

## Preliminary W78C354



# MONITOR MICROCONTROLLER

## GENERAL DESCRIPTION

The W78C354 is a high-performance monitor microcontroller that is based on the embedded 80C32 microcontroller core. The W78C354 includes a 16 KB ROM, 512 byte internal data RAM, a 6-bit A/D converter, two 12-bit and fourteen 8-bit PWM static DACs, one 12-bit and three 8-bit PWM dynamic DACs, a sync processor, an I<sup>2</sup>C port, a DDC port, a watchdog timer, and glue logic specially designed for monitor applications.

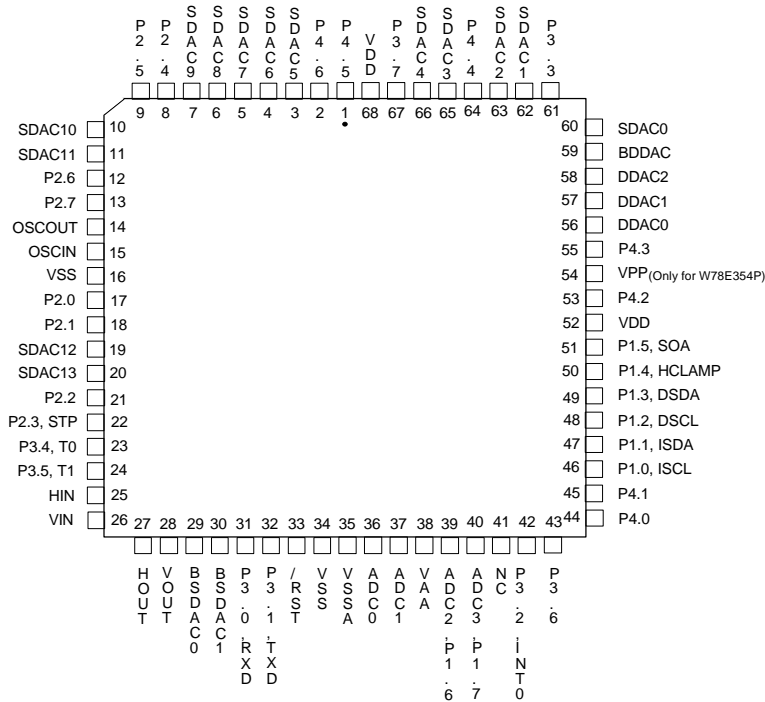
The W78C354 is suitable for monitors applying VESA DDC1/DDC2B/DDC2B+. This product's high level of integration and the availability of a one-time programmable (OTP) flash PROM version (the W78E354) help to reduce unit costs, development costs, and development time.

## FEATURES

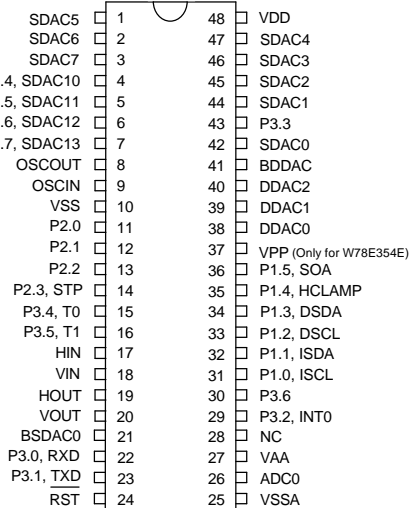
- 80C32 MCU core included
- 20 MHz maximum operating frequency
- 16 KB ROM for program storage
- 512 bytes of on-chip data RAM:
  - Lower 256 bytes accessed as in the 80C32
  - Higher 256 bytes accessed as an external data memory via "MOVX @Ri".
- One SPI/RS232 port (80C32 standard serial port)
- One external interrupt input
- Two timers/counters
- One 8-bit auto-reload timer for software time base
- PWM DACs:
  - Two 12-bit PWM/BRM static DACs
  - Fourteen 8-bit PWM static DACs
  - One 12-bit PWM/BRM dynamic DAC
  - Three 8-bit PWM dynamic DACs
- One 6-bit ADC with 4 multiplexed analog inputs
- Sync processor:
  - Horizontal & vertical polarity detector
  - Sync separator for composite sync
  - Horizontal & vertical frequency counter
  - Programmable dummy frequency generator
  - Programmable H-clamp pulse output
  - Safe operation area (SOA) output
  - Self-test pattern output
- One software I<sup>2</sup>C port
- One DDC port (master/slave mode I<sup>2</sup>C, supports DDC1/DDC2B/DDC2B+)
- Watchdog timer
- Moire cancellation
- Two 15 mA output pins for driving LED
- Power-low reset
- OTP type: W78E354 (16 KB flash PROM)
- Three package types:
  - PLCC68 (W78C/E354P), DIP48 (W78C/E354E), DIP40 (W78C/E354)

## PIN CONFIGURATIONS

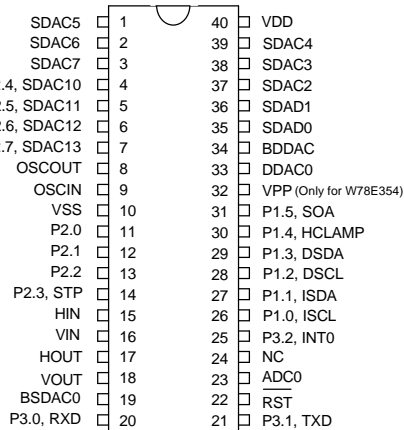
### W78C/E354P (PLCC68)



### W78C/E354E (DIP48)



### W78C/E354 (DIP40)



## PIN ARRANGEMENT REFERENCE TABLE

| DIP-40 | DIP-48 | PLCC-68 | PIN NAME                | DIP-40 | DIP-48 | PLCC-68 | PIN NAME        |
|--------|--------|---------|-------------------------|--------|--------|---------|-----------------|
| 22     | 24     | 33      | $\overline{\text{RST}}$ | -      | -      | 37      | ADC1            |
| 15     | 17     | 25      | HIN                     | -      | -      | 39      | ADC2(P1.6)      |
| 16     | 18     | 26      | VIN                     | -      | -      | 40      | ADC3(P1.7)      |
| 17     | 19     | 27      | HOUT                    | -      | 27     | 38      | VAA             |
| 18     | 20     | 28      | VOUT                    | -      | 25     | 35      | VSSA            |
| 35     | 42     | 60      | SDAC0                   | 11     | 11     | 17      | P2.0            |
| 36     | 44     | 62      | SDAC1                   | 12     | 12     | 18      | P2.1            |
| 37     | 45     | 63      | SDAC2                   | 13     | 13     | 21      | P2.2            |
| 38     | 46     | 65      | SDAC3                   | 14     | 14     | 22      | P2.3 (STP)      |
| 39     | 47     | 66      | SDAC4                   | 4      | 4      | 8       | P2.4 (SDAC10)   |
| 1      | 1      | 3       | SDAC5                   | 5      | 5      | 9       | P2.5 (SDAC11)   |
| 2      | 2      | 4       | SDAC6                   | 6      | 6      | 12      | P2.6 (SDAC12)   |
| 3      | 3      | 5       | SDAC7                   | 7      | 7      | 13      | P2.7 (SDAC13)   |
| -      | -      | 6       | SDAC8                   | 20     | 22     | 31      | P3.0 (RXD )     |
| -      | -      | 7       | SDAC9                   | 21     | 23     | 32      | P3.1 (TXD )     |
| -      | -      | 10      | SDAC10                  | 25     | 29     | 42      | P3.2 (INT0)     |
| -      | -      | 11      | SDAC11                  | -      | 43     | 61      | P3.3            |
| -      | -      | 19      | SDAC12                  | -      | 15     | 23      | P3.4 (T0)       |
| -      | -      | 20      | SDAC13                  | -      | 16     | 24      | P3.5 (T1)       |
| 19     | 21     | 29      | BSDAC0                  | -      | 30     | 43      | P3.6            |
| -      | -      | 30      | BSDAC1                  | -      | -      | 67      | P3.7            |
| 40     | 48     | 68      | V <sub>DD</sub>         | -      | -      | 44      | P4.0            |
| 10     | 10     | 16      | V <sub>SS</sub>         | -      | -      | 45      | P4.1            |
| 34     | 41     | 59      | BDDAC                   | -      | -      | 53      | P4.2            |
| 33     | 38     | 56      | DDAC0                   | -      | -      | 55      | P4.3            |
| -      | 39     | 57      | DDAC1                   | -      | -      | 64      | P4.4            |
| -      | 40     | 58      | DDAC2                   | -      | -      | 1       | P4.5            |
| 26     | 31     | 46      | P1.0 (ISCL)             | -      | -      | 2       | P4.6            |
| 27     | 32     | 47      | P1.1 (ISDA)             | 24     | 28     | 41      | NC              |
| 28     | 33     | 48      | P1.2 (DSCL)             | 32     | 37     | 54      | V <sub>PP</sub> |
| 29     | 34     | 49      | P1.3 (DSDA)             | -      | -      | 52      | V <sub>DD</sub> |
| 30     | 35     | 50      | P1.4 (HCLAMP)           | -      | -      | 34      | V <sub>SS</sub> |
| 31     | 36     | 51      | P1.5 (SOA)              | 8      | 8      | 14      | OSCOU           |
| 23     | 26     | 36      | ADC0                    | 9      | 9      | 15      | OSCIN           |

## PIN DESCRIPTION

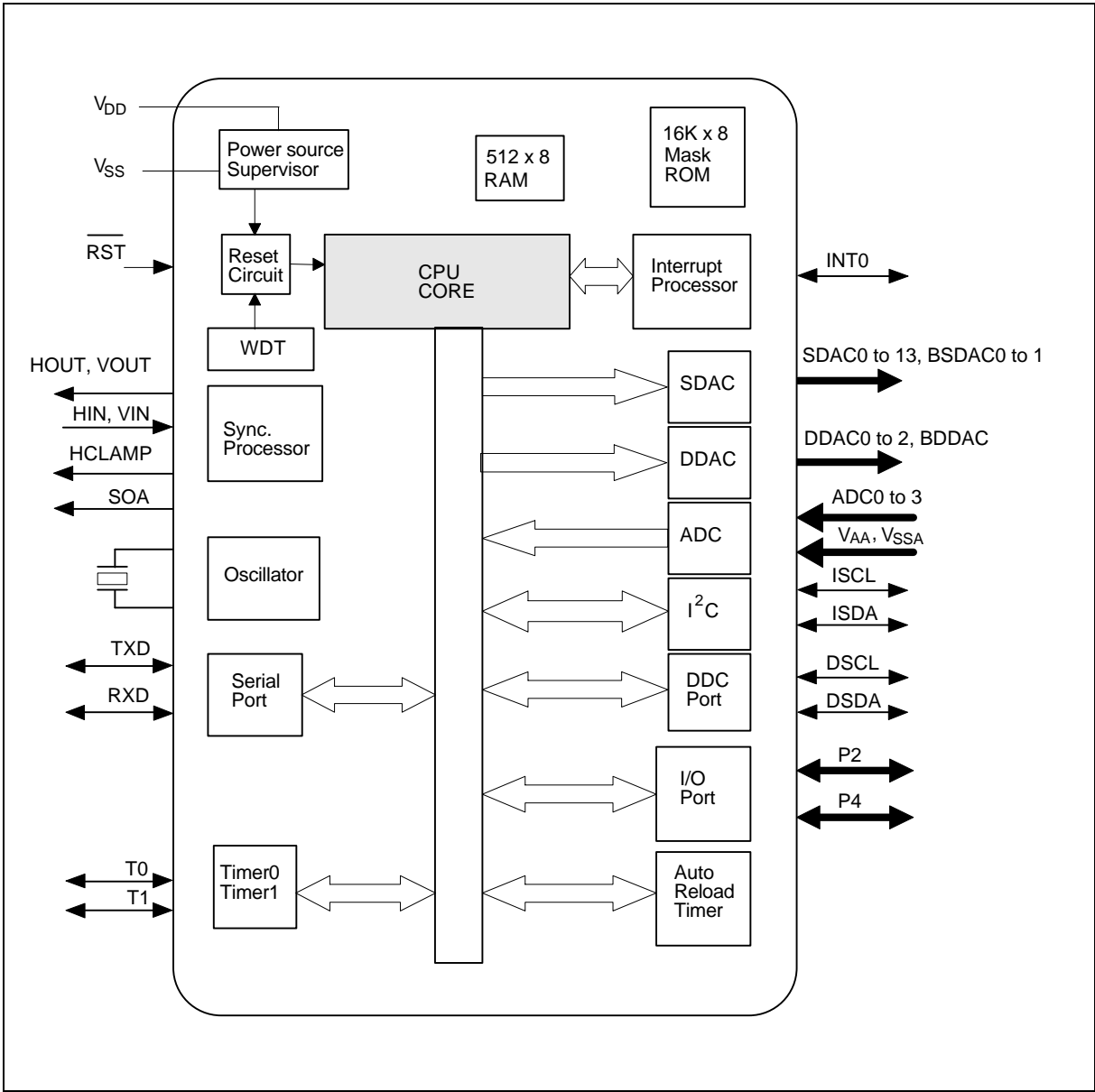
| PIN NAME                                   | I/O TYPE | FUNCTION  |
|--|----------|---|
| SDAC0-7                                    | O        | 8-bit PWM static DAC output.<br>Sink/source current 4 mA/-4 mA.   |
| SDAC8-13                                   | O        | 8-bit PWM static DAC output.<br>Sink/source current 4 mA/-4 mA.   |
| BSDAC0-1                                   | O        | 12-bit PWM/BRM static DAC output.<br>Sink/source current 8 mA/-8 mA.  |
| DDAC0-2                                    | O        | 8-bit PWM dynamic DAC output.<br>Sink/source current 8 mA/-8 mA.  |
| BDDAC                                      | O        | 12-bit PWM/BRM dynamic DAC output.<br>Sink/source current 8 mA/-8 mA.   |
| ADC0<br>ADC1<br>ADC2 (P1.6)<br>ADC3 (P1.7) | I        | Analog signal input channel to AD converter.<br>Alternate function:<br>ADC2: P1.6 input (input only).<br>ADC3: P1.7 input (input only).   |
| P1.0-P1.1                                  | I/O      | General purpose I/O.<br>Open-drain, Sink current 2 mA.  |
| P1.2 (DSCL)<br>P1.3 (DSDA)                 | I/O      | General purpose I/O.<br>Open-drain, Sink current 6 mA.<br>Alternate function:<br>P1.2: DDC port serial clock DSCL.<br>P1.3: DDC port serial data DSDA.  |
| P1.4<br>(HCLAMP)                           | I/O      | General purpose I/O.<br>Sink/source current 4 mA/-100 $\mu$ A.<br>Alternate function:<br>P1.4: HCLAMP (H-clamp pulse) output.<br>While outputting special function, P1.4 sink/source current is 4 mA/-4 mA. |
| P1.5 (SOA)                                 | I/O      | General purpose O/P.<br>Sink/source current 4 mA/-4 mA.<br>Alternate function:<br>P1.5: SOA (safe operation area) output.   |
| P2.0-P2.1                                  | I/O      | General purpose I/O.<br>Sink/source current 15 mA/-100 $\mu$ A.   |



Pin Description, continued

| PIN NAME  | I/O TYPE | FUNCTION   |
|---|----------|--|
| P2.2<br>P2.3 (STP)<br>P2.4 (SDAC10)<br>P2.5 (SDAC11)<br>P2.6 (SDAC12)<br>P2.7 (SDAC13)    | I/O      | General purpose I/O.<br>Sink/source current 4 mA/-100 $\mu$ A.<br>Alternate function:<br>P2.3: STP (Self-Test Pattern) output.<br>P2.4–P2.7: SDAC10–13 outputs.<br>While outputting special function, P2.3–P2.7 sink/source current is 4 mA/-4 mA. |
| P3.0 (RXD)<br>P3.1 (TXD)<br>P3.2 (INT0)<br>P3.3<br>P3.4 (T0)<br>P3.5 (T1)<br>P3.6<br>P3.7 | I/O      | General purpose I/O.<br>Sink/Source current 2 mA/-100 $\mu$ A.<br>Alternate function:<br>P3.0: Serial input port.<br>P3.1: Serial output port.<br>P3.2: External interrupt input.<br>P3.4, P3.5: Timer/counter 0, 1 external inputs.               |
| P4.0–P4.6   | O        | Output port.<br>Sink/source current 2 mA/-2 mA.  |
| HIN<br>VIN  | I        | HIN: Hsync/composite sync input.<br>VIN: Vsync input.<br>Schmitt trigger input pin.  |
| HOUT<br>VOUT  | O        | HOUT: Hsync output.<br>VOUT: Vsync output.<br>Sink/source current 4 mA/-4 mA.  |
| $\overline{\text{RST}}$   | I        | Reset the controller (active low).<br>Schmitt trigger input pin.   |
| OSCOU   | O        | Output from inverting oscillator amplifier.  |
| OSCIN   | I        | Input to inverting oscillator amplifier.   |
| VPP   | I        | High voltage supply input for flash PROM.  |
| VDD   | I        | Positive power supply for digital circuit, +5V.  |
| VSS   | I        | Digital ground.  |
| VAA   | I        | Positive power supply for analog circuit, +5V.   |
| VSSA  | I        | Analog ground.   |

## BLOCK DIAGRAM





## FUNCTIONAL DESCRIPTION

The W78C354's core architecture consists of an 80C32 MCU surrounded by various special function registers, or SFRs (some of these are 80C32 standard registers, while others are newly added; see Table 1), three general purpose I/O ports (P1, P2, and P3), one output-only port (P4), 256 bytes of scratchpad RAM, two timer/counters (Timer0 and Timer1) and one 80C32 standard serial port. The processor supports 109 different instructions (without "MOVX A, @DPTR" and "MOVX @DPTR, A"), which are all compatible with the 80C32 family instruction set.

