



## 16-bit port expander with ultra-low power consumption

Xpander Logic™

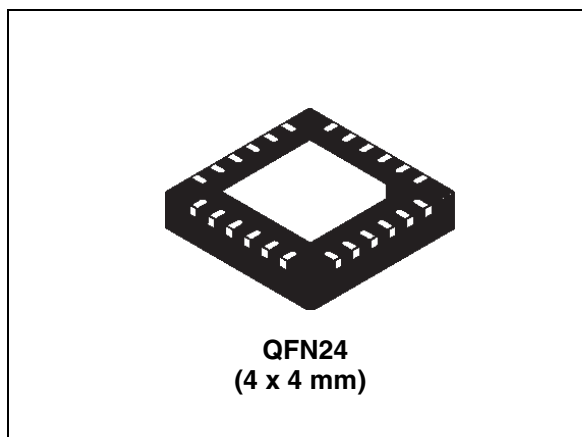
Datasheet –production data

### Features

- 16 GPIOs which default to 16 inputs on power-up
- Serial I<sup>2</sup>C interface (0 to 400 kHz) to the host with noise filter
- Operating voltage 1.65 V - 3.6 V
- I/O voltage 1.65 V - 3.6 V
- Interrupt output pin
- Internal power-on-reset
- Wakeup feature on each I/O
- Up to 8 devices sharing the same bus
- (3 address pins)
- 8 mA current drive/sink on each GPIO at 3.3 V
- < 1µA suspend current
- ESD protection exceeds 2 KV HBM per JESD22-A114
- Latch-up testing exceeding 100 mA
- Package: QFN24 (4 x 4 mm with 0.5 mm pitch)

### Applications

- Portable media players
- Game consoles
- Mobile phones
- Smart phones



### Description

The STMPE1600 is a GPIO (general purpose input/output) port expander able to interface a main digital ASIC via the two-line bidirectional bus (I<sup>2</sup>C). A separate GPIO expander IC is often used in mobile multimedia platforms to solve the problems of the limited amount of GPIOs typically available on the digital engine.

I/O expanders provide a simple solution when additional I/O are needed for several interface functions such as sensors, pushbuttons, LEDs, fans, etc.

The STMPE1600 offers great flexibility as each I/O can be configured as input or output. The device has been designed with very low quiescent current and includes a wakeup feature for each I/O, to optimize the power consumption of the device.

Table 1. Device summary

| Order code   | Package | Packing       |
|--------------|---------|---------------|
| STMPE1600QTR | QFN24   | Tape and reel |

# Contents

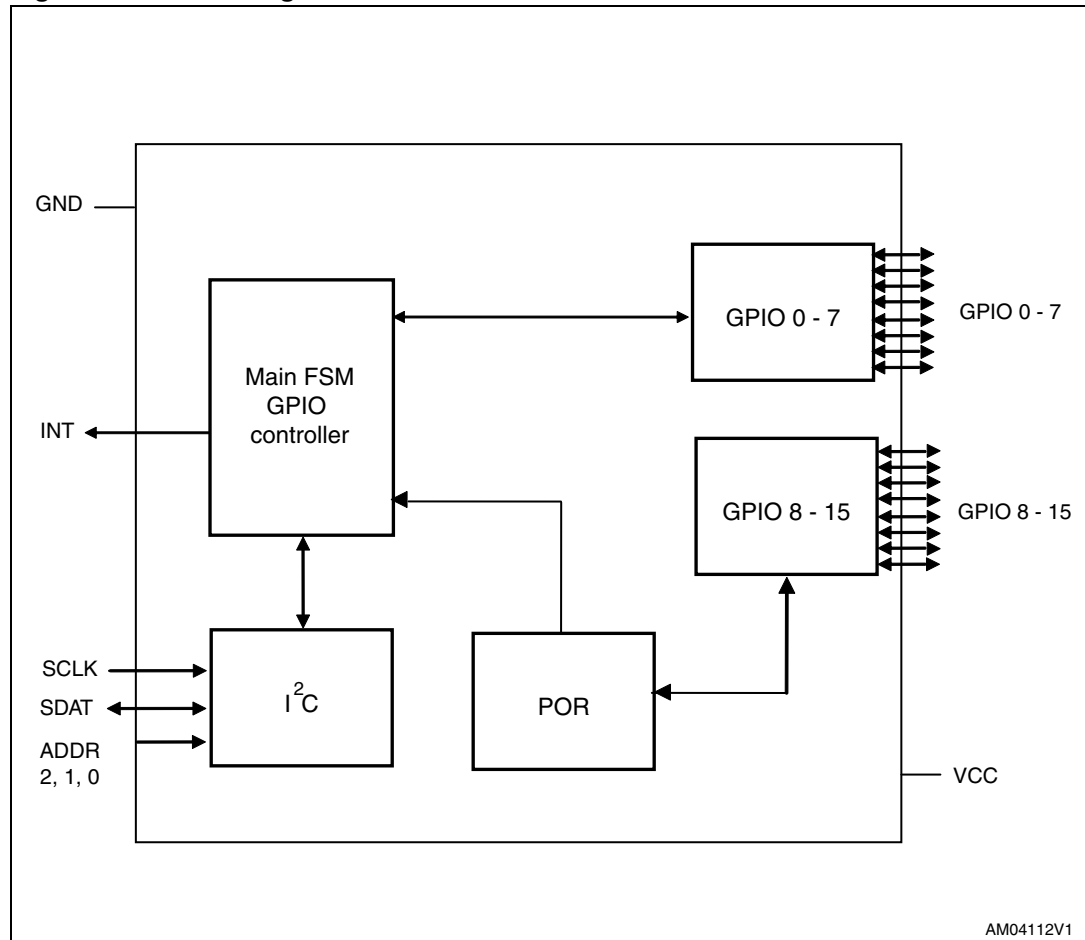
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# 1 STMPE1600 functional overview

The STMPE1600 device consists of the following blocks:

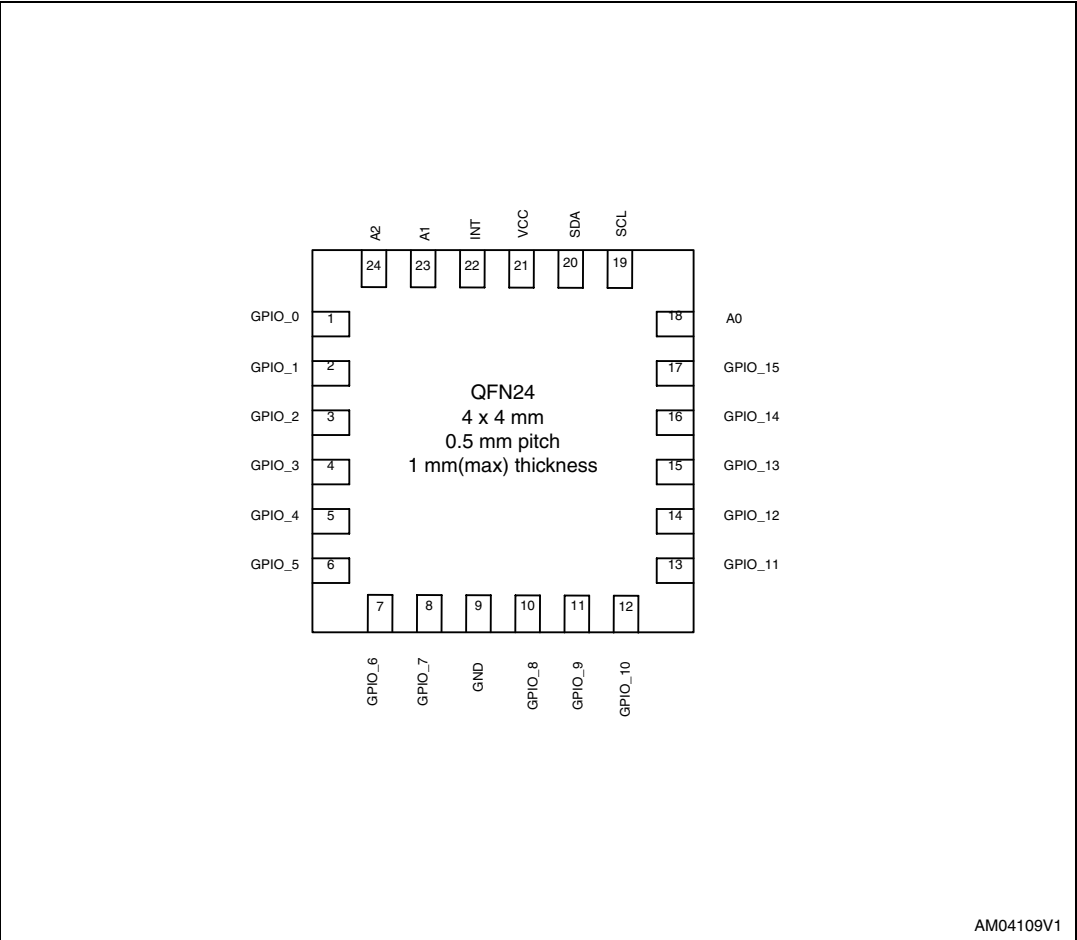
- Main FSM GPIO controller
- I<sup>2</sup>C interface
- POR
- GPIOs

**Figure 1. Block diagram**



## 1.1 Pin assignment

Figure 2. QFN24 pin-mapping



## 1.2 Pin assignment (QFN24 package)

Table 2. Pin assignment

| Pin number | Name   | Type | Function          |
|------------|--------|------|-------------------|
| 1          | GPIO_0 | IO   | GPIO 0            |
| 2          | GPIO_1 | IO   | GPIO 1            |
| 3          | GPIO_2 | IO   | GPIO 2            |
| 4          | GPIO_3 | IO   | GPIO 3            |
| 5          | GPIO_4 | IO   | GPIO 4            |
| 6          | GPIO_5 | IO   | GPIO 5            |
| 7          | GPIO_6 | IO   | GPIO 6            |
| 8          | GPIO_7 | IO   | GPIO 7            |
| 9          | GND    | -    | Ground connection |
| 10         | GPIO_8 | IO   | GPIO 8            |
| 11         | GPIO_9 | IO   | GPIO 9            |

**Table 2. Pin assignment**

| Pin number | Name    | Type | Function                                                           |
|------------|---------|------|--------------------------------------------------------------------|
| 12         | GPIO_10 | IO   | GPIO 10                                                            |
| 13         | GPIO_11 | IO   | GPIO 11                                                            |
| 14         | GPIO_12 | IO   | GPIO 12                                                            |
| 15         | GPIO_13 | IO   | GPIO 13                                                            |
| 16         | GPIO_14 | IO   | GPIO 14                                                            |
| 17         | GPIO_15 | IO   | GPIO 15                                                            |
| 18         | A0      | I    | I <sup>2</sup> C address 0. Up to 8 such devices can be addressed. |
| 19         | SCL     | I    | I <sup>2</sup> C Clock. Fail-safe                                  |
| 20         | SDA     | IO   | I <sup>2</sup> C Data. Fail-safe                                   |
| 21         | VCC     | -    | Power supply for I <sup>2</sup> C and digital core and GPIOs       |
| 22         | INT     | O    | Interrupt output pin. Fail-safe                                    |
| 23         | A1      | I    | I <sup>2</sup> C address 1. Up to 8 such devices can be addressed. |
| 24         | A2      | I    | I <sup>2</sup> C address 2. Up to 8 such devices can be addressed. |

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

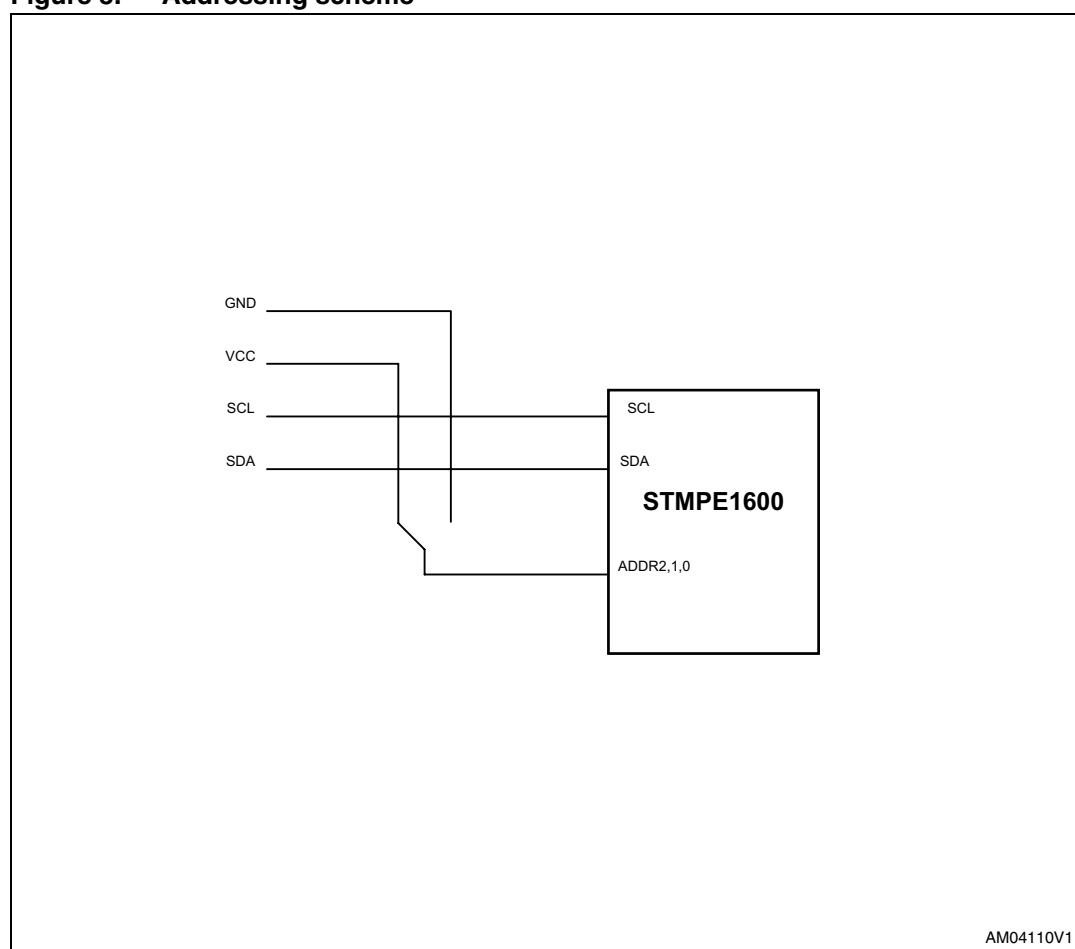
### 2.1 I<sup>2</sup>C module

The STMPE1600 is interfaced to the main processor using an I<sup>2</sup>C bus.

