Mountain Top Applications for Single Board Computers

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Willem AC0KQ

Applications

- Site management
  - Device control & monitoring
- Networking
  - IP services like DNS, NTP,
  - Monitoring, cping, intrusion detection, ...
- Repeater linking
  - AllStarLink analog linking
  - MMDVM digital linking
- APRS, packet, RMS
- Webcam
- Software Defined Radio (SDR)

Mountain Top Considerations

- Reliability
  - Difficult access
  - Noisy and unreliable power
- Environment
  - High RF fields
  - Lightning
  - High density altitude
  - Large temperature swings
- Things to consider in all installations

Single Board vs. Desktop/Server

- SBC pros
  - DC power (5V ~1A)
  - No fan or spinning disk
  - Small form factor
  - Serial/I2C/SPI/GPIO and expansion
  - Inexpensive
- Desktop/server pros
  - Better performance
  - SATA and other hard disk
  - Expandable memory

Classes of Single Board Computers

- **Microcomputer**: Full multitasking (linux) OS
  - Raspberry Pi
  - Beaglebone Black
- **Microcontroller:** Single program
  - Arduino
  - Raspberry Pi Pico
  - Adafruit Feather
  - ESP8266, ESP32, etc
  - Popular in Internet of Things (IOT)

Add on boards/Daughterboards

- rPi **H**ardware **A**ttached on **T**op (**HAT**)
- rPi Zero **Bonnet**
- Beaglebone **cape**
- Arduino **Shield**
- Adafruit **Featherwing**

Native Connectivity

- IP
  - Raspberry Pi (ethernet & wifi)
  - Beaglebone Black (ethernet)
  - ESP8266/ESP32 (wifi only)
- Serial/USB
  - Arduino
  - Raspberry Pi Pico
  - Arduino Feather
  - IP often provided by ESP8266 daughter board

SBC Device Connectivity

- USB
- Serial (TTL level)
- I^{2}C (Inter-Integrated Circuit)
- SPI (Serial Peripheral Interface)
- GPIO (General Purpose I/O)
  - PWM (Pulse Width Modulation)
  - 1wire
  - General bit banging
- Analog in/out

USB & Serial Point-to-Point

- Serial
    - TTL 0-5V (RS-232 +/-15V)
    - Ground, Rx, Tx
        - RTS, CTS optional
    - 115,200 bits/sec common
- Universal Serial Bus
    - Ground, D+, D-, +5V
        - Type C adds more
   - 1.5 Mb/s-20Gb/s
    - Can be expanded using a hub

• I^2C – Inter-Integrated Circuit

- a.k.a SMBus
- Bidirectional Serial
- Supports up to 127 devices
- Gnd, SDA (data), SCL (clock), Vdd
- Default speed 400 kb/s
- Commonly used for fast low level chip-chip
  – INA219 current/voltage sensor
  – LCD displays
 – Temperature/pressure/RH sensors
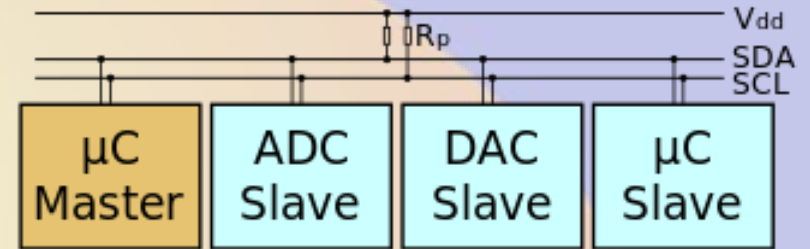
SPI Serial Peripheral Interface

- Bidirectional Serial

- Gnd, SCLK, MOSI, MISO CE/SS for every slave

- Speeds up to 250Mbps

- Commonly used for faster IO
  - Memory
  - Ethernet/WiFi/Bluetooth/RFID
 - GPS,
  - Full duplex
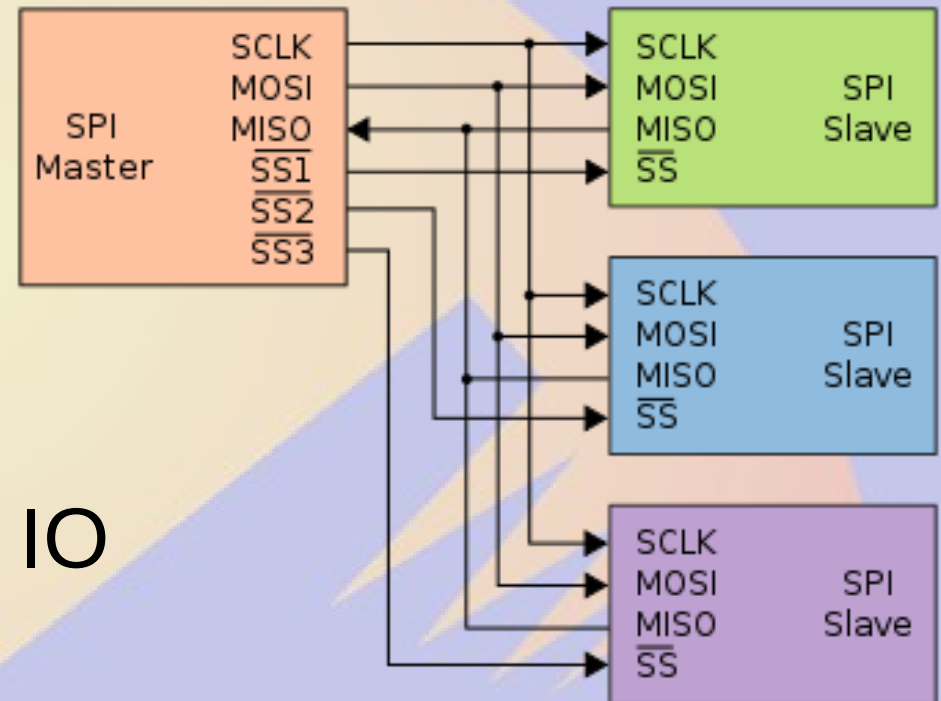
GPIO and Analog IO

- General Purpose IO
  - Bidirectional digital IO (**typically 3.3V**)
  - Some GPIO pins have special functions (e.g. PWM)
  - Can be bit banged to perform other functions
  - Max current ~50mA
- Analog IO
  - In and out typically different (**BB 1.8V**)
  - Use voltage divider for other voltages (Feather A7)
- Many pins can be programmed for different uses
  - CPU pins and board pins overloads names
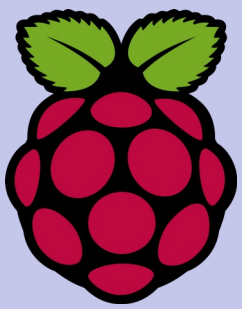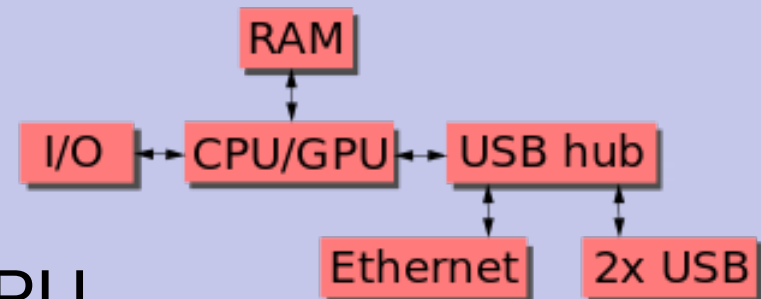
Raspberry Pi 3B+
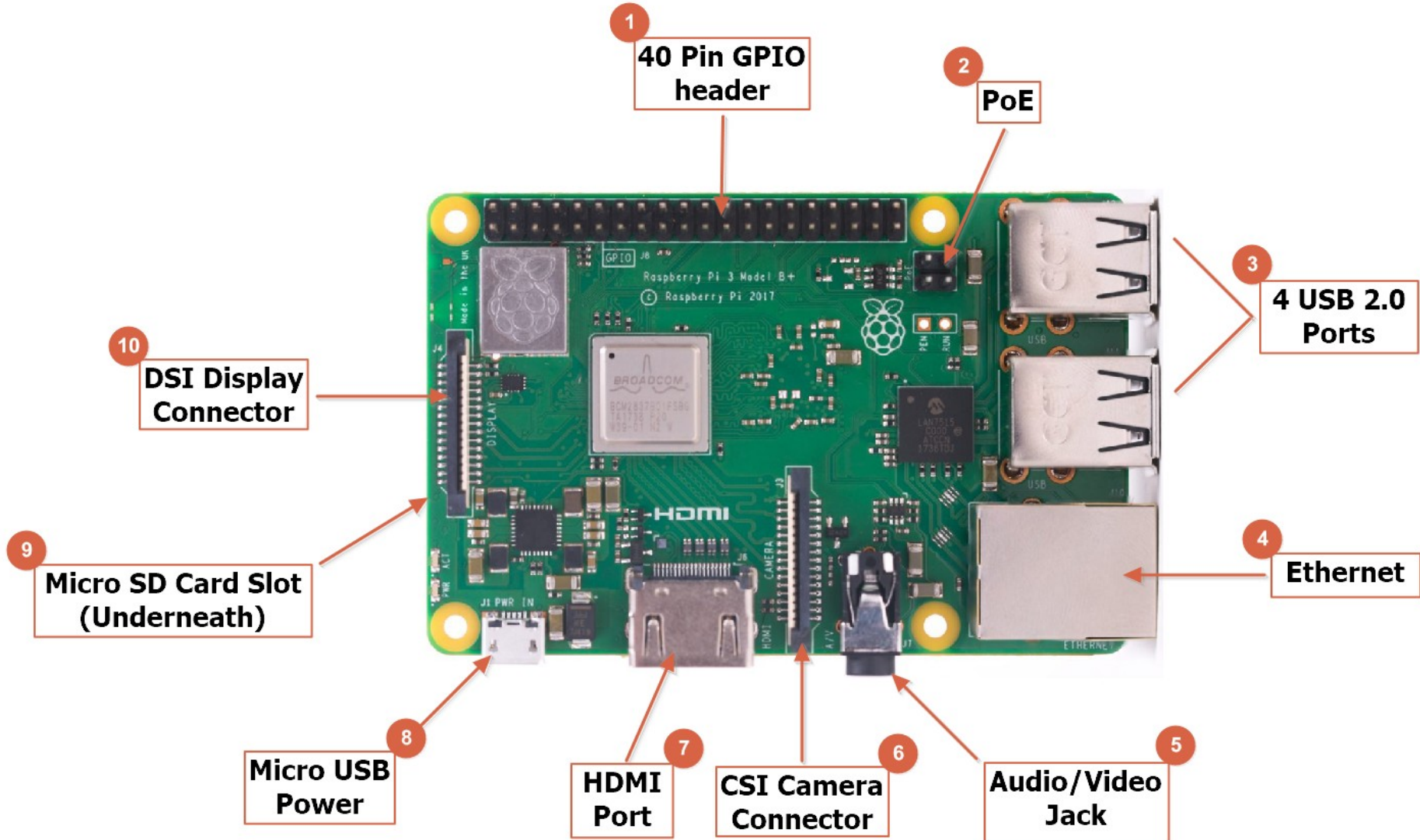
Raspberry Pi Pros and Cons

- Pros
  - Full multitasking OS
  - Active development (more than 35 million sold)
  - Large user community (most popular by far)
    - Many HATs to expand capabilities
    - Well supported in software (debian derivatives and others)

