

32K Flash Embedded 8-Bit MCU

GMS99C58

DATA SHEET

Jun. 2001

Ver 1.02



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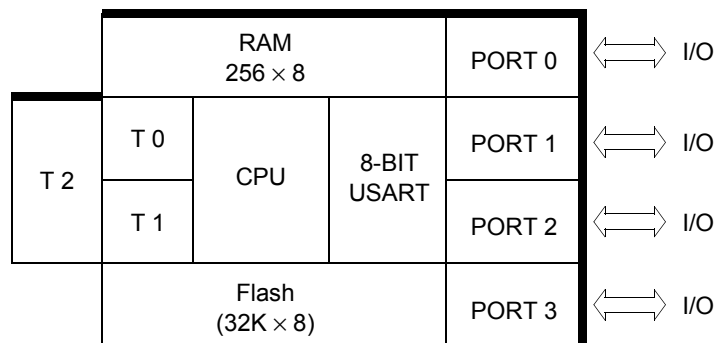
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GMS99C58

(32K Flash Embedded 8-Bit MCU)

Chapter 1. Overview

- Fully compatible to standard 8051 micro controller
- 4.5V to 5.5V operating range
- Versions for 12/24 MHz operating frequency
- 32K × 8Bit Flash (Endurance: 100 Write/Erase Cycles)
- 256 × 8Bit RAM
- Four 8 Bit ports
- Three 16-bit Timers / Counters (Timer 2 with Up/Down Counter feature)
- USART
- Six interrupt sources, two priority levels
- Power Saving Modes
- 40-PDIP, 44- PLCC and 44-MQFP package
- Temperature ranges : T = 0 °C ~ 70 °C

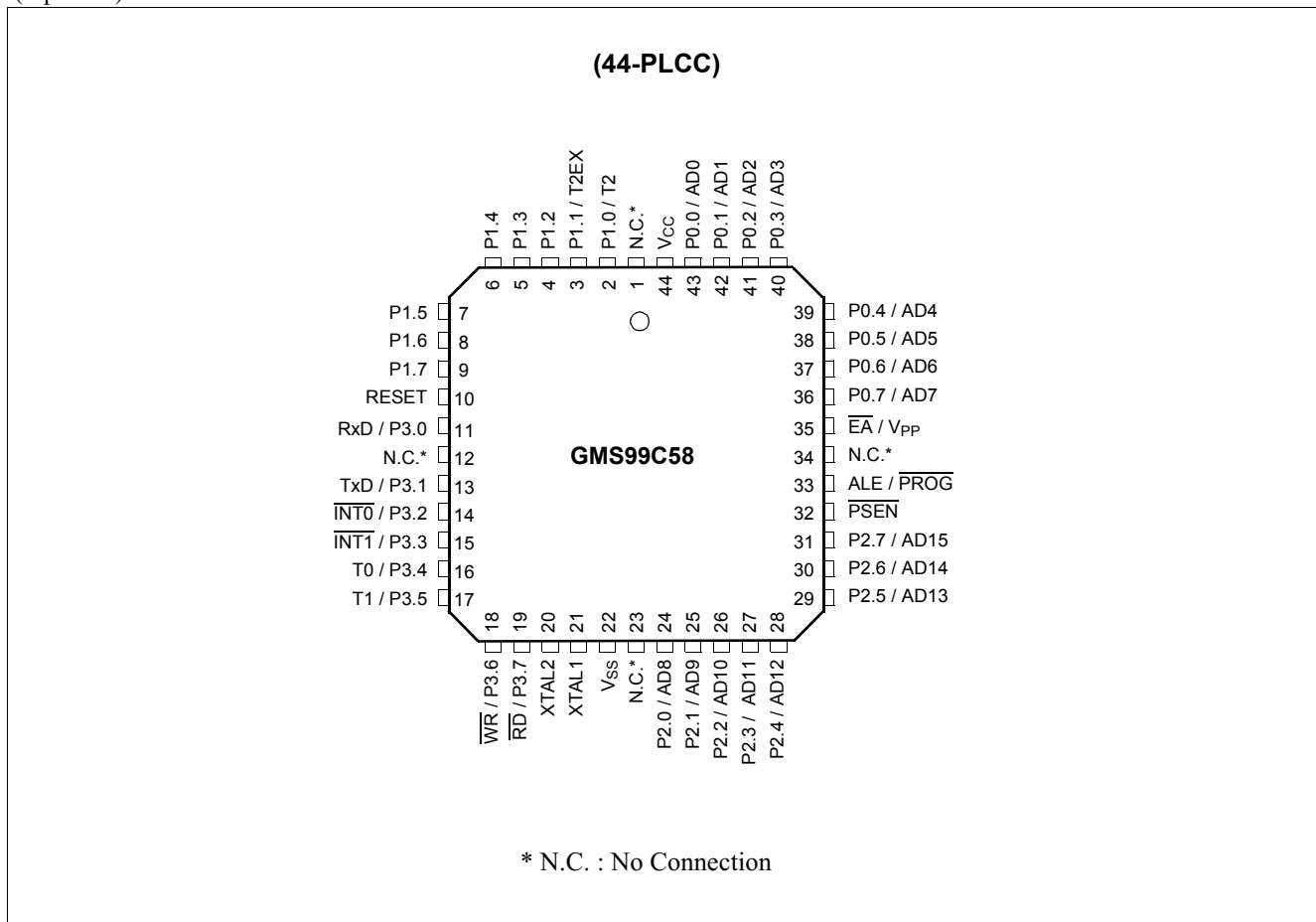


1.1 Ordering Information

TYPE	Package	Description
GMS99C58 GMS99C58-PL GMS99C58-Q	40 PDIP 44 PLCC 44 MQFP	with 12 MHz
GMS99C58-24 GMS99C58-PL-24 GMS99C58-Q-24	40 PDIP 44 PLCC 44 MQFP	with 24 MHz

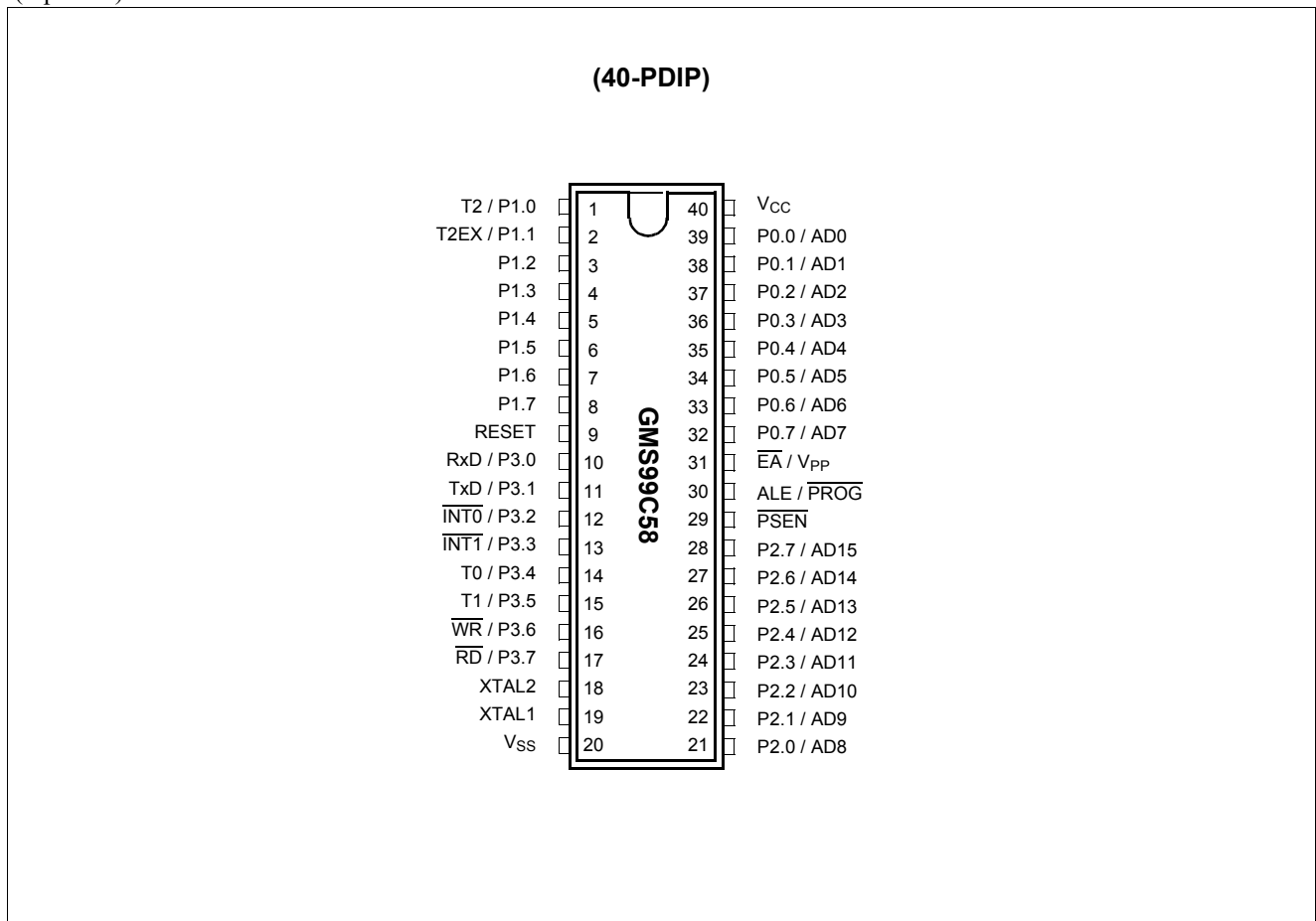
1.2 Pin Configuration of 44 PLCC Type

(top view)



