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Instructor's Manual and PowerPoints

to accompany

THE 8051 MICROCONTROLLER

Fourth Edition

I. Scott MacKenzie

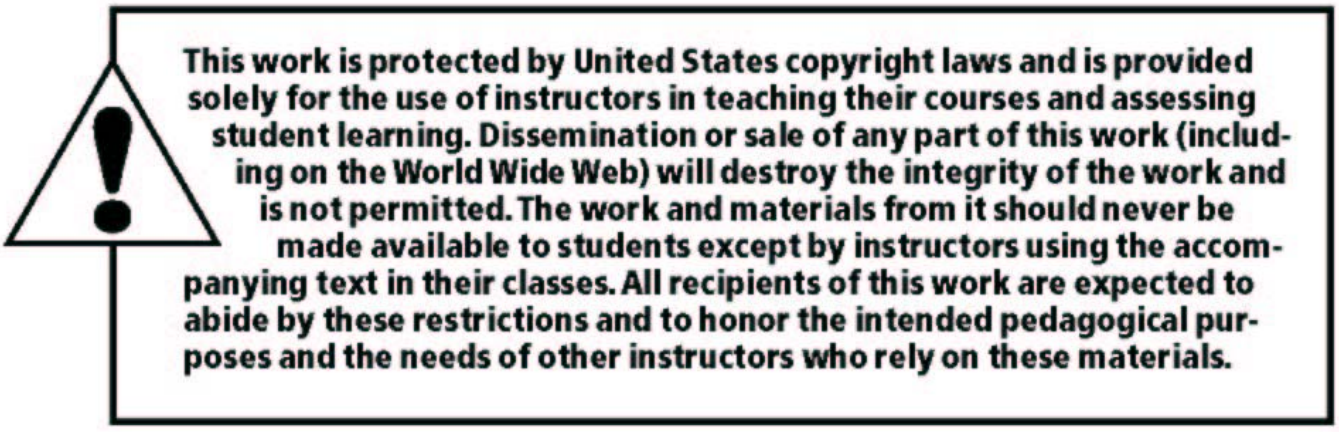
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10 9 8 7 6 5 4 3 2 1

ISBN 0-13-060386-4

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THE 8051 MICROCONTROLLER

Fourth Edition

Instructor's Manual

This manual contains solutions to the problems at the end of the chapters in The 8051 Microcontroller (4th edition). Additional materials are provided that should prove useful for instructors delivering a lecture + lab course on the 8051 microcontroller. These include the following:

- Discussions on the solutions
- Laboratory project suggestions

Discussions on solutions are provided to assist instructors in discussing with students the solutions to problems.

Laboratory project suggestions are provided with selected problems which lend themselves to further exploration in a laboratory setting. Instructors may wish to distribute the initial solution (given in this manual) to assist students in getting started. Extensions to the basic problem are given in the form of defined tasks to be solved using software and/or hardware. The tasks are defined in a manner that facilitates demonstration in the laboratory.

Courses based on the 8051 will require a single-board computer for laboratory projects. Although many 8051 SBCs are available (sources are provided in Appendix H in the text), the SBC-51 described in Chapter 10 is a logical choice for the initial laboratory project. A section is provided at the end of this manual to facilitate construction and testing of the SBC-51.

This solutions manual has been updated with a total of 72 new questions have been added, for a total of 200.

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August 2003

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Chapter 1 - Introduction to Microcontrollers

1. (a) The first widely used microprocessor was the 8080.
   (b) The 8080 was introduced in 1970 by Intel Corp.

2. MOS Technology was responsible for the 6502 microprocessor, Zilog for the Z80.

3. (a) The 8051 was introduced in 1980.
   (b) The predecessor of the 8051 was the 8048, introduced in 1976.

4. (a) RAM (random access memory) and ROM (read-only memory).
   (b) ROM retains its contents even when powered-off.
   (c) The term "non-volatile" describes this property of ROM.

5. (a) The program counter
   (b) The program counter contains the address of the next instruction to be executed.

