The Windfreak Technologies SynthUSB3 is a RF Signal Generator with a lot of features, some simple and some more complex. In general, the software GUI provided with the hardware makes it easy for a user to control the basic features of the hardware.
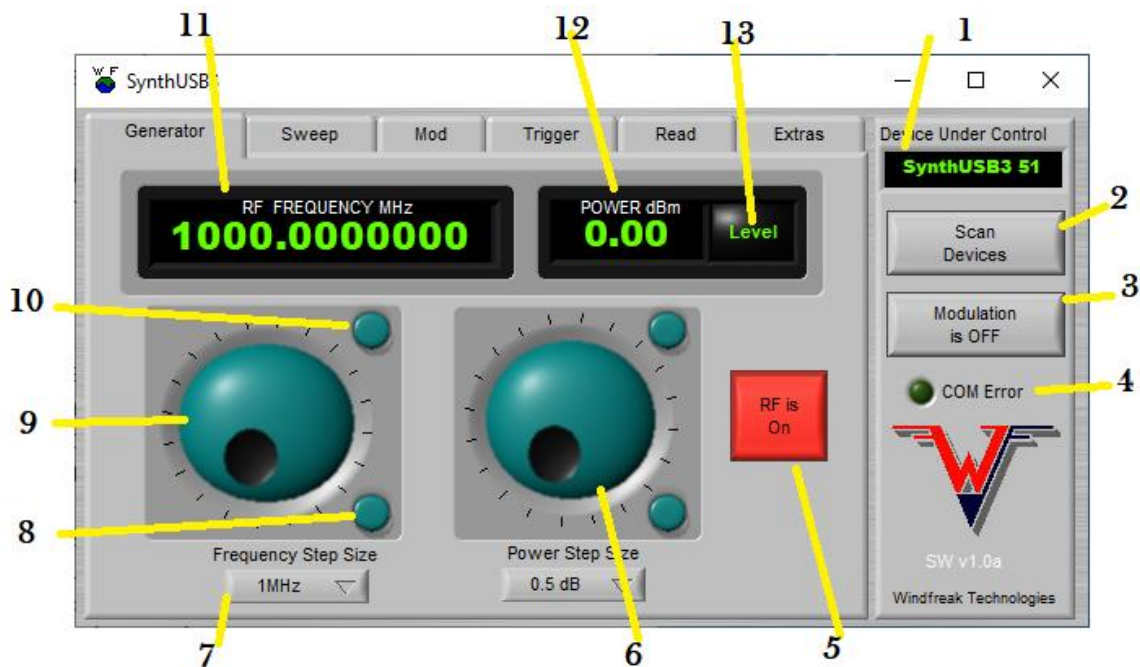

Figure 1 – Generator Tab

The **Generator Tab** (figure 1) is the main place to conduct CW frequency and amplitude adjustments.

1. **Device Under Control.** When first loaded, the SynthUSB3 GUI will attempt to find SynthUSB3 hardware plugged in via USB. If a device is detected, it will display here and show the serial number for that device. If it finds more than 1 device, the software will ask you which device you want to control.

2. **Scan Devices.** This button will scan for new devices if you have plugged or unplugged SynthUSB3s. In general, the software will release the COM port if nothing is going on with the GUI. This allows you to plug and unplug without shutting down the GUI. When you click Scan Devices, all the variables from the hardware will load into the GUI. Otherwise the GUI will be out of sync with newly added hardware. Once you power down a SynthUSB3 and re-power the device, it loads all the variables from internal nonvolatile memory, not from the software that is open. This also requires clicking Scan Devices to get the software back in sync with the hardware.

