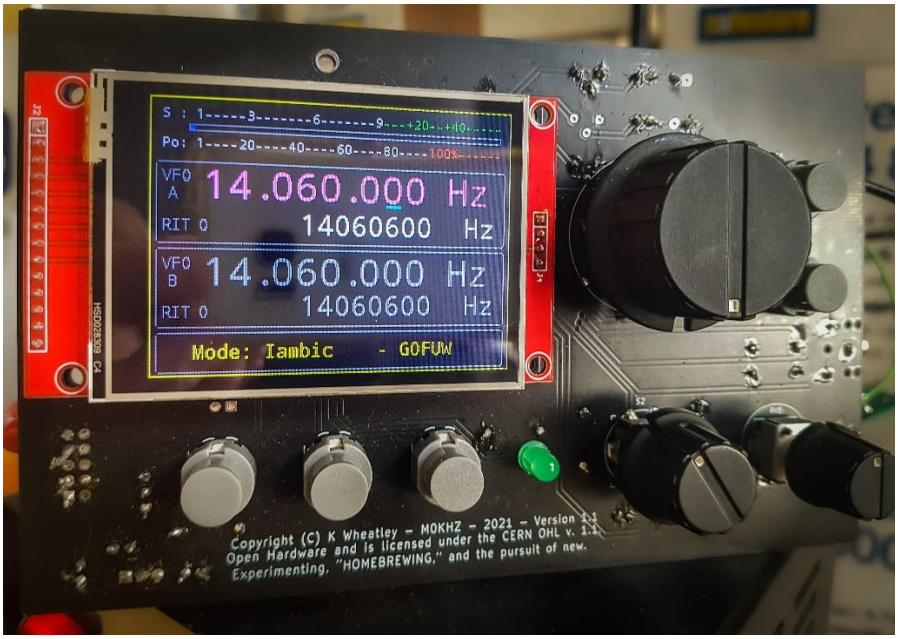
Sudden SCD Digital VFO – Outline Instructions



Introduction

This module was developed as part of the update of the G3RJV SCD project. However, it occurred to me that it could be used to join up the G-QRP Club's Limerick Sudden Receiver and Transmitter kits, or indeed, any direct conversion receiver/CW transmitter combination.

In addition to the twin digital VFO function, the module provides Receiver Incremental Tuning (RIT), sidetone, a keyer with some memories, and an audio S-meter. The receiver's gain pot can also be fitted so the PCB effectively becomes your rig's front panel.

These instructions outline how to build the Digital VFO and how to connect it to the Sudden kits. They assume a degree of knowledge about using Arduino microprocessors and their like.

I must record massive thanks to Kevin, M0KHZ, for the detailed design and the PCB layout.

73, Steve, G0FUW

Chairman

G-QRP Club

Version 2.3

Module Overview

The module is driven by a Teensy 3.2 microprocessor. This has been described by some as an Arduino on steroids. It is small, not expensive, has lots of computing power and is easy to programme.

The Teensy's software functions includes RF frequency generating via two independent VFOs, Receiver Incremental Tuning (RIT), S-meter, keyer and sidetone.

The frequency generating bit is done by an Si5351 break out board. One of the Clock outputs provides RF to the Receiver PCB and another Clock output goes to the Transmitter PCB. The Teensy switches the Clocks on and off with the keying action. This could probably do a full break-in system but the Sudden combination is not geared up for that. The outputs go via pre-set potentiometers so you can easily set the levels to suit your project.

Main Tuning and RIT is provided by a pair of rotary encoders. The tuning step size can be selected from the front panel; 100kHz, 10kHz, 1kHz, 100Hz, 10Hz.

The RIT can be set to a predetermined off-set, or you can set it to zero, tune a station to zero beat and then use the RIT to get the tone you want. The benefit of the second method is that you can tune either side of zero beat to avoid QRM.

The display is a 2.8" colour TFT screen. It includes the S-meter, frequencies for VFO A and VFO B, the keyer mode and your callsign.

The keyer can be set to a wide range of speeds and a number of modes. It includes some memories too. Instructions are built in and are displayed on the screen.

There is space on the PCB for the Receiver RF Gain pot, in case you want to integrate your Sudden kits into a single transceiver enclosure.

Parts Required

Many parts are 'common or garden' varieties and are widely available. (Suggested suppliers and parts numbers for the less-common parts are included, but you may know of others). These are suggested, rather than recommended, and there may be better ones out there!

Parts List

PCB (G-QRP Club Sales)

Teensy 3.2 microprocessor (U1)

- www.CoolComponents.co.uk part number 1775

TFT 2.8" 240x320 display (U2)

- https://www.ebay.co.uk/itm/264490769841

Si5351 Break Out Board (U3)

- https://www.ebay.co.uk/itm/313148052130

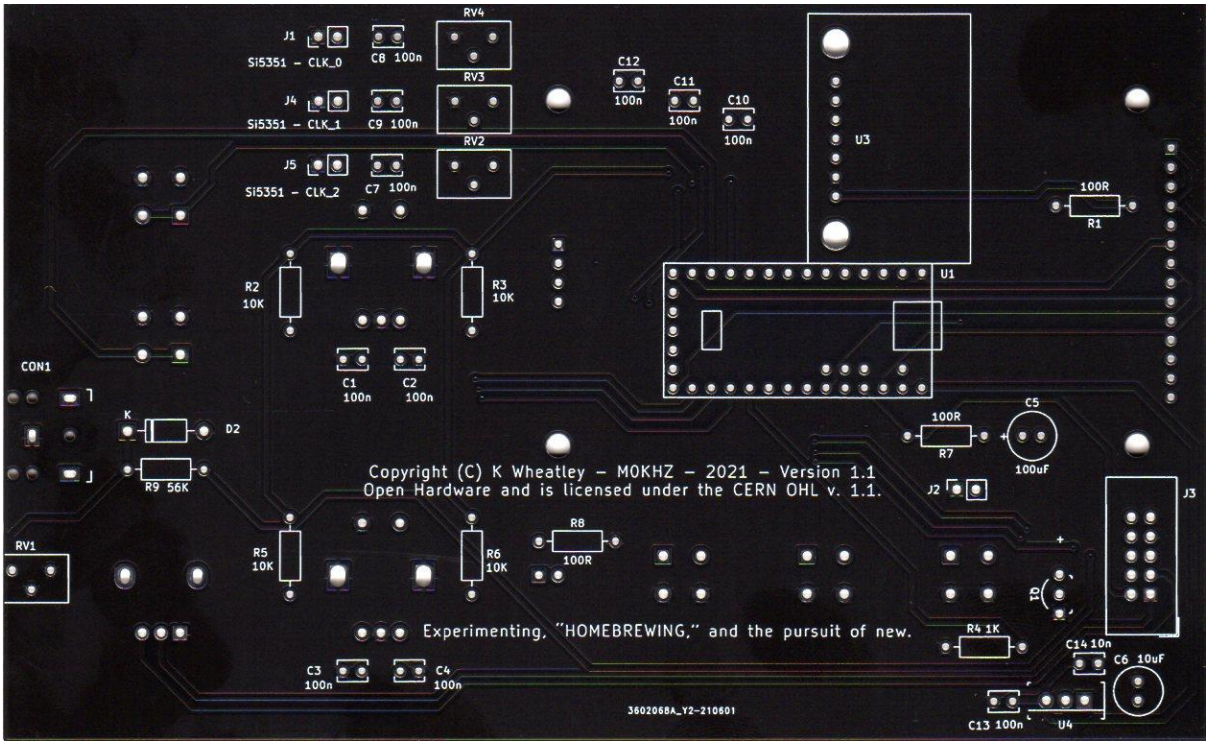
Other parts:

- Encoders with push switch = 2 (S1 & S2)
  - www.DigiKey.co.uk part number PEC11R-4215F-S0024-ND or
  - www.uk.rs-online.com part number PEC11R-4215F-S0024
- Push to Make switches = 5 (S3-7)
  - www.DigiKey.co.uk part number 401-1973-ND
- 3.5mm key socket = 1 (CON 1)
- LED = 1 (D1)
- 2v4 Zener diode = 1 (D2)
- 2N7000 = 1 (Q1)
- 7805 Voltage Regulator = 1 (U4)

- 100Ω = 3 (R1, R7, R8)
- 1kΩ = 1 (R4)
- 10kΩ = 4 (R2, R3, R5, R6)
- 56kΩ = 1 (R9)
- 20kΩ pre-set pot = 1 (RV1)
    - www.DigiKey.co.uk part number 3299P-203LF-ND
- 1kΩ pre-set pot = 1 (RV2 & RV4)
    - www.uk.rs-online.com part number 3386V-1-102LF
- 1kΩ Lin pot = 1 (RV4)
    - www.uk.rs-online.com part number PTV09A-4025F-B103
- 100nF = 11 (C1, C2, C3, C4, C7, C8, C10, C12, C13)
- 10nF = 1 (C14)
- 10uF = 1 (C6)
- 100uF = 1 (C5)
- 3 or 4 pin header =1, & 14 pin header = 2
    - www.uk.rs-online.com part number 251-8632 provides enough with a few spare
- Knob large = 1 (VFO)
- Knob Medium = 1 (RIT)
- Knob small = 1 (RF Gain)

Build Instructions

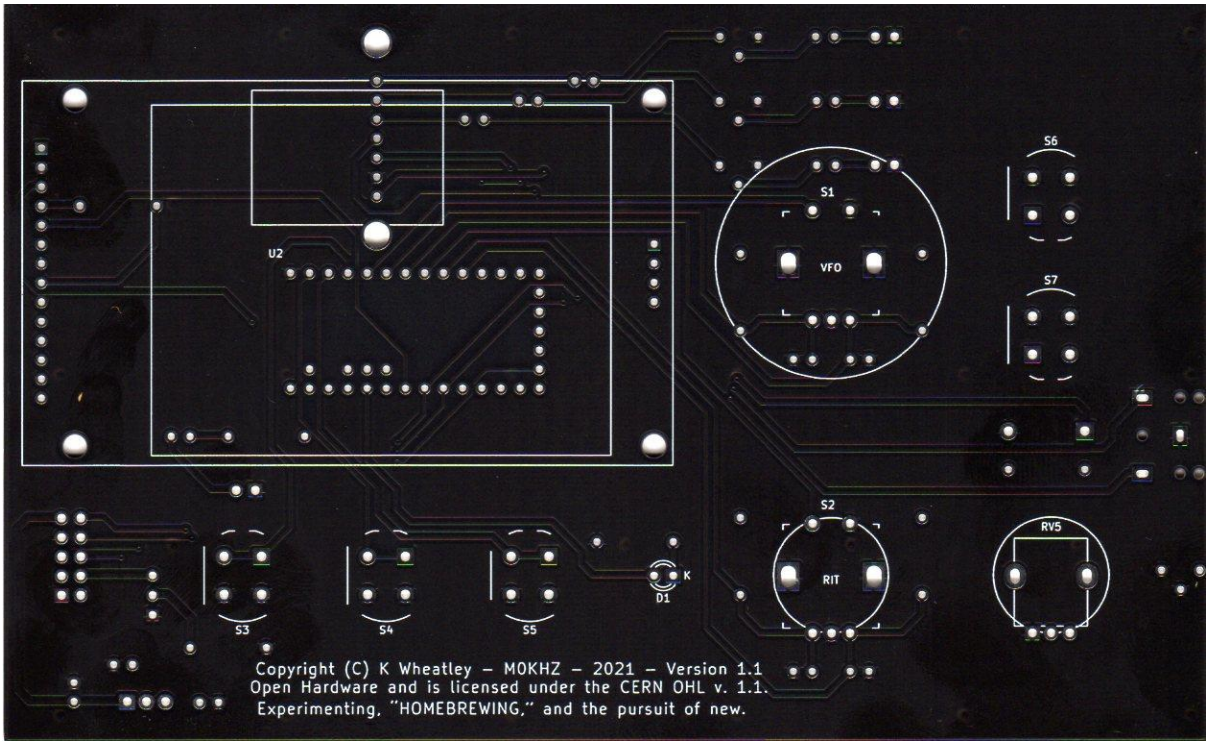
Stage 1 – Fitting Resistors, Capacitors and other parts to rear side



Fit the following on side showing component outlines:

R1	100Ω		C1	100nF	
R2	10kΩ		C2	100nF	
R3	10kΩ		C3	100nF	
R4	1kΩ		C4	100nF	
R5	10kΩ		C5	100uF	
R6	10kΩ		C6	10uF -ve next to C6 label	
R7	100Ω		C7	100nF	
R8	100Ω		C8	100nF	
R9	56kΩ		C10	100nF	
RV1	20k pre-set pot		C12	100nF	
RV2	1k pre-set pot		C13	100nF	
RV4	1k pre-set pot		C14	10nF	
CON1	3.5mm Key socket		Q1	2N7000 – note flat side faces edge of PCB	
U4	5v Regulator –fit a heatsink, or bolt to metal case?		D2	Zener diode - note cathode faces RV1	

Stage 2 – Fitting LED, Switches & Encoders on front side



Fit the following on side showing component outlines.

Note: All push switches have flat sides facing the left hand side of the PCB as seen above.

