



Z86L81/86/98

***28-Pin Low-Voltage
Infrared Microcontrollers***

Product Specification



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Table of Contents

| | |
|---|----|
| Features | 1 |
| General Description | 3 |
| Pin Description | 6 |
| Absolute Maximum Ratings | 8 |
| Standard Test Conditions | 9 |
| Capacitance | 9 |
| DC Characteristics | 10 |
| Additional Timing | 12 |
| Pin Functions | 15 |
| Standard Mode | 15 |
| Functional Description | 21 |
| Program Memory | 21 |
| RAM | 21 |
| Expanded Register File | 23 |
| Register File | 26 |
| Counter/Timer Register Description | 26 |
| Stack | 27 |
| Register Description | 28 |
| Counter/Timer Functional Blocks | 36 |
| Expanded Register File Control Registers (0D) | 64 |
| Expanded Register File Control Registers (0F) | 69 |
| Package Information | 79 |
| Ordering Information | 82 |



List of Figures

| | |
|---|----|
| Figure 1. Counter/Timers Diagram | 4 |
| Figure 2. Functional Block Diagram | 5 |
| Figure 3. 28-Pin DIP/SOIC/SSOP Pin Assignment | 6 |
| Figure 4. Test Load Diagram | 9 |
| Figure 5. Additional Timing | 12 |
| Figure 6. Port 0 Configuration | 16 |
| Figure 7. Port 2 Configuration | 17 |
| Figure 8. Port 3 Configuration | 18 |
| Figure 9. Port 3 Counter/Timer Output Configuration | 20 |
| Figure 10. Program Memory Map (64 KB ROM) | 22 |
| Figure 11. Expanded Register File Architecture | 24 |
| Figure 12. Register Pointer | 25 |
| Figure 13. Register Pointer—Detail | 27 |
| Figure 14. Glitch Filter Circuitry | 37 |
| Figure 15. Transmit Mode Flowchart | 38 |
| Figure 16. 8-Bit Counter/Timer Circuits | 39 |
| Figure 17. T8_OUT in Single-Pass Mode | 40 |
| Figure 18. T8_OUT in Modulo-N Mode | 40 |
| Figure 19. Demodulation Mode Count Capture Flowchart | 42 |
| Figure 20. Demodulation Mode Flowchart | 43 |
| Figure 21. 16-Bit Counter/Timer Circuits | 44 |
| Figure 22. T16_OUT in Single-Pass Mode | 45 |
| Figure 23. T16_OUT in Modulo-N Mode | 45 |
| Figure 24. Ping-Pong Mode | 47 |
| Figure 25. Output Circuit | 47 |
| Figure 26. Interrupt Block Diagram | 49 |
| Figure 27. Oscillator Configuration | 52 |
| Figure 28. Port Configuration Register (PCON) (Write Only) | 54 |
| Figure 29. Stop-Mode Recovery Register | 55 |
| Figure 30. SCLK Circuit | 56 |
| Figure 31. Stop-Mode Recovery Source | 57 |
| Figure 32. Stop-Mode Recovery Register 2 ((0F) DH:D2–D4, D6 Write Only) | 59 |
| Figure 33. Watch-Dog Timer Mode Register (Write Only) | 60 |
| Figure 34. Resets and WDT | 62 |



| | |
|---|----|
| Figure 35. T8 Control Register ((0D) 0H: Read/Write Except Where Noted) | 64 |
| Figure 36. T8 and T16 Common Control Functions ((0D) 1h: Read/Write) | 65 |
| Figure 37. T16 Control Register ((0D) 2h: Read/Write Except Where Noted) | 67 |
| Figure 38. Low-Voltage Detection | 68 |
| Figure 39. Stop-Mode Recovery Register ((0F) 0Bh: D6–D0=Write Only, D7=Read Only) 69 | 69 |
| Figure 40. Stop-Mode Recovery Register 2 ((0F) 0Dh:D2–D4, D6 Write Only) | 70 |
| Figure 41. Watch-Dog Timer Register ((0F) 0Fh: Write Only) | 71 |
| Figure 42. Port Configuration Register (PCON) ((0F) 0h: Write Only) | 72 |
| Figure 43. Port 2 Mode Register (F6h: Write Only) | 72 |
| Figure 44. Port 3 Mode Register (F7h: Write Only) | 73 |
| Figure 45. Port 0 and 1 Mode Register (F8h: Write Only) | 74 |
| Figure 46. Interrupt Priority Register (F9h: Write Only) | 75 |
| Figure 47. Interrupt Request Register (FAh: Read/Write) | 76 |
| Figure 48. Interrupt Mask Register (FBh: Read/Write) | 76 |
| Figure 49. Flag Register (FCh: Read/Write) | 77 |
| Figure 50. Register Pointer (FDh: Read/Write) | 77 |
| Figure 51. Stack Pointer High (FEh: Read/Write) | 78 |
| Figure 52. Stack Pointer Low (FFh: Read/Write) | 78 |
| Figure 53. 28-Pin DIP Package Diagram | 79 |
| Figure 54. 28-Pin SOIC Package Diagram | 80 |
| Figure 55. 28-Pin SSOP Package Diagram | 81 |



List of Tables

| | | |
|-----------|---|----|
| Table 1. | Features | 1 |
| Table 2. | Power Connections | 3 |
| Table 3. | 28-Pin DIP, SOIC, and SSOP Pin Identification | 6 |
| Table 4. | Absolute Maximum Ratings | 8 |
| Table 5. | Capacitance | 9 |
| Table 6. | DC Characteristics | 10 |
| Table 7. | Additional Timing | 13 |
| Table 8. | Pin Assignments | 19 |
| Table 9. | Expanded Register Group D | 26 |
| Table 10. | CTR0 (D)00 Counter/Timer8 Control Register | 30 |
| Table 11. | CTR(D)01h Register Descriptions | 32 |
| Table 12. | CTR2 (D)02h: Counter/Timer16 Control Register | 34 |
| Table 13. | SMR2(F)0Dh: Stop-Mode Recovery Register 2 | 36 |
| Table 14. | Interrupt Types, Sources, and Vectors | 50 |
| Table 15. | IRQ Register* | 50 |
| Table 16. | Stop-Mode Recovery Source | 58 |
| Table 17. | WDT Time Select* | 61 |
| Table 18. | Mask Selectable Options | 63 |



Features

Table 1 shows the features of the Z86L81/86/98.

Table 1. Features

| Device | ROM (KB) | RAM* (Bytes) | I/O Lines | Voltage Range |
|--------|----------|--------------|-----------|---------------|
| Z86L81 | 24 | 237 | 23 | 2.0 V–3.6 V |
| Z86L86 | 32 | 237 | 23 | 2.0 V–3.6 V |
| Z86L98 | 64 | 237 | 23 | 2.0 V–3.6 V |

Note: *General purpose

- Low power consumption—40 mW (typical)
- Three standby modes
 - Stop—2 μ A (typical)
 - Halt—0.8 mA (typical)
 - Low voltage
- Special architecture to automate both generation and reception of complex pulses or signals:
 - One programmable 8-bit counter/timer with two capture registers and two load registers
 - One programmable 16-bit counter/timer with one 16-bit capture register pair and one 16-bit load register pair
 - Programmable input glitch filter for pulse reception
- Six priority interrupts
 - Three external
 - Two assigned to counter/timers
 - One low-voltage detection interrupt
- Low-voltage detection with flag
- Programmable watch-dog/power-on reset circuits
- Two independent comparators with programmable interrupt polarity
- Mask selectable transistor pull-ups on ports 0, 2, 3



- Programmable mask options
 - Oscillator selection: RC oscillator or crystal/other clock source
 - Oscillator operational mode: normal high-frequency operation enabled or 32-KHz operation enabled
 - Port 0: 0–3 pull-ups
 - Port 0: 4–7 pull-ups
 - Port 2: 0–7 pull-ups
 - Port 3: pull-ups
 - Port 0: 0–3 mouse mode: normal mode ($.5V_{DD}$ input threshold) versus mouse mode ($.4V_{DD}$ input threshold)

► **Note:** The mask option pull-up transistor has a *typical* equivalent resistance of $200\text{ K}\Omega \pm 50\%$ at $V_{CC}=3\text{ V}$ and $450\text{ K}\Omega \pm 50\%$ at $V_{CC}=2\text{ V}$.



General Description

Based on the Z8 MCU single-chip family of IR microcontrollers, the Z86L81/86/98 features 237 bytes of general-purpose RAM and 24/32/64 KB of ROM. The Maxim CMOS microcontrollers offer fast executing, efficient use of memory, sophisticated interrupts, input/output bit manipulation capabilities, automated pulse generation/reception, and internal key-scan pull-up transistors.

The Z86L81/86/98 architecture is based on the Maxim 8-bit microcontroller core with an Expanded Register File to allow access to register-mapped peripherals, input/output (I/O) circuits, and powerful counter/timer circuitry. The Z8 offers a flexible I/O scheme, an efficient register and address space structure, and a number of ancillary features that are useful in many consumer, automotive, computer peripheral, and battery-operated hand-held applications.

There are three basic address spaces available to support a wide range of configurations: Program Memory, Register File, and Expanded Register File. The register file is composed of 256 bytes of RAM. It includes 3 I/O port registers, 16 control and status registers, and 236 general-purpose registers. Register FEh (SPH) can be used as a general-purpose register. The Expanded Register File consists of two additional register groups (F and D).

To unburden the program from coping with such real-time problems as generating complex waveforms or receiving and demodulating complex waveform/pulses, the Z86L81/86/98 offers a new intelligent counter/timer architecture with 8-bit and 16-bit counter/timers (see Figure 1, Figure 2, Figure 3, and Table 3). Also included are a large number of user-selectable modes, and two on-board comparators to process analog signals with separate reference voltages (Figure 9 on page 20).

Power connections use the conventional descriptions listed in Table 2.

Table 2. Power Connections

| Connection | Circuit | Device |
|------------|----------|----------|
| Power | V_{CC} | V_{DD} |
| Ground | GND | V_{SS} |

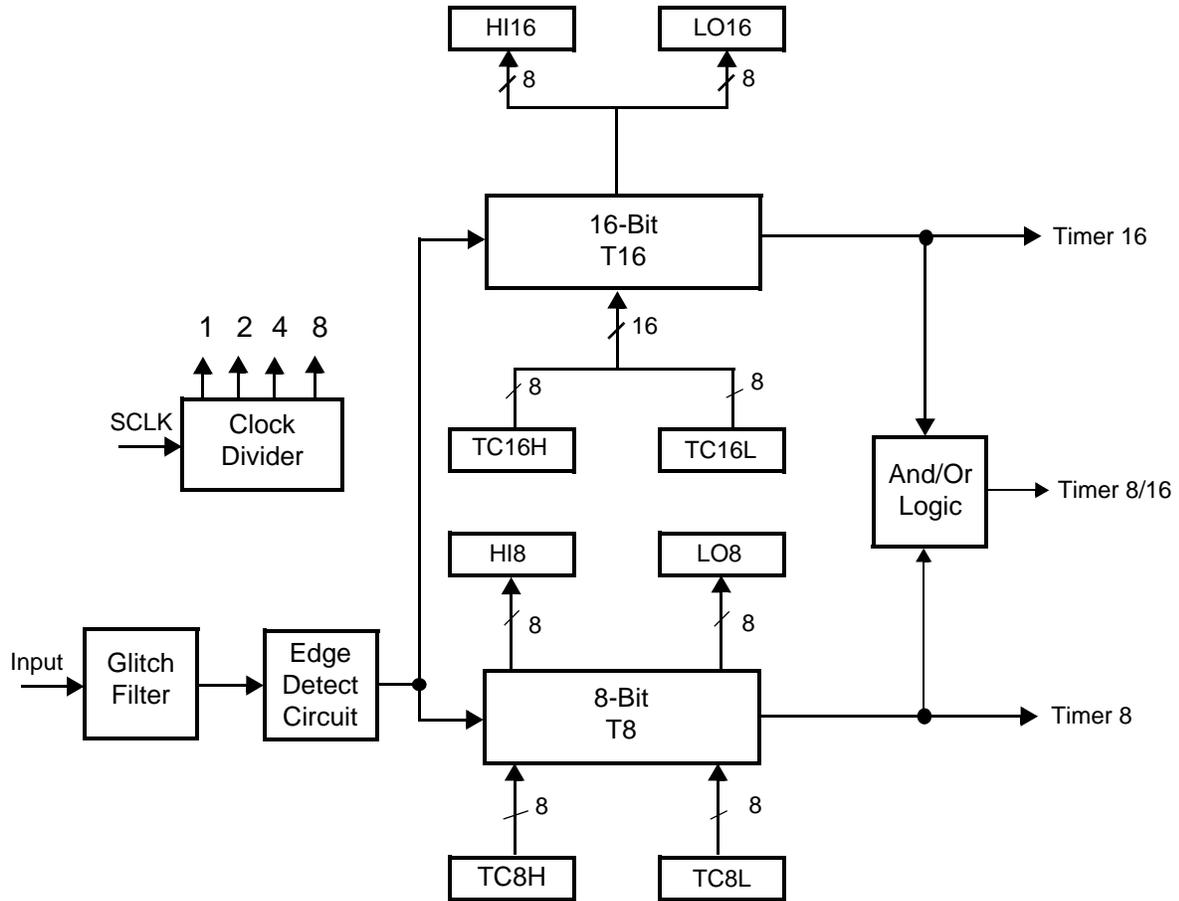


Figure 1. Counter/Timers Diagram

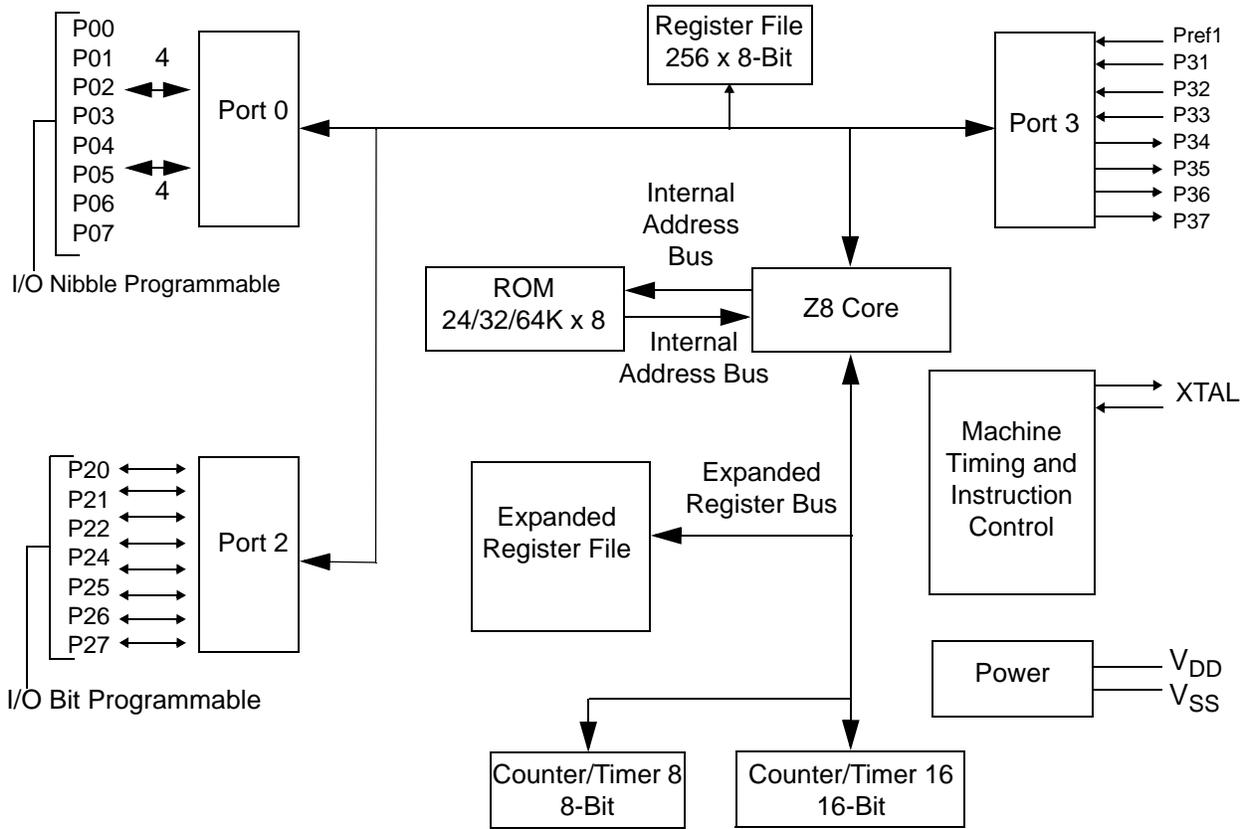


Figure 2. Functional Block Diagram



Pin Description

The pins are shown in Figure 3 and described in Table 3.

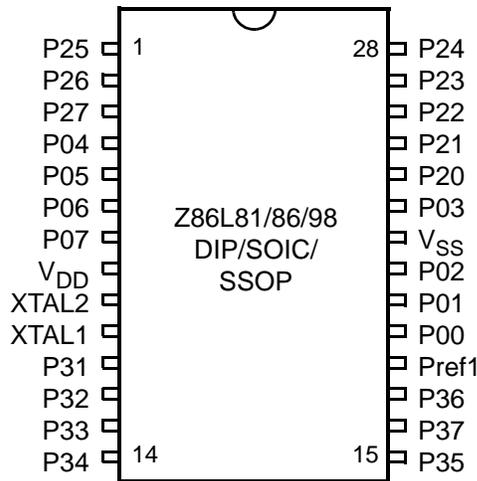


Figure 3. 28-Pin DIP/SOIC/SSOP Pin Assignment

Table 3. 28-Pin DIP, SOIC, and SSOP Pin Identification

| 28-Pin DIP, SOIC, and SSOP | Standard Mode | Direction | Description |
|----------------------------|---------------|--------------|----------------------------------|
| 19 | P00 | Input/Output | Port 0 is Nibble Programmable |
| 20 | P01 | Input/Output | Port 0-3 can be configured as a |
| 21 | P02 | Input/Output | mouse/trackball input |
| 23 | P03 | Input/Output | |
| 4 | P04 | Input/Output | |
| 5 | P05 | Input/Output | |
| 6 | P06 | Input/Output | |
| 7 | P07 | Input/Output | |
| 24 | P20 | Input/Output | Port 2 pins are individually |
| 25 | P21 | Input/Output | configurable as input or output. |
| 26 | P22 | Input/Output | |
| 27 | P23 | Input/Output | |
| 28 | P24 | Input/Output | |



Table 3. 28-Pin DIP, SOIC, and SSOP Pin Identification (Continued)

| 28-Pin DIP, SOIC, and SSOP | Standard Mode | Direction | Description |
|----------------------------|-----------------|--------------|---------------------------|
| 1 | P25 | Input/Output | |
| 2 | P26 | Input/Output | |
| 3 | P27 | Input/Output | |
| 18 | Pref1 | Input | Analog Ref Input |
| 11 | P31 | Input | IRQ2/Modulator input |
| 12 | P32 | Input | IRQ0 |
| 13 | P33 | Input | IRQ1 |
| 14 | P34 | Output | T8 output |
| 15 | P35 | Output | T16 output |
| 17 | P36 | Output | T8/T16 output |
| 16 | P37 | Output | |
| 10 | XTAL1 | Input | Crystal, Oscillator Clock |
| 9 | XTAL2 | Output | Crystal, Oscillator Clock |
| 8 | V _{DD} | | Power Supply |
| 22 | V _{SS} | | Ground |



Absolute Maximum Ratings

Stresses greater than those listed in Table 4 might cause permanent damage to the device. This rating is a stress rating only. Functional operation of the device at any condition above those indicated in the operational sections of these specifications is not implied. Exposure to absolute maximum rating conditions for an extended period might affect device reliability.

Table 4. Absolute Maximum Ratings

| Symbol | Description | Min | Max | Units |
|-----------|----------------------------|------|-------|-------|
| V_{CC} | Supply Voltage (*) | -0.3 | +7.0 | V |
| T_{STG} | Storage Temperature | -65° | +150° | C |
| T_A | Oper. Ambient Temperature. | | † | C |

Notes:

*Voltage on all pins with respect to GND.

†See Ordering Information on page 82.



Standard Test Conditions

The characteristics listed in this product specification apply for standard test conditions as noted. All voltages are referenced to GND. Positive current flows into the referenced pin (see Figure 4).

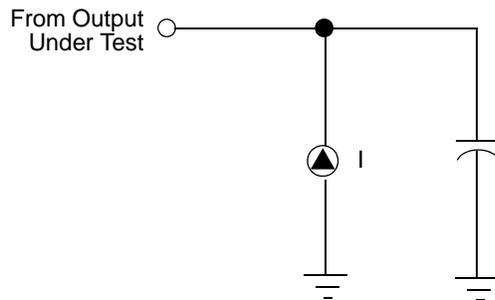


Figure 4. Test Load Diagram

Capacitance

The capacitances are listed in Table 5.

Table 5. Capacitance

| Parameter | Max |
|--------------------|-------|
| Input capacitance | 12 pF |
| Output capacitance | 12 pF |
| I/O capacitance | 12 pF |

Note: $T_A = 25\text{ }^\circ\text{C}$, $V_{CC} = \text{GND} = 0\text{ V}$, $f = 1.0\text{ MHz}$, unmeasured pins returned to GND



DC Characteristics

Table 6 lists the DC characteristics.

