



TB3099

Extending Relay Life by Switching at Zero Cross

Author: Stephen Allen
Microchip Technology Inc.

INTRODUCTION

This short technical brief describes how to implement a Zero-Cross Detect feature on the PIC16F1708 microcontroller. This will also be used to switch a 220V relay to a 220 volt AC motor. Switching the relay at the zero-crossing point reduces spark across the contacts, extending relay life, and also reduces EMI. Switching at the zero-crossing point reduces EMI in both relays and high-voltage solid-state switches.

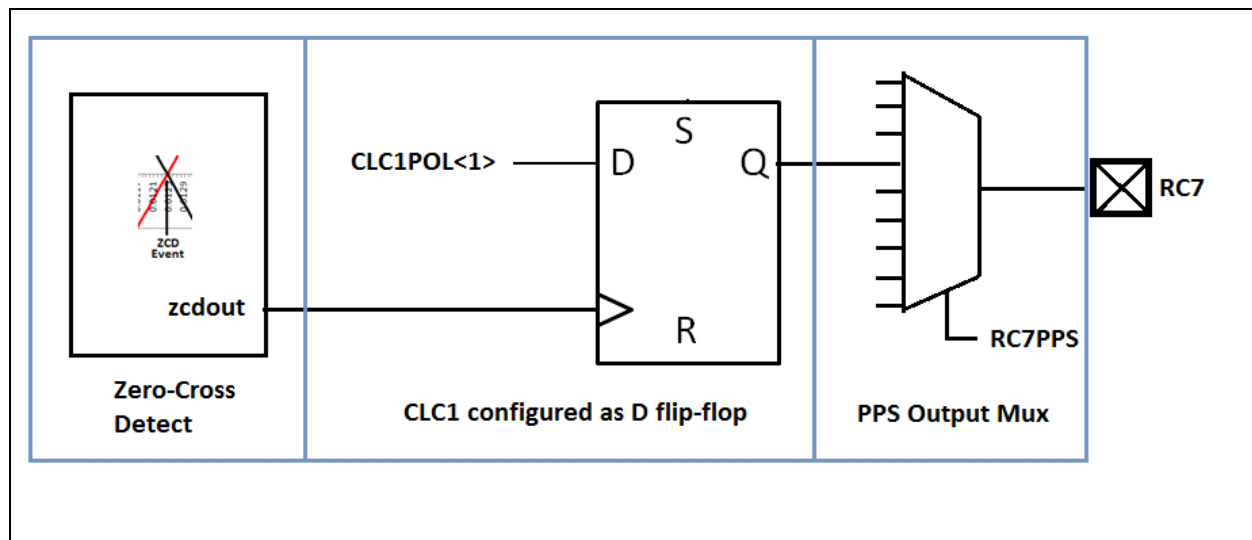
This application also demonstrates the “Core Independent Peripherals” concept, wherein interconnected peripherals are set up in advance of events, allowing fast switching with no processor interruption.

The zero-crossing detect event is routed through the CLC module to cause the switch to happen within microseconds of the zero-cross detect event occurring. Making use of the CLC for this function has numerous benefits:

- Fast response to the zero-crossing event:
 - No CPU intervention required
 - Switching speed is independent of processor speed
 - Switch occurs on microsecond scale
- It frees CPU to handle other processes while events occur.
- It can operate while device is in Sleep to lower current consumption.

The zero cross has been structured such that the main program requests the switch, and the switch will occur at the next zero-cross rising edge event. The flip-flop receives its clock from the zero-cross detect output signal. The data into the flip-flop is controlled through the CLC1POL<1> bit. The data is routed to the RC7 output pin through the RC7PPS MUX.

FIGURE 1: STRUCTURE OF ZERO-CROSS DETECT SWITCH



This technical brief will provide the implementation for a motor switch. The user can switch the motor off and on with a momentary button press. The relay will be opened and closed at the zero-crossing point in order to extend the life of the relay contacts and reduce EMI. Switching at zero cross also has applications in power-factor correction.

