

MDT2020

1. General Description

This EPROM-Based 8-bit micro-controller uses a fully static CMOS design technology combines higher speed and smaller size with the low power and high noise immunity of CMOS.

On chip memory system includes 2.0 K bytes of ROM, and 80 bytes of static RAM.

2. Features

The followings are some of the features on the hardware and software :

- ◆ Fully COMS static design
- ◆ 8-bit data bus
- ◆ On chip ROM size : 2 K words
- ◆ Internal RAM size : 80 bytes
(72 general purpose, 8 special registers)
- ◆ 36 single word instructions
- ◆ 14-bit instructions
- ◆ 2-level stacks
- ◆ Operating voltage : 2.3 V ~ 6.3 V
- ◆ Operating frequency : 0 ~ 20 MHz
- ◆ The most fast execution time is 200 ns under 20 MHz in all single cycle instructions except the branch instruction.
- ◆ Addressing modes include direct, indirect and relative addressing modes
- ◆ Power-on Reset
- ◆ Power Edge-detector Reset
- ◆ Sleep mode for power saving
- ◆ 4 oscillator start-up time :
150 μ s, 20 ms, 40 ms, 80 ms
- ◆ 8-bit real time clock/counter(RTCC) with 8-bit programmable prescaler
- ◆ 4 types of oscillator can be selected by code options :
RC - Low cost RC oscillator
LFXT - Low frequency crystal oscillator
XTAL - Standard crystal oscillator
HFXT - High frequency crystal oscillator
- ◆ On-chip RC oscillator based Watchdog Timer(WDT) can be operated freely

- ◆ 20 I/O pins with their own independent direction control

3. Applications

The application areas of this MDT2020 range from appliance motor control and high speed automotive to low power remote transmitters/receivers, pointing devices, and telecommunications processors, such as Remote controller, small instruments, chargers, toy, automobile and PC peripheral ... etc.

4. Pin Assignment

| | | | |
|-----------------|----|----|-------|
| RTCC | 1 | 28 | /MCLR |
| V _{dd} | 2 | 27 | OSC1 |
| N/C | 3 | 26 | OSC2 |
| V _{ss} | 4 | 25 | PC7 |
| N/C | 5 | 24 | PC6 |
| PA0 | 6 | 23 | PC5 |
| PA1 | 7 | 22 | PC4 |
| PA2 | 8 | 21 | PC3 |
| PA3 | 9 | 20 | PC2 |
| PB0 | 10 | 19 | PC1 |
| PB1 | 11 | 18 | PC0 |
| PB2 | 12 | 17 | PB7 |
| PB3 | 13 | 16 | PB6 |
| PB4 | 14 | 15 | PB5 |

5. Pin Function Description

| Pin Name | I/O | Function Description |
|-----------------|-----|---|
| PA0~PA3 | I/O | Port A, TTL input level |
| PB0~PB7 | I/O | Port B, TTL input level |
| PC0~PC7 | I/O | Port C, TTL input level |
| RTCC | I | Real Time Clock/Counter, Schmitt Trigger input levels |
| /MCLR | I | Master Clear, Schmitt Trigger input levels |
| OSC1 | I | Oscillator Input |
| OSC2 | O | Oscillator Output |
| V _{dd} | | Power supply |
| V _{ss} | | Ground |

