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Technology Review of Mobile Computing

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Mobile computing is becoming popular all over the world. Especially, notebook PCs are playing an important role in mobile computing. Fujitsu has been focusing on the importance of mobile computing and has been developing new technologies for downsizing, power management, and communication. These technologies have been applied to the latest notebook PCs and to a mobile information tool called INTERTop. This paper looks at the development history of Fujitsu's mobile computing products, the features of the latest models, and the technologies required in mobile computing. Then, we describe the current trends in Fujitsu's technology development. Finally, we describe the important technology of simulation by giving an example of transmission waveform simulation technology on a printed-circuit board (PCB). This technology is one of the key elements that enabled us to achieve the high graphic performance of the FMV-BIBLO 6266NA (called Lifebook 990Tx2 in North America and Europe) released in April 1998.

1. Introduction

Recently, with the wide spread of mobile computing, more and more compact and lightweight mobile information tools are entering the market.[1] Also, notebook PCs are playing an important role in personal computing.[2] The following are considered to be three basic reasons of these trends:

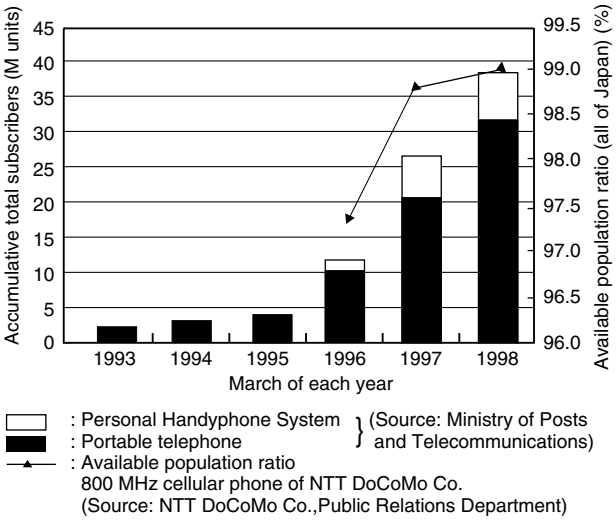


Figure 1.
Change in mobile communication infrastructure in Japan.

1) Realization of compact, lightweight, high-performance hardware.
2) Sufficient communication infrastructures focusing on mobile communication (**Figure 1**).[3),4)]
3) Various applications (e.g., the Internet).[5),6)]

The development of compact and lightweight mobile computing products requires different technologies for desktop models. Fujitsu has developed mobile-oriented products (e.g., notebook PC, pen note PC,[7] portable Japanese word processor) at an early stage and has developed technologies for mobile computing. Also, we have emphasized the components of the communication link for example, acoustic couplers, modems and communication software. These technologies must be adopted and used in the latest products.

This paper describes the development history of mobile computing products and the features of the latest models. Then, we review the technologies required for mobile computing and our current stage of technology development. Finally, we look at the increasingly important technology of the simulation of transmission waveforms on a PC

board as an example of these technologies.

2. History of Fujitsu's Activities in Mobile Computing

2.1 Overview

Fujitsu makes the following mobile computing products[8),9)]: portable Japanese word processors, notebook PCs, pen note PCs, and a mobile information tool called INTERTop which is designed for a new type of use (Note: in a broad sense, business-use hand-held terminals and communication terminals can be regarded as mobile information tools; however, this paper refers to mobile information tools in a narrower sense.).

In all these fields, Fujitsu has pursued not only solo-use but also systemized network linkage through communication. For example, we provide built-in modems, local area networks (LANs) and wireless communication cards[10)], develop communication applications (for bundled installation), and provide communication services such as NIFTY SERVE. Market trends show that the Internet is a big factor in the use of mobile computing tools and Fujitsu is actively promoting its development.

Fujitsu is also energetically developing compact, lightweight, and high-performance mobile computing technologies. We offer a wide range of products, from large server computers to notebook PCs and mobile information tools. The technologies developed to reduce size and weight and increase density are also raise the performance of large computers, transmission time must be reduced, compact and high-density are thus essential.[11),12)]

In the development of notebook PCs, we use the multichip module (MCM) mounting technology, high-density PC boards, cooling technology, and high-speed signal wiring technology all of which are also important in the development of large