#### 2.1.1 I<sup>2</sup>C address

The addressing scheme of STMPE1600 is designed to allow up to 8 devices to be connected to the same I<sup>2</sup>C bus. The slave device address is a 7-bit or 10-bit address where they are 42h, 43h, 44h, 45h, 46h, 47h, 48h and 49h (equivalent values in 7-bit and 10-bit addressing).

**Figure 3. Addressing scheme**

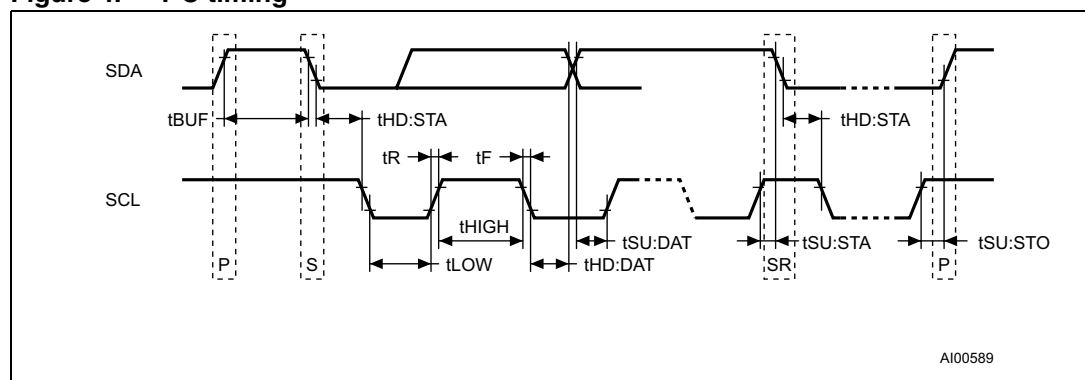


**Table 3. Eight programmable slave addresses**

| A2 | A1 | A0 | Slave device address<br>(7-bit or 10-bit addressing) |
|----|----|----|------------------------------------------------------|
| 0  | 0  | 0  | 42h                                                  |
| 0  | 0  | 1  | 43h                                                  |
| 0  | 1  | 0  | 44h                                                  |
| 0  | 1  | 1  | 45h                                                  |
| 1  | 0  | 1  | 46h                                                  |
| 1  | 0  | 1  | 47h                                                  |
| 1  | 1  | 0  | 48h                                                  |
| 1  | 1  | 1  | 49h                                                  |

For the bus master to communicate to the slave device, the bus master must initiate a Start condition and 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**

**Table 4. I<sup>2</sup>C bus timing**

| Symbol              | Parameter                                                                  | Min | Typ | Max | Uni |
|---------------------|----------------------------------------------------------------------------|-----|-----|-----|-----|
| f <sub>SCL</sub>    | SCL clock frequency                                                        | 0   | –   | 400 | kHz |
| t <sub>LOW</sub>    | Clock low period                                                           | 1.3 | –   | –   | μs  |
| t <sub>HIGH</sub>   | Clock high period                                                          | 600 | –   | –   | ns  |
| t <sub>F</sub>      | SDA and SCL fall time                                                      | –   | –   | 300 | ns  |
| t <sub>HD:STA</sub> | START condition hold time (after this period the first clock is generated) | 600 | –   | –   | ns  |
| t <sub>SU:STA</sub> | START condition setup time (only relevant for a repeated start period)     | 600 | –   | –   | ns  |
| t <sub>SU:DAT</sub> | Data setup time                                                            | 100 | –   | –   | ns  |
| t <sub>HD:DAT</sub> | Data hold time                                                             | 0   | –   | –   | μs  |
| t <sub>SU:STO</sub> | STOP condition setup time                                                  | 600 | –   | –   | ns  |
| t <sub>BUF</sub>    | Time the bus must be free before a new transmission can start              | 1.3 | –   | –   | μs  |



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

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

- I<sup>2</sup>C slave device
- Operates from 1.65 V to 3.6 V
- Compliant to Philips I<sup>2</sup>C specification version 2.1
- Supports standard (up to 100Kbps) and fast (up to 400Kbps) modes
- 7-bit and 10-bit device addressing modes with up to 8 slave device addresses
- General call
- Start/Restart/Stop
- Address up to 8 STMPE1600 devices via I<sup>2</sup>C

### Start condition

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

### Stop condition

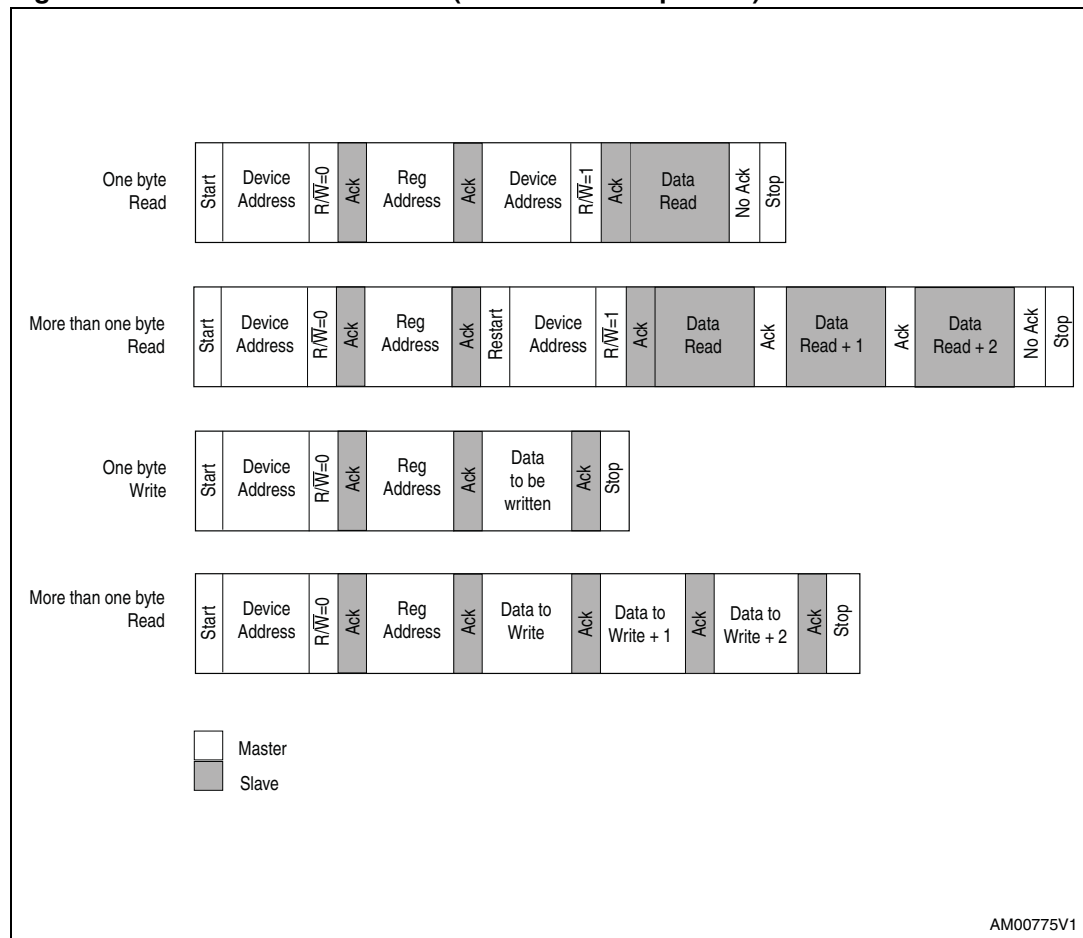
A Stop condition is identified by a rising edge of SDA while SCL is stable at high state. A Stop condition terminates communication between the slave device and bus master. A read command that is followed by NoAck can be followed by a Stop condition to force the slave device into idle mode. When the 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 SDA after sending eight bits of data. During the ninth bit, the receiver pulls the SDA low to acknowledge the receipt of the eight bits of data. The receiver may leave the SDA in high state if it would to not acknowledge the receipt of the data.

