



STMPE812

Enhanced 4-wire resistive touchscreen controller with PWM

Preliminary data

Features

- 4 GPIOs (8 mA drive, 12 mA sink at 3.3 V)
- 1 additional, general purpose 12-bit ADC
- Operating voltage 1.65 - 3.6 V
- Integrated 4-wire touchscreen controller, pen-down/real-time mode, fully-autonomous
- 1 PWM controller
- Auto-hibernation and low power
 - Typ 0.5 μ A in Hibernation mode
 - Typ 100 μ A in Active mode
- Interrupt output pin (optional)
- Reset input pin (optional)
- Wake-up feature on each port configured as GPIO input
- I²C 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 STMPE812 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
STMPE812BJR	Flip-chip 12 (2.17 x 1.67 mm)	Tape and reel

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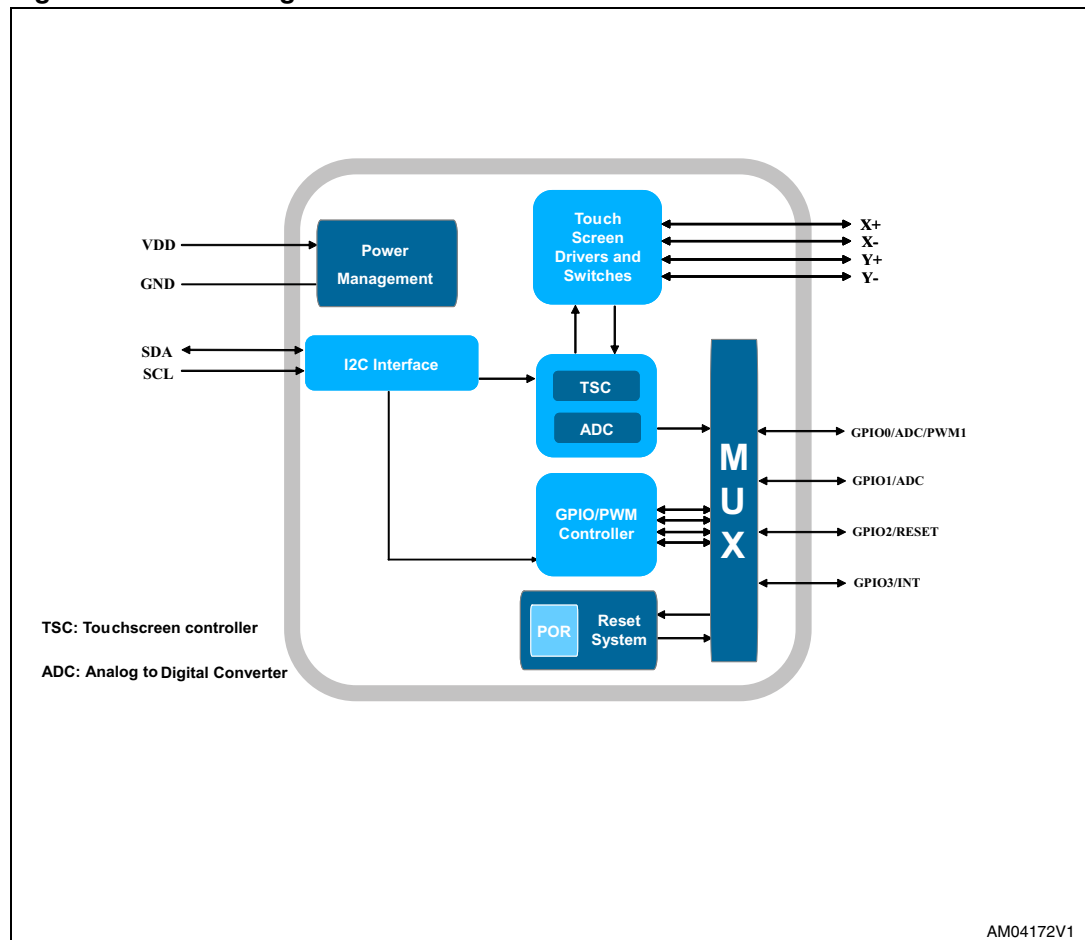
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1 STMPE812 functional overview

The STMPE812 consists of the following blocks:

- I²C interface
- GPIO/PWM controller
- Touchscreen controller (TSC)
- Analog-to-digital converted (ADC)
- Driver and switch control unit

Figure 1. Block diagram



1.1 Pin configuration and functions

Figure 2. Pin configuration (top through view)

