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Details

Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	22
Program Memory Size	3.5КВ (2К х 14)
Program Memory Type	FLASH
EEPROM Size	64 x 8
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	4V ~ 5.5V
Data Converters	A/D 5x10b
Oscillator Type	External
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	28-SSOP (0.209", 5.30mm Width)
Supplier Device Package	28-SSOP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16f870-e-ss

Email: info@E-XFL.COM

Address: Room A, 16/F, Full Win Commercial Centre, 573 Nathan Road, Mongkok, Hong Kong

Key Features PICmicro™ Mid-Range MCU Family Reference Manual (DS33023)	PIC16F870	PIC16F871
Operating Frequency	DC - 20 MHz	DC - 20 MHz
RESETS (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	2K	2K
Data Memory (bytes)	128	128
EEPROM Data Memory	64	64
Interrupts	10	11
I/O Ports	Ports A,B,C	Ports A,B,C,D,E
Timers	3	3
Capture/Compare/PWM modules	1	1
Serial Communications	USART	USART
Parallel Communications	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels
Instruction Set	35 Instructions	35 Instructions

2.2.2.2 OPTION_REG Register

bit

bit

bit

bit

bit

bit

The OPTION_REG register is a readable and writable register, which contains various control bits to configure the TMR0 prescaler/WDT postscaler (single assignable register known also as the prescaler), the External INT interrupt, TMR0 and the weak pull-ups on PORTB.

Note:	To achieve a 1:1 prescaler assignment for
	the TMR0 register, assign the prescaler to
	the Watchdog Timer.

REGISTER 2-2: OPTION_REG REGISTER (ADDRESS: 81h,181h)

	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
Γ	RBPU	INTEDG	TOCS	TOSE	PSA	PS2	PS1	PS0
k	oit 7							bit 0
Ē	RBPU. PC		ın Enable bi	t				
	1 = PORT	B pull-ups :	are disabled	·				
(= PORT	B pull-ups	are enabled	by individual	l port latch val	ues		
I	NTEDG:	Interrupt Ec	lge Select b	it				
1	1 = Interru	ipt on rising	edge of RE	80/INT pin				
(0 = Interru	pt on fallin	g edge of RE	30/INT pin				
1	TOCS: TM	R0 Clock S	Source Selec	t bit				
]	1 = Transi 1 = Interna	tion on RA4 al instructio	4/10CKI pin n cycle cloci	k (CLKO)				
ì	TOSE: TM	R0 Source	Edge Selec	t bit				
1	1 = Increm	nent on hig	h-to-low tran	sition on RA	4/T0CKI pin			
(o = Increm	nent on low	-to-high tran	sition on RA	4/T0CKI pin			
F	PSA: Pres	scaler Assig	nment bit					
1	1 = Presca	aler is assig	ned to the V	VDT				
(0 = Presca	aler is assig	gned to the	imer0 modu	le			
ł	PS2:PS0:	Prescaler	Rate Select	bits				
	-	Bit Value	TMR0 Rate	WDT Rate				
		000	1:2	1:1				
		001	1:4 1:8	1:2				
		011	1:16	1:8				
		100	1:32	1:16				
		101	1:64	1:32				
		111	1:128	1:128				
		I						
l	Legend:							
F	R = Reada	able bit	W = V	Writable bit	U = Unim	plemented l	oit, read as	'0'
-	- n = Value	e at POR	'1' =	Bit is set	'0' = Bit is	cleared	x = Bit is u	Inknown

2.3 PCL and PCLATH

The Program Counter (PC) is 13-bits wide. The low byte comes from the PCL register, which is a readable and writable register. The upper bits (PC<12:8>) are not readable, but are indirectly writable through the PCLATH register. On any RESET, the upper bits of the PC will be cleared. Figure 2-3 shows the two situations for the loading of the PC. The upper example in the figure shows how the PC is loaded on a write to PCL (PCLATH<4:0> \rightarrow PCH). The lower example in the figure shows how the PC is loaded during a CALL or GOTO instruction (PCLATH<4:3> \rightarrow PCH).

FIGURE 2-3: LOADING OF PC IN DIFFERENT SITUATIONS



2.3.1 COMPUTED GOTO

A computed GOTO is accomplished by adding an offset to the program counter (ADDWF PCL). When doing a table read using a computed GOTO method, care should be exercised if the table location crosses a PCL memory boundary (each 256-byte block). Refer to the application note, *"Implementing a Table Read"* (AN556).