Table 6. DC Characteristics

| $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ | | | | | | | |
|---|--|----------|--------------|--------------|---------------|------------------------------------|-------|
| Sym | Parameter | V_{CC} | Min | Max | Units | Conditions | Notes |
| | Max Input Voltage | 2.0 V | | 7 | V | $I_{IN} < 250 \mu\text{A}$ | |
| | | 3.6 V | | 7 | V | $I_{IN} < 250 \mu\text{A}$ | |
| V_{CH} | Clock Input High Voltage | 2.0 V | $0.8 V_{CC}$ | $V_{CC}+0.3$ | V | Driven by External Clock Generator | |
| | | 3.6 V | $0.8 V_{CC}$ | $V_{CC}+0.3$ | V | Driven by External Clock Generator | |
| V_{CL} | Clock Input Low Voltage | 2.0 V | $V_{SS}-0.3$ | $0.2 V_{CC}$ | V | Driven by External Clock Generator | |
| | | 3.6 V | $V_{SS}-0.3$ | $0.2 V_{CC}$ | V | Driven by External Clock Generator | |
| V_{IH} | Input High Voltage | 2.0 V | $0.7 V_{CC}$ | $V_{CC}+0.3$ | V | | |
| | | 3.6 V | $0.7 V_{CC}$ | $V_{CC}+0.3$ | V | | |
| V_{IL} | Input Low Voltage | 2.0 V | $V_{SS}-0.3$ | $0.2 V_{CC}$ | V | | |
| | | 3.6 V | $V_{SS}-0.3$ | $0.2 V_{CC}$ | V | | |
| V_{OH1} | Output High Voltage | 2.0 V | $V_{CC}-0.4$ | | V | $I_{OH} = -0.5 \text{ mA}$ | |
| | | 3.6 V | $V_{CC}-0.4$ | | V | $I_{OH} = -0.5 \text{ mA}$ | |
| V_{OH2} | Output High Voltage (P36, P37, P00, P01) | 2.0 V | $V_{CC}-0.8$ | | V | $I_{OH} = -7 \text{ mA}$ | |
| | | 3.6 V | $V_{CC}-0.8$ | | V | $I_{OH} = -7 \text{ mA}$ | |
| V_{OL1} | Output Low Voltage | 2.0 V | | 0.4 | V | $I_{OL} = 1.0 \text{ mA}$ | |
| | | 3.6 V | | 0.4 | V | $I_{OL} = 4.0 \text{ mA}$ | |
| V_{OL2^*} | Output Low Voltage | 2.0 V | | 0.8 | V | $I_{OL} = 5.0 \text{ mA}$ | |
| | | 3.6 V | | 0.8 | V | $I_{OL} = 7.0 \text{ mA}$ | |
| V_{OL2} | Output Low Voltage (P00, P01, P36, P37) | 2.0 V | | 0.8 | V | $I_{OL} = 10 \text{ mA}$ | |
| | | 3.6 V | | 0.8 | V | $I_{OL} = 10 \text{ mA}$ | |
| V_{OFFSET} | Comparator Input Offset Voltage | 2.0 V | | 25 | mV | | |
| | | 3.6 V | | 25 | mV | | |
| I_{IL} | Input Leakage | 2.0 V | -1 | 1 | μA | $V_{IN} = 0 \text{ V}, V_{CC}$ | |
| | | 3.6 V | -1 | 1 | μA | $V_{IN} = 0 \text{ V}, V_{CC}$ | |



Table 6. DC Characteristics (Continued)

| T _A = 0°C to +70°C | | | | | | | |
|-------------------------------|--|-----------------|-----|------|-------|---|---------|
| Sym | Parameter | V _{CC} | Min | Max | Units | Conditions | Notes |
| I _{OL} | Output Leakage | 2.0 V | -1 | 1 | μA | V _{IN} = 0 V, V _{CC} | |
| | | 3.6 V | -1 | 1 | μA | V _{IN} = 0 V, V _{CC} | |
| I _{CC} | Supply Current | 2.0 V | | 10 | mA | at 8.0 MHz | 1, 2 |
| | | 3.6 V | | 15 | mA | at 8.0 MHz | 1, 2 |
| | | 2.0 V | | 250 | μA | at 32 kHz | 1, 2, 3 |
| | | 3.6 V | | 850 | μA | at 32 kHz | 1, 2, 3 |
| I _{CC1} | Standby Current (HALT Mode) | 2.0 V | | 3 | mA | V _{IN} = 0 V, V _{CC} at 8.0 MHz | 1, 2 |
| | | 3.6 V | | 5 | mA | Same as above | 1, 2 |
| | | 2.0 V | | 2 | mA | Clock Divide-by-16 at 8.0 MHz | 1, 2 |
| | | 3.6 V | | 4 | mA | Same as above | 1, 2 |
| I _{CC2} | Standby Current (STOP Mode) | 2.0 V | | 8 | μA | V _{IN} = 0 V, V _{CC} WDT is not Running | 4, 5, 8 |
| | | 3.6 V | | 10 | μA | Same as above | 4, 5, 8 |
| | | 2.0 V | | 500 | μA | V _{IN} = 0 V, V _{CC} WDT is Running | 4, 5, 8 |
| | | 3.6 V | | 800 | μA | Same as above | 4, 5, 8 |
| T _{POR} | Power-On Reset | 2.0 V | 12 | 75 | ms | | |
| | | 3.6 V | 5 | 20 | ms | | |
| V _{BO} | V _{CC} Low Voltage Protection (Reset) | | | 2.0 | V | 8 MHz max Ext. CLK Freq. | 7 |
| V _{LVD} | V _{CC} Low Voltage Detection | | | 2.55 | V | | |

Notes:

1. All outputs unloaded, inputs at rail.
2. CL1 = CL2 = 100 pF.
3. 32-kHz clock driver input.
4. Same as note 1, except inputs at V_{CC}.
5. Oscillator stopped.
6. Not applicable
7. The V_{BO} is measured at room temperature and typically is 1.6 V. V_{BO} increases as the temperature decreases.
8. WDT, Comparators, Low Voltage Detection, and ADC (if applicable) are disabled. The IC might draw more current if any of the about peripherals is enabled.



Additional Timing

Figure 5 and Table 7 describe additional timing characteristics.

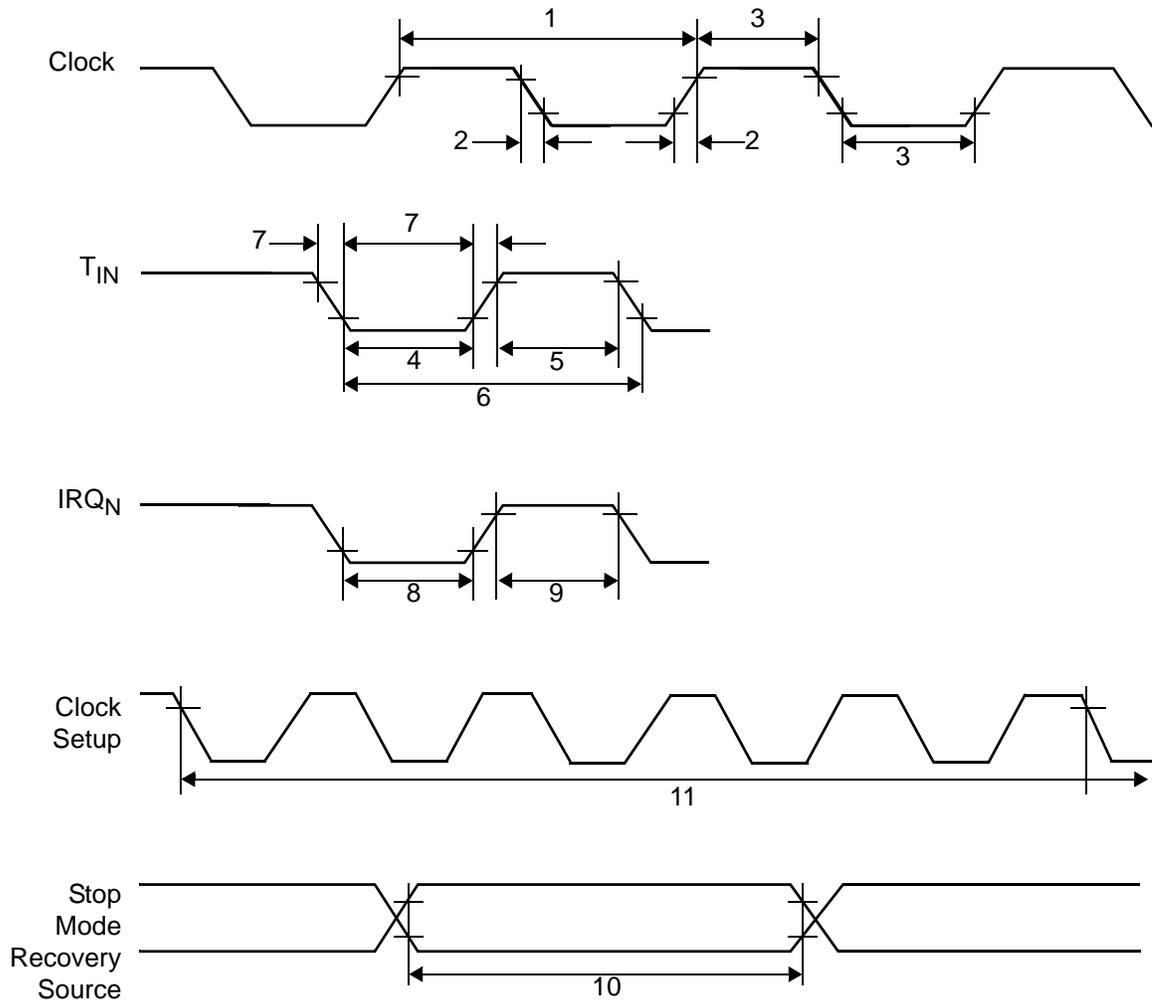


Figure 5. Additional Timing



Table 7. Additional Timing

| No | Sym | Parameter | V _{CC} | T _A = 0°C to +70°C 8.0 MHz | | Units | Notes | Stop-Mode Recovery (D1, D0) |
|----|--------------|-----------------------------------|-----------------|--|------|-------|-------|-----------------------------------|
| | | | | Min | Max | | | |
| 1 | TpC | Input Clock Period | 2.0 V | 121 | DC | ns | 1 | |
| | | | 3.6 V | 121 | DC | ns | 1 | |
| 2 | TrC, TfC | Clock Input Rise and Fall Times | 2.0 V | | 25 | ns | 1 | |
| | | | 3.6 V | | 25 | ns | 1 | |
| 3 | TwC | Input Clock Width | 2.0 V | 37 | | ns | 1 | |
| | | | 3.6 V | 37 | | ns | 1 | |
| 4 | TwTinL | Timer Input Low Width | 2.0 V | 100 | | ns | 1 | |
| | | | 3.6 V | 70 | | ns | 1 | |
| 5 | TwTinH | Timer Input High Width | 2.0 V | 3TpC | | | 1 | |
| | | | 3.6 V | 3TpC | | | 1 | |
| 6 | TpTin | Timer Input Period | 2.0 V | 8TpC | | | 1 | |
| | | | 3.6 V | 8TpC | | | 1 | |
| 7 | TrTin, TfTin | Timer Input Rise and Fall Timers | 2.0 V | | 100 | ns | 1 | |
| | | | 3.6 V | | 100 | ns | 1 | |
| 8A | TwIL | Interrupt Request Low Time | 2.0 V | 100 | | ns | 1,2 | |
| | | | 3.6 V | 70 | | ns | 1,2 | |
| 8B | TwIL | Interrupt Request Low Time | 2.0 V | 5TpC | | | 1,3 | |
| | | | 3.6 V | 5TpC | | | 1,3 | |
| 9 | TwIH | Interrupt Request Input High Time | 2.0 V | 5TpC | | | 1,2 | |
| | | | 3.6 V | 5TpC | | | 1,2 | |
| 10 | Twsm | Stop-Mode Recovery Width Spec | 2.0 V | 12 | | ns | | |
| | | | 3.6 V | 12 | | ns | | |
| 11 | Tost | Oscillator Start-Up Time | 2.0 V | | 5TpC | | 4 | |
| | | | 3.6 V | | 5TpC | | 4 | |



Table 7. Additional Timing (Continued)

| No | Sym | Parameter | V _{CC} | T _A = 0°C to +70°C | | Units | Notes | Stop-Mode Recovery (D1, D0) |
|----|------|----------------------------|-----------------|-------------------------------|-----|-------|-------|-----------------------------------|
| | | | | Min | Max | | | |
| 12 | Twdt | Watch-Dog Timer Delay Time | 2.0 V | 12 | | ms | 5 | 0, 0 |
| | | | 3.6 V | 5 | | ms | 5 | |
| | | | 2.0 V | 25 | | ms | 5 | 0, 1 |
| | | | 3.6 V | 10 | | ms | 5 | |
| | | | 2.0 V | 50 | | ms | 5 | 1, 0 |
| | | | 3.6 V | 20 | | ms | 5 | |
| | | | 2.0 V | 200 | | ms | 5 | 1, 1 |
| | | | 3.6 V | 80 | | ms | 5 | |

Notes:

1. Timing Reference uses 0.9 V_{CC} for a logic 1 and 0.1 V_{CC} for a logic 0.
2. Interrupt request through Port 3 (P33–P31).
3. Interrupt request through Port 3 (P30).
4. SMR – D5 = 0.
5. For internal RC oscillator.



Pin Functions

Standard Mode

XTAL1 Crystal 1 (Time-Based Input)

This pin connects a parallel-resonant crystal, ceramic resonator, LC, or RC network to the on-chip oscillator input. An external single-phase clock to the on-chip oscillator input is also an option.

XTAL2 Crystal 2 (Time-Based Output)

This pin connects a parallel-resonant crystal, ceramic resonant, LC, or RC network to the on-chip oscillator output.

Port 0 (P07–P00)

Port 0 is an 8-bit, bidirectional, CMOS-compatible port (see Figure 6). These eight I/O lines are configured under software control as a nibble I/O port. The output drivers are push-pull or open drain controlled by bit D2 in the PCON register. If one or both nibbles are required for I/O operation, they must be configured by writing to the Port 0 mode register. After a hardware reset, Port 0 is configured as an input port.

A mask option is available to program 0.4 V_{DD} CMOS trip inputs on P00–P03. This option allows direct interface to mouse/trackball IR sensors.

An optional pull-up transistor is available as a mask option on all Port 0 bits with nibble select.

- **Note:** Internal pull-ups are disabled on any given pin or group of port pins when programmed into output mode.

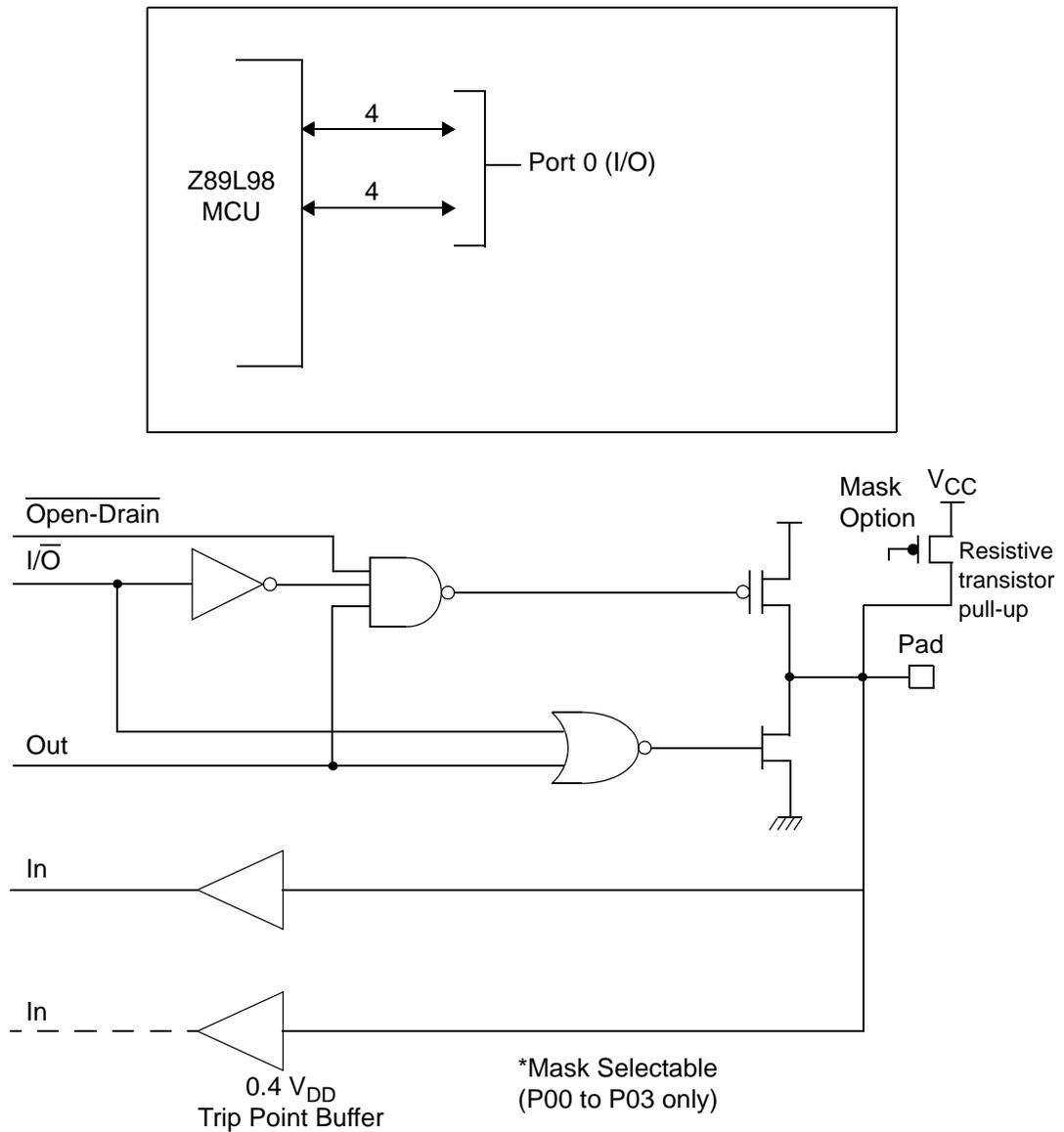


Figure 6. Port 0 Configuration

Port 2 (P27–P20)

Port 2 is an 8-bit, bidirectional, CMOS-compatible I/O port (see Figure 7). These eight I/O lines can be independently configured under software control as inputs or outputs. Port 2 is always available for I/O operation. A mask option is available to connect eight pull-up transistors on this port. Bits programmed as outputs are



globally programmed as either push-pull or open-drain. The POR resets with the eight bits of Port 2 configured as inputs.

Port 2 also has an 8-bit input OR and AND gate, which can be used to wake up the part. P20 can be programmed to access the edge-detection circuitry in demodulation mode.

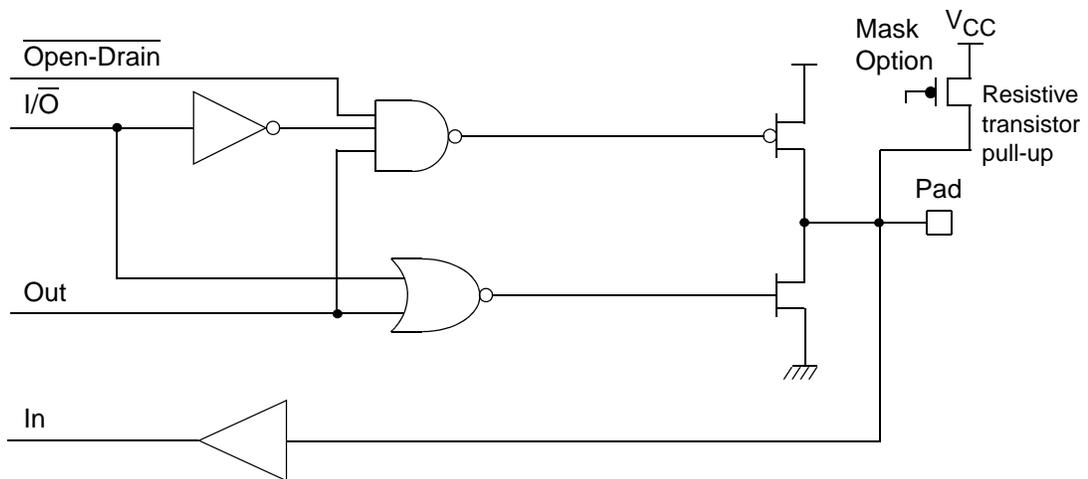
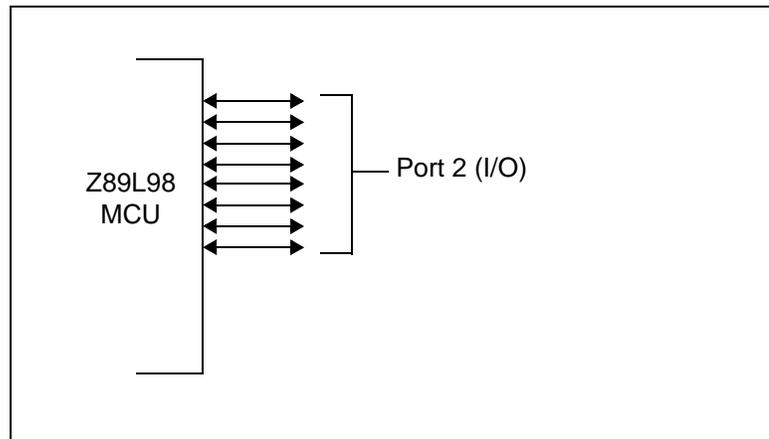


Figure 7. Port 2 Configuration

Port 3 (P37–P31)

Port 3 is a 7-bit, CMOS-compatible fixed I/O port (see Figure 8). Port 3 consists of three fixed input (P33–P31) and four fixed output (P37–P34), and each can be configured under software control for interrupt and output from the counter/timers. P31, P32, and P33 are standard CMOS inputs; P34, P35, P36 and P37 are push-pull outputs.

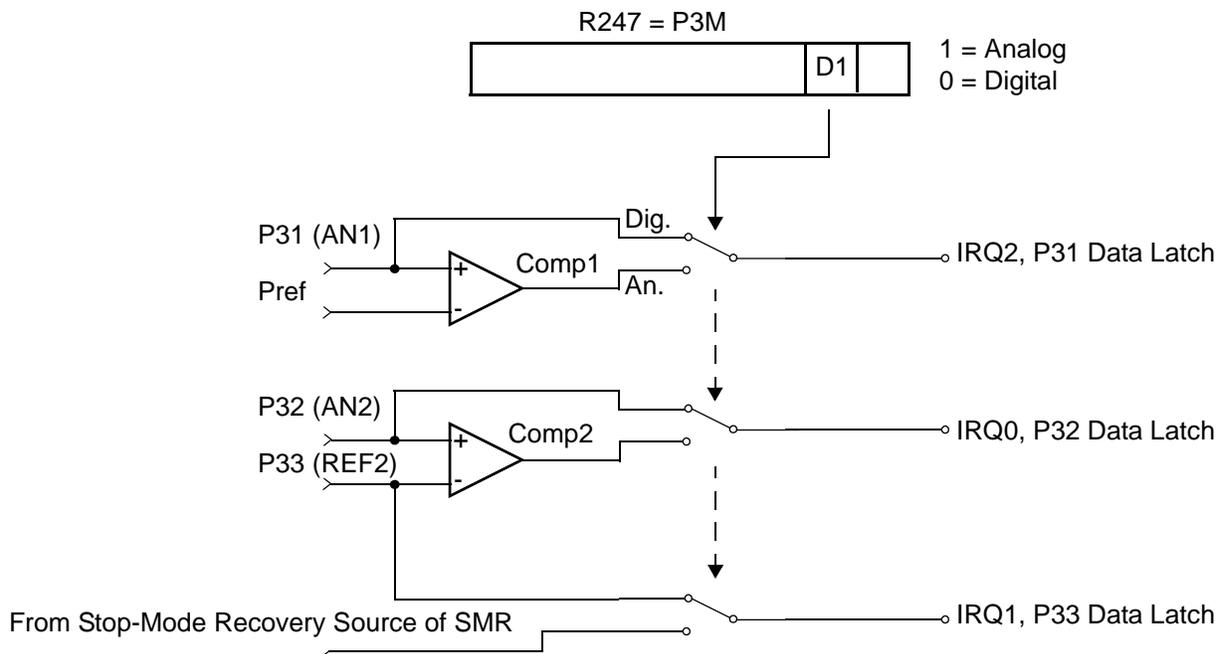
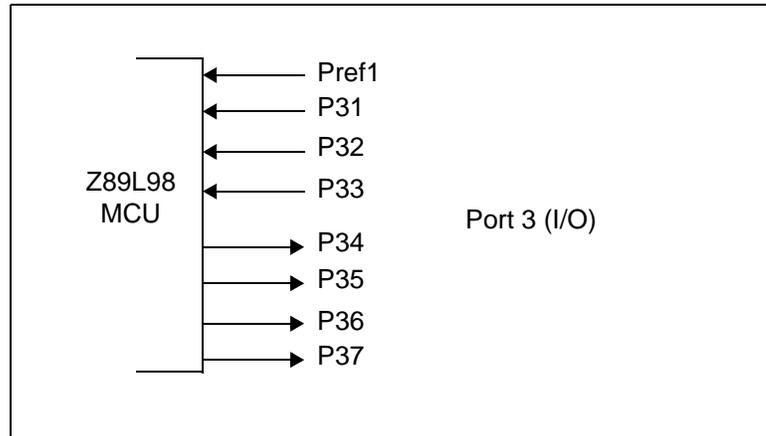


Figure 8. Port 3 Configuration

Two on-board comparators process analog signals on P31 and P32, with reference to the voltage on Pref1 and P33. The analog function is enabled by programming the Port 3 Mode Register (bit 1). P31 and P32 are programmable as rising, falling, or both edge triggered interrupts (IRQ register bits 6 and 7). Pref1 and P33 are the comparator reference voltage inputs. Access to the Counter Timer edge-detection circuit is through P31 or P20 (see “CTR1 Register Description” on page 32). Other edge detect and IRQ modes are described in Table 8.



