



Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of "Quality Parts,Customers Priority,Honest Operation,and Considerate Service",our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!



Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: <http://www.renesas.com>

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (<http://www.renesas.com>)

Send any inquiries to <http://www.renesas.com/inquiry>.

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: “Standard”, “High Quality”, and “Specific”. The recommended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as “Specific” without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as “Specific” or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is “Standard” unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.
 - “Standard”: Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.
 - “High Quality”: Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.
 - “Specific”: Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

User's Manual

78K0/LE3

8-Bit Single-Chip Microcontrollers

μ PD78F0441

μ PD78F0442

μ PD78F0443

μ PD78F0444

μ PD78F0445

μ PD78F0451

μ PD78F0452

μ PD78F0453

μ PD78F0454

μ PD78F0455

μ PD78F0461

μ PD78F0462

μ PD78F0463

μ PD78F0464

μ PD78F0465

[MEMO]

① VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ PRECAUTION AGAINST ESD

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ STATUS BEFORE INITIALIZATION

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

⑤ POWER ON/OFF SEQUENCE

In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current.

The correct power on/off sequence must be judged separately for each device and according to related specifications governing the device.

⑥ INPUT OF SIGNAL DURING POWER OFF STATE

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

EEPROM is a trademark of NEC Electronics Corporation.

SuperFlash is a registered trademark of Silicon Storage Technology, Inc. in several countries including the United States and Japan.

Caution: This product uses SuperFlash® technology licensed from Silicon Storage Technology, Inc.

- **The information in this document is current as of July, 2008. The information is subject to change without notice. For actual design-in, refer to the latest publications of NEC Electronics data sheets or data books, etc., for the most up-to-date specifications of NEC Electronics products. Not all products and/or types are available in every country. Please check with an NEC Electronics sales representative for availability and additional information.**

- No part of this document may be copied or reproduced in any form or by any means without the prior written consent of NEC Electronics. NEC Electronics assumes no responsibility for any errors that may appear in this document.

- NEC Electronics does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from the use of NEC Electronics products listed in this document or any other liability arising from the use of such products. No license, express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC Electronics or others.

- Descriptions of circuits, software and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software and information in the design of a customer's equipment shall be done under the full responsibility of the customer. NEC Electronics assumes no responsibility for any losses incurred by customers or third parties arising from the use of these circuits, software and information.

- While NEC Electronics endeavors to enhance the quality, reliability and safety of NEC Electronics products, customers agree and acknowledge that the possibility of defects thereof cannot be eliminated entirely. To minimize risks of damage to property or injury (including death) to persons arising from defects in NEC Electronics products, customers must incorporate sufficient safety measures in their design, such as redundancy, fire-containment and anti-failure features.

- NEC Electronics products are classified into the following three quality grades: "Standard", "Special" and "Specific".

The "Specific" quality grade applies only to NEC Electronics products developed based on a customer-designated "quality assurance program" for a specific application. The recommended applications of an NEC Electronics product depend on its quality grade, as indicated below. Customers must check the quality grade of each NEC Electronics product before using it in a particular application.

"Standard": Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots.

"Special": Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support).

"Specific": Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems and medical equipment for life support, etc.

The quality grade of NEC Electronics products is "Standard" unless otherwise expressly specified in NEC Electronics data sheets or data books, etc. If customers wish to use NEC Electronics products in applications not intended by NEC Electronics, they must contact an NEC Electronics sales representative in advance to determine NEC Electronics' willingness to support a given application.

(Note)

(1) "NEC Electronics" as used in this statement means NEC Electronics Corporation and also includes its majority-owned subsidiaries.

(2) "NEC Electronics products" means any product developed or manufactured by or for NEC Electronics (as defined above).

M8E 02. 11-1

INTRODUCTION

Readers

This manual is intended for user engineers who wish to understand the functions of the 78K0/LE3 and design and develop application systems and programs for these devices. The target products are as follows.

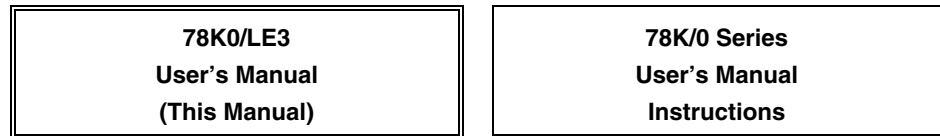
78K0/LE3: μ PD78F0441, 78F0442, 78F0443, 78F0444, 78F0445,
 μ PD78F0451, 78F0452, 78F0453, 78F0454, 78F0455,
 μ PD78F0461, 78F0462, 78F0463, 78F0464, 78F0465

Purpose

This manual is intended to give users an understanding of the functions described in the **Organization** below.

Organization

The 78K0/LE3 manual is separated into two parts: this manual and the instructions edition (common to the 78K0 microcontrollers).



- Pin functions
- Internal block functions
- Interrupts
- Other on-chip peripheral functions
- Electrical specifications
- CPU functions
- Instruction set
- Explanation of each instruction

How to Read This Manual

It is assumed that the readers of this manual have general knowledge of electrical engineering, logic circuits, and microcontrollers.

- To gain a general understanding of functions:
 - Read this manual in the order of the **CONTENTS**. The mark "<R>" shows major revised points. The revised points can be easily searched by copying an "<R>" in the PDF file and specifying it in the "Find what:" field.
- How to interpret the register format:
 - For a bit number enclosed in angle brackets, the bit name is defined as a reserved word in the RA78K0, and is defined as an sfr variable using the #pragma sfr directive in the CC78K0.
- To know details of the 78K0 microcontroller instructions:
 - Refer to the separate document **78K/0 Series Instructions User's Manual (U12326E)**.

Conventions

Data significance:	Higher digits on the left and lower digits on the right
Active low representations:	$\overline{\text{xxx}}$ (overscore over pin and signal name)
Note:	Footnote for item marked with Note in the text
Caution:	Information requiring particular attention
Remark:	Supplementary information
Numerical representations:	Binary ...xxxx or xxxxB
	Decimal ...xxxx
	Hexadecimal ...xxxxH

Related Documents

The related documents indicated in this publication may include preliminary versions. However, preliminary versions are not marked as such.