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3. **Modulation Monitor.** This is partially a control, but mostly a display. The SynthUSB3 can simultaneously have multiple modulations on at once. If you have plugged in a SynthUSB3 that has modulation turned on as a memory preset, this button will be lit (after GUI sync) showing that the device has modulations turned on. When lit, this button can be clicked to turn off all modulations at once. It will not turn on modulation. This should be done from the Mod Tab.
4. **Com Error.** This is an indicator showing that there are USB communications errors. All attempts are made to clear errors in the software and hardware when these occur, but this doesn't always work with all computers. If you have tried to control a device when none are plugged in, it could cause problems that may require restarting the GUI or restarting the PC.
5. **RF On / OFF.** This button turns the RF completely on and off by disabling the PLL chip and reference in the SynthUSB3.
6. **Power Knob.** Dial the RF power knob to change the amplitude of the signal. This knob can be adjusted with a wheel mouse by hovering over it.
7. **Step Size.** Frequency and Amplitude have step size adjustment dropdown boxes to adjust the resolution of the knobs. Select the proper step size for your application.
8. **Step Down.** Frequency and Amplitude have round buttons to the right of each knob that will increment or decrement by one step size for fine tuning.
9. **Frequency Knob.** Dial the Frequency knob to change the frequency of the signal. This knob can be adjusted with a wheel mouse by hovering over it.
10. **Step Up.** Frequency and Amplitude have round buttons to the right of each knob that will increment or decrement by one step size for fine tuning.
11. **Frequency Display.** Highlight the numbers in the display and type in the frequency (in MHz) with your keyboard.
12. **Power Display.** Highlight the numbers in the display and type in the amplitude (in dBm) from your keyboard.
13. **Leveled Display.** Shows "Level" if the calibration routine is properly calibrating the output level. Will show "Unlevel" if at the ends of the output power capability, either high or low, at the given frequency. The SynthUSB3 has non linear resolution, with finer resolution at higher powers. This display does not necessarily mean the power setting is accurate, although for power levels above around -10dBm the setting should be within a dB of accuracy.
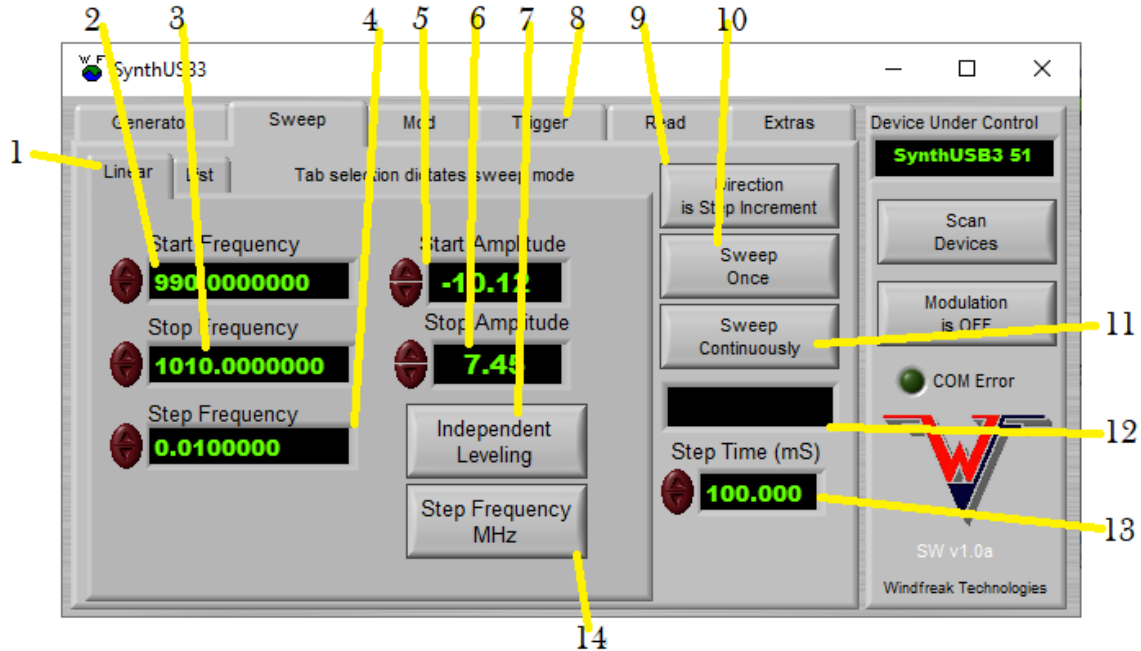
Figure 2 – Sweep Tab – Linear Sweep

The **Sweep Tab** (figure 2) is the place to set up sweeps. Sweeps can be either linear or come from a table.

1. **Sweep Type Tab.** Choose either Linear (which includes Percentage Sweep) or List. List is explained in Figure 3.
2. **Start Frequency.** Click in the box and enter the starting (lower) frequency with your keyboard. Frequency is in MHz. Start frequency is always less than stop frequency.
3. **Stop Frequency.** Click in the box and enter the stop (higher) frequency with your keyboard. Frequency is in MHz. Start frequency is always less than stop frequency.
4. **Step Size.** Click in the box and enter the step size in MHz with your keyboard. Step size is always positive.
5. **Start Amplitude.** This box is for the amplitude associated with the start (lower) frequency. During the sweep, amplitude will follow a line between the Start and Stop Amplitude settings.
6. **Stop Amplitude.** This box is for the amplitude associated with the stop (higher) frequency. During the sweep, amplitude will follow a line between the Start and Stop Amplitude settings.
7. **Independent Leveling.** When in "Independent Leveling Mode" the Start Amplitude and Stop Amplitude boxes can be edited and used for linearly sloped amplitude changes during sweep. Clicking this box switches to "Leveling from Main Power" control via the Generator Tab and the Amplitude Knob or Amplitude display entry box. While leveling from the main power control, the Start and Stop Amplitudes are set equally to the main power display setting.

