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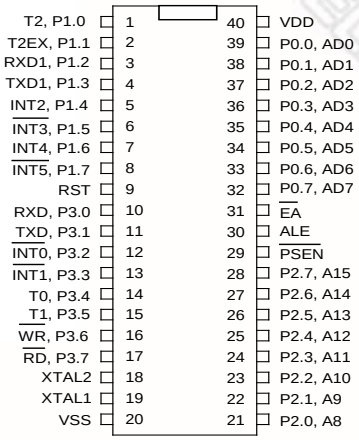
Applications of "Embedded - Microcontrollers"

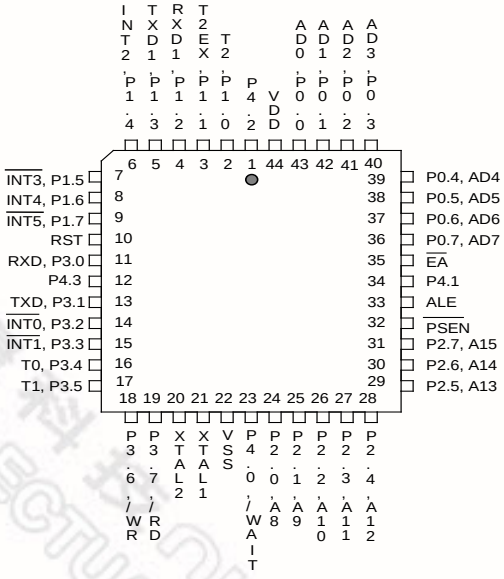
Details	
Product Status	Active
Core Processor	8051
Core Size	8-Bit
Speed	25MHz
Connectivity	EBI/EMI, Serial Port
Peripherals	POR, WDT
Number of I/O	36
Program Memory Size	128KB (128K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	1K x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	-
Oscillator Type	Internal
Operating Temperature	0°C ~ 70°C (TA)
Mounting Type	Surface Mount
Package / Case	44-LCC (J-Lead)
Supplier Device Package	-
Purchase URL	https://www.e-xfl.com/product-detail/nuvoton-technology-corporation-america/w77l532a25pl

3. PIN CONFIGURATIONS

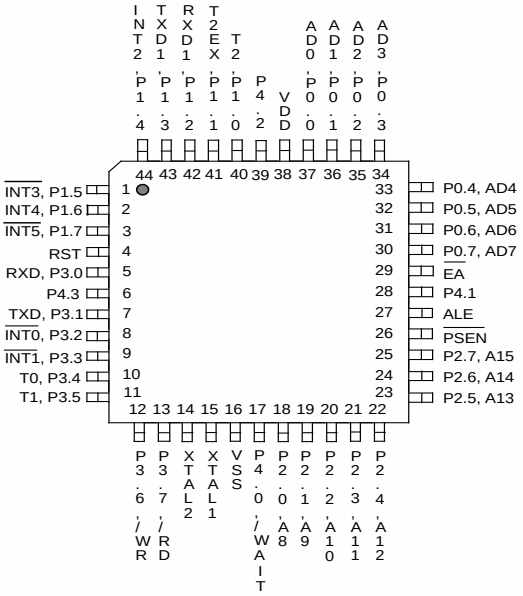
40-Pin DIP



44-Pin PLCC



44-Pin QFP



5. FUNCTIONAL DESCRIPTION

The W77L532 is 8052 pin compatible and instruction set compatible. It includes the resources of the standard 8052 such as four 8-bit I/O Ports, three 16-bit timer/counters, full duplex serial port and interrupt sources.

The W77L532 features a faster running and better performance 8-bit CPU with a redesigned core processor without wasted clock and memory cycles. it improves the performance not just by running at high frequency but also by reducing the machine cycle duration from the standard 8052 period of twelve clocks to four clock cycles for the majority of instructions. This improves performance by an average of 1.5 to 3 times. The W77L532 also provides dual Data Pointers (DPTRs) to speed up block data memory transfers. It can also adjust the duration of the MOVX instruction (access to off-chip data memory) between two machine cycles and nine machine cycles. This flexibility allows the W77L532 to work efficiently with both fast and slow RAMs and peripheral devices. In addition, the W77L532 contains on-chip 1KB MOVX SRAM, the address of which is between 0000H and 03FFH. It only can be accessed by MOVX instruction; this on-chip SRAM is optional under software control.

The W77L532 is an 8052 compatible device that gives the user the features of the original 8052 device, but with improved speed and power consumption characteristics. It has the same instruction set as the 8051 family, with one addition: DEC DPTR (op-code A5H, the DPTR is decreased by 1). While the original 8051 family was designed to operate at 12 clock periods per machine cycle, the W77L532 operates at a much reduced clock rate of only 4 clock periods per machine cycle. This naturally speeds up the execution of instructions. Consequently, the W77L532 can run at a higher speed as compared to the original 8052, even if the same crystal is used. Since the W77L532 is a fully static CMOS design, it can also be operated at a lower crystal clock, giving the same throughput in terms of instruction execution, yet reducing the power consumption.

The 4 clocks per machine cycle feature in the W77L532 is responsible for a three-fold increase in execution speed. The W77L532 has all the standard features of the 8052, and has a few extra peripherals and features as well.

I/O Ports

The W77L532 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. Port 1 and 3 act as I/O ports with alternate functions. Port 4 is only available on 44-pin PLCC/QFP package type. It serves as a general purpose I/O port as Port 1 and Port 3. The P4.0 has an alternate function $CP/\overline{RL2}$ which is the wait state control signal. When wait state control signal is enabled, P4.0 is input only.

Serial I/O

The W77L532 has two enhanced serial ports that are functionally similar to the serial port of the original 8052 family. However the serial ports on the W77L532 can operate in different modes in order to obtain timing similarity as well. **Note that the serial port 0 can use Timer 1 or 2 as baud rate generator, but the serial port 1 can only use Timer 1 as baud rate generator**. The serial ports have the enhanced features of Automatic Address recognition and Frame Error detection.

A brief description of the SFRs now follows.

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

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. Besides, it has internal pull-up resisters enabled by setting P0UP of P4CSIN (A2H) to high.

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

The Stack Pointer stores the Scratchpad 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

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

This is the high byte of the standard 8052 16-bit data pointer.