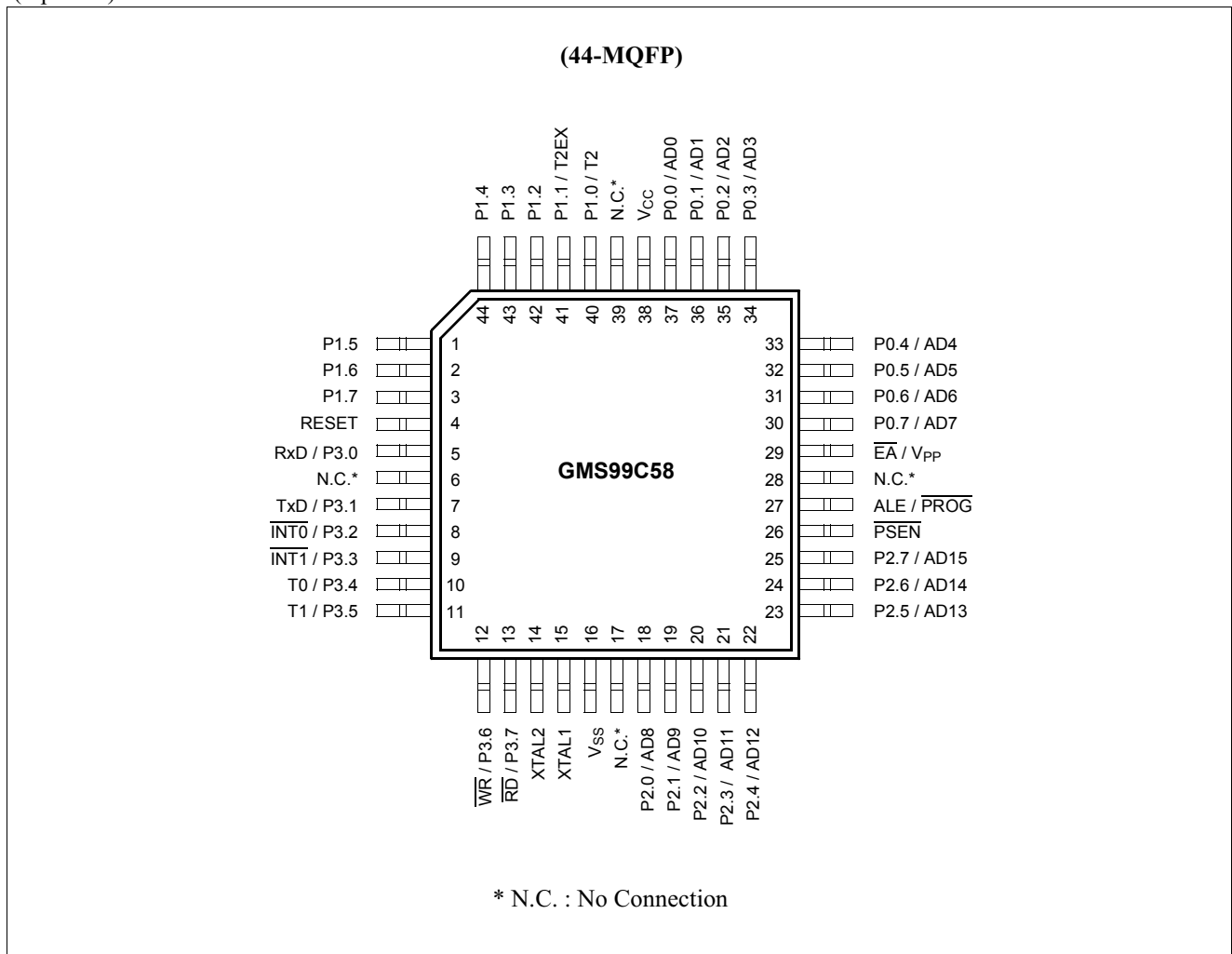
1.3 Pin Configuration of 40-PDIP Type

(top view)

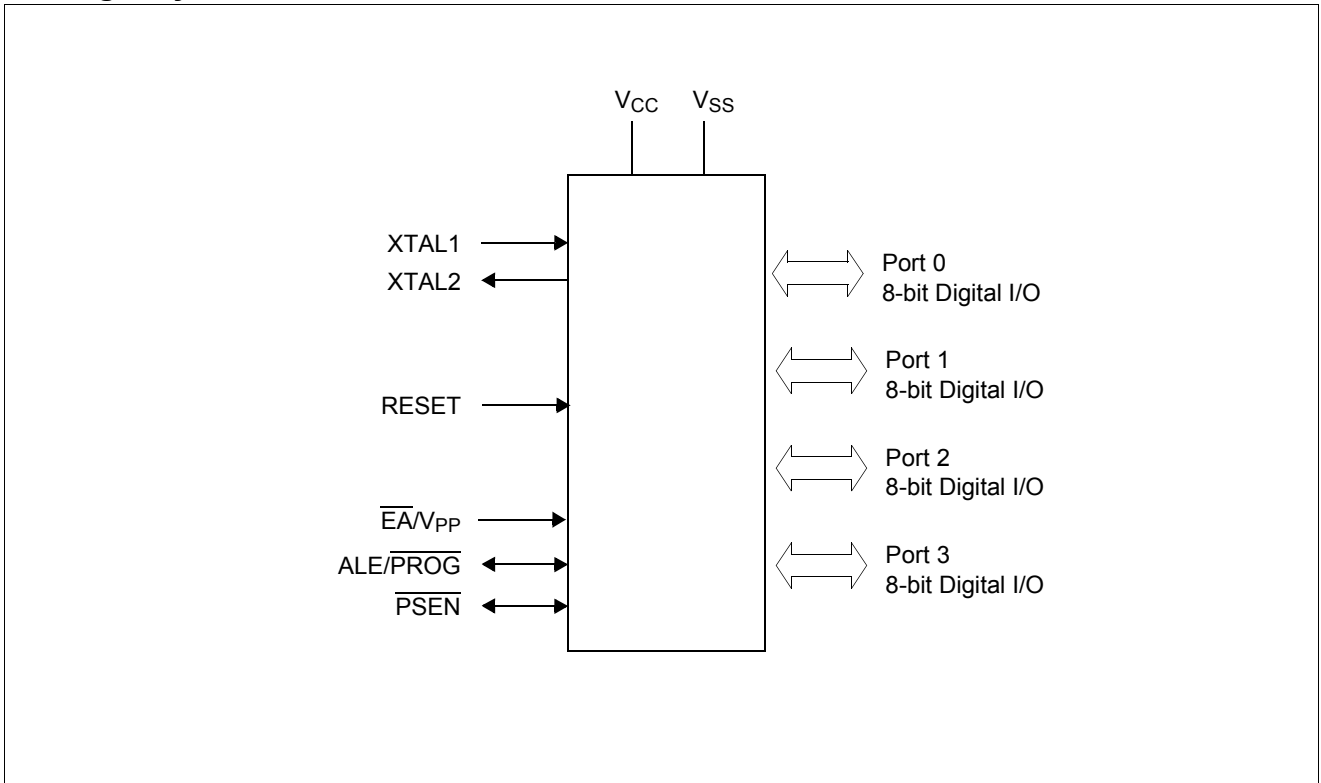


1.4 Pin Configuration of 44-MQFP Type

(top view)



1.5 Logic Symbol



1.6 PIN DEFINITIONS AND FUNCTIONS

Symbol	Pin Number			Input/ Output	Function
	44- PLCC	40- PDIP	44- MQFP		
P1.0-P1.7	2-9 2 3	1-8 1 2	40-44, 1-3 40 41	I/O	<p>Port 1: Port1 is an 8-bit bidirectional I/O port with internal pullups. The Port 1 output buffers can drive LS TTL inputs. Port 1 pins that have '1' written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 1 pins that are externally pulled low will source current (IIL, on the data sheet) because of the internal pull-ups. In addition, Port 1 serves the functions of the following</p> <p>P1.0 : T2 (External Count Input to Timer/ Counter 2), Clock-Out</p> <p>P1.1 : T2EX (Timer/Counter 2 Capture/ Reload Trigger and Direction Control</p> <p>Port 1 receives the low-order address bytes during Flash programming and verifying.</p>
P3.0-P3.7	11, 13-19 11 13 14 15 16 17 18 19	10-17 10 11 12 13 14 15 16 17	5, 7-13 5 7 8 9 10 11 12 13	I/O	<p>Port 3 : Port 3 is an 8-bit bidirectional I/O port with internal pullups. The Port 3 output buffers can drive LS TTL inputs. Port 3 pins that have '1' written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 3 pins that are externally pulled low will source current (IIL, on the data sheet) because of the pullups. Port 3 also serves the functions of various special features of the 8051 Family, as listed below:</p> <p>P3.0 : RXD(serial input port) P3.1 : TXD(serial output port) P3.2 : $\overline{\text{INT0}}$(external interrupt 0) P3.3 : $\overline{\text{INT1}}$(external interrupt 1) P3.4 : T0(Timer 0 external input) & also receives the MSB address byte during flash program, verify, and erase memory algorithm P3.5 : T1(Timer 1 external input) P3.6 : $\overline{\text{WR}}$(external data memory write strobe) P3.7 : $\overline{\text{RD}}$(external data memory read strobe)</p>
XTAL2	20	18	14	O	XTAL2 Output of the inverting oscillator amplifier.
XTAL1	21	19	15	I	XTAL1 : Input to the inverting oscillator amplifier.

Symbol	Pin Number			Input/ Output	Function
	44- PLCC	40- PDIP	44- MQFP		
P2.0-P2.7	24-31	21-28	18-25	I/O	<p>Port 2 : Port 2 is an 8-bit bidirectional I/O port with internal pullups. The Port 2 output buffers can drive LS TTL inputs. Port 2 pins that have '1' written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 2 pins that are externally pulled low will source current (IIL, on the data sheet) because of the internal pullups.</p> <p>Port 2 emits the high-order address byte during fetches from external Program Memory and during accesses to external Data Memory that use 16-bit addresses (MOVX @DPTR). In this application it uses strong internal pullups when emitting '1'. During accesses to external Data Memory that use 8-bit addresses (MOVX @Ri), Port 2 emits the contents of the P2 Special Function Register.</p> <p>Some Port 2 pins receive the high-order address bits during flash program, verify, and erase memory algorithm</p>
$\overline{\text{PSEN}}$	32	29	26	O	<p>$\overline{\text{PSEN}}$: Program Store Enable is the read strobe to external Program Memory.</p> <p>When the executing code from external Program Memory, $\overline{\text{PSEN}}$ is activated twice each machine cycle, except that two $\overline{\text{PSEN}}$ activations are skipped during each access to external Data Memory.</p>
RESET	10	9	4	I	<p>RST : Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device. The port pins will be driven to their reset condition when a minimum VIH1 voltage is applied whether the oscillator is running or not. An internal pulldown resistor permits a power-on reset with only a capacitor connected to VCC.</p>
$\overline{\text{ALE}} / \overline{\text{PROG}}$	33	30	27	O	<p>ALE : Address Latch Enable output pulse for latching the low byte of the address during accesses to external memory. This pin ($\overline{\text{ALE}} / \overline{\text{PROG}}$) is also the program pulse input during Flash programming.</p> <p>In normal operation ALE is emitted at a constant rate of 1/6 the oscillator frequency, and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external Data Memory.</p> <p>With this bit set, the pin is weakly pulled high.</p> <p>The ALE disable feature will be terminated by reset. Setting the ALE-disable bit has no affect if the microcontroller is in external execution mode.</p> <p>Throughout the remainder of this data sheet, $\overline{\text{ALE}}$ will refer to the signal coming out of the $\overline{\text{ALE}} / \overline{\text{PROG}}$ pin, and the pin will be referred to as the $\overline{\text{ALE}} / \overline{\text{PROG}}$ pin.</p>

Symbol	Pin Number			Input/ Output	Function
	44- PLCC	40- PDIP	44- MQFP		
\overline{EA} / V_{PP}	35	31	29	I	<p>\overline{EA}/V_{PP} : External Access enable. \overline{EA} must be strapped to VSS in order to enable the device to fetch code from external Program Memory locations 00000H to 0FFFFH. Note; however, that if any of the Lock bits are programmed, \overline{EA} will be internally latched on reset.</p> <p>\overline{EA} should be strapped to VCC for internal program executions.</p> <p>This pin also receives the programming supply voltage (VPP) during Flash programming and erase.</p>
P0.0-P0.7	36-43	32-39	30-37	I/O	<p>Port0 : Port 0 is an 8-bit, open drain, bidirectional I/O port. As an output port each pin can sink several LS TTL inputs. Port 0 pins that have '1' written to then float, and in that state can be used as high impedance inputs.</p> <p>Port 0 is also the multiplexed low-order address and data bus during accesses to external Program and Data Memory. In this application it uses strong internal pullups when emitting '1'. and can source and sink several LS TTL inputs.</p> <p>Port 0 also receives the code bytes during Flash programming, and outputs the code bytes during program verification.</p> <p>External pullup resistors are required during program verification.</p>
V _{SS}	22	20	16	-	Circuit ground potential
V _{CC}	44	40	38	-	Supply terminal for all operating modes
N.C.	1,12 23,34	-	6,17 28,39	-	No connection

Chapter 2. FUNCTIONAL DESCRIPTION

The GMS99C58 (8-Bit MCU) is fully compatible to the standard 8051 microcontroller family.

