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Product List

SM39A16M1U32,

Description

The SM39A16M1 is a 1T (one machine cycle per clock) single-chip 8-bit microcontroller. It has 16K-byte embedded Flash for program, and executes all ASM51 instructions fully compatible with MCS-51

SM39A16M1 contains 1K+256B on-chip RAM, up to 30 GPIOs (32L package), various serial interfaces and many peripheral functions as described below. It can be programmed via writers. Its on-chip ICE is convenient for users in verification during development stage.

The high performance of SM39A16M1 can achieve complicated manipulation within short time. About one third of the instructions are pure 1T, and the average speed is 8 times of traditional 8051, the fastest one among all the 1T 51-series. Its excellent EMI and ESD characteristics are advantageous for many different applications.

Ordering Information

SM39A16M1ihhkL yymmV

i: process identifier { U = 1.8V ~ 5.5V}

hh: pin count

k: package type postfix {as table below }

L:PB Free identifier

{No text is Non-PB free, "P" is PB free}

yy: year

mm: month

v: version identifier{ A, B,...}

Postfix	Package
V	LQFP

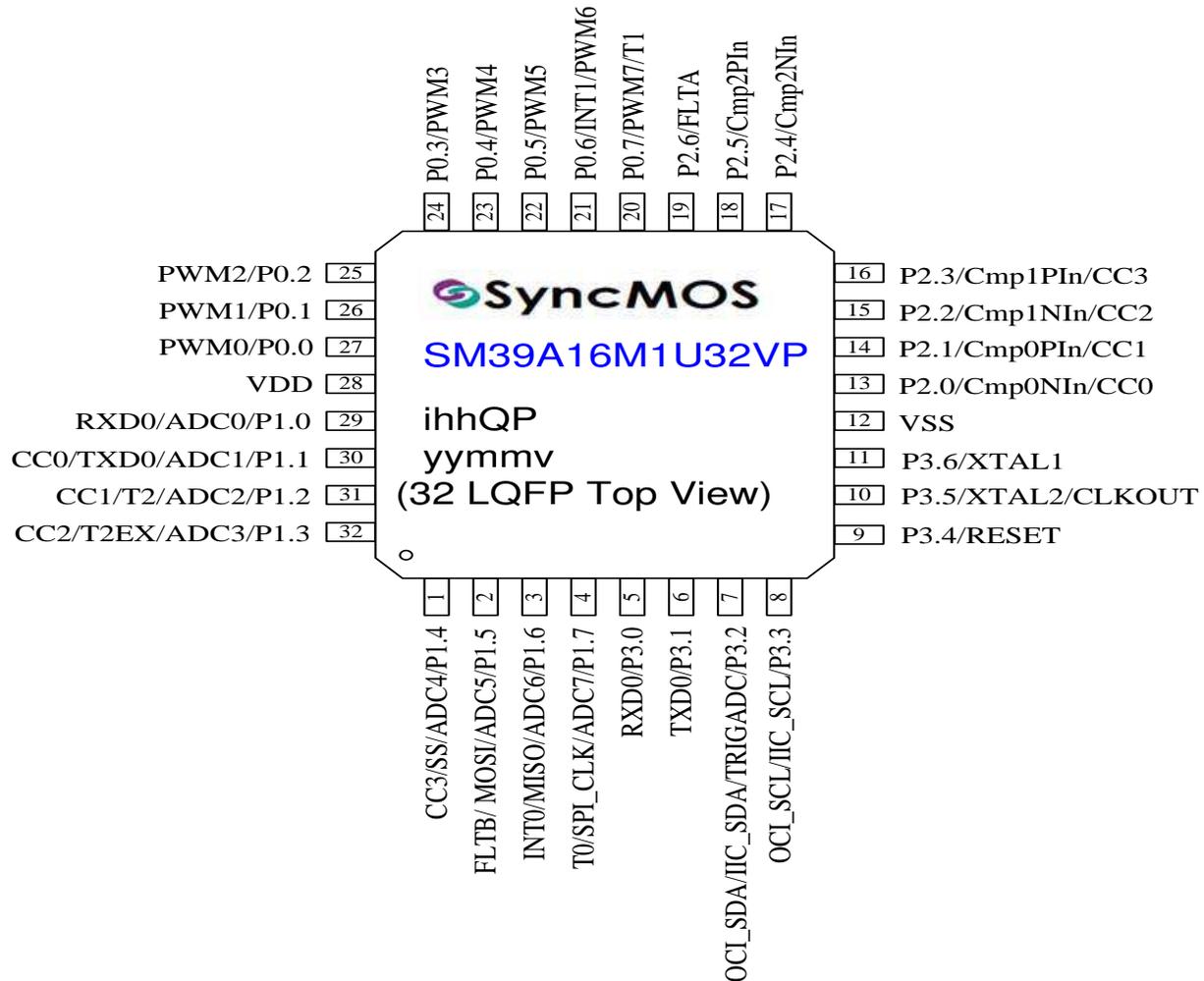
Features

- Main Flash ROM 16KB , 128B/page
- Working voltage 1.8V~5.5V
- High speed architecture of 1 clock/machine cycle runs up to 25MHz.
- 256 bytes SRAM as standard 8052, plus 1K bytes on-chip expandable SRAM.
- Dual 16-bit Data Pointers (DPTR0 & DPTR1).
- One serial peripheral interfaces in full duplex mode (UART0).
 - Synchronous mode, fixed baud rate, Serial 0 only. Synchronous mode, fixed baud rate, Serial 0 only.
 - 8-bit UART mode, variable baud rate.
 - 9-bit UART mode, fixed baud rate, Serial 0 only.
 - 9-bit UART mode, variable baud rate.
- Additional Baud Rate Generator for Serial port.
- Three 16-bit Timer/Counters. (Timer 0, 1, 2).
- Programmable watchdog timer.
- One IIC interface. (Master/Slave mode).
- One SPI interface. (Master/Slave mode)
- 8-channel 14-bit PWM for motor control
- 3 On-Chip Comparator
- 4-channel 16-bit compare / capture / load functions.
 - Comparator out can be CCU input source internally.
 - Noise filter with CCU input with sample frequency select.
- Auto-triggered by specific PWM interrupts.
- XTAL, Internal RC Oscillator 22.1184MHz
- ISP/IAP/ICP functions.
- EEPROM function.
- On-Chip in-circuit emulator (ICE) functions with On-Chip Debugger (OCD).
- Fast multiplication-division unit (MDU): 16*16, 32/16, 16/16, 32-bit L/R shifting and 32-bit normalization.
- LVI/LVR (LVR deglitch 500ns)
- Enhance user code protection.
- Power management unit for IDLE and power down modes.

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Pin Configuration

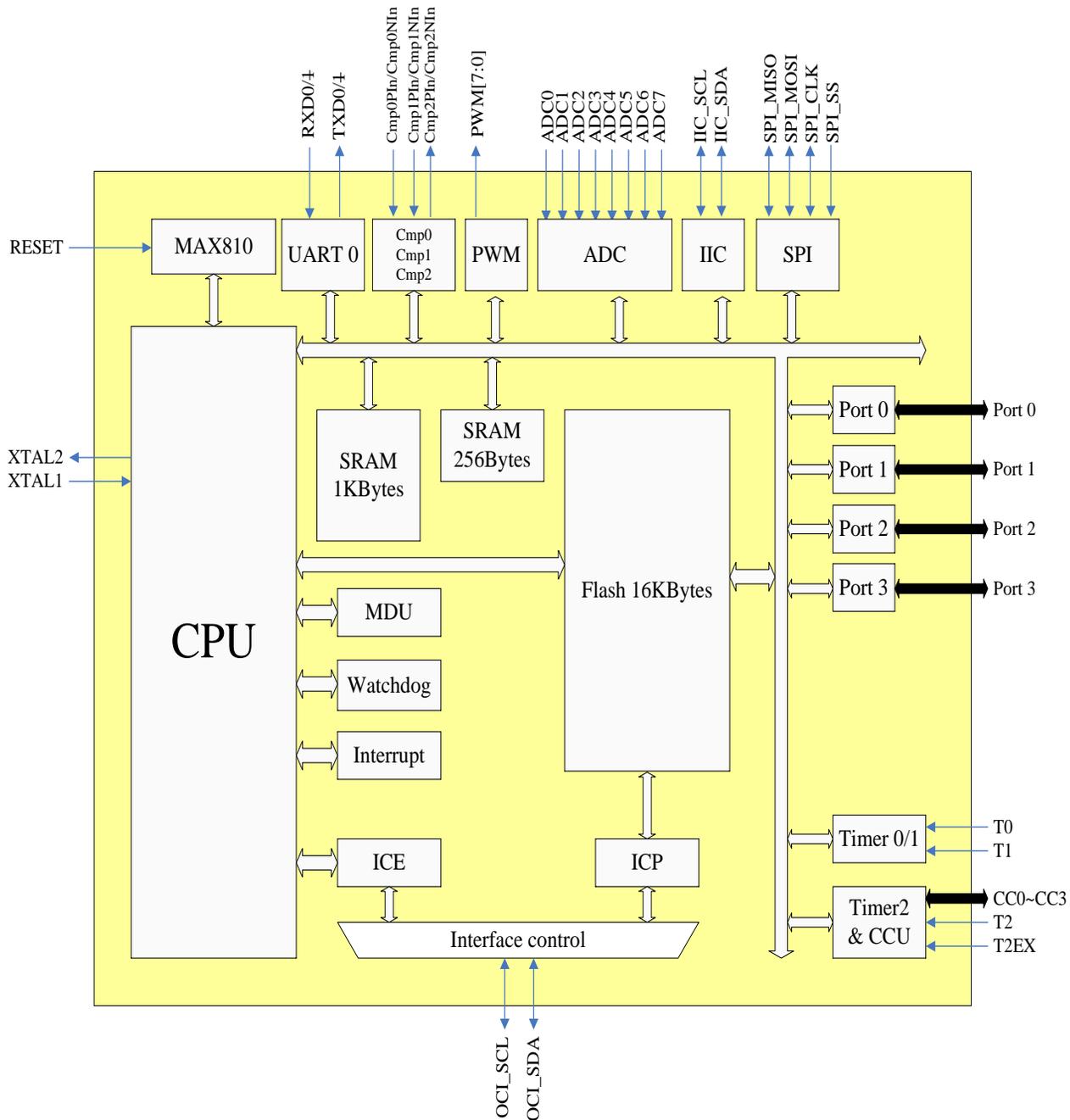
32 Pin LQFP



Notes :

- (1) The pin Reset/P3.4 factory default is GPIO (P3.4), user must keep this pin at low during power-up. User can configure it to reset by a flash programmer.
- (2) To avoid accidentally entering ISP-Mode(refer to section 18.4), care must be taken not asserting pulse signal at RXD P1.0 during power-up while P1.2,P1.3 or P1.4 or P3.0 are set to high.
- (3) To apply ICP function, OCI_SDA/P3.2 and OCI_SCL/P3.3 must be set to Bi-direction mode if they are configured as GPIO in system.

Block Diagram



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Pin Description

32L LQFP	Symbol	I/O	Description
29	P1.0/ADC0/RXD0	I/O	Bit 0 of port 1 & ADC input channel 0 & Serial interface channel 0 receive data
30	P1.1/ADC1/TXD0/C0	I/O	Bit 1 of port 1 & ADC input channel 1 & Serial interface channel 0 Transmit data & Timer 2 compare/capture Channel 0
31	P1.2/ADC2/T2/CC1	I/O	Bit 2 of port 1 & ADC input channel 2 & Timer 2 external input clock & Timer 2 compare/capture Channel 1
32	P1.3/ADC3/T2EX/C2	I/O	Bit 3 of port 1 & ADC input channel 3 & Timer 2 capture trigger & Timer 2 compare/capture Channel 2
1	P1.4/ADC4/SS/CC3	I/O	Bit 4 of port 1 & ADC input channel 4 & SPI interface Slave Select pin & Timer 2 compare/capture Channel 3
2	P1.5/ADC5/MOSI/FLT_B	I/O	Bit 5 of port 1 & ADC input channel 5 & SPI interface Serial Data Master Output or Slave Input pin & Fault_B
3	P1.6/ADC6/MISO/INT0	I/O	Bit 6 of port 1 & ADC input channel 6 & SPI interface Serial Data Master Input or Slave Output pin & External interrupt 0
4	P1.7/ADC7/SPI_CLK/T0	I/O	Bit 7 of port 1 & ADC input channel 7 & SPI interface Clock pin & Timer 0 external input
5	P3.0/RXD0	I/O	Bit 0 of port 3 & Serial interface channel 0 receive/Transmit data
6	P3.1/TXD0	I/O	Bit 1 of port 3 & Serial interface channel 0 Transmit data or receive clock in mode 0
7	P3.2/TRIGADC/IIC_SDA/OCI_SDA	I/O	Bit 2 of port 3 & external pin to trigger ADC & IIC SDA pin & On-Chip Instrumentation SDA
8	P3.3/IIC_SCL/OCI_SCL	I/O	Bit 3 of port 3 & IIC SCL pin & On-Chip Instrumentation SCL
9	P3.4/RESET	I/O	Bit 4 of port 3 & Reset pin
10	P3.5/XTAL2/CLKOUT	I/O	Bit 5 of port 3 & Crystal output & clock out
11	P3.6/XTAL1	I/O	Bit 6 of port 3 & Crystal input
12	VSS		Ground
13	P2.0/Cmp0NIn/CC0	I/O	Bit 0 of port 2 & Cmp0 Negative Input & Timer 2 compare/capture Channel 0
14	P2.1/Cmp0PIn/CC1	I/O	Bit 1 of port 2 & Cmp0 Positive Input & Timer 2 compare/capture Channel 1
15	P2.2/Cmp1NIn/CC2	I/O	Bit 2 of port 2 & Cmp1 Negative Input & Timer 2 compare/capture Channel 2
16	P2.3/Cmp1PIn/CC3	I/O	Bit 3 of port 2 & Cmp1 Positive Input & Timer 2 compare/capture Channel 3
17	P2.4/Cmp2NIn	I/O	Bit 4 of port 2 & Cmp2 Negative Input
18	P2.5/Cmp2PIn	I/O	Bit 5 of port 2 & Cmp2 Positive Input
19	P2.6/FLTA	I/O	Bit 6 of port 2 & Fault_A
20	P0.7/PWM7/T1	I/O	Bit 7 of port 0 & PWM Channel 7 & Timer 1 external input
22	P0.5/PWM5	I/O	Bit 5 of port 0 & PWM Channel 5
23	P0.4/PWM4	I/O	Bit 4 of port 0 & PWM Channel 4
24	P0.3/PWM3	I/O	Bit 3 of port 0 & PWM Channel 3
25	P0.2/PWM2	I/O	Bit 2 of port 0 & PWM Channel 2
26	P0.1/PWM1	I/O	Bit 1 of port 0 & PWM Channel 1
27	P0.0/PWM0	I/O	Bit 0 of port 0 & PWM Channel 0
28	VDD	I	Power supply

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Special Function Register (SFR)

A map of the Special Function Registers is shown as below:

In-direct access Mode

Hex\Bin	X000	X001	X010	X011	X100	X101	X110	X111	Bin/Hex
F8	IICS	IICCTL	IICA1	IICA2	IICRWD	IICEBT	Cmp0CON	Cmp1CON	FF
F0	B	SPIC1	SPIC2	SPITXD	SPIRXD	SPIS	OpPin	TAKEY	F7
E8		MD0	MD 1	MD 2	MD 3	MD 4	MD 5	ARCON	EF
E0	ACC	ISPF AH	ISPF AL	ISPF D	ISPF C		lvC	SWRES	E7
D8		PFC ON	P3M0	P3M1					DF
D0	PSW	CCEN2	P0M0	P0M1	P1M0	P1M1	P2M0	P2M1	D7
C8	T2CON	CCCON	CRCL	CRCH	TL2	TH2	OpPin2	Cmp2CON	CF
C0	IRCON	CCEN	CCL1	CCH1	CCL2	CCH2	CCL3	CCH3	C7
B8	IEN1	IP1	SRELH				PAGESEL		BF
B0	P3						WDTC	WDTK	B7
A8	IEN0	IP0	SRELL	ADCC1	ADCC2	ADCDH	ADCDL	ADCCS	AF
A0	P2	RSTS	PWM ADDR	PWM DATA					A7
98	SCON	SBUF	IEN2						9F
90	P1	AUX	AUX2					IRCON2	97
88	TCON	TMOD	TL0	TL1	TH0	TH1	CKCON	IFCON	8F
80	P0	SP	DPL	DPH	DPL1	DPH1	RCON	PCON	87
Hex\Bin	X000	X001	X010	X011	X100	X101	X110	X111	Bin/Hex



Page Mode: page0

Hex\Bin	X000	X001	X010	X011	X100	X101	X110	X111	Bin/Hex
F8	IICS	IICCTL	IICA1	IICA2	IICRWD	IICEBT	Cmp0CON	Cmp1CON	FF
F0	B	SPIC1	SPIC2	SPITXD	SPIRXD	SPIS	OpPin	TAKEY	F7
E8		MD0	MD1	MD2	MD3	MD4	MD5	ARCON	EF
E0	acc	ISPF AH	ISPF AL	ISPF D	ISPF C		lvC	SWRES	E7
D8		PFC ON	P3M0	P3M1					DF
D0	psw	CCEN2	P0M0	P0M1	P1M0	P1M1	P2M0	P2M1	D7
C8	t2con	CCCON	CRCL	CRCH	TL2	TH2	OpPin2	Cmp2CON	CF
C0	IRCON	CCEN	CCL1	CCH1	CCL2	CCH2	CCL3	CCH3	C7
B8	IEN1	IP1	SRELH				PAGESEL		BF
B0	P3						WDTC	WDTK	B7
A8	IEN0	IP0	SRELL	ADCC1	ADCC2	ADCDH	ADC DL	ADCCS	AF
A0	P2	RSTS							A7
98	SCON	SBUF	IEN2						9F
90	P1	AUX	AUX2					IRCON2	97
88	TCON	TMOD	TL0	TL1	TH0	TH1	CKCON	IFCON	8F
80	P0	SP	DPL	DPH	DPL1	DPH1	RCON	PCON	87
Hex\Bin	X000	X001	X010	X011	X100	X101	X110	X111	Bin/Hex

Page Mode: page1

Hex\Bin	X000	X001	X010	X011	X100	X101	X110	X111	Bin/Hex
F8		PWMTB C0	PWMTB C1	PWMOP MOD	TBCOUN TERL	TBCOUN TERH			FF
F0	B	PERIOD L	PERIOD H	SEVTCM PL	SEVTCM PH	PWMEN		TAKEY	F7
E8		DEADTI ME0	DEADTI ME1	DEADTI ME2	DEADTI ME3	PWMSE V	PWMTB POST SCALE		EF
E0	ACC	ISPFAL	ISPFAL	ISPFAL	ISPFAL		IVC	SWRES	E7
D8		PFCON		FLTCON FIG	FLTNF	PWMPO LARITY	OVRIDEDI S	OVRIDEDA TA	DF
D0	PSW	DUTY0L	DUTY0H	DUTY1L	DUTY1H	DUTY2L	DUTY2H	DUTY3L	D7
C8	T2CON	DUTY3H			TL2	TH2			CF
C0	IRCON								C7
B8	IEN1	IP1	SRELH		PWMINT F		PAGESEL		BF
B0	P3						WDTC	WDTK	B7
A8	IEN0	IP0	SRELL	ADCC1	ADCC2	ADCDH	ADCDC	ADCCS	AF
A0	P2								A7
98	SCON	SBUF	IEN2						9F
90	P1	AUX	AUX2					IRCON2	97
88	TCON	TMOD	TL0	TL1	TH0	TH1	CKCON	IFCON	8F
80	P0	SP	DPL	DPH	DPL1	DPH1	RCON	PCON	87
Hex\Bin	X000	X001	X010	X011	X100	X101	X110	X111	Bin/Hex

Note: Special Function Registers reset values and description for SM39A16M1.

Register	Location: 80h ~ 8Fh			Reset value	Description
	Method 1	Method 2 Page 0	Method 2 Page 1		
SYSTEM					
SP	81h	81h	81h	07h	Stack Pointer
ACC	E0h	E0h	E0h	00h	Accumulator
PSW	D0h	D0h	D0h	00h	Program Status Word
B	F0h	F0h	F0h	00h	B Register
DPL	82h	82h	82h	00h	Data Pointer 0 low byte
DPH	83h	83h	83h	00h	Data Pointer 0 high byte
DPL1	84h	84h	84h	00h	Data Pointer 1 low byte
DPH1	85h	85h	85h	00h	Data Pointer 1 high byte
AUX	91h	91h	91h	00h	Auxiliary register
PCON	87h	87h	87h	00h	Power Control
CKCON	8Eh	8Eh	8Eh	10h	Clock control register
PAGESEL	BEh	BEh	BEh	00h	Page select
INTERRUPT & PRIORITY					
IRCON	C0h	C0h	C0h	00h	Interrupt Request Control Register
IRCON2	97h	97h	97h	00h	Interrupt Request Control Register 2
IEN0	A8h	A8h	A8h	00h	Interrupt Enable Register 0
IEN1	B8h	B8h	B8h	00h	Interrupt Enable Register 1
IEN2	9Ah	9Ah	9Ah	00h	Interrupt Enable Register 2
IP0	A9h	A9h	A9h	00h	Interrupt Priority Register 0
IP1	B9h	B9h	B9h	00h	Interrupt Priority Register 1
UART					
PCON	87h	87h	87h	00h	Power Control
AUX	91h	91h	91h	00h	Auxiliary register
SCON	98h	98h	98h	00h	Serial Port, Control Register
SBUF	99h	99h	99h	00h	Serial Port, Data Buffer
SRELL	AAh	AAh	AAh	00h	Serial Port, Reload Register, low byte
SRELH	BAh	BAh	BAh	00h	Serial Port, Reload Register, high byte
PFCON	D9h	D9h	D9h	00h	Peripheral Frequency control register
ADC					
ADCC1	ABh	ABh	ABh	00h	ADC Control 1 Register
ADCC2	ACH	ACH	ACH	08h	ADC Control 2 Register
ADCDH	ADh	ADh	ADh	00h	ADC data high byte
ADCDL	Aeh	Aeh	Aeh	00h	ADC data low byte
ADCCS	AFh	AFh	AFh	00h	ADC clock select
WDT					
RSTS	A1h	A1h		00h	Reset status register
WDTC	B6h	B6h	B6h	04h	Watchdog timer control register

Specifications subject to change without notice contact your sales representatives for the most recent information.

Register	Location: 80h ~ 8Fh			Reset value	Description
	Method 1	Method 2 Page 0	Method 2 Page 1		
WDTK	B7h	B7h	B7h	00h	Watchdog timer refresh key.
TAKEY		F7h		00h	Time Access Key register
PWM					
ADCC2	ACh	ACh	ACh	08H	ADC control 2 Reg.
PWMTBC0			F9	00H	PWM Time Base Control 0 Reg.
PWMTBC1			FA	10H	PWM Time Base Control 1 Reg.
PWMOPMOD			FB	00H	PWM Output Pair Mode Reg.
TBCOUNTERL			FC	00H	Time Base Counter (Low)
TBCOUNTERH			FD	00H	Time Base Counter (High)
PERIODL			F1	FFH	PWM Period (Low) Reg.
PERIODH			F2	3FH	PWM Period(High) Reg.
SEVTCMPL			F3	FFH	Special Event Compare Low Reg.
SEVTCMPH			F4	3FH	Special Event Compare High Reg.
PWMEN			F5	00H	PWM Output Enable Reg.
PWMSEV			ED	00H	PWM Special Event Reg.
PWMTBPOST SCALE			EE	00H	PWM TIME BASE POST SCALE Reg.
PWMINTF			BCh	00H	PWM INT Flag Reg.
DEADTIME0			E9	00H	Dead Time 0 Reg.
DEADTIME1			EA	00H	Dead Time 1 Reg.
DEADTIME2			EB	00H	Dead Time 2 Reg.
DEADTIME3			EC	00H	Dead Time 3 Reg.
FLTCONFIG			DB	80H	Fault Config Reg.
FLTNF			DC	00H	Fault noise filter Reg.
PWMPOLARITY			DD	FFH	PWM Polarity Reg.
OVRIDEDIS			DE	FFH	Override Disable Reg.
OVRIDEDATA			DF	00H	Override Data Reg.
DUTY0L			D1	00H	PWM 0 Duty Low byte Reg.
DUTY0H			D2	00H	PWM 0 Data High byte Reg.
DUTY1L			D3	00H	PWM 1 Duty Low byte Reg.
DUTY1H			D4	00H	PWM 1 Data High byte Reg.
DUTY2L			D5	00H	PWM 2 Duty Low byte Reg.
DUTY2H			D6	00H	PWM 2 Duty High byte Reg.
DUTY3L			D7	00H	PWM 3 Duty Low byte Reg.
DUTY3H			C9	00H	PWM 3 Duty High byte Reg.
PWMADDR	A2h			00H	PWM Address Register
PWMDATA	A3h			00H	PWM Data Register
TIMER0/TIMER1					
TCON	88h	88h	88h	00h	Timer/Counter Control

Specifications subject to change without notice contact your sales representatives for the most recent information.

Register	Location: 80h ~ 8Fh			Reset value	Description
	Method 1	Method 2 Page 0	Method 2 Page 1		
TMOD	89h	89h	89h	00h	Timer Mode Control
TL0	8Ah	8Ah	8Ah	00h	Timer 0, low byte
TL1	8Bh	8Bh	8Bh	00h	Timer 1, low byte
TH0	8Ch	8Ch	8Ch	00h	Timer 0, high byte
TH1	8Dh	8Dh	8Dh	00h	Timer 1, high byte
PFCON	D9h	D9h	D9h	00h	Peripheral Frequency control register
PCA(TIMER2)					
AUX2	92h	92h	92h		Auxiliary 2 register
CCEN	C1h	C1h		00h	Compare/Capture Enable Register
CCL1	C2h	C2h		00h	Compare/Capture Register 1, low byte
CCH1	C3h	C3h		00h	Compare/Capture Register 1, high byte
CCL2	C4h	C4h		00h	Compare/Capture Register 2, low byte
CCH2	C5h	C5h		00h	Compare/Capture Register 2, high byte
CCL3	C6h	C6h		00h	Compare/Capture Register 3, low byte
CCH3	C7h	C7h		00h	Compare/Capture Register 3, high byte
T2CON	C8h	C8h	C8h	00h	Timer 2 Control
CCCON	C9h	C9h		00h	Compare/Capture Control
CRCL	CAh	CAh		00h	Compare/Reload/Capture Register, low byte
CRCH	CBh	CBh		00h	Compare/Reload/Capture Register, high byte
TL2	CCh	CCh	CCh	00h	Timer 2, low byte
TH2	CDh	CDh	CDh	00h	Timer 2, high byte
CCEN2	D1h	D1h		00h	Compare/Capture Enable 2 register
GPIO					
P0	80h	80h	80h	User define	Port 0
P1	90h	90h	90h	FFh	Port 1
P2	A0h	A0h	A0h	7Fh	Port 2
P3	B0h	B0h	B0h	7Fh	Port 3
P0M0	D2h	D2h		00h	Port 0 output mode 0
P0M1	D3h	D3h		00h	Port 0 output mode 1
P1M0	D4h	D4h		00h	Port 1 output mode 0
P1M1	D5h	D5h		00h	Port 1 output mode 1
P2M0	D6h	D6		00h	Port 2 output mode 0
P2M1	D7h	D7		00h	Port 2 output mode 1
P3M0	DAh	DAh		00h	Port 3 output mode 0
P3M1	DBh	DBh		00h	Port 3 output mode 1
ISP/IAP/EEPROM					

Specifications subject to change without notice contact your sales representatives for the most recent information.

Register	Location: 80h ~ 8Fh			Reset value	Description
	Method 1	Method 2 Page 0	Method 2 Page 1		
IFCON	8Fh	8Fh	8Fh	00h	Interface control register
ISPF AH	E1h	E1h	E1h	FFh	ISP Flash Address-High register
ISPF AL	E2h	E2h	E2h	FFh	ISP Flash Address-Low register
ISPF D	E3h	E3h	E3h	FFh	ISP Flash Data register
ISPF C	E4h	E4h	E4h	00h	ISP Flash control register
TAKEY	F7h	F7h	F7h	00h	Time Access Key register
LVI/LVR/SOFTRESET					
RSTS	A1h	A1h		00h	Reset status register
LVC	E6h	E6h	E6h	20h	Low voltage control register
SWRES	E7h	E7h	E7h	00h	Software Reset register
TAKEY	F7h	F7h	F7h	00h	Time Access Key register
SPI					
SPIC1	F1h	F1h		08h	SPI control register 1
SPIC2	F2h	F2h		00h	SPI control register 2
SPITXD	F3h	F3h		00h	SPI Transmit data buffer
SPIRXD	F4h	F4h		00h	SPI receive data buffer
SPIS	F5h	F5h		40h	SPI status register
IIC					
IICS	F8h	F8h		00h	IIC status register
IICCTL	F9h	F9h		04h	IIC control register
IICA1	FAh	FAh		A0h	IIC channel 1 Address 1 register
IICA2	FBh	FBh		60h	IIC channel 1 Address 2 register
IICRWD	FCh	FCh		00h	IIC channel 1 Read / Write Data buffer
IICEBT	FDh	FDh		00h	IIC Enable Bus Transaction register
OPA					
OPPIN	F6h	F6h		00h	Comparator Pin Select register
OPPIN2	CEh	CEh		00h	Comparator Pin Select2 register
CMP0CON	FEh	FEh		00h	Comparator 0 Control register
CMP1CON	FFh	FFh		00h	Comparator 1 Control register
CMP2CON	CFh	CFh		00h	Comparator 2 Control register

Function Description

1. General Features

SM39A16M1 is an 8-bit micro-controller. All of its functions and the detailed meanings of SFR will be given in the following sections.

