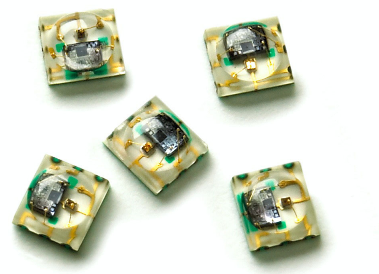
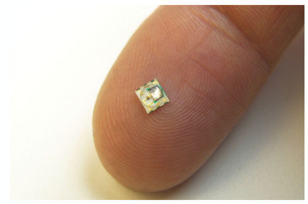
AEDR-8400

Application of Optical Encoder in Camera Phone Zooming Mechanism

Application Note 5269





Introduction

Avago AEDR-8400 encoder is miniature incremental encoder incorporating leadless surface mount capability. Its miniature dimensions of 3.00mm x 3.28mm x 1.26mm make it the smallest optical encoder with digital outputs in the market. With both the LED light source and the photo detector IC in a single package, the encoder employs reflective technology to sense rotary or linear motions. The small size and reflective technology allow the AEDR-8400 encoder to be used in a wide range of commercial applications, particularly where space and weight are primary concerns e.g. zooming mechanism in camera phone.

The AEDR-8400 encoder offers 254 lines per inch (LPI) resolution which is equivalents to 10 lines per mm (LPmm) with two channel digital outputs. The encoder is designed to operate over -20°C to 85°C temperature range. One of the critical criterions in the camera module inside camera phone is being able to operate at lower voltage level, and with the operating voltage of 2.8V typically, AEDR-8400 encoder will comfortably suits the needs of such application.

Zooming

Zooming in camera phone may have an optical zoom, a digital zoom, or both.

An optical zoom actually changes the effective focal length of the camera lens such that the original image is magnified and could be captured by the image sensor (CCD or CMOS). With greater magnification, the light is spread across the entire image sensor and all of the pixels can be used. An optical zoom could be interpreted as a true zoom that will improve the quality of pictures captured.

Whereas for digital zoom is a bit different. Software algorithm is applied rather than the actual hardware movement (i.e. lenses positioning) to magnify the image. Such magnification only involves certain portion of the captured image. It is known as the interpolation technique. Using such technique or algorithm, additional information needs to be added in order to enlarge that corresponding image portion. It may seem that the image captured is being magnified, however, in fact there is only certain portion of the real image information being utilized and the rest are come from the interpolation outputs.

One thing worth mentioning is that the higher the digital zoom, the smaller the real information portion is taken. Therefore many of the originally captured information on the image sensor will be discarded and more interpolated image data will be incorporated to the resultant image.

Seeing that, the optical zooming is an important mechanism in determining the true zooming power of a camera phone without losing any image data. Having accurate lens positioning control in optical zoom will be crucial to ensure quality enlarge image.

Figure 1 illustrates a typical example of zooming mechanism in a camera module inside a camera cell phone. Lenses are aligned such that image could be focused onto the image sensor (CMOS or CCD).The zooming mechanism involves synchronization movement between two or more lens (lens group). By varying the distance between the lenses, the actual effective focal length of the camera lens changes accordingly. Hence, a magnified image would be captured by CCD / CMOS image sensor.