6. (a) The address bus contains the content of the program counter. The data bus contains the opcode of the instruction.
   (b) The information on the address bus is output, originating from the CPU. The information on the data bus is input, originating from the RAM.

7. $2^{18} = 2^8 \times 2^{10} = 256$K bytes.

8. The phrase "16-bit computer" refers to a computer system with 16 lines on its data bus.

9. Online storage is directly accessible through software, whereas archival storage is "off-line" and must be loaded onto a system by a human operator before it can be accessed by software.

10. Optical disks are also used for archival storage.

11. Human factors is a field of engineering which seeks to match the characteristics of people with (computing) machines, to achieve a safe, comfortable, and efficient working environment.

12. Input devices: joystick, light pen, mouse, and microphone
    Output device: loudspeaker

13. (a) The lowest level of software is the input/output subroutines.

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Since a 1 kHz square wave has high- and low-times of 500 μs each, 16-bit timer mode is required. The error introduced in re-initializing the timer after each interrupt is shown (in machine cycles) in parentheses following the relevant instructions. The SJMP overhead is indicated as "2+2" to allow for the execution time of the instruction and the implicit CALL instruction that executes as part of interrupt acceptance.

Sixteen cycles are added to COUNT as an adjustment. The SET directive sets COUNT to -500 initially, and then to COUNT + ADJUST. Recall that SET is the same as EQU except that values can be re-assigned using a subsequent SET.

3.

```
HCOUNT  EQU     -43     ;high-time (ms) unadjusted
LCOUNT  EQU     -100    ;low-time (ms) unadjusted
        ORG     0
        LJMP    MAIN
        ORG     000BH
        LJMP    T0ISR
        ORG     0030H
MAIN:   MOV     TMOD,#01H       ;16-bit timer
        SETB    TF0             ;force first interrupt
        MOV     IE,#82H         ;enable Timer 0 interrupt
        SJMP    $               ;nothing left to do
T0ISR:  CLR     TR0             ;stop timer
        JBC     P1.6,SKIP       ;nice use of "JBC" here!
        SETB    P1.6            ;begin high-time
        MOV     TH0,#HIGH HCOUNT
        MOV     TL0,#LOW HCOUNT
        SJMP    EXIT
SKIP:   MOV     TH0,#HIGH LCOUNT ;begin low-time
        MOV     TL0,#LOW LCOUNT
EXIT:   SETB    TR0             ;turn timer on and
        RETI                    ; return to SJMP
```

A 7 kHz waveform has a period of approximately 143 μs. For a 30% duty cycle, the required high- and low-times are approximately 43 μs and 100 μs respectively.

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```
NEXT022: CJNE R2, #10100000B, NEXT023
         JB P2.1, NEXT023
         JB P2.6, NEXT023
         MOV P3, #00010000B
         LJMP BACK1
NEXT023: CJNE R1, #00000101B, NEXT024
         JB P2.6, NEXT024
         JB P2.1, NEXT024
         MOV P3, #00010000B
         LJMP BACK1
NEXT024: CJNE R2, #01100000B, NEXT025
         JB P2.2, NEXT025
         JB P2.7, NEXT025
         MOV P3, #10010000B
         LJMP BACK1
NEXT025: CJNE R1, #00000011B, CHKL04
         JB P2.7, CHKL04
         JB P2.2, CHKL04
         MOV P3, #10010000B
         LJMP BACK1
CHKL04:  MOV A, #00H
         MOV C, P0.5
         MOV ACC.7, C
         MOV C, P1.5
         MOV ACC.6, C
         MOV C, P2.5
         MOV ACC.5, C
         CJNE A, #01100000B, NEXT034
         JB P0.0, NEXT034
         JB P0.5, NEXT034
         MOV P3, #10000000B
         LJMP BACK1
NEXT034: CJNE A, #10100000B, NEXT035
         JB P1.0, NEXT035
         JB P1.5, NEXT035
         MOV P3, #00100000B
         LJMP BACK1
NEXT035: CJNE A, #11000000B, NEXT033
         JB P2.0, NEXT033
         JB P2.5, NEXT033
         MOV P3, #11100000B
         LJMP BACK1
```

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