AN2579
Application note

LIS302DL 3-axis digital MEMS accelerometer translates finger taps into actions

Introduction

This document is intended to provide application information for the LIS302DL low-voltage 3-axis digital output linear MEMS accelerometer housed in an LGA package.

The LIS302DL is an ultra-compact low-power 3-axis linear accelerometer that includes a sensing element and an IC interface capable taking information from the sensing element and providing the measured acceleration data to external applications via an I2C/SPI serial interface.

The sensing element used to detect acceleration is manufactured using a dedicated process developed by ST to produce inertial sensors and actuators in silicon.

The IC interface is instead manufactured using a CMOS process that allows a high level of integration to design a dedicated circuit which is factory trimmed to better match the sensing element characteristics.

The LIS302DL has a user-selectable full scale of ±2g and ±8g and is capable of measuring accelerations with an output data rate of 100 Hz or 400 Hz. A self-test capability allows the user to check that the system is operating correctly.

The device features two independent, highly programmable interrupt sources that can be configured either to generate an inertial wake-up interrupt signal when a programmable acceleration threshold is exceeded along one of the three axes, to detect a free-fall or to recognize single/double click events.

Two independent pins can be configured to provide interrupt signals to connected devices.

The LIS302DL is available in a plastic SMD package and is designed to operate over a temperature range extending from -40 °C to +85 °C.

The ultra small size and weight of the SMD package make it an ideal choice for handheld portable applications such as cell phones and PDAs, or any other application where reduced package size and weight are required.

Contents

1 Theory of operation

The single click and double click recognition functions featured in the LIS302DL help to create a man-machine interface with little software loading. The device can be configured to output an interrupt signal on a dedicated pin when tapped in any direction.

If the sensor is exposed to a single input stimulus, it generates an interrupt request on inertial interrupt pin INT1 and/or INT2. A more advanced feature allows the generation of an interrupt request when a double input stimulus with programmable time between the two events is recognized, enabling a mouse button-like functionality.

This function can be fully programmed by the user in terms of expected amplitude and timing of the stimuli by means of the dedicated set of registers described in *Chapter 2: Register description*.

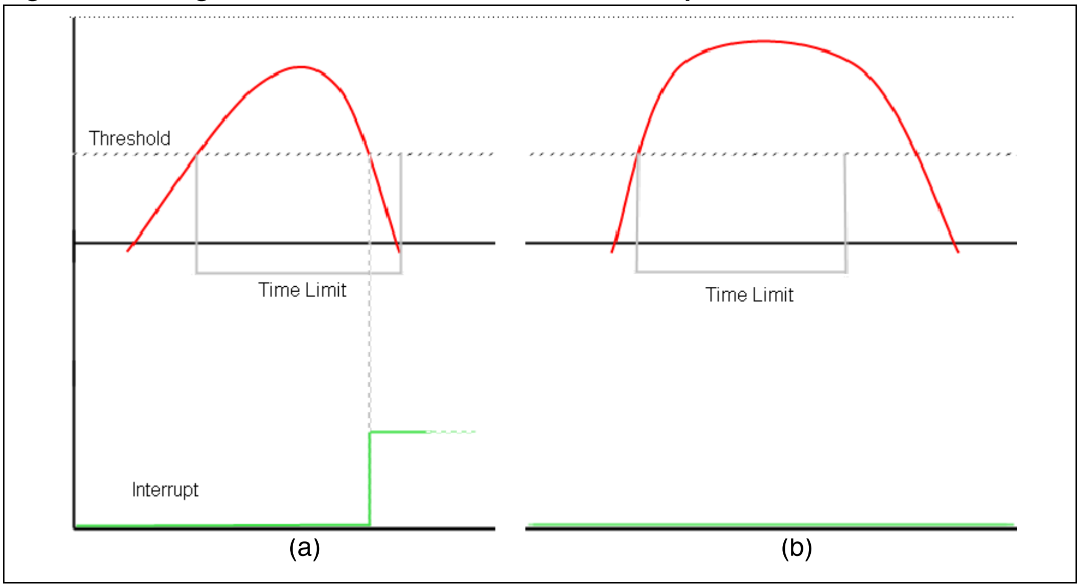
The single and double click recognition works independently on the selected output data rate.