There are two major differences between the W78C354 and 80C32. First, the W78C354 cannot access an external program or data memory. This function is unnecessary, because the W78C354's 16 KB of internal ROM and 512 bytes of on-chip RAM should be enough for most monitor applications. Second, the W78C354 has a number of new SFRs (see Table 2), which provide more powerful functions.

**Table 1. W78C354 special function registers (SFRs)**

|    |            |          |         |        |          |          |          |          |    |
|----|------------|----------|---------|--------|----------|----------|----------|----------|----|
| F8 |            |          |         |        |          |          |          |          | FF |
| F0 | + B        |          |         |        |          |          |          |          | F7 |
| E8 |            |          |         |        |          |          |          |          | EF |
| E0 | + ACC      |          |         |        |          |          |          |          | E7 |
| D8 | + S1CON    | S1STA    | S1DAT   | S1ADR  |          |          |          |          | DF |
| D0 | + PSW      |          |         |        |          |          |          |          | D7 |
| C8 | + CONTREG4 |          |         |        |          |          |          |          | CF |
| C0 |            |          |         |        |          |          |          |          | C7 |
| B8 | + IP       | SBRM0    | SBRM1   | PORT4  | SOAREG   | SOACLR   |          |          | BF |
| B0 | + P3       | ADC      | INTVECT | STATUS | HFCOUNTL | HFCOUNTH | VFCOUNTL | VFCOUNTH | B7 |
| A8 | + IE       | SDAC7    | SDAC8   | SDAC9  | SDAC10   | SDAC11   | SDAC12   | SDAC13   | AF |
| A0 | + P2       | SDAC0    | SDAC1   | SDAC2  | SDAC3    | SDAC4    | SDAC5    | SDAC6    | A7 |
| 98 | + SCON     | SBUF     | BSDAC0  | BSDAC1 | WDTCLR   | DDAC0    | DDAC1    | DDAC2    | 9F |
| 90 | + P1       | AUTOLOAD | DHREG   | DVREG  | DDC1     | INTMSK   | BDDAC    | DBRM     | 97 |
| 88 | + TCON     | TMOD     | TL0     | TL1    | TH0      | TH1      | PARAL    | PARAH    | 8F |
| 80 | + CONTREG1 | SP       | DPL     | DPH    | CONTREG5 | CONTREG2 |          | PCON     | 87 |

Notes:

1. SFRs with a "+" are both byte and bit-addressable.
2. The registers in the shaded region are newly added to the 80C32.

### A. Memory Address Space

The W78C354 operates in three separate address spaces:

- (1) The first (Figure 1-1) is the 16 KB internal program space (0000H–3FFFH).
- (2) The second (Figure 1-2) is the data memory space, which is 256 bytes in size (0000H–00FFH).  
The data memory is integrated inside the chip rather than outside the chip, as in a standard 80C32. This data memory space must be accessed by the "MOVX @Ri" instruction.
- (3) The third (Figure 1-3) is the same as in the standard 80C32.

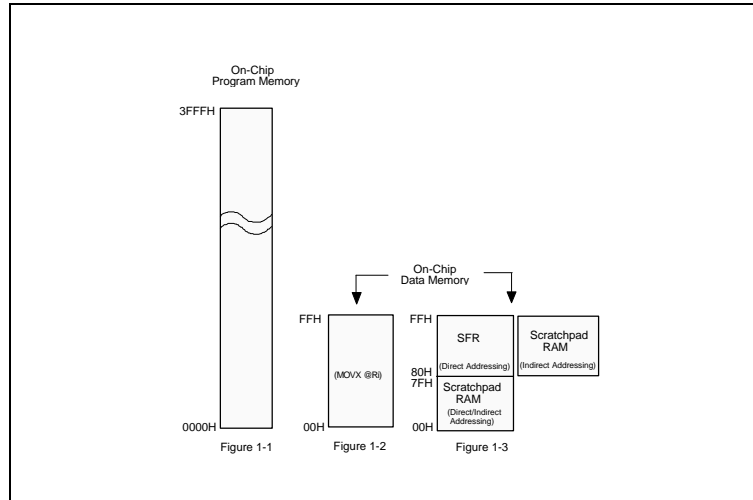


Figure 1. Memory address space

## B. Modified 80C32 SFRs

### 1. Timer/Counter Control Register (TCON):

| BIT           | NAME | FUNCTION  |
|---------------|------|---|
| TCON.7        | TF1  | Timer 1 overflow flag.<br>Set by hardware on timer/counter overflow. Cleared by hardware when processor vectors to interrupt routine. |
| TCON.6        | TR1  | Timer 1 run control bit.<br>Set/cleared by software to turn timer/counter on or off.  |
| TCON.5        | TF0  | Timer 0 overflow flag.<br>Set by hardware on timer/counter overflow. Cleared by hardware when processor vectors to interrupt routine. |
| TCON.4        | TR0  | Timer 0 run control bit.<br>Set/cleared by software to turn timer/counter on or off.  |
| <b>TCON.3</b> | -    | <b>Reserved</b>   |
| <b>TCON.2</b> | -    | <b>Reserved</b>   |
| TCON.1        | IE0  | Interrupt 0 edge flag.<br>Set by hardware when external interrupt edge detected. Cleared by hardware when interrupt processed.        |
| TCON.0        | IT0  | Interrupt 0 type control bit.<br>Set/cleared by software to specify falling edge/low level triggered external interrupt.              |

Note: The registers in the shaded region are modified from the 80C32 SFRs.





**2. Power Control Register (PCON):**

| NAME | FUNCTION                  |
|------|---------------------------|
| SMOD | Double baud rate bit.     |
| -    | Reserved                  |
| -    | Reserved                  |
| -    | Reserved                  |
| GF1  | General-purpose flag bit. |
| GF0  | General-purpose flag bit. |
| -    | <b>Reserved</b>           |
| IDL  | Idle mode bit.            |

Notes:

1. The SFR is not bit-addressable.
2. The registers in the shaded region are modified from the 80C32 SFRs.

**3. Interrupt Enable Register (IE):**

| BIT         | NAME      | FUNCTION  |
|-------------|-----------|---|
| IE.7        | EA        | If EA = 0, no interrupt will be acknowledged (disable all interrupts).<br>If EA = 1, each interrupt source is individually enabled or disabled by setting or clearing its enable bit. |
| IE.6        | -         | (Reserved)  |
| <b>IE.5</b> | <b>*1</b> | <b>Set/clear to enable/disable the DDC port's I<sup>2</sup>C interrupt.</b>   |
| IE.4        | ES        | Set/clear to enable/disable the serial port 0 interrupt.  |
| IE.3        | ET1       | Set/clear to enable/disable the Timer 1 overflow interrupt.   |
| <b>IE.2</b> | <b>*1</b> | <b>Set/clear to enable/disable the *2 interrupt.</b>  |
| IE.1        | ET0       | Set/clear to enable/disable the Timer 0 overflow interrupt.   |
| IE.0        | EX0       | Set/clear to enable/disable the external interrupt 0.   |

Notes:

- \*1. No name for ASSEMBLER, must be used via "IE.x".
- \*2. DSCLINT+ADCINT+TIMEOUT+SOAINT+VEVENT+PARAINT +DDC1INT.

#### 4. Interrupt Priority Register (IP)

| BIT         | NAME      | FUNCTION   |
|-------------|-----------|--|
| IP.7        | -         | (Reserved)   |
| IP.6        | -         | (Reserved)   |
| <b>IP.5</b> | <b>*1</b> | <b>Define the DDC port's I<sup>2</sup>C interrupt priority level.</b><br><b>If IP.5 = 1, the priority level is higher.</b> |
| IP.4        | PS        | Define the serial port interrupt priority level.<br>If PS = 1, the priority level is higher.                               |
| IP.3        | PT1       | Define the Timer 1 interrupt priority level.<br>If PT1 = 1, the priority level is higher.                                  |
| <b>IP.2</b> | <b>*1</b> | <b>Define the *2 priority level.</b><br><b>If IP.2 = 1, the priority level is higher.</b>                                  |
| IP.1        | PT0       | Define the Timer 0 interrupt priority level.<br>If PT0 = 1, the priority level is higher.                                  |
| IP.0        | PX0       | Define the external interrupt 0 priority level.<br>If PX0 = 1, the priority level is higher.                               |

Notes:

\*1. No name for ASSEMBLER, must be used via "IP.x".

\*2. DSCLINT+ADCINT+TIMEOUT+SOAINT+VEVENT+PARAINT+DDC1INT.

#### C. Newly Added Special Function Registers

In addition to the 80C32 SFRs, the W78C354 has forty-nine new SFRs in the SFR address space, as listed in Table 2.

**Table 2. New special function registers**

|    | REGISTER | ADDRESS | FUNCTION  | LENGTH | R/W TYPE | RESET CONTENT |
|----|----------|---------|---|--------|----------|---------------|
| 1  | CONTREG1 | 80H     | Control register 1, bit-addressable               | 8      | R/W      | 00H           |
| 2  | CONTREG5 | 84H     | Control register 5                                | 8      | R/W      | 00H           |
| 3  | CONTREG2 | 85H     | Control register 2                                | 8      | W        | 00H           |
| 4  | PARAL    | 8EH     | Parabola interrupt generator low byte register    | 8      | W        | 00H           |
| 5  | PARAH    | 8FH     | Parabola interrupt generator high byte register   | 8      | W        | 00H           |
| 6  | AUTOLOAD | 91H     | 8-bit auto-reload timer register                  | 8      | W        | 00H           |
| 7  | DHREG    | 92H     | Dummy Hsync frequency generator register          | 4      | W        | 00H           |
| 8  | DVREG    | 93H     | Dummy Vsync frequency generator register          | 8      | W        | 00H           |
| 9  | DDC1     | 94H     | DDC port's DDC1 data buffer                       | 8      | W        | 00H           |
| 10 | INTMSK   | 95H     | Interrupt mask register                           | 8      | W        | 00H           |
| 11 | BDDAC    | 96H     | 8-bit PWM register for 12-bit PWM/BRM dynamic DAC | 8      | W        | 00H           |
| 12 | DBRM     | 97H     | 4-bit BRM register for 12-bit PWM/BRM dynamic DAC | 4      | W        | 00H           |



Table 2. New special function registers, continued

|    | REGISTER | ADDRESS | FUNCTION  | LENGTH | R/W TYPE | RESET CONTENT |
|----|----------|---------|---|--------|----------|---------------|
| 13 | BSDAC0   | 9AH     | 8-bit PWM register for 12-bit PWM/BRM Static DAC0 | 8      | W        | 00H           |
| 14 | BSDAC1   | 9BH     | 8-bit PWM register for 12-bit PWM/BRM Static DAC1 | 8      | W        | 00H           |
| 15 | WDTCLR   | 9CH     | Watch-dog timer clear register                    | -      | W        | -             |
| 16 | DDAC0    | 9DH     | 8-bit PWM dynamic DAC0 register                   | 8      | W        | 00H           |
| 17 | DDAC1    | 9EH     | 8-bit PWM dynamic DAC1 register                   | 8      | W        | 00H           |
| 18 | DDAC2    | 9FH     | 8-bit PWM dynamic DAC2 register                   | 8      | W        | 00H           |
| 19 | SDAC0    | A1H     | 8-bit PWM static DAC0 register                    | 8      | W        | 00H           |
| 20 | SDAC1    | A2H     | 8-bit PWM static DAC1 register                    | 8      | W        | 00H           |
| 21 | SDAC2    | A3H     | 8-bit PWM static DAC2 register                    | 8      | W        | 00H           |
| 22 | SDAC3    | A4H     | 8-bit PWM static DAC3 register                    | 8      | W        | 00H           |
| 23 | SDAC4    | A5H     | 8-bit PWM static DAC4 register                    | 8      | W        | 00H           |
| 24 | SDAC5    | A6H     | 8-bit PWM static DAC5 register                    | 8      | W        | 00H           |
| 25 | SDAC6    | A7H     | 8-bit PWM static DAC6 register                    | 8      | W        | 00H           |
| 26 | SDAC7    | A9H     | 8-bit PWM static DAC7 register                    | 8      | W        | 00H           |
| 27 | SDAC8    | AAH     | 8-bit PWM static DAC8 register                    | 8      | W        | 00H           |
| 28 | SDAC9    | ABH     | 8-bit PWM static DAC9 register                    | 8      | W        | 00H           |
| 29 | SDAC10   | ACH     | 8-bit PWM static DAC10 register                   | 8      | W        | 00H           |
| 30 | SDAC11   | ADH     | 8-bit PWM static DAC11 register                   | 8      | W        | 00H           |
| 31 | SDAC12   | AEH     | 8-bit PWM static DAC12 register                   | 8      | W        | 00H           |
| 32 | SDAC13   | AFH     | 8-bit PWM static DAC13 register                   | 8      | W        | 00H           |
| 33 | ADC      | B1H     | 6-bit ADC result register                         | 8      | R        | 00H           |
| 34 | INTVECT  | B2H     | Interrupt vector register                         | 8      | R/W      | 00H           |
| 35 | STATUS   | B3H     | Status register                                   | 4      | R        | 00H           |
| 36 | HFCOUNTL | B4H     | Horizontal frequency counter low byte register    | 8      | R        | 00H           |
| 37 | HFCOUNTH | B5H     | Horizontal frequency counter high byte register   | 8      | R        | 00H           |
| 38 | VFCOUNTL | B6H     | Vertical frequency counter low byte register      | 8      | R        | 00H           |
| 39 | VFCOUNTH | B7H     | Vertical frequency counter high byte register     | 8      | R        | 00H           |
| 40 | SBRM0    | B9H     | 4-bit BRM register for 12-bit PWM/BRM Static DAC0 | 4      | W        | 00H           |
| 41 | SBRM1    | BAH     | 4-bit BRM register for 12-bit PWM/BRM Static DAC1 | 4      | W        | 00H           |
| 42 | PORT4    | BBH     | Output latch register                             | 7      | W        | 00H           |
| 43 | SOAREG   | BCH     | Safe operation area register                      | 8      | W        | 00H           |
| 44 | SOACLR   | BDH     | Safe operation area clear register                | -      | W        | -             |
| 45 | CONTREG4 | C8H     | Control register 4                                | 8      | R/W      | 00H           |
| 46 | S1CON    | D8H     | SIO1 port control register                        | 8      | R/W      | 00H           |
| 47 | S1STA    | D9H     | SIO1 port status register                         | 8      | R        | F8H           |
| 48 | S1DAT    | DAH     | SIO1 port data register                           | 8      | R/W      | 00H           |
| 49 | S1ADR    | DBH     | SIO1 port address register                        | 8      | R/W      | 00H           |

Notes:

1. "-" means the SFR has no real hardware but only an address.
2. Three SFRs (CONTREG1, CONTREG4, SICON) can be accessed by bit addressing.

## D. Status and Control Register Overview

### 1. STATUS: Status Register

| BIT | NAME | FUNCTION                                  |
|-----|------|---|
| 0   | HP   | Hsync polarity. 0: Positive, 1: Negative. |
| 1   | VP   | Vsync polarity. 0: Positive, 1: Negative. |
| 2   | NOH  | Set by hardware if no Hsync.              |
| 3   | NOV  | Set by hardware if no Vsync.              |

## 2. CONTREG1: Control Register1, Bit-addressable

| BIT | NAME    | FUNCTION   |
|-----|---------|--|
| 0   | ADCS0   | ADC channel select bit 0.  |
| 1   | ADCS1   | ADC channel select bit 1.  |
| 2   | ENDDC1  | Enable/Disable DDC1 mode.<br>0: Disable DDC1 mode; the pin P1.3/DSDA is accessed data in the DDC2B/2B+ mode.<br>1: Enable DDC1 mode ; the pin P1.3/DSDA is output data in the DDC1 mode. |
| 3   | HCES    | H-Clamp Edge Select.<br>0: Pin P1.4 will output H-clamp pulse, if the leading edge of Hsync occurs.<br>1: Pin P1.4 will output H-clamp pulse, if the trailing edge of Hsync occurs.      |
| 4   | HCWS0   | H-Clamp Width Select bit 0.  |
| 5   | HCWS1   | H-Clamp Width Select bit 1.  |
| 6   | DUMMYEN | Enable/Disable dummy frequency generator.<br>0: Disable, 1: Enable.  |
| 7   | ADCSTRT | Start ADC conversion.<br>0: Stop, 1: Start.  |

## 3. CONTREG2: Control Register2

| BIT | NAME | FUNCTION  |
|-----|------|---|
| 0   | ENVS | Enable/Disable Vsync Separator.<br>0: Disable, 1: Enable. |
| 1   | HSPS | Hout Sync Polarity Select.<br>0: Positive, 1: Negative.   |
| 2   | VSPS | Vout Sync Polarity Select.<br>0: Positive, 1: Negative.   |
| 3   | -    | Reserved.   |



## 3. CONTREG2: Control Register2, continued

| BIT | NAME   | FUNCTION  |
|-----|--------|---|
| 4   | EINTES | External INT Edge Select.<br>0: High-level/rising-edge triggered.<br>1: Low-level/falling-edge triggered.                   |
| 5   | ENM0   | Enable/Disable SDAC0 morie cancel function.<br>0: Disable, 1: Enable.   |
| 6   | ENM1   | Enable/Disable SDAC1 morie cancel function.<br>0: Disable, 1: Enable.   |
| 7   | VDISHC | Disable H-Clamp pulse at the Vsync pulse period. In initial state, it enables the H-Clamp output.<br>0: Enable, 1: Disable. |

## 4. CONTREG4: Control Register4, Bit-addressable

| BIT | NAME   | FUNCTION  |
|-----|--------|---|
| 0   | P24SF  | Enable/Disable Port 2.4 Special Function.<br>P24SF = 0: General I/O pin.<br>P24SF = 1 and P2.4 = 0: SDAC10 output.  |
| 1   | P25SF  | Enable/Disable Port 2.5 Special Function.<br>P25SF = 0: General I/O pin.<br>P25SF = 1 and P2.5 = 0: SDAC11 output.  |
| 2   | P26SF  | Enable/Disable Port 2.6 Special Function.<br>P26SF = 0: General I/O pin.<br>P26SF = 1 and P2.6 = 0: SDAC12 output.  |
| 3   | P27SF  | Enable/Disable Port 2.7 Special Function.<br>P27SF = 0: General I/O pin.<br>P27SF = 1 and P2.7 = 0: SDAC13 output.  |
| 4   | P14SF  | Enable/Disable Port 1.4 Special Function.<br>P14SF = 0: General I/O pin.<br>P14SF = 1 and P1.4 = 0: H-Clamp output. |
| 5   | P15SF  | Enable/Disable Port 1.5 Special Function.<br>P15SF = 0: General I/O pin.<br>P15SF = 1 and P1.5 = 0: SOA output.     |
| 6   | P23SF  | Enable/Disable Port 2.3 Special Function.<br>P23SF = 0: General I/O pin.<br>P23SF = 1 and P2.3 = 0: STP output.     |
| 7   | INVSTP | Invert Self-Test Pattern.   |

Note: To let the Px.y output special function, set PxySF and clear Px.y.