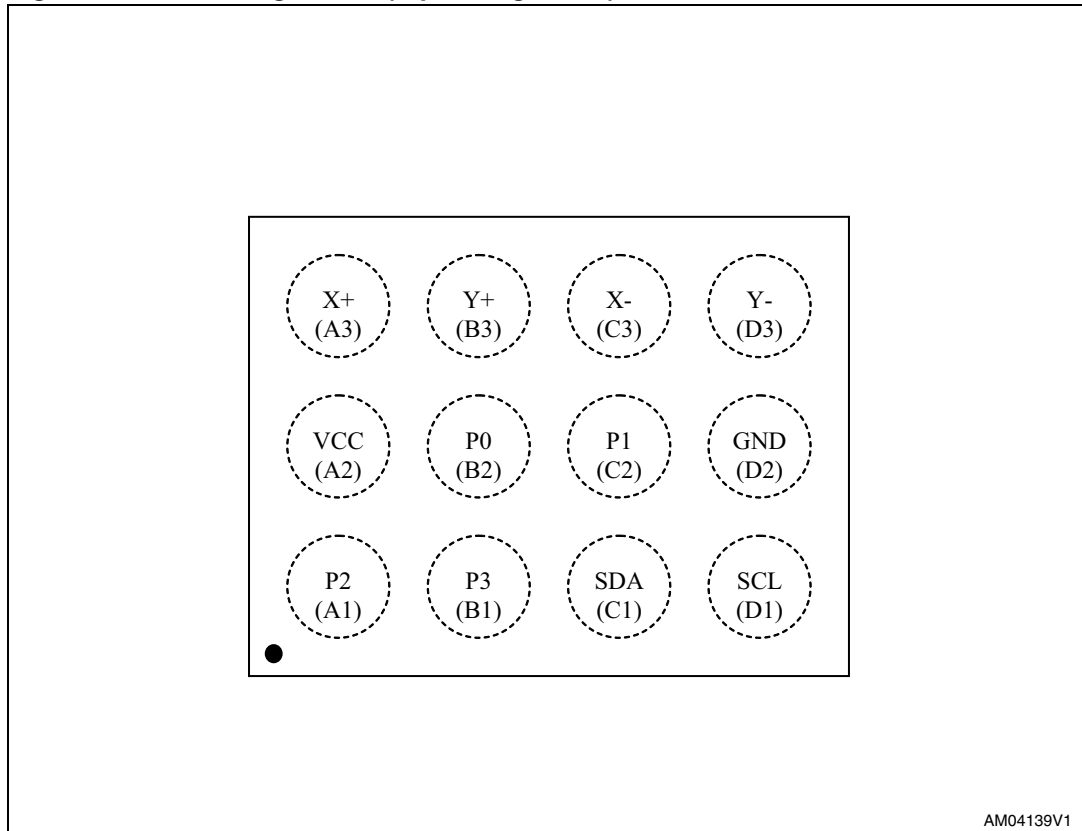


Table 2. Pin assignments

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	P1	+8 mA/-12 mA at 3.3 V	GPIO-0 / ADC / PWM1 (3.6 V tolerant within V_{CC} valid range)
D2	GND	Can be > 80 mA load at touchscreen and GPIO drive	Ground
D1	SCL	-4 mA	I ² C clock (fail safe, tolerant to 3.6 V regardless of V_{CC})
C1	SDA	-4 mA	I ² C data (fail safe, tolerant to 3.6 V regardless of V_{CC})
B1	P3	+8 mA/-12 mA at 3.3 V	GPIO-3 / INT (3.6 V tolerant within V_{CC} valid range)
A1	P2	+8 mA/-12 mA at 3.3 V	GPIO-2 / RESET (3.6 V tolerant within V_{CC} valid range)

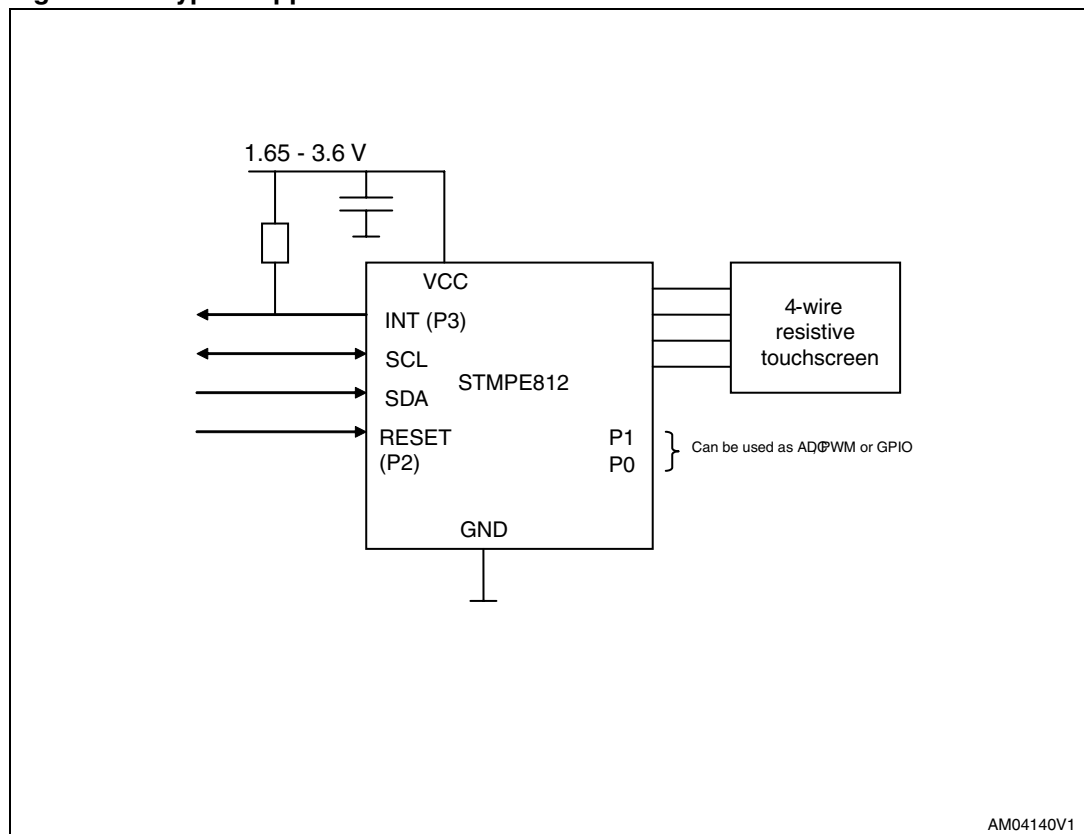
Table 2. Pin assignments (continued)

Pin	Name	Current capacity	Function
B2	P0	+8 mA/-12 mA at 3.3 V	GPIO-1 / ADC (V_{IN} must be less than V_{CC})
A2	V_{CC}	Can be > 80 mA load at touchscreen and GPIO drive	1.65 - 3.6 V core/IO supply (0.1 μ F decoupling cap) No low-voltage detection for POR 20 μ s POR from power stable
A3	X+	50 mA current limit	X+

Note: All I/O operates on V_{CC} . All I/O tolerant up to 3.6 V, across $V_{CC} = 1.65 - 3.6$ V.
8 kV HBM ESD on all touchscreen pins (+/- 8 kV vs GND).
0.5 μ A max input leakage as input, across V_{CC} range (GPIO, SCL/SDA).
4 μ s hardware filter on the 4 GPIOs as input.

1.2 Typical application

Figure 3. Typical application



2 I²C 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. I²C timing diagram

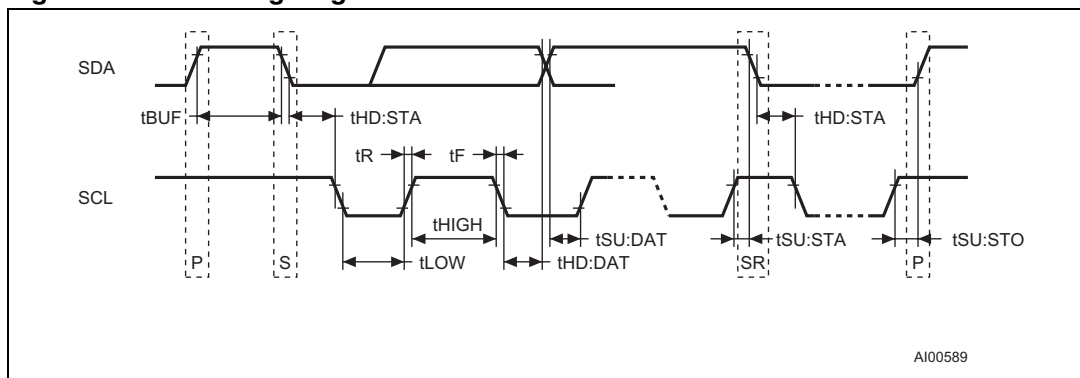


Table 3. I²C timing

Symbol	Parameter	Min	Typ	Max	Uni
f_{SCL}	SCL clock frequency	0	–	400	kHz
t_{LOW}	Clock low period	1.3	–	–	μ s
t_{HIGH}	Clock high period	600	–	–	ns
t_F	SDA and SCL fall time	–	–	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	–	–	μ 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	–	–	μ s