### Data input

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

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

| Mode  | Byte | Programming sequence                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Read  | ≥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.                                                                                                                                                                                                                                                 |
| Write | ≥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 will be kept static throughout the entire write operation. Refer to the memory map table for the address ranges that are auto and non-increment. |

### 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 more 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 byte, the bus master must not acknowledge the last output byte and follow 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 will be coming from consecutive addresses, with the internal Address Counter automatically increments after each byte output. After the last memory address, the Address Counter 'rolls-over' and the device continue to output data from the memory address of 0x00. Similarly, for the address of register that falls within non-increment range of addresses, the output data byte comes from the same address (which is the address pointed 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 low state, then the slave device terminates and switches back to its idle mode, waiting for the next command.

### 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 (pointed by the Address Counter). The slave device again acknowledges and the bus master terminates the transfer with a Stop condition. If the bus master would like to continue to write more data, it can just continue write operation without issuing the Stop condition. Whether the Address Counter auto increments 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' on the next data byte write.

### General call

A general call address is a transaction with the slave address of 0x00 and R/W = 0. When a general call address is made, the device responds to this transaction with an acknowledgement and behaves as a slave-receiver mode. The meaning of a general call address is defined in the second byte sent by the master-transmitter.

**Table 6. General call**

| R/W | Second Byte Value | Definition                                                                                                                                                |
|-----|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0   | 0x06              | 2-byte transaction in which the second byte tells the slave device to reset and write (or latch in) the 1-bit programmable part of the slave address.     |
| 0   | 0x04              | 2-byte transaction in which the second byte tells the slave device not to reset and write (or latch in) the 1-bit programmable part of the slave address. |
| 0   | 0x00              | Not allowed as second byte.                                                                                                                               |

Note: All other second byte values will be ignored.

### 3.1 Turning I<sup>2</sup>C block OFF and ON

The STMPE1600 operates entirely on the I<sup>2</sup>C clock. When there is no activity on the I<sup>2</sup>C bus, current consumption of the device is extremely low. However, when there is activity on the I<sup>2</sup>C bus, current consumption increases, even if the I<sup>2</sup>C traffic is not directed to the assigned address.

The host system may choose to shut-down the I<sup>2</sup>C block in the STMPE1600, if no access to the registers is required. This feature allows the current consumption to drop to the minimum. Host system turns OFF the I<sup>2</sup>C block by writing '1' into the I2C\_SHDN bit. The I2C block will shut down on the next valid clock edge of the I<sup>2</sup>C clock signal. In this state, the device cannot be accessed by I<sup>2</sup>C, as the I<sup>2</sup>C has shut down completely.

To turn ON the I<sup>2</sup>C block, system host must reset the STMPE1600 in order to re-activate the I<sup>2</sup>C block either by removing V<sub>CC</sub> and bringing it back again. Or by using GPIO\_0 for wake-up function.

## 4 Register map

**Table 7. Register map**

| Address   | Register name | Size (bit) | Function                             |
|-----------|---------------|------------|--------------------------------------|
| 0x00      | Chip ID LSB   | 8          | 0x00                                 |
| 0x01      | Chip ID MSB   | 8          | 0x16                                 |
| 0x02      | Version ID    | 8          | Revision number (0x01)               |
| 0x03      | SystemControl | 8          | Reset and interrupt control          |
| 0x04-0x07 | Reserved      |            | Reserved                             |
| 0x08      | IEGPIOR       | 8          | GPIO interrupt enable register LSB   |
| 0x09      |               | 8          | GPIO interrupt enable register MSB   |
| 0x0A      | ISGPIOR       | 8          | GPIO interrupt status register LSB   |
| 0x0B      |               | 8          | GPIO interrupt status register MSB   |
| 0x10      | GPMR          | 8          | GPIO monitor pin state register LSB  |
| 0x11      |               | 8          | GPIO monitor pin state register MSB  |
| 0x12      | GPSR          | 8          | GPIO set pin state register LSB      |
| 0x13      |               | 8          | GPIO set pin state register MSB      |
| 0x14      | GPDR          | 8          | GPIO set pin direction register LSB  |
| 0x15      |               | 8          | GPIO set pin direction register MSB  |
| 0x16      | GPPIR         | 8          | GPIO polarity inversion register LSB |
| 0x17      |               | 8          | GPIO polarity inversion register MSB |
| 0x18-0xFF | Reserved      |            | Reserved                             |

## 5 System control register

### SYS\_CTRL

### System control register

| 7             | 6        | 5         | 4        | 3        | 2          | 1        | 0            |
|---------------|----------|-----------|----------|----------|------------|----------|--------------|
| SOFT<br>RESET | I2C_SHDN | Wakeup_En | RESERVED | RESERVED | INT_Enable | RESERVED | INT_Polarity |
| RW            | RW       | RW        | —        | —        | RW         | —        | RW           |

**Address:** 0x03

**Type:** RW

**Reset:** 0x00

**Description:** System control register.

[7] SOFT RESET:

Writing '1' to this bit causes a soft reset  
Cleared by hardware.

[6] I2C\_SHDN:

Writing '1' to this bit shuts down the I2C block on the next valid I2C clock.  
In shut-down mode, only 2 possible ways exist to re-activate the device:

- Remove and reconnect Vcc
- Wake\_up through the GPIO\_0 pin if programmed as a hot-key and if Wakeup Enable bit of this register is enabled

All GPIO states remain the same on entering shut-down mode.

