SX8722 operating modes
Current consumption and timings

Technical note TN8722.01

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1 Introduction

This document is provided to you as a complement to the datasheet. It is a guideline to set up SX8722 in its different operating modes and sums up the corresponding current consumptions and timings.

It is recommended to go though the datasheet first so as to have a detail description of SX8722

1.1 What is SX8722?

SX8722 main function is analog signal acquisition from Wheatstone bridges or single ended sensors. The input can be a pressure sensor, a GMR or AMR magnetic sensor, a chemical sensor, a thermistor or a mix of several of these sensors.

SX8722 Sensor interface is totally configurable through an I^2C compatible interface. Several parameters are configurable through this interface such as alarms or signal post processing.

SX8722 has three operating modes:

- **active mode**
- **sleep mode**
- **shutdown mode**

The different modes are controlled by the embedded program and these are described in this document.

1.2 Documentation about the SX8722

The following documents about SX8722 and the tools are also available:

- SX8722 Datasheet
- SX8722 Errata
- XE8000EV120 Users Guide
- XE8000EV120 Interfacing your first pressure sensor

1.3 SX8722 state diagram

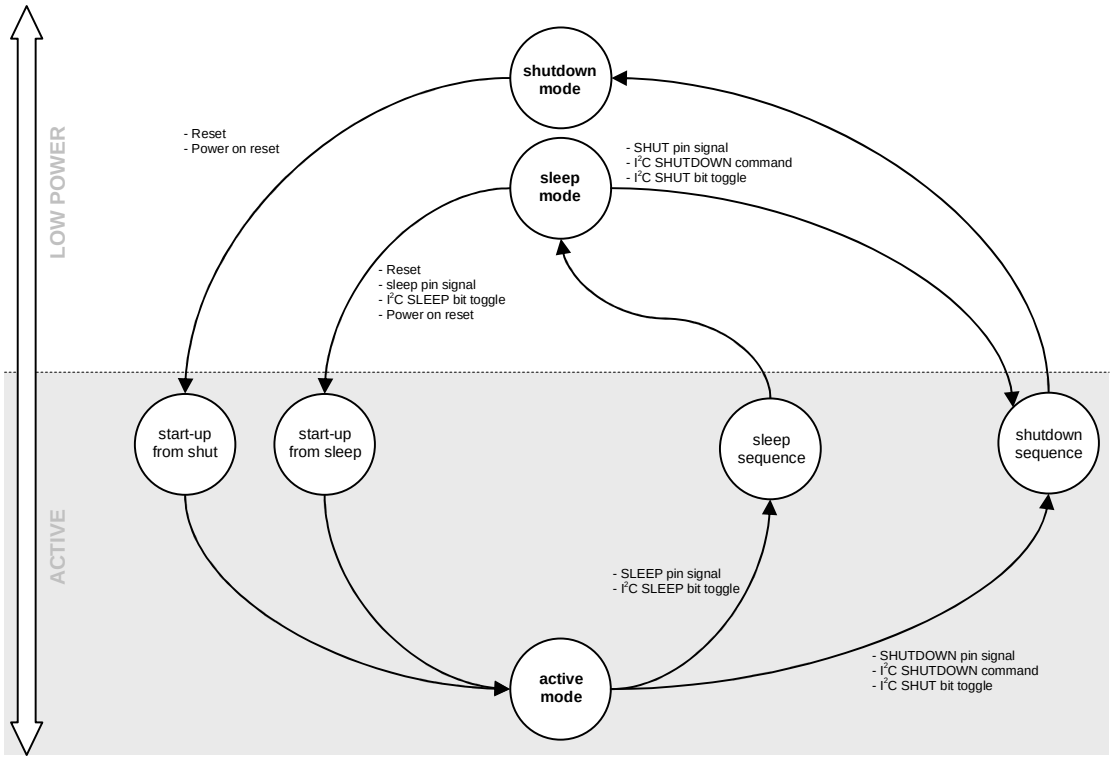

Figure 1: SX8722 mode state diagram

The transition states:

Start-up from shutdown:
- Initializes the SX8722
- Load EEPROM if present
- Restores EEPROM configuration and set the SX8722

Start-up from sleep:
- Restores the RC active value
- Enables VLD
- Restores SX8722 configuration saved in RAM

Sleep sequence:
- Waits for I^2C STOP sequence
- Stops the ADC
- Disable VLD
- Bias current off
- Set the clock to RC minimum value or to Xtal if present
- asm “HALT”

Shutdown sequence:
- Waits for I^2C STOP sequence
- Stops the ADC
- Disable VLD
- Bias current off
- Stops the SX8722

The timing of the transition states depends mainly on the Xtal presence, the EEPROM presence and if the transition is caused by an I^2C command or by a pin signal (SLEEP, SHUT, RESET).

See time specification chapter in this document and SX8722 datasheet for more information.

2 Active mode

In this chapter you will find:

- The description of the active mode
- The operating specifications
- How to set SX8722 in active mode

2.1 Description

In active mode, SX8722 and all its peripherals can work and execute the embedded program. The acquisition chain, the alarms and the signal post processing can be activated and parameterized.

2.2 Operating specifications

2.2.1 Pin activity

SX8722 generates pulses on the pin READY in active mode.

At 1.8 MHz RC with the external 32.768 kHz Xtal, a pulse of 3µs occurs every 36ms..

The READY pin generates a single signal used to interrupt the host microcontroller when a new sample value is available on SX8722 output register.

This signal can be used to verify that SX8722 is in active mode.

2.2.2 External 32k Xtal

If there is no external Xtal and if no calibration is needed, the CAL pin must be connected to Vss for SX8722 to operate.

If there is an external Xtal, the CAL pin must be connected to Vbat.

2.2.3 Internal voltage multiplier enabled below 3V VDD

An internal voltage multiplier (VMULT) is automatically enabled when the power supply goes below 3 Volts to power the ZoomingADC™, and this internal voltage multiplier requires an external capacitor from the VMULT pin to the ground. The value of this capacitor must be between 1 and 3nF.

2.2.4 I^2C communication

10kΩ pull up resistors are necessary on SCL and SDA as mentioned in the I^2C protocol specification. Pull-up resistors on EE_SDA and EE_SCL pins are necessary for EEPROM communication too.

The SDA and SCL IO are open collectors when waiting for communication.

EE_SDA and EE_SCL are grounded. In this case SX8722 is the master and these signals are active only at start-up to load a configuration or when a SAVE/LOAD EEPROM command is received by the SX8722.

The EEPROM is powered by the EE_POWER pin of SX8722 only

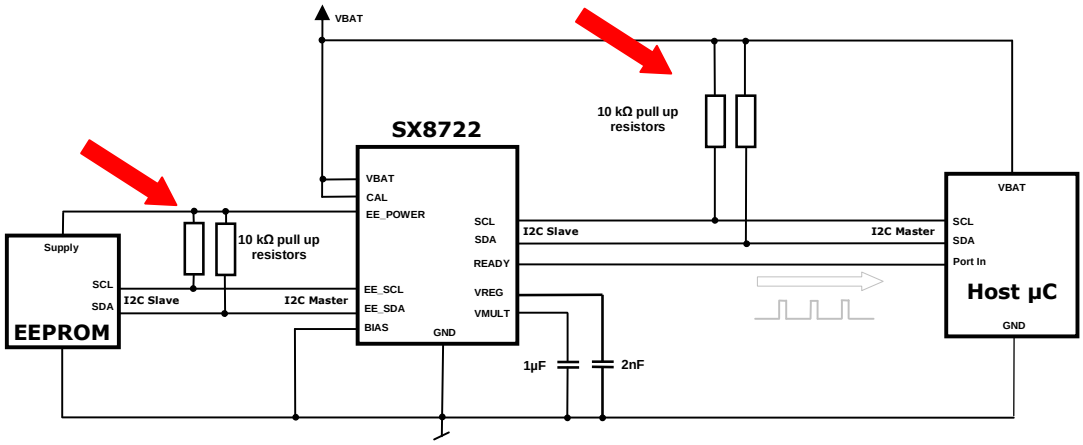

Figure 2: pull-up resistor on I²C wire

2.2.5 SX8722 current consumption

SX8722 mean current consumption in active mode is around 200 [µA], without enabled PGA. The value of the gain of de PGA can have a negligible influence on consumption in active mode.