DATA POINTER LOW1

Bit:	7	6	5	4	3	2	1	0
	DPL1.7	DPL1.6	DPL1.5	DPL1.4	DPL1.3	DPL1.2	DPL1.1	DPL1.0

Mnemonic: DPL1 Address: 84h

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

SM0/FE: Serial port 0, Mode 0 bit 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.

SM1: Serial port Mode bit 1:

SM0	SM1	Mode	Description	Length	Baud rate
0	0	0	Synchronous	8	4/12 Tclk
0	1	1	Asynchronous	10	Variable
1	0	2	Asynchronous	11	64/32 Tclk
1	1	3	Asynchronous	11	Variable

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.

REN: Receive enable: When set to 1 serial reception is enabled, otherwise reception is disabled.

TB8: This is the 9th bit to be transmitted in modes 2 and 3. This bit is set and cleared by software as desired.

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.

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.

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.

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

SBUF.7-0: Serial data on the serial port 0 is read from or written to this location. It actually consists of two separate internal 8-bit registers. One is the receive resister, and the other is the transmit buffer. Any read access gets data from the receive data buffer, while write access is to the transmit data buffer.

Software Reset

Set CHPCON = 0X83, timer and enter IDLE mode. CPU will reset and restart from APFLASH after time out.

PORT 2

Bit:	7	6	5	4	3	2	1	0
	P2.7	P2.6	P2.5	P2.4	P2.3	P2.2	P2.1	P2.0

Mnemonic: P2 Address: A0h

P2.7-0: 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.

PORT 4 CHIP-SELECT POLARITY

Bit:	7	6	5	4	3	2	1	0
	P43INV	P42INV	P42INV	P40INV	-	-	-	P0UP

Mnemonic: P4CSIN Address: A2h

P4xINV: The active polarity of P4.x when set it as chip-select signal. High = Active High. Low = Active Low.

P0UP: Enable Port 0 weak pull up.

PORT 4

Bit:	7	6	5	4	3	2	1	0
	-	-	-	-	P4.3	P4.2	P4.1	P4.0

Mnemonic: P4 Address: A5h

P4.3-0: Port 4 is a bi-directional I/O port with internal pull-ups. Port 4 can not use bit-addressable instruction (SETB or CLR).

INTERRUPT ENABLE

Bit:	7	6	5	4	3	2	1	0
	EA	ES1	ET2	ES	ET1	EX1	ET0	EX0

Mnemonic: IE Address: A8h

EA: Global enable. Enable/disable all interrupts except for PFI.
ES1: Enable Serial Port 1 interrupt.
ET2: Enable Timer 2 interrupt.
ES: Enable Serial Port 0 interrupt.
ET1: Enable Timer 1 interrupt
EX1: Enable external interrupt 1
ET0: Enable Timer 0 interrupt
EX0: Enable external interrupt 0

RI_1: 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_1 apply to this bit. This bit can be cleared only by software.

SERIAL DATA BUFFER 1

Bit:	7	6	5	4	3	2	1	0
	SBUF1.7	SBUF1.6	SBUF1.5	SBUF1.4	SBUF1.3	SBUF1.2	SBUF1.1	SBUF1.0

Mnemonic: SBUF1 Address: C1h

SBUF1.7-0: Serial data of the serial port 1 is read from or written to this location. It actually consists of two separate 8-bit registers. One is the receive resister, and the other is the transmit buffer. Any read access gets data from the receive data buffer, while write accesses are to the transmit data buffer.

WSCON

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

Mnemonic: WSCON Address: C2h

WS: Wait State Signal Enable. Setting this bit enables the $\overline{WAIT}$ signal on P4.0. The device will sample the wait state control signal $\overline{WAIT}$ via P4.0 during MOVX instruction. This bit is time access protected.

```
TA      REG   C7H
WSCON   REG   C2H
CKCON   REG   8EH
MOV     TA, #AAH
MOV     TA, #55H
ORL     WSCON, #10000000B  ; Set  WS bit  and stretch value = 0 to enable wait
                             signal.
```

POWER MANAGEMENT REGISTER

Bit:	7	6	5	4	3	2	1	0
	CD1	CD0	SWB	-	-	ALE-OFF	-	DME0

Mnemonic: PMR Address: C4h

CD1, CD0: Clock Divide Control. These bit selects the number of clocks required to generate one machine cycle. There are three modes including divide by 4, 64 or 1024. Switching between modes must first go back divide by 4 mode. For instance, to go from 64 to 1024 locks/machine cycle the device must first go from 64 to 4 clocks/machine cycle, and then from 4 to 1024 clocks/machine cycle.

ACCUMULATOR

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

Mnemonic: ACC Address: E0h

ACC.7-0: The A (or ACC) register is the standard 8052 accumulator.

EXTENDED INTERRUPT ENABLE

Bit:	7	6	5	4	3	2	1	0
	-	-	-	EWDI	EX5	EX4	EX3	EX2

Mnemonic: EIE Address: E8h

EIE.7-5: Reserved bits, will read high

EWDI: Enable Watchdog timer interrupt

EX5: External Interrupt 5 Enable.

EX4: External Interrupt 4 Enable.

EX3: External Interrupt 3 Enable.

EX2: External Interrupt 2 Enable.

B REGISTER

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

Mnemonic: B Address: F0h

B.7-0: The B register is the standard 8052 register that serves as a second accumulator.

EXTENDED INTERRUPT PRIORITY

Bit:	7	6	5	4	3	2	1	0
	-	-	-	PWDI	PX5	PX4	PX3	PX2

Mnemonic: EIP Address: F8h

EIP.7-5: Reserved bits.

PWDI: Watchdog timer interrupt priority.

PX5: External Interrupt 5 Priority. 0 = Low priority, 1 = High priority.

PX4: External Interrupt 4 Priority. 0 = Low priority, 1 = High priority.

PX3: External Interrupt 3 Priority. 0 = Low priority, 1 = High priority.

PX2: External Interrupt 2 Priority. 0 = Low priority, 1 = High priority.

