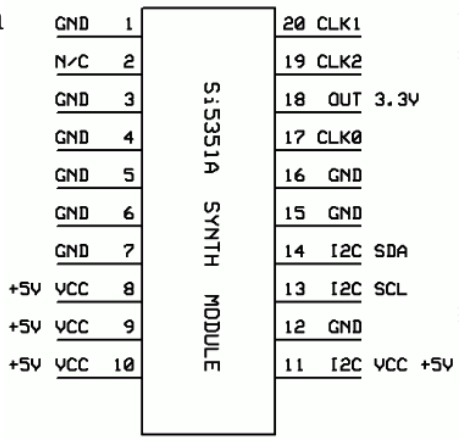
QRP Labs Si5351A Synthesiser Module

The QRP Labs Si5351A-based synthesizer module can generate up to 3 different square-wave frequencies simultaneously in the range 8kHz to 160MHz with 50-ohm output impedance. It is easy to build, requiring no surface mount soldering. The Si5351A chip is truly tiny (3 x 3mm chip, 10 pins with 0.5mm spacing) but for your convenience, has been pre-soldered already to the PCB by the manufacturer! The chip is set-up using the I2C (two-wire interface) serial data protocol.

The Si5351A Synth module has a 2 x 10-pin header connector, with a footprint and pinout (see diagram, right) somewhat similar to the popular AD9850 DDS module (from eBay and elsewhere). In particular, the module is directly compatible with the Ultimate3 QRSS/WSPR kits (U3) [see Ref 1], it may be used in place of the original AD9850 DDS module, without hardware modification. Use with the U3 kit requires firmware versions v3.07 or higher, which are able to drive the I2C programmed Si5351A. Provision on the board is also made for soldering SMA sockets at the board edges for each of the three outputs, so that the module may also be used as an Si5351A “break-out” board.