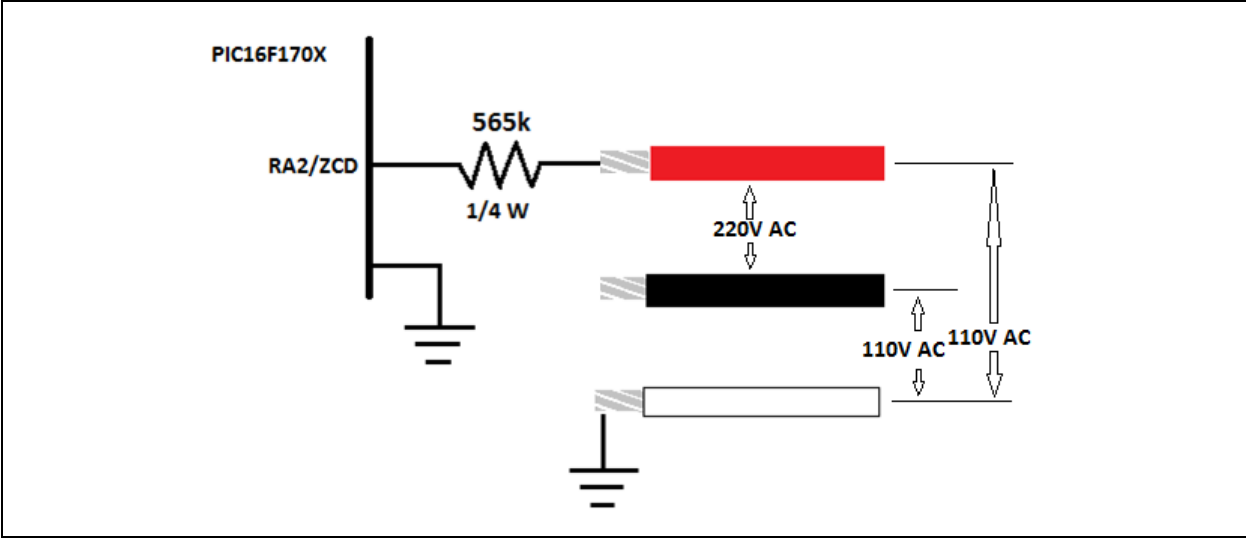
RESOURCE REQUIREMENTS

TABLE 1: RESOURCE REQUIREMENTS FOR ZERO-CROSS SWITCHING

CLC modules	1
RAM	1 byte
Program memory	119 of 4096 locations

PIC16F170X products are equipped with a zero-cross detect circuit. The zero-cross detect feature requires the use of one high-value resistor. It is important to use a large resistor to prevent overcurrent/overvoltage from damaging the PIC® device. The circuit diagram for zero-cross detect is shown below (Figure 2):

FIGURE 2: CONNECTION DIAGRAM FOR ZERO-CROSS PIN (RA2/ZCD) TO HIGH-VOLTAGE MAINS



Note that the zero-cross detect pin has been hooked to the red (hot) wire through the 565 kΩ resistor. It could optionally be hooked to the black (hot) wire. It is necessary that the ground be hooked to the white (common) wire.

