 for Port D
PE0~3	I/O	Bit 0~3 for Port E
PF0~3	I/O	Bit 0~3 for Port F
R _{ADJ}	I	Connect an external resistor to adjust the sensitivity, or keep floating.

* PA0~PA3, PB0~PB3, PC0~PC3 and PD0~PD3 shared with Touch-Key1~16.

* PE0~PE3 and PF0~PF3 shared with PWM-IO.

* PE0 is shared with reset pin.

5. MEMORY ORGANIZATION

There are maximum 16K words ROM, 96 nibbles of RAM and 14 nibbles of dedicated system control register. The RAM page register (PG) is without address allocation, and they can only be accessed by the special instruction MPG.

5.1 ROM

A large program/data/LED single ROM is provided and its structure is shown below. The reserved region contains system information and can't be utilized by users. The program page is limited by the unconditional branch instruction: JMP and CALL. Because it can only handle 14-bit length address of ROM, the program page size is 16K words.

Address	ROM
0x000000	Reset Vector
0x000001	
0x00000F	
0x000010	Interrupt Vector
0x00001E	
0x00001F	Reserved
0x0001FF	
0x000200	Program & Data Space
0x000FFF	Program Page 0
0x001000	
0x003FFF	Program & Data Space

5.2 RAM

Each page of RAM contains 48 nibbles. The NY9T provides maximum 96 nibbles of 2 pages. The page number (PG) register of RAM defined by the MPG instruction, and its initial value is 0. The address for RAM is 0x10~0x3F.

6. CLOCK GENERATOR

The clock generator is a built-in Ring oscillator, and users can only select the internal resistor (INT-R). The INT-R oscillator accuracy is up to $\pm 1\%$. The system clock is 400KHz for instructions running.

After power-on, NY9T will start its reset process. The power on stable time is about 131ms. Then NY9T will enter normal operation. In normal operating mode, the system clock is 400KHz and user can implement sorts of application. On the other hand, users can select RC16K mode or Halt mode to save power consumption.

7. IO PORTS

There are 24 I/O Ports at most, designated as PAX through PFX, and x=0~3. All the I/O Ports can be configured as input or output by registers, i.e. normal I/O. For the input Port, we provide an internal pull-low register option for convenience. For the output port, users can select the normal sink current output or drive current output. When the PE0~3 or PF0~3 pins are optioned as normal I/O, the output sink current can be optioned as normal sink current, large sink current (33%, 50%, 83%, 100%) or constant sink current (33%, 50%, 83%, 100%). **The PE1 and PE2 pins can be optioned as constant drive current (CDC) output in NY9T001A and NY9T008A (refer to the following table). In NY9T001A and NY9T008A, the PE pins can be optioned as constant drive current output (refer to the following table).**

The PA0~3, PB0~3, PC0~3 or PD0~3 pins can be optioned as a Touch-Key individually. The PE0~3 or PF0~3 pins can be optioned as PWM-IO output pin individually, and each output pin can be optioned as large sink current (33%, 50%, 83%, 100%), constant sink current (33%, 50%, 83%, 100%) or drive current output. **The PE1 and PE2 pins can be optioned as constant drive current (CDC) output (refer to the following table).** The PE0 pin can be optioned as an external reset pin, which can possess a pull-low resistor.

The pull-low resistor of all the I/O Ports has two kinds of option: weak and strong. The weak one is about $1M\Omega$ @3V for normal application and the strong one is about $100k\Omega$ @3V usually for key matrix function. Each I/O can be configured as the weak or strong pull-low resistor individually.

Before using an I/O Port, configure its direction register first. The execution result of the read / write operation perform on the data register depends on the direction register. When an I/O Port is configured as an input Port (PxIO = 1), the data read from the data register is the pad status. Otherwise, it reads out the data stored in the data register.

The data register of an input Port is only used for wake-up sequence. Because the difference between the pad and the register leads to a wake-up from the halt mode, users have to read the pad status and save back to the data register before entering the halt mode.

Contrastingly, the content of the data register is the pad status output by this output Port.

If a PWM-IO output is required, option an I/O Port as a PWM-IO Port first. If a Touch-Key is required, option an I/O Port as Touch-Key first. When I/O Port is assign to PWM-IO or Touch-Key, the I/O direction is not controlled by the direction register.

If users want to use PWM-IO output with constant sink current, the related I/O option must be set as constant sink current.

The following table shows the I/O Port options for MaskROM products.

NY9T001A with 4 I/Os

I/O	Option		Description
PA0	Touch-Key input		Enable
PE0~PE2	Normal I/O	Input pull-low resister	Floating
			Weak
			Strong
		Output type	CMOS
			Open Drain
		Output drive current	Constant Drive (PE1, PE2)
		Output sink current	Normal Sink
			Large Sink 33%
			Large Sink 50%
			Large Sink 83%
			Large Sink 100%
			Constant Sink 33%
			Constant Sink 50%
			Constant Sink 83%
	PWM-IO output	Constant Sink 100%	
		Disable	
		Large Sink 33%	
		Large Sink 50%	
		Large Sink 83%	
		Large Sink 100%	
		Constant Sink 33%	
		Constant Sink 50%	
		Constant Sink 83%	
Constant Sink 100%			
Reset input (PE0 only)	Drive		
	Constant Drive (PE1, PE2)		
	Disable		
		Enable	

NY9T004A with 8 I/Os

I/O	Option		Description
PA0~PA3	Normal I/O	Input pull-low resister	Floating
			Weak
			Strong
		Output type	CMOS
	Open Drain		
	Touch-Key input		Disable
			Enable
	PE0~PE3	Normal I/O	Input pull-low resister
Weak			
Strong			
Output type			CMOS
			Open Drain
Output sink current			Normal Sink
			Large Sink 33%
			Large Sink 50%
			Large Sink 83%
			Large Sink 100%
		Constant Sink 33%	
		Constant Sink 50%	
Constant Sink 83%			
Constant Sink 100%			
PWM-IO output		Disable	
		Large Sink 33%	
		Large Sink 50%	
		Large Sink 83%	
		Large Sink 100%	
		Constant Sink 33%	
		Constant Sink 50%	
		Constant Sink 83%	
		Constant Sink 100%	
		Drive	
Reset input (<i>PE0 only</i>)		Disable	
		Enable	

NY9T008A with 16 I/Os

<i>I/O</i>	<i>Option</i>		<i>Description</i>	
PA0~PA3 PB0~PB3	Normal I/O	Input pull-low resistor	Floating	
			Weak	
			Strong	
		Output type	CMOS	
	Open Drain			
	Touch-Key input		Disable	
			Enable	
	PE0~PE3 PF0~PF3	Normal I/O	Input pull-low resistor	Floating
Weak				
Strong				
Output type			CMOS	
			Open Drain	
Output drive current			Constant Drive (PE2)	
Output sink current			Normal Sink	
			Large Sink 33%	
			Large Sink 50%	
			Large Sink 83%	
		Large Sink 100%		
		Constant Sink 33%		
		Constant Sink 50%		
Constant Sink 83%				
Constant Sink 100%				
PWM-IO output				Disable
				Large Sink 33%
				Large Sink 50%
				Large Sink 83%
				Large Sink 100%
			Constant Sink 33%	
			Constant Sink 50%	
			Constant Sink 83%	
			Constant Sink 100%	
			Drive	
		Constant Drive (PE2)		
Reset input (<i>PE0 only</i>)			Disable	
			Enable	

