SiFive HiFive1 Getting Started Guide

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Release Information

Version	Date	Changes
1.0.3	April 11, 2017	Corrected OTP Contents, some helpful hints for using screen
1.0.2	Jan 3, 2017	Added RGB LED Pinout and corrections to udev rules
1.0.1	Dec 21, 2016	Corrections to Software Development Flow
1.0.0	Dec 20, 2016	First Release

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HiFive1 Diagram

1.1 HiFive1 Components

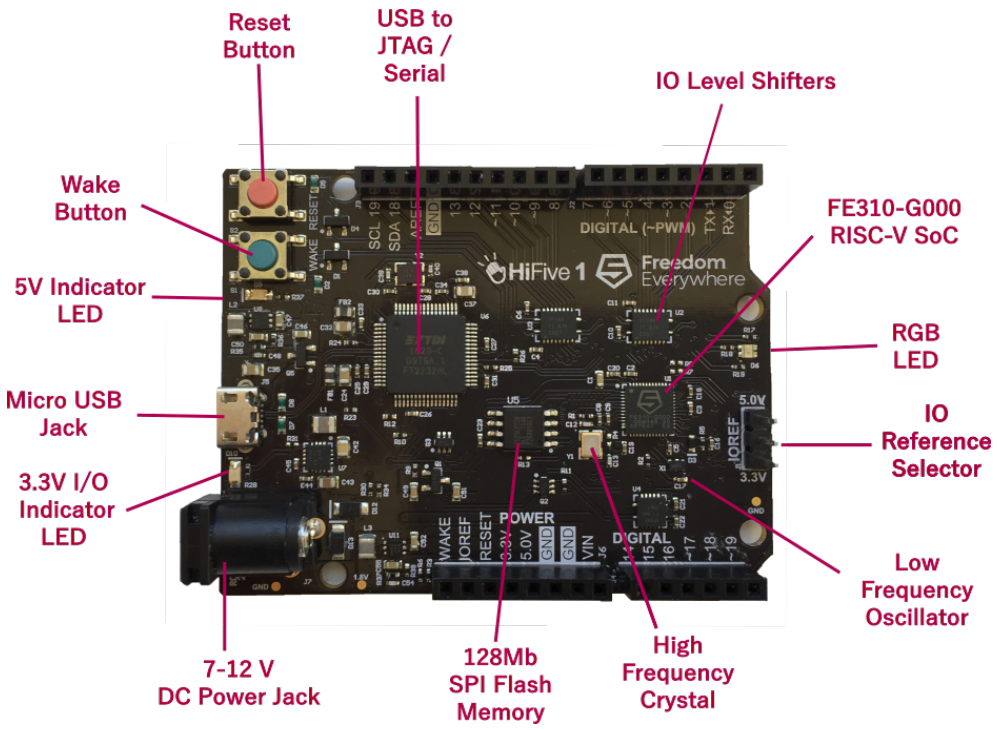


Figure 1.1: HiFive1 Board

Figure 1.1 shows the HiFive1 with the parts which are described in this document.

1.2 HiFive1 Schematics

Schematics and design files for the HiFive1 are available at

`http:/dev.sifive.com/hifive1`

Chapter 2

Required Hardware

Using the HiFive1 Dev Kit requires the following hardware:

2.1 HiFive1 Dev Kit

SiFive's HiFive1 development board is based around the FE310-G000 chip, an SoC based around a RISC-V RV32IMAC core. It can be purchased from Crowd Supply:

`http://www.crowdsupply.com/sifive/hifive1`

2.2 USB A to Micro-B Cable

Any standard USB Type A Male to Micro-B Male cable can be used to interface with the HiFive1.

`http://store.digilentinc.com/usb-a-to-micro-b-cable/`

Chapter 3

Optional Hardware

3.1 External Power Supply

While the USB A to Micro-B cable is necessary for programming and communicating with the HiFive1, the board can run off of an external 7-12V DC supply as well, or a USB power supply or battery pack.