Table 8. Pin Assignments

| Pin | I/O | C/T | Comp. | Int. |
|-------|-----|-------|-------|------|
| Pref1 | | | RF1 | |
| P31 | IN | IN | AN1 | IRQ2 |
| P32 | IN | | AN2 | IRQ0 |
| P33 | IN | | RF2 | IRQ1 |
| P34 | OUT | T8 | AO1 | |
| P35 | OUT | T16 | | |
| P36 | OUT | T8/16 | | |
| P37 | OUT | | AO2 | |
| P20 | I/O | IN | | |

Port 3 also provides output for each of the counter/timers and the AND/OR Logic (see Figure 9). Control is performed by programming bits D5-D4 of CTR1, bit 0 of CTR0 and bit 0 of CTR2.

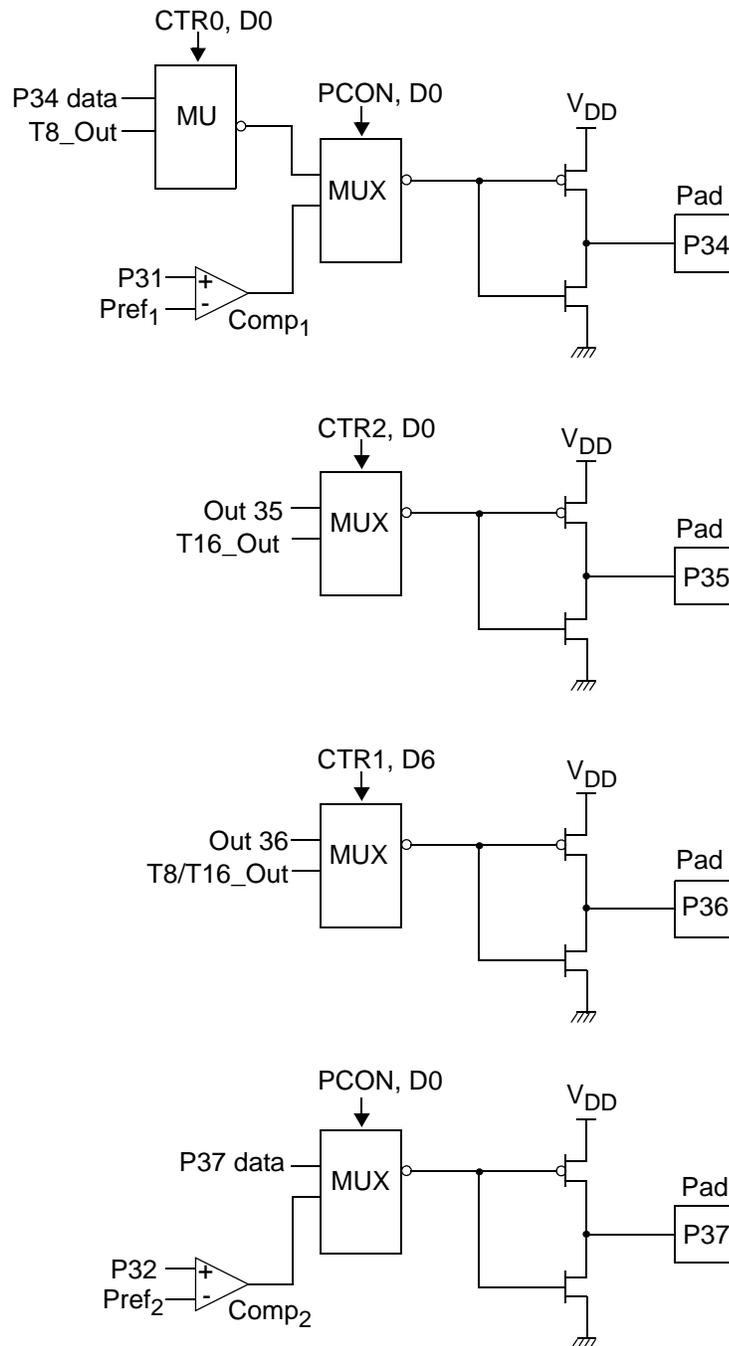


Figure 9. Port 3 Counter/Timer Output Configuration



Comparator Inputs

In analog mode, P31 and P32 have a comparator front end. The comparator reference is supplied to P33 and Pref1. In this mode, the P33 internal data latch and its corresponding IRQ1 is diverted to the SMR sources (excluding P31, P32, and P33) as indicated in Figure 8 on page 18. In digital mode, P33 is used as D3 of the Port 3 input register, which then generates IRQ1.

- ▶ **Note:** Comparators are powered down by entering Stop Mode. For P31–P33 to be used in a Stop-Mode Recovery source, these inputs must be placed into digital mode.

Comparator Outputs

These outputs can be programmed to be output on P34 and P37 through the PCON register.

Functional Description

The Z86L81/86/98 incorporates special functions to enhance the Z8's functionality in consumer and battery-operated applications.

Program Memory

The Z86L81/86/98 family addresses 24/32/64 KB of internal program memory. The first twelve bytes are reserved for interrupt vectors. These locations contain the five 16-bit vectors, which correspond to the five available interrupts.

RAM

The Z86L81/86/98 device has 237 bytes of RAM, which make up the register file. See Figure 10.

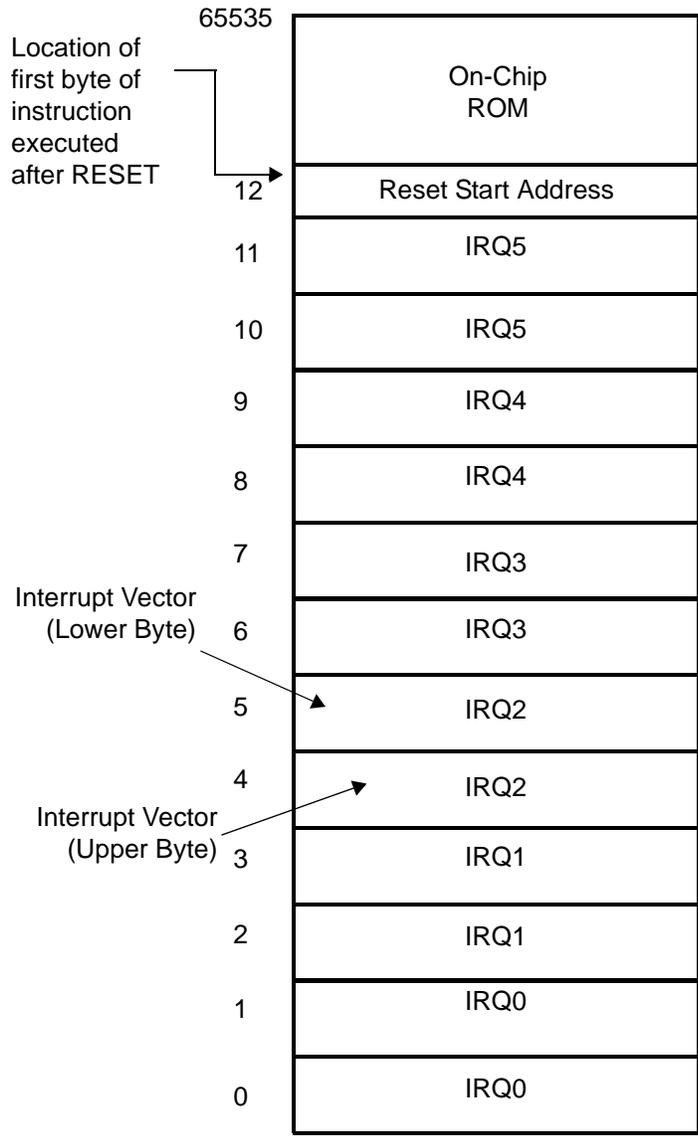


Figure 10. Program Memory Map (64 KB ROM)



Expanded Register File

The register file has been expanded to allow for additional system control registers, and for mapping of additional peripheral devices into the register address area. The Z8 register address space R0 through R15 has been implemented as 16 banks, with 16 registers per bank. These register groups are known as the ERF (Expanded Register File). Bits 7–4 of register RP select the working register group. Bits 3–0 of register RP select the expanded register file bank.

- ▶ **Note:** An expanded register bank is also referred to as an expanded register group (see Figure 11).

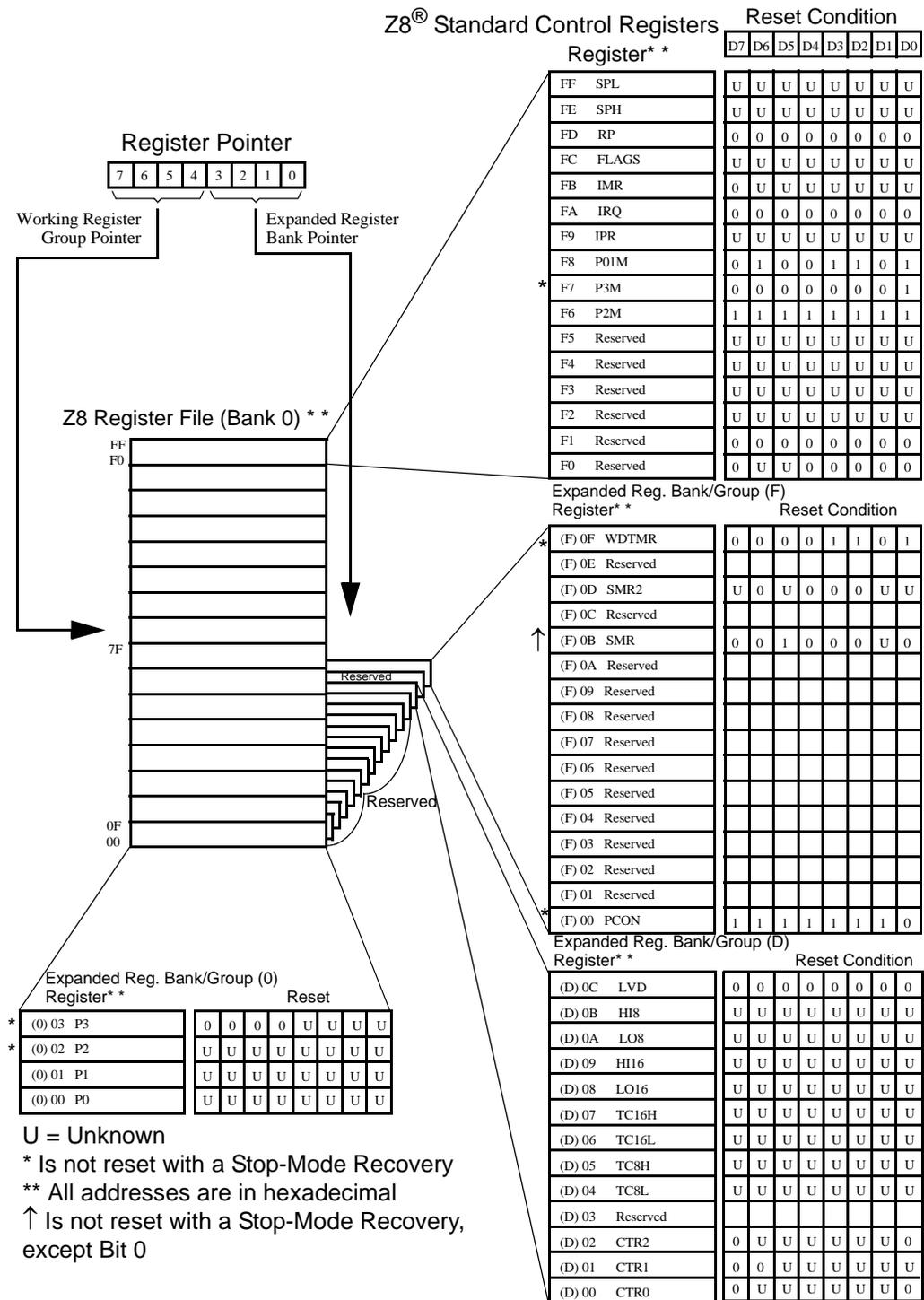


Figure 11. Expanded Register File Architecture



The upper nibble of the register pointer (see Figure 12) selects which working register group, of 16 bytes in the register file, is accessed out of the possible 256. The lower nibble selects the expanded register file bank and, in the case of the Z86L81/86/98 family, banks 0, F, and D are implemented. A 0h in the lower nibble allows the normal register file (bank 0) to be addressed, but any other value from 1h to Fh exchanges the lower 16 registers to an expanded register bank.

R253 RP

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|

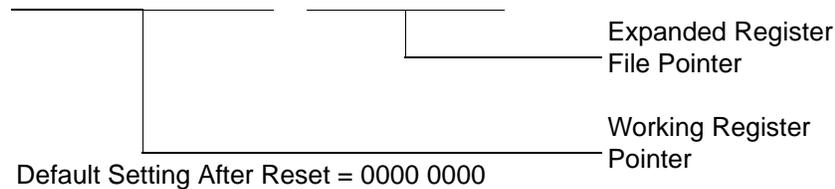


Figure 12. Register Pointer

Example: Z86L81/86/98: (See Figure 11 on page 24)

R253 RP = 00h
R0 = Port 0
R1 = Port 1
R2 = Port 2
R3 = Port 3

But if:

R253 RP = 0Dh
R0 = CTRL0
R1 = CTRL1
R2 = CTRL2
R3 = Reserved

The counter/timers are mapped into ERF group D. Access is easily performed using the following:

```
LD    RP, #0Dh    ; Select ERF D for access to bank D
        (working register group 0)
LD    R0, #xx    ; load CTRL0
LD    1, #xx    ; load CTRL1
LD    R1, 2      ; CTRL2→CTRL1
```



```
LD    RP, #0Dh    ; Select ERF D for access to bank D
      (working register group 0)
LD    RP, #7Dh    ; Select expanded register bank D and working
      register group 7 of bank 0 for access.
LD    71h, 2      ; CTRL2→register 71h
LD    R1, 2       ; CTRL2→register 71h
```

Register File

The register file (bank 0) consists of 4 I/O port registers, 237 general-purpose registers, and 16 control and status registers (R0–R3, R4–R239, and R240–R255, respectively). Additionally, there are two expanded registers groups in Banks D (see Table 9) and F. Instructions can access registers directly or indirectly through an 8-bit address field, thereby allowing a short, 4-bit register address to use the Register Pointer (Figure 13). In the 4-bit mode, the register file is divided into 16 working register groups, each occupying 16 continuous locations. The Register Pointer addresses the starting location of the active working register group.

Counter/Timer Register Description

Table 9. Expanded Register Group D

| | |
|--------|----------|
| (D)0Ch | LVD |
| (D)0Bh | HI8 |
| (D)0Ah | LO8 |
| (D)09h | HI16 |
| (D)08h | LO16 |
| (D)07h | TC16H |
| (D)06h | TC16L |
| (D)05h | TC8H |
| (D)04h | TC8L |
| (D)03h | Reserved |
| (D)02h | CTR2 |
| (D)01h | CTR1 |
| (D)00h | CTR0 |

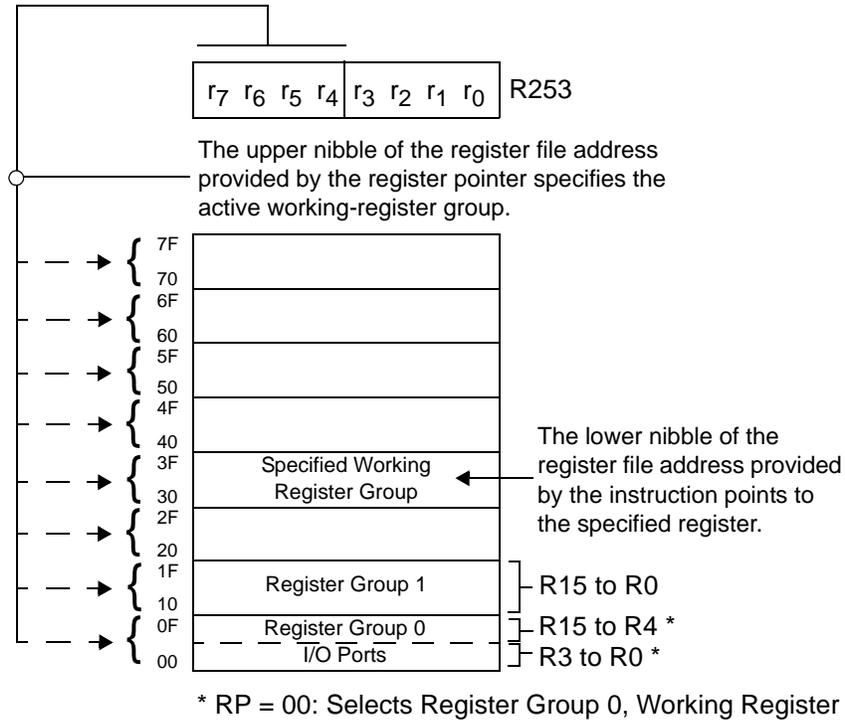


Figure 13. Register Pointer—Detail

- **Note:** Working register group E0–EF can only be accessed through working registers and indirect addressing modes.

Stack

The Z86L81/86/98 internal register file is used for the stack. An 8-bit Stack Pointer (R255) is used for the internal stack that resides in the general-purpose registers (R4–R239). SPH is used as a general-purpose register only when using internal stacks.

- **Note:** When SPH is used as a general-purpose register, and Port 0 is in address mode, the contents of SPH are loaded into Port 0 whenever the internal stack is accessed.



Register Description

LVD (D) 0Ch. Low-Voltage Detection Register

Bit 0 enables/disables the Low-Voltage Detection Circuit. Bit 1 flags if low voltage is detected. Interrupt 5 is triggered when the flag bit is set, given that IRQ5 is not masked.

- **Note:** The LVD flag will be valid after enabling the detection for 20 μ S (design estimation, not tested in production). LVD does not work at STOP mode. It must be disabled during STOP mode in order to reduce current.

| Field | Bit Position | | | Description |
|-------|--------------|-----|----|-----------------------|
| LVD | 765432-- | | | Reserved No Effect |
| | -----1- | R | 1 | LV flag set |
| | | | 0* | LV flag reset |
| | -----0 | R/W | 1 | Enable LVD |
| | | | 0* | Disable LVD |

Note:

*Default after POR

HI8(D)0Bh

This register holds the captured data from the output of the 8-bit Counter/Timer0. Typically, this register is used to hold the number of counts when the input signal is 1.

| Field | Bit Position | | | Description |
|---------------|--------------|---|--|---------------|
| T8_Capture_HI | 76543210 | R | | Captured Data |
| | | W | | No Effect |

L08(D)0Ah

This register holds the captured data from the output of the 8-bit Counter/Timer0. Typically, this register is used to hold the number of counts when the input signal is 0.

| Field | Bit Position | | | Description |
|---------------|--------------|---|--|---------------|
| T8_Capture_L0 | 76543210 | R | | Captured Data |
| | | W | | No Effect |



HI16(D)09h

This register holds the captured data from the output of the 16-bit Counter/Timer16, while also holding the MS-Byte of the data.

| Field | Bit Position | Description | |
|----------------|--------------|-------------|---------------|
| T16_Capture_HI | 76543210 | R | Captured Data |
| | | W | No Effect |

L016(D)08h

This register holds the captured data from the output of the 16-bit Counter/Timer16, while also holding the LS-Byte of the data.

| Field | Bit Position | Description | |
|----------------|--------------|-------------|---------------|
| T16_Capture_LO | 76543210 | R | Captured Data |
| | | W | No Effect |

TC16H(D)07h

Counter/Timer2 MS-Byte Hold Register.

| Field | Bit Position | Description | |
|-------------|--------------|-------------|------|
| T16_Data_HI | 76543210 | R/W | Data |

TC16L(D)06h

Counter/Timer2 LS-Byte Hold Register.

| Field | Bit Position | Description | |
|-------------|--------------|-------------|------|
| T16_Data_LO | 76543210 | R/W | Data |

TC8H(D)05h

Counter/Timer8 High Hold Register.

| Field | Bit Position | Description | |
|-------------|--------------|-------------|------|
| T8_Level_HI | 76543210 | R/W | Data |



TC8L(D)04h

Counter/Timer8 Low Hold Register.

| Field | Bit Position | Description |
|-------------|--------------|-------------|
| T8_Level_LO | 76543210 | R/W Data |

CTR0 Counter/Timer8 Control Register

Table 10 lists and briefly describes the fields for this register.

Table 10. CTR0 (D)00 Counter/Timer8 Control Register

| Field | Bit Position | Value | Description | |
|------------------|--------------|-------|-------------|---------------------------|
| T8_Enable | 7----- | R | 0* | Counter Disabled |
| | | | 1 | Counter Enabled |
| | | W | 0 | Stop Counter |
| | | | 1 | Enable Counter |
| Single/Modulo-N | -6----- | R/W | 0 | Modulo-N |
| | | | 1 | Single Pass |
| Time_Out | --5----- | R | 0 | No Counter Time-Out |
| | | | 1 | Counter Time-Out Occurred |
| | | W | 0 | No Effect |
| | | | 1 | Reset Flag to 0 |
| T8_Clock | ---43--- | R/W | 00 | SCLK |
| | | | 01 | SCLK/2 |
| | | | 10 | SCLK/4 |
| | | | 11 | SCLK/8 |
| Capture_INT_MASK | -----2-- | R/W | 0 | Disable Data Capture Int. |
| | | | 1 | Enable Data Capture Int. |
| Counter_INT_Mask | -----1- | R/W | 0 | Disable Time-Out Int. |
| | | | 1 | Enable Time-Out Int. |
| P34_Out | -----0 | R/W | 0* | P34 as Port Output |
| | | | 1 | T8 Output on P34 |

Note:

*Indicates the value upon Power-On Reset.

T8 Enable

This field enables T8 when set (written) to 1.



Single/Modulo-N

When set to 0 (modulo-N), the counter reloads the initial value when the terminal count is reached. When set to 1 (single pass), the counter stops when the terminal count is reached.

Timeout

This bit is set when T8 times out (terminal count reached). To reset this bit, a 1 should be written to its location.



Caution: Writing a 1 is the only way to reset the Terminal Count status condition. Therefore, reset this bit before using/enabling the counter/timers.

