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nuvoTon

8-BIT MICROCONTROLLER

Table of Contents-

1 GENERAL DESCRIPTION

The W78I054D/W78I052D/W78I051D series is an 8-bit microcontroller which can accommodate a wider frequency range with low power consumption. The instruction set for the W78I054D/ W78I052D/ W78I051D series is fully compatible with the standard 8052.

The W78I054D/W78I052D/W78I051D series contains 16K/8K/4K bytes Flash EPROM programmable by hardware writer; a 256 bytes RAM; four 8-bit bi-directional (P0, P1, P2, P3) and bit-addressable I/O ports; an additional 4-bit I/O port P4; three 16-bit timer/counters; a hardware watchdog timer and a serial port. These peripherals are supported by 8 sources 4-level interrupt capability. To facilitate programming and verification, the Flash EPROM inside the W78I054D/W78I052D/W78I051D series allows the program memory to be programmed and read electronically. Once the code is confirmed, the user can protect the code for security.

The W78I054D/W78I052D/W78I051D series microcontroller has two power reduction modes, idle mode and power-down mode, both of which are software selectable. The idle mode turns off the processor clock but allows for continued peripheral operation. The power-down mode stops the crystal oscillator for minimum power consumption. The external clock can be stopped at any time and in any state without affecting the processor. The W78I054D/W78I052D/W78I051D series contains In-System Programmable (ISP) 2KB LD Flash EPROM for loader program, operating voltage from 3.3V to 5.5V.

The W78I054D/W78I052D/W78I051D series feature industrial temperature rage (-40 degrees Celsius to +85 degrees Celsius).

2 FEATURES

- Fully static design 8-bit CMOS microcontroller
- Optional 12T or 6T mode
  - 12T Mode, 12 clocks per machine cycle operation (default), Speed up to 40 MHz/5V
  - 6T Mode, 6 clocks per machine cycle operation set by the writer, Speed up to 20 MHz/5V
- Wide supply voltage of 2.4V to 5.5V
- Temperature grade is (-40°C~85°C)
- Pin and Instruction-sets compatible with MCS-51
- 256 bytes of on-chip scratchpad RAM
- 16K/8K/4K bytes electrically erasable/programmable Flash EPROM
- 2K bytes LDROM support ISP function (Reference Application Note)
- 64KB program memory address space
- 64KB data memory address space
- Four 8-bit bi-directional ports
- 8-sources, 4-level interrupt capability
- One extra 4-bit bit-addressable I/O port, additional $\overline{INT2}$ / $\overline{INT3}$ (available on PQFP, PLCC and LQFP package)
- Three 16-bit timer/counters
- One full duplex serial port
- Watchdog Timer
- EMI reduction mode
- Software Reset
- Built-in power management with idle mode and power down mode
- Code protection
- Packages:
  - Lead Free (RoHS) DIP 40: W78I054DDG
  - Lead Free (RoHS) PLCC 44: W78I054DPG
  - Lead Free (RoHS) PQFP 44: W78I054DFG
  - Lead Free (RoHS) LQFP 48: W78I054DLG
  - Lead Free (RoHS) DIP 40: W78I052DDG
  - Lead Free (RoHS) PLCC 44: W78I052DPG
  - Lead Free (RoHS) PQFP 44: W78I052DFG
  - Lead Free (RoHS) LQFP 48: W78I052DLG
  - Lead Free (RoHS) DIP 40: W78I051DDG
  - Lead Free (RoHS) PLCC 44: W78I051DPG
  - Lead Free (RoHS) PQFP 44: W78I051DFG
  - Lead Free (RoHS) LQFP 48: W78I051DLG