### 5. CONTREG5: Control Register5

| BIT | NAME    | FUNCTION   |
|-----|---------|--|
| 0   | -       | Reserved.  |
| 1   | -       | Reserved.  |
| 2   | -       | Reserved.  |
| 3   | -       | Reserved.  |
| 4   | -       | Reserved.  |
| 5   | HDSEL   | HCLAMP Source SElect.  |
| 6   | DPARAIN | Enable parabola interrupt with dummy signal.<br>DPARAIN = 0; V dummy signal will generate VEVENT interrupt.<br>DPARAIN = 1; V dummy signal will not generate VEVENT interrupt. |
| 7   | -       | Reserved.  |

### E. I/O Port

The I/O ports available in the W78C354 vary with the package, as shown in the table below:

| I/O PORT | 68-PIN PLCC | 48-PIN DIP | 40-PIN DIP |
|----------|-------------|------------|------------|
| Port 1   | 6 bits      | 6 bits     | 6 bits     |
| Port 2   | 8 bits      | 8 bits     | 8 bits     |
| Port 3   | 8 bits      | 7 bits     | 3 bits     |
| Port 4   | 7 bits      | N.A.       | N.A.       |

P1, P2, and P3 are the SFR latches of ports 1, 2, and 3, respectively. Writing a "1" to a bit of a port SFR (P1, P2, or P3) causes the corresponding port output pin to switch to high. Writing a "0" causes the port output pin to switch to low. When a port is used as an input, the external state of the port pin will be read into the port SFR (i.e., if the external state is low, the corresponding SFR bit will contain a "0"; if it is high, the bit will contain a "1"). The block diagrams and control registers are shown below.

#### E-1 Port 1

Besides general purpose I/O functions, port 1 provides the functions shown in the following table.

| PINS | SPECIAL FUNCTION | SPECIAL FUNCTION CONTROL BIT | DESCRIPTION                  |
|------|------------------|------------------------------|------------------------------|
| P1.0 | ISCL             | -                            | s/w I <sup>2</sup> C SCL pin |
| P1.1 | ISDA             | -                            | s/w I <sup>2</sup> C SDA pin |
| P1.2 | DSCL             | -                            | DDC port's SCL pin           |
| P1.3 | DSDA             | -                            | DDC port's SDA pin           |
| P1.4 | HCLAMP           | P14SF                        | H-clamp pulse output         |
| P1.5 | SOA              | P15SF                        | SOA output                   |

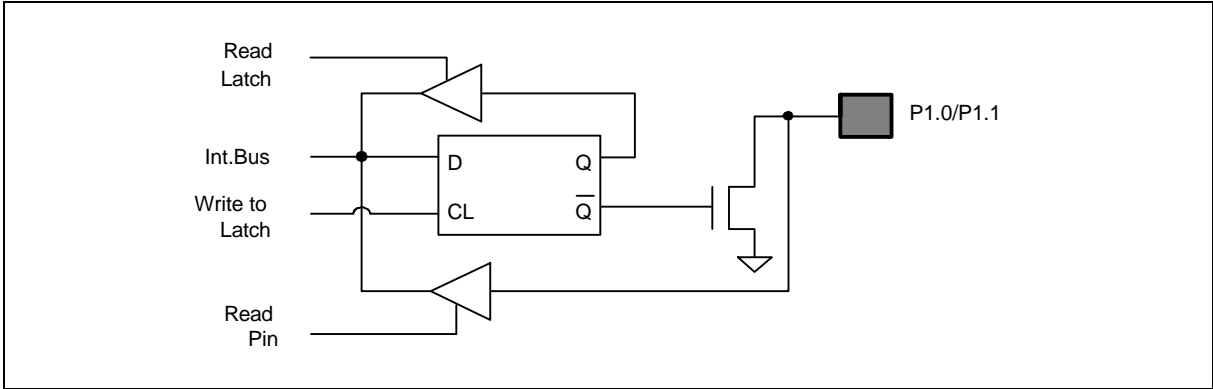


Figure 2-1. P1.0/P1.1 architecture

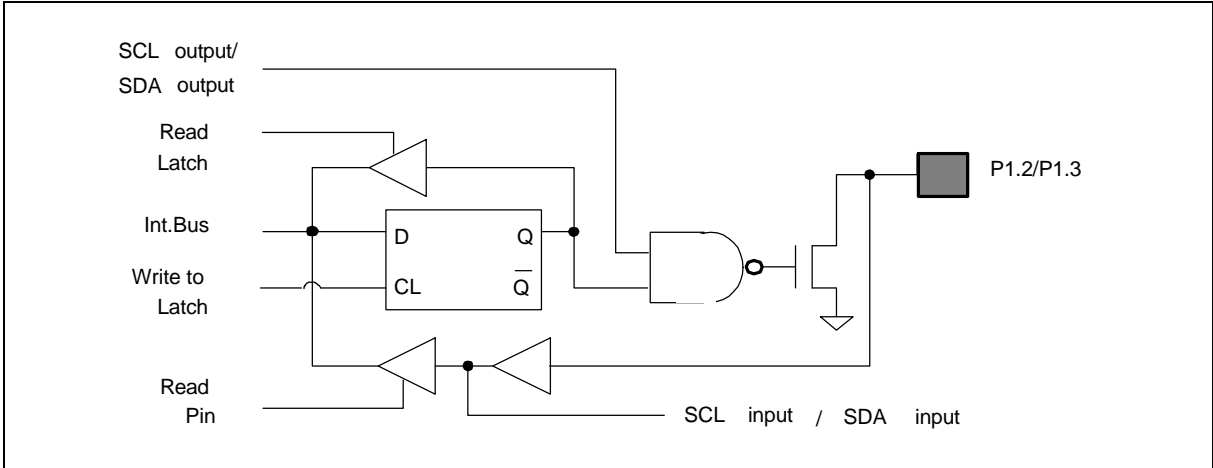


Figure 2-2. P1.2/P1.3 architecture

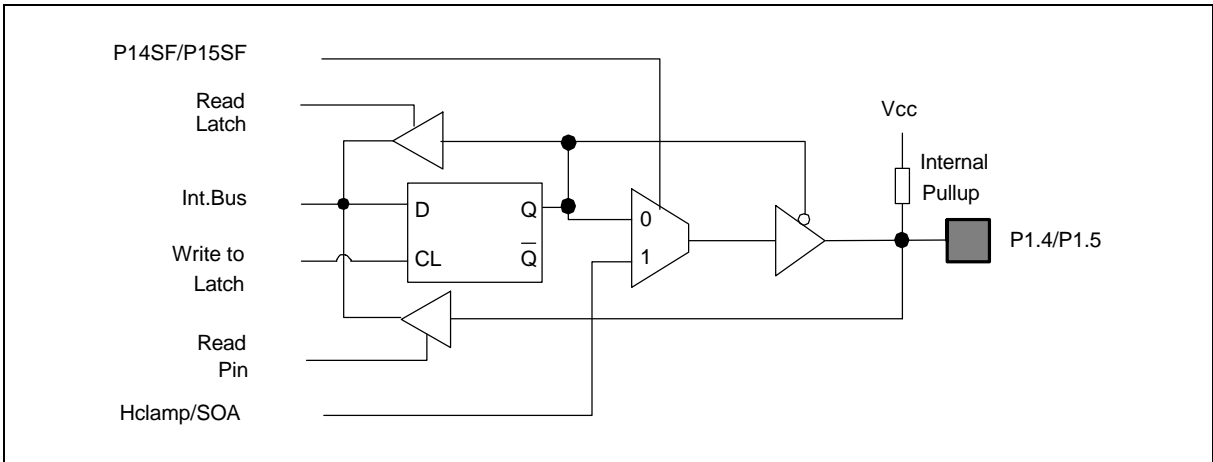


Figure 2-3. P1.4/P1.5 architecture



To use the alternate function H-clamp pulse (SOA output) of P1.4 (P1.5), bit P14SF (P15SF) of the SFR CONTREG4 must be set to "1" and a "0" must be written to P1.4 (P1.5).

| CONDITION OF P14SF   | PORT 1.4 I/O PIN FUNCTION | CONDITION OF P15SF   | PORT 1.5 I/O PIN FUNCTION |
|----------------------|---------------------------|----------------------|---------------------------|
| P14SF = 0            | General I/O pin           | P15SF = 0            | General output pin        |
| P14SF = 1 & P1.4 = 0 | Hclamp pulse output       | P15SF = 1 & P1.5 = 0 | SOA output                |

## E-2 Port 2

Port 2.0–2.2 are used for general purpose I/O functions only, whereas 2.3–2.7 have alternate functions, as shown below. In the 40-pin and 48-pin DIP packages, SDAC10–13 have no dedicated output pins, but share pins with P2.4–P2.7. Each pin can be used as an I/O or SDAC output pin by bit-addressing SFR CONTREG4. When a pin is used for a special function, the output source current is 4 mA. Otherwise, the source current is 100  $\mu$ A.

| PINS | SPECIAL FUNCTION | SPECIAL FUNCTION CONTROL BIT | DESCRIPTION               |
|------|------------------|------------------------------|---------------------------|
| P2.0 | -                | -                            | -                         |
| P2.1 | -                | -                            | -                         |
| P2.2 | -                | -                            | -                         |
| P2.3 | STP              | P23SF                        | Self -test pattern output |
| P2.4 | SDAC10           | P24SF                        | SDAC10 PWM output         |
| P2.5 | SDAC11           | P25SF                        | SDAC11 PWM output         |
| P2.6 | SDAC12           | P26SF                        | SDAC12 PWM output         |
| P2.7 | SDAC13           | P27SF                        | SDAC13 PWM output         |

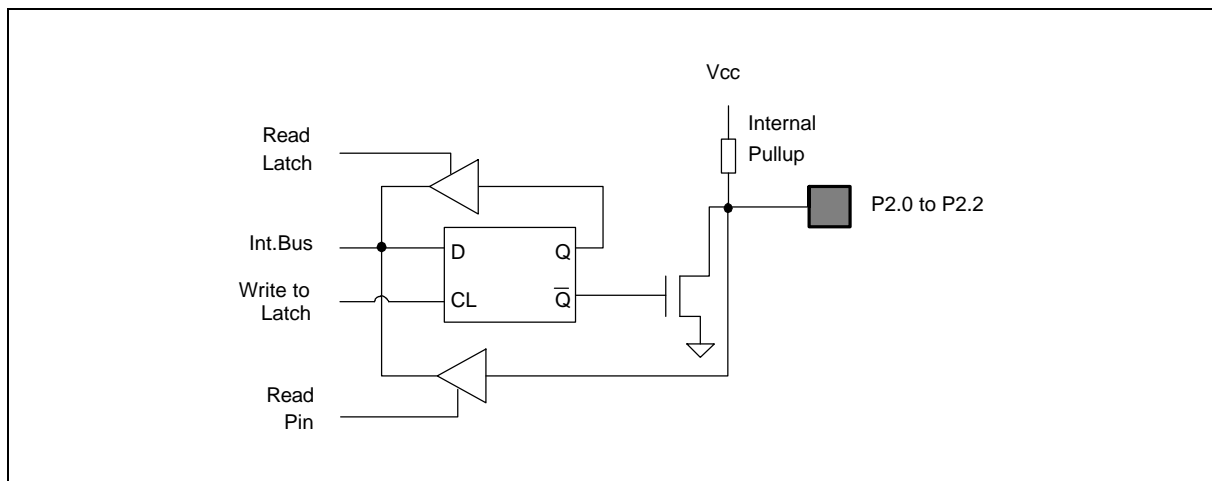


Figure 3-1. P2.0 to P2.2 architecture



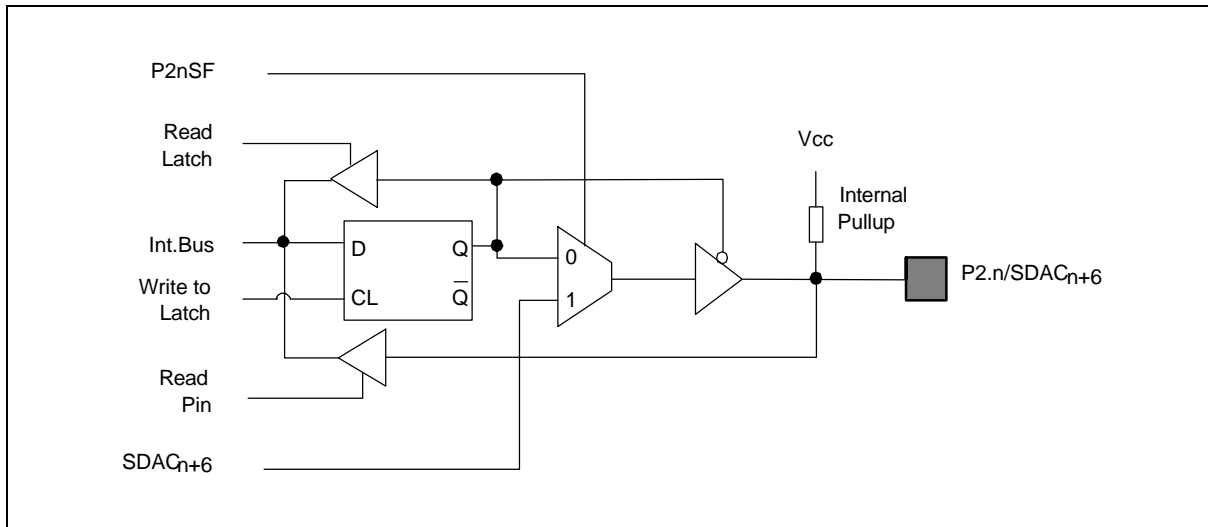


Figure 3-2. P2.4 to P2.7 architecture (where n = 4-7)

**E-3 Port 3**

The architecture of Port 3 is similar to that of P2.0. There are no special function control bits for these bits; the output latch of the bits must be set to high to enable the special functions.

| PINS | SPECIAL FUNCTION | DESCRIPTION  |
|------|------------------|--|
| P3.0 | SPID/RXD         | If serial port is in mode 0, the pin works as the data line of the SPI port.<br>If serial port is in mode 1, 2, or 3, the pin works as the RXD of the 80C32 standard.  |
| P3.1 | SPIC/TXD         | If serial port is in mode 0, the pin works as the clock line of the SPI port.<br>If serial port is in mode 1, 2, or 3, the pin works as the TXD of the 80C32 standard. |
| P3.2 | INT0             | External Interrupt input   |
| P3.3 | -                |  |
| P3.4 | T0               | Counter/Timer 0 input  |
| P3.5 | T1               | Counter/Timer 1 input  |
| P3.6 | -                |  |
| P3.7 | -                |  |

#### E-4 Port 4

Port 4 is an output port. The W78C354 can write data to this port using SFR PORT4.