1.1 Embedded Flash

The program can be loaded into the embedded 16KB Flash memory via its writer or In-System Programming (ISP). The high-quality Flash has a 100K-write cycle life · suitable for re-programming and data recording as EEPROM.

1.2 IO Pads

The SM39A16M1 has Four I/O ports: Port 0, Port 1, Port 2 and Port 3. Ports 0, 1 are 8-bit ports and Port 2, 3 are 7-bit ports. These are: quasi-bidirectional (standard 8051 port outputs), push-pull, open drain, and input-only. As description in section 5.

All the pads for P0 · P1 · P2 and P3 are with slew rate to reduce EMI. The IO pads can withstand 4KV ESD in human body mode guaranteeing the SM39A16M1's quality in high electro-static environments.

The RESET Pin can define as General I/O P3.4 when user use Internal RESET.

The XTAL2 and XTAL1 can define as P3.5 and P3.6 by writer or ISP · when user use internal OSC as system clock ; when user use external OSC as system clock and input into XTAL1 · Only XTAL2 can be defined as P3.5.

1.3 Instruction timing Selection

The conventional 52-series MCUs are 12T, i.e., 12 oscillator clocks per machine cycle. SM39A16M1 is a 1T to 8T MCU, i.e., its machine cycle is one-clock to eight-clock. In the other words, it can execute one instruction within one clock to only eight clocks.

Mnemonic: CKCON						Address: 8Eh		
7	6	5	4	3	2	1	0	Reset
-	ITS[2:0]			-	-	CLKOUT[1:0]		10H

ITS: Instruction timing select.

ITS [2:0]	Instruction timing
000	1T mode
001	2T mode (default)
010	3T mode
011	4T mode
100	5T mode
101	6T mode
110	7T mode
111	8T mode

The default is in 2T mode, and it can be changed to another Instruction timing mode if CKCON [6:4] (at address 8Eh) is change any time. Not every instruction can be executed with one machine cycle. The exact machine cycle number for all the instructions are given in the next section.

1.4 Clock Out Selection

The SM39A16M1 can generate a clock out signal at P3.5, when user use Oscillator (XTAL1 as clock input) or internal OSC as system clock. The CKCON [1:0] (at address 8Eh) can change any time.

CLKOUT: Clock output select.

CKCON [1:0]	Mode.
00	GPIO(default)
01	Fosc
10	Fosc/2
11	Fosc/4

It can be used when the system clock is the internal RC oscillator.

1.5 RESET

1.5.1 Hardware RESET function

SM39A16M1 provides Internal reset circuit inside, the Internal reset time can set by writer or ISP.

Internal Reset time
25ms (default)
200ms
100ms
50ms
16ms
8ms
4ms

1.5.2 Software RESET function

SM39A16M1 provides one software reset mechanism to reset whole chip. To perform a software reset, the firmware must write three specific values 55h, AAh and 5Ah sequentially to the TAKEY register to enable the Software Reset register (SWRES) write attribute. After SWRES register obtain the write authority, the firmware can write FFh to the SWRES register. The hardware will decode a reset signal that "OR" with the other hardware reset. The SWRES register is self-reset at the end of the software reset procedure.

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Software Reset function											
RSTS	Reset status register	A1h	-	LVRLP INTF	LVRLP F	PDRF	WDTF	SWRF	LVRF	PORF	00H
TAKEY	Time Access Key register	F7h	TAKEY [7:0]								00H
SWRES	Software Reset register	E7h	SWRES [7:0]								00H

1.5.3 Reset status

Mnemonic: RSTS							Address: A1h	
7	6	5	4	3	2	1	0	Reset
-	LVRLP INTF	LVRLPF	PDRF	WDTF	SWRF	LVRF	PORF	00H

LVRLPINTF “Internal” Low voltage reset flag.

When MCU is reset by LVR_LP_INT, LVRLPINTF flag will be set to one by hardware. This flag clear by software.

LVRLPF Low voltage reset(Low Power) flag.

When MCU is reset by LVR(Low Power), LVRLPF flag will be set to one by hardware. This flag clear by software.

PDRF: Pad reset flag.

When MCU is reset by reset pad, PDRF flag will be set to one by hardware. This flag clear by software.

WDTF: Watchdog timer reset flag.

When MCU is reset by watchdog, WDTF flag will be set to one by hardware. This flag clear by software.

SWRF: Software reset flag.

When MCU is reset by software, SWRF flag will be set to one by hardware. This flag clear by software.

LVRF: Low voltage reset flag.

When MCU is reset by LVR, LVRF flag will be set to one by hardware. This flag clear by software.

PORF: Power on reset flag.

When MCU is reset by POR, PORF flag will be set to one by hardware. This flag clear by software.

1.5.4 Time Access Key register (TAKEY)

Mnemonic: TAKEY							Address:F7H	
7	6	5	4	3	2	1	0	Reset
TAKEY [7:0]								00H

Software reset register (SWRES) is read-only by default, software must write three specific values 55h, AAh and 5Ah sequentially to the TAKEY register to enable the SWRES register write attribute.

That is:

```
MOV TAKEY, #55h
MOV TAKEY, #0AAh
MOV TAKEY, #5Ah
```

1.5.5 Software Reset register (SWRES)

Mnemonic: SWRES

Address: E7H

7	6	5	4	3	2	1	0	Reset
SWRES [7:0]								00H

SWRES [7:0]: Software reset register bit. These 8-bit is self-reset at the end of the reset procedure.

SWRES [7:0] = FFh, software reset.

SWRES [7:0] = 00h ~ FEh, MCU no action.

1.5.6 Example of software reset

```
MOV TAKEY, #55h
MOV TAKEY, #0AAh
MOV TAKEY, #5Ah ; enable SWRES write attribute
MOV SWRES, #0FFh ; software reset MCU
```

1.6 Clocks

The default clock is the 22.1184MHz Internal OSC. This clock is used during the initialization stage. The major work of the initialization stage is to determine the clock source used in normal operation.

The internal clock sources are from the internal OSC with difference frequency division As shown in Table 1-1, the clock source can set by writer or ICP.

Table 1-1: Selection of clock source

Clock source
external crystal (use XTAL1 and XTAL2 pins)
external crystal (only use XTAL1, the XTAL2 define as I/O)
22.1184MHz from internal OSC
22.1184MHz/2 from internal OSC
22.1184MHz/4 from internal OSC
22.1184MHz/8 from internal OSC
22.1184MHz/16 from internal OSC

There may be having a little variance in the frequency from the internal OSC. The max variance as giving in Table 1-2.

Table 1-2: Temperature with variance

Temperature	Max Variance
25°C	±2%

2. Instruction Set

All SM39A16M1 instructions are binary code compatible and perform the same functions as they do with the industry standard 8051. The following tables give a summary of the instruction set cycles of the SM39A16M1 Microcontroller core. As given in Table

Table 2-1: Arithmetic operations

Mnemonic	Description	Code	Bytes	Cycles
ADD A,Rn	Add register to accumulator	28-2F	1	1
ADD A,direct	Add direct byte to accumulator	25	2	2
ADD A,@Ri	Add indirect RAM to accumulator	26-27	1	2
ADD A,#data	Add immediate data to accumulator	24	2	2
ADDC A,Rn	Add register to accumulator with carry flag	38-3F	1	1
ADDC A,direct	Add direct byte to A with carry flag	35	2	2
ADDC A,@Ri	Add indirect RAM to A with carry flag	36-37	1	2
ADDC A,#data	Add immediate data to A with carry flag	34	2	2
SUBB A,Rn	Subtract register from A with borrow	98-9F	1	1
SUBB A,direct	Subtract direct byte from A with borrow	95	2	2
SUBB A,@Ri	Subtract indirect RAM from A with borrow	96-97	1	2
SUBB A,#data	Subtract immediate data from A with borrow	94	2	2
INC A	Increment accumulator	04	1	1
INC Rn	Increment register	08-0F	1	2
INC direct	Increment direct byte	05	2	3
INC @Ri	Increment indirect RAM	06-07	1	3
INC DPTR	Increment data pointer	A3	1	1
DEC A	Decrement accumulator	14	1	1
DEC Rn	Decrement register	18-1F	1	2
DEC direct	Decrement direct byte	15	2	3
DEC @Ri	Decrement indirect RAM	16-17	1	3
MUL AB	Multiply A and B	A4	1	5
DIV	Divide A by B	84	1	5
DA A	Decimal adjust accumulator	D4	1	1

Table 2-2: Logic operations

Mnemonic	Description	Code	Bytes	Cycles
ANL A,Rn	AND register to accumulator	58-5F	1	1
ANL A,direct	AND direct byte to accumulator	55	2	2
ANL A,@Ri	AND indirect RAM to accumulator	56-57	1	2
ANL A,#data	AND immediate data to accumulator	54	2	2
ANL direct,A	AND accumulator to direct byte	52	2	3
ANL direct,#data	AND immediate data to direct byte	53	3	4
ORL A,Rn	OR register to accumulator	48-4F	1	1
ORL A,direct	OR direct byte to accumulator	45	2	2
ORL A,@Ri	OR indirect RAM to accumulator	46-47	1	2
ORL A,#data	OR immediate data to accumulator	44	2	2
ORL direct,A	OR accumulator to direct byte	42	2	3
ORL direct,#data	OR immediate data to direct byte	43	3	4
XRL A,Rn	Exclusive OR register to accumulator	68-6F	1	1
XRL A,direct	Exclusive OR direct byte to accumulator	65	2	2
XRL A,@Ri	Exclusive OR indirect RAM to accumulator	66-67	1	2
XRL A,#data	Exclusive OR immediate data to accumulator	64	2	2
XRL direct,A	Exclusive OR accumulator to direct byte	62	2	3
XRL direct,#data	Exclusive OR immediate data to direct byte	63	3	4
CLR A	Clear accumulator	E4	1	1
CPL A	Complement accumulator	F4	1	1
RL A	Rotate accumulator left	23	1	1
RLC A	Rotate accumulator left through carry	33	1	1
RR A	Rotate accumulator right	03	1	1
RRC A	Rotate accumulator right through carry	13	1	1
SWAP A	Swap nibbles within the accumulator	C4	1	1

Table 2-3: Data transfer

Mnemonic	Description	Code	Bytes	Cycles
MOV A,Rn	Move register to accumulator	E8-EF	1	1
MOV A,direct	Move direct byte to accumulator	E5	2	2
MOV A,@Ri	Move indirect RAM to accumulator	E6-E7	1	2
MOV A,#data	Move immediate data to accumulator	74	2	2
MOV Rn,A	Move accumulator to register	F8-FF	1	2
MOV Rn,direct	Move direct byte to register	A8-AF	2	4
MOV Rn,#data	Move immediate data to register	78-7F	2	2
MOV direct,A	Move accumulator to direct byte	F5	2	3
MOV direct,Rn	Move register to direct byte	88-8F	2	3
MOV direct1,direct2	Move direct byte to direct byte	85	3	4
MOV direct,@Ri	Move indirect RAM to direct byte	86-87	2	4
MOV direct,#data	Move immediate data to direct byte	75	3	3
MOV @Ri,A	Move accumulator to indirect RAM	F6-F7	1	3
MOV @Ri,direct	Move direct byte to indirect RAM	A6-A7	2	5
MOV @Ri,#data	Move immediate data to indirect RAM	76-77	2	3
MOV DPTR,#data16	Load data pointer with a 16-bit constant	90	3	3
MOVC A,@A+DPTR	Move code byte relative to DPTR to accumulator	93	1	3
MOVC A,@A+PC	Move code byte relative to PC to accumulator	83	1	3
PUSH direct	Push direct byte onto stack	C0	2	4
POP direct	Pop direct byte from stack	D0	2	3
XCH A,Rn	Exchange register with accumulator	C8-CF	1	2
XCH A,direct	Exchange direct byte with accumulator	C5	2	3
XCH A,@Ri	Exchange indirect RAM with accumulator	C6-C7	1	3
XCHD A,@Ri	Exchange low-order nibble indir. RAM with A	D6-D7	1	3

Table 2-4: Program branches

Mnemonic	Description	Code	Bytes	Cycles
ACALL addr11	Absolute subroutine call	xxx11	2	6
LCALL addr16	Long subroutine call	12	3	6
RET	from subroutine	22	1	4
RETI	from interrupt	32	1	4
AJMP addr11	Absolute jump	xxx01	2	3
LJMP addr16	Long iump	02	3	4
SJMP rel	Short jump (relative addr.)	80	2	3
JMP @A+DPTR	Jump indirect relative to the DPTR	73	1	2
JZ rel	Jump if accumulator is zero	60	2	3
JNZ rel	Jump if accumulator is not zero	70	2	3
JC rel	Jump if carry flag is set	40	2	3
JNC	Jump if carry flag is not set	50	2	3
JB bit,rel	Jump if direct bit is set	20	3	4
JNB bit,rel	Jump if direct bit is not set	30	3	4
JBC bit,direct rel	Jump if direct bit is set and clear bit	10	3	4
CJNE A,direct rel	Compare direct byte to A and jump if not equal	B5	3	4
CJNE A,#data rel	Compare immediate to A and jump if not equal	B4	3	4
CJNE Rn,#data rel	Compare immed. to reg. and jump if not equal	B8-BF	3	4
CJNE @Ri,#data rel	Compare immed. to ind. and jump if not equal	B6-B7	3	4
DJNZ Rn,rel	Decrement register and jump if not zero	D8-DF	2	3
DJNZ direct,rel	Decrement direct byte and jump if not zero	D5	3	4
NOP	No operation	00	1	1

Table 2-5: Boolean manipulation

Mnemonic	Description	Code	Bytes	Cycles
CLR C	Clear carry flag	C3	1	1
CLR bit	Clear direct bit	C2	2	3
SETB C	Set carry flag	D3	1	1
SETB bit	Set direct bit	D2	2	3
CPL C	Complement carry flag	B3	1	1
CPL bit	Complement direct bit	B2	2	3
ANL C,bit	AND direct bit to carry flag	82	2	2
ANL C,/bit	AND complement of direct bit to carry	B0	2	2
ORL C,bit	OR direct bit to carry flag	72	2	2
ORL C,/bit	OR complement of direct bit to carry	A0	2	2
MOV C,bit	Move direct bit to carry flag	A2	2	2
MOV bit,C	Move carry flag to direct bit	92	2	3

3. Memory Structure

The SM39A16M1 memory structure follows general 8052 structure. It is 16KB program memory

3.1 Program Memory

The SM39A16M1 has 16KB on-chip flash memory which can be used as general program memory or EEPROM, on which include up to 1K byte specific ISP service program memory space. The address range for the 16K byte is \$0000 to \$3FFF. The address range for the ISP service program is \$3C00 to \$3FFF. The ISP service program size can be partitioned as N blocks of 128 byte (N=0 to 8). When N=0 means no ISP service program space available, total 16K byte memory used as program memory. When N = 1 means address \$3F80 to \$3FFF reserved for ISP service program. When N=2 means memory address \$3F00 to \$3FFF reserved for ISP service program...etc. Value N can be set and programmed into SM39A16M1 information block by writer. As shown in Fig. 3-1

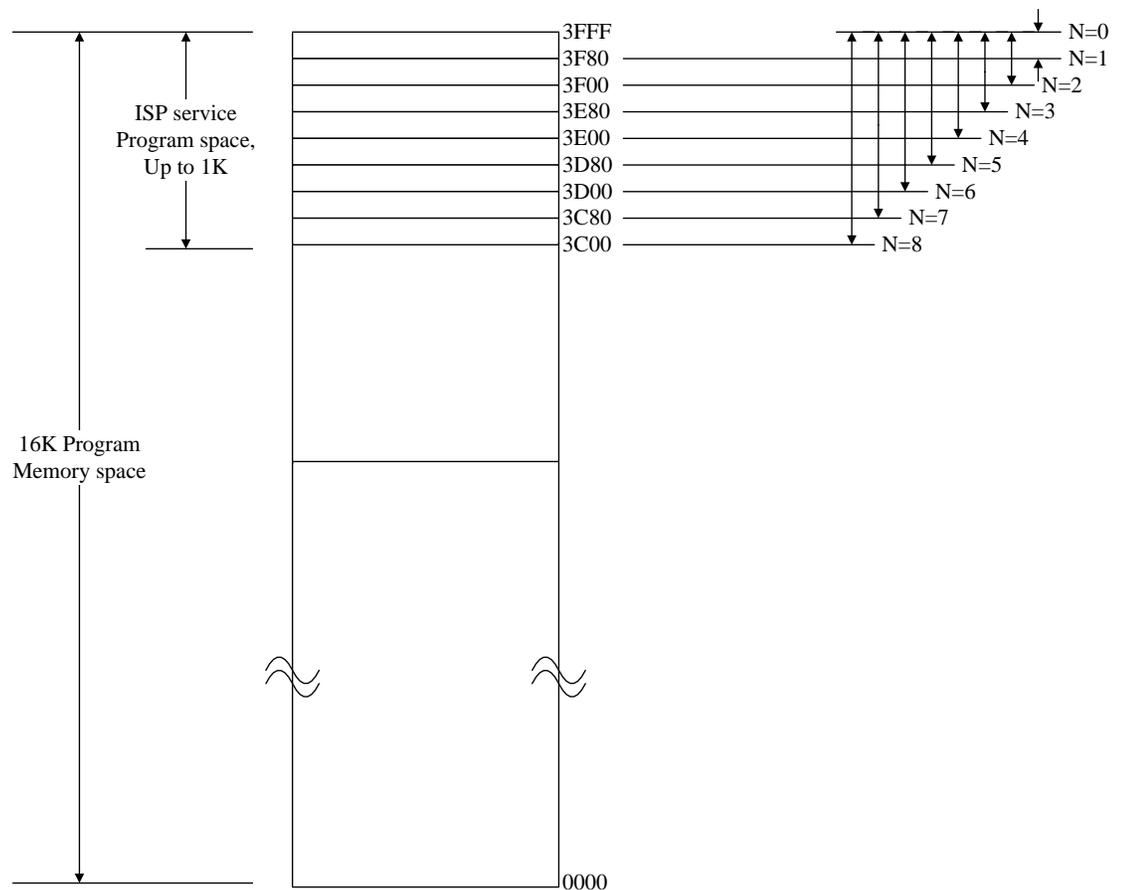


Fig. 3-1: SM39A16M1 programmable Flash

3.2 Data Memory

The SM39A16M1 has 1K + 256B on-chip SRAM, 256B of it are the same as general 8052 internal memory structure while the expanded 1K Bytes on-chip SRAM can be accessed by external memory addressing method (by instruction MOVX.). As shown in Fig. 3-2

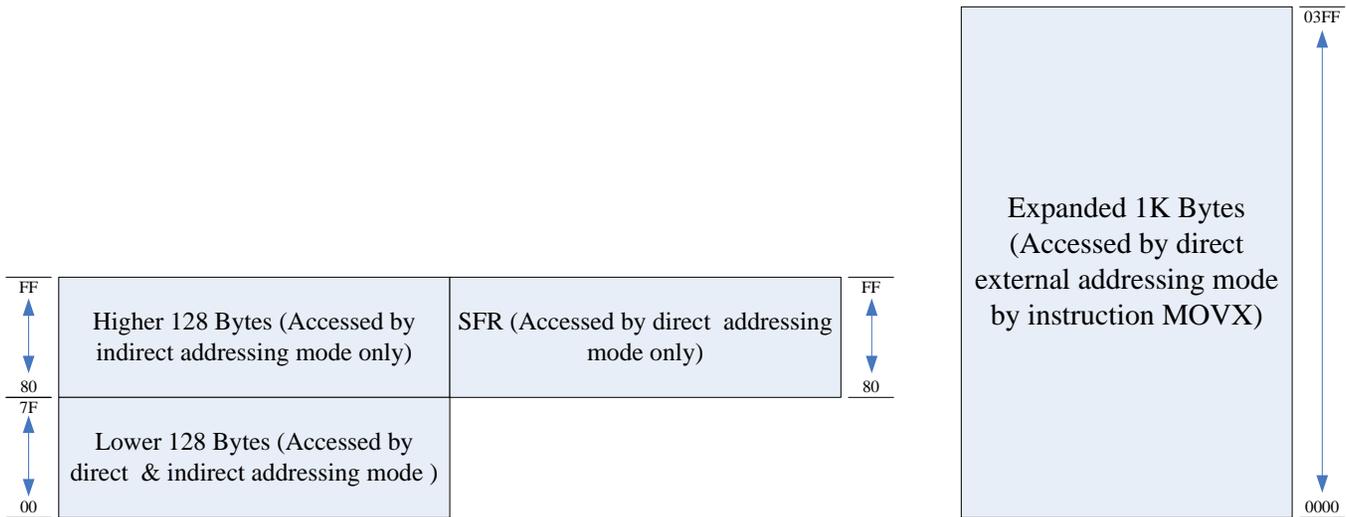


Fig. 3-2: RAM architecture

3.3 Data memory - lower 128 byte (00h to 7Fh)

Data memory 00h to FFh is the same as 8052.
 The address 00h to 7Fh can be accessed by direct and indirect addressing modes.
 Address 00h to 1Fh is register area.
 Address 20h to 2Fh is memory bit area.
 Address 30h to 7Fh is for general memory area.

3.4 Data memory - higher 128 byte (80h to FFh)

The address 80h to FFh can be accessed by indirect addressing mode.
 Address 80h to FFh is data area.

3.5 Data memory - Expanded 1K Bytes (0000h ~ 0x03FFh)

From external address 0000h to 03FFh is the on-chip expanded SRAM area, total 1K Bytes. This area can be accessed by external direct addressing mode (by instruction MOVX). The address space of instruction MOVX @Ri, i=0, 1 is determined by RCON [7:0] of special function register \$86 RCON (internal RAM control register). The default setting of RCON [7:0] is 00h (page0). One page of data RAM is 256 bytes. When EMEN = 0, the internal 1K expanded RAM is enabled.

4. CPU Engine

The SM39A16M1 engine is composed of four components:

- (1) Control unit
- (2) Arithmetic – logic unit
- (3) Memory control unit
- (4) RAM and SFR control unit

The SM39A16M1 engine allows to fetch instruction from program memory and to execute using RAM or SFR. The following chapter describes the main engine register.

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST	
8051 Core												
ACC	Accumulator	E0h	ACC.7	ACC.6	ACC.5	ACC.4	ACC.3	ACC.2	ACC.1	ACC.0	00H	
B	B register	F0h	B.7	B.6	B.5	B.4	B.3	B.2	B.1	B.0	00H	
PSW	Program status word	D0h	CY	AC	F0	RS[1:0]		OV	PSW.1	P	00H	
SP	Stack Pointer	81h	SP[7:0]									07H
DPL	Data pointer low 0	82h	DPL[7:0]									00H
DPH	Data pointer high 0	83h	DPH[7:0]									00H
DPL1	Data pointer low 0	84h	DPL1[7:0]									00H
DPH1	Data pointer high 0	85h	DPH1[7:0]									00H
AUX	Auxiliary register	91h	BRGS	P21CC	-	P1UR	-	-	-	DPS	00H	
CKCON	Clock control register	8Eh	-	ITS[2:0]					CLKOUT[1:0]		10H	
IFCON	Interface control register	8Fh	-	CDPR	-	-	-	-	-	ISPE	00H	

4.1 Accumulator

ACC is the Accumulator register. Most instructions use the accumulator to store the operand.

Mnemonic: ACC								Address: E0h	
7	6	5	4	3	2	1	0	Reset	
ACC.7	ACC.6	ACC.5	ACC.4	ACC.3	ACC.2	ACC.1	ACC.0	00h	

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

4.2 B Register

The B register is used during multiply and divide instructions. It can also be used as a scratch pad register to store temporary data.

Mnemonic: B								Address: F0h	
7	6	5	4	3	2	1	0	Reset	
B.7	B.6	B.5	B.4	B.3	B.2	B.1	B.0	00h	

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

4.3 Program Status Word

Mnemonic: PSW							Address: D0h	
7	6	5	4	3	2	1	0	Reset
CY	AC	F0	RS [1:0]		OV	F1	P	00h

CY: Carry flag.

AC: Auxiliary Carry flag for BCD operations.

F0: General purpose Flag 0 available for user.

RS[1:0]: Register bank select, used to select working register bank.

RS[1:0]	Bank Selected	Location
00	Bank 0	00h – 07h
01	Bank 1	08h – 0Fh
10	Bank 2	10h – 17h
11	Bank 3	18h – 1Fh

OV: Overflow flag.

F1: General purpose Flag 1 available for user.

P: Parity flag, affected by hardware to indicate odd/even number of “one” bits in the Accumulator, i.e. even parity.

4.4 Stack Pointer

The stack pointer is a 1-byte register initialized to 07h after reset. This register is incremented before PUSH and CALL instructions, causing the stack to start from location 08h.

Mnemonic: SP							Address: 81h	
7	6	5	4	3	2	1	0	Reset
SP [7:0]								07h

SP[7:0]: The Stack Pointer stores the scratchpad RAM address where the stack begins. In other words, it always points to the top of the stack.

4.5 Data Pointer

The data pointer (DPTR) is 2-bytes wide. The lower part is DPL, and the highest is DPH. It can be loaded as a 2-byte register (e.g. MOV DPTR, #data16) or as two separate registers (e.g. MOV DPL, #data8). It is generally used to access the external code or data space (e.g. MOVC A, @A+DPTR, @DPTR respectively).

Mnemonic: DPL							Address: 82h	
7	6	5	4	3	2	1	0	Reset
DPL [7:0]								00h

DPL[7:0]: Data pointer Low 0

Mnemonic: DPH							Address: 83h	
7	6	5	4	3	2	1	0	Reset
DPH [7:0]								00h

DPH [7:0]: Data pointer High 0

4.6 Data Pointer 1

The Dual Data Pointer accelerates the moves of data block. The standard DPTR is a 16-bit register that is used to address external memory or peripherals. In the SM39A16M1 core the standard data pointer is called DPTR, the second data pointer is called DPTR1. The data pointer select bit chooses the active pointer. The data pointer select bit is located in LSB of AUX register (DPS).

The user switches between pointers by toggling the LSB of AUX register. All DPTR-related instructions use the currently selected DPTR for any activity.

Mnemonic: DPL1							Address: 84h	
7	6	5	4	3	2	1	0	Reset
DPL1 [7:0]								00h

DPL1[7:0]: Data pointer Low 1

Mnemonic: DPH1							Address: 85h	
7	6	5	4	3	2	1	0	Reset
DPH1 [7:0]								00h

DPH1[7:0]: Data pointer High 1

Mnemonic: AUX							Address: 91h	
7	6	5	4	3	2	1	0	Reset
BRGS	P21CC	-	P1UR	-	-	-	DPS	00H

DPS: Data Pointer select register.

DPS = 1 is selected DPTR1.

4.7 Clock control register

Mnemonic: CKCON							Address: 8Eh	
7	6	5	4	3	2	1	0	Reset
-	ITS[2:0]		-	-	CLKOUT[1:0]		10H	

ITS[2:0]: Instruction timing select.

ITS [2:0]	Mode
000	1T mode
001	2T mode (default)
010	3T mode
011	4T mode
100	5T mode
101	6T mode
110	7T mode
111	8T mode

CLKOUT[1:0]: Clock output select.

CLKOUT[1:0]	Mode
00	GPIO(default)
01	Fosc
10	Fosc/2
11	Fosc/4

It can be used when the system clock is the internal RC oscillator.

Specifications subject to change without notice contact your sales representatives for the most recent information.

4.8 Interface control register

Mnemonic: IFCON							Address: 8Fh	
7	6	5	4	3	2	1	0	Reset
-	CDPR	-	-	-	-	-	ISPE	00H

CDPR: Code protect (Read Only)

ISPE: ISP function enable bit

ISPE = 1, enable ISP function

ISPE = 0, disable ISP function

4.9 PAGESEL (Page Select)

The SM59A16U1 provide two different methods to set Special Function Register (SFR) are as follow:

- SFR Method 1 (Indirect Mode): This method is only an SFR page. If you want to use PWM registers of the Method 2, can be used indirectly addressable setting.
Example: Write a data 0x80h to PWMEN Register in Method 1.
PAGESEL = 0x0h; // Method 1.
PWMADDR = 0xF5h; // PWMEN indirect address: 0xF5h (Indirect mode)
// (Refer Page1 Table of the Method 2)
PWMDATA = 0x80h; // Write data 0x80h to PWMEN.
- SFR Method 2 (Page Mode): This method provides two SFR page to set the registers.
Example: Write a data 0x80h to PWMEN Register in Method 2, Page 1.
PAGESEL = 0x3h; // Method 2, Page 1 (Page mode)
PWMEN = 0x80h; // Write data 0x80h to PWMEN.
- SFR Page Mode Table:

Page_mode	Page_num	SFR Select
0	0	SFR Method 1
0	1	SFR Method 1
1	0	SFR Method 2, Page 0
1	1	SFR Method 2, Page 1

Mnemonic: PAGESEL							Address: BEh	
7	6	5	4	3	2	1	0	Reset
						Page num	Pagemode	00H

Page_num: This flag is used only in the SFR method 2

0 = page 0 mode

1 = page 1 mode.

