Integrated Camera Solution

KAWAGUCHI Hiroshi, TAKAMI Kazuhiko, SUGIYAMA Mikio

Abstract

We have compiled the set of items required for incorporating a camera module in the cellular phone, including the hardware, software, services and know-how, into a "camera integration solution" and are now offering it for the final products manufacturers and device manufacturers in the cellular phone market.

This paper describes the development of the integration solution and introduces the CE130 camera engine for cellular phone use featuring high print quality and a 5M-pixel camera module incorporating the CE130.

1. Introduction

The costs and schedule for development of cellular phone have been increasing rapidly recently due to the complexity of services, diversification of end users' tastes and the increasing sophistication of products. In addition, the trends of reduction of product lifecycles and strong pressure for price reduction due to severe competition have made a critical issue of how to efficiently develop competitive and highly functional products at the lowest cost and shortest period as possible.

Nevertheless, since it is hard to develop all of the required software and hardware within the company or to manage the information on competitors' products and software that are being enhanced every day, the demand for solutions that enable development of highly functional products at low cost and in a short period by allowing limited resources to be concentrated in critically competitive areas has become very high among the final product and device manufacturers.

When a cellular phone manufacturer wishes to incorporate a camera function into a cellular terminal, it had previously been necessary for the manufacturer to procure each of the required parts and functions, such as the lens, sensor and LSI, from different vendors. However, it was a high hurdle for a cellular phone manufacture to introduce camera parts that they were not specialized in, and it has been difficult for them to release products that truly matched market needs.

To solve the problems described above, we extracted all of the element technologies required for implementing the camera function and compiled them together with the operation verification service into a product being marketed under the name of "System Technology Platform (STP)."

This paper is intended to introduce our camera engine (CE130) for cellular phone use and the 5M-pixel camera module incorporating the camera engine.

2. Development of Camera Engine (CE130) for Cellular Phone Use Featuring High Print Quality

We developed an image processing camera engine (CE130) with up to 5M-pixel capability for use in cellular phones (**Photo 1**).

The CE130 camera engine is offered together with all of the technology solutions required for development of a cellular phone with built-in camera, including the software determining the picture quality, technology for combination of sensor
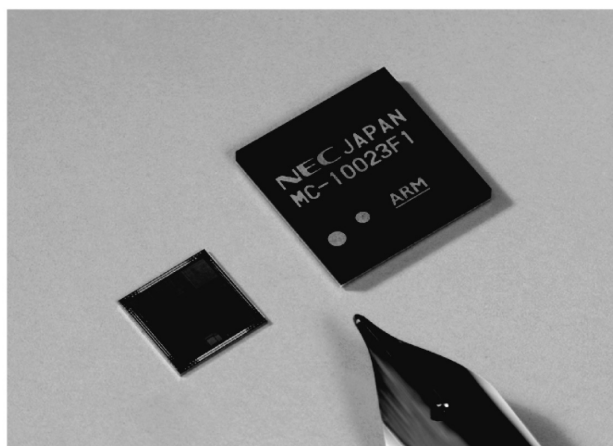

Photo 1 Camera engine for cellular phone (CE130).

and lens, technology for design and manufacturing of the module and the system verification platform as well as consulting service.

The CE130 camera engine and the solution allows cellular phone product manufacturers to shorten the development period of a cellular phone incorporating a high-quality 5M-pixel camera by about 1/3 compared to the previous period and concentrate on development of technologies that may lead to the superiority of their final products, so they can develop strategic final products at lower cost and launch them into the market earlier. Meanwhile, the CE130 also allows cellular phone users to shoot pictures that offer high picture quality comparable to digital still cameras when they are printed, using their cellular phone terminals.

The main features of the CE130 are as follows.

(1) Shooting 5M Pixel Pictures with the Top Class Quality among Cellular Phone Cameras

This device makes it possible the shooting and storage of pictures up to 5M pixels. This technology allows a small cellular phone terminal to shoot pictures that can be printed with equivalent quality than digital still cameras.

(2) Versatile Functions for Picture Quality Equivalent to Digital Still Cameras

The CE130 incorporates functions that are indispensable for the shooting of high-quality pictures such as flash control, image stabilization, noise correction, image magnification, image rotation and JPEG compression.

