



NUST CHIP DESIGN CENTRE

## Digital Design Verification

### Lab Manual # 12 – Introduction to RISC-V Assembly & Custom Processor Design

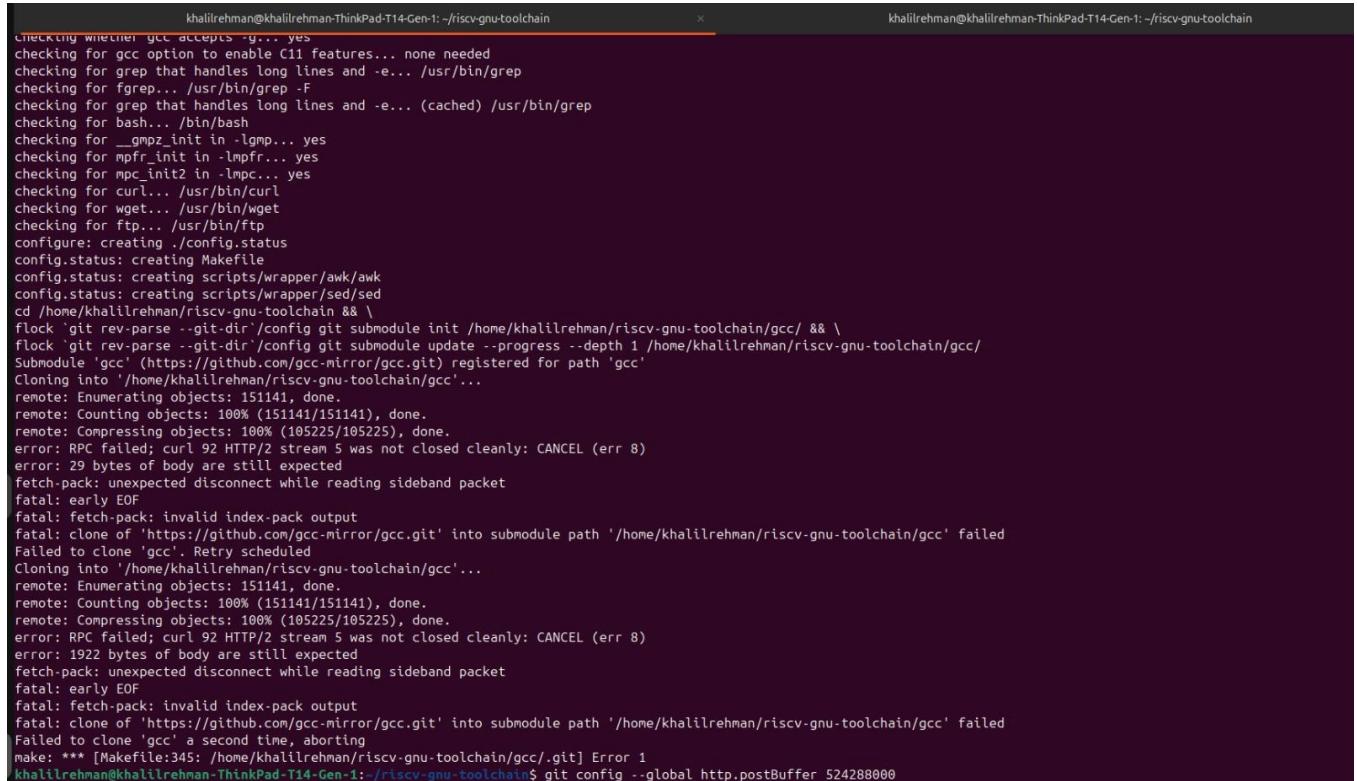
|                   |   |
|-------------------|---|
| <u>Name</u>       | <i>Khalil Rehman</i>                    |
| <u>Instructor</u> | <i>Sir Umer Farooq</i>                  |
| <u>Date</u>       | <u><i>13<sup>th</sup> July 2025</i></u> |

