Python HW Link

High Level Overview

As Flight Simulators increasingly offer support for API interfaces (e.g. DCS, P3D), it now is feasible to move away from using Joystick interfaces (along with fun of dealing with USB issues) to a distributed system using Ethernet. Such as approach also simplifies output interfacing (e.g. indicators and gauges) as tasks and processes can be divided up across a number of devices and technologies.

This project builds on the Python/Raspberry Pi project used in the Huey Warning panel.

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Definitions

Primary Flight Simulator – the PC running an instance of the flight simulator
Primary Node – the Raspberry Pi node that communicates to the Primary Flight Simulator
Distributed Node – either a Raspberry Pi or Arduino (with Ethernet shield) that communicates to the Primary node.

Principles

- Use UDP for all communications where possible. This removes any possible performance issues associated with Nagle and TCP slow start. It also means components are loosely coupled, enabling them to be restarted without impacted other modules.
- Accept inputs from push, toggle, rotary, and rotary encoders.
- Outputs – analog and digital, text. All outputs are normalised before being send to output card/block. Should consider the format used by DCS-BIOS
- Multiple Sim support. As outputs are normalised the and loosely coupled now simulator support can be added without negatively impacting existing sim support. The receive interface from the Sim listens on unique ports, allowing the code to be running at all times.

- A shallow native shim is used to link the simulator to this hardware modules. As an example, LUA is used with DCS, for P3D Sim Connect used.
- Remote shutdown of all Pi nodes is provided through the master, once this has been invoked the nodes will shut down the OS, requiring either a hardware reset, and a power cycle to resume. Ideally outputs will display a checker board to reflect a shutdown command has been received.
- Indicator test, a single command will be supported to light all indicators, and perhaps cycle gauges.
- Downstream nodes should accept a request to report input switch position. On receipt of such a request the node will send a report of switch positions, probably at a rate of 20 per second. Need to consider reporting toggle switches in off position and three position switches.
- Will initially develop using DCS, and the variable names currently used by the A10
- The IP addressing of the 'internal' network (i.e. between the primary Flight Simulator computer) as well as between nodes will use the 172.16.1.X network. This enabled multiple flight simulators to share a common 192.168.X.X network. If there is only a single simulator the 172.16.1.X network can exist as a secondary address on the Primary network interface, if multiple Simulators share a network, then the internal network should use a different network interface on the Primary Computer.
- Mapping of physical inputs to simulator functions is performed on the Primary Pi node. This keeps the distributed nodes independent of flight sim, and relatively simple, enabling the use Arduino nodes as needed without adding unneeded complexity.
- Each distributed node will have a Unique identifier, which largely is used to uniquely identify different input modules.
- Each distributed node will maintain a state machine for its interfaces, sending only deltas to the Primary Node
- Distributed nodes receiving non-string values receive data as A=V:A1=V1:A2=V2
- Packets from input nodes will have the format of DX:A=V:A1=V1, where X is the input node number. The Node number is only indicated in the front of the packet, not at the individual AV pair.
- If an AV pair is not known it will be silently discarded unless the Primary node is in learning mode – where it will ask the operator what task should be assigned to the unknown AV pair.
- Learning Mode is determined by an argument on the command line 'learning' or in the
- Debug Mode is determined by an argument on the command line 'debug'

Hardware Approach

The simulator is divided into three zones, each linked using Ethernet and power. This enables the simulator to be easily assembled/disassembled without having to disconnect/reconnect a large number of cables.

As described later in this document the Primary interface to the Simulator is a Raspberry Pi

which then interfaces inputs and outputs from Arduino with Ethernet Shields in the front, left, and right sections of the pit.

Printed Circuit Boards

Design and Manufacturing of the PCB

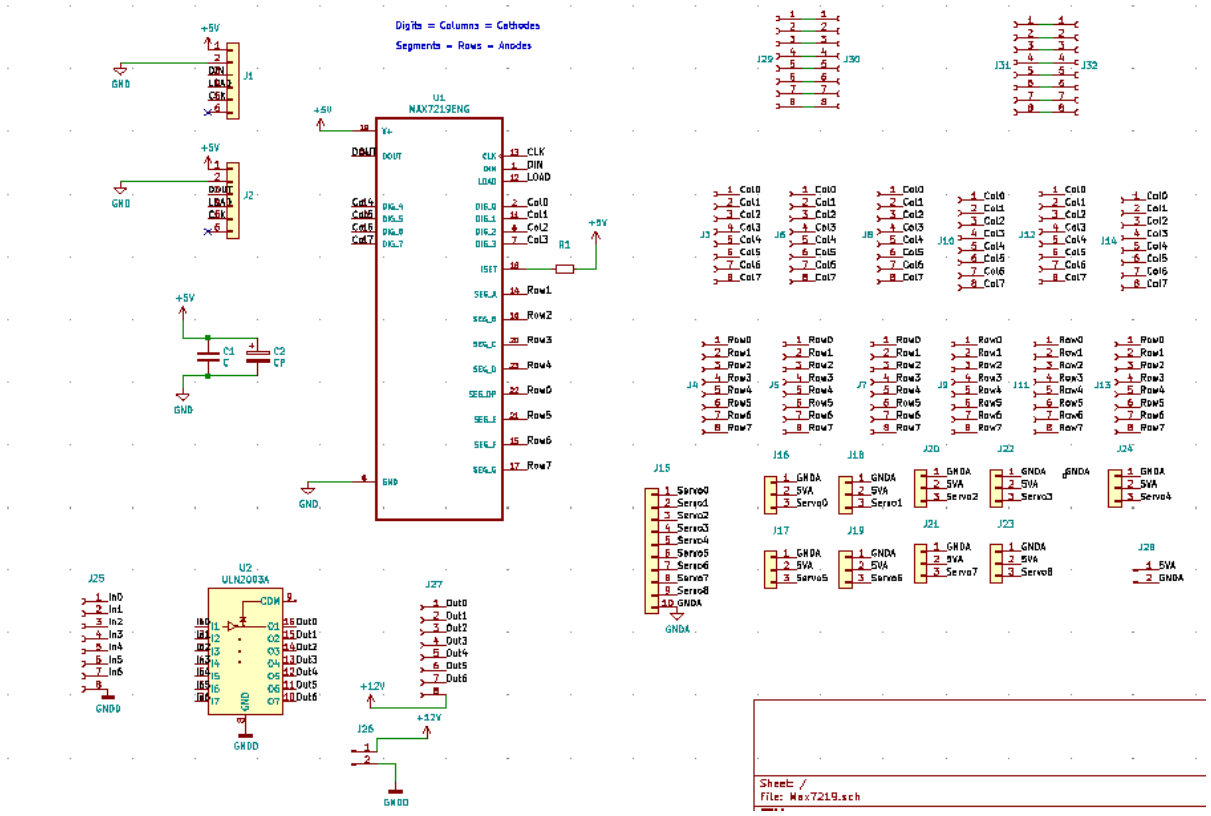
KiCad[1] was used for drawing schematics and PCB design. KiCad an Open Source Electronics Design Automation Suite which enables you to quickly sketch up a circuit diagram, assign footprints to devices, and then layout a PCB. Whilst KiCad is Open Source – it is supported by donations manged by CERN[2] (the same group who fostered the developed of the web and the large Hadron Collider). KiCad runs on both Mac and Windows.

One thing KiCad does not currently do is auto-routing of PCB tracks, which can get a little tedious after the first 100 tracks on a PCB. The good news there is a FreeRouting[3], it is powered by Java (so you'll need need to install Java Runtime).

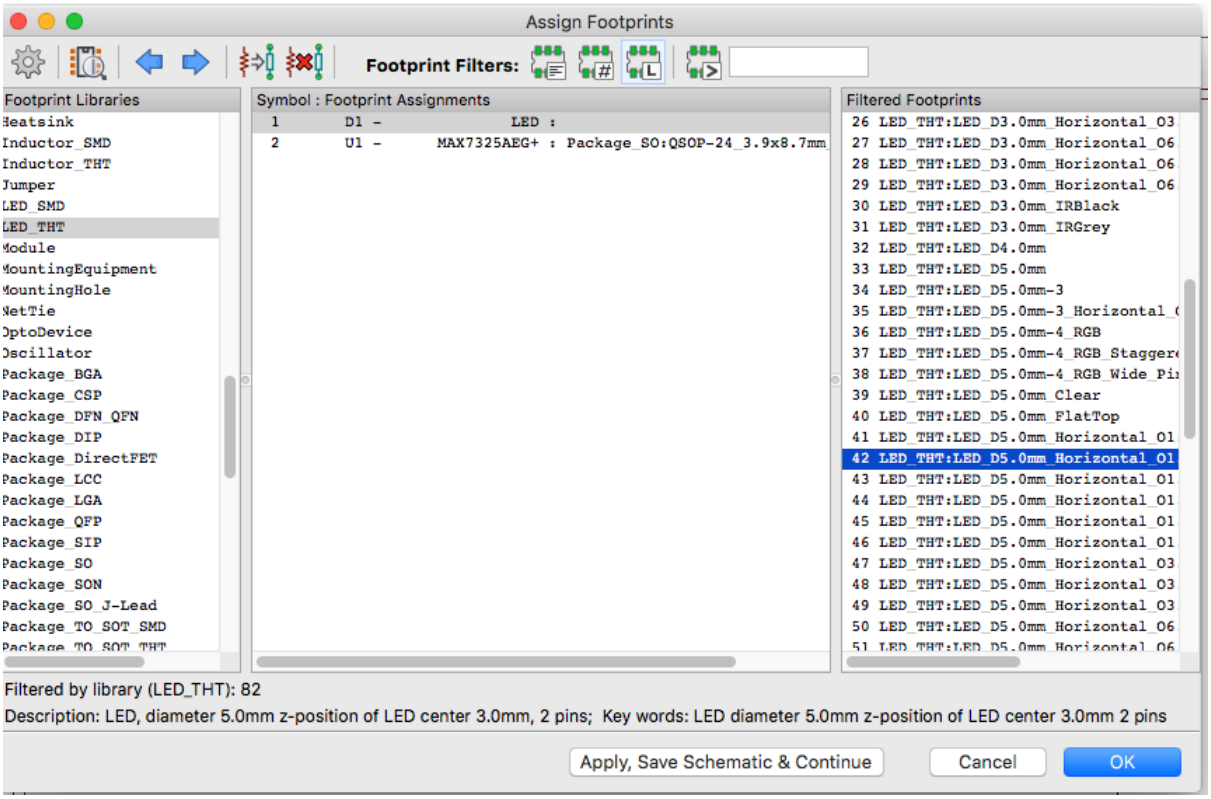
Using KiCad

Draw up the circuit diagram – remember to assign footprint to devices. Where there are a relatively number number of connections to connections – its a good idea to use buses so the diagram is not overload with criss-crossing tracks.

1 KiCad - http://www.kicad-pcb.org/
2 Donate to KiCad - https://cernandsocietyfoundation.cern/projects/kicad-development
3 Free Routing - https://freerouting.org/freerouting/using-with-kicad

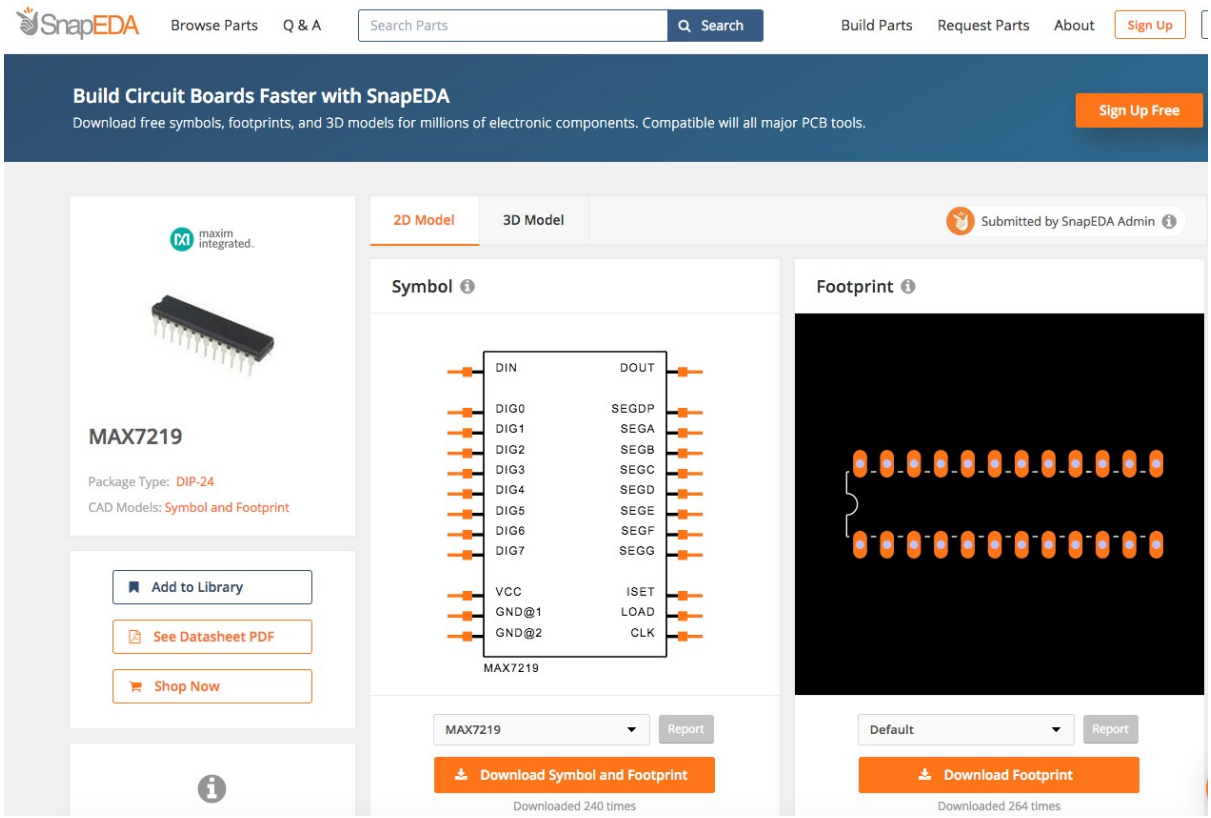


Ensure all devices have a footprint assigned – Tools → Assign Footprints. Generally we'll be using THT (Through Hole) instead of SMD.

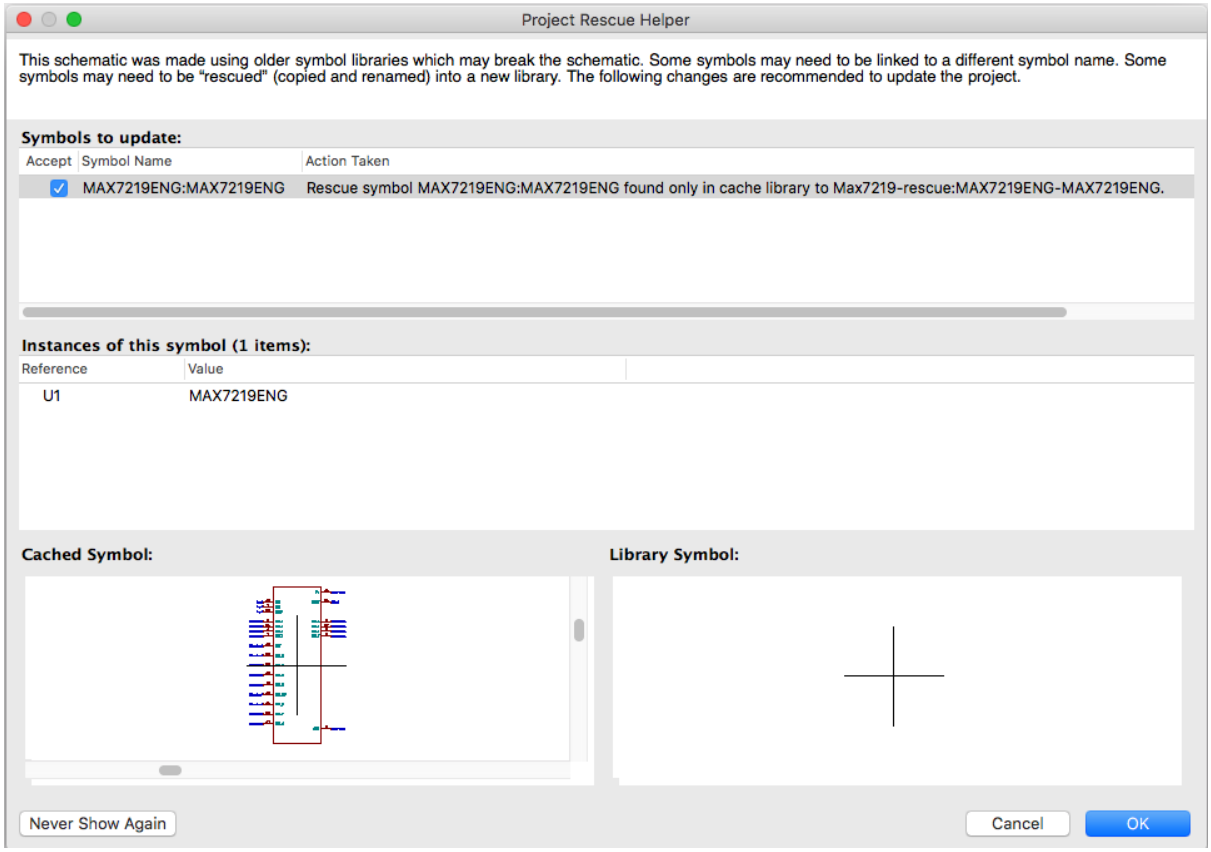


Once the drawing is complete, assign device numbers by annotating the schematic – Tools → Annotate Schematic. If there has been a bunch of adds/moves/etc it is not a bad idea to Reset Existing Annotations.

It is possible that the device you want to use is not included in the default KiCad library. I ran into this with the Max7219. If you are dealing with a new component, SnapEDA offers libraries that can be imported into KiCad. You do need to register and validate your email.



If you edit an existing design on a new computer without the component libraries installed you may get the following



The most simple thing to do if this happens is using the rescue symbol.

Once you've downloaded the zip file, add it to KiCad (SnapEDA will provide you with steps – which I've duplicated here)

In KiCad, go to *Tools > Edit PCB Footprints*.

1. Click on *Preferences > Manage Footprint Libraries*.
2. Click on *Browse Libraries* and navigate to the downloaded .mod file.
   Then click *OK*. The library will appear in the *Global Libraries* tab.
3. In the table, make sure that the Plugin Type is set to *Legacy*. Then click *OK*.
4. Click on *Load footprint from library > Select by Browser*.
5. Navigate to the footprint you imported and double-click to open it.