Additional consumption depends on the active PGA and on the bias current parameter.

	I_{PGA1} [µA]	I_{PGA2} [µA]	I_{PGA3} [µA]
bias 25%	50	40	50
bias 50%	95	75	98
bias 75%	140	110	145
bias 100%	185	145	190

Table 1: PGA current consumption in [µA]

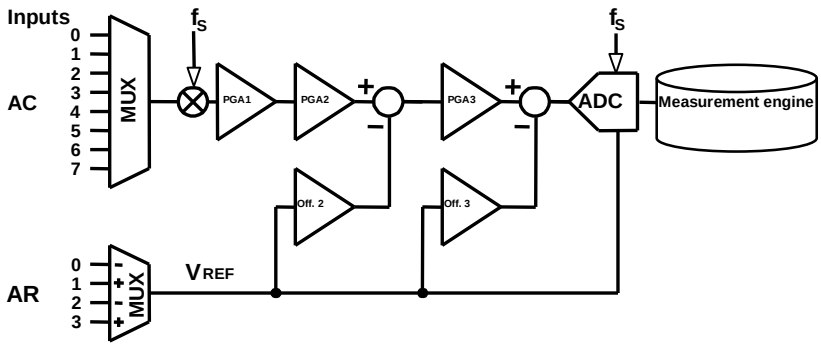

Figure 3: acquisition chain

2.2.5.1 Example 1

Bias current: 25%

PGA1: enabled
PGA2: enabled
PGA3: enabled

SX8722 measured current consumption: ~330 µA

2.2.5.2 Example 2

Bias current: 100%

PGA1: enabled
PGA2: enabled
PGA3: enabled

SX8722 measured current consumption: ~710 µA

2.3 How to set SX8722 in active mode

2.3.1 Start-up

At start-up SX8722 is automatically set in active mode.
If there is no EEPROM configuration loaded at start-up, PGA are not active.

2.3.2 From Sleep mode

- Positive pulse on RESET pin
- Negative pulse on the SLEEP pin
- SLEEP bit toggle in the SXCtrl1 register (I^2C write mask command)
- Other interruption

2.3.3 From Shutdown mode

- Positive pulse on RESET pin
- Power-on-reset (negative pulse on VBAT pin)

3 Sleep mode

In this chapter you will find:

- The description of the sleep mode
- The operating specifications in sleep mode
- How to set SX8722 in sleep mode

3.1 Description

The sleep mode is a low power mode. It can be called by an I^2C sequence or by sending a negative pulse to SX8722 SLEEP pin.

3.2 Operating specifications of the sleep mode

3.2.1 Summary

- SX8722 configuration saved in RAM
- ADC stopped
- VLD stopped (voltage level detector)
- If Xtal present, clock set to Xtal 32k
- If Xtal not present, clock set to RC minimum value (~80kHz)
- Bias current off
- Program HALT, SX8722 needs an interrupt to wake up (I^2C communication, SLEEP pin signal, reset, etc).

3.2.2 SX8722 sleep current consumption below 3V Vbat

Below 3 Volts SX8722 enables the internal voltage multiplier to power the ZoomingADC™. This internal voltage multiplier is automatically enabled when the power supply goes below 3V Vbat.

This voltage multiplier increases SX8722 consumption. This is why the chip consumption in sleep mode with 2.5V supply is higher than with 5.5V supply.

