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

NY9TP Series *(OTP for NY9T)*

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

Version 1.0

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Revision History

Version	Date	Description	Modified Page
1.0	2017/08/31	Formal release.	-

1. 概述

NY9TP016A 產品爲單晶片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，是九齊科技爲了支援 NY9T 系列MaskROM 產品所專門開發的崁入式EPROM架構的OTP IC (One Time Programmable)。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。(*同 MaskROM IC 的工作電壓範圍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。

- 只有1個OTP母體，ROM容量為16Kx10-bit，程式和資料共用同一塊ROM。

IC Type (OTP)	I/O	ROM (bits)	RAM (bits)	Touch-Key	PWM-IO	*LED Brightness Level
NY9TP16A	24	16K x 10	96 x 4	16	8	256

NY9T系列 MaskROM IC 的實際容量和I/O腳數如下：

IC Type (MaskROM)	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

- a). NY9T001A – <u>Touch-Key:</u> *PA0,* <u>PWM-IO:</u> *PE0~PE2.*

- b). NY9T004A – <u>Touch-Key:</u> *PA0~PA3,* <u>PWM-IO:</u> *PE0~PE3.*

- c). NY9T008A – <u>Touch-Key:</u> *PA0~PA3, PB0~PB3,* <u>PWM-IO:</u> *PE0~PE3, PF0~PF3.*

- d). NY9T016A – <u>Touch-Key:</u> *PA0~PA3, PB0~PB3, PC0~PC3, PD0~PD3,* <u>PWM-IO:</u> *PE0~PE3, PF0~PF3.*

- 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-IO 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-IO 輸出(PE0~3 與 PF0~3)，PWM-IO 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，在 PE1 與 PE2 提供定拉電流輸出(CDC)。

- PWM-IO 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。

- 提供特殊的快速燒錄模式，以加快OTP燒錄時間。

- 支援特殊的ICP (In Circuit Programming) 燒錄功能，以方便客戶先組裝PCBA模組再進行燒錄。

- 提供可程式的Code資料保護模式。 *(當Security-Bit 被燒斷後，資料將無法讀取。)*

- 提供 Dice, COB, SOP8, SOP16, SSOP24, SOP28 多種出貨型態，以滿足客戶不同的應用需求。

1. GENERAL DESCRIPTION

The NY9TP16A series IC is a powerful 4-bit micro-controller based LED control processor with capacitive touch sensing function. It is embedded EPROM architecture, and the OTP (One Time Programmable) IC that is designed to support NY9T MaskROM products. 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 resister 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 is one body. 16Kx10-bit ROM is the maximum. Program and LED data share the same ROM space.

IC Type (OTP)	I/O	ROM (bits)	RAM (bits)	Touch-Key	PWM-IO	*LED Brightness Level
NY9TP16A	24	16K x 10	96 x 4	16	8	256

Regarding NY9T MaskROM series, the ROM size and I/O counts are shown below.

IC Type (MaskROM)	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

a). NY9T001A – Touch-Key: *PA0*, PWM-IO: *PE0~PE2.*

b). NY9T004A – Touch-Key: *PA0~PA3*, PWM-IO: *PE0~PE3.*

c). NY9T008A – Touch-Key: *PA0~PA3, PB0~PB3*, PWM-IO: *PE0~PE3, PF0~PF3.*

d). NY9T016A – Touch-Key: *PA0~PA3, PB0~PB3, PC0~PC3, PD0~PD3*, PWM-IO: *PE0~PE3, PF0~PF3.*

- 96x4-bit RAM, divided into 2 pages.

- 400KHz instruction frequency.

- Precisely 400KHz oscillator with built-in resistor Rosc 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-IO 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-IO 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-IO 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.

- A unique fast writing mode is provided to speed up OTP writing time.

- A special ICP (In Circuit Programming) writing function is supported for user to fabricate PCBA in advance.

- Programmable code protection is provided. *(When the Security-Bit is burnt down, data can't be read.)*

- Various shipping type of Dice, COB, SOP8, SOP16, SSOP24 and SOP28 for different application requirement.

