Lineup for Camera Modules in Mobile Devices from Image-processing Solution LSI "Milbeaut" M-4MO (MB91688)/MC-3 (MB91685)

Products from the Milbeaut Series for cellular phone cameras.
These products integrate an image engine that processes high-resolution, high-speed, and small CMOS image sensor images beautifully and at high speed with low power consumption processes utilizing 90nm CMOS technology. We have developed high-performance M-4MO that is capable of processing up to 5 million pixels and MC-3 that can help construct small, low-price camera modules.

Introduction

The Milbeaut Series are image-processing system LSIs that have an excellent reputation and track record as imaging devices in wide applications from digital single-lens reflex cameras and compact cameras to cellular phone camera modules. M-4MO (MB91688) and MC-3 (MB91685) are the Milbeaut Series products for cellular phone cameras that adopt the image-processing technology of digital single-lens reflex cameras.

M-4MO and MC-3 incorporate image engines that process high-resolution, high-speed, and small CMOS images sensor images beautifully and at high speed with low power consumption processes achieved by 90nm CMOS technology. While camera functions are now integrated in most cellular phones and are taken for granted, by adopting these products, it is possible to differentiate FUJITSU's camera function from those of other manufacturers.

M-4MO is capable of processing up to 5 million pixels, and therefore has functions equivalent to DSC signal-processing devices. It has a frame buffer that allows multiple-path processing as well as various image effect functions and a reinforced noise reduction function. MC-3 can execute the necessary signal processing without an external memory by utilizing the built-in line buffer in the LSI. This enables the construction of small and low-price camera modules. MC-3 is capable of processing images up to 3 million pixels.

In the future, we plan to realize high-speed serial input/output (MIPI), which is expected to be the standard for future cellular phones, as well as higher speed and resolution and HDTV (H.264, HDMI output) in the Milbeaut Series.

Overview

Since its introduction in 2000, FUJITSU's Milbeaut Series has been widely adopted in digital imaging systems of many varieties ranging from single-lens reflex cameras and compact cameras to the camera modules of cellular phones. It has earned an excellent reputation and a good track record for its image quality. During the seven years we have worked to advance digital images, FUJITSU has upgraded the core color-processing engines, improved the overall efficiency, increased the operating

frequency, and improved the functions to adjust image quality such as noise reduction and edge enhancement to satisfy demands for increased pixels, faster processing speed, improved image quality, high function development, reduced power consumption, and cost reduction.

Fig.1 presents the success of Milbeaut technology.

M-4MO and MC-3 integrate image-processing engines that are equivalent to those of the single-lens reflex camera products currently in the lineup and have specialized functions for mobile devices.

Unlike systems that are completely governed by Milbeaut such as digital still cameras, the base band chip set (host) governs the system and the processing device for the camera operates as a peripheral device (slave) to the host in mobile devices. Some customers may wish to utilize the existing system and only add or improve the camera block. Furthermore, camera units may need to transmit large-size image data at high speed and require a special bus connection. To satisfy this need and transmit image data at high speed, these products integrate an image output bus for outputting YUV images and a command interface for communication with the host. By using this bus, it is possible to transmit images of Wide-VGA size (800 ×480) at 30fps or higher.

The sensor interface supports the serial (CCP2) type and parallel type that allow connection to the CMOS sensor often adopted for cellular phone cameras to enable processing of high-speed image output. In addition, we plan to support the MIPI interface in the next model.

Fig.2 presents the development roadmap of the Milbeaut solution.

Product Features

Reproduction of vivid colors with fidelity

A special engine with high freedom that adopts our original algorithm is integrated for color processing (color interpolation), which is the core of digital cameras. It realizes high image quality that is satisfactory even for high-end single-lens reflex products from CCD/CMOS sensor data with primary color Bayer assignment with high-speed processing only possible with special hardware. This algorithm can not only reproduce colors and enhance the edge but also minimize the noise and image disturbances such as the false color, jaggies, and moire that are specific to sensors.