Page_mode: This flag is used to select SFR register table.

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0 : SFR Method 1 (indirect mode).

1 : SFR Method 2 (page mode).

5. GPIO

The SM39A16M1 has four I/O ports: Port 0, Port 1, Port 2, Port 3. Ports 0, 1, 2 are 8-bit ports and Ports 2, 3 are 7-bit ports. These are: quasi-bidirectional (standard 8051 port outputs), push-pull, open drain, and input-only. Two configuration registers for each port select the output type for each port pin. All I/O port pins on the SM39A16M1 may be configured by software to one of four types on a pin-by-pin basis, shown as below:

Mnemonic	Description	Direct	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RESET	
I/O port function register												
P0M0	Port 0 output mode 0	D2h					P0M0 [7:0]				~OP18	
P0M1	Port 0 output mode 1	D3h					P0M1[7:0]				00H	
P1M0	Port 1 output mode 0	D4h					P1M0[7:0]				00H	
P1M1	Port 1 output mode 1	D5h					P1M1[7:0]				00H	
P2M0	Port 2 output mode 0	D6h	-					P2M0[6:0]				00H
P2M1	Port 2 output mode 1	D7h	-					P2M1[6:0]				00H
P3M0	Port 3 output mode 0	DAh	-					P3M0[6:0]				00H
P3M1	Port 3 output mode 1	DBh	-					P3M1[6:0]				00H

*OP18 by writer programming set.

PxM1.y	PxM0.y	Port output mode
0	0	Quasi-bidirectional (standard 8051 port outputs) (pull-up)
0	1	Push-pull
1	0	Input only (high-impedance)
1	1	Open drain

The RESET Pin can define as General I/O P3.4 when user use Internal RESET.

The XTAL2 and XTAL1 can define as P3.5 and P3.6 by writer or ISP , when user use internal OSC as system clock ; when user use external OSC as system clock and input into XTAL1 , Only XTAL2 can be defined as P3.5.

For general-purpose applications, every pin can be assigned to either high or low independently As shown below:

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Ports											
Port 3	Port 3	B0h	-	P3.6	P3.5	P3.4	P3.3	P3.2	P3.1	P3.0	7Fh
Port 2	Port 2	A0h	-	P2.6	P2.5	P2.4	P2.3	P2.2	P2.1	P2.0	7Fh
Port 1	Port 1	90h	P1.7	P1.6	P1.5	P1.4	P1.3	P1.2	P1.1	P1.0	FFh
Port 0	Port 0	80h	P0.7	P0.6	P0.5	P0.4	P0.3	P0.2	P0.1	P0.0	~OP19

*OP19 by writer programming set.

Mnemonic: P0								Address: 80h	
7	6	5	4	3	2	1	0	Reset	
P0.7	P0.6	P0.5	P0.4	P0.3	P0.2	P0.1	P0.0	~OP19	

P0.7~ 0: Port0 [7] ~ Port0[0]

Mnemonic: P1								Address: 90h	
7	6	5	4	3	2	1	0	Reset	
P1.7	P1.6	P1.5	P1.4	P1.3	P1.2	P1.1	P1.0	FFh	

P1.7~ 0: Port1 [7] ~ Port1 [0]

Mnemonic: P2								Address: A0h	
7	6	5	4	3	2	1	0	Reset	
-	P2.6	P2.5	P2.4	P2.3	P2.2	P2.1	P2.0	7Fh	

P2.6~ 0: Port2 [6] ~ Port2 [0]

Mnemonic: P3								Address: B0h	
7	6	5	4	3	2	1	0	Reset	
-	P3.6	P3.5	P3.4	P3.3	P3.2	P3.1	P3.0	7Fh	

P3.6~ 0: Por3 [6] ~ Port3 [0]

6. Multiplication Division unit

This on-chip arithmetic unit provides 32-bit division, 16-bit multiplication, shift and normalize features. All operations are unsigned integer operation.

Table 6-1 Multiplication Division Register

Mnemonic	Description	Direct	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RESET
Multiplication Division Unit											
PCON	Power control	87H	SMO D	MD UF	-	-	-	-	STOP	IDLE	40H
ARCON	Arithmetic Control register	EFh	MDEF	MD OV	SLR	SC[4:0]				00H	
MD0	Multiplication/ Division Register 0	E9h	MD0[7:0]								00H
MD1	Multiplication/ Division Register 1	EAh	MD1[7:0]								00H
MD2	Multiplication/ Division Register 2	EBh	MD2[7:0]								00H
MD3	Multiplication/ Division Register 3	ECh	MD3[7:0]								00H
MD4	Multiplication/ Division Register 4	EDh	MD4[7:0]								00H
MD5	Multiplication/ Division Register 5	EEh	MD5[7:0]								00H

6.1 Operating registers of the MDU

The MDU is handled by eight registers, which are memory mapped as special function registers. The arithmetic unit allows operations concurrently to and independent of the CPU's activity. Operands and results registers are MD0 to MD5. Control register is ARCON. Any calculation of the MDU overwrites its operands.

Mnemonic: ARCON					Address: EFh			
7	6	5	4	3	2	1	0	
MDEF	MDOV	SLR	SC[4:0]			Reset		00H

MDEF- Multiplication Division Error Flag.

The MDEF is an error flag. The error flag is read only. The error flag indicates an improperly performed operation (when one of the arithmetic operations has been restarted or interrupted by a new operation). The error flag mechanism is automatically enabled with the first write to MD0 and disabled with the final read instruction from MD3 multiplication or shift/normalizing) or MD5 (division) in phase three.

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The error flag is set when:

- Phase two in process and write access to mdx registers (restart or interrupt calculations)

The error flag is reset only if:

Phase two finished (arithmetic operation successful completed) and read access to MDx registers.

MDOV - Multiplication Division Overflow flag. The overflow flag is read only.

The overflow flag is set when:

- Division by Zero
- Multiplication with a result greater then 0000FFFFh
- Start of normalizing if the most significant bit of MD3 is set(MD3.7 = 1)

The overflow flag is reset when:

Write access to MD0 register (Start Phase one)

SLR - Shift direction bit.

SLR = 0 – shift left operation.

SLR = 1 – shift right operation.

SC[4:0] - Shift counter.

When preset with 00000b, normalizing is selected. After normalize sc.0 – sc.4 contains the number of normalizing shifts performed. When sc.4 – sc.0 ≠ 0, shift- operation is started. The number of shifts performed is determined by the count written to sc.4 to sc.0. sc.4 – MSB ... sc.0 – LSB

6.2 Operation of the MDU

Operations of the MDU consist of three phases:

6.2.1 First phase: Loading the MDx registers.

The type of calculation the MDU has to perform is selected following the order in which the mdx registers are written to.

Table 6-2 MDU registers write sequence

Operation	32bit/16bit	16bit/16bit	16bit x 16bit	shift/normalizing
First write	MD0 Dividend Low MD1 Dividend MD2 Dividend MD3 Dividend High MD4 Divisor Low	MD0 Dividend Low MD1 Dividend High	MD0 Multiplicand Low MD4 Multiplier Low MD1 Multiplicand High	MD0 LSB MD1 MD2 MD3 MSB
Last write	MD5 Divisor High	MD4 Divisor Low MD5 Divisor High	MD5 Multiplier High	ARCON start conversion

A write to md0 is the first transfer to be done in any case. Next writes must be done as shown in Table 6-2 to determine MDU operation. Last write finally starts selected operation.

6.2.2 Second phase: Executing calculation.

During executing operation, the MDU works on its own parallel to the CPU. When MDU is finished, the MDUF register will be set to one by hardware and the flag will clear at next calculation.

Mnemonic: PCON						Address: 87h		
7	6	5	4	3	2	1	0	Reset
SMOD	MDUF	-	-	-	-	STOP	IDLE	40H

MDUF: MDU finish flag.

When MDU is finished, the MDUF will be set by hardware and the bit will clear by hardware at next calculation.

Table 6-3 MDU execution times

Operation	Number of Tclk
Division 32bit/16bit	17 clock cycles
Division 16bit/16bit	9 clock cycles
Multiplication	11 clock cycles
Shift	min 3 clock cycles , max 18 clock cycles
Normalize	min 4 clock cycles , max 19 clock cycles

6.2.3 Third phase: Reading the result from the MDx registers.

Read out sequence of the first MDx registers is not critical but the last read (from MD5 - division and MD3 - multiplication, shift and normalizing) determines the end of a whole calculation (end of phase three).

Table 6-4 MDU registers read sequence

Operation	32Bit/16Bit	16Bit/16Bit	16Bit x 16Bit	shift/normalizing
First read	MD0 Quotient Low	MD0 Quotien Low	MD0 Product Low	MD0 LSB
	MD1 Quotient	MD1 Quotien High	MD1 Product	MD1
	MD2 Quotient		MD2 Product	MD2
	MD3 Quotient High			
Last read	MD4 Remainder L	MD4 Remainder Low		
	MD5 Remainder H	MD5 Remainder High	MD3 Product High	MD3 MSB

6.3 Normalizing

All reading zeroes of integers variables in registers MD0 to MD3 are removed by shift left operations. The whole operation is completed when the MSB (most significant bit) of MD3 register contains a '1'. After normalizing, bits ARCON.4 (MSB) to ARCON.0 (LSB) contain the number of shift left operations, which were done.

6.4 Shifting

SLR bit (ARCON.5) has to contain the shift direction, and ARCON.4 to ARCON.0 the shift count (which must not be 0). During shift, zeroes come into the left or right end of the registers MD0 or MD3, respectively.

7. Timer 0 and Timer 1

The SM39A16M1 has three 16-bit timer/counter registers: Timer 0, Timer 1 and Timer 2. All can be configured for counter or timer operations.

In timer mode, the Timer 0 register or Timer 1 register is incremented every 1/12/96 machine cycles, which means that it counts up after every 1/12/96 periods of the clk signal. It's dependent on SFR(PFCON).

In counter mode, the register is incremented when the falling edge is observed at the corresponding input pin T0 or T1. Since it takes 2 machine cycles to recognize a 1-to-0 event, the maximum input count rate is 1/2 of the oscillator frequency. There are no restrictions on the duty cycle, however to ensure proper recognition of 0 or 1 state, an input should be stable for at least 1 machine cycle.

Four operating modes can be selected for Timer 0 and Timer 1. Two Special Function registers (TMOD and TCON) are used to select the appropriate mode.

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Timer 0 and 1											
TL0	Timer 0, low byte	8Ah					TL0[7:0]				00H
TH0	Timer 0, high byte	8Ch					TH0[7:0]				00H
TL1	Timer 1, low byte	8Bh					TL1[7:0]				00H
TH1	Timer 1, high byte	8Dh					TH1[7:0]				00H
TMOD	Timer Mode Control	89h	GATE	C/T	M1	M0	GATE	C/T	M1	M0	00H
TCON	Timer/Counter Control	88h	TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0	00H
PFCON	Peripheral Frequency control register	D9h	-	-	SRELPS[1:0]		T1PS[1:0]		T0PS[1:0]		00H

7.1 Timer/counter mode control register (TMOD)

Mnemonic: TMOD								Address: 89h	
7	6	5	4	3	2	1	0	Reset	
GATE	C/T	M1	M0	GATE	C/T	M1	M0	00h	
Timer 1				Timer 0					

GATE: If set, enables external gate control (pin INT0 or INT1 for Counter 0 or 1, respectively). When INT0 or INT1 is high, and TRx bit is set (see TCON register), a counter is incremented every falling edge on T0 or T1 input pin

C/T: Selects Timer or Counter operation. When set to 1, a counter operation is performed, when cleared to 0, the corresponding register will function as a timer.

M1	M0	Mode	Function
0	0	Mode0	13-bit counter/timer, with 5 lower bits in TL0 or TL1 register and 8 bits in TH0 or TH1 register (for Timer 0 and Timer 1, respectively). The 3 high order bits of TL0 and TL1 are hold at zero.
0	1	Mode1	16-bit counter/timer.
1	0	Mode2	8-bit auto-reload counter/timer. The reload value is kept in TH0 or TH1, while TL0 or TL1 is incremented every machine cycle. When

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			TLx overflows, a value from THx is copied to TLx.
1	1	Mode3	If Timer 1 M1 and M0 bits are set to 1, Timer 1 stops. If Timer 0 M1 and M0 bits are set to 1, Timer 0 acts as two independent 8 bit timers / counters.

7.2 Timer/counter control register (TCON)

Mnemonic: TCON							Address: 88h	
7	6	5	4	3	2	1	0	Reset
TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0	00h

TF1: Timer 1 overflow flag set by hardware when Timer 1 overflows. This flag can be cleared by software and is automatically cleared when interrupt is processed.

TR1: Timer 1 Run control bit. If cleared, Timer 1 stops.

TF0: Timer 0 overflow flag set by hardware when Timer 0 overflows. This flag can be cleared by software and is automatically cleared when interrupt is processed.

TR0: Timer 0 Run control bit. If cleared, Timer 0 stops.

IE1: Interrupt 1 edge flag. Set by hardware, when falling edge on external pin INT1 is observed. Cleared when interrupt is processed.

IT1: Interrupt 1 type control bit. Selects falling edge or low level on input pin to cause interrupt. IT1=1, interrupt 1 select falling edge trigger. IT1=0, interrupt1 select low level trigger.

IE0: Interrupt 0 edge flag. Set by hardware, when falling edge on external pin INT0 is observed. Cleared when interrupt is processed.

IT0: Interrupt 0 type control bit. Selects falling edge or low level on input pin to cause interrupt. IT0=1, interrupt 0 select falling edge trigger. IT0=0, interrupt 0 select low level trigger.

7.3 Peripheral Frequency control register

Mnemonic: PFCON				Address: D9h				
7	6	5	4	3	2	1	0	Reset
-	-	SRELPS[1:0]		T1PS[1:0]		T0PS[1:0]		00H

T1PS[1:0]: Timer1 Prescaler select

T1PS[1:0]	Prescaler
00	Fosc/12
01	Fosc
10	Fosc/96
11	reserved

T0PS[1:0] Timer0 Prescaler select

T0PS[1:0]	Prescaler
00	Fosc/12
01	Fosc
10	Fosc/96
11	reserved

7.4 Mode 0 (13-bit Counter/Timer)

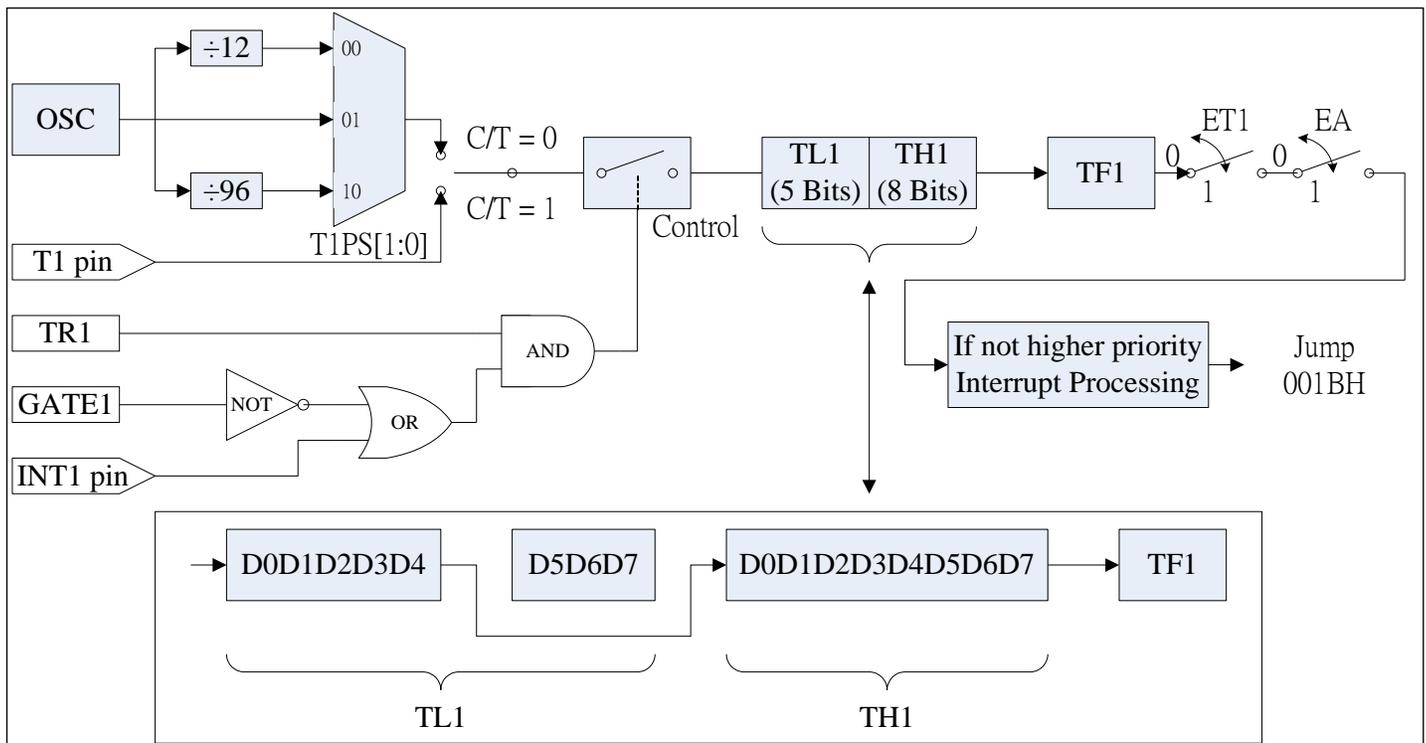


Fig. 7-1: Mode 0 -13 bit Timer / counter operation

7.5 Mode 1 (16-bit Counter/Timer)

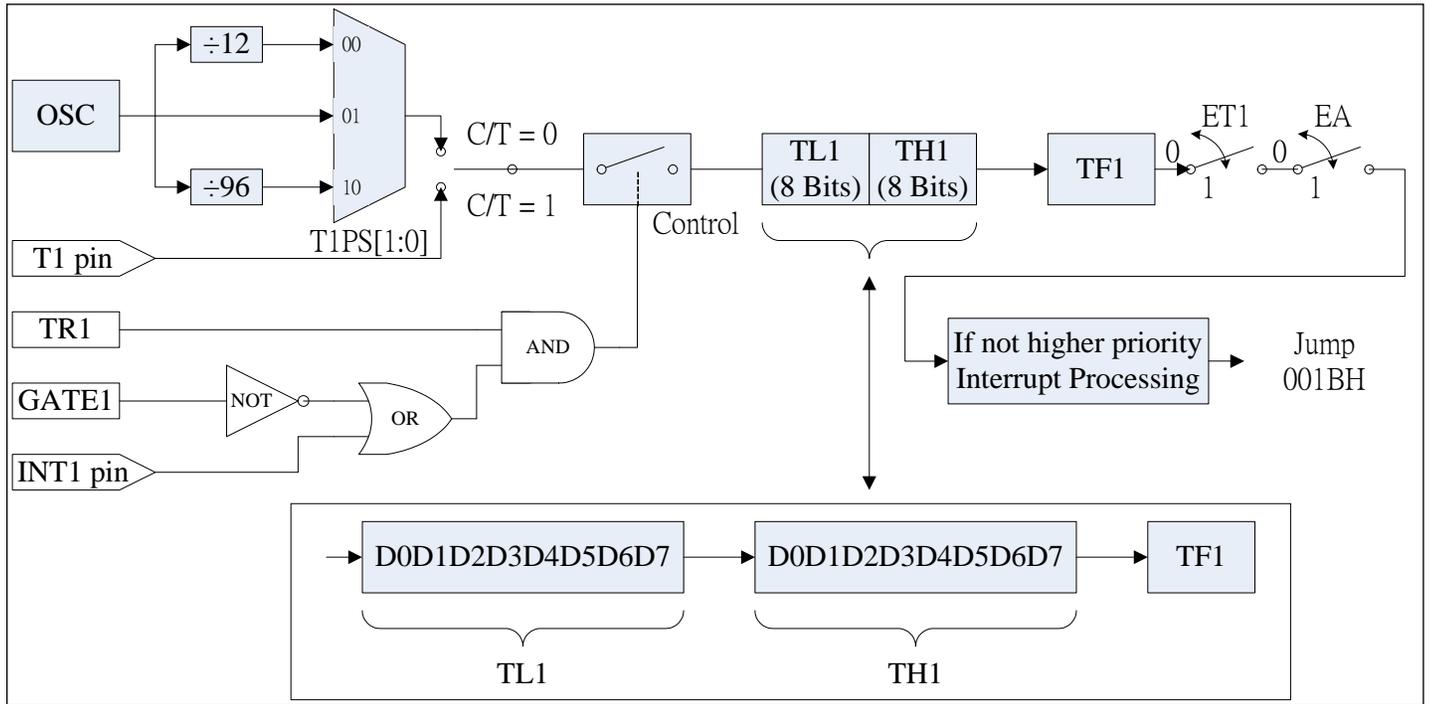


Fig. 7-2: Mode 1 16 bit Counter/Timer operation

7.6 Mode 2 (8-bit auto-reload Counter/Timer)

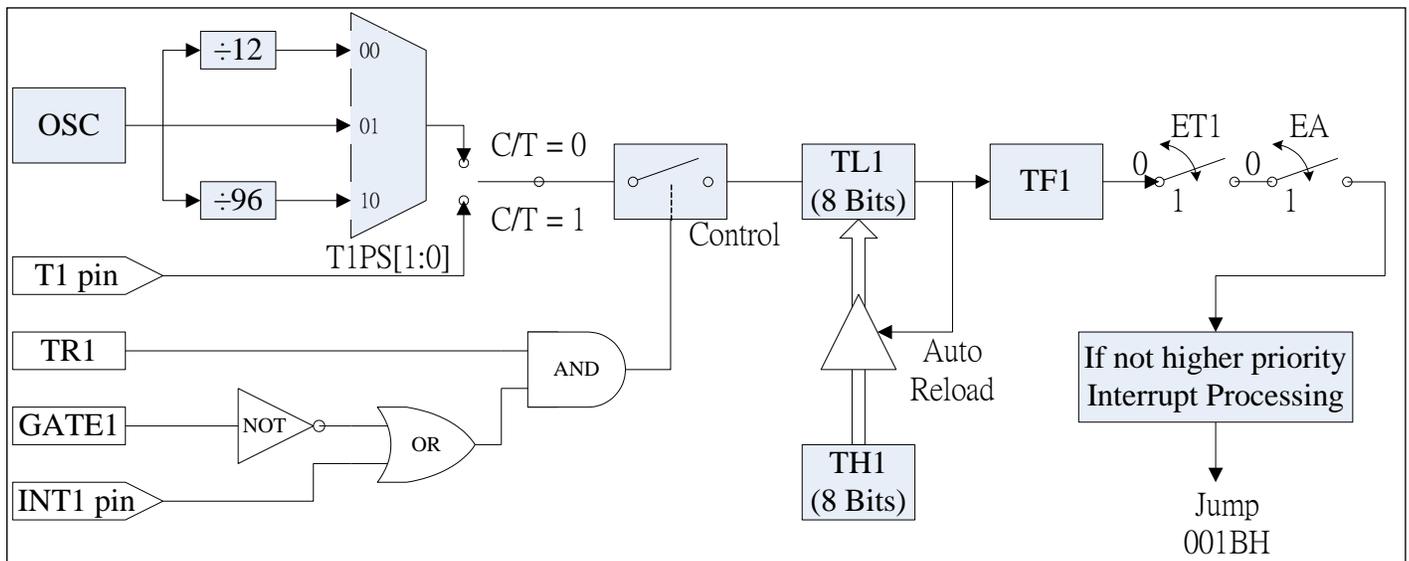


Fig. 7-3: Mode 2 8-bit auto-reload Counter/Timer operation.

7.7 Mode 3 (Timer 0 acts as two independent 8 bit Timers / Counters)

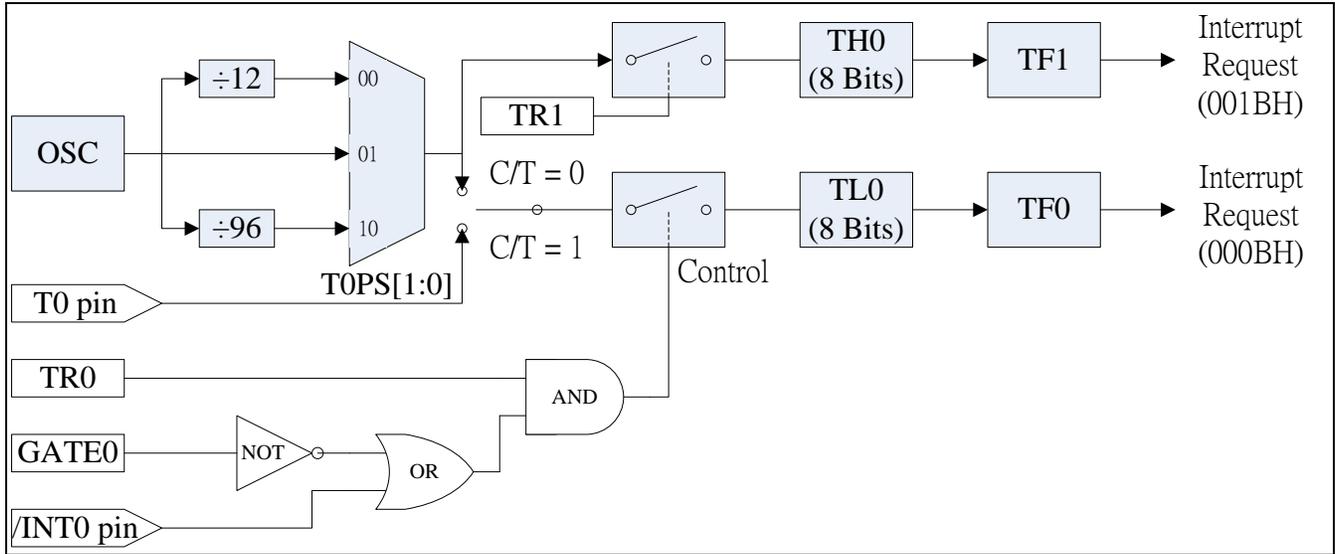


Fig. 7-4: Mode 3 Timer 0 acts as two independent 8 bit Timers / Counters operatin

8. Timer 2 and Capture Compare Unit

Timer 2 is not only a 16-bit timer, also a 4-channel unit with compare, capture and reload functions. It is very similar to the programmable counter array (PCA) in some other MCUs except pulse width modulation (PWM).

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Timer 2 and Capture Compare Unit											
AUX	Auxiliary register	91h	BRG S	P21C C	-	P1UR	-	-	-	DPS	00H
AUX2	Auxiliary 2 register	92h	CCU3 Soure	CCU2 Soure	CCU1 Soure	-	CCUINF[1:0]	CCUINFCLK[1:0]			00H
T2CON	Timer 2 control	C8h	T2PS[2:0]		T2R[1:0]		-	T2I[1:0]			00H
CCCON	Compare/Capture Control	C9h	CCI3	CCI2	CCI1	CCI0	CCF3	CCF2	CCF1	CCF0	00H
CCEN	Compare/Capture Enable register	C1h	-	COCAM1[2:0]		-	COCAM0[2:0]				00H
CCEN2	Compare/Capture Enable 2 register	D1h	-	COCAM3[2:0]		-	COCAM2[2:0]				00H
TL2	Timer 2, low byte	CCh	TL2[7:0]								00H
TH2	Timer 2, high byte	CDh	TH2[7:0]								00H
CRCL	Compare/Reload/Capture register, low byte	CAh	CRCL[7:0]								00H
CRCH	Compare/Reload/Capture register, high byte	CBh	CRCH[7:0]								00H
CCL1	Compare/Capture register 1, low byte	C2h	CCL1[7:0]								00H
CCH1	Compare/Capture register 1, high byte	C3h	CCH1[7:0]								00H
CCL2	Compare/Capture register 2, low byte	C4h	CCL2[7:0]								00H
CCH2	Compare/Capture register 2, high byte	C5h	CCH2[7:0]								00H
CCL3	Compare/Capture register 3, low byte	C6h	CCL3[7:0]								00H
CCH3	Compare/Capture register 3, high byte	C7h	CCH3[7:0]								00H

Mnemonic: AUX							Address: 91h	
7	6	5	4	3	2	1	0	Reset
BRGS	P21CC	-	P1UR	-	-	-	DPS	00H

P21CC : P21CC = 0 – Capture/Compare function on P1.

P21CC = 1 – Capture/Compare function on P2.