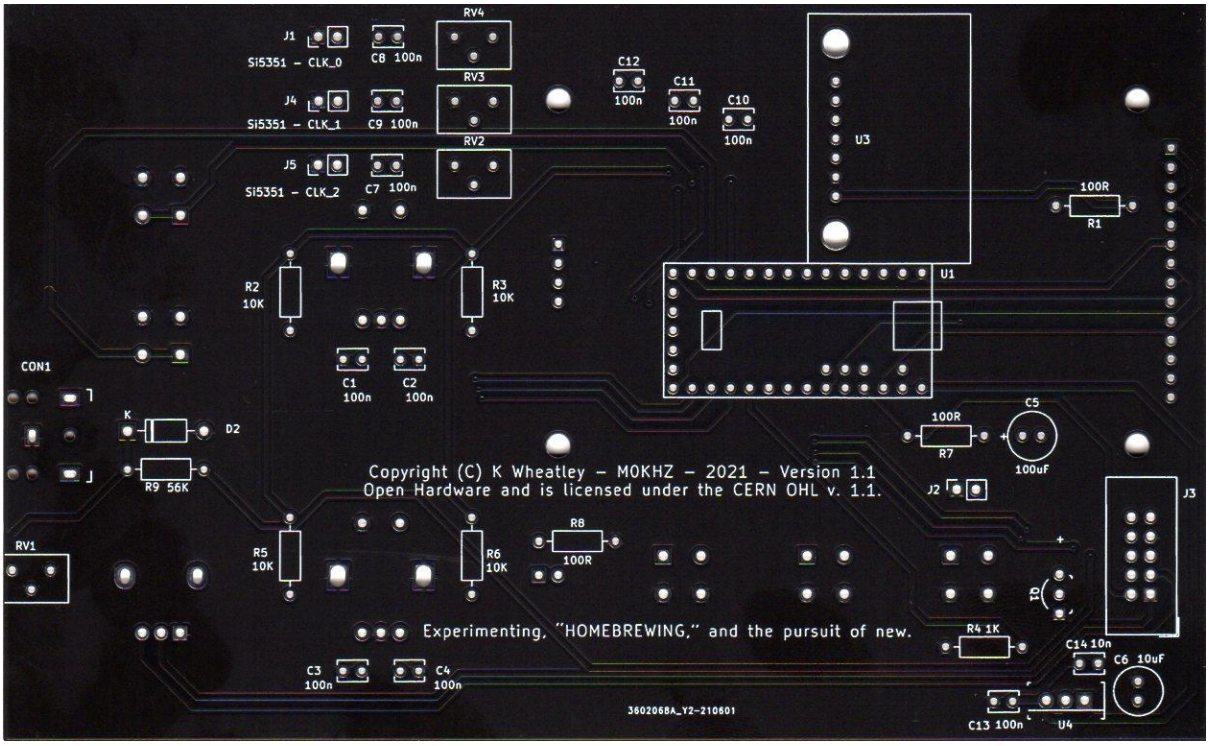
S3	Push to Make switch – Keyer Settings		S1	VFO Encoder
S4	Push to Make switch – Keyer Memory 1		S2	RIT Encoder
S5	Push to Make switch – Keyer Memory 2		D1	LED – note cathode (flat side) is facing the right hand side of the PCB as seen above.
S6	Push to Make switch – VFO increase tuning rate		RV5	Receiver RF Gain
S7	Push to Make switch – VFO reduce tuning rate			

Stage 3 – Fitting Si5351 Break Out Board

Solder the 7-pin header that comes with the Si5351 Break Out Board (U3) to the PCB. It doesn't matter which way up you fit the header – I find it easier putting the long pins through the board with the short pins up ready for the break out board.

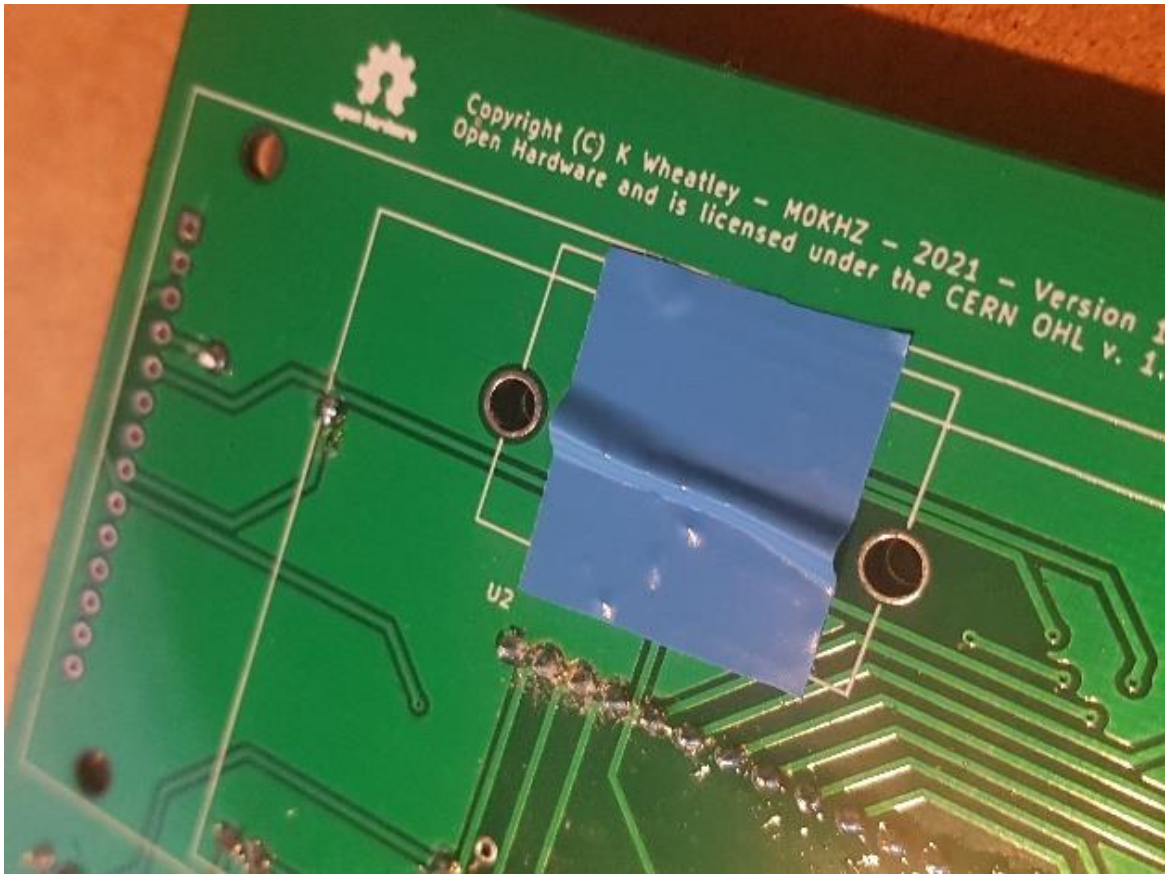
Now solder the Si5351 Break Out Board (U3) onto the header; following the outline on the PCB (see below); you need the Si5351 and associated parts to be on the top so you can see them. A blob of Blu-Tac may be useful for holding it level.

Note: only fit the SMA sockets if you intend to use them (I just solder miniature coax to the pads – it's your call).



Remove the excess pin length from header.

After cooling, stick a piece of insulating tape over the pins as shown below.



This is merely a safety precaution as a metal cover on the back of the display ends up quite close to these pins.

