

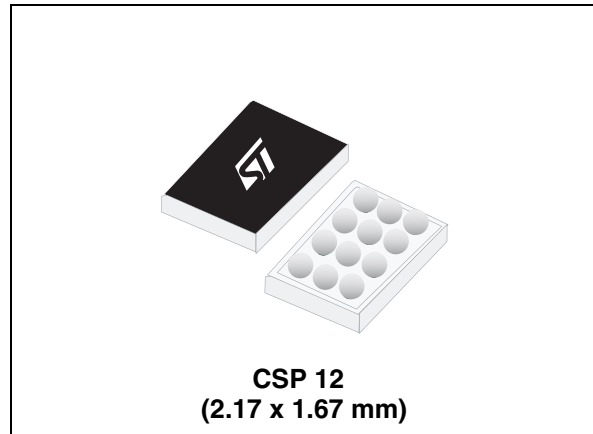


# STMPE812A

## Touchscreen controller S-Touch<sup>®</sup> with PWM and dedicated RESET pin

### Features

- Integrated 4-wire resistive touchscreen controller, pen-down/real-time mode, fully-autonomous
- 12-bit ADC for high-resolution touchscreen
- Operating voltage 1.65 - 3.6 V
- Low power consumption:
  - Hibernation mode: 0.5  $\mu$ A
  - Active mode: 100  $\mu$ A
- Auto-hibernation and hotkey wake-up features
- Up to 3 GPIOs with alternate functions
  - 1 PWM controller
  - 1 general purpose 12-bit ADC input
  - Optional interrupt output pin
- Dedicated reset input pin
- 400 kHz I<sup>2</sup>C interface
- 8 kV HBM, 1 kV CDM ESD protection on X+/X-/Y+/Y-
- 2 kV HBM, 250 V CDM ESD protection on all other pins



### Description

The STMPE812A is a 4-wire resistive touchscreen controller with 4-bit port expander integrated.

The touchscreen controller is designed to be fully autonomous, requiring only minimal CPU intervention for sampling, filtering and pre-processing operations.

### Applications

- Portable media players
- Game consoles
- Mobile and smart phones

**Table 1. Device summary**

Order code	Package	Packaging
STMPE812ABJR	CSP 12 (2.17 x 1.67 mm)	Tape and reel

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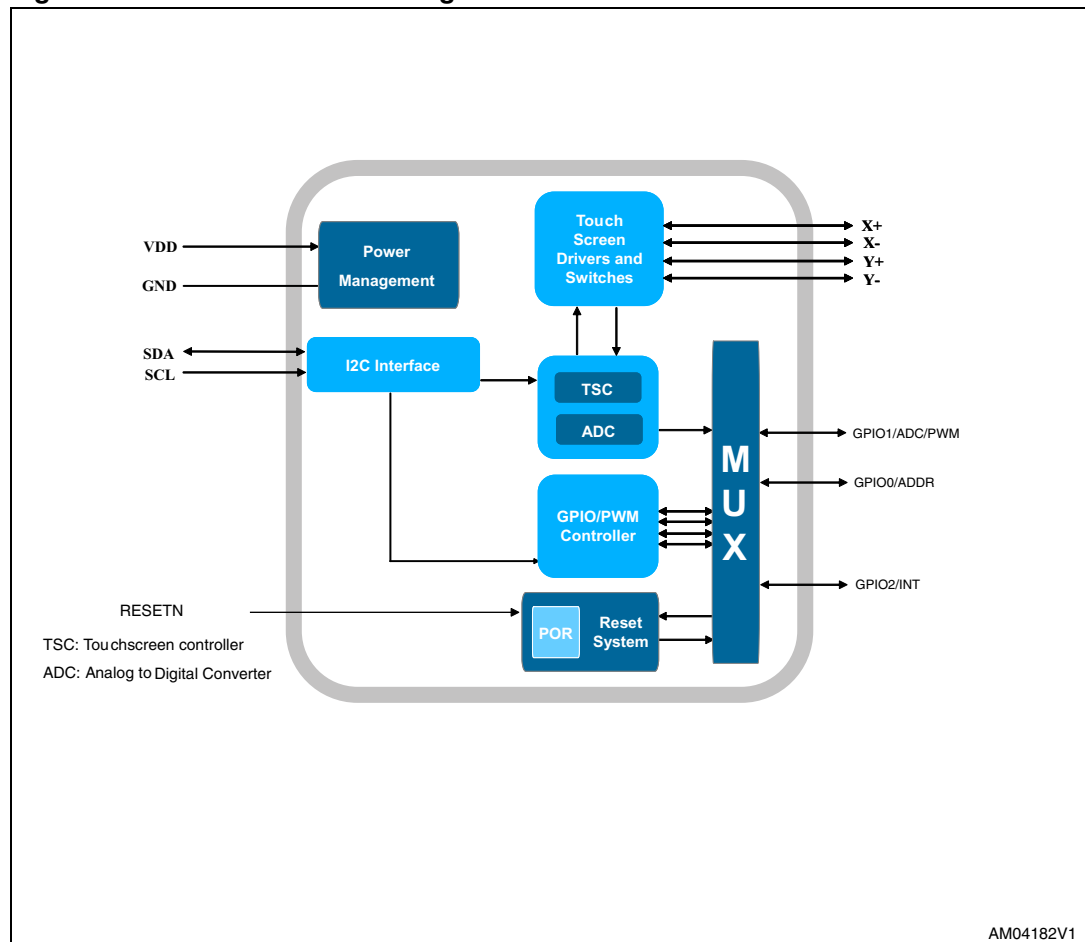
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# 1 STMPE812A functional overview

The STMPE812A consists of the following blocks:

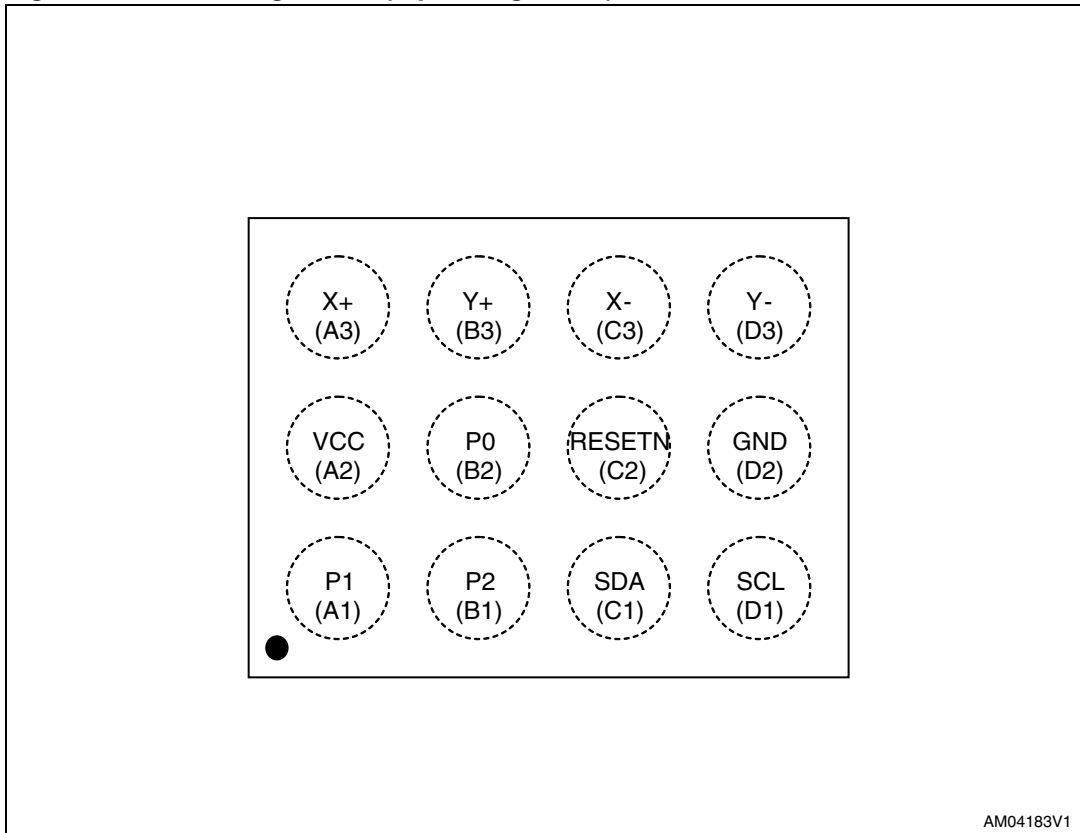
- I<sup>2</sup>C interface
- GPIO/PWM controller
- Touchscreen controller (TSC)
- Analog-to-digital converted (ADC)
- Driver and switch control unit

**Figure 1. STMPE812A block diagram**



## 1.1 Pin configuration and functions

Figure 2. Pin configuration (top through view)



AM04183V1

Table 2. Pin assignments

Pin	Name	Current capacity	Function
B3	Y+	50 mA current limit	Y+
C3	X-	50 mA current limit	X-
D3	Y-	50 mA current limit	Y-
C2	RESETN	+8 mA/-12 mA at 3.3 V	Active low RESET (3.6 V tolerant within $V_{CC}$ valid range). Typical reset filter duration is 788 ns at 1.8 V $V_{CC}$ .
D2	GND	Can be > 80 mA load at touchscreen and GPIO drive	Ground
D1	SCL	-4 mA	I <sup>2</sup> C clock (fail safe, tolerant to 3.6 V regardless of $V_{CC}$ )

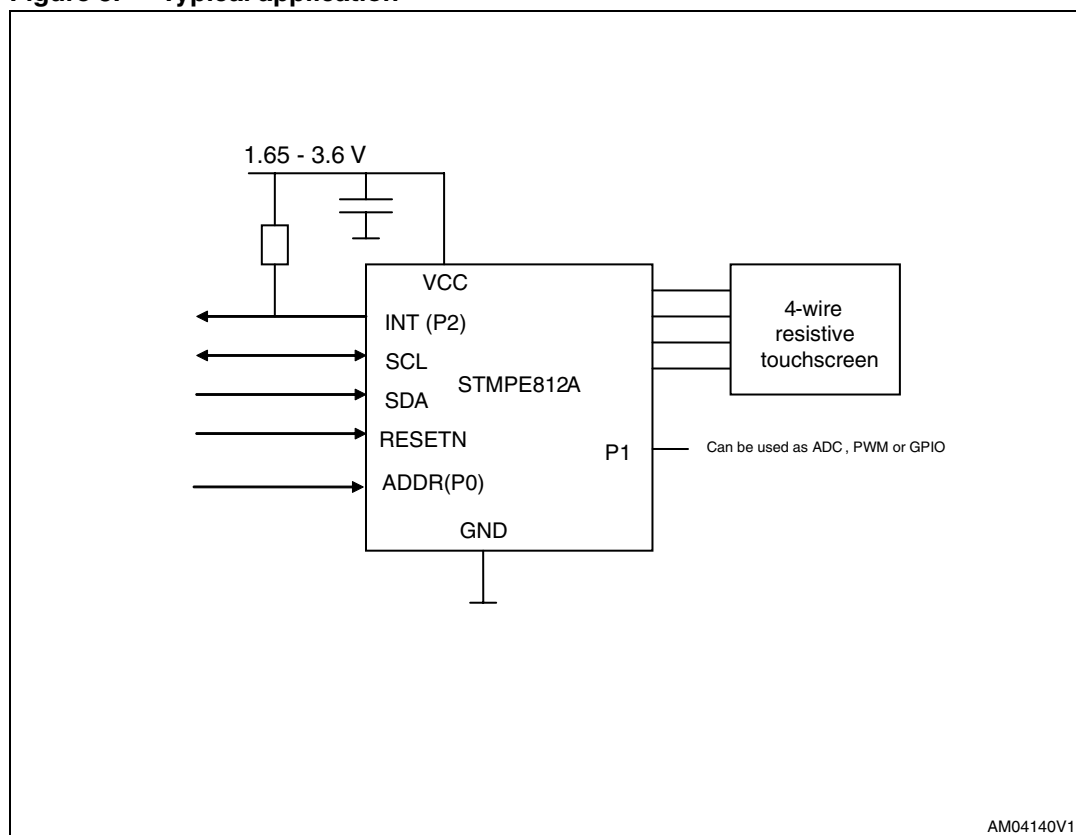
**Table 2. Pin assignments (continued)**