Once the circuit diagram is complete – save it and open up the PCB. One thing that takes a little getting used to is using the Keyboard and Mouse to do the editing, or a little more use of the Right Click. As an example to move something around you select with the mouse and

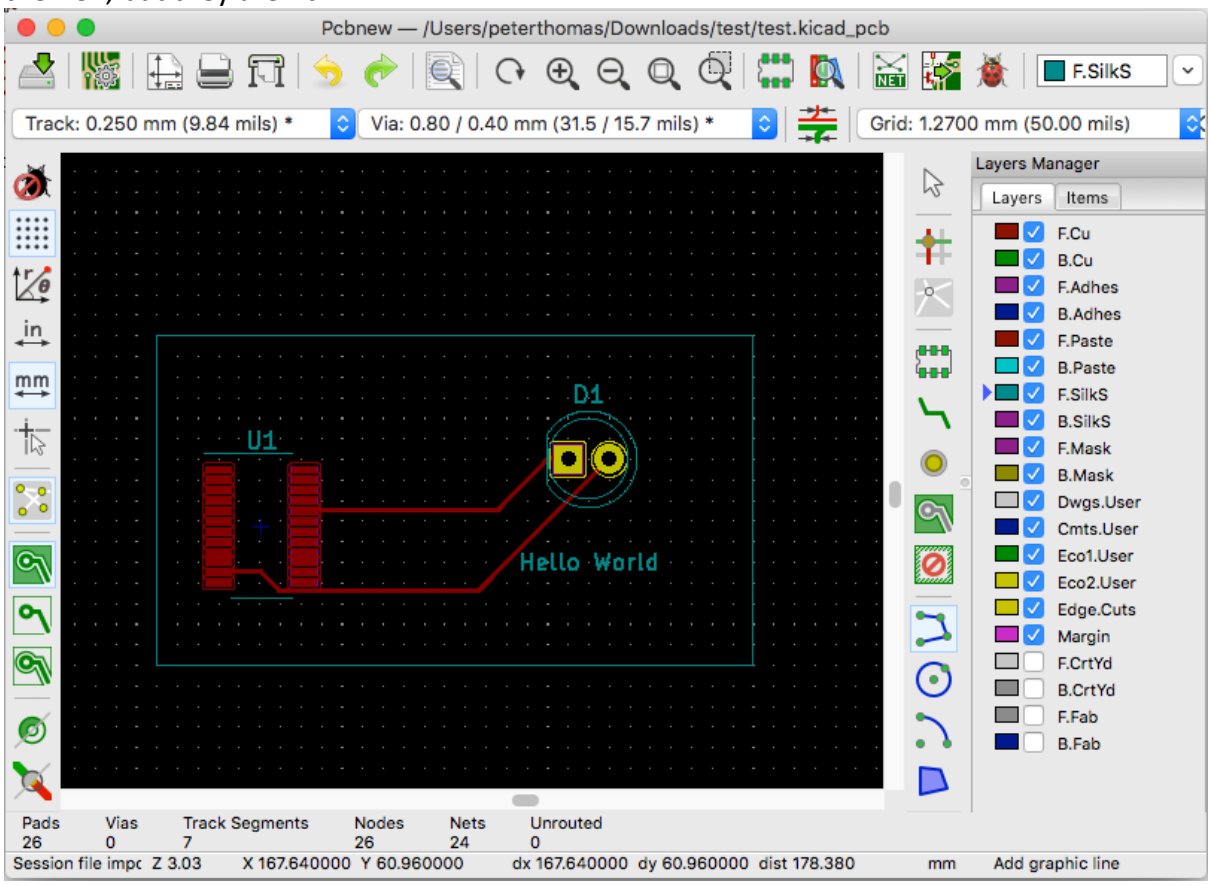
then either press M or right-click Move.

Once components are correct positioning then you can either manually route tracks or use Free Router. Whilst the Freerouting page calls out that it is included in layout – you won't find it with a simple search when using the Mac – Right Click on Layout in Applications folder – show package contents[4] – and copy it to a folder thats easy to find.

A dialog to the Freerouting tool will be opened. In this dialog you can export a Spectra Design File (.DSN). This is the input file you will need with FreeRouting. After opening FreeRouting open this file and preform the routing. When routing is finished store the result to a Spectra Session File (.SES). In the same KiCAD dialog this file with the routing results can be imported.

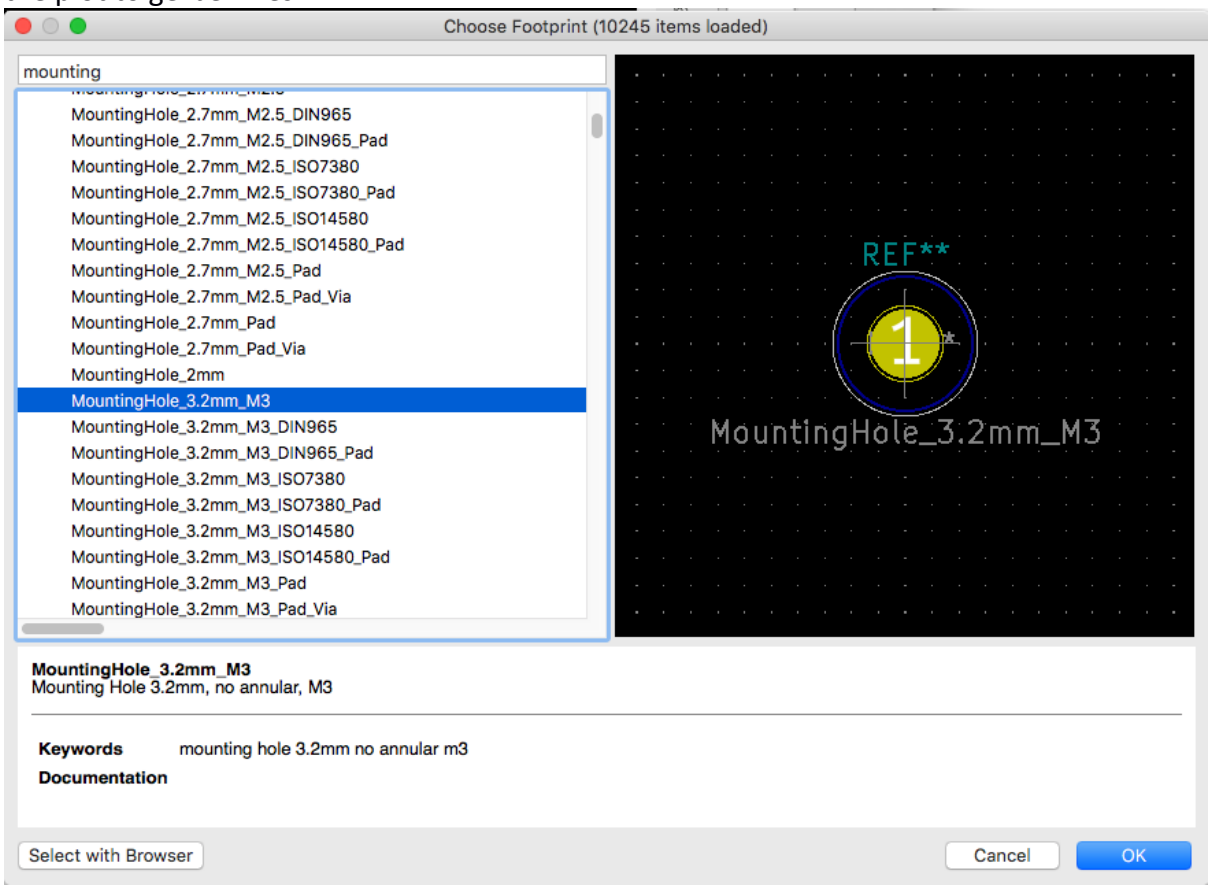
Then return to the PCB Editor in KiCad and import Spectra Session File.

You can then add useful text to the silkscreen – don't forget to select the Front Silkscreen layer and potentially hide layers from the view – as it may look like values will be drawn on the PCB, but they aren't.

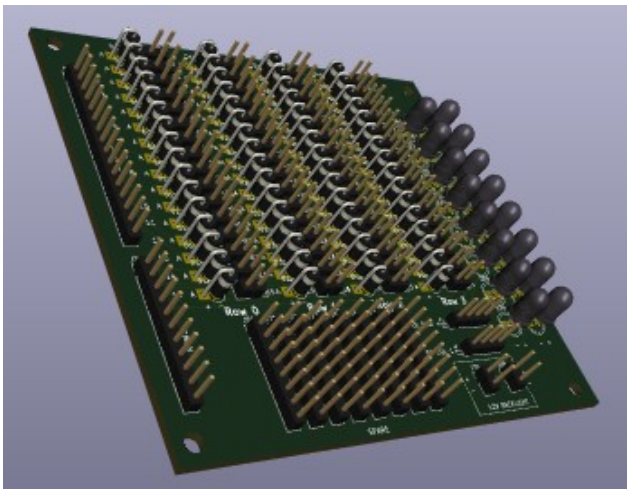


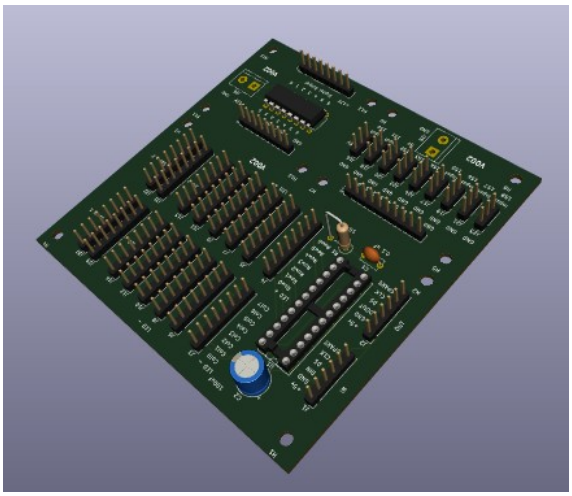
4 The version of freeRouter.jar I used was version 1.3.1 which was based on 1.2.43 from Alfons Wirtz It is 1.4M

Earlier versions of KiCad didn't support mounting holes, they are supported today. Simply select add footprint. One thing you may to do is assign a 'counter' to the hole otherwise you the plot to gerber files.



One the PCB design is ready to send off – Plot the PCB and generate drill files (an option from the Plot Dialog box). It is probably a good idea to preview the PCB in 3D view





Manufacturing the PCB

There are a bunch of companies who specialise in the manufacturing of Prototype PCBs. There are a couple of things to consider when selecting a manufacturer, firstly whats the lead time for the PCB, and whats the costs to ship the completed board.

I've recently started using PCBgogo[5], they offer 2 day turn around with a solid web interface, which makes ordering, tracking, and reordering very simple. Additionally they offer an online gerber viewer so you can preview you files. Your files are checked before the order is accepted, so by the time you get to actually place the order – the files are verified, and shipping costs can be accurately estimated.

If the PCB is smaller than 100mm*100mm then 5 boards cost only USD$5 to manufacture, plus the cost of shipping. PCBgogo offer a wide choice of courier companies – so if you are in a hurry in could have the PCB in your hands within 7 days of submitting the gerber files.

A couple of little tricks

- The minimum number of boards for an order is 5, which cost $5, I've found I can order 10 boards and still only pay $5. So try it out :)
- Shipping is often more expensive than the boards, you can add multiple board designs to a single order.
- I did manage to confuse things a little by adding lines to the silk screen which PCBgogo thought were lines for cutting, so if you run into a speed bump like that just delete the lines from the silk screen. Normally designs are validated with 10 minutes – if to takes more than a couple of hours (during PCBgogo opening hours), something is up.

PCBs Used in the Project

There are 6 PCBs used in the projects

	Version	Brief Description
Arduino Output	001	Attaches to output Arduino. 2 Servo outs, 1 Digital out, 1 Max7219 Out. Optional (but recommended) 5V input for driving Max7219. The servos are supply 5V at the Output PCB
Output	002	Basically three PCBs in one. The Max7219 Led driver, with multiple connections
Arduino Input	001	Attaches to the input Arduino, connectivity only aside from the 10K pull-up resistors
Input	001	Connectivity only with multiple connections for Panel PCB inputs to connect to.
Small Panel	002	For the smaller panels, supporting up to 24 switch positions and

5 https://www.pcbgogo.com/

		8 LEDs. It also has backlighting connector and a row of pins for miscellaneous requirements.
Large Panel	002	For the larger panels, supporting up to 64 switch positions and 16 LEDS. It also has a backlighting connector and a row of pins for miscellaneous requirements.

Arduino Output

This PCB attaches to the Arduino providing output services. The same PCB is used in the centre, left and front sections.

It has two connectors for servo out (actually each connector is duplicated enabling four separate panels with servos to be supports. Additionally there is a connector to connect to the Max 7219 section of the Output board, and a digital output connector. As the software uses pins on another section of the Arduino Mega, a piece of aerial plumbing is needed to connect the Max7219 interface.

The Servo Connectors provide a total of 18 outputs to the servo board sections of the servo break out section of the Output board. Pin 10 of the servo output connectors is the ground connector. R2 and R4 would normally be a jumper wire, for reasons that elude me now the spot for a resistor was added, but as it is going to ground is it better not to have it there.

The Servos receive +5V via connector on the Servo Breakout Section of the Output board.

Mega Expansion Port Pin No	Output Pin Servo1	
3	1	
4	2	
5	3	
6	4	
7	5	
8	6	
9	7	
10	8	
11	9	
	10	GND (via R2)

Mega Expansion Port Pin No	Output Pin Servo2	
12	1	
13	2	
14	3	
15	4	
16	5	
17	6	
18	7	
19	8	
20	9	
	10	GND (via R4)

The Digital Out Connector is generally intended for non-LED loads that need additional driver circuitry such as Magnetically held switches, relays, and higher voltage (eg 12V/24V) lamps. As with the Servo out, pin 10 on the connector should be wired to ground, ie a jumper installed for R3. As the UN2003 only has 7 inputs, typically an eight pin connector is installed in the last 8 pin positions of the Digital Out Connector

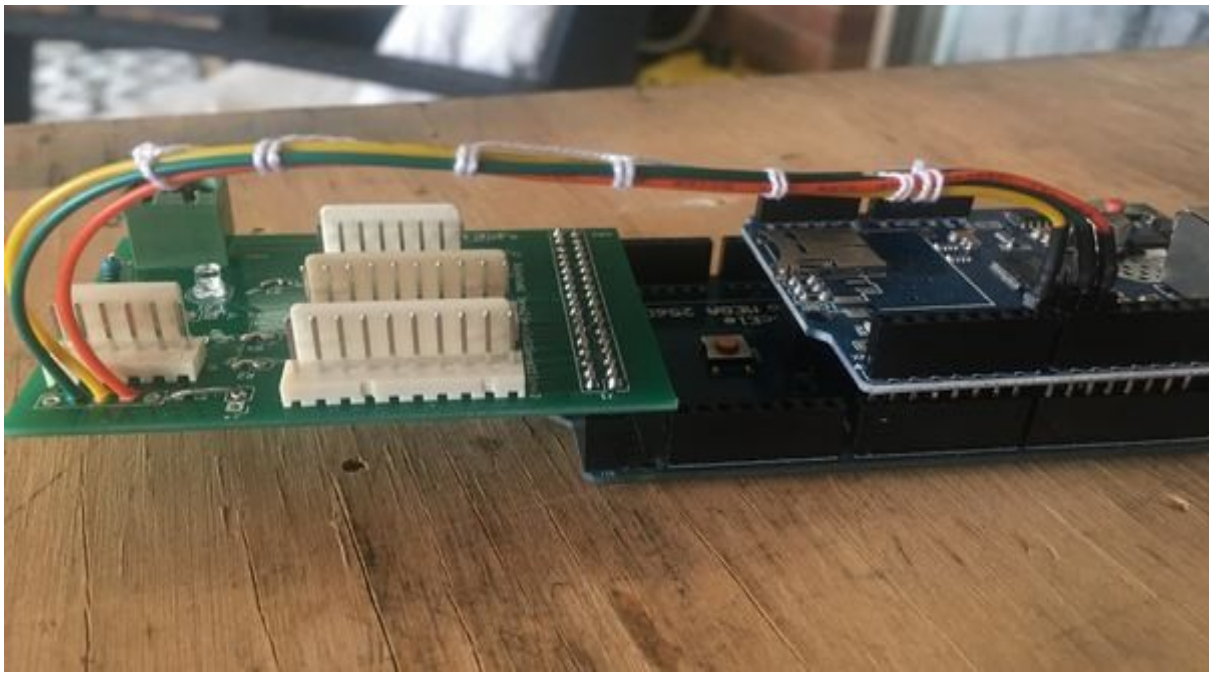
Mega Expansion Port Pin No	Output Pin Digital Out	
21	1	
22	2	
23	3	
24	4	
25	5	
26	6	
27	7	
28	8	
28	9	
	10	GND (via R3)

Max7219 Port

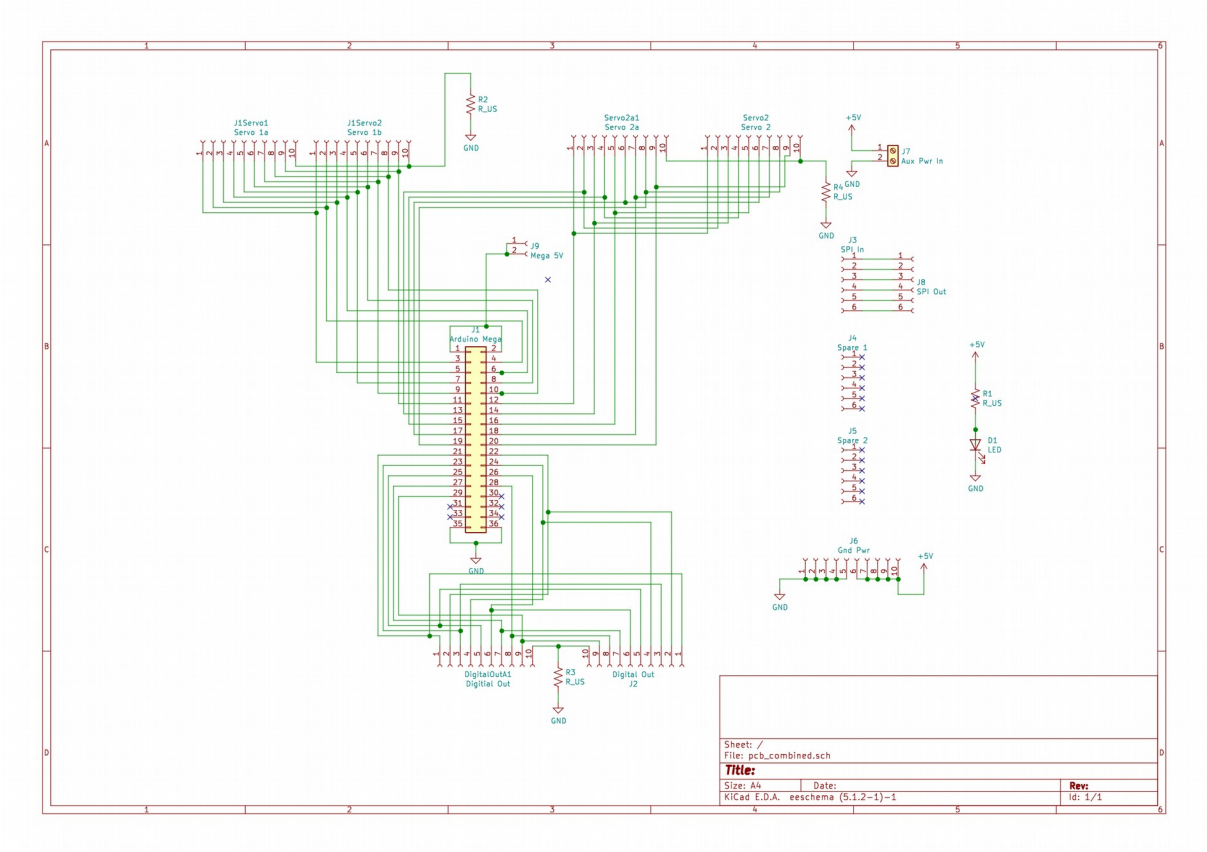
Ports J3 and J8 are basically an anchor point for MAx7219 connectivity. It is optional to power the Max7219 through the Arduino 5V rail or from the 5V connector on this board. All

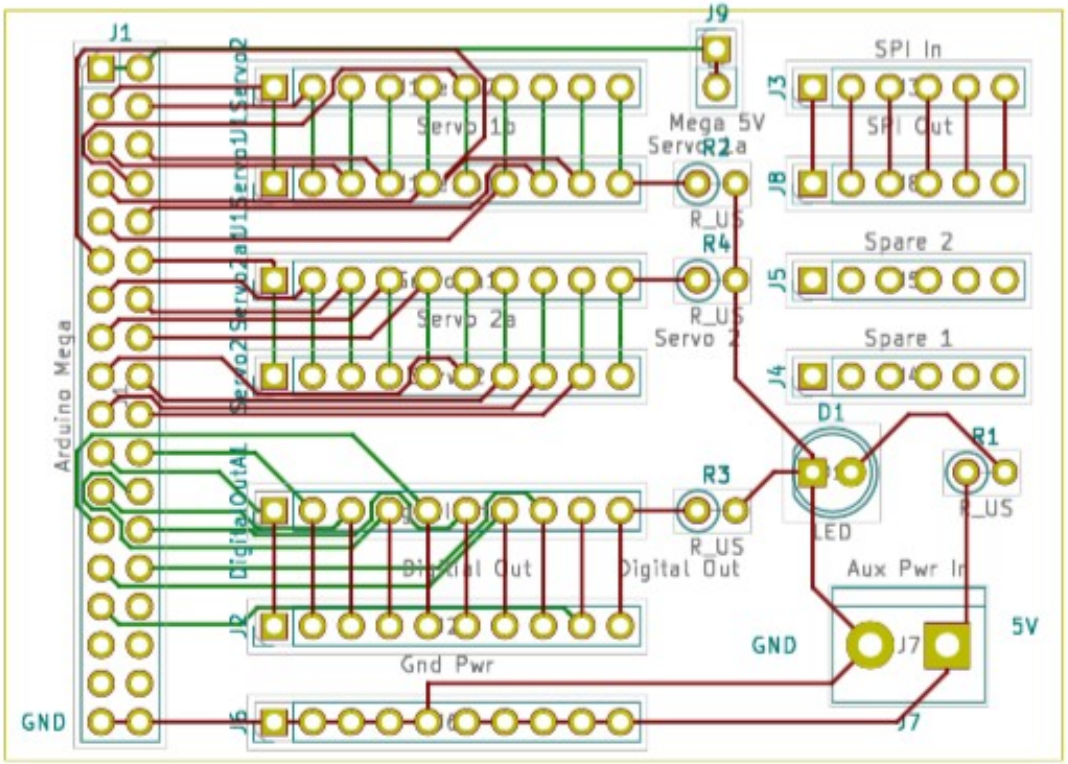
of the pins for these connectors must be manually wired, including GND, 5V, and the aerial connections to the pins on the Mega. The pinout used is based on that commonly found with Max7219 mini-circuit boards found on Ebay, which are useful for performing tests.