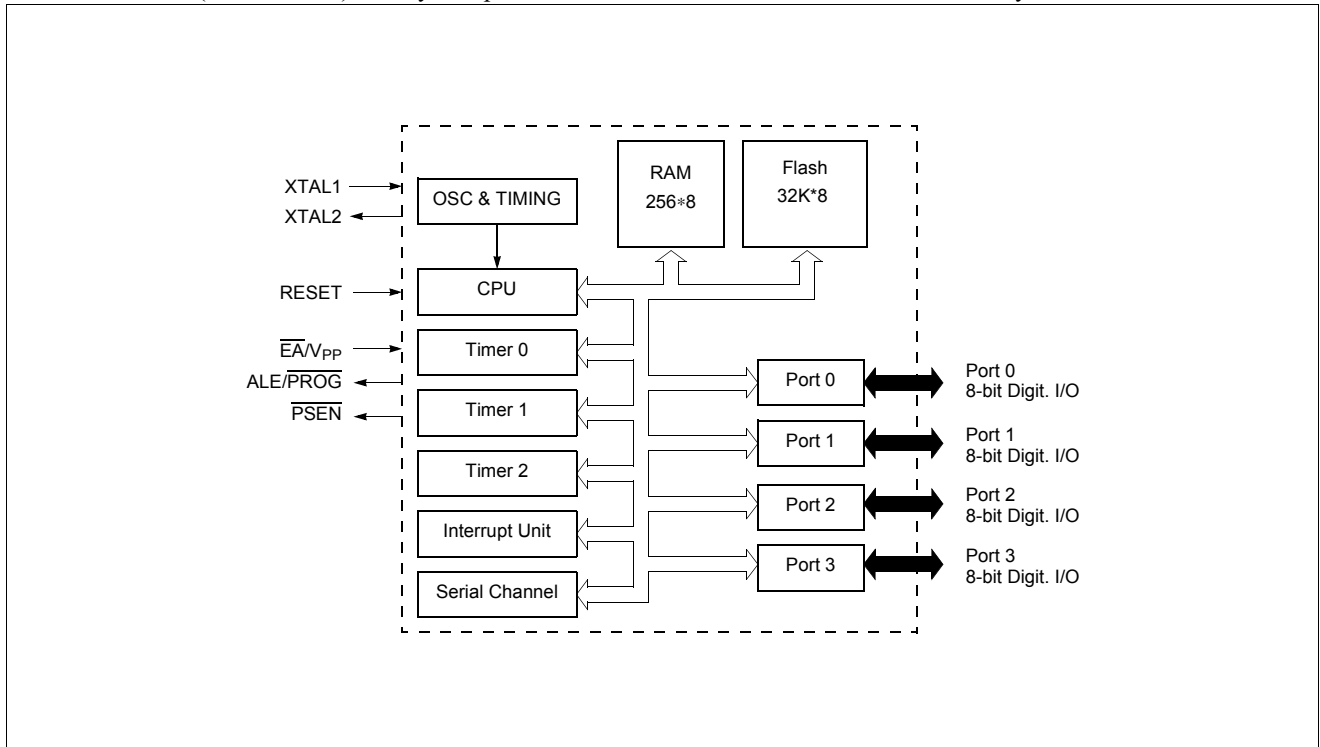
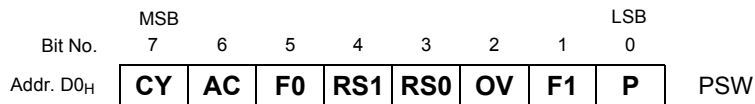


Figure 1. Block Diagram of the GMS99C58

2.1 CPU

The GMS99C58 is efficient both as a controller and as an arithmetic processor. It has extensive facilities for binary and BCD arithmetic and excels in its bit-handling capabilities. Efficient use of program memory results from an instruction set consisting of 44% two-byte, and 15% three-byte instructions. With a 12 MHz crystal, 58% of the instructions are executed in 1.0µs (25MHz: 500ns).

2.1.1 Special Function Register PSW



Bit	Function
CY	Carry Flag
AC	Auxiliary Carry Flag (for BCD operations)
F0	General Purpose Flag

Bit		Function
RS1	RS0	Register Bank select control bits
0	0	Bank 0 selected, data address 00 _H - 07 _H
0	1	Bank 1 selected, data address 08 _H - 0F _H
1	0	Bank 2 selected, data address 10 _H - 17 _H
1	1	Bank 3 selected, data address 18 _H - 1F _H
OV		Overflow Flag
F1		General Purpose Flag
P		Parity Flag Set/cleared by hardware each instruction cycle to indicate an odd/even number of "one" bits in the accumulator, i.e. even parity.

2.2 SPECIAL FUNCTION REGISTERS

All registers, except the program counter and the four general purpose register banks, reside in the special function register area. The 27 special function registers (SFR) include pointers and registers that provide an interface between the CPU and the other on-chip peripherals. There are also 128 directly addressable bits within the SFR area.

All SFRs are listed in Table 1, Table 2, and Table 3.

In Table 1, they are organized in numeric order of their addresses. In Table 2 they are organized in groups which refer to the functional blocks of the GMS90 Series. Table 3 illustrates the contents of the SFRs.

Table 1. Special Function Registers in Numeric Order of their Addresses

Address	Register	Contents after Reset	Address	Register	Contents after Reset
80H	P0 ¹⁾	FFH	90H	P1 ¹⁾	FFH
81H	SP	07H	91H	reserved	00H
82H	DPL	00H	92H	reserved	XXH ²⁾
83H	DPH	00H	93H	reserved	XXH ²⁾
84H	reserved	XXH ²⁾	94H	reserved	XXH ²⁾
85H	reserved	XXH ²⁾	95H	reserved	XXH ²⁾
86H	reserved	XXH ²⁾	96H	reserved	XXH ²⁾
87H	PCON	0XXX0000B ²⁾	97H	reserved	XXH ²⁾
88H	TCON ¹⁾	00H	98H	SCON ¹⁾	00H
89H	TMOD	00H	99H	SBUF	XXH ²⁾
8AH	TL0	00H	9AH	reserved	XXH ²⁾
8BH	TL1	00H	9BH	reserved	XXH ²⁾
8CH	TH0	00H	9CH	reserved	XXH ²⁾
8DH	TH1	00H	9DH	reserved	XXH ²⁾
8EH	AUXR0	XXXXXXXX0B ²⁾	9EH	reserved	XXH ²⁾
8FH	reserved	XXH ²⁾	9FH	reserved	XXH ²⁾

1) Bit-addressable Special Function Register.

2) X means that the value is indeterminate and the location is reserved.

Address	Register	Contents after Reset	Address	Register	Contents after Reset
A0H A1H A2H A3H A4H A5H A6H A7H	P2 ¹⁾ reserved reserved reserved reserved reserved reserved reserved	FFH XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾	C8H C9H CAH CBH CCH CDH CEH CFH	T2CON ¹⁾ T2MOD RC2L RC2H TL2 TH2 reserved reserved	00H XXXXXX00B ²⁾ 00H 00H 00H 00H XXH ²⁾ XXH ²⁾
A8H A9H AAH ABH ACH ADH AEH AFH	IE ¹⁾ reserved reserved reserved reserved reserved reserved reserved	0X000000B ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾	D0H D1H D2H D3H D4H D5H D6H D7H	PSW ¹⁾ reserved reserved reserved reserved reserved reserved reserved	00H XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾
B0H B1H B2H B3H B4H B5H B6H B7H	P3 ¹⁾ reserved reserved reserved reserved reserved reserved reserved	FFH XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾	D8H D9H DAH DBH DCH DDH DEH DFH	reserved reserved reserved reserved reserved reserved reserved reserved	XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾
B8H B9H BAH BBH BCH BDH BEH BFH	IP ¹⁾ reserved reserved reserved reserved reserved reserved reserved	XX000000B ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾	E0H E1H E2H E3H E4H E5H E6H E7H	ACC ¹⁾ reserved reserved reserved reserved reserved reserved reserved	00H XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾
C0H C1H C2H C3H C4H C5H C6H C7H	reserved reserved reserved reserved reserved reserved reserved	XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾	E8H E9H EAH EBH ECH EDH EEH EFH	reserved reserved reserved reserved reserved reserved reserved reserved	XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾

Address	Register	Contents after Reset	Address	Register	Contents after Reset
F0H	B ¹⁾	00H	F8H	reserved	XXH ²⁾
F1H	reserved	XXH ²⁾	F9H	reserved	XXH ²⁾
F2H	reserved	XXH ²⁾	FAH	reserved	XXH ²⁾
F3H	reserved	XXH ²⁾	FBH	reserved	XXH ²⁾
F4H	reserved	XXH ²⁾	FCH	reserved	XXH ²⁾
F5H	reserved	XXH ²⁾	FDH	reserved	XXH ²⁾
F6H	reserved	XXH ²⁾	FEH	reserved	XXH ²⁾
F7H	reserved	XXH ²⁾	FFH	reserved	XXH ²⁾

1) Bit-addressable Special Function Register.

2) X means that the value is indeterminate and the location is reserved.

Table 2. Special Function Registers - Functional Blocks

Block	Symbol	Name	Address	Contents after Reset
CPU	ACC	Accumulator	E0H ¹⁾	00H
	B	B-Register	F0H ¹⁾	00H
	DPH	Data Pointer, High Byte	83H	00H
	DPL	Data Pointer, Low Byte	82H	00H
	PSW	Program Status Word Register	D0H ¹⁾	00H
	SP	Stack Pointer	81H	07H
Interrupt System	IE	Interrupt Enable Register	A8H ¹⁾	0X000000B ²⁾
	IP	Interrupt Priority Register	B8H ¹⁾	XX000000B ²⁾
Ports	P0	Port 0	80H ¹⁾	FFH
	P1	Port 1	90H ¹⁾	XXH
	P2	Port 2	A0H ¹⁾	FFH
	P3	Port 3	B0H ¹⁾	FFH
Serial Channels	PCON ³⁾	Power Control Register	87H	0XXX0000B ²⁾
	SBUF	Serial Channel Buffer Reg.	99H	XXH ²⁾
	SCON	Serial Channel 0 Control Reg.	98H ¹⁾	00H
Timer 0/ Timer 1	TCON	Timer 0/1 Control Register	88H ¹⁾	00H
	TH0	Timer 0, High Byte	8CH	00H
	TH1	Timer 1, High Byte	8DH	00H
	TL0	Timer 0, Low Byte	8AH	00H
	TL1	Timer 1, Low Byte	8BH	00H
	TMOD	Timer Mode Register	89H	00H
Timer 2	T2CON	Timer 2 Control Register	C8H ¹⁾	00H
	T2MOD	Timer 2 Mode Register	C9H	00H
	RC2H	Timer 2 Reload Capture Reg., High Byte	CBH	00H
	RC2L	Timer 2 Reload Capture Reg., Low Byte	CAH	00H
	TH2	Timer 2, High Byte	CDH	00H
	TL2	Timer 2, Low Byte	CCH	00H

Table 2. Special Function Registers - Functional Blocks

Block	Symbol	Name	Address	Contents after Reset
Power Saving Modes	PCON	Power Control Register	87H	0XXX0000B ²⁾
-	AUXR0	Aux. Register 0	8EH	XXXXXXXX0B ²⁾

1) Bit-addressable Special Function register

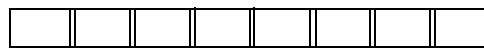
2) X means that the value is indeterminate and the location is reserved

3) This special function register is listed repeatedly since some bit of it also belong to other functional blocks

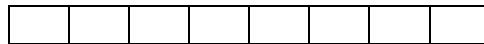
Table 3. Contents of SFRs, SFRs in Numeric Order

Address	Register	Bit 7	6	5	4	3	2	1	0
80H	P0								
81H	SP								
82H	DPL								
83H	DPH								
87H	PCON	SMOD	-	-	-	GF1	GF0	PDE	IDLE
88H	TCON	TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0
89H	TMOD	GATE	C/T	M1	M0	GATE	C/T	M1	M0
8AH	TL0								
8BH	TL1								
8CH	TH0								
8DH	TH1								
8EH	AUXR0	-	-	-	-	-	-	-	A0
90H	P1								
98H	SCON	SM0	SM1	SM2	REN	TB8	RB8	TI	RI
99H	SBUF								
A0H	P2								
A8H	IE	EA	-	ET2	ES	ET1	EX1	ET0	EX0
B0H	P3								
B8H	IP	-	-	PT2	PS	PT1	PX1	PT0	PX0
C8H	T2CON	TF2	EXF2	RCLK	TCLK	EXEN2	TR2	C/T2	CP/RL2

Address	Register	Bit 7	6	5	4	3	2	1	0
C9H	T2MOD	-	-	-	-	-	-	T2OE	DCEN
CAH	RC2L								
CBH	RC2H								
CCH	TL2								
CDH	TH2								
D0H	PSW	CY	AC	F0	RS1	RS0	OV	F1	P
E0H	ACC								
F0H	B								



SFR bit and byte addressable



SFR not bit addressable

- : this bit location is reserved

2.3 TIMER / COUNTER 0 AND 1

Timer/Counter 0 and 1 can be used in four operating modes as listed in Table 4.

