mØxpd©

Receiver Shield *for the* Arduino

The Kanga / m0xpd Arduino Rx Shield is a simple Direct Conversion receiver sub-system for the HF bands.

It is offered as an Arduino "shield", allowing a **complete receiver** to be assembled from an Arduino single board computer (UNO or MEGA) and an appropriate RF generator (either the Kanga / m0xpd DDS Shield or the new Kanga / m0xpd Si5351 Shield). Optionally, the Kanga / m0xpd Tx Shield can also be added to form a **complete CW Transceiver**.

The Rx shield will operate on any HF band – the band is selected by an external band-pass filter on the input *(NOT SUPPLIED).*

Example software (Arduino "sketches"), including code for the full CW transceiver, is available for download from the m0xpd blog.

The Rx shield may also be used as the foundation of a conventional receiver, independent of an Arduino or any such digital system, in which case only a VFO signal (plus band-pass filter) is required.

The Rx Shield uses a 602/612 Gilbert Cell Mixer, followed by a two-stage audio path which supports limited on-board filtering, an off-board send/return loop (*in which the user can add volume control, further filtering or processing, etc*), on-board Rx muting, and a level control. There is an on-board (LM386) amplifier, which will easily drive low impedance headphones or a speaker.

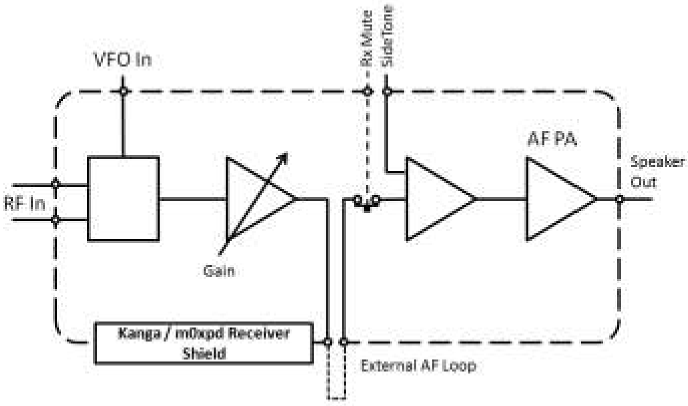
The system can be powered by the Arduino "VIn" power line, or an external power source can be selected.

History

The present Rx Shield has its origins in the receiver constructed for the "Occam's Microcontroller" Transceiver. That Rx was heavily influenced by the receiver section of w7el's "Optimised Transceiver for 40m" and used a discrete mixer and transformers wound on toroidal cores. A second receiver shield was produced according to a simplified design produced as a (deliberate) homage to g3rjv's "Sudden", for presentation at the G-QRP's 2013 Mini-Convention. That second receiver preserved the muting arrangement of the first design (inspired by w7el) and is the basis for the present Kanga / m0xpd Arduino Rx Shield, which differs only in the substitution of a surface-mount package for the input mixer (as this part is no longer manufactured in a DIL package) and in some rationalisation of the audio filtering.

Structure

The overall structure of the Rx Shield is shown below...



RF (from the input band-pass filter) is applied to the mixer, which mixes it directly to audio frequency. The first stage of the audio path applies some high-pass filtering and amplifies the signal at variable gain, before providing a low-impedance drive for the external audio loop.

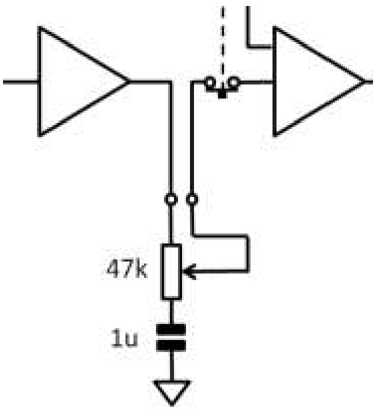
This loop allows external filtering or other processing to be applied to the signal path (it can optionally be bypassed by a simple jumper, supplied).

Signals returning from the external loop can be muted, under the control of a logic signal usually derived from the hosting Arduino computer, after which the second stage of amplification applies further high-pass and low-pass filtering, before passing the audio onward to the power amplifier, where still more low-pass filtering is applied.