Mnemonic: AUX2						Address: 92h		
7	6	5	4	3	2	1	0	Reset
CCU3 Source	CCU2 Source	CCU1 Source	-	CCUINF[1:0]		CCUINFCLK[1:0]		00H

The following Fig. 8-1 is set CCU action

CCU3 Capture input source 3

CCU3 = 0 - external Pin to be CCU3 capture input source

CCU3 = 1 - analog comparator 2 output to be CCU3 capture input source

CCU2 Capture input source 2

CCU2 = 0 - external Pin to be CCU2 capture input source

CCU2 = 1 - analog comparator 1 output to be CCU2 capture input source

CCU1 Capture input source 1

CCU1= 0 - external Pin to be CCU1 capture input source

CCU1=1 - analog comparator 0 output to be CCU1 capture input source

CCUINF[1:0] CCU capture input Noise Filter(CCU1,CCU2,CCU3)

CCUINF[1:0] = 00 - 1 consecutive same value recognize as valid data.

CCUINF[1:0] = 01 - 2 consecutive same value recognize as valid data.

CCUINF[1:0] = 10 - 4 consecutive same value recognize as valid data.

CCUINF[1:0] = 11 - 8 consecutive same value recognize as valid data.

CCUINFCLK[1:0] CCU capture input Noise Filter(CCU1,CCU2,CCU3) frequency select.

CCUINFCLK[1:0] = 00 - Freq/1

CCUINFCLK[1:0] = 01 - Freq/4

CCUINFCLK[1:0] = 10 - Freq/8

CCUINFCLK[1:0] = 11 - Freq/16

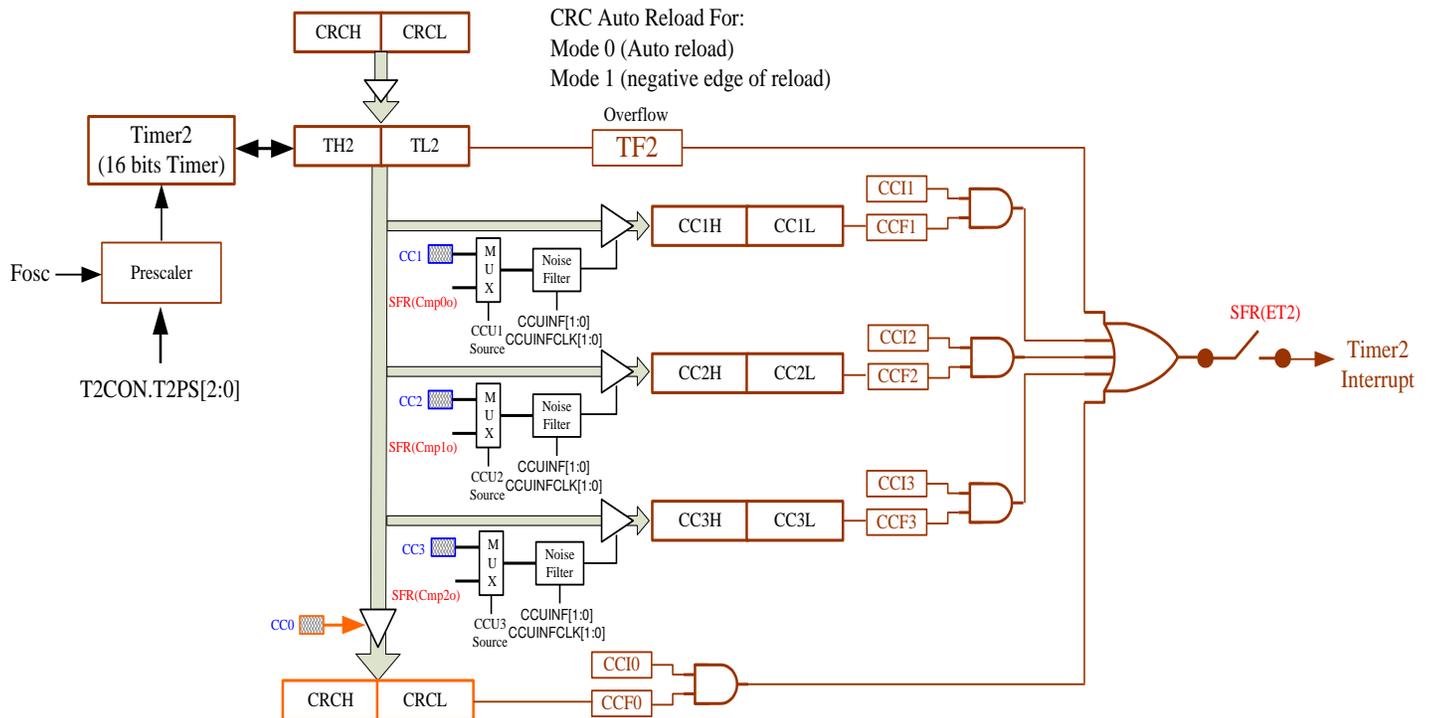


Fig. 8-1: CCU action diagram

Mnemonic: T2CON				Address: C8h				
7	6	5	4	3	2	1	0	Reset
T2PS[2:0]			T2R[1:0]		-	T2I[1:0]		00H

T2PS[2:0]: Prescaler select bit:

- T2PS = 000 – timer 2 is clocked with the oscillator frequency.
- T2PS = 001 – timer 2 is clocked with 1/2 of the oscillator frequency.
- T2PS = 010 – timer 2 is clocked with 1/4 of the oscillator frequency.
- T2PS = 011 – timer 2 is clocked with 1/6 of the oscillator frequency.
- T2PS = 100 – timer 2 is clocked with 1/8 of the oscillator frequency.
- T2PS = 101 – timer 2 is clocked with 1/12 of the oscillator frequency.
- T2PS = 110 – timer 2 is clocked with 1/24 of the oscillator frequency.

T2R[1:0]: Timer 2 reload mode selection

- T2R[1:0] = 0X – Reload disabled
- T2R[1:0] = 10 – Mode 0: Auto Reload
- T2R[1:0] = 11 – Mode 1: T2EX Falling Edge Reload

T2I[1:0]: Timer 2 input selection

- T2I[1:0] = 00 – Timer 2 stop
- T2I[1:0] = 01 – Input frequency from prescaler (T2PS[2:0])
- T2I[1:0] = 10 – Timer 2 is incremented by external signal at pin T2
- T2I[1:0] = 11 – internal clock input is gated to the Timer 2

Mnemonic: CCCON							Address: C9h	
7	6	5	4	3	2	1	0	Reset
CCI3	CCI2	CCI1	CCI0	CCF3	CCF2	CCF1	CCF0	00H

CCI3: Compare/Capture 3 interrupt control bit.

CCI3 = 1 is enable.

CCI2: Compare/Capture 2 interrupt control bit.

CCI2 = 1 is enable.

CCI1: Compare/Capture 1 interrupt control bit.

CCI1 = 1 is enable.

CCI0: Compare/Capture 0 interrupt control bit.

CCI0 = 1 is enable.

CCF3: Compare/Capture 3 flag set by hardware. This flag can be cleared by software.

CCF2: Compare/Capture 2 flag set by hardware. This flag can be cleared by software.

CCF1: Compare/Capture 1 flag set by hardware. This flag can be cleared by software.

CCF0: Compare/Capture 0 flag set by hardware. This flag can be cleared by software.

Compare/Capture interrupt share T2 interrupt vector.

Mnemonic: CCEN					Address: C1h			
7	6	5	4	3	2	1	0	Reset
-	COCAM1[2:0]			-	COCAM0[2:0]		00H	

COCAM1[2:0] 000 - Compare/Capture disable

001 - Compare enable but no output on Pin

010 - Compare mode 0

011 - Compare mode 1

100 - Capture on rising edge at pin CC1

101 - Capture on falling edge at pin CC1

110 - Capture on both rising and falling edge at pin CC1

111 - Capture on write operation into register CC1

COCAM0[2:0] 000 - Compare/Capture disable

001 - Compare enable but no output on Pin

010 - Compare mode 0

011 - Compare mode 1

100 - Capture on rising edge at pin CC0

101 - Capture on falling edge at pin CC0

110 - Capture on both rising and falling edge at pin CC0

111 - Capture on write operation into register CC0

Mnemonic: CCEN2				Address: D1h			
7	6	5	4	3	2	1	0
-	COCAM3[2:0]			-	COCAM2[2:0]		Reset
							00H

COCAM3[2:0] 000 - Compare/Capture disable

001 - Compare enable but no output on Pin

010 - Compare mode 0

011 - Compare mode 1

100 - Capture on rising edge at pin CC3

101 - Capture on falling edge at pin CC3

110 - Capture on both rising and falling edge at pin CC3

111 - Capture on write operation into register CC3

COCAM2[2:0] 000 - Compare/Capture disable

001 - Compare enable but no output on Pin

010 - Compare mode 0

011 - Compare mode 1

100 - Capture on rising edge at pin CC2

101 - Capture on falling edge at pin CC2

110 - Capture on both rising and falling edge at pin CC2

111 - Capture on write operation into register CC2

8.1 Timer 2 function

Timer 2 can operate as timer, event counter, or gated timer as explained later.

8.1.1 Timer mode

In this mode Timer 2 can be incremented in various frequency that depending on the prescaler. The prescaler is selected by bit T2PS[2:0] in register T2CON. As shown in Fig. 8-2

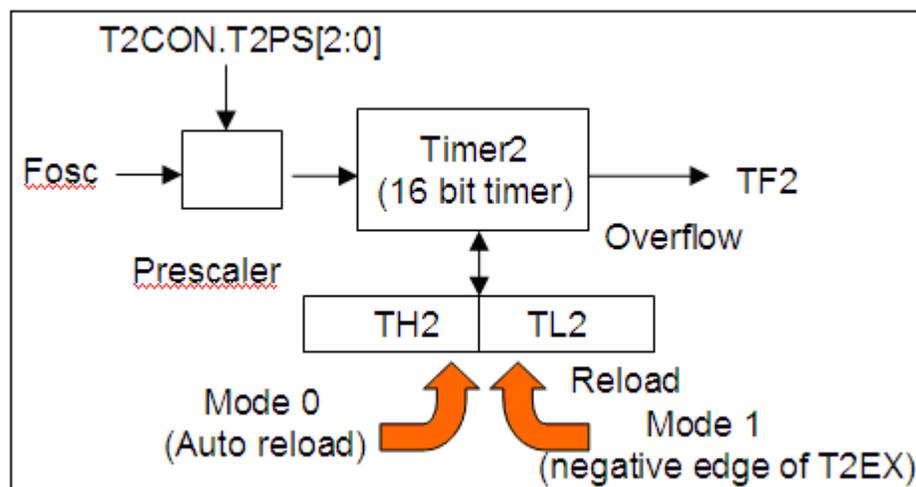


Fig. 8-2: Timer mode and Reload mode function

8.1.2 Event counter mode

In this mode, the timer is incremented when external signal T2 change value from 1 to 0. The T2 input is sampled in every cycle. Timer 2 is incremented in the cycle following the one in which the transition was detected. As shown in Fig. 8-3.

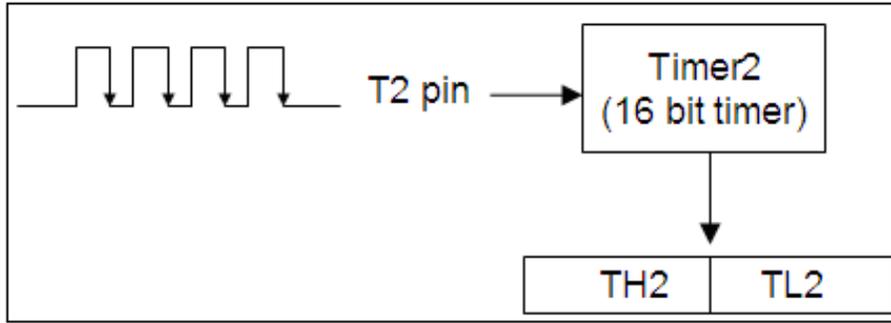


Fig. 8-3: Event counter mode function

8.1.3 Gated timer mode

In this mode, the internal clock which incremented timer 2 is gated by external signal T2. As shown in Fig. 8-4

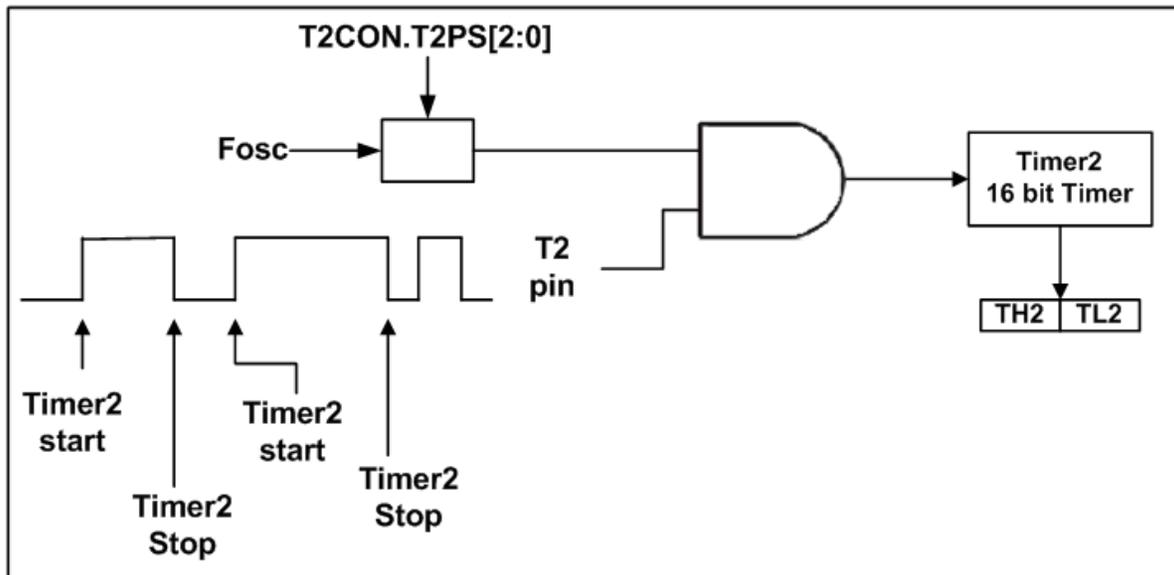


Fig. 8-4: Gated timer mode function

8.1.4 Reload of Timer 2

Reload (16-bit reload from the crc register) can be executed in the following two modes:

Mode 0: Reload signal is generate by a Timer 2 overflows - auto reload

Mode 1: Reload signal is generate by a negative transition at the corresponding input pin T2EX.

8.2 Compare function

In the four independent comparators, the value stored in any compare/capture register is compared with the contents of the timer register. The compare modes 0 and 1 are selected by bits C0CAMx. In both compare modes, the results of comparison arrives at Port 1 within the same machine cycle in which the internal compare signal is activated.

8.2.1 Compare Mode 0

In mode 0, when the value in Timer 2 equals the value of the compare register, the output signal changes from low to high. It goes back to a low level on timer overflow. In this mode, writing to the port will have no effect, because the input line from the internal bus and the write-to-latch line are disconnected. As shown in Fig. 8-5 illustrates the function of compare mode 0.

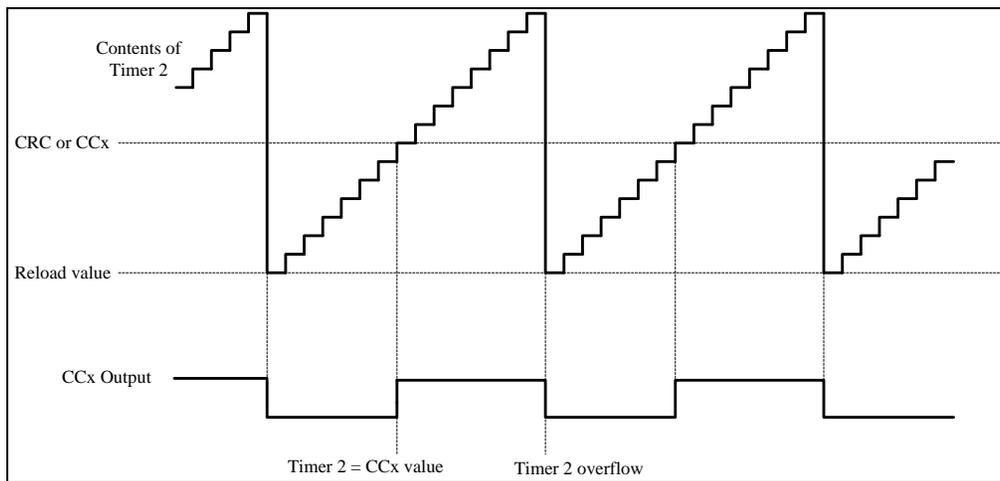


Fig. 8-5: Compare mode 0 function

8.2.2 Compare Mode 1

In compare mode 1, the transition of the output signal can be determined by software. A timer 2 overflow causes no output change. In this mode, both transitions of a signal can be controlled. As shown in Fig. 8-6 and Fig. 8-7 a functional diagram of a register/port configuration in compare Mode 1. In compare Mode 1, the value is written first to the "Shadow Register", when compare signal is active, this value is transferred to the output register.

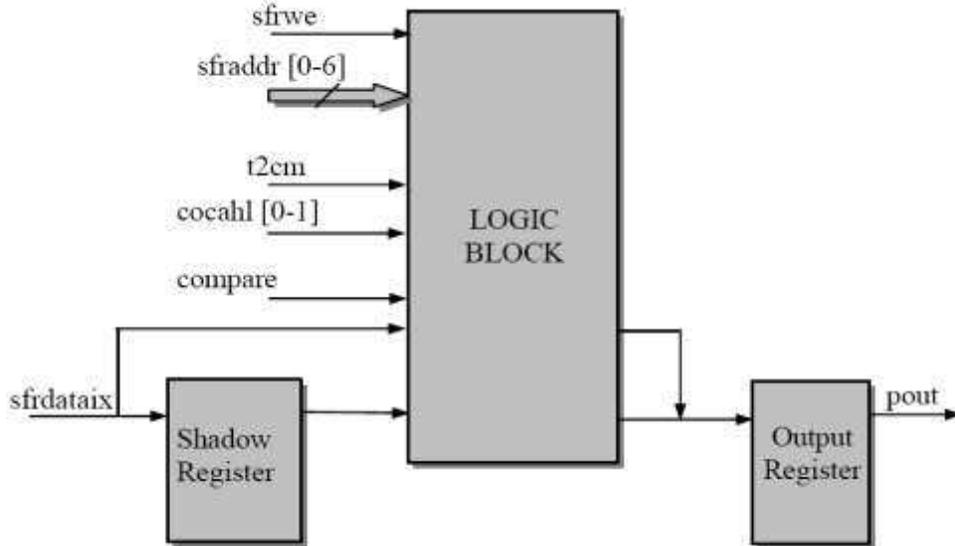


Fig. 8-6: Mode 1 Register/Port Function

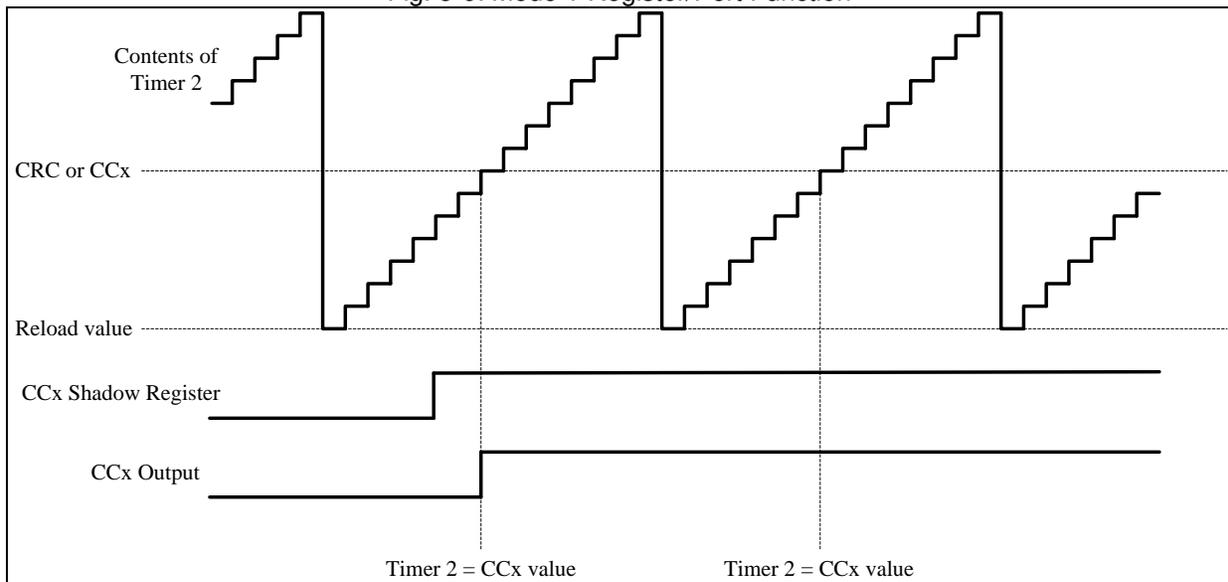


Fig. 8-7: Compare mode 1 function

8.3 Capture function

Actual timer/counter contents can be saved into registers CCx or CRC upon an external event (mode 0) or a software write operation (mode 1).

8.3.1 Capture Mode 0 (by Hardware)

In mode 0, value capture of Timer 2 is executed when:

- (1) Rising edge on input CC0-CC3
- (2) Falling edge on input CC0-CC3
- (3) Both rising and falling edge on input CC0-CC3

The contents of Timer 2 will be latched into the appropriate capture register. As shown in Fig. 8-8

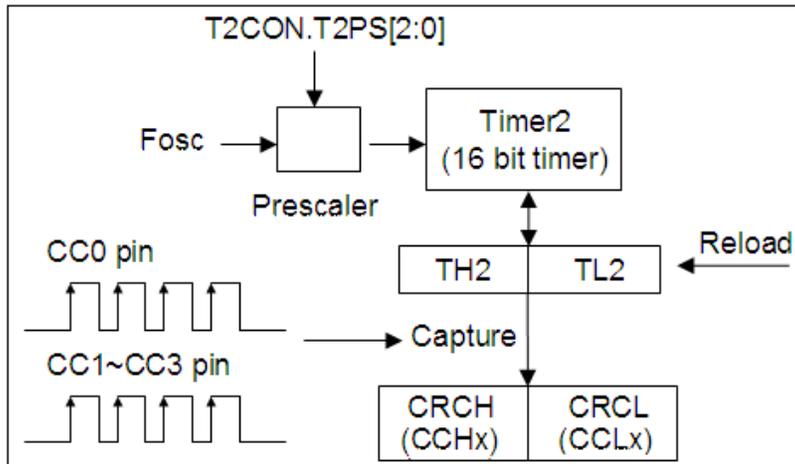


Fig. 8-8: Capture mode 0 function

8.3.2 Capture Mode 1 (by Software)

In mode 1, value capture of timer 2 is caused by writing any value into the low-order byte of the dedicated capture register. The value written to the capture register is irrelevant to this function. The contents of Timer 2 will be latched into the appropriate capture register. As shown in Fig. 8-9

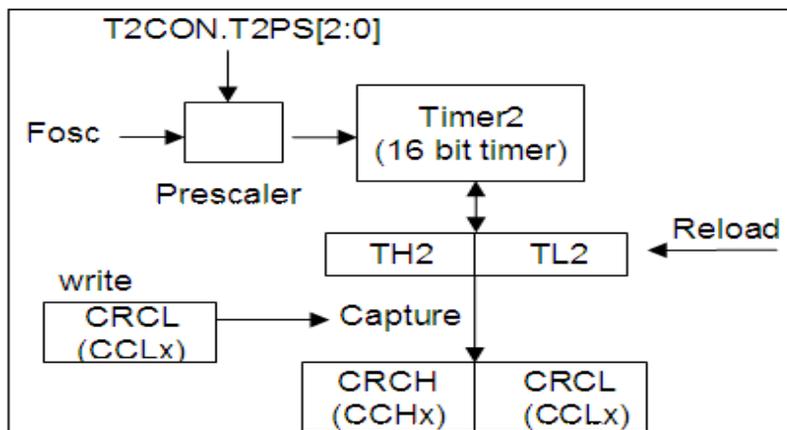


Fig. 8-9: Capture mode 1 function

9. Serial interface

The serial buffer consists of two separate registers, a Transmit buffer and a receive buffer.

Writing data to the Special Function Register SBUF sets this data in serial output buffer and starts the transmission. Reading from the SBUF reads data from the serial receive buffer. The serial port can simultaneously Transmit and receive data. It can also buffer 1 byte at receive, which prevents the receive data from being lost if the CPU reads the first byte before transmission of the second byte is completed.

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Serial interface 0 and 1											
PCON	Power control	87H	SMOD	-	-	-	-	-	STOP	IDLE	00H
AUX	Auxiliary register	91h	BRGS	P21CC	-	P1UR	-	-	-	DPS	00H
SCON	Serial Port control register	98H	SM0	SM1	SM2	REN	TB8	RB8	TI	RI	00H
SRELL	Serial Port reload register low byte	AAH	SREL.7	SREL.6	SREL.5	SREL.4	SREL.3	SREL.2	SREL.1	SREL.0	00H
SRELH	Serial Port reload register high byte	BAH	-	-	-	-	-	-	SREL.9	SREL.8	00H
SBUF	Serial Port data buffer	99H	SBUF[7:0]								00H
PFCON	Peripheral Frequency control register	D9h	-	-	SRELPS[1:0]		T1PS[1:0]		T0PS[1:0]		00H

Mnemonic: AUX **Address: 91h**

7	6	5	4	3	2	1	0	Reset
BRGS	P21CC		P1UR		-	-	DPS	00H

BRGS: Baud rate generator.

BRGS = 0 - baud rate generator from Timer 1.

BRGS = 1 - baud rate generator by SREL.

P1UR: P1UR = 0 – Serial interface 0 function on P3.

P1UR = 1 – Serial interface 0 function on P1.

Mnemonic: SCON **Address: 98h**

7	6	5	4	3	2	1	0	Reset
SM0	SM1	SM2	REN	TB8	RB8	TI	RI	00H

SM0, SM1: Serial Port 0 mode selection.

SM0	SM1	Mode
0	0	0
0	1	1
1	0	2
1	1	3

The 4 modes in UART, Mode 0 ~ 3, are explained later.

SM2: Enables multiprocessor communication feature

REN: If set, enables serial reception. Cleared by software to disable reception.

TB8: The 9th transmitted data bit in modes 2 and 3. Set or cleared by the CPU depending on

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the function it performs such as parity check, multiprocessor communication etc.

RB8: In modes 2 and 3, it is the 9th data bit received. In mode 1, if SM2 is 0, RB8 is the stop bit. In mode 0, this bit is not used. Must be cleared by software.

TI: Transmit interrupt flag, set by hardware after completion of a serial transfer. Must be cleared by software.

RI: Receive interrupt flag, set by hardware after completion of a serial reception. Must be cleared by software.

9.1 Serial interface

The Serial Interface can operate in the following 4 modes:

SM0	SM1	Mode	Description	Board Rate
0	0	0	Shift register	Fosc/12
0	1	1	8-bit UART	Variable
1	0	2	9-bit UART	Fosc/32 or Fosc/64
1	1	3	9-bit UART	Variable

Here Fosc is the crystal or oscillator frequency.