Documents Related to Devices

Document Name	Document No.
78K0/LE3 User's Manual	This manual
78K/0 Series Instructions User's Manual	U12326E
78K0 Microcontrollers Self Programming Library Type01 User's Manual ^{Note}	U18274E
78K0 Microcontrollers EEPROM™ Emulation Library Type01 User's Manual ^{Note}	U18275E

Note This document is under engineering management. For details, consult an NEC Electronics sales representative.

Documents Related to Development Tools (Software) (User's Manuals)

Document Name	Document No.	
RA78K0 Ver. 3.80 Assembler Package	Operation	U17199E
	Language	U17198E
	Structured Assembly Language	U17197E
CC78K0 Ver. 3.70 C Compiler	Operation	U17201E
	Language	U17200E
ID78K0-QB Ver. 3.00 Integrated Debugger	Operation	U18492E
PM+ Ver. 6.30		U18416E

Documents Related to Development Tools (Hardware) (User's Manuals)

Document Name	Document No.
QB-78K0LX3 In-Circuit Emulator	U18511E
QB-MINI2 On-Chip Debug Emulator with Programming Function	U18371E

Documents Related to Flash Memory Programming

Document Name	Document No.
PG-FP5 Flash Memory Programme	U18865E

Caution The related documents listed above are subject to change without notice. Be sure to use the latest version of each document when designing.

Other Documents

Document Name	Document No.
SEMICONDUCTOR SELECTION GUIDE – Products and Packages –	X13769X
Semiconductor Device Mount Manual	Note
Quality Grades on NEC Semiconductor Devices	C11531E
NEC Semiconductor Device Reliability/Quality Control System	C10983E
Guide to Prevent Damage for Semiconductor Devices by Electrostatic Discharge (ESD)	C11892E

Note See the “Semiconductor Device Mount Manual” website (<http://www.necel.com/pkg/en/mount/index.html>).

Caution The related documents listed above are subject to change without notice. Be sure to use the latest version of each document when designing.

CONTENTS

CHAPTER 1 OUTLINE	17
1.1 Features	17
1.2 Applications	18
1.3 Ordering Information	19
1.4 Pin Configuration (Top View)	20
1.5 78K0/Lx3 Microcontroller Series Lineup	24
1.6 Block Diagram	28
1.7 Outline of Functions (μPD78F044x)	29
1.8 Outline of Functions (μPD78F045x)	32
1.9 Outline of Functions (μPD78F046x)	35
CHAPTER 2 PIN FUNCTIONS	38
2.1 Pin Function List	38
2.2 Description of Pin Functions	43
2.2.1 P11 to P14 (port 1).....	43
2.2.2 P20 to P27 (port 2).....	44
2.2.3 P31 to P34 (port 3).....	44
2.2.4 P40 to P44 (port 4).....	45
2.2.5 P80 to P83 (port 8).....	46
2.2.6 P100 to P103 (port 10).....	46
2.2.7 P110 to P113 (port 11).....	47
2.2.8 P120 to P124 (port 12).....	47
2.2.9 P140 to P143 (port 14).....	48
2.2.10 P150 to P153 (port 15).....	48
2.2.11 AV_{REF} (μ PD78F045x and 78F046x only).....	49
2.2.12 AV_{SS} (μ PD78F045x and 78F046x only)	49
2.2.13 COM0 to COM7	49
2.2.14 V_{LCO} to V_{LCS}	49
2.2.15 \overline{RESET}	49
2.2.16 REGC.....	49
2.2.17 V_{DD}	49
2.2.18 V_{SS}	49
2.2.19 FLMD0	49
2.3 Pin I/O Circuits and Recommended Connection of Unused Pins	50
CHAPTER 3 CPU ARCHITECTURE	54
3.1 Memory Space	54
3.1.1 Internal program memory space	66
3.1.2 Internal data memory space.....	68
3.1.3 Special function register (SFR) area	68
3.1.4 Data memory addressing	69
3.2 Processor Registers	79
3.2.1 Control registers.....	79

3.2.2	General-purpose registers	83
3.2.3	Special function registers (SFRs).....	84
3.3	Instruction Address Addressing	90
3.3.1	Relative addressing	90
3.3.2	Immediate addressing.....	91
3.3.3	Table indirect addressing.....	92
3.3.4	Register addressing.....	92
3.4	Operand Address Addressing	93
3.4.1	Implied addressing.....	93
3.4.2	Register addressing.....	94
3.4.3	Direct addressing.....	95
3.4.4	Short direct addressing.....	96
3.4.5	Special function register (SFR) addressing.....	97
3.4.6	Register indirect addressing	98
3.4.7	Based addressing.....	99
3.4.8	Based indexed addressing.....	100
3.4.9	Stack addressing	101
CHAPTER 4	PORT FUNCTIONS.....	102
4.1	Port Functions.....	102
4.2	Port Configuration	105
4.2.1	Port 1	106
4.2.2	Port 2.....	109
4.2.3	Port 3.....	111
4.2.4	Port 4.....	113
4.2.5	Port 8.....	116
4.2.6	Port 10.....	117
4.2.7	Port 11.....	118
4.2.8	Port 12.....	121
4.2.9	Port 14.....	125
4.2.10	Port 15.....	126
4.3	Registers Controlling Port Function.....	127
4.4	Port Function Operations.....	134
4.4.1	Writing to I/O port.....	134
4.4.2	Reading from I/O port	134
4.4.3	Operations on I/O port	134
4.5	Settings of PFALL, PF2, PF1, ISC, Port Mode Register, and Output Latch When Using Alternate Function.....	134
CHAPTER 5	CLOCK GENERATOR.....	138
5.1	Functions of Clock Generator.....	138
5.2	Configuration of Clock Generator	139
5.3	Registers Controlling Clock Generator	141
5.4	System Clock Oscillator	152
5.4.1	X1 oscillator	152
5.4.2	XT1 oscillator	152
5.4.3	When subsystem clock is not used.....	155
5.4.4	Internal high-speed oscillator	155

