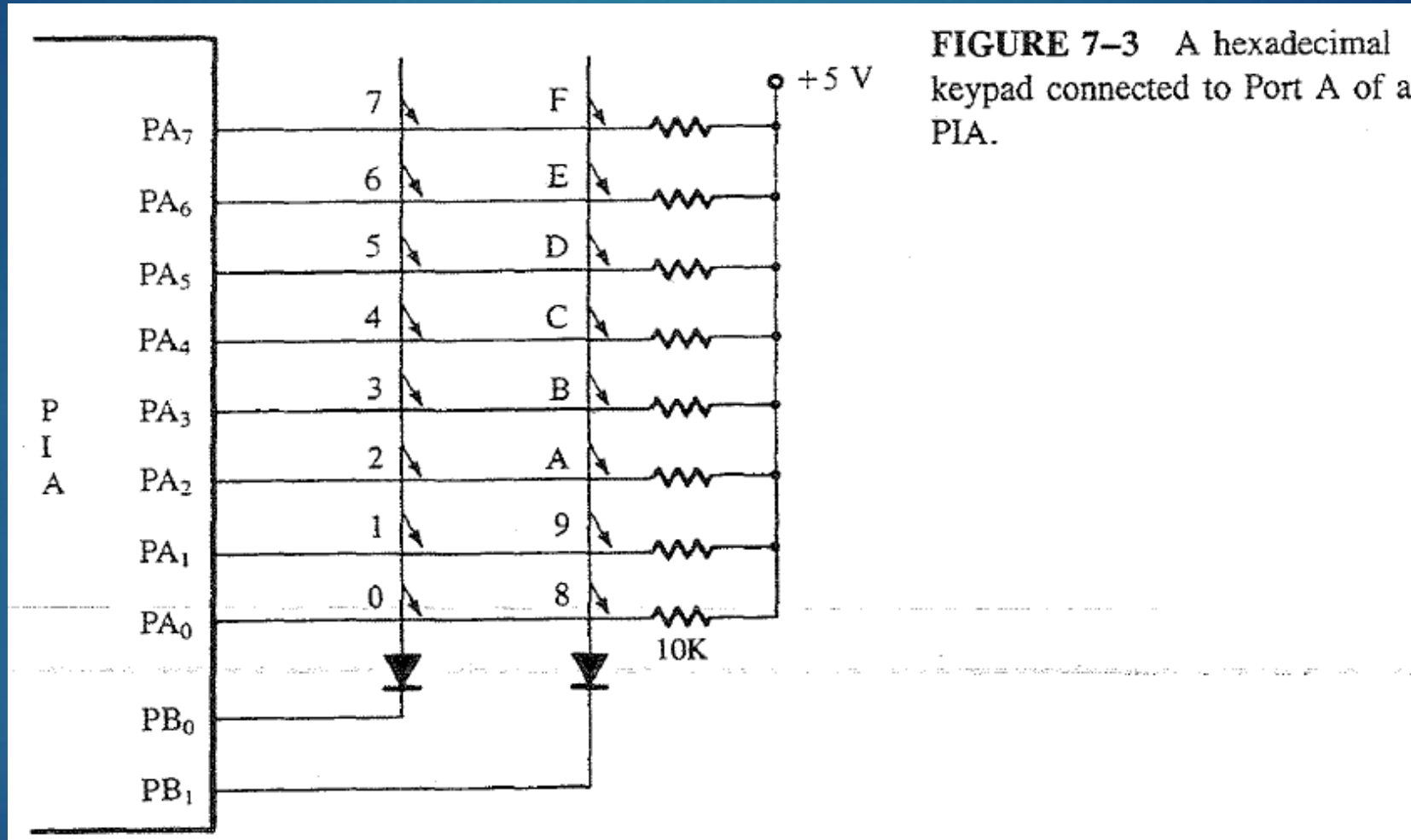
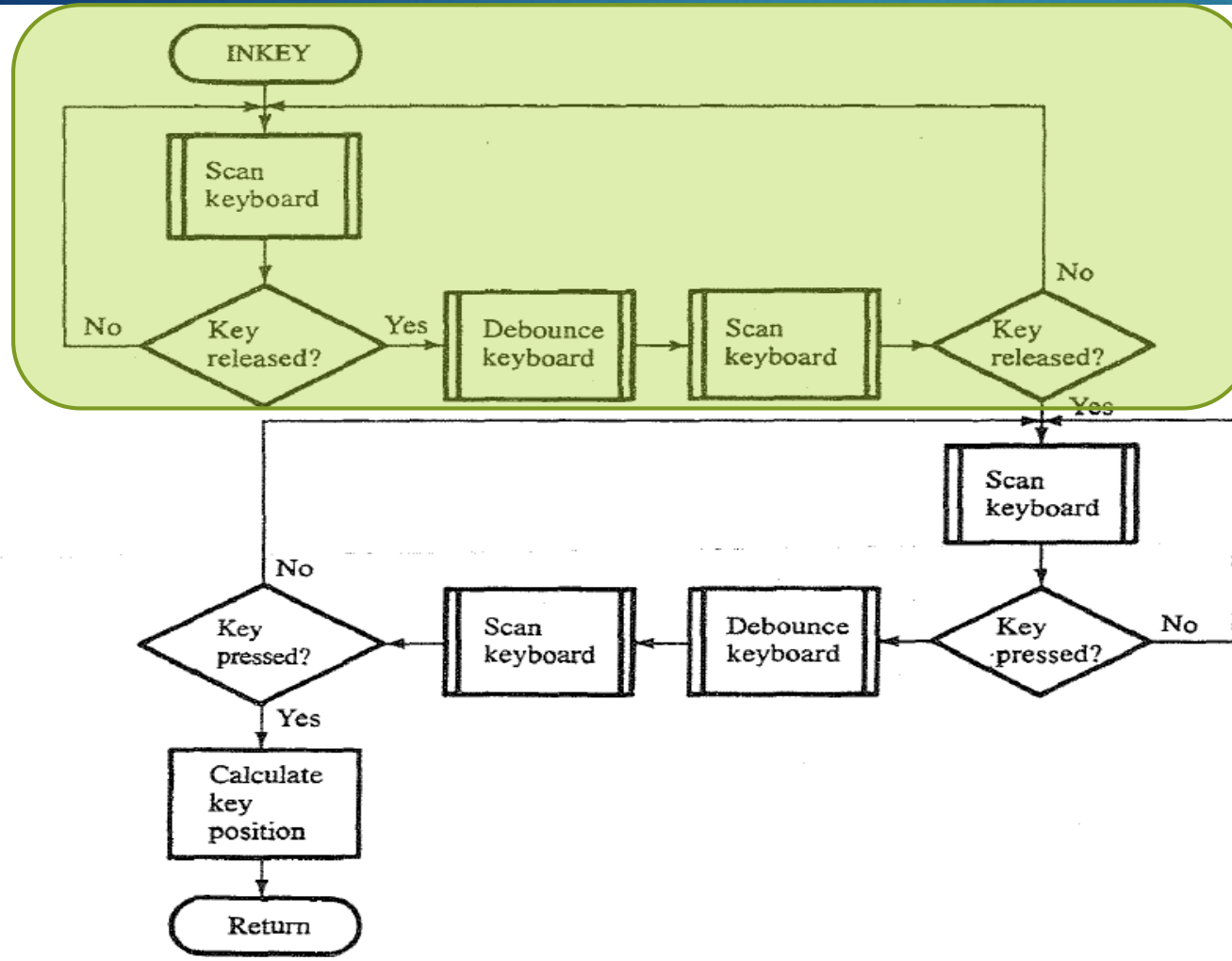


