1. General Description

This ROM-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 CMOS static design
- ◆ 8-bit data bus
- ◆ On chip ROM size : 2 K words
- ◆ Internal RAM size : 80 bytes

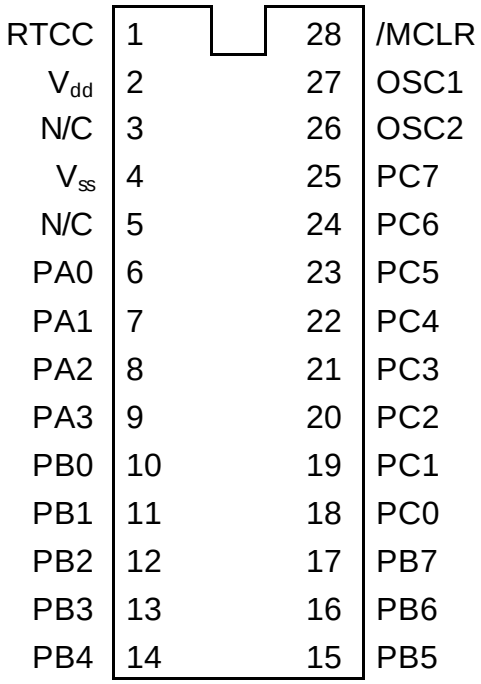
(72 general purpose, 8 special registers)

- ◆ 36 single word instructions
- ◆ 14-bit instructions
- ◆ 2-level stacks
- ◆ Operating voltage : 2.3 V ~ 6.3 V
- ◆ Operating frequency : 0 ~ 20 MHz
- ◆ The fastest 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 μs, 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
- ◆ Pull up resistors for the following pins : PA0~PA3, PB0~PB7,PC0~PC7, /MCLR, RTCC
- ◆ Pull down resistors for the following pins :
  - PA0~PA3, PB0~PB7, PC0~PC7, RTCC
- ◆ 20 I/O pins with their own independent direction control

3. Applications

The application areas of this MDT1020 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