2.1 I²C features

The features that are supported by the I²C interface are listed below:

- I²C slave device
- Operates at V_{CC} (1.65 V - 3.6 V)
- Compliant to Philips I²C specification version 2.1
- Supports standard (up to 100 Kbps) and fast (up to 400 Kbps) modes
- I2C address in 0x41 (0x82/83 including Rd/Wr bit)

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 I²C 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.

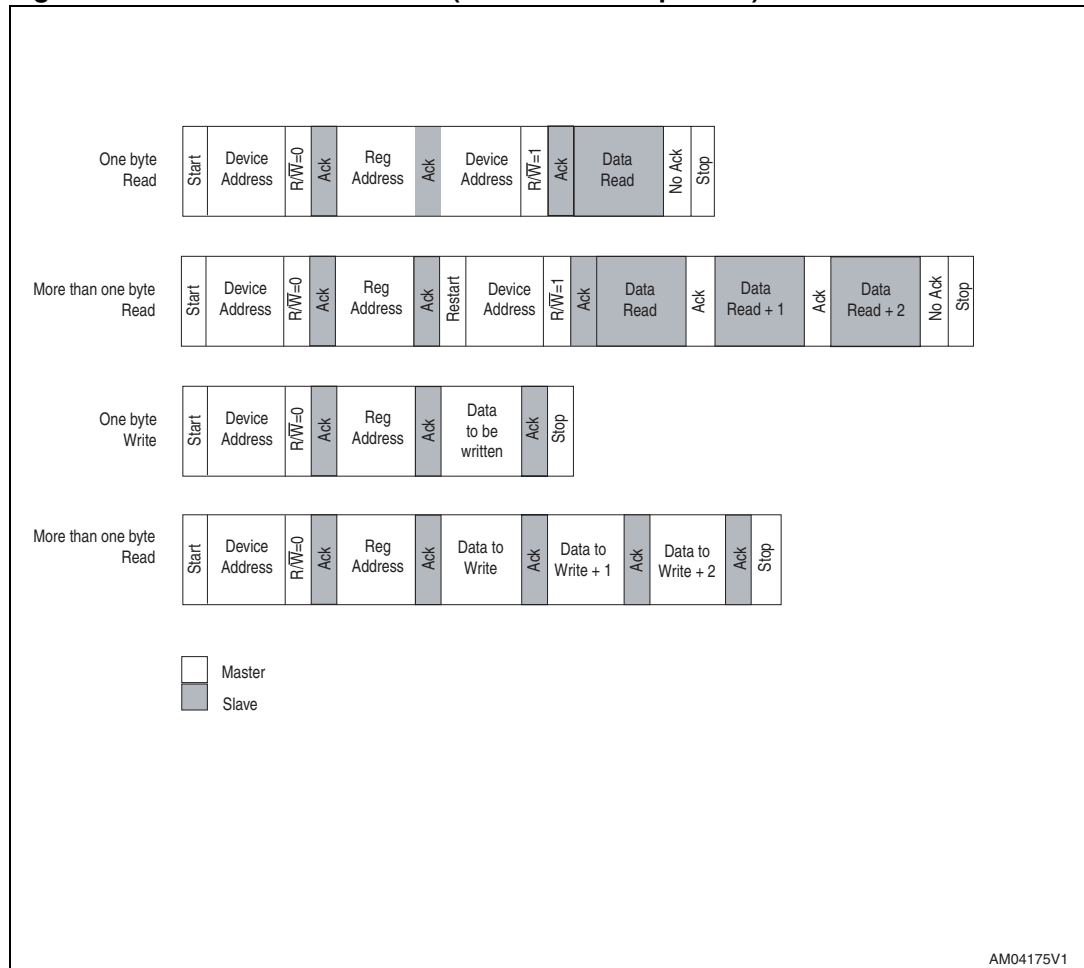
Table 4. Operating modes

Mode	Byte	Programming sequence
Read	≥1	Start, Device address, R/W = 0, Register address to be read
		Restart, Device address, R/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.

Table 4. Operating modes

Mode	Byte	Programming sequence
Write	≥1	Start, Device address, R/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 comes 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 STMPE812 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 STMPE812 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 STMPE812 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 STMPE812 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 cause a transition to “active” state, if an input change is detected.

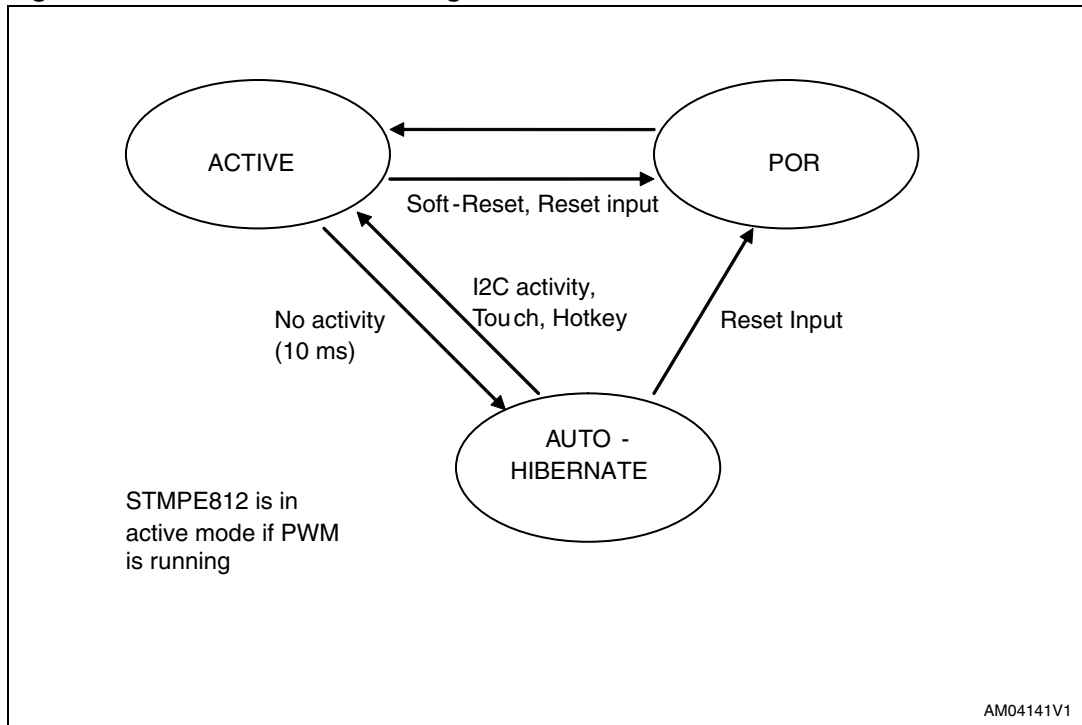
-Pen down even causes transition to “active” state if the touchscreen controller is enabled.