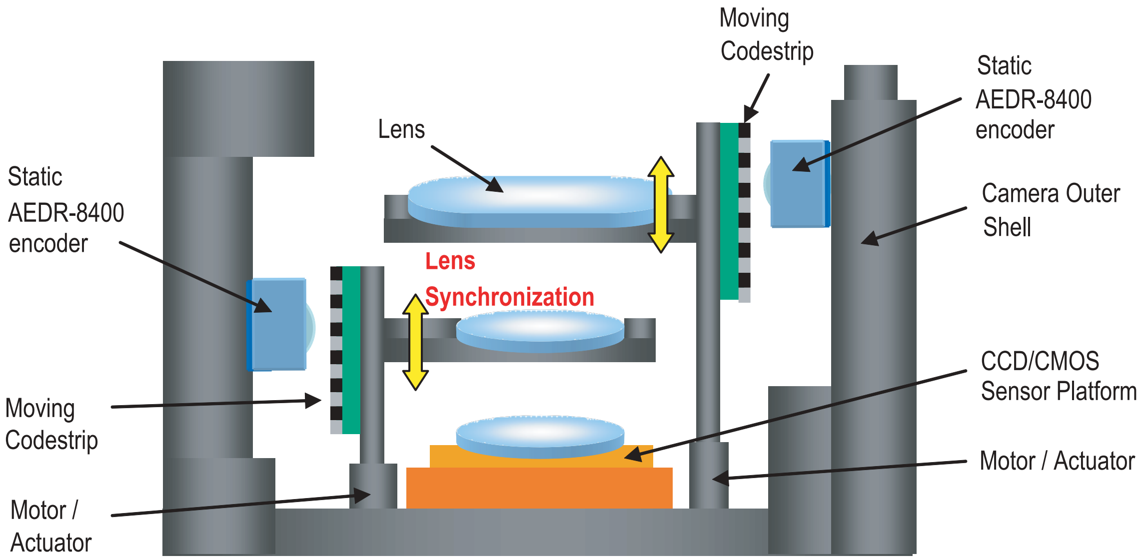


Figure 1. Typical zooming mechanism in camera phone with AEDR-8400 encoder

For the simplicity of wiring process, the encoders are mounted at the camera module shell and will remains in a fixed position. The moving portion would then be the codestrip that act as the translator for lens linear movement. Casting the window and bar image back to the encoder could feedback all the necessary information for prompt and accurate lens positioning.

With conventional zooming mechanism, combination of mechanical cam and gearing is a common approach for lens position controlling. However, such approach will suffer unavoidable wear and tear issue. Having so, the accuracy of lens positioning will degrade overtime and bringing direct impact to the quality of zoomed images.

The introduction of AEDR-8400 encoder would help to resolve the issue. The feedback from the encoder provides necessary information for real-time calibration whenever there is any back-lashing from gears and mechanical cams. This could ensure precise and accurate lens positioning. Furthermore, in some customized camera module design, removing the mechanical cam is possible.

Taking the piezo-actuator as an example, incorporating the AEDR-8400 encoder into such camera module could basically eliminate the use of mechanical cams. Since there is no mechanical cams involvement, there will be no fixed zooming position and the new camera module system now could have a continuous zooming function.

In terms of power consumption, piezo-actuators system tends to consume less power compare to voice coil solution as well as servo solution. Also, piezo solution could keep the noise and vibration level to the very minimum where this is something that stepper motor solution and voice coil solution could not achieved.

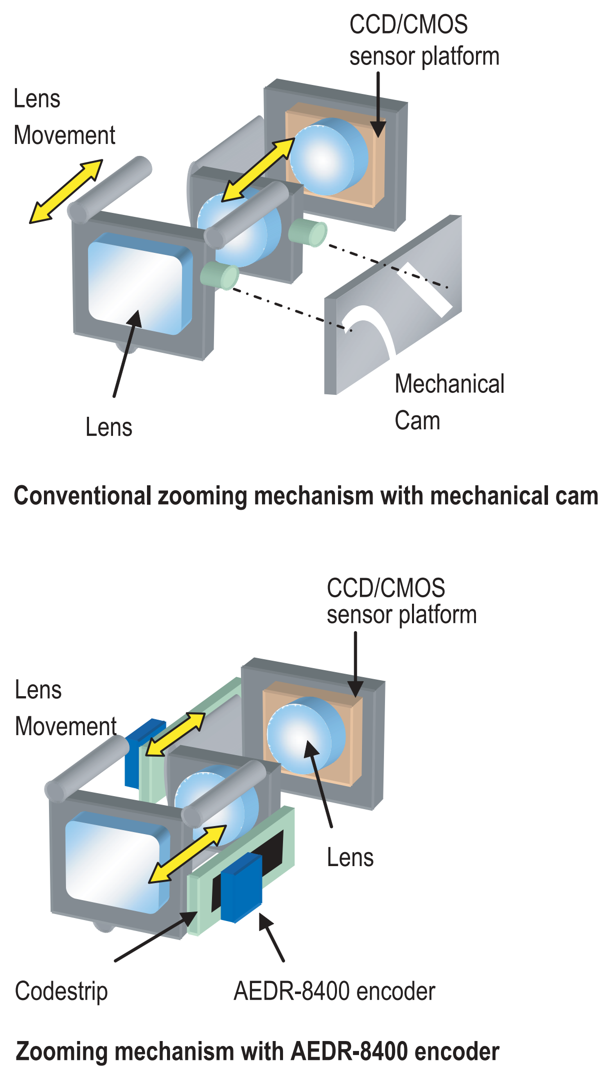


Figure 2. Introduction of Agilent reflective AEDR-8400 encoder for zooming mechanism in camera phone.

