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Hand-held Terminal with Multi-code Reader

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Fujitsu has developed a hand-held terminal that incorporates a scanner with a CCD camera for capturing image data such as handwritten signatures and reading every type of one-dimensional and two-dimensional code in use in today's business world. This terminal is the same size as conventional hand-held terminals for reading one-dimensional barcodes. This paper discusses the features and key technologies of the new hand-held terminal.

A two-dimensional barcode can contain 10 to 30 times more coded information than a one-dimensional barcode of the same area. The terminal's error correction function allows it to read blurred or distorted data. Data can also be read from any direction. Two-dimensional codes are expected to be widely used in the near future, and standards are already being established in the United States and Japan for different business categories.

1. Introduction

Two-dimensional codes have an information density that is about 10 to 30 times greater than that of a conventional barcode, and their labels are highly resistant to staining and other damage. Also, they can handle a wide variety of characters in addition to alphanumeric characters and allow a label to be read from any direction. To encourage widespread use of two-dimensional codes, the American National Standards Institute (ANSI), the Automotive Industrial Action Group (AIAG), and the Electronic Industries Association (EIA) in the United States are creating standards that will make the best use of the PDF417, Data Matrix, and Maxi Code codes. The most commonly used two-dimensional codes in Japan are PDF417, Data Matrix, and QR Code. (Each of these codes is used in specific types of industries.) Maxi Code may predominate if the transportation label defined by the ISO standard is accepted as the JIS label without modification.

Since two-dimensional codes are quickly replacing conventional barcodes there could be confusion for some time. To avoid this confusion, Fujitsu's FHT261 (Cat's Eye) hand-held terminal is an optimal solution because it can read any existing type of barcode as well as the two-dimensional codes. The FHT261 can even import handwritten signatures and other image data and has functions that can be used for building a wide-area mobile system using radio, a cable LAN, or a radio WAN.

2. Background

Fujitsu released the general-purpose F3588A/B in 1982 and then released a hand-held terminal with a barcode reader in 1990 and a notebook version in 1996.

Always abreast of the latest industry developments, Fujitsu has been improving and upgrading its product line to ensure an optimal operating environment. See **Figure 1**.

This paper focuses on hand-held terminals equipped with a barcode reader and describes the development of hand-held terminals with a multi-code reader.

The F3793A is a hand-held terminal with a pen-type barcode reader. It was released in 1990 and is still popular because it is inexpensive and is small and lightweight enough to fit comfortably in the hand.

In 1991, Fujitsu released the F3793B/BT. The gun-type laser scanner of this model makes it ideal for merchandise inspection and inventory control. The F3793BL radio model was added to the lineup in 1992 followed by the FHT201 contact-read model with a CCD scanner in 1994. In 1997, Fujitsu released the FHT251, which is a breast-pocket model with a large screen and enhanced functions and performance. To make it a global product, the FHT251 is being adapted for use with the various standards and languages in use throughout the world.

Fujitsu has supplied various types of hand-held terminals to meet the differing requirements of customers and to give them an optimal operating environment.

Over the years, however, the trends toward deregulation, borderless commerce, and globalization have radically changed the business environment. To survive in the new environment, many companies are studying and adopting an efficient method called supply chain management (SCM), which integrates stages from procurement to manufacturing to distribution. Under the new system, the types of controls required seem to extend beyond the capacity of conventional barcodes. Therefore, to meet this new need, Fujitsu has developed a hand-held terminal with a multi-code reader and put it on the market at the end of May 1999 as a basic terminal for SCM.

3. Features of the FHT261 Hand-held Terminal with Multi-code Reader

The FHT261 is a new hand-held terminal with a multi-code reader and a built-in CCD camera. It has the same housing as the FHT251 and can read any current type of one-dimensional barcode and two-dimensional barcodes. The standard external interfaces of the unit are an infrared interface IrDA 1.0 (38.4 kbps) and a PC card slot (Type II). A short-range radio type is available for a mobile printer, and a spread spectrum (SS) is available for an RF LAN. If an optional LAN

