# Development of the One-Chip LSI “EMMA3PF” for BD and Reference System

OKUYAMA Tomoyuki, ITO Masahiro, ONODA Yoshio
MIYAMOTO Atsushi, MIYAUCHI Tetsuo, SUYAMA Hiroo

**Abstract**

For yet another world first achievement NEC Electronics has developed the EMMA3PF, a system LSI integrating all of the major functions of a Blu-ray Disc (BD) player in a single chip. The functions integrated into the EMMA3PF include those for reading signals from optical discs, those for decoding the signals into video/audio signals and those for supplying the HDMI output. It also incorporates high-performance multi-core CPUs and a graphics engine for significantly improving the player’s operability. At the same time as the release of the EMMA3PF, NEC Electronics is also planning to launch a reference board and software compliant to the latest BD standard.

**Keywords**

Blu-ray, BD, Player, System LSI, Solution

## 1. Introduction

Since their release in 2006, BD players are rapidly being disseminated on a worldwide scale. On the other hand, the market price per set has been falling continuously, until it was below US$200 by the end of 2008, although compliance with the BD standards had added several new functions. These market trends have increased the need for a system LSI that can reduce costs at the same time as increasing the number of functions. Accordingly, NEC Electronics have achieved another world first by developing the EMMA3PF, a system LSI integrating all of the major functions required to implement a BD player in a single chip ( **Photo 1** ).

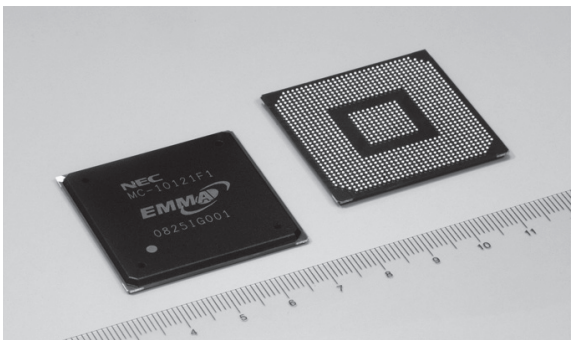


Photo 1 External view of EMMA3PF (MC-10121).

## 2. Features of EMMA3PF

The EMMA3PF has the following features.

1) Integration of all of the major functions required to implement a BD player from the input of an analog signal read from an optical disc to the decoding of the video encoded with H.264/AVC etc., audio encoded with DTS-HD etc., graphics involved in display processing and the TV output via HDMI (High-Definition Multimedia Interface) ( **Fig. 1** ).

2) Reduction by 50% of the mounting area compared to previous systems thanks to the reduction of the number of components. These include one chip implementation, integration of the external memory to the DDR2 memory using UMA (Unified Memory Architecture) and the incorporation of peripheral functions such as the USB2.0 host controller and Ethernet controller.

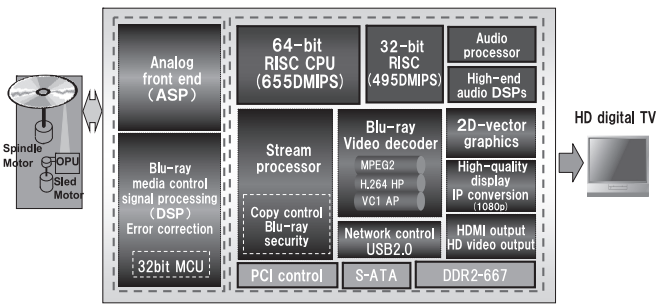


Fig. 1 Function units built into EMMA3PF.

3) Compatibility with the latest BD standard "BD-ROM Profile 2.0" due to the 2-screen video playback and the possibility of downloading additional contents via network connection.
4) Quick program launching and significant operability improvement due to the multi-core CPUs with the 1,150DMIPS (Dhrystone MIPS) speeds at the industry's fastest level and the graphics processing accelerator.

## 3. Outline of the EMMA3PF Functions

The EMMA3PF consists of the front-end function block that reads signals from an optical disc and the back-end function block that decodes various codecs, etc. **Table 1** shows the list of specifications of the EMMA3PF.

