Topics to be prepared

- DATA SHEET
- COMPONENTS OF ELECTRONICS
- TEMPERATURE OF ELECTRONICS COMPONENTS
- TERMINALS OF ELECTRONICS COMPONENTS
- TYPES OF ELECTRONIC COMPONENTS AND THEIR PURPOSE
- MEASUREMENT OF ELECTRONICS COMPONENTS

DATA SHEET:

Data sheets are manufacturer-provided documents that explain what an electronic component does, provide a summary of a component's technical characteristics, and describe how and when to use the component. Devoting the time during the design process to thoroughly researching your parts' data sheets will be well worth it.

Engineers and designers understand the importance of how to analyze and 'decode' the data sheet sections for each of the components being placed on a PCB. For example, when a designer decides to include a specific part within a PCB layout, he or she will reference the data sheet for that part in order to select an appropriately corresponding pad layout for the PCB surface. By doing this, the designer can then be confident in knowing the chosen pad locations on the board will properly align with the leads of the component body during assembly.

Screaming Circuits relies on the information found in data sheets on a daily basis, they help us prevent mistakes and increase accuracy within our manufacturing processes. On a typical PCB assembly project, machine programmers and/or assemblers may use data sheets to cross-check package dimensions, verify the polarity of a part, determine the location of PIN #1 on a component, or review the process information related to reflow and solder paste deposit.

In short, data sheets provide us with a means to quickly reference the various qualities and attributes of the components we are working with, aiding both the designer and manufacturer while helping each project run as smoothly as possible. Not all data sheets are created equal, but most will have some or all of the following sections:

Summary or general description

The summary provides an overview of the component's functions and specifications.

Specifications

The specifications page lists the numbers that describe the needs and capabilities of the component.

Pin connection diagram or pinout

Lists the part's pins, their locations and their functions.

Timing diagrams
Provides a description of timing relationships in signals: how data is sent and what speed at which it should be sent and received.
Schematics
Provides example schematics for circuits using the component.
Absolute minimum and maximum ratings
Lists minimum and maximum allowable supply voltage, power consumption, input currents, temperatures for storage, operating, soldering, etc.
Application information
This page should give detailed descriptions of the pin functions, instructions about how to communicate with the part and lists of commands.
Recommended operating conditions
These conditions could include voltage and ranges for various functions, timing information, temperature ranges, bus addresses, and other useful performance information.
Typical performance characteristics or truth tables
Truth tables explain how different inputs affect different outputs from the component.
Physical dimensions
Will typically include minimum/typical/maximum dimensions, contact locations and sizes.
Ordering information
Lists the different ordering codes of different packages.
Packaging information
Provides dimensions of the packages a part comes in: highly useful information for PCB layout.

Assuming the data sheet has all of this information, it should answer all of your questions about whether or not the part will satisfy the demands of your PCB design.

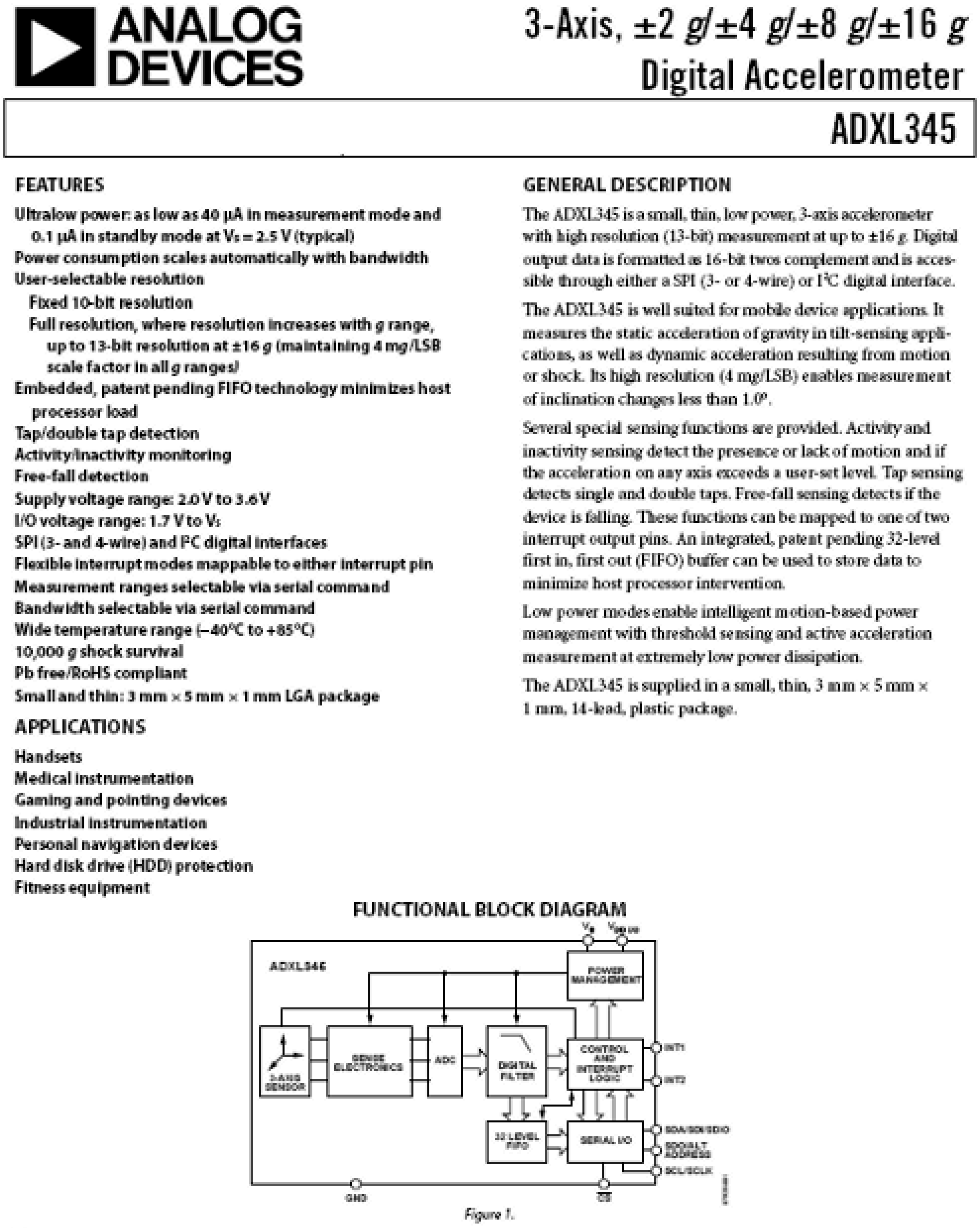
When researching information for your own components, be sure to double check for instances of multiple part versions being included on the same data sheet. This is an issue we sometimes encounter at Screaming Circuits, it can easily be overlooked at first, and then it can cause problems further down the line with differences in component package size, or unwanted deviation to the pad layout on the PCB.

How to Read a Datasheet

Datasheets are instruction manuals for electronic components. They (hopefully) explain exactly what a component does and how to use it. Unfortunately these documents are usually written by engineers for other engineers, and as such they can often be difficult to read, especially for newcomers. Nevertheless, datasheets are still the best place to find the details you need to design a circuit or get one working.

A datasheet’s contents will vary widely depending on the type of part, but they will usually have most of the following sections:

The first page is usually a **summary** of the part’s function and features. This is where you can quickly find a description of the part's functionality, the basic **specifications** (numbers that describe what a part needs and can do), and sometimes a **functional block diagram** that shows the internal functions of the part. This page will often give you a good first impression as to whether potential part will work for your project or not:


ANALOG DEVICES

3-Axis, ±2 *g*/±4 *g*/±8 *g*/±16 *g* Digital Accelerometer

ADXL345

FEATURES

Ultralow power: as low as 40 µA in measurement mode and 0.1 µA in standby mode at V_S = 2.5 V (typical)
Power consumption scales automatically with bandwidth
User-selectable resolution
Fixed 10-bit resolution
Full resolution, where resolution increases with *g* range, up to 13-bit resolution at ±16 *g* (maintaining 4 m*g*/LSB scale factor in all *g* ranges)
Embedded, patent pending FIFO technology minimizes host processor load
Tap/double tap detection
Activity/inactivity monitoring
Free-fall detection
Supply voltage range: 2.0 V to 3.6 V
I/O voltage range: 1.7 V to V_S
SPI (3- and 4-wire) and I^2C digital interfaces
Flexible interrupt modes mappable to either interrupt pin
Measurement ranges selectable via serial command
Bandwidth selectable via serial command
Wide temperature range (−40°C to +85°C)
10,000 *g* shock survival
Pb free/RoHS compliant
Small and thin: 3 mm × 5 mm × 1 mm LGA package

APPLICATIONS

Handsets
Medical instrumentation
Gaming and pointing devices
Industrial instrumentation
Personal navigation devices
Hard disk drive (HDD) protection
Fitness equipment

GENERAL DESCRIPTION

The ADXL345 is a small, thin, low power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 *g*. Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I^2C digital interface.

The ADXL345 is well suited for mobile device applications. It measures the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Its high resolution (4 mg/LSB) enables measurement of inclination changes less than 1.0°.

Several special sensing functions are provided. Activity and inactivity sensing detect the presence or lack of motion and if the acceleration on any axis exceeds a user-set level. Tap sensing detects single and double taps. Free-fall sensing detects if the device is falling. These functions can be mapped to one of two interrupt output pins. An integrated, patent pending 32-level first in, first out (FIFO) buffer can be used to store data to minimize host processor intervention.

Low power modes enable intelligent motion-based power management with threshold sensing and active acceleration measurement at extremely low power dissipation.

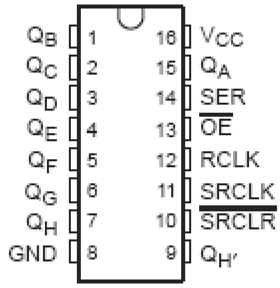
The ADXL345 is supplied in a small, thin, 3 mm × 5 mm × 1 mm, 14-lead, plastic package.

FUNCTIONAL BLOCK DIAGRAM

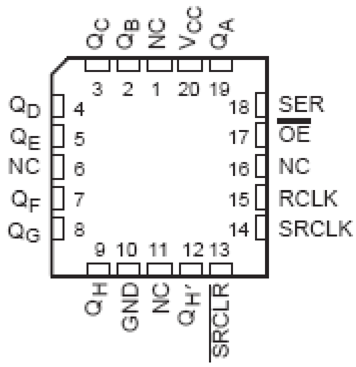
Figure 1.

A **pinout** lists the part’s pins, their functions, and where they’re physically located on the part for various packages the part might be available in. Note the special marks on the part for determining where pin 1 is (this is important when you plug the part into your circuit!), and how the pins are numbered (the below parts are numbered counterclockwise). You'll find some acronyms here: VCC is the supply voltage (commonly 5V or 3.3V), CLK is clock, CLR is clear, OE is output enable, etc. These acronyms should be spelled out later in the datasheet, but if not, try Google or Wikipedia. If a pin has a star next to it or a line over the name, that's an indication that the pin is *active low* which means that you'll pull the pin low (0V) to activate it, rather than H (VCC):

SN54HC595 . . . J OR W PACKAGE
SN74HC595 . . . D, DB, DW, N, OR NS PACKAGE
(TOP VIEW)



SN54HC595 . . . FK PACKAGE
(TOP VIEW)



NC − No internal connection

Detailed tables of electrical specifications follow. These will often list the **absolute maximum ratings** a part can withstand before being damaged. Never exceed these or you'll be replacing a possibly expensive part!

ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
Acceleration	
Any Axis, Unpowered	10,000 *g*
Any Axis, Powered	10,000 *g*
V_S	−0.3 V to +3.6 V
$V_{DD\ I/O}$	−0.3 V to +3.6 V
Digital Pins	−0.3 V to $V_{DD\ I/O}$ + 0.3 V or 3.6 V, whichever is less
All Other Pins	−0.3 V to +3.6 V
Output Short-Circuit Duration (Any Pin to Ground)	Indefinite
Temperature Range	
Powered	−40°C to +105°C
Storage	−40°C to +105°C

You'll also see the more normal **recommended operating conditions**. These may include voltage and current ranges for various functions, timing information, temperature ranges, bus addresses, and other useful performance information. The below excerpt contains a good example where the fine print can help you out: "Note 3" in this set of specifications states that "All unused inputs of the device must be held at VCC or GND to ensure proper device operation." This is a reminder to tie all unused inputs H or L to prevent them from "floating" between H and L which can make your circuit malfunction and be difficult to debug:

recommended operating conditions (see Note 3)

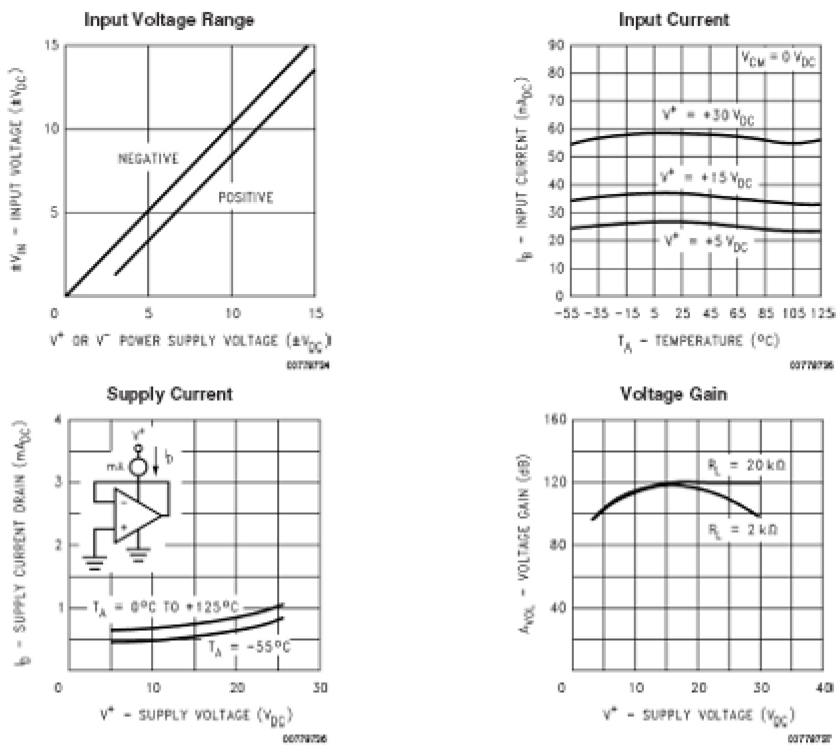
			SN54HC595			SN74HC595			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage		2	5	6	2	5	6	V
V_{IH}	High-level input voltage	V_{CC} = 2 V	1.5			1.5			V
		V_{CC} = 4.5 V	3.15			3.15			
		V_{CC} = 6 V	4.2			4.2			
V_{IL}	Low-level input voltage	V_{CC} = 2 V			0.5			0.5	V
		V_{CC} = 4.5 V			1.35			1.35	
		V_{CC} = 6 V			1.8			1.8	
V_I	Input voltage		0		V_{CC}	0		V_{CC}	V
V_O	Output voltage		0		V_{CC}	0		V_{CC}	V
$\Delta t/\Delta v$‡	Input transition rise/fall time	V_{CC} = 2 V			1000			1000	ns
		V_{CC} = 4.5 V			500			500	
		V_{CC} = 6 V			400			400	
T_A	Operating free-air temperature		−55		125	−40		85	°C

NOTE 3: All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

‡ If this device is used in the threshold region (from V_{IL}max = 0.5 V to V_{IH}min = 1.5 V), there is a potential to go into the wrong state from induced grounding, causing double clocking. Operating with the inputs at t_t = 1000 ns and V_{CC} = 2 V does not damage the device; however, functionally, the CLK inputs are not ensured while in the shift, count, or toggle operating modes.

Some parts will have one or more **graphs** showing the part's performance vs. various criteria (supply voltage, temperature, etc.) Keep an eye out for "safe zones" where reliable operation is guaranteed:

Typical Performance Characteristics



Truth tables show how changing the *inputs* to a part will affect its *output*. Each line has all the part's inputs set to specific states, and the resulting output of the part. "H" means that input is a logical high (usually VCC), "L" means a logical low (usually GND), "X" means the chip doesn't care what the input is (could be H or L), and an arrow means that that you should change the state of that pin from L to H or H to L depending on the arrow direction. This is called "clocking" an input, and many chips rely on this for proper operation:

SN54HC595, SN74HC595
8-BIT SHIFT REGISTERS
WITH 3-STATE OUTPUT REGISTERS
SCLS041G – DECEMBER 1982 – REVISED FEBRUARY 2004

FUNCTION TABLE

INPUTS					FUNCTION
SER	SRCLK	$\overline{SRCLR}$	RCLK	$\overline{OE}$	
X	X	X	X	H	Outputs Q_A–Q_H are disabled.
X	X	X	X	L	Outputs Q_A–Q_H are enabled.
X	X	L	X	X	Shift register is cleared.
L	↑	H	X	X	First stage of the shift register goes low. Other stages store the data of previous stage, respectively.
H	↑	H	X	X	First stage of the shift register goes high. Other stages store the data of previous stage, respectively.
X	X	X	↑	X	Shift-register data is stored in the storage register.

Timing diagrams show how data should be sent to and received from the part, and what speed it should be sent / received. These are typically laid out with various inputs and outputs as horizontal lines, showing the logic transitions that happen to those lines over time. If the trace dips down, that's a L input or output. If the line rises higher, that's a H input our output. Timing specifications are laid out as arrows between transitions (names are referenced back to timing numbers in the electrical specs), and vertical bars or arrows will link related transitions:

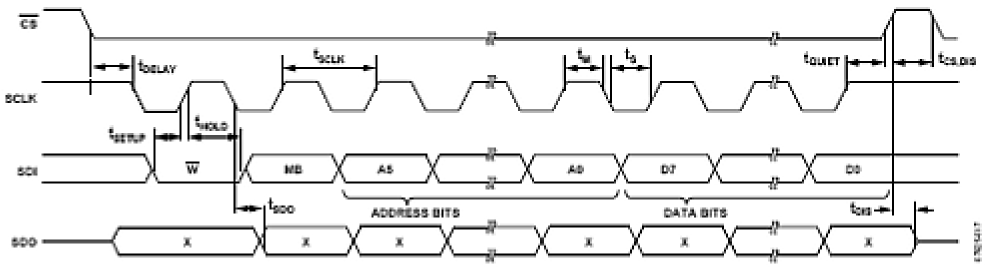


Figure 5. SPI 4-Wire Write

Complex parts will have extensive **application information**. This varies depending on the part, but may include detailed descriptions of pin functions, how to communicate with the part, lists of commands, memory tables, etc. This is often very useful information, so read through it carefully:

ADXL345

I²C

With $\overline{CS}$ tied high to $V_{DD\ I/O}$, the ADXL345 is in I²C mode, requiring a simple 2-wire connection as shown in Figure 8. The ADXL345 conforms to the *UM10204 I²C-Bus Specification and User Manual*, Rev. 03—19 June 2007, available from NXP Semiconductor. It supports standard (100 kHz) and fast (400 kHz) data transfer modes if the timing parameters given in Table 11 and Figure 10 are met. Single- or multiple-byte reads/writes are supported, as shown in Figure 9. With the SDO/ALT ADDRESS pin high, the 7-bit I²C address for the device is 0x1D, followed by the R/$\overline{W}$ bit. This translates to 0x3A for a write and 0x3B for a read. An alternate I²C address of 0x53 (followed by the R/$\overline{W}$ bit) can be chosen by grounding the SDO/ALT ADDRESS pin (Pin 12). This translates to 0xA6 for a write and 0xA7 for a read.

If other devices are connected to the same I²C bus, the nominal operating voltage level of these other devices cannot exceed $V_{DD\ I/O}$ by more than 0.3 V. External pull-up resistors, R_P, are necessary for proper I²C operation. Refer to the *UM10204 I²C-Bus Specification and User Manual*, Rev. 03—19 June 2007, when selecting pull-up resistor values to ensure proper operation.

Table 10. I²C Digital Input/Output Voltage

Parameter	Limit[1]	Unit
Digital Input Voltage		
Low Level Input Voltage (V_{IL})	$0.25 \times V_{DD\ I/O}$	V max
High Level Input Voltage (V_{IH})	$0.75 \times V_{DD\ I/O}$	V min
Digital Output Voltage		
Low Level Output Voltage (V_{OL})[2]	$0.2 \times V_{DD\ I/O}$	V max

[1] Limits based on characterization results; not production tested.
[2] The limit given is only for $V_{DD\ I/O} < 2$ V. When $V_{DD\ I/O} > 2$ V, the limit is 0.4 V max.

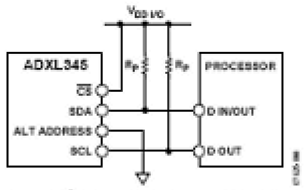


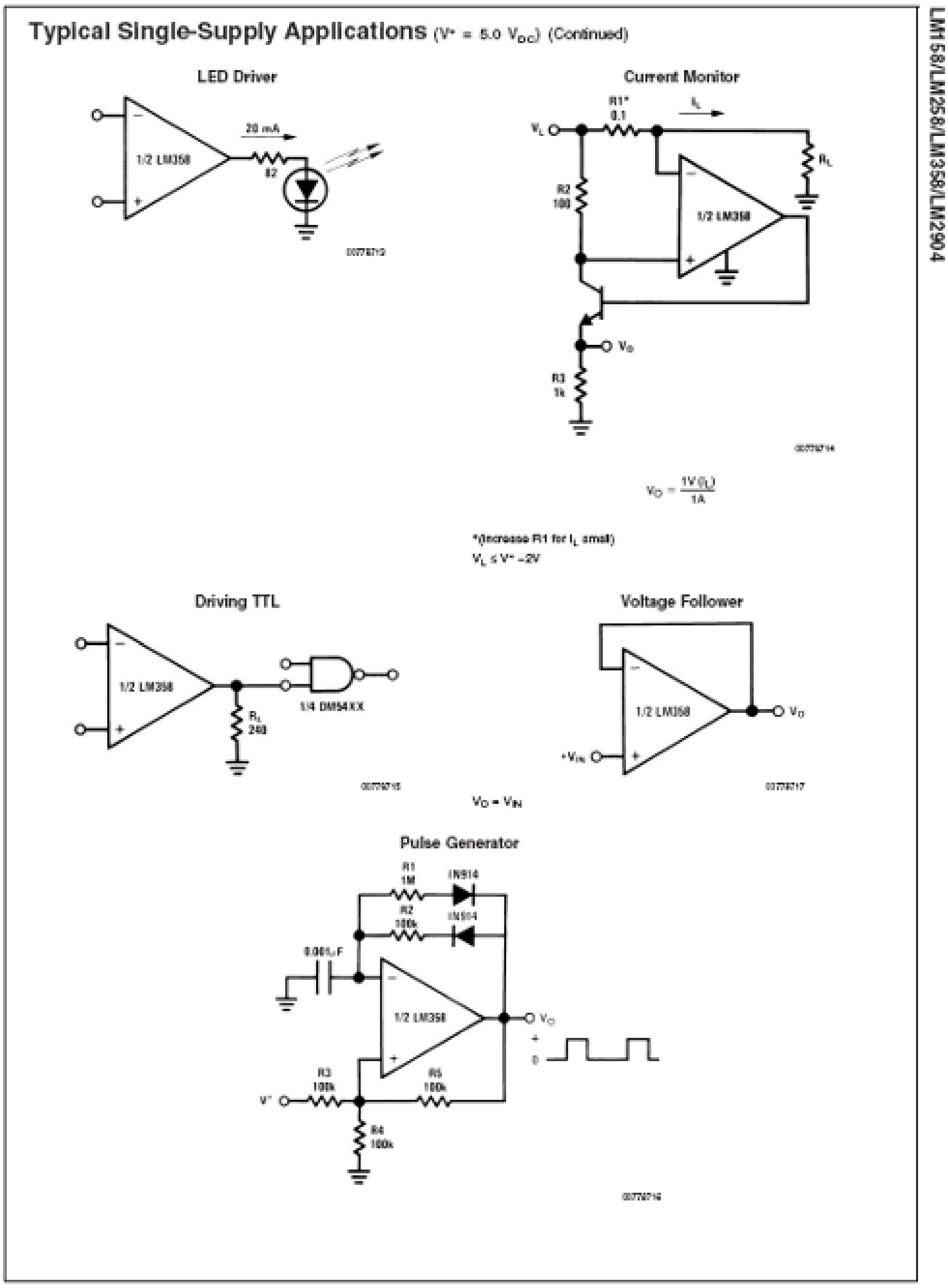
Figure 8. I²C Connection Diagram (Address 0x53)

[1]THIS START IS EITHER A RESTART OR A STOP FOLLOWED BY A START.

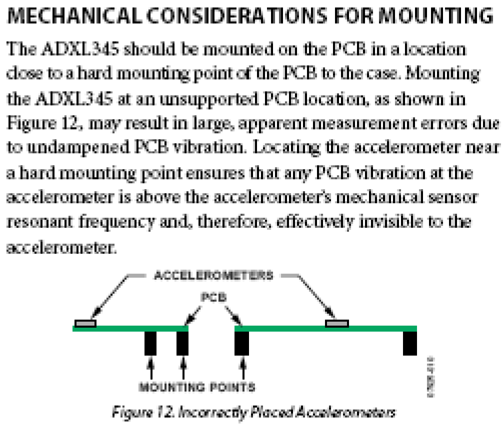
NOTES
1. THE SHADED AREAS REPRESENT WHEN THE DEVICE IS LISTENING.

Figure 9. I²C Device Addressing

Some datasheets will include **example schematics** for various circuits that can be built around the part. These are often very useful building blocks for interesting projects, so be sure to look through them:



Some parts are sensitive to the way they’re built into a circuit, and the datasheet will provide **layout considerations**. These can range from noise-reduction techniques, to dealing with thermal issues, to mechanical mounting considerations as with the accelerometer below. This all tends to be very good advice, that if followed from the start will lead to the most trouble-free circuits. Likewise, if you don't follow this advice, your circuit may have problems later on that can be hard to diagnose, and harder to fix:

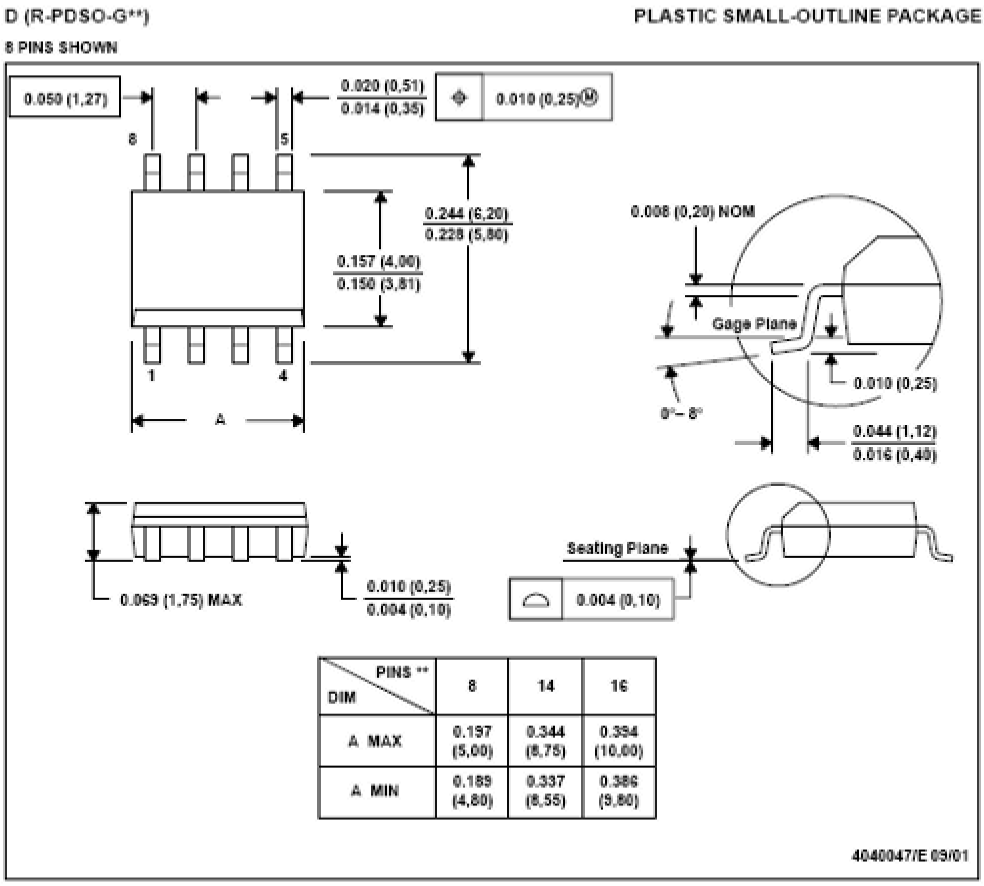


MECHANICAL CONSIDERATIONS FOR MOUNTING

The ADXL345 should be mounted on the PCB in a location close to a hard mounting point of the PCB to the case. Mounting the ADXL345 at an unsupported PCB location, as shown in Figure 12, may result in large, apparent measurement errors due to undampened PCB vibration. Locating the accelerometer near a hard mounting point ensures that any PCB vibration at the accelerometer is above the accelerometer's mechanical sensor resonant frequency and, therefore, effectively invisible to the accelerometer.

Figure 12. Incorrectly Placed Accelerometers

At the end of many datasheets is **packaging information,** which provides accurate dimensions of the packages a part is available in. This is very useful for PCB layout, see our **EAGLE tutorials** for information on creating a new part footprint:



DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

Finally, a few of our customers have correctly pointed out that datasheets are subject to having errors just like anything else, and running into one of these errors can be frustrating to say the least. To reduce this possibility, be sure you have the latest version of a datasheet before doing any serious work. These are available at the manufacturer's website; we at SparkFun do our best to keep our datasheet links up to date, but things can and do slip through the cracks (please let us know if they do!) Also check for **errata** documents, which are updates and corrections to a part's specifications often found after the part went to production. And if nothing else helps, many manufacturers have applications engineers you can contact to get help on hard-to-solve problems.

TEMPERATURE OF ELECTRONIC COMPONENTS

The temperature of electronics components varies depending on several factors including the type of component, its operating conditions, and the environment in which it operates. Here are some general guidelines:

Semiconductors (such as transistors, diodes, and integrated circuits): These components typically have specified operating temperature ranges provided by the manufacturer. They may operate within a range of -40°C to 125°C or even higher. However, excessive heat can degrade their performance or even damage them, so proper heat dissipation mechanisms such as heat sinks or fans may be necessary in some cases.

Resistors and Capacitors: These passive components usually have wider operating temperature ranges compared to semiconductors. Commonly, they can operate from -55°C to 125°C or more, depending on their construction materials and design.

Connectors and Cables: These components can withstand a wide range of temperatures as well, typically from -40°C to 85°C or higher.

Printed Circuit Boards (PCBs): The operating temperature of PCBs depends on the materials used in their construction. Standard FR-4 boards can usually withstand temperatures up to 130°C, while specialized materials may allow for even higher temperatures.

Electrolytic Capacitors and Batteries: These components can be sensitive to temperature extremes. High temperatures can reduce their lifespan or cause leakage, while low temperatures can affect their performance. Operating temperatures for electrolytic capacitors and batteries typically range from -40°C to 85°C or less.

In any electronic system, it's essential to monitor and control temperatures to ensure reliable operation and longevity of the components. Thermal management techniques such as proper ventilation, heat sinks, fans, and temperature sensors are commonly employed to maintain temperatures within safe limits. Additionally, adhering to manufacturer specifications and guidelines regarding operating temperatures is crucial for preventing component damage and ensuring optimal performance.