1.1 Single click

If the device is configured for single click event detection, an interrupt is generated when the input acceleration on the selected channel exceeds the programmed threshold, and returns below it within a time window defined by the TimeLimit register.

If the LIR bit of the CLICK_CFG register is not set, the interrupt is kept high for the duration of the Latency window. If the LIR bit is set, the interrupt is kept high until the CLICK_SRC register is read.

Figure 1. Single click event with non latched interrupt



In *Figure 1*(a) the click has been recognized, while in *Figure 1*(b) the click has not been recognized because the acceleration goes under the threshold after the TimeLimit has expired.

1.2 Double click

If the device is configured for double click event detection, an interrupt is generated when, after a first click, a second click is recognized. The recognition of the second click occurs only if the event satisfies the rules defined by the Latency and Windows registers.

In particular, after the first click has been recognized, the second click detection procedure is delayed for an interval defined by the Latency register. This means that after the first click has been recognized, the second click detection procedure will start only if the input acceleration exceeds the threshold after the Latency window but before the Window has expired [*Figure 2*(a)] or if the acceleration is still above the threshold after the Latency has expired [*Figure 3*(b)].

Once the second click detection procedure is initiated, the second click will be recognized with the same rule as the first: the acceleration must return below the threshold before the TimeLimit has expired.

Appropriately defining the Latency window is important to avoid unwanted clicks due to spurious bouncing of the input signal.

Figure 2. Single and double click recognition

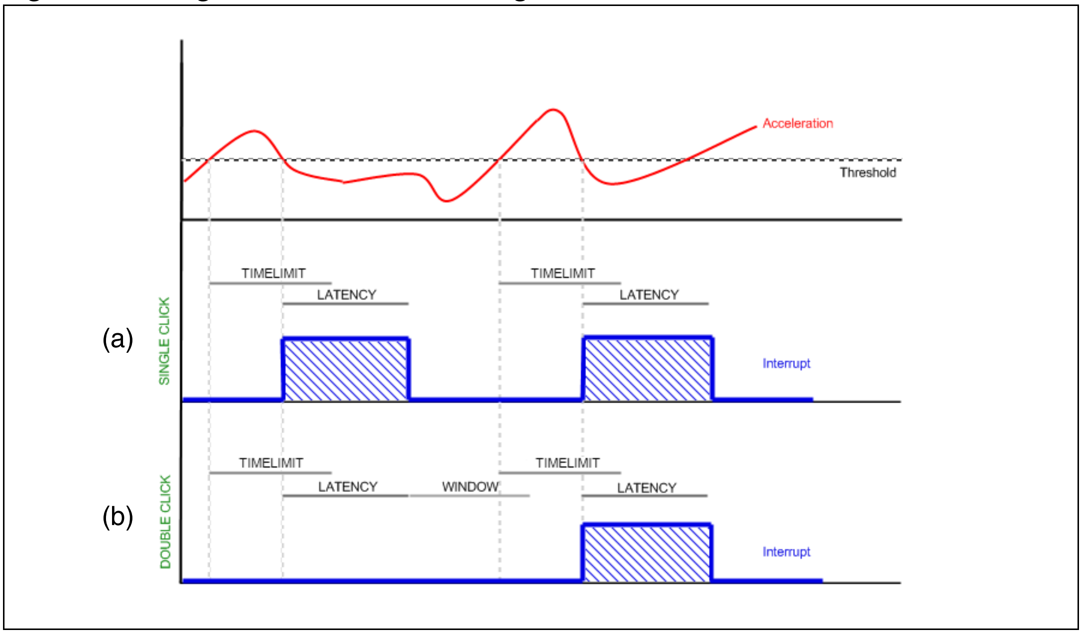
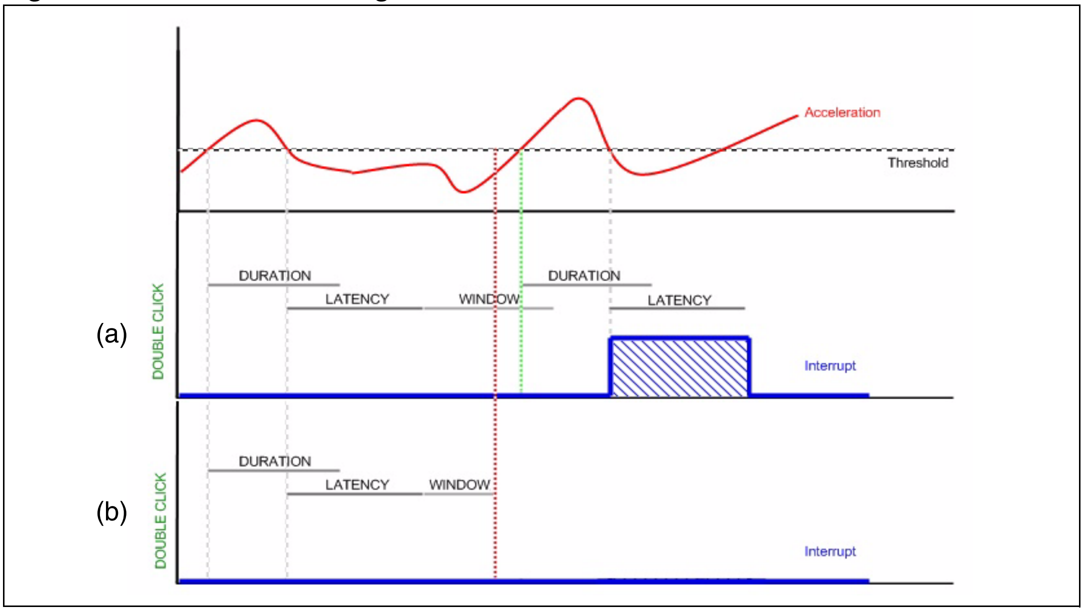