I/O Systems

Hexadecimal Keypad Interface

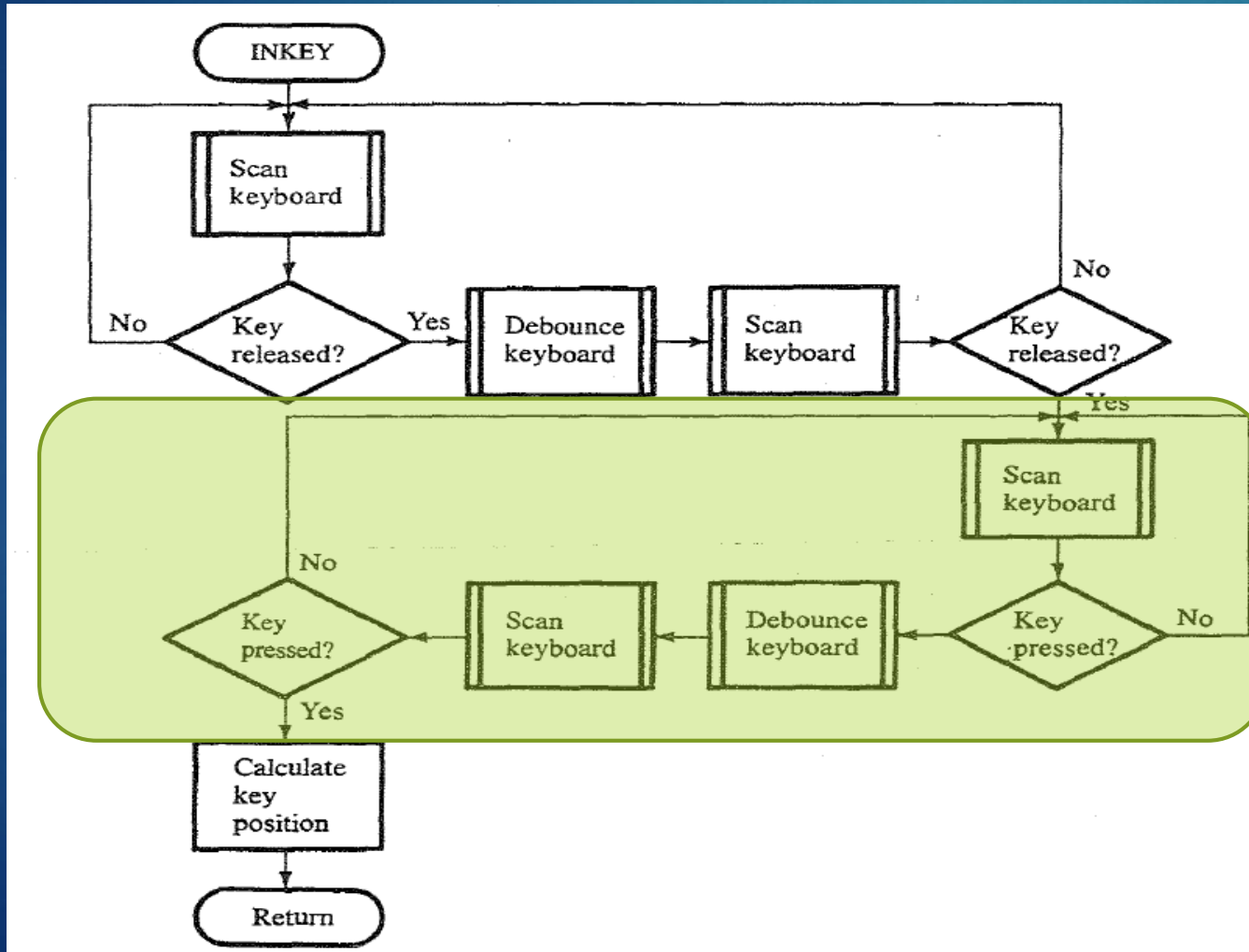


Hexadecimal Keypad Interface – The Flowchart



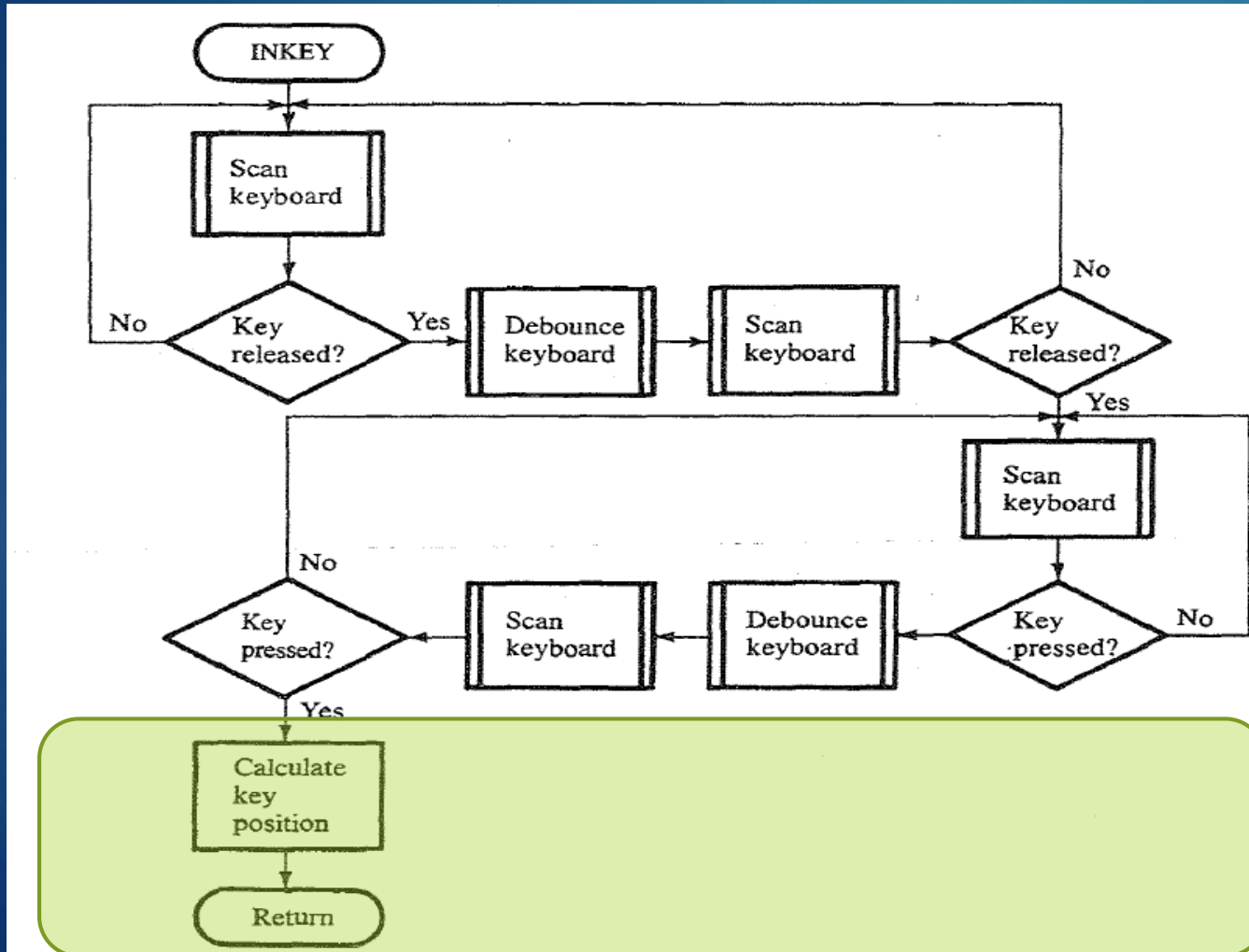
wait for a key release

Hexadecimal Keypad Interface – The Flowchart



wait for a
key depression

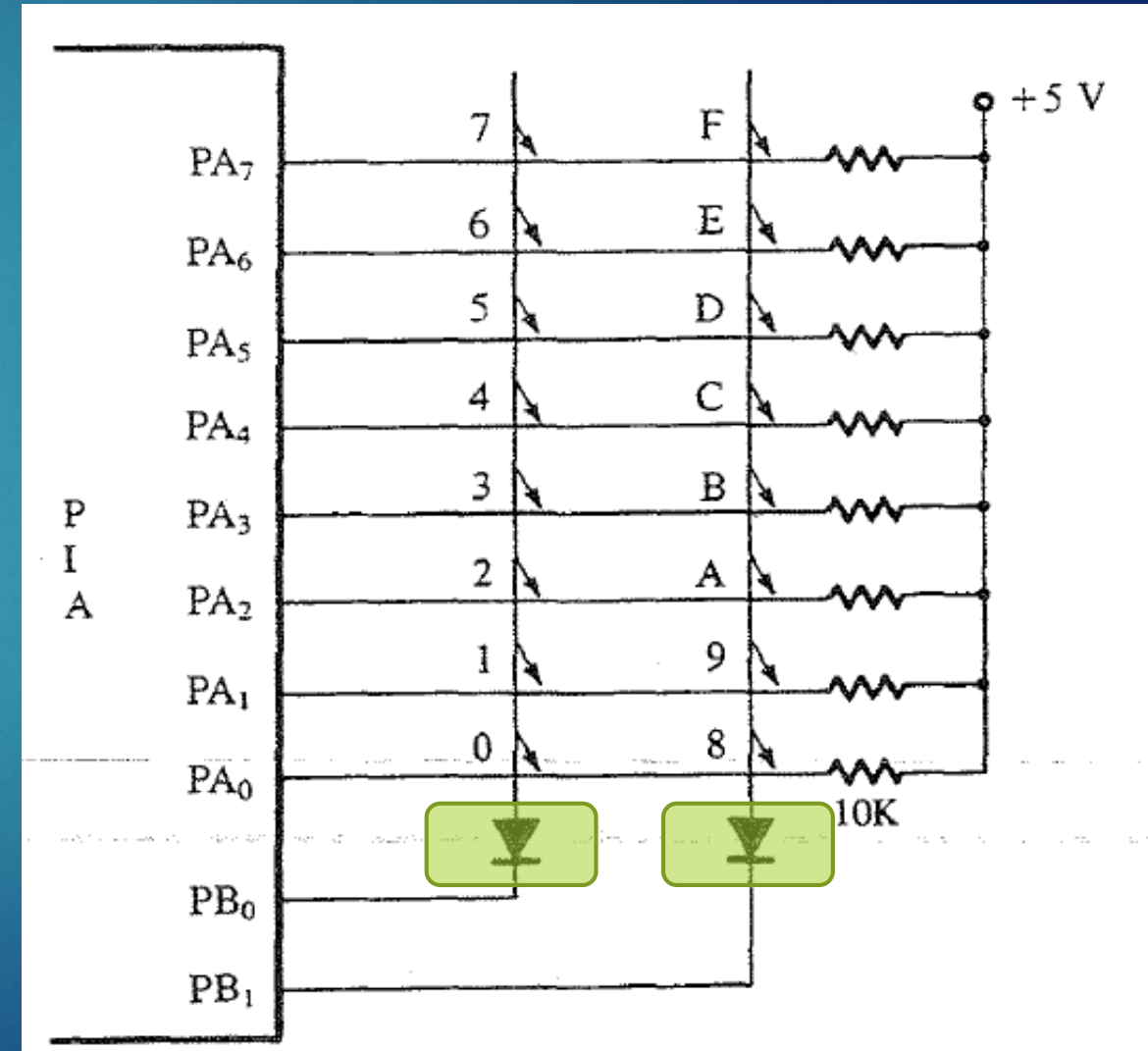
Hexadecimal Keypad Interface – The Flowchart



calculate the key
code

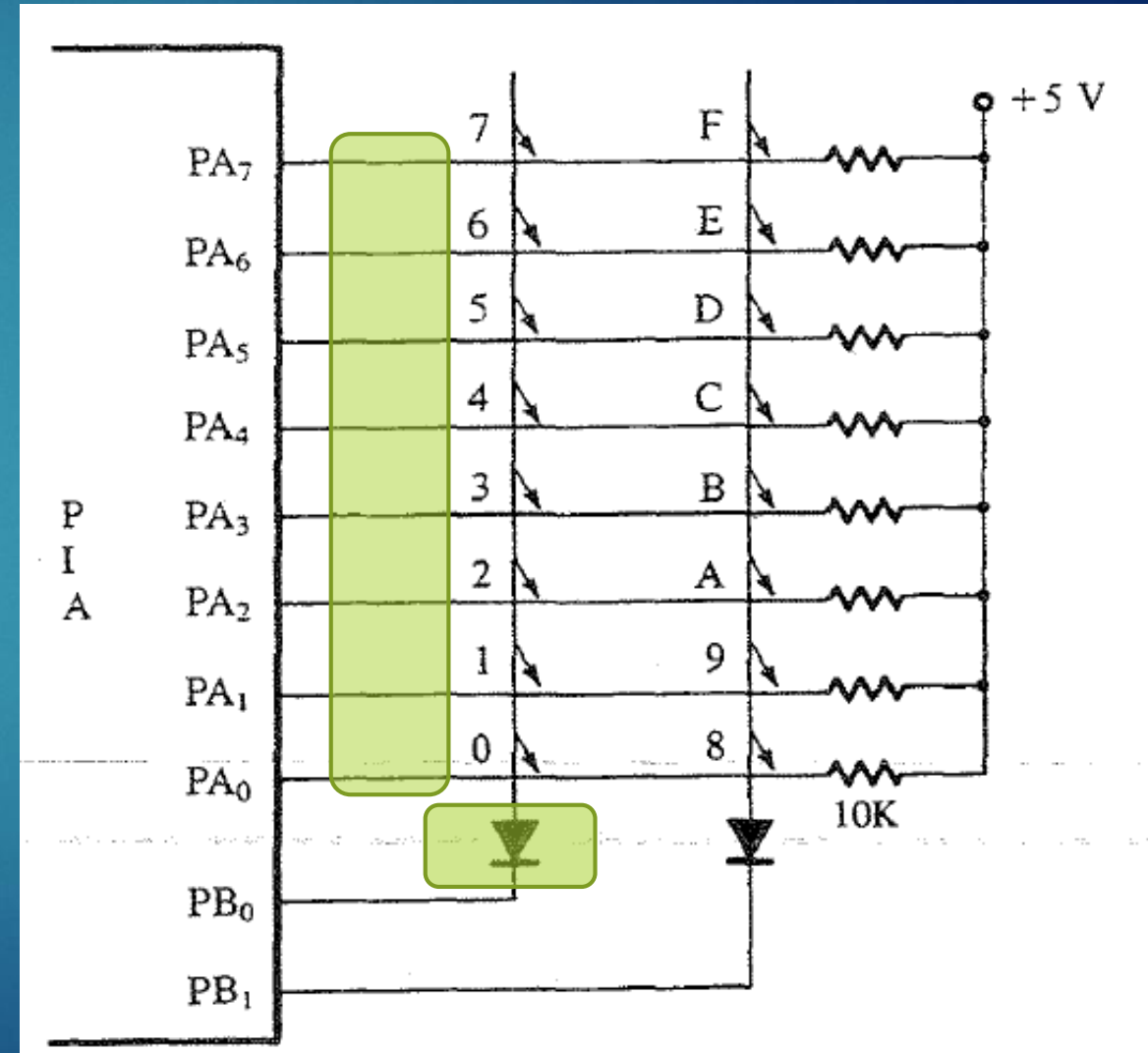
Keypad Software

- ▶ When developing the software for the 8085A keypad interface, binary bit patterns 0000 0010 and 0000 0001 are chosen as codes to select the columns, and binary bit patterns



