eFinger™ – Button

eKT2201

Capacitive Touchpad Controller

Product Specification

DOC. VERSION 1.3

ELAN MICROELECTRONICS CORP.

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Contents

Specification Revision History

Doc. Version	Revision Description	Date
1.0	Initial version	2009/09/09
1.1	Modify some description error	2009/11/01
1.2	1. Modify some description error 2. Button operate mode from first only change to Unrestricted mode in I/O mode. 3. Add Initial default function in protocol mode. 4. Add button release level select (BRLS) control bit in address 0x07 . 5. Modify touch level defulat value in I/O mode. 6. Add global sensivity control in address 0xBB. 7. Remove “touch” and “release” toggle I/O output function.	2009/11/24
1.3	1. Modify initial function from 10 buttons to 5 buttons mapping to 5 I/Os in protocol mode. 2. Modify suggest resistance value from 100KΩ to 10KΩ.	2010/01/17

1 Introduction

The eKT2201 is single chip solution for capacitive button touchpad. This series are 8-bit RISC architecture microcontroller devices.

For function application, the touchpad controller supports I/O and protocol operation mode. In I/O mode, touchpad controller provides buttons to I/O outputs mapping operation without host. User can adjust touchpad parameter through I/O. In protocol mode, it provides I2C slave interface communication with host. Up to 10 I/Os which can be defined to touched button or output port. Users can define those ports for application. In data communication, Customers can use the protocol to get valid button messages and they can get button information from I2C interface and to control relative peripheral component.

The capacitive touchpad sensor is covered with a plastic or glass case. It can auto-calibrate the parameter for a wide range of capacitance on the touchpad sensor.

2 Feature

Touch Pad sensor

- Operating voltage: 3.0V~5.5V, Ripple < 200mVpp
- Power-on time: Stable time for operating < 150ms
- The dependable cover thickness:

Type	Min. ~ Max.	Unit
Plastic	1~4	mm
Glass	1~4	mm

- Low external component
- I/O or protocol operation mode support.

  I/O mode:

  - Buttons to I/O outputs mapping operate without host
  - Button operates in unrestricted mode
  - I/O output supports active low.
  - 4 touch level select. (ETLS1, ETLS0)
  - Power saving select (ELPS)
  - Sleep I/O control (shared with IOmode pin)
  - Operating current: (@ 3.3V)

Mode	Power consumption
ELPS=0	<200uA
ELPS=1	<100uA

Protocol mode:

- Interface features: Standard I2C @100K bps
- Up to 10 capacitive sensor inputs/ 5 output pins can be defined by user
- Operating current : (@ 3.3V)

Mode	Description	Power consumption
Normal	High scan rate and never sleep	2.0mA
Low power	Idle and normal mode alternate	<300uA
Sleep	Deep sleep	<2uA

- Package type:

  16-pin QFN, 4mm x 4mm

  14-pin SOP, 300mil

  10-pin MSOP, 118mil
- Green and RoHS

Application

- Portable media device (MP3/MP4…)
- Remote controls (TV remote controller…)
- Mobile phone and others hand-held device
- Feature toys (doll…)

3 Pin Assignment

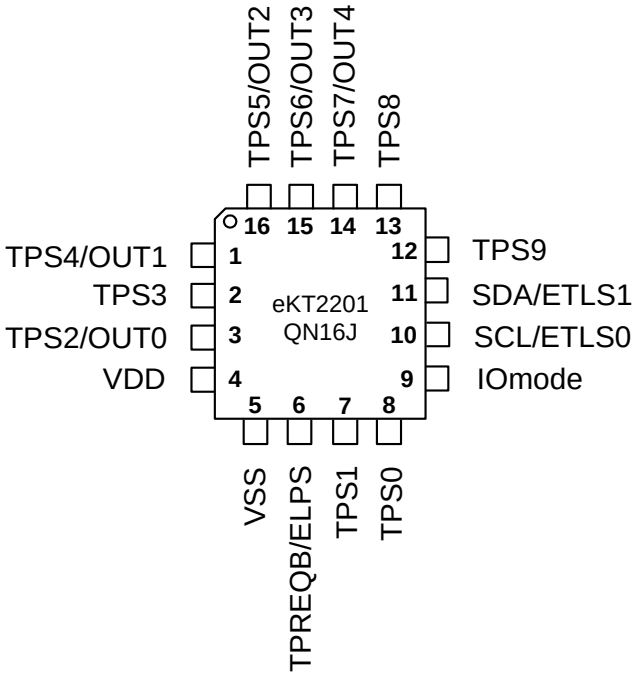


Fig. 3-1, eKT2201QN16J pin assignment

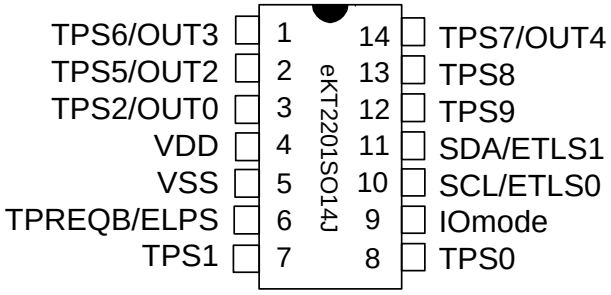


Fig. 3-2, eKT2201SO14J pin assignment

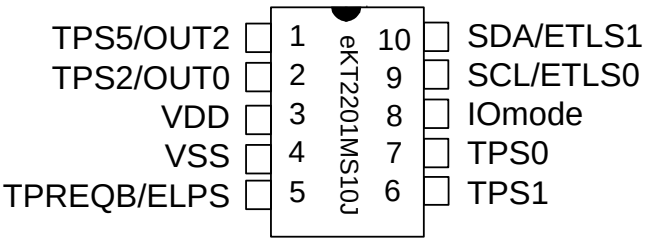


Fig. 3-3, eKT2201MS10J pin assignment

4 Pin Description

4.1 eKT2201QN16J

Symbol	DIR	Pin No.	Function Description
VDD	I	4	Power supply input
VSS	I	5	Digital ground
IOmode	I	9	I/O and protocol mode select in power on initialited stage. If “IOmode”=0, eKT2201 operates in protocol mode. It provides I2C communication (SCL, SDA, TPREQB) with host. Otherwises, eKT2201 operates in I/O mode. It provide buttons to outputs mapping control directly without host. And then “IOmode” acts as sleep control pin after power on. Host can control eKT2201 sleep mode by this pin setting 0 to enter or 1 to leave sleep mode.
SDA/ETLS1, SCL/ETLS0	I/O	11, 10	*I/O mode*: Those pins provide four touch level selection and default are internal pull high. *Protocol mode*: Those pins are support I2C intrface with host.
TPREQB/ELPS	I/O	6	*I/O mode*:Sensing interval time select in low power mode. *Protocol mode:* *Power-on mode*: when eKT2201 completed power-on initialited, TPREQB will go to low and return to high after a few time. *Normal mode*: TPREQB act as interrupt signal pin. If “TPREQB”=0, eKT2201 has data packet to transmit. If “TPREQB”=1, eKT2201 has no data packet to transmit and ready to receive command data from host.
TPS0, TPS1, TPS3, TPS8, TPS9	I	8, 7, 2, 13, 12	Touch sensor input pins.
TPS2/OUT0, TPS4/OUT1, TPS5/OUT2, TPS6//OUT3, TPS7/OUT4	I/O	3, 1, 16, 15, 14	Touch sensor inputs pin/outputs pin(OUTx). This pins can be defined to button or OUT function throuh users configured.

4.2 eKT2201SO14J

Symbol	DIR	Pin No.	Function Description
VDD	I	4	Power supply input
VSS	I	5	Digital ground
IOmode	I	9	I/O and protocol mode select in power on initialited stage. If “IOmode”=0, eKT2201 operates in protocol mode. It provides I2C communication (SCL, SDA, TPREQB) with host. Otherwises, eKT2201 operates in I/O mode. It provide buttons to outputs mapping control directly without host. And then “IOmode” acts as sleep control pin after power on. Host can control eKT2201 sleep mode by this pin setting 0 to enter or 1 to leave sleep mode.
SDA/ETLS1, SCL/ETLS0	I/O	11,10	*I/O mode*: Those pins provide four touch level selection and default are internal pull high. *Protocol mode*: Those pins are support I2C intrface with host.
TPREQB/ELPS	I/O	6	*I/O mode*: Sensing interval time select in low power mode. *Protocol mode:* *Power-on mode*: when eKT2201 completed power-on initialited, TPREQB will go to low and return to high after a few time. *Normal mode*: TPREQB act as interrupt signal pin. If “TPREQB”=0, eKT2201 has data packet to transmit. If “TPREQB”=1, eKT2201 has no data packet to transmit and ready to receive command data from host.
TPS0, TPS1, TPS8, TPS9	I	8, 7, 13, 12	Touch sensor input pins.
TPS2/OUT0, TPS5/OUT2, TPS6//OUT3, TPS7/OUT4	I/O	3, 2, 1, 14	Touch sensor inputs pin/outputs pin (OUTx). This pins can be defined to button or OUT function throuh users configured.

4.3 eKT2201MS10J

Symbol	DIR	Pin No.	Function Description
VDD	I	3	Power supply input
VSS	I	4	Digital ground
IOmode	I	8	I/O and protocolmode select in power on initialited stage. If “IOmode”=0, eKT2201 operates in protocol mode. It provides I2C communication (SCL, SDA, TPREQB) with host. Otherwises, eKT2201 operates in I/O mode. It provide buttons to outputs mapping control directly without host. And then “IOmode” acts as sleep control pin after power on. Host can control eKT2201 sleep mode by this pin setting 0 to enter or 1 to leave sleep mode.
SDA/ETLS1, SCL/ETLS0	I/O	10,9	*I/O mode*: Those pins provide four touch level selection and default are internal pull high. *Protocol mode*: Those pins are support I2C intrface with host.
TPREQB/ELPS	I/O	5	*I/O mode*: Sensing interval time select in low power mode. *Protocol mode:* *Power-on mode*: when eKT2201 completed power-on initialited, TPREQB will go to low and return to high after a few time. *Normal mode*: TPREQB act as interrupt signal pin. If “TPREQB”=0, eKT2201 has data packet to transmit. If “TPREQB”=1, eKT2201 has no data packet to transmit and ready to receive command data from host.
TPS0, TPS1	I	6, 7	Touch sensor input pins.
TPS2/OUT0, TPS5/OUT2	I/O	2, 1	Touch sensor inputs pin/outputs pin (OUTx). This pins can be defined to button or OUT function throuh users configured.

5 Common description

5.1 Power pin

The VDD pin should be connected to power supply and through 0.1uF and 16V/10uF capacitors to ground. To series connect a 0 ohm option resistor between VDD pin and system supply. If has serious power ripple on power line, user can adjust resistance value to reduce power ripple. The resistance value suggests range between 0 and 10.