New free color conversion function (M-4MO)

Even when vivid colors are reproduced with fidelity, the colors perceived by the human eye and the actual colors may vary. As such, 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 developers. 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

Figure 1 The Success of Milbeaut

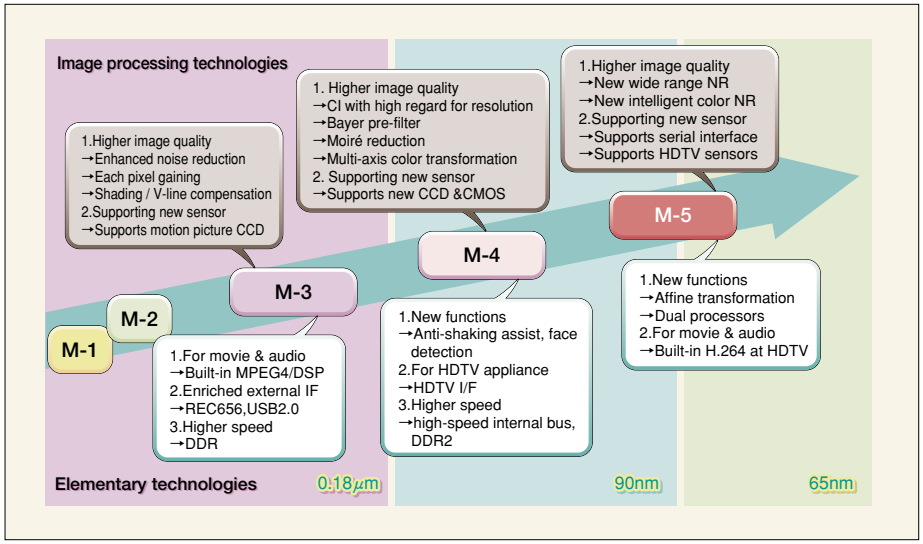
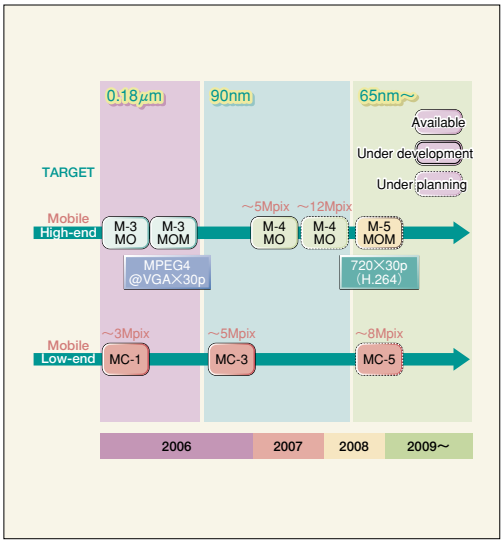


Figure 2 Milbeaut Solution Development Roadmap



the color of the sky or human skin when the green color of grass is enhanced. This function gives us the capability to convert color spaces freely.

High noise reduction performance

Recent CCD and CMOS sensors tend to include a great deal of noise in the data due to the circuit sophistication that arose from the miniaturization to support multiple pixels, speedup, moving image support, etc. Furthermore, many optical units have sacrificed brightness, image distortion, and so forth due to the miniaturization and price reduction, leading to greater adverse effects on the S/N ratio of the output image data.

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

Strong noise reduction usually adversely affects resolution but this is not so with FUJITSU's original adaptive technology, which efficiently removes the noise and retains the resolution.

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 technology that is effective for shooting scenes in low light has been developed and incorporated. This function realizes to increase the sensitivity by 1EV to 2EV, by utilizing pixels surrounding the specific pixel effectively.

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.

Built-in CPU core "FR80"

Milbeaut integrates our original high-performance 32-bit RISC microcontroller, "FR80." FR80 is optimized for system control and delivers advanced operation-processing capability by focusing the applications in devices to be embedded from the architecture stages.

Packaging technology

MC-3 delivers WLP (Wafer-Level Package) products and M-4MO SiP (System in Package) products integrating image-processing LSIs, Flash memory, and SDRAM in our product lineup.

WLP is an ultra-small package with nearly equivalent chip size and package size. It is optimal for cellular phones and other applications that require high-density integration. This package achieves JEDEC Level 1 for moisture sensitivity.

SiP is a package that integrates multiple chips in 1 package to enable it to function as a system block. It offers the following features:

- Miniaturization and thickness reduction (multilayer chip, optimization of wiring, etc.)
- Density increase (free selection of memory size and type)
- Speedup (memory interface concluded within the package)

Rich peripheral circuits

Necessary functions for controlling cellular phone cameras are integrated:

Sensor interface

2-channel subLVDS/12-bit parallel interface realized

Host interface

Output with the YUV/JPEG code possible at the YUV16-bit terminal

Other control functions

These products integrate PWM, which can be used to control lens motors and electronic flashes, serial interfaces for communicating with various devices, I^2C 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.