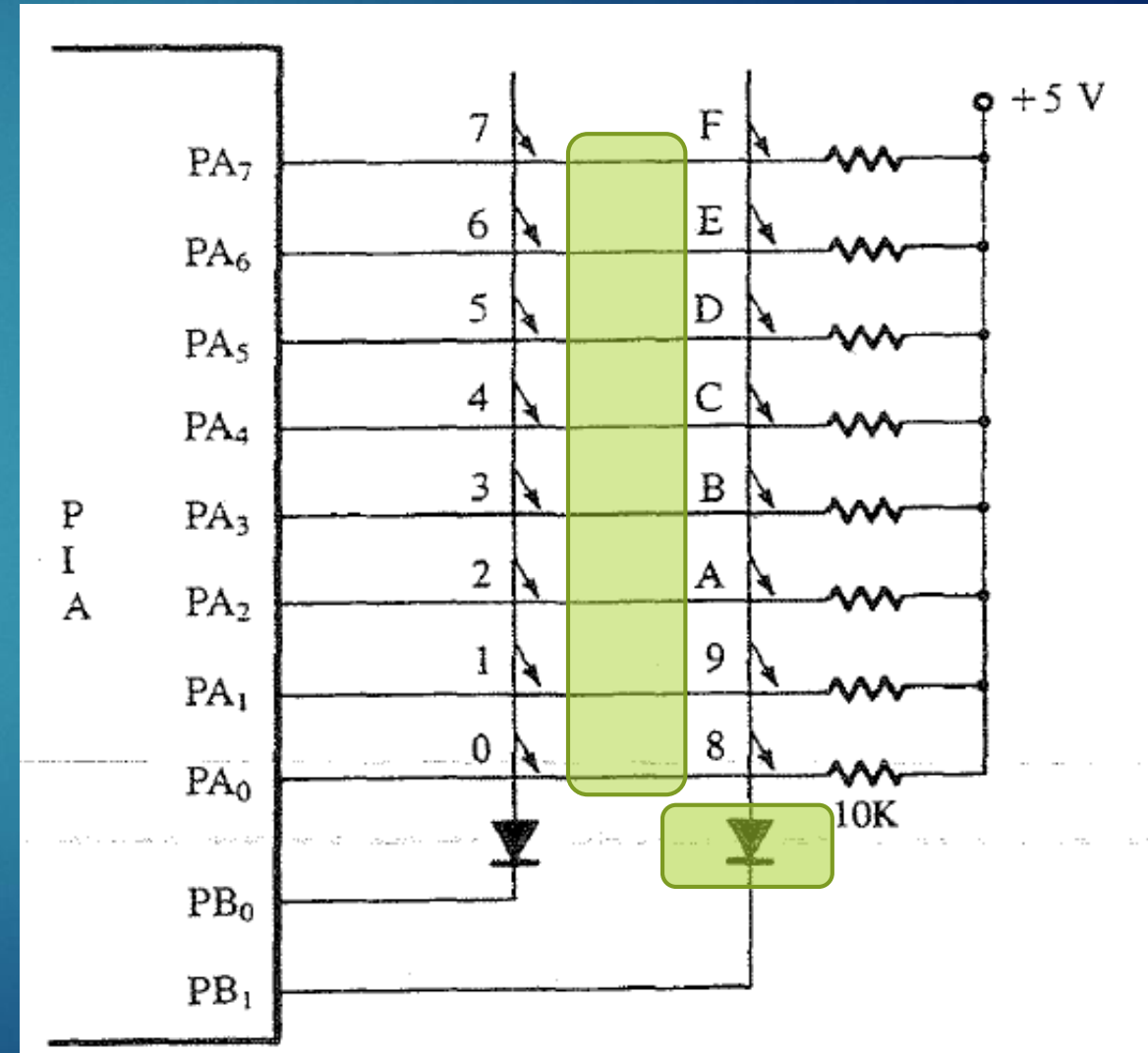
Keypad Software

- ▶ 0000 0000 is chosen as an indicator for the first key in the selected column.



Keypad Software

- ▶ 0000 1000 are chosen as an indicator for the first key in the selected column.



Keypad Software

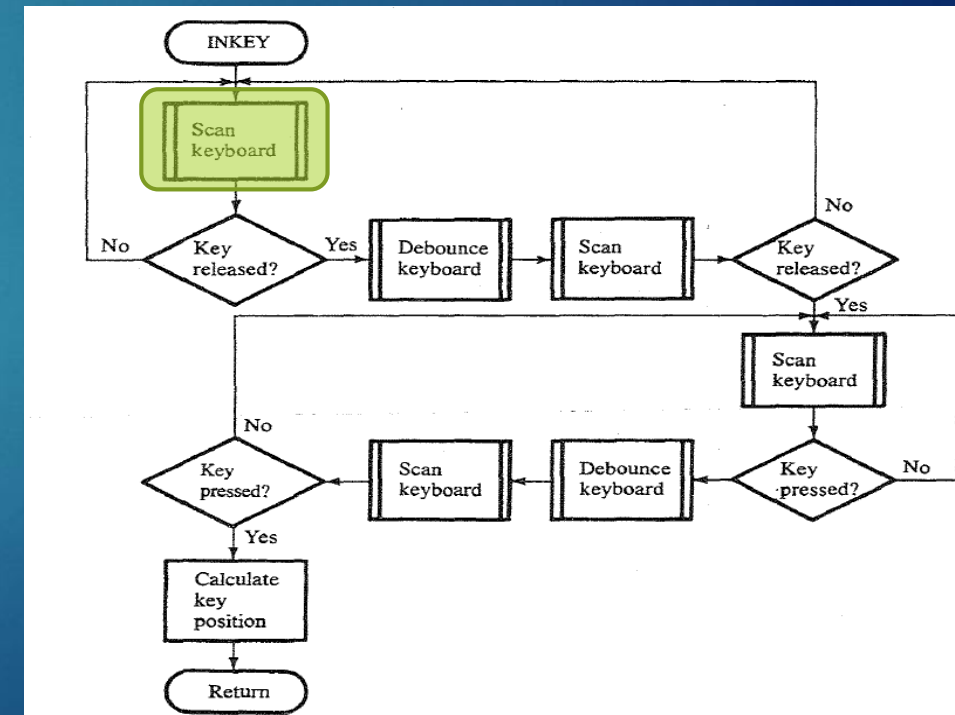
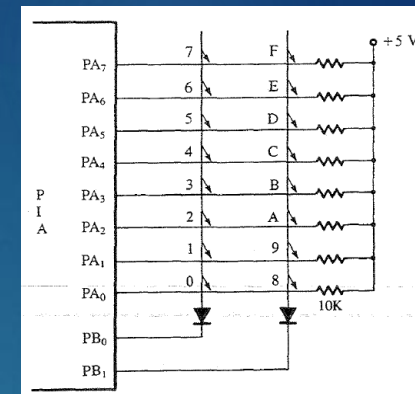
```
                ;initialization dialog for the 8155
                ;keyboard interface
                ;
0000 3E02      RESET:  MVI  A,00000010B    ;set port A = input
0002 D310      OUT    COMMAND             ;set port B = output
```

Keypad Software

```

;8085A assembly language version
;
;subroutine to detect a keystroke and return
;with the key code in the C-register.
;
;all registers except HL are destroyed
;uses the SCAN and DELAY subroutines
2000                ORG    2000H
;
;check for key release
;
2000 CD2F20    INKEY:    CALL    SCAN    ;check all keys
2003 C20020    JNZ      INKEY    ;if key is depressed
2006 CD2520    CALL     DELAY    ;debounce
2009 CD2F20    CALL     SCAN    ;check all keys
200C C20020    JNZ      INKEY    ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:    CALL     SCAN    ;check all keys
2012 CA0F20    JZ       LOOP    ;if no key depressed
2015 CD2520    CALL     DELAY    ;debounce
2018 CD2F20    CALL     SCAN    ;check all keys
201B CA0F20    JZ       LOOP    ;if no key depressed
;
;determine key code
;
201E 0D        DCR      C
201F 0F        LOOP1:  RRC      ;locate row
2020 0C        INR      C        ;modify key code
2021 DA1F20    JC       LOOP1    ;if not found
2024 C9        RET

```

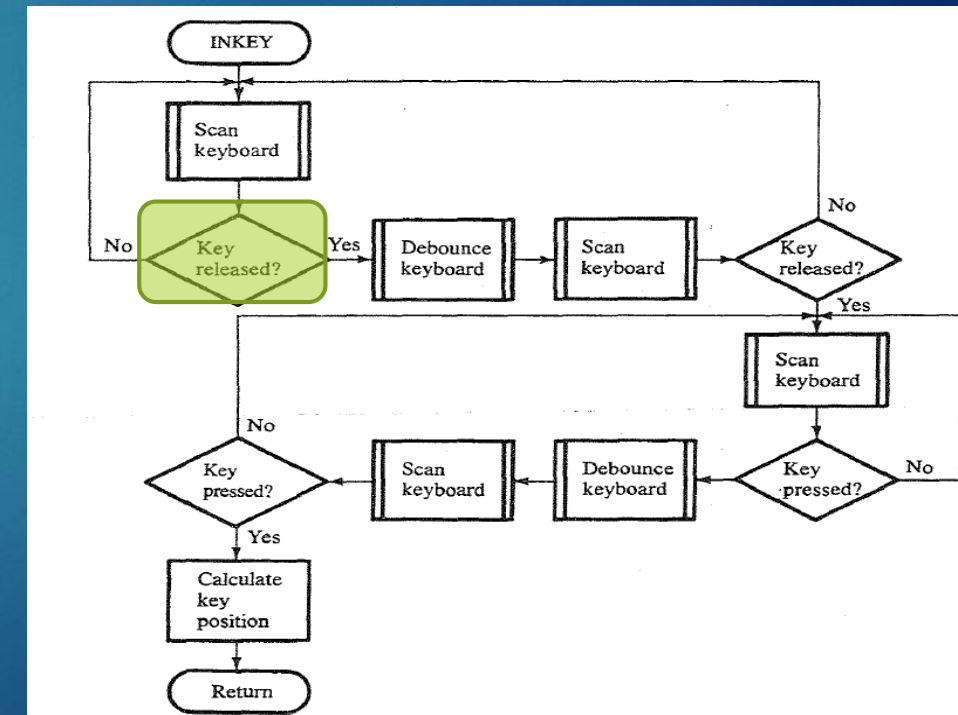
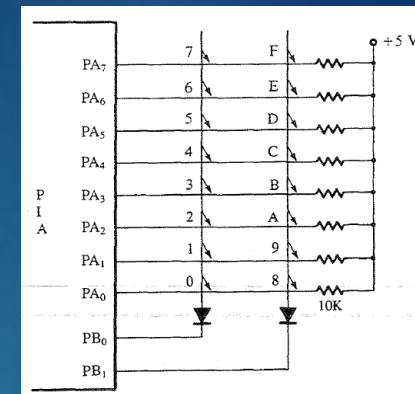