8. INSTRUCTION TIMING

The instruction timing for the W77L532 is an important aspect, especially for those users who wish to use software instructions to generate timing delays. Also, it provides the user with an insight into the timing differences between the W77L532 and the standard 8032. In the W77L532 each machine cycle is four clock periods long. Each clock period is designated a state. Thus each machine cycle is made up of four states, C1, C2 C3 and C4, in that order. Due to the reduced time for each instruction execution, both the clock edges are used for internal timing. Hence it is important that the duty cycle of the clock be as close to 50% as possible to avoid timing conflicts. As mentioned earlier, the W77L532 does one op-code fetch per machine cycle. Therefore, in most of the instructions, the number of machine cycles needed to execute the instruction is equal to the number of bytes in the instruction. Of the 256 available op-codes, 128 of them are single cycle instructions. Thus more than half of all op-codes in the W77L532 are executed in just four clock periods. Most of the two-cycle instructions are those that have two byte instruction codes. However there are some instructions that have only one byte instructions, yet they are two cycle instructions. One instruction which is of importance is the MOVX instruction. In the standard 8032, the MOVX instruction is always two machine cycles long. However in the W77L532, the user has a facility to stretch the duration of this instruction from 2 machine cycles to 9 machine cycles. The $\overline{RD}$ and $\overline{WR}$ strobe lines are also proportionately elongated. This gives the user flexibility in accessing both fast and slow peripherals without the use of external circuitry and with minimum software overhead. The rest of the instructions are either three, four or five machine cycle instructions. Note that in the W77L532, based on the number of machine cycles, there are five different types, while in the standard 8032 there are only three. However, in the W77L532 each machine cycle is made of only 4 clock periods compared to the 12 clock periods for the standard 8032. Therefore, even though the number of categories has increased, each instruction is at least 1.5 to 3 times faster than the standard 8032 in terms of clock periods.