Don't worry about the green colour of the PCB, or the orientation of the pins that the tape is covering. This was from the first batch of PCBs we had made; the current version is Limerick Sudden black and the Si5351 has been rotated by 90 degrees. The advice to cover the pins is still valid!

Stage 4 – Programming the Teensy

Note: If your Teensy microprocessor has been pre-programmed ignore this stage go straight to stage 5.

If your Teensy microprocessor is a new one, it is easier to programme it now.

You need the standard Arduino IDE software (**NOT** the App version – the Teensy loader will not work with the App version). You then need the Teensyduino loader. Full info is here: https://www.pjrc.com/teensy/td_download.html

M0KHZ's sketch and associated libraries are available here: https://github.com/m0khz/SCD_2021_V0_13/tree/master

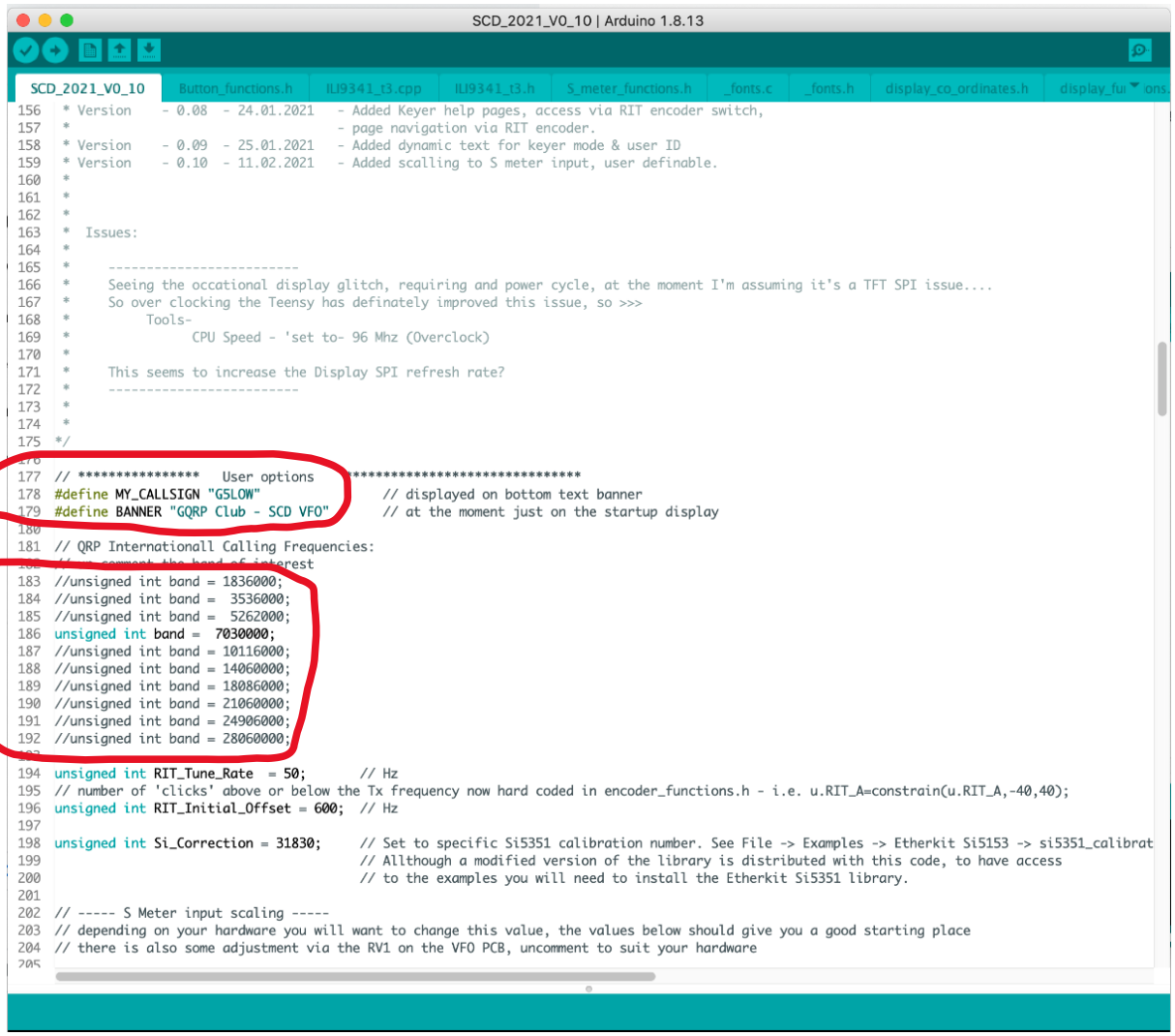
Once downloaded you need to unzip and save with your Arduino sketches and remove the 'master' suffix.

You can compile and load the sketch and libraries by selecting the Teensy 3.2 and relevant COM port in the Arduino IDE.

> **Arduino Update Issue:** if you have an older version of the Arduino IDE software, the sketch should compile and load without a problem. If you have just downloaded the Arduino IDE for the first time, it may not compile. This is due to changes in recent updates in the Arduino IDE.
>
> To fix this bug, working as administrator, navigate to the TeensyThreads.cpp file and edit the file in Notepad. You need to remove (or comment out) the line #include "utils/debug.h" (towards the top of the file).
>
> Save the file (you may need to change the file permissions to allow saving your edit).
>
> The sketch should now compile and load without error. This has been tested by M0KHZ and GW4JUN.

The 'off the shelf' sketch has been supplied configured for G5LOW and 7MHz.

To reconfigure the sketch simply change 'G5LOW' to your own callsign, add '//' ahead of the 7MHz line and remove the '//' from the band you want to use – see screenshot below – relevant lines are circled in red.



You can then reload the sketch and libraries by selecting the Teensy 3.2 and relevant COM port in the Arduino IDE.

Once the load is completed, disconnect the Teensy and cut the on-board DC supply track with a modelling knife – see picture below.

Note: *Once the track is cut, the Teensy will need external power; the USB will no longer power the PCB.*

In our project, it will be powered via the 5v regulator on the main PCB.

