![ICS controllers logo]

# PI-REPEATER-2X

HARDWARE REVISION 3.1

1. WELCOME

Thank you for purchasing the PI-REPEATER-2X, the first repeater controller board designed to be powered by the ubiquitous Raspberry Pi computer systems.

This little piece of hardware mates to the Raspberry Pi just like any other daughter card you may have used for the Raspberry Pi, Arduino, or other development platform.

This system enables you to have a variety of control options for your station, including simplex, duplex, 2 independent repeaters, a voting station, etc. Anything you can imagine that can be done with 2 receive radios and 2 transmit radios is possible.

We use multiturn potentiometers for fine adjustment of the audio, offer hardware pre-emphasis filtering, active high / active low selects for each COS / CTCSS input signal, and have inputs tolerant to 18Vdc for the signals coming from the radio.

This board will work with any software that is capable of interacting with the sound card, and GPIO (I2C required)) for radio interfaces. We recommend getting started with SVXlink, but the choice is ultimately yours! Feel free to experiment and decide which system best fits your requirements.

GPS PORT 2

There are many features built into this little board that you should be aware of as they can easily be missed when setting up the hardware for the first time. Your software selection may or may not support all the features right out of the gate.

This board contains the following features which will be discussed in more detail in the following sections

- 2 independent repeater channels
    - Selectable High/Low COS/COR
    - Selectable High/Low CTCSS
    - Selectable Flat Audio
    - Adjustable audio input level
    - Adjustable audio output level
- Built in audio (input/output)
- Analog to Digital Converter
- GPIO expansion
- GPS (Optional expansion)
- I2C Expansion Header
- SPI Expansion Header
- I2S Expansion Header
- 1-Wire Header
- UART Header (shared with GPS)
- PI Stacking Header

UART

SPI

I2C

ADC

GPIO

PORT 2

PORT 1

Stacking Header
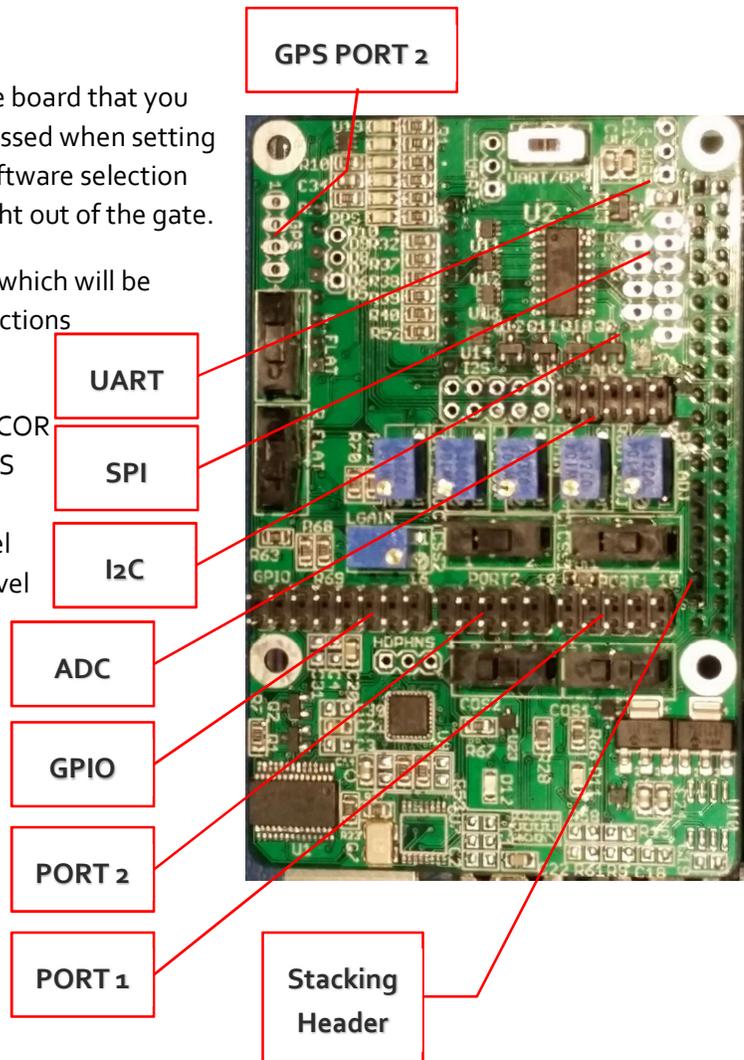
3.1 INDEPENDENT REPEATER CHANNELS

