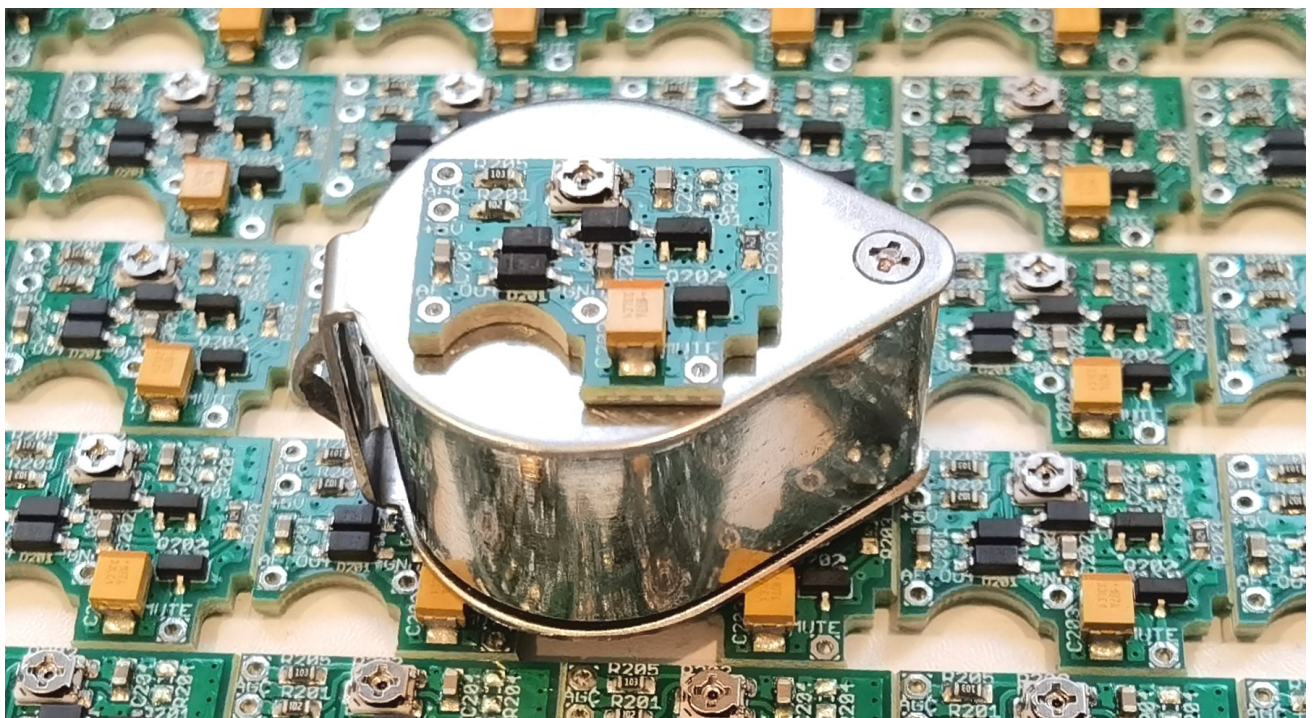

QCX-series AGC module installation instructions

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1. Introduction

QCX-series transceivers (QCX, QCX+ and QCX-mini) do not have built-in Automatic Gain Control (AGC).

This small 19 x 16mm ready-assembled AGC module is based on the proposal by Jim AJ8S in this thread on the QRP Labs groups.io forum:

https://groups.io/g/QRPLabs/topic/a_simple_qcx_agc/80821592

The shape of the AGC module is specifically designed to fit snugly into the QCX-mini, where it should sit on top of IC8 and IC9, a few mm above the main PCB. The perimeter of the AGC board is designed to fit between the surrounding through-hole components on the QCX-mini. On the QCX and QCX+ there is much more space available so installation position is less critical.

It's not the most perfect performant AGC circuit in the world. But it works very well for a very small number of components and avoids any modifications to the QCX apart from making the four (or five) connections. The circuit provides a very useful degree of AGC and will protect you from sudden very loud signals.

Additionally a few additional components have been added such that a control signal can switch on/off the AGC. In QCX firmware version 1.08 and above, there is a menu item in the "Other" menu, which allows you to switch AGC On/Off. This requires a connection from LCD Pin D6 to the "AGC" control input of the AGC module. If you prefer to keep the AGC always on, there are a pair of pads on the PCB that you can short with a solder blob, a small wire, or an 0603 zero-ohm resistor.

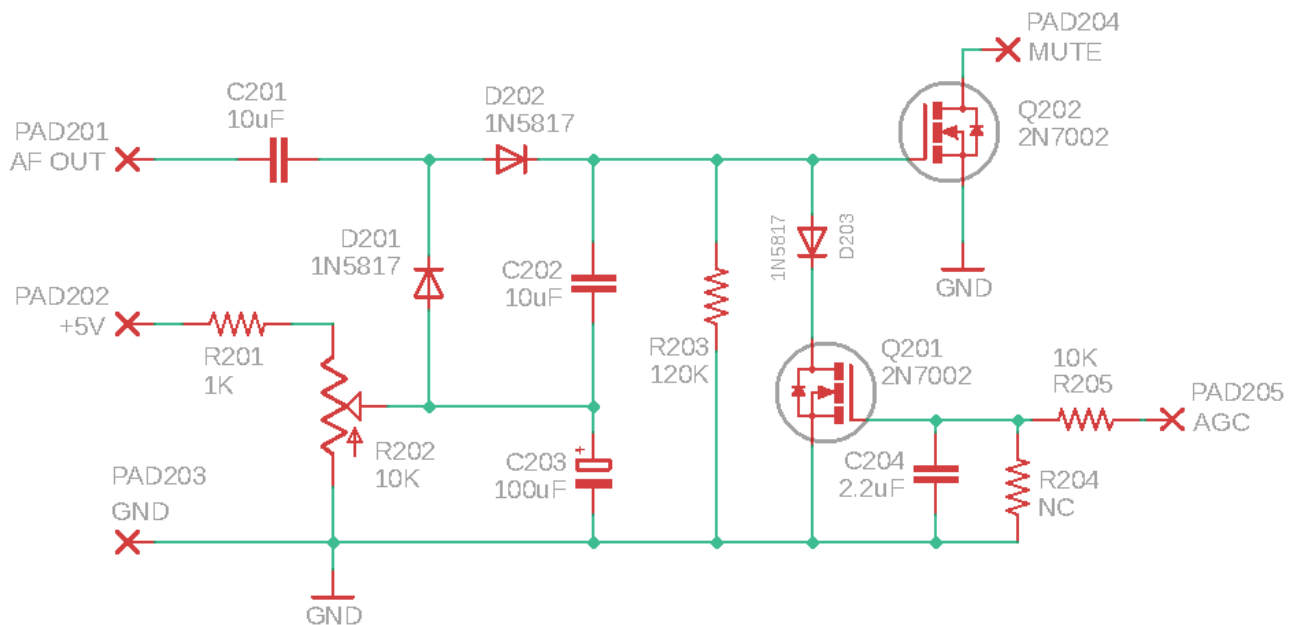
The AGC module can be installed in ANY of the QCX-series transceivers. This document includes instructions for each model.

On a QCX-mini Rev 3 (and above) PCB, there are 5 holes on the main QCX-mini PCB that line up exactly with the 5 holes on the AGC module. Installation is therefore exceptionally easy using 5 component lead off-cuts to make the connection between the two boards, and no other changes.

On other QCX-series models, all of which essentially share the same schematic, the principles of circuit operation are the same, but you will need to install wires to make the connections.

2. Design details

2.1 Schematic and circuit explanation



The AGC module schematic is shown above.

The “AF OUT” connection at the top left is connected to IC10 pin 1, which is the output of the QCX receiver. This audio signal is rectified and applied to the gate of MOSFET Q202. The drain of this MOSFET is the module’s “MUTE” connection which is connected to the wiper of the QCX volume control. As the amplitude of the audio increases, the gate voltage rises, switching on the MOSFET. The MOSFET’s resistance in parallel with the lower part of the volume control potentiometer therefore reduces the volume of the receiver.

Trimmer potentiometer R202 provides an adjustment facility so that you can choose a level of AGC action that is most comfortable to you. It applies a bias voltage to the rectified audio. The more positive the bias voltage is, the more sensitive the AGC circuit becomes; since it will require a smaller amount of audio to switch on the MOSFET.

Note that the MOSFET action is not an ON/OFF switch. There’s a range of operation where the gate voltage gradually lowers the resistance of the MOSFET.

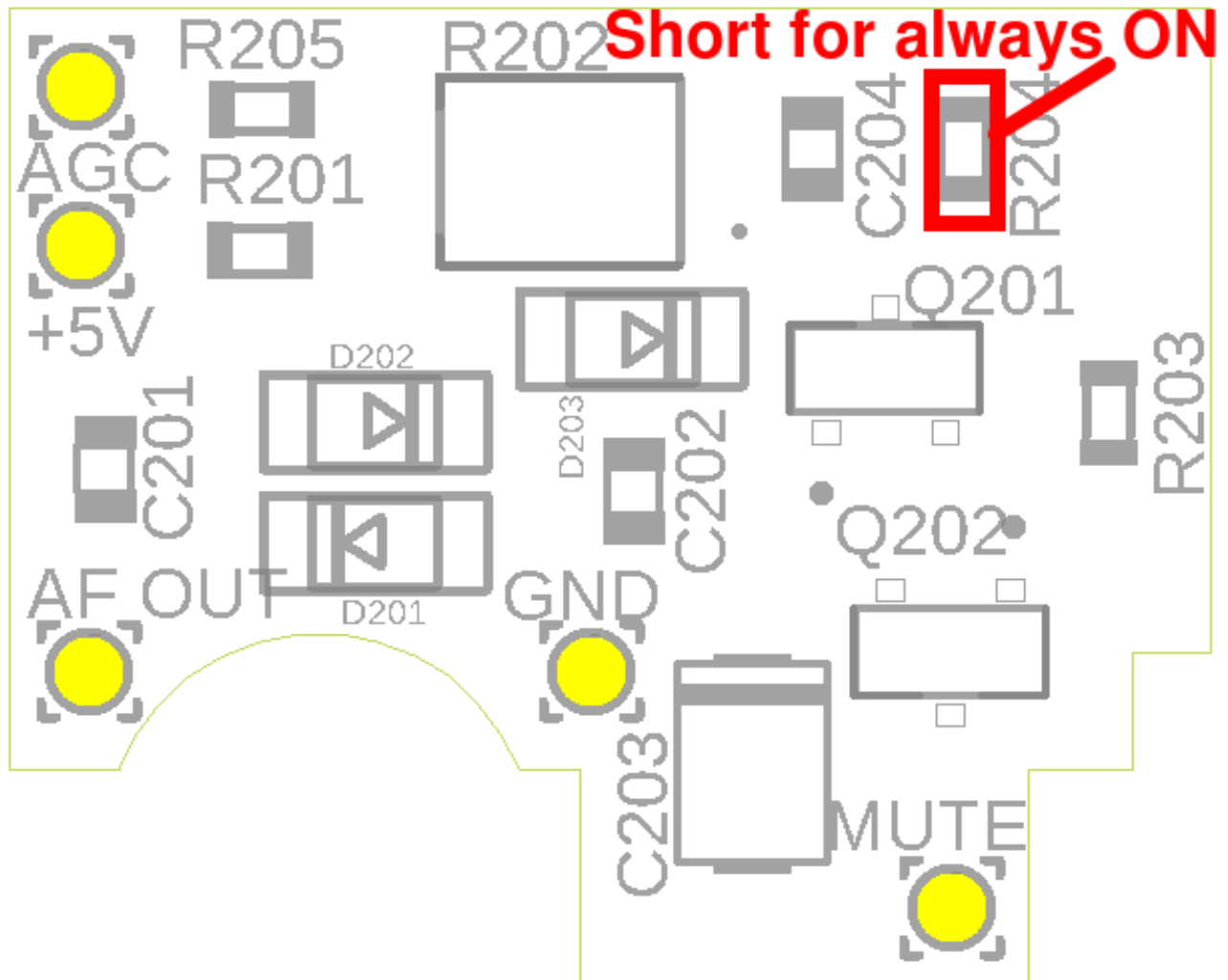
Transistor Q201 provides a way for the control input named “AGC” to switch the AGC on or off. When a voltage (+5V) is applied to the transistor gate, the transistor turns ON, and the Q202 gate voltage is pulled to ground through Q201, causing the muting MOSFET Q202 to be switched OFF completely.

This signal is provided from the QCX signal LCD_D6. During write operations to the LCD, the data on this signal would cause transistor Q201 to switch on and off rapidly and this could potentially be audible in the earphones. To avoid this, R205 (10K) and C204 (2.2uF) form an integrator with a time constant much longer than the micro-second data pulses when the processor talks to the LCD.

Resistor R204 is not fitted on the board. The pads of this resistor can be shorted together if you want to keep the AGC circuit always active. In this case, you would not need to connect the “AGC” signal to the QCX signal LCD_D6 (though if you do, that will not harm anything either).

