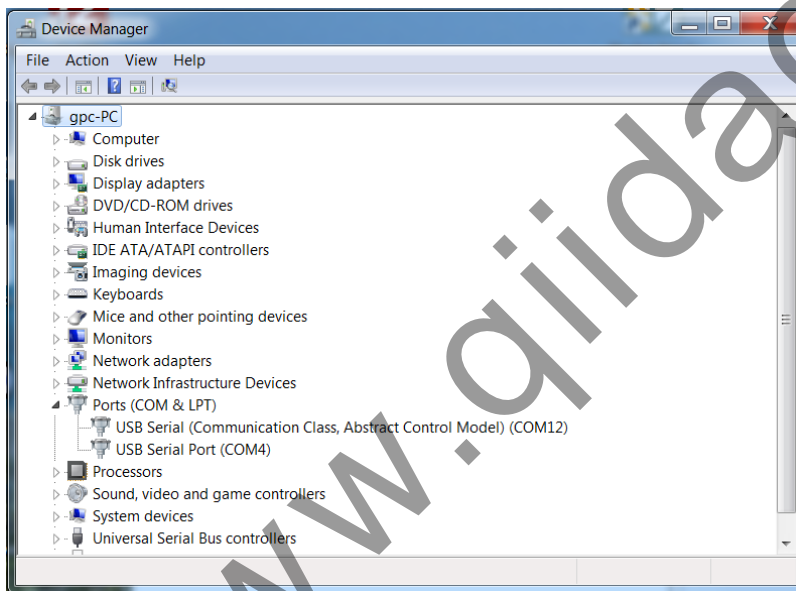


Windfreak Technologies SynthUSB3 Programming Interface

The SynthUSB3 responds to commands that come in through its USB port. The USB port, when plugged in and powered will be assigned a COM port by its operating system that will accept serial commands from your code or from a basic terminal emulator. With Linux and Windows 10 the drivers are supplied automatically by the OS. If using older versions of Windows, you will need to install the drivers from the CD or software download.

Communicating with the SynthUSB3:

First you need to know the COM Port that your computer assigns to your SynthUSB3. Go to Device Manager and see what has been assigned. In this case we are using COM12. Yours may say Teensy in the description. If you have a few COM ports assigned it is a good idea to plug and unplug the device to know for sure which is which.



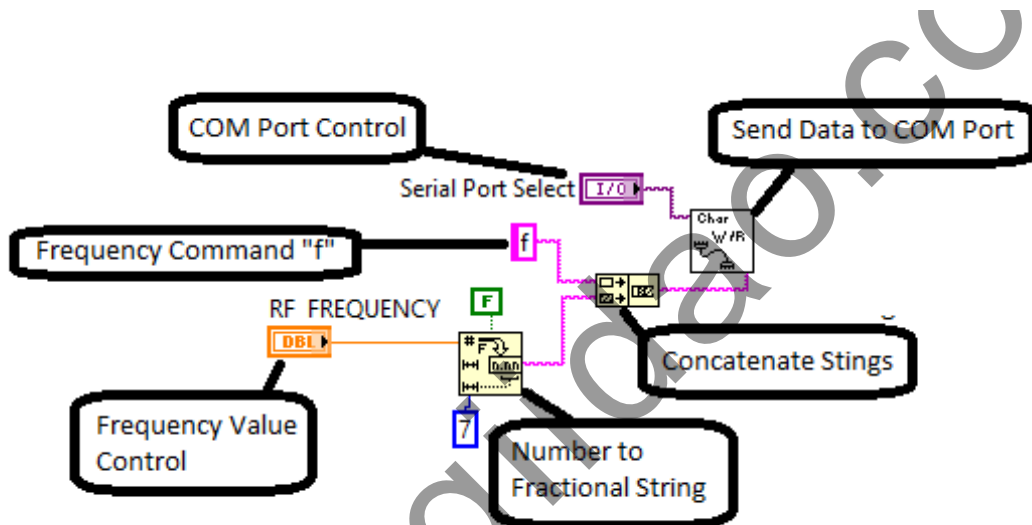
Once you know the SynthUSB3 COM port, communicating with it is as simple as:

- 1) Open the COM port
- 2) Send a command character (example “f” without quotes)
- 3) Send data characters (example “1000.0” without quotes)
- 4) Close the COM port

If you know the cable will not be unplugged, you could leave the COM Port open. All the legacy COM port settings such as Baud Rate, Data bits, Stop bits, etc. are “don’t cares”. All communication will go at full USB speed no matter what these settings are.