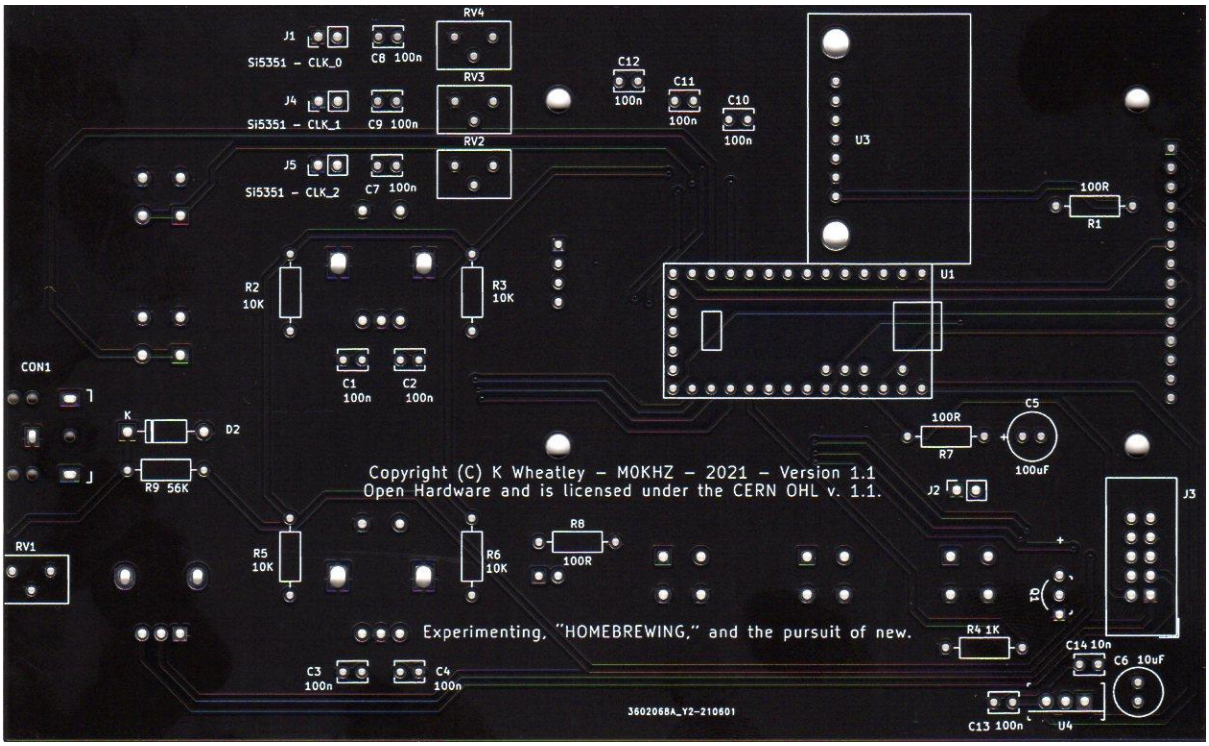
So, if you decide to re-programme the digital VFO you will need the main PCB to be connected to a 12v supply and then use the USB for uploading the sketch.

If you have any questions about the sketch, please contact Kevin, M0KHZ via Kevin.m0khz@gmail.com To help Kevin, please include 'Sudden SCD VFO' in your e-mail subject line.

Stage 5 – Fitting the Teensy

Prepare the Teensy (U1) for fitting to the PCB. Headers are fitted to both sides, but not the end; you can ignore the holes at the end.

Note: *you may find this easier if you temporarily fit the headers into the PCB and then place the Teensy on top. This aligns the pins to prevent wonky soldering.*



Solder the Teensy (U1) in place on the same side as the Si5351 Break Out Board following the outline on the PCB (see below); you need the main components and the USB socket to be on the top so you can see them. When it comes to soldering it is best to do one pin and check nothing has moved before doing the rest.

When all pins are soldered, remove the excess pin length.

Stage 6 – Fitting the TFT Display

Solder a 3 or 4 pin header to the TFT Display. The header goes at the opposite end to the main header, which is pre-fitted, with the pins facing in the same direction as the main header.

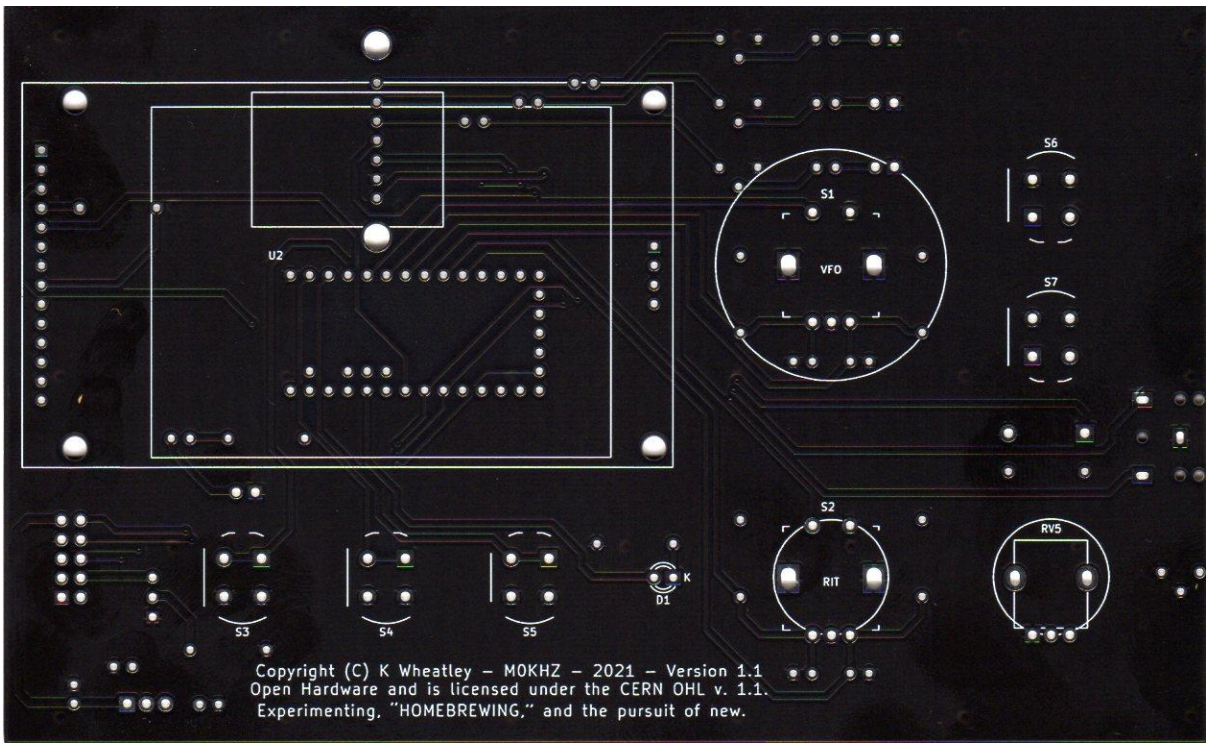
The long pins must face away from the display PCB or they will not reach the main PCB.

There are 4 holes – it matters not which you use for the 3 pin header; the header is just providing mechanical support.

Note: *the display does <u>not</u> go all the way to the PCB so you cannot do the temporary fit thing. Just be careful to get the 3 pins sitting straight and square; a blob of Blu-Tac works wonders.*

Fit the display to the main PCB on the same side as the push to make switches and encoders following the outline on the PCB (see below).

You will quickly realise that it cannot be pushed all the way 'home' but needs to sit so that about 2mm of the headers protrude on the solder side. Again. Soldering one pin at each end and checking alignment before soldering all pins makes good sense.