Keypad Software

```

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;
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;with the key code in the C-register.
;
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;
;check for key release
;
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2003 C20020    JNZ     INKEY                    ;if key is depressed
2006 CD2520    CALL    DELAY                    ;debounce
2009 CD2F20    CALL    SCAN                    ;check all keys
200C C20020    JNZ     INKEY                    ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL    SCAN                ;check all keys
2012 CA0F20    JZ      LOOP                    ;if no key depressed
2015 CD2520    CALL    DELAY                    ;debounce
2018 CD2F20    CALL    SCAN                    ;check all keys
201B CA0F20    JZ      LOOP                    ;if no key depressed
;
;determine key code
;
201E 0D        DCR     C
201F 0F        RRC
2020 0C        INR     C
2021 DA1F20    JC      LOOP1                    ;locate row
2024 C9        RET                                ;modify key code
;if not found
;return

```

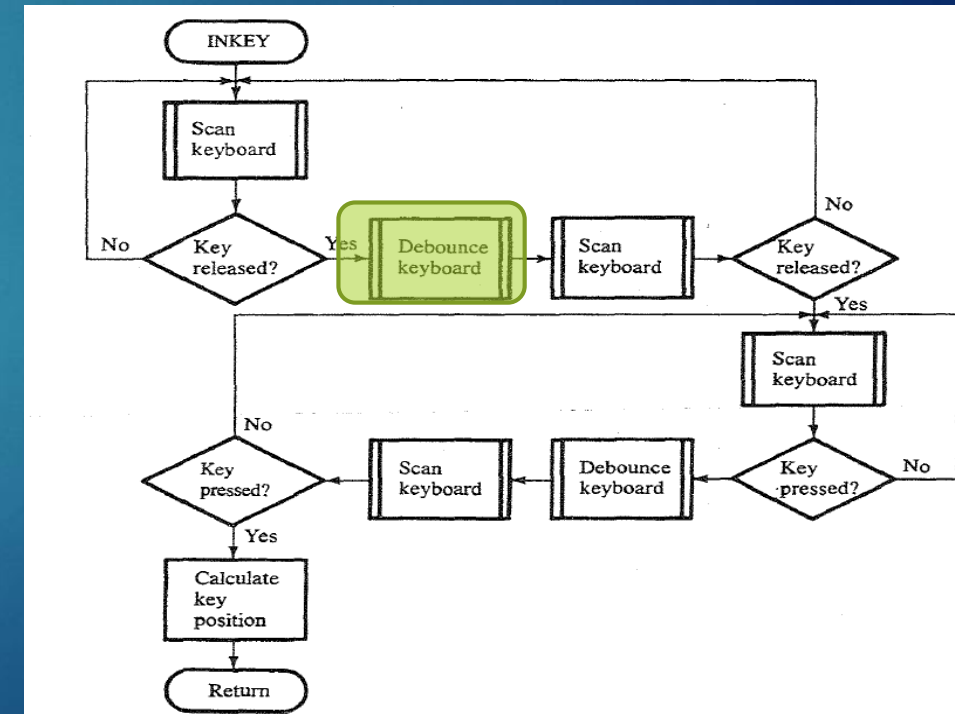
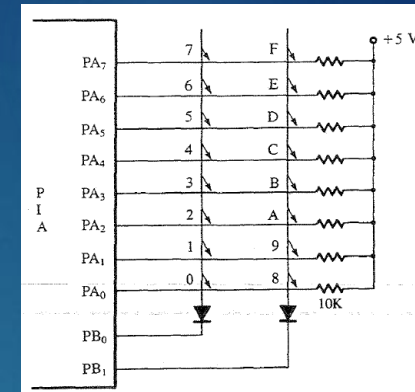


Keypad Software

```

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2003 C20020    JNZ     INKEY            ;if key is depressed
2006 CD2520    CALL    DELAY            ;debounce
2009 CD2F20    CALL    SCAN            ;check all keys
200C C20020    JNZ     INKEY            ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL    SCAN      ;check all keys
2012 CA0F20    JZ      LOOP             ;if no key depressed
2015 CD2520    CALL    DELAY            ;debounce
2018 CD2F20    CALL    SCAN            ;check all keys
201B CA0F20    JZ      LOOP             ;if no key depressed
;
;determine key code
;
201E 0D        DCR      C
201F 0F        LOOP1:  RRC              ;locate row
2020 0C        INR      C               ;modify key code
2021 DA1F20    JC      LOOP1           ;if not found
2024 C9        RET

```

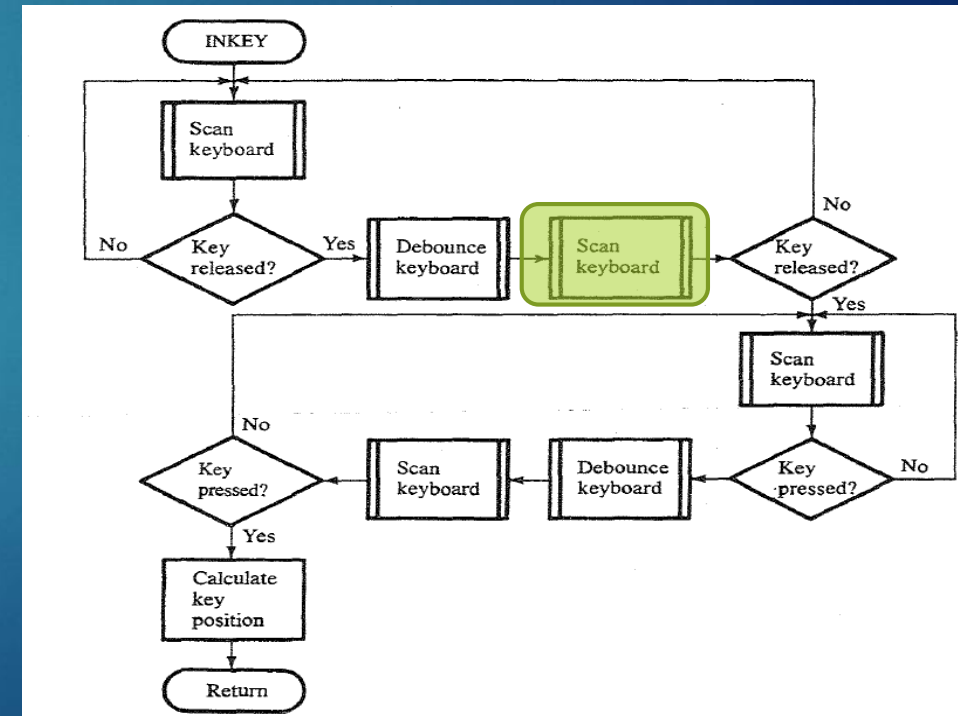
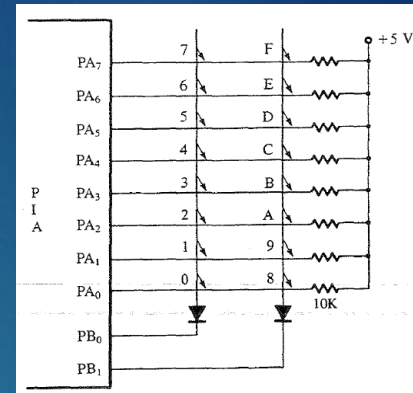


Keypad Software

```

;8085A assembly language version
;
;subroutine to detect a keystroke and return
;with the key code in the C-register.
;
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2000          ORG    2000H
;
;check for key release
;
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2006 CD2520    CALL    DELAY              ;debounce
2009 CD2F20    CALL    SCAN              ;check all keys
200C C20020    JNZ     INKEY              ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL    SCAN        ;check all keys
2012 CA0F20    JZ      LOOP                ;if no key depressed
2015 CD2520    CALL    DELAY              ;debounce
2018 CD2F20    CALL    SCAN              ;check all keys
201B CA0F20    JZ      LOOP                ;if no key depressed
;
;determine key code
;
201E 0D        DCR     C
201F 0F        LOOP1:  RRC                  ;locate row
2020 0C        INR     C                    ;modify key code
2021 DA1F20    JC      LOOP1              ;if not found
2024 C9        RET

```

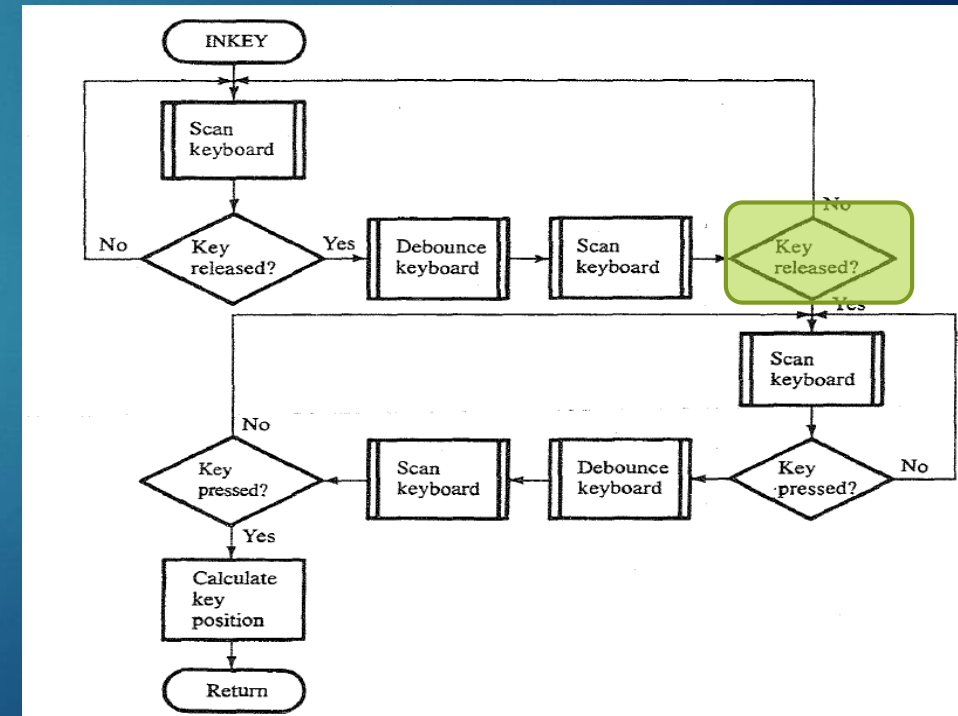
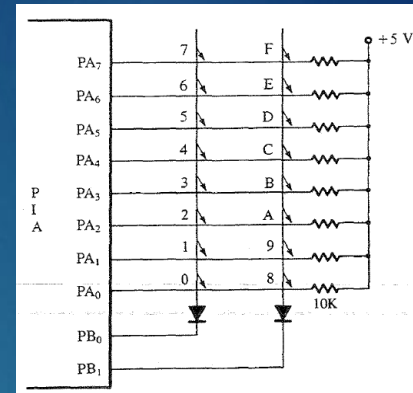