The board supports 2 independent repeater channels, or ports 1 and 2. Each channel provides several helpful features

- Selectable High/Low COS/COR
  - Select the switch setting as shown in the following sections to select the polarity of active signaling for your radio (typically active low)
- Selectable High/Low CTCSS
  - Select the switch setting as shown in the following sections to select the polarity of active signaling for your radio (typically active low)
- Selectable Flat Audio
- Adjustable audio input level
- Adjustable audio output level
- Optional Pull-up circuit for PTT
  - (for active high rigs, not installed by default, contact us if you need this functionality)

3.1.1 REPEATER CHANNEL 1

Input AUDIO Adjust

Output AUDIO Adjust

FLAT AUDIO SELECT

Output Amplifier Gain

CTCSS HI <-> LOW

PIN 1

PORT 1 Interface

COS LOW <-> HI

Input AUDIO Adjust

FLAT AUDIO SELECT

Output AUDIO Adjust

Output Amplifier Gain

CTCSS HI <-> LOW

PIN 1

PORT 2
Interface

COS
HI <-> LOW
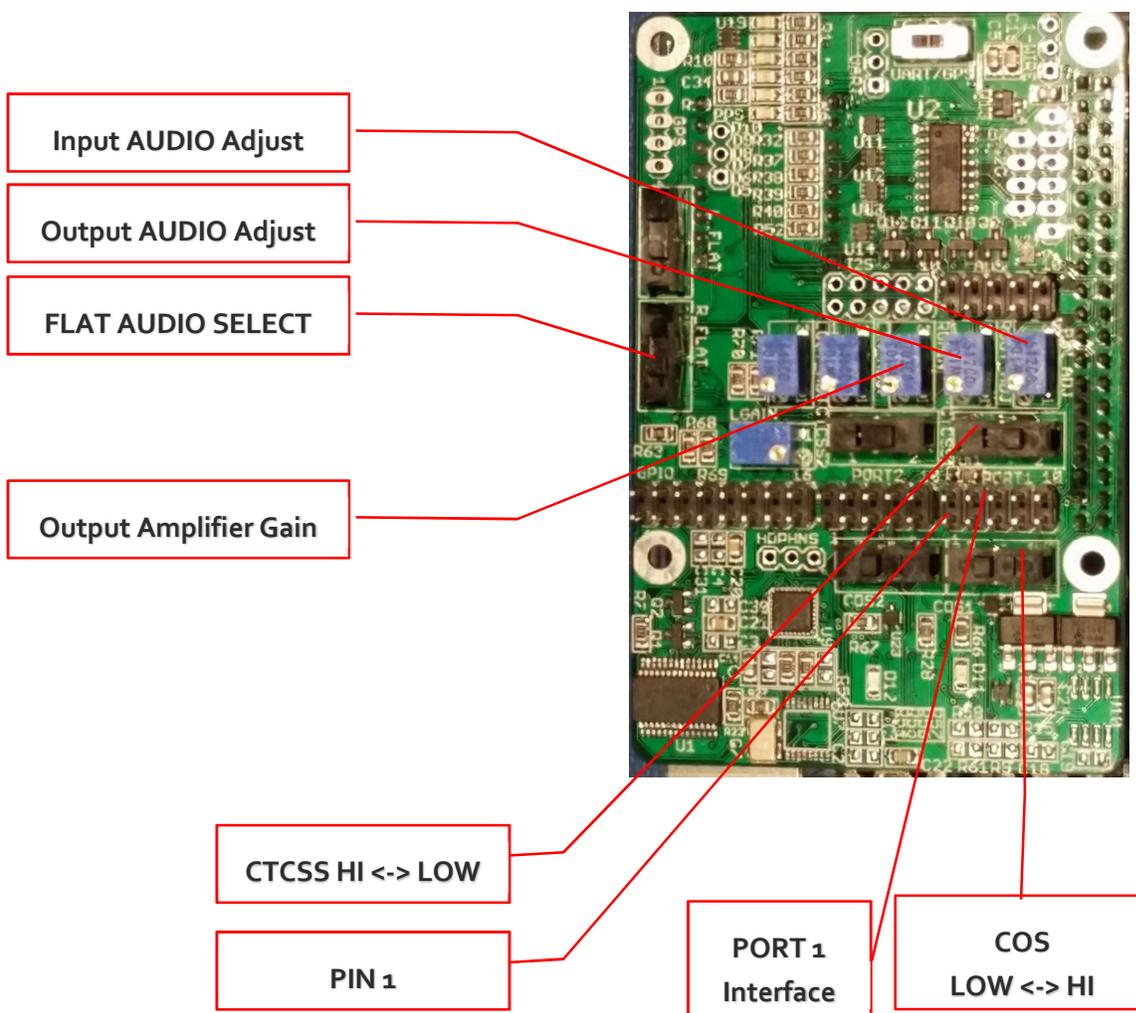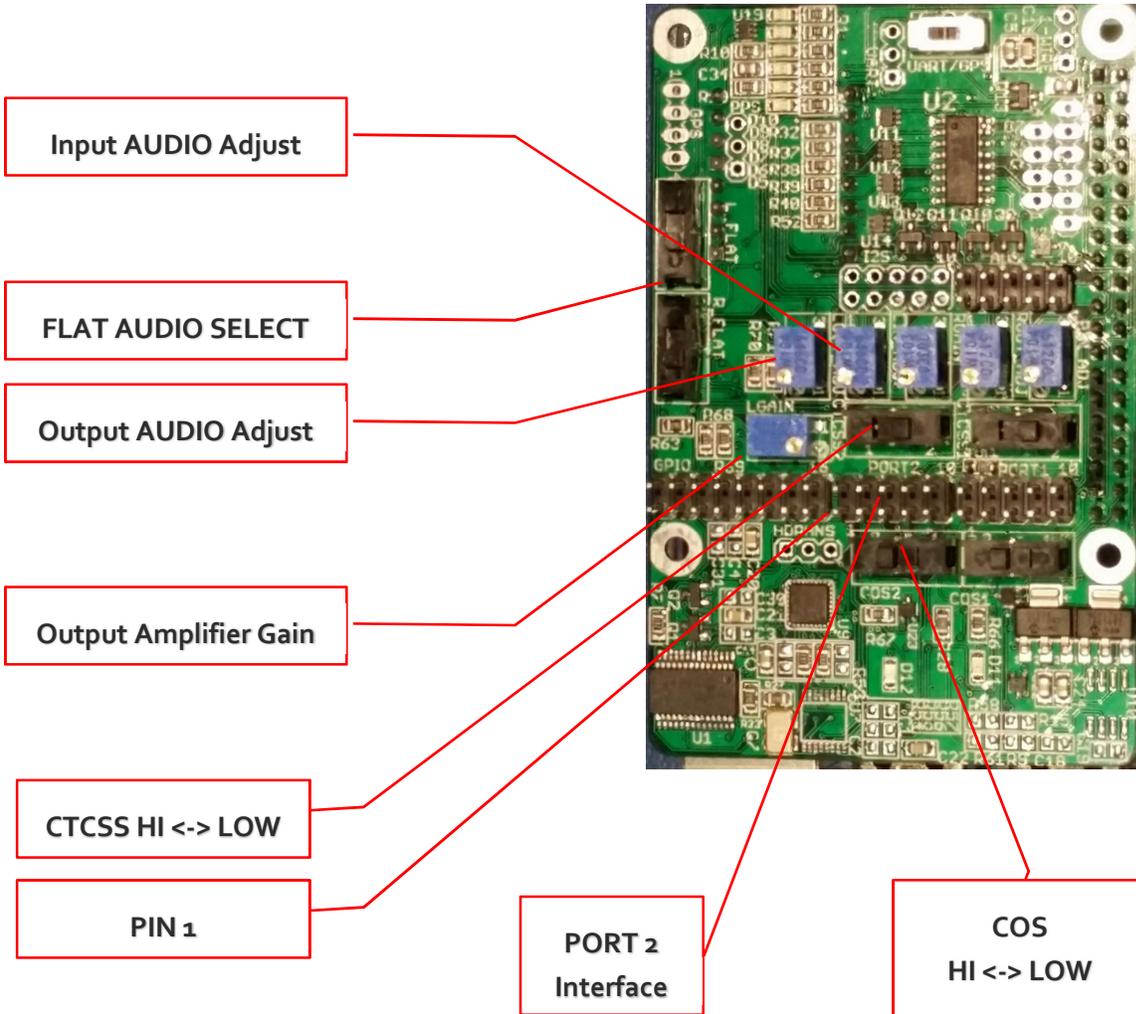
3.1.3   INPUT AUDIO ADJUST