3. BLOCK DIAGRAM
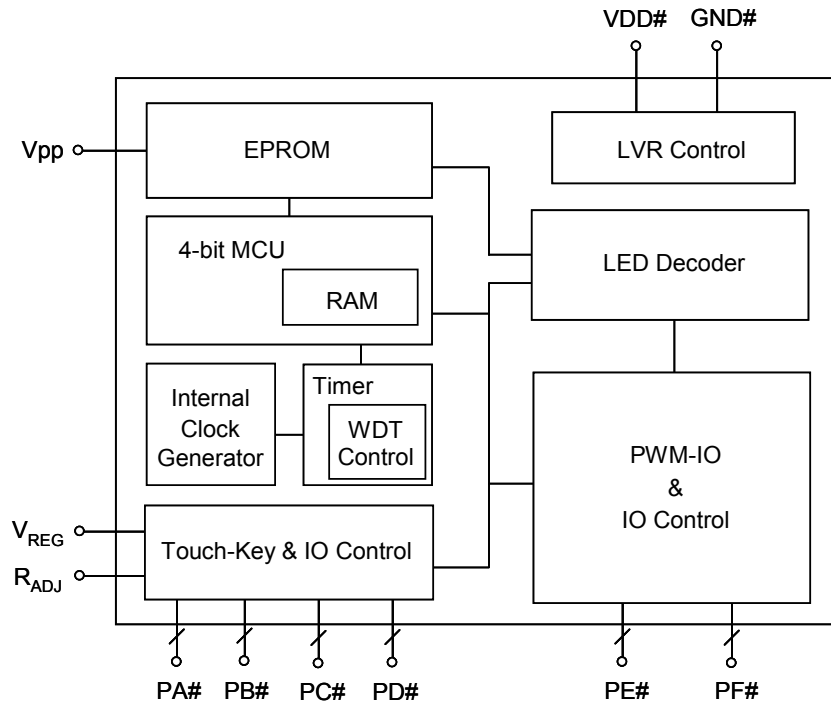
4. PAD DESCRIPTION

Pad Name	ATTR.	Description
VDD	Power	Positive power
GND1, 2	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 /Vpp	I/O	Bit 0 for Port E, or positive high power for programming.
PE1 /SDO	I/O	Bit 1 for Port E, or serial data output at programming mode.
PE2 /SCK	I/O	Bit 2 for Port E, or serial clock input at programming mode.
PE3	I/O	Bit 3 for Port E
PF0~3	I/O	Bit 0~3 for Port F
R_{ADJ} /SDI	I	Connect an external resistor to adjust the sensitivity, or keep floating. Or serial data input at programming mode.

* 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 0x00001E	Interrupt Vector
0x00001F 0x0001FF	Reserved
0x000200 0x000FFF	Program & Data Space 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 ±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 resister.

The pull-low resister of all the I/O Ports has two kinds of option: weak and strong. The weak one is about 1MΩ @3V for normal application and the strong one is about 100kΩ @3V usually for key matrix function. Each I/O can be configured as the weak or strong pull-low resister 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%
			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 (PE1, PE2)
	Reset input *(PE0 only)*		Disable
			Enable

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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	Floating
			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 *(PE0 only)*		Disable
			Enable

NY9T008A with 16 I/Os

I/O	Option		Description
PA0~PA3 PB0~PB3	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	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 *(PE0 only)*		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	Floating
			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 *(PE0 only)*		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 consummation. 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.
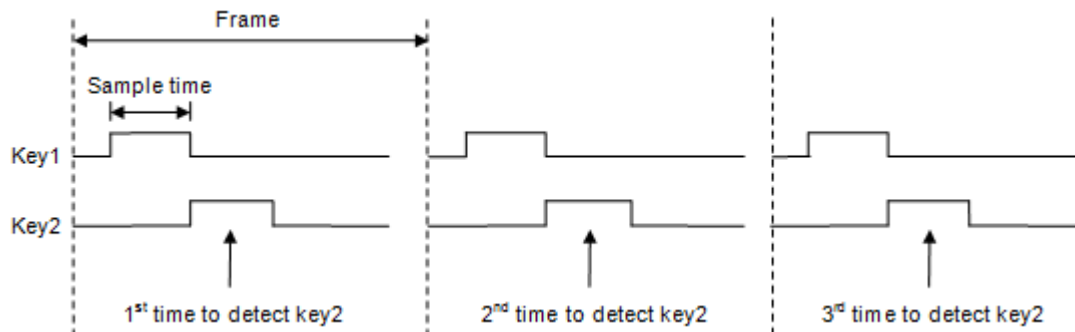
9.3 Sample Time

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.

Options	Selected items
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.

Options	Selected items
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.

Options	Selected items
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 + 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.

IC Type	Enlarge
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.

Options	Selected item
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.

Options	Selection item
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.

Options	Selected item
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.

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

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
750KΩ *(+/-1% tolerance)*	0 (000)
360KΩ *(+/-1% tolerance)*	1 (001)
180KΩ *(+/-1% tolerance)*	2 (010)
120KΩ *(+/-1% tolerance)*	3 (011)
82KΩ *(+/-1% tolerance)*	4 (100)
51KΩ *(+/-1% tolerance)*	5 (101)
33KΩ *(+/-1% tolerance)*	6 (110)
16KΩ *(+/-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
Vdd - Vss	Supply voltage	-0.5 ~ +6.5	V
Vin	Input voltage	Vss–0.3V ~ Vdd+0.3	V
Top	Operating Temperature	0 ~ +70	°C
Tst	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}	Supply Current	RC16K mode		3		0.4		uA	16KHz, no load
				4.5		1.0			
		Standby mode		3		0.9		uA	Key1 (PA0) wakeup, 16 samples per frame
				4.5		1.6			
		Operating mode		3		150		uA	400KHz, no load
				4.5		160			
I_{IH}	Input current (Internal pull-low)	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		%	$\dfrac{Fosc(3.0v) - Fosc(2.4v)}{Fosc(3v)}$
				4.5		1.0			$\dfrac{Fosc(4.5v) - Fosc(3.0v)}{Fosc(4.5v)}$
ΔF/F	Frequency lot deviation (400kHz)			3	-1		1	%	$\dfrac{F_{MAX}(3.0v) - F_{TYP}(3.0v)}{F_{MAX}(3.0v)}$
F_{OSC}	Oscillation Frequency			-	370	400	430	KHz	V_{DD} = 2.0 ~ 6.0V