Pin	Name	Current capacity	Function
C1	SDA	-4 mA	I <sup>2</sup> C data (fail safe, tolerant to 3.6 V regardless of V <sub>CC</sub> )
B1	P2	+8 mA/-12 mA at 3.3 V	GPIO-2/ INT (3.6 V tolerant within V <sub>CC</sub> valid range)
A1	P1	+8 mA/-12 mA at 3.3 V	GPIO-1/ADC/PWM (3.6 V tolerant within V <sub>CC</sub> valid range except VIN_ADC must be less than V <sub>CC</sub> )
B2	P0	+8 mA/-12 mA at 3.3 V	GPIO-0/ADDR (3.6 V tolerant within V <sub>CC</sub> valid range)
A2	V <sub>CC</sub>	Can be > 80 mA load at touchscreen and GPIO drive	1.65 - 3.6 V core/IO supply (0.1 µF decoupling cap) No low-voltage detection for POR 20 µs POR from power stable
A3	X+	50 mA current limit	X+

*Note:* All I/O operates on V<sub>CC</sub>. All I/O tolerant up to 3.6 V, across V<sub>CC</sub> = 1.65 - 3.6 V  
 8 kV HBM ESD on all touchscreen pins (+/- 8 kV vs GND)  
 0.5 µA max input leakage as input, across V<sub>CC</sub> range (GPIO, SCL/SDA)  
 4 µs hardware filter on the 3 GPIOs as input

## 1.2 Typical application

Figure 3. Typical application



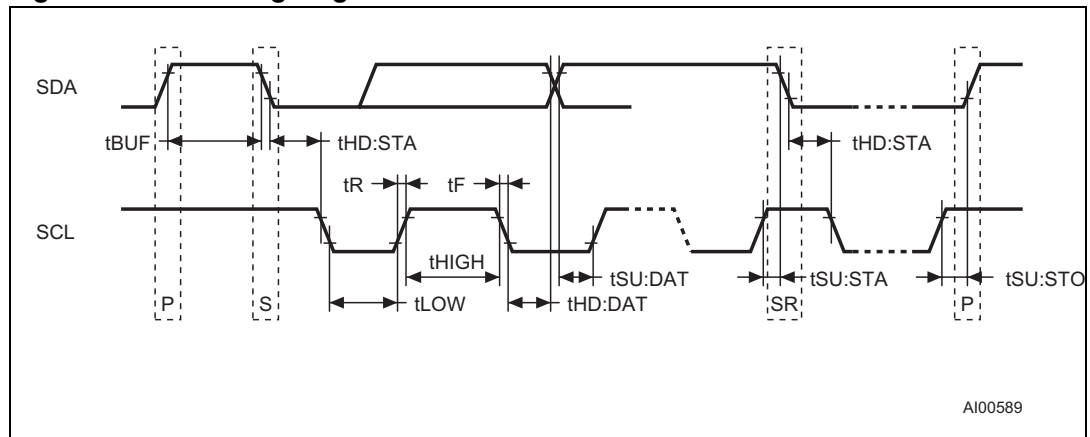
AM04140V1

## 2 I<sup>2</sup>C interface

For the bus master to communicate to the slave device, the bus master must initiate a Start condition and be followed by the slave device address. Accompanying the slave device address, there is a read/write bit (R/W). The bit is set to 1 for read and 0 for write operation.

If a match occurs on the slave device address, the corresponding device gives an acknowledge on the SDA during the 9th bit time. If there is no match, it deselects itself from the bus by not responding to the transaction.

**Figure 4. I<sup>2</sup>C timing diagram**



**Table 3. I<sup>2</sup>C timing**

Symbol	Parameter	Min	Typ	Max	Unit
$f_{SCL}$	SCL clock frequency	0	-	400	kHz
$t_{LOW}$	Clock low period	1.3	-	-	$\mu$ s
$t_{HIGH}$	Clock high period	600	-	-	ns
$t_F$	SDA and SCL fall time	Note <sup>(1)</sup>	-	300	ns
$t_{HD:STA}$	START condition hold time (after this period the first clock is generated)	600	-	-	ns
$t_{SU:STA}$	START condition setup time (only relevant for a repeated start period)	600	-	-	ns
$t_{SU:DAT}$	Data setup time	100	-	-	ns
$t_{HD:DAT}$	Data hold time	0	-	-	$\mu$ s
$t_{SU:STO}$	STOP condition setup time	600	-	-	ns
$t_{BUF}$	Time the bus must be free before a new transmission can start	1.3	-	-	$\mu$ s

1. Minimum  $T_F$  is subject to system capacitive load ( $C_{LOAD}$ ) condition.



## 2.1 I<sup>2</sup>C features

The features that are supported by the I<sup>2</sup>C interface are listed below:

- I<sup>2</sup>C slave device
- Operates at V<sub>CC</sub> (1.65 V - 3.6 V)
- Compliant to Philips I<sup>2</sup>C specification version 2.1
- Supports standard (up to 100 Kbps) and fast (up to 400 Kbps) modes
- I<sup>2</sup>C address in 0x41 (0x82/83 including Rd/Wr bit) or 0x40 (0x80/81 including Rd/Wr bit)

The slave address is selected by the state of P0 pin. The state of the pin is read upon reset and then the pin can be configured for normal operation. The pin shall have an external pull-up or pull-down to set the address.

**Table 4. Slave address**

ADDR (P0)	7-bit I <sup>2</sup> C slave address
0	40h
1	41h

### Start condition

A Start condition is identified by a falling edge of SDATA while SCLK is stable at high state. A Start condition must precede any data/command transfer. The device continuously monitors for a Start condition and does not respond to any transaction unless one is encountered.

### Stop condition

A Stop condition is identified by a rising edge of SDATA while SCLK is stable at high state. A Stop condition terminates communication between the slave device and the bus master. A read command that is followed by NoAck can be followed by a Stop condition to force the slave device into idle mode. When the slave device is in idle mode, it is ready to receive the next I<sup>2</sup>C transaction. A Stop condition at the end of a write command stops the write operation to registers.

### Acknowledge bit

The acknowledge bit is used to indicate a successful byte transfer. The bus transmitter releases the SDATA after sending eight bits of data. During the ninth bit, the receiver pulls the SDATA low to acknowledge the receipt of the eight bits of data. The receiver may leave the SDATA in high state if it does not acknowledge the receipt of the data.

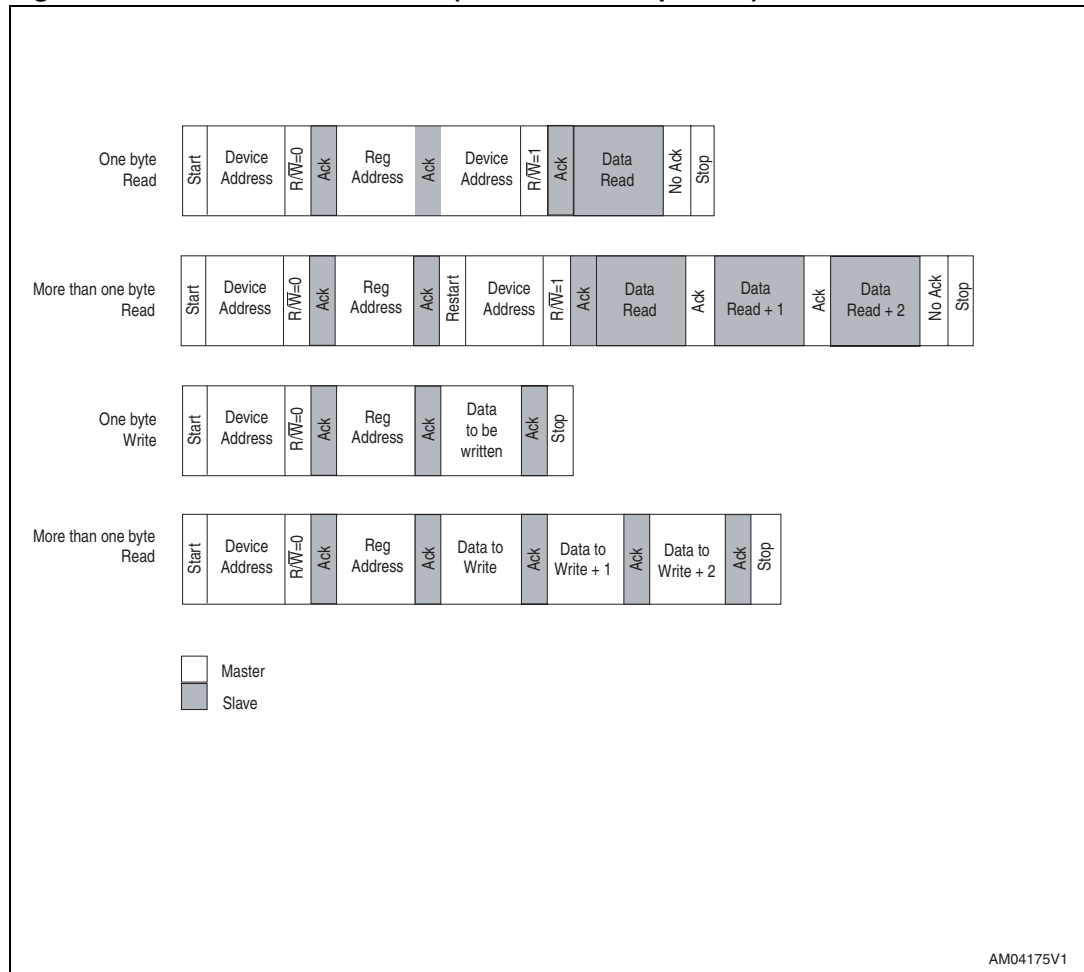
## 2.2 Data input

The device samples the data input on SDATA on the rising edge of the SCLK. The SDATA signal must be stable during the rising edge of SCLK and the SDATA signal must change only when SCLK is driven low.

Table 5. Operating modes

Mode	Byte	Programming sequence
Read	$\geq 1$	Start, Device address, $R/\overline{W} = 0$ , Register address to be read
		Restart, Device address, $R/\overline{W} = 1$ , Data Read, Stop
		If no Stop is issued, the Data Read can be continuously performed. If the register address falls within the range that allows an address auto-increment, then the register address auto-increments internally after every byte of data being read. For register address that falls within a non-incremental address range, the address is kept static throughout the entire read operations. Refer to the memory map table for the address ranges that are auto and non-increment.
Write	$\geq 1$	Start, Device address, $R/\overline{W} = 0$ , Register address to be written, Data Write, Stop
		If no Stop is issued, the Data Write can be continuously performed. If the register address falls within the range that allows address auto-increment, then the register address auto-increments internally after every byte of data being written in. For those register addresses that fall within a non-incremental address range, the address is kept static throughout the entire write operation. Refer to the memory map table for the address ranges that are auto and non-increment.

**Figure 5. Read and write modes (random and sequential)**



## 2.3 Read operation

A write is first performed to load the register address into the Address Counter but without sending a Stop condition. Then, the bus master sends a reStart condition and repeats the Device Address with the R/W bit set to 1. The slave device acknowledges and outputs the content of the addressed byte. If no additional data is to be read, the bus master must not acknowledge the byte and terminates the transfer with a Stop condition.

If the bus master acknowledges the data byte, then it can continue to perform the data reading. To terminate the stream of data bytes, the bus master must not acknowledge the last output byte, and be followed by a Stop condition. If the address of the register written into the Address Counter falls within the range of addresses that has the auto-increment function, the data being read is coming from consecutive addresses, which the internal Address Counter automatically increments after each byte output. After the last memory address, the Address Counter 'rolls-over' and the device continues to output data from the memory address of 0x00. Similarly, for the register address that falls within a non-increment range of addresses, the output data byte comes from the same address (which is the address referred by the Address Counter).

### Acknowledgement in read operation

For the above read command, the slave device waits, after each byte read, for an acknowledgement during the ninth bit time. If the bus master does not drive the SDA to a low state, then the slave device terminates and switches back to its idle mode, waiting for the next command.