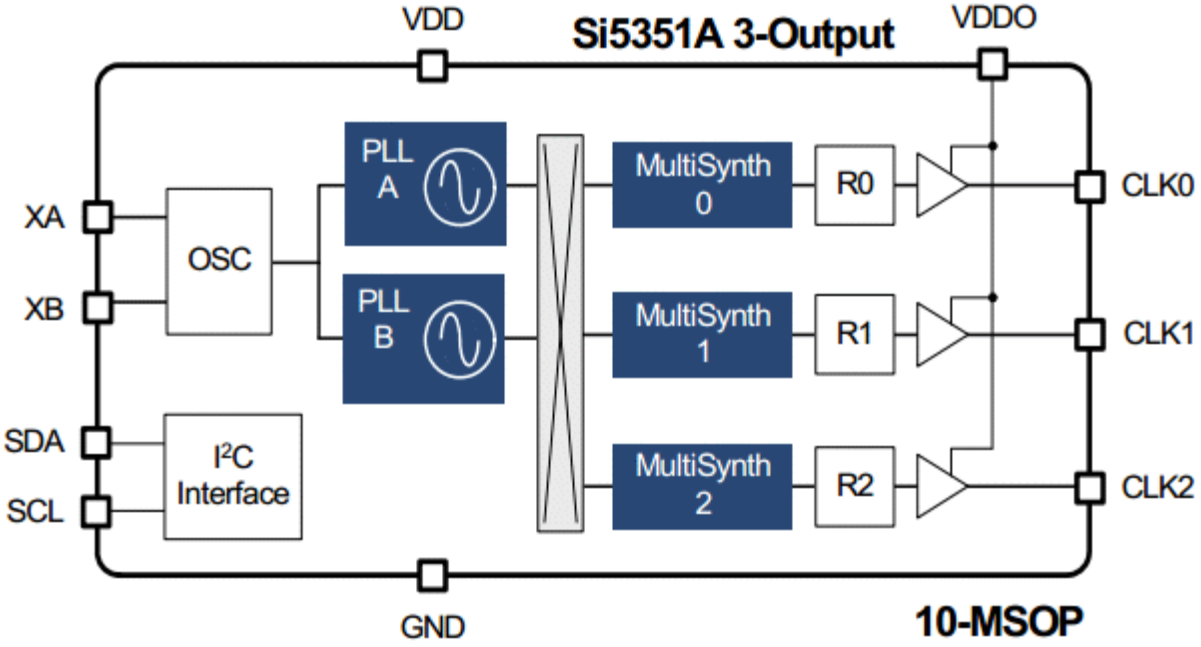


The module may be powered by 5V as it has an on-board voltage regulator to supply the Si5351A chip with 3.3V. This regulated supply voltage is also made available at pin 18. The circuit also includes level converters to interface to a 5V I2C bus. If desired, the voltage regulator and level converters can be left off the board, converting it for 3.3V operation. In this case do not fit R1, R2, R5, R6, IC2, Q1 and Q2. Fit a jumper wire across IC2 pins 2 and 3, and jumper wire between drain and source connections of the Q1 and Q2 pads.

Theory of Operation

The SiLabs Si5351A chip is a cousin of the famous and popular Si570 chip, but is much less expensive. Unlike the Si570 however, the Si5351A has no quartz crystal inside. An external reference oscillator or crystal must be provided. The reference frequency may be 25MHz or 27MHz.

In this module, a 27MHz crystal is used. This frequency is chosen because it is possible to configure the chip to produce the exact 1.46Hz tone spacing for WSPR, on any amateur radio band from 2200m (136kHz) to 2m (145MHz). A 25MHz crystal cannot provide WSPR tone spacing on the 2m band.



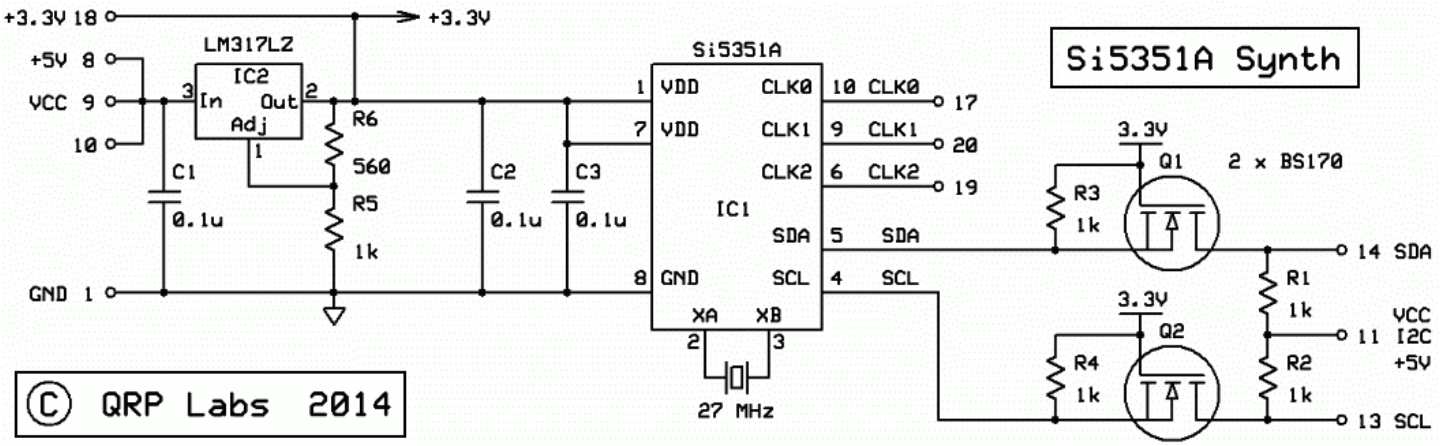
In summary, the Si5351A chip synthesizes output frequencies in three stages. The block diagram of the chip is shown to the above (from the Si5351A datasheet).

