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# **ePS5002**

**RISC II Series  
Microcontroller**

# **Product Specification**

**DOC. VERSION 1.1**

**ELAN MICROELECTRONICS CORP.**

May 2014

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### Specification Revision History

| Doc. Version | Revision Description                                                                                                                                                              | Date       |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 0.1          | Initial version                                                                                                                                                                   | 2007/08/29 |
| 0.2          | 1. Added a Note in Section 6 <i>Code Option</i> .<br>2. Modified the max. supply voltage in Section 9.<br>3. Modified the supply current in Section 9                             | 2008/10/21 |
| 0.3          | 1. Added the High-frequency 150kHz in Section 2 and Section 9.                                                                                                                    | 2009/04/28 |
| 1.0          | 1. Modified the pin description of the OSCI pin in Section 5.1.<br>2. Deleted the VDD=3.0V Electrical Characteristics entries.<br>3. Modified the Operating voltage to 1.5V only. | 2010/11/03 |
| 1.1          | 1. Added a Note for the special register "LCDARL" in Section 1.<br>2. Modified the Electrical Characteristics.                                                                    | 2014/05/13 |

## 1 General Description

The **ePS5002** is an 8-bit RISC MCU embedded with a 5×40 LCD driver along with two 8-bit timers, one 16-bit general timer, and a Watchdog Timer. It has also an on-chip 512 bytes RAM and 4K words program ROM. It is highly ideal for advance scientific calculator application, particularly those requiring high performance and low cost solution.

The MCU core is one of ELAN's second generation RISC based IC's, known as RISC II (RII) series. The core is specifically designed for low power and portable device applications. The ePS5002 also supports Fast, Slow and Idle modes, as well as Sleep mode to enhance its low power consumption features.

### IMPORTANT NOTES

- Do not use Register BSR (05h) Bit 7 ~ Bit 2.
- Do not use Register BSR1 (07h) Bit 7 ~ Bit 2.
- Check the range of BSR and BSR1, which should be from 0x00~0x03.
- Do not use LCD RAM 28h ~ FFh.
- Do not use JDNZ at FSR1 (04h) special register.
- Do not use JDNZ at LCDARL (09h) special register.
- Do not to use PUSH, POP by "MOV A,r" to avoid affecting S\_Z.

## 2 Features

### MCU

- 8 bit RISC MCU
- Operating voltage: 1.2V~1.8V
- Clock Source: Dual system clock
  - Low-frequency: 32kHz Internal RC oscillator / Crystal oscillator
  - High-frequency: 150kHz / 200kHz / 300kHz / 500kHz External RC oscillator
- One Instruction cycle time = 2 × System clock time
- Program ROM addressing: Maximum 4K words
- 128 bytes un-banked RAM including special registers and common registers
- 4×128 bytes banked RAM
- Max. of 32-level RAM stack
- Lookup Table function is fast and highly efficient when combined with Repeat instruction

- Register-to-Register move instruction
- Compare and Branch in one instruction (2 cycles)
- Single Repeat function (256 repeat times max.)
- Decimal ADD and SUB instruction
- Full range Call and Jump ability (2 cycles)

### **Peripheral**

- 4 input pins (Port A.0~3) and 12 general I/O pins (Port A.4~7, Port B.0~7)
- 5/4/3 COM × 40 SEG LCD driver (embedded)
- One 16-bit timer (Timer 0) with event counter function
- One 8-bit timer (Timer 1) with wake-up function
- One 8-bit timer (Timer 2)
- One 8-bit Watchdog Timer
- Key I/O function with a maximum of 48 keys (Key matrix: Port A.0~2 and SEG0~15 with automatic key scan)

### **Internal Specification**

- Watchdog Timer with its own on-chip RC oscillator
- MCU operating modes: Sleep Mode, Idle Mode, Slow Mode, and Fast Mode
- Supports RC and Crystal oscillation for system clock
- MCU wake-up function consists of input wake up and Timer 1 wake up
- MCU interrupt function consist of Input port interrupt and Timer interrupt (Timers 0 ~ 2)
- MCU reset function includes power-on reset, RSTB pin reset, and Watchdog timer reset

