I. Objectives

1. Understand the serial components used in the MTS-51 trainer.
2. Demonstrates the technique of output port expansion using 8051 serial port in mode 0.

II. Circuit Description

The MTS-51 trainer contains three serial components 74164, 74165, and RS-232. DIP switch SW1 is used to select the serial components connected to RXD (P3.0) and TXD (P3.1) pins.

Figure #1 shows the circuit of output port expansion. This circuit is used to demonstrate the application of 8051 UART operating in mode 0. The data is serially transmitted from 8051 serial port to the input of serial-in parallel-out shift register 74164. The parallel outputs of 74164 are connected to BCD-to-7-segment decoder 74LS47 to drive 7-segment display, and connected to buffer 74LS240 to drive LEDs.
Exercise#1

*Place SW1-1 and SW1-6 in ON position.*

*Functional Description:*

1. Sequentially turn on/off LEDs from left to right 4 times.
2. Sequentially turn on/off LEDs from right to left 4 times.
Source Program:

ORG 000H

MOV SCON,#00000000B ;SET MODE 0

START:

MOV R5,#4 ;SET COUNTER
MOV A,#00000001B

NR1:

RR A
MOV SBUF,A ;SEND DATA
JNB TI,$
CLR TI
CALL DELAY
JNB A.0,NR1
DJNZ R5,NR1

MOV R5,#4 ;SET COUNTER
MOV A,#10000000B

NL1:

RL A
MOV SBUF,A ;SEND DATA
JNB TI,$
CLR TI
CALL DELAY
JNB A.7,NL1
DJNZ R5,NL1

DELAY:

MOV R6,#200

DL1:

MOV R7,#249
DJNZ R7,$
DJNZ R6,DL1
RET
END
Program Description

Each byte of pattern data for LED control is sent through RXD to the serial in of SIPO shift register. To do so, three instructions are inserted into every instruction sequence for pattern data display.

- **MOV SBUF, A** ; used to transmit the pattern data through RXD
- **JNB TI, #** ; checks to whether the 8-bit pattern data is transmitted or not.
- **CLR TI** ; clears transmit interrupt flag for next data transmission.

8051 registers related to serial port:

Registers SBUF and SCON are the most important registers in UART operation.

1. **SBUF: Serial Data Buffer**

   The SBUF is actually two separate registers, one transmits buffer register and one receive buffer register. When a byte data is moved to SBUF, it goes to the transmit buffer where it is held for serial transmission. When a byte data is moved from SBUF, it comes from the receive buffer.

2. **SCON: Serial Port Control Register**

   The serial port control and status register SCON locates in the address 98H of SFR. Its bit diagram is shown below. This register contains not only the mode selection bits, but also the 9\(^{th}\) data bit for transmit and receive (TB8 and RB8), and the serial port interrupt bits (TI and RI).
1. SM0 (SCON.7): Serial port mode select bit 0

2. SM1 (SCON.6): Serial port mode select bit 1

There are four modes in UART operation specified by the bits SM0 and SM1. A table of mode 0 is shown below.

<table>
<thead>
<tr>
<th>SM0</th>
<th>SM1</th>
<th>Mode</th>
<th>Function</th>
<th>Baud Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Shift register</td>
<td>Fosc/12</td>
</tr>
</tbody>
</table>

Mode 0 is usually used to expand the I/O lines. *(For more details about mode 0 transmission, return to serial port modes pages (39-41))*

3. TI (SCON.1): Transmit interrupt flag

Set by hardware at the end of the 8th bit time in mode 0, or at the beginning of the stop bit in the other modes, in any serial transmission. *This flag must be cleared by software.*

4. RI (SCON.0): Receive interrupt flag

Set by hardware at the end of the 8th bit time in mode 0, or halfway through the stop bit time in the other modes, in any serial reception (except see SM2). *This flag must be cleared by software.*