## 2.4 Write operations

A write is first performed to load the register address into the Address Counter without sending a Stop condition. After the bus master receives an acknowledgement from the slave device, it may start to send a data byte to the register (referred by the Address Counter). The slave device again acknowledges and the bus master terminates the transfer with a Stop condition.

If the bus master needs to write more data, it can continue the write operation without issuing the Stop condition. Whether the Address Counter autoincrements or not after each data byte write depends on the address of the register written into the Address Counter. After the bus master writes the last data byte and the slave device acknowledges the receipt of the last data, the bus master may terminate the write operation by sending a Stop condition. When the Address Counter reaches the last memory address, it 'rolls-over' to the next data byte write.

### 3 Power supply

The STMPE812A GPIO operates from a supply pin  $V_{CC}$ . For better resolution and noise immunity,  $V_{CC}$  above 2.8 V is recommended.

#### **Power up reset**

The STMPE812A is equipped with an internal POR circuit that holds the device in reset state, until the  $V_{CC}$  supply input is valid. The internal POR is tied to the  $V_{CC}$  supply pin.

## 4 Charge pump

The STMPE812A is integrated with an internal charge-pump. The charge pump is required for any ADC/TSC operations when  $V_{CC}$  is less than 2.5 V.

Activating the charge pump when  $V_{CC} > 2.5$  V may result in permanent damage of the device.

## 5 Power modes

The STMPE812A operates in a 2 states: active and hibernate.

Active:

- Whenever PEN-DOWN is detected, the device remains in active mode
- Whenever PWM is active, the device remains in active mode
- Whenever ADC is active, the device remains in ACTIVE MODE

Hibernate:

-PWM/ADC must be “off” (clock disable bit SET)

-Any GPIO input, with interrupt enabled, causes a transition to “active” state, if an input change is detected.

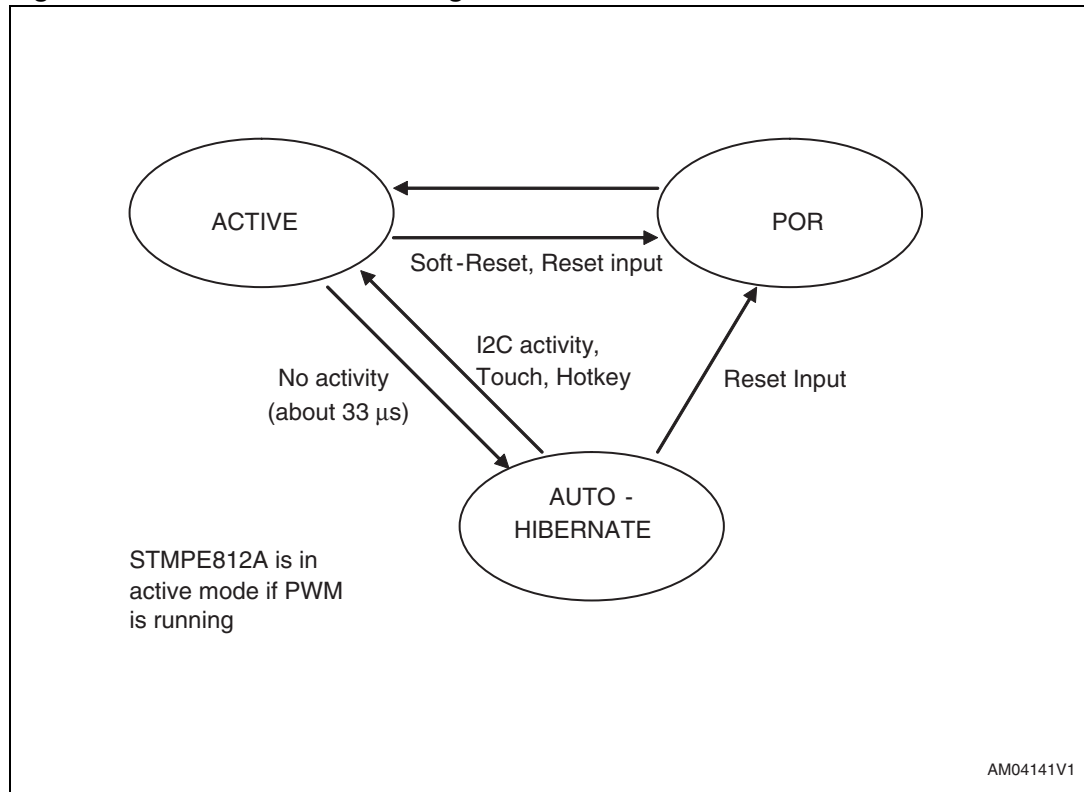
-Pen down even causes transition to “active” state if the touchscreen controller is enabled.

**Table 6. Power mode**

Power mode	Active	Hibernate
Current consumption	280 $\mu$ A (max) <sup>(1)</sup>	1.0 $\mu$ A (max.)
GPIO hotkey	Yes	Yes
Touchscreen	Yes	Yes
Interface (I <sup>2</sup> C)	Yes	Yes

1. At Vcc=1.8V, TCS running at 100sets of X/Y per second, MAV disabled.

Figure 6. Power modes state diagram



On power up reset, device goes to active state. However, as all the functional blocks are clocked off by default, no touch/hotkey activity is possible. If there are no I<sup>2</sup>C activities, device goes into auto-hibernate mode automatically.

The auto-hibernate feature of STMPE812A is always enabled. Whenever there is a period of inactivity, the device enters this mode to reduce power consumption. On detection a touch, correctly addressed I<sup>2</sup>C data, GPIO activity, the device wakes up immediately.

As the device is able to wake up very quickly, there is no loss of touch data.



## 6 STMPE812A registers

This section lists and describes the registers of the STMPE812A device, starting with a register map and then provides detailed descriptions of register types.

**Table 7. Register summary map table**

Address	Register name	Bit	Type	Reset value	Function
Registers from 0x00 - 0x0F are always accessible.					
0x00 - 01	CHIP_ID	16	R	0xA812	Device identification
0x02	ID_VER	8	R	0x10	Revision number 0x10 for engineering sample
0x03	SYS_CTRL	8	R/W	0x0F	System control register
0x04	PORT_FUNCTION	8	R/W	0xF8	Port function control register
0x06 - 07	SCRATCH_PAD	16	R/W	0x00	General purpose storage register
0x08	INT_CTRL	8	R/W	0x00	Interrupt control register
0x09	INT_EN	8	R/W	0x00	interrupt enable register
0x0A	INT_STA	8	R	0x00	Interrupt status register
Registers from 0x10 - 0x1F are accessible only if "GPIO_OFF" bit in SYS_CTRL is set to "0".					
0x10	GPIO_SET_PIN	8	R/W	0x00	GPIO set pin register
0x11	GPIO_CLR_PIN	8	R/W	0x00	GPIO clear pin register
0x12	GPIO_MP_STA	8	R/W	0x00	GPIO monitor pin state register
0x13	GPIO_DIR	8	R/W	0x00	GPIO falling edge register
0x14	GPIO_ED	8	R/W	0x00	GPIO rising edge register
Registers from 0x20 - 0x2F are accessible only if "ADC_OFF" bit in SYS_CTRL is set to "0".					
0x20	ADC_CTRL	8	R/W	0x33	ADC control
0x21 - 22	ADC_DATA	16	R	0x0000	ADC data
Registers from 0x40 - 0x4F are accessible only if "TSC_OFF" bit in SYS_CTRL is set to "0".					
0x40	TSC_CTRL	8	R/W	0x00	4-wire touchscreen controller setup
0x41	TSC_DET_CFG 1	8	R/W	0xA4	Touchscreen controller configuration 1
0x42	TSC_DET_CFG 2	8	R/W	0xB0	Touchscreen controller configuration 2
0x43	TSC_SAMPLING_RATE	8	R/W	0x0A	Touchscreen controller sampling rate register

**Table 7. Register summary map table (continued)**

Address	Register name	Bit	Type	Reset value	Function
0x44	TSC_DATA	8	R	-	Non auto-increment address
Registers from 0x50 - 0x5F are accessible only if "PWM_OFF" bit in SYS_CTRL is set to "0".					
0x50	PWM_CLOCK_DIV	8	R/W	0x00	PWM clock divider
0x51	PWM_CTRL1	8	R/W	0x00	Master control of PWM channel 1

## 6.1 Auto-increment/non auto-increment address

The STMPE812A supports auto-increment accesses on all, except for TSC data register (0x44). While accessing auto-increment register location, consecutive read/write access data from the consecutive registers. Note that for register accesses started on auto-incremental addresses, the address 0x44 is skipped.

For example:

Write register address (0x40)

Read data (data of 0x40)

Read data (data of 0x41)

Read data (data of 0x42)

Read data (data of 0x43)

Read data (data of 0x45) <= 0x44 is skipped.

## 7 System and identification registers

**Table 8. System and identification registers map**

Address	Register name	Bit	Type	Reset	Function
0x00 - 01	CHIP_ID	16	R	0x0A812	Device identification
0x02	ID_VER	8	R	0x10	Revision number 0x10 for engineering sample
0x03	SYS_CTRL	8	R/W	0xF8	System control register
0x04	PORT_FUNCTION	8	R/W	0x00	Port function control register
0x06 - 07	SCRATCH_PAD	16	R/W	0x00	General purpose storage register

### SYS\_CTRL

### System control register

7	6	5	4	3	2	1	0
RESERVED	SOFT_RESET	TSC_EN	RESERVED	PWM_OFF	GPIO_OFF	TSC_OFF	ADC_OFF
0	0	0	0	1	1	1	1

**Address:** 0x03

**Type:** R/W

**Reset:** 0x0F

**Description:** System control register.

[7] RESERVED

[6] SOFT\_RESET

Reset the 812 using serial communication

ALL REGISTER VALUES ARE RESET. State machines all back to POR states.

[5] TSC\_EN

Write '1' to enable operation of TSC. Write '0' to disable it.

[4] RESERVED

[3] PWM\_OFF

Writing '1' switches OFF the clock supply to PWM

[2] GPIO\_OFF

Writing '1' switches OFF the clock supply to GPIO

[1] TSC\_OFF

Writing '1' switches OFF the clock supply to touchscreen controller

[0] ADC\_OFF

Writing '1' switches OFF the clock supply to ADC

If the clock supply to a particular functional block is turned off, the registers of these modules are not accessible.