NY9T016A with 24 I/Os

I/O	Option		Description
PA0~PA3 PB0~PB3 PC0~PC3 PD0~PD3	Normal I/O	Input pull-low resister	Floating
			Weak
			Strong
		Output type	CMOS
	Open Drain		
	Touch-Key input		Disable
			Enable
	PE0~PE3 PF0~PF3	Normal I/O	Input pull-low resister
Weak			
Strong			
Output type			CMOS
			Open Drain
Output sink current			Normal Sink
			Large Sink 33%
			Large Sink 50%
			Large Sink 83%
			Large Sink 100%
		Constant Sink 33%	
		Constant Sink 50%	
		Constant Sink 83%	
Constant Sink 100%			
PWM-IO output		Disable	
		Large Sink 33%	
		Large Sink 50%	
		Large Sink 83%	
		Large Sink 100%	
		Constant Sink 33%	
		Constant Sink 50%	
		Constant Sink 83%	
Reset input (<i>PE0 only</i>)		Drive	
		Disable	
		Enable	

8. LED CONTROL

The NY9T provides a hardware LED control and driver function. Users can play a LED section by setting the extension value to FOSC[1:0] and LED channel output register OEN[7:0] first, then executing the PLAY command.

Step	Process	Instruction
1	Set LED start address in RPT3, RPT2, RPT1, RPT0	
2	Set extension value FOSC[1:0] and LED channel output register OEN[7:0]	
3	Start to play	PLAY
4	Pause: Write 1 to PAUSE/RESUME	
5	Resume: Write 0 to PAUSE/RESUME	
6	Stop playing	STOP

The LED output is an 8-bit hardware PWM. The NY9T provides 3 kinds of options of constant sink current, large sink current or drive current for each PWM-IO pin individually. The large sink current and constant sink current (CSC) can be optioned as different current output of 100%, 83%, 50% and 33%, but the drive current and constant drive current (CDC) are only 100%.

The NY9T has maximum 8-channel PWM-IO output, optioned by mask. LED channel output control register decides which channel will be played.

The LED start address is loaded to LPR when executing the PLAY command. The NY9T supports 8-bit PWM-IO data that means 256 levels resolution of LED brightness. The LED frame rate can be selected from 128Hz, 4KHz and 66KHz. Frame rate 128Hz and 4KHz can support up to 256 levels of brightness, however 66KHz only supports 32 levels resolutions. Basically, the LED section is encoded and combined by different LED samples, and any LED sample period can be one of 1/128, 1/64, 1/16 and 1/4 second.

LED sample period = (1 / frame rate) * n, n=1, 2, 8, 32.

- The LED frame rate can be selected from 128Hz, 4KHz and 66KHz. Different IC Body provides different LED frame rate option, and there are some restrictions in 4KHz and 66KHz.
- For 4KHz, only PE0, PE1 and PE2 can be set as PWM-IO.
- For 66KHz, only supports 32 levels resolutions and only one I/O can be set as PWM-IO.

The following table shows the PWM frame rate of each NY9T Body.

IC Type	PWM Frame Rate
NY9T001A	4KHz, 66KHz
NY9T004A	128Hz
NY9T008A	128Hz, 4KHz
NY9T016A	128Hz, 4KHz

The LED control register LEDCTL contains the FOSC of LED sample extension control, the PAUSE/RESUME and the BUSY flag of playing LED.

Control Register	Name	Mode	Bit	Function description
LEDCTL	FOSC[1:0]	R/W	[1:0]	LED sample extension x 8 LED sample extension x 4 LED sample extension x 2 LED sample extension x 1
	PAUSE/RESUME	R/W	[2]	Pause/Resume LED
	BUSY	R	[3]	Busy

9. TOUCH-KEY CONTROL

The NY9T provides a capacitive sensing Touch-Key function. With built-in LDO for touch sensor, it can reduce the false detection which is induced by the various power supply voltage. The hardware calibration function is also built-in to adjust the environment changing to fit the sensitivity. Besides, it accepts the multi-key entry function or only single-key entry function optioned by mask. And a slow mode of Touch-Key that re-arranges the Touch-Key scan mode can reduce the power consumption. From the Touch-Key data register, users can distinguish which Touch-Key is pressed on/off by software polling or interrupt routine.

The NY9T provides 2 ways of Custom mode and Preset mode for users to set up the sensitivity threshold. At any mode, there are eight levels sensitivity to control the touch sensitivity, which can be selected by software.

9.1 Touch-Key Control Register

Control register	Name	Mode	Bit	Function description
TPCTL	TPEN	R/W	[0]	Touch-Key enable/disable
	TP_SLOW	R/W	[1]	Touch-Key slow mode
	CALIB1	R/W	[2]	Auto-Judge calibration mode
	CALIB2	R/W	[3]	Enforce calibration mode

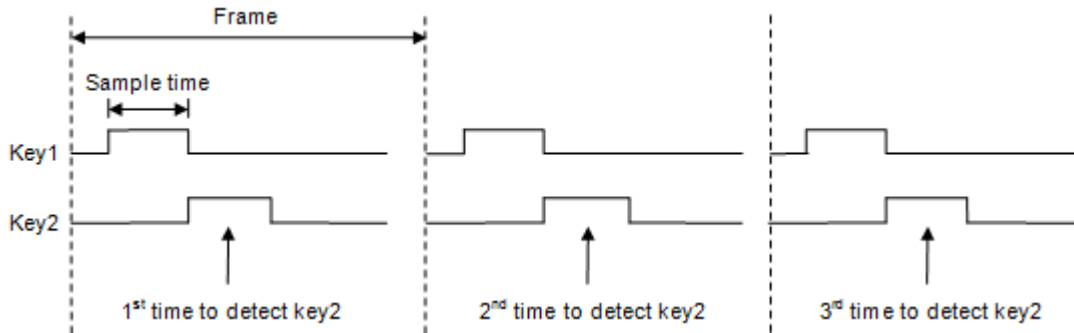
The TPEN bit of TPCTL register can enable/disable Touch-Key function. To enable the Touch-Key function, the bit has to be set as “1”. On the contrary, to disable the Touch-Key function, the bit has to be set as “0”.

Touch-Key function enables the slow mode by setting the TP_SLOW bit of TPCTL register as “1”. When IC enters the slow mode, the Touch-Key scan rate will be slower than normal mode for saving power.

Users must calibrate the environment to acquire the background parameter. NY9T provides two kinds of calibration modes that are Auto-Judge calibration and Enforce calibration by setting the corresponding bit of CALIB1 and CALIB2 to “1”.

9.2 Touch-Key Scan Time

The touch hardware can not sense all Touch-Keys at the same time, and it only senses a Touch-Key once every time normally. Therefore, a timing of Touch-Key scan is arranged to detect all Touch-Keys.