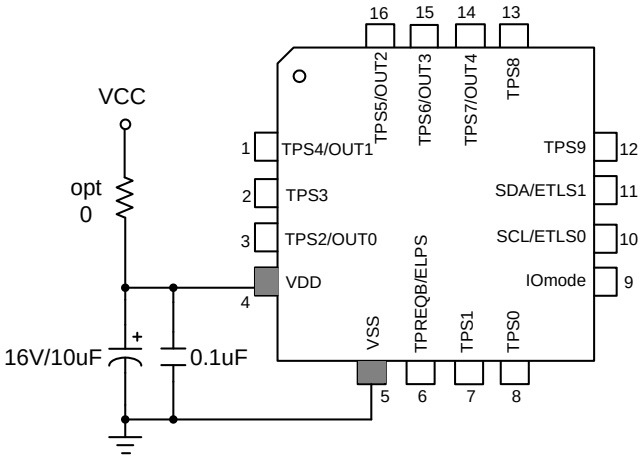


Fig 4-1, power pins connection

5.2 I/Omode pin

The eKT2201 provides I/O and protocol operation mode for various application necessary. IOmode pin is used to select I/O and protocol mode in power on initial stage. IOmode pin configures to high, eKT2201 operates in I/O mode. Otherwise, eKT2201 operates in protocol mode. The setting method is as follows:

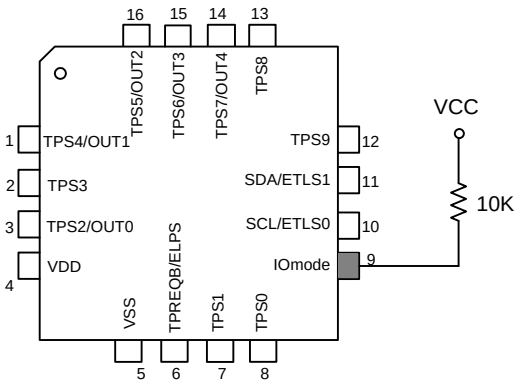


Fig 4-2, eKT2201 configure to I/O mode

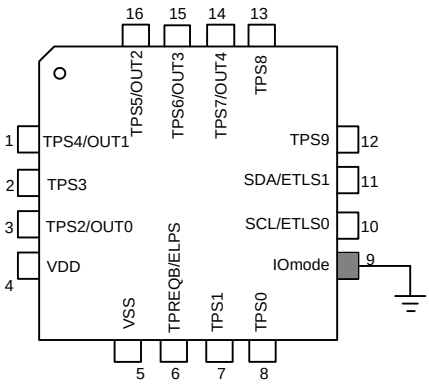


Fig 4-3, eKT2201 configure to protocol mode

Please refer to the below chapters for description of I/O and protocol mode

5.3 Touch sensor pin/output pin

eKT2201 provides up to 10 touch sensor pins for users programming in QFN16 package. 5 touch sensors also provide the output function among them at the same time.

Touch sensor pin: Only can be configured to button or undefined state.

Touch sensor pin/output pin: Can be configured to button, output or undefined state.

In I/O mode, those pins are already defined initially by ELAN, and provide buttons to I/O outputs mapping function. The below table shows the relationship is between supporting buttons to I/O outputs mapping in different package type.

Table 5-1 The relationship is between supporting Buttons map to I/O outputs in different package type.

Touch sensor input	eKT2201MS10J	eKT2201SO14J	eKT2201QN16J
TPS0	OUT0	OUT0	OUT0
TPS3	-	-	OUT1
TPS1	OUT2	OUT2	OUT2
TPS8	-	OUT3	OUT3
TPS9	-	OUT4	OUT4

"- " no supporting in this package

In protocol mode, the initial functions are defined the same as I/O mode. But they can be redistributed to the button or output pin by I2C protocol. That provides the most flexible. Customers can set them according to their application necessary. After touch sensor/output pins are organized by I2C protocol, I/O will be set to output status and outputs low if touch sensor/output pin are configured to -undefined.

6 I/O mode

IOmode pin is configured to high in power on initial stage, eKT2201 will execute I/O mode. It only provides buttons to I/O outputs mapping operation without host. Button operation mode is defined to unrestricted mode. The user can touch combine key at the same time. I/O output function only supports active low, so I/O outputs “High” in the situation that the buttons are not been touched. When any button is touched, the mapping I/O will output “low” until buttons released.

Besides, eKT2201 also provides selecting function with 4 I/O, including ETLS1, ETLS0, ELPS and sleep. The I/O function description is as follows:

6.1 External touch level select (ETLS1:ETLS0)

ETLS1, 0 pins to provide 4 touch level for different cover thinness and material. ETLS1, 0 pins default are internal pull high. It can save external component. If any button is pressed over 30 seconds, touch pad will execute auto-calibration to avoid wrong touched.

Table 6-1 Touch level selection

ETLS1	ETLS0	Touch level
0	0	175
0	1	150
1	0	125
1	1	100 (default value)

Button release value is defined to touch level*0.75.

6.2 External low power select (ELPS)

eKT2201 only provides low power operation in I/O mode. There are two sensing interval times selection despond on ELPS pin setting for power and response requirement. When ELPS connects to low, this mode provides fast TP sensing time interval and higher consumption than setting of ELPS connects to high.

TP sensing interval time and power consumption show as follows:

Table 6-2 I/O mode sensing interval time and power consumption during finger untouched.

ELPS	Sensing interval time	Power consumption
0	~330ms	<150uA
1	~800ms	<100uA

The timing diagram of button touch/release and relationship of operation mode translation are as below.

ELPS =0:

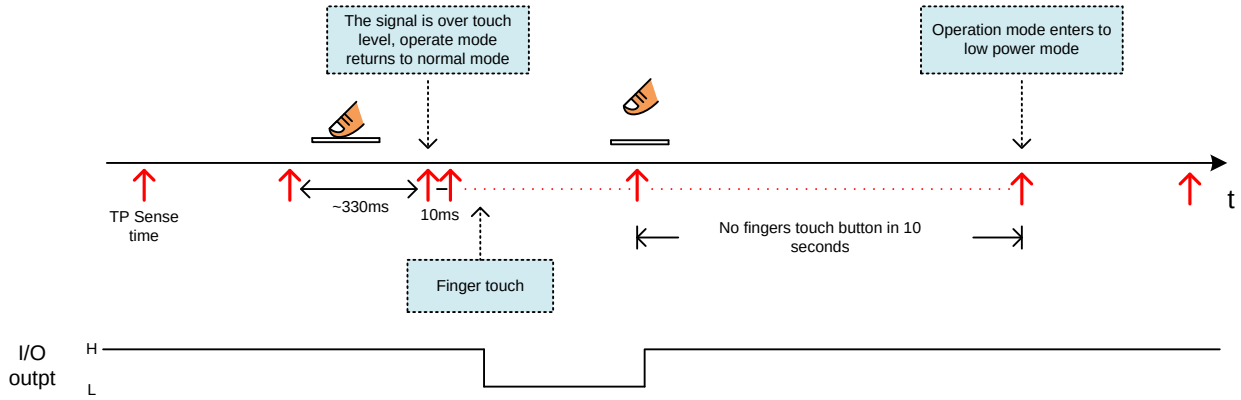


Fig 6-1, The timing diagram of button touch/release and relationship of operation mode translation under ELPS=0 condition.

Touch signal is over touch level which ETLS1, 0 setting as soon as the operation mode from low power mode to normal mode. The scan rate is 10 ms in normal mode. If touch isn't confirmed, the operate mode return to low power mode right now. Otherwise, touch pad controller will stay in normal mode 10 seconds as long as no finger touched after touch released. And then it will return to low power mode.

ELPS =1:

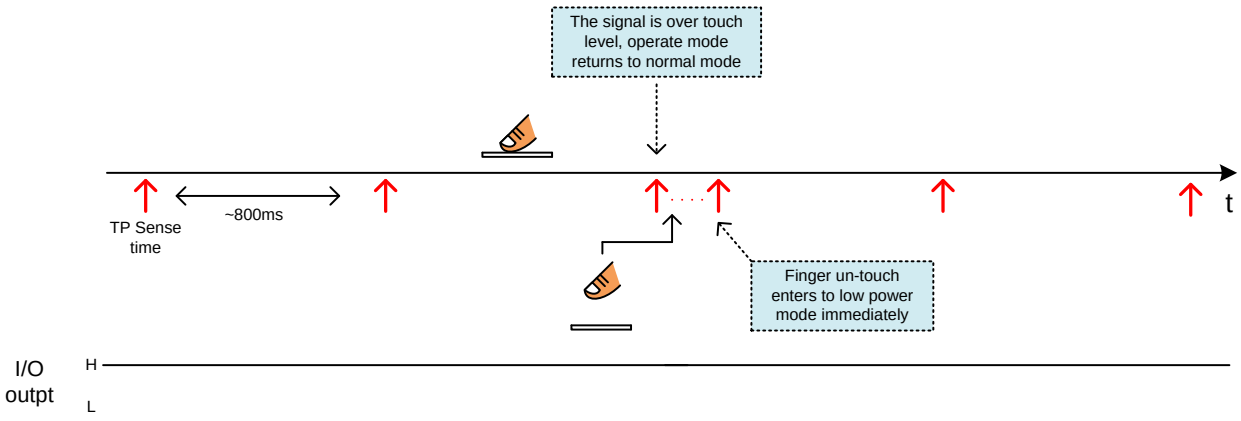


Fig 6-2, The timing diagram of button touch/release and relationship of operation mode translation under ELPS=1 condition.

6.3 External sleep control

IOmode pin will be defined sleep I/O control function after I/O mode selected. When sleep I/O set to low, eKT2201 will enter sleep mode that will provides the lowest power operation. In this mode, touchpad controller will not execute any function. The current consumption in sleep mode is measured as 2uA. Until sleep I/O set to high, the operation will return to original mode.

7 Protocol mode

IOmode pin is configured to low, eKT2201 will perform protocol mode. This mode supports standard I2C protocol (SCL, SDA) and a request signal (TPREQB). The Fig 7-1 shows the system block diagram of I2C slave interface.

Host can read or write eKT2201 via I2C protocol. eKT2201 always be slave device. In I2C slave interface, the SCL and SDA signals should be pulled high with resistors at the end of the host. The termination resistors commonly range from 1kΩ to 10kΩ and should be chosen so that the rise times on SCL and SDA meet the specification. The host processor has to provide a serial clock signal (SCL) to eKT2201.

If eKT2201 has any message to host, TPREQB will have a falling edge to notify for transmit request. The TPREQB signal suggests pull high with 10KΩ resistance value.

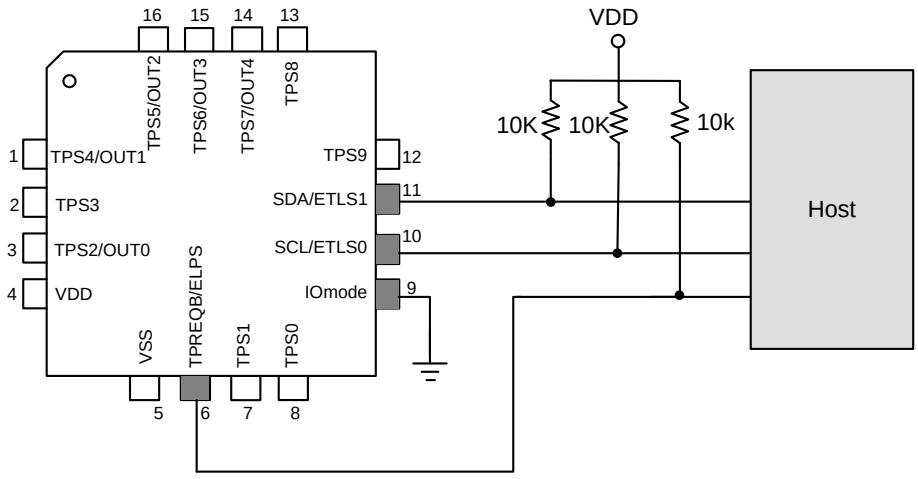


Fig 7-1, eKT2201 connects to host with I2C interface

7.1 I2C operation

All communication is start from an START condition and the followed is Slave address packet, the address packet is 9 bits long, consisting of 7 slave address bits, one READ/WRITE control bit and an acknowledge bit. When the touch pad controller recognizes that it is being addressed, it will acknowledge by pulling SDA low in the ninth SCL (ACK) cycle. All data packets are 9 bits long, consisting of one data byte and an acknowledge bit. An Acknowledge (ACK) is signaled by the Receiver pulling the SDA line low during the ninth SCL cycle. If the Receiver leaves the SDA line high, a NACK is signaled. Each write or read cycle must end with a STOP condition.

