High-resolution Compact Auto Focus Module with 7 µm Pixels

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1. Introduction

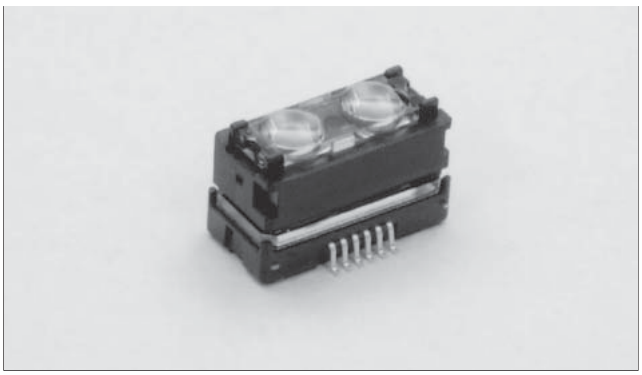
A high-speed externally attachable auto focus (AF) system is in demand for both conventional film cameras and digital still cameras (DSCs). The trends toward smaller size and lighter weight are advancing rapidly in the compact camera industry, and the extent to which Fuji Electric's AF modules (AFMs) follow these trends will be a decisive factor in their acceptance in the market.

Fuji Electric is already recognized as a successful producer of AFMs. Specifically, in 1992 Fuji Electric began mass-producing an AFM that integrated an optical system with an AFIC, which combined an A/D converter to convert sensor data and AF logic to perform range calculations into a single chip. Then in 1998, Fuji began mass-producing an analog output-type AFM, which enabled the sensor pitch to be made smaller, and this analog output-type AFM has been well received in the marketplace. In response to demands for even further miniaturization driven by the emergence of the advanced photo system (APS) film camera, Fuji Electric has been mass-producing the FM6255AT42, an AFM for 2× zoom cameras featuring a 12 µm pitch sensor and a compact optical system.

In response to demands for miniaturization for AF-equipped powerful zoom cameras, Fuji Electric has recently developed the FM6270W45, which features a newly designed IC package and an analog output-type 7 µm pitch sensor for 3× and higher zoom class film cameras and DSCs.

Figure 1 shows the external appearance of the FM6270W45, the structure and features of which are described below. Table 1 lists Fuji Electric's product line-up of analog output-type AFMs.

Fig.1 Appearance of FM6270W45 AFM



2. Main Features of the FM6270W45

2.1 IC features

(1) Improved range resolution

Due to the reduction in sensor pitch from the 12 µm pitch of prior models to the 7 µm pitch of the FM6270W45, range resolution has been improved

Table 1 Fuji Electric's product line-up of analog output-type AFMs

Item \ Model	FM6255 AT42	FM6266 W37	FM6270 W45
AFIC utilized	FB6255AT (clear mold package)	FB6266W (new structure)	FB6270W (new structure)
Number of pins	16	12	12
Target camera	2× and lower zoom compact cameras	3× and higher zoom compact cameras	3× and higher zoom compact cameras
Baseline length B (mm)	5.566	5.566	5.566
Focal length f (mm)	5.7	10.7	5.7
$B \cdot f$ product (mm^2)	32.6	61	32.1
Number of photodiodes	2 × 130	2 × 224	2 × 224
Pitch of photodiodes p (µm)	12	12	7
Sensor response (V/s) (Standard source A: 5EV)	200	147	230
Full view angle of sensor area (degrees)	10.8	10.1	10.8
DC power supply voltage (V)	4.0 to 6.0	3.0 to 6.0	3.0 to 5.5
Range resolution (Bf / p)	2.717	5.083	4.586

without changing the *Bf* product.

(2) Improved flexibility and ease-of-use

Prior models had two selectable sensitivity levels, high sensitivity or low sensitivity. The FM6270W45 allows greater flexibility in the setting of sensitivity, and sensitivity can be selected from among four levels. Also, by designating the pixel address, a partial readout can be obtained.

2.2 A new IC package

Features of the high-resolution compact AFM housed in a newly designed IC package structure (hereafter referred to as the new package) are listed below:

(1) Improved package

A new package structure is utilized in which the IC chip is sealed with soft material so that almost no stress is generated during sealing. This new package structure prevents the generation of stress that could lead to fluctuation in product characteristics.