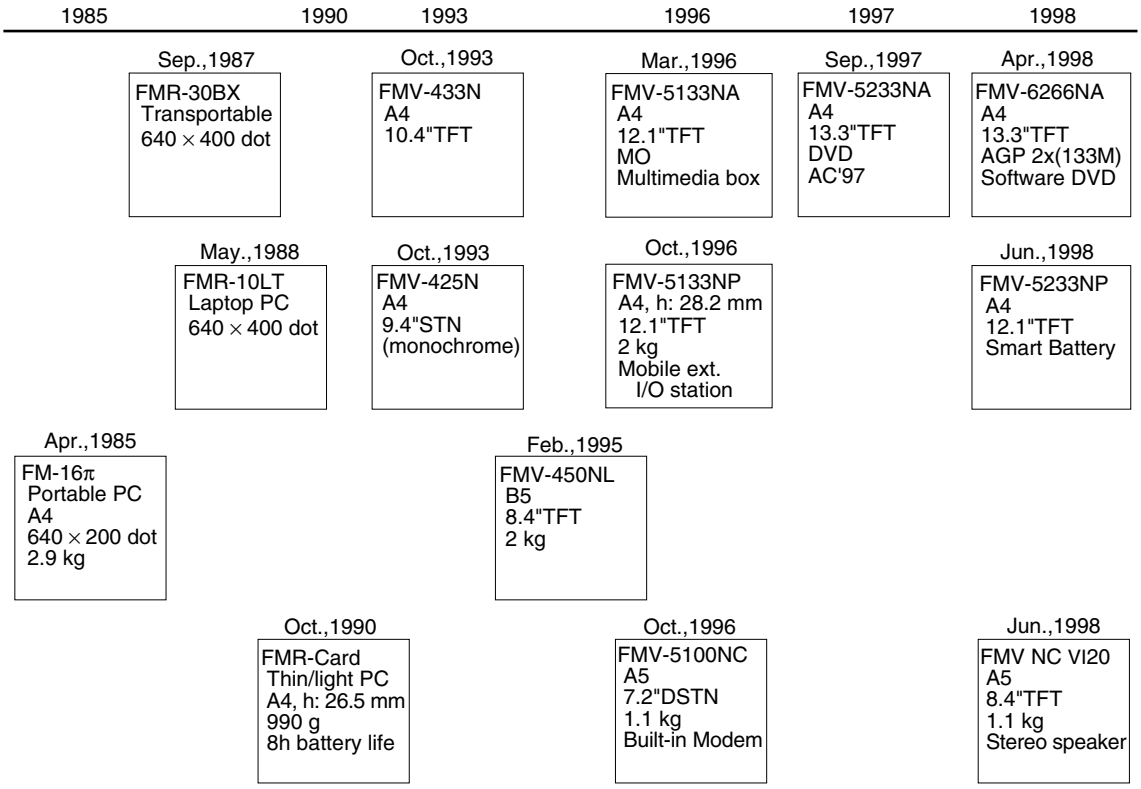


Figure 2.
History of Fujitsu's Notebook PCs and Portable PCs.

computers.

2.2 History of Hardware of Notebook PCs

This section describes the history of mobile computing from the viewpoint of the hardware of notebook PCs.

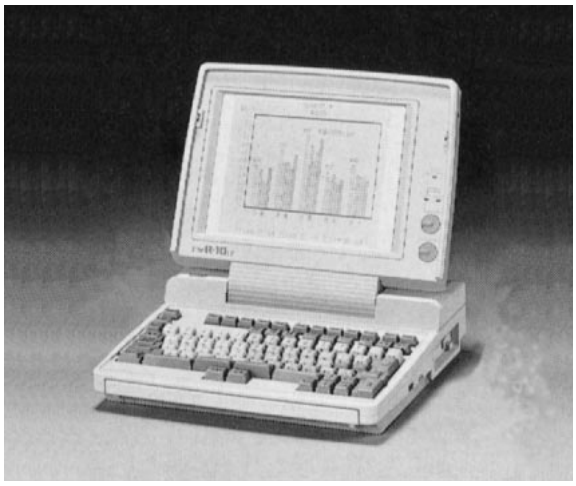
First we will look at the development flow (**Figure 2**),[13)-15)] features and technologies of the first models and the current architecture of the FMV-BIBLO (called Lifebook in North America and Europe) series.

1) Types and features of the first notebook PCs

The FM-16π was Fujitsu's first portable PC and was released in April 1985 (**Figure 3**). The portable FMR-30BX, with updated architecture[16)] was released in September 1987, and the laptop FMR-10LT was released in May 1988 (**Figures 4** and **5**). The FMR-30BX was designed to be a desk-top computer that took up little space and could easily be carried around. The FMR-10LT was as portable as current notebook PCs. In October

Figure 3.
FM-16π.