Pin	Function	Cable Colour
1	+5V	Red
2	GND	Black
3	Mega Pin 9	Orange
4	Mega Pin 7	Yellow
5	Mega Pin 8	Green
6	Not Used	



The drawing was done before I understood the benefit of using buses, so it is a little busy.


J1Servo1
Servo 1a
J1Servo2
Servo 1b
Servo2a1
Servo 2a
Servo2
Servo 2
J7
Aux Pwr In
J9
Mega 5V
J3
SPI In
J8
SPI Out
J1
Arduino Mega
J4
Spare 1
J5
Spare 2
J6
Gnd Pwr
D1
LED
R1
R2
R3
R4
R_US
GND
+5V
DigitalOut1
Digital Out
Digital Out
J2
Sheet: /
File: pcb_combined.sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. eeschema (5.1.2-1)-1
Id: 1/1

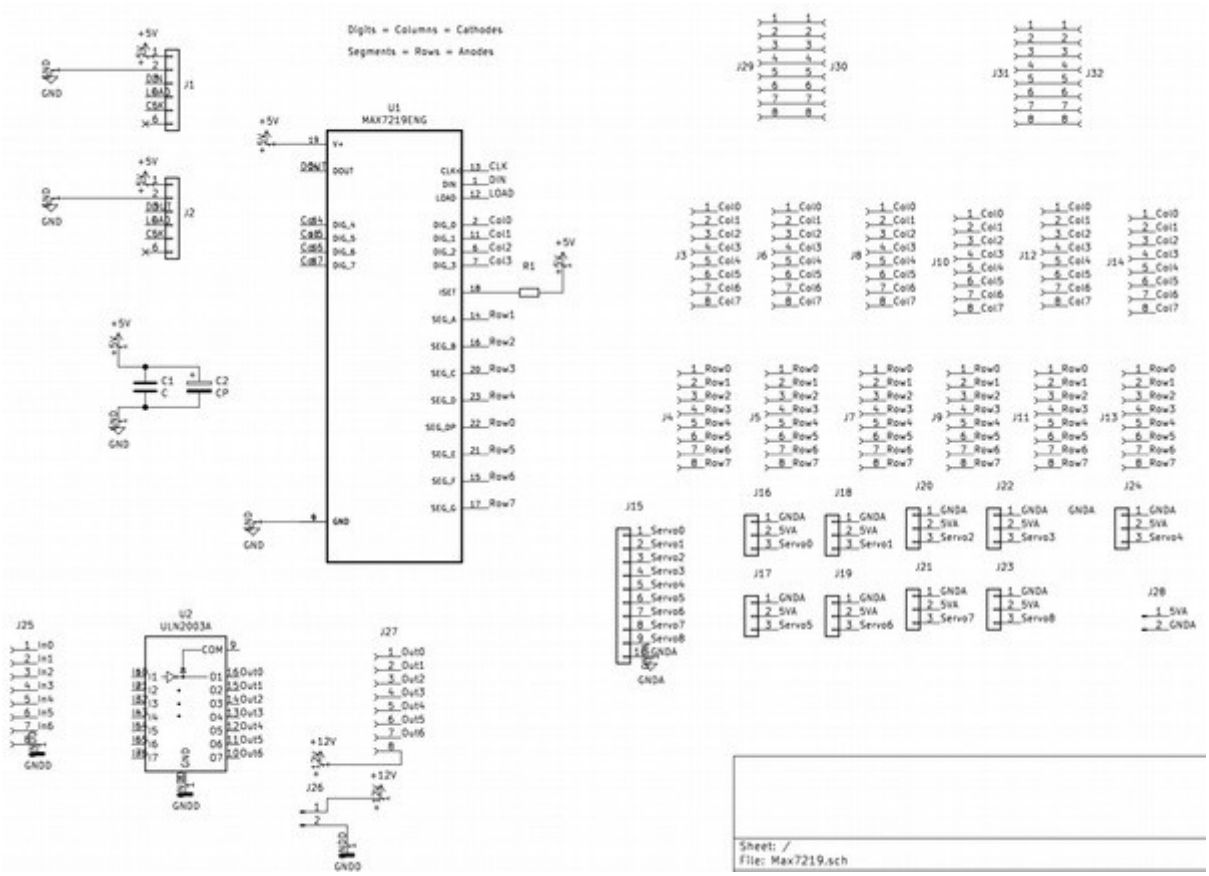

J1
J9
SPI In
J3
Mega 5V
Servo 1b
Servo 2a
SPI Out
J8
R2
R_US
R4
Spare 2
J5
Servo 2a
Servo 2
Spare 1
J4
Arduino Mega
D1
R1
R3
LED
DigitalOut1
Digital Out
Digital Out
Aux Pwr In
J2
Gnd Pwr
GND
J7
5V
J6

Output PCB

This PCB is really a combination of three PCBs, a Max7219, a servo breakout (passive), and a ULN2003 driver for non-LED loads. Note the three PCB sections are completely isolated and can be physically separated if needed. Its probably a smart idea to leave the PCBs together, evening if you aren't planning to use pieces of the board. You can simply leave the components out of that section.

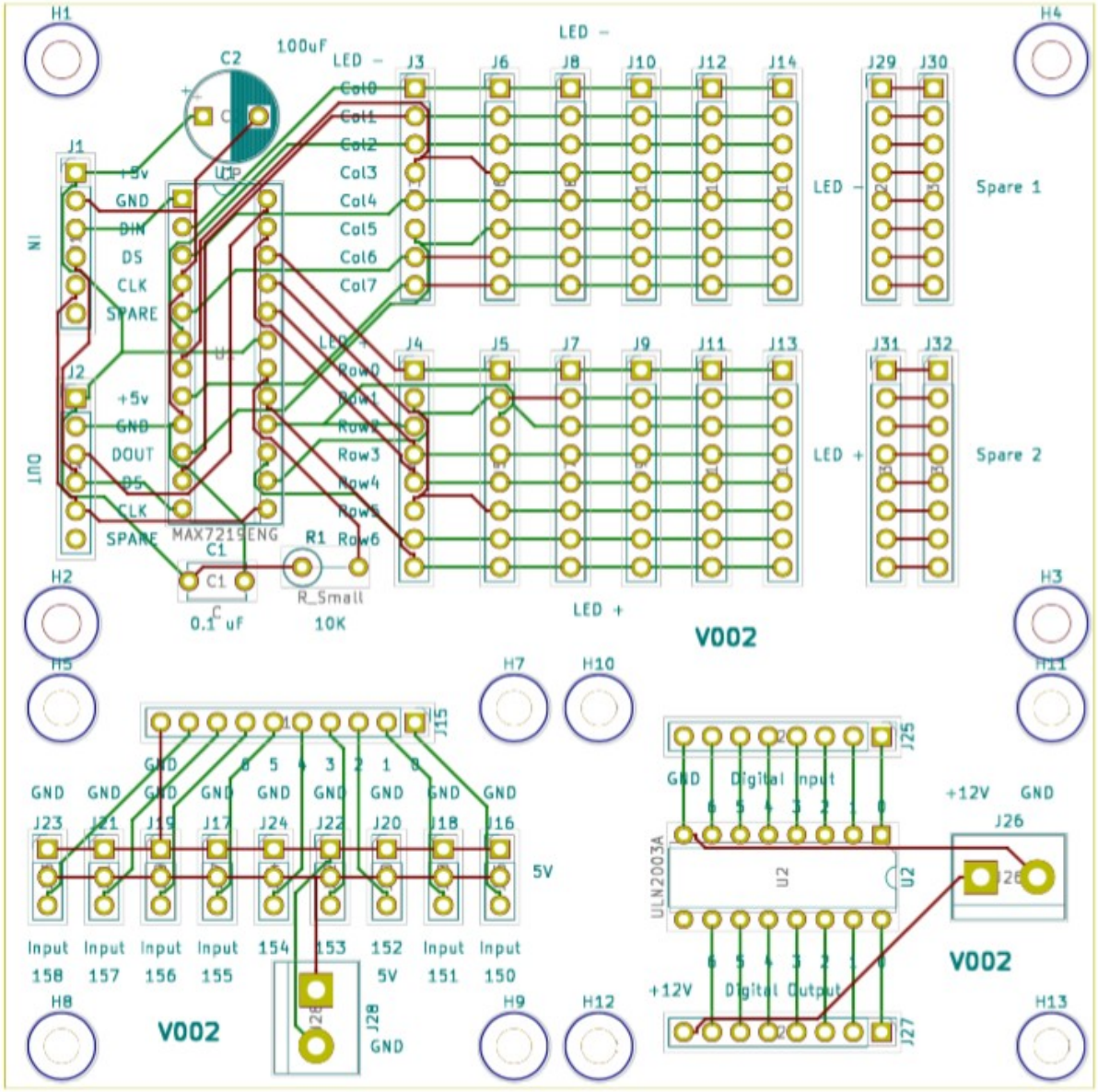
Note that J2 – Data Out hasn't yet been tested.

Pin – J1 Data In	Function
1	+5V
2	Gnd
3	Data In - DIN
4	Load
5	Clock - CLK
6	Not Used



Note there are three different grounds, GNDA, GND0, and GND. This was done to enable

the board to be split in three if needed, but ultimately these represent the same electrical ground.



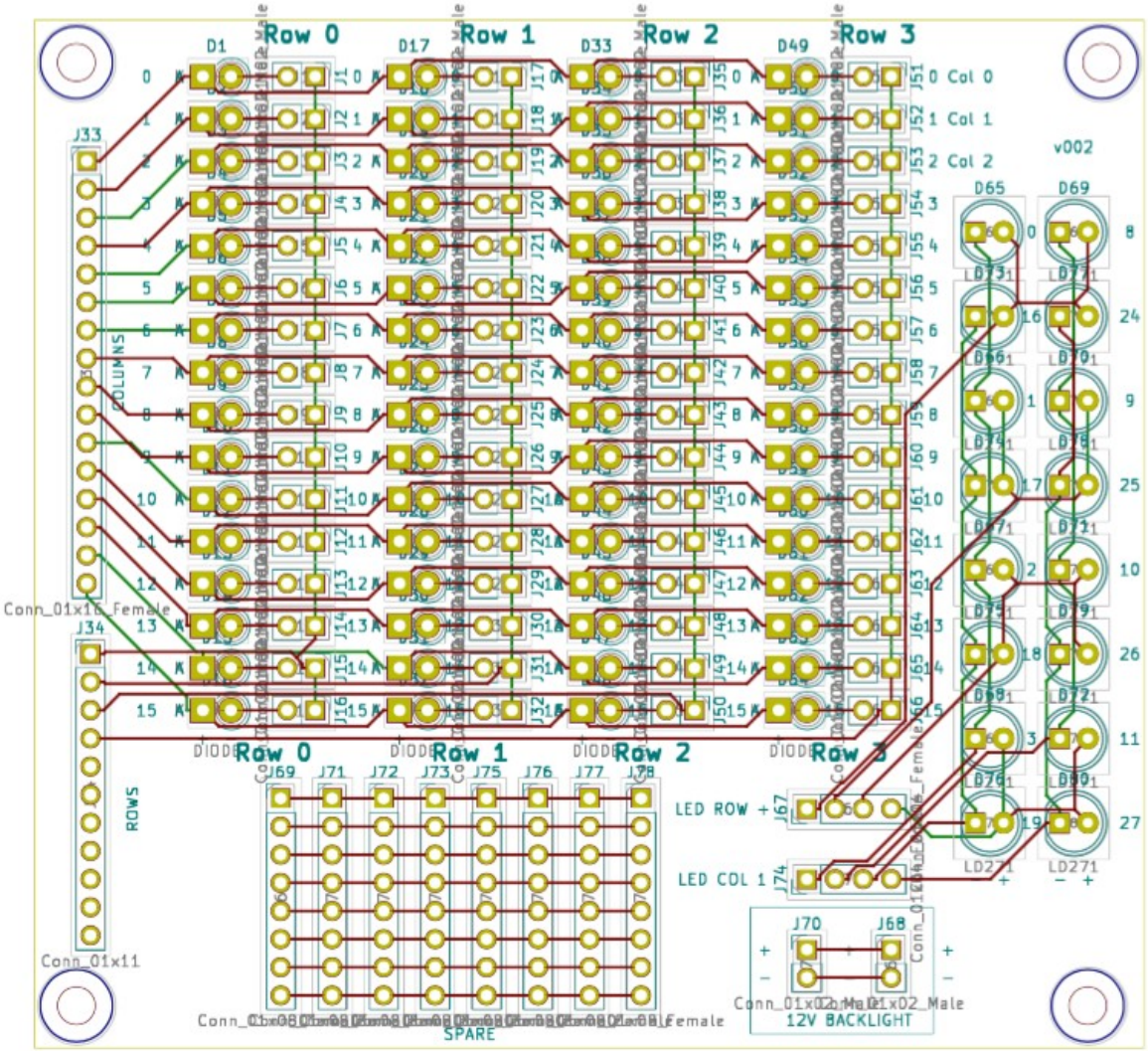
Components used in Output PCB

Ref	Value	Description
U1	Max7219	Led Driver for driving up to 64 Leds or Eight Seven Segment displays
U2	UN2003A	Array of seven NPN Darlington transistors capable of 500 mA, 50 V output.
C1	01.uF	Capacitor for reducing high frequency noise
C2	100-300uF	Electrolytic Capacitor for reducing lower frequency noise on the 5V rail.

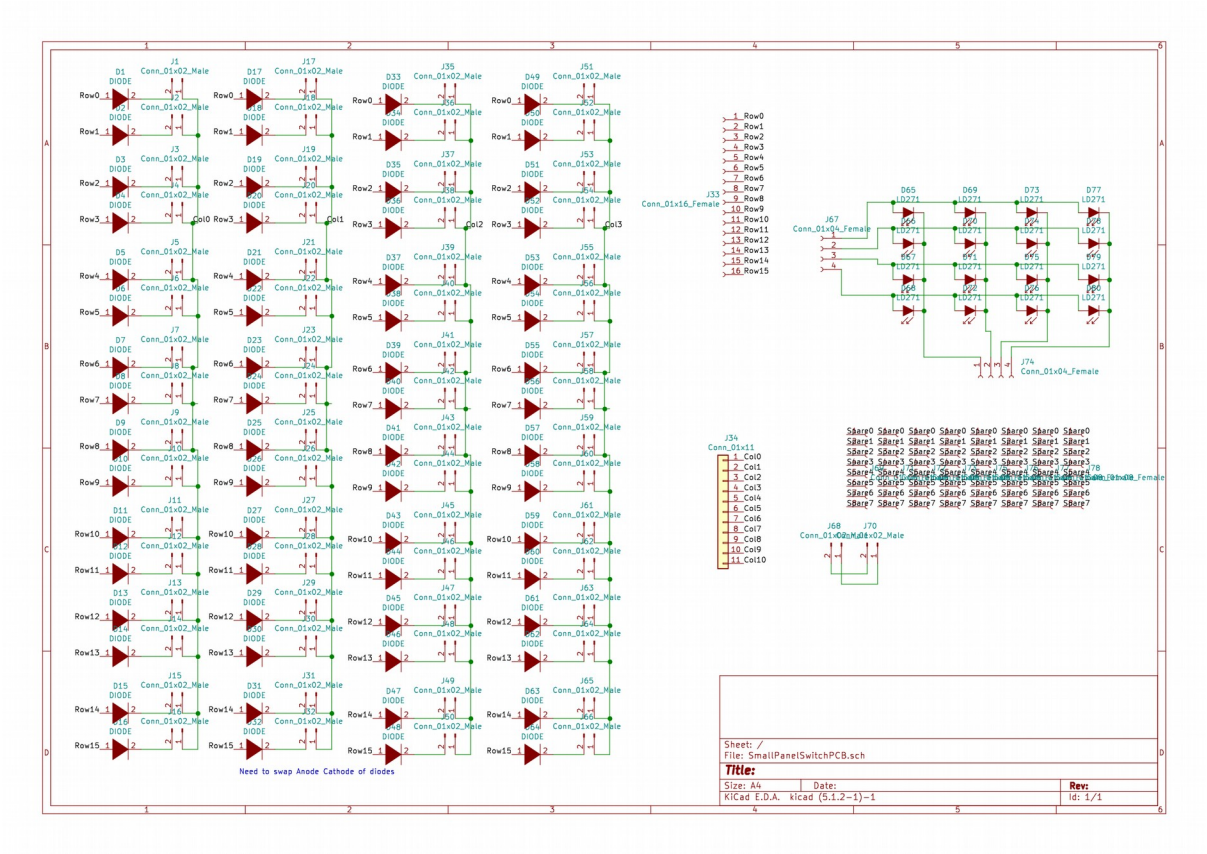
Ref	Value	Description
R1	10K	Sets the current per LED of the MAX7219

