

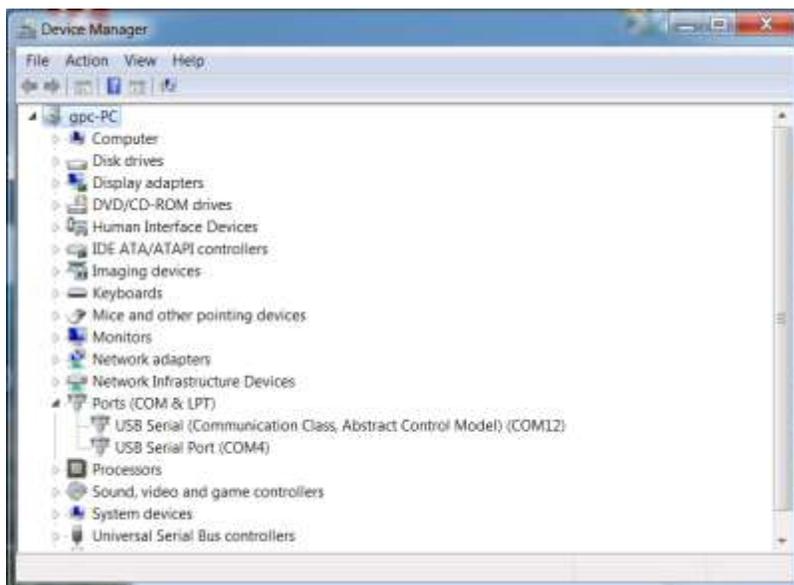
Windfreak Technologies SynthHD Programming Interface

The SynthHD and SynthHD PRO have the same command sets, so will be referred to as just the SynthHD throughout this document.

The SynthHD 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 SynthHD:

First you need to know the COM Port that your computer assigns to your SynthHD. 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 SynthHD COM port, communicating with it is as simple as:

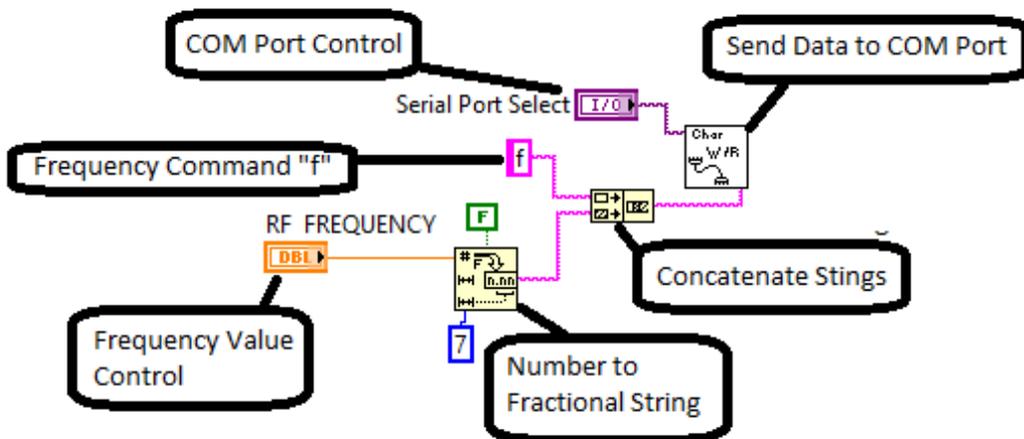
- 1) Open the COM port
- 2) Send a command character (example "f" without quotes)
- 3) Send data characters (example "1000.0" without quotes)
- 4) Close the COM port

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.

