SI5351C reference source User manual

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Contents

Change History

Version	Author	Date	Changes
1.0	Da_Stier	19.09.2023	Initial draft
1.1	Da_Stier	07.03.2024	Updated for HW version 1.1
1.2	Da_Stier	17.03.2024	Small modification for first release version
1.3	Hk	07.04.2024	Minor form adjustments and CE Conformity
1.4	Da_Stier	21.04.2024	Added LED description on page 8
1.5	Hk	21.04.2024	Minor Changes for Print Version

SI5351C reference source User manual

Overview

The SI5351C reference source is an OCXO based multichannel frequency reference. It offers up to eight channels that can be programmed either via serial terminal or a webserver accessed over Wifi

Each channel can be programmed with a 1Hz resolution to offer maximum flexibility.

Possible use cases can be everything from testgear synchronization, RF-transceiver, -transverter and SDR setups to laboratory use as a multi channel signal generator. For SDR use, especially the unit offers two built in IQ channels.

The SI5351C reference source is intended to be anything from a „set it once and forget it“ type of equipment, to an evaluation kit on the SI5351C IC, to a multi channel signal generator with IQ functionality.

The unit encourages modification, custom firmware and any mods required for the intended use.

Example:

Provide a stable and phase coherent reference for a QO-100 HAM setup. In this example the unit is used to provide both a 25MHz reference for the LNB used in the RX path, as well as a 40MHz reference for the LimeSDR mini SDR transceiver used in both the RX and TX path.

Disclaimer

All units are carefully assembles, programmed and tested before delivery. If you run into any trouble with your unit, please let us know.

All units are calibrated by comparing the phase to a known good GPSDO.

The units don’t have a certified, traceable calibration. If this is required, feel free to do it yourself.

Technical specifications and modifications subject to change.

Electrical Data

The following table gives an overview of the electrical parameters.

Recommended Supply voltage	V_{sup_nom}	10 – 13.8 V	There will be more losses the higher the voltage, since all internal supply rails use linear regulation.
Absolute max. supply voltage	V_{sup_max}	9 – 15V (limited to 16.7V by TVS)	
Absolute max. transient voltage	V_{peak_max}	18V	Input limited to 16.7V by SMB TVS diode.
Supply current	I_{sup}	~ 675mA during heating ~ 300mA continuous	@ 12V and +25°C ambient temperature
Output DC voltage	V_{out_DC}	0V tolerates 12V DC offset	Outputs are AC coupled via 100nF
Output power	P_{out}	~ 3dBm @ 2mA ~ 9dBm @ 4mA ~ 11dBm @ 6mA ~ 13dBm @ 8mA	Dependent on the output setting in mA
Frequency Range	f_{out}	~ 1MHz – 200MHz IQ: ~ 7MHz – 150MHz	Programmable Output Frequencies
Voltage at enable input	V_{EN}	Logic low: 0V - 2V	Do not exeed the supply voltage on the enable pin
		Logic high: 3V3 - V_{sup}	
Current at enable input	I_{EN}	< 2mA, typ. ~ 1mA @ V_{sup} = 12V	
Voltage at reference switch input	V_{ref_sw}	Logic low: 0V – 500mV Logic high: 1.2V - V_{sup}	Don’t apply voltages in the undefined region
Current ata reference switch input	I_{ref_sw}	< 2mA, typ. ~ 1mA @ V_{sup} = 12V	
Operating temperature	T_{op}	-25°C to +45°C (See chapter Temperature behavior for further information)	During development the units were tested up to +85°C without failure, however, temperatures over 60°C can change the frequency calibration.

Interface description

This chapter gives an overview of the interfaces on the unit.

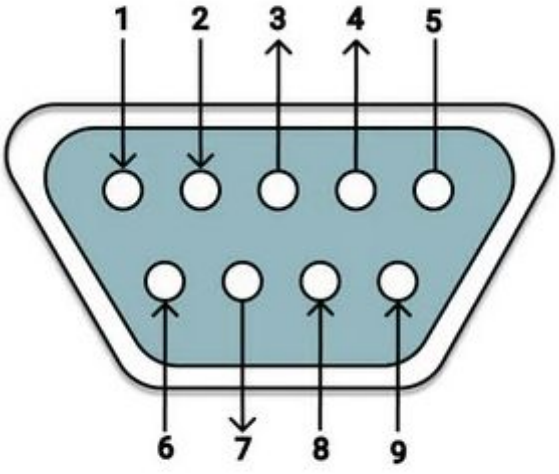
Frontpanel

Nr.	Type	description
1	DB-9 male	Main connector for power and usage flags
2	SMA female	Input / output for the 10MHz reference
3	LEDs	User LEDs
4	USB-C	Virtual COM port for configuring the device currently only works with USB type-A to type-C cables currently can’t be used to supply the device

