Họ và tên: Bùi Vân Anh

MSSV: 20184026

Học phần: Thực hành kiến trúc máy tính

Mã lớp: 122032

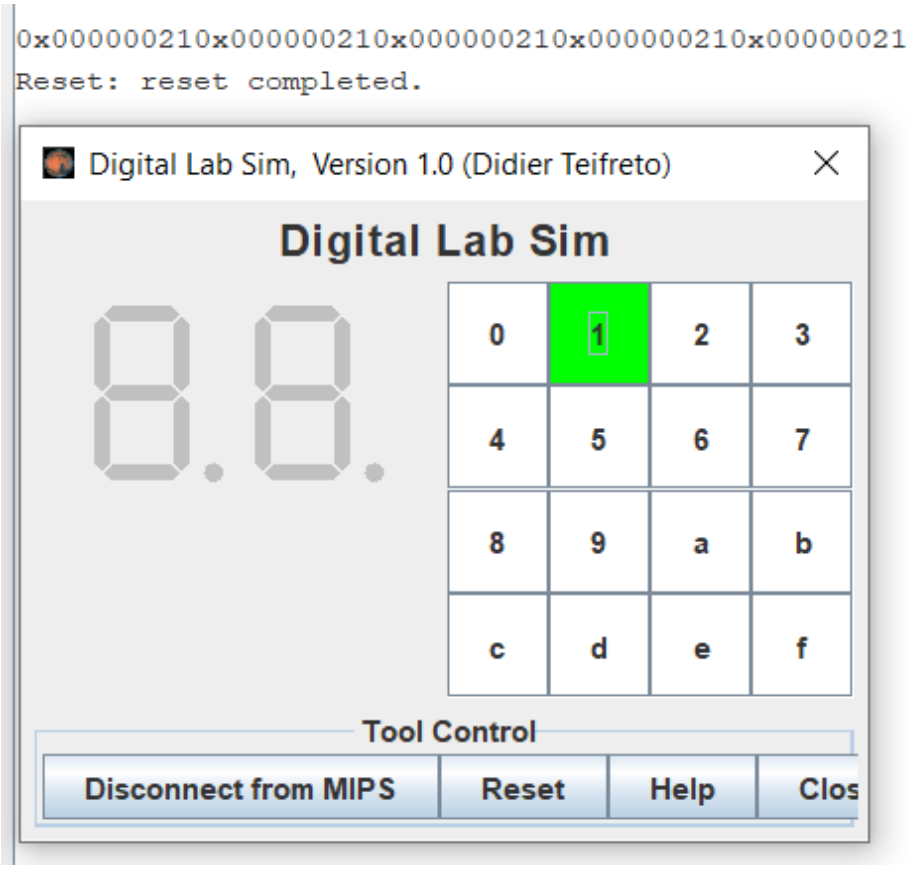
Báo cáo LAB11

1. **Assignment 1**

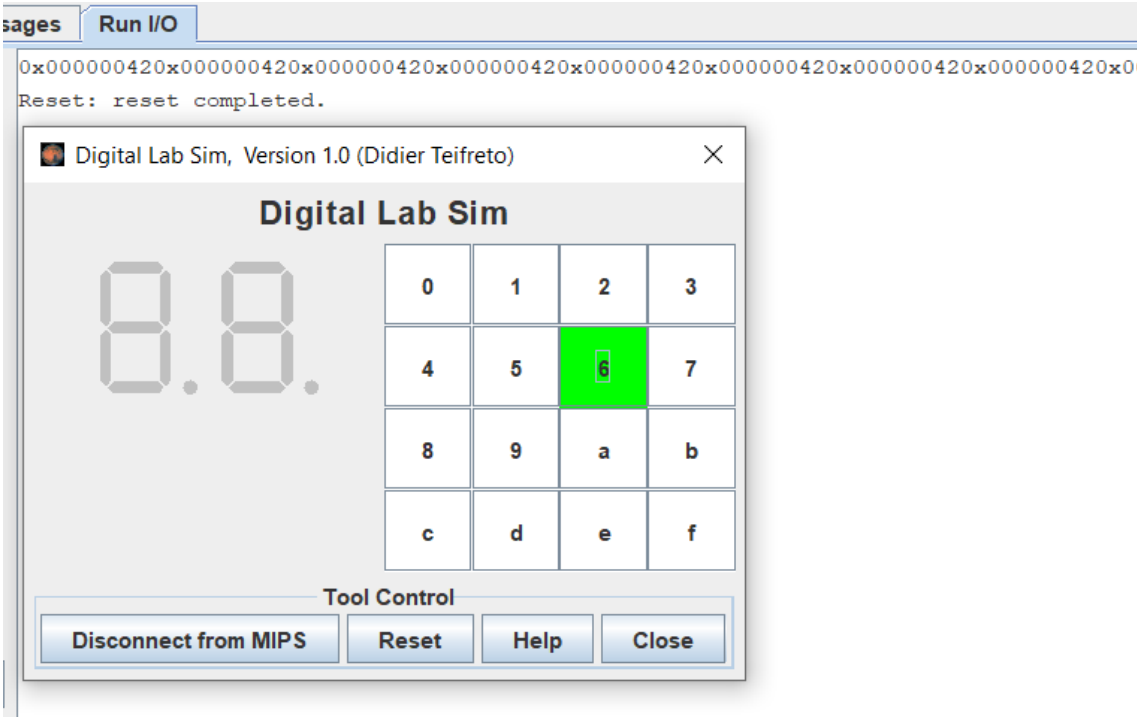
```
.eqv IN_ADRESS_HEXA_KEYBOARD 0xFFFF0012
.eqv OUT_ADRESS_HEXA_KEYBOARD 0xFFFF0014
.text
main:   li $t1, IN_ADRESS_HEXA_KEYBOARD
     li $t2, OUT_ADRESS_HEXA_KEYBOARD
     li $t3, 0x1     # check row 1 with key 0,1,2,3
     li $t4, 0x2     # check row 2 with key 4,5,6,7
     li $t5, 0x4     # check row 3 with key 8,9,a,b
     li $t6, 0x8     # check row 4 with key c,d,e,f
polling:
row1:
     sb $t3, 0($t1 ) # must reassign expected row
     lb $a0, 0($t2)  # read scan code of key button
     bnez $a0, print
row2:
     sb $t4, 0($t1 ) # must reassign expected row
     lb $a0, 0($t2)  # read scan code of key button
     bnez $a0, print
row3:
     sb $t5, 0($t1 ) # must reassign expected row
     lb $a0, 0($t2)  # read scan code of key button
     bnez $a0, print
row4:
     sb $t6, 0($t1 ) # must reassign expected row
     lb $a0, 0($t2)  # read scan code of key button
     bnez $a0, print
print:     li $v0, 34      # print integer (hexa)
     syscall
sleep:     li $a0, 100     # sleep 100ms
     li $v0, 32
     syscall
back_to_polling:
     j polling  # continue polling
```

Kết quả:

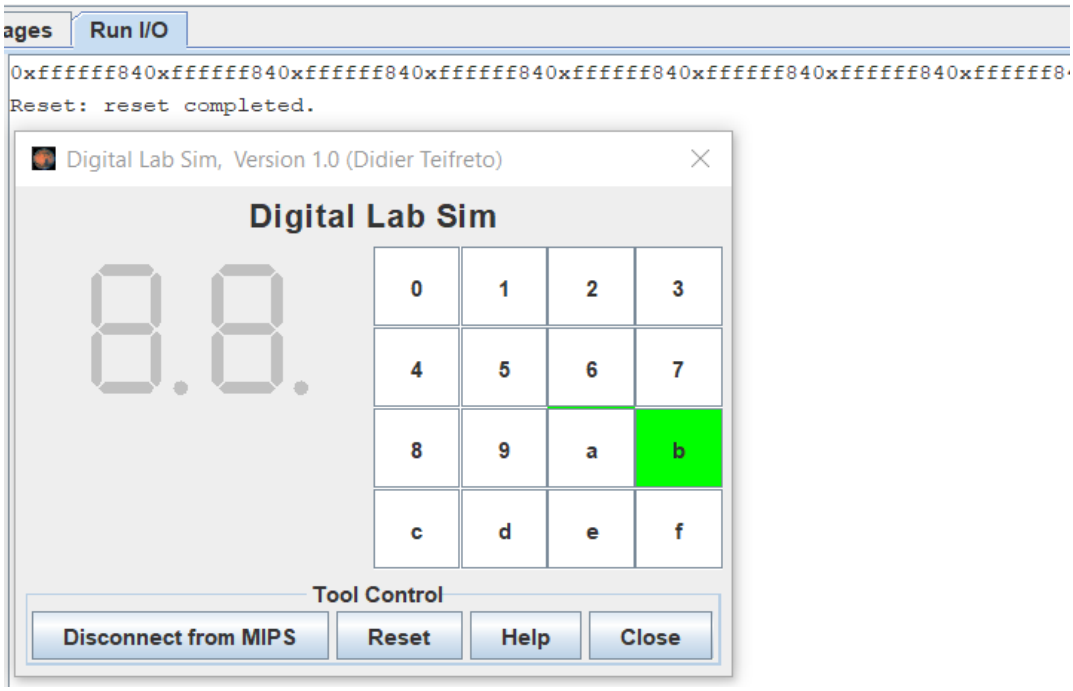
- Ấn số 1



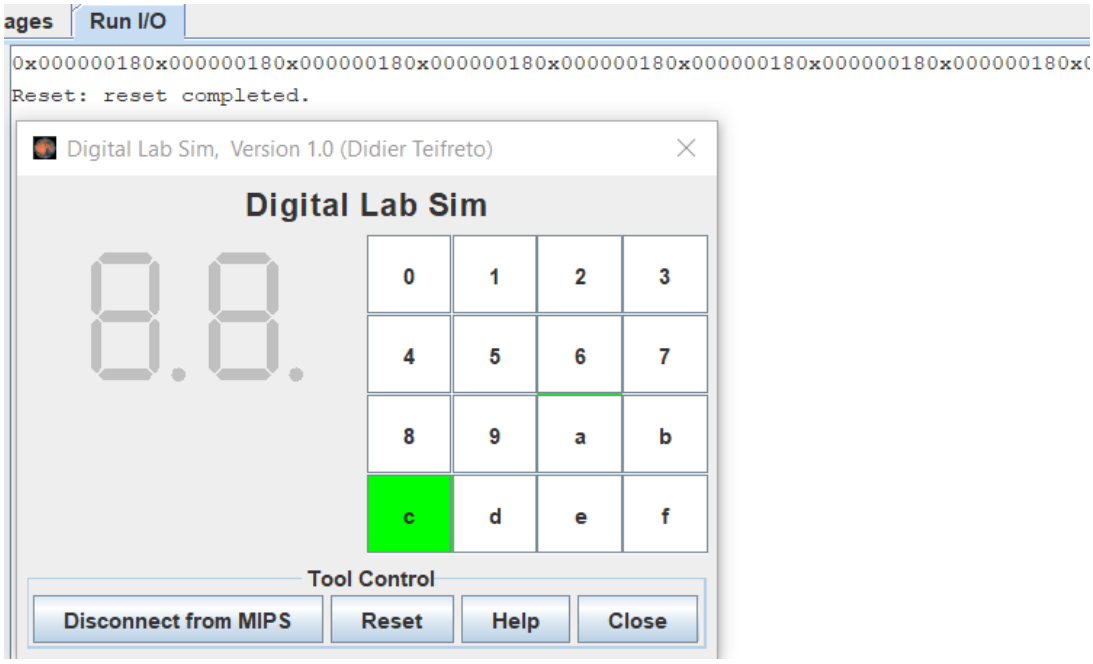
- Ấn số 6



- Ấn b


ages
Run I/O
0xffffff840xffffff840xffffff840xffffff840xffffff840xffffff840xffffff840xffffff8
Reset: reset completed.
Digital Lab Sim, Version 1.0 (Didier Teifreto)
Digital Lab Sim
0 1 2 3
4 5 6 7
8 9 a b
c d e f
Tool Control
Disconnect from MIPS
Reset
Help
Close

