



**Z8 GP™ Microcontrollers**

## **ZGP323L OTP MCU Family**

**Preliminary Product Specification**

PS023702-1004

This publication is subject to replacement by a later edition. To determine whether a later edition exists, or to request copies of publications, contact:

### **ZiLOG Worldwide Headquarters**

532 Race Street  
San Jose, CA 95126-3432  
Telephone: 408.558.8500  
Fax: 408.558.8300  
[www.zilog.com](http://www.zilog.com)

ZiLOG is a registered trademark of ZiLOG Inc. in the United States and in other countries. All other products and/or service names mentioned herein may be trademarks of the companies with which they are associated.

### **Document Disclaimer**

©2004 by ZiLOG, Inc. All rights reserved. Information in this publication concerning the devices, applications, or technology described is intended to suggest possible uses and may be superseded. ZiLOG, INC. DOES NOT ASSUME LIABILITY FOR OR PROVIDE A REPRESENTATION OF ACCURACY OF THE INFORMATION, DEVICES, OR TECHNOLOGY DESCRIBED IN THIS DOCUMENT. ZiLOG ALSO DOES NOT ASSUME LIABILITY FOR INTELLECTUAL PROPERTY INFRINGEMENT RELATED IN ANY MANNER TO USE OF INFORMATION, DEVICES, OR TECHNOLOGY DESCRIBED HEREIN OR OTHERWISE. Devices sold by ZiLOG, Inc. are covered by warranty and limitation of liability provisions appearing in the ZiLOG, Inc. Terms and Conditions of Sale. ZiLOG, Inc. makes no warranty of merchantability or fitness for any purpose. Except with the express written approval of ZiLOG, use of information, devices, or technology as critical components of life support systems is not authorized. No licenses are conveyed, implicitly or otherwise, by this document under any intellectual property rights.

# Table of Contents

Development Features .....	1
General Description .....	2
Pin Description .....	4
Absolute Maximum Ratings .....	10
Standard Test Conditions .....	10
DC Characteristics .....	11
AC Characteristics .....	14
Pin Functions .....	16
XTAL1 Crystal 1 (Time-Based Input) .....	16
XTAL2 Crystal 2 (Time-Based Output) .....	16
Port 0 (P07–P00) .....	16
Port 1 (P17–P10) .....	17
Port 2 (P27–P20) .....	18
Port 3 (P37–P30) .....	19
RESET (Input, Active Low) .....	23
Functional Description .....	23
Program Memory .....	23
RAM .....	23
Expanded Register File .....	24
Register File .....	28
Stack .....	29
Timers .....	30
Counter/Timer Functional Blocks .....	38
Expanded Register File Control Registers (0D) .....	64
Expanded Register File Control Registers (0F) .....	69
Standard Control Registers .....	73
Package Information .....	80
Ordering Information .....	89
Precharacterization Product .....	95

## List of Figures

Figure 1. Functional Block Diagram .....	3
Figure 2. Counter/Timers Diagram .....	4
Figure 3. 20-Pin PDIP/SOIC/SSOP/CDIP* Pin Configuration .....	5
Figure 4. 28-Pin PDIP/SOIC/SSOP/CDIP* Pin Configuration .....	6
Figure 5. 40-Pin PDIP/CDIP* Pin Configuration .....	7
Figure 6. 48-Pin SSOP Pin Configuration .....	8
Figure 7. Test Load Diagram .....	10
Figure 8. AC Timing Diagram .....	14
Figure 9. Port 0 Configuration .....	17
Figure 10. Port 1 Configuration .....	18
Figure 11. Port 2 Configuration .....	19
Figure 12. Port 3 Configuration .....	20
Figure 13. Port 3 Counter/Timer Output Configuration .....	22
Figure 14. Program Memory Map (32K OTP) .....	24
Figure 15. Expanded Register File Architecture .....	26
Figure 16. Register Pointer .....	27
Figure 17. Register Pointer—Detail .....	29
Figure 18. Glitch Filter Circuitry .....	38
Figure 19. Transmit Mode Flowchart .....	39
Figure 20. 8-Bit Counter/Timer Circuits .....	40
Figure 21. T8_OUT in Single-Pass Mode .....	41
Figure 22. T8_OUT in Modulo-N Mode .....	41
Figure 23. Demodulation Mode Count Capture Flowchart .....	42
Figure 24. Demodulation Mode Flowchart .....	43
Figure 25. 16-Bit Counter/Timer Circuits .....	44
Figure 26. T16_OUT in Single-Pass Mode .....	45
Figure 27. T16_OUT in Modulo-N Mode .....	45
Figure 28. Ping-Pong Mode Diagram .....	47
Figure 29. Output Circuit .....	47
Figure 30. Interrupt Block Diagram .....	49
Figure 31. Oscillator Configuration .....	51
Figure 32. Port Configuration Register (PCON) (Write Only) .....	53
Figure 33. STOP Mode Recovery Register .....	55
Figure 34. SCLK Circuit .....	56

Figure 35. Stop Mode Recovery Source . . . . .	57
Figure 36. Stop Mode Recovery Register 2 ((0F)DH:D2–D4, D6 Write Only) . . . . .	59
Figure 37. Watch-Dog Timer Mode Register (Write Only) . . . . .	60
Figure 38. Resets and WDT . . . . .	61
Figure 39. TC8 Control Register ((0D)00H: Read/Write Except Where Noted) . . . . .	64
Figure 40. T8 and T16 Common Control Functions ((0D)01H: Read/Write) . . . . .	65
Figure 41. T16 Control Register ((0D) 2H: Read/Write Except Where Noted) . . . . .	67
Figure 42. T8/T16 Control Register (0D)03H: Read/Write (Except Where Noted) . . . . .	68
Figure 43. Voltage Detection Register . . . . .	69
Figure 44. Port Configuration Register (PCON)(0F)00H: Write Only) . . . . .	70
Figure 45. Stop Mode Recovery Register ((0F)0BH: D6–D0=Write Only, D7=Read Only) . . . . .	71
Figure 46. Stop Mode Recovery Register 2 ((0F)0DH:D2–D4, D6 Write Only) . . . . .	72
Figure 47. Watch-Dog Timer Register ((0F) 0FH: Write Only) . . . . .	73
Figure 48. Port 2 Mode Register (F6H: Write Only) . . . . .	73
Figure 49. Port 3 Mode Register (F7H: Write Only) . . . . .	74
Figure 50. Port 0 and 1 Mode Register (F8H: Write Only) . . . . .	75
Figure 51. Interrupt Priority Register (F9H: Write Only) . . . . .	76
Figure 52. Interrupt Request Register (FAH: Read/Write) . . . . .	77
Figure 53. Interrupt Mask Register (FBH: Read/Write) . . . . .	77
Figure 54. Flag Register (FCH: Read/Write) . . . . .	78
Figure 55. Register Pointer (FDH: Read/Write) . . . . .	78
Figure 56. Stack Pointer High (FEH: Read/Write) . . . . .	79
Figure 57. Stack Pointer Low (FFH: Read/Write) . . . . .	79
Figure 58. 20-Pin CDIP Package . . . . .	80
Figure 59. 20-Pin PDIP Package Diagram . . . . .	81
Figure 60. 20-Pin SOIC Package Diagram . . . . .	81
Figure 61. 20-Pin SSOP Package Diagram . . . . .	82
Figure 62. 28-Pin CDIP Package . . . . .	83
Figure 63. 28-Pin SOIC Package Diagram . . . . .	84
Figure 64. 28-Pin PDIP Package Diagram . . . . .	85
Figure 65. 28-Pin SSOP Package Diagram . . . . .	86
Figure 66. 40-Pin CDIP Package . . . . .	87
Figure 67. 40-Pin PDIP Package Diagram . . . . .	87
Figure 68. 48-Pin SSOP Package Design . . . . .	88

## List of Tables

Table 1.	Features	1
Table 2.	Power Connections	3
Table 3.	20-Pin PDIP/SOIC/SSOP/CDIP* Pin Identification.	5
Table 4.	28-Pin PDIP/SOIC/SSOP/CDIP* Pin Identification.	6
Table 5.	40- and 48-Pin Configuration	8
Table 6.	Absolute Maximum Ratings	10
Table 7.	Capacitance	11
Table 8.	DC Characteristics	11
Table 9.	EPROM/OTP Characteristics	13
Table 10.	AC Characteristics	15
Table 11.	Port 3 Pin Function Summary	21
Table 12.	CTR0(D)00H Counter/Timer8 Control Register	31
Table 13.	CTR1(0D)01H T8 and T16 Common Functions.	33
Table 14.	CTR2(D)02H: Counter/Timer16 Control Register.	36
Table 15.	CTR3 (D)03H: T8/T16 Control Register	37
Table 16.	Interrupt Types, Sources, and Vectors.	50
Table 17.	IRQ Register	50
Table 18.	SMR2(F)0DH:Stop Mode Recovery Register 2*	56
Table 19.	Stop Mode Recovery Source	58
Table 20.	Watch-Dog Timer Time Select	61
Table 21.	EPROM Selectable Options	62

## Development Features

Table 1 lists the features of ZiLOG®'s Z8 GP™ OTP MCU Family family members.

**Table 1. Features**

Device	OTP (KB)	RAM (Bytes)	I/O Lines	Voltage Range
ZGP323L OTP MCU Family	4, 8, 16, 32	237	32, 24 or 16	2.0V–3.6V

- Low power consumption—6mW (typical)
- T = Temperature  
S = Standard 0° to +70°C  
E = Extended -40° to +105°C  
A = Automotive -40° to +125°C
- Three standby modes:
  - STOP—2µA (typical)
  - HALT—0.8mA (typical)
  - Low voltage reset
- 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 and high voltage detection flags
- Programmable Watch-Dog Timer/Power-On Reset (WDT/POR) circuits
- Two independent comparators with programmable interrupt polarity
- Programmable EPROM options
  - Port 0: 0–3 pull-up transistors
  - Port 0: 4–7 pull-up transistors

- Port 1: 0–3 pull-up transistors
- Port 1: 4–7 pull-up transistors
- Port 2: 0–7 pull-up transistors
- EPROM Protection
- WDT enabled at POR

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

## General Description

The Z8 GP™ OTP MCU Family is an OTP-based member of the MCU family of infrared microcontrollers. With 237B of general-purpose RAM and up to 32KB of OTP, ZiLOG®'s 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 Z8 GP™ OTP MCU Family architecture (Figure 1) is based on ZiLOG's 8-bit microcontroller core with an Expanded Register File allowing 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 (B) of RAM. It includes 4 I/O port registers, 16 control and status registers, and 236 general-purpose registers. 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 Z8 GP OTP MCU offers a new intelligent counter/timer architecture with 8-bit and 16-bit counter/timers (see Figure 2). Also included are a large number of user-selectable modes and two on-board comparators to process analog signals with separate reference voltages.

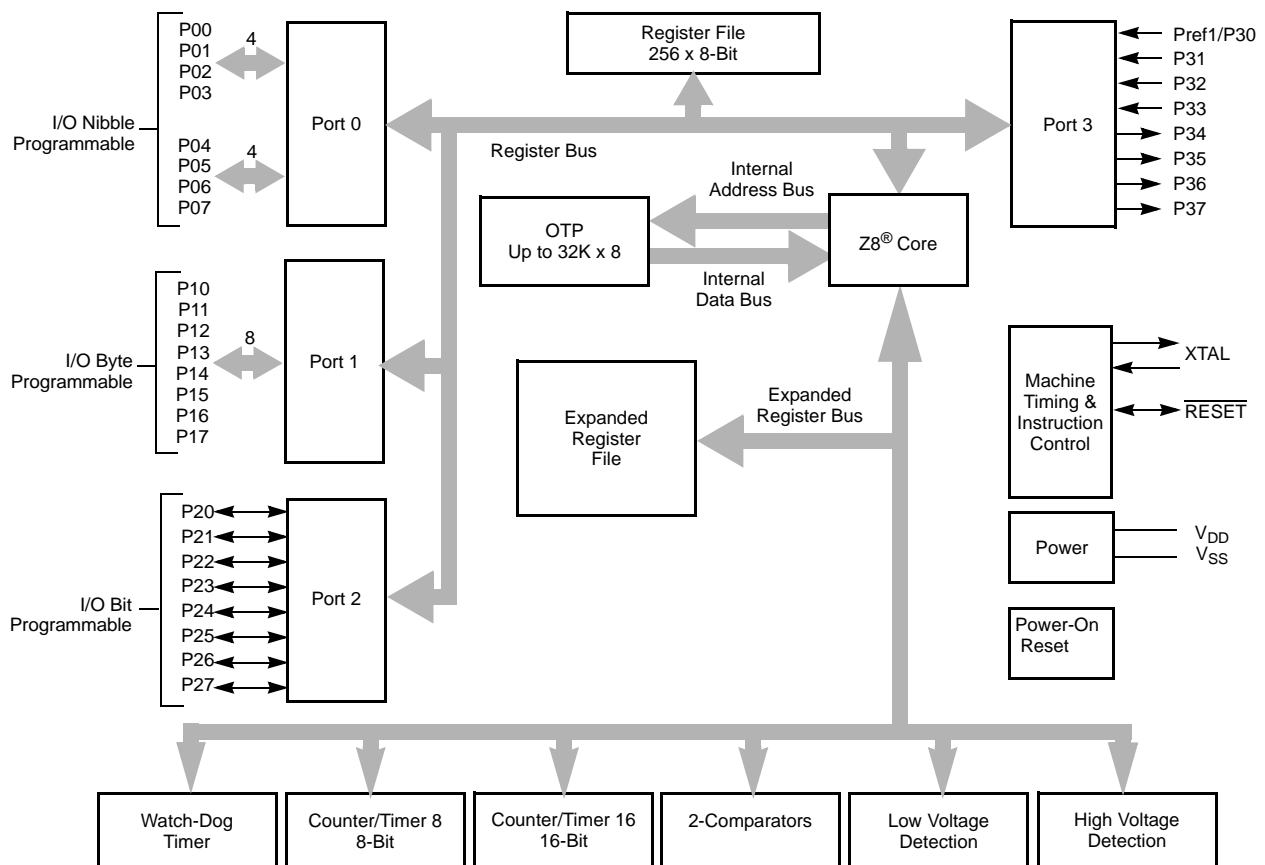
► **Note:** All signals with an overline, " $\overline{\quad}$ ", are active Low. For example,  $\overline{B/W}$ , in which WORD is active Low, and  $\overline{B/W}$ , in which BYTE is active Low.

Power connections use the conventional descriptions listed in Table 2.



**Table 2. Power Connections**

Connection	Circuit	Device
Power	V <sub>CC</sub>	V <sub>DD</sub>
Ground	GND	V <sub>SS</sub>



Note: Refer to the specific package for available pins.

**Figure 1. Functional Block Diagram**

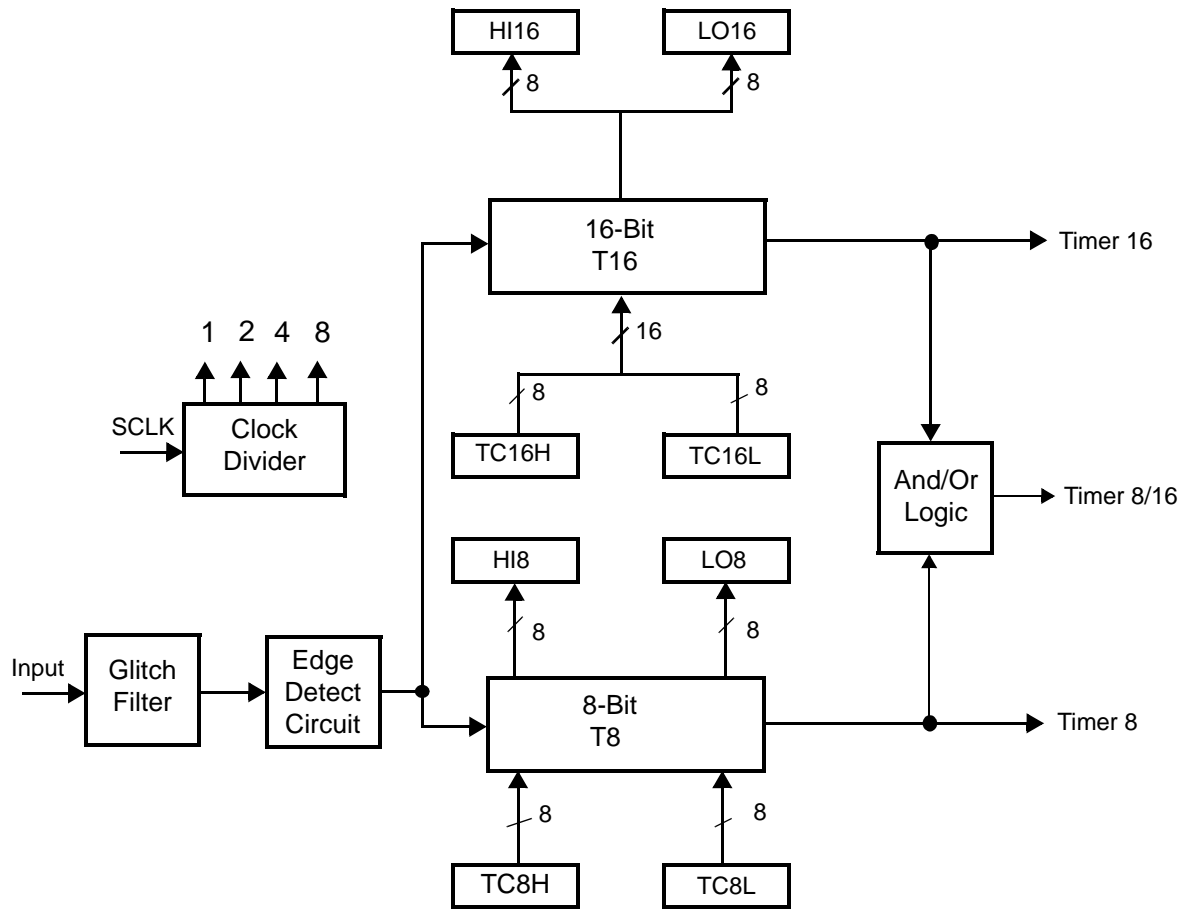


Figure 2. Counter/Timers Diagram

## Pin Description

The pin configuration for the 20-pin PDIP/SOIC/SSOP is illustrated in Figure 3 and described in Table 3. The pin configuration for the 28-pin PDIP/SOIC/SSOP are depicted in Figure 4 and described in Table 4. The pin configurations for the 40-pin PDIP and 48-pin SSOP versions are illustrated in Figure 5, Figure 6, and described in Table 5.

For customer engineering code development, a UV erasable windowed cerdip packaging is offered in 20-pin, 28-pin, and 40-pin configurations. ZiLOG does not recommend nor guarantee these packages for use in production.

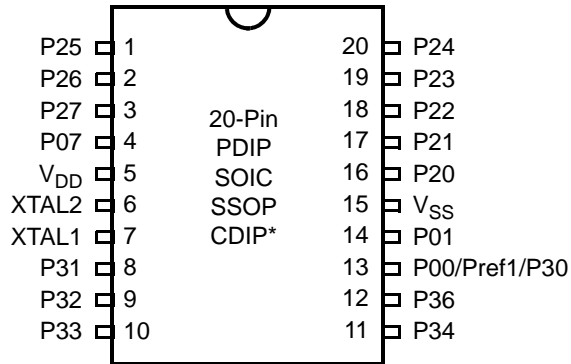


Figure 3. 20-Pin PDIP/SOIC/SSOP/CDIP\* Pin Configuration

Table 3. 20-Pin PDIP/SOIC/SSOP/CDIP\* Pin Identification

Pin #	Symbol	Function	Direction
1–3	P25–P27	Port 2, Bits 5,6,7	Input/Output
4	P07	Port 0, Bit 7	Input/Output
5	V <sub>DD</sub>	Power Supply	
6	XTAL2	Crystal Oscillator Clock	Output
7	XTAL1	Crystal Oscillator Clock	Input
8–10	P31–P33	Port 3, Bits 1,2,3	Input
11,12	P34, P36	Port 3, Bits 4,6	Output
13	P00/Pref1/P30	Port 0, Bit 0/Analog reference input Port 3 Bit 0	Input/Output for P00 Input for Pref1/P30
14	P01	Port 0, Bit 1	Input/Output
15	V <sub>SS</sub>	Ground	
16–20	P20–P24	Port 2, Bits 0,1,2,3,4	Input/Output

► **Note:** \*Windowed Cerdip. These units are intended to be used for engineering code development only. ZiLOG does not recommend/guarantee this package for production use.

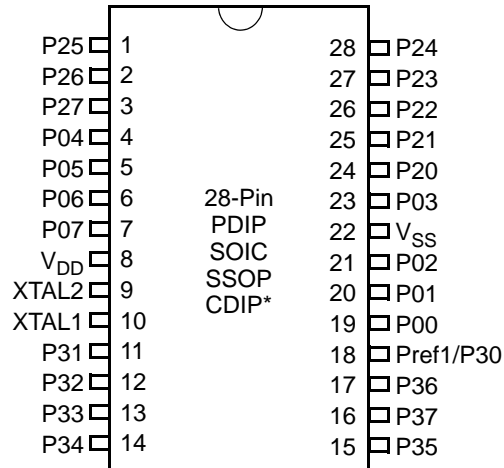


Figure 4. 28-Pin PDIP/SOIC/SSOP/CDIP\* Pin Configuration

Table 4. 28-Pin PDIP/SOIC/SSOP/CDIP\* Pin Identification

Pin	Symbol	Direction	Description
1-3	P25-P27	Input/Output	Port 2, Bits 5,6,7
4-7	P04-P07	Input/Output	Port 0, Bits 4,5,6,7
8	V <sub>DD</sub>		Power supply
9	XTAL2	Output	Crystal, oscillator clock
10	XTAL1	Input	Crystal, oscillator clock
11-13	P31-P33	Input	Port 3, Bits 1,2,3
14	P34	Output	Port 3, Bit 4
15	P35	Output	Port 3, Bit 5
16	P37	Output	Port 3, Bit 7
17	P36	Output	Port 3, Bit 6
18	Pref1/P30 Port 3 Bit 0	Input	Analog ref input; connect to V <sub>CC</sub> if not used Input for Pref1/P30
19-21	P00-P02	Input/Output	Port 0, Bits 0,1,2
22	V <sub>SS</sub>		Ground
23	P03	Input/Output	Port 0, Bit 3
24-28	P20-P24	Input/Output	Port 2, Bits 0-4

► **Note:** \*Windowed Cerdip. These units are intended to be used for engineering code development only. ZiLOG does not recommend/guarantee this package for production use.

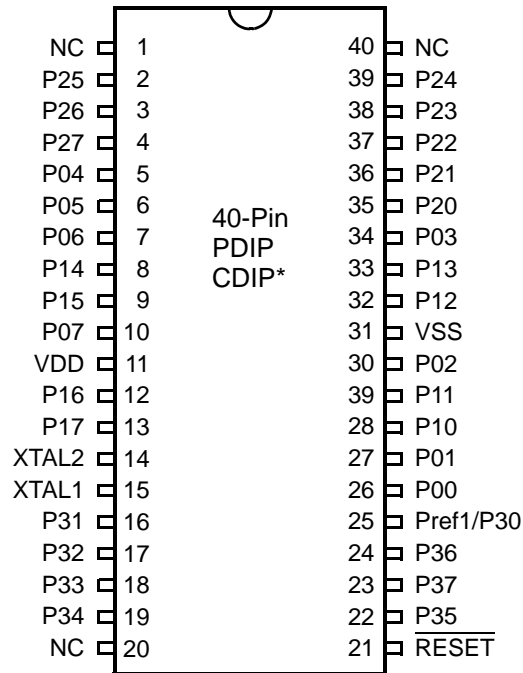


Figure 5. 40-Pin PDIP/CDIP\* Pin Configuration

► **Note:** \*Windowed Cerdip. These units are intended to be used for engineering code development only. ZiLOG does not recommend/guarantee this package for production use.