Table 4. TIMER / COUNTER 0 AND 1 Operating Modes .

Mode	Description	TMOD				Input Clock	
		Gate	C/T	M1	M0	internal	external (Max.)
0	8-bit timer/counter with a divide-by-32 prescaler	X	X	0	0	$f_{osc} \div (12 \times 32)$	$f_{osc} \div (24 \times 32)$
1	16-bit timer/counter	X	X	0	1	$f_{osc} \div 12$	$f_{osc} \div 24$
2	16-bit timer/counter with 8-bit auto-reload	X	X	1	0	$f_{osc} \div 12$	$f_{osc} \div 24$
3	Timer/counter 0 used as one 8-bit timer/counter and one 8-bit timer Timer 1 stop	X	X	1	1	$f_{osc} \div 12$	$f_{osc} \div 24$

In the "timer" function ($C/\overline{T} = "0"$) the register is incremented every machine cycle. Therefore the count rate is $f_{OSC}/12$. In the "counter" function the register is incremented in response to a 1-to-0 transition at its corresponding external input pin (P3.4/T0, P3.5/T1). Since it takes two machine cycles to detect a falling edge the max. count rate is $f_{OSC}/24$. External inputs $\overline{INT0}$ and $\overline{INT1}$ (P3.2, P3.3) can be programmed to function as a gate to facilitate pulse width measurements. Figure 2 illustrates the input clock logic.

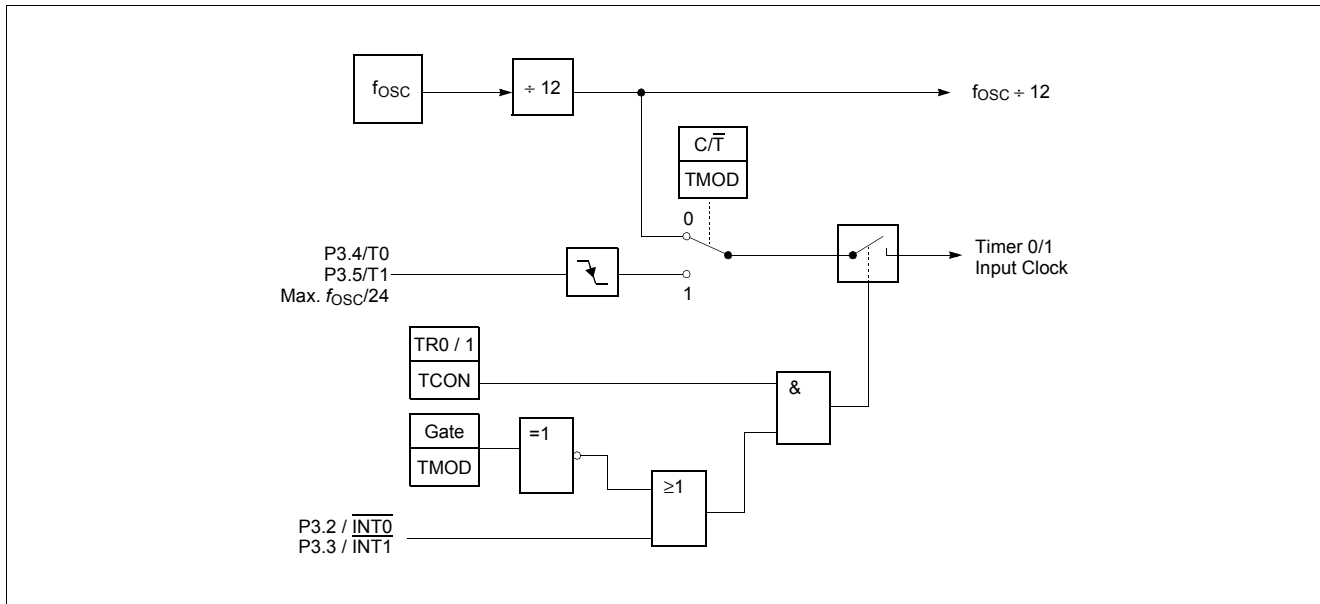


Figure 2. Timer/Counter 0 and 1 Input Clock Logic


2.4 TIMER 2

Timer 2 is a 16-bit timer/Counter with an up/down count feature. It can operate either as timer or as an event counter which is selected by bit $C/\overline{T2}$ (T2CON.1). It has three operating modes as shown in Table 5.

Table 5. Timer/Counter2 Operating Modes.

Mode	T2CON			T2 MOD	T2CON	P1.1/ T2EX	Remarks	Input Clock	
	RCLK or TCLK	CP/ RL2	TR2	DCEN	EXEN2			internal	external (P1.0/T2)
16-bit Auto- Reload	0	0	1	0	0	X	reload upon over- flow reload trig- ger (falling edge) Down counting Up counting	$f_{OSC} \div 12$	Max. $f_{OSC} \div 24$
	0	0	1	0	1	↓			
	0	0	1	1	X	0			
	0	0	1	1	X	1			
16-bit Capture	0	1	1	X	0	X	16 bit Timer/ Counter (only up- counting) capture TH2,TL2 → RC2H,RC2L	$f_{OSC} \div 12$	Max. $f_{OSC} \div 24$
	0	1	1	X	1	↓			

Mode	T2CON			T2 MOD	T2CON	P1.1/ T2EX	Remarks	Input Clock	
	RCLK or TCLK	CP/ RL2	TR2	DCEN	EXEN2			internal	external (P1.0/T2)
Baud Rate Generator	1	X	1	0	0	X	no overflow interrupt request (TF2) extra external interrupt ("Timer 2")	f _{osc} ÷ 12	Max. f _{osc} ÷ 24
	1	X	1	1	1	↓			
Off	X	X	0	X	X	X	Timer 2 stops	-	-

Note: ↓ =  falling edge

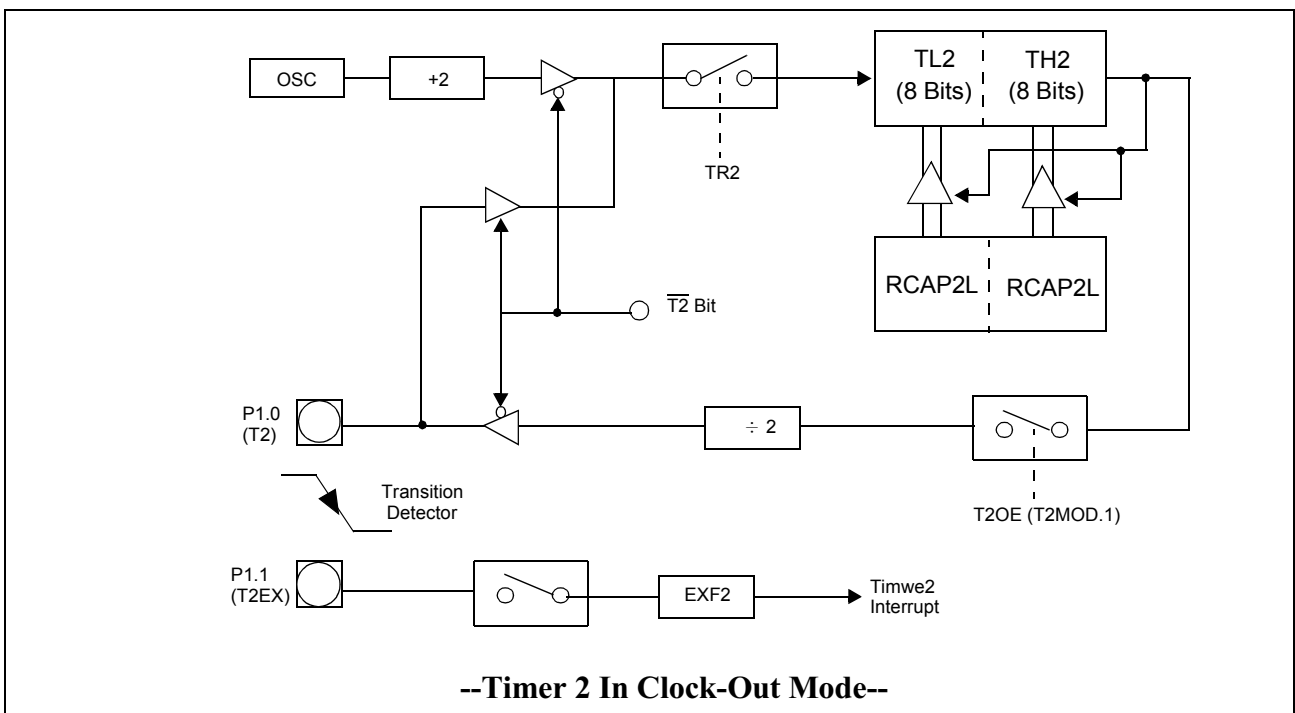
***PROGRAMMABLE CLOCK OUT**

A 50% duty cycle clock can be programmed to come out on P1.0. This pin, besides being a regular I/O pin, has two alternate functions. To configure the Timer/Counter 2 as a clock generator, C/T2 (T2CON.1) must be cleared and bit T2OE(T1MOD.1) must be set. Bit TR2 (T2CON.2) starts and stops the timer.

The Clock-Out frequency depends on the oscillator frequency and the reload value of Timer 2 capture registers (RCAP2H, TCAP2L) as shown in this equation:

$$\text{Clock-Out Frequency} = \frac{\text{Oscillator Frequency}}{4 \times (65536 - \text{RCAP2H}, \text{RCAP2L})}$$

In the clock-out mode, Timer 2 roll-overs will not generate an interrupt. This is similar to when Timer 2 is used as a baud-rate generator. It is possible to use Timer 2 as a baud-rate generator and a clock generator simultaneously. Note, however, that the baud-rate and clock-out frequencies can not be determined independently from one another since they both use RCAP2H and RCAP2L.



2.5 SERIAL INTERFACE (USART)

The serial port is full duplex and can operate in four modes (one synchronous mode, three asynchronous modes) as illustrated in Table 6. The possible baud rates can be calculated using the formulas given in Table 7.