Figure 7-2 and 7-3 show bit level waveform of I2C master Write/Read data to/from I2C slave

device with 7 bit addressing mode. When R/~W bit is set to 0, I2C master can writer data to I2C slave that only slave address is verified. On the contrary, when R/~W bit is set to 1, I2C master can read data from I2C slave if slave address is verified. If slave address verify is error, I2C slave will not work.

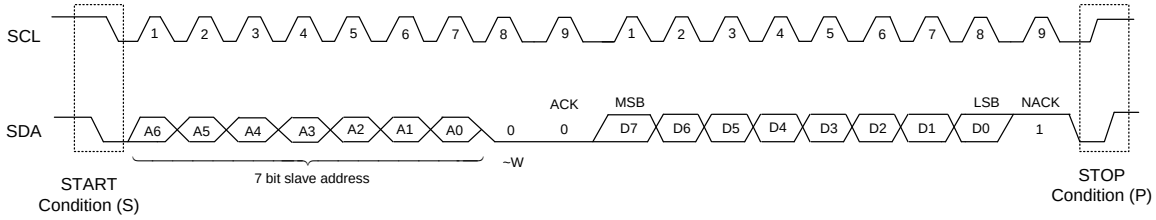


Fig. 7-2 Bit level waveform of I2C master write data to I2C slave (R/~W=0)

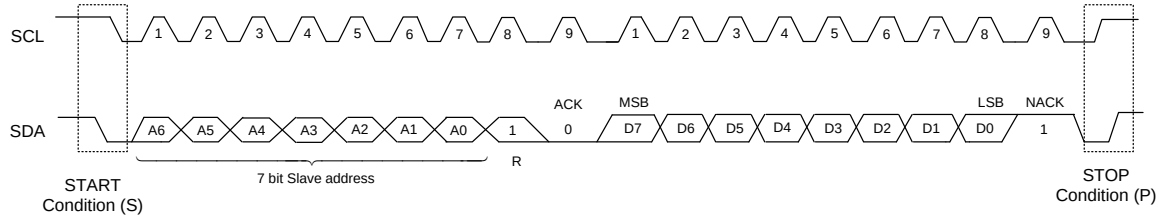


Fig. 7-3 Bit level waveform of I2C master read data from I2C slave (R/~W=1)

The I2C bit level waveform of Fig 7-2 and Fig 7-3 are supported by eKT2201. The eKT2201 touch pad controller is defined as a slave device of I2C and host is defined as a master. The device address of touch pad controller is designed as 7-bits address format. The touch pad controller address default is 0x10.

***NOTE: the default slave address of eKT2201 is 0010 000.**

7.2 Write to the eKT2201

The eKT2201 supports I2C write protocol. The first byte of a write access is the command code. The next one or n bytes, respectively, are the data to be written. The eKT2201 acknowledges each byte, and the entire transaction is finished with a STOP condition.

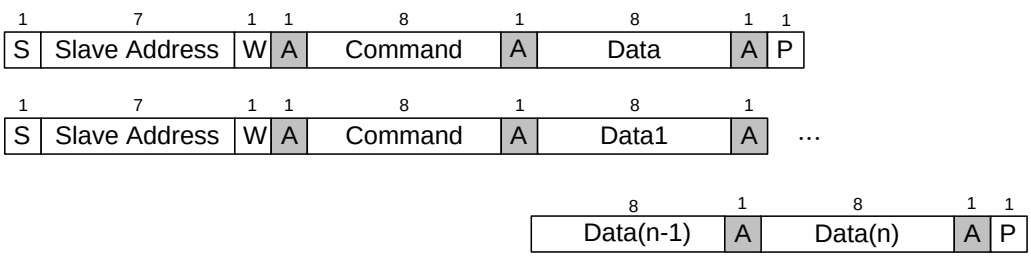


Fig 7-4, Single write mode and continue write mode

7.3 Read from the eKT2201

Reading data is slightly more complicated than writing data. First the host must write a command to eKT2201. Then it must follow that command with a repeated START condition to denote a read from the slave address. The eKT2201 then returns one or n bytes of data. Note that a NACK signifies the end of the read transfer.

Fig 7-5, Single read mode and continue read mode

7.4 Timing Condition

Fig 7-6 below shows the timing condition and characteristics of the I2C interface. The eKT2201 adopts a bit rate of up to 100k bit/sec.

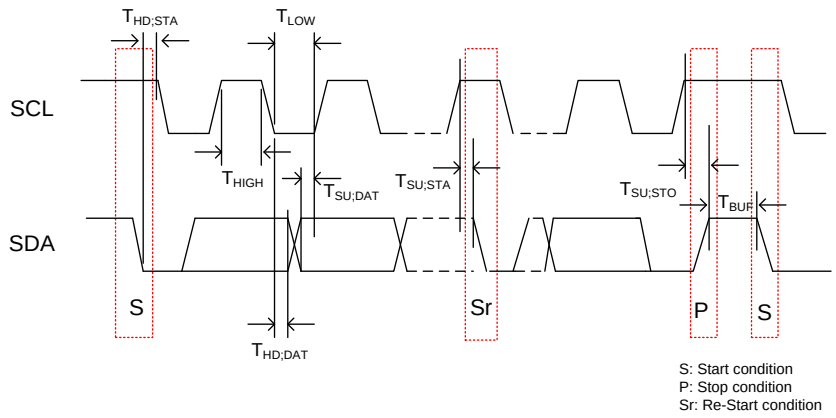


Fig 7-6, timing of I2C interface

Table 7-1 Characteristics of the SDA and SCL pins for I2C interface

Symbol	Description	Standard Mode		Unit
		Min	Max	
F_{SCL}	SCL clock frequency	0	100	kHz
$T_{HD;STA}$	Hold time (repeated) START condition. After this period, the first clock pulse is generated.	4.0	-	us
T_{LOW}	LOW period of the SCL clock	4.7	-	us
T_{HIGH}	HIGH period of the SCL clock	4.0	-	us
$T_{SU;STA}$	Set-up time for a repeated START condition	4.7	-	us
$T_{HD;DAT}$	Data hold time	0	-	us
$T_{SU;DAT}$	Data set-up time	250	-	ns
$T_{SU;STO}$	Set-up time for STOP condition	4.0	-	us
T_{BUF}	Bus free time between a STOP and START condition	20	-	us

*** The I2C Master must support arbitration function.**

7.5 TPREQB

The TPREQB pin is used to alert the host of any changes to any of the button state, thus reducing the need for wasteful I2C communications. After power on the touchpad controller, the host can simply not communicate with the device, except when the TPREQB pin goes active. TPREQB goes inactive again only when the host performs a read byte/word.

The host can make use of the TPREQB pin output to initiate a communication; this will guarantee the optional polling rate. If the host cannot make use of the TPREQB pin, the poll rate should be no faster than once per button scan and will slow down the chip operation.

There are two kind of TPREQB operation mode for users. Users can decide one of them for satisfy hold-system request.

TPREQB waiting mode:

The TPREQB state is normal high. If the touchpad controller detects the button state has changed, it will pull the TPREQB signal low first. After the host performs a read byte/word from touchpad controller, the touchpad controller will pull-high the TPREQB signal again. If host isn't performs read procedure during TPREQB.

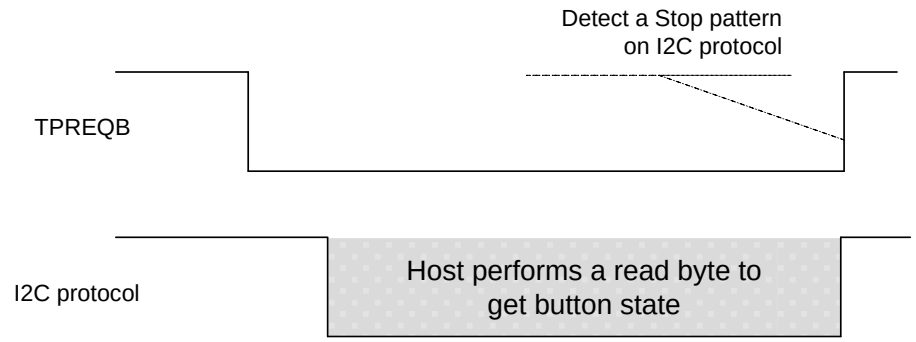


Fig. 7-7, TPREQB signal when address 0x4, bit 6, REQBM is set to 0

TPREQB time-out mode:

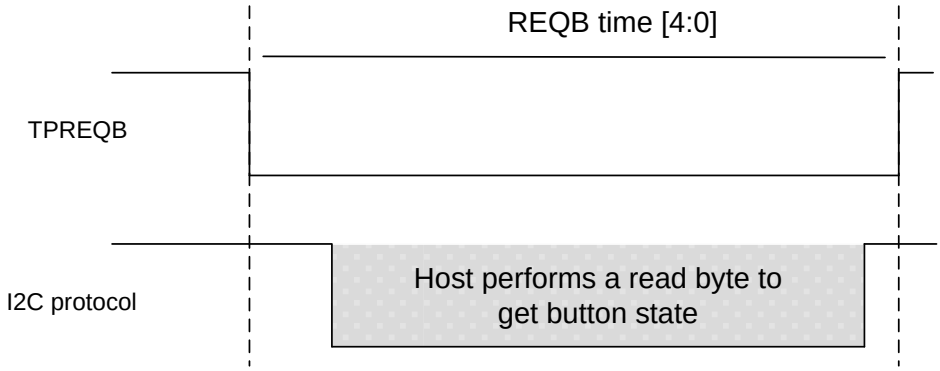


Fig. 7-8, TPREQB signal when address 0x4, bit 6, REQBM is set to 1
And set REQB time [4:0]

The TPREQB state is normal high. If the touchpad controller detects the button state has changed, it will pull the TPREQB signal low first and start REQB timer. TPREQB will return to high until REQB timer time-out. If REQB time is set too large, TPREQB will still keep at low state even I2C communication finished. So, the suitable value for REQB time [4:0] is very important when use this mode.