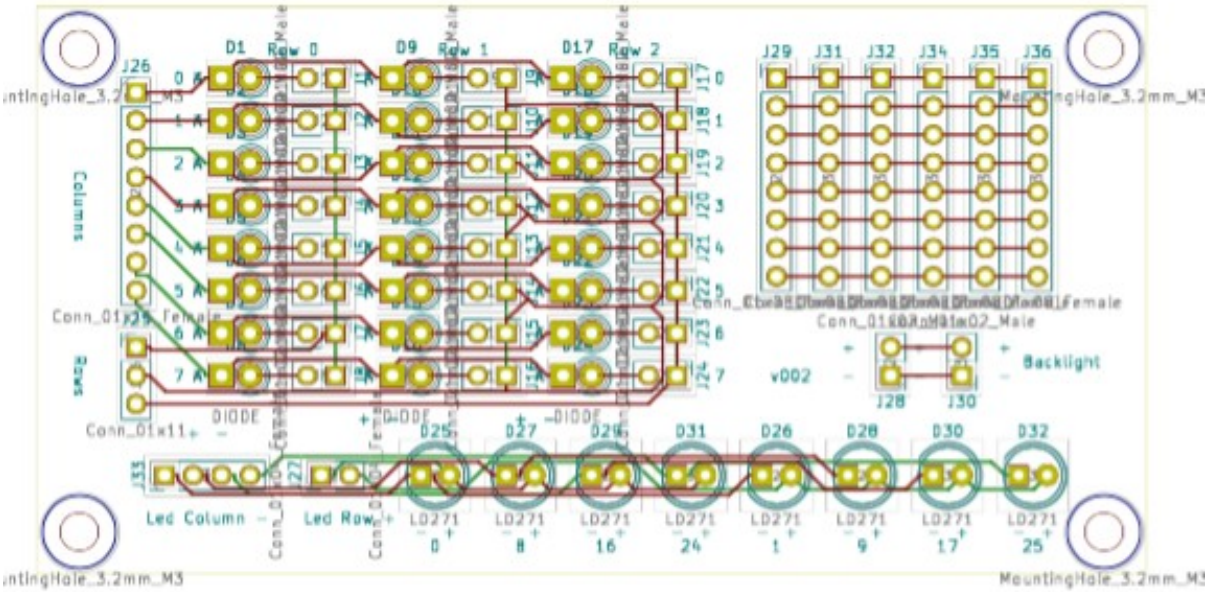
Panel Switch PCB

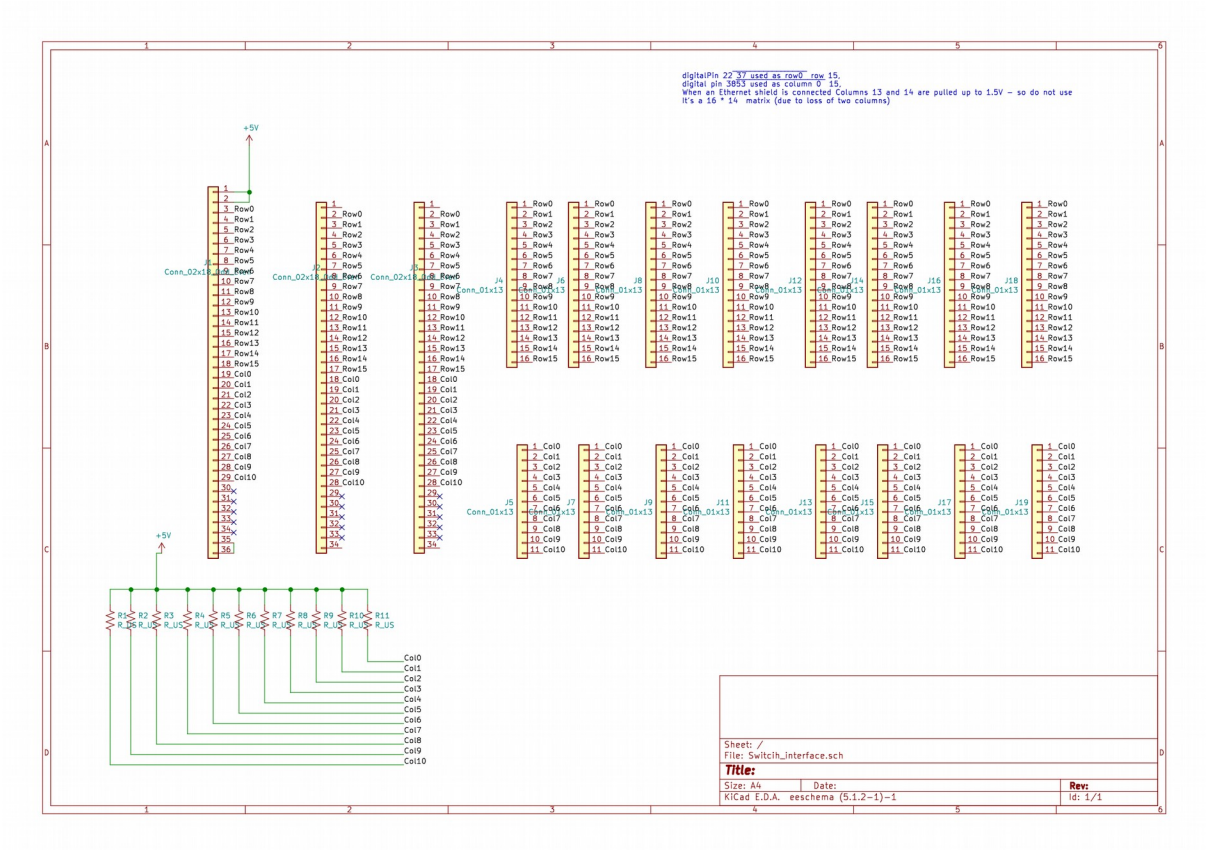
The Panel Switch PCB is designed to provide an interface to a large panel, or perhaps a bunch of panels that are collocated. Supporting up to 64 switch positions, along with 16 LEDs, it should support the largest of panels. Both the Panel Switch PCB and the Small Panel Switch PCB support the diodes needed for a Matrix input. Single switches could use connectors (eg J1-J64), but is also practical

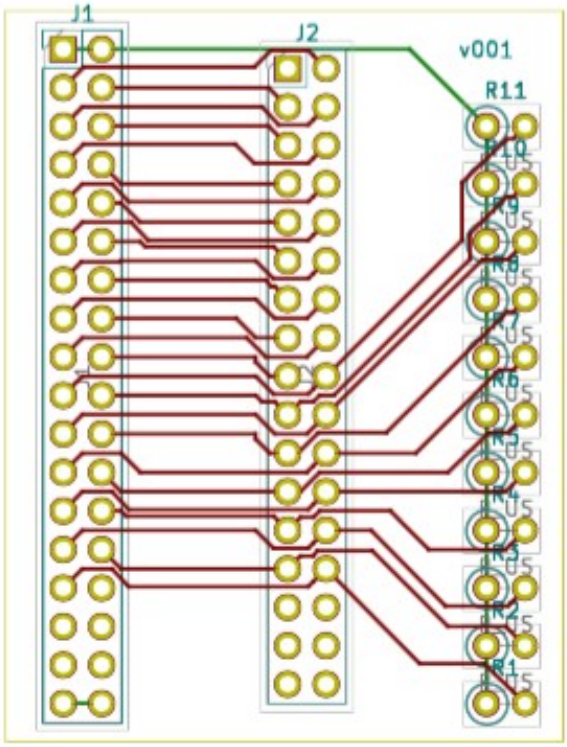


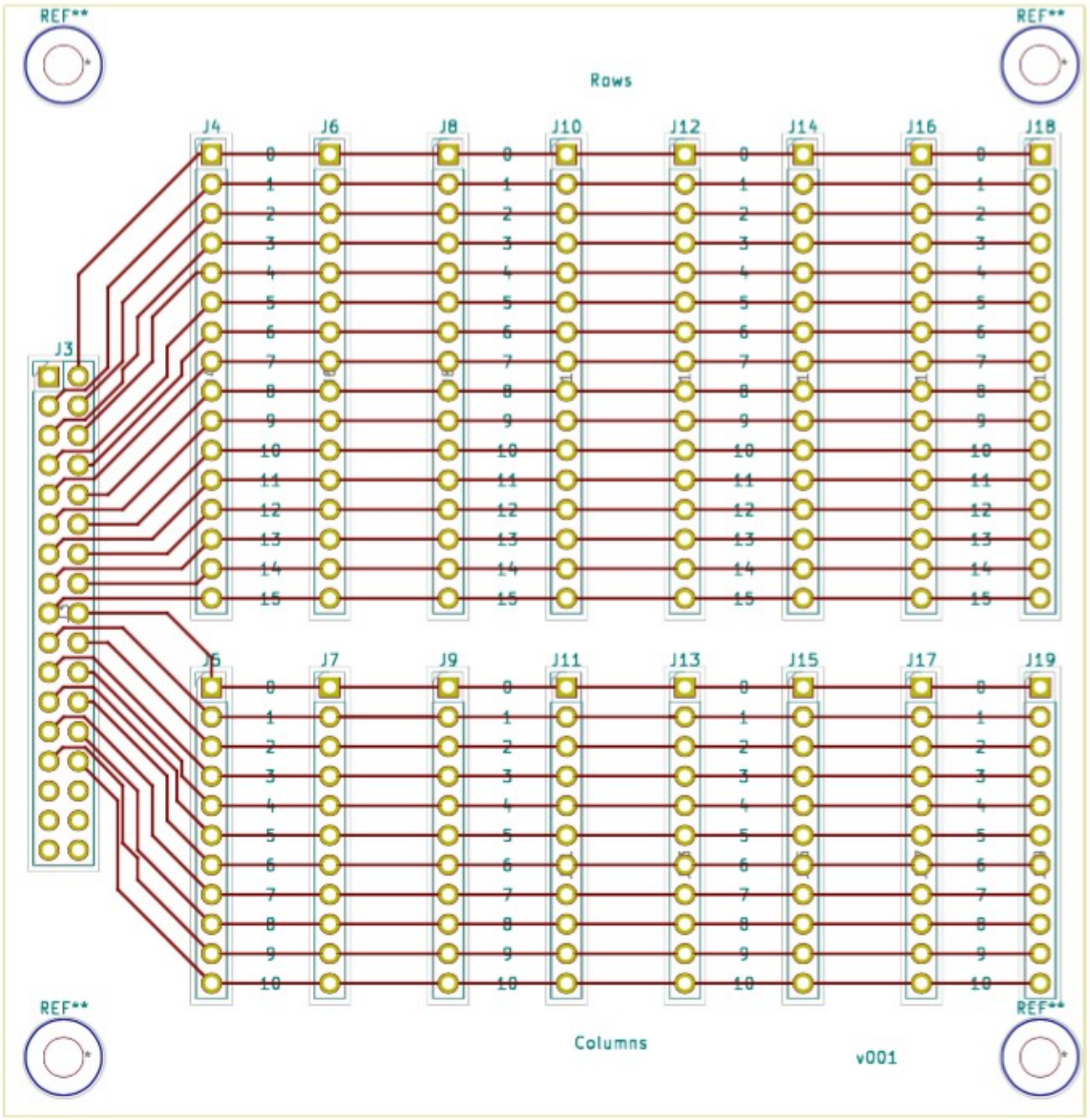
Small PCB


Need to swap Anode Cathode of diodes
Sheet: /
File: SmallPanelSwitchPCB.sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad (5.1.2-1)-1
Id: 1/1


D1 Row 0
D9 Row 1
D17 Row 2
Columns
Rows
Led Column
Led Row
Backlight
MountingHole_3.2mm_M3


digitalPin 22 37 used as row0 row 15.
digital pin 3053 used as column 0 15.
When an Ethernet shield is connected Columns 13 and 14 are pulled up to 1.5V – so do not use
It's a 16 * 14 matrix (due to loss of two columns)
+5V
Conn_02x18
Conn_01x13
R_US
Col0
Col1
Col2
Col3
Col4
Col5
Col6
Col7
Col8
Col9
Col10
Sheet: /
File: Switch_interface.sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. eeschema (5.1.2-1)-1
Id: 1/1


J1
J2
v001
R11
R10
R9
R8
R7
R6
R5
R4
R3
R2
R1



Interfacing to the Sims.

P3d

Traditionally I'd worked with FSUIPC, work has provided a very consistent interface through the different generations of Microsoft's, and now P3d sims. As SimConnect is now increasingly commonly used using that for the interface to the Sim.

This does mean at least part of the workload has to run on the PC. It is intended this will be

a very shallow shim, with the bulk of the workload running on the Pi.

SimConnect is used to subscribe to a dataflow - which means that code must either be installed either on the PC running P3d or on a second PC with SimConnect installed and configured to point to primary PC.

As the code is light weight the plan is to run on Primary PC

Where necessary keystrokes will be used to send commands to the Sim (or using SimConnect)

Useful URLS

https://www.prepar3d.com/SDKv4/sdk/simconnect_api/managed_simconnect_projects.html

Variables

https://www.prepar3d.com/SDKv4/sdk/references/variables/simulation_variables.html

Code Fragments to Support SimConnect

```
// User-defined win32 event

const int WM_USER_SIMCONNECT = 0x0402;

// SimConnect object
SimConnect simconnect = null;

// this is how you declare a data structure so that
// simconnect knows how to fill it/read it.
// When Adding variables to receive need to add them to this datastructure as well as
the request itself ininitDataRequest

    [StructLayout(LayoutKind.Sequential, CharSet = CharSet.Ansi, Pack = 1)]
    struct Struct1
    {
        // this is how you declare a fixed size string
        [MarshalAs(UnmanagedType.ByValTStr, SizeConst = 256)]
        public String title;
        public double latitude;
        public double longitude;
        public double altitude;
        public double airspeed;
        public double elapsedsimtime;
        public double zulu_time;
        public Int32 time_zone_offset;
        public double absolute_time;
        public double plane_heading_degrees_true;
        public double plane_heading_degrees_magnetic;
    };
void simconnect_OnRecvSimobjectData(SimConnect sender, SIMCONNECT_RECV_SIMOBJECT_DATA
data)
{

   displayText("Received something don't know what to do with it but trying");

   switch ((DATA_REQUESTS)data.dwRequestID)
```

```
{
   case DATA_REQUESTS.REQUEST_1:
      Struct1 s1 = (Struct1)data.dwData[0];

      displayText("titles:             " + s1.title);
      displayText("Lat:               " + s1.latitude);
      displayText("Lon:               " + s1.longitude);
      displayText("Alt:               " + s1.altitude);
      displayText("Airspeed           " + s1.airspeed);
      displayText("Sim Time           " + s1.elapsedsimtime);
      displayText("Zulu Time          " + s1.zulu_time);
      displayText("Time Zone Offset   " + s1.time_zone_offset);
      displayText("Absolute Time      " + s1.absolute_time);
      displayText("Plane Heading True " + s1.plane_heading_degrees_true);
      displayText("Plane Heading Mag  " + s1.plane_heading_degrees_magnetic);

      UDP_Playload = "latitude:" + s1.latitude;
      UDP_Playload = UDP_Playload + ",longitude:" + s1.longitude.ToString();
      UDP_Playload = UDP_Playload + ",altitude:" + s1.altitude.ToString();
      UDP_Playload = UDP_Playload + ",airspeed:" + s1.airspeed.ToString();
      UDP_Playload = UDP_Playload + ",zulutime:" + s1.zulu_time.ToString();
      UDP_Playload = UDP_Playload + ",timezoneoffset:" +
         s1.time_zone_offset.ToString();
      UDP_Playload = UDP_Playload + ",trueheading:" +
         s1.plane_heading_degrees_true.ToString();
      UDP_Playload = UDP_Playload + ",magheading:" +
         s1.plane_heading_degrees_magnetic.ToString();

       span = DateTime.Now - TimeLastPacketSent;
       mS = (int)span.TotalMilliseconds;
        displayText("Its been this many mS since sending last packet: " +
           mS.ToString());

        if (mS >= 500)
        {
           Byte[] senddata = Encoding.ASCII.GetBytes(UDP_Playload);
           udpClient.Send(senddata, senddata.Length);

           TimeLastPacketSent = DateTime.Now;
         }
      break;

    default:
      displayText("Unknown request ID: " + data.dwRequestID);
      break;
  }
```

DCS

The type of interface used in DCS depends heavily on the aircraft being flown. The study models will use commands sent over UDP.

For the more generic models keystrokes will need to be send to the Sim. This means a

shallow shim will need to run on the primary Sim. Current plan is to send Windows Keycodes over UDP, with the Windows API being used to inject keystrokes into the Keyboard buffer.

Testing basic LUA – turning off left most Stability switch in the A10C

Enter Target IP Address [192.168.1.138]: 172.16.1.3
Enter Target Port [7790]: 7780
Would you like all commands to be prefex with a D [N]:
2019-05-25 11:59:50,907:DEBUG:UDP target IP: 172.16.1.3 UDP target Port: 7780
Enter Command String to Send: C38,3003,0.0
2019-05-25 12:02:28,901:DEBUG:UDP target IP: 172.16.1.3 UDP target port: 7780
2019-05-25 12:02:28,908:DEBUG:Sending: "C38,3003,0.0

Probably the single most challenging thing is trying to work out what button maps to what command string. Fortunately the DCSBIOS team have documented it. The commands are found in the lib directory (dcs-bios-xx→ Scripts→DCS-BIOS→lib. For the A10C the file is A10C.lua. Search towards the tail end of the file to find the commands.

Aircraft such as the A10C largely focus on mapping switches in panels, the HOTAS commands are present in clickabledata.lua (and DCS-BOIS). They are, however found in command_defs.lua, which is also in the Mods → aircraft→ A-10C→Cockpit→Scripts folder. As an example here's the values for speedbrake from the A-10C command_defs

Plane_HOTAS_SpeedBrakeSwitchForward = 577,
Plane_HOTAS_SpeedBrakeSwitchAft = 578,
Plane_HOTAS_SpeedBrakeSwitchCenter = 579,

The values in commanddefs are not able to be triggered using the same lua mechanisim as the ones in clickabledata. With clickabledata we are setting something on a device (panel), switch, switch value. The performClickableAction method is performed on the device.

```
lCommandArgs = StrSplit(string.sub(lInput,2),",")
lDevice = GetDevice(lCommandArgs[1])
lLastValue = tostring(lDevice)
if type(lDevice) == "table" then
      lDevice:performClickableAction(lCommandArgs[2],lCommandArgs[3])
end
```

To raise(or lower – need to verify) the landing gear handle the following command is included in the json file, "API_Open": "C39,3001,0.0". The leading C indicates the perform clickable action will be used.

Whereas with command_defs we are setting something which is global, the LoSetCommand method is used with just a single parameter

```
lCommand = string.sub(lInput,1,1)

if lCommand == "R" then
      ResetChangeValues()
end

if (lCommand == "C") then
      lCommandArgs = StrSplit(string.sub(lInput,2),",")
      LoSetCommand(lCommandArgs[1])
      -- Using Panel Specific Commands from clickabledata.lua
      lCommandArgs = StrSplit(string.sub(lInput,2),",")
      lDevice = GetDevice(lCommandArgs[1])
      lLastValue = tostring(lDevice)
      if type(lDevice) == "table" then
            lDevice:performClickableAction(lCommandArgs[2],lCommandArgs[3])
      end
end

- If there is not a specific panel to use (eg HOTAS then use commands from
- command_defs.lua)

if (lCommand == "P") then
      -- data is PXXX where XXX is command integer from command_defs
      lCommandArgs = StrSplit(string.sub(lInput,2),",")
      LoSetCommand(lCommandArgs[1])
End
```

To close the speedbrake the following command is configured in the json file. "API_Open": "P577". The leading P indicates that LoSetCommand is to be used.

The relevant piece of export.lua

X-Plane

Originally tried to use the API interface that allowed reading and writing to variables, found the reading worked very well for subscribing to a data stream from the Simulator.

UDP Port	Use
49000	X-Plane receives commands
49001	X-Plane sends UDP payloads
49002	X-Plane to iPad

Simply select the values of Interest, (eg Speeds, Lat,Long, Altitude) in the Telemetry screen.

A warning will be presented that the Network Data Output hasn't been configured. Enter IP Address and target port (as of 20181229 using common port 13136 - but this is likely to change)

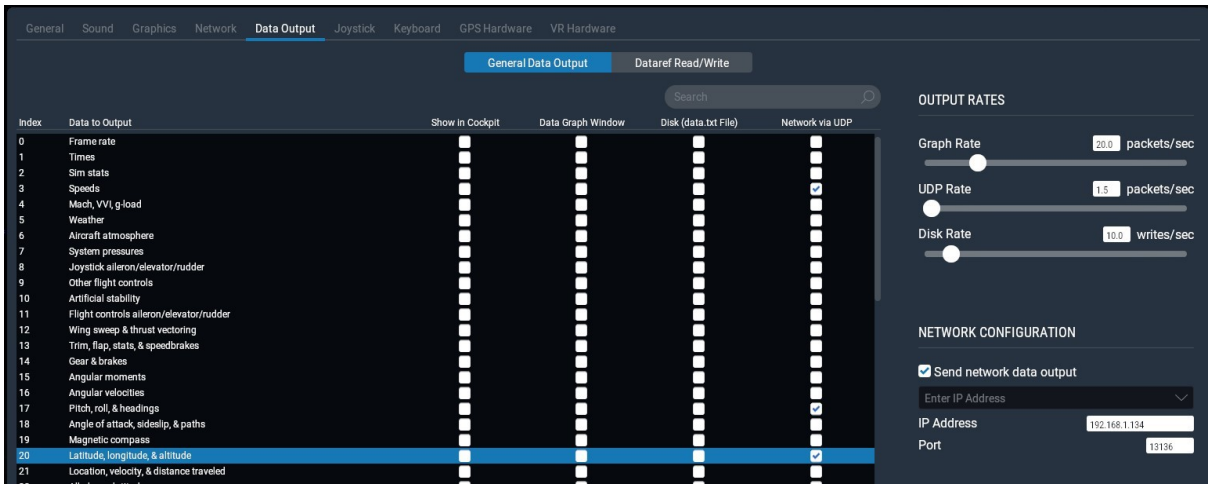


Figure 1: X-Plane - Selecting Indexes to export

The following settings are used for driving the GPS

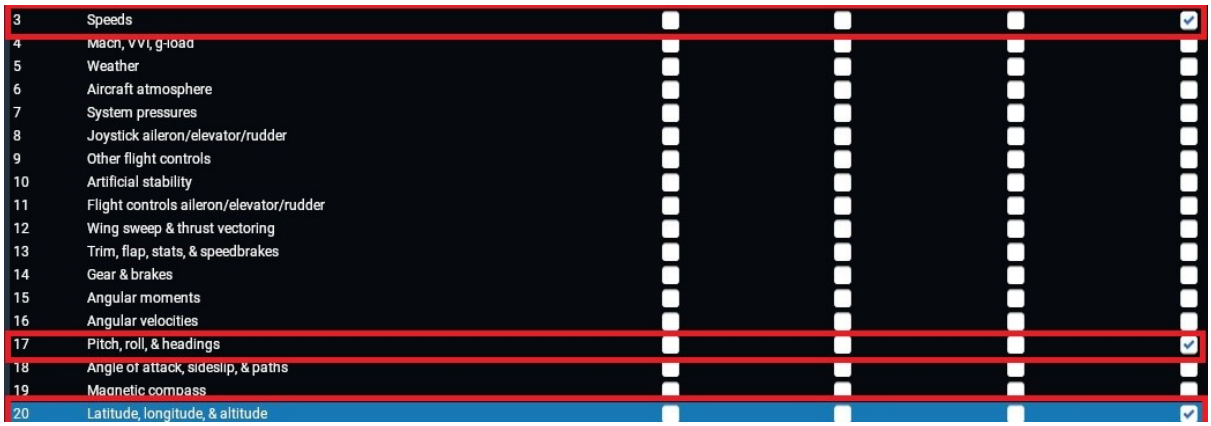


Figure 2: X-Plane GPS Indexes selected

The mapping of values is described here https://www.x-plane.com/kb/data-set-output-table/

Selecting the three indexes results in there being three record sets sent per update (in a single packet). A very useful site that explains how this hangs together is http://www.nuclearprojects.com/xplane/receivedata.shtml.