Keypad Software

```

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;with the key code in the C-register.
;
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2000                ORG    2000H
;
;check for key release
;
2000 CD2F20    INKEY:  CALL  SCAN        ;check all keys
2003 C20020                JNZ    INKEY    ;if key is depressed
2006 CD2520                CALL  DELAY    ;debounce
2009 CD2F20                CALL  SCAN    ;check all keys
200C C20020                JNZ    INKEY    ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL  SCAN        ;check all keys
2012 CA0F20                JZ     LOOP    ;if no key depressed
2015 CD2520                CALL  DELAY    ;debounce
2018 CD2F20                CALL  SCAN    ;check all keys
201B CA0F20                JZ     LOOP    ;if no key depressed
;
;determine key code
;
201E 0D                DCR    C
201F 0F                LOOP1:  RRC        ;locate row
2020 0C                INR    C        ;modify key code
2021 DA1F20            JC     LOOP1    ;if not found
2024 C9                RET            ;return

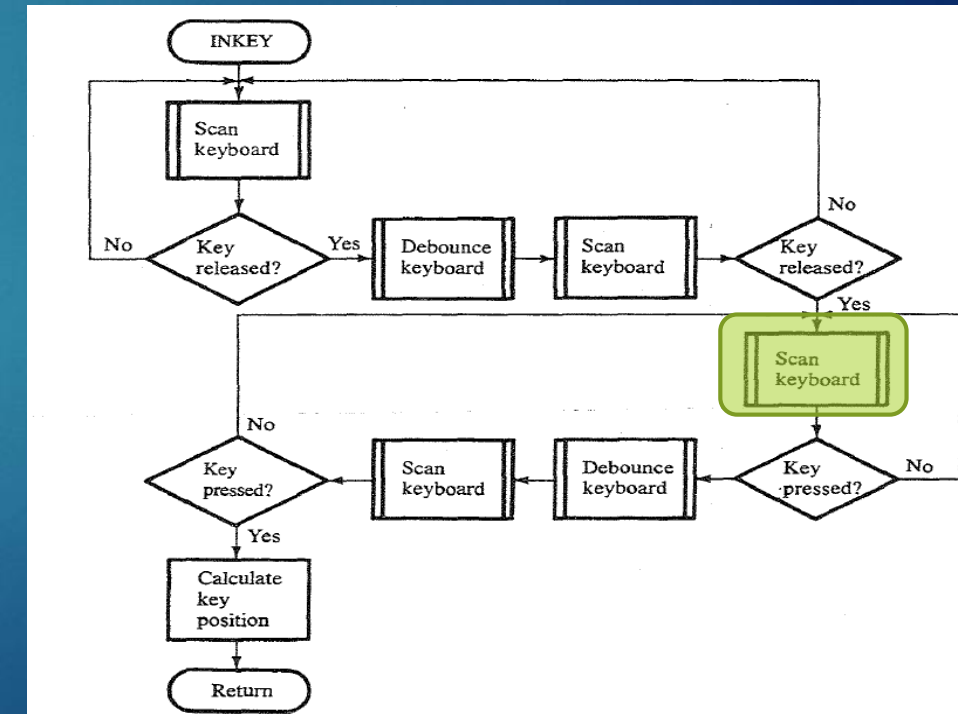
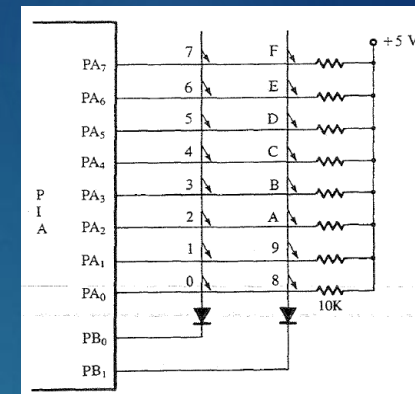
```



Keypad Software

```

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2009 CD2F20                CALL  SCAN    ;check all keys
200C C20020                JNZ    INKEY    ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL  SCAN        ;check all keys
2012 CA0F20                JZ     LOOP    ;if no key depressed
2015 CD2520                CALL  DELAY    ;debounce
2018 CD2F20                CALL  SCAN    ;check all keys
201B CA0F20                JZ     LOOP    ;if no key depressed
;
;determine key code
;
201E 0D                DCR    C
201F 0F                LOOP1:  RRC        ;locate row
2020 0C                INR    C        ;modify key code
2021 DA1F20            JC     LOOP1    ;if not found
2024 C9                RET            ;return
  
```

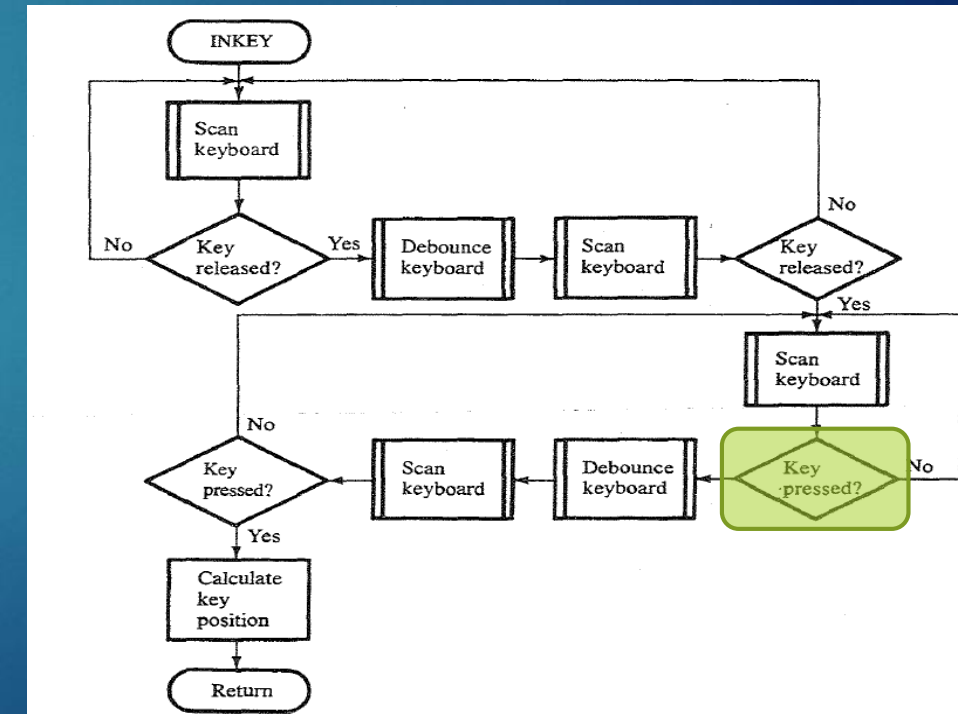
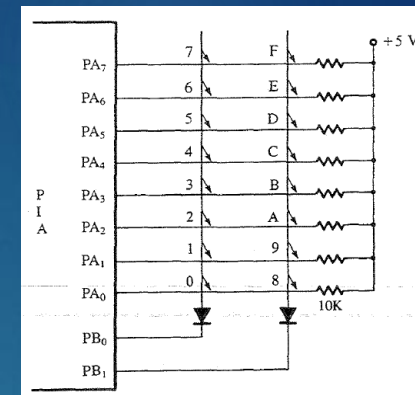


Keypad Software

```

;8085A assembly language version
;
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;with the key code in the C-register.
;
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;
;check for key release
;
2000 CD2F20    INKEY:  CALL  SCAN        ;check all keys
2003 C20020                JNZ    INKEY    ;if key is depressed
2006 CD2520                CALL  DELAY    ;debounce
2009 CD2F20                CALL  SCAN    ;check all keys
200C C20020                JNZ    INKEY    ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL  SCAN        ;check all keys
2012 CA0F20                JZ     LOOP    ;if no key depressed
2015 CD2520                CALL  DELAY    ;debounce
2018 CD2F20                CALL  SCAN    ;check all keys
201B CA0F20                JZ     LOOP    ;if no key depressed
;
;determine key code
;
201E 0D                DCR    C
201F 0F                LOOP1:  RRC        ;locate row
2020 0C                INR    C        ;modify key code
2021 DA1F20            JC     LOOP1    ;if not found
2024 C9                RET            ;return

```

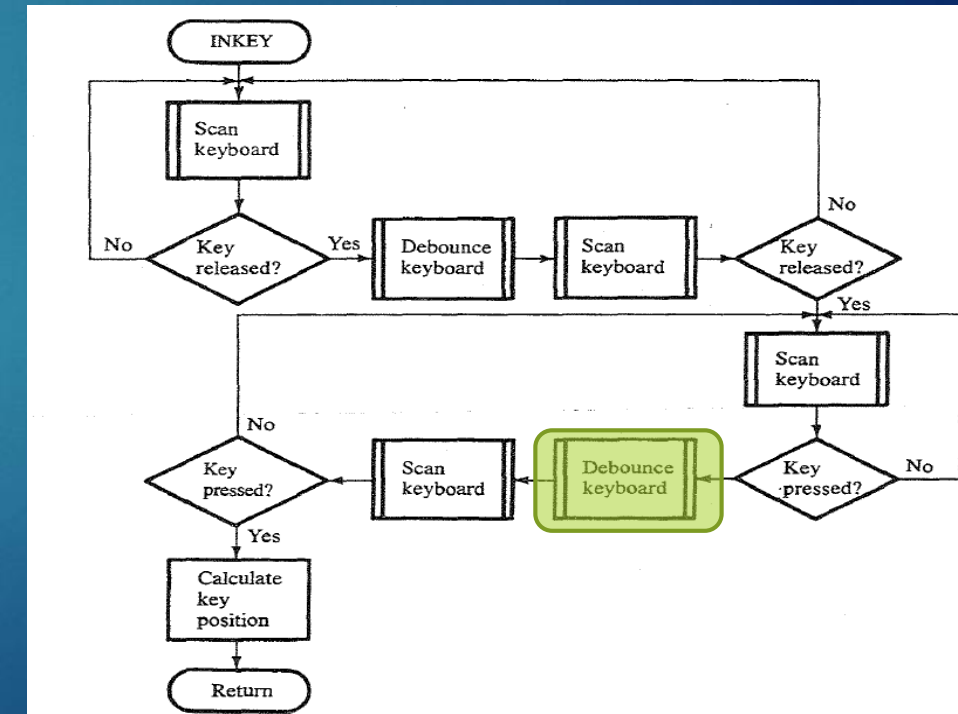
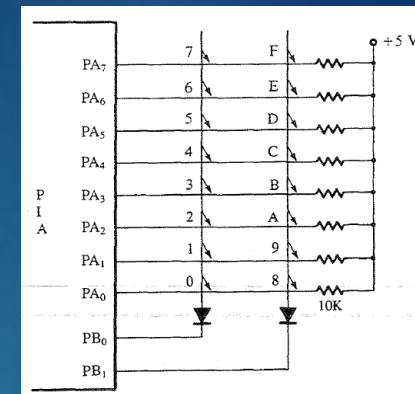


