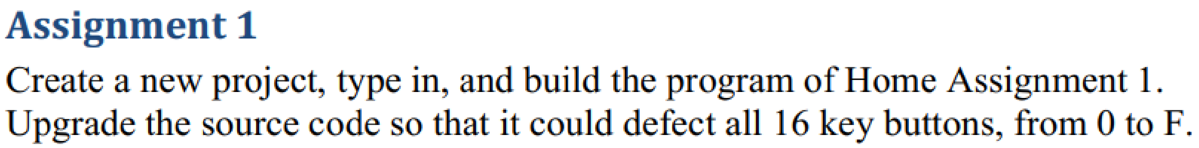
Báo cáo thực hành KTMT

HỌ VÀ TÊN: LÊ ANH DŨNG

MSSV: 20194522



Assignment 1

Create a new project, type in, and build the program of Home Assignment 1. Upgrade the source code so that it could defect all 16 key buttons, from 0 to F.

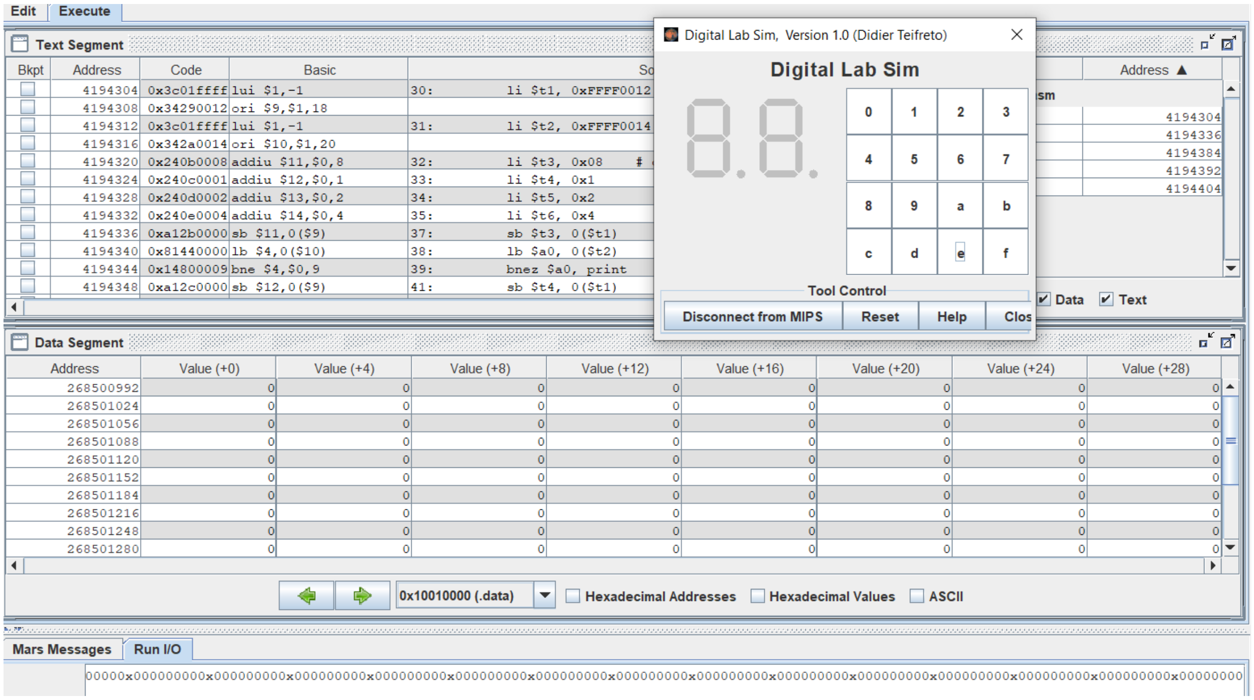
CODE:

```
#-----------------------------------------------------
#             col 0x1 col 0x2 col 0x4 col 0x8
#
# row 0x1     0       1       2       3
#             0x11    0x21    0x41    0x81
#
# row 0x2     4       5       6       7
#             0x12    0x22    0x42    0x82
#
# row 0x4     8       9       a       b
#             0x14    0x24    0x44    0x84
#
# row 0x8     c       d       e       f
#             0x18    0x28    0x48    0x88
#
#-----------------------------------------------------
# command row number of hexadecimal keyboard (bit 0 to 3)
# Eg. assign 0x1, to get key button 0,1,2,3
# assign 0x2, to get key button 4,5,6,7
# NOTE must reassign value for this address before reading,
# eventhough you only want to scan 1 row
```

```
.eqv IN_ADRESS_HEXA_KEYBOARD 0xFFFF0012
# receive row and column of the key pressed, 0 if not key pressed
# Eg. equal 0x11, means that key button 0 pressed.
# Eg. equal 0x28, means that key button D pressed.
.eqv OUT_ADRESS_HEXA_KEYBOARD 0xFFFF0014

.text
main:
        li $t1, IN_ADRESS_HEXA_KEYBOARD
        li $t2, OUT_ADRESS_HEXA_KEYBOARD
        li $t3,   0x08     # check row 4 with key C, D, E, F
        li $t4, 0x1
        li $t5, 0x2
        li $t6, 0x4
polling:
        sb $t3, 0($t1)          # must reassign expected row
        lb $a0, 0($t2)          # read scan code of key button