Whilst it specifically discussed coding in c#, the packet format on the wire is the common.

All data is sent as bytes

- There are 41 bytes per sentence

- The first 5 bytes are the message header, or "prologue"
  - First 4 of the 5 prologue bytes are the message type, like "DATA"
  - Fifth byte of prologue is an "internal-use" byte
- The next 36 bytes are the message
  - First 4 bytes of message indicates the index number of a data element, as shown in the Data Output screen in X-Plane
  - Last 32 bytes is the data, up to 8 single-precision floating point numbers (4 bytes per floating point number)

Using that API that was used for reading values don't work so nicely in the opposite direction. This was resolved relatively simply, over googling around, found the needed information was sitting with the X-Plane installation itself.

```
D:\Xplane11\X-Plane 11\Instructions\X-Plane SPECS from Austin\Exchanging
Data with X-Plane.rtfd
```

Some important Tips from this guide

```
NOTE: X-Plane always receives on port 49000.
NOTE: Any strings that you send should be null-terminated!

To send a UDP message to X-Plane:
-the 4-letter label
-a byte of value '0'
-the message data you want to send

RUN A COMMAND: CMND
DATA INPUT STRUCTURE is a string

     CMND0+sim/flight_controls/flaps_up

The data part of this message is simply the command that you want X-Plane
to initiate!

To see available X-Plane commands, run X-Plane and go to the Settings menu,
Keyboard tab or the Joystick Tab.
The commands are the group name you see in the centre of the screen, PLUS
command string in the right side, all run together.
Commands can be seen by hovering over the desired action
```

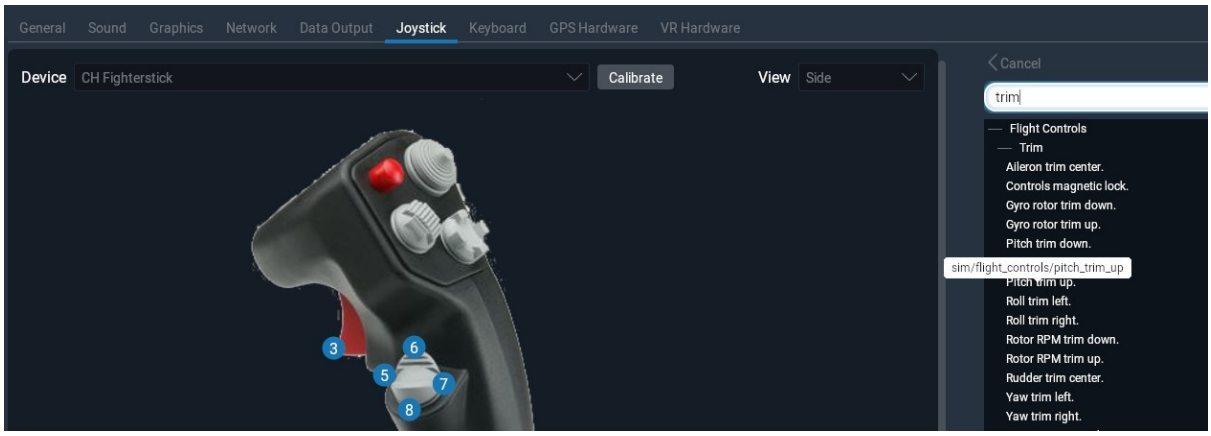


Figure 3: X-Plane Joystick showing commands

Or via the keyboard

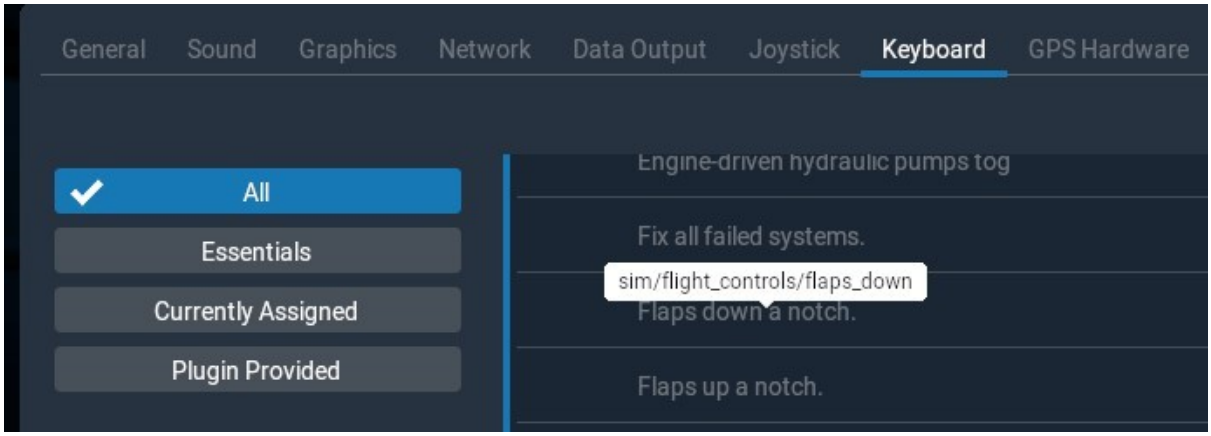


Figure 4: X-Plane Keyboard showing commands

To set values in X-Plane you can explicitly write to a DREF, this blog provides a very useful guide - https://blog.shahada.abubakar.net/post/linux-udp-network-client-library-for-x-plane-10-and-11?

BECN - Beacon broadcast. There is no equivalent feature for this in ExtPlane. Every running instance of X-Plane will broadcast it's IP address and command port number on your LAN in a BECN message, every second. With this, it is possible for devices on your LAN to "auto-discover" the IP and port number of the X-Plane server. It is also possible to auto-detect if there are multiple X-Plane servers running on your LAN, and offer the user a choice of which one they wish the device to connect to. It's a lot better than having the user manually configure the device with the IP and port number of the server, and helps a lot when you have more than one X-Plane PC. Note that this is a multicast datagram, so you will need to "subscribe" to the multicast address 239.255.1.1 port 49707.

RREF - Request subscription to a DataRef. The client sends this message to X-Plane's command port, together with a frequency (in Hz) and an identifying number. X-Plane will then automatically send the client a response RREF message at the frequency specified containing the current value of that DataRef . To unsubscribe, you send the RREF again with a frequency of 0.

DREF - Set the value of a DataRef. You send a DREF together with the value you want, and the name of the dataref.

CMND - Gets X-Plane to execute a command. You send a CMND together with the name of the Command you want invoked, and X-Plane executes it.

Choice of platform for the hardware interface.

Whilst the Raspberry Pi offers the nicest development and troubleshooting environment, it lacks the high pincount found on an Arduino. The Arduino will require an Ethernet shield (and not all Ethernet shields are created equal, have run into issues with an IOT shield that had a poorly cooled chip which caused lock ups).

As the Arduino codes runs without an intermediate operating system, it offers the highest performance for IO related tasks such as driving stepper motors.

Have ran into issues with lockups in the 737 overhead display, possibly due to incorrectly terminated strings or invalid characters included in string. Strongly bounds checking will be performed on the Pi before strings are send to Arduino displays.

As we are not bound by the 128 input limit associated with either windows DirectX or the 32 input limit associated with FSUIPC, OverPro's Arduino Joystick interface can be used with 256 inputs reducing the number of controllers needed for the pit. Hopefully a single controller for Port, Starboard and Forward zones can be used. OverPro's code will be modified removing the USB interface, instead storing switch state and reporting deltas after completing a full scan of 256 inputs. Unsure if rotaries will be supported, no logical reason why not.

Program tasks

The workload is divided into two programs – one dealing with inputs, the other with outputs. Both are fundamentally loops which briefly block awaiting receipt of a UDP packet either from the simulator/shim or from the input devices.

Command line parameters are used to get a debugging level as well as enable a configuration mode.

Configurations will be held in two separate files, the format of these files is yet to be determined, but JSON is mostly likely. The configuration files include:

1. IP Address code listens on (optional - if not explicitly configured 127.0.0.1)
2. Port Code listens on (optional – if not explicitly configured 7784 for input module and 7785 for output module. (still considering whether to leave export.lua sending direct to existing Arduino units)
3. Mapping of input to aircraft commands and aircraft outputs to physical displays/gauges.

Protocols

Where possibly output values will be carried directly mapping to value to be displayed, and may be integer, float, or string. Indicators/Solenoids will be represented as a 0 or 1.

Data will be carried as AV pairs A1:V2, A2:V2. The data packet will be preceded with a D.

Operational tasks such as shutdown, reboot, refresh switch state will be preceded with a C (command), and a single operational task. e.g. C9999.

Operational Task

Task Id	Task	
CQ	Send all switch states	

Ikarus uses the following format

```
# If Sending Commands to DCS with Ikarus installed
# The values to be sent can be found
# C:\Program Files\Eagle Dynamics\DCS World\Mods\aircraft\Uh-1H\Input\UH-1H\joystick
# Structure is
# C - Command
# 15 - Cockpit Device Id
# 3003 - Unknown but seen in multiple places
# Switch Position
# Send to Port UDP_PORT = 26027
# MESSAGE = "C15,3003,-1" - Turns Test Switch on - All warning lights
# MESSAGE = "C15,3003,0" - Turns Test Switch to centre
# MESSAGE = "C15,3003,1" - Turns Test Switch to Reset - clears caution on front panel
# Bright/Dim 15,3004
```

Learning's from Different Modules

Determining which Simulator is Operational

Ideally the number of changes made to ‘downstream’ modules should be minimised. As X-Plane packets always originate from 49001, this can help distinguish which Sim is running. The following approach was used in the GPS code.

```
# Need to decode the payload to convert from bytes object to a string
# Don't do this is the packet is from XPlane Sourced from 49001
if (Source_Port != 49001):
   # SimConnect P3d
   SendingSim = 'SimConnect'
   ReceivedPacket = data.decode()
   ReceivedPacket = str(ReceivedPacket)
else:
   SendingSim = 'XPlane'
   ReceivedPacket = data
```

Raspberry Pi

The USB.Core library provides a low level interface for the Raspberry Pi. It is able to scan the USB bus and report back what is attached.

The code scans the USB bus looking for a specific device, and then detaches the device from the Kernel driver. Once this is completes it then runs a set configuration, and then asks for a data block from the target device on a frequent interval.

A quick check is made to see if the value returned is different from the last interval, if it is then the list holding switch positions if refreshed

Maintaining the Pi

```
pi@GenFrontPi:~ $ sudo apt-get upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
pi@GenFrontPi:~ $ sudo apt-get dist-upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
pi@GenFrontPi:~ $
```

The Pi now supports the Arduino IDE. To install:

```
sudo apt-get update && sudo apt-get upgrade
sudo apt-get install arduino
```

Unlike the Windows or Mac IDE, the Pi IDE doesn't appear to support the online librarus. Needed to download the Led Control Library, unzip it, and then upload from source. It didn't like special characters in the library name. As multiple Arduinos are connected to the hub, its important to be care about which device you are programming, generally easiest to just the non-target Arduinos from the USB hub.

Initiating Scripts on Pi Nodes

Instead of trying to start python directly from crontab, use shell script (usually my_server) to start things

To get the script to autostart

```
sudo crontab -e
```

And add line

```
@reboot sh /home/pi/Documents/Flightsim/Huey\ Caution\ Panel/my_server 2>&1
```

Which results in the crontab file looking like

```
# Edit this file to introduce tasks to be run by cron.
..
..
#
@reboot sh /home/pi/Documents/Flightsim/Huey\ Caution\ Panel/my_server 2>&1
```

Originally a separate shutdown script was operated, need to work out why it was commented out, possibly as the script below only ever reaches remoteshut.py after the receiver code exits, which is never…

```
### BEGIN INIT INFO
# Provides: my_server
# Required-Start: $remote_fs $syslog $network
# Required-Stop: $remote_fs $syslog $network
# Default-Start: 2 3 4 5
# Default-Stop: 0 1 6
# Short-Description: Simple Web Server
# Description: Simple Web Server
### END INIT INFO

#! /bin/sh
# /etc/init.d/my_server

export HOME
echo "Starting My Server"
```

```
cd /home/pi/Documents/Flightsim/Huey\ Caution\ Panel
sudo /usr/bin/python receiver_004.py  2>&1 &
#sudo /usr/bin/python remoteshut.py 2>&1 &
exit 0
```

Receive UDP Port utilisation

A number of these values are referenced from soic_conv_ExportStart.lua from DCS

Port	IP Address	Description
	127.0.0.1	New DCS Emulator
7777	127.0.0.1	SOIC on Primary Sim PC[6]
7784		Input Codes listens on
7788	127.0.0.1	Arduino Sender Emulator. Sends to Pri_Node_Input
7788	127.0.0.1	Arduino Sensor. Sends to Pri_Node_Input
7789	127.0.0.1	GUI_Sender. Sends packets to Pri_Node_Input
7790	PC Running Sim	Keystroke_Sender
7791	127.0.0.1	Lamp_Output_Emulator
7792	127.0.0.1	Display_Output_Emulator
7793	127.0.0.1	XPlane_Decode
7794	127.0.0.1	Radio_Control
7795	127.0.0.1	USB_Reader
13135	192.168.1.105	Fuel Hands on A10
13135	192.168.1.106	Fuel Display (OLED on A10)
13135	192.168.1.107	Compass and Clock Analog hands
13135	192.168.1.108	Clock Digits
13135	192.168.1.109	General Stepper
13135	172.16.1.21	General_Sim_7219
26027	127.0.0.1	Pri_Node_Input
26028	127.0.0.1	Pri_Node_Output
27000	127.0.0.1	UDP_Reflector
49000	127.0.0.1	X-Plane UDP listener

IP Addressing – Backend 172.16.1.X

6 The SOIC port points to another Shim which maintains a TCP connection to the SOIC processes, converting the UDP payload into a TCP stream. Currently error handling does not address a restart of SOIC processes.

Backend		
172.16.1.2	Primary Pi	
Input Devices		
172.16.1.10	Left Aurduino	
172.16.1.11	Front Arduino – Device id 1	0xA9,0xE7,0x3E,0xCA,0x35,0x02 A9:E7:3E:CA:35:02
172.16.1.12	Right Arduino – Device id 2	0xA9,0xE7,0x3E,0xCA,0x35,0x04 A9:E7:3E:CA:35:04. Had real weirdo where traffic would pass through home switch and wireless – used {0x00,0xD0,0x3E,0xCA,0x35,0x04} to resolve
Output		
172.16.1.21	Front Led Arduino	0xA9,0xE7,0x3E,0xCA,0x35,0x03 A9:E7:3E:CA:35:03

Adding RS232 Interface

Ref - https://www.instructables.com/id/Read-and-write-from-serial-port-with-Raspberry-Pi/

Using Max 3232 based interface which supports 3.3 to 5V
Pin Used (remembering pin numbers does include both sides of header – so these pins are adjacent.
4 (5V),
6 (GND)
8 (TX),
10 (RX)

Can use sudo raspi-config → Interfacing Options → Serial to enable/disable console through serial interface. In the disti used in Dec 2018 it is disabled by default – enabled to validate the TX led flashes during the reload process.

Notes from the Huey readme

Git Commands

Clone Repo
git clone https://github.com/bnepethomas/bne-arduino-flight-simulator-interfaces.git

git config --global user.email "your email”
git config user.name "your name"

Watch for untracked files

$ git add .
$ git commit .
$ git push

System Flows

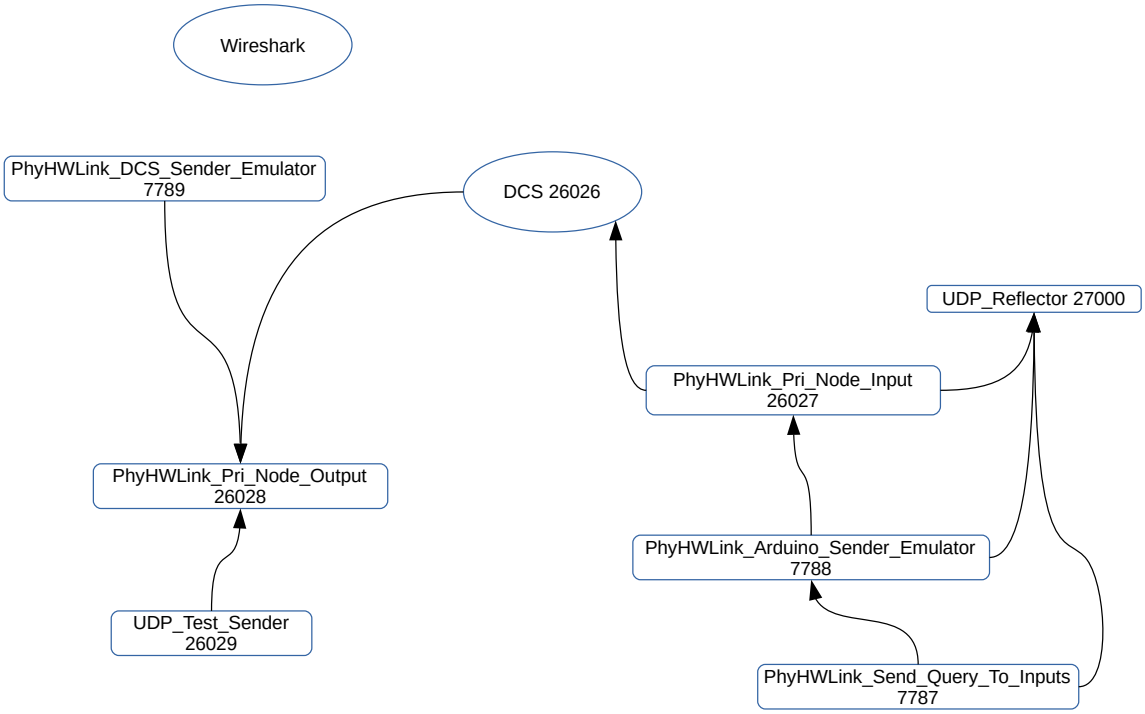


Figure 5: System Flows

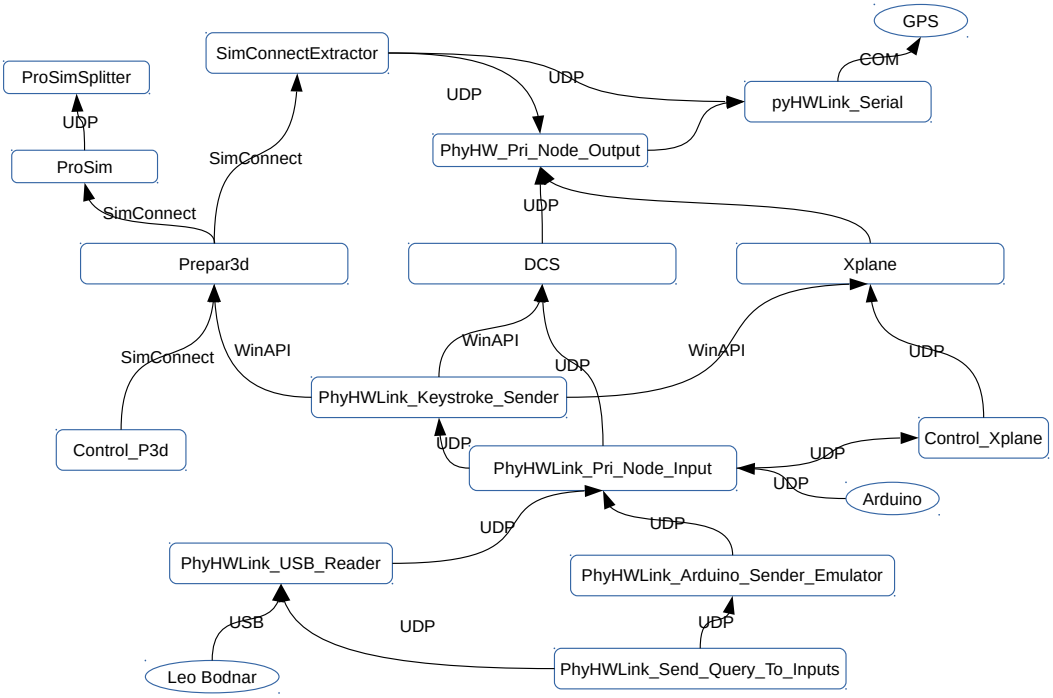


Figure 6: Detailed System Flows

Code Modules

General Sim 7219

This Arduino sketch provides an interface to Servo, General I/O and Max7219 powered Leds.

