

Experiment 0

Self-Test

on HaHa v3.0 Board

In this experiment, you will go through a complete test of the Hardware Hacking (HaHa) v3.0 Board.

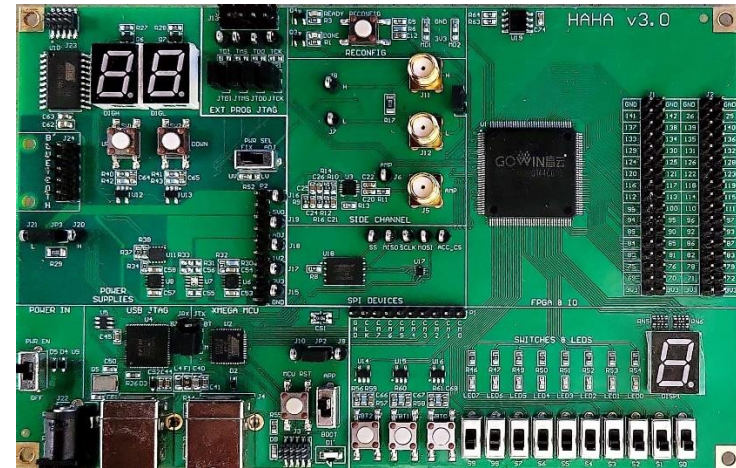
Instructor: Dr. Swarup Bhunia

Co-Instructor: Reiner Dizon-Paradis

Experiment Set-up: Configuration

The hardware and software needed for this experiment include:

1. The HaHa v3.0 Board
2. A USB A-to-B cable
3. A Windows machine/computer with ≥ 2 USB ports.
 - a. GOWIN FPGA Designer (≥ 1.98) to program the FPGA [1].
 - i. First, get your license using [2].
 - ii. Link [1] gives direct download. If you want to use a later version, you need to make an account [3].
 - b. Microchip Studio [4] to write programs for the microcontroller.
 - c. Atmel FLIP [5] to program code to the microcontroller.
4. An oscilloscope or Analog Discovery (AD) Board
 - a. *Optional* – Waveforms 2015 to view AD board signals [6].



Instructions and Questions

To perform the following self-test procedures, you must download the Self-Test code binaries for the HaHa board. Also, you must install the GOWIN FPGA Designer ($\geq 1.9.8$) [1], Microchip Studio, and Atmel FLIP programs into your Windows machine. Instructions for installing the required and optional software will be included at the end of this document.

NOTE: If you have any questions for parts II-V, please refer to the FAQs at the end of this document or the HaHa Board Manual.

PART I: Test the Power Supply and Voltage Regulators

1. Connect the HaHa v3.0 board to the USB Power supply (J14) with a USB A-to-B cable to your Windows machine. Turn on the power to see if the power light is on.
2. Using an oscilloscope or Analog Discovery board, check the voltages in the pins along header (P2) on the board. There should be ten pins on this header along with five test pins/points to the right. Starting from the top pin:
 - a. Pins 1-2 probe the input voltage.
 - b. Pins 3-4 output the adjustable voltage. Use button SW1 and SW2 to change the voltage.
 - i. Answer this question: what is the adjustable voltage range?
 - ii. Take a picture showing the minimum voltage of the 3.3A test point.
 - c. Pins 7-8 have a constant 3.3 V output.
 - d. Pins 9-10 are ground pins.
 - i.

NOTE: After doing voltage measurement, remember to set “PWR SEL” to “FIX” to make sure you can program both chips successfully.

PART II: Test the FPGA and the Peripherals

1. Make sure the HaHa v3.0 board is still connected to the USB Power supply (J14) Open [GOWIN FPGA Designer](#) and navigate to **Tools > Programmer** in the menu bar. The *Programmer* window will appear with another window called *Cable Setting*. Make sure the *Port* is set to "Gowin USB Cable(FT2CH)/0/..." Click on the **Find Device** button (first button below menu bar that has a magnifying glass). Double click on **GW1N-9C**. A new entry will now show up on the first row. Double click on *Read Device Codes* and change the following settings and then Press **Save**:
 - a. Access Mode = *Embedded Flash Mode*
 - b. Operation = *embFlash Erase,Program,Verify*
 - c. File name = <location/of/self_test_fpga_haha3.fs/file>

You are now ready to program the board. Navigate to **Edit > Program/Configure**. Wait until the programming is complete. For more information, you can refer to the *GOWIN FPGA Guide for HaHa v3.0 Board* document.

