Raspberry Pi

A Low Cost Platform
For Amateur Radio Projects

Ed James, KA8JMW
ARRL NM Assistant Section Manager

Presentation to
High Desert Amateur Radio Club
September 18th, 2013

Dedicated to Art James

WD8MMG

1924-2013

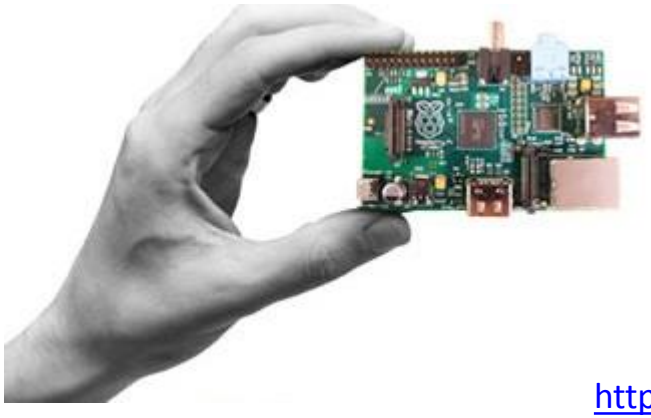
My Dad, a member of

”The Greatest Generation”

Raspberry Pi (Wiki)

*"The **Raspberry Pi** is a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation with the intention of promoting the teaching of basic computer science in schools."*

"The Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor"

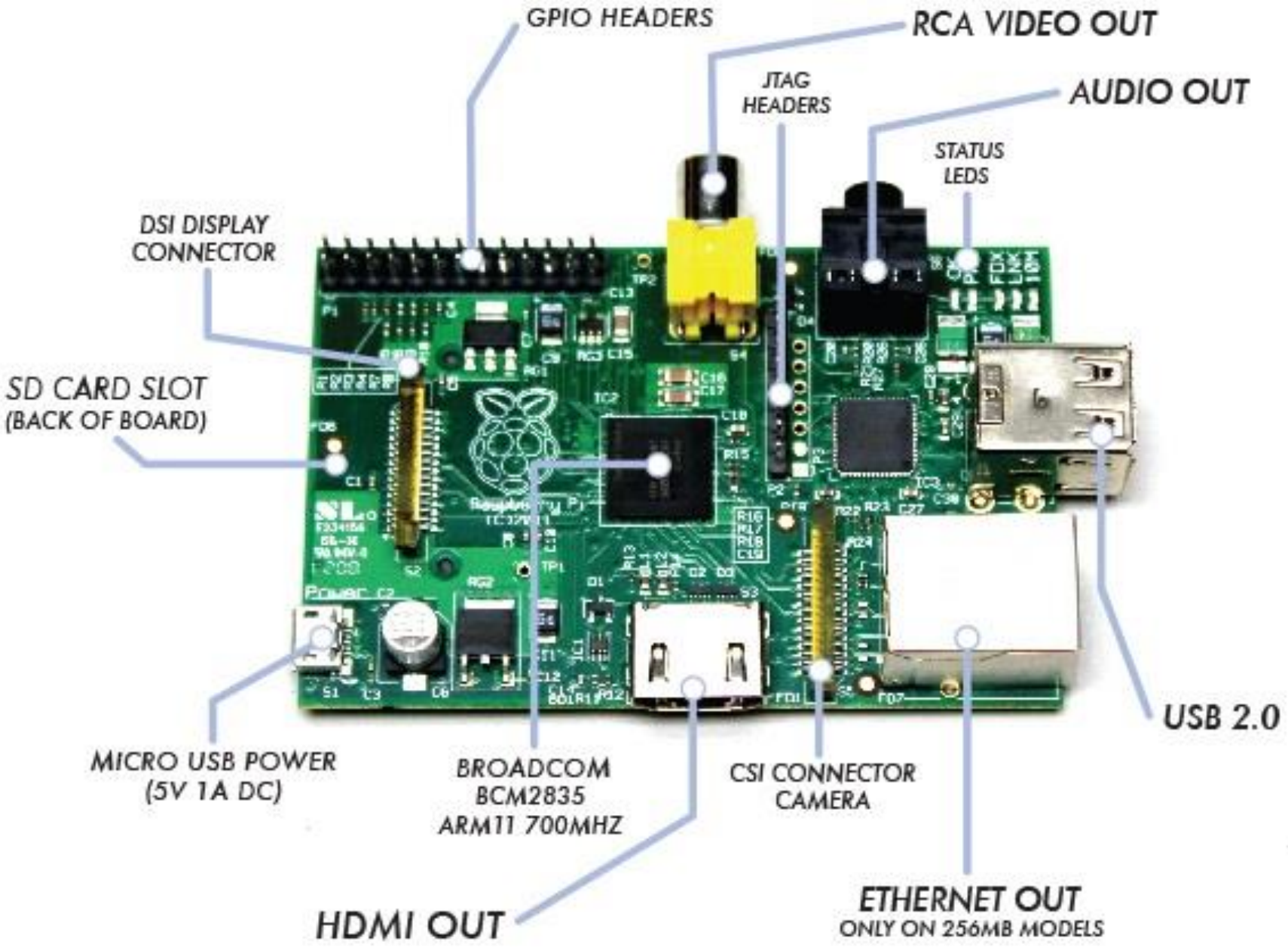


Two versions available:

	RAM	USB	Ethernet	Cost
Model A	256MB	1	NO	$25
Model B	512MB	2	YES	$35

http://en.wikipedia.org/wiki/Raspberry_Pi

Raspberry Pi layout (Model B)



Supported Operating Systems

Linux *(The Preferred Environment)*

Raspbian, Debian GNU/Linux, Fedora, Arch Linux ARM

RISC OS

Unix:

FreeBSD, NetBSD

Plan 9

Android 2.3 (Gingerbread), 4.0 (Ice Cream Sandwich)

Google Chrome OS

Firefox OS

AROS

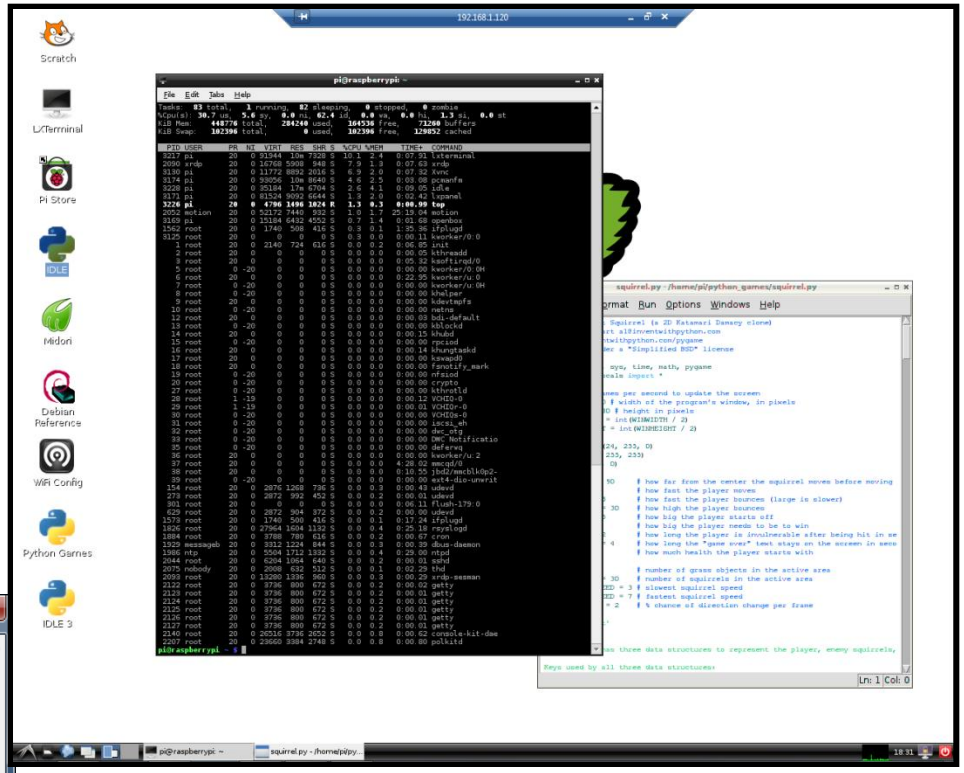
…

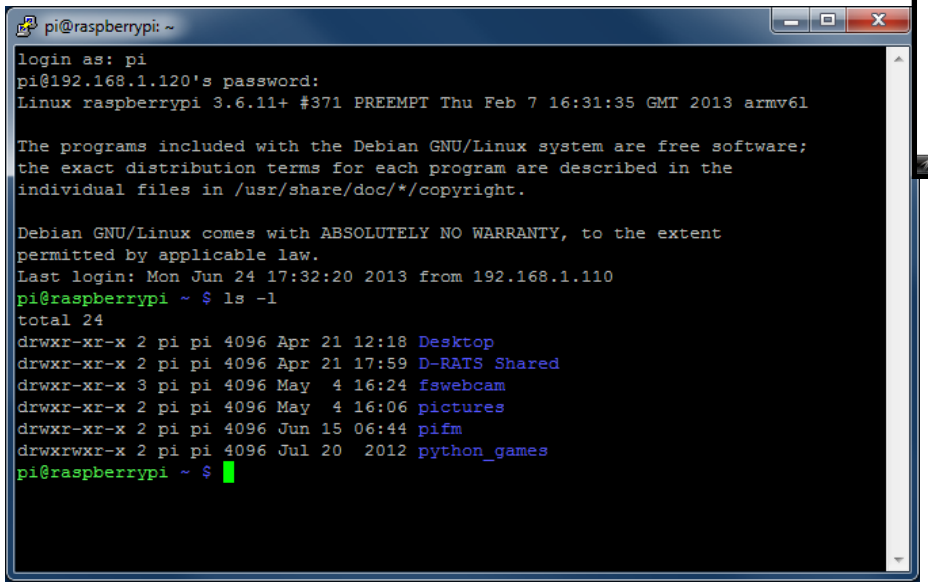
And the list just keeps on growing.

http://en.wikipedia.org/wiki/Raspberry_Pi

Connecting with your RPi
The User Interface

- X-windows GUI
  - Keyboard, mouse, HDMI
  - Xrdp (headless)