It is intentional simple, with 'fancy' work performed by PyHWLink_Pri_Node_Output.

Data Packet – AV pairs preceded by a 'D'

D,1:0,2:1,3:1,4:1,5:0,6:0,7:0,8:0,9:1,10:1

All outputs accept only integer values.

Input Data Ranges	Outputs	Pins	Total Outputs
1-64 (65-128 Rsrvd)	Led outputs driving		
150-	Servos	21-39	18
200-208	Digital I/O	40 - 48	9

Listens to	Port
p3d_PyHWLink_Pri_Node_Output	13135

Hornet Altimeter

The Altimeter project is broken into two pieces – the code to drive the needle, and the code to drive the OLED. Originally the code was all run on an Arduino, but largely due to my lack

of skills in dealing with an environment that needs to be interrupt driven, the workload is split between an Arduino for driving the motor, and a Raspberry Pi for the OLED code.

Altimeter OLED

The Altimeter OLED displays the Altitude (ten thousands, thousands, hundreds) and the pressure setting (QNH). The last two digits will either not be displayed
The Altimeter OLED code is based on sample code from Adafruit. Hardware interfacing details are found later in this document.

'Rolling' characters are used, which do increase the workload but considerably improve the realism of the altimeter. The minor digits (ones and tens) are now updated, they are left as '0's which may either be engraved in the faceplate or just simply rendered as '0's. The major digits (ten thousands, thousands, and hundreds) are updated and do roll.

There are two special use cases, the left hand hash, which sits in the ten thousands column, and the value at which digits roll. The digits should hold a centered position until they are close to changing value, and only then do then do they roll. The roll is done within the last 100 feet. As the hash is different height to characters it as its own position value (hatch_top). It is located on the ten thousands column.

Drawing the hash. Whilst an option was considered to use a predrawn graphic for the hatch, it ultimately was not a large coding effort to draw the hatch. This is done by drawing a white box and then drawing a series of black lines

PIL is used for the graphical elements.

Characters are drawn using column spacing, with a spacing currently of 23 pixels. Pixels are used to locate elements on the canvas. On the X co-ordinates numbers increase from left to right. Row positions are a little more interesting, with negative values used for the top most rows.

PyHWLink_Arduino_Sender_Emulator

Emulates a Arduino running OverPro's Joystick interface with an Ethernet shield.
As we aren't exposed to an any Joystick button limits, there are 256 buttons supported
Instead of using the stub to provide a Joystick via USB, delta are sent to a process running on a Raspberry Pi which maps these deltas to commands for the Sim

The Arduino code is independent of the aircraft and simulator that is running, which simplifies its operation.

There is a receive operation where the Arduino will report the state of all
256 inputs. This will be spread across several packets with a 300mS delay between
the packets. The trigger packet is a simple 'CQ'

It is configurable, with the Input_Module_Number, which determines which input module it is emulating, the max packet size (basically to throttle the number of entries in a single packet), which hopefully throttles the number of entries concurrently hitting the downstream modules.

The likelihood of change determines the rate of change of ‘input’ values in a given cycle.

Sends to	Port
PyHWLink_Pri_Node_Input	26027
UDP_Reflect	27000

Listens to	Port
PyHWLink_Send_Query_To_Inputs	26027

The Packet format is a D followed by Module_Number, Switch_No, Current_Switch_State

The packet payload is not fixed length -

```
D00:003:0,00:005:0,00:006:1,00:007:1,00:009:1
```

PyHWLink_Display_Output_Emulator

This module receives UDP packets containing desire output state for displays such as OLED or 7 Segment Led..

Listens to	Port
PyHWLink_Pri_Node_Output	7792

b'D,1:0,2:1,3:1,4:1,5:0,6:0,7:0,8:0,9:1,10:1,11:

PyHWLink_GUI_Sender

As the name suggests this module was developed to provide a GUI to send simulated button/switch transitions to Pri_Node_Input. It uses the tkinter library that provides platform support for MacOS, Windows and the Raspberry Pi. Only MacOs required an install of the tkinter environment.

There are two types of button actions provided:
1: Classic Toggle Switch Action where switch position is held, and
2: A Push button, where a simulated Push and Release action is transmitted with a relatively short delay. Its is up to Pri_Node_Input to determine if it will act only on the Press or on both Press and Release (as may be needed if Key Strokes are being sent)

The same packet format is used as the Arduino_Sender_Emulator

```
b'D01:005:1'
```

The user can select which module is being emulated (1-5)

Sends to	Port
PyHWLink_Pri_Node_Input	26027
UDP_Reflect	27000

The GUI is manually laid out.

Figure 7: PhyHWLink_GUI_Sender GUI

Switch No	Role	Pressed	Released	Temp or Held
1	Gear	Gear Down	Gear Up	Held
2	Landing Lights	Lights On	Lights off	Held
3	Flaps Increment Up	Flaps Inc Up		Temp
4	Pause Sim	Pause Sim		Temp
5	Exit Sim	Exit Sim		Temp
6	Wheel Brakes	Brakes On	Brakes Off	
7	Flaps Increment Down	Flaps Inc Down		
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				

Switch No	Role	Pressed	Released	Temp or Held
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				

PyHWLink_Lamp_Output_Emulator

This module receives UDP packets containing desire output state for lamps. It may be extended to receive string information for airspeed, radios etc, but initially just aimed at displaying output state.

Listens to	Port

PyHWLink_Pri_Node_Output	7791

This only has two fields as it emulates a single end point. The same packet format is used as the Display_Output_Emulator

```
D,1:0,2:1,3:1,4:1,5:0,6:0,7:0,8:0,9:1,10:1
```

PyHWLink_Keystroke_Sender

This module receives characters to be send to whatever application has focus, which should ultimately be the flight sim. It uses a low level API to increase the likelihood interoperability with DirectX based games.

Did struggle with the code only appearing to work on simple Applications such as notepad and also X-Plane. Nothing received in DCS or P3d. Then discovered windows appears to have added some security which appears to stop the API working with DirectX games.

https://www.tenforums.com/software-apps/49635-sendkeys-not-working-windows-10-a-3.html

SendKeys are locked in Win 10 and 8.1 by the UAC. If you need to use Sendkeys you may want to try Disabling it in the Registry :
HKLM>Software>Microsoft>Windows>CurrentVersion>Policies>System>EnableLUA=0.

Also needused to use DirectX mappings which is different to classic keycodes. Have held original keycodes just in case the directX doesn't work with other games.
After restarting due to the change, things worked on all applications I tested.

Found best way to test if characters are being send was to go into DCS, → Options -> Controls Keyboard. Select an acition and then play characters into that.

Sends to	Port
Whatever Application currently has focus	Windows API for local machine

Listens to	Port

PyHWLink_Pri_Node_Inputs (and derivatives)	7790

PyHWLink_Pri_Node_Input

This module is the input workhorse of the simulator infrastructure. It receives AV pairs from input devices/process over UDP, translating them into either commands that are send direct to the Sim, or are send to Control_Via_Keyboard, which as the name suggests injects keystrokes into the Simulator using the Windows API.

It has a learning mode which, as the name suggests, listens to events, and enables the user to assign a task to an event. Events are stored in 'input_assignments.json'.

1. To enable learning change the learning value in 'input_config.py' to True."

Pri_Node_Input is reflector enabled, which means it sends a copy of its outputs to the UDP_Reflector process for forwarding to WireShark as needed.

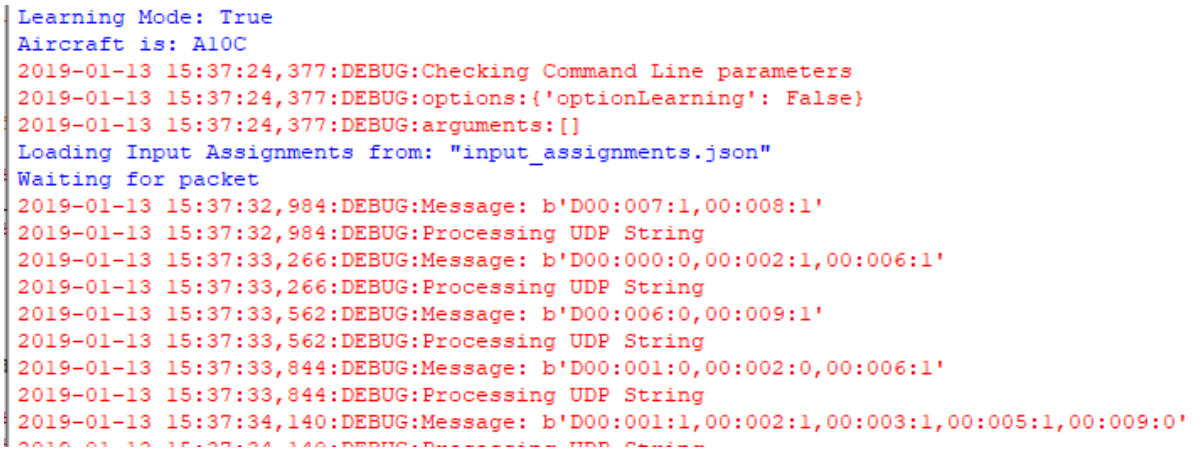


Figure 8: PhyHWLink_Pri_Node_Input User Interface

PyHWLink_Pri_Node_Putput

This module is the output workhorse of the simulator infrastructure. It receives AV pairs from Simulator, and then tranlates these to hardware modules

Sends to	Port
172.16.1.21	13135

Listens to	Port
SimConnect_to_IP	26028

pyHWLink_Radio_Control

This module listens to state updates from USB_Reader. It is currently in a experimental stage with the following goals:

1. Locally Store State (such as current radio frequency) and either directly or incremental update Sim state. Ideally direct updates will occur, which should be possible with P3d, but unsure if DCS allows direct setting of radios, or if button commands will be needed to increment radio channels
2. Enable different roles to be assigned to a single rotary encoder based on whether the encoder is pressed or not
3. Determine how to 'accelerate' updates of a rotary encoder. This is largely for roles where precision is required, but a large number of values must be moved through, such as heading and airspeed settings on the autopilot panel.

Sends to	Port
TBA	

Listens to	Port
PyHWLink_USB_Reader	7794

pyHWLink_Serial

This module is probably better called pyHWLink_GPS, initially named to develop a Rasperberry Pi serial stack. The single modules supports DCS, P3d and X-Plane simultaneously. In part this is due to a common on the wire format used for P3D (as information comes via a SimConnect shim).

X-Plane is a little different over the wire as data is packed using a binary format.

Sends to	Port
Serial Port on Pi	

Listens to	Port
DCS, XPlane, and lightweight SimConnect Shim	13136

DCS Interfacing Code

As DCS is a API/Script Native, there was little extra to do to export information to drive GPS. The same target port and X-Plane was used (13136)

The initialisation code largely is involved with configuring the socket to use.

```
package.path  = package.path..";.\\LuaSocket\\?.lua"
package.cpath = package.cpath..";.\\LuaSocket\\?.dll"

socket = require("socket")

gps_export_port = 13136
gps_export_host = "192.168.1.135"
gps_export_socket = require("socket")
gps_export_con = socket.try(gps_export_socket.udp())
gps_export_socket.try(gps_export_con:settimeout(.001))
gps_export_socket.try(gps_export_con:setpeername(gps_export_host,gps_export_port))
```

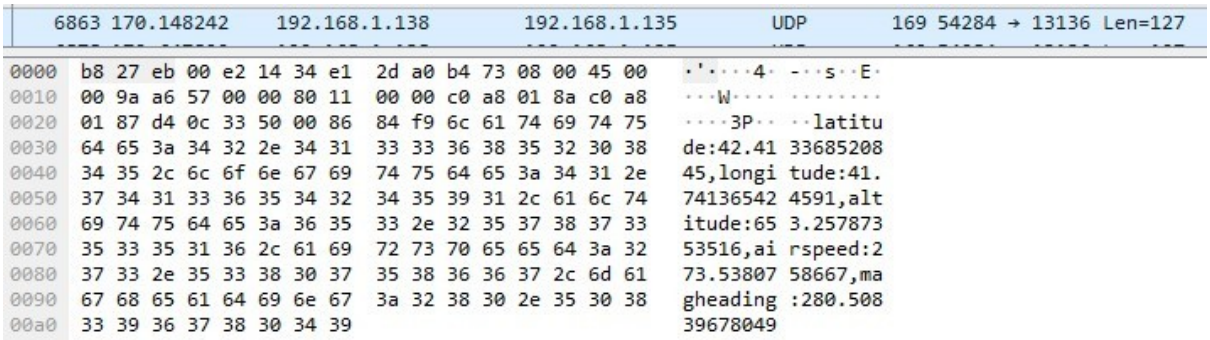
Text 1: DCS LUA Initialisation - Code Export.lua

The Event code clears a table and progressively add entries to the table. Once the 5 rows are populated, they are assembled and send out the socket. The event is then rescheduled to fire again in 500mS.

```
function LuaExportActivityNextEvent(t)

  local tNext = t
  local gps_export_flightData = {}



  table.insert(gps_export_flightData,"latitude:"..LoGetSelfData().LatLongAlt.Lat)
   -- LATITUDE

  table.insert(gps_export_flightData,"longitude:"..LoGetSelfData().LatLongAlt.Long)
    -- LONGITUDE

  table.insert(gps_export_flightData,"altitude:"..LoGetAltitudeAboveSeaLevel())
    -- ALTITUDE SEA LEVEL(MTS TO FT)

  table.insert(gps_export_flightData,"airspeed:"..LoGetTrueAirSpeed() * 1.94)
    -- TRUE AIRSPEED (M/S TO KNOTS)

  table.insert(gps_export_flightData,"magheading:"..LoGetSelfData().Heading * 57.3)
       -- HEADING (RAD TO DEG)

  gps_export_packet =  gps_export_flightData[1] .. "," ..
  gps_export_flightData[2] .. "," .. gps_export_flightData[3] .. ","
  gps_export_packet =  gps_export_packet .. gps_export_flightData[4] .. "," ..
  gps_export_flightData[5]

  gps_export_socket.try(gps_export_con:send(gps_export_packet))

  tNext = tNext + 0.5 --repeat every 1/2 second
  return tNext
end
```

Text 2: DCA LUA Event Code - Export.lua

The packet format uses ‘,’ separators which ‘:’ as a demarcation for attribute name and values.



X-Plane

The name data output is packed binary. Once the needed values are selected for output, X-

Plane exports them in a packed format.

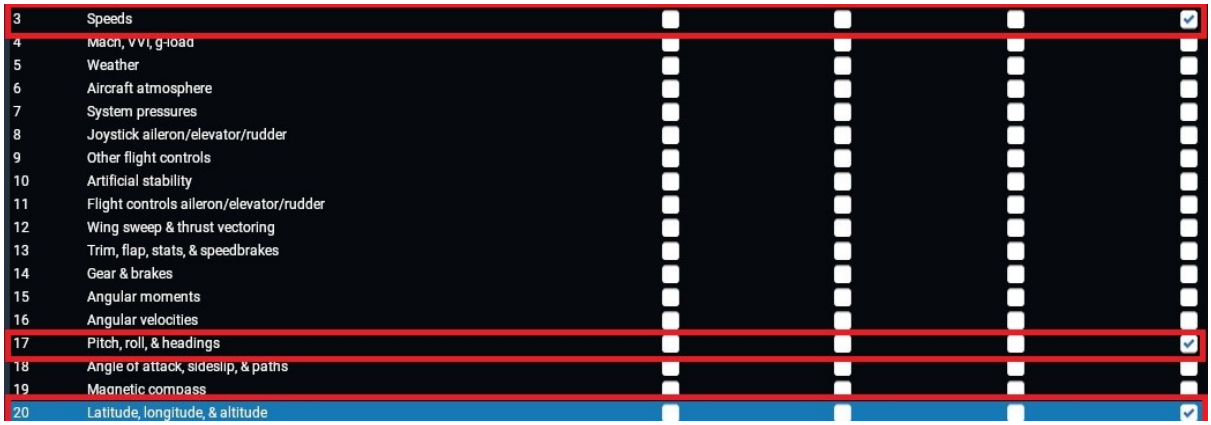


Figure 9: Fields Selected for GPS Output

As the data is encoded in a binary format , it looks a little hostile on the wire.

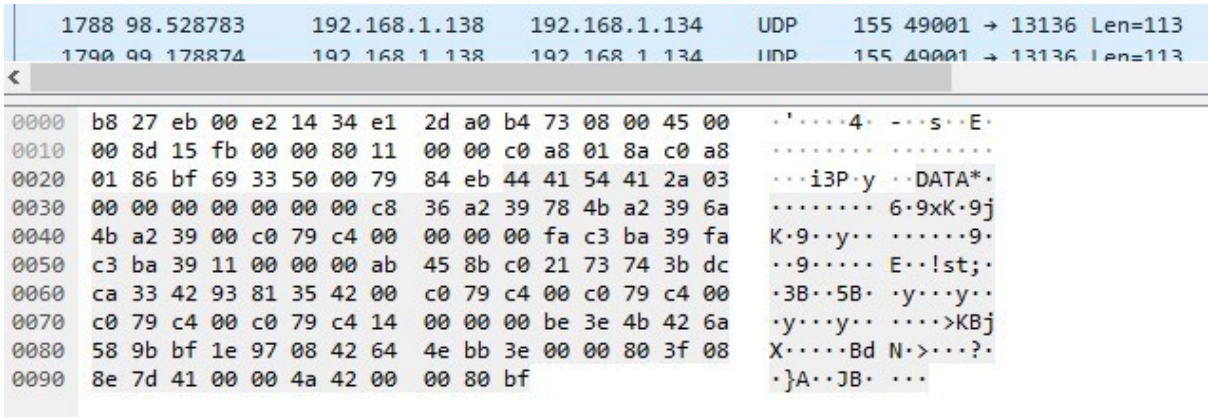


Figure 10: X-Plane GPS Data on the wire

As discussed earlier in this document, for every field selected, a separate UDP packet will be sent. Each Index 'flow' is able to be identified by the 6th byte in the payload.

pyHWLink_USB_Reader

This module interfaces directly to USB hardware. It runs a loop looking for any deltas in button positions. If a delta is detected, only the changed button sates are sent to Pri_Node_Input.

It also listens out for a request from Send_Query_To_Inputs, on receipt of such a request, all button state is send to Pri_Node_Input. Button state delivery is staggered in 20mS intervals to reduce the likelihood of over whelming the target simulator. Both open and closed button state is sent.