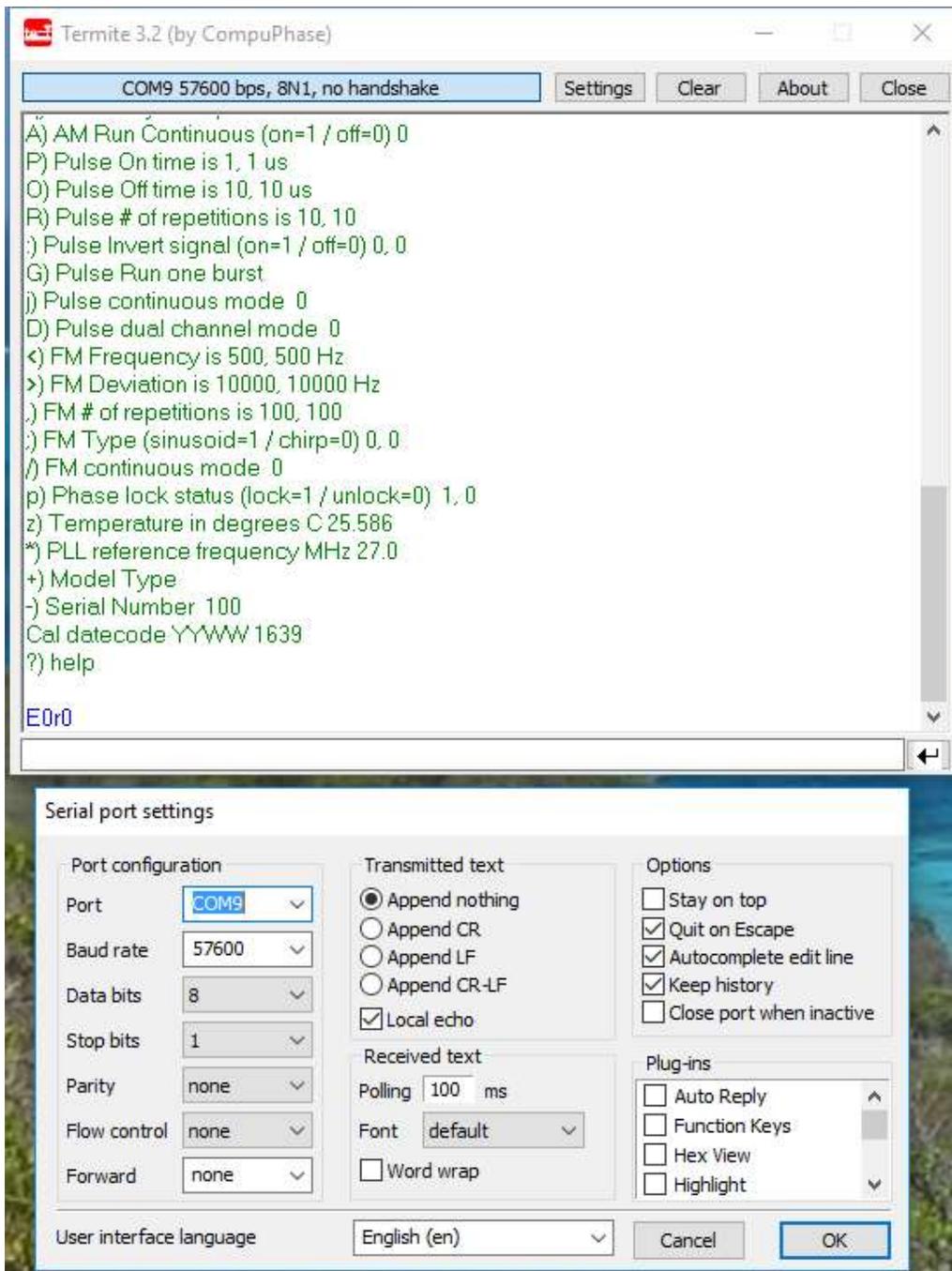
The SynthHD does not accept termination characters such as carriage return or line feed. This was done to make the USB communication scheme as simple and fast as possible. It is possible to string together multiple commands. For example, setting frequency and power to 1000.0MHz and 0.0dBm would be formatted 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 SynthHD 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. Windfreak Tech recommends a free program called Termite from www.compuphase.com. Other programs like PuTTY will work but have a bit harder setups and may not allow you to turn off the termination characters. Terminal programs can be found for all major operating systems including apps from the Google Play store. 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.



