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QRP2000 USB-Controlled Synthesizer

1. INTRODUCTION

This easy to build project can generate almost any frequency between 3.5MHz and up to 160 MHz and higher with a resolution of 1 Herz or less using the Silicon Labs Si570 Programmable Crystal Controlled Oscillator device. An Atmel ATtiny 45 Micro controller interfaces the Si570 via the I2C bus to the USB bus to a Personal Computer. The frequency of the Si570 can be set using an Application like PowerSDR, which may be downloaded from Sourceforge Website or a standalone program Si570 USB Control, supplied as hostware.

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2. Bill of Materials
3. Kit Assembly
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5. Driver installation verification
6. Functional Tests
7. Interfacing with Softrock RXTX 6.1 and 6.2
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Main Applications:

- CMOS Kit: Full Band or Multi Band coverage of Softrock RXTX V6.1 and V6.2 Transceiver
- External Local Oscillator for other SDR hardware Projects – using PowerSDR application
- Wide range oscillator – output frequency programmable in steps < 1 Hz.
- External /PTT output for other projects

Basic Specification:

- Frequency Range 3.5 MHz to 1400 MHz (10MHz to 160 MHz guaranteed by SiLab
- Stability +/- 50 ppm CMOS or +/- 20 ppm LVDS version – Jitter < 0.4 ps
- Output: Square wave : CMOS version 2.6V pk-pk 15pF , LVDS version 0.7V pk-pk into 100 Ohm
- Power Supply: USB Powered or +5V to +12V Power Supply – approx 80mA for Si570 CMOS version, or 100mA for Si570 LVDS version
- PCB size 41 x 48 mm

Acknowledgments: This project was designed by QRP2000 Design team:

Tom - DG8SAQ – Firmware and Host Application

Guido PE1NNZ and **Alan M0PUB** - PowerSDR Support Of USB Interface

John G8BTR – PCB Design **Steve G0XAR** Beta build – Documentation review

Jan G0BBL – Hardware design – Documentation – Kit Production

Thanks also to **Alex VE3NEA** who kindly provided Rocky USB support for this project

2. BILL OF MATERIALS

QRP2000 Design – USB LO SYNTHESIZER - BOM

Pcs/kit	Designation	Value	Remarks
2	C1, C10	10uF 16V	Radial
	C2, C3, C5, C6, C7,		
9	C8, C9 + 2 spare	0.1uF	0805 SMD
1	C4	1nF	0805 SMD Marked black
1	D1	1N4001	
2	D2, D3	3.6V Zener	BZX55-3V6 500mW
1	J1	USB-B Socket	
1	JP1a	shorting jumper	0.1"
1	JP1	3 pin header male	0.1" (Power selection USB or 12V)
1	JP2	2 pin header male	0.1" (RF Output connector)
2	R1, R2	68 Ohm	0.4W (red red black brown brown)
1	R3	2k2	0.4W Axial (red red black brown brown)
1	R4	1M	0.4W (brown black black yellow brown)
	R5, R6, R7, R8,		
6	R11, R12	4k7	0.4W (yellow violet black brown brown)
0	R9, R10	0.00	Wirelink (Not supplied)
1	U1	ATTiny45-20PU	DG8SAQ FW
1	U2	Si570CAC000141DG	CMOS (Or Si570BBC000141DG as
1	U3	LF33ABV	Regulator TO220
1	PCB	USB-LO Synthesizer	QRP2000 Design
1	IC Socket	8 pin DIL	
5	PCB pins	1mm dia	

Please note: J2 and T1 are optional and therefore not supplied

() Inventory of Kit parts is highly recommended – see Fig 1 below.

Caution: Please observe antistatic precautions for semiconductor devices

Do not remove Si570 device from anti-static bag until needed

Note: If you have a question about the kit, please contact Jan G0BBL via **sdrkits @ gmail.com**
(remove all spaces in email address)

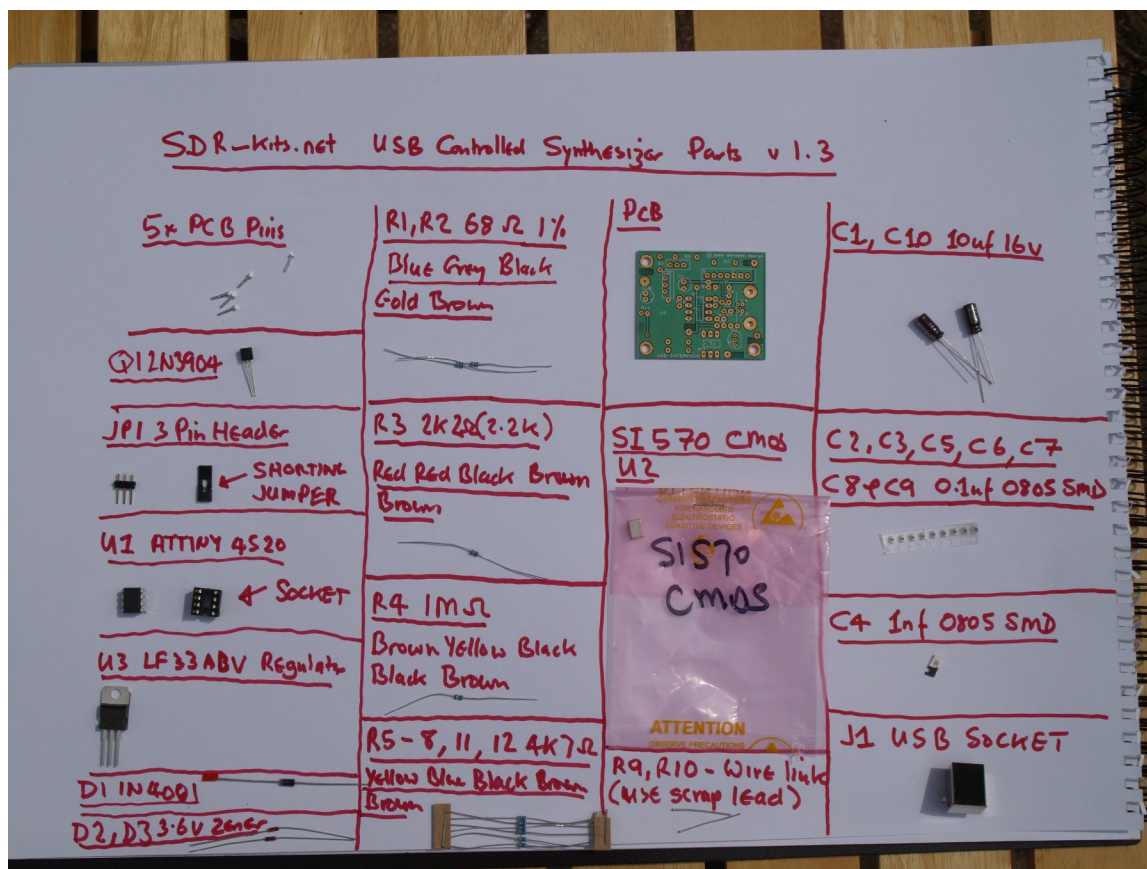


Fig 1 Inventory of Kit Parts – (photo by Steve G0XAR)