Firure 4.
FMR-30 BX.



Firure 5.
FMR-10LT.

Figure 6.
FMR Card.

1990, the revolutionary, FMR CARD PC notebook was released (**Figure 6**). The FMR CARD was only A4 size, 26.5 mm thick, weighed less than 1 kg, and had a VGA display. It could be operated continuously for 8 hours on just two alkali batteries.

These features were made possible by the ultra-lightweight housing technology used to develop a lightweight resin mold, a high-density mounting technology for installing high-density packages on a thin PCB, and an energy-saving design technology adopted various following technologies.

The power-saving design uses low-voltage LSIs, a two-level automatic stop function (i.e., a CPU automatic stop function and automatic power-off function), low-power LCDs, and a power control system which reduces excess power consumption using a dedicated control LSI. These measures are commonly used in current notebook PCs so the FMR CARD already boasted long-life operation. Then, the technology to realize low-power consumption by using a slow clock speed in low-power mode was implemented in the PoqetPad pen note PC released in May 1992.

2) Types and features of the FMV series notebook PCs

Fujitsu's current main-architecture FMV series was released in October 1993. At the same time we released the desktop PCs, we also released the FMV-433N and FMV-425N notebook PCs,[17] which were among the first products of our early commitment in the FMV series to mobile computing. The FMV-433N was the world's first PC with a 10.4-inch TFT liquid crystal display. These days, the increase in display size of notebook PCs is a dominant trend.[18] It was a pioneer of notebook PCs.

In March 1996, the high-end FMV-5133NA was released. This was the world's first PC with a built in a magneto-optical disk drive (MO drive) as standard and it incorporated a multimedia box with a TV tuner and a capture function. The FMV-5133NA became the pioneer of the multimedia notebook PCs, thus the features of the FMV-5133NA were inherited by the FMV-5233NA released in September 1997 and latest FMV series. The FMV-5233NA has a built-in digital video disk (DVD) and an Audio Codec'97 (AC '97) with digital sound and optical interfaces.

Next, we will take a look at mobility-oriented lightweight, thin notebook PCs. The FMV-450NL was released in February 1995. It was world's first B5 size notebook PC weighing 2 kg and featuring interchangeable bay structure units. In October 1996, the FMV-5133NP and FMV-5100NC were released. The FMV-5133NP weighed only 2 kg and was only 28.2 mm thick with its built-in 12.1-inch LCD. The basic input-output functions were built-in, and the extended input-output station could be separated from the main body. Also, the FMV-5133NP was the first to employ the design concept of a mobile extended input-output station, which is a different concept from the concept of conventional desktop-type extended stations. The FMV-5100NC was compact, weighed only 1.1 kg and provided the same efficiency and ease of use in the mobile environment as ordinary notebook PCs by employing a 7.2-inch display, a touch-type keyboard, and a built-in modem.

3. Features of Hardware of Latest Notebook PCs

The latest PCs, which were released in April and June of 1998, have inherited these concepts. We will now describe the hardware features of the following PCs.

1) High-end FMV-6266NA (Lifebook 990 Tx2)

The FMV-6266NA (**Figure 7** and **Table 1**) is one of the latest high-end PCs, it incorporates the conventional development concepts and greatly improves multimedia performance.

For the CPU, the FMV-6266NA has a Pentium-II processor, a high-performance graphics chip for efficient graphics system performance, and a 133 MHz AGP 2X bus for the graphics bus. The FMV-6266NA was the world's first 133 MHz-AGP-bus notebook PC. This was made possible

Table 1. Technical specifications.