9.3 Sample Time

The sample time is the duration to scan one Touch-Key, and either 1ms or 2ms sample time is provided for Touch-Keys. The TIMES option represents how much time to scan one Touch-Key. Longer sample time will get more touch accuracy but longer touch detecting time.

<i>Options</i>	<i>Selected items</i>
TIMES	1ms/2ms

9.4 Frame Rate

The frame rate is the period to complete the scanning for all Touch-Keys, and it can be composed of 8 or 16 samples. That FM32MS option decides how many samples to finish one frame. The frame rate is TIMES*FM32MS. More samples in one frame will consume less power, but longer touch detecting time.

<i>Options</i>	<i>Selected items</i>
FM32MS	8/16 samples in one frame

Note: For NY9T016A, the FM32MS is fixed as 16 samples.

9.5 Debounce Time

The debounce time defines how many frames to detect the identical Touch-Key pressed/released continuously in order to recognize the specified Touch-Key On/Off. The DETS option provides four kinds of debounce time. More debounce time will get more touch accuracy but longer touch detecting time. For high noise environment such as home appliance application, more debounce time is suggested.

<i>Options</i>	<i>Selected items</i>
DETS	"Touch-Key On" needs 1 frame, "Touch-Key Off" need 1 frame
	"Touch-Key On" needs 2 frames, "Touch-Key Off" need 1 frame.
	"Touch-Key On" needs 4 frames, "Touch-Key Off" need 2 frames.
	"Touch-Key On" needs 6 frames, "Touch-Key Off" need 3 frames.

9.6 Detect Time

Base on the Touch-Key sensing time arrangement, the maximum scan time to detect one key touched is $TIMES * FM32MS * n + \text{Wake-up time}$, $n=1/2/4/6$ depend on the "Touch-Key On" frame of DETS.

Wake-up time is zero at normal mode, $3 * TIMES * FM32MS$ at slow mode or $4 * TIMES * FM32MS$ at slow-green mode.

9.7 Enlarge Scan Time

If touch key sensitivity threshold do not distinguish enough, user can enlarge scan time to gain better resolution and the detect time will extend too. Every touch keys can be set as Enlarge Scan Time or not through *Q-Touch*. Different IC type has different enlarge multiple.

<i>IC Type</i>	<i>Enlarge</i>
NY9T001A	X2, X4
NY9T004A	N/A
NY9T008A	X2
NY9T016A	N/A

9.8 Touch-Key Scan Mode

In Touch-Key scan mode, there are normal mode and slow mode configured by software. Users can enable the slow mode by setting the TP_SLOW bit of TPCTL register as "1". When IC enters the slow mode, the interval of each Touch-Key scan will become 4 times of the normal mode in order to save power. And when any Touch-Key is pressed on successfully, IC will leave the slow mode for normal mode and the TP_SLOW will be set as "0" automatically.

NY9T supports maximum 16 Touch-Keys, which shares with Port A to Port D optioned by mask. When users configure 8 Touch-Keys above, another slow-green mode could be optioned instead of slow mode. That is, if GREEN option is enabled, the slow mode will become slow-green mode. At this moment, if the TP_SLOW register is set as "1", it will enter slow-green mode.

<i>Options</i>	<i>Selected item</i>
GREEN	Slow-green mode enable/disable

Basically, it's a trade-off between the operating current and touch sensitivity for different scan modes. At normal mode, every Touch-Key is scanned once a frame, and it will get more sensitive but more power consumption. At slow mode, every Touch-Key is scanned once 4 frames, and it will get less power consumption but less sensitive. At slow-green mode, every 2 or 4 Touch-Keys is simultaneously scanned once 4 frames. Users can set different scan mode by software for the balance between power consumption and sensitivity.

9.9 Wake-Up

When NY9T enters slow mode (or slow-green mode), if any Touch-Key is detected as pressed, IC will go back to normal mode automatically. This operation is called wake-up. Therefore, if users want to calculate the maximum “Touch-Key On” time while Touch-Key scanning, the wake-up time must be included.

Once the Touch-Key is pressed successfully, the TP_SLOW bit will be cleared automatically, and the scan mode will be kept at normal mode immediately. But if touch is not successful, the scan mode is still at slow mode (or slow-green) after the finger touch is released.

The wake-up key can be optioned as Any Key or Key1 (PA0) by mask. When Key1 (PA0) is optioned, the other Touch-Keys can’t wake-up the system, and the power consumption is minimized.

<i>Options</i>	<i>Selection item</i>
WAKEUPS	Any-Key / Key1 (PA0)

9.10 Single/Multi-Key Touch

The NY9T supports single-key touch or multi-key simultaneous touch by hardware option. The single-key function is for detecting one key pressed and the other keys have no effect, and it is similar with input-irretrigger function and simple to use. The multi-key function enables multi keys active at the same time, and users can design complicated touch function by software programming as they want. The SINGLE option decides the Touch-Key function is single or not.

<i>Options</i>	<i>Selected item</i>
SINGLE	Single-key / Multi-key

9.11 Sensitivity Level

8 levels of sensitivity can be set by software after users finish the sensitivity threshold measurement. The most to less sensitive is level-0 to level-7. The SENS register store the sensitivity level as following.

<i>SENS</i>	<i>Sensitivity level</i>	<i>Sensitivity</i>
000	0	Most sensitive
001	1	↑
010	2	
011	3	
100	4	Typical
101	5	↓
110	6	
111	7	

9.12 External Adjust

Except software sensitivity control, an external hardware sensitivity control is reserved. Through R_{ADJ} pad connecting a resistor to GND, users can adjust the sensitivity for different background environment. After IC power on and wait 8 instruction cycle, user can follow the steps below to get SENS value to modify sensitivity level.

Recommended R_{ADJ}	Mapping Sensitivity Level
750K Ω (+/-1% tolerance)	0 (000)
360K Ω (+/-1% tolerance)	1 (001)
180K Ω (+/-1% tolerance)	2 (010)
120K Ω (+/-1% tolerance)	3 (011)
82K Ω (+/-1% tolerance)	4 (100)
51K Ω (+/-1% tolerance)	5 (101)
33K Ω (+/-1% tolerance)	6 (110)
16K Ω (+/-1% tolerance)	7 (111)

9.13 Touch-Key Anti-Interference

According to PCB layout, if the electrode pad of Touch-Keys are very close, the neighboring Touch-Key will influence each other by the parasitic capacitance. The Touch-Key Anti-Interference function can reduce the coupling effect to improve the noise immunity. But the total capacitance of Touch-Key will be increased, and it will reduce the sensitivity a little. Thus, if the neighboring Touch-Key will interfere with other Touch-Key, users can enable Touch-Key Anti-Interference option. If not, it is suggested to disable Touch-Key Anti-Interference option. The TP_NOSCAN option decides the Touch-Key Anti-Interference enabled or disabled.

Options	Selected item
TP_NOSCAN	Touch-Key Anti-Interference

9.14 Touch-Key Hysteresis Level

The hysteresis function is to avoid noise interference when the edge of trigger pad is touched by hand caused continuous triggers. There are 2 kinds of hysteresis level, Hysteresis Level Small (shift 1 level) and Hysteresis Level Large (shift 1/2). When any Touch-Key is pressed, the sensitivity level auto decrease 1 level or divided the sensitivity threshold value by 2, until all Touch-Key is released.