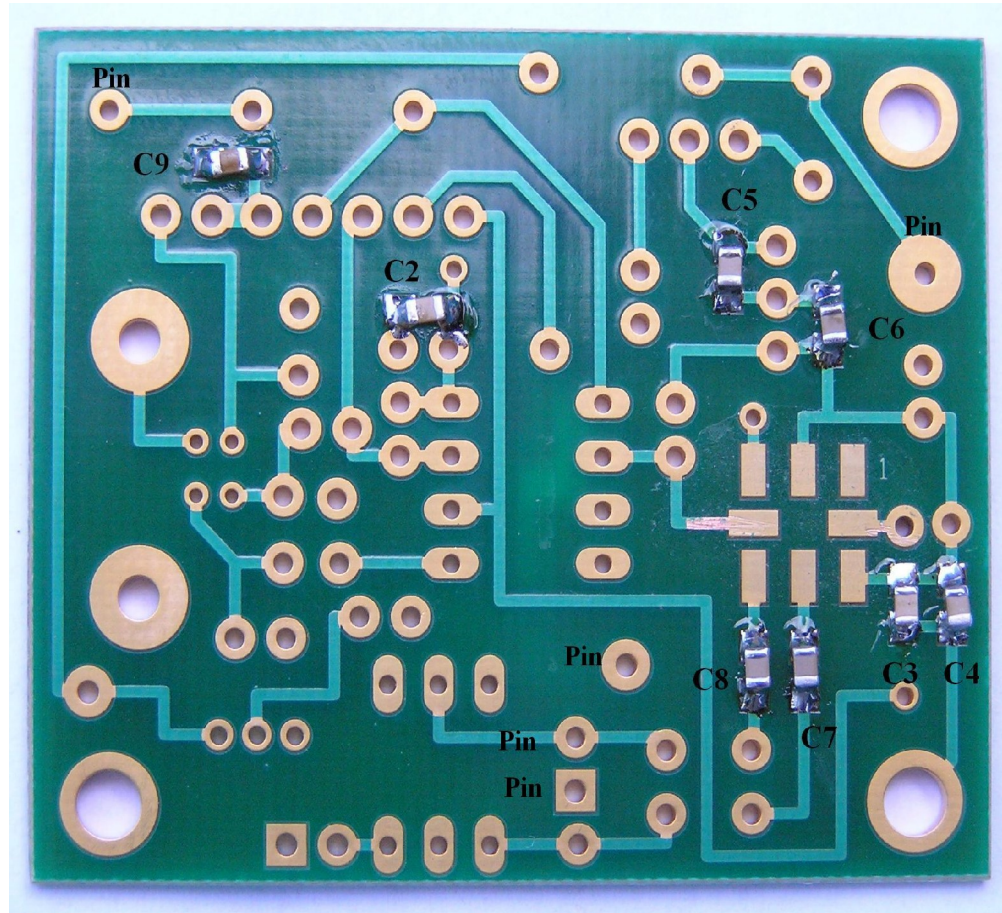
3. KIT ASSEMBLY

Introduction:

Making this kit will involve the soldering of surface mount components. This is not difficult but some care and patience is needed. You will need a well lit and clear work surface, a suitable soldering iron with a small tip, some fine (for example 24SWG – 0.5mm) resin cored solder and a pair of long tweezers, The type of tweezers should allow you to hold the component GENTLY, otherwise the your tweezers may act as a rocket launcher for tiny SMD parts!! Firstly make sure that the PCB is held securely to the work surface so it does not move around. Using "Blue Tack" on the edges of the board is one way of doing this. Then identify the pair of lands on the pcb that the surface mount component will be soldered to. Melt a small blob of solder on to one of the lands as a coat. Then, using the tweezers, pick up the the surface mount component and place it across the lands and melt the solder on the pre soldered land. This should effectively hold the component in place whilst you solder it to the unsoldered land. Then resolder it to the to the first land. Then check that the joints are good using a magnifying glass. This all sounds very complicated but it works in practice. If this is your first time using SMD you may wish to find a junk computer card and practice on it first. There are also a

number of excellent tutorials on the internet - and no you **do not need an oven or an SM workstation**. An ordinary soldering iron (preferably temperature controlled is good enough. **Good luck – Viel spass – Veel plezier -**

Bottom PC mounted components



*Fig 2 PCB with all components except Si570 fitted at bottom of board
Please note: floating pad C9 requires wire link to “CW Pin”*

- () Remove any components from PCB so PCB is bare
- () Check Kit contents against Bill of Materials
- () Place PCB upside down as in fig 2.
- () Look at Figure 2 to see the exact placement of the SMD capacitors C2, C3 and C5 through C9, and the PCB terminals. The SMD Capacitors are the small oblong shapes (0805 package), the soldered ends of the PCB terminals show as shiny circles. Figure 1 does NOT show C4 to avoid confusing it with C2. It looks exactly the same but has a different

value. Follow the instructions below exactly to avoid mistakes

- () Adjust Temperature of Temperature Controlled Soldering Station to correct temperature for soldering SMD components. Temperature depends on type of solder you are using
- () Solder SMD 0.1uF 0805 Capacitors C2, C3 and C5 through C9 as shown in Figure 2. Then check against Figure 2.
- () Solder C4 1nF 0805 Capacitor (identified with BLACK mark) next to C3 (Lower right hand side of the board)
- () Check all joints – the board should look like fig 2 below
- () **Note:** The placing of the PCB pins are shown for to suit CMOS Si570 kit for Softrock RXTX. If you are using the kit for other purposes then solder PCB pins to suit your particular application.
- () Fit PCB terminals as shown in Fig 2 by pressing pin through PCB using a hard metal surface or long nose pliers making sure that you do NOT damage any of the SMD capacitors in the process and solder at Bottom layer . The location of the PCB terminals.
Note: *In the first production boards, two holes, one near C9 and also the RF output pin are smaller than 1mm and will need enlarging with a 1mm drill for the PCB pin to fit. If you enlarge the hole, cut the bottom of the pcb pin and solder the PCB pin at both sides to ensure solid connnection between the top and bottom tracks*
- () In some versions of PCB, the track between PCB Terminal “CW” and left hand side of C9 is missing. If this is the case solder a short wire between “CW” pin and the floating track of C9 (see fig 2.)
- () Turn board over