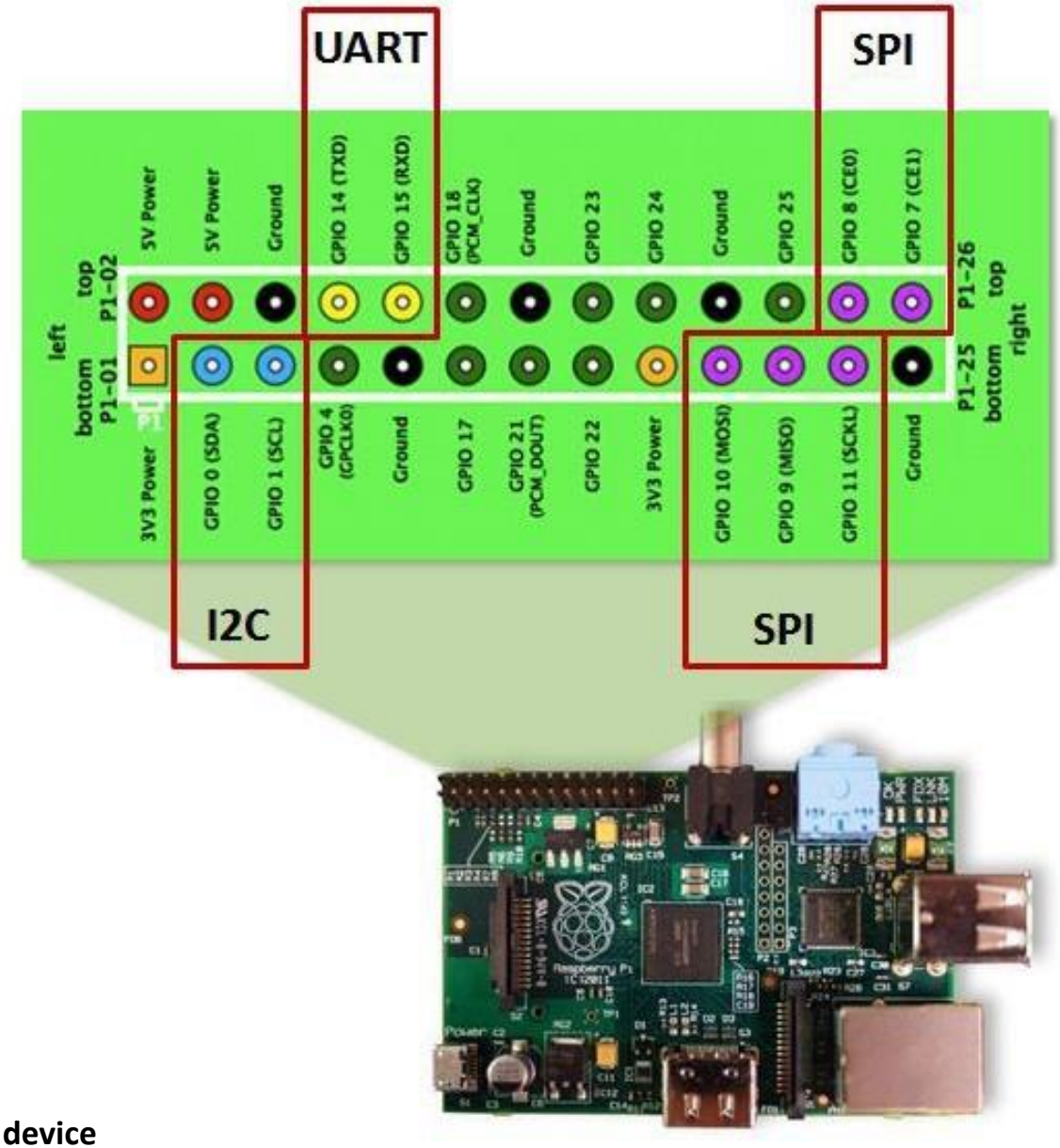


- Command line
  - Serial Terminal
  - SSH user interface (headless)

Let's Dig in a little deeper
Raspberry Pi (RPi) General Purpose Input/Output (I/O)

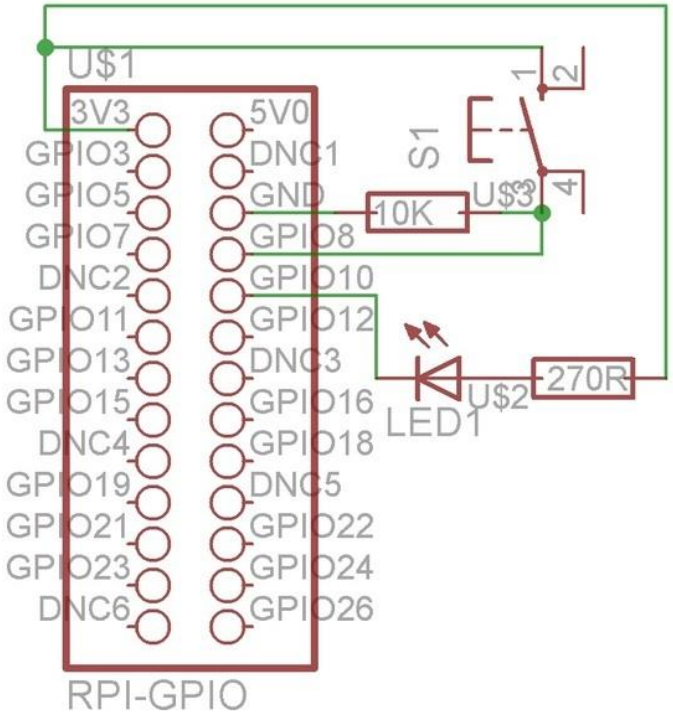
- The RPi board has a 26-pin expansion header with 17 GPIO pins as well as +3.3 V, +5 V and GND supply lines.
- The default configuration provides 15 GPIO pins and a UART.
- The operating system also supports predefined alternate functions for some of the pins
  - I^2C (Inter-Integrated Circuit) is a two wire communication bus developed by Philips, for chip to chip communication. Commonly used for connecting sensors and port expanders.
  - Serial Peripheral Interface (SPI) bus is a synchronous serial data bus designed by Motorola. Commonly used in high speed applications such as digital audio, digital signal processing and telecommunications.
  - UART, TXD and RXD
  - A Pulse Width Modulator (PWM)
- Operating system makes the hardware available to a variety of high level program languages including Python, C, Java, BASIC along with Perl and Bash shell scripts.
- Additional I/O pins are available via bit-banging and hacking

RPi GPIO Pinout



1. **The RPi is a 3.3V device**
2. **The GPIO pins are unbuffered and unprotected, so if you short something out, you could fry your whole RPi, be careful!**

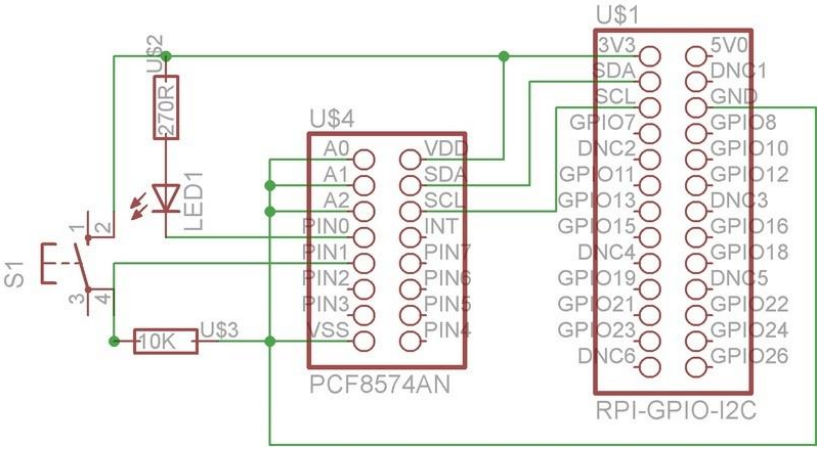
GPIO I/O Example




```
# example1.py
# Import the required module.
import RPi.GPIO as GPIO
# Set the mode of numbering the pins.
GPIO.setmode(GPIO.BOARD)
# GPIO pin 10 is the output.
GPIO.setup(10, GPIO.OUT)
GPIO pin 8 is the input.
GPIO.setup(8, GPIO.IN)
# Initialise GPIO10 to high (true) so that the LED is off.
GPIO.output(10, True)
while 1:
   if GPIO.input(8):
      GPIO.output( 10, False)
   else:
      # When the button switch is not pressed, turn off the LED.
      GPIO.output( 10, True)
```

http://www.cl.cam.ac.uk/projects/raspberrypi/tutorials/turing-machine/two.html

I²C I/O Example



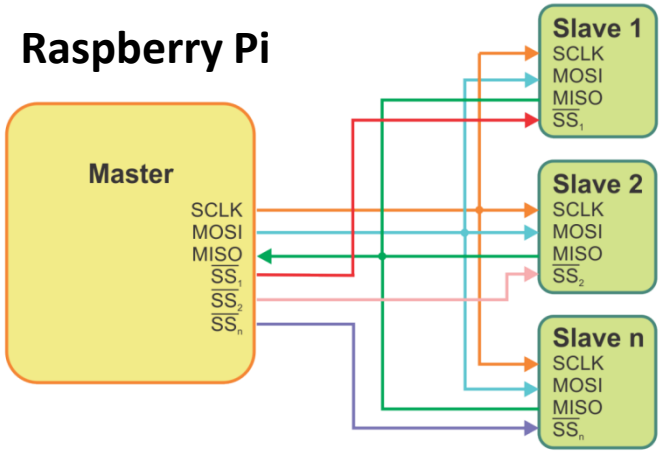
PCF8574A 8-bit I/O Expander for I²C BUS

```
# example2.py
import smbus
# Access the i2c bus now.
bus = smbus.SMBus(0)
# Now write 1 to the device with the address 56, turn off the LED by setting pin 0 to 1, and
reset the switch by switching pin 1 to 0.
bus.write_byte(56, 1)
while 1:
# If the button is pressed, pin 1 will be 1 and the byte read from the device with address 56 will
be 00000010 (2) or 0000000011 (3).
   if bus.read_byte(56) in (2,3):
# Write 00000000, setting pin 0 to 0, turning on the LED, and resetting the switch with pin 1 to
0.
      bus.write_byte(56, 0)
   else:
# Write 00000010, setting pin 0 to 1, turning off the LED, and pin 1 to 0 to reset the switch.
      bus.write_byte(56, 1)
```