Table 6. USART Operating Modes

Mode	SCON		Baudrate	Description
	SM0	SM1		
0	0	0	$\frac{f_{OSC}}{12}$	Serial data enters and exits through RxD. Tx/D outputs the shift clock. 8-bit are transmitted/received (LSB first)
1	0	1	Timer 1/2 overflow rate	8-bit UART 10 bits are transmitted (through Tx/D) or received (RxD)
2	1	0	$\frac{f_{OSC}}{32}$ or $\frac{f_{OSC}}{64}$	9-bit UART 11 bits are transmitted (Tx/D) or received (RxD)
3	1	1	Timer 1/2 overflow rate	9-bit UART Like mode 2 except the variable baud rate

Table 7. Formulas for calculating Baud rates

Baud Rate derived from	Interface Mode	Baudrate
Oscillator	0	$\frac{f_{OSC}}{12}$
	2	$\frac{2^{SMOD}}{64} \times f_{OSC}$
Timer 1 (16-bit timer) (8-bit timer with 8-bit auto reload)	1,3	$\frac{2^{SMOD}}{32} \times (Timer\ 1\ overflow)$
	1,3	$\frac{2^{SMOD}}{32} \times \frac{f_{OSC}}{12 \times [256 - (TH1)]}$
Timer 2	1,3	$\frac{f_{OSC}}{32 \times [65536 - (RC2H, RC2L)]}$

2.6 INTERRUPT SYSTEM

The GMS99C58 provides 6 interrupt sources with two priority levels. Figure 3 gives a general overview of the interrupt sources and illustrates the request and control flags.

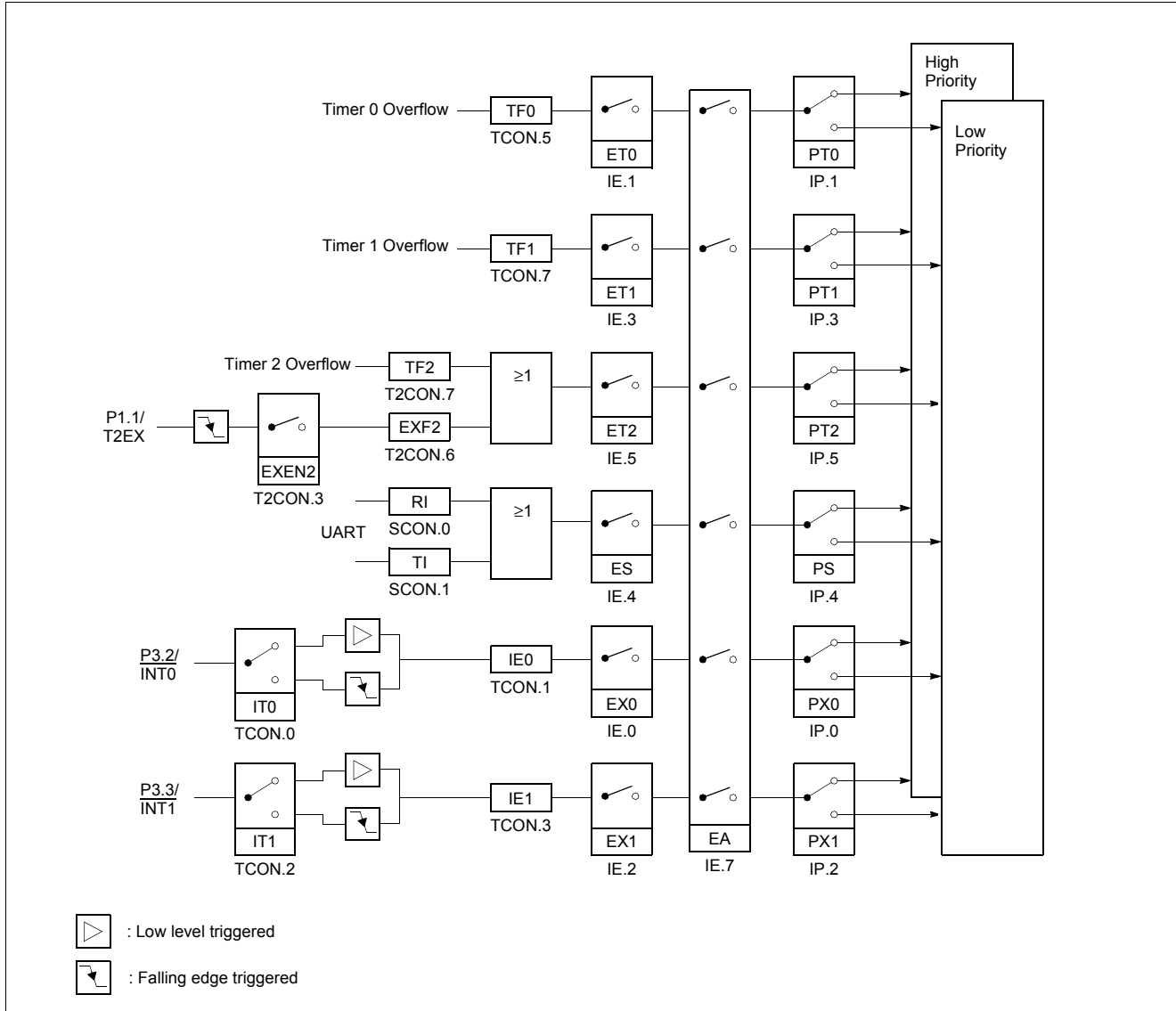


Figure 3. Interrupt Structure

Table 8. Interrupt Sources and their corresponding interrupt vectors

Source (Request Flags)	Vectors	Vector Address
RESET	RESET	0000H
IE0	External interrupt 0	0003H
TF0	Timer 0 interrupt	000BH
IE1	External interrupt 1	0013H
TF1	Timer 1 interrupt	001BH
RI + TI	Serial port interrupt	0023H
TF2 + EXF2	Timer 2 interrupt	002BH

A low-priority interrupt can itself be interrupted by a high-priority interrupt, but not by another low priority interrupt. A high-priority interrupt cannot be interrupted by any other interrupt source.

If two requests of different priority level are received simultaneously, the request of higher priority is serviced. If requests of the same priority are received simultaneously, an internal polling sequence determines which request is serviced. Thus within each priority level there is a second priority structure determined by the polling sequence as shown in Table 9.

Table 9. Interrupt Priority-Within-Level

Interrupt Source		Priority
External Interrupt 0	IE0	High
Timer 0 Interrupt	TF0	↓
External Interrupt 1	IE1	↓
Timer 1 Interrupt	TF1	↓
Serial Channel	RI + TI	↓
Timer 2 Interrupt	TF2 + EXF2	Low

2.7 Power Saving Modes

Two power down modes are available, the Idle Mode and Power Down Mode.

The bits PDE and IDLE of the register PCON select the Power Down mode or the Idle mode, respectively. If the Power Down mode and the Idle mode are set at the same time, the Power Down mode takes precedence. Table 10 gives a general overview of the power saving modes.

Table 10. Power Saving Modes Overview

Mode	Entering Instruction Example	Leaving by	Remarks
Idle mode	ORL PCON, #01H	Enabled interrupt. Hardware Reset.	CPU is gated off. CPU status registers maintain their data. Peripherals are active.
Power-Down mode	ORL PCON, #02H	Hardware Reset	Oscillator is stopped, contents of on-chip RAM and SFR's are maintained (leaving Power Down Mode means redefinition of SFR contents).

In the Power Down mode of operation, V_{CC} can be reduced to minimize power consumption. It must be ensured, however, that V_{CC} is not reduced before the Power Down mode is invoked, and that V_{CC} is restored to its normal operating level, before the Power Down mode is terminated. The reset signal that terminates the Power Down mode also restarts the oscillator. The reset should not be activated before V_{CC} is restored to its normal operating level and must be held active long enough to allow the oscillator to restart and stabilize (similar to power-on reset).

Chapter 3. ELECTRICAL CHARACTERISTICS

3.1 Absolute Maximum Ratings

Ambient temperature under bias (T_A).....	-40 to + 85 °C
Storage temperature (T_{ST}).....	-65 to + 150 °C
Voltage on V_{CC} pins with respect to ground (V_{SS})	-0.5V to 6.5V
Voltage on any pin with respect to ground (V_{SS}).....	-0.5V to $V_{CC} + 0.5V$
Input current on any pin during overload condition.....	-10mA to +10mA
Absolute sum of all input currents during overload condition	100mA
Power dissipation.....	TBD

Note: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage of the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for longer periods may affect device reliability. During overload conditions ($V_{IN} > V_{CC}$ or $V_{IN} < V_{SS}$) the Voltage on V_{CC} pins with respect to ground (V_{SS}) must not exceed the values defined by the absolute maximum ratings.

3.2 DC Characteristics (5V Version)

$V_{CC} = 5V \pm 10\%$; $V_{SS} = 0V$; $T_A = 0^\circ C$ to $70^\circ C$

Parameter	Symbol	Limit Values		Unit	Test Conditions
		Min.	Max.		
Input low voltage (except \overline{EA} , RESET)	V_{IL}	-0.5	$0.2V_{CC} - 0.1$	V	-
Input low voltage (\overline{EA})	V_{IL1}	-0.5	$0.1V_{CC} - 0.1$	V	-
Input low voltage (RESET)	V_{IL2}	-0.5	$0.2V_{CC} + 0.1$	V	-
Input high voltage (except XTAL1, \overline{EA} , RESET)	V_{IH}	$0.2V_{CC} + 0.9$	$V_{CC} + 0.5$	V	-
Input high voltage to XTAL1	V_{IH1}	$0.7V_{CC}$	$V_{CC} + 0.5$	V	-
Input high voltage to \overline{EA} , RESET	V_{IH2}	$0.6V_{CC}$	$V_{CC} + 0.5$	V	-
Output low voltage (ports 1, 2, 3)	V_{OL}	-	0.45	V	$I_{OL} = 1.6mA$ ¹⁾
Output low voltage (port 0, ALE, \overline{PSEN})	V_{OL1}	-	0.45	V	$I_{OL} = 3.2mA$ ¹⁾
Output high voltage (ports 1, 2, 3)	V_{OH}	2.4 $0.9V_{CC}$	-	V	$I_{OH} = -80\mu A$ $I_{OH} = -10\mu A$
Output high voltage (port 0 in external bus mode, ALE, \overline{PSEN})	V_{OH1}	2.4 $0.9V_{CC}$	- -	V	$I_{OH} = -800\mu A$ ²⁾ $I_{OH} = -80\mu A$ ²⁾
Logic 0 input current (ports 1, 2, 3)	I_{IL}	-10	-50	μA	$V_{IN} = 0.45V$

Parameter	Symbol	Limit Values		Unit	Test Conditions
		Min.	Max.		
Logical 1-to-0 transition current (ports 1, 2, 3)	I_{TL}	-65	-650	μA	$V_{IN} = 2.0V$
Input leakage current (port 0, \overline{EA})	I_{LI}	-	± 1	μA	$0.45 < V_{IN} < V_{CC}$
Pin capacitance	C_{IO}	-	10	pF	$f_C = 1MHz$ $T_A = 25^\circ C$
Power supply current:					
Active mode, 12MHz ³⁾	I_{CC12}	-	21	mA	$V_{CC} = 5V$ ⁴⁾
Idle mode, 12MHz ³⁾	I_{Idle12}	-	18	mA	$V_{CC} = 5V$ ⁵⁾
Active mode, 24 MHz ³⁾	I_{CC24}	-	36	mA	$V_{CC} = 5V$
Idle mode, 24MHz ³⁾	I_{Idle24}	-	20	mA	$V_{CC} = 5V$
Power Down Mode ³⁾	I_{PD}	-	50	μA	$V_{CC} = 5V$ ⁶⁾

- 1) Capacitive loading on ports 0 and 2 may cause spurious noise pulses to be superimposed on the V_{OL} of ALE and port 3. The noise is due to external bus capacitance discharging into the port 0 and port 2 pins when these pins make 1-to-0 transitions during bus operation. In the worst case (capacitive loading $> 100pF$), the noise pulse on ALE line may exceed 0.8V. In such cases it may be desirable to qualify ALE with a schmitt-trigger, or use an address latch with a schmitt-trigger strobe input.
- 2) Capacitive loading on ports 0 and 2 may cause the V_{OH} on ALE and \overline{PSEN} to momentarily fall below the $0.9V_{CC}$ specification when the address lines are stabilizing.
- 3) I_{CC} Max at other frequencies is given by:
active mode: $I_{CC} = 1.27 \times f_{OSC} + 5.73$
idle mode: $I_{CC} = 0.28 \times f_{OSC} + 1.45$.
where f_{OSC} is the oscillator frequency in MHz. I_{CC} values are given in mA and measured at $V_{CC} = 5V$.
- 4) I_{CC} (active mode) is measured with:
XTAL1 driven with $t_{CLCH}, t_{CHCL} = 5ns$, $V_{IL} = V_{SS} + 0.5V$, $V_{IH} = V_{CC} - 0.5V$; XTAL2 = N.C.;
 $\overline{EA} = \text{Port0} = \text{RESET} = V_{CC}$; all other pins are disconnected. I_{CC} would be slightly higher if a crystal oscillator is used (appr. 1mA).
- 5) I_{CC} (Idle mode) is measured with all output pins disconnected and with all peripherals disabled;
XTAL1 driven with $t_{CLCH}, t_{CHCL} = 5ns$, $V_{IL} = V_{SS} + 0.5V$, $V_{IH} = V_{CC} - 0.5V$; XTAL2 = N.C.;
 $\text{RESET} = \overline{EA} = V_{SS}$; $\text{Port0} = V_{CC}$; all other pins are disconnected;
- 6) I_{PD} (Power Down Mode) is measured under following conditions:
 $\overline{EA} = \text{Port0} = V_{CC}$; $\text{RESET} = V_{SS}$; XTAL2 = N.C.; XTAL1 = V_{SS} ; all other pins are disconnected.