Components mounted on Top ~Layer of PCB (Top Silk)

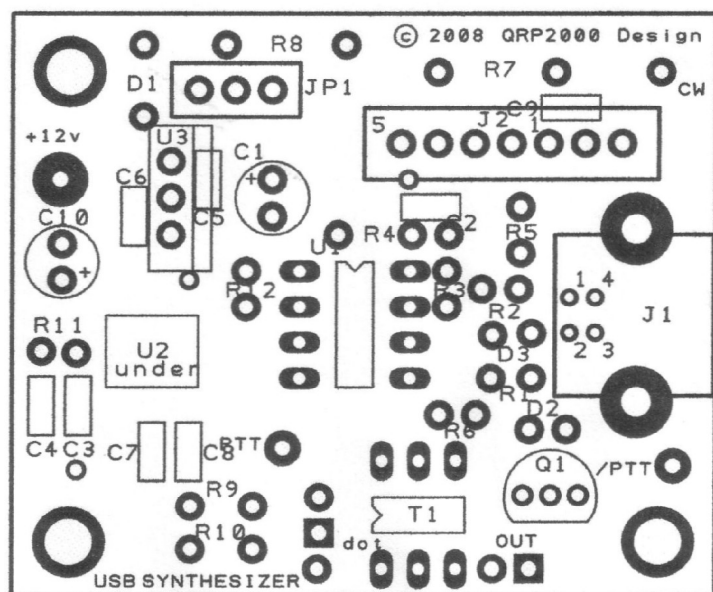


Fig 3 Component lay-out diagram

Place the board so you can see the components side with the placement (silk screen) diagram in view. Orient the board so that the words "©2008 QRP Design" is at the top right.

- () 8 pin IC socket for U1 ensuring that the indentation on the end of the socket matches that on the silk screen
- () USB Socket – solder pins including the ground connections.
- () Mount D1, D2 and D3 -
Note: observe cathode band and solder observing the polarity of the diode.
 For D1 the white band should be facing the hole closest to U3.
 For D2 and D3 the black band should be facing the holes next to USB socket J1. The polarity is not marked on the board so if in doubt consult the circuit diagram.
- () Mount Resistors R1 and R2 (68 Ohm blue grey black gold brown).
 Mount R3 (2K2 red red black brown brown).
 R4 (1M brown black black yellow brown).
 Mount R5, R6, R7, R8, R11 and R12 (4K7 yellow violet black brown brown)
Note: When installing the resistors make sure you put the right values in the right places. If in doubt as to the value please check them first using a meter.
- () Fit Capacitor C1 (10uF) and C10 (10uF) – **Note:** observe polarity and solder
- () Solder two links (discarded resistor wires) in R9 and R10

- () **Caution: when handling semiconductors observe anti-static precautions: Preferably wear anti-static Strap or touch unpainted metal ground before handling semiconductors**
- () Fit transistor Q1 – **Note:** observe position against top silk and solder
- () Fit U3 (LF33ABV) – **Note:** observe correct position against top silk and solder
- () Fit Connector JP1 (3 pin) and solder
- () Fit 2 pin Output Connector and solder –

LVDS Transformer T1 (supplied with complete Si570 LVDS Kit only)

- () Cut enamelled wire in 3 pieces of 18 cm (7 inches) each and twist uniformly to 4 turns per cm
- () Wind 5 turns trifilar on 43BN2402 supplied.
- () Scrape and tin end of enamelled wire and fit T1 on PCB if required.

Interim Test Procedure

Note: Jumper 1 is used to set the source of the power for the board. If it is next to the diode the source is supplied from the external power line, if in the alternative position the power is supplied from the USB port

- () Set Jumper JP1 to pin next to Diode D1
- () Connect 5-12V DC Power to PCB – **Note:** observe polarity
- () Check Voltage on U3 pin 3 to Ground - **Note:** reading should be 3.3V +/- 0.1V
- () Remove Power to PCB
- () **Caution: observe anti-static precautions handling semiconductor**
- () Plug ATTiny45 U1 into IC holder – pin 1 should be aligned towards U1 on the top silk
- () Connect USB Synthesizer to USB socket of a Personal Computer and measure voltage between U1 Pin 8. Reading should be 4.9 – 5.1V
- () Disconnect USB cable from USB Synthesizer

Final assembly of Si570 Device

- () **Caution: observe antistatic precautions handling semiconductors**

- () The Si570 device is soldered on the bottom of the PCB
- () Locate the Dot marking on the Si570 device and align with pin 1 marked on the PCB and solder

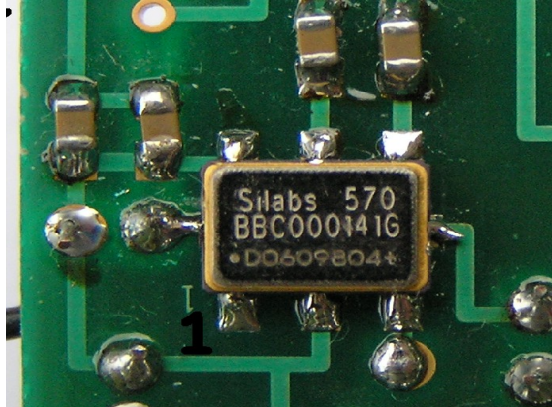


Fig 4 Location of S570 chip – dot bottom left pin is Pin 1

- () **Note:** take care soldering the connections of U2 pin 7 and pin 8. if there is not enough copper, then remove some of the solder-resist from the tracks to ensure a good joint.