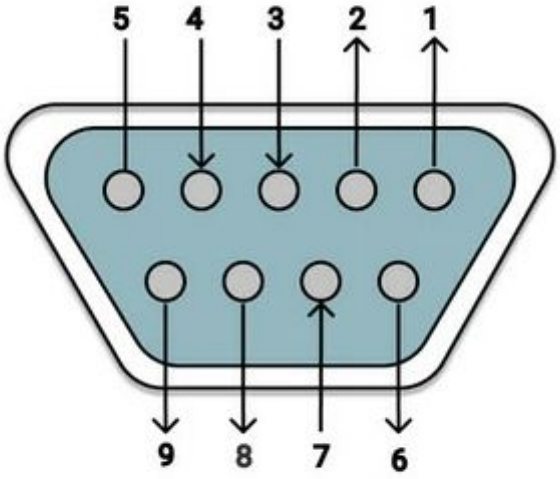
Pinout of the DB-9 connector:

Pin No.	Name	Function
1	VCC	Power Supply of the unit. Connect to V_{sup}.
2	PWR_EN	Enable pin of the unit. LOW or Float → unit is off HIGH → unit is enabled
3	EXT-IN	User input (can be programmed)
4	EXP	Connected to an internal expansion header for future expansion. Do not connect.
5	GND	Power GND of the unit. Connect to GND.
6	VCC	Power Supply of the unit. Connect to V_{sup}.
7	INT_EXT_REF	Switches between reference mode and PLL mode. LOW or Float → reference mode (uses the internal OCXO) HIGH → PLL mode (needs an external reference)
8	EXT-OUT	User output (can be programmed) either pulled to GND or pulled to V_{sup} via 10kΩ
9	GND	Power GND of the unit. Connect to GND.

DB-9 Male
(as on the device)



DB-9 Female



Backpanel

Nr.	Type	description
1	SMA female	Eight outputs for the generated clocks

LEDs

The two LEDs are used to signal the current state of the unit to the user. There are the following states:

(The LED states are also listed in the “help” command)

LEDs	description
Both on	Fault at hardware startup
counting	Waiting for OCXO to get to temperature
LED1 blinking	Normal operation
Both blinking	Normal operation and connected to Wifi network
Alternate blinking	Fault condition
Both blinking fast	A control command has been received

Disassembly

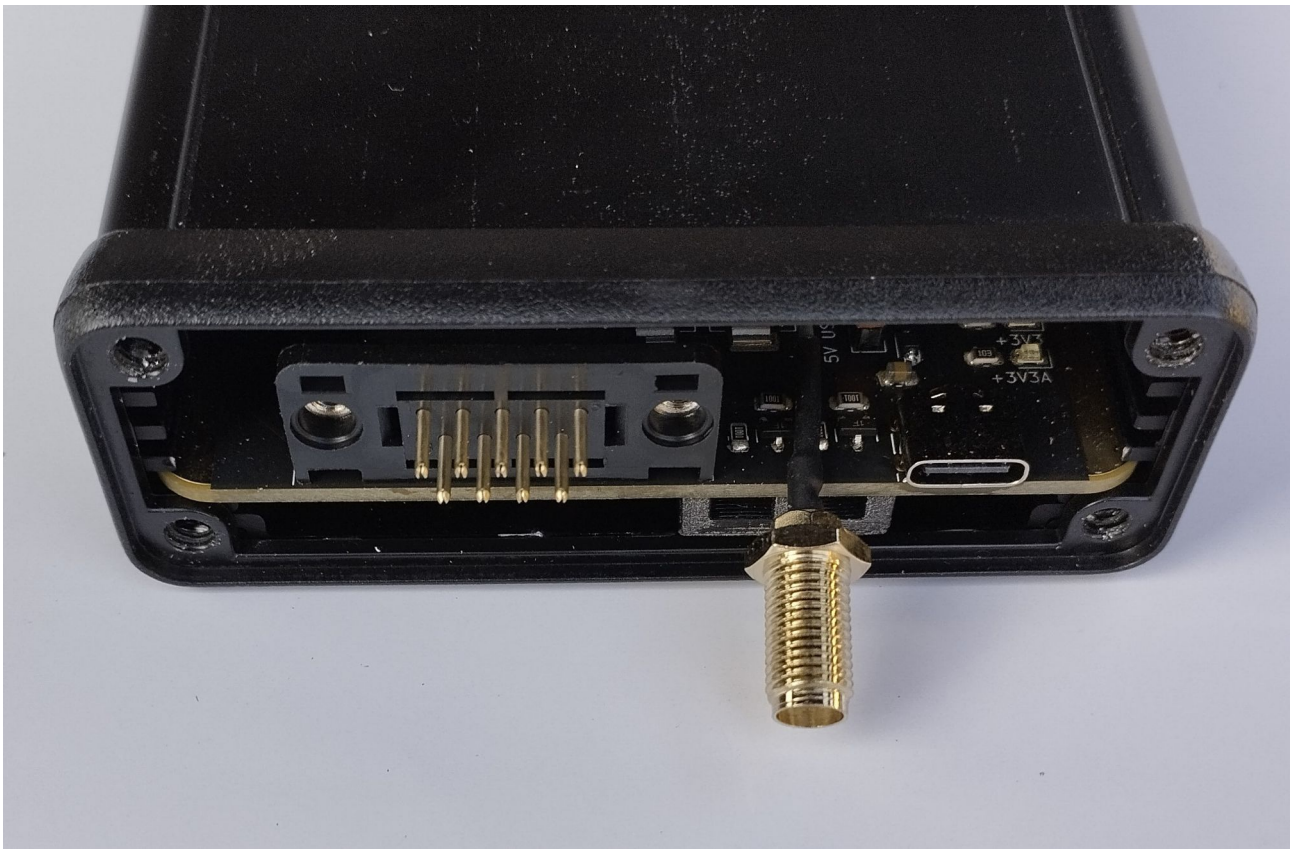
This chapter shows how to take the unit apart. It is important to be very careful when doing so, to avoid damage to any internal or external component. Make sure to use an ESD safe workplace. If possible wear an ESD wrist strap.