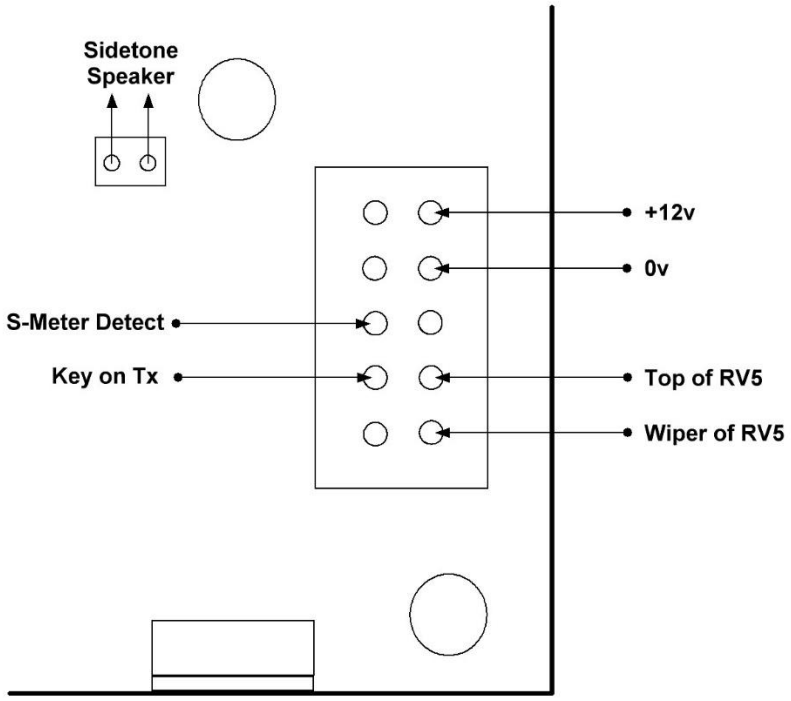
Stage 7 - Fitting Connecting Leads & Testing.

Fit the large knob to the top encoder = VFO Tune.

Fit the medium knob to the bottom encoder = RIT Tune.

Fit the small knob to the RF Gain Pot (if fitted).

There is provision for a 10-pin connector but you can simply solder hook up wires as shown below, if you prefer:



The two holes near electrolytic C5 and R7 are for a sidetone speaker. If you intend to use that facility you can wire it up accordingly.

Apply power and the unit should boot up and the display should look something like the picture on page 1.

Rotating the top knob should tune the VFO

Pressing S6 (upper top right) then moves the cursor to increase the VFO tuning rate

Pressing S7 (lower top right) moves the cursor to decrease the VFO tuning rate

Rotating the bottom knob sets the RIT – set to same as VFO when tuning around, zero beat other station then use RIT to give the tone you want, or simply set it to the appropriate off-set for your use.

Pressing the top VFO knob switches to VFO B, which is totally independent of VFO A but works in the same way.

Pressing the lower knob opens the keyer screen which shows instructions on how to set up the keyer. They are self-explanatory.

With a scope (or RF probe) on Si5351 Clk2 output you should see a square wave output around 5v pk-pk. Rotating RV2 should allow the level to be set to anything from 0 to 5v.

Plug in your paddle key and listen on a separate receiver to check that the keyer works and the RIT frequency shifts as it should; with no off-set dialled in the frequency should be the same on key up and key down. With the RIT set to, say 600Hz +/-, the frequency should shift with the keying action.

Once you know the unit works it can be used; it is ready to be connected to the Sudden kits.

Connecting to the Sudden kits

1- the Receiver

If you have a Sudden receiver kit already built, you will need to remove some of the original VFO components. If you are building one to use with the Digital VFO, you need not fit some of the parts.

Parts to be removed/omitted:

R5

C8

C9

C10

C11

C12

L3

Tuning Cap

Depending on how you intend to box up your new project, you may wish to fit RV5 on the Digital VFO PCB and re-route the wires for the RF Gain Pot.

Connect a length of miniature coax from the output of Clk 2 (PCB ref J5) to the Receiver PCB. I used the vacant pads of C9 and C10. The coax inner goes to the left hand pad of C10 (i.e. nearest IC1) and the braid to the right hand pad of C9 (i.e. furthest away from IC1).

Power up the receiver (9v) and the Digital VFO (12v) and adjust the VFO output using RV2. I simply increased the level until it resolved signals. If you want to measure it, I found about 800mV p-p on measured across the Si5351 end of the coax did a good job.

2 - the Transmitter

If you have a Sudden transmitter kit already built, you will need to remove some of the original VXO components. If you are building one to use with the Digital VFO, you need not fit some of the parts.

Parts to be removed/omitted:

X1 – crystal

VC1 – VXO tuning cap

L1

C1

C2

C3

C4

R1

R2

R3

T1

Connect a length of miniature coax from the output of Clk 0 (PCB ref J1) to the Transmitter PCB. I used the vacant pads of C3 and C4. The coax inner goes to the top pad of C4 (i.e. nearest T2) and the braid to the bottom pad of C3 (i.e. furthest away from T2).

It is worth mentioning that the VFO's built-in keyer is set for Iambic keying but you can select a straight key by following the menu instructions (press RIT encoder to access keyer instructions). The menu instructions also explain how you can change the keying speed and use a couple of memories.

Power up the transmitter and the Digital VFO and adjust the VFO output using RV4. I simply increased the level until it produced the usual 2-2.5W output. If you want to measure it, I found about 2V p-p measured across the Si5351 end of the coax did a good job.

You may need to adjust RV1 on the transmitter PCB to get the necessary output. George's advice was not to push it much above 2W output.