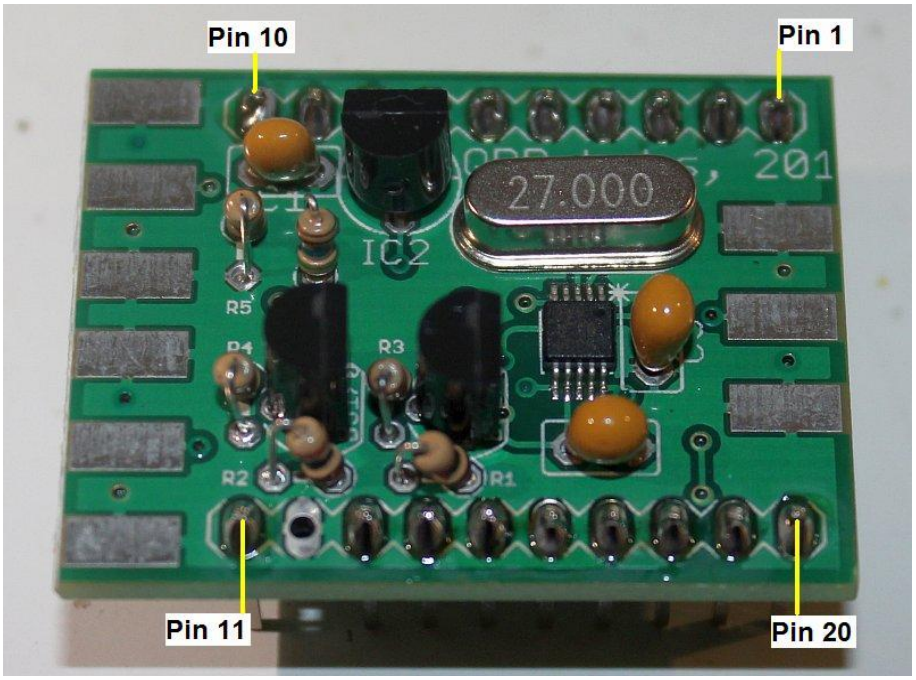
First, a crystal reference oscillator is multiplied up to internal frequency in the range 600-900MHz. There are two PLL's in the chip, each may be selected to choose a different internal frequency. At the second stage one of the PLL frequencies is divided down to each of up to three required output frequencies. Both the upward multiplication to the internal PLL Output frequency, and the division down to the output frequency, use fractional ratios – an integer plus a fractional part consisting of 20-bit numerator and denominator. Optionally a third division stage may be configured to divide each output by a power of 2, for a maximum division ratio of 128. It is used for generating low frequency outputs between 8kHz and 500kHz.

There are a great many other facilities available in this synthesis chip. Please study the Si5351A datasheet for all the details [Ref 2].

Other than the Si5351A chip, the other components on the board are a LM317LZ variable voltage regulator configured for about 3.3V output, and a pair of bi-directional 3.3 to 5V level converters for the I2C interface. The level conversion circuit using two BS170 MOSFETs is popular and well-proven.

The circuit diagram of the Si5351A synthesizer module kit is shown below.