The input audio adjust is used to adjust the amplitude of the volume coming from the receiver, with clockwise rotation turning the amplitude down <needs confirmed>. This is an 18 turn, 10kΩ potentiometer, multiple turns are required to effect a large change in amplitude, while fractional turns yield fine resolution adjustments.

The input audio should be approximately <TBD> volts peak to peak as measured at Q1/Q2 (Bottom left corner near mounting hole) as applicable for the channel being measure.

3.1.4 FLAT AUDIO SELECT

This is use to select if the audio coming in requires the addition of a flat-audio filter (removes pre-emphasis). To enable the addition of the flat audio filtering, the switches should be in the down position (towards the USB/ETH jacks on the PI).

To pass the audio unfiltered, the switches should be in the up position as shown in the figures above.

To learn more about "Flat Audio" we recommend starting here:

http://www.repeater-builder.com/tech-info/flat-audio.html

3.1.5 OUTPUT AUDIO ADJUST

The output audio adjust is used to adjust the amplitude of the volume coming from the repeater board. This is an multi turn, 10kΩ potentiometer, multiple turns are required to effect a large change in amplitude, while fractional turns yield fine resolution adjustments.

This function is used to adjust the amplitude of the repeated audio being sent to your transmitter radio. This output amplitude should be adjusted per the transmitter radio specifications.

3.1.6 CTCSS ACTIVE HIGH/LOW

This switch is used to select the active on state for the CTCSS signal from the receiver radio. Typically this will be active low, but some radios output an active high signal. This input can be used for 3-18Vdc signal levels.

3.1.7 PORT CONNECTOR & PIN 1

Each repeater port comes out to a 2x5 male header. This header is typically connected 1:1 into a DB9 Female connector, but the user may also make a custom cable/adaptor for their own equipment if desired.

Connector Selection: Due to the tight spacing of the board, it is important to select mating connectors that do not exceed the width of the male pin alignment blocks, or you risk mechanical interference with the port 2 header. For custom cables we suggest using connector block 952-2033-ND from Digikey, or a similar variant. **STANDARD IDC RIBBON CABLE CONNECTORS WILL NOT FIT.**

Pin 1 is located in the bottom left corner as shown above in section 3.1. When using ICS-CTRL provided DB9 connectors, will correspond with the brown wire.

CONNECTOR PINOUT:

1- CTCSS ENCODE OUTPUT
2- CTCSS INPUT FROM RX RADIO
3- PUSH TO TALK (OPEN COLLECTOR)
4- AUDIO OUTPUT
5- AUDIO INPUT
6- GROUND
7- COS INPUT FROM RX RADIO
8- GROUND
9- GROUND
10- GROUND (DB9 SHELL)

3.2 OUTPUT AMPLIFIER GAIN

This is a multi-turn, 10kΩ potentiometer that can be used to further adjust the output audio amplitude. It is recommended to leave this potentiometer at the midpoint value for normal operations.

3.3 BUILT-IN AUDIO

The system contains a SGTL5000 Audio codec chip which provides stereo input and output capability so you won't require a USB sound card to have receive audio capability.

The stereo audio is split into 2 mono channels, channel 1 uses the RIGHT audio channel and channel 2 uses the LEFT channel.

Software is required to provide the mixing of the channels should you desire to blend channel 1 and 2 audio. Any base images provided by ICS-CTRL will have this built in by default.

3.4   ANALOG TO DIGITAL CONVERTER

A MCP3208 is built into the system to provide analog input capabilities with support for 8 channels with 12-bit resolution per channel.

Each channel is provided with some input protection through a current limiting resistor and a Zener diode. It is the user's responsibility to ensure the inputs are not over driven beyond a 5V maximum input voltage to prevent damage to the ADC unit.