Options	Selected item
Touch-Key Hysteresis	Small/Large/Disable

Note: This function is not supported by NY9T004A.

10. ELECTRICAL CHARACTERISTICS
10.1 Absolute Maximum Rating

Symbol	Parameter	Rated Value	Unit
V _{DD} - V _{SS}	Supply voltage	-0.5 ~ +6.5	V
V _{IN}	Input voltage	V _{SS} -0.3V ~ V _{DD} +0.3	V
T _{OP}	Operating Temperature	0 ~ +70	°C
T _{ST}	Storage Temperature	-25 ~ +85	°C

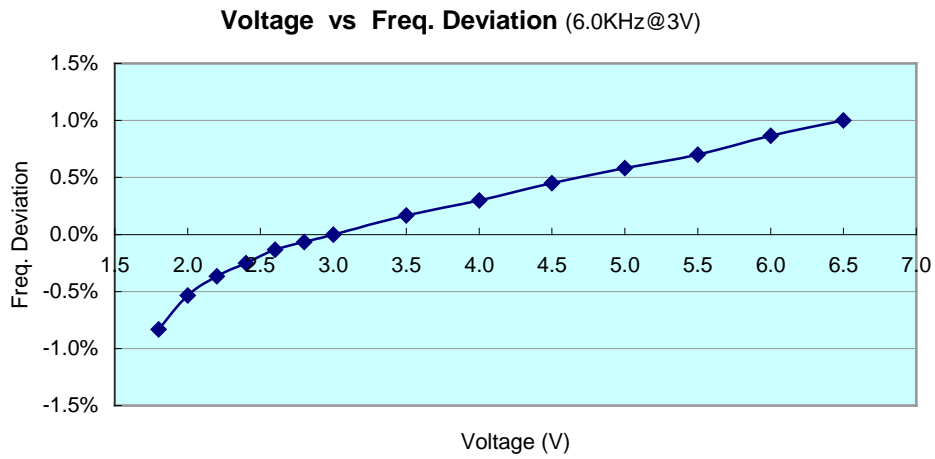
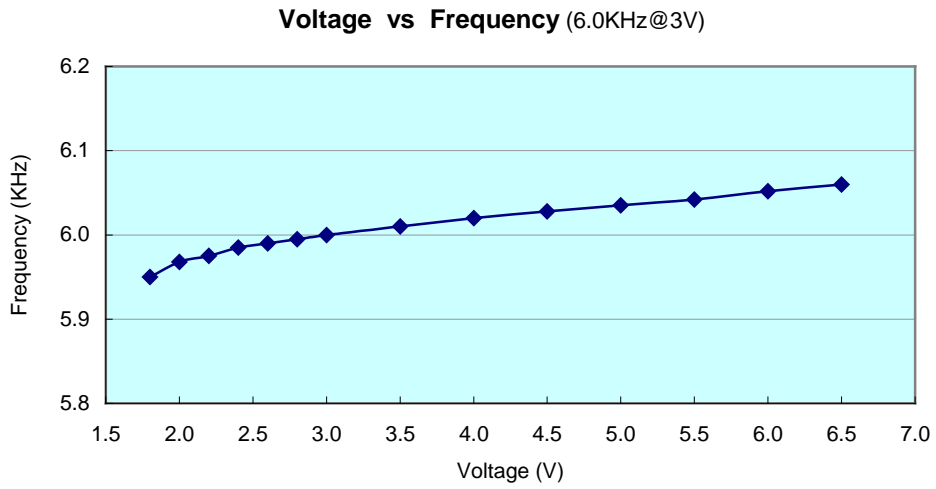
10.2 DC Characteristics

Symbol	Parameter	V _{DD}	Min.	Typ.	Max.	Unit	Condition
V _{DD}	Operating voltage		2.0	3	6.0	V	400KHz
I _{SB}	Halt mode	3		0.1	0.5	uA	Sleep, no load LVR disable
		4.5		0.1	0.5		
I _{OP}	RC16K mode	3		0.7		uA	16KHz, no load
		4.5		2.2			
	Standby mode	3		1.6		uA	Key1 (PA0) wakeup, 16 samples per frame
		4.5		3.3			
Operating mode	3		350		uA	400KHz, no load	
	4.5		500				
I _{IH}	Weak (1M ohms)	3		3		uA	V _{IH} =V _{DD}
		4.5		8			
	Strong (100k ohms)	3		30			
		4.5		80			
I _{OH}	Output drive current	3		-10		mA	V _{OH} =2.0V
		4.5		-16			V _{OH} =3.5V
	Output constant drive current	3		-3.4		mA	V _{OH} =2.0V
		4.5		-3.8			V _{OH} =3.5V
I _{OL}	Output normal sink current	3		20		mA	V _{OL} =1.0V
		4.5		30			
	Output large sink current (100%)	3		50			
		4.5		70			
	Output constant sink current (100%)	3		19			
		4.5		20			
ΔF/F	Frequency deviation by voltage drop (400kHz)	3		-0.5		%	$\frac{F_{osc}(3.0v)-F_{osc}(2.4v)}{F_{osc}(3v)}$
		4.5		1.0			$\frac{F_{osc}(4.5v)-F_{osc}(3.0v)}{F_{osc}(4.5v)}$
ΔF/F	Frequency lot deviation (400kHz)	3	-1		1	%	$\frac{F_{max}(3.0v)-F_{min}(3.0v)}{F_{max}(3.0v)}$
F _{OSC}	Oscillation Frequency	-	370	400	430	KHz	V _{DD} =2.0~6.0V

