Architetture dei Sistemi Di Elaborazione	Delivery date: 14th December 2023
Laboratory 8	Expected delivery of lab_08.zip must include: - zipped project folders for Exercise1, Exercise2 - this lab track completed and converted to pdf format.

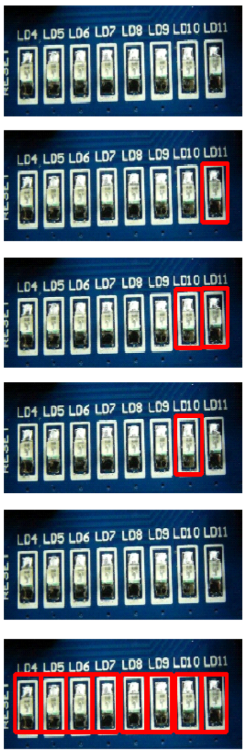
Exercise 1)

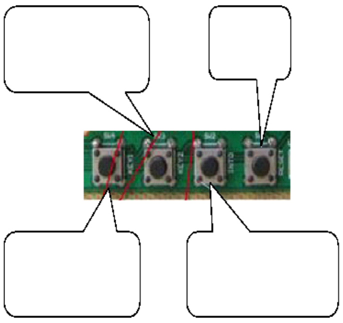
- Download the **template project** for Keil µVision "***03_sample_BUTTON_LED***" from the course material.

Implement an 8-bit "signed counter" by using LANDTIGER board; the software permits to use buttons to update a counting value which could be either positive or negative, and the LEDs to show the current value. By first using emulation capabilities (later, move your firmware on the board), please implement the following functionalities:

- increment a variable every time the button KEY1 is pressed
- decrement when KEY2 if pressed (in case, go to negative number)
- reset the count when INT0 is pressed.

LEDs are showing the current count in a binary, 2's complement representation.





HINT: It could be useful to use a global variable to keep the information about turned ON LEDs. For example, using a variable called "`char led_value`", already available in the project.

Q1: Do you observe any unexpected behaviour on the board with respect to SW emulation? Please describe.
Yes, sometimes the value displayed on LEDs is not consistent with the expected outcome. This is due to the **bouncing** phenomenon, that is, it's as if the key gets pressed multiple times in a row rather than just once.

Exercise 2) Experiment the SVC instruction.

- Download the **template project** for Keil µVision “**01_SVC**” from the course material.
- You must execute the debug of the project on the LandTiger Board.

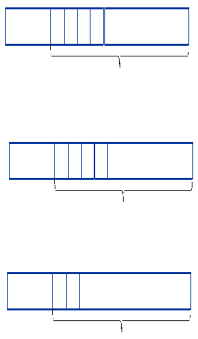
2.1) Write, compile, and execute a code that invokes an `SVC` instruction in the reset handler.

You must set the control to `user mode(unprivileged)`.

By means of invoking a SuperVisor Call, we want to implement a RESET, a NOP and a MEMCPY functions. The MEMCPY function is used to copy a block of data from a source address to a destination address and return information about the data transfer execution.

In the handler of `SVC`, the following functionalities are implemented according to the **`SVC` number**:

1. 0 to 7: RESET the content of register R?, where ? can assume values from 0 to 7
2. 8 to 15: NOP (no operation)
3. 64 to 127: the `SVC` call must implement a MEMCPY operation, with the following input parameters and return values:
   - o the 6 least significant bits of the SVC number indicates the number of bytes to move.
   - o source and destination start addresses of the areas to copy are 32 bits values passed through stack.
   - o by again using the stack, it returns the number of transferred bytes.



Example: the following `SVC` invokes MEMCPY from a given source to a destination

```
LDR   R0, SourceStartAddress
LDR   R1, DestinationStartAddress
PUSH  R0
PUSH  R1
SVC   0x48; 2_01001000 binary value of the SVC number
POP   R0
```

Q1: Describe how the stack structure is used by your project.
A1:
1. PUSH of R0-R1(parameters) into PSP(in case of MEMCPY)
2. PUSH of Stack frame(R0-R3,R12,LR,PC,xPSR) into PSP
3. PUSH of R0-R12,LR into MSP
4. POP of R0-R12,LR out of MSP
5. POP of Stack frame out of PSP
6. POP of R0 out of PSP(in case of MEMCPY)

Q2: What needs to be changed in the `SVC` handler if the access level of the caller is privileged? Please report a code chunk that solves this request.
A2:
The MSP must be used to retrieve the parameters(and store result) instead of the PSP.

Q3: Is the encoding of the SVC numbers complete? Please comment.
A3:
No, numbers from 16 to 63 and from 128 to 255 are not used.