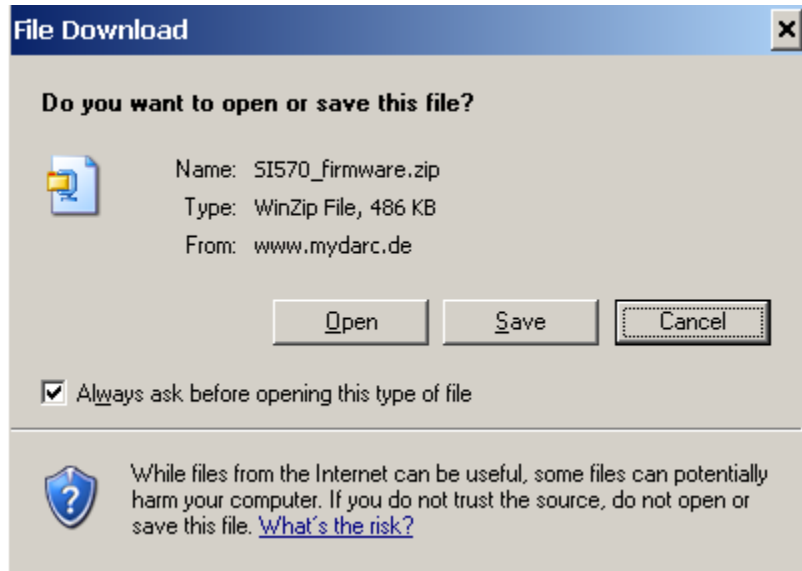
Final Test and commissioning

- () Set Jumper JP1 to pin 1 and 2 next to Diode D1 **(External Power supply)**
- () Connect PCB to a 5-12V DC Power Supply and measure Current Consumption typically should be around 70-85mA
- () Set Jumper JP1 to pin 2 and 3 towards letters “JP1” on PCB **(USB Powered)**

THIS COMPETES KIT ASSEMBLY

4. DRIVER INSTALLATION PROCEDURE MICROSOFT XP

- Download SI570_Firmware from: <http://www.mydarc.de/dg8saq/SI570/index.shtml>



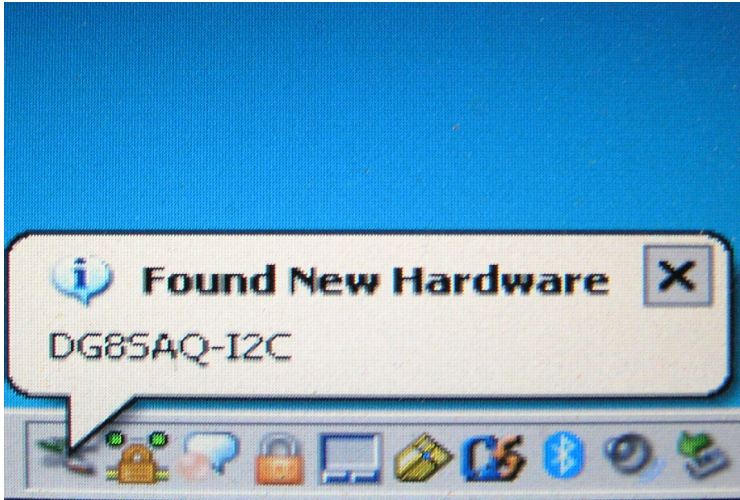
- Press “Save target as”
- Unzip the file SI570_firmware.zip

The following directories will be created



Driver Installation Procedure

- Plug in the USB-Synthesizer module into USB port
- The following Screen should be displayed:



Problem solving: If this screen is NOT displayed

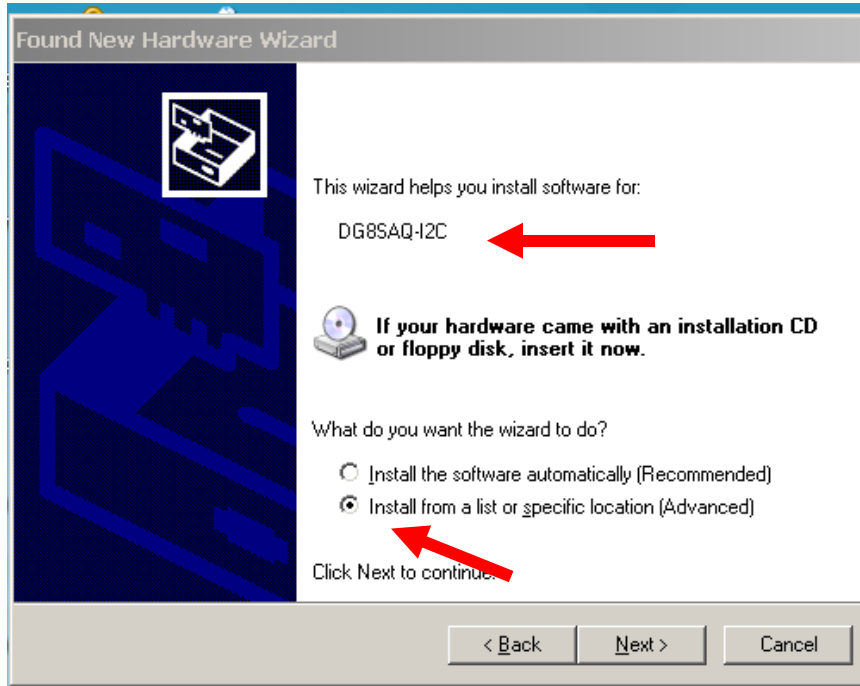
- *Check the USB-Synthesizer hardware for correct operation*
- *Is ATTiny45-20 microprocessor plugged in correctly*
- *Has ATTiny45-20 been loaded with correct firmware*
- *Connect the USB-Synthesizer to the USB port of a different computer*

After about 5 seconds the message below should be displayed:



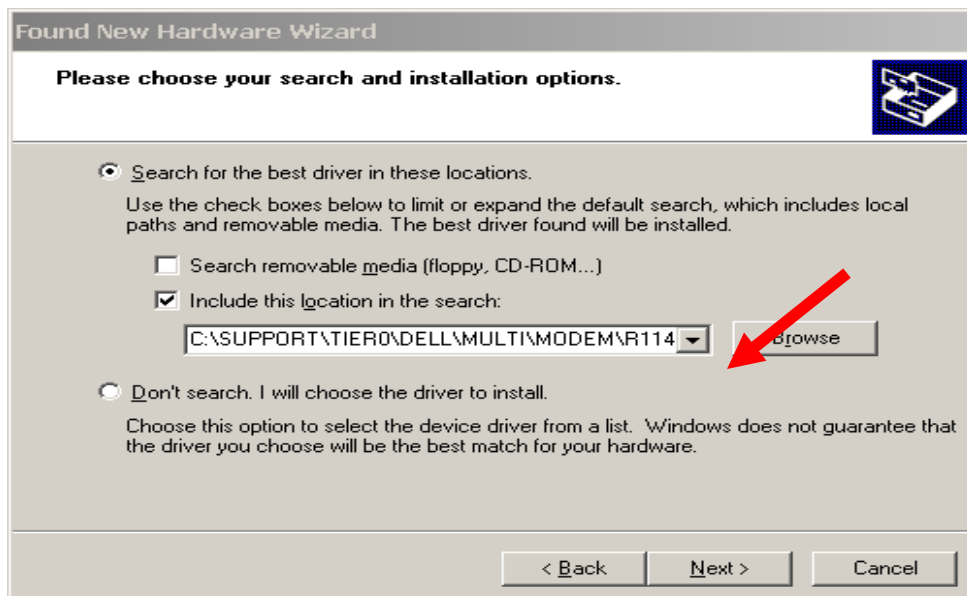
- Select “No, not this time”
- Press “NEXT”

The following screen should now be displayed:

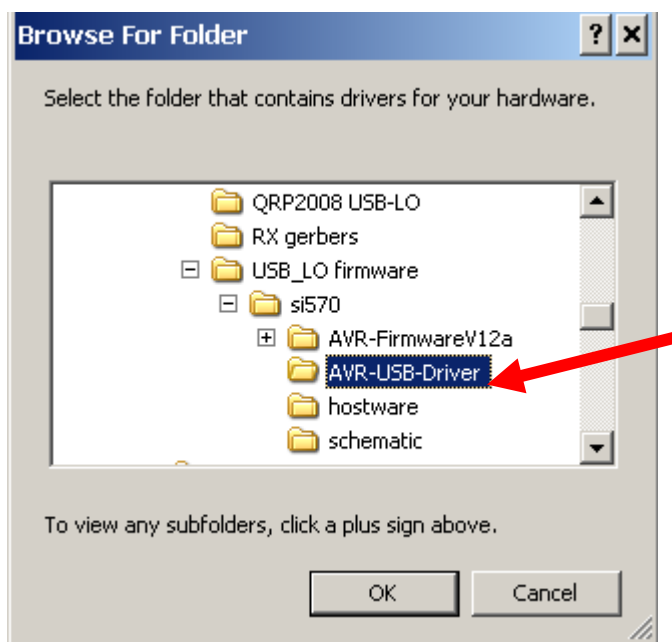


Deselect “Install the software automatically”
Select “install from a list or specific location”
Press “Next>”

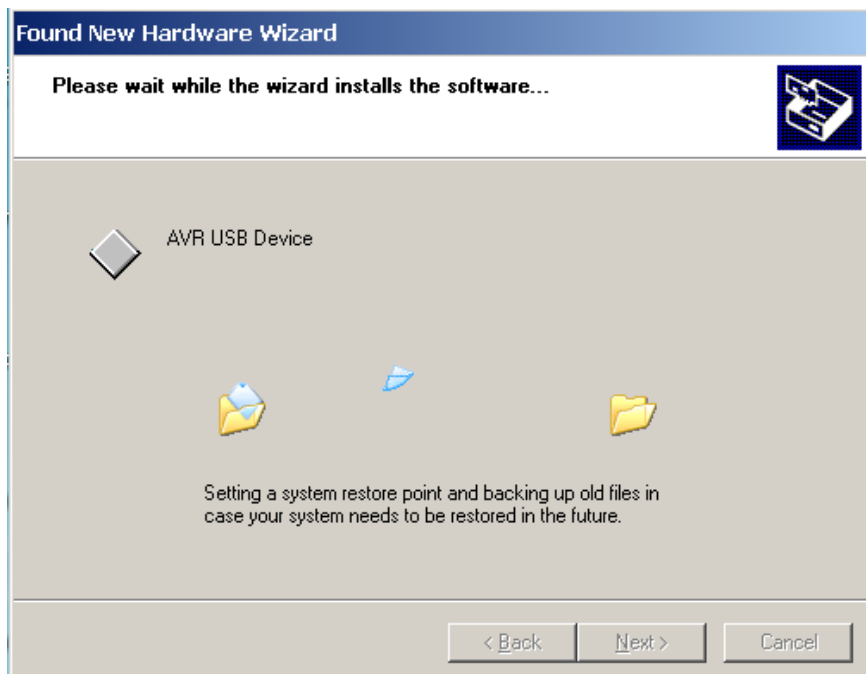
The following screen is displayed



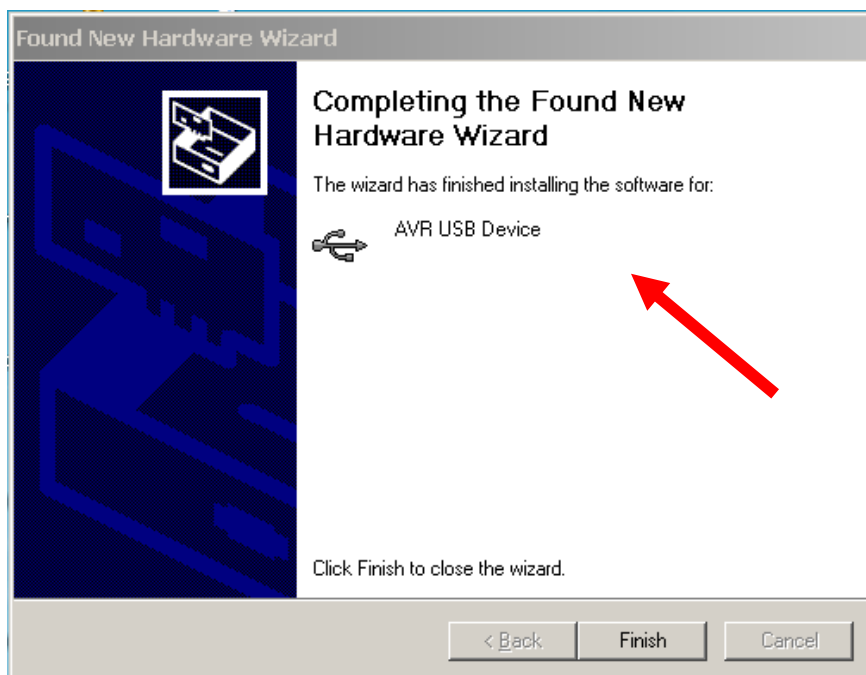
- Deselect “Search removable Media”
- Select “Include this location in the search”
- Press “Browse”
- Select Folder AVR-USB-Driver as shown below