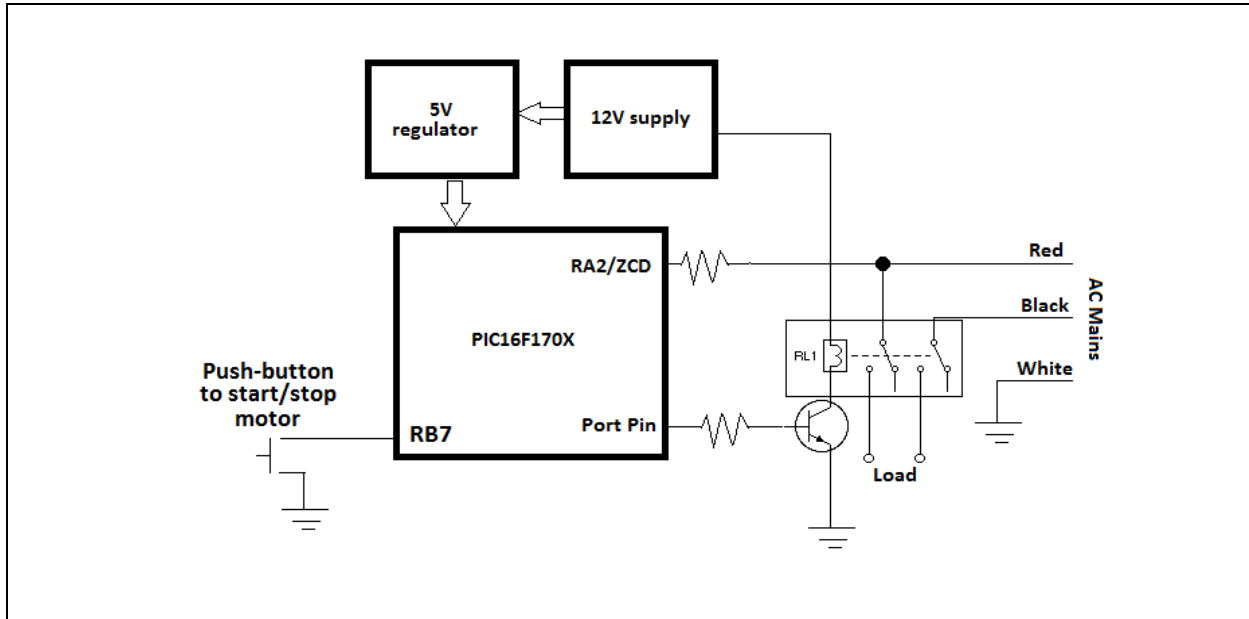
The RA2/ZCD pin should nominally sink/source 300 μA maximum. For a 120V (RMS) sine wave, it will have a peak of $(120 \cdot 2^{1/2}) = 169.7V$, using Ohm's law:

$$V/I = R = 169.7/300 \mu A = 565 \text{ k}\Omega$$

The zero-cross detect peripheral has the option of generating interrupts on positive and negative-slope zero crossings. Two different power modes (High and Low) give flexibility in managing power consumption.

For this example, we are going to switch a 220V relay with a 12V DC coil. A push button switch (connected to pin RB7) is configured with an internal weak pull-up. The block diagram below (Figure 3) shows the primary connections:

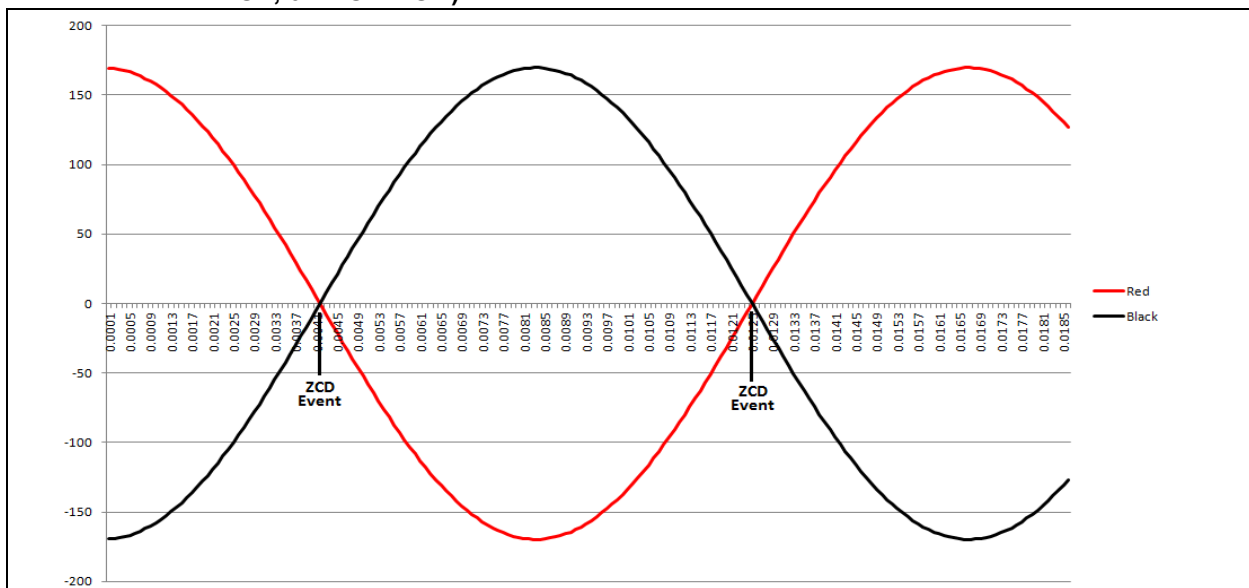
FIGURE 3: SCHEMATIC DIAGRAM FOR ZERO-CROSS DETECT MOTOR SWITCHING



AC VOLTAGE WAVEFORMS (60 Hz)

The voltages on the red and black power connections are sine waves which are 180° out of phase with each other. The graph below (Figure 4) shows AC waveforms and the zero-crossing point. Note that if we switch at the zero-crossing point for one of the “hot” wires, it will be the same as the zero-crossing for the other “hot” wire. 110V (RMS) is the voltage of red or black with respect to the center line. It is easy to see that by taking the potential between both wires (red and black) you have doubled the amplitude of voltage difference (220V RMS).

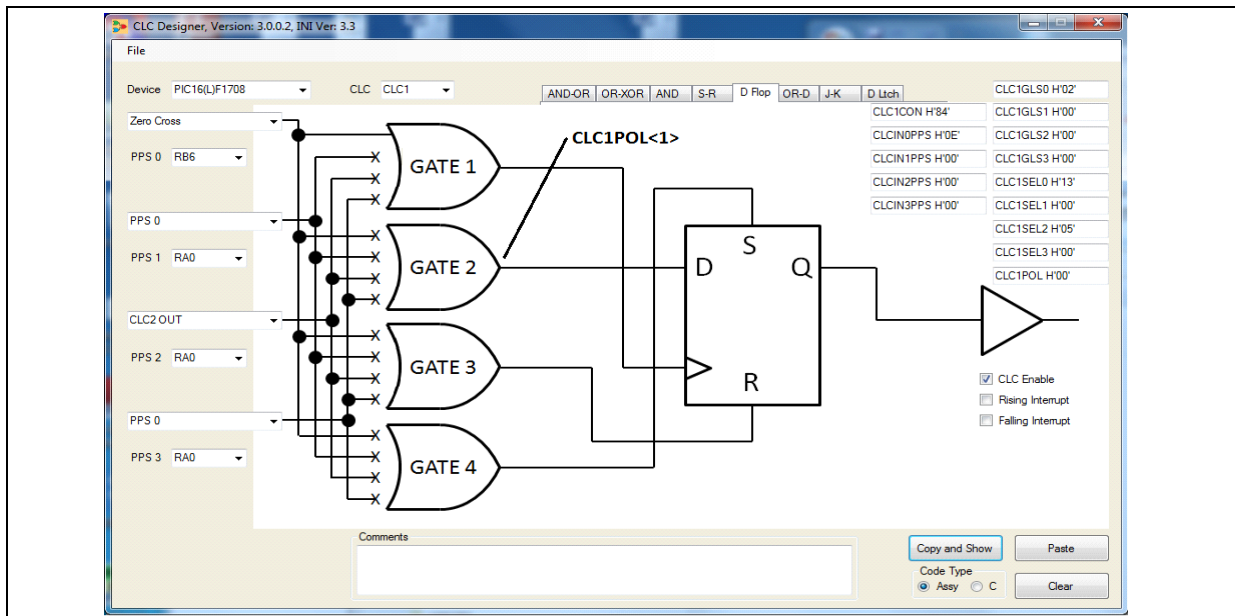
FIGURE 4: 60 Hz AC MAIN WAVEFORMS AS A FUNCTION OF TIME (RED - HOT, BLACK - HOT, 0 - COMMON)