There is a possibility to consume less current when the Vbat voltage is lower than 3V: the SLEEP signal has to be sent to the SLEEP pin when Vbat is higher than 3V, and then decrease the Vbat value. In this case, the voltage multiplier is not activated.

3.2.3 SX8722 sleep current consumption with the 32.768 kHz Xtal

The sleep mode current consumption with the presence of the 32.768 kHz Xtal is around 1µA if the supply voltage is above 3V. Below 3V, the current consumption is around 4 µA because the VMULT is enabled.

In addition to set the precise RC frequency, the presence of an external 32.768 kHz Xtal allows SX8722 sleep current consumption 3x lower than without the Xtal.

In this case SX8722 main clock is generated by the Xtal.

3.2.4 SX8722 sleep current consumption without the 32.768 KHz Xtal

The current consumption in sleep mode without the 32.768 kHz Xtal is around 3 µA if the supply voltage is above 3V. Below 3V, the current consumption is around 9 µA because the voltage multiplier is enabled. The RC min frequency is set and its value is around 80 kHz.

3.2.5 Current consumption measurements results

Vbat [V]	Temp. [°C]	I_{SLEEP} [µA]	I_{SLEEP}(1) [µA]	I_{SLEEP} [µA] with Xtal	I_{SLEEP} [µA] with Xtal(1)
2.5	-40	7.69	2.69	3.028	0.988
	25	8.792	2.844	3.864	1.062
	85	9.536	2.976	4.362	1.264
5.5	-40	2.84	6.58	0.998	3.28
	25	3.024	7.538	1.074	4.158
	85	3.196	8.146	1.292	4.426

Table 2: sleep mode current consumption

(1) **Indirect measurement:** the SLEEP signal is sent on SLEEP pin, and then the Vbat voltage is changed. The 5.5V orange cases have not real application. The voltage multiplier is forced on.

As indicated in the table, the sleep mode current consumption is around 3 times lower with a Xtal presence.

3.3 How to set SX8722 in sleep mode

3.3.1 I²C sleep

Through the I²C interface, send a write mask command at address 00 and toggle the SLEEP bit of the SXCtrl1 register.

I2C SEQUENCE:

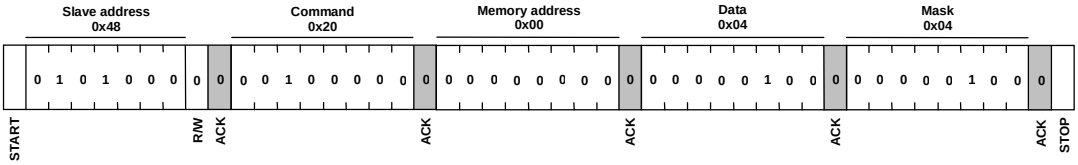

Figure 4: I2C sequence to set in sleep mode

When SX8722 is in sleep mode, send a write mask command at address 00 and toggle the SLEEP bit to restore SX8722 active mode.

I2C SEQUENCE:

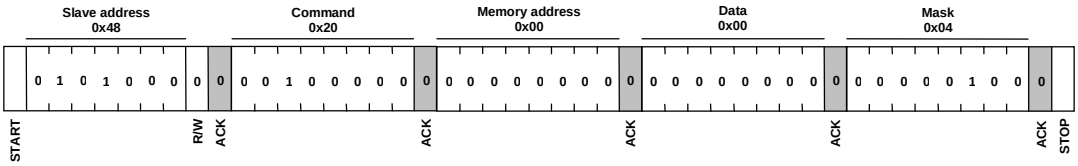

Figure 5: I2C sequence to wake up from sleep mode

WARNING: The I²C SLEEP command does not allow reaching as low current consumption as the SLEEP pin command or writing the SXCtrl1 register SLEEP bit.

The sleep mode called by I²C SLEEP command (0x40) has a current consumption around 80µA.

3.3.2 SLEEP pin

Put the SLEEP input signal to VSS, the SLEEP input is active on negative edge.