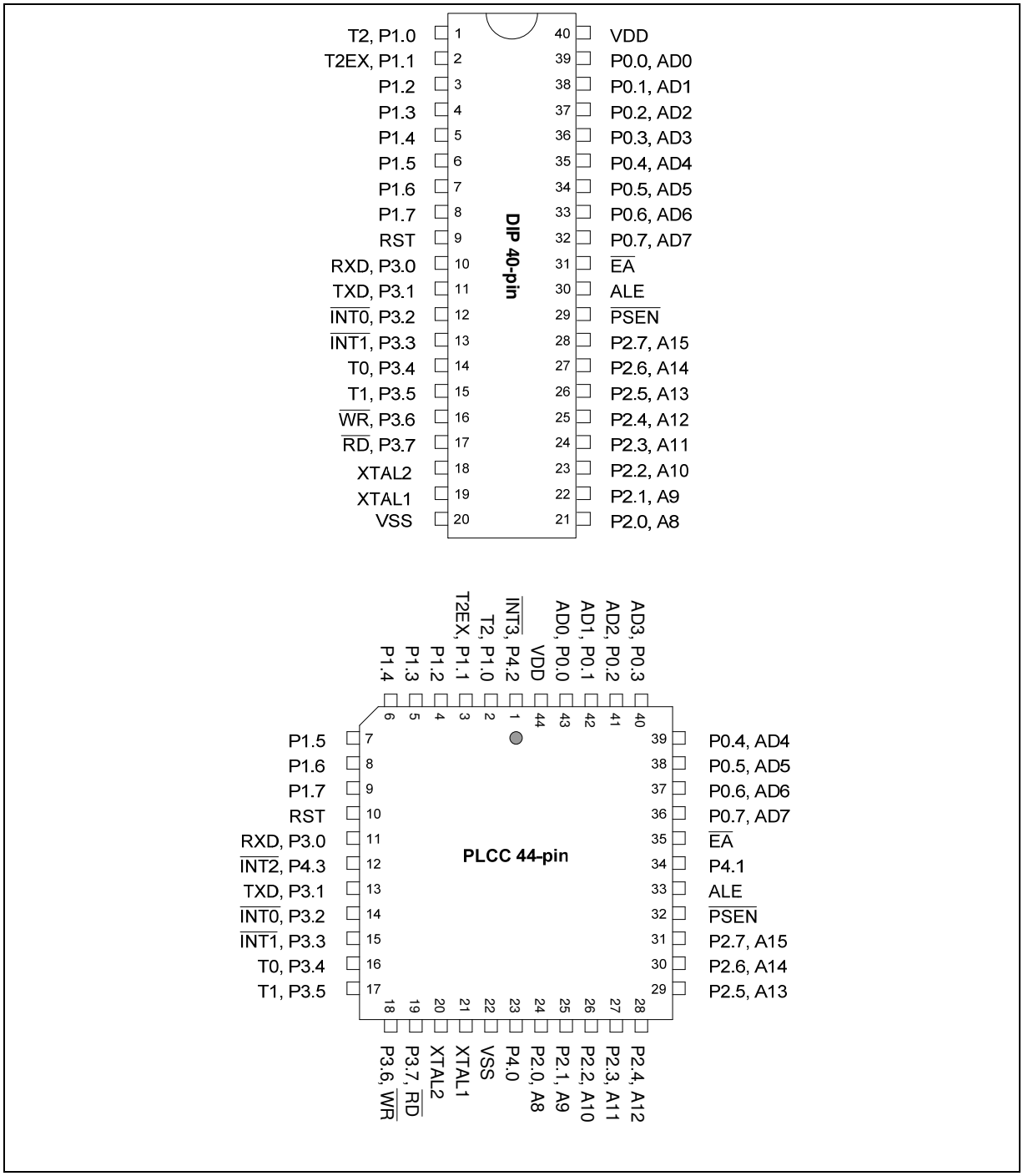
3 PARTS INFORMATION LIST

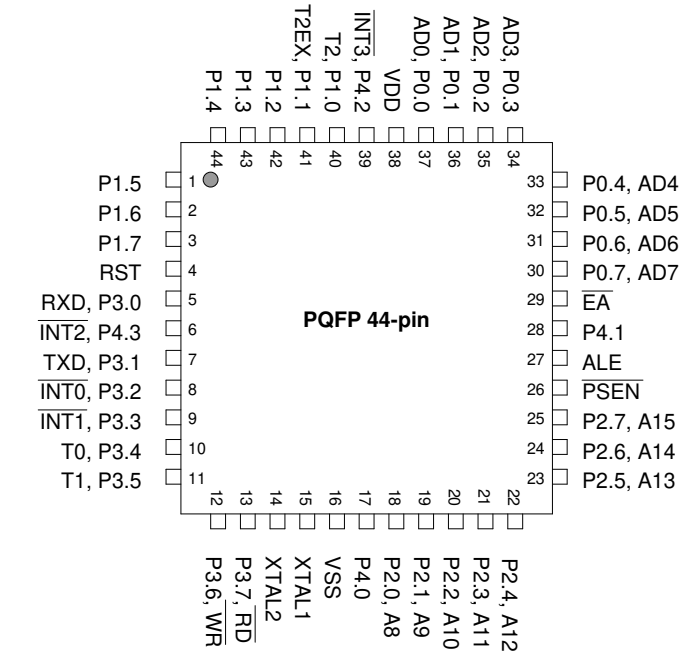
3.1 Lead Free (RoHS) Parts information list

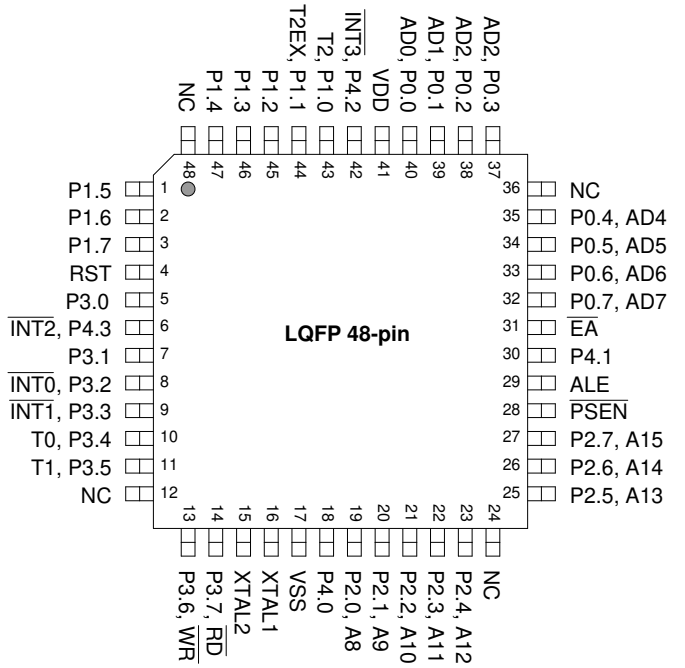
Table 3-1: Lead Free (RoHS) Parts information list

PART NO.	RAM	LD FLASH SIZE	AP FLASH SIZE	PACKAGE	Temperature grade
W78I054DDG	256 Bytes	2K Bytes	14K Bytes	DIP-40 Pin	-40°C~85°C
		0	16K Bytes		
W78I054DPG		2K Bytes	14K Bytes	PLCC-44 Pin	-40°C~85°C
		0	16K Bytes		
W78I054DFG		2K Bytes	14K Bytes	PQFP-44 Pin	-40°C~85°C
		0	16K Bytes		
W78I054DLG		2K Bytes	14K Bytes	LQFP-48 Pin	-40°C~85°C
		0	16K Bytes		
W78I052DDG		2K Bytes	8K Bytes	DIP-40 Pin	-40°C~85°C
W78I052DPG				PLCC-44 Pin	-40°C~85°C
W78I052DFG				PQFP-44 Pin	-40°C~85°C
W78I052DLG				LQFP-48 Pin	-40°C~85°C
W78I051DDG		2K Bytes	4K Bytes	DIP-40 Pin	-40°C~85°C
W78I051DPG				PLCC-44 Pin	-40°C~85°C
W78I051DFG				PQFP-44 Pin	-40°C~85°C
W78I051DLG				LQFP-48 Pin	-40°C~85°C

4 PIN CONFIGURATIONS




PQFP 44-pin
1 P1.5
2 P1.6
3 P1.7
4 RST
5 RXD, P3.0
6 INT2, P4.3
7 TXD, P3.1
8 INT0, P3.2
9 INT1, P3.3
10 T0, P3.4
11 T1, P3.5
12 P3.6, WR
13 P3.7, RD
14 XTAL2
15 XTAL1
16 VSS
17 P4.0
18 P2.0, A8
19 P2.1, A9
20 P2.2, A10
21 P2.3, A11
22 P2.4, A12
23 P2.5, A13
24 P2.6, A14
25 P2.7, A15
26 PSEN
27 ALE
28 P4.1
29 EA
30 P0.7, AD7
31 P0.6, AD6
32 P0.5, AD5
33 P0.4, AD4
34 AD3, P0.3
35 AD2, P0.2
36 AD1, P0.1
37 AD0, P0.0
38 VDD
39 INT3, P4.2
40 T2, P1.0
41 T2EX, P1.1
42 P1.2
43 P1.3
44 P1.4