Figure 2 illustrates a single click event (a) and a double click event (b). The device is able to distinguish between (a) and (b) by changing the settings of the CLICK_CFG register from single to double click recognition.

Figure 3. Double click recognition



In *Figure 3*(a) the double click event has been correctly recognized, while in *Figure 3*(b) the interrupt has not been generated because the input acceleration exceeds the threshold after the Window interval has expired.

2 Register description

2.1 CLICK_CFG (38h)

Table 1. Register

-	LIR	Double_Z	Single_Z	Double_Y	Single_Y	Double_X	Single_X

Table 2. Description

LIR	Latch interrupt request to CLICK_SRC reg with the CLICK_SRC reg refreshed by reading CLICK_SRC reg. Default value: 0 (0: interrupt request not latched; 1: interrupt request latched)
Double_Z	Enable interrupt generation on double click event on Z axis. Default value: 0 (0: disable interrupt request; 1: enable interrupt request)
Single_Z	Enable interrupt generation on single click event on Z axis. Default value: 0 (0: disable interrupt request; 1: enable interrupt request)
Double_Y	Enable interrupt generation on double click event on Y axis. Default value: 0 (0: disable interrupt request; 1: enable interrupt request)
Single_Y	Enable interrupt generation on single click event on Y axis. Default value: 0 (0: disable interrupt request; 1: enable interrupt request)
Double_X	Enable interrupt generation on double click event on X axis. Default value: 0 (0: disable interrupt request; 1: enable interrupt request)
Single_X	Enable interrupt generation on single click event on X axis. Default value: 0 (0: disable interrupt request; 1: enable interrupt request)

Table 3. Truth table

Double_Z / Y / X	Single_Z / Y / X	Click output
0	0	0
0	1	Single
1	0	Double
1	1	Single or double