5.4.5 Internal low-speed oscillator	155
5.4.6 Prescaler	155
5.5 Clock Generator Operation	156
5.6 Controlling Clock.....	159
5.6.1 Example of controlling high-speed system clock	159
5.6.2 Example of controlling internal high-speed oscillation clock.....	161
5.6.3 Example of controlling subsystem clock.....	163
5.6.4 Example of controlling internal low-speed oscillation clock.....	165
5.6.5 Clocks supplied to CPU and peripheral hardware.....	165
5.6.6 CPU clock status transition diagram	166
5.6.7 Condition before changing CPU clock and processing after changing CPU clock.....	171
5.6.8 Time required for switchover of CPU clock and main system clock	172
5.6.9 Conditions before clock oscillation is stopped.....	173
5.6.10 Peripheral hardware and source clocks	174
CHAPTER 6 16-BIT TIMER/EVENT COUNTER 00.....	175
6.1 Functions of 16-Bit Timer/Event Counter 00	175
6.2 Configuration of 16-Bit Timer/Event Counter 00.....	176
6.3 Registers Controlling 16-Bit Timer/Event Counter 00	181
6.4 Operation of 16-Bit Timer/Event Counter 00	190
6.4.1 Interval timer operation	190
6.4.2 Square wave output operation	193
6.4.3 External event counter operation	196
6.4.4 Operation in clear & start mode entered by TI000 pin valid edge input.....	200
6.4.5 Free-running timer operation.....	213
6.4.6 PPG output operation.....	222
6.4.7 One-shot pulse output operation	225
6.4.8 Pulse width measurement operation	230
6.4.9 External 24-bit event counter operation	238
6.4.10 Cautions for external 24-bit event counter	242
6.5 Special Use of TM00.....	244
6.5.1 Rewriting CR010 during TM00 operation	244
6.5.2 Setting LVS00 and LVR00	244
6.6 Cautions for 16-Bit Timer/Event Counter 00.....	246
CHAPTER 7 8-BIT TIMER/EVENT COUNTERS 50, 51, AND 52.....	251
7.1 Functions of 8-Bit Timer/Event Counters 50, 51, and 52.....	251
7.2 Configuration of 8-Bit Timer/Event Counters 50, 51, and 52	251
7.3 Registers Controlling 8-Bit Timer/Event Counters 50, 51, and 52.....	255
7.4 Operations of 8-Bit Timer/Event Counters 50, 51, and 52.....	263
7.4.1 Operation as interval timer	263
7.4.2 Operation as external event counter	265
7.4.3 Square-wave output operation	266
7.4.4 PWM output operation	267
7.5 Cautions for 8-Bit Timer/Event Counters 50, 51, and 52	270

CHAPTER 8 8-BIT TIMERS H0, H1, AND H2.....	273
8.1 Functions of 8-Bit Timers H0, H1, and H2	273
8.2 Configuration of 8-Bit Timers H0, H1, and H2	273
8.3 Registers Controlling 8-Bit Timers H0, H1, and H2	278
8.4 Operation of 8-Bit Timers H0, H1 and H2.....	285
8.4.1 Operation as interval timer/square-wave output	285
8.4.2 Operation as PWM output.....	288
8.4.3 Carrier generator operation (8-bit timer H1 only)	294
8.4.4 Control of number of carrier clocks by timer 51 counter.....	301
CHAPTER 9 REAL-TIME COUNTER	302
9.1 Functions of Real-Time Counter.....	302
9.2 Configuration of Real-Time Counter	302
9.3 Registers Controlling Real-Time Counter	304
9.4 Real-Time Counter Operation	318
9.4.1 Starting operation of real-time counter.....	318
9.4.2 Shifting to STOP mode after starting operation	319
9.4.3 Reading/writing real-time counter	320
9.4.4 Setting alarm of real-time counter.....	322
9.4.5 1 Hz output of real-time counter.....	323
9.4.6 32.768 kHz output of real-time counter	323
9.4.7 512 Hz, 16.384 kHz output of real-time counter.....	324
9.4.8 Example of watch error correction of real-time counter.....	325
CHAPTER 10 WATCHDOG TIMER	330
10.1 Functions of Watchdog Timer	330
10.2 Configuration of Watchdog Timer	331
10.3 Register Controlling Watchdog Timer	332
10.4 Operation of Watchdog Timer.....	333
10.4.1 Controlling operation of watchdog timer.....	333
10.4.2 Setting overflow time of watchdog timer	334
10.4.3 Setting window open period of watchdog timer.....	335
CHAPTER 11 BUZZER OUTPUT CONTROLLER	337
11.1 Functions of Buzzer Output Controller.....	337
11.2 Configuration of Buzzer Output Controller	338
11.3 Registers Controlling Buzzer Output Controller.....	338
11.4 Operations of Buzzer Output Controller	339
CHAPTER 12 10-BIT SUCCESSIVE APPROXIMATION TYPE A/D CONVERTER (μPD78F045x and 78F046x only).....	340
12.1 Function of 10-Bit Successive Approximation Type A/D Converter.....	340
12.2 Configuration of 10-Bit Successive Approximation Type A/D Converter	341
12.3 Registers Used in 10-Bit Successive Approximation Type A/D Converter.....	343
12.4 10-Bit Successive Approximation Type A/D Converter Operations	351