### 3 Block Diagram

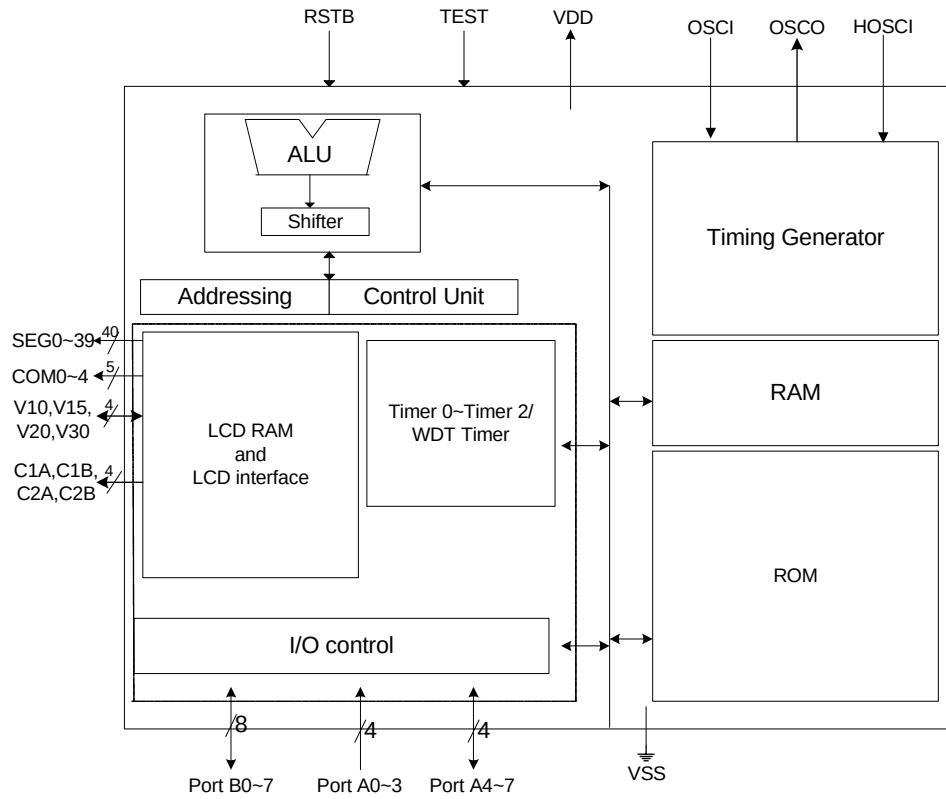


Figure 3-1 ePS5002 Block Diagram

## 4 Pin Assignment

### ■ 68-pin Chip form

| No. | Pin Name       | No. | Pin Name       | No. | Pin Name             | No. | Pin Name |
|-----|----------------|-----|----------------|-----|----------------------|-----|----------|
| 1   | NC             | 26  | NC             | 51  | NC                   | 76  | NC       |
| 2   | NC             | 27  | NC             | 52  | NC                   | 77  | NC       |
| 3   | NC             | 28  | NC             | 53  | NC                   | 78  | NC       |
| 4   | NC             | 29  | NC             | 54  | NC                   | 79  | NC       |
| 5   | NC             | 30  | NC             | 55  | NC                   | 80  | NC       |
| 6   | NC             | 31  | NC             | 56  | NC                   | 81  | NC       |
| 7   | COM4           | 32  | NC             | 57  | SEG29                | 82  | C1A      |
| 8   | COM3           | 33  | SEG12/Strobe12 | 58  | SEG30                | 83  | C1B      |
| 9   | COM2           | 34  | SEG13/Strobe13 | 59  | SEG31                | 84  | C2A      |
| 10  | COM1           | 35  | SEG14/Strobe14 | 60  | PortA.7              | 85  | C2B      |
| 11  | COM0           | 36  | SEG15/Strobe15 | 61  | PortA.6              | 86  | V20      |
| 12  | SEG0/Strobe0   | 37  | SEG16          | 62  | PortA.5              | 87  | V15      |
| 13  | SEG1/Strobe1   | 38  | SEG17          | 63  | PortA.4              | 88  | V10      |
| 14  | SEG2/Strobe2   | 39  | SEG18          | 64  | VSS                  | 89  | PortA.0  |
| 15  | SEG3/Strobe3   | 40  | SEG19          | 65  | SEG32/PortB.0        | 90  | PortA.1  |
| 16  | SEG4/Strobe4   | 41  | SEG20          | 66  | SEG33/PortB.1        | 91  | PortA.2  |
| 17  | SEG5/Strobe5   | 42  | SEG21          | 67  | SEG34/PortB.2        | 92  | PortA.3  |
| 18  | SEG6/Strobe6   | 43  | SEG22          | 68  | SEG35/PortB.3        | 93  | TEST     |
| 19  | SEG7/Strobe7   | 44  | SEG23          | 69  | SEG36/PortB.4        | 94  | RESETB   |
| 20  | SEG8/Strobe8   | 45  | SEG24          | 70  | SEG37/PortB.5        | 95  | OSCO     |
| 21  | SEG9/Strobe9   | 46  | SEG25          | 71  | SEG38/PortB.6        | 96  | OSCI     |
| 22  | SEG10/Strobe10 | 47  | SEG26          | 72  | SEG39/PortB.7 (EVIN) | 97  | HOSCI    |
| 23  | SEG11/Strobe11 | 48  | SEG27          | 73  | V30                  | 98  | VDD      |
| 24  | NC             | 49  | SEG28          | 74  | NC                   | 99  | NC       |
| 25  | NC             | 50  | NC             | 75  | NC                   | 100 | NC       |