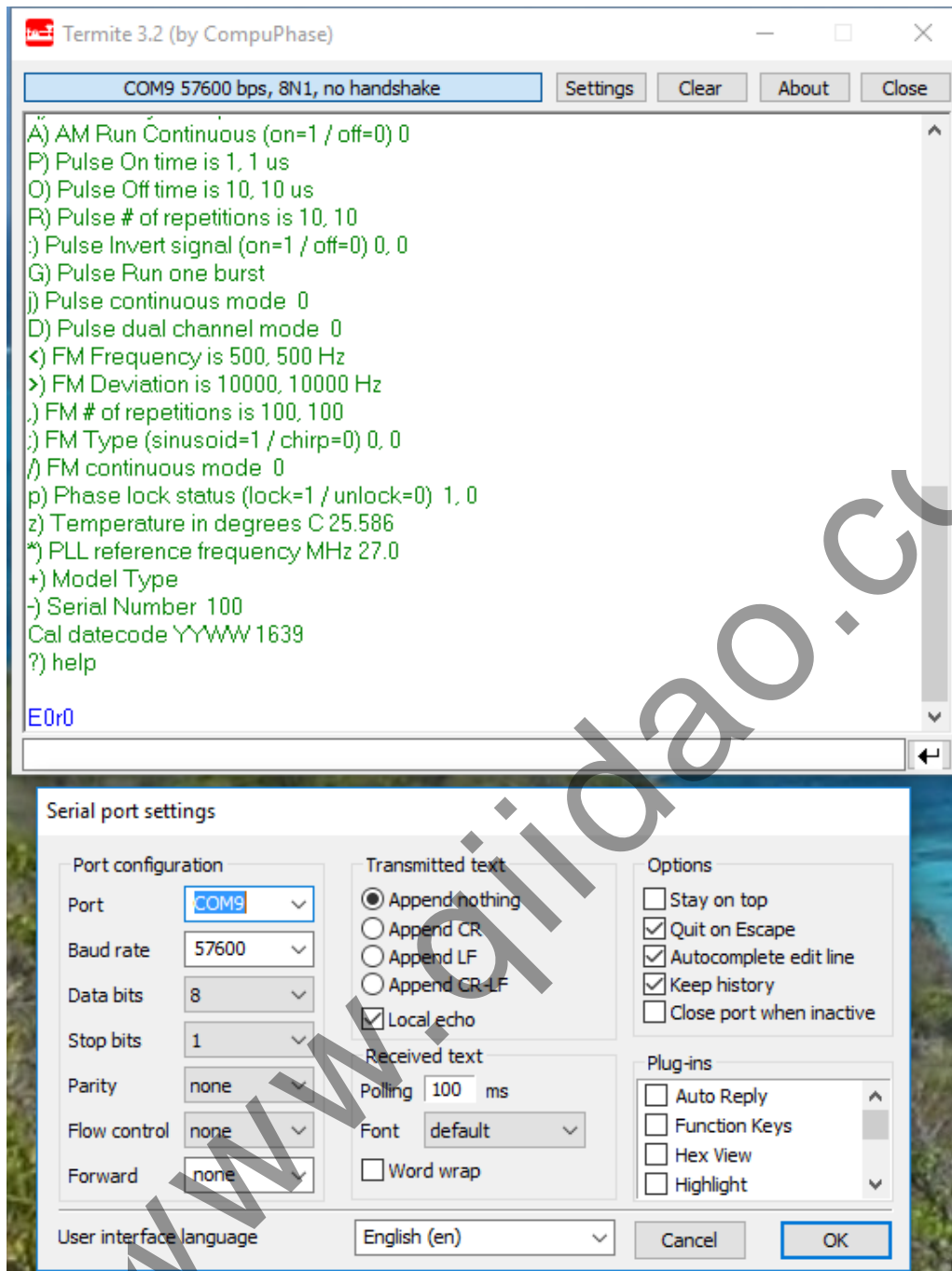
The SynthUSB3 does not accept termination characters such as carriage return or line feed. This was done to make the USB communication scheme as simple and fast as possible. It is possible to string together multiple commands. For example, setting frequency and power to 1000.0MHz and 0.0dBm would be formatted like: “f1000.0W0.0” (without the quotes or any termination characters). Since there are no termination characters it is essential that the command and data are sent as a packet all at once.

Finally, the SynthUSB3 expects case sensitive characters. It is essential that for any data you send to the device you convert any number values to their corresponding characters. In other words, the number 255 has a value that is represented as a single byte value (b11111111), but it will need to be converted to 3 bytes of characters 2,5, and 5. Programming languages such as LabVIEW have a native function to do this shown below:

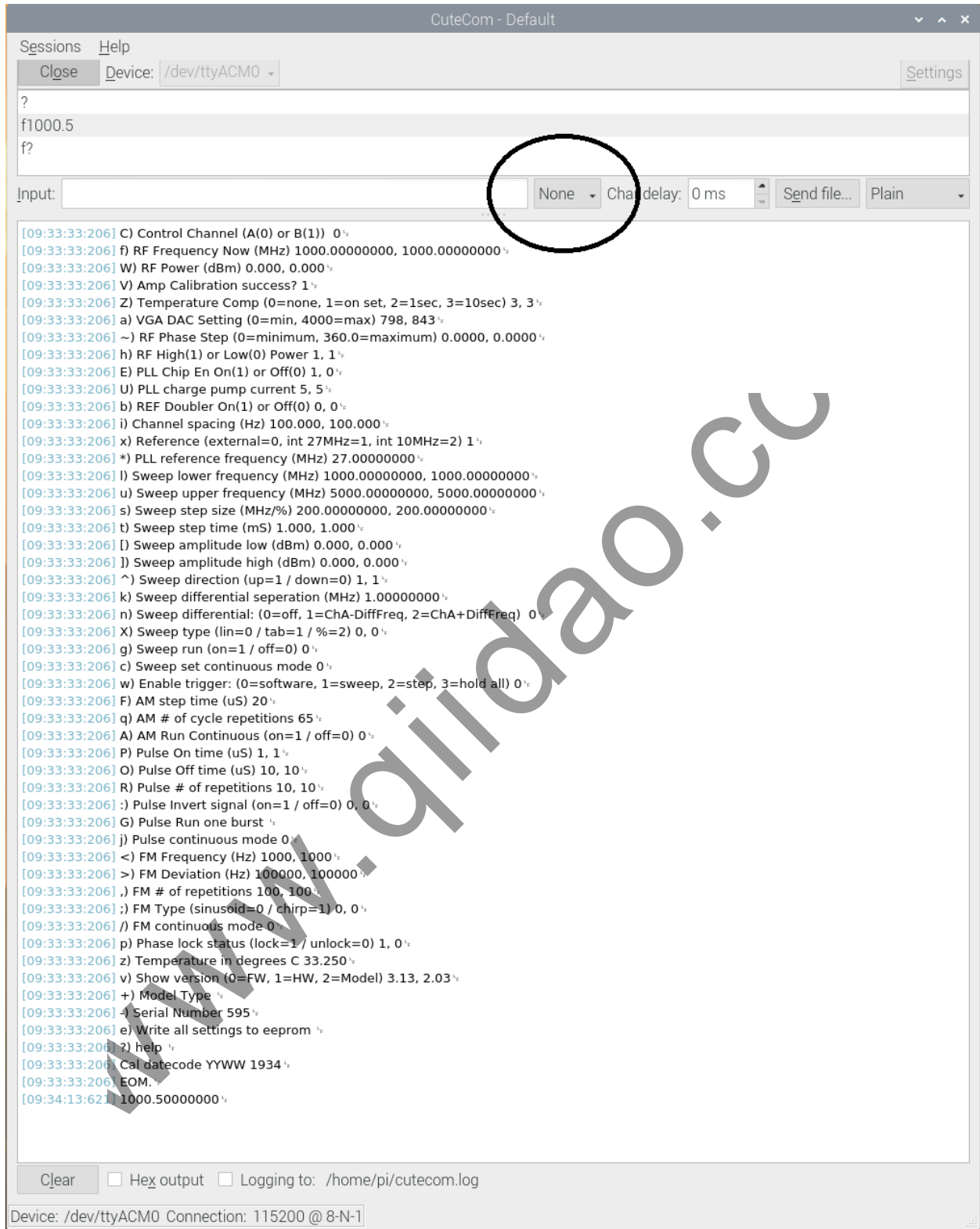


Using a Serial Terminal like Termite:

Before beginning your programming project, it might be a good idea to do some communicating with a 3rd party terminal program to understand how some of the commands work. In Windows, Windfreak Tech recommends a free program called Termite from www.compuphase.com. CuteCom is recommended for Linux. Serial USB Terminal is recommended for Android. The following graphic shows the use and setup of Termite. The only thing to set up is under Setting / “Transmitted text”. There you will need to set “Append nothing” to transmitted characters. A Cutecom screen capture follows with the circled portion showing how to remove termination characters in that program for Linux.



At the bottom of the screen is the command and data entry box. Send a “?” to have the SynthUSB3 respond back with a list of its commands. Try sending a frequency or power command like already mentioned and watch for the change on your spectrum analyzer. Also try sending queries like “f?” to have the SynthUSB3 respond with the status of that particular command. All responses are terminated with a “\n” which is a LF (or New Line) character.



After sending a “?” command the SynthUSB3 will respond with a list of its commands and settings similar to the following list. Click the links below for quick access to further details on each command.

[f\) RF Frequency Now \(MHz\) 1000.00000000](#)
[W\) RF Power \(dBm\) 0.000](#)
[V\) Amp Calibration success? 1](#)
[a\) VGA DAC Setting \(0=min, 63=max\) 22](#)
[E\) PLL Chip En On\(1\) or Off\(0\) 1](#)
[U\) PLL charge pump current 15](#)
[D\) REF Doubler On\(1\) or Off\(0\) 1](#)
[i\) Channel spacing \(Hz\) 0.100](#)
[x\) Reference \(external=0, int 27MHz=1\) 1](#)
[*\) PLL reference frequency \(MHz\) 27.00000000](#)
[l\) Sweep lower frequency \(MHz\) 990.00000000](#)
[u\) Sweep upper frequency \(MHz\) 1010.00000000](#)
[s\) Sweep step size \(MHz/%\) 0.10000000](#)
[t\) Sweep step time \(mS\) 100.000](#)
[l\) Sweep amplitude low \(dBm\) 0.000](#)
[l\) Sweep amplitude high \(dBm\) 0.000](#)
[^\) Sweep direction \(up=1 / down=0\) 1](#)
[X\) Sweep type \(lin=0 / tab=1 / %=2\) 0](#)
[d\) set sweep display \(off=0 / freq=1 / freq + amp=2\) 0](#)
[g\) Sweep run \(on=1 / off=0\) 0](#)
[c\) Sweep set continuous mode 0](#)
[y\) Enable trigger: \(0=software, 1=sweep, 2=step, 3=hold all, ...\) 0](#)
[Y\) Trigger Polarity \(active low=0 / active high=1\) 0](#)
[F\) AM step time \(uS\) 20](#)
[q\) AM # of cycle repetitions 200](#)
[A\) AM Run Continuous \(on=1 / off=0\) 0](#)
[P\) Pulse On time \(uS\) 100](#)
[O\) Pulse Off time \(uS\) 1000](#)
[R\) Pulse # of repetitions 10](#)
[G\) Pulse Run one burst](#)
[j\) Pulse continuous mode 0](#)
[<\) FM Frequency \(Hz\) 1](#)
[>\) FM Deviation \(Hz\) 100000](#)
[.\) FM # of repetitions 100](#)
[;\) FM Type \(sinusoid=0 / chirp=1\) 1](#)
[/\) FM continuous mode 0](#)