12.4.1	Basic operations of A/D converter.....	351
12.4.2	Input voltage and conversion results.....	353
12.4.3	A/D converter operation mode	354
12.5	How to Read Successive Approximation Type A/D Converter Characteristics Table	356
12.6	Cautions for 10-bit successive approximation type A/D Converter.....	358
CHAPTER 13	16-BIT $\Delta\Sigma$ TYPE A/D CONVERTER (μPD78F046x only)	362
13.1	Function of 16-Bit $\Delta\Sigma$ Type A/D Converter.....	362
13.2	Configuration of 16-Bit $\Delta\Sigma$ Type A/D Converter	363
13.3	Registers Used in 16-Bit $\Delta\Sigma$ Type A/D Converter.....	365
13.4	Circuit Configuration Example of 16-Bit $\Delta\Sigma$ Type A/D Converter	375
13.5	16-Bit $\Delta\Sigma$ Type A/D Converter Operations	376
13.5.1	Basic operations of 16-bit $\Delta\Sigma$ type A/D converter.....	376
13.5.2	Operation mode of 16-bit $\Delta\Sigma$ type A/D converter.....	376
13.6	How to Read $\Delta\Sigma$ Type A/D Converter Characteristics Table.....	379
13.7	Cautions for 16-Bit $\Delta\Sigma$ Type A/D Converter	383
CHAPTER 14	SERIAL INTERFACE UART0	386
14.1	Functions of Serial Interface UART0.....	386
14.2	Configuration of Serial Interface UART0	387
14.3	Registers Controlling Serial Interface UART0.....	390
14.4	Operation of Serial Interface UART0	396
14.4.1	Operation stop mode.....	396
14.4.2	Asynchronous serial interface (UART) mode	397
14.4.3	Dedicated baud rate generator.....	403
14.4.4	Calculation of baud rate	404
CHAPTER 15	SERIAL INTERFACE UART6	408
15.1	Functions of Serial Interface UART6.....	408
15.2	Configuration of Serial Interface UART6	412
15.3	Registers Controlling Serial Interface UART6.....	415
15.4	Operation of Serial Interface UART6	426
15.4.1	Operation stop mode.....	426
15.4.2	Asynchronous serial interface (UART) mode	427
15.4.3	Dedicated baud rate generator.....	441
15.4.4	Calculation of baud rate	443
CHAPTER 16	SERIAL INTERFACE CSI10	449
16.1	Functions of Serial Interface CSI10.....	449
16.2	Configuration of Serial Interface CSI10	449
16.3	Registers Controlling Serial Interface CSI10.....	451
16.4	Operation of Serial Interface CSI10	455
16.4.1	Operation stop mode.....	455
16.4.2	3-wire serial I/O mode	455

CHAPTER 17 LCD CONTROLLER/DRIVER.....	465
17.1 Functions of LCD Controller/Driver	465
17.2 Configuration of LCD Controller/Driver	467
17.3 Registers Controlling LCD Controller/Driver	469
17.4 Setting LCD Controller/Driver	477
17.4.1 Setting method when not using segment key scan function (KSON = 0).....	477
17.4.2 Setting method when using segment key scan function (KSON = 1).....	478
17.5 LCD Display Data Memory	480
17.6 Common and Segment Signals	481
17.7 Display Modes	491
17.7.1 Static display example	491
17.7.2 Two-time-slice display example	494
17.7.3 Three-time-slice display example.....	499
17.7.4 Four-time-slice display example	507
17.7.5 Eight-time-slice display example.....	512
17.8 Operation of Segment Key Scan Function	517
17.8.1 Circuit configuration example.....	517
17.8.2 Example of procedure for using segment key scan function.....	518
17.9 Cautions When Using Segment Key Scan Function	521
17.10 Supplying LCD Drive Voltages V_{LC0}, V_{LC1}, V_{LC2}, and V_{LC3}	523
17.10.1 Internal resistance division method.....	523
17.10.2 External resistance division method.....	525
CHAPTER 18 MANCHESTER CODE GENERATOR.....	527
18.1 Functions of Manchester Code Generator	527
18.2 Configuration of Manchester Code Generator.....	527
18.3 Registers Controlling Manchester Code Generator	530
18.4 Operation of Manchester Code Generator	533
18.4.1 Operation stop mode	533
18.4.2 Manchester code generator mode	534
18.4.3 Bit sequential buffer mode	543
CHAPTER 19 REMOTE CONTROLLER RECEIVER.....	552
19.1 Remote Controller Receiver Functions	552
19.2 Remote Controller Receiver Configuration.....	552
19.3 Registers to Control Remote Controller Receiver	560
19.4 Operation of Remote Controller Receiver	563
19.4.1 Format of type A reception mode.....	563
19.4.2 Operation flow of type A reception mode	563
19.4.3 Format of type B reception mode.....	565
19.4.4 Operation flow of type B reception mode	565
19.4.5 Format of type C reception mode.....	567
19.4.6 Operation flow of type C reception mode.....	567
19.4.7 Timing	569
19.4.8 Compare register setting.....	573
19.4.9 Error interrupt generation timing	575
19.4.10 Noise elimination.....	581

CHAPTER 20 INTERRUPT FUNCTIONS	584
20.1 Interrupt Function Types	584
20.2 Interrupt Sources and Configuration	584
20.3 Registers Controlling Interrupt Functions.....	589
20.4 Interrupt Servicing Operations	597
20.4.1 Maskable interrupt acknowledgment.....	597
20.4.2 Software interrupt request acknowledgment	599
20.4.3 Multiple interrupt servicing	600
20.4.4 Interrupt request hold	603
 CHAPTER 21 KEY INTERRUPT FUNCTION	 604
21.1 Functions of Key Interrupt	604
21.2 Configuration of Key Interrupt	604
21.3 Register Controlling Key Interrupt	605
 CHAPTER 22 STANDBY FUNCTION	 606
22.1 Standby Function and Configuration	606
22.1.1 Standby function	606
22.1.2 Registers controlling standby function.....	607
22.2 Standby Function Operation	609
22.2.1 HALT mode	609
22.2.2 STOP mode	614
 CHAPTER 23 RESET FUNCTION.....	 620
23.1 Register for Confirming Reset Source	629
 CHAPTER 24 POWER-ON-CLEAR CIRCUIT.....	 630
24.1 Functions of Power-on-Clear Circuit.....	630
24.2 Configuration of Power-on-Clear Circuit	631
24.3 Operation of Power-on-Clear Circuit.....	631
24.4 Cautions for Power-on-Clear Circuit	634
 CHAPTER 25 LOW-VOLTAGE DETECTOR	 636
25.1 Functions of Low-Voltage Detector.....	636
25.2 Configuration of Low-Voltage Detector	637
25.3 Registers Controlling Low-Voltage Detector.....	637
25.4 Operation of Low-Voltage Detector	640
25.4.1 When used as reset	641
25.4.2 When used as interrupt	646
25.5 Cautions for Low-Voltage Detector	651
 CHAPTER 26 OPTION BYTE.....	 654
26.1 Functions of Option Bytes	654
26.2 Format of Option Byte	656