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8. **Trigger Sweep**. Click the dropdown box, which lets you select the 3 options that affect sweeping: No Triggers, Full Sweep Triggering and Single Sweep Step Triggering. *No Triggering* just means the GUI will start either a single sweep, or a continuous (repetitive) sweep by software button press. *Full Sweep triggering* means that pulling the Trigger SMA Connector center pin low will initiate a full sweep, then stop at the end. Another low going pulse on the Trigger Connector will again start another single sweep. If the Trigger Connector is held low, the sweep will run as if continuous software triggered sweep is on. *Step triggering* will control individual steps set up in the sweep. Pulling the Trigger Connector low will initiate a single step. The step time is a way of debouncing the trigger signal, but insure that you remove the low pulse before your step time is up or the sweep will continue to the next step. The trigger signal is level sensitive not edge sensitive. Note: The Trigger polarity is adjustable.
9. **Direction is Increment or Decrement.** This button switches between sweeping up and sweeping down.
10. **Sweep Once**. Use this button to initiate a single sweep.
11. **Sweep Continuously**. Use this button to turn on continuous repetitive sweeping.
12. **Sweeping Indicator**. Indicates the SynthUSB3 is sweeping.
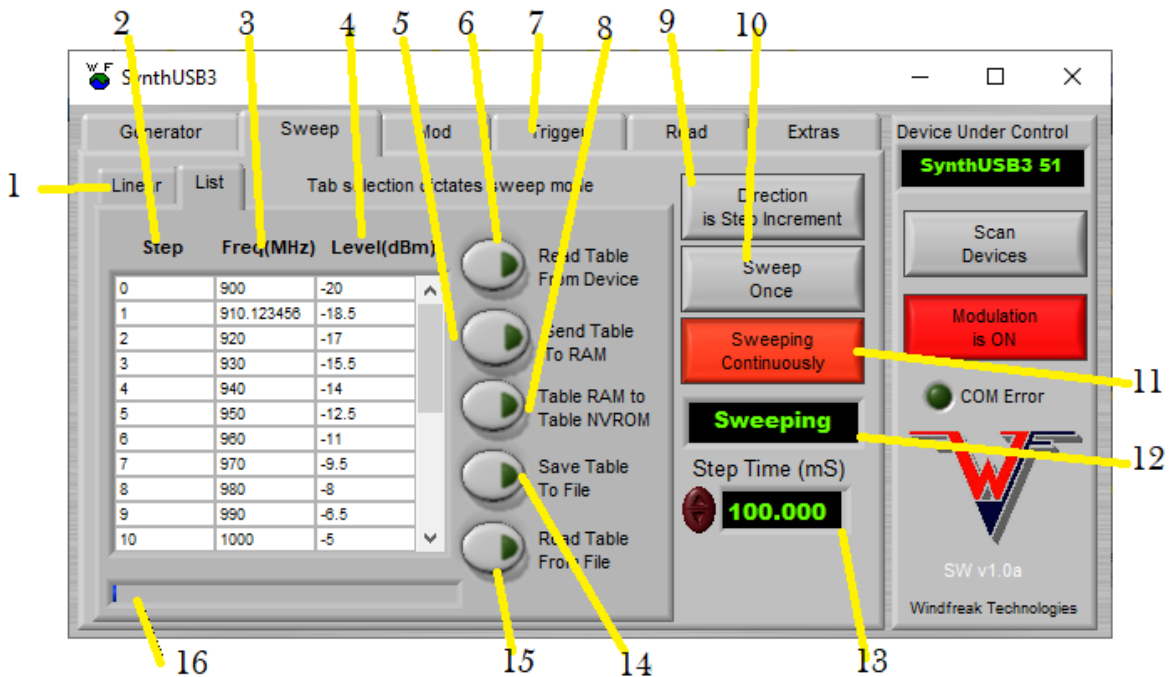13. **Step Time**. Value in milliseconds for each step in a sweep.

Figure 3 – Sweep Tab – List Sweep

1. **Sweep Type Tab.** Choose either Linear (which includes Percentage Sweep) or List. Linear is explained in Figure 2. The table can be a total of 500 unique frequencies and amplitudes. List sweep acts almost exactly like linear sweep except it steps in arbitrary ways defined by the user. Right click on the table or a

cell for advanced editing tools. The first step must always be zero.

2. **Step.** This cell has to be populated for active frequency steps starting with zero. It dictates which position the line item is placed in SynthUSB3 RAM. It's possible to skip a number and save the line item to the SynthUSB3, but the SynthUSB3 will consider any step with a zero frequency value to be the end of the sweep. It's also possible to enter the steps out of order. When sending the table to SynthUSB3 RAM, the SynthUSB3 will put them in the proper order based on Step value.

3. **Frequency.** Populate this cell with the frequency (in MHz) of the step. Be sure and use only frequencies between 12.5MHz and 6.4GHz. The first frequency cell with a zero value is considered the end of the sweep, even if line items after it are populated.

4. **Amplitude.** Populate this cell with the desired CW amplitude (in dBm) for that frequency.

5. **Send Table to RAM.** Nothing is communicated to the SynthUSB3 during editing of the table until this button is clicked. After clicking this button, the table is then sent to SynthUSB3 volatile memory (RAM) which will be reset during a power cycle event. At this point list sweeping can be performed.

6. **Read Table from Device.** Loads the table to the GUI through USB.

7. **Trigger List**. Click the dropdown box, which lets you select the 3 options that affect sweeping: No Triggers, Full Sweep Triggering and Single Sweep Step Triggering. *No Triggering* just means the GUI will start either a single sweep, or a continuous (repetitive) sweep by software button press. *Full Sweep triggering* means that pulling the Trigger SMA Connector center pin low will initiate a full sweep, then stop at the end. Another low going pulse on the Trigger Connector will again start another single sweep. If the Trigger Connector is held low, the sweep will run as if continuous software triggered sweep is on. *Step triggering* will control individual steps set up in the sweep. Pulling the Trigger Connector low will initiate a single step. The step time is a way of debouncing the trigger signal, but insure that you remove the low pulse before your step time is up or the sweep will continue to the next step. The trigger signal is level sensitive not edge sensitive. Note: The Trigger polarity is adjustable.

