

# Lineup for Compact Cameras from Milbeaut M-4 Series Image Processing System LSI for Digital Cameras **MB91683/MB91686**

A new lineup of 1) a low-price product and 2) a product incorporating a moving image function in M-4 Series that realizes high speed and high image quality utilizing 90nm technology and an advanced color conversion algorithm. An advanced noise reduction function and sensitizing function have been added.

## Overview

Since its introduction in 2000 as M-1 Series, Milbeaut has been widely adopted in digital cameras of many varieties ranging from single-lens reflex cameras and compact cameras to the camera modules of cell phone.

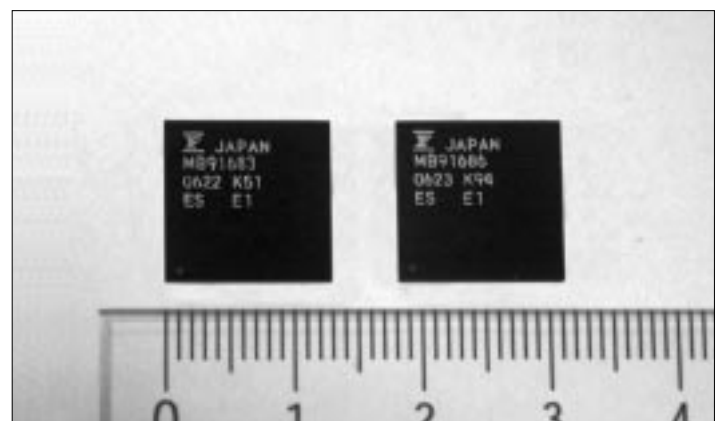
During the six years we have worked to advance digital cameras, FUJITSU has upgraded the core color processing engines over four generations in order to address demands for increased pixels, faster processing speed, improved image quality, high function development, reduced power consumption, and cost reduction. We have realized improvement in overall efficiency and functions to adjust image quality such as noise reduction and edge enhancement. Moreover, we have achieved operating frequency speedup and have substantiated multimedia functions such as MPEG-4 and audio processing. All of these improvements culminate in our new major upgrade, M-4 Series debuted in the spring of 2006.

MB91680, the first shot product, targets single-lens reflex and prestige-class compact cameras. It is capable of supporting connection to a large 2-line output-type CCD or HDTV. It

also mounts 16-bit high-speed DSP to enable advanced image and audio processing utilizing software.

We have now added two products to M-4 Series: M-4A, which has high functions and high integration, and M-4ML, which has MPEG-4 moving image functions. M-4A has took peripheral functions into it to make it applicable to low-price,

Photo 1 External View



compact digital cameras. It also mounts an adaptive noise reduction function that efficiently removes noise unique to compact devices as well as an adaptive pixel addition function that supports shooting in low light. M-4ML supports MPEG-4 moving images, HDMI connection, and high audio quality through DSP and also offers functions equivalent to M-4A to substantiate its multimedia functions.

In the next generation, we plan to mount the H.264 function, which is the latest moving image compression technology available for digital terrestrial broadcasting.

## Product Features

### ■ Reproduction of vivid colors with fidelity

By developing the original color interpolation process as hardware from the 1-plane image with Bayer assignment output from general sensors, beautiful full-color images are generated at high speed using a complex algorithm.

Since the launch of the second-generation M-2 Series, digital single-lens reflex cameras have been renowned for their fidelity reproduction of vivid colors.

The fourth-generation M-4 is capable of generating vivid and clear images with drastically improved resolution. It also offers the powerful color reproduction capability nurtured in former generations.

Various and rich parameters are offered that enable color creation to be user customized even during hardware processing.

### ■ New free color conversion function

Even when vivid colors are reproduced with fidelity, the colors perceived by the human eye and the colors actually obtained may vary. In addition, recent digital cameras have begun to incorporate methods for expressing colors that are more vivid than the actual ones or expressing what is called “memorable color,” which is not the color seen but the color that a person remembers.