6. Memory Map

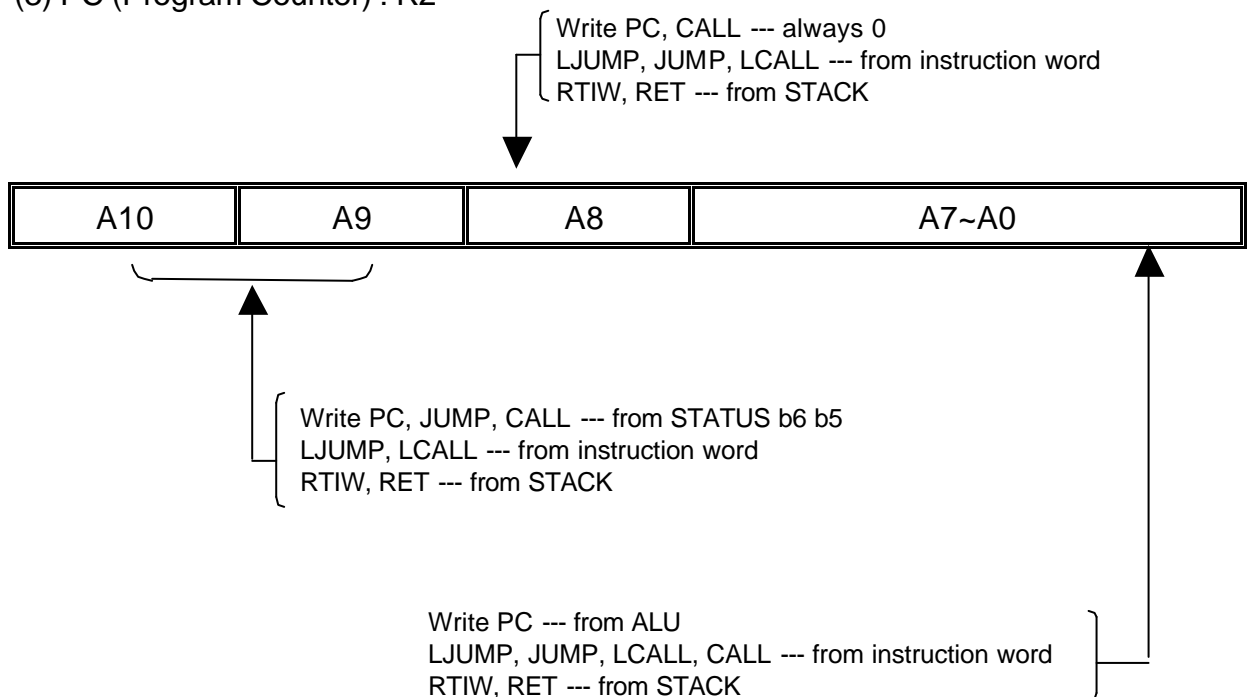
(A) Register Map

| Address | Description |
|---------|--|
| 00 | Indirect Addressing Register |
| 01 | RTCC |
| 02 | PC |
| 03 | STATUS |
| 04 | MSR |
| 05 | Port A |
| 06 | Port B |
| 07 | Port C |
| 08~0F | Internal RAM, General Purpose Register |
| 10~1F | Internal Memory Select Register |
| 30~3F | Internal Memory Select Register |
| 50~5F | Internal Memory Select Register |
| 70~7F | Internal Memory Select Register |

(1) IAR (Indirect Address Register) : R0

(2) RTCC (Real Time Counter/Counter Register) : R1

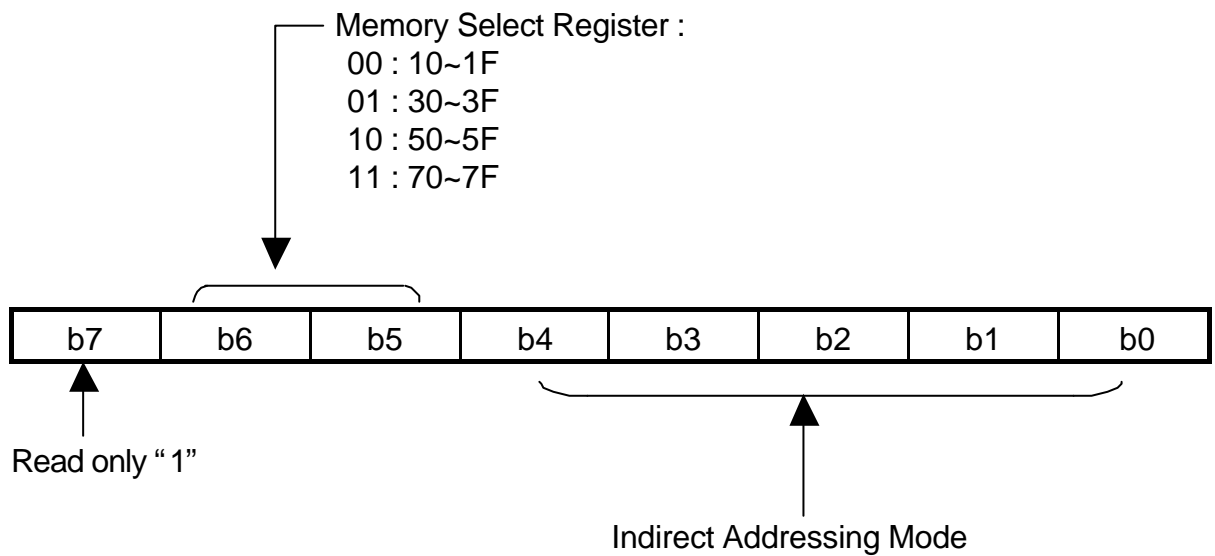
(3) PC (Program Counter) : R2



(4) STATUS (Status register) : R3

| Bit | Symbol | Function |
|-----|--------|---|
| 0 | C | Carry bit |
| 1 | HC | Half Carry bit |
| 2 | Z | Zero bit |
| 3 | PF | Power loss Flag bit |
| 4 | TF | Time overflow Flag bit |
| 6—5 | page | Page select bit : 00 : 000H --- 1FFH 01 : 200H --- 3FFH 10 : 400H --- 5FFH 11 : 600H --- 7FFH |
| 7 | — | General purpose bit |