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

OTP (Simulated Body)	Touch Keys	Samples of Frame	VDD	Touch-Key Scan Current			
				Normal Mode	PA0 Wakeup Slow Mode	Any-Key Wakeup Slow Mode	Any-Key Wakeup Slow-Green Mode
NY9TP16A (NY9T001A)	1-key	8	3.0V	4.4 uA	1.4 uA		
		8	4.5V	5.2 uA	2.1 uA		
		16	3.0V	2.4 uA	0.9 uA		
		16	4.5V	3.1 uA	1.6 uA		
NY9TP16A (NY9T004A)	2-key	8	3.0V	9.2 uA	1.4 uA	2.6 uA	
		8	4.5V	10.0 uA	2.1 uA	3.4 uA	
		16	3.0V	4.9 uA	0.9 uA	1.5 uA	
		16	4.5V	5.7 uA	1.6 uA	2.2 uA	
	4-key	8	3.0V	12.3 uA	1.4 uA	3.5 uA	
		8	4.5V	13.2 uA	2.1 uA	4.3 uA	
		16	3.0V	6.5 uA	0.9 uA	1.9 uA	
		16	4.5V	7.3 uA	1.6 uA	2.6 uA	
NY9TP16A (NY9T008A)	6-key	8	3.0V	19.3 uA	1.4 uA	5.6 uA	3.6 uA
		8	4.5V	20.3 uA	2.1 uA	6.4 uA	4.3 uA
		16	3.0V	10.8 uA	0.9 uA	3.0 uA	2.0 uA
		16	4.5V	11.7 uA	1.6 uA	3.7 uA	2.7 uA
	8-key	8	3.0V	22.3 uA	1.4 uA	6.5 uA	3.6 uA
		8	4.5V	23.3 uA	2.1 uA	7.3 uA	4.3 uA
		16	3.0V	12.4 uA	0.9 uA	3.5 uA	2.0 uA
		16	4.5V	13.3 uA	1.6 uA	4.2 uA	2.7 uA
NY9TP16A (NY9T016A)	10-key		3.0V				
			4.5V				
		16	3.0V	17.5 uA	0.9 uA	5.1 uA	2.0 uA
		16	4.5V	18.5 uA	1.6 uA	5.8 uA	2.6 uA
	12-key		3.0V				
			4.5V				
		16	3.0V	19.0 uA	0.9 uA	5.5 uA	2.0 uA
		16	4.5V	20.0 uA	1.6 uA	6.2 uA	2.6 uA
	14-key		3.0V				
			4.5V				
		16	3.0V	20.3 uA	0.9 uA	6.0 uA	2.0 uA
		16	4.5V	21.3 uA	1.6 uA	6.6 uA	2.6 uA
	16-key		3.0V				
			4.5V				
		16	3.0V	21.6 uA	0.9 uA	6.4 uA	2.0 uA
		16	4.5V	22.6 uA	1.6 uA	7.0 uA	2.6 uA

10.4 Voltage vs. Frequency

Voltage vs Frequency (6.0KHz@3V)

Voltage vs Freq. Deviation (6.0KHz@3V)
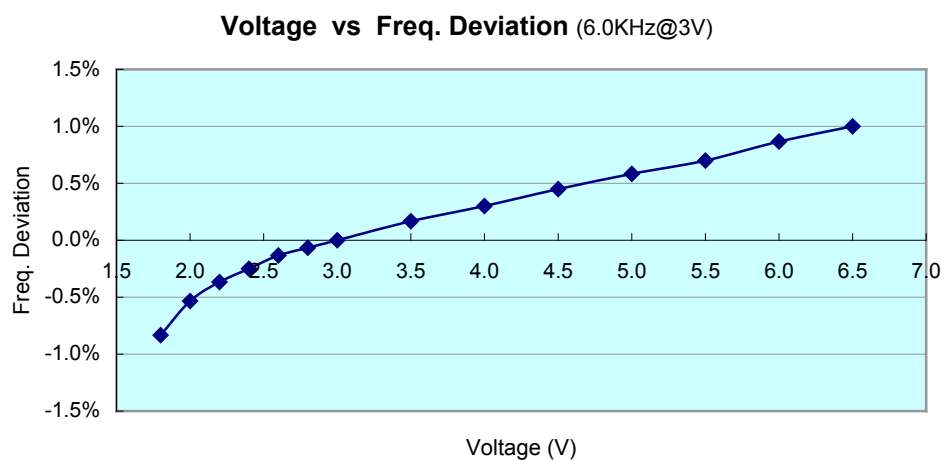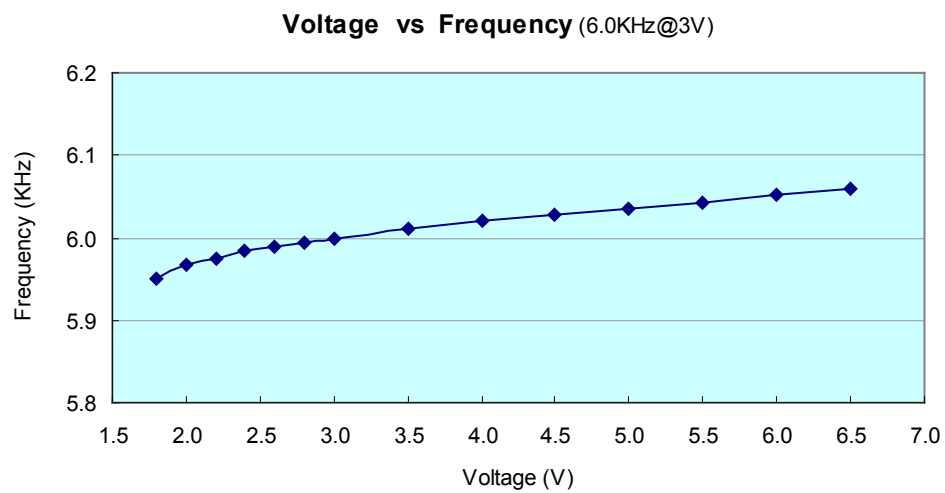
11. APPLICATION