## 5 Pin Description

### 5.1 MCU System Pins (7 Pins)

| Name  | I/O/P Type | Description                                                                                                            | Note           |
|-------|------------|------------------------------------------------------------------------------------------------------------------------|----------------|
| VDD   | P          | Digital and Analog positive power supply, ranging from 1.2V~1.8V. Connect to VSS through the capacitors (0.1 $\mu$ F). | –              |
| VSS   | P          | Digital and Analog negative power supply.                                                                              | –              |
| RSTB  | I          | System reset pin. Low active. Connect 0.1 $\mu$ F to VSS.                                                              | Int. pull-up   |
| TEST  | I          | Test mode select pin (High active). For chip internal test only. Normally connect to VSS.                              | Int. Pull Down |
| OSCI  | I          | Crystal oscillator connecting pin                                                                                      | –              |
| OSCO  | O          | Crystal oscillator connecting pin                                                                                      | –              |
| HOSCI | I          | Hi-Speed RC oscillator connecting pin                                                                                  | Ext. R to VDD  |

### 5.2 Embedded LCD Pins (53 Pins)

| Name                     | I/O/P Type | Description                                                           | Note |
|--------------------------|------------|-----------------------------------------------------------------------|------|
| COM0~COM4                | O          | LCD common signal output pin                                          | –    |
| SEG0~SEG15               | O          | LCD segment signal output pin shared with Key Strobe 0~15             | –    |
| SEG16~ SEG31             | O          | LCD segment signal output pin                                         | –    |
| SEG32~SEG39 / Port B.0~7 | I/O        | LCD segment signal output pin or I/O pin; defined by code option      | –    |
| C1A, C1B                 | –          | LCD voltage charge-pump pin. Connect 0.1 $\mu$ F between C1A and C1B. | –    |
| C2A, C2B                 | –          | LCD voltage charge-pump pin. Connect 0.1 $\mu$ F between C2A and C2B. | –    |
| V30, V20, V15, V10       | O          | LCD bias Pin. Connect 0.1 $\mu$ F to Vss                              | –    |