**PORT\_FUNCTION**

**Port function control register**

7	6	5	4	3	2	1	0
PORT 2 FUNCTION		RESERVED		PORT 1 FUNCTION		PORT 0 FUNCTION	
1	1	1	1	1	0	0	0

**Address:** 0x04

**Type:** R/W

**Reset:** 0xF8

**Description:** Port function control register.

[7:6] PORT 2 FUNCTION

[5:4] RESERVED

[3:2] PORT 1 FUNCTION

[1:0] PORT 0 FUNCTION

Port function:

'00' - GPIO input

'01' - GPIO output

'10' - ADC input (P1 only)

'11' - Special function

Special function for:

P0 - NONE

P1 - PWM

P2 - INT output

**SCRATCH\_PAD**

**Scratch pad register**

7	6	5	4	3	2	1	0
SCRATCHPAD							
0	0	0	0	0	0	0	0

**Address:** 0x06 - 07

**Type:** R/W

**Reset:** 0x00

**Description:** General purpose scratch pad register. Could be used for testing of serial interface reliability.

[15:0] SCRATCHPAD

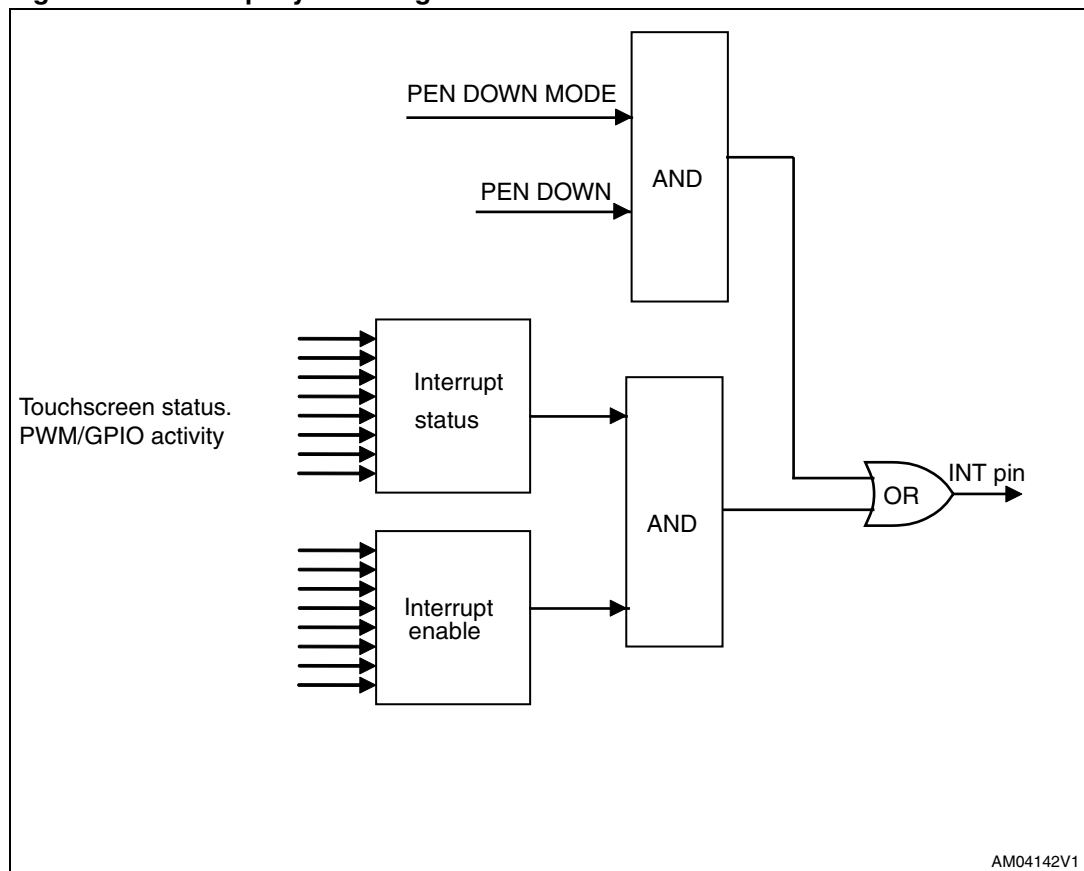
## 8 Interrupt system

The STMPE812A uses a 2-tier interrupt structure. In normal mode, interrupts from the GPIO and touchscreen controller assert the INT pin and are available in the Interrupt Status register (ISR).

In pen down mode, the INT pin is asserted as long as pen down is detected.

Since the INT pin is a OR function of the pen down and all other enabled interrupts, in order for INT pin to provide the exclusive indication of pen down (INT = Low) and pen up (INT = High), as such benefit from minimal I<sup>2</sup>C transactions, it is recommended to use pen down mode when the GPIO/PWM/ADC functions are not required or the GPIO/PWM/ADC interrupts are disabled.

**Figure 7. Interrupt system diagram**



**INT\_CTRL**

**Interrupt control register**

7	6	5	4	3	2	1	0
INT_MODE	RESERVED			INT_POLARITY	INT_TYPE	GLOBAL_INT	
0	0			0	0	0	

**Address:** 0x08

**Type:** R/W

**Reset:** 0x00

**Description:** This register is used to enable the interruption from a system related interrupt source to the host.

[7] INT\_MODE:

'0' for Pen-Down INT mode (INT pin asserted as long as pen down detected). Nothing can de-assert the INT pin as long as PEN is down. TSC\_TOUCH in INT\_EN register must be enabled for PEN\_DOWN interrupt to operate.

If any other interrupt sources are enabled, the INT output is:  
PEN\_STATUS OR OTHER\_INT

INT\_E setting is not required for PEN-DOWN mode. It is recommended Pen-Down INT mode enabled in applications where GPIO/ADC/PWM functions or interrupts are not in used, such that the INT pin signal provides the exclusive indication for pen down and pen up.

'1' for normal INT mode (INT pin asserted if any bit in INT STATUS REGISTER is set)

When INT\_MODE is changed, all interrupt status are cleared. Pending INT output (if any) is cleared too.

[6:3] RESERVED

[2] INT\_POLARITY:

'1' for active high/rising edge

'0' for active low/falling edge

Interrupt pin should be pulled to V<sub>CC</sub> if "active low" polarity is used, and pulled to GND if "active high" polarity is used.

[1] INT\_TYPE:

'1' for edge interrupt (pulse width = 50-150 μs)

'0' for level interrupt

Edge interrupt does not work in PEN\_DOWN INT mode

This bit is ignored in PEN\_DOWN INT mode.

[0] GLOBAL\_INT:

'1' allows global interrupt

'0' stops all interrupt

This bit overwrites INT\_MODE: If global\_int is stop (in pen down INT\_MODE), even pen down does not generate an interrupt.

**INT\_EN**

**Interrupt enable register**

7	6	5	4	3	2	1	0
TSC_ERR	TSC_RELEASE	P2	RESERVED	P1	P0	TSC_DATA	TSC_TOUCH
0	0	0	0	0	0	0	0

**Address:** 0x09

**Type:** R/W

**Reset:** 0x00

**Description:** This register is used to enable the interruption from a system related interrupt source to the host.

- [7] TSC\_ERR  
Error encountered in coordinate calculation in touchscreen controller
- [6] TSC\_RELEASE:  
Release of TSC is detected
- [5] P2:  
Port 2 activity (GPIO)
- [4] RESERVED
- [3] P1  
Port 1 activity (GPIO/ADC/PWM)
- [2] P0  
Port 0 activity (GPIO)
- [1] TSC\_DATA  
Touch data available
- [0] TSC\_TOUCH  
Touch is detected

*Note:* \* Hotkey interrupt should have respond time of <5 μs in active mode and less than 1 ms in hibernate mode.

**ISR**

**Interrupt status register**

7	6	5	4	3	2	1	0
TSC_ERR	TSC_RELEASE	P2	RESERVED	P1	P0	TSC_DATA	TSC_TOUCH
0	0	0	0	0	0	0	0

**Address:** 0x0A

**Type:** R

**Reset:** 0x00

**Description:** ISR register monitors the status of the interruption from a particular interrupt source to the host. Regardless whether the INT\_EN bits are enabled, the ISR bits are still updated.  
 Writing to this register has no effect. Reading the register clears any asserted bit  
 Implementation: A shadow register MUST be used to ensure that Read+Clear action DOES NOT clear up any bit that is not READ.

*Note: Reading the Interrupt Enable Register also clears the ISR. It is recommended that no read operation on IER to be executed during normal operation. IER should only be accessed during initialization.*

- [7] TSC\_ERR  
Error encountered in coordinate calculation in TSC, or touch detect not valid after sampling
- [6] TSC\_RELEASE:  
Release of touch is detected
- [5] P2  
Port 2 activity (GPIO)
- [4] RESERVED
- [3] P1  
Port 1 activity (GPIO/ADC/PWM)
- [2] P0  
Port 0 activity (GPIO)
- [1] TSC\_DATA  
Touch data available. In internal timer and host-read controlled mode, this bit can only be cleared after the data has been read by the host. In ACQ mode, this bit is cleared after the data or the ISR is read by the host.
- [0] TSC\_TOUCH  
Touch is detected.  
(In PEN-DOWN interrupt mode, this bit is never cleared until pen is removed)

In PEN\_DOWN interrupt mode, this status register will still be updated with event interrupt status data, and cleared on read. However no interrupt will be issued based on this status register.



## 9 ADC controller

A 12-bit ADC is integrated in the STMPE812A. The ADC could be used as generic analog-digital converter, or a touchscreen controller capable of controlling a 4-wire resistive touchscreen.

The ADC works ONLY with internal reference (equal to  $V_{CC}$ ), always 12 bit.

**Table 9. ADC controller registers**

Address	Register name	Bit	Type	Reset	Description
0x20	ADC control	8	R/W	0x33	ADC control
0x21-0x22	ADC data	16	R	0x0000	ADC data access (P1)

ADC control register

ADC control

7	6	5	4	3	2	1	0
ADC_MODE	ADC_CAP	ADC_FREQ		CP_ARM	CP_Lock[1:0]		RESERVED
0	0	1	1	0	0	1	1

**Address:** 0x20

**Type:** R/W

**Reset:** 0x33

**Description:** This register is used to configure the ADC operations.

- [7] **ADC\_MODE:** ADC capture mode  
 '0' – Continuous capture according to sampling rate specified by ADC\_FREQ register. New data over-writes old data in ADC\_DATA register.  
 '1' – One-shot capture. One sample is taken every time system writes '1' to ADC\_CAP bit
- [6] **ADC\_CAP:** ADC channel data capture  
 In one-shot mode:  
 Write '1' to initiate data acquisition for the corresponding channel. Writing '0' has no effect.  
 Reads '1' if conversion is in progress. Reads '0' if conversion is completed.  
 One-shot mode ADC generates interrupt in corresponding interrupt status bit on completion of conversion  
 In continuous capture mode:  
 Write '1' to initiate data acquisition for the corresponding channel. Writing '0' to stop capturing.
- [5:4] **ADC\_FREQ:** ADC sampling frequency based on 1MHz RC (minimum 880 KHz)  
 00 – 10 K samples/sec  
 01 – 12.5 K samples/sec  
 10 – 15 K samples/sec  
 11 – 20 K samples/sec  
 NOTE: As the ADC is also used for TSC operation. This setting affects the maximum sampling rate possible with TSC.
- [3] **CP\_Arm:** Writing '1' arms the charge-pump for unlocking  
 Writing '0' un-arms it  
 Charge-pump is required for ADC/TSC operation when V<sub>CC</sub> is less than 2.5 V. **Activating the charge pump when V<sub>CC</sub> is more than 2.5 V may result in permanent damage of the device.**  
 Charge-pump can be activated by unlocking CP\_Lock after it is armed.
- [2:1] **CP\_Lock[1:0]:** Only effective if CP\_Arm is set to '1'.  
 Always reads '00'.  
 Writing '01' when CP\_Arm is '1' activates the charge pump.  
 Writing '00', '10' and '11' does NOT activate the charge-pump, and clears the CP\_Arm bit.  
 CP\_Arm MUST BE set before writing to CP\_Lock. Accesses to CP\_Lock will be ignored, if CP\_Arm is '0'.  
 Note: CP\_Arm and CP\_Lock CANNOT be accessed in a single I<sup>2</sup>C transaction. System must first ARM the CP with 1 I<sup>2</sup>C transaction, and unlocks it in the next. CP\_LOCK reads "00" if charge pump is activated  
 CP\_LOCK reads "01" if charge pump is not activated
- [0] **RESERVED**

**ADC data****ADC data register**

7	6	5	4	3	2	1	0
ADC_DATA_7	ADC_DATA_6	ADC_DATA_5	ADC_DATA_4	ADC_DATA_3	ADC_DATA_2	ADC_DATA_1	ADC_DATA_0
0	0	0	0	0	0	0	0

**Address:** 0x21-0x22

**Type:** R

**Reset:** 0x0000

**Address:** ADC data register.

[7:0] ADC\_DATAx

**Note:** When the I<sup>2</sup>C master accesses the data register, upper/lower byte consistency must be guaranteed (once access starts, content will only be updated after BOTH bytes has been read, OR I<sup>2</sup>C master accesses other register address):

- 0x21 is LSB

- 0x22 is MSB

# 10 PWM controller

The PWM allows the brightness control of a LED/motor driver.

The PWM uses base clock that is 1/2 of the OSC frequency (typically 600 kHz). The base clock is divided by a programmable DIV[4:0], which scales it to 18.75-600 kHz. This clock goes into PWM controller and outputs a signal that is pulse-width modulated (16 steps), with a frequency 16 times smaller.