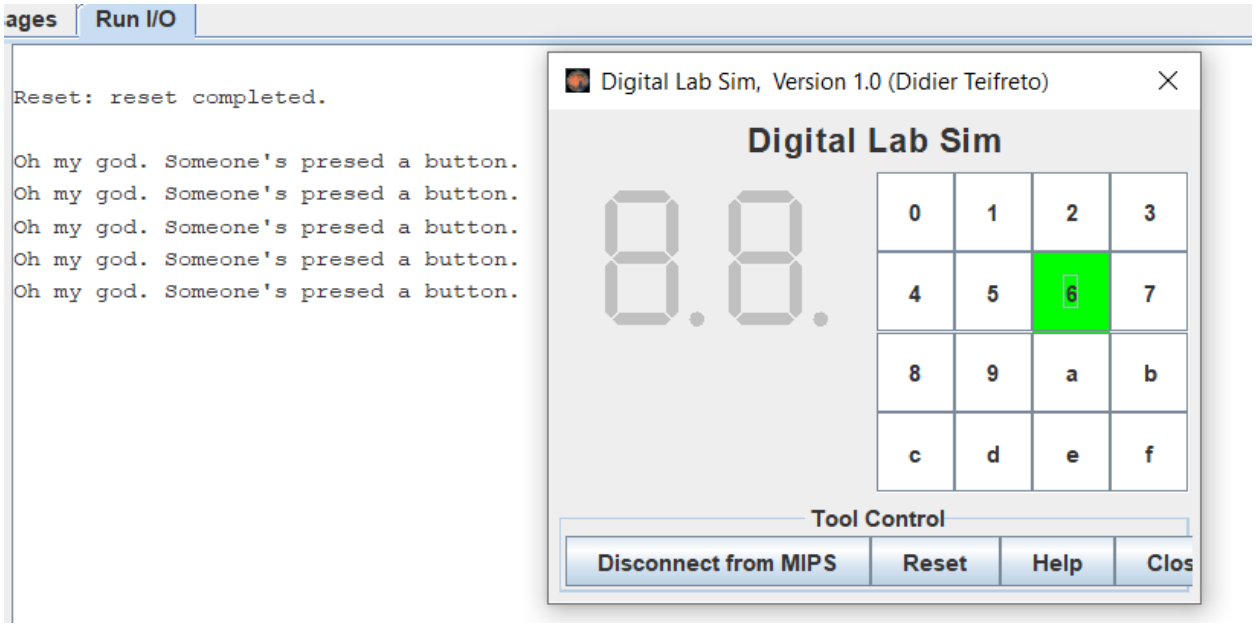
- Ấn c


ages
Run I/O
0x000000180x000000180x000000180x000000180x000000180x000000180x000000180x000000180x0
Reset: reset completed.
Digital Lab Sim, Version 1.0 (Didier Teifreto)
Digital Lab Sim
0 1 2 3
4 5 6 7
8 9 a b
c d e f
Tool Control
Disconnect from MIPS
Reset
Help
Close

2. **Assignment 2**

```
.eqv IN_ADRESS_HEXA_KEYBOARD 0xFFFF0012
.data
Message: .asciiz "Oh my god. Someone's pressed a button.\n"
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# MAIN Procedure
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
.text
main:
#-------------------------------------------------------
# Enable interrupts you expect
#-------------------------------------------------------
# Enable the interrupt of Keyboard matrix 4x4 of Digital Lab Sim
li $t1, IN_ADRESS_HEXA_KEYBOARD
li $t3, 0x80 # bit 7 of = 1 to enable interrupt
sb $t3, 0($t1)
#-------------------------------------------------------
# No-end loop, main program, to demo the effective of interrupt
#-------------------------------------------------------
Loop: nop
      nop
      nop
      nop
      b Loop # Wait for interrupt
end_main:
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# GENERAL INTERRUPT SERVED ROUTINE for all interrupts
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
.ktext 0x80000180
#-------------------------------------------------------
# Processing
#-------------------------------------------------------
IntSR: addi $v0, $zero, 4 # show message
      la $a0, Message
      syscall
#-------------------------------------------------------
# Evaluate the return address of main routine
# epc <= epc + 4
#-------------------------------------------------------
next_pc:mfc0 $at, $14 # $at <= Coproc0.$14 = Coproc0.epc
      addi $at, $at, 4 # $at = $at + 4 (next instruction)
      mtc0 $at, $14 # Coproc0.$14 = Coproc0.epc <= $at
return: eret # Return from exception
```