CLC CONFIGURATION

To switch near the zero-crossing point, we are feeding the clock of a D flip-flop with the zero-cross signal. The screen shot below (Figure 5) shows CLC1 configured as a D flip-flop with the clock fed from the zero-cross signal, and the data is provided via the CLC1POL<1> bit.

FIGURE 5: CLC DESIGNER TOOL WITH CLC1 CONFIGURED AS D FLIP-FLOP

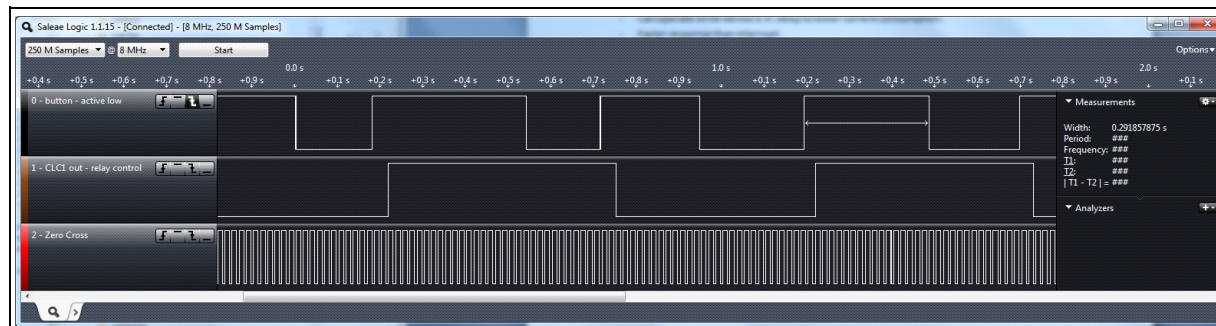


The logic waveform below (Figure 6) shows the following signals:

- Push button (active-low with internal pull-up from PIC device)
- Relay switching signal
- Zero-cross detect signal (brought out on port pin through the CLC module).

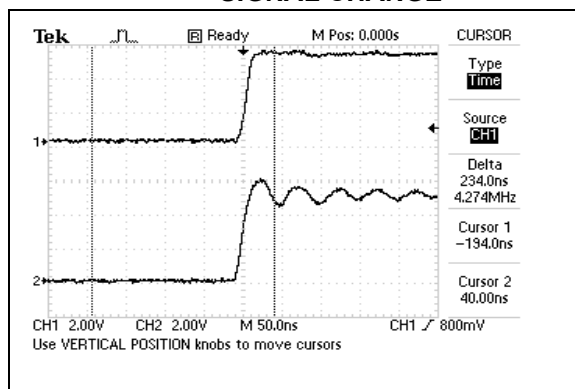
Notice that after each button press, there is a short delay to debounce the button, and then the state of the relay toggles. This allows a momentary push button to turn a motor on/off with successive presses. The change in CLC1OUT occurs on the rising edge of the zero-cross signal.

FIGURE 6: WAVEFORM SHOWING MULTIPLE BUTTON PRESSES AND RELAY OUTPUT TOGGLING



The next scope plot shows a zoomed-in view of the switch taking place at the zero-crossing point (Figure 7). The delay between the zero-cross signal and “CLC1OUT” is solely gate propagation delay and is independent of the processor clock. The signals are almost simultaneous because the zero-cross signal is internal to the PIC device. Propagation delay in the CLC is negligible, but each signal sees the same delay at the respective output pad.

