The GRUB Switch - Quickstart Guide

Ruediger Willenberg

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This guide expects that you know how to use the Linux command-line in a console window and are familiar with commands to change directories, list files and start bash scripts. You will also need *super user* access for some steps, so make sure you have **sudo** rights.

Refer to the detailed documentation if these quick steps do not work on your platform.

Table of Contents

1   Downloading and installing GRUB Switch files

The GRUB Switch scripts and files are designed to be installed and used under Linux. There are two ways to obtain the files:

- Via **git clone**:
  - Go to your preferred working directory
  - Clone the repository with

    `git clone  https://github.com/rw-hsma-fpga/grub-switch.git`

  - All GRUB Switch files are now available in the path

    `./grub-switch`

- Via **download**:
  - Download to your preferred directory:
    https://github.com/rw-hsma-fpga/grub-switch/archive/refs/heads/master.zip
  - Unzip with GUI-tool or on the command line with

    `unzip grub-switch-master.zip`

  - All GRUB Switch files are now available in the path

    `./grub-switch-master`

2 Configuring your boot choices

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3 Adding GRUB Switch to your GRUB installation

Aa

4   Using regular USB flash drives for boot choice

Picking and configuring boot entries with option **2** in the **CONFIGURE_GRUBswitch.sh** script has generated directories and files like these in your directory **grub-switch/bootfiles** :

`bootfiles/boot.1/SWITCH.GRB`

`bootfiles/boot.2/SWITCH.GRB`

`bootfiles/boot.2/SWITCH.GRB`

You will find **boot.*** dirs according to the positions you assigned during configuration. There won't be a **boot.0** dir because that choice is reserved for the GRUB menu. Each directory holds a **SWITCH.GRB** file that sets the variable for the corresponding boot choice when called by GRUB. You can open it with a text editor, though I don't recommend editing it by hand.

You will now need as many USB flash drives as you have picked boot choices (excluding the GRUB menu).

- Make sure each flash drive is formatted with a FAT file system (FAT12/16/32, exFAT, VFAT), not with NTFS or any other file system.
  You do not need to re-format an existing drive, or even delete its files (although you might want to for reasons of cleanliness, data protection, privacy, etc.).

- Copy each **SWITCH.GRB** file to a separate flash drive and mark the drive with the corresponding number, OS name or whatever helps you tell them apart.

- Before powering on your computer or rebooting, plug in the flash drive representing your boot choice.

- If you want the GRUB menu to appear, make sure none of the drives are plugged in.

- If multiple of your drives are plugged in by accident, boot choice will depend on the ordering of USB connections in your BIOS, which you might not be able to tell easily.

All further chapters are not relevant if you stick with this method to make your boot choice.

5 Using hardware switches and a programmable USB board for boot choice

If you want to make your boot choice through an electromechanical switch, you need to use a programmable USB board, flash it with our firmware and connect a suitable switch to it.

Our firmware is designed for boards with the Microchip/Atmel ATmega32u4 chip, which can act as a USB device. All related files can be found in **`grub-switch/2_usb_device`**

5.1 Supported boards

Currently the project includes pre-built firmware images for the following products:

- PJRC Teensy 2.0

- Arduino Micro

- SparkFun Pro Micro (3V and 5V versions) and various clones

- Adafruit ItsyBitsy 32u4 (3V and 5V versions)

- DFRobot Beetle

- Our self-designed, non-commercial Custom Hardware PCB (see 5.2.3)

It is fairly simple to adapt the firmware to another board with the ATmega32u4 and build a firmware image. See the detailed documentation for instructions.

5.2 Programming the boards with GRUB Switch firmware

On the Linux command-line, go to the **`grub-switch/2_usb_device/prebuilt_images`** directory, where you can find the suitable image and programming scripts.

5.2.1 Teensy 2.0

Teensy 2.0 has a proprietary bootloader which works with its own GUI programming tool, Teensy Loader. You can find precise installation and download instructions here:

https://www.pjrc.com/teensy/loader_linux.html

The corresponding image is **`prebuilt_images/GRUB_SWITCH_TEENSY20.hex`**

5.2.2 Arduino-compatible boards

Arduino Micro, **ItsyBitsy**, **Pro Micro** and **Beetle** all use a bootloader that is compatible with Arduino IDE, however the IDE does not have an option for downloading any random *.hex file.

We therefore require a command-line tool called **avrdude**, which is available in many Linux repositories. Under Ubuntu, for example, you can install it with

```
sudo apt-get install avrdude
```

To simplify the use of **avrdude**, we have provided a script in **prebuilt_images**. After plugging in your board, it can be started with:

```
sudo ./program_grubswitch_arduino.sh CORRECT_FIRMWARE.hex
```

(The use of *sudo* might not be required on your installation)

The script will ask you to put the connected board into *bootloader mode*, which for the **Arduino Micro** and **ItsyBitsy** can be accomplished by pushing the reset button twice.

The **Pro Micro** does not have a reset button; you have to short the **GND** and **RST** pads twice in short order with a wire.

The **Beetle** has a group of 6 tiny contact pads on the bottom side under its USB connector:

```
1 3 5      Pad number 1 is square, not round.
# O O      Short the round pads number 5 and 6 twice in
O O O      short order to put Beetle into bootloader mode
2 4 6
```

After putting your board into *bootloader mode*, you have between 5 and 10 seconds to press a keyboard key for the programming script to continue; any longer, and the board leaves *bootloader mode* again.

After successful firmware programming, the board identifies as a FAT12 storage device. Depending on your Linux GUI, you might get a device notification.

NOTE: There are separate firmware images for the 3V and 5V versions of both ItsyBitsy and Pro Micro, as they need different oscillator configurations. Downloading the wrong firmware will not cause harm, the firmware will just not function. The board can be brought into *bootloader mode* again, and reprogrammed with the correct firmware.

5.2.3 THE GRUB SWITCH custom USB hardware Rev.B

Our custom USB device design relies on the *DFU bootloader* which is factory-built into each ATmega32u4 chip. There is an open source command-line tool called **dfu-programmer** which needs to be installed for firmware falshing. Under Ubuntu Linux, it can be installed with:

```
sudo apt-get install dfu-programmer
```

To simplify the use of **dfu-programmer**, we have provided a script in `prebuilt_images`. After plugging in your board, it can be started with:

`sudo ./program_grubswitch_dfu.sh GRUB_SWITCH_CUSTOMHW_REVB.hex`

(The use of *sudo* might not be required on your installation)

Before or after starting the script, the chip needs to be brought into *bootloader mode* by pushing or shorting the **PROG** button. Unlike the Arduino boards, there is no bootloader timeout. Pressing a key on the keyboard will start programming.

After successful firmware programming, the board identifies as a FAT12 storage device. Depending on your Linux GUI, you might get a device notification.

5.3   Writing the GRUB Switch boot configuration onto your storage device

Together with the **boot.*** directories, option **2** of the `CONFIGURE_GRUBswitch.sh` script has also written a single text file holding the complete list and order of boot choices:

`bootfiles/.entries.txt`

You can open with a text editor to see the ordered list of boot choices, however it is not recommended to edit the file by hand. Because the filename starts with a period, it is only visible if you use the -**a** option with **ls**:

`ls -la bootfiles/`

If you mount your USB storage device automatically through the GUI, you can just copy the file onto the device and unmount.

Alternatively, you can use option **4 - Write GRUBswitch bootfile to GRUBswitch USB device** in the `CONFIGURE_GRUBswitch.sh` script. This requires giving the *sudo* password because the mounting and unmounting of the device is being forced.

NOTE: Your USB device is not a regular flash drive. `.entries.txt` is the only file that will be accepted for writing, and only if the **Write-Protect** jumper is not set on the board (see wiring section). The only other (read-only) files on the device are:

`SWITCH.GRB` – The actual boot setting script read by GRUB. If there are no switch connections on the board yet, this will be empty because that is the default leading to the GRUB menu.

`.bootpins.txt` – This file (also hidden without `ls -a`) shows the choice pins currently connected to GND as ones. It is only included for testing purposes.

5.4   Electrical connections to the GRUB Switch boards

This section shows the various ways to connect switches to each board to control the boot choice.