8. **Table RAM to Table NVROM.** Stores the table to nonvolatile memory, which is safe during power down. This allows you to run list sweeps without having a PC hooked up to the SynthUSB3. All other items on the SynthUSB3 are saved to NVROM on the Extras Tab EXCEPT the Sweep Table (and AM waveform). Be sure and save it here.

9. **Direction is Increment or Decrement.** This button switches between stepping up the list and stepping down.

10. **Sweep Once**. Use this button to initiate a single sweep.

11. **Sweep Continuously**. Use this button to turn on continuous repetitive sweeping.

12. **Sweeping Indicator**. Indicates the SynthUSB3 is sweeping.

13. **Step Time**. Value in milliseconds for each step in a sweep.

14. **Save Table to File.** Saves the table in text format to your PC. It is then possible to use other editors.

15. **Read Table from File.** Read saved tables from your PC.
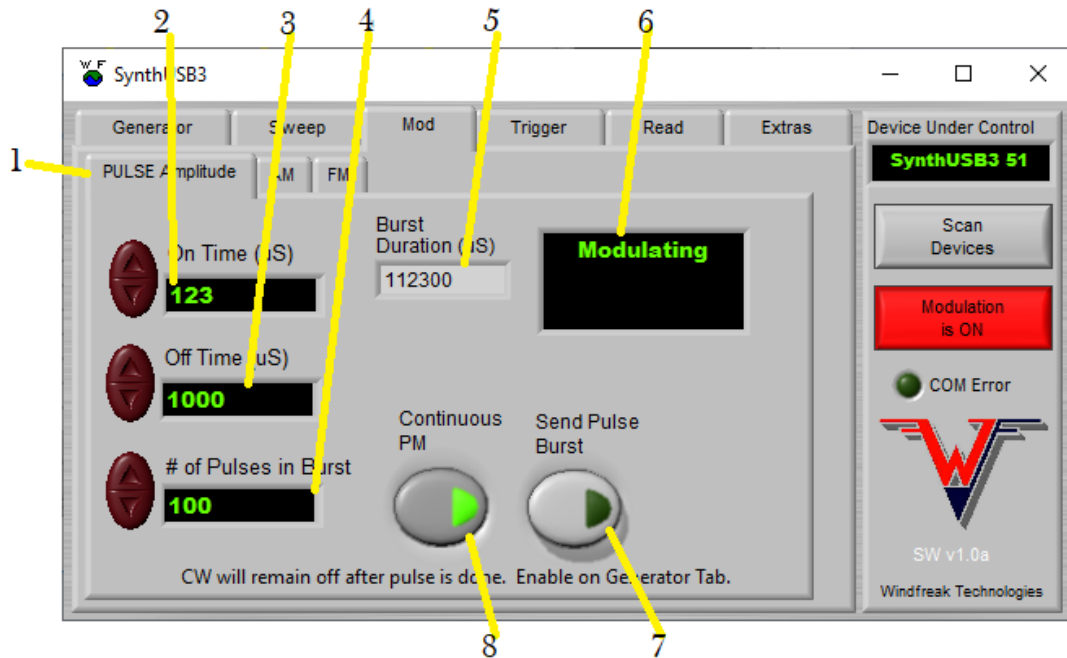16. **Upload Progress Bar.**