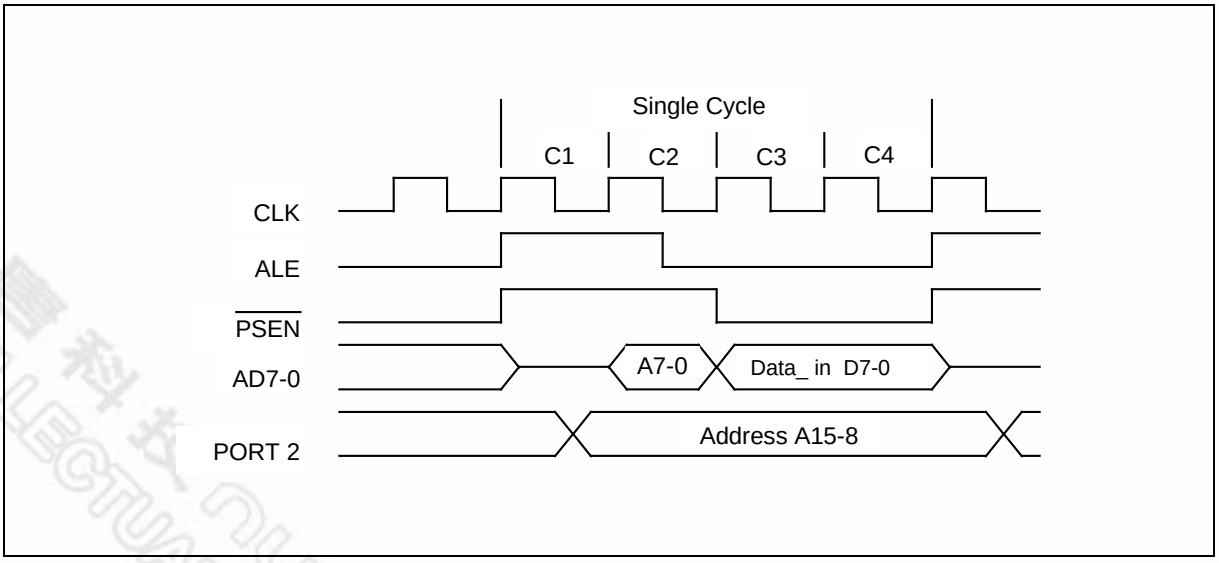


Figure 3. Single Cycle Instruction Timing

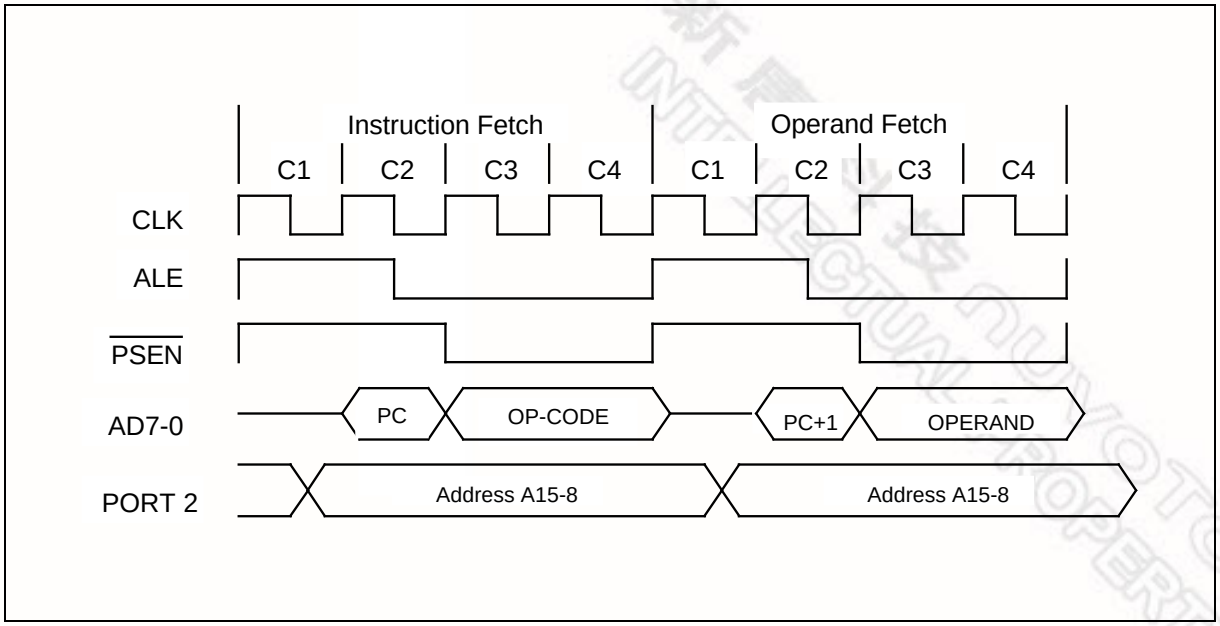


Figure 4. Two Cycle Instruction Timing

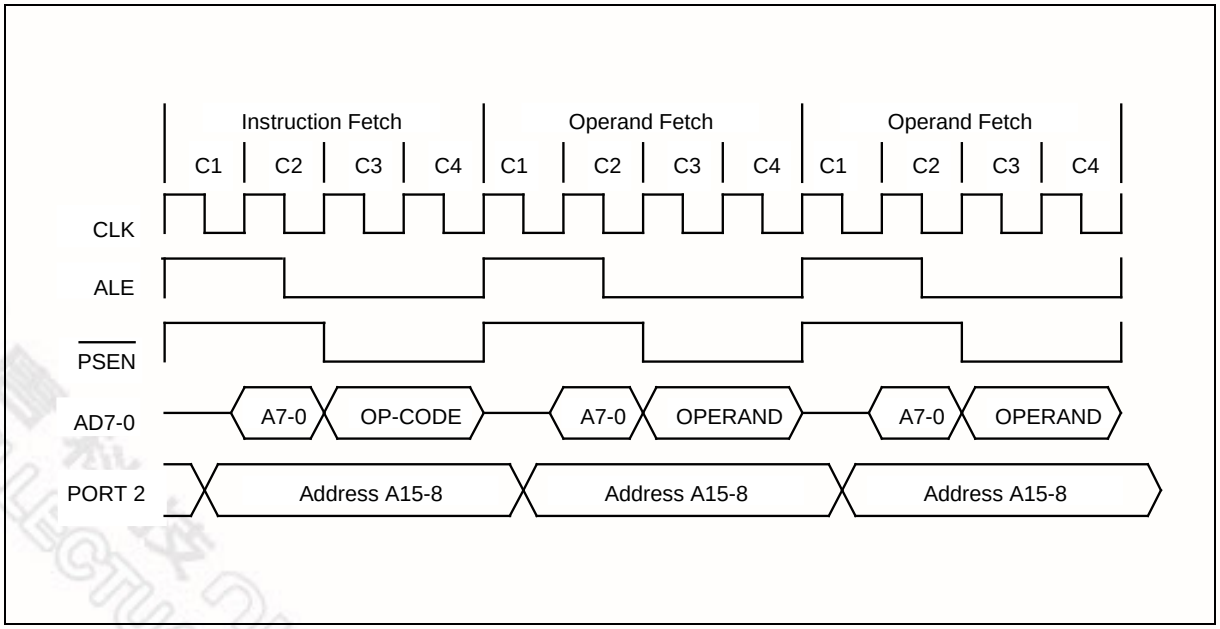


Figure 5. Three Cycle Instruction Timing

MOVX Instruction

The W77L532, like the standard 8032, uses the MOVX instruction to access external Data Memory. This Data Memory includes both off-chip memory as well as memory mapped peripherals. While the results of the MOVX instruction are the same as in the standard 8032, the operation and the timing of the strobe signals have been modified in order to give the user much greater flexibility.

The MOVX instruction is of two types, the MOVX @Ri and MOVX @DPTR. In the MOVX @Ri, the address of the external data comes from two sources. The lower 8-bits of the address are stored in the Ri register of the selected working register bank. The upper 8-bits of the address come from the port 2 SFR. In the MOVX @DPTR type, the full 16-bit address is supplied by the Data Pointer.

Since the W77L532 has two Data Pointers, DPTR and DPTR1, the user has to select between the two by setting or clearing the DPS bit. The Data Pointer Select bit (DPS) is the LSB of the DPS SFR, which exists at location 86h. No other bits in this SFR have any effect, and they are set to 0. When DPS is 0, then DPTR is selected, and when set to 1, DPTR1 is selected. The user can switch between DPTR and DPTR1 by toggling the DPS bit. The quickest way to do this is by the INC instruction. The advantage of having two Data Pointers is most obvious while performing block move operations. The accompanying code shows how the use of two separate Data Pointers speeds up the execution time for code performing the same task.

Block Move with single Data Pointer:

```
; SH and SL are the high and low bytes of Source Address
; DH and DL are the high and low bytes of Destination Address
; CNT is the number of bytes to be moved
```

			Machine cycles of W77L532 #
MOV	R2, #CNT	; Load R2 with the count value	2
MOV	R3, #SL	; Save low byte of Source Address in R3	2
MOV	R4, #SH	; Save high byte of Source address in R4	2
MOV	R5, #DL	; Save low byte of Destination Address in R5	2
MOV	R6, #DH	; Save high byte of Destination address in R6	2
LOOP:			
MOV	DPL, R3	; Load DPL with low byte of Source address	2
MOV	DPH, R4	; Load DPH with high byte of Source address	2
MOVX	A, @DPTR	; Get byte from Source to Accumulator	2
INC	DPTR	; Increment Source Address to next byte	2
MOV	R3, DPL	; Save low byte of Source address in R3	2
MOV	R4, DPH	; Save high byte of Source Address in R4	2
MOV	DPL, R5	; Load low byte of Destination Address in DPL	2
MOV	DPH, R6	; Load high byte of Destination Address in DPH	2
MOVX	@DPTR, A	; Write data to destination	2
INC	DPTR	; Increment Destination Address	2
MOV	DPL, R5	; Save low byte of new destination address in R5	2
MOV	DPH, R6	; Save high byte of new destination address in R6	2
DJNZ	R2, LOOP	; Decrement count and do LOOP again if count <> 0	2

Machine cycles in standard 8032 = 10 + (26 * CNT)
Machine cycles in W77L532 = 10 + (26 * CNT)
If CNT = 50
Clock cycles in standard 8032= ((10 + (26 *50)) * 12 = (10 + 1300) * 12 = 15720
Clock cycles in W77L532 = ((10 + (26 * 50)) * 4 = (10 + 1300) * 4 = 5240

Block Move with Two Data Pointers in W77L532:

; SH and SL are the high and low bytes of Source Address
; DH and DL are the high and low bytes of Destination Address
; CNT is the number of bytes to be moved

			Machine cycles of W77L532 #
MOV	R2, #CNT	; Load R2 with the count value	2
MOV	DPS, #00h	; Clear DPS to point to DPTR	2
MOV	DPTR, #DHDL	; Load DPTR with Destination address	3
INC	DPS	; Set DPS to point to DPTR1	2
MOV	DPTR, #SHSL	; Load DPTR1 with Source address	3
LOOP:			
MOVX	A, @DPTR	; Get data from Source block	2
INC	DPTR	; Increment source address	2
DEC	DPS	; Clear DPS to point to DPTR	2
MOVX	@DPTR, A	; Write data to Destination	2
INC	DPTR	; Increment destination address	2
INC	DPS	; Set DPS to point to DPTR1	2
DJNZ	R2, LOOP	; Check if all done	3

Machine cycles in W77L532 = 12 + (15 * CNT)
If CNT = 50
Clock cycles in W77L532 = (12 + (15 * 50)) * 4 = (12 + 750) * 4 = 3048

We can see that in the first program the standard 8032 takes 15720 cycles, while the W77L532 takes only 5240 cycles for the same code. In the second program, written for the W77L532, program execution requires only 3048 clock cycles. If the size of the block is increased then the saving is even greater.