- Click “Ok”
- Press “Next>”
- Software is being installed



When successfully installed, following message displayed:



Click "Finish"

Message displayed "Found New hardware successfully installed"

END OF DRIVER INSTALLATION PROCEDURE

5. DRIVER INSTALLATION VERIFICATION

A check can be made at any time if the driver is properly installed **but only if the USB-module is plugged in**

- Press “START”
- Press “Control Panel”
- Select “System”

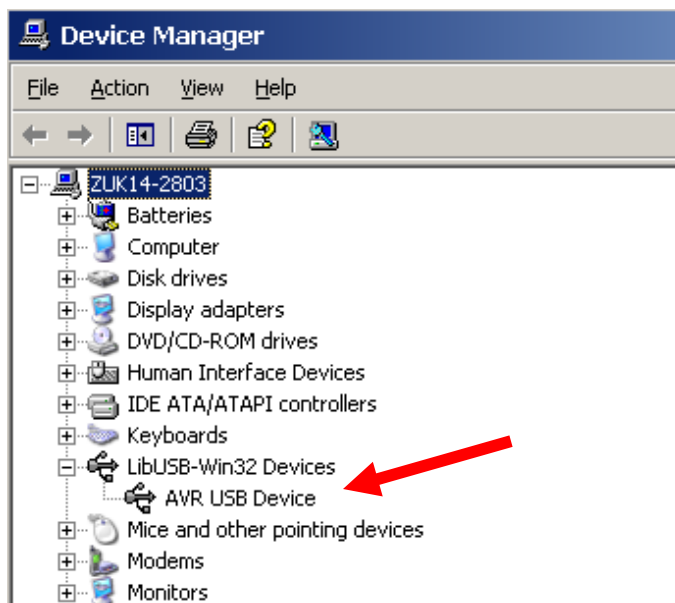
Following Screen is displayed



- Select “Hardware”
- Select “Device Manager”

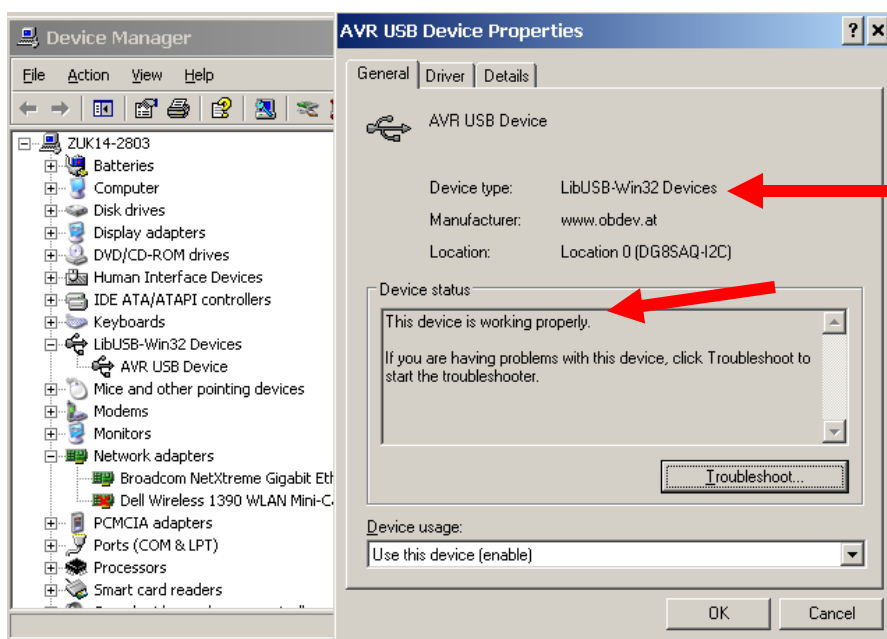
A folder “LibUSB-Win32 Devices” should be displayed (only when USB-Synthesizer is Plugged-in)

- Press to Expand AVR-USB Device folder



Click on “AVR USB Device”

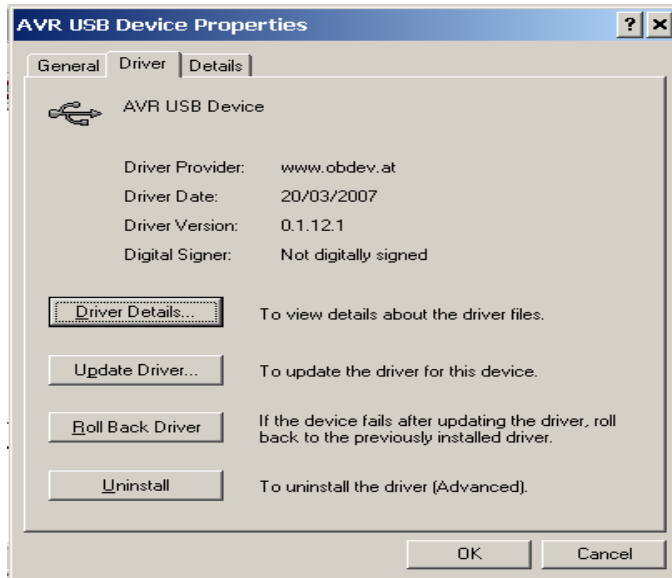
Proper operation of the Driver may now be checked



- Select tab “Driver”

The screen below is displayed and options made available to

- Remove Driver
- Update Driver
- Reinstall Driver



END OF DRIVER INSTALLATION VERIFICATION

6. FUNCTIONAL TESTS

Once driver is installed the USB Synthesizer board can be tested with the application "PROJECT 1" which is located in folder "Si570/hostware"

Start "Project 1"

Check SI570 i2c adr is set as follows

- LVDS Si570BBC000141DG i2c address = 55 Hex
- CMOS Si570CAC000141DG i2c address = 55 Hex

Click button "TestUSB"

The following screen should be shown.