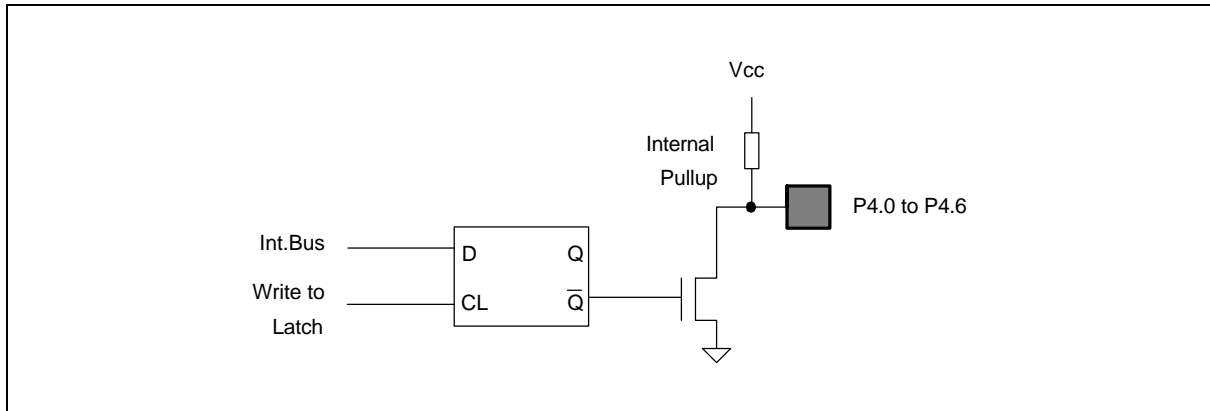


Figure 4-1. Port 4 architecture

#### F. SPI (Synchronous Peripheral Interface) and RS232 Port

- P3.0 (RXD) and P3.1 (TXD) can be used as an SPI port (serial port mode 0 on the standard 80C32) or an RS232 port (serial port mode 1, 2, or 3 on the standard 80C32).
- The SPI port can be used to communicate with an OSD chip, DAC, and so on.
- The RS232 port can be used to communicate with an auto-alignment system, by using a 18.432 MHz crystal. Maximum baud rate is 19200 bps.

#### G. DDC Port (Display Data Channel Port)

The DDC port is composed of the SIO1 and DDC1 ports, and the SIO1 port shares the DSDA pin with the DDC1 port (as shown in Figure 5). The DDC port is designed to support DDC1, DDC2B, and DDC2B+ applications.

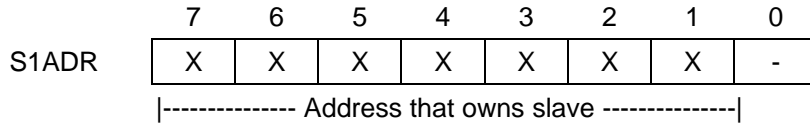
##### G-1 SIO1 Port

SIO1 is an I<sup>2</sup>C serial I/O port. SIO1 provides a serial interface that meets the I<sup>2</sup>C bus specification and supports all transfer modes from and to the I<sup>2</sup>C bus. The SIO1 port handles byte transfers autonomously.

The W78C354 interfaces to the SIO1 port through the following four special function registers: S1CON (SIO1 control register), S1STA (SIO1 status register), S1DAT (SIO1 data register), and S1ADR (SIO1 address register). The SIO1 port interfaces to the DDC I<sup>2</sup>C bus via two pins: P1.2 / DSCL (DDC I<sup>2</sup>C serial clock line) and P1.3/DSDA (DDC I<sup>2</sup>C serial data line). The output latches of P1.2 and P1.3 must be set to "1" in order to enable the SIO1 port. For more detailed information, refer to the description of the Philips I<sup>2</sup>C bus.

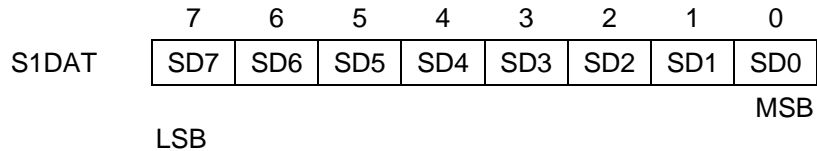
##### G-1.1 S1ADR (SIO1 Address Register) (DAH)

The W78C354 can read from and write to this 8-bit newly added SFR S1ADR. When the the SIO1 port is in a master mode, the content of this register is irrelevant. In slave mode, the seven most significant bits must be loaded with the address that owns the slave.



### G-1.2 S1DAT (SIO1 Data Register) (DBH)

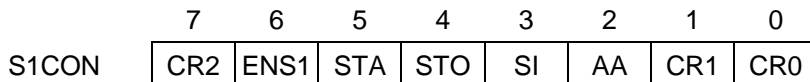
This register contains a byte of serial data that is waiting to be transmitted or has just been received. When the W78C354 is not performing a shifting operation, data can be read from or written to SFR S1DAT. Data in the S1DAT remain stable as long as SI is set. Data in the S1DAT are shifted from the most significant bit to the least significant bit, and while data are being shifted out, data on the bus are simultaneously being shifted in. S1DAT always contains the last data byte present on the bus. Thus, if arbitration is lost, the transition from master transmitter to slave receiver is made with the correct data in S1DAT.



Eight bits of data in the S1DAT are shifted out or in, followed by an acknowledge bit. The acknowledge (ACK) bit is controlled by the SIO1 port hardware and cannot be accessed by the W78C354. Serial data are shifted through the ACK flag into S1DAT on the rising edges of the serial clock pulses on the SCL line and are shifted out from the S1DAT on the falling edges of the SCL clock pulse. When a byte has been shifted into the S1DAT, the serial data are available in S1DAT, and the acknowledge bit is returned by the control logic during the ninth clock pulse.

### G-1.3 S1CON (SIO1 Control Register) (D8H)

The newly added SFR S1CON can be read or written by the programmer. Two bits (SI and STO) are affected by the SIO1 port hardware. When a serial interrupt is requested, the bit SI is automatically set, and when a stop condition is present on the bus, the bit STO is cleared. The bit STO is also cleared when ENS1 = "0."



### G-1.4 ENS1 (SIO1 Enable Bit)

When the bit ENS1 is "0," the SDA and SCL outputs are in a high impedance state, the SIO1 port is in the "not addressed" slave mode, and no other bits are affected, except that the bit STO in S1CON is forced to "0." P1.2 and P1.3 may be used as open drain I/O pins.

When ENS1 is "1," SIO1 is enabled. The P1.2 and P1.3 pins must be set to high.



#### G-1.5 STA (SIO1 Start Flag)

When STA is "1," the SIO1 port will enter the master mode. After the SIO1 port checks the status of the I<sup>2</sup>C bus, it will generate a start condition if the bus is free. If the bus is not free, the SIO1 port will wait for a stop condition and then generate a start condition after a delay.

If the bit STA is set while SIO1 is already in master mode and one or more bytes are to be transmitted or received, SIO1 will transmit a repeated start condition. The bit STA may also be set when SIO1 is an addressed slave.

When STA is "0," no start condition or repeated start condition will be generated.

#### G-1.6 STO (SIO1 Stop Flag)

When STO is "1," the SIO1 port is in the master mode and a stop condition is transmitted to the I<sup>2</sup>C bus. When the stop condition is detected on the bus, the SIO1 port will clear STO. In the slave mode, STO may be set to recover from an error condition. In this case, no stop condition exists the I<sup>2</sup>C bus, but the SIO1 port behaves as if a stop condition has been received and switches to the defined "not addressed" slave receiver mode. STO is automatically cleared by hardware.

#### G-1.7 SI (SIO1 Serial Interrupt Flag)

When SI is "1," if the bits EA and ES1 (in the IE register) are also set, then once a serial interrupt is requested, SI will automatically be set by hardware. The only state that does not cause SI to be set is state F8H, which indicates that no relevant state information is available.

When the bit SI is "1," the low period of the serial clock on the SCL pin is extended, and the serial transfer is suspended. SI must be reset by software.

When SI is "0," no serial interrupt is requested, so there is no extension of the serial clock on the SCL pin.

#### G-1.8 AA (SIO1 Assert Acknowledge Flag)

If AA is "1," an acknowledge signal (low level to the SDA pin) will be generated during the acknowledge clock pulse on the SCL pin when:

- (1) The address owning the slave has been received.
- (2) A data byte has been received while the SIO1 port is in the master receiver mode.
- (3) A data byte has been received while the SIO1 port is in the addressed slave receiver mode.

If the bit AA is "0," a not acknowledge signal (high level to the SDA pin) will be generated during the acknowledge clock pulse on the SCL pin when:

- (1) A data byte has been received while the SIO1 port is in the master receiver mode
- (2) A data byte has been received while the SIO1 port is in the addressed slave receiver mode.

#### G-1.9 CR0, CR1 and CR2 (SIO1 Clock Rate Bits)

When the SIO1 port is in master mode, these three bits will determine the serial clock frequency (see the table below). These bits are unimportant when SIO1 is in slave mode. In slave mode, the SIO1 port will automatically synchronize with any clock frequency up to 100 KHz on the I<sup>2</sup>C bus.

**Table 3. Serial clock rates**

| CR2 | CR1 | CR0 | BIT FREQUENCY (KHz) AT THE SCL PIN |            |        | FORMULA  |
|-----|-----|-----|------------------------------------|------------|--------|----------|
|     |     |     | 16 MHz                             | 18.432 MHz | 20 MHz |          |
| 0   | 0   | 0   | 63                                 | 72         | 78     | Fosc/256 |
| 0   | 0   | 1   | 71                                 | 82         | 89     | Fosc/224 |
| 0   | 1   | 0   | 83                                 | 96         | -      | Fosc/192 |
| 0   | 1   | 1   | 100                                | -          | -      | Fosc/160 |
| 1   | 0   | 0   | 17                                 | 19         | 20     | Fosc/960 |
| 1   | 0   | 1   | -                                  | -          | -      | Fosc/120 |
| 1   | 1   | 0   | -                                  | -          | -      | Fosc/60  |

**G-1.10 S1STA (SIO1 Status Register) (D9H)**

The newly added SFR S1STA is an 8-bit read-only register. The three least significant bits are always zero. The five most significant bits contain the status code. There are 26 possible status codes. When the S1STA contains F8H, no serial interrupt is requested. All other the S1STA values correspond to defined SIO1 states (refer to the Philips specification for the I<sup>2</sup>C bus). When each of these states is entered, a status interrupt is requested (SI = 1). A valid status code is present in the S1STA one machine cycle after the bit SI is set by hardware and is still present one machine cycle after the bit SI has been reset by software.

**G-2 DDC1 Port**

DDC1 is a serial output port that supports DDC1 communication. After the DDC1 control circuit loads the next data byte from the data buffer to the shift register and generates a DDC1INT signal to the CPU, eight data bits and one zero (for the "acknowledge" signal) are shifted out to the DSDA pin sequentially on each rising edge of the VIN signal. In the interrupt service routine, the W78C354 should fetch the next byte of EDID data and write it to SFR DDC1. If the bit ENDDC1 of SFR CONTREG1 is cleared to zero, the shift register is stopped, and the DSDA output is kept high.

- One DDC1 port to support DDC1; ENDDC1 must be set to 1.
- One SIO1 port support DDC2B/2B+; ENDDC1 must be set to 0.

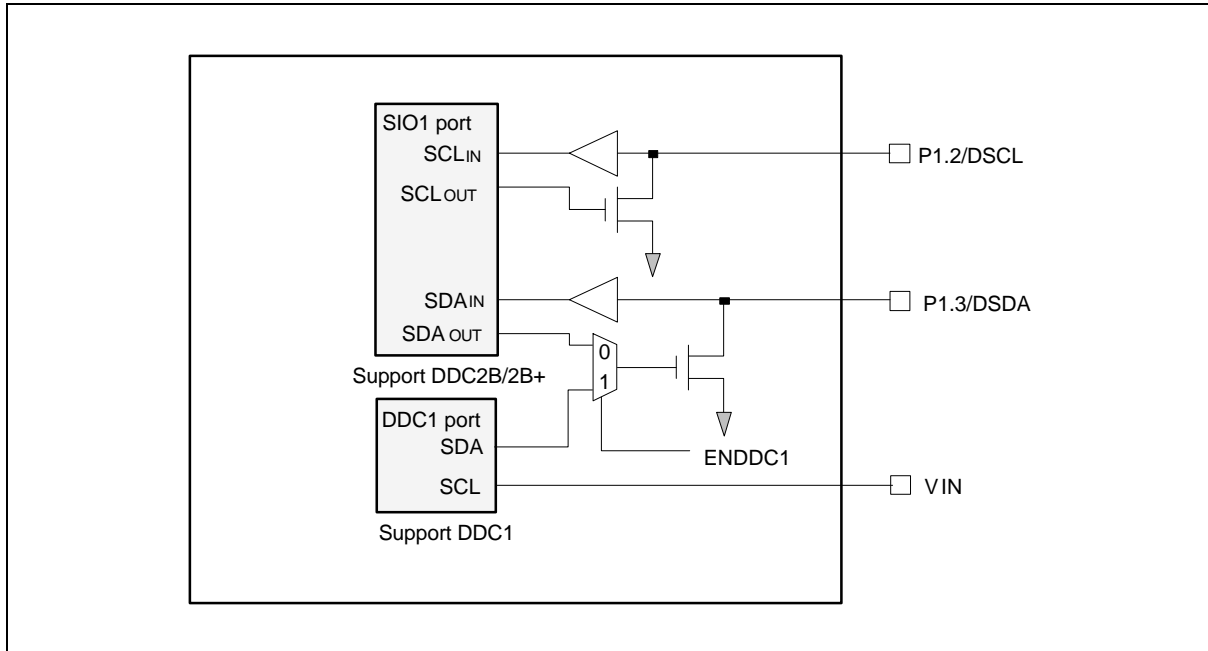


Figure 5. DDC port

## H. Interrupts

The W78C354 has six interrupt sources. Five (except  $\overline{\text{INT}}1$ , at vector address 0013H) are identical to those in the 80C51 series, while the sixth (at vector address 002BH) is newly added. All the interrupt sources and the corresponding interrupt vector addresses for the W78C354 are described in the following table:

| SOURCE | VECTOR ADDRESS | DESCRIPTION                                    | PRIORITY |
|--------|----------------|--|----------|
| IE0    | 0003H          | External interrupt 0 (same as the 80C31)       | Highest  |
| TF0    | 000BH          | Timer 0 overflow interrupt (same as the 80C31) |          |
| *1     | 0013H          | Replaces $\overline{\text{INT}}1$ of the 80C31 |          |
| TF1    | 001BH          | Timer 1 overflow interrupt (same as the 80C31) |          |
| RI+TI  | 0023H          | Serial port interrupt (same as the 80C31)      |          |
| *2     | 002BH          | New (similar to TF2+EXF2 in the 80C32)         | Lowest   |

Notes:

\*1. DSCLINT+ADCINT+TIMEOUT+SOAINT+VEVENT+PARAINT+DDC1INT.

\*2. This is the interrupt generated by the I<sup>2</sup>C in the DDC port.



**H-1. Interrupt at Vector Address 0013H**

The interrupt at vector address 0013H is driven by another seven different sources, which are a high-to-low transition on the DSCL pin of the DDC port, the A/D converter, the auto-reload timer, the SOA output, Vsync frequency event, the parabola interrupt generator, and DDC1 in the DDC port. These sources are described below.

(1) DSCLINT:

Interrupt generated when DSCL-pin changes from high to low and stays high for 12 clock periods. Once DDCLINT interrupt is received, the programmer should disable DDC1 port by writing "0" to the bit ENDDC1 of SFR CONTREG1.

|          |               |                   |               |
|----------|---------------|-------------------|---------------|
|          | <b>16 MHz</b> | <b>18.432 MHz</b> | <b>20 MHz</b> |
| DSCL low | 750 nS        | 651 nS            | 600 nS        |

(2) ADCINT:

Refer to section K for a description of the ADC.

(3) TIMEOUT:

Refer to section I for a description of the auto-reload timer.

(4) SOAINT:

When an SOA condition occurs, SOAINT will interrupt the CPU to perform the necessary operations. Refer to section M-6 for a description of the SOA function.

(5) VEVENT:

When the V retrace signal is detected or the V-frequency counter overflows, which means that the Vsync frequency is so low that it is out of range, the W78C354 will generate the VEVENT interrupt. In the interrupt service routine, the programmer can check bit 3 (NOV) of SFR STATUS to determine whether the V frequency is out of range. If NOV = 1, the software should go to DPMS process. If NOV = 0, the software can read the HFCOUNT and VFCOUNT registers, and the bits HP and VP of STATUS will determine the preset mode of the incoming frequency. Refer to section M for a description of the sync processor.

(6) PARAINIT:

The parabola interrupt generator is used to generate interrupts to the W78C354 for loading the parabola waveform data to dynamic DACs. The software should calculate the value of the PARAH and PARAL registers by  $(Vcount \times 16) \div$  section number. Refer to section J for a description of the parabola interrupt generator.

(7) DDC1INT:

Refer to section G-2 for a description of the DDC1 operation.

Programmer must read SFR INTVECT (bits 0–6) to determine the source of the interrupt request. These seven interrupt sources can be enabled individually by setting SFR INTMSK (bits 0–6). The newly added interrupt at vector address 002BH is driven by the I<sup>2</sup>C circuit in the DDC port.

The interrupt enable control bits for the two interrupts at 0013H and 002BH are IE.2 and IE.5 in the IE register, respectively. The interrupt priority control bits are IP.2 and IP.5 in the IP register. The interrupts can be disabled by clearing IE.7 (disable all interrupts). For example, the programmer can enable the A/D converter interrupt by the "MOV INTMSK, #00000010B" instruction. When the

converter is completed, the interrupt will be generated and the bit ADCINT in the INTVECT will automatically be set. To clear the bit ADCINT to receive the next interrupt, the programmer can use the "MOV INTVECT, #00000010B" instruction. See Figure 6.