CHAPTER 27 FLASH MEMORY	659
27.1 Internal Memory Size Switching Register	659
27.2 Internal Expansion RAM Size Switching Register	660
27.3 Writing with Flash memory programmer	661
27.4 Programming Environment	664
27.5 Communication Mode	664
27.6 Connection of Pins on Board	666
27.6.1 FLMD0 pin	666
27.6.2 Serial interface pins	666
27.6.3 RESET pin	668
27.6.4 Port pins.....	668
27.6.5 REGC pin.....	668
27.6.6 Other signal pins.....	668
27.6.7 Power supply	668
27.7 Programming Method	669
27.7.1 Controlling flash memory	669
27.7.2 Flash memory programming mode	669
27.7.3 Selecting communication mode	670
27.7.4 Communication commands	671
27.8 Security Settings	672
27.9 Processing Time for Each Command When PG-FP5 Is Used (Reference)	674
27.10 Flash Memory Programming by Self-Programming	677
27.10.1 Boot swap function.....	685
CHAPTER 28 ON-CHIP DEBUG FUNCTION	687
28.1 Connecting QB-MINI2 to 78K0/LE3	687
28.2 Reserved Area Used by QB-MINI2	688
CHAPTER 29 INSTRUCTION SET	689
29.1 Conventions Used in Operation List	689
29.1.1 Operand identifiers and specification methods	689
29.1.2 Description of operation column	690
29.1.3 Description of flag operation column.....	690
29.2 Operation List	691
29.3 Instructions Listed by Addressing Type	699
CHAPTER 30 ELECTRICAL SPECIFICATIONS (STANDARD PRODUCTS)	702
CHAPTER 31 PACKAGE DRAWINGS	724
CHAPTER 32 RECOMMENDED SOLDERING CONDITIONS	726
CHAPTER 33 CAUTIONS FOR WAIT	727
33.1 Cautions for Wait	727
33.2 Peripheral Hardware That Generates Wait	728

APPENDIX A DEVELOPMENT TOOLS	729
A.1 Software Package	732
A.2 Language Processing Software	732
A.3 Control Software	733
A.4 Flash Memory Writing Tools	734
A.4.1 When using flash memory programmer PG-FP5 and FL-PR5.....	734
A.4.2 When using on-chip debug emulator with programming function QB-MINI2	734
A.5 Debugging Tools (Hardware)	735
A.5.1 When using in-circuit emulator QB-78K0LX3.....	735
A.5.2 When using on-chip debug emulator with programming function QB-MINI2	736
A.6 Debugging Tools (Software)	736
 APPENDIX B REVISION HISTORY	 737
B.1 Major Revisions in This Edition	737

CHAPTER 1 OUTLINE

1.1 Features

- Minimum instruction execution time can be changed from high speed (0.2 μ s: @ 10 MHz operation with high-speed system clock) to ultra low-speed (122 μ s: @ 32.768 kHz operation with subsystem clock)
- General-purpose register: 8 bits \times 32 registers (8 bits \times 8 registers \times 4 banks)
- ROM, RAM capacities

Part Number	Item	Program Memory (ROM)		Data Memory		
				Internal High-Speed RAM ^{Note 1}	Internal Expansion RAM ^{Note 1}	LCD Display RAM
μ PD78F0441, 78F0451, 78F0461	Flash memory ^{Note 1}	16 KB	768 bytes	-	< μ PD78F044x, 78F045x> 32 \times 4 bits (28 \times 8 bits) [28 \times 4 bits (24 \times 8 bits)] ^{Note 2}	
μ PD78F0442, 78F0452, 78F0462		24 KB	1 KB			
μ PD78F0443, 78F0453, 78F0463		32 KB		1 KB		
μ PD78F0444, 78F0454, 78F0464		48 KB				
μ PD78F0445, 78F0455, 78F0465		60 KB	< μ PD78F046x> 24 \times 4 bits (20 \times 8 bits) [20 \times 4 bits (16 \times 8 bits)] ^{Note 2}			

Notes 1. The internal flash memory, internal high-speed RAM capacities, and internal expansion RAM capacities can be changed using the internal memory size switching register (IMS) and the internal expansion RAM size switching register (IXS).

2. The items in parentheses are applicable when 8com is used.

The items in square brackets are applicable when using the UART6 pins (RxD6, TxD6) on the bottom side.

<R>

- On-chip single-power-supply flash memory
- Self-programming (with boot swap function)
- On-chip debug function
- On-chip power-on-clear (POC) circuit and low-voltage detector (LVI)
- On-chip watchdog timer (operable with internal low-speed oscillation clock)
- LCD controller/driver (external resistance division and internal resistance division are switchable)

μ PD78F044x: Segment signals: 28, Common signals: 8 (1/4 bias)

: Segment signals: 32, Common signals: 4 (1/3 bias)

: Segment signals: 32, Common signals: 3 (1/3, 1/2 bias)

: Segment signals: 32, Common signals: 2 (1/2 bias)

: Segment signals: 32, Common signals: 1 (Static)

μ PD78F045x: Segment signals: 28, Common signals: 8 (1/4 bias)

: Segment signals: 32, Common signals: 4 (1/3 bias)

: Segment signals: 32, Common signals: 3 (1/3, 1/2 bias)

: Segment signals: 32, Common signals: 2 (1/2 bias)

: Segment signals: 32, Common signals: 1 (Static)

μ PD78F046x: Segment signals: 20, Common signals: 8 (1/4 bias)

: Segment signals: 24, Common signals: 4 (1/3 bias)

: Segment signals: 24, Common signals: 3 (1/3, 1/2 bias)

: Segment signals: 24, Common signals: 2 (1/2 bias)

: Segment signals: 24, Common signals: 1 (Static)

- <R>
- On-chip segment key scan function: 8 channels
 - On-chip key interrupt function: 5 channels
 - On-chip buzzer output controller
 - I/O ports: 46
 - Timer: 9 channels
 - 16-bit timer/event counter: 1 channel
 - 8-bit timer/event counter: 3 channels
 - 8-bit timer: 3 channels
 - Real-time counter (RTC): 1 channel
 - Watchdog timer: 1 channel
 - Serial interface: 2 channels
 - UART (LIN (Local Interconnect Network)-bus supported): 1 channel
 - CSI/UART^{Note}: 1 channel

Note Select either of the functions of these alternate-function pins.