A fixed-gain audio input is provided to the second audio stage, usually connected to Arduino pin D9, which provides Sidetone outputs in the m0xpd software. This connection is made by header, such that the shield can be easily reconfigured for other purposes as required.

Using the External Audio Loop

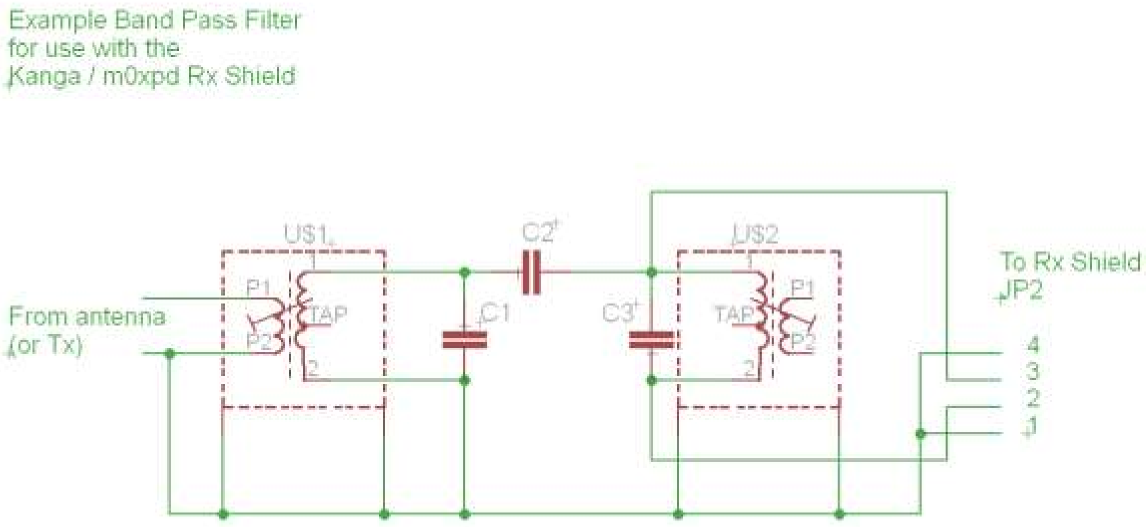
The provision of an off-board loop for the addition of extra processing in the audio path was originally intended to support sophisticated filtering (such as the m0xpd CW filter described in SPRAT 146). However, it can be either ignored (by bypassing with a header jumper, as suggested in the figure above) or it can be used to provide a convenient volume control. The "gain" control on the shield is only a small trimmer and the shield may not be positioned to allow easy access to this trimmer in use – so a real "volume control" is better for operation.



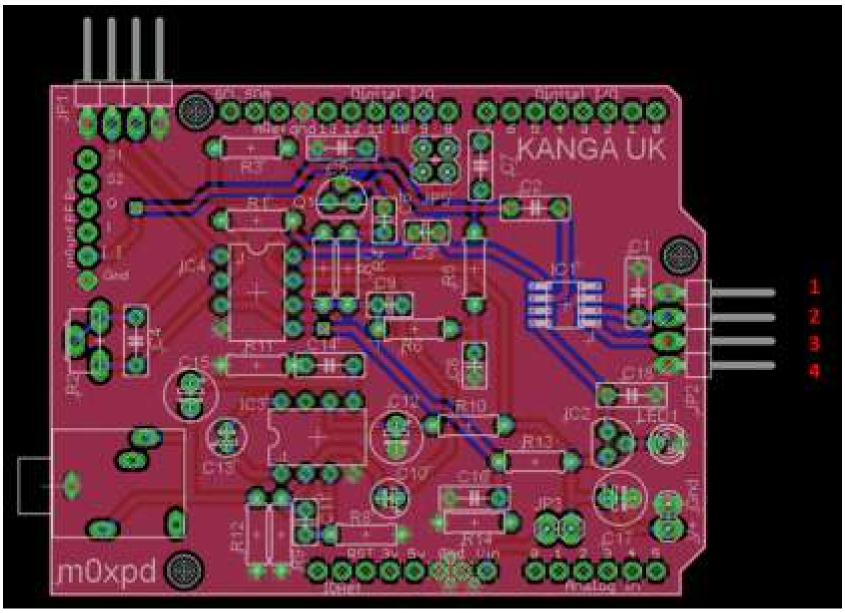
The external loop must preserve the dc "biasing" of the audio signal in order to the Rx mute to work, so a simple way to implement a volume control is suggested in the figure left, in which a potentiometer, configured as an ordinary potential divider, is grounded not to "ground" but to an "ac ground", provided by a large capacitor.