The screenshot shows a Windows application window titled "Form1". The main area displays USB device information for a device with Vendor ID 0x16c0 and Product ID 0x05dc. The information includes manufacturer (www.obdev.at), product (DG8SAQ-I2C), and serial number (Beta1.1). Below this, there are fields for wTotalLength (18), bNumInterfaces (1), bConfigurationValue (1), iConfiguration (0), bmAttributes (80h), and MaxPower (100). Further down, there are fields for bInterfaceNumber (0), bAlternateSetting (0), bNumEndpoints (0), bInterfaceClass (0), bInterfaceSubClass (0), bInterfaceProtocol (0), and iInterface (0).

Below the information, there are several control sections:

- USB_control_msg data to host:** Includes a "request" field with value 3, a "value" field with value 0, and an "index" field with value 0. There are buttons for "read SI570 registers" and "read calc registers".
- SI570 i2c adr = 55 Hex:** A field for the SI570 i2c address, currently set to 55 in hex.
- TestUSB:** A button for testing the USB connection.
- Device Name = DG8SAQ-I2C:** A field for the device name.
- 56.320000 MHz:** A frequency field, currently set to 56.320000 MHz.
- cal on startup freq:** A button for calculating the startup frequency.
- USB_control_msg data to USB device:** Includes a "set freq by registers" button and a "set freq by value" button.
- RXTX level:** A checkbox for the RXTX level.
- continuously query cw key:** A button for continuously querying the CW key.
- key status:** A green circular indicator showing the key status.
- Data to be sent:** A field for data to be sent, currently set to 02 00 00 00 00 00 00 00.
- Length = 01:** A field for the length of the data to be sent, currently set to 01.
- startup f = last f:** A button for setting the startup frequency to the last frequency.
- USB transfer return value = 00 Hex:** A field for the USB transfer return value, currently set to 00 in hex.

Setting Frequency:

Enter the desired frequency in the Window **MHz**

- Example frequency entered **16.400 MHz**
- click "set freq by value"
- click "read SI570 registers"

Following screen should be displayed

Form1

Register 8 = C2 Hex
 Register 9 = C3 Hex
 Register 10 = 2C Hex
 Register 11 = 20 Hex
 Register 12 = E6 Hex

RFREQ = 44.1982735618949
 N1 = 27
 nN1 = 28
 HS_DIV = 7
 nHS_DIV = 11
 frequency = 16.3999990065622 MHz

USB_control_msg data to host SI570 i2c adr = 55 Hex TestUSB

3 0 0 read SI570 registers read calc registers
 HEX 16.40000 MHz cal on startup freq

request value index Device Name = DG8SAQ-42C
 USB_control_msg data to USB device set freq by registers set freq by value ☐ RXTX level continuously query cw key

02 00 00 00 00 00 00 00 startup f = last f
 Data to be sent Length = 01 HEX key status

END OF FUNCTIONAL TEST PROCEDURE

7. INTERFACING TO SOFTROCK RXTX V6.1 or V6.2 TRANSCEIVER

Three connections are required to connect the USB-Synthesizer to the RXTX V6.x transceiver as follows:

- () Prepare a 10cm (4 inch) length of RG174 miniature coaxial cable by removing 1 cm plastic at either end of the cable. Next remove 3mm insulation from the inner conductor at both ends.



Fig 5: Preparation of 10cm 4 inch Coaxial cable

- () On RXTX PCB, disable the Crystal Oscillator by removing 2 pin Jumper from JP2.
- () On RXTX PCB remove 2 pin Jumper from JP1.
- () Solder Inner conductor of coaxial cable to JP1 pin 2 as shown in fig 5 below:

- () Solder Outer conductor of coaxial cable to JP1 pin 4 (Ground) as shown below.

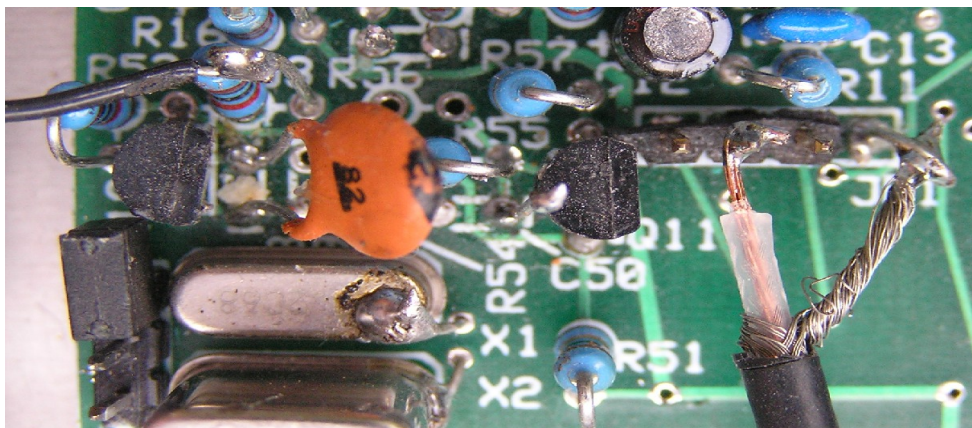


Fig 6: Connection of Coaxial Cable to RXTX PCB JP1

- () On USB Synthesizer board solder inner conductor of coax cable to pin A
- () Solder outer braid of coax cable to centre pin B
- () Connect wire from +12V terminal to +12VDC terminal of RXTX PCB
- () Connect wire from USB-Synthesizer “PTT” to RXTX PCB “PTT_IN”