3.3 AC Characteristics

Explanation of the AC Symbols

Each timing symbol has 5 characters. The first character is always a 't' (stand for time). The other characters, depending on their positions, stand for the name of a signal or the logical status of that signal. The following is a list of all the characters and what they stand for.

A: Address
 C: Clock
 D: Input Data
 H: Logic level HIGH
 I: Instruction (program memory contents)
 L: Logic level LOW, or ALE
 P: PSEN
 Q: Output Data
 R: RD signal

T: Time
 V: Valid
 W: WR signal
 X: No longer a valid logic level
 Z: Float

For example,
 t_{AVLL} = Time from Address Valid to ALE Low
 t_{LLPL} = Time from ALE Low to PSEN Low

3.3.1 For $f_{osc}=3.5\text{MHz} \sim 12\text{MHz}$

$V_{CC}=5V \pm 10\%$; $V_{SS}=0V$; $T_A=0^\circ\text{C}$ to 70°C

(C_L for port 0, ALE and $\overline{\text{PSEN}}$ outputs = 100pF; C_L for all other outputs = 80pF)

Table 11. Program Memory Characteristics

Parameter	Symbol	12 MHz Oscillator		Variable Oscillator 1/ t_{CLCL} = 3.5 to 12MHz		Unit
		Min.	Max.	Min.	Max.	
ALE pulse width	t_{LHLL}	127	-	$2t_{CLCL}-40$	-	ns
Address setup to ALE	t_{AVLL}	43	-	$t_{CLCL}-40$	-	ns
Address hold after ALE	t_{LLAX}	30	-	$t_{CLCL}-53$	-	ns
ALE low to valid instruction in	t_{LLIV}	-	233	-	$4t_{CLCL}-100$	ns
ALE to $\overline{\text{PSEN}}$	t_{LLPL}	58	-	$t_{CLCL}-25$	-	ns
$\overline{\text{PSEN}}$ pulse width	t_{PLPH}	215	-	$3t_{CLCL}-35$	-	ns
$\overline{\text{PSEN}}$ to valid instruction in	t_{PLIV}	-	150	-	$3t_{CLCL}-100$	ns
Input instruction hold after $\overline{\text{PSEN}}$	t_{PXIX}	0	-	0	-	ns
Input instruction float after $\overline{\text{PSEN}}$	t_{PXIZ}^\dagger	-	63	-	$t_{CLCL}-20$	ns
Address valid after $\overline{\text{PSEN}}$	t_{PXAV}^\dagger	75	-	$t_{CLCL}-8$	-	ns
Address to valid instruction in	t_{AVIV}	-	302	-	$5t_{CLCL}-115$	ns
Address float to $\overline{\text{PSEN}}$	t_{AZPL}	0	-	0	-	ns

† Interfacing the GMS99C58 to devices with float times up to 75 ns is permissible. This limited bus contention will not cause any damage to port 0 Drivers.

Table 12. External Data Memory Characteristics

Parameter	Symbol	12 MHz Oscillator		Variable Oscillator 1/t _{CLCL} = 3.5 to 12MHz		Unit
		Min.	Max.	Min.	Max.	
\overline{RD} pulse width	t _{RLRH}	400	-	6t _{CLCL} -100	-	ns
\overline{WR} pulse width	t _{WLWH}	400	-	6t _{CLCL} -100	-	ns
Address hold after ALE	t _{LLAX2}	30	-	t _{CLCL} -53	-	ns
\overline{RD} to valid data in	t _{RLDV}	-	252	-	5t _{CLCL} -165	ns
Data hold after \overline{RD}	t _{RHDX}	0	-	0	-	ns
Data float after \overline{RD}	t _{RHDZ}	-	97	-	2t _{CLCL} -70	ns
ALE to valid data in	t _{LLDV}	-	517	-	8t _{CLCL} -150	ns
Address to valid data in	t _{AVDV}	-	583	-	9t _{CLCL} -165	ns
ALE to \overline{WR} or \overline{RD}	t _{LLWL}	200	300	3t _{CLCL} -50	3t _{CLCL} +50	ns
Address valid to \overline{WR} or \overline{RD}	t _{AVWL}	203	-	4t _{CLCL} -130	-	ns
\overline{WR} or \overline{RD} high to ALE high	t _{WHLH}	43	123	t _{CLCL} -40	t _{CLCL} +40	ns
Data valid to \overline{WR} transition	t _{QVWX}	33	-	t _{CLCL} -50	-	ns
Data setup before \overline{WR}	t _{QVWH}	433	-	7t _{CLCL} -150	-	ns
Data hold after \overline{WR}	t _{WHQX}	33	-	t _{CLCL} -50	-	ns
Address float after \overline{RD}	t _{RLAZ}	-	0	-	0	ns

Table 13. External Clock Drive

Parameter	Symbol	Variable Oscillator (Freq. = 3.5 to 12MHz)		Unit
		Min.	Max.	
Oscillator period	t _{CLCL}	83.3	285.7	ns
High time	t _{CHCX}	20	t _{CLCL} - t _{CLCX}	ns
Low time	t _{CLCX}	20	t _{CLCL} - t _{CHCX}	ns
Rise time	t _{CLCH}	-	20	ns
Fall time	t _{CHCL}	-	20	ns

3.3.2 for $f_{osc}=3.5\text{MHz} \sim 24\text{MHz}$

$V_{CC}=5V \pm 10\%$; $V_{SS}=0V$; $T_A=0^\circ\text{C}$ to 70°C

(C_L for port 0, ALE and $\overline{\text{PSEN}}$ outputs = 100pF; C_L for all other outputs = 80pF)

Table 14. Program Memory Characteristics

Parameter	Symbol	24 MHz Oscillator		Variable Oscillator 1/ $t_{CLCL} = 3.5$ to 24MHz		Unit
		Min.	Max.	Min.	Max.	
ALE pulse width	t_{LHLL}	43	-	$2t_{CLCL}-40$	-	ns
Address setup to ALE	t_{AVLL}	17	-	$t_{CLCL}-25$	-	ns
Address hold after ALE	t_{LLAX}	17	-	$t_{CLCL}-25$	-	ns
ALE low to valid instruction in	t_{LLIV}	-	80	-	$4t_{CLCL}-87$	ns
ALE to $\overline{\text{PSEN}}$	t_{LLPL}	22	-	$t_{CLCL}-20$	-	ns
$\overline{\text{PSEN}}$ pulse width	t_{PLPH}	95	-	$3t_{CLCL}-30$	-	ns
$\overline{\text{PSEN}}$ to valid instruction in	t_{PLIV}	-	60	-	$3t_{CLCL}-65$	ns
Input instruction hold after $\overline{\text{PSEN}}$	t_{PXIX}	0	-	0	-	ns
Input instruction float after $\overline{\text{PSEN}}$	t_{PXIZ}^\dagger	-	32	-	$t_{CLCL}-20$	ns
Address valid after $\overline{\text{PSEN}}$	t_{PXAV}^\dagger	75	-	$t_{CLCL}-5$	-	ns
Address to valid instruction in	t_{AVIV}	-	148	-	$5t_{CLCL}-60$	ns
Address float to $\overline{\text{PSEN}}$	t_{AZPL}	0	-	0	-	ns

† Interfacing the GMS99C58 to devices with float times up to 35 ns is permissible. This limited bus contention will not cause any damage to port 0 Drivers.

Table 15. External Data Memory Characteristics

Parameter	Symbol	24 MHz Oscillator		Variable Oscillator 1/ $t_{CLCL} = 3.5$ to 24MHz		Unit
		Min.	Max.	Min.	Max.	
$\overline{\text{RD}}$ pulse width	t_{RLRH}	180	-	$6t_{CLCL}-70$	-	ns
$\overline{\text{WR}}$ pulse width	t_{WLWH}	180	-	$6t_{CLCL}-70$	-	ns
Address hold after ALE	t_{LLAX2}	15	-	$t_{CLCL}-27$	-	ns
$\overline{\text{RD}}$ to valid data in	t_{RLDV}	-	118	-	$5t_{CLCL}-90$	ns
Data hold after $\overline{\text{RD}}$	t_{RHDX}	0	-	0	-	ns
Data float after $\overline{\text{RD}}$	t_{RHDZ}	-	63	-	$2t_{CLCL}-20$	ns
ALE to valid data in	t_{LLDV}	-	200	-	$8t_{CLCL}-133$	ns
Address to valid data in	t_{AVDV}	-	220	-	$9t_{CLCL}-155$	ns
ALE to $\overline{\text{WR}}$ or $\overline{\text{RD}}$	t_{LLWL}	75	175	$3t_{CLCL}-50$	$3t_{CLCL}+50$	ns

Parameter	Symbol	24 MHz Oscillator		Variable Oscillator 1/t _{CLCL} = 3.5 to 24MHz		Unit
		Min.	Max.	Min.	Max.	
Address valid to \overline{WR} or \overline{RD}	t _{AVWL}	67	-	4t _{CLCL} -97	-	ns
\overline{WR} or \overline{RD} high to ALE high	t _{WHLH}	17	67	t _{CLCL} -25	t _{CLCL} +25	ns
Data valid to \overline{WR} transition	t _{QVWX}	5	-	t _{CLCL} -37	-	ns
Data setup before \overline{WR}	t _{QVWH}	170	-	7t _{CLCL} -122	-	ns
Data hold after \overline{WR}	t _{WHQX}	15	-	t _{CLCL} -27	-	ns
Address float after \overline{RD}	t _{RLAZ}	-	0	-	0	ns

Table 16. External Clock Drive

Parameter	Symbol	Variable Oscillator (Freq. = 3.5 to 24MHz)		Unit
		Min.	Max.	
Oscillator period	t _{CLCL}	41.7	285.7	ns
High time	t _{CHCX}	12	t _{CLCL} - t _{CLCX}	ns
Low time	t _{CLCX}	12	t _{CLCL} - t _{CHCX}	ns
Rise time	t _{CLCH}	-	12	ns
Fall time	t _{CHCL}	-	12	ns

