808 Gilman Street Berkeley, CA., 94710 p:925.253.2960 www.furaxa.com

VARPULSE20 Variable Width 20V-Differential Ultra-High Rep Rate Low Jitter USB Microwave Pulse/Comb Generator

REV A Preliminary User Manual 11/07/20

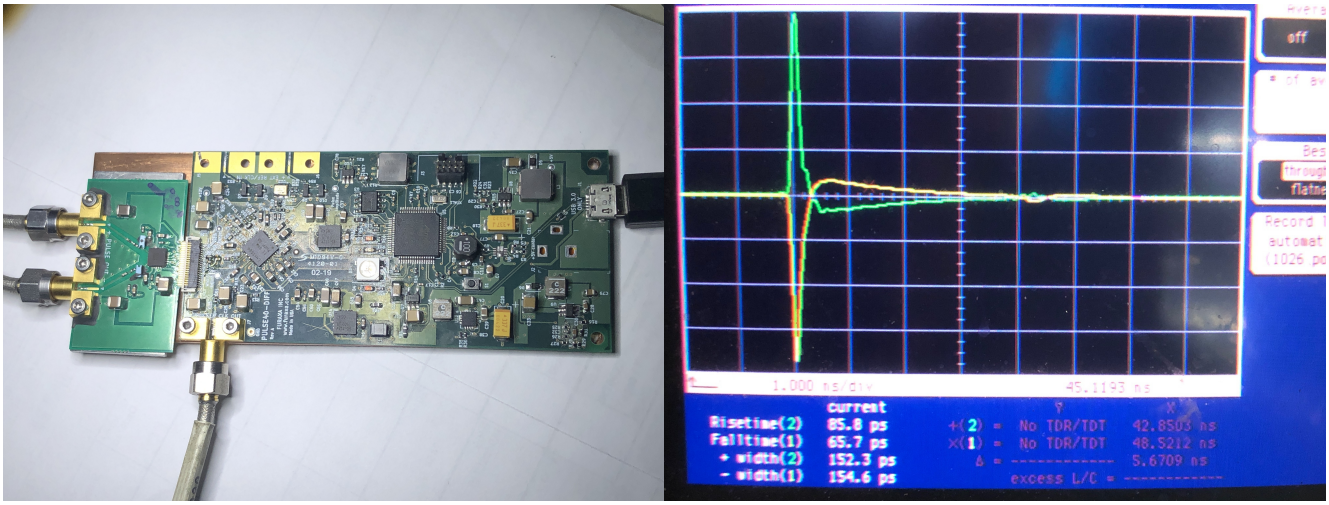

Figure 1. L VARIPULSE20.(<<replace with cased version>>>, R, 20V differential pulses.

FEATURES:

- **Fully Differential Pulse Outputs with amplitude up to 20V** into two 50 ohm loads or 100 ohm differential load, **or two opposing single-ended 10V pulses.**
- **65ps to 400ps programmable rise time** and 140ps to 800ps FWHM pulse widths
- **10 MPPS to 2 GPPS** programmable pulse rate in single-ended mode.
  10 MPPS to 50 MPPS in differential mode. Pulse shape independent of rate
- Internal reference (150fs RMS jitter) or external reference/clock, SW selectable.
- Ultra-low jitter internal LMX2594 synthesizer allows virtually any pulse rate with sub-Hertz resolution, and precise synchronization, including 1:1 clocking, with external reference/clock, with programmable external clock to pulse delay,
- Concurrent low-jitter square wave sync/trigger output in sync with pulse outputs.
- USB 3.0/3.1 Interface. No external power required. 5.5” L x 2” W x 0.6” D
- Powerful **QT software interface and cross-platform C libraries**
- Generates **ultra-low phase noise combs to 10GHz in single-ended mode.**

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INTRODUCTION

The VARPULSE20 differential/single-ended microwave pulse / comb generator provides an unmatched level of ultra-high repetition rate, picosecond-jitter, independently adjustable amplitude and width, widely programmable repetition rate, tight differential gain and phase matching, and the ability to be driven by either an external clock or internal timebase. Its unique Dynamic Cascode Exchange architecture (US Pat: 6,433,720 and others pending) provides up to a 20V differential output without the repetition rate limitations and high jitter of conventional pulsers that used avalanche transistors or step recovery diodes, and it produces much higher output voltage than is possible with NLTL-based pulsers, along with a 6:1 range of pulse rise time, width and amplitudue adjustment that is not attainable by any of these conventional technologies. Its differential current-steering architecture further eliminates the need for external BALUNs when driving differential loads. For single ended applications, either of its outputs can be used depending on whether a positive or negative pulse is desired, without the need to terminate the unused output.