Model Number	FMV-6266NA / Lifebook 990Tx2
Processor	266MHz Pentium II
System Memory (Standard / Max)	32MB / 160MB SDRAM w/ECC (2 upgrade slots)
L2 Cache	512KB
Bus Architecture	PCI, CardBus, AGP2x
Display	13.3" XGA TFT
Video Memory	4MB SGRAM
Max Resolution/Max Colors	1024 × 768/16M 800 × 600 / 16M
Simultaneous Display	Yes
External Monitor (Max Res / Color)	1600 × 1200 / 64K
Hard Drive	5.0GB
Floppy Disk Drive	3.5" Modular
CD-ROM Drive	24x max Modular
Simultaneous FDD and CD-ROM	Yes
Audio	16-bit Stereo (SB-Compatible), 3D-Positioning (Windows 98) Wavetable, Two Speakers
Video	MPEG-1, Zoomed Video, 3D-Graphics, TV Out
Internal Modem	56K Modem with DSVD (K56Flex)
Keyboard (Pitch/Stroke)	19mm / 3mm; Windows 95 Keys
Pointing Device	Ergo Trac
Infrared Port	IrDA Compatible; 4Mbps
PC Card Slots	2 Type II / 1 Type III
Standard Ports	2 USB, 1 Serial, 1 Parallel, 1 External Monitor, 2 PS/2, 1 External FDD, 1 RJ-11, TV Out, 1 MIDI Joystick, 1 Docking Port
Audio / Video Jacks	1 Headphone, 1 Stereo Line In, 1 Microphone, S-Video In/Out, NTSC/PAL
Battery Type/Life	Modular Lithium ion / Up to 1.5 Hrs Dual Batteries Optional / Up to 3 Hrs
Warm -swapping	Yes
Dimensions (l × w × h)	308 × 256 × 59 mm (excluding projection)
Weight	about 4.0 kg (with FDD and Battery)
Power Management	ACPI 1.0
DMI	DMI 2.0
Popular Options	2nd Lithium ion Battery 2nd 3.0GB Hard Drive LANdock and Port Replicator 1.5×max DVD Drive

Figure 7.
FMV-6266NA.

Figure 8.
FMV-5233NP.

by the development of high-speed wiring technology, which is based on high-density mounting technologies and simulation.

According to a benchmark evaluation of competitive Pentium-II notebook PCs conducted by a PC magazine, the, FMV-6266NA offers approximately twice the performance of its competitors having the same CPU performance (e.g., at the Business Graphics WinMark' 98).[19] Because of this high graphics performance, the FMV-6266NA was the world's first notebook PC to have a DVD player based on software. Conventionally, DVD players are realized in notebook PCs using hardware. Also in the audio unit, multimedia performance was greatly improved by adapting the Wavetable method for MIDI sound sources and adopting PCI audio.

2) Portable PCs: FMV-5233NP (Lifebook 690 Tx) and FMV-BIBLO NC Ⅵ20

The FMV-5233NP (**Figure 8** and **Table 2**) is a separable-type portable PC based on the concept of the FMV-5133NP. To greatly improve portable performance, the FMV-5233NP uses smart batteries and energy-saving technology. That is, simultaneous discharge of parallel batteries (which used to be impossible in conventional PCs), energy-saving using a control LSI, and improved safety were realized. We presented a proposal for standardizing these technologies at the Smart Battery Systems Implementers' Forum.[20]

The FMV-BIBLO NC Ⅵ20 (**Figure 9** and **Table 3**) is a lightweight portable PC that implements the development concept of the FMV-5100NC. The FMV-BIBLO NC Ⅵ20 is the lighter weight of 1.1 kg than that of other Pentium built-in PCs, yet it has an 8.4-inch LCD, a Pentium processor with a cache, a 56 kbps built-in modem, and stereo speakers. In communication and multimedia performance in mobile environment, the FMV-BIBLO NC Ⅵ20 outperforms competing A5 and smaller size notebook PCs.

4. Technological Elements

From the viewpoint of a notebook PC, next, we will review the technological elements in mobile computing and the development trends in the PC industry and Fujitsu's case in technology development.

4.1 Compact, lightweight Technology

The main requirements for notebook PCs are a performance equivalent to that of a desktop PC and compactness and lightweight. These two requirements may conflict with one another.

Figure 10 shows the relation between the size and weight of notebook PCs. As can be seen, there is a strong correlation between the size and weight of a PC.

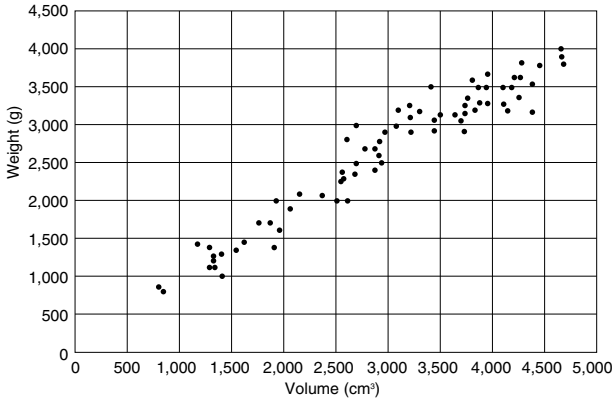
Table 2. Technical specifications.