Band Pass Filter

The Rx Shield requires an input band-pass filter for correct operation. A suitable circuit is given here...



Pay particular attention to the wiring of the input to the Rx shield, JP2 – notice that the “bottom” of the parallel LC network at the second coil is NOT grounded. Also pay attention to the pin numbering of JP2 – the outer pins both are grounds, but if you mix up pins 2 and 3 when you hook up the band-pass filter you’ll lose a lot of sensitivity...



Appropriate inductor / capacitor values for each amateur band are detailed on the following G-QRP technical page, which describes a similar (not identical) network built around “TOKO” coils: http://www.gqrp.com/technical1.htm

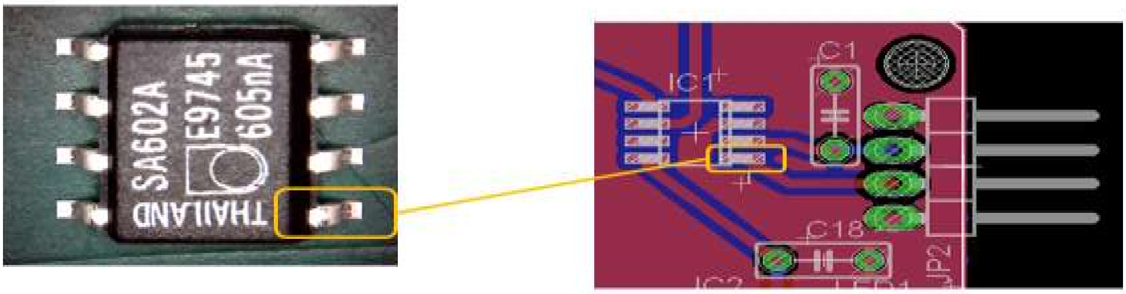
Replacements for the Toko coils are now available from the range manufactured by Spectrum Communications Limited and available through the G-QRP club.

Construction and Testing

Although this is a relatively simple kit, it is best to approach construction in a structured manner as this will allow systematic testing.

The mixer, IC1, is supplied as a surface mount device, which is soldered directly onto the (top) of the board. This will require the greatest degree of "access" with the soldering iron – particularly if you are not used to dealing with surface-mount components. Accordingly, it is best to solder this component in place first, whilst there is nothing else to obstruct you!

The device must be mounted in the correct orientation, with Pin 1 on the pad labelled with a nearby "1" on the mask. Generally, IC packages are labelled such that when you hold the package in the correct orientation to be able to read the text, Pin 1 is at bottom left. Here's a photo of the SA602 chip with pin 1 identified and a portion of the board with the pad associated with Pin 1 also identified...



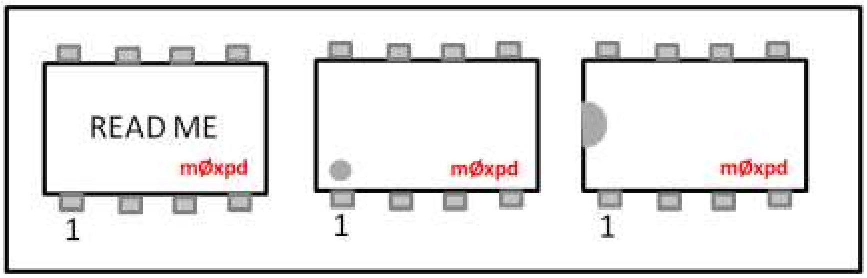
Once IC1 is successfully mounted, leave it – we are not going to power it up until later in the construction process.

Next, we turn our attention to the audio power amplifier, IC3...