        bnez $a0, print

        sb $t4, 0($t1)          # must reassign expected row
        lb $a0, 0($t2)          # read scan code of key button
        bnez $a0, print

        sb $t5, 0($t1)          # must reassign expected row
        lb $a0, 0($t2)          # read scan code of key button
        bnez $a0, print

        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:



Text Segment

Bkpt	Address	Code	Basic	So
□	4194304	0x3c01ffff	lui $1,-1	30: li $t1, 0xFFFF0012
□	4194308	0x34290012	ori $9,$1,18	
□	4194312	0x3c01ffff	lui $1,-1	31: li $t2, 0xFFFF0014
□	4194316	0x342a0014	ori $10,$1,20	
□	4194320	0x240b0008	addiu $11,$0,8	32: li $t3, 0x08 #
□	4194324	0x240c0001	addiu $12,$0,1	33: li $t4, 0x1
□	4194328	0x240d0002	addiu $13,$0,2	34: li $t5, 0x2
□	4194332	0x240e0004	addiu $14,$0,4	35: li $t6, 0x4
□	4194336	0xa12b0000	sb $11,0($9)	37: sb $t3, 0($t1)
□	4194340	0x81440000	lb $4,0($10)	38: lb $a0, 0($t2)
□	4194344	0x14800009	bne $4,$0,9	39: bnez $a0, print
□	4194348	0xa12c0000	sb $12,0($9)	41: sb $t4, 0($t1)

	Address ▲
sm	
	4194304
	4194336
	4194384
	4194392
	4194404

☑ Data ☑ Text

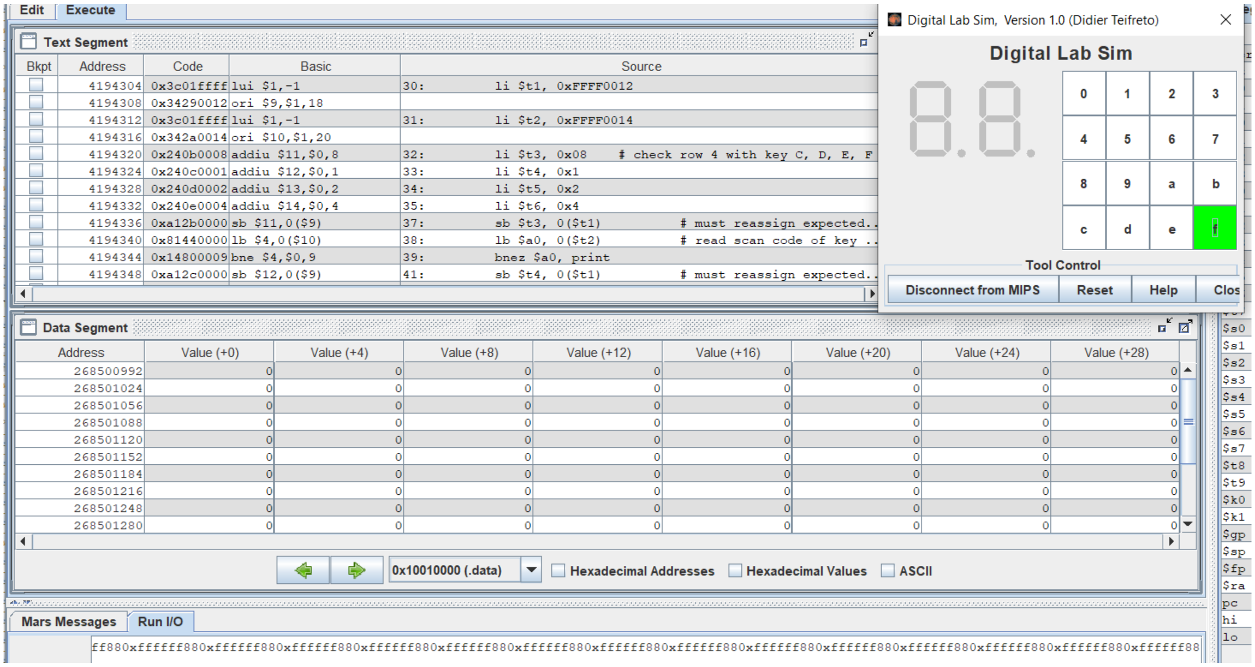
Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+12)	Value (+16)	Value (+20)	Value (+24)	Value (+28)
268500992	0	0	0	0	0	0	0	0
268501024	0	0	0	0	0	0	0	0
268501056	0	0	0	0	0	0	0	0
268501088	0	0	0	0	0	0	0	0
268501120	0	0	0	0	0	0	0	0
268501152	0	0	0	0	0	0	0	0
268501184	0	0	0	0	0	0	0	0
268501216	0	0	0	0	0	0	0	0
268501248	0	0	0	0	0	0	0	0
268501280	0	0	0	0	0	0	0	0

0x10010000 (.data) □ Hexadecimal Addresses □ Hexadecimal Values □ ASCII

Mars Messages | Run I/O