### 5.3 I/O Port (8 Pins)

| Port   | Bit                     | Function              | I/O Type | Power Source | Description                          | Note                                                               |
|--------|-------------------------|-----------------------|----------|--------------|--------------------------------------|--------------------------------------------------------------------|
| Port A | Bits 2~0 (for key scan) | General Input         | I        | VDD          | Key input                            | Int. Pull-up (R1: small resistor, R2: Large controllable resistor) |
|        |                         | Interrupt and wake up | I        | VDD          | Input port interrupt and wake-up pin |                                                                    |
|        | Bit 3                   | General Input         | I        | VDD          | –                                    |                                                                    |
|        |                         | Interrupt and wake up | I        | VDD          | Input port interrupt and wake-up pin |                                                                    |
|        | Bits 7~4                | General Input         | I        | VDD          | –                                    | Int. Pull-up (R2: Large controllable resistor)                     |
|        |                         | Interrupt and wake up | I        | VDD          | Input port interrupt and wake-up pin |                                                                    |
|        |                         | General Output        | O        | VDD          |                                      |                                                                    |

## 6 Code Option

Located at Address 0x000C~0x000F of Program ROM

- Initial mode after reset:
  - Select “Slow” mode or “Fast” mode

### NOTE

*For Initial mode after reset, it is recommended that user set it to “Slow mode”.*

- Operating voltage option: 1.5V only
- Low Frequency Oscillator:
  - Select “Crystal” oscillator or “Internal RC” oscillator
- Reset pin condition:
  - Select “Level hold” or “One short” for reset pin
- Maximum duty ratio and LCD bias option:
  - Select “1/5 duty and 1/3 bias” or “1/4 duty and 1/3 bias” or “1/3 duty and 1/2 bias”
- Port B low nibble control bit (SEG32~SEG35):
  - Select “LCD segment signal output” or “general I/O functions”
- Port B high nibble control bit (SEG36~SEG39):
  - Select “LCD segment signal output” or “general I/O functions”
- Key matrix combination:
  - Select “Port A and SEG” or “Port A and Port B”