Table 5. Power mode

Power mode	Active	Hibernate
Current consumption	280 μ A (max) ⁽¹⁾	1.0 μ A (max.)
GPIO hotkey	Yes	Yes
Touchscreen	Yes	Yes
Interface (I ² 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, the 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 I²C activities, device goes into auto-hibernate mode automatically.

The auto-hibernate feature of STMPE812 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 I²C 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 STMPE812 registers

This section lists and describes the registers of the STMPE812 device, starting with a register map and then provides detailed descriptions of register types.

Table 6. 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	0x0812	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	0x00	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	0x32	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 6. 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 STMPE812 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 7. System and identification registers map

Address	Register name	Bit	Type	Reset	Function
0x00 - 01	CHIP_ID	16	R	0x0812	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	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 RESETTED. 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.

System and identification registers

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PORT_FUNCTION

Port function control register

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

Address: 0x04

Type: R/W

Reset: 0x00

Description: Port function control register.

[7:6] PORT 3 FUNCTION

[5:4] PORT 2 FUNCTION

[3:2] PORT 1 FUNCTION

[1:0] PORT 0 FUNCTION

Port function:

'00' - GPIO input

'01' - GPIO output

'10' - ADC input (P0/P1 only)

'11' - Special function

Special function for:

P0 - NONE

P1 - PWM

P2 - RESET input (low pulse > 4 μ s triggers a hard-reset)

P3 - 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.

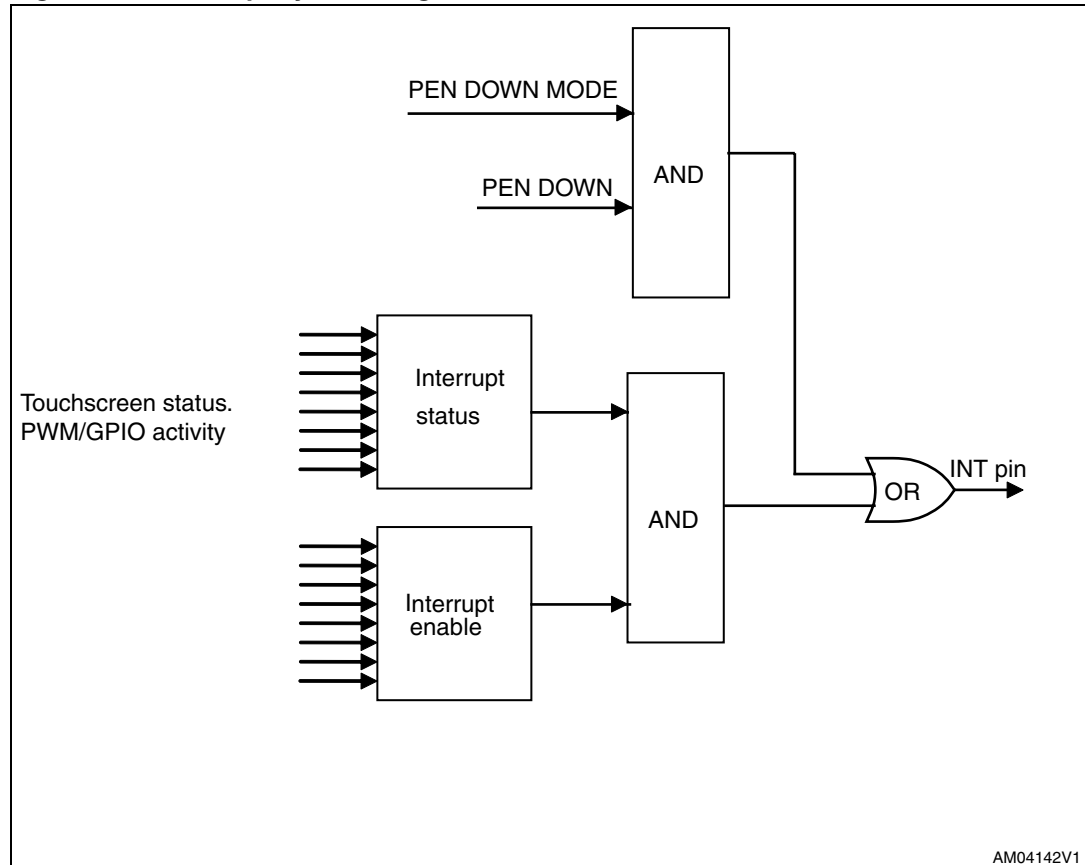
[15:0] SCRATCHPAD

8 Interrupt system

The STMPE812 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.

Figure 7. Interrupt system diagram



Interrupt system

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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.

'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_{CC} 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 μ s)

'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	P3	P2	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] P3
Port 3 activity (GPIO)
- [4] P2
Port 2 activity (GPIO)
- [3] P1
Port 1 activity (GPIO/ADC/PWM)
- [2] P0
Port 0 activity (GPIO/ADC)
- [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	P3	P2	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] P3
Port 3 activity (GPIO)
- [4] P2
Port 2 activity (GPIO)
- [3] P1
Port 1 activity (GPIO/ADC/PWM)
- [2] P0
Port 0 activity (GPIO/ADC)
- [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 when host reads the ISR.
- [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 is still updated with event interrupt status data, and cleared on read. However no interrupt is issued based on this status register.

9 ADC controller

A 12-bit ADC is integrated in the STMPE812. 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 8.

Address	Register name	Bit	Type	Reset	Description
0x20	ADC control	8	R/W	0x32	ADC control
0x21-0x22	ADC data	16	R	0x0000	ADC data access (P0/P1)

ADC controller

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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]		ADC_PORT
0	0	1	1	0	0	1	0

Address: 0x20

Type: R/W

Reset: 0x32

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 Vcc is less than 2.5V. **Activating the charge pump when Vcc is more than 2.5V 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 is ignored, if CP_Arm is '0'.