- Cons
  - Single serial port (second on later models)
  - No analog I/O
  - No native audio input
  - USB limits I/O speeds
  - Pins connect directly to CPU

Raspberry Pi Models

| Model	CPU	RAM	Ether	Wifi	USB	Price
2B	0.9GHz quad	1GB	100Mb	--	4	$30
3B	1.2GHz quad	1GB	100Mb	2.4GHz	4	$35
3B+	1.4GHz quad	1GB	1Gb	2.4GHz	4	$35
4B	1.5GHz quad	1GB-8GB	1Gb	2.4/5GHz	4	$35-75
0	1.0GHz single	512M	--	--	1	$5
0W	1.0GHz single	512M	--	2.4GHz	1	$10

- My preference is the 3B+ because it does not need a fan
- Current draw (depends on the load and daughterboards)
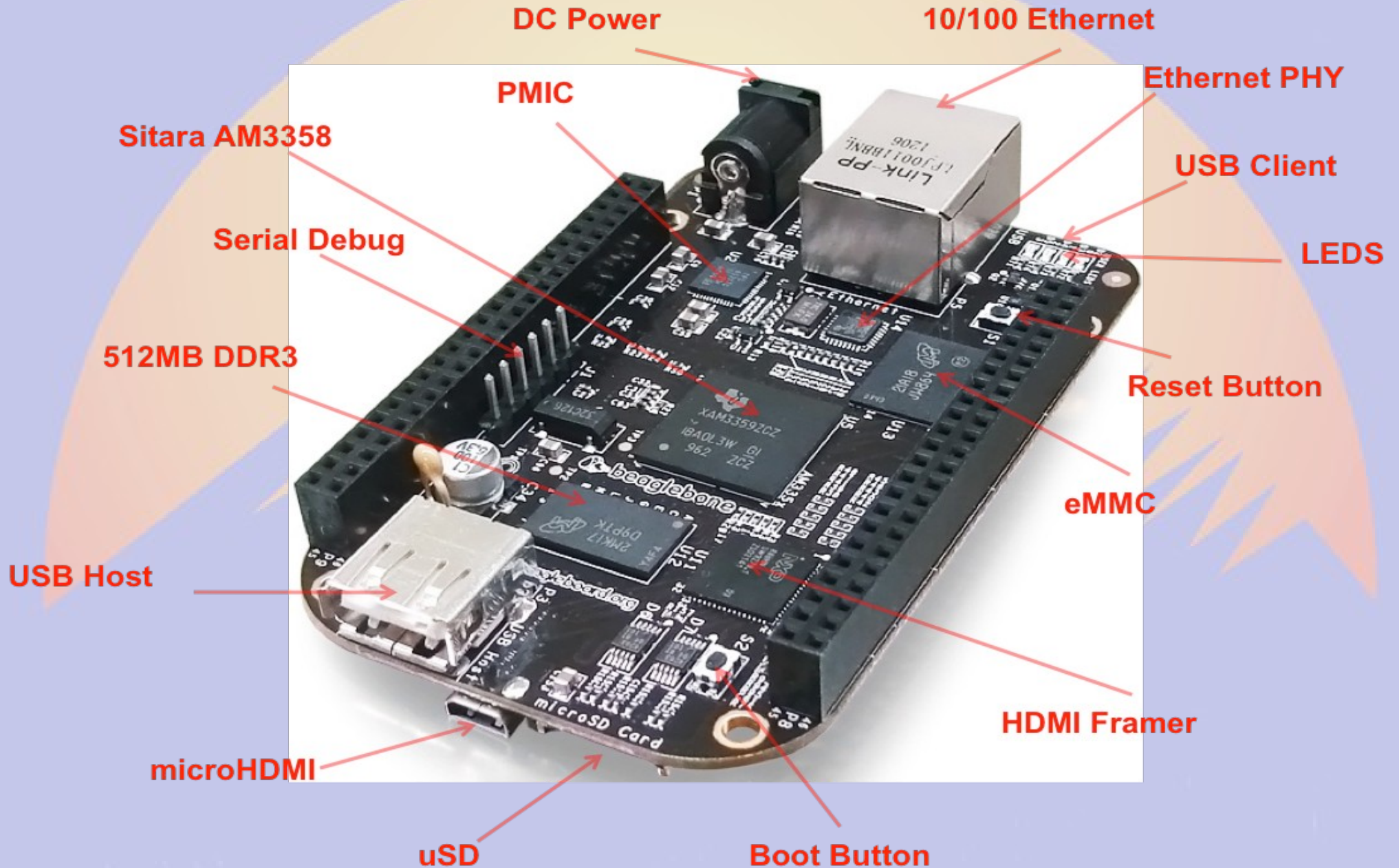   - 0W   250mA
    - 3B+   500mA
    - 4B   800mA

# Raspberry Pi Pinout
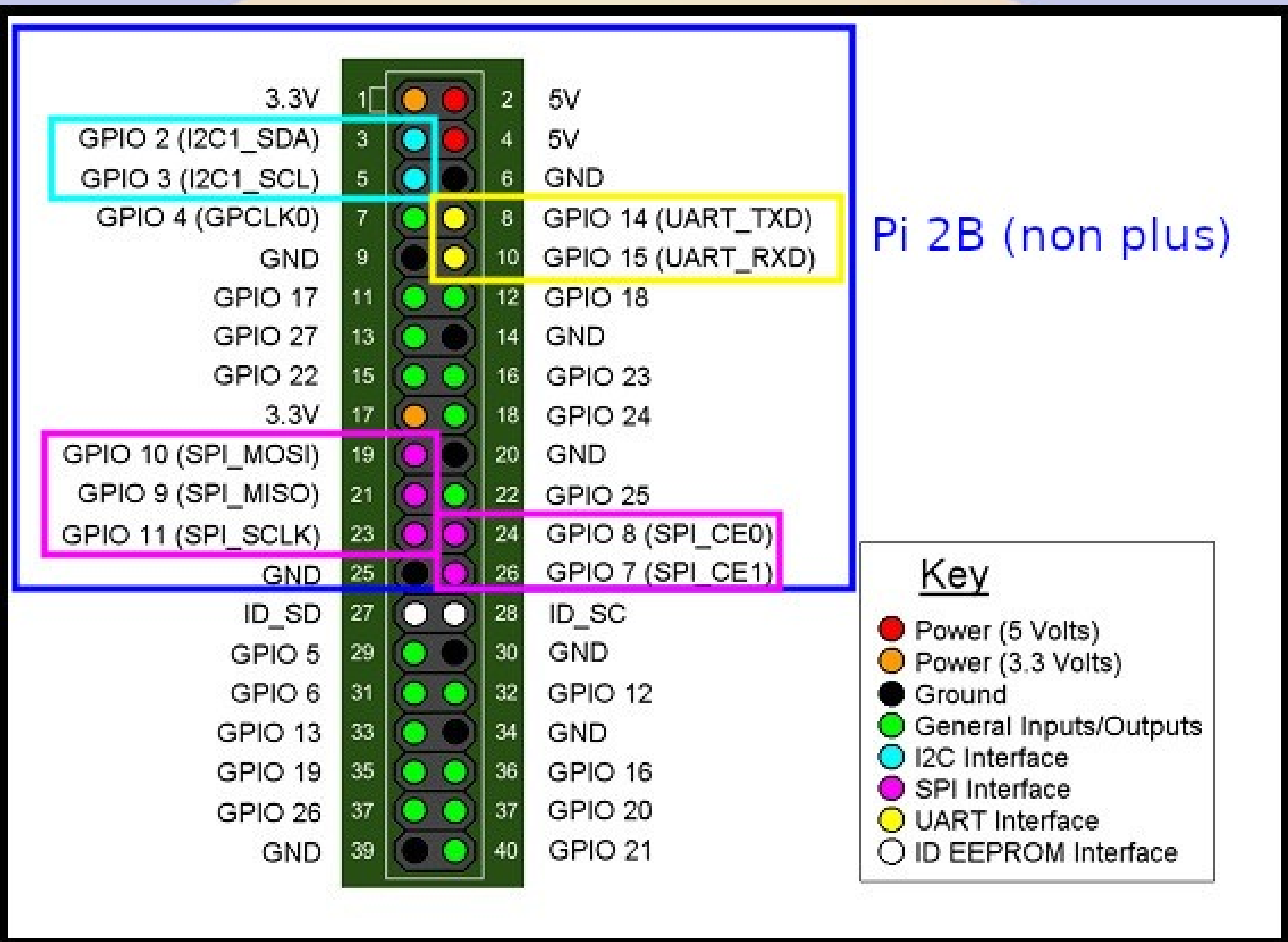
Beagle Bone Black

Beagle Bone Black Pinout

P9

DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
UART4_RXD	11	12	GPIO_60
UART4_TXD	13	14	EHRPWM1A
GPIO_48	15	16	EHRPWM1B
SPIO_CS0	17	18	SPI0_D1
I2C2_SCL	19	20	I2C2_SDA
SPIO_D0	21	22	SPIO_SCLK
GPIO_49	23	24	UART1_TXD
GPIO_117	25	26	UART1_RXD
GPIO_115	27	28	SPI1_CS0
SPI1_D0	29	30	GPIO_112
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	ECAPPWMO
DGND	43	44	DGND
DGND	45	46	DGND
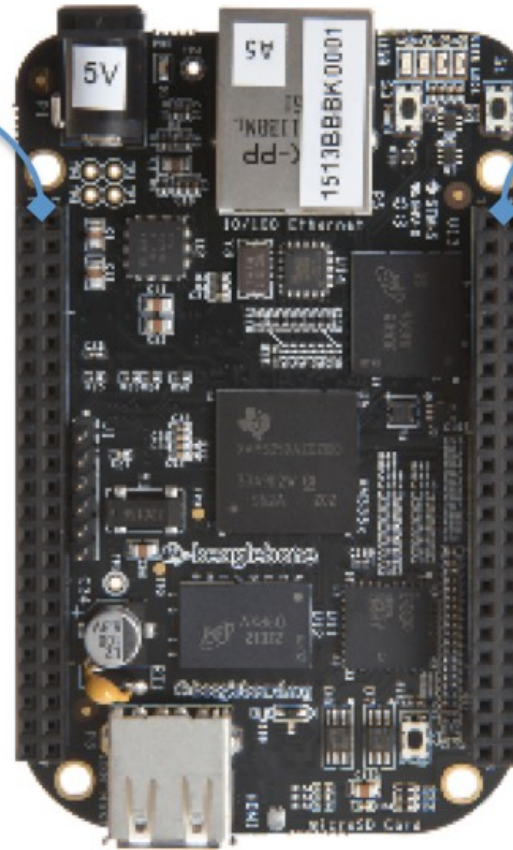
P8

DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
GPIO_66	7	8	GPIO_67
GPIO_69	9	10	GPIO_68
GPIO_45	11	12	GPIO_44
EHRPWM2B	13	14	GPIO_26
GPIO_47	15	16	GPIO_46
GPIO_27	17	18	GPIO_65
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT4	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO_61
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_AC_BIAS
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

LEGEND

- POWER/GROUND/RESET
- AVAILABLE DIGITAL
- AVAILABLE PWM
- SHARED I2C BUS
- RECONFIGURABLE DIGITAL
- ANALOG INPUTS (1.8V)