## 7 MCU System

### 7.1 Power-up and Reset Timing

- Power-on Reset Timing

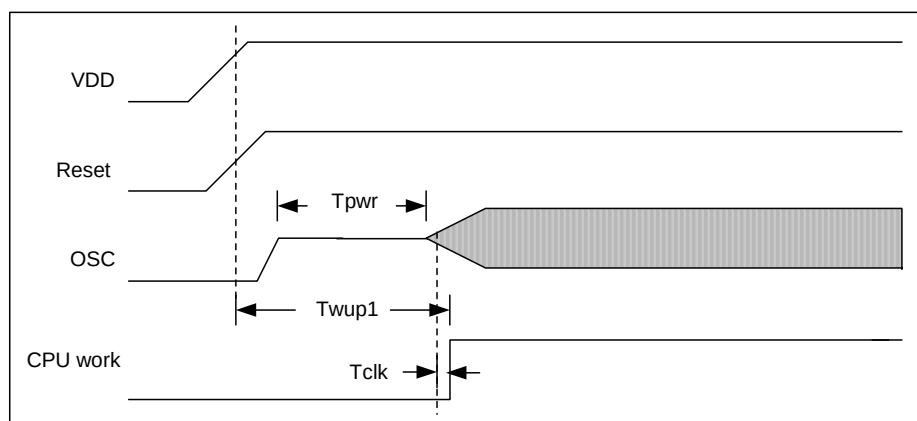


Figure 7-1 Power-on Reset Timing Diagram

### ■ Sleep Mode Wake-up Timing

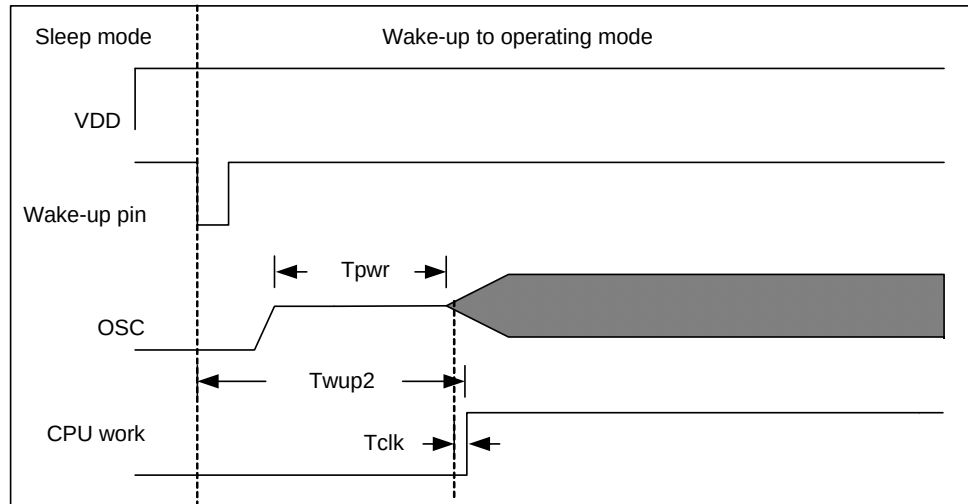


Figure 7-2 Sleep Mode Wake-up Timing Diagram

Condition: Vdd = 1.5V, Cosc = 20pF and Ta = 25°C

| Symbol | Characteristics                       | Min. | Typ. | Max. | Unit |
|--------|---------------------------------------|------|------|------|------|
| Tpw    | Oscillator start up time              | -    | 480  | 780  | ms   |
| Twup1  | CPU warm up time (Power-on reset)     | -    | 500  | 800  | ms   |
| Twup2  | CPU warm up time (Sleep mode wake-up) | -    | 485  | 785  | ms   |
| Tclk   | Detect slow clock time                | -    | 1.0  | 1.1  | ms   |

## 7.2 MCU Operation Timing

### ■ Slow Mode to Fast Mode Timing:

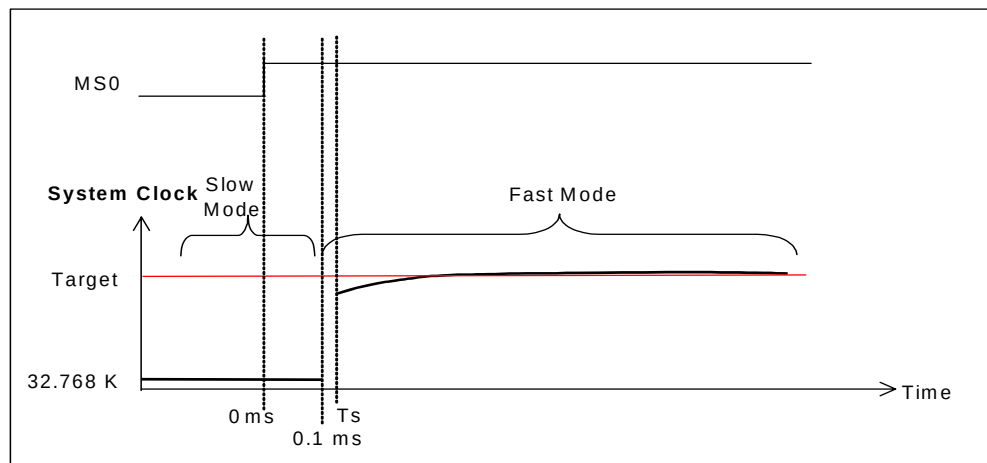


Figure 7-3 Slow Mode to Fast Mode Timing Diagram

- Note:**
1. Slow Mode switches to Fast Mode at Time = 0 ms.
  2. System clock will switch to Fast Mode after a delay of 0.1ms by oscillator and enters into Fast Mode (i.e., system clock will be at 200, 300, or 500kHz).
  3. High frequency RC will be stabilized at Time=Ts (15 μs~30 μs).