Note: NOTE: CP_Arm and CP_Lock CANNOT be accessed in a single I²C transaction.

System must first ARM the CP with 1 I²C 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] ADC_PORT: selects one of the port as ADC input.
 00- Port 0
 01- Port 1

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 I²C master accesses the data register, upper/lower byte consistency must be guaranteed (Once access starts, content is updated only after BOTH bytes has been read, OR I²C 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 $\frac{1}{2}$ 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 9. 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 600 kHz clock divided by (Div[4:0] + 1).

Effectively, PWM clock is:

600 kKz (msx.)

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 PWM sequence causes the P0 bit in interrupt status register to be asserted.

11 Touchscreen controller

The STMPE812 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.

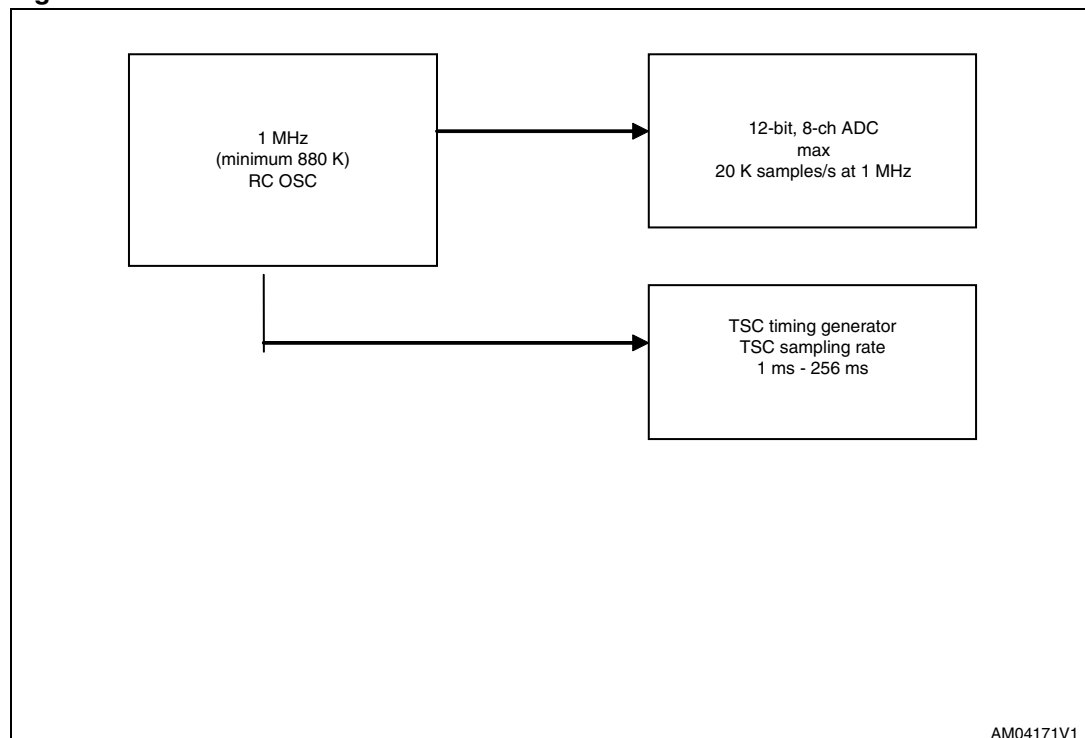
The TSC is based on an internal 20Ksamples/sec ADC, running off a 1 MHz (Minimum 880 kHz) RC OSC.

Sampling time = Touch Detect Delay*2 + (Settling Time + (ADC Conversion Time*MAV)) *3

Table 10. 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 μ s	40 μ s	40 μ s	None	$40*2 + 3*(40+(50*1)) = 350 \mu$ s (2.8K sample sets/sec)
880 kHz	50 μ s	40 μ s	40 μ s	10-2	$40*2 + 3*(40+(50*10))=1700 \mu$ s (588 sample sets/sec)
880 kHz	50 μ s	640 μ s	640 μ s	20-4	$640*2 + 3*(640+(50*20)) =6200 \mu$ s (161 sample sets/sec)

Figure 8. Touchscreen controller internal RC OSC connection



11.1 Touchscreen controller detection sequence

Following is the sequence of detection in the STMPE812 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 “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 “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 11. 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 4x oversampling)

'111' – 8 remove none (Equal to 8x 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 resetted when this bit is written to.

[3:2] Precharge[1:0]

Pre-charge driver for touch detection

'00' – no pre-charge

'01' – 2 μ s pre-charge

'10' – 4 μ s pre-charge

'11' – 8 μ s 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 μ s

'001' = 80 μ s

'010' = 160 μ s

'011' = 320 μ s

'100' = 640 μ s - Default

'101' = 1.28 ms

'110' = 2.56 ms

'111' = 5.12 ms

[2:0] Settling[2:0]

Panel driver settling time

'000' = 40 μ s

'001' = 80 μ s

'010' = 160 μ s

'011' = 320 μ s/ns

'100' = 640 μ s - 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 interrupt status read in data port. (Default)

Reading data port in this mode clears interrupt status (equivalent to accessing interrupt status register)

‘0’ – no interrupt 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, STMPE812 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.

STMPE812

Touchscreen controller

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 μ s (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 scontroller 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: *IT IS EXTREMELY IMPORTANT FOR SYSTEM HOST TO READ EXACTLY THE NUMBER OF BYTES IN EACH OPERATING MODE, TO PRESERVE THE INTEGRITY OF DATA STORED.*

Note: *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 12. 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	Interrupt Status	[11:4] of X	[3:0] of X [11:8] of Y	[7:0] of Y	[7:0] of Z
1	1	4	Interrupt Status	[11:4] of X	[3:0] of X [11:8] of Y	[7:0] of Y	-

11.4 Programming model

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

A. 811-style 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 μ C host, yet the sampling timer is up for the next data, the STMPE812 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 μ 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 STMPE812 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 int_sts (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 4/6 configurable ports are available in the STMPE812 port expander device. If configured as GPIO input/output, they are controlled by the GPIO registers.