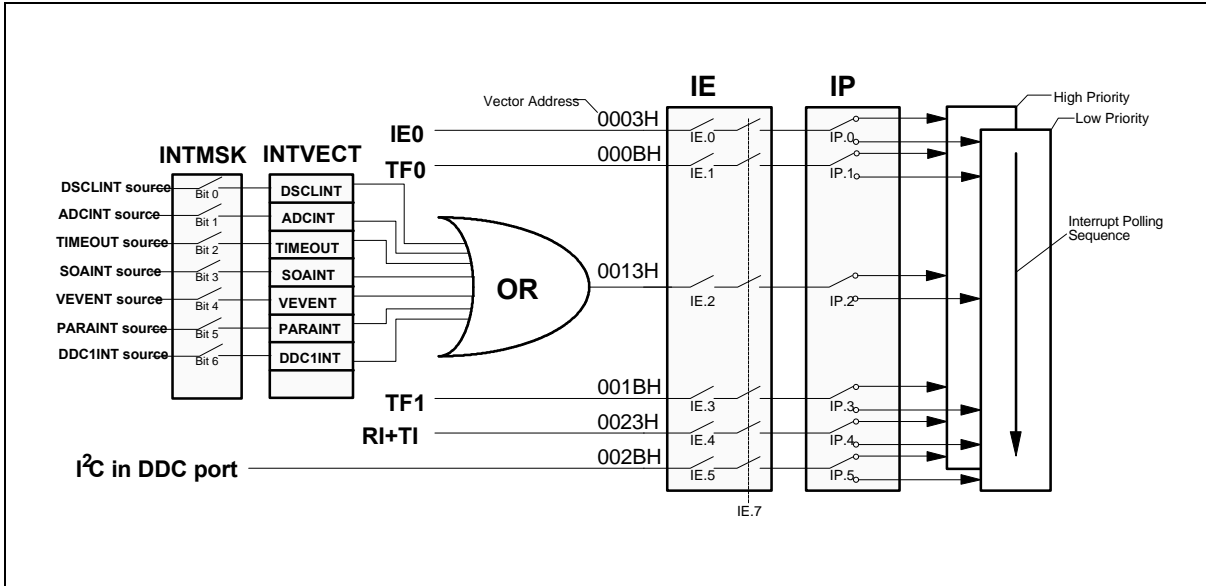


Figure 6. Interrupt block diagram

### H-2. Newly Added External Interrupt 0 Function (INT0)

INT0 can be set to be falling-edge or low-level active by setting/clearing the IT0 bit in TCON. If programmers wish to use a rising-edge or high-level signal as interrupt on the pin INT0, INT0 can also be activated by setting/clearing the EINTES bit in SFR CONTREG2 (see Figure 7). In other words, there are four trigger types for INT0 (falling-edge, low-level, rising-edge, and high-level). In the initial state, INT0 will be triggered by a rising-edge or high-level signal.

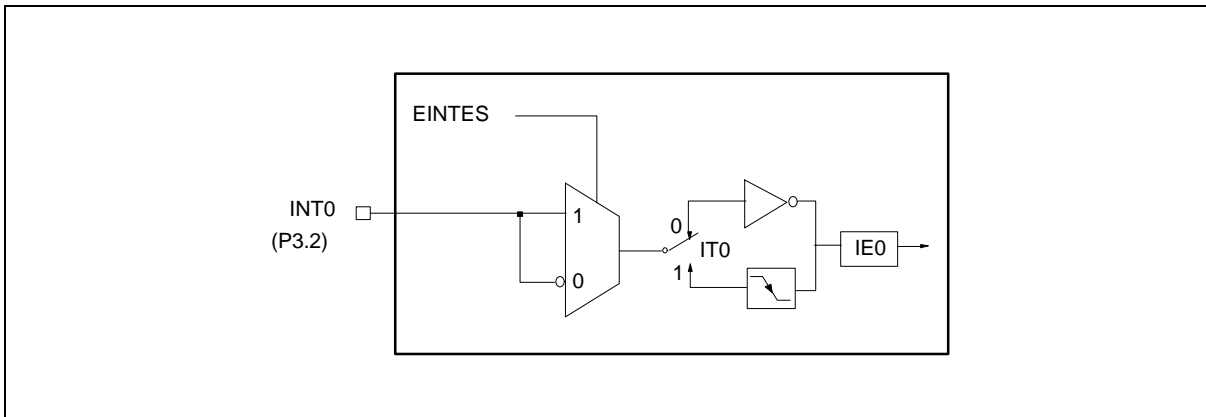


Figure 7. External interrupt 0



**INTVECT: Interrupt Vector Register (B2H)**

| BIT | NAME    | FUNCTION  |
|-----|---------|---|
| 0   | DSCLINT | Set by hardware when DSCL is toggled low.                           |
| 1   | ADCINT  | Set by hardware when ADC conversion is completed.                   |
| 2   | TIMEOUT | Set by hardware when autoloader timer times out.                    |
| 3   | SOAINT  | Set by hardware when SOA is high.                                   |
| 4   | VEVENT  | Set by hardware when Vsync or vertical frequency counter times out. |
| 5   | PARAINT | Set by hardware when parabola interrupt generator times out.        |
| 6   | DDC1INT | Set by hardware when DDC port functions in the DDC1 mode .          |
| 7   | -       | Reserved.   |

## Notes:

1. Each of the above interrupt flags will be set by hardware when the corresponding interrupt source is masked by writing a "1" to the the INTMSK register.
2. To clear the interrupt flag, write a "1" (not "0") to the corresponding bit.

**INTMSK: Interrupt Mask Register (95H)**

| BIT | NAME    | FUNCTION  |
|-----|---------|---|
| 0   | DSCLINT | Enable/Disable DSCLINT interrupt.<br>0: Disable, 1: Enable. |
| 1   | ADCINT  | Enable/Disable ADCINT interrupt.<br>0: Disable, 1: Enable.  |
| 2   | TIMEOUT | Enable/Disable TIMEOUT interrupt.<br>0: Disable, 1: Enable. |
| 3   | SOAINT  | Enable/Disable SOAINT interrupt.<br>0: Disable, 1: Enable.  |
| 4   | VEVENT  | Enable/Disable VEVENT interrupt.<br>0: Disable, 1: Enable.  |
| 5   | PARAINT | Enable/Disable PARAINT interrupt.<br>0: Disable, 1: Enable. |
| 6   | DDC1INT | Enable/Disable DDC1INT interrupt.<br>0: Disable, 1: Enable. |
| 7   | -       | Reserved  |



## I. Timer/Counter

The W78C354 has two 16-bit timer/counters, Timer/counter 0 and Timer/counter 1, which are identical with those on the standard 80C32, and one 8-bit auto-reload timer. Once the "MOV AUTOLOAD, #data" instruction is executed, the auto-reload timer will load the specified data and start to count. If the TIMEOUT bit in INTMSK is set, the auto-reload timer will periodically generate an interrupt to the CPU.

The auto-reload timer interval is programmable:

- Minimum timer interval =  $1/(F_{CLOCK} \div 1024)$
- Desired timer interval = Minimum interval  $\times$  [(preset value of the AUTOLOAD)+1]
- Maximum timer interval = Minimum interval  $\times$  255
- AUTOLOAD: 8-bit auto-reload timer register which stores preset value.

|                  | 16 MHz     | 18.432 MHz | 20 MHz       |
|------------------|------------|------------|--------------|
| Minimum Interval | 64 $\mu$ S | 55 $\mu$ S | 51.2 $\mu$ S |
| Maximum Interval | 16.3 mS    | 14.2 mS    | 13.1 mS      |

## J. Parabola Interrupt Generator

The parabola interrupt generator is a 16-bit binary count-up auto-reload timer that is used to generate the parabola interrupt to the W78C354 for loading parabola waveform data to dynamic DACs. It periodically generates an interrupt by setting the PARALNT bit in INTMSK, if the "MOV PARAL, #Low byte data" and "MOV PARAH, #High byte data" instructions are executed.

The parabola interrupt generator period is programmable:

Time base =  $1/F_{CLOCK}$

- Desired interrupt period = Time base  $\times$  {[preset value of the (PARAH, PARAL)]+1}
- Maximum period = Time base  $\times$  65535
- PARAL: Parabola interrupt generator register that stores low byte preset value
- PARAH: Parabola interrupt generator register that stores high byte preset value

## K. 6-bit A/D Converter

The 6-bit analog-to-digital converter uses the successive approximation method to convert one of the four analog input channels into a digital data value. The A/D converter resolution is  $\pm 1$  LSB, and the conversion time is 100 usec. The result is read from SFR ADC.

Bit-pairs (ADCS1, ADCS2) in SFR CONTREG1 are used to select one of the four channels as the analog input (see Table 3). Conversion is started by setting the bit ADCSTRT in CONTREG1 by software. When the A/D conversion is completed, the ADCSTRT bit is automatically cleared by hardware to stop the A/D converter's operation, and the ADCINT bit in INTVECT is set by hardware at the same time. To enable the A/D converter interrupt, set the ADCINT bit in INTMSK.

**Table 4. Select A/D converter channel**

| (ADCS1, ADCS0)   | (0, 0) | (0, 1) | (1, 0) | (1, 1) |
|------------------|--------|--------|--------|--------|
| Selected channel | ADC0   | ADC1   | ADC2   | ADC3   |



## L. PWM DACs

There are two 12-bit and fourteen 8-bit PWM static DACs and one 12-bit and three 8-bit PWM dynamic DACs on this chip. The number of the PWM outputs is different with the package.

|             | 68-PIN PLCC | 48-PIN DIP | 40-PIN DIP |
|-------------|-------------|------------|------------|
| 8-bit SDAC  | 14          | 8 + 4*     | 8 + 4*     |
| 12-bit SDAC | 2           | 1          | 1          |
| 8-bit DDAC  | 3           | 3          | 1          |
| 12-bit DDAC | 1           | 1          | 1          |

Note : 4\* : the SDACs share with P2.4–P2.7

### L-1.1 14-channel 8-bit PWM Static DAC

The static DACs (SDAC0 to 13) are used to generate DC voltage control (0 to 5V) by an RC circuit, as shown in Figure 8, and to execute the "MOV SDACn, #Value" instruction. There are 14 registers, corresponding to the 14 channels of 8-bit PWM output. The unused PWM channel can be used as an output pin, since 0 or 5V can be obtained from the pin.

- Duty cycle of the PWM output = Preset value of SDACn  $\div$  255, where n = 0 to 13
- DC voltage after low-pass filter =  $V_{CC} \times$  duty cycle
- SDAC0–SDAC13: 8-bit PWM static DAC registers storing preset values

| PRESET VALUE | DUTY CYCLE | DC VOLTAGE        |
|--------------|------------|-------------------|
| 0            | 0/255      | 0V                |
| 1            | 1/255      | $1/255 \times 5V$ |
| n            | n/255      | $n/255 \times 5V$ |
| 255          | 255/255    | +5V               |

- PWM frequency  $F_{PWM} = F_{CLOCK} \div 255$

|                  |               |               |               |
|------------------|---------------|---------------|---------------|
| Fclock           | 16 MHz        | 18.432 MHz    | 20 MHz        |
| F <sub>PWM</sub> | 62.745 KHz    | 72.282 KHz    | 78.431 KHz    |
| T <sub>PWM</sub> | 15.94 $\mu$ S | 13.83 $\mu$ S | 12.75 $\mu$ S |

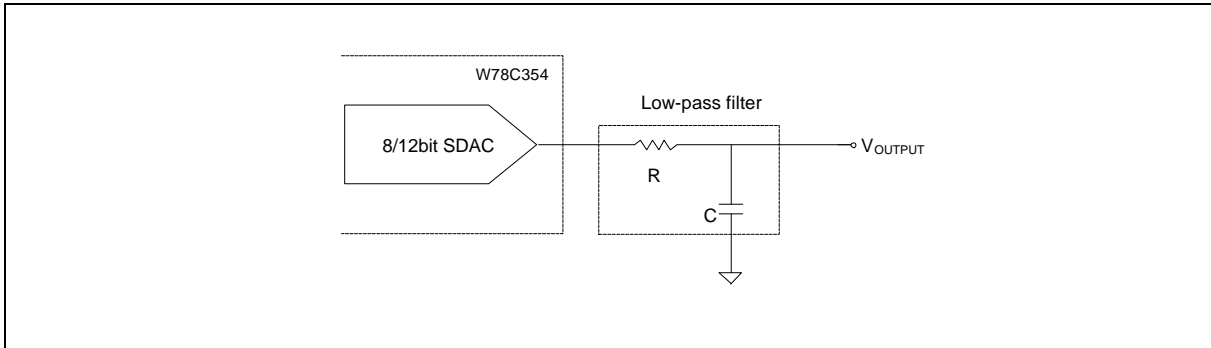


Figure 8. SDAC application circuit (where  $T = RC$ ,  $V_{OUTPUT} = V_{CC} \times n/255$ , if  $T \gg T_{PWM}$ )

When bit ENM0 of SFR CONTREG2 is set to high, SDAC0 will output PWM in one frame and then keep low for the next frame. Thus SDAC0 can be used for H moire cancellation. SDAC1 can also be configured with the same operation for V moire cancellation by setting bit ENM1. The application circuit is shown below.

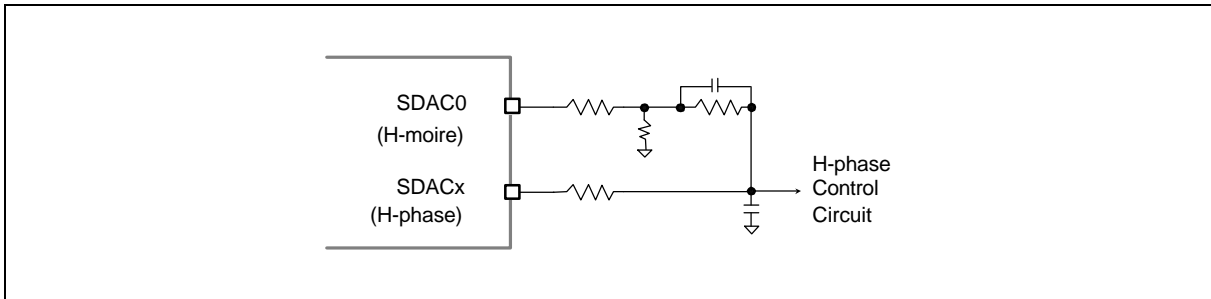


Figure 9. Moire application circuit

### L-1.2 Two-channel 12-bit PWM/BRM Static DAC

The two 12-bit PWM/BRM outputs (BSDAC0,1) are composed of an 8-bit PWM and a 4-bit BRM (bit rate multiplier). The value of the 4-bit BRMs (SFRs SBRM0, 1) determine to which positions one clock pulse will be added in every 16 PWM outputs of 12-bit PWM/BRM static DAC0,1. When the "MOV BSDACn, #value" or "MOV SBRMn, #value" instruction is executed, the related output pin will output the PWM waveform needed by the user. The 12-bit PWM/BRM frequency is the same as that of the 8-bit PWM output.

| VALUE OF SBRM0 OR SBRM1<br>(BIT3 BIT2 BIT1 BIT0) | ONE CLOCK PLUSE INCREMENTED IN THE N-TH<br>OUTPUT EVERY 16 PWM OUTPUTS |
|--|--|
| 0000   | None   |
| 0001   | n = 8  |
| 0010   | n = 4, 12  |
| 0100   | n = 2, 6, 10, 14   |
| 1000   | n = 1, 3, 5, 7, 9, 11, 13, 15  |

In the following table, in the positions marked with an "⊙" one clock pulse will be added to every 16 PWM outputs.

| SBRM0,<br>SBRM1 | PWM/BRM OUTPUT CYCLE |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|-----------------|----------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
|                 | 0                    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0000            | -                    | - | - | - | - | - | - | - | - | - | -  | -  | -  | -  | -  | -  |
| 0001            | -                    | - | - | - | - | - | - | - | ⊙ | - | -  | -  | -  | -  | -  | -  |
| 0010            | -                    | - | - | - | ⊙ | - | - | - | - | - | -  | ⊙  | -  | -  | -  | -  |
| 0011            | -                    | - | - | - | ⊙ | - | - | - | ⊙ | - | -  | ⊙  | -  | -  | -  | -  |
| 0100            | -                    | - | ⊙ | - | - | - | ⊙ | - | - | - | ⊙  | -  | -  | -  | ⊙  | -  |
| 0101            | -                    | - | ⊙ | - | - | - | ⊙ | - | ⊙ | - | ⊙  | -  | -  | -  | ⊙  | -  |
| 0110            | -                    | - | ⊙ | - | ⊙ | - | ⊙ | - | - | - | ⊙  | -  | ⊙  | -  | ⊙  | -  |
| 0111            | -                    | - | ⊙ | - | ⊙ | - | ⊙ | - | ⊙ | - | ⊙  | -  | ⊙  | -  | ⊙  | -  |
| 1000            | -                    | ⊙ | - | ⊙ | - | ⊙ | - | ⊙ | - | ⊙ | -  | ⊙  | -  | ⊙  | -  | ⊙  |
| 1001            | -                    | ⊙ | - | ⊙ | - | ⊙ | - | ⊙ | ⊙ | - | ⊙  | -  | ⊙  | -  | ⊙  | ⊙  |
| 1010            | -                    | ⊙ | - | ⊙ | ⊙ | ⊙ | - | ⊙ | - | ⊙ | -  | ⊙  | ⊙  | ⊙  | -  | ⊙  |
| 1011            | -                    | ⊙ | - | ⊙ | ⊙ | ⊙ | - | ⊙ | ⊙ | ⊙ | -  | ⊙  | ⊙  | ⊙  | -  | ⊙  |
| 1100            | -                    | ⊙ | ⊙ | ⊙ | - | ⊙ | ⊙ | ⊙ | - | ⊙ | ⊙  | ⊙  | -  | ⊙  | ⊙  | ⊙  |
| 1101            | -                    | ⊙ | ⊙ | ⊙ | - | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙  | ⊙  | -  | ⊙  | ⊙  | ⊙  |
| 1110            | -                    | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | - | ⊙ | ⊙  | ⊙  | ⊙  | ⊙  | ⊙  | ⊙  |
| 1111            | -                    | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙ | ⊙  | ⊙  | ⊙  | ⊙  | ⊙  | ⊙  |

### L-2. Three-channel 8-bit and One-channel 12-bit PWM Dynamic DACs

The 8-bit PWM dynamic DACs (DDAC0-2) and 12-bit PWM dynamic DAC (BDDAC) are used to achieve geometric compensation by generating a parabola output waveform by the integrator circuit shown in Figure 6 and by executing the "MOV DDACn, #value," "MOV BDDAC, #value," or "MOV DBRM, #value" instructions by a software program. The PWM waveforms and operating criteria of the related registers are similar to those of the static DACs. The unused dynamic DACs can be used as static DACs.