FIGURE 7: RELATIVE TIMINGS BETWEEN ZERO-CROSS RISING EDGE AND OUTPUT SIGNAL CHANGE



CONCLUSION

It is our hope that this technical brief provides a starting point for developing applications using the zero-cross detect peripheral. Switching at zero cross reduces EMI. This may provide cost reductions for some applications by reducing PCB noise and filtering components.

APPENDIX A

Software License Agreement

The software supplied herewith by Microchip Technology Incorporated (the "Company") is intended and supplied to you, the Company's customer, for use solely and exclusively with products manufactured by the Company.

The software is owned by the Company and/or its supplier, and is protected under applicable copyright laws. All rights are reserved. Any use in violation of the foregoing restrictions may subject the user to criminal sanctions under applicable laws, as well as to civil liability for the breach of the terms and conditions of this license.

THIS SOFTWARE IS PROVIDED IN AN "AS IS" CONDITION. NO WARRANTIES, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE APPLY TO THIS SOFTWARE. THE COMPANY SHALL NOT, IN ANY CIRCUMSTANCES, BE LIABLE FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, FOR ANY REASON WHATSOEVER.

Code to switch the relay at the zero-crossing point is listed below.

```
#include "p16f1708.inc"
#define RELAY_CONTROL CLC1POL,1
#define debounce_count 0x71 ; RAM location for debounce counter

start

    org 0x0000

    nop
    banksel ZCD1CON
    bsf ZCD1CON,ZCD1EN ; Let's get started by turning on the Zero-cross detect module.

    banksel ANSELB
    clrf ANSELB ; make port B digital
    movlw 0x04
    movwf ANSELA ; make port A digital
    movlw 0x04
    movwf ANSELC ; make port C digital, except RC2.

    banksel TRISC
    movlw 0x04
    movwf TRISC ; port C all outputs, except RC2.
    movlw 0xC0
    movwf TRISB ; port B all outputs, except RB7 and RB6
    movlw 0x04
    movwf TRISA ; port A all outputs, except RA2.

    #include "zcd-clc1.inc" ; this sets up the CLC1 module as a d-type flip-flop
                          ; with "zero-cross" as clock and data provided through CLC1POL<1>

    banksel RC7PPS
    movlw 0x04
    movwf RC7PPS ; map CLC1 output (relay control) to RC7.

    banksel RC6PPS
    movlw 0x13
    movwf RC6PPS ; map "Zero-Cross" to RC6 (for visualization)

    banksel WPUA
    clrf WPUA ; make sure weak pull-up is not turned on for RA2/ZCD

    banksel OPTION_REG
    bcf OPTION_REG,7 ; enable weak pull-ups.

main_loop
    banksel PORTB
    btfsc PORTB,7 ; Is button depressed?
    goto main_loop ; No.

debounce
    movlw 0xff ; Yes - button was pressed.
    movwf debounce_count ; load a counter to debounce my switch.
```

```
debounce_loop
    btfss    PORTB,7          ; Is button released?
    goto     debounce        ; No.
    call     delay            ; Yes. short delay,
    decfsz   debounce_count  ; and decrement counter. Has counter expired?
    goto     debounce_loop   ; No.
    banksel  CLC1POL
    btfss    RELAY_CONTROL    ; Is relay currently on?
    goto     relayon          ; No. request turn on.
    goto     relayoff         ; Yes. request turn off.

relayon
    bsf      RELAY_CONTROL    ; raise signal to request relay turn-on.
    goto     main_loop

relayoff
    bcf      RELAY_CONTROL    ; lower signal to request relay turn-off.
    goto     main_loop

delay
    nop
    nop
    return

end
```

APPENDIX B

Software License Agreement

The software supplied herewith by Microchip Technology Incorporated (the "Company") is intended and supplied to you, the Company's customer, for use solely and exclusively with products manufactured by the Company.