```
00000x000000000x000000000x000000000x000000000x000000000x000000000x000000000x000000000x000000000x000000000x000000000x000000000x000000000x00000000
```



Text Segment

Bkpt	Address	Code	Basic	Source
□	4194304	0x3c01ffff	lui $1,-1	30: li $t1, 0xFFFF0012
□	4194308	0x34290012	ori $9,$1,18	
□	4194312	0x3c01ffff	lui $1,-1	31: li $t2, 0xFFFF0014
□	4194316	0x342a0014	ori $10,$1,20	
□	4194320	0x240b0008	addiu $11,$0,8	32: li $t3, 0x08 # check row 4 with key C, D, E, F
□	4194324	0x240c0001	addiu $12,$0,1	33: li $t4, 0x1
□	4194328	0x240d0002	addiu $13,$0,2	34: li $t5, 0x2
□	4194332	0x240e0004	addiu $14,$0,4	35: li $t6, 0x4
□	4194336	0xa12b0000	sb $11,0($9)	37: sb $t3, 0($t1) # must reassign expected..
□	4194340	0x81440000	lb $4,0($10)	38: lb $a0, 0($t2) # read scan code of key ..
□	4194344	0x14800009	bne $4,$0,9	39: bnez $a0, print
□	4194348	0xa12c0000	sb $12,0($9)	41: sb $t4, 0($t1) # must reassign expected..

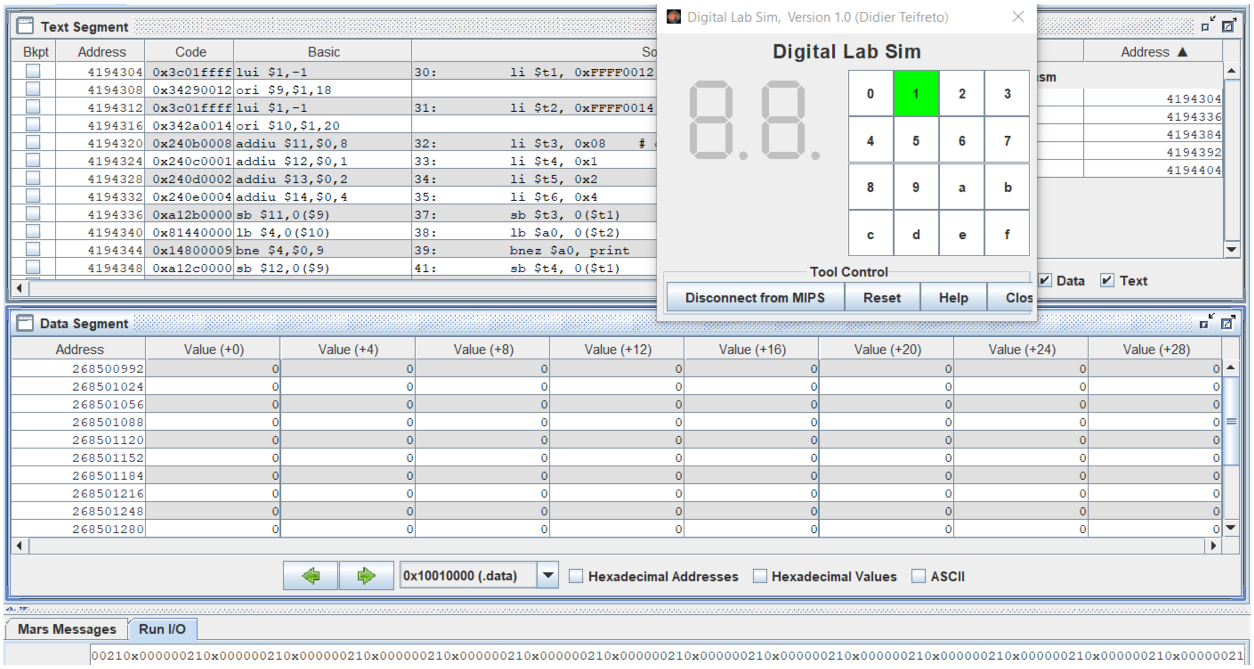
Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+12)	Value (+16)	Value (+20)	Value (+24)	Value (+28)
268500992	0	0	0	0	0	0	0	0
268501024	0	0	0	0	0	0	0	0
268501056	0	0	0	0	0	0	0	0
268501088	0	0	0	0	0	0	0	0
268501120	0	0	0	0	0	0	0	0
268501152	0	0	0	0	0	0	0	0
268501184	0	0	0	0	0	0	0	0
268501216	0	0	0	0	0	0	0	0
268501248	0	0	0	0	0	0	0	0
268501280	0	0	0	0	0	0	0	0

0x10010000 (.data) □ Hexadecimal Addresses □ Hexadecimal Values □ ASCII

Mars Messages | Run I/O