[p\) Phase lock status \(lock=1 / unlock=0\) 1](#)
[m\) Automatic communication mode \(UART=1 / USB=0\) 0](#)
[T\) Send test message to both USB and UART](#)
[v\) Show version \(0=firmware, 1=hardware\) 1.01](#)
[+\) Model Type SynthUSB3](#)
[-\) Serial Number 51](#)
[e\) Write all settings to eeprom](#)
[?\) help](#)
 Cal datecode YYWW 2042
 EOM.

Features not listed in the SynthUSB3 Help “?” Response:

[List Mode Definitions \(Command L\)](#)
[Notes on External Modulations](#)
[AM Definitions \(Command @\)](#)

Command Definitions:

Set Frequency in MHz (Command f):

The SynthUSB3 frequency is settable between 12.5MHz and 6400MHz. The setting is always in MHz.

fxxxxx.xxxxxxx sets frequency to x MHz in 0.1Hz resolution
f? queries frequency setting in 0.01Hz resolution

Set Power in dBm (Command W):

The SynthUSB3 RF power is settable between -50dBm and +10dBm depending on frequency. With this setting the SynthUSB3 will automatically calibrate itself and set the power as close as it can get to what is requested.

Wxx.xxx sets RF power to x dBm in 0.01dB resolution
W? queries the RF output power setting in 0.01dB resolution

Query for Successful Calibration Completion (Command V):

If the SynthUSB3 can successfully complete its calibration routine upon frequency or amplitude set, it will set a flag of 1 showing the output should be leveled.

V queries if there was successful calibration. 1=success, 0=failure

Set Raw DAC Value (Command a):

The SynthUSB3 RF power setting can be bypassed and set with a raw VGA DAC value between 0 and 63. A setting of 0 is minimal and 63 would be maximum gain. Response is non-linear.

ax sets DAC value for x drive level where x is between 0 and 63
a? queries the DAC setting

Set PLL Power On (Command E):

The SynthUSB3 PLL can be powered down for absolute minimum noise on the output connector. This command enables and disables the PLL, VCO and internal reference to save energy and can take 20mS to boot up.

Ex sets the enable function where $x=1$ =powered on and $x=0$ =powered off

E? queries the setting

Program PLL Charge Pump Current (Command U):

The charge pump current setting affects the loop filter bandwidth and shape. Use to adjust the tradeoff between inband spurs and phase noise. Also use to smooth frequency transitions during FM modulation.

Uxx sets charge pump current where x is between 1 and 15

U? queries the charge pump current

Set Reference Doubler (Command D):

The SynthUSB3 reference can be doubled in frequency before going to the phase detector. This can make phase noise better

Dx sets the enable function where $x=1$ =enabled and $x=0$ =disabled

D? queries the setting

Set Channel Spacing in Hz (Command i):

The SynthUSB3 channel spacing is settable between 0.01Hz and 10000000.0Hz. The setting is always in Hz. This setting affects the resolution for setting RF frequency and possibly affects inband spurs. Default is 0.1Hz.

ixxxxx.xxxxxxx sets channel spacing to x Hz

i? queries channel spacing setting

Set Internal or External Reference (Command x):

The SynthUSB3 has one internal reference at 27MHz. It also has the ability to use an external reference. If using an external reference see the “*” PLL Reference Frequency Command.

xy sets the reference where $y=0$ =external, $y=1$ =internal 27MHz

x? queries the setting

Set Reference Frequency in MHz (Command *):

The SynthUSB3 reference frequency is settable between 10.0MHz and 100.0MHz. The setting is always in MHz.