[5] Wakeup\_En:

Wakeup Enable bit  
'1' to enable GPIO\_0 as clock gating signal during shutdown  
'0' to disable the above

[4] RESERVED

[3] RESERVED

[2] INT\_Enable:

'1' to enable interrupt output  
'0' to disable interrupt output

When the interrupt output is disabled, it is in floating condition but it does not consume current

[1] RESERVED

[0] INT\_Polarity:

Interrupt polarity  
'1' for active High  
'0' for active LOW

# 6      Interrupt system

The STMPE1600 can be configured to generate an interrupt when there is a logic transition on any of the GPIO configured as an input.

IEGPOR

Interrupt enable GPIO mask register

|       |       |       |       |       |       |      |      |      |      |      |      |      |      |      |      |
|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|
| 15    | 14    | 13    | 12    | 11    | 10    | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
| IEG15 | IEG14 | IEG13 | IEG12 | IEG11 | IEG10 | IEG9 | IEG8 | IEG7 | IEG6 | IEG5 | IEG4 | IEG3 | IEG2 | IEG1 | IEG0 |
| RW    | RW    | RW    | RW    | RW    | RW    | RW   | RW   | RW   | RW   | RW   | RW   | RW   | RW   | RW   | RW   |

Address:0x08, 0x09

Type:RW

Reset:0x00

Description:Interrupt enable GPIO mask register (IEGPOR)  
The IEGPOR register is used to enable the interruption from a particular GPIO interrupt source to the host. The IEG[15:0] bits are the interrupt enable mask bits corresponding to the GPIO[15:0] pins.  
[15:0] IEG[x]: Interrupt enable GPIO mask (where x = 15 to 0)  
Writing a '1' to the IE[x] bit will enable the interruption to the host.

# 7 Interrupt status GPIO register (ISGPiOR)

## ISGPiOR Interrupt status GPIO mask register

| 15    | 14    | 13    | 12    | 11    | 10    | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|
| ISG15 | ISG14 | ISG13 | ISG12 | ISG11 | ISG10 | ISG9 | ISG8 | ISG7 | ISG6 | ISG5 | ISG4 | ISG3 | ISG2 | ISG1 | ISG0 |
| RW    | RW    | RW    | RW    | RW    | RW    | RW   | RW   | RW   | RW   | RW   | RW   | RW   | RW   | RW   | RW   |

**Address:** 0x0A, 0x0B

**Type:** RW

**Reset:** 0

**Description:** Interrupt status GPIO register (ISGPiOR)

The ISGPiOR register monitors the status of the interruption from a particular GPIO pin interrupt source to the host. Regardless of the IEGPiOR bits are enabled or not, the ISGPiOR bits are still updated. The ISG[15:0] bits are the interrupt status bits corresponding to the GPIO[15:0] pins.

[15:0] ISG[x]: Interrupt status GPIO (where x = 15 to 0)

Read:

Interrupt Status of the GPIO[x]. Reading the register will clear any bits that has been set to '1'

Write:

Writing to this register has no effects



## 8 GPIO controller

A total of 16 GPIOs are available in the STMPE1600 port expander IC. The GPIO controller contains the registers that allow the host system to configure each of the pins into either a GPIO (input or output), or into one of the alternate functions. Unused GPIOs should be configured as outputs to minimize the power consumption.

A group of registers are used to control the exact function of each of the 16 GPIOs. The registers and their respective address are listed in the following table.

**Table 8. GPIO controller registers**

| Address | Register name | Description                      | Auto-increment (during sequential R/W) |
|---------|---------------|----------------------------------|----------------------------------------|
| 0x10    | GPMR          | GPIO monitor pin state register  | Yes                                    |
| 0x12    | GPSR          | GPIO set pin state register      | Yes                                    |
| 0x14    | GPDR          | GPIO set pin direction register  | Yes                                    |
| 0x16    | GPPIR         | GPIO polarity inversion register | Yes                                    |

*Note:* Once the last register address 0x16-0x17 location is accessed, the locations of 0x18 to 0xFF are reserved. After 0xFF location, the pointer rolls over to the 0x00 register address location.

All GPIO registers are named as GPxx, where:

xx represents the functional group.

|       |       |       |       |       |       |      |      |      |      |      |      |      |      |      |      |
|-------|-------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|
| 15    | 14    | 13    | 12    | 11    | 10    | 9    | 8    | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    |
| IO-15 | IO-14 | IO-13 | IO-12 | IO-11 | IO-10 | IO-9 | IO-8 | IO-7 | IO-6 | IO-5 | IO-4 | IO-3 | IO-2 | IO-1 | IO-0 |

The function of each bit is shown in the following table:

**Table 9. GPIO bit function**

| 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 causes the corresponding GPIO to go to '0' state. |
| GPIO set pin direction  | '0' sets the corresponding GPIO to input state, and '1' sets it to output state. All bits are '0' on reset.                                         |
| GPIO polarity inversion | Writing a '1' enables polarity inversion on the Input Port. Writing a '0', the input port polarity is retained. The reset value is 0.               |

On power-up reset, all GPIOs are set as input.

## 9 Polarity inversion register

### PINV

### Polarity inversion register

| 15      | 14      | 13      | 12      | 11      | 10      | 9     | 8     | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|---------|---------|---------|---------|---------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| PINV 15 | PINV 14 | PINV 13 | PINV 12 | PINV 11 | PINV 10 | PINV9 | PINV8 | PINV7 | PINV6 | PINV5 | PINV4 | PINV3 | PINV2 | PINV1 | PINV0 |
| RW      | RW      | RW      | RW      | RW      | RW      | RW    | RW    | RW    | RW    | RW    | RW    | RW    | RW    | RW    | RW    |

**Address:** 0x16, 0x17

**Type:** RW

**Reset:** 0

**Description:** Polarity inversion register.

This register allows the user to invert the polarity of the input port register data. If a bit in this register is set (written with '1'), the Input Port Data polarity is inverted. If a bit in this register is cleared (written with a '0'), the Input Port Data polarity is retained. This is for Active HIGH or Active LOW operation register. The polarity of the read register can be inverted with this register.

[15:0] PINV[x]: Polarity inversion register (where x = 15 to 0)

Writing a '1' to the PINV[x] bit will enable polarity inversion on the Input Port. Writing a '0', the input port polarity is retained. The reset value is 0.

### 9.1 Power supply

The STMPE1600 operates with a single power supply VCC that ranges from 1.65V to 3.6V. The GPIO remains valid until the V<sub>CC</sub> is removed. When the V<sub>CC</sub> is removed, the GPIO is reset.

### 9.2 Reset

The STMPE1600 is equipped with an internal POR circuit that holds the device in reset state, until the V<sub>CC</sub> supply input is valid. The internal POR is tied to the V<sub>CC</sub> supply pin.

In the duration when reset pin is asserted, all GPIO are reset and default to input states.

## 9.3 Fail safe conditions

The STMPE1600\_I/Os (SDA, SCL, INT, A2, A1, A0) are fail-safe I/Os that support 4 mA current drive.