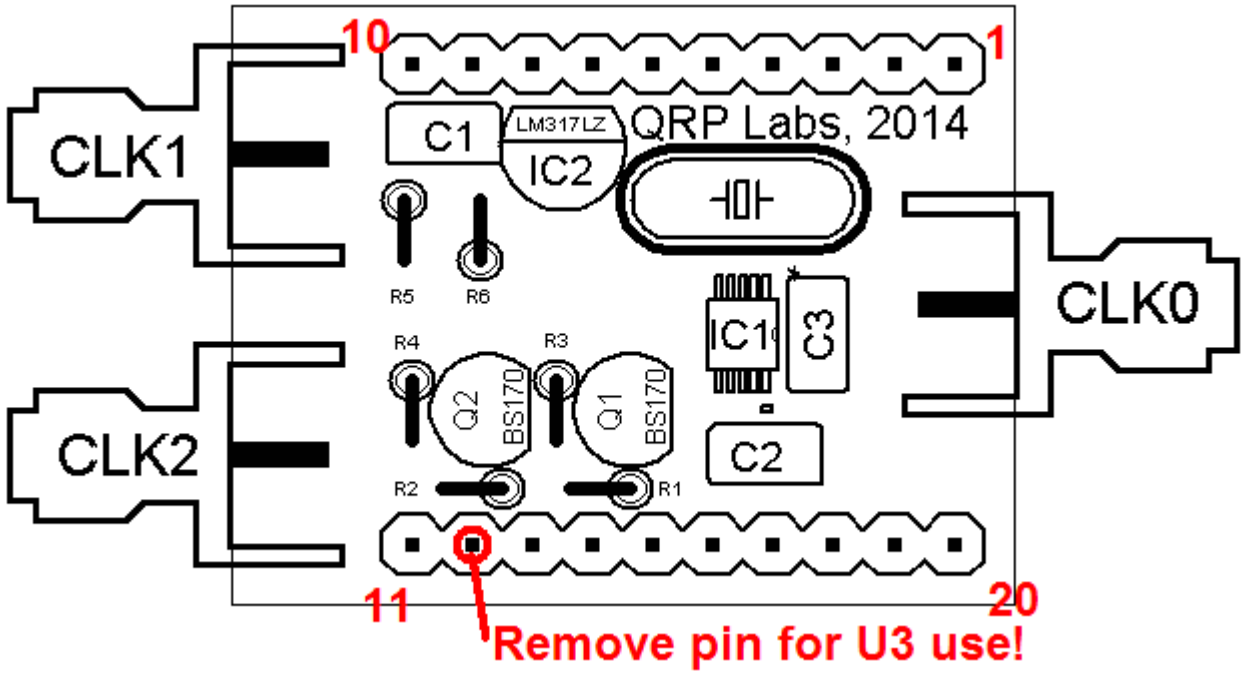
All module pins labeled "GND" are internally connected within the module. Similarly +5V pins (8, 9, 10) are also internally connected on the module PCB. Pin 11 is the pull-up resistor positive supply voltage for the level converters. For ordinary use, with a +5V I2C bus, pin 11 should be connected to +5V. The connection is provided separately (not connected to +5V internally) in case you wish to use a different I2C bus voltage.

Note that in relating the pinout

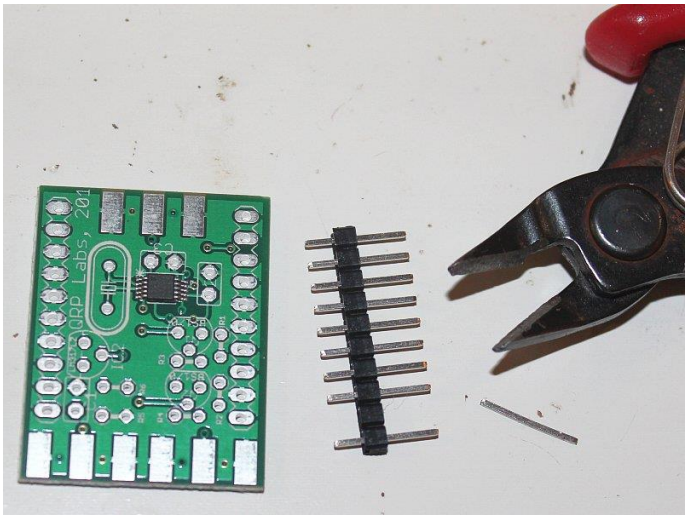
to the physical module, designated pin 1 is near the shorter PCB end of the module, as shown in this photograph.

Construction

Assembly is very straightforward, there are very few components and the board density is not high. Please refer to the parts placement diagram below.



For those of you intending to use this module with a Ultimate3 QRSS/WSPR kit [Ref 1], you must remove pin 12 from the pin header, as indicated in the diagram above, and also in the photograph on the previous page. This is because this pin is grounded on the module, but on the U3 the connection was used for one of the data control signals to the AD9850 DDS module, and is also shared with an LCD data pin. Grounding this connection would prevent anything being displayed on the U3 LCD, so the pin must be removed from the pin header, before installation. The pin is easy to pull out with plyers or a wire-cutter (see photograph, right). **The pin does not need to be removed for use in the U3S kit.**