The software is owned by the Company and/or its supplier, and is protected under applicable copyright laws. All rights are reserved. Any use in violation of the foregoing restrictions may subject the user to criminal sanctions under applicable laws, as well as to civil liability for the breach of the terms and conditions of this license.

THIS SOFTWARE IS PROVIDED IN AN "AS IS" CONDITION. NO WARRANTIES, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE APPLY TO THIS SOFTWARE. THE COMPANY SHALL NOT, IN ANY CIRCUMSTANCES, BE LIABLE FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, FOR ANY REASON WHATSOEVER.

Appendix B contains the CLC configuration file that was generated with the CLC Designer Tool.

BANKSEL CLCIN0PPS	BANKSEL CLC2GLS0
movlw H'0E'	movlw H'02'
movwf CLCIN0PPS	movwf CLC2GLS0
movlw H'00'	movlw H'00'
movwf CLCIN1PPS	movwf CLC2GLS1
movlw H'00'	movlw H'20'
movwf CLCIN2PPS	movwf CLC2GLS2
movlw H'00'	movlw H'00'
movwf CLCIN3PPS	movwf CLC2GLS3
	movlw H'0E'
BANKSEL CLC1GLS0	movwf CLC2SEL0
movlw H'02'	movlw H'00'
movwf CLC1GLS0	movwf CLC2SEL1
movlw H'00'	movlw H'06'
movwf CLC1GLS1	movwf CLC2SEL2
movlw H'00'	movlw H'00'
movwf CLC1GLS2	movwf CLC2SEL3
movlw H'00'	movlw H'00'
movwf CLC1GLS3	movwf CLC2POL
movlw H'13'	movlw H'81'
movwf CLC1SEL0	movwf CLC2CON
movlw H'0E'	
movwf CLC1SEL1	BANKSEL CLC3GLS0
movlw H'05'	movlw H'02'
movwf CLC1SEL2	movwf CLC3GLS0
movlw H'00'	movlw H'00'
movwf CLC1SEL3	movwf CLC3GLS1
movlw H'00'	movlw H'00'
movwf CLC1POL	movwf CLC3GLS2
movlw H'84'	movlw H'00'
movwf CLC1CON	movwf CLC3GLS3
	movlw H'0E'
	movwf CLC3SEL0
	movlw H'04'
	movwf CLC3SEL1
	movlw H'06'
	movwf CLC3SEL2
	movlw H'00'
	movwf CLC3SEL3
	movlw H'02'
	movwf CLC3POL
	movlw H'84'
	movwf CLC3CON

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, dsPIC, FlashFlex, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC³² logo, rPIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MTP, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.


Analog-for-the-Digital Age, Application Maestro, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniscent Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICtail, REAL ICE, rLAB, Select Mode, SQI, Serial Quad I/O, Total Endurance, TSHARC, UniWinDriver, WiperLock, ZENA and Z-Scale are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

GestIC and ULPP are registered trademarks of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2013, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

ISBN: 9781620774120

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
== ISO/TS 16949 ==

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
<http://www.microchip.com/support>
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

Santa Clara
Santa Clara, CA
Tel: 408-961-6444
Fax: 408-961-6445

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon
Hong Kong
Tel: 852-2401-1200
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Hangzhou
Tel: 86-571-2819-3187
Fax: 86-571-2819-3189

China - Hong Kong SAR
Tel: 852-2943-5100
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8864-2200
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-3019-1500

Japan - Osaka
Tel: 81-6-6152-7160
Fax: 81-6-6152-9310

Japan - Tokyo
Tel: 81-3-6880-3770
Fax: 81-3-6880-3771

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-213-7828
Fax: 886-7-330-9305

Taiwan - Taipei
Tel: 886-2-2508-8600
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