Table 13. 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-3	IO-2	IO-1	IO-0

The function of each bit is shown in [Table 14](#):

Table 14. 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 15. Absolute maximum rating

Symbol	Ratings	Maximum value	Unit
V _{CC}	Supply voltage	4.5	V
V _{i-i2c}	Input voltage at SDA/SCL	4.5	V
V _{i-io}	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 16. Thermal data

Symbol	Parameter	Value	Unit
T _J	Thermal resistance junction-ambient (Flip-chip12)	68	°C / W
T	Operating temperature	-40°C-85°C	°C
T _{STG}	Storage temperature	-65°C-125°C	°C

Table 17. Power consumption (T_{amb} = -40 °C to 85 °C)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V _{CC}	Core supply voltage		1.65	–	3.6	V
I _{CC} max	Operating current	V _{CC} = 1.8 V TSC running at 100 sets of X/Y per second MAV disabled	–	100	120	µA
		V _{CC} = 1.8 V TSC Running at 100 sets of X/Y per second MAV 6 remove 2	–	230	280	
I _{CC} max	Operating current	V _{CC} = 3.3 V TSC running at 100 sets of X/Y/Z per second MAV 10 remove 2	–	670	810	µA
		V _{CC} = 1.8 V TSC running at 100 sets of X/Y/Z per second MAV 10 remove 2	–	470	570	

Table 17. Power consumption ($T_{amb} = -40\text{ °C}$ to 85 °C) (continued)

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

*operating current excludes current driving the touchscreen.

13.1 DC electrical characteristics

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

Table 18. DC electrical characteristics

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
V_{IL}	Input voltage low state	$V_{CC} = 1.65 - 3.3\text{ V}$	-0.3	–	$0.20 V_C$ C	V
V_{IH}	Input voltage high state	$V_{CC} = 1.65 - 3.3\text{ V}$	$0.80 V_{CC}$	–	$V_{CC}+0.3$	V
V_{OL}	Output voltage low state	$V_{CC}= 3.3\text{ V}$, $I_{OL} = 12\text{ mA}$	-0.3	–	0.45	V
V_{OH}	Output voltage high state	$V_{CC} = 1.65\text{ V}$, $I_{OH}=8\text{ mA}$	$0.85 V_{CC}$	–	$V_{CC}+0.3$	V
$I_{leakage}$	All input pins except for touchscreen I/O and P0/P1	$V_{CC} = 1.65\text{ V}$, $V_{IN} 3.6\text{ V}$	–	0.1	0.5	μA

13.2 AC electrical characteristics

Table 19. AC electrical characteristics (-40 °C to 85 °C)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
Max ClkI2C	I2C maximum SCLK	$V_{CC} = 1.8 - 3.3\text{ V}$	–	–	400	KHz
MaxClkI2C	I2C maximum SCLK	$V_{CC} = 1.8 - 3.3\text{ V}$	–	–	120	KHz

Electrical specification

STMPE812

Table 19. AC electrical characteristics (-40 °C to 85 °C)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
Treset	Minimum RESET pulse width		4	–	–	µs
Tin	Minimum INPUT width required for GPIO state transition		4	–	–	µs
F _{osc}	Internal RC OSC frequency	V _{CC} = 1.8 V	900	1200	1500	kHz
F _{osc}	Internal RC OSC frequency	V _{CC} = 3.3 V	900	1200	1500	kHz

Table 20. ADC specification

Parameter	Test conditions	Min	Typ	Max	Unit
Full-scale input span		0	–	V _{CC}	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
Noise	Including internal V _{ref}	–	50	–	uVrms
Power supply rejection ratio		–	50	–	dB
Throughput rate		–	180	–	Ksamples/s

Table 21. Switch drivers specification

Parameter	Test conditions	Min	Typ	Max	Unit
ON resistance X+, Y+	V _{CC} = 1.65 - 3.6 V	–	7	15	OHM
ON resistance X-, Y-	V _{CC} = 1.65 - 3.6 V	–	7	15	OHM
Drive current (at 5 mA limit)	V _{CC} = 1.65 - 3.6 V X+/X- or Y+/Y- shorted together externally	–	–	10	mA

Table 21. Switch drivers specification (continued)

Parameter	Test conditions	Min	Typ	Max	Unit
Drive current (at 10 mA limit)	$V_{CC} = 1.65 - 3.6 V$ X+/X- or Y+/Y- shorted together externally	–	–	20	mA
Drive current (at 20 mA limit)	$V_{CC} = 1.65 - 3.6 V$ X+/X- or Y+/Y- shorted together externally	–	–	40	mA
Drive current (at 30 mA limit)	$V_{CC} = 1.65 - 3.6 V$ X+/X- or Y+/Y- shorted together externally	–	–	60	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. ECOPACK[®] is an ST trademark.