Figure 3 – Mod Tab – Pulse Amplitude Modulation

1. **Pulse Amplitude Modulation.** This Modulation Tab controls RF Pulsing or On-Off-Keying (OOK). Peak pulse power is controlled in the Generator Tab with the RF power control knob.
2. **On Time.** Sets the amount of time the RF is ON in microseconds.
3. **Off Time.** Sets the amount of time the RF is OFF in microseconds.
4. **# of Pulses in Burst.** Sets the number of pulses sent in one burst. This number is limited to a maximum of 65500 and should be at least 1. Higher numbers may reduce jitter since the processor will concentrate more on pulsing and less on other things like checking USB.
5. **Burst Duration.** Calculates the approximate time a burst will last.
6. **Modulation Readout.** Shows SynthUSB3 is being modulated.
7. **Send Pulse Burst.** Sends just one pulse burst the length of the number of pulses in the burst.
8. **Continuous PM.** Turns on Pulse Mod indefinitely until it is turned off again. Firmware keeps repeating the number of pulses in a burst.
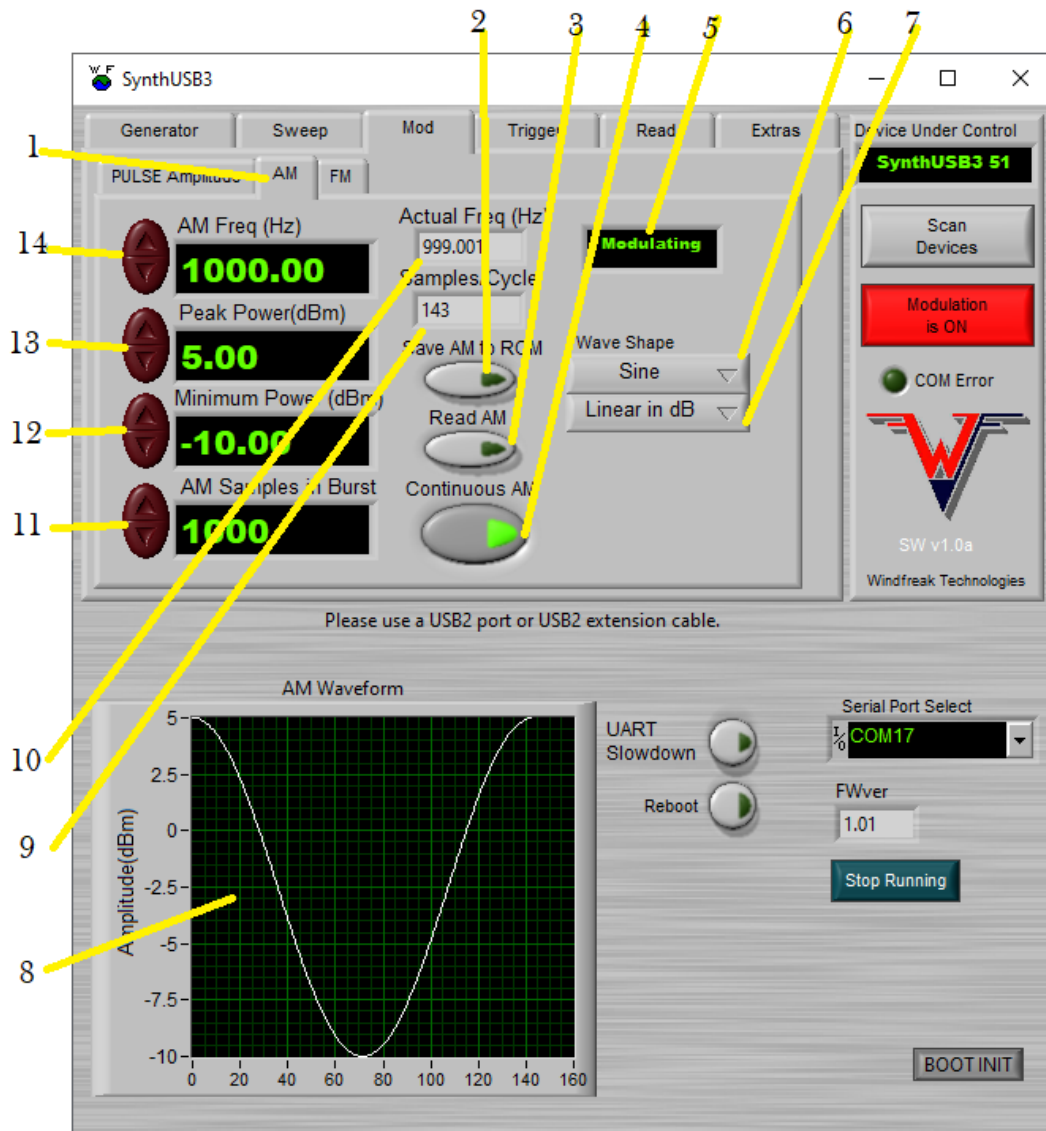
Figure 4 – Mod Tab – Amplitude Modulation

1. **Amplitude Modulation Tab.** Amplitude modulation is driven by serial digital writes to the PLL gain control. AM frequency is derived by an algorithm that adjusts the number of samples per cycle and the delay per sample. This allows for AM modulation frequencies up to about 5KHz.
2. **Save AM to ROM.** Saves the AM signal to nonvolatile memory so AM can be run right after power up without a PC connected.
3. **Read AM.** Loads the AM trace from the SynthUSB3 through USB.
4. **Continuous AM.** Turns AM on and off. After turning AM off, the RF power will be at a random RF amplitude depending on where in the cycle it turned off. Click RF Power or Frequency knob reset.
5. **Modulation Readout.** Shows SynthUSB3 is being modulated.
6. **Wave Shape.** Choose between Sine, Ramp, or Triangle AM shapes.