(2) Improved light shielding ability

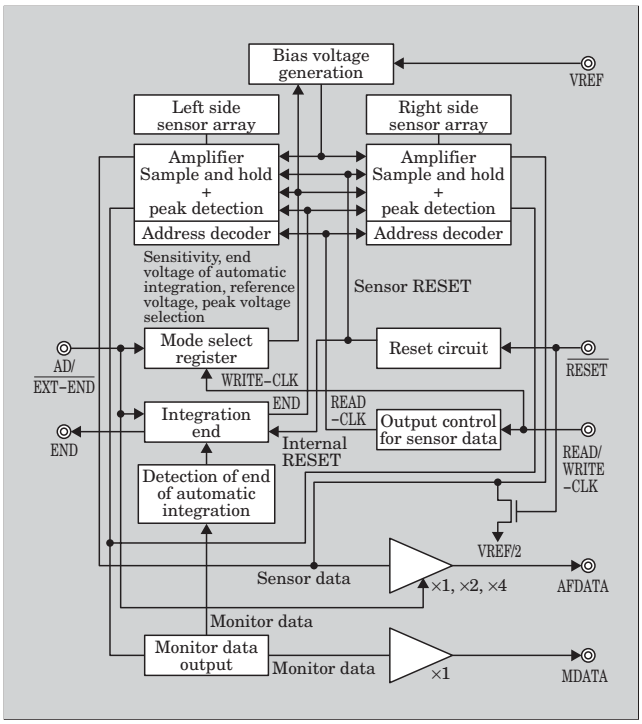
Use of this new package structure simplifies the light shielding that had been required for the conventional clear mold package. Consequently, the new package can be implemented in a smaller size than a conventional package.

3. AFIC Circuit Configuration

Figure 2 shows a block circuit diagram of the FM6270W45. In this IC, the photocurrent from each photodiode in the left-side and right-side sensor arrays is converted into a voltage by a MOS (metal oxide semiconductor) based sensing circuit (integrator) and amplifier, and then amplified, sampled and held as sensor data.

Sensing (integration) starts at the reference voltage V_{ref}, and the circuit provides for the output voltage to decrease in proportion to the duration of the sensing interval. Upon receiving an integration end signal, the voltage at that time is sampled and held. The sensor data of each pixel is selected and output in synchronization with an external clock. As can be seen in Fig. 3, in areas where the subject image is bright, the corresponding pixel output voltage is low, and in dark areas, the corresponding pixel output voltage is a value near V_{ref}.

Fig.2 FM6270W45 block diagram



4. Use of a 7 µm Pitch Sensor

Among Fuji Electric's AFMs currently in mass production, the minimum sensor pitch of the