(1) 1 Touch-Key with External R_{ADJ} Sensitivity Control
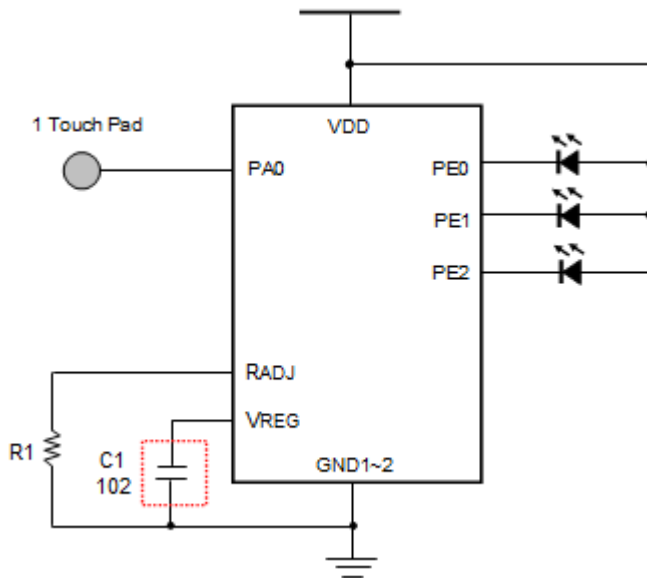
(2) 4 Touch-Keys without External R_{ADJ} Sensitivity Control
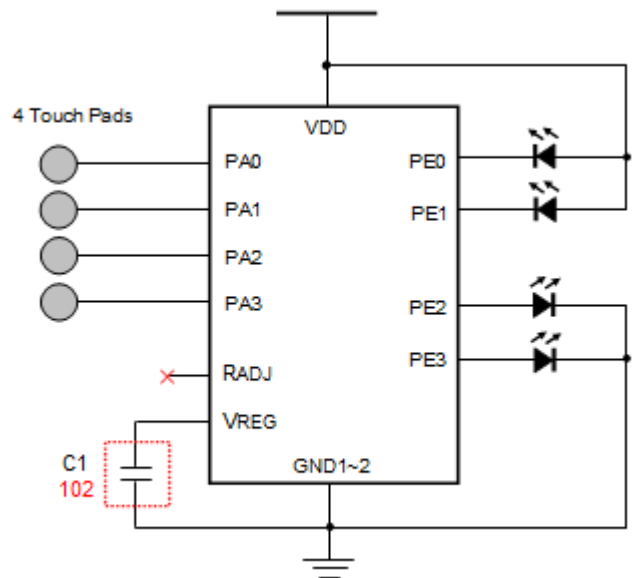
(3) 8 Touch-Keys with External R_{ADJ} Sensitivity Control
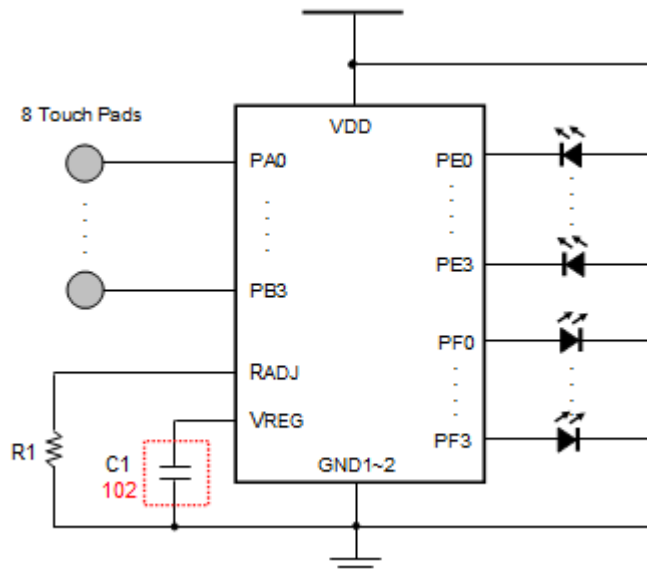
(4) 16 Touch-Keys without External R_{ADJ} Sensitivity Control
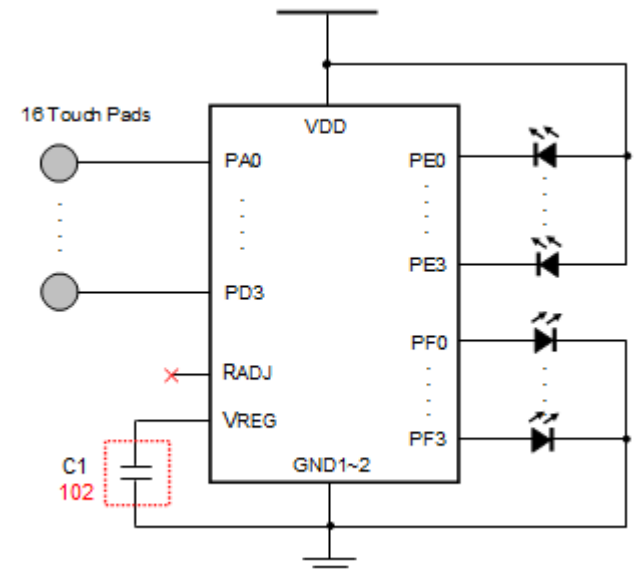
* For DC battery application, please note that C1 is NOT necessary and can be saved.
For AC application with high power noise, the capacitance of 1000pF (102) is suggested for C1 to filter the noise.