```
ff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff880xffffff88
```



Text Segment

Bkpt	Address	Code	Basic	So
□	4194304	0x3c01ffff	lui $1,-1	30: li $t1, 0xFFFF0012
□	4194308	0x34290012	ori $9,$1,18	
□	4194312	0x3c01ffff	lui $1,-1	31: li $t2, 0xFFFF0014
□	4194316	0x342a0014	ori $10,$1,20	
□	4194320	0x240b0008	addiu $11,$0,8	32: li $t3, 0x08 #
□	4194324	0x240c0001	addiu $12,$0,1	33: li $t4, 0x1
□	4194328	0x240d0002	addiu $13,$0,2	34: li $t5, 0x2
□	4194332	0x240e0004	addiu $14,$0,4	35: li $t6, 0x4
□	4194336	0xa12b0000	sb $11,0($9)	37: sb $t3, 0($t1)
□	4194340	0x81440000	lb $4,0($10)	38: lb $a0, 0($t2)
□	4194344	0x14800009	bne $4,$0,9	39: bnez $a0, print
□	4194348	0xa12c0000	sb $12,0($9)	41: sb $t4, 0($t1)

Data Segment

Address	Value (+0)	Value (+4)	Value (+8)	Value (+12)	Value (+16)	Value (+20)	Value (+24)	Value (+28)
268500992	0	0	0	0	0	0	0	0
268501024	0	0	0	0	0	0	0	0
268501056	0	0	0	0	0	0	0	0
268501088	0	0	0	0	0	0	0	0
268501120	0	0	0	0	0	0	0	0
268501152	0	0	0	0	0	0	0	0
268501184	0	0	0	0	0	0	0	0
268501216	0	0	0	0	0	0	0	0
268501248	0	0	0	0	0	0	0	0
268501280	0	0	0	0	0	0	0	0

0x10010000 (.data) □ Hexadecimal Addresses □ Hexadecimal Values □ ASCII

Mars Messages | Run I/O