2.2 Board layout

The diagram below shows the parts layout. The five connections to QCX are the header pads coloured yellow. The diagram also highlights in red, the position of the un-installed resistor R204; if you want the AGC circuit to be always active, you simply short this resistor, either with a solder blob, a small wire, or a zero-ohm 0603 sized resistor. In this case you do not need to connect the “AGC” signal at the top left corner of the board.



2.3 Performance

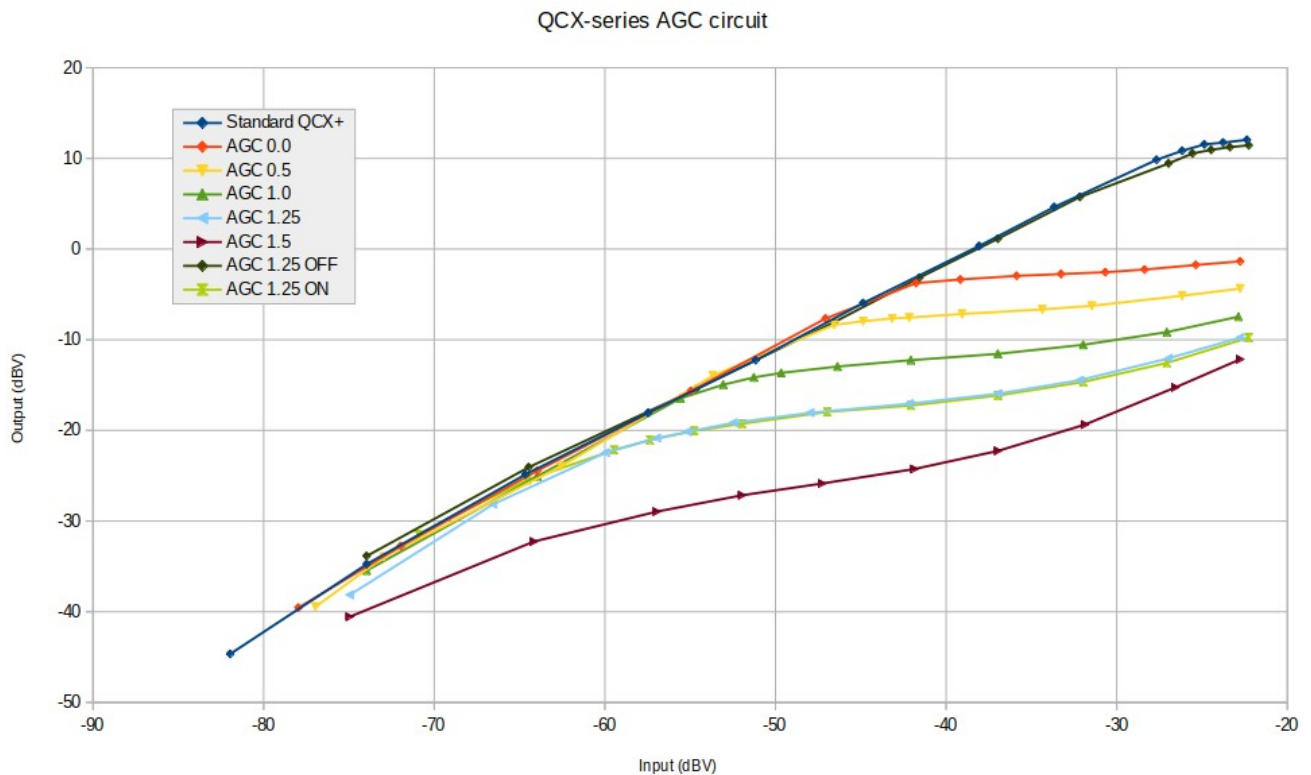
The graph below shows the measured performance of the circuit. Input audio amplitude is shown on the horizontal axis, and output audio amplitude on the vertical axis.

The various curves are shown in the legend with a number such as “AGC 1.25”. This number is the voltage measured at the wiper of the adjustment potentiometer.

The top line (dark blue) is a standard unmodified QCX+. The next line (red) shows the AGC action when the adjustment is all the way clockwise (0V bias, lowest sensitivity). As the bias voltage is increased by turning the adjustment potentiometer more and more anticlockwise, the AGC starts acting at lower audio levels (becoming more sensitive).

Next, the “AGC” control signal was connected to the QCX signal LCD_D6. The pale green line “AGC 1.25 ON” (control signal is zero volts) shows the resulting response curve and exactly overlaps the pale blue line “AGC 1.25” before the connection was made. The black line ‘AGC 1.25 OFF” (control signal is +5V) shows the resulting curve when the QCX menu switches off the AGC circuit – it overlaps the “standard unmodified QCX+” case, as you would expect. This validates the correct operation of the control signal switching the AGC on/off.

Note that AGC On/Off control from the QCX menu requires firmware 1.08 or higher.



2.4 Adjustment

Adjustment of the sensitivity of the AGC action is made using the onboard trimmer potentiometer R202. **Be very careful to use the correct sized screwdriver and do not force it: the potentiometer is a small SMD device and is quite delicate.** Least sensitive AGC action is fully clockwise, most sensitive is fully anticlockwise. Take great care when adjusting this potentiometer which is small and delicate.

One way to adjust the AGC is:

- Ensure AGC is switched ON in the menu (or you have shorted R204).
- Turn the adjustment potentiometer to its clockwise limit (least sensitive)
- Tune QCX to an empty to tune to an empty part of the band (no received signals),
- Turn the adjustment potentiometer slowly anticlockwise until you just about hear a slight reduction in volume.

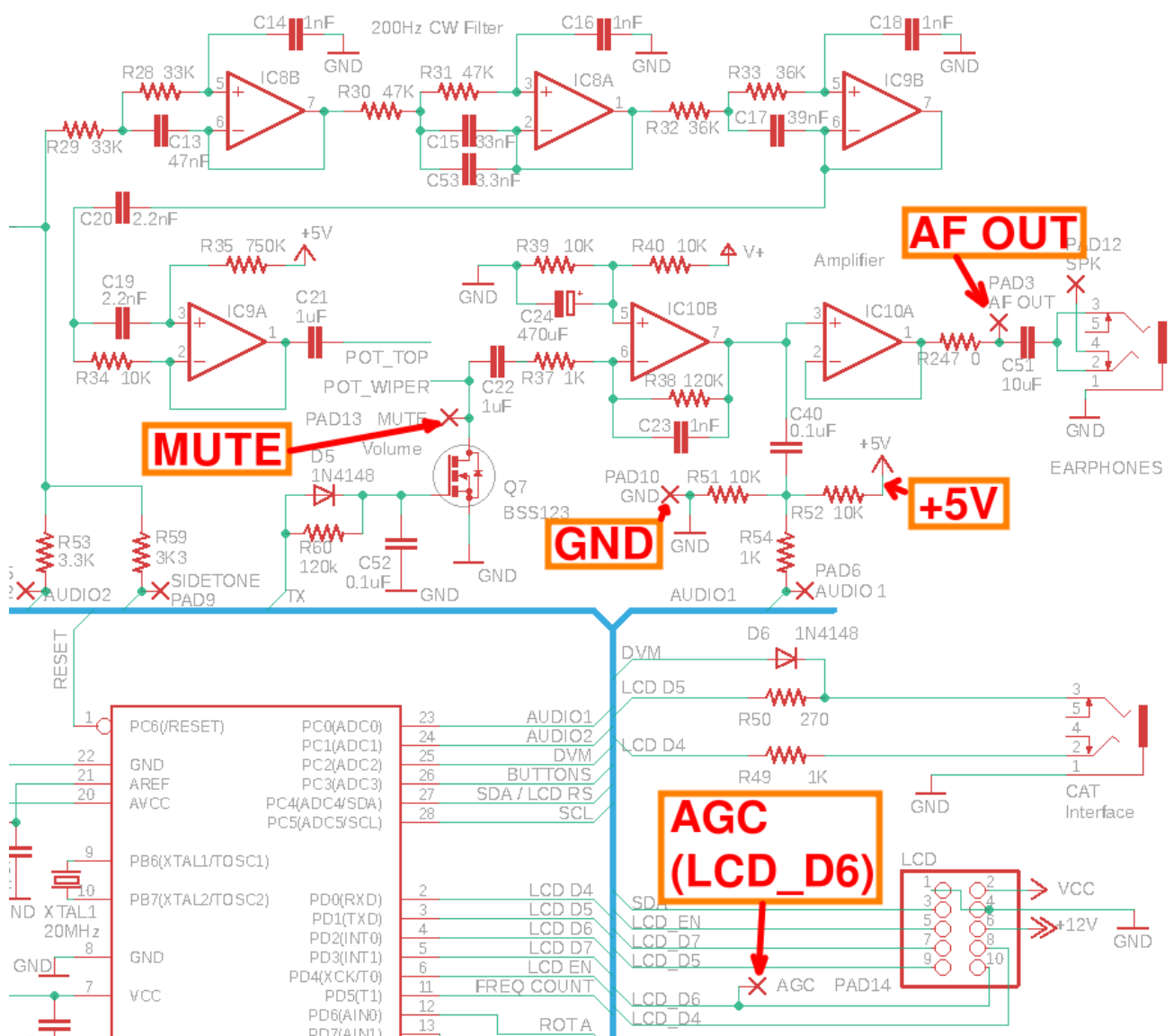
Even so, you will certainly wish to experiment with the adjustment according to your preference.

3. Installation

Installation instructions for this AGC module vary depending on which model and which PCB revision of QCX you have. Assuming that you know the model (QCX, QCX+ or QCX-mini), the PCB revision is written somewhere prominently on the PCB silkscreen.

3.1 Installation in QCX-mini PCB Rev 3 and above

The five connections of the AGC PCB are connected to schematic points as shown below.

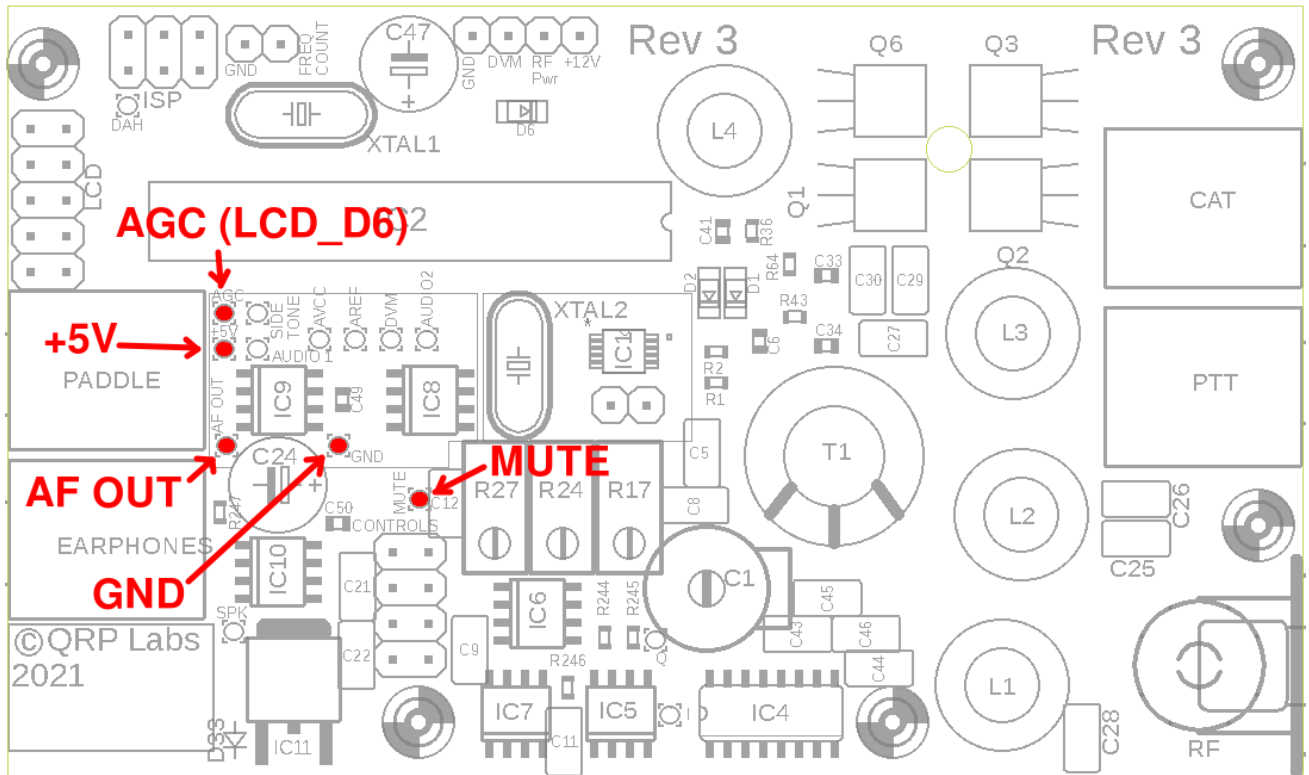


The AGC board fits snugly in the area of the PCB above IC8 and IC9. The AGC PCB shape is designed to fit between the surrounding through-hole components.