Channel A0 has a unique configuration to allow for the use of a LM335 temperature sensor device. It is recommended to use this channel last to minimize potential confusion due to the unique configuration.
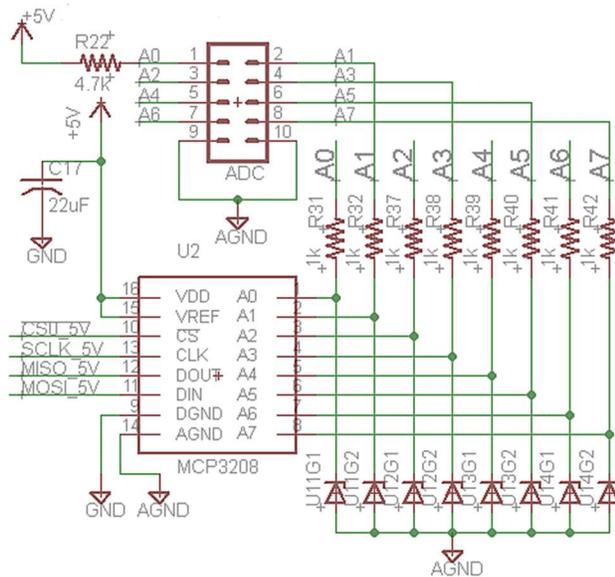
3.5   GPIO EXPANSION

As the repeater board consumes most of the signals from the 40 pin header, an additional 8 pins are made available through a 16 pin header. This header connects to PORT A on a MCP23017 IC, and provides input circuit protection through Zener diodes which limit the input voltage to 3.5V maximum.

Caution should be exercised to ensure only **3.3V logic levels** are used to connect to these pins.

The GPIO expander provides the option to include pull-up resistors should your circuit need these, but are not turned on by default, you will be responsible for configuration of these pins if used.
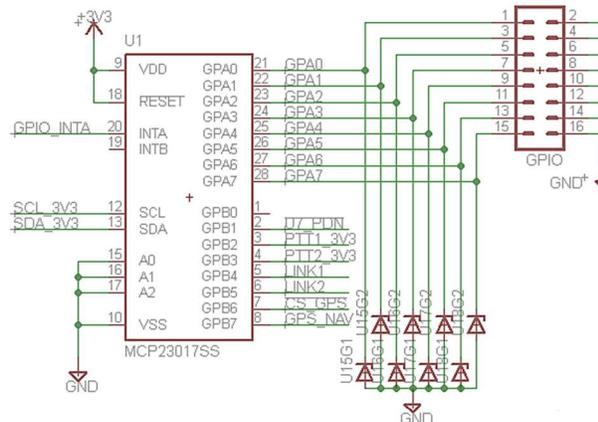
Connector Selection: Due to the tight spacing of the board, it is important to select mating connectors that do not exceed the width of the male pin alignment blocks, or you risk mechanical interference with the port 2 header. For custom cables we suggest using connector block 952-2037-ND from Digikey, or a similar variant. **STANDARD IDC RIBBON CABLE CONNECTORS WILL NOT FIT.**

3.6   GPS OPTION

An expansion header is provided so you may add an off-the shelf GPS board (SparkFun.com #GPS-11058). The use of this GPS unit also requires the purchase of qty 2, PN ED5908-ND from Digikey, and the GPS antenna of your choice with SMA interface. We have tested Sparkfun #GPS-00464, but any passive GPS antenna should work fine.
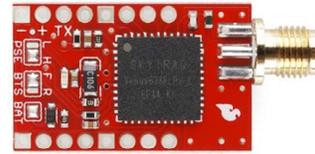
Installation of the GPS antenna requires the connectors be soldered on the **BOTTOM** of the GPS board as indicated by the silk screen.
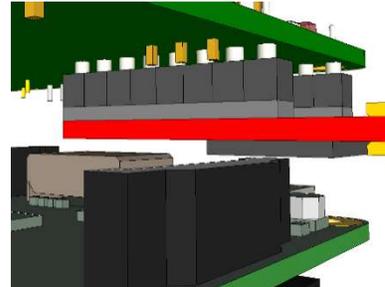
We suggest installing the pins first into the repeater board sockets, mounting the GPS board to the pins and then soldering to ensure proper alignment as the female sockets float a bit in the holes and may also be slightly angled.