Populate R8:12, C11:18, X2 (the 3.5mm jack socket), an 8-pin DIL socket for IC3 (observing correct orientation), the male headers at JP3 (to make a temporary 12V connection) and the right-angle headers at JP1 (to make a temporary ground connection). Test the resistance between JP3 pin 2 (12V) and JP1 pin 1 or 4 (ground), to check for unexpected shorts – should be an open-circuit.

Now insert IC3, after forming the legs to ensure correct spacing.

Ensure correct orientation as you insert IC3 - pin 1 is marked on the board and the "text rule" above applies to orient the socket and the chip [additionally i) there may be a "dot" near pin one on the package or ii) there may be a semi-circular cut-out at the end of the left-hand end of the package when held in the orientation such that pin 1 is at bottom left]. A summary of the "pin 1 identification rules" is given below...



Apply +12V to JP3 pin 2, relative to a ground connection to JP1 pin 1 or 4.

Current consumption with no (speaker) load connected and no input should be approximately **3.2mA**

Now connect a suitable loudspeaker to the jack – you should be able to hear a buzzing noise if you touch IC3 pin 2 or 3 (and current consumption will rise accordingly – perhaps to 40mA if you're driving a low impedance load).

If all is well, move on to construct the audio path...

Populate R1:4, R7, R13 and R14. Populate C1:6, C9 and C10. Populate the 2*2 male header at JP5 and the Insert Q1, forming the leads to ensure correct orientation. Insert an 8-pin DIL socket for IC4, ensuring correct orientation.

The audio path has a LOT of available gain (to allow for lossy filters in the external loop). Set the gain control close to minimum gain for initial testing – this is achieved by rotating the trimmer CLOCKWISE to near the end of its travel.

Check for accidental shorts in the power supply, by measuring the resistance between JP3 pin 2 (12V) and JP1 pin 1 or 4 (ground), which now will show the 20k combination of R13 and R14.

Insert IC4, after forming the legs to ensure correct spacing and observing correct orientation.

Adding the regulated power supply to the mixer, by adding IC2 and LED1, and fitting JP1 will allow the entire system to be tested.

At this point, incoming RF from an antenna system must be applied via an input BPF (as previously described) via JP1 and the mixer must be supplied with an oscillator signal via pin 5 of the "m0xpd RF Bus" on the Shield. This pin (via a convention established on the original Kanga / m0xpd DDS Shield) is named "Spare" and marked "[ ]" on the silk screening on the board.

Current consumption of the Rx Shield driving a typical small speaker (in the test a pair of surplus computer loudspeakers, driven in parallel to present a 4 Ohm load were used) to comfortable listening level is approximately **50mA**.

At this point you can also confirm correct operation of the Rx mute system, by taking the mute line to ground – connecting JP5 pin 4 to ground should mute the audio path.

Sidetone Input

The Rx shield has a fixed-gain input to the final stages of the audio chain – provided for sidetone when the system is used in a transceiver.

The suggested component values C7 & 8 and R5 & 6 are indicative and – whilst successful, have been found to generate too loud a sidetone signal in some applications (particularly for headphone use).

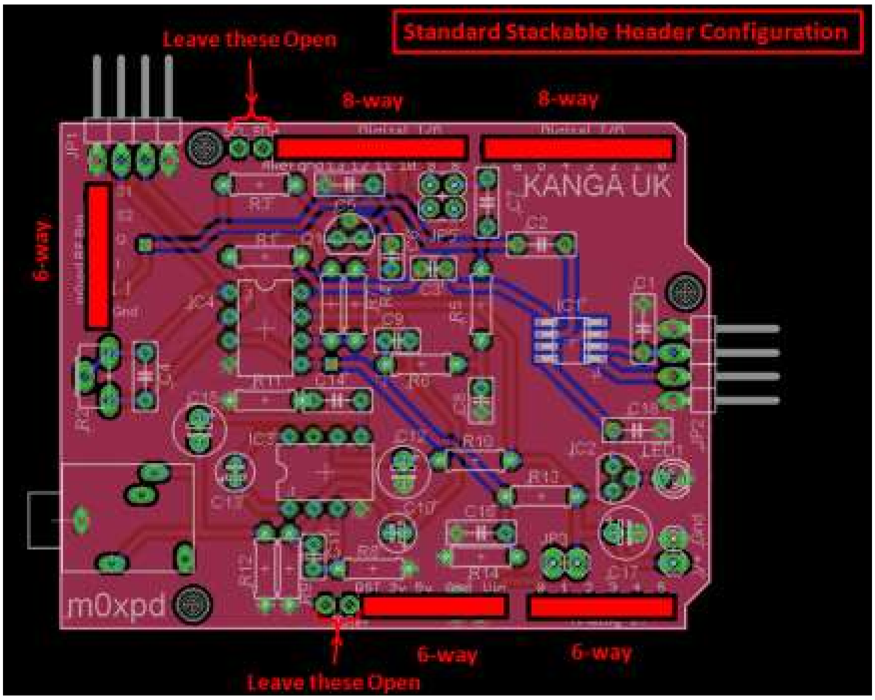
Users are encouraged to experiment with these values in their own application – which is why their installation is left until this late stage of construction.