Sends to	Port
PyHWLink_Pri_Node_Inputs	26027
UDP_Reflector	27000

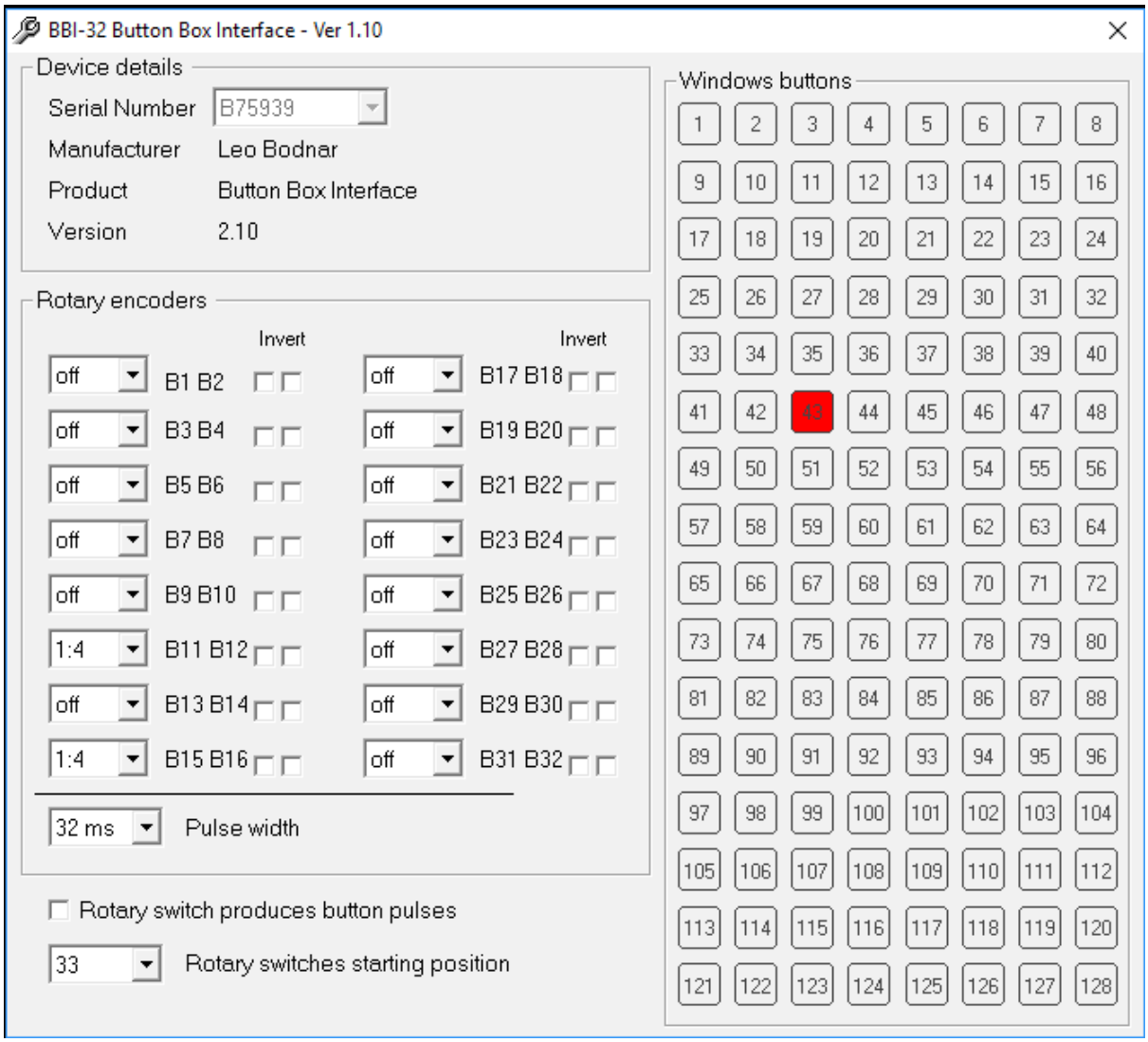
Listens to	Port
Send_Query_To_Inputs	

USB Interfaces

There still is a need to use USB interfaces, such as for a High Resolution Analog interface (which already has noise reduction built in) or for Rotary Encoders. As the Leo Bodnar cards provide a solid rotary interface they will be used for inputs on radios and autopilots.

The follow vendor and product Ids are used for the Leo Bodnar cards:

	Vendor Id	Product Id
BU0836	0x16c0	0x05b5
BU0836X	0x1dd2	0x1001
BBI-32	0x1dd2	0x1150



The BBI-32 supports a special adapter for rotary switches that uses only two pins to monitor 12 inputs. This considerable reduces the amount of cabling needed to track rotary switch inputs. Up to 11 of these can be used on a single BBI-32, and they must be connected to the first 11 inputs. The BBI-32 configuration software enables you to determine at what port number the additional ports will start appearing

Rotary encoders can be connected to any two sequential inputs. The BBI-32 rotary encoder configuration defaults to 80mS which means the minimum time between pulses is 80mS. Need to decrease to get a faster response time.

Needed to change the Rotary encoder from 1:1 to 1:4 to stop immediate echo as well as increase Pulse width to 32mS

The USB interfaces will still be normalised over the UDP interfaces, and should support requests to report the status of all Joystick interfaces, perhaps with a 10mS delay between the sending the status of each button input.

It appears that different Operating Systems provide different levels of accessibility, especially around devices they are Human Interfaces (HIDs). The Mac won't let you easily attach to the HID. This isn't too much of an issue, but does mean testing needs to be done on the Pi itself.

SimConnect_To_IP

Currently SimConnect_To_IP is functional but can do with a clean up, and probably a rename. It currently sits outside the folder where the bulk of the python code exits. The folder is 'bne-arduino-flight-simulator-interfaces\SimConnectExtractor'. The project is called SimConnect_to_IP.sln

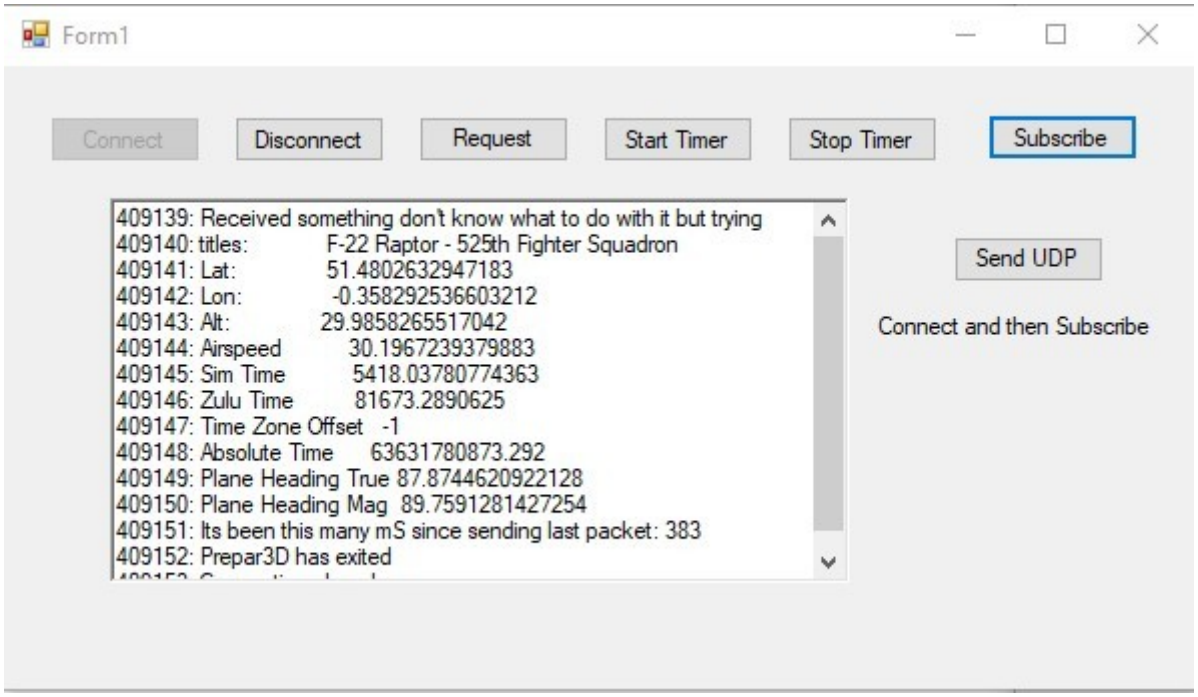


Figure 11: SimConnect_To_IP GUI

As of Jan 28 2019 there a number of buttons that aren't needed. All that is needed to operate the code is to select connect, and then subscribe. As the button suggests, SimConnect_To_IP will then subscribe to a data stream from P3d. This is more efficient that polling P3d, as you are setting up structures and allowing P3d to update on a time base it expects.

Sends to	Port
pyHWLink_Serial	13136

Listens to	Port
P3d SimConnect	SimConnect API

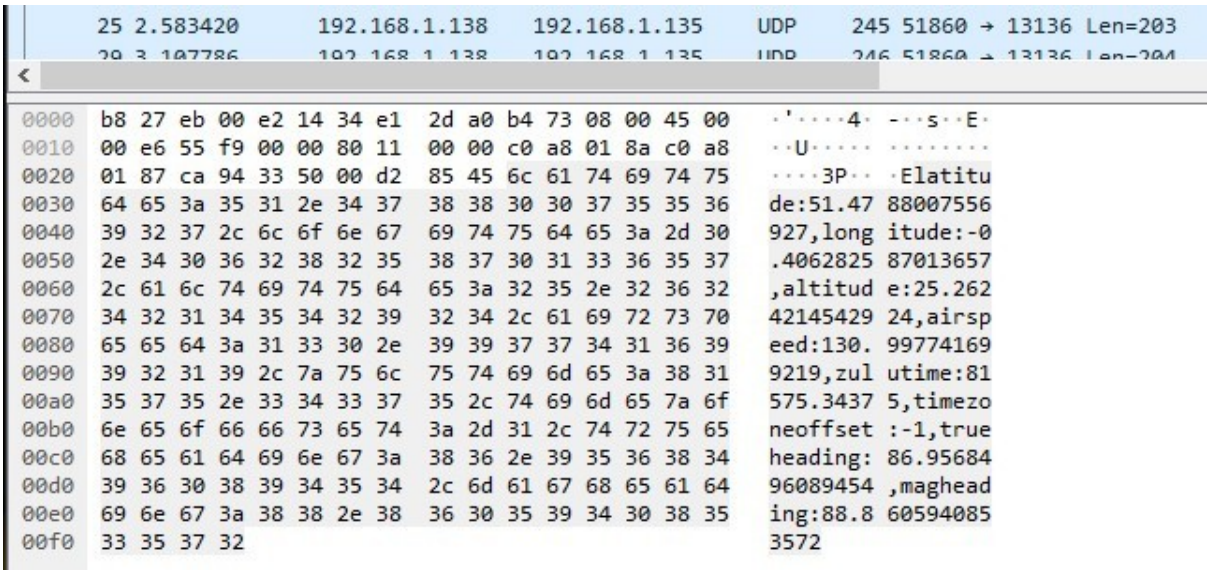


Figure 12: SimConnect_To_IP Data on the wire

PyHWLink_Control_XPlane

Whilst extracting information from X-Plane was relatively straight forward, trying to control X-Plane was a little more exciting.

Was originally trying to use the 'inverse' of data extraction by writing to an offset with a set of parameters.

```
('DATA'.encode('utf-8'), 0, 14, 0, -999, -999, -999, -999, -999, -999, -999)
```

This didn't work so well. However found some very useful information at

http://blog.shahada.abubakar.net/post/linux-udp-network-client-library-for-x-plane-10-and-11, specifically in the section

CMND (Client to X-Plane)

- char [5] name = CMND\0
- char[] cmnd = "sim/flight_controls/flaps_down"

This references a document in the X=Plane folder which explains how to control X-Plane,for X-Plane 11.26, it is found in X-Plane → Instructions → X-Plane SPECS from Austin → Exchanging Data with X-Plane.

The commands that are available to sent can be found :

> To see the (plethora) of X-Plane commands, run X-Plane and go to the Settings menu, Joystick and Equipment screen, Buttons:Advanced tab.
>
> The commands are the group name you see in the center of the screen, PLUS command string in the right side, all run together.

This didn't seem to be there in 11.26, but if you go Keyboard → All and then over over something if interest, you see the required string.

Once you have the needed string it needs to be assembled, packed and sent. The payload header is CMD, followed by a 0 (need to work out what that is), and then the string to be send.

```
values = ('CMND'.encode('utf-8'), 0, 'sim/flight_controls/flaps_down'.encode('utf-8'))
packer = struct.Struct('4s B 32s')
packed_data = packer.pack(*values)
sock = socket.socket(socket.AF_INET, socket.SOCK_DGRAM) # UDP
sock.sendto((packed_data), (UDP_IP_Address, UDP_Port))
```

During initial testing – not all values operated. Inc-Flaps-Up, Inc-Flaps-Down. Wheels-Brakes-On appeared to operate at start of flight, not not after flight. Sim Pause and Quit operated ok, Gear-Up, Gear Down, Landing Lights didn't operate. This was due a slightly lazy copy of the initial config which has a fixed length for the string.

After correcting that – landing lights and brakes not operating correctly. Changed from brakes_maximum to brakes_regular (which mapped to keystroke B)

Lights was due to another copy and paste mistake, second part of string was flight controls when it should have been lights.

sim/flight_controls/landing_lights_on
sim/lights/landing_lights_on

Assigned a keystroke to the hold brakes regular, what this seems to do is require keystroke to be held, so for the moment will avoid hold commands.

Sends to	Port
X-Plane	49000
UDP_Reflect	27000

Listens to	Port
PyHWLink_Pri_Node_Inputs	TBA

UDP_Input_Control

Based on OverPro's Joystick controller, this reads a matrix of switches and sends changes over UDP. As this is running on a Arduino Mega – it is not coded in Python. Currently it is used just for digital inputs, but could be extended to also monitor analog axis, sending deltas as the input move, just need to consider what 'smoothing' algorithm could be used.

Sends to	Port
PyHWLink_Pri_Node_Inputs	26027
UDP_Reflector	27000

Listens to	Port
Send_Query_To_Inputs	7788

OverPro's original code supported 256 buttons, in a 16 * 16 Matrix on a Arduino Mega (2560 R3), but due to the Ethernet Shield pulling Columns 13 and 14 to 1.5V at all times the Matrix is 16 * 14. As of 21/4/2019 had issues with Column 12 (counting from 0 – which may explain 13 above) and above not reporting changes. Column 12 cases Arduino to crash)

Digital Pins 22- 37 used as row0 ~ row 15,
Digital pin 38-53 used as column 0 ~ 15,

Even though internal pull-ups are enabled, found that the addition of 10K pull ups reduced noise induced transitions.

Code Approach

On initialisation the pin modes are set, the arrays holding past and current switch state are initialised to 0. Currently a UDP ping is send out to the reflector in initialisation.

The code then enters a loop where all rows are individually pulled down. After a row is pulled down, there us a predetermined delay, after which the column results are read. The column results are then stored in an array (joyReport.button).

After checking if the indicator led should be transitioned, a comparison is made of past and future state. During this loop, any changes are individually sent out over UDP to both the Reflector and the Input Processing module.

UDP_Reflector

Displays and optionally forwards packets to a WireShark receiver. Intended to be 'always on', acting basically as a sink hole until needed for troubleshooting. By having all IP enabled endpoints sending a couple of their payload to UDP reflector, packet monitoring is turned on at a single point instead of across all code modules.

By default displays all packets but will filter using simple character matching (no wild

carding)

Listens to	Port
All	27000

Command line options
a: filterstring - display packets containing this string
b: IP Address and Port to send to WireShark

Code Status

	Complete	Cmd_line	Debug	Config_File	Doc
pyHWLink_Serial	No				
pyHWLink_USB_Reader					
UDP_Reflector					

Coding Learnings

Logging

The logging module (import logging) enable you to determine which messages will be

displayed on the console

```
logging.basicConfig(format='%(asctime)s:%(levelname)s:%(message)s',level=logging.INFO)
#logging.basicConfig(format='%(asctime)s:%(levelname)s:%(message)s',level=logging.DEBUG)
```

Once the value is set it cannot be changed mid-execution, so it is best to set at the top of the program.

Command Line Parameters

Command line parameters (from optparse import OptionParser) are easily managed with this module.

```
D:\>UDP_Reflector.py --help
2019-01-13 07:49:41,712:INFO:Unable to find UDP_Reflector_config.py
Usage: UDP_Reflector.py [options]

Options:
  -h, --help            show this help message and exit
  -w opt_W_Host, --wh=opt_W_Host
                        Wireshark Target IP Address
  -u opt_W_Port, --wp=opt_W_Port
                        Wireshark Target Port. 27001 is used if not explicity
                        specified
```

Command line options are easily added, including help.

```
parser = OptionParser()


parser.add_option("-w","--wh", dest="opt_W_Host",
      help="Wireshark Target IP Address",metavar="opt_W_Host")
parser.add_option("-u","--wp", dest="opt_W_Port",
      help="Wireshark Target Port. 27001 is used if not explicitly specified",
      metavar="opt_W_Port")

(options, args) = parser.parse_args()



logging.debug("options:" + str(options))
logging.debug("arguments:" +  str(args))


if options.opt_W_Host != None:
      wireshark_IP_Address = str(options.opt_W_Host)

if options.opt_W_Port != None:
      wireshark_Port = str(options.opt_W_Port)


if wireshark_IP_Address != None:
      logging.info("Wireshark host is : " + wireshark_IP_Address)
      logging.info("Wireshark UDP port is : " + str(wireshark_Port))

if len(args) != 0:
      filterString = args[0]
      logging.info("Display Filter is :" + str(args[0]))
```

Configuration Files

A local file can hold settings for a program. Its a good idea to simple extend the name of the primary code with '_config' at the end. The file type should be '.py'

e.g. PyHWLink_UDP_Reflector configuration file is UDP_Reflector_config.py

The values are loaded early in the code

```
try:

    if not (os.path.isfile(config_file)):

        logging.info('Unable to find ' + config_file)


    else:
        try:
            from config_file import *


        except Exception as other:
            logging.critical("Error in Initialisation: " + str(other))

            print('Unable to open "' + config_file + '"' )
            print('Or variable assignment incorrect - forgot quotes for string?')
            print('Defaults used')
```

The configuration file looks like a series of variable assignments

```
learning = True
AircraftType = 'A10C'
```

Error Handling In Python

Its good form to use the try and except constructs,

```
def ReceivePacket():


    while True:

        try:

            data, (Source_IP, Source_Port)  = serverSock.recvfrom(1500)

            ReceivedPacket = data
            packets_processed = packets_processed + 1

            ProcessReceivedString( str(ReceivedPacket), Source_IP , str(Source_Port) )

            logging.debug("Iterations since last packet " + str(iterations_Since_Last_Packet))


        except socket.timeout:
            iterations_Since_Last_Packet = iterations_Since_Last_Packet +  1
            if debugging == True and (iterations_Since_Last_Packet > 10000):
                print("[i] Mid Receive Timeout - " + time.asctime())
                iterations_Since_Last_Packet=0


                last_time_display = time.time()
                packets_processed = 0
            continue

        except Exception as other:
            logging.critical('Error in ReceivePacket: ' + str(other))
```

Of note in this code, is a workaround to avoid the use of threads. As the code has a single purposed of receiving a workload and then processing it, blocking isn't a big issue. However it is good form to provide some updates to the user

```
2019-01-13 08:25:39,410:INFO:Unable to find UDP_Reflector_config.py
Listening on port 27000
2019-01-13 08:25:44,424:INFO:Keepalive check 0 Packets Processed. 0 packets per second.
2019-01-13 08:25:49,438:INFO:Keepalive check 0 Packets Processed. 0 packets per second.
```

Having a catch-all exception handler ensures that something is logged if an exception occurs. Included in excepted captures should be a Ctrl-C to gracefully exit, cleaning up resources.

```
def CleanUpAndExit():
    try:
        # Catch Ctl-C and quit
        print('')
        print('Exiting')
        print('')
        try:
            serverSock.close()
        except:
            logging.critical('Unable to close server socket')
        sys.exit(0)

    except Exception as other:
        logging.critical('Error in CleanUpAndExit: ' + str(other))
        sys.exit(0)


def Main():

    print('Listening on port ' + str(UDP_Port))
    try:

        ReceivePacket()

    except KeyboardInterrupt:
        # Catch Ctl-C and quit
        CleanUpAndExit()

    except Exception as other:
        logging.critical('Error in Main: ' + str(other))

Main()
```

Persisting Information

The two major design principles used in this project are only loosely couple (i.e. avoid maintaining state), and minimise the number of locations where unique configuration is stored. This approach keeps input modules simple, with only the primary input and output nodes needing to hold major pieces of configuration data.