2.3.2 STACK

The PIC16FXXX family has an 8-level deep x 13-bit wide hardware stack. The stack space is not part of either program or data space and the stack pointer is not readable or writable. The PC is PUSHed onto the stack when a CALL instruction is executed, or an interrupt causes a branch. The stack is POPed in the event of a RETURN, RETLW or a RETFIE instruction execution. PCLATH is not affected by a PUSH or POP operation.

The stack operates as a circular buffer. This means that after the stack has been PUSHed eight times, the ninth push overwrites the value that was stored from the first push. The tenth push overwrites the second push (and so on).

Note 1: There are no status bits to indicate stack overflow or stack underflow conditions.

2: There are no instructions/mnemonics called PUSH or POP. These are actions that occur from the execution of the CALL, RETURN, RETLW and RETFIE instructions, or the vectoring to an interrupt address.

2.4 Program Memory Paging

The PIC16FXXX architecture is capable of addressing a continuous 8K word block of program memory. The CALL and GOTO instructions provide 11 bits of the address, which allows branches within any 2K program memory page. Therefore, the 8K words of program memory are broken into four pages. Since the PIC16F872 has only 2K words of program memory or one page, additional code is not required to ensure that the correct page is selected before a CALL or GOTO instruction is executed. The PCLATH<4:3> bits should always be maintained as zeros. If a return from a CALL instruction (or interrupt) is executed, the entire 13-bit PC is popped off the stack. Manipulation of the PCLATH is not required for the return instructions.

2.5 Indirect Addressing, INDF and FSR Registers

The INDF register is not a physical register. Addressing the INDF register will cause indirect addressing.

Indirect addressing is possible by using the INDF register. Any instruction using the INDF register actually accesses the register pointed to by the File Select register, FSR. Reading the INDF register itself indirectly (FSR = 0) will read 00h. Writing to the INDF register indirectly results in a no operation (although status bits may be affected). An effective 9-bit address is obtained by concatenating the 8-bit FSR register and the IRP bit (STATUS<7>), as shown in Figure 2-4.

A simple program to clear RAM locations 20h-2Fh using indirect addressing is shown in Example 2-1.

EXAMPLE 2-1:	INDIRECT ADDRESSING
--------------	---------------------

NEXT	movlw movwf clrf incf btfss goto	0x20 FSR INDF FSR,F FSR,4 NEXT	;initialize pointer ;to RAM ;clear INDF register ;inc pointer ;all done? ;no clear next
CONTIN	UE		
:			;yes continue

8.2 Capture Mode

In Capture mode, CCPR1H:CCPR1L captures the 16-bit value of the TMR1 register when an event occurs on pin RC2/CCP1. An event is defined as one of the following:

- Every falling edge
- · Every rising edge
- Every 4th rising edge
- Every 16th rising edge

The type of event is configured by control bits CCP1M3:CCP1M0 (CCP1CON<3:0>). When a capture is made, the interrupt request flag bit CCP1IF (PIR1<2>) is set. The interrupt flag must be cleared in software. If another capture occurs before the value in register CCPR1 is read, the old captured value is overwritten by the new value.

8.2.1 CCP PIN CONFIGURATION

In Capture mode, the RC2/CCP1 pin should be configured as an input by setting the TRISC<2> bit.

Note:	If the RC2/CCP1 pin is configured as an
	output, a write to the port can cause a
	capture condition.

FIGURE 8-1: CAPTURE MODE OPERATION BLOCK DIAGRAM



8.2.2 TIMER1 MODE SELECTION

Timer1 must be running in Timer mode, or Synchronized Counter mode, for the CCP module to use the capture feature. In Asynchronous Counter mode, the capture operation may not work.

8.2.3 SOFTWARE INTERRUPT

When the Capture mode is changed, a false capture interrupt may be generated. The user should keep bit CCP1IE (PIE1<2>) clear to avoid false interrupts and should clear the flag bit, CCP1IF, following any such change in Operating mode.

8.2.4 CCP PRESCALER

There are four prescaler settings, specified by bits CCP1M3:CCP1M0. Whenever the CCP module is turned off, or the CCP module is not in Capture mode, the prescaler counter is cleared. Any RESET will clear the prescaler counter.