It is difficult to convert the colors of the sky, grass, and human skin individually using conventional color conversion functions. Human skin appears overly pale when the blue color of the sky is enhanced. Similarly, when the green color of grass is enhanced the color of the sky may seem lackluster even if the actual color was beautiful.

The color conversion function that was newly developed for this product resolves this color conflict for digital camera manufactures. It allows color conversion that does not affect the color of grass or human skin even when the blue is enhanced and it does not affect the color of the sky or human skin when the green color of grass is enhanced. The combination of these functions naturally gives users the capability to convert colors freely.

### ■ High noise reduction performance

Recent CCD and CMOS sensors include a great deal of noise in the data due to circuit sophistication that arose from the miniaturization to support multiple pixels, speedup, moving image support, etc. Furthermore, many cameras have irrational optical designs in the optical unit due to miniaturization and price reduction, leading to greater adverse effects on the output image data.

Using its original technology, FUJITSU mounts an appropriate noise reduction function in steps before and after the color interpolation process.

Strong noise reduction usually sacrifices resolution. Not so with FUJITSU’s original technology: it efficiently removes the noise remaining the resolution.

It mounts a strong removal function against the color moiré unique to Bayer, lattice-shaped noise, and uneven colors in addition to the noise from sensors or hardware. Color moiré is removed effectively by detecting the color moiré itself instead of shading off the color. Similarly, lattice-shaped noise is also removed effectively without losing the resolution by detecting the noise itself.

As with the color interpolation function and other processing tasks, the noise removal function is hard-wired into the hardware, enabling the execution of advanced and complex processes in real time.

### ■ Adaptive pixel addition functions

A new sensitizing technique effective for shooting scenes in low light has been developed and incorporated. This function uses peripheral pixels effectively to increase the sensitivity by 1EV to 2EV.

Normally, when shooting scenes in low light, one may encounter a variety of problems including strong noise, insufficient gain, and camera shake. This function can assist shooting in dark environments.

### ■ Other image processing functions

The previous four functions execute a series of processes in real time by taking Bayer data from the CCD. For completed full-color images, it is possible to add the following tasks by hardware processing later:

- A resolution converter suitable for saving images and digital zooming (bicubic, bilinear, etc.)
- Filtering functions capable of space filtering and color conversion
- 90-degree image rotation function that can change the vertical and horizontal direction of the image
- Two-screen synthesis function that allows advanced operation on two different images

- Real-time encoding/decoding function of MPEG-4 or VGA30fps for products supporting moving images (VGA30fps motion JPEGs can be supported even in products not supporting moving images).

#### ■ CPU core “FR80” with drastically improved bus speed

Milbeaut mounts our original high-performance 32-bit RISC microcontroller, “FR.” FR is optimized for system control and delivers an advanced operation processing capability by focusing the applications in devices to be embedded from the architecture stages.

The bus speed efficiency, the Achilles heel of the conventional FR70 Series, has been nearly quadrupled in FR80 adopted in M-4. Thanks to this, large amounts of data can now be rapidly transferred to the USB2.0 or high-speed Flash media required in digital camera systems. The execution of advanced software processing is possible as well.

It also has a built-in 16-bit DSP independent from FR80 to rapidly process the product-sum operation of the media system. More advanced software processing is also possible by using these two CPUs efficiently.