The first clock of T8 might not feature complete clock width and can occur any time when enabled.



Note: Care must be taken when using the OR or AND commands to manipulate CTR0, bit 5 and CTR1, bits 0 and 1 (Demodulation Mode). These instructions use a Read-Modify-Write sequence in which the current status from the CTR0 and CTR1 registers is ORed or ANDed with the designated value and then written back into the registers.

Example

When the status of bit 5 is 1, a timer reset condition occurs.

T8 Clock

This bit defines the frequency of the input signal to T8.

Capture_INT_Mask

Set this bit to allow an interrupt when data is captured into either LO8 or HI8 upon a positive or negative edge detection in demodulation mode.

Counter_INT_Mask

Set this bit to allow an interrupt when T8 has a timeout.

P34_Out

This bit defines whether P34 is used as a normal output pin or the T8 output.



CTR1(D)01h

This register controls the functions in common with the T8 and T16.

CTR1 Register Description

Table 11 lists and briefly describes the fields for this register.

Table 11. CTR(D)01h Register Descriptions

| Field | Bit Position | | Value | Description |
|------------------------------------|--------------|-----------------------|--|---|
| Mode | 7----- | R/W | 0* | Transmit Mode Demodulation Mode |
| P36_Out/ Demodulator_Input | -6----- | R/W | 0* 1 0 1 | Transmit Mode Port Output T8/T16 Output Demodulation Mode P31 P20 |
| T8/T16_Logic/ Edge_Detect | --54---- | R/W | 00 01 10 11 00 01 10 11 | Transmit Mode AND OR NOR NAND Demodulation Mode Falling Edge Rising Edge Both Edges Reserved |
| Transmit_Submode/ Glitch_Filter | ----32-- | R/W | 00 01 10 11 00 01 10 11 | Transmit Mode Normal Operation Ping-Pong Mode T16_Out = 0 T16_Out = 1 Demodulation Mode No Filter 4 SCLK Cycle 8 SCLK Cycle Reserved |
| Initial_T8_Out/ Rising Edge | -----1- | R/W R W | 0 1 0 1 0 1 | Transmit Mode T8_OUT is 0 Initially T8_OUT is 1 Initially Demodulation Mode No Rising Edge Rising Edge Detected No Effect Reset Flag to 0 |



Table 11. CTR(D)01h Register Descriptions (Continued)

| Field | Bit Position | | Value | Description |
|----------------------------------|--------------|-----|-------|--|
| Initial_T16_Out/ Falling_Edge | -----0 | R/W | 0 | Transmit Mode |
| | | | 1 | T16_OUT is 0 Initially T16_OUT is 1 Initially |
| | | R | 0 | Demodulation Mode |
| | | | 1 | No Falling Edge Falling Edge Detected |
| | | W | 0 | No Effect |
| | | | 1 | Reset Flag to 0 |

Note:

*Default upon Power-On Reset

Mode

If it is 0, the counter/timers are in the transmit mode; otherwise, they are in the demodulation mode.

P36_Out/Demodulator_Input

In Transmit Mode, this bit defines whether P36 is used as a normal output pin or the combined output of T8 and T16.

In Demodulation Mode, this bit defines whether the input signal to the Counter/Timers is from P20 or P31.

T8/T16_Logic/Edge_Detect

In Transmit Mode, this field defines how the outputs of T8 and T16 are combined (AND, OR, NOR, NAND).

In Demodulation Mode, this field defines which edge should be detected by the edge detector.

Transmit_Submode/Glitch_Filter

In Transmit Mode, this field defines whether T8 and T16 are in the Ping-Pong mode or in independent normal operation mode. Setting this field to “Normal Operation Mode” terminates the “Ping-Pong Mode” operation. When set to 10, T16 is immediately forced to a 0; a setting of 11 forces T16 to output a 1.

In Demodulation Mode, this field defines the width of the glitch that must be filtered out.

Initial_T8_Out/Rising_Edge

In Transmit Mode, if 0, the output of T8 is set to 0 when it starts to count. If 1, the output of T8 is set to 1 when it starts to count. When the counter is not enabled and this bit is set to 1 or 0, T8_OUT is set to the opposite state of this bit. This



measure ensures that when the clock is enabled, a transition occurs to the initial state set by CTR1, D1.

In Demodulation Mode, this bit is set to 1 when a rising edge is detected in the input signal. In order to reset it, a 1 should be written to this location.

Initial_T16 Out/Falling _Edge

In Transmit Mode, if it is 0, the output of T16 is set to 0 when it starts to count. If it is 1, the output of T16 is set to 1 when it starts to count. This bit is effective only in Normal or Ping-Pong Mode (CTR1, D3, D2). When the counter is not enabled and this bit is set, T16_OUT is set to the opposite state of this bit. This measure ensures that when the clock is enabled, a transition occurs to the initial state set by CTR1, D0.

In Demodulation Mode, this bit is set to 1 when a falling edge is detected in the input signal. In order to reset it, a 1 should be written to this location.

► **Note:** Modifying CTR1, (D1 or D0) while the counters are enabled causes unpredictable output from T8/16_OUT.

CTR2 Counter/Timer 16 Control Register

Table 12 lists and briefly describes the fields for this register.

Table 12. CTR2 (D)02h: Counter/Timer16 Control Register

| Field | Bit Position | | Value | Description |
|-----------------|--------------|-----------------|-------|-----------------------------|
| T16_Enable | 7----- | R | 0* | Counter Disabled |
| | | | 1 | Counter Enabled |
| | | W | 0 | Stop Counter |
| | | | 1 | Enable Counter |
| Single/Modulo-N | -6----- | R/W | 0 | Transmit Mode |
| | | | 1 | Modulo-N |
| | | | 0 | Single Pass |
| | | | 1 | Demodulation Mode |
| Time_Out | --5----- | R | 0 | T16 Recognizes Edge |
| | | | 1 | T16 Does Not Recognize Edge |
| | | W | 0 | No Counter Timeout |
| | | | 1 | Counter Timeout Occurred |
| | 0 | No Effect | | |
| | 1 | Reset Flag to 0 | | |



Table 12. CTR2 (D)02h: Counter/Timer16 Control Register (Continued)

| Field | Bit Position | | Value | Description |
|------------------|--------------|-----|-------|---|
| T16_Clock | ---43--- | R/W | 00 | SCLK |
| | | | 01 | SCLK/2 |
| | | | 10 | SCLK/4 |
| | | | 11 | SCLK/8 |
| Capture_INT_Mask | ----2-- | R/W | 0 | Disable Data Capture Int. |
| | | | 1 | Enable Data Capture Int. |
| Counter_INT_Mask | -----1- | R/W | 0 | Disable Timeout Int. Enable Timeout Int. |
| P35_Out | -----0 | R/W | 0* | P35 as Port Output |
| | | | 1 | T16 Output on P35 |

Note:

*Indicates the value upon Power-On Reset.

T16_Enable

This field enables T16 when set to 1.

Single/Modulo-N

In Transmit Mode, when set to 0, the counter reloads the initial value when terminal count is reached. When set to 1, the counter stops when the terminal count is reached.

In Demodulation Mode, when set to 0, T16 captures and reloads on detection of all the edges. When set to 1, T16 captures and detects on the first edge, but ignores the subsequent edges. For details, see the description of T16 Demodulation Mode on page 45.

Time_Out

This bit is set when T16 times out (terminal count reached). To reset the bit, write a 1 to this location.

T16_Clock

This bit defines the frequency of the input signal to Counter/Timer16.

Capture_INT_Mask

This bit is set to allow an interrupt when data is captured into LO16 and HI16.



Counter_INT_Mask

This bit is set to allow an interrupt when T16 times out.

P35_Out

This bit defines whether P35 is used as a normal output pin or T16 output.

SMR2 Stop-Mode Recovery Register 2

Table 13 lists and briefly describes the fields for this register.

Table 13. SMR2(F)0Dh: Stop-Mode Recovery Register 2

| Field | Bit Position | | Value | Description |
|----------------|--------------|---|-------|------------------------------|
| Reserved | 7----- | | 0 | Reserved (Must be 0) |
| Recovery Level | -6----- | W | 0* | Low |
| | | | 1 | High |
| Reserved | --5----- | | 0 | Reserved (Must be 0) |
| Source | ---432-- | W | 000* | A. POR Only |
| | | | 001 | B. NAND of P23–P20 |
| | | | 010 | C. NAND of P27–P20 |
| | | | 011 | D. NOR of P33–P31 |
| | | | 100 | E. NAND of P33–P31 |
| | | | 101 | F. NOR of P33-P31, P00, P07 |
| | | | 110 | G. NAND of P33-P31, P00, P07 |
| | | | 111 | H. NAND of P33-P31, P22–P20 |
| Reserved | -----10 | | 00 | Reserved (Must be 0) |

Notes:

* Indicates the value upon Power-On Reset

Counter/Timer Functional Blocks

Input Circuit

The edge detector monitors the input signal on P31 or P20. Based on CTR1 D5–D4, a pulse is generated at the Pos Edge or Neg Edge line when an edge is detected. Glitches in the input signal that have a width less than specified (CTR1 D3, D2) are filtered out (see Figure 14).

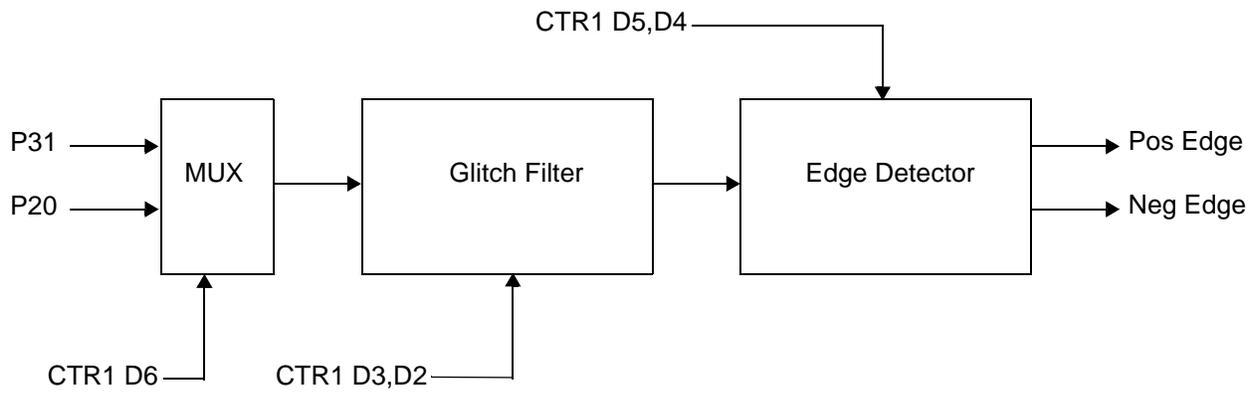


Figure 14. Glitch Filter Circuitry

T8 Transmit Mode

Before T8 is enabled, the output of T8 depends on CTR1, D1. If it is 0, T8_OUT is 1; if it is 1, T8_OUT is 0. See Figure 15.

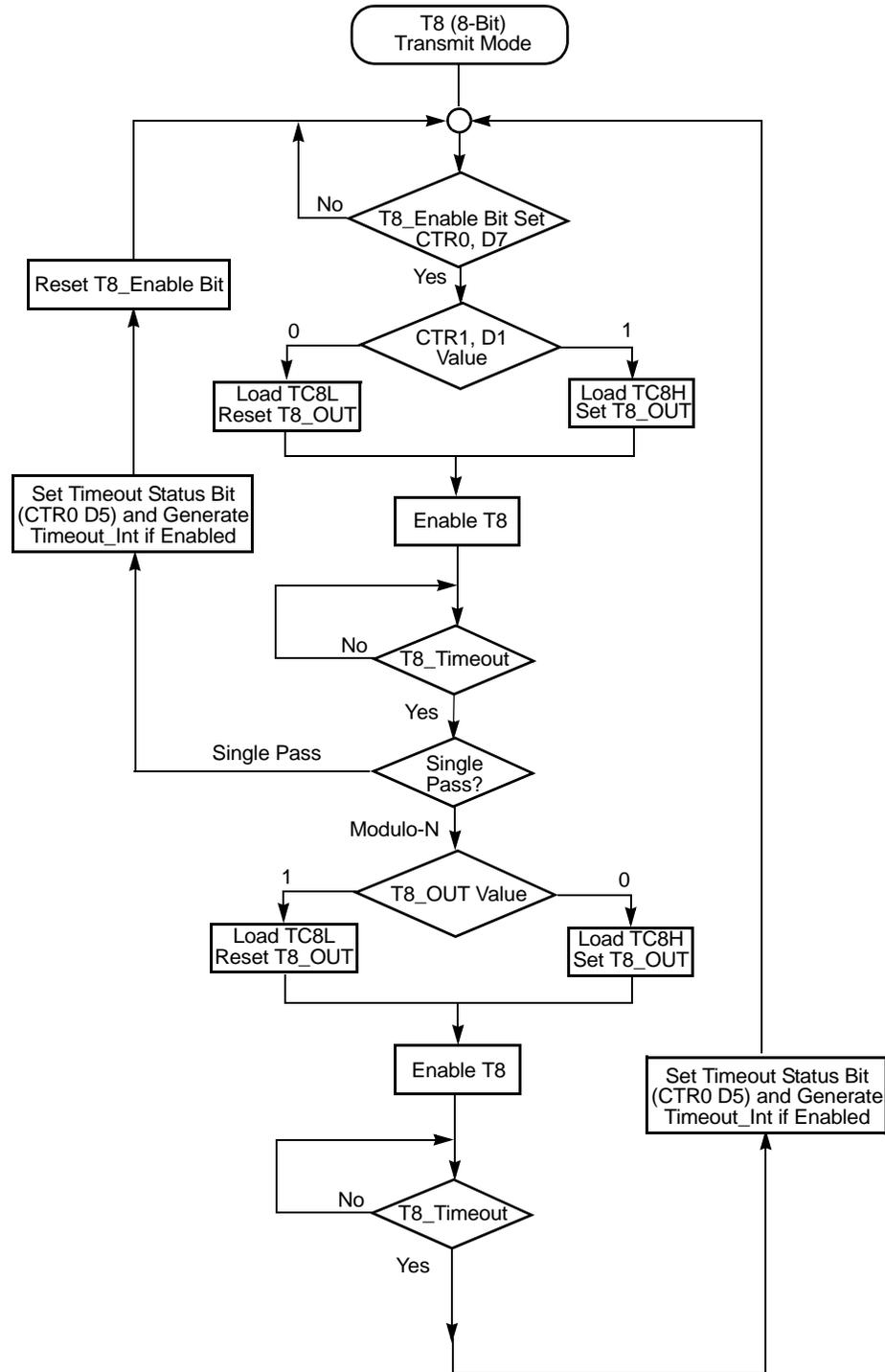


Figure 15. Transmit Mode Flowchart



When T8 is enabled, the output T8_OUT switches to the initial value (CTR1, D1). If the initial value (CTR1, D1) is 0, TC8L is loaded; otherwise, TC8H is loaded into the counter. In Single-Pass Mode (CTR0, D6), T8 counts down to 0 and stops, T8_OUT toggles, the timeout status bit (CTR0, D5) is set, and a timeout interrupt can be generated if it is enabled (CTR0, D1). In Modulo-N Mode, upon reaching terminal count, T8_OUT is toggled, but no interrupt is generated. From that point, T8 loads a new count (if the T8_OUT level now is 0), TC8L is loaded; if it is 1, TC8H is loaded. T8 counts down to 0, toggles T8_OUT, sets the timeout status bit (CTR0, D5) and generates an interrupt if enabled (CTR0, D1). One cycle is thus completed. T8 then loads from TC8H or TC8L according to the T8_OUT level, and repeats the cycle. See Figure 16.

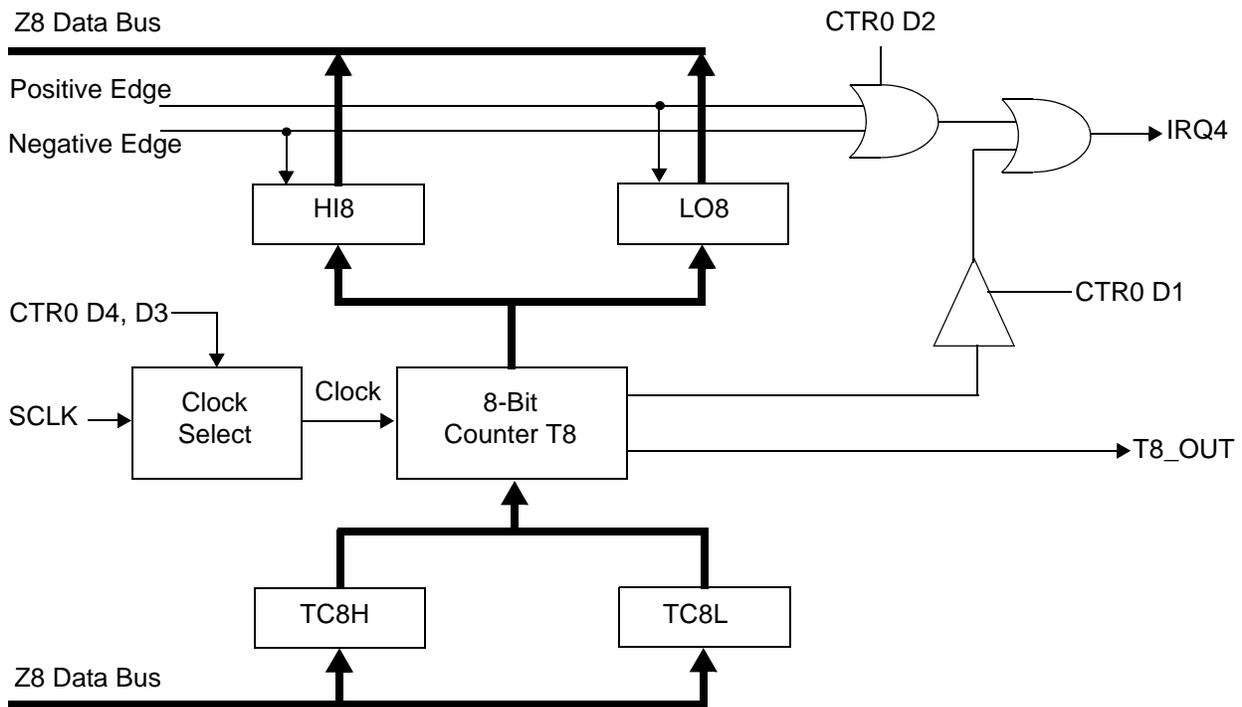


Figure 16. 8-Bit Counter/Timer Circuits

You can modify the values in TC8H or TC8L at any time. The new values take effect when they are loaded.



Caution: Do not write these registers at the time the values are to be loaded into the counter/timer to ensure known operation. An



initial count of "1" is not allowed (a non-function occurs). An initial count of "0" causes TC8 to count from 0 to FFh to FEh.

► **Note:** The letter *h* is used for hexadecimal values.

Transition from 0 to FFh is not a timeout condition.

⚠ **Caution:** Using the same instructions for stopping the counter/timers and setting the status bits is not recommended.

Two successive commands are necessary. First, the counter/timers must be stopped. Second, the status bits must be reset. These commands are required because it takes one counter/timer clock interval for the initiated event to actually occur. See Figure 17 and Figure 18.

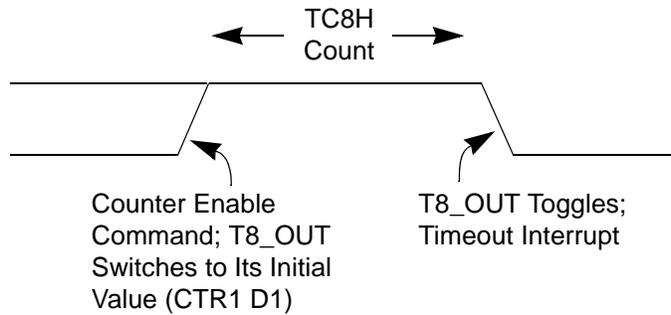


Figure 17. T8_OUT in Single-Pass Mode

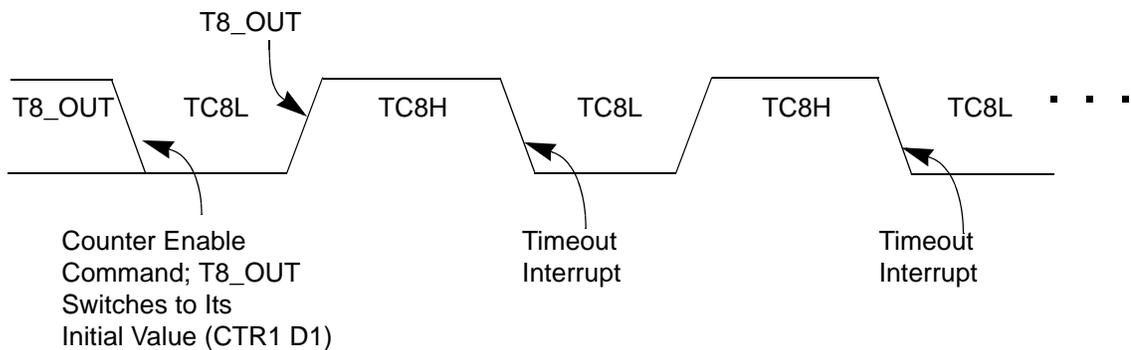


Figure 18. T8_OUT in Modulo-N Mode



T8 Demodulation Mode

Program TC8L and TC8H to FFh. After T8 is enabled, when the first edge (rising, falling, or both depending on CTR1, D5; D4) is detected, it starts to count down. When a subsequent edge (rising, falling, or both depending on CTR1, D5; D4) is detected during counting, the current value of T8 is complemented and put into one of the capture registers. If it is a positive edge, data is put into LO8, if negative edge, HI8. One of the edge detect status bits (CTR1, D1; D0) is set, and an interrupt can be generated if enabled (CTR0, D2). Meanwhile, T8 is loaded with FFh and starts counting again. If T8 reaches 0, the timeout status bit (CTR0, D5) is set, an interrupt can be generated if enabled (CTR0, D1), and T8 continues counting from FFh (see Figure 19 and Figure 20).