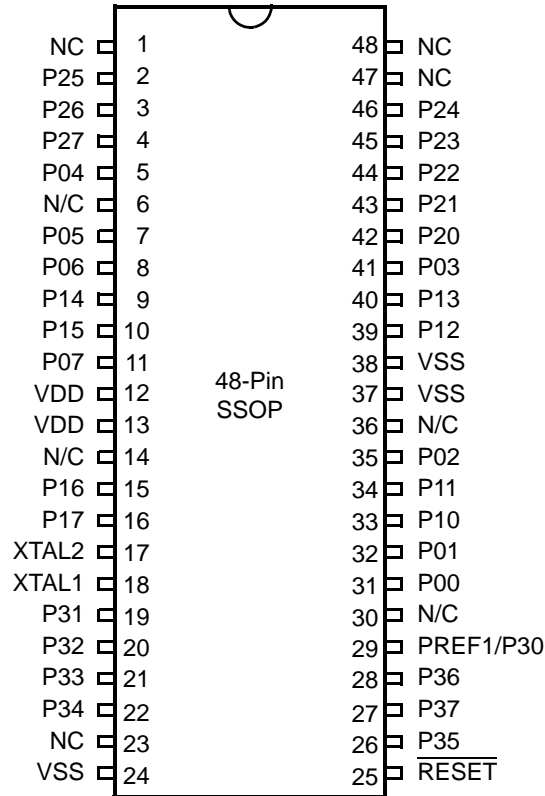


Figure 6. 48-Pin SSOP Pin Configuration

Table 5. 40- and 48-Pin Configuration

40-Pin PDIP/CDIP* #	48-Pin SSOP #	Symbol
26	31	P00
27	32	P01
30	35	P02
34	41	P03
5	5	P04
6	7	P05
7	8	P06
10	11	P07
28	33	P10
29	34	P11
32	39	P12

**Table 5. 40- and 48-Pin Configuration (Continued)**

40-Pin PDIP/CDIP* #	48-Pin SSOP #	Symbol
33	40	P13
8	9	P14
9	10	P15
12	15	P16
13	16	P17
35	42	P20
36	43	P21
37	44	P22
38	45	P23
39	46	P24
2	2	P25
3	3	P26
4	4	P27
16	19	P31
17	20	P32
18	21	P33
19	22	P34
22	26	P35
24	28	P36
23	27	P37
20	23	NC
40	47	NC
1	1	NC
21	25	RESET
15	18	XTAL1
14	17	XTAL2
11	12, 13	V <sub>DD</sub>
31	24, 37, 38	V <sub>SS</sub>
25	29	Pref1/P30
	48	NC

## Absolute Maximum Ratings

Stresses greater than those listed in Table 7 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.

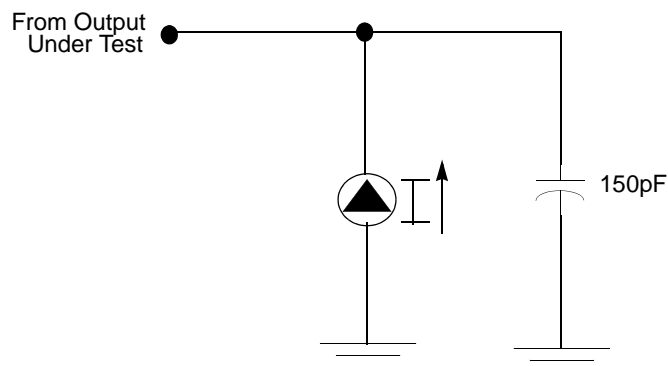
**Table 6. Absolute Maximum Ratings**

Parameter	Minimum	Maximum	Units	Notes
Ambient temperature under bias	0	+70	C	
Storage temperature	-65	+150	C	
Voltage on any pin with respect to $V_{SS}$	-0.3	+5.5	V	1
Voltage on $V_{DD}$ pin with respect to $V_{SS}$	-0.3	+3.6	V	
Maximum current on input and/or inactive output pin	-5	+5	$\mu$ A	
Maximum output current from active output pin	-25	+25	mA	
Maximum current into $V_{DD}$ or out of $V_{SS}$		75	mA	

Notes:  
This voltage applies to all pins except the following:  $V_{DD}$ , P32, P33 and  $\overline{\text{RESET}}$ .

## 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 7).



**Figure 7. Test Load Diagram**



## Capacitance

Table 7 lists the capacitances.

**Table 7. Capacitance**

Parameter	Maximum
Input capacitance	12pF
Output capacitance	12pF
I/O capacitance	12pF

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

## DC Characteristics

**Table 8. DC Characteristics**

Symbol	Parameter	$V_{CC}$	$T_A = 0^\circ\text{C to } +70^\circ\text{C}$			Units	Conditions	Notes
			Min	Typ	Max			
$V_{CC}$	Supply Voltage		2.0		3.6	V	See Note 5	5
$V_{CH}$	Clock Input High Voltage	2.0-3.6	0.8		$V_{CC}+0.3$	V	Driven by External Clock Generator	
$V_{CL}$	Clock Input Low Voltage	2.0-3.6	$V_{SS}-0.3$		0.5	V	Driven by External Clock Generator	
$V_{IH}$	Input High Voltage	2.0-3.6	$0.7 V_{CC}$		$V_{CC}+0.3$	V		
$V_{IL}$	Input Low Voltage	2.0-3.6	$V_{SS}-0.3$		$0.2 V_{CC}$	V		
$V_{OH1}$	Output High Voltage	2.0-3.6	$V_{CC}-0.4$			V	$I_{OH} = -0.5\text{mA}$	
$V_{OH2}$	Output High Voltage (P36, P37, P00, P01)	2.0-3.6	$V_{CC}-0.8$			V	$I_{OH} = -7\text{mA}$	
$V_{OL1}$	Output Low Voltage	2.0-3.6			0.4	V	$I_{OL} = 1.0\text{mA}$ $I_{OL} = 4.0\text{mA}$	
$V_{OL2}$	Output Low Voltage (P00, P01, P36, P37)	2.0-3.6			0.8	V	$I_{OL} = 10\text{mA}$	
$V_{OFFSET}$	Comparator Input Offset Voltage	2.0-3.6			25	mV		
$V_{REF}$	Comparator Reference Voltage	2.0-3.6	0		$V_{DD}$ -1.75	V		
$I_{IL}$	Input Leakage	2.0-3.6	-1		1	$\mu\text{A}$	$V_{IN} = 0\text{V}$ , $V_{CC}$ Pull-ups disabled	
$I_{OL}$	Output Leakage	2.0-3.6	-1		1	$\mu\text{A}$	$V_{IN} = 0\text{V}$ , $V_{CC}$	
$I_{CC}$	Supply Current	2.0			10	mA	at 8.0 MHz	1, 2
		3.6			15	mA	at 8.0 MHz	1, 2

Table 8. DC Characteristics (Continued)

Symbol	Parameter	V <sub>CC</sub>	T <sub>A</sub> = 0°C to +70°C		Units	Conditions	Notes
			Min	Typ Max			
I <sub>CC1</sub>	Standby Current (HALT Mode)	2.0		3	mA	V <sub>IN</sub> = 0V, V <sub>CC</sub> at 8.0MHz	1, 2
		3.6		5		Same as above	1, 2
		2.0		2		Clock Divide-by-16 at 8.0MHz	1, 2
		3.6		4		Same as above	1, 2
I <sub>CC2</sub>	Standby Current (Stop Mode)	2.0		8	μA	V <sub>IN</sub> = 0 V, V <sub>CC</sub> WDT is not Running	3
		3.6		10		Same as above	3
		2.0		500		V <sub>IN</sub> = 0 V, V <sub>CC</sub> WDT is Running	3
		3.6		800		Same as above	3
I <sub>LV</sub>	Standby Current (Low Voltage)			10	μA	Measured at 1.3V	4
V <sub>BO</sub>	V <sub>CC</sub> Low Voltage Protection			2.0	V	8MHz maximum Ext. CLK Freq.	
V <sub>LVD</sub>	V <sub>CC</sub> Low Voltage Detection			2.4	V		
V <sub>HVD</sub>	V <sub>CC</sub> High Voltage Detection			2.7	V		

**Notes:**

1. All outputs unloaded, inputs at rail.
2. CL1 = CL2 = 100 pF.
3. Oscillator stopped.
4. Oscillator stops when V<sub>CC</sub> falls below V<sub>BO</sub> limit.
5. It is strongly recommended to add a filter capacitor (minimum 0.1 μF), physically close to the V<sub>DD</sub> and V<sub>SS</sub> pins if operating voltage fluctuations are anticipated, such as those resulting from driving an Infrared LED.

**Table 9. EPROM/OTP Characteristics**

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
	Erase Time	15			Minutes	1,3
	Data Retention @ use years		10		Years	2
	Program/Erase Endurance	25			Cycles	1

Notes:

1. For windowed cerdip package only.
2. Standard: 0°C to 70°C; Extended: -40°C to +105°C; Automotive: -40°C to +125°C.  
Determined using the Arrhenius model, which is an industry standard for estimating data retention of floating gate technologies:

$$AF = \exp[(Ea/k)*(1/Tuse - 1/TStress)]$$

Where:

Ea is the intrinsic activation energy (eV; typ. 0.8)

k is Boltzman's constant (8.67 x 10<sup>-5</sup> eV/°K)

°K = -273.16°C

Tuse = Use Temperature in °K

TStress = Stress Temperature in °K

3. At a stable UV Lamp output of 20mW/CM<sup>2</sup>

## AC Characteristics

Figure 8 and Table 10 describe the Alternating Current (AC) characteristics.

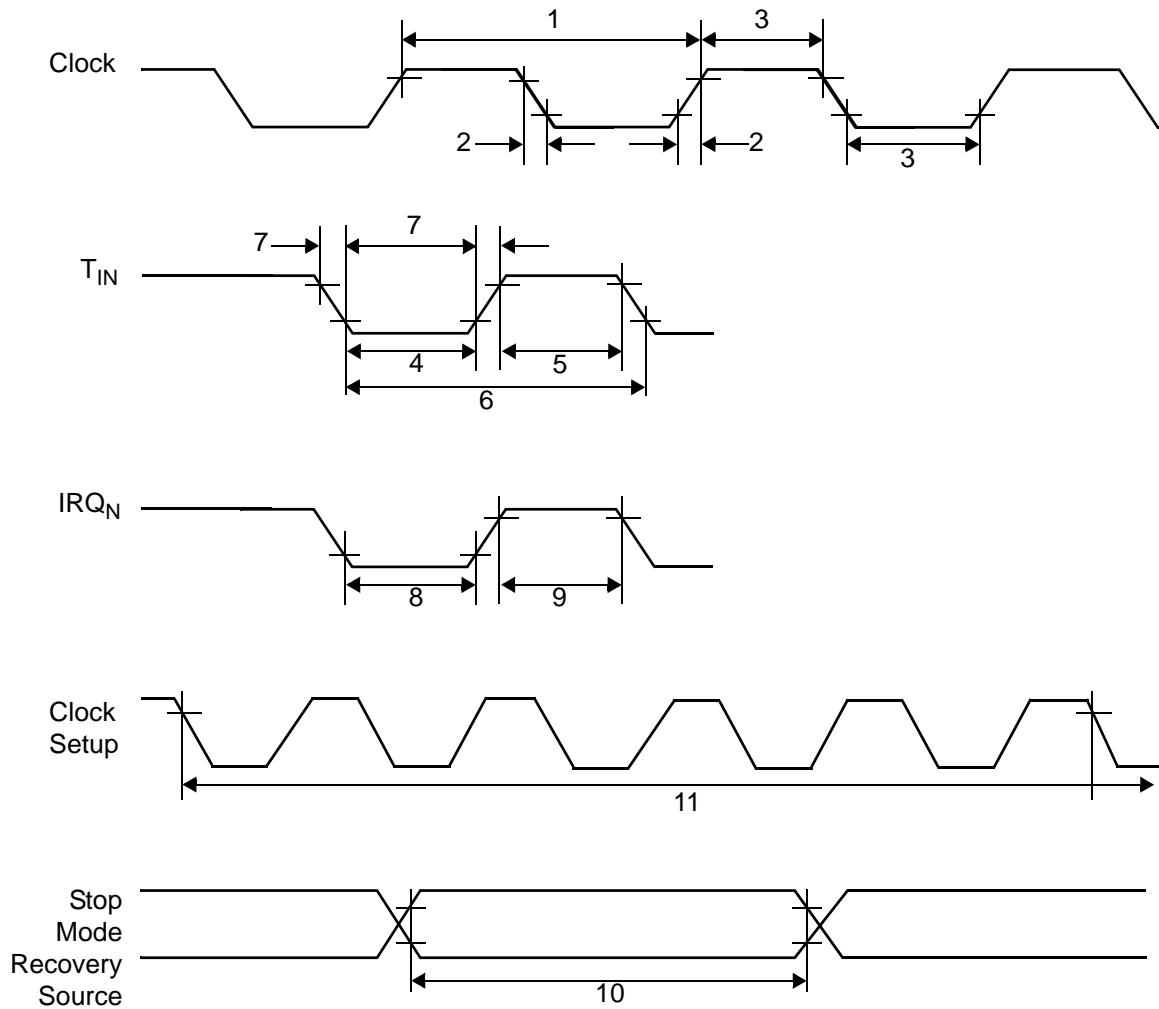


Figure 8. AC Timing Diagram

Table 10. AC Characteristics

No	Symbol	Parameter	V <sub>CC</sub>	T <sub>A</sub> =0°C to +70°C 8.0MHz		Units	Notes	Watch-Dog Timer Mode Register (D1, D0)
				Minimum	Maximum			
1	TpC	Input Clock Period	2.0–3.6	121	DC	ns	1	
2	TrC,TfC	Clock Input Rise and Fall Times	2.0–3.6		25	ns	1	
3	TwC	Input Clock Width	2.0–3.6	37		ns	1	
4	TwTinL	Timer Input Low Width	2.0 3.6	100 70		ns	1	
5	TwTinH	Timer Input High Width	2.0–3.6	3TpC			1	
6	TpTin	Timer Input Period	2.0–3.6	8TpC			1	
7	TrTin,TfTin	Timer Input Rise and Fall Timers	2.0–3.6		100	ns	1	
8	TwIL	Interrupt Request Low Time	2.0 3.6	100 70		ns	1, 2	
9	TwIH	Interrupt Request Input High Time	2.0–3.6	5TpC			1, 2	
10	Twsm	Stop-Mode Recovery Width Spec	2.0–3.6	12 10TpC		ns	3 4	
11	Tost	Oscillator Start-Up Time	2.0–3.6		5TpC		4	
12	Twdt	Watch-Dog Timer Delay Time	2.0–3.6 2.0–3.6 2.0–3.6 2.0–3.6	5 10 20 80		ms ms ms ms	0, 0 0, 1 1, 0 1, 1	
13	T <sub>POR</sub>	Power-On Reset	2.0–3.6	2.5	10	ms		

Notes:

1. Timing Reference uses 0.9 V<sub>CC</sub> for a logic 1 and 0.1 V<sub>CC</sub> for a logic 0.
2. Interrupt request through Port 3 (P33–P31).
3. SMR – D5 = 1.
4. SMR – D5 = 0.

## Pin Functions

### XTAL1 Crystal 1 (Time-Based Input)

This pin connects a parallel-resonant crystal or ceramic resonator to the on-chip oscillator input. Additionally, an optional external single-phase clock can be coded to the on-chip oscillator input.

### XTAL2 Crystal 2 (Time-Based Output)

This pin connects a parallel-resonant crystal or ceramic resonator to the on-chip oscillator output.

### Port 0 (P07–P00)

Port 0 is an 8-bit, bidirectional, CMOS-compatible port. 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 needed 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.

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

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

The Port 0 direction is reset to be input following an SMR.

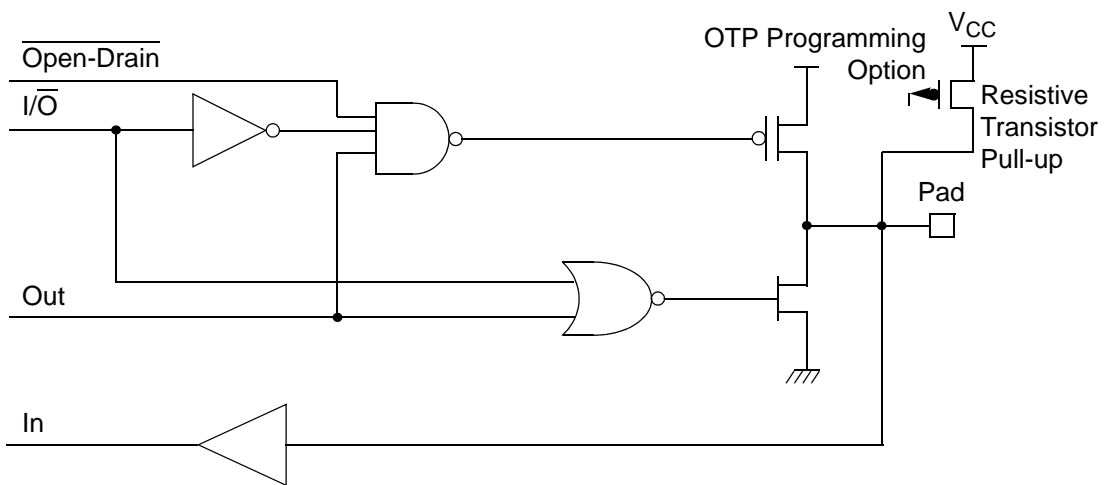
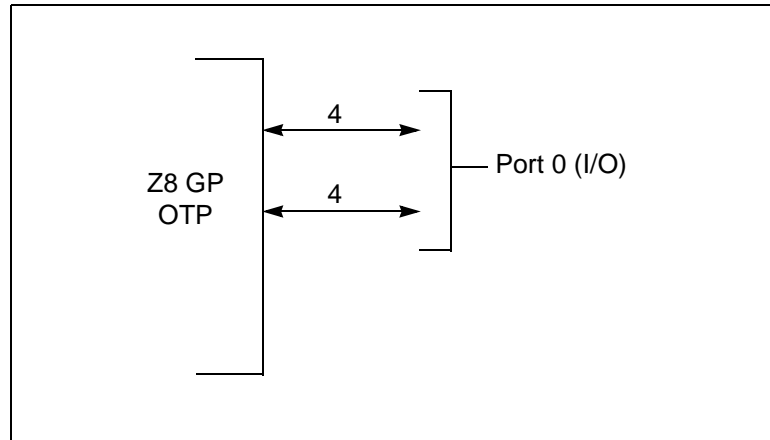


Figure 9. Port 0 Configuration

### Port 1 (P17–P10)

Port 1 (see Figure 10) Port 1 can be configured for standard port input or output mode. After POR, Port 1 is configured as an input port. The output drivers are either push-pull or open-drain and are controlled by bit D1 in the PCON register.

► **Note:** The Port 1 direction is reset to be input following an SMR.

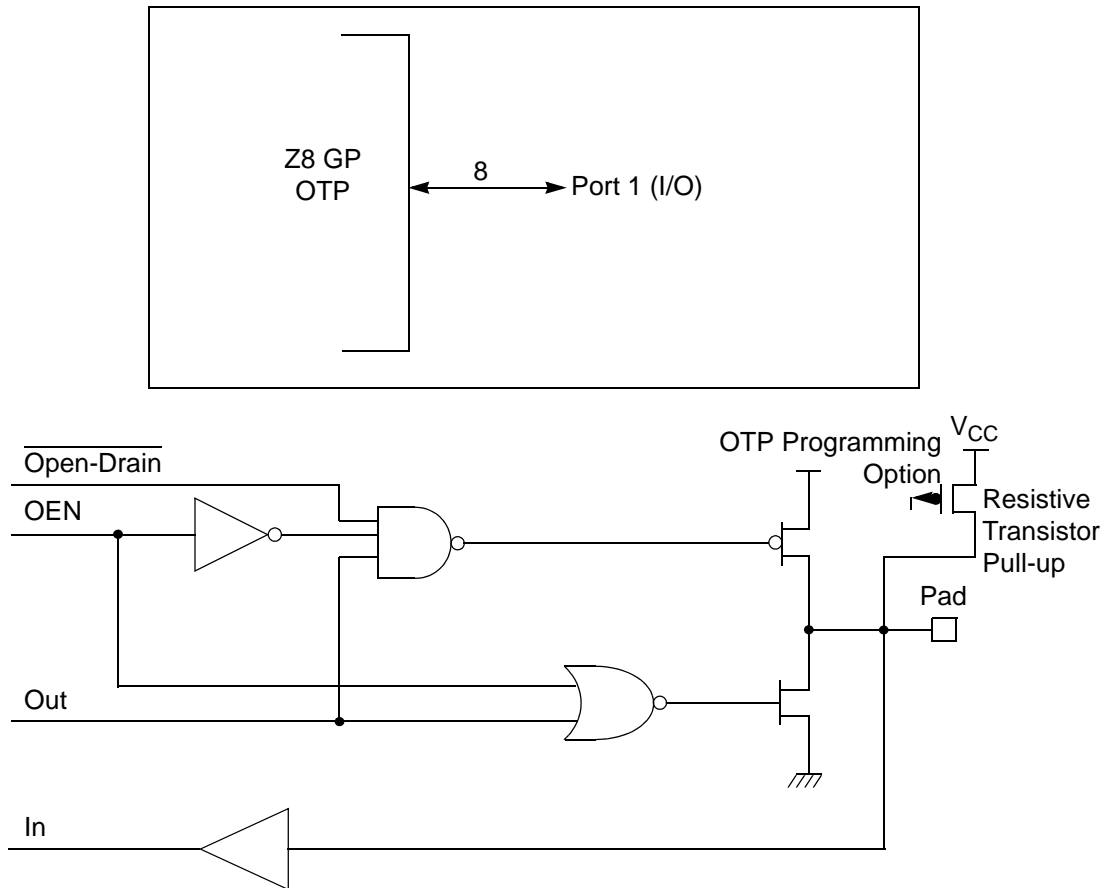


Figure 10. Port 1 Configuration

## Port 2 (P27–P20)

Port 2 is an 8-bit, bidirectional, CMOS-compatible I/O port (see Figure 11). 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.