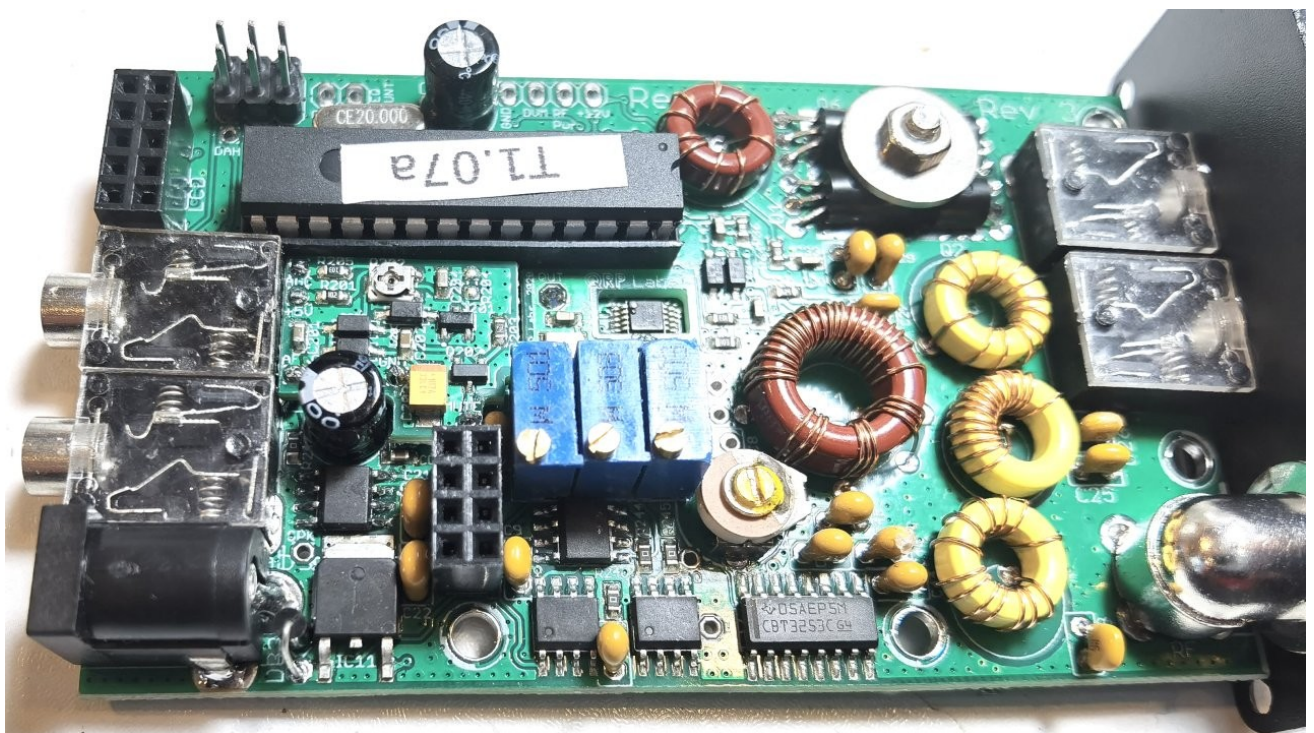
Don't worry if it seems a very tight fit or jams with something. If necessary you can carefully file away up to a mm or so at the right edge of the AGC board. Even then, if it doesn't fit totally square, this is not a problem.

On the QCX-mini Rev 3 (and above) PCB, all five connections from the AGC board to the main board, are simply made using component lead offcuts (or similar). The five holes on

the AGC board line up perfectly with five corresponding holes on the main QCX-mini PCB. All you have to do is thread five pieces of wire through and solder on the top side and bottom side. The five holes are identified in the diagram below.

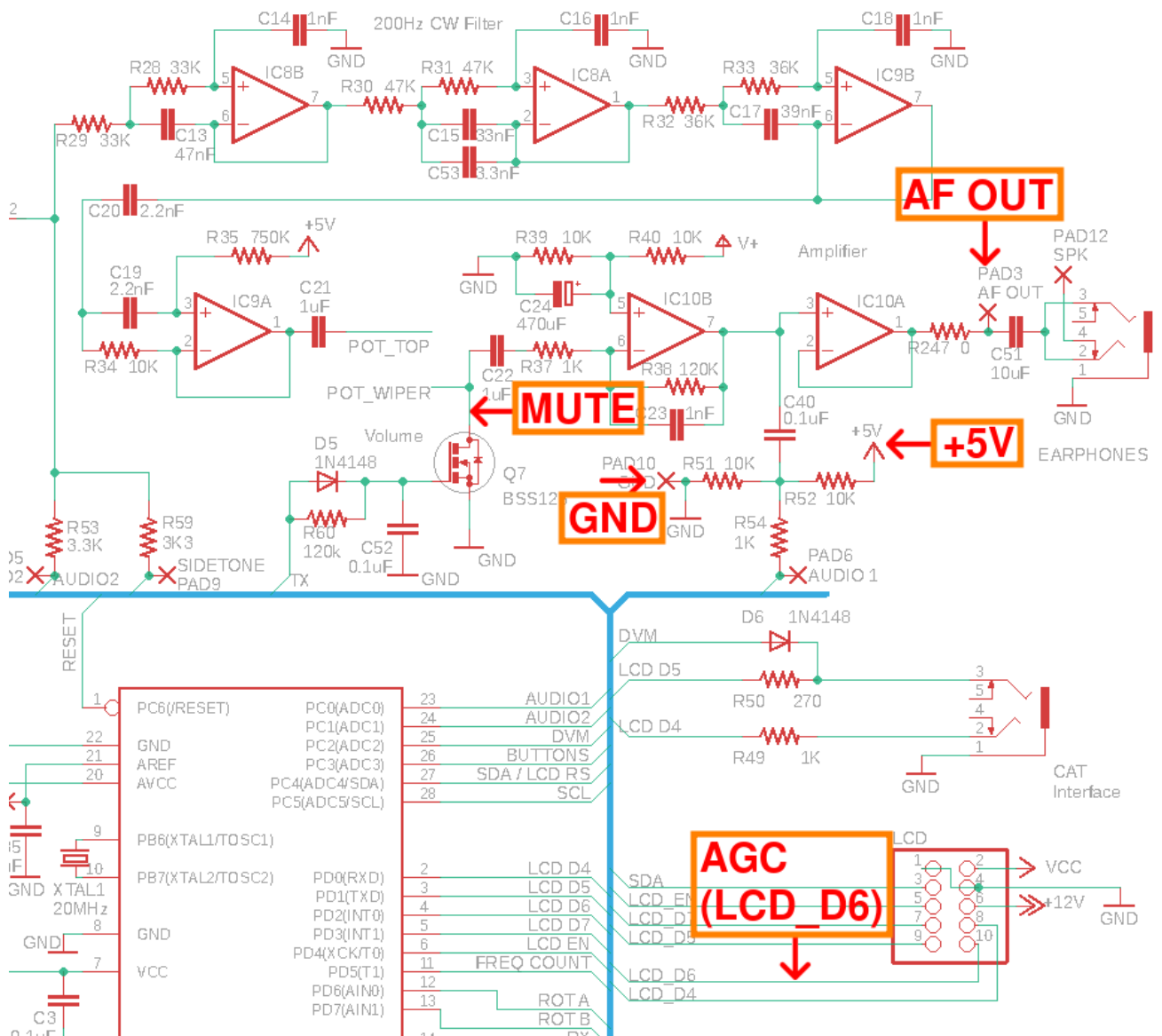


The photograph below shows the completed assembly. This is a QCX-mini 17m, with both TCXO and AGC options installed.



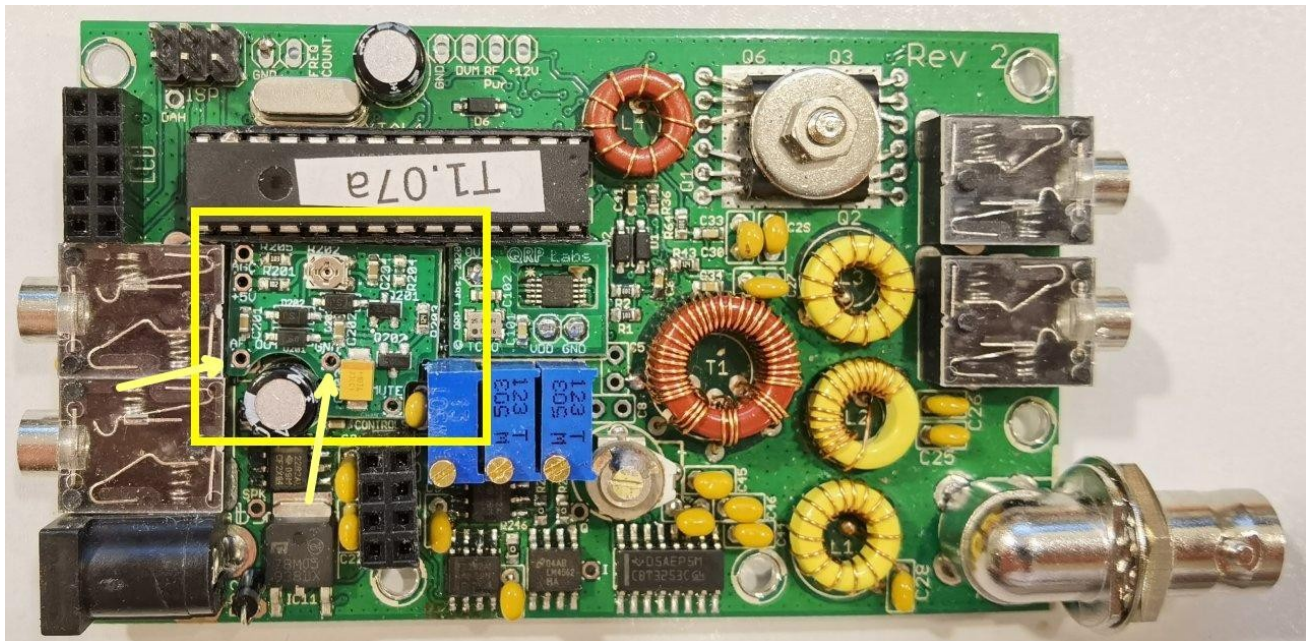
3.2 Installation in QCX-mini PCB Rev 2

The five connections of the AGC PCB are connected to schematic points as shown below.

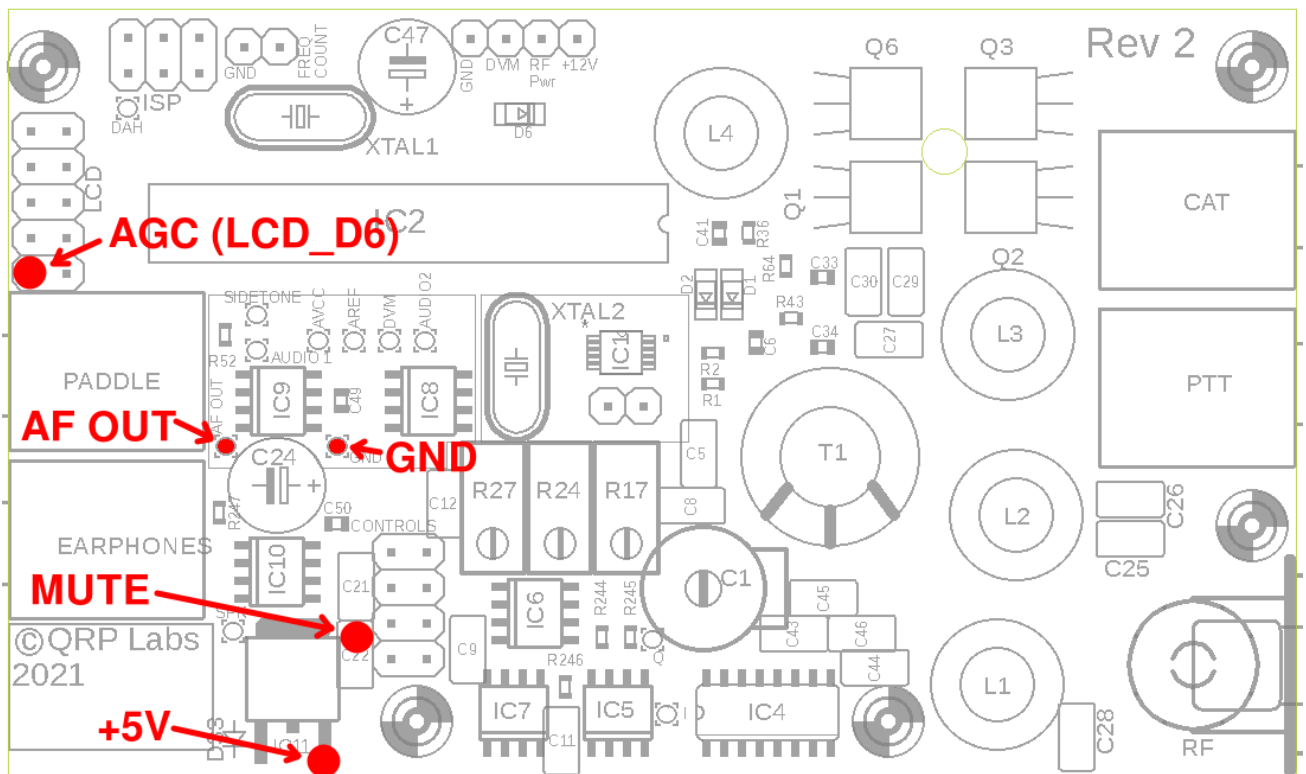


The AGC board fits snugly in the area of the PCB above IC8 and IC9. The AGC PCB shape is designed to fit between the surrounding through-hole components as shown in the photograph below.