```
00210x000000210x000000210x000000210x000000210x000000210x000000210x000000210x000000210x000000210x000000210x000000210x000000210x000000210x00000021
```

- **Các giá trị 0x1, 0x2, 0x4, 0x8 tương ứng với các row 1,2,3,4 trong digital lab slim và trong mỗi row, $a0 nhận được pressed (giá trị khác 0) thì sẽ được in ra màn hình console.**

Assignment 2

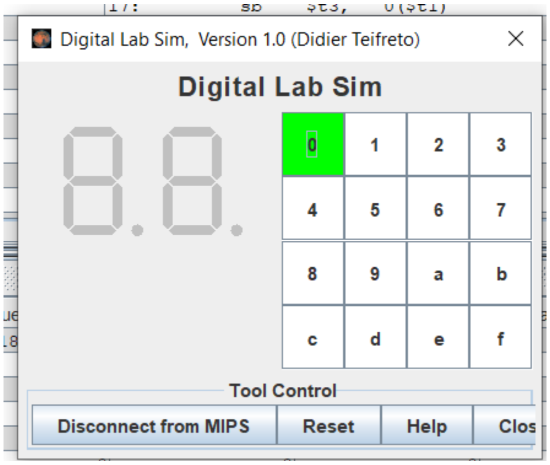
Create a new project, type in, and build the program of Home Assignment 2.

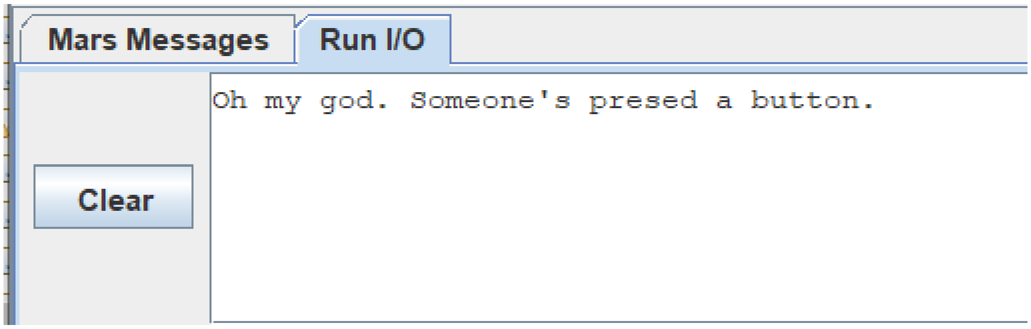
CODE:

```
.eqv IN_ADRESS_HEXA_KEYBOARD 0xFFFF0012


.data
Message: .asciiz "Oh my god. Someone's presed 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:





```
Oh my god. Someone's presed a button.
```

Assignment 3

Create a new project, type in, and build the program of Home Assignment 3. Upgrade the source code so that it could defect all 16 key buttons, from 0 to F.

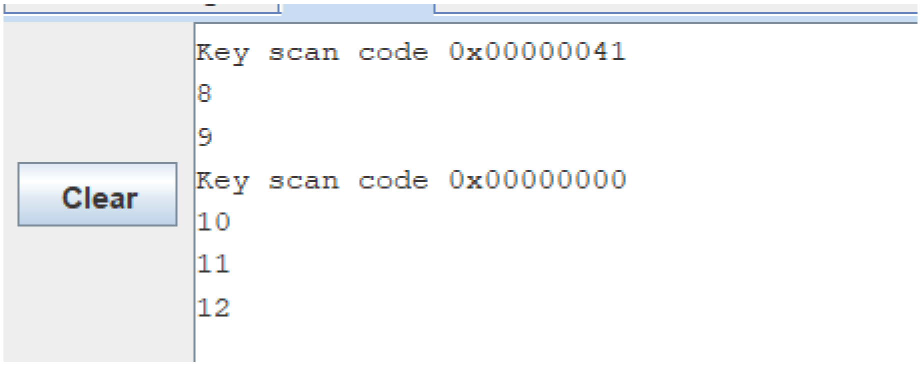
```
CODE:

.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               # print endofline
        li $a0,'\n'
        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
get_cod:
        li $t1, IN_ADRESS_HEXA_KEYBOARD
        li $t3, 0x88                    # 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

        li $t1, IN_ADRESS_HEXA_KEYBOARD
        li $t3, 0x81                      # check row 1 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

        li $t1, IN_ADRESS_HEXA_KEYBOARD
        li $t3, 0x82                      # 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

        li $t1, IN_ADRESS_HEXA_KEYBOARD
        li $t3, 0x84                      # 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

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
```