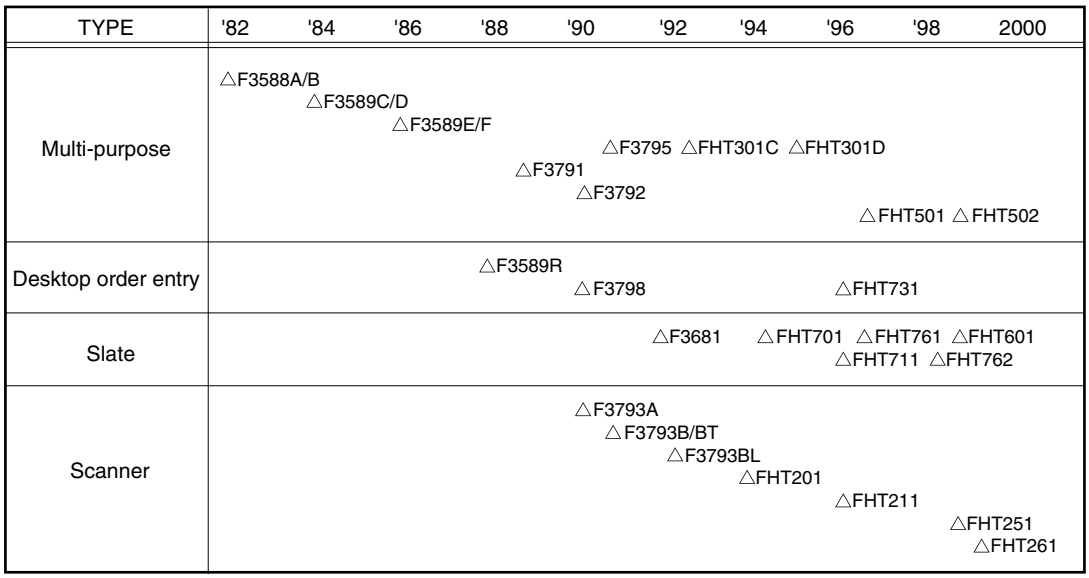


Figure 1
Product lines.

adapter is connected, a cable LAN can be constructed. Currently, various RF types for WANs are being certified worldwide (see **Figure 2** and **Table 1**).

4. Key technologies

1) Code reader with CCD camera

– Images photographed by a two-dimensional, 330 000-pixel CCD camera are imported after A/D conversion into image memory as a digital image of 256 gradations. Using gray-scale image processing, codes are extracted and decoded, then the decoded data is output serially. This series of operations is controlled by software running on a 32-bit RISC processor. If the imported image is too dark, the gain setting can be changed or the light can be turned on to optimize the image (see **Figure 3**).

– The CCD camera enables the user to manu-

Figure 2
Hand-held terminal with multi-code reader: FHT261.

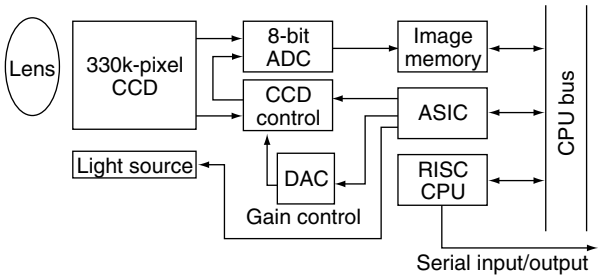


Figure 3
Block diagram.

Table 1
FHT261 specifications.

CPU	VG330 (V30MX) 32 MHz	
Memory	ROM: 2/4 MB (Flash memory), RAM: 4 MB (DRAM)	
Operating system	MS-DOS (ROM Version 5.0)	
Display LCD	Dimensions	128 × 240 pixels (dot pitch: 0.32 × 0.32 mm)
	Characters & Lines	16 × 13
	Backlight	EL-backlight (green)
	Control	Monochrome VGA resolution (Model 1)
Keyboard	Tactile	19 keys: BKS, CLR, ENT, PWR, SFT, 0~9, three barcode trigger keys, and decimal point
	Touch Panel	Non-glare (Hard coating)
Interface	One PCMCIA Type II slot IrDA 1.0, up to 38.4 Kbps	
Power	Main battery	Li-ION battery 3.6 V / 1400 mA
	Backup battery	Li rechargeable battery (3.0 V/90 mAh) Back up time: Approximately 40 hours
	Operating time	8 hours below 25°C (at 2 scans/10 seconds, EL back light off and Automatic Off LCD system active [figure also depends on CPU operation conditions])
	Charging time	Approximately 3 hours by pack charger and 5 hours by CIU at room temperature
	Charging device	CIU (Communication Interface Unit), Charging adapter, Pack charger, Multi-pack charger (charges up to 4 battery packs)
Scanner	Speed (2D-Code)	0.2 to 0.25 second
	(1D-Code)	0.1 to 0.15 second
	Light source	Red LED
	Code type	JAN/EAN/UPC/NW7/ITF/Code39/Code128 Data Matrix/Maxi Code/PDF417/QR Code/Customer Code
	Image capture	
Attachment	Main battery, Sub battery, Wrist strap	
Environment	Operating temperature / Humidity: 0 to 50°C / 20 to 85% Storage temperature / Humidity: −20 to 60°C / 8 to 95% (without battery pack)	
Size	W 60 × H 150 × D 37 (without RF antenna)	
Weight	Approximately 300 g (without RF antenna)	

Table 2
Comparison of performance of CCD camera and laser type scanners.