10.3 Touch-Key Scan Current (Sample_Time=1ms, Calibration_Period=4s, T_A=25°C, unless otherwise specified)

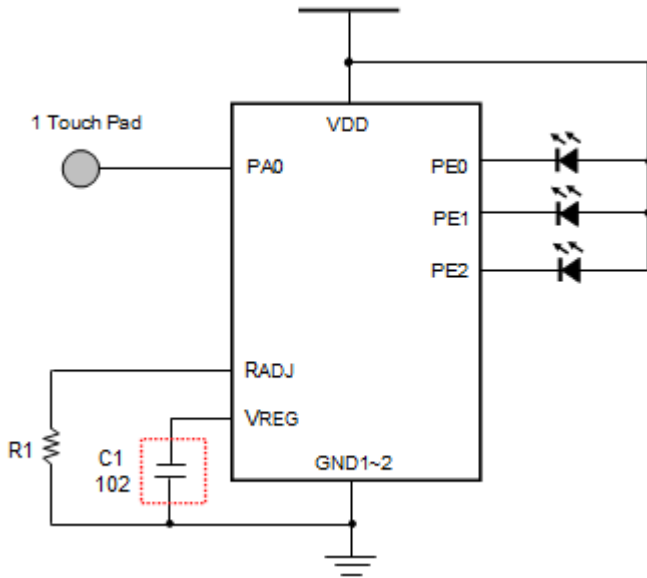
Body (Wakeup Key)	Touch Keys	Samples of Frame	VDD	Touch-Key Scan Current				
				Normal Mode	PA0 Wakeup	Any-Key Wakeup		
					Slow Mode	Slow Mode	Slow-Green Mode	
NY9T001A	1-key	8	3.0V	4.1 uA	1.6 uA	/	/	
			4.5V	6.3 uA	3.3 uA			
		16	3.0V	2.4 uA	1.2 uA			
			4.5V	4.3 uA	2.8 uA			
NY9T004A	2-key	8	3.0V	10.1 uA	1.6 uA	2.8 uA	/	
			4.5V	12.7 uA	3.3 uA	4.8 uA		
		16	3.0V	5.5 uA	1.2 uA	2.0 uA		
			4.5V	7.5 uA	2.8 uA	3.4 uA		
	4-key	8	3.0V	13.0 uA	1.6 uA	3.7 uA		/
			4.5V	17.0 uA	3.3 uA	6.0 uA		
		16	3.0V	7.0 uA	1.2 uA	2.3 uA		
			4.5V	9.6 uA	2.8 uA	4.1 uA		
NY9T008A	6-key	8	3.0V	21.5 uA	1.8 uA	6.0 uA	4.1 uA	
			4.5V	27.0 uA	3.5 uA	8.8 uA	6.4 uA	
		16	3.0V	11.5 uA	1.4 uA	3.5 uA	2.7 uA	
			4.5V	15.1 uA	3.0 uA	5.7 uA	4.6 uA	
	8-key	8	3.0V	24.8 uA	1.8 uA	6.9 uA	4.1 uA	
			4.5V	31.6 uA	3.5 uA	9.8 uA	6.4 uA	
		16	3.0V	13.0 uA	1.4 uA	4.1 uA	2.7 uA	
			4.5V	17.2 uA	3.0 uA	6.2 uA	4.6 uA	
NY9T016A	10-key	/	3.0V	/	/	/	/	
			4.5V	/	/	/	/	
		16	3.0V	20.0 uA	1.6 uA	5.8 uA	2.9 uA	
			4.5V	25.0 uA	3.3 uA	8.5 uA	4.9 uA	
	12-key	/	3.0V	/	/	/	/	
			4.5V	/	/	/	/	
		16	3.0V	21.7 uA	1.6 uA	6.3 uA	2.9 uA	
			4.5V	27.1 uA	3.3 uA	9.0 uA	4.9 uA	
	14-key	/	3.0V	/	/	/	/	
			4.5V	/	/	/	/	
		16	3.0V	23.3 uA	1.6 uA	6.7 uA	2.9 uA	
			4.5V	29.3 uA	3.3 uA	9.5 uA	4.9 uA	
	16-key	/	3.0V	/	/	/	/	
			4.5V	/	/	/	/	
		16	3.0V	24.6 uA	1.6 uA	7.1 uA	2.9 uA	
			4.5V	31.8 uA	3.3 uA	11.8 uA	4.9 uA	

10.4 Voltage vs. Frequency

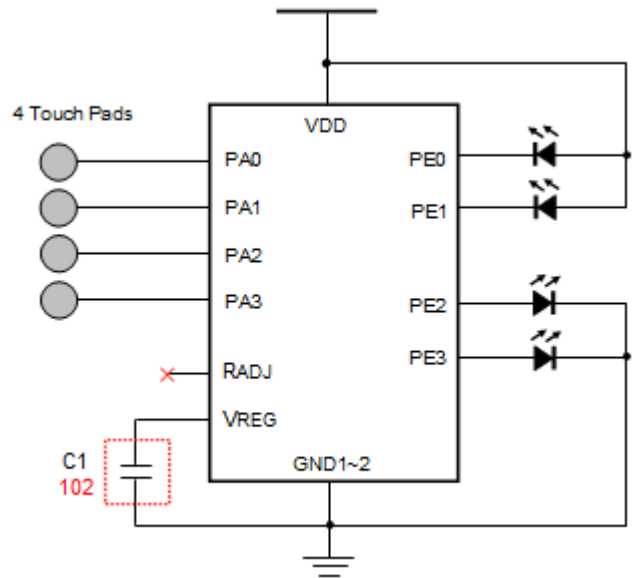


11. APPLICATION

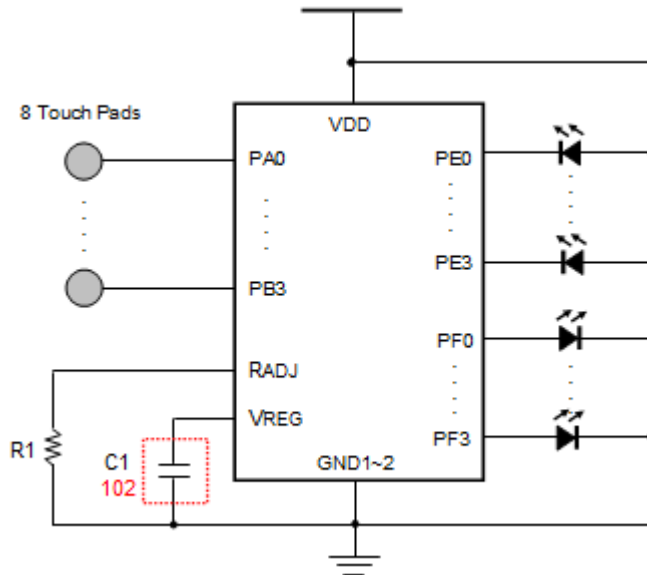
(1) 1 Touch-Key with External R_{ADJ} Sensitivity Control



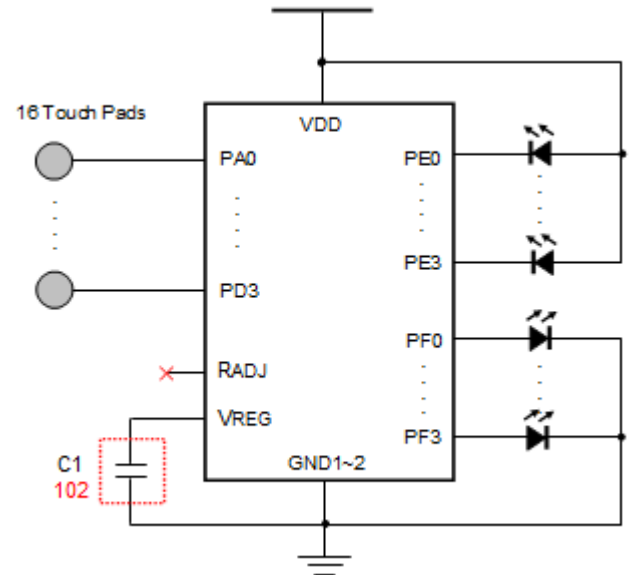
(2) 4 Touch-Keys without External R_{ADJ} Sensitivity Control