At the bottom of the screen is the command and data entry box. Send a “?” to have the SynthHD 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 SynthHD 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 SynthHD 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.

- [C\) Control Channel \(A\(0\) or B\(1\)\) 0](#)
- [f\) RF Frequency Now \(MHz\) 1000.0, 1000.0](#)
- [W\) RF Power \(dBm\) 0.000, 0.000](#)
- [V\) RF Calibration success? 1, 1](#)
- [Z\) Temperature Comp \(0=none, 1=on set, 2=1sec, 3=10sec\) 3, 3](#)
- [a\) VGA DAC Setting \(0=min, 45000=max\) 19589, 19487](#)
- [~\) RF Phase Step \(0=minimum, 360.0=maximum\) 0.0000, 0.0000](#)
- [h\) RF High\(1\) or Low\(0\) Power 1, 1](#)
- [r\) PA On\(1\) or Off\(0\) 0, 0](#)
- [E\) PLL Chip En On\(1\) or Off\(0\) 0, 0](#)
- [I\) PLL output power 2, 2](#)
- [U\) PLL charge pump current 6, 6](#)
- [d\) PLL mute till LD 1, 1](#)
- [m\) Muxout function 6, 6](#)
- [T\) Autocal On\(1\) or Off\(0\) 1, 1](#)
- [b\) Feedback select Fundamental\(1\) or Divided\(0\) 0, 0](#)
- [i\) Channel spacing \(Hz\) 1000](#)
- [v\) Show version \(0=firmware, 1=hardware\)](#)
- [e\) Write all settings to eeprom](#)
- [x\) Reference \(external=0, int 27MHz=1, int 10MHz=2\) 1](#)
- [w\) Enable trigger: \(0=software, 1=sweep, 2=step, 3=hold all\) 0](#)
- [l\) Sweep lower frequency \(MHz\) 1000.0, 1000.0](#)
- [u\) Sweep upper frequency \(MHz\) 5000.0, 5000.0](#)
- [s\) Sweep step size \(MHz\) 200.0, 200.0](#)
- [t\) Sweep step time \(mS\) 50.000 ms, 50.000 ms](#)
- [\[\) Sweep amplitude low \(dBm\) 0.00, 0.00](#)
- [\] Sweep amplitude high \(dBm\) 0.00, 0.00](#)
- [^\) Sweep direction \(up=1 / down=0\) 1, 1](#)
- [k\) Sweep differential frequency separation \(MHz\) 1.0](#)
- [n\) Sweep differential: \(0=off, 1=ChA-DiffFreq, 2=ChA+DiffFreq\) 0](#)
- [X\) Sweep type \(linear=0 / tabular=1\) 0, 0](#)
- [g\) Sweep run \(on=1 / off=0\) 0](#)

c) Sweep set continuous mode 0
F) AM step time in microseconds 8
q) AM # of cycle repetitions 65
A) AM Run Continuous (on=1 / off=0) 0
@) Program AM Lookup Table
P) Pulse On time is 1, 1 us
O) Pulse Off time is 10, 10 us
R) Pulse # of repetitions is 10, 10
:) Pulse Invert signal (on=1 / off=0) 0, 0
G) Pulse Run one burst
j) Pulse continuous mode 0
D) Pulse dual channel mode 0
<) FM Frequency is 500, 500 Hz
>) FM Deviation is 10000, 10000 Hz
,) FM # of repetitions is 100, 100
;) FM Type (sinusoid=1 / chirp=0) 0, 0
/) FM continuous mode 0
p) Phase lock status (lock=1 / unlock=0) 0, 0
z) Temperature in degrees C 26.494
*) PLL reference frequency MHz 27.0
+) Model Type
-) Serial Number 100
Cal datecode YYWW 1639
?) help

Command Definitions:

Set Channel (Command C):

The SynthHD has two channels. On the physical device these channels are called RFoutA and RFoutB. RFoutA is channel 0 and RFoutB is channel 1. The SynthHD will boot up with a (EEPROM settable) default channel. Query which channel currently set by sending a C? The SynthHD will continue to have that controlling channel set until changed or powered down. All commands sent to the SynthHD will be set for the channel under control.