The unit is controlled and powered by a USB3.0 or 3.1 interface, and includes powerful QT and LabVIEW GUI software, including all source code, as well as a C-language library for users wishing to control the unit with their own software. The QT and C-language software are compatible with Windows 10 and Centos/Redhat Linux___

The VARPULSE is very easy to use, and can be connected to the host system using a micro-USB to type A cable (included) to **any USB 3.0 or USB 3.1 host with Windows 10** operating system.

Pulse rate may be programmed from 10 MPPS (Million Pulses Per Second) to 50 MPPS when using differential mode, and the much wider range of 10MHz to 2000MPPS in single-ended negative-pulse-only mode. The pulse frequency can be programmed using the internal low-phase-noise LMX2594 synthesizer driven from either the unit's internal 100MHz low-jitter (150fs RMS) oscillator, or from an external clock or reference. Pulse rate can be programmed to be exactly the same (1:1) as the input clock or virtually any multiple or divide of that clock. In 1:1 mode, the phase of the pulses may be software programmed from 0 degrees to over 360 degrees in 7.5 degree increments.

SPECIFICATIONS:

- Pulse leading edge rise time **(10-90%)** **65ps to 400ps programmable**
- Pulse rate: Single-ended mode: **10 MPPS to 2 GPPS**
  Differential mode: **10 MPPS to 50 MSPS**
- Differential Phase Matching (10-50MPPS) **20 ps max**
- Differential Amplitude Matching (") **2% typ, 5% max**
- Output Amplitude Range (each output into 50 ohms, diff=twice this value):
  - 100-400ps rise time setting: **2V to 10V peak (6-20V diff)**
  - 65-100ps rise time setting: **1.5V to 7V peak (6-14V diff)**
- Pulse jitter, cycle-to-cycle, both + and – outputs::
  - Internal Ref, Fpulse= 50 MPPS **<1ps RMS**
  - Internal Ref, Fpulse = 10 MPPS **< TBD >**
  - Internal Ref, Fpulse = 1000 MPPS **< TBD >**
  - Ext 100MHz Ref, Fpulse=50 MPPS **< TBD >**
  - Ext 50 MHz Clock, Fpulse=50 MPPS **< TBD >**

- Spurious pulse energy
  - Recovery, ringing — **<10% pulse amplitude (see fig TBD)**
  - Interpulse energy — <5%, width always <20ps

- Host Interface Compatibility: — **USB 3.0 or 3.1**
- Max current draw from USB host: — **1A (pulse amplitude <12V diff)**
  1.3A (pulse amplitude <20V diff)

- Size and weight: — **5.3” x 2” x 0.6” 2 ounces**

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SIGNAL CONNECTIONS TO THE VARPULSE20:

The **PULSE+ and PULSE- SMA output jacks** produce either a well-matched differential pulse output, or alternately either jack may be used separately, the first producing positive-going pulses and the second producing negative-going pulses. While the outputs are designed to nominally drive 50 ohm loads (or a floating 100 ohm differential load), they will not suffer damage if driving a short circuit. Also, in single-ended mode it is not necessary to terminate the unused pulse output.

At the same time the VARPULSE20 is producing pulses, it is also concurrently outputting a square wave output **"SYNCOUT" that is synchronous with, and at the same frequency as the pulses.** SYNCOUT may optionally be used to trigger external equipment, such as an oscilloscope or external sampling unit that is viewing the pulses and/or any resulting responses from the external system being stimulated by the pulses. The amplitude of SYNCOUT may be adjusted using to have any signal level between 200mV p-p and 1V p-p, using the Output B slider in the QT or LabVIEW GUI.

In the case where the internal reference is used, no further connection is required to the VARPULSE20. However, if an external clock is to be used to clock the pulser, or if the pulser frequency is desired to precisely track an external reference signal between 1 and 250MHz, then this **optional external clock or external reference should be inputted to the EXTIN SMA connector. A square wave clock input is preferred over a sine wave. Amplitude must be between 200mV p-p and 1V p-p.** In the case where any such signal is fed into EXTIN, or even if an un-driven cable is connected to the EXTIN SMA, the "Internal Clock" box in the GUI must be unchecked – otherwise the two clocks will "fight" and the pulses will not be at the desired frequency.

QT GRAPHICAL USER INTERFACE SOFTWARE DIRECTIONS
Windows 10: Unzip Qt GUI package. Run the executable in the release directory. Make sure to select the right COM port and verify communications are occuring by watching the 'alive' button blink in the upper right.

QT COMMAND LINE SOFTWARE DIRECTIONS
Windows 10: Unzip QT Command Line package. Open a command prompt and, for internal clock, run the executable in the release directory with an argument of the frequency desired. Running the program with 2 arguments uses the desired synthesized frequency as the first argument and the external reference frequency as the second argument.