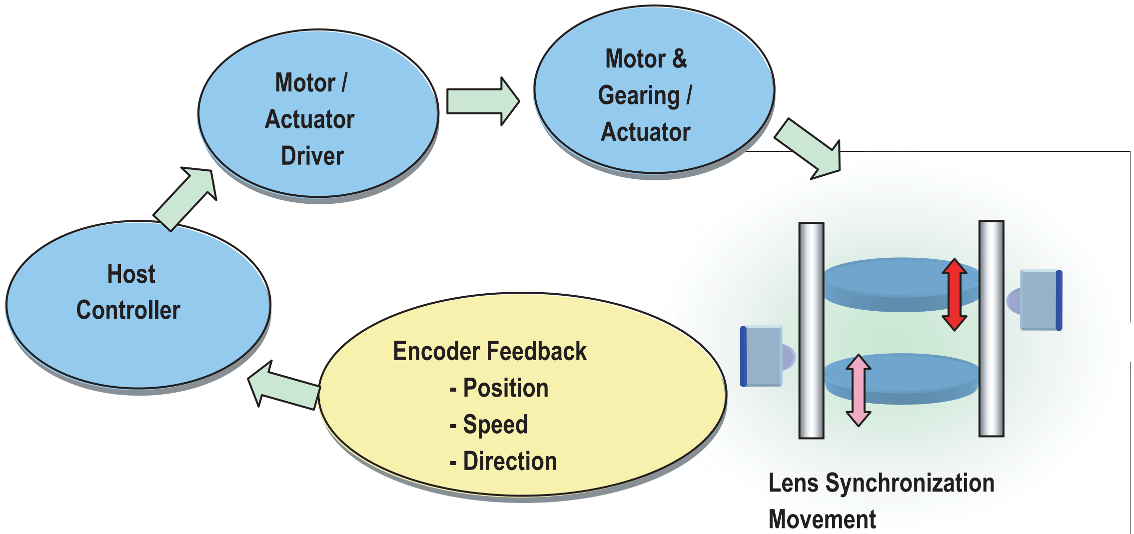


Figure 3. Block diagram illustrates Zooming mechanism with Encoder feedback.

The overall camera module design could be shrunk to a smaller size compare to a stepper motor solution or a voice coil solution. Although the motor size is comparable to the piezo-actuator, however, with the removal of mechanical cams and gearing, this enables the overall camera module dimension to be brought down further to meet the existing market demands.

In short, the AEDR-8400 encoder helps to provide precise positioning control between both the lenses and results a better quality zoom image. Synchronization of lenses movement could be performed fast and accurately.

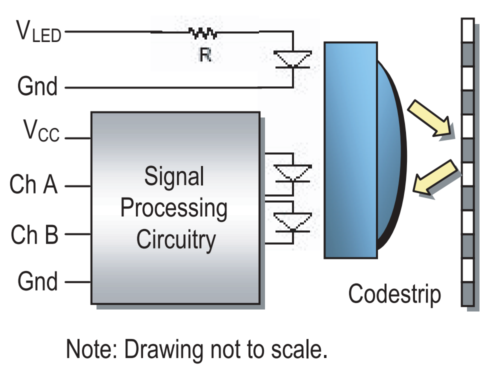


Figure 4. Optical arrangement of reflective encoder.

The Encoder Operating Principle

The sensor consists of an LED light source and a photo-detector IC in a single SO-6 (Small Outline-6 Pin) surface mount leadless package. Figure 4 shows the optical arrangement of AEDR-8400 encoder used with a reflective codestrip. The lens focuses the light from the LED onto the window and bar of the codestrip. Likewise, the reflected images of the window and bar are focused to the photodiodes. As the codestrip moves, an alternating pattern of light and shadow cast by the window and bar, respectively, falls upon the photodiodes. The detector IC converts this pattern into digital TTL compatible outputs representing the codestrip linear motion hence the lens movements. An important parameter is resolution, which is defined as the density of window/bar in a unit distance and is typically defined as lines per inch (LPI) or lines per mm (LPmm). Higher resolution means 'finer' control of the linear motion.