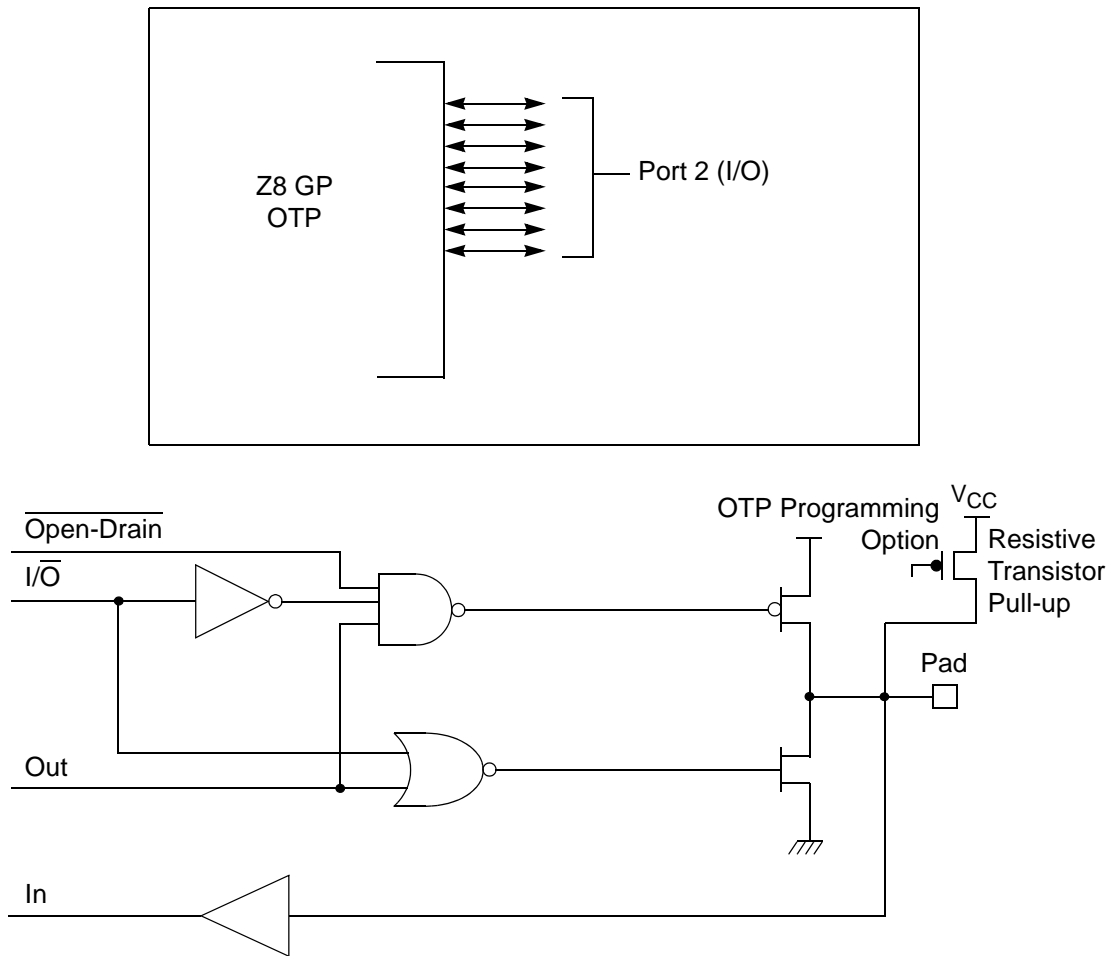
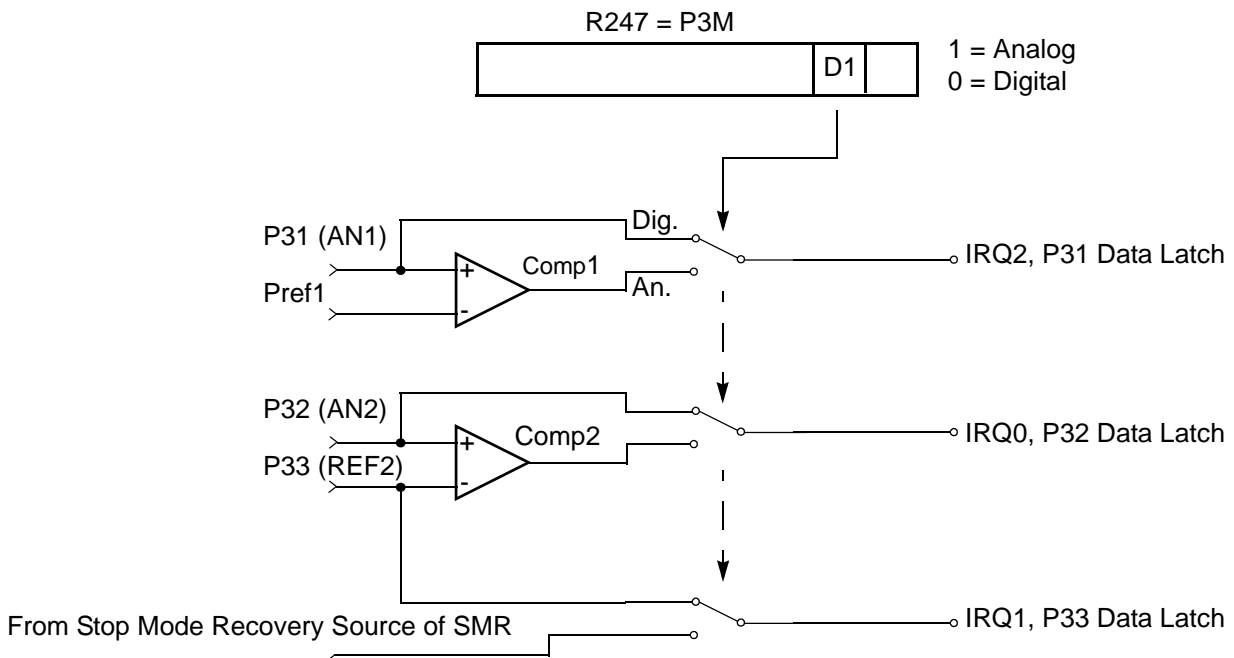
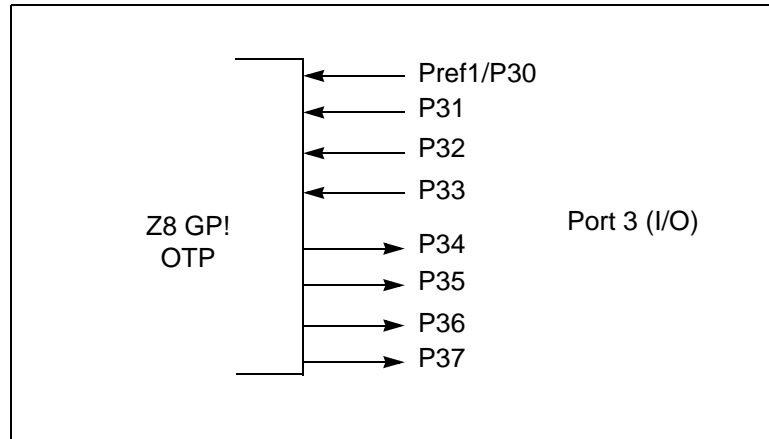


Figure 11. Port 2 Configuration

### Port 3 (P37–P30)

Port 3 is a 8-bit, CMOS-compatible fixed I/O port (see Figure 12). Port 3 consists of four fixed input (P33–P30) and four fixed output (P37–P34), which can be configured under software control for interrupt and as output from the counter/timers. P30, P31, P32, and P33 are standard CMOS inputs; P34, P35, P36, and P37 are push-pull outputs.



**Figure 12. 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 “T8 and T16 Common Functions—

CTR1(0D)01H” on page 33). Other edge detect and IRQ modes are described in Table 11.

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

**Table 11. Port 3 Pin Function Summary**

Pin	I/O	Counter/Timers	Comparator	Interrupt
Pref1/P30	IN		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 13). Control is performed by programming bits D5–D4 of CTR1, bit 0 of CTR0, and bit 0 of CTR2.

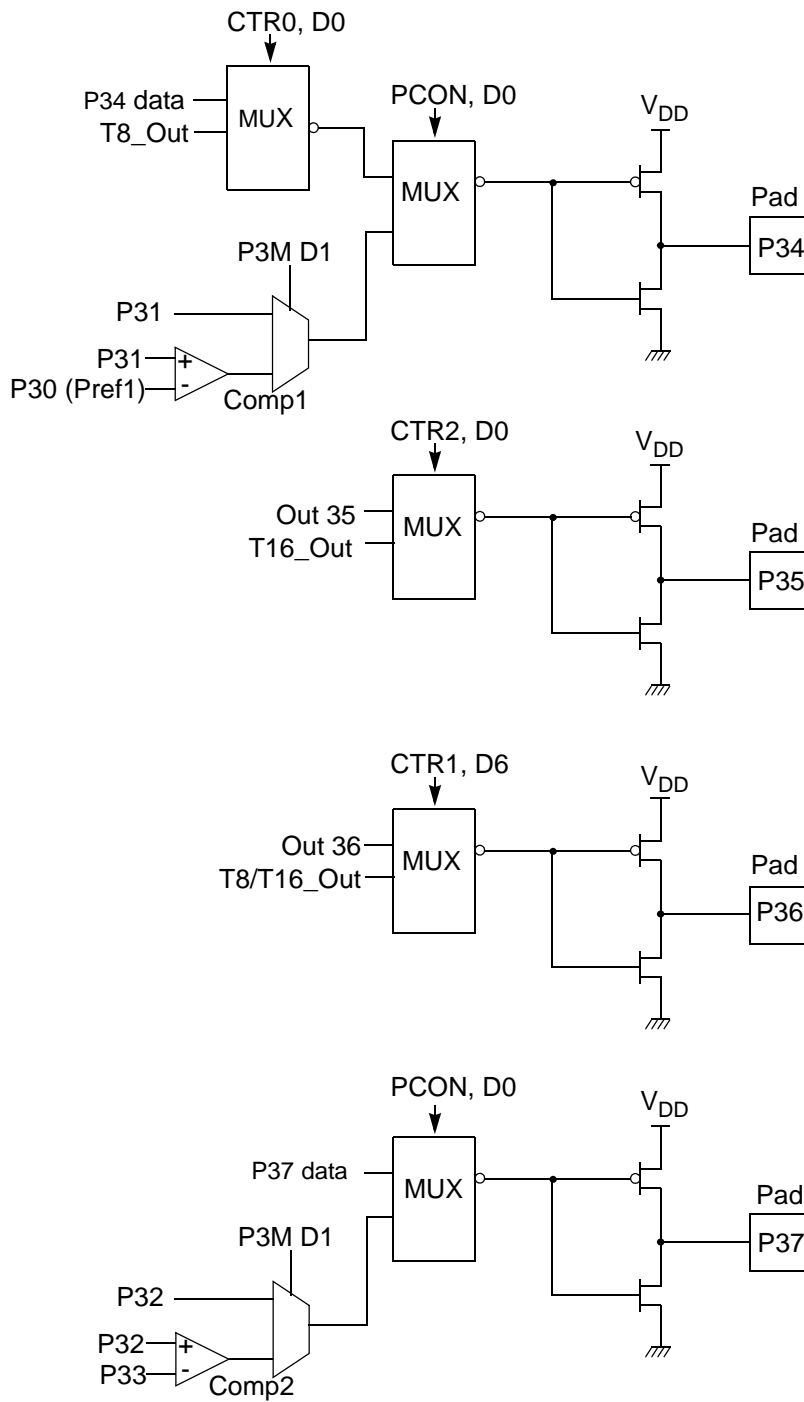


Figure 13. Port 3 Counter/Timer Output Configuration

### 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 are diverted to the SMR sources (excluding P31, P32, and P33) as indicated in Figure 12 on page 20. 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 channels can be programmed to be output on P34 and P37 through the PCON register.

## RESET (Input, Active Low)

Reset initializes the MCU and is accomplished either through Power-On, Watch-Dog Timer, Stop Mode Recovery, Low-Voltage detection, or external reset. During Power-On Reset and Watch-Dog Timer Reset, the internally generated reset drives the reset pin Low for the POR time. Any devices driving the external reset line must be open-drain to avoid damage from a possible conflict during reset conditions. Pull-up is provided internally.

When the Z8 GP™ asserts (Low) the RESET pin, the internal pull-up is disabled. The Z8 GP™ does not assert the RESET pin when under VBO.

- ▶ **Note:** The external Reset does not initiate an exit from STOP mode.

## Functional Description

This device incorporates special functions to enhance the Z8® functionality in consumer and battery-operated applications.

### Program Memory

This device addresses up to 32KB of OTP memory. The first 12 Bytes are reserved for interrupt vectors. These locations contain the six 16-bit vectors that correspond to the six available interrupts.

### RAM

This device features 256B of RAM. See Figure 14.

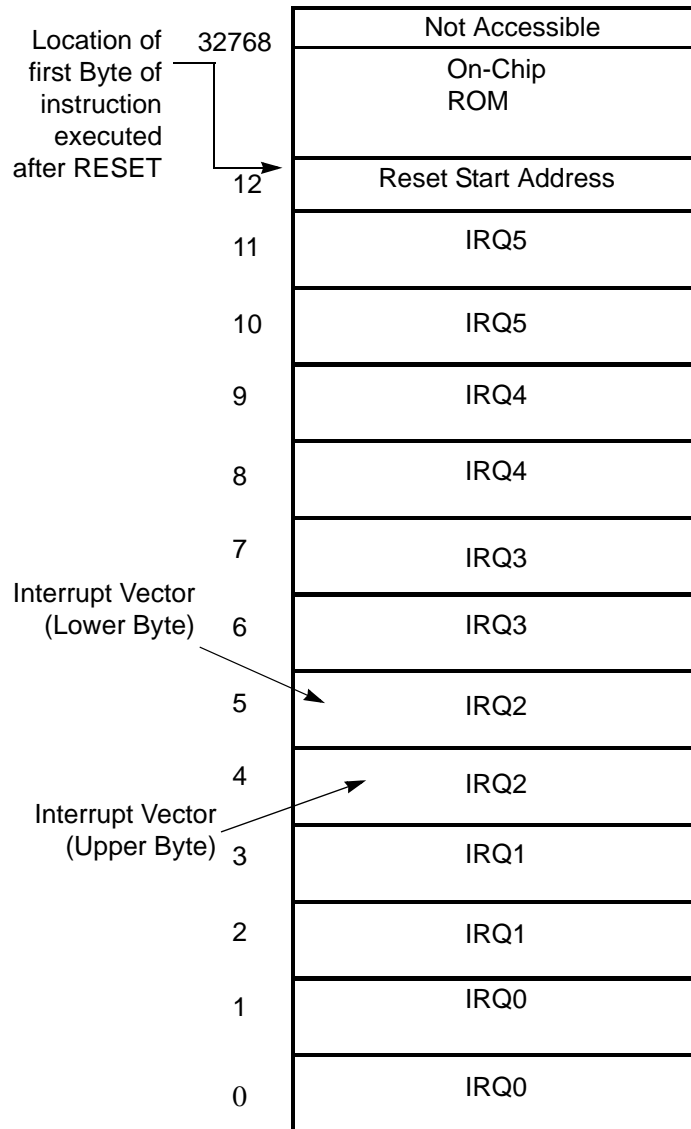


Figure 14. Program Memory Map (32K OTP)

## 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 15).

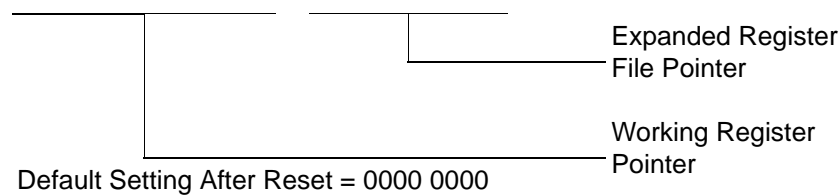




The upper nibble of the register pointer (see Figure 16) selects which working register group, of 16 bytes in the register file, is accessed out of the possible 256. The lower nibble selects the expanded register file bank and, in the case of the Z8 GP family, banks 0, F, and D are implemented. A 0H in the lower nibble allows the normal register file (bank 0) to be addressed. 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 16. Register Pointer**

**Example: Z8 GP: (See Figure 15 on page 26)**

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
; 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, 16 control and status registers (R0–R3, R4–R239, and R240–R255, respectively), and two expanded registers groups in Banks D (see Table 12) 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 17). 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.

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

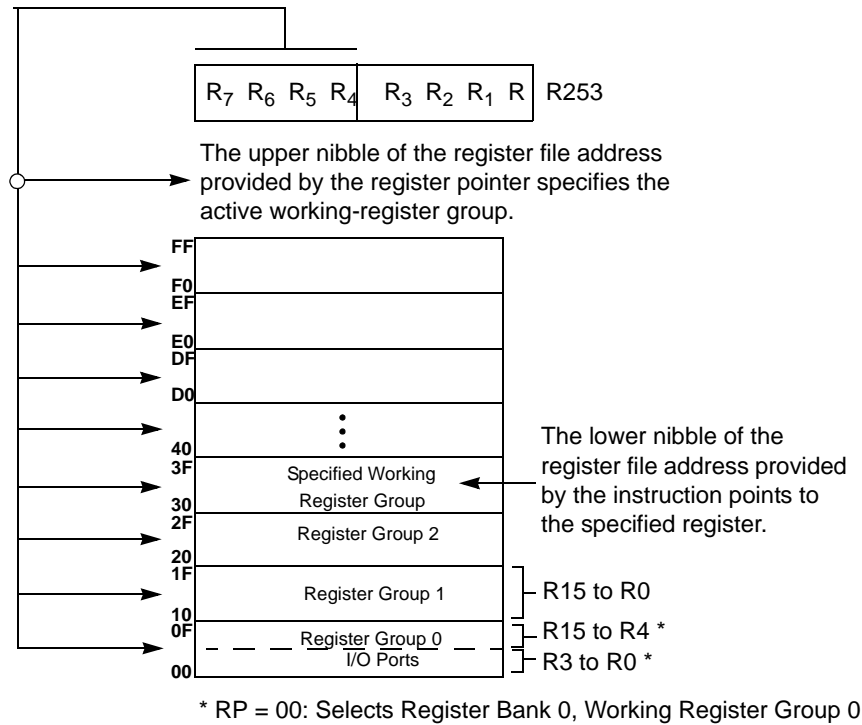


Figure 17. Register Pointer—Detail

## Stack

The internal register file is used for the stack. An 8-bit Stack Pointer SPL (R255) is used for the internal stack that resides in the general-purpose registers (R4–R239). SPH (R254) can be used as a general-purpose register.

## Timers

### T8\_Capture\_HI—HI8(D)0BH

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

Field	Bit Position	Description
T8_Capture_HI	[7:0]	R/W Captured Data - No Effect

### T8\_Capture\_LO—L08(D)0AH

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

Field	Bit Position	Description
T8_Capture_LO	[7:0]	R/W Captured Data - No Effect

### T16\_Capture\_HI—HI16(D)09H

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

Field	Bit Position	Description
T16_Capture_HI	[7:0]	R/W Captured Data - No Effect

### T16\_Capture\_LO—L016(D)08H

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

Field	Bit Position	Description
T16_Capture_LO	[7:0]	R/W Captured Data - No Effect

### Counter/Timer2 MS-Byte Hold Register—TC16H(D)07H

Field	Bit Position	Description
T16_Data_HI	[7:0]	R/W Data

**Counter/Timer2 LS-Byte Hold Register—TC16L(D)06H**

Field	Bit Position	Description
T16_Data_LO	[7:0]	R/W Data

**Counter/Timer8 High Hold Register—TC8H(D)05H**

Field	Bit Position	Description
T8_Level_HI	[7:0]	R/W Data

**Counter/Timer8 Low Hold Register—TC8L(D)04H**

Field	Bit Position	Description
T8_Level_LO	[7:0]	R/W Data

**CTR0 Counter/Timer8 Control Register—CTR0(D)00H**

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

**Table 12. CTR0(D)00H Counter/Timer8 Control Register**

Field	Bit Position		Value	Description
T8_Enable	7-----	R/W	0*	Counter Disabled
			1	Counter Enabled
			0	Stop Counter
			1	Enable Counter
Single/Modulo-N	-6-----	R/W	0	Modulo-N
			1	Single Pass
Time_Out	--5-----	R/W	0	No Counter Time-Out
			1	Counter Time-Out Occurred
			0	No Effect
			1	Reset Flag to 0
T8_Clock	---43---	R/W	0 0	SCLK
			0 1	SCLK/2
			1 0	SCLK/4
			1 1	SCLK/8
Capture_INT_Mask	----2--	R/W	0	Disable Data Capture Interrupt
			1	Enable Data Capture Interrupt

**Table 12. CTR0(D)00H Counter/Timer8 Control Register (Continued)**

Field	Bit Position		Value	Description
Counter_INT_Mask	-----1-	R/W	0	Disable Time-Out Interrupt
			1	Enable Time-Out Interrupt
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, write a 1 to its location.



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

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



**Note:** Take care 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.

**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.

### T8 and T16 Common Functions—CTR1(0D)01H

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

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

**Table 13. CTR1(0D)01H T8 and T16 Common Functions**

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

Table 13. CTR1(0D)01H T8 and T16 Common Functions (Continued)

Field	Bit Position	Value	Description	
Transmit_Submode/ Glitch_Filter	----32--	R/W	Transmit Mode	
		00*	Normal Operation	
		01	Ping-Pong Mode	
		10	T16_Out = 0	
		11	T16_Out = 1	
			Demodulation Mode	
		00*	No Filter	
		01	4 SCLK Cycle	
		10	8 SCLK Cycle	
		11	Reserved	
Initial_T8_Out/ Rising Edge	-----1-	R/W	Transmit Mode	
		0*	T8_OUT is 0 Initially	
		1	T8_OUT is 1 Initially	
			Demodulation Mode	
		R	0*	No Rising Edge
		1	Rising Edge Detected	
		W	0	No Effect
		1	Reset Flag to 0	
Initial_T16_Out/ Falling_Edge	-----0	R/W	Transmit Mode	
		0*	T16_OUT is 0 Initially	
		1	T16_OUT is 1 Initially	
			Demodulation Mode	
		R	0*	No Falling Edge
		1	Falling Edge Detected	
		W	0	No Effect
		1	Reset Flag to 0	

**Note:**

\*Default at Power-On Reset.

\*\*Default at Power-On Reset. Not reset with Stop Mode recovery.

**Mode**

If the result is 0, the counter/timers are in TRANSMIT mode; otherwise, they are in 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.

If the input signal is from Port 31, a capture event may also generate an IRQ2 interrupt. To prevent generating an IRQ2, either disable the IRQ2 interrupt by clearing its IMR bit D2 or use P20 as the input.



### 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 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 the mode, 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 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/T16\_OUT.

### CTR2 Counter/Timer 16 Control Register—CTR2(D)02H

Table 14 lists and briefly describes the fields for this register.

**Table 14. 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
T16_Clock	---43---	R/W	00**	No Effect
			01	Reset Flag to 0
			10	SCLK
			11	SCLK/2
Capture_INT_Mask	-----2--	R/W	0**	SCLK/4
			1	SCLK/8
Counter_INT_Mask	-----1-	R/W	0	Disable Data Capture Int.
			1	Enable Data Capture Int.
P35_Out	-----0	R/W	0*	Disable Timeout Int.
			1	Enable Timeout Int.

**Note:**

\*Indicates the value upon Power-On Reset.

\*\*Indicates the value upon Power-On Reset. Not reset with Stop Mode recovery.

**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 it reaches the terminal count. 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

Set this bit 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.

#### CTR3 T8/T16 Control Register—CTR3(D)03H

Table 15 lists and briefly describes the fields for this register. This register allows the T<sub>8</sub> and T<sub>16</sub> counters to be synchronized.

**Table 15. CTR3 (D)03H: T8/T16 Control Register**

Field	Bit Position		Value	Description
T <sub>16</sub> Enable	7-----	R	0*	Counter Disabled
		R	1	Counter Enabled
		W	0	Stop Counter
		W	1	Enable Counter
T <sub>8</sub> Enable	-6-----	R	0*	Counter Disabled
		R	1	Counter Enabled
		W	0	Stop Counter
		W	1	Enable Counter
Sync Mode	--5-----	R/W	0**	Disable Sync Mode
			1	Enable Sync Mode

**Table 15. CTR3 (D)03H: T8/T16 Control Register (Continued)**

Field	Bit Position		Value	Description
Reserved	---43210	R	1	Always reads 11111
		W	x	No Effect

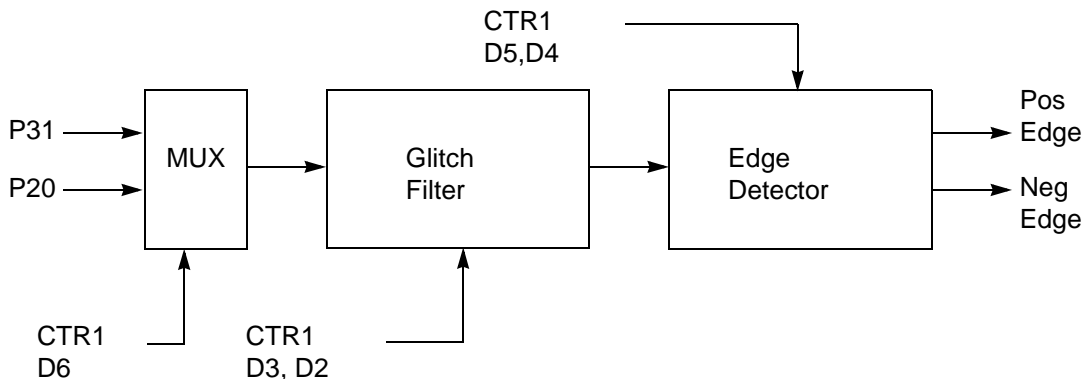
Note: \*Indicates the value upon Power-On Reset.

\*\*Indicates the value upon Power-On Reset. Not reset with Stop Mode recovery.

## 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 18).



**Figure 18. 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 19.

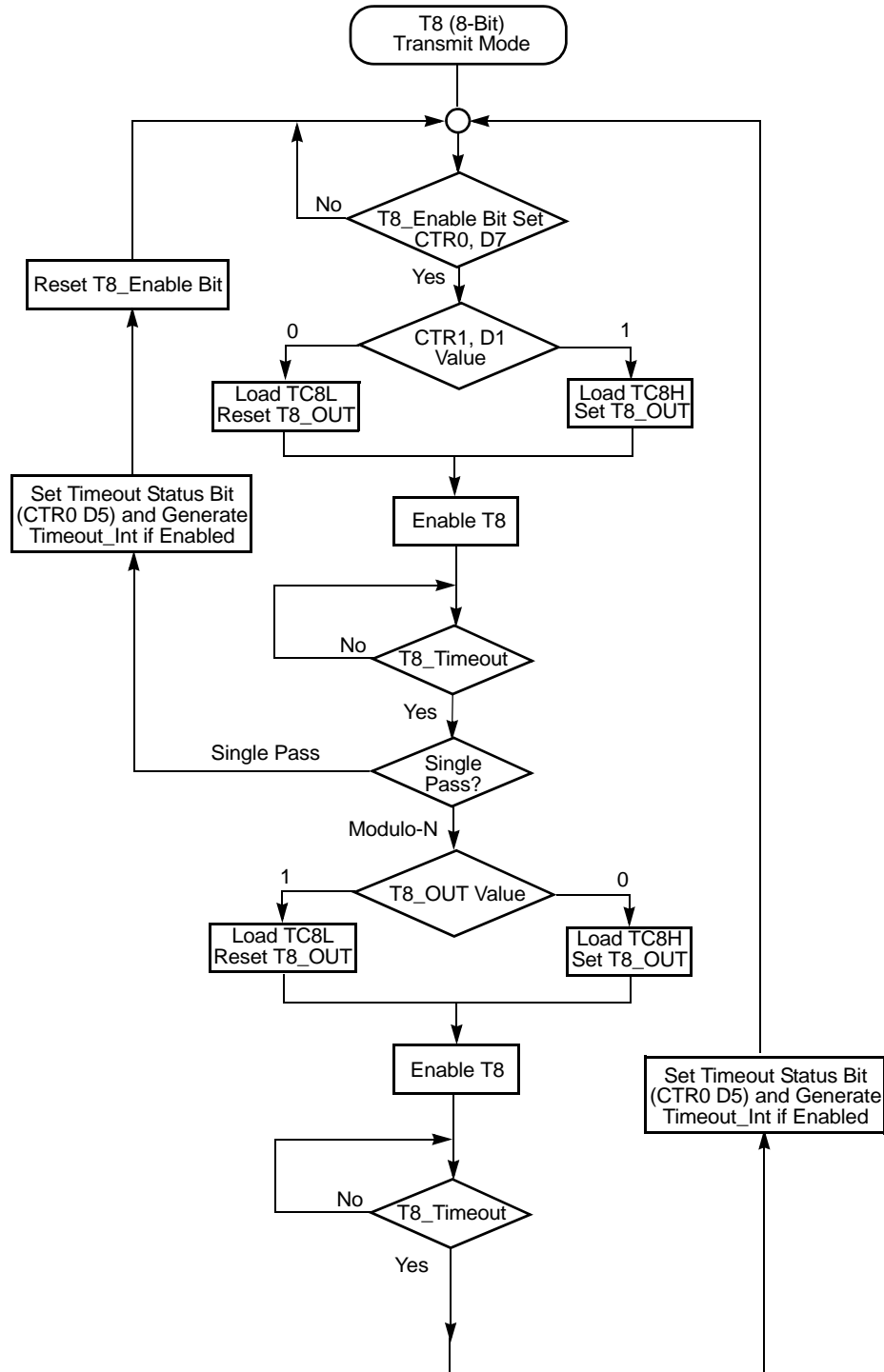


Figure 19. Transmit Mode Flowchart

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, and sets the timeout status bit (CTR0, D5), thereby generating 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 20.