3.2 IOREF Jumper

Your HiFive1 comes with a single jumper for selecting the IO Reference voltage. If you need to replace it, these can be purchased from DigiKey:

`http://www.digikey.com/product-detail/en/sullins-connector-solutions/SPC02SYAN/S9001-ND/76375`

3.3 Compatible Shields

Shields are devices which are designed to fit on the I/O headers on devices which match the Arduino form factor, to provide additional functionality. The shield manufacturer usually provides libraries designed to work with the Arduino IDE.

We have tested the following shields with the HiFive1 and ported their libraries.

- Adafruit's Resistive Touchscreen & LED Display:

  `https://www.adafruit.com/products/1651`

  Library: `http://github.com/sifive/Adafruit_ILI9341`

- Adafruit's BLE SPI Friend:

  `https://www.adafruit.com/products/2633`

  Library: `http://github.com/sifive/Adafruit_BluefruitLE_nRF51`

Generally, shields which communicate with SPI, UART, and digital I/Os should be easy to use with the HiFive1, but their supporting library may need minor tweaks to recognize the HiFive1.

Shields with Analog input requirements will need an adapter as the FE310-G000 does not include analog components.

Chapter 4

Board Setup

4.1 Installing the IOREF Jumper

Your HiFive1 will come with a jumper installed on J1, to select the IO Reference Level. Depending on the shields you want to drive, select 3.3V or 5.V using the jumper. You must install the jumper on one side or the other in order to drive or read any signals on the IO headers.

4.2 Connecting the USB Interface

Connect the USB Type A to Micro-B cable between the USB port of the HiFive1 and the host machine. This provides UART console access to the HiFive1 as well as a 5V power source for the board. This is also how software will be programmed and debugged on the HiFive1.

Connect the other end of the cable to your host machine. You will see the green power indication LEDs D10 and D9 light up. This means that both the main 5V supply is on, as well as the 3.3V “mostly off” supply.

Chapter 5

Boot and Run

The HiFive1 comes programmed with a simple bootloader and a demo software program which prints to the UART and cycles through the RGB LED in a rainbow pattern. You can respond on the UART to indidcate that the LEDs are changing and get a “PASS” message.

This program will be overwritten in the SPI Flash when you program new software into the board with the SDK, but the bootloader code will not be modified.

Using a terminal emulator such as GNU screen on Linux, open a console connection from the host computer to the HiFive1.

Set the following parameters:

Speed	115200
Parity	None
Data bits	8
Stop bits	1
Hardware Flow	None

For example, on Linux using GNU Screen:

```
sudo screen /dev/ttyUSB1 115200
```

You can use `Ctrl-a k` to "kill" (exit) the running screen session.

Depending on your setup, you may need additional drivers or permissions to communicate over the USB port.

If you are running on Ubuntu-style Linux, the below is an example of steps you may need to follow to access your dev kit without `sudo` permissions:

1. With your board's debug interface connected, make sure your device shows up with the `lsusb` command:

   ```
   > lsusb
   ...
   Bus XXX Device XXX: ID 0403:6010 Future Technology Devices
   International, Ltd FT2232C Dual USB-UART/FIFO IC
   ```

2. Set the udev rules to allow the device to be accessed by the `plugdev` group:

   ```
   > sudo vi /etc/udev/rules.d/99-openocd.rules
   ```

   Add the following lines and save the file (if they are not already there):

   ```
   # These are for the HiFive1 Board
   SUBSYSTEM=="usb", ATTR{idVendor}=="0403",
     ATTR{idProduct}=="6010", MODE="664", GROUP="plugdev"

   SUBSYSTEM=="tty", ATTRS{idVendor}=="0403",
     ATTRS{idProduct}=="6010", MODE="664", GROUP="plugdev"

   # These are for the Olimex Debugger for use with E310 Arty Dev Kit
   ```

```
SUBSYSTEM=="usb", ATTR{idVendor}=="15ba",
  ATTR{idProduct}=="002a", MODE="664", GROUP="plugdev"

SUBSYSTEM=="tty", ATTRS{idVendor}=="15ba",
  ATTRS{idProduct}=="002a", MODE="664", GROUP="plugdev"
```

3. See if your board shows up as a serial device belonging to the `plugdev` group:

   ```
   > ls /dev/ttyUSB*
   /dev/ttyUSB0 /dev/ttyUSB1
   ```

   (If you have other serial devices or multiple boards attached, you may have more devices listed). For serial communication with the UART, you will always want to select the higher number of the pair, in this example `/dev/ttyUSB1`.