**Table 10. Fail safe conditions**

| V <sub>CC</sub> (core and IO supply) | Condition                     |
|--------------------------------------|-------------------------------|
| Present                              | Normal operating condition    |
| Absent                               | Complete power-down condition |

Note that “present” state implies that the supply is present. The “absent” state implies that the power is lost (grounded) condition. In the fail-safe condition, the leakage current flowing into the STMPE1600 device is prevented.

### Fail Safe condition

When chip supply is 0 V and when V<sub>IO</sub> (SDA, SCL, INT, A2, A1, A0) is 3.6 V, this is classified as a fail-safe condition. In this case, the chip is protected and the current per I/O is limited to a very small value.

### Overvoltage condition

The second condition is the overvoltage condition which occurs when V<sub>CC</sub> = 1.65 V and V<sub>IO</sub> = 3.6 V. In this condition, the current drawn by the device per IO can be 10 µA (typical) and 25 µA (worst case). This device should not be operated under this condition.

So it is recommended to operate the IO at the same voltage as the supply voltage (either 1.8 V or 3.3 V). Also the fail safe I/Os are special I/Os which can have a voltage present while the supply voltage V<sub>CC</sub> is 0 V. Current will be limited from the fail safe I/Os when supply voltage V<sub>CC</sub> is 0 V.

## 10 Maximum rating

Stressing the device above the ratings listed in the “Absolute maximum ratings” table may cause permanent damage to the device. These are stress ratings only, and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect the device’s reliability.

**Table 11. Absolute maximum ratings**

| Symbol           | Parameter                             | Value | Unit |
|------------------|---------------------------------------|-------|------|
| V <sub>CC</sub>  | Supply voltage                        | 4.5   | V    |
| V <sub>IO</sub>  | GPIO supply voltage                   | 4.5   | V    |
| V <sub>ESD</sub> | ESD protection on each GPIO pin (HBM) | 2     | kV   |

**Table 12. Thermal data**

| Symbol           | Parameter                           | Value      | Unit |
|------------------|-------------------------------------|------------|------|
| Θ <sub>JA</sub>  | Thermal resistance junction-ambient | TBD        | °C/W |
| T <sub>OPR</sub> | Operating temperature               | -40 to 85  | °C   |
| T <sub>J</sub>   | Storage temperature                 | -65 to 155 | °C   |

### 10.1 DC electrical characteristics

**Table 13. Supplies**

| Symbol                | Parameter                                                                       | Test conditions                                                                                                                      | Value |     |     | Unit |
|-----------------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------|-----|-----|------|
|                       |                                                                                 |                                                                                                                                      | Min   | Typ | Max |      |
| V <sub>CC</sub>       | Core supply voltage                                                             |                                                                                                                                      | 1.65  | –   | 3.6 | V    |
| I <sub>CC400kHz</sub> | Operating current with I <sup>2</sup> C CLK = 400 kHz with full traffic density | SCL_running at 400 kHz<br>V <sub>CC</sub> = 1.8 - 3.3 V<br>100% traffic density<br>I/O = inputs<br>No peripheral activity or no load | –     | 200 | 500 | μA   |
| I <sub>CC100kHz</sub> | Operating current with I <sup>2</sup> C CLK = 100 kHz with full traffic density | SCL running at 100 kHz<br>V <sub>CC</sub> = 1.8 - 3.3 V<br>100% traffic density<br>I/O=inputs<br>No peripheral activity or no load   | –     | 135 | 200 | μA   |

Table 13. Supplies (continued)

| Symbol               | Parameter                     | Test conditions                                                                                                                            | Value |      |     | Unit    |
|----------------------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-----|---------|
|                      |                               |                                                                                                                                            | Min   | Typ  | Max |         |
| $I_{CC(normal)}$     | Normal mode operating current | SCL running at 400KHz<br>$V_{CC}=1.8-3.3V$<br>1% traffic density<br>No peripheral activity or no load                                      | –     | 10   | 15  | $\mu A$ |
| $I_{CC(suspend)}$    | Standby operating current     | No $I^2C$ activity (SCL=0kHz)<br>$V_{CC} = 1.8 - 3.3 V$<br>$V_{inputs}=GND$ or $V_{CC}$<br>No peripheral activity or no load<br>I/O=inputs | –     | 0.25 | 1   | $\mu A$ |
| $I_{CC(powerdown)}$  | Power down current            | $I^2C$ block OFF<br>$V_{CC} = 1.8 - 3.3 V$                                                                                                 | –     | 0.25 | 1   | $\mu A$ |
| $I_{IO(fail\ safe)}$ | Fail-safe IO current          | $V_{CC}=0 V$<br>$V_{io} (fail\ safe)= 3.6 V$                                                                                               | –     | 0.25 | 1   | $\mu A$ |

Table 14. Input/outputs

| Sym bol    | Parameter                  | Test conditions                              | Value        |     |              | Unit    |
|------------|----------------------------|----------------------------------------------|--------------|-----|--------------|---------|
|            |                            |                                              | Min          | Typ | Max          |         |
| $V_{IL}$   | Input voltage low state    | $V_{CC} = 1.65 - 3.6 V$                      | –            | –   | $0.2V_{CC}$  | V       |
| $V_{IH}$   | Input voltage high state   | $V_{CC} = 1.65 - 3.6 V$                      | $0.8V_{CC}$  | –   | –            | V       |
| $V_{hyst}$ | Schmitt trigger hysteresis |                                              |              | 0.2 | –            | V       |
| $I_{IL}$   | Input low leakage current  | $V_I = GND$                                  | –            | –   | 1            | $\mu A$ |
| $I_{IH}$   | Input high leakage current | $V_I = V_{CC}$                               | –            | –   | -1           | $\mu A$ |
| $V_{OL}$   | Output voltage low state   | $V_{CC} = 1.65 - 3.6 V$ ,<br>$I_{OL} = 8 mA$ | –            | –   | $0.15V_{CC}$ | V       |
| $V_{OH}$   | Output voltage high state  | $V_{CC} = 1.65 - 3.6 V$ ,<br>$I_{OL} = 8 mA$ | $0.85V_{CC}$ | –   | –            | V       |

**Table 15. Digital inputs (A2, A1, A0 pins)**

| Symbol   | Parameter                | Test conditions       | Value              |     |                    | Unit |
|----------|--------------------------|-----------------------|--------------------|-----|--------------------|------|
|          |                          |                       | Min                | Typ | Max                |      |
| $V_{IL}$ | Low-level input voltage  |                       | –                  | –   | 0.2V <sub>CC</sub> | V    |
| $V_{IH}$ | High-level input voltage |                       | 0.8V <sub>CC</sub> | –   | –                  | V    |
| $I_L$    | Leakage current          | $V_I = V_{CC}$ or GND | -1                 | –   | 1                  | μA   |

