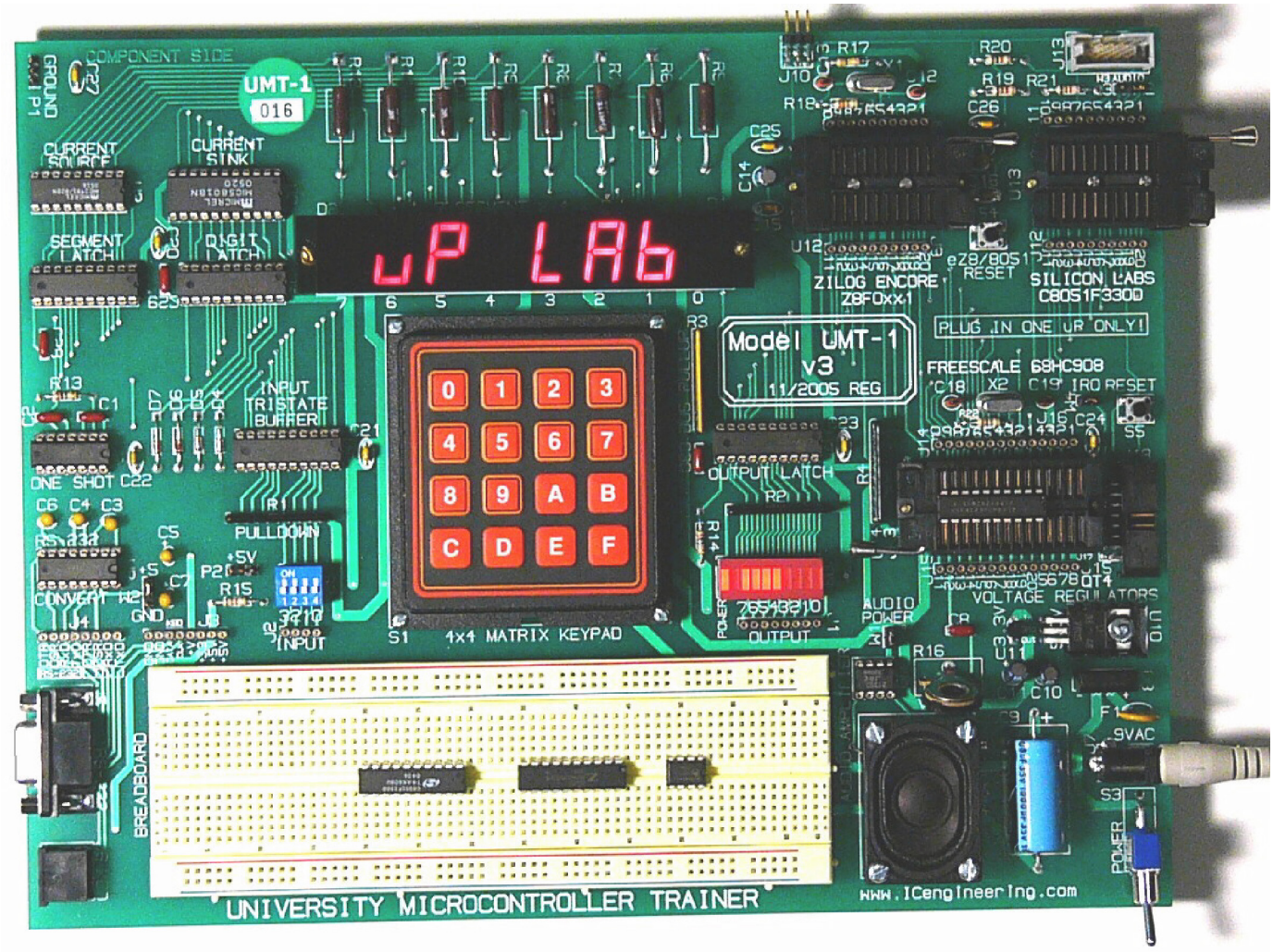
MICROCONTROLLER LAB

Programming the 68HC08, 8051, and eZ8 in Assembly Language

Robert E. Glaser



Microcontroller Lab

Programming the 68HC08, 8051, and eZ8 in Assembly Language

Second Edition

Robert E. Glaser, Ph.D.

IC Engineering, Inc.

The Johns Hopkins University

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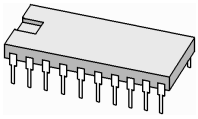

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This project is dedicated to C. Roger Westgate, who led the way

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0.3 To the Instructor

Chapters 0-5 are intended for the first semester, and the remaining chapters for a second semester. I have used a shortened version for the accelerated summer session, in which the students have much less time to complete their assignments: Chapters 0-4 for the first session, followed by Chapters 6-10 for the second session (with the eZ8 left out). I also reduced the assignment requirements for the shortened course.