Headers for Arduino Stacking

Once the system is complete and tested, those users wishing to operate the shield as part of a "stack" on an Arduino and/or other shields should connect the five stacking header connectors.

Note that the board supports the full Arduino 1.0 pin out, with the IOREF signal on the power bus and the additional I2C lines "above" D13. The receiver uses neither of these resources and the kit is shipped with the "standard" complement of stacking headers.

When you fit the stacking headers, be careful to populate the supplied headers only in the correct locations, as shown below...



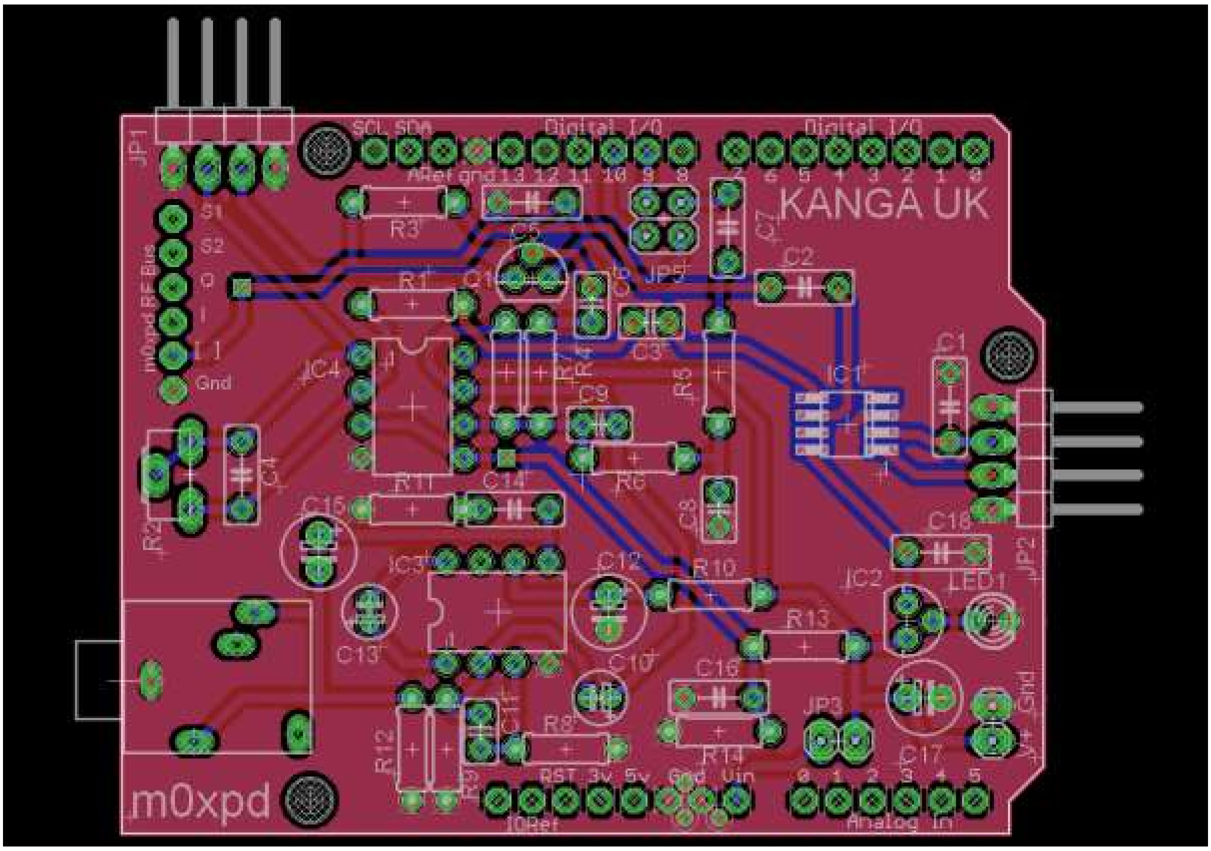
[Any users who wish to fit wider headers to conduct the I2C and IOREF bus signals to another board stacked above the receiver must supply their own 8- or 10-pin component.]