#### ■ Rich peripheral circuits

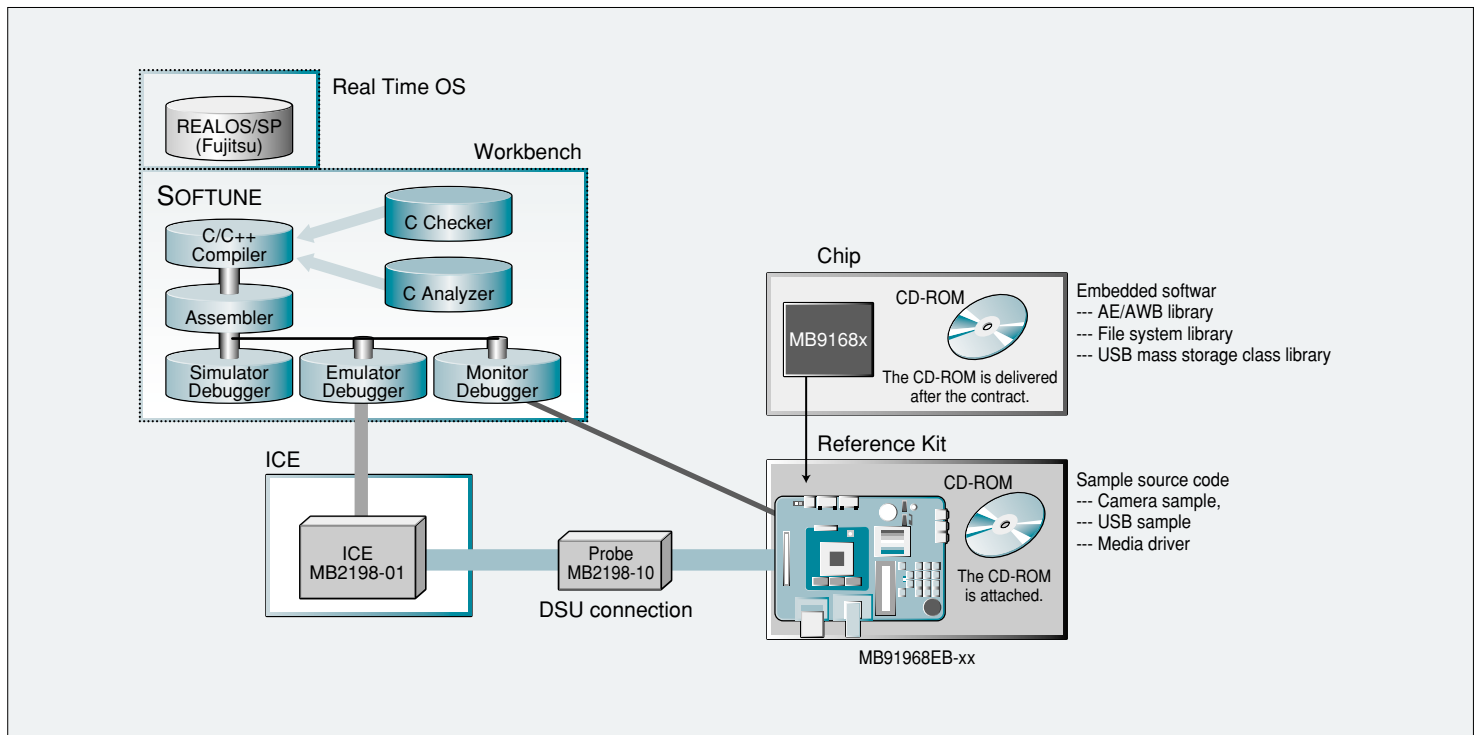
It mounts most of the functions necessary in digital cameras.

As such, this eliminates the need to mount external single function devices.

\* Supported peripheral functions vary depending on the model.

- USB2.0 (High Speed) interface  
USB, which is now mounted almost as standard, supports 2.0 High Speed. M-4 Series realizes high bus speed by mounting FR80 and this High Speed can be fully utilized.
- Flash card media interface  
This product supports various interfaces including SD card (v1.1), MMC, memory stick (Pro), and NAND Flash. It also supports system booting from NAND Flash. Like USB, M-4 Series has a high-speed CPU bus and the increased speed of card media can be utilized fully.
- Digital LCD interface  
It can be directly connected to most digital camera LCDs including ITU-R601, ITU-R656, and delta-type LCDs.
- TV interface  
The TV interface of M-4 supports HDTV output (HDMI interface) in addition to the conventional NTSC/PAL (an external encoder is required separately).
- Other control functions  
This product incorporates PWM, which can be used to control lens motors and electronic flashes, serial interfaces for

Figure 1 Milbeaut Development Environment



communicating with various devices, I<sup>2</sup>C communication interfaces, timers, general-purpose ports, etc.

PWM is capable of alternately outputting not only a simple waveform but also two different waveforms. As such, it is possible to execute more complex motor control such as a special actuator.