### 3.1 Front–end Function Block

The front-end function block includes the analog signal processor (ASP) block that converts the analog data read from an optical disc into digital data and the digital signal processor (DSP) block that performs data modulation and error correction by means of firmware processing using the built-in MCU (Micro-Controller Unit). The combination of the ASP and DSP blocks achieves identification of BD, DVD and CD discs and read out of error-corrected digital data.

The EMMA3PF integrates these functions while maintaining compatibility with the SCOMBO/UM2, which is the optical disc drive LSI of NEC Electronics. Specifically, the circuit characteristics and external terminal configuration of the ASP block are designed in common so that the circuitry outside the LSI can be mounted using the same configuration and the registers and memory map of the DSP block can maintain compatibility with the firmware developed for the SCOMBO/UM2 so that it may also be used actively.

In addition, the EMMA3PF has also integrated the SDRAM into the DDR2 memory, which had previously to be attached externally to the SCOMBO/UM2. This integration increases the delay in the DDR2 memory access compared to the external SDRAM configuration and particularly reduces the error correction efficiency. We have therefore added new hardware for increasing the error correction processing in order to provide the error correction performance required for the BD reproduction without modifying the firmware.

Table 1 EMMA3PF specifications.

| Item | Specifications |
|---|---|
| Front-end | Reproduction of all optical disc media including BD-ROM, BD-R/-RE, DVD-ROM, DVD ± R/RW, DVD-RAM, CD-ROM and CD-R/RW.<br>ASP (Analog Signal Processor) built in.<br>PRML digital read channel function, adaptive equalizer function. |
| CPUs | VR5500 RISC CPU (655 Dhrystone MIPS),<br>MIPS 32 CPU (495 Dhrystone MIPS) |
| Video decoding | 2-screen playback capability.<br>H.264/AVC High Profile/Main Profile Level 4.1 for BD-ROM.<br>VC-1 Advanced Profile Level 3.<br>MPEG2 MP@HL, MPEG1, MPE4 Advanced Simple Profile |
| Audio decoding | Dolby Digital, Dolby Digital Plus, Dolby TrueHD, DTS, DTS-HD,<br>MPEG1 Layer 1/2, MPEG2 AAC, MPEG2 BC,<br>LPCM for BD-ROM, DVD-Video, CD-DA, CD-ROM. |
| Video interfaces | 5CH, 12-bit with built-in DAC.<br>HD-compatible component output, NTSC/PAL/SECAM composite outputs. |
| Audio interfaces | PCM audio output, S/PDIF output. |
| Security processing | DES, 3-DES, AES, CSS, CPRM, BD CPS, AACS, BD+ |
| Memory interface | DD2-667 32-bit bus width x 2, 512M-bit/1G-bit DDR2 support. |
| Storage interface | Serial ATA (1.5Gbps) |
| HDMI | HDMI1.3a, Deep Color, xvYCC, High bit-rate audio support. |
| Ethernet interface | 100Mbps Ethernet MAC. |
| USB interface | USB2.0 Host Controller x 2 |
| PCI interface | 33MHz, 32-bit PCI, 3.3V |
| Peripheral | FUART x 2, CSI x 2, I²C x 2, IR Receiver, Timer, general-purpose I/O |
| Supply voltage | 3.3V (LSI I/O), 1.8V (DDR2 SDRAM I/F), 1.5V, 1.05V (Core Logic) |

### 3.2 Back–end Function Block

**(1) CPUs**
The VR5500 64-bit CPU with 655DMIPS is a high-performance CPU featuring flexibility with respect to applications. The 32-bit CPU with 495DMIPS of MIPS Technologies handles the drivers and AV processing that requires real-time processing.

**(2) Stream Processor**
This is our original processor that is specialized in stream processing. It is optimized for the BD player and compatible with latest standard "BD-ROM Profile 2.0".

**(3) Security Engines**
In order to enhance the security and toughness of the BD player, the security engines incorporate the AACS scrambler/descrambler as well as various encryption processing functions such as the AES and Triple DES and also manage and save the key information of various encryption systems in the built-in memory of the EMMA3PF.

**(4) Video Decoding Engines**
To handle various codecs used with the BD, decoding engines for H.264/AVC, VC-1 and MPEG2 MP@HL are incorporated. These are compatible with dual decoding so that they enable the PinP (Picture in Picture) display. In addi-

tion, they are also capable of DivX-compliant video decoding.

**(5) High-end Audio Engines**

The high-end audio engines include the high-end audio DSP and audio processor, which are compatible with audio formats, including DTS-HD Master Audio, Dolby True HD and Dolby Digital Plus. In addition, compatibility is also provided with the DTS encoding for the bit stream output from S/PDIF and with the Dolby Digital compatible output as well as for simultaneous playback of BD primary/secondary and interactive audio.

**(6) HDMI Transmitter**

The HDMI transmitter complies with the HDMI Ver. 1.3a and HDCP Rev. 1.2 standards. The compatibility with Deep Color, xvYCC and high bit rate HD audio allows high-quality video/audio to be output.

**(7) Display Controller/Graphics Engine**

A powerful display controller is incorporated in order to meet the BD standards. It supports three video planes, four OSD planes and one background color and has compatibility with the anti-flicker filter and 256 levels of alpha blending. Other functions enabling high display quality include the motion-adaptive IP conversion providing 1,920 × 1,080 full HD (High Definition) compatibility as well as various noise reduction systems and picture controls for enabling sharpness and brightness, etc.

The graphics engine incorporates a vector graphics accelerator that is effective for font drawing. It also supports the high-speed block transfer of 2D images, color space conversion that is effective for deployment of font drawing and a size conversion function.

**(8) Video Encoder**

The digital video output, component output and S-Video/composite outputs can be output simultaneously. The analog outputs that are the component and S-Video/composite outputs employ 148MHz, 12-bit DACs.

**(9) DDR2 Memory Interface Unit**

Arbitrates data transfer requests between all the units that use memory including the front-end function block, allocates contiguous address space for two systems of 32-bit bus DDR2 memory interface, and efficiently allocates memory band required for BD playback.

**(10) Peripheral Functions**

As the peripheral functions, the interfaces optimized for the BD player are incorporated. These include the USB2.0 host controller, 10/100Mbps Ethernet controllers, serial ATA UART, $I^2C$ and CSI.

Table 2 Solution specifications.

| Item | Specifications |
|---|---|
| Target system | Blu-Ray Disc Player |
| LSI | EMMA3PF |
| Memory | DDR2 SDRAM, FLASH ROM |
| User IF | GUI, Front Panel, Remote Controller |
| I/O | HDMI, Component, Composite, Analog Audio (7.1ch/2ch), SPDIF, LAN, USB, |
| BDJ specification | BDJ profile 2.0 ( local storage 1Gbyte ) |
| Compatible media format | BD-ROM ( HDMV, BD-J), BD-R/RE (BDAV, BDMV), DVD-Video, DVD-R/RW (Video mode), DVD-R/RW (AVCHD), CDDA ,MP3, WMA, JPEG |

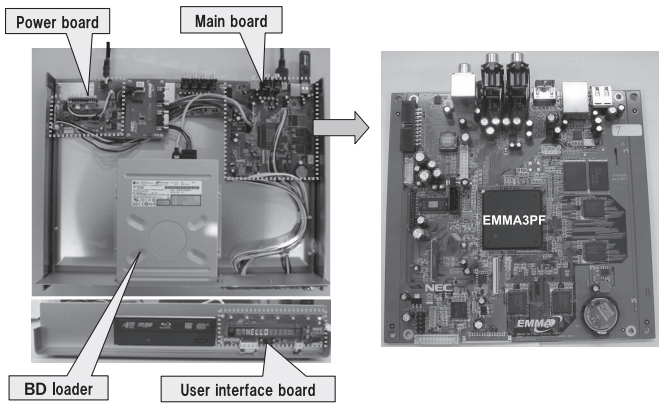


Photo 2 Configuration of the reference board.

## 4. Outline of Solutions

The BD player requires a long development period because it not only reproduces high-quality audio and video but also requires complex software processing such as the reproduction of interactive contents that make full use of the graphics and network functions. The set manufacturers developing BD players request provision of solutions as well as the LSI alone. We are therefore actively developing innovative and effective solutions in order to satisfy these requests. **Table 2** shows the main specifications of the solutions that we are currently developing.

### 4.1 Hardware Configuration

As the developed solution should be of a low-cost design that allows the set prices to be reduced, we have designed the reference board by considering the cost reduction of the en-

tire system including the circuit boards and peripheral components. We have thus succeeded in implementing the reference board into a 4-layer board architecture by taking care of the interconnection layout.

The reference board ( **Photo 2** ) consists of the main board including the EMMA3PF and sub-microcomputer, the user interface board including a display panel, the power board and the BD loader that reads data from the optical disc.

The main board carries the analog video output terminals including the component and composite outputs, 2-channel analog audio output terminals, HDMI output terminal and digital audio output terminal. It also has the LAN terminal, USB terminal, motor driver connection terminal, etc.

### 4.2 Outline of Software

・Software Configuration

The software used by the solution is composed of five layers. These are: the application, middleware, media framework, device driver and OS layers ( **Fig. 2** ).

The application layer controls the external sub-microcomputer and device driver as well as the overall system according to the user interface.

The middleware layer includes the DVD navigation, BD navigation and BD-J (Blu-ray Disc Java) functions. It implements the navigation functions for analyzing data read out from the optical disc and the handling of the stream to the media framework layer, GUI (Graphical User Interface) with rich expressive power, playback of video contents via a network and gaming. Our solution employs the Valution BD of VideAce, Inc., a company of high-end middleware technology.

The media framework layer provides the function for reproducing the stream data handed from the middleware layer.

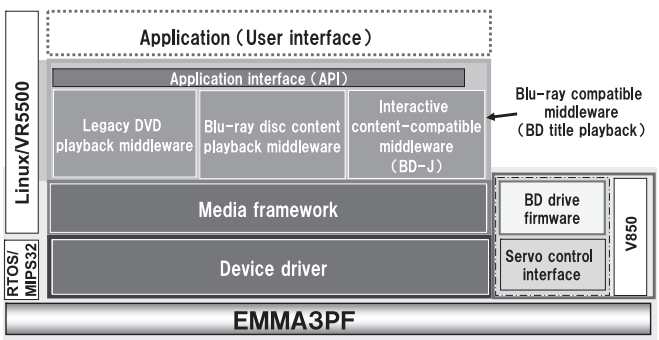


Fig. 2 Software configuration of EMMA3PF.

The device driver layer controls the EMMA3PF hardware and decodes the encoded audio and video data.

The OS layer employs Linux, which is an OS equipped with functions sufficient for tracing the services to be expanded in the future.

## 5. Conclusion

In the above, we describe the range of features of the EMMA3PF functions. The use of this LSI and its solutions will make it possible to reduce the development period of low-priced, high-performance BD players. At NEC Electronics, we intend to actively the system LSIs that are currently being optimized in order to support BD players. This market is expected to continue its rapid growth into the future.



### Authors' Profiles

**OKUYAMA Tomoyuki**
SoC Systems Division,
2nd SoC Operations Unit,
NEC Electronics Corporation

**ITO Masahiro**
SoC Systems Division,
2nd SoC Operations Unit,
NEC Electronics Corporation

**ONODA Yoshio**
Digital Consumer LSI Division,
2nd SoC Operations Unit,
NEC Electronics Corporation

**MIYAMOTO Atsushi**
Digital Consumer LSI Division,
2nd SoC Operations Unit,
NEC Electronics Corporation

**MIYAUCHI Tetsuo**
SoC Software Division,
2nd SoC Operations Unit,
NEC Electronics Corporation

**SUYAMA Hiroo**
Software Development Planning Department,
2nd SoC Operations Unit,
NEC Electronics Corporation