This makes a cellular phone terminal capable of quality shooting with an ease-of-use that is similar to digital cameras.

(3) Interfaces Enabling Construction of Various Systems

In addition to the I2C* bus, the serial peripheral interface (SPI) with high-speed data transfer capability is included to enable downloading and execution of external program software. This facilitates the use of various third-party software as well as maintenance operations in case of software problems, and makes control more flexible compared to a cellular phone based on incorporated software. In addition, a high-speed interface for SRAM connection is also provided.

These interface technologies allow cellular phone manufacturers to develop cellular phones incorporating camera systems that are optimum for their required specifications.

(4) Platform Implementation of Application Interfaces and Camera Engine for Facilitating Development of Camera Functions

The camera engine platform is implemented based on the CE130 camera engine and firmware developed to be used in combination with it.

This allows final product manufacturers to develop cellular phone products easily by using the same command interface even when the sensor or lens is changed or a new camera engine is adopted, except for when introducing new functions.

・Establishment of API specification

This abstraction layer offers to the customer an independent set of functions using the LSI specifications.

・Interface abstracting the H/W driver

The driver layer that reduces effects of LSI change in the firmware layer.

Fig. shows the outline of CE130 platform and **Table 1** shows its main specifications.

The function blocks and interface layer are separated from the CE130 firmware.

① Command layer

This layer interprets and controls the commands exchanged with the system software.

② Function control layer

This layer implements the shooting and communication functions.

③ Optical control/image function

This layer turns the shooting functions into function blocks.

Optical Control: Optical quality adjustment; AF/AE/AWB,...

Image Function: Image I/O control, image stabilization, JPEG, etc.

④ Driver

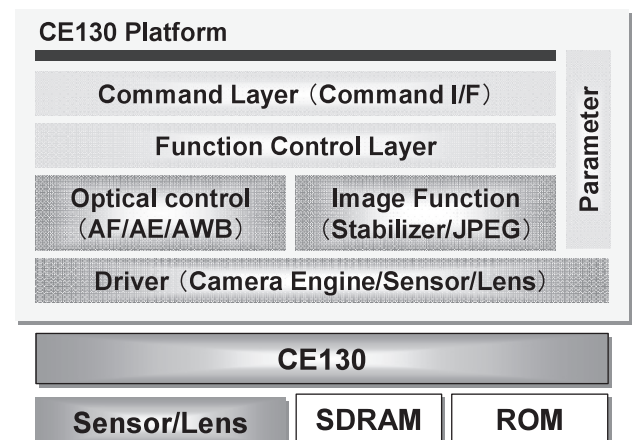Drivers of the camera engine (LSI), sensor, lens, communication, etc.

---

*I2C: Stands for Inter Integrated Circuit. This is a serial bus proposed by Philips. It uses two signal lines for interfacing of information between devices that are located relatively close to each other.

Fig. Outline of CE130 platform.

Integrated Camera Solution

Table 1 Main specifications of CE130.

Items	Specifications
Package	10 × 10 × 142mm 277pin BGA
Sensor	Max. 5M-pixel, 12bit, primary color RGB Bayer sensor
Optical sync control	Iris, mechanical shutter, flash, LED, AF and optical zooming
Optical correction circuits	Aberration correction, damage correction, smear reduction
Image processing circuits	White balance, AE, AF, gamma, black level correction, dark noise correction, sharpening, smoothening, YCC color processing, magnification/reduction data blending, rotation
Memory I/F	M-SDRAM
Host I/F	I2C, SPI, SRAM
YCC Out	YCC(4:2:2 16bit/8bit) / RGB(18bit/16bit)/ JPEG
I/O	GPIO[*], 64 lines
Other	JPEG Enc built in

[*]GPIO: Stands for General Purpose Input/Output Port.

3. Development of Camera Module Facilitating Construction of Cellular Phone with Built-in 5M-Pixel Camera

We grouped the hardware required for cellular phone, including the image processor engine (CE130), CMOS sensor, lens, autofocusing mechanism, shutter and flash memory, and the set of software for controlling the hardware into a single module, adjusted them so that they can operated under optimum conditions and developed a camera module product.