Removing the backpanel

First the backpanel containing the in/ext Ref connector needs to be removed. To do so, remove the four case screws (PH1) as well as the two standoffs (SW 5) at the DSUB connector as shown below.

Next the backpanel can be pulled out very carefully. Note that the REF IN/OUT pigtail will still be attached. Also the metal bezel of the DSUB connector is a single piece that will come loose.

To completely remove the backpanel, pull it out just enough to have access to the pigtail. Next loosen the nut and remove it from the backpanel. To do so you can either carefully use pliers or a set of two 8mm spanners.

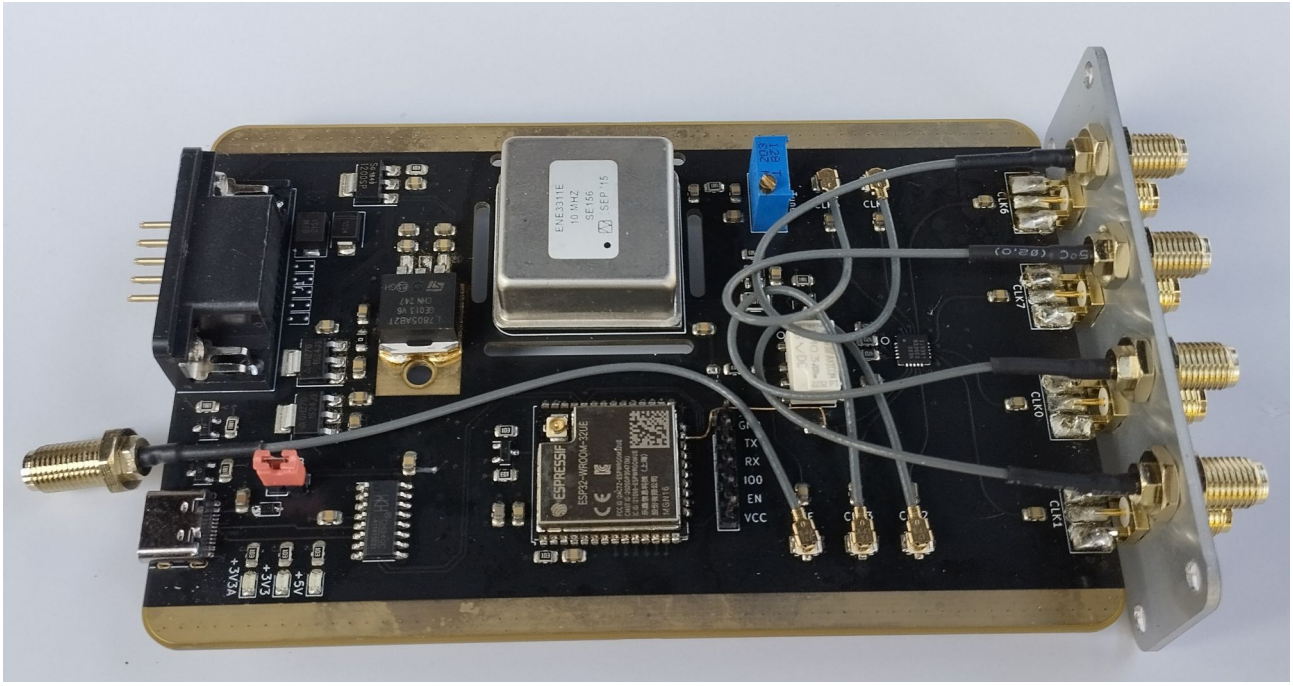


The unit should now look like this.

Taking off the case

To remove the case, take out the four case screws (PH1) on the frontpanel.

