Keyboard Design

1	2	3	A
4	5	6	B
7	8	9	C
F	0	E	D

PIA

I0
I1
I2
I3
I4
I5
I6
I7

5V
5V
5V
5V

1. If no key is pressed rows (I4, I5, I6, I7) reads high
2. If a key is pressed either one of columns (I0, I1, I2, I3) is shorted to rows
3. Keystroke is detected by rotating 0 among columns

Keyboard Design

Array Index	Row, Column	Symbol	Data in Memory
1	1,1	1	0000 0001
2	1,2	2	0000 0010
3	1,3	3	0000 0011
4	1,4	A	0000 1010
5	2,1	4	0000 0100
6	2,2	5	0000 0101
:			
16	4,4	D	1101 0000

1	2	3	A
4	5	6	B
7	8	9	C
F	0	E	D

Array_Index= (Row-1)*NumberOfColumns+Column

Ex: Array Index of 5:
Row=2; Column=2
Array_Index= 1*4+2=6

Keyboard Design

```
COND     LDA A, $0F              DELAY   LDA IX, $AAAA
         STA A, <DIRECT>         DECR    DEC IX
         LDA A, $02                      BNEQ DECR
         STA A, <STAT/COND>              RTS
         RTS

SHIFT    LDA A, $FE              START   LDA SP, $A000
REW1     STA A, <PORT>                   BSR COND
         BSR DELAY               REW2    BSR SHIFT
         ROL A                           BR REW2
         CMP A, $EF
         BEQ SHIFT
         BR REW1
         RTS
```
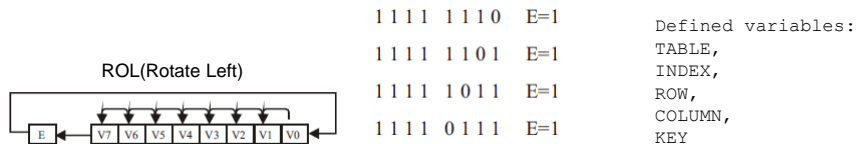
```
1111 1110   E=1        Defined variables:
1111 1101   E=1        TABLE,
                       INDEX,
1111 1011   E=1        ROW,
1111 0111   E=1        COLUMN,
                       KEY
```

ROL(Rotate Left)

«Read Key» and «Find Key» subroutines

```
RDKEY    SET E                           KEY     CLR E
         LDA B, $FE                              CLR C
REW3     STA B, <PORT>                           COM B
         LDA A, <PORT>                   COLNR   INC C
         AND A, $F0                              SHR B
         CMP A, $F0                              BNC COLNR
         BEQ SCAN                                STA C, COLUMN
         STA A, ROW                              SHR A
         STA B, COLUMN                           SHR A
         BSR KEY                                 SHR A
         RTS                                     SHR A
SCAN     ROL B                                   COM A
         CMP B, $EF                              CLR E
         BNEQ REW3                               CLR C
         RTS                            ROWNR    INC C
                                                 SHR A
                                                 BNC ROWNR
                                                 STA C, ROW
                                                 RTS
```

1.Column: 1111 1110
2.Column: 1111 1101
3.Column: 1111 1011
4.Column: 1111 0111

1	2	3	A
4	5	6	B
7	8	9	C
F	0	E	D

B: 1111 1101
A: 1101 1111
B->Column=2
A->Row=2

```
1111 1110   E=1
1111 1101   E=1
1111 1011   E=1
1111 0111   E=1
```

ROL (Rotate Left)

«Compute Key Index» and «Interrupt» subroutines
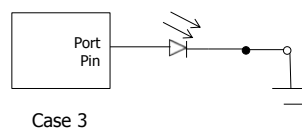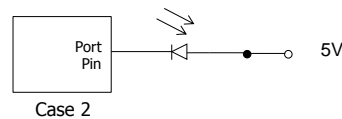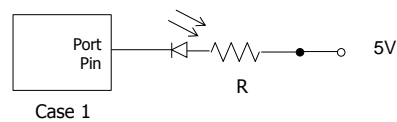
```
KEYIX   LDA A, <ROW>              INTRPT  BSR RDKEY
        DEC A                             BSR KEYIX
        MUL A, $04                        LDA IX, <TABLE>
        LDA A, <COLUMN>                   CLR C
        ADD A, B                          LDA D, <INDEX>
        STA A, INDEX                      LDA A, <IX+CD+00>
        RTS                               STA A, KEY
                                          RTI
```

Display Design

- Simple output Device: LED
  - Case-1
    - LED is ON for an output of zero
    - Most LEDs drop 1.7 to 2.5 volts and need about 10ma
    - Current is (5-2)/R
  - Case-2
    - Too much current
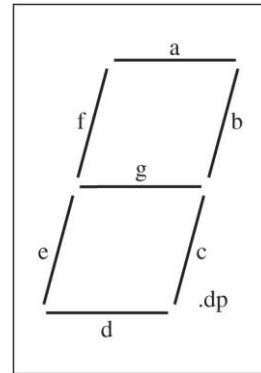   - Failure of Port or LED
  - Case-3
    - Not enough drive (1ma)
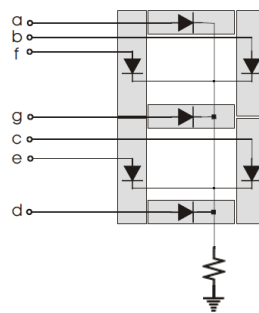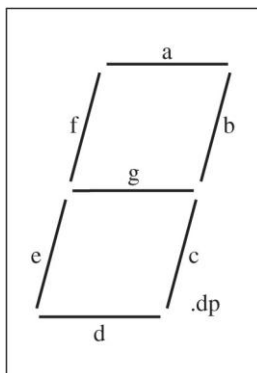   - LED too dim

Case 1

Case 2

Case 3

Display Design

- Seven-segment LEDs
  - Often used to display BCD numbers (1 through 9) and a few letters

  - A group of seven LEDs physically mounted in the shape of the number eight

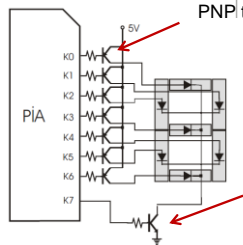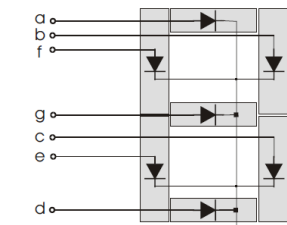 - Each LED is called a segment and labeled as 'a' through 'g'.

Display Design

Common Cathode
(Common Ground) Segments need
Logic High to display

- Two types of seven-segment LEDs
  - Common anode
  - Common cathode

Display Design

PNP transistor – Needs 0 to conduct

NPN transistor – Needs 1 to conduct

	K7	K6/d	K5/e	K4/c	K3/g	K2/f	K1/b	K0/a
0	1	0	0	0	1	0	0	0
1	1	1	1	0	1	1	0	1
2	1	0	0	1	0	1	0	0
3	1	0	1	0	0	1	0	0
4	1	1	1	0	0	0	0	1
5	1	0	1	0	0	0	1	0
6	1	0	0	0	0	0	1	0
7	1	1	1	0	1	1	0	0
8	1	0	0	0	0	0	0	0
9	1	1	1	0	0	0	0	0
A	1	1	0	0	0	0	0	0
C	1	0	0	1	0	1	0	0
E	1	0	0	1	0	0	1	0