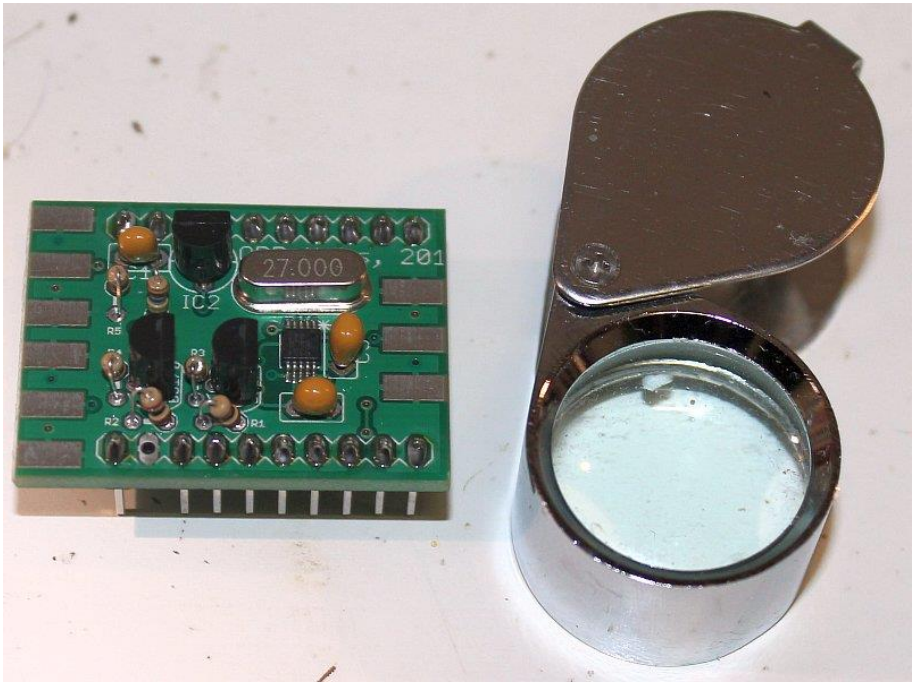


Take care to follow the silkscreen printing on the PCB for the correct position and orientation of IC2 (the LM317LZ) and transistors Q1/Q2. Capacitors C1, C2 and C3 are identical (0.1uF). Be careful to check the resistors carefully before installation:

R1-5: 1K-ohm (colour code: brown-black-red)
R6: 560 ohms (colour code: green-blue-brown)

I recommend installation in this order: resistors, capacitors, crystal, then transistors/voltage regulator, and finally the two 10-pin headers. It will be easier to solder the components BEFORE installation of the pin headers. But really, construction order is not critical at all.

If you are using this Si5351A Synthesizer module for your own projects (not in the Ultimate3 kit), you may wish to solder on SMA socket connectors to positions CLK0, CLK1 and CLK2 as indicated in the parts placement diagram above.



After completing the soldering, it is always a good idea to admire (and check!) your work using a magnifying glass or jewelers loupe such as the one pictured here.

Check the resistors are installed in the right place (remember R6 is 560 ohms) and the voltage regulator is IC2 (don't mix LM317LZ and BS170!). Check the Si5351A chip is nicely soldered too: even factory SMD robots might make mistakes sometimes!

For those using the module in the Ultimate3 kit, make sure there is no pin soldered at pin 12. When using the module in the Ultimate3S kit, you can keep pin 12.

On applying power to the board, you should find a voltage of approximately 3.3V (up to 3.5V) at pin 18 of the module. No output frequencies are generated until you have programmed the Si5351A configuration registers via the I2C interface.

References:

1) Ultimate3 QRSS/WSPR kit: http://www.qrp-labs.com/ultimate3

2) SiLabs Si5351A page (including datasheet): http://www.silabs.com/products/clocksoscillators/clock-generator/Pages/clock-vcxo.aspx

3) QRP Labs web site kit page: http://www.qrp-labs.com/synth

4) QRP Labs Yahoo group forum: https://groups.yahoo.com/neo/groups/QRPLabs

Document updates:

1) 05-Jan-2016: clarification of what components to omit and jumpers to fit, for 3.3V supply operation. References updated to http://www.qrp-labs.com and kit web page