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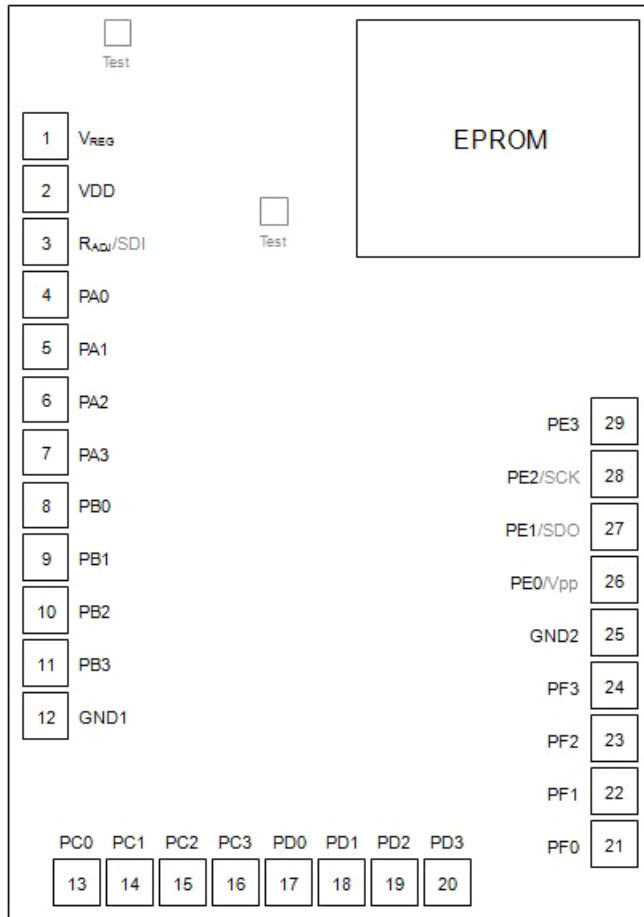
* The IC substrate must be connected to GND or Floating.

13. COB PIN ASSIGNMENT
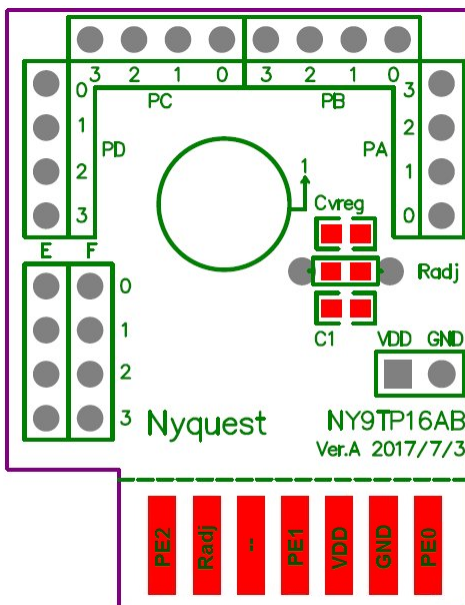
Note: C1 is VDD power cap.

Cvreg is V_{REG} cap.

Radj is touch sensitivity resistor.