Don't worry if it seems a very tight fit or jams with something. If necessary you can carefully file away up to a mm or so at the right edge of the AGC board. Even then, if it doesn't fit totally square, this is not a problem.



The following diagram is for PCB Rev 2:



The “AF OUT” and “GND” connections are the easiest because the holes on the AGC board line up precisely with corresponding existing holes on the main QCX-mini PCB. These holes are the ones nearest to the 470uF capacitor, and are also identified by the yellow arrows in the photograph above.

Before connecting “AF OUT” and “GND”, you should connect three hookup wires to the remaining three connections “+5V”, “MUTE” and “AGC”. I used the same 0.33mm (AWG #28) wire used for winding the toroids. There is always some left over. This is convenient because the wire is thin enough to pass easily through existing holes on the PCB. The

reason for connecting these wires NOW is that you can then ensure that you have tightly trimmed any excess wire on the underside of the AGC board. If you install the wires later and solder them from the top, it would be too easy to have long enough excess wire on the underside of the board, to risk contact with the main QCX-mini PCB.

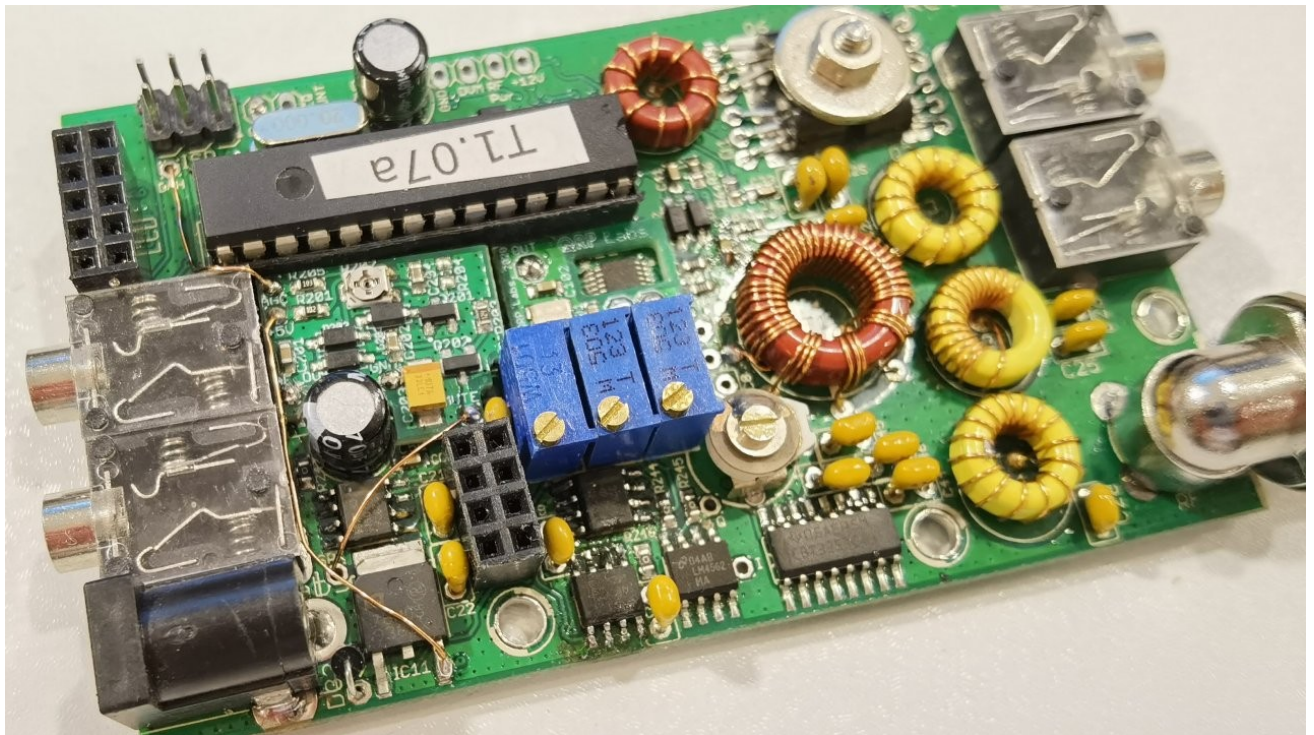
If you are sure that you want the AGC always ON, you can omit the AGC connection (top left pad) and instead add a solder bridge across R204 as described in section 2.2 above.

If you want the capability to switch the AGC ON/OFF from a QCX-mini menu item, then you need to make sure you have firmware 1.08 or higher; and you connect this hookup wire.

Once the three hookup wires are soldered to the “+5V”, “MUTE” and “AGC” pads, you can proceed with making connections for the “AF OUT” and “GND” pads, using component off-cut wires for example.

All you need to do is solder a wire between the two boards (refer to the yellow arrows in the photograph above). For example, you can use two pieces of component lead offcut. Before soldering, ensure that the AGC PCB sits nice and flat on top of the op-amps IC8 and IC9.

The remaining three connections need to be made using hookup wire. In the photographs below, I am using enameled copper wire, left over from the toroid winding:

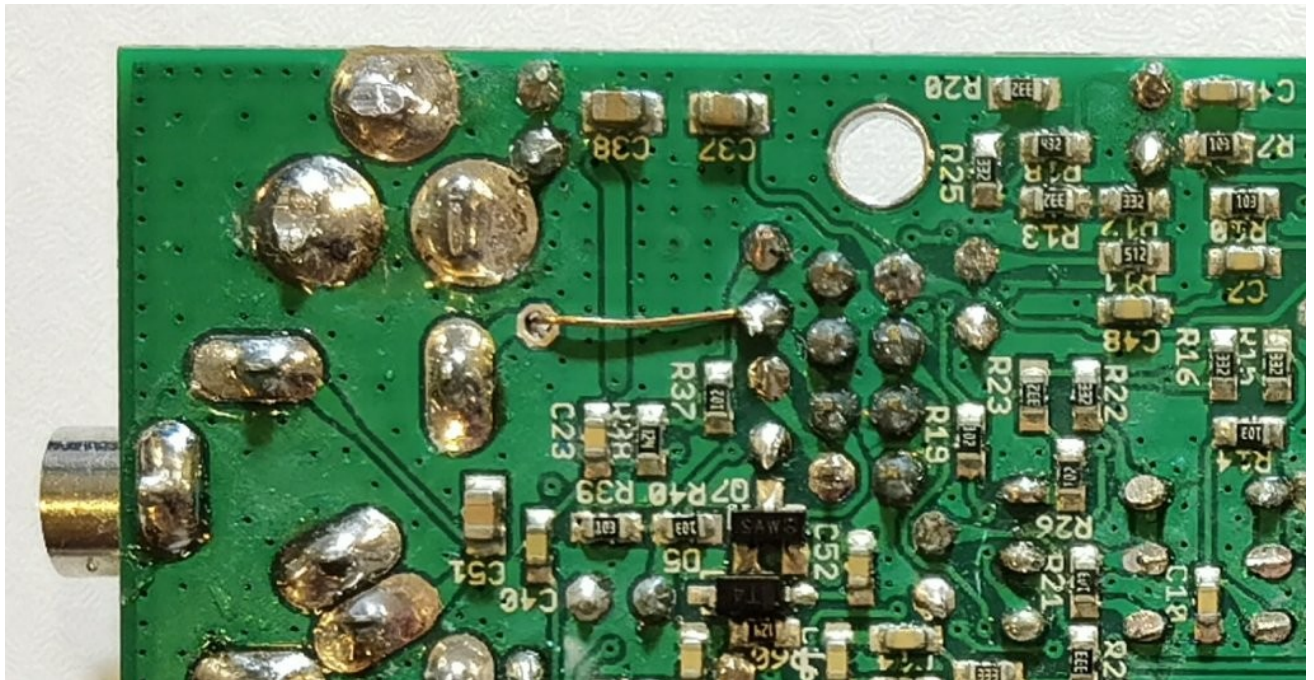


Firstly, the +5V connection must be made from the +5V pad of the AGC board, to the voltage regulator. Connect this wire to the rightmost pin of the 7805 voltage regulator (as shown in the photograph).

Next connect the “MUTE” AGC board pad. This is the bottom right corner connection of the AGC board, nearest the blue rectangular trimmer potentiometers.

The best route for this wire is to take it through the hole which is just between the metal tab of the voltage regulator, and the DC Power connector, in the bottom left corner of the photograph above. Now turn the board over and connect the wire to the one leg of capacitor C22; the wire crosses the board almost horizontally to reach this capacitor leg.

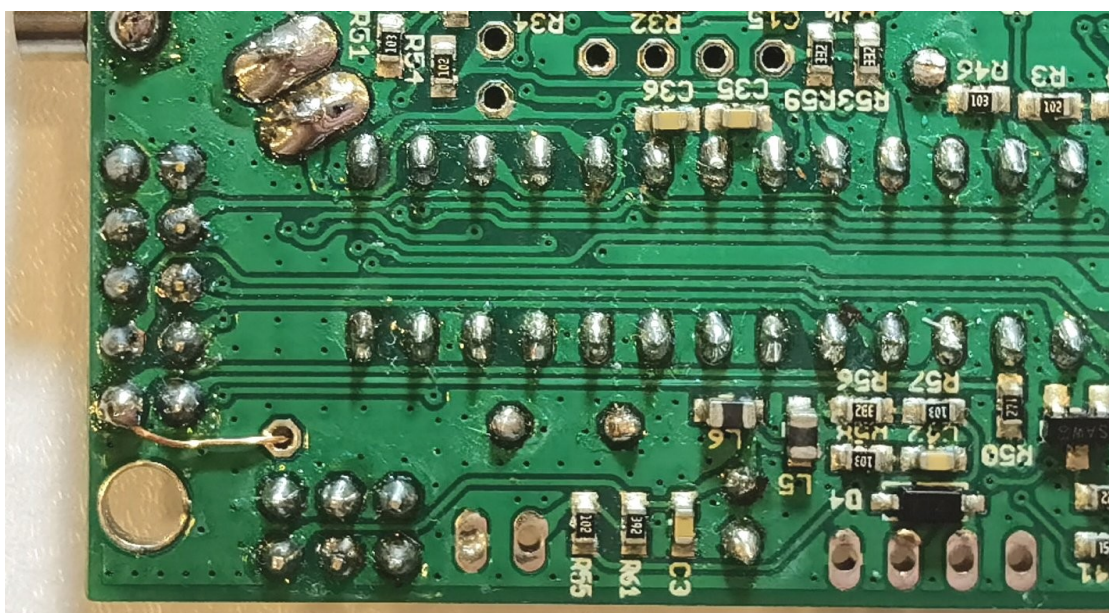
Please refer to the photograph below. Remember to first remove the wire enamel if you are using enameled copper wire; either by sanding it or scraping with a knife or my preferred method: heating it in a blob of solder on the tip of the soldering iron.