Item	Camera type	Laser type
Reading of two-dimensional code	Very good	Acceptable
Capturing of images (e.g., seals and signatures)	Very good	Not possible
Reading direction	Very good 360° (any direction)	Acceptable Single direction only
Reading of one-dimensional code of bad quality (blur, distortion, code height of 5 mm or less)	Good	Acceptable

ally produce very natural images. The typical performance specifications are as follows:

- Reading speed
  1D code : 0.1 to 0.15 second
  2D code (100 digits) : 0.2 to 0.25 second
- Reading angle
  Satisfactory reading even at an angle of 35° to 40° to the code surface
- Reading distance
  1D code : Max. 200 mm
  2D code : Max. 200 mm

– **Table 2** shows the advantages of this code reader compared with conventional laser-type scanners.

2) Spread spectrum (SS) RF LAN

The FHT261 hand-held terminal uses the SS RF LAN system, which supports a higher-speed and higher quality communication than other systems. Frequency hopping (FS) has been selected for the SS RF system because of its superior transmission efficiency during very high traffic conditions and its superior tolerance to noise compared with direct sequence (DS) SS RF. To ensure sufficient anti-drop strength and prevent density fluctuations in certain operating environments, a diversity antenna has been fully built in. Also, this hand-held terminal has a roaming function, so it is capable of seamless communication even when the access point changes during movement. See **Table 3**.

Table 3
SS RF specifications.

Item	Specification
Standard	IEEE 802.11
Modulation method	Spread spectrum by frequency hopping
Frequency band	2.4 GHz
Speed	2 Mbps

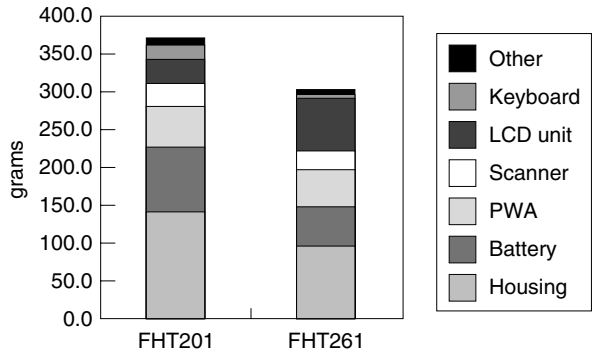


Figure 4
Comparison of weight distributions.

Table 4
High-density parts of FHT261.

Parts	Quantity	Lead spacing
LSI (QFP) 176-pin	1	0.5 mm
160-pin	1	0.5 mm
100-pin	1	0.5 mm
144-pin	2	0.5 mm
Connector 40-pin	1	0.5 mm
30-pin	1	0.5 mm

3) Technologies for reducing size and weight

Figure 4 compares the weight distributions of the FHT261 and the conventional FHT201 model. In the FHT201, which weighs about 375 g, the housing accounts for 37.8% of the weight, the battery for 21.9%, and the PC board for 15.9%. Collectively, these three items account for 75% of the total weight. The FHT261, on the other hand, weighs only about 300 g. The technologies used for reducing the weight of the PC board and housing are outlined below.

– Thin printed circuit board

The FHT261 uses small, high-density parts (**Table 4**) and a BVH board that is 0.8 mm thick,

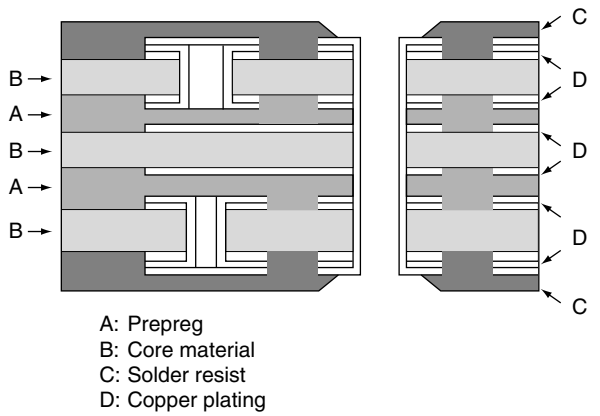


Figure 5
Six-layer BVH.

has six layers, and a minimum line width of 0.1 mm (**Figure 5**).