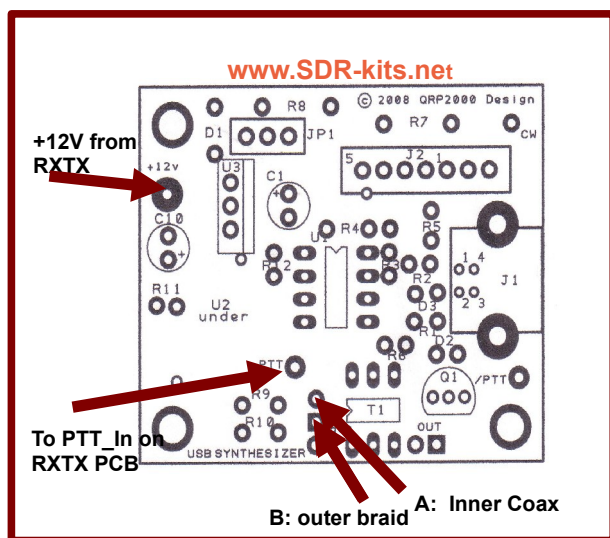


Fig 7: Connections on USB-Synthesizer PCB to support Softrock RXTX

8 PowerSDR SETUP FOR RXTX USB SUPPORT

- () Download PowerSDR application from sourceforge
<http://powersdr-sr40.sourceforge.net/> and install as per instructions
 Beta versions may be posted on www.SDR-Kits.net website
- () After installation select “Setup” and tick “Si570 VFO on USB, Set Multiplier to “4” and enter Fxtal (Hz) to 114324000 and select “Apply”

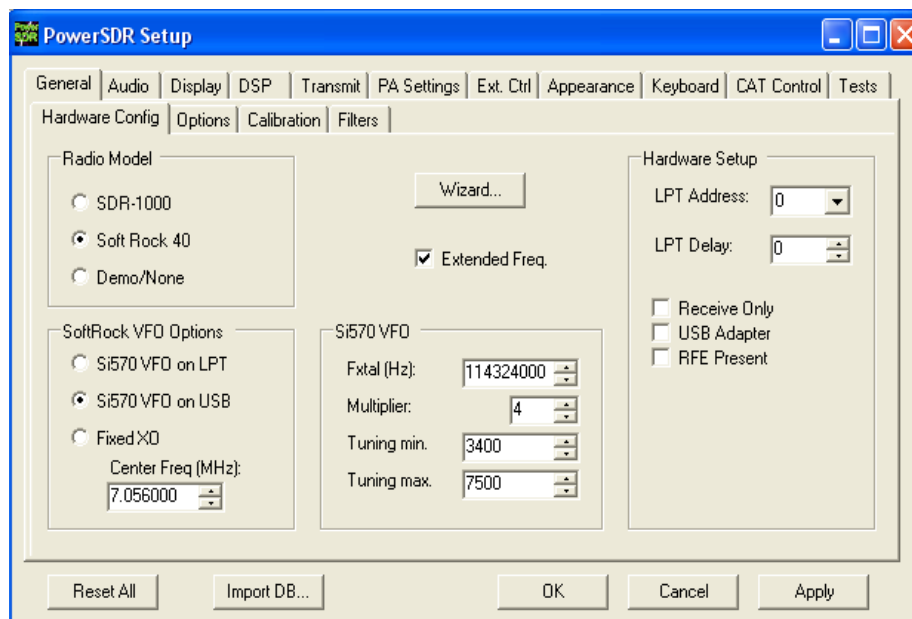


Fig 8: PowerSDR USB setup Screen

Note: Your existing CW keying arrangements (Parallel port or Serial port) as documented in the PowerSDR documentation continues to be supported. The use of the USB-Synthesizer - Straight CW Key-input is optional.

8.1 Si570 FREQUENCY CALIBRATION

Definitions:

Fa = Actual Receive Frequency (Frequency of known Radio Station or Radio Signal published in Frequency list or measured)

Ft = Frequency entered to receive the “known Radio Station”

Fxo = Frequency of the Si570 internal Crystal used in calculate and set “Ft”

Fxn = Corrected Frequency of the Si570 Internal Crystal to set “Ft” to the same frequency as “Fa”

Formula to calculate $F_{xn} = F_{xo} - (F_t - F_a) / F_a * F_{xo}$

Example = $F_{xo} = 114,300.500 \text{ kHz}$
 $F_a = 10,000.000 \text{ kHz}$ (WWV reception on 10 MHz)
 $F_t = 9,995.355 \text{ kHz}$ Frequency set to receive WWV

$F_{xn} = 114,353.593$ (Corrected Crystal frequency – which
 should be stored (in Hz) for future use by
the program)

9 Rocky V3.5 Setup

The popular Rocky SDR Program by Alex VE3NEA may be downloaded from:
<http://www.dxatlas.com/Rocky/>

To enable USB Support, Start Rocky, Select “VIEW”, Select “Setting”, Select “DSP”
Tick “Use Si570-USB”, Tick “Multi-Band” and Check Address is set to “85” press “ok”

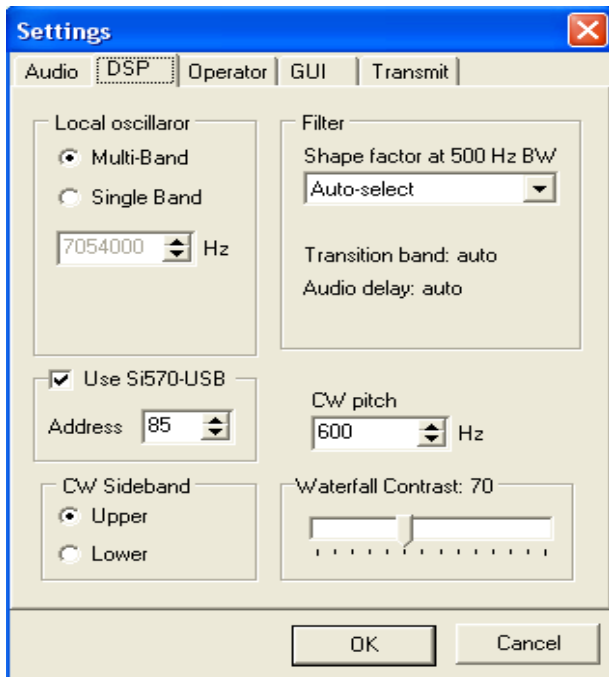


Fig 9: Rocky USB setup Screen

Note: Your existing CW keying arrangements (Parallel port or Serial port) as documented in the Rocky documentation is still supported. The use of the USB-Synthesizer - Straight CW Key-input is optional.

END OF DOCUMENT