7. **Linear in dB or Volts.** Choose if your wave shape will be linear in dB or Volts. A spectrum analyzer in zero span mode with a vertical axis in dB will show a nice waveform if the setting is linear in dB. If you are driving an envelope detector, which detects volts, it might be best to use linear in volts.
8. **Wave Shape Display.** Shows the approximate shape (in dB) of the wave.
9. **Samples per Cycle.** Display used to estimate how many samples are in a given cycle, which is important when combining modulations.
10. **Actual Frequency (Hz).** Shows the approximate frequency of the AM modulation since there is some error due to sample rate limitations.
11. **AM Samples in Burst.** Used when combining modulations. Leave at 1 or increase to possibly help jitter.
12. **Minimum Power.** AM RF power is determined by minimum and maximum power in this tab and is not affected by the RF Amplitude controls on the Generator Tab. Minimum power controls the minimum power excursion of the wave.
13. **Peak Power.** Sets the maximum power excursion of the wave. See the Wave Shape Display for the final wave shape and amplitudes.
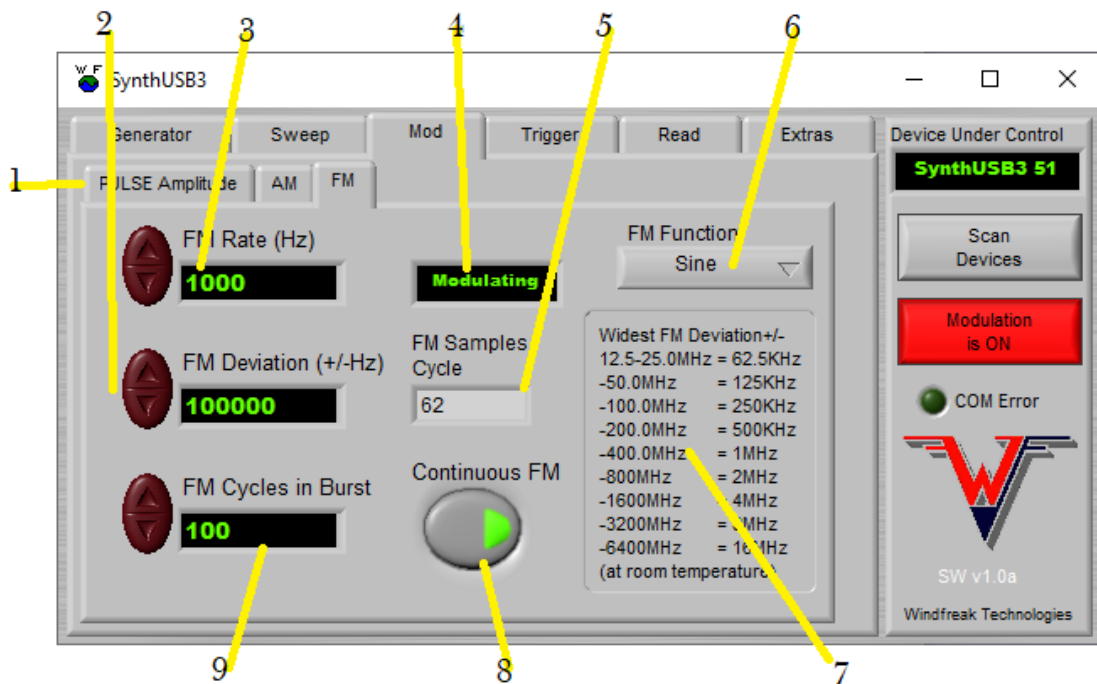14. **AM Frequency.** Amplitude Modulation Frequency in Hz.

Figure 5 – Mod Tab – Frequency Modulation

1. **Frequency Modulation Tab.** Frequency modulation is driven by high speed 64 bit digital writes to the PLL chip. Sample rate is roughly 20uS per point. FM frequency is derived by an algorithm that adjusts the number of samples per cycle and the delay per sample. This allows for FM modulation frequencies up to

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about 5KHz. It's possible to adjust the PLL loop filter cutoff frequency to help smooth out the quantization steps.

2. **FM Deviation.** Sets the FM deviation around the center frequency in +/- Hz.
3. **FM Rate.** Sets the FM frequency in Hz. Actual frequency may have small errors due to sample rate limitations.
4. **Modulation Readout.** Shows the SynthUSB3 is modulating.
5. **FM Samples / Cycle.** This display is used when combining modulations together.
6. **FM Function.** Choose between a sinusoidal FM shape, or an FM Ramp (Chirp).
7. **Widest FM Deviation Table.** Maximum FM deviation depends on frequency. The higher the frequency the more deviation is allowed up to a total of +/- 20MHz.
8. **Continuous FM.** Turn FM modulation on and off.
9. **FM Samples in a Burst.** Normally set this to the number of Samples in the Cycle when combining modulations such as doing a pulsed chirp.
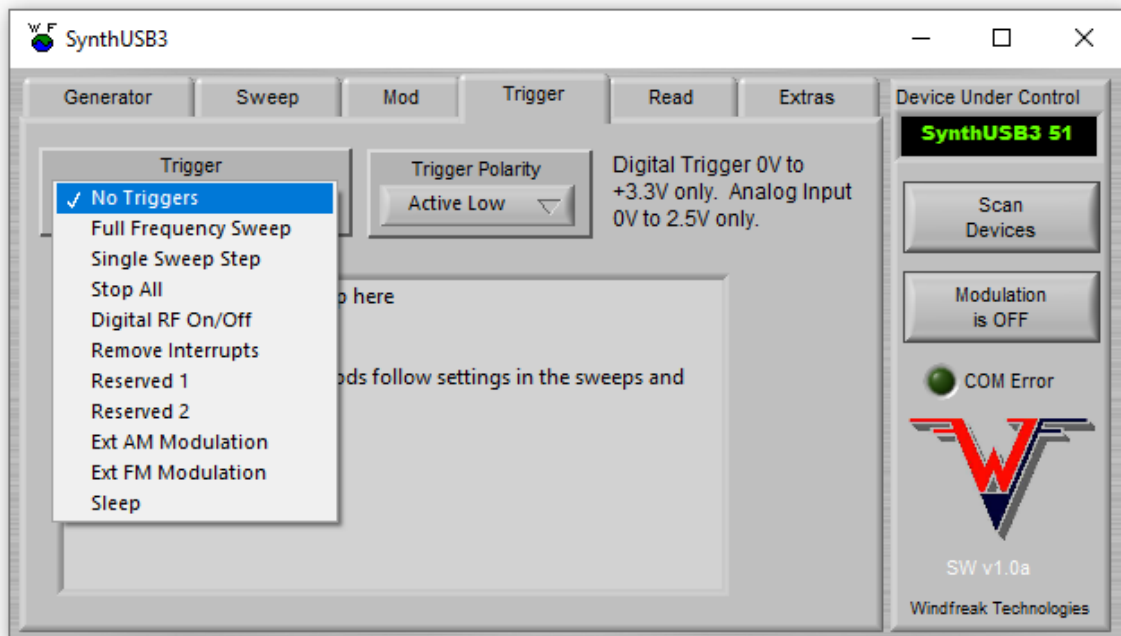

