

Understanding Optical Mice



White Paper

Today's computer mouse comes in many shapes, and in a wide range of features, sizes and prices. The two main technologies driving this input device are optical and mechanical. The mechanical engine was the earlier system and was introduced in the 1960s. Optical technology was introduced in the 1980s but didn't gain much traction until the early part of 2000.

Since then, with the massive adoption of computers for communication, data storage, and networking, the mouse's function as an input device has grown increasingly more critical—particularly in accommodating the higher tracking speeds and better response required by demanding users.

Fueled by this insatiable appetite for performance, the mouse has come a long way from its humble beginnings. From a single button, corded device, now there is a version for every type of user including cordless models, and even high performance models oriented toward gaming.

The Birth of the Computer Mouse

The mouse was invented by Douglas Engelbart and developed the first one with his Chief Engineer, Bill English, of Stanford Research Institute (now SRI international) in 1963. It was intended as an input device for Engelbart's oN-Line System (NLS). Their creation used two perpendicular wheels attached to potentiometers to track its movement along the horizontal and vertical axes.

In 1971, Xerox Palo Alto Research Center (PARC) signed an agreement with SRI licensing Xerox to use the mouse. The Xerox PARC mouse replaced the external wheels with a single ball, which could rotate in any direction. The ball's motion was detected using perpendicular wheels connected

to electrical commutators to move the onscreen cursor. The first Alto mouse was operational in 1972. Today's mechanical mouse owes a great deal to this Xerox PARC design.

A couple of reasons for the slow adoption of mice from the 1970s to the early 1980s were the limited number of personal computers in the market, as well as their high prices. The Xerox PARC mouse in those days would set a buyer back a whopping \$400 and required an additional \$300 computer interface.

Another milestone in mechanical mouse history came through Apple. Unlike prior mouse designs that used electrical commutators, the Apple mouse used optical encoders along the ball's equator, 90 degrees apart.

Microsoft made its debut in the mouse market in 1983. Known as the "Green Eye Mouse", the main function of this mouse was to provide navigation support for the GUI context of Microsoft Word for MS-DOS v. 1.00. The mouse has two protruding green buttons, hence its "green eye" nickname, and was equipped with a 25-pin D-plug to attach to the serial port on the original PC and compatibles. On the underside it had three small steel balls that allowed it to glide over a surface and a large steel ball in the center to register its position.

One of the earliest optical mouse design started with the Mouse Systems model. Commercially available from 1982 to 1995, this mouse used a four-segment photodiode chip, and could only be used on a special mirrored surface having a grid of fine lines. Ultimately several versions were available for Amiga computers, while other versions were packaged with a PS/2 connector to hook-up with an IBM PC or compatible.

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Then in 1985, Xerox introduced the 6085 Star, which featured the first optical mouse that was not tied to a precision surface. Although it was supplied with a pad having a printed dot pattern, it would also operate on other surfaces that had high-contrast printing. It could not, however, work on ordinary random surfaces such as most mouse pads or tabletops.

In 1999, Agilent Technologies introduced a revolutionary optical position sensor. This innovative sensor operates by actually "taking a picture" of the surface on which it is navigating, and comparing images sequentially to detect the speed and direction of movement. The device is able to navigate on a wide variety of surfaces, freeing the user from the space limitation of any mouse pad.

Enhancing the optical technology, in September 2004, Agilent (now Avago Technologies) revealed laser illumination and tracking technology. Providing more surface tracking power than LED-based optical mice, laser-based optical mice with Avago LaserStream technology can easily track on painted metal, translucent plastics, frosted glass and many other previously difficult to navigate surfaces. Avago's laser engines also have increased navigation performance compared to position sensors using LED illumination. Boasting some of the highest performance benchmarks, including motion velocity up to 45 inches per second, frame rates in excess of 7,000 frames per second and a high resolution of 2,000 counts-per-inch, mouse performance has been bumped up a couple of notches.

Today's Mice

Today, there is an extremely wide variety of computer mice and other pointing devices such as trackballs, both mechanical and optical, on the market. The shapes, performance and ergonomics vary widely, which means that a purchaser should, if at all, try some of the various configurations before they buy a pointing device. Also, keep in mind that if you are using an older PC, in which the mouse is connected through the serial port, your choices may be extremely limited. Most mice today are designed to operate via a USB or a PS/2 port.

A mouse, like other electrical appliances, has to conform to domestic and international safety standards, ensuring consumers are purchasing a quality and approved product. Some of the more well-known standards include Electromagnetic Interference (EMI), Electromagnetic Compatibility (EMC), and Electrostatic Discharge (ESD). For the enforcement of these standards, each country will have their own key agencies. A few of them are listed below:

- United States: FCC, MIL, EMC Mark, UL Mark, CSA, TUV, ITE,
- Canada: Industry Canada (ICES), UL Mark, CSA
- Australia: C-Tick
- Asia: VCCI and EMC (Japan), CCC-Mark (China), BSMI (Taiwan), and MIC (South Korea)
- Europe: CE Mark, GS (Germany), EMC Mark
- Russia – GOST-R

In the case of an optical mouse, one important safety aspect is to ensure that the LEDs or laser diodes used are within the permitted safe levels. In particular, the eye safety level. Generally, if the device is labeled as Class 1, this represents the safest level for eye safety, requiring no special eye protection, unlike Class 2 and 3.

Another aspect of a mouse is the price tag. For just a few dollars, you can get a budget mechanical mouse. Even versions with a scroll wheel will go for about \$10 or less. An entry-level optical mouse can be found priced starting in the \$10 to \$20 range. Some of these, too, include a scroll wheel or even additional features.

As for the operating environment, the mechanical mouse is perfectly happy operating on virtually any mouse pad, including those with a glossy surface and complex color graphics. However, the same mechanical mouse has moving parts that often collect dust, rendering inaccurate cursor movements, and needing maintenance.

In contrast, the optical mouse is a solid-state device requiring minimal maintenance. It is able to navigate on many surfaces, often not requiring any special mouse pad. With vast improvements in optical navigation technology, such as high-resolution sensitivity, illumination source, tracking performance, the optical mouse is fast gaining acceptance as the mainstream PC input device of today.

How do you know the mouse is optical ?

An optical mouse is ball-less with a clear lens underneath, whereas a mechanical mouse has a rolling ball underneath (Fig. 1). On many LED-based optical mice, light from a visible LED, typically red, can be seen while in use (Fig. 2). When not in motion, the LED light gets dimmer or blinks. With laser and IR (infrared)-based optical mice, the light cannot be seen.



Figure 1. The underside of a typical ball mouse



Figure 2: A typical red LED-based mouse with cord

The first generation optical mouse – LED-based

The heart of an optical mouse is a low-resolution mini camera called a sensor. The navigation LED illuminates a surface, the light reflects off the surface, and is collected through the lens. Most mouse manufacturers use a visible red LED (Fig. 2), while some also produce versions using an IR LED.

When the mouse is moved the sensor takes continuous snapshots of the surface and compares the images to determine the distance and direction traveled utilizing digital signal processing (Fig. 3). The results are sent to the computer to move the cursor on screen accordingly. Even though the optical mouse sensor is able to navigate on virtually all surfaces, there are still a few which the sensor is not able to navigate on. For example: mirrors, glass surfaces, glossy surfaces, magazine printing and "holographic" surfaces.

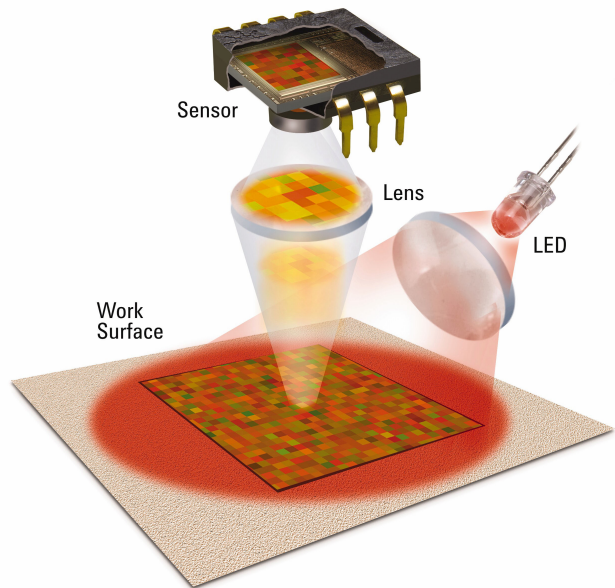


Figure 3. Optical mice illuminate an area of the work surface with an LED, and the patterns seen are reflected onto the navigation sensor.

How does a laser-based mouse work and why is it better?

The laser mouse operating principle is basically the same as an LED-based optical mouse, except the laser mouse uses a laser diode as an illumination source. The coherent nature of laser light creates patterns of high contrast when its light is reflected off a surface. The pattern appearing on the sensor reveals details on any surface, even glossy ones that would look totally uniform when exposed to the incoherent LED illumination. The precision image sensor then has no difficulties in tracking on these patterns and calculating position and movement. With enhanced image contrast providing a 20-times improvement, the laser mouse can track on surfaces where a conventional LED-based optical mouse cannot. The first commercially available laser mouse is also cordless (Fig. 4).



Figure 4. The first commercially-available laser mouse is the Logitech MX 1000 Laser Cordless Mouse

Corded Optical Mouse

A corded optical mouse has a cable to connect with a computer. The most common interfaces today are via USB and PS/2 connectors. These mice do not require batteries. They are powered directly by the computer via the mouse cable.

Cordless Optical Mouse

A cordless optical mouse is based on RF technology (i.e. 24 MHz, 27 MHz, 2.4 GHz or Bluetooth). This type of mice has two parts to it. The main part is the mouse itself, and the other is the transceiver. With a cordless mouse, a transceiver acts as a relay station between the PC and the mouse. Normally, the transceiver is connected via the computer's USB port.

Cordless mice need either conventional or rechargeable batteries for operation. The most common batteries are either AAA or AA cells, usually in pairs. Depending on the mouse designs, these vary in battery life spans.

To ensure the cordless system works, the mice and transceiver need to be synchronized to begin the communication between them. There are two basic steps to follow. First, make sure that the channel settings on both mouse and transceiver are the same. Second, press the synchronize button on the transceiver, followed by the synchronize button on the mouse. If the synchronizing is successful, an LED will light up (normally on the transceiver and it's usually green).

Other Optical Pointing Devices

Other pointing devices that are optical-based include trackballs, pen mice, and integrated trackballs on keyboards. These devices offer consumers an alternative form of input device, and the best one for a particular user depends on his or her requirements in terms of ergonomics and application.

Understanding Optical Mouse Specifications

Connection: USB and PS/2 are the most common computer peripheral interfaces for mice. Most can be plugged into both USB and PS/2 since USB mice usually come with a USB-PS/2 converter (PS/2 mice can only be used with PS/2 interface).



Figure 5. Connectors used on today's corded mice: USB and PS/2, and a USB-to-PS/2 converter

Resolution: Resolution reflects the accuracy of the image captured by the “camera” in the optical mouse, expressed in cpi (counts-per-inch). Mice with resolutions of 400 and 800 cpi are suitable for most office applications. Mice with higher resolution (up to 2000 cpi) are aimed at gaming and some graphics-intensive applications, where they offer enhanced precision.

Frame rate: This figure tells us how many pictures are taken by the “camera” every second. This number varies between 500 fps (frame per second) to more than 7000 fps.

Some examples of LED-based optical mouse sensors:

		Corded				
Sensor		ADNS-2610	ADNS-2620	ADNS-2051	ADNS-3060	ADNS-3080
General Features	Units	Entry Level	Entry Level	Mid Range	High Performance	High Sensitivity
Power Consumption - Running	mA	15 (typ)	15 (typ)	15 (typ)	40(max)	40(max)
Max Speed	ips	12 (@1500fps)	12 (@1500fps)	14 (@1500fps)	40 (@6400fps)	40 (@6400fps)
Frame Rate	fps	1500	500-2300	500-2300	500-6469	500-6469
Resolution	cpi	400	400	400/800	400/800	400/1600
Acceleration form Sleep Mode	g	0.25g @ 1500fps	0.25g @ 1500fps	0.15g @ 1500fps	15g @ 6469fps	15g @ 6469fps

		Cordless	
Sensor		ADNS-2030	ADNS-3040
General Features	Units	Low Power	Lowest Power
Pwer Consumption-Running	mA	13 (typ)	2.9 (typ)
Max Speed	ips	14 (@ 1500fps)	20
Frame Rate	fps	500-2300	Auto
Resolution	cpi	400 / 800	400 / 800
Acceleration form Sleep Mode	g	0.15g @ 1500fps	8g

Some examples of laser-based optical mouse sensors:

		Corded		Cordless
Sensor		ADNS-6000	ADNS-6010	ADNS-6030
General Features	Units	High Performance	High Sensitivity	Low Power
Pwer Consumption-Running	mA	50 (max)	53 (max)	2.5 (typ)
Max Speed	ips	20	45	20
Frame Rate	fps	500-6469	2000-7080	Auto
Resolution	cpi	400/800	400/800/1600/2000	400/800
Acceleration form Sleep Mode	g	8g	20g	8g

Buttons: The most basic optical mouse contains two buttons: a left button and a right button. For users of Windows, these two buttons can usually be programmed to suit both right-handed and left-handed users via the Mouse Control Panel. Also, the double-click speed can be set.

Most mice in today's market are three button versions: left, middle and right, with the middle button often combined with a scroll wheel. There are also mice with more than three buttons. The additional buttons are called "feature buttons" which needs some programming. To enable them, these mice usually come with a feature installation CD. Without installing the matching program, the feature buttons may not work.

Z wheel scrolling system (a.k.a. scroll wheel): Most optical mice have a z-wheel on top of the middle button. Basic z-wheel enables up-scrolls, down-scrolls and auto up/down cruise. Today, some mice even provide horizontal scroll functions via a tilting z-wheel.

With new developments such as the LaserStream optical technology, tilt-wheel scroll button, and multi-feature buttons, today's optical mouse is a sophisticated input device. Gone are the days where the mouse was a mere two-button, ball-in-a-cavity casing that was connected via a 28-pin serial port. In those days, the sole operating purpose was just to move the cursor around, launching individual programs. Today's mouse not only does that but also has superior performance and features, greatly out-maneuvering, out-surfing, out-pacing and out-featuring its ancestors.

For product information and a complete list of distributors, please go to our web site: www.avagotech.com

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