Table 6. SFR Reset Value, continued

SFR NAME	RESET VALUE	SFR NAME	RESET VALUE
SCON	00000000b	B	00000000b
SBUF	xxxxxxxxb	EIP	xxx00000b
P2	11111111b	PC	00000000b
SADDR1	00000000b	SADEN1	00000000b
SCON1	00000000b	SBUF1	xxxxxxxxb
WSCON	00000000b	PMR	010xx0x0b
EXIF	0000xxx0b	STATUS	000x0000b
P4	xxxx1111b		

The WDCON SFR bits are set/cleared in reset condition depending on the source of the reset.

	External reset	Watchdog reset	Power on reset
WDCON	0x0x0xx0b	0x0x01x0b	01000000b

The POR bit WDCON.6 is set only by the power on reset. The PFI bit WDCON.4 is set when the power fail condition occurs. However, a power-on reset will clear this bit. The WTRF bit WDCON.2 is set when the Watchdog timer causes a reset. A power on reset will also clear this bit. The EWT bit WDCON.1 is cleared by power on resets. This disables the Watchdog timer resets. A watchdog or external reset does not affect the EWT bit.

INTERRUPTS

The W77L532 has a two priority level interrupt structure with 12 interrupt sources. Each of the interrupt sources has an individual priority bit, flag, interrupt vector and enable bit. In addition, the interrupts can be globally enabled or disabled.

Interrupt Sources

The External Interrupts $\overline{INT0}$ and $\overline{INT1}$ can be either edge triggered or level triggered, depending on bits IT0 and IT1. The bits IE0 and IE1 in the TCON register are the flags which are checked to generate the interrupt. In the edge triggered mode, the INTx inputs are sampled in every machine cycle. If the sample is high in one cycle and low in the next, then a high to low transition is detected and the interrupts request flag IEx in TCON or EXIF is set. The flag bit requests the interrupt. Since the external interrupts are sampled every machine cycle, they have to be held high or low for at least one complete machine cycle. The IEx flag is automatically cleared when the service routine is called. If the level triggered mode is selected, then the requesting source has to hold the pin low till the interrupt is serviced. The IEx flag will not be cleared by the hardware on entering the service routine. If the interrupt continues to be held low even after the service routine is completed, then the processor may acknowledge another interrupt request from the same source. Note that the external interrupts INT2 to $\overline{INT5}$ are edge triggered only. By default, the individual interrupt flag corresponding to external interrupt 2 to 5 must be cleared manually by software. It can be configured with hardware cleared by setting the corresponding bit HCx in the T2MOD register. For instance, if HC2 is set hardware will clear IE2 flag after program enters the interrupt 2 service routine.

12. PROGRAMMABLE TIMERS/COUNTERS

The W77L532 has three 16-bit programmable timer/counters and one programmable Watchdog timer. The Watchdog timer is operationally quite different from the other two timers.

TIMER/COUNTERS 0 & 1

The W77L532 has two 16-bit Timer/Counters. Each of these Timer/Counters has two 8 bit registers which form the 16 bit counting register. For Timer/Counter 0 they are TH0, the upper 8 bits register, and TL0, the lower 8 bit register. Similarly Timer/Counter 1 has two 8 bit registers, TH1 and TL1. The two can be configured to operate either as timers, counting machine cycles or as counters counting external inputs.

When configured as a "Timer", the timer counts clock cycles. The timer clock can be programmed to be thought of as 1/12 of the system clock or 1/4 of the system clock. In the "Counter" mode, the register is incremented on the falling edge of the external input pin, T0 in case of Timer 0, and T1 for Timer 1. The T0 and T1 inputs are sampled in every machine cycle at C4. If the sampled value is high in one machine cycle and low in the next, then a valid high to low transition on the pin is recognized and the count register is incremented. Since it takes two machine cycles to recognize a negative transition on the pin, the maximum rate at which counting will take place is 1/24 of the master clock frequency. In either the "Timer" or "Counter" mode, the count register will be updated at C3. Therefore, in the "Timer" mode, the recognized negative transition on pin T0 and T1 can cause the count register value to be updated only in the machine cycle following the one in which the negative edge was detected.

The "Timer" or "Counter" function is selected by the "$C/\overline{T}$" bit in the TMOD Special Function Register. Each Timer/Counter has one selection bit for its own; bit 2 of TMOD selects the function for Timer/Counter 0 and bit 6 of TMOD selects the function for Timer/Counter 1. In addition each Timer/Counter can be set to operate in any one of four possible modes. The mode selection is done by bits M0 and M1 in the TMOD SFR.

Time-Base Selection

The W77L532 gives the user two modes of operation for the timer. The timers can be programmed to operate like the standard 8051 family, counting at the rate of 1/12 of the clock speed. This will ensure that timing loops on the W77L532 and the standard 8051 can be matched. This is the default mode of operation of the W77L532 timers. The user also has the option to count in the turbo mode, where the timers will increment at the rate of 1/4 clock speed. This will straight-away increase the counting speed three times. This selection is done by the T0M and T1M bits in CKCON SFR. A reset sets these bits to 0, and the timers then operate in the standard 8051 mode. The user should set these bits to 1 if the timers are to operate in turbo mode.

MODE 0

In Mode 0, the timer/counters act as a 8 bit counter with a 5 bit, divide by 32 pre-scale. In this mode we have a 13 bit timer/counter. The 13 bit counter consists of 8 bits of THx and 5 lower bits of TLx. The upper 3 bits of TLx are ignored.