Jumpers

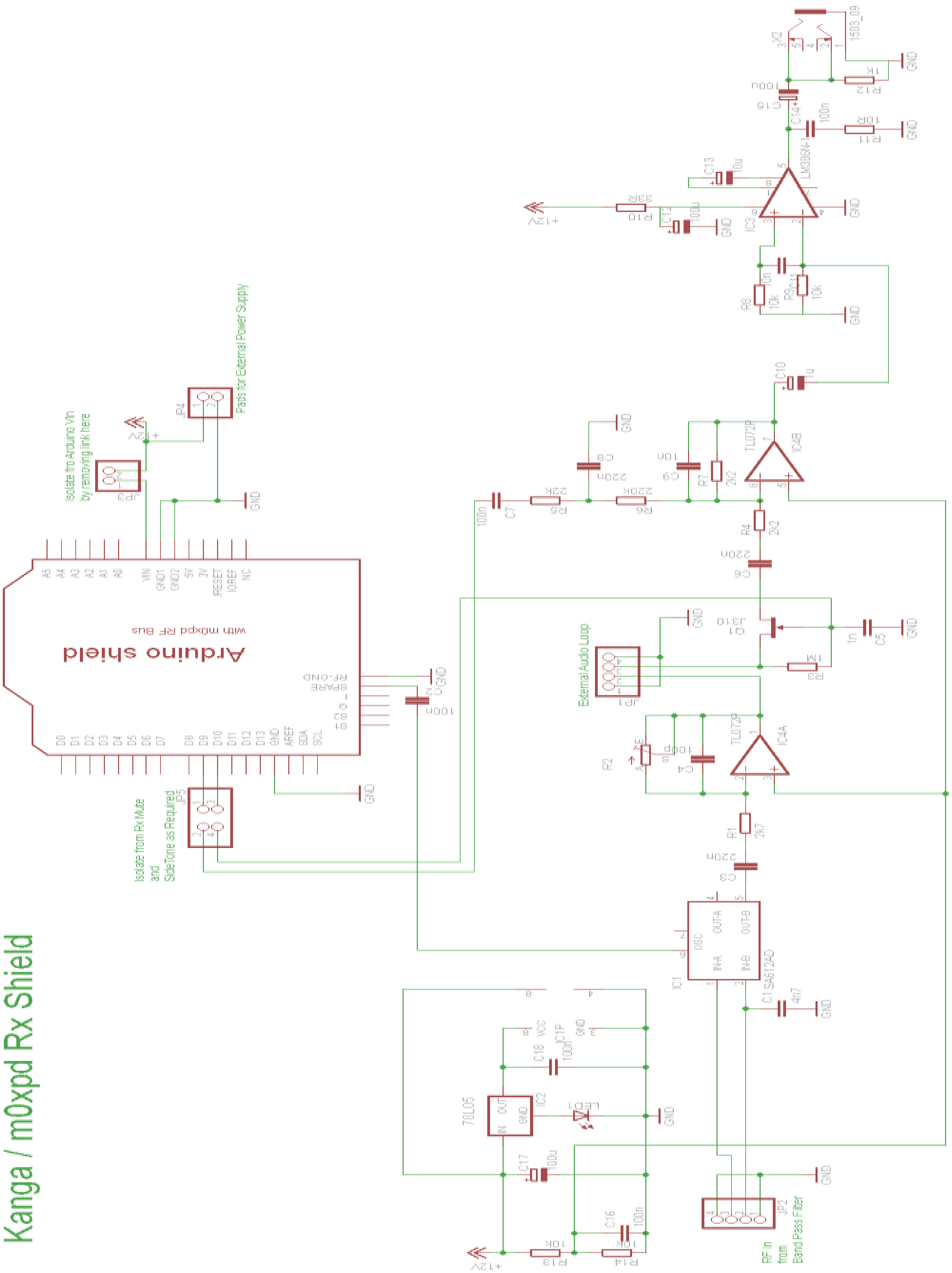
The Rx Shield is provided with a number of male headers to allow a degree of flexibility in configuration. These are explained in the following table.