Model Number	BIBLO 5233NP/ Lifebook 690Tx
Processor	233MHz Pentium w / MMX Technology (BIBLO 5233NP) 266MHz Pentium w / MMX Technology (Lifebook 690Tx)
System Memory (Standard/Max)	32MB / 96MB SDRAM (1 upgrade slot)
L2 Cache	512KB
Bus Architecture	PCI, CardBus
Display	12.1" XGA TFT
Video Memory	2MB EDO
Max Resolution / Max Colors	1024 × 768 / 64K 800 × 600 / 16M
Simultaneous Display	Yes
External Monitor (Max Res / Color)	1024 × 768 / 64K
Hard Drive	4.0GB
Floppy Disk Drive	3.5" Internal in LAN Enhancement Unit
CD-ROM Drive	20max in LAN Enhancement Unit
Audio	16-bit Stereo (SB-Compatible) 3-D Stereo 2 Speakers (LAN Enhancement Unit)
Video	MPEG-1, Zoomed Video
Internal Modem	56K modem with DSVD (K56Flex)
Keyboard (Pitch/Stroke)	19mm / 3mm; Windows 95 Keys
Pointing Device	TouchPad
Infrared Port	IrDA Compatible; 4Mbps
PC Card Slots	2 Type II / 1 Type III
Standard Ports	2 USB, 1 parallel, 1 RJ-11 1 External Monitor, 1 PS / 2, 1 External FDD 1 Docking Port LAN Enhancement Unit Includes: Port Replicator plus 2 USB 1 10/100 Ethernet 1 MIDI / Joystick TV Out 1 Serial
Audio / Video Jacks	1 Headphone, 1 Stero Line In, 1 Microphone 1 Stero Line Out in LAN Enhancement Unit
Battery Type/Life	Dual Lithium ion / Up to 4 Hours; (External Smart Battery Included) Up to 4 Hours
Warm-swapping	Yes, Battery Only
Hot-docking	Yes
Dimensions (l × w × h)	297 × 232 × 31 mm (excluding projection)
Weight	about 2.0 kg
Power Management	ACPI 1.0
DMI	DMI 2.0 / WFM 1.1
Popular Options	Base Enhancement Unit External Floppy Disk Drive Additional External Batteries

Figure 9.
FMV BIBLO NC VI20.

Table 3. Technical specifications.

Model Number	BIBLO NC VI20
Processor	200MHz Pentium w / MMX Technology
System Memory (Standard / Max)	32MB / 96 MB / SDRAM (1 upgrade slots)
L2 Cache	256KB
Bus Architecture	PCI, CardBus
Display	8.4" SVGA TFT
Video Memory	1.1MB EDO
Max Resolution / Max Colors	800 × 600 / 64K
Simultaneous Display	Yes
External Monitor (Max Res / Color)	1024 × 768 / 256
Hard Drive	2.1GB
Floppy Disk Drive	3.5" External Floppy Disk Drive
CD-ROM Drive	No
Audio	16-bit Stereo (SB-Compatible), 2 Speakers
Video	MPEG-1, Zoomed Video
Internal Modem	56K Modem with DSVD (K56Flex)
Keyboard (Pitch / Stroke)	15mm / 2mm; OADG 85 Keys
Pointiog Device	QuickPoint II
Infrared Port	IrDA Compatible; 4Mbps
PC Card Slots	1 Type II
Standard Ports	1 External FDD, 1 RJ-11, Connector Box Port Connector Box Includes: 2 USB, 1 Parallel, 1 Serial, 1 External Monitor, 2 PS / S
Audio / Video Jacks	1 Headphone, 1 Microphone
Battery Type / Life	Modular Lithium ion / Up to 1.8 Hrs Dual Batteries Optional / Up to 5.7 Hrs
Dimensions (l × w × h)	230 × 170 × 34 mm (excluding projection)
Weight	1.1 kg
Power Management	ACPI 1.0
Popular Options	2nd Lithium ion Battery



Firure 10.
Size and weight of notebook PCs.

To make a notebook PC compact and lightweight, various technologies are required. For example, it is necessary to develop strong, lightweight housing materials and high-density mounting technologies. Also, we must solve the cooling problem that comes with the compactness and high-density packaging of notebook PCs.

Fujitsu has developed new mold materials and high-density mounting technologies for a compact, lightweight notebook PCs since the release of FMR Card and OASYS Pocket (portable Japanese word processor weighing only 600g weight). Details of these technologies are described in "Hybrid Housing for Notebook Computers" and "Low-cost Flip Chip Technology for Organic Substrates" of this issue.

4.2 Energy-Saving Technology and Battery Technology

A long battery life is essential for battery-operated mobile computing devices. Especially, notebook PCs are expected to operate in the same operation environment as that of desktop PCs. Therefore, the available operation time must be increased with the minimum functions and performance maintained.