7.6 Registers map

Table 7-2 Command summary table

Command (Address)	Access Direction	Description	Note
0x00	R	Product ID code	
0x01	R	Firmware version	
0x02	R	Device status	
0x03	RW	General configure	
0x04	RW	TPREQB control	
0x05	RW	Positive drift tracking	
0x06	RW	Negative drift tracking	
0x07	RW	Button configure	
0x08	RW	Button press/release debounce time control	
0x0D	RW	Output pin control	
0x0F	RW	Button to output map	
0x11	R	Button status 0	*
0x12	R	Button status 1	*
0x1A	RW	Operation mode configure	
0x1B	RW	Normal stay time	
0x20~0x29	RW	TPS0 ~ TPS9 touch level	
0xA0	RW	Button enable 0	
0xA1	RW	Button enable 1	
0xA9	RW	Output pin enable	
0xB0~0xB9	RW	TPS0 ~ TPS9 individual sensitivity	
0xBB	RW	Global sensitivity	

* TPREQB pin will go actives while these registers have been changed

Note: Do not access any other address that does not list in the summary table or some unexpected error will occur.

7.7 Registers description

7.7.1 Address 0x00: Product ID

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
PID7	PID6	PID5	PID4	PID3	PID2	PID1	PID0
R-0	R-0	R-1	R-0	R-0	R-0	R-1	R-0

There is 8-bits product ID code for host identifying. It is read-only. The default value is defined by ELAN.

7.7.2 Address 0x01: Firmware version

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Major version				Minor version			
R-0	R-0	R-0	R-1	R-0	R-0	R-1	R-1

There is 8-bits firmware version code. Users can read it to confirm the code is correct or not. It is read-only

7.7.3 Address 0x02: Device status

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TPTO	TPOV	-	BuildOK	-	-	-	-
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

Bit 0~3, 5~7: Un-used.

Bit 4 (BuildOK): Touchpad structure re-build completed indicator.

Bit 6 (TPOV): TP trace overflow indicator. Any both touch sensor pin are shorted each other, this bit is set.

Bit 7 (TPTO): TP trace timeout indicator. Any touch sensor is shorted with ground, this bit is set.

7.7.4 Address 0x03: General configure

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
SReset	-	-	Build	ReCal	-	-	-
R/W-0	R-0	R-0	R/W-0	R/W-0	R-0	R-0	R-0

Bit 0~2, 5 ~ 6: Un-used.

Bit 3 (ReCal): Re-Calibration bit. Host can set this bit to 1 to re-calibration variable. This bit will be cleared to 0 after re-calibration completed.

Bit 4 (Build): Touch Pad pin assignment. When Build bit is set, TP runs in pin and function assignment mode. Host can change TP configuration content [0x20~0x29, 0xA0~0xA1, 0xA9 and 0xB0~0xB9] in this moment. TP will carry out structure of Build until Build bit from 1 to 0 by Host. When building procedure is completed, BuildOK bit will be set to 1.

Bit 7 (Software Reset): Enable WDT reset. When reset finish, this bit clear.

0: Disable

1: Enable

7.7.5 Address 0x04: TPREQB control

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
REQBD	REQBM	-	REQB timeout				
R/W-0	R/W-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0~4 (REQB timeout): TPREQB timeout formula: (1+ REQB [4:0])*16 ms±30%

Bit 5: Un-used

Bit 6 (REQBM): TPREQB mode select.

0: Return to High immediately while Host finish once read procedure.

1: Keep Low for REQB timeout [4:0] time setting and then return to High.

Bit 7(REQBD): TPREQB function disable. TPREQB function is disabled. TPREQB will always keep High status, whether button is touched or not.

0: Enable

1: Disable

7.7.6 Address 0x05: Positive drift tracking time

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	Positive drift tracking time (PDTT)						
R-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0~6 (PDTT): Positive drift tracking time (T_{PDT}= PDTT * 12.5ms+ LPWR stay time)) configuration.

The eKT2201 provides a Baseline data tracking method for capacity, operation voltage and temperature varying. This baseline data tracking to ensures touch pad controller operation correctly in rigorous environment. The rate of baseline data adjustment must be performed slowly or else legitimate detections can also be ignored. The baseline tracking is provided on each channel independently in eKT2201.

When any button is touched, Baseline tracking will be terminated to ensure operation correctly. The baseline tracking will execute again until button is released.

The eKT2201 provides “Positive compensate length” and “Negative compensate length” control registers to configure Baseline tracking time parameter. The baseline signal tracking is “asymmetric”: the tracking in one direction faster than it does in the other. In general, it tracks faster for negative drift than for positive drift signals. Positive drift signals should not be tracked for quickly, since an approaching finger could be compensated for partially or entirely while approaching the sense electrode.

When tracking length is equal positive drift tracking time (PDTT), the Baseline signal will increase. The positive drift tracking will be terminated until Baseline signal already compensate.

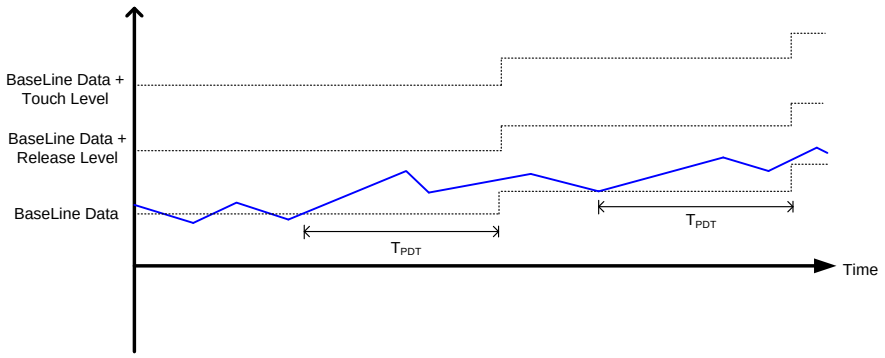


Fig. 7-9, illustrates an example of
the positive drift tracking algorithm following a temperature change.

7.7.7 Address 0x06: Negative drift tracking time

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	Negative drift tracking time (NDTT)						
R-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0~6 (NDTT): Negative drift tracking time (T_{NDT}= NDTT * 12.5ms + LPWR stay time) configuration.

When tracking length is equal negative drift tracking time (NDTT), the Baseline signal will decrease. The negative drift tracking will be terminated until Baseline signal already compensate.

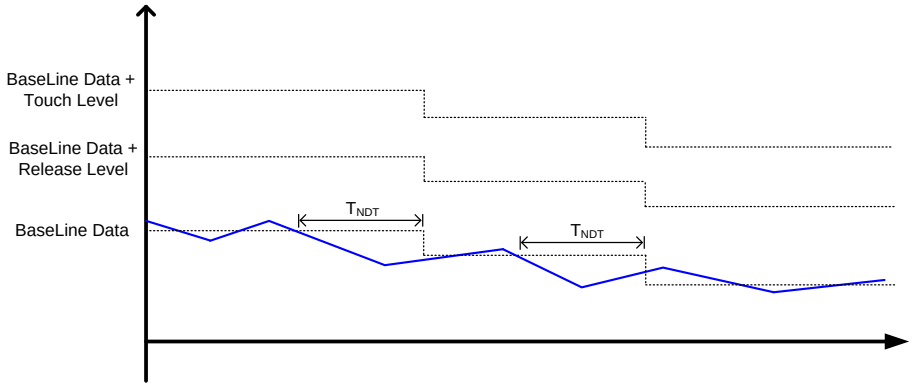


Fig.7-10, illustrates an example of
the negative drift tracking algorithm following a temperature change.

7.7.8 Address 0x07: Button configure

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
BOM		-	-	-	-	-	BRLS
R/W-0	R/W-0	R-0	R-0	R-0	R-0	R-0	R/W-0

Bit 1 (BRLS): Button release level select.

0: Button release level configure to (touch level * 0.75).

1: Button release level configure to (touch level * 0.5).

Bit 1~5: Un-used.

Bit 6~7 (BOM): Button operate mode.

Table 7- 3 Button operate mode

BOM [1:0]	Description
00	First only mode. The user touches multiple button only first touched button to be in operation.
01	Maximun offset mode. The user touches multiple button only the maximun offset button te be in operation.
10	Unrestricted mode. The user can touch any combine button.
11	Last touch mode. The user touches multiple button only the last touched button to be in operation.

7.7.9 Address 0x08: Button press/release debounce time control

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Touch debounce time				Release debounce time			
R/W-0	R/W-0	R/W-1	R/W-1	R/W-0	R/W-0	R/W-1	R/W-1

Bit 0~3: Release debounce time. Default is 3.

Bit 4~7: Touch debounce time. Default is 3.

This register is the debounce time control for Buttons. The bounce time mechanism reduces the effects of noise on button states. The touchpad controller provides touch and release debounce time control to against noise effect. The figure below shows an example of detection with Touch bounce Time = 3 and Release bounce Time = 2 meaning 3 consecutive samples are necessary to trigger the key detection or 2 consecutive samples are necessary to end of detection.

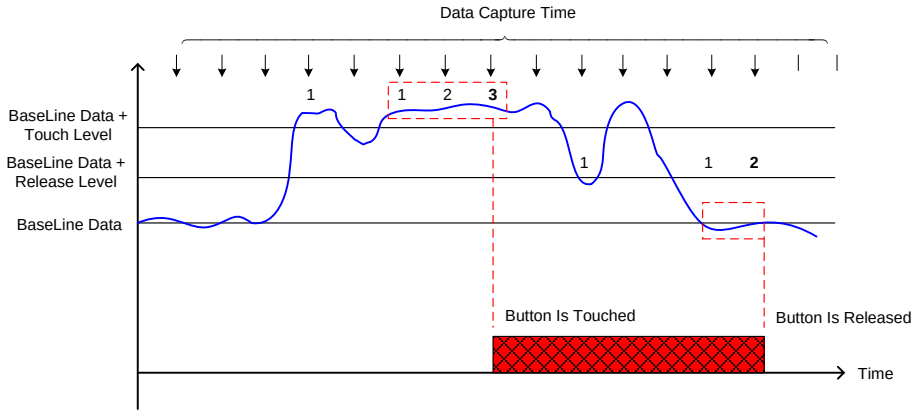


Fig.7-11, illustrates an example of bounce time operation

The debounce time interval: 12.5ms±30%.

7.7.10 Address 0x0D: Output pin control

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	-	-	OUT4	OUT3	OUT2	OUT1	OUT0
R-0	R-0	R-0	RW-0	RW-0	RW-0	RW-0	RW-0

When any one of TPS2, TPS4~TPS7 are set to output mode, the corresponding bit will control I/O output high or low. Host can set this register to control I/O output status through I2C protocol if any I/O configured to output and Button to Output mapping function isn't enabled.

Bit 0 (OUT0): 1/0 → Output high/low.

Bit 1 (OUT1): 1/0 → Output high/low.

Bit 2 (OUT2): 1/0 → Output high/low.

Bit 3 (OUT3): 1/0 → Output high/low.

Bit 4 (OUT4): 1/0 → Output high/low.

Bit 5 ~ 7: Un-used

7.7.11 Address 0x0F: Button to output map

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	MOM	-	MapE4	MapE3	MapE2	MapE1	MapE0
RW-0	RW-0	R-0	RW-0	RW-0	RW-0	RW-0	RW-0

When any bit of MapE0~MapE4 are set, the corresponding bit of output pin control will be disabled function. The I/O output control through touch pad in this moment. The output mode will be depended on MOM bits setting.

Bit 0 (MapE0): Capacitive button of TPS0 map to OUT0.