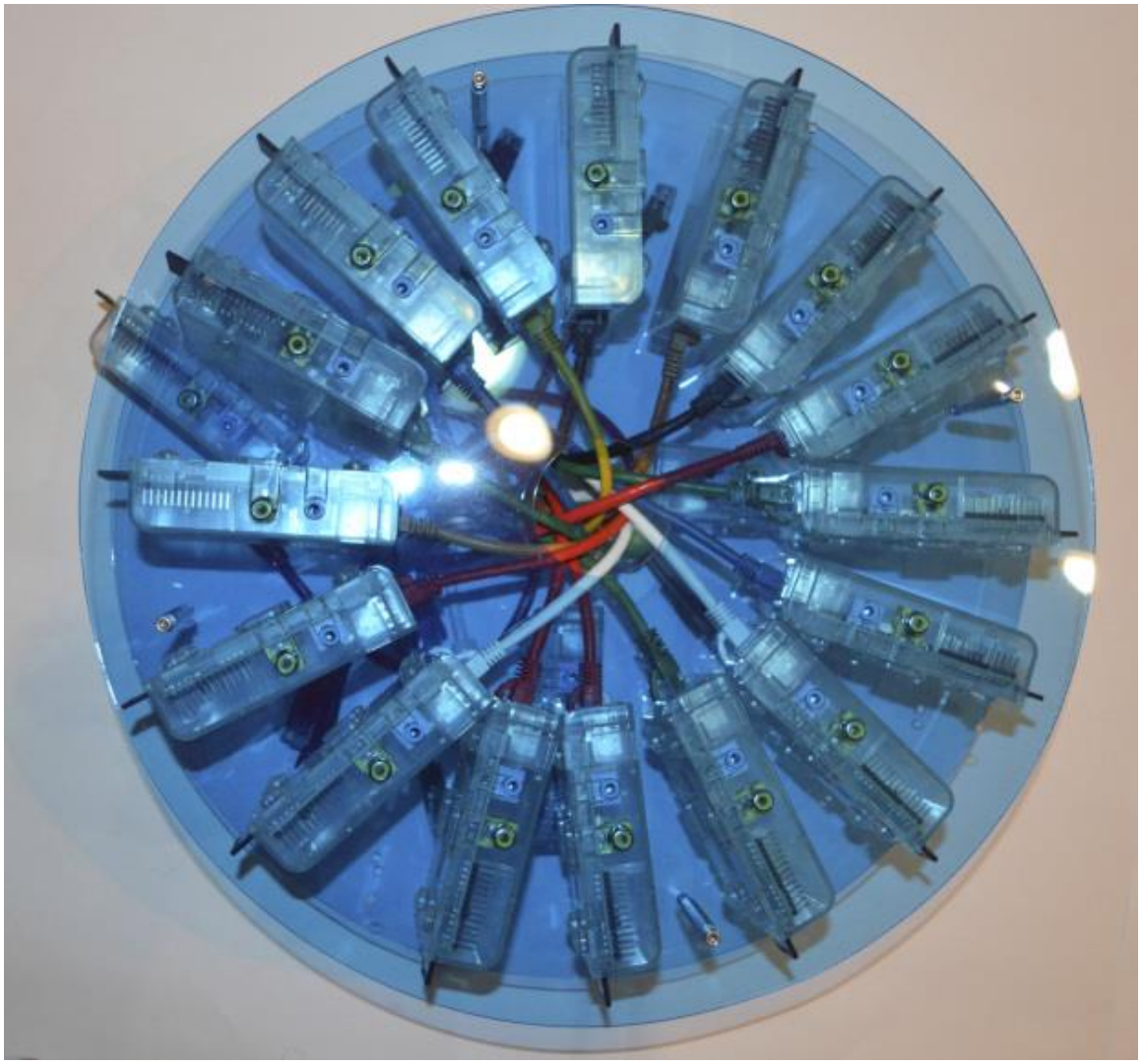

http://www.cl.cam.ac.uk/projects/raspberrypi/tutorials/turing-machine/two.html

Serial Peripheral Interface (SPI)

- Full duplex communication
- Higher throughput than I²C
- Complete protocol flexibility for the bits transferred
  - Not limited to 8-bit words
  - Arbitrary choice of message size, content, and purpose
- Extremely simple hardware interfacing
  - Typically lower power requirements than I²C
  - No arbitration or associated failure modes
  - Slaves use the master's clock, and don't need precision oscillators
  - Slaves don't need a unique address — unlike I²C
  - Transceivers are not needed
- Uses only four pins on IC packages, and wires in board layouts or connectors, much fewer than parallel interfaces
- At most one unique bus signal per device (chip select); all others are shared
- Signals are unidirectional allowing for easy isolation
- Not limited to any maximum clock speed, enabling potentially high throughput



What Can I Do With My RPi?



32 RPi low-cost
“Supercomputer” Cluster

An Eclectic Mix of RPi Projects Projects

WiFi
Internet Radio Player

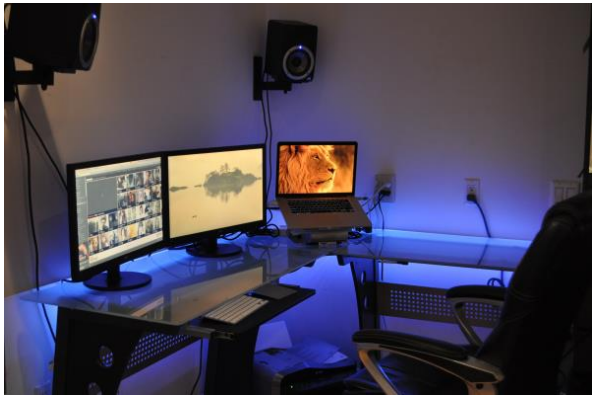
XBMC Media Player remote control

Cat Feeder

Event Countdown Clock

High Altitude Balloon Controller

Soil Moisture Monitor



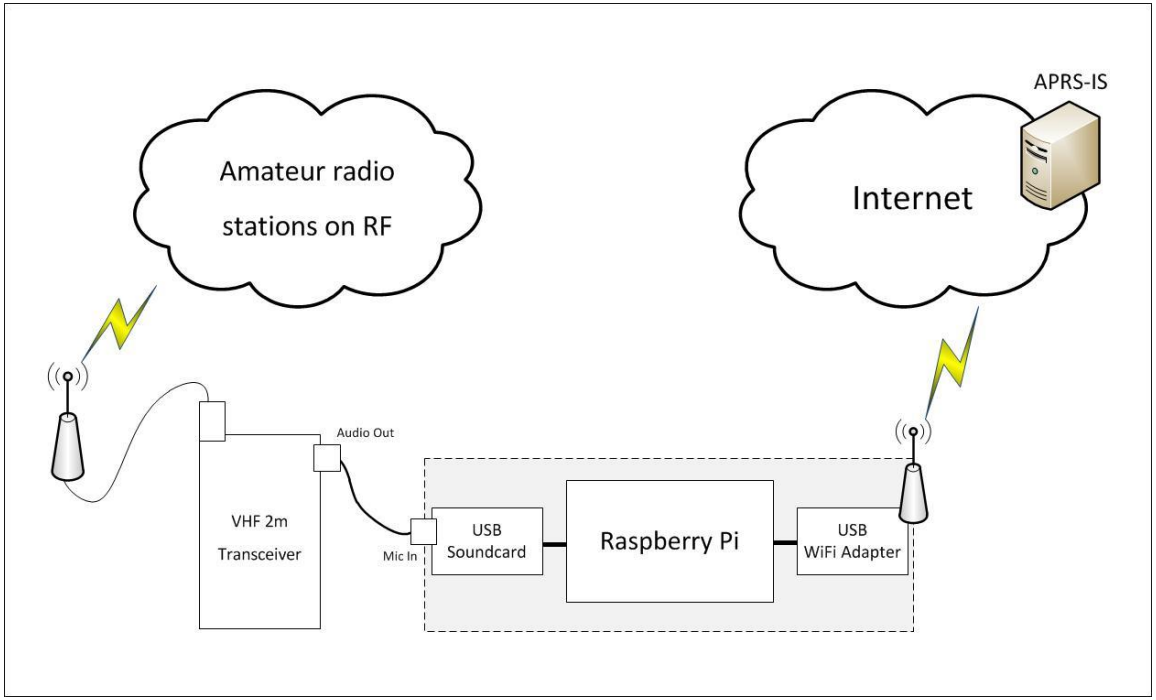
Lighting Controller

Home Alarm System

Now, The Really Fun Stuff
Amateur Radio and the RPi

piGate – an APRS iGate implementation using the Raspberry-Pi

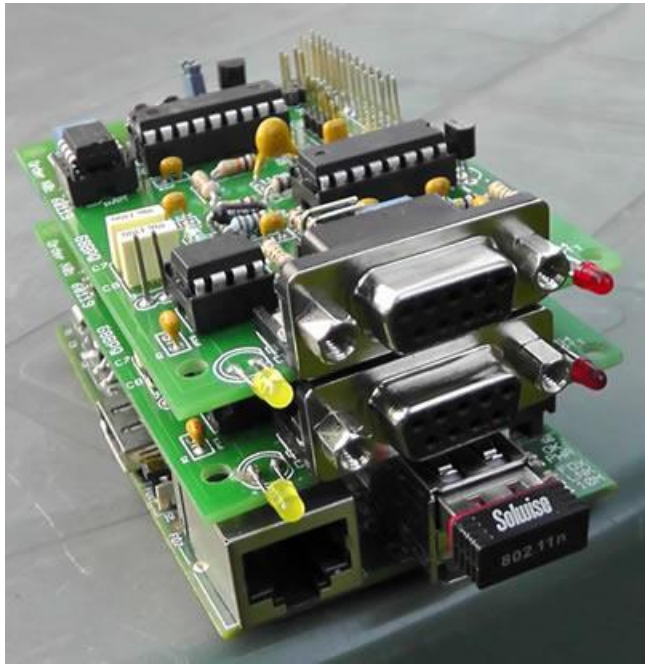
Software running on the Raspberry-Pi reads the audio signal coming into the sound-card, demodulates the signal, decodes the packet and then sends it to an APRS-IS server over the WiFi link