Beagle Bone Pros and COns

- Pros
  - Capes mechanically more sound
  - 4 serial ports, 8 analog in ports
  - Up to 67 GPIO pins
- Cons
  - More expensive ($80)
  - Smaller user base
  - Fewer capes available
  - Single USB

SD cards

- OS requires 4GB with desktop, <1GB headless
- rPiOS optimized to not wear out SD card
  - Never run a database on an SD card
- Buy a reputable brand
  - I swear by SanDisk Ultra
  - 16GB good price point
  - UHS-1 (Class 10) good speed
  - $6 each in 3pack
  - Have not lost one in 5+ years

Real Time Clock

- rPi does not have a hardware clock
- rPiOS will use NTP to set time if it has IP
  - Shutdown time saved to SD card, so clock starts from that time if no IP connection on reboot
- Many options to add RTC if it matters
  - PiFace Shim
  - Adafruit PiRTC
  - Typically I2C based
- Use GPS HAT if precise time matters but no IP available

Power Supplies

- Bad power is the primary failure mode

- Nominal 5.1V (alerts at 4.63V, max 5.25V)

- DC-DC converters helps with noisy power
  - oversize it
  - short, fat leads

- SMAKN DC-DC
  - 8-50V in
  - 5V3A out
  - micro USB
  - $14

Enclosures

- Shielding is important in high RF environments
- Passive cooling and shielding metal enclosure
  - Onboard wifi range significantly limited
- Add chip heatsink of case does not touch chip
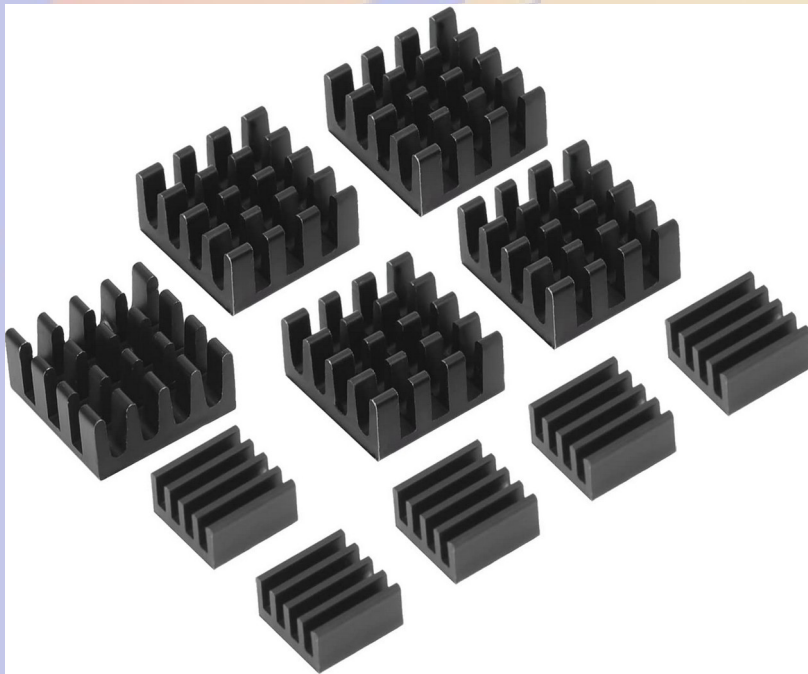
Download and Install OS

- Raspberry Pi OS
  - `https://www.raspberrypi.org/software/operating-systems/#raspberry-pi-os-32-bit`
  - **desktop** for graphical login
  - **lite** for text interface (headless)

- Copy to SD card
  - `https://www.raspberrypi.org/software/`
  - Imager for Windows/macOS/Linux
  - Use dd if you know what you are doing

- For headless enable ssh
  - `touch <mountpoint>/boot/ssh`

- Configure with `raspi-config`

sudo raspi-config
5 Interfacing Options

```
┌─ Raspberry Pi Software Configuration Tool (raspi-config) ─┐
│                                                           │
│  P1 Camera       Enable/Disable connection to the Raspberry Pi Camera │
│  P2 SSH          Enable/Disable remote command line access to your Pi using │
│  P3 VNC          Enable/Disable graphical remote access to your Pi using Rea │
│  P4 SPI          Enable/Disable automatic loading of SPI kernel module │
│  P5 I2C          Enable/Disable automatic loading of I2C kernel module │
│  P6 Serial       Enable/Disable shell and kernel messages on the serial conn │
│  P7 1-Wire       Enable/Disable one-wire interface │
│  P8 Remote GPIO  Enable/Disable remote access to GPIO pins │
│                                                           │
│                                                           │
│                                                           │
│             <Select>                <Back>                │
│                                                           │
└───────────────────────────────────────────────────────────┘
```

Accessing the Hardware

- Linux kernel support
  - Enable using raspi-config
  - File system access through /sys
- Circuit Python
  - Python libraries from Adafruit
- pigpio
  - C library

File Access to Hardware

- ***On Unix everything is a file***
- Make pin 18 an output pin and set value high
  - echo "18" > /sys/class/gpio/export
  - echo "out" > /sys/class/gpio/gpio18/direction
  - echo "1" > /sys/class/gpio/gpio18/value
- Read value of pin 20
  - echo "20" > /sys/class/gpio/export
  - echo "in" > /sys/class/gpio/gpio20/direction
  - cat /sys/class/gpio/gpio20/value
- Export and direction is required only once

Remote Access

- ssh (secure shell)
  - **ssh** ***user@host*** (or use *Putty* or equivalent)
  - Passwordless access
    - ssh-keygen -t rsa -b 4096 -C "*user@domain.com*"
    - ssh-copy-ide *user@host*
- DevDBd
  - Uses Mikrotik protocol for communications
  - Runs commands remotely
  - Read/write files on remote system

Break

Power Overview

- Typical Voltage Conversions
    - AC-to-5V
    - AC-to-12V-to-5V
    -
    - AC-to-5V-UPS-to-5V
    - AC-to-12V-UPS-to-5V

Power Overview

- Microcontrollers
  - Arduino, Feather, ESP8266
  - Generally tolerant of power fluctuations and loss

- Microcomputers
  - Linux-based
  - Raspberry Pi, PC
  - Needs graceful shutdown to prevent file corruption
  - Be careful with power!

5 Volt Power

- Sensitivity of Rpi to 5V Power Input
  - 5V Critical Input Range
    - "All models require a 5.1V supply…"
    - "There is low-voltage detection circuitry that will detect if the supply voltage drops below 4.63V (+/- 5%). This will result in a <u>warning icon</u> being displayed on all attached displays and an entry being added to the kernel log."
    -
  - Current
    - Include Current of USB-Powered Devices, e.g. Keyboard, Mouse

Product	Recommended PSU current capacity	Maximum total USB peripheral current draw	Typical bare-board active current consumption

-

-

- <https://www.raspberrypi.org/documentation/hardware/raspberrypi/power>
  -

AC-to-5V

- AC-to-5V Wallwart
  - Don't forget you are powering USB devices, too!
  - 5V, 3.5A
  - $15

- https://smile.amazon.com/gp/product/B00L88M8TE

AC-to-5V

- AC-to-5V Wallwart
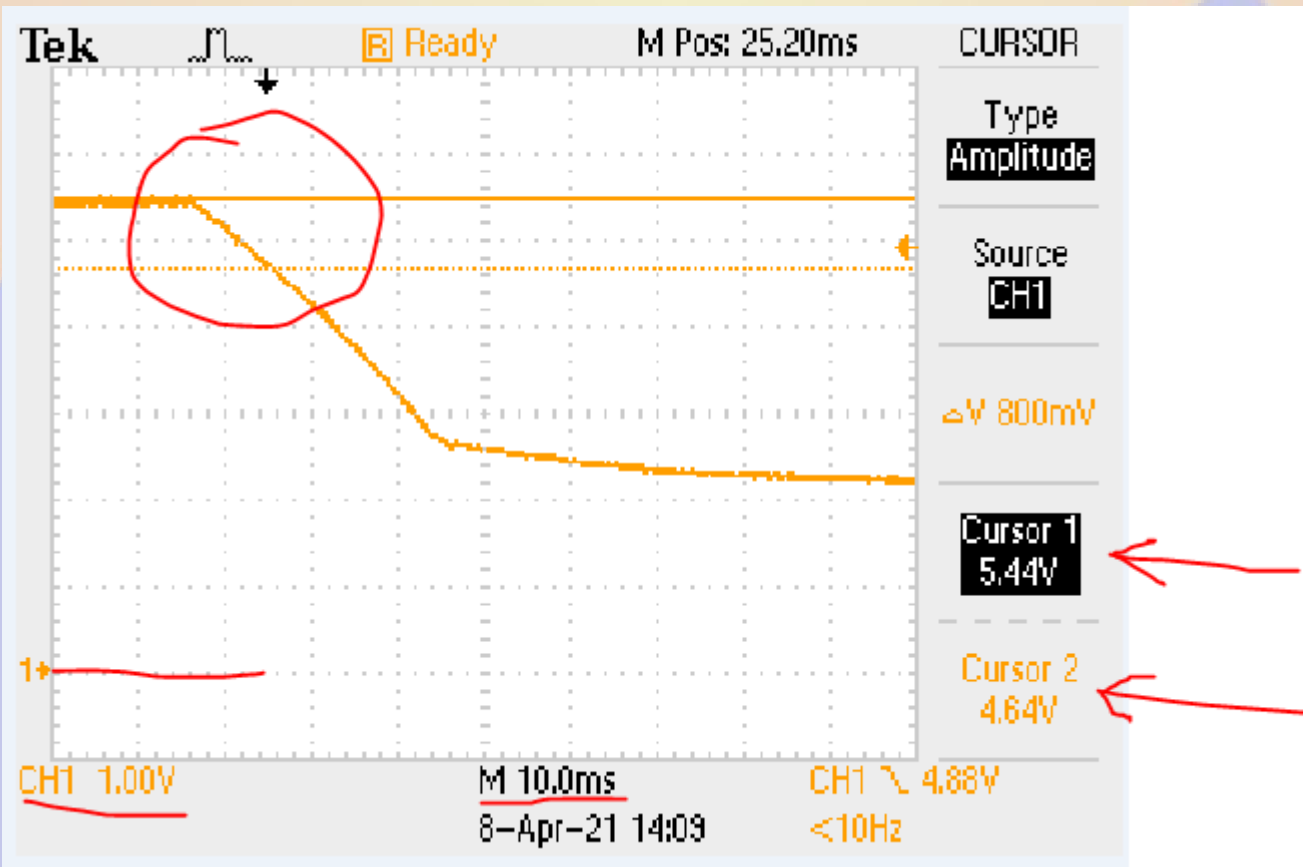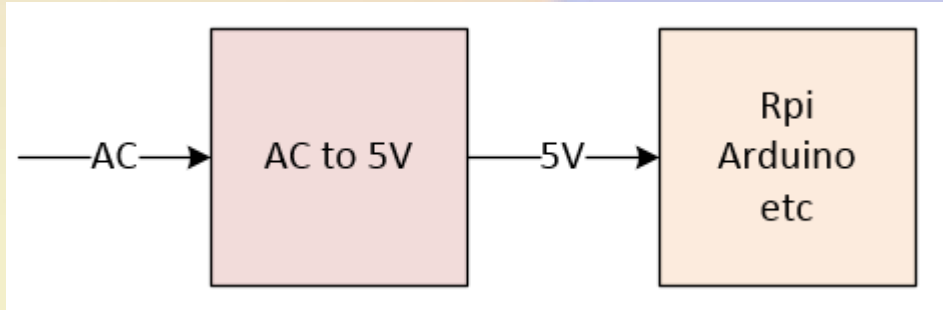
AC-to-5V-UPS