Switching from one capture prescaler to another may generate an interrupt. Also, the prescaler counter will not be cleared, therefore, the first capture may be from a non-zero prescaler. Example 8-1 shows the recommended method for switching between capture prescalers. This example also clears the prescaler counter and will not generate the "false" interrupt.

EXAMPLE 8-1:	CHANGING BETWEEN
	CAPTURE PRESCALERS

CLRF MOVLW	CCP1CON NEW CAPT PS	;	Turn CCP module off
110 V LIW	NEW_CAFT_F5	'	the new prograder
		;	the new prescaler
	2001 2017	;	move value and CCP ON
MOAME	CCPICON	;	Load CCPICON with this
		;	value

8.3 Compare Mode

In Compare mode, the 16-bit CCPR1 register value is constantly compared against the TMR1 register pair value. When a match occurs, the RC2/CCP1 pin is:

- Driven high
- Driven low
- · Remains unchanged

The action on the pin is based on the value of control bits, CCP1M3:CCP1M0 (CCP1CON<3:0>). At the same time, interrupt flag bit CCP1IF is set.

FIGURE 8-2: COMPARE MODE OPERATION BLOCK DIAGRAM



8.3.1 CCP PIN CONFIGURATION

The user must configure the RC2/CCP1 pin as an output by clearing the TRISC<2> bit.

Note:	Clearing the CCP1CON register will force
	the RC2/CCP1 compare output latch to
	the default low level. This is not the
	PORTC I/O data latch.

8.3.2 TIMER1 MODE SELECTION

Timer1 must be running in Timer mode, or Synchronized Counter mode, if the CCP module is using the compare feature. In Asynchronous Counter mode, the compare operation may not work.

8.3.3 SOFTWARE INTERRUPT MODE

When Generate Software Interrupt mode is chosen, the CCP1 pin is not affected. The CCPIF bit is set, causing a CCP interrupt (if enabled).

8.3.4 SPECIAL EVENT TRIGGER

In this mode, an internal hardware trigger is generated, which may be used to initiate an action.

The special event trigger output of CCP1 resets the TMR1 register pair, and starts an A/D conversion (if A/D module is enabled). This allows the CCPR1 register to effectively be a 16-bit programmable period register for Timer1.

Note: The special event trigger from the CCP1 module will not set interrupt flag bit TMR1IF (PIR1<0>).

8.4 PWM Mode (PWM)

In Pulse Width Modulation mode, the CCP1 pin produces up to a 10-bit resolution PWM output. Since the CCP1 pin is multiplexed with the PORTC data latch, the TRISC<2> bit must be cleared to make the CCP1 pin an output.

Note:	Clearing the CCP1CON register will force
	the CCP1 PWM output latch to the default
	low level. This is not the PORTC I/O data
	latch.

Figure 8-3 shows a simplified block diagram of the CCP module in PWM mode.

For a step-by-step procedure on how to set up the CCP module for PWM operation, see Section 8.4.3.

FIGURE 8-3: SIMPLIFIED PWM BLOCK DIAGRAM



A PWM output (Figure 8-4) has a time base (period) and a time that the output stays high (duty cycle). The frequency of the PWM is the inverse of the period (1/period).





8.4.1 PWM PERIOD

The PWM period is specified by writing to the PR2 register. The PWM period can be calculated using the following formula:

PWM frequency is defined as 1 / [PWM period].

When TMR2 is equal to PR2, the following three events occur on the next increment cycle:

- TMR2 is cleared
- The CCP1 pin is set (exception: if PWM duty cycle = 0%, the CCP1 pin will not be set)
- The PWM duty cycle is latched from CCPR1L into CCPR1H

Note:	The Timer2 postscaler (see Section 7.1) is
	not used in the determination of the PWM
	frequency. The postscaler could be used
	to have a servo update rate at a different
	frequency than the PWM output.

8.4.2 PWM DUTY CYCLE

The PWM duty cycle is specified by writing to the CCPR1L register and to the CCP1CON<5:4> bits. Up to 10-bit resolution is available. The CCPR1L contains the eight MSbs and the CCP1CON<5:4> contains the two LSbs. This 10-bit value is represented by CCPR1L:CCP1CON<5:4>. The following equation is used to calculate the PWM duty cycle in time:

PWM duty cycle = (CCPR1L:CCP1CON<5:4>) • Tosc • (TMR2 prescale value)

CCPR1L and CCP1CON<5:4> can be written to at any time, but the duty cycle value is not latched into CCPR1H until after a match between PR2 and TMR2 occurs (i.e., the period is complete). In PWM mode, CCPR1H is a read-only register.