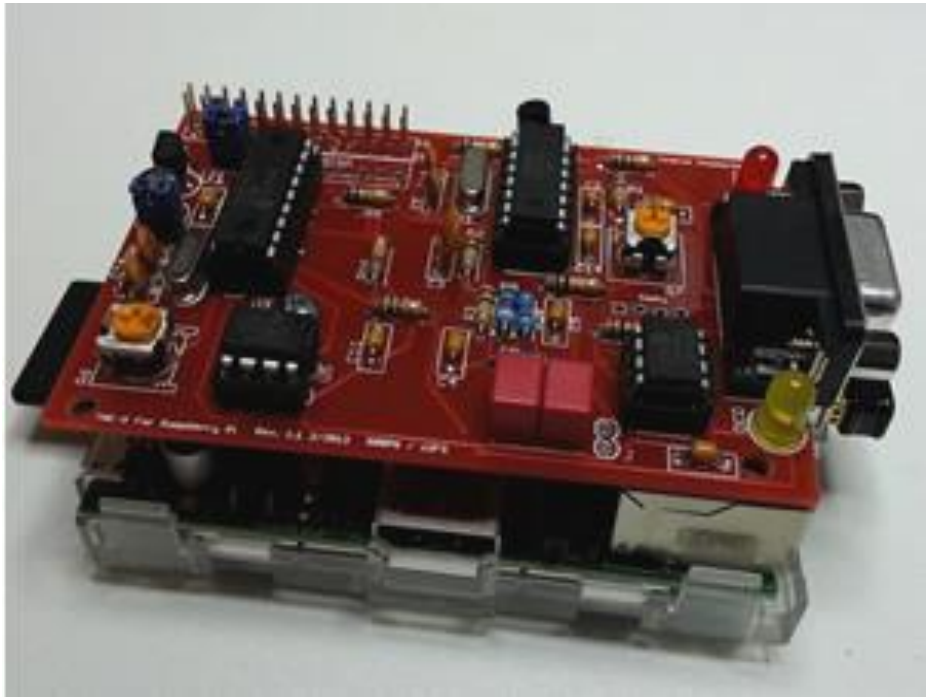


http://www.ultratechie.com/2012/10/pigate/

TNC-Pi RPi

TNC-Pi is a special version of TNC-X designed to interface directly with the Raspberry Pi computer. It can connect to the Pi either via the Pi's serial port, or via the I2C protocol. In the latter case, a single Pi can support multiple TNC-Pi's at the same time, since each TNC-Pi can be given a unique I2C address.

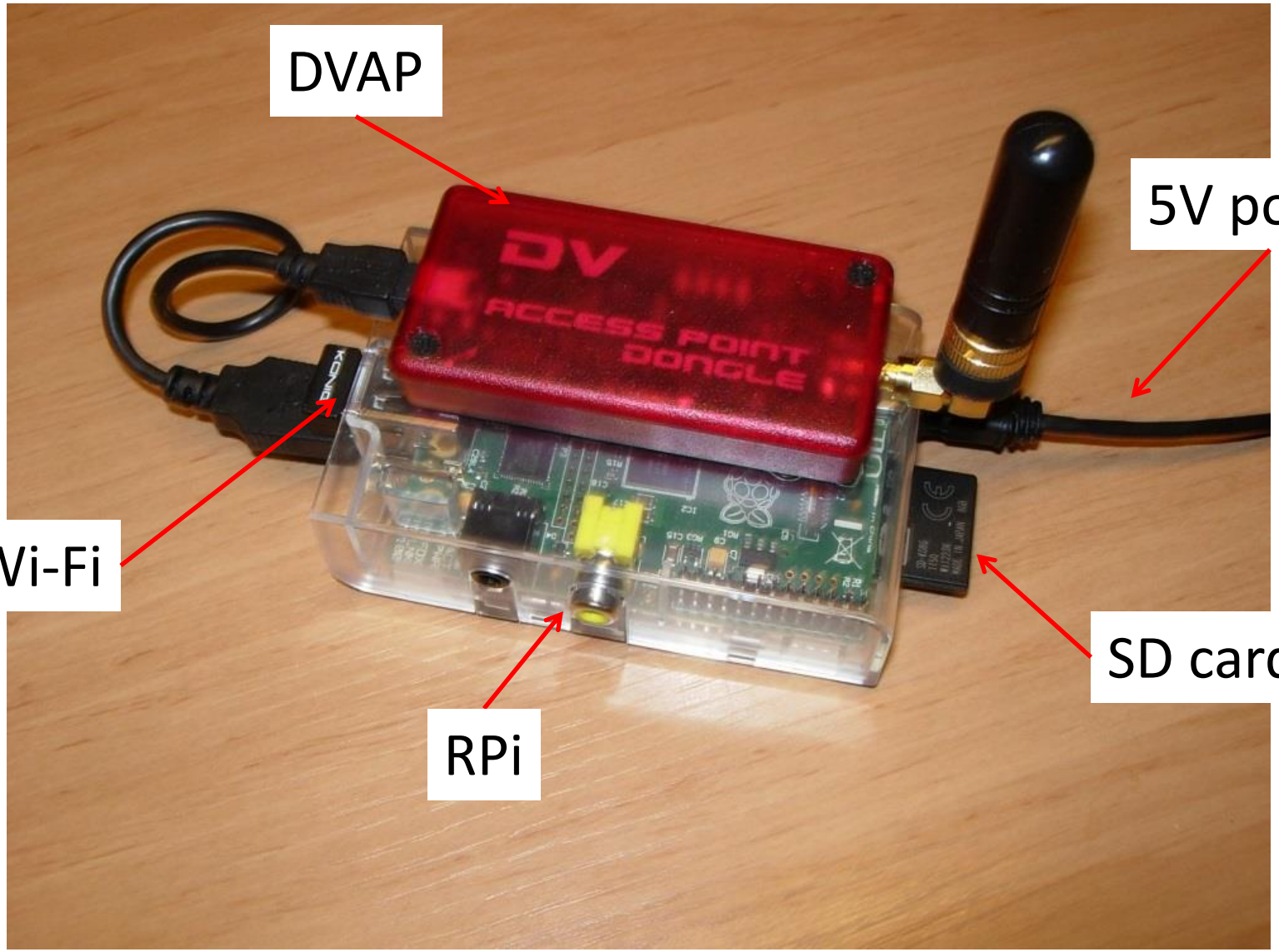




Run a pair of TNC-Pi's with a single RPi to create a dual frequency digipeater.

http://tnc-x.com/

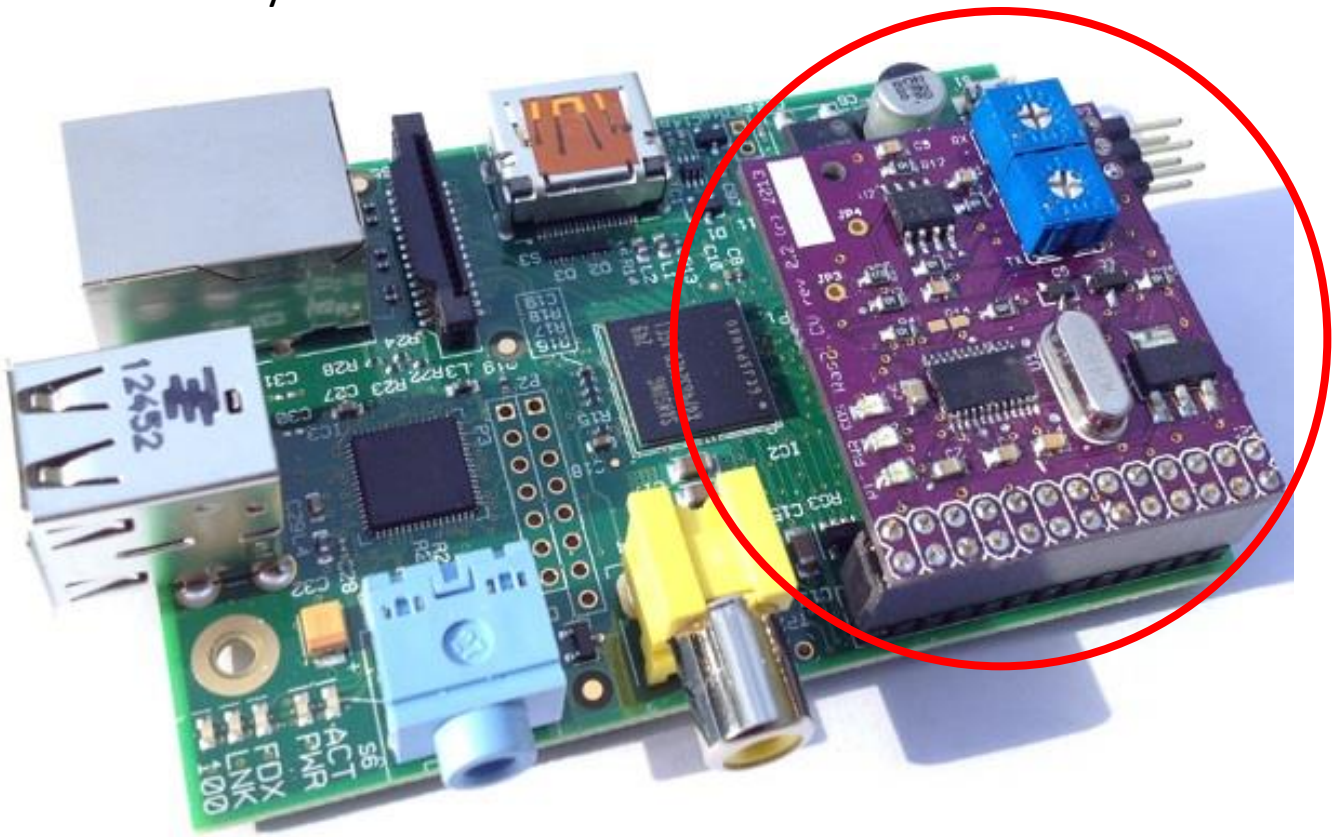
D-Star DV Access Point Dongle & RPi



Creates a point of presence on the D-Star network

GMSK modem for the RPi

The Raspberry Pi GMSK Modem board needs only a suitable narrowband FM radio .. add TWO radios and you get a D-Star repeater...add an internet connection for a fully functioning D-Star gateway, either simplex or full duplex! This boards CMX589 GMSK modem connects directly to the GPIO socket.