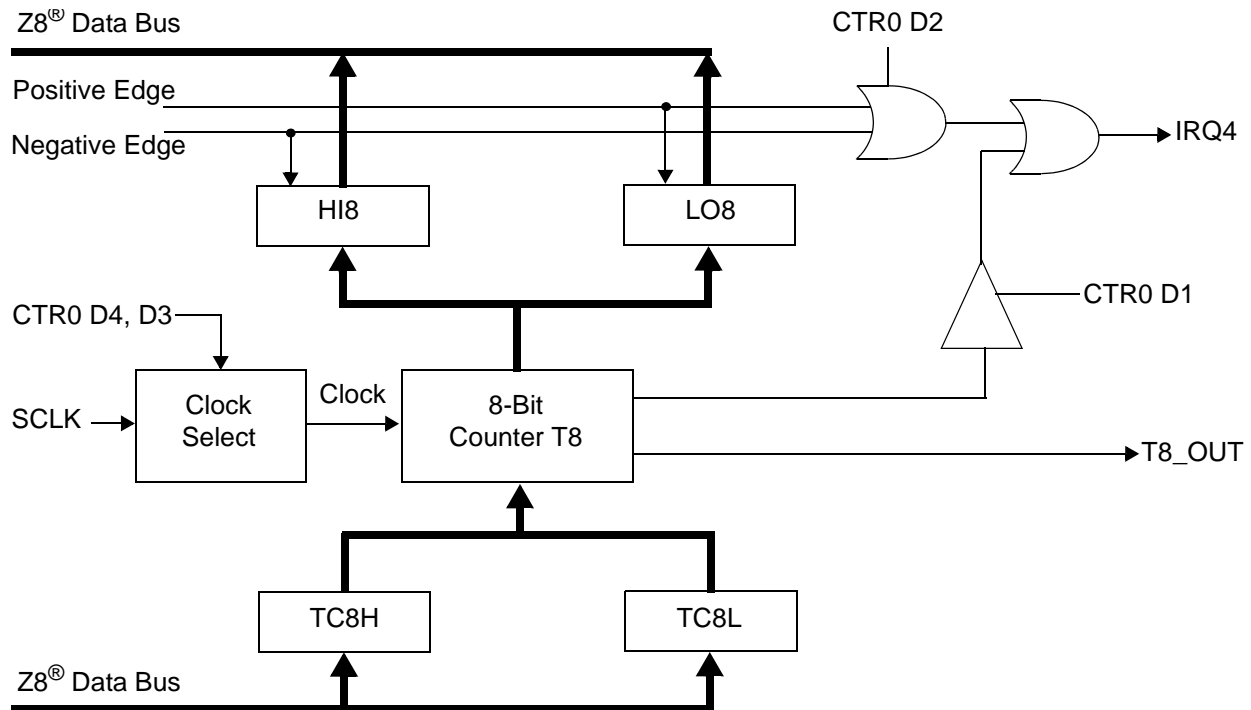


Figure 20. 8-Bit Counter/Timer Circuits

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

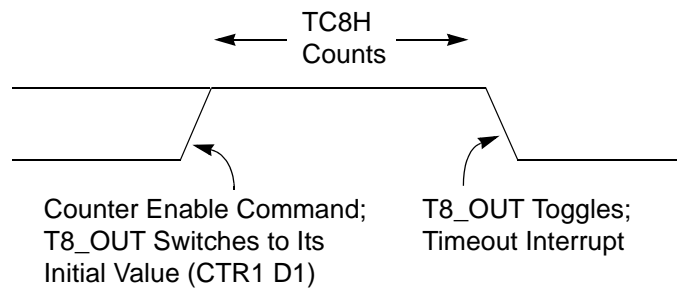


**Caution:** To ensure known operation do not write these registers at the time the values are to be loaded into the counter/timer. An initial count of 1 is not allowed (a non-function occurs). An initial count of 0 causes TC8 to count from 0 to FFH to FEH.

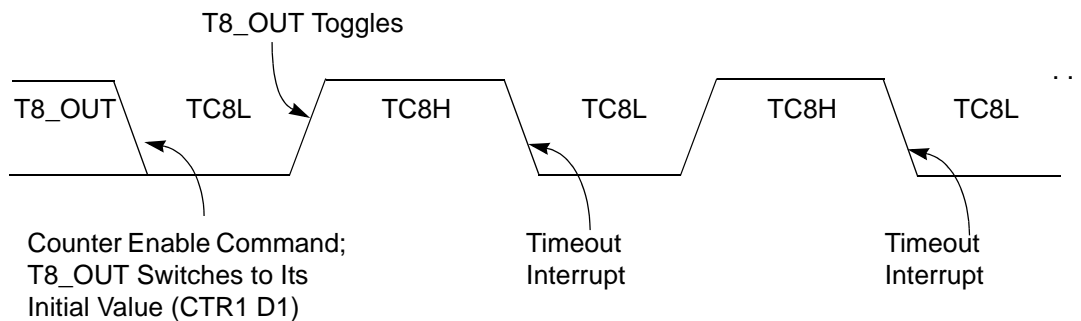
► **Note:** The letter h denotes hexadecimal values.  
Transition from 0 to FFh is not a timeout condition.

⚠ **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 21 and Figure 22.



**Figure 21. T8\_OUT in Single-Pass Mode**



**Figure 22. T8\_OUT in Modulo-N Mode**

**T8 Demodulation Mode**

The user must 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 it is a negative edge, data is put into HI8. From that point, 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, and an interrupt can be generated if enabled (CTR0, D1). T8 then continues counting from FFh (see Figure 23 and Figure 24).

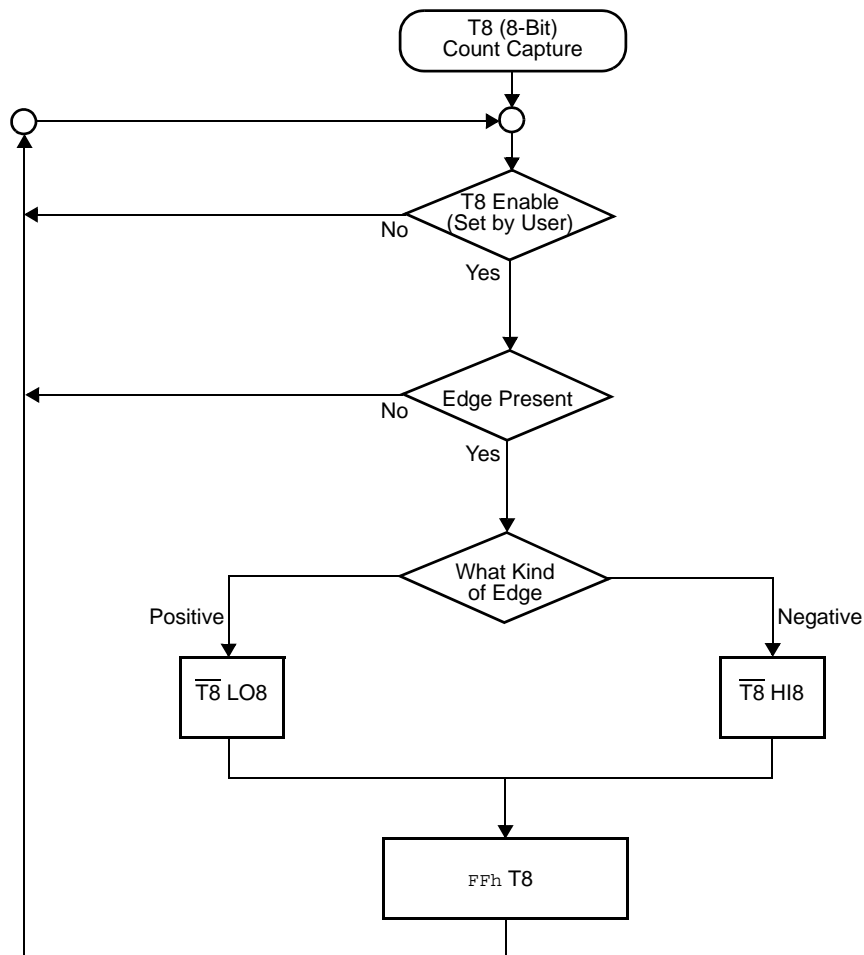


Figure 23. Demodulation Mode Count Capture Flowchart



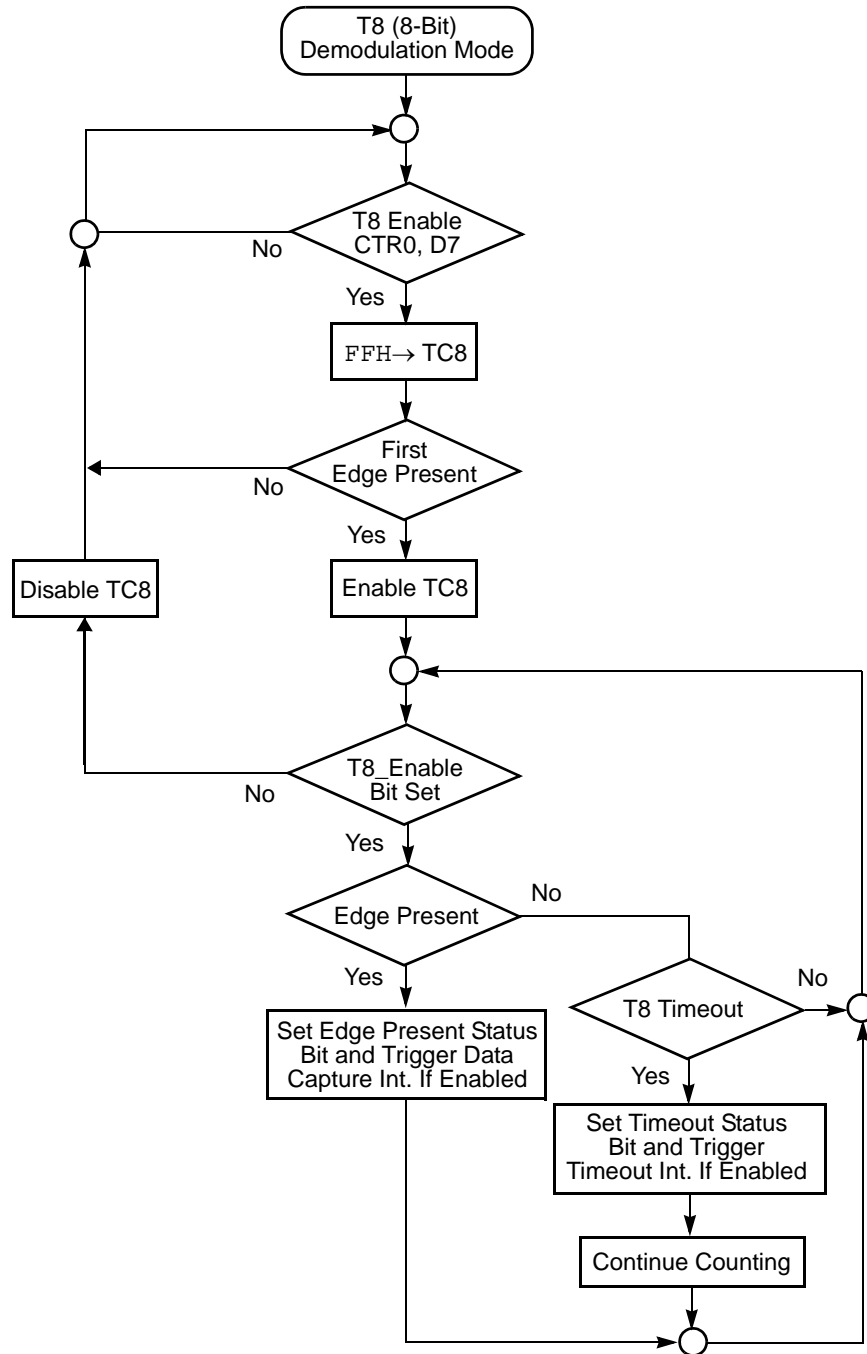
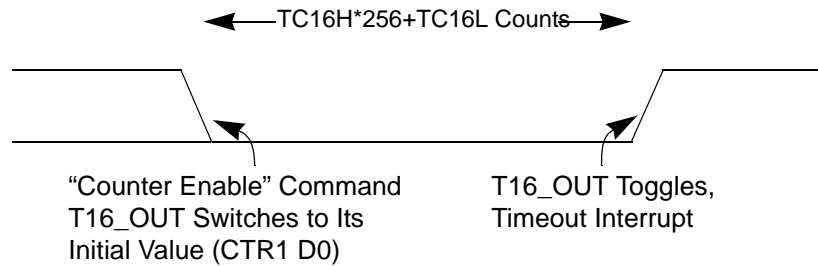


Figure 24. Demodulation Mode Flowchart

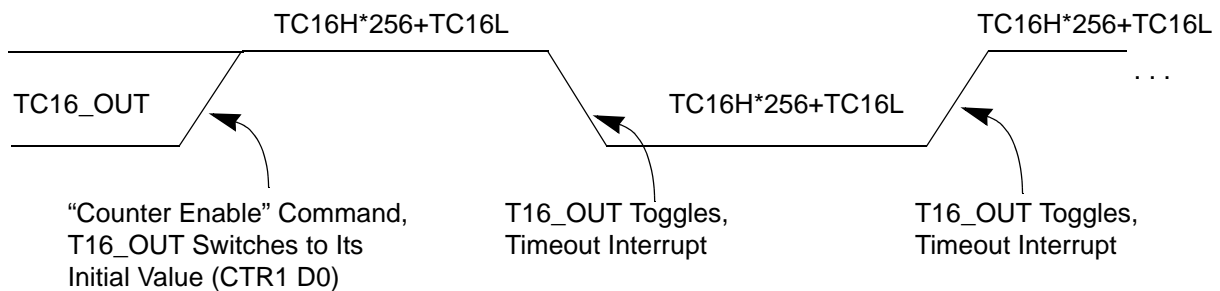




**Caution:** Do not load these registers at the time the values are to be loaded into the counter/timer to ensure known operation. An initial count of 1 is not allowed. An initial count of 0 causes T16 to count from 0 to FFFFH to FFFE<sub>H</sub>. Transition from 0 to FFFF<sub>H</sub> is not a timeout condition.



**Figure 26. T16\_OUT in Single-Pass Mode**



**Figure 27. T16\_OUT in Modulo-N Mode**

### T16 DEMODULATION Mode

The user must program TC16L and TC16H to FF<sub>H</sub>. 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). T16 is loaded with FFFF<sub>H</sub> and starts again.

This T16 mode is generally used to measure space time, the length of time between bursts of carrier signal (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), continuing to ignore subsequent edges.

This T16 mode generally measures mark time, the length of an active carrier signal burst.

If T16 reaches 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 then 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, repeating the entire cycle. 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 28.

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

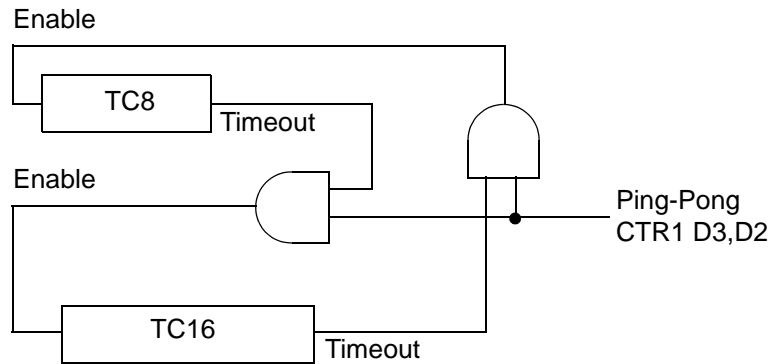


Figure 28. Ping-Pong Mode Diagram

### Initiating PING-PONG Mode

First, make sure both counter/timers are not running. 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 can be in random order. Finally, start PING-PONG mode by enabling either T8 (CTR0, D7) or T16 (CTR2, D7). See Figure 29.

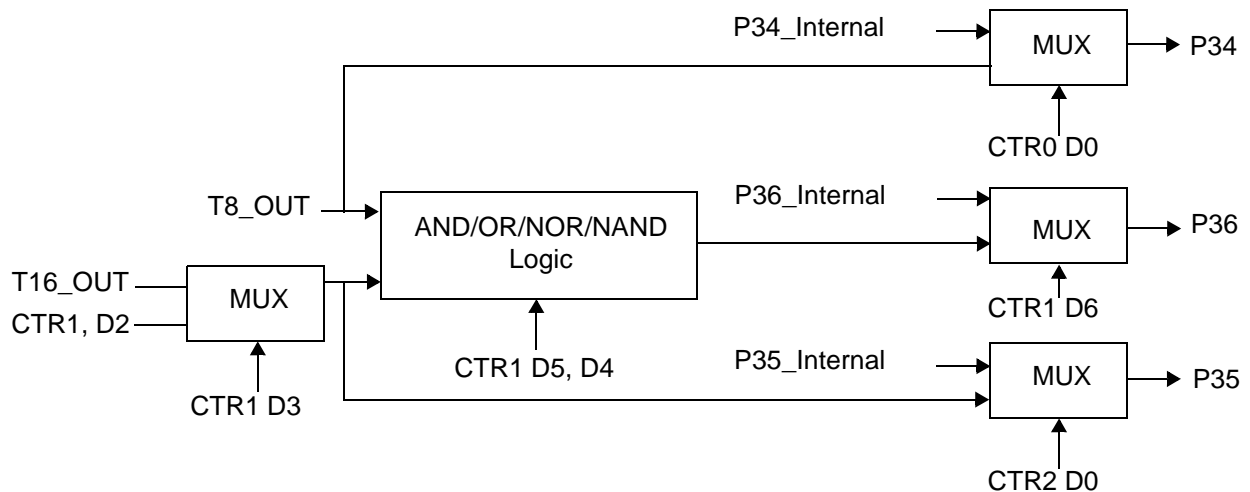


Figure 29. Output Circuit

The initial value of T8 or T16 must not be 1. Stopping the timer and restarting the timer reloads 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.

### Timer Output

The output logic for the timers is illustrated in Figure 29. P34 is used to output T8-OUT when D0 of CTR0 is set. P35 is used to output the value of T16-OUT when D0 of CTR2 is set. When D6 of CTR1 is set, P36 outputs the logic combination of T8-OUT and T16-OUT determined by D5 and D4 of CTR1.

### Interrupts

The Z8 GP™ OTP MCU Family features six different interrupts (Table 16). The interrupts are maskable and prioritized (Figure 30). The six sources are divided as follows: three sources are claimed by Port 3 lines P33–P31, two by the counter/timers (Table 16) and one for low voltage detection. The Interrupt Mask Register (globally or individually) enables or disables the six interrupt requests.

The source for IRQ is determined by bit 1 of the Port 3 mode register (P3M). When in digital mode, Pin P33 is the source. When in analog mode the output of the Stop mode recovery source logic is used as the source for the interrupt. See Figure 35, Stop Mode Recovery Source, on page 57.

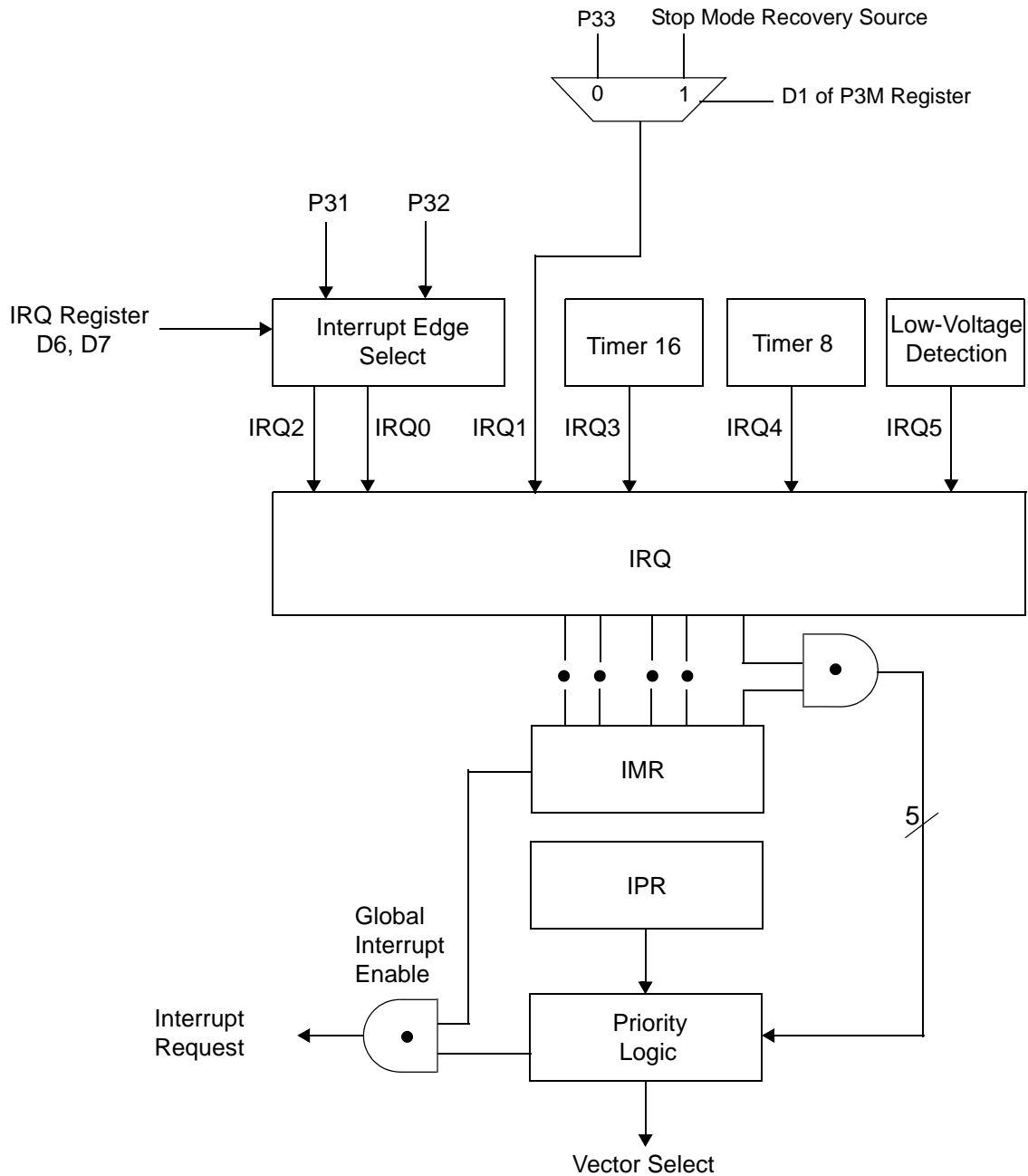


Figure 30. Interrupt Block Diagram

**Table 16. 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 <sub>IN</sub>	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 activates 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 Z8 GP™ OTP MCU Family 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 can be rising, falling, or both edge triggered. These interrupts 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 17.