14. PACKAGE PIN ASSIGNMENT

8-pin SOP (150mil)

	NY9TP16AS8	
VDD 1		8 PE2/SCK
R$_{ADJ}$/SDI 2		7 PE1/SDO
PA0 3		6 PE0/VPP
PA1 4		5 GND

16-pin SOP (150mil)

	NY9TP16AS16	
PA0 1		16 VDD
PA1 2		15 R$_{ADJ}$/SDI
PA2 3		14 PE3
PA3 4		13 PE2/SCK
PB0 5		12 PE1/SDO
PB1 6		11 PE0/VPP
PB2 7		10 GND
PB3 8		9 PF0
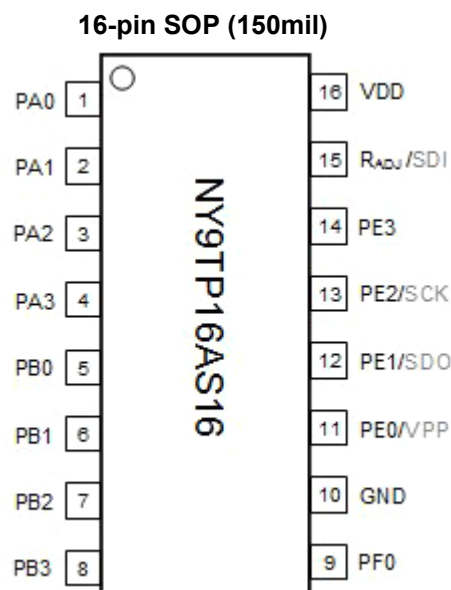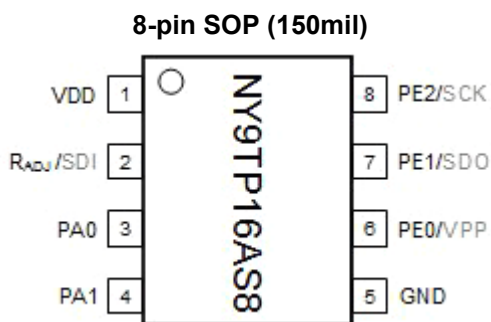
24-pin SSOP (150mil, 0.635mm Pitch)

	NY9TP16AU24	
V$_{REG}$ 1		24 VDD
PA0 2		23 R$_{ADJ}$/SDI
PA1 3		22 PE3
PA2 4		21 PE2/SCK
PA3 5		20 PE1/SDO
PB0 6		19 PE0/VPP
PB1 7		18 GND
PB2 8		17 PF3
PB3 9		16 PF2
PC0 10		15 PF1
PC1 11		14 PF0
PC2 12		13 PC3

28-pin SOP (300mil)

	NY9TP16AS28	
V$_{REG}$ 1		28 VDD
PA0 2		27 R$_{ADJ}$/SDI
PA1 3		26 PE3
PA2 4		25 PE2/SCK
PA3 5		24 PE1/SDO
PB0 6		23 PE0/VPP
PB1 7		22 GND
PB2 8		21 PF3
PB3 9		20 PF2
PC0 10		19 PF1
PC1 11		18 PF0
PC2 12		17 PD3
PC3 13		16 PD2
PD0 14		15 PD1
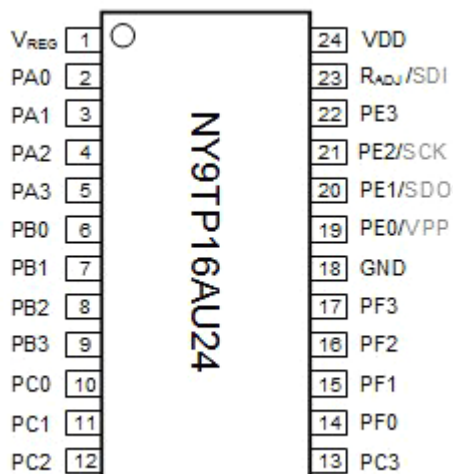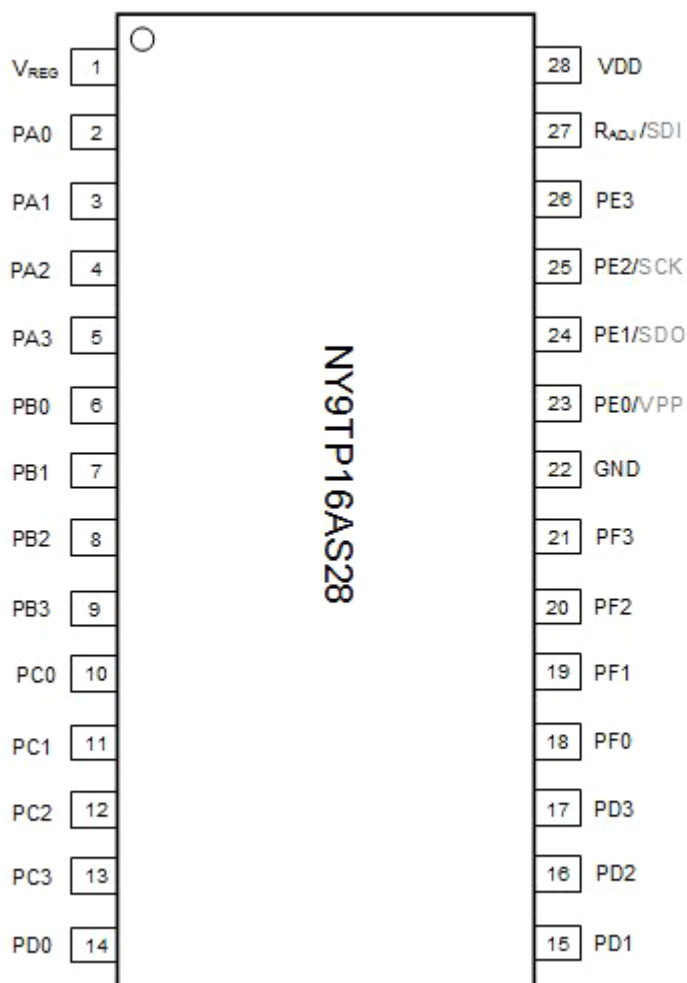
15.Package Dimension