The AEDR-8400 encoder is designed such that both the LED and detector IC of the encoder should be placed parallel to the window/bar orientation. As such, the encoder is robust against radial play. This concept is illustrated in Figure 5.

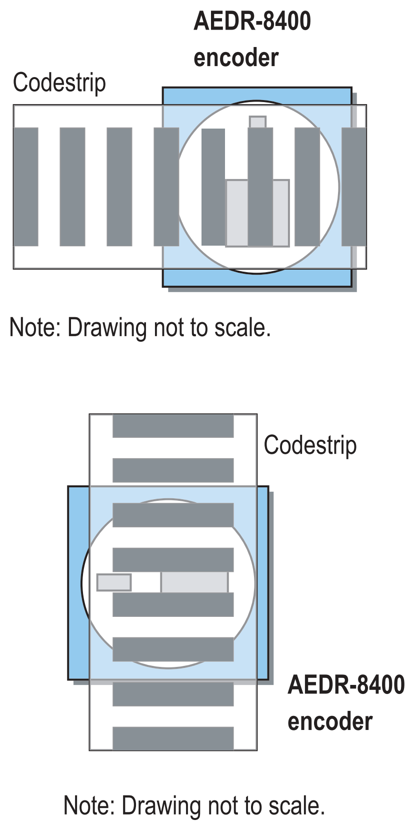


Figure 5. Optical alignment of emitter / detector with respect to window / bar, as viewed from top.

Using the Encoder Outputs

The encoder outputs, namely Channel A and Channel B, are characterized by their quadrature relationship. As shown in Figure 6, there is a phase shift of 90 electrical degrees between the channels. In addition, the channels are also characterized by their 4 states, i.e. State 1 to State 4, each spanning a nominal 90 electrical degrees. Information about linear motion, e.g. movement speed and distance travel can be derived from the parameters of the output such as pulse period and number of pulses, whilst the direction of linear movement is determined by the phase relationship between the two outputs. When the codestrip moves in one direction, Channel A leads Channel B by 90 electrical degree. When the codestrip moves in the other direction, Channel B will lead Channel A by the same amount. This concept is illustrated in Figure 7.

Resolution higher than that of the codestrip is achievable via interpolation, where different levels of interpolation exist. Counting every rising edge of one channel (e.g. Channel A) is called 1X decoding. The codestrip resolution can be doubled by counting every rising and falling edge of one channel to further increase the resolution. This is called 2X decoding. When every transition of both Channel A and Channel B is utilized (or every logic state), 4X decoding is achievable.

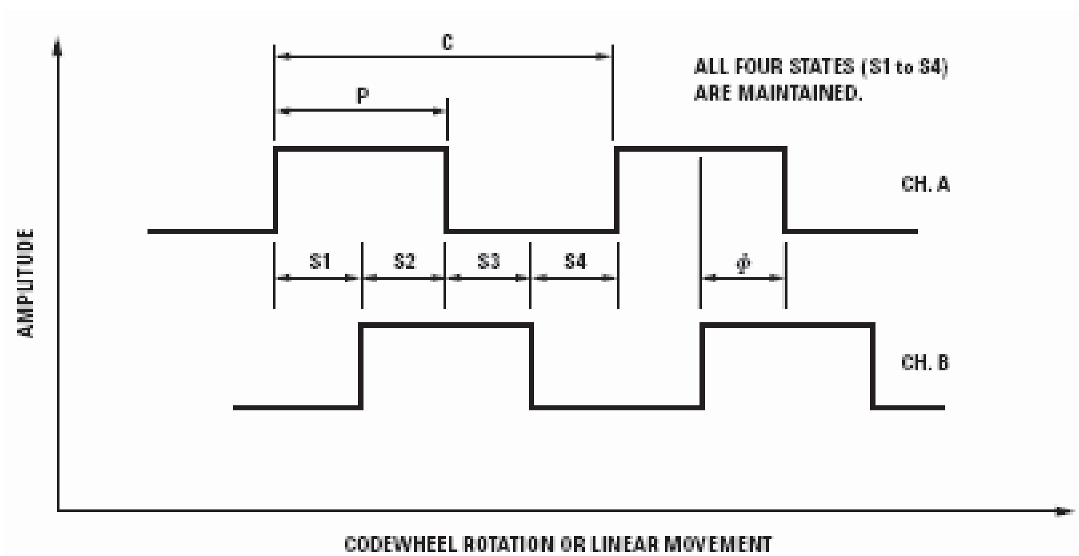


Figure 6. Quadrature characteristics of Channel A and B.