(3) 8 Touch-Keys with External R_{ADJ} Sensitivity Control



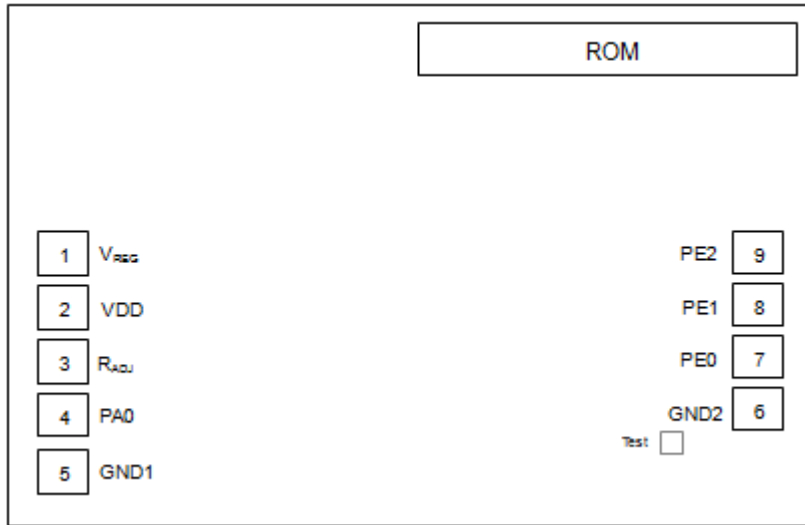
(4) 16 Touch-Keys without External R_{ADJ} Sensitivity Control



- * For DC battery application, please note that C1 is NOT necessary and can be saved.
For AC application with high power noise, the capacitance of 1000pF (102) is suggested for C1 to filter the noise.
- * R1 is used to adjust the Touch Sensitivity, which must be cooperated with software programming.
- * The length of R1 trace from IC to resistor must be within 0.5cm, and also avoids any parallel trace, or parallel GND nearby or at different layer

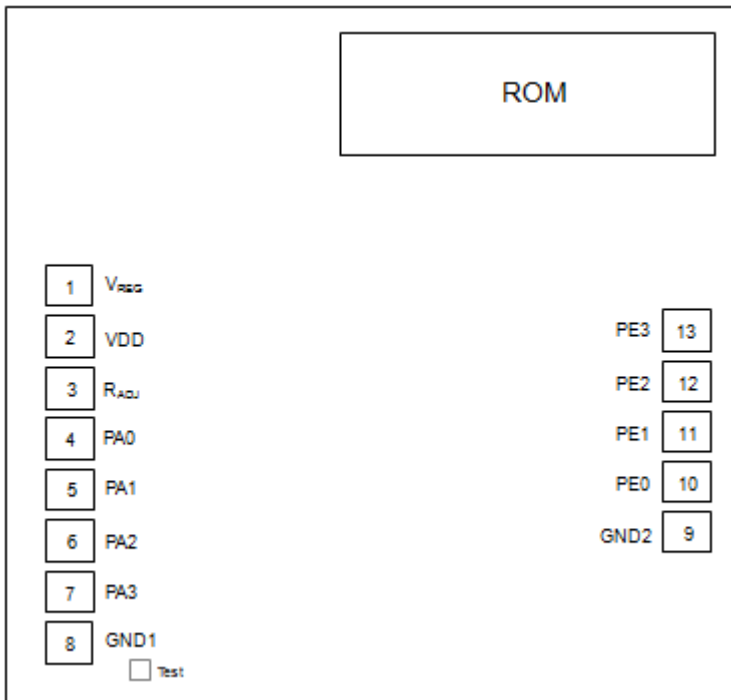
12. DIE PAD DIAGRAM

(1) NY9T001A



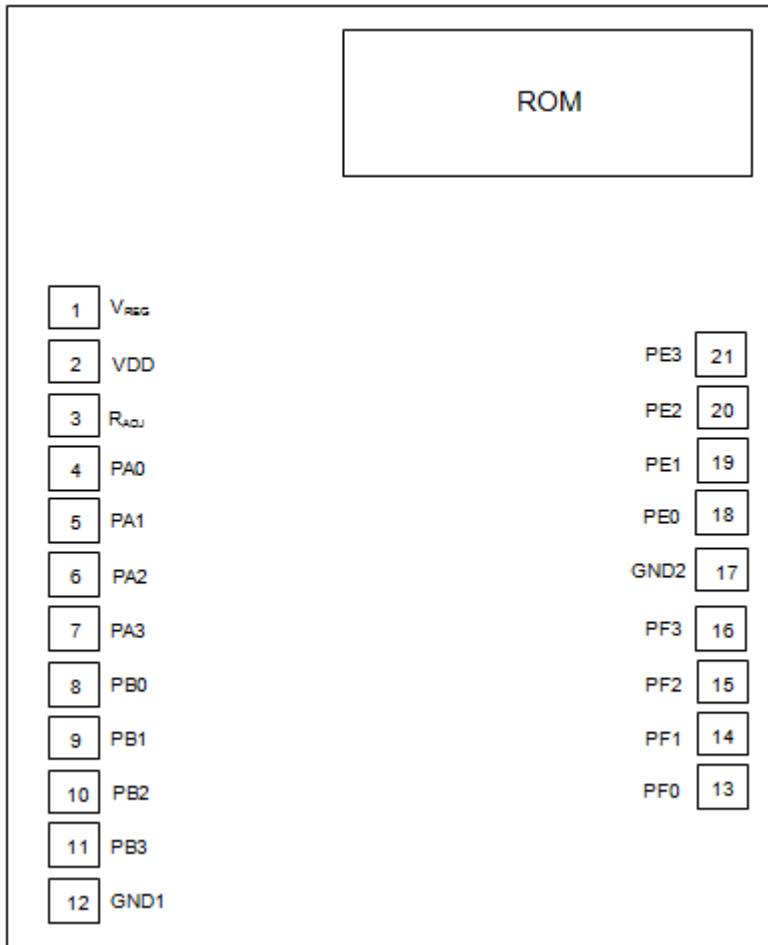
* The IC substrate must be connected to GND or Floating.

(2) NY9T004A



* The IC substrate must be connected to GND or Floating.