Header	Name	Description
JP1	AF Loop	Fit jumper between pins 2 & 3 to bypass external loop OR See notes on "Using the External Audio Loop"
JP3	V In Isolate	Fit jumper to power Rx shield from Arduino "V In" Power source OR Leave open to apply external power at pads provided at "JP4"
JP5 [1:2]	Sidetone Isolate	Fit Header to connect to standard SideTone Source (D9) OR Leave open to Isolate
JP5 [3:4]	RxMute Isolate	Fit Header to connect to standard Rx Mute Source (D10) OR Leave open to Isolate

Board Layout



Schematic


Kanga / m0xpd Rx Shield
Arduino shield
with m0xpd RF Bus
Isolate fro Arduino Vin by removing link here
Pads for External Power Supply
Isolate from Rx Mute and SideTone as Required
External Audio Loop
RF In from Band Pass Filter

Component Listing

X	Part	Type	Marking	Notes
	R1	2.7KΩ	Red, Violet, Red, Gold	
	R2	100kΩ	Blue	6mm Trimmer
	R3	1MΩ	Brown, Black, Green, Gold	
	R4	2.2KΩ	Red, Red, Red, Gold	
	R5	22KΩ	Red, Red, Orange, Gold	
	R6	220KΩ	Red, Red, Yellow, Gold	
	R7	2.2KΩ	Red, Red, Red, Gold	
	R8	10KΩ	Brown, Black, Orange, Gold	
	R9	10KΩ	Brown, Black, Orange, Gold	
	R10	33Ω	Orange, Orange, Black, Gold	
	R11	10Ω	Brown, Black, Black, Gold	
	R12	1KΩ	Brown, Black, Red, Gold	
	R13	10KΩ	Brown, Black, Orange, Gold	
	R14	10KΩ	Brown, Black, Orange, Gold	

	C1	4N7	4n7K	
	C2	100nF	104	
	C3	220nF	224	
	C4	100pF	101	
	C5	1nF	102	
	C6	220nF	224	
	C7	100nF	104	Brown Disc Ceramic
	C8	220nF	224	
	C9	10nF	103	
	C10	1µF	1µF 16v	Electrolytic Observe Polarity
	C11	10nF	103	
	C12	100µF	100µF 16v	Electrolytic Observe Polarity
	C13	10µF	10µF 16v	Electrolytic Observe Polarity
	C14	100nF	104	
	C15	100µF	100µF 16v	Electrolytic Observe Polarity
	C16	100nF	104	
	C17	100µF	100µF 16v	Electrolytic Observe Polarity
	C18	100nF	104	

X	Part	Type	Marking	Notes
	IC1	SA602/612		SMD
	IC2	5v Regulator	78ls05	TO92
	IC3	LM386	LM386-N1	8 Pin DIL
	IC4	NE5532	NE5532	8 Pin DIL
	Q1	J310	J310	FET

Misc Parts

☐	3.5mm Stereo Socket	x 1
☐	8 Pin Header (Arduino)	x 2
☐	6 Pin Header (Arduino)	x3
☐	90° Angle Header Pin	x2
☐	2x2 Pin Header (Straight)	x 1
☐	2 Pin Header (Straight)	x 2
☐	Jumpers	x 4
☐	Shield PCB	x1