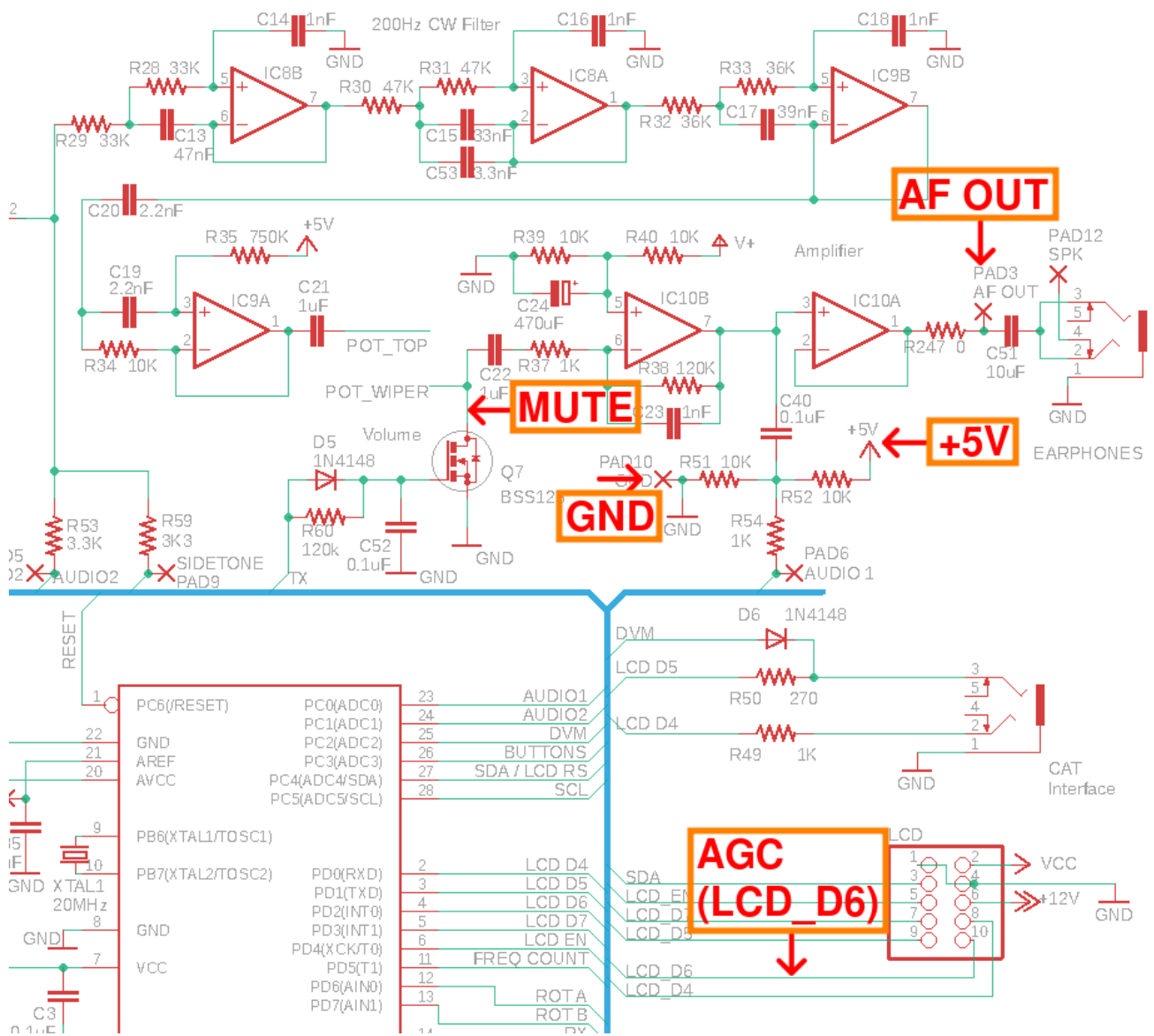
Finally, the connection that controls AGC ON/OFF, if you are installing it.

The “AGC” control signal connection is in the top corner of the board and shown in the photograph on the preceding page. This should be passed through the hole in the board that is labeled ‘DVM’; this hole is on the right, next to the 2x5-pin display board header, near the top left of the main QCX-mini PCB in the photograph on the preceding page.

Now turn the board over and solder the wire carefully to the bottom left pin of the 2x5-pin header, which is the pin nearest the board edge and the corner of the board. Refer to the photograph below. Remember to first remove the wire enamel if you are using enameled copper wire; either by sanding it or scraping with a knife or my preferred method: heating it in a blob of solder on the tip of the soldering iron.



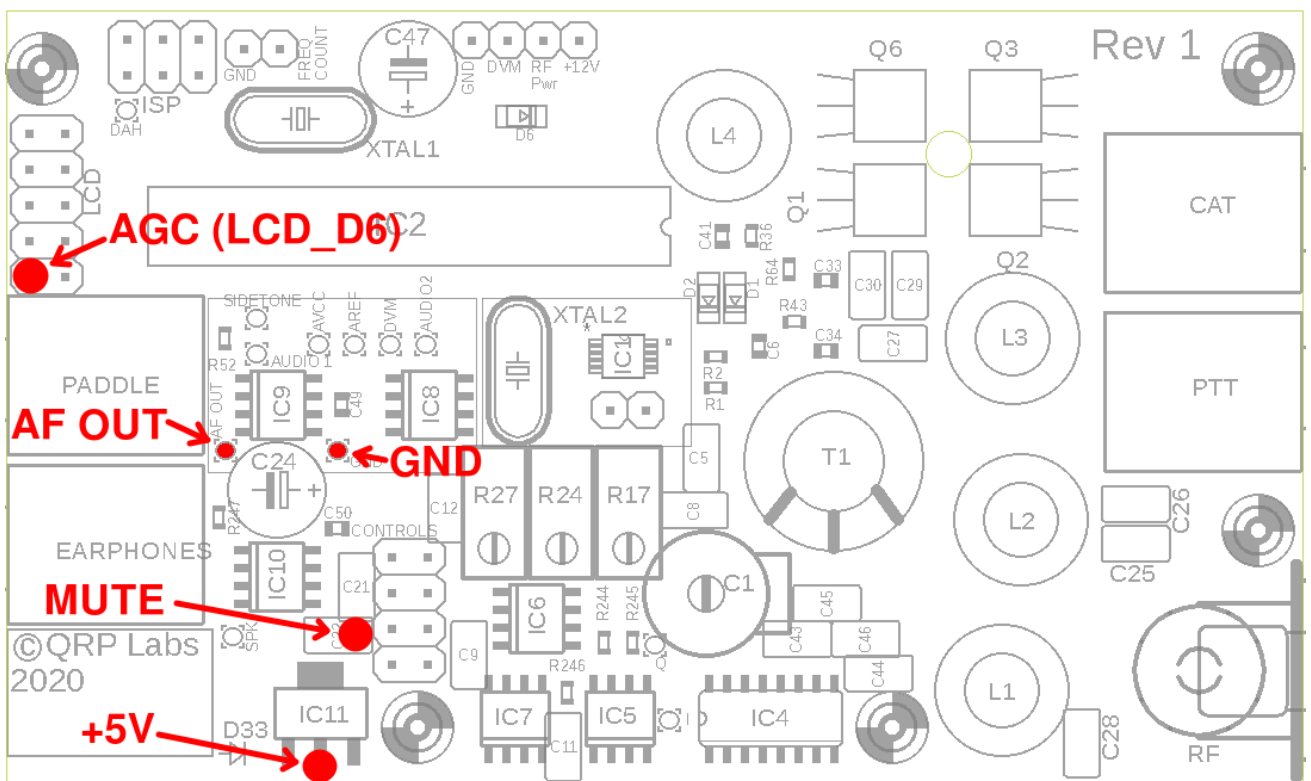
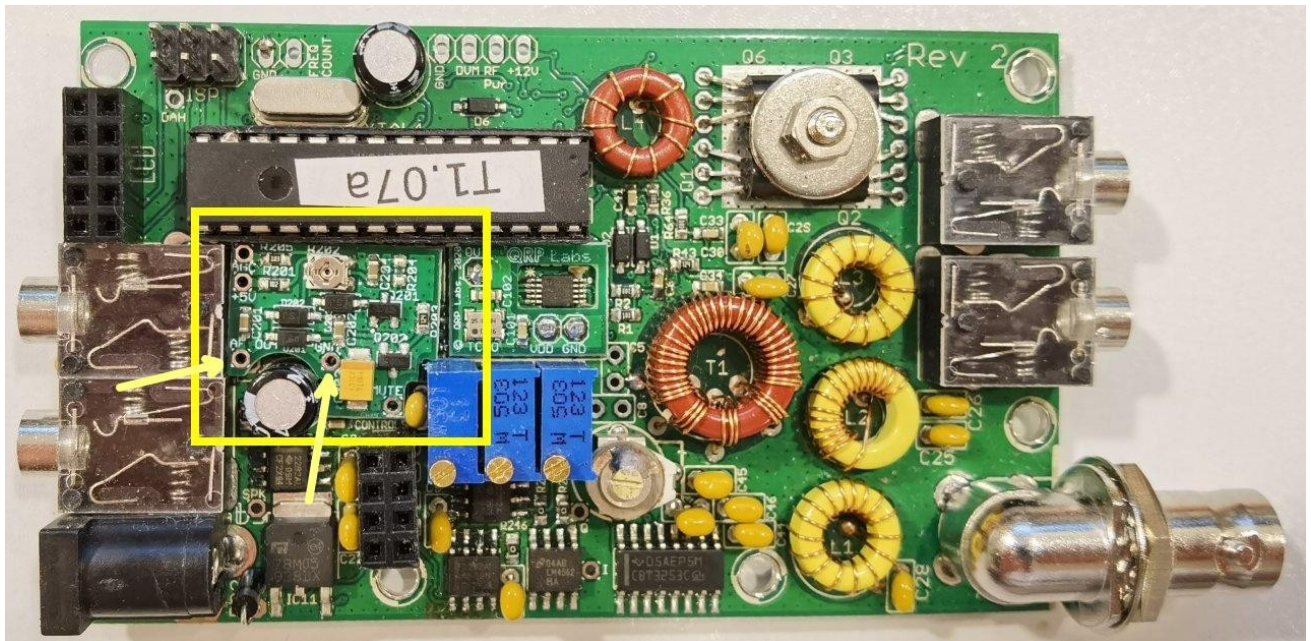
3.3 Installation in QCX-mini PCB Rev 1



The AGC board fits snugly in the area of the PCB above IC8 and IC9. The AGC PCB shape is designed to fit between the surrounding through-hole components as shown below.

Don't worry if it seems a very tight fit or jams with something. If necessary you can carefully file away up to a mm or so at the right edge of the AGC board. Even then, if it doesn't fit totally square, this is not a problem.

The following photograph is of PCB Rev 2 but applies equally to PCB Rev 1.



The “AF OUT” and “GND” connections are the easiest because the holes on the AGC board line up precisely with corresponding existing holes on the main QCX-mini PCB. These holes are the ones nearest to the 470uF capacitor, and are also identified by the yellow arrows in the photograph above.

Before connecting “AF OUT” and “GND”, you should connect three hookup wires to the remaining three connections “+5V”, “MUTE” and “AGC”. I used the same 0.33mm (AWG #28) wire used for winding the toroids. There is always some left over. This is convenient because the wire is thin enough to pass easily through existing holes on the PCB. The reason for connecting these wires NOW is that you can then ensure that you have tightly trimmed any excess wire on the underside of the AGC board. If you install the wires later

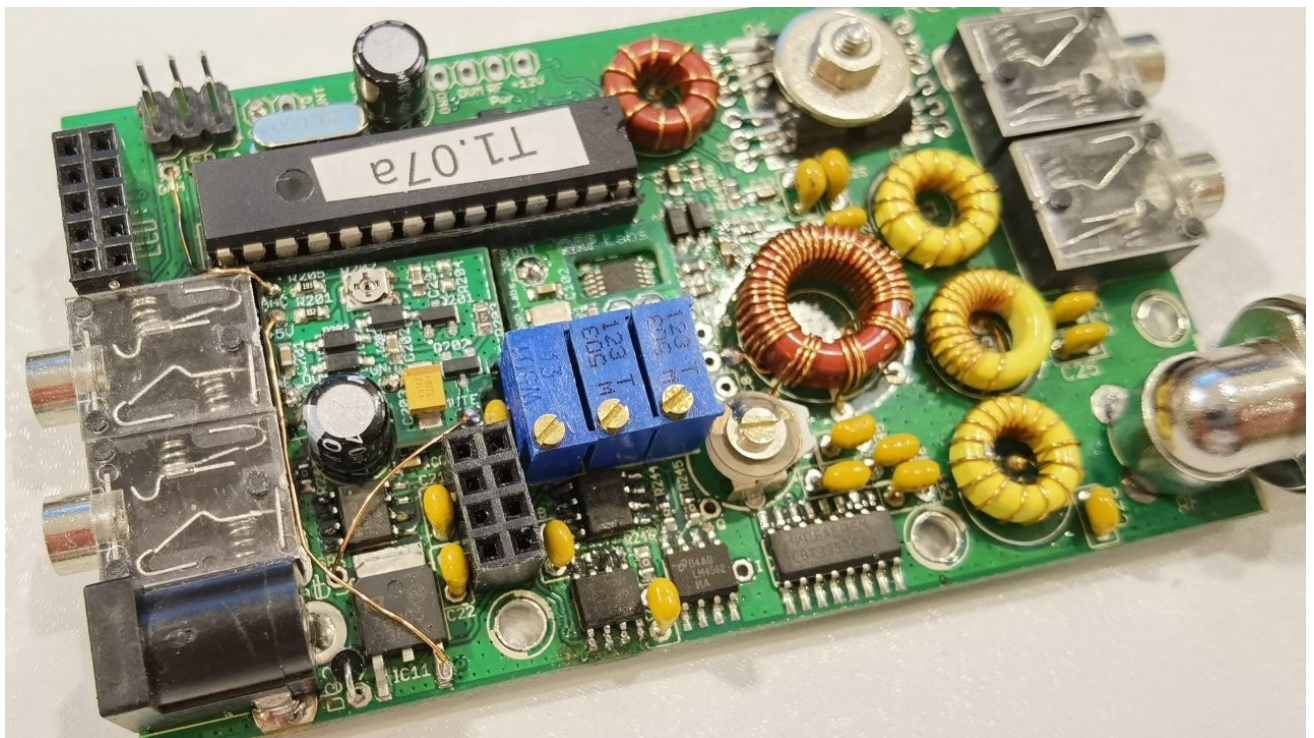
and solder them from the top, it would be too easy to have long enough excess wire on the underside of the board, to risk contact with the main QCX-mini PCB.