0: Disable

1: Enable

Bit 1 (MapE1): Capacitive button of TPS3 map to OUT1.

0: Disable

1: Enable

Bit 2 (MapE2): Capacitive button of TPS1 map to OUT2.

0: Disable

1: Enable

Bit 3 (MapE3): Capacitive button of TPS8 map to OUT3.

0: Disable

1: Enable

Bit 4 (MapE4): Capacitive button of TPS9 map to OUT4.

0: Disable

1: Enable

Bit 5: Un-used.

Bit 6 (MOM): Map output mode.

Table 7- 4 Map output mode

MOM	Description
0	Action low mode. When button is pressed, output pin will output low status. The output pin will return to high until button is released.
1	Action high mode. The otuput status is opposite with active Low mode.

Bit 7: Un-used.

7.7.12 Address 0x11: Button status 0

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
BtnS7	BtnS6	BtnS5	BtnS4	BtnS3	BtnS2	BtnS1	BtnS0
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

When any one of TPS0~TPS7 are set to button mode, the corresponding bit will response pressed or released information with 1 or 0.

Bit 0 (BtnS0): Button status for TPS0

0: Released

1: Pressed

Bit 1 (BtnS1): Button status for TPS1

0: Released

1: Pressed

Bit 2 (BtnS2): Button status for TPS2

0: Released

1: Pressed

Bit 3 (BtnS3): Button status for TPS3

0: Released

1: Pressed

Bit 4 (BtnS4): Button status for TPS4

0: Released

1: Pressed

Bit 5 (BtnS5): Button status for TPS5

0: Released

1: Pressed

Bit 6 (BtnS6): Button status for TPS6

0: Released

1: Pressed

Bit 7 (BtnS7): Button status for TPS7

0: Released

1: Pressed

Note: If any buttons are pressed over 30 seconds, touch pad will execute auto-calibration to avoid wrong touch.

7.7.13 Address 0x12: Button status 1

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	-	-	-	-	-	BtnS9	BtnS8
R-0	R-0	R-0	R-0	R-0	R-0	R-0	R-0

When any one of TPS8~TPS9 are set to button mode, the corresponding bit will response pressed or released information with 1 or 0.

Bit 0 (BtnS8): Button status for TPS8

0: Released

1: Pressed

Bit 1 (BtnS9): Button status for TPS9

0: Released

1: Pressed

Bit 2 ~ 7: Un-used

7.7.14 Address 0x1A: Operation mode configure

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
SLEEP	LPWR	LPWR idle time					
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0~5 (LPWR idle time): set eKT2201 touch sensor IC idle timing for using at low power mode. eKT2201 will wake up from low power mode after idle timing time-out.

LPWR idle time = (1 + LPWR idle time [5:0]) * 16ms ± 30%

Low power mode operation:

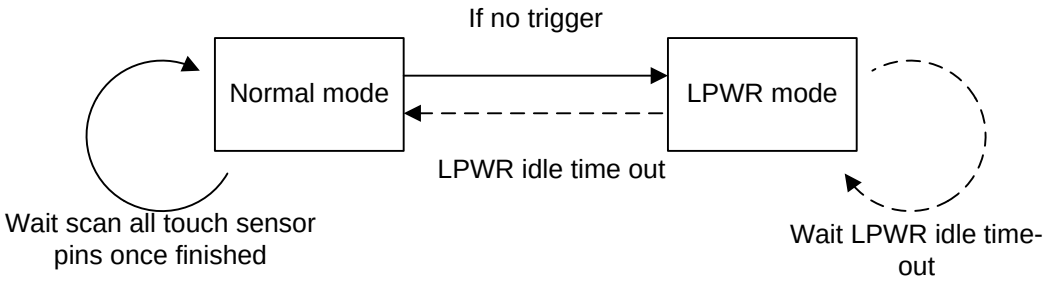


Fig.7-12, Low power mode operation when no trigger occurred

In low power mode such as Fig7-12, eKT2201 will return to normal mode after LPWR idle time out. eKT2201 executes scanning all touch sensor pins once to confirm any touch sensor pins triggered. If nothing, eKT2201 will go to LPWR mode and wait next LPWR idle time out.

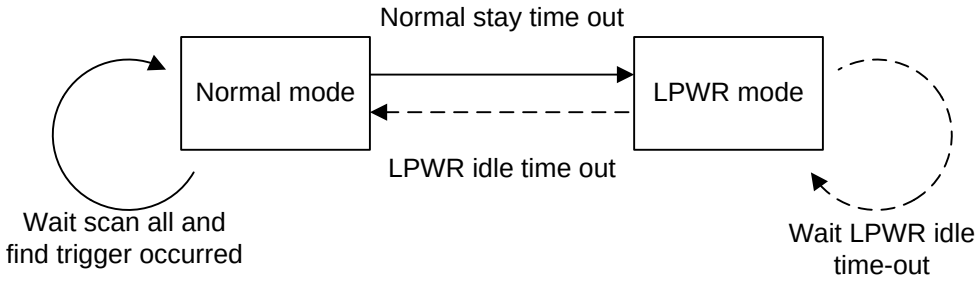


Fig.7-13, Low power mode operation when find trigger occurred

In Fig7-13, eKT2201 returned to normal mode from low power mode and executed scanning once. At this time, one touch sensor pin is triggered by human touched, the normal stay time will be enabled after the touch sensor is released. During normal stay timer counting, the normal stay timer will be cleared and re-counting by any touch sensor pins trigger event occurred. Until normal stay timer time out, eKT2201 will return to low power mode and wait next LPWR idle timer time out.

Bit 6 (LPWR): eKT2201 touch sensor IC go to low power mode. The low power mode is designed to alternate idle mode and normal mode.

0: Disable low power mode. eKT2201 will run at normal mode always.

1: Enable low power mode.

Bit 7 (SLEEP): eKT2201 touch sensor IC go to sleep mode

0: eKT2201 will be waked up from sleep mode and run in normal mode.

1: eKT2201 into sleep mode.

7.7.15 Address 0x1B: Normal stay time

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Normal stay time							
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0~7 (Normal stay time): set the eKT2201 normal stay timing.

Normal stay time = (1 + normal stay time [7:0]) * 40.5ms ± 30%

7.7.16 Address 0x20 ~ 0x29: TPS0 ~ TPS9 touch level

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TPS0 ~ TPS9 Touch level							
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

These registers are the touch level for button0~button9. As Fig. 7-11, the touch level is used to button pressed detection. The button release level is depending on BTLS (Bit 0 of address 0x07) setting in touchpad controller. The release level is used to button released detection. The touch and release level construct to hysteresis in order to prevent erratic behavior.

7.7.17 Address 0xA0: Button enable 0

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
BtnE7	BtnE6	BtnE5	BtnE4	BtnE3	BtnE2	BtnE1	BtnE0
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 (BtnE0): set touch sensor pin, TPS0 to be a capacitive button or undefined.

0: Undefined

1: TPS0 will be a capacitive button.

Bit 1 (BtnE1): set touch sensor pin, TPS1 to be a capacitive button or undefined.

0: Undefined

1: TPS1 will be a capacitive button.

Bit 2 (BtnE2): set touch sensor pin, TPS2 to be a capacitive button or undefined.

0: Undefined

1: TPS2 will be a capacitive button.

Bit 3 (BtnE3): set touch sensor pin, TPS3 to be a capacitive button or undefined.

0: Undefined

1: TPS3 will be a capacitive button.

Bit 4 (BtnE4): set touch sensor pin, TPS4 to be a capacitive button or undefined.

0: Undefined

1: TPS4 will be a capacitive button.

Bit 5 (BtnE5): set touch sensor pin, TPS5 to be a capacitive button or undefined.

0: Undefined

1: TPS5 will be a capacitive button.

Bit 6 (BtnE6): set touch sensor pin, TPS6 to be a capacitive button or undefined.

0: Undefined

1: TPS6 will be a capacitive button.

Bit 7 (BtnE7): set touch sensor pin, TPS7 to be a capacitive button or undefined.

0: Undefined

1: TPS7 will be a capacitive button.

Note: the configuration priority from highest to lowest is button and output.

7.7.18 Address 0xA1: Button enable 1

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	-	-	-	-	-	BtnE9	BtnE8
R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0

Bit 0 (BtnE8): set touch sensor pin, TPS8 to be a capacitive button or undefined.

0: Undefined

1: TPS8 will be a capacitive button.

Bit 1 (BtnE9): set touch sensor pin, TPS9 to be a capacitive button or undefined.

0: Undefined

1: TPS9 will be a capacitive button.

Bit 2 ~ 7: Un-used

7.7.19 Address 0xA9: Output pin enable

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
OUTE4	OUTE3	OUTE2	OUTE1	-	OUTE0	-	-
R/W-0	R/W-0	R/W-0	R/W-0	R-0	R/W-0	R-0	R-0

Bit 0~1, 3: Un-used

Bit 2 (OUTE0): set touch sensor pin, TPS2 to be OUT0 port or undefined.

0: Undefined

1: TPS2 will be output port

Bit 4 (OUTE1): set touch sensor pin, TPS4 to be OUT1 port or undefined.

0: Undefined

1: TPS4 will be output port

Bit 5 (OUTE2): set touch sensor pin, TPS5 to be OUT2 port or undefined.

0: Undefined

1: TPS5 will be output port

Bit 6 (OUTE3): set touch sensor pin, TPS6 to be OUT3 port or undefined.

0: Undefined

1: TPS6 will be output port

Bit 7 (OUTE4): set touch sensor pin, TPS7 to be OUT4 port or undefined.

0: Undefined

1: TPS7 will be output port

7.7.20 Address 0xB0 ~ 0xB9: TPS0 ~ TPS9 individual sensitivity

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-				TPS0 ~TPS9 individual sensitivity			
R-0	R-0	R-0	R-0	R/W-1	R/W-0	R/W-0	R/W-0

Bit 0~3: 4-bit sensitivity adjustment of touch sensor pin, TPS0 ~ TPS9. The highest sensitivity value is 0xF, but the lowest is 0x0.

Bit 4~7: Un-used

7.7.21 Address 0xBB: Global sensitivity

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-				Global sensitivity			
R-0	R-0	R-0	R-0	R/W-0	R/W-1	R/W-1	R/W-1

Bit 0~3: 4-bit global sensitivity adjustment for all capacitive sensors. This register provides base sensitivity adjustment. After finish base (rough) sensitivity adjustment, use 0xB0~0xB9 command to do slight adjustment for each capacitive sensors in order to meet with any kinds of application. The highest sensitivity value is 0xF, but the lowest is 0x0.