9.1.1 Mode 0

Pin RXD serves as input and output. TXD outputs the shift clock. 8 bits are transmitted with LSB first. The baud rate is fixed at 1/12 of the crystal frequency. Reception is initialized in Mode 0 by setting the flags in SCON as follows: RI = 0 and REN = 1. In other modes, a start bit when REN = 1 starts receiving serial data. As shown in Fig. 9-1 and Fig. 9-2



Fig. 9-1: Transmit mode 0

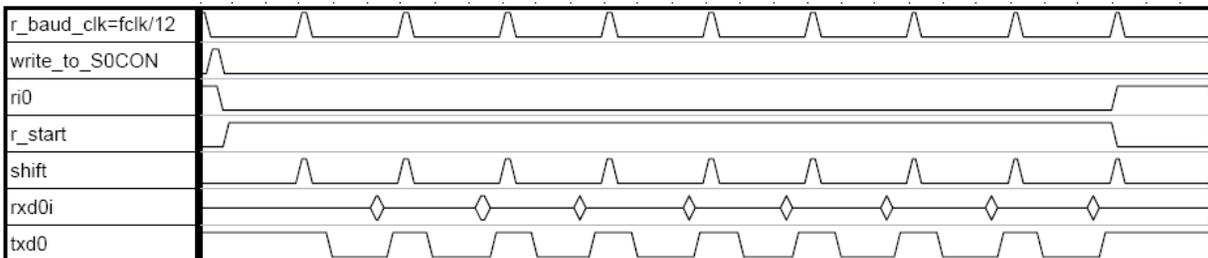


Fig. 9-2: Receive mode 0

9.1.2 Mode 1

Pin RXD serves as input, and TXD serves as serial output. No external shift clock is used, 10 bits are transmitted: a start bit (always 0), 8 data bits (LSB first), and a stop bit (always 1). On receive, a start bit synchronizes the transmission, 8 data bits are available by reading SBUF, and stop bit sets the flag RB8 in the Special Function Register SCON. In mode 1 either internal baud rate generator or timer 1 can be use to specify baud rate. As shown in Fig. 9-3 and Fig. 9-4

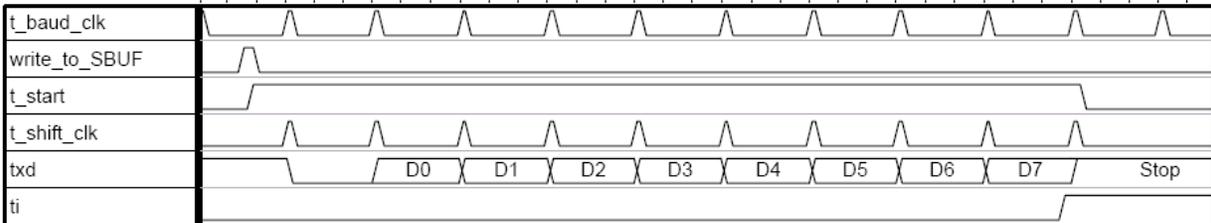


Fig. 9-3: Transmit mode 1

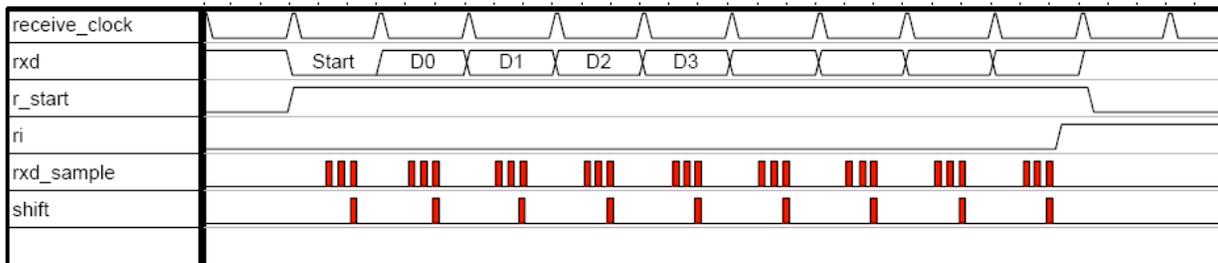


Fig. 9-4: Receive mode 1

9.1.3 Mode 2

This mode is similar to Mode 1, with two differences. The baud rate is fixed at 1/32 (SMOD=1) or 1/64(SMOD=0) of oscillator frequency and 11 bits are transmitted or received: a start bit (0), 8 data bits (LSB first), a programmable 9th bit, and a stop bit (1). The 9th bit can be used to control the parity of the serial interface: at transmission, bit TB8 in SCON is output as the 9th bit, and at receive, the 9th bit affects RB8 in Special Function Register SCON.

9.1.4 Mode 3

The only difference between Mode 2 and Mode 3 is that in Mode 3 either internal baud rate generator or timer 1 can be use to specify baud rate. As shown in Fig. 9-5 and Fig. 9-6.



Fig. 9-5: Transmit modes 2 and 3

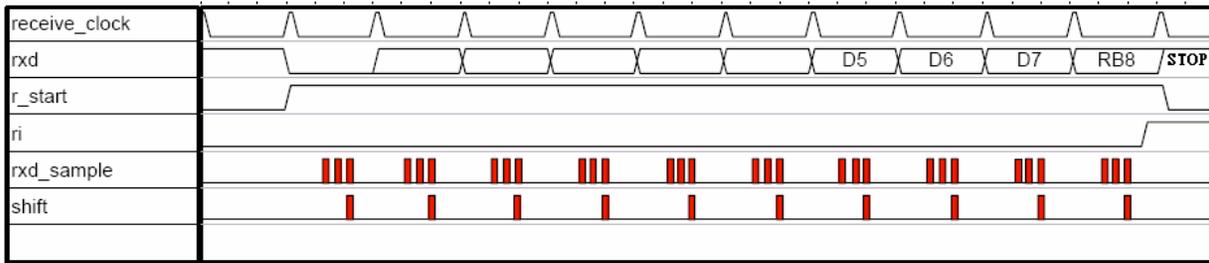


Fig. 9-6: Receive modes 2 and 3

9.2 Multiprocessor Communication of Serial Interface

The feature of receiving 9 bits in Modes 2 and 3 of Serial Interface can be used for multiprocessor communication. In this case, the slave processors have bit SM2 in SCON set to 1. When the master processor outputs slave's address, it sets the 9th bit to 1, causing a serial port receive interrupt in all the slaves. The slave processors compare the received byte with their network address. If there is a match, the addressed slave will clear SM2 and receive the rest of the message, while other slaves will leave SM2 bit unaffected and ignore this message. After addressing the slave, the host will output the rest of the message with the 9th bit set to 0, so no serial port receive interrupt will be generated in unselected slaves.

9.3 Peripheral Frequency control register

Mnemonic: PFCON						Address: D9h		
7	6	5	4	3	2	1	0	Reset
-	-	SRELPS[1:0]	T1PS[1:0]	T0PS[1:0]				00H

SRELPS[1:0]: SREL Prescaler select

SRELPS[1:0]	Prescaler
00	Fosc/64
01	Fosc /32
10	Fosc /16
11	Fosc /8

T1PS[1:0]: Timer1 Prescaler select

T1PS[1:0]	Prescaler
00	Fosc/12
01	Fosc
10	Fosc/96
11	reserved

9.4 Baud rate generator

9.4.1 Serial interface modes 1 and 3

9.4.1.1 When BRGS = 0 (in Special Function Register AUX).

(1) T1PS[1:0] is 00

$$\text{Baud Rate} = \frac{2^{\text{SMOD}} \times F_{\text{osc}}}{32 \times 12 \times (256 - \text{TH1})}$$

(2) T1PS[1:0] is 01

$$\text{Baud Rate} = \frac{2^{\text{SMOD}} \times F_{\text{osc}}}{32 \times (256 - \text{TH1})}$$

(3) T1PS[1:0] is 10

$$\text{Baud Rate} = \frac{2^{\text{SMOD}} \times F_{\text{osc}}}{32 \times 96 \times (256 - \text{TH1})}$$

9.4.1.2 When BRGS = 1 (in Special Function Register AUX).

(1) SRELPS[1:0] is 00

$$\text{Baud Rate} = \frac{2^{\text{SMOD}} \times F_{\text{osc}}}{64 \times (2^{10} - \text{SREL})}$$

(2) SRELPS[1:0] is 01

$$\text{Baud Rate} = \frac{2^{\text{SMOD}} \times F_{\text{osc}}}{32 \times (2^{10} - \text{SREL})}$$

(3) SRELPS[1:0] is 10

$$\text{Baud Rate} = \frac{2^{\text{SMOD}} \times F_{\text{osc}}}{16 \times (2^{10} - \text{SREL})}$$

(4) SRELPS[1:0] is 11

$$\text{Baud Rate} = \frac{2^{\text{SMOD}} \times F_{\text{osc}}}{8 \times (2^{10} - \text{SREL})}$$

10. Watchdog timer

The Watch Dog Timer (WDT) is an 8-bit free-running counter that generate reset signal if the counter overflows. The WDT is useful for systems which are susceptible to noise, power glitches, or electronics discharge which causing software dead loop or runaway. The WDT function can help user software recover from abnormal software condition. The WDT is different from Timer0, Timer1 and Timer2 of general 8052. To prevent a WDT reset can be done by software periodically clearing the WDT counter. User should check WDTF bit of WDTC register whenever un-predicted reset happened. After an external reset the watchdog timer is disabled and all registers are set to zeros.

The watchdog timer has a free running on-chip RC oscillator (23 KHz). The WDT will keep on running even after the system clock has been turned off (for example, in sleep mode). During normal operation or sleep mode, a WDT time-out (if enabled) will cause the MCU to reset. The WDT can be enabled or disabled any time during the normal mode. Please refer the WDTE bit of WDTC register. The default WDT time-out period is approximately 178.0ms (WDTM [3:0] = 0100b).

The WDT has selectable divider input for the time base source clock. To select the divider input, the setting of bit3 ~ bit0 (WDTM [3:0]) of Watch Dog Timer Control Register (WDTC) should be set accordingly. As shown in Table 10-1.

$$\text{WDTCLK} = \frac{23\text{KHz}}{2^{\text{WDTM}}}$$

$$\text{Watchdog reset time} = \frac{256}{\text{WDTCLK}}$$

Table 10-1: WDT time-out period

WDTM [3:0]	Divider (23 KHz RC oscillator in)	Time period @ 23KHz
0000	1	11.1ms
0001	2	22.2ms
0010	4	44.5ms
0011	8	89.0ms
0100	16	178.0ms (default)
0101	32	356.1ms
0110	64	712.3ms
0111	128	1.4246s
1000	256	2.8493s
1001	512	5.6987s
1010	1024	11.397s
1011	2048	22.795s
1100	4096	45.590s
1101	8192	91.180s
1110	16384	182.36s
1111	32768	364.72s

Note: RC oscillator (23 KHz), about ± 20% of variation

When MCU is reset, the MCU will be read WDTEN control bit status. When WDTEN bit is set to 1, the watchdog function will be disabled no matter what the WDTE bit status is. When WDTEN bit is clear to 0, the watchdog function will be enabled if WDTE bit is set to 1 by program. User can to set WDTEN on the writer or ISP.

The program can enable the WDT function by programming 1 to the WDTE bit premise that WDTEN control bit is clear to 0. After WDTE set to 1, the 8 bit-counter starts to count with the selected time base source clock which set by WDTM [3:0]. It will generate a reset signal when overflows. The WDTE bit will be cleared to 0 automatically when MCU been reset, either hardware reset or WDT reset. As shown in Fig. 10-1.

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Once the watchdog is started it cannot be stopped. User can refresh the watchdog timer to zero by writing 0x55 to Watch Dog Timer refresh Key (WDTK) register. This will clear the content of the 8-bit counter and let the counter re-start to count from the beginning. The watchdog timer must be refreshed regularly to prevent reset request signal from becoming active.

When Watchdog timer is overflow, the WDTF flag will set to one and automatically reset MCU. The WDTF flag can be clear by software or external reset or power on reset.

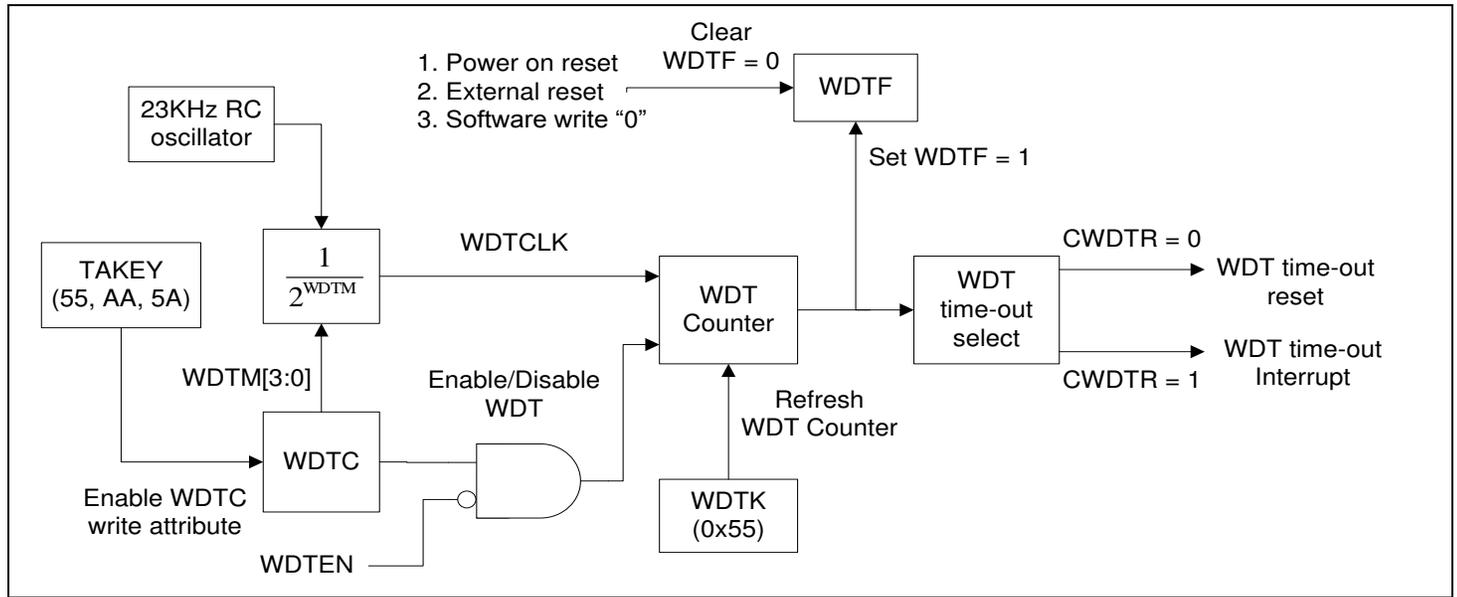
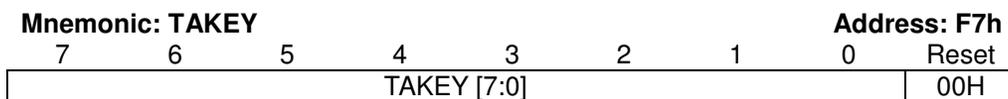


Fig. 10-1: Watchdog timer block diagram

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Watchdog Timer											
TAKEY	Time Access Key register	F7h	TAKEY [7:0]								00H
WDC	Watchdog timer control register	B6h	-	CWDTR	WDTE	-	WDTM [3:0]				04H
WDTK	Watchdog timer refresh key	B7h	WDTK[7:0]								00H
RSTS	Reset status register	A1h	-	-	-	PDRF	WDTF	SWRF	LVRF	PORF	00H



Watchdog timer control register (WDC) is read-only by default; software must write three specific values 55h, AAh and 5Ah sequentially to the TAKEY register to enable the WDC write attribute. That is:

```

MOV TAKEY, #55h
MOV TAKEY, #0AAh
MOV TAKEY, #5Ah
  
```

Mnemonic: WDTC							Address: B6h	
7	6	5	4	3	2	1	0	Reset
-	CWDTR	WDTE	-	WDTM [3:0]				04H

CWDTR: Watch dog states select bit(Support stop mode wakeup)

CWDTR = 0 - Enable watch dog reset.

CWDTR = 1 - Enable watch dog interrupt.

WDTE: Control bit used to enable Watchdog timer.

The WDTE bit can be used only if WDTEN is "0". If the WDTEN bit is "0", then WDT can be disabled / enabled by the WDTE bit.

WDTE = 0 - Disable WDT.

WDTE = 1 - Enable WDT.

The WDTE bit is not used if WDTEN is "1". That is, if the WDTEN bit is "1", WDT is always disabled no matter what the WDTE bit status is. The WDTE bit can be read and written.

WDTM [3:0]: WDT clock source divider bit. As seen in Fig. 10-1 to reference the WDT time-out period.

Mnemonic: RSTS							Address: A1h	
7	6	5	4	3	2	1	0	Reset
-	-	-	PDRF	WDTF	SWRF	LVRF	PORF	00h

WDTF: Watchdog timer reset flag. When MCU is reset by watchdog, WDTF flag will be set to one by hardware. This flag clear by software

Mnemonic: WDTK							Address: B7h	
7	6	5	4	3	2	1	0	Reset
WDTK[7:0]								00h

WDTK: Watchdog timer refresh key.

A programmer must write 0x55 into WDTK register, and then the watchdog timer will be cleared to zero.

For example 1, if enable WDT and select time-out reset period is 2.8493s.

First, programming the information block OP3 bit7 WDTEN to "0".

Secondly,

MOV TAKEY, #55h

MOV TAKEY, #0AAh

MOV TAKEY, #5Ah ; enable WDTC write attribute.

MOV WDTC, #28h ; Set WDTM [3:0] = 1000b. Set WDTE =1 to enable WDT function.

.

.

.

MOV WDTK, #55h ; Clear WDT timer to 0.



For example 2, if enable WDT and select time-out Interrupt period is 178.0ms.

First, programming the information block OP3 bit7 WDTEN to "0".

Secondly,

MOV TAKEY, #55h

MOV TAKEY, #0AAh

MOV TAKEY, #5Ah ; enable WDTC write attribute.

MOV WDTC, #64h ;Set WDTM [3:0] = 0100b. ;Set WDTE =1 to enable WDT function
; and Set CWDTR =1 to enable period interrupt function

11. Interrupt

The SM39A16M1 provides 13 interrupt sources with four priority levels. Each source has its own request flag(s) located in a special function register. Each interrupt requested by the corresponding flag could individually be enabled or disabled by the enable bits in SFR's IEN0, IEN1.

When the interrupt occurs, the engine will vector to the predetermined address as given in Table 11-1. Once interrupt service has begun, it can be interrupted only by a higher priority interrupt. The interrupt service is terminated by a return from instruction RETI. When an RETI is performed, the processor will return to the instruction that would have been next when interrupt occurred.

When the interrupt condition occurs, the processor will also indicate this by setting a flag bit. This bit is set regardless of whether the interrupt is enabled or disabled. Each interrupt flag is sampled once per machine cycle, and then samples are polled by hardware. If the sample indicates a pending interrupt when the interrupt is enabled, then interrupt request flag is set. On the next instruction cycle the interrupt will be acknowledged by hardware forcing an LCALL to appropriate vector address.

Interrupt response will require a varying amount of time depending on the state of microcontroller when the interrupt occurs. If microcontroller is performing an interrupt service with equal or greater priority, the new interrupt will not be invoked. In other cases, the response time depends on current instruction. The fastest possible response to an interrupt is 7 machine cycles. This includes one machine cycle for detecting the interrupt and six cycles for perform the LCALL.

Table 11-1: Interrupt vectors

	Interrupt Request Flags	Interrupt Vector Address	Interrupt Number *(use Keil C Tool)
1	IE0 – External interrupt 0	0003h	0
2	TF0 – Timer 0 interrupt	000Bh	1
3	IE1 – External interrupt 1	0013h	2
4	TF1 – Timer 1 interrupt	001Bh	3
5	RI0/TI 0– Serial channel 0 interrupt	0023h	4
6	TF2/EXF2 – Timer 2 interrupt	002Bh	5
7	PWMIF – PWM interrupt	0043h	8
8	SPIIF – SPI interrupt	004Bh	9
9	ADCIF – A/D converter interrupt	0053h	10
10	LVIIIF – Low Voltage Interrupt	0063h	12
11	IICIF – IIC interrupt	006Bh	13
12	WDT – Watchdog interrupt	008Bh	17
13	Comparator interrupt	0093h	18

*See Keil C about C51 User's Guide about Interrupt Function description

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Interrupt											
IEN0	Interrupt Enable 0 register	A8H	EA	-	ET2	ES	ET1	EX1	ET0	EX0	00H
IEN1	Interrupt Enable 1 register	B8H	EXEN2	-	IEIIC	IELVI	-	IEADC	IESPI	-	00H
IEN2	Interrupt Enable 2 register	9AH	-	-	-	-	-	ECmpl	EWDT	-	00H
IRCON	Interrupt request register	C0H	EXF2	TF2	IICIF	LVIIF		ADCIF	SPIIF		00H
IRCON2	Interrupt request register 2	97H	-	-	-	-	-	CmplIF	WDTIF	-	00H
IP0	Interrupt priority level 0	A9H	-	-	IP0.5	IP0.4	IP0.3	IP0.2	IP0.1	IP0.0	00H
IP1	Interrupt priority level 1	B9H	-	-	IP1.5	IP1.4	IP1.3	IP1.2	IP1.1	IP1.0	00H

Mnemonic: IEN0

Address: A8h

7	6	5	4	3	2	1	0	Reset
EA	-	ET2	ES	ET1	EX1	ET0	EX0	00h

EA: EA=0 – Disable all interrupt.

EA=1 – Enable all interrupt.

ET2: ET2=0 – Disable Timer 2 overflow or external reload interrupt.

ET2=1 – Enable Timer 2 overflow or external reload interrupt.

ES: ES=0 – Disable Serial channel 0 interrupt.

ES=1 – Enable Serial channel 0 interrupt.

ET1: ET1=0 – Disable Timer 1 overflow interrupt.

ET1=1 – Enable Timer 1 overflow interrupt.

EX1: EX1=0 – Disable external interrupt 1.

EX1=1 – Enable external interrupt 1.

ET0: ET0=0 – Disable Timer 0 overflow interrupt.

ET0=1 – Enable Timer 0 overflow interrupt.

EX0: EX0=0 – Disable external interrupt 0.

EX0=1 – Enable external interrupt 0.

Mnemonic: IEN1

Address: B8h

7	6	5	4	3	2	1	0	Reset
EXEN2	-	IEIIC	IELVI	-	IEADC	IESPI	-	00H

EXEN2: Timer 2 reload interrupt enable.

EXEN2 = 0 – Disable Timer 2 external reload interrupt.

EXEN2 = 1 – Enable Timer 2 external reload interrupt.

IEIIC: IIC interrupt enable.

IEIICS = 0 – Disable IIC interrupt.

IEIICS = 1 – Enable IIC interrupt.

IELVI: LVI interrupt enable.

IELVI = 0 – Disable LVI interrupt.

IELVI = 1 – Enable LVI interrupt.

IEADC: A/D converter interrupt enable

IEADC = 0 – Disable ADC interrupt.

IEADC = 1 – Enable ADC interrupt.

IESPI: SPI interrupt enable.

IESPI = 0 – Disable SPI interrupt.

IESPI = 1 – Enable SPI interrupt.

Mnemonic: IEN2

Address: 9Ah

7	6	5	4	3	2	1	0	Reset
-	-	-	-	-	ECmpl	EWDT	-	00H

ECmpl Enable Comparator interrupt(include comparator_0 and comparator_1).

ECmpl = 0 – Disable Comparator interrupt.

ECmpl = 1 – Enable Comparator interrupt.

EWDT: Enable Watch dog interrupt.

EWDT = 0 – Disable Watch dog interrupt.

EWDT = 1 – Enable Watch dog interrupt.

Mnemonic: IRCON

Address: C0h

7	6	5	4	3	2	1	0	Reset
EXF2	TF2	IICIF	LVIIIF	-	ADCIF	SPIIF	-	00H

EXF2: Timer 2 external reload flag. Must be cleared by software.

TF2: Timer 2 overflow flag. Must be cleared by software.

IICIF: IIC interrupt flag.

LVIIIF: LVI interrupt flag.

ADCIF: A/D converter end interrupt flag.

SPIIF: SPI interrupt flag.

Mnemonic: IRCON2							Address: 97h	
7	6	5	4	3	2	1	0	Reset
-	-	-	-	-	CmpIF	WDTIF	-	00H

CmpIF Comparator interrupt flag

HW will clear this flag automatically when enter interrupt vector.

SW can clear this flag also.(in case analog comparator INT disable)

WDTIF: Watch dog interrupt flag

11.1 Priority level structure

All interrupt sources are combined in groups, As given in Table 11-2.

Table 11-2: Priority level groups

Groups		
External interrupt 0	-	PWM interrupt
Timer 0 interrupt	Watchdog interrupt	SPI interrupt
External interrupt 1	Comparator interrupt	ADC interrupt
Timer 1 interrupt	-	
Serial channel 0 interrupt	-	LVI interrupt
Timer 2 interrupt	-	IIC interrupt

Each group of interrupt sources can be programmed individually to one of four priority levels by setting or clearing one bit in the special function register ip0 and one in ip1. If requests of the same priority level will be received simultaneously, an internal polling sequence determines which request is serviced first. As given in Table 11-3 and Table 11-4 and Table 11-5.

Mnemonic: IP0							Address: A9h	
7	6	5	4	3	2	1	0	Reset
-	-	IP0.5	IP0.4	IP0.3	IP0.2	IP0.1	IP0.0	00h

Mnemonic: IP1							Address: B9h	
7	6	5	4	3	2	1	0	Reset
-	-	IP1.5	IP1.4	IP1.3	IP1.2	IP1.1	IP1.0	00h

Table 11-3: Priority levels

IP1.x	IP0.x	Priority Level
0	0	Level0 (lowest)
0	1	Level1
1	0	Level2
1	1	Level3 (highest)

Table 11-4: Groups of priority

Bit	Group		
IP1.0, IP0.0	External interrupt 0	-	PWM interrupt
IP1.1, IP0.1	Timer 0 interrupt	Watchdog interrupt	SPI interrupt
IP1.2, IP0.2	External interrupt 1	Comparator interrupt	ADC interrupt
IP1.3, IP0.3	Timer 1 interrupt	-	
IP1.4, IP0.4	Serial channel 0 interrupt	-	LVI interrupt
IP1.5, IP0.5	Timer 2 interrupt	-	IIC interrupt

Table 11-5: Polling sequence

Interrupt source	Sequence
External interrupt 0	 Polling sequence
PWM interrupt	
Timer 0 interrupt	
Watchdog interrupt	
SPI interrupt	
External interrupt 1	
Comparator interrupt	
ADC interrupt	
Timer 1 interrupt	
Serial channel 0 interrupt	
LVI interrupt	
Timer 2 interrupt	
IIC interrupt	

12. Power Management Unit

Power management unit serves two power management modes, IDLE and STOP, for the users to do power saving function.

Mnemonic: PCON						Address: 87h		
7	6	5	4	3	2	1	0	Reset
SMOD	-	-	-	-	-	STOP	IDLE	00h

STOP: Stop mode control bit. Setting this bit turning on the Stop Mode.

Stop bit is always read as 0

IDLE: Idle mode control bit. Setting this bit turning on the Idle Mode.

Idle bit is always read as 0

12.1 Idle mode

Setting the IDLE bit of PCON register invokes the IDLE mode. The IDLE mode leaves internal clocks and peripherals running. Power consumption drops because the CPU is not active. The CPU can exit the IDLE state with any interrupts or a reset.

12.2 Stop mode

Setting the STOP bit of PCON register invokes the STOP mode. All internal clocking in this mode is turn off. The CPU will exit this state from a no-clocked interrupt (external INT0/1 and LVI \ Watchdog interrupt) or a reset (WDT and LVR) condition. Internally generated interrupts (timer, serial port ...) have no effect on stop mode since they require clocking activity.

13. Pulse Width Modulation (PWM)

PWM module features:

- Eight-channel (four-pair) PWM output pins.
- 14-bit resolution.
- Center and Edge Alignment output mode.
- Dead time generator.
- PWM and Special Event Interrupt Trigger.
- Output Override Function for motor control.
- Overdrive current protect for the fault (FLTA and FLTB)

There under is the working module of the PWM, As shown in Fig. 13-1

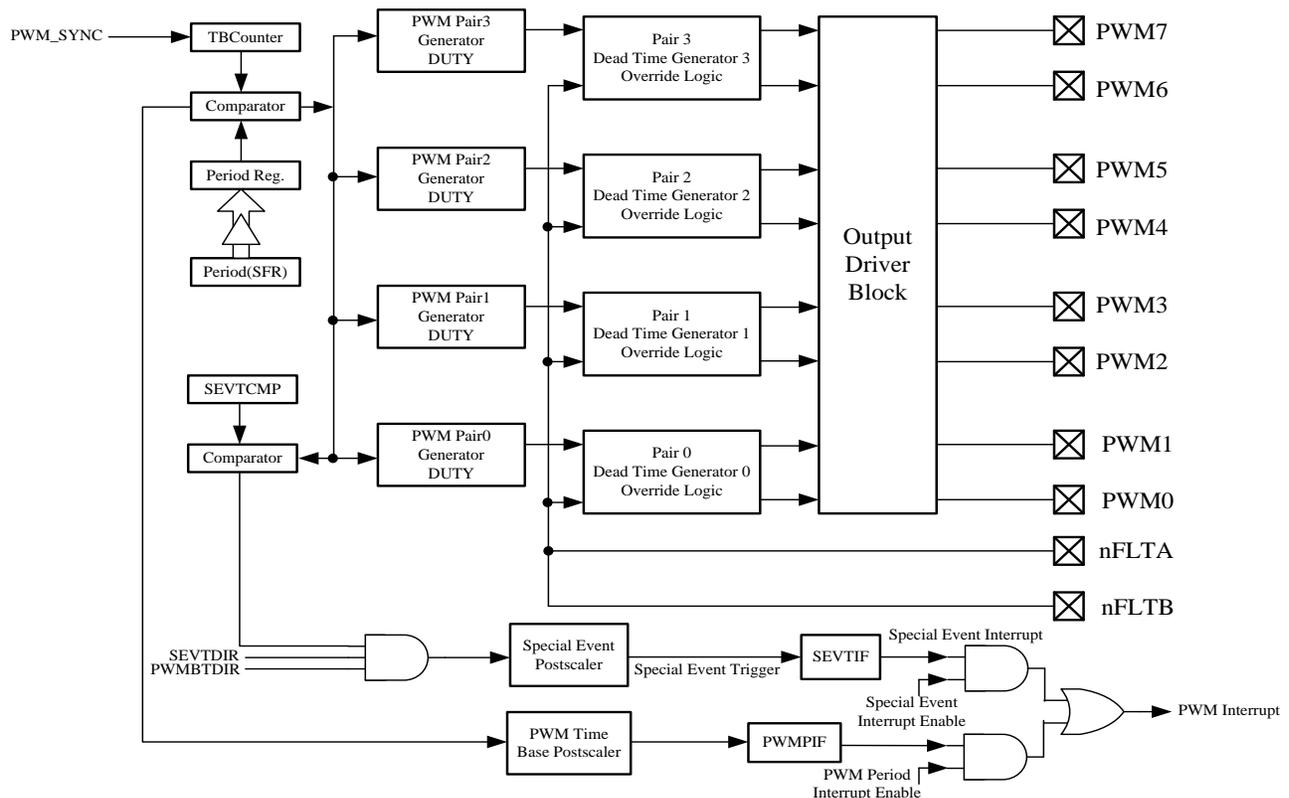


Fig. 13-1: Working module of the PWM

The interrupt vector is 43h.