2.2 CLICK_SRC (39h)

Table 4. Register

X	IA	Double_Z	Single_Z	Double_Y	Single_Y	Double_X	Single_X

Table 5. Description

IA	Interrupt active. Default value: 0 (0: no interrupt has been generated; 1: one or more interrupt events have been generated)
Double_Z	Double click on Z axis event. Default value: 0 (0: no interrupt; 1: Double Z event has occurred)
Single_Z	Single click on Z axis event. Default value: 0 (0: no interrupt; 1: Single Z event has occurred)
Double_Y	Double click on Y axis event. Default value: 0 (0: no interrupt; 1: Double Y event has occurred)
Single_Y	Single click on Y axis event.Default value: 0 (0: no interrupt; 1: Single Y event has occurred)
Double_X	Double click on X axis event. Default value: 0 (0: no interrupt; 1: Double X event has occurred)
Single_X	Single click on X axis event. Default value: 0 (0: no interrupt; 1: Single X event has occurred)
IA	Interrupt active. Default value: 0 (0: no interrupt has been generated; 1: one or more interrupt events have been generated)

2.3 CLICK_THSY_X (3Bh)

Table 6. Register

THSy3	THSy2	THSy1	THSy0	THSx3	THSx2	THSx1	THSx0

Table 7. Description

THSy3, THSy0	Click threshold on Y axis. Default value: 0000
THSx3, THSx0	Click threshold on X axis. Default value: 0000

2.4 CLICK_THSZ (3Ch)

Table 8. Register

X	X	X	X	THSz3	THSz2	THSz1	THSz0

Table 9. Description

THSz3, THSz0	Click threshold on Z axis. Default value: 0000

From 0.5g(0001) to 7.5g(1111) with increments of 0.5g.

The THSx, THSy and THSz registers define the threshold which is used by the system to start the click detection procedure. The threshold value is expressed over 4 bits as an unsigned number.

2.5 CLICK_TimeLimit (3Dh)

Table 10. Register

Dur7	Dur6	Dur5	Dur4	Dur3	Dur2	Dur1	Dur0

From 0 to 127.5 msec in increments of 0.5 msec.

Dur7 through Dur0 define the maximum time interval that can elapse between the start of the click detection procedure (the acceleration on the selected channel exceeds the programmed threshold) and when the acceleration goes back below the threshold.

2.6 CLICK_Latency (3Eh)

Table 11. Register

Lat7	Lat6	Lat5	Lat4	Lat3	Lat2	Lat1	Lat0

From 0 to 255 msec in increments of 1 msec.

Lat7 through Lat0 define the time interval that starts after the first click detection where the click detection procedure is disabled, in cases where the device is configured for double click detection.

2.7 CLICK_Window (3Fh)

Table 12. Register

Win7	Win6	Win5	Win4	Win3	Win2	Win1	Win0

From 0 to 255 msec in increments of 1 msec.

Win7 through Win0 define the maximum interval of time that can elapse after the end of the latency interval in which the click detection procedure can start, in cases where the device is configured for double click detection.

2.8 CTRL_REG3 [Interrupt CTRL register] (22h)

Table 13. Register

IHL	PP_OD	I2CFG2	I2CFG1	I2CFG0	I1CFG2	I1CFG1	I1CFG0

Table 14. Description

IHL	Interrupt active high/low. Default value 0. (0: active high; 1: active low)
PP_OD	Push-pull/open drain selection on interrupt pad. Default value 0. (0: push-pull; 1: open drain)

Table 14. Description (continued)

I2CFG2 I2CFG1 I2CFG0	Data signal on Int2 pad control bits. Default value 000. (see table below)
I1CFG2 I1CFG1 I1CFG0	Data signal on Int1 pad control bits. Default value 000. (see table below)

Table 15. Truth table

I1(2)_CFG2	I1(2)_CFG1	I1(2)_CFG0	Int1(2) Pad
0	0	0	GND
0	0	1	FF_WU_1
0	1	0	FF_WU_2
0	1	1	FF_WU_1 or FF_WU_2
1	0	0	Data ready
1	1	1	Click interrupt

3 Examples

The following figures show the click interrupt generation in different conditions. The illustrations have been captured on a PC running the EK302DL GUI interface. The content of the LIS302DL registers have been modified via the dedicated panel of the software interface that allows the user to evaluate all the different settings and features of the click embedded function. In the following examples, only the Y axis has been enabled for the click interrupt generation.