5.4.1 Arduino Micro

```
1-OF-N MODE  with  ON/OFF/ON toggle switch:
------------------------------------------

To choose this mode, pin PF1 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF6 to GND or PF7 (adjacent pad, driving a low level).

Using a three-position on/off/on switch permits choosing between two
OS options, while the neutral middle position leads to the GRUB menu


                                          #####              [1]
                    .----------o=#    #            ////
                    |           #    #||    ////
                    |      .---o=#    #||////          [0] Menu
                    |      |     #    #||
                    |   .---|---o=#    #
                    |   |   |     #####              [2]
                    |   |   |
                    |   |   |
 .------------------------------------+---+---+---------------------.
 | O   O   O   O   O   O   O   O   O   O   O   O   O   O   O   O   O  |
 | 12  11  10  9   8   7   6   5   4   3   2  GND RST RX  TX  SS  MOSI |
 | PD6 PB7 PB6 PB5 PB4 PE6 PD7 PC6 PD4 PD0 PD1         PD2 PD1 PB0 PB2  |
 |                                                                   |
 |                                                                   |
 |========#                                                          |
 | USB    #                                                          |
 |        #                      ARDUINO MICRO                       |
 | MICRO-B #                                                         |
 |========#                                                          |
 |                                                                   |
 |                                                                   |
 |                                                                   |
 | PC7         PF7 PF6 PF5 PF4 PF1 PF0                      PB3  PB1  |
 | 13  3V3 AREF A0  A1  A2  A3  A4  A5        5V0 RST GND VIN MISO SCK |
 | O   O   O   O   O   O   O   O   O   O   O   O   O   O   O   O   O  |
 '--------------+---+-----------------------------------------------'
                |   |
                |   |
                |   |
                  ?
              /WR_PROT
```

```
1-OF-N MODE with rotary switch: (Motto: "This one goes to 11!")
----------------------------------------------------------------

To choose this mode, pin PF1 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF6 to GND or PF7 (adjacent pad, driving a low level).

Common rotary switches have up to 12 positions (some can be limited to fewer
positions with a mechanical keyring). Keeping the first position [0] unconnected
permits choosing the GRUB menu and leaves 11 boot choices, which is the maximum
number of pins sampled. Connecting one of the pins PD1..PD6 to GND
therefore reflects boot choices 1..11 (hexadecimal 0x1..0xB). Accidentally
connecting multiple pins results in the lowest-order entry being chosen.


      .------------------------------------------o [11/0xB]
      |   .----------------------------------o [10/0xA]
      |   |   .------------------------------o [9]
      |   |   |   .--------------------------o [8]
      |   |   |   |   .--------------------o [7]
      |   |   |   |   |   .----------------o [6]          x-----o
      |   |   |   |   |   |   .------------o [5]         /      |
      |   |   |   |   |   |   |   .--------o [4]        /       |
      |   |   |   |   |   |   |   |  .------o [3]      /        |
      |   |   |   |   |   |   |   |  |   .---o [2]    /         |
      |   |   |   |   |   |   |   |  |   |  .-o [1]             |
      |   |   |   |   |   |   |   |  |   |  |   o [0] Menu      |
      |   |   |   |   |   |   |   |  |   |  |                   |
      |   |   |   |   |   |   |   |  |   |  |   .-------------'
      |   |   |   |   |   |   |   |  |   |  |   |
  .---+---+---+---+---+---+---+---+--+---+--+---+---------------------.
  |   o   o   o   o   o   o   o   o  o   o  o   o   o   o   o   o   o  |
  |   12  11  10  9   8   7   6   5  4   3  2  GND RST RX  TX  SS MOSI |
  |   PD6 PB7 PB6 PB5 PB4 PE6 PD7 PC6 PD4 PD0 PD1        PD2 PD1 PB0 PB2 |
  |                                                                   |
  |                                                                   |
  |========#                                                          |
  | USB    #                                                          |
  |        #                  ARDUINO MICRO                           |
  | MICRO-B #                                                         |
  |========#                                                          |
  |                                                                   |
  |                                                                   |
  | PC7         PF7 PF6 PF5 PF4 PF1 PF0                    PB3   PB1   |
  | 13 3V3 AREF A0  A1  A2  A3  A4  A5           5V0 RST GND VIN MISO SCK |
  | o   o   o   o   o   o   o   o   o   o   o   o   o   o   o   o   o  |
  '--------------+---+------------------------------------------------'
                 |   |
                 |   |
                   ?
              /WR_PROT


                              10
```

BINARY MODE:

To choose this mode, pin PF1 needs to be tied to GND or adjacent pad PF0.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF6 to GND or PF7 (adjacent pad, driving a low level).

Common binary-encoding rotary switches have 10 to 16 positions and connect
the corresponding bit values 1,2,4,8 [LSB..MSB] to the 'C'-contacts; using the
device's binary mode means tieing the four pins PD1..PC6 [LSB..MSB] to GND/0V
as to encode the corresponding boot choices 0(GRUB Menu) up to 15(0xF).
Obviously a proper nerd can also use four separate switches to encode the
choice in binary herself!
(Reminder: The device interprets a pin tied to GND as a '1', so all four
connections mean choice 15/0xF, while no connection means 0.

```
                    .---------------.
                    |               |
              .--+ 2     ---     4 +--.
              |  |      /   \      |  |
              |  | C   | --> |  C +--|-----------.
              |  |      \   /      |  |           |
            .--|--+ 8     ---     1 +--|-------.   |
            |  | | |               | |        |   |
            |  | | '---------------' |        |   |
            |  '--------------------|---.     |   |
            |                       |   |     |   |
            '--------------------.  |   |     |   |
                                 |  |   |     |   |
 .-------------------------------+---+---+---+---------------------.
 | O   O   O   O   O   O   O   O   O   O   O   O   O   O   O   O   O  |
 | 12  11  10  9   8   7   6   5   4   3   2  GND RST RX  TX  SS MOSI |
 | PD6 PB7 PB6 PB5 PB4 PE6 PD7 PC6 PD4 PD0 PD1         PD2 PD1 PB0 PB2 |
 |                                                                  |
 |                                                                  |
 |========#                                                         |
 | USB    #                                                         |
 |        #                 ARDUINO MICRO                           |
 | MICRO-B #                                                        |
 |========#                                                         |
 |                                                                  |
 |                                                                  |
 | PC7         PF7 PF6 PF5 PF4 PF1 PF0                  PB3   PB1 |
 | 13  3V3 AREF A0  A1  A2  A3  A4  A5          5V0 RST GND VIN MISO SCK |
 | O   O   O   O   O   O   O   O   O   O   O   O   O   O   O   O   O  |
 '-------------+---+----------+---+--------------------------------'
              |   |          |   |
              |   |          '---'
              ?             /BM
         /WR_PROT
```

5.4.2 Adafruit ItsyBitsy 3V/5V

```
1-OF-N MODE  with  ON/OFF/ON toggle switch:
-------------------------------------------

To choose this mode, pin PF1 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF6 to GND or PF7 (adjacent pad, driving a low level).

Using a three-position on/off/on switch permits choosing between two
OS options, while the neutral middle position leads to the GRUB menu
```

```
.-----------------------------------------------------.
| O   O   O   O   O   O   O   O   O   O   O   O   O   O |
| BAT GND USB  13  12  11  10  9   7   5* SCL SDA  TX  RX |
|             PC7 PD6 PB7 PB6 PB5 PE6     PD0 PD1 PD3 PD2 |
|                                                     |      #####              [1]
|                                      PD4 4 O |  .-----o=#    #        ////
|                                              |  |     #   #||     ////
|========#                             PD7 6 O +--'  .--o=#   #||////        [0] Menu
| USB    #                                     |     |   #   #||
|        #          ItsyBitsy 3V/5V    PB4 8 O +-----|--o=#    #
| MICRO-B #                                    |     |   #####              [2]
|========#                             GND O +-----'
|                                              |
|                                      EN O |
|                                              |
|              PF7 PF6 PF5 PF4 PF1 PF0 PB1 PB2 PB3  |
| RST  *  ARf  *  A0  A1  A2  A3  A4  A5  SCK MOSIMISO * |
| O    O   O   O   O   O   O   O   O   O   O   O   O   O |
'------------------+---+--------------------------------'
                   |   |
                   |   |
                     ?
                  /WR_PROT
```

1-OF-N MODE with rotary switch: (Motto: "This one goes to 11!")

To choose this mode, pin PF1 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF6 to GND or PF7 (adjacent pad, driving a low level).