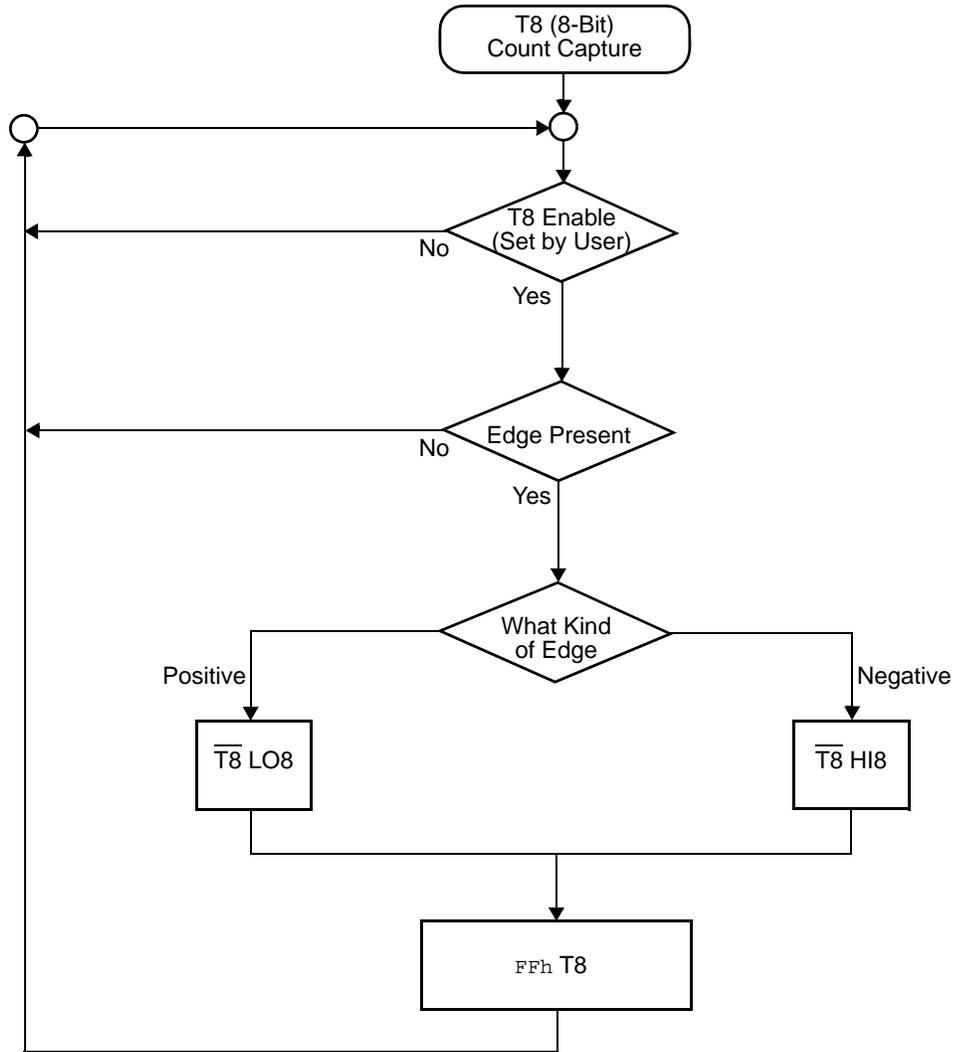


Figure 19. Demodulation Mode Count Capture Flowchart

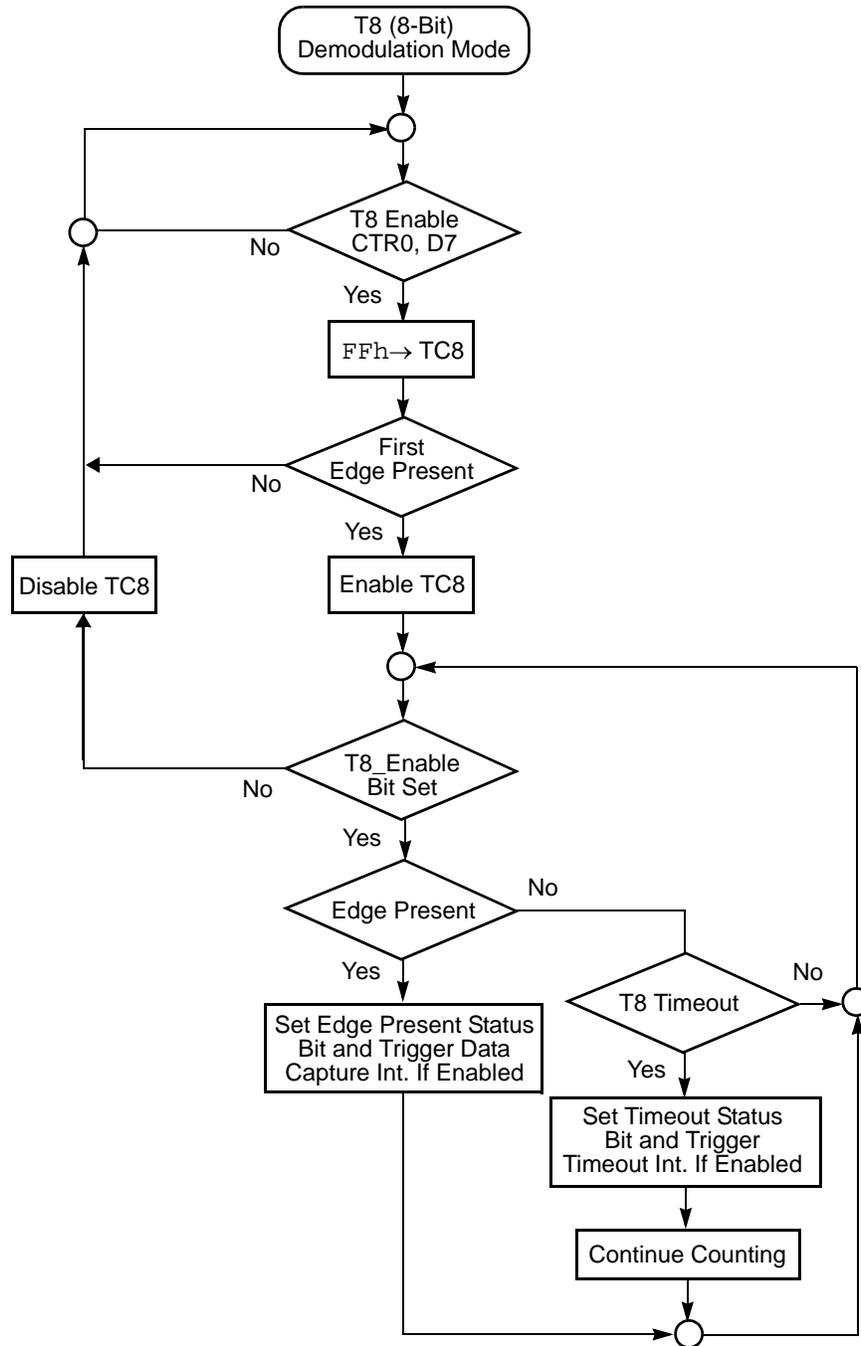


Figure 20. Demodulation Mode Flowchart



Caution: Do not load these registers at the time the values are to be loaded into the counter/timer to ensure known operation. An initial count of 1 is not allowed. An initial count of 0 causes T16 to count from 0 to $FFFFh$ to $FFFEh$. Transition from 0 to $FFFFh$ is not a timeout condition.

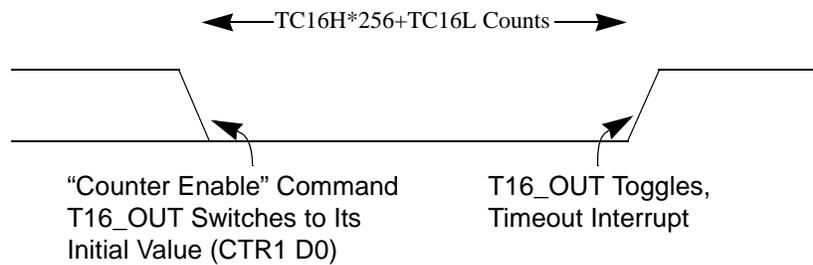


Figure 22. T16_OUT in Single-Pass Mode

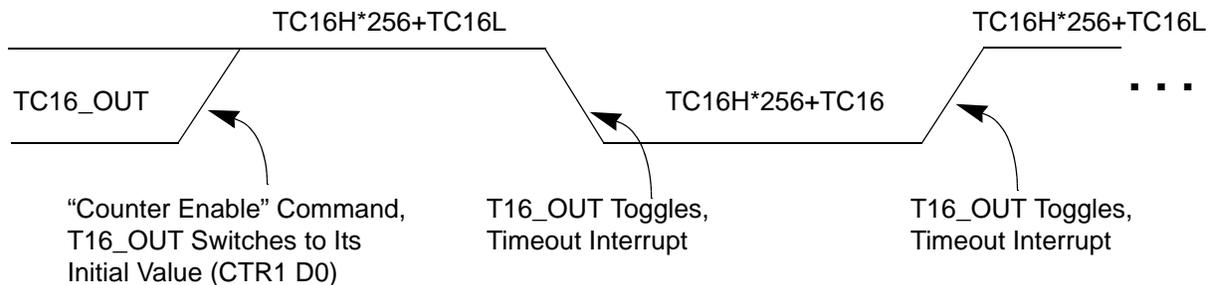


Figure 23. T16_OUT in Modulo-N Mode

T16 Demodulation Mode

Program TC16L and TC16H to FFh . After T16 is enabled, and the first edge (rising, falling, or both depending on CTR1 D5, D4) is detected, T16 captures HI16 and LO16, reloads, and begins counting.

If D6 of CTR2 Is 0

When a subsequent edge (rising, falling, or both depending on CTR1, D5; D4) is detected during counting, the current count in T16 is complemented and put into HI16 and LO16. When data is captured, one of the edge detect status bits (CTR1, D1; D0) is set and an interrupt is generated if enabled (CTR2, D2). From that point, T16 is loaded with $FFFFh$ and starts again.



This T16 mode is generally used to measure mark time, defined as the length of time between carrier signal bursts (marks).

If D6 of CTR2 Is 1

T16 ignores the subsequent edges in the input signal and continues counting down. A timeout of T8 causes T16 to capture its current value and generate an interrupt if enabled (CTR2, D2). In this case, T16 does not reload and continues counting. If the D6 bit of CTR2 is toggled (by writing a 0 then a 1 to it), T16 captures and reloads on the next edge (rising, falling, or both depending on CTR1, D5; D4), thereby continuing to ignore subsequent edges.

This T16 mode is generally used to measure mark time, defined as the length of time between carrier signal bursts (marks).

If T16 reach 0, T16 continues counting from `FFFFh`. Meanwhile, a status bit (CTR2 D5) is set, and an interrupt timeout can be generated if enabled (CTR2 D1).

Ping-Pong Mode

This operation mode is only valid in Transmit Mode. T8 and T16 must be programmed in Single-Pass Mode (CTR0, D6, CTR2, D6) and Ping-Pong Mode must be programmed in CTR1, D3; D2. The user can begin the operation by enabling either T8 or T16 (CTR0, D7 or CTR2, D7). For example, if T8 is enabled, T8_OUT is set to this initial value (CTR1, D1). According to T8_OUT's level, TC8H or TC8L is loaded into T8. After the terminal count is reached, T8 is disabled and T16 is enabled. T16_OUT switches to its initial value (CTR1, D0), data from TC16H and TC16L is loaded, and T16 starts to count. After T16 reaches the terminal count, it stops, T8 is enabled again, and the whole cycle repeats. Interrupts can be allowed when T8 or T16 reaches terminal control (CTR0, D1; CTR2, D1). To stop the Ping-Pong operation, write 00 to bits D3 and D2 of CTR1. See Figure 24.

- **Note:** Enabling Ping-Pong operation while the counter/timers are running might cause intermittent counter/timer function. Disable the counter/timers and then reset the status flags before instituting this operation.

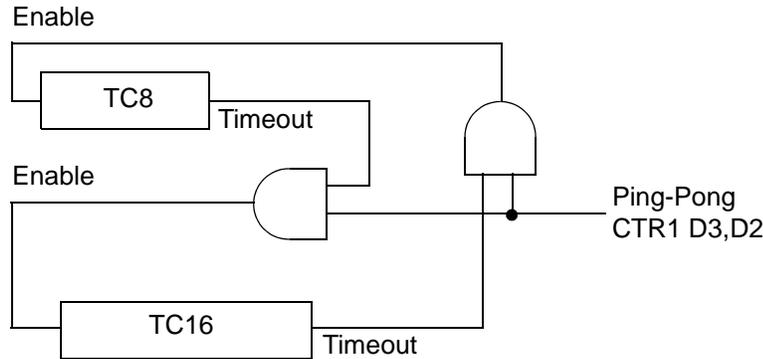


Figure 24. Ping-Pong Mode

Initiating Ping-Pong Mode

First, make sure both counter/timers are not running. Then, set T8 into Single-Pass Mode (CTR0 D6), set T16 into Single-Pass Mode (CTR2 D6), and set the Ping-Pong Mode (CTR1 D2, D3). These instructions do not have to be in any particular order. Finally, start Ping-Pong Mode by enabling either T8 (CTR0 D7) or T16 (CTR2 D7). See Figure 25.

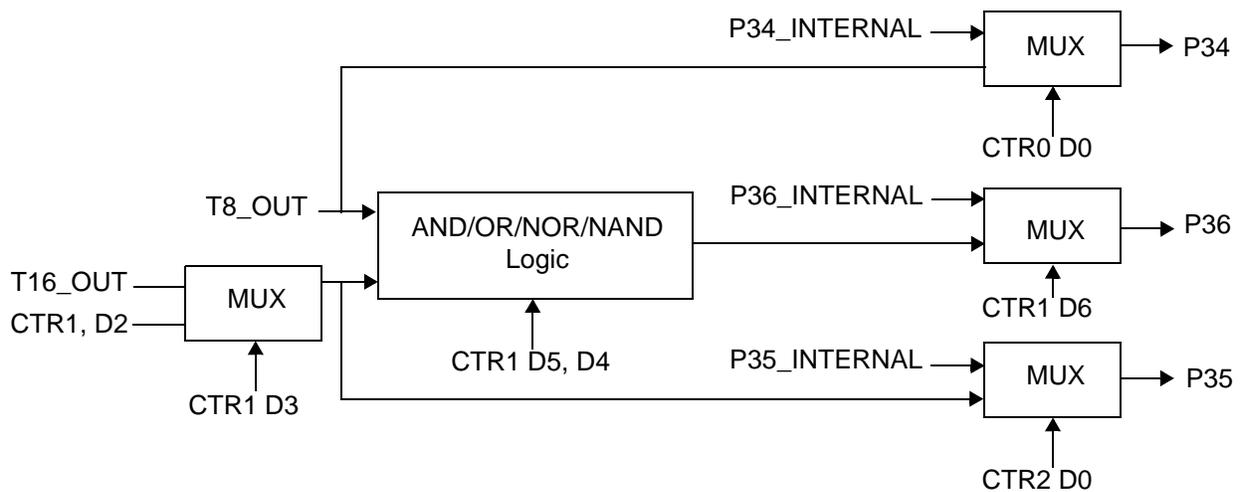


Figure 25. Output Circuit

The initial value of T8 or T16 must not be 1. If you stop the timer and start the timer again, reload the initial value to avoid an unknown previous value.



During Ping-Pong Mode

The enable bits of T8 and T16 (CTR0 D7, CTR2 D7) are set and cleared alternately by hardware. The timeout bits (CTR0 D5, CTR2 D5) are set every time the counter/timers reach the terminal count.

Interrupts

The Z86L81/86/98 features six different interrupts (Table 14). The interrupts are maskable and prioritized (Figure 26). The six sources are divided as follows: three sources are claimed by Port 3 lines P33–P31, two by the counter/timers, and one by LVD (Table 14). The Interrupt Mask Register globally or individually enables or disables the six interrupt requests.

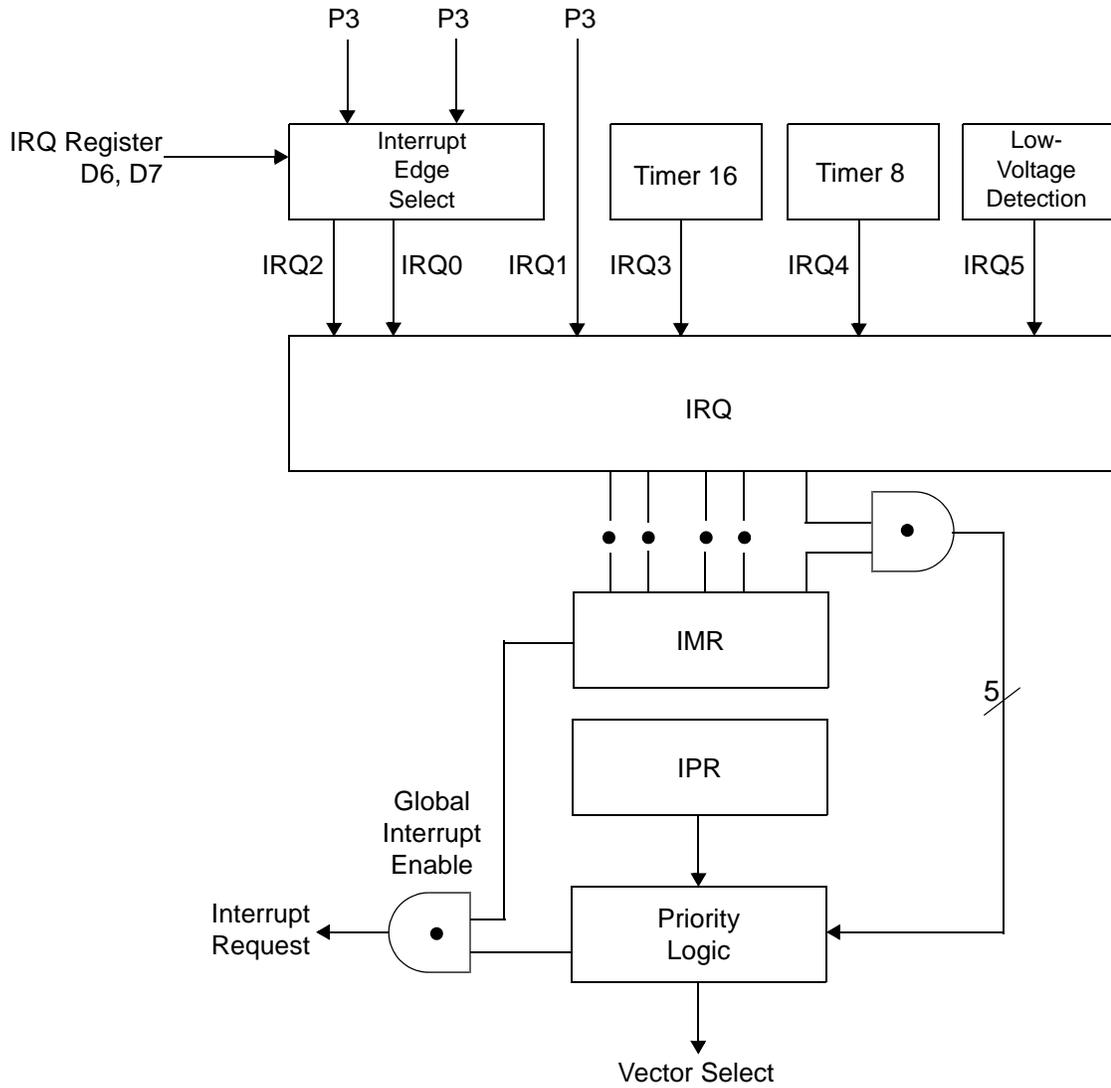


Figure 26. Interrupt Block Diagram



Table 14. Interrupt Types, Sources, and Vectors

| Name | Source | Vector Location | Comments |
|------|----------------------|-----------------|---|
| IRQ0 | P32 | 0,1 | External (P32), Rising Falling Edge Triggered |
| IRQ1 | P33 | 2,3 | External (P33), Falling Edge Triggered |
| IRQ2 | P31, T _{IN} | 4,5 | External (P31), Rising Falling Edge Triggered |
| IRQ3 | T16 | 6,7 | Internal |
| IRQ4 | T8 | 8,9 | Internal |
| IRQ5 | LVD | 10,11 | Internal |

When more than one interrupt is pending, priorities are resolved by a programmable priority encoder controlled by the Interrupt Priority Register. An interrupt machine cycle is activated when an interrupt request is granted. As a result, all subsequent interrupts are disabled, and the Program Counter and Status Flags are saved. The cycle then branches to the program memory vector location reserved for that interrupt. All Z86L81/86/98 interrupts are vectored through locations in the program memory. This memory location, and the next byte, contain the 16-bit address of the interrupt service routine for that particular interrupt request. To accommodate polled interrupt systems, interrupt inputs are masked, and the Interrupt Request register is polled to determine which of the interrupt requests require service.

An interrupt resulting from AN1 is mapped into IRQ2, and an interrupt from AN2 is mapped into IRQ0. Interrupts IRQ2 and IRQ0 may be rising, falling, or both edge triggered; all are programmable by the user. The software can poll to identify the state of the pin.

Programming bits for the Interrupt Edge Select are located in the IRQ Register (R250), bits D7 and D6. The configuration is indicated in Table 15.

Table 15. IRQ Register*

| IRQ | | Interrupt Edge | |
|-----|----|----------------|------------|
| D7 | D6 | IRQ2(P31) | IRQ0 (P32) |
| 0 | 0 | F | F |
| 0 | 1 | F | R |
| 1 | 0 | R | F |



Table 15. IRQ Register* (Continued)

| IRQ | | Interrupt Edge | |
|-----|---|----------------|-----|
| 1 | 1 | R/F | R/F |

Notes:

F = Falling Edge

R = Rising Edge

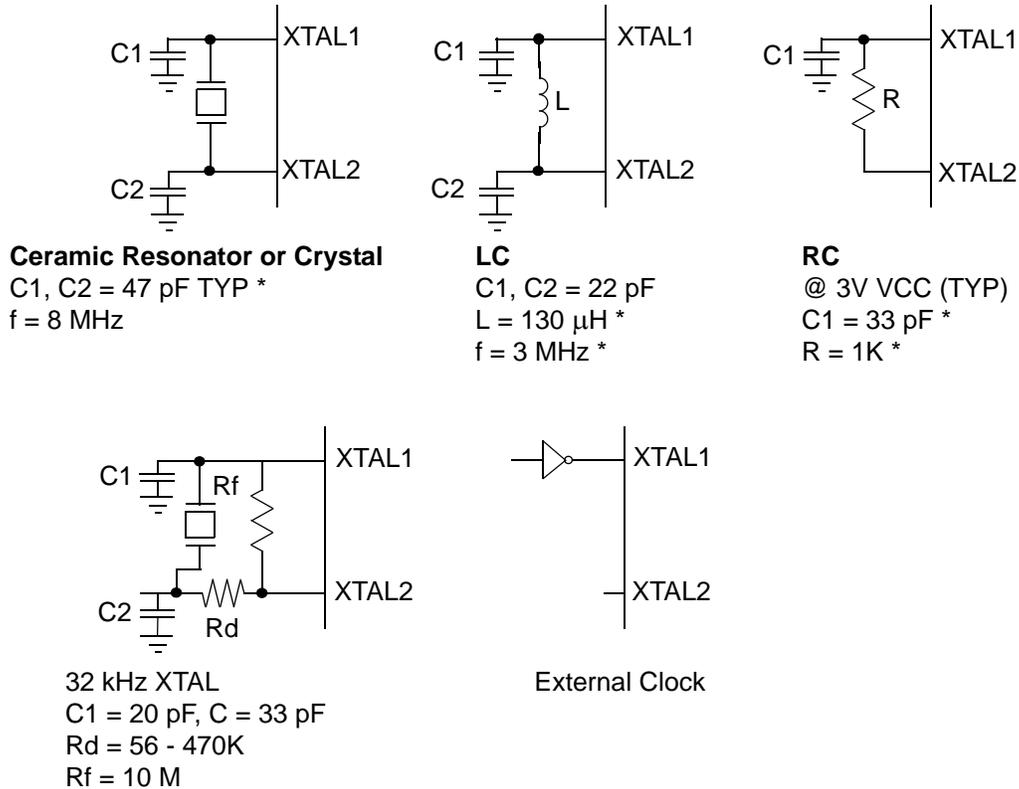
*In stop mode, the comparators are turned off.