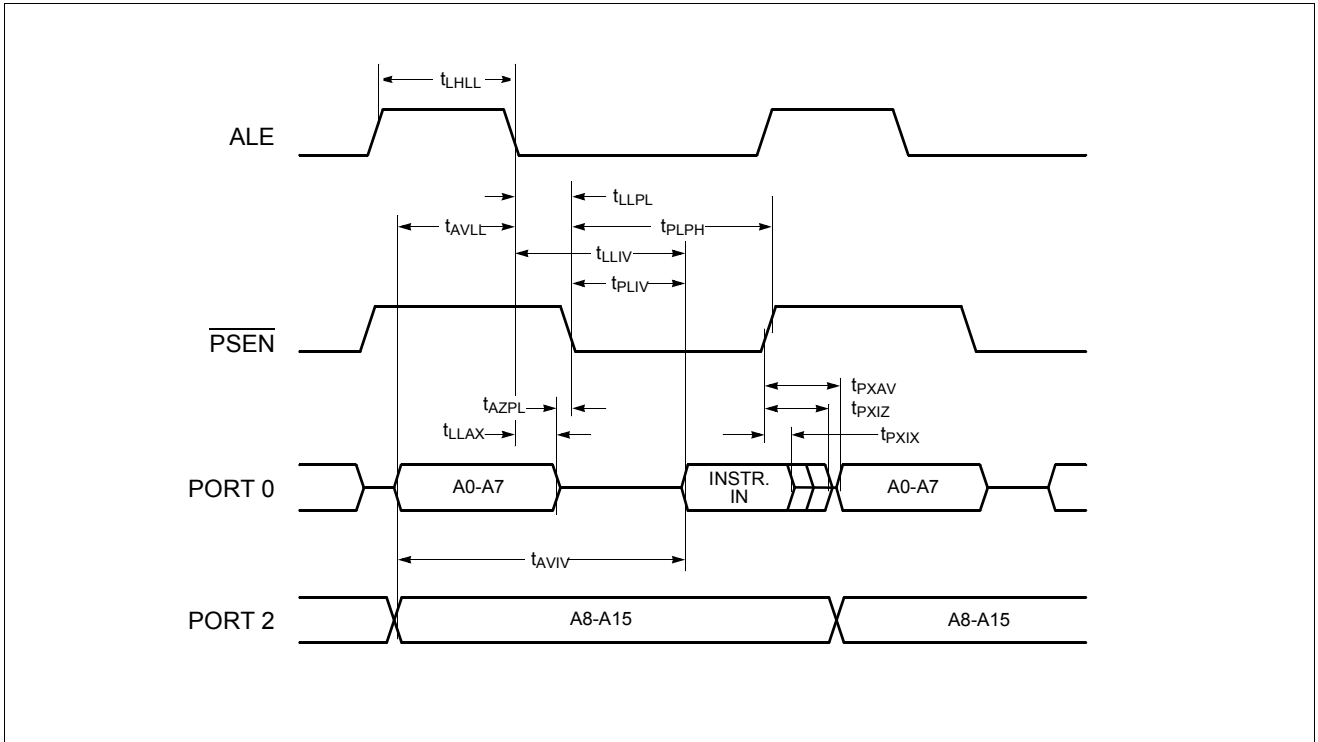


Figure 4. External Program Memory Read Cycle

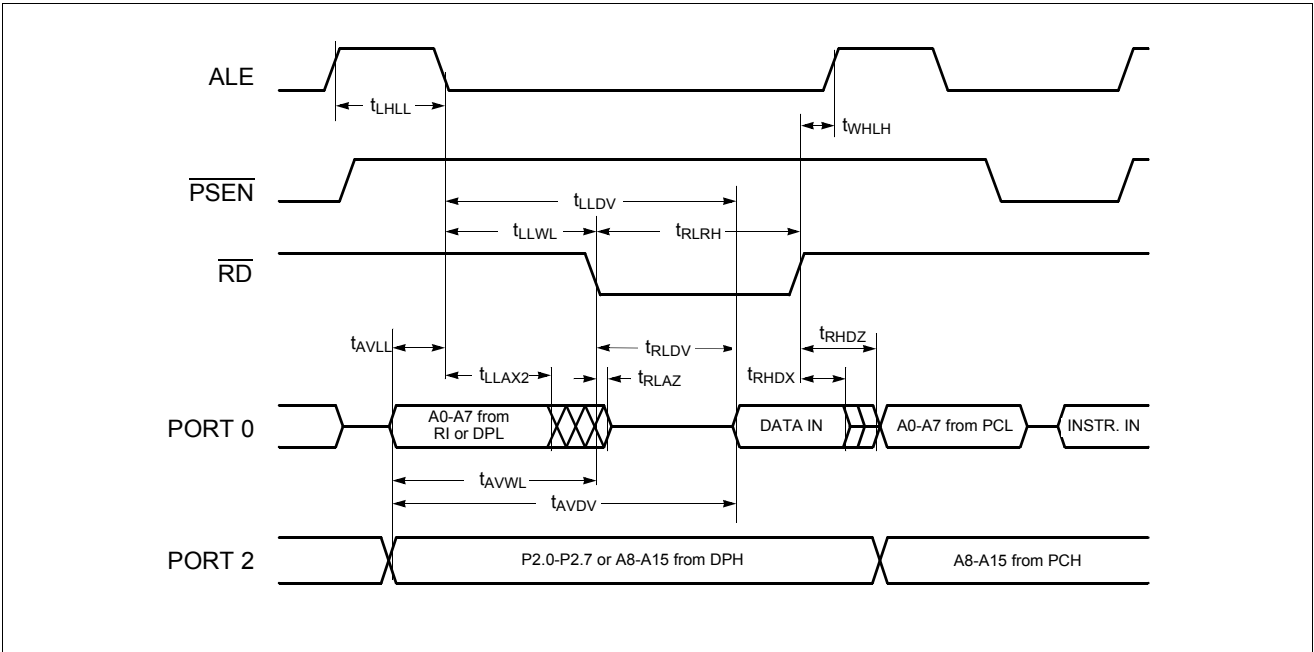


Figure 5. External Data Memory Read Cycle

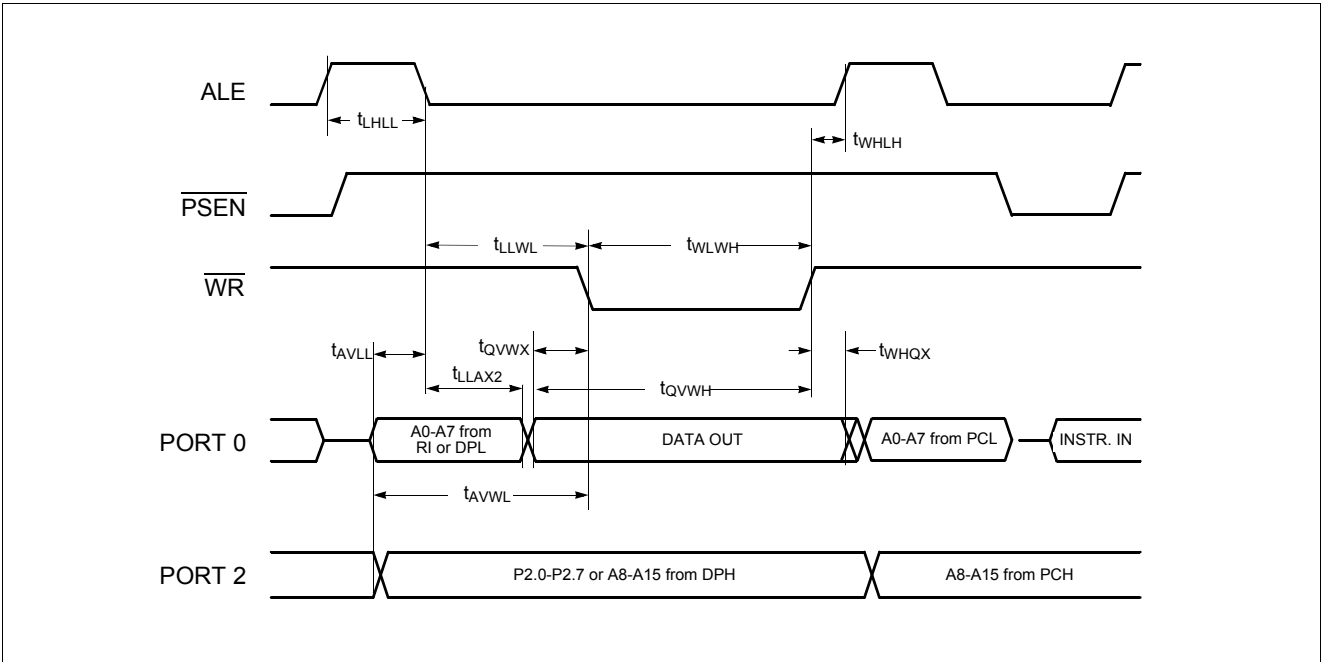


Figure 6. External Data Memory Write Cycle

Chapter 4. Flash Characteristics

4.1 Flash Characteristics

The GMS99C58 is programmed by using a Pulse Programming algorithm. Table 17 shows the logic levels for reading the main memory, for programming the main memory, for programming the encryption table, for programming the security bits, and erase the all Flash cell memory. The circuit configuration and waveforms are shown in Figure 7 and Figure 9. Figure 10 shows the circuit configuration for normal program memory verification.

4.2 Program Operation

The setup for pulse programming is shown in Figure 8. Note that the GMS99C58 is running with a 4 to 6MHz oscillator. The reason the oscillator needs to be running is that the device is executing internal address and program data transfers. The address of the Flash location to be programmed is applied to ports 1 and 2, port3 as shown in Figure 7. The code byte to be programmed into that location are held at the “Pgm code Data” levels indicated in Table 17.

To program the encryption table, repeat the pulse programming sequence for addresses 0 through 3FH, using the “Pgm Encryption table” levels. Do not forget that after the encryption table is programmed, verification cycles will produce only encrypted data.

To program the security bits, repeat the pulse programming sequence using the “Pgm Security Bit” levels after one security bit is programmed, further programming of the code memory and encryption table is disabled. However, the other security bit can still be programmed.

Note that the EA/VPP pin must not be allowed to go above the maximum specified VPP level for any amount of time. Even a narrow glitch above that voltage can cause permanent damage to the device. The VPP source should be well regulated and free glitches and overshoot.

4.3 Program Verify Operation

If security bit 2 has not been programmed, the on-chip program memory can be read out for program verification. The address of the memory location to be read is applied to ports 1, 2, and 3 as shown in Figure 10. The other pins are held at the “Verify Code Data” levels indicated in Table 17. The contents of the address location will be emitted on port 0 for this operation.

If the encryption table has been programmed, the data presented at port 0 will be the exclusive NOR of the program byte with one of the encryption bytes. The user will have to know the encryption table contents in order to correctly decode the verification data. The encryption table itself cannot be read out.

4.4 Chip erase

All Flash cells are erased electrically at the same time. Chip erase is initiated by using the proper combination of control signal using “Chip Erase mode”. The main memory, lock bit, and encryption memory are written with all “1” in the Chip erase operation. In this mode, Chip erase is self timed and takes about more than 200ms

4.5 Program/Verify Algorithms

Any algorithm in agreement with the conditions listed in Table 17, and which satisfies the timing specifications, is suitable.

Table 17. Flash Programming Modes

Mode		RST	PSEN	PROG	EV/Vpp	P2.7	P2.6	P3.7	P3.6
Verify	Verify code data	1	0	1	1	0	0	1	1
PGM	Pgm code data	1	0	0	Vpp	1	0	1	1
	Pgm encryption table	1	0	0	Vpp	1	0	1	0
	Pgm security bit 1	1	0	0	Vpp	1	1	1	1
	Pgm security bit 2	1	0	0	Vpp	1	1	0	0
Chip erase		1	0	0	Vpp	0	1	0	0

Note:

1. "0": valid low for that pin, "1": valid high for that pin.
2. VPP= 11.75V ± 0.25V.
3. VCC= 5V ± 10% during programming ,verification, and erasing.
4. ALE/PROG receivers programming and erasing pulses while Vpp is held at 11.75V.
5. ALE/PROG Low Pulse width and repeat limit are 20us and 4 times during programming.
6. ALE/PROG Low Pulse width and repeat limit are 30ms and 5 times during erasing.
7. A14, A13, A12 are forced to Low during the erasing time.