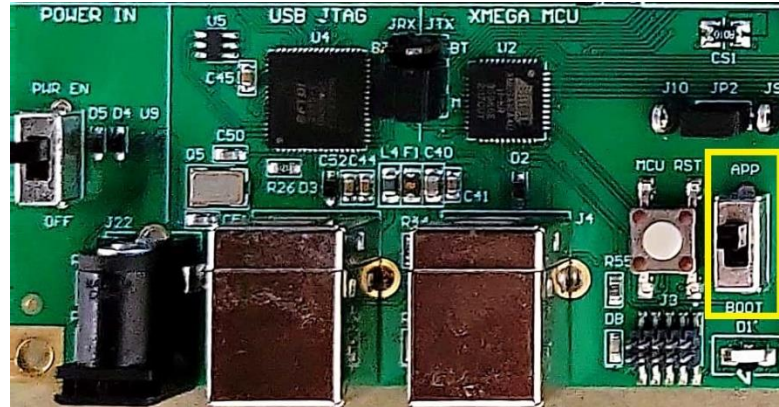
If this is successful, the 8 LEDs on the board should be blinking, and the 7-segment display a hexadecimal digit counting from 0 to F. To check the function of the 10 user switches, just switch any of them and you will see the 8 LEDs will change their pattern of blinking. There are two different patterns of blinking. Whenever any of the switches are flipped, the pattern should change. If not, please let the instructor or TAs know.

To check the function of the pushbuttons, just push any of them, and you should see the 7-segment display stops counting and start to repeat blinking with a fixed number. If not, please let the instructor or TAs know.

- a. **Answer these questions:**
 - a. What are the two LED patterns occurring in the board?
 - b. Which patterns of switches trigger either of the LED patterns?
- b. **Answer this question:** What happens to the digit on the 7-segment display when you keep pressing any of the key buttons?
- c. **Deliverable:** Attach a picture of the board with one of the LED patterns and a hexadecimal digit displayed in 7-segment display.

PART III: Test the Microcontroller and the Accelerometer

1. Connect the HaHa v3.0 board to the USB Power supply (J4) with a USB A-to-B cable to your Windows machine. In the HaHa v3.0 board, place the following switch (see yellow rectangle below) to **BOOT** (switch down). Double tap **MCU RST** button.



Follow the instructions in the Linux installation guide (in the docs folder) to program the provided file (U_ACC.hex).

Read the *XMega Microcontroller Guide for HaHa v3.0 Board* document for instructions in programming the microcontroller.

To run the programmed executable, move the switch from BOOT to APP and press the MCU RST button a couple times.

The microcontroller will read the acceleration data from the accelerometer and send it to the FPGA. The FPGA will show the value in binary on the eight LEDs if you place the most significant four switches to “1001”. Please rotate the board and see if the values are showing on the LEDs are changing. NOTE: You may need to tap MCU RST button multiple times before the LEDs show the correct value and change as you move the board.

- a. **Deliverable:** Attach a photo of the board showing the acceleration value on the LEDs in your report.

Open GOWIN FPGA Designer. Go to **File > New**. Select **FPGA Design Project**. Name the project *haha3_self_test* with the directory of your choosing. In the device selection window, use the following filters:

- Series: *GW1N*
- Device: *GW1N-9*
- Device Version: *C*
- Package: *LQFP144*
- Speed: *C6/I5*

Select the Part Number: **GW1N-UV9LQ144C6/I5**. The project creation process is just needed to unlock the GOWIN Analyzer Oscilloscope (GAO) tool. Go to **Tools > Gowin Analyzer Oscilloscope**. Press the folder button. Navigate to the location of the provided file (*self_test_fpga_haha3.rao*) and click **Open**. Check **Enable Programmer**. Press the button with the magnifying glass. Select *GW1N-9C*. Check the box below *Enable*. Under Fs File, click the empty field. Navigate to the location of the provided file (*self_test_fpga_haha3.fs*). Press the small green play button (under *Enable Programmer*) to program the FPGA. After successfully programming, press the **F2 key**. You should see the two signals.