**Table 17. IRQ Register**

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

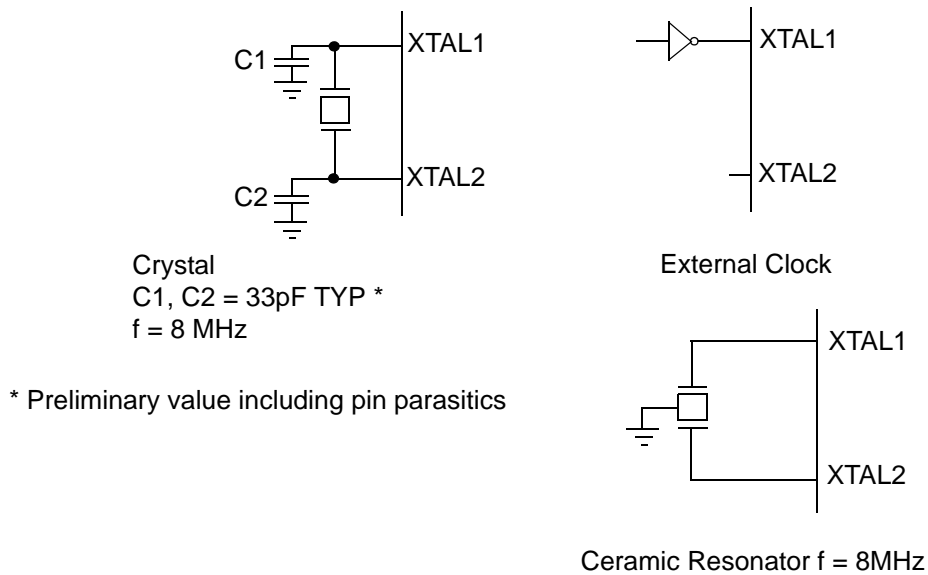
**Note:** F = Falling Edge; R = Rising Edge



### Clock

The device's on-chip oscillator has a high-gain, parallel-resonant amplifier, for connection to a crystal, 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 Ω. The on-chip oscillator can be driven with a suitable external clock source.

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.



**Figure 31. Oscillator Configuration**

### Power-On Reset

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  $V_{DD}$  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 2.5 ms minimum. Bit 5 of the Stop-Mode Register determines whether the POR timer is bypassed after Stop-Mode Recovery (typical for external clock).

### HALT Mode

This instruction turns off the internal CPU clock, but not the XTAL oscillation. The counter/timers and external interrupts IRQ0, IRQ1, IRQ2, IRQ3, IRQ4, and IRQ5 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 HALT Mode.

### STOP Mode

This instruction turns off the internal clock and external crystal oscillation, reducing the standby current to 10  $\mu$ A or less. STOP Mode is terminated only by a reset, such as WDT timeout, POR, SMR or external reset. This condition causes the processor to restart the application program at address 000CH. To enter STOP (or HALT) mode, first flush the instruction pipeline to avoid suspending execution in mid-instruction. Execute a NOP (Opcode = FFH) immediately before the appropriate sleep instruction, as follows:

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

or

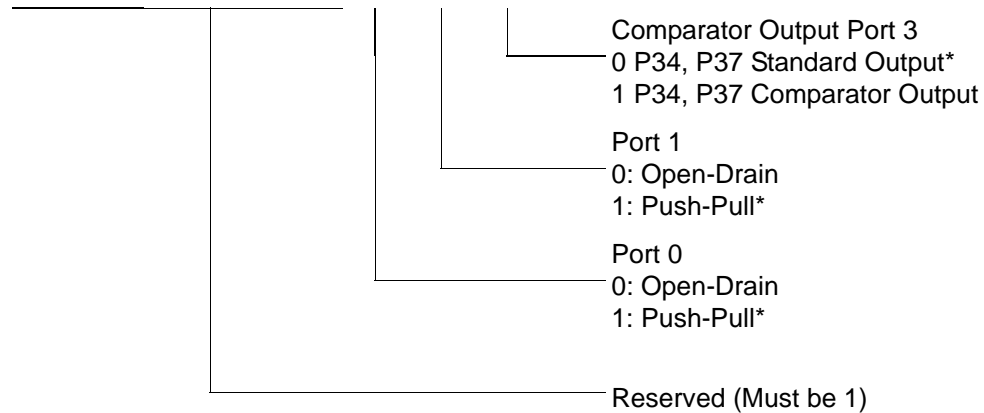
```
FF      NOP      ; clear the pipeline
7F      HALT     ; enter HALT Mode
```

### Port Configuration Register

The Port Configuration (PCON) register (Figure 32) 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 32. 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.

#### Port 1 Output Mode (D1)

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

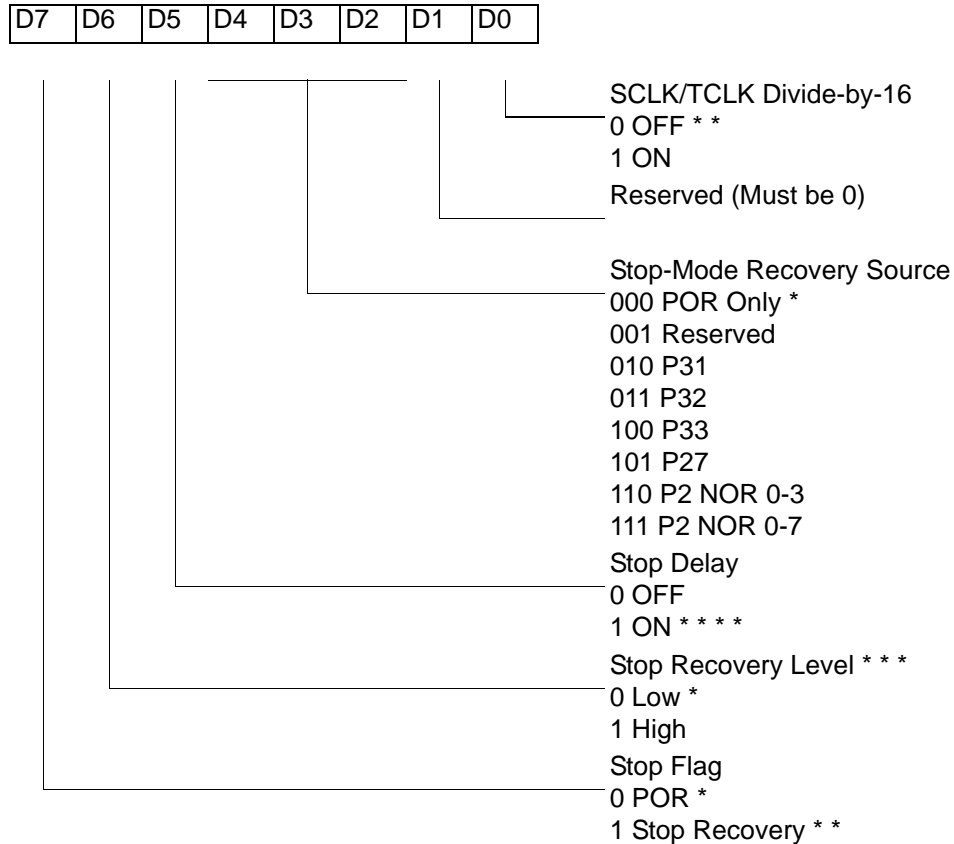
### Port 0 Output Mode (D2)

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 33). 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 (Figure 35 on page 57) is required from the recovery source. Bit 5 controls the reset delay after recovery. Bits D2, D3, and D4 of 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)0BH



- \* Default after Power On Reset or Watch-Dog Reset
- \* \* Set after STOP Mode Recovery
- \* \* \* At the XOR gate input
- \* \* \* \* Default setting after reset. Must be 1 if using a crystal or resonator clock source.

**Figure 33. 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 34). This control selectively reduces 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.

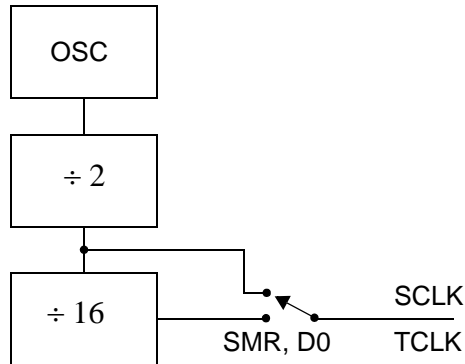


Figure 34. SCLK Circuit

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

These three bits of the SMR specify the wake-up source of the Stop recovery (Figure 35 and Table 19).

### Stop-Mode Recovery Register 2—SMR2(F)0DH

Table 18 lists and briefly describes the fields for this register.

Table 18. 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 <sup>†</sup>	Low
		1	High
Reserved	--5-----	0	Reserved (Must be 0)
Source	---432--	W 000 <sup>†</sup>	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:**

\* Port pins configured as outputs are ignored as a SMR recovery source.

<sup>†</sup> Indicates the value upon Power-On Reset

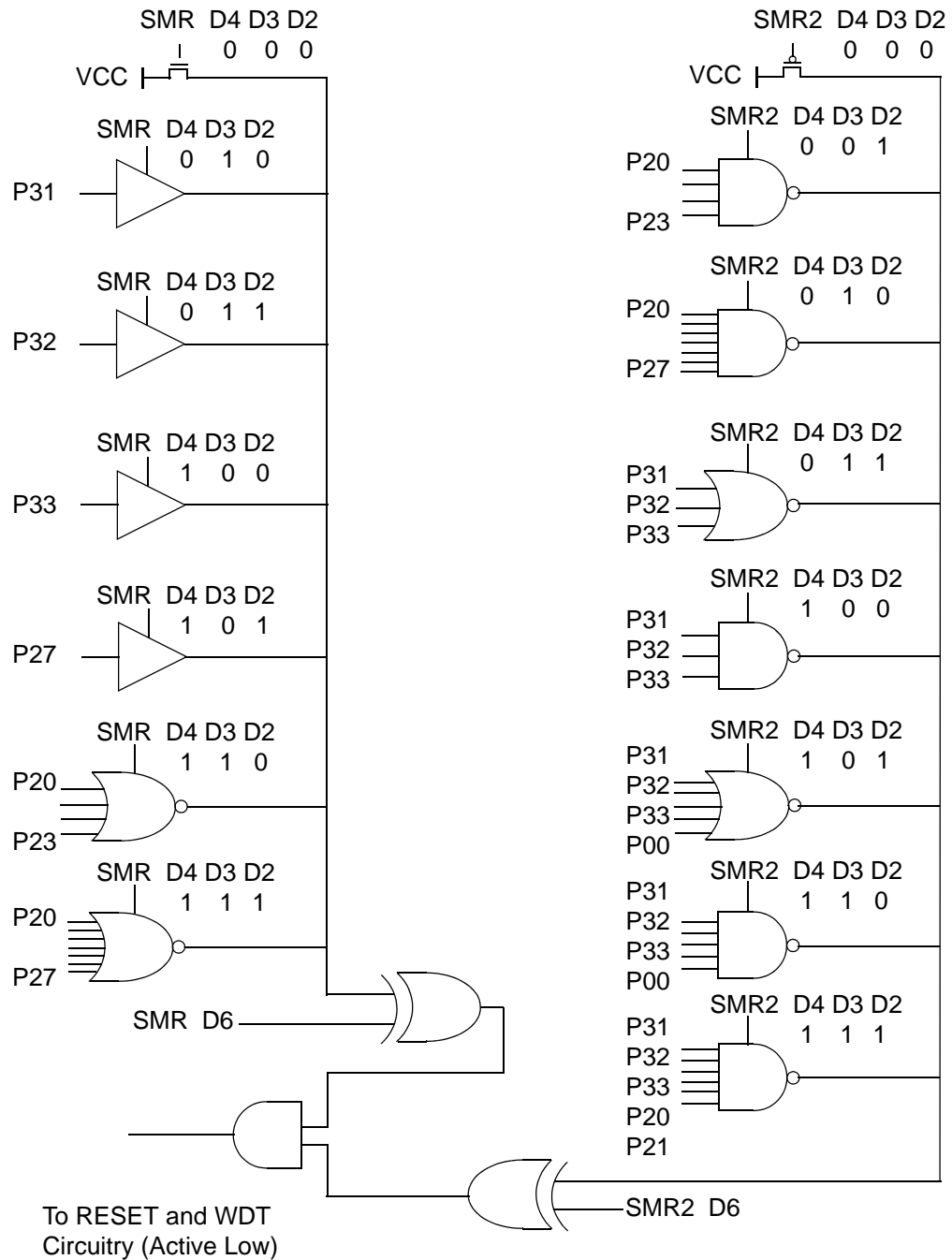


Figure 35. Stop Mode Recovery Source

**Table 19. 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. For example, if the NOR of P23-P20 is selected as the recovery source and P20 is configured as an output, the remaining SMR pins (P23-P21) form the NOR equation. This condition allows the remaining inputs to control the AND/OR function. Refer to SMR2 register on page 59 for other recover sources.

#### Stop Mode Recovery Delay Select (D5)

This bit, if Low, disables the  $T_{POR}$  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  $T_{pC}$ .

- **Note:** It is recommended that this bit be set to 1 if using a crystal or resonator clock source. The  $T_{POR}$  delay allows the clock source to stabilize before executing instructions.

#### 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 device from Stop Mode. A 0 indicates Low level recovery. The default is 0 on POR.

#### Cold or Warm Start (D7)

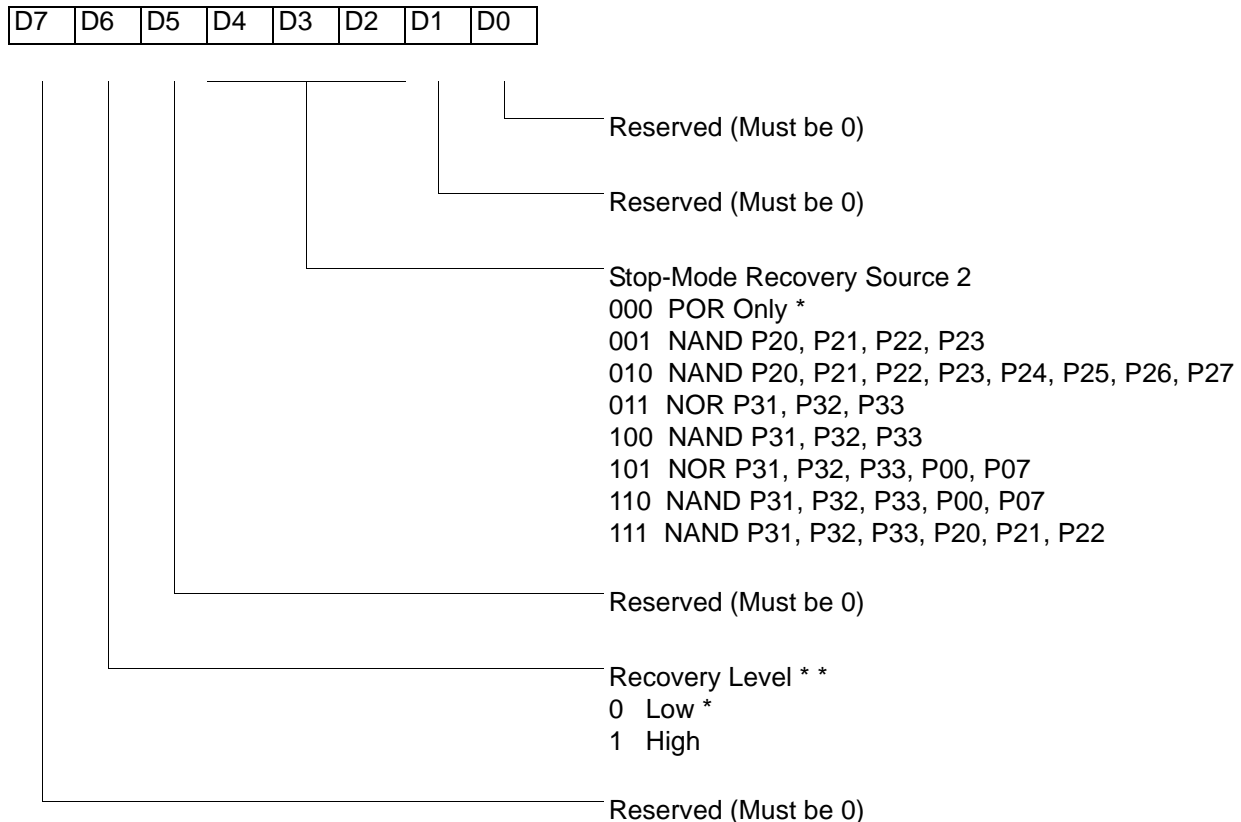
This bit is read only. It is set to 1 when the device is recovered from Stop Mode. The bit is set to 0 when the device reset is other than Stop Mode Recovery (SMR).



### Stop Mode Recovery Register 2 (SMR2)

This register determines the mode of Stop Mode Recovery for SMR2 (Figure 36).

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 36. 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.

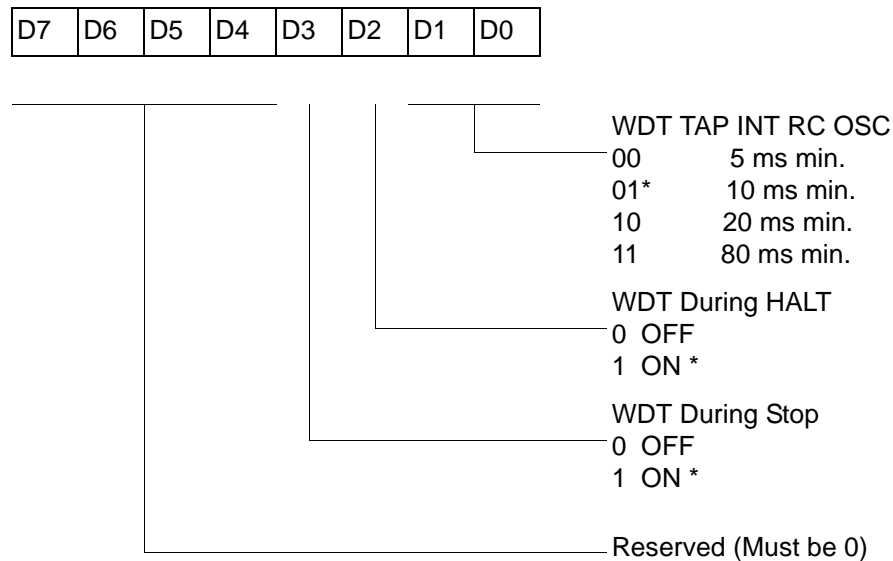
- **Note:** Port pins configured as outputs are ignored as an SMR or SMR2 recovery source. For example, if the NAND or P23–P20 is selected as the recovery source and P20 is configured as an output, the remaining SMR pins (P23–P21) form the NAND equation.

### Watch-Dog Timer Mode Register (WDTMR)

The Watch-Dog Timer (WDT) is a retriggerable one-shot timer that resets the Z8® CPU 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. The WDT instruction affects the Zero (Z), Sign (S), and Overflow (V) flags.

The POR clock source the internal RC-oscillator. Bits 0 and 1 of the WDT register control a tap circuit that determines the minimum timeout period. Bit 2 determines whether the WDT is active during HALT, and Bit 3 determines WDT activity during Stop. Bits 4 through 7 are reserved (Figure 37). This register is accessible only during the first 60 processor cycles (120 XTAL clocks) from the execution of the first instruction after Power-On-Reset, Watch-Dog Reset, or a Stop-Mode Recovery (Figure 36). 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 37.

WDTMR(0F)0Fh



\* Default setting after reset

**Figure 37. Watch-Dog Timer Mode Register (Write Only)**

#### WDT Time Select (D0, D1)

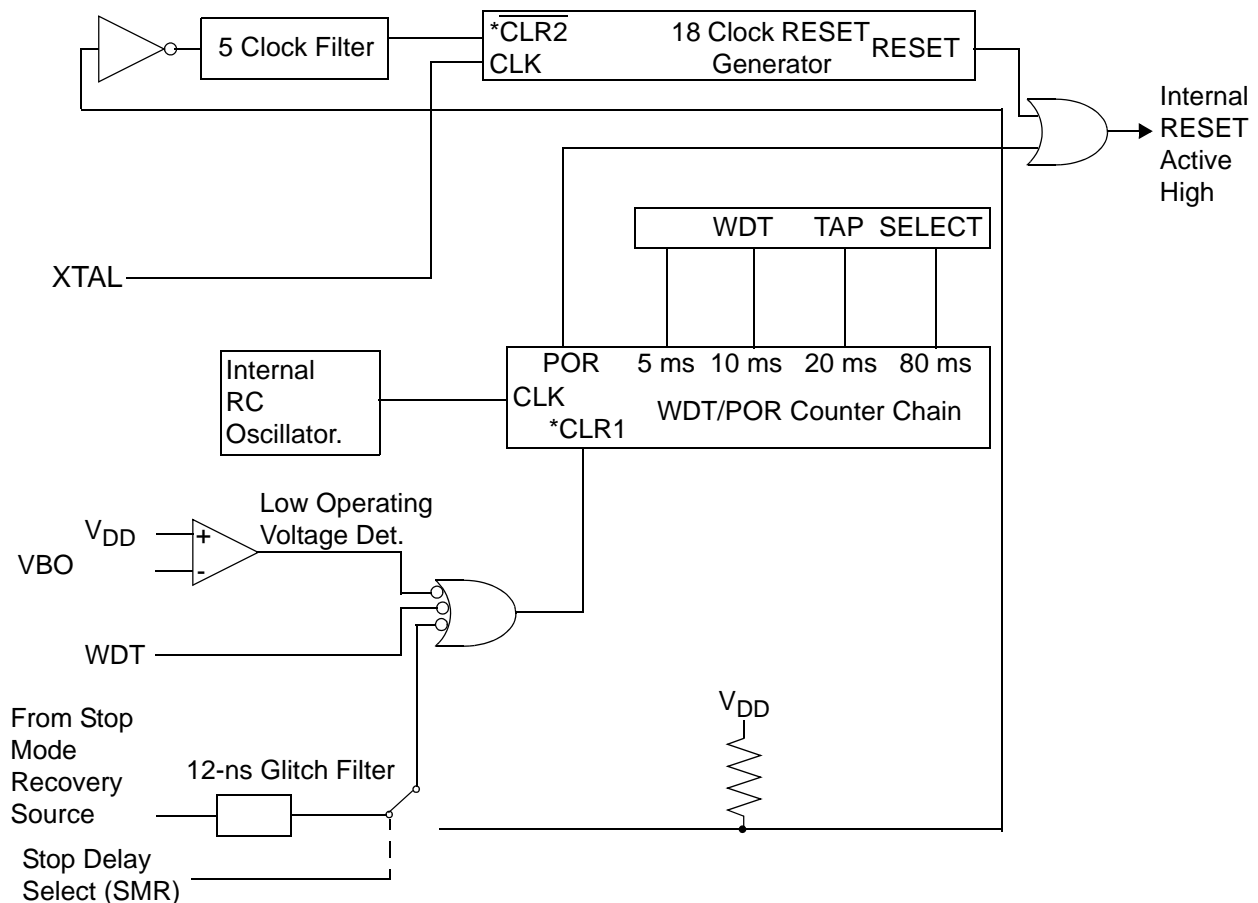
This bit selects the WDT time period. It is configured as indicated in Table 20.

**Table 20. Watch-Dog Timer Time Select**

D1	D0	Timeout of Internal RC-Oscillator
0	0	5ms min.
0	1	10ms min.
1	0	20ms min.
1	1	80ms min.

**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 38.



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

**Figure 38. 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.

### EPROM Selectable Options

There are seven EPROM Selectable Options to choose from based on ROM code requirements. These options are listed in Table 21.

**Table 21. EPROM Selectable Options**

Port 00–03 Pull-Ups	On/Off
Port 04–07 Pull-Ups	On/Off
Port 10–13 Pull-Ups	On/Off
Port 14–17 Pull-Ups	On/Off
Port 20–27 Pull-Ups	On/Off
EPROM Protection	On/Off
Watch-Dog Timer at Power-On Reset	On/Off

### Voltage Brown-Out/Standby

An on-chip Voltage Comparator checks that the  $V_{DD}$  is at the required level for correct operation of the device. Reset is globally driven when  $V_{DD}$  falls below  $V_{BO}$ . A small drop in  $V_{DD}$  causes the XTAL1 and XTAL2 circuitry to stop the crystal or resonator clock. If the  $V_{DD}$  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 Register—LVD(D)0Ch

- **Note:** Voltage detection does not work at Stop mode. It must be disabled during Stop mode in order to reduce current.

Field	Bit Position			Description
LVD	76543---			Reserved No Effect
	----2--	R	1 0*	HVD flag set HVD flag reset
	-----1-	R	1 0*	LVD flag set LVD flag reset
	-----0	R/W	1 0*	Enable VD Disable VD

\*Default after POR

- **Note:** Do not modify register P01M while checking a low-voltage condition. Switching noise of both ports 0 and 1 together might trigger the LVD flag.

### Voltage Detection and Flags

The Voltage Detection register (LVD, register 0Ch at the expanded register bank 0Dh) offers an option of monitoring the  $V_{CC}$  voltage. The Voltage Detection is enabled when bit 0 of LVD register is set. Once Voltage Detection is enabled, the  $V_{CC}$  level is monitored in real time. The flags in the LVD register valid 20 $\mu$ s after Voltage Detection is enabled. The HVD flag (bit 2 of the LVD register) is set only if  $V_{CC}$  is higher than  $V_{HVD}$ . The LVD flag (bit 1 of the LVD register) is set only if  $V_{CC}$  is lower than the  $V_{LVD}$ . When Voltage Detection is enabled, the LVD flag also triggers IRQ5. The IRQ bit 5 latches the low voltage condition until it is cleared by instructions or reset. The IRQ5 interrupt is served if it is enabled in the IMR register. Otherwise, bit 5 of IRQ register is latched as a flag only.