Cx where x=0=channel0=RFoutA and where x=1=channel1=RFoutB

C? queries which channel is currently under control

Set Frequency in MHz (Command f):

The SynthHD frequency is settable between 53.0MHz and 13999.999999MHz. The setting is always in MHz.

fxxxxx.xxxxxxx sets frequency to x MHz in 0.1Hz resolution

f? queries frequency setting for current channel in 0.1Hz resolution

Set Power in dBm (Command W):

The SynthHD RF power is settable between -60dBm and +20dBm depending on frequency.

With this setting the SynthHD 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 0.001dB resolution

W? queries the RF output power setting for current channel in 0.001dB resolution

Query for Successful Calibration Completion (Command V):

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

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

Set Temperature Compensation Method (Command Z):

The SynthHD RF power can be stabilized over temperature. “On set” means that it will only be adjusted for when frequency or power is set. The 1 second and 10 second setting will also both be adjusted “on set” as well but also automatically compensate every 1 or 10 seconds respectively.

The default setting is to automatically run the routine every 10 seconds. During modulation, the temperature compensation routine is put on hold and resumes once modulation is turned off.

Zx sets the method for temperature compensation (x=0=none, 1=on set, 2=1sec, 3=10sec).

Z? queries the setting for Temperature Compensation

Set Raw DAC Value (Command a):

The SynthHD RF power setting can be bypassed and set with a raw VGA DAC value between 0 and 45000. A setting of 0 is minimal and 45000 would be maximum gain.

ax sets DAC value for x drive level where x is between 0 and 45000

a? queries the DAC setting

Set Phase Step Value (Command ~):

The SynthHD RF phase can be adjusted on each channel. These adjustments are relative adjustments that add the phase amount to the current phase being generated. There is no way (currently) to know the absolute phase setting of the SynthHD.

~xxx.xxx sends a phase increment to the SynthHD channel under control in x degrees. (Sending x359.0 will appear to decrement the phase by 1.0 degrees).

~? Has no real meaning.

Set RF Mute (Command h):

The SynthHD output power can be muted without fully powering down the PLL and output amplifier stages. The amount of muting depends on frequency.

hx sets the muting function where x=1=not muted and x=0=muted

h? queries the setting

Set PA Power On (Command r):

The SynthHD output power stage can be powered down without fully powering down the PLL and output amplifier stages. This command enables and disables the linear regulator that supplies the VGA output power stage to save energy. The amount of muting depends on frequency. The SynthHD software GUI uses this command and the “E” command to toggle the output RF on and off. (E0r0=full quiet, E1r1=fully operational)

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

r? queries the setting

Set PLL Power On (Command E):

The SynthHD PLL can be powered down for absolute minimum noise on the output connector. This command enables and disables the PLL and VCO to save energy and can take 20mS to boot up. The SynthHD software GUI uses the “r” command and the “E” command to toggle the output RF on and off. (E0r0=full quiet, E1r1=fully operational)

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

E? queries the setting

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

All of the settings currently set in the SynthHD can be programmed to the SynthHD nonvolatile memory for default operation on power up. Verify that the SynthHD 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 SynthHD for power up boot

Set Internal or External Reference (Command x):

The SynthHD has two internal references (10MHz and 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, y=2=internal 10MHz

x? queries the setting

Set Trigger Connector Functions (Command w):

The SynthHD 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 SynthHD
- 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)

wx sets the Trigger connector as described above to x
w? 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 SynthHD 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).

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 53MHz – 14000MHz.

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 53MHz – 14000MHz.

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 4mS and 10,000 mS.