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

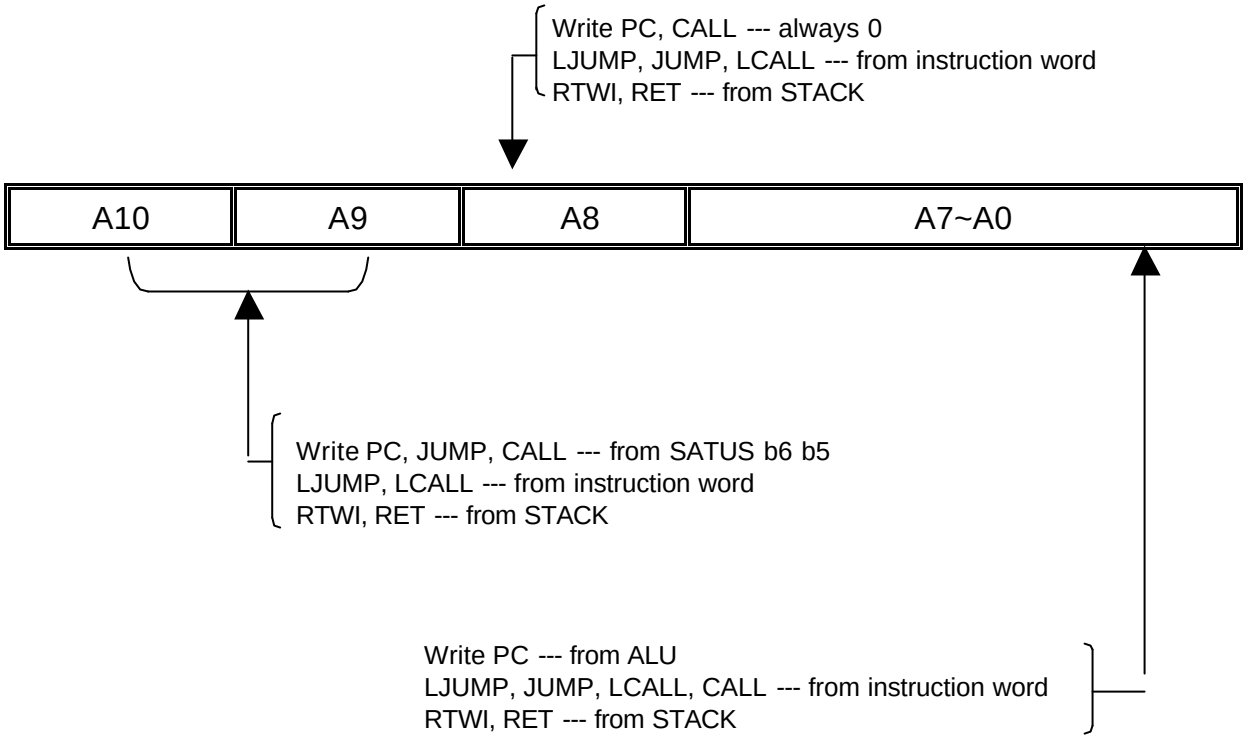
(A) Register Map

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

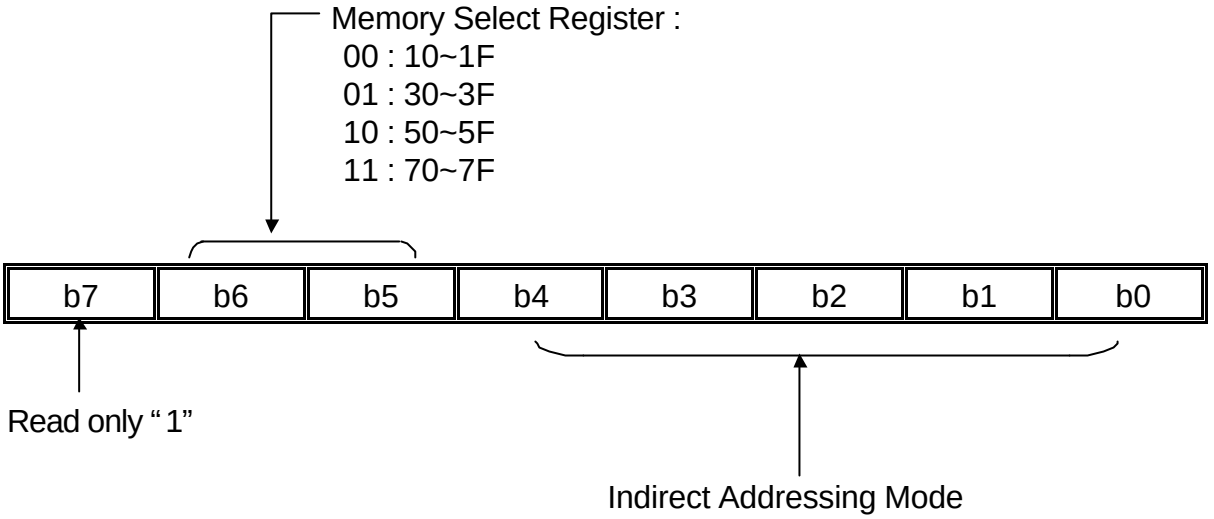
(3) PC (Program Counter) : R2



(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 bits

(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		
		Prescaler Value	RTCC rate	WDT rate
2—0	PS2—0	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) Configuration ROM :

Bit 1	Bit 0	Oscillator Type
0	0	RC Oscillator
0	1	LFXT Oscillator
1	0	XTAL Oscillator
1	1	HFXT Oscillator

Bit 3	Bit 2	Oscillator Start-up Time
0	0	150 μs
0	1	20 ms
1	0	40 ms
1	1	80 ms

Bit 4	Watchdog Timer control
0	Watchdog timer disable all the time
1	Watchdog timer enable all the time

(B) Program Memory

Address	Description
000-7FF	Program memory
7FF	The starting address of the power on, external reset or WDT

7. Reset Condition for all Registers

Register	Address	Power-On Reset	/MCLR or WDT Reset
CPIO A	－－	1111 1111	1111 1111
CPIO B	－－	1111 1111	1111 1111
CPIO C	－－	1111 1111	1111 1111
TMR	－－	--11 1111	--11 1111
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
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 iiiiiiii	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
Instruction Code	**Mnemonic Operands**	**Function**	**Operating**	**Status**

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 iiiiiiii	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 iiiiiiii	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 iiiiiiii	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)→r(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
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 iiiiiiii	RTWI 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}	0.8 V
V_{ih}	PA, PB, PC	2.0 V	V_{dd}
	RTCC, /MCLR	3.4 V	V_{dd}

Threshold Voltage :

Port A, Port B, Port C V_{th}=1.3 V

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

(C) Output Voltage

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

PA, PB, PC Port	
I_{oh}=−20.0 mA	V_{oh}=3.60 V
I_{ol}=20.0 mA	V_{ol}=0.35 V
I_{oh}=−5.0 mA	V_{oh}=4.70 V
I_{ol}=5.0 mA	V_{ol}=0.08 V

(D) Leakage Current

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

I_{il}	－ 1.0 μA (Max.)
I_{ih}	＋ 1.0 μA (Max.)