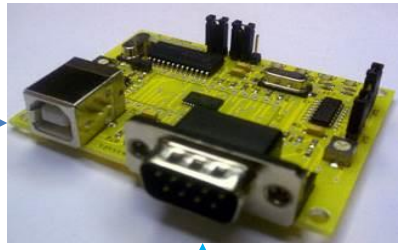


http://ki6zum.com/dstar/dv_overview.htm

W5MPZ D-Rats ratflector (then)

Dell Optiplex 755 running Ubuntu Linux OS and D-RATS ratflector software

USB



Moencom Starboard GMSK Node Adapter

Audio in/out
PTT

The Internet

Yaesu FT-2600FM Transceiver
9600 bps capable

W5MPZ D-Rats ratflector (and now)

RPi
Running
D-RATS ratflector software

USB

Moencom
Starboard
GMSK Node
Adapter

The
Internet

Audio in/out
PTT

Yaesu FT-2600FM Transceiver
9600 bps capable

Turning the RPi into an FM Transmitter PiFM

- Using the existing hardware on the RPi that is intended to generate spread-spectrum clock signals to output FM RF.
- This means that all you need to do to turn the Raspberry-Pi into a FM Transmitter is to connect an antenna onto GPIO pin 4 and run the code.

http://www.icrobotics.co.uk/wiki/index.php/Turning_the_Raspberry_Pi_Into_an_FM_Transmitter

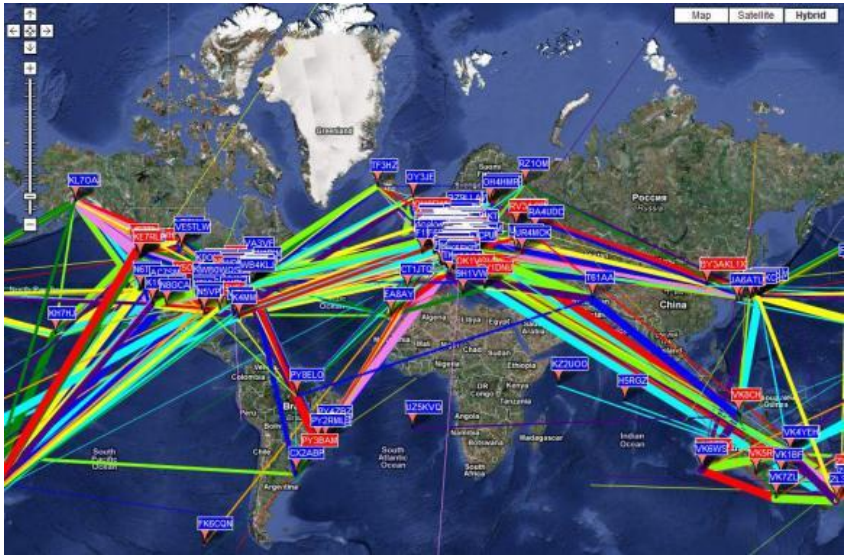
PiFM Demonstration

sudo ./pifm sound.wav 100.1

RPi LF/MF/HF/VHF WSPR Transmitter

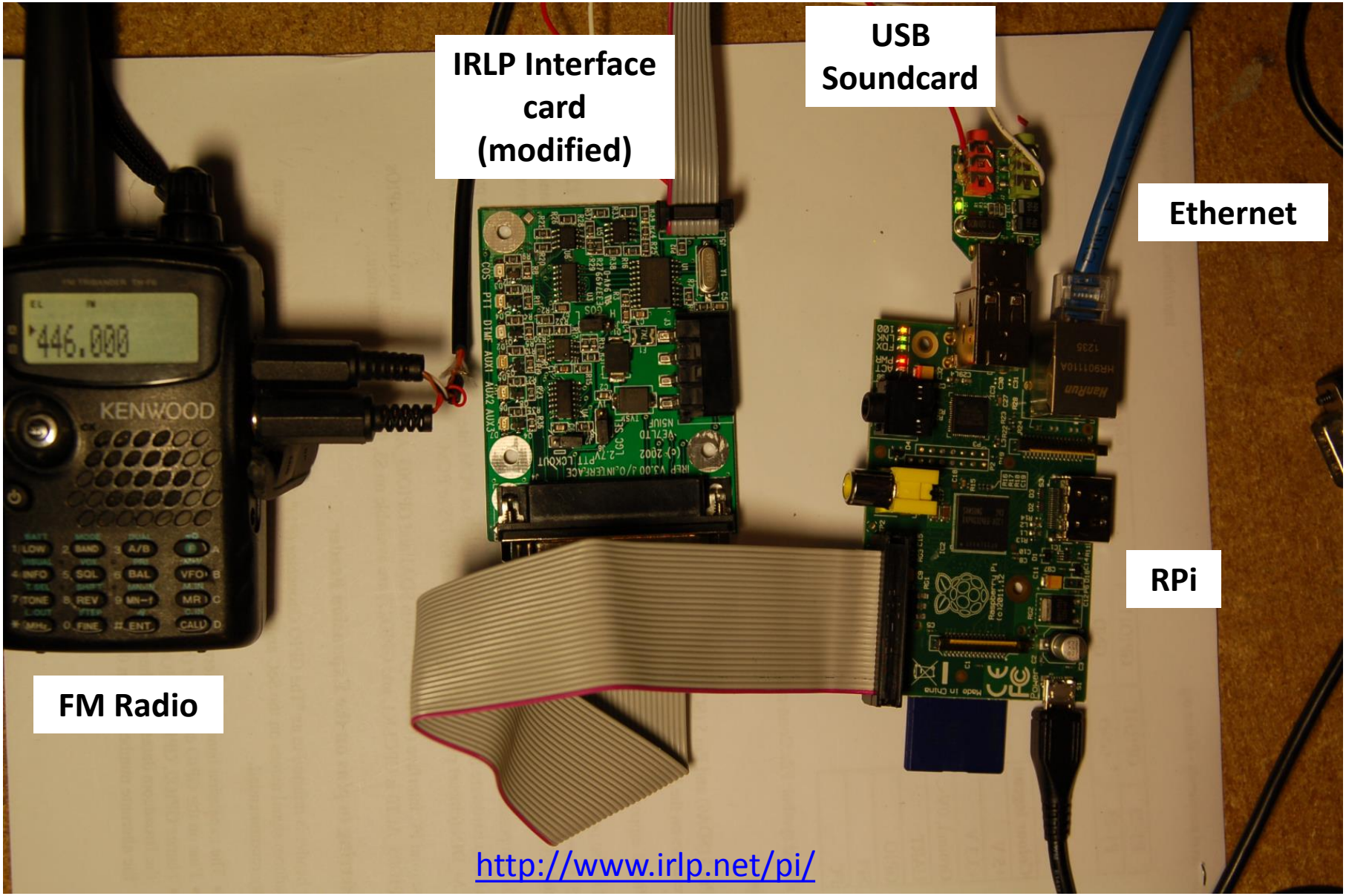
- Weak Signal Propagation Reporter (WSPR).
- Used for weak-signal radio communication between amateur radio operators.
- Designed for sending and receiving low-power transmissions to test propagation paths on the MF and HF bands.
- WSPR implements a protocol designed for probing potential propagation paths with low-power transmissions.
- Transmissions carry a station's callsign, Maidenhead grid locator, and transmitter power in dBm.
- Stations with internet access can automatically upload their reception reports to a central database called WSPRnet, which includes a mapping facility.

- **With a little code**
  - **PiFM with a wrapper**
- **A low pass filter**
- **Your RPi is good to go**
  - **0 to 250MHz**
  - **+10dBm (10mw)**



https://github.com/threeme3/WsprryPi

PiIRLP (IRLP on a RPi)