- a. **Deliverable:** Attach a screenshot of the GOWIN Analyzer Oscilloscope window showing the aforementioned signals.
- b. **Answer the following:**
 - i. What is the first signal in the oscilloscope? Where is this signal coming from on the board?
 - ii. What is the second signal in the oscilloscope? Where is this signal coming from on the board?

PART IV: Test the Temperature Sensor

1. Finish Part III before proceeding. Refer to Part III for microcontroller programming steps. Program the microcontroller with the provided file (U_TEMP.hex). The microcontroller will read the data from its internal temperature sensor and send it to the FPGA. Put switches S9 – S6 to “1001” to see the values on the LEDs.
 - a. **Deliverable:** Attach a photo of the board showing the microcontroller temperature value in your report.
 - b. **Deliverable:** Attach a screenshot of the GOWIN Analyzer Oscilloscope window showing the aforementioned signals.

PART V: Test the Flash Memory

1. Finish Part III before proceeding. Refer to Part III for microcontroller programming steps. Program the microcontroller with the provided file (U_FLASH.hex). The microcontroller will read a signature of the EEPROM and send it to the FPGA. Put switches S9 – S6 to “1001” to see the values on the LEDs. The LEDs should be showing 00101001 (0x29).
 - a. **Deliverable:** Attach a photo of the board showing the value 0x29 on the LEDs in your report.
 - b. **Deliverable:** Attach a screenshot of the GOWIN Analyzer Oscilloscope window, showing 0x29 for the second signal.

PART VI: Feedback

Please note this part is *not* optional. **Answer these questions:**

1. What problems have you met when doing the tests? How did you solve them?
2. What suggestions do you have to make the test process easier and more friendly to students?

Lab Report Guidelines and Demonstration

1. In your report, answer ALL the questions.
2. Give screenshots and photos as required to your written report.
3. Record a video demonstration of your working HaHa board by showing all parts of the Self-Test.

References

- [1] https://cdn.gowinsemi.com.cn/Gowin_V1.9.8.11_win.zip
- [2] <https://www.gowinsemi.com/en/support/license/>
- [3] https://www.gowinsemi.com/en/support/download_eda/
- [4] <https://ww1.microchip.com/downloads/aemDocuments/documents/DEV/ProductDocuments/SoftwareTools/as-installer-7.0.2594-full.exe>
- [5] <https://ww1.microchip.com/downloads/aemDocuments/documents/DEV/ProductDocuments/SoftwareTools/JRE-Flip-Installer-3.4.7.112.exe>
- [6] <https://mautic.digilentinc.com/asset/110:waveforms-windows-64-bit-download>