## 10.1 Register map for PWM function

**Table 10. PWM function registers**

Address	Register name	Bit	Type	Reset	Description
0x50	PWM_ClockDiv	8	R/W	0x00	PWM clock divider
0x51	PWM_Control_1	8	R/W	0x00	Master control of PWM channel 1 Output at port 0

### PWM clock div register

### PWM clock divider register

7	6	5	4	3	2	1	0
BurstLength [1:0]			DIV[4:0]				
0	0	0	0	0	0	0	0

**Address:** 0x50  
**Type:** R/W  
**Reset:** 0x00  
**Description:** PWM clock divider register.

[7:5] BurstLength[2:0]  
 Burst length of PWM output  
 '000' – 8 ms  
 '001' – 16 ms  
 '010' – 32 ms  
 '011' – 64 ms  
 '100' – 128 ms  
 '101' – 256 ms  
 '110' – 512 ms  
 '111' – 1024 ms

[4:0] Div[4:0]  
 PWM controller is based on 600KHz clock divided by (Div[4:0] + 1).  
 Effectively, PWM clock is:  
 600 KHz (MAX)  
 600 KHz/32 = 18.75 KHz (MIN)



**PWM control1 register**

**PWM control1 register**

7	6	5	4	3	2	1	0
Brightness				BurstMultiplier		Off_State	Enable
0				0		0	0

**Address:** 0x51

**Type:** R/W

**Reset:** 0x00

**Description:** PWM control1 register.

[7:4] This defines the of the PWM channel output which in turn determines the brightness level of the LED that the PWM output drives. Note that this is assuming LED is connected in SINKING MODE. System host should program the brightness in a reverse way if sourcing configuration were to be used.

0000: duty cycle ratio 1:15 (6.25%, minimum brightness)

0001: duty cycle ratio 2:14 (12.50%)

0010: duty cycle ratio 3:13 (18.75%)

0011: duty cycle ratio 4:12 (25.00%)

0100: duty cycle ratio 5:11 (31.25%)

0101: duty cycle ratio 6:10 (37.50%)

0110: duty cycle ratio 7: 9 (43.75%)

0111: duty cycle ratio 8: 8 (50.00%)

1000: duty cycle ratio 9: 7 (56.25%)

1001: duty cycle ratio 10: 6 (62.50%)

1010: duty cycle ratio 11: 5 (68.75%)

1011: duty cycle ratio 12: 4 (75.00%)

1100: duty cycle ratio 13: 3 (81.25%)

1101: duty cycle ratio 14: 2 (87.50%)

1110: duty cycle ratio 15: 1 (93.75%)

1111: duty cycle ratio 16: 0 (100.00%, maximum brightness)

[3:2] BurstMultiplier

PWM output continues for time = BurstLength \* BurstMultiplier

\*If BurstMultiplier = 0, PWM output indefinitely (until PWM is turned OFF)

1 Off\_State

'0' : PWM Output "HI" when PWM not running

'1' : PWM Output "LOW" when PWM not running

0 Enable

Writing '1' to this bit starts the PWM controller sequence

Writing '0' has stops it

Reads '1' when PWM is running.

## 10.2 Interrupt of PWM controller

When non-infinite sequence is used, the completion of the PWM sequence causes the P0 bit in interrupt status register to be asserted.

# 11 Touchscreen controller

The STMPE812A is integrated with a hard-wired touchscreen controller for 4-wire resistive type touchscreen. The touchscreen controller is able to operate completely autonomously, and would interrupt the connected CPU only when pre-defined event occurs.

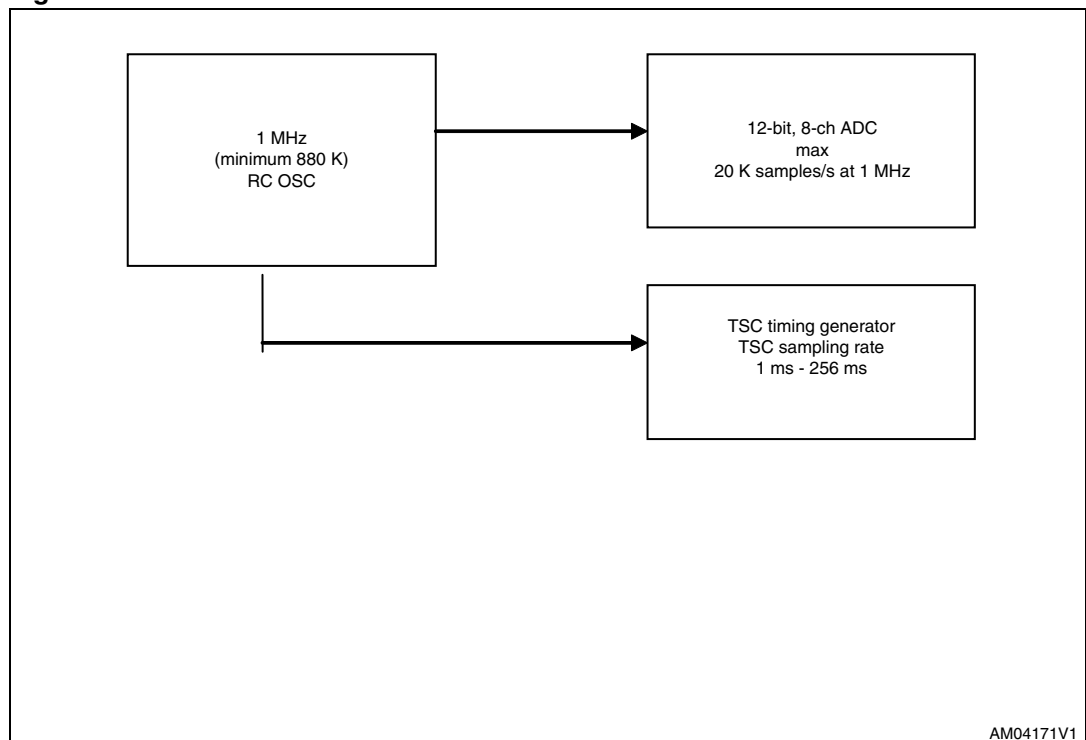
The TSC is based on an internal 20Ksamples/sec ADC, running off a 1 MHz (minimum 880 kHz) RC OSC.

$$\text{Sampling time} = \text{touch detect delay} * 2 + (\text{settling time} + (\text{ADC conversion time} * \text{MAV}) ) * 3$$

**Table 11. Sampling time/frequency calculation**

Oscillator speed	ADC conversion time	Touch detect delay	Settling time	Median average	Sampling time/freq (complete X/Y/Z sample sets)
880 kHz	50 μs	40 μs	40 μs	None	$40 * 2 + 3 * (40 + (50 * 1)) = 350 \mu s$ (2.8K sample sets/sec)
880 kHz	50 μs	40 μs	40 μs	10-2	$40 * 2 + 3 * (40 + (50 * 10)) = 1700 \mu s$ (588 sample sets/sec)
880 kHz	50 μs	640 μs	640 μs	20-4	$640 * 2 + 3 * (640 + (50 * 20)) = 6200 \mu s$ (161 sample sets/sec)

**Figure 8. Touchscreen controller internal RC OSC connection**



AM04171V1

## 11.1 Touchscreen controller detection sequence

Following is the sequence of detection in the STMPE812A touchscreen controller for X, Y and Z:

1. Touch detect
2. Drive Y
3. Wait for settling time
4. Measure Y
5. Stop drive
6. Drive Z
7. Wait for settling time
8. Measure Z
9. Stop drive
10. Drive X
11. Wait for settling time
12. Measure X
13. Stop drive
14. Touch detect

## 11.2 3 modes of acquisition

1. Data acquisition timed by internal timer:

The host system selects a “sampling period” with, based on internal timer, the touchscreen controller takes a complete set of samples on every period. The host system may choose to read the data by:

- Waiting for the INT
- Polling for INT\_STATUS register for TOUCH DATA
- Reading the TSC\_DATA at approximately the same timing. (Use “Data Valid Status Read” option in this mode)

2. Data acquisition triggered by a write to “ACQ” bit:

As and when sampling is desired, host writes to the ACQ bit and:

- Poll the ACQ to wait for completion
- Wait for INT for Touch Data access
- Poll the FIFO after approximate time required for sampling. (Use “Data Valid Status Read” option in this mode)

3. Data acquisition using host-controlled sampling rate control

The host sets the internal timer for the desired data-rate. On starting the touchscreen controller in this mode, a complete set of sample is taken immediately. The touchscreen controller enters in hibernate mode (clock is turned OFF, only monitors the PEN-DOWN status). When system host reads the Touch Data available in FIFO, another set of data is taken immediately.



## 11.3 Touchscreen controller registers

Table 12. Touchscreen controller registers

Address	Register name	Bit	Type	Reset	Function
0x40	TSC_CTRL	8	R/W	0x00	Touchscreen control
0x41	TSC_DET_CFG1	8	R/W	0xA4	Touchscreen detection config 1
0x42	TSC_DET_CFG2	8	R/W	0xB0	Touchscreen detection config 2
0x43	TSC_SAMPLING_RATE	8	R/W	0x0A	Touchscreen sampling rate
0x44	TSC_DATA	8	R	-	Touchscreen data

**TSC CTRL**

**TSC control register**

7	6	5	4	3	2	1	0
MAV_MODE[2:0]			ACQ	Precharge[1:0]		Current Limit [1:0]	
0			0	0		0	

**Address:** 0x40

**Type:** R/W

**Reset:** 0x00

**Description:** Touchscreen control register.

[7:5] MAV\_MODE[2:0]

- '000' – MAV filter disabled
- '001' – 6 remove 2
- '010' – 8 remove 4
- '011' – 10 remove 2
- '100' – 12 remove 4
- '101' – 20 remove 4
- '110' – 4 remove none (equal to 4 x oversampling)
- '111' – 8 remove none (equal to 8 x oversampling)

[4] ACQ

Only valid in acquisition mode '01' (acquisition initiated by system host writing to ACQ bit)  
 Writing '1' to this bit initiates a TSC data acquisition  
 Writing '0' has no effect  
 Reads '1' if data acquisition is in progress  
 Reads '0' if data is ready  
 If Data is already available in buffer and not read by system host, setting this bit to '1' renders the data in buffer "invalid". DATA available bit in Interrupt Status register is reset by hardware automatically. Pending interrupt due to DATA available (if any) is cleared.  
 Data pointer in multi-byte read operation is reset when this bit is written to.

[3:2] Precharge[1:0]

Pre-charge driver for touch detection  
 '00' – no pre-charge  
 '01' – 2 µs pre-charge  
 '10' – 4 µs pre-charge  
 '11' – 8 µs pre-charge

[1:0] Current Limit [1:0]

Current limit of touchscreen driver  
 '00' – 5 mA  
 '01' – 10 mA  
 '10' – 20 mA  
 '11' – 30 mA

**TSC detect config**

**TSC detection configuration 1 register**

7	6	5	4	3	2	1	0
PenStrength[1:0]		TDetDly[2:0]			Settling[2:0]		
1	0	1	0	0	1	0	0

**Address:** 0x41

**Type:** R/W

**Reset:** 0xA4

**Description:** Touchscreen controller detection configuration 1 register.

[7:6] PenStrength[1:0]  
 Pen detect strength threshold  
 '00' – least sensitive (50 K pull-up)  
 '01' – sensitive (40 K pull-up)  
 '10' – more sensitive (30 K pull-up) - Default  
 '11' – most sensitive (20 K pull-up)

[5:3] TDetDly[2:0]  
 Touch detect delay  
 '000' = 40 μs  
 '001' = 80 μs  
 '010' = 160 μs  
 '011' = 320 μs  
 '100' = 640 μs - Default  
 '101' = 1.28 ms  
 '110' = 2.56 ms  
 '111' = 5.12 ms

[2:0] Settling[2:0]  
 Panel driver settling time  
 '000' = 40 μs  
 '001' = 80 μs  
 '010' = 160 μs  
 '011' = 320 μs/ns  
 '100' = 640 μs - Default  
 '101' = 1.28 ms  
 '110' = 2.56 ms  
 '111' = 5.12 ms

For large panels (> 6 inches), a capacitor of 10 nF is recommended at the touchscreen terminals for noise filtering. In this case, settling time of 1 ms or more is recommended.

