Small, Wide-Angle Autofocus Modules

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1. Introduction

In the compact camera market, there is strong competition for higher performance and smaller size cameras with a built-in zoom function. In particular, the relative merits of autofocus (AF) systems largely influence performance of compact cameras.

In the past, Fuji Electric developed small, light and high-performance range sensors which we call AF modules by adding an optical system to a single-chip autofocus IC (AFIC) that integrated an analog-to-digital (A-D) converter for sensor data with a range data calculation circuit. Fuji Electric has been producing these modules since 1992.

Moreover, AF modules with analog image data output were developed for further miniaturization of the cameras based on the advanced photo system. Fuji Electric has continued production of this type of module since 1998 with favorable market acceptance.

Fuji Electric also has developed a small, low-priced FM6260W80 AF module capable of wide-angle range measurement. This module with an analog data output type of sensor and a new optical system can be used in digital cameras and point and shoot cameras with the X2-class zoom lens.

Figure 1 shows a picture of the FM6260W80 module. This paper describes the configuration, structure and features of the FM6260W80 module. Table 1 lists the product line of AF modules with MOS analog sensors.

2. Main Features of FM6260W80

With an analog data output type of sensor and a new optical system, this module has the following

Fig.1 External view of the FM6260W80 AF modules

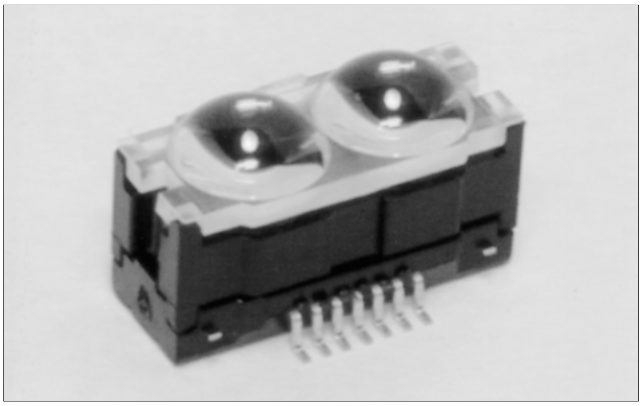


Table 1 Line-up of AF modules with MOS analog sensors

Item \ Type	FM6256T36	FM6254T34	FM6255AT42	FM6260W80
Applied AFIC	FB6256T	FB6254T	FB6255T	FB6260
Number of terminals (pins)	24	24	16	14
Terget camera	Compact camera LS : zoom×(3 or more)	Compact camera LS : zoom×(3 or more)		Compact camera LS : zoom×(2 or less) Digital still camera LS : zoom×(3 or less)
Base length *B* (mm)	7.118	5.566	5.566	5.566
Forcal length *f* (mm)	10.7	10.7	5.7	4.2
Number of photodiodes	2×224	2×130	2×130	2×200
Photosensor pitch (μm)	12	21	12	14
Sensor response (V/s) [standard source A : 5EV]	147	220	200	880
Full view angle of sensor area (degreees)	10.1	10.1	10.8	25.9
DC power supply voltage (V)	5.0 (typ.)	5.0 (typ.)	5.0 (typ.)	3.3/5.0 (typ.)