3.1 Playing with CLICK_TimeLimit

Figure 4 shows an acquisition carried out with CLICK_TimeLimit = 02h (1 ms). With this setting, the single click recognition window is short and often the acceleration does not return below the threshold in time.

In *Figure 5* an acquisition done with CLICK_TimeLimit = FFh (127 ms) is shown. With this setting the single click recognition window is longer, and it is easier for the event to be recognized.

Figure 4. Short TimeLimit

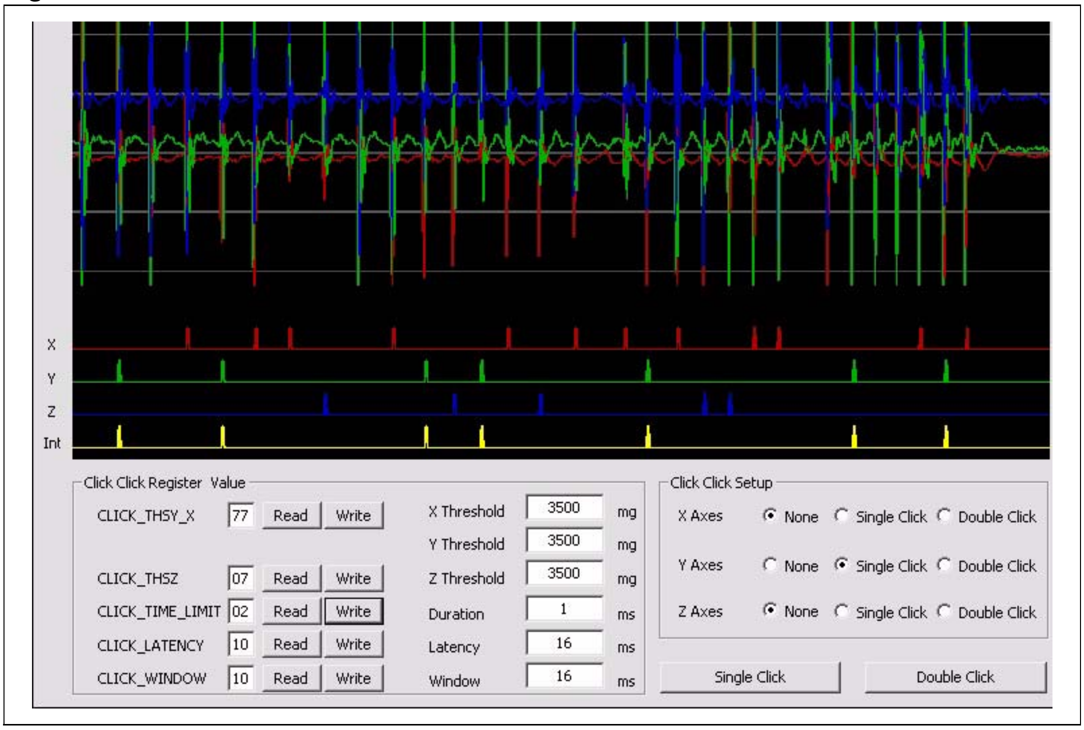
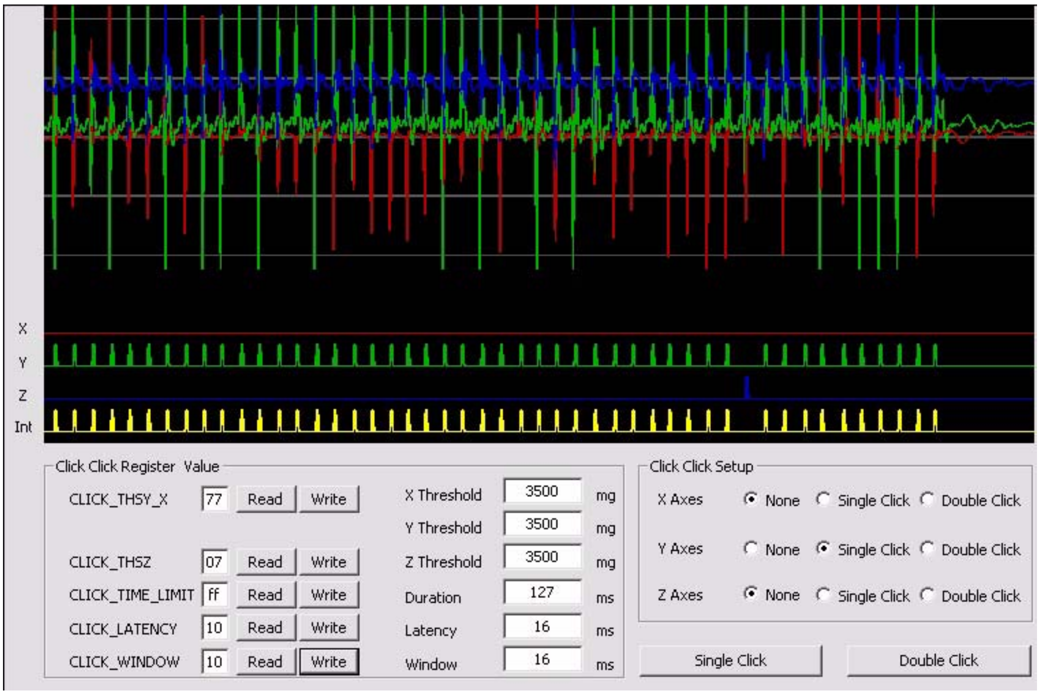