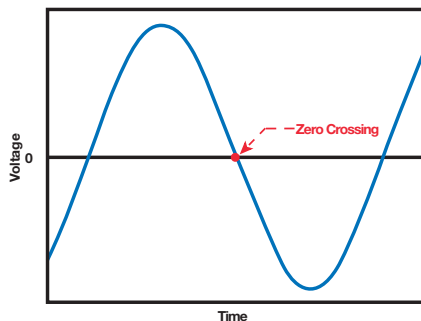
Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820



Zero-Crossing Technology Drives Long-Lasting Intermatic Solutions

Ensure your next lighting installation is designed to last for the long haul with reliable lighting controls from Intermatic. Select Intermatic timers, photocontrols and occupancy sensors include innovative zero-crossing technology, which helps minimize the damaging effects of high inrush current events.



What is Zero Crossing?

Zero Crossing refers to the relay switching technology found in a variety of high-performance Intermatic controls. These models are designed to trigger load switching when AC voltage passes the zero mark rather than when operating current is near its peak.

Without this built-in technology, lighting controls can face severe high inrush transients that are up to 100 times the recommended operating level. Over time, this can damage or even completely destroy controls.

Key to Preventing Damage

Zero-crossing technology helps lighting controls match the long lifespan of new LED lighting systems. By taking a proactive approach and confirming lighting controls are compatible with LED bulbs, you can avoid maintenance issues and unexpected replacement costs down the road.

Finding the Right Match

Intermatic has a strong lineup of LED-rated controls that are UL-certified and designed to fit a wide range of applications. From outdoor billboards and parking lot lights to indoor offices and hydroponic applications, our zero-crossing solutions have you covered.

MEET OUR TEAM OF ZERO-CROSSING SOLUTIONS

ET2000 Series Basic+ Electronic Time Switches:

The ET2000 Series offers an easy-to-use interface and detailed scheduling options to match nearly any application. With up to 96 ON/OFF events and 50 holiday blocks, it's a robust digital control that fits seamlessly into existing Intermatic enclosures. The unit's 100-hour capacitor also helps safeguard against power outages.

NightFox™ Pro Series:

Balancing efficiency, durability and functionality, NightFox Pro Series provides municipalities, utilities and co-ops a new level of customization with photocontrols. Tested at full load to 5 k, 10 k, and 15 k ON/OFF cycles with NEMA 410 inrush load abilities, they help meet a wide variety of application needs and budgets without sacrificing quality. They're a top-level photocontrol solution that's tested and warranted to match the life expectancy of LED fixtures.

NightFox™ Series:

Similar to the NightFox Pro Series, standard NightFox Series photocontrols are designed to match the long life of LED and induction lighting fixtures. They come with a 10- to 20-year service life expectancy and include solid-state light sensors and relays that feature zero-crossing technology for more

precise control. Locking type models in two voltage ranges, 120-277 V or 347-480 V, which makes it easy to accommodate any power supply configuration.

talento smart™ Time Switch:

The new talento smart product family was developed with electricians at its core. Its compact DIN rail design streamlines the installation process while Bluetooth® connectivity and the intuitive talento smart mobile app makes it easy to save time programming the device. Zero-crossing technology, 365-day scheduling and automatic Astronomic dusk-to-dawn functionality, it's the perfect digital time switch to manage energy costs in both commercial and residential settings.

Commercial Grade Occupancy Sensors

Intermatic Commercial Grade Occupancy Sensors help installers save on energy costs while adding a level of convenience and security to all types of facilities. Choose from both in-wall and ceiling mount styles, as well as PIR or Dual Technology solutions, to match your project's needs. Our Occupancy Sensors are compatible with incandescent, fluorescent, CFL and LED fixtures, and include zero-crossing technology to maximize the lifespan and performance of fixtures.

- In-Wall Mount Models:
IOS-DSR/DOV/DDR,
IOS-DOV-DT-WH
- Ceiling Mount Models:
IOS-CMP-DT-U,
IOS-HB-U, IOS-CMP-U

Contact your Intermatic sales representative today to learn more about our full catalog of zero-crossing solutions.