Fig.2 Block diagram of the AFIC with MOS analog sensors

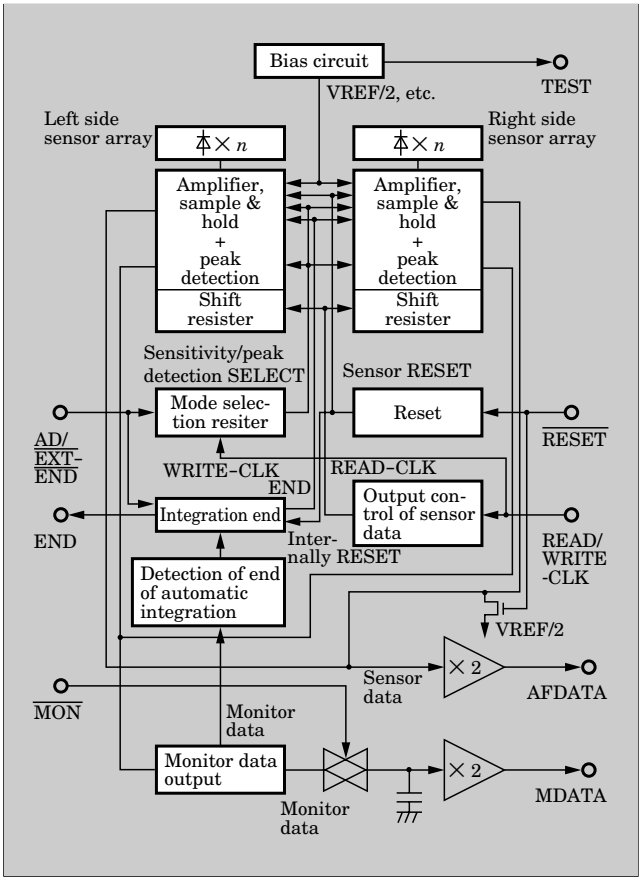


Fig.3 Example of sensor data output

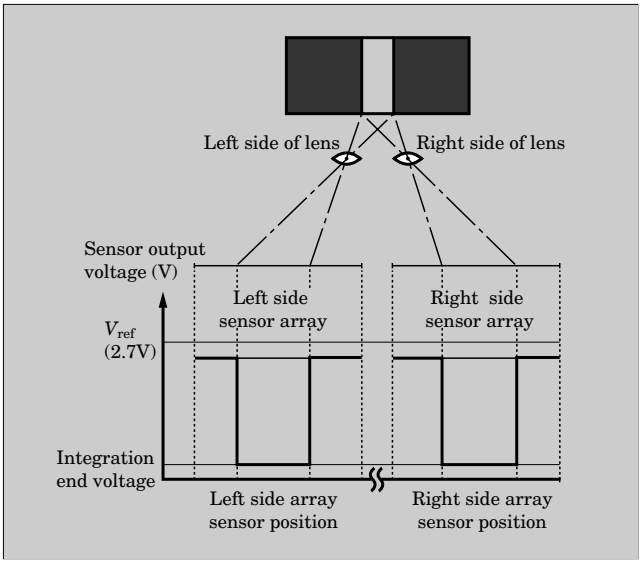
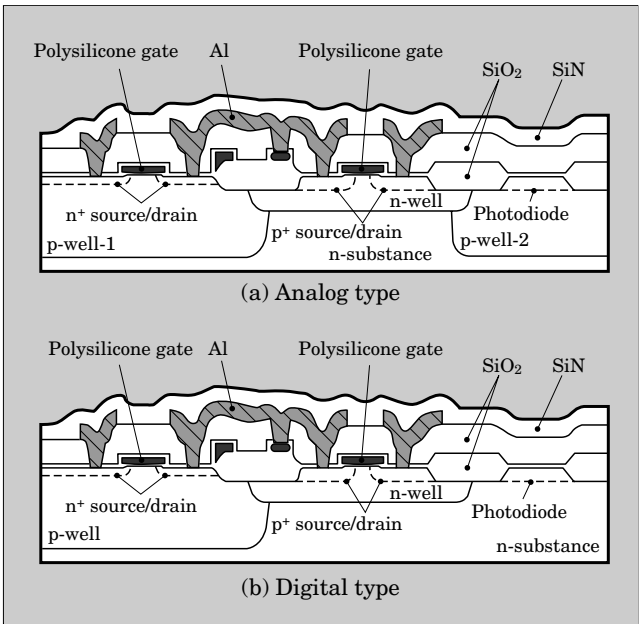


Fig.4 Structure of the photodiode



features.

(1) Miniaturization

Because the sensor pitch can be made smaller by using an analog data output type sensor, miniaturization of the module can be realized.

(2) Low price

The IC unit and optical system were separated in the conventional AF module. By adopting an integrated structure, the number of processes could be reduced and lower cost realized.

(3) Shading

A new structure eliminates the need for shading, which had been implemented as a clear molded part in the past, and reduces the size of the mounting space of the module.

(4) High sensitivity

Due to the adoption of a bright aspherical lens, range measurement can be performed with a response time of 200ms even when the brightest point of the object to be measured is –1.3EV.

(5) Wide angle

The angle of view covers a visual field of approximately 26 degrees.

3. Circuit Configuration of the Analog AFIC

Figure 2 shows a block diagram of an AFIC with MOS analog sensors. A detailed explanation is omitted, but this IC is configured such that the photocurrent of each photodiode on the left and right side sensor arrays is converted into a voltage and then amplified by integrator and amplifier circuits that are both composed of MOS transistors. Sample-and-hold of the voltage is then performed as sensor data.