After removing these screws, the PCB can be pushed out of the case from the back. You should end up with the bare PCB with all the pigtails as well as the frontpanel still attached.



Reassembly

To reassemble the unit follow the disassembly steps in reverse order.

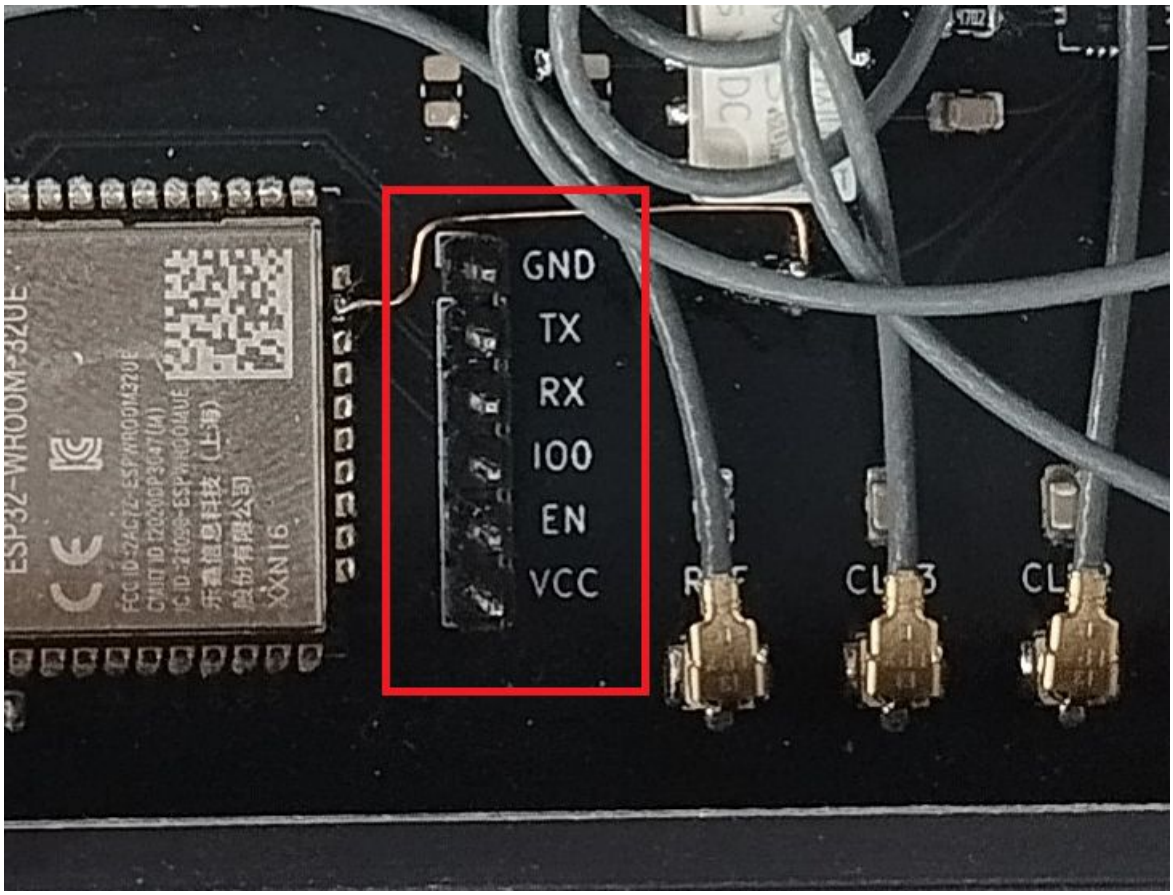
Updating the firmware / flashing the unit

This chapter shows how to flash the unit with a firmware update / custom firmware. There are two options for flashing the unit. One is to open the unit and connect directly to the ESP32 via UART and two control lines. The other is to flash the unit over its configuration USB.

Flashing using an external programmer

To flash the unit with an external programmer start by disassembling the unit. To do so, refer to the chapter „disassembly“.

The following six pin header is used to program the ESP32.



The ESP32 can be flashed by using all common programmers available for this task. It can be flashed by using either the Arduino IDE with the ESP32 board plugin or the standalone ESP32 flash-tool application. (included in the documentation folder).

Flashing using the configuration USB port

The unit can be flashed via the same USB connection that is used for configuring the device.

The unit will be recognized as a CH340 USB to serial converter.

