inżynier przyszłości
Wzmocnienie potencjału dydaktycznego
Politechniki Poznańskiej

Marcin Rodziewicz

# INSTRUCTIONS FOR 8051 MICROCONTROLLER

Materiały dydaktyczne dzięki dofinansowaniu ze środków
Europejskiego Funduszu Społecznego dystrybuowane są bezpłatnie

KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

Projekt współfinansowany ze środków Unii Europejskiej w ramach Europejskiego Funduszu Społecznego

Poznan University of Technology
Faculty of Electronics and Telecommunications

# 8051 MICROCONTROLLER

## Sequential Keyboard and Timers

Poznań 2014

# 1. Introduction

## 1.1 Sequential Keyboard

The ports of the 8051 microcontroller can operate either as input or output ports. In reality, they are the so-called pseudo-bidirectional ports. When the ports are treated as an output, the program should be responsible for writing data to the ports registers. In the case of input port the state of the port informs which pins can be read for incoming data. The configuration of the pins of each port can be decided individually.

The port of the microcontroller is constructed in such a way that the state of the pins of the port can be externally changed to zero. Since after the RESET signal, all the pins of the ports are set to a high state, by default they are treated as input ports.

In the DSM-51 system, part of the P3 port is by default used as input pins. For instance, pin 5 (P3.5) is used for reading the state of the keyboard connected to the 7-segment display. This keyboard consists of 6 buttons: [↵], [Esc], [←], [→], [↑], [↓]. If each of these buttons was connected individually to the microcontroller, that would require six pins to be used as input. As it is pointed out above, in the DSM-51 evaluation board, only pin 5 of port 3 is used for this purpose. The keyboard connection to the 7-segment display allows for sequential checking of the state of the buttons. In fact, this way of connecting keyboards is very common in microprocessor systems. The selection of a button to read from is made by a buffer connected to a bus of the microcontroller. In the case of the DSM-51 system, it is the same buffer as the one used for the selection of a 7-segment display, i.e., the cursor select buffer. The result of this approach is that one can read the states of those buttons for which corresponding 7-segment displays are turned on. For example, if the first 7-segment display is turned on, one can read the state of the first button of the keyboard (in the DSM-51 case, that is the Enter key ([↵]). The mapping of each button to a corresponding cursor and bit in the cursor select buffer is shown in the table below.

Table 1.1.1

| Cursor select bi | Active button |
|---|---|
| 0 | [↵] |
| 1 | [Esc] |
| 2 | [→] |
| 3 | [↑] |
| 4 | [↓] |
| 5 | [←] |
| 6 | |

P1.6 - Activation/Deactivation of the sequential keyboard.
0FF30H - Address of the cursor select buffer.

## 1.2 Microcontroller Timers

The 8051 microcontroller is equipped with two 16-bit timers/counters. In the timer mode of the operation, the timer counts the impulses coming from the quartz oscillator divided by 12. In the counter mode of operation, the timer counts the impulses coming from the input pins of the microcontroller. The 16-bit resolution of the timers means that the maximum value that can be stored in the counter is 65535 ($2^{16} - 1$). The overflow of a timer, i.e., the transition from the FFFFH state to the 0000H state, is indicated by an appropriate flag. The flag of a timer is also used to trigger an interrupt. Th initial state of a timer can be manually adjusted by writing to its registers. This way, a timer can be used for counting elapsed time.

As it was mentioned, the timers can work as counters that count impulses coming from input pins of the microcontroller. In the case of the 8051 microcontroller, Timer 0 is connected to pin 4 of port 3 (also known as T0) and Timer 1 is connected to pin 5 of port 3 (also known as T1).

In the DSM-51 evaluation board, T1 pin is also connected to the sequential keyboard of the 7-segment display (as described in section 1). By using the keys of this keyboard, one can trigger impulses on pin T1. Therefore, the number of impulses can be counted by Timer 1.

The registers used by the timers are located within the special function registers area. This includes:

**TL0** - lower byte of Timer 0
**TH0** - higher byte of Timer 0
**TL1** - lower byte of Timer 1
**TH1** - higher byte of Timer 1
**TMOD** - register that sets the mode of the timers
**TCON**- register that controls the operation of the timers.

In the TMOD register, four lower bits are responsible for setting the mode of operation for Timer 0, whereas the higher four bits are responsible for the mode of Timer 1.

| Timer 1 | | | | Timer 0 | | | |
|---|---|---|---|---|---|---|---|
| GATE | C/$\overline{T}$ | M1 | M0 | GATE | C/$\overline{T}$ | M1 | M0 |

Figure 1.2.1

The C/$\overline{T}$ bit determines the mode of operation either as a timer, or a counter. Low state indicates the timer mode and high state indicate counter mode.

The GATE bit determines the means of control of a timer. Low state indicates that the start/stop of a timer is determined by the TRx bit of TCON register. High state indicates that, additionally, the state of the INTx pin is taken into account.

The M1 and M0 bits sets the mode (0-3) of a timer.

The TCON register contains four bits, two bits for each timer, which controls the timers.

**TRx** 1 – timer start,
0 – timer stop.

**TFx** Overflow flag. Automatically set to 1 in the overflow event.

The timers of the 8051 microcontroller can operate in four different modes:

Mode 0 – in this mode, the timer operates as a 13-bit register (5 bits of the TLx register and 8 bits of the THx register). In fact, the TLx register is still a 8-bit register and it counts on 8-bits. However, the carry from the TLx register to the THx register is triggered by the overflow of the lower 5-bits of the TLx register. A timer configured in this mode can count to 8191 (8192 impulses).

Mode 1 – in this mode, the timer operates as a full 16-bit register. The overflow flag is set when the timer counts 65536 impulses.

Mode 2 – in this mode, the timer operates as an 8-bit register. Only the lower part of the timer is used. The overflow flag is set after counting 256 impulses in the TLx. In the overflow event, the lower part of the timer is loaded with the value stored in the THx register. For example, by writing 256 – 10 value to the THx register, one can achieve the period of the overflow event of 10 impulses.
Mode 3 – this mode configures timer 0, so that registers TL0 and TH0 operate as separate 8-bit timers. This mode is provided for applications requiring an additional 8-bit timer or counter. TL0 uses the timer 0 control bits C/T0 and GATE0 in the TMOD register, and TR0 and TF0 in the TCON register in a normal manner. TH0 is locked into a timer function (counting $f_{osc}/6$) and takes over the use of the timer 1 interrupt (TF1) and run control (TR1) bits. Thus, the operation of timer 1 is restricted when timer 0 is in mode 3. Placing Timer 1 in mode 3 causes it to halt and hold its count. This can be used to halt Timer 1 when TR1 run control bit is not available, i.e., when Timer 0 is in mode 3.

## 2. Exercise

Write an „event counter” program that demonstrates all four modes of 8051 microcontroller timers. The program should be able to count how many times a button of the sequential keyboard was pressed.
In the program:

- choose and configure an appropriate timer,
- activate one button of the sequential keyboard,
- each button press should increment the value held by the timer. This value should be displayed on the LCD of the DSM-51 evaluation board.

The program should work in all four operation modes of the timer.