3.3.3 Is SX8722 in SLEEP mode?

There are pulses on the READY pin in active mode every 36ms. In sleep mode there is no pulse on the READY pin.

3.3.4 Wake up from sleep mode to active mode

In sleep mode the internal program is in “HALT” assembler equivalent mode. The SLEEP bit toggling in SXCtrl1 or a signal on the SLEEP pin can wake up the SX8722.

See active mode section for more information.

4 Shutdown mode

In this chapter you will find:

- The description of the shutdown mode
- The operating specifications
- How to set SX8722 in shutdown mode

4.1 Description

This is a very low-power mode because all circuit clocks and all peripherals are stopped. Only some service blocks remain active.

4.2 Operating specifications in shutdown mode

4.2.1 Summary

- ADC stopped
- VLD stopped
- If Xtal present, clock set to Xtal 32k
- If Xtal not present, clock set to RC minimum value (~80kHz)
- Bias current off
- Program HALT, interrupt off
- No possible I^2C communication.

4.2.2 Internal voltage multiplier

Like in sleep mode, internal voltage multiplier is automatically enabled when the power supply goes below 3 Volts but the internal voltage multiplier requires an external capacitor between VMULT pin and Vss, the value of this capacitor must be between 1 and 3nF.

4.2.3 Shutdown mode current consumption

The current consumption in shutdown mode is around 0.5 µA if the supply voltage is above 3V. Below 3V, the current consumption is around 3.5 µA because the voltage multiplier is enabled.

4.2.4 Current consumption measurements results

voltage [V]	temperature [°C]	I_{SHUT} [µA]	$I_{SHUT}^{(1)}$ [µA]
2.5	-40	2.6	0.492
	25	3.478	0.53
	85	3.628	0.69
5.5	-40	0.5	2.85
	25	0.54	3.63
	85	0.73	3.538

Table 3: shutdown mode current consumption

(1) Indirect measurement: at first, the signal command is set on the SHUTDOWN pin, and then the supply voltage is changed, from 5.5V to 2.5V or from 2.5V to 5.5V.

The 5.5V orange cases have not real application. The voltage multiplier is forced on.

4.2.5 How to set shutdown mode consumption around 0.5µA

By default, with a supply voltage below 3V the shutdown mode current is around 3.5µA. To obtain 0.5µA consumption, the shut command (I2C, pin) has to be received by the SX8722 when the internal voltage multiplier is not enabled. It means when the supply voltage is above 3V.

Then, if the supply voltage is lowered under 3V, the SX8722 will conserve the 0.5µA consumption.

4.3 How to set SX8722 in shutdown mode

4.3.1 I²C Shutdown command

Send the 0x50 command through the I²C interface.

I2C SEQUENCE:

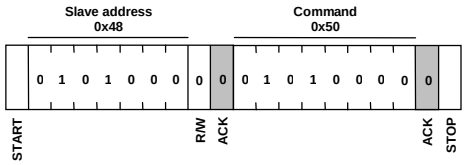

Figure 6: I2C command to set in shutdown mode

4.3.2 I²C SHUT bit toggle

Through the I²C interface, send a write mask command at address 00 and toggle the SHUT bit of the SXCtrl1 register.

I2C SEQUENCE:

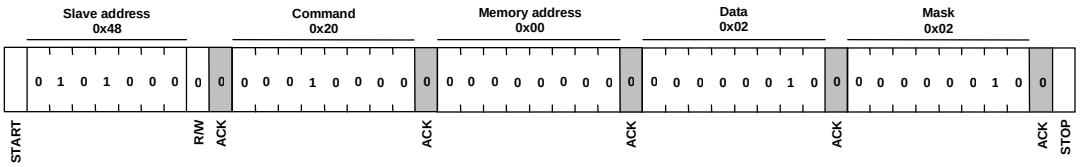

Figure 7: I2C sequence to set in shutdown mode

4.3.3 SHUT pin

Put the SHUT input signal to VSS, the SHUT input is active on negative edge.