Clock

The Z86L81/86/98 on-chip oscillator has a high-gain, parallel-resonant amplifier, for connection to a crystal, LC, ceramic resonator, or any suitable external clock source (XTAL1 = Input, XTAL2 = Output). The crystal must be AT cut, 1 MHz to 8 MHz maximum, with a series resistance (RS) less than or equal to 100 Ohms. The Z86LXX on-chip oscillator can be driven with a low-cost RC network or other suitable external clock source.

For 32-kHz crystal operation, both an external feedback (Rf) and serial resistor (Rd) are required. See Figure 27.

The crystal must be connected across XTAL1 and XTAL2 using the recommended capacitors (capacitance greater than or equal to 22 pF) from each pin to ground. The RC oscillator configuration is an external resistor connected from XTAL1 to XTAL2, with a frequency-setting capacitor from XTAL1 to ground (Figure 27).



* Preliminary value including pin parasitics

Figure 27. Oscillator Configuration

Power-On Reset (POR)

A timer circuit clocked by a dedicated on-board RC oscillator is used for the Power-On Reset (POR) timer function. The POR time allows V_{CC} and the oscillator circuit to stabilize before instruction execution begins.

The POR timer circuit is a one-shot timer triggered by one of three conditions:

- Power Fail to Power OK status, including Waking up from V_{BO} Standby
- Stop-Mode Recovery (if D5 of SMR = 1)
- WDT Timeout

The POR timer is a nominal 5 ms. Bit 5 of the Stop-Mode Register determines whether the POR timer is bypassed after Stop-Mode Recovery (typical for external clock, RC, LC oscillators).



HALT

HALT turns off the internal CPU clock, but not the XTAL oscillation. The counter/timers and external interrupts IRQ0, IRQ1, IRQ2, IRQ3, and IRQ4 remain active. The devices are recovered by interrupts, either externally or internally generated. An interrupt request must be executed (enabled) to exit HALT Mode. After the interrupt service routine, the program continues from the instruction after the HALT.

STOP

This instruction turns off the internal clock and external crystal oscillation, thereby reducing the standby current to 10 μ A or less. STOP Mode is terminated only by a reset (such as WDT timeout), POR, SMR, or external reset. This termination causes the processor to restart the application program at address 000Ch. In order to enter STOP (or HALT) mode, first flush the instruction pipeline to avoid suspending execution in mid-instruction. Execute a NOP (Op Code = FFh) immediately before the appropriate sleep instruction, as follows:

```
FF      NOP      ; clear the pipeline
6F      STOP     ; enter STOP Mode
```

or

```
FF      NOP      ; clear the pipeline
7F      HALT     ; enter HALT Mode
```

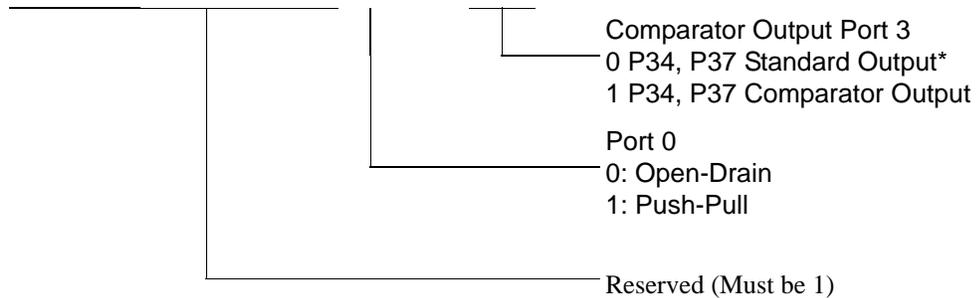
Port Configuration Register (PCON)

The PCON register (Figure 28) configures the comparator output on Port 3. It is located in the expanded register 2 at Bank F, location 00.



PCON (FH) 00H

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



* Default setting after reset

Figure 28. Port Configuration Register (PCON) (Write Only)

Comparator Output Port 3 (D0)

Bit 0 controls the comparator used in Port 3. A 1 in this location brings the comparator outputs to P34 and P37, and a 0 releases the Port to its standard I/O configuration.

Port0 Output Mode (D2)

Bit 2 controls the output mode of port 0. A 1 in this location sets the output to push-pull, and a 0 sets the output to open-drain.

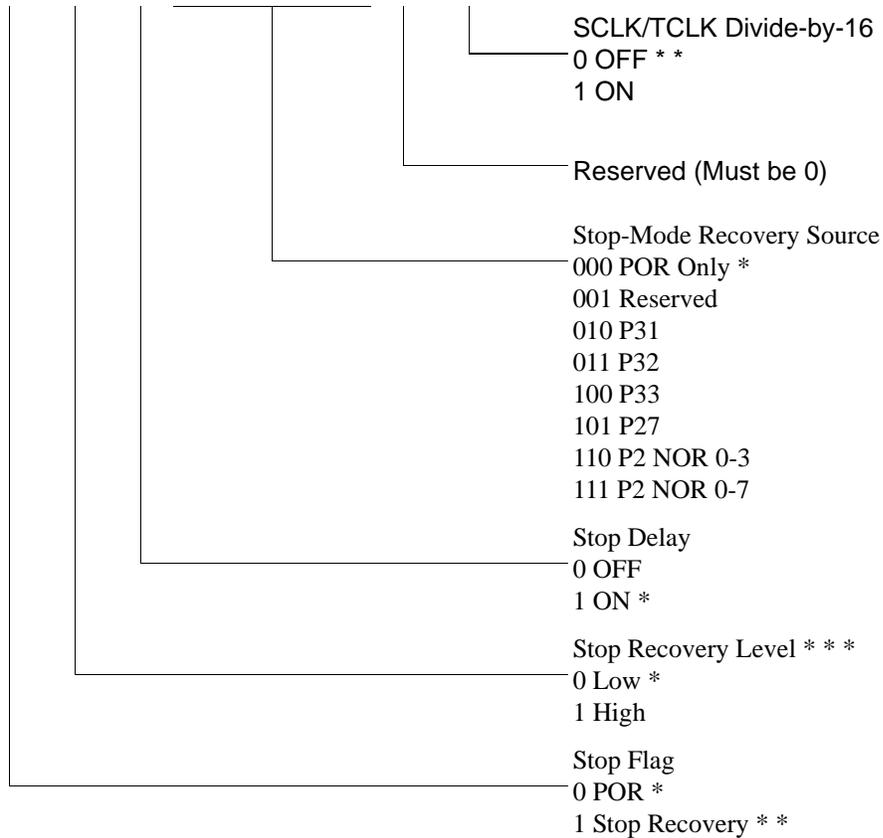
Stop-Mode Recovery Register (SMR)

This register selects the clock divide value and determines the mode of Stop-Mode Recovery (Figure 29). All bits are write only except bit 7, which is read only. Bit 7 is a flag bit that is hardware set on the condition of STOP recovery and reset by a power-on cycle. Bit 6 controls whether a low level or a high level at the XOR-gate input is required from the recovery source. Bit 5 controls the reset delay after recovery. Bits D2, D3, and D4, or the SMR register, specify the source of the Stop-Mode Recovery signal. Bit D0 determines if SCLK/TCLK are divided by 16 or not. The SMR is located in Bank F of the Expanded Register Group at address 0Bh.



SMR (0F) 0B

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



- * Default setting after reset
- ** Default setting after reset and stop-mode recovery
- *** At the XOR gate input

Figure 29. Stop-Mode Recovery Register

SCLK/TCLK Divide-by-16 Select (D0)

D0 of the SMR controls a divide-by-16 prescaler of SCLK/TCLK (Figure 30). The purpose of this control is to selectively reduce device power consumption during normal processor execution (SCLK control) and/or HALT Mode (where TCLK sources interrupt logic). After Stop-Mode Recovery, this bit is set to a 0.

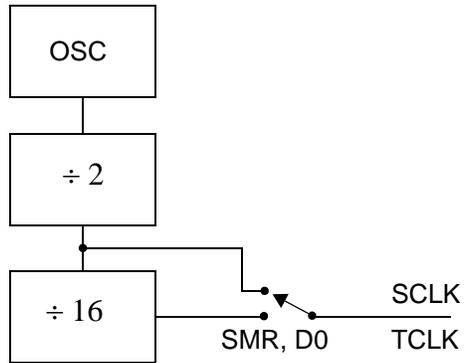


Figure 30. SCLK Circuit

Stop-Mode Recovery Source (D2, D3, and D4)

These three bits of the SMR specify the wake-up source of the STOP recovery (Figure 31 and Table 16).

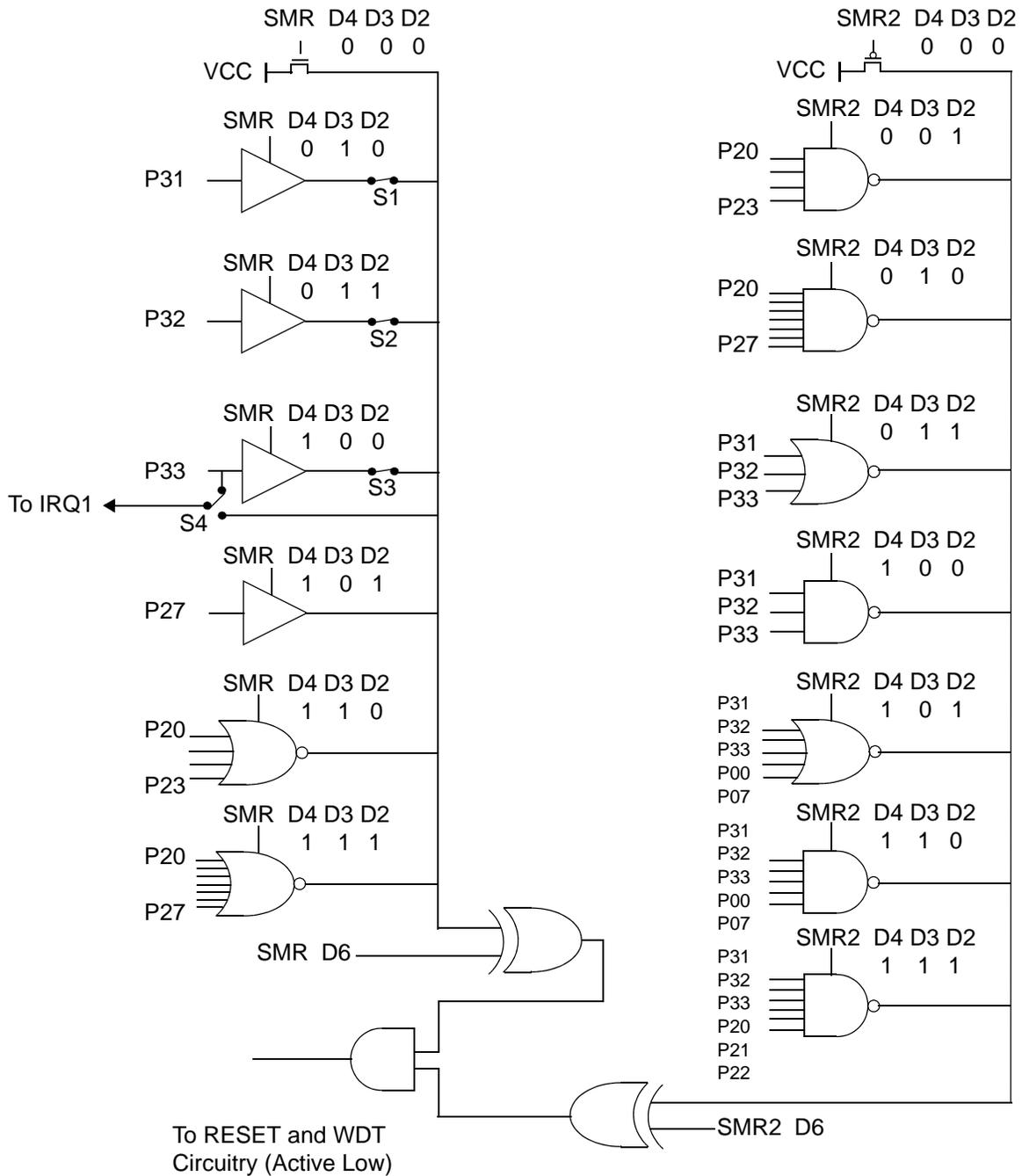


Figure 31. Stop-Mode Recovery Source



Table 16. Stop-Mode Recovery Source

| SMR:432 | | | Operation |
|---------|----|----|------------------------------------|
| D4 | D3 | D2 | Description of Action |
| 0 | 0 | 0 | POR and/or external reset recovery |
| 0 | 0 | 1 | Reserved |
| 0 | 1 | 0 | P31 transition |
| 0 | 1 | 1 | P32 transition |
| 1 | 0 | 0 | P33 transition |
| 1 | 0 | 1 | P27 transition |
| 1 | 1 | 0 | Logical NOR of P20 through P23 |
| 1 | 1 | 1 | Logical NOR of P20 through P27 |

► **Note:** Any Port 2 bit defined as an output drives the corresponding input to the default state to allow the remaining inputs to control the AND/OR function. Refer to SMR2 register on page 58 for other recover sources.

Stop-Mode Recovery Delay Select (D5)

This bit, if low, disables the 5 ms $\overline{\text{RESET}}$ delay after Stop-Mode Recovery. The default configuration of this bit is 1. If the “fast” wake up is selected, the Stop-Mode Recovery source must be kept active for at least 5 TpC.

Stop-Mode Recovery Edge Select (D6)

A 1 in this bit position indicates that a High level on any one of the recovery sources wakes the Z86L81/86/98 from STOP Mode. A 0 indicates Low level recovery. The default is 0 on POR.

Cold or Warm Start (D7)

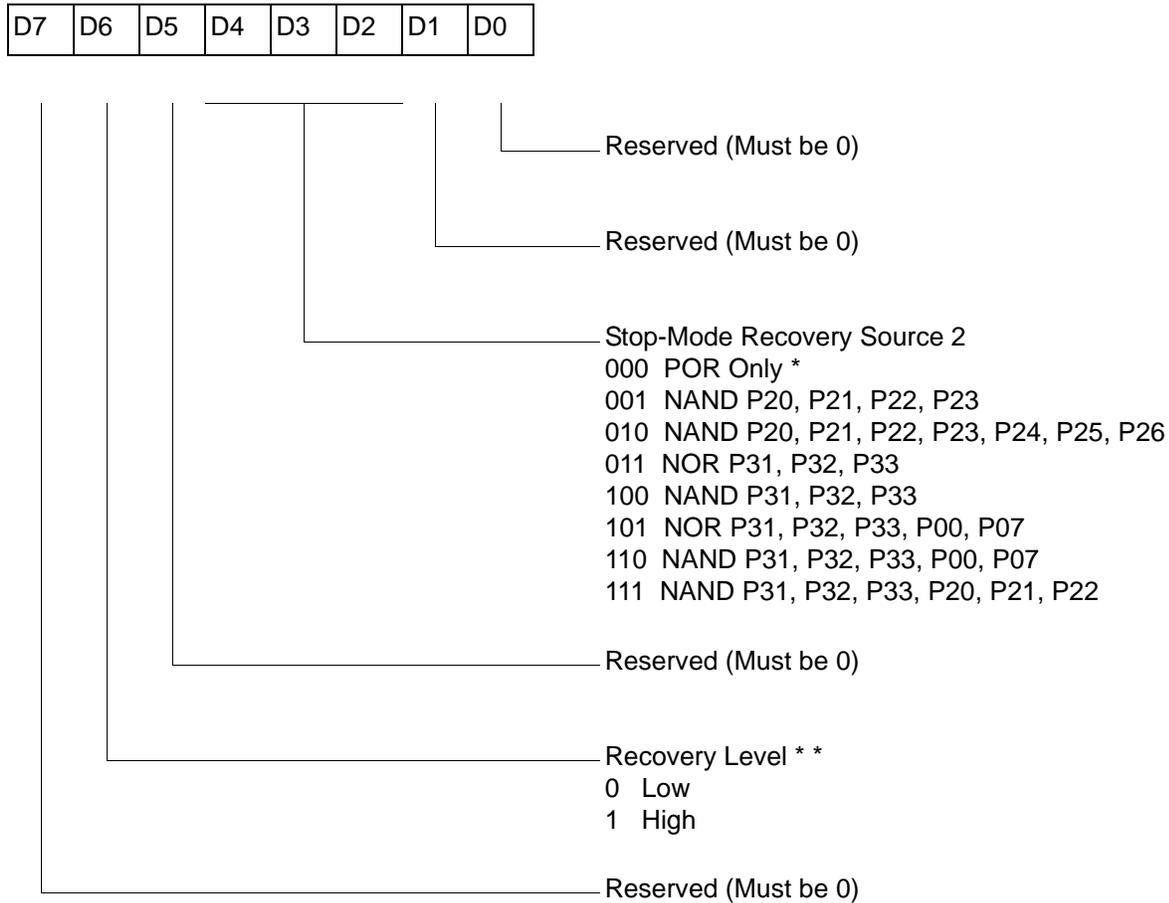
This bit is read only, and it is set to 1 when the device is recovered from stop mode. The bit is set to 0 when the device reset is other than Stop Mode Recovery (SMR).

Stop-Mode Recovery Register 2 (SMR2)

This register determines the mode of Stop-Mode Recovery for SMR2 (Figure 32).



SMR2 (0F) DH



Note: If used in conjunction with SMR, either of the two specified events causes a Stop-Mode Recovery.

* Default setting after reset

** At the XOR gate input

Figure 32. Stop-Mode Recovery Register 2 ((0F) DH:D2–D4, D6 Write Only)

If SMR2 is used in conjunction with SMR, either of the specified events causes a Stop-Mode Recovery.

► **Note:** Port pins configured as outputs are ignored as an SMR or SMR2 recovery source. For example, if the NAND or P23–P20 is selected as the recovery source and P20 is configured as an output, the remaining SMR pins (P23–P21) form the NAND equation.

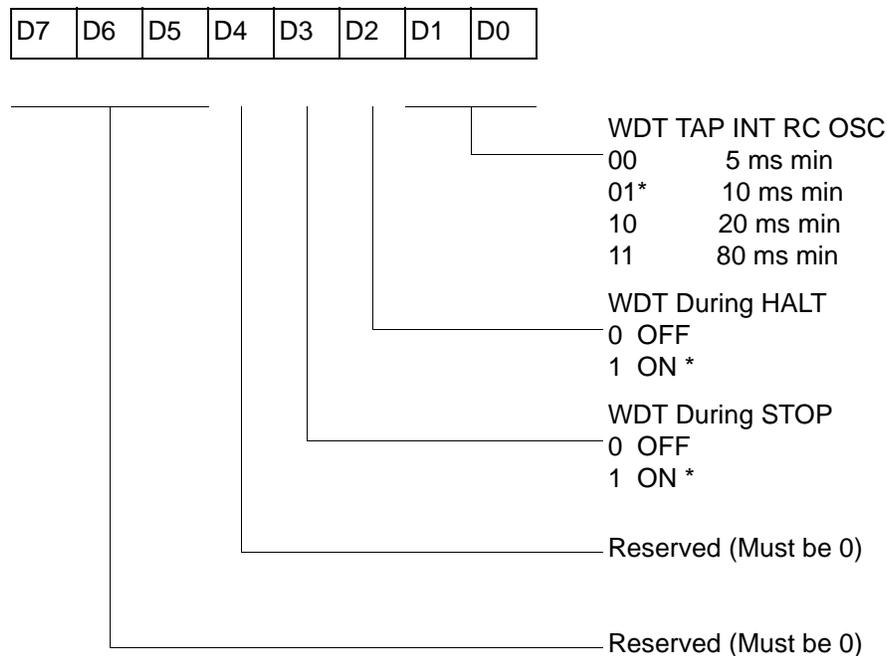


Watch-Dog Timer Mode Register (WDTMR)

The WDT is a retriggerable one-shot timer that resets the Z8 if it reaches its terminal count. The WDT must initially be enabled by executing the WDT instruction. On subsequent executions of the WDT instruction, the WDT is refreshed. The WDT circuit is driven by an on-board RC oscillator or external oscillator from the XTAL1 pin. The WDT instruction affects the Zero (Z), Sign (S), and Overflow (V) flags.

The POR clock source is selected with bit 4 of the WDT register. Bit 0 and 1 control a tap circuit that determines the minimum time-out period. Bit 2 determines whether the WDT is active during HALT, and Bit 3 determines WDT activity during STOP. Bits 5 through 7 are reserved (Figure 8). This register is accessible only during the first 61 processor cycles (122 XTAL clocks) from the execution of the first instruction after Power-On-Reset, Watch-Dog Reset, or a Stop-Mode Recovery (Figure 33). After this point, the register cannot be modified by any means (intentional or otherwise). The WDTMR cannot be read. The register is located in Bank F of the Expanded Register Group at address location 0Fh. It is organized as shown in Figure 33.

WDTMR (0F) 0F



* Default setting after reset

Figure 33. Watch-Dog Timer Mode Register (Write Only)



WDT Time Select (D0, D1)

Selects the WDT time period. It is configured as indicated in Table 17.

Table 17. WDT Time Select*

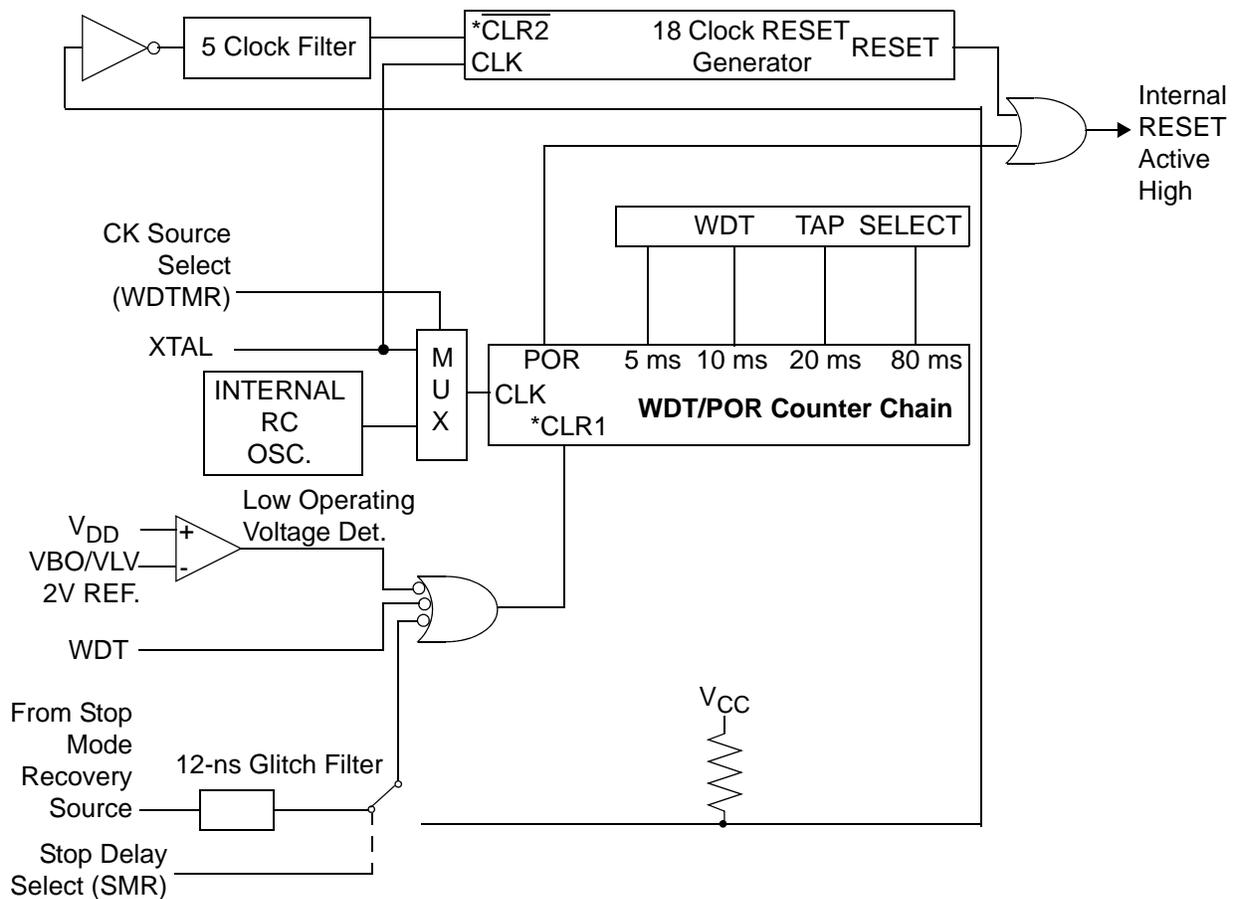
| D1 | D0 | Timeout of Internal RC OSC |
|----|----|----------------------------|
| 0 | 0 | 5 ms min |
| 0 | 1 | 10 ms min |
| 1 | 0 | 20 ms min |
| 1 | 1 | 80 ms min |

Note:

*TpC = XTAL clock cycle. The default on reset is 10 ms.