Common rotary switches have up to 12 positions (some can be limited to fewer
positions with a mechanical keyring). Keeping the first position [0] unconnected
permits choosing the GRUB menu and leaves 11 boot choices, which is the maximum
number of pins sampled. Connecting one of the pins PB4..PB7 to GND
therefore reflects boot choices 1..11 (hexadecimal 0x1..0xB). Accidentally
connecting multiple pins results in the lowest-order entry being chosen.

```
                      .------------------------------------------o [11/0xB]
                      |  .---------------------------------------o [10/0xA]
                      |  |  .----------------------------------o [9]
                      |  |  |  .----------------------------o [8]
                      |  |  |  |   .-------------------o [7]
                      |  |  |  |   |   .---------------o [6]            x-----o
                      |  |  |  |   |   |  .-----------o [5]           /     |
                      |  |  |  |   |   |  |  .--------o [4]          /      |
                      |  |  |  |   |   |  |  |  .-----o [3]         /       |
.---------------------+---+---+---+-------+---+---+--. |  .--o [2]  /       |
| O   O   O   O   O   O   O   O   O   O   O   O   O   O | |  |  o [1]        |
| BAT GND USB  13  12  11  10  9   7   5* SCL SDA  TX  RX | |  |  | o [0] Menu  |
|         PC7 PD6 PB7 PB6 PB5 PE6     PD0 PD1 PD3 PD2 | |  |  |            |
|                                                    |  |  |  |            |
|                                          PD4 4 O  +--'  |  |            |
|                                                    |    |  |            |
|========#                                 PD7 6 O  +------'  |            |
| USB    #                                           |       |            |
|        #              ItsyBitsy 3V/5V    PB4 8 O  +---------'            |
| MICRO-B #                                          |                     |
|========#                                 GND O  +-----------------------'
|                                                    |
|                                          EN O  |
|                                                    |
|                                                    |
|            PF7 PF6 PF5 PF4 PF1 PF0 PB1 PB2 PB3     |
| RST  *  ARf  *  A0  A1  A2  A3  A4  A5  SCK MOSIMISO *  |
| O    O   O   O   O   O   O   O   O   O   O   O   O   O  |
'------------------+---+------------------------------'
                  |   |
                  |   |
                    ?
                /WR_PROT
```
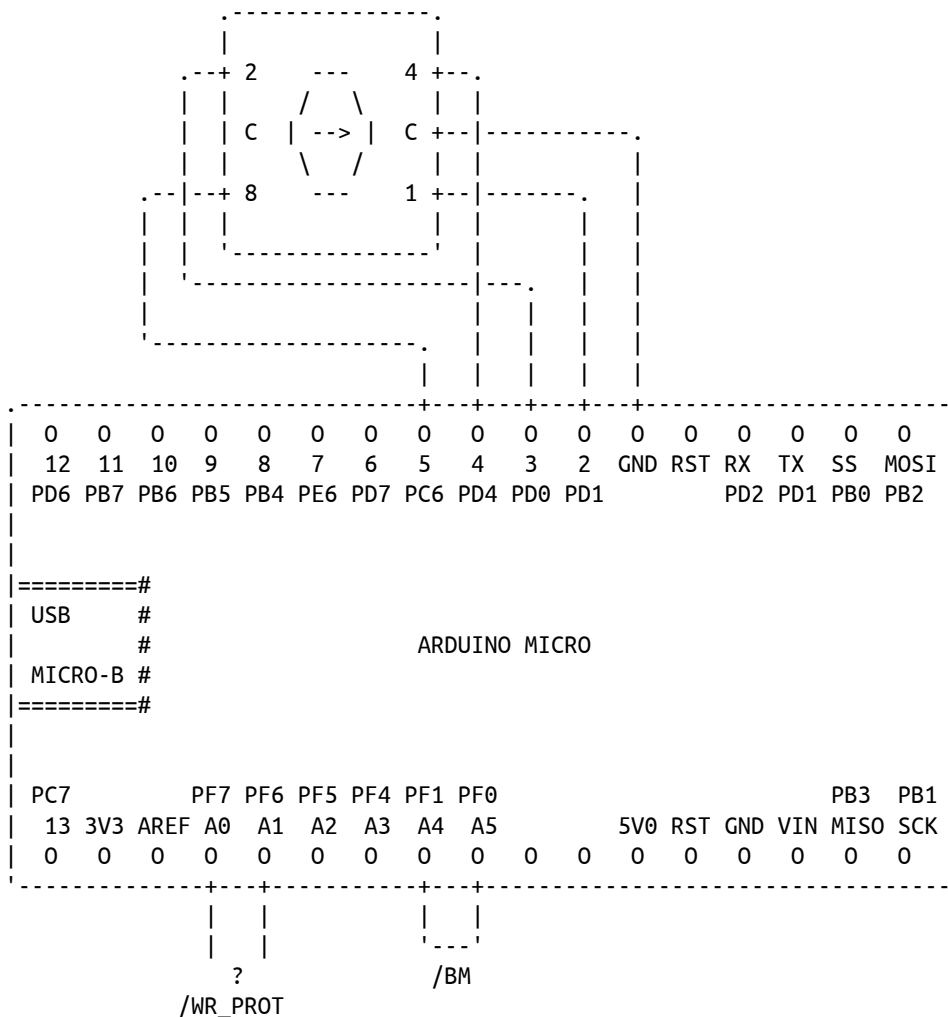
13

```
BINARY MODE:
------------

To choose this mode, pin PF1 needs to be tied to GND or adjacent pad PF0.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF6 to GND or PF7 (adjacent pad, driving a low level).

Common binary-encoding rotary switches have 10 to 16 positions and connect
the corresponding bit values 1,2,4,8 [LSB..MSB] to the 'C'-contacts; using the
device's binary mode means tieing the four pins PB4..PD2 [LSB..MSB] to GND/0V
as to encode the corresponding boot choices 0(GRUB Menu) up to 15(0xF).
Obviously a proper nerd can also use four separate switches to encode the
choice in binary herself!
(Reminder: The device interprets a pin tied to GND as a '1', so all four
connections mean choice 15/0xF, while no connection means 0.
```
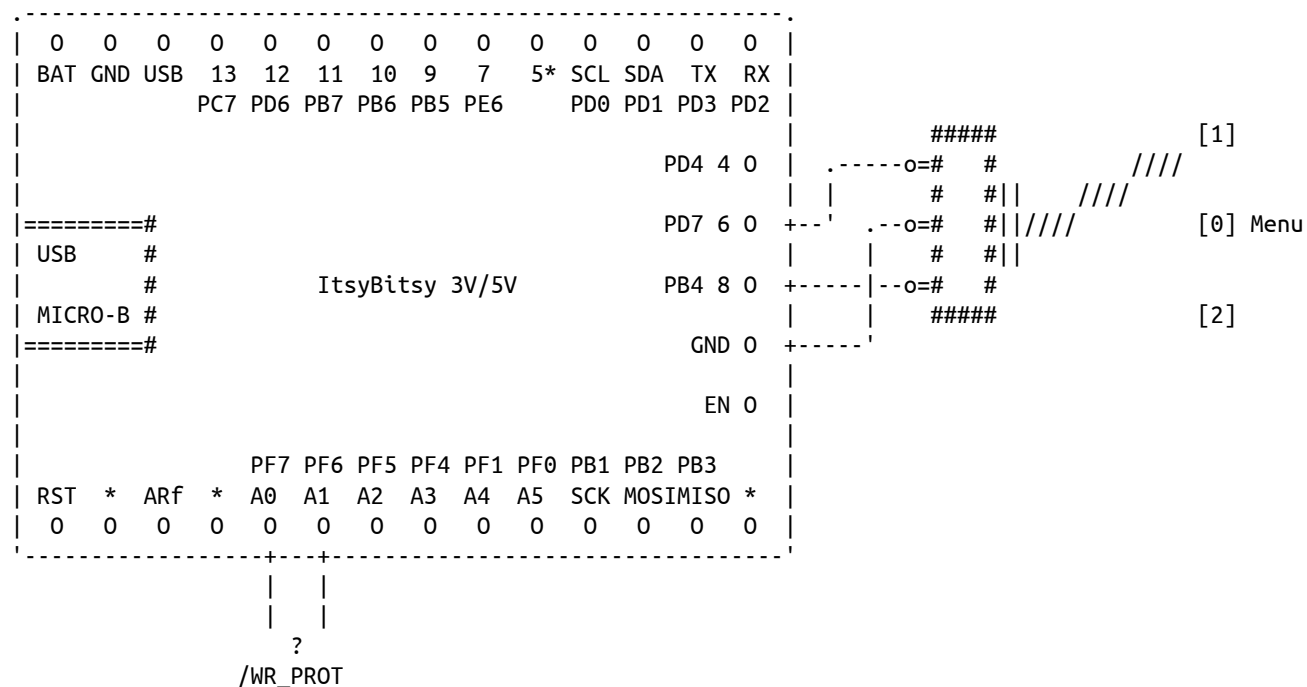
```
                                  .---------------.
                                  |               |
                           .--+ 2      ---      4 +--.
                           |  |      /   \       |  |
                           |  | C   | --> |   C  +--|-----------.
                           |  |      \   /       |  |           |
                         .--|--+ 8      ---      1 +--|-------.   |
                         |  |  |  |                 |  |      |   |
                         |  |  |  '---------------' |  |      |   |
                         |  |  '-------------------|---.      |   |
                         |  |                      |   |      |   |
                         |  '-----------------.    |   |      |   |
                         |                    |    |   |      |   |
  .-----------------------------------------------+--. |      |   |
  |                                              |  | |      |   |
  | O   O   O   O   O   O   O   O   O   O   O   O   O   O  |  | |      |   |
  | BAT GND USB  13  12  11  10  9   7   5* SCL SDA  TX  RX |  | |      |   |
  |             PC7 PD6 PB7 PB6 PB5 PE6     PD0 PD1 PD3 PD2 |  | |      |   |
  |                                                        |  | |      |   |
  |                                              PD4 4 O  +--'  | |      |   |
  |                                                        |    | |      |   |
  |=========#                                    PD7 6 O  +------'  | |
  | USB     #                                              |        | |
  |         #          ItsyBitsy 3V/5V           PB4 8 O  +----------'  |
  | MICRO-B #                                              |            |
  |=========#                                    GND   O  +-------------'
  |                                                        |
  |                                              EN    O  |
  |                                                        |
  |              PF7 PF6 PF5 PF4 PF1 PF0 PB1 PB2 PB3       |
  | RST   *   ARf  *  A0  A1  A2  A3  A4  A5  SCK MOSIMISO *  |
  | O   O   O   O   O   O   O   O   O   O   O   O   O   O  |
  '------------------+---+-----------+---+-----------------'
                     |   |           |   |
                     |   |           '---'
                      ?              /BM
                 /WR_PROT
```