**Table 16. Interrupt (INT pin)**

| Symbol   | Parameter                           | Test conditions                            | Value               |     |                     | Unit |
|----------|-------------------------------------|--------------------------------------------|---------------------|-----|---------------------|------|
|          |                                     |                                            | Min                 | Typ | Max                 |      |
| $I_{OL}$ | Open-drain low-level output current | $V_{OL} = 0.4$ V                           | –                   | 4   | –                   | mA   |
| $V_{OL}$ | Output voltage low state            | $V_{CC} = 1.8 - 3.3$ V,<br>$I_{OL} = 4$ mA | –                   | –   | 0.15V <sub>CC</sub> | V    |
| $V_{OH}$ | Output voltage high state           | $V_{CC} = 1.8 - 3.3$ V,<br>$I_{OL} = 4$ mA | 0.85V <sub>CC</sub> | –   | –                   | V    |

**Table 17. Input (SCL), Input/Output (SDA)**

| Symbol                         | Parameter                 | Test conditions                            | Value               |     |                     | Unit |
|--------------------------------|---------------------------|--------------------------------------------|---------------------|-----|---------------------|------|
|                                |                           |                                            | Min                 | Typ | Max                 |      |
| $V_{IL}$                       | Low-level input voltage   |                                            | –                   | –   | 0.2V <sub>CC</sub>  | V    |
| $V_{IH}$                       | High-level input voltage  |                                            | 0.8V <sub>CC</sub>  | –   | –                   | V    |
| $I_L$                          | Leakage current           | $V_I = V_{CC}$ or GND                      | -1                  | –   | 1                   | μA   |
| $V_{OL}$<br>(I <sup>2</sup> C) | Output voltage low state  | $V_{CC} = 1.8 - 3.3$ V,<br>$I_{OL} = 4$ mA | –                   | –   | 0.15V <sub>CC</sub> | V    |
| $V_{OH}$<br>(I <sup>2</sup> C) | Output voltage high state | $V_{CC} = 1.8 - 3.3$ V,<br>$I_{OL} = 4$ mA | 0.85V <sub>CC</sub> | –   | –                   | V    |

## 11 Package mechanical data

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 6. Package outline for QFN24 (4 x 4 x 1 mm) - 0.5 mm pitch**

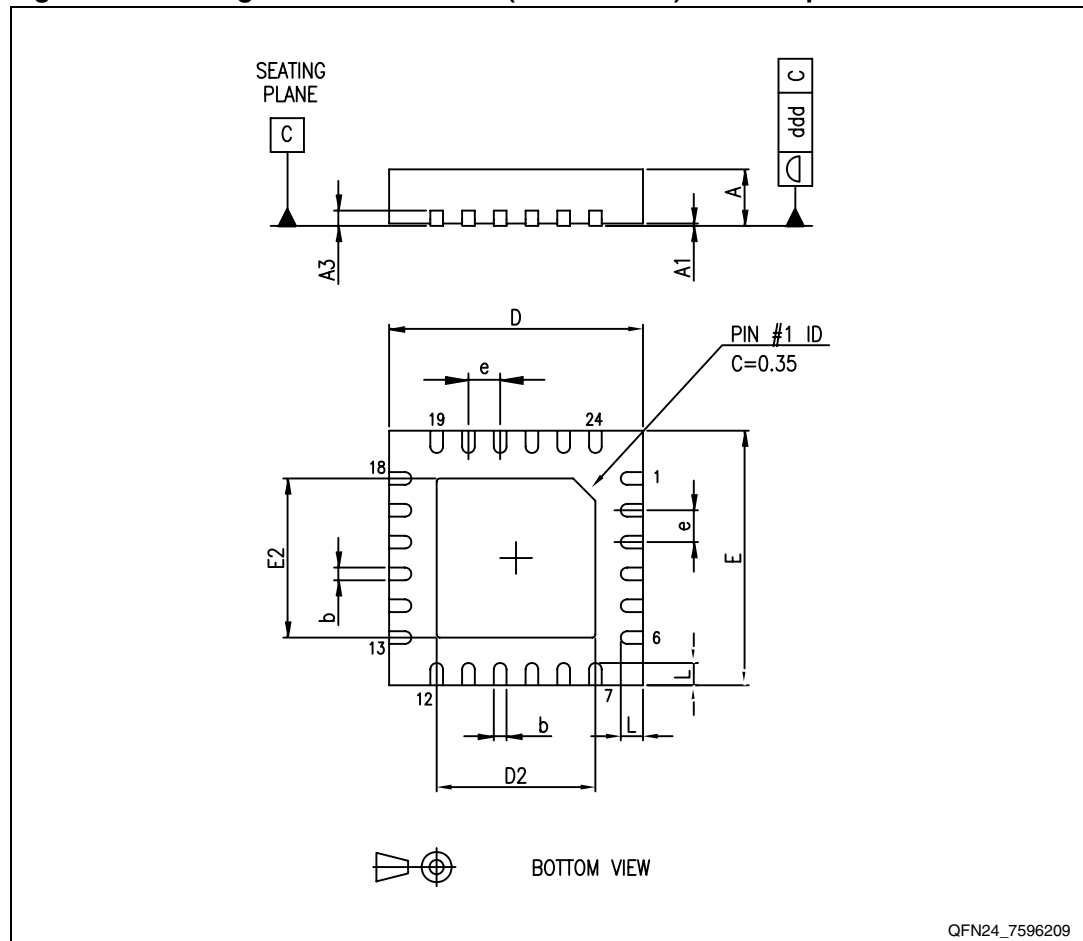
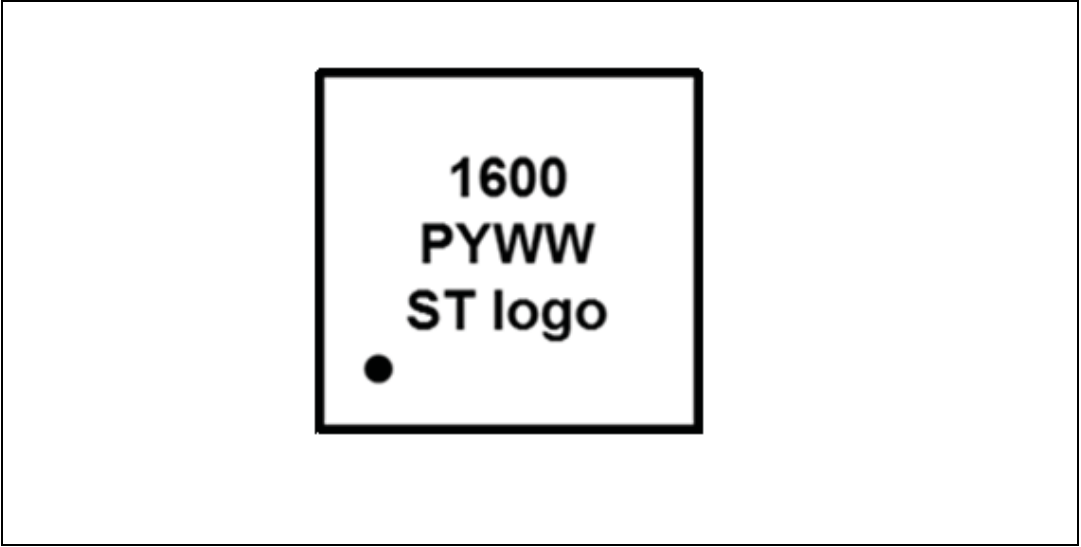