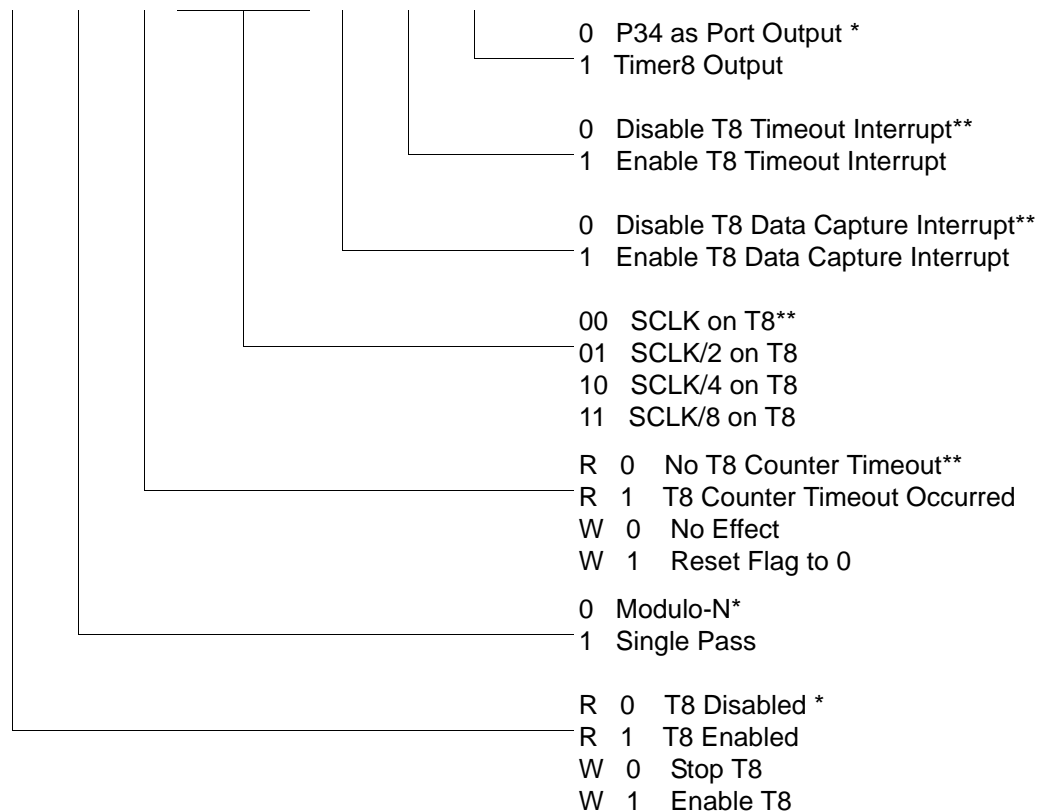
- **Notes:** If it is necessary to receive an LVD interrupt upon power-up at an operating voltage lower than the low battery detect threshold, enable interrupts using the Enable Interrupt instruction (EI) prior to enabling the voltage detection.

## Expanded Register File Control Registers (0D)

The expanded register file control registers (0D) are depicted in Figure 39 through Figure 43.

CTR0(0D)00H

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



\* Default setting after reset

\*\*Default setting after reset. Not reset with Stop Mode recovery.

Figure 39. TC8 Control Register ((0D)00H: Read/Write Except Where Noted)



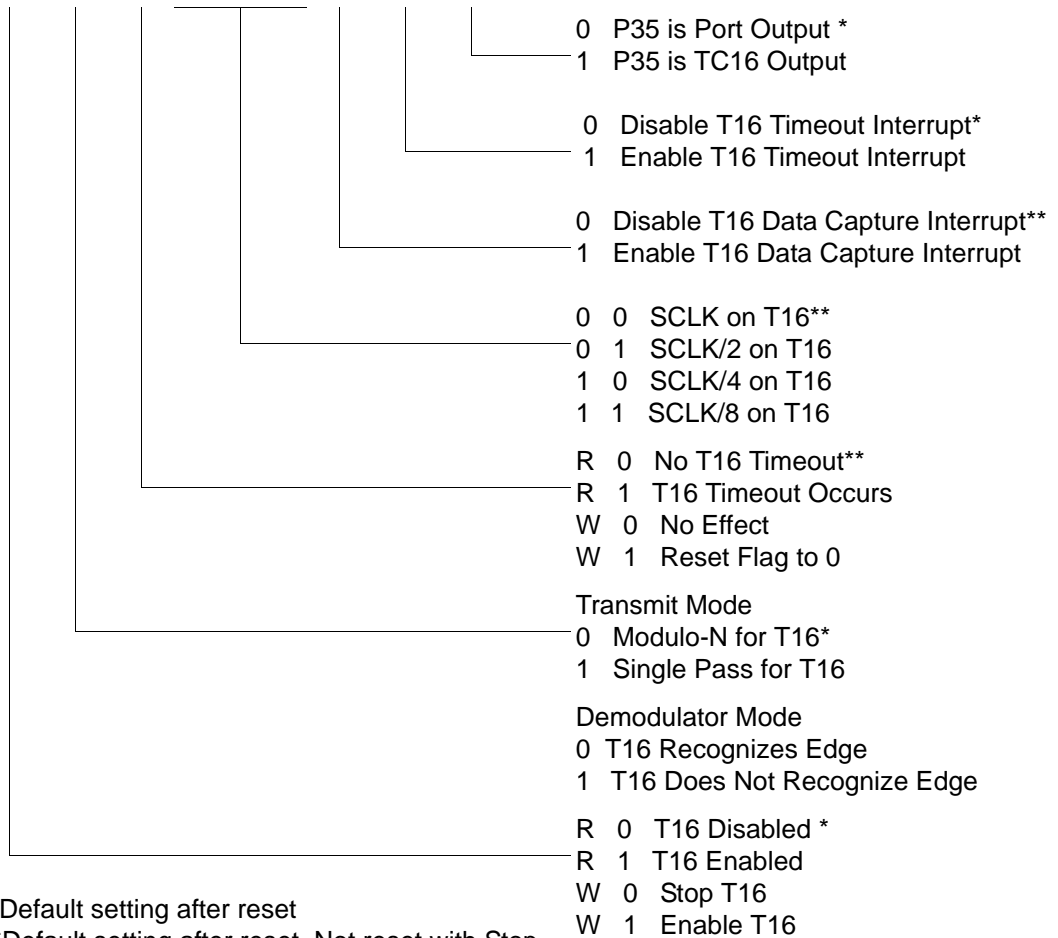
- ▶ **Notes:** Take care in differentiating the Transmit Mode from Demodulation Mode. Depending on which of these two modes is operating, the CTR1 bit has different functions.

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



CTR2(0D)02H

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



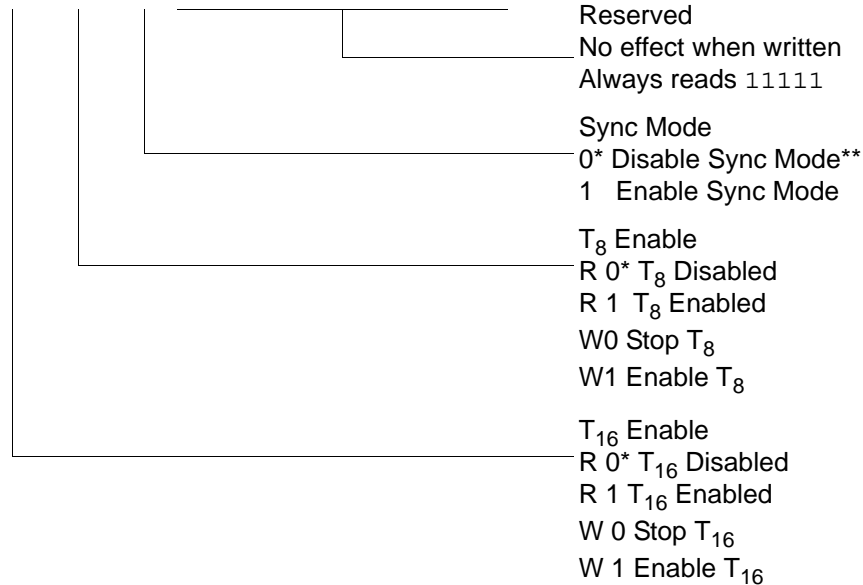
\* Default setting after reset

\*\*Default setting after reset. Not reset with Stop Mode recovery.

**Figure 41. T16 Control Register ((0D) 2H: Read/Write Except Where Noted)**

CTR3(0D)03H

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



\* Default setting after reset.

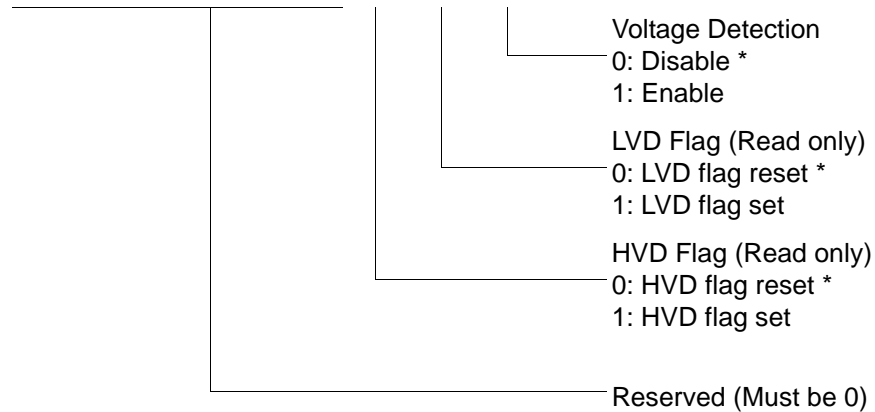
\*\* Default setting after reset. Not reset with Stop Mode recovery.

**Figure 42. T8/T16 Control Register (0D)03H: Read/Write (Except Where Noted)**

► **Note:** If Sync Mode is enabled, the first pulse of T8 carrier is always synchronized with T16 (demodulated signal). It can always provide a full carrier pulse.

LVD(0D)0CH

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



\* Default

**Figure 43. Voltage Detection Register**

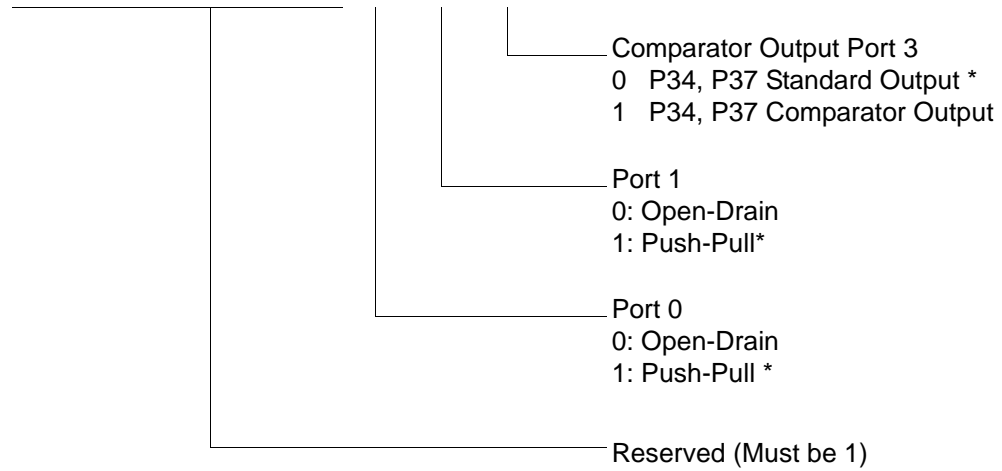
- **Note:** Do not modify register P01M while checking a low-voltage condition. Switching noise of both ports 0 and 1 together might trigger the LVD flag.

## Expanded Register File Control Registers (0F)

The expanded register file control registers (0F) are depicted in Figures 44 through Figure 57.

PCON(0F)00H

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



\* Default setting after reset

**Figure 44. Port Configuration Register (PCON)(0F)00H: Write Only)**

SMR(0F)0BH

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

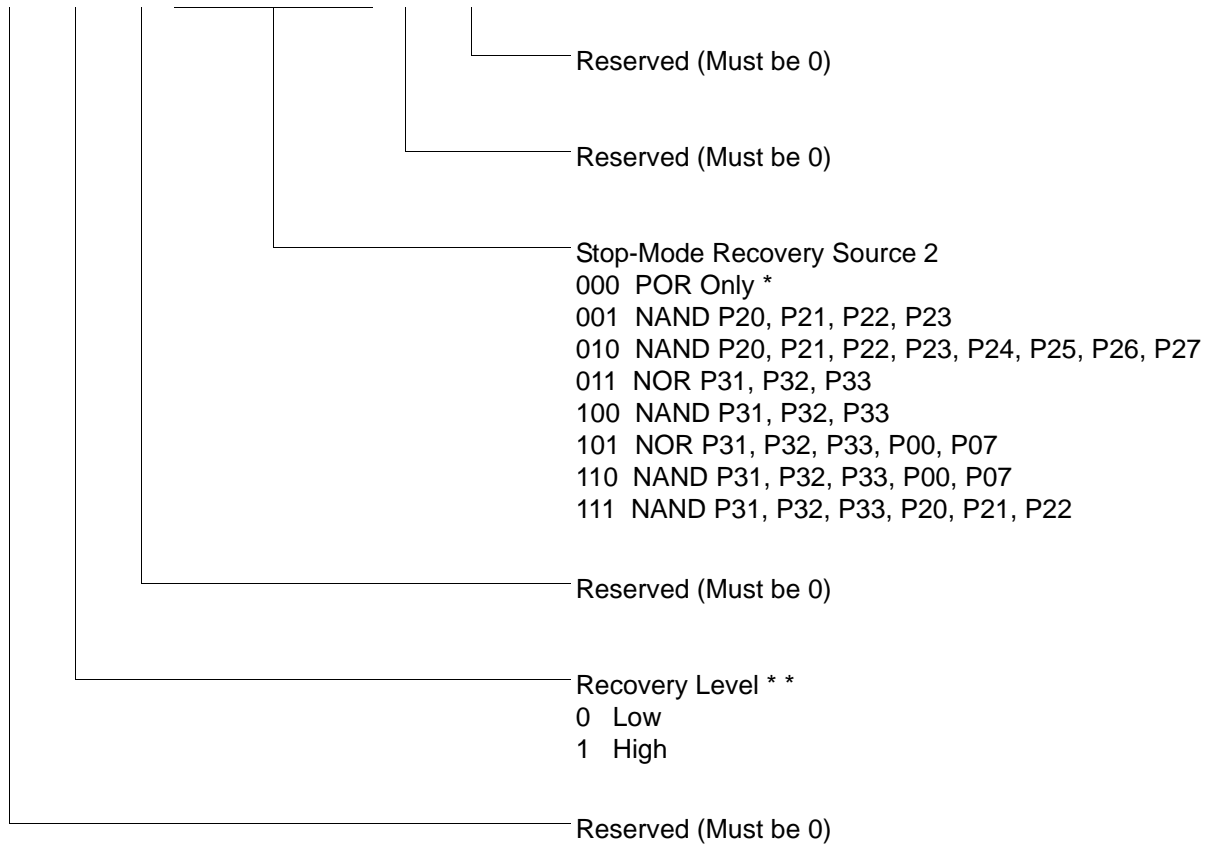


- \* Default setting after Reset
- \*\* Set after STOP Mode Recovery
- \*\*\* At the XOR gate input
- \*\*\*\* Default setting after Reset. Must be 1 if using a crystal or resonator clock source.
- \*\*\*\*\* Default setting after Power On Reset. Not Reset with a Stop Mode recovery.

**Figure 45. Stop Mode Recovery Register ((0F)0BH: D6–D0=Write Only, D7=Read Only)**

SMR2(0F)0DH

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.

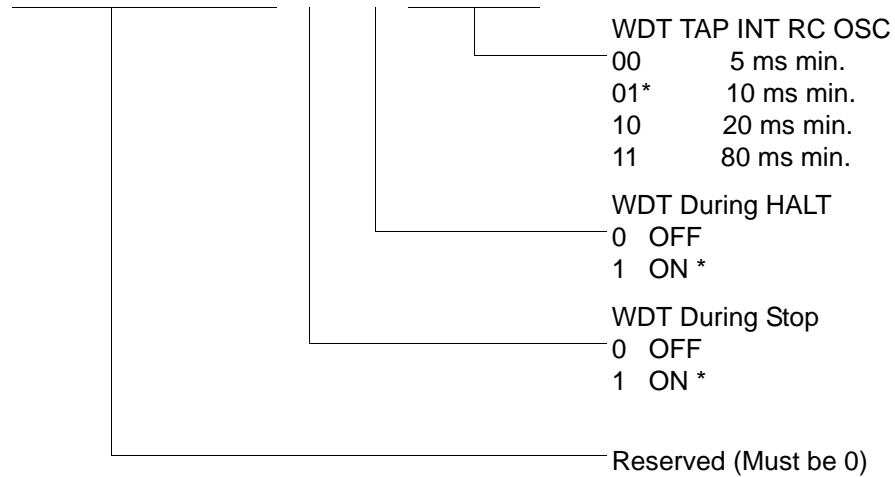
\* Default setting after reset

\*\* At the XOR gate input

Figure 46. Stop Mode Recovery Register 2 ((0F)0DH:D2–D4, D6 Write Only)

WDTMR(0F)0FH

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



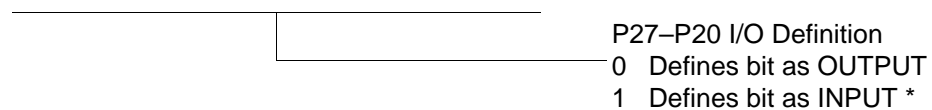
\* Default setting after reset

Figure 47. Watch-Dog Timer Register ((0F) 0FH: Write Only)

## Standard Control Registers

R246 P2M(F6H)

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

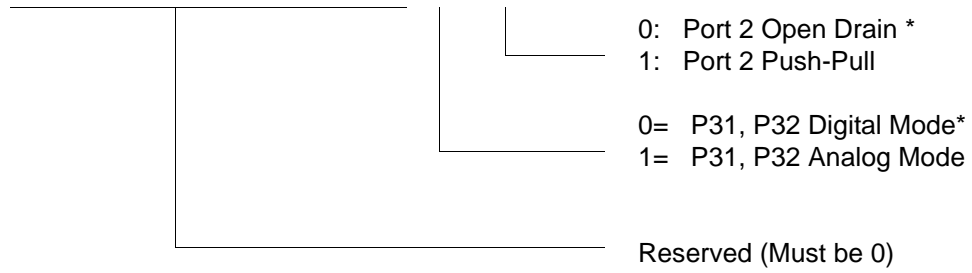


\* Default setting after reset

Figure 48. Port 2 Mode Register (F6H: Write Only)

R247 P3M(F7H)

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



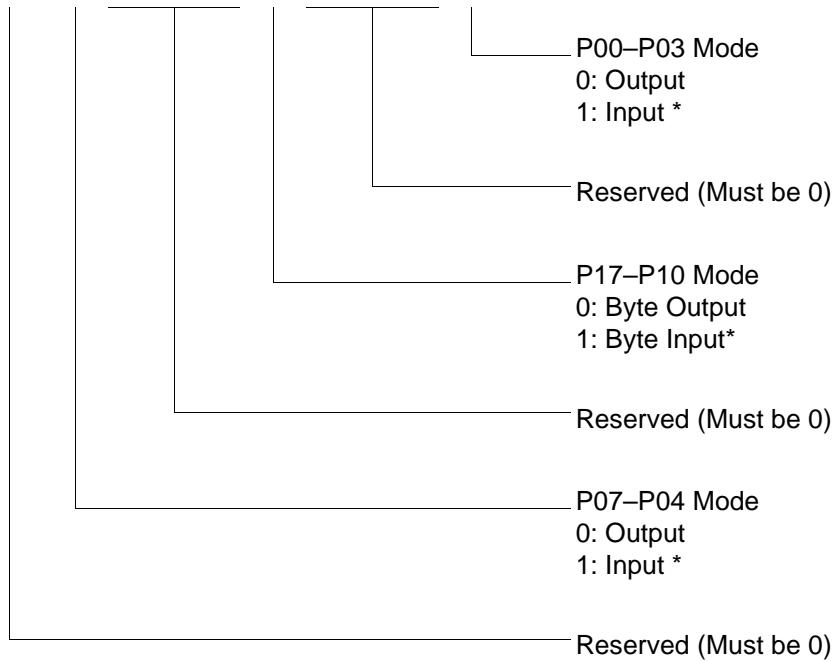
\* Default setting after reset. Not reset with Stop Mode recovery.

**Figure 49. Port 3 Mode Register (F7H: Write Only)**



R248 P01M(F8H)

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



\* Default setting after reset; only P00, P01 and P07 are available in 20-pin configurations.