5.4.3 Sparkfun Pro Micro 3V/5V (and clones)

```
1-OF-N MODE  with  ON/OFF/ON toggle switch:
-------------------------------------------

To choose this mode, pin PD2 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF4 to GND or PF5 (adjacent pad, driving a low level).

Using a three-position on/off/on switch permits choosing between two
OS options, while the neutral middle position leads to the GRUB menu


                    /WR_PROT
                       ?
                     |   |
                     |   |
       .-------------+---+------------------------.
       | 0   0   0   0   0   0   0   0   0   0   0   0 |
       | RAW GND RST VCC  A3  A2  A1  A0  15  14  16  10 |
       |                 PF4 PF5 PF6 PF7 PB1 PB3 PB2 PB6 |
       |                                                |
       |========#                                       |
       | USB    #                                       |
       |        #        Pro Micro 3.3V/5V              |
       | MICRO-B #                                      |
       |========#                                       |
       |                                                |
       | PD3 PD2         PD1 PD0 PD4 PC6 PD7 PE6 PB4 PB5 |
       | TXO RXI GND GND  2   3   4   5   6   7   8   9 |
       | 0   0   0   0   0   0   0   0   0   0   0   0 |
       '-------------+---+---+------------------------'
                     |   |   |
                     |   |   |                 #####            [1]
                     |   |   '-----------o=#    #       ////
                     |   |               #   #||   ////
                     '---|---------------o=#   #||////       [0] Menu
                         |               #   #||
                         '---------------o=#    #
                                         #####            [2]
```
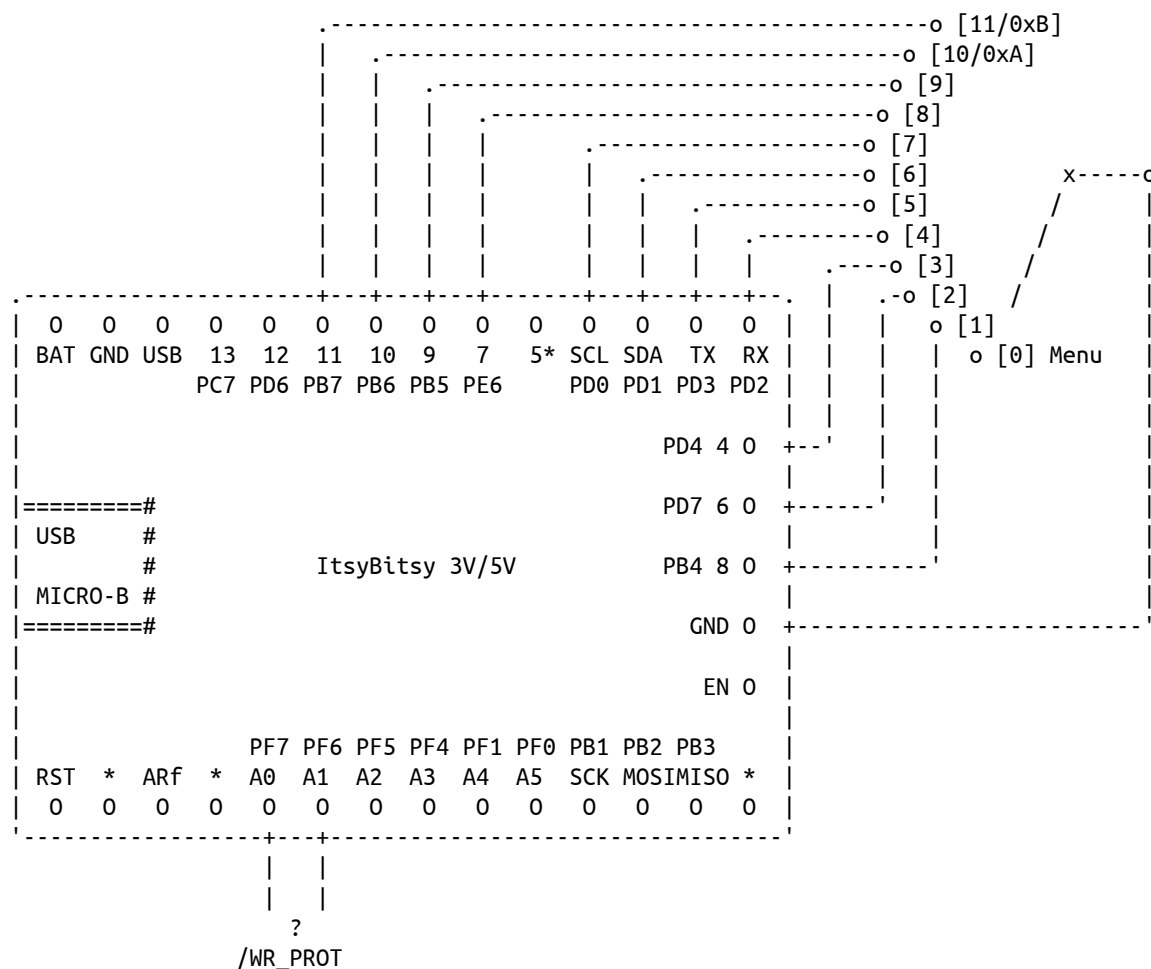
1-OF-N MODE with rotary switch: (Motto: "This one goes to 11!")
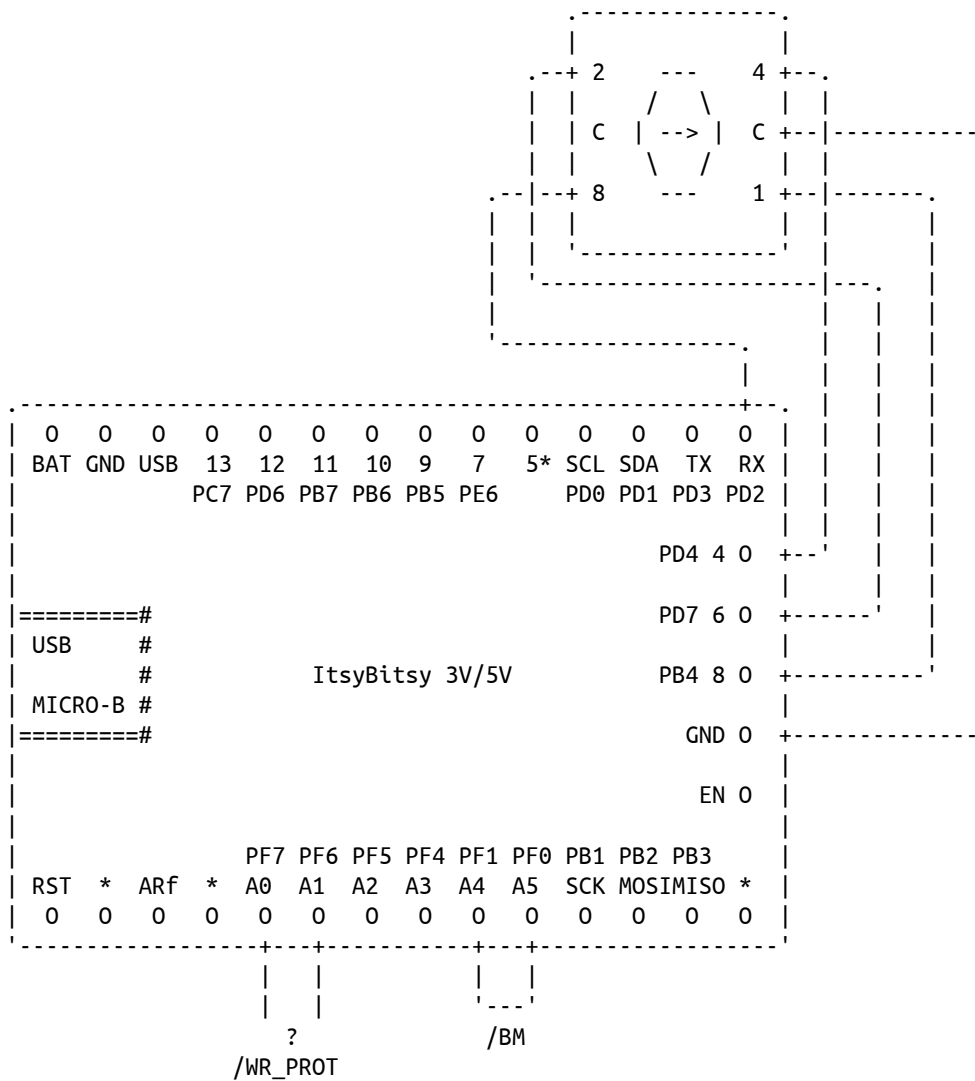---

To choose this mode, pin PD2 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF4 to GND or PF5 (adjacent pad, driving a low level).