Keypad Software

```

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;with the key code in the C-register.
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2009 CD2F20                CALL  SCAN    ;check all keys
200C C20020                JNZ    INKEY    ;if key is depressed
;
;check for a key
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200F CD2F20    LOOP:   CALL  SCAN        ;check all keys
2012 CA0F20                JZ     LOOP    ;if no key depressed
2015 CD2520                CALL  DELAY    ;debounce
2018 CD2F20                CALL  SCAN    ;check all keys
201B CA0F20                JZ     LOOP    ;if no key depressed
;
;determine key code
;
201E 0D                DCR    C
201F 0F                LOOP1:  RRC        ;locate row
2020 0C                INR    C        ;modify key code
2021 DA1F20            JC     LOOP1    ;if not found
2024 C9                RET            ;return

```

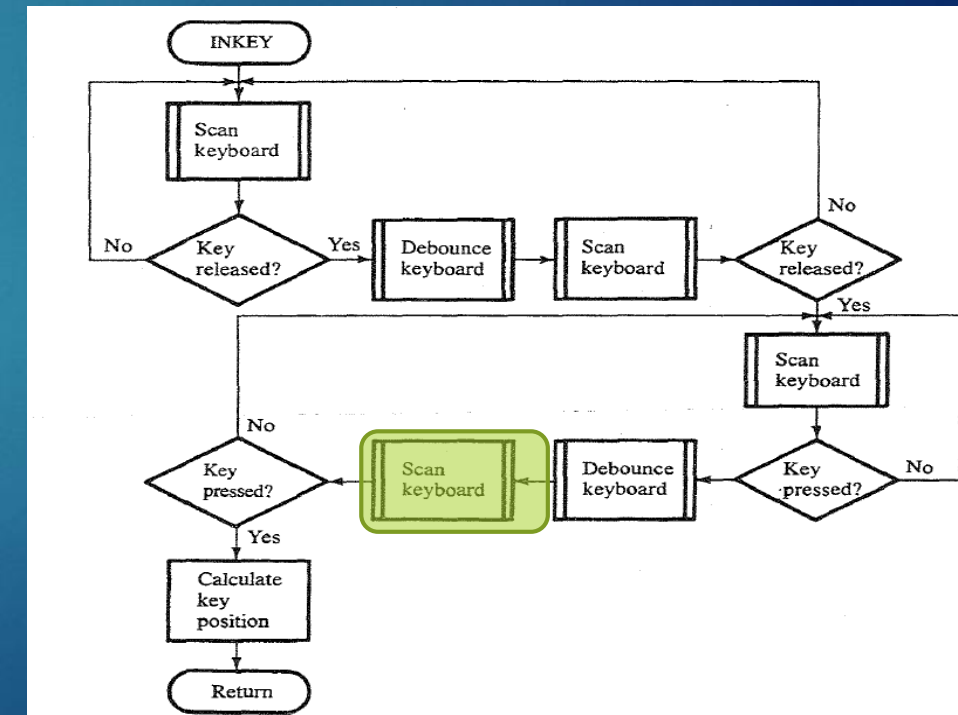
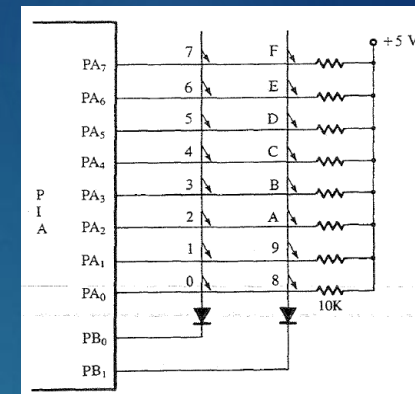


Keypad Software

```

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;
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;uses the SCAN and DELAY subroutines
2000          ORG    2000H
;
;check for key release
;
2000 CD2F20    INKEY:  CALL  SCAN          ;check all keys
2003 C20020    JNZ     INKEY              ;if key is depressed
2006 CD2520    CALL    DELAY              ;debounce
2009 CD2F20    CALL    SCAN              ;check all keys
200C C20020    JNZ     INKEY              ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL    SCAN        ;check all keys
2012 CA0F20    JZ      LOOP               ;if no key depressed
2015 CD2520    CALL    DELAY              ;debounce
2018 CD2F20    CALL    SCAN              ;check all keys
201B CA0F20    JZ      LOOP               ;if no key depressed
;
;determine key code
;
201E 0D        DCR     C
201F 0F        RRC
2020 0C        INR     C
2021 DA1F20    JC      LOOP1             ;locate row
2024 C9        RET                      ;modify key code
;if not found
;return

```

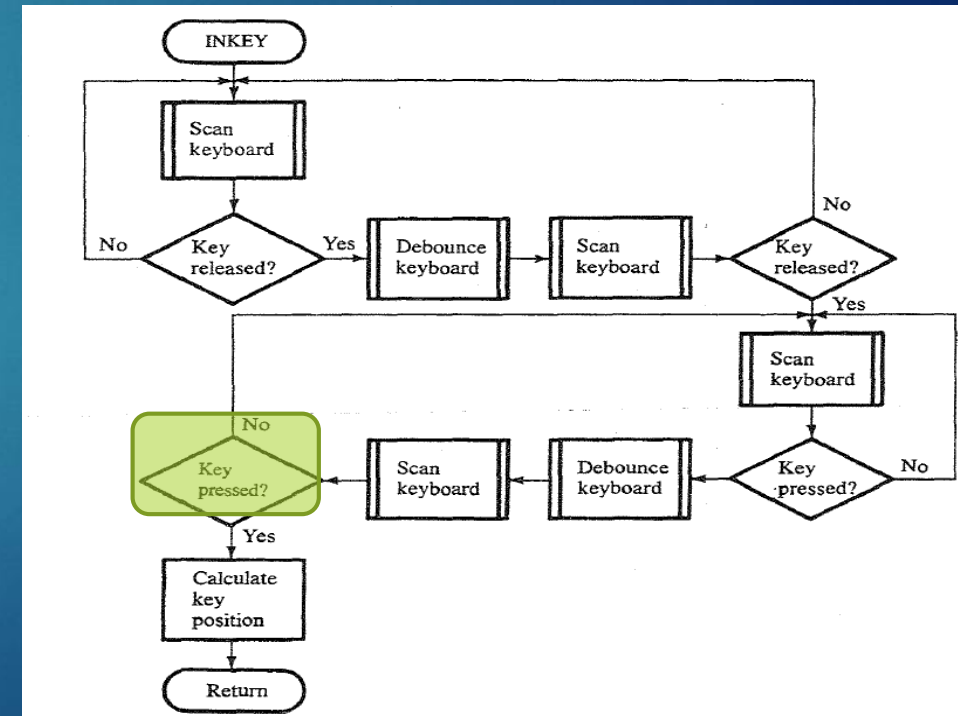
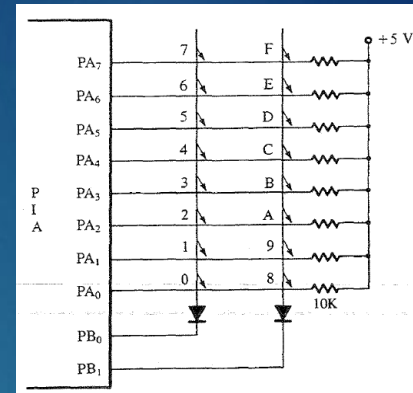


Keypad Software

```

;8085A assembly language version
;
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;with the key code in the C-register.
;
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2018 CD2F20                CALL  SCAN    ;check all keys
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;
;determine key code
;
201E 0D                DCR    C
201F 0F                LOOP1:  RRC        ;locate row
2020 0C                INR    C        ;modify key code
2021 DA1F20            JC     LOOP1    ;if not found
2024 C9                RET            ;return

```

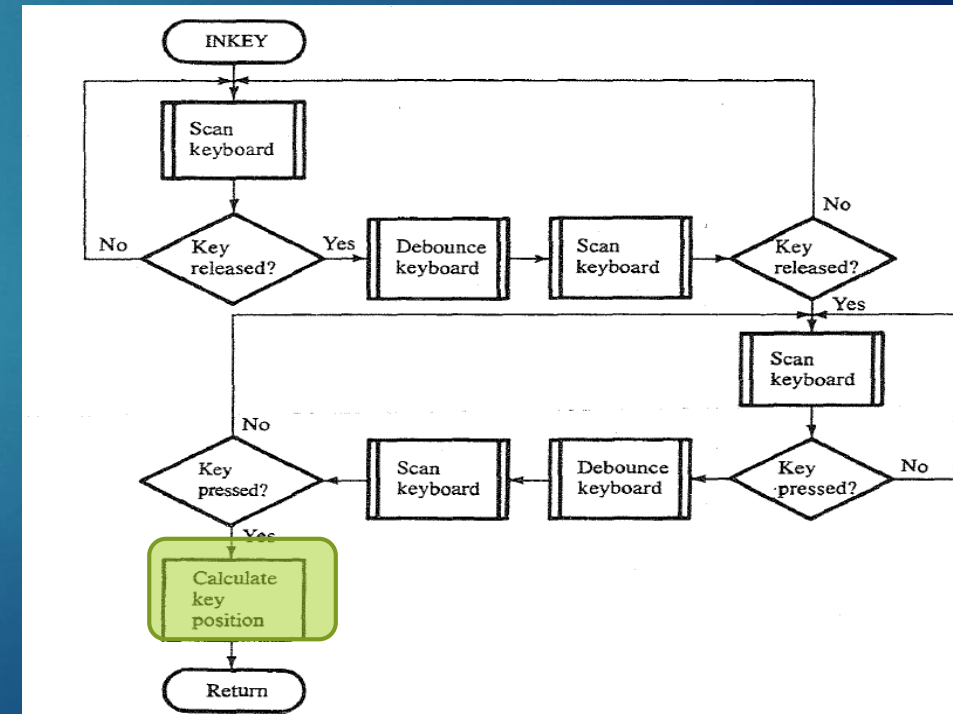
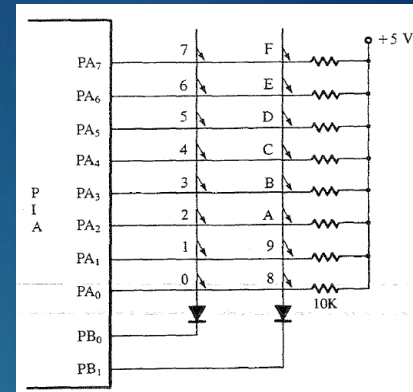