LQFP 48-pin
1 P1.5
2 P1.6
3 P1.7
4 RST
5 P3.0
6 INT2, P4.3
7 P3.1
8 INT0, P3.2
9 INT1, P3.3
10 T0, P3.4
11 T1, P3.5
12 NC
13 P3.6, WR
14 P3.7, RD
15 XTAL2
16 XTAL1
17 VSS
18 P4.0
19 P2.0, A8
20 P2.1, A9
21 P2.2, A10
22 P2.3, A11
23 P2.4, A12
24 NC
25 P2.5, A13
26 P2.6, A14
27 P2.7, A15
28 PSEN
29 ALE
30 P4.1
31 EA
32 P0.7, AD7
33 P0.6, AD6
34 P0.5, AD5
35 P0.4, AD4
36 NC
37 AD2, P0.3
38 AD2, P0.2
39 AD1, P0.1
40 AD0, P0.0
41 VDD
42 INT3, P4.2
43 T2, P1.0
44 T2EX, P1.1
45 P1.2
46 P1.3
47 P1.4
48 NC

5 PIN DESCRIPTIONS

SYMBOL	TYPE	DESCRIPTIONS
$\overline{EA}$	I	EXTERNAL ACCESS ENABLE: This pin forces the processor to execute out of external ROM. It should be kept high to access internal ROM. The ROM address and data will not be present on the bus if $\overline{EA}$ pin is high and the program counter is within internal ROM area. Otherwise they will be present on the bus.
$\overline{PSEN}$	O H	PROGRAM STORE ENABLE: $\overline{PSEN}$ enables the external ROM data onto the Port 0 address/data bus during fetch and MOVC operations. When internal ROM access is performed, no $\overline{PSEN}$ strobe signal outputs from this pin.
ALE	O H	ADDRESS LATCH ENABLE: ALE is used to enable the address latch that separates the address from the data on Port 0.
RST	I L	RESET: A high on this pin for two machine cycles while the oscillator is running resets the device.
XTAL1	I	CRYSTAL1: This is the crystal oscillator input. This pin may be driven by an external clock.
XTAL2	O	CRYSTAL2: This is the crystal oscillator output. It is the inversion of XTAL1.
VSS	I	GROUND: Ground potential
VDD	I	POWER SUPPLY: Supply voltage for operation.
P0.0–P0.7	I/O H	PORT 0: Port 0 is an open-drain bi-directional I/O port. This port also provides a multiplexed low order address/data bus during accesses to external memory.
P1.0–P1.7	I/O H	PORT 1: Port 1 is a bi-directional I/O port with internal pull-ups. The bits have alternate functions which are described below: T2 (P1.0): Timer/Counter 2 external count input T2EX (P1.1): Timer/Counter 2 Reload/Capture control
P2.0–P2.7	I/O H	PORT 2: Port 2 is a bi-directional I/O port with internal pull-ups. This port also provides the upper address bits for accesses to external memory.

Pin Description, continued

SYMBOL	TYPE	DESCRIPTIONS
P3.0–P3.7	I/O H	PORT 3: Port 3 is a bi-directional I/O port with internal pull-ups. All bits have alternate functions, which are described below: RXD (P3.0): Serial Port 0 input TXD (P3.1): Serial Port 0 output $\overline{INT0}$ (P3.2) : External Interrupt 0 $\overline{INT1}$ (P3.3) : External Interrupt 1 T0 (P3.4) : Timer 0 External Input T1 (P3.5) : Timer 1 External Input $\overline{WR}$ (P3.6) : External Data Memory Write Strobe $\overline{RD}$ (P3.7) : External Data Memory Read Strobe
P4.0–P4.3	I/O H	PORT 4: Another bit-addressable bidirectional I/O port P4. P4.3 and P4.2 are alternative function pins. It can be used as general I/O port or external interrupt input sources ($\overline{INT2}$ / $\overline{INT3}$).

* Note: TYPE I: input, O: output, I/O: bi-directional, H: pull-high, L: pull-low, D: open drain.

In application if MCU pins need external pull-up, it is recommended to add a pull-up resistor (10KΩ) between pin and power (V_{DD}) instead of directly wiring pin to V_{DD} for enhancing EMC.