WDTMR During HALT (D2)

This bit determines whether or not the WDT is active during HALT Mode. A 1 indicates active during HALT. The default is 1. See Figure 34.



* $\overline{\text{CLR1}}$ and $\overline{\text{CLR2}}$ enable the WDT/POR and 18 Clock Reset timers upon a Low-to-High input translation.

Figure 34. Resets and WDT

WDTMR During STOP (D3)

This bit determines whether or not the WDT is active during STOP Mode. Because the XTAL clock is stopped during STOP Mode, the on-board RC has to be selected as the clock source to the WDT/POR counter. A 1 indicates active during STOP. The default is 1.

Clock Source for WDT (D4)

This bit determines which oscillator source is used to clock the internal POR and WDT counter chain. If the bit is a 1, the internal RC oscillator is bypassed and the POR and WDT clock source is driven from the external pin, XTAL1. The default configuration of this bit is 0, which selects the RC oscillator.



Mask Selectable Options

There are seven Mask Selectable Options to choose from based on ROM code requirements. These are listed in Table 18.

Table 18. Mask Selectable Options

| RC/Other | RC/XTAL |
|--|---------|
| 32 kHz XTAL | On/Off |
| Port 04-07 Pull-Ups | On/Off |
| Port 00-03 Pull-Ups | On/Off |
| Port 20-27 Pull-Ups | On/Off |
| Port 3 Pull-Ups | On/Off |
| Port0: 0-3 Mouse Mode 0.4 V _{DD} Trip | On/Off |

Brown-Out Voltage/Standby

An on-chip Voltage Comparator checks that the V_{CC} is at the required level for correct operation of the device. Reset is globally driven when V_{CC} falls below V_{BO}. A small further drop in V_{CC} causes the XTAL1 and XTAL2 circuitry to stop the crystal or resonator clock. Typical Low-Voltage power consumption in this Low Voltage Standby mode (I_{LV}) is about 20 μA. If the V_{CC} is allowed to stay above V_{ram}, the RAM content is preserved. When the power level is returned to above V_{BO}, the device performs a POR and functions normally.

Low-Voltage Detection and Flag

A Low-Voltage Detection circuit can be used optionally when the voltage decreases to V_{LVD}. Expanded Register Bank 0Dh register 0Ch bit 0 and 1 are used for this option.

Bit D0 is used to enable/disable this function.

Bit D1 is the status flag bit of the LVD.

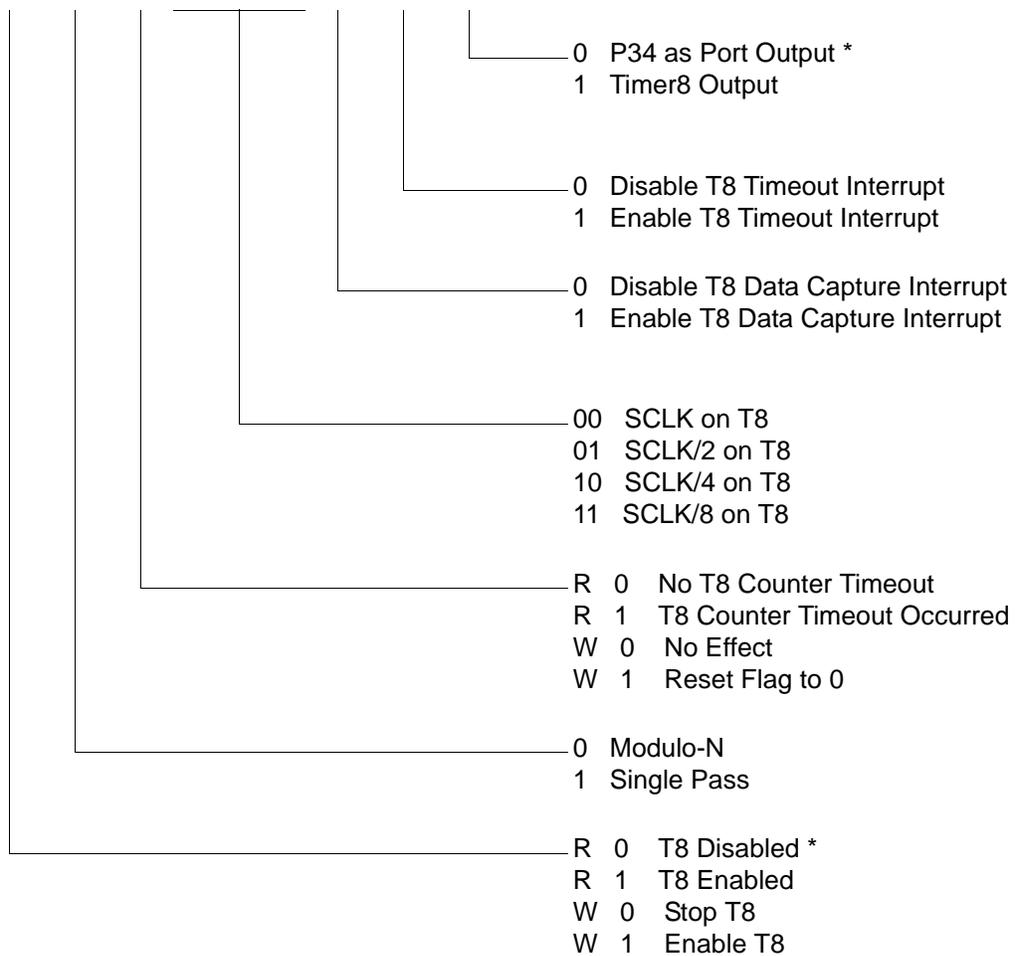


Expanded Register File Control Registers (0D)

The expanded register file control registers (0D) are shown in Figure 35 through Figure 38.

CTR0 (0D) 0H

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



* Default setting after reset

Figure 35. T8 Control Register ((0D) 0H: Read/Write Except Where Noted)



CTR1 (0D) 1H

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|

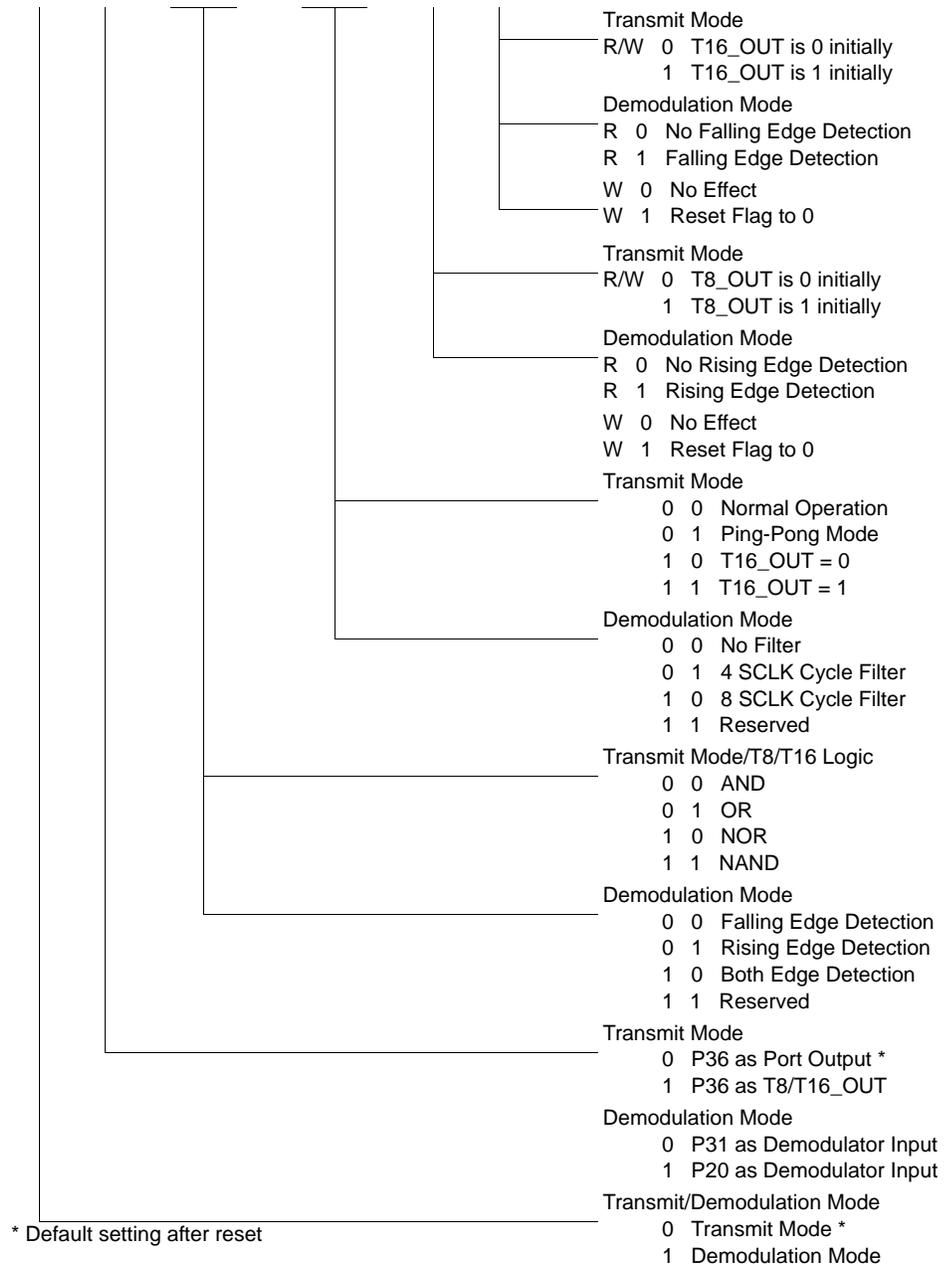


Figure 36. T8 and T16 Common Control Functions ((0D) 1h: Read/Write)



- ▶ **Notes:** Care must be taken in differentiating Transmit Mode from Demodulation Mode. Depending on which of these two modes is operating, the CTR1 bit has different functions.

Changing from one mode to another cannot be done without disabling the counter/timers.



CTR2 (0D) 02H

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|

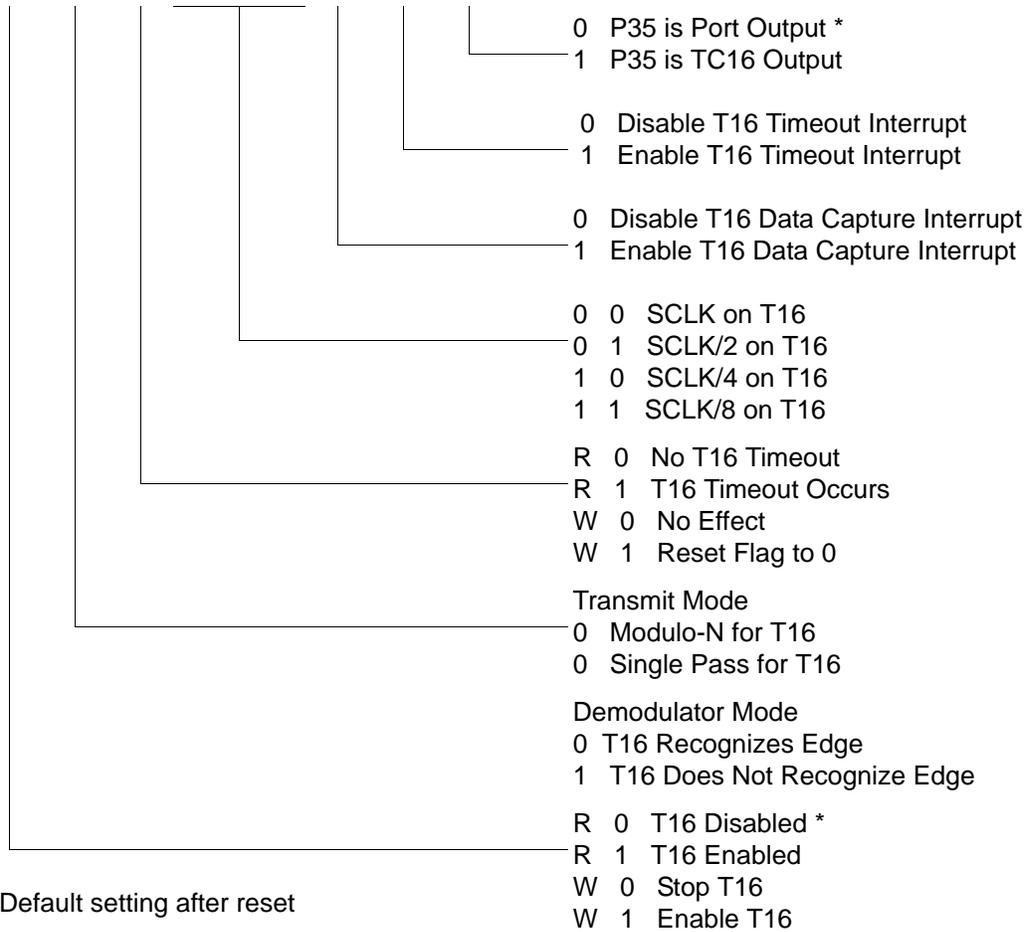
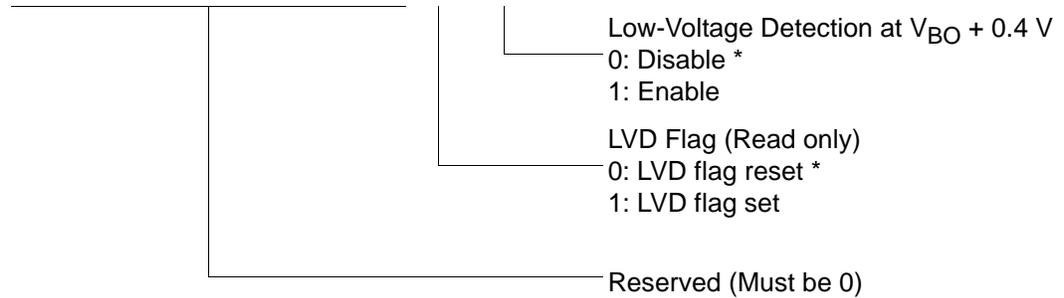


Figure 37. T16 Control Register ((0D) 2h: Read/Write Except Where Noted)



LVD (0D) 0CH

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



* Default

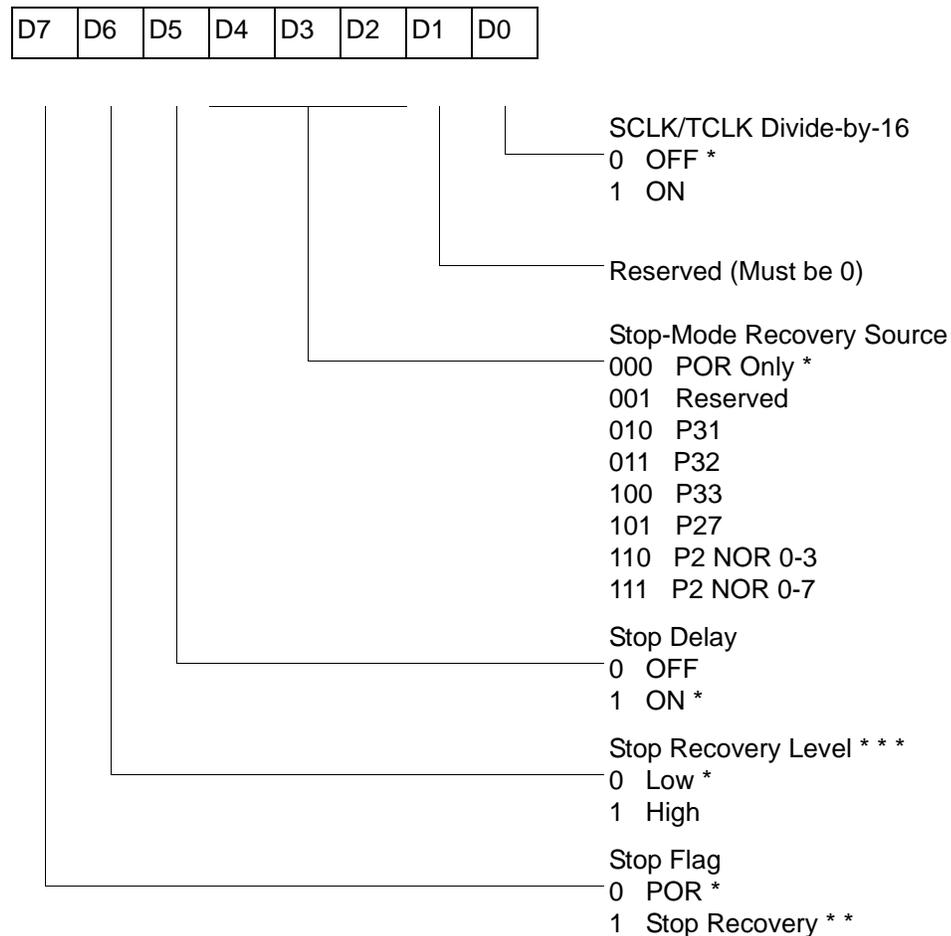
Figure 38. Low-Voltage Detection



Expanded Register File Control Registers (0F)

The expanded register file control registers (0F) are shown in Figure 39 through Figure 52.

SMR (0F) 0B



* Default setting after reset

** Default setting after reset and stop-mode recovery

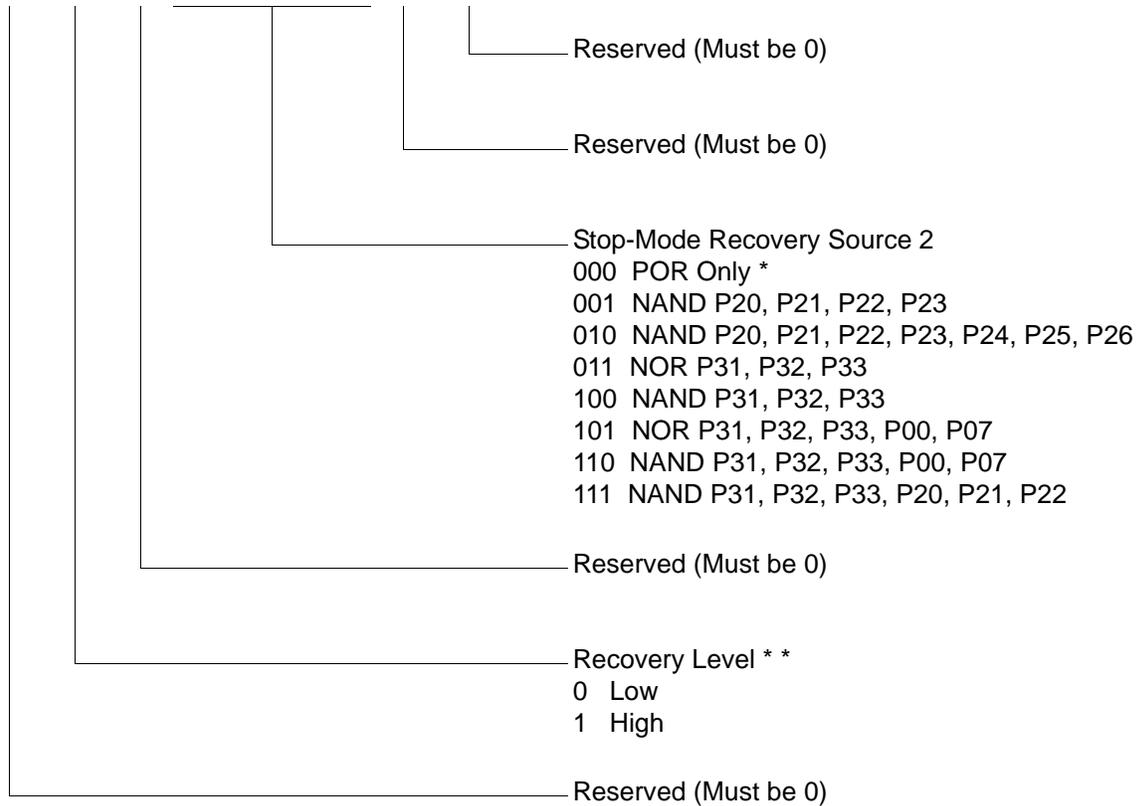
*** At the XOR gate input

Figure 39. Stop-Mode Recovery Register ((0F) 0Bh: D6–D0=Write Only, D7=Read Only)



SMR2 (0F) DH

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



Note: If used in conjunction with SMR, either of the two specified events causes a Stop-Mode Recovery.