NOTE: using the GPS board is very close to the LCD flex cable socket, and may interfere with the ability to use a touch screen depending on the cable used. We have successfully folded back a ribbon cable while having the GPS unit installed, but the clearances are tight and the tight bend radius may damage your flex cable, have a spare flex cable and proceed with caution.

NOTE: "UART/GPS" switch must be in the correct position as shown for the GPS to communicate with the Raspberry Pi platform.
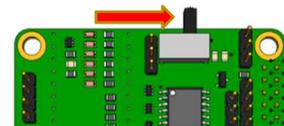
3.7   I2C EXPANSION

A 4 pin header has been included to allow you to expand the I2C bus to include your own devices, but you must ensure that the signals are 3.3V. Voltages above 3.3V will damage both the Raspberry Pi and the repeater board. Zener Diodes are included in the data signals, but should not be counted upon to protect the boards from overvoltage.
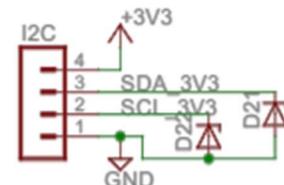
It is recommended to utilize MCP23017 gpio expander device if additional gpio functionality is desired. The MCP23017 device is recommended due to wide usage and support provided by current raspbian distributions. **Note:** Use of this chipset requires a user developed Device Tree Overlay to prevent interference with the PTT and existing GPIO expander functionality. The provided overlays only support the chipset already on-board, which is part of the repeater board's core functionality.

3.8   SPI EXPANSION

A SPI expansion header has been included for the user to be able to install any SPI device desired. It should be noted that this header only supports 5V logic devices. If you install 3.3V logic devices, they may become damaged.

It is the user's responsibility to provide logic level translation if a 3V3 device is used in the port.

The Chip Select CS1 has been routed to this port, which is supported natively with Device Tree Overlays for convenience, additional SPI devices can be used on this port as well, but the user is responsible for providing the Chip Select connectivity.
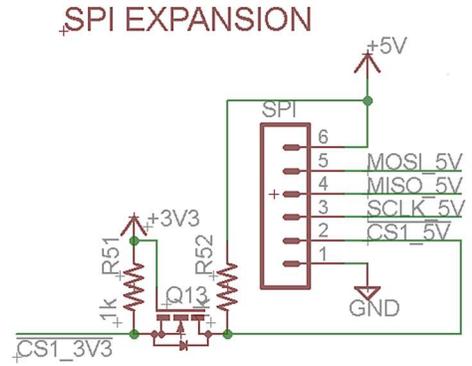
It is recommended to utilize MCP23S17 gpio expander device if a Chip Select source is needed for multiple SPI devices are desired. The MCP23S17 device is recommended due to wide usage and support provided by current Raspberry Pi distributions.

3.9   I2S EXPANSION

A 10 pin header has been included to allow for specialized I2S sound card devices to be used. This is provided for user design. **INSTALLED I2S SOUND CHIPS IN LOCATIONS U7 OR U9 MUST BE REMOVED PRIOR TO INSTALLING ANYTHING ON THIS HEADER.**
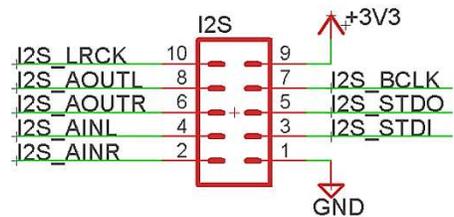
3.10   1-WIRE HEADER

A 3 pin header has been included to allow for specialized 1-wire devices to be used. This is provided for user design and devices on this port are not supported by ICS-CTRL.