   ```
   > ls -l /dev/ttyUSB1
   crw-rw-r-- 1 root plugdev 188, 1 Nov 28 12:53 /dev/ttyUSB1
   ```

4. Add yourself to the `plugdev` group. You can use the `whoami` command to determine your user name.

   ```
   > whoami your_user_name > sudo usermod -a -G plugdev your_user_name
   ```

5. Log out and log back in, then check that you're now a member of the plugdev group:

   ```
   > groups
   ...  plugdev ...
   ```

Now you should be able to access the serial (UART) and debug interface without sudo permissions.

5.1 Terminal Log

If you have your serial setup correctly, this is what you will see on your terminal (you may need to hit the 'Reset' button to restart the program):

```
               SIFIVE, INC.

        55555555555555555555555
       5555                   5555
      5555                     5555
     5555                       5555
    5555       555555555555555555555
   5555       5555555555555555555555
  5555                               5555
 5555                                 5555
5555                                   5555
555555555555555555555555555           55555
 55555           555555555           55555
   55555           55555           55555
     55555           5           55555
       55555                   55555
         55555               55555
           55555           55555
             55555       55555
               55555   55555
                 555555555
                   55555
                     5

             'led_fade' Demo

55555555555555555555555555555555555555555555555555
5555555 Are the LEDs Changing? [y/n]  555555555
55555555555555555555555555555555555555555555555555
y
PASS
```

Chapter 6

Software Development Flow

The HiFive1's boot code contains a jump to the external SPI Flash on the board, at address 0x20400000. You can change the program which the dev kit runs by using the debug/programming interface to flash a new compiled program into the SPI Flash.

SiFive supports two methods of obtaining the software development toolchain: compiling the Freedom E SDK from source, and installing precompiled tools using the Arduino IDE. The two techniques will install the same set of tools, but the install paths and associated software libraries are different.

6.1 Supported Platforms

This document assumes that you are running on a Linux system, either natively or on a Linux Virtual Machine. Future versions of this document will include details on how to install on other platforms.

6.2 Software Development with the Freedom E SDK

6.2.1 Compiling the Freedom E SDK Toolchain

The Freedom E Software Development Kit provides everything required to compile, customize, and debug C and/or RISC-V assembly programs: GCC 6.1.0 cross-compilation toolchain, RISC-V enabled GDB and OpenOCD, etc.

To clone the Freedom E SDK git repository:

```
git clone --recursive https://github.com/sifive/freedom-e-sdk.git
```

Install all the necessary packages described in the repository's `README.md` file.

To build the software toolchain:

```
cd freedom-e-sdk
make tools
```

To keep your software toolchain up to date with the upstream repository:

```
cd freedom-e-sdk
git pull origin master
git submodule update --init --recursive
make tools
```

6.2.2 Compiling Software Programs

To build a C program that will be loaded by the debugger/programmer into the SPI Flash, use the Freedom E SDK to compile. An example is provided in the `software/demo_gpio` directory. To build the program:

```
cd freedom-e-sdk
make software PROGRAM=demo_gpio BOARD=freedom-e300-hifive1
```

To compile the Dhrystone benchmark instead:

```
cd freedom-e-sdk
make software PROGRAM=dhrystone BOARD=freedom-e300-hifive1
```

6.2.3 Uploading Software Programs

To upload the program to the SPI flash, connect the board's debug interface as described in Chapter 4. Then execute:

```
cd freedom-e-sdk
make upload PROGRAM=<your desired program> BOARD=freedom-e300-hifive1
```

6.2.4 Debugging Running Programs

To debug your program with GDB, connect your board and launch the debugger:

```
cd freedom-e-sdk
make run_debug PROGRAM=<your desired program> BOARD=freedom-e300-hifive1
```

This will automatically launch OpenOCD and GDB, connect to the board, and halt the currently running program. You can step through the running program with `stepi`, or load the new program using `load`. The usual suite of GDB commands are available to set breakpoints, examine and modify memory, continue execution, etc.