## 8 ROM and RAM

### 8.1 Program ROM Map

| ROM Size = 4K Words |                                |
|---------------------|--------------------------------|
| Address             | Description                    |
| 0000h<br> <br>000Bh | Interrupt Vector<br>(12 words) |
| 000Ch<br> <br>000Fh | Code Option<br>(4 words)       |
| 0010h<br> <br>001Fh | Test Program<br>(16 words)     |
| 0020h<br> <br>0FFFh | Program or Fixed data region   |

### 8.2 RAM Map

RAM Size: 86 Bytes + 4 Banks × 128 Bytes = 598 Bytes

#### 8.2.1 Un-banked RAM

| Address         | Unbanked            |
|-----------------|---------------------|
| 00h<br> <br>12h | Special Registers   |
| 13h<br> <br>1Fh | General Purpose RAM |
| 20h<br> <br>36h | Control Registers   |
| 37h<br> <br>7Fh | General Purpose RAM |

#### 8.2.2 Banked General RAM

| Address         | Bank 0                    | Bank 1                    | Bank 2                    | Bank 3                    |
|-----------------|---------------------------|---------------------------|---------------------------|---------------------------|
| 80h<br> <br>FFh | General<br>Purpose<br>RAM | General<br>Purpose<br>RAM | General<br>Purpose<br>RAM | General<br>Purpose<br>RAM |

## 8.3 LCD RAM Map

### ■ 1/5 Duty

| RAM Address |     | COM0  | COM1  | COM2  | COM3  | COM4  | -     | -     | -     |
|-------------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| LCDARL      |     | Bit 0 | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 |
| SEG0        | 00H |       |       |       |       |       |       |       |       |
| :           | :   |       |       |       |       |       |       |       |       |
| SEG39       | 27H |       |       |       |       |       |       |       |       |

### ■ 1/4 Duty

| RAM Address |     | COM0  | COM1  | COM2  | COM3  | -     | -     | -     | -     |
|-------------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| LCDARL      |     | Bit 0 | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 |
| SEG0        | 00H |       |       |       |       |       |       |       |       |
| :           | :   |       |       |       |       |       |       |       |       |
| SEG39       | 27H |       |       |       |       |       |       |       |       |

### ■ 1/3 Duty

| RAM Address |     | COM0  | COM1  | COM2  | -     | -     | -     | -     | -     |
|-------------|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| LCDARL      |     | Bit 0 | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 |
| SEG0        | 00H |       |       |       |       |       |       |       |       |
| :           | :   |       |       |       |       |       |       |       |       |
| SEG39       | 27H |       |       |       |       |       |       |       |       |

## 9 Electrical Characteristics

### 9.1 VDD = 1.5V Electrical Characteristics

#### ■ Absolute Maximum Ratings

| Items                              | Sym. | Condition | Limits           | Unit |
|------------------------------------|------|-----------|------------------|------|
| Supply voltage                     | VDD  | –         | –0.3 to +2.0     | V    |
| Input voltage (general input port) | VIN  | –         | –0.5 to VDD +0.5 | V    |
| Operating temperature range        | TOPR | –         | –10 to +70       | °C   |
| Storage temperature range          | TSTR | –         | –55 to +125      | °C   |

#### ■ Recommended Operating Conditions

| Items                 | Sym. | Condition | Limits           | Unit |
|-----------------------|------|-----------|------------------|------|
| Supply voltage        | VDD  | –         | 1.2 to 1.8       | V    |
| Input voltage         | VIH  | –         | VDD x 0.9 to VDD | V    |
|                       | VIL  | –         | 0 to VDD x 0.1   | V    |
| Operating temperature | TOPR | –         | –10 to +70       | °C   |