6 BLOCK DIAGRAM

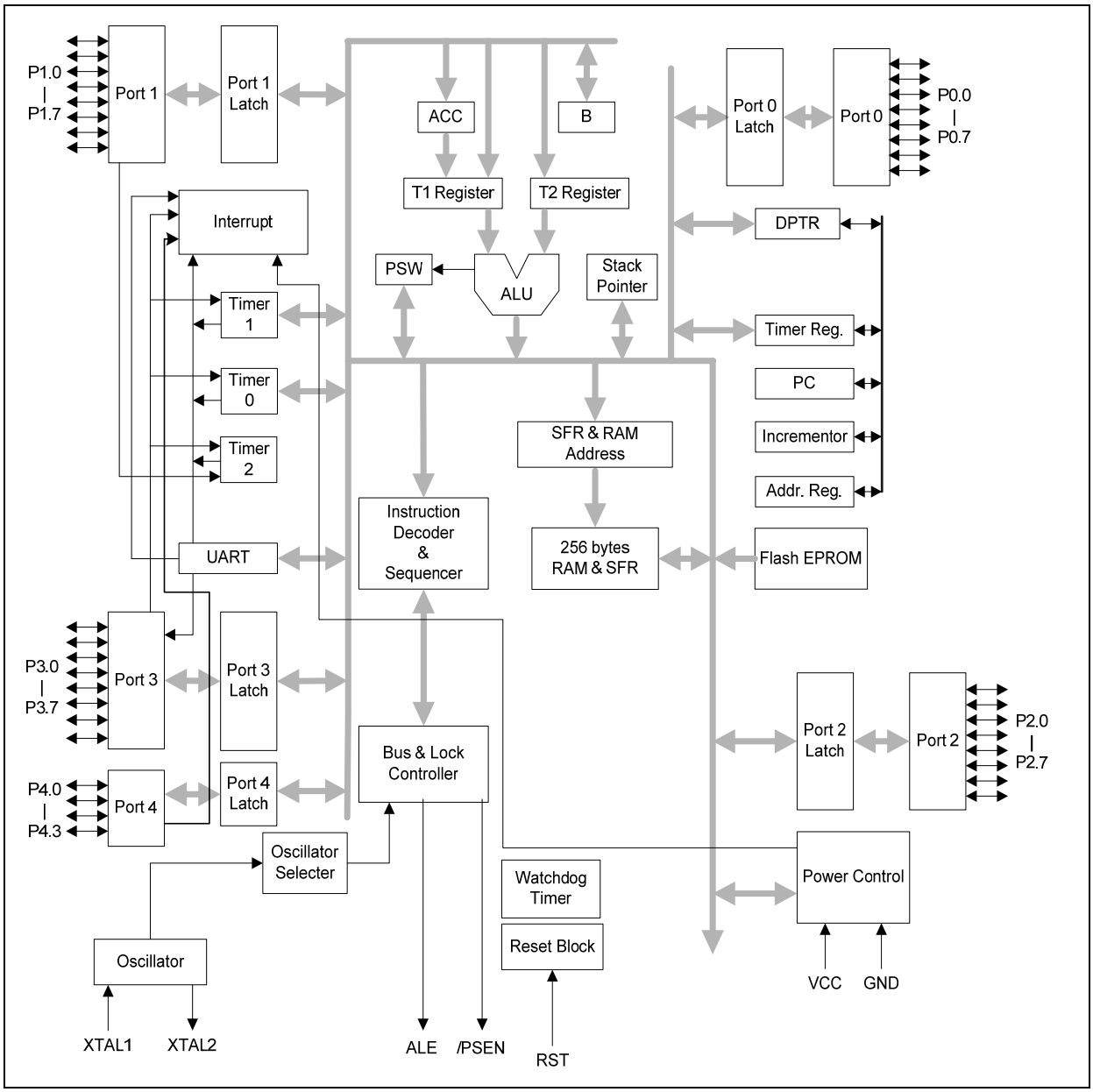


Figure 6- 1 W78I054D/W78I052D/W78I051D Block Diagram

7 FUNCTIONAL DESCRIPTION

The W78I054D/W78I052D/W78I051D series architecture consists of a core controller surrounded by various registers, five general purpose I/O ports, 16K/8K/4K flash EPROM, 2K FLASH EPROM for ISP function, 256 bytes of RAM, three timer/counters, and a serial port. The processor supports 111 different op-codes and references both a 64K program address space and a 64K data storage space.

7.1 On-Chip Flash EPROM

The W78I054D/W78I052D/W78I051D series include one 16K/8K/4K bytes of main Flash EPROM for application program.

7.2 I/O Ports

The W78I054D/W78I052D/W78I051D series has four 8-bit ports and one extra 4-bit port. Port 0 can be used as an Address/Data bus when external program is running or external memory/device is accessed by MOVC or MOVX instruction. In these cases, it has strong pull-ups and pull-downs, and does not need any external pull-ups. Otherwise it can be used as a general I/O port with open-drain circuit. Port 2 is used chiefly as the upper 8-bits of the Address bus when port 0 is used as an address/data bus. It also has strong pull-ups and pull-downs when it serves as an address bus. Port1 and 3 act as I/O ports with alternate functions. Port 4 is only available on PLCC/PQFP/LQFP package type. It serves as a general purpose I/O port as Port 1 and Port 3. Another bit-addressable bidirectional I/O port P4. P4.3 and P4.2 are alternative function pins. It can be used as general I/O port or external interrupt input sources ($\overline{INT2}$ / $\overline{INT3}$).

7.3 Serial I/O

The W78I054D/W78I052D/W78I051D series have one serial port that is functionally similar to the serial port of the original 8032 family. However the serial port on the W78I054D/ W78I052D/ W78I051D series can operate in different modes in order to obtain timing similarity as well.

7.4 Timers

Timers 0, 1, and 2 each consist of two 8-bit data registers. These are called TL0 and TH0 for Timer 0, TL1 and TH1 for Timer 1, and TL2 and TH2 for Timer 2. The TCON and TMOD registers provide control functions for timers 0 and 1. The T2CON register provides control functions for Timer 2. RCAP2H and RCAP2L are used as reload/capture registers for Timer 2.

The operations of Timer 0 and Timer 1 are the same as in the 8051 CPU. Timer 2 is a special feature of the W78I054D/W78I052D/W78I051D: it is a 16-bit timer/counter that is configured and controlled by the T2CON register. Like Timers 0 and 1, Timer 2 can operate as either an external event counter or as an internal timer, depending on the setting of bit C/T2 in T2CON. Timer 2 has three operating modes: capture, auto-reload, and baud rate generator. The clock speed at capture or auto-reload mode is the same as that of Timers 0 and 1.

7.5 Interrupts

The Interrupt structure in the W78I054D/W78I052D/W78I051D is slightly different from that of the standard 8052. Due to the presence of additional features and peripherals, the number of interrupt sources and vectors has been increased. The W78I054D/W78I052D/W78I051D provides 8 interrupt resources with four priority level, including four external interrupt sources, three timer interrupts, serial I/O interrupts.

7.6 Data Pointers

The data pointer of W78I054D/W78I052D/W78I051D series is same as standard 8052 that have one 16-bit Data Pointer (DPTR).

7.7 Architecture

The W78I054D/W78I052D/W78I051D series are based on the standard 8052 device. It is built around an 8-bit ALU that uses internal registers for temporary storage and control of the peripheral devices. It can execute the standard 8052 instruction set.

7.7.1 ALU

The ALU is the heart of the W78I054D/W78I052D/W78I051D series. It is responsible for the arithmetic and logical functions. It is also used in decision making, in case of jump instructions, and is also used in calculating jump addresses. The user cannot directly use the ALU, but the Instruction Decoder reads the op-code, decodes it, and sequences the data through the ALU and its associated registers to generate the required result. The ALU mainly uses the ACC which is a special function register (SFR) on the chip. Another SFR, namely B register is also used Multiply and Divide instructions. The ALU generates several status signals which are stored in the Program Status Word register (PSW).

7.7.2 Accumulator

The Accumulator (ACC) is the primary register used in arithmetic, logical and data transfer operations in the W78I054D/W78I052D/W78I051D series. Since the Accumulator is directly accessible by the CPU, most of the high speed instructions make use of the ACC as one argument.

7.7.3 B Register

This is an 8-bit register that is used as the second argument in the MUL and DIV instructions. For all other instructions it can be used simply as a general purpose register.

7.7.4 Program Status Word

This is an 8-bit SFR that is used to store the status bits of the ALU. It holds the Carry flag, the Auxiliary Carry flag, General purpose flags, the Register Bank Select, the Overflow flag, and the Parity flag.

7.7.5 Scratch-pad RAM

The W78I054D/W78I052D/W78I051D series has a 256 byte on-chip scratch-pad RAM. This can be used by the user for temporary storage during program execution. A certain section of this RAM is bit addressable, and can be directly addressed for this purpose.

7.7.6 Stack Pointer

The W78I054D/W78I052D/W78I051D series has an 8-bit Stack Pointer which points to the top of the Stack. This stack resides in the Scratch Pad RAM in the W78I054D/W78I052D/W78I051D. Hence the size of the stack is limited by the size of this RAM.