To prolong the operation time of notebook PCs, energy saving, efficient use of the power supply, high-efficiency batteries, and efficient control over the use of batteries are required.

Fujitsu has been developing energy saving methods and methods of prolonging the operation time of notebook PCs since the start of PC development. The technologies applied to products in the past are, after modification and further development, still in use.

Modern notebook PCs are being standardized through close linkage between the OS, firmware, CPU, peripheral circuits, power supply, and batteries (e.g., ACPI, OnNow, and Smart Battery). Fujitsu promotes these standardization efforts and applies the agreed on standards to the latest FMV series.

The technological development of power and battery use is described in this issue, "Power Management Technology."

4.3 Simulation Technology

As mentioned above, improvement of notebook PC performance means among other things, making them smaller and lighter. For example, CPU power consumption increases 2 times per 3 years.[21] However, because a compact, lightweight notebook PC cannot use the type of cooling system found in server computers or desktop PCs, new cooling technologies must be developed.

Regarding PCB wiring, operating speed is becoming faster,[22] nevertheless mounting density is increasing.[21] Therefore, the transmission waveforms, wiring, and electromagnetic compatibility (EMC) are difficult problems to solve.

It is necessary to evaluate these problems for the entire machine, and in many cases measurement is only possible when a pilot machine has been made after the design is completed. However, since some PCs must be developed in a short time, sometime there is not enough time to change the design after evaluating the pilot machine. Therefore, the use of simulation technology in the design and development stages are important.

Cooling methods for high heat generation parts such as the CPU and methods of dissipating heat without adversely affecting heat sensitive parts such as LCDs are required. See "Pack-

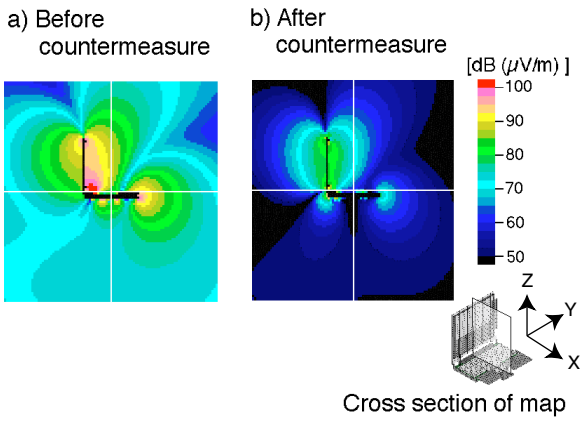


Figure 11.
Electric field map.

aging Technologies for Mobile Notebook PCs" and "Fan-less Cooling Technology for Notebook Computers" in this issue for a description of cooling design and simulation technology.

For the transmission waveform, reflection, crosstalk, ringing, and waveform distortion must be taken into consideration.[23] See Chapter 5 of this paper for an application of transmission waveform simulation to the latest notebook PC FMV-6266 NA.

Unlike the case for a desktop PC with a metal housing, sufficient attention must be paid to EMC and the effects of electromagnetic radiation. EMC design for notebook PCs is conducted using a Fujitsu-developed electromagnetic simulation tool called ACCUFIELD which uses moment method technology.[24)-26)] **Figure 11** shows an example simulation of the intensity of electromagnetic radiation from PC boards of the FMV-6266 NA, which transmit high-speed signals. The left figure shows that the surrounding end-surfaces of PC boards have a big effect. Based on this information, filters consisting of resistances and capacitors were installed around the PC board to reduce the EMI. The simulation result is shown in Figure 11 (right hand).

These types of simulation technologies make it possible to develop a high-performance and high-density notebook PC in a short period.

4.4 Component Technology

Unlike desktop products, these components and devices must be specially developed for the mobile environment.

Because of the expansion of the LCD market, improved LCD performance, and lower costs, LCDs are now being used in desktop PCs. Fujitsu has developed new technologies (e.g., MVA; Multi-domain Vertically Aligned[27]) for LCDs, however LCD technology is still developing at a rapid rate.[28] Product technology, display quality, and size differ among companies, and there is no standard LCD from certain manufacturer.[29] Therefore, to develop notebook PCs using the LCD as part of component, it is necessary to study the display qualification required for the PCs, evaluate various LCDs from the finding, and decide which LCD to develop. Fujitsu conducted standardization as the basic by setting the amount of display quality, which has induction feature, per item (refer to this issue "LCD Technology"). Fujitsu conducted product development of user friendly display quality.