Keypad Software

```

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;
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;
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2006 CD2520                CALL  DELAY    ;debounce
2009 CD2F20                CALL  SCAN    ;check all keys
200C C20020                JNZ    INKEY    ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL  SCAN        ;check all keys
2012 CA0F20                JZ     LOOP    ;if no key depressed
2015 CD2520                CALL  DELAY    ;debounce
2018 CD2F20                CALL  SCAN    ;check all keys
201B CA0F20                JZ     LOOP    ;if no key depressed
;
;determine key code
;
201E 0D                DCR    C
201F 0F                RRC
2020 0C                INR    C
2021 DA1F20            JC     LOOP1
2024 C9                RET
                ;locate row
                ;modify key code
                ;if not found
                ;return

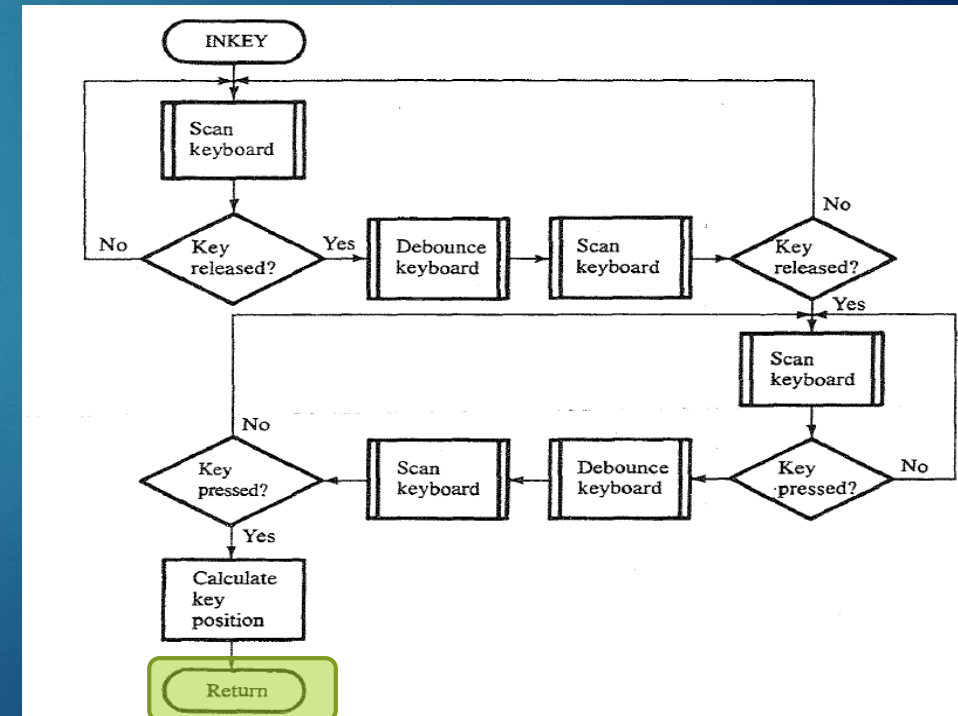
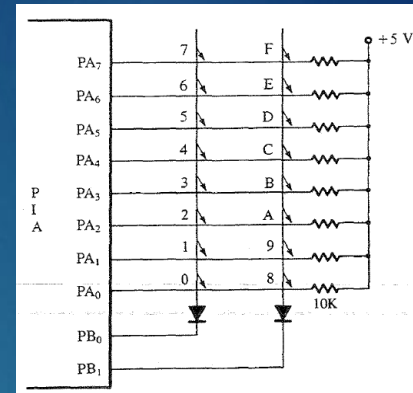
```



Keypad Software

```

;8085A assembly language version
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2009 CD2F20                CALL  SCAN    ;check all keys
200C C20020                JNZ    INKEY    ;if key is depressed
;
;check for a key
;
200F CD2F20    LOOP:   CALL  SCAN        ;check all keys
2012 CA0F20                JZ     LOOP    ;if no key depressed
2015 CD2520                CALL  DELAY    ;debounce
2018 CD2F20                CALL  SCAN    ;check all keys
201B CA0F20                JZ     LOOP    ;if no key depressed
;
;determine key code
;
201E 0D                DCR    C
201F 0F                LOOP1:  RRC        ;locate row
2020 0C                INR    C        ;modify key code
2021 DA1F20            JC     LOOP1    ;if not found
2024 C9                RET            ;return
  
```



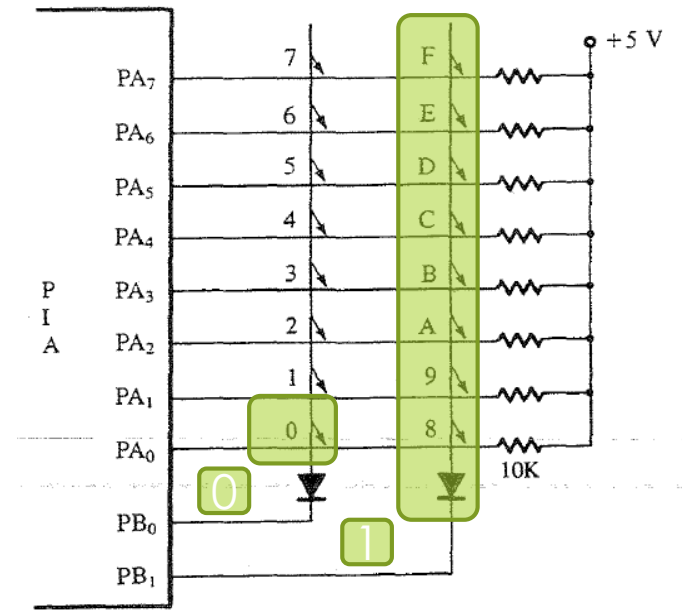
Keyboard Scanning

Result according to column in Register C

```

;keyboard scanning subroutine
;modifies B and C, destroys A and I
;return zero = no keystroke
;return not zero = keystroke
SCAN:
    MOV     A,2           ;select a column
    MVI     C,0           ;set row starting code
    OUT     PORTB
    IN      PORTA         ;check rows
    CPI     OFFH
    RNZ
    MVI     A,1           ;return on key
    OUT     PORTB         ;select next column
    IN      PORTA         ;check rows
    CPI     OFFH
    MVI     C,8
    RET                  ;return

```



Keyboard Scanning

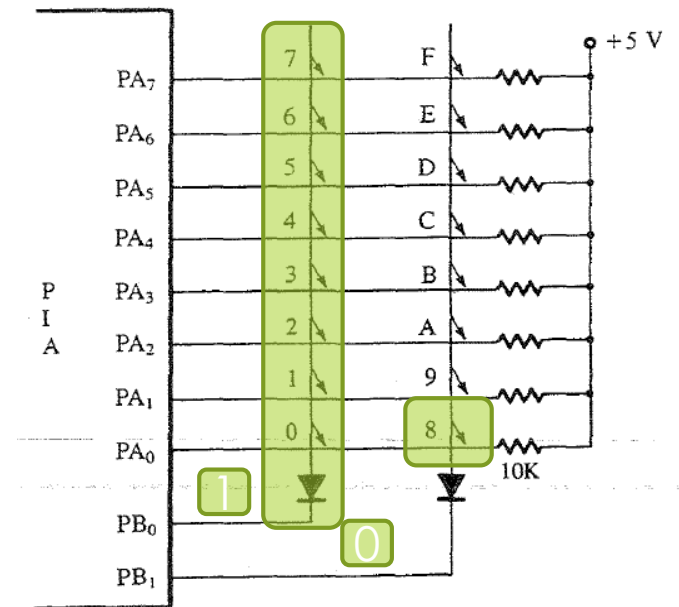
```

;keyboard scanning subroutine
;modifies B and C, destroys A and F
;return zero = no keystroke
;return not zero = keystroke
SCAN:      MOV     A,2           ;select a column
           MVI     C,0           ;set row starting code
           OUT     PORTB
           IN      PORTA         ;check rows
           CPI     0FFH
           RNZ
           MVI     A,1           ;return on key
           OUT     PORTB
           IN      PORTA         ;select next column
           CPI     0FFH
           MVI     C,C+1
           ;check rows
           ;return

```

202F 7A
2030 0E00
2032 D312
2034 DB11
2036 FEFF
2038 C0
2039 3E01
203B D312
203D DB11
203F FEFF
2041 0E08
2043 C9

Result
according to
column in
Register C



Keypad Software – Delay Subroutine

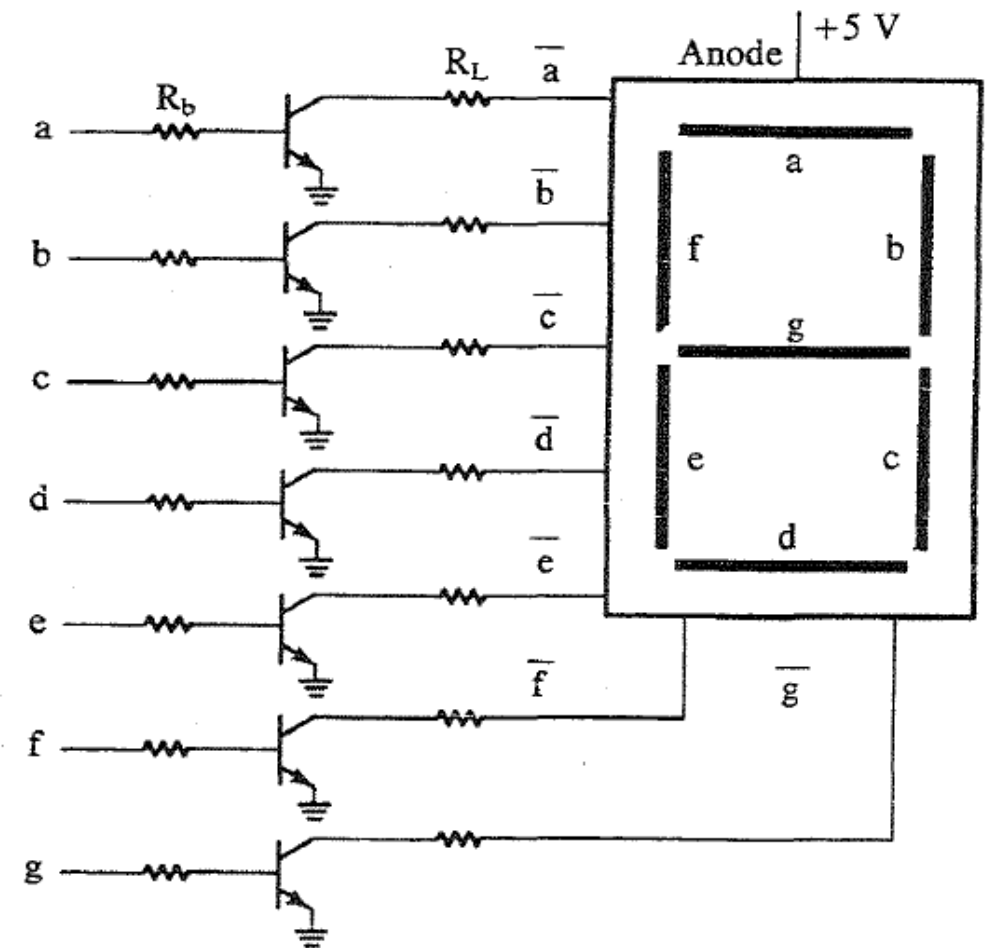
```
                ;time delay subroutine (20 ms)
                ;
2025 112006      DELAY:  LXI    D,1568      ;load count
2028 1B          DELAY1: DCX    D          ;decrement count
2029 7A          MOV     A,D             ;test DE for a 0
202A B3          ORA     E
202B C22820      JNZ     DELAY1          ;if DE not 0
202E C9          RET
```

The amount of time used for the contact debounce delay is left up to the user, since it varies with different switches. The count 1568 in the DELAY subroutine is chosen for a 20-ms time delay for this example.