SOFTWARE DEVELOPMENT:
The client programs were developed with Qt 5.12 using the MSVC 2017 64 bit compiler. Other versions of Qt should work but may require some changes.
MSVC 2017 64 bit can be downloaded from:
Qt 5.12 can be downloaded from:
Install MSVC 2017 64 bit first. Then install Qt 5.12 second so Qt can detect the MSVC install.
Open the .pro file in Qt Creator from either the command line or GUI program directory.
Make changes to the front end programs and then rebuild and run.

FIRMWARE DEVELOPMENT:
The firmware that runs on the board is built using Arduino Sketches.
PC instructions: Download Arduino 1.8.10 (1.8.11 and 1.8.12 do NOT work)
Using Arduino, add the 'adafruit' board. Files → preferences → Additional Boards Manager URLs:
https://adafruit.github.io/arduino-board-index/package_adafruit_index.json
Then go to Tools → Board → Boards Manager and add the 'adafruit' board.
Using Arduino, add the 'adafruit neopixel' library. Tools → manage libraries.
Modify the .ino file provided and upload to the correct COM port using compile option 'optimize:-o2'.

If the modifications to the firmware break communications on the board such that new firmware cannot be loaded, press the physical reset button on the board twice in rapid succession. This will return the board to bootloader mode where communications always work so the board can be flashed to a working state.

Figure 2. Connecting the VARIPULSE20 to an external clock and observing the output pulses

on a sampling oscilloscope.

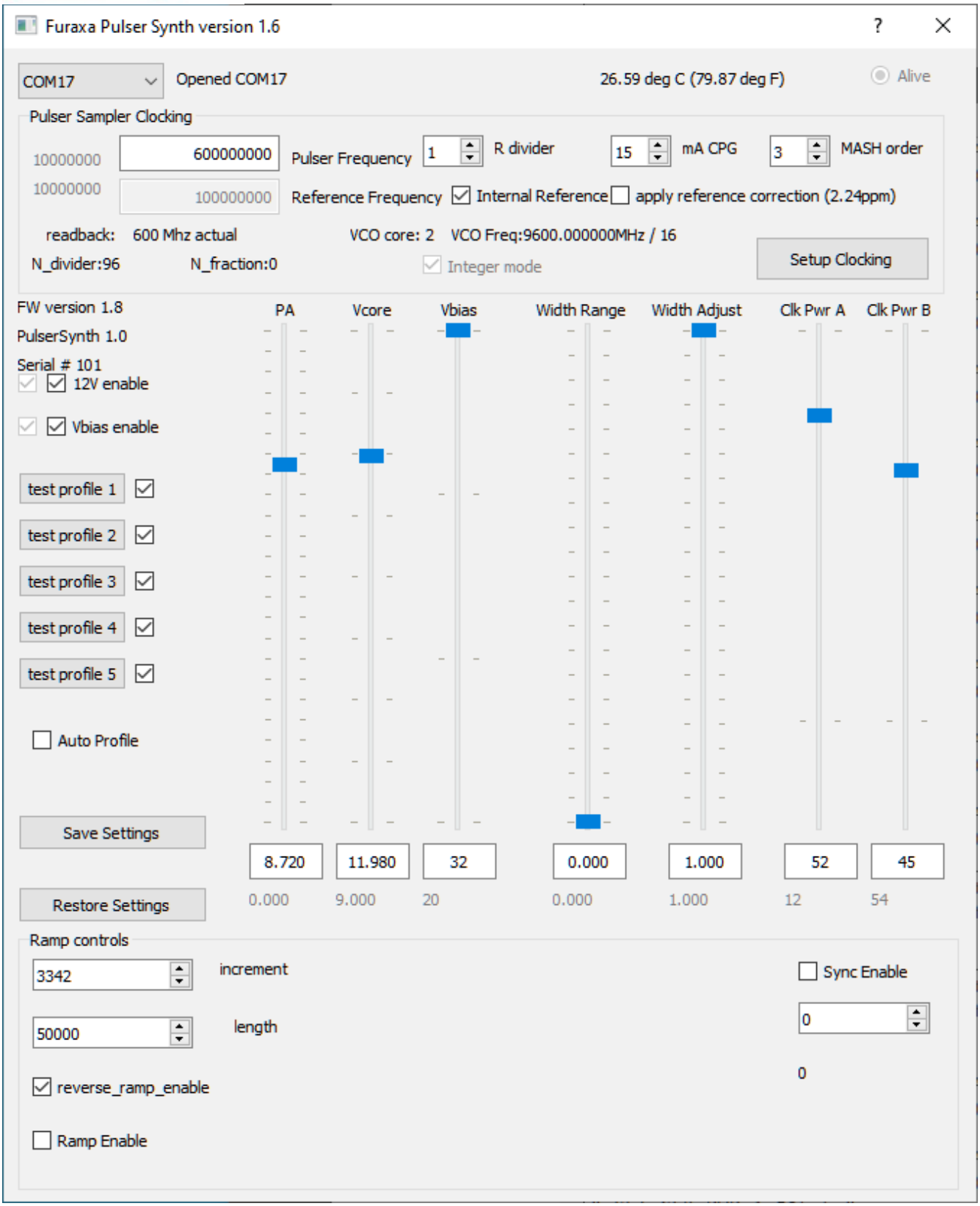

Figure 3. QT GUI for adjusting pulse parameters, showing settings for 65ps rise pulses at 600 MPPS with amplitude 7.5V P on Pulse- output.