If you are sure that you want the AGC always ON, you can omit this connection and instead add a solder bridge across R204 as described in section 2.2 above.

If you want the capability to switch the AGC ON/OFF from a QCX-mini menu item, then you need to make sure you have firmware 1.08 or higher; and to connect this hookup wire.

All you need to do is solder a wire between the two boards (refer to the yellow arrows in the photograph above). For example, you can use two pieces of component lead offcut. Before soldering, ensure that the AGC PCB is sitting nice and flat on top of the op-amps IC8 and IC9.

Once the three hookup wires are soldered to the “+5V”, “MUTE” and “AGC” pads, you can proceed with making connections for the “AF OUT” and “GND” pads. These remaining three connections need to be made using hookup wire. In the photographs below, I am using enameled copper wire, left over from the toroid winding. The following photograph is Rev 2, but applies equally to Rev 1, except that on Rev 1 the +5V wire is soldered to the center pin of the voltage regulator (see diagram above).

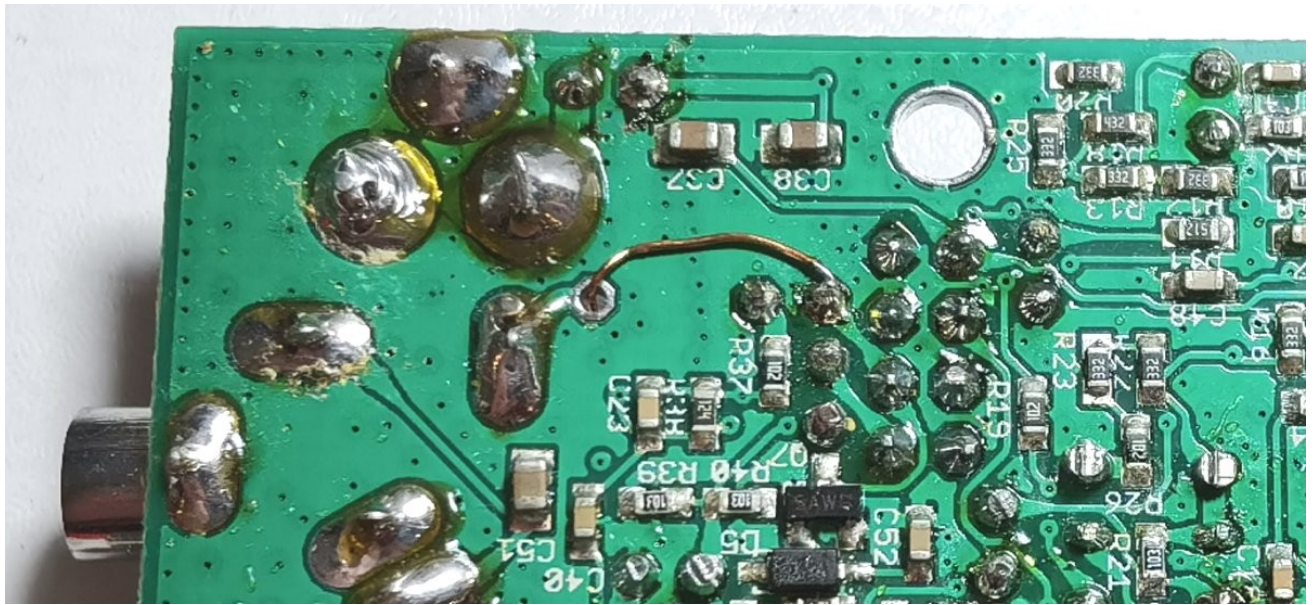


Firstly, the +5V connection must be made from the +5V pad of the AGC board, to the voltage regulator. **Connect this wire to the center pin of the AMS1117-5.0 voltage regulator (as shown in the diagram on the preceding page, NOT the above photo which is a Rev 2 board).**

Next connect the “MUTE” AGC board pad. This is the bottom right corner connection of the AGC board, nearest the blue rectangular trimmer potentiometers.

The best route for this wire is to take it through the hole which is just between the metal tab of the voltage regulator, and the DC Power connector, in the bottom left corner of the photograph above. Now turn the board over and connect the wire to the one leg of capacitor C22 as shown; the wire crosses the board almost horizontally to reach this

capacitor leg. Please refer to the photograph below. Remember to first remove the wire enamel if you are using enameled copper wire; either by sanding it or scraping with a knife or my preferred method: heating it in a blob of solder on the tip of the soldering iron.

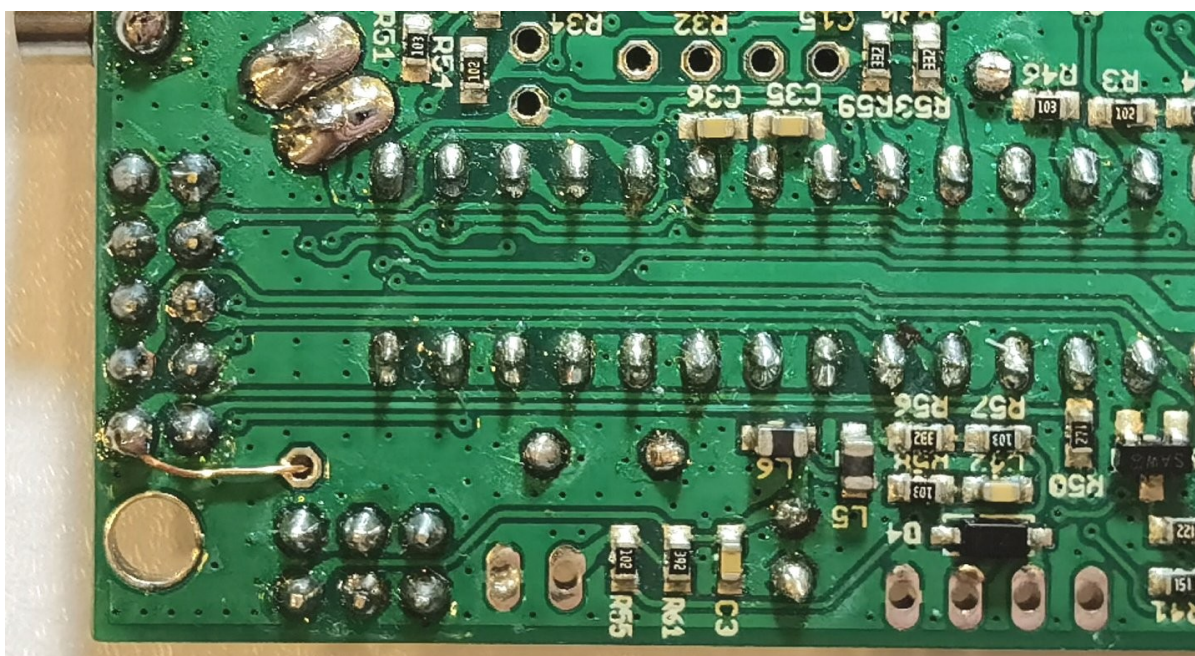


Finally, the connection that controls AGC ON/OFF, if you are installing it.

The “AGC” control signal connection is in the top left corner of the board and shown in the photograph on the preceding page. This should be passed through the hole in the board that is labeled ‘DVM’; this hole is on the right, next to the 2x5-pin display board header, near the top left of the main QCX-mini PCB in the photograph on the preceding page.

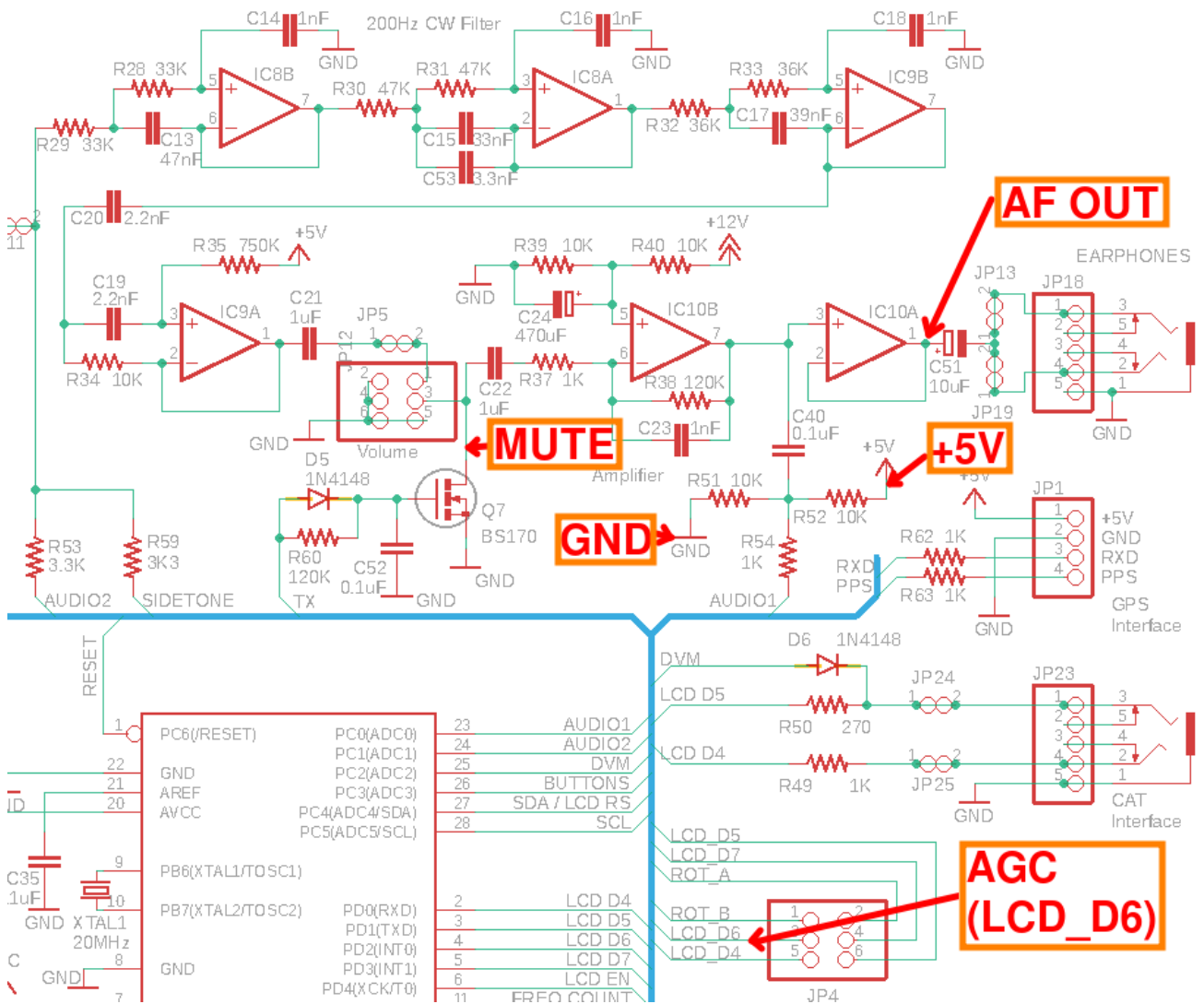
Now turn the board over and solder the wire carefully to the bottom left pin of the 2x5-pin header, which is the pin nearest the board edge and the corner of the board. Refer to the photograph below.

Remember to first remove the wire enamel if you are using enameled copper wire; either by sanding it or scraping with a knife or my preferred method: heating it in a blob of solder on the tip of the soldering iron.



3.4 Installation in QCX+ Rev 1, 2 and 3

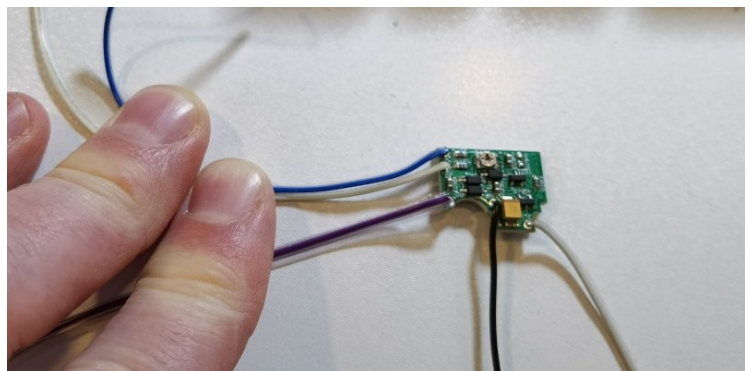
The five connections of the AGC PCB are connected to schematic points as shown below.