As this module allows the cellular phone terminal manufacturers to save the effort of separately procuring individual parts such as lens and sensor, and adjusting the parts into optimum conditions, even a manufacturer without camera expertise can easily produce a cellular phone product incorporating a high-function camera with 5M-pixel resolution comparable to digital still cameras.

(1) 5M-Pixel Camera Module with Top-Class Picture Quality among Cellular Phone Cameras

The developed 5M-pixel camera module (**Photo 2**) achieves top-class resolution among cellular phone cameras.

It employs a 5M-pixel CMOS sensor and a lens unit with autofocusing and shutter mechanisms. It can capture images of quality equivalent to digital still cameras by controlling
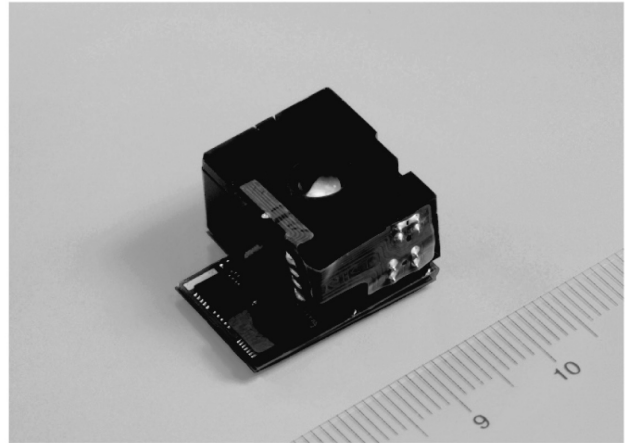

Photo 2 5M-pixel camera module.

the CE130 image processor LSI using the firmware stored in the flash memory.

(2) Versatile Functions for Picture Quality Equivalent to Digital Still Cameras

The camera module incorporates functions that are indispensable for the shooting and printing of high-quality pictures such as flash control, noise correction, image magnification, image rotation and JPEG compression as well as image stabilization (optional).

This makes it possible to provide a cellular phone terminal with ease of use equivalent to digital cameras and advanced picture shooting capabilities.

(3) Verification Platform for Verifying the Connection with Phone Terminal

We developed a verification platform for use in verification of the camera module operations, making possible system verification even when the main body of the cellular phone system is not available.

・Verification of hardware level functions and image processor system LSI.
・Verification of camera module functions, development of application interfaces and development of firmware.
・Picture quality tuning.

(4) Means of Evaluation of Picture Quality Equivalent to Digital Still Cameras

We asked professional photographers to evaluate the picture quality of the camera module.

・Collection and characteristic evaluation of basic data including brightness, saturation, hue error, lens and noise.
・Actual shooting in various situations for evaluation of tendencies and properties.

Table 2 shows main specifications of 5M-pixel camera module.

Table 2 Specifications of 5M-pixel camera module.

Items	Specifications	
Sensor	1/2.5 inch, 5M-pixel compatible CMOS sensor	
Max. pixels	5.51 million pixels	
Effective pixels	2,544(H) × 1,908(V)	
Effective area	5.7mm(H) × 4.3mm(V)	
Pixel size	2.2μm(H) × 2.2μm(V)	
Filter layout	RGB primary color, Bayer arrangement	
Frame rate	VGA 30 fps (in monitor mode)	
Host interfaces	I2C	Bus format standard I2C, max. 400kbps
	SPI	Serial I/F, max. 66Mbps in slave mode
Supply voltage	1.8V, 2.8V, VCC host (I/O), VBAT (for motor drive)	
Optical specifications	Lens configuration	4 components (plastic & glass)
	Optical lenses F-number	F2.8 / F5.6
	Focal distance	6.77mm
	Shutter	Mechanical shutter
	Focusing method	Stepping motor

4. Conclusion

Using the image processor system LSI (CE130) and the 5M-pixel camera module described above, we will propose camera integration solutions to final product and device manufacturers developing cellular phones. At the same time, we will also develop more advanced image processor system LSIs and system technology platforms by anticipating future market needs.

Authors' Profiles

KAWAGUCHI Hiroshi
Project Manager,
Device SI Division,
NEC Electronics Corporation

TAKAMI Kazuhiko
Team Manager,
Device SI Division,
NEC Electronics Corporation

SUGIYAMA Mikio
Team Manager,
Device SI Division,
NEC Electronics Corporation