Comb Generator with Excellent Harmonic Flatness to >40 GHz

Wayne Thomas, R. Clayton Smith, and Kipp Schoen

Picosecond Pulse Labs (PSPL), Boulder, CO, 80301, USA

***Abstract* — A comb generator that produces frequency pickets with excellent harmonic flatness to greater than 40 GHz has been fabricated and characterized. Driven by a 2 GHz sine wave with +10 dBm power, this comb generator outputs a comb spectrum with greater than -20 dBm of power per picket past 40 GHz. Driven by the same input, time domain characteristics of the output show impulses of approximately 15 ps FWHM with -2 V amplitude. In addition, this comb generator exhibits good characteristics for input frequencies ranging from 1 GHz to 9 GHz.**

I. Introduction and Background

Comb generators provide an effective method of generating frequency harmonics from an input signal. Their applications include frequency multipliers [1], frequency synthesizers [2], Built-In-Self-Test (BIST) sources, and test equipment [3].

Many comb generator designs generate harmonics by utilizing Step-Recovery-Diodes (SRD's) [4]. In this application, SRD's sharpen an edge of the input signal thereby producing harmonics. A comb generator may be combined with other components such as amplifiers and band pass filters to function as a frequency multiplier. Additionally, a comb generator may be used with an oscillator to provide its own fundamental frequency source.

Comb generators may be characterized by parameters such as input frequency range, power per picket, and harmonic content. The power per picket is a function of the input power and the frequency content of the output. A very high-speed transition in the time domain will translate into rich harmonic content.

Comb generators that accept a range of input frequencies allow the user to vary the spacing of the frequency pickets to meet the needs of their application. In addition, broadly spaced pickets may be more easily picked off with a wider band pass filter.

II. Description of Comb Generator Design

The comb generator described in this paper consists of an input amplifier, a Non-Linear-Transmission-Line (NLTL), and an impulse forming network. A simplified block diagram showing the main components of the comb generator is given in Figure 1. The amplifier is operated in saturation and provides both signal amplification and some transition time compression. The NLTL circuits further compress the negative transition time of the signal and the impulse forming network differentiates the signal, converting the output to an impulse.

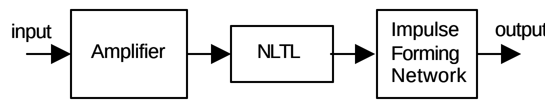

Figure 1. Comb Generator Block Diagram

The amplifier used in this design has 26 dB of saturated gain and a saturated output of approximately 8 Vpp. The NLTL circuits utilize GaAs Schottky diodes as non-linear elements and were produced using a GaAs/thin film process. NLTL circuits exhibit non-linear properties that have been demonstrated to sharpen transition edges [5].

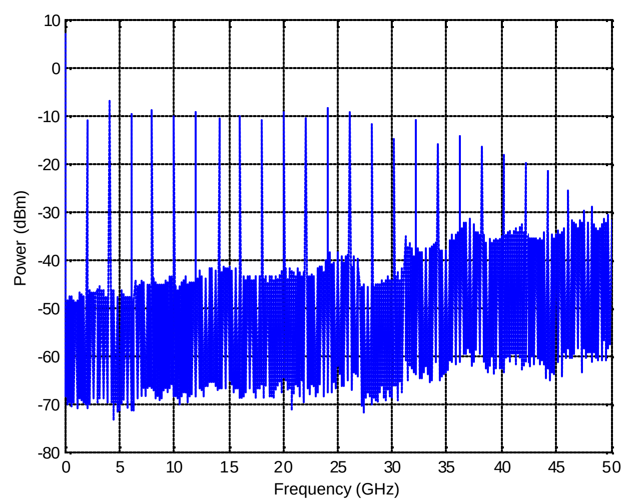

Figure 2. Comb Generator
Frequency Domain Measurement

II. Experimental Set-Up

The comb generator was characterized with a range of sinusoidal inputs in both the frequency and the time domains. The sinusoidal input was generated using a

Hewlett Packard 8672A Synthesized Signal Generator. The frequency domain measurements were taken using an Agilent 8565EC Spectrum Analyzer.

The time domain measurements were made using a Tektronix 8000 Digital Sampling Oscilloscope with a 80E01 Sampling Module. A PSPL 14 dB pickoff tee and a PSPL divide by 8 trigger countdown were used to supply the trigger input to the oscilloscope.

III. RESULTS

The comb generator was tested with sinusoidal inputs ranging from 1 GHz to 9 GHz. For the purpose of collecting data to present in this paper, a 2 GHz, +10 dBm sinusoidal was used for the input.