Common rotary switches have up to 12 positions (some can be limited to fewer
positions with a mechanical keyring). Keeping the first position [0] unconnected
permits choosing the GRUB menu and leaves 11 boot choices, which is the maximum
number of pins sampled. Connecting one of the pins PD1..PB3 to GND
therefore reflects boot choices 1..11 (hexadecimal 0x1..0xB). Accidentally
connecting multiple pins results in the lowest-order entry being chosen.

```
                      /WR_PROT               .--------------------.
                         ?               |   .--------------.   |
                       |   |             |   |   .-------.   |   |
                       |   |             |   |   |       |   |   |
        .--------------------+---+-------------+---+---+--.  |   |   |
        |  0   0   0   0   0   0   0   0   0   0   0   0  |  |   |   |
        | RAW GND RST VCC  A3  A2  A1  A0  15  14  16  10 |  |   |   |
        |                 PF4 PF5 PF6 PF7 PB1 PB3 PB2 PB6 |  |   |   |
        |                                                 |  |   |   |
        |========#                                        |  |   |   |
        | USB    #                                        |  |   |   |
        |        #       Pro Micro 3.3V/5V                |  |   |   |
        | MICRO-B #                                       |  |   |   |
        |========#                                        |  |   |   |
        |                                                 |  |   |   |
        | PD3 PD2         PD1 PD0 PD4 PC6 PD7 PE6 PB4 PB5 |  |   |   |
        | TXO RXI GND GND  2   3   4   5   6   7   8   9  |  |   |   |
        |  0   0   0   0   0   0   0   0   0   0   0   0  |  |   |   o [11/0xB]
        '-------------+---+---+---+---+---+---+---+---+--' |   | 'o [10/0xA]
                      |   |   |   |   |   |   |   |   |     '--o [9]
                      |   |   |   |   |   |   |   |   '-------o [8]
                      |   |   |   |   |   |   |   '---------o [7]
                      |   |   |   |   |   |   '-------------o [6]        x-----o
                      |   |   |   |   |   '---------------o [5]         /     |
                      |   |   |   |   '-----------------o [4]          /      |
                      |   |   |   '---------------------o [3]         /       |
                      |   |   '-------------------------o [2]        /        |
                      |   '-----------------------------o [1]                 |
                      |                                   o [0] Menu           |
                      |                                                        |
                      '--------------------------------------------------------'
```
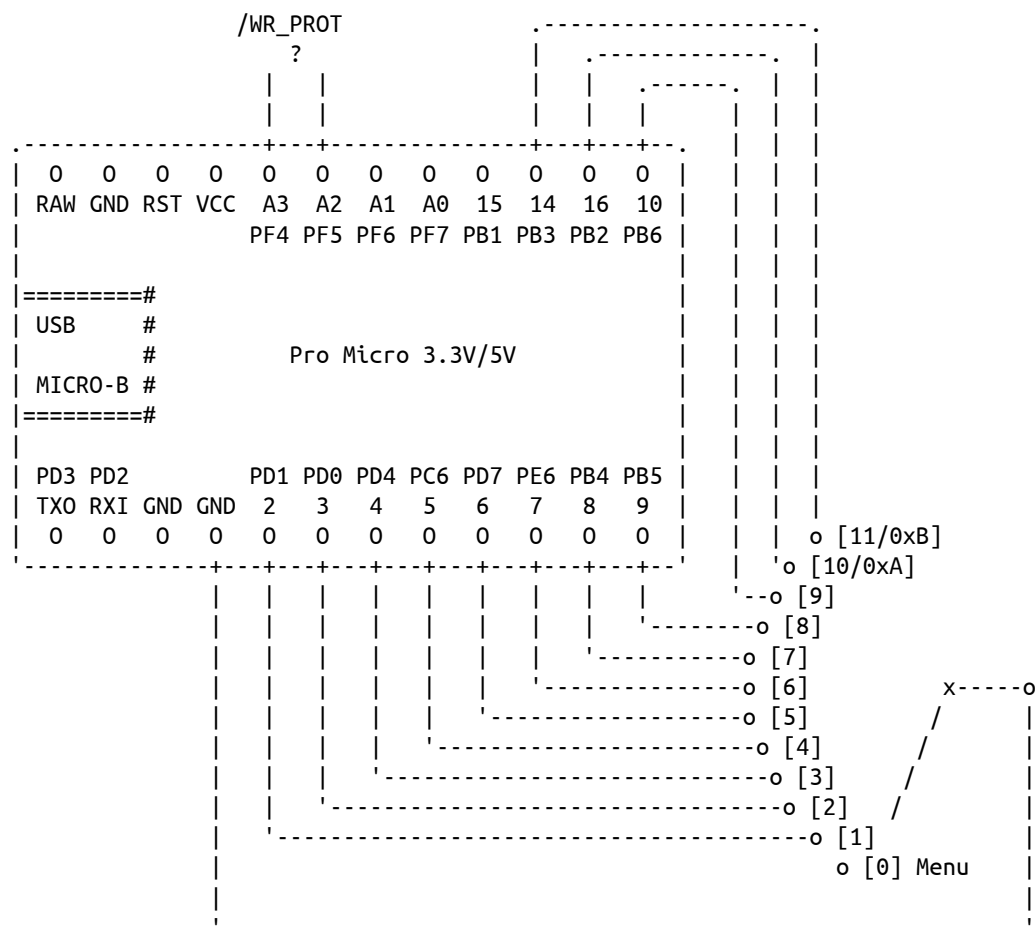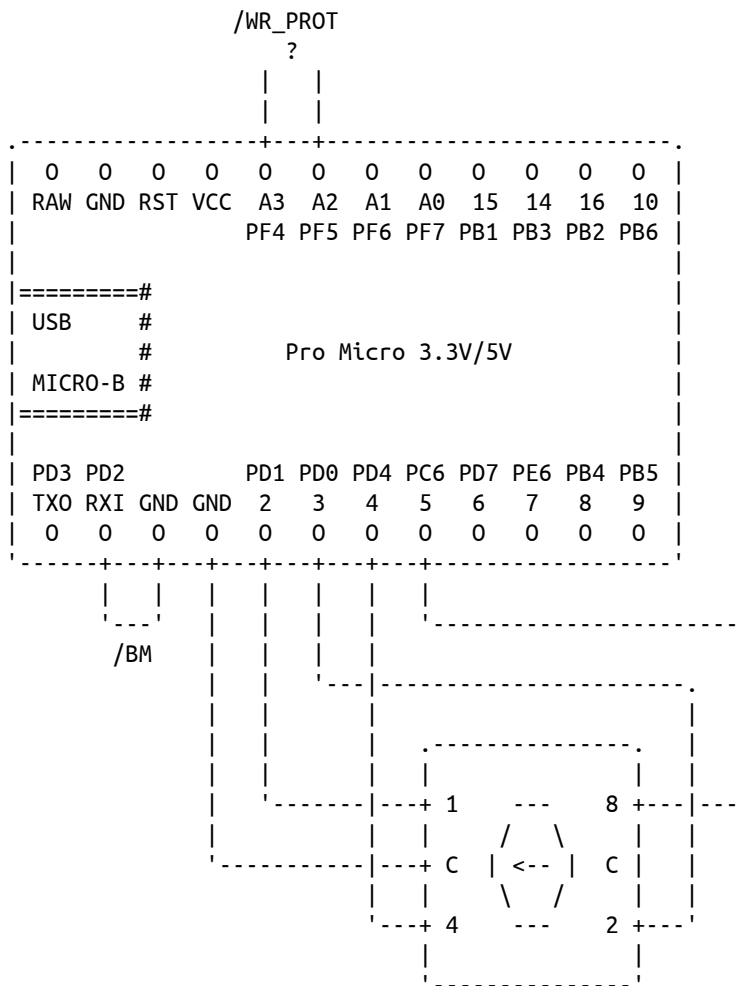
```
BINARY MODE:
------------


To choose this mode, pin PD2 needs to be tied to the adjacent GND pin.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF4 to GND or PF5 (adjacent pad, driving a low level).

Common binary-encoding rotary switches have 10 to 16 positions and connect
the corresponding bit values 1,2,4,8 [LSB..MSB] to the 'C'-contacts; using the
device's binary mode means tieing the four pins PD1..PC6 [LSB..MSB] to GND/0V
as to encode the corresponding boot choices 0(GRUB Menu) up to 15(0xF).
Obviously a proper nerd can also use four separate switches to encode the
choice in binary herself!
(Reminder: The device interprets a pin tied to GND as a '1', so all four
connections mean choice 15/0xF, while no connection means 0.



                      /WR_PROT
                         ?

                         |   |
                         |   |
     .------------------+---+------------------------.
     | O   O   O   O   O   O   O   O   O   O   O   O |
     | RAW GND RST VCC  A3  A2  A1  A0  15  14  16  10 |
     |                 PF4 PF5 PF6 PF7 PB1 PB3 PB2 PB6 |
     |                                                |
     |=========#                                      |
     | USB     #                                      |
     |         #          Pro Micro 3.3V/5V           |
     | MICRO-B #                                      |
     |=========#                                      |
     |                                                |
     | PD3 PD2         PD1 PD0 PD4 PC6 PD7 PE6 PB4 PB5 |
     | TXO RXI GND GND  2   3   4   5   6   7   8   9 |
     | O   O   O   O   O   O   O   O   O   O   O   O |
     '------+---+---+---+---+---+---+------------------'
           |   |   |   |   |   |   |
           '---'   |   |   |   |   '---------------------.
                   |   |   |   |                         |
           /BM     |   |   |   |                         |
                   |   |   '---|----------------------.  |
                   |   |       |                      |  |
                   |   |       |    .--------------.  |  |
                   |   |       |    |              |  |  |
                   |   '-------|---+ 1     ---    8 +---|---'
                   |           |   |      /   \    |   |
                   '-----------|---+ C   | <-- |  C |   |
                               |   |      \   /    |   |
                               '---+ 4     ---    2 +---'
                                   |              |
                                   '--------------'


                           17
```

5.4.4 DFRobot Beetle

```
1-OF-N MODE  with  ON/OFF/ON toggle switch:
-------------------------------------------
```

To choose this mode, pin PB6 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PB7 to GND.

Using a three-position on/off/on switch permits choosing between two
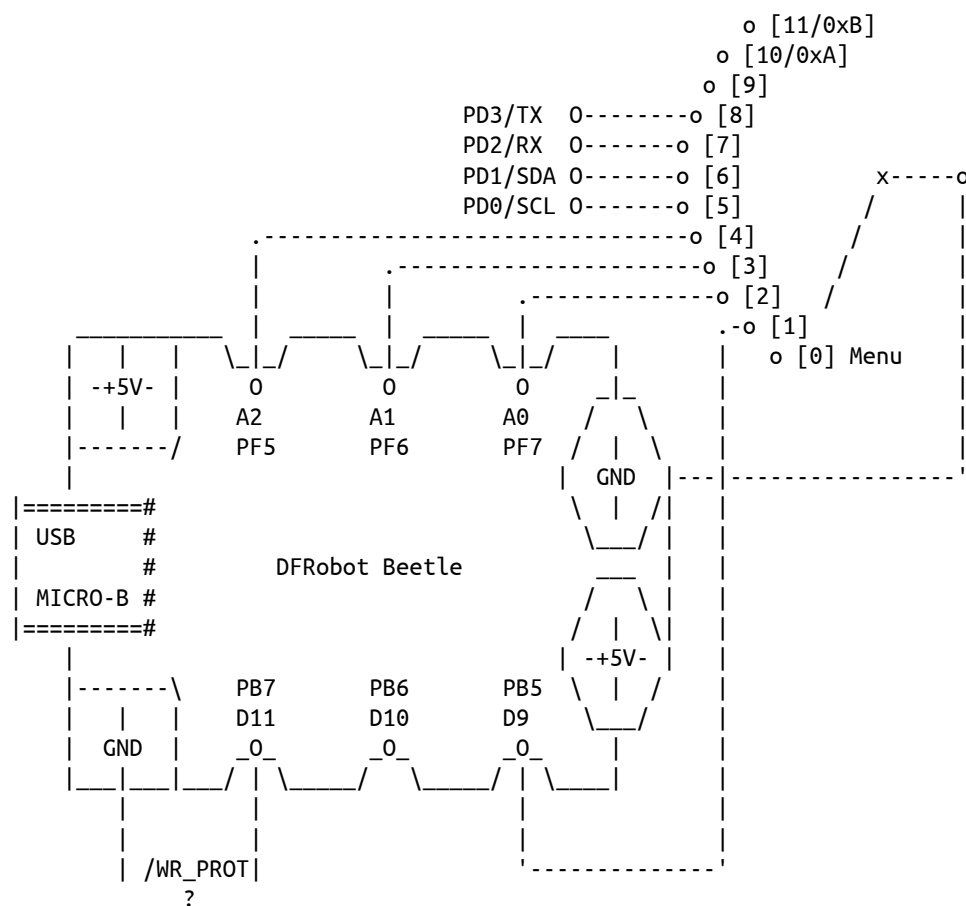OS options, while the neutral middle position leads to the GRUB menu

```
                                   .------------------.
                                   |                  |
                                   |                  |
      _____  _____  _____   __|__ ____           |
     |   |   | | \___/   \___/   \_|_/ |            |
     | -+5V- | |   O       O       O   _|_          |       #####              [1]
     |   |   | |   A2      A1      A0  /   \     '---o=#    #           ////
     |-------/     PF5     PF6     PF7 / |  \         #   #||    ////   ////
     |                              | | GND |-----------o=#   #||////        [0] Menu
     |========#                     \  | /|            #   #||
     | USB    #                      \___/ |       .---o=#    #
     |        #       DFRobot Beetle   ___  |       |   #####              [2]
     | MICRO-B #                      /   \ |       |
     |========#                      /  |  \|       |
     |                              | -+5V- |       |
     |-------\     PB7     PB6     PB5 \  | /        |
     |   |   |     D11     D10     D9   \___/        |
     |  GND  |     _O_     _O_     _O_    |          |
     |___|___|___/ | \_____/  \_____/ | \____|       |
         |         |               |           |
         |         |               |           |
         | /WR_PROT|               '------------------'
            ?
```
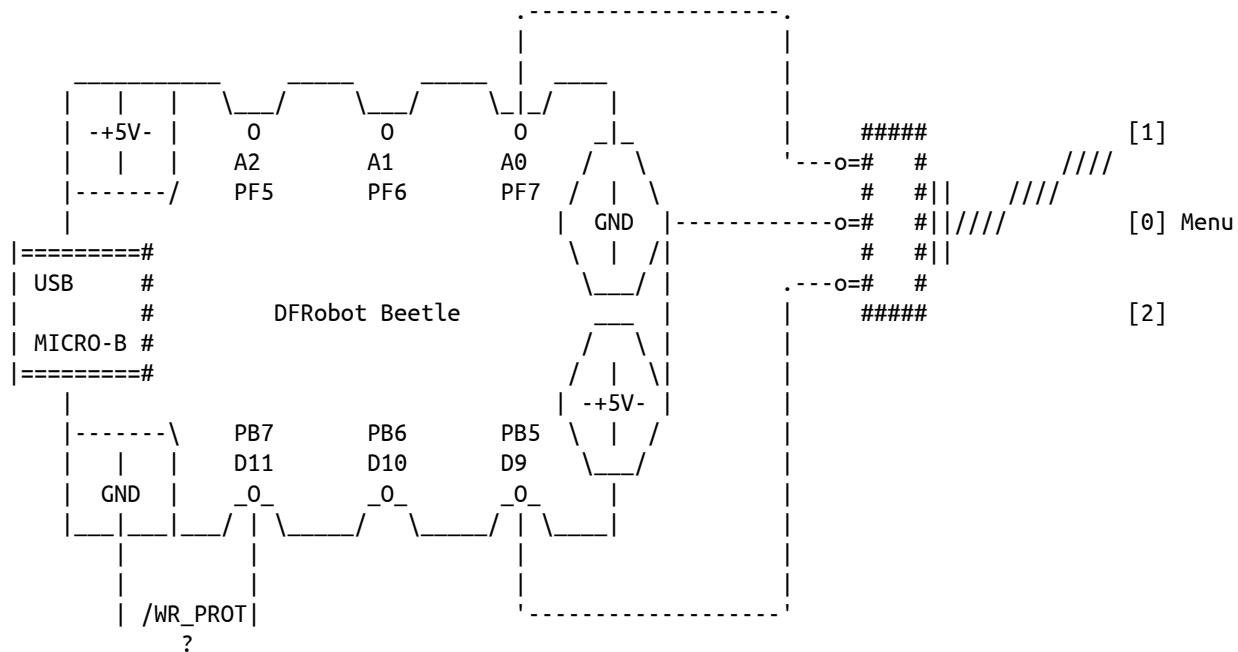
1-OF-N MODE with rotary switch: (Motto: "This one goes to 11!")