http://www.irlp.net/pi/

A Software Defined Radio Server

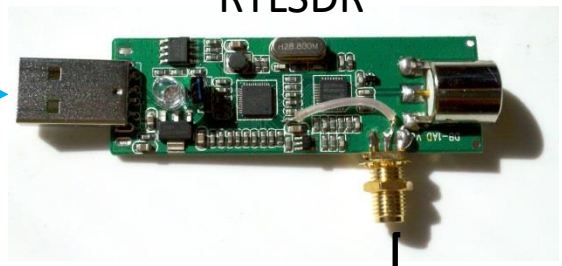
RPi and SDR mounted at antenna

5VDC

RPi
Running
GNU Radio
Open SDR
client software

USB

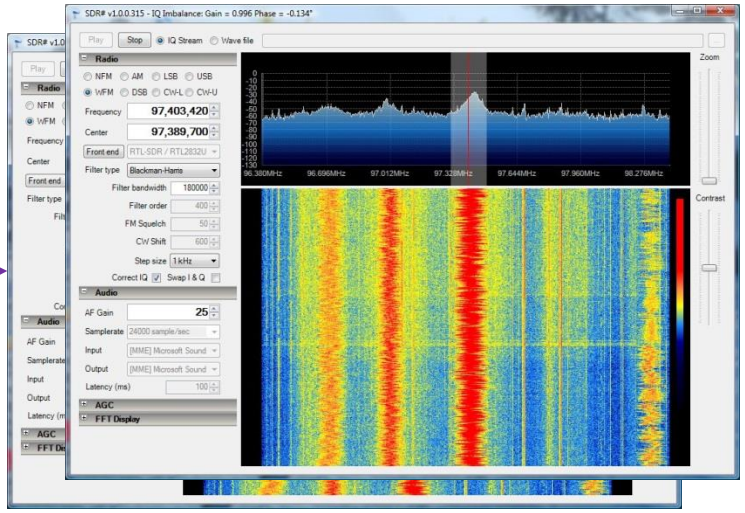
RTLSDR



POE

I & Q data
Streamed
Across network

Home
LAN



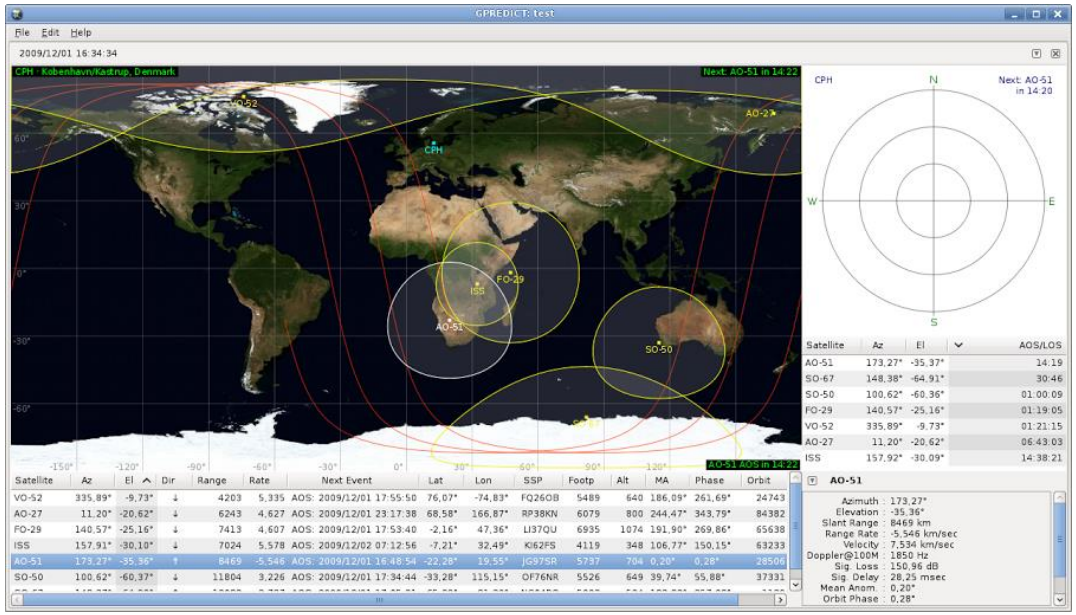
LAN client(s) running SDR# software

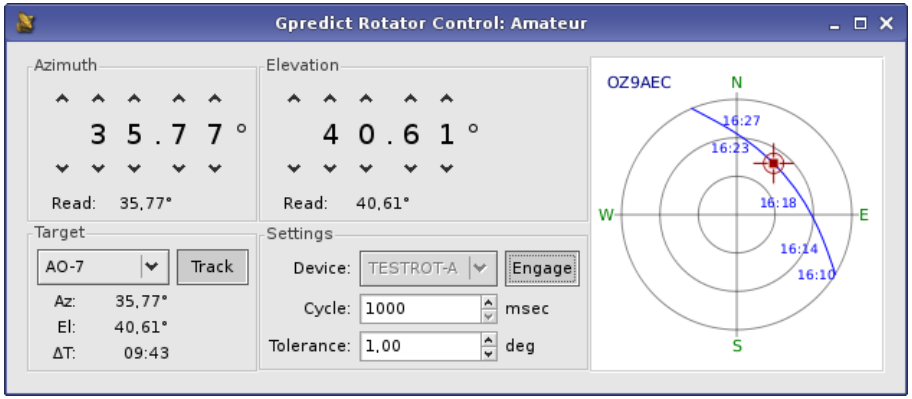
Satellite Tracking and Antenna Rotator Control

(a work in progess)

GPREDICT

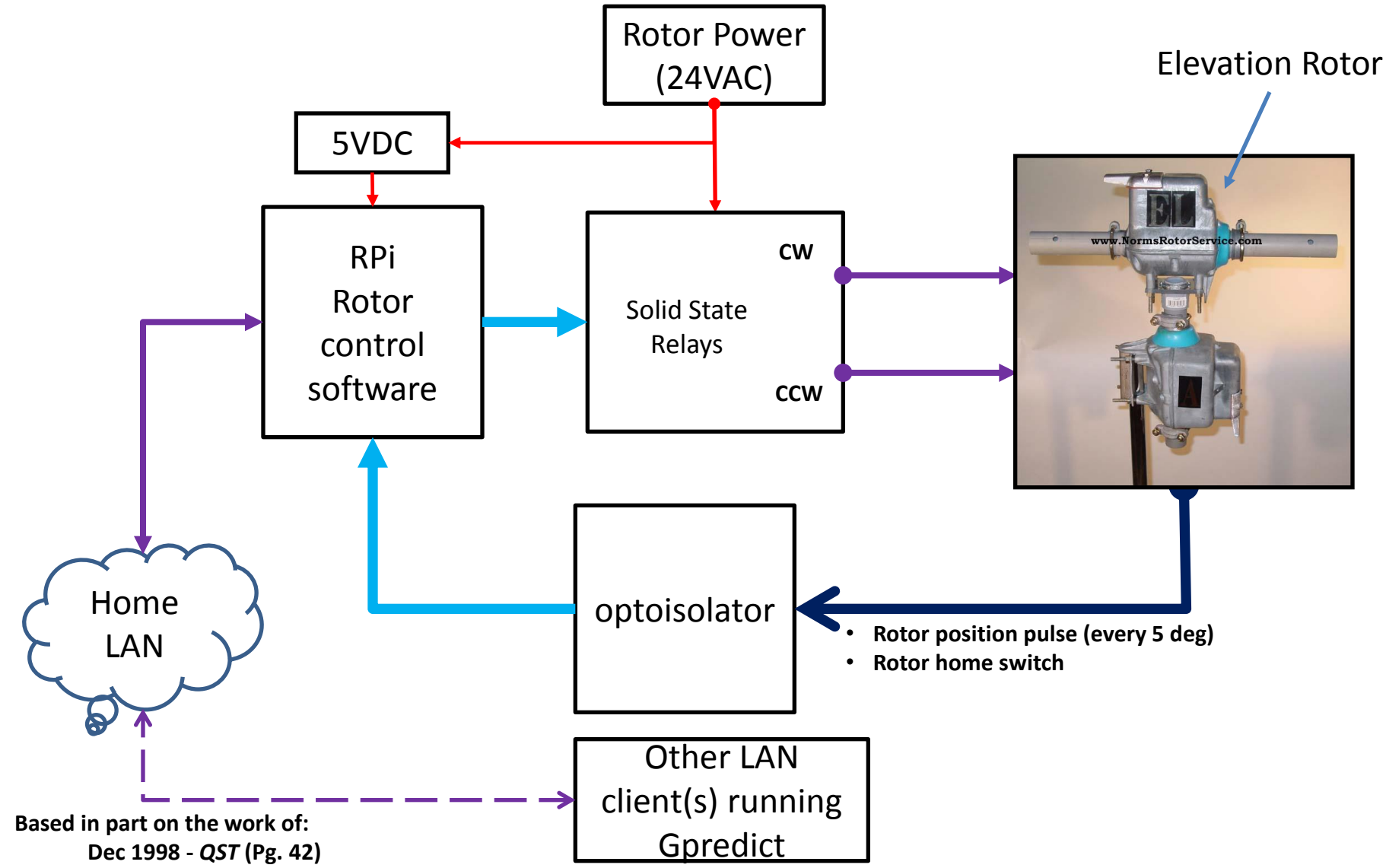
- Gpredict is free software that runs under Windows, Linux and Mac OS.
- Gpredict has the hooks in it for interfacing to antenna rotors
- Gpredict runs on the Raspberry Pi!





Satellite Tracking and Antenna Rotator Control (cont.)

(a work in progress)



Based in part on the work of:

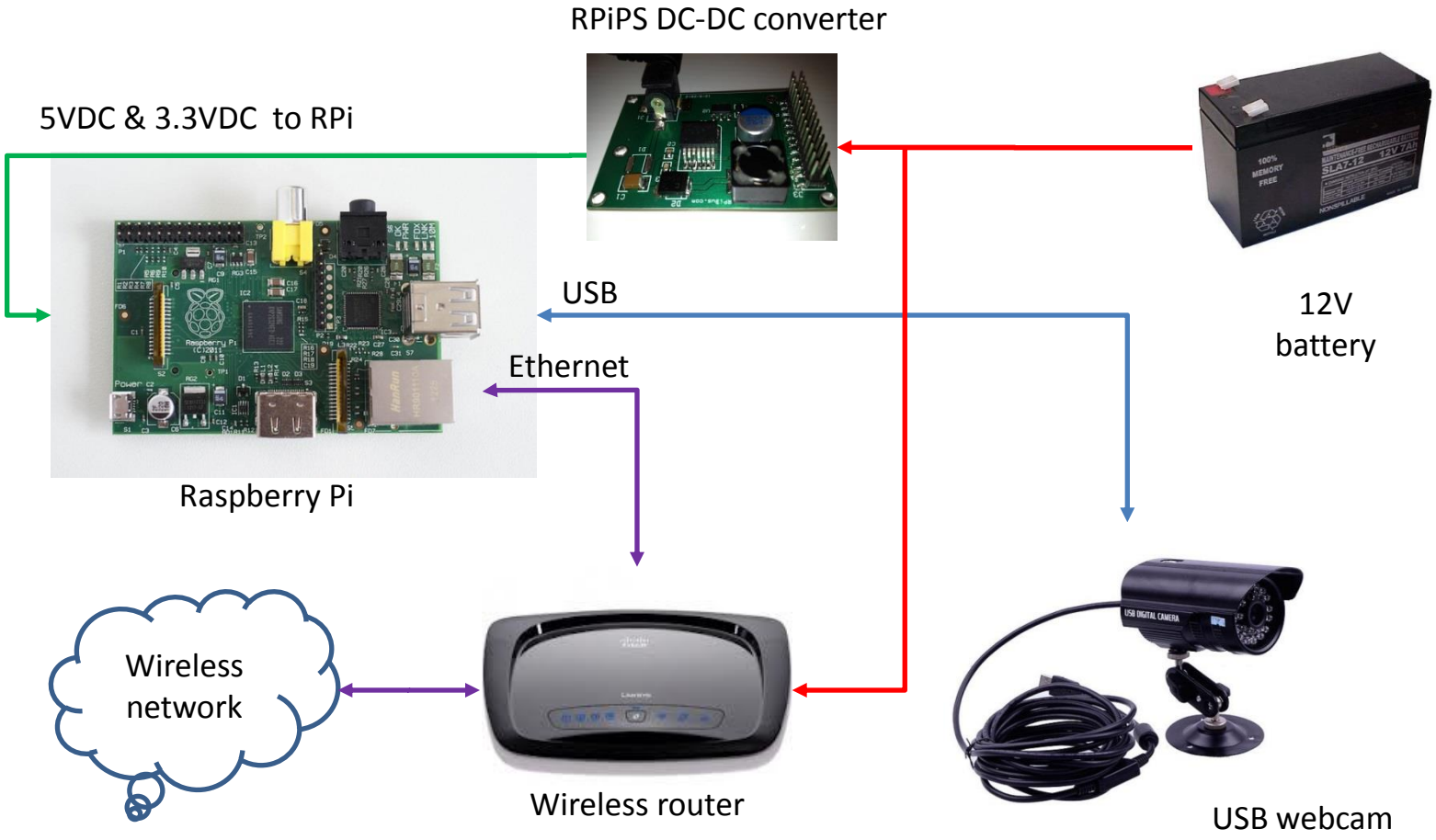
Dec 1998 - *QST* (Pg. 42)

'An Inexpensive Az-El Rotator System'

Koehler, Jim, VE5FP

Portable Webcam

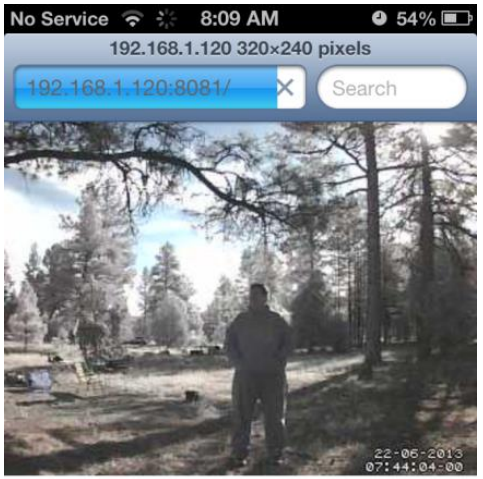
- RPi running Motion software
- Software captures video whenever motion has been detected
- Captures a still frame every minute
- Streaming video available via Wifi



Mount on a tripod for your next Hamfest, tailgate, Field day or club activity

Portable Webcam W5MPZ

ARRL Field Day
June 22 & 23, 2013
www.arrl.org



Third Party Prototype & I/O Boards for the RPi

Pi Face: Allows the RPi to control and sense physical devices such as lights, motors and sensors.