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
PWM											
ADCC2	ADC control 2 Reg.	ACh	Start	Adjust	PWMT rigger EN	EXTTri ggerE N	ADCM ODE	ADCCH[2:0]			08h
PWMTBC0	PWM Time Base Control 0 Reg.	F9	-				PWMTBPRE[1:0]		PWMTBMOD[1:0]		00H
PWMTBC1	PWM Time Base Control 1 Reg.	FA	PWMT BEN	-	-	PWM Protec tDIS	-		SEVT IE	PWMP IE	10H
PWMOPMOD	PWM Output Pair Mode Reg.	FB	-		-		PWM OP3M OD	PWM OP2M OD	PWM OP1M OD	PWM OP0M OD	00H
TBCOUNTL	Time Base Counter (Low)	FC	Time Base Counter Low 8 bit								00H
TBCOUNTLH	Time Base Counter (High)	FD	-		Time Base Counter High 6 bit					00H	
PERIODL	PWM Period (Low) Reg.	F1	PWM Period Low 8 bit								FFH
PERIODH	PWM Period(High) Reg.	F2	-		PWM Period High 6 bit					3FH	
SEVTCMPL	Special Event Compare Low Reg.	F3	Special Event Compare Low 8 bit								FFH
SEVTCMPH	Special Event Compare High Reg.	F4	-		Special Event Compare High 6 bit					3FH	
PWMEN	PWM Output Enable Reg.	F5	PWM7 EN	PWM6 EN	PWM5 EN	PWM4 EN	PWM3 EN	PWM2 EN	PWM1 EN	PWM0 EN	00H
PWMSEV	PWM Special Event Reg.	ED	SEVPOST[3:0]				SEVT DIR	-	UDIS	OSYN C	00H
PWMTBPOST SCALE	PWM TIME BASE POST SCALE Reg.	EE	PWMTBPOST[7:0]								00H
PWMINTF	PWM INT Flag Reg.	BCh	PWMT BDIR	-	-	-	-		SEVT IF	PWMP IF	00H
DEADTIME0	Dead Time 0 Reg.	E9	DT0PRE[1:0]		DT0[5:0]					00H	
DEADTIME1	Dead Time 1 Reg.	EA	DT1PRE[1:0]		DT1[5:0]					00H	
DEADTIME2	Dead Time 2 Reg.	EB	DT2PRE[1:0]		DT2[5:0]					00H	
DEADTIME3	Dead Time 3 Reg.	EC	DT3PRE[1:0]		DT3[5:0]					00H	
FLTCONFIG	Fault Config Reg.	DB	BRFE N	FLTB S	FLTB MOD	FLTB EN	FLT CON	FLTA S	FLTA MOD	FLTA EN	80H
FLTNF	Fault noise filter Reg.	DC	-		FLTB LS	FLTA LS	FLTBNF[1:0]		FLTANF[1:0]		00H

Specifications subject to change without notice contact your sales representatives for the most recent information.

PWMPOLARITY	PWM Polarity Reg.	DD	Polarity7	Polarity6	Polarity5	Polarity4	Polarity3	Polarity2	Polarity1	Polarity0	FFH
OVRIDEDIS	Override Disable Reg.	DE	OV7 DIS	OV6 DIS	OV5 DIS	OV4 DIS	OV3 DIS	OV2 DIS	OV1 DIS	OV0 DIS	FFH
OVRIDEDATA	Override Data Reg.	DF	OV7 DATA	OV6 DATA	OV5 DATA	OV4 DATA	OV3 DATA	OV2 DATA	OV1 DATA	OV0 DATA	00H
DUTY0L	PWM 0 Duty Low byte Reg.	D1	PWM0 Duty Low 8 bit								00H
DUTY0H	PWM 0 Data High byte Reg.	D2	-	PWM0 Duty High 6 bit							00H
DUTY1L	PWM 1 Duty Low byte Reg.	D3	PWM1 Duty Low 8 bit								00H
DUTY1H	PWM 1 Data High byte Reg.	D4	-	PWM1 Duty High 6 bit							00H
DUTY2L	PWM 2 Duty Low byte Reg.	D5	PWM2 Duty Low 8 bit								00H
DUTY2H	PWM 2 Duty High byte Reg.	D6	-	PWM2 Duty High 6 bit							00H
DUTY3L	PWM 3 Duty Low byte Reg.	D7	PWM3 Duty Low 8 bit								00H
DUTY3H	PWM 3 Duty High byte Reg.	C9	-	PWM3 Duty High 6 bit							00H

13.1.1 ADCC2 (ADC Control Register 2)

Mnemonic: ADCC2					Address: ACh			
7	6	5	4	3	2	1	0	Reset
Start	Adjust	PWMTriggerEN	EXTTriggerEN	ADCMODE	ADCCH[2:0]			08H

Start When this bit is set, the ADC will be start conversion.
(SW trigger conversion)

ADJUST Adjust the format of ADC conversion DATA.

ADJUST = 0: (default value)

ADC data high byte ADCD [9:2] = ADCDH [7:0].

ADC data low byte ADCD [1:0] = ADCDL [1:0].

ADJUST = 1:

ADC data high byte ADCD [9:8] = ADCDH [1:0].

ADC data low byte ADCD [7:0] = ADCDL [7:0].

PWMTriggerEN PWM trigger ADC to start conversion.

(HW internal trigger conversion)

0 = disable

1 = enable

EXTTriggerEN External Pin trigger ADC to start conversion.

(HW external trigger conversion)

0 = disable

Specifications subject to change without notice contact your sales representatives for the most recent information.

1 = enable

ADCMODE 0 = continuous mode

1 = single-shot mode

ADCCH[2:0] ADC channel select.

ADCCH [2:0]	Channel
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

13.1.2 PWMTBC0 (PWM Time Base Control 0)

Mnemonic: PWMTBC0						Address: F9h		
7	6	5	4	3	2	1	0	Reset
-				PWMTBPRE[1:0]		PWMTBMOD[1:0]		00H

PWMTBPRE PWM Time Base PreScale

[1:0]

PWMTBPRE [1:0]	Mode
00	Fosc
01	Fosc/4
10	Fosc/16
11	Fosc/64

PWMTBMOD PWM Time Base Mode

PWMTBMOD [1:0] = 00 - Free Running mode

PWMTBMOD [1:0] = 01 - single-shot mode

PWMTBMOD [1:0] = 10 - continuous up/down counting mode. (TBCOUNTER = PERIOD generate an interrupt)

PWMTBMOD [1:0] = 11 - continuous up/down counting with interrupt for double PWM updates. (TBCOUNTER = PERIOD and TBCOUNTER = 0 generate an interrupt)

Freq = 24MHz, Period = 14 bit		
Prescale	PWM Frequency Edge-align	PWM Frequency center-align
1:1	1500 Hz	750 Hz
1:4	375 Hz	188 Hz
1:16	94 Hz	47 Hz
1:64	23 Hz	12 Hz

13.1.3 PWMTBC1 (PWM Time Base Control 1)

Mnemonic: PWMTBC1							Address: FAh	
7	6	5	4	3	2	1	0	Reset
PWMTBEN	-	-	PWMPProtectDIS	-	-	SEVTIE	PWMPPIE	10H

PWMTBEN PWM Time Base Enable

0 = PWM Time Base Disable

1 = PWM Time Base Enable

WMPProtectDIS: PWM Protect Set

0 = Enable

1 = Disable

PWM0/PWM1, PWM2/PWM3, PWM4/PWM5, PWM6/PWM7, Protect enable/disable.

As shown in Fig. 13-2.

SEVTIE: Special Event Interrupt Enable

SEVTIE = 0 - Special Event Interrupt Disable

SEVTIE = 1 - Special Event Interrupt Enable

PWMPPIE: PWM Period Interrupt Enable

PWMPPIE = 0 - PWM Period Interrupt Diabile

PWMPPIE = 1 - PWM Period Interrupt Enable

	PWM 0(2/4/6)	PWM 1(3/5/7)		PWM 0(2/4/6)	PWM 1(3/5/7)		
	In-active	In-active	Protect →	In-active	In-active	Polarity →	
	In-active	active		In-active	active		
	active	In-active		active	In-active		
	active	active		In-active	In-active		

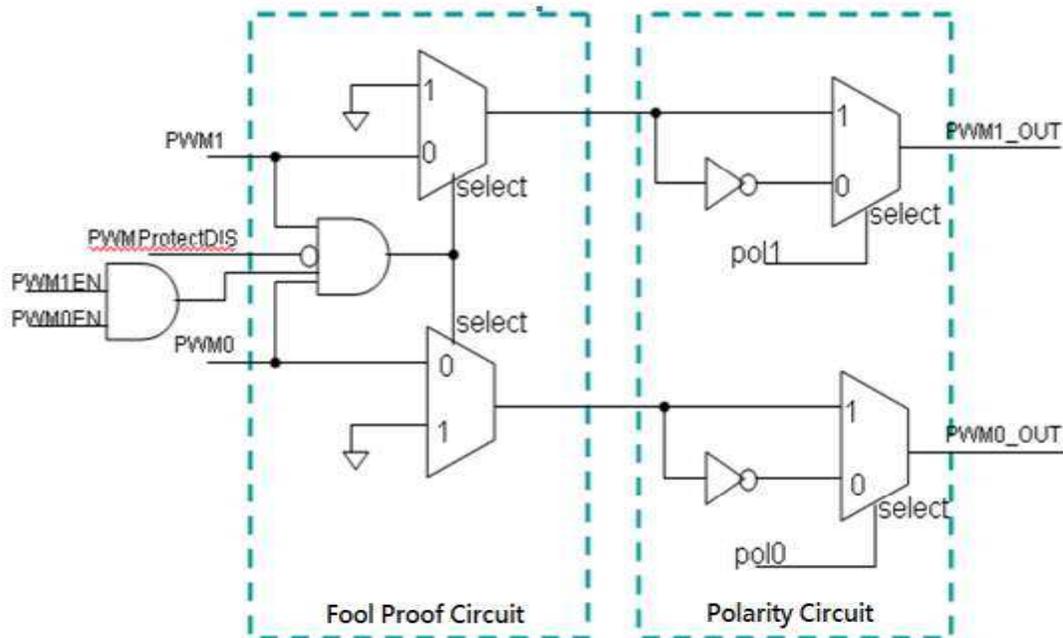


Fig. 13-2: Operation of the PWM Protect Mode

13.1.4 PWMOPMOD (PWM Output Pair Mode)

Mnemonic: PWMOPMOD						Address: FBh		
7	6	5	4	3	2	1	0	Reset
				PWMOP3MOD	PWMOP2MOD	PWMOP1MOD	PWMOP0MOD	00H

PWMOP3MOD PWM Output Pair 3 Mode

0 = (PWM6, PWM7) is complementary mode

1 = (PWM6, PWM7) is independent mode

PWMOP2MOD PWM Output Pair 2 Mode

0 = (PWM4, PWM5) is complementary mode

1 = (PWM4, PWM5) is independent mode

PWMOP1MOD PWM Output Pair 1 Mode

0 = (PWM2, PWM3) is complementary mode

1 = (PWM2, PWM3) is independent mode

PWMOP0MOD PWM Output Pair 0 Mode

0 = (PWM0, PWM1) is complementary mode

1 = (PWM0, PWM1) is independent mode

Mnemonic: PWMEN

Address: F5h

7	6	5	4	3	2	1	0	Reset
PWM7EN	PWM6EN	PWM5EN	PWM4EN	PWM3EN	PWM2EN	PWM1EN	PWM0EN	00H

PWM7EN PWM 7 Enable

PWM7EN = 0 - PWM7 Output Disable

PWM7EN = 1 - PWM7 Output Enable

PWM6EN PWM 6 Enable

PWM6EN = 0 - PWM6 Output Disable

PWM6EN = 1 - PWM6 Output Enable

PWM5EN PWM 5 Enable

PWM5EN = 0 - PWM5 Output Disable

PWM5EN = 1 - PWM5 Output Enable

PWM4EN PWM 4 Enable

PWM4EN = 0 - PWM4 Output Disable

PWM4EN = 1 - PWM4 Output Enable

PWM3EN PWM 3 Enable

PWM3EN =0 - PWM3 Output Disable

PWM3EN =1 - PWM3 Output Enable

PWM2EN PWM 2 Enable

PWM2EN =0 - PWM2 Output Disable

PWM2EN =1 - PWM2 Output Enable

PWM1EN PWM 1 Enable

PWM1EN =0 - PWM1 Output Disable

PWM1EN =1 - PWM1 Output Enable

PWM0EN PWM 0 Enable

PWM0EN =0 - PWM0 Output Disable

PWM0EN =1 - PWM0 Output Enable

13.1.5 PWMSEV (PWM Special Event)

Mnemonic: PWMSEV							Address: EDh	
7	6	5	4	3	2	1	0	Reset
SEVPOST[3:0]			SEVTDIR		-	UDIS	OSYNC	00H

SEVPOST Special Event Postscale Set (How many PWM period happen will a trigger need)

SEVPOST [3:0] 0000 = 1:1 Postscale

SEVPOST [3:0] 0001 = 1:2 Postscale

:

:

SEVPOST [3:0] 1111 = 1:16 Postscale

SEVTDIR Special event trigger time base direction

SEVTDIR = 0 - PWM time base is counting upwards.

SEVTDIR = 1 - PWM time base is counting downwards.

UDIS PWM update disable. (This bit affects PERIOD, DUTY, SEVTCMP;

OVRIDEDIS, OVRIDEDATA)

UDIS = 0 - update from duty cycle and period buffer are Enable

UDIS = 1 - update from duty cycle and period buffer are Disable

OSYNC PWM output override synchronization

OSYNC = 0 - Output overrides via the OVRIDEDIS register are asynchronous.

OSYNC = 1 - Output overrides via the OVRIDEDIS register are synchronized to the PWM time base.

Mnemonic: PWMTBPOSTSCALE							Address: EEh	
7	6	5	4	3	2	1	0	Reset
PWMTBPOST [7:0]								00H

PWMTBPOST[7:0] PWM Time Base Post Scale. (How many PWM period happen will a trigger need)

0000_0000 = 1: 1 Postscale

0000_0001 = 1: 2 Postscale

:

:

0000_1111 = 1: 16 Postscale

0001_0000 = 1: 17 Postscale

:

:

1111_1111 = 1: 256 Postscale

13.1.6 PWMINTF (PWM Interrupt Flag)

Mnemonic: PWMINTF

Address: BCh

7	6	5	4	3	2	1	0	Reset
Start	Adjust	PWMTriggerEN	EXTTriggerEN	ADCMODE	ADCCH[2:0]	00H	-	00H

PWMTBDIR:	PWM Time Base Count Direction Status(Read only) 0 = counts up 1 = counts down
SEVTIF:	Special Event Interrupt Flag
PWMPIF:	PWM Period Interrupt Flag

13.2 Dead Time

When the half-bridge circuit is applying, at the same time of upper and lower arm turn state period, due to characters of TON and TOFF, power crystal can not instantaneous complete turn state, so as to cause a short circuit, then must spare a certain time to allow power crystal turn state.

Each pair of complementary PWM output have a 6 bit down counter, due to produce dead time as below figure, each dead time unit has a rising edge and falling edge detector, according to the counter and when the value of number is zero, the output is just converted. As shown in Fig. 13-3.

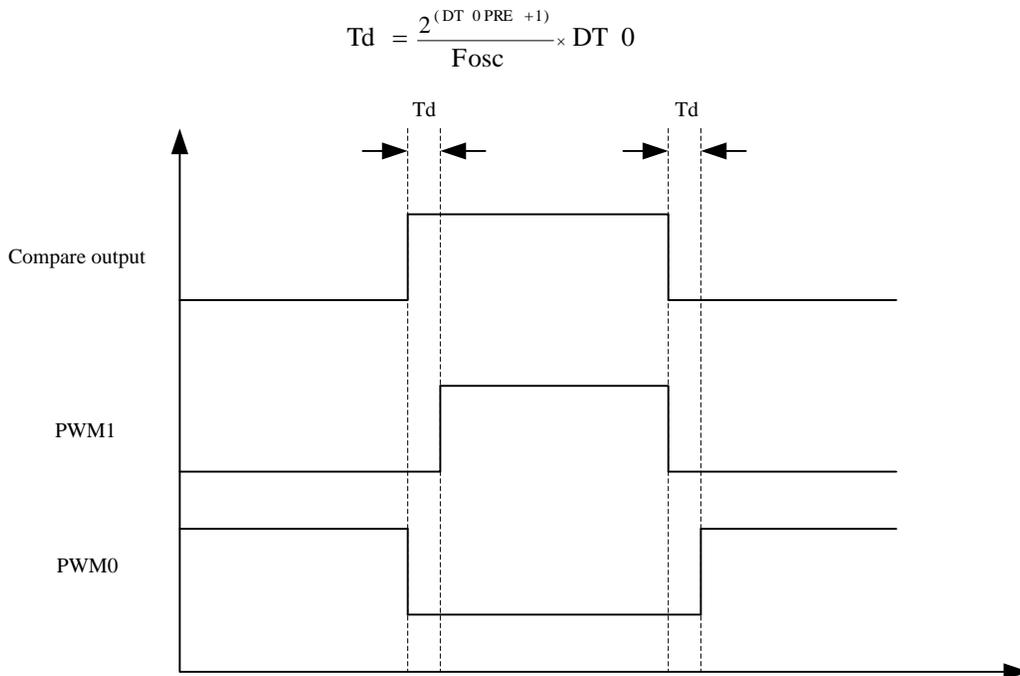


Fig. 13-3: PWM output Compare

13.2.1 DEADTIME0 (Dead Time 0 for PWM Pair 0)

Mnemonic: DEADTIME0

Address: E9h

7	6	5	4	3	2	1	0	Reset
DT0PRE[1:0]		DT0[5:0]					00H	

DT0PRE[1:0]	Dead Time 0 Prescale 00 = Fosc/2 01 = Fosc/4 10 = Fosc/8 11 = Fosc/16
DT0[5:0]	Dead Time 0 00_0000 = 1 Dead Time 0 Unit. 00_0001 = 2 Dead Time 0 Units 11_1111 = 64 Dead Time 0 Units.

Freq = 24MHz, Period = 14 bit		
Prescale	Dead Time Min	Dead Time Max
1:2	83 ns	5.3 us (To apply to CCD)
1:4	166 ns	10.6 us
1:8	332 ns	21.2 us
1:16	664 ns	42.4 us

13.2.2 DEADTIME1 (Dead Time 1 for PWM Pair 1)

Mnemonic: DEADTIME1

Address: EAh

7	6	5	4	3	2	1	0	Reset
DT1PRE[1:0]		DT1[5:0]					00H	

DT1PRE[1:0]	Dead Time 1 Prescale 00 = Fosc/2 01 = Fosc/4 10 = Fosc/8 11 = Fosc/16
DT1[5:0]	Dead Time 1 00_0000 = 1 Dead Time 1 Unit. 00_0001 = 2 Dead Time 1 Units 11_1111 = 64 Dead Time 1 Units.

13.2.3 DEADTIME2 (Dead Time 2 for PWM Pair 2)

Mnemonic: DEADTIME2

Address: EBh

7	6	5	4	3	2	1	0	Reset
DT2PRE[1:0]		DT2[5:0]					00H	

DT2PRE[1:0]	Dead Time 2 Prescale
-------------	----------------------

Specifications subject to change without notice contact your sales representatives for the most recent information.

	00 = Fosc/2 01 = Fosc/4 10 = Fosc/8 11 = Fosc/16
DT2[5:0]	Dead Time 2 00_0000 = 1 Dead Time 2 Unit. 00_0001 = 2 Dead Time 2 Units 11_1111 = 64 Dead Time 2 Units.

13.2.4 DEADTIME3 (Dead Time 3 for PWM Pair 3)

Mnemonic: DEADTIME3							Address: ECh	
7	6	5	4	3	2	1	0	Reset
DT3PRE[1:0]		DT3[5:0]					00H	

DT3PRE[1:0]	Dead Time 3 Prescale 00 = Fosc/2 01 = Fosc/4 10 = Fosc/8 11 = Fosc/16
DT3[5:0]	Dead Time 3 00_0000 = 1 Dead Time 3 Unit. 00_0001 = 2 Dead Time 3 Units 11_1111 = 64 Dead Time 3 Units.

13.2.5 OVRIDEDIS (Override Disable)

Mnemonic: OVRIDEDIS								Address: DEh
7	6	5	4	3	2	1	0	Reset
OV7DIS	OV6DIS	OV5DIS	OV4DIS	OV3DIS	OV2DIS	OV1DIS	OV0DIS	FFH

OV7DIS Override Disable 7 Action Selection

OV7DIS = 0 - PWM7 Override Enable

OV7DIS = 1 - PWM7 Override Disable

OV6DIS Override Disable 6 Action Selection

OV6DIS = 0 - PWM6 Override Enable

OV6DIS = 1 - PWM6 Override Disable

OV5DIS Override Disable 5 Action Selection

OV5DIS = 0 - PWM5 Override Enable

OV5DIS = 1 - PWM5 Override Disable

OV4DIS Override Disable 4 Action Selection

OV4DIS = 0 - PWM4 Override Enable

OV4DIS = 1 - PWM4 Override Disable

OV3DIS Override Disable 3 Action Selection

OV3DIS = 0 - PWM3 Override Enable

Specifications subject to change without notice contact your sales representatives for the most recent information.

OV3DIS = 1 - PWM3 Override Disable
 OV2DIS Override Disable 2 Action Selection
 OV2DIS = 0 - PWM2 Override Enable
 OV2DIS = 1 - PWM2 Override Disable
 OV1DIS Override Disable 1 Action Selection
 OV1DIS = 0 - PWM1 Override Enable
 OV1DIS = 1 - PWM1 Override Disable
 OV0DIS Override Disable 0 Action Selection
 OV0DIS = 0 - PWM0 Override Enable
 OV0DIS = 1 - PWM0 Override Disable

13.2.6 OVRIDEDATA (Override Data)

Mnemonic: OVRIDEDATA

Address: DFh

7	6	5	4	3	2	1	0	Reset
OV7DATA	OV6DATA	OV5DATA	OV4DATA	OV3DATA	OV2DATA	OV1DATA	OV0DATA	00H

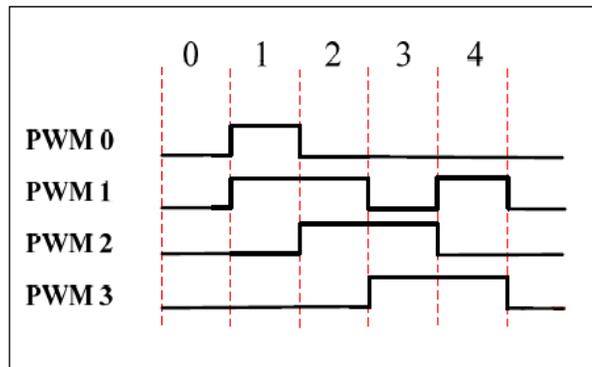
OV7DATA Ovrde Data 7
 OV7DATA = 0 - PWM7 Override Data
 OV7DATA = 1 - PWM7 Override Data
 OV6DATA Ovrde Data 6
 OV6DATA = 0 - PWM6 Override Data
 OV6DATA = 1 - PWM6 Override Data
 OV5DATA Ovrde Data 5
 OV5DATA = 0 - PWM5 Override Data
 OV5DATA = 1 - PWM5 Override Data
 OV4DATA Ovrde Data 4
 OV4DATA = 0 - PWM4 Override Data
 OV4DATA = 1 - PWM4 Override Data
 OV3DATA Ovrde Data 3
 OV3DATA = 0 - PWM3 Override Data
 OV3DATA = 1 - PWM3 Override Data
 OV2DATA Ovrde Data 2
 OV2DATA = 0 - PWM2 Override Data
 OV2DATA = 1 - PWM2 Override Data
 OV1DATA Ovrde Data 1
 OV1DATA = 0 - PWM1 Override Data
 OV1DATA = 1 - PWM1 Override Data
 OV0DATA Ovrde Data 0

OV0DATA = 0 - PWM0 Override Data

OV0DATA = 1 - PWM0 Override Data

Example: PWM Output overrides waveform.

Period Cycle	OVRIDEDIS[7:0]	OVRIDEDATA[7:0]	PWMPOLARITY[7:0]
1	11110000b	0000011b	11111111b
2	11110000b	0000110b	11111111b
3	11110000b	00001100b	11111111b
4	11110000b	00001010b	11111111b



13.2.7 PWMPOLARITY (PWM Polarity)

Mnemonic: PWMPOLARITY

Address: DDh

7	6	5	4	3	2	1	0	Reset
POLARITY7	POLARITY6	POLARITY5	POLARITY4	POLARITY3	POLARITY2	POLARITY1	POLARITY0	FFh

POLARITY7 PWM Polarity 7

POLARITY7 = 0 - PWM7 Polarity active low

POLARITY7 = 1 - PWM7 Polarity active high

POLARITY6 PWM Polarity 6

POLARITY6 = 0 - PWM6 Polarity active low

POLARITY6 = 1 - PWM6 Polarity active high

POLARITY5 PWM Polarity 5

POLARITY5 = 0 - PWM5 Polarity active low

POLARITY5 = 1 - PWM5 Polarity active high

POLARITY4 PWM Polarity 4

POLARITY4 = 0 - PWM4 Polarity active low

POLARITY4 = 1 - PWM4 Polarity active high

POLARITY3 PWM Polarity 3

POLARITY3 = 0 - PWM3 Polarity active low

POLARITY3 = 1 - PWM3 Polarity active high

POLARITY2 PWM Polarity 2

Specifications subject to change without notice contact your sales representatives for the most recent information.

POLARITY2 = 0 - PWM2 Polarity active low
POLARITY2 = 1 - PWM2 Polarity active high
POLARITY1 PWM Polarity 1
POLARITY1 = 0 - PWM1 Polarity active low
POLARITY1 = 1 - PWM1 Polarity active high
POLARITY0 PWM Polarity 0
POLARITY0 = 0 - PWM0 Polarity active low
POLARITY0 = 1 - PWM0 Polarity active high

13.3 FLTCONFIG (Fault Configure)

When FLTA or FLTB are in use, if hardware detects any abnormal signals, the status of PMW will shift to inactive automatically.

13.4 PWM Fault Inputs

The PWM module provides a fault function via FLTA and FLTB tw0 output. To disable the output signals of the PWM is their main function and as well as to enter an inactive status. When the fault occurs, the hardware will performer forthwith and shift the PWM in an inactive status; and meanwhile remain power-on connected to the PWM . Under normal working status, either low or high active can be directed by the users by simple operations.

13.5 Each of the fault inputs have two modes of operation

Inactive Mode

If the Fault occurs, the output signals of the PWM are deactivated. The status of the PWM will remain in inactive and correspond to flag of the FLT_xS flag and also set it up. If the PWM need to be recovered in a normal output working status by the time the Fault flag of the FLT_xS status must be cleared by the software.

Cycle-by-Cycle Mode

When the Fault function occurs, the output of the PWM is deactivated. The status of the PWM pin will remain in inactive status and correspond to flag of the FLT_xS flag and set it up. When the Fault is relieved, the FLT_xS will be relatively cleared, and the output of the PWM will be recovered to normal working status.

Mnemonic: FLTCONFIG

Address: DBh

7	6	5	4	3	2	1	0	Reset
BRFEN	FLTBS	FLTBMOD	FLTBEN	FLTCON	FLTAS	FLTAMOD	FLTAEN	80H

BRFEN Breakpoint Fault Enable

BRFEN = 0 - Disable

BRFEN = 1 - Enable

FLTBS Fault B status, must be cleared by SW(inactive mode)

FLTBS = 0 - No Fault

FLTBS = 1 - FLTB is asserted.

FLTBMOD FLTB Mode Set

FLTBMOD = 0 - inactive mode

FLTBMOD = 1 - cycle-by-cycle mode

FLTBEN FLTB Active Set

Specifications subject to change without notice contact your sales representatives for the most recent information.

FLTBEN = 0 - Disable Fault B function
 FLTBEN = 1 - Enable Fault B function
 FLTCON 0 = inactive PWM[5:0]
 1 = inactive PWM[7:0]
 FLTAS Fault A status, must be cleared by SW(inactive mode)
 FLTAS = 0 - No Fault
 FLTAS = 1 - FLTA is asserted.
 FLTAMOD FLTA Mode Set
 FLTAMOD = 0 - inactive mode
 FLTAMOD = 1 - cycle-by-cycle mode
 FLTAEN FLTA Active Set
 FLTAEN = 0 - Disable Fault A function
 FLTAEN = 1 - Enable Fault A function

13.6 FLTNF (Fault Noise Filter)

Mnemonic: FLTNF						Address: DCh		
7	6	5	4	3	2	1	0	Reset
-	-	FLTBLS	FLTALS	FLTBNF[1:0]		FLTANF[1:0]		00H

FLTBLS:	Fault B level select 0: active low 1: active high
FLTALS:	Fault A level select 0: active low 1: active high
FLTANF [1:0]	Fault A noise filter 00 = Fosc/1 01 = Fosc/2 10 = Fosc/4 11 = Fosc/8
FLTBNF [1:0]	Fault B noise filter 00 = Fosc/1 01 = Fosc/2 10 = Fosc/4 11 = Fosc/8

14. IIC function

The IIC module uses the SCL (clock) and the SDA (data) line to communicate with external IIC interface. Its speed can be selected to 400Kbps (maximum) by software setting the IICBR [2:0] control bit. The IIC module provided 2 interrupts (RXIF, TXIF). It will generate START, repeated START and STOP signals automatically in master mode and can detects START, repeated START and STOP signals in slave mode. The maximum communication length and the number of devices that can be connected are limited by a maximum bus capacitance of 400pF.