(E) Sleep Current

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

V_{dd}＝2.3 V ~ 6.3 V, I_{dd}＜0.1 μA

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

V_{dd}＝2.3 V	I_{dd}＜1.0 μA
V_{dd}＝3.0 V	I_{dd}＝2.0 μA
V_{dd}＝4.0 V	I_{dd}＝5.0 μA
V_{dd}＝5.0 V	I_{dd}＝10.0 μA
V_{dd}＝6.3 V	I_{dd}＝20.0 μA

(F) Operating Current / Voltage

Temperature＝25℃, the typical value as followings :

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

Cext. (F)	Rext. (Ohm)	Frequency (Hz)	Current (A)
3P	4.7 K	11.76 M	1.90 m
	10.0 K	7.40 M	1.12 m
	47.0 K	1.96 M	315.00 μ
	100.0 K	952.50 K	175.00 μ
	300.0 K	310.00 K	90.00 μ
	470.0 K	196.1 K	75.00 μ
20P	4.7 K	6.45 M	950.0 μ
	10.0 K	3.70 M	540.0 μ
	47.0 K	869.60 K	160.0 μ
	100.0 K	416.80 K	105.0 μ
	300.0 K	137.90 K	65.0 μ
	470.0 K	88.88 K	60.0 μ

Cext. (F)	Rext. (Ohm)	Frequency (Hz)	Current (A)
100P	4.7 K	2.00 M	325.0 μ
	10.0 K	1.11 M	190.0 μ
	47.0 K	256.40 K	80.0 μ
	100.0 K	121.20 K	65.0 μ
	300.0 K	40.00 K	55.0 μ
	470.0 K	25.60 K	50.0 μ
300P	4.7 K	833.20 K	160.0 μ
	10.0 K	454.00 K	105.0 μ
	47.0 K	105.30 K	65.0 μ
	100.0 K	50.00 K	55.0 μ
	300.0 K	16.60 K	50.0 μ
	470.0 K	10.50 K	49.0 μ

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

Voltage/Frequency	32 K	455 K	1 M	Sleep
2.3 V	4.0 μA	X	X	＜0.1 μA
3.0 V	7.0 μA	48.0 μA	X	＜0.1 μA
4.0 V	10.0 μA	70.0 μA	150.0 μA	＜0.1 μA
5.0 V	15.0 μA	105.0 μA	210.0 μA	＜0.1 μA
6.3 V	30.0 μA	150.0 μA	290.0 μA	＜0.1 μA

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

Voltage/Frequency	1 M	4 M	10 M	Sleep
2.1 V	70.0 μA	220.0 μA	500.00 μA	＜0.1 μA
3.0 V	130.0 μA	365.0 μA	820.00 μA	2.0 μA
4.0 V	250.0 μA	560.0 μA	1.20 mA	5.0 μA
5.0 V	470.0 μA	780.0 μA	1.70 mA	10.0 μA
6.3 V	530.0 μA	1.2 mA	2.30 mA	20.0 μA

(iv) OSC Type＝HF (C=10 p); WDT－Enable

Voltage/Frequency	4 M	10 M	20 M	Sleep
2.1 V	230.0 μA	530.00 μA	970.00 μA	＜0.1 μA
3.0 V	400.0 μA	890.00 μA	1.60 mA	2.0 μA
4.0 V	620.0 μA	1.30 mA	2.40 mA	5.0 μA
5.0 V	890.0 μA	1.90 mA	3.40 mA	10.0 μA
6.3 V	1.3 mA	2.60 mA	5.00 mA	20.0 μA

(G) Pull Resistance

@ Input Mode : V_{dd}＝3.0 V

PORT	Pull-High Resistance	R_{hi}＝370.0 KOhm
	Pull-Low Resistance	R_{lo}＝370.0 KOhm
RTCC	Pull-High Resistance	R_{hi}＝370.0 KOhm
	Pull-Low Resistance	R_{lo}＝370.0 KOhm
/MCLR	Pull-High Resistance	R_{hi}＝370.0 KOhm