6.3 Software Development Using the Arduino IDE

SiFive also supports software development for the HiFive1 with the Arduino IDE. When using this method, the Freedom E SDK is automatically installed, so you do not need to install it seperately. Follow these steps:

6.3.1 Installing the HiFive1 Board Package

1. Download and install the Arduino IDE, following the instructions at

   `https://www.arduino.cc/en/Guide/HomePage`

2. Launch the Arduino IDE

3. Navigate to `File` → `Preferences` and add the SiFive additional Board Manager URL as shown in Figure 6.1:

   `http://static.dev.sifive.com/bsp/arduino/package_sifive_index.json`

4. Add the SiFive development kit boards using the Board Manager:

   `Tools` → `Board` → `Board Manager`.

   Search for "SiFive" and click Install to download and install the package. Restart your Arduino IDE, then find the HiFive1 under `Tools` → `Board`, as shown in Figure 6.2.

5. Select `SiFive OpenOCD` as the Programmer from the Tools menu.

6. To compile and upload a simple example program, select

   `File` → `Examples` → `Basics` → `Blink`

   Click the "upload" button in the Arduino IDE, your program will compile and upload to your Dev Kit, and the green LED will blink.

6.3.2 Open Source Board Support Package Code

The code installed with the Board package is open-source, and available to view or download at:

`http://github.com/sifive/cinco`

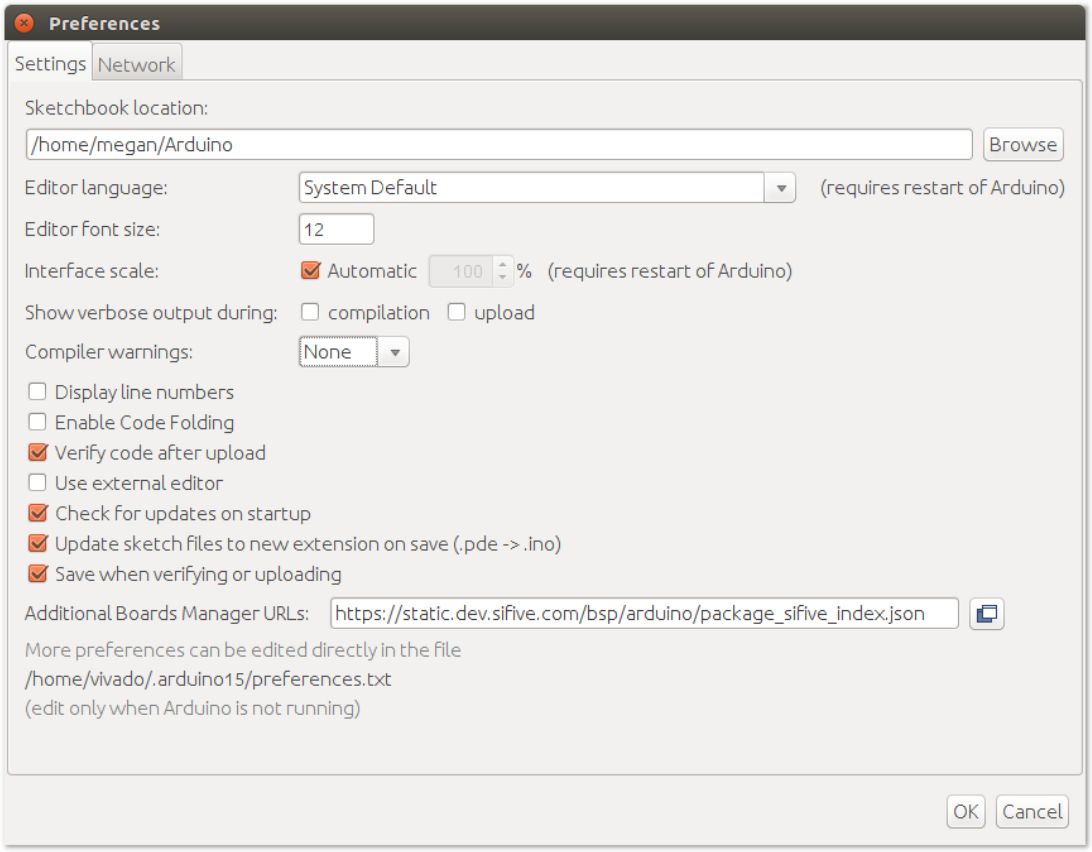


Figure 6.1: Adding the SiFive Dev Kits Board URL to your Arduino IDE

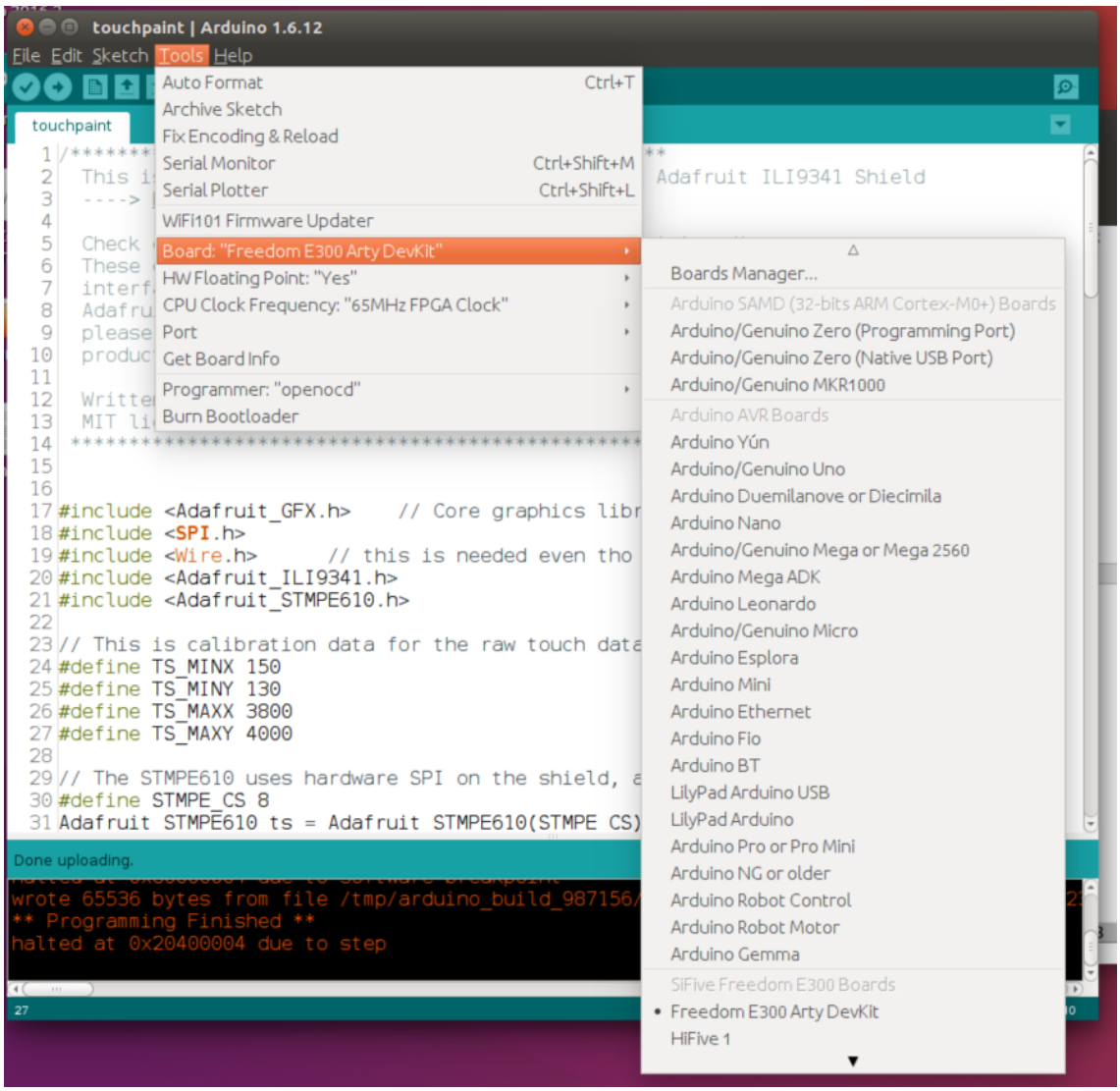


Figure 6.2: Selecting HiFive1 in the Arduino IDE

Chapter 7

HiFive1 Additional Notes

This chapter gives some additional information about how your FE310-G000 chip is configured on the HiFive1 board.

To understand the FE310-G000 internals, please refer to

`https://dev.sifive.com/documentation/freedom-e310-g000-manual/`

7.1 Freedom E310 Pinout

The Freedom E310 design on the HiFive1 has 32 SW-accessible GPIO registers. Not all of these are available on the 48-pin package and are therefore not connected to the GPIO Headers on the board. Table 7.1 gives the mapping between the software GPIO offset and labeled pin on the board.

Table 7.1: HiFive1 GPIO Offset to Board Pin Number

HiFive1 Pin Number	GPIO Offset	IOF0	IOF1	LED
0	16	UART0:RX		
1	17	UART0:TX		
2	18			
3	19		PWM1_1	GREEN
4	20		PWM1_0	
5	21		PWM1_2	BLUE
6	22		PWM1_3	RED
7	23			
8	0		PWM0_0	
9	1		PWM0_1	
10	2	SPI1:SS0	PWM0_2	
11	3	PI1:SD0/MOSI	PWM0_3	
12	4	SPI1:SD1/MISO		
13	5	SPI1:SCK		
14		*Not Connected*		
15	9	SPI1:SS2		
16	10	SPI1:SS3	PWM2_0	
17	11		PWM2_1	
18	12		PWM2_2	
19	13		PWM2_3	

Figure 8 gives a graphical depition of the HiFive1's pin functions.

7.2 OTP Contents

The FE310-G000 on the HiFive1 board contains a one-time programmable memory (OTP). This OTP is shipped with code that enables your HiFive1 to boot out of reset (vs. loading a program with the programmer and running it). The OTP also contains trim values for the high-frequency oscillator on your FE310-G000 and a unique identifier.

The OTP contents are critical for the proper functioning of your FE310-G000 and HiFive1 board. You are strongly discouraged from modifying the OTP contents. OTP contents can NOT be restored if modified.