The negative edge of the clock increments the count in the TLx register. When the fifth bit in TLx moves from 1 to 0, then the count in the THx register is incremented. When the count in THx moves from FFh to 00h, then the overflow flag TFx in TCON SFR is set. The counted input is enabled only if TRx is set and either GATE = 0 or $\overline{INTx}$ = 1. When $C/\overline{T}$ is set to 0, then it will count clock cycles, and if $C/\overline{T}$ is set to 1, then it will count 1 to 0 transitions on T0 (P3.4) for timer 0 and T1 (P3.5) for timer 1. When the 13 bit count reaches 1FFFh the next count will cause it to roll-over to 0000h. The timer overflow flag TFx of the relevant timer is set and if enabled an interrupts will occur. Note that when used as a timer,

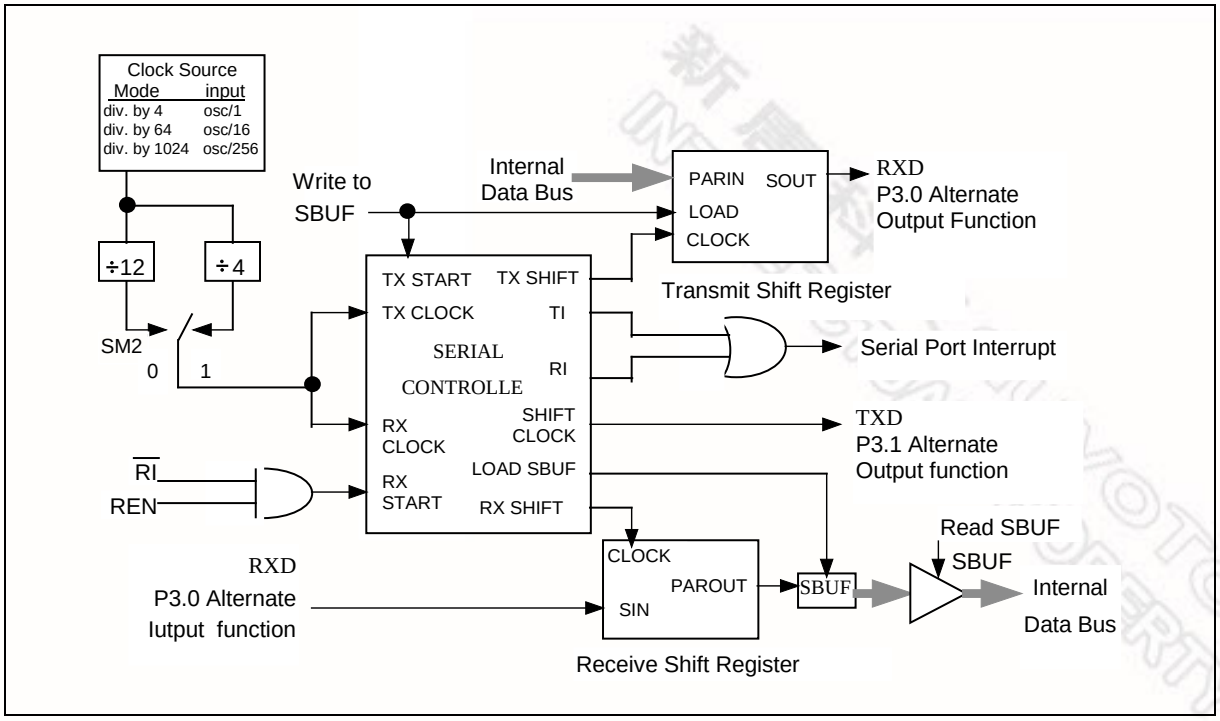


Figure 20. Serial Port Mode 1

The TI flag is set high in C1 following the end of transmission of the last bit. The serial port will receive data when REN is 1 and RI is zero. The shift clock (TxD) will be activated and the serial port will latch data on the rising edge of shift clock. The external device should therefore present data on the falling edge on the shift clock. This process continues till all the 8 bits have been received. The RI flag is set in C1 following the last rising edge of the shift clock on TxD. This will stop reception, till the RI is cleared by software.

MODE 1

In Mode 1, the full duplex asynchronous mode is used. Serial communication frames are made up of 10 bits transmitted on TXD and received on RXD. The 10 bits consist of a start bit (0), 8 data bits (LSB first), and a stop bit (1). On receive, the stop bit goes into RB8 in the SFR SCON. The baud rate in this mode is variable. The serial baud can be programmed to be 1/16 or 1/32 of the Timer 1 overflow. Since the Timer 1 can be set to different reload values, a wide variation in baud rates is possible.

Transmission begins with a write to SBUF. The serial data is brought out on to TxD pin at C1 following the first roll-over of divide by 16 counter. The next bit is placed on TxD pin at C1 following the next rollover of the divide by 16 counter. Thus the transmission is synchronized to the divide by 16 counter and not directly to the write to SBUF signal. After all 8 bits of data are transmitted, the stop bit is transmitted. The TI flag is set in the C1 state after the stop bit has been put out on TxD pin. This will be at the 10th rollover of the divide by 16 counter after a write to SBUF.

Reception is enabled only if REN is high. The serial port actually starts the receiving of serial data, with the detection of a falling edge on the RxD pin. The 1-to-0 detector continuously monitors the RxD line, sampling it at the rate of 16 times the selected baud rate. When a falling edge is detected, the divide by 16 counter is immediately reset. This helps to align the bit boundaries with the rollovers of the divide by 16 counter.

MODE 2

This mode uses a total of 11 bits in asynchronous full-duplex communication. The functional description is shown in the figure below. The frame consists of one start bit (0), 8 data bits (LSB first), a programmable 9th bit (TB8) and a stop bit (0). The 9th bit received is put into RB8. The baud rate is programmable to 1/32 or 1/64 of the oscillator frequency, which is determined by the SMOD bit in PCON SFR. Transmission begins with a write to SBUF. The serial data is brought out on to TxD pin at C1 following the first roll-over of the divide by 16 counter. The next bit is placed on TxD pin at C1 following the next rollover of the divide by 16 counter. Thus the transmission is synchronized to the divide by 16 counter, and not directly to the write to SBUF signal. After all 9 bits of data are transmitted, the stop bit is transmitted. The TI flag is set in the C1 state after the stop bit has been put out on TxD pin. This will be at the 11th rollover of the divide by 16 counter after a write to SBUF. Reception is enabled only if REN is high. The serial port actually starts the receiving of serial data, with the detection of a falling edge on the RxD pin. The 1-to-0 detector continuously monitors the RxD line, sampling it at the rate of 16 times the selected baud rate. When a falling edge is detected, the divide by 16 counter is immediately reset. This helps to align the bit boundaries with the rollovers of the divide by 16 counter. The 16 states of the counter effectively divide the bit time into 16 slices. The bit detection is done on a best of three basis. The bit detector samples the RxD pin, at the 8th, 9th and 10th counter states. By using a majority 2 of 3 voting system, the bit value is selected. This is done to improve the noise rejection feature of the serial port.