(5) MSR (Memory Select Register) : R4



(6) PORT A : R5

PA3~PA0, I/O Register

(7) PORT B : R6

PB7~PB0, I/O Register

(8) PORT C : R7

PC7~PC0, I/O Register

(9) TMR (Time Mode Register)

| Bit | Symbol | Function | | |
|-------|---------|--|-----------|----------|
| 2—0 | PS2—0 | Prescaler Value | RTCC rate | WDT rate |
| | | 0 0 0 | 1 : 2 | 1 : 1 |
| | | 0 0 1 | 1 : 4 | 1 : 2 |
| | | 0 1 0 | 1 : 8 | 1 : 4 |
| | | 0 1 1 | 1 : 16 | 1 : 8 |
| | | 1 0 0 | 1 : 32 | 1 : 16 |
| | | 1 0 1 | 1 : 64 | 1 : 32 |
| | | 1 1 0 | 1 : 128 | 1 : 64 |
| 1 1 1 | 1 : 256 | 1 : 128 | | |
| 3 | PSC | Prescaler assignment bit : 0 — RTCC 1 — Watchdog Timer | | |
| 4 | TCE | RTCC signal Edge : 0 — Increment on low-to-high transition on RTCC pin 1 — Increment on high-to-low transition on RTCC pin | | |
| 5 | TCS | RTCC signal set : 0 — Internal instruction cycle clock 1 — Transition on RTCC pin | | |

(10) CPIO A, CPIO B, CPIO C (Control Port I/O Mode Register)

The CPIO register is “write-only”

= “0”, I/O pin in output mode;

= “1”, I/O pin in input mode.

(11) EPROM Option by Writer Programming:

| Oscillator Type | Oscillator Start-up Time |
|-----------------|--------------------------|
| RC Oscillator | 150 μs,20ms,40ms,80ms |
| HFXT Oscillator | 20 ms,40ms,80ms |
| XTAL Oscillator | 20ms,40 ms,80ms |
| LFXT Oscillator | 80 ms |

| Watchdog Timer control |
|-------------------------------------|
| Watchdog timer disable all the time |
| Watchdog timer enable all the time |

| | |
|-------------------|---------|
| Power Edge Detect | |
| PED | Disable |
| PED | Enable |

| | |
|-----------------------|--|
| Security bit | |
| Security weak Disable | |
| Security Disable | |
| Security Enable | |

7. Reset Condition for all Registers

| Register | Address | Power-On Reset | /MCLR or WDT Reset |
|----------|---------|----------------|--------------------|
| IAR | 00h | - | - |
| RTCC | 01h | xxxx xxxx | uuuu uuuu |
| PC | 02h | 1111 1111 | 1111 1111 |
| STATUS | 03h | 0001 1xxx | 000# #uuu |
| MSR | 04h | 100x xxxx | 100u uuuu |
| PORT A | 05h | ---- xxxx | ---- uuuu |
| PORT B | 06h | xxxx xxxx | uuuu uuuu |
| PORT C | 07h | xxxx xxxx | uuuu uuuu |

Note : u = unchanged, x = unknown, - = unimplemented, read as "0"
= value depends on the condition of the following table

| Condition | Status: bit 4 | Status: bit 3 |
|--------------------------------|---------------|---------------|
| /MCLR reset (not during SLEEP) | u | u |
| /MCLR reset during SLEEP | 1 | 0 |
| WDT reset (not during SLEEP) | 0 | 1 |
| WDT reset during SLEEP | 0 | 0 |

8. Instruction Set

| Instruction Code | Mnemonic Operands | Function | Operating | Status |
|------------------|-------------------|--------------------------|----------------|--------|
| 010000 00000000 | NOP | No operation | None | |
| 010000 00000001 | CLRWT | Clear Watchdog timer | 0 WT | TF, PF |
| 010000 00000010 | SLEEP | Sleep mode | 0 WT, stop OSC | TF, PF |
| 010000 00000011 | TMODE | Load W to TMODE register | W TMODE | None |

| Instruction Code | Mnemonic Operands | Function | Operating | Status |
|------------------|-------------------|----------------------------------|-------------------------------|----------|
| 010000 00000100 | RET | Return | Stack PC | None |
| 010000 00000rrr | CPIO R | Control I/O port register | W CPIO r | None |
| 010001 1rrrrrrr | STWR R | Store W to register | W R | None |
| 011000 trrrrrrr | LDR R, t | Load register | R t | Z |
| 111010 iiiiii | LDWI I | Load immediate to W | I W | None |
| 010111 trrrrrrr | SWAPR R, t | Swap halves register | [R(0~3) ↔ R(4~7)] t | None |
| 011001 trrrrrrr | INCR R, t | Increment register | R + 1 t | Z |
| 011010 trrrrrrr | INCRSZ R, t | Increment register, skip if zero | R + 1 t | None |
| 011011 trrrrrrr | ADDWR R, t | Add W and register | W + R t | C, HC, Z |
| 011100 trrrrrrr | SUBWR R, t | Subtract W from register | R - W t (R+W+1 t) | C, HC, Z |
| 011101 trrrrrrr | DECR R, t | Decrement register | R - 1 t | Z |
| 011110 trrrrrrr | DECRSZ R, t | Decrement register, skip if zero | R - 1 t | None |
| 010010 trrrrrrr | ANDWR R, t | AND W and register | R W t | Z |
| 110100 iiiiii | ANDWI I | AND W and immediate | I W W | Z |
| 010011 trrrrrrr | IORWR R, t | Inclu. OR W and register | R W t | Z |
| 110101 iiiiii | IORWI I | Inclu. OR W and immediate | I W W | Z |
| 010100 trrrrrrr | XORWR R, t | Exclu. OR W and register | R W t | Z |
| 110110 iiiiii | XORWI I | Exclu. OR W and immediate | I W W | Z |
| 011111 trrrrrrr | COMR R, t | Complement register | /R t | Z |
| 010110 trrrrrrr | RRR R, t | Rotate right register | R(n) R(n-1), C R(7) R(0) C | C |
| 010101 trrrrrrr | RLR R, t | Rotate left register | R(n) (n+1), C R(0) R(7) C | C |
| 010000 1xxxxxxx | CLRW | Clear working register | 0 W | Z |
| 010001 0rrrrrrr | CLRR R | Clear register | 0 R | Z |
| 0000bb brrrrrrr | BCR R, b | Bit clear | 0 R(b) | None |
| 0010bb brrrrrrr | BSR R, b | Bit set | 1 R(b) | None |
| 0001bb brrrrrrr | BTSC R, b | Bit Test, skip if clear | Skip if R(b)=0 | None |
| 0011bb brrrrrrr | BTSS R, b | Bit Test, skip if set | Skip if R(b)=1 | None |

| Instruction Code | Mnemonic Operands | Function | Operating | Status |
|------------------|-------------------|------------------------------|----------------------|--------|
| 100nnn nnnnnnnn | LCALL n | Long CALL subroutine | n PC , PC+1 Stack | None |
| 101nnn nnnnnnnn | LJUMP n | Long JUMP to address | n PC | None |
| 110000 nnnnnnnn | CALL n | Call subroutine | n PC, PC+1 Stack | None |
| 110001 iiiiii | RTIW i | Return, place immediate to W | Stack PC, i W | None |
| 11001n nnnnnnnn | JUMP n | JUMP to address | n PC | None |

Note :

| | | | |
|--------|-----------------------------|----|-----------------------------|
| W | : Working register | b | : Bit position |
| WT | : Watchdog timer | t | : Target |
| TMODE | : TMODE mode register | 0 | : Working register |
| CPIO | : Control I/O port register | 1 | : General register |
| TF | : Timer overflow flag | R | : General register address |
| PF | : Power loss flag | C | : Carry flag |
| PC | : Program Counter | HC | : Half carry |
| OSC | : Oscillator | Z | : Zero flag |
| Inclu. | : Inclusive ‘ ’ | / | : Complement |
| Exclu. | : Exclusive ‘ ’ | x | : Don’ t care |
| AND | : Logic AND ‘ ’ | i | : Immediate data (8 bits) |
| | | n | : Immediate address |

9. Electrical Characteristics

(A) Operating Voltage & Frequency

V_{dd} : 2.3 V ~ 6.3 V

Frequency : 0 Hz ~ 20 MHz

(B) Input Voltage

@ $V_{dd} = 5.0$ V, Temperature = 25

| | Port | Min. | Max. |
|----------|-------------|----------|----------|
| V_{il} | PA, PB, PC | V_{ss} | 1.0 V |
| | RTCC, /MCLR | V_{ss} | 1.0 V |
| V_{ih} | PA, PB, PC | 2.0 V | V_{dd} |
| | RTCC, /MCLR | 3.5 V | V_{dd} |

*** Threshold Voltage :**

Port A, Port B, Port C $V_{th} = 1.5\text{ V}$

RTCC, /MCLR $V_{il} = 1.3\text{ V}$, $V_{ih} = 3.0\text{ V}$ (Schmitt Trigger)

(C) Output Voltage

@ $V_{dd} = 5.0\text{ V}$, Temperature = 25 , the typical value as followings :

| PA, PB, PC Port | |
|----------------------------|--------------------------|
| $I_{oh} = -20.0\text{ mA}$ | $V_{oh} = 4.20\text{ V}$ |
| $I_{ol} = 20.0\text{ mA}$ | $V_{ol} = 0.50\text{ V}$ |
| $I_{oh} = -5.0\text{ mA}$ | $V_{oh} = 4.80\text{ V}$ |
| $I_{ol} = 5.0\text{ mA}$ | $V_{ol} = 0.10\text{ V}$ |

(D) Leakage Current

@ $V_{dd} = 5.0\text{ V}$, Temperature = 25 , the typical value as followings :

| | |
|----------|----------------------------|
| I_{il} | - 0.1 μA (Max.) |
| I_{ih} | + 0.1 μA (Max.) |