8 MEMORY ORGANIZATION

The W78I054D/W78I052D/W78I051D series separate the memory into two separate sections, the Program Memory and the Data Memory. The Program Memory is used to store the instruction op-codes, while the Data Memory is used to store data or for memory mapped devices.

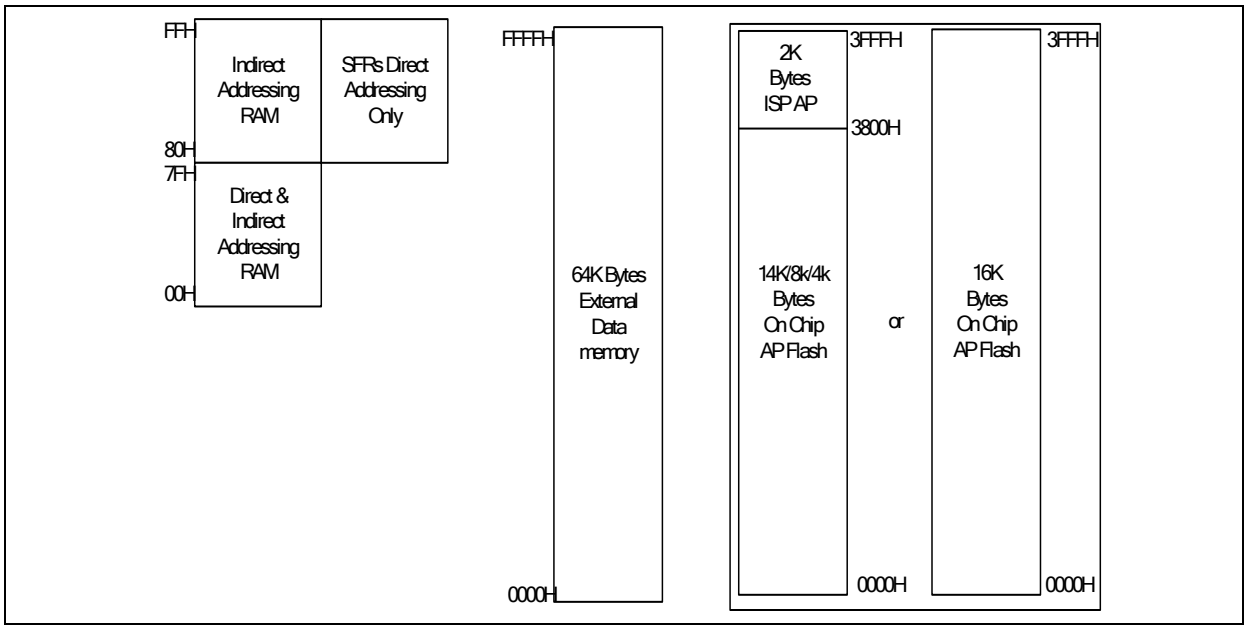


Figure 8- 1 Memory Map

8.1 Program Memory (on-chip Flash)

The Program Memory on the W78I054D/W78I052D/W78I051D series can be up to 16K/8K/4K bytes (2K bytes for ISP F/W, share with the W78E054D) long. All instructions are fetched for execution from this memory area. The MOVC instruction can also access this memory region.

8.2 Scratch-pad RAM and Register Map

As mentioned before the W78I054D/W78I052D/W78I051D series have separate Program and Data Memory areas. There are also several Special Function Registers (SFRs) which can be accessed by software. The SFRs can be accessed only by direct addressing, while the on-chip RAM can be accessed by either direct or indirect addressing.

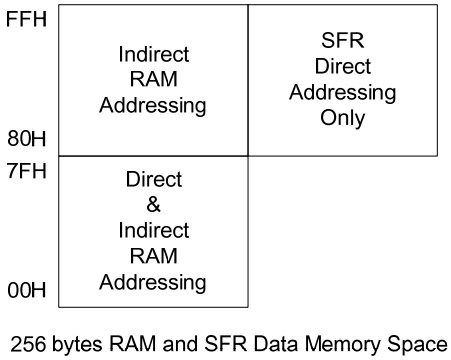


Figure 8- 2 W78I054D/W78I052D/W78I051D RAM and SFR Memory Map

Since the scratch-pad RAM is only 256bytes it can be used only when data contents are small. There are several other special purpose areas within the scratch-pad RAM. These are illustrated in next figure.

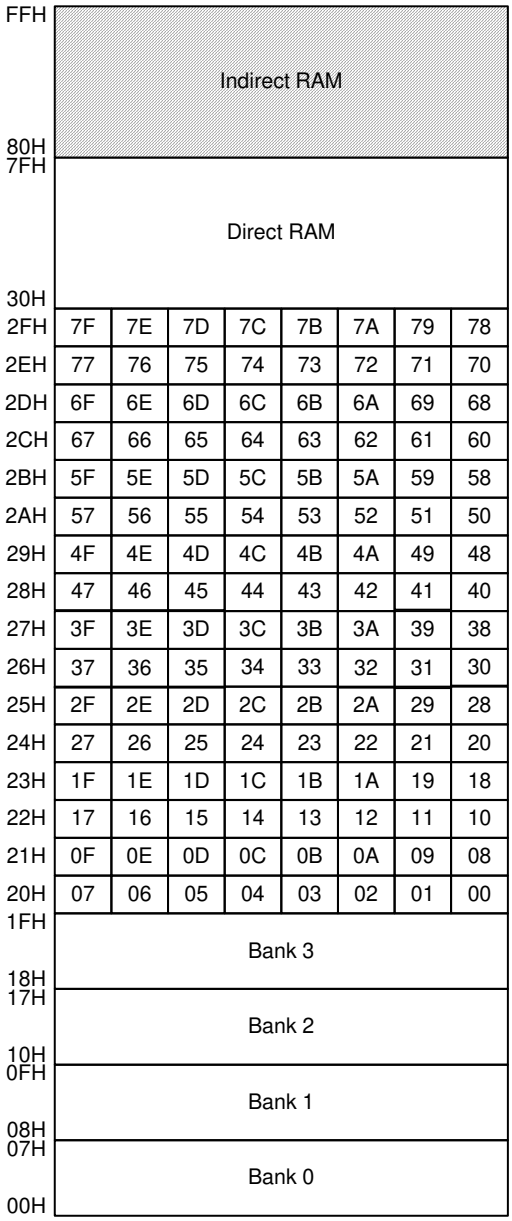


Figure 8- 3 Scratch-pad RAM

8.2.1 Working Registers

There are four sets of working registers, each consisting of eight 8-bit registers. These are termed as Banks 0, 1, 2, and 3. Individual registers within these banks can be directly accessed by separate instructions. These individual registers are named as R0, R1, R2, R3, R4, R5, R6 and R7. However, at one time the W78I054D/W78I052D/W78I051D series can work with only one particular bank. The bank selection is done by setting RS1-RS0 bits in the PSW. The R0 and R1 registers are used to store the address for indirect accessing.