## Digital Design Verification

### **1. In-Lab Tasks: (Write your lab task & screenshots here)**

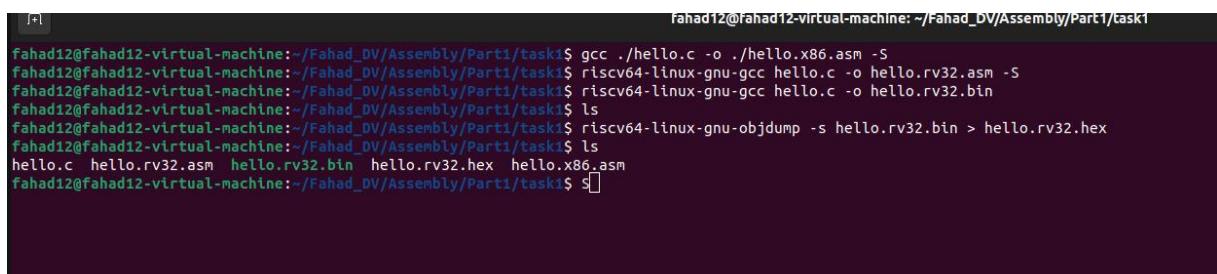
#### **Part A:**

I encountered an issue on my laptop while installing the RISC-V unknown GNU toolchain kit, as shown in the evidence attached below. This caused a delay, so I sought assistance from a friend and completed the task on their laptop.



```
khailrehman@khalilrehman:~/riscv-gnu-toolchain$ ./configure
checking whether gcc accepts -g... yes
checking for gcc option to enable C11 features... none needed
checking for grep that handles long lines and -e... /usr/bin/grep
checking for fgrep... /usr/bin/grep -F
checking for grep that handles long lines and -e... (cached) /usr/bin/grep
checking for bash... /bin/bash
checking for __gmpz_init in -lgmp... yes
checking for mpfr_init in -lmpfr... yes
checking for mpc_init2 in -lmpc... yes
checking for curl... /usr/bin/curl
checking for wget... /usr/bin/wget
checking for ftp... /usr/bin/ftp
configure: creating ./config.status
config.status: creating Makefile
config.status: creating scripts(wrapper/awk/awk
config.status: creating scripts(wrapper/sed/sed
cd /home/khalilrehman/riscv-gnu-toolchain && \
flock 'git rev-parse --git-dir' /config git submodule init /home/khalilrehman/riscv-gnu-toolchain/gcc/ && \
flock 'git rev-parse --git-dir' /config git submodule update --progress --depth 1 /home/khalilrehman/riscv-gnu-toolchain/gcc/
Submodule 'gcc' (https://github.com/gcc-mirror/gcc.git) registered for path 'gcc'
Cloning into '/home/khalilrehman/riscv-gnu-toolchain/gcc'...
remote: Enumerating objects: 151141, done.
remote: Counting objects: 100% (151141/151141), done.
remote: Compressing objects: 100% (105225/105225), done.
error: RPC failed; curl 92 HTTP/2 stream 5 was not closed cleanly: CANCEL (err 8)
error: 29 bytes of body are still expected
fetch-pack: unexpected disconnect while reading sideband packet
fatal: early EOF
fatal: fetch-pack: invalid index-pack output
fatal: clone of 'https://github.com/gcc-mirror/gcc.git' into submodule path '/home/khalilrehman/riscv-gnu-toolchain/gcc' failed
Failed to clone 'gcc'. Retry scheduled
Cloning into '/home/khalilrehman/riscv-gnu-toolchain/gcc'...
remote: Enumerating objects: 151141, done.
remote: Counting objects: 100% (151141/151141), done.
remote: Compressing objects: 100% (105225/105225), done.
error: RPC failed; curl 92 HTTP/2 stream 5 was not closed cleanly: CANCEL (err 8)
error: 1922 bytes of body are still expected
fetch-pack: unexpected disconnect while reading sideband packet
fatal: early EOF
fatal: fetch-pack: invalid index-pack output
fatal: clone of 'https://github.com/gcc-mirror/gcc.git' into submodule path '/home/khalilrehman/riscv-gnu-toolchain/gcc' failed
Failed to clone 'gcc' a second time, aborting
make: *** [Makefile:345: /home/khalilrehman/riscv-gnu-toolchain/gcc/.git] Error 1
khailrehman@khalilrehman:~/riscv-gnu-toolchain$ git config --global http.postBuffer 524288000
```