(E) Sleep Current

@WDT - Disable, Temperature = 25 , the typical value as followings :

| | |
|-------------------------|------------------------------|
| $V_{dd} = 2.3\text{ V}$ | $I_{dd} < 1.0\ \mu\text{A}$ |
| $V_{dd} = 3.0\text{ V}$ | $I_{dd} < 1.0\ \mu\text{A}$ |
| $V_{dd} = 4.0\text{ V}$ | $I_{dd} = 1.0\ \mu\text{A}$ |
| $V_{dd} = 5.0\text{ V}$ | $I_{dd} = 5.0\ \mu\text{A}$ |
| $V_{dd} = 6.3\text{ V}$ | $I_{dd} = 10.0\ \mu\text{A}$ |

@WDT - Enable, Temperature = 25 , the typical value as followings :

| | |
|-------------------------|------------------------------|
| $V_{dd} = 2.3\text{ V}$ | $I_{dd} < 1.0\ \mu\text{A}$ |
| $V_{dd} = 3.0\text{ V}$ | $I_{dd} = 4.0\ \mu\text{A}$ |
| $V_{dd} = 4.0\text{ V}$ | $I_{dd} = 8.0\ \mu\text{A}$ |
| $V_{dd} = 5.0\text{ V}$ | $I_{dd} = 15.0\ \mu\text{A}$ |
| $V_{dd} = 6.3\text{ V}$ | $I_{dd} = 30.0\ \mu\text{A}$ |

F) Operating Current

Temperature = 25 °C, the typical value as followings :

(i) OSC Type = RC ; WDT - Enable; @ $V_{dd} = 5.0\text{ V}$

| Cext. (F) | Rext. (Ohm) | Frequency (Hz) | Current (A) |
|-----------|-------------|----------------|-------------------|
| 3P | 4.7 K | 9.4 M | 1.9 mA |
| | 10.0 K | 4.9 M | 1.1 mA |
| | 47.0 K | 1.1 M | 428 μA |
| | 100.0 K | 528 K | 315 μA |
| | 300.0 K | 178 K | 248 μA |
| | 470.0 K | 115 K | 235 μA |
| 20P | 4.7 K | 4.6 M | 1.1 mA |
| | 10.0 K | 2.4 M | 675 μA |
| | 47.0 K | 560 K | 320 μA |
| | 100.0 K | 263 K | 265 μA |
| | 300.0 K | 89 K | 230 μA |
| | 470.0 K | 57 K | 225 μA |
| 100P | 4.7 K | 1.5 M | 505 μA |
| | 10.0 K | 768 k | 360 μA |
| | 47.0 K | 168 K | 246 μA |
| | 100.0 K | 80 K | 230 μA |
| | 300.0 K | 27 K | 220 μA |
| | 470.0 K | 17 K | 218 μA |
| 300P | 4.7 K | 612 K | 330 μA |
| | 10.0 K | 308 K | 275 μA |
| | 47.0 K | 68 K | 228 μA |
| | 100.0 K | 32 K | 220 μA |
| | 300.0 K | 11.8 K | 215 μA |
| | 470.0 K | 6.8 K | 214 μA |

(ii) OSC Type = LF (C=20 p); WDT - Disable

| Voltage/Frequency | 32 K | 455 K | 1 M | Sleep |
|-------------------|---------------|------------------|-------------------|-------------|
| 2.3 V | 3.5 μ A | @2.5v 78 μ A | @2.6v 132 μ A | < 1 μ A |
| 3.0 V | 69.0 μ A | 115.0 μ A | 168.0 μ A | < 1 μ A |
| 4.0 V | 123.0 μ A | 190.0 μ A | 260.0 μ A | 1 μ A |
| 5.0 V | 195.0 μ A | 280.0 μ A | 370.0 μ A | 5 μ A |
| 6.3 V | 305.0 μ A | 425.0 μ A | 555.0 μ A | 10 μ A |

(iii) OSC Type = XT (C=10 p); WDT - Enable

| Voltage/Frequency | 1 M | 4 M | 10 M | Sleep |
|-------------------|---------------|---------------|------------------|---------------|
| 2.1 V | 98.0 μ A | 300.0 μ A | @2.3v779 μ A | < 1.0 μ A |
| 3.0 V | 205.0 μ A | 520.0 μ A | 1.20 mA | 4.0 μ A |
| 4.0 V | 350.0 μ A | 790.0 μ A | 1.60 mA | 8.0 μ A |
| 5.0 V | 538.0 μ A | 1.1 mA | 2.20 mA | 15.0 μ A |
| 6.3 V | 890.0 μ A | 1.65 mA | 3.10 mA | 30.0 μ A |

(iv) OSC Type = HF (C=10 p); WDT - Enable

| Voltage/Frequency | 4 M | 10 M | 20 M | Sleep |
|-------------------|---------------|-------------|--------------|---------------|
| 2.1 V | 318.0 μ A | 695 μ A | @2.2v 1.47mA | < 1.0 μ A |
| 3.0 V | 540.0 μ A | 1.15 mA | 2.10 mA | 4.0 μ A |
| 4.0 V | 815.0 μ A | 1.70 mA | 3.00 mA | 8.0 μ A |
| 5.0 V | 1.2 mA | 2.30 mA | 4.00 mA | 15.0 μ A |
| 6.3 V | 1.8 mA | 3.30 mA | 5.60 mA | 30.0 μ A |