Kết quả:


ages
Run I/O
Reset: reset completed.
Oh my god. Someone's presed a button.
Oh my god. Someone's presed a button.
Oh my god. Someone's presed a button.
Oh my god. Someone's presed a button.
Oh my god. Someone's presed a button.
Digital Lab Sim, Version 1.0 (Didier Teifreto)
Digital Lab Sim
8.8.
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b
c
d
e
f
Tool Control
Disconnect from MIPS
Reset
Help
Clos

3. **Assignment 3**

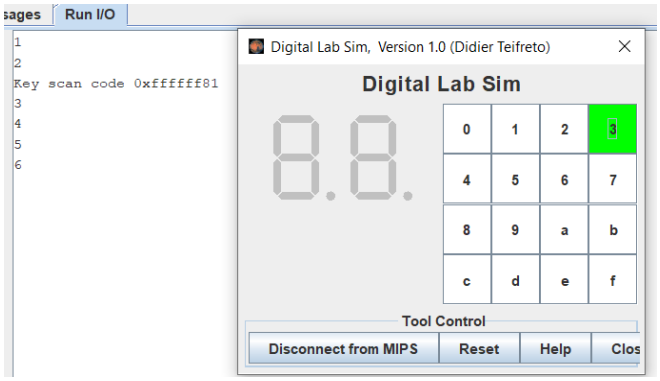
```
.eqv IN_ADRESS_HEXA_KEYBOARD 0xFFFF0012
.eqv OUT_ADRESS_HEXA_KEYBOARD 0xFFFF0014
.data
Message: .asciiz "Key scan code "
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# MAIN Procedure
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
.text
main:
      #---------------------------------------------------------
      # Enable interrupts you expect
      #---------------------------------------------------------
      # Enable the interrupt of Keyboard matrix 4x4 of Digital Lab Sim
      li $t1, IN_ADRESS_HEXA_KEYBOARD
      li $t3, 0x80 # bit 7 = 1 to enable
      sb $t3, 0($t1)
      #---------------------------------------------------------
      # Loop an print sequence numbers
      #---------------------------------------------------------
      xor $s0, $s0, $s0 # count = $s0 = 0
Loop:       addi $s0, $s0, 1 # count = count + 1
prn_seq:addi $v0,$zero,1
      add $a0,$s0,$zero # print auto sequence number
      syscall
prn_eol:addi $v0,$zero,11
      li $a0,'\n' # print endofline
      syscall
sleep:      addi $v0,$zero,32
      li $a0,300 # sleep 300 ms
      syscall
      nop # WARNING: nop is mandatory here.
      b Loop # Loop

end_main:
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# GENERAL INTERRUPT SERVED ROUTINE for all interrupts
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
.ktext 0x80000180
      #---------------------------------------------------------
      # SAVE the current REG FILE to stack
      #---------------------------------------------------------
IntSR:      addi $sp,$sp,4 # Save $ra because we may change it later
      sw $ra,0($sp)
      addi $sp,$sp,4 # Save $at because we may change it later
      sw $at,0($sp)
      addi $sp,$sp,4 # Save $sp because we may change it later
      sw $v0,0($sp)
      addi $sp,$sp,4 # Save $a0 because we may change it later
      sw $a0,0($sp)
      addi $sp,$sp,4 # Save $t1 because we may change it later
```