Figure 9. Package outline for Flip-chip 12

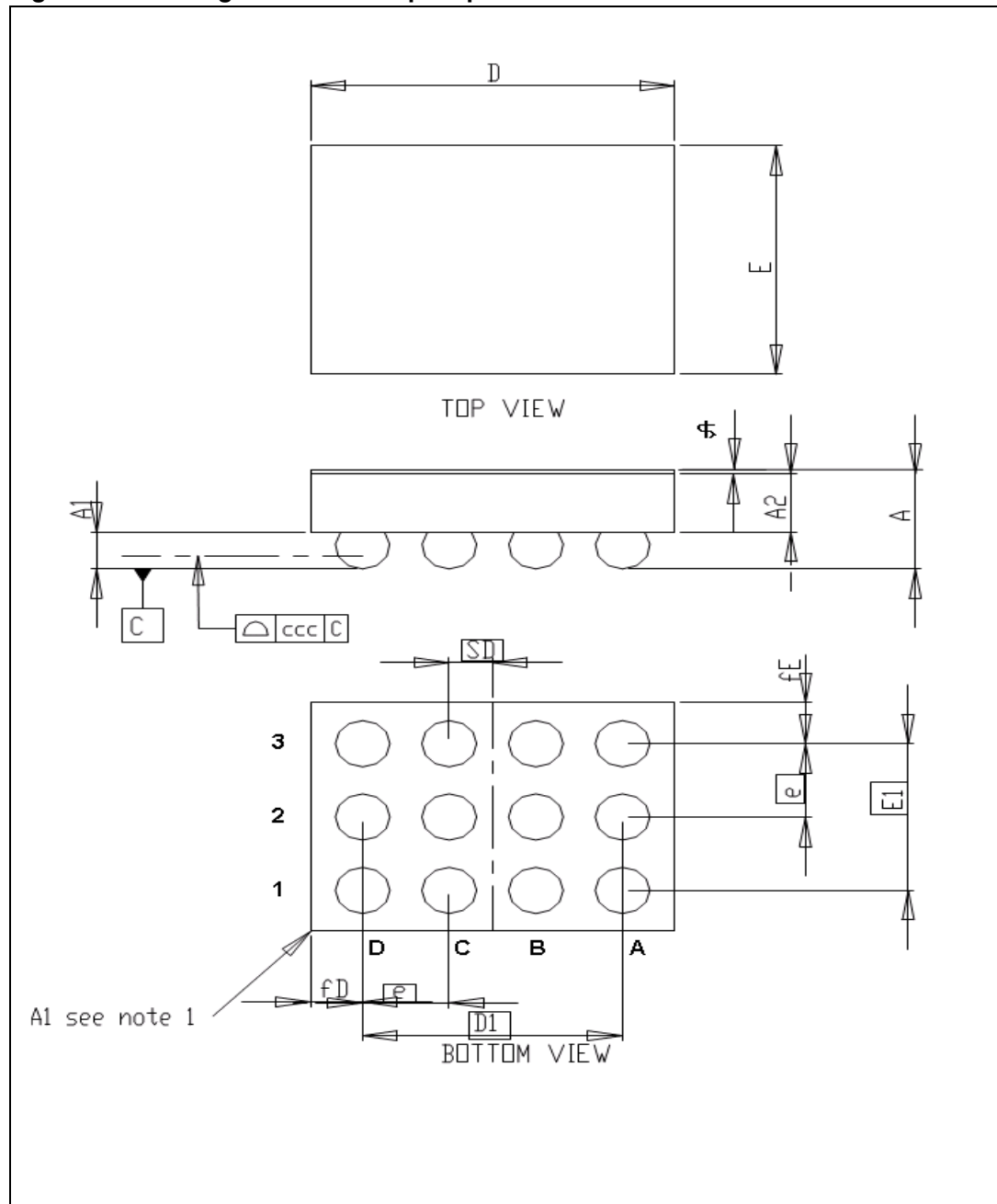


Table 22. Flip-chip 12 mechanical data

Symbol	Millimeters		
	Min	Typ	Max
A	0.60	0.65	0.70
A1	0.22	0.25	0.28
A2	0.33	0.35	0.37
b	0.290	0.315	0.340
D	2.155	2.17	2.185
D1	1.49	1.5	1.51
E	1.655	1.67	1.685
E1	0.99	1.0	1.01
e	0.46	0.5	0.54
fD	0.327	0.335	0.343
fE	0.327	0.335	0.343
SD	-	0.25	-
ccc	-	0.08	-
\$	-	0.05	-