- 16-bit $\Delta\Sigma$ type A/D converter^{Note}: 3 channels (μ PD78F046x only)
- 10-bit successive approximation type A/D converter: 8 channels (μ PD78F045x and 78F046x only)
- Remote controller receiver
- Manchester code generator
- Power supply voltage: $V_{DD} = 1.8$ to 5.5 V
- Operating ambient temperature: $T_A = -40$ to $+85^\circ\text{C}$

Note The specifications of the 16-bit $\Delta\Sigma$ A/D converter may have been changed.

For details of the specifications, contact an NEC Electronics sales representative or authorized dealer.

1.2 Applications

Digital cameras, AV equipments, household electrical appliances, utility meters, health care equipments, and measurement equipment, etc.

1.3 Ordering Information

- Flash memory version (Lead-free products)

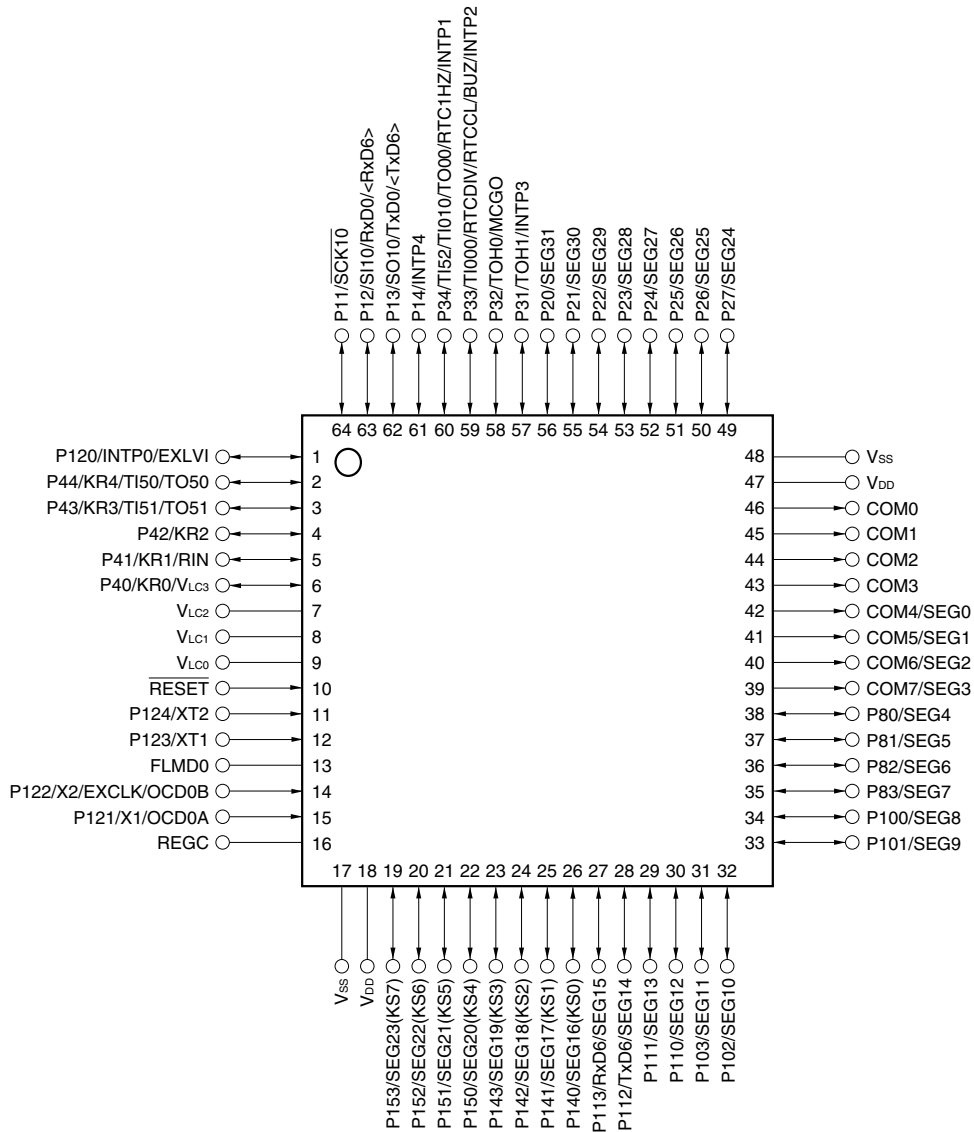
Part Number	Package
μ PD78F0441GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0442GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0443GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0444GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0445GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0441GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0442GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0443GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0444GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0445GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0451GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0452GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0453GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0454GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0455GB-GAH-AX	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0451GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0452GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0453GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0454GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0455GK-GAJ-AX	64-pin plastic LQFP (12 × 12)
μ PD78F0461GB-GAH-AX ^{Note}	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0462GB-GAH-AX ^{Note}	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0463GB-GAH-AX ^{Note}	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0464GB-GAH-AX ^{Note}	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0465GB-GAH-AX ^{Note}	64-pin plastic LQFP (fine pitch) (10 × 10)
μ PD78F0461GK-GAJ-AX ^{Note}	64-pin plastic LQFP (12 × 12)
μ PD78F0462GK-GAJ-AX ^{Note}	64-pin plastic LQFP (12 × 12)
μ PD78F0463GK-GAJ-AX ^{Note}	64-pin plastic LQFP (12 × 12)
μ PD78F0464GK-GAJ-AX ^{Note}	64-pin plastic LQFP (12 × 12)
μ PD78F0465GK-GAJ-AX ^{Note}	64-pin plastic LQFP (12 × 12)

Note Under development

1.4 Pin Configuration (Top View)

(1) μ PD78F0441, 78F0442, 78F0443, 78F0444, 78F0445

- 64-pin plastic LQFP (fine pitch) (10 × 10)
- 64-pin plastic LQFP (12 × 12)