### ■ Leading-edge 90nm processing technology

Until 2005, all products employed the 0.18 $\mu$ m process. We have now shifted all products to the leading-edge 90nm process by taking advantage of its startup.

This 90nm process enables a high degree of integration and low power consumption, both of which were impossible for conventional products.

## Rich Support System

**Fig. 1** shows Milbeaut development environment outline.

### Enhanced development environment

The development environment for Milbeaut Series is composed of a real-time OS, libraries, an in-circuit emulator (ICE), and an evaluation kit on an FR-integrated development environment SOFTUNE base. The evaluation kit includes a free library and sample software to operate the evolution kit that supports most of the camera functions in the manner of a real camera.

### ■ Software development tool

- SOFTUNE integrated development tool

It is an integrated development environment equipped with the following tools. A common interface is used for all 8-bit to 32-bit FUJITSU microcontrollers:

#### IPackage contentsI

- C/C++ compiler, assembler
- Emulation debugger, monitor debugger, simulator
- C checker, C analyzer

#### REALOS real-time OS

- Conforms to  $\mu$ ITRON 3.0 or 4.0
- Debugging possible by SOFTUNE debugger

### ■ Libraries

#### AE/AWB library (free)

- An AE (automatic exposure) library capable of real-time processing by detection signals.
- An AWB (automatic white balance) library capable of judging the light sources. A PC tool for adjustment is also offered.

#### FAT32 file system library (free)

Supports both FAT32 and FAT16 file systems.

#### USB mass storage library (free)

Use of the USB mass storage class library allows simple connection to PCs. The PictBridge library is currently being developed.

### ■ Sample software

It covers most of the camera functions.

#### IMajor functionsI

- Automatic exposure, automatic focusing, automatic white balance
- Motion JPEG
- USB control
- Screen display (OSDC)
- Application examples of each macro
- Application examples of each library

Optimal sample software is successively released to match each model.

### ■ In-circuit emulator

- MB2198-01+MB2198-10

A debugging function is available via direct communication with the CPU core using the DSU (debugging support unit) built into the CPU and several signal lines.

### ■ Milbeaut evaluation kit

An evaluation kit is provided for each product to cover digital camera functions ranging from actual photograph shooting to recording onto Flash card media.

### Strong tie-up with various parts manufacturers

FUJITSU provides optimal support in strong cooperation with various parts manufacturers for lenses, lens modules, CCDs, AFEs, LCDs, etc.

## Flexible support for various applications

**Fig. 2** outlines the development roadmap for Milbeaut.

### ■ Optimal solution for high-performance single-lens reflex

A single-lens reflex combining a high-performance lens and a sensor with large and stable signals requires maximum color reproduction and resolution capabilities for the vivid data from the sensor.

M-4 Series has image expression capabilities that can fully exert the optical performance of the latest digital single-lens reflex cameras and the performance of the sensor. At present, the newest and best solution is MB91680 (code name: M-4).

**Optimal solution for low-price, compact digital cameras**

The optical features of low-price compact cameras tend to deteriorate with the miniaturization of the lens unit. They are also susceptible to significant noise in the sensor due to the higher pixel counts and moving image support.

The latest M-4A and M-4ML incorporate robust noise reduction and color conversion functions as well as the color interpolation process developed for single-lens reflex and high-end compact cameras. As such, high-quality images can be realized in terms of noise, resolution, and color even in compact digital cameras.

For products requiring moving image functions, FUJITSU offers M-4ML mounting MPEG-4 — this allows VGA30fps processing as the best product.

**Optimal solution for cell phone camera units**

There are two categories of cell phone camera units. One is very much like that of a digital camera—it mounts a multi-pixel CCD and camera unit nearly identical to DSC that incorporates; the other mounts a small CMOS sensor of 2M to 5M class.

We also offer a lineup of specialized products for cell phones mounting 2M to 5M CMOS.  
(Please contact us for details.)

**New Product**

**MB91683 (code name: M-4A)**

A product for low-price compact cameras in which the price has been kept low while maintaining the image processing capability of products for high-class cameras. Compared to M-4, it is equipped with more enhanced functions to address the strong noise and weak sensitivity that are unique to compact cameras. Operates at FR-core: 108MHz, image processing block: 54MHz.