**TSC\_DET\_CFG2**

**TSC detection configuration 2 register**

7	6	5	4	3	2	1	0
Acq_Mode		StatusRead	OpMode	Z-Divider[3:0]			
1	0	1	1	0	0	0	0

**Address:** 0x42

**Type:** R/W

**Reset:** 0xB0

**Description:** Touchscreen controller detection configuration 2 register.

[7:6] Acq\_Mode

- '00' – Data acquisition timed by internal timer
- '01' – Data acquisition triggered by a write to “ACQ” bit
- '10' – Data acquisition using Host-Controlled Sampling Rate Control. (Default)
- '11' – Reserved

In mode '10', device sample a complete data set every time host accesses the buffer. After completion of sampling, device enters hibernate mode, until data is accessed again. (Or PEN-UP causing interrupt to de-assert)

[5] StatusRead

- '1' inserts data valid (data available) status read in data port. (Default)  
Reading data port in this mode clears the ISR register (equivalent to accessing interrupt status register)
- '0' – no data valid (data available) status access by data port

[4] OpMode

- TSC operating mode
- '0' for 12-bit X, 12-bit Y, 8-bit Z acquisition
- '1' for 12-bit X, 12-bit Y only (Default)

This field cannot be written on, when EN=1

[3:0] Z-Divider[3:0]

- Pen-Pressure is internally calculated as a 16-bit integer. As 16-bit resolution is typically not required for touchscreen operation, STMPE812A right-shifts the value internally by Z-Divider[3:0].
- Z-value read through the TSC Data register is the lowest 8-bit of the shifted value.

**TSC sampling rate**

**TSC sampling rate register**

7	6	5	4	3	2	1	0
SAMPLING							
0	0	0	0	1	0	1	0

**Address:** 0x43

**Type:** R/W

**Reset:** 0x0A

**Description:** Touchscreen controller sampling rate control register.

[7:0] Sampling[7:0]

Sets the sampling rate of touchscreen controller.

Sampling Time = (sampling[7:0]+1) in ms

Clock cycle = 1 μs (1 MHz RC OSC)

Sampling time = 1 ms – 256 ms

NOTE:

This is used as “TSC regular initiator signal”. As long as there remains a valid touch, every interval of this timing, the touchscreen controller executes a complete drive/settling/multi-sample/MAV/data calculation. It is the user’s responsibility to choose a sampling time that is enough, based on ADC\_FREQ, settling time and filter.

**TSC\_data**

**Touchscreen data register**

7	6	5	4	3	2	1	0
TSC_DATA_7	TSC_DATA_6	TSC_DATA_5	TSC_DATA_4	TSC_DATA_3	TSC_DATA_2	TSC_DATA_1	TSC_DATA_0
0	0	0	0	0	0	0	0

**Address:** 0x42

**Type:** R/W

**Reset:** 0xB0

**Description:** The data format of the touchscreen controller data register depends on the setting of “OpMode” field in the touchscreen detection configuration 2 register. The samples acquired are accessed in “packed samples”. The size of each “packed sample” depends on which mode the touchscreen controller is operating in.

[7:0] TSC\_DATA\_x: Data byte from touchscreen controller.

*Note:*

- In order to preserve the integrity of the data, it is mandatory to ensure the following:*
- System host to read exactly the number of bytes according to the programmed operating mode*
- I2C host to insert a STOP condition after each data read command*
- Data pointer in this 1-level buffer could be reset by:*
- User issued ACQ in user initiated acquisition mode. In mode ‘10’, every time sampling is completed, it overwrites the buffer, and reset the data pointer*

**Table 13. Touchscreen controller data register**

TSCDetectConfig2		Number of bytes to read from TSCData	Byte0	Byte1	Byte2	Byte3	Byte4
OpMode	StatusRead						
0	0	4	[11:4] of X	[3:0] of X [11:8] of Y	[7:0] of Y	[7:0] of Z	
1	0	3	[11:4] of X	[3:0] of X [11:8] of Y	[7:0] of Y	-	
0	1	5	Data Valid Status	[11:4] of X	[3:0] of X [11:8] of Y	[7:0] of Y	[7:0] of Z
1	1	4	Data Valid Status	[11:4] of X	[3:0] of X [11:8] of Y	[7:0] of Y	-

**Data Valid Status Byte Structure**

7	6	5	4	3	2	1	0
RESERVED						DATA VALID	RESERVED

[7:2] RESERVED

[1] DATA VALID

1: Touch data available/valid

0: Touch data not available/not valid

Bit reset upon read

[0] RESERVED

Data Valid Status Read in data port is useful together with Pen Down mode whereby accessing the ISR is not needed so as to achieve the best I<sup>2</sup>C bandwidth efficiency (i.e. minimal I<sup>2</sup>C transactions).

*Note: Reading the Data valid Status byte also clears the ISR.*

## 11.4 Programming model

Below are steps to configure the Touchscreen controller in 3 different acquisition modes.

### A. Autonomous touchscreen controller, 100 Hz, lowest power possible

1. Initialize the touchscreen controller (choose ACQ\_Mode '00' - data acquisition timed by internal timer)
2. Initialize interrupt (with TSC\_Data enabled, normal interrupt mode)
3. Wait for interrupt
4. On interrupt: Read interrupt status (this clears the set bits too)
5. If data is available, read data.

*Note:* If one set of data is available in buffer, and not accessed by the  $\mu$ C host, yet the sampling timer is up for the next data, the STMPE812A samples the next data as scheduled.  
 If old data is still NOT accessed when new data is ready to be written to the buffer, it is overwritten.  
 If old data is IN PROGRESS of being accessed, new data is DISCARDED.  
 If  $\mu$ C host accessed PART OF the data, and moved on to read ANY OTHER REGISTER LOCATION, the existing data is CONSIDERED READ, and new data ready to be written into buffer

### B. Non-autonomous touchscreen controller style-interrupt, 100Hz, lowest power possible:

1. Initialize TSC (Choose ACQ\_Mode '01' - Data acquisition triggered by a write to "ACQ" bit)
2. Initialize Interrupt (With TSC\_Data, TSC\_Touch enabled, PEN\_DOWN interrupt mode)
3. Wait for Interrupt
4. On Interrupt: Read Interrupt Status (this clears the set bits too)
5. If PEN\_DOWN, start SYSTEM\_TIMER (10 ms typically)
6. On TIMEOUT, write ACQ bit to start acquisition
7. Poll interrupt status register or ACQ bit to check for acquisition status
8. ON issuing ACQ, 812 may assume that data in buffer is already accessed by I2C host, and reset the relevant pointers.

### C. Host-controlled sampling rate (lowest bus utilization)

1. Initialize TSC (choose ACQ\_Mode '10' - Data acquisition using host-controlled sampling rate control)
2. Initialize interrupt (with TSC\_Data, TSC\_Touch enabled, PEN\_DOWN interrupt mode)
3. Wait for Interrupt
4. On interrupt: Read Interrupt Status (this clears the set bits too)
5. If PEN\_DOWN, start SYSTEM\_TIMER (10 ms typically)
6. On TIMEOUT, read data

The STMPE812A samples a new data set immediately after every complete read.  
If the host does not complete a data-set read, no further samples are taken.

**For each data point (4 bytes), number of I2C transaction required is:**

A: read Data Valid Status (1 byte), read data (4 bytes)

B: write ACQ (1 byte), read ACQ (1 byte), read data (4 bytes)

C: read (4 bytes)



## 12 GPIO port controller

A total of 3 configurable ports are available in the STMPE812A port expander device. If configured as GPIO input/output, they are controlled by the GPIO registers.

**Table 14. GPIO registers**

Address	Register	Bit	Type	Reset	Function
0x10	GPIO_SET_PIN	8	R/W	0x00	Set pin state
0x11	GPIO_CLR_PIN	8	R/W	0x00	Clear pin state
0x12	GPIO_MP_STA	8	R/W	0x00	Monitor pin state
0x13	GPIO_DIR	8	R/W	0x00	Falling edge detection enable
0x14	GPIO_ED	8	R/W	0x00	Rising edge detection enable

All GPIO registers are named as GPxx, where: Xxx represents the functional group

Bit	7	6	5	4	3	2	1	0
GPxx					IO-2	RESERVED	IO-1	IO-0

The function of each bit is shown in [Table 15](#):

**Table 15. GPIO registers**

Register name	Function
GPIO monitor pin state	Reading this bit yields the current state of the bit. Writing has no effect.
GPIO set pin state	Writing '1' to this bit causes the corresponding GPIO to go to '1' state. Writing '0' to this bit has no effect Reading this register always yield 0x00
GPIO clear pin state	Writing '1' to this bit causes the corresponding GPIO to go to '0' state. Writing '0' to this bit has no effect Reading this register always yield 0x00
GPIO falling edge detection enable	Writing '1' to this bit allows interrupt generation when there is a falling edge at the corresponding GPIO Writing '0' disables the interrupt generation on falling edge detection
GPIO rising edge detection enable	Writing '1' to this bit allows interrupt generation when there is a rising edge at the corresponding GPIO Writing '0' disables the interrupt generation on rising edge detection

If both GPFE and GPRE are not set, state transition on a GPIO does not cause an interrupt. On power-up reset, all GPIO are set as input.

# 13 Electrical specification

**Table 16. Absolute maximum rating**

Symbol	Ratings	Maximum value	Unit
V <sub>CC</sub>	Supply voltage	4.5	V
V <sub>i-i2c</sub>	Input voltage at SDA/SCL	4.5	V
V <sub>i-io</sub>	Input voltage at P0-P5	4.5	V
ESD	On all touchscreen and GPIO pins (HBM)	±8	kV
	On all other pins (HBM)	±2	kV

**Table 17. Thermal data**

Symbol	Parameter	Value	Unit
T <sub>J</sub>	Thermal resistance junction-ambient (CSP 12)	68	°C / W
T	Operating temperature	-40°C-85°C	°C
T <sub>STG</sub>	Storage temperature	-65°C-125°C	°C

## 13.1 DC electrical characteristics

**Table 18. Power consumption (T<sub>amb</sub> = -40 °C to 85 °C)**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I <sub>CC</sub> max	Operating current	V <sub>CC</sub> = 1.8 V TSC running at 100 sets of X/Y per second MAV disabled	–	100	120	µA
		V <sub>CC</sub> =1.8V TSC Running at 100 sets of X/Y per second MAV 6 remove 2	–	230	280	
I <sub>CC</sub> max	Operating current	V <sub>CC</sub> = 3.3 V TSC running at 100 sets of X/Y/Z per second MAV 10 remove 2	–	670	810	µA
		V <sub>CC</sub> =1.8 V TSC running at 100 sets of X/Y/Z per second MAV 10 remove 2	–	470	570	

**Table 18. Power consumption (T<sub>amb</sub> = -40 °C to 85 °C) (continued)**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I <sub>CC</sub> max	Operating current	V <sub>CC</sub> = 1.8 V TSC running at 100 sets of X/Y/Z per second MAV 20 remove 4	–	870	1050	μA
I <sub>CC</sub> max	Operating current	V <sub>CC</sub> = 3.3 V TSC running at 100 sets of X/Y/Z per second MAV 20 remove 4	–	1190	1430	μA
I <sub>CC</sub> suspend	Suspend current	No I2C/ADC activity V <sub>CC</sub> = 1.8 V - 3.3 V	–	0.5	1	μA

\*operating current excludes current driving the touchscreen.