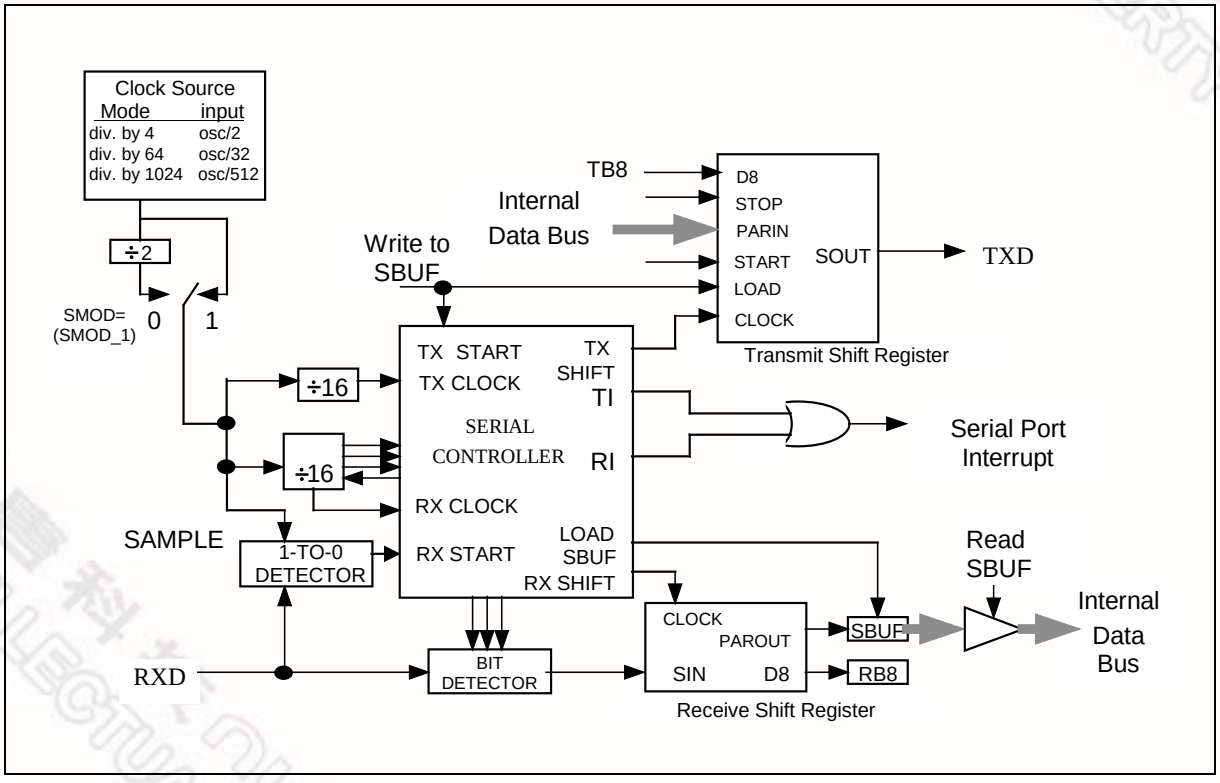


Figure 22. Serial Port Mode 2

Table 10. Serial Ports Modes

SM1	SM0	MODE	TYPE	BAUD CLOCK	FRAME SIZE	START BIT	STOP BIT	9TH BIT FUNCTION
0	0	0	Synch.	4 or 12 TCLKS	8 bits	No	No	None
0	1	1	Asynch.	Timer 1 or 2	10 bits	1	1	None
1	0	2	Asynch.	32 or 64 TCLKS	11 bits	1	1	0, 1
1	1	3	Asynch.	Timer 1 or 2	11 bits	1	1	0, 1

Framing Error Detection

A Frame Error occurs when a valid stop bit is not detected. This could indicate incorrect serial data communication. Typically the frame error is due to noise and contention on the serial communication line. The W77L532 has the facility to detect such framing errors and set a flag which can be checked by software.

The Frame Error FE(FE_1) bit is located in SCON.7(SCON1.7). This bit is normally used as SM0 in the standard 8051 family. However, in the W77L532 it serves a dual function and is called SM0/FE (SM0_1/FE_1). There are actually two separate flags, one for SM0 and the other for FE. The flag that is actually accessed as SCON.7(SCON1.7) is determined by SMOD0 (PCON.6) bit. When SMOD0 is set to 1, then the FE flag is indicated in SM0/FE. When SMOD0 is set to 0, then the SM0 flag is indicated in SM0/FE.

The FE bit is set to 1 by hardware but must be cleared by software. Note that SMOD0 must be 1 while reading or writing to FE or FE_1. If FE is set, then any following frames received without any error will not clear the FE flag. The clearing has to be done by software.

Multiprocessor Communications

Multiprocessor communications makes use of the 9th data bit in modes 2 and 3. In the W77L532, the RI flag is set only if the received byte corresponds to the Given or Broadcast address. This hardware feature eliminates the software overhead required in checking every received address, and greatly simplifies the software programmer task.

In the multiprocessor communication mode, the address bytes are distinguished from the data bytes by transmitting the address with the 9th bit set high. When the master processor wants to transmit a block of data to one of the slaves, it first sends out the address of the targeted slave (or slaves). All the slave processors should have their SM2 bit set high when waiting for an address byte. This ensures that they will be interrupted only by the reception of a address byte. The Automatic address recognition feature ensures that only the addressed slave will be interrupted. The address comparison is done in hardware not software.