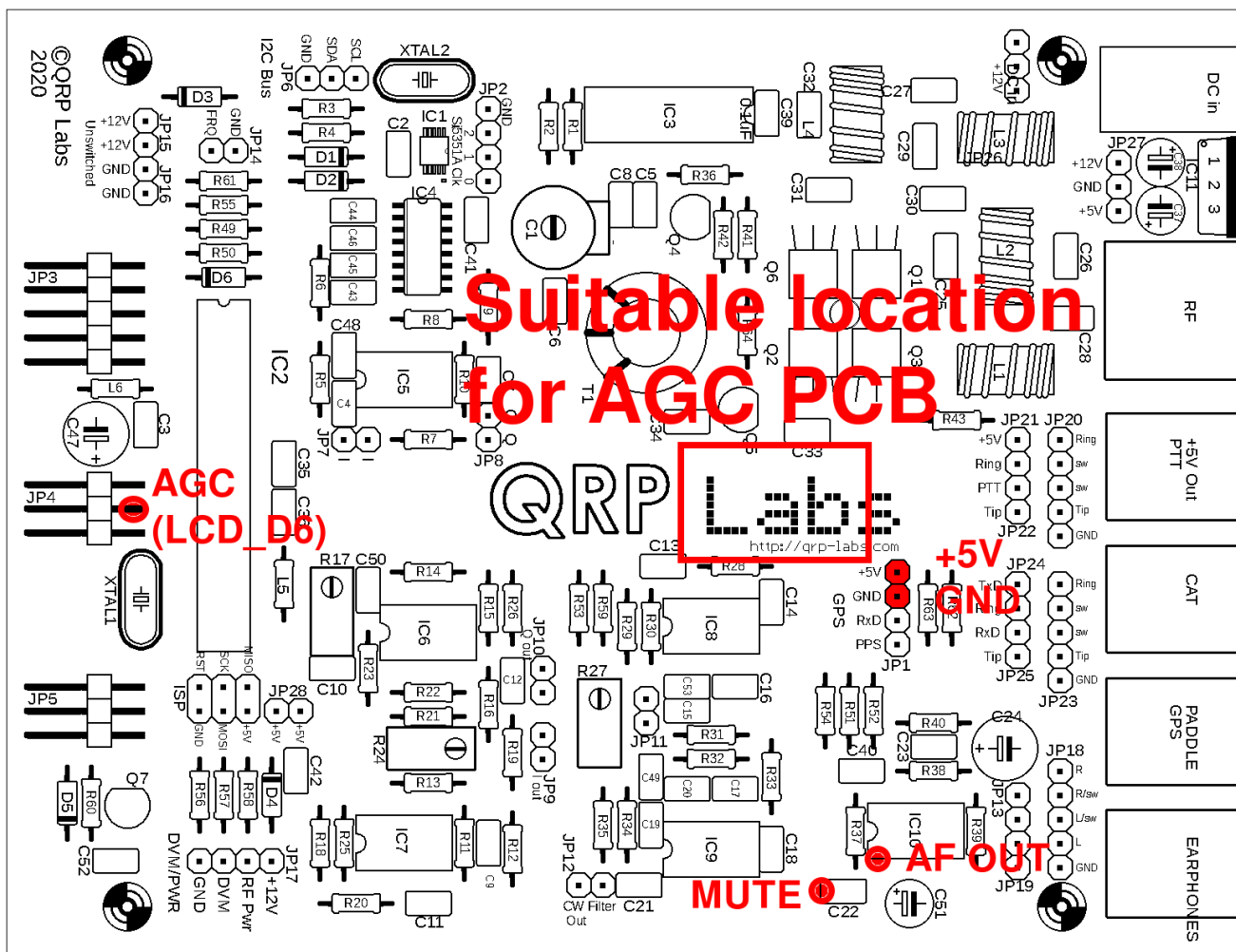


The AGC board needs a place to sit. An appropriate location where there is enough space, is on top of the “Labs” part of the QRP Labs logo, right in the middle of the QCX+ PCB. You can secure it to the PCB using double-sided tape or hot glue or some other type of glue. Before gluing it down, solder on five hookup wires for the five connections.

If you are sure that you want the AGC always ON, you can omit this connection and instead add a solder bridge across R204 as described in section 2.2 above.

If you want the capability to switch the AGC ON/OFF from a QCX-mini menu item, then you need to make sure you have firmware 1.08 or higher; and you need to connect this hookup wire.





The five hookup wires should be soldered as follows. Refer to the photograph below.

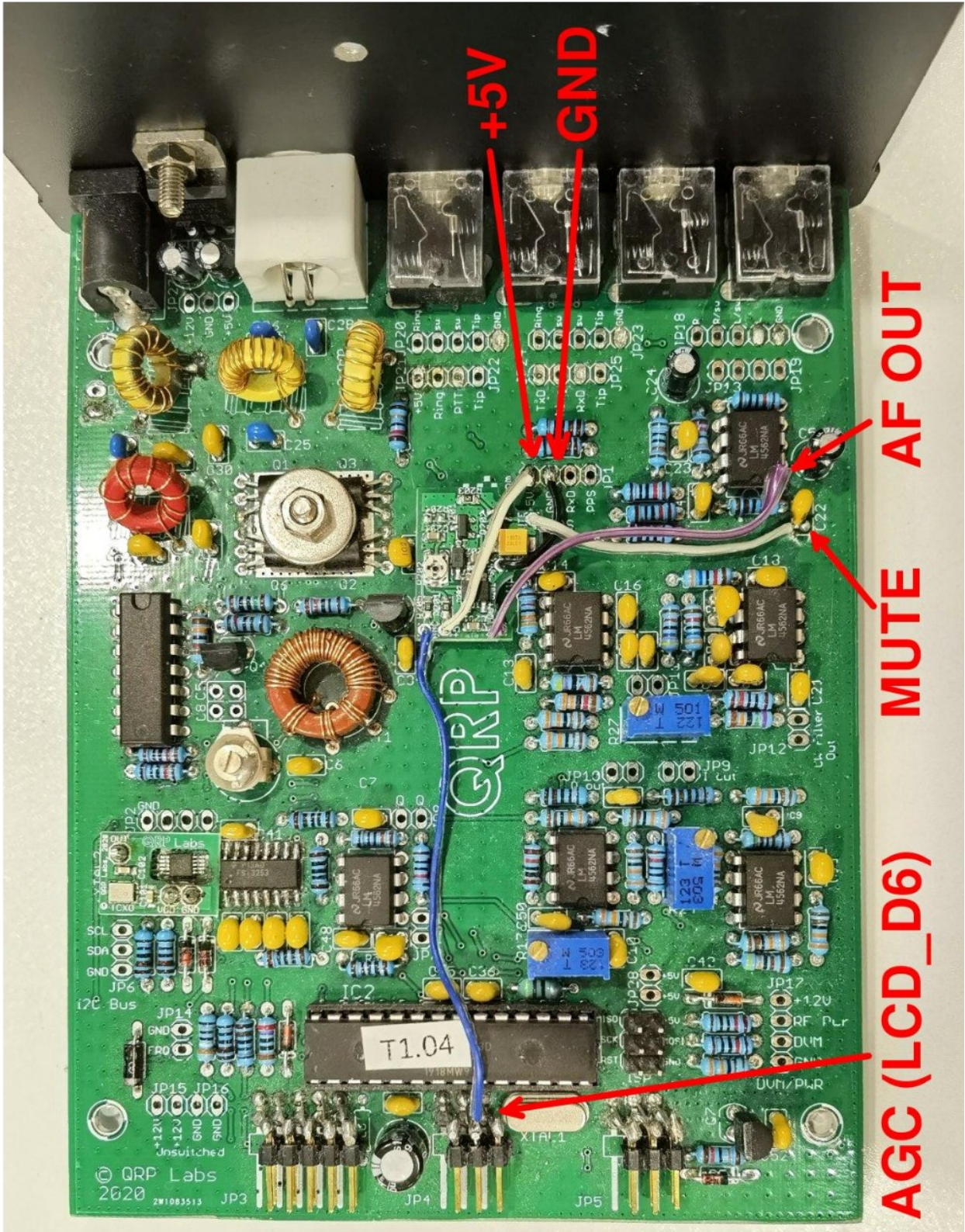
+5V (white wire in the photograph): this can be conveniently soldered to the +5V pin header of the GPS connection strip. There are also other alternative locations if you prefer, such as at JP21 behind the PTT jack connector.

GND (black wire in the photograph): this can be conveniently soldered to the GND pin header of the GPS connection strip, or any other convenient location if you prefer, such as JP23 behind the CAT jack connector.

AF OUT (purple wire in the photograph): should be soldered directly to IC10 pin 1. Note that IC10 pin 1 and pin 2 are connected together. So if you accidentally create a solder bridge between pins 1 and 2, there is no harm done.

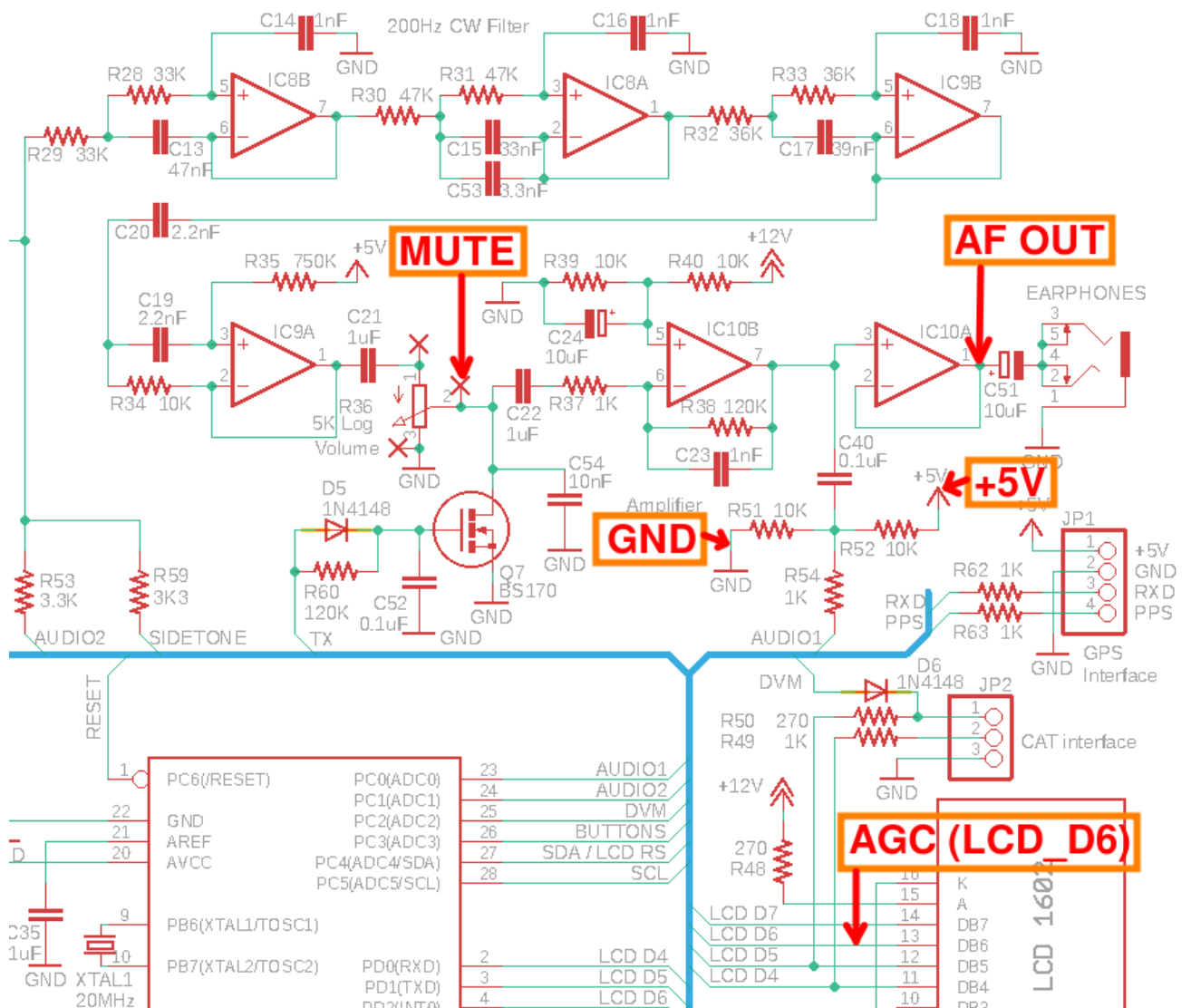
MUTE (pale grey wire in the photograph): should be soldered to the left hand side of capacitor C22 (the side of C22 that is furthest from chip IC10 as shown in the photograph). With care, you will be able to solder the wire to the pad on the top side of the board. You can use a DMM to check for short circuits if you are worried that you may have created a short with a solder bridge.

AGC (blue wire in the photograph): IF you are connecting the AGC On/Off control signal: This should be connected to the middle top pin of the middle pin header connector between the front and main boards. This is the LCD_D6 signal.