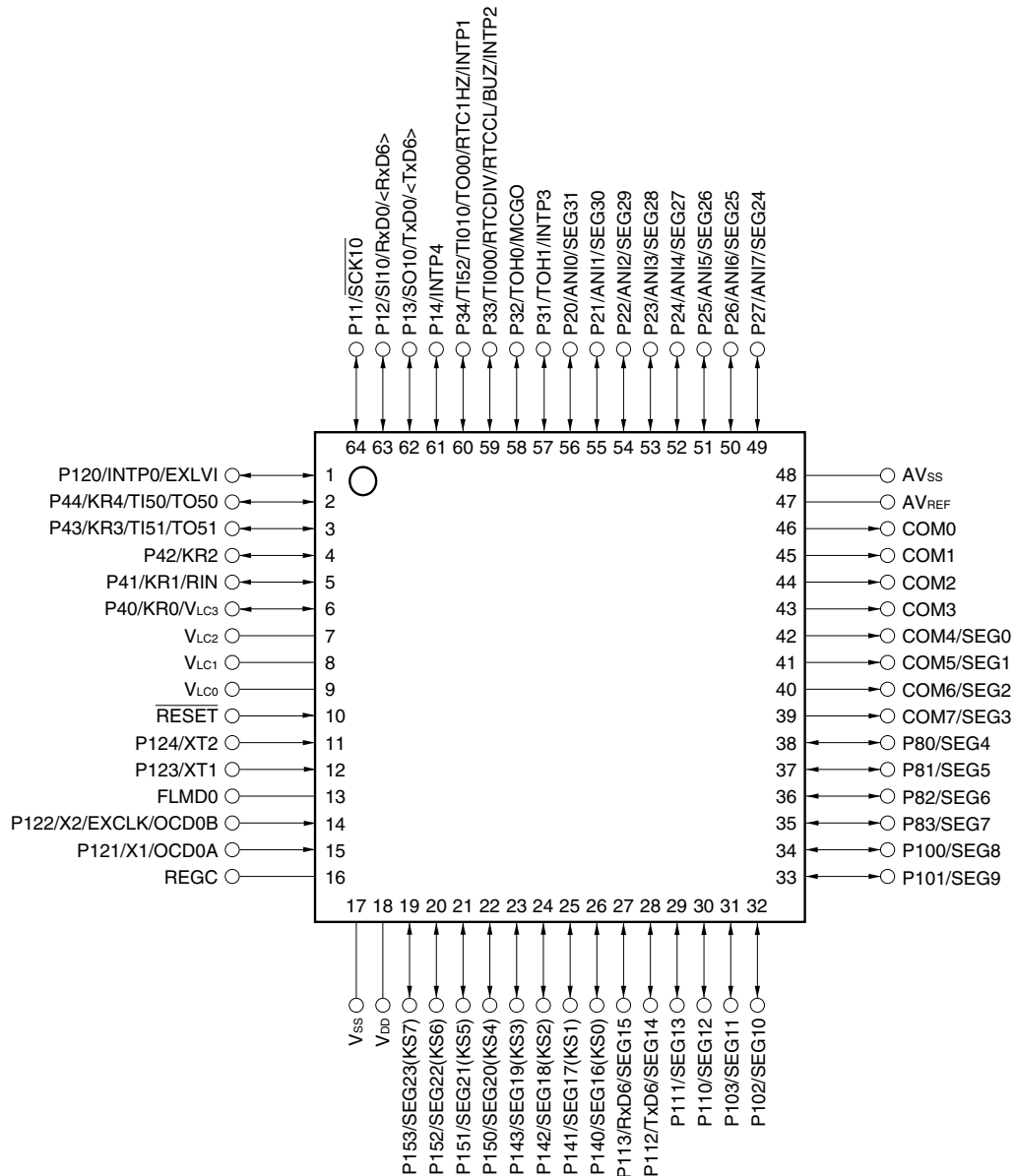
- Cautions**
1. Connect the REGC pin to V_{SS} via a capacitor (0.47 to 1 μ F: recommended).
 2. Only the bottom side pins (pin numbers 27 and 28) correspond to the UART6 pins (RxD6 and TxD6) when writing by a flash memory programmer. Writing cannot be performed by the top side pins (pin numbers 63 and 62).
 3. Make V_{DD} (pin number 18) and V_{DD} (pin number 47), V_{SS} (pin number 17) and V_{SS} (pin number 48) the same potential.

- Remarks**
1. The functions within arrowheads (< >) can be assigned by setting the input switch control register (ISC).
 2. The functions within parentheses can be used by setting the LCD mode register (LCDMD).

<R>

(2) μ PD78F0451, 78F0452, 78F0453, 78F0454, 78F0455

- 64-pin plastic LQFP (fine pitch) (10 × 10)
- 64-pin plastic LQFP (12 × 12)