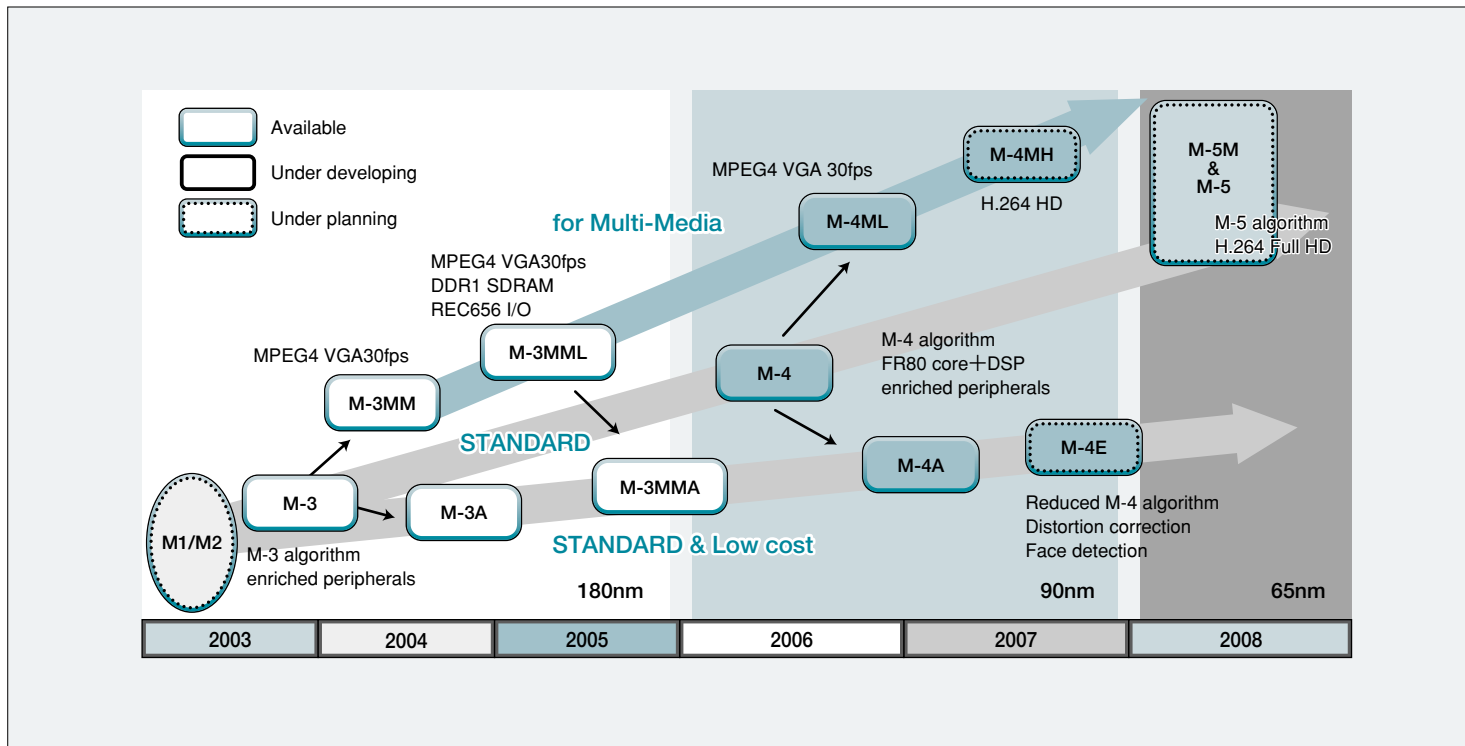
Fig.3 shows the block diagram for M-4A.

**MB91686 (code name: M-4ML)**

A product in which the MPEG-4 VGA30fps moving image processing engine has been added to M-4A. It is optimal for compact cameras applying moving images as the main feature. Audio DSP is also embedded for audio processing in moving images. Operates at FR-core: 132MHz, image processing block: 66MHz.