- 5V Uninterruptable Power Supply (UPS)
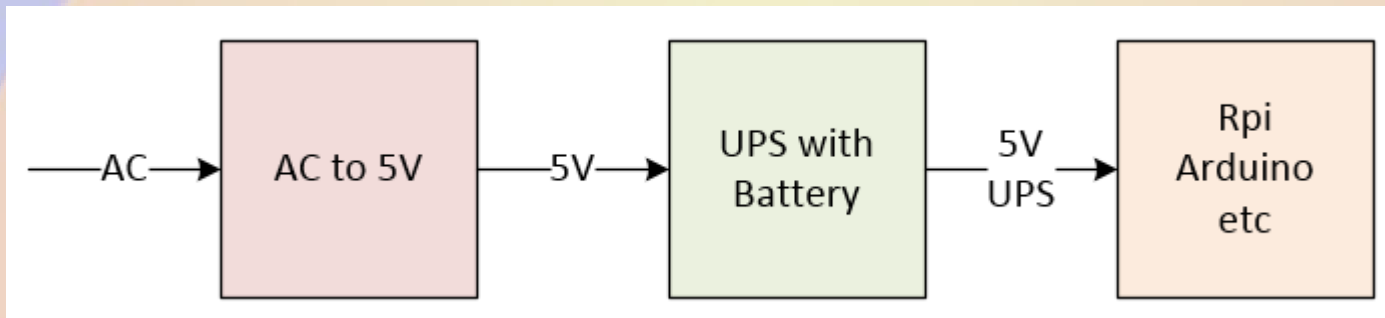
- Attributes
  - Backup Battery keeps Rpi up long enough for clean shutdown.
  - Notify Rpi when to shut down
  - Rpi confirms shut down, then UPS powers off
  - Auto power-on
  - Lithium Charger
  - Parameters are Configurable

5V UPS

- PiJuice
  - Includes Real Time Clock
  - Full UPS
  - Reports Battery Status to RPi
  - Auto Shutdown
  - Configurable Power On
  - Open Source
  - Choose battery size for uptime requirement,
    - 1820 mAh, Rpi 3B+ >2 hours

- https://www.sparkfun.com/products/14803
- https://github.com/PiSupply/PiJuice/blob/master/Documentation/PiJuice%20Guide.pdf
- https://learn.pi-supply.com/battery-levels

AC-to-12V

- Typical at Radio Sites
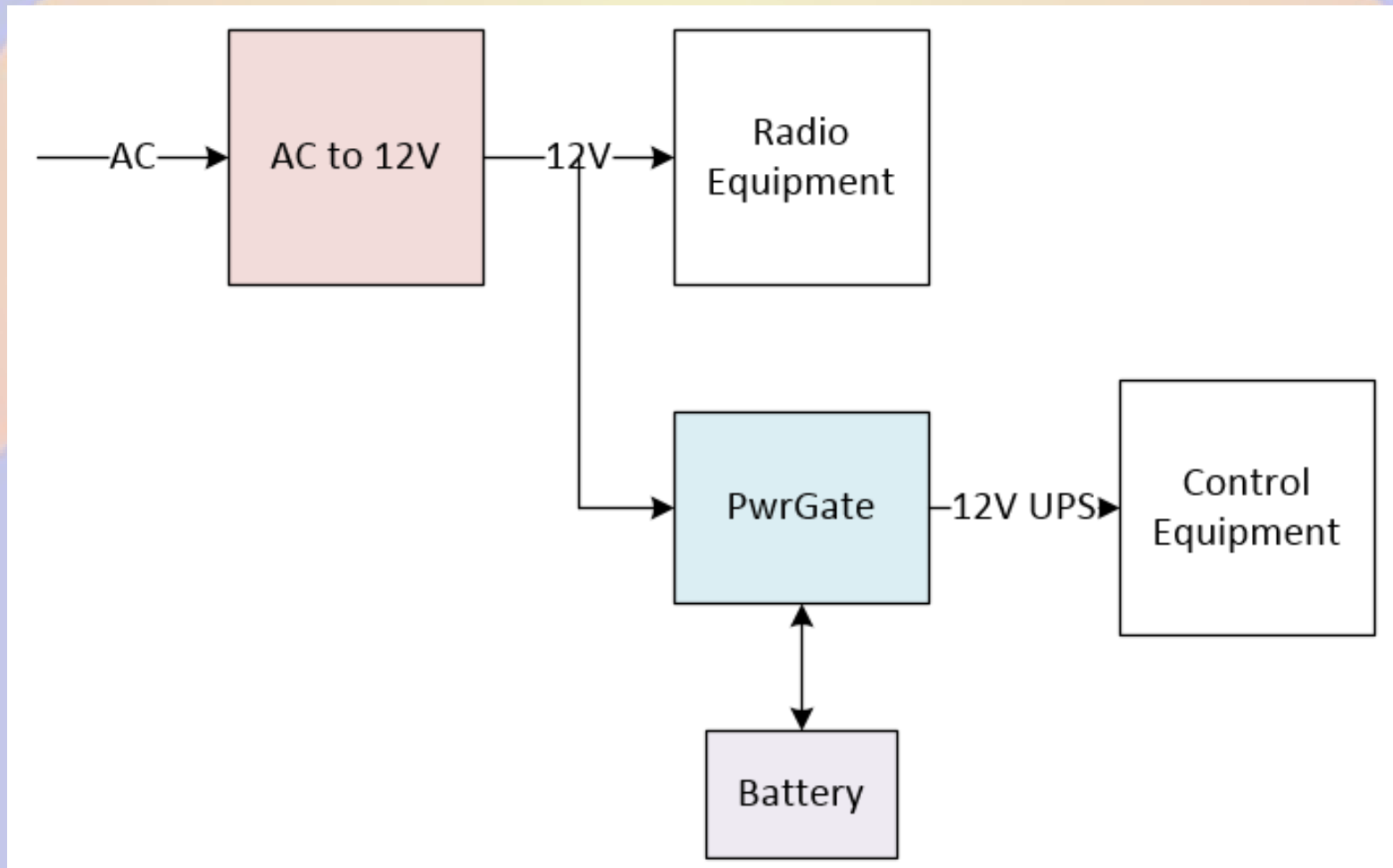
12V UPS

- PwrGate?
  - Power Switch and SLA Battery Charger
  -

- Flint Hills Radio (KI0BK)
  - 25A, Low Loss FET Switch, $85
  - http://www.flinthillsradioinc.com
  -

- West Mountain Radio
  - PWRgate PW40S, 40A, $140
  - http:// www.westmountainradio.com/ product_info.php? products_id=pg40s
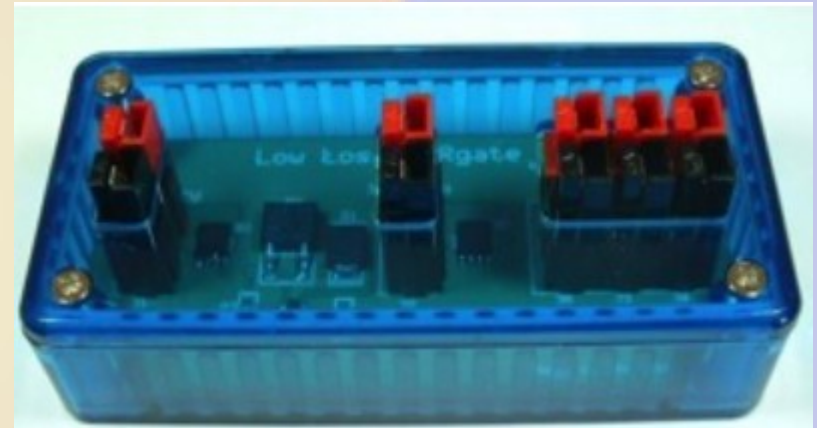
12V-to-5V

- Can use with 12V-UPS

- Bad power is the primary failure mode

- Nominal 5.1V (alerts at 4.63V, max 5.25V)

- DC-DC converters helps with noisy power
  - oversize it
  - short, fat leads

- SMAKN DC-DC
  - 8-50V in
  - 5V3A out
  - micro USB
  - $14

12V-to-5V

- Use with 12V UPS

- TOBSUN

- Input: 8V-40V DC

- Output 5V 10A DC

- Built-in Protection
  - Over-voltage,
  - Over current,
  - Over temperature,
  - Short circuit auto protection
  - Return to normal conditions when fault clears

- $10

Buffer that I/O!

- A sure way to damage your RPi is to directly connect unbuffered signals to your board!!!
- Bad
    - A long wire connected to a GPIO to a door switch
    - Long wires for I2C to a temp sensor 10 feet away
    - A 5V device to your 3.3V GPIO
- Good
    - I2C Buffer to external devices
    - GPIO Digital Input Buffer
    - GPIO Digital Output Buffer or Relay
    - Level Translators
    - A2D Input Buffer

Buffer that I/O!

- Watch the Absolute Maximum Ratings!

Table 36-1.   Absolute Maximum Ratings

Symbol	Parameter	Condition	Min.	Max.	Units
V_{DD}	Power supply voltage		0	3.8	V
I_{VDD}	Current into a V_{DD} pin		-	92	mA
I_{GND}	Current out of a GND pin		-	130	mA
V_{PIN}	Pin voltage with respect to GND and V_{DD}		GND-0.3V	V_{DD}+0.3V	V
$T_{storage}$	Storage temperature		-60	150	°C

Note: 1.   Maximum source current is 46mA and maximum sink current is 65mA per cluster. A cluster is a group of GPIOs as shown in Table 36-2. Also note that each V_{DD}/GND pair is connected to 2 clusters so current consumption through the pair will be a sum of the clusters source/sink currents.

Buffer that I/O!