**Figure 50. Port 0 and 1 Mode Register (F8H: Write Only)**

R249 IPR(F9H)

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

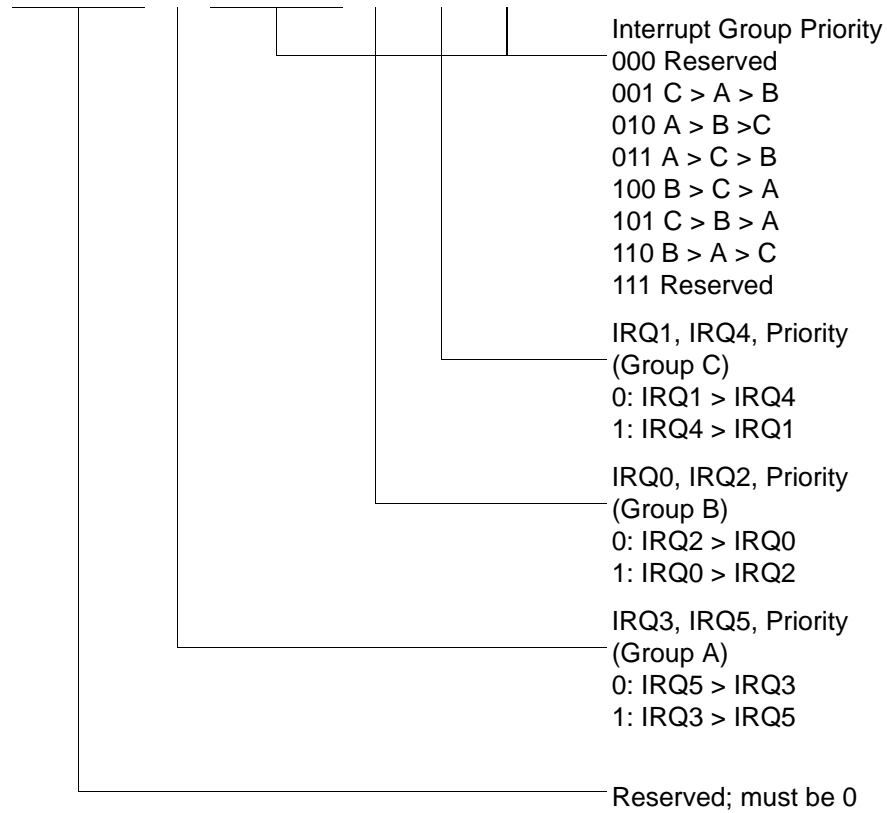


Figure 51. Interrupt Priority Register (F9H: Write Only)

R250 IRQ(FAH)

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

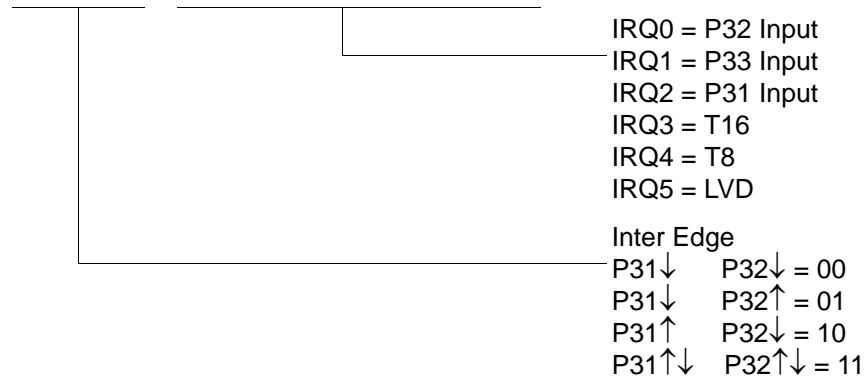
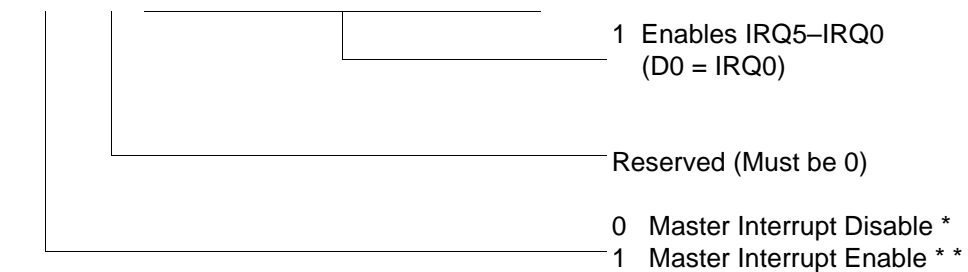


Figure 52. Interrupt Request Register (FAH: Read/Write)

R251 IMR(FBH)

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

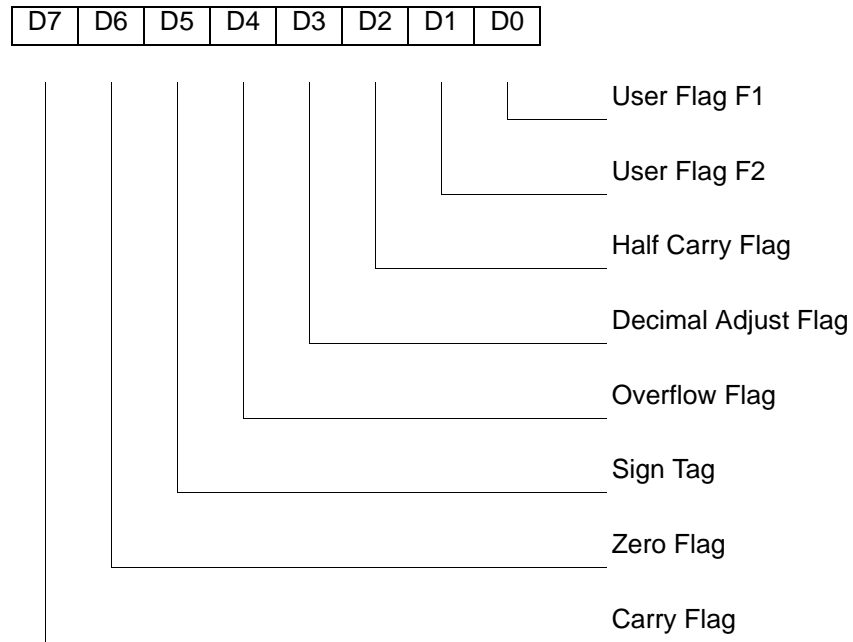


\* Default setting after reset

\*\* Only by using EI, DI instruction; DI is required before changing the IMR register

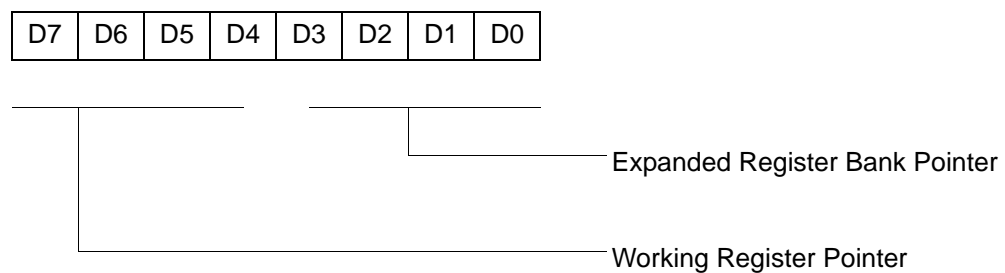
Figure 53. Interrupt Mask Register (FBH: Read/Write)

R252 Flags(FCH)



**Figure 54. Flag Register (FCH: Read/Write)**

R253 RP(FDH)



Default setting after reset = 0000 0000

**Figure 55. Register Pointer (FDH: Read/Write)**

R254 SPH(FEH)

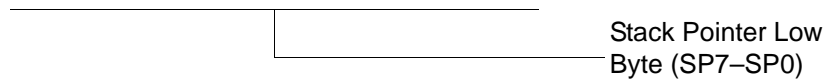
D7	D6	D5	D4	D3	D2	D1	D0
----	----	----	----	----	----	----	----



**Figure 56. Stack Pointer High (FEH: Read/Write)**

R255 SPL(FFH)

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



**Figure 57. Stack Pointer Low (FFH: Read/Write)**

## Package Information

Package information for all versions of Z8 GP™ OTP MCU Family are depicted in Figures 58 through Figure 68.

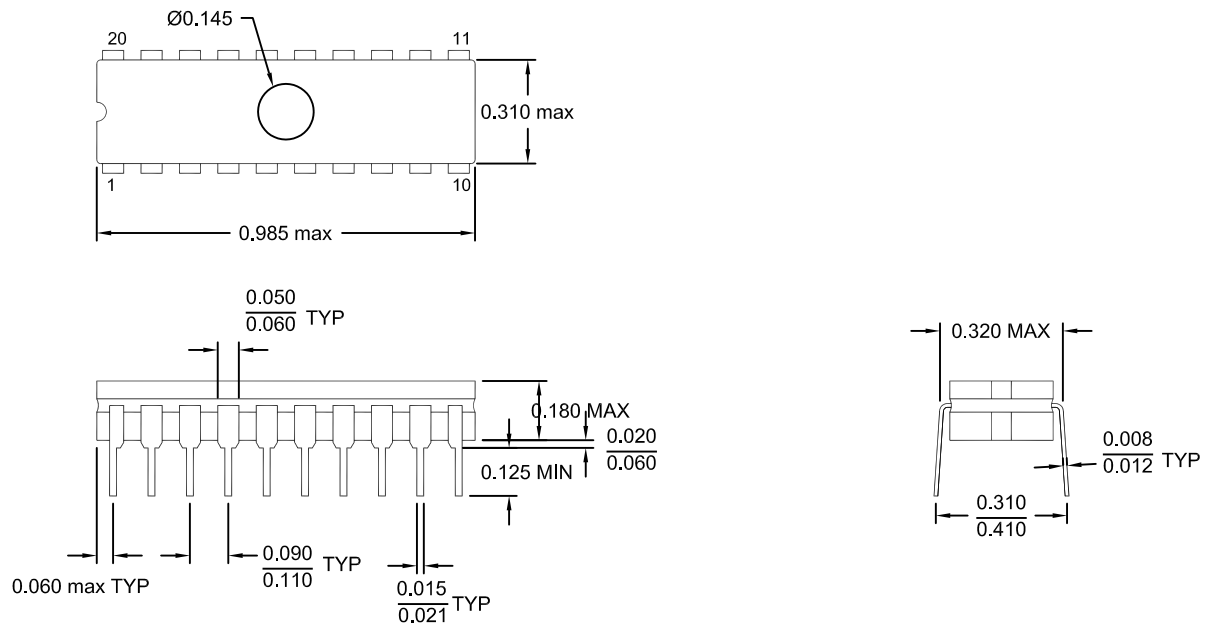
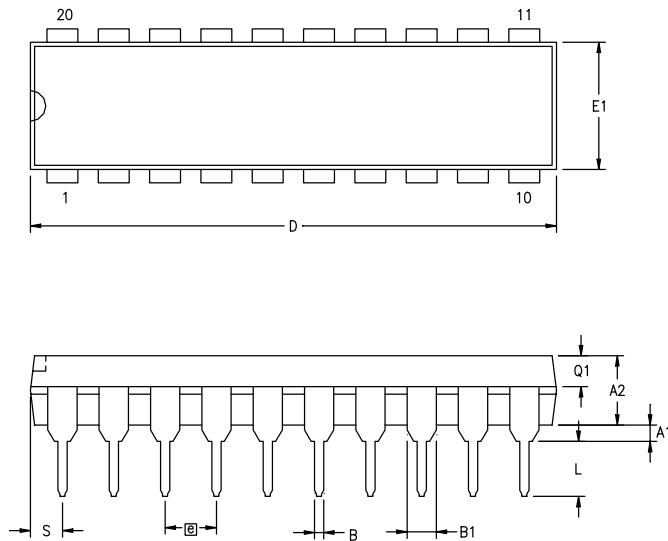


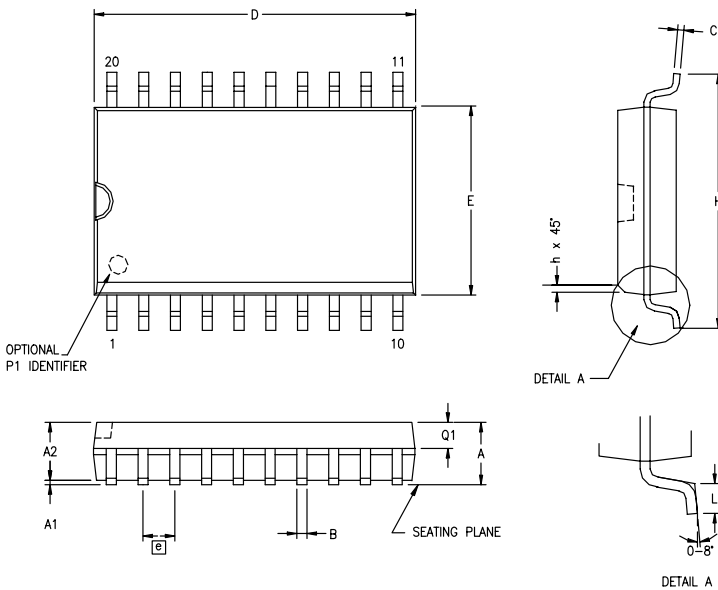
Figure 58. 20-Pin CDIP Package



SYMBOL	MILLIMETER		INCH	
	MIN	MAX	MIN	MAX
A1	0.38	0.81	.015	.032
A2	3.25	3.68	.128	.145
B	0.41	0.51	.016	.020
B1	1.47	1.57	.058	.062
C	0.20	0.30	.008	.012
D	25.65	26.16	1.010	1.030
E	7.49	8.26	.295	.325
E1	6.10	6.65	.240	.262
ⓐ	2.54 BSC		.100 BSC	
eA	7.87	9.14	.310	.360
L	3.18	3.43	.125	.135
Q1	1.42	1.65	.056	.065
S	1.52	1.65	.060	.065

CONTROLLING DIMENSIONS : INCH

Figure 59. 20-Pin PDIP Package Diagram



SYMBOL	MILLIMETER		INCH	
	MIN	MAX	MIN	MAX
A	2.40	2.65	.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	12.60	12.95	.496	.510
E	7.40	7.60	.291	.299
ⓐ	1.27 BSC		.050 BSC	
H	10.00	10.65	.394	.419
h	0.30	0.40	.012	.016
L	0.60	1.00	.024	.039
Q1	0.97	1.07	.038	.042

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

Figure 60. 20-Pin SOIC Package Diagram

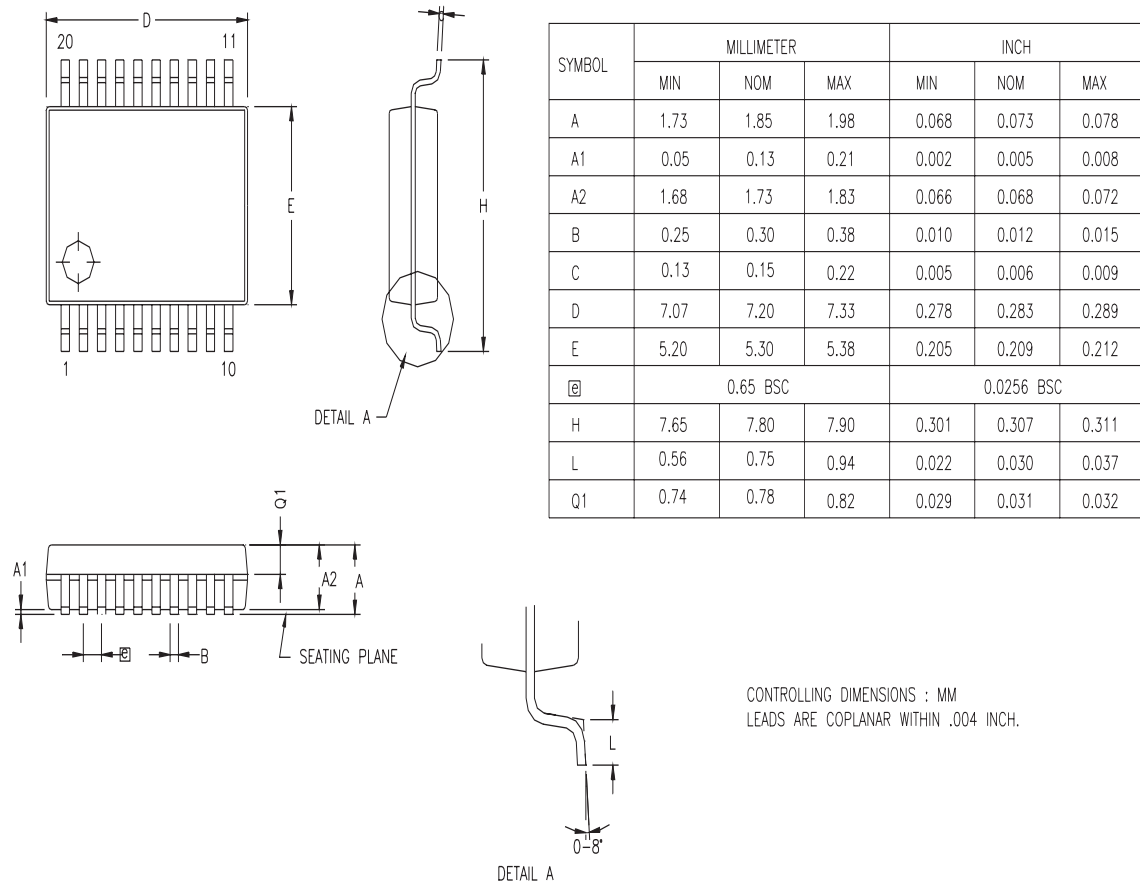


Figure 61. 20-Pin SSOP Package Diagram



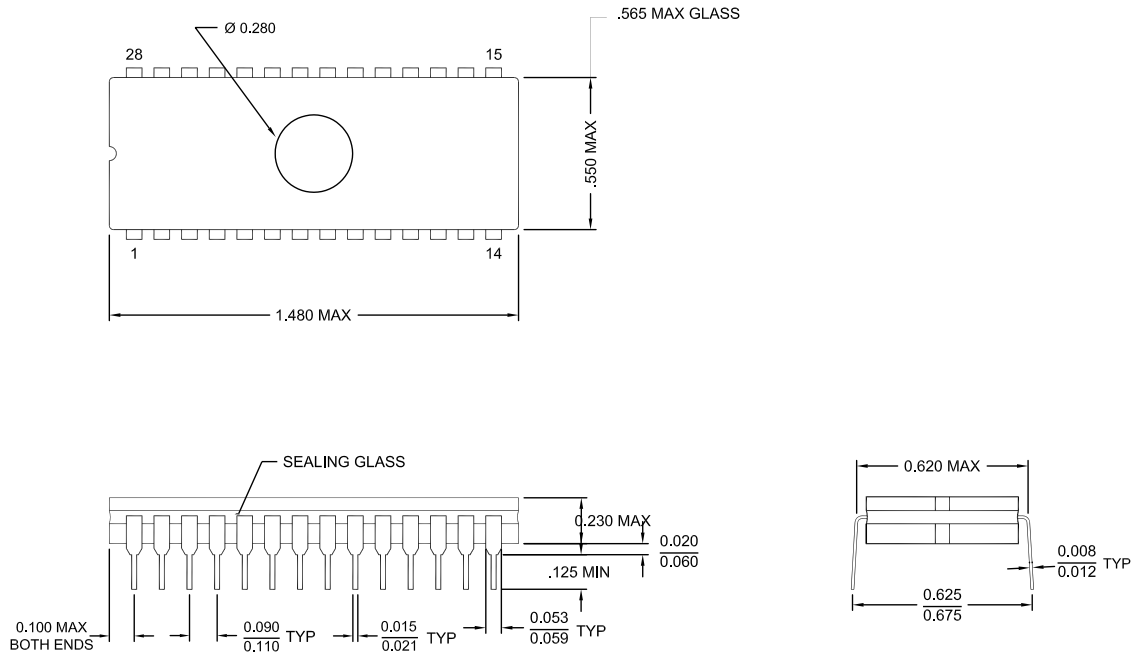
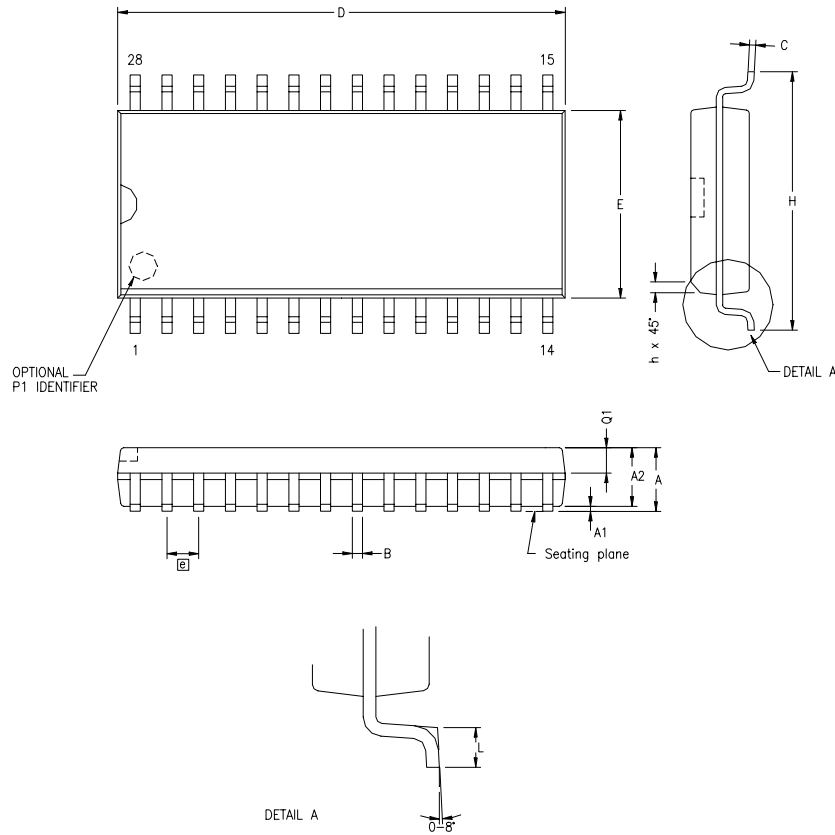


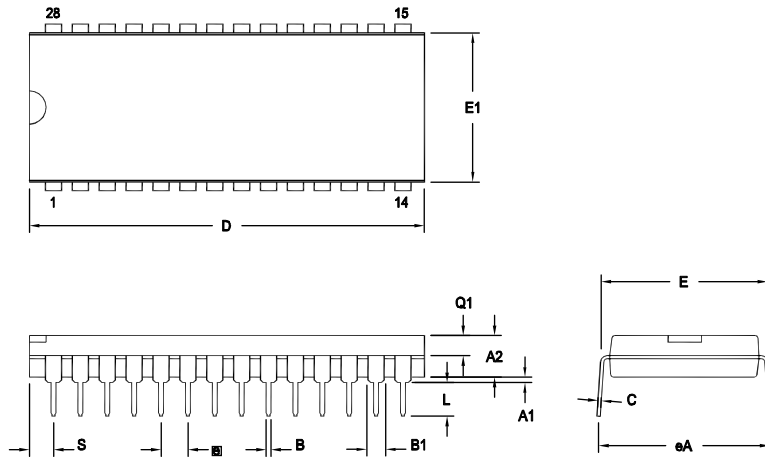
Figure 62. 28-Pin CDIP Package



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
ⓐ	1.27 BSC		.050 BSC	
H	10.00	10.65	.394	.419
h	0.30	0.71	.012	.028
L	0.61	1.00	.024	.039
Q1	0.97	1.09	.038	.043

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

Figure 63. 28-Pin SOIC Package Diagram



OPTION TABLE	
OPTION #	PACKAGE
01	STANDARD
02	IDF

Note: ZILOG supplies both options for production. Component layout PCB design should cover bigger option 01.

Figure 64. 28-Pin PDIP Package Diagram

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 BSC	
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