The interrupt vector is 6Bh.

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
IIC function											
IICCTL	IIC control register	F9h	IICEN	MSS	MAS	AB_EN	BF_EN	IICBR[2:0]			04H
IICS	IIC status register	F8h	-	MPIF	LAIF	RXIF	TXIF	RXAK	TXAK	RW or BB	00H
IICA1	IIC Address 1 register	FAh	IICA1[7:1]							MATC H1 or RW1	A0H
IICA2	IIC Address 2 register	FBh	IICA2[7:1]							MATC H2 or RW2	60H
IICRWD	IIC Read/Write register	FCh	IICRWD[7:0]								00H
IICEBT	IIC Enable Bus Transaction	FDh	FU_EN	-	-	-	-	-	-	-	00H

Mnemonic: IICCTL

Address: F9h

7	6	5	4	3	2	1	0	Reset
IICEN	MSS	MAS	AB_EN	BF_EN	IICBR[2:0]		04h	

IICEN: Enable IIC module

IICEN = 1 is Enable

IICEN = 0 is Disable.

MSS: Master or slave mode select.

MSS = 1 is master mode.

MSS = 0 is slave mode.

*The software must set this bit before setting others register.

MAS: Master address select (master mode only)

MAS = 0 is to use IICA1.

MAS = 1 is to use IICA2.

AB_EN: Arbitration lost enable bit. (Master mode only)

If set AB_EN bit, the hardware will check arbitration lost. Once arbitration lost occurred, hardware will return to IDLE state. If this bit is cleared, hardware will not care arbitration lost condition. Set this bit when multi-master and slave connection. Clear this bit when single master to single slave.

BF_EN: Bus busy enable bit. (Master mode only)

If set BF_EN bit, hardware will not generate a start condition to bus until BF=0. Clear this bit

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will always generate a start condition to bus when MStart is set. Set this bit when multi-master and slave connection. Clear this bit when single master to single slave.

IICBR[2:0]: Baud rate selection (master mode only), where Fosc is the external crystal or oscillator frequency. The default is Fosc/512 for users' convenience.

IICBR[2:0]	Baud rate
000	Fosc/32
001	Fosc/64
010	Fosc/128
011	Fosc/256
100	Fosc/512
101	Fosc/1024
110	Fosc/2048
111	Fosc/4096

Mnemonic: IICS							Address: F8H	
7	6	5	4	3	2	1	0	Reset
-	MPIF	LAIF	RXIF	TXIF	RXAK	TxAK	RW or BB	00H

MPIF: The Stop condition Interrupt Flag

The stop condition occurred and this bit will be set. Software need to clear this bit

LAIF: Arbitration lost bit. (Master mode only)

The Arbitration Interrupt Flag, the bus arbitration lost occurred and this bit will be set. Software need to clear this bit

RxIF: The data Receive Interrupt Flag (RXIF) is set after the IICRWD (IIC Read Write Data Buffer) is loaded with a newly receive data.

TxIF: The data Transmit Interrupt Flag (TXIF) is set when the data of the IICRWD (IIC Read Write Data Buffer) is downloaded to the shift register.

RxAK: The Acknowledge Status indicate bit. When clear, it means an acknowledge signal has been received after the complete 8 bits data Transmit on the bus.

TxAK: The Acknowledge status Transmit bit. When received complete 8 bits data, this bit will set (NoAck) or clear (Ack) and Transmit to master to indicate the receive status.

RW or BB: Master Mode:

BB : Bus busy bit

If detect scl=0 or sda=0 or bus start, this bit will be set. If detect stop, this bit will be cleared. This bit can be cleared by software to return ready state.

Slave Mode:

RW: The slave mode read (received) or wrote (Transmit) on the IIC bus. When this bit is clear, the slave module received data on the IIC bus (SDA). (Slave mode only).

As shown in Fig. 14-1

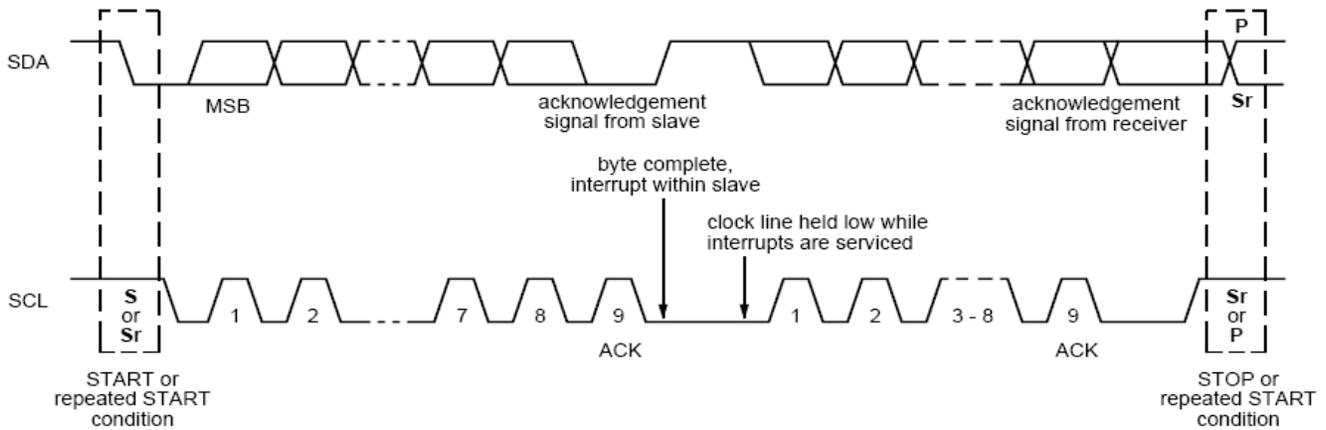
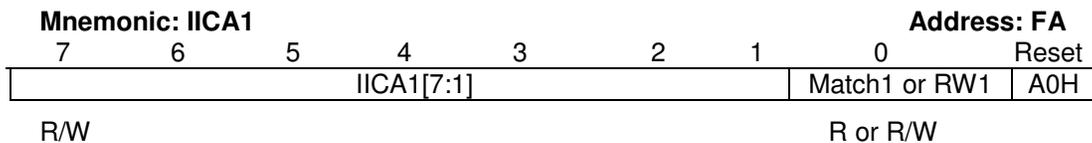


Fig. 14-1: Acknowledgement bit in the 9th bit of a byte transmission



Slave mode:

IICA1[7:1]: IIC Address registers

This is the first 7-bit address for this slave module. It will be checked when an address (from master) is received

Match1: When IICA1 matches with the received address from the master side, this bit will set to 1 by hardware. When IIC bus gets first data, this bit will clear.

Master mode:

IICA1[7:1]: IIC Address registers

This 7-bit address indicates the slave with which it wants to communicate.

RW1: This bit will be sent out as RW of the slave side if the module has set the MStart or RStart bit. It appears at the 8th bit after the IIC address as below figure. It is used to tell the slave the direction of the following communication. If it is 1, the module is in master receive mode. If 0, the module is in master Transmit mode. As shown in Fig. 14-2

RW1=1, master receive mode

RW1=0, master Transmit mode

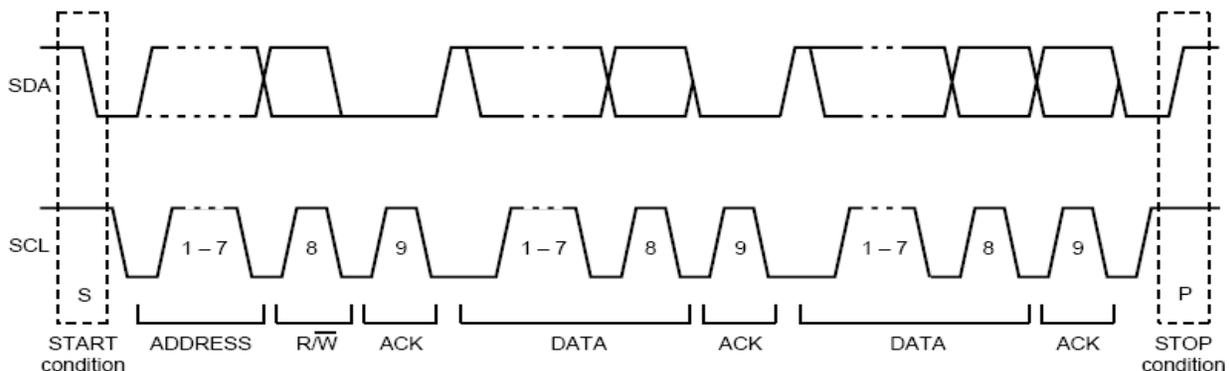


Fig. 14-2: RW bit in the 8th bit after IIC address

Mnemonic: IICA2							Address: FB	
7	6	5	4	3	2	1	0	Reset
IICA2[7:1]							Match2 or RW2	60H
R/W							R or R/W	

Slave mode:

IICA2[7:1]: IIC Address registers

This is the second 7-bit address for this slave module.

It will be checked when an address (from master) is received

Match2: When IICA2 matches with the received address from the master side, this bit will set to 1 by hardware. When IIC bus gets first data, this bit will clear.

Master mode:

IICA2[7:1]: IIC Address registers

This 7-bit address indicates the slave with which it wants to communicate.

RW2: This bit will be sent out as RW of the slave side if the module has set the MStart or RStart bit. It is used to tell the slave the direction of the following communication. If it is 1, the module is in master receive mode. If 0, the module is in master Transmit mode.

RW2=1, master receive mode

RW2=0, master Transmit mode

Mnemonic: IICRWD							Address: FCh	
7	6	5	4	3	2	1	0	Reset
IICRWD[7:0]								00h

IICRWD[7:0]: IIC read write data buffer.

In receiving (read) mode, the received byte is stored here.

In Transmitting mode, the byte to be shifted out through SDA stays here.

Mnemonic: IICEBT							Address: FDH	
7	6	5	4	3	2	1	0	Reset
FU_EN	-	-	-	-	-	-	-	00H

Master Mode :

00: reserved

01: IIC bus module will enable read/write data transfer on SDA and SCL.

10: IIC bus module generate a start condition on the SDA/SCL, then send out address which is stored in the IICA1/IICA2(selected by MAS control bit)

11: IIC bus module generates a stop condition on the SDA/SCL.

FU_EN[7:6] will be auto-clear by hardware, so setting FU_EN[7:6] repeatedly is necessary.

Slave mode:

01: FU_EN[7:6] should be set as 01 only. The other value is inhibited.

Notice:



FU_EN[7:6] should be set as 01 before read/write data transfer for bus release; otherwise, SCL will be locked(pull low).

FU_EN[7:6] should be set as 01 after read/write data transfer for receiving a stop condition from bus master.

In Transmit data mode(slave mode), the output data should be filled into IICRWD before setting FU_EN[7:6] as 01.

FU_EN[7:6] will be auto-clear by hardware, so setting FU_EN[7:6] repeatedly is necessary.

15. SPI Function - Serial Peripheral Interface

Serial Peripheral Interface (SPI) is a synchronous protocol that allows a master device to initiate communication with slave devices.

The interrupt vector is 4Bh.

There are 4 signals used in SPI, they are

SPI_MOSI: data output in the master mode, data input in the slave mode,
 SPI_MISO: data input in the master mode, data output in the slave mode,
 SPI_SCK: clock output from the master, the above data are synchronous to this signal
 SPI_SS: input in the slave mode.

This slave device detects this signal to judge if it is selected by the master. As shown in Fig. 15-1

In the master mode, it can select the desired slave device by any IO with value = 0. As below figure is an example showing the relation of the 4 signals between master and slaves.

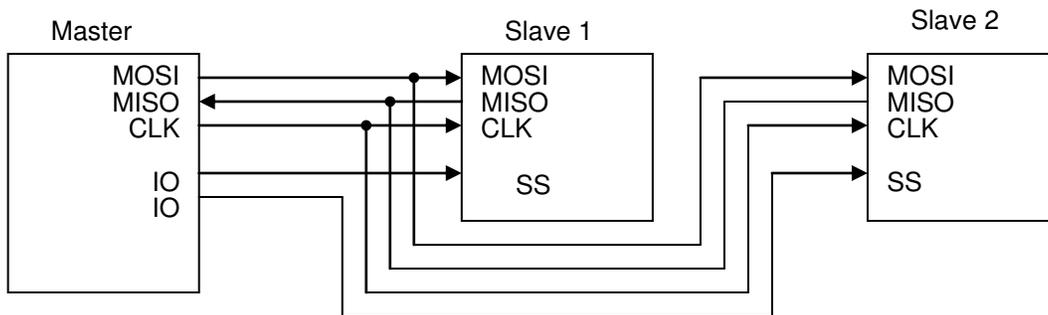


Fig. 15-1: SPI signals between master and slave devices

There is only one channel SPI interface. The SPI SFRs are shown as below:

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
SPI function											
SPIC1	SPI control register 1	F1h	SPIEN	SPIMSS	SPISSP	SPICKP	SPICKE	SPIBR[2:0]			08H
SPIC2	SPI control register 2	F2h	SPIFD	TBC[2:0]			SPIRST	RBC[2:0]			00H
SPIS	SPI status register	F5h	SPIRF	SPIMLS	SPIOV	SPITXIF	SPITDR	SPIRXIF	SPIRDR	SPIRS	40H
SPITXD	SPI Transmit data buffer	F3h	SPITXD[7:0]								00H
SPIRXD	SPI receive data buffer	F4h	SPIRXD[7:0]								00H

Mnemonic:SPIC1						Address:F1H	
7	6	5	4	3	2	1	0
SPIEN	SPIMSS	SPISSP	SPICKP	SPICKE	SPIBR[2:0]		Reset
							08H

SPIEN: Enable SPI module.

SPIEN = 1 - is Enable.

SPIEN = 0 - is Disable.

SPIMSS: Master or Slave mode Select

SPIMSS = 1 - is Master mode.

SPIMSS = 0 - is Slave mode.

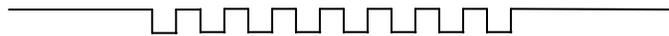
SPISSP: SS or CS active polarity.(Slave mode used only)

SPISSP = 1 - high active.

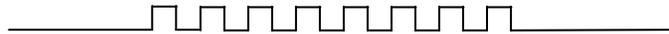
SPISSP = 0 - low active.

SPICKP: Clock idle polarity select. (Master mode used only)

SPICKP = 1 - SCK will idle high. Ex :



SPICKP = 0 - SCK will idle low. Ex :

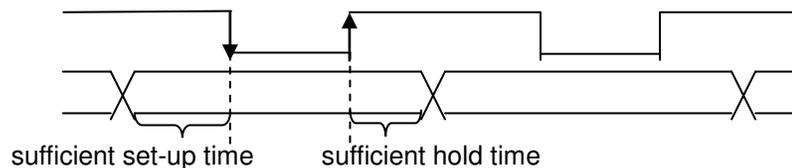


SPICKE: Clock sample edge select.

SPICKE = 1 - rising edge latch data.

SPICKE = 0 - falling edge latch data.

* To ensure the data latch stability, SM39A16M1 generate the output data As shown in the following example, the other side can latch the stable data no matter in rising or falling edge.



SPIBR[2:0]: SPI baud rate select. (Master mode used only)

SPIBR[2:0]	Baud rate
0:0:0	Fosc/4
0:0:1	Fosc /8
0:1:0	Fosc /16
0:1:1	Fosc /32
1:0:0	Fosc /64
1:0:1	Fosc /128
1:1:0	Fosc /256
1:1:1	Fosc /512

Mnemonic: SPIC2						Address: F2H	
7	6	5	4	3	2	1	0
SPIFD	TBC[2:0]			SPIRST	RBC[2:0]		Reset
							00H

SPIFD: Full-duplex mode enable.

SPIFD = 1 is enable full-duplex mode.

SPIFD = 0 is disable full-duplex mode.

When it is set, the TBC[2:0] and RBC[2:0] will be reset and keep to zero. When the Master device Transmits data to the Slave device via the MOSI line, the Slave device responds by sending data to the Master device via the MISO line. This implies full-duplex transmission with both data out and data in synchronized with the same clock. As shown in Fig. 15-2

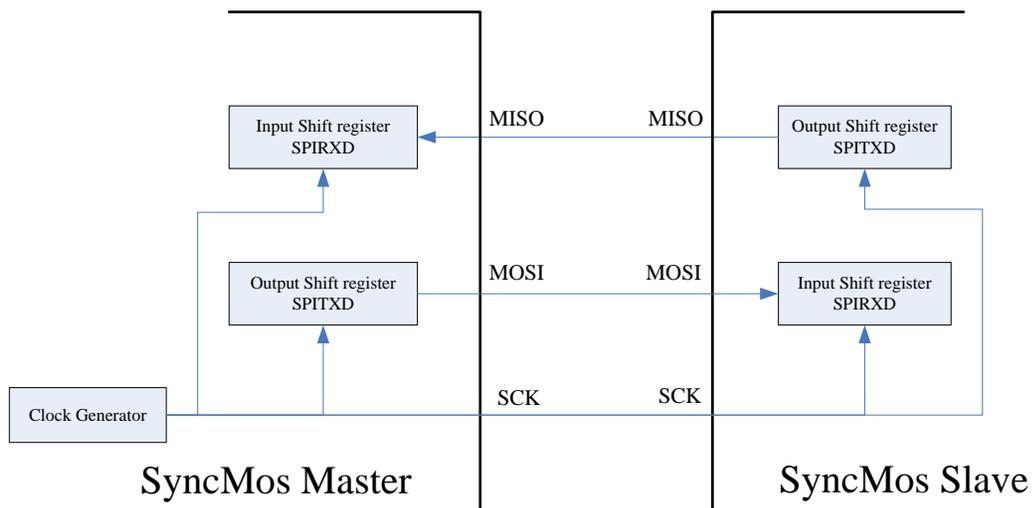


Fig. 15-2: SPI Mater and slave transfer method

SPIRST: SPI Re-start (Slave mode used only)

SPIRST = 0 - Re-start function disable. SPI Transmit/receive data when SS active.

In SPITXD/SPIRXD buffer, data got from previous SS active period will not be removed (i.e. it's valid).

SPIRST = 1 - Re-start function enable. SPI Transmit/receive new data when SS re-active;

In SPITXD/SPIRXD buffer, data got from previous SS active period will be removed (i.e. It's invalid).

TBC[2:0]: SPI Transmitter bit counter.

TBC[2:0]	Bit counter
0:0:0	8 bits output
0:0:1	1 bit output
0:1:0	2 bits output
0:1:1	3 bits output
1:0:0	4 bits output
1:0:1	5 bits output
1:1:0	6 bits output
1:1:1	7 bits output

RBC[2:0]: SPI receiver bit counter.

RBC[2:0]	Bit counter
0:0:0	8 bits input
0:0:1	1 bit input
0:1:0	2 bits input
0:1:1	3 bits input
1:0:0	4 bits input
1:0:1	5 bits input
1:1:0	6 bits input
1:1:1	7 bits input

Mnemonic: SPIS

Address:F5H

7	6	5	4	3	2	1	0	Reset
SPIRF	SPIMLS	SPIOV	SPITXIF	SPITDR	SPIRXIF	SPIRDR	SPIRS	40H

SPIRF: SPI SS pin Release Flag.

This bit is set when SS pin release & SPIRST as '1'.

SPIMLS: MSB or LSB first output /input Select.

SPIMLS = 1 is MSB first output/input.

SPIMLS = 0 is LSB first output/input.

SPIOV: Overflow flag.

When SPIRDR is set and next data already into shift register, this flag will be set.

It is clear by hardware, when SPIRDR is cleared.

SPITXIF: Transmit Interrupt Flag.

This bit is set when the data of the SPITXD register is downloaded to the shift register.

SPITDR: Transmit Data Ready.

When MCU finish writing data to SPITXD register, the MCU needs to set this bit to '1' to inform the SPI module to send the data. After SPI module finishes sending the data from SPITXD, this bit will be cleared automatically.

SPIRXIF: Receive Interrupt Flag.

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This bit is set after the SPIRXD is loaded with a newly receive data.

SPIRDR: Receive Data Ready.

The MCU must clear this bit after it gets the data from SPIRXD register. The SPI module is able to write new data into SPIRXD only when this bit is cleared.

SPIRS: Receive Start.

This bit set to "1" to inform the SPI module to receive the data into SPIRXD register.

Mnemonic: SPITXD							Address: F3H	
7	6	5	4	3	2	1	0	Reset
SPITXD[7:0]								00H

SPIRXD[7:0]: Transmit data buffer.

Mnemonic: SPIRXD							Address: F4H	
7	6	5	4	3	2	1	0	Reset
SPIRXD[7:0]								00H

SPIRXD[7:0]: Receive data buffer.

P.S. MISO pin must be float when SS or CS no-active in slave mode.

16. LVI & LVR – Low Voltage Interrupt and Low Voltage Reset

The interrupt vector 63h

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Watchdog Timer											
RSTS	Reset status register	A1h	-	LVRLP INTF	LVRLP F	PDRF	WDTF	SWRF	LVRF	PORF	00H
LVC	Low voltage control register	E6h	LVI_EN	LVRLPE	LVRE	LVIF	LVRLP INTE	-	LVIS[1:0]		20H

Mnemonic: RSTS

Address: A1h

7	6	5	4	3	2	1	0	Reset
-	LVRLP INTF	LVRLPF	PDRF	WDTF	SWRF	LVRF	PORF	00H

LVRLPINTF “Internal” Low voltage reset flag.

When MCU is reset by LVR_LP_INT, LVRLPINTF flag will be set to one by hardware. This flag clear by software.

LVRLPF “External” Low voltage reset flag.

When MCU is reset by LVR(External Low Power), LVRLPF flag will be set to one by hardware. This flag clear by software.

PDRF: Pad reset flag.

When MCU is reset by reset pad, PDRF flag will be set to one by hardware. This flag clear by software.

LVRF: Low voltage reset flag.

When MCU is reset by LVR, LVRF flag will be set to one by hardware. This flag clear by software.

PORF: Power on reset flag.

When MCU is reset by POR, PORF flag will be set to one by hardware. This flag clear by software.

Mnemonic: LVC

Address: E6h

7	6	5	4	3	2	1	0	Reset
LVI_EN	LVRLPE	LVRE	LVIF	LVRLP INTE	-	LVIS[1:0]		20H

LVI_EN: Low voltage interrupt function enable bit.

LVI_EN = 0 - disable low voltage detect function.

LVI_EN = 1 - enable low voltage detect function.

LVRLPE External low voltage reset function (Low Power)enable bit.

LVRLPE = 0 - disable external low voltage reset(Low Power) function.

LVRLPE = 1 - enable external low voltage reset(Low Power) function.

LVRE: External low voltage reset function enable bit.

LVRXE = 0 - disable external low voltage reset function.

LVRXE = 1 - enable external low voltage reset function.

Note: LVR = 1.50 V

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LVIF: Low Voltage interrupt Flag(i.e., Low Voltage Interrupt Status Flag)

LVRLP LVR_LP_INT("Internal" low voltage reset) function enable bit.

INTE: LVRLPINTE = 0 - disable internal low voltage reset function.

LVRLPINTE = 1 - enable internal low voltage reset function.

LVIS[1:0] LVI level select:

00: 1.65V

01: 2.60V

10: 3.20V

11: 4.00V

17. 10-bit Analog-to-Digital Converter (ADC)

The SM39A16M1 provides 8 channels 10-bit ADC. The Digital output DATA [9:0] were put into ADCD [9:0]. The ADC the block diagram show in Fig. 17-1

The ADC interrupt vector is 53H.

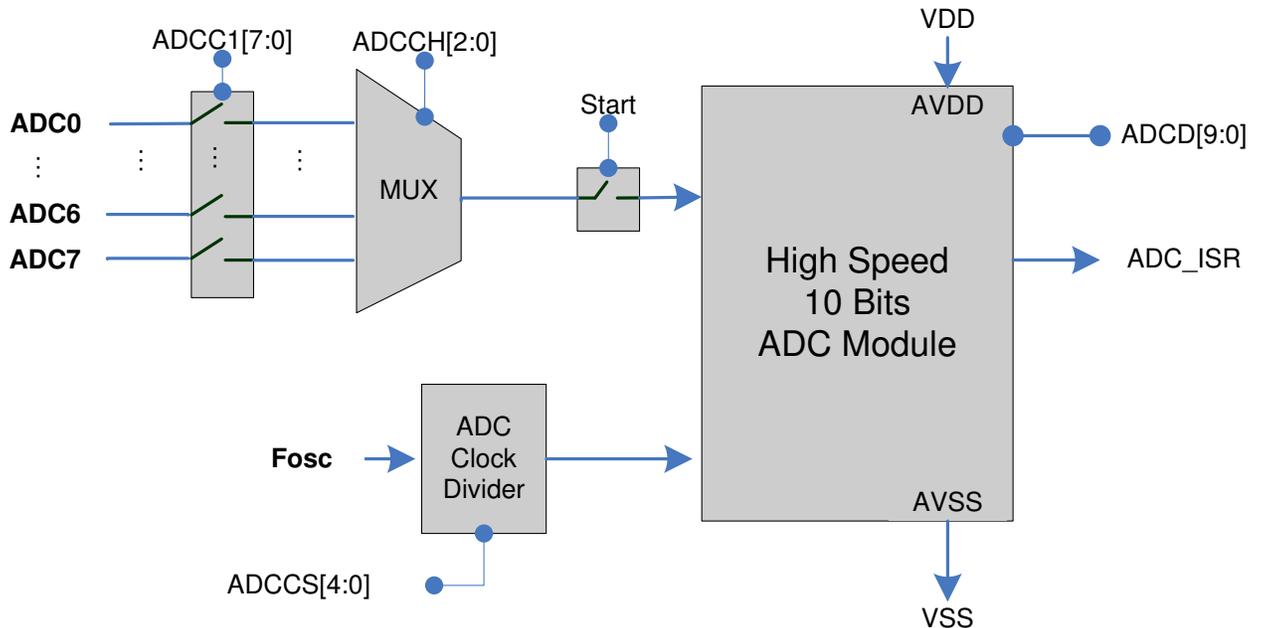


Fig. 17-1: ADC Analog to Digital converter operation set

The ADC SFR show as below:

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
ADC											
ADCC1	ADC Control register 1	ABh	ADC7 EN	ADC6 EN	ADC5 EN	ADC4 EN	ADC3 EN	ADC2 EN	ADC1 EN	ADC0 EN	00H
ADCC2	ADC Control register 2	ACh	Start	ADJUST	PWMTriggerEN	EXTTriggerEN	ADCMODE	ADCCH[2:0]		08H	
ADCDH	ADC data high byte	ADh	ADCDH [7:0]							00H	
ADCDL	ADC data low byte	A Eh	ADCDL [7:0]							00H	
ADCCS	ADC clock select	AFh	-	-	-	ADCCS[4:0]			00H		

Mnemonic: ADCC1

Address: ABh

7	6	5	4	3	2	1	0	Reset
ADC7EN	ADC6EN	ADC5EN	ADC4EN	ADC3EN	ADC2EN	ADC1EN	ADC0EN	00H

ADC7EN: ADC channels 7 enable.

ADC7EN = 1 - Enable ADC channel 7

ADC6EN: ADC channels 6 enable.

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ADC6EN = 1 - Enable ADC channel 6
 ADC5EN: ADC channels 5 enable.
 ADC5EN = 1 - Enable ADC channel 5
 ADC4EN: ADC channels 4 enable.
 ADC4EN = 1 - Enable ADC channel 4
 ADC3EN: ADC channels 3 enable.
 ADC3EN = 1 - Enable ADC channel 3
 ADC2EN: ADC channels 2 enable.
 ADC2EN = 1 - Enable ADC channel 2
 ADC1EN: ADC channels 1 enable.
 ADC1EN = 1 - Enable ADC channel 1
 ADC0EN: ADC channels 0 enable.
 ADC0EN = 1 - Enable ADC channel 0

Mnemonic: ADCC2

Address: ACh

7	6	5	4	3	2	1	0	Reset
Start	Adjust	PWMTriggerEN	EXTTriggerEN	ADCMODE	ADCCCH[2:0]			08H

Start When this bit is set, the ADC will be start conversion.

(SW trigger conversion)

ADJUST Adjust the format of ADC conversion DATA.

ADJUST = 0 - (default value)

ADC data high byte ADCD [9:2] = ADCDH [7:0].

ADC data low byte ADCD [1:0] = ADCDL [1:0].

ADJUST = 1- ADC data high byte ADCD [9:8] = ADCDH [1:0].