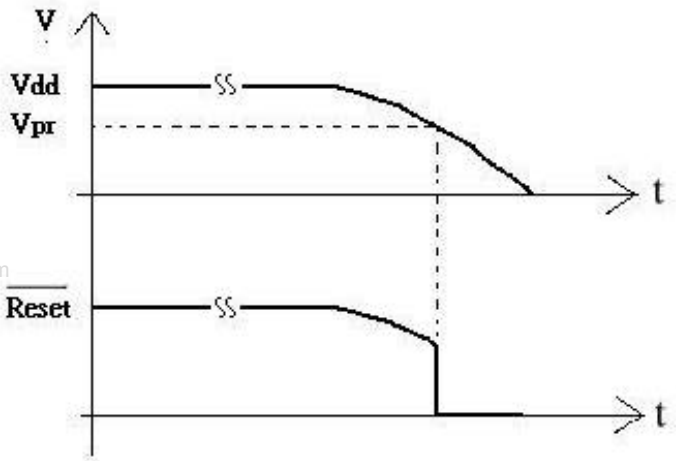
@ Input Mode : V_{dd}＝5.0 V

PORT	Pull-High Resistance	R_{hi}＝170.0 KOhm
	Pull-Low Resistance	R_{lo}＝170.0 KOhm
RTCC	Pull-High Resistance	R_{hi}＝170.0 KOhm
	Pull-Low Resistance	R_{lo}＝170.0 KOhm
/MCLR	Pull-High Resistance	R_{hi}＝170.0 KOhm

p.s. : It is only a reference value for the Pull High/Low Resistance, and the accurate value of the Resistance depends on the various parameter of the Process. But the variation of the value will be not more than 20%.

(H) 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)