Software Installation Instructions

PART I: Install GOWIN FPGA Designer

1. Get a free license to use GOWIN FPGA Designer using link [1]. Please note that this will take one or business days to obtain. You will need your Ethernet's MAC address.
 - a. Use the command in Command Prompt: `ipconfig /all`
2. Go to link [2] and download the zip file. Unzip the installer.
 - a. If you would like the latest version, go to link [3] and create a GOWIN account.
3. Open the GOWIN FPGA Designer installer. The following prompt may come up. Press **More Info**. Otherwise, proceed to Step 5.
4. Click on **Run anyway**.
5. Gowin installer will now open. Click **Open**.
6. Read the license agreement. Click **I Agree** button if you would like to proceed.
7. Make sure all components below are checked. Press **Next >**.
8. Choose the installation location. You may leave this as it is. Click **Install**.
9. After installation, it will prompt you to install FTDI and USB drivers. Click **Finish**.
10. The UAC prompts for both FTDI and USB drivers will come up. For this tutorial, let's install the FTDI CDM drivers first. Find the window that looks like this. Click **Extract**.
11. A new window pops up that looks like the following. Click **Next**.
12. Read the license agreement. Click **Next** if you would like to proceed.
13. The FTDI drivers finished installing. Click **Finish**.
14. Find the other driver installation window, which looks like this. Click **Install**.
15. The USB driver finished installing. Click **Close**.
16. Locate your installation of Gowin FPGA Designer and open it.
17. If this is your first installation of GOWIN FPGA Designer, you will get this prompt. Press **OK**.
18. GOWIN License Manager will open. Click **Browse** to locate your local license file that was provided to you. Then, press **OK**.
19. Press **Check**. Your license information will appear. Press **OK**.
20. Click **Save**. The following prompt will pop up. Press **OK**.
21. Press **Close**. GOWIN FPGA Designer installation is now complete.

PART II: Install Microchip Studio

1. Go to link [4] and download the installer file.
 - a. If you would like the latest version, go to link [5]
2. Open the Microchip Studio installer. Read the license agreement and check the agreement statement if you would like to proceed. Optionally, you can opt out of anonymous information collection if you would like by unchecking that box. Press **Next**.
3. At a minimum, you need to check **AVR**. The rest is up to you. Press **Next**.
4. The following extensions are optional. Press **Next**.
5. Address any issues in this screen. Afterwards, press **Next**.
6. During installation, the installer will install some dependencies. The first of these is MPLAB XC8 compiler, which will not be used. However, Microchip Studio requires this. Press **Next**.
7. Read the license agreement. Select the first button and press **Next** if you would like to proceed.
8. There should only be one license type option (Free). Press **Next**.
9. Specify installation directory. You may leave it as it is. Press **Next**.
10. Leave the Compiler Settings as they are (see below). Press **Next**.
11. Press **Next**.
12. MPLAB XC8 installation is complete. Press **Next**.
13. Click **Finish**.
14. Another prompt will show up for installing Visual Studio. This will be done automatically.
15. A series of device driver installation prompts will appear. Press **Install** for all of them.
16. Microchip Studio installation is now complete. Press **Close**.

PART III: Install Atmel FLIP

1. Go to link [6] and download the installer file.
 - a. If you would like the latest version, go to link [7]
2. Open the Atmel FLIP installer. If you don't have JRE installed, you will be prompted to install it. Press **Install**. If it's already installed, proceed to Step 5.
3. Read the license agreement. Press **Accept** if you would like to proceed.
4. JRE is now installed. Click **Finish**.
5. Atmel FLIP installer will start. Click **Next**.
6. Read the license agreement. Check the box and press **Next** if you would like to proceed.
7. Choose the Atmel FLIP installation location. You may leave as it is. Press **Next**.
8. Choose the Atmel FLIP Start Menu Folder. You may leave as it is. Press **Next**.
9. Atmel FLIP is now installed. Press **Next**.
10. Press **Finish** to close the installation wizard.

Optional: Install Digilent Waveforms (Only if you have AD2 board)

1. Go to [8]. It should be directed to the download link for Waveforms 2015. If it does not, go to [9] and provide your information to get the download link.
2. Open the Digilent Waveforms installer. Click **Next**.
3. Read the license agreement. Check the box and press **Next** if you would like to proceed.
4. Choose the installation components. You may leave it as it is. Click **Next**.
5. Select a shortcut option. You may leave it as it is. Press **Next**.
6. Specify the installation location. You may leave it as it is. Press **Install**.
7. During installation, a device driver installation window will pop up. Press **Install**.
8. Waveforms installation is done. You can change the options below or leave as it is. Press **Finish**.

References

- [1] <https://www.gowinsemi.com/en/support/license/>
- [2] https://cdn.gowinsemi.com.cn/Gowin_V1.9.8.11_win.zip
- [3] https://www.gowinsemi.com/en/support/download_eda/
- [4] <https://ww1.microchip.com/downloads/aemDocuments/documents/DEV/ProductDocuments/SoftwareTools/as-installer-7.0.2594-full.exe>
- [5] <https://www.microchip.com/en-us/tools-resources/develop/microchip-studio>
- [6] <https://ww1.microchip.com/downloads/aemDocuments/documents/DEV/ProductDocuments/SoftwareTools/JRE-Flip-Installer-3.4.7.112.exe>
- [7] <https://www.microchip.com/en-us/development-tool/flip>
- [8] <https://mautic.digilentinc.com/asset/110:waveforms-windows-64-bit-download>
- [9] <https://mautic.digilentinc.com/waveforms-download>

Frequently Asked Questions

FAQ about the Microcontroller

1. Q: After I program the Microcontroller and turn off the board, will the program remain in the Microcontroller?

A: Yes.

2. Q: Why is my program for the Microcontroller not working as soon as I succeeded in programming it?

A: Your program will not be running until you reboot the board.

3. Q: Why cannot I program the Microcontroller?

A: You could have made these mistakes:

You are using the wrong USB port. You must use J4, instead of J14.

Or, you turned the switch next to MCU RST button to APP.

4. Q: Why is the Microcontroller not running the code I programmed after I reboot the board?

A: To run the code, you should:

- a. Turn the switch next to MCU RST button to APP. Then, press the MCU RST button a couple of times.

5. Q: Why cannot I re-program the Microcontroller? It seems it is always running the code I programmed last time.

A: To re-program the chip, you should:

- a. Turn the switch next to MCU RST button to BOOT.
- b. Press the MCU RST button a couple of times.

FAQ about the FPGA

1. Q: Which version of GOWIN FPGA Installer should I install to program the FPGA?
A: Version 1.9.8 or higher. You can download it from GOWIN website.
2. Q: I created the bitstream file, but why I cannot program with it?
A: You should make sure you chose the correct device part number when you were building the project. You can find the number on the marking of the chip.
3. Q: After I program the FPGA and turn off the board, will the program remain in the FPGA?
A: It depends. If you programmed it to the SRAM, it would be lost after the power is off. If it is programmed to the embedded Flash, it would stay. Refer to the next answer for more details.
4. Q: Which kind of file is recommended to program the FPGA?
A: GOWIN only has the FS file to program the FPGA. The GOWIN Programmer has settings that can send the bitstream either to SRAM (volatile) or embedded Flash (non-volatile, survives power down). You should only program to the embedded Flash if you are 100% sure your design will do no harm to the board. Each of the I/O ports of your design should be assigned to a pin number. It is highly recommended to use the gowin_pin_assignments.cst file to help assign the FPGA pins correctly.
5. Q: Why cannot I see any output from the FPGA?
A: You may forget to assign signals to the pins.
6. Q: Why am I getting the following error?
Directory "<some/directory/to/file>" has null character.
A: The directory or path contains a space or dashes, which can stop any of the processes. Please move your project to conform to this naming standard.

FAQ about the Experiments

1. Q: For a variable in Verilog, where is the LSB?
A: LSB means least significant bit. No matter how the variables are declared, the LSB is always on the right side. For example, the LSB for aaa [1:8] is aaa[8], and the LSB for bbb [63:0] is bbb[0].
2. Q: When I am trying to see the power up values in the SRAM of the Microcontroller, I find every time they stay the same. Why?
A: You have to totally power off the board before you power up. Plug out both the USB cables.
3. Q: Why I cannot write or read from the EEPROM on the board.
A: You may forget to configure the 'hold' pin of the EEPROM. Please refer to its datasheet for details.
4. Q: In the bus snooping experiment, why do I not see any signal in the Waveforms software?
A: You may try zooming in with a higher time base.
5. Q: Why is the ADC on the Microcontroller not working well?
A: Make sure the ADC is set up correctly on the Microcontroller. Refer to its datasheet for more information.
6. Q: Do I need to use the FPGA to implement the ADC?
A: You do not. This is done in the microcontroller and then sent to the FPGA via the chip interconnection if needed.