There is a trade off between the need to make keyboards small, thin, and lightweight, and achieving an ergonomically good key pitch and keystroke. Fujitsu is developing keyboards that are small and thin which are nevertheless easy to use. These keyboards are used in Fujitsu's notebook PCs. ("Small, Low-profile Keyboard that Does Not Impair Operability")

4.5 Applied Technology

To create a good mobile computing environment, in addition to the hardware, we must also develop peripheral devices and applications appropriate for mobile computing.

Fujitsu has focused on the importance of network linkage in mobile computing, and has incorporated modem and communication applications in portable OASYS and notebook PCs. In the latest notebook PCs, modems and LAN are standard installation items even though they increase the size and degrade the energy saving performance

of notebook PCs. As for wireless communication infrastructures, Fujitsu is developing next generation wireless communication technology as a total system for mobile computing, (refer to this issue "Third Generation Mobile Radio Systems (IMT-2000) Using Wideband CDMA Technology and Interference Canceler for Its Base Station").

For peripheral devices suitable for mobile computing, a mobile pen-size image scanner[30] ("Mobile Image Scanner"); the secure PC card, which protects data in a mobile environment ("Secure PC Card"), and a fingerprint recognition card for personal authentication in a mobile environment[31] have been developed. The mobile image scanner and Secure PC card are already on the market.

Mobile communication security, an application which enables wireless communication in a high-noise environment ("Network Applications for Mobile Computing"), WildBird[32] which provides information services for mobile terminals in a mobile environment, and INTERTop World for INTERTop dedicated services ("INTERTop WORLD Services – Official Homepage for New Portable Information Tool: INTERTop") are provided as applications for mobile computing.

5. Development Technology of Latest Models – Transmission Waveform Simulation Technology

Next, we describe a transmission waveform simulation technology using examples of its application in one of our latest models.

The transmission waveform simulation technology incorporated in a Fujitsu CAD system called ICAD/PCB DesignTheater was used to develop the FMV-6266NA, which is the world's first 133 MHz high speed AGP 2X bus in notebook PCs.

A complete noise analysis that utilizes conventional noise analysis system requires an enormous number of combinations of timing fluctuations and operating conditions, all of which must be entered manually. In addition, after these combinations are analyzed, the resulting waveform must be checked manually. These operations require a great deal of labor and time.

The new system automatically sets combinations of timing fluctuations and operating conditions for the elements and produces and produces a high-precision analysis of noise, based on original methods of calculation and original models of coupled wires and I/O circuits. The system also automatically evaluates the results of the analysis, thus providing less experienced engineers with the ability to discover problems easily in a short time (**Figure 12**).

Figure 13 shows the circuit diagram of the FMV-6266NA which was analyzed using the transmission waveform simulation tool incorporated in ICAD/PCB DesignTheater, and **Figure 14** shows the analysis result. Generally, in high-speed transmission, reflection, crosstalk, ringing caused by package and connector inductance and capacitance, and waveform distortion are problems. In Figure 14, crosstalk is a problem. To decrease crosstalk, it is necessary to widen the clearances between wires, but this will lower the mounting density. In the development of the FMV-6266NA, various parameters were changed based on simulation, the layer structure of the PC boards was optimized, and the wiring rules and signal tim-

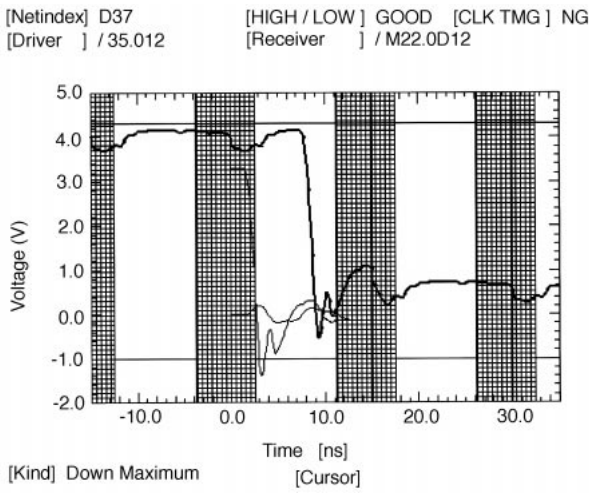


Figure 12.
Example of analyzed waveform and automatical evaluation.

ings were optimized according to the functions of individual signals. As a result, this computer has a 133-MHz high-speed wiring system that does not require a reduced mounting density.