Rich lineup of applications

For differentiation and high function development, the following software applications are available:

- Face detection
- Camera shake correction for still images
- Camera shake correction for moving images
- WDR (Wide Dynamic Range)

Support System

Enhanced development environment

The development environment for the Milbeaut Series is composed of a real-time OS, libraries, an in-circuit emulator (ICE), and an evaluation board on an FR-integrated development environment SOFTUNE base.

Software development tools

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:

[Package contents]

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

REALOS real-time OS

- Conforms to μITRON 3.0 or 4.0
- Debugging possible by the 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 light sources. A PC tool for adjustment is also offered.

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.

Introduction of Products

MB91685 (MC-3)

This product is capable of supporting up to 3 million pixels as the size of the image from the sensor. Since all processes can be executed using only the built-in line buffer, it enables construction of a small, low-price camera system.

- 90nm CMOS technology
- Operating frequency:
  CPU core 132MHz, image-processing block 96MHz, YUV IF 72MHz
  Sensor input (parallel): 72MHz
  Sensor input (Sub-LDVS): 325MHz×2 channels (1,300Mbps)
- Package: FBGA-240-pin (0.5mm pin pitch)
  WLP (4.5mm×5.1mm×0.6mm, 0.4mm pin pitch)

MB91688 (M-4MO)

This product is capable of supporting up to 5 million pixels as the size of the image from the sensor. It executes complex processes such as multi-path JPEG equivalent to digital cameras using the frame buffer. It is also possible to execute high-speed processing without using the frame buffer in a similar fashion to MC-3.

- 90nm CMOS technology
- Operating frequency:
  CPU core 132MHz, image-processing block 104MHz, YUV IF 69.3MHz,
  Sensor input (parallel): 72MHz
  Sensor input (Sub-LDVS): 325MHz×2 channels (1,300Mbps)
- Package: FBGA-193-pin (0.5mm pin pitch)

Table 1 presents the comparison of functions and **Fig.3** the block diagram for M-4MO. ✱

Figure 3 M-4MO Block Diagram

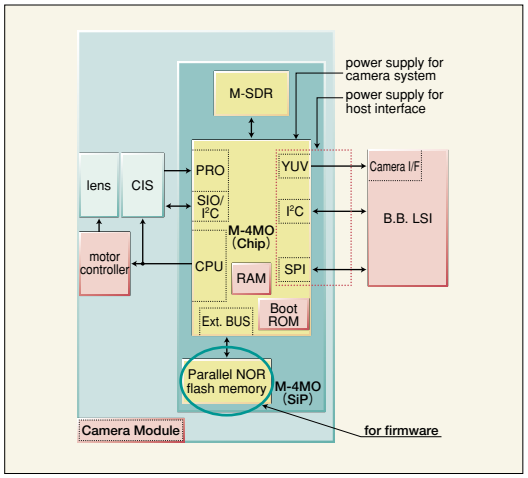


Table 1 Comparison of Functions

	MC-3	M-4MO
CPU	FR80-132MHz	FR80-132MHz
Work memory	Built-in line buffer	Built-in SDR-SDRAM (128M-bit)
Program storage memory	Built-in RAM (384Kbytes)	Built-in NOR Flash (1Mbytes)
Built-in work RAM	384Kbytes (shared with program memory)	128Kbytes
Sensor supported	CMOS (3 million pixels at max.)	CMOS (5 million pixels at max.)
Sensor interface	sLVDS-2 channels/12-bit parallel	sLVDS-2 channels/12-bit parallel
Lens control (AF/zoom)	Possible	Possible
Frame processing (resize/inter-frame operation, etc.)	Not possible	Possible
JPEG	Possible (1 path only)	Possible (2 paths possible)
Moving image stabilizer	Possible (H/W + software processing)	Possible (H/W + software processing)
Still image stabilizer	Not possible	Possible (software processing)
Face detection	Not possible	Possible (software processing)
YUV interface (output)	8-/16-bit	8-/16-bit
Host interface SIO (SPI) /I²C	Included	Included
Lens control interface (PWM/timer/I²C)	Included	Included
Package	FBGA-240-pin (0.5mm pin pitch) WLP (4.5mm×5.1mm×0.6mm, 0.4mm pin pitch)	FBGA-193-pin (0.5mm pin pitch)