4.3.4 Wake-up from shutdown mode to active mode

There are two possible ways to wake-up from the shutdown mode:

- The POR (power-on-reset caused by a power-down followed by power-on).
- The RESET pin.

In both case the RAM information is lost. SX8722 configuration must be restored from the EEPROM saved configuration.

4.3.5 Change from shutdown mode to sleep mode

This is not possible.

5 Time specifications

In this chapter you will find:

- The start-up time specification of the SX8722.
- The time values to change the mode of SX8722 with the 32k Xtal presence

5.1 Time specification without the 32.768 kHz Xtal

The internal SX8722 RC oscillator accuracy depends on technology tolerance. It can reach ± 50% difference from one chip to another

In this case, and if no calibration is done, the clock is centred around 1.2 MHz.

SX8722 timing values without Xtal can thus differ of ± 50% to these with a Xtal.

5.2 Start-up time with the 32.768 kHz Xtal presence

The mean time of EEPROM loading at the start-up is 140 ms if configuration data are saved in.
In this case SX8722 will provide the first sample after 180ms.

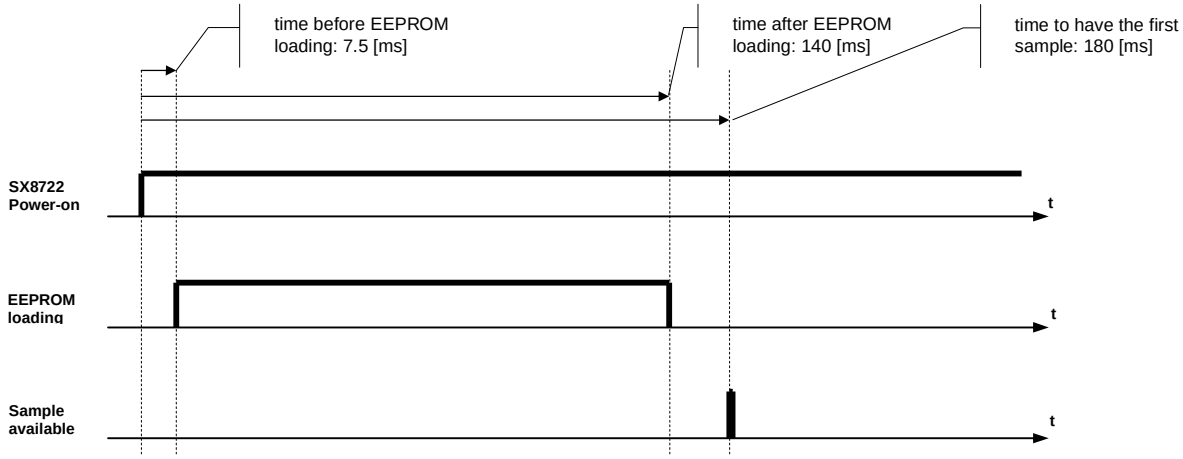

Figure 8: start-up timing diagram with EEPROM loading

5.3 Changing mode by pin signal

↓To \ From →	SHUT	SLEEP	ACTIVE
SHUT		640 ms	650 ms
SLEEP			660 ms
ACTIVE	inst. (1)	inst. (1)	

Table 4: changing mode timings by pin setting

5.4 Changing mode by I²C command

↓To \ From →	SHUT	SLEEP	ACTIVE
SHUT		700 µs	700 µs
SLEEP			470 µs
ACTIVE		inst.(1)	

Table 5: changing mode timings by I²C command

(1) instantaneous

We consider the ACTIVE mode as NOT low power mode. When time to change mode is instantaneous, it doesn't means that the chip is totally ready to work. There are for examples initialization times, EEPROM loading or code execution.

We consider the transition time as not low power.

6 ANNEXE

In this chapter you will find:

- The average result of SX8722 current measurements.