8.2.2 Bit addressable Locations

The Scratch-pad RAM area from location 20h to 2Fh is byte as well as bit addressable. This means that a bit in this area can be individually addressed. In addition some of the SFRs are also bit addressable. The instruction decoder is able to distinguish a bit access from a byte access by the type of the instruction itself. In the SFR area, any existing SFR whose address ends in a 0 or 8 is bit addressable.

8.2.3 Stack

The scratch-pad RAM can be used for the stack. This area is selected by the Stack Pointer (SP), which stores the address of the top of the stack. Whenever a jump, call or interrupt is invoked the return address is placed on the stack. There is no restriction as to where the stack can begin in the RAM. By default however, the Stack Pointer contains 07h at reset. The user can then change this to any value desired. The SP will point to the last used value. Therefore, the SP will be incremented and then address saved onto the stack. Conversely, while popping from the stack the contents will be read first, and then the SP is decreased.

9 SPECIAL FUNCTION REGISTERS

The W78I054D/W78I052D/W78I051D series uses Special Function Registers (SFRs) to control and monitor peripherals and their Modes. The SFRs reside in the register locations 80-FFh and are accessed by direct addressing only. Some of the SFRs are bit addressable. This is very useful in cases where users wish to modify a particular bit without changing the others. The SFRs that are bit addressable are those whose addresses end in 0 or 8. The W78I054D/W78I052D/W78I051D series contain all the SFRs present in the standard 8052. However some additional SFRs are added. In some cases the unused bits in the original 8052, have been given new functions. The list of the SFRs is as follows.

F8									FF
F0	B								F7
E8									EF
E0	ACC								E7
D8	P4								DF
D0	PSW								D7
C8	T2CON	T2MOD	RCAP2L	RCAP2H	TL2	TH2			CF
C0	XICON				SFRAL	SFRAH	SFRRD	SFRCN	C7
B8	IP						EAPAGE	CHPCON	BF
B0	P3							IPH	B7
A8	IE								AF
A0	P2								A7
98	SCON	SBUF							9F
90	P1								97
88	TCON	TMOD	TL0	TL1	TH0	TH1	AUXR	WDTC	8F
80	P0	SP	DPL	DPH			P0UPR	PCON	87

Table 9-1: Special Function Register Location Table

Note:

1. The SFRs in the column with dark borders are bit-addressable

2. The table is condensed with eight locations per row. Empty locations indicate that these are no registers at these addresses. When a bit or register is not implemented, it will read high.

Special Function Registers:

SYMBOL	DEFINITION	ADDRESS	MSB			BIT ADDRESS, SYMBOL				LSB	RESET
B	B register	F0H	(F7)	(F6)	(F5)	(F4)	(F3)	(F2)	(F1)	(F0)	0000 0000B
ACC	Accumulator	E0H	(E7)	(E6)	(E5)	(E4)	(E3)	(E2)	(E1)	(E0)	0000 0000B
P4	Port 4	D8H					INT2	INT3			0000 1111B
PSW	Program status word	D0H	(D7) CY	(D6) AC	(D5) F0	(D4) RS1	(D3) RS0	(D2) OV	(D1) F1	(D0) P	0000 0000B
TH2	T2 reg. high	CDH									0000 0000B
TL2	T2 reg. low	CCH									0000 0000B
RCAP2H	T2 capture low	CBH									0000 0000B
RCAP2L	T2 capture high	CAH									0000 0000B
T2MOD	Timer 2 Mode	C9								DCEN	0000 0000B
T2CON	Timer 2 control	C8H	(CF) TF2	(CE) EXF2	(CD) RCLK	(CC) TCLK	(CB) EXEN2	(CA) TR2	(C9) C/T2	(C8) CP/RL2	0000 0000B
SFRCN	SFR program of control	C7H			NOE	NCE	CTRL3	CTRL2	CTRL1	CTRL0	0000 0000B
SFRRD	SFR program of data register	C6H									0000 0000B
SFRAH	SFR program of address high byte	C5H									0000 0000B
SFRAL	SFR program of address low byte	C4H									0000 0000B
XICON	External interrupt control	C0H	PX3	EX3	IE3	IT3	PX2	EX2	IE2	IT2	0000 0000B
CHPCON	Chip control	BFH	SWRST	-		-	-	-	FBOOTSL	ENP	0000 0000B
EAPAGE	Erase page operation modes	BEH							EAPG1	EAPG0	0000 0000B
IP	Interrupt priority	B8H	(BF) -	(BE) -	(BD) PT2	(BC) PS	(BB) PT1	(BA) PX1	(B9) PT0	(B8) PX0	1100 0000B
IPH	Interrupt priority High	B7H									0000 0000B
P3	Port 3	B0H	(B7) RD	(B6) WR	(B5) T1	(B4) T0	(B3) INT1	(B2) INT0	(B1) TXD	(B0) RXD	1111 1111B
IE	Interrupt enable	A8H	(AF) EA	(AE) -	(AD) ET2	(AC) ES	(AB) ET1	(AA) EX1	(A9) ET0	(A8) EX0	0100 0000B
P2	Port 2	A0H	(A7) A15	(A6) A14	(A5) A13	(A4) A12	(A3) A11	(A2) A10	(A1) A9	(A0) A8	1111 1111B
SBUF	Serial buffer	99H									0000 0000B
SCON	Serial control	98H	(9F) SM0/FE	(9E) SM1	(9D) SM2	(9C) REN	(9B) TB8	(9A) RB8	(99) TI	(98) RI	0000 0000B
P1	Port 1	90H	(97)	(96)	(95)	(94)	(93)	(92)	(91) T2EX	(90) T2	1111 1111B
WDTC	Watchdog control	8FH	ENW	CLRW	WIDL	-	-	PS2	PS1	PS0	0000 0000B
AUXR	Auxiliary	8EH	-	-	-	-				ALEOFF	0000 0110B
TH1	Timer high 1	8DH									0000 0000B
TH0	Timer high 0	8CH									0000 0000B
TL1	Timer low 1	8BH									0000 0000B
TL0	Timer low 0	8AH									0000 0000B
TMOD	Timer mode	89H	GATE	C/T	M1	M0	GATE	C/T	M1	M0	0000 0000B
TCON	Timer control	88H	(8F) TF1	(8E) TR1	(8D) TF0	(8C) TR0	(8B) IE1	(8A) IT1	(89) IE0	(88) IT0	0000 0000B
PCON	Power control	87H	SMOD	SMOD0	-	POR	GF1	GF0	PD	IDL	0011 0000B
P0UPR	Port 0 pull up option Register	86H	-	-	-	-	-	-	-	P0UP	0000 0001B
DPH	Data pointer high	83H									0000 0000B