Hardware Requirements

In addition to the **University Microcontroller Trainer UMT-1**, the following materials are needed:

For the 68HC908JK3/QT4: Either the USB-ML-MON08 (USB version) or the MON08 Multilink (parallel port version) from P&E Microcomputer Systems, `www.PEmicro.com`. The USB version is more convenient and less expensive; the parallel port version includes a wall wart power supply, but you'll also need an IEEE-1284 extension cable for it. The software is more robust with the parallel interface.

For the C8051F330D: Silicon Laboratories part number C8051F330DK, "DEV KIT FOR C8051F330/F331." SiLabs' University Program offers a discount. `www.Digikey.com` 336-1264, `www.Mouser.com` 634-C8051F330DK-G. The development kit includes a USB Adapter and the Standard JTAG Cable EC-SJ; these can be purchased separately from `www.SiLabs.com`, but the development kit includes the software. You get a small surface mount board with the kit which we don't use.

For the Z8F0421: Zilog part number Z8F08200100KIT, "DEV KIT FOR Z8 ENCORE 4K TO 8K" (Serial interface). `www.Digikey.com` 269-3183, `www.Mouser.com` 692-Z8F08200100KIT. You get a small surface mount board with the kit which we don't use.

Small Parts: the assignments use the following:

Section 9.5: 2N7000 and lamp (Mouser part number 606-CM7219, `www.Mouser.com`)

Section 9.6: 1K ohm resistor

Sections 10.2, 10.6, 10.7: 1N4148, 1K ohm resistor

Section 11.2: PS/2 keyboard

Section 13.7: 6-pin mini-DIN plug (Digikey CP-2060, Mouser 171-2606); a keyboard extender cable (Digikey AE9875, Mouser 545-P222-010) also helpful

Laboratory Computers: Workstation PC's with Win2000, WinXP, or Win98 (USB finicky with 98); a serial port; and either a USB or a parallel port, dependent upon which MON08 interface is used.

Software Requirements

For the 68HC908JK3/QT4: `Drivers_install.exe` if the USB MON08 pod is used, from P&E Microcomputer Systems, a free download at `www.PEmicro.com`.

For the 68HC908JK3: `ics08jlz_install.exe`, from P&E Microcomputer Systems, a free download at `www.PEmicro.com`.

For the C8051F330D: Silicon Laboratories IDE V1.9. Comes with the C8051F330DK development kit.

For the Z8F0421: Zilog "ZDS II - Z8 Encore! Family 4.9.5". Comes with the Z8F08200100KIT development kit. Also a free download at `www.Zilog.com`.

For the 68HC908QT4: `ics08qtqyz_install.exe`, from P&E Microcomputer Systems, a free download at `www.PEmicro.com`.

Support Documentation

I provide a folder on a network drive accessible from the student workstations containing supplementary documentation. Also check the `www.ICengineering.com` UMT-1 support section. The following are PDF documents which are free downloads from the manufacturers' websites:

"MC68HC908JL3/H - Rev 1.0", "MC68HC908QY4/D Family Data Sheet Rev. 4", "HCS08 Family Reference Manual HCS08RMv1/D Rev. 1 6/2003": `www.Freescale.com`

"C8051F330/1/2/3/4/5 C8051F330D Rev. 1.3 3/05": `www.SiLabs.com`

"Product Specification Z8 Encore!® 8K Series PS022509-0305", "eZ8 CPU User Manual UM012811-0904": `www.Zilog.com`.

P0SKIP, P1SKIP

We can instruct the CPU to skip port pins when assigning them to peripherals with the P0SKIP (0D4h) and P1SKIP (0D5h) SFR's. Setting a bit in these registers makes the corresponding chip pin unavailable for peripherals. Bit assignments look, in order, at bits 0 to 7 in P0 and bits 0 to 7 in P1. So to assign CEX0 to P0.4, make P0SKIP = 00001111; to assign CEX0 to P0.5, make P0SKIP = 00011111.

9.4 PWM on the Z8F0421

Review section 7.4. The two timers also have a PWM mode of operation: to activate it, set the TMODE2-TMODE1-TMODE0 bits in the Timer Control Register to 011 (instead of 001 for continuous mode we previously employed). The prescaler and timer reload registers operate in the same way as for the continuous mode.

Each timer also has two PWM value registers: TxPWMH and TxPWML (x=0,1) which hold the match value high and low bytes, respectively. These are read/write registers. Their addresses are:

T0PWMH=0F04h T0PWML=0F05h T1PWMH=0F0Ch T1PWML=0F0Dh

If the Timer Control Register TPOL bit = 1, upon timer reload the output pin goes high; when the timer counter matches the value in the PWM registers the output pin goes low (active high PWM output). The duty cycle is (PWM value)/(reload value).