3 – Transmitter and Receiver Together

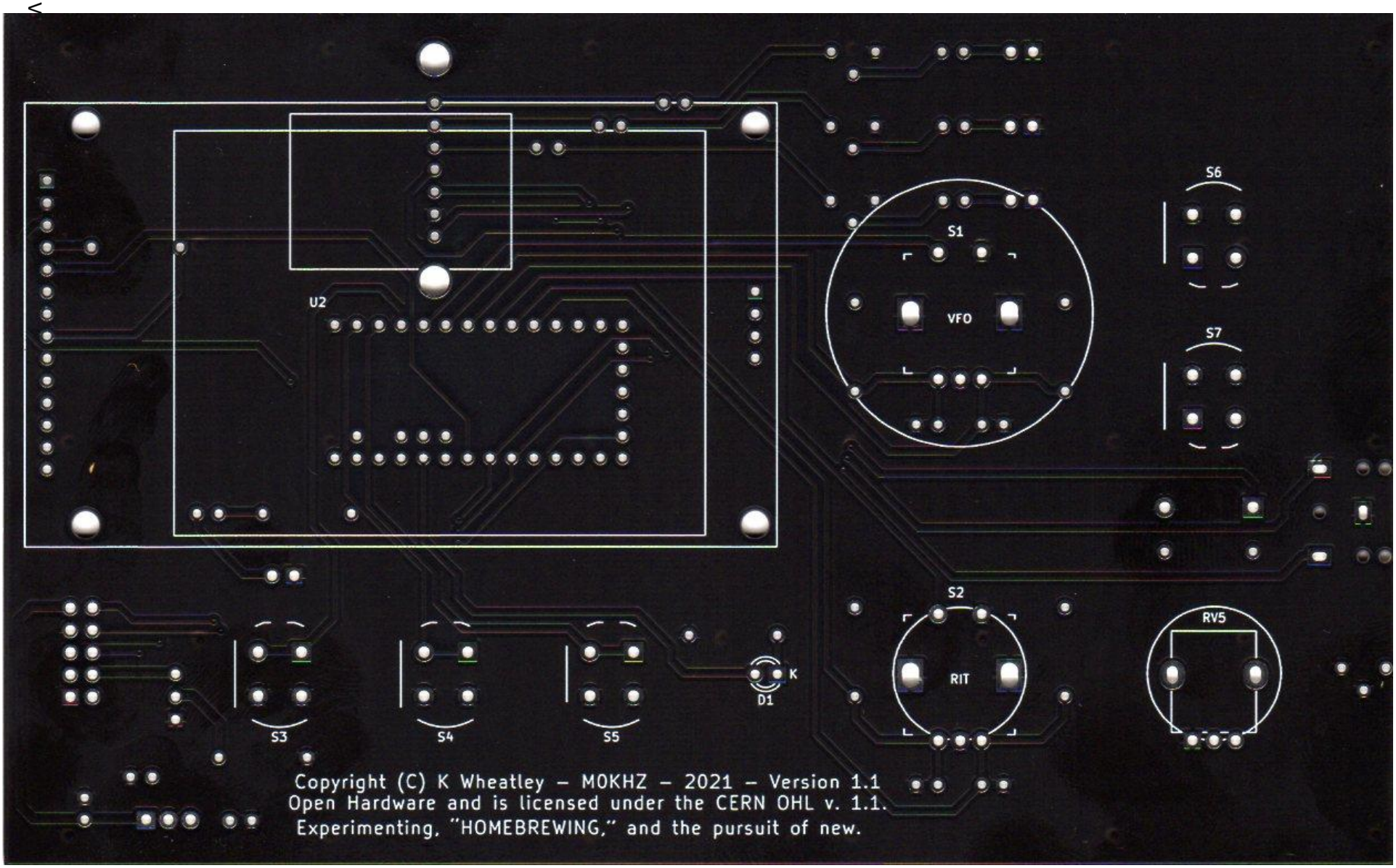
You should now be able to use the three PCBs as a transceiver. If you listen to the VFO on a separate receiver you should be able to detect the shift on transmit if there is some RIT dialled in, but no change when the RIT off-set is set to zero. It is worth experimenting working into a dummy load before going on the air for the first time.

Credits

PCB design work and Teensy sketch done by Kevin, M0KHZ

Concept and instructions by Steve, G0FUW

If you find any errors in the instructions, or have any suggestions for improvement, please e-mail via g0fuw@gqrp.co.uk


U2
S1
VFO
S6
S7
S2
RIT
RV5
S3
S4
S5
K
D1
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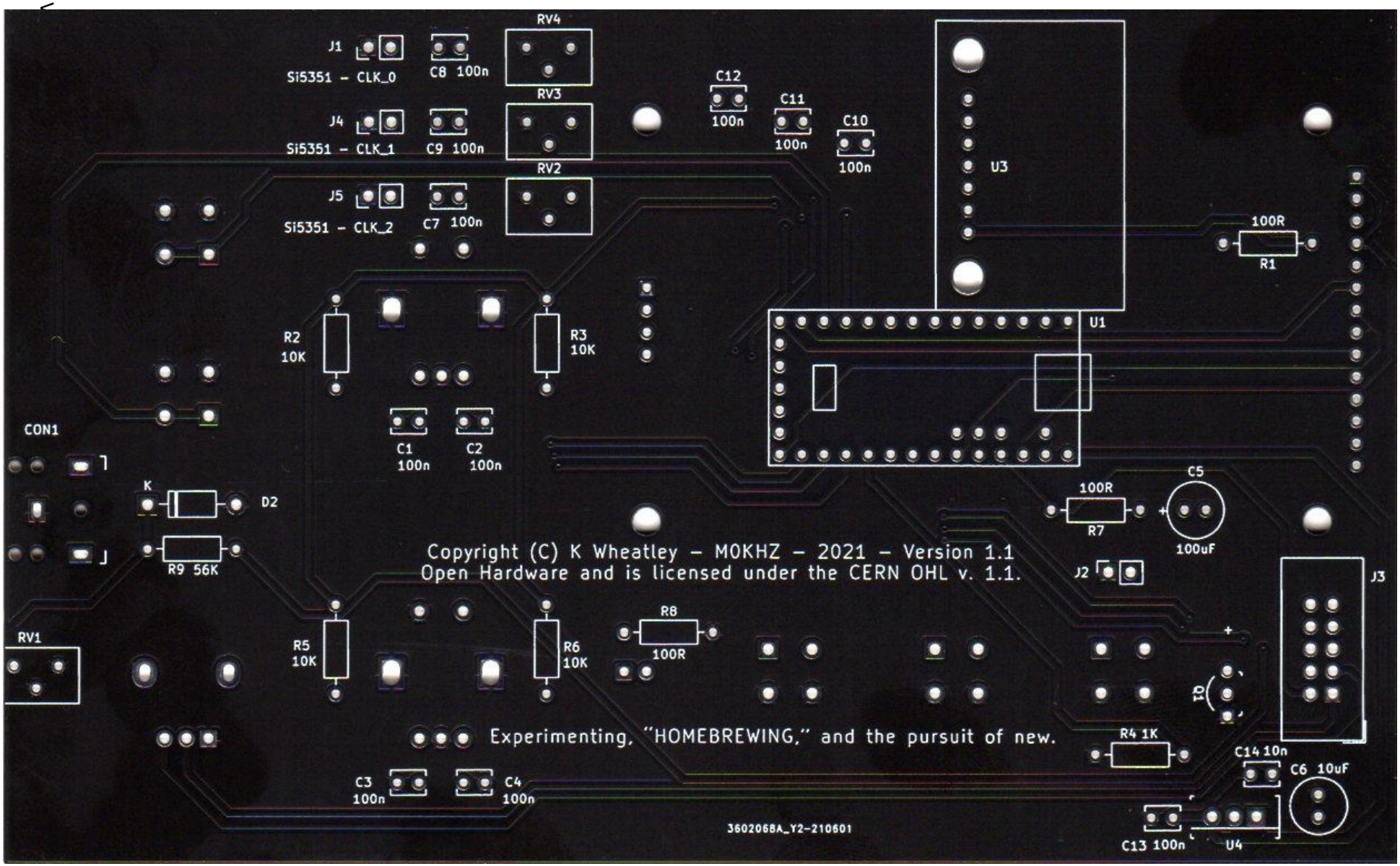
Experimenting, "HOMEBREWING," and the pursuit of new.