#### ■ DC Electrical Characteristics (Condition: Ta = 25°C, VDD = 1.5V)

| Parameter      | Sym.              | Condition                                 |                                                           | Min.    | Typ.   | Max.    | Unit |
|----------------|-------------------|-------------------------------------------|-----------------------------------------------------------|---------|--------|---------|------|
| Clock          | F <sub>HOSC</sub> | Main-clock frequency                      | RC OSC. R=2 MΩ                                            | 105     | 150    | 195     | kHz  |
|                |                   |                                           | RC OSC. R=1.5 MΩ                                          | 140     | 200    | 260     |      |
|                |                   |                                           | RC OSC. R=1 MΩ                                            | 210     | 300    | 390     |      |
|                |                   |                                           | RC OSC. R=560 KΩ                                          | 350     | 500    | 650     |      |
|                | F <sub>osc</sub>  | Sub-clock frequency                       | Internal RC OSC.                                          | 24.6    | 32.8   | 41      | kHz  |
|                |                   |                                           | Crystal OSC.                                              | –       | 32.768 | –       |      |
| Supply Current | I <sub>dd1</sub>  | Sleep mode                                | VDD=1.5V, no load                                         | –       | –      | 1       | μA   |
|                | I <sub>dd2</sub>  | Idle mode                                 | VDD=1.5V RC OSC / Crystal, LCD enabled, no load           | –       | 2      | 3       |      |
|                | I <sub>dd3</sub>  | Slow mode                                 | VDD=1.5V, RC OSC, LCD disabled, no load                   | –       | 3      | 4       |      |
|                |                   |                                           | VDD=1.5V, Crystal OSC, LCD enabled, no load               | –       | 3      | 5       |      |
|                | I <sub>dd5</sub>  | Fast mode                                 | VDD=1.5V, F <sub>HOSC</sub> =200kHz, LCD enabled, no load | –       | 15     | 20      |      |
|                | I <sub>dd6</sub>  |                                           | VDD=1.5V, F <sub>HOSC</sub> =300kHz, LCD enabled, no load | –       | 20     | 30      |      |
|                | I <sub>dd7</sub>  |                                           | VDD=1.5V, F <sub>HOSC</sub> =500kHz, LCD enabled, no load | –       | 30     | 50      |      |
| Input Voltage  | VIH1              | PA[0:7] , PB[0:7] (as general input port) |                                                           | VDD×0.7 | –      | VDD     | V    |
|                | VIL1              |                                           |                                                           | 0       | –      | VDD×0.3 |      |