Table 7.2: HiFive1 Default OTP Contents

OTP Offset	Value	Field Description
0x0000	7f50106f (`j 0x1FF4`)	Reset Vector from 0x1000. Executes a relative jump to the last fence block in the OTP.
0x0004	00000000	Included Config String from 0x1004. This is left unburned as the Config String specification is not yet finalized.
...	...	
0x1FE4	*Varies*	Board Identifier
0x1FE8	00000000	LFROSC Trim Setting, left unburned on HiFive1
0x1FEC	*Varies*	HFROSC Trim Setting for 72MHz
0x1FF0	0x00000001	Indicates the other fields were successfully programmed
0x1FF4	0x0000000F (`fence`)	This functions as a NOP which allows later modification of the program the OTP executes. This word could be modified to a short relative jump elsewhere in the OTP. The target instruction block should also start with a `fence` instruction to allow later modifications to be chained in this way.
0x1FF8	200002b7 (`lui t0, 0x20000`)	Load t0 with 0x20000000
0x1FFC	00028067 (`jr t0`)	Jump to start of SPI Flash

7.3 HiFive1 Boot Sequence

The HiFive1 Board is shipped with a modifiable boot loader at the begnning of SPI Flash (0x20000000). At the end of this program's execution the core jumps to the main user portion of code at 0x20400000. This program is designed to allow quick boot, but also a "safe" reboot option if a "bad" program is flashed into the HiFive1's SPI Flash. A "bad" program is one which makes it impossible for the programmer to communicate with the HiFive1. For example, a program which disables FE310's active clock, or which puts the FE310 to sleep with no way of waking it up. Bad programs can always be restarted using the RESET button, and using the "safe" bootloader can be halted before they perform any unsafe behavior.