ADC data low byte ADCD [7:0] = ADCDL [7:0].

PWMTriggerEN PWM trigger ADC to start conversion.

(HW internal trigger conversion)

0 = disable

1 = enable

EXTTriggerEN External Pin trigger ADC to start conversion.

(HW external trigger conversion)

0 = disable

1 = enable

ADCMODE 0 = continuous mode

1 = single-shot mode

ADCCH[2:0] ADC channel select.

ADCCH [2:0]	Channel
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

ADJUST = 0:

Mnemonic: ADCDH **Address: ADh**

7	6	5	4	3	2	1	0	Reset
ADCD[9]	ADCD[8]	ADCD[7]	ADCD[6]	ADCD[5]	ADCD[4]	ADCD[3]	ADCD[2]	00H

Mnemonic: ADCDL **Address: AEh**

7	6	5	4	3	2	1	0	Reset
-	-	-	-	-	-	ADCD[1]	ADCD[0]	00H

ADJUST = 1:

Mnemonic: ADCDH **Address: ADh**

7	6	5	4	3	2	1	0	Reset
-	-	-	-	-	-	ADCD[9]	ADCD[8]	00H

Mnemonic: ADCDL **Address: AEh**

7	6	5	4	3	2	1	0	Reset
ADCD[7]	ADCD[6]	ADCD[5]	ADCD[4]	ADCD[3]	ADCD[2]	ADCD[1]	ADCD[0]	00H

ADCD[9:0]: ADC data register.

Mnemonic: ADCCS **Address: AFh**

7	6	5	4	3	2	1	0	Reset
-	-	-	ADCCS[4]	ADCCS[3]	ADCCS[2]	ADCCS[1]	ADCCS[0]	00H

ADCCS[4:0]: ADC clock select.

*The ADC clock maximum 12.5MHz.

*The ADC Conversion rate maximum N/A KHz.

ADCCS[4:0]	ADC Clock(Hz)	Clocks for ADC Conversion
00000	Fosc /2	46
00001	Fosc/4	92
00010	Fosc /6	138
00011	Fosc /8	184
00100	Fosc /10	230
00101	Fosc /12	276
00110	Fosc /14	322
00111	Fosc /16	368
01000	Fosc /18	414

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01001	Fosc /20	460
01010	Fosc /22	506
01011	Fosc /24	552
01100	Fosc /26	598
01101	Fosc /28	644
01110	Fosc /30	690
01111	Fosc /32	736
10000	Fosc /34	782
10001	Fosc /36	828
10010	Fosc /38	874
10011	Fosc /40	920
10100	Fosc /42	966
10101	Fosc /44	1012
10110	Fosc /46	1058
10111	Fosc /48	1104
11000	Fosc /50	1150
11001	Fosc /52	1196
11010	Fosc /54	1242
11011	Fosc /56	1288
11100	Fosc /58	1334
11101	Fosc /60	1380
11110	Fosc /62	1426
11111	Fosc /64	1472

$$\text{ADC_Clock} = \frac{\text{Fosc}}{2 \times (\text{ADCCS} + 1)}$$

$$\text{ADC_Conversion_Rate} = \frac{\text{ADC_Clock}}{13}$$

18. In-System Programming (Internal ISP)

The SM39A16M1 can generate flash control signal by internal hardware circuit. Users utilize flash control register, flash address register and flash data register to perform the ISP function without removing the SM39A16M1 from the system. The SM39A16M1 provides internal flash control signals which can do flash program/chip erase/page erase/protect functions. User need to design and use any kind of interface which SM39A16M1 can input data. User then utilize ISP service program to perform the flash program/chip erase/page erase/protect functions.

18.1 ISP service program

The ISP service program is a user developed firmware program which resides in the ISP service program space. After user developed the ISP service program, user then determine the size of the ISP service program. User need to program the ISP service program in the SM39A16M1 for the ISP purpose.

The ISP service programs were developed by user so that it should includes any features which relates to the flash memory programming function as well as communication protocol between SM39A16M1 and host device which output data to the SM39A16M1. For example, if user utilize UART interface to receive/Transmit data between SM39A16M1 and host device, the ISP service program should include baud rate, checksum or parity check or any error-checking mechanism to avoid data transmission error.

The ISP service program can be initiated under SM39A16M1 active or idle mode. It can not be initiated under power down mode.

18.2 Lock Bit (N)

The Lock Bit N has two functions: one is for service program size configuration and the other is to lock the ISP service program space from flash erase function.

The ISP service program space address range \$3C00 to \$3FFF. It can be divided as blocks of $N \times 128$ byte. (N=0 to 8). When N=0 means no ISP function, all of 16K byte flash memory can be used as program memory. When N=1 means ISP service program occupies 128 byte while the rest of 15.875K byte flash memory can be used as program memory. The maximum ISP service program allowed is 1K byte when N=16. Under such configuration, the usable program memory space is 15K byte.

After N determined, SM39A16M1 will reserve the ISP service program space downward from the top of the program address \$3FFF. The start address of the ISP service program located at \$3x00 while x is depending on the lock bit N. Please see section 3.1 program memory diagram for this ISP service program space structure.

The lock bit N function is different from the flash protect function. The flash erase function can erase all of the flash memory except for the locked ISP service program space. If the flash not has been protected, the content of ISP service program still can be read. If the flash has been protected, the overall content of flash program memory space including ISP service program space can not be read. As given in Table 18-1.

Table 18-1 ISP code area

	ISP service program address
0	No ISP service program
1	128 bytes (\$3F80h ~ \$3FFFh)
2	256 bytes (\$3F00h ~ \$3FFFh)
3	384 bytes (\$3E80h ~ \$3FFFh)
4	512 bytes (\$3E00h ~ \$3FFFh)
5	640 bytes (\$3D80h ~ \$3FFFh)
6	768 bytes (\$3D00h ~ \$3FFFh)
7	896 bytes (\$3C80h ~ \$3FFFh)
8	1.0 K bytes (\$3C00h ~ \$3FFFh)

ISP service program configurable in N*128 byte (N= 0 ~ 8)

18.3 Program the ISP Service Program

After Lock Bit N is set and ISP service program been programmed, the ISP service program memory will be protected (locked) automatically. The lock bit N has its own program/erase timing. It is different from the flash memory program/erase timing so the locked ISP service program can not be erased by flash erase function. If user needs to erase the locked ISP service program, he can do it by writer only. User can not change ISP service program when SM39A16M1 was in system.

18.4 Initiate ISP Service Program

To initiate the ISP service program is to load the program counter (PC) with start address of ISP service program and execute it. There are four ways to do so:

- (1) Blank reset. Hardware reset with first flash address blank (\$0000=#FFH) will load the PC with start address of ISP service program. The hardware reset includes MAX810 (power on reset) and external pad reset. The hardware will issue a strobe window about 256us after hardware reset.
- (2) Execute jump instruction can load the start address of the ISP service program to PC.
- (3) Enter's ISP service program by hardware setting. User can force SM39A16M1 enter ISP service program by setting P1.2, P1.3 "active low" or P1.4 " active low" during hardware reset period. The hardware reset includes MAX810 (power on reset) and external pad reset. The hardware will issue after hardware reset. In application system design, user should take care of the setting of P1.2,P1.3 or P1.4 at reset period to prevent SM39A16M1 from entering ISP service program.
- (4) Enter's ISP service program by hardware setting, the P3.0(RXD) will be detected the two clock signals during hardware reset period. The hardware reset includes MAX810 (power on reset) and external pad reset. The hardware will issue to detect 2 clock signals after hardware reset.

During the strobe window, the hardware will detect the status of P1.2, P1.3 (or P1.4)/P1.0. If they meet one of above conditions, chip will switch to ISP mode automatically. After ISP service program executed, user need to reset the SM39A16M1, either by hardware reset or by WDT, or jump to the address \$0000 to re-start the firmware program.

There are 6 kinds of entry mechanisms for user different applications. This entry method will select on the writer or ISP.

- (1) First Address Blank. i.e. \$0000 = 0xFF. And triggered by Internal reset signal.
- (2) First Address Blank. i.e. \$0000 = 0xFF. And triggered by PAD reset signal.
- (3) P1.2, P1.3 (or P1.4) = 0. And triggered by Internal reset signal.
- (4) P1.2, P1.3 (or P1.4) = 0. And triggered by PAD reset signal.
- (5) P3.0 input 2 clocks. And triggered by Internal reset signal.
- (6) P3.0 input 2 clocks. And triggered by PAD reset signal.

18.5 ISP register – TAKEY, IFCON, ISPF AH, ISPFAL, ISPF D and ISPF C

Mnemonic	Description	Dir.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
ISP function											
TAKEY	Time Access Key register	F7h	TAKEY [7:0]								00H
IFCON	Interface Control register	8Fh	-	CDPR	-	F5K	-	-	EMEN	ISPE	00H
ISPF AH	ISP Flash Address – High register	E1h	ISPF AH [7:0]								FFH
ISPFAL	ISP Flash Address - Low register	E2h	ISPFAL [7:0]								FFH
ISPF D	ISP Flash Data register	E3h	ISPF D [7:0]								FFH
ISPF C	ISP Flash Control register	E4h	EMF1	EMF2	EMF3	EMF4	-	ISPF.2	ISPF.1	ISPF.0	00H

Mnemonic: TAKEY

Address: F7H

7	6	5	4	3	2	1	0	Reset
TAKEY [7:0]								00H

ISP enable bit (ISPE) is read-only by default, software must write three specific values 55h, AAh and 5Ah sequentially to the TAKEY register to enable the ISPE bit write attribute. That is:

```
MOV TAKEY, #55h
MOV TAKEY, #0AAh
MOV TAKEY, #5Ah
```

Mnemonic: IFCON

Address: 8FH

7	6	5	4	3	2	1	0	Reset
-	CDPR	-	F5K	-	-	EMEN	ISPE	00H

The bit 0 (ISPE) of IFCON is ISP enable bit. User can enable overall SM39A16M1 ISP function by setting ISPE bit to 1, to disable overall ISP function by set ISPE to 0. The function of ISPE behaves like a security key. User can disable overall ISP function to prevent software program be erased accidentally. ISP registers ISPF AH, ISPFAL, ISPF D and ISPF C are read-only by default. Software must be set ISPE bit to 1 to enable these 4 registers write attribute.

Mnemonic: ISPAH

Address: E1H

7	6	5	4	3	2	1	0	Reset
-	-	ISPAH5	ISPAH4	ISPAH3	ISPAH2	ISPAH1	ISPAH0	FFH

ISPAH [5:0]: Flash address-high for ISP function

Mnemonic: ISPAL

Address: E2H

7	6	5	4	3	2	1	0	Reset
ISPAL7	ISPAL6	ISPAL5	ISPAL4	ISPAL3	ISPAL2	ISPAL1	ISPAL0	FFH

ISPAL [7:0]: Flash address-Low for ISP function

The ISPAH & ISPAL provide the 14-bit flash memory address for ISP function. The flash memory address should not include the ISP service program space address. If the flash memory address indicated by ISPAH & ISPAL registers overlay with the ISP service program space address, the flash program/page erase of ISP function executed thereafter will have no effect.

Mnemonic: ISPDF

Address: E3H

7	6	5	4	3	2	1	0	Reset
ISPDF7	ISPDF6	ISPDF5	ISPDF4	ISPDF3	ISPDF2	ISPDF1	ISPDF0	FFH

ISPDF [7:0]: Flash data for ISP function.

The ISPDF provide the 8-bit data register for ISP function.

Mnemonic: ISPF

Address: E4H

7	6	5	4	3	2	1	0	Reset
EMF1	EMF2	EMF3	EMF4	-	ISPF[2]	ISPF[1]	ISPF[0]	00H

EMF1: Entry mechanism (1) flag, clear by reset. (Read only)

EMF2: Entry mechanism (2) flag, clear by reset. (Read only)

EMF3: Entry mechanism (3) flag, clear by reset. (Read only)

EMF4: Entry mechanism (4) flag, clear by reset. (Read only)

ISPF [2:0]: ISP function select bit.

ISPF[2:0]	ISP function
000	Byte program
001	Chip protect
010	Page erase
011	Chip erase
100	Write option
101	Read option
110	Erase option
111	reserved

One page of flash memory is 128byte

The Option function can access the XTAL1 and XTAL2 swap to I/O pins
select(description in section 1.2) 、 Internal reset time select(description in section

1.4.1) · clock source select(description in section 1.5) · Reset swap to I/O pins
function select(description in section 5) · WDTEN control bit(description in section
10) · or ISP entry mechanisms select(description in section 18).

When chip protected or no ISP service, option can only read.

The choice ISP function will start to execute once the software write data to ISPFCH register.

To perform byte program/page erases ISP function, user need to specify flash address at first. When performing page erase function, SM39A16M1 will erase entire page which flash address indicated by ISPFCH & ISPFCHL registers located within the page.

e.g. flash address: \$XYMN

page erase function will erase from \$XY00 to \$XYFF

To perform the chip erase ISP function, SM39A16M1 will erase all the flash program memory except the ISP service program space. To perform chip protect ISP function, the SM39A16M1 flash memory content will be read #00H.

e.g. ISP service program to do the byte program - to program #22H to the address \$1005H

```
MOV TAKEY, #55h
MOV TAKEY, #0AAh
MOV TAKEY, #5Ah ; enable ISPE write attribute
ORL IFCON, #01H ; enable SM39R08A3 ISP function
MOV ISPFCH, #10H ; set flash address-high, 10H
MOV ISPFCHL, #05H ; set flash address-low, 05H
MOV ISPFCHD, #22H ; set flash data to be programmed, data = 22H
MOV ISPFCH, #00H ; start to program #22H to the flash address $1005H
MOV TAKEY, #55h
MOV TAKEY, #0AAh
MOV TAKEY, #5Ah ; enable ISPE write attribute
ANL IFCON, #0FEH ; disable SM39A16M1 ISP function
```

19. Comparator

SM39A16M1 had integrated Comparator in chip. When use it as comparator, the comparator output is logical one when positive input greater than negative input, otherwise the output is a zero. Following is the work of a block diagram of the comparator, as Fig. 19-1 shown. The user can set the operation mode with reference to the block diagram.

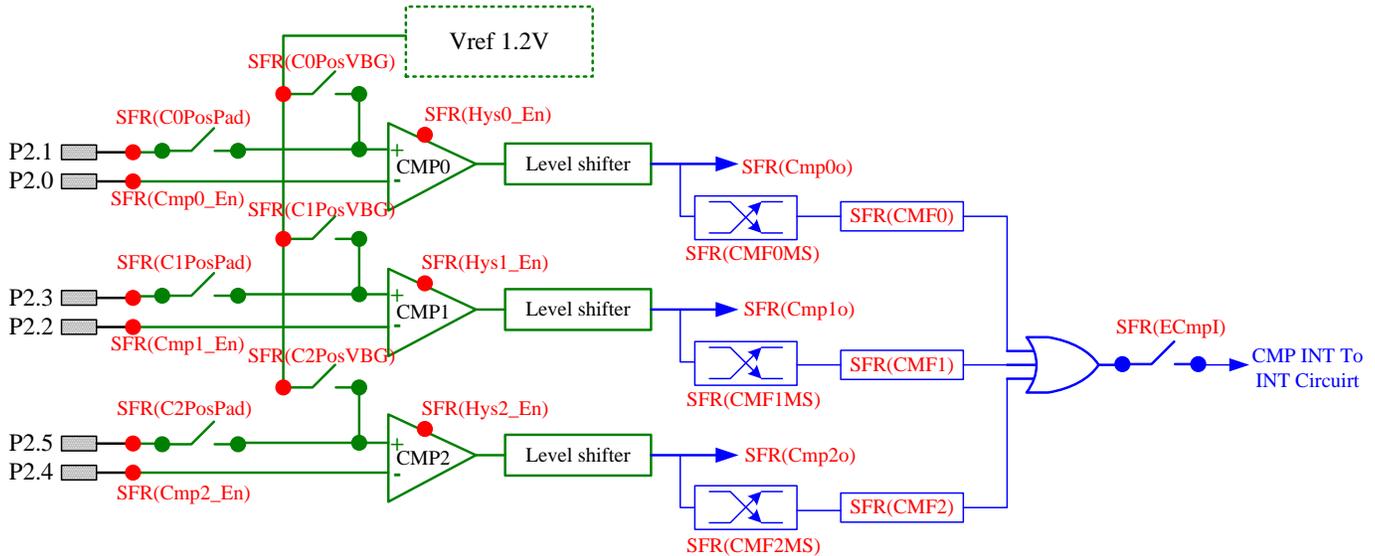


Fig. 19-1: Operation of Comparator Mode

If OPA and Comparator Mode both are enabled at same module, the OPA Mode has higher priority.

Mnemonic	Description	Addr	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	RST
Comparator											
OpPin	OpCmp Pin Select	F6h	-	Cmp0_En	C0PosVB G	C0PosP AD	-	Cmp1_En	C1PosVB G	C1PosP AD	~OP 11
OpPin2	OpCmp Pin Select 2	CEh	-	Cmp2_En	C2PosVB G	C2PosP AD	-	-	-	-	~OP 16
Cmp0CON	Comparator_0 control	FEh	Hys0_En	Cmp0o	CMF0MS 1	CMF0MS 0	CMF 0	-	-	-	00h
Cmp1CON	Comparator_1 control	FFh	Hys1_En	Cmp1o	CMF1MS 1	CMF1MS 0	CMF 1	-	-	-	00h
Cmp2CON	Comparator_2 control	CFh	Hys2_En	Cmp2o	CMF2MS 1	CMF2MS 0	CMF 2	-	-	-	00h

*OP11 and OP16 by writer programming set.

Mnemonic: OpPin

Address: F6h

7	6	5	4	3	2	1	0	Reset
-	Cmp0_En	C0PosVBG	C0PosPad	-	Cmp1_En	C1PosVBG	C1PosPad	~OP11

Cmp0_En : Cmp0 enable.

Cmp0_En = 1 - Comparator_0 circuit enables and switch to corresponding signal in multi-function pin P2.0/P2.1 by HW automatically.

C0PosVBG : Select Comparator_0 positive input source

Cmp0_En = 1 - set positive input source as internal reference voltage (1.2V±10%)

C0PosPad: Select Comparator_0 positive input source

C0PosPad = 1 - set positive input source as external pin

Cmp1_En : Cmp1 enable.

Cmp1_En =1 - Comparator_1 circuit enables and switch to corresponding signal in multi-function pin P2.2/P2.3 by HW automatically.

C1PosVBG: Select Comparator_1 positive input source

C1PosVBG =1 - set positive input source as internal reference voltage (1.2V±10%)

C1PosPad: Select Comparator_1 positive input source

C1PosPad =1 - set positive input source as external pin

CmpxOut、Cmpx_En、CxPosVBG 及 CxPosPad setting table :

Cmpx_En	CxPosVBG	CxPosPad	CmpxOut_En	Comparator	
				CmpxPln	CmpxNln
0	X	X	X	IO	IO
1	0	1	0	IO	CMP
1	0	1	1	IO	IO
1	1	0	0	CMP	CMP
1	1	0	1	CMP	CMP

Mnemonic: OpPin2

Address:CEh

7	6	5	4	3	2	1	0	Reset
-	Cmp2_En	C2PosVBG	C2PosPad	-	-	-	-	~OP16

Cmp2_En : Cmp2 enable.

Cmp2_En= 1 - Comparator_2 circuit enable and switch to corresponding signal in multi-function pin P2.4/P2.5 by HW automatically.

C2PosVBG: Select Comparator_2 positive input source

C2PosVBG = 1- set positive input source as bandgap reference voltage

C2PosPad: Select Comparator_2 positive input source

C2PosPad =1 - set positive input source as external pin

Mnemonic: Cmp0CON							Address: FEh	
7	6	5	4	3	2	1	0	Reset
Hys0En	Cmp0o	CMF0MS1	CMF0MS0	CMF0	-	-	-	00h

Hys0En: Hysteresis function enable

Hys0En = 0 - disable Hysteresis at comparator_0 input

Hys0En = 1 - enable

Cmp0o: Comparator_0 output (read only)

Cmp0o = 0 - The positive input source was lower than negative input source

Cmp0o = 1 - The positive input source was higher than negative input source

CMF0MS[1:0] : CMF0(Comparator_0 Flag) setting mode select

CMF0MS[1:0] = 00 - CMF0 will be set when comparator_0 output toggle

CMF0MS[1:0] = 01 - CMF0 will be set when comparator_0 output rising

CMF0MS[1:0] = 10 - CMF0 will be set when comparator_0 output falling

11: reserved

CMF0: Comparator_0 Flag

This bit is setting by hardware according to meet CMF0MS [1:0] select condition.

This bit must clear by software.

Mnemonic: Cmp1CON							Address: FFh	
7	6	5	4	3	2	1	0	Reset
Hys1En	Cmp1o	CMF1MS1	CMF1MS0	CMF1	-	-	-	00h

Hys1En: Hysteresis function enable

Hys1En = 0 - disable Hysteresis at comparator_1 input

Hys1En = 1 - enable

Cmp1o: Comparator_1 output (read only)

Cmp1o = 0 - The positive input source was lower than negative input source

Cmp1o = 1 - The positive input source was higher than negative input source

CMF1MS[1:0] : CMF1(Comparator_1 Flag) setting mode select

CMF1MS[1:0] = 00 - CMF1 will be set when comparator_1 output toggle

CMF1MS[1:0] = 01 - CMF1 will be set when comparator_1 output rising

CMF1MS[1:0] = 10 - CMF1 will be set when comparator_1 output falling

11: reserved

CMF1: Comparator_1 Flag

This bit is setting by hardware according to meet CMF1MS [1:0] select condition.

This bit must clear by software.



Mnemonic: Cmp2CON							Address: CFh	
7	6	5	4	3	2	1	0	Reset
Hys2En	Cmp2o	CMF2MS1	CMF2MS0	CMF2	-	-	-	00h

Hys2En: Hysteresis function enable

Hys2En = 0 - disable Hysteresis at comparator_2 input

Hys2En = 1 - enable

Cmp2o: Comparator_1 output (read only)

Cmp2o = 0 - The positive input source was lower than negative input source

Cmp2o = 1 - The positive input source was higher than negative input source

CMF2MS[1:0] : CMF1(Comparator_2 Flag) setting mode select

CMF2MS[1:0] = 00 – CMF2 will be set when comparator_2 output toggle

CMF2MS[1:0] = 01 – CMF2 will be set when comparator_2 output rising

CMF2MS[1:0] = 10 – CMF2 will be set when comparator_2 output falling

CMF2MS[1:0] = 11 - reserved

CMF2: Comparator_2 Flag

This bit is setting by hardware according to meet CMF2MS [1:0] select condition.

This bit must clear by software.

Operating Conditions

Symbol	Description	Min.	Typ.	Max.	Unit.	Remarks
TA	Operating temperature	-40	25	85	°C	Ambient temperature under bias
VDD	Supply voltage	1.8		5.5	V	
Vref	Internal reference voltage	1.1	1.2	1.3	V	

DC Characteristics

TA = -40°C to 85°C, VCC = 5.0V

Symbol	Parameter	Valid	Min	Typical	Max	Units	Conditions
VIL1	Input Low-voltage	Port 0,1,2,3	-0.5	-	0.8	V	Vcc=5V
VIL2	Input Low-voltage	RES, XTAL1	0	-	0.8	V	-
VIH1	Input High-voltage	Port 0,1,2,3	2.0	-	VCC + 0.5	V	-
VIH2	Input High-voltage	RES, XTAL1	70%Vcc	-	VCC + 0.5	V	-
VOL	Output Low-voltage	Port 0 (3.)	-	-	0.45	V	IOL=40mA Vcc=5V
		Port 1,2,3 (4.)	-	-	0.45	V	IOL=20mA Vcc=5V
VOH1	Output High-voltage using Strong Pull-up(1)	Port 0	4.6	-	-	V	IOH= -12mA
		Port 1,2,3	4.6	-	-	V	IOH= -7mA
VOH2	Output High-voltage using Weak Pull-up(2)	Port 0,1,2,3	2.6	-	-	V	IOH= -350uA
IIL	Logic 0 Input Current	Port 0,1,2,3	-	-	-75	uA	Vin= 0.45V
ITL	Logical Transition Current	Port 0,1,2,3	-	-	-650	uA	Vin= 2.0V
ILI	Input Leakage Current	Port 0,1,2,3	-	-	±10	uA	0.45V<Vin<Vcc
RRST	Reset Pull-down Resistor	RES	50	-	300	kΩ	-
CIO	Pin Capacitance	-	-	-	10	pF	Freq= 1MHz, Ta= 25°C
ICC	Power Supply Current	VDD	-	3.19	4.78	mA	Active mode ,IRC=22.1184MHz
			-	5.5	8.25	mA	Active mode, 12MHz VCC=5V 25 °C
			-	4.5	7.25	mA	Idle mode, 12MHz VCC =5V 25 °C
			-	3	7	uA	Power down mode VCC =5V 25 °C

Notes:

- (1) Port in Push-Pull Output Mode
- (2) Port in Quasi-Bidirectional Mode
- (3) Maximum IOL per port0 pin : 40mA
- (4) Maximum IOL per port1,2,3 pin : 20mA

Specifications subject to change without notice contact your sales representatives for the most recent information.

TA = -40°C to 85°C, VCC = 3.0V

Symbol	Parameter	Valid	Min	Typical	Max	Units	Conditions
VIL1	Input Low-voltage	Port 0,1,2,3	-0.5	-	0.8	V	Vcc=3.0V
VIL2	Input Low-voltage	RES, XTAL1	0	-	0.8	V	-
VIH1	Input High-voltage	Port 0,1,2,3	2.0	-	VCC + 0.5	V	-
VIH2	Input High-voltage	RES, XTAL1	70%Vcc	-	VCC + 0.5	V	-
VOL	Output Low-voltage	Port 0 (3.)	-	-	0.45	V	IOL=20mA Vcc=3V
		Port 1,2,3 (4.)	-	-	0.45	V	IOL=12mA Vcc=3V
VOH1	Output High-voltage using Strong Pull-up(1)	Port 0	2.6	-	-	V	IOH=- 9mA
		Port 1,2,3	2.6	-	-	V	IOH= -5mA
VOH2	Output High-voltage using Weak Pull-up(2)	Port 0,1,2,3	2.4	-	-	V	IOH= -70uA
IIL	Logic 0 Input Current	Port 0,1,2,3	-	-	-75	uA	Vin= 0.45V
ITL	Logical Transition Current	Port 0,1,2,3	-	-	-650	uA	Vin=1.5V
ILI	Input Leakage Current	Port 0,1,2,3	-	-	±10	uA	0.45V<Vin<Vcc
RRST	Reset Pull-down Resistor	RES	50	-	300	kΩ	-
CIO	Pin Capacitance		-	-	10	pF	Freq= 1MHz, Ta= 25°C
ICC	Power Supply Current	VDD	-	3.15	4.73	mA	Active mode ,IRC=22.1184MHz
			-	2.77	4.16	mA	Active mode ,12MHz VCC = 3.0 V 25 °C
			-	1.77	3.16	mA	Idle mode, 12MHz VCC =3.0V 25 °C
			-	1	5	uA	Power down mode VCC=3.0V 25 °C

Notes:

- (1) Port in Push-Pull Output Mode
- (2) Port in Quasi-Bidirectional Mode
- (3) Maximum IOL per port0 pin : 20mA
- (4) Maximum IOL per port1,2,3 pin : 12mA

Absolute Maximum Ratings

SYMBOL	PARAMETER	MAX	UNIT
Maximum sourced current	An I/O pin	N/A	mA
	Total I/O pins	150	mA
Maximum sink current	An I/O pin	N/A	mA
	Total I/O pins	150	mA
Tj	Max. Junction Temperature	150	°C

Specifications subject to change without notice contact your sales representatives for the most recent information.

Comparator Characteristics

Ta=25°C

Symbol	Description	Test Condition		MIN	TPY	MAX	Unit
		V _{DD}	Condition				
I _{OP}	Operating current	5	-	-	10	10	μA
-	Power Down Current	5	-	-	-	0.1	μA
-	Offset voltage	5	-	-10	-	+10	mV
V _{CM}	Input voltage common mode range	-	-	V _{SS}	-	V _{DD} -1.5	V
T _p	Propagation delay	5	△ V _{in} =10mV	-	3	6	us

LVI & LVR Characteristics

	LVR		
	Min	Typical	Max
1.8V ~ 5.5V	VIL=1.42V (VIH=1.62V)	VIL=1.50V (VIH=1.70V)	VIL=1.57V (VIH=1.77V)

	LVI		
	Min	Typical	Max
LVIS[1:0] = 00	VIL=1.57V (VIH=1.77V)	VIL=1.65V (VIH=1.85V)	VIL=1.73V (VIH=1.93V)
LVIS[1:0] = 01	VIL=2.47V (VIH=2.67V)	VIL=2.60V (VIH=2.80V)	VIL=2.73V (VIH=2.93V)
LVIS[1:0] = 10	VIL=3.04V (VIH=3.24V)	VIL=3.20V (VIH=3.40V)	VIL=3.36V (VIH=3.56V)
LVIS[1:0] = 11	VIL=3.80V (VIH=4.00V)	VIL=4.00V (VIH=4.20V)	VIL=4.20V (VIH=4.40V)