The CCPR1H register and a 2-bit internal latch are used to double buffer the PWM duty cycle. This double buffering is essential for glitch-free PWM operation.

When the CCPR1H and 2-bit latch match TMR2, concatenated with an internal 2-bit Q clock, or 2 bits of the TMR2 prescaler, the CCP1 pin is cleared.

The maximum PWM resolution (bits) for a given PWM frequency is given by the formula:

Resolution =
$$\frac{\log(\frac{Fosc}{FPWM})}{\log(2)}$$
 bits

Note: If the PWM duty cycle value is longer than the PWM period, the CCP1 pin will not be cleared.

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value POR,	e on: BOR	Valu all o RES	e on ther ETS
0Bh,8Bh, 10Bh, 18Bh	INTCON	GIE	PEIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000	000x	0000	000u
0Ch	PIR1	PSPIF ⁽¹⁾	ADIF	RCIF	TXIF	—	CCP1IF	TMR2IF	TMR1IF	0000	-000	0000	-000
8Ch	PIE1	PSPIE ⁽¹⁾	ADIE	RCIE	TXIE	—	CCP1IE	TMR2IE	TMR1IE	0000	-000	0000	-000
87h	TRISC	PORTC [PORTC Data Direction Register							1111	1111	1111	1111
11h	TMR2	Timer2 Module's Register							0000	0000	0000	0000	
92h	PR2	Timer2 M	Timer2 Module's Period Register					1111	1111	1111	1111		
12h	T2CON	_	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0	-000	0000	-000	0000
15h	CCPR1L	Capture/0	Compare/PV	VM Register	r1 (LSB)					xxxx	xxxx	uuuu	uuuu
16h	CCPR1H	Capture/Compare/PWM Register1 (MSB)							xxxx	xxxx	uuuu	uuuu	
17h	CCP1CON	_	_	CCP1X	CCP1Y	CCP1M3	CCP1M2	CCP1M1	CCP1M0	00	0000	00	0000

TABLE 8-4: REGISTERS ASSOCIATED WITH PWM AND TIMER2

Legend: x = unknown, u = unchanged, - = unimplemented, read as '0'. Shaded cells are not used by PWM and Timer2.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16F870; always maintain these bits clear.

9.2.3 SETTING UP 9-BIT MODE WITH ADDRESS DETECT

When setting up an Asynchronous Reception with Address Detect enabled:

- Initialize the SPBRG register for the appropriate baud rate. If a high speed baud rate is desired, set bit BRGH.
- Enable the asynchronous serial port by clearing bit SYNC and setting bit SPEN.
- If interrupts are desired, then set enable bit RCIE.
- Set bit RX9 to enable 9-bit reception.
- Set ADDEN to enable address detect.
- Enable the reception by setting enable bit CREN.

- Flag bit RCIF will be set when reception is complete, and an interrupt will be generated if enable bit RCIE was set.
- Read the RCSTA register to get the ninth bit and determine if any error occurred during reception.
- Read the 8-bit received data by reading the RCREG register, to determine if the device is being addressed.
- If any error occurred, clear the error by clearing enable bit CREN.
- If the device has been addressed, clear the ADDEN bit to allow data bytes and address bytes to be read into the receive buffer, and interrupt the CPU.





FIGURE 9-8: ASYNCHRONOUS RECEPTION WITH ADDRESS BYTE FIRST



TABLE 9-7: REGISTERS ASSOCIATED WITH ASYNCHRONOUS RECEPTION

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other RESETS
0Bh, 8Bh, 10Bh,18Bh	INTCON	GIE	PEIE	TOIE	INTE	RBIE	TOIF	INTF	R0IF	x000 0000x	0000 000u
0Ch	PIR1	PSPIF ⁽¹⁾	ADIF	RCIF	TXIF	_	CCP1IF	TMR2IF	TMR1IF	0000 -000	0000 -000
18h	RCSTA	SPEN	RX9	SREN	CREN	ADDEN	FERR	OERR	RX9D	x000 000x	0000 000x
1Ah	RCREG	USART Receive Register						0000 0000	0000 0000		
8Ch	PIE1	PSPIE ⁽¹⁾	ADIE	RCIE	TXIE	_	CCP1IE	TMR2IE	TMR1IE	0000 -000	0000 -000
98h	TXSTA	CSRC	TX9	TXEN	SYNC	_	BRGH	TRMT	TX9D	0000 -010	0000 -010
99h	SPBRG	Baud Rate	Generato	or Registe	r					0000 0000	0000 0000

Legend: x = unknown, - = unimplemented locations read as '0'. Shaded cells are not used for asynchronous reception.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16F870; always maintain these bits clear.