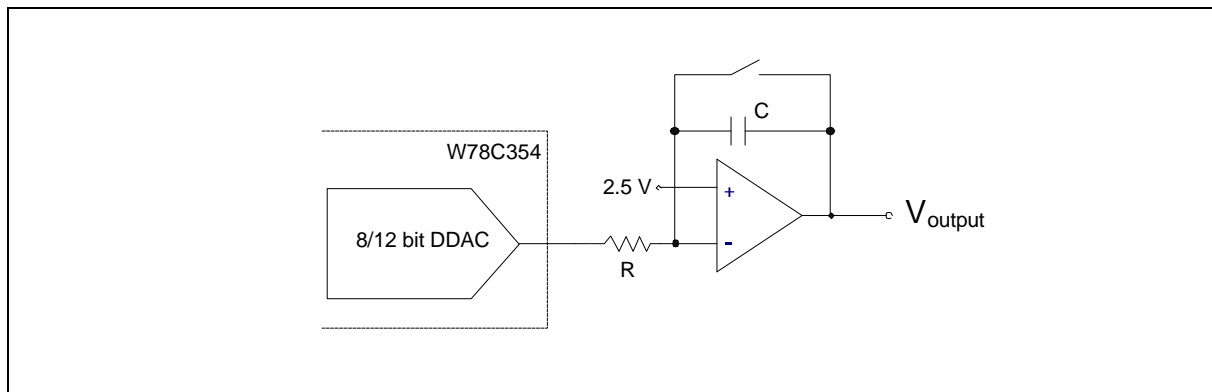





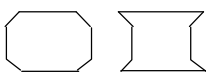
Figure 10. Dynamic DAC application circuit



The objective of the dynamic DAC is to generate geometric compensation parabola waveforms. Several examples are given below.

**L-3. Examples**

L-3.1 DDAC0 used to compensate for H size distortion

- 1. Pincushion (PCC amplitude) 
- 2. Trapezoid (Keystone) 
- 3. CBOW (S-comp) 
- 4. PCC corner 

L-3.2 DDAC1 used to compensate for H center distortion

- 1. Pin balance (Bow) 
- 2. Key balance (Tilt) 

**M. Sync Processor**

The sync processor is composed of a polarity detector, sync separator, H/V frequency counter, H/V dummy frequency generator, H-clamp generator, and SOA generator. Figure 11 is a block diagram of the sync processor. The related control bits are defined in SFR CONTREG2. The sync processor supports powerful functions that enable users to employ the V/H , H-clamp, and SOA outputs to easily control and protect the deflection circuit.

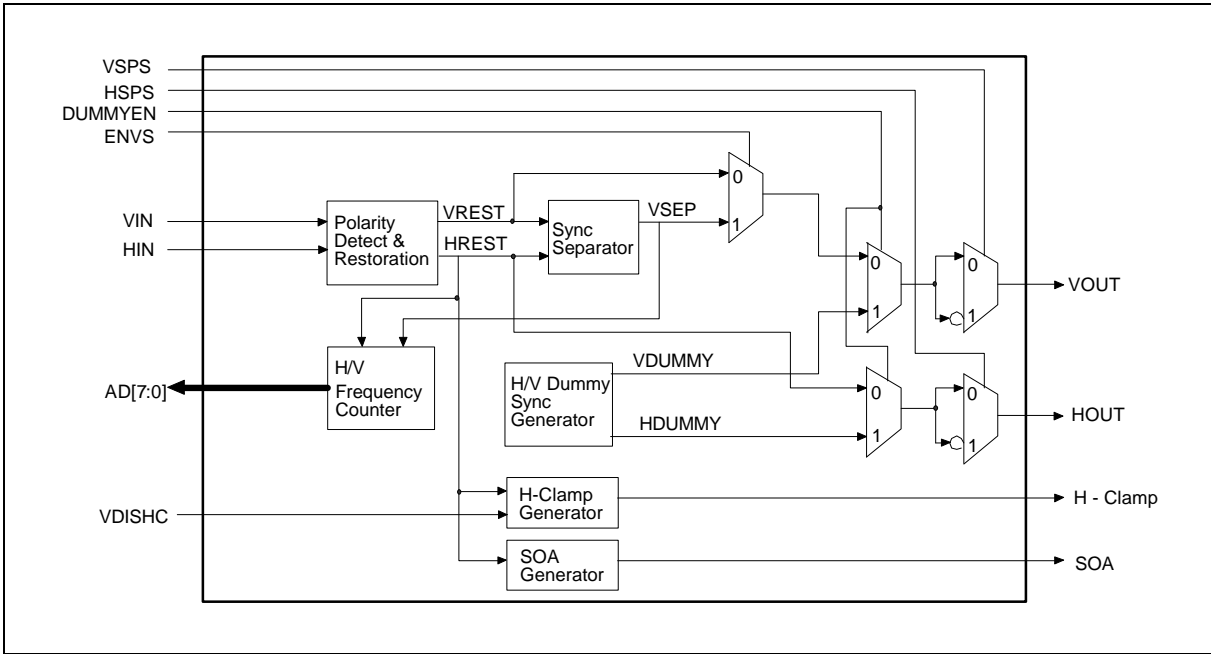


Figure 11. Sync processor

**M-1. Polarity Detector**

The H/V polarity is detected automatically and can be read from SFR STATUS. The polarity of the H/V input signals is then restored (they signals become HREST/VREST) for internal processing and output to HOUT/VOUT to drive the deflection circuit.

Maximum sync width to HIN pin:  $(1/F_{CLOCK}) \times 2^{14}$

Maximum sync width to VIN pin:  $(1/F_{CLOCK}) \times 2^{14}$

| FCLOCK                  | 16 MHz  | 18.432 MHz | 20 MHz |
|-------------------------|---------|------------|--------|
| Max. sync width for HIN | 1024 μS | 888 μS     | 819 μS |
| Max. sync width for VIN | 1024 μS | 888 μS     | 819 μS |

**M-2. Sync Separator**

Vsync is separated from the composite sync automatically, without any additional software programming. Figure 12 shows the waveforms of VOUT that result from a composite or non-composite Hsync input.

If ENV5 = 1, the limitations on the Vsync signal are:

VIN pulse width must be larger than  $W_{vmin} = [(1/F_{CLOCK}) \cdot \sqrt{128.5}] \pm 1/(2 \times F_{CLOCK})$

VOUT is delayed from VIN signal by  $T_{delay} = [(1/F_{CLOCK}) \cdot \sqrt{128.5}] \pm 1/(2 \times F_{CLOCK})$

| F <sub>CLOCK</sub>  | 16 MHz       | 18.432 MHz   | 20 MHz       |
|---|--------------|--------------|--------------|
| 1/F <sub>clock</sub>  | 62.5 nS      | 54 nS        | 50 nS        |
| Min. Vsync width (W <sub>vmin</sub> )                             | 8031 ± 31 nS | 6939 ± 27 nS | 6425 ± 25 nS |
| V <sub>OUT</sub> delay from V <sub>IN</sub> (T <sub>delay</sub> ) | 8031 ± 31 nS | 6939 ± 27 nS | 6425 ± 25 nS |

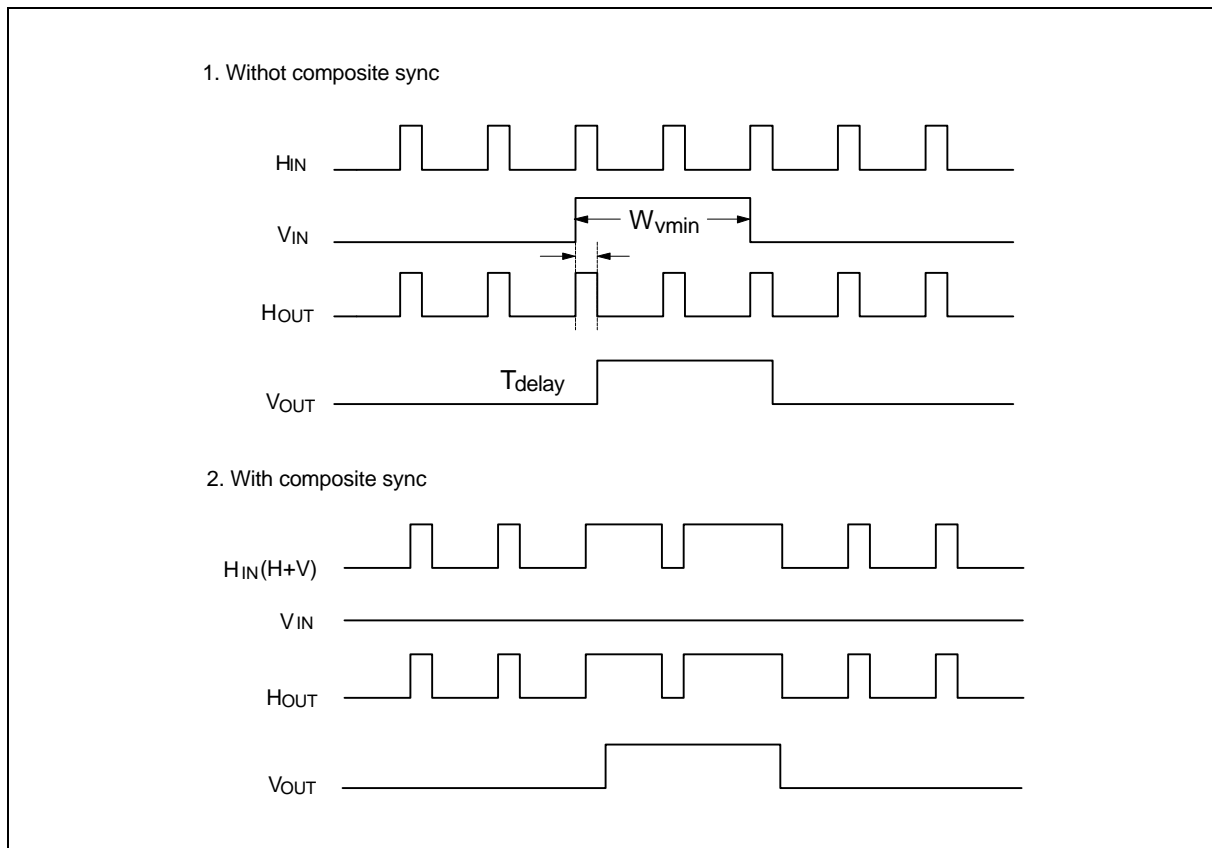


Figure 12. Vsync separator output (when DUMMYEN = 0, ENV5 = 1)

### M-3. Horizontal & Vertical Frequency Counter

There are two 16-bit counters that automatically count the horizontal and vertical frequency. When a VEVENT interrupt occurs, the W78C354 reads the count value (H<sub>COUNT</sub> and V<sub>COUNT</sub>) from the 8-bit counter registers (HFCOUNT<sub>TH</sub>, HFCOUNT<sub>TL</sub>, VFCOUNT<sub>TH</sub>, and VFCOUNT<sub>TL</sub>) to calculate the H and V frequency by the formulas listed below.





### V frequency:

- Resolution of V frequency counter:  $VRESOL = (1/FCLOCK) \times 16$
- V-frequency:  $VFREQ = 1/(VCOUNT \times VRESOL)$
- Lowest V frequency can be detected:  $FCLOCK \geq 1048576$

### H frequency:

- Resolution of H frequency counter:  $HRESOL = (1/FCLOCK) \geq 8$
- H-frequency:  $HFREQ = 1/(HCOUNT \times HRESOL)$
- Lowest H frequency can be detected:  $FCLOCK \geq 8192$

|              | 16 MHz    | 18.432 MHz | 20 MHz  |
|--------------|-----------|------------|---------|
| Vresol       | 1 $\mu$ S | 868 nS     | 800 nS  |
| Lowest VFREQ | 15 Hz     | 17.6 Hz    | 19 Hz   |
| Hresol       | 7.8 nS    | 6.8 nS     | 6.3 nS  |
| Lowest HFREQ | 1.9 KHz   | 2.3 KHz    | 2.4 KHz |

### M-4. Dummy Frequency Generator

The dummy H and V frequencies are generated for factory burn-in measurement and for displaying a warning message when there is no input H/V frequency. The dummy sync generator includes two newly added SFRs, DHREG and DVREG. DHREG is a 4-bit register used to determine the dummy Hsync output frequency. DVREG is an 8-bit register that can be used to preset a constant into DVREG to determine the dummy Vsync output frequency by the formulas listed below.

- Dummy Hsync frequency  $F_{dH} = FCLOCK \geq 32 \geq (DHREG+1)$
- Dummy Vsync frequency  $F_{dV} = F_{dH} \geq 8 \geq (DVREG+1)$

Example: Assume system clock = 16 Mhz

| DHREG | F <sub>DH</sub> | DVREG | F <sub>DV</sub> |
|-------|-----------------|-------|-----------------|
| 15    | 31.25K          | 48    | 79.7 Hz         |
| 12    | 38.5K           | 59    | 80.2 Hz         |
| 10    | 45.5K           | 70    | 80.1 Hz         |
| 9     | 50K             | 77    | 80.1 Hz         |
| 7     | 62.5K           | 96    | 80.5 Hz         |
| 5     | 82K             | 127   | 80.1 Hz         |
| 4     | 100K            | 155   | 80.1 Hz         |

The relations between the bit DUMMYEN and the outputs of the H/V frequencies are listed below:

|             | HOUT   | VOUT                                      |
|-------------|--------|---|
| DUMMYEN = 0 | HREST  | VREST (if ENVS = 0)<br>VSEP (if ENVS = 1) |
| DUMMYEN = 1 | HDUMMY | VDUMMY                                    |

**M-5. H-clamp Pulse Generator**

If the P14SF bit is set in the newly added SFR CONTREG4 (bit-addressable), the output pin P1.4 can be used as the H-clamp pulse output (refer to Figure 13). The Hsync trigger type can be selected to generate the H-clamp output pulse, and the pulse width of the H-clamp output can be determined by programming the bits HCES, HCWS1, and HCWS2 in SFR CONTREG1. For details, see the following figure and description.

| CONDITION OF P14SF   | PORT 1.4 I/O PIN FUNCTION |
|----------------------|---------------------------|
| P14SF = 0            | General I/O pin           |
| P14SF = 1 & P1.4 = 0 | H-clamp pulse output      |

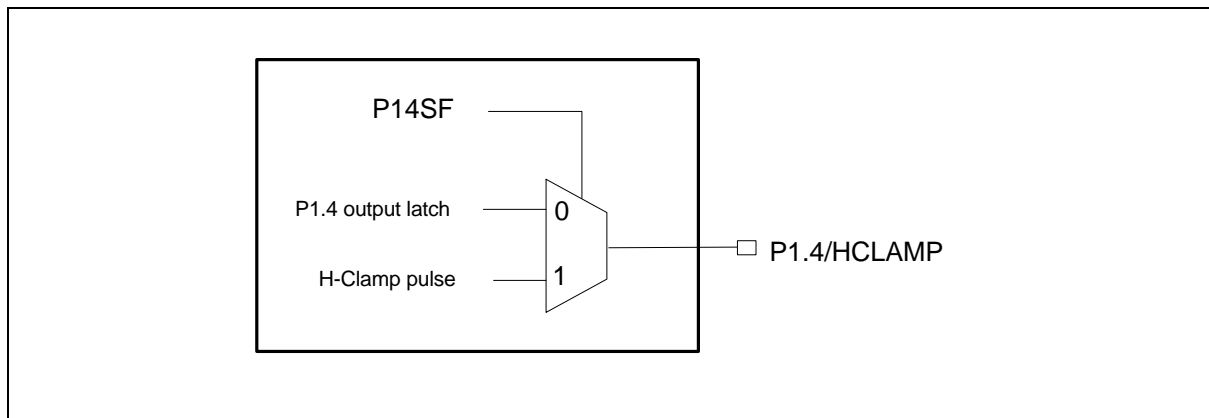


Figure 13. Alternate function of P1.4

1. Select the leading edge or trailing edge of Hsync:
  - HCES = 0: select leading edge
  - HCES = 1: select trailing edge

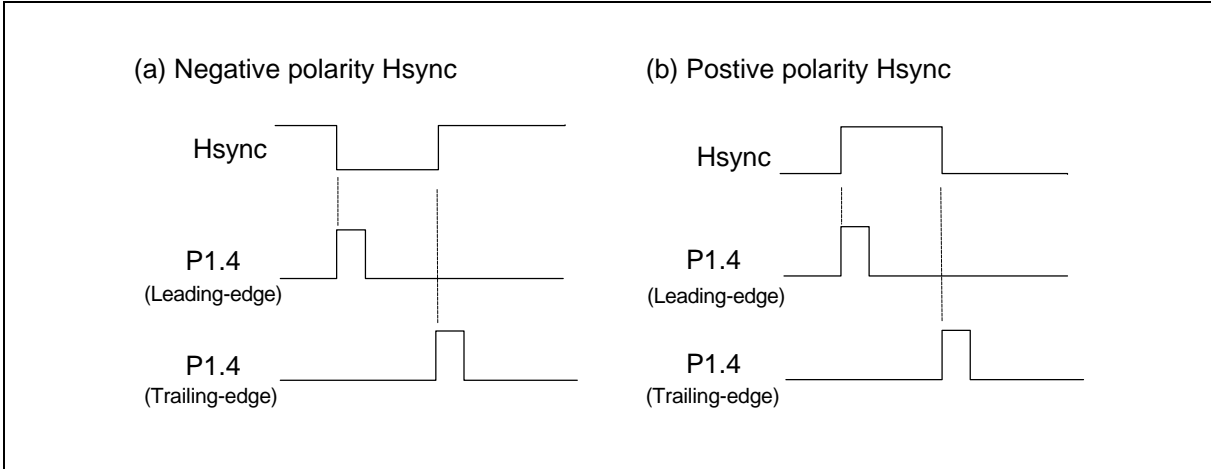


Figure 14. Pin P1.4 outputs the H-clamp pulse at the leading edge or trailing edge of Hsync.