To choose this mode, pin PB6 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PB7 to GND.

Common rotary switches have up to 12 positions (some can be limited to fewer
positions with a mechanical keyring). Keeping the first position [0] unconnected
permits choosing the GRUB menu and in principle leaves 11 boot choices, however
Beetle only has 8 accessible connection points left, side pads PB5..BF5 for
positions [1]..[4] and the PCB bottom pads PD0..PD3 for positions [5]..[8]
Connecting one of those pads to GND through the switch reflects the boot
choices 1..8. Accidentally connecting multiple pins results in the lowest-order
entry being chosen.

```
                                                 o [11/0xB]
                                               o [10/0xA]
                                             o [9]
                        PD3/TX  O--------o [8]
                        PD2/RX  O-------o [7]
                        PD1/SDA O-------o [6]            x-----o
                        PD0/SCL O-------o [5]           /      |
              .------------------------------o [4]     /       |
              |          .---------------------o [3]  /        |
              |          |          .------------o [2] /        |
 _____  |   ____   |   ____   |   ____   |     .-o [1]    |
|   |   |   | \_|_/    \_|_/    \_|_/      |    |  o [0] Menu   |
| -+5V- |   |   O        O        O      _|_    |              |
|   |   |   |   A2       A1       A0    /   \    |              |
|-------/   PF5      PF6      PF7 /  |  \    |              |
|                              |  GND  |---|-----------------'
|========#                      \   |  /|    |
| USB    #                       \___/ |    |
|        #      DFRobot Beetle     ___  |    |
| MICRO-B #                       /   \ |    |
|========#                       /  |  \|    |
|                               | -+5V- |    |
|-------\    PB7      PB6      PB5 \  |  /    |
|   |   |    D11      D10      D9   \___/     |
|  GND  |    _O_      _O_      _O_    |       |
|___|___|___/ | \_____/  \_____/ | \___|      |
    |         |                  |            |
    |         |                  '------------'
    | /WR_PROT|
        ?
```
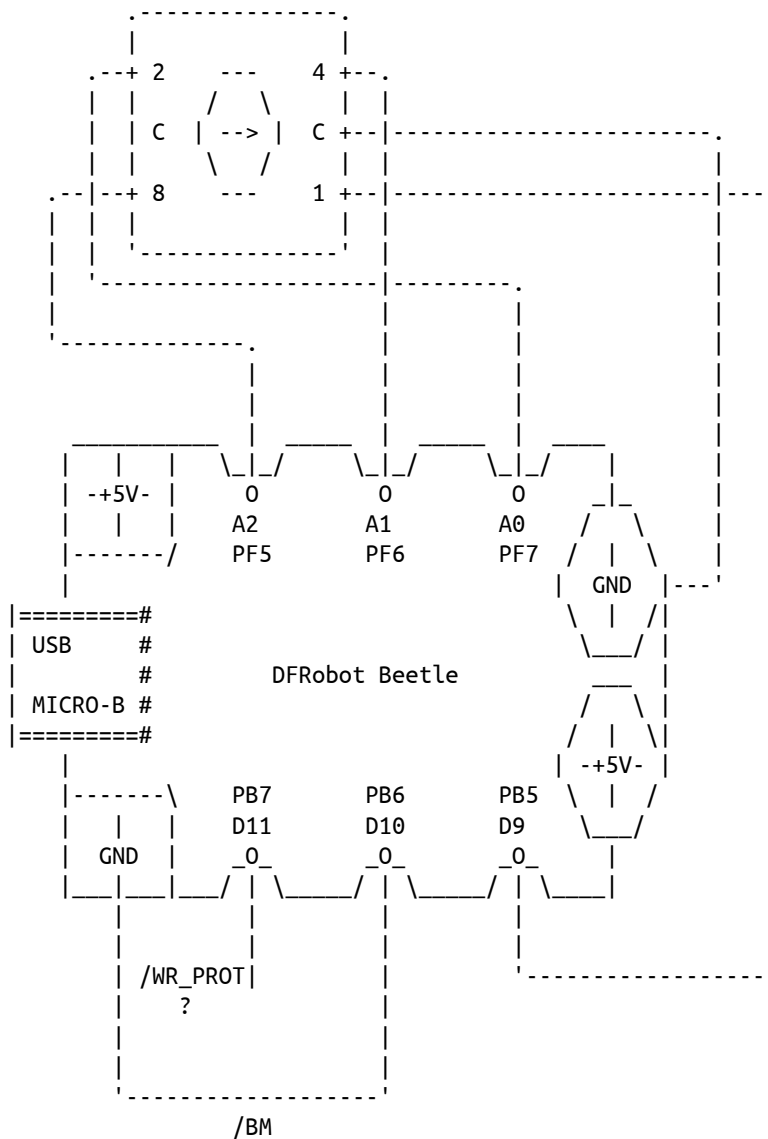
19

BINARY MODE:

To choose this mode, pin PB6 needs to be tied to GND.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PB7 to GND.

Common binary-encoding rotary switches have 10 to 16 positions and connect
the corresponding bit values 1,2,4,8 [LSB..MSB] to the 'C'-contacts; using the
device's binary mode means tieing the four pins PB5..PF5 [LSB..MSB] to GND/0V
as to encode the corresponding boot choices 0(GRUB Menu) up to 15(0xF).
Obviously a proper nerd can also use four separate switches to encode the
choice in binary herself!
(Reminder: The device interprets a pin tied to GND as a '1', so all four
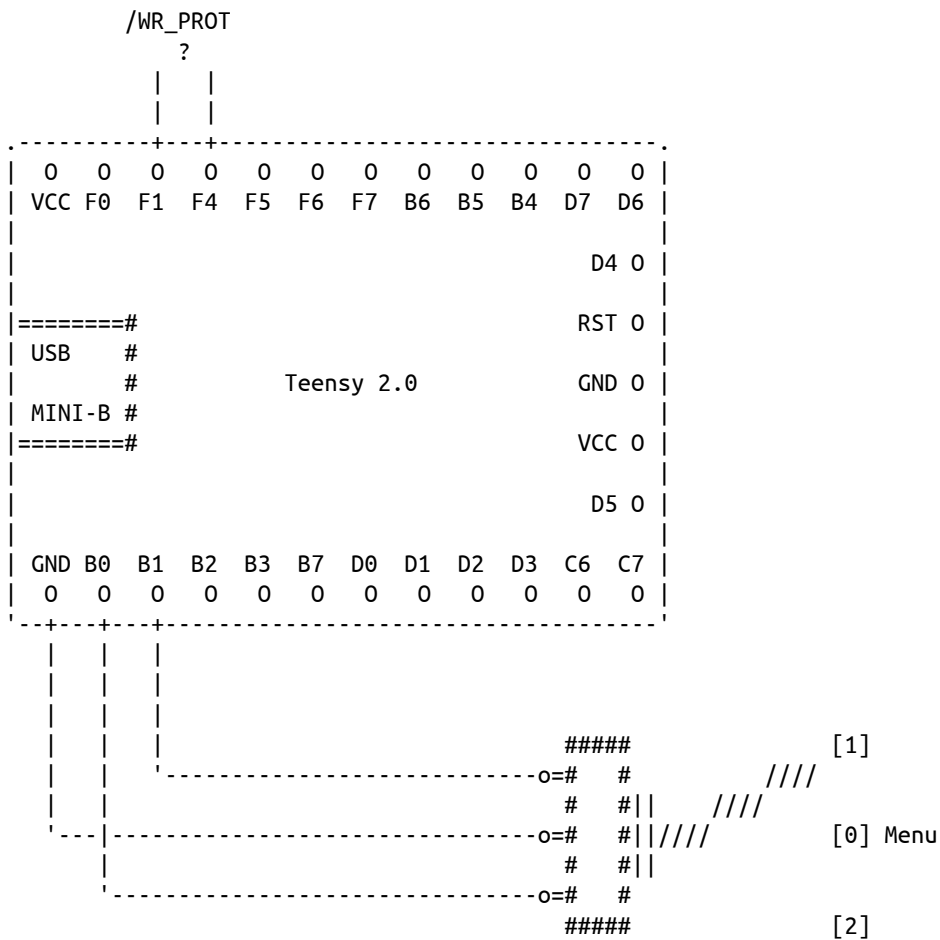connections mean choice 15/0xF, while no connection means 0.)

```
                    .---------------.
                    |               |
              .--+ 2      ---      4 +--.
              |  |       /   \      |  |
              |  | C  | --> |  C +--|----------------------.
              |  |       \   /      |  |                   |
        .--|--+ 8      ---       1 +--|----------------------|---.
        |  |  |  |               |  |                   |   |
        |  |  |  '---------------'  |                   |   |
        |  |  '--------------------|---------.          |   |
        |  |                       |         |          |   |
        '--------------.           |         |          |   |
                       |           |         |          |   |
                       |           |         |          |   |
         _____   |   _____   |  _____  |  _____   |   |
        |  |  |  |  |  \_|_/   \_|_/   \_|_/  |         |   |
        |  -+5V- |     O       O       O      _|_       |   |
        |  |  |  |     A2      A1      A0     /   \      |   |
        |-------/     PF5     PF6     PF7   /  |  \     |   |
        |                                 |  GND  |---'  |
  |=========#                             \   |  /|      |
  | USB     #                              \___/ |       |
  |         #        DFRobot Beetle         ___  |       |
  | MICRO-B #                              /   \ |       |
  |=========#                             /  |  \|       |
        |                                |  -+5V- |       |
        |-------\     PB7     PB6     PB5 \   |  /        |
        |  |  |     D11     D10     D9   \___/         |
        |  GND |    _O_     _O_     _O_     |          |
        |___|___|___/ | \_____/ | \_____/ | \___|        |
            |       |         |         |              |
            |       |         |         |              |
            | /WR_PROT|       |         '------------------'
            |      ?        |
            |               |
            |               |
            '---------------'
                   /BM
```