(G) Power Edge-detector Reset Voltage (Not in Sleep Mode), @ $V_{dd} = 5.0$ V

V_{pr} 1.1~1.3 V

V_{pr} : V_{dd} (Power Supply)

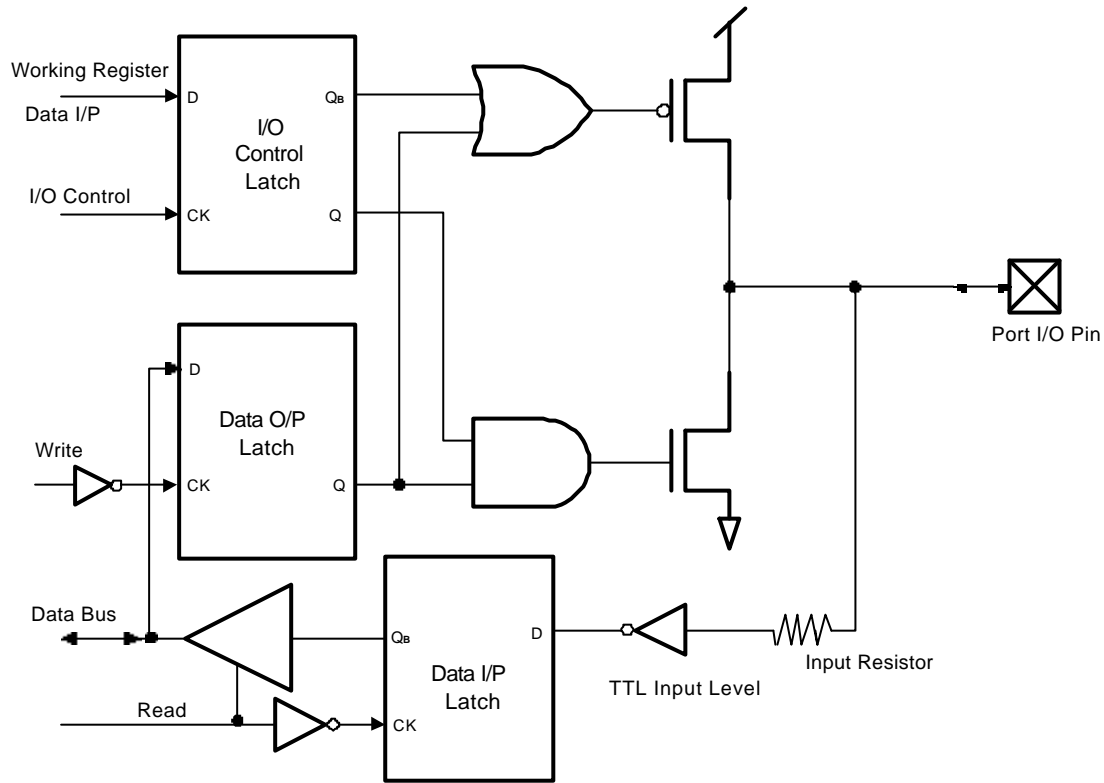
(H) The basic WDT time-out cycle time

@Temperature = 25 , the typical value as followings :