15.1 8-Pin Plastic SOP (150 mil)

	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.183	-	0.202	4.65	-	5.13
B	0.144	0.150	0.163	3.66	3.81	4.14
C	0.068	-	0.074	1.35	-	1.88
D	0.010	-	0.020	0.25	-	0.51
F	0.015	-	0.035	0.38	-	0.89
G	0.050 BSC			1.27 BSC		
J	0.007	-	0.010	0.19	-	0.25
K	0.005	-	0.010	0.13	-	0.25
L	0.189	-	0.205	4.80	-	5.21
M	-	-	8°	-	-	8°
P	0.228	-	0.244	5.79	-	6.20

Note: For 8-pin SOP IC, 100 units per tube.

15.2 16-Pin Plastic SOP (150 mil)

	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.236 BSC			6.00 BSC		
B	0.154 BSC			3.90 BSC		
C	0.012	-	0.020	0.31	-	0.51
C'	0.390 BSC			9.90 BSC		
D	0.065	-	0.069	1.64	-	1.75
E	0.050 BSC			1.27 BSC		
F	0.004	-	0.010	0.10	-	0.25
G	0.016	-	0.050	0.40	-	1.27
H	0.004	-	0.010	0.10	-	0.25
α	-	-	8°	-	-	8°

Note: For 16-pin SOP, 50 units per tube.

15.3 24-Pin Plastic 0.635-SSOP (150 mil, Lead pitch 0.635mm)

	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.049	-	0.061	1.25	-	1.55
A1	0.002	-	0.010	0.05	-	0.25
B	0.008	-	0.012	0.19	-	0.31
C	0.006	-	0.010	0.15	-	0.25
D	0.337	-	0.344	8.55	-	8.75
e	0.025 BSC			0.635 BSC		
E	0.150	-	0.157	3.80	-	4.00
H	0.224	-	0.248	5.70	-	6.30
L	0.012	-	0.035	0.30	-	0.90
θ	0°	-	7°	0°	-	7°

Note: For 24-pin SSOP, 50 units per tube.
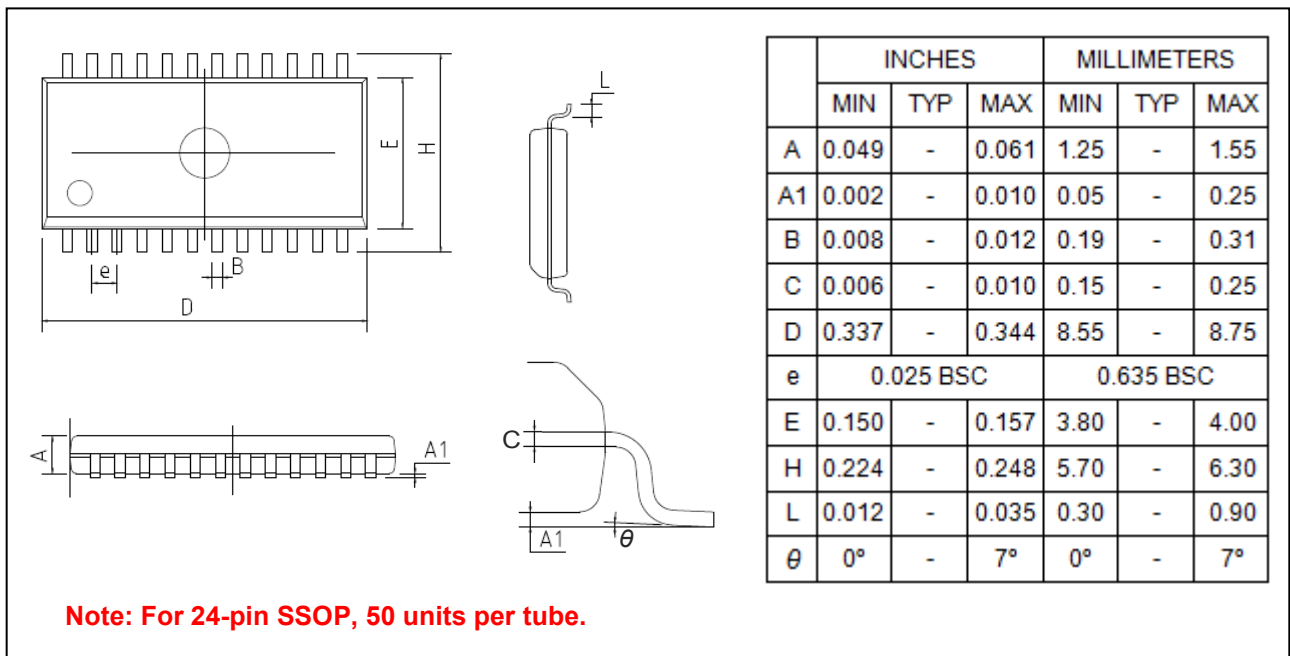
15.4 28-Pin Plastic SOP (300 mil)