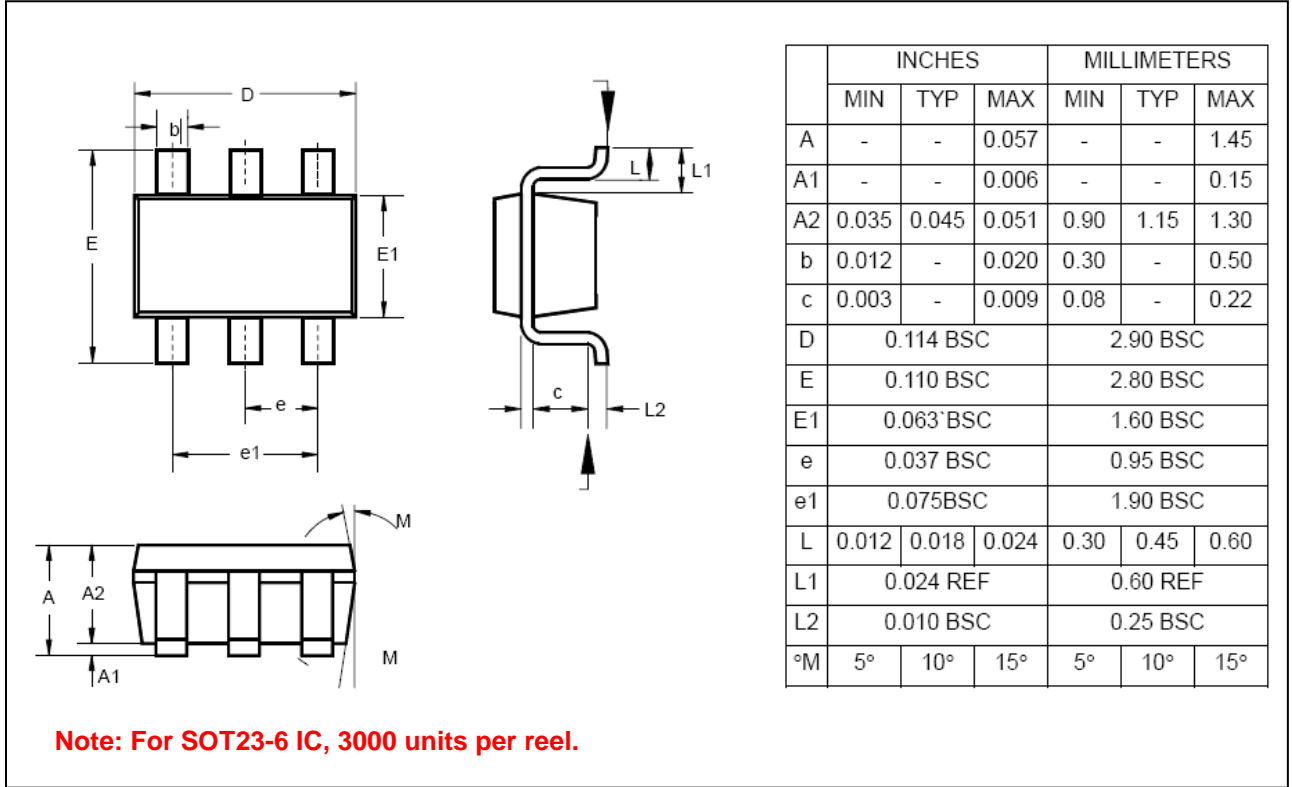
(3) NY9T008A



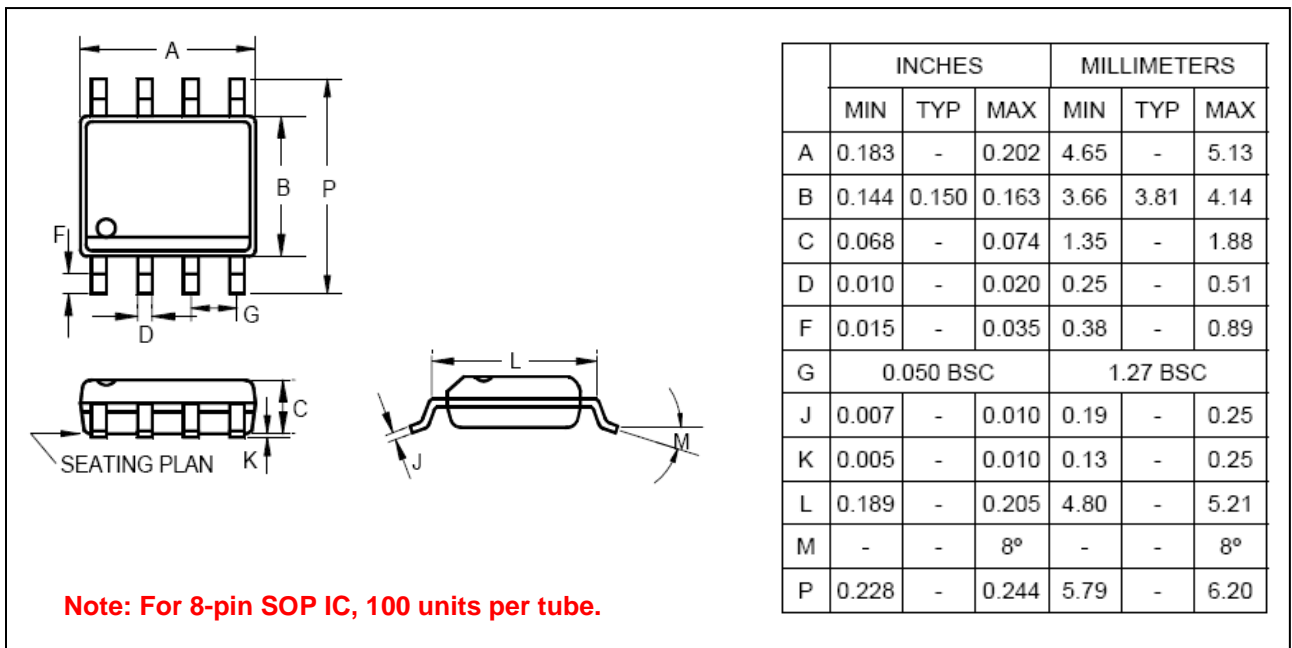
* The IC substrate must be connected to GND or Floating.

13. Package Dimension

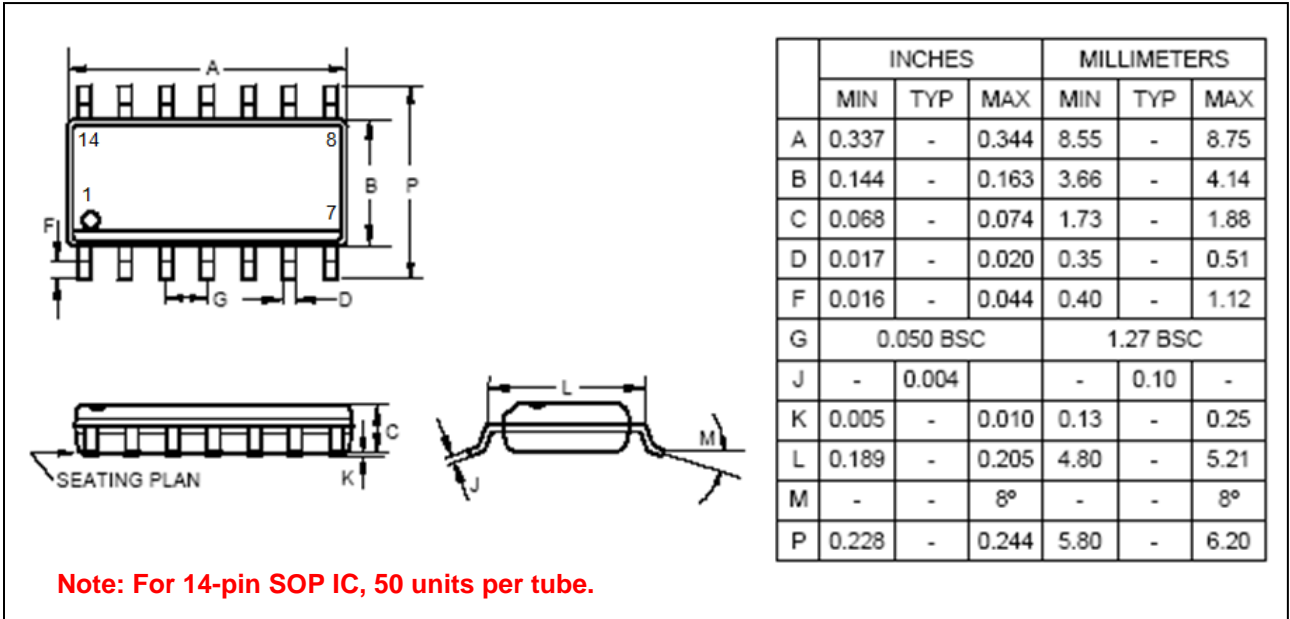
13.1 6-Pin Plastic SOT23-6 (63 mil)