Table 18. Package mechanical data for QFN24 (4 x 4 x 1 mm) - 0.5 mm pitch

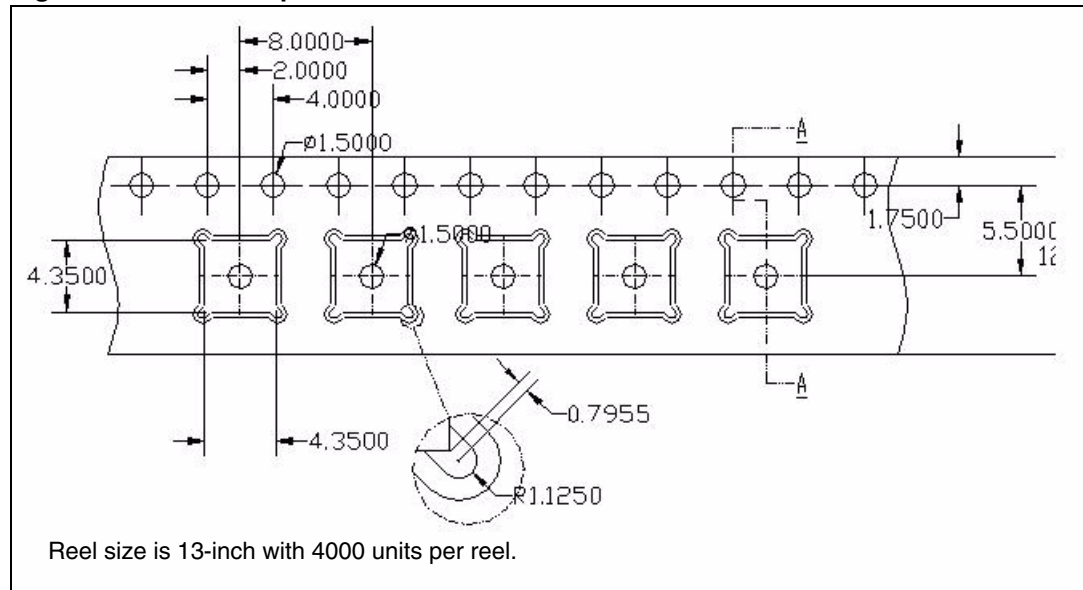
| Symbol | Millimeters |      |      |
|--------|-------------|------|------|
|        | Min         | Typ  | Max  |
| A      | 0.80        | 0.90 | 1.00 |
| A1     | 0.00        | 0.02 | 0.05 |
| A3     | –           | 0.20 | –    |
| b      | 0.18        | 0.25 | 0.30 |
| D      | 3.85        | 4.00 | 4.15 |
| D2     | 2.40        | 2.50 | 2.60 |
| E      | 3.85        | 4.00 | 4.15 |
| E2     | 2.40        | 2.50 | 2.60 |
| e      | –           | 0.50 | –    |
| L      | 0.30        | 0.40 | 0.50 |
| ddd    | –           | –    | 0.08 |

Figure 7. STMPE1600 top side marking information

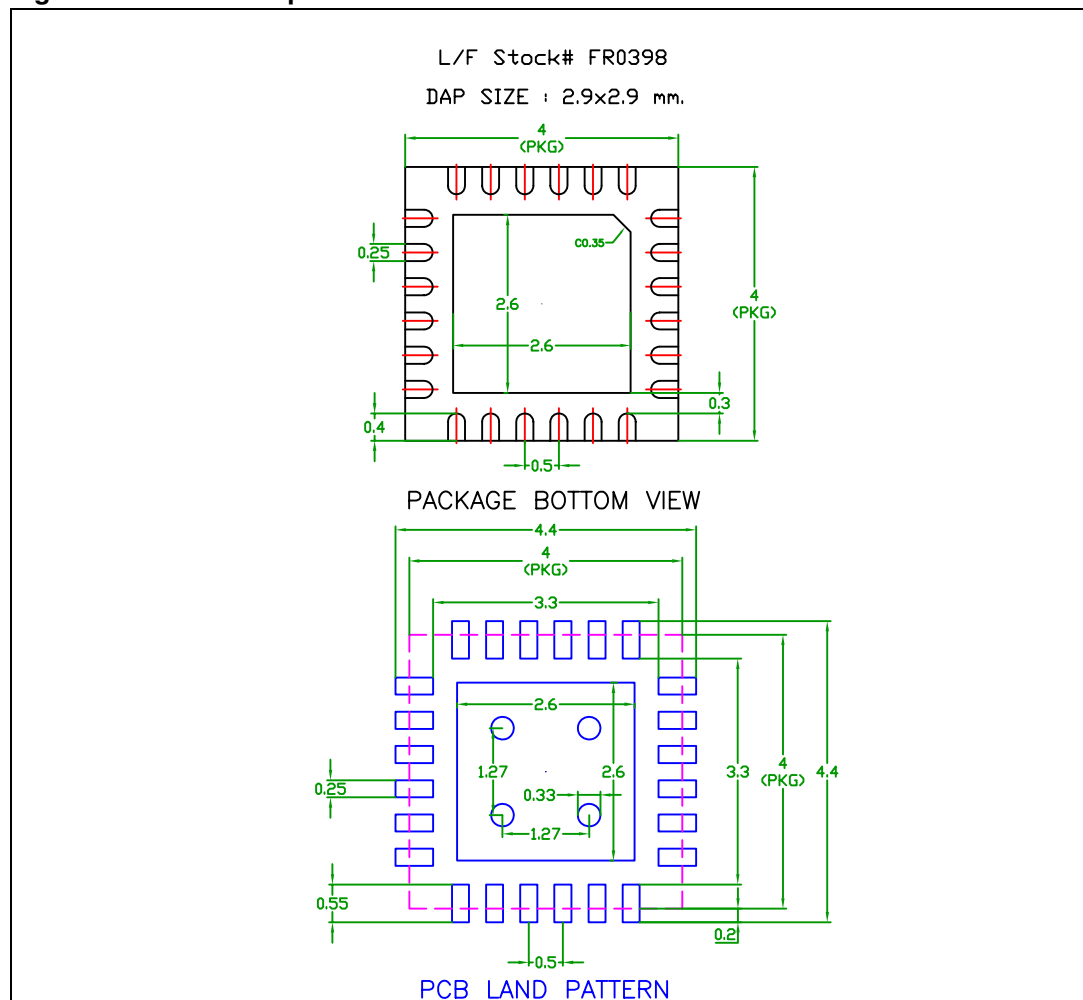




### Figure 8. Carrier tape and reel info



**Figure 9. PCB land pattern**



## 12 Revision history

**Table 19. Document revision history**

| Date        | Revision | Changes                                                                   |
|-------------|----------|---------------------------------------------------------------------------|
| 26-Mar-2010 | 1        | Initial release.                                                          |
| 08-Jan-2013 | 2        | Document status has been promoted from “Preliminary data” to “Datasheet”. |
| 05-Feb-2013 | 3        | Updated <a href="#">Figure 7</a> .                                        |

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