Figure 10. Footprint recommendation

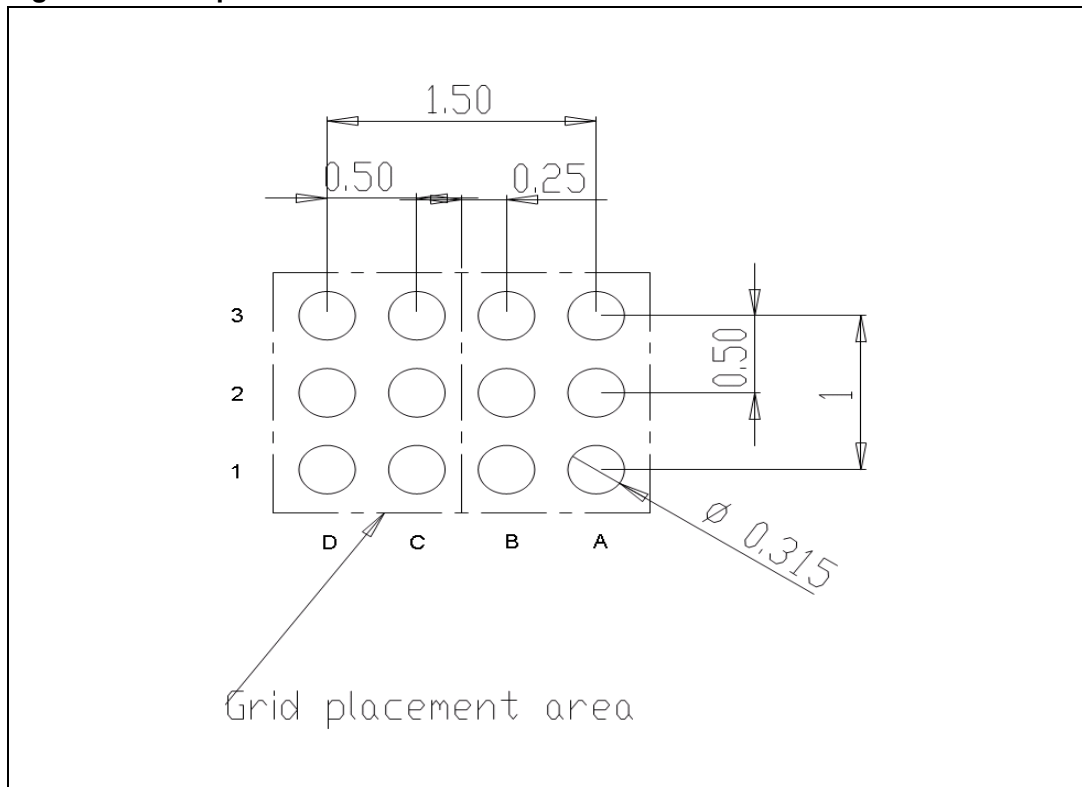


Figure 11. Tape information

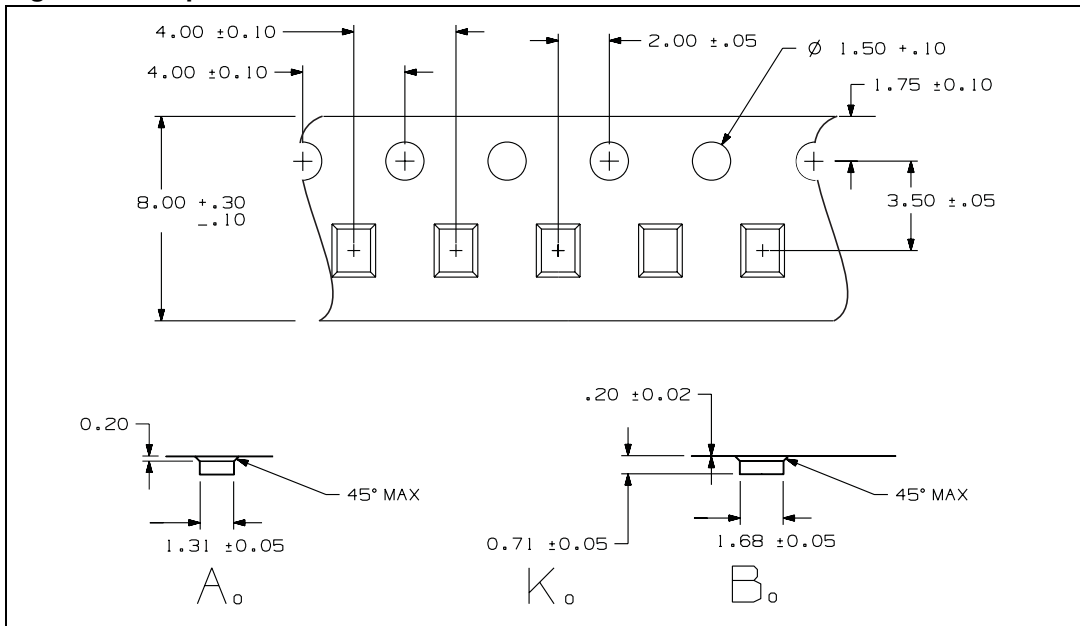


Figure 12. Tape orientation

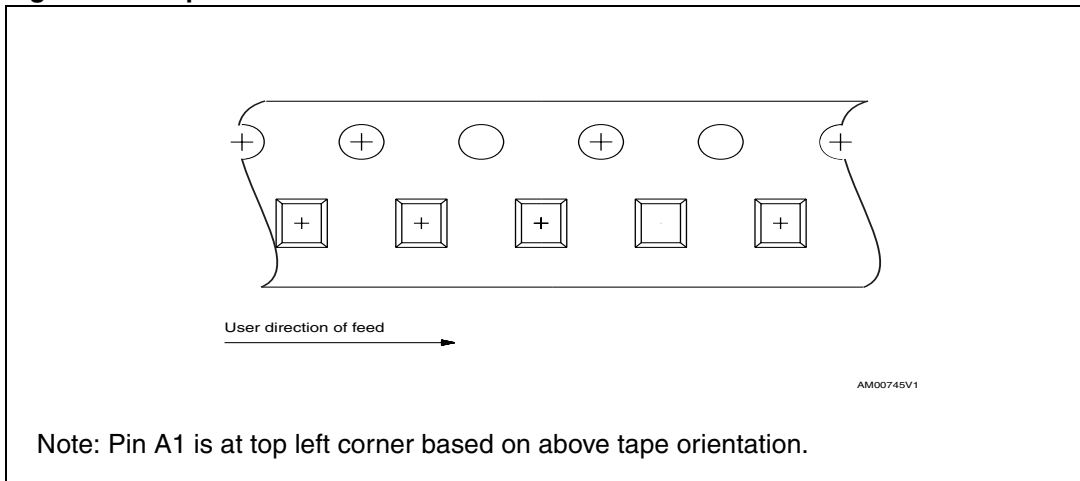
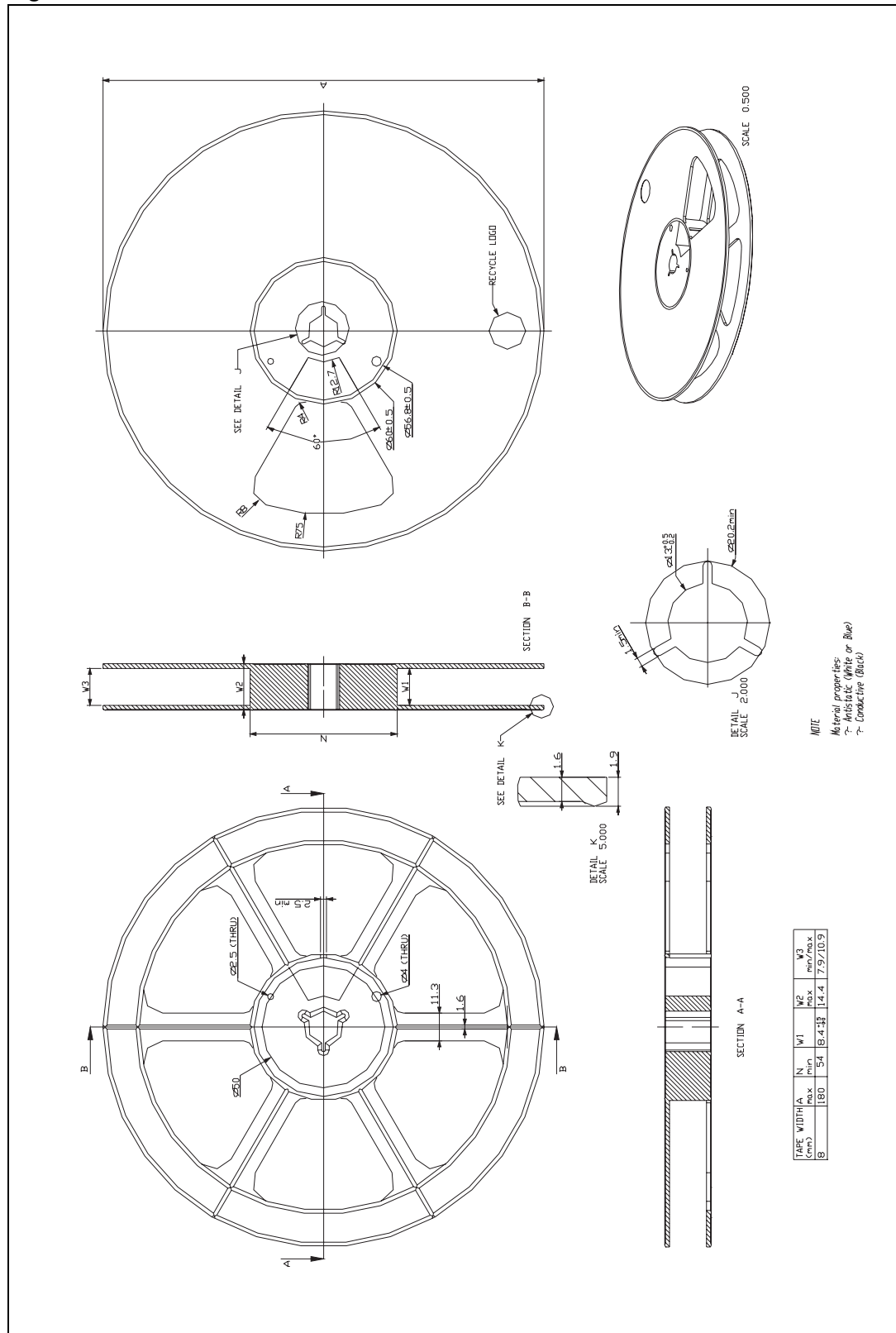


Figure 13. Reel information



15 Revision history

Table 23. Document revision history

Date	Revision	Changes
20-Jul-2010	1	Initial release.

STMPE812

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