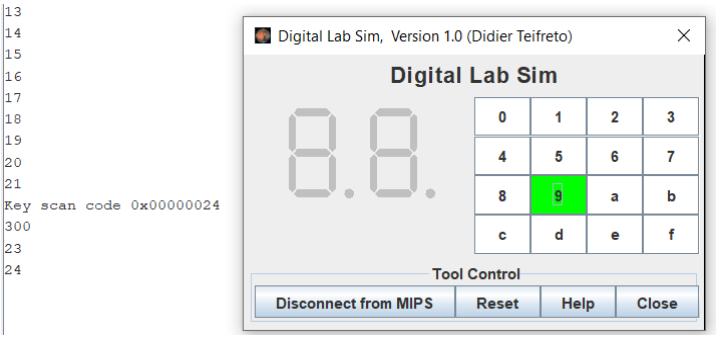
```
     sw $t1,0($sp)
     addi $sp,$sp,4 # Save $t3 because we may change it later
     sw $t3,0($sp)
     #-------------------------------------------------------
     # Processing
     #-------------------------------------------------------
prn_msg:addi $v0, $zero, 4
     la $a0, Message
     syscall
     li $t6, 0x1
     li $t3, 0x81 # check row 4 and re-enable bit 7
get_cod:li  $t1, IN_ADRESS_HEXA_KEYBOARD
     bgt $t3, 0x88, reset_getcod   # check row 4 and re-enable bit 7
     sb  $t3, 0($t1) # must reassign expected row
     li  $t1, OUT_ADRESS_HEXA_KEYBOARD
     lb  $a0, 0($t1)
     bnez $a0, prn_cod
     mul $t6, $t6, 2
     add $t3, $t6, 0x80
     j get_cod
prn_cod:li  $v0,34
     syscall
     li  $v0,11
     li  $a0,'\n' # print endofline
     syscall
     #-------------------------------------------------------
     # Evaluate the return address of main routine
     # epc <= epc + 4
     #-------------------------------------------------------
next_pc:mfc0 $at, $14 # $at <= Coproc0.$14 = Coproc0.epc
     addi $at, $at, 4 # $at = $at + 4 (next instruction)
     mtc0 $at, $14 # Coproc0.$14 = Coproc0.epc <= $at
     #-------------------------------------------------------
     # RESTORE the REG FILE from STACK
     #-------------------------------------------------------
restore:lw $t3, 0($sp) # Restore the registers from stack
     addi $sp,$sp,-4
     lw $t1, 0($sp) # Restore the registers from stack
     addi $sp,$sp,-4
     lw $a0, 0($sp) # Restore the registers from stack
     addi $sp,$sp,-4
     lw $v0, 0($sp) # Restore the registers from stack
     addi $sp,$sp,-4
     lw $ra, 0($sp) # Restore the registers from stack
     addi $sp,$sp,-4
     lw $ra, 0($sp) # Restore the registers from stack
     addi $sp,$sp,-4
return: eret    # Return from exception
reset_getcod:
     li  $t3, 0x81
     li  $t6, 0x1
     j get_cod
```

Kết quả:

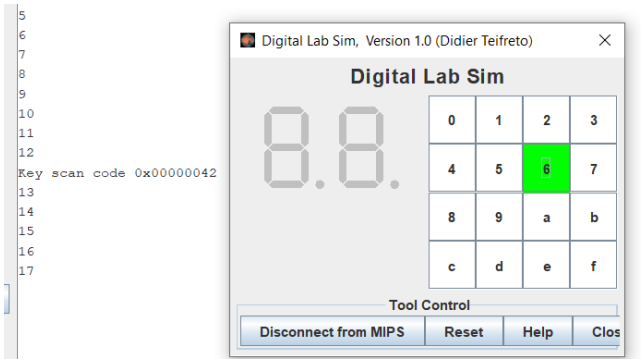
- Ấn 3



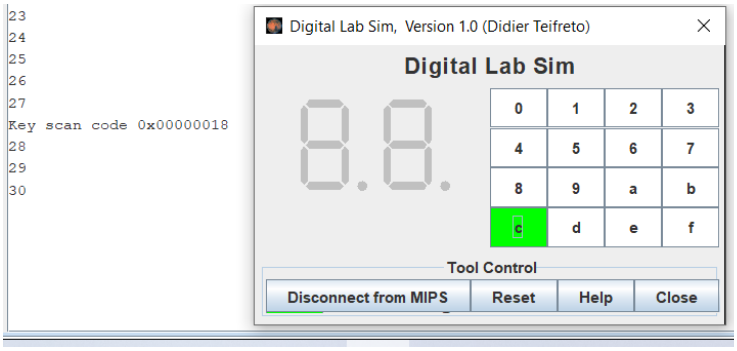
- Ấn 9



- Ấn 6



- Ấn c



4. **Assignment 4**

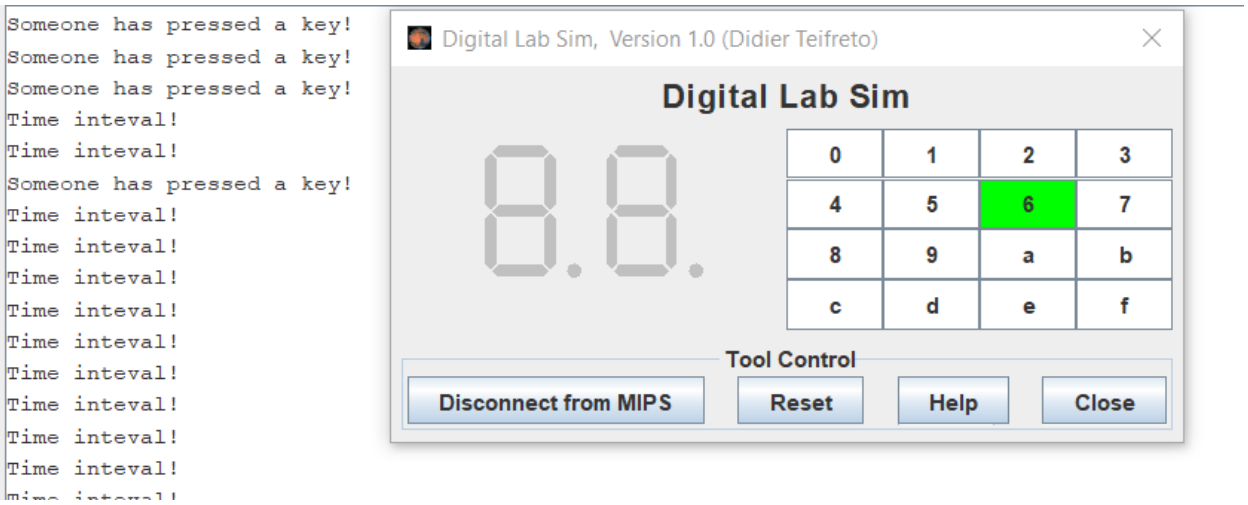
```
.eqv IN_ADRESS_HEXA_KEYBOARD 0xFFFF0012
.eqv COUNTER 0xFFFF0013 # Time Counter
.eqv MASK_CAUSE_COUNTER 0x00000400 # Bit 10: Counter interrupt
.eqv MASK_CAUSE_KEYMATRIX 0x00000800 # Bit 11: Key matrix interrupt

.data
msg_keypress: .asciiz "Someone has pressed a key!\n"
msg_counter: .asciiz "Time interval!\n"
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# MAIN Procedure
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
.text
main:
     #-------------------------------------------------------
     # Enable interrupts you expect
     #-------------------------------------------------------
     # Enable the interrupt of Keyboard matrix 4x4 of Digital Lab Sim
     li $t1, IN_ADRESS_HEXA_KEYBOARD
     li $t3, 0x80 #
     sb $t3, 0($t1)
     # Enable the interrupt of TimeCounter of Digital Lab Sim
     li $t1, COUNTER
     sb $t1, 0($t1)
     #-------------------------------------------------------
     # Loop an print sequence numbers
     #-------------------------------------------------------
Loop:      nop
     nop
     nop
sleep:     addi $v0,$zero,32 # BUG: must sleep to wait for Time Counter
     li $a0,200 # sleep 300 ms
     syscall
     nop # WARNING: nop is mandatory here.
     b Loop
     end_main:
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
# GENERAL INTERRUPT SERVED ROUTINE for all interrupts
#~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

.ktext 0x80000180
IntSR:     #-------------------------------------------------------