- CAUTION!!! Don't let the smoke out!!!
- 3.3V to 5V, Bidirectional, Flexible Voltage Range
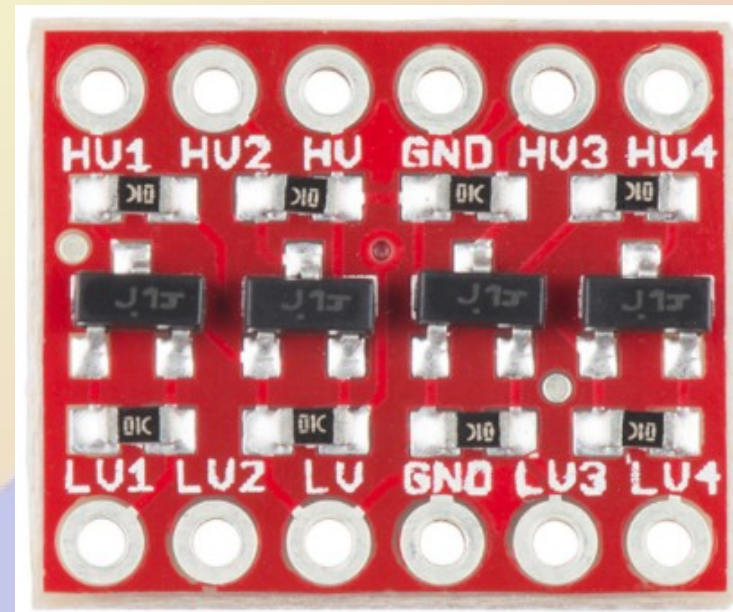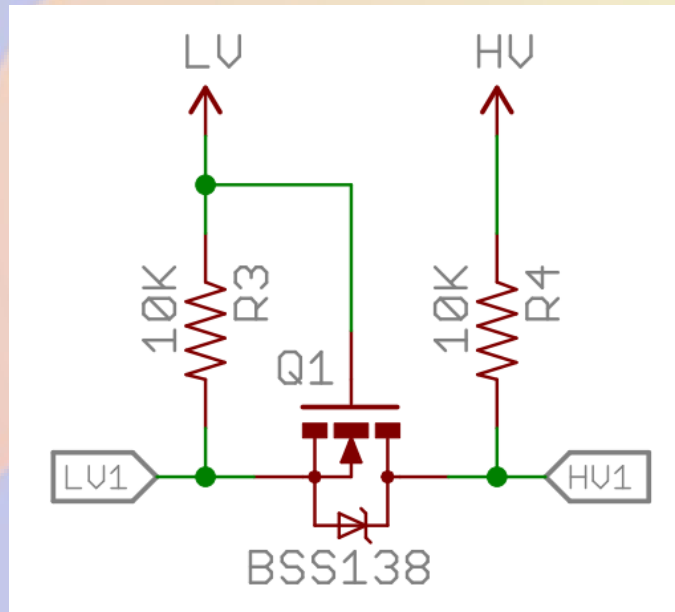
- https://www.sparkfun.com/products/12009
- $3

Digital Input Buffer

- Translators

- Optoisolators

- https://www.sparkfun.com/products/9118
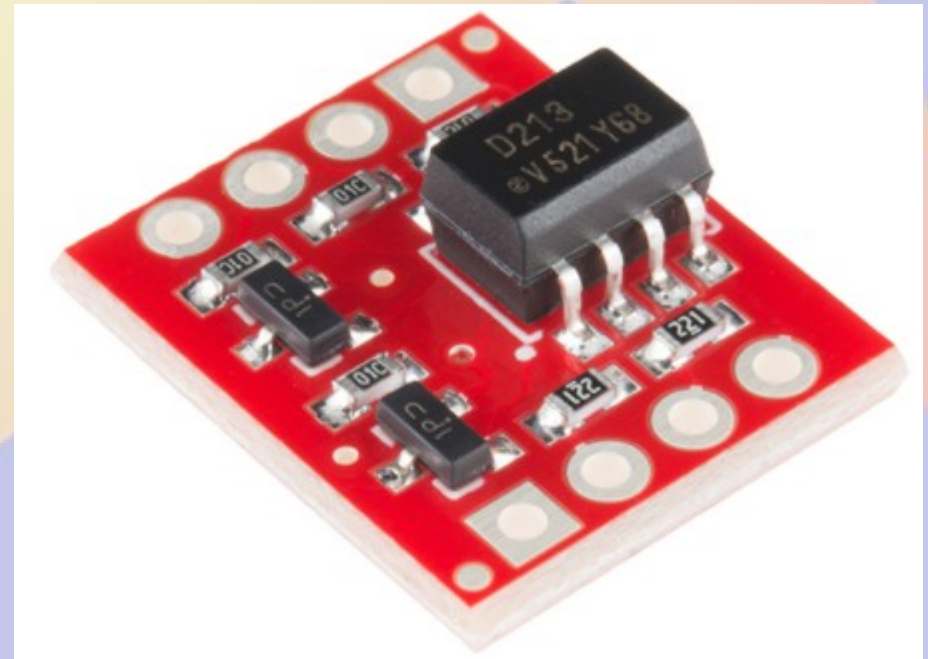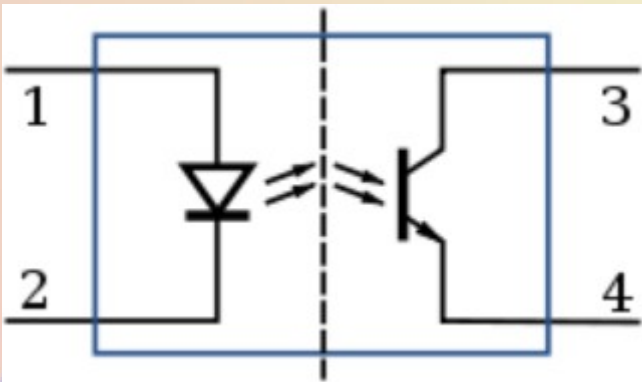
Digital Output Buffer

- FET Buffers

- TPIC6B596

- SPI Interface

- Outputs
  - 50V Max
  - 150 mA Max

- $2

- https://www.mouser.com/ProductDetail/Texas-Instruments/TPIC6B596N

TPIC6B596
POWER LOGIC 8-BIT SHIFT REGISTER

SLIS095A – MARCH 2000 – REVISED MAY 2005

logic diagram (positive logic)
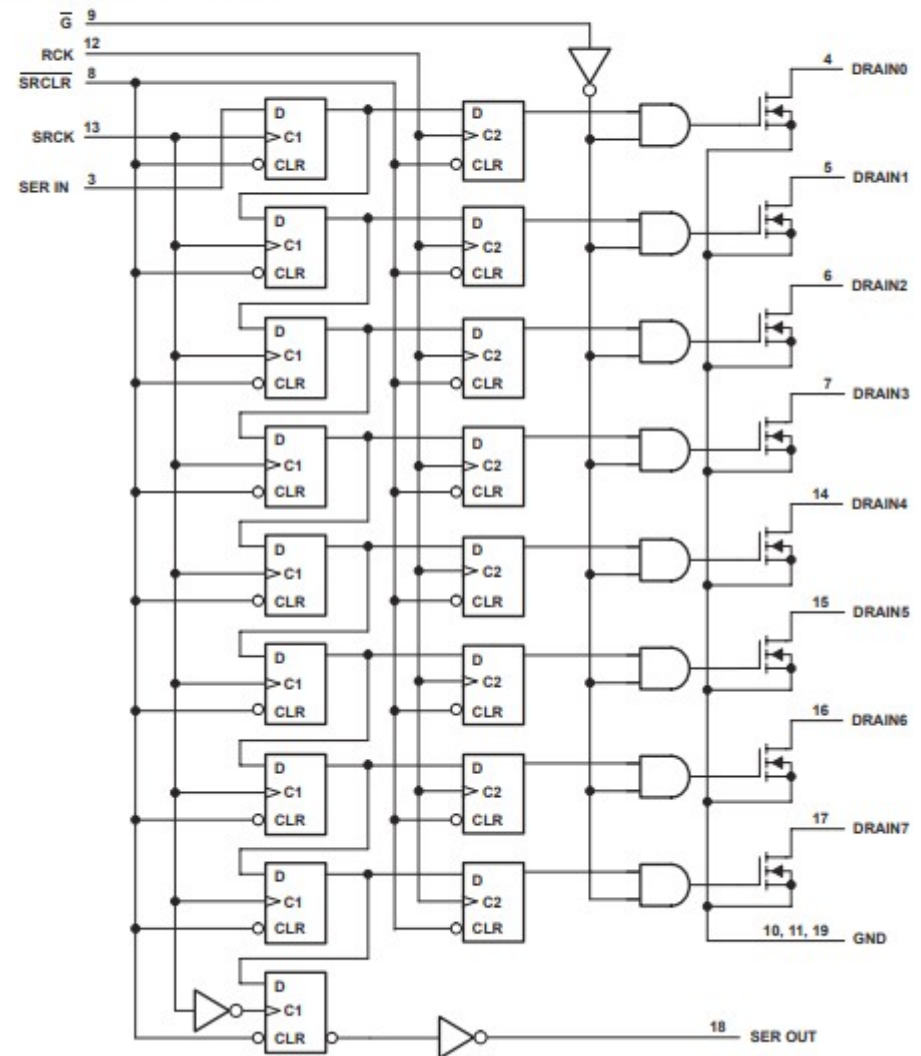
Digital Output Buffer

- FET Buffers
- 60V Max
- 32A Max
- $1

- http://cdn.sparkfun.com/datasheets/Components/General/
FQP30N06L.pdf
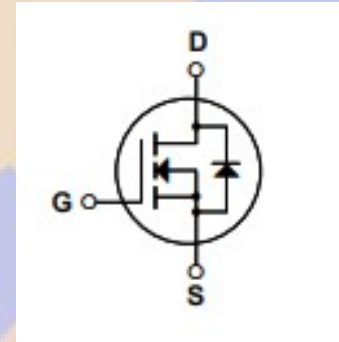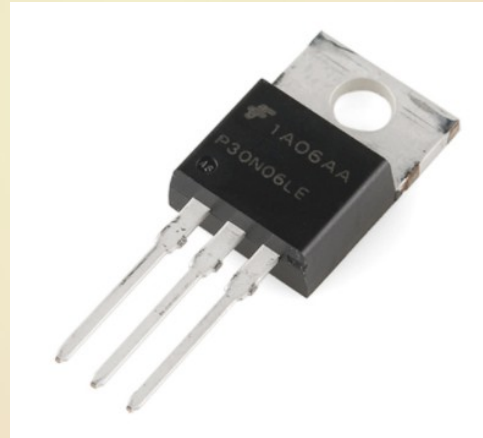
Digital Output Buffer

- FET Buffers
- 60V Max
- 450 mA Max
- <$1

- https://www.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/2N7002
- https://smile.amazon.com/MSOP10-Transfer-Adapter-SOT-23-MSOP-10/dp/B07PBGXP77
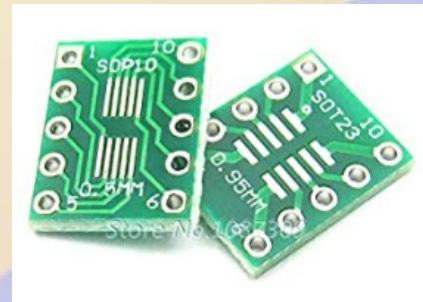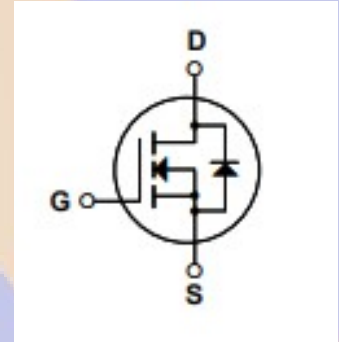
Digital Output Buffer