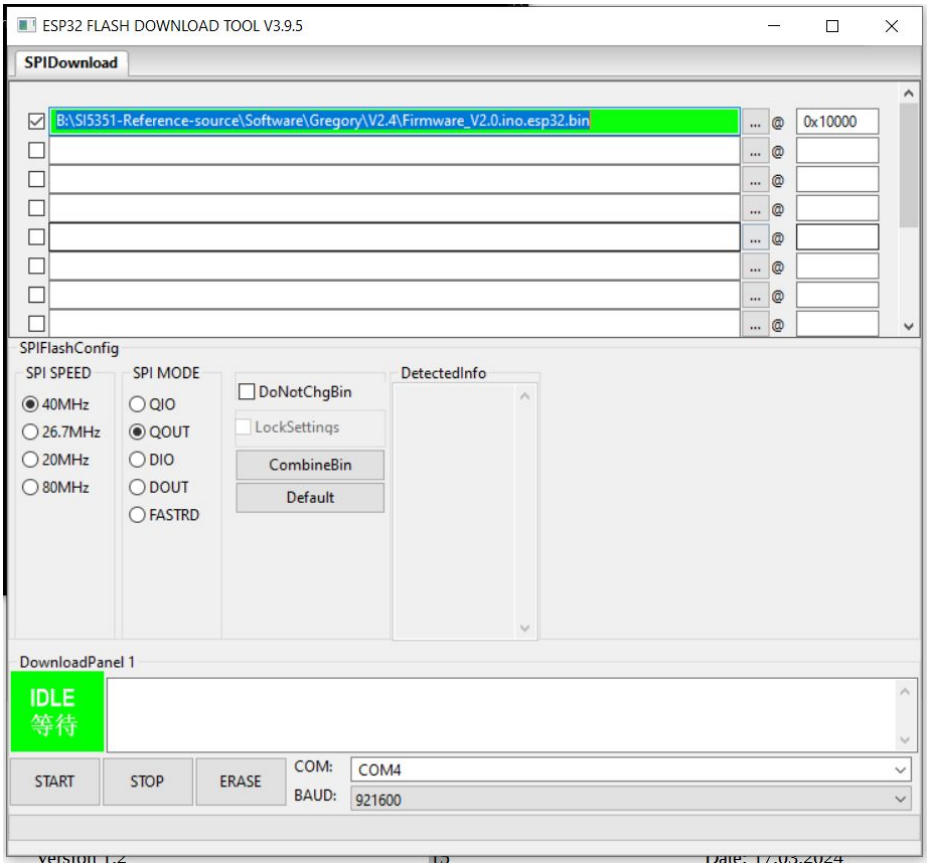
For further information on this topic, check the chapter „Checking the serial connection“

The unit can be directly accessed via the Arduino IDE as with any other Arduino compatible board.

Going back to official firmware

The units can be flashed with custom firmware via the Arduino framework.

If you wish to go back to official firmware, the official binary needs to be flashed. To do so, the ESP32 flash tool is used. To do so start the tool in ESP32 mode and use the following settings:

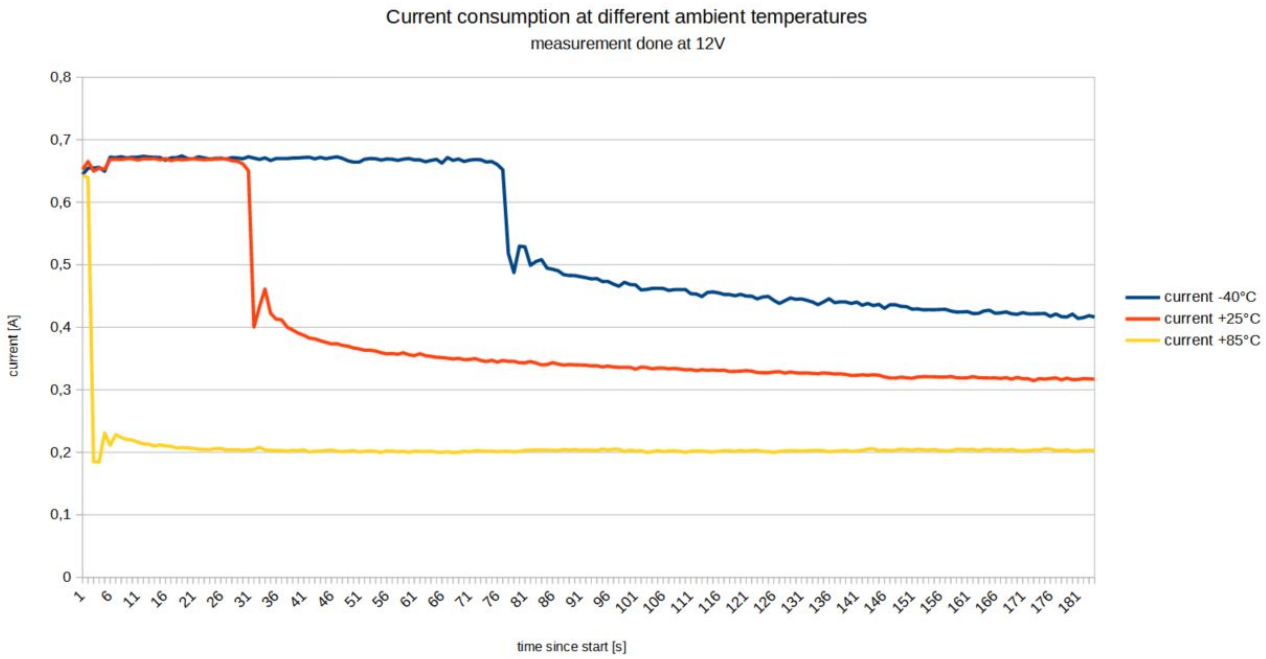


Note the 0x10000 address and make sure to choose the correct COM port for your unit.