     # Temporary disable interrupt
     #-------------------------------------------------------
dis_int:li $t1, COUNTER # BUG: must disable with Time Counter
     sb $zero, 0($t1)
     # no need to disable keyboard matrix interrupt
     #-------------------------------------------------------
     # Processing
     #-------------------------------------------------------
get_caus: mfc0 $t1, $13 # $t1 = Coproc0.cause
```

```
IsCount:  li $t2, MASK_CAUSE_COUNTER# if Cause value confirm Counter..
          and $at, $t1,$t2
          beq $at,$t2, Counter_Intr
IsKeyMa:  li $t2, MASK_CAUSE_KEYMATRIX # if Cause value confirm Key..
        and $at, $t1,$t2
        beq $at,$t2, Keymatrix_Intr
others:   j end_process # other cases
Keymatrix_Intr: li $v0, 4 # Processing Key Matrix Interrupt
           la $a0, msg_keypress
           syscall
           j end_process
Counter_Intr:   li $v0, 4 # Processing Counter Interrupt
           la $a0, msg_counter
           syscall
           j end_process
end_process:
      mtc0 $zero, $13 # Must clear cause reg
en_int: #-----------------------------------------------------------
      # Re-enable interrupt
      #-----------------------------------------------------------
      li $t1, COUNTER
      sb $t1, 0($t1)
      #-----------------------------------------------------------
      # Evaluate the return address of main routine
      # epc <= epc + 4
      #-----------------------------------------------------------
next_pc:mfc0 $at, $14 # $at <= Coproc0.$14 = Coproc0.epc
      addi $at, $at, 4 # $at = $at + 4 (next instruction)
      mtc0 $at, $14 # Coproc0.$14 = Coproc0.epc <= $at
return: eret # Return from exception
```