(-40 °C to 85 °C. All GPIO complies to JEDEC standard JESD-8-7)

**Table 19. DC electrical characteristics**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V <sub>CC</sub>	Core supply voltage		1.65	-	3.6	V
V <sub>IL</sub>	Input voltage low state	V <sub>CC</sub> = 1.65 - 3.6 V	-0.3	–	0.20 V <sub>C</sub> C	V
V <sub>IH</sub>	Input voltage high state	V <sub>CC</sub> = 1.65 - 3.6 V	0.80 V <sub>CC</sub>	–	V <sub>CC</sub> +0.3	V
V <sub>OL</sub>	Output voltage low state	V <sub>CC</sub> = 3.6 V, I <sub>OL</sub> = 12 mA	-0.3	–	0.45	V
V <sub>OH</sub>	Output voltage high state	V <sub>CC</sub> = 1.65 V, I <sub>OH</sub> = 8 mA	0.85 V <sub>CC</sub>	–	V <sub>CC</sub> +0.3	V
I <sub>leakage</sub>	All input pins except for touchscreen I/O and P0/P1	V <sub>CC</sub> = 1.65 V, V <sub>IN</sub> 3.6 V	–	0.1	0.5	μA

## 13.2 AC electrical characteristics

**Table 20. AC electrical characteristics (-40 °C to 85 °C)**

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
Max ClkI2C	I <sup>2</sup> C maximum SCLK	V <sub>CC</sub> = 1.65 - 3.6 V	–	–	400	KHz
T <sub>RESET</sub>	Minimum RESET pulse width		4	–	–	µS
T <sub>IN</sub>	Minimum INPUT width required for GPIO state transition		4	–	–	µS
F <sub>osc</sub>	Internal RC OSC frequency	V <sub>CC</sub> = 1.65 - 3.6 V	900	1200	1500	KHz

**Table 21. ADC specification**

Parameter	Test conditions	Min	Typ	Max	Unit
Full-scale input span		0	–	V <sub>CC</sub>	V
Absolute input range		-0.2	–	$V_{CC} + \frac{0.2}{2}$	V
Input capacitance		–	25	–	pF
Leakage current		–	0.1	–	µA
Resolution		–	12	–	Bits
No missing codes		11	–	–	Bits
Integral linearity error		–	±4	–	LSB
Offset error		–	±5	±5	LSB
Gain error		–	±14	±18	LSB
Throughput rate		–	180	–	Ksamples/s

**Table 22. Switch drivers specification**

Parameter	Test conditions	Min	Typ	Max	Unit
ON resistance X+, Y+ ON resistance X-, Y-	V <sub>DD</sub> = 1.65 V, 5 mA setting	–	34	–	Ω
ON resistance X+, Y+ ON resistance X-, Y-	V <sub>DD</sub> = 1.65 V, 10 mA setting	–	24	–	Ω
ON resistance X+, Y+ ON resistance X-, Y-	V <sub>DD</sub> = 1.65 V, 20 mA setting	–	17	–	Ω
ON resistance X+, Y+ ON resistance X-, Y-	V <sub>DD</sub> = 1.65 V, 30 mA setting	–	15	–	Ω
ON resistance X+, Y+ ON resistance X-, Y-	V <sub>DD</sub> = 3.6 V, 5 mA setting	–	31	–	Ω

**Table 22. Switch drivers specification (continued) (continued)**

Parameter	Test conditions	Min	Typ	Max	Unit
ON resistance X+, Y+ ON resistance X-, Y-	VDD = 3.6 V, 10mA setting	–	22	–	Ω
ON resistance X+, Y+ ON resistance X-, Y-	VDD = 3.6 V, 20 mA setting	–	16	–	Ω
ON resistance X+, Y+ ON resistance X-, Y-	VDD = 3.6 V, 30 mA setting	–	14	–	Ω
Drive current (at 5 mA limit)	V <sub>DD</sub> =1.65 V X+/X- or Y+/Y- shorted together externally		5		mA
Drive current (at 10 mA limit)	V <sub>DD</sub> =1.65 V X+/X- or Y+/Y- shorted together externally		10		mA
Drive current (at 20 mA limit)	V <sub>DD</sub> =1.65 V X+/X- or Y+/Y- shorted together externally		19		mA
Drive current (at 30 mA limit)	V <sub>DD</sub> = 1.65 V X+/X- or Y+/Y- shorted together externally		28		mA
Drive current (at 5 mA limit)	V <sub>DD</sub> = 3.6 V X+/X- or Y+/Y- shorted together externally		7		mA
Drive current (at 10 mA limit)	V <sub>DD</sub> = 3.6 V X+/X- or Y+/Y- shorted together externally		13		mA
Drive current (at 20 mA limit)	V <sub>DD</sub> = 3.6 V X+/X- or Y+/Y- shorted together externally		25		mA
Drive current (at 30 mA limit)	V <sub>DD</sub> = 3.6 V X+/X- or Y+/Y- shorted together externally		36		mA

# 14 Package mechanical section

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

Figure 9. Package outline for CSP 12 (2.17 x 1.67 mm)

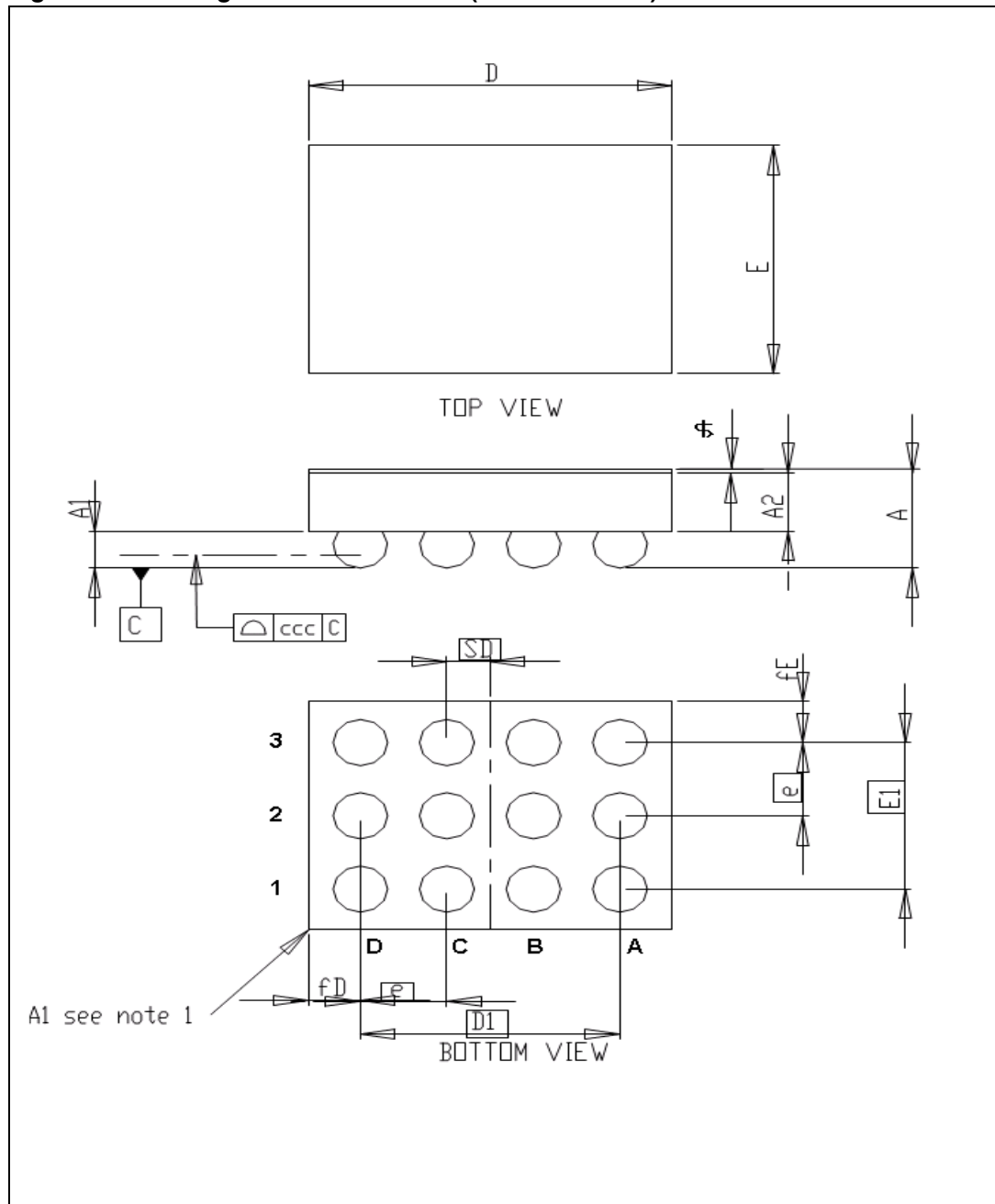


Table 23. CSP 12 (2.17 x 1.67 mm) mechanical data

Symbol	Millimeters		
	Min	Typ	Max
A	0.585	0.650	0.715
A1	0.21	0.25	0.29
A2	–	0.35	–
b	0.265	0.315	0.365
D	2.12	2.17	2.22
D1	–	1.5	–
E	1.62	1.67	1.72
E1	–	1.0	–
e	0.45	0.5	0.55
fD	–	0.335	–
fE	–	0.335	–
SD	–	0.25	–
ccc	–	0.08	–
\$	–	0.05	–

Figure 10. Footprint recommendation

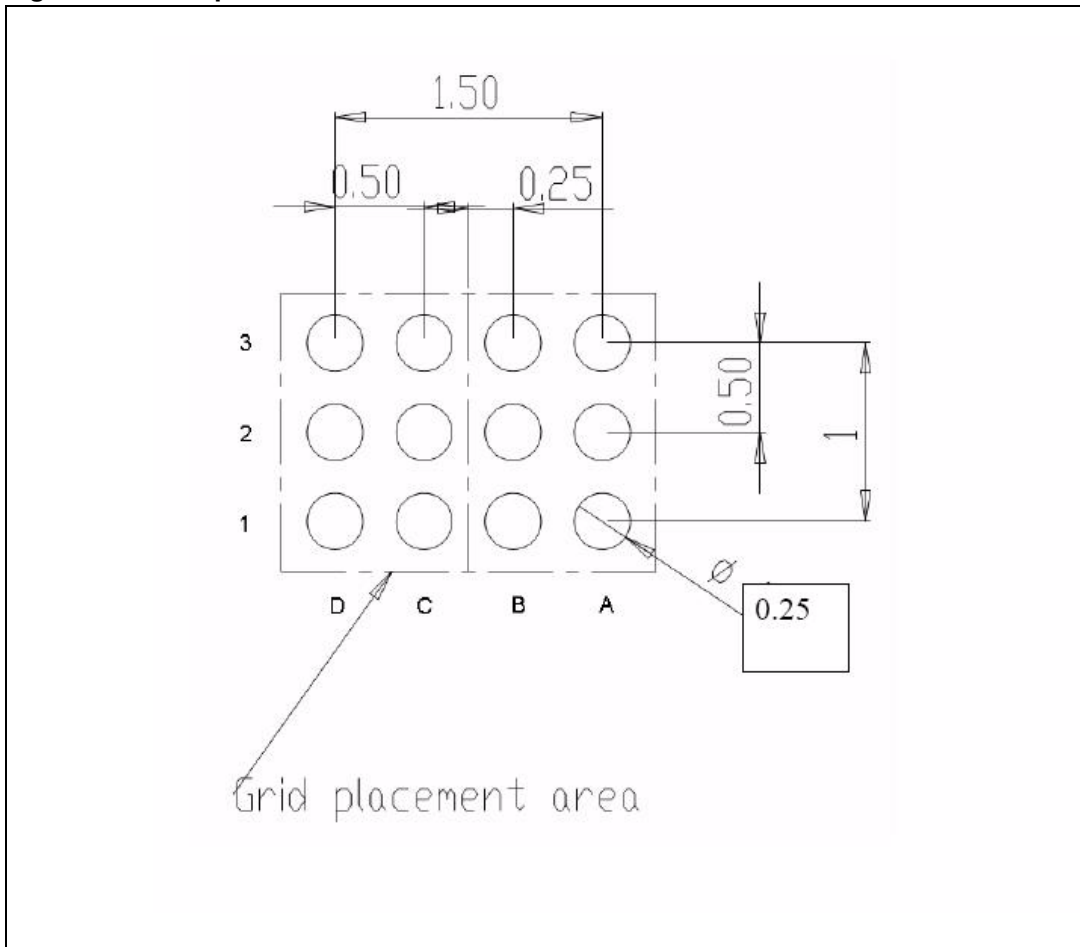
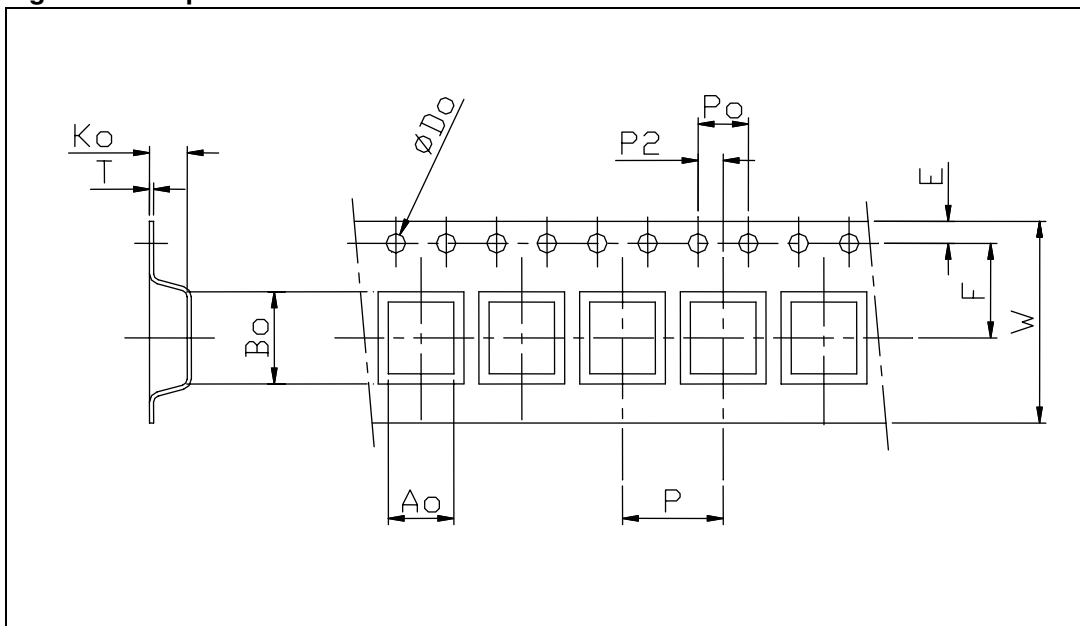