- Relay Board
  - Buffer for low drive current

- https://smile.amazon.com/Electronics-Salon-Signal-Version-Arduino-Raspberry-Pi/dp/B00M90SR3G
- https://images-na.ssl-images-amazon.com/images/I/91Ml0Tph-rL.pdf
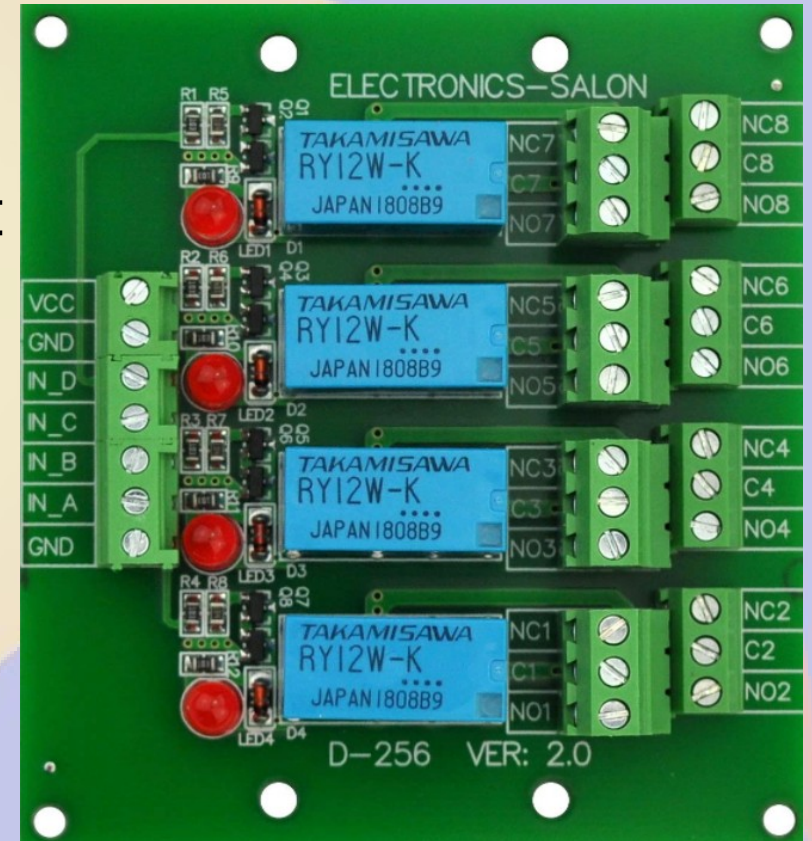
Digital Output Buffer

- AC Outlet Strip
  - $27
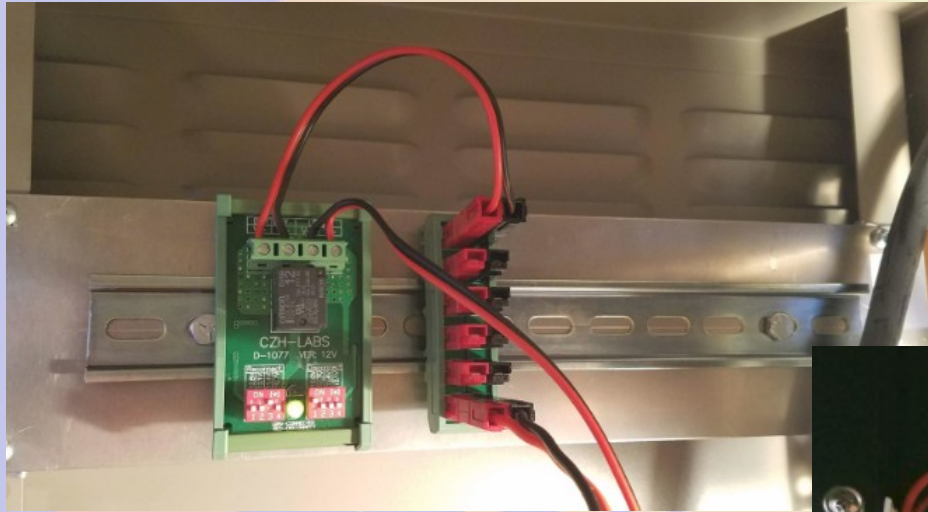 - 1 outlet always
  - 1 normally ON
  - 2 normally OFF
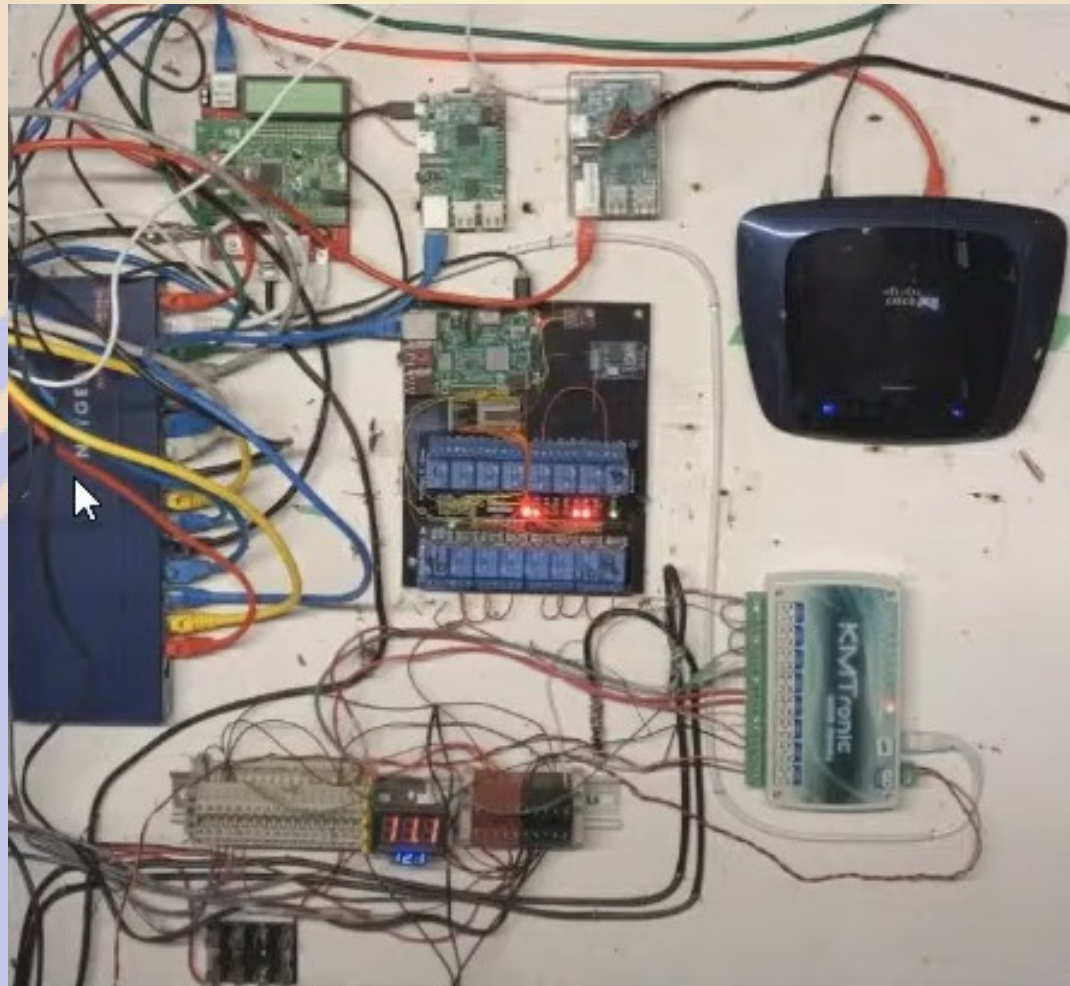
  - https://smile.amazon.com/gp/product/B00WV7GMA2
  - http://www.digital-loggers.com/iot2faqs.html

Site Organization?
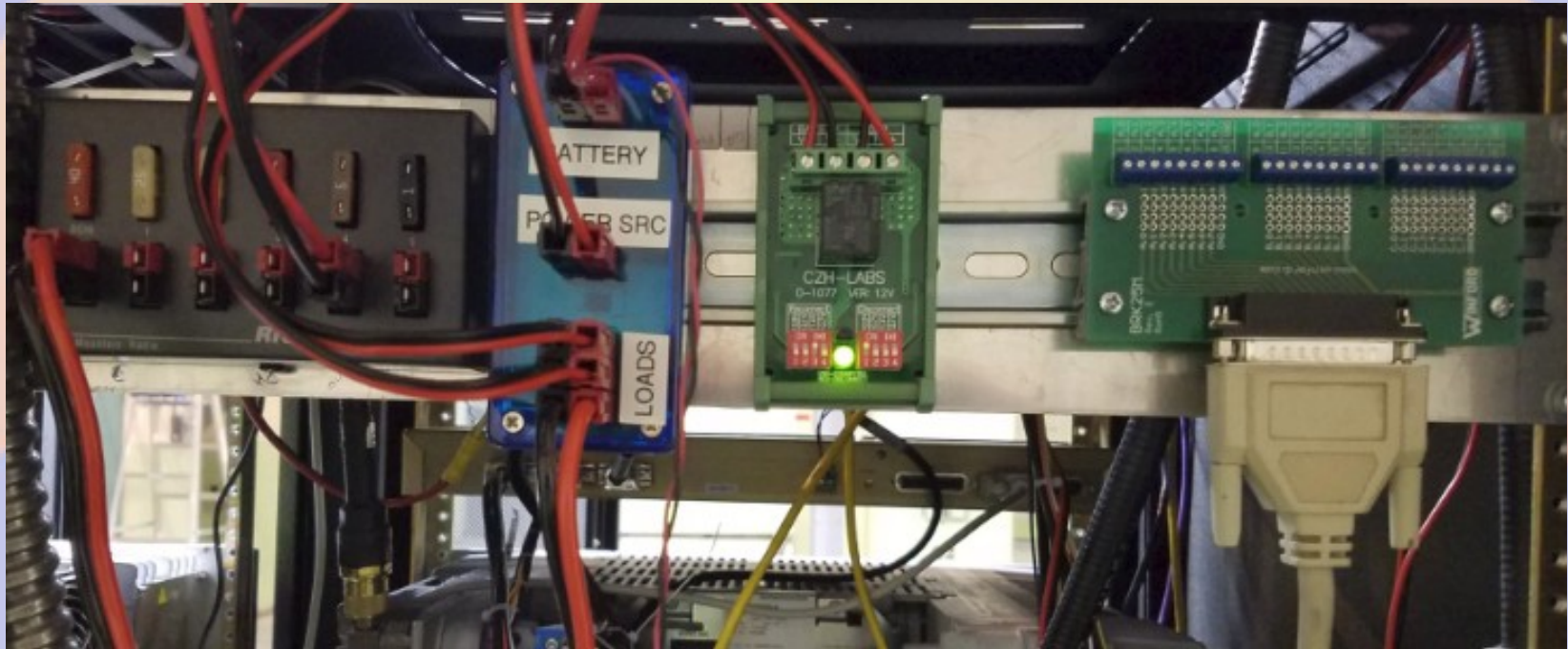
- Now where was that connected?

Site Organization?