J1
Si5351 - CLK_0
C8 100n
RV4
RV3
J4
Si5351 - CLK_1
C9 100n
RV2
J5
Si5351 - CLK_2
C7 100n
C12
100n
C11
100n
C10
100n
U3
100R
R1
U1
R2
10K
R3
10K
C1
100n
C2
100n
CON1
K
D2
R9 56K
100R
R7
C5
100uF
J2
J3
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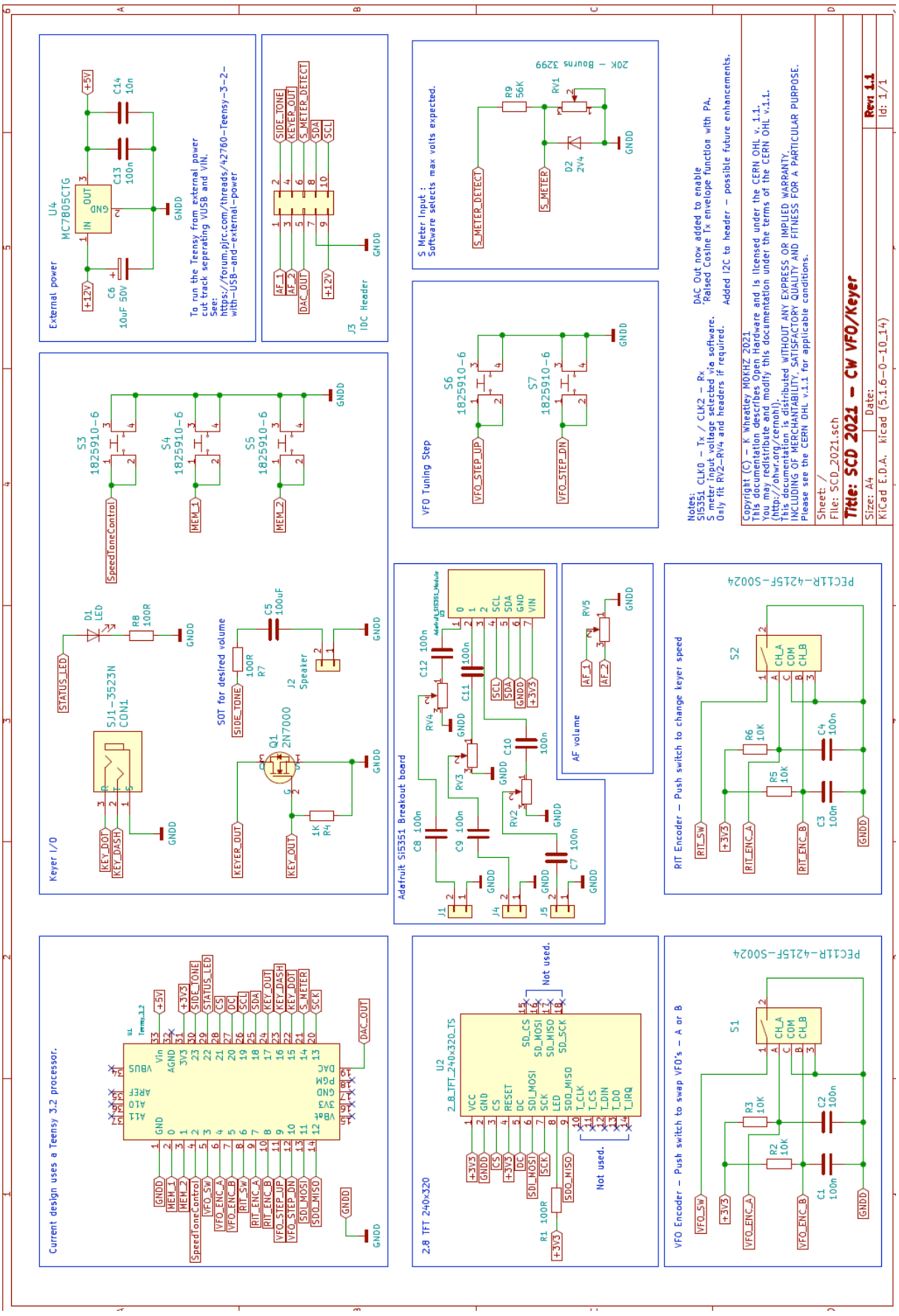
RV1
R5
10K
R6
10K
R8
100R
Experimenting, "HOMEBREWING," and the pursuit of new.
R4 1K
C14 10n
C6 10uF
C3
100n
C4
100n
3602068A_Y2-210601
C13 100n
U4


Title: SCD 2021 – CW VFO/Keyer
Rev 1.1
Size: A4
Date:
KiCad E.D.A. kicad (5.1.6-0-10_14)
Id: 1/1
Sheet: /
File: SCD_2021.sch
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Notes:
SI5351 CLK0 – Tx / CLK2 – Rx
S meter input voltage selected via software.
Only fit RV2–RV4 and headers if required.
DAC Out now added to enable
Raised Cosine Tx envelope function with PA.
Added I2C to header – possible future enhancements.
External power
U4
MC7805CTG
C14 10n
C13 100n
C6 10uF 50V
+5V
+12V
GNDD
To run the Teensy from external power
cut track seperating VUSB and VIN.
See:
https://forum.pjrc.com/threads/42760-Teensy-3-2-with-USB-and-external-power
J3
IDC Header
SIDE_TONE
KEYER_OUT
S_METER_DETECT
SDA
SCL
AF_1
AF_2
DAC_OUT
S Meter Input :
Software selects max volts expected.
R8 56K
RV1 20K – Bourns 3299
D2 2V4
S_METER
VFO Tuning Step
S6
1825910-6
S7
1825910-6
VFO_STEP_UP
VFO_STEP_DN
Keyer I/O
S3
1825910-6
S4
1825910-6
S5
1825910-6
SpeedToneControl
MEM_1
MEM_2
D1 LED
R8 100R
STATUS_LED
SJ1-3523N
CON1
KEY_DOT
KEY_DASH
SOT for desired volume
C5 100uF
100R R7
J2 Speaker
Q1 2N7000
1K R4
Adafruit Si5351 Breakout board
C12 100n
C11 100n
C10 100n
C8 100n
C9 100n
C7 100n
RV4
RV3
RV2
J1
J4
J5
AF volume
RV5
RIT Encoder – Push switch to change keyer speed
S2
PEC11R-4215F-S0024
R6 10K
R5 10K
C4 100n
C3 100n
RIT_SW
RIT_ENC_A
RIT_ENC_B
VFO Encoder – Push switch to swap VFO's – A or B
S1
R3 10K
R2 10K
C2 100n
C1 100n
VFO_SW
VFO_ENC_A
VFO_ENC_B
2.8 TFT 240x320
U2
2.8_TFT_240x320_TS
R1 100R
Not used.
Current design uses a Teensy 3.2 processor.
U1
Teensy_3.2
DAC_OUT

Version 2.3