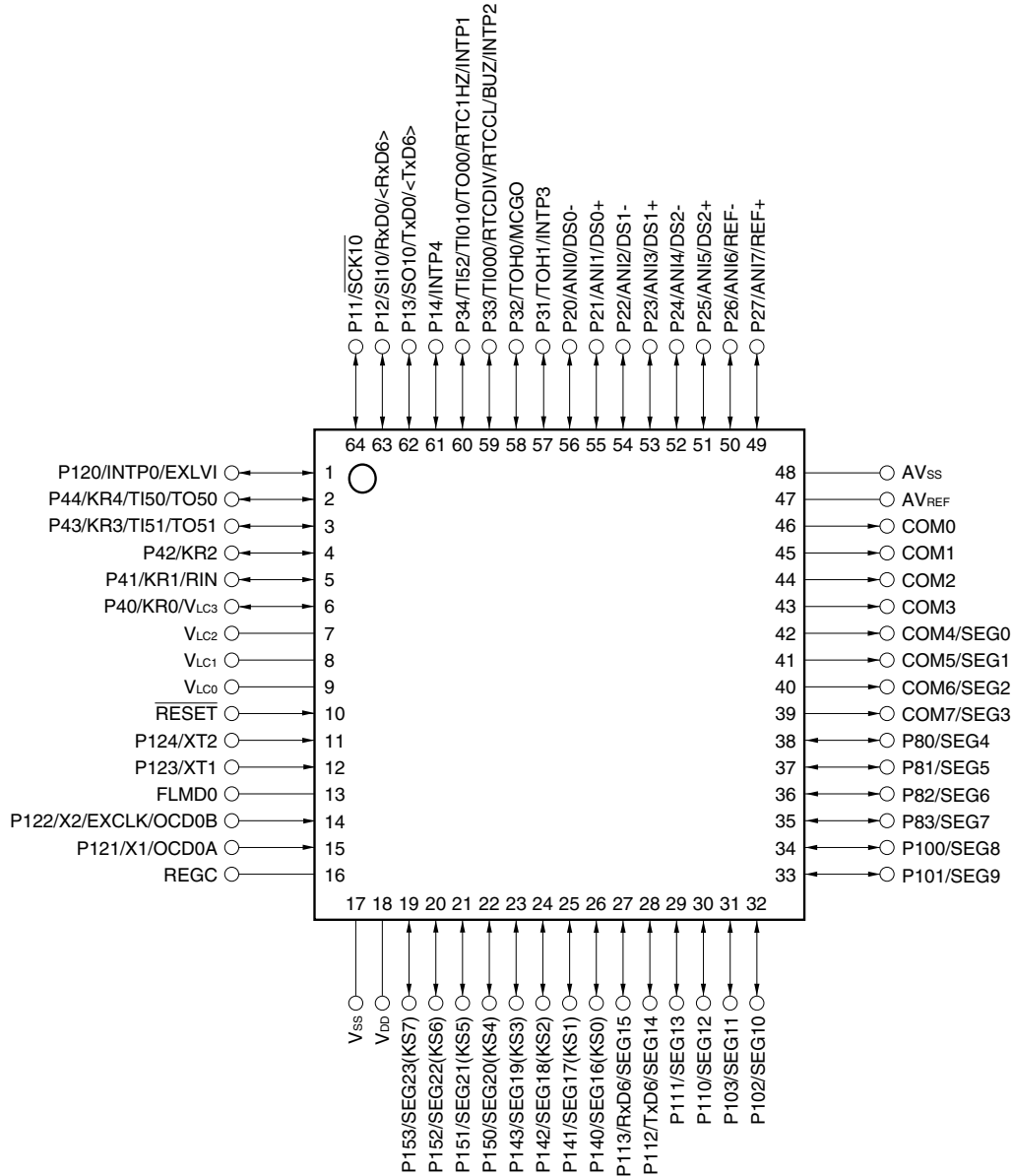
- Cautions**
1. Connect the AV_{ss} pin to V_{ss}.
 2. Connect the REGC pin to V_{ss} via a capacitor (0.47 to 1 μ F: recommended).
 3. ANI0/P20 to ANI7/P27 are set in the analog input mode after release of reset.
 4. Only the bottom side pins (pin numbers 27 and 28) correspond to the UART6 pins (RxD6 and TxD6) when writing by a flash memory programmer. Writing cannot be performed by the top side pins (pin numbers 63 and 62).

- Remarks**
1. The functions within arrowheads (< >) can be assigned by setting the input switch control register (ISC).
 2. The functions within parentheses can be used by setting the LCD mode register (LCDMD).

<R>

(3) μ PD78F0461, 78F0462, 78F0463, 78F0464, 78F0465

- 64-pin plastic LQFP (fine pitch) (10 × 10)
- 64-pin plastic LQFP (12 × 12)



- Cautions**
1. Connect the AV_{ss} pin to V_{ss}.
 2. Connect the REGC pin to V_{ss} via a capacitor (0.47 to 1 μ F: recommended).
 3. ANI0/P20 to ANI7/P27 are set in the analog input mode after release of reset.
 4. Only the bottom side pins (pin numbers 27 and 28) correspond to the UART6 pins (RxD6 and TxD6) when writing by a flash memory programmer. Writing cannot be performed by the top side pins (pin numbers 63 and 62).

- Remarks**
1. The functions within arrowheads (< >) can be assigned by setting the input switch control register (ISC).
 2. The functions within parentheses can be used by setting the LCD mode register (LCDMD).

<R>

Pin Identification

ANI0 to ANI7 ^{Note 1} :	Analog input	REF+ ^{Note 2} :	$\Delta\Sigma$ Analog reference voltage (+)
AV _{REF} ^{Note 1} :	Analog reference voltage	REF- ^{Note 2} :	$\Delta\Sigma$ Analog reference voltage (-)
AV _{SS} ^{Note 1} :	Analog ground	RIN:	Remote control input
BUZ:	Buzzer output	RTC1HZ:	Real-time counter correction clock (1 Hz) output
COM0 to COM7:	Common output	RTCCL:	Real-time counter clock (32.768 kHz original oscillation) output
DS0+ to DS2+ ^{Note 2} :	$\Delta\Sigma$ Analog input (+)	RTCDIV:	Real-time counter clock (32.768 kHz divided frequency) output
DS0- to DS2- ^{Note 2} :	$\Delta\Sigma$ Analog input (-)	SEG0 to SEG23:	Segment output
EXCLK:	External clock input (main system clock)	SEG24 to SEG31 ^{Note 3} :	Segment output
EXLVI:	External potential input for low-voltage detector	SEG16 (KS0) to SEG23 (KS7):	Segment key scan
FLMD0:	Flash programming mode	SCK10:	Serial clock input/output
INTP0 to INTP4:	External interrupt input	SI10:	Serial data input
KR0 to KR4:	Key return	SO10:	Serial data output
MCGO:	Manchester code generator output	TI000, TI010:	Timer input
OCD0A, OCD0B:	On chip debug input/output	TI50, TI51, TI52:	Timer input
P11 to P14:	Port 1	TO00:	Timer output
P20 to P27:	Port 2	TO50, TO51:	Timer output
P31 to P34:	Port 3	TOH0, TOH1:	Timer output
P40 to P44:	Port 4	TxD0, TxD6:	Transmit data
P80 to P83:	Port 8	V _{DD} :	Power supply
P100 to P103:	Port 10	V _{SS} :	Ground
P110 to P113:	Port 11	V _{LC0} to V _{LC3} :	LCD power supply
P120 to P124:	Port 12	X1, X2:	Crystal oscillator (main system clock)
P140 to P143:	Port 14	XT1, XT2:	Crystal oscillator (subsystem clock)
P150 to P153:	Port 15		
REGC	Regulator capacitance		
RESET:	Reset		
RxD0, RxD6:	Receive data		

Notes 1. μ PD78F045x and 78F046x only.

2. μ PD78F046x only.

3. μ PD78F044x and 78F045x only.