Operation of the integrator circuit starts from the initial reference voltage V_{ref} and the output voltage descends according to its integration time. Upon receiving the integration end signal, sample-and-hold of the voltage is performed at that time. After synchronization with an external clock signal, each pixel's sensor data is selected and passed to the output. As shown Fig. 3, the output sensor voltages which corresponds to pixels projected from bright parts of the object image are low, and the output voltage of pixels

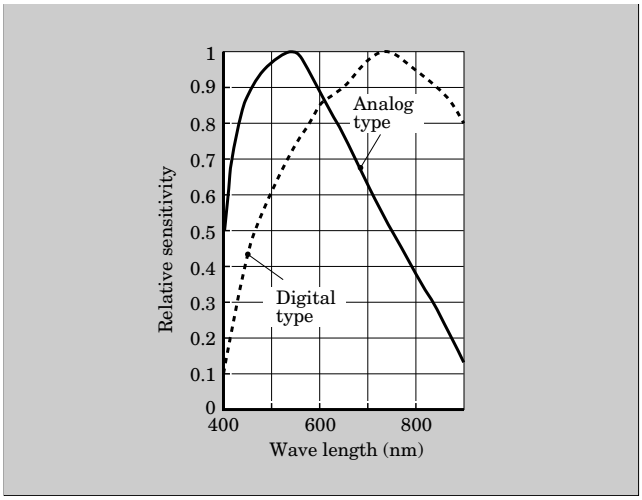
which corresponds to dark parts of the image approximate to V_{ref}.

4. Structure and Characteristics of the Photodiode

In MOS analog sensors, alteration of the aforementioned sensor circuitry also modified the photodiode structure, which had been used in conventional digital types. Figure 4 is a cross section of the IC structure showing the transistor part. In contrast to the conventional digital types, the photodiode is configured to be electrically isolated from the substrate. This decreases the influence of carriers generated in the substrate. Consequently, any noise in the image data is reduced.

As shown in Fig. 5, this structural modification of the photodiode also changes its spectral sensitivity characteristic. Namely, since the carriers generated from deep regions of the substrate are absorbed at the junction between the substrate and p well-2, sensitivity to light with long wavelengths is decreased in comparison with the digital type. As the dynamic range of the spectral sensitivity characteristic narrows, the influence due to chromatic aberration of lenses is reduced and sharper image signals have been achieved.

Fig.5 Spectral sensitivity characteristics



5. Features of New Module Structure

5.1 Low price

Figure 6 compares structures of the FM6260W80 module and the conventional FM6255AT42 module.

In manufacturing the conventional FM6255AT42 module, the AFIC unit (clear molded package) was manufactured first by sealing the AFIC chip in transparent epoxy resin after attaching the die to the lead frame and wiring. Next, the optical system (shading case with lens) was positioned and bonded to this AFIC unit to form the AF module.

Fig.6 Comparison of structures of the AF modules

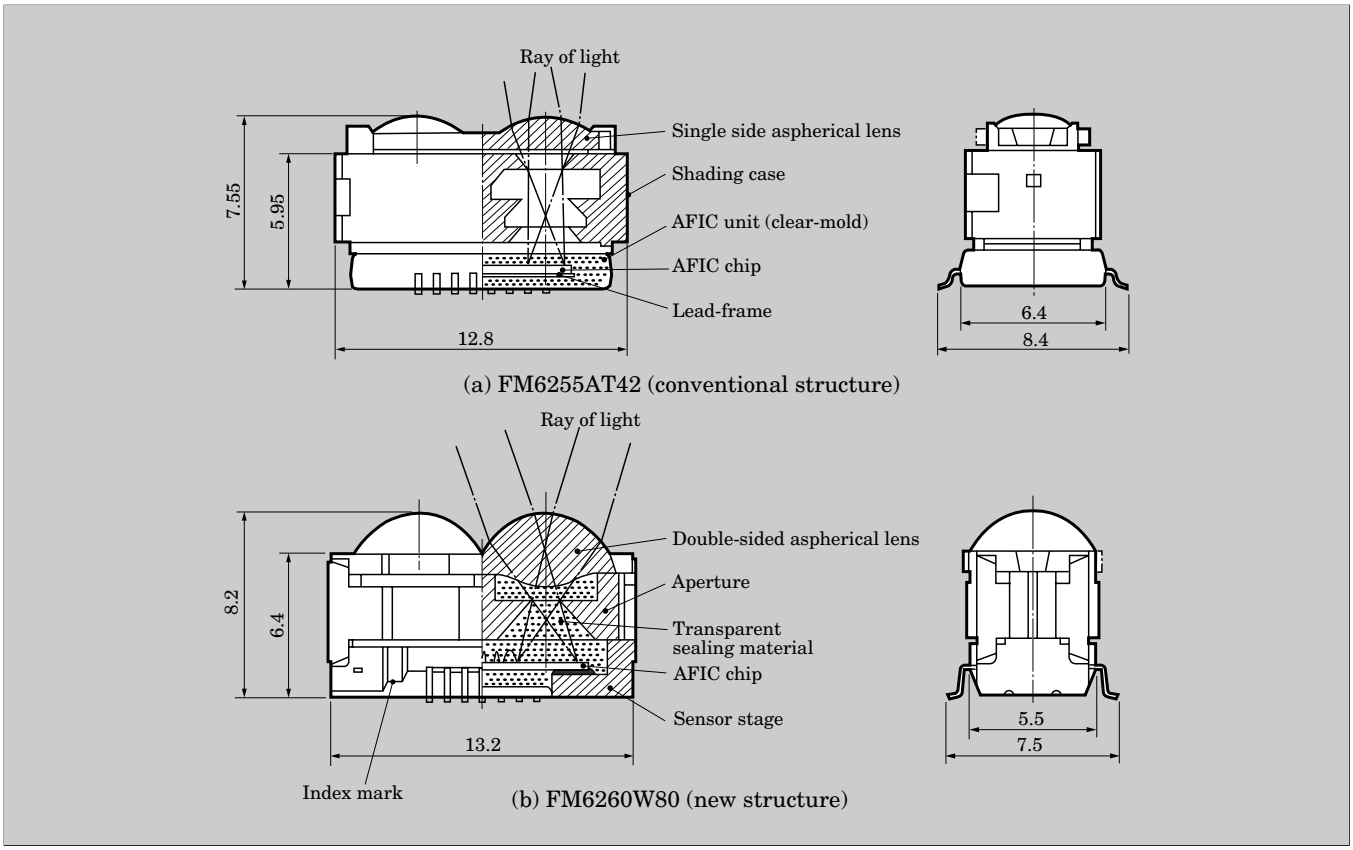
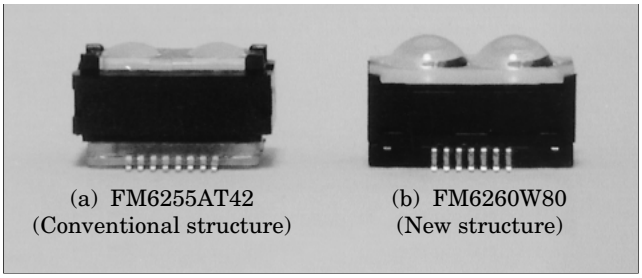