Figure 5. Long TimeLimit



3.2 Playing with CLICK_Latency

Figure 6 illustrates an acquisition done with CLICK_Latency = 06h (6 ms). With this setting the device recognizes as a click nearly every acceleration peak. In *Figure 7* an acquisition carried out with CLICK_Latency = ffh (255 ms) is displayed. With this setting the device recognizes as a click one peak in every two.

Figure 6. Short Latency

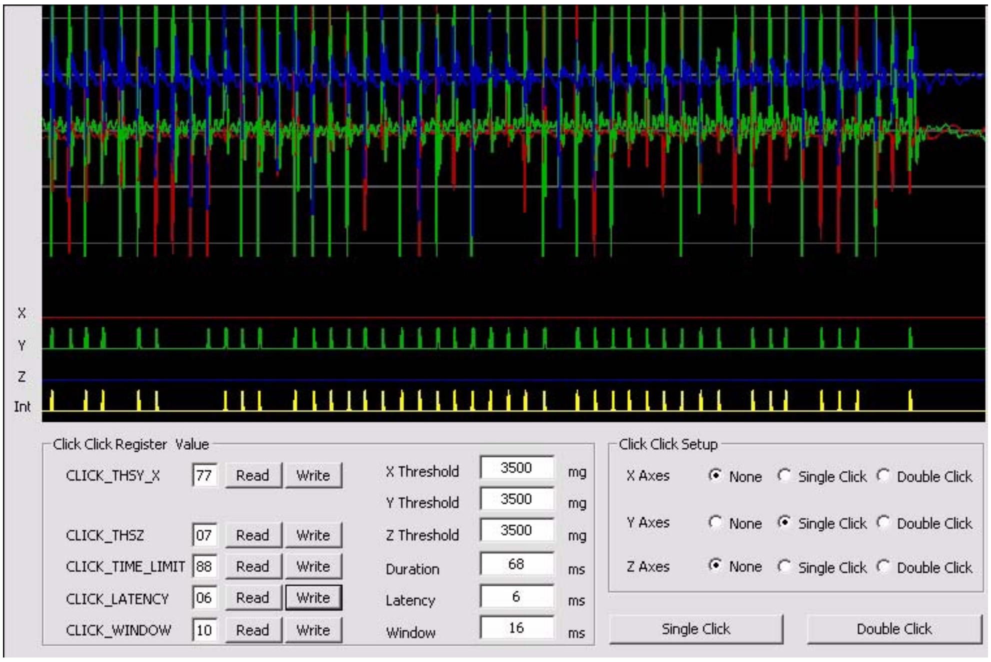
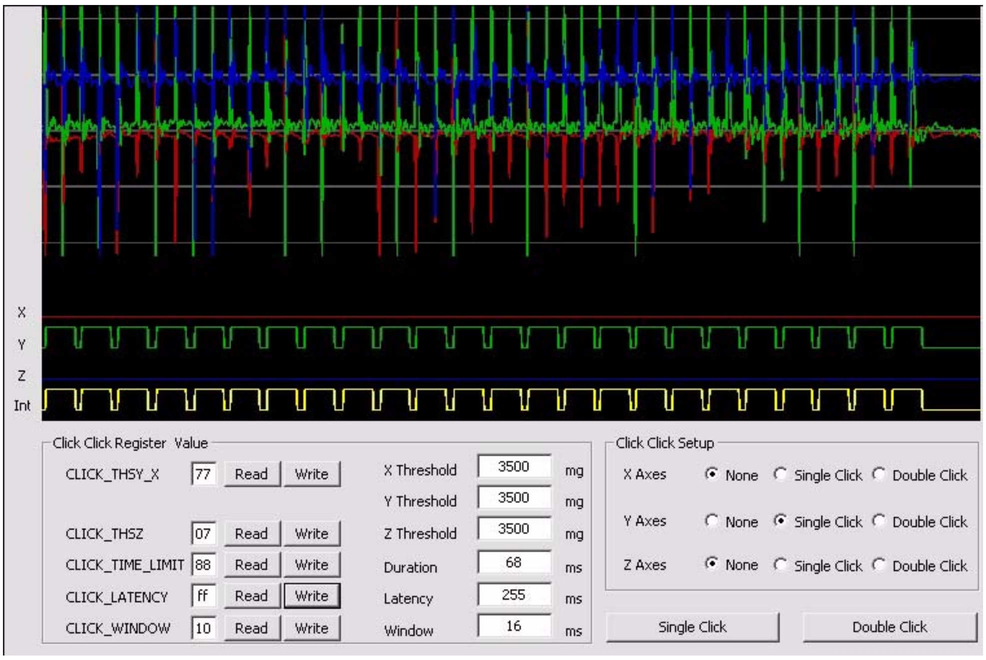


Figure 7. Long Latency



3.3 Playing with CLICK_Window

In cases of double click recognition, the CLICK _Latency + CLICK_Window defines the maximum distance between two consecutive clicks to be recognized as double click event. By fixing the latency to avoid spurious bouncing of the signal, one can play with the CLICK_Window as with the “double-click speed” settings of the mouse properties on the PC.

Figure 8 shows an acquisition done with CLICK_Window = 10h (10 ms). With this setting the two consecutive peaks of acceleration are too far apart and the second one occurs outside of the Window.

In *Figure 9* an acquisition carried out with CLICK_Window = ffh (255 ms) is shown. With this setting the device correctly generates the double click interrupt after the second acceleration peak.