**xxx.xxx sets frequency to x MHz in 0.001MHz resolution*

**? queries reference frequency setting*

Sweep Definitions:**Lower Frequency for Linear Sweep (Command l):**

Sets the lower frequency for the linear sweep in MHz. This frequency should be lower than the Upper Frequency and kept within 12.5MHz – 6400MHz.

lx sets the lower frequency where x is the frequency in MHz

l? queries the setting

Upper Frequency for Linear Sweep (Command u):

Sets the upper frequency for the linear sweep in MHz. This frequency should be higher than the Lower Frequency and kept within 12.5MHz – 6400MHz.

ux sets the upper frequency where x is the frequency in MHz

u? queries the setting

Step Size Frequency for Linear Sweep (Command s):

Sets the step size frequency for the linear sweep in MHz. This frequency should be smaller than the range between Lower and Upper frequencies.

sx sets the step size frequency where x is the frequency in MHz

s? queries the setting

Step Time for Linear Sweep (Command t):

Sets the step time for the linear sweep in mS. Step time should be kept between 0.25mS and 60,000 mS.

txxxx.xxx sets the step size frequency where x is the time in mS.

t? queries the setting

Linear Sweep Power Low (Command l):

Sets the sweep RF power in dBm for the Lower Frequency setting of the sweep. RF Power should be within the range of -50 to +10dBm. This value is used in combination with the Sweep Power High (h) and causes a linear adjustment of power as the sweep occurs. Keep both values the same to have a level sweep.

[xx.xxx sets the lower RF sweep power setting in dBm.

[? queries the setting

Linear Sweep Power High (Command h):

Sets the sweep RF power in dBm for the Upper Frequency setting of the sweep. RF Power should be within the range of -50 to +10dBm. This value is used in combination with the Sweep Power Low (l) and causes a linear adjustment of power as the sweep occurs. Keep both values the same to have a level sweep.

[xx.xxx sets the upper frequency RF sweep power setting in dBm.

[? queries the setting

Sweep Direction (Command ^):

Sets the linear sweep direction from upper frequency to lower frequency or vice versa. Also sets the direction of the tabular sweep.

^x sets the direction where x=0 is from upper frequency to lower frequency and x=1 is from lower frequency to upper frequency. For tabular sweep x=0 reverses the order of the steps and x=1 is normal increment.

^? queries the setting

Sweep Type (Command X):

Determines whether to do a linear sweep or a tabular sweep (500 point table hopping).

Xy toggles the type of sweep to perform where y=0=linear and y=1=tabular

X? queries the setting

Set Sweep Display style (Command d):

Sets the SynthUSB3 to display the frequency in MHz and/or power in dBm after every new frequency is set in the generator - only during an automated sweep. Every value of the sweep is followed by a “/n” (line feed) termination character and the total sweep is final after an “EOM./n” end of message flag.

A sweep of 6 data points from 1000.0MHz to 2000.0MHz at 200.0MHz steps combined with sweep amplitude settings from -10dBm to +5dBm with a “d2” setting would look similar to:

1000.0000000

-10.00

1200.0000000

-7.00

1400.0000000

-4.00

1600.0000000

-1.00

1800.0000000

2.00

2000.0000000

5.00

EOM.

Using the sweep display setting will slow down the sweep and is not practical for sweep times faster than the eye can see.

dx sets sweep display style, where x=0 is don't display, x=1 is display frequency, and x=2 is display frequency and amplitude.

d? queries the setting

Run Sweep (Command g):

Starts a sweep. Once complete the value is automatically returned to 0 unless Sweep Continuous “c” is set to 1. If “c” is set to 1 then the sweep process automatically repeats forever. If Sweep Continuous “c” is set to 0 a g1 will completely restart the sweep no matter where the sweep is at. If “c” is set to 1 a “g0” will pause the sweep and a “g1” will continue the sweep.

gx controls running a single sweep when x=1=start, restart or continue and x=0=pause

g? queries the setting

Sweep Continuously (Command c):

Sets sweep continuously mode. If asserted (“c1”) the Run Sweep “g” command will not be reset to 0 after a complete sweep and sweeping or hopping will continue until a “g0” command is sent. Alternatively, a “c0” will terminate the sweep after it is complete.

cx controls running a single sweep when x=0 and continuous, repetitive sweeping when x=1

c? queries the setting

List Mode Sweep Definitions:

List is run by storing frequencies and amplitudes at memory locations designated by the “L” command. Read the table by sending “L?”. Delete the whole table by sending “Ld”. Save the whole table to nonvolatile memory with “Le”. The “f” command loads frequency in MHz and the “a” command loads amplitude in dBm. If the whole table is not deleted, the table will stop the sweep at a memory location that has a frequency value of 0.0MHz.

While its possible to load an individual memory location, the Windfreak SynthUSB 3 GUI, every time a value is changed with a click to “Send Table To Ram” the whole table is deleted with “Ld” and then resent as a concatenated string. An example is here:

“LdL0f1000.0L0a-30.0L1f1001.0L1a10.0L2f1234.12L2a0.0”

After sending a “L?” command, you should receive a response like this:

L00f1000.0000000a-30.00

L01f1001.0000000a10.00

L02f1234.1200000a0.00

EOM.