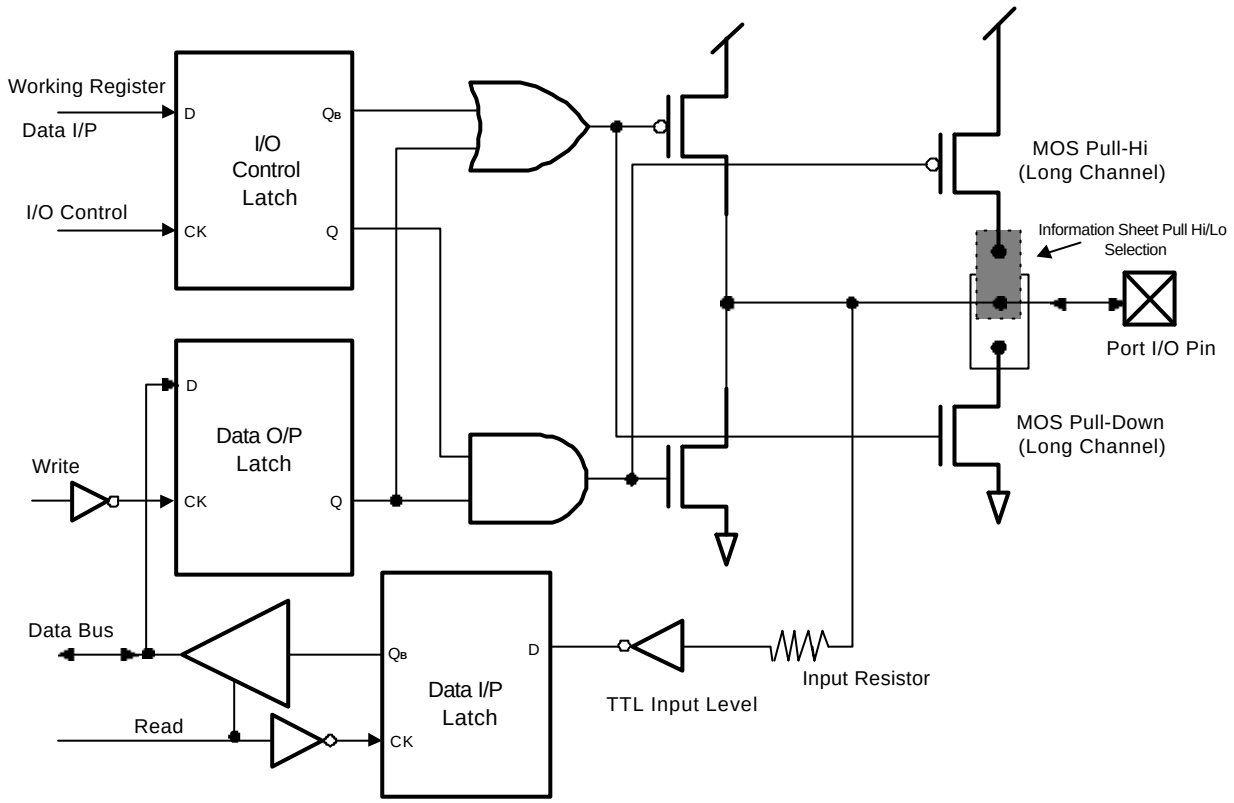


(I) The basic WDT time-out cycle time

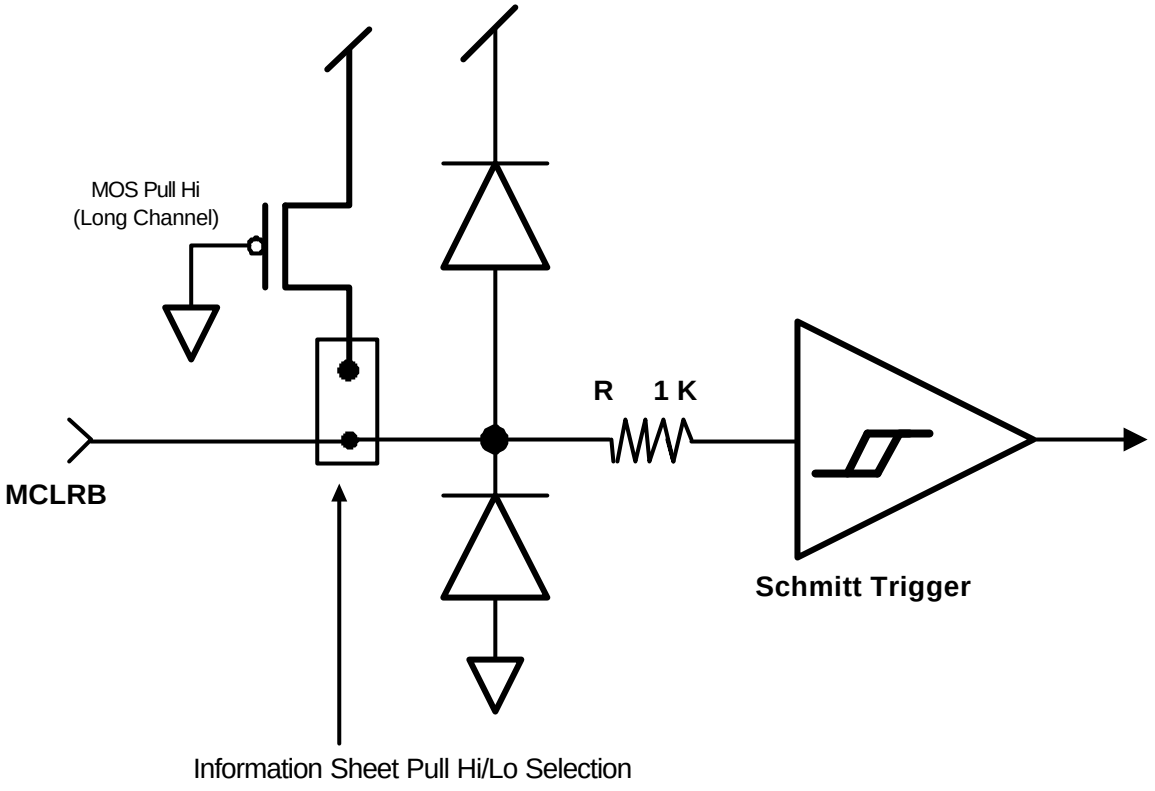
@Temperature＝25 ℃, the typical value as followings :

