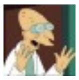


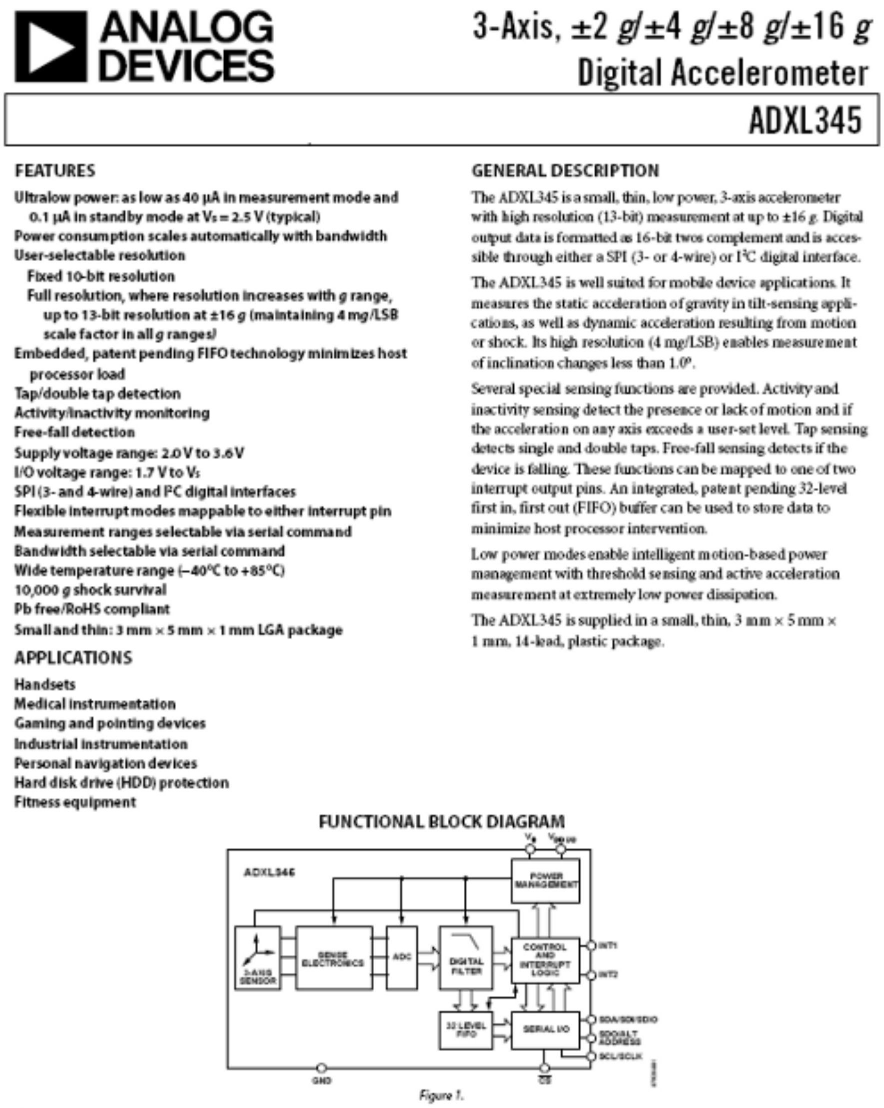
How to Read a Datasheet

by MikeGrusin | November 17, 2010 | 4 comments Skill Level: ★ Beginner

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.

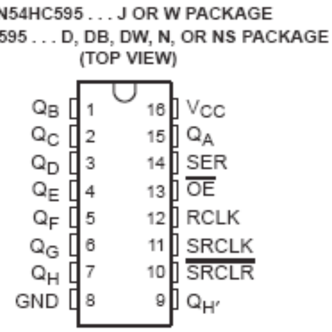
Low power modes enable intelligent motion-based power management with threshold sensing and active acceleration measurement at extremely low power dissipation.

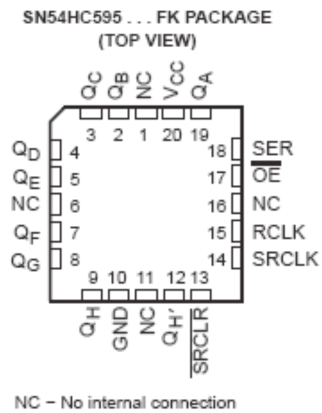
The ADXL345 is supplied in a small, thin, 3 mm × 5 mm × 1 mm, 14-lead, plastic package.

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):





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)

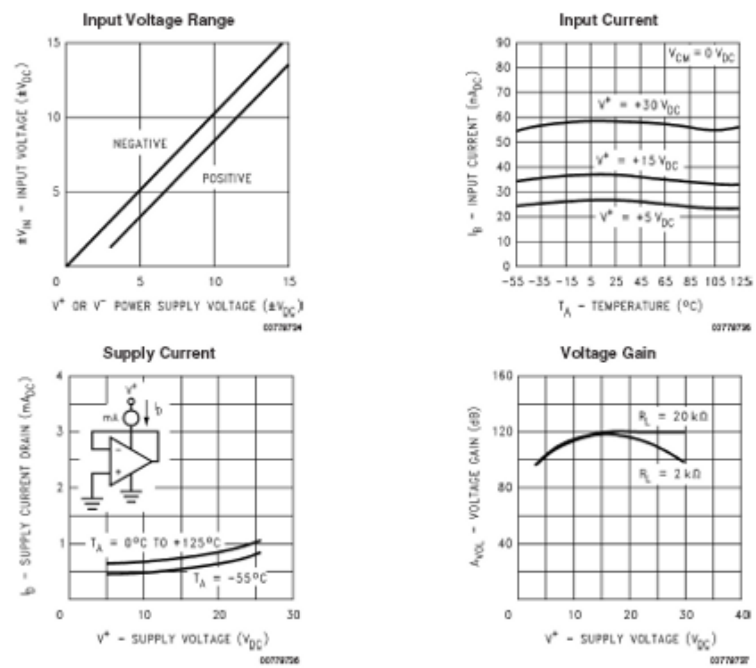
			SN54HC595			SN74HC595			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage		2	5	6	2	5	6	V
V_{IH}	High-level input voltage	V_{CC} = 2 V	1.5			1.5			V
		V_{CC} = 4.5 V	3.15			3.15			
		V_{CC} = 6 V	4.2			4.2			
V_{IL}	Low-level input voltage	V_{CC} = 2 V			0.5			0.5	V
		V_{CC} = 4.5 V			1.35			1.35	
		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
Δt/Δv‡	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:

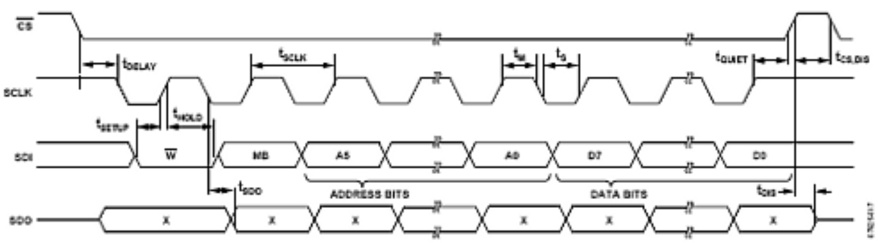
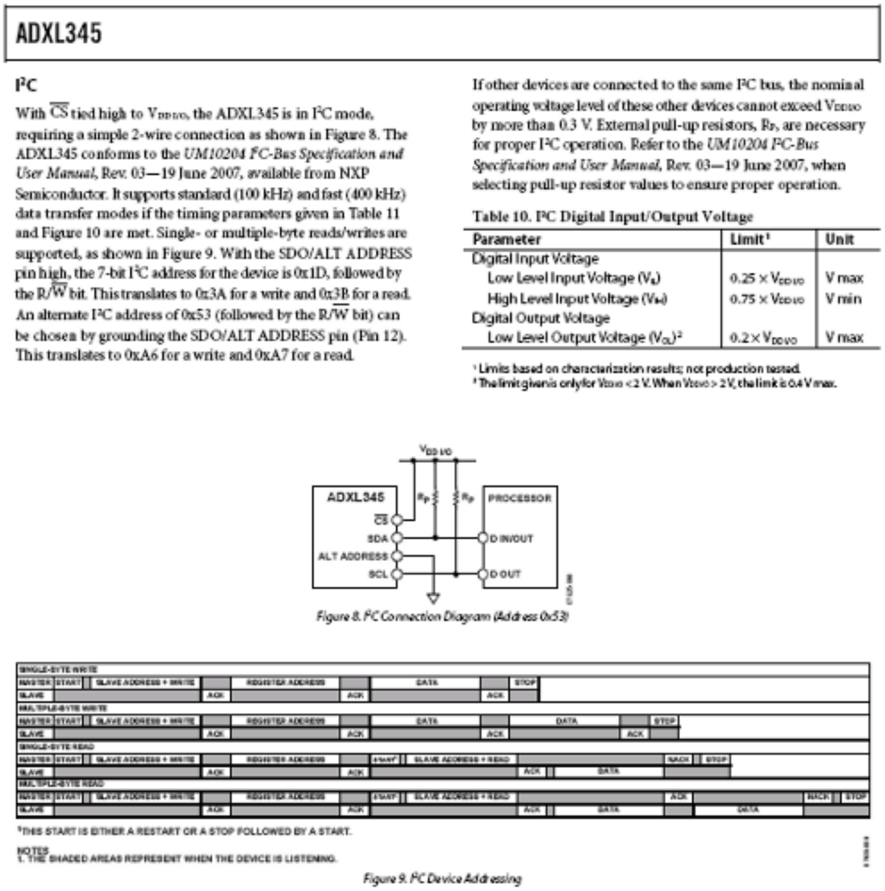


Figure 5. SPI 4-Wire Write

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

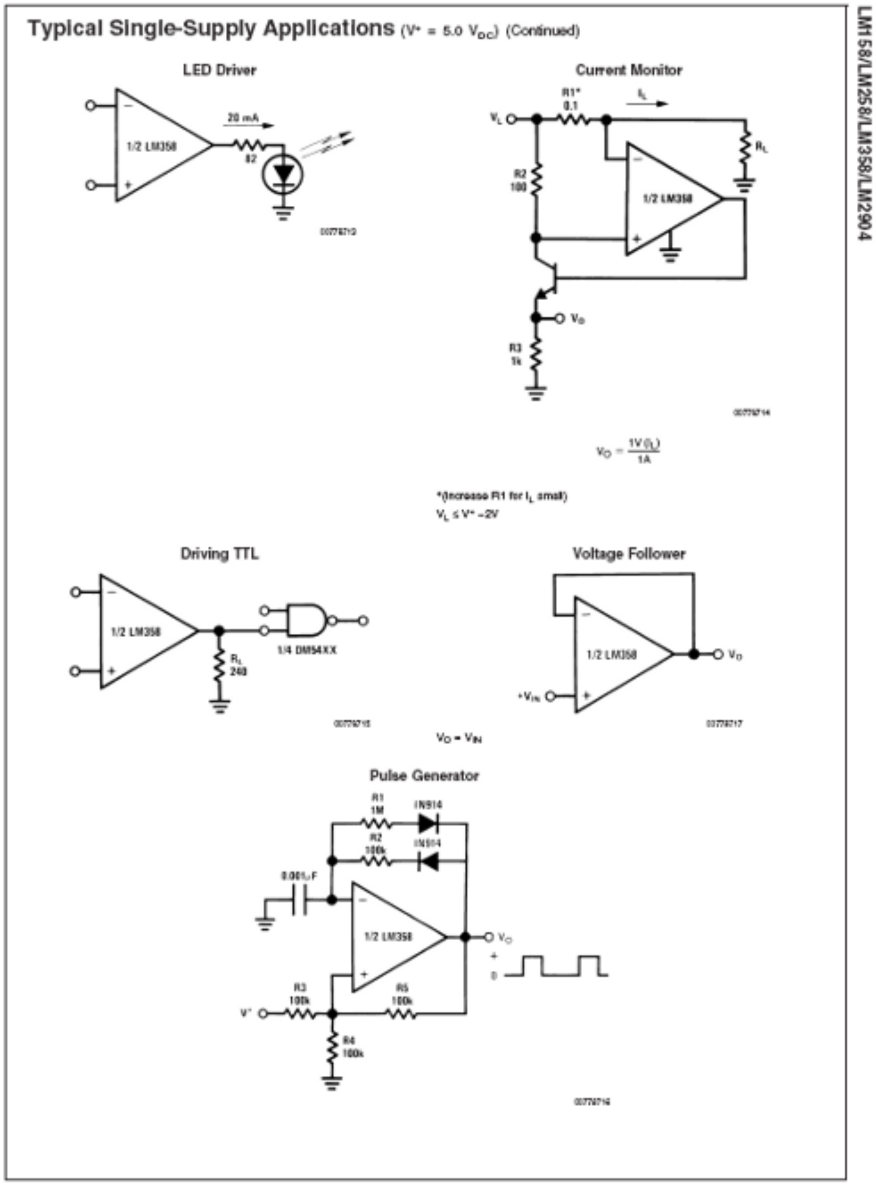
[1] Limits based on characterization results; not production tested.
[2] The limit given is only for $V_{DD I/O}$ < 2 V. When $V_{DD I/O}$ > 2 V, the limit is 0.4 V max.

Figure 8. I²C Connection Diagram (Address 0x53)

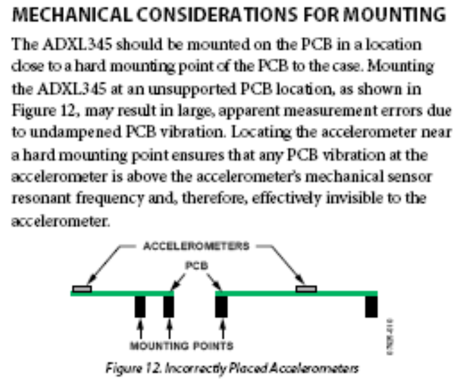
*THIS START IS EITHER A RESTART OR A STOP FOLLOWED BY A START.
NOTES
1. THE SHADED AREAS REPRESENT WHEN THE DEVICE IS LISTENING.

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:



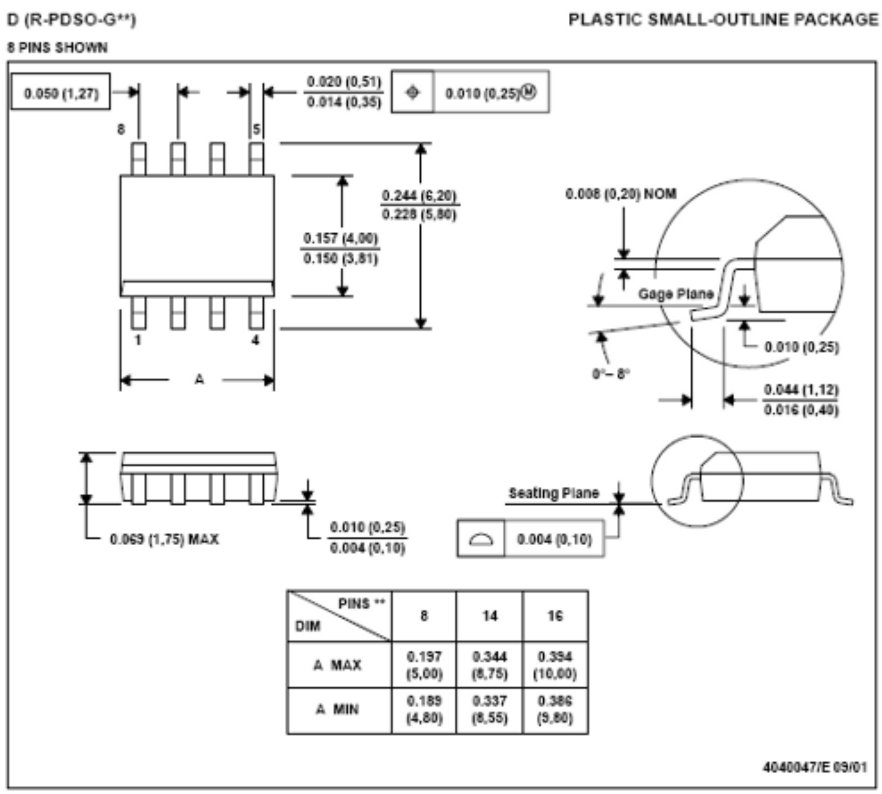
Some parts are sensitive to the way they're built into a circuit, and the datasheet will provide **layout considerations**. These can range from noise-reduction techniques, to dealing with thermal issues, to mechanical mounting considerations as with the accelerometer below. This all tends to be very 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.

When working with a new part for the first time, or when deciding which part to use for your project, it’s a very good idea to read that part’s datasheet from beginning to end, paying close attention to the fine print. You’ll often come up with a bit of knowledge or a shortcut that will save you hours of grief later on.

Example Question

A datasheet is the best place to find:

A. What voltage a part needs to run

B. How fast a part will run

C. How to communicate with a part

D. All of the above

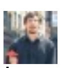
The correct answer is *D: all of the above*. Pretty much any technical information you need to know about a part should be *somewhere* in the datasheet. The trick is finding it in the fine print.

Comments 4 comments

Log in or register to post comments.


sgrace / about 6 years ago / ★ 2

Reading datasheets is not as easy as it looks. A lot of times the information you want is buried in the document. Before you even choose a part for a project, read the datasheets provided about the IC/device you want to use. Understand the datasheet and know where keep points are. I recommend highlighting keep information, or marking pages for quick reference.
One thing I see a lot of new hobbyists do is choose a part and then after running into issues and talking with others realize they chose the wrong part. Please, spend a few hours doing proper research before throwing money away. I will usually spend about 1-2 hours PER PART of research before compiling a BOM.


c-scott / about 7 years ago / ★ 2

It may be worth showing an example of a pcb footprint diagram, which is not always provided but is different from (and more useful than) the mechanical package diagram. Also, there are many “standard” packages, and often there will a separate datasheet for the package itself somewhere on the manufacturer’s site. It’s worth a look.

On the subject of packages: beware the TO92! Often what is shown is the pinout “looking up” from below the chip, which is the exact opposite of what you probably expect.

Also: beware of undocumented features. If the graphs section doesn’t cover your proposed parameters, or there’s a suspicious gap explaining exactly how some feature might work–chances are the manufacturer hasn’t tested this, might not know the answer, and even if you figured out some behavior for one particular chip, it won’t be guaranteed to be the same in all manufactured chips. Specs not in the datasheet may change at any time. The datasheet is usually good about describing what the expected variation in a parameter is, but I find that a common “rookie mistake” is to measure the behavior of one particular unit, and assume the results hold for all such chips manufactured by the company. There are device-to-device variations, lot-to-lot, month-to-month — and often even revision to revision: the manufacturer might redesign your product from the ground up (perhaps they’ve got a new process running in the factory) and as long as the new devices matches *the specs guaranteed in the datasheet* they won’t bother to tell you. It’s your risk if you dependent on anything not written down.

Phil Hutchinson / about 7 years ago / ★ 2

This is great for us noobs. Thanks!

The picture in the timing diagrams section seems to be missing at the moment.

Member #376784 / about 4 years ago / ★ 1

Question from a newbie. I am considering the use of the TI MPC508 multiplexer: http://www.ti.com/lit/gpn/mpc508 . I would like to know how much current I can drive through it to affect a load on its output. I looked through and it was not clear to me where that information lies in the datasheet. Can anyone help point this out or show how to determine/compute this characteristic? The input source will be 12V DC capable of 2Amps. The load is an inductor that requires 12V and generates 4.8 Watts (from the inductor's specs).

Thanks!