Of the components used in this hand-held terminal, the BVH PC board, which no longer requires via hole allocation for the layers unrelated to wiring, is especially effective for high-density mounting. The BVH PC board can reduce the weight by 20 percent and the parts mounting area by 30 percent when compared to conventional models.

– Thin-wall housing

The housing is made of reinforced ABS. We made full use of 3D-CAD simulation and our extensive experience in weight reduction; shock, drop, and vibration resistance; and water resistance to minimize the wall thickness (minimum thickness: 0.8 mm, average thickness: 1.2 mm). As a result, although the FHT261 weighs only about 300 g, it also passes a 1.5 m drop test and conforms to the JIS water resistance Class II standard.

4) Usability

The FHT261 can be operated with one hand, even the non-dominant hand. Because it is small and easy-to-grip, the FHT261 can be easily operated at a position and angle that suits the user's hand and can be kept in a breast pocket.

The large touch panel LCD unit, three trigger keys on each side of the keyboard, and a unique layout results in a high level of usability (see Figure 2).

5) Environmental resistance

This terminal is resistant to drops, vibration, shock, rain, dust, extreme temperatures, and high humidity. The memory contents are preserved even after the terminal has been dropped from a height of 1.5 m. The terminal can withstand rainfall at a rate of about 150 mm/hour. Normal operation is guaranteed from 0 to 50ºC and in a humidity range from 20 to 85%.

6) Energy saving and environmental protection

Because Fujitsu is making extra effort to save energy and protect the global environment, we have made the FHT261 compliant with the ISO14000 standard. By reducing the thickness of the housing wall, PC board, and other parts, we have drastically reduced the use of materials and are reducing the use of environmental resources. An automatic power-off function, automatic backlight off function, and power compensation function that makes full use of battery capacity help save energy.

7) Simulation technology

We used 3D-CAD to improve the development efficiency and design quality.

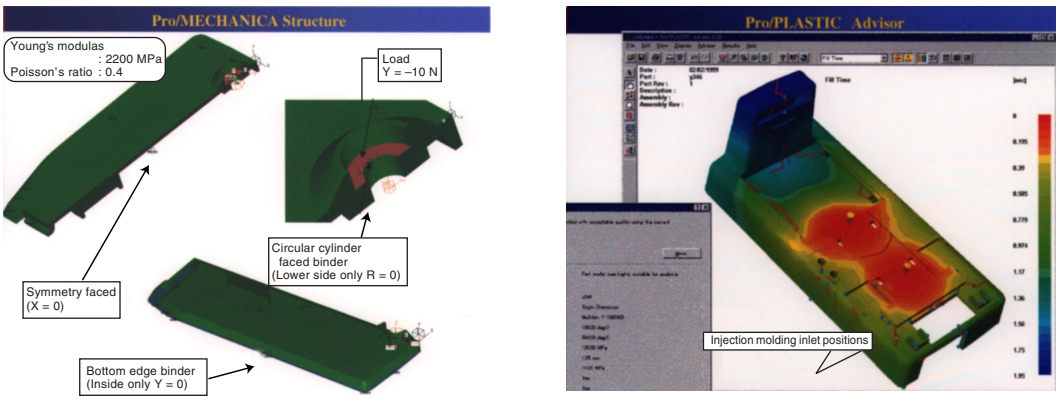
1) Improving the development efficiency

Using 3D-CAD data for similar previous models, we were able to very quickly design a mold. At the same time, a mold manufacturer purchased the necessary mold materials and prepared the 3D-CAD data for use. As a result of these steps, we were able to reduce the total mold development period by about 30 percent.

2) Improving the design quality

– Before the molds were designed, rapid prototyping (RP) technology was used to create prototype housings from an ultraviolet curable resin based on 3D-CAD data to check engagements, dimensions, and other geometric parameters.

– In addition to the conventional environmental protection techniques (including design rules



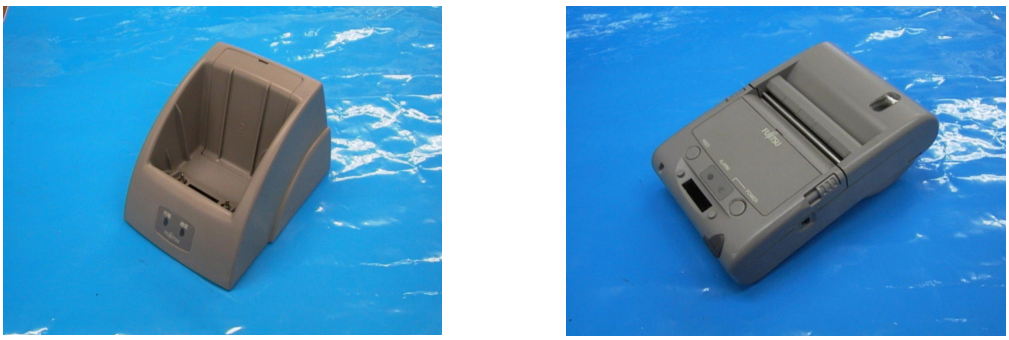
(a) Stress analysis

(b) Resin fluidity checking

Figure 6
3D-CAD simulations.