DPL	Data pointer low	82H									0000 0000B
SP	Stack pointer	81H									0000 0111B
P0	Port 0	80H	(87)	(86)	(85)	(84)	(83)	(82)	(81)	(80)	1111 1111B

9.1 SFR Detail Bit Descriptions

Port 0

Bit:	7	6	5	4	3	2	1	0
	P0.7	P0.6	P0.5	P0.4	P0.3	P0.2	P0.1	P0.0

Mnemonic: P0 Address: 80h

BIT	NAME	FUNCTION
7-0	P0.[7:0]	Port 0 is an open-drain bi-directional I/O port if SFR P0UPR.0 (bit P0UP) clear to “0”, and when SFR P0UPR.0 (bit P0UP) set to “1”, Port 0 pins are internally pulled-up. This port also provides a multiplexed low order address/data bus during accesses to external memory.

STACK POINTER

Bit:	7	6	5	4	3	2	1	0
	SP.7	SP.6	SP.5	SP.4	SP.3	SP.2	SP.1	SP.0

Mnemonic: SP Address: 81h

BIT	NAME	FUNCTION
7-0	SP.[7:0]	The Stack Pointer stores the Scratch-pad RAM address where the stack begins. In other words it always points to the top of the stack.

DATA POINTER LOW

Bit:	7	6	5	4	3	2	1	0
	DPL.7	DPL.6	DPL.5	DPL.4	DPL.3	DPL.2	DPL.1	DPL.0

Mnemonic: DPL Address: 82h

BIT	NAME	FUNCTION
7-0	DPL.[7:0]	This is the low byte of the standard 8052 16-bit data pointer.

DATA POINTER HIGH

Bit:	7	6	5	4	3	2	1	0
	DPH.7	DPH.6	DPH.5	DPH.4	DPH.3	DPH.2	DPH.1	DPH.0

Mnemonic: DPH Address: 83h

BIT	NAME	FUNCTION
7-0	DPH.[7:0]	This is the high byte of the standard 8052 16-bit data pointer.

Port 0 Pull Up Option Register

Bit:	7	6	5	4	3	2	1	0

-	-	-	-	-	-	-	P0UP

Mnemonic: P0UPR Address: 86h

BIT	NAME	FUNCTION
0	P0UP	0: Port 0 pins are open-drain. 1: Port 0 pins are internally pulled-up. Port 0 is structurally the same as Port 2.

Power Control

Bit:	7	6	5	4	3	2	1	0
	SMOD	SMOD0	-	POR	GF1	GF0	PD	IDL

Mnemonic: PCON Address: 87h

BIT	NAME	FUNCTION
7	SMOD	1: This bit doubles the serial port baud rate in mode 1, 2, and 3 when set to 1.
6	SMOD 0	0: Framing Error Detection Disable. SCON.7 (SM0/FE) bit is used as SM0 (standard 8052 function). 1: Framing Error Detection Enable. SCON.7 (SM0/FE) bit is used to reflect as Frame Error (FE) status flag.
5	-	Reserved
4	POR	0: Cleared by software. 1: Set automatically when a power-on reset has occurred.
3	GF1	General purpose user flags.
2	GF0	General purpose user flags.
1	PD	1: The CPU goes into the POWER DOWN mode. In this mode, all the clocks are stopped and program execution is frozen.
0	IDL	1: The CPU goes into the IDLE mode. In this mode, the clocks CPU clock stopped, so program execution is frozen. But the clock to the serial, timer and interrupt blocks is not stopped, and these blocks continue operating.

Timer Control

Bit:	7	6	5	4	3	2	1	0
	TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0

Mnemonic: TCON Address: 88h

BIT	NAME	FUNCTION
7	TF1	Timer 1 Overflow Flag. This bit is set when Timer 1 overflows. It is cleared automatically when the program does a timer 1 interrupt service routine. Software can also set or clear this bit.
6	TR1	Timer 1 Run Control. This bit is set or cleared by software to turn timer/counter on or off.
5	TF0	Timer 0 Overflow Flag. This bit is set when Timer 0 overflows. It is cleared automatically when the program does a timer 0 interrupt service routine. Software can also set or clear this bit.

4	TR0	Timer 0 Run Control. This bit is set or cleared by software to turn timer/counter on or off.
3	IE1	Interrupt 1 Edge Detect Flag: Set by hardware when an edge/level is detected on $\overline{INT1}$. This bit is cleared by hardware when the service routine is vectored to only if the interrupt was edge triggered. Otherwise it follows the inverse of the pin.
2	IT1	Interrupt 1 Type Control. Set/cleared by software to specify falling edge/ low level triggered external inputs.
1	IE0	Interrupt 0 Edge Detect Flag. Set by hardware when an edge/level is detected on $\overline{INT0}$. This bit is cleared by hardware when the service routine is vectored to only if the interrupt was edge triggered. Otherwise it follows the inverse of the pin.
0	IT0	Interrupt 0 Type Control: Set/cleared by software to specify falling edge/ low level triggered external inputs.

Timer Mode Control

Bit:	7	6	5	4	3	2	1	0
	GATE	C/$\overline{T}$	M1	M0	GATE	C/$\overline{T}$	M1	M0
	TIMER1				TIMER0			

Mnemonic: TMOD Address: 89h

BIT	NAME	FUNCTION
7	GATE	Gating control: When this bit is set, Timer/counter 1 is enabled only while the $\overline{INT1}$ pin is high and the TR1 control bit is set. When cleared, the $\overline{INT1}$ pin has no effect, and Timer 1 is enabled whenever TR1 control bit is set.
6	C/$\overline{T}$	Timer or Counter Select: When clear, Timer 1 is incremented by the internal clock. When set, the timer counts falling edges on the T1 pin.
5	M1	Timer 1 mode select bit 1. See table below.
4	M0	Timer 1 mode select bit 0. See table below.
3	GATE	Gating control: When this bit is set, Timer/counter 0 is enabled only while the $\overline{INT0}$ pin is high and the TR0 control bit is set. When cleared, the $\overline{INT0}$ pin has no effect, and Timer 0 is enabled whenever TR0 control bit is set.
2	C/$\overline{T}$	Timer or Counter Select: When clear, Timer 0 is incremented by the internal clock. When set, the timer counts falling edges on the T0 pin.
1	M1	Timer 0 mode select bit 1. See table below.
0	M0	Timer 0 mode select bit 0. See table below.