- Now where was that connected?
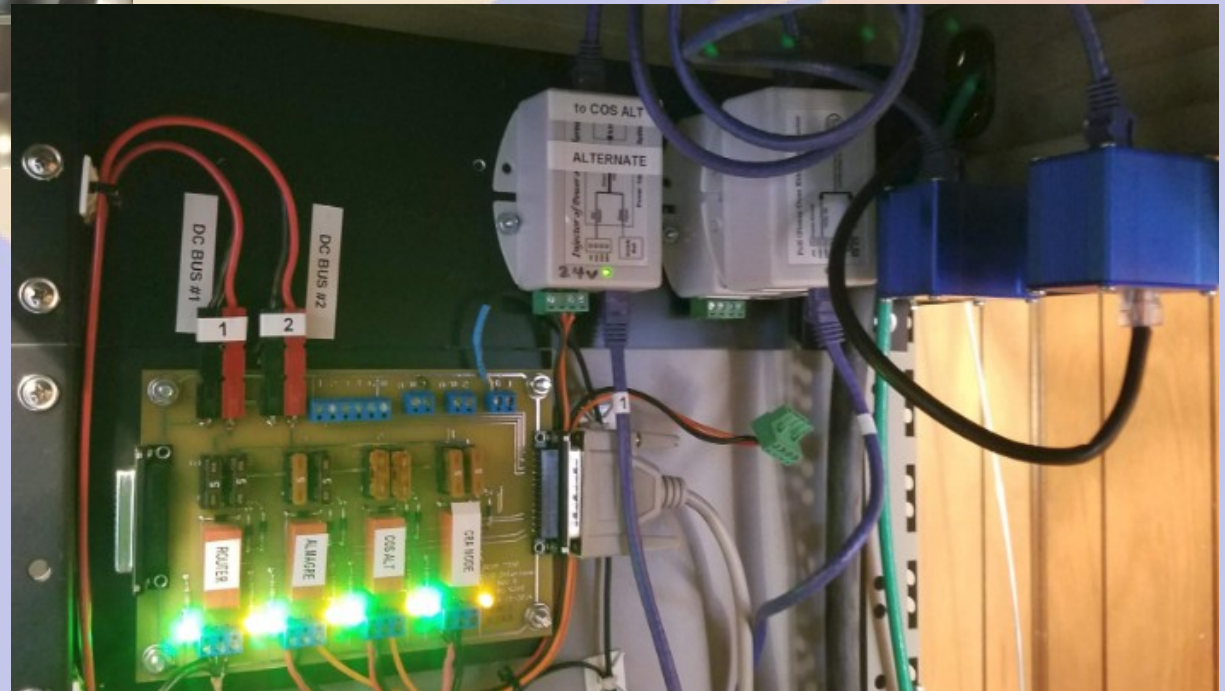
Site Organization?

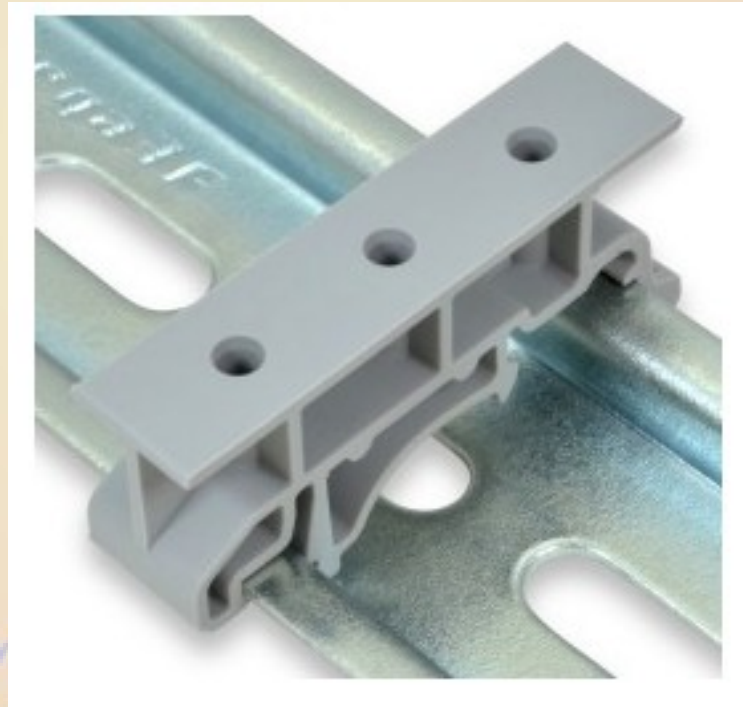- Now where was that connected?

DIN Rail Mounting

- Raspberry Pi
- DINrPlate
- $13

- https://smile.amazon.com/gp/product/B018J33308

DIN Rail Mounting

- Brackets
- $1

- http://www.winford.com/products/dinm01.php

DIN Rail Mounting

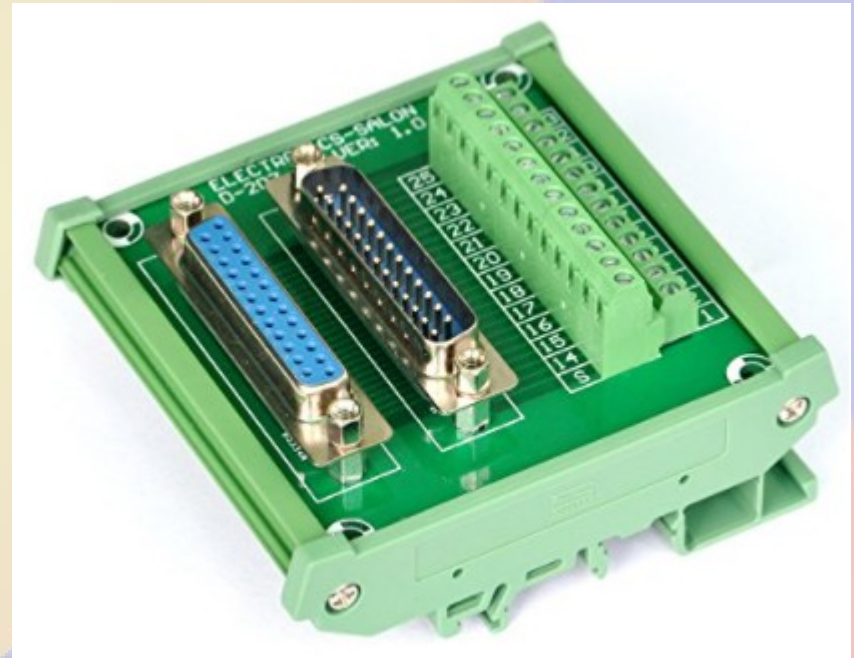- Brackets
- $2

- http://www.winford.com/products/dinm01.php
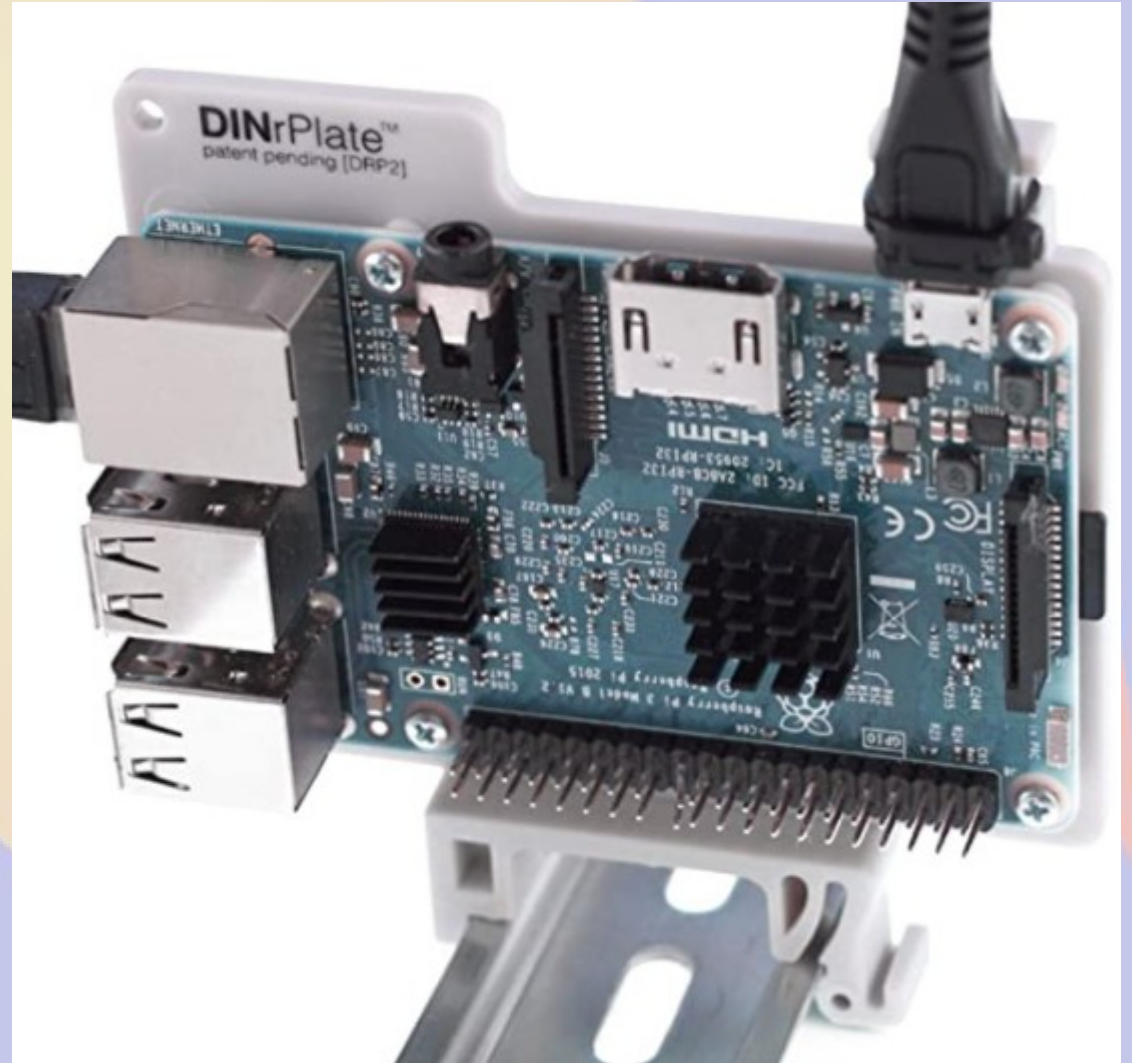
DIN Rail Mounting

- Terminal Strips
- $20

CircuitPython

- Boards it supports
  - ST-Nucleo
  - Feather
  - Arduino
  - Rpi Pico
  - Many, Many More...

  - https://circuitpython.org/
  - https://learn.adafruit.com/welcome-to-circuitpython

- Also on the Raspberry Pi
  - https://learn.adafruit.com/circuitpython-on-raspberrypi-linux

CircuitPython

- Many Libraries to support board peripherals

```
import board
import digitalio
import time

led = digitalio.DigitalInOut(board.D13)
led.direction = digitalio.Direction.OUTPUT

while True:
        led.value = True
        time.sleep(0.5)
        led.value = False
        time.sleep(0.5)
```

-

Node-Red

- Developed by IBM in 2013
- Browser-based Visual Programming for non-programmers
- WYSIWIG event-action framework

Node-Red

Node-Red

Node-Red

- Advanced Display

Node-Red

Node-Red

- References
  - https://nodered.org/
  - https://nodered.org/docs/getting-started/

- Forum for Help and Discussion
  - https://groups.io/g/nodered-hamradio

- Ham Radio Remote Station Control Presentation by Mike Walker, VA3MW, FlexRadio
  - https://www.youtube.com/watch?v=AJGhu8r7cYU&t=22715s
  - Start at timestamp 4:15:30