6. Conclusion

The mobile computing market is rapidly expanding, and various competitive products with different functions and uses and of different sizes are on the market. We feel it is very important to provide customers an attractive concept within the limitations of the mobile environment and develop technologies for manufacturing appropriate products.

Fujitsu will continue to develop new technologies for compactness, lightness, energy saving, and communications to provide better products for users.

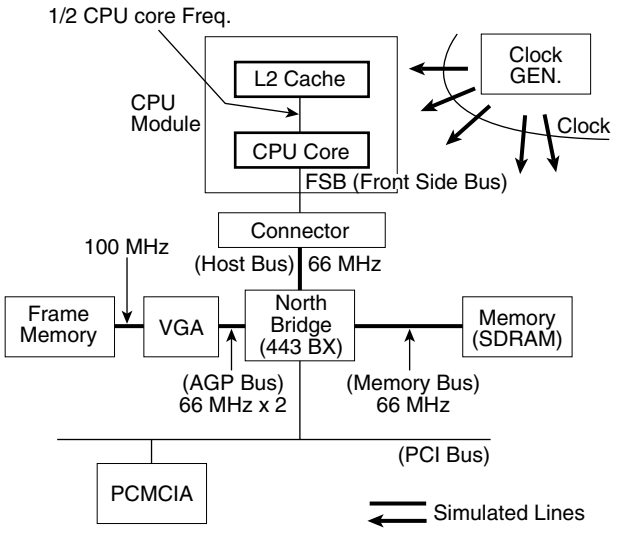


Figure 13.
Simulation model of the FMV-6266NA.

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012	MD0	/U19.AF04	/J1.003	OK	OK	OK	0.92	2.14	0.37	2.93	OK	OK	−0.60	3.83	OK	OK	1.90	−1.30
013	MD0	/U19.AF04	/J3.003	NG	NG	OK	1.03	2.19	0.37	2.92	OK	OK	−0.63	3.84	OK	NG	0.60	0.10
014	MD1	/U19.AE04	/J1.005	OK	OK	OK	0.88	2.19	0.32	2.98	OK	OK	−0.54	3.79	OK	OK	2.10	−1.30
015	MD1	/U19.AE04	/J3.005	NG	NG	OK	1.08	2.15	0.34	2.96	OK	OK	−0.59	3.81	OK	NG	0.70	0.10
016	MD2	/U19.AF05	/J1.007	OK	OK	OK	0.93	2.15	0.36	2.94	OK	OK	−0.55	3.84	OK	OK	1.90	−1.40
017	MD2	/U19.AF05	/J3.007	OK	OK	OK	0.78	2.43	0.34	2.96	OK	OK	−0.58	3.81	OK	OK	0.60	−0.20
018	MD3	/U19.AD06	/J1.009	OK	OK	OK	0.97	2.11	0.40	2.91	OK	OK	−0.60	3.88	OK	OK	1.90	−1.30
019	MD3	/U19.AD06	/J3.009	OK	OK	OK	0.91	2.31	0.37	2.93	OK	OK	−0.62	3.84	OK	OK	0.60	−0.10
020	MD4	/U19.AE06	/J1.013	NG	NG	OK	1.05	2.02	0.45	2.85	OK	OK	−0.67	3.89	OK	NG	1.90	1.00
021	MD4	/U19.AE06	/J3.013	OK	OK	OK	0.85	2.36	0.42	2.88	OK	OK	−0.69	3.92	OK	OK	0.60	−0.20
022	MD5	/U19.AB07	/J1.015	NG	NG	OK	1.08	2.00	0.48	2.81	OK	OK	−0.65	3.91	OK	NG	1.60	1.00
023	MD5	/U19.AB07	/J3.015	OK	OK	OK	0.82	2.35	0.46	2.85	OK	OK	−0.67	3.94	OK	OK	0.30	−0.20
024	MD6	/U19.AC07	/J1.017	NG	NG	OK	1.03	2.04	0.43	2.86	OK	OK	−0.61	3.86	OK	NG	1.60	0.60
025	MD6	/U19.AC07	/J3.017	OK	OK	OK	0.74	2.40	0.40	2.92	OK	OK	−0.61	3.90	OK	OK	0.40	−0.40
026	MD7	/U19.AF07	/J1.019	NG	NG	OK	1.10	1.98	0.49	2.82	OK	OK	−0.65	3.89	OK	NG	1.60	1.00
027	MD7	/U19.AF07	/J3.019	OK	OK	OK	0.83	2.33	0.46	2.85	OK	OK	−0.69	3.94	OK	OK	0.40	−0.20

Figure 14.
Analysis result.

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