M1, M0: Mode Select bits:

M1	M0	MODE
0	0	Mode 0: 13-bit timer/counter TLx serves as 5-bit pre-scale.
0	1	Mode 1: 16-bit timer/counter, no pre-scale.
1	0	Mode 2: 8-bit timer/counter with auto-reload from THx.
1	1	Mode 3: (Timer 0) TL0 is an 8-bit timer/counter controlled by the standard Timer0 control bits. TH0 is an 8-bit timer only controlled by Timer1 control bits. (Timer 1)

		Timer/Counter 1 is stopped.

Timer 0 LSB

Bit:	7	6	5	4	3	2	1	0
	TL0.7	TL0.6	TL0.5	TL0.4	TL0.3	TL0.2	TL0.1	TL0.0

Mnemonic: TL0 Address: 8Ah

BIT	NAME	FUNCTION
7-0	TL0.[7:0]	Timer 0 LSB.

Timer 1 LSB

Bit:	7	6	5	4	3	2	1	0
	TL1.7	TL1.6	TL1.5	TL1.4	TL1.3	TL1.2	TL1.1	TL1.0

Mnemonic: TL1 Address: 8Bh

BIT	NAME	FUNCTION
7-0	TL1.[7:0]	Timer 1 LSB.

Timer 0 MSB

Bit:	7	6	5	4	3	2	1	0
	TH0.7	TH0.6	TH0.5	TH0.4	TH0.3	TH0.2	TH0.1	TH0.0

Mnemonic: TH0 Address: 8Ch

BIT	NAME	FUNCTION
7-0	TH0.[7:0]	Timer 0 MSB.

Timer 1 MSB

Bit:	7	6	5	4	3	2	1	0
	TH1.7	TH1.6	TH1.5	TH1.4	TH1.3	TH1.2	TH1.1	TH1.0

Mnemonic: TH1 Address: 8Dh

BIT	NAME	FUNCTION
7-0	TH1.[7:0]	Timer 1 MSB.

AUXR

Bit:	7	6	5	4	3	2	1	0
	-	-	-	-	-	-	-	ALE_OFF

Mnemonic: AUXR Address: 8Eh

BIT	NAME	FUNCTION
0	ALE_OFF	1: Disenable ALE output 0: Enable ALE output

Watchdog Timer Control Register

Bit:	7	6	5	4	3	2	1	0
	ENW	CLRW	WIDL	-	-	PS2	PS1	PS0

Mnemonic: WDTC Address: 8FH

BIT	NAME	FUNCTION
7	ENW	Enable watch-dog if set.
6	CLRW	Clear watch-dog timer and Pre-scalar if set. This flag will be cleared automatically.
5	WIDL	If this bit is set, watch-dog is enabled under IDLE mode. If cleared, watch-dog is disabled under IDLE mode. Default is cleared.
2-0	PS2-0	Watch-dog Pre-scalar timer select. Pre-scalar is selected when set PS2–0 as follows:

PS2	PS1	PS0	PRE-SCALAR SELECT
0	0	0	2
0	0	1	8
0	1	0	4
0	1	1	16
1	0	0	32
1	0	1	64
1	1	0	128
1	1	1	256

Port 1

Bit:	7	6	5	4	3	2	1	0
	P1.7	P1.6	P1.5	P1.4	P1.3	P1.2	P1.1	P1.0

Mnemonic: P1 Address: 90h

BIT	NAME	FUNCTION
7-0	P1.[7:0]	General purpose I/O port. Most instructions will read the port pins in case of a port read access, however in case of read-modify-write instructions, the port latch is read.

Serial Port Control

Bit:	7	6	5	4	3	2	1	0
	SM0/FE	SM1	SM2	REN	TB8	RB8	TI	RI

Mnemonic: SCON Address: 98h

BIT	NAME	FUNCTION
7	SM0/FE	Serial port mode select bit 0 or Framing Error Flag: The SMOD0 bit in PCON SFR determines whether this bit acts as SM0 or as FE. The operation of SM0 is described below. When used as FE, this bit will be set to indicate an invalid stop bit. This bit must be manually cleared in software to clear the FE condition.
6	SM1	Serial Port mode select bit 1. See table below.
5	SM2	Multiple processors communication. Setting this bit to 1 enables the multiprocessor communication feature in mode 2 and 3. In mode 2 or 3, if SM2 is set to 1, then RI will not be activated if the received 9th data bit (RB8) is 0. In mode 1, if SM2 = 1, then RI will not be activated if a valid stop bit was not received. In mode 0, the SM2 bit controls the serial port clock. If set to 0, then the serial port runs at a divide by 12 clock of the oscillator. This gives compatibility with the standard 8052. When set to 1, the serial clock become divide by 4 of the oscillator clock. This results in faster synchronous serial communication.
4	REN	Receive enable: 0: Disable serial reception. 1: Enable serial reception.
3	TB8	This is the 9th bit to be transmitted in modes 2 and 3. This bit is set and cleared by software as desired.
2	RB8	In modes 2 and 3 this is the received 9th data bit. In mode 1, if SM2 = 0, RB8 is the stop bit that was received. In mode 0 it has no function.
1	TI	Transmit interrupt flag: This flag is set by hardware at the end of the 8th bit time in mode 0, or at the beginning of the stop bit in all other modes during serial transmission. This bit must be cleared by software.
0	RI	Receive interrupt flag: This flag is set by hardware at the end of the 8th bit time in mode 0, or halfway through the stop bits time in the other modes during serial reception. However the restrictions of SM2 apply to this bit. This bit can be cleared only by software.

SM1, SM0: Mode Select bits:

Mode	SM0	SM1	Description	Length	Baud Rate
0	0	0	Synchronous	8	Tclk divided by 4 or 12
1	0	1	Asynchronous	10	Variable
2	1	0	Asynchronous	11	Tclk divided by 32 or 64
3	1	1	Asynchronous	11	Variable

Serial Data Buffer

Bit:	7	6	5	4	3	2	1	0
	SBUF.7	SBUF.6	SBUF.5	SBUF.4	SBUF.3	SBUF.2	SBUF.1	SBUF.0

Mnemonic: SBUF Address: 99h