PIC16F870/871





15.0 DC AND AC CHARACTERISTICS GRAPHS AND TABLES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore, outside the warranted range.

"Typical" represents the mean of the distribution at 25°C. "Maximum" or "minimum" represents (mean + 3σ) or (mean - 3σ) respectively, where σ is a standard deviation, over the whole temperature range.





FIGURE 15-2: MAXIMUM IDD vs. Fosc OVER VDD (HS MODE)



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PIC16F870/871















FIGURE 15-21: MINIMUM AND MAXIMUM VIN vs. VDD (ST INPUT, -40°C TO 125°C)





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28-Lead Plastic Small Outline (SO) – Wide, 300 mil (SOIC)

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



	Units	INCHES*			MILLIMETERS			
Dimension	Limits	MIN	NOM	MAX	MIN	NOM	MAX	
Number of Pins	n		28			28		
Pitch	р		.050			1.27		
Overall Height	Α	.093	.099	.104	2.36	2.50	2.64	
Molded Package Thickness	A2	.088	.091	.094	2.24	2.31	2.39	
Standoff §	A1	.004	.008	.012	0.10	0.20	0.30	
Overall Width	E	.394	.407	.420	10.01	10.34	10.67	
Molded Package Width	E1	.288	.295	.299	7.32	7.49	7.59	
Overall Length	D	.695	.704	.712	17.65	17.87	18.08	
Chamfer Distance	h	.010	.020	.029	0.25	0.50	0.74	
Foot Length	L	.016	.033	.050	0.41	0.84	1.27	
Foot Angle Top	¢	0	4	8	0	4	8	
Lead Thickness	С	.009	.011	.013	0.23	0.28	0.33	
Lead Width	В	.014	.017	.020	0.36	0.42	0.51	
Mold Draft Angle Top	α	0	12	15	0	12	15	
Mold Draft Angle Bottom	β	0	12	15	0	12	15	

* Controlling Parameter

§ Significant Characteristic

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side. JEDEC Equivalent: MS-013

Drawing No. C04-052

28-Lead Plastic Shrink Small Outline (SS) - 209 mil, 5.30 mm (SSOP)

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging







		INCHES		MILLIMETERS*			
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		28			28	
Pitch	р		.026			0.65	
Overall Height	Α	.068	.073	.078	1.73	1.85	1.98
Molded Package Thickness	A2	.064	.068	.072	1.63	1.73	1.83
Standoff §	A1	.002	.006	.010	0.05	0.15	0.25
Overall Width	E	.299	.309	.319	7.59	7.85	8.10
Molded Package Width	E1	.201	.207	.212	5.11	5.25	5.38
Overall Length	D	.396	.402	.407	10.06	10.20	10.34
Foot Length	L	.022	.030	.037	0.56	0.75	0.94
Lead Thickness	С	.004	.007	.010	0.10	0.18	0.25
Foot Angle	φ	0	4	8	0.00	101.60	203.20
Lead Width	В	.010	.013	.015	0.25	0.32	0.38
Mold Draft Angle Top	α	0	5	10	0	5	10
Mold Draft Angle Bottom	β	0	5	10	0	5	10

* Controlling Parameter § Significant Characteristic

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side. JEDEC Equivalent: MS-150 Drawing No. C04-073

APPENDIX C: CONVERSION CONSIDERATIONS

This appendix discusses the considerations for converting from previous versions of a device to the ones listed in this data sheet. Typically, these changes are due to the differences in the process technology used. An example of this type of conversion is from a PIC17C756 to a PIC18F8720.

Not Applicable

APPENDIX D: MIGRATION FROM MID-RANGE TO ENHANCED DEVICES

A detailed discussion of the differences between the mid-range MCU devices (i.e., PIC16CXXX) and the enhanced devices (i.e., PIC18FXXX) is provided in AN716, "Migrating Designs from PIC16C74A/74B to PIC18C442." The changes discussed, while device specific, are generally applicable to all mid-range to enhanced device migrations.

This Application Note is available as Literature Number DS00716.

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