Figure 6 – Trigger Tab

The trigger connector on the SynthUSB3 is a multi-function input for controlling the device in ways detailed below. Digital triggering requires standard 3.3V CMOS input, although it is 5V tolerant. Analog modulation inputs are DC coupled between 0V and 1.2V. Both modes have a ~35K ohm pullup resistor to 3.3V.

Trigger polarity is programmable via the Trigger Polarity dropdown box. Default is active low for all modes, and not settable for Remove Interrupts.

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For FM and AM modulations, it is required to set up internal FM or AM modulations as described below before using external modulation. For linear Vin Vs Mod Out the internal modulation HAS to be set to Chirp for FM or Ramp for AM.

1. **No Triggers.** This mode disables the trigger input and allows the SynthNV to be controlled fully by software.
2. **Full Frequency Sweep.** Detailed in Figure 2 and Figure 3 Item 10.
3. **Single Sweep Step.** Detailed in Figure 2 and Figure 3 Item 10.
4. **Stop All.** Stop All puts a "do nothing" hold on the SynthUSB3 operating system. It only responds to the Trigger and to USB communication. This allows you to trigger bursts of pulses or other modulations.
5. **Digital RF On/Off.** Quickly mutes the RF power when low. A high level restores RF power to the GUI setting. (Pulse Mod)
6. **Remove interrupts.** Remove interrupts reduces jitter in modulations that are timing critical such as radar chirp. When Trigger is pulled low RF is ON and Interrupts are off. When Trigger is high RF is OFF and the SynthUSB3 will respond to USB commands. *Warning! This mode blocks USB communications when the trigger signal is pulled low. Clicking any controls wile in this mode will cause the software to lock up, possibly requiring reboot of the PC. Disconnect everything from the trigger, allowing it to float high, and exit this mode before resuming normal operation.*
7. **External AM Modulation.** External AM Modulation is driven through the Trigger connector and responds to analog voltages between 0 and 1.2V. It responds to settings 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 200 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 200 steps in between. Sample rate is roughly 22uS.
8. **External FM Modulation.** External FM Modulation is driven through the Trigger connector and responds to analog voltages between 0 and 1.2V. It responds to settings 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 200 samples. Set the wave shape to CHIRP. 0V input will correspond with the (neg) FM Deviation setting and 1.2V will drive to the (pos) Deviation setting with 200 steps in between. Sample rate is roughly 22uS.
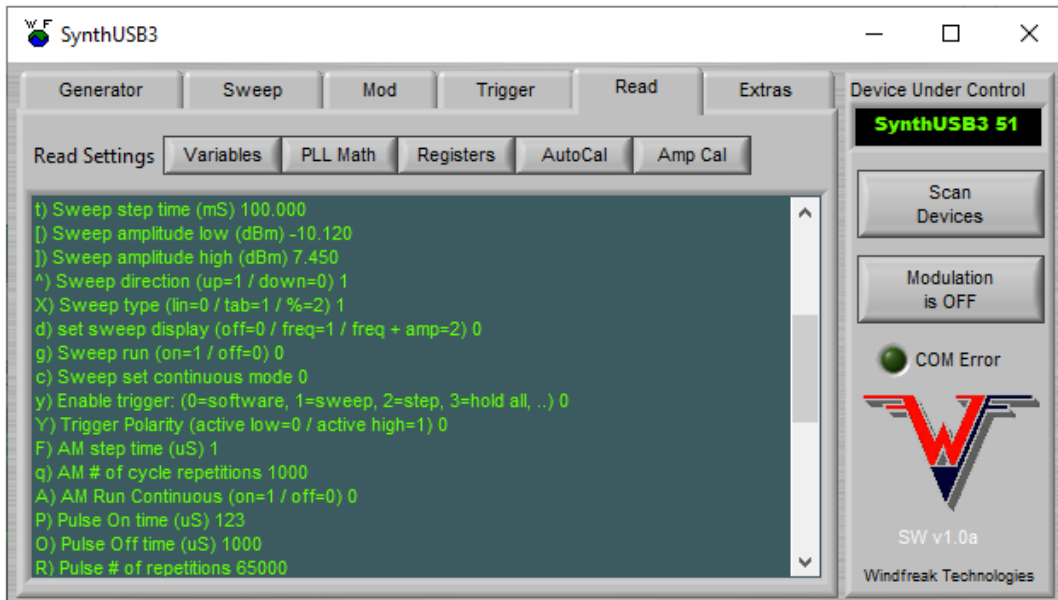
Figure 7 – Read Tab