- Four momentary contact push switches
- Four LEDs.
- Two 10-A relays
- 8 general purpose open-collector outputs

'Pi Face' Digital I/O board atop a RPi

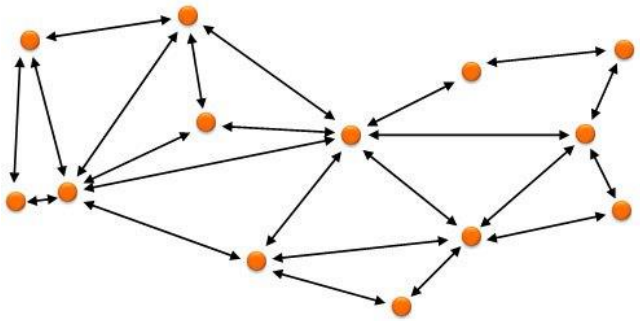
'Com Pi' board atop a RPi

Com Pi :

- RS232 Serial port
- I^2C serial bus

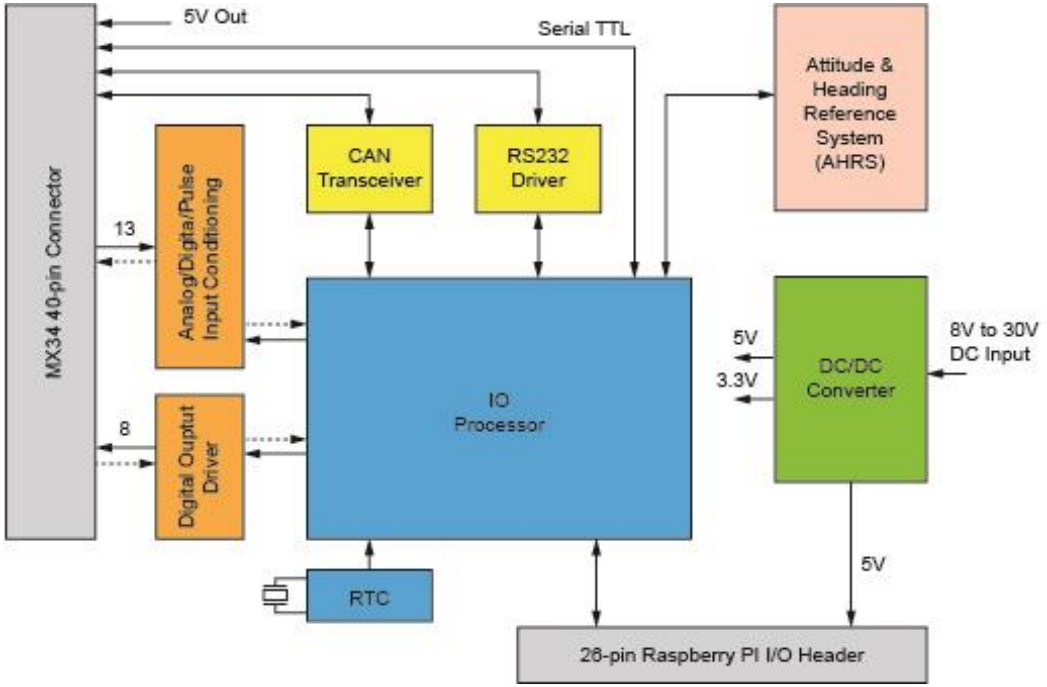
MESH Networking & RPi

- Use to create a MESH network node
- OLSR software runs on the RPi
  - Configured as a MESH node
  - Able to perform other simultaneous tasks
    - Webcam server
    - Wireless sensor network node
    - Internet gateway
    - File server
    - DRATS server/bridge
    - …
- MESH networking no longer tied to out of production hardware or the 2.4GHz band.



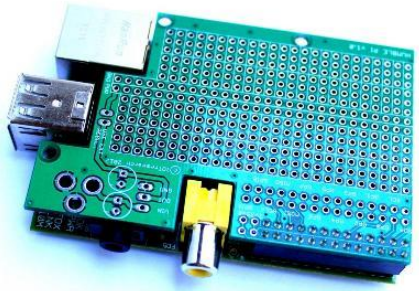
RIO (Raspberry IO)

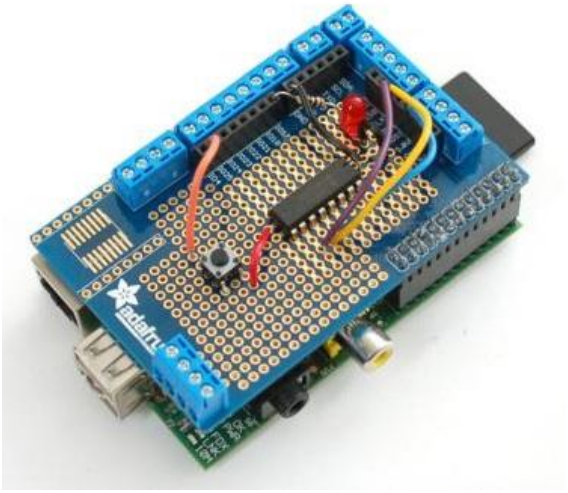
- I/O and power supply card for Raspberry PI.
- 13 Ana/Digital/Pulse Inputs
- 2 Ana Outs
- 8 Digital 1A Outs
- RS232
- RS485
- CAN
- Optional 3 AXIS AHRS
- Connects via the SPI buss

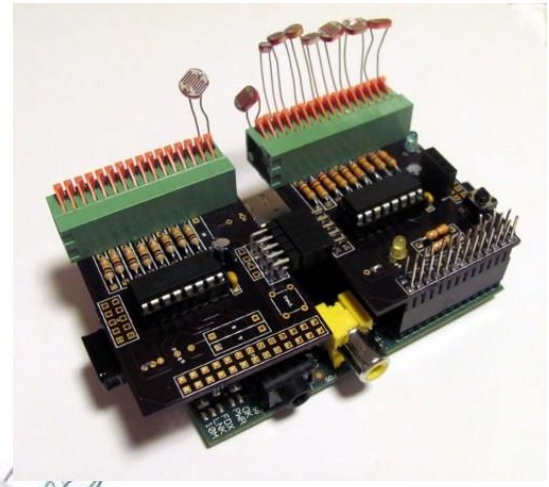


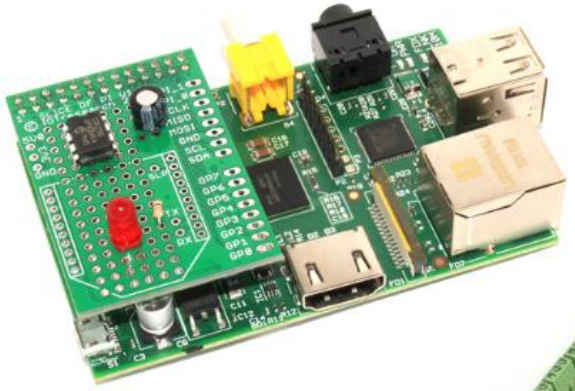
http://www.kickstarter.com/projects/95547492/smart-io-expansion-card-for-raspberry-pi

And Many More









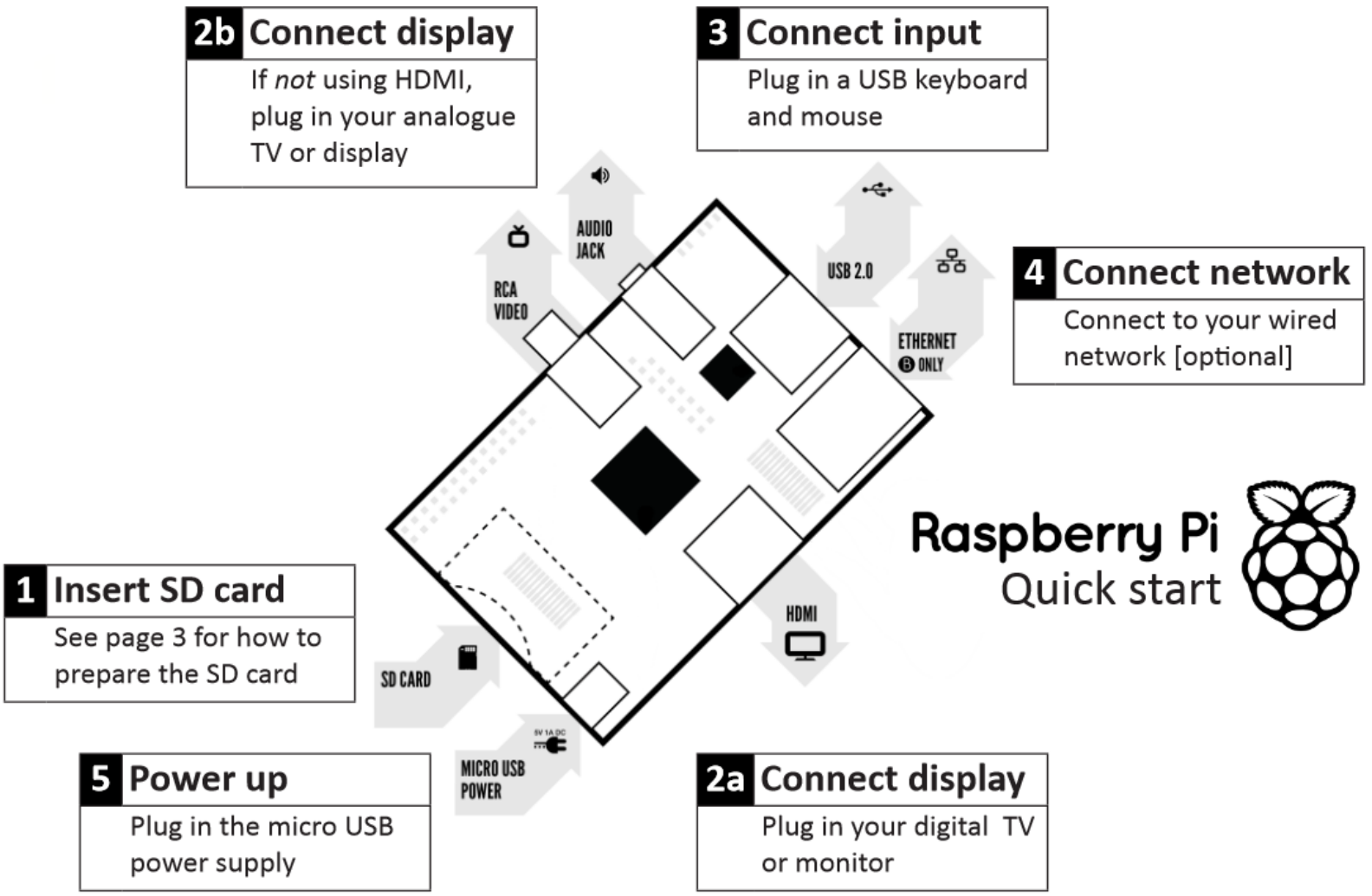
Over 75 different boards and counting!