2. Pulse width of H-clamp pulse:

- Select the weighting of H-clamp pulse by programming bits HCWS0 and HCWS1 in CONTREG1
- Pulse width of H-clamp output:  $[(1/F_{CLOCK}) \times \text{Weighting}] \pm [1/(2 \times F_{CLOCK})]$

| (HCWS1, HCWS0) | WEIGHTING | 16 MHz      | 18.432 MHz  | 20 MHz      |
|----------------|-----------|-------------|-------------|-------------|
| (0, 0)         | 4.5       | 281 ±31 nS  | 244 ±27 nS  | 225 ±25 nS  |
| (0, 1)         | 8.5       | 531 ±31 nS  | 461 ±27 nS  | 425 ±25 nS  |
| (1, 0)         | 16.5      | 1031 ±31 nS | 896 ±27 nS  | 825 ±25 nS  |
| (1, 1)         | 32.5      | 2031 ±31 nS | 1764 ±27 nS | 1625 ±25 nS |

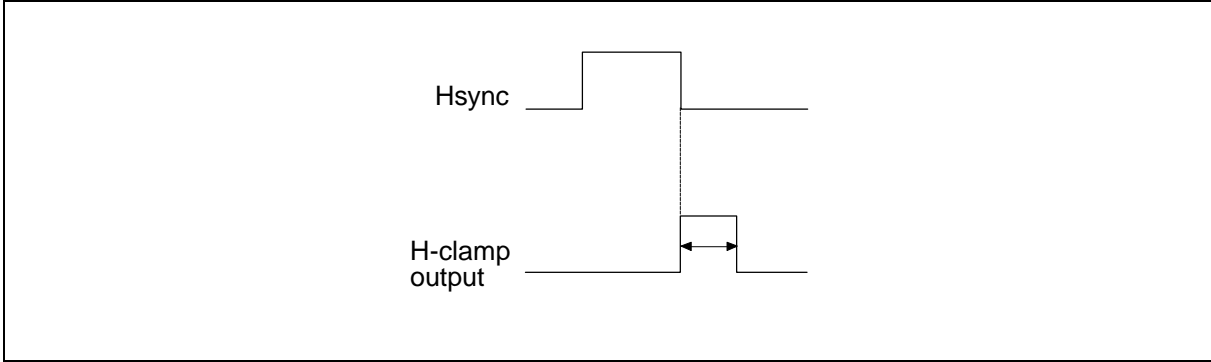


Figure 15. Pulse width of H-clamp output



If the bit VDISHC of SFR CONTREG2 is set high, the H-clamp pulse output will be disabled in the V sync pulse period.

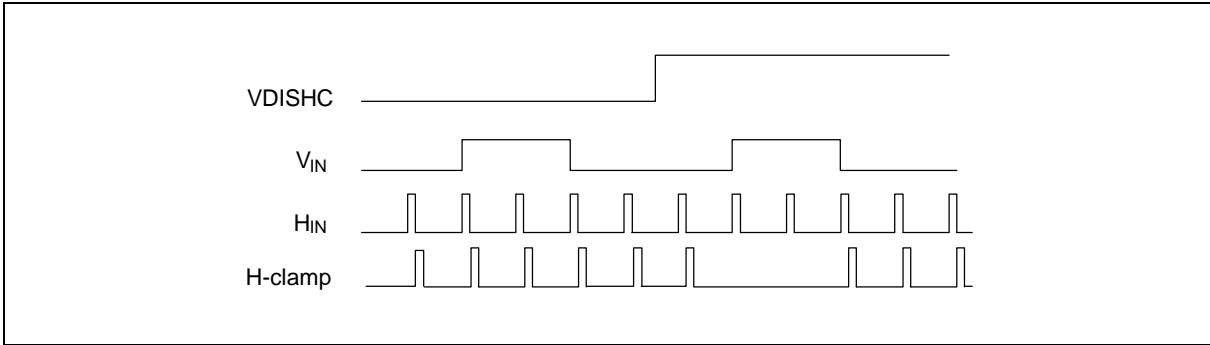


Figure 16. Disable H-clamp output

**M-6. Safe Operation Area (SOA) Output**

The purpose of the SOA output is to protect the HOT (horizontal oscillating transistor) and other critical circuitry by responding quickly if the Hsync frequency suddenly drops below a preset boundary frequency. When the Hsync frequency is lower than the preset boundary frequency for three consecutive cycles or stops for a certain period, the SOA pin (P1.5) will change to a "high" state to activate an external circuit to protect the monitor. If the bit P15SF is set in SFR CONTREG4, the pin P1.5 can be used as the SOA output (refer to Figure 17). The SOA pin can be released by writing any value to SFR SOACLR.

| CONDITION OF P15SF   | PORT 1.5 I/O PIN FUNCTION |
|----------------------|---------------------------|
| P15SF = 0            | General I/O pin           |
| P15SF = 1 & P1.5 = 0 | SOA output                |

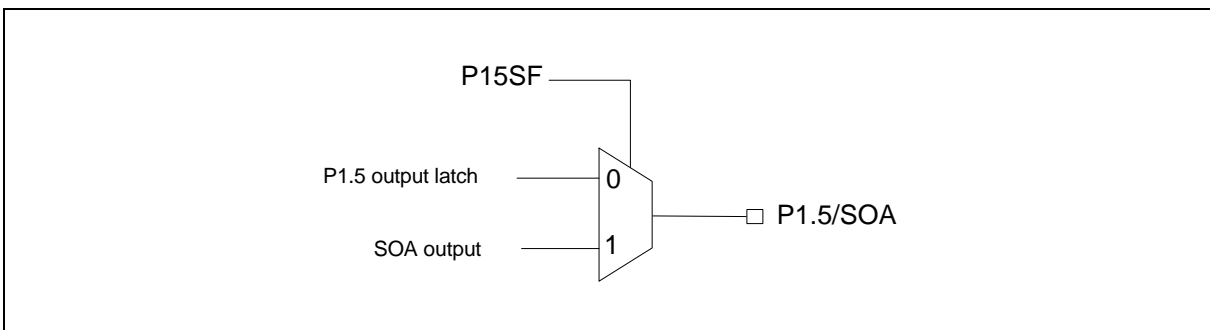


Figure 17. Alternate function of P1.5

- Boundary frequency  $H_{BOUND} = 2 \text{ MHz} \div (\text{Value of SOAREG})$   
 Example: If 50 KHz is considered the boundary frequency, then value of  $SOAREG = 2\text{M} \div 50\text{K} = 40$ .
- No Hsync response time =  $2048 \times (1/F_{CLOCK})$ .

|                        |               |                   |               |
|------------------------|---------------|-------------------|---------------|
|                        | <b>16 MHz</b> | <b>18.432 MHz</b> | <b>20 MHz</b> |
| No Hsync response time | 128 $\mu$ S   | 111 $\mu$ S       | 102 $\mu$ S   |

**M-7. Self-test Pattern Output**

When the dummy frequency generator is enabled, if bit P23SF of SFR CONTREG4 is set, the STP output will provide a checkerboard pattern for burn-in or self-diagnostic purposes. The bit INVSTP of CONTREG4 can invert the checkerboard pattern to avoid phosphor damage during factory burn-in.

| CONDITION of P23SF   | PORT 2.3 I/O PIN FUNCTION |
|----------------------|---------------------------|
| P23SF = 0            | General I/O pin           |
| P23SF = 1 & P2.3 = 0 | STP output                |

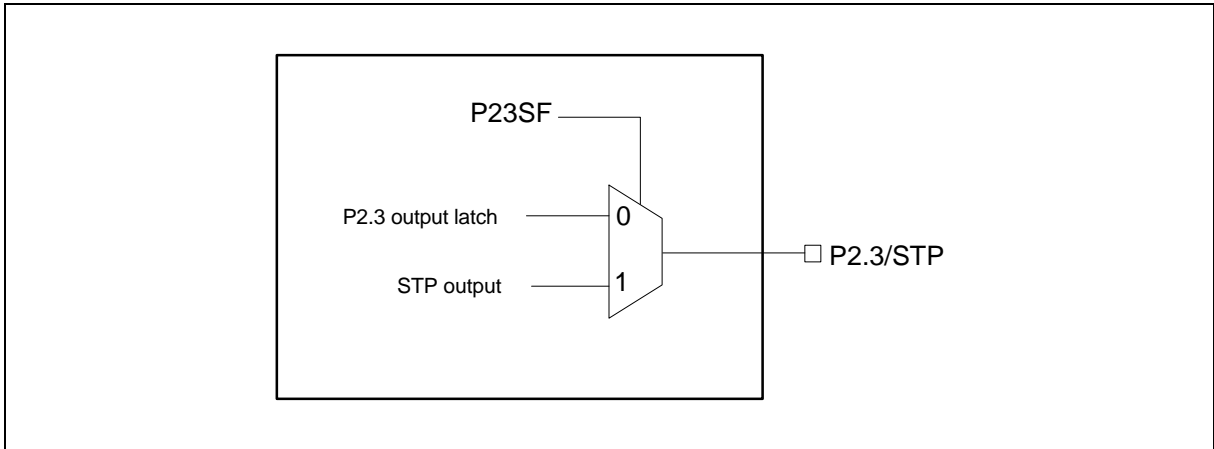


Figure 18. Alternate function of P2.3

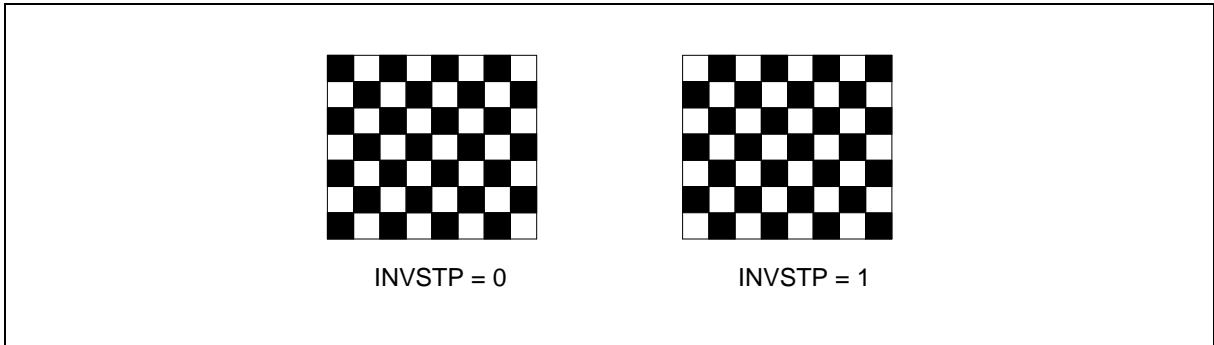


Figure 19. Checkerboard pattern

## N. Power Supervisor, Watchdog Timer, and Reset Circuitry

Reset signals can come from three sources: an external reset input (active low), power-low detection, or the watchdog timer. Figure 20 is a block diagram of the reset circuitry. The power-low detection circuit generates a reset signal if VCC falls below 3.8V, and the reset signal will keep twenty-four machine cycle after VCC rises to 4.3V. Thus we can make sure the chip can be reseted perfectly when the monitor is first powered on, and avoid the w78c354's overwriting the E<sup>2</sup>PROM mistakenly when the monitor is powered down. The power-low detection circuit can be enabled or disabled by code option 1.

The purpose of the watchdog timer is to reset the W78C354 if it enters an abnormal processor state (caused by electrical noise or RFI, for example). The clock source of the watchdog timer comes from the internal system clock. The timer can be enabled or disabled by the code option 2. When enabled, the watchdog circuitry will generate a system reset if the user's program fails to reload the watchdog timer within a specified length of time after executing the "MOV WDTCLR, # Value" instruction. This length of time is known as the "watchdog interval" (TWDT). Four selections are available for the watchdog interval (type A, B, C, and D); the selections, which are programmed by code option 3, are indicated by the formulas in table below.

There are three code options in the reset circuitry:

- Code option 1: Enable/disable the power-low detector.
- Code option 2: Enable/disable the watchdog timer.
- Code option 3: Select one watchdog interval (type A, B, C, D as listed in the table below.)

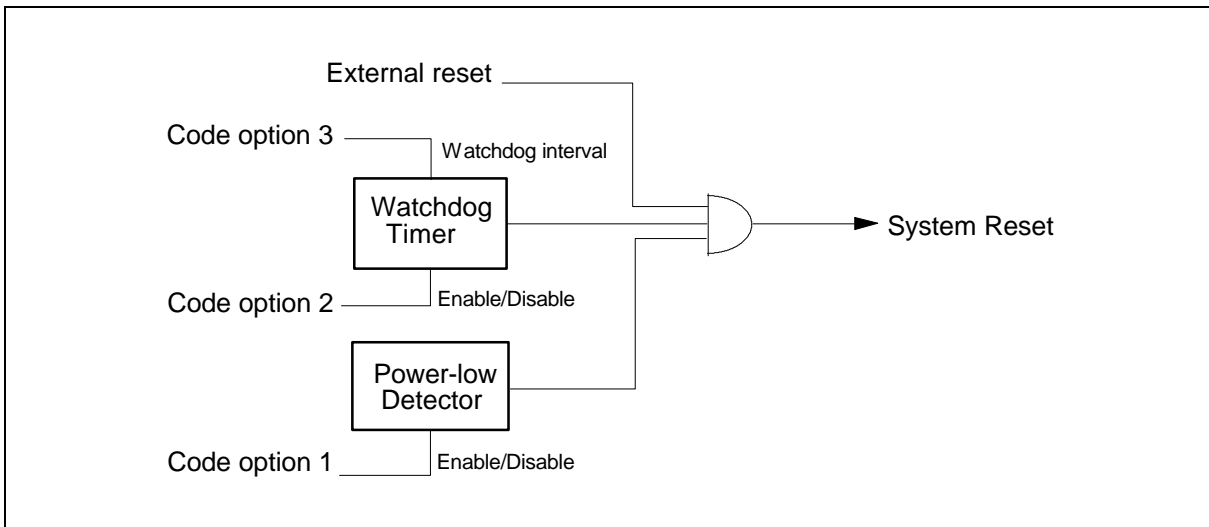


Figure 20. Reset circuitry



Table4. Watchdog Interval

| TWDT          |                    | FcLOCK  |            |        |
|---------------|--------------------|---------|------------|--------|
| CODE OPTION 3 | FORMULA            | 16 MHz  | 18.432 MHz | 20 MHz |
| Type-A        | $2^{19}/F_{CLOCK}$ | 32 mS   | 28 mS      | 26 mS  |
| Type-B        | $2^{21}/F_{CLOCK}$ | 131 mS  | 113 mS     | 104 mS |
| Type-C        | $2^{23}/F_{CLOCK}$ | 524 mS  | 452 mS     | 417 mS |
| Type-D        | $2^{24}/F_{CLOCK}$ | 1048 mS | 905 mS     | 834 mS |

### ABSOLUTE MAXIMUM RATINGS

| PARAMETER             | SYMBOL                           | MIN.                 | MAX.                 | UNIT |
|-----------------------|----------------------------------|----------------------|----------------------|------|
| DC Power Supply       | V <sub>CC</sub> -V <sub>SS</sub> | -0.3                 | +7.0                 | V    |
| Input Voltage         | V <sub>IN</sub>                  | V <sub>SS</sub> -0.3 | V <sub>CC</sub> +0.3 | V    |
| Operating Temperature | T <sub>A</sub>                   | 0                    | 70                   | °C   |
| Storage Temperature   | T <sub>ST</sub>                  | -55                  | +150                 | °C   |

Note: Exposure to conditions beyond those listed under Absolute Maximum Ratings may adversely affect the life and reliability of the device.