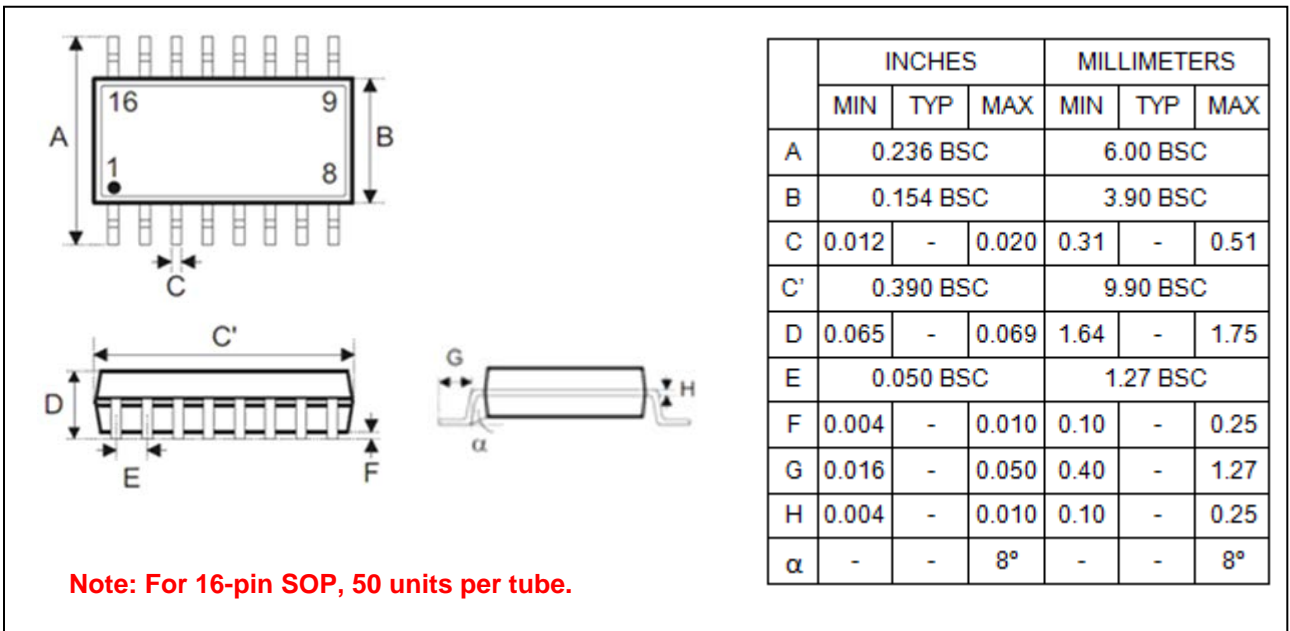
13.2 8-Pin Plastic SOP (150 mil)

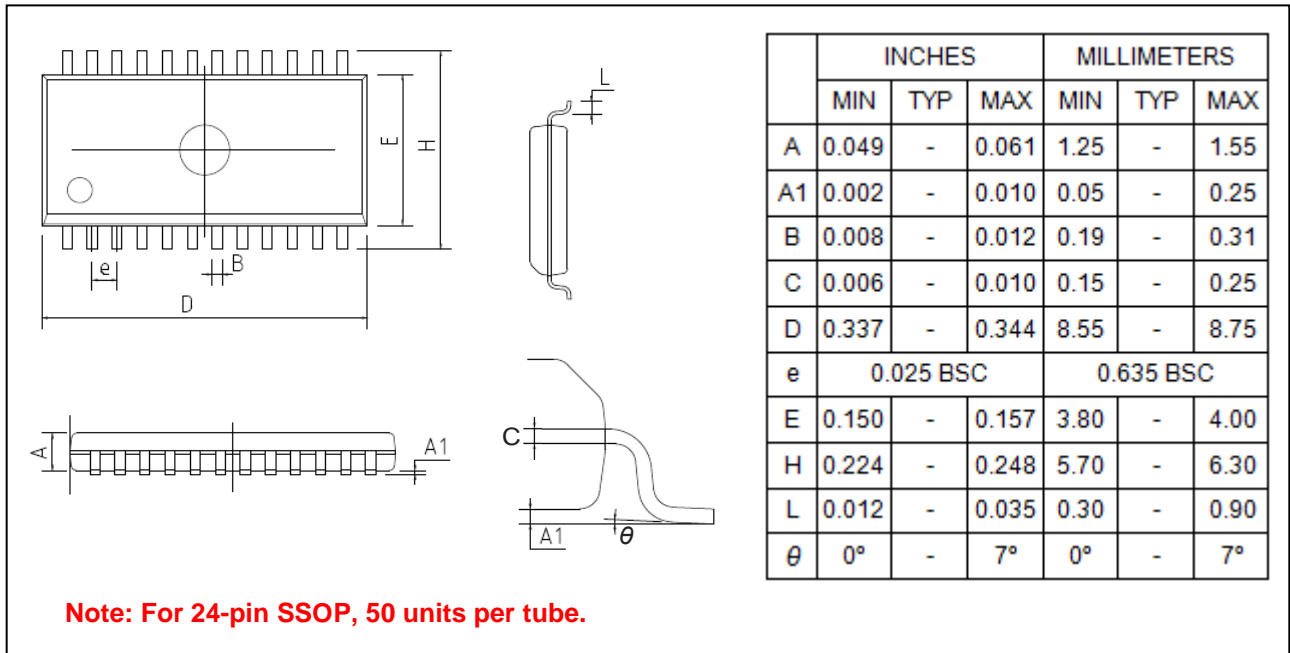


13.3 14-Pin Plastic SOP (150 mil)



13.4 16-Pin Plastic SOP (150 mil)



13.5 24-Pin Plastic 0.635-SSOP (150 mil, Lead pitch 0.635mm)

14. ORDERING INFORMATION

P/N	Shipping Type	Remarks
NY9T001A	Die	-
NY9T001AS6-xxx	SOT23-6	Standard code, Width 63 mil
NY9T001AS8-xxx	SOP-8	Standard code, Width 150 mil
NY9T004A	Die	-
NY9T004AS8-xxx	SOP-8	Standard code, Width 150 mil
NY9T004AS14-xxx	SOP-14	Standard code, Width 150 mil
NY9T008A	Die	-
NY9T008AS16-xxx	SOP-16	Standard code, Width 150 mil
NY9T008AU24-xxx	0.635-SSOP-24	Standard code, Width 150 mil, Pin Pitch 0.635mm
NY9T016A	Die	-
NY9T016AU24-xxx	0.635-SSOP-24	Standard code, Width 150 mil, Pin Pitch 0.635mm