Fig.3 Example of sensor data output

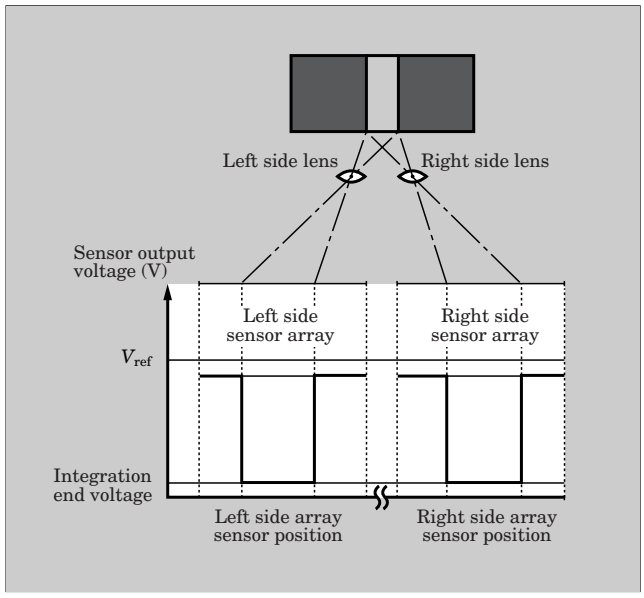


Fig.4 Module downsizing due to sensor pitch reduction

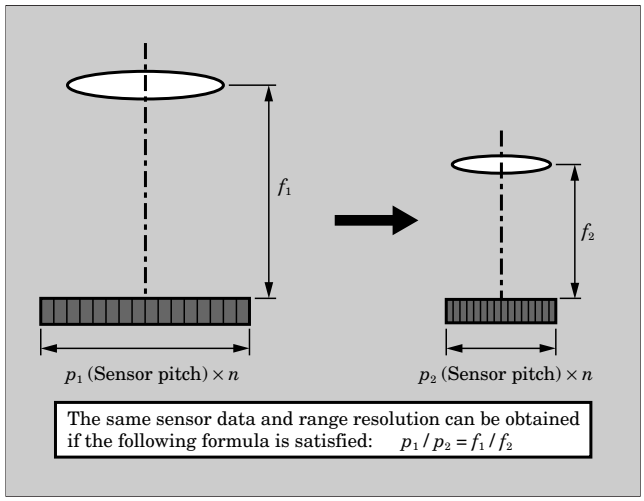


Fig.5 Comparison of conventional and new AFM package dimensions

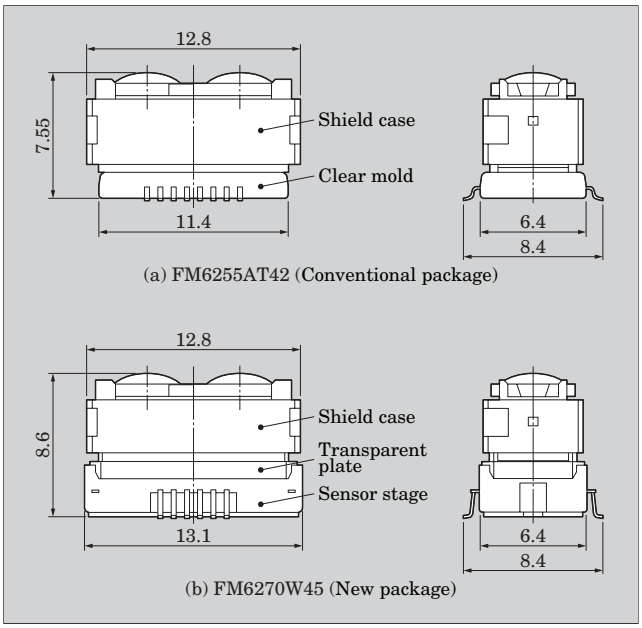
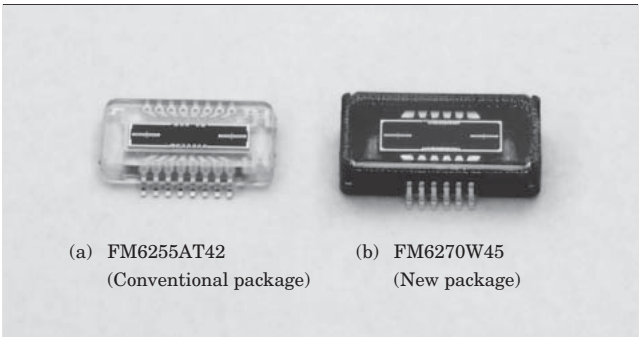


Fig.6 Comparison of conventional and new AFM packages



FM6255AT42, FM6266W37 and other models is 12 μm. The recently developed FM6270W45 has a sensor pitch of 7 μm, however. As can be seen in Fig. 4, if the sensor pitch is reduced and the focal length f of the lens is reduced in the same proportion, the identical range resolution can be achieved without having to change the ratio of the subject image size with respect to the sensor pitch. Accordingly, in approximately the same size package as the FM6255AT42, the FM6270W45 can achieve range resolution sufficient for an AFM for 3× and higher zoom cameras.

5. Features of the New Module Structure

5.1 A new package

Figure 5 shows a comparison between the external dimensions of the FM6255AT42 AFM, which has a conventional package structure, and the FM6270W45, which has a new package structure.

In the construction of the conventional package of the FM6255AT42, an AFIC unit (clear mold package) is initially formed by sealing an AFIC chip, which has been die bonded and wire bonded onto a lead frame, with a transparent epoxy resin. Lens-mounted shield cases are positioned and affixed one at a time onto the AFIC units to complete the AFMs.

With the new package structure of the FM6270W45, however, instead of the conventional clear mold, an AFIC chip is die bonded and wire bonded to a sensor stage made of resin and formed by insert injection molding with a lead terminal. After a transparent plate is bonded to the sensor stage, a transparent encapsulant is injected between the transparent plate and the AFIC. This encapsulant is then cured to produce the AFIC unit. Then in the same manner as conventional processing, lens-mounted shield cases are individually positioned and affixed one at a time onto the AFIC units to complete the AFMs.

5.2 Improved sensor characteristics

The new package structure also has led to improved sensor characteristics. In the conventional molded IC package, the stress applied to a transparent epoxy resin covered AFIC chip varied according to the temperature and humidity, and this had a subtle effect on sensor characteristics. The effect was negligible when the sensor pitch was large, but became increasingly problematic as the sensor pitch was made narrower.

Because the encapsulant used for the FM6270W45 is not required to provide structural support, a soft material can be utilized and since almost no stress is applied to the AFIC chip, the device characteristics will not fluctuate.

5.3 Improved light shielding

When installing an AFM into a camera, it had previously been necessary to use black tape or to form a structural partition inside the camera in order to shield the transparent clear mold completely. As shown in Fig. 6, in the FM6270W45, the area corresponding to that of the conventional clear mold is formed almost entirely with black resin. In an AFM, this chip only requires minimal shielding at the periphery of the transparent plate where the shield case connects to the new package, and therefore the module requires fewer production processes and less space for installation.

6. Conclusion

An overview of the 7 μm sensor pitch, high-resolution compact AFM has been presented.

Fuji Electric will continue to develop higher performance, lower cost AFMs, and will strive to develop highly original products to meet customer needs.