1. **Read Variables from SynthUSB3.** Investigate all settings reported by the SynthUSB3. If there are any issues with the device, Windfreak Tech Customer Service may ask for a copy and paste of this data.
2. **PLL Math.** Get information about the PLL settings, including estimated frequency error.
3. **Read Registers.** Get the exact register settings for the PLL chip.
4. **VCO Autocal.** Details of the VCO band settings over frequency.
5. **Amp Cal.** Details of the unique amplitude calibration per device.
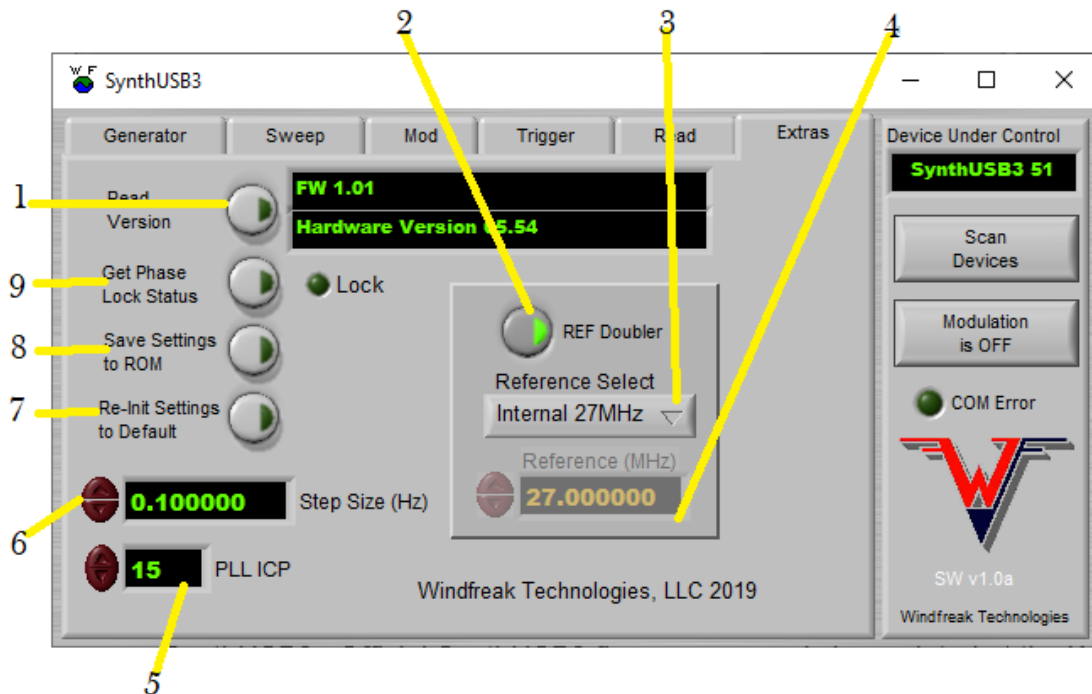
Figure 8 – Extras Tab

1. **Read Version.** Click to get the Firmware and Hardware versions of the SynthUSB3. Official SynthUSB3 firmware can only be updated at the Windfreak Technologies Headquarters in Florida. Older firmware operating with newer software may have problems with some features.
2. **Reference Doubler.** Doubles the reference frequency going into the PLL phase comparator. Gives better phase noise when doubled, so default setting is doubled.
3. **Reference Select.** Allows you to hack the PCB of the SynthUSB3 and bring in your own reference between 10MHz and 100MHz. Select Internal or External reference. Future revisions may have the reference go to a pin on the USB3 connector.
4. **Reference Frequency.** Programmable frequency setting if using an external reference. Internal reference is a fixed 27MHz 2.5ppm TCXO.
5. **PLL ICP.** This adjusts the PLL Charge Pump Current, which in turn changes the response of the PLL loop filter. Values between 0 and 15 can be set. The nominal loop filter bandwidth is about 50KHz. The response is non-linear, so try multiple settings depending on your application. This could help in smoothing out some of the quantization noise when doing Frequency Modulation. Otherwise it is advised to leave it set at the factory default setting of 15.
6. **Step Size (Hz).** Change the frequency resolution of the device. Default is 0.1Hz. May have some effect on spurs. 0.01Hz may have slow moving "walking" spurs.
7. **ReInit Settings to Default.** Resets the SynthUSB3 such that it boots from it hard coded settings and erases old settings.
8. **Save Settings to ROM.** Save all settings from the GUI to the SynthUSB3

hardware nonvolatile memory bank. These settings will be remembered, even after powering down the hardware. The device can fire up without a computer in any state, including modulations.

9. **Get Phase Lock Status.** Push and hold this button to check for phase lock status. As previously noted, the SynthUSB3 does not always report lock even though it may be locked. After reading the PLL registers is one case.

Please send questions to:
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