This port connects directly to the processor and misconnected devices may cause damage to the system. Please use appropriate precautions to prevent damage to you Raspberry Pi.
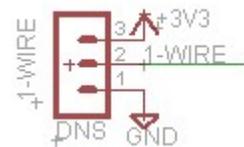
3.11   UART HEADER

The UART interface from the Raspberry PI has been brought out to a switch that allows the user to select to use the UART for either a terminal or other serial device, or, to use the UART interface to receive data from the optional GPS board.
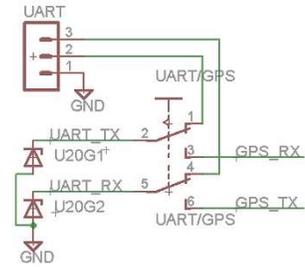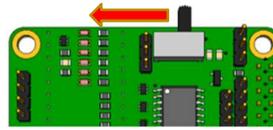
The signal levels on this connection are all 3.3V logic, and Zener diodes have been included to help protect the devices, but are intended to protect against transient voltage spikes resulting from mating connectors or similar. These will not protect again improper voltages applied to the pins.

3.12   PI STACKING HEADER

As it has been anticipated that users may wish to design custom daughter boards, the primary 40 pin header has been left exposed so the user may design standard form-factor boards.

It is important to remember that the majority of the native GPIO pins have already been utilized and these pins must be left unconnected in any custom designed daughter boards.

The illustration at the right shows the availability of each of the pins on the 2x20 header, along with shared bus pins that must be used as configured for the system to maintain functionality.
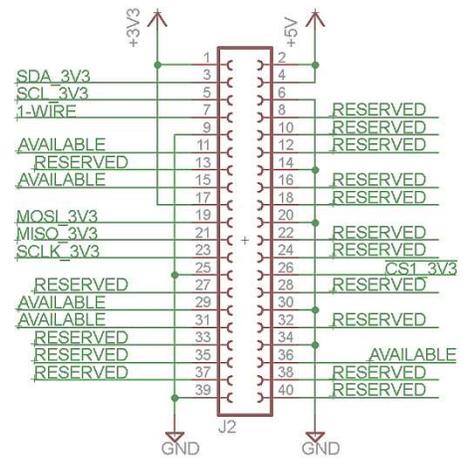
Signals such as the I2C, SPI, 1-wire, etc. are broken out into dedicated headers that may or may not be simpler to design around, this is left to the user to decide. It is critical to remember that the signals on this connecter are 3.3V logic, and 5V logic levels can damage your devices.

4 GETTING STARTED WITH SVXLINK

Introduction: svxlink is a powerful open source controller software that works on many Linux based platforms. This implementation is specific to the ICS-CTRL hardware which includes additional modules that allows you to have access to specific hardware included with your ICS-CTRL PI-Repeater-2X.

Svxlink supports custom code so you can create new features beyond what we have included if your application has specific needs not covered by our base image. We would love to hear about your custom needs, and especially your custom modules. Odds are if you have a specific need, you are not unique and sharing your code will help to support others who follow.

4.1 HARDWARE PIN NUMBERS (SVXLINK BASED)

Port 1 PINS:
PTT – GPIO506 Active high
COS – GPIO26 Active Low   **GPIO PINS:**
CTCSS – GPIO24 Active Low   **GPA0 – GPIO496**
Audio input – FE Pi Right Channel   **GPA1 – GPIO497**
Audio output – FE PI Right Channel   **GPA2 – GPIO498**
PORT 2 PINS: **GPA3 – GPIO499**
PTT – GPIO507 Active high   **GPA4 – GPIO500**
COS – GPIO23 Active Low   **GPA5 – GPIO501**
CTCSS – GPIO25 Active Low   **GPA6 – GPIO502**
Audio input – FE Pi Left Channel   **GPA7 – GPIO503**
Audio output – FE PI Left Channel

4.2 ADVANCED CONFIGURATIONS

Svxlink has a lot of features and they are continuously evolving, so be sure to have a recent copy of the manual for svxlink at hand. We will provide some examples for the most common setups encountered as starting points. Sample configurations will be provided on our Yahoo group and our website as we get them created.

If you have a specific hardware need, please make the request to the Yahoo Group for ICS-Controllers or for SVXlink support, at the SVXlink support page respectively. Both pages have a good support community and we monitor the ICS-Controllers group actively.

As the SVXlink software updates frequently, it is best to ask there for software specific issues, but we will do our best to help as well, but may not have the depth of knowledge that you will get from the SVXlink community.

Hardware Support Page: https://groups.yahoo.com/neo/groups/ICS-Controllers/info

SVXlink Support Page: https://github.com/smosvx/svxlink/wiki/GettingSupport

ICS Pi Repeater 2x schematic, Sheet 1/2, REV 3.1