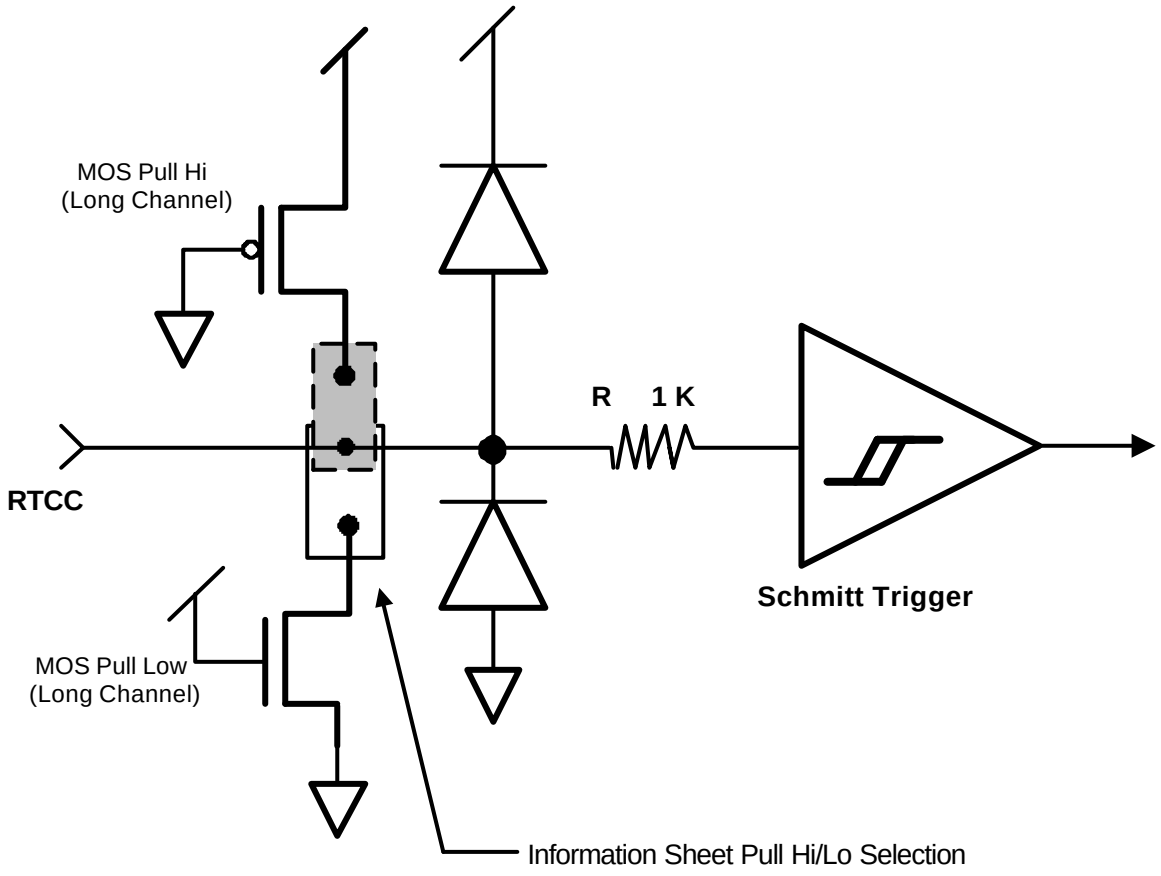
Voltage (V)	Basic WDT time-out cycle time (ms)
2.3	29.84
3.0	26.88
4.0	23.91
5.0	20.70
6.3	18.98