MULTIPLEXED DISPLAYS

- ▶ Display devices are normally multiplexed to reduce the component count in a microprocessor based system.
- ▶ In microprocessors, the seven-segment code is developed with software to further reduce the amount of external hardware required in the system.

FIGURE 7-5 A seven-segment LED display illustrating the segment drivers.



BCD to Seven-Segment Code Conversion

TABLE 7-1 Common anode seven-segment lookup table.

Address	Data								Displayed Data
	X	a	b	c	d	e	f	g	
TABLE	0	1	1	1	1	1	1	0	0
TABLE+1	0	0	1	1	0	0	0	0	1
TABLE+2	0	1	1	0	1	1	0	1	2
TABLE+3	0	1	1	1	1	0	0	1	3
TABLE+4	0	0	1	1	0	0	1	1	4
TABLE+5	0	1	0	1	1	0	1	1	5
TABLE+6	0	1	0	1	1	1	1	1	6
TABLE+7	0	1	1	1	0	0	0	0	7
TABLE+8	0	1	1	1	1	1	1	1	8
TABLE+9	0	1	1	1	1	0	1	1	9

BCD to Seven-Segment Code Conversion

```
                ;8085A assembly language version
                ;
                ;subroutine to convert the contents of
                ;the accumulator to 7-segment code.
                ;HL is destroyed
                ;refer to table 7-1
                ;
0000 E60F      CONVERT: ANI    0FH      ;mask left nibble
0002 210010    LXI    H,TABLE  ;point to lookup table
0005 85        ADD    L        ;add BCD to address (HL)
0006 6F        MOV    L,A
0007 7C        MOV    A,H
0008 CE00      ACI    0
000A 67        MOV    H,A
000B 7E        MOV    A,M      ;get 7-segment data
000C C9        RET
```

Multiple-Digit Display

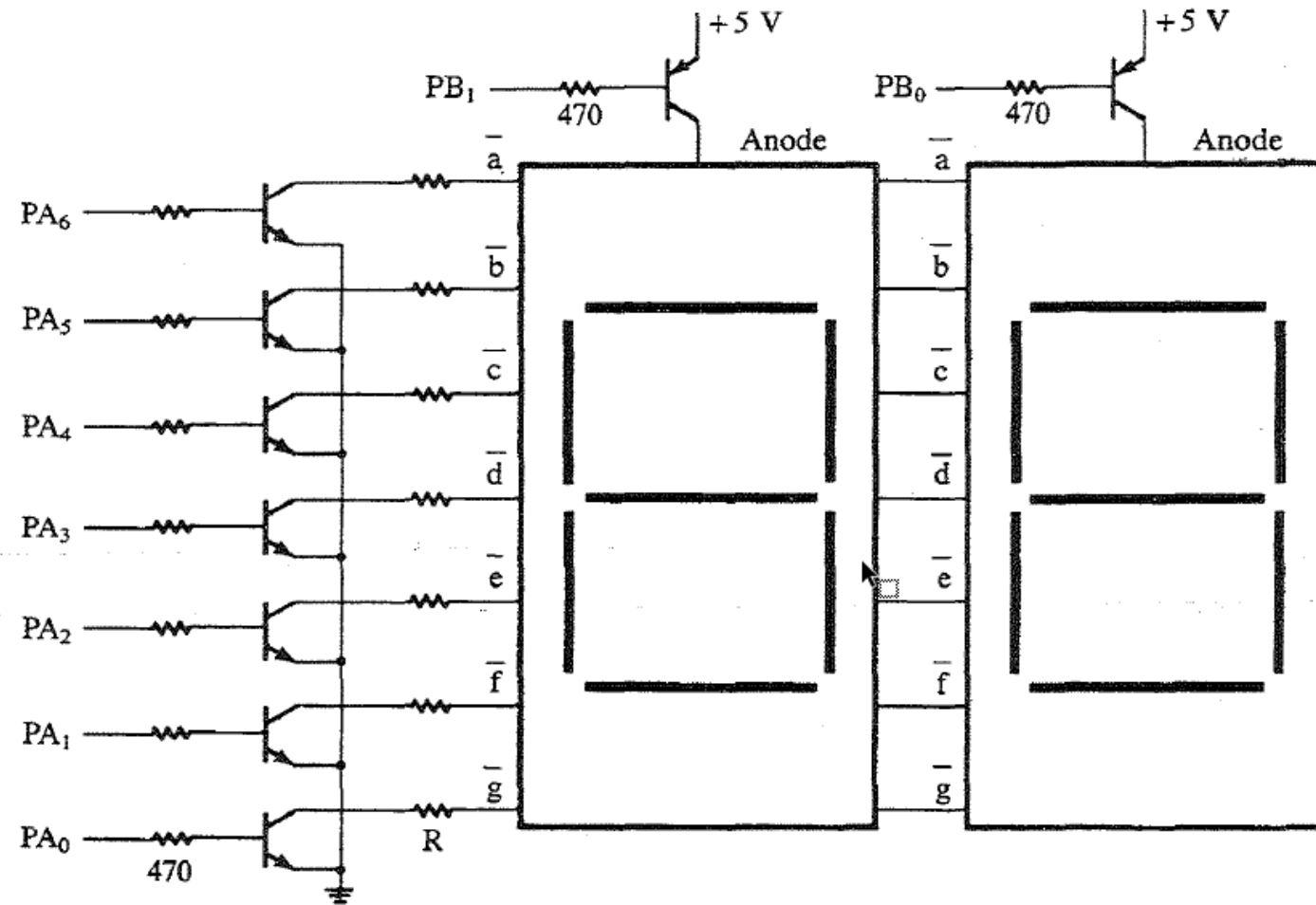
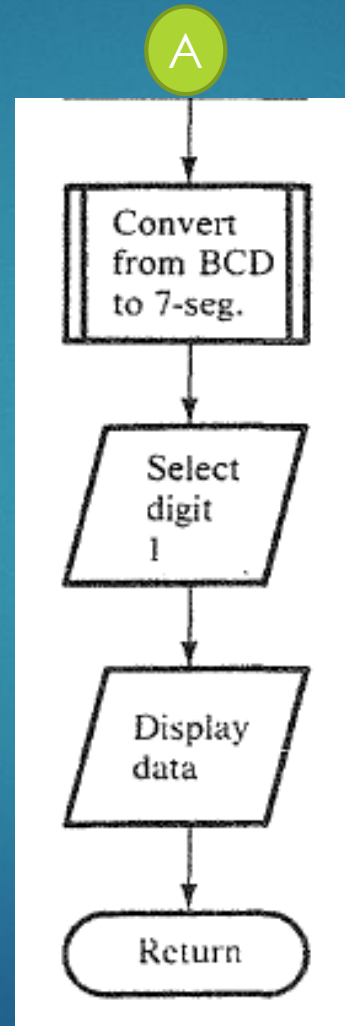
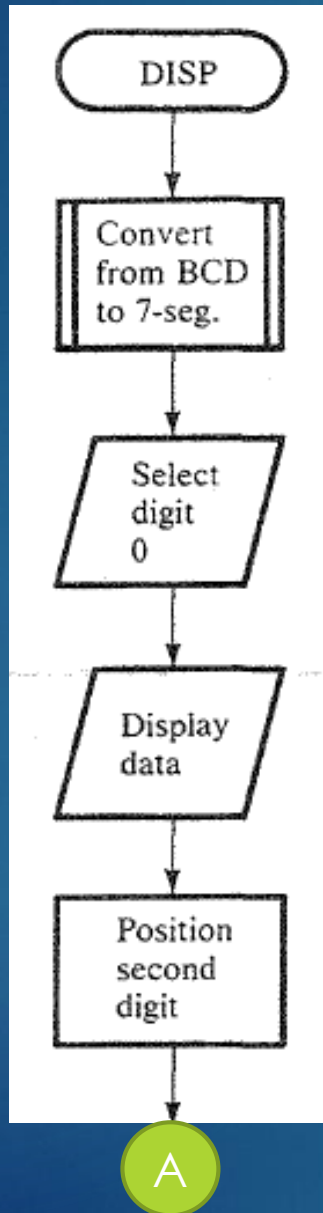


FIGURE 7-6 A two-digit multiplexed seven-segment LED display.

Flowchart of Multiple-Digit Display



Multiple-Digit Display Software

```

;8085 assembly language version
;subroutine to display the packed BCD number
;in the accumulator on the two-digit display
;
0100          ORG    100H
0100 F5        DISP:  PUSH  PSW          ;save BCD
0101 CDXXXX    CALL  CONVERT          ;convert to 7-segment code
0104 D311      OUT   PORTA            ;send data
0106 3E02      MVI   A,2              ;select digit 0
0108 D312      OUT   PORTB
010A CDXXXX    CALL  DELAY            ;wait 1 ms
010D F1        POP   PSW              ;get BCD
010E 0F        RRC                    ;position next digit
010F 0F        RRC
0110 0F        RRC
0111 0F        RRC
0112 CDXXXX    CALL  CONVERT          ;convert to 7-segment code
0115 D311      OUT   PORTA            ;send data
0117 3E01      MVI   A,1              ;select digit 1
0119 D312      OUT   PORTB
011B CDXXXX    CALL  DELAY            ;wait 1 ms
011E C9        RET

```

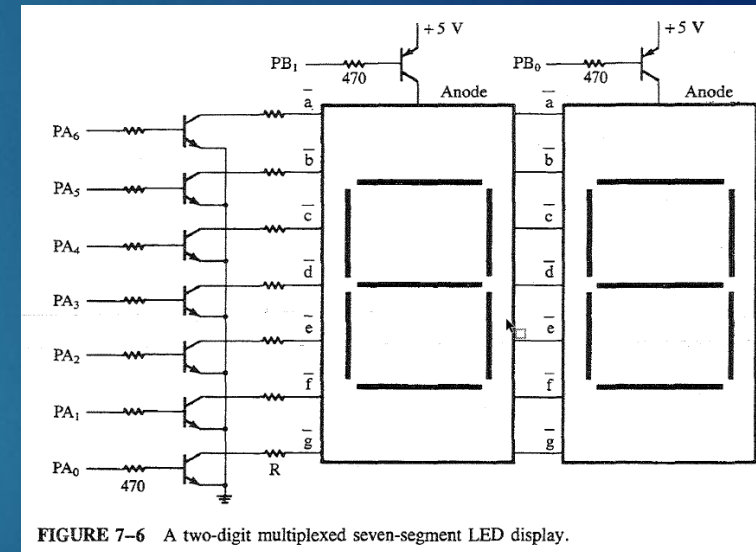


FIGURE 7-6 A two-digit multiplexed seven-segment LED display.