Then just press „Start“ to flash the firmware.

Temperature behavior

The unit uses an OCXO in order to be very stable over a wide range of temperatures. This OCXO uses an internal temperature of around 65°C. This means that it should be able to compensate everything below around 60°C. The input power of the reference will depend on the ambient temperature. The following illustration shows this dependency.



It can be seen that both the heating time as well as the final stationary current are heavily dependent on the ambient temperature. At +85°C the proper calibration of the reference frequency can’t be guaranteed, since it is higher than the OCXO temperature.

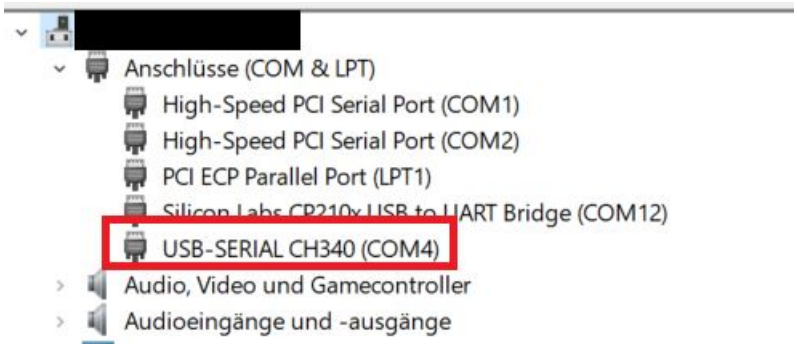
Setting the output parameters

To setup the up to eight outputs of the unit, a serial interface is used. The USB to UART bridge used is the CH340C.

Checking the serial connection

Make sure that the reference is correctly identified by your computer.

Under windows it should look something like this.



If the device is not correctly identified, install either the provided CH340C driver or download the driver from the manufacturers website.

Connecting to the device

To connect to the device, the following parameters need to be used.

- 115200 baud
- 8 data bits
- 1 stop bit
- no parity
- newline at CR + LF
- no flowcontrol at enter

A serial terminal emulator is used to connect. For example H-Term, Tera-term or something similar, depending on which operating system is used.

integrated help menu

The terminal offers an integrated help menu. To view the help page, follow the instructions as displayed and type ***help*** into the terminal. The help menu should look similar to this.

```
------------------------------------------------------------------------
  H E L P
------------------------------------------------------------------------

set - > is used to set the frequency and power of a channel

Syntax: set, [channel], [power], [frequeny in Hz]

[channel] -> clk_a .... clk_h
[power] -> 2, 4, 6, 8
[frequency in Hz] -> 100000 to 200000000
this equals values from 100kHz to 200MHz

Example: set, clk_a, 4, 12000000
-> sets clk_a to drive strength 4mA at 12MHz


get -> is used to get the current frequency and power settings
of a channel.

Syntax: get, [channel]

[channel] -> clk_a .... clk_h or all

Example: get, clk_a
-> gets the power and frequency settings for clk_a


enable -> is used to enable all eight outputs via the output enable
of the SI5351C PLL chip
```

Each entry shows the command, the necessary syntax, the range for all parameters as well an example. The exact entries might vary depending on your firmware version.

Complete list of commands

The following commands are supported by the device:

set

The set command is used to set the parameters of a single output.

Command	parameters	explanation
set	Channel → clk_a … clk_h → iq_ab, iq_ba, iq_ef, iq_fe	Chooses which channel to set Can either be a single channel or an iq definition
	Frequency → 6300000 … 150000000	Defines the requested frequency in Hz valid range: 6.3MHz to 150MHz
	Amplitude → 2, 4, 6, 8	Defines the drive strength in mA in 4 steps

Examples:

set clk_a 10000000 8

→sets output A to 10MHz @ 8mA drive strength

set clk_e 23456789 2

→ sets output E to 23.456789MHz @ 2mA drive strength

set iq_ab 12000000 6

→ sets outputs A and B to produce an IQ signal with output A as the leading signal @ 6mA drive strength

set iq_ba 7000000 4

→ sets outputs A and B to produce an IQ signal with output B as the leading signal @ 4mA drive strength

get

The get command is used to get the current settings of an output.