| Parameter                         | Sym. | Condition                                                         |                                                                 | Min.    | Typ. | Max.     | Unit |
|-----------------------------------|------|-------------------------------------------------------------------|-----------------------------------------------------------------|---------|------|----------|------|
| Input Threshold Voltage (Schmitt) | VT+  | RSTB                                                              |                                                                 | 0.5×VDD | –    | 0.75×VDD | V    |
|                                   | VT–  |                                                                   |                                                                 | 0.2×VDD | –    | 0.4×VDD  |      |
| Input Leakage Current             | IIL  | All Input port (without pull up/down resistor)<br>Vin= VDD or GND |                                                                 | –       | –    | ±1       | μA   |
| Large Pull-up Resistance          | RPU5 | RSTB                                                              | Vin=GND                                                         | 300     | 450  | 800      | KΩ   |
| Small Pull-up Resistance          | RPU6 | RSTB                                                              | Vin=1V                                                          | 10      | 30   | 60       | KΩ   |
| Large Pull-down Resistance        | RPD1 | TEST                                                              | Vin=VDD                                                         | 250     | 500  | 800      | KΩ   |
| Small Pull-down Resistance        | RPD2 | TEST                                                              | Vin=0.5V                                                        | 3       | 6    | 12       | KΩ   |
| Data Retention Voltage            | Vret | –                                                                 |                                                                 | 1.2     | –    | –        | V    |
| Output Current                    | IOH1 | PA[4:7], PB[0:7] (as general output port)                         | VDD=1.5V, VOH=1.2V, LCD enabled                                 | -0.1    | -0.4 | -0.8     | mA   |
|                                   | IOL1 |                                                                   | VDD=1.5V, VOL=0.2V, LCD enabled                                 | 0.6     | 0.9  | 1.5      |      |
| Large Pull-up Resistance          | RPU1 | PA[0:7]                                                           | Key high resistance, pulled-up by R2, LCD enabled, Vin2=0.5V    | 110     | 280  | 800      | KΩ   |
|                                   | RPU3 | PB[0:7]                                                           | Vin=0.5V, LCD enabled                                           | 100     | 320  | 800      |      |
| Small Pull-up Resistance          | RPU2 | PA[0:3]                                                           | Key high resistance, pulled-up by R2//R1, LCD enabled, Vin2=0 V | 6       | 18   | 60       | KΩ   |
|                                   | RPU4 | PA[4:7]                                                           | Vin=1V, LCD enabled                                             | 15      | 30   | 75       |      |
| LCD Driver                        |      |                                                                   |                                                                 |         |      |          |      |
| LCD Display Output ON-resistance  | ROC  | Com[0:4]                                                          | VOH=V30 ± 0.2V                                                  | 0.35    | 0.4  | 0.5      | KΩ   |
|                                   |      |                                                                   | VOM=V20 ± 0.2V                                                  | 0.55    | 0.65 | 0.75     |      |
|                                   |      |                                                                   | VOM=V10 ± 0.2V                                                  | 0.35    | 0.40 | 0.45     |      |
|                                   |      |                                                                   | VOL=0.2V                                                        | 0.25    | 0.3  | 0.35     |      |
|                                   | ROS  | Seg[0:39]                                                         | VOH=V30 ± 0.2V                                                  | 0.35    | 0.4  | 0.5      | KΩ   |
|                                   |      |                                                                   | VOM=V15 ± 0.2V                                                  | 0.45    | 0.6  | 0.85     |      |
|                                   |      |                                                                   | VOL=0.1V                                                        | 0.25    | 0.3  | 0.35     |      |
|                                   |      |                                                                   |                                                                 |         |      |          |      |
| Strobe Output ON-resistance       | ROP  | Seg[0:15] (as key strobe)                                         | V=VDD-0.2V                                                      | 80      | 200  | 500      | KΩ   |
|                                   | RON  |                                                                   | V=0.2V                                                          | 0.85    | 1.1  | 1.3      |      |

## 10 Application Circuits

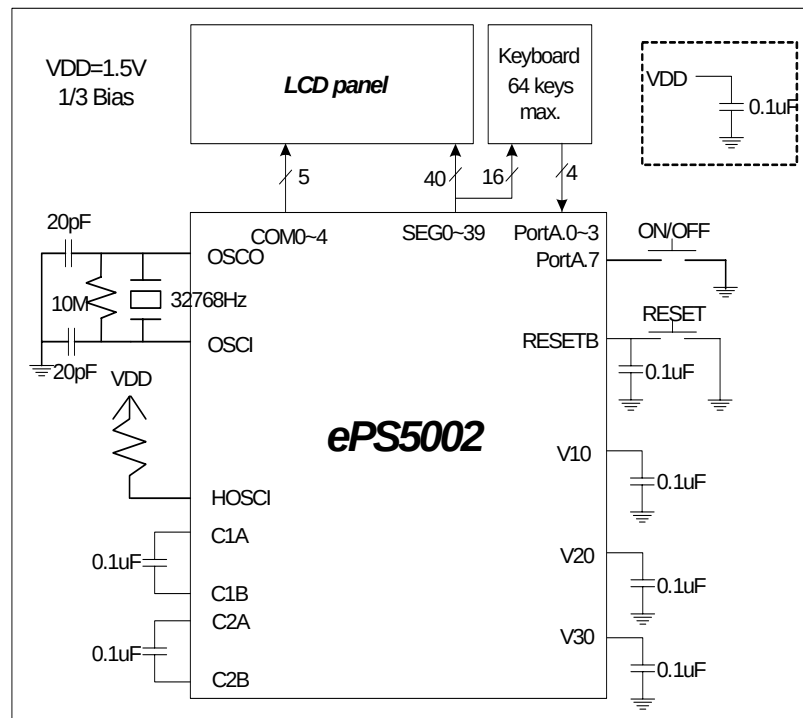


Figure 10-1 VDD=1.5 Application Circuits Diagram