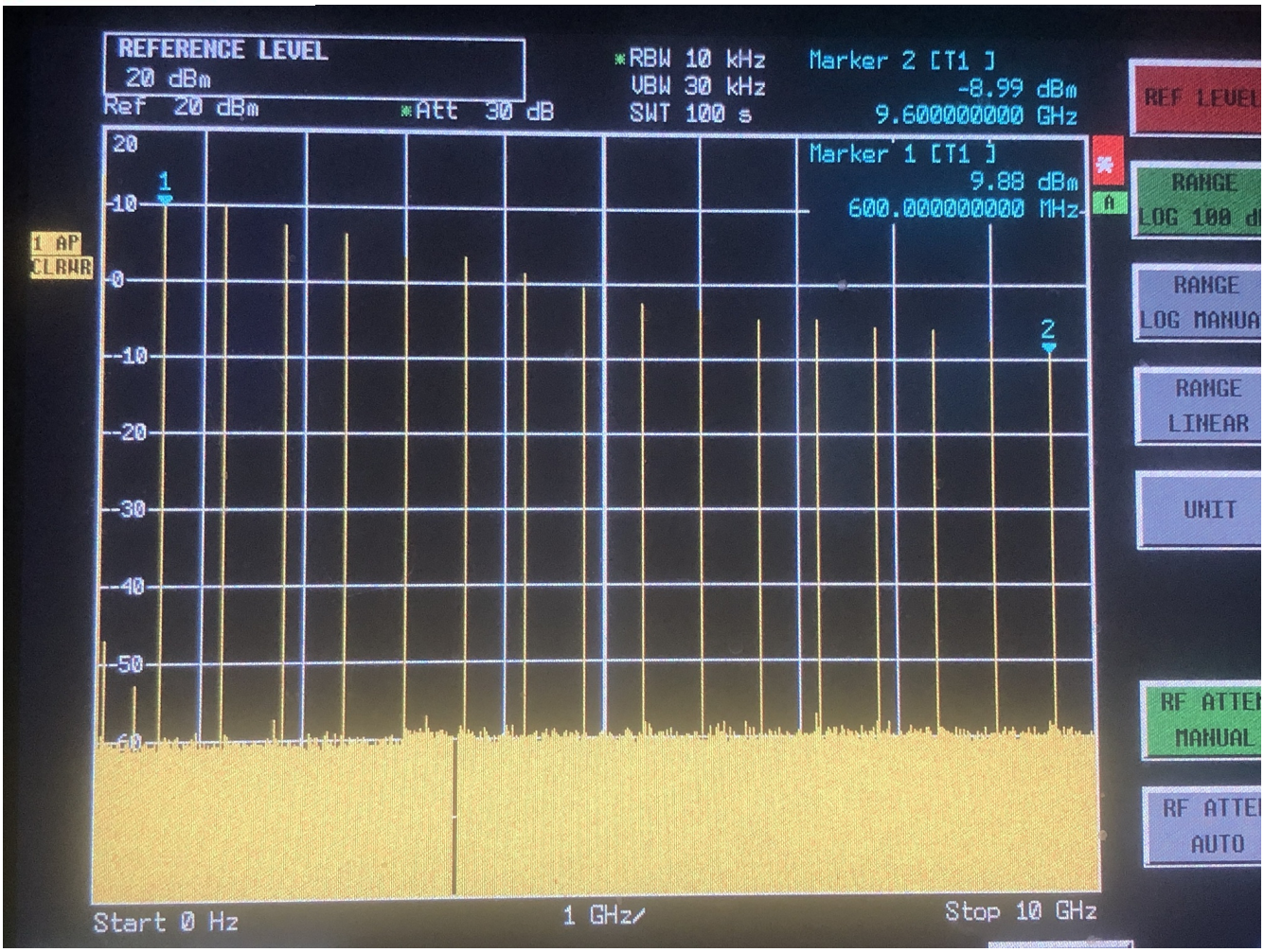

Figure 4. Spectral comb for pulse- output, when producing 600MPPS at fastest rise time setting, using settings shown in Figure 3. Note +10dBM output at 600MHz and 1.2GHz, and -9dBM output at 9.6 GHz.

SPECIFICATIONS <TBA>

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