The addressed slave clears the SM2 bit, thereby clearing the way to receive data bytes. With SM2 = 0, the slave will be interrupted on the reception of every single complete frame of data. The unaddressed slaves will be unaffected, as they will be still waiting for their address. In Mode 1, the 9th bit is the stop bit, which is 1 in case of a valid frame. If SM2 is 1, then RI is set only if a valid frame is received and the received byte matches the Given or Broadcast address.

13. TIMED ACCESS PROTECTION

The W77L532 has several new features, like the Watchdog timer, on-chip ROM size adjustment, wait state control signal and Power on/fail reset flag, which are crucial to proper operation of the system. If left unprotected, errant code may write to the Watchdog control bits resulting in incorrect operation and loss of control. In order to prevent this, the W77L532 has a protection scheme which controls the write access to critical bits. This protection scheme is done using a timed access.

In this method, the bits which are to be protected have a timed write enable window. A write is successful only if this window is active, otherwise the write will be discarded. This write enable window is open for 3 machine cycles if certain conditions are met. After 3 machine cycles, this window automatically closes. The window is opened by writing AAh and immediately 55h to the Timed Access(TA) SFR. This SFR is located at address C7h. The suggested code for opening the timed access window is

```
TA      REG    0C7h          ;define new register TA, located at 0C7h
MOV     TA, #0AAh
MOV     TA, #055h
```

When the software writes AAh to the TA SFR, a counter is started. This counter waits for 3 machine cycles looking for a write of 55h to TA. If the second write (55h) occurs within 3 machine cycles of the first write (AAh), then the timed access window is opened. It remains open for 3 machine cycles, during which the user may write to the protected bits. Once the window closes the procedure must be repeated to access the other protected bits.

Examples of Timed Assessing are shown below.

Example 1: Valid access

```
MOV     TA, #0AAh       3 M/C
MOV     TA, #055h       3 M/C
MOV     WDCON, #00h     3 M/C
```

Note: M/C = Machine Cycles

Example 2: Valid access

```
MOV     TA, #0AAh       3 M/C
MOV     TA, #055h       3 M/C
NOP                     1 M/C
SETB    EWT             2 M/C
```

Example 3: Valid access

```
MOV     TA, #0Aah       3 M/C
MOV     TA, #055h       3 M/C
ORL     WDCON, #00000010B   3M/C
```

Example 4: Invalid access

```
MOV     TA, #0AAh       3 M/C
MOV     TA, #055h       3 M/C
NOP                     1 M/C
NOP                     1 M/C
CLR     POR             2 M/C
```

17. SECURITY BITS

Using device programmer, the Flash EPROM can be programmed and verified repeatedly. Until the code inside the Flash EPROM is confirmed OK, the code can be protected. The protection of Flash EPROM and those operations on it are described below. The W77L532 has Special Setting Register which can be accessed by device programmer. The register can only be accessed from the Flash EPROM operation mode. Those bits of the Security Registers can not be changed once they have been programmed from high to low. They can only be reset through erase-all operation.

B7	B6	B5	B4	B3	B2	B1	B0

Security Bits

B5 : 0 -> Eable H/W reboot with P4.3
B4 : 0 -> Enable H/W reboot with P2.6, P2.7
B1 : 0 -> MOVC Inhibited
B0 : 0-> Data out lock
Default 1 for each bit.

Special Setting Registers

B0: Lock bit

This bit is used to protect the customer's program code in the W77L532. It may be set after the programmer finishes the programming and verifies sequence. Once this bit is set to logic 0, both the Flash EPROM data and Special Setting Registers can not be accessed again.

B1: MOVC Inhibit

This bit is used to restrict the accessible region of the MOVC instruction. It can prevent the MOVC instruction in external program memory from reading the internal program code. When this bit is set to logic 0, a MOVC instruction in external program memory space will be able to access code only in the external memory, not in the internal memory. A MOVC instruction in internal program memory space will always be able to access the ROM data in both internal and external memory. If this bit is logic 1, there are no restrictions on the MOVC instruction.

B4: H/W Reboot with P2.6 and P2.7

If this bit is set to logic 0, enable to reboot 4k LDFLASH mode while RST =H, P2.6 = L and P2.7 = L state. CPU will start from LDFLASH to update the user's program.

B5: H/W Reboot with P4.3

If this bit is set to logic 0, enable to reboot 4k LDFLASH mode while RST =H and P4.3 = L state. CPU will start from LDFLASH to update the user's program.

```
READ_VERIFY_64K:
        MOV  SFRAL, R2          ; SFRAL = LOW ADDRESS
        MOV  TCON, #10H         ; TCON = 10H, TR0 = 1,GO
        MOV  PCON, #01H
        INC  R2
        MOVX  A, @DPTR
        INC  DPTR
        CJNE  A, SFRFD,ERROR_64K
        CJNE  R2, #0H, READ_VERIFY_64K
        INC  R1
        MOV  SFRAH, R1
        CJNE  R1, #0H, READ_VERIFY_64K

;*******************************************************************************
;* PROGRAMMING COMPLETLY, SOFTWARE RESET CPU
;*******************************************************************************
        MOV  TA, #AAH
        MOV  TA, #55H
        MOV  CHPCON, #83H       ; SOFTWARE RESET. CPU will restart from APFLASH0

ERROR_64K:
        DJNZ  R4,UPDATE_64K     ; IF ERROR OCCURS, REPEAT 3 TIMES.
.                               ; IN-SYST PROGRAMMING FAIL, USER'S PROCESS TO DEAL WITH IT.
                .
                .
                .
```

22. REVISION HISTORY

VERSION	DATE	PAGE	DESCRIPTION
A1	May 14, 2003	-	Initial Issued
A2	Nov. 10, 2003	2	Replace 4.5V with 2.7V.
A3	April 11, 2005	2	Add lead free package part number
A4	Aug. 19, 2005	2, 4, 12 70	Add Port 0 pull-up resisters information Remove encrypt function of Security bits B2 description
A5	September 27, 2006		Remove block diagram
A6	October 31, 2006		Remove all leaded package parts
A7	February 1, 2007	14	Revise the Timer Mode Setting to “Mode 1: 16-bits, no prescale”.
A8	April 17, 2007	42	Revise that Power Down Mode is released by external interrupt configured as either level or edge detect.
A9	November 19, 2007	- 79	Remove W77LE532 part Change chapter 19.1 Figure A to crystal connections
A10	December 4, 2008	2	Revise 2nd item of Features from 25MHz to 20MHz.

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