

Build Guide for TinyTitan with SPH

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Notes Before Beginning Your Build

TinyTitan and This Guide

TinyTitan is a mini model-supercomputer originally designed and built to demonstrate principles of supercomputing to visitors, young and old, at the Oak Ridge Leadership Computing Facility (Oak Ridge National Laboratory, TN). Constructed from commodity parts and the popular raspberry-pi, TinyTitan has grown from a single model living at Oak Ridge National Laboratory into an idea that can be realized by others and shared in new spaces.

This guide is motivated by the growing number of do-it-yourselfers and tech-adventurous educational communities interested in building and designing their own TinyTitan. The goal of this guide is to provide a basic overview and instruction set for building your own TinyTitan. In making this guide, we have tried to include the important steps and address key challenges; however *this guide is not comprehensive*. Both TinyTitan and this guide are a continuing work in progress.

Building TinyTitan will require a do-it-yourself spirit: the patience to problem-solve (and forgive the shortcomings of this guide!), the willingness to research, and the resourcefulness to find help from others when needed. We hope it is a fun and rewarding challenge!

We are very excited and supportive of new builders. If you are looking for support, we rarely can help directly, but we do recommend:

- Engaging with other builders in your social network
- Contacting a local hackerspace community (these groups are usually very happy to help!)
- Join us on Github and post to the community: <https://tinytitan.github.io>

Background Material

- If you're new to raspberry-pis, there are many online resources. One place to start is to order a 'raspberry pi starter kit' and/or a guidebook. We happen to like this one (but no official endorsements): 'Getting Starting with Raspberry Pi (Make: Projects)' : <http://www.amazon.com/Getting-Started-Raspberry-Pi-Make/dp/1449344216/>
- Some familiarity with UNIX/LINUX environments is strongly recommended. If this is your first exposure to these environments, we suggest you start with 1 raspberry pi and play around until you feel comfortable.

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A. Parts and Examples

Below is a table of parts with bit.ly links to examples for each part. The examples are not endorsements, guarantees, or <insert here every other form of disclaimer!>. They are meant to provide a specific example of the part.

Main Components

#	Part	Notes	Link: https://bit.ly/
2 - 9	raspberrypi model B (or B+)	Available from many retailers: e.g. Amazon, Micro Center	ExampleParts_pi
2 - 9	SD cards with NOOBS (or Raspbian OS) pre-installed	These may come with your pis, if not, order separate.	ExampleParts_SD
1	Ethernet Switch	Switch must have at least as many ports as you have pis	ExampleParts_switch
2-9	Ethernet cable	One for each pi	
1-3	USB chargers	We suggest a charger using 4amps or or more.	ExampleParts_usbCharger
2-9	USB to micro-usb charging cord	One per pi. You can buy regular or light-up power cords.	ExampleParts_usbCord
1	XBox wireless controller with transceiver	You can also use a wired controller.	ExampleParts_Xbox

Parts for Programmable LEDs

TinyTitan and SPH take advantage of programmable LEDs to visually connect each pi to the job it is running. SPH will run without LEDs installed, but we highly recommend including them. This guide has two build options for the LEDs.

[1] USB powered LEDs - the simple but more costly option.

[2] GPIO LEDs - cheap option, but more time and effort to install.

See “Installing LED’s” section for other parts you may wish to buy.

#	Part	Notes	Link https://bit.ly/
2 - 9	USB programmable LED		
1	Daisy chain programmable LED	You can probably find this from other sellers	ExampleParts_LEDs

Additional Parts

Other parts you will need for TinyTitan include:

- Monitor (or television) - to see TinyTitan output
- Cord to connect TinyTitan to your monitor -Raspberry Pis use HDMI for video output. A modern monitor/tv is likely to have HDMI or DVI input. You can find HDMI to HDMI or HDMI to DVI cables at most electronics stores.
- Power strip/ surge protector. TinyTitan needs more than one outlet. We strongly suggest including a power strip/ surge protector as art of your TinyTitan.
- Keyboard with usb connector
- Mouse with usb connector
- Wi-Fi adaptor (recommended) OR Ethernet cable - you will need to be able to connect each raspberry pi to the internet. For this install, you only ever need to connect one pi at a time to the internet. You can use an Ethernet cable from the parts list above, but they might be too short for convenience.

B. Basic Set-up of Your Raspberry Pi

The following steps assume a new raspberry-pi and a new SD card with no operating system installed but with NOOBS. If you are new to raspberry-pis, you will probably want/need to supplement with other materials. There are many online (and more detailed!) resources for these basic steps.

Powering On Your Pi

1. Insert SD card into SD slot.
2. Connect pi to monitor via HDMI port.
3. Connect keyboard to pi via USB port.
4. Connect pi to power. Pis are powered via the micro-USB port. Connect the micro-USB power cord to the pi and to the USB charger.

You should now see the pi output as it boots on your monitor.