Figure 8. Short Window

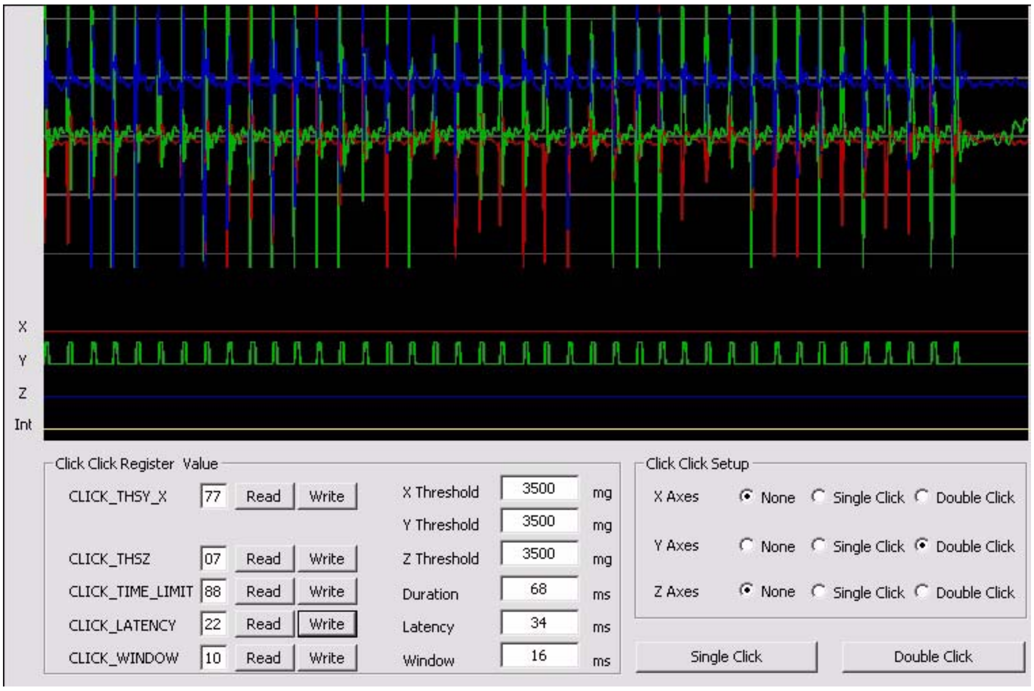
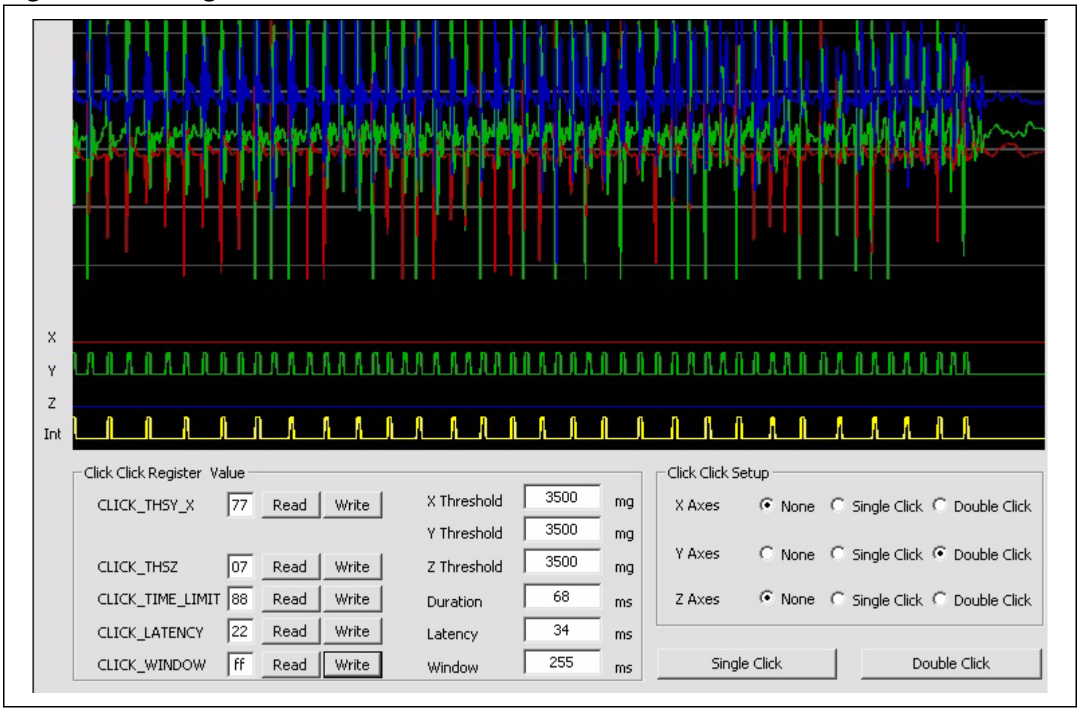


Figure 9. Long Window



4 Revision history

Table 16. Document revision history

Date	Revision	Changes
17-Jan-2008	1	Initial release