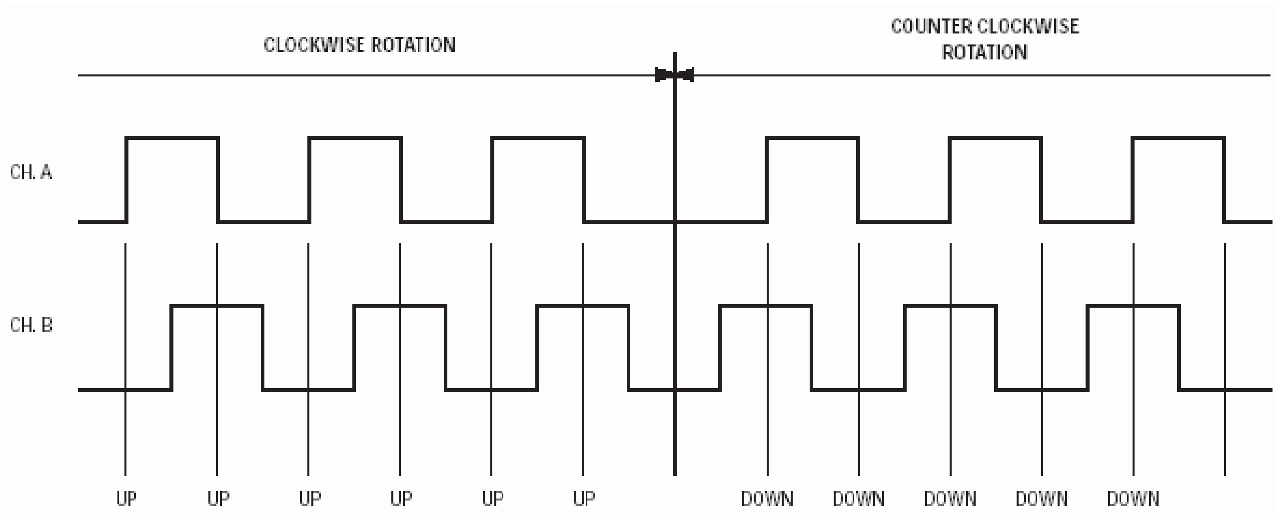


Figure 7. Phase lead and lag between Channel A and B indicates direction of rotation.

Advantages of AEDR-8400 Encoder for Zooming

- Accurate movement between lenses for better zoom image.
- Fast Zooming mechanism: Real time calibration for motor and gear back lashing.
- Provide additional information such as speed and direction.
- No wear and tear due to optical technology.
- Helps to reduce module size when incorporates with piezo solution by removing the mechanical cams and gearing.
- Also, provides continuous zooming as not fixed lens position by mechanical cams.
- AEDR-8400 together with piezo solution consumes less power than existing stepper motor / VCM and mechanical cam combination.
- Furthermore, the noise and vibration level will be kept to very minimum.
- AEDR-8400 with optical reflective technology is robust towards gap tolerance and manufacturability compare to magnetic encoder for high resolution application.

The Codestrip

The codestrip surface must be reflective and specular (mirror-like) so that the image of the pattern is reflected back onto the photo-diodes of the AEDR-8400 encoder. Potential materials include metal and reflective film. One method to determine whether the codestrip will work with the reflective optical encoder is using a Scatterometer.

Reflective surfaces with a specular reflectance of 60% or higher as measured by the device were compatible with the reflective encoder. The non-reflective areas should have a reflectance of less than 10%.

When testing for specular reflectance, testing should be done such that reflective surfaces are tested separately from non-reflective surfaces. Test the reflective surface by itself, and then test the non-reflective surface. Do not perform tests on the patterned surface, as this will only give an average reflectance across the pattern.

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

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