To activate "normal" boot mode, press the RESET button on the HiFive1. After approximately 1s, the green LED will flash for 1/2 second, then the user program will execute.

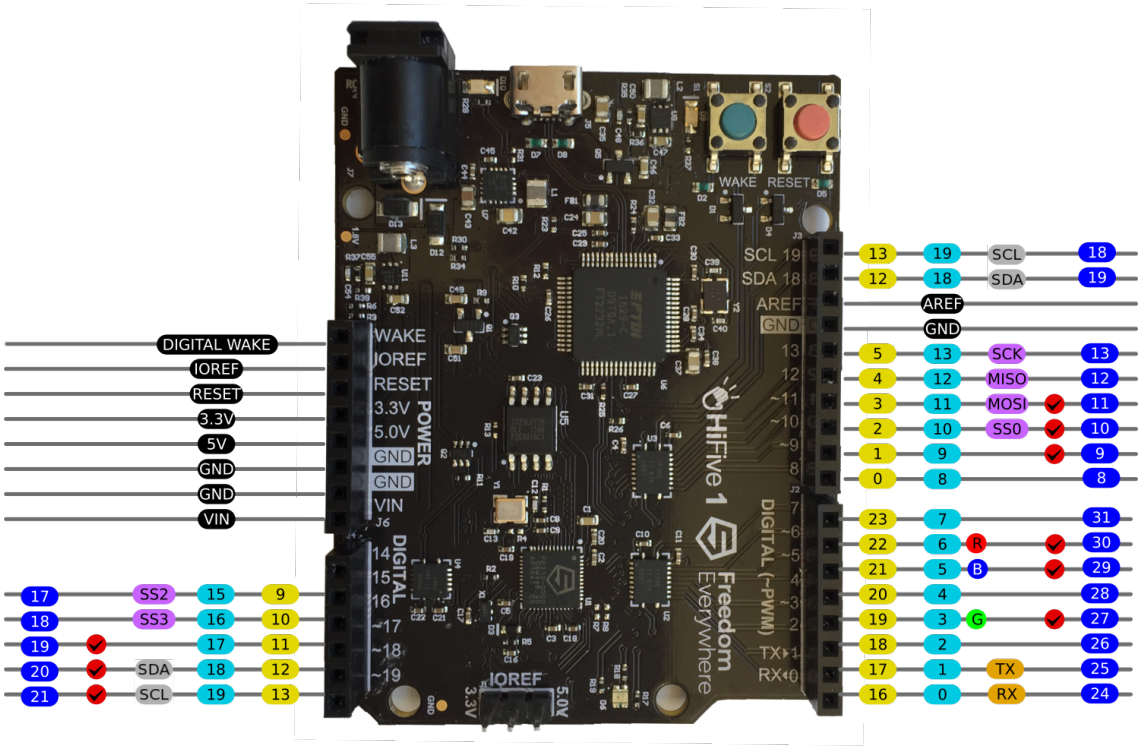
To activate "safe" boot mode, press the RESET button. When the green LED flashes, immediately press the RESET button again. After 1 second, the red LED will blink. The user program will not execute, and the programmer can connect. To exit "safe" boot mode, press the RESET button a final time.

Chapter 8

For More Information

Additional information, the latest version of this guide, and supporting files can be found at `http://dev.sifive.com/hifive1`.
Questions are best answered on the SiFive Forums at `http://forums.sifive.com`.
More information about RISC-V in general is available at `http://riscv.org`.

HiFive1 Pinout



GPIO PIN POWER SERIAL SPI PWM INTERRUPT SW I2C