Common troubleshooting

- Loose SD cards are a number 1 source of problems. Unplug your pi and give your SD card an extra push.
- Check your monitor and pi are both connected to a power supply.
- Check your monitor/tv input is on the correct input.

Install the Operating System

NOOBS will have several OS options. Follow the on-screen instructions for installing Rasbian O.S. If you get stuck, check online for help.

Bare Basics of Getting Around Your Pi

Refer to other resources for more details. But the following are the bare basics.

- The default login name is “pi” (no quotes).
- The default password is “raspberry” (no quotes). TinyTitan installation assumes ‘raspberry’ is password. Do not Change!
- To start the GUI that comes with your pi, type in the command line:

```
$ startx
```

- To shutdown your pi, type in the command line:

```
$ sudo shutdown -h now
```

C. Connect to the Internet

You must be able to connect each pi to the internet. To physically connect, connect through direct Ethernet cord OR plug in Wi-Fi adapter into raspberry pi USB. After the pi is physically connected via Ethernet or Wi-Fi adapter, you may need to adjust settings so the

pi can 'see' the internet. For users less familiar with UNIX/LINUX, this is most easily done through the GUI. Please see other resources for help with this step.

D. Download Packages From Github

There are two install scripts for TinyTitan located at <https://tinytitan.github.io>. One script *pi_setup.sh*, you will download and run on each pi. The second script, *pi_post_setup.sh* you will download and run on only the master pi (pi1). Information on each script is in the appendix.

1. Choose one pi to be the master node. This is 'pi1'. Set pi1 aside.

2. On all pis EXCEPT pi1

- i. Connect pi to monitor, keyboard, and internet. The following steps are performed in the command line.

- ii. Make sure you are in the home directory by typing into the command line:

```
$ cd ~
```

- iii. Backup the file */etc/network/interfaces* by typing into the command line:

```
$ sudo cp /etc/network/interfaces /etc/network/interfaces_backup
```

- iv. Download *pi_setup.sh* by typing into the command line:

```
$ curl -kfsSLO https://raw.githubusercontent.com/TinyTtian/TinySetup/master/pi_setup.sh
```

- v. Run the *pi_setup.sh* by typing into the command line:

```
$ bash ~/pi_setup.sh
```

- vi. When prompted for the node number, start with '2'. For each new pi, increase the number.

- vii. When complete, if necessary, shutdown pi and disconnect from internet, monitor, and keyboard to allow the next pi to connect.

- viii. Suggestion: using a small sticky label, label the SD card with its' corresponding number from step 'vi': '2', '3' etc.

3. Connect pi1 (master node) to the internet, monitor, and keyboard

- i. Make sure you are in home directory by typing:

```
$ cd ~
```

- ii. Backup the file */etc/network/interfaces* by typing into the command line:

```
$ sudo cp /etc/network/interfaces /etc/network/interfaces_backup
```

- iii. Download *pi_setup.sh* by typing into the command line:

```
$ curl -kfsSLO https://raw.githubusercontent.com/TinyTtian/TinySetup/master/pi_setup.sh
```

- iv. Download TinySetup with *pi_post_setup.sh* script:

```
$ git clone https://github.com/TinyTitan/TinySetup.git
```

- v. Run *pi_setup.sh* by typing into the command line:

```
$ bash ~/pi_setup.sh
```

- vi. When prompted for the node number, enter '1'.

To run the *pi_post_setup.sh* script on pi1, TinyTitan must be all connected together (step E).

Common Troubleshooting

- Unable to connect to github through 'curl' or 'clone'
 - Try online resources or find a friend familiar with LINUX and github to help.
 - Try your pi's internet connection to download from Github via web browser
- Unable to connect to internet AFTER running *pi_setup.sh*

After running *pi_setup.sh*, your pi will likely not be able to connect to Wi-Fi or internet until you have reinstated the original */etc/network/interfaces* file. This file was overwritten when you ran the *pi_setup.sh* script. Fortunately, you made a backup in steps 2iii and 3ii! Here is how to undo it.

1. Backup TinyTitan */etc/network/interfaces* file:

```
$ sudo cp /etc/network/interfaces /etc/network/interfaces_TinyTitan
```

2. Re-instate network backup file:

```
$ sudo mv /etc/network/interfaces_backup /etc/network/interfaces
```

3. Restart pi
4. Don't forget, the TinyTitan interfaces file must be reinstated for the pi to work with TinyTitan.

E. Connect TinyTitan Together.

1. Connect each pi to the Ethernet switchbox using the Ethernet cables.
2. Connect pi1 to the monitor/tv
3. Connect pi1 to keyboard (and mouse if desired).
4. Connect each pi to the power supply (micro-USB)
5. Connect Ethernet switchbox to power supply
6. In command line of pi1, run the *pi_post_setup.sh* script:

```
$ cd ~/TinySetup
```

```
$ bash pi_post_setup.sh
```


F. Run SPH

Your TinyTitan is ready (fingers crossed!). To test TinyTitan and SPH follow these steps:

1. Connect the xbox controller to pi1 through the USB port.
2. Hit the center circle button on the xbox controller. You should see green lights moving in a circular pattern around the large center button.
3. Setup the xbox interface. Enter the home directory (`$ cd ~`) and type:

```
$ sudo rmmmod xpad
```

```
$ sudo xboxdrv --config~/SPH/controller_1.cnf --silent &
```

4. The green lights on the xbox controller should have stopped moving. The light should be fixed next to the '1' marker on the controller.
5. Run SPH by typing the following into the command line. Replace '9' with the total number of nodes, including pi1, in your TinyTitan.

```
$ cd ~
```

```
$ mpirun -f ../mpihostfile -n 9 ../sph.out
```

6. Loading SPH can take a minute or two, but it should start running.
7. To exit the SPH game, use CTRL-C

Common Troubleshooting

- SPH doesn't run – a few common problems
 - Check the GPU has 128 MB of memory:
 1. Open raspberry pi configuration:

```
$ sudo raspi-config
```
 2. In the GUI, select 'Advanced Options' -> 'Memory Split'.
 3. Enter 128 for GPU. Select 'Ok' -> 'Finish' -> (would you like to reboot now?) 'Yes'
 - Communication error to the pis

Try the 'ping' command to test the communication between pi1 and each pi. If you find the trouble pi, likely the SD card is loose. Also check the power and the ethernet cables are properly in place.
 - Another problem? SPH code works on a fresh SD card. If you have played with ssh passwords, the pi password, file ownership (e.g. making files from root), then SPH may not run. Try wiping the SD card, re-installing the OS and installing the SPH code. You can also do this by ordering a new SD card. We hope the community may fix some of these bugs in the future!
- The xbox controller doesn't work
 - Try restarting pi1 with the xbox controller in a different usb port. Also, unplug unnecessary usb dongles (e.g. mouse).

- Not as fun, but you can run SPH with some basic features using the keyboard

G. LED Installation

The Github SPH program supports usb-connected LEDs OR GPIO pin-connected LEDs.

USB-connected LEDs

1. Connect each usb-LED into the usb port for each pi. Done!

GPIO pin-connected LEDs

There are several ways you can connect GPIO pin-connected LEDs. A few examples include [1] wire-wrapping (noooo!), [2] crimping (impress your tech savy friends with your ideal choice!), [3] cheating via pre-made female pin-connectors, wire-stripping, and soldering (or electrical tape and watch your tech savy friends cringe!).

From experience, choice [3] is the most accessible to the less experienced (and method of choice for our most novice author), we therefore include guidance for choice [3].

Connecting LEDs via pre-made pin connectors

You will need/want:

- pre-made female pin connectors - we found ours in MicroCenter

(e.g. bit.ly/ExampleParts_Fpin)

- wire strippers
- solder an solder iron (else electrical tape, but the connections may be more susceptible to breaking)
- heat shrink wrap (looks nice) or electrical tape (not as nice).

Directions

Do a test run with 1 LED first!

1. *Identify the side of the LED wires that connect to the pins.* The LEDs have directionality! You must connect the correct side of the LED wires to the GPIO pins. To determine which side, look at the daisy-chain of LEDs. One end will have a female pin connector (it will look like you could just plug it into your pi's GPIO pins). Call this end the left-hand-side.
2. Cut your LEDs from the daisy chain. Take the left-most LED and cut the wire on the right-hand side of the LED close to the LED itself. Your LED should now be free from the daisy chain. The LED has one side with long-wires sticking out (the left-hand side), and one side with very short wires (the right hand side). If this is the first LED, the long-wires will still be attached to the GPIO-pin connector. Cut this connector so you just have the LED with its' wire.

3. Connect each LED wire to a female pin-connector. Please use online resources for methods for connecting two wires: stripping, twisting, soldering and heat shrink wrapping.
4. Identify LED wires. Your LED has four wires: +5V, Ground, Data, and Clock. Use the LED manufacturer's specifications to know which wire color corresponds to which label (+5V, Ground, Data, or Clock).
5. Identify GPIO pins. Using manufacturer's specifications to identify which raspberry-pi GPIO pins corresponds with +5V, Ground, Data, and Clock.
6. Connect LEDs to pi by connecting each female pin connector to the correct male pin on the raspberry-pi, one LED per pi.

Appendix

Description of Github Scripts

pi_setup.sh

The primary job of this script is:

- Update your pi with the latest available configurations
- Install packages necessary for Tiny Titan including:
 - parallel programming (mpich2)
 - pi to pi communication via ssh (sshpass)
 - xbox controller (xboxdrv)
- Rename pi
- Set network configurations for communication via the Ethernet switch

pi_post_setup.sh

The primary job of this script is:

- Provide pi1, the master node, with a list of IP addresses for each pi and corresponding pi name. This information is written to: *~/mpihostfile*
- Provide pi1, master node, with the ssh key for each pi. This enables pi1 to communicate with each pi without a human entering passwords each time.