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

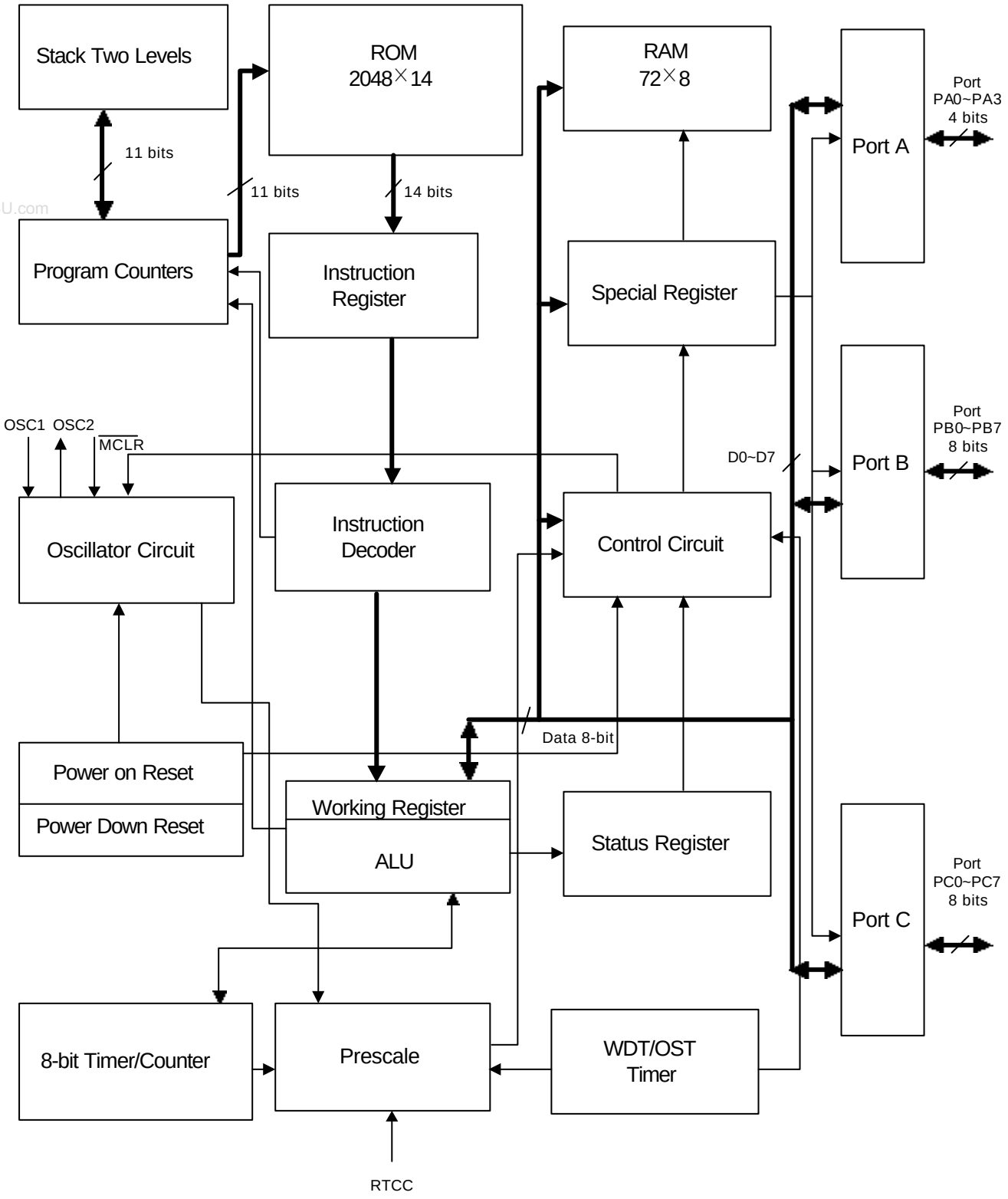


11. MCLRB and RTCC Input Equivalent Circuit





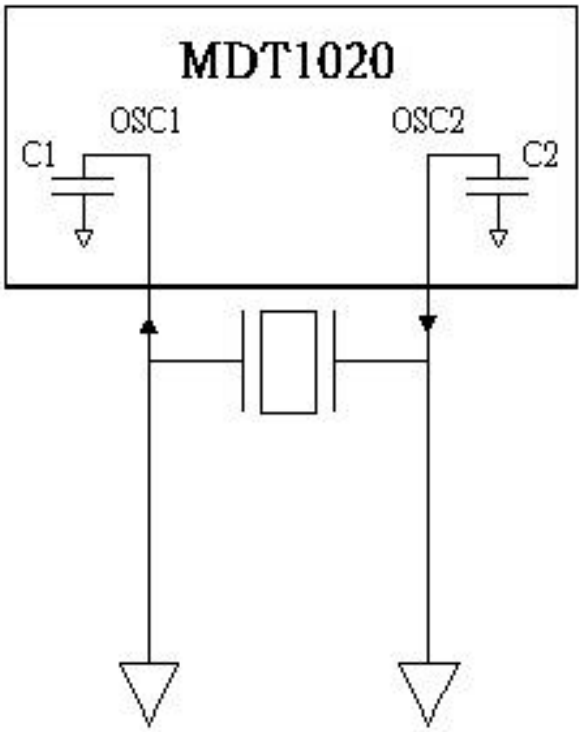
12. Block Diagram



13. Capacitor Selection For Crystal Oscillator

(a) With built-in Oscillation Capacitors (Default for HF,XT,LF)

@ V_{dd}＝2.3V~5.5 V， C1=C2=10P~15P



(b) Without built-in Oscillation Capacitors

@ V_{dd}＝3.0 V~ 5.0 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