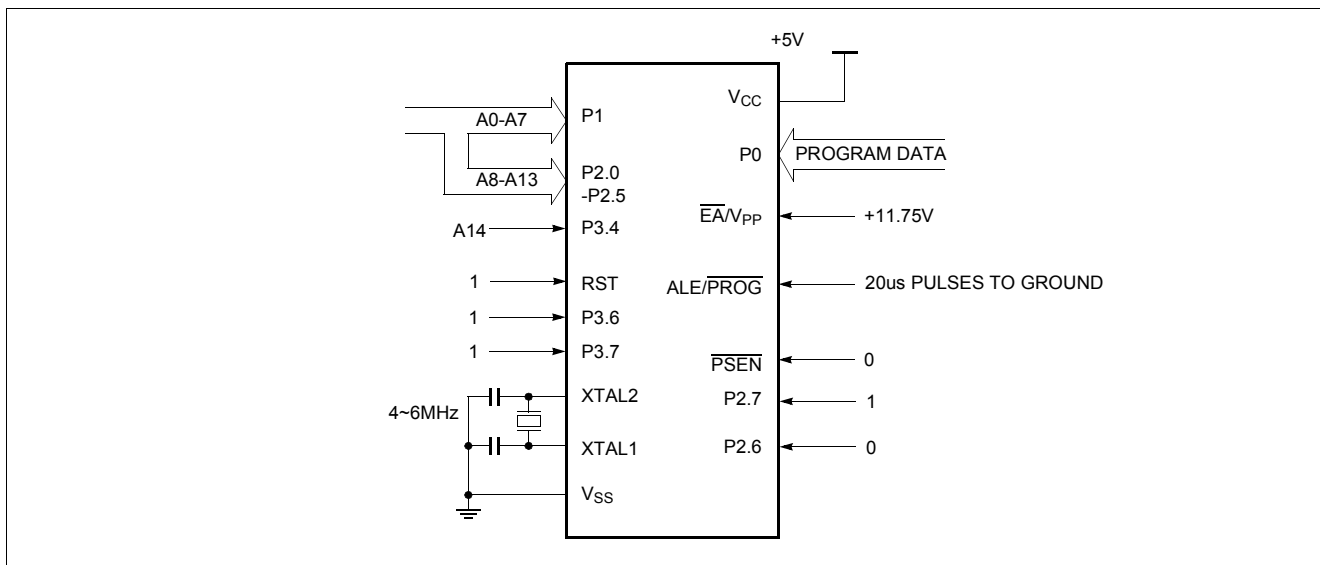


Figure 7. Programming Code data Configuration

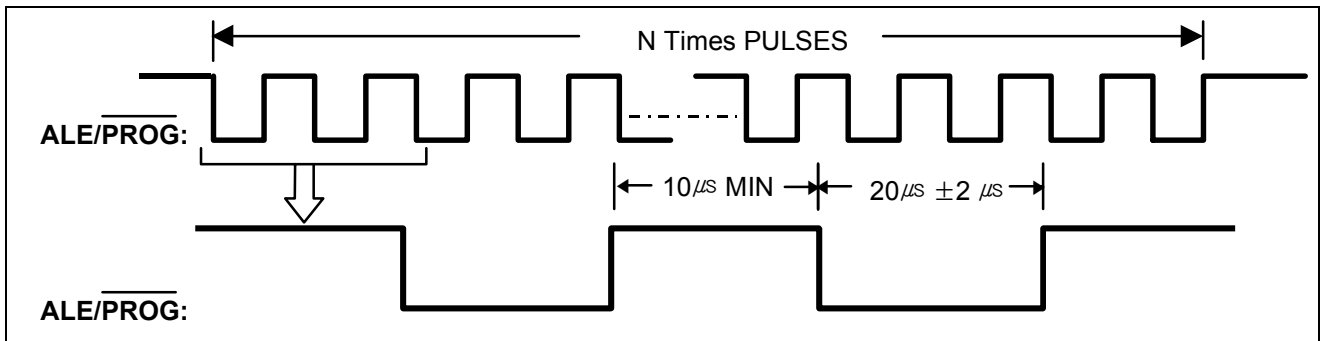


Figure 8. /PROG waveform

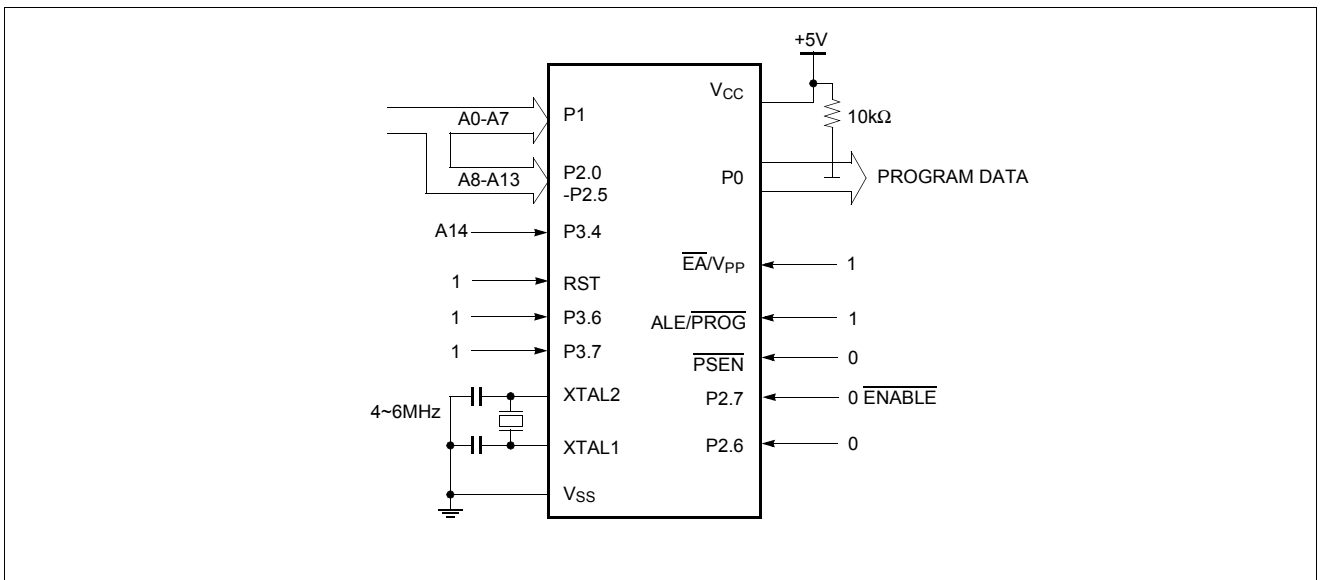


Figure 9. Program Verification

4.6 Flash Programming and Verification Characteristics

$T_A = 21^\circ\text{C}$ to 27°C , $V_{CC} = 5\text{V} \pm 10\%$, $V_{SS} = 0\text{V}$;

Parameter	Symbol	Limit Values		Unit
		Min.	Max.	
Programming supply voltage	V_{PP}	11.5	12.0	V
Programming supply current	I_{PP}	-	50	mA
Oscillator frequency	$1/t_{CLCL}$	4	6	MHz
Address setup to $\overline{\text{PROG}}$ low	t_{AVGL}	$48t_{CLCL}$	-	-
Address hold after $\overline{\text{PROG}}$	t_{GHAX}	$48t_{CLCL}$	-	-
Data setup to $\overline{\text{PROG}}$ low	t_{DVGL}	$48t_{CLCL}$	-	-
Data hold after $\overline{\text{PROG}}$	t_{GHDX}	$48t_{CLCL}$	-	-
P2.7 ($\overline{\text{ENABLE}}$) high to V_{PP}	t_{EHS}	$48t_{CLCL}$	-	-
V_{PP} setup to $\overline{\text{PROG}}$ low	t_{SHGL}	10	-	μs
V_{PP} hold after $\overline{\text{PROG}}$	t_{GHSL}	10	-	μs
$\overline{\text{PROG}}$ width of Program	t_{GLGH}	18	22	μs
$\overline{\text{PROG}}$ width of Erase	t_{GLGH}	90	110	ms
Address to data valid	t_{AVQV}	-	$48t_{CLCL}$	-
$\overline{\text{ENABLE}}$ low to data valid	t_{ELQV}	-	$48t_{CLCL}$	-
Data float after $\overline{\text{ENABLE}}$	t_{EHQZ}	0	$48t_{CLCL}$	-
$\overline{\text{PROG}}$ high to $\overline{\text{PROG}}$ low	t_{GHGL}	5	-	μs

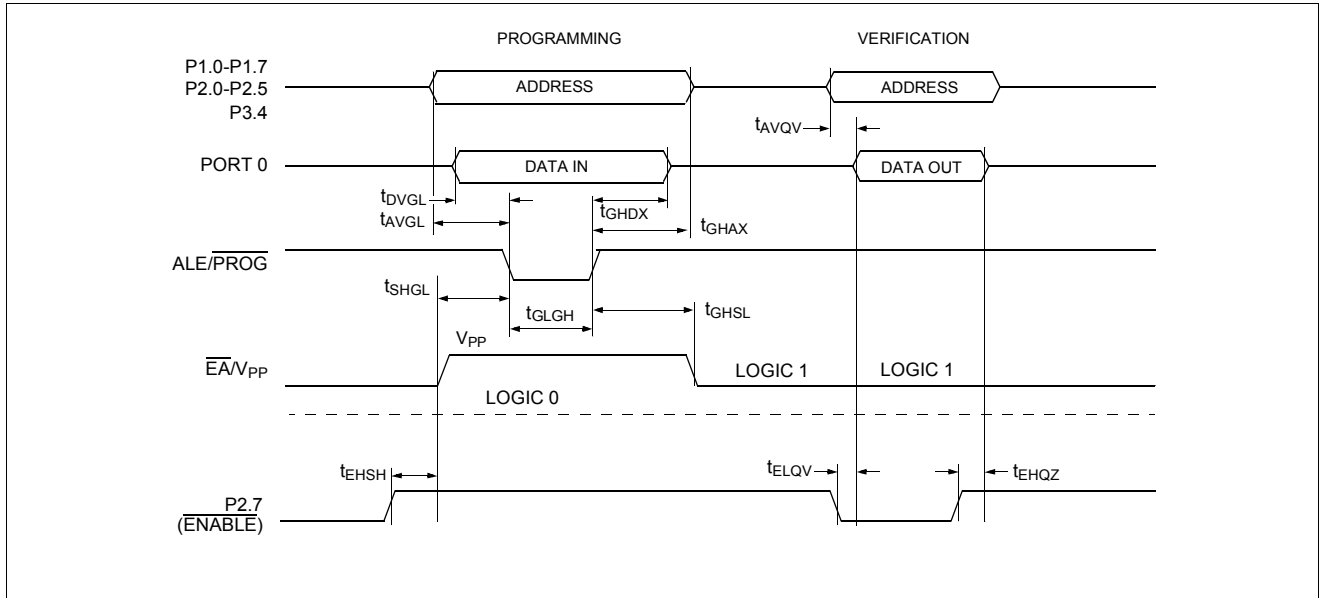


Figure 10. Flash Programming and Verification

Chapter 5. Recommended Oscillator Circuits