Fig.4 shows the block diagram for M-4ML.

Figure 2 Milbeaut Roadmap



## Conventional Products

### ■ MB91680 (M-4)

A standard product of M-4 Series. Applies the leading-edge 90nm process and adopts M-4 algorithm for image processing and FR80 as the CPU core. 14-bit Bayer input is possible. Operates at FR-core: 132MHz, image processing block: 66MHz.

### ■ MB91386 (M-3MML)

The highest performance product in M-3 Series that mounts an MPEG-4 codec engine capable of encoding/decoding at VGA 30fps. Equipped with a 16-bit DSP and REC656 input/output terminal, it is also suited to multimedia-type applications. Operates at FR-core: 108MHz, image processing block: 54MHz.

### ■ MB91396 (M-3MMA)

A product with optimized peripheral functions for compact cameras with an MPEG-4 macro offering identical performance to M3-MML. Capable of startup from NAND Flash and

incorporates a real-time clock. Operates at FR-core: 108MHz, image processing block: 54MHz.

### ■ MB91388 (M-3MOM)/MB91394 (M-3MO)

A product capable of operating as a peripheral device for camera processing when another CPU is installed for overall system control (as in cell phones). This product has a built-in slave I/F and image data output bus to allow communication with the host CPU. An Optimal device for camera functions in cell phones, etc.

**Table 1** presents a table comparing the functions of these products. \*

#### NOTE

\* Other company names and brand names are the trademarks or registered trademarks of their respective owners.