20

5.4.5 PJRC Teensy 2.0

```
1-OF-N MODE  with  ON/OFF/ON toggle switch:
-------------------------------------------

To choose this mode, pin PB6 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF4 to GND or PF1 (adjacent pad, driving a low level).

Using a three-position on/off/on switch permits choosing between two
OS options, while the neutral middle position leads to the GRUB menu
```
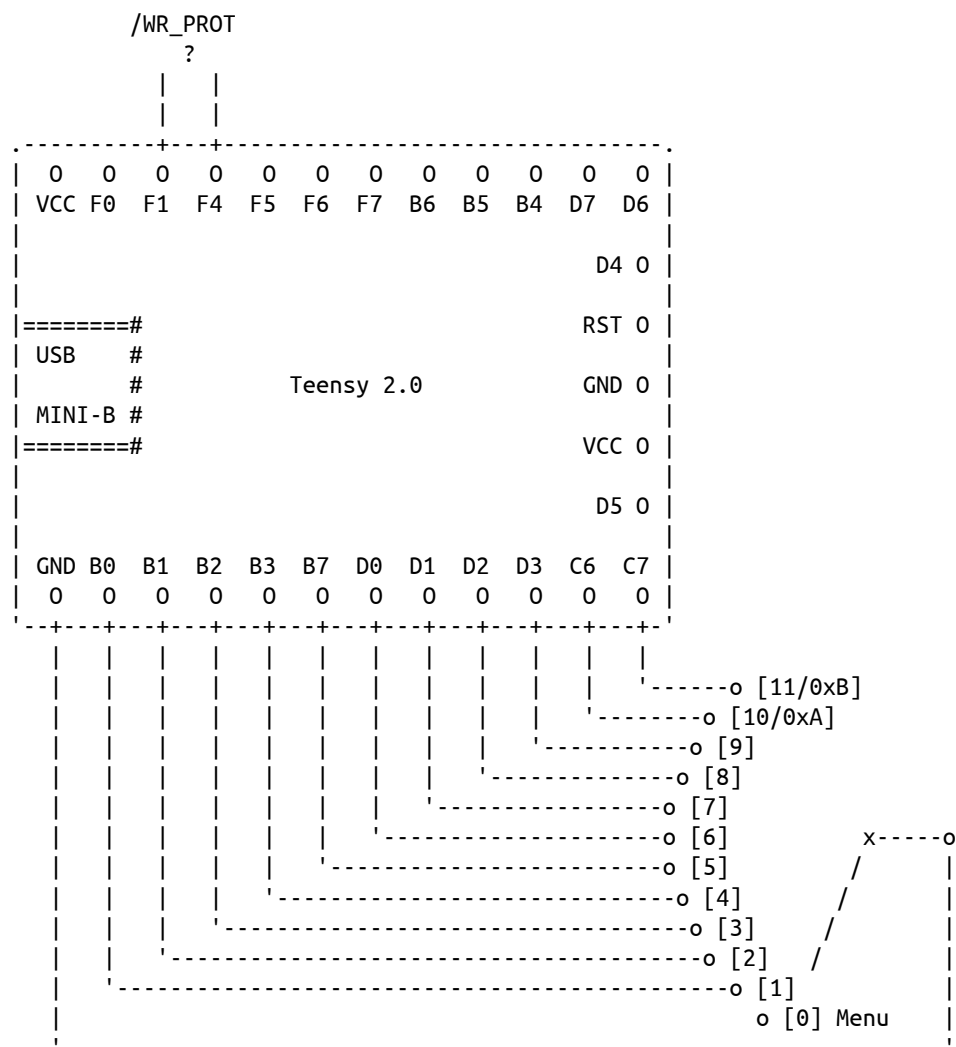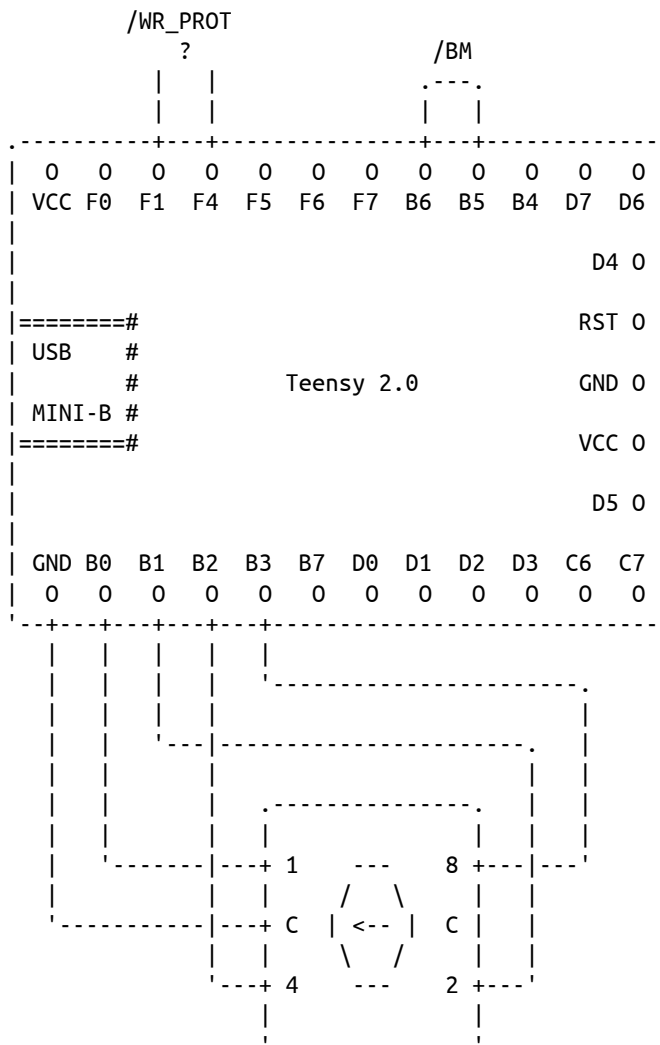
```
             /WR_PROT
                ?
               |   |
               |   |
 .-----------+---+-------------------------------.
 | O   O   O   O   O   O   O   O   O   O   O   O |
 | VCC F0  F1  F4  F5  F6  F7  B6  B5  B4  D7  D6 |
 |                                               |
 |                                        D4 O |
 |                                               |
 |=======#                                RST O |
 | USB    #                                      |
 |        #        Teensy 2.0             GND O |
 | MINI-B #                                      |
 |=======#                                VCC O |
 |                                               |
 |                                        D5 O |
 |                                               |
 | GND B0  B1  B2  B3  B7  D0  D1  D2  D3  C6  C7 |
 | O   O   O   O   O   O   O   O   O   O   O   O |
 '--+---+---+-----------------------------------'
    |   |   |
    |   |   |
    |   |   |
    |   |   |                             #####                [1]
    |   |   '---------------------------o=#   #        ////
    |   |                                 #   #||    ////
    '---|-------------------------------o=#   #||////        [0] Menu
        |                                 #   #||
        '-------------------------------o=#   #
                                         #####                [2]
```

```
1-OF-N MODE with rotary switch: (Motto: "This one goes to 11!")
--------------------------------------------------------------

To choose this mode, pin PB6 needs to stay UNCONNECTED.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF4 to GND or PF1 (adjacent pad, driving a low level).

Common rotary switches have up to 12 positions (some can be limited to fewer
positions with a mechanical keyring). Keeping the first position [0] unconnected
permits choosing the GRUB menu and leaves 11 boot choices, which is the maximum
number of pins sampled. Connecting one of the pins PB0..PC7 to GND
therefore reflects boot choices 1..11 (hexadecimal 0x1..0xB). Accidentally
connecting multiple pins results in the lowest-order entry being chosen.


          /WR_PROT
             ?
           |   |
           |   |
  .--------+---+--------------------------.
  | O   O   O   O   O   O   O   O   O   O   O   O |
  | VCC F0  F1  F4  F5  F6  F7  B6  B5  B4  D7  D6 |
  |                                         |
  |                                   D4 O  |
  |                                         |
  |=======#                           RST O |
  | USB   #                                 |
  |       #        Teensy 2.0         GND O |
  | MINI-B #                                |
  |=======#                           VCC O |
  |                                         |
  |                                   D5 O  |
  |                                         |
  | GND B0  B1  B2  B3  B7  D0  D1  D2  D3  C6  C7 |
  | O   O   O   O   O   O   O   O   O   O   O   O |
  '--+---+---+---+---+---+---+---+---+---+---+-'
     |   |   |   |   |   |   |   |   |   |   |   |
     |   |   |   |   |   |   |   |   |   |   |   '------o [11/0xB]
     |   |   |   |   |   |   |   |   |   |   '--------o [10/0xA]
     |   |   |   |   |   |   |   |   |   '----------o [9]
     |   |   |   |   |   |   |   |   '------------o [8]
     |   |   |   |   |   |   |   '----------------o [7]
     |   |   |   |   |   |   '--------------------o [6]          x-----o
     |   |   |   |   |   '------------------------o [5]         /     |
     |   |   |   |   '----------------------------o [4]        /      |
     |   |   |   '--------------------------------o [3]       /       |
     |   |   '------------------------------------o [2]      /        |
     |   '----------------------------------------o [1]               |
     |                                        o [0] Menu     |
     '--------------------------------------------------------'


                              22
```

```
BINARY MODE:
------------


To choose this mode, pin PB6 needs to be tied to GND or adjacent pad PB5.

The Write Protect against modifying boot entry configurations is activated
by tieing/jumpering pin PF4 to GND or PF1 (adjacent pad, driving a low level).

Common binary-encoding rotary switches have 10 to 16 positions and connect
the corresponding bit values 1,2,4,8 [LSB..MSB] to the 'C'-contacts; using the
device's binary mode means tieing the four pins PB0..PB3 [LSB..MSB] to GND/0V
as to encode the corresponding boot choices 0(GRUB Menu) up to 15(0xF).
Obviously a proper nerd can also use four separate switches to encode the
choice in binary herself!
(Reminder: The device interprets a pin tied to GND as a '1', so all four
connections mean choice 15/0xF, while no connection means 0.


          /WR_PROT
             ?                       /BM
            |  |                     .---.
            |  |                     |   |
            |  |                     |   |
 .----------+---+--------------+---+-------------.
 | O   O   O   O   O   O   O   O   O   O   O   O |
 | VCC F0  F1  F4  F5  F6  F7  B6  B5  B4  D7  D6 |
 |                                              |
 |                                        D4 O |
 |                                              |
 |=======#                                RST O |
 | USB    #                                     |
 |        #          Teensy 2.0           GND O |
 | MINI-B #                                     |
 |=======#                                VCC O |
 |                                              |
 |                                         D5 O |
 |                                              |
 | GND B0  B1  B2  B3  B7  D0  D1  D2  D3  C6  C7 |
 | O   O   O   O   O   O   O   O   O   O   O   O |
 '--+---+---+---+---+--------------------------'
    |   |   |   |   |
    |   |   |   |   '----------------------.
    |   |   |   |                          |
    |   |   '---|----------------------.   |
    |   |       |                      |   |
    |   |       |   .--------------.   |   |
    |   |       |   |              |   |   |
    |   '-------|---+ 1     ---    8 +---|---'
    |           |   |      /   \    |   |
    '-----------|---+ C   | <-- |  C |   |
                |   |      \   /     |   |
                '---+ 4     ---    2 +---'
                    |                |
                    '----------------'
```