Data is persisted in json, with the two major files being ‘input_assignments.json’, and temp_input_assignments.json’.

The following modules are used to manage data persistence.

```
from collections import OrderedDict
import json
```

Drawing 1: Enabling JSON

Networking in Python

Sockets are the basis of the network stack in the project, with UDP being the preferred transport of choice due to its loose coupling.

With the following declaration the process will accept traffic from any host as we are using a '0' as opposed to a 127.0.0.1 which would only allow traffic from the local host. For Windows, it appears you can't simply use '0'. Also a very short timeout has been set, this means the programs can loop quickly

```
# UDP_IP_ADDRESS = "127.0.0.1"
UDP_IP_ADDRESS = "0"
UDP_PORT_NO = 26027

serverSock = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
serverSock.settimeout(0.0001)
serverSock.bind((UDP_IP_ADDRESS, UDP_PORT_NO))
```

Drawing 2: Network Stack Initialisation

Once initialised the we enter into a loop waiting for packets, and providing the user with a status updates when there are no packets being received. This approach may be changed once code has been completed, with perhaps a 1 second socket timeout.

```
def ReceivePacket():

    # a is used to track the number of timeouts between packets
    # throws a keepalive message to indicate we are still alive
    a=0
    while True:

        try:
            data, addr = serverSock.recvfrom(1500)

            logging.debug("Message: " + str(data))
            ReceivedPacket = data.decode('utf-8')
            logging.debug("Message: " + ReceivedPacket)
            ProcessReceivedString(str(ReceivedPacket))


            a=0


        except socket.timeout:
            a=a+1
            if (a > 100000):
                logging.info("Long Receive Timeout")
                a=0
            continue


        except Exception as other:
            logging.critical("Error in ReceivePacket: " + str(other)
```

Text 3: Packet Receive Loop

Pick a Python Version

While documenting and testing the project, run into a surprise for junior hackers. The code running on the Raspberry Pi was exhibiting some subtle differences in behaviour. Originally I thought all code was running Python 3.5 or 3.7

But when running the Pri_Node_Input, on the Pc or Mac, I wasn't capturing the informational updates associating with the Socket timeouts I was seeing on the Pi. Additionally I was seeing the PC asking for strings to be converting to byte objects, which wasn't seeing on the Pi.

The quick addition of the following to the code quickly answered the question:

```
import system
print ('Running Python ' + sys.version)
```

The code running through the shell on the Raspberry Pi was reporting 2.7.13. Pi Idle3 was reporting 3.5.1 (not much of a surprise there…). Running from Thonny reported a 3.5.3.

On the PC through the explorer launched 3.7.2

To permanently change the preference on the Pi to run 3.5[7]

```
// Check to see if an alternative has been made
# update-alternatives --list python

# sudo update-alternatives --install /usr/bin/python python /usr/bin/python3.5 1

// Validate changes have been made
# update-alternatives --list python
```

Updating the default version of python immediately impacted the Pri_Node_Input module, loosing timeouts.

Added code to check for minimum version of Python (yeap it could be optimised)

7 https://linuxconfig.org/how-to-change-from-default-to-alternative-python-version-on-debian-linux

```
MIN_VERSION_PY3 = 5    # min. 3.x version
if (sys.version_info[0] < 3):
        Warning_Message = "ERROR: This script requires a minimum of Python 3." +
             str(MIN_VERSION_PY3)
        print('')
        logging.critical(Warning_Message)
        print('')
        print('Invalid Version of Python running')
        print('Running Python earlier than Python 3.0! ' + sys.version)
        sys.exit(Warning_Message)

elif (sys.version_info[0] == 3 and sys.version_info[1] < MIN_VERSION_PY3):
        Warning_Message = "ERROR: This script requires a minimum of Python 3." +
             str(MIN_VERSION_PY3)
        print('')
        logging.critical(Warning_Message)
        print('')
        print('Invalid Version of Python running')
        print('Running Python ' + sys.version)
        sys.exit(Warning_Message)
```

After validating this noted a consideration difference in socket timeouts between Windows and the Pi, using the ‘same timeout’ windows reports every 15 seconds, whereas on the Pi it is reported every second.

Processing Data

Data packets have a similar format that that of SOIC, with the first byte of the packet either having a ‘D’ for Data, or ‘C’ for commands. The received string is then split into records sets that are separated by a ‘,’. Individual attributes are separate by a ‘:’

For the Pri_Node_Input module, the ability to dynamically assign a task in response to a given input. In the following code snippet a check is made to see if there is an existing assignment, if there no assignment, and the module is running in learning mode, an update is performed, otherwise a look up is make, and the resulting value is added the Values to be sent to the Sim

```
# Switch is Opened
if str(workingFields[2]) == '0':
       if learning and input_assignments[workingkey]['Open'] == None:
              updateOpenAction(workingkey)
       print('Value for Open is : ' +
              str (input_assignments[workingkey]['Open']))
       if input_assignments[workingkey]['Open'] != None:
              addValueToSend(str (input_assignments[workingkey]['Open']))
```

```
def ProcessReceivedString(ReceivedUDPString):
    global input_assignments
    global send_string
    global learning

    send_string = ""

    try:
        if len(ReceivedUDPString) > 0 and ReceivedUDPString[0] == 'D':

            # Remove leading D
            ReceivedUDPString = str(ReceivedUDPString[1:])
            logging.debug('Checking for correct format :')

            workingSets =''
            workingSets = ReceivedUDPString.split(',')
            logging.debug('There are ' + str(len(workingSets)) + ' records')
            counter = 0
            for workingRecords in workingSets:
                logging.debug('Record workingRecord number ' + str(counter) + ' ' +
                      workingRecords)
                counter = counter + 1


                workingFields = ''
                workingFields = workingRecords.split(':')


                if len(workingFields) != 3:
                    logging.warn('WARNING - There are an incorrect number of fields in: ' +
                           str(workingFields))
                elif str(workingFields[2]) != '0' and str(workingFields[2]) != '1':
                    logging.warn('WARNING - Invalid 3rd parameter: ' + str(workingFields[2]))
                else:
                    logging.debug('Stage 2 Processing: ' + str(workingFields))

                    try:
                        workingkey = workingFields[0] + ':' + workingFields[1]
                        logging.debug('Working key is: ' + workingkey)

                        logging.debug('Working Fields for working key are: ' +
                              str(input_assignments[workingkey]))

                        logging.debug('The value is: ' +
                              str(input_assignments[workingkey]['Description']))

                        print('Value for Description is : ' +
                              str (input_assignments[workingkey]['Description']))

                        # Switch is Closed
                        if str(workingFields[2]) == '1':

                            print('Value for Close is : ' +
                              str (input_assignments[workingkey]['Close']))
                            if input_assignments[workingkey]['Close'] != None:
                                addValueToSend(str (input_assignments[workingkey]['Close']))

                        # Switch is Opened
                        if str(workingFields[2]) == '0':

                            print('Value for Open is : ' +
                                  str (input_assignments[workingkey]['Open']))
                            if input_assignments[workingkey]['Open'] != None:
                                addValueToSend(str (input_assignments[workingkey]['Open']))
```

Working with Datasets

As some of the modules (e.g. Pri_Node_Input) deal with largish datasets that should be persisted. The first design choice was which file format should be used, JSON was chosen for readability and ability to update in other programs.

The second decision point was what Python construct should be used to retrieve, update and store these datasets. The Ordered Dictionary was chosen.

Declarations

```
from collections import OrderedDict
import json
```

Load

```
print('Loading Input Assignments from: "' + input_assignments_file +'"')

try:
    input_assignments = json.load(open(input_assignments_file))
```

Save

```
def save_and_reload_assignments():
    # Save out to a temporary file and reload to ensure it is in shape
    global input_assignments


    try:


        json.dump(input_assignments,
             fp=open(temp_input_assignments_file,'w'),indent=4,sort_keys=True)

        input_assignments = None

        input_assignments = json.load(open(temp_input_assignments_file))
```

Update

```
input_assignments[workingkey]['Description'] = wrkstring
```

Working with Dictionaries of Dictionaries

The data set representing input assignments is multi-dimensional, in that a key points to another dictionary.

The dictionary is initialised with a simple declaration using curly brackets

```
# Empty the Dictionaries
OuterSavedValues = {}
InnerSavedValues= {}
```

Once the dictionaries are initialised values are assigned/read using square brackets. A simple dictionary is referenced by

```
LocalVar = MySimpleDict[value]
```

In the case of Pri_Node_Input we have a multi-dimensional array, so information is accessed using two sets of brackets.

```
input_assignments[workingkey]['Description']
```

So given the following piece of JSON

```
"01:001": {
    "Description": "Landing Gear",
    "KeyboardClose": null,
    "KeyboardOpen": null,
    "UDPClose": "sim/flight_controls/landing_gear_down",
    "UDPOpen": "sim/flight_controls/landing_gear_up"
},
```

If workingkey is “01:001” then LocalVar would be assigned “Landing Gear”

```
workingkey = "01:001"
LocalVar = input_assignments[workingkey]['Description']
```

To add an item to the ‘outer’ dictionary (input_assignments in this example) you need to first create the inner dictionary and assign values to it. Here’s an example that was used to couple entries from an Element Tree to a Dictionary.

```
# Create Inner Dictionary Entry
InnerSavedSGACLs = {}
InnerSavedSGACLs['Name'] = subelem.attrib['name']
InnerSavedSGACLs['Description'] = subelem.attrib['description']
InnerSavedSGACLs['ACL'] = newroot.find('ACLContent').text

# Create Outer Dictionary Entry by assigning Assign Inner Dictionary Entry
OuterSavedSGACLs[subelem.attrib['id']] = InnerSavedSGACLs
```

Working with a GUI

One of the most common Cross Platform GUIs in Python is ‘tkinter’.

Basic starting code

```
from tkinter import *
root = Tk()
# Title bar text
root.wm_title("pyHWLink Lamp Output Emulator")

# Create the Canvas
canvas = Canvas(root, width=420, height=260)
canvas.pack()


# This is called from code just before mainloop

def tick():

    # Non selective clearing of canvas if needed
    canvas.delete(ALL)

    # Draw a 8*8 Matrix and randomly pick Red or Black

    for x in range(0,8):
        for y in range(0,8):
            if (random.randint(0,1) == 1):
                canvas.create_rectangle(50 * x, 30 + y * 30, 52 + 50 * x,
                    62 + y * 30, fill='red')
            else:
                 canvas.create_rectangle(50 * x, 30 + y * 30, 52 + 50 * x,
                    62 + y * 30, fill='black')

    if timetoexit == 0:
        canvas.destroy()
        root.destroy()
        root.quit()
    else:
        canvas.after(100, tick)


# Do something - as it is event driven, if we aren’t waiting for user input need to
set a timer
# Refers to
canvas.after(1, tick)

root.mainloop()
```

PI Addressing

General Pi Configuration

As the internal network is isolated – IP Addresses are static assigned. To do this you can either manually edit /etc/dhcpdc.conf or right click on the wireless icon at the top right – and select Wireless and Wired Network Settings.

Then select interface of interest – for sim it is eth0 – with a setting of 172.16.1.2/24. Leave the other settings blank

```
pi@GenFrontPi:/etc $ ip -4 addr show | grep global
    inet 172.16.1.2/24 brd 172.16.1.255 scope global eth0
    inet 192.168.1.139/24 brd 192.168.1.255 scope global wlan0
pi@GenFrontPi:/etc $ cat dhcpcd.conf

interface eth0
static ip_address=172.16.1.2/24
static routers=
static domain_name_servers=
static domain_search=
pi@GenFrontPi:/etc $
```

Huey Configuration

The Pi Ethernet interface has been configured with a secondary interface. This doesn't seem possible using dhcpd.conf - so using /etc/network/interfaces. Using the Wireless interface to assign a default route and DNS server.

Currently unable to SSH to 144 but can 145 (wired). Also if a ping is made to wired interface - the reply originates with Mac address of wireless

```
auto lo
iface lo inet loopback

auto eth0
allow-hotplug eth0
iface eth0 inet static
        address 192.168.1.145
        netmask 255.255.255.0


auto eth0:1
iface eth0:1 inet static
        address 192.168.3.100
```

```
        netmask 255.255.255.0


auto wlan0
allow-hotplug wlan0
iface wlan0 inet dhcp
wpa-conf /etc/wpa_supplicant/wpa_supplicant.conf
```

Interfacing to a GPS

The Lowrance 2000C supports a NEMA input over a serial interface. The GPS has traditionally been connected directly to the PC running FSX, driven by the native GPS interface in FSUIPC. As P3D, DCS, and X-Plane are now all in use, it was time to build a common interface to the GPS.

The Lowrance 2000 supports the following NEMA Sentences
GLL, RMC, RMB, GGA, GSA, GSV, APB
Currently Exporting - RMC, GGA and GSA

NEMA Sentences
$GPGGA - Global Positioning System Fix Data
$GPGSA - GPS DOP and active satellites
$GPRMC - Recommended minimum specific GPS/Transit data
$GPRMB - Recommended minimum navigation info
$GPGSV - GPS Satellites in view
$GPAPB - Auto Pilot

After been driven nuts trying to understand why the Lowrance GPS seemed to be displaying incorrect data went to the Digital Data screen - it also mismatched the data I was sending to it. discovered previous owner has DM enabled, not DMS and Datum selection was set to NA 1983.. This was resolved by setting Datum to WGS 84 and coordinate system using DMS, and now things align

Also worthy of note is Seconds should be sent as Decimal value and the GPS will convert to Degrees ie 50 beings 30

Hardware Details

Graphical OLED – SSD1306

After a number of years of working with Character based OLED displays, the time finally came to expand coding horizons to add a Graphical Based OLED. The need arose from needing some hatching and different font sizes with the Hornet Altimeter.

Originally attempted to have the graphical code run alongside Stepper motor code on the Arduino, but my bodgy code didn't co-exist, and as I wasn't up for learning multi-threaded code on Arduino, the code moved to the Raspberry Pi. The different generations of code are still in the Git Repo (well as of 20190311).

Some of the following is duplicated in the Pi code, but decided I'd prefer to see a single spot to reference hardware setup.

Altimeter OLED code - used in conjunction with Arduino for driving stepper

This code is based of the SSD1306 code developed by the adafruit team. Suggest starting with same code form Adafruit team to ensure hardware is correctly configured. The adafruit library will need to be grabbed from Github

```
https://learn.adafruit.com/ssd1306-oled-displays-with-raspberry-pi-and-beaglebone-black/overview
```

Then use this code.

Font used in Arduino build is FreeMonoBold which is basically Courier
As the same font wasn't easily found, used 'monofonto.ttf' from
`http://www.dafont.com/bitmap.php`
This font is fixed width, and digits are centered which make the dial look more natural
The file needs to be copied to the directory where the python will execute from

This code assumes used on the SPI interface, which must be enabled in the pi
To validate the SPI interface is active 'ls /dev/*spi*'. This should return
`'spidev0.0 spidev0.1'`.

The SSD1306

The following is the 'as wired' for the Arudino – noting that the SSD1306 is now connected to a Raspberry Pi to improve stepper performance on the Arduino. The SPI bus continues to be used. Of interest is the SSD1306 has options for SPI3 and SPI4 for addressing

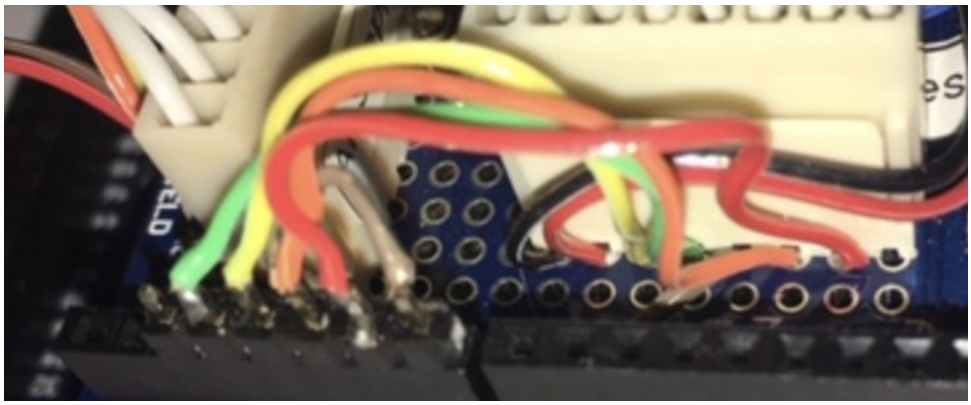
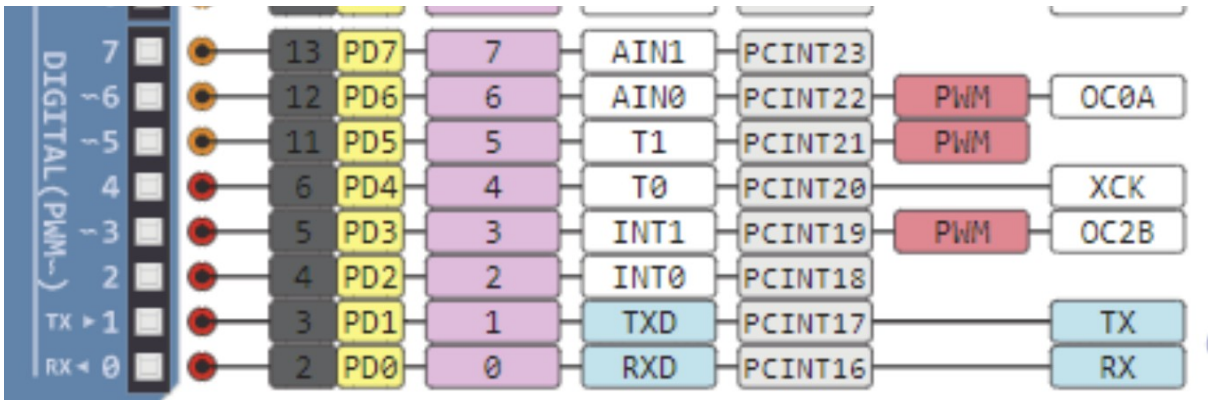


Figure 13: SSD1306 Arduino Wiring

SSD 1306 Pin		Color	Arduino Pin	Pi Pin	Pi Role
1	Gnd	Black		9	Gnd
2	Vdd	Red		1	3.3V
3	SCK D0	Yellow	PD-3	23	SPI_CLK
4	SDA D1	Green	PD-4	19	MOSI
5	RES	Brown	PD-5	18	GPIO 24
6	DC	Orange	PD-6	16	GPIO 23
7	CS	Red	PD-7	24	SPI_CE0
8					



MISO (Master In Slave Out) - A line for sending data to the Master device

- MOSI (Master Out Slave In) - The Master line for sending data to peripheral devices
- SCK (Serial Clock) - A clock signal generated by the Master device to synchronise data transmission.

System Build

All target systems should have git, LibreOffice and python3 installed. If Arduino code is to be developed, the Mac and Window's environments support installation of the Arduino IE. The Windows environments needs the C# development environment, which typically is Visual Studio Community Edition.

Windows Build (as of 20190504)
Chrome
Free Download Manager 5 (Chrome extension enabled)
GitHub Desktop (1.6.5)
Python 3 (3.7.3)
LibreOffice (6.2.3.2)
Visual Studio 12
Acronis True Image 2017
Notepad++

Lockheed Martin p3d v2
DCS World 2.5.4
X-Plane 11 Demo

20190615 – added VNC viewer show Pi work can be done from Sim computer (no mouse and keyboard swapping)

It appeared post Visual Studio installation, p3D v2 errored with missing mfc100.dll. After trying a range of things finally resolved with Microsoft Visual C++ 2015-2019 Redistributable (x86) – 14.20.27508.

Download Visual Studio developer pack 4.72 (base reference for projects)
Enabled Community license

Resized Primary Screen size to bit Soniq Monitor (1804 * 1004)
Adjust Power Savings to Never Turon off and PC, and Sleep the screen after 25 minutes.
Linked PC to MS Account
Disabled One Drive (removed in Optional Windows Components – which had done a nasty

and moved desk to a OneDrive directory – which of course was deleted
Changed UAC never to notify to stop alters when launching p3D and DCS.

Code To Dos

pyHWLink_USB_Reader

1. Add Network stack for both sending state, as well as listening for Send_Query
2. Add error handler
3. Add Standardised logging
4. for UDP_Input add code to respond to send all input state (ie respond to a CQ)

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