	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.090	0.092	0.094	2.286	2.337	2.388
A1	0.006	-	-	0.152	-	-
B	0.012	0.016	0.020	0.305	0.406	0.508
D	0.703	0.705	0.707	17.86	17.91	17.96
E	0.293	0.295	0.297	7.442	7.493	7.544
eB	0.406	0.410	0.414	10.31	10.41	10.52
L	0.025	-	-	0.635	-	-
θ	0°	4°	8°	0°	4°	8°

Note: For 28-pin SOP, 26 units per tube.
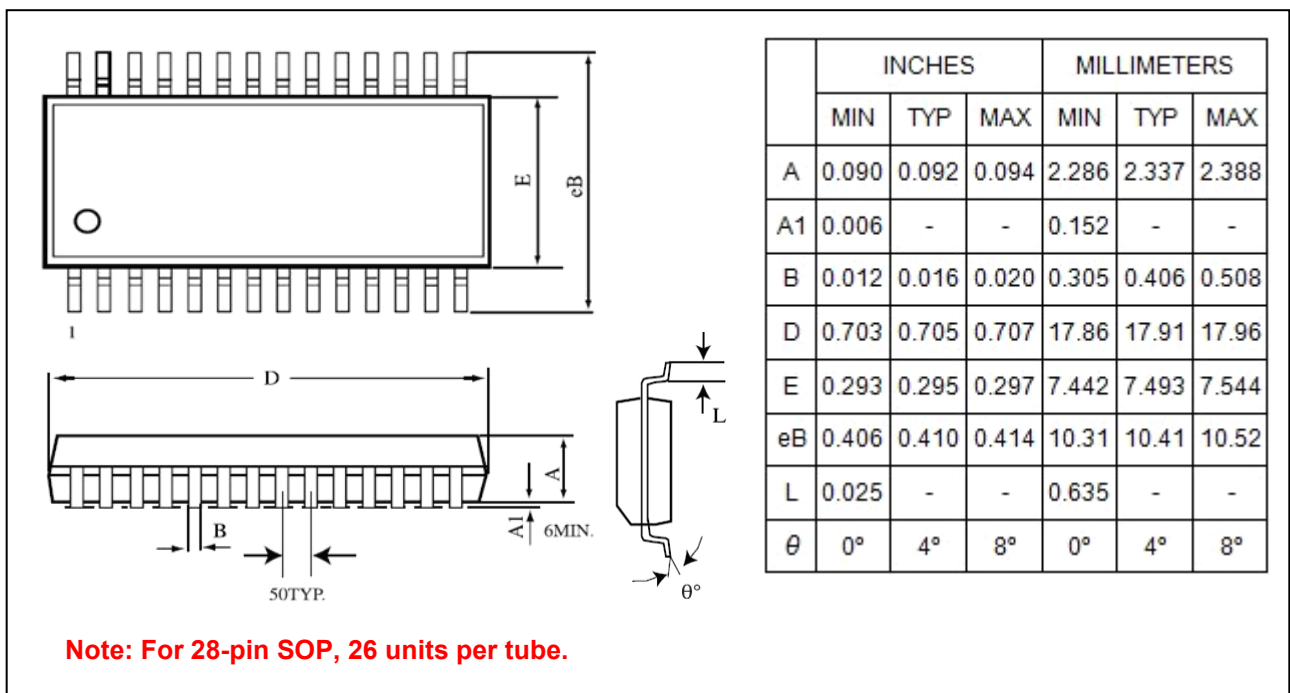
16. ORDERING INFORMATION

P/N	Shipping Type	Remarks
NY9TP16A	Die	Empty ROM data
NY9TP16A-xxxx [1]	Die	Programmed ROM data
NY9TP16AW-xxxx [1]	Wafer	Programmed ROM data
NY9TP16AB	COB	26.8 mm x 26.5 mm (26.8 mm x 34.6 mm w/ V-Cut)
NY9TP16AS8-xxx	SOP-8	Width 150 mil
NY9TP16AS16-xxx	SOP-16	Width 150 mil
NY9TP16AU24-xxx	0.635-SSOP-24	Width 150 mil, Pin Pitch 0.635mm
NY9TP16AS28-xxx	SOP-28	Width 300 mil

1 "xxxx": Code number.