A typical frequency domain measurement of the comb generator is given in Figure 2. This data shows significant harmonic content and excellent harmonic flatness to beyond 40 GHz. This compares very favorably with previously reported results for a comb generator that utilized NLTL circuits [3]. The spacing of the frequency pickets is 2 GHz since the input was a 2 GHz sine wave. It should be noted that an input frequency as high as 9 GHz can be used and would result in a picket spacing of 9 GHz.

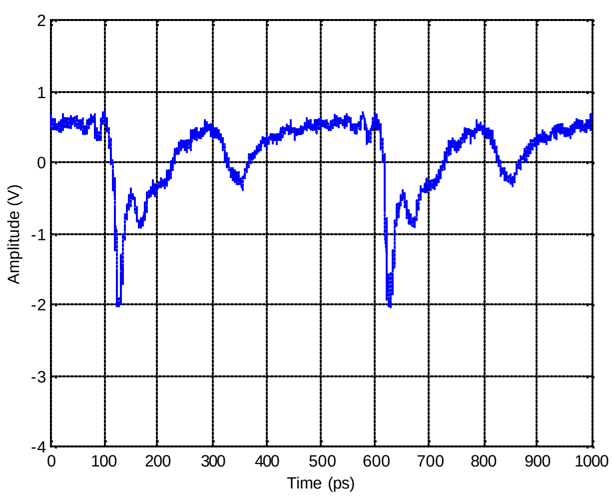

Figure 3. Amplifier Time Domain Output

The time domain output of the amplifier is given in Figure 3 and shows considerable alteration of the input sine wave and the sine wave's transition time. The time domain output of the NLTL circuits is shown in Figure 4 and shows the additional transition time compression that is provided by the NLTL circuits.

A typical time domain measurement of the overall output of the comb generator (i.e. the output of the impulse forming network) is shown in Figure 5. This data shows negative going impulses with -2 Vpp amplitude, a FWHM of 15 ps, and a 2 GHz repetition rate.

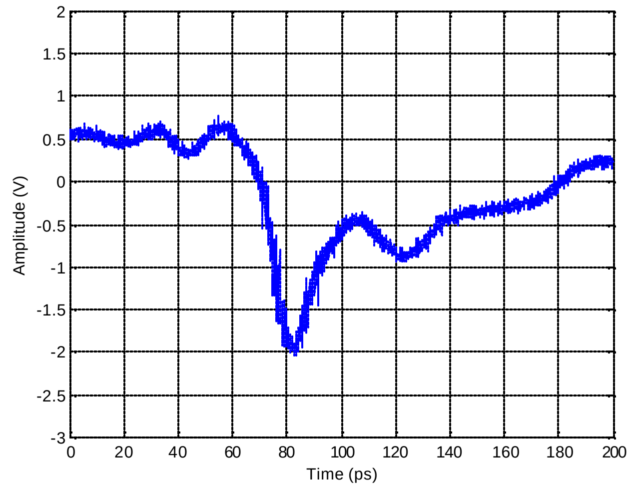

Figure 4. NLTL Circuit Time Domain Output

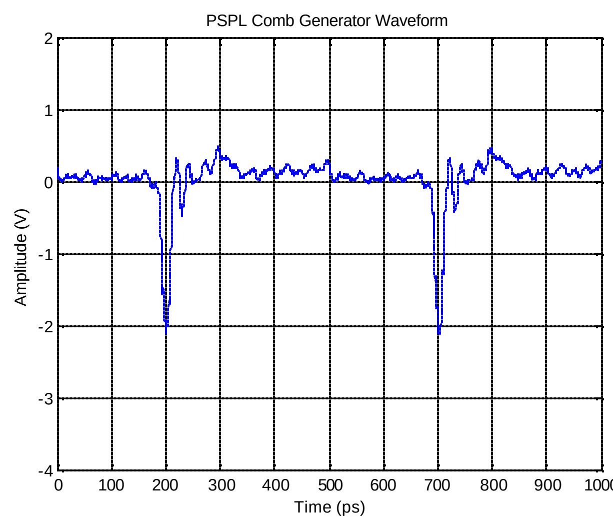

Figure 5. Comb Generator Time Domain Output (Output of Impulse Forming Network)

V. SUMMARY AND CONCLUSIONS

The comb generator described in this paper has been shown to provide significant harmonic content and excellent flatness to beyond 40 GHz. In addition, the operation of each component of the comb generator has been described and the contribution of each component to the overall performance of the has been demonstrated.

This particular design was also characterized over a broad range of input frequencies and maintains its basic performance characteristics for inputs ranging from 1 GHz to 9 GHz.

REFERENCES

[1] J. Zhang and A.V Raisanen, "Computer-Aided Design of Step Recovery Diode Frequency Multipliers", IEEE Transactions on Microwave Theory and Techniques, Vol. 44, No. 12, pp. 2612-2616, December 1996

[2] F.Y. Min, "Low Phase Noise Broadