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White
Paper

MEMS: THE NEW CLASS OF BAR CODE SCANNER

Intermec
Honours Partner

Introduction

Bar code technology users no longer need to make a choice between the outstanding reliability provided by solid-state CCD readers and the fast performance associated with laser scanners. A major innovation in laser scanner design and manufacturing provides outstanding reliability and performance. By adapting highly proven, highly reliable MEMS technology for bar code reading, MEMS-based laser scanners provide faster reading, better recognition and processing of poor quality or damaged bar codes than traditional lasers, and extreme reliability even in demanding scanning environments. MEMS scan engines are also extremely compact – about the size of a sugar cube – which leads to lightweight, ergonomic and power-friendly scanners.

MEMS stands for microelectromechanical systems. MEMS devices combine electronic circuitry with miniaturized mechanical devices, which may include sensors, gyroscopes, actuators, motors, pumps and other components, on a silicon substrate that can be smaller than a grain of sand. MEMS is the underlying technology behind antilock brakes and vehicle airbags, and is used in numerous industrial and commercial products, including inkjet printers, projection systems, large-screen and digital televisions, optical networking gear, medical imaging, diagnostic equipment and battlefield displays. MEMS bar code scanning represents a new application for an established technology.

This white paper will explain how MEMS are used for bar code scanning, the reliability and performance advantages MEMS scanners have over traditional lasers, and the opportunities and limitations for using MEMS-based scanners.

What Is Mems?

MEMS is a nearly $10 billion industry that includes millions of devices in use in numerous industries. Many MEMS applications are very mature and established, such as automotive airbag and antilock brake sensors. Analog Devices, for example, produces and ships more than 1 million MEMS airbag sensors each week. Designs and production techniques for the MEMS components used for bar code scanning are also well established, because the components are used in mature market segments such as projection systems, consumer electronics and medical imaging. The optical segment of the MEMS market, which includes bar code scanners, is expected to triple in size between 2003 to 2007, reaching $1.7 billion, according to research by In-stat.

MEMS motors and other components can be smaller in diameter than a human hair. Components are assembled on silicon using integrated circuit production techniques. Further processing can be used to etch away parts of the silicon wafer or to add additional components. The assembly may include sensors (e.g. gyroscope, temperature, light, etc.) to collect input, electronics to process it, and a mechanical component (e.g. pump, actuator, motor, etc.) to perform an action based on the processed input. MEMS devices are sometimes called "systems on a chip." MEMS is not nanotechnology, which involves engineering at the molecular level.

MEMS devices were first developed in the 1970s and were commercialized in the early 1990s. In 1997, the Fraunhofer Institute for Photonic Microsystems (IPMS) in Dresden, Germany began developing a MEMS scanning mirror. Fraunhofer Society is Europe's largest organization for applied research and development. Intermec Technologies and Fraunhofer IPMS collaborated for five years to develop the EL10 MEMS laser scan engine, which was successfully tested in live customer applications around the world for more than a year before being released.

Bar Code Scanning Basics

Just like traditional laser bar code scanners, the EL10 uses a mirror to focus and direct a laser light source to scan a bar code symbol. The symbol is decoded in the traditional manner, with a sensor measuring the amount of light reflected back. The light measurement is converted to a digital signal and the decoding algorithm is applied. The EL10 uses a lens to collect reflected light, which optimizes the laser scanning process. Traditional laser designs can't accommodate separate lens and mirror assemblies, so the mirror does double duty to reflect and collect light. Compact MEMS technology enables separate lens and mirror components optimized for their specific tasks to be built into the scanner.

The most important differences between traditional and MEMS laser scanners are the mirror assembly and scanner size. Traditional scanners use a motor to oscillate the mirror to move the laser beam across the symbol. The scan speed is expressed as the number of times the beam can be swept over the symbol each second.

Motorized mirrors have proven problematic for traditional laser scanners. The mirror assemblies are soldered or wired into place, which is a consistent point of failure when scanners are dropped or bumped. To reduce the chance of damage, scanners can be ruggedized with heavier casings and by adding protective rubber, but these measures add size and weight to the device and reduce ease of use. MEMS components have considerably less mass than their counterparts in traditional laser scanners, which makes MEMS devices much more resistant to damage from drops. MEMS scanners are also more resistant to wear. Motors produce friction, which loosens and wears down components. Mirrors can also get out of alignment over time, which seriously degrades scanning performance. These dangers are mitigated or eliminated in MEMS designs.

Users who value dependability often choose charge-coupled device (CCD) bar code readers. CCDs are extremely reliable because they have no moving parts. Light emitting diodes (LEDs) illuminate the bar code symbol. The light reflected back is captured and converted into a digital signal that can be decoded. The LED, light sensor and signal processor are combined in solid-state construction that has proven to perform in challenging industrial and retail environments.

Mems Scanning

MEMS scanners deliver the reliability of CCDs to the laser category. MEMS scanners do not use a motor to move the mirror, which eliminates an important source of failure. In MEMS scanners, the mirror is etched directly on silicon and utilizes a unique method of frictionless oscillation that requires less power and offers increased speed as well as two-dimensional (2D) matrix scanning capability. MEMS mirrors are also much smaller than mirrors used in motor-driven scanners, making them more power efficient and easy to manipulate. The mirror, film and actuators are assembled in an integrated package that is shorter than a paper clip, and requires less power than motor-driven laser scanners.

MEMS scanners get attention for their small size, but the technology provides many other important benefits, which are explained below.

Scanning Speed

The small assembly makes efficient use of power and materials to oscillate the mirror very quickly. The scan rate for Intermec's first MEMS scan engine, the EL 10, is about 500 scans per second, which is approximately 14 times faster than common handheld laser scanners and five times faster than traditional "high speed" models. The speed advantage is expected to widen significantly as MEMS scanning matures. Traditional laser scanners have been developed and improved for 30 years. MEMS scanners are at the beginning of their development cycle. MEMS scanners are expected to perform several thousands scans per second and will offer increased scan rates as decoders are adapted to take advantage of the higher oscillation rates that MEMS technology produces.

Today's faster scan rates provide reading advantages compared to traditional lasers. Performing hundreds of scans a second produces more readings the scanner can use to recognize and process damaged and low-quality bar code symbols. The high scan rate makes the scanner more tolerant than traditional lasers of low contrast, torn and other problematic symbols.

Size

Smaller components are always welcome for electronic devices, especially those that are used by hand. The EL10 includes all the optics, mechanics and processors needed to scan linear and stacked bar codes in a shock- and drop-resistant package measuring 0.44 inch (11.1mm) high, 0.68 inch (17.2mm) deep and 0.81 inch (20.6mm) wide. The compact assembly is ideal for integrating into handheld and wearable computers, and adds less weight than other scan engines.

Reliability

The combination of frictionless scanning and solid-state construction eliminates the leading causes of failure in motor-driven laser scanners. MEMS scanners are produced to the same standard drop and shock resistance ratings as other bar code readers. It is important to appreciate that MEMS technology has been widely implemented and proven reliable in applications that are much more demanding than bar code scanning. In automotive collisions, MEMS devices measure the amount of force, process the information and deploy the airbag if necessary – all in milliseconds during a violent crash. Other MEMS devices provide real-time views of battlefields during combat. MEMS bar code scanners have been tested extensively and performed reliably for more than a year in a variety of usage conditions.

Range

First-generation MEMS scanners have a reading range comparable to common laser scanners. The EL10 can read a standard UPC/EAN symbol from about 30 centimeters (12 inches), which is 5 to 7.6 cm (2 to 3 inches) better than many common lasers. As with speed, range performance is expected to improve significantly as component technology matures. Oscillation techniques and the optics that collect reflected light will be optimized for use with MEMS scanners to add scanning range.

Power Consumption

Less power is required to oscillate a MEMS mirror than is required to power a mirror motor, which makes MEMS scanners more power efficient than motor-driven lasers. The current power draw is comparable and will provide only a marginal improvement to the battery life for handheld devices. MEMS scanner engineers expect to be able to reduce the power requirement by up to 50 percent by optimizing signal converters and other scanning components.

Limitations

First-generation MEMS scanners compare favorably with traditional lasers for range, speed and cost. Like all linear laser scanners, current MEMS devices are limited in their initial ability to process two-dimensional (2D) symbologies and read bar codes in any orientation. The linear laser beam that MEMS scanners produce outperforms traditional laser scanners for PDF 417 and other stacked 2D symbologies because of its high speed, but does not yet process matrix-style symbologies such as QR Code and Data Matrix. Future mirror assemblies and other design changes already on the drawing board will enable omnidirectional and raster scanning and extended range. The result will be MEMS scanners that read stacked and matrix 2D symbologies, as well as introduce new omnidirectional reading capabilities and perform long-range reading.

Conclusion

MEMS is not new technology, but provides an important new option for bar code scanning. The MEMS option should be considered when extreme reliability and responsiveness are desirable in scanning operations. Until specialty MEMS scanners are released, the technology is not an option for long-range and select 2D reading applications.

MEMS scanning is advantageous for daily operations in these environments, providing long term reliability and total cost of ownership (TCO) benefits. MEMS-based bar code scanners meet or exceed the speed and range performance users expect from common laser scanners while setting new standards for dependability and size. Ironically, the forthcoming innovations in materials, components and design that are expected to rapidly improve scanning performance may also help make MEMS scanners even smaller and more power efficient. MEMS scanner will also benefit from innovations to components and production techniques shared with larger and more established MEMS applications.

Intermec has a long history of innovation, including development of Code 39, still the world's most widely used bar code symbology; the type of smart battery management systems used in most of today's laptop computers; UHF RFID (radio frequency identification) technology; the use of micro fuel cells in automatic data collection equipment; CCD linear imaging; and patented bar code decoding technology. Fraunhofer adds a long history of its own innovation. By working together, Intermec and Fraunhofer are leveraging their expertise to optimize MEMS technology for bar code scanning.

Intermec offers a full range of bar code readers, including MEMS scanners, linear imagers, CMOS-based 2D imagers, laser scanners and scan engines to meet virtually every bar code reading requirement. Intermec has a product designed specifically to meet virtually every environmental, scanning and ergonomic need. For more information on Intermec scanning solutions, contact Intermec Technologies Corp. at 1-800-347-2636 or visit Intermec's Web site at www.intermec.com.

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