Bit 4~7: Un-used

7.8 Operation mode

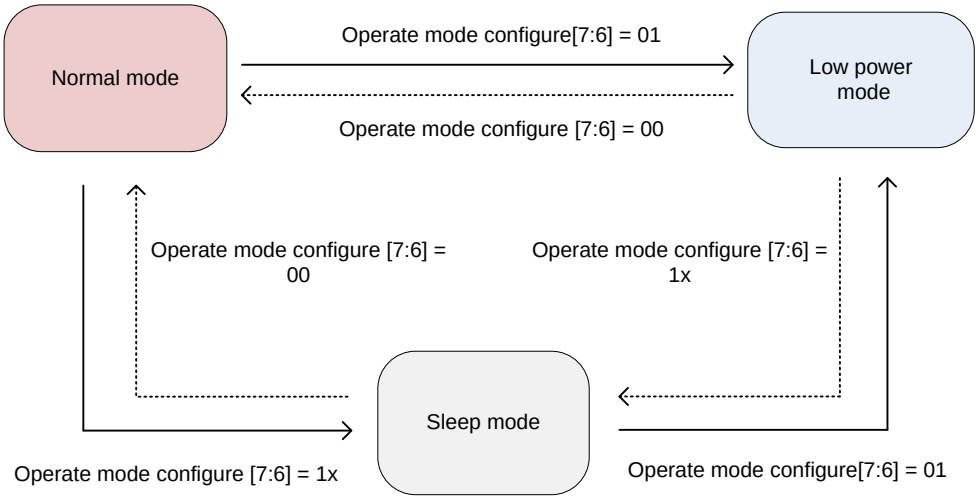


Fig.7-14, operation mode transfer in protocol mode (IOmode=0)

7.8.1 Normal mode

This is default mode on eKT2201. In normal mode, eKT2201 will run at high speed and high scan rate always and never rest. Due to eKT2201 runs full speed, the power consumption at normal mode is higher than low power mode and sleep mode.

Set eKT2201 runs at normal mode:

a. From Low power mode to normal mode: write address 0x1A, Operate mode configure [7:6] = 00.

b. From Sleep mode to normal mode: write address 0x1A, Operate mode configure [7:6] = 00.

7.8.2 Low power mode

Users can set eKT2201 to run at low power mode for decreasing power consumption. When eKT2201 is operated in this mode, there are two registers about timing control, address 0x1A, operate mode configure [5:0] and address 0x1B, normal stay time [7:0]. The detail description about them, users can refer to section 7.7.14.

Set eKT2201 runs at low power mode:

a. From normal mode to low power mode: write address 0x1A, Operate mode configure [7:6] = 01.

b. From sleep mode to low power mode: write address 0x1A, Operate mode configure [7:6] = 01.

7.8.3 Sleep mode

Sleep mode is the lowest power consumption. eKT2201 will go to deep sleep and wait wake up command from host. There is only method for eKT2201 into sleep mode and wake-up from sleep mode. Users can set address 0x1A [7:6] into the sleep mode or wake up from sleep mode into the others mode, normal mode or low power mode.

Set eKT2201 go to sleep and wake up:

a. From low power and normal mode into sleep mode: write address 0x1A, Operate mode select [7:6] = 1x.

b. Wake-up from sleep mode into normal mode: write address 0x1A, Operate mode configure [7:6] = 00.

c. Wake-up from sleep mode into low power mode: write address 0x1A, Operate mode configure [7:6] = 01.

7.9 Power-on reset/initial and function configuration flow

7.9.1 Power-on Reset/Initial

After the touchpad is powered on, this controller will do initialization. The initialization includes MCU and some parameter initialization. After the initial process, the TPREQB pin will output low and return to high to report the initial TP state to host to let the host know that the touchpad is ready to work. Fig. 7-15 shows the process after power up. Touchpad power-on initiation time is typical 150ms.

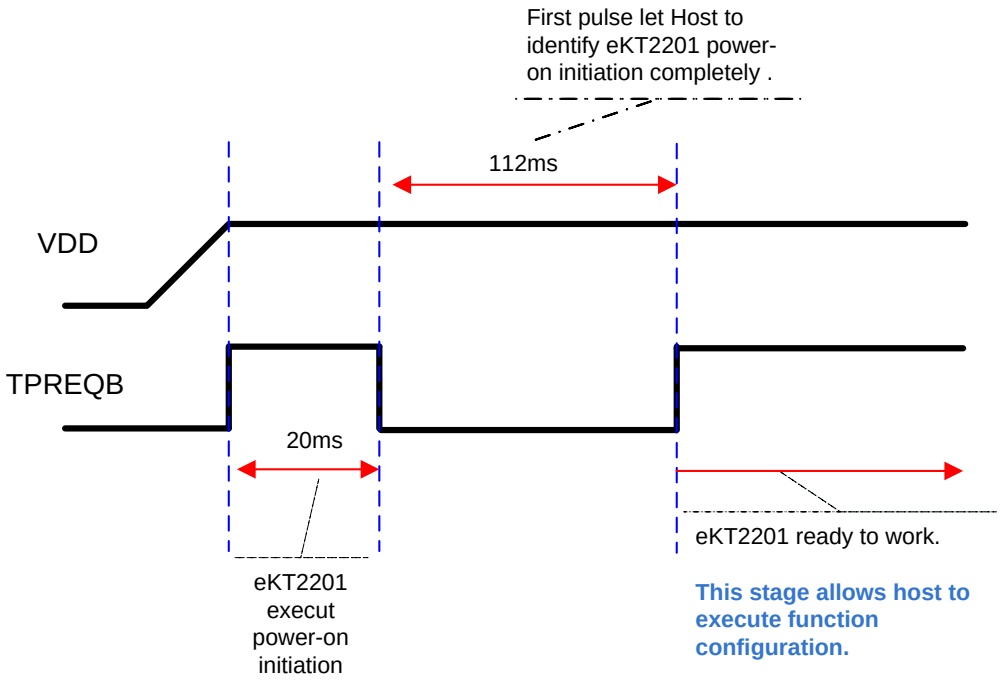


Fig. 7-15, Power-on Reset and Initiate Timing Diagram

After eKT2201 completed power-on initiation, users can start to read or write eKT2201 via I2C protocol.

7.9.2 Function configuration flow

Although eKT2201 already provides initial function in protocol mode, user also can redistribute function to meet their application by I2C communication. After eKT2201 completed power-on reset and initiation, users can start to configure eKT2201 through I2C. The configuration as follows:

Step1:
Users should send a command to write address 0x03, General configure, bit 4, Build to 1 for eKT2201 at structure re-build mode.

Step2:
Host sets button number and output trace. Those relation registers are address 0xA0, 0xA1 and 0xA9. And then host configures sensitivities (0xB0~0xB9), touch level (0x20~0x29) and positive/negative drift tracking (0x05, 0x06) for defined touch sensor pins. If user has defined buttons and output function, it is necessary to decide button mode (0x07), button debounce (0x08) and Button map to output (0x0F).

Step3:
Host sets others function, such as operation mode (0x1A), TPREQB mode (0x04) and timing control relationship with operation mode (0x1A), TPREQB mode (0x04).

Step4:
After host loaded all setting to eKT2201, host should send a command to clear address 0x03, General configure, bit 4, Build to 0 for eKT2201 executing host's configuration.

Step5:
Host can read address 0x02, Device status, bit 4, buildOK to confirm the configuration completed or not. 1 is represented completed, but 0 is represent un-completed. The configuration time will be depended on functions complicacy or not.