Set Trigger Connector Functions (Command y):

The SynthUSB3 Trigger input is a multifunction input. It is used for trigger events, but also used for other things like external FM, AM and Pulse modulation inputs. The values are:

- 0) No Triggers
- 1) Trigger full frequency sweep
- 2) Trigger single frequency step
- 3) Trigger “stop all” which pauses sequencing through all functions of the SynthUSB3
- 4) Trigger digital RF ON/OFF – Could be used for External Pulse Modulation
- 5) Remove Interrupts (Makes modulation have less jitter – use carefully)
- 6) Reserved
- 7) Reserved
- 8) External AM modulation input (requires AM Internal modulation LUT set to ramp)
- 9) External FM modulation input (requires FM Internal modulation set to chirp)
- 10) Sleep

wx sets the Trigger connector as described above to x

w? queries the setting

Set Trigger Polarity (Command Y):

Trigger polarity can be changed to make hardware hookup easier. There is an internal pullup resistor on the trigger line no matter the polarity setting.

Yx sets the enable function where x=1=active high and x=0=active low

Y? queries the setting

Notes on External Modulations:

External AM Modulation is driven through the Trigger connector and responds to analog voltages between 0 and 1.2V. It responds to setting stored in the AM look up table and cycles through each sample. For best performance set the AM frequency to 1Hz which gives the maximum of 100 samples. Set the wave shape to RAMP and select whether you want the response linear in dB or Volts. 0V input will correspond with the Minimum Power setting

and 1.2V will drive to the Peak Power setting with 100 steps in between. Sample rate is roughly 22uS.

External FM Modulation is driven through the Trigger connector and responds to analog voltages between 0 and 1.2V. It responds to setting stored in the FM control tab and cycles through each sample it creates. For best performance set the FM frequency to 1Hz which gives the maximum of 100 samples. Set the wave shape to CHIRP. 0V input will correspond with the (negative) FM Deviation setting and 1.2V will drive to the (positive) Deviation setting with 100 steps in between. Sample rate is roughly 22uS per point.

Software doesn't necessarily have to perform these functions every time. The SynthUSB3 can be programmed for the proper external modulation and the data be saved to nonvolatile EEPROM so that its always there. Use the supplied GUI to do these functions as well as set any other defaults (uses the "e" command).

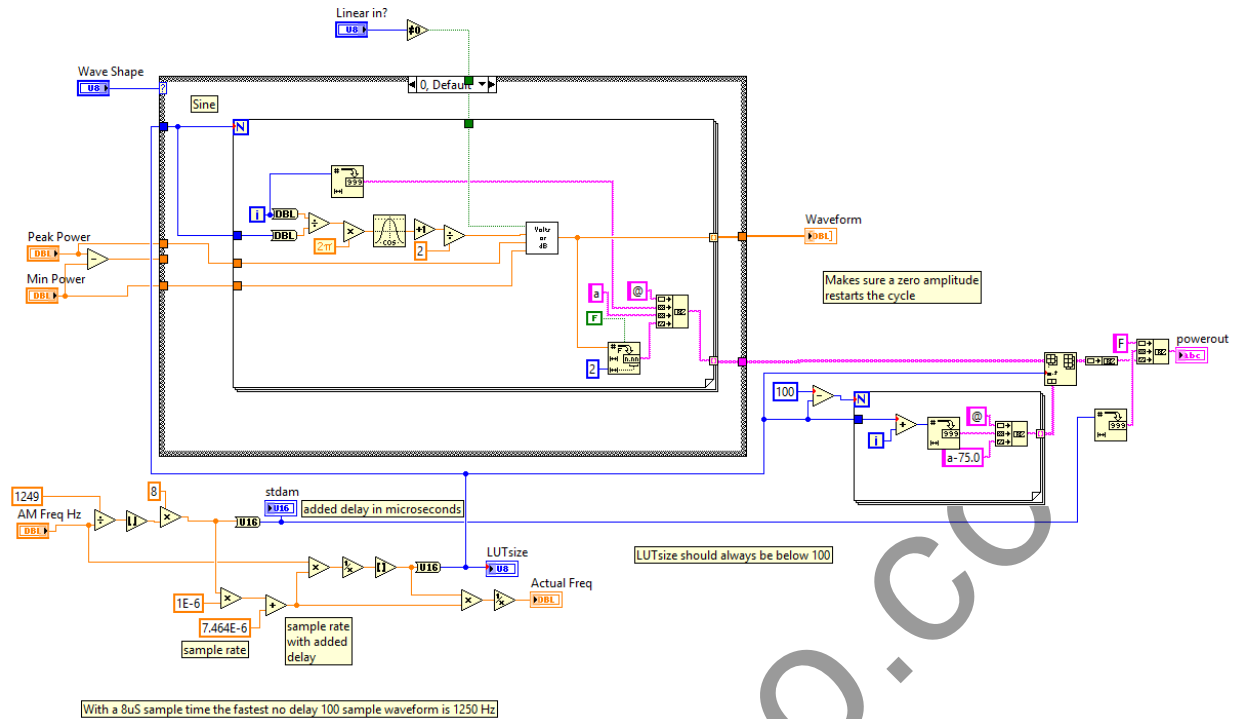
Amplitude Modulation Definitions:

AM modulation is achieved through a digital sampled waveform that has to be uploaded to the device and "played" with a certain sample rate. The waveform is always loaded 100 samples long, but any sample with a value of -75.0dBm is not played. So frequency is determined both by the number of samples played in the waveform and the samples per second play rate.