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

t? queries the setting

Linear Sweep Power Low (Command I):

Sets the sweep RF power in dBm for the Lower Frequency setting of the sweep. RF Power should be within the range of -60 to +20dBm. This value is used in combination with the Sweep Power High (J) 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 J):

Sets the sweep RF power in dBm for the Upper Frequency setting of the sweep. RF Power should be within the range of -60 to +20dBm. This value is used in combination with the Sweep Power Low (I) and causes a linear adjustment of power as the sweep occurs. Keep both values the same to have a level sweep.

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

J? 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

Differential Frequency Separation (Command k):

Sets the differential frequency between the two channels in MHz. This frequency should be smaller than the range of the frequency capabilities of the SynthHD when considered for the operation of both channels. Once the sweep or tabular stepping is started both channels will step together with this constant frequency separation between channels.

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

k? queries the setting

Sweep Differential Method (Command n):

Turns on Sweep Differential and sets the differential signal frequency location, above the swept channel or below the swept channel.

nx turns on or off Differential Sweeping where x=0=off, x=1=ChA-DiffFreq,

x=2=ChA+DiffFreq

n? queries the setting

Sweep Type (Command X):

Determines whether to do a linear sweep or a tabular sweep (100 point table hopping).

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

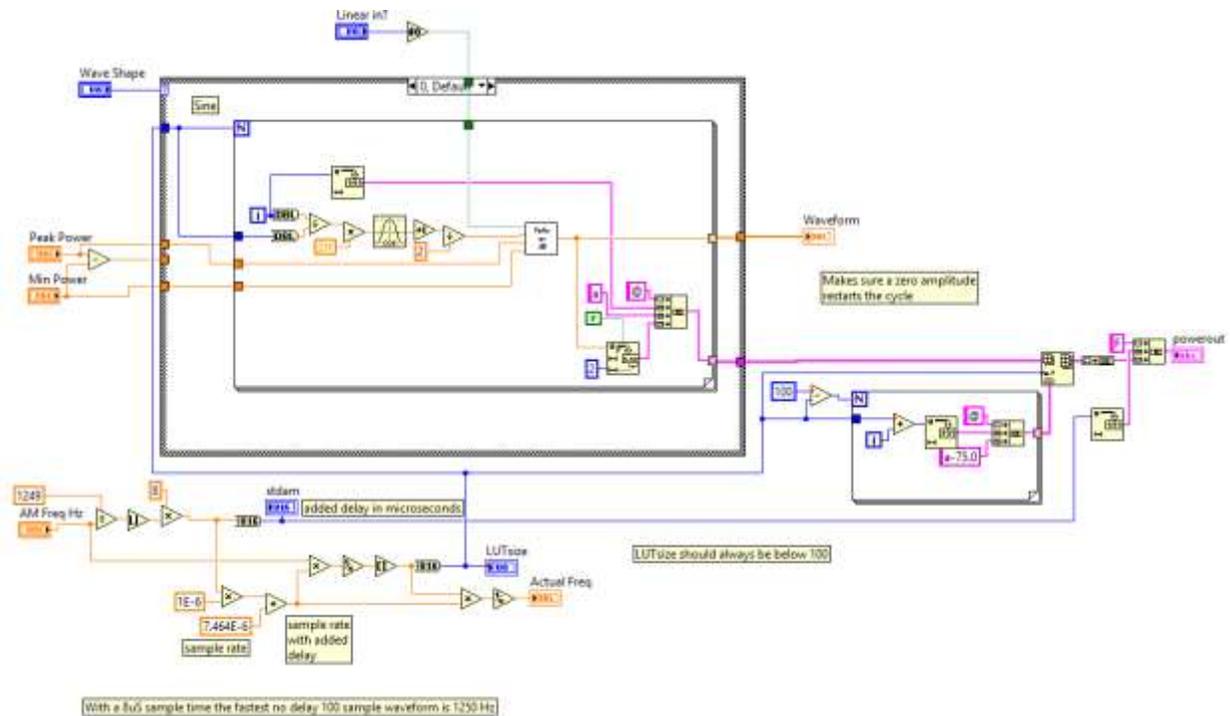
Amplitude Modulation Definitions:

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.