8 Application circuit

8.1 I/O mode

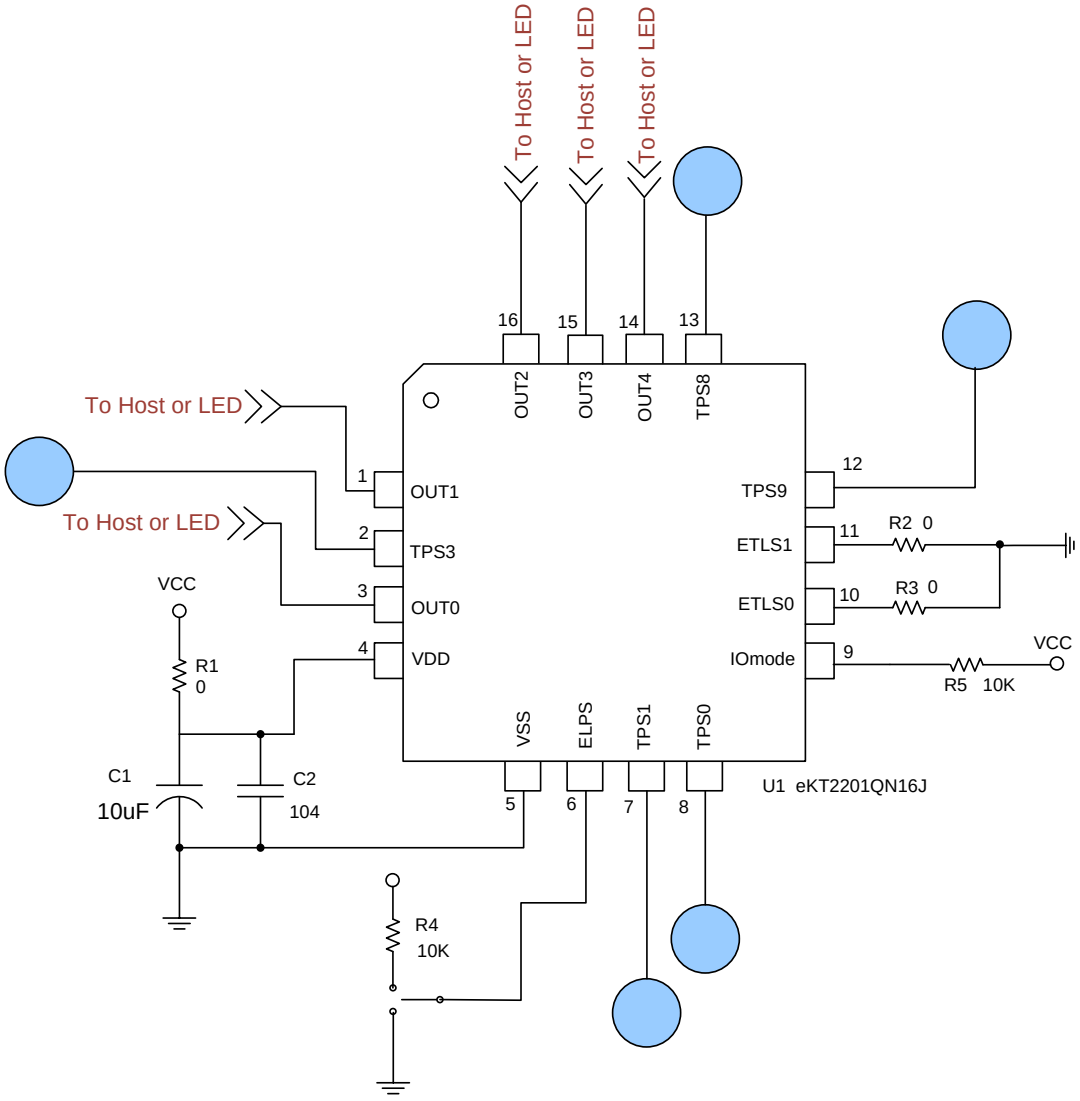


Fig.8-1, 5 buttons to 5 I/O outputs mapping operate in QFN16 package type

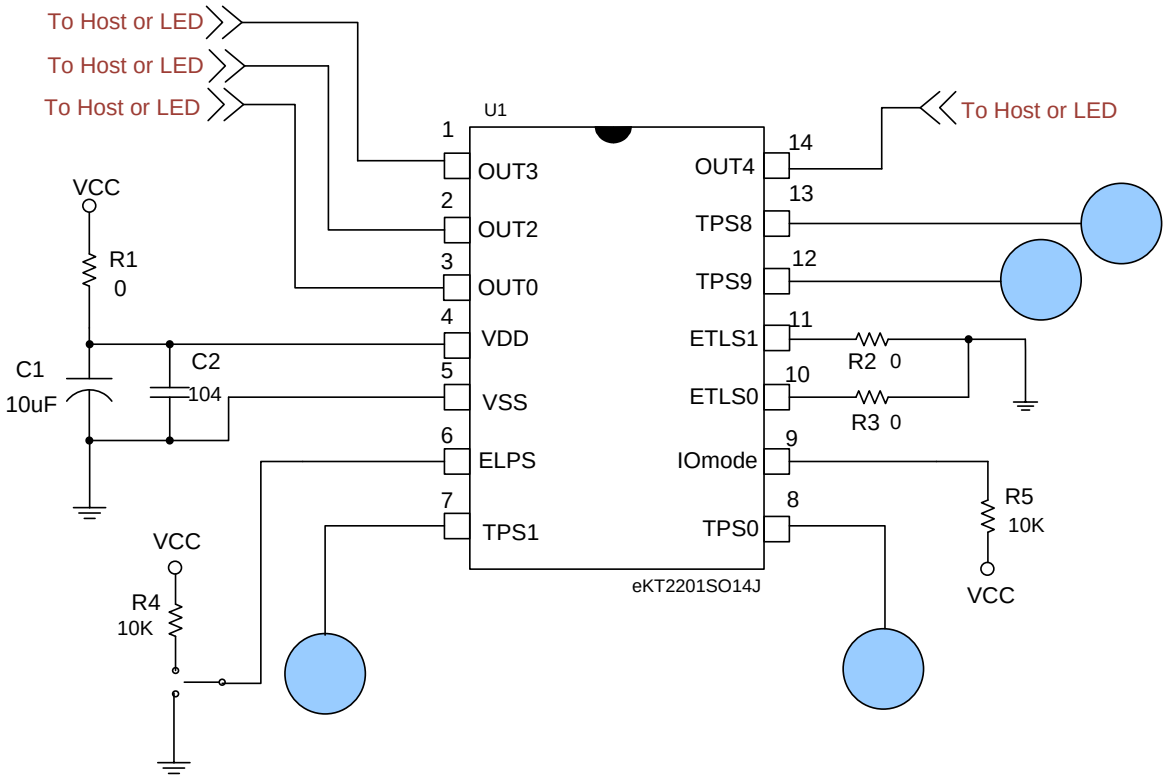


Fig.8-2, 4 buttons to 4 I/O outputs mapping operate in SOP14 package type

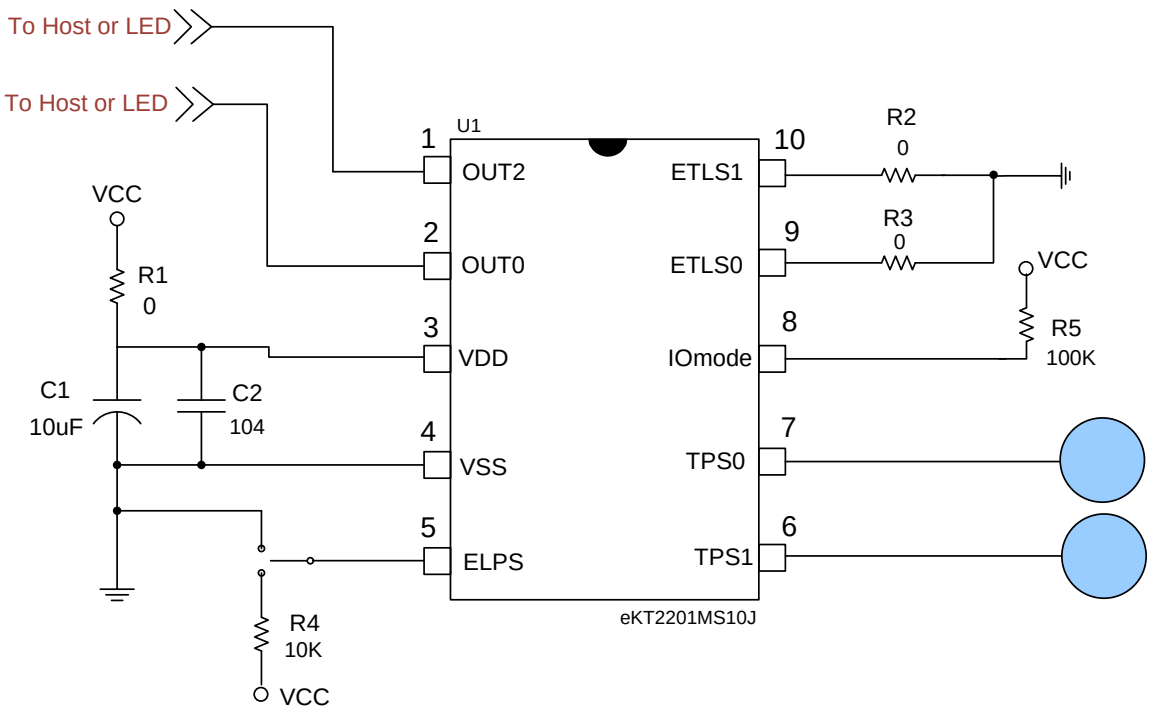


Fig.8-3, 2 buttons to 2 I/O outputs mapping operate in MSOP10 package type

Note:

- IOmode pin must be configured to high.
- If any sensor is unused in circuit, the sensor pin must keep **float state.**
- R2 and R3 are option resister for touch level selection.
- If has serious power ripple in power line, User can adjust R1 to reduce power ripple. R1 suggests range is between 0 and 10.
- The sensor trace must avoid cross each other on PCB.

8.2 Protocol mode

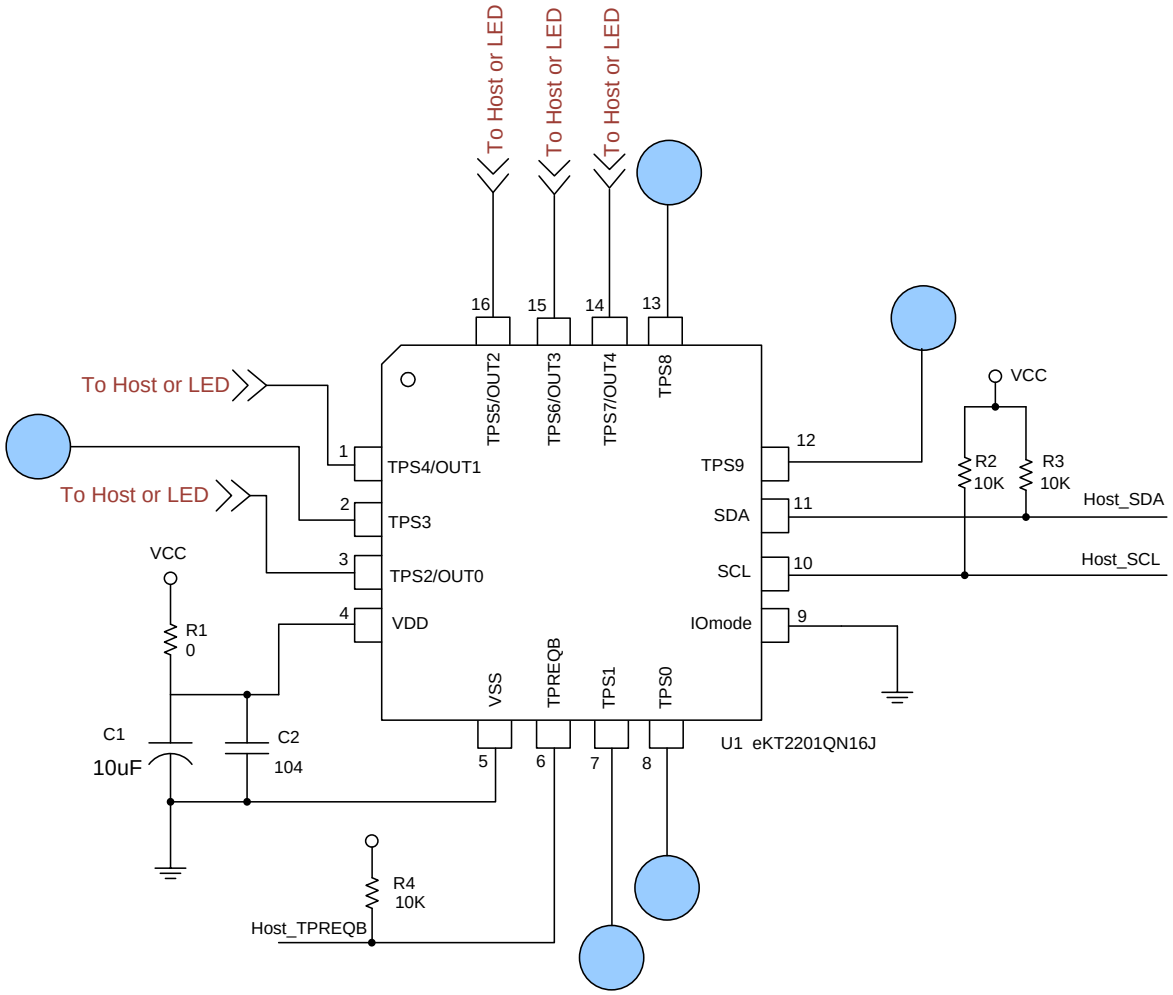


Fig.8-4, The five sensor traces configure to Button and others configure to output operation thorough I2C protocol.