### DC ELECTRICAL CHARACTERISTICS

V<sub>CC</sub>-V<sub>SS</sub> = 5V ± 10%, T<sub>A</sub> = 25° C, F<sub>osc</sub> = 20 MHz, unless otherwise specified

| PARAMETER   | SYM.              | CONDITIONS   | MIN. | TYP | MAX. | UNIT |
|---|-------------------|--|------|-----|------|------|
| Operating Voltage   | V <sub>DD</sub>   |  | 4.5  | 5   | 5.5  | V    |
| Operating Current   | I <sub>DD</sub>   | No load, V <sub>DD</sub> = 5.5V                                  | -    | -   | 65   | mA   |
| Idle Current  | I <sub>IDLE</sub> | Idle mode, V <sub>DD</sub> = 5.5V                                | -    | -   | 30   | mA   |
| Logic 0 Input Current<br>P1, P2, P3<br>(except P1.0 to P1.3,P1.5) | I <sub>IN1</sub>  | V <sub>DD</sub> = 5.5V<br>V <sub>IN</sub> = 0V                   | -75  | -   | -10  | μA   |
| Input Current<br>$\overline{\text{RESET}}$ [*1]                   | I <sub>IN2</sub>  | V <sub>DD</sub> = 5.5V<br>V <sub>IN</sub> = 0V                   | -250 | -   | -    | μA   |
| Input Current<br>H <sub>IN</sub> , V <sub>IN</sub> [*2]           | I <sub>IN3</sub>  | V <sub>DD</sub> = 5.5V<br>V <sub>IN</sub> = V <sub>DD</sub>      | -    | -   | +30  | μA   |
| Input Leakage Current<br>P1.0 to P1.3, ADC0 to<br>ADC3            | I <sub>LK</sub>   | V <sub>DD</sub> = 5.5V<br>0V < V <sub>IN</sub> < V <sub>DD</sub> | -10  | -   | +10  | μA   |

## DC Electrical Characteristics, continued

| PARAMETER   | SYM. | CONDITIONS                 | MIN. | TYP. | MAX.     | UNIT |
|---|------|----------------------------|------|------|----------|------|
| Logical 1-to-0 Transition Current P1, P2, P3 <sup>[*3]</sup><br>(except P1.0 to P1.3, P1.5)           | ITL  | VDD = 5.5V<br>VIN = 2.0V   | -650 | -    | -        | μA   |
| Input Low Voltage<br>$\overline{\text{RESET}}$ , OSCIN <sup>[*4]</sup><br>(except P1.0 to P1.3, P1.5) | VIL1 | VDD = 4.5V                 | 0    | -    | 0.8      | V    |
| Input Low Voltage<br>HIN, VIN <sup>[*5]</sup>   | VIL2 | VDD = 4.5V                 | 0    | -    | 0.8      | V    |
| Input Low Voltage<br>P1.0 to P1.3   | VIL3 | VDD = 4.5V                 | 0    | -    | 1.5      | V    |
| Input High Voltage<br>P1, P2, P3<br>(except P1.0 to P1.3, P1.5)                                       | VIH1 | VDD = 5.5V                 | 2.4  | -    | VDD +0.2 | V    |
| Input High Voltage<br>$\overline{\text{RESET}}$ , OSCIN <sup>[*4]</sup>                               | VIH2 | VDD = 5.5V                 | 3.5  | -    | VDD +0.2 | V    |
| Input High Voltage<br>HIN, VIN <sup>[*5]</sup>  | VIH3 | VDD = 5.5V                 | 2.4  | -    | VDD +0.2 | V    |
| Input High Voltage<br>P1.0 to P1.3  | VIH4 | VDD = 5.5V                 | 3.0  | -    | VDD +0.2 | V    |
| Output Low Voltage<br>P1.4, P1.5, P2.2 to P2.7<br>SDAC0 to SDAC13<br>HOUT, VOUT                       | VOL1 | VDD = 4.5V<br>IOL = +4 mA  | -    | -    | 0.45     | V    |
| Output Low Voltage<br>P1.0, P1.1  | VOL2 | VDD = 4.5V<br>IOL = +2 mA  | -    | -    | 0.4      | V    |
| Output Low Voltage<br>P1.2, P1.3  | VOL3 | VDD = 4.5V<br>IOL = +6 mA  | -    | -    | 0.4      | V    |
| Output Low Voltage<br>P2.0, P2.1  | VOL4 | VDD = 4.5V<br>IOL = +15 mA | -    | -    | 0.45     | V    |
| Output Low Voltage P3,<br>P4  | VOL5 | VDD = 4.5V<br>IOL = +2 mA  | -    | -    | 0.45     | V    |





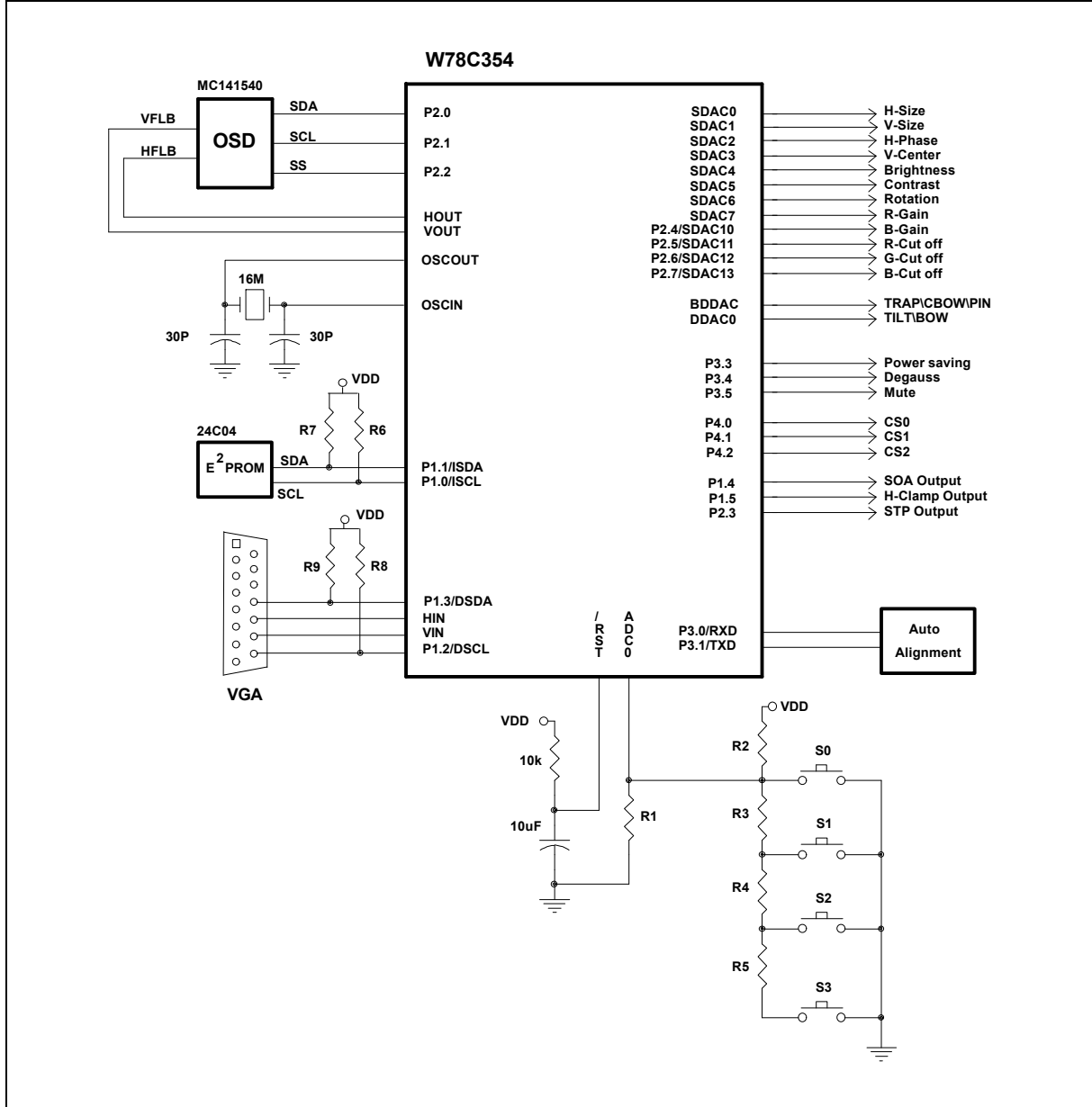
## DC Electrical Characteristics, continued

| PARAMETER   | SYM. | CONDITIONS                       | MIN. | TYP. | MAX. | UNIT |
|---|------|----------------------------------|------|------|------|------|
| Output Low Voltage<br>BSDAC0-1, DDAC0-2,<br>BDDAC   | VOL6 | VDD = 4.5V<br>IOL = +8 mA        | -    | -    | 0.45 | V    |
| Output High Voltage<br>P1.4, P2, P3   | VOH1 | VDD = 4.5V<br>IOH = -100 $\mu$ A | 2.4  | -    | -    | V    |
| Output High Voltage<br>P1.5, SDAC0-13, HOUT,<br>VOUT, Special Function<br>of P1.4 and P2.3~P2.7 | VOH2 | VDD = 4.5V<br>IOH = -4 mA        | 2.4  | -    | -    | V    |
| Output High Voltage,<br>BSDAC0-1, DDAC0-2,<br>BDDAC   | VOH3 | VDD = 4.5V<br>IOH = -8 mA        | 2.4  | -    | -    | V    |
| Output High Voltage P4  | VOH4 | VDD = 4.5V<br>IOH = -2mA         | 2.4  | -    | -    | V    |

## Notes:

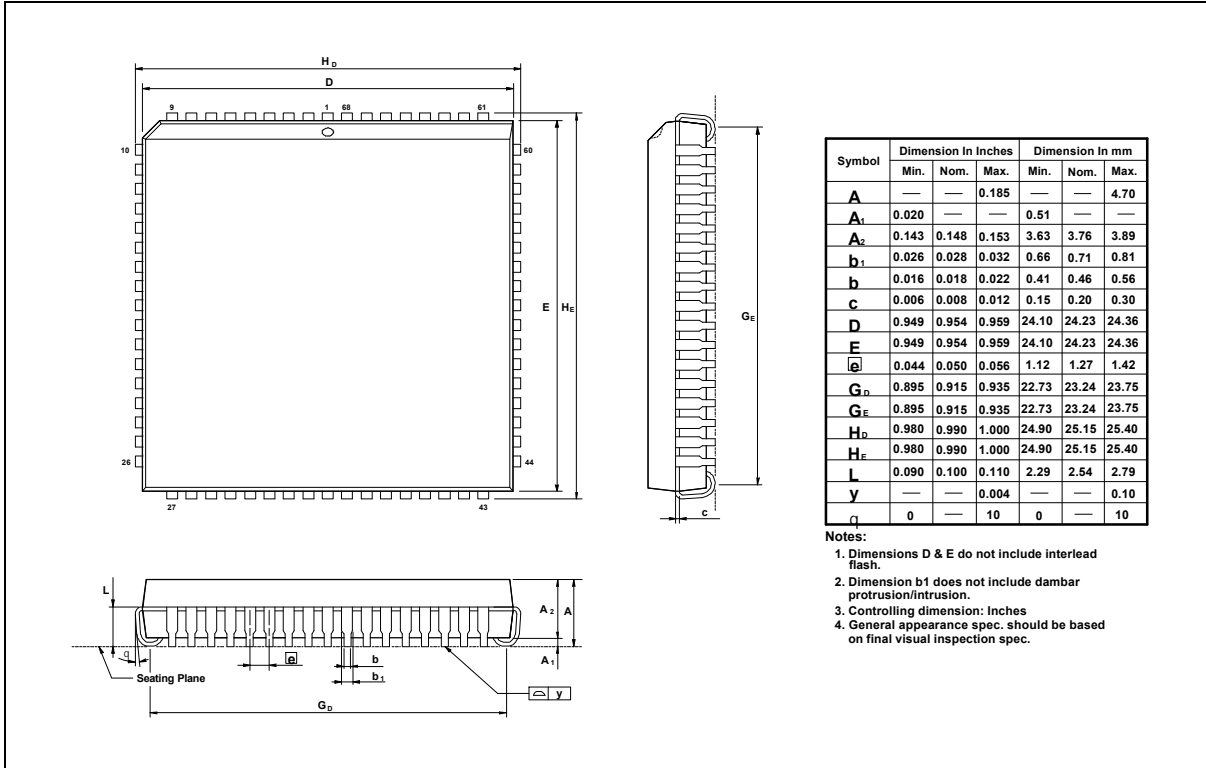
1. The RESET pin has an internal pull-up resistor with a resistance of about 30 K $\Omega$ .
2. Pins HIN and VIN have an internal pull-down resistor with a resistance of about 200 K $\Omega$ .
3. Pins P1, P2, and P3 (except P1.0-P1.3 and P1.5) source a transition current when they are being externally driven from 1 to 0. The transition current reaches its maximum value when VIN is approximately 2V.
4. RESET is a Schmitt trigger input, and OSCIN is a CMOS input.
5. HIN and VIN are Schmitt trigger inputs.

## TYPICAL APPLICATION CIRCUIT

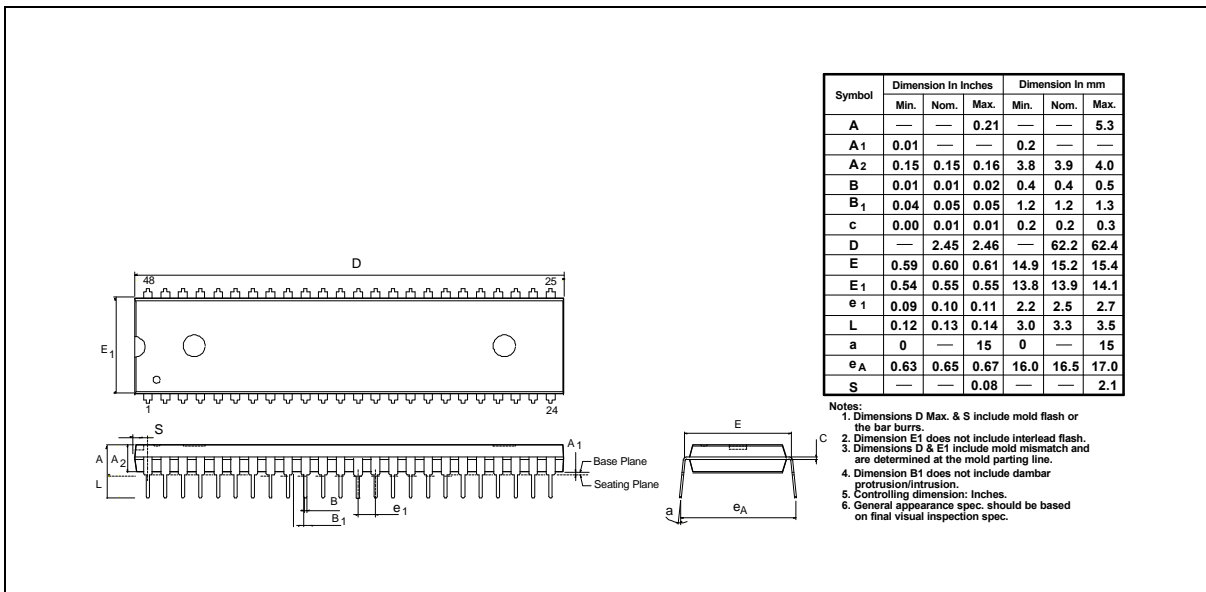


## PACKAGE DIMENSIONS

### 68-pin PLCC

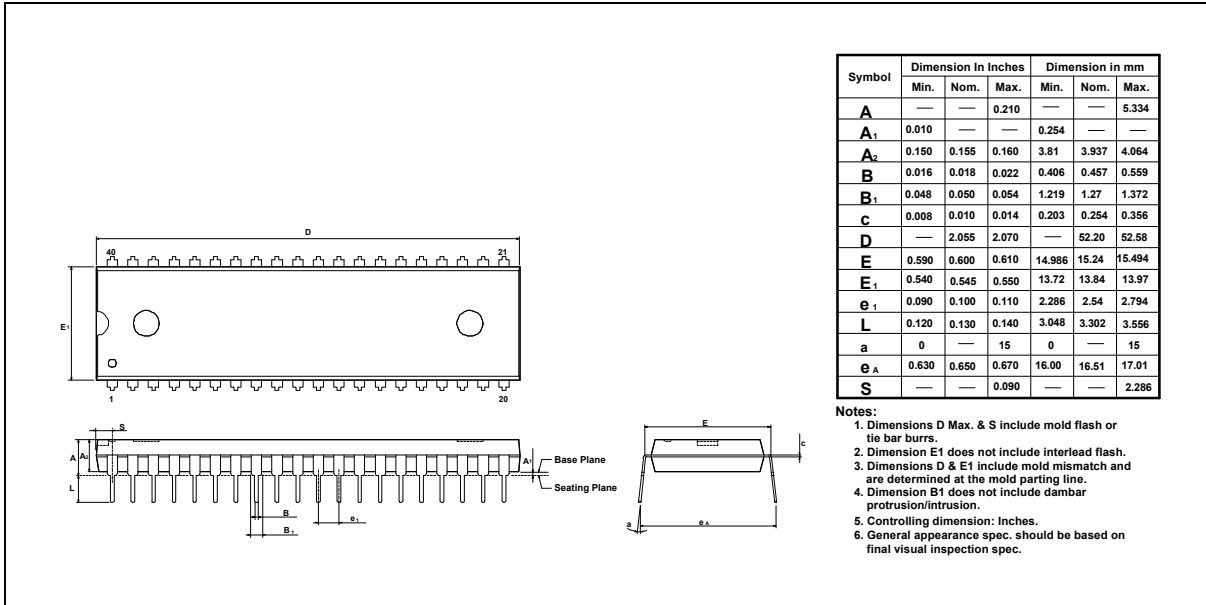


### 48-pin DIP





## 40-pin DIP



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Note: All data and specifications are subject to change without notice.