Vdd [V]	temperature [°C]	I_{SLEEP} [µA]	I_{SLEEP} (1) [µA]	I_{SLEEP} [µA] with XTAL	I_{SLEEP} [µA] with XTAL(1)	I_{SHUT} [µA]	I_{SHUT} (1) [µA]	I_{ACTIVE} (2) [µA]
2.5	-40	7.69	2.69	3.028	0.988	2.6	0.492	176.6
	25	8.792	2.844	3.864	1.062	3.478	0.53	205.8
	85	9.536	2.976	4.362	1.264	3.628	0.69	227.1
5.5	-40	2.84	6.58	0.998	3.28	0.5	2.85	178.8
	25	3.024	7.538	1.074	4.158	0.54	3.63	212.8
	85	3.196	8.146	1.292	4.426	0.73	3.538	233.8

Table 6: average current measurements

(1) Indirect measurement: at first, the signal command is set on the pin, and then the supply voltage is changed. The 5.5V orange cases have not real application. The voltage multiplier is forced on.

(2) The measurements are done without activating the PGAs.

7 TAPE & REEL SPECIFICATION

7.1 MLP/QFN (0.70mm - 0.90mm package thickness)

- Single Sprocket holes
- Tolerances for Ao & Bo are +/- 0.20mm
- Tolerances for Ko is +/- 0.10mm
- Tolerance for Pocket Pitch is +/- 0.10mm
- Tolerance for Tape width is +/-0.30mm
- Package Orientation and Feed Direction

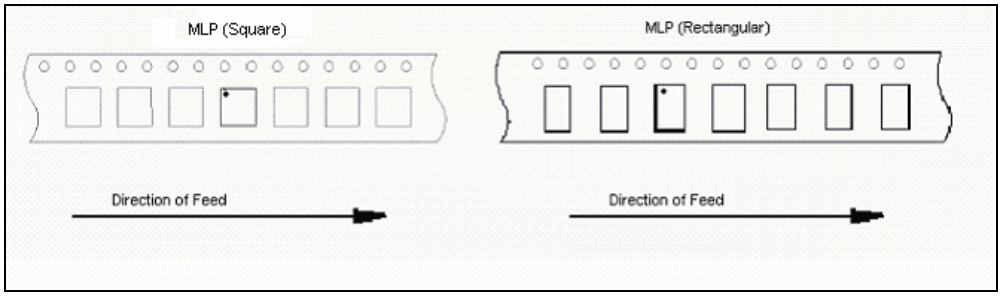

Figure 9: Direction of feed

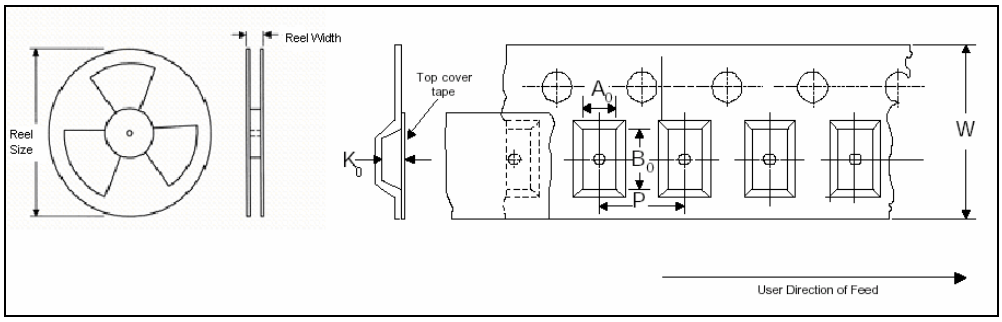

Figure 10: Tape and reel

Pkg size	carrier tape (mm)					Reel				
	Tape Width (W)	Pocket Pitch (P)	Ao	Bo	Ko	Reel Size (in)	Reel Width (mm)	Trailer Length (mm)	Leader Length (mm)	QTY per Reel
8x8	16	12	8.30	8.30	1.10	13	16.4	400	400	3000

Table 7: Tape and reel dimensions

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	Fax: 86-21-6391-0831		Fax: 33-(0)169-28-12-98
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