UltraComb-8G  High Power Variable-Fence Microwave Comb Generator

GaN Comb Generator with USB-programmable Spectral Energy Weighting and Software Programmable 10MHz to 2GHz Picket (Comb Tooth) Spacing

The UltraComb-8G is a new class of GaN microwave comb generator providing formerly unattainable output power levels, low jitter and spectral content programmability. Based on a custom ultra-high-repetition-rate GaN differential pulser IC, the palm-sized UltraComb-8G is powered from any USB3.0/3.1 port through which the user can program comb amplitude, comb picket spacing and low/high-frequency spectral weighting.

Ultra-flexible Ultrawideband (UWB) Comb Generation

Comb picket spacing can be software-programmed to any frequency from 10MHz to 2GHz in single-ended-output mode (10-50MHz in differential output mode) in 0.01 Hz steps, generated by an on-board low-phase-noise LMX2594 synthesizer driven from either an internal 150fs-jitter reference clock or a 10-500MHz external reference. The unit can also be programmed in 1:1 clock mode, enabling the pulse repetition rate (which is also the comb picket spacing) to be the same as the external reference/clock input. Its differential outputs
provide a 3dB higher total output power than a single-ended pulse generator, and facilitate
direct antenna connections without the use of an expensive and large broadband BALUN.

The Ultracom-8G has the further unique ability to create strings of pulses with widths
varying from 100ps to 800ps, enabling it to generate relatively flat combs with usable energy
to 10GHz or, alternatively, combs with much higher power, but with most of the energy
concentrated below 2GHz. This is useful, for example, in antenna testing, in which high
volumes of lossy materials can be characterized with improved SNR using a low-frequency
weighting, while smaller volumes can be characterized using a full-frequency weighting.

**Very High Output Power**

At the narrowest pulse width setting, and with a 500 Million Pulse Per Second (500
MPPS) pulse repetition frequency (500MHz picket spacing), each generated picket up to
3GHz has over +10dBm power level (see Fig. 1). Even up to 6GHz, each picket has over
0dBm power. The picket at 8GHz has a level of -7.5dBm. Figure 2 shows the unit generating
a comb with a finer 200MHz picket spacing and flat response with 0dBm/picket power to
3GHz, -3dBm at 5.4GHz and -10dBm at 8GHz. For higher power, the picket spacing can be
increased. Figure 3 shows a 1250MPPs pulse repetition rate (i.e.1250MHz picket spacing),
resulting in the first picket being at +16dBm, and the 8.4 and 9.6GHz pickets being at -2dBm.
The higher per-picket-power at higher pulse repetition rates is the result of the generator
producing a higher number of pulses per second, and hence a higher aggregate power level.

**Programmable Pulse Width and Corresponding Low/High Spectral Weighting**

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varying from 100ps to 800ps, enabling it to generate relatively flat combs with usable energy
to 10GHz or, alternatively, combs with much higher power, but with most of the energy
concentrated below 2GHz. This is useful, for example, in antenna testing, in which low
frequency antennas can be tested over very long ranges or transmitting through lossy media,
while retaining the ability to test over a wider bandwidth when using shorter ranges. Figure 4
shows the generation of precisely matched differential pulses of 152ps FWHM (top blue
traces) and then, by software selection, a 350ps FWHM differential pulse (yellow and green
traces, shown at 200ps/div in the top window, and 1ns/div in the bottom window).

**Cross-Platform Operability for Flexible Field Use Environment**

The palm size of the unit enables its use in the field, directly connected to antennas or
devices using low-loss cables of only a few centimeters in length. Virtually any desktop or
laptop computer can be used as the GUI software, is included for Windows10, OSX, Linux
Mint 18 and RHEL/Centos 7.x. In addition to the GUI, full QT source is supplied, enabling
users to dynamically control the comb amplitude, picket spacing, and frequency weighting in
real time as part of a larger field or laboratory environment.
FEATURES AND SPECIFICATIONS:

A) 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. Also can produce 28V differential into 75 ohm loads.

B) Pulse leading edge rise time (10-90%) 65ps to 380ps programmable

C) Pulse width (FWHM) 160ps to 860ps programmable

D) Pulse rate:   
   Differential mode: 10 MPPS to 50 MSPS
   Single-ended mode: 10 MPPS to 1.5 GPPS

E) Differential Phase Matching (10-50MPPS) 18 ps max

F) Differential Amplitude Matching (" ) 3% typ, 6% max

G) Output Amplitude Range (each output into 50 ohms, diff=twice this value):  
   H) 100-400ps rise time setting: 4V to 10V peak (8-20V diff)
   I) 65-100ps rise time setting: 4V to 14V peak (8-28V diff)

J) Pulse jitter, cycle-to-cycle, both + and – outputs:
   K) Internal Ref, Fpulse= 50 MPPS 1ps RMS (for 65ps pulses), <3ps (all)

L) Spurious pulse energy
   M) Recovery, ringing <10% pulse amplitude
   N) Inter-pulse energy of single spur pulse <5%, width of spur pulse <20ps

O) Internal 150fs jitter reference or external ref/clock, SW selectable. Internal LMX2594 synthesizer allows virtually any pulse rate with sub-Hertz resolution, including 1:1 clocking with external clock and programmable clock-to-pulse delay in 7.5° increments.

P) Concurrent low-jitter square wave sync/trigger output in sync with pulse outputs.

Q) USB 3.0/3.1 Interface. No external power required – Draw from USB is 1.3A at full 20 pulse amplitude. (<1A for pulse amplitudes <12V).

Mechanical: Dimensions (LxWxD): 7cm x 14cm x 3.2cm
Weight 13 ounces.

R) QT C software interface and cross-platform Windows/Linux C libraries, with full source.

S) Generates ultra-low phase noise combs to 10GHz in single-ended mode:
   T) Typ. comb energy at 1.2GPPS: >16dBm@1.2GHz, >-2dBm@9.6GHz
   U) Typ. comb energy at 600MPPS: >10dBm@600MHz, >-9dBm@9.6GHz
Fig 1. Ultracomb-8G generating comb with 500MHz-spaced pickets, with +10dBm amplitudes to 3GHz, -3dBm at 5.4GHz, 0dBm at 6GHz and -10dBm at 8GHz. The main and complementary comb/pulse outputs of the Ultracomb-8G are at the top. A jack for an optional reference or clock input is on the right side. The output of the internal synthesizer that generates the ultra-low-jitter clock to the pulse-comb multiplier is on the left side, has under 500fs of jitter with respect to the comb pulses, and may be used to synchronously trigger/clock external receiving electronics, such as samplers and ADCs.
Fig 2. Ultracom-8G generating comb with 200MHz-spaced pickets, with 0dBm amplitudes to 3GHz, -3dBm at 5.4GHz and -11dBm at 8GHz and -18dBm at 10GHz.

Fig 3. Higher power comb with 1.25GHz-spaced pickets, generating +16dBM amplitude at 1.25GHz, 12dBm at 2.5GHz, 0dBm at 6GHz and 7.2GHz and -2dBm at 8.4GHz and 9.6GHz.
Fig 4  Adjustable pulse widths of 152ps FWHM (top blue traces) and 350ps FWHM (yellow and green traces), displayed at 200ps/div, and also displayed at 1ns/div in bottom window.