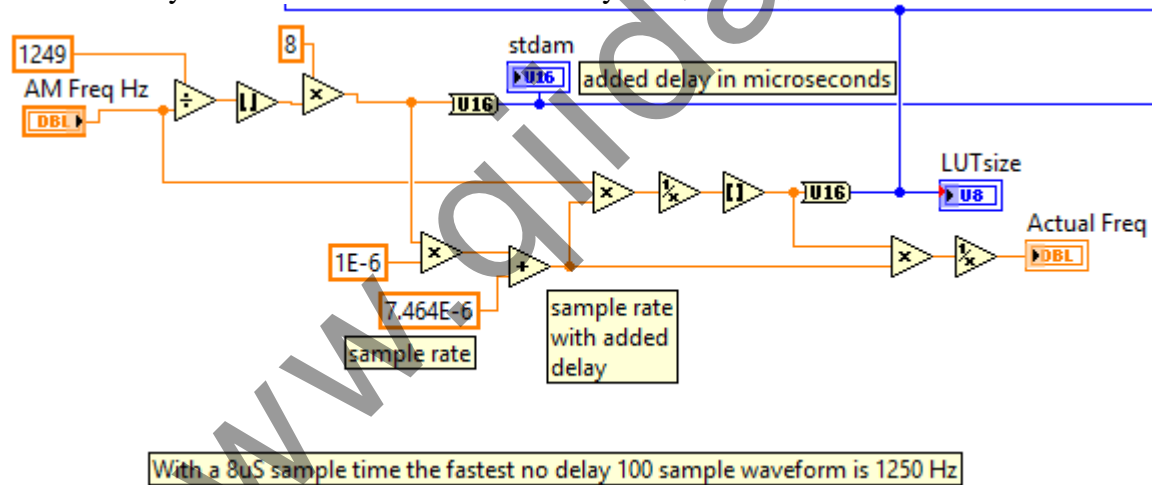
An example of loading a sinusoidal, 1KHz, -20dBm to +20dBm table to the device would be:

```
F8@0a20.00@1a19.91@2a19.63@3a19.16@4a18.52@5a17.71@6a16.73@7a15.59@8a14.31
@9a12.90@10a11.36@11a9.72@12a7.99@13a6.18@14a4.32@15a2.41@16a0.48@17a-
1.45@18a-3.37@19a-5.25@20a-7.09@21a-8.86@22a-10.55@23a-12.14@24a-13.62@25a-
14.97@26a-16.18@27a-17.24@28a-18.14@29a-18.87@30a-19.42@31a-19.79@32a-
19.98@33a-19.98@34a-19.79@35a-19.42@36a-18.87@37a-18.14@38a-17.24@39a-
16.18@40a-14.97@41a-13.62@42a-12.14@43a-10.55@44a-8.86@45a-7.09@46a-5.25@47a-
3.37@48a-
1.45@49a0.48@50a2.41@51a4.32@52a6.18@53a7.99@54a9.72@55a11.36@56a12.90@57a1
4.31@58a15.59@59a16.73@60a17.71@61a18.52@62a19.16@63a19.63@64a19.91@65a-
75.0@66a-75.0@67a-75.0@68a-75.0@69a-75.0@70a-75.0@71a-75.0@72a-75.0@73a-
75.0@74a-75.0@75a-75.0@76a-75.0@77a-75.0@78a-75.0@79a-75.0@80a-75.0@81a-
75.0@82a-75.0@83a-75.0@84a-75.0@85a-75.0@86a-75.0@87a-75.0@88a-75.0@89a-
75.0@90a-75.0@91a-75.0@92a-75.0@93a-75.0@94a-75.0@95a-75.0@96a-75.0@97a-
75.0@98a-75.0@99a-75.0
```

For reference here is the LabVIEW code used to generate a table:



How the delay is calculated in the Windfreak SynthUSB3 GUI:



AM Step Time in Microseconds (Command F):

Sets the additive delay on top of the minimum sample rate achieved by the DAC driving the VGA to achieve AM modulation.

Fx sets the delay where *x* is in microseconds

F? queries the setting

AM Number of Samples to Play in a Burst (Command q):

Sets the number of samples to play in one burst. Usually this is the number of total samples in a cycle or multiples thereof. Used when mixed with other functions like stepping. It's possible to sweep and for every step in the sweep generate a given number of AM cycles.

qx sets the number x of samples to play

q? queries the setting

AM Run Continuously (Command A):

Turns continuous AM modulation on or off.

Ax turns AM on or off with x=1=on and x=0=off

A? queries the setting

Program a Spot in the AM Lookup Table in dBm (Command @):

Programming the AM lookup table requires programming memory locations of 0-199 with an amplitude value in dBm. The command is a series of two commands.

@xay sets value in AM LUT where x=memory value between 0 and 199, and y= value in dBm

@xa? Queries value at memory location x

Pulse Modulation Commands:**Pulse On Time (Command P):**

Sets the Pulse Modulation On time in microseconds. Range is 100uS to 10,000,000 uS (10 seconds).