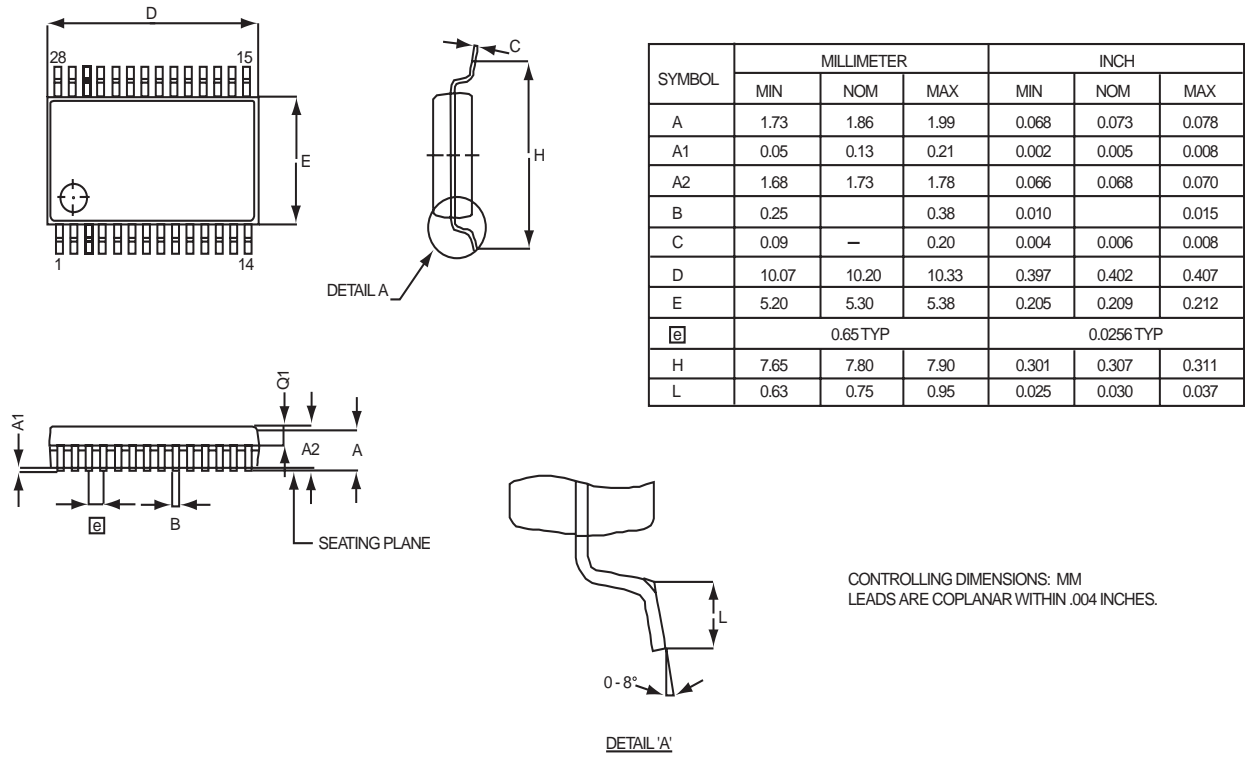


Figure 65. 28-Pin SSOP Package Diagram

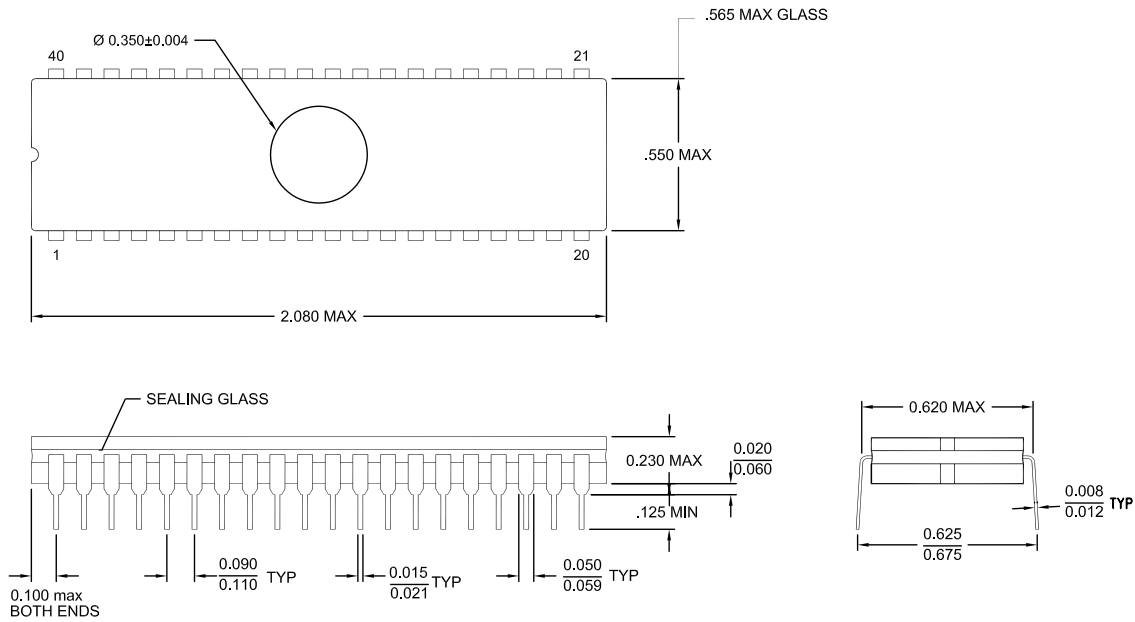


Figure 66. 40-Pin CDIP Package

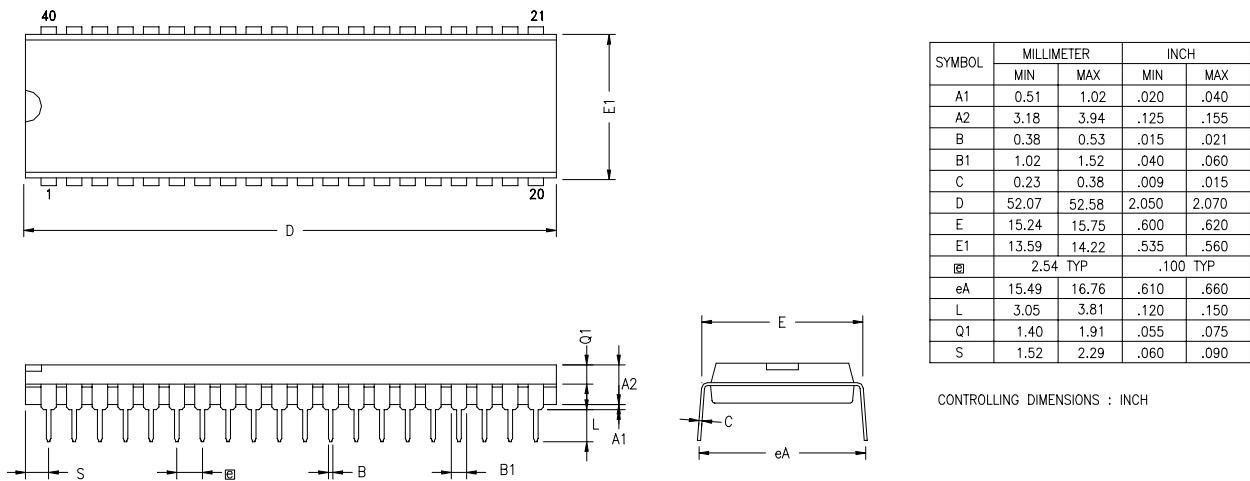
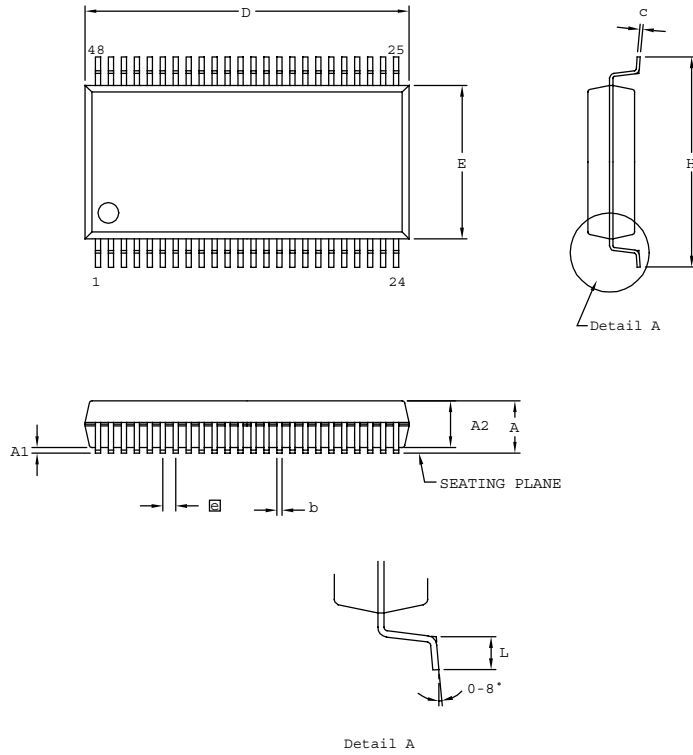


Figure 67. 40-Pin PDIP Package Diagram



SYMBOL	MILLIMETER		INCH	
	MIN	MAX	MIN	MAX
A	2.41	2.79	0.095	0.110
A1	0.23	0.38	0.009	0.015
A2	2.18	2.39	0.086	0.094
b	0.20	0.34	0.008	0.0135
c	0.13	0.25	0.005	0.010
D	15.75	16.00	0.620	0.630
E	7.39	7.59	0.291	0.299
ⓐ	0.635 BSC		0.025 BSC	
H	10.16	10.41	0.400	0.410
L	0.51	1.016	0.020	0.040

CONTROLLING DIMENSIONS : MM  
LEADS ARE COPLANAR WITHIN .004 INCH

Figure 68. 48-Pin SSOP Package Design

- **Note:** Check with ZiLOG on the actual bonding diagram and coordinate for chip-on-board assembly.

## Ordering Information

<b>32KB Standard Temperature: 0° to +70°C</b>			
<b>Part Number</b>	<b>Description</b>	<b>Part Number</b>	<b>Description</b>
ZGP323LSH4832C	48-pin SSOP 32K OTP	ZGP323LSS2832C	28-pin SOIC 32K OTP
ZGP323LSP4032C	40-pin PDIP 32K OTP	ZGP323LSH2032C	20-pin SSOP 32K OTP
ZGP323LSH2832C	28-pin SSOP 32K OTP	ZGP323LSP2032C	20-pin PDIP 32K OTP
ZGP323LSP2832C	28-pin PDIP 32K OTP	ZGP323LSS2032C	20-pin SOIC 32K OTP
ZGP323LSK2032E	20-pin CDIP 32K OTP	ZGP323LSK4032E	40-pin CDIP 32K OTP
		ZGP323LSK2832E	28-pin CDIP 32K OTP

<b>32KB Extended Temperature: -40° to +105°C</b>			
<b>Part Number</b>	<b>Description</b>	<b>Part Number</b>	<b>Description</b>
ZGP323LEH4832C	48-pin SSOP 32K OTP	ZGP323LES2832C	28-pin SOIC 32K OTP
ZGP323LEP4032C	40-pin PDIP 32K OTP	ZGP323LEH2032C	20-pin SSOP 32K OTP
ZGP323LEH2832C	28-pin SSOP 32K OTP	ZGP323LEP2032C	20-pin PDIP 32K OTP
ZGP323LEP2832C	28-pin PDIP 32K OTP	ZGP323LES2032C	20-pin SOIC 32K OTP

<b>32KB Automotive Temperature: -40° to +125°C</b>			
<b>Part Number</b>	<b>Description</b>	<b>Part Number</b>	<b>Description</b>
ZGP323LAH4832C	48-pin SSOP 32K OTP	ZGP323LAS2832C	28-pin SOIC 32K OTP
ZGP323LAP4032C	40-pin PDIP 32K OTP	ZGP323LAH2032C	20-pin SSOP 32K OTP
ZGP323LAH2832C	28-pin SSOP 32K OTP	ZGP323LAP2032C	20-pin PDIP 32K OTP
ZGP323LAP2832C	28-pin PDIP 32K OTP	ZGP323LAS2032C	20-pin SOIC 32K OTP

Note: Replace C with G for Lead-Free Packaging

**16KB Standard Temperature: 0° to +70°C**

Part Number	Description	Part Number	Description
ZGP323LSH4816C	48-pin SSOP 16K OTP	ZGP323LSS2816C	28-pin SOIC 16K OTP
ZGP323LSP4016C	40-pin PDIP 16K OTP	ZGP323LSH2016C	20-pin SSOP 16K OTP
ZGP323LSH2816C	28-pin SSOP 16K OTP	ZGP323LSP2016C	20-pin PDIP 16K OTP
ZGP323LSP2816C	28-pin PDIP 16K OTP	ZGP323LSS2016C	20-pin SOIC 16K OTP

**16KB Extended Temperature: -40° to +105°C**

Part Number	Description	Part Number	Description
ZGP323LEH4816C	48-pin SSOP 16K OTP	ZGP323LES2816C	28-pin SOIC 16K OTP
ZGP323LEP4016C	40-pin PDIP 16K OTP	ZGP323LES2016C	20-pin SOIC 16K OTP
ZGP323LEH2816C	28-pin SSOP 16K OTP	ZGP323LEH2016C	20-pin SSOP 16K OTP
ZGP323LEP2816C	28-pin PDIP 16K OTP	ZGP323LEP2016C	20-pin PDIP 16K OTP

**16KB Automotive Temperature: -40° to +125°C**

Part Number	Description	Part Number	Description
ZGP323LAH4816C	48-pin SSOP 16K OTP	ZGP323LAS2816C	28-pin SOIC 16K OTP
ZGP323LAP4016C	40-pin PDIP 16K OTP	ZGP323LAH2016C	20-pin SSOP 16K OTP
ZGP323LAH2816C	28-pin SSOP 16K OTP	ZGP323LAP2016C	20-pin PDIP 16K OTP
ZGP323LAP2816C	28-pin PDIP 16K OTP	ZGP323LAS2016C	20-pin SOIC 16K OTP

Note: Replace C with G for Lead-Free Packaging



**8KB Standard Temperature: 0° to +70°C**

Part Number	Description	Part Number	Description
ZGP323LSH4808C	48-pin SSOP 8K OTP	ZGP323LSS2808C	28-pin SOIC 8K OTP
ZGP323LSP4008C	40-pin PDIP 8K OTP	ZGP323LSH2008C	20-pin SSOP 8K OTP
ZGP323LSH2808C	28-pin SSOP 8K OTP	ZGP323LSP2008C	20-pin PDIP 8K OTP
ZGP323LSP2808C	28-pin PDIP 8K OTP	ZGP323LSS2008C	20-pin SOIC 8K OTP

**8KB Extended Temperature: -40° to +105°C**

Part Number	Description	Part Number	Description
ZGP323LEH4808C	48-pin SSOP 8K OTP	ZGP323LES2808C	28-pin SOIC 8K OTP
ZGP323LEP4008C	40-pin PDIP 8K OTP	ZGP323LEH2008C	20-pin SSOP 8K OTP
ZGP323LEH2808C	28-pin SSOP 8K OTP	ZGP323LEP2008C	20-pin PDIP 8K OTP
ZGP323LEP2808C	28-pin PDIP 8K OTP	ZGP323LES2008C	20-pin SOIC 8K OTP

**8KB Automotive Temperature: -40° to +125°C**

Part Number	Description	Part Number	Description
ZGP323LAH4808C	48-pin SSOP 8K OTP	ZGP323LAS2808C	28-pin SOIC 8K OTP
ZGP323LAP4008C	40-pin PDIP 8K OTP	ZGP323LAH2008C	20-pin SSOP 8K OTP
ZGP323LAH2808C	28-pin SSOP 8K OTP	ZGP323LAP2008C	20-pin PDIP 8K OTP
ZGP323LAP2808C	28-pin PDIP 8K OTP	ZGP323LAS2008C	20-pin SOIC 8K OTP

Note: Replace C with G for Lead-Free Packaging

**4KB Standard Temperature: 0° to +70°C**

Part Number	Description	Part Number	Description
ZGP323LSH4804C	48-pin SSOP 4K OTP	ZGP323LSS2804C	28-pin SOIC 4K OTP
ZGP323LSP4004C	40-pin PDIP 4K OTP	ZGP323LSH2004C	20-pin SSOP 4K OTP
ZGP323LSH2804C	28-pin SSOP 4K OTP	ZGP323LSP2004C	20-pin PDIP 4K OTP
ZGP323LSP2804C	28-pin PDIP 4K OTP	ZGP323LSS2004C	20-pin SOIC 4K OTP

**4KB Extended Temperature: -40° to +105°C**

Part Number	Description	Part Number	Description
ZGP323LEH4804C	48-pin SSOP 4K OTP	ZGP323LES2804C	28-pin SOIC 4K OTP
ZGP323LEP4004C	40-pin PDIP 4K OTP	ZGP323LEH2004C	20-pin SSOP 4K OTP
ZGP323LEH2804C	28-pin SSOP 4K OTP	ZGP323LEP2004C	20-pin PDIP 4K OTP
ZGP323LEP2804C	28-pin PDIP 4K OTP	ZGP323LES2004C	20-pin SOIC 4K OTP

**4KB Automotive Temperature: -40° to +125°C**

Part Number	Description	Part Number	Description
ZGP323LAH4804C	48-pin SSOP 4K OTP	ZGP323LAS2804C	28-pin SOIC 4K OTP
ZGP323LAP4004C	40-pin PDIP 4K OTP	ZGP323LAH2004C	20-pin SSOP 4K OTP
ZGP323LAH2804C	28-pin SSOP 4K OTP	ZGP323LAP2004C	20-pin PDIP 4K OTP
ZGP323LAP2804C	28-pin PDIP 4K OTP	ZGP323LAS2004C	20-pin SOIC 4K OTP

Note: Replace C with G for Lead-Free Packaging

**Additional Components**

Part Number	Description	Part Number	Description
ZGP323ICE01ZEM	Emulator/programmer	ZGP32300100ZPR	Programming System

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

**Codes**

ZG = ZiLOG General Purpose Family

P = OTP

323 = Family Designation

L = Voltage Range

2V to 3.6V

T = Temperature Range:

S = 0 to 70 degrees C (Standard)

E = -40 to +105 degrees C (Extended)

A = -40 to +125 degrees C (Automotive)

P = Package Type:

K = Windowed Cerdip

P = PDIP

H = SSOP

S = SOIC

## = Number of Pins

CC = Memory Size

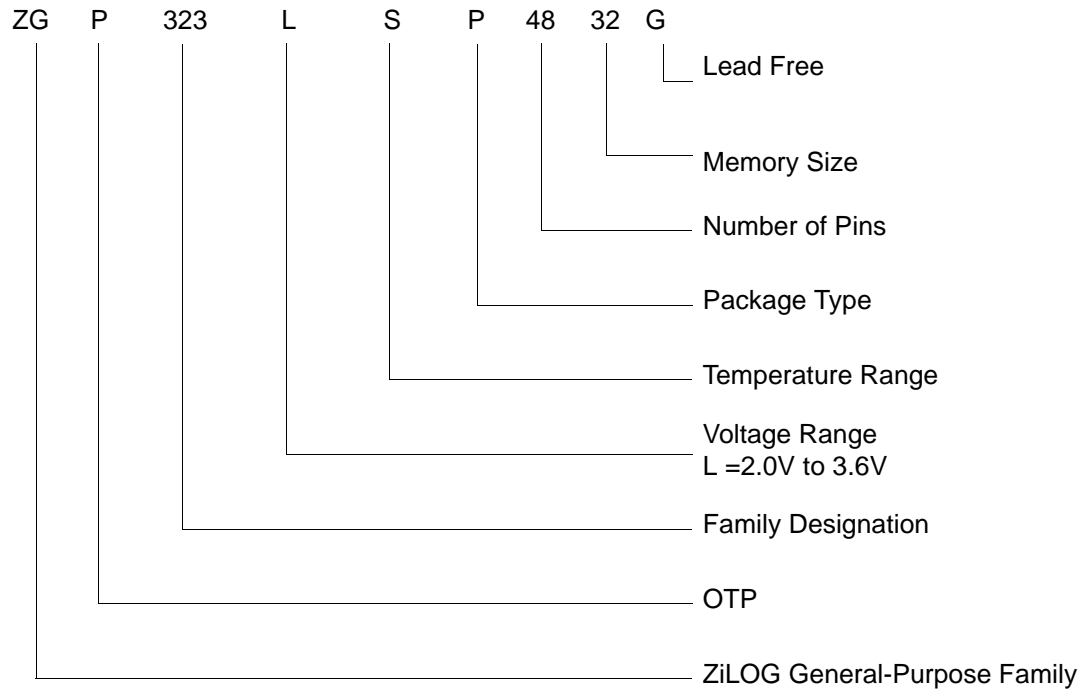
M = Packaging Options

C = Non Lead-Free

G = Lead-Free

E = CDIP

**Example**



## Precharacterization Product

The product represented by this document is newly introduced and ZiLOG has not completed the full characterization of the product. The document states what ZiLOG knows about this product at this time, but additional features or nonconformance with some aspects of the document might be found, either by ZiLOG or its customers in the course of further application and characterization work. In addition, ZiLOG cautions that delivery might be uncertain at times, due to start-up yield issues.

ZiLOG, Inc.

532 Race Street

San Jose, CA 95126-3432

Telephone: (408) 558-8500

FAX: 408 558-8300

Internet: <http://www.ZiLOG.com>

# Index

## Numerics

16-bit counter/timer circuits 44  
20-pin DIP package diagram 81  
20-pin SSOP package diagram 82  
28-pin DIP package diagram 85  
28-pin SOIC package diagram 84  
28-pin SSOP package diagram 86  
40-pin DIP package diagram 87  
48-pin SSOP package diagram 88  
8-bit counter/timer circuits 40

## A

absolute maximum ratings 10  
AC  
    characteristics 14  
    timing diagram 14  
address spaces, basic 2  
architecture 2  
    expanded register file 26

## B

basic address spaces 2  
block diagram, ZLP32300 functional 3

## C

capacitance 11  
characteristics  
    AC 14  
    DC 11  
clock 51  
comparator inputs/outputs 23  
configuration  
    port 0 17  
    port 1 18  
    port 2 19  
    port 3 20  
    port 3 counter/timer 22

counter/timer  
    16-bit circuits 44  
    8-bit circuits 40  
brown-out voltage/standby 62  
clock 51  
demodulation mode count capture flowchart 42  
demodulation mode flowchart 43  
EPROM selectable options 62  
glitch filter circuitry 38  
halt instruction 52  
input circuit 38  
interrupt block diagram 49  
interrupt types, sources and vectors 50  
oscillator configuration 51  
output circuit 47  
ping-pong mode 46  
port configuration register 53  
resets and WDT 61  
SCLK circuit 56  
stop instruction 52  
stop mode recovery register 55  
stop mode recovery register 2 59  
stop mode recovery source 57  
T16 demodulation mode 45  
T16 transmit mode 44  
T16\_OUT in modulo-N mode 45  
T16\_OUT in single-pass mode 45  
T8 demodulation mode 41  
T8 transmit mode 38  
T8\_OUT in modulo-N mode 41  
T8\_OUT in single-pass mode 41  
transmit mode flowchart 39  
voltage detection and flags 63  
watch-dog timer mode register 60  
watch-dog timer time select 61  
CTR(D)01h T8 and T16 Common Functions 33

## D

- DC characteristics 11
- demodulation mode
  - count capture flowchart 42
  - flowchart 43
  - T16 45
  - T8 41
- description
  - functional 23
  - general 2
  - pin 4

## E

- EPROM
  - selectable options 62
- expanded register file 24
- expanded register file architecture 26
- expanded register file control registers 69
  - flag 78
  - interrupt mask register 77
  - interrupt priority register 76
  - interrupt request register 77
  - port 0 and 1 mode register 75
  - port 2 configuration register 73
  - port 3 mode register 74
  - port configuration register 73
  - register pointer 78
  - stack pointer high register 79
  - stack pointer low register 79
  - stop-mode recovery register 71
  - stop-mode recovery register 2 72
  - T16 control register 67
  - T8 and T16 common control functions register 65
  - T8/T16 control register 68
  - TC8 control register 64
  - watch-dog timer register 73

## F

- features
  - standby modes 1

## functional description

- counter/timer functional blocks 38
- CTR(D)01h register 33
- CTR0(D)00h register 31
- CTR2(D)02h register 35
- CTR3(D)03h register 37
- expanded register file 24
- expanded register file architecture 26
- HI16(D)09h register 30
- HI8(D)0Bh register 30
- L08(D)0Ah register 30
- L016(D)08h register 30
- program memory map 24
- RAM 23
- register description 63
- register file 28
- register pointer 27
- register pointer detail 29
- SMR2(F)0D1h register 38
- stack 29
- TC16H(D)07h register 30
- TC16L(D)06h register 31
- TC8H(D)05h register 31
- TC8L(D)04h register 31

## G

- glitch filter circuitry 38

## H

- halt instruction, counter/timer 52

## I

- input circuit 38
- interrupt block diagram, counter/timer 49
- interrupt types, sources and vectors 50

## L

- low-voltage detection register 63

## M

memory, program 23  
modulo-N mode  
    T16\_OUT 45  
    T8\_OUT 41

## O

oscillator configuration 51  
output circuit, counter/timer 47

## P

package information  
    20-pin DIP package diagram 81  
    20-pin SSOP package diagram 82  
    28-pin DIP package diagram 85  
    28-pin SOIC package diagram 84  
    28-pin SSOP package diagram 86  
    40-pin DIP package diagram 87  
    48-pin SSOP package diagram 88  
pin configuration  
    20-pin DIP/SOIC/SSOP 5  
    28-pin DIP/SOIC/SSOP 6  
    40- and 48-pin 8  
    40-pin DIP 7  
    48-pin SSOP 8  
pin functions  
    port 0 (P07 - P00) 16  
    port 0 (P17 - P10) 17  
    port 0 configuration 17  
    port 1 configuration 18  
    port 2 (P27 - P20) 18  
    port 2 (P37 - P30) 19  
    port 2 configuration 19  
    port 3 configuration 20  
    port 3 counter/timer configuration 22  
    reset) 23  
    XTAL1 (time-based input 16  
    XTAL2 (time-based output) 16  
ping-pong mode 46  
port 0 configuration 17  
port 0 pin function 16

port 1 configuration 18  
port 1 pin function 17  
port 2 configuration 19  
port 2 pin function 18  
port 3 configuration 20  
port 3 pin function 19  
port 3counter/timer configuration 22  
port configuration register 53  
power connections 3  
power supply 5  
precharacterization product 95  
program memory 23  
    map 24

## R

ratings, absolute maximum 10  
register 59  
    CTR(D)01h 33  
    CTR0(D)00h 31  
    CTR2(D)02h 35  
    CTR3(D)03h 37  
    flag 78  
    HI16(D)09h 30  
    HI8(D)0Bh 30  
    interrupt priority 76  
    interrupt request 77  
    interruptmask 77  
    L016(D)08h 30  
    L08(D)0Ah 30  
    LVD(D)0Ch 63  
    pointer 78  
    port 0 and 1 75  
    port 2 configuration 73  
    port 3 mode 74  
    port configuration 53, 73  
    SMR2(F)0Dh 38  
    stack pointer high 79  
    stack pointer low 79  
    stop mode recovery 55  
    stop mode recovery 2 59  
    stop-mode recovery 71  
    stop-mode recovery 2 72  
    T16 control 67



- T8 and T16 common control functions 65
- T8/T16 control 68
- TC16H(D)07h 30
- TC16L(D)06h 31
- TC8 control 64
- TC8H(D)05h 31
- TC8L(D)04h 31
- voltage detection 69
- watch-dog timer 73
- register description
  - Counter/Timer2 LS-Byte Hold 31
  - Counter/Timer2 MS-Byte Hold 30
  - Counter/Timer8 Control 31
  - Counter/Timer8 High Hold 31
  - Counter/Timer8 Low Hold 31
  - CTR2 Counter/Timer 16 Control 35
  - CTR3 T8/T16 Control 37
  - Stop Mode Recovery2 38
  - T16\_Capture\_LO 30
  - T8 and T16 Common functions 33
  - T8\_Capture\_HI 30
  - T8\_Capture\_LO 30
- register file 28
  - expanded 24
- register pointer 27
  - detail 29
- reset pin function 23
- resets and WDT 61

## S

- SCLK circuit 56
- single-pass mode
  - T16\_OUT 45
  - T8\_OUT 41
- stack 29
- standard test conditions 10
- standby modes 1
- stop instruction, counter/timer 52
- stop mode recovery
  - 2 register 59
  - source 57
- stop mode recovery 2 59
- stop mode recovery register 55

## T

- T16 transmit mode 44
- T16\_Capture\_HI 30
- T8 transmit mode 38
- T8\_Capture\_HI 30
- test conditions, standard 10
- test load diagram 10
- timing diagram, AC 14
- transmit mode flowchart 39

## V

- VCC 5
- voltage
  - brown-out/standby 62
  - detection and flags 63
- voltage detection register 69

## W

- watch-dog timer
  - mode registerwatch-dog timer mode register 60
  - time select 61

## X

- XTAL1 5
- XTAL1 pin function 16
- XTAL2 5
- XTAL2 pin function 16