Figure 11. Tape information

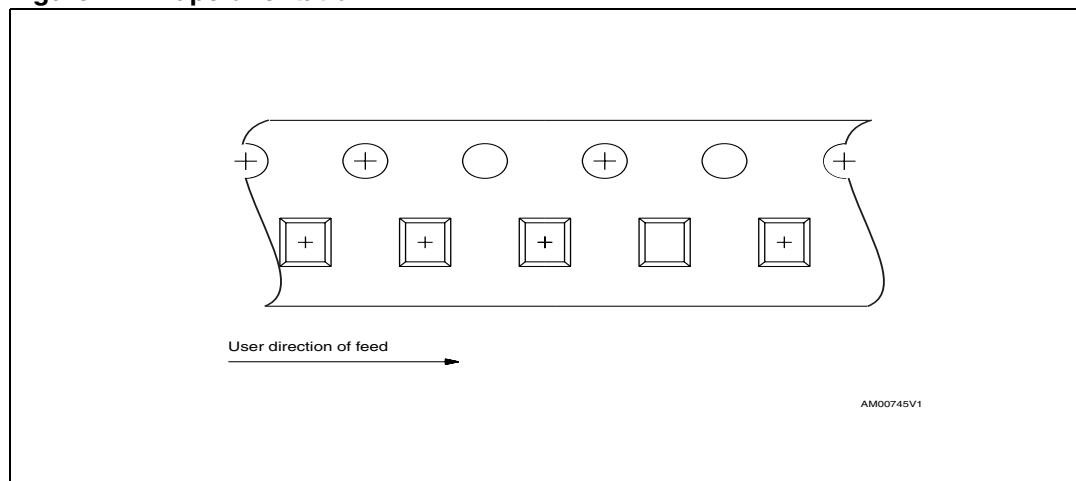




**Table 24. Tape specifications**

Symbol	Millimeters		
	Min	Typ	Max
Ao	1.78	1.83	1.88
Bo	2.34	2.29	2.34
Ko	0.68	0.73	0.78
F	3.45	3.50	3.55
E	1.65	1.75	1.85
W	7.90	8.00	8.30
P2	1.95	2.00	2.05
Po	3.90	4.00	4.10
10Po	39.80	40.00	40.20
Do	1.50	1.55	1.60
T	0.185	0.200	0.215
P	3.90	4.00	4.10

**Figure 12. Tape orientation**



1. Pin A1 is at top left corner based on above tape orientation.

Figure 13. Device marking

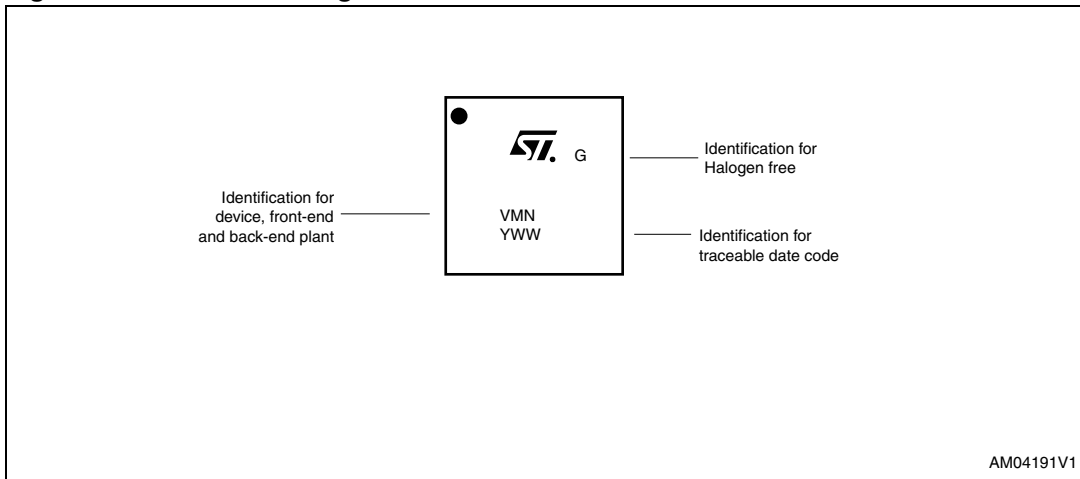


Figure 14. Reel drawing (front)

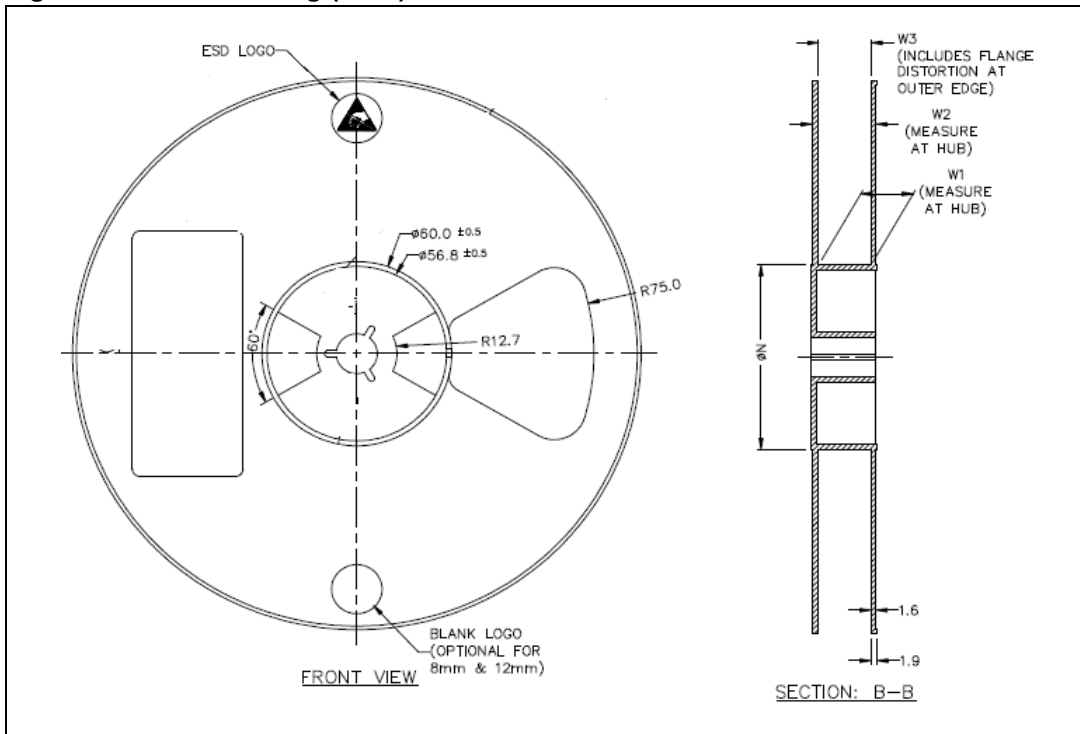


Figure 15. Reel drawing (back)

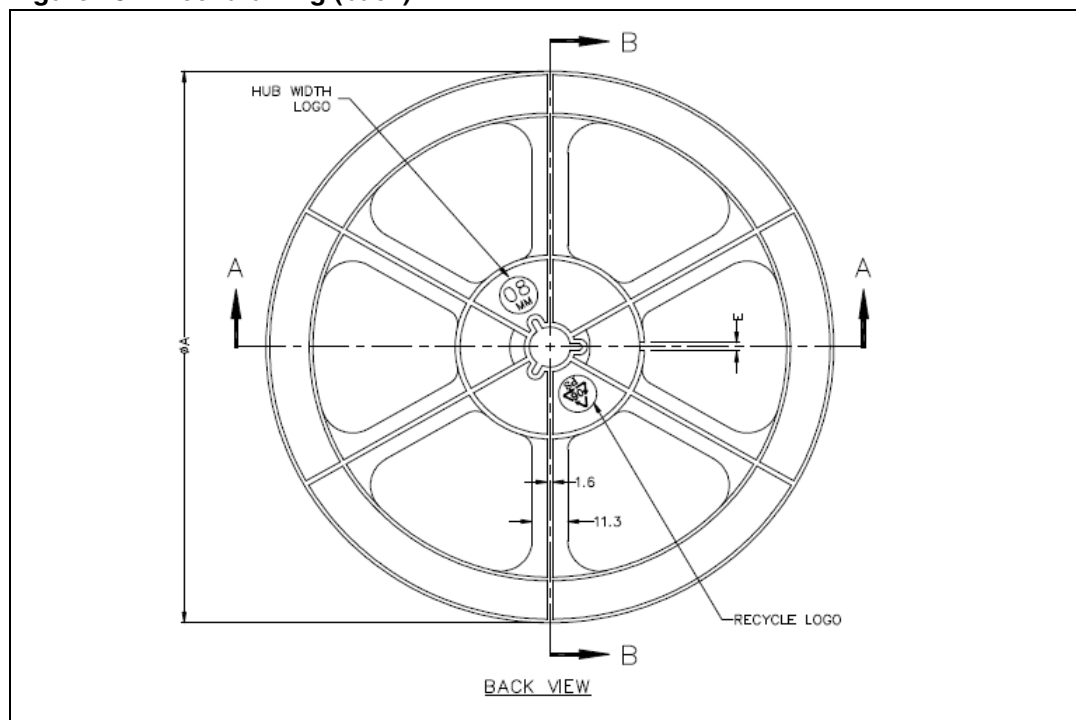


Table 25. Tape width (millimeters)

Tape width	A	N	W1	W2	W3	
	max	min	max	max	min	max
8	180	60	8,4	14.4	7.9	10.9

## 15 Revision history

**Table 26. Document revision history**

Date	Revision	Changes
18-Nov-2010	1	Initial release.
09-Mar-2011	2	Document status promoted from preliminary data to datasheet. Updated <a href="#">Table 2</a> .
23-May-2011	3	Updated: Footprint recommendation in <a href="#">Figure 10</a> . and <a href="#">Table 22</a> Replaced: Flip-chip 12 with CSP 12.
14-Jul-2011	4	Updated: features description, title and template. Modified: <a href="#">Table 3: I2C timing</a> and <a href="#">Section 13: Electrical specification</a> .

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