http://elinux.org/RPi_Expansion_Boards

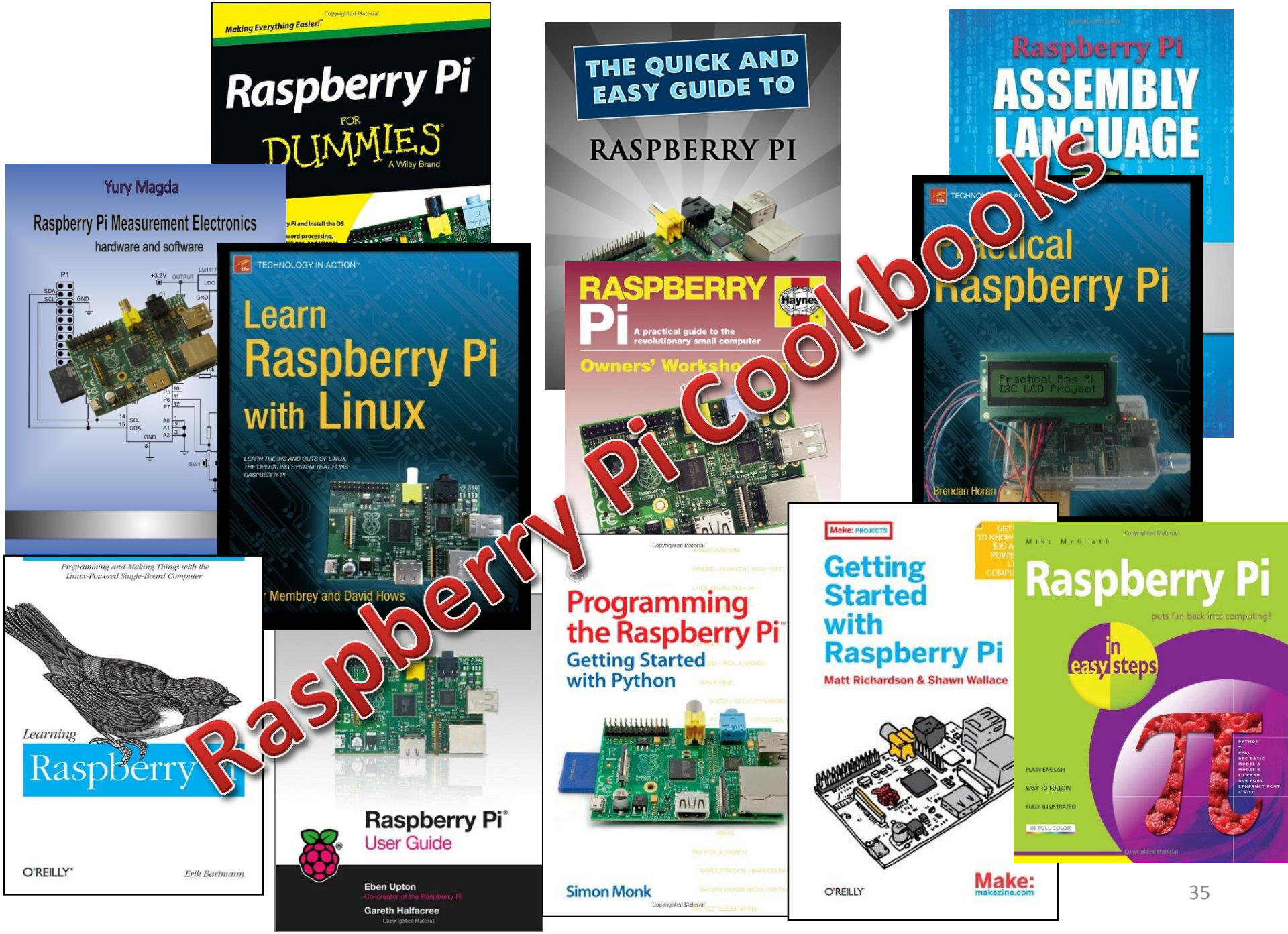
Setting up your RPI

It's almost this easy

Rpi Setup Quick Start



http://www.raspberrypi.org/quick-start-guide


Raspberry Pi Cookbooks
Raspberry Pi
FOR DUMMIES
A Wiley Brand
THE QUICK AND EASY GUIDE TO
RASPBERRY PI
Raspberry Pi
ASSEMBLY LANGUAGE
Yury Magda
Raspberry Pi Measurement Electronics
hardware and software
TECHNOLOGY IN ACTION
Learn Raspberry Pi with Linux
LEARN THE INS AND OUTS OF LINUX, THE OPERATING SYSTEM THAT RUNS RASPBERRY PI
RASPBERRY Pi
A practical guide to the revolutionary small computer
Owners' Worksho
Practical Raspberry Pi
Practical Ras Pi I2C LCD Project
Brendan Horan
Programming and Making Things with the Linux-Powered Single-Board Computer
Learning Raspberry Pi
O'REILLY
Erik Bartmann
Membrey and David Hows
Programming the Raspberry Pi
Getting Started with Python
Simon Monk
Make: PROJECTS
Getting Started with Raspberry Pi
Matt Richardson & Shawn Wallace
O'REILLY
Make: makezine.com
Mike McGrath
Raspberry Pi
puts fun back into computing!
in easy steps
PLAIN ENGLISH
EASY TO FOLLOW
FULLY ILLUSTRATED
IN FULL COLOR
Raspberry Pi User Guide
Eben Upton
Co-creator of the Raspberry Pi
Gareth Halfacree

Additional Resources

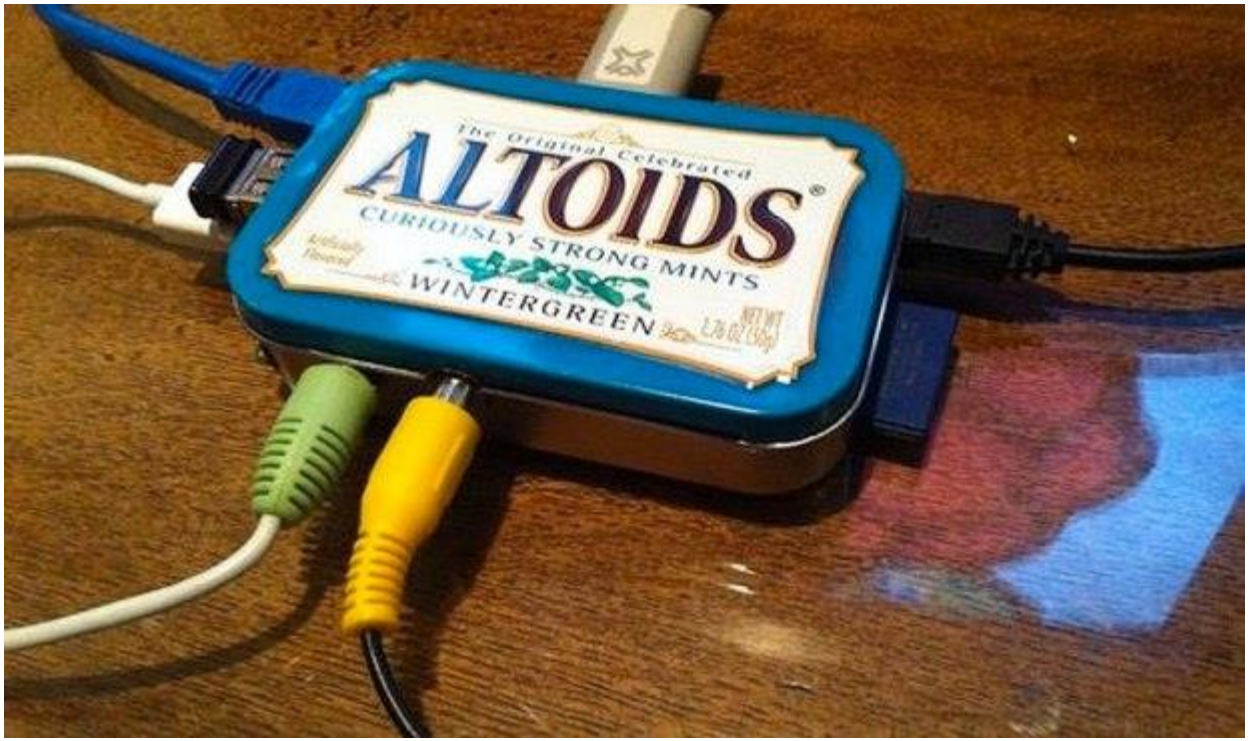
http://www.raspberrypi.org

Raspberry Pi Amateur Radio Yahoo Group

http://groups.yahoo.com/group/Raspberry_Pi_4-Ham_RADIO/

Raspberry Connect

http://www.raspberryconnect.com/raspbian-packages-list/item/71-raspbian-hamradio



Discussion/Questions?

Speaker Bio

Ed James, KA8JMW of Albuquerque, NM is originally from Canton, OH where he was licensed over thirty five years ago. Since then, Ed has savored from the broad palette that amateur radio offers. Activities have included the design and fabrication of various projects from DC to daylight, QRP, net operations, traffic handling, rag chewing, contesting, DX, transmitter hunting, Search and Rescue, public service, satellites, EME and as an elmer to many a new ham. The thrill of that first QSO hasn't diminished. He has over 29 years of service as an electrical engineer leading space based and defense projects at Sandia National Laboratories. Ed, his wife Carol and their five daughters are all active amateur radio operators. Ed is an Assistant Section Manager for the ARRL New Mexico Section and can be reached via email at ka8jmw@arrl.net.