KẾT QUẢ:



```
Key scan code 0x00000041
8
9
Key scan code 0x00000000
10
11
12
```

Assignment 4

Create a new project, type in, and build the program of Home Assignment 4.

CODE:

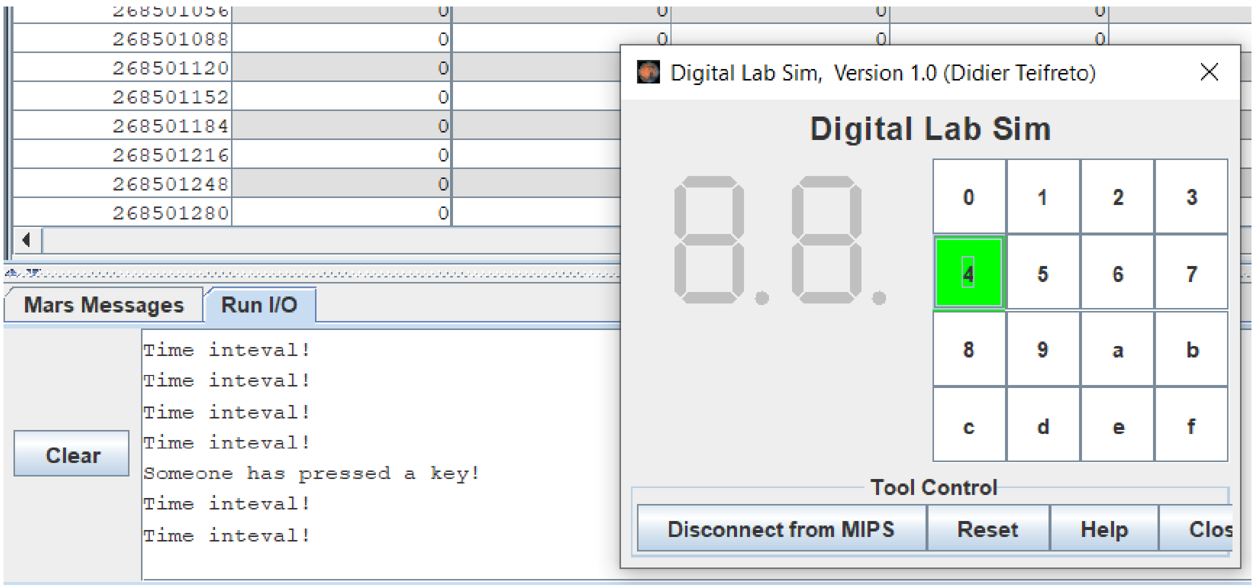
```
.eqv IN_ADRESS_HEXA_KEYBOARD 0xFFFF0012
.eqv COUNTER 0xFFFF0013                    # Time Counter

.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 inteval!\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 = 1 to enable
```

```
        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:



268501056	0	0	0	0
268501088	0	0	0	0
268501120	0			
268501152	0			
268501184	0			
268501216	0			
268501248	0			
268501280	0			

```
Time inteval!
Time inteval!
Time inteval!
Time inteval!
Someone has pressed a key!
Time inteval!
Time inteval!
```

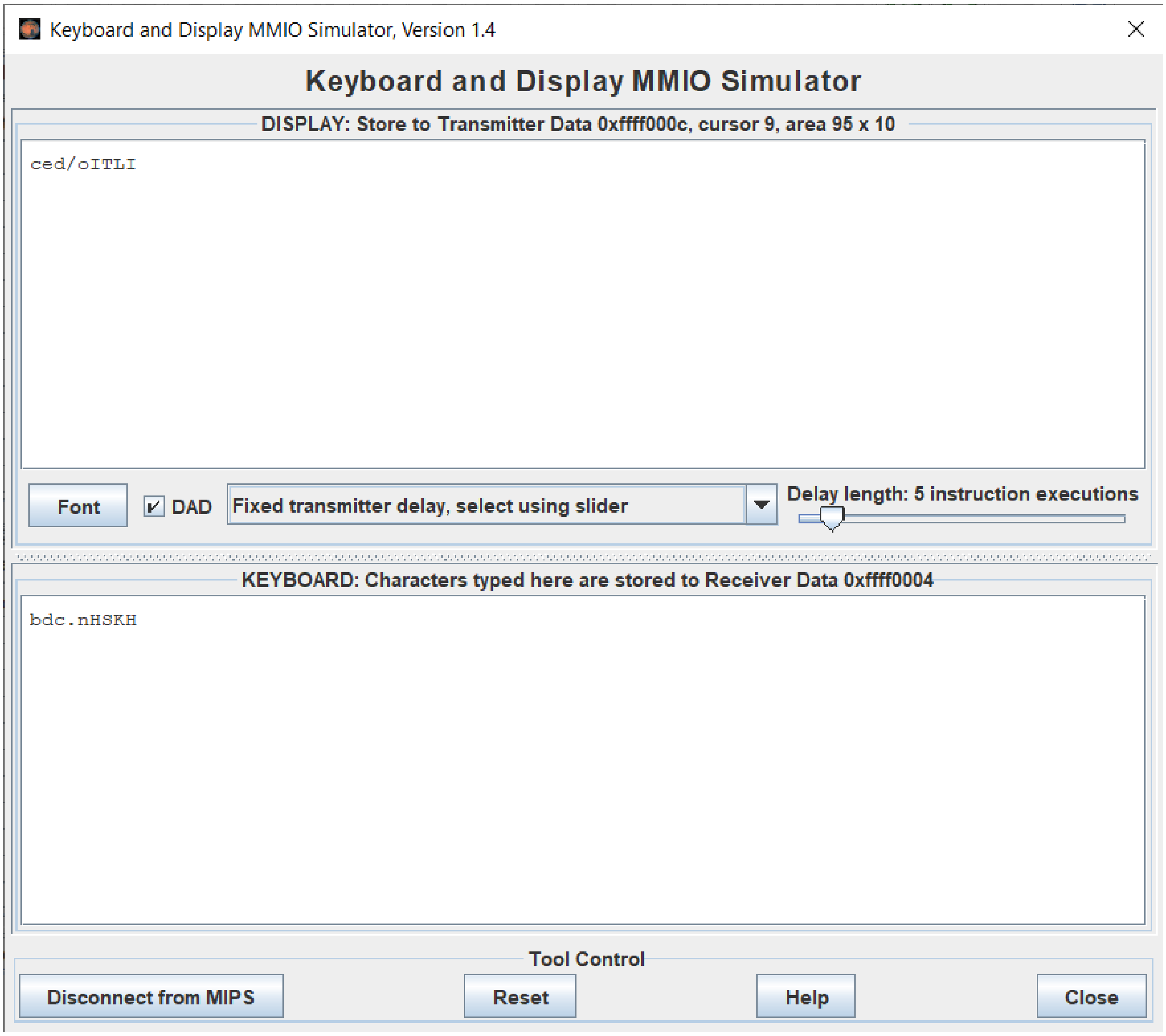
Assignment 5

Create a new project, type in, and build the program of Home Assignment 5.

CODE:

```
.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
```

KẾT QUẢ:



Keyboard and Display MMIO Simulator, Version 1.4

Keyboard and Display MMIO Simulator

DISPLAY: Store to Transmitter Data 0xffff000c, cursor 9, area 95 x 10

```
ced/oITLI
```

☑ DAD

Fixed transmitter delay, select using slider

Delay length: 5 instruction executions

KEYBOARD: Characters typed here are stored to Receiver Data 0xffff0004

```
bdc.nHSKH
```

Tool Control