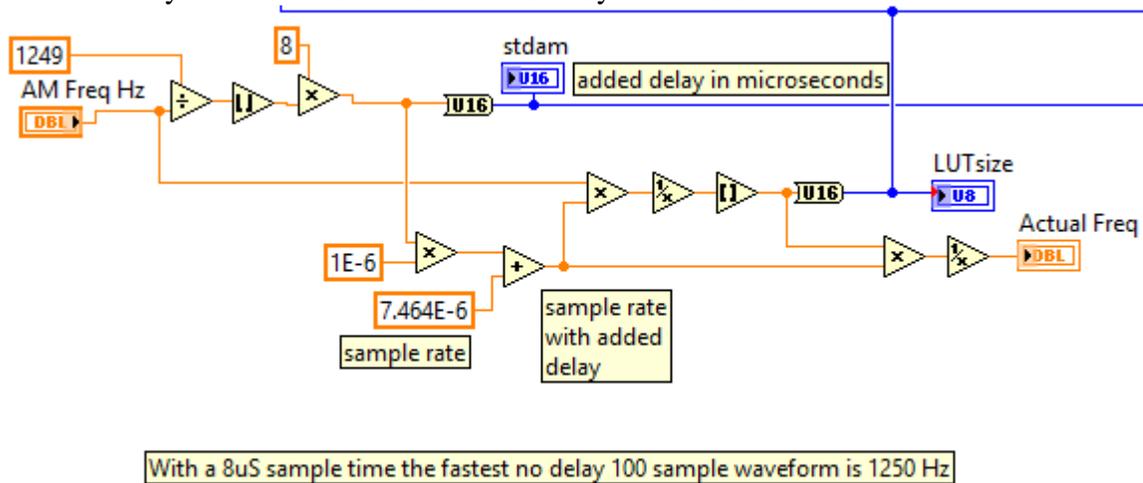
An example of loading a sinusoidal, 1KHz, -20dBm to +20dBm table to the device would be:

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 SynthHD 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 0-99 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 99, 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 1uS 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 2uS 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 65500. 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

Pulse Invert Signal (Command :):

Inverts the Pulse polarity.
This feature is needed if other modulations are required inside the pulse. With a setting of 0 the SynthHD firmware will turn on the RF, delay for the on time, turn off the RF, delay for the off time, (multiply by the burst number) and then go service other routines like USB communication and other modulations. After setting the Invert Pulse to 1, the order is reversed so that the RF is left on during the servicing of those routines. For example, this allows you to do an FM chirp during the pulse on time. When Invert Pulse is ON, the On Time and Off Time get reversed. Finally, since the PAM feature could be used on power amplifiers where the average power is much less than the CW power, RF power is left off after the burst is finished when Invert Pulse is set to 0. This helps protect power amplifiers. Send "h1" (RF Mute OFF) to re-assert CW power.

:x sets the CW off time x of the RF pulse in microseconds
:? 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

Enable Dual Channel Pulse Modulation Mode (Command D):

Enables pulse amplitude modulation for both channel 0 and channel 1 at the same rate.
Procedure: Set up both channels for their respective RF frequency and power levels. Select the channel that will dictate the pulse modulation parameters. Enable dual channel mode “D1”, then start the modulation (“G” or “j1”).
Dx enables dual channel pulse modulation mode where x=0=off and x=1=enabled
D? 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 10 Hz and range maximum is specified by band for the table below.
>? queries the setting

Carrier Frequency (MHz)	Max FM Deviation (+/-Hz)
54-106.25	160,000
106.25 – 212.5	312,000
212.5 - 425	625,000
425 - 850	1,250,000
850 - 1700	2,500,000
1700 - 3400	5,000,000
3400 - 6800	10,000,000
6800 - 13600	20,000,000

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 Internal Temperature (Command z):

Checks the temperature of the SynthHD.

z Queries temperature and returns the value in C.

Set Reference Frequency in MHz (Command *):

The SynthHD 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*