Command	parameters	explanation
get	Channel → clk_a … clk_h → iq_ab, iq_ba, iq_ef, iq_fe	Chooses which channel to get if the IQ mode is active, only its settings are reported back, not the polarity if the IQ mode is not active, get iq… will return nothing

Examples:

get clk_a

→gets the current output settings for output A

```
clk_a enabled 7000000 8 \r\n
```

get iq_ab

→ checks if the IQ mode is activated for the output A&B combination

```
IQ mode is enabled for clk_a, clk_b.\r\n
iq_ab enabled 7000000 8 \r\n
iq_ab enabled 7000000 8 \r\n
```

enable

The enable command is used to enable one or all of the output channels.

Command	parameters	explanation
enable	Channel → clk_a … clk_h → all	Chooses which channel enable.

Examples:

enable clk_a

→enables output A

enable all

→ enables all the channels.

Note:

The „all“ parameter is uses the output enable pin of the SI5351C.

The Setting is not permanent and is not affected by the save command.

disable

The disable command is used to disable one or all of the output channels.

Command	parameters	explanation
disable	Channel → clk_a … clk_h → all	Chooses which channel disable.

Examples:

disable clk_a

→disables output A

disable all

→ disables all the channels.

Note:

The „all“ parameter is uses the output enable pin of the SI5351C.

The Setting is not permanent and is not affected by the save command.

save

The save command is used to save the current settings of all channels. The saved settings are automatically recalled at startup. The saved settings are the following:

- Frequency of each channel
- Drive strength of each channel
- output enable / disable state
- in case of an IQ setup the phase of the channels used

Command	parameters	explanation
save		Saves all the current settings to flash memory. The save command expects no parameters.

Examples:

save

→saves all the channels

wifi_config

The wifi_config command is used to configure a wifi connection needed to access the web interface used to remotely control the unit.

Command	parameters	explanation
wifi_config	SSID → the SSID of the network to be set	Chooses the network to connect to.
	Password → the password to the wifi network	Is used to log the device into the network.

Examples:

wifi_config Testnet password12345

→logs the device into the wifi network called „Testnet“

Note:

The wifi credentials are stored in flash memory. The device will automatically check if the network is available during startup and connect if the network is present.

The IP-address at which the webclient can be accessed will be displayed on the serial interface.

wifi_get

The wifi_get command is used to check if wifi credentials have been stored and if so shows them.

Command	parameters	explanation
wifi_get		Checks for saved wifi credentials

Examples:

wifi_get

→returns stored wifi credentials.

```
CONNECTED IP: 192.168.178.44 SSID: br4F3-tr4vel13R PASS: W1fi-d3Bug-0x2A \r\n
```

ocxo_get

The ocxo_get command is used to get the current consumed by the OCXO.

Command	parameters	explanation
ocxo_get		Returns the OCXO current.

Examples:

ocxo_get

→returns the OCXO current.

```
STABLE Iocxo: 70 mA
```

product_get

The product_get command is used to get further information about the product.

Command	parameters	explanation
product_get		Gives further information on the product.

Examples:

product_get

→returns the additional information on the product.

```
UNIT ID: 2ac3dc24 FW: 2.20 - 22/02/2024 HW: 1.1
```

The Webserver

If the unit is connected wo a wifi network, it hosts a webserver that can be used to control the unit.

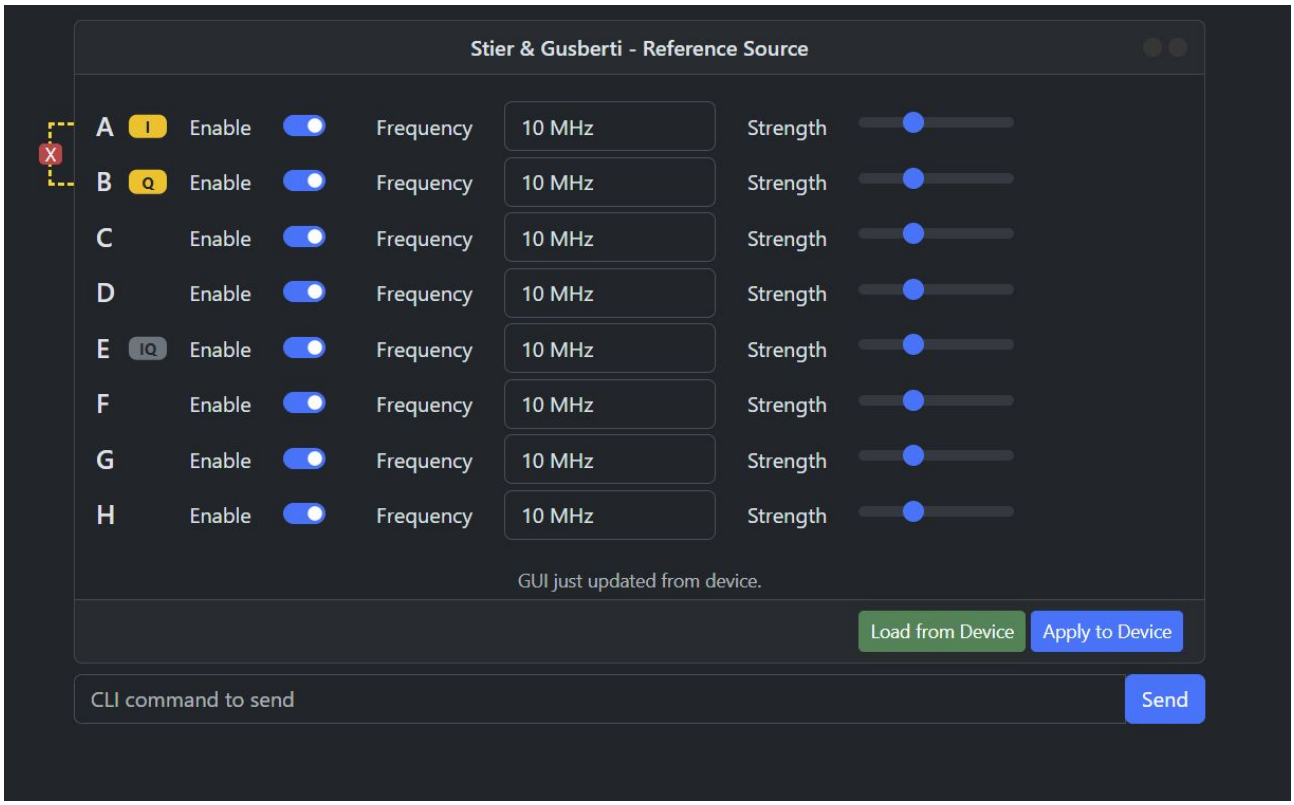
(For further information on how to setup the connection, see chapter „wifi_config“.)