Fig.7 Comparison of shading structures of the AF modules



(a) FM6255AT42 (Conventional structure)

(b) FM6260W80 (New structure)

In contrast, the FM6260W80 module has a new structure. The die-bonding of the AFIC chip and wiring are performed on the sensor stage, which is made from resin by injection molding with the lead frame. After the aperture and lens are bonded to the sensor stage, transparent sealing material is injected and hardened between the lens and AFIC chip.

Because a new AF module can be manufactured with the same number of man-hours as an AFIC unit, a substantial cost reduction is possible compared with a conventional structure.

5.2 Improved sensor characteristic

The AF module features not only lowered cost but also improved sensor characteristics by means of a new structure. With the conventional clear-mold, the stress to the AFIC chip from transparent epoxy resin was not ignorant. That stress, which varies due to the temperature or humidity, could change the sensor characteristics. When the sensor pitch is wide, this stress variation does not make much influence on the sensor characteristic. However, the influence grows in accordance with the sensor pitch narrows.

The sealing material used for the FM6260W80 module need not support the structure of the module. Therefore, a flexible material can be utilized as the sealing material. Consequently, the stress hardly affects the AFIC chip, and there is no resulting change in characteristics.

5.3 Improved shading

When the AF module was installed in the camera, it was necessary to shade the clear-mold part completely with black tape or a partition. Because the part of the FM6260W80 module that corresponds to the conventional clear mold package is constructed with a black resin (shown in Fig. 7), it is already shaded. Therefore, the number of man-hours required for assembly and the mounting space in the camera can be reduced.

6. Bright Wide-Angle Lens

The FM6260W80 is available under low illumination in which the supplementary light is needed with the conventional system.

Therefore, by adjusting the f-number of the lens to 1.4 (approximately four times the brightness of the previous value of 3.0) and optimizing the sensitivity of the sensor chip to the sensor pitch, the sensitivity of the AF module was raised to 880V/s as shown in Table 1. Range measurement at –1.3EV (the brightest part of the object) is available with a response time 200ms. So that the contrast of the object could easily be acquired, the angle of view was designed to be approximately 26 degrees, twice the angle of the conventional type.

The lens shape on not only the front side but also the sealing material side is designed as an aspheric surface to correct individual aberrations such as distortion. Sufficient performance is obtained so that brightness and the wide angle can coexist.

7. Conclusion

The AF module of low-cost, wide-angle, small size and high sensitivity has been introduced. To meet user's needs, Fuji Electric will continue to develop advanced AF modules and to provide highly original products.