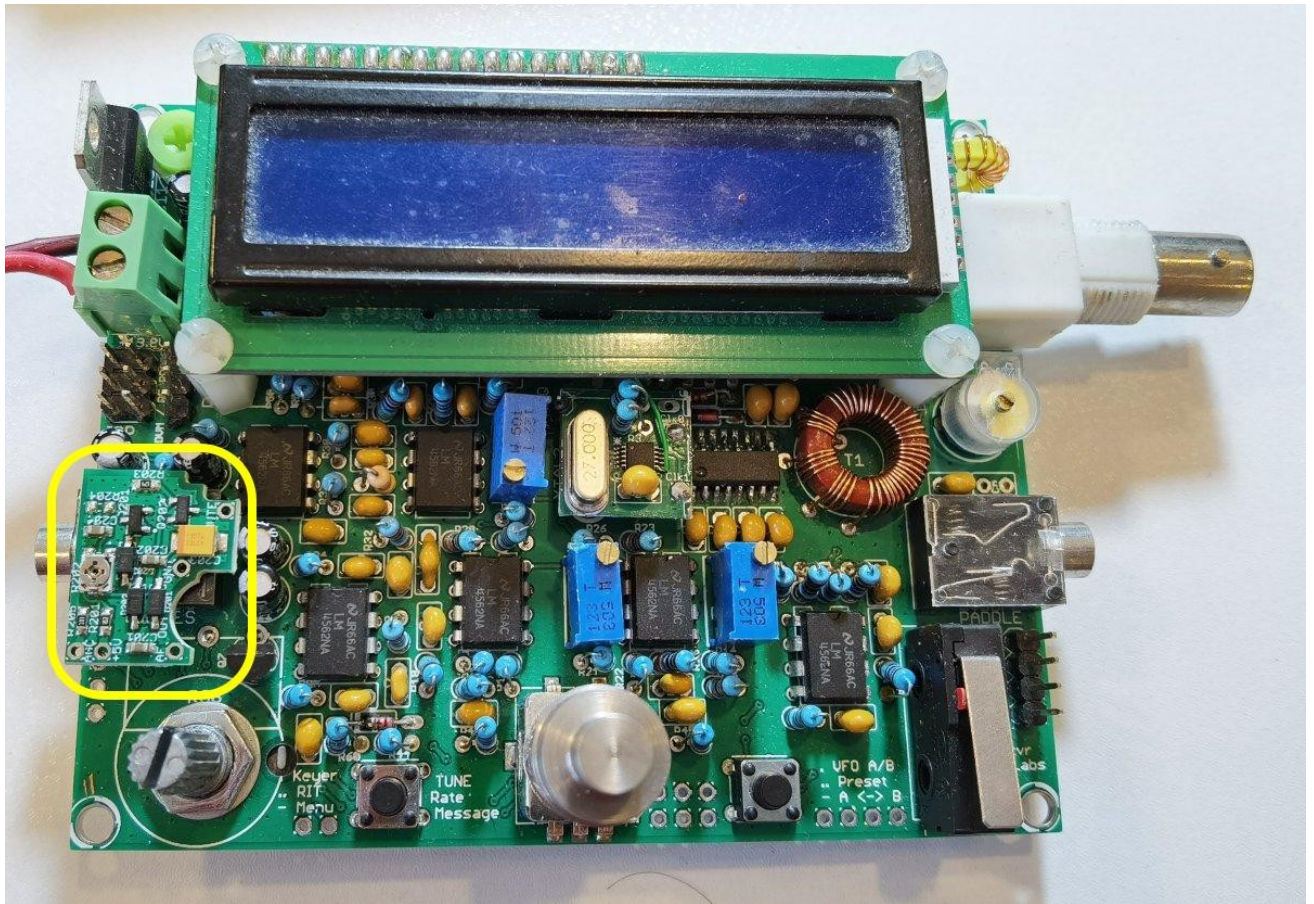


3.5 Installation in QCX (QCX Classic) Rev 1, 2, 3, 4 and 5

The five connections of the AGC PCB are connected to schematic points as shown below.



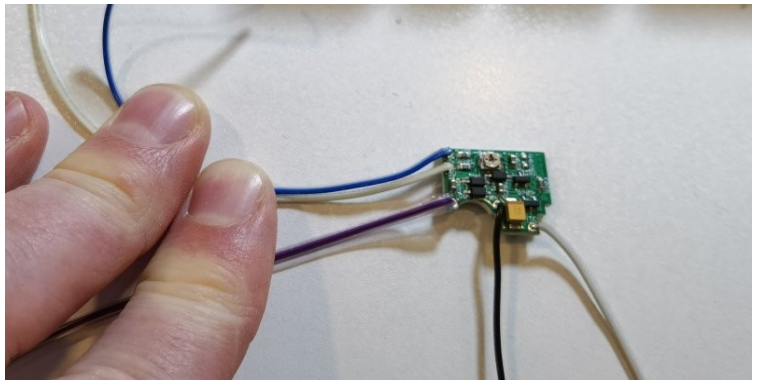
The AGC board needs a place to sit. An appropriate location where there is enough space, is on top of the audio output jack connector on the left side of the QCX PCB. You can secure it to the PCB using double-sided tape or hot glue or some other type of glue.

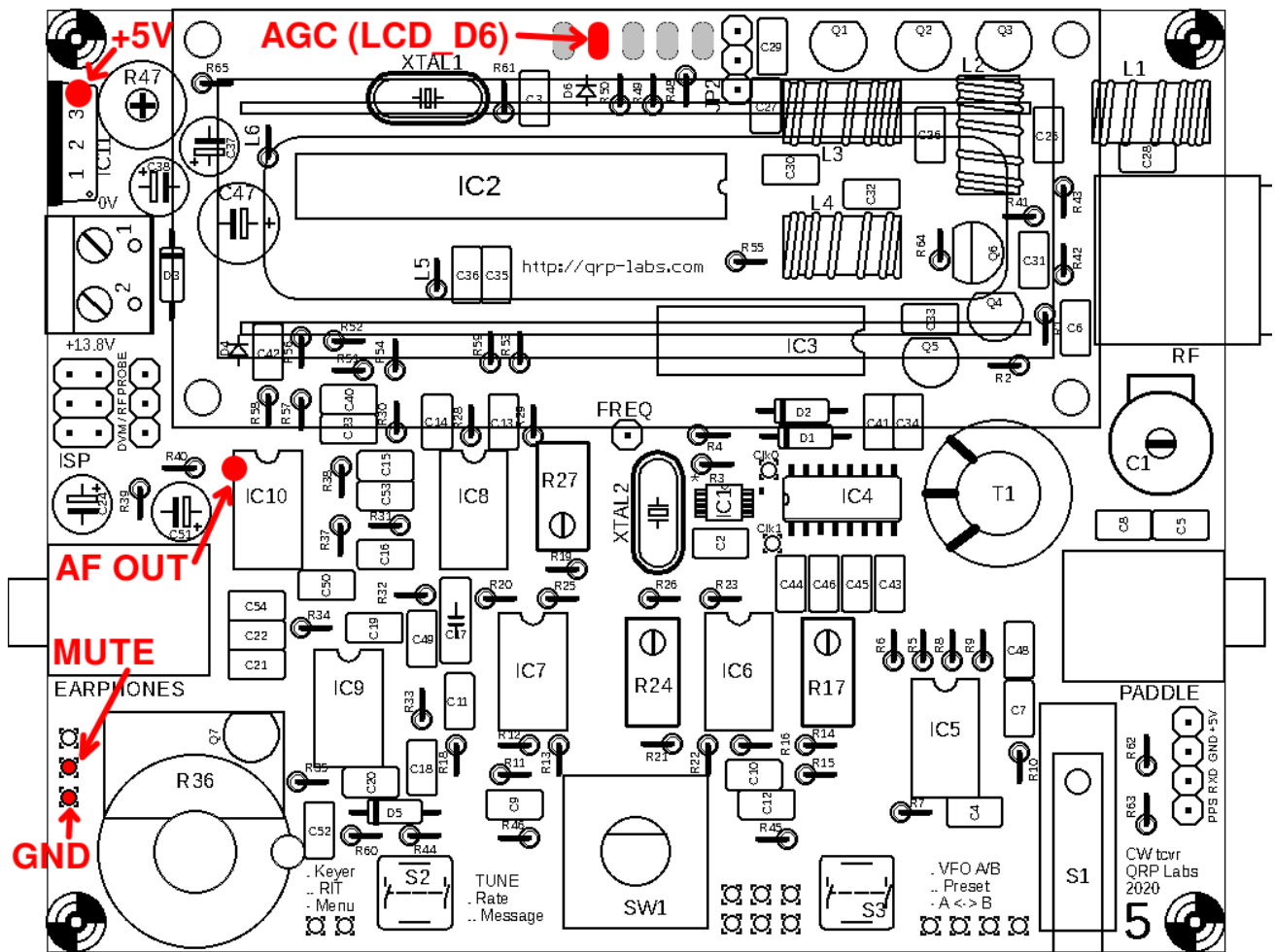


Before gluing it down, solder on five hookup wires for the five connections.

If you are sure that you want the AGC always ON, you can omit this connection and instead add a solder bridge across R204 as described in section 2.2 above.

If you want the capability to switch the AGC ON/OFF from a QCX-mini menu item, then you need to make sure you have firmware 1.08 or higher; and you need to connect this hookup wire.





The five hookup wires should be soldered as follows. Refer to my diagram above.

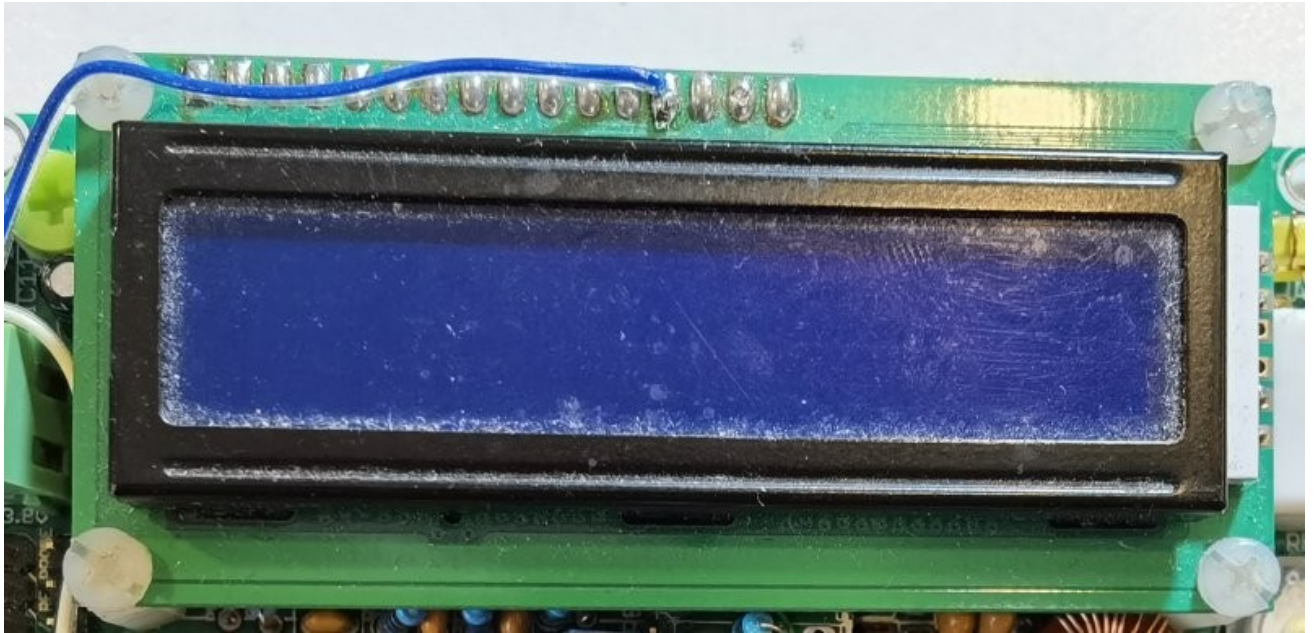
+5V (white wire in the photographs): this can be soldered to the +5V pin of the 7805 voltage regulator chip, on the top side of the board or the bottom side, as you prefer; it is the pin closest to the top left corner of the board. You may prefer other locations but make sure they are really connected to + 5V.

GND (black wire in the photographs): this can be conveniently soldered to the GND pin header of the R36 off-board header pads if not in use, or any other convenient location if you prefer. It is the pad closed to the bottom left corner of the board.

AF OUT (purple wire in the photographs): should be soldered directly to IC10 pin 1. Note that IC10 pin 1 and pin 2 are connected together. So if you accidentally create a solder bridge between pins 1 and 2, there is no harm done.

MUTE (pale grey wire in the photographs): should be soldered to the left middle pad of the R36 off-board headers. .

AGC (blue wire in the photographs): IF you are connecting the AGC On/Off control signal: This should be connected to D6 of the LCD module directly; this is the 4th pin from the right, as shown in the above diagram and the photograph below.



4. Resources

- For updates relating to this kit please visit the QRP Labs AGC module page <http://qrp-labs.com/agc>
- For any questions regarding the assembly and operation of this kit please join the QRP Labs group, see <http://qrp-labs.com/group> for details

5. Document Revision History

1.00 03-Dec-2021 First version 1.00