Kết quả:



5. **Assignment 5**

```
.eqv KEY_CODE 0xFFFF0004   # ASCII code from keyboard, 1 byte
.eqv KEY_READY 0xFFFF0000  # =1 if has a new keycode ?
# Auto clear after lw
.eqv DISPLAY_CODE 0xFFFF000C     # ASCII code to show, 1 byte
.eqv DISPLAY_READY 0xFFFF0008    # =1 if the display has already to do
                     # Auto clear after sw
.eqv MASK_CAUSE_KEYBOARD 0x0000034 # Keyboard Cause
.text
                li $k0, KEY_CODE
                li $k1, KEY_READY
                li $s0, DISPLAY_CODE
                li $s1, DISPLAY_READY
loop:           nop
WaitForKey:     lw $t1, 0($k1)  # $t1 = [$k1] = KEY_READY
                beq $t1, $zero, WaitForKey # if $t1 == 0 then Polling
MakeIntR:       teqi $t1, 1     # if $t0 = 1 then raise an Interrupt
                j loop
#--------------------------------------------------------------
# Interrupt subroutine
#--------------------------------------------------------------
.ktext 0x80000180
get_caus:  mfc0 $t1, $13   # $t1 = Coproc0.cause
IsCount:   li $t2, MASK_CAUSE_KEYBOARD# if Cause value confirm Keyboard..
           and $at, $t1,$t2
           beq $at,$t2, Counter_Keyboard
           j end_process
Counter_Keyboard:
ReadKey:   lw $t0, 0($k0)  # $t0 = [$k0] = KEY_CODE
WaitForDis:lw $t2, 0($s1)  # $t2 = [$s1] = DISPLAY_READY
           beq $t2, $zero, WaitForDis # if $t2 == 0 then Polling
Encrypt:   addi $t0, $t0, 1 # change input key
ShowKey:   sw $t0, 0($s0)  # show key
           nop
end_process:
next_pc:   mfc0 $at, $14   # $at <= Coproc0.$14 = Coproc0.epc
           addi $at, $at, 4 # $at = $at + 4 (next instruction)
           mtc0 $at, $14   # Coproc0.$14 = Coproc0.epc <= $at
return:    eret       # Return from exception
```