Table 5
Optional devices.

Unit	Model	Remarks
Pack charger	FHTCA261	Unit for charging a battery pack Charging time: About 3 hours
Charging adapter	FHTLC261	Adapter for charging battery pack built into main unit Charging time: About 5 hours
Multi-pack charger	FHTMC261	Unit for charging up to 4 battery packs Charging time: About 3 hours
IC memory card	FHTCM001~005	SRAM cards for external storage (128 KB/256 KB/512 KB/1 MB/2 MB)
Flash disk card	FHTFC004A/ 008A/040A	Flash disk card for external storage (4 MB/8 MB/40 MB)
Pen	FHTPN701	Dedicated touch panel



(a) Communication interface unit

(b) Mobile printer

Figure 7
Optional equipment.

and fault examples), we performed 3D-CAD simulations for stress analysis (**Figure 6 (a)**), resin fluidity checking (**Figure 6 (b)**), and interference checking. Before mold manufacturing was even started, several faults were detected and corrected. As a result, there was hardly any need to go

back and modify the design, delivery was on schedule, and the mold development costs were reduced.

– Fujitsu will perfect its simulation technology so that we can develop other models, even completely new designs, to the same high standard as this model and within the same amount of time or faster.

5. Optional equipment

The FHT261 can be used in a wide range of applications, for example, inventory control and checking, information searching, delivery checking, route sales, and meter reading and maintenance. We have also prepared the following options for the FHT261.

1) Communication Interface Unit

An optical adapter can be mounted on the hand-held terminal to enable communication with a PC, modem, LAN adapter, or other device and to charge the built-in battery.

– Communication function: Supports communication speeds up to 38.4 kbps. Up to eight optical adapters can be connected in a daisy chain.

– Charging function: Charges the main battery of the hand-held terminal in about five hours. The battery can be charged during communication if necessary.

2) Mobile printer

A mobile printer that fits on the operator's belt enables wireless printing via short-range RF or IrDA.

– 80 mm paper width

– Operation time: 8 hours (3000 lines in ANK mode)

3) Pack charger, charging adapter, multi-pack charger, IC memory card, flash disk card, and pen (see **Table 5** and **Figure 7**).

6. Conclusion

1) Popularizing two-dimensional codes

– The spread of SCM will further increase the information density in product codes. Since the unification of coding for all business areas is being studied, two-dimensional codes will grow in popularity.

2) Future development

– A CMOS element is now being developed for the two-dimensional imagers of the next generation of products. This element consumes only 1/10 of the power needed by a CCD, requires fewer peripheral circuits, and operates on 3.3 V.

The CMOS element will reduce the size of the camera, current consumption, and cost. Before long, camera-type models will occupy a large percentage of the laser scanner market.

– We will continue to make improvements in functionality, usability, and resistance against various environmental stresses to satisfy our customers' needs.

Yasuya Tanaka received the B.S. degree in Instrumentation Engineering from Keio University, Yokohama, Japan in 1977. He joined Fujitsu Limited, Kawasaki, Japan in 1977. Up to 1992, he was engaged in development of data communication systems. Between 1986 and 1990, he was a member of the technical staff of Florida R&D in Fujitsu America, Inc., where he was engaged in development of data communication systems. Since 1992, he has been engaged in development of mobile computing products.

Yoji Satoh graduated from the Department of Electricity at Maiya Technical High School. In 1965, he joined Fujitsu Limited, where he has been involved in the development of various terminal products. In 1982, he started work on the physical design of hand-held terminals. Since 1998, he has been on loan to Fujitsu Kiden Ltd., where he is developing hand-held terminals.

Motofumi Kashi received the B.S. degree in Material Engineering from Tokyo Institute of Technology, Tokyo, Japan in 1973. He joined Tohken Co., Ltd., Tokyo, Japan in 1978, where he was engaged in design of industrial microcomputer systems. Since 1987, he has been the vice president of the R&D Division of Tohken Co., Ltd.