If the Timer Control Register TPOL bit = 0, upon timer reload the output pin goes low; when the timer counter matches the value in the PWM registers the output pin goes high (active low PWM output). The duty cycle is (reload value - PWM value)/(reload value).

The PWM period is (reload value x prescale value)/(system clock frequency).

These timers operate in 16-bit mode only; however, since you define the reload value you can set the maximum timer count to any value less than 65,536 (making it 255 creates 8-bit PWM). The PWM registers should be loaded with values less than or equal to the reload registers.

You can interrupt as for continuous mode, but this is not needed for basic PWM generation.

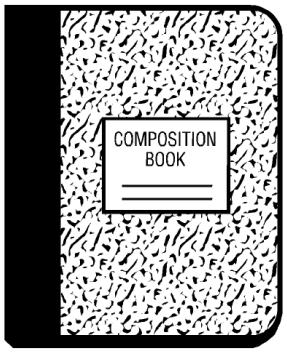
PWM Pinouts

Timer0 only!

PA1 is on the bus ☹

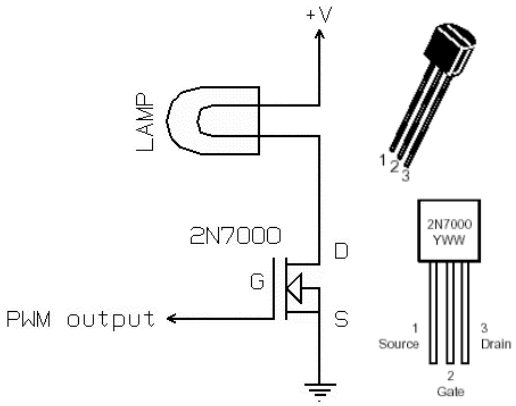
The Alternate Function sub-register described in section 5.5 connects the timer PWM outputs to port pins. Timer0 uses PA1 (J8 pin 9) and Timer1 uses PC1. You'll note that *there is no PC1* on this chip! (That information applies to larger pin count versions of the microcontroller.) So you can only use Timer0 for PWM generation with the Z8F0421. Since PA1 is wired to the trainer's bus, you can't use the I/O subroutines when the PWM alternate function is selected.

9.5 Assignment 9a: PWM Lamp Control



Program a timer on the microcontroller of your choice to generate a PWM output which cyclically ramps the duty cycle from 0% to 100% over a reasonable time period (5-30 seconds). Observe the waveform on an oscilloscope. Construct the following circuit:

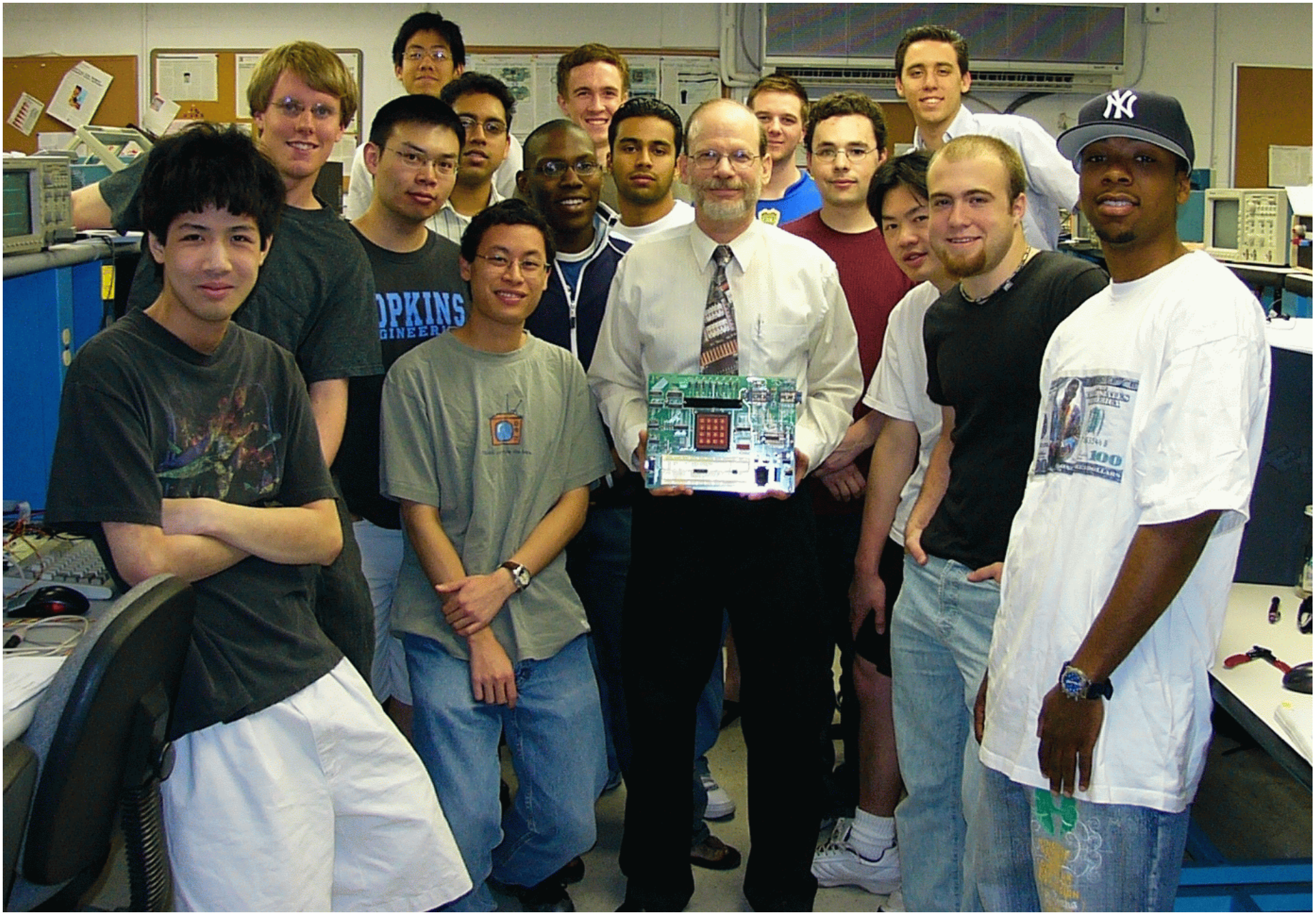
The incandescent lamp is rated at 12 volts, 60 ma.; Mouser part number 606-CM7219 is suitable. The +V on the trainer is approximately 11 volts. First, wire the schematic's PWM output to +5v and measure the drain-source voltage and the current through the lamp. Calculate the power dissipated in the switching transistor (at full load). Calculate the power efficiency of the circuit when driven with a 50% duty cycle.



Wire your microcontroller's PWM output to the transistor gate and test your program.

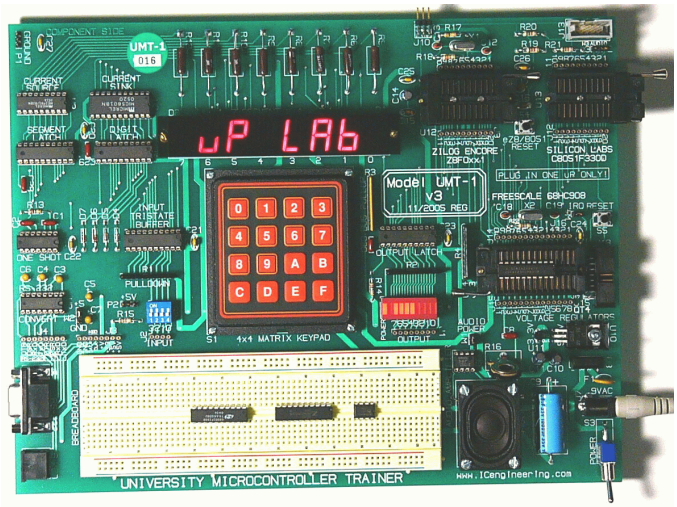
Note that with the 68HC908JK3 and the Z8F0421 you cannot simultaneously generate a PWM signal and control the trainer's I/O ports. However, you can drive the LED's from the former by temporarily discontinuing the PWM function and writing to the LED latch; and on the latter you can control the LED's 7-2 and 0 because they follow the PA port. On the C8051F330D you can generate PWM independently from trainer wiring, and you don't lose I/O capability.

Optional: ramp up/down instead of just up; display activity on LED's and displays; provide for keypad controls (pause, up, down, rate, etc.).



The author has been designing and constructing microprocessor-based systems since the 4004, and for twenty years has taught the Microprocessor Lab courses in the Electrical and Computer Engineering Department at *The Johns Hopkins University*.

Microcontroller Lab



Programming the 68HC08, 8051, and eZ8 in Assembly Language

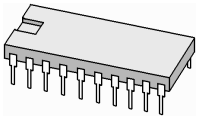
Second Edition

Robert E. Glaser

Assignments are on the:

University Microcontroller Trainer, Model UMT-1

IC Engineering, Inc.



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