* Default setting after reset

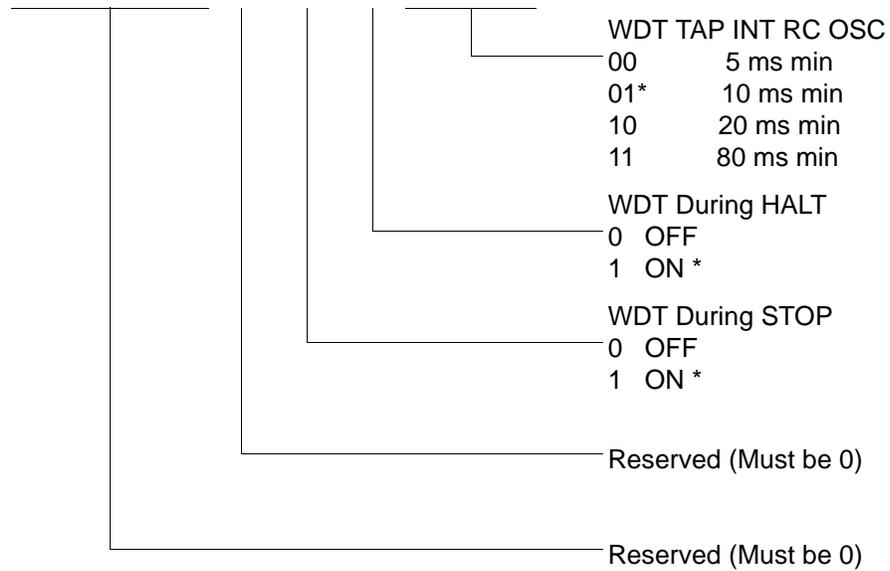
** At the XOR gate input

Figure 40. Stop-Mode Recovery Register 2 ((0F) 0Dh:D2–D4, D6 Write Only)



WDTMR (0F) 0F

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



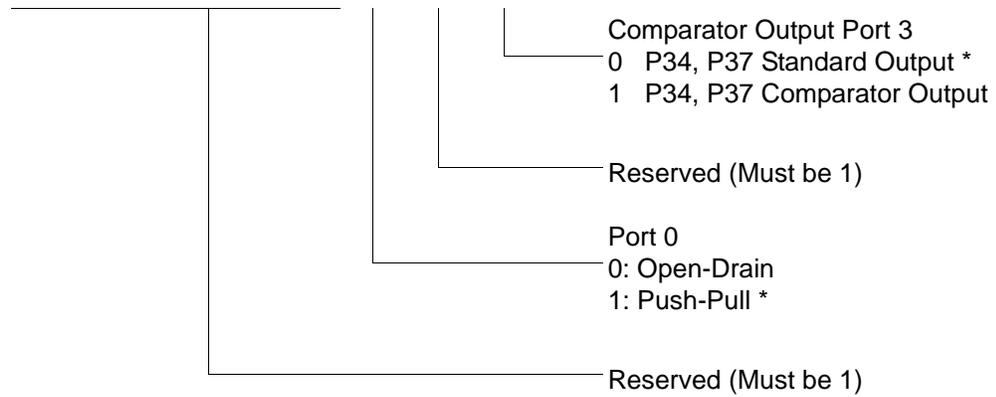
* Default setting after reset

Figure 41. Watch-Dog Timer Register ((0F) 0Fh: Write Only)



PCON (FH) 00H

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|

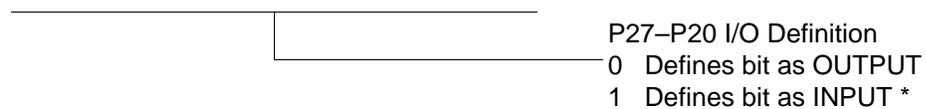


* Default setting after reset

Figure 42. Port Configuration Register (PCON) ((0F) 0h: Write Only)

R246 P2M

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



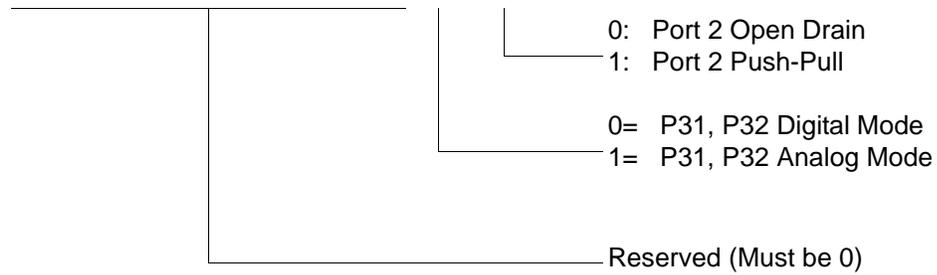
* Default setting after reset

Figure 43. Port 2 Mode Register (F6h: Write Only)



R247 P3M

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



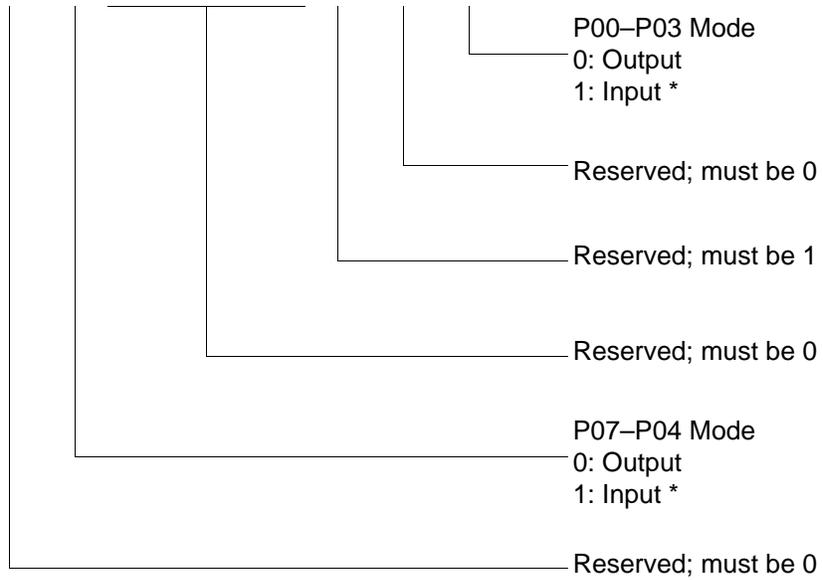
* Default setting after reset

Figure 44. Port 3 Mode Register (F7h: Write Only)



R248 P01M

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



* Default setting after reset

Figure 45. Port 0 and 1 Mode Register (F8h: Write Only)



R249 IPR

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|

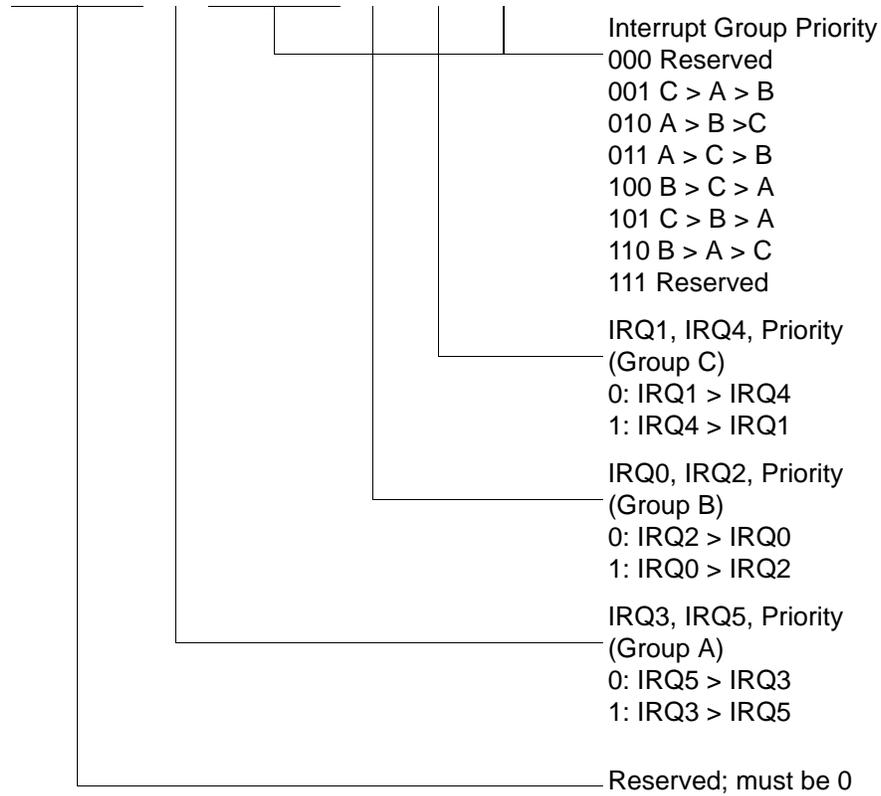


Figure 46. Interrupt Priority Register (F9h: Write Only)



R250 IRQ

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|

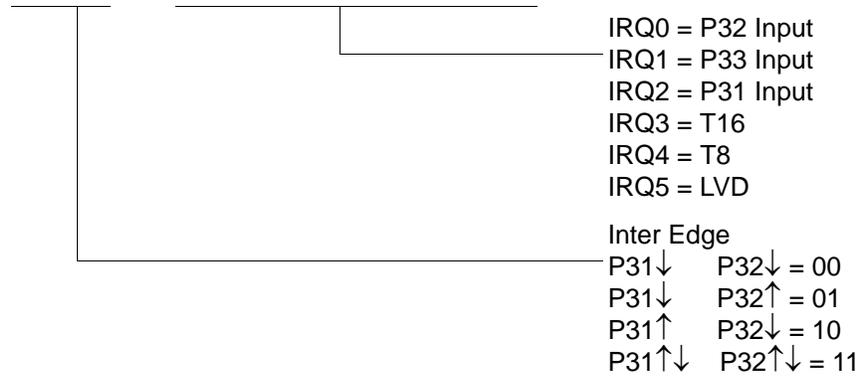
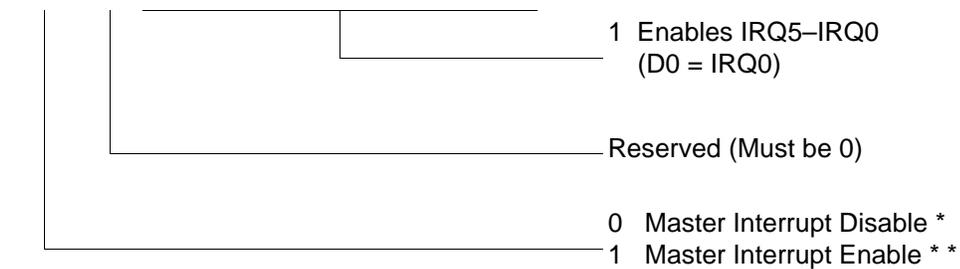


Figure 47. Interrupt Request Register (FAh: Read/Write)

R251 IMR

| | | | | | | | |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|



* Default setting after reset

** Only by using E1, D1 instruction; D1 is required before changing the IMR register

Figure 48. Interrupt Mask Register (FBh: Read/Write)



R252 Flags

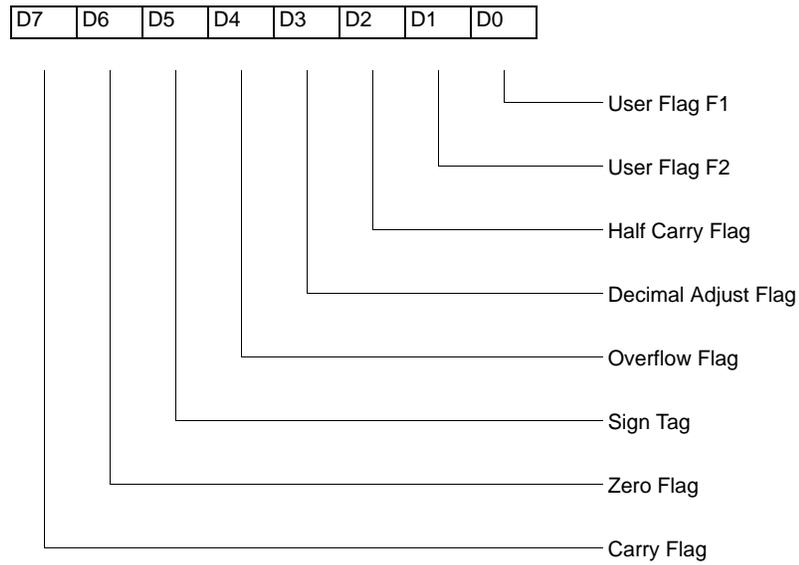
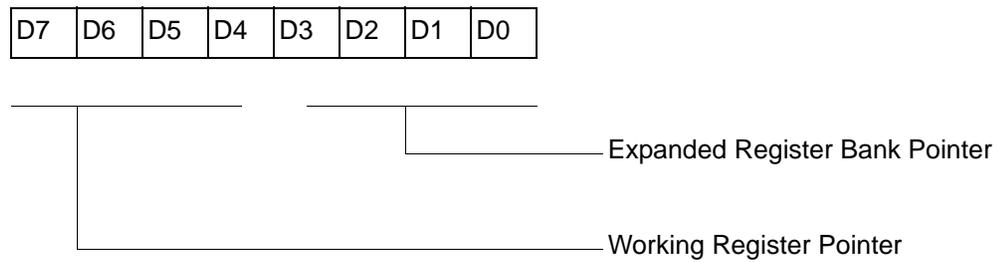


Figure 49. Flag Register (FCh: Read/Write)

R253 RP



Default setting after reset = 0000 0000

Figure 50. Register Pointer (FDh: Read/Write)



R254 SPH



Figure 51. Stack Pointer High (FEh: Read/Write)

R255 SPL

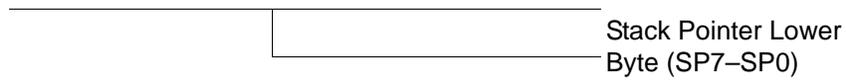
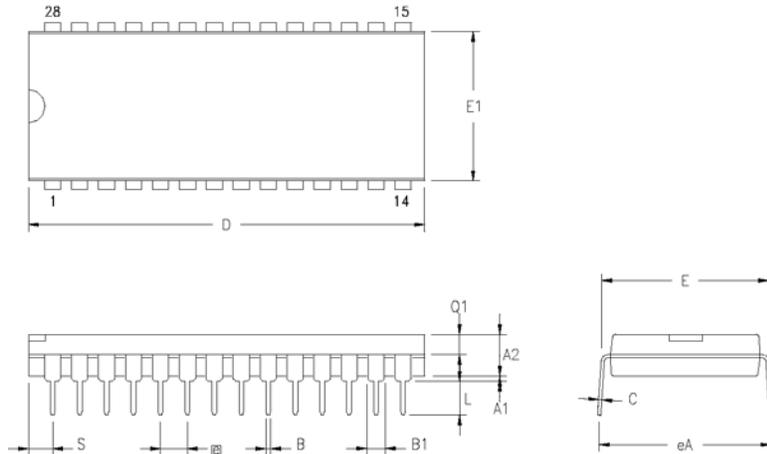


Figure 52. Stack Pointer Low (FFh: Read/Write)



Package Information

Package information is shown in Figure 53, Figure 54, and Figure 55.



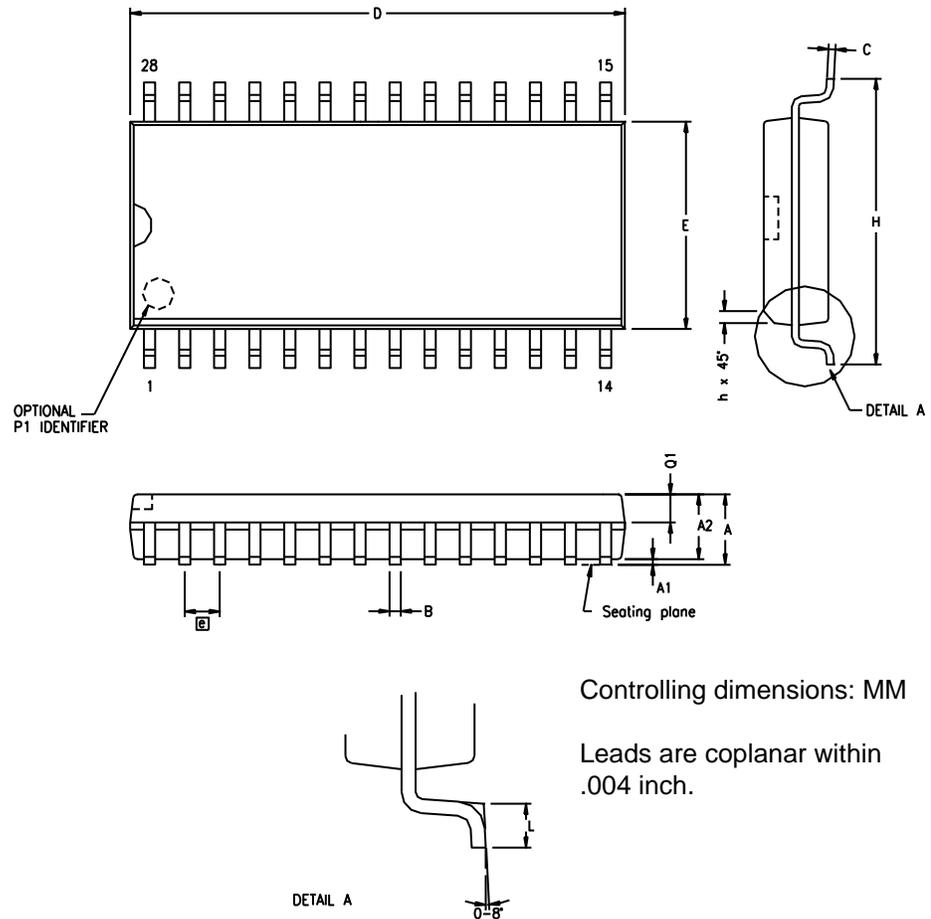
| SYMBOL | OPT # | MILLIMETER | | INCH | |
|--------|-------|------------|-------|----------|-------|
| | | MIN | MAX | MIN | MAX |
| A1 | | 0.38 | 1.02 | .015 | .040 |
| A2 | | 3.18 | 4.19 | .125 | .165 |
| B | | 0.38 | 0.53 | .015 | .021 |
| B1 | 01 | 1.40 | 1.65 | .055 | .065 |
| | 02 | 1.14 | 1.40 | .045 | .055 |
| C | | 0.23 | 0.38 | .009 | .015 |
| D | 01 | 36.58 | 37.34 | 1.440 | 1.470 |
| | 02 | 35.31 | 35.94 | 1.390 | 1.415 |
| E | | 15.24 | 15.75 | .600 | .620 |
| E1 | 01 | 13.59 | 14.10 | .535 | .555 |
| | 02 | 12.83 | 13.08 | .505 | .515 |
| e | | 2.54 TYP | | .100 TYP | |
| eA | | 15.49 | 16.76 | .610 | .660 |
| L | | 3.05 | 3.81 | .120 | .150 |
| Q1 | 01 | 1.40 | 1.91 | .055 | .075 |
| | 02 | 1.40 | 1.78 | .055 | .070 |
| S | 01 | 1.52 | 2.29 | .060 | .090 |
| | 02 | 1.02 | 1.52 | .040 | .060 |

CONTROLLING DIMENSIONS : INCH

| OPTION TABLE | |
|--------------|----------|
| OPTION # | PACKAGE |
| 01 | STANDARD |
| 02 | IDF |

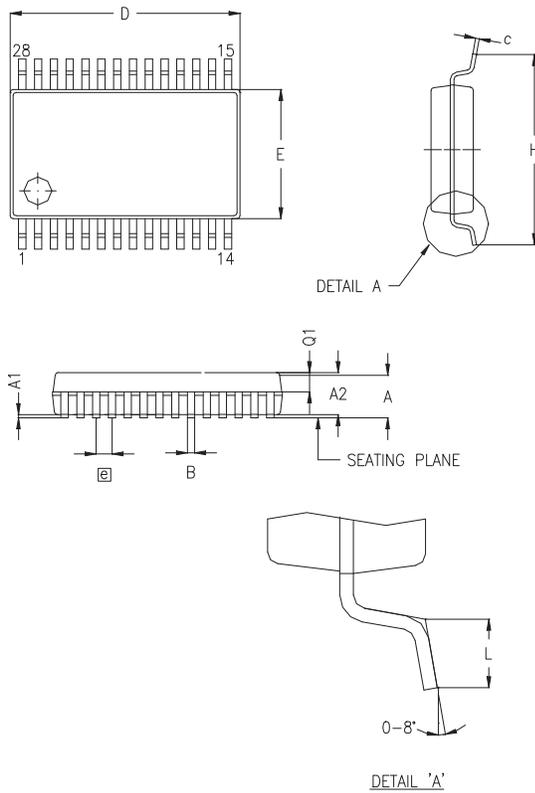
Figure 53. 28-Pin DIP Package Diagram

- **Note:** Please check with Maxim on the actual bonding diagram and coordinate for chip-on-board assembly.



| Symbol | Millimeter | | Inch | |
|---|------------|-------|----------|------|
| | Min | Max | Min | Max |
| A | 2.40 | 2.64 | .094 | .104 |
| A1 | 0.10 | 0.30 | .004 | .012 |
| A2 | 2.24 | 2.44 | .088 | .096 |
| B | 0.36 | 0.46 | .014 | .018 |
| C | 0.23 | 0.30 | .009 | .012 |
| D | 17.78 | 18.00 | .700 | .710 |
| E | 7.40 | 7.60 | .291 | .299 |
| e | 1.27 typ | | .050 typ | |
| H | 10.00 | 10.65 | 0.394 | .419 |
| h | 0.30 | 0.71 | .012 | .028 |
| L | 0.61 | 1.00 | .024 | .039 |
| Q1 | 0.97 | 1.07 | .038 | .042 |

Figure 54. 28-Pin SOIC Package Diagram



| SYMBOL | MILLIMETER | | | INCH | | |
|--------|------------|-------|-------|------------|-------|-------|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 1.73 | 1.86 | 1.99 | 0.068 | 0.073 | 0.078 |
| A1 | 0.05 | 0.13 | 0.21 | 0.002 | 0.005 | 0.008 |
| A2 | 1.68 | 1.73 | 1.78 | 0.066 | 0.068 | 0.070 |
| B | 0.25 | | 0.38 | 0.010 | | 0.015 |
| C | 0.09 | - | 0.20 | 0.004 | 0.006 | 0.008 |
| D | 10.07 | 10.20 | 10.33 | 0.397 | 0.402 | 0.407 |
| E | 5.20 | 5.30 | 5.38 | 0.205 | 0.209 | 0.212 |
| ⓐ | 0.65 TYP | | | 0.0256 TYP | | |
| H | 7.65 | 7.80 | 7.90 | 0.301 | 0.307 | 0.311 |
| L | 0.63 | 0.75 | 0.95 | 0.025 | 0.030 | 0.037 |

CONTROLLING DIMENSIONS : MM
LEADS ARE COPLANAR WITHIN .004 INCH.

Figure 55. 28-Pin SSOP Package Diagram



Ordering Information

| Z86L81/86/98—8.0 MHz | | | |
|----------------------|-----------------------|-------------|-------------|
| 28-Pin DIP | Z86L8108PSC | Z86L8608PSC | Z86L9808PSC |
| 28-Pin SOIC | Z86L8108SSC | Z86L8608SSC | Z86L9808SSC |
| 28-Pin SSOP | Z86L8108HSC | Z86L8608HSC | Z86L9808HSC |
| Die Form | Please contact Maxim. | | |

For fast results, contact your local Maxim sales office for assistance in ordering the part required.

| Codes | |
|----------------------|---|
| Package | P = Plastic DIP S = SOIC (Small Outline Integrated Circuit) H = SSOP (Shrink Small Outline Package) |
| Temperature | S = 0 °C to +70 °C |
| Speed | 8 = 8.0 MHz |
| Environmental | C = Plastic Standard G = Lead Free |

Example

Z 86L98 08 P S C is a Z86L98, 8 MHz, DIP, 0 °C to 70 °C, Plastic Standard Flow