23

5.4.6 The GRUB SWITCH Custom Hardware Revision B

Our custom PCB has been designed with an eye to directly mounting and soldering two common types of switches for **1-of-n mode** (shorting one single choice pin to ground at a time).

The silhouettes for both a **1-of-12 rotary switch** and a **on/off/on toggle switch** are visible on the PCB side titled with "THE GRUB SWITCH" (the *bottom* layer in the PCB files). The switches are supposed to be *through-hole*-mounted on this side (which means they will be soldered on the side labeled with "1/n-mode"). Therefore, this is also the side facing the front panel of a case.

Because both types of switches are available with a screw thread for front-panel mounting, the PCB and switch can be affixed mechanically to a case.
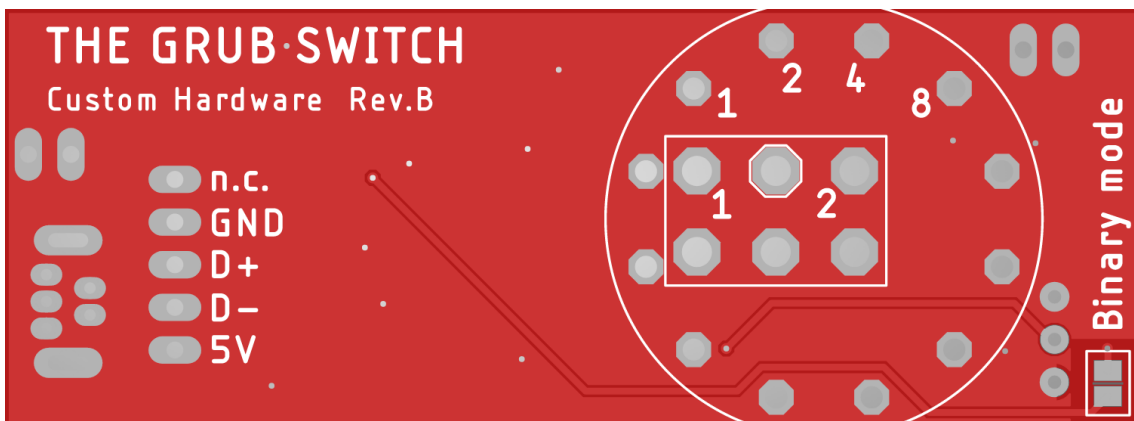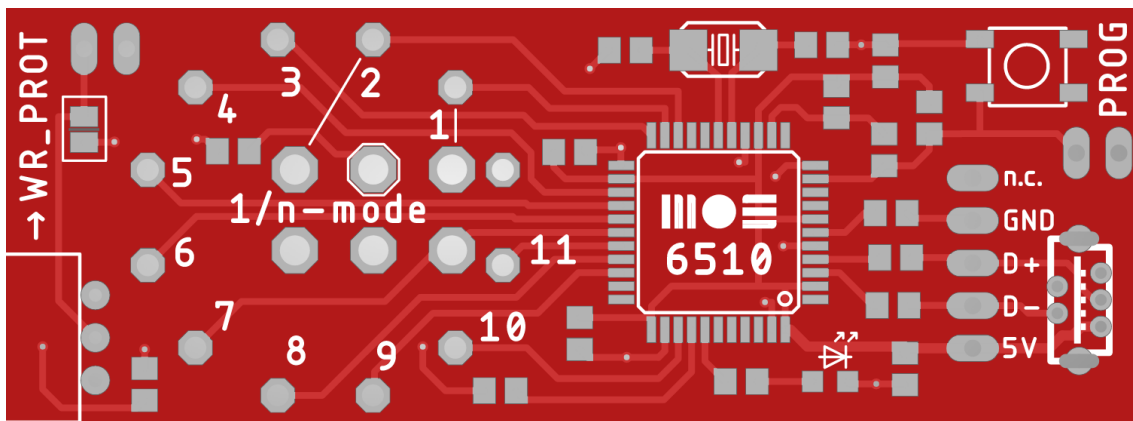
1-of-n mode with ON/OFF/ON switch

The rectangular white silhouette shows the mounting position for a two-channel on/off/on toggle switch (DPDT - "double-pole/double-throw"). Only the upper channel is actually used; the two channel model was chosen to decrease mechanical stress on solder pads and increase stability.

The pad numbers 1 and 2 indicate the boot choices made through electrical connection to the center pad. Note that the toggle switch lever moves across a fixed pivot, so moving the lever to the left (as seen from the front) actually connects choice 2, while moving the lever to the right chooses boot option 1. The neutral center position leads to the GRUB menu.

The following toggle switch series include DPDT on/off/on models with the required 4.7-4.75mm distance between PCB pins:

    APEM Series 5000   E-Switch Series 100

    NKK Series M   TE-Connectivity Gemini A

(these suggestions should not be considered a commercial endorsement)

1-of-n mode with 1-of-12 rotary switch

The round silhouette indicates the mounting position of a 1-of-12 rotary switch. On the PCB side labeled with "1/n-mode" the 11 switch positions for boot choices of increasing order are indicated; position 0 leads to the menu. Because the switch is mounted on the other PCB side, choices increase by turning the switch clockwise.

The switch's main connection pin, which is tied to GND, shares a pad with the toggle switch and is indicated by an octagonal silhouette. It is not in the center of the rotary switch, therefore the switch can only be mounted in exactly one position.

Compatible rotary switches with various actuator shapes and lengths, as well as metric and imperial mounting holes and threads, are available from multiple vendors:

    C&K A112.**.*.NC.**   E-Switch KC52.*.***.**.NP.*

    LORLIN CK1049/CK1059 (metric), CK1044/CK1054 (imperial)

(these suggestions should not be considered a commercial endorsement)

Make sure to order the 1x12 variation, as there are also 2x6, 3x4 and 4x3 models. Most switches come with a metal keyring that can be inserted before tightening the screw and that will limit the range of movement to less than 12 steps; so if you only need, say, 4 boot choices including the GRUB menu option, the range of movement can be fixed to 4 steps.

Binary mode

The Custom PCB isn't designed to hold a binary-encoding switch, but binary mode can be selected anyway by connecting the solder bridge marked with "Binary mode". The numbers 1, 2, 4, 8 inside the round silhouette indicate the pads to connect to GND to choose the corresponding power of 2. GND level is available at the pad marked with an octagonal silhoutte.

Write-protect

A fully-equipped board should include a slide switch to enable and disable *write-protect* for the boot configuration file. Two alternatives are:

- *Write-protect* can be enabled permanently by connecting the solder bridge marked with a rectangle next to the WR_PROT label.

- Next ot the solder bridge are pads for a 1x2 pin header, which can be jumpered to enable *write-protect* non-permanently.

Further details about the custom PCB can be found in the full documentation.