After the unit booted, it will provide the IP-address at which it hosts the webserver to the serial console.

```
INFO: Found stored WiFi credential. Trying to connect.\r\n
INFO: WiFi CONNECTED\r\n
INFO: WiFi IP:\r\n
INFO: 192.168.178.44\r\n
```

The webserver can be accessed by opening a browser (a modern browser is recommended, for example Firefox, Chrome, etc.) and typing the provided IP-address into the URL line.

Afterwards the following page should be loaded.



Note: For the webserver application to download all the resources, an internet connection on the host computer is necessary.

The GUI elements allow to set all the parameters of the unit. If a change is done, the GUI automatically pushed the changes over to the unit. All changes will take effect immediately. To store the setup permanently, the integrated CLI command line can be used to enter the „save“ command.

Note:

There is no feedback from the CLI entry through the webserver.

Known issues / known mods

This chapter gives an overview about known issues of both the hard- and software.
It also provides some recommendations about possible easy mods to do if required.

USB-C to USB-C connection

The current implementation of the USB interface does not provide any power delivery functionality. This means that it can’t be used on a USB-C port by using a USB-C to USB-C cable, since the port won’t provide any power. One modification around this is to remove R26 and populate R27 with a 0R resistor or solder bridge.

Note: This enables the use of a USB-C to USB-C cable however the USB connection only works when the reference is enabled.

External Wifi antenna

If the small patch antenna inside the unit doesn’t provide a stable connection, the ref in/out SMA connector can be used to attach an external antenna. This can be done as follows:

- start by opening the unit. See chapter „Disassembly“ on how this is done.
- Next disconnect the IPX connector of the internal Wifi antenna. Make sure to either completely remove the internal antenna or insulate the IPX connector with heatshrink to avoid short circuits.
- Next disconnect the IPX connector labeled „Ref“ and connect it to the ESP32.
- Reassemble the unit.

Compliance

CE-Konformitätserklärung / CE Declaration of Conformity

Der Hersteller,
The manufacturer,

hentronic UG
Luisenstr. 56
76689 Karlsdorf-Neuthard
Germany

erklärt in alleiniger Verantwortung, dass das Produkt,
declares in sole responsibility, that the product,

Bezeichnung: Frequenznormal
Model: DS-SI5351C
Seriennummer: 2024/2
Baujahr: 2024

den einschlägigen Bestimmungen der folgenden EG-Richtlinien entspricht:
is in conformity with the relevant essential requirements of the following EU-directives:

2014/30/EU Elektromagnetische Verträglichkeit / electromagnetic compatibility
2011/65/EU RoHS-Richtlinie / RoHS Directive
2014/35/EU Niederspannungsrichtlinie / Low Voltage Directive

Folgende harmonisierte Normen wurden angewandt:
Applicable Harmonized Standards:

Norm	**Titel**
IEC 63000 2019-05	Technische Dokumentation zur Beurteilung von Elektro- und Elektronikgeräten hinsichtlich der Beschränkung gefährlicher Stoffe
EN IEC 61000-6-2:2019	Elektromagnetische Verträglichkeit (EMV) – Teil 6-2: Fachgrundnormen – EMV Prüfungen Störaussendung und Störfestigkeit

Neuthard, 05.04.2024

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