Px sets the on time x of the RF pulse in microseconds

P? queries the setting

Pulse Off Time (Command O):

Sets the Pulse Modulation Off time in microseconds. Range is 100uS to 10,000,000 uS (10 seconds).

Ox sets the off time x of the RF pulse in microseconds

O? queries the setting

Pulse Number of Repetitions in a Burst (Command R):

Sets the Pulse Modulation number of repetitions in a burst. Range is 1 to 65000. Burst size is used when mixed with other functions like stepping. It's possible to sweep and for every step in the sweep generate the given number of Pulse On/Off cycles in the burst.

Rx sets the CW off time x of the RF pulse in microseconds

R? queries the setting

Run One Pulse Burst (Command G):

Starts one cycle of a pulse burst.

G starts a burst

Run Pulse Modulation Continuously (Command j):

Starts continuous pulse amplitude modulation.

jx starts continuous pulse modulation where x=1 starts the modulation and x=0 stops the modulation

j? queries the setting

Frequency Modulation Commands:

FM Frequency (Command <):

Sets FM modulation frequency.

<x Sets FM modulation frequency where x is frequency in Hz and the range is 1Hz – 5000Hz

<? queries the setting

FM Deviation (Command >):

Sets FM deviation frequency.

>x Sets FM modulation deviation where x is frequency in +/- Hz. The range minimum is depends on the channel spacing setting and range maximum is specified by band for the table below.

>? queries the setting

Widest FM Deviation+/-

12.5-25.0MHz = 62.5KHz

-50.0MHz = 125KHz

-100.0MHz = 250KHz

-200.0MHz = 500KHz

-400.0MHz = 1MHz

-800MHz = 2MHz

-1600MHz = 4MHz

-3200MHz = 8MHz

-6400MHz = 16MHz

FM Number of Samples in Burst (Command ,):

Sets the number of FM samples to play in one burst. Usually this is the number of total samples in a cycle or multiples thereof. Used when mixed with other functions like stepping. It's possible to sweep and for every step in the sweep generate a given number of FM cycles.

,x Sets FM modulation number of samples in a burst

,? queries the setting

FM Modulation Type (Command ,):

Sets the FM modulation type to either sinusoid or chirp (ramp).

,x Sets FM modulation shape for x=0=chirp and x=1=sinusoid

,? queries the setting

Run FM Continuous Modulation (Command /):

Starts continuous frequency amplitude modulation.

/x starts continuous frequency modulation where x=1 starts the modulation and x=0 stops the modulation

/? queries the setting

Query for PLL Phase Lock Status (Command p):

Checks if PLL for given channel is phase locked.

p Queries PLL to see if its locked and returns a 0=unlocked or a 1=locked

Query for Communication Mode (Command m):

The SynthUSB3 will respond with what communications mode, either USB or UART, after this command is sent. UART can be slower so it helps software to know in what way it is communicating.

m Queries the processor and returns a 0=USB mode or a 1=UART mode

Query to Send Test Message to both USB and UART (Command T):

Sends a test message to both communications ports telling where it came from and where it went.

If the command came from USB:

- 1) USB will receive message: "Test Message to USB from USB."
- 2) UART will receive message: "Test Message to UART from USB."

If the command came from UART:

- 1) USB will receive message: "Test Message to USB from UART."
- 2) UART will receive message: "Test Message to UART from UART."

T Queries SynthUSB3 for messages to help troubleshoot UART hardware design.

Query to Show Version (Command v):

Shows the version of firmware and hardware used in the SynthUSB3.

vx shows version where x=0 shows firmware version and x=1 shows hardware version

Query to Show Model type (Command +):

Shows the version of firmware and hardware used in the SynthUSB3. Example: "SynthUSB3 55"

+ shows model type and serial number

Query to Show Serial Number (Command -):

Shows the unique serial number used in the SynthUSB3. It's the same number as shown on the sticker on the bottom of the device.

- shows serial number

Program all Settings to Nonvolatile Memory (EEPROM) (Command e):

All of the settings currently set in the SynthUSB3 can be programmed to the SynthUSB3 nonvolatile memory for default operation on power up. Verify that the SynthUSB3 is set exactly the way you need it set before sending this command since it will also save a state that may not work. Almost all functions like modulation, sweep etc. are saved. Lookup tables (sweep, FM, AM) may not be saved.

e saves all variables in the SynthUSB3 for power up boot

Query to Show Help (Command ?):

Shows either a human version of all variables in the device (as in the table of contents for this document), or a version more suitable for programming allowing quick swapping of variables with software. See below for an example of “?1”. Each variable is followed by a “/n” and the message is ended with “EOM./n”. For humans it is ok to only send “?”.

?x shows version where x=0 gives the human version of help and x=1 gives a programming version of all variable settings

```
f1000.00000000
W5.000
V1
a39
E1
U15
D1
i0.100
x1
*27.00000000
l1000.00000000
u2000.00000000
s200.00000000
t100.000
[-10.000
]5.000
^1
X0
d2
g0
c0
y0
Y0
F20
q200
A0
P100
O1000
R10
j0
<1
>100000
,100
;l
/0
p1
m0
v1.01
-51
EOM.
```