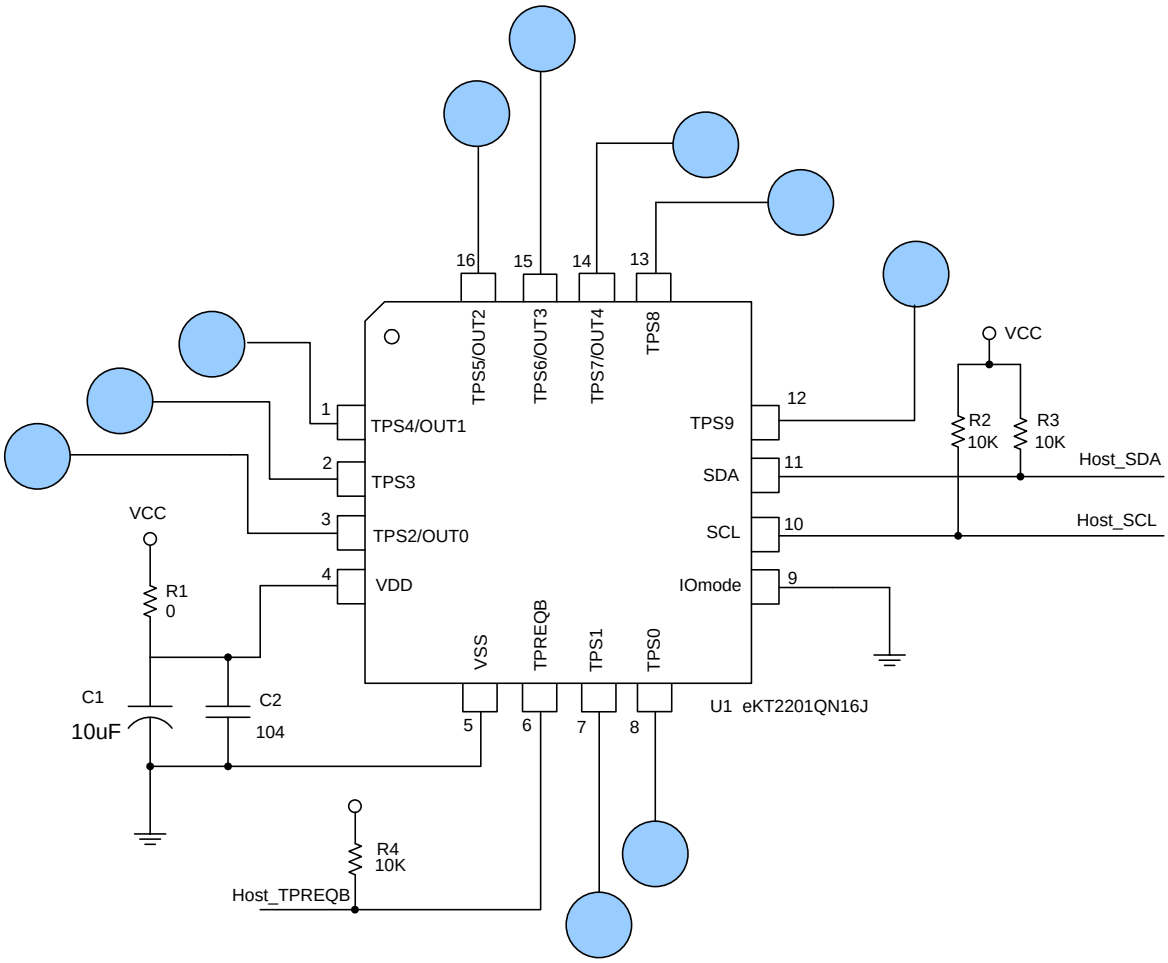


Fig.8-5, All sensor traces configure to Button operation thorough I2C protocol.

Note:

- IOmode pin must be configured to low.
- If any sensor is unused in circuit, the sensor pin must configure to **undefined state**.
- If has serious power ripple in power line, User can adjust R1 to reduce power ripple. R1 suggests range is between 0 and 10.
- The sensor trace must avoid cross each other on PCB.

9 Electrical Characteristics

■ Absolute Maximum Ratings

Items	Rating		
Temperature under bias	-40°C	to	85°C
Storage temperature	-65°C	to	150°C
Input voltage	Vss-0.3V	to	Vdd+0.5V
Output voltage	Vss-0.3V	to	Vdd+0.5V
Working Voltage	3.0V	to	5.5V
Working Frequency	DC	to	4 MHz

■ DC/AC Electrical Characteristics (Ta= -40~85℃, VSS= 0V, Cx=5pF)

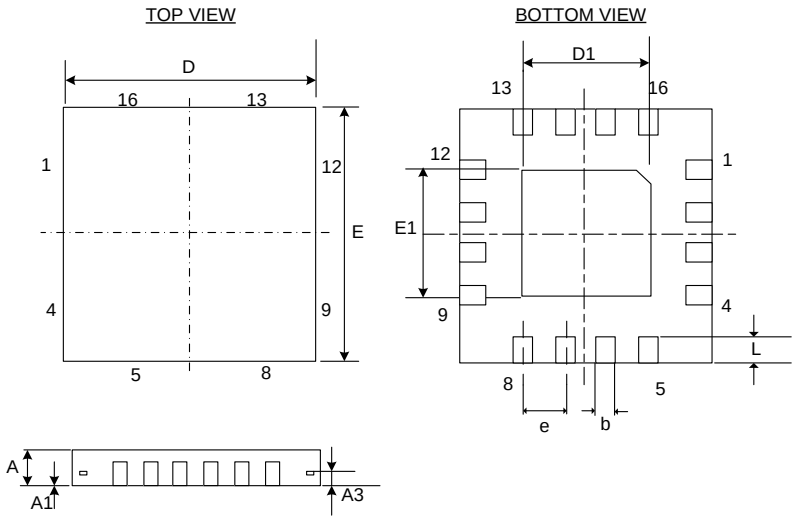
Parameter	Condition	Min.	Typ.	Max.	Unit
Power supply voltage request	General purpose	3.0V	-	5.5	V
System operation frequency	IRC (RCM0 : RCM1=1:1)	3.68	4	4.32	MHz
Input Leakage Current for input pins	VIN = VDD, VSS	-1	0	1	mA
Input High Voltage (Schmitt trigger)	Power supply	0.7VDD	-	VDD+0.3V	V
Input Low Voltage (Schmitt trigger)	Power supply	-0.3V	-	0.3VDD	V
Output Port Source Current (IOH)	VOH = 0.9VDD	11	12	13.5	mA
Output Port Sink Current (IOL)	VOL = 0.1VDD	22	24	27	mA
I/O mode operating current					
Normal mode	finger touched, ELPS=0, IRC=4MHz @ 3.3V, QN16J package	1.5	-	1.9	mA
Low power mode 0	Buttons to I/O outputs mapping operation, finger untouched, ELPS=0, IRC=4MHz @ 3.3V	-	-	200	uA
Low power mode 1	Buttons to I/O outputs mapping operate, finger untouched, ELPS=1, IRC=4MHz @ 3.3V	-	-	100	uA
Protocol mode operating current					
Normal mode	10 buttons operate, finger untouched, IRC=4MHz @ 5V	2.7	2.8	2.9	mA

	10 buttons operate, finger untouched, IRC=4MHz @ 3.3V	1.9	2.0	2.1	mA
	10 buttons operate, finger touched, IRC=4MHz @ 3.3V	2.02	2.12	2.22	mA
	5 buttons operate, others are undefined, finger untouched, IRC=4MHz @ 3.3V	1.6	1.8	1.8	mA
Low power mode	10 buttons operate, others are undefined, finger untouched, IRC=4MHz @ 3.3V, Idle interval = 112ms	-	-	300	uA
	10 buttons operate, others are undefined, finger untouched, IRC=4MHz @ 3.3V, Idle interval = 250ms	-	-	200	uA
	10 buttons operate, others are undefined, finger untouched, IRC=4MHz @ 3.3V, Idle interval = 500ms	-	-	170	uA
Sleep mode	Operation mode configure[7:6]=1x, IRC=4MHz @ 3.3V	-	-	2	uA

APPENDIX

A Package type

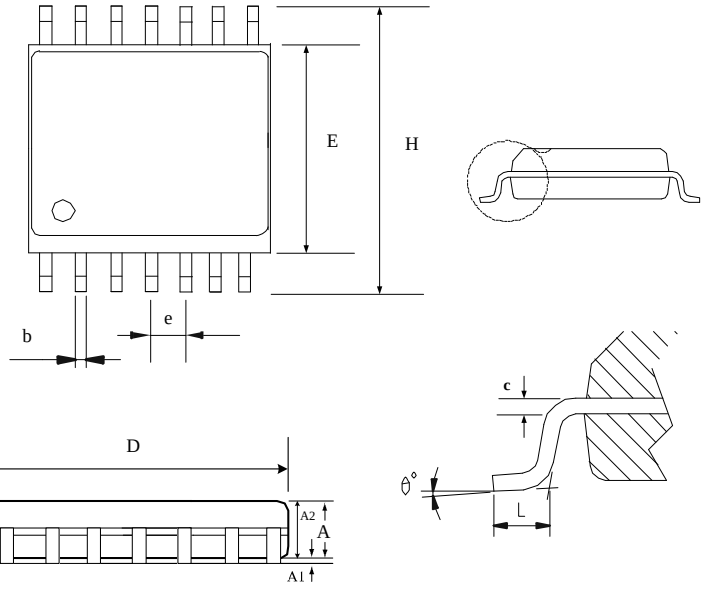
A.1 16 Pin-QFN



Symbal	Min	Normal	Max
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.203 REF	
b	0.25	0.30	0.35
D	3.85	4.00	4.15
D1	2.40	2.50	2.60
E	3.85	4.00	4.15
E1	2.40	2.50	2.60
e		0.65BSC	
L		0.40	
y	0		0.08

義隆電子股份有限公司 ELAN MICROELECTRONICS CORPORATION			TITLE: QFN 24L (4*4* 0.8 MM) PACKAGE OUTLINE DIMENSION	
DWG NO: POD-091			File : QFN 16L	Edtion: A
	Name	Date		Unit : mm
Draw	鍾玉真	2008/12/3		Scale: Free
Check				Material:
Approved				Sheet:1 of 1

A.2 14 Pin-SOP

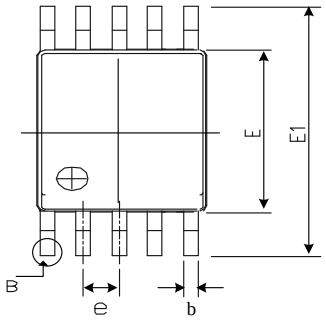


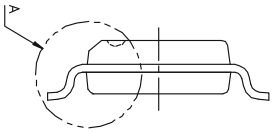
Symbal	Min	Normal	Max
A	1.350		1.750
A1	0.100		0.250
b	0.330		0.510
c	0.190		0.250
E	3.800		4.000
H	5.800		6.200
D	8.550		8.750
L	0.600		1.270
e	1.27(TYP)		
θ°	0		8

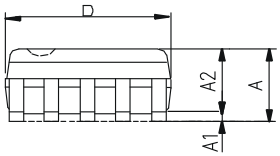
TITLE:
SOP-14L(150MIL) PACKAGE OUTLINE DIMENSION

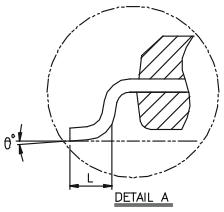
File : NSO14	Edtion: A
	Unit : mm
	Scale: Free
	Material:
	Sheet:1 of 1

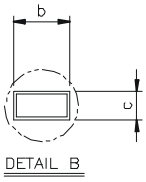
A.3 10 Pin-MSOP











Symbal	Min	Normal	Max
A			1.1
A1	0.05		0.15
A2	0.75	0.85	0.95
D	2.90	3.00	3.10
E	2.90	3.00	3.10
E1	4.7	4.9	5.1
b	0.19		0.28
c	0.15		0.2
L	0.4		0.7
e	0.5BSC		
θ	0°	-	8°

ELAN MICROELECTRONICS CORPORATION			TITLE: MSOP 10L (118MIL)PACKAGE OUTLINE DIMENSION	
DWG NO: POD-089			File : MSOP 10 L	Edtion: A
	Name	Date		Unit : mm
Draw:	鍾玉真	2008/8/18		Scale: Free
Check:	何明龍	2008/8/18		Material:
Approved				Sheet:1 of 1

B Approved Code Form of eKT2201

The Following Items are Filled-in by Customer

1. Part Number : _____ , Quantity : _____
   Part Number : _____ , Quantity : _____

2. Contact details
   Company name : _____
   First name : _____ Last name : _____
   Job Title : _____
   eMail : _____
   Address : _____
   Phone : _____ Fax : _____

3. Shipping details (if different from above)
   Company name : _____
   First name : _____ Last name : _____
   Job Title : _____
   eMail : _____
   Address : _____
   Phone : _____ Fax : _____

4. Shipper A/C number : _____

5. Delivery Schedule: Date _____

   Signature Customer: _____Date: _____Tel : _____

   ELAN Sales: _____ Date: _____

   ELAN FAE : _____ Date: _____