Figure 3 M-4A Block Diagram

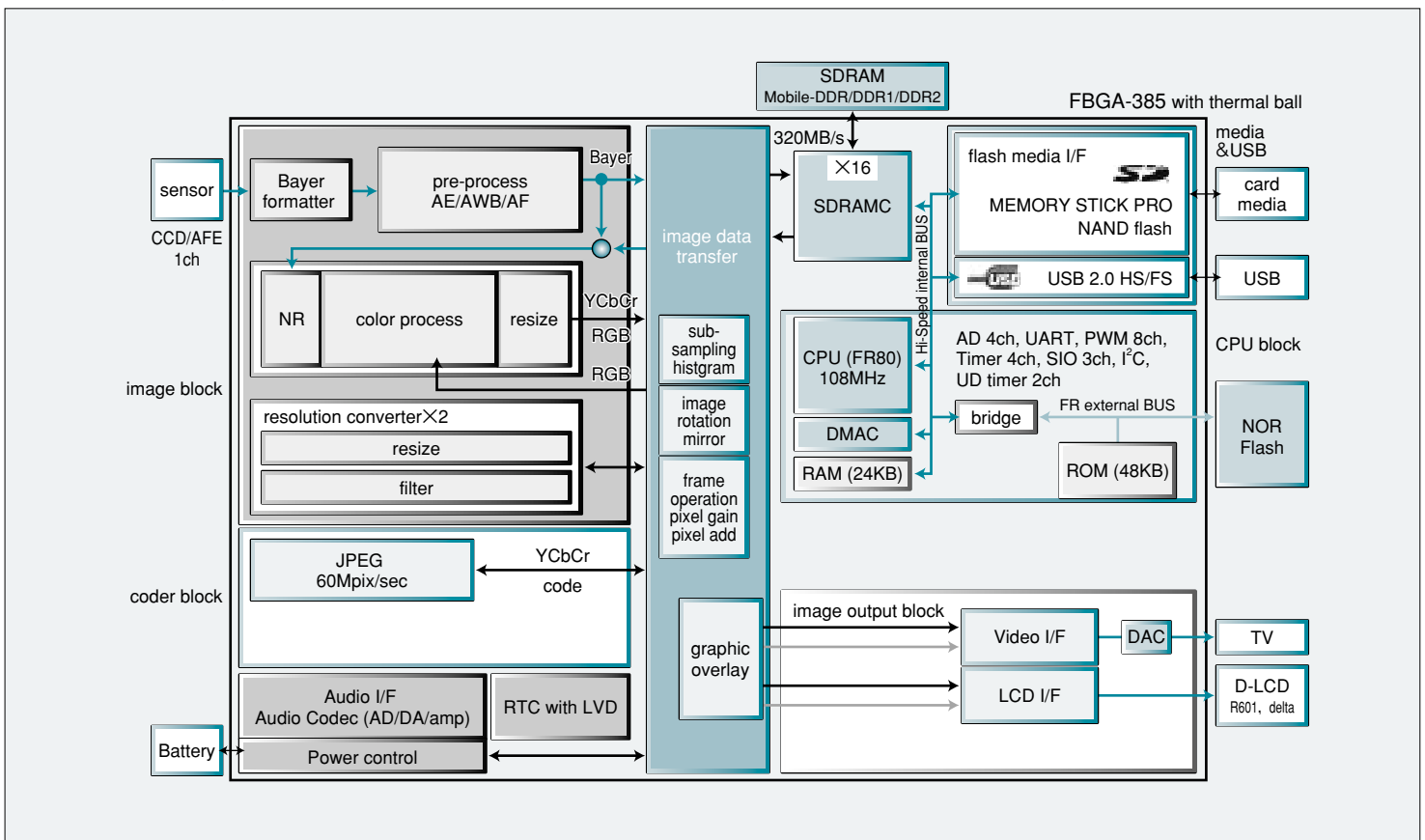


Figure 4 M-4ML Block Diagram

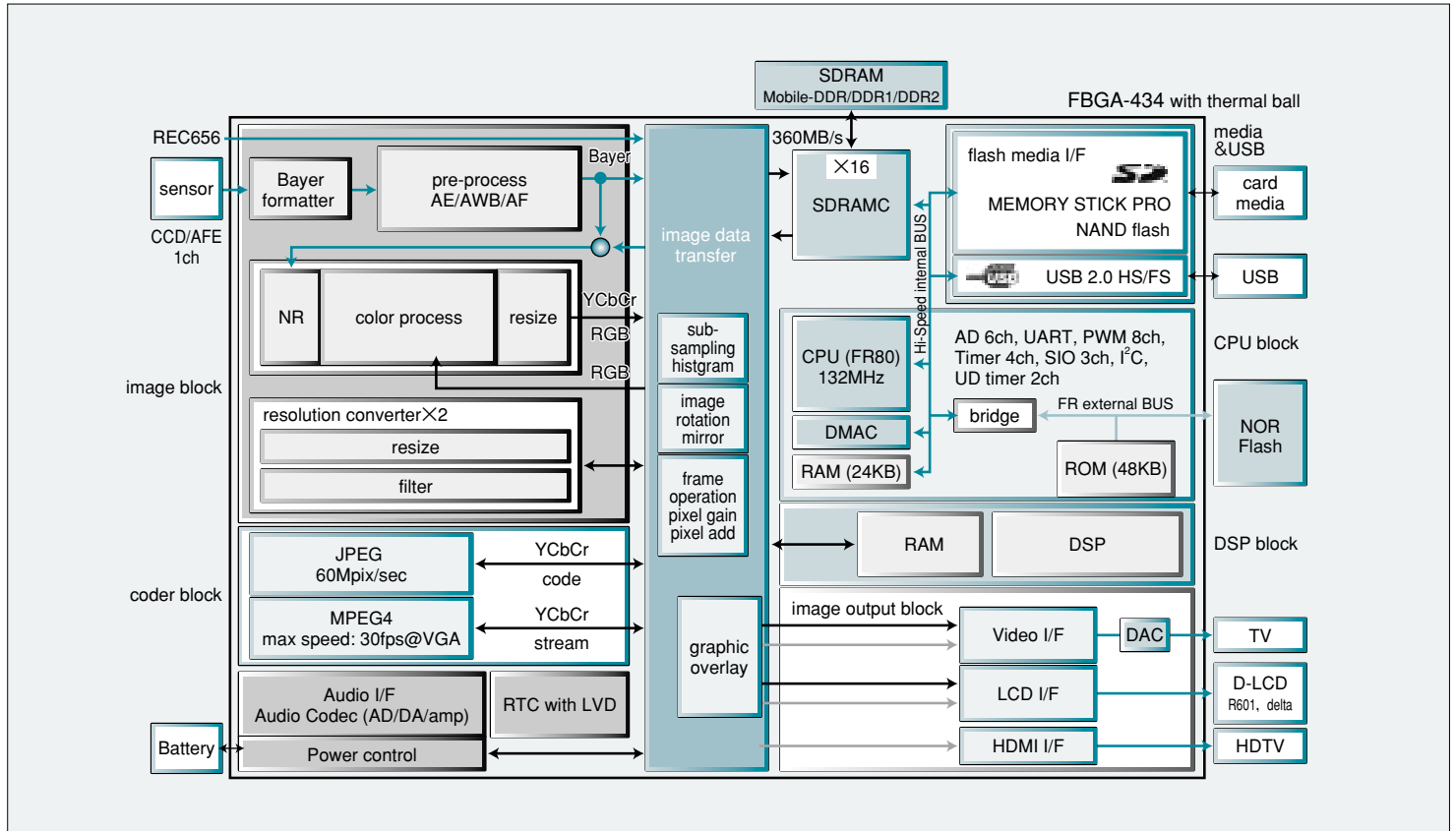


Table 1 Functional Comparison of FUJITSU Products

Model	Model No.	MB91386	MB91396	MB91388	MB91394	MB91680	MB91683	MB91686
	Code name	M-3MML	M-3MMA	M-3MOM	M-3MO	M-4	M-4A	M-4ML
	Major application	Multimedia applications	Compact cameras	Mobile devices	Mobile devices	Single-lens reflex DSC	Compact cameras	Multimedia applications
LSI outline	CMOS technology	0.18μm	0.18μm	0.18μm	0.18μm	90nm	90nm	90nm
	Package type	FBGA-385	FBGA-385	FBGA-385	FBGA-240	FBGA-506	FBGA-385	FBGA-434 FBGA-385
	Pin pitch	0.5mm	0.65mm	0.5mm	0.5mm	0.5mm	0.5mm	0.5mm 0.65mm
	16-bit DSP	○	×	○	×	○	×	○
	External RAM supported (SDRAM)	SDR×32 DDR1×16	SDR×32 DDR×16	SDR×32 DDR×16	SDR×16 DDR×16	DDR2×16 DDR2×32	DDR2×16 DDR1×16 Mobile DDR×16	DDR2×16 DDR1×16 Mobile DDR×16
Operation frequency	FR-core	FR71	FR71	FR71	FR71	FR80	FR80	FR80