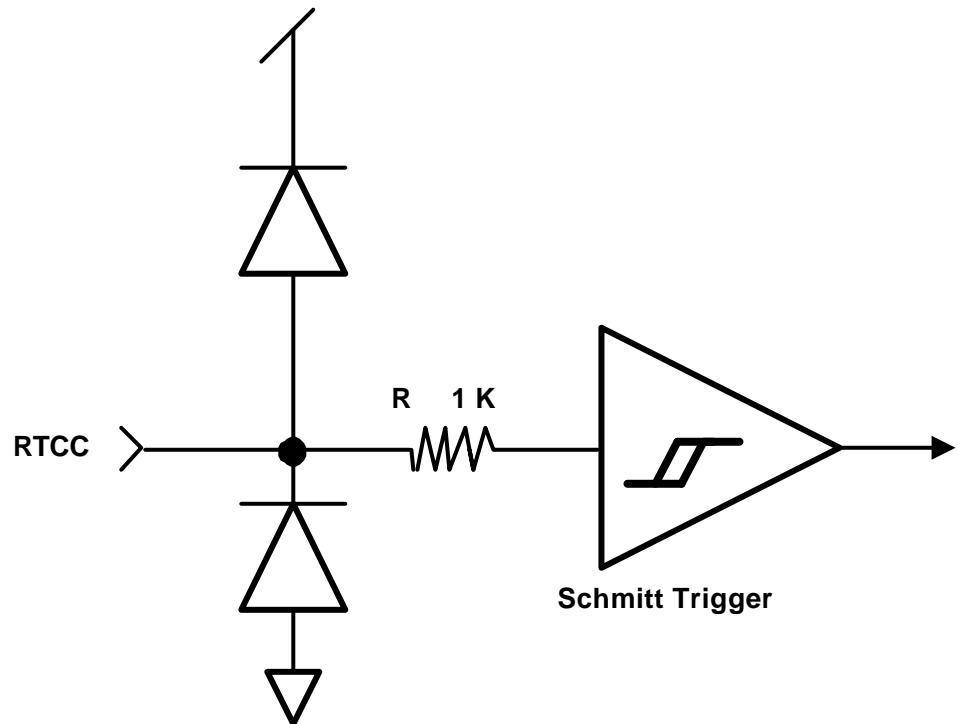
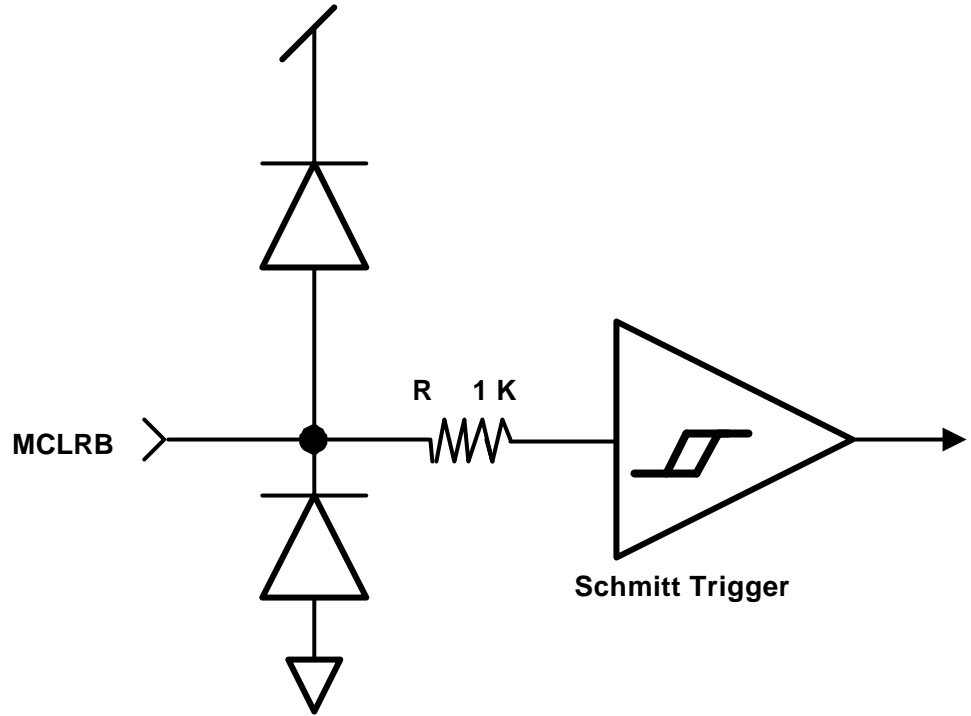
V_{dd} =5.0 V, Temperature=25 ,the typical value as followings:

| Voltage (V) | Basic WDT time-out cycle time (ms) |
|-------------|------------------------------------|
| 2.3 | 25.60 |
| 3.0 | 22.50 |
| 4.0 | 20.00 |
| 5.0 | 18.10 |
| 6.3 | 16.20 |

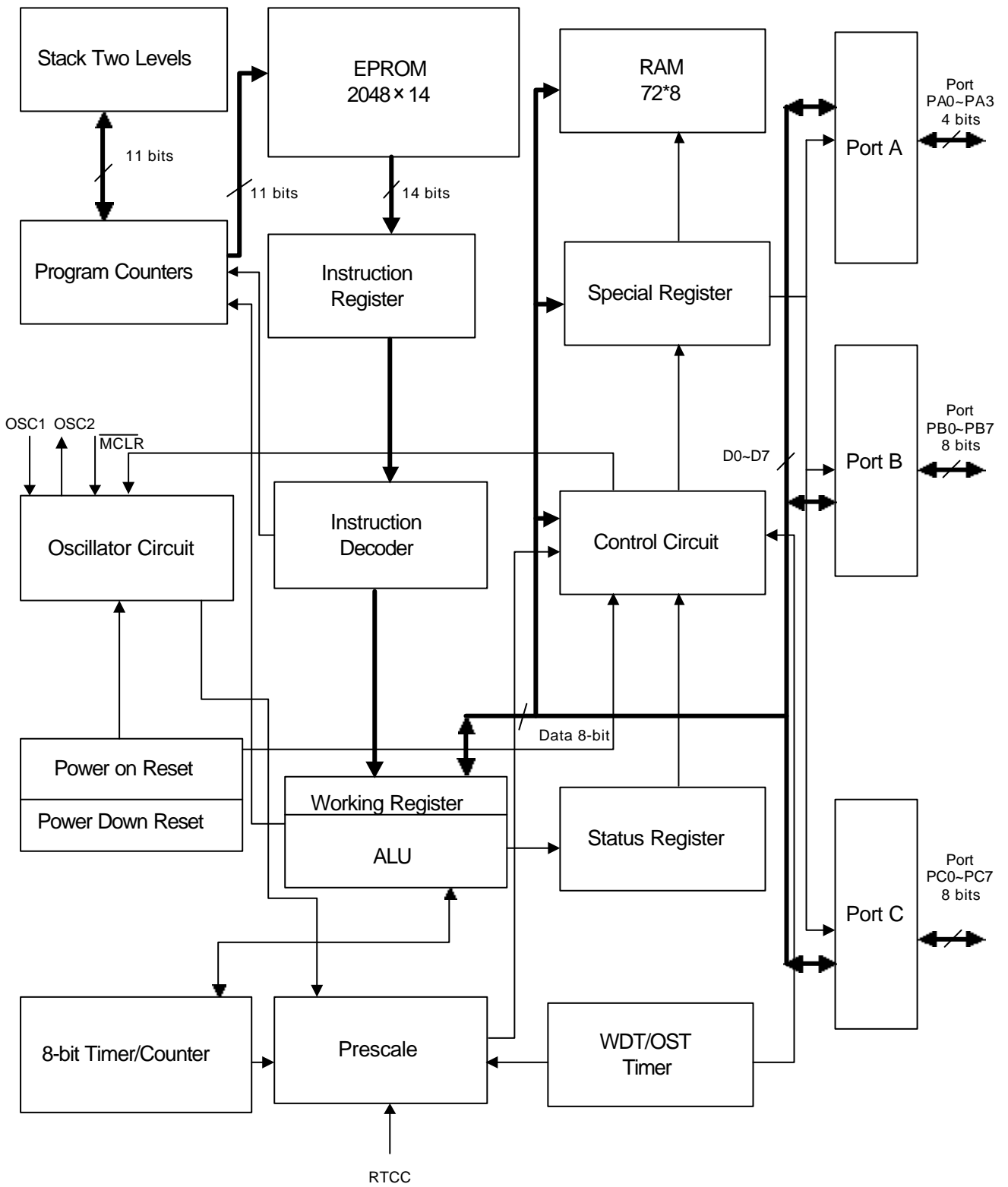
10. Port A ,Port B and Port C Equivalent Circuit



11. MCLRB and RTCC Input Equivalent Circuit



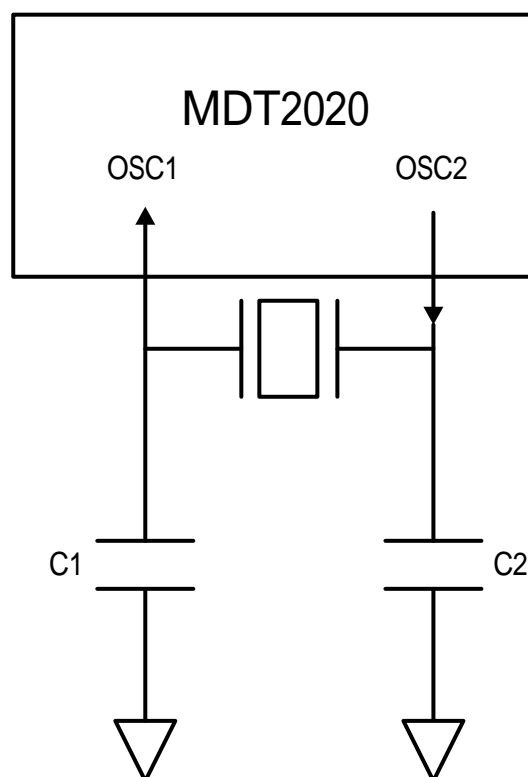
12. Block Diagram



13. External Capacitor Selection For Crystal Oscillator

@ $V_{dd} = 3.0\text{ V} \sim 5.0\text{ V}$

| Osc. Type | Resonator Freq. | C1 | C2 |
|-----------|-----------------|--------------|---------------|
| HF | 20 MHz | 5 pF ~10 pF | 10 pF~30 pF |
| | 10 MHz | 10 pF ~50 pF | 20 pF ~100 pF |
| | 4 MHz | 10 pF ~50 pF | 20 pF ~100 pF |
| XT | 10 MHz | 10 pF ~30 pF | 10 pF ~50 pF |
| | 4 MHz | 10 pF ~50 pF | 20 pF ~100 pF |
| | 1 MHz | 10 pF ~30 pF | 20 pF ~50 pF |
| LF | 1 MHz | 3 pF ~5 pF | 3 pF ~5 pF |
| | 455 K | 10 pF ~30 pF | 20 pF ~50 pF |
| | 32 K | 10 pF ~20 pF | 15 pF ~30 pF |



To increase the stability of oscillator and the ability of anti-noise, the above values of the external capacitor range can be recommended for reference, but the higher capacitance also increases the start-up time.