Break

Relay Controller

- Relay MUST be opto-isolated and 5V

- 1,2,4,8 clusters for Arduino works great

- May be lo or hi to activate relay

- Good for 110AC, high current applications

- Solid state relay more expensibe but faster and more reliable
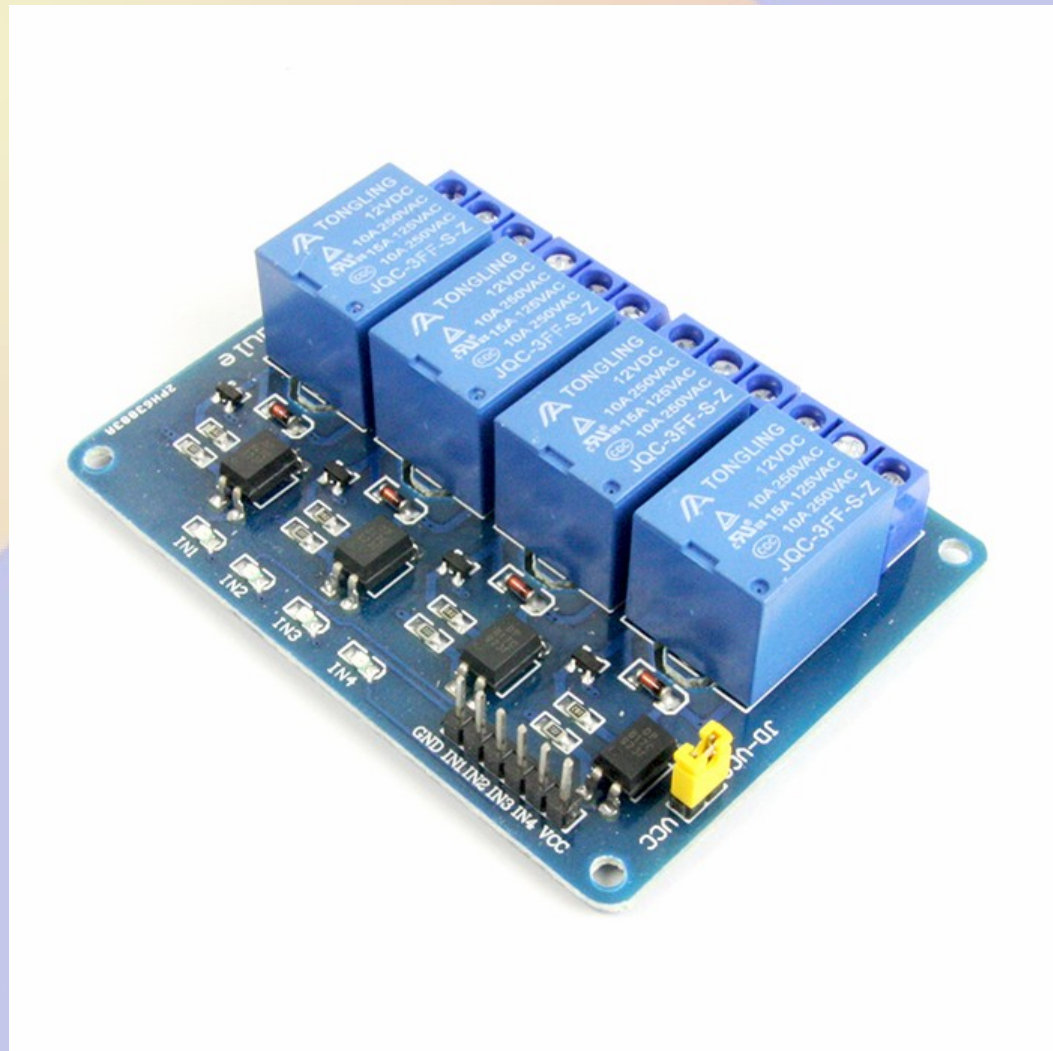
Serial Control

- ssh to rPi/BBB, minicom to serial device
- Serial is TTL level and direct from CPU
  - protect from RF
- Serial HAT
  - MAX232 to generate +/-15V
- USB serial
  - DB9/DB25
- USB parallel

Temperature Measurement

- rPi CPU Tempreature

  `cat /sys/class/thermal/thermal_zone0/temp`

  Result 23406 means 23.406ºC (74.1ºF)

- 1wire pin 18

  - Supported in kernel

  - **Shield wires!!!**

  - Access from file system or CircuitPython

- 1wire USB (PL2303TA)

  - More tolerant of RF

  - `apt-get install digitemp`

  - `digitemp_DS9097 -i -s /dev/ttyUSB0`

Network monitoring with **cping**
https://www.prinmath.com/ham/cping.zip

- ping and traceroute from remote site
  - Uses curses for graphic like display
- Real time network monitoring
  - Helps to find jitter and intermittent problems
  - Helps find split or flapping routes

```
2021-04-06 17:14:07   #383   Period 1s Ping time x1 x10 x100 x1000
Traceroute to    GrMesa West

Hop Host                   IP         50        40        30        20        10         0    ms    min   avg   max lost
  1 router.saddleback.rmham 10.30.32.1 1111111111111111111111111111111111111111111111111111111   0.6   0.5   0.6   1.0    0
  2 router.squaw.rmham     10.20.13.1 11121211121112121111112111121112211112121211111121112115511   1.2   0.9   1.5  18.5    0
  3 router.devilshead.rmham 10.20.5.2 44323353332333334233333343337323533333133323333733333463   2.8   1.9   3.5  21.3    0
  4 router.badger.rmham    10.20.14.2 64445454564444441857445566746427785554247474545855444875   4.6   2.9   5.4  26.5    0
  5 router.mosquito.rmham  10.20.31.2 76816579675766589866568779757628196575297516816866655979   8.7   4.5   7.5  26.3    0
  6 router.upperdowd.rmham 10.20.32.2 181189911818176891199717819799281199112911989191187993111111.2   5.8   9.9  31.9    0
  7 router.bellyache.rmham 10.20.40.2 911191111118711111111191211138119911291191119111111311111  11.6   6.9  12.4  33.3    0
  8 router.castlepeak.rmham 10.20.41.2 11111111111111111113111112111311311112XXX111111111131111  15.0   9.2  14.9  46.1    3
  9 router.sunlight.rmham  10.20.42.2 11111111121111111113111112111311311112XXX121111111131111  15.8  10.4  17.1  46.7    3
 10 router.grandmesa.rmham 10.30.180.1 1112111121112122211321122211312311112XXX221112111132211  16.9  12.3  19.3  46.7    3
```

DNS

- Full DNS
  - apt-get install bind0
  - Allows internal and external view of network
  - Ability to add local domains
- PiHole (DNS masquerade)
  - *https://pi-hole.net/*
  - Network-wide Ad Blocking
  - Can be used to block undesirable domains
  - Can still add local domains
  - Really helps if bandwidth is limited

RADIUS

- Remote Authentication Dial In User Service
  - Allow centralized user login management
- No login if server is unreachable
  - Fail over to other servers
- User database can be stored in SQL database
  - ONLY appropriate use of a database!!!
  - Easy remote updates
- RMHAM usually combine DNS & RADIUS
  - Manage via DevDB

Network Time Protocol (NTP)

- NTP syncs system clocks
  - Important to correlate log entries
  - IP peers (mS accuracy, depends on latency)

- Stratum 1 gets time from GPS (µS accuracy)
  - GPS PPS supported in Linux kernel
    - NOT enabled in Raspbian

```
git clone https://github.com/davidk/adafruit-raspberrypi-linux-pps.git
cd adafruit-raspberrypi-linux-pps
cp kernel.img /boot/kernel.img.pps
cp -a modules/* /lib/modules
echo 'pps-gpio' >> /etc/modules
echo "kernel=kernel.img.pps" >> /boot/config.txt
echo "gpu_mem=16" >> /boot/config.txt
```

Remote Controled iGate

KE0VH-10 Akron iGate

Direwolf status=active
Frequency 144.390 MHz

Select Frequency [144.390 MHz ⌄]

[Restart Direwolf]

- ## Use API module

- ## freq.sh

  ```
  FREQ=144.390M
  ```

- ## direwolf.sh

  ```
  #  Load frequency
  . freq.sh
  if [ -z "$FREQ" ]; then FREQ="144.390M"; fi
  #  Run rtl-dw
  rtl_fm -f $FREQ - | direwolf -c /home/pi/sdr.conf -r 24000 -D
  ```

- ## devdbd.conf

  ```
  [direwolf]
  run    restart  root /bin/systemctl restart direwolf
  run    status   root /bin/systemctl is-active direwolf
  write freq root:root:744 /usr/local/bin/freq.sh
  ```

AllStarLink Node

https://wiki.allstarlink.org/wiki/Beginners_Guide

- USB Radio Interface Module (URI or RIM)
  - CM119 Digital-Analog Audio Chip
  - PTT & COR/CTCSS lines
  - Heartbeat, Tx, COS, etc LEDs
- Raspberry Pi & AllStarLink modules
  - Install using Debian packages
- Can run 1 or 2 repeaters from an rPi3B
  - Local or remote management with AllMon2
  - Connect full duplex to other nodes via IP
  - Several HATs available to run as hotspot

AllStarLink Remote Base
https://wiki.allstarlink.org/wiki/Remote_Base

- Special AllStarLink node
  - Half-duplex
  - Limited to one connection at a time
- USB Radio Interface Module (URI or RIM)
- Channel steering via GPIO or RIM or serial
  - VHF: Kenwood, Motorola, …
  - HF: FT-897, IC-706, ...

AllStarLink Mixer/Voter

- Radio connects to RTCM (Radio Thin Client Module)
- RTCM send 20ms voice packets to node via IP
  - Mix mode mixes packets for retransmit
  - Voter mode chooses strongest among receivers
    - Requires GPS for accurate time stamps
- Node sends voice packets to transmitter RTCM
- Needs stable IP
  - ~100 kbps audio streams
  - Sensitive to latency and jitter between RTCM and Node
  - Tolerant of latency and jitter between nodes

AllStarLink Hub

- AllStarLink node with no local repeater

- Lots of ~100kbps data streams

  - Can overload rPi3B, may need rPi4

- Use mix of nodes and hubs

  - Example: Colorado Connections

    - Thorodin: Main hub is VM

    - Akron: RTCM+rPi Node on site

    - Glenwood & Pallisade: RTCM on site, rPi at Castle Peak

MMDVM/PiStar

https://www.repeater-builder.com/products/stm32-dvm.html
http://www.pistar.uk/

- Digital equivalent of AllStarLink
  - DMR, D-Star, Fusion, P25, NXDN, POCSAG
  - Popular for digital hotspots
    - Repeater interface or pair of mobiles for repeater use
- PiStar software to run node
  - See K0NGA tech talk from 3/24/2021
    https://youtu.be/mVsWeWyWUto

BPQ/Packet
https://www.prinmath.com/ham/bpq-config

- TNC/Pi, TNC/Black, TNC/Pi9K6, TAPR
  - about $50 as a kit
  - Mostly 1200bps, some 9600bps
  - Stackable (I^2C or multiple serial)
  - Pactor/KPC/KAM/... via USB
- BPQ
  - Multi-port BBS with advanced routing
  - Multi-port RMS to Winlink
  - Digipeater
- Configure with bpq-config
  - Manage via web interface

Software Defined Radio

https://www.rmham.org/wp-content/uploads/2020/04/rPiSDR.pdf

- Remote receiver (or transceiver)
  - RTL-SDR (VHF/UHF) about $20 (but a bit deaf)
  - SDRplay, HackRF, etc
- Streaming entire spectrum many Mbps
- Decode on site, stream audio
  - GNUradio for advanced
  - <20 kpbs per stream
  - CPU intensive
    - rPi3 OK, rPi4 better
    - Both will run hot

WebCam

- Many camera options
  - rPi camera module
    - Standard
    - NoIR for IR light
    - Third party cameras
  - USB web cam
- Video stream bandwidth depends on resolution
  - Can also take stills

Useful Links

- https://www.rmham.org/course-syllabus/
- www.adafruit.com
- www.sparkfun.com
- www.raspberrypi.org

Questions?