	FR-core operating frequency	108MHz	108MHz	108MHz	108MHz	132MHz	108MHz	132MHz
	Image processing block	54MHz	54MHz	54MHz	54MHz	66MHz	54MHz	66MHz
Image processing	Color interpolation system version	3+	3+	3+	3+	4	4+	4+
	VGA moving image CCD connection	○	○	○	○	○	○	○
	MPEG-4	○	○	○	×	×	×	○
	Adaptive pixel addition function	×	×	×	×	×	○	○
Peripheral functions	USB type	FS/HS	FS/HS	FS/HS	×	FS/HS	FS/HS	FS/HS
	Digital LCD (ITU-R601, delta array)	○	○	○	×	○	○	○
	HDTV/HDMI interface	×	×	×	×	○	×	○
	NAND Flash booting	×	○	×	×	×	○	○
	Analog audio codec	×	○	×	×	×	◎(+Spk amp)	◎(+Spk amp)
	Real-time clock	×	○	×	×	×	○(+power supply control)	○(+power supply control)
Card interface	Compact Flash	○	×	×	×	◎(with buffer)	×	×
	Memory stick (PRO)	○	×	×	×	○	○	○
	SD card (ver1.1)	○	○	○	×	○	○	○
	NAND Flash	○	○	×	×	○(X2 channels)	○(X2 channels)	○(X2 channels)
Host CPU connection	Slave interface	×	×	○	○	×	×	×
	YUV output bus	○	×	○	○	×	×	×