#### **Lab Task # 1**



```
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly/Part1/task1$ gcc ./hello.c -o ./hello.x86.asm -S
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly/Part1/task1$ riscv64-linux-gnu-gcc hello.c -o hello.rv32.asm -S
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly/Part1/task1$ riscv64-linux-gnu-gcc hello.c -o hello.rv32.bin
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly/Part1/task1$ ls
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly/Part1/task1$ riscv64-linux-gnu-objdump -s hello.rv32.bin > hello.rv32.hex
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly/Part1/task1$ ls
hello.c  hello.rv32.asm  hello.rv32.bin  hello.rv32.hex  hello.x86.asm
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly/Part1/task1$ $
```

## Digital Design Verification

### Lab Task # 2

```
es Terminal 12:38 13 آذار fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly
```

```
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly$ ls hello.c hello.rv32.asm hello.x86.asm 'Lab 12 (Introduction to Assembly Custom Processor Design).pdf' 'support_files_for_custom_processor.zip'
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly$ riscv64-linux-gnu-gcc hello.c -o hello.rv32.asm -S
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly$ riscv64-linux-gnu-gcc hello.c -o hello.rv32.bin
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly$ ls
codde hello.c hello.rv32.asm hello.rv32.bin hello.x86.asm 'Lab 12 (Introduction to Assembly Custom Processor Design).pdf' 'support_files_for_custom_processor.zip'
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly$ ls
codde hello.c hello.rv32.asm hello.rv32.bin hello.rv32.hex hello.x86.asm 'Lab 12 (Introduction to Assembly Custom Processor Design).pdf' 'support_files_for_custom_processor.zip'
fahad12@fahad12-virtual-machine:~/Fahad_DV/Assembly$
```

### Lab Task # 3

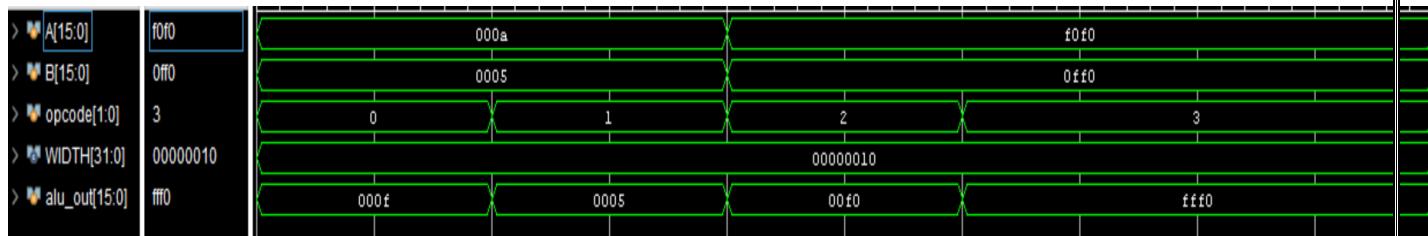
```
Open ↗ hello.rv32.hex ~/Fahad_DV/Assembly/Part1/task1
```

```
60 Contents of section .rela.plt:
61 0540 18200000 00000000 05000000 02000000 . .....
62 0550 00000000 00000000 20200000 00000000 ..... .
63 0560 05000000 04000000 00000000 00000000 ..... .
64 Contents of section .plt:
65 0570 97230000 3303c341 03be83a9 130343fd .#..3..A.....C.
66 0580 938283a9 13531300 83b28200 67000e00 ....S.....g...
67 0590 172e0000 033e8ea8 67030e00 13000000 .....>..g.....
68 05a0 172e0000 033e0ea8 67030e00 13000000 .....>..g.....
69 Contents of section .text:
70 05b0 ef002002 aa871725 00000335 25a88265 ... ....%...5..e
71 05c0 30001371 01ff8146 01470a88 eff05ffc 0..q....F.G....._
72 05d0 02909721 00009381 e1228280 00001725 ...!....."....%
73 05e0 00001305 a5a29727 00009387 27a26388 .....'....'.C.
74 05f0 a7009727 000083b7 e7a391c3 82878280 .....'.....
75 0600 17250000 130585a0 97250000 938505a0 .%. ....%.....
76 0610 898d93d7 3540fd91 be958585 95c59727 ....5@.....'
77 0620 000083b7 a7a291c3 82878280 411122e0 ..... ....A.".
78 0630 17240000 130404a2 83470400 06e485e3 $......G.....
79 0640 97270000 83b707a0 91c71725 00000335 .'.....%...5
80 0650 659b8297 eff0bfff 85472300 f400a260 e.....G#....'
81 0660 02644101 828069bf 411106e4 22e00008 .dA...i.A..."...
82 0670 17050000 13050502 eff09ff2 81473e85 ..... ....G>.
83 0680 a2600264 41018280 ..`dA...
84 Contents of section .rodata:
85 0688 01000200 00000000 4b68616c 696c2052 .....Khalil R
86 0698 65686d61 6e00 ehman.
```

### Part B:

### Lab Task # 1

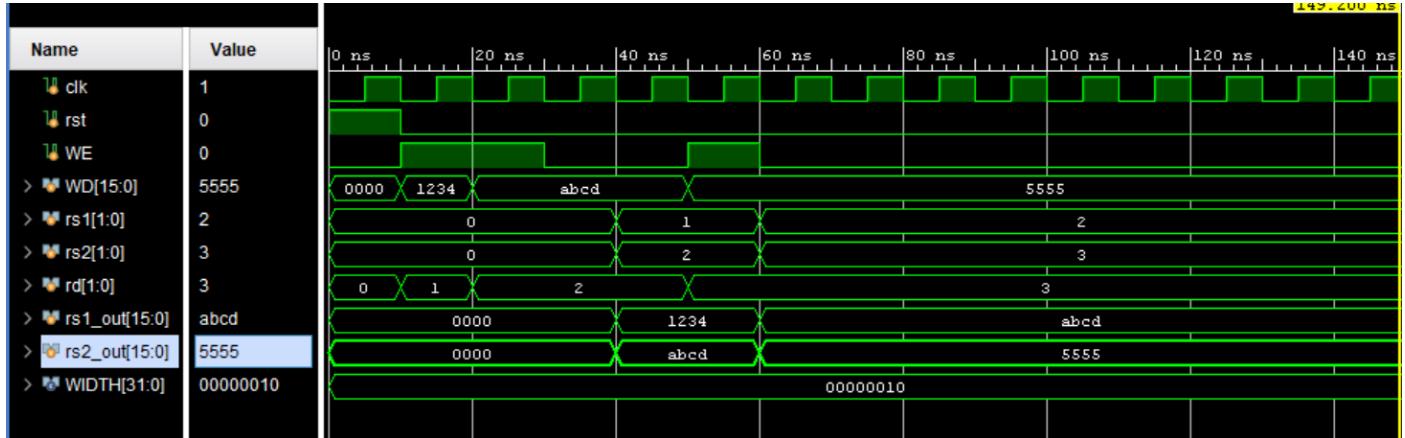
#### Waveform:



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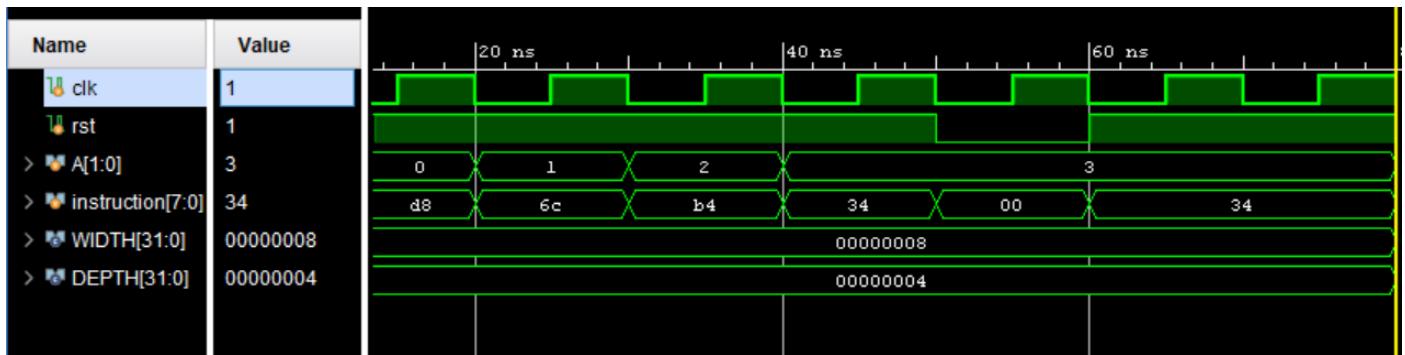
### Lab Task # 2

#### Waveform:



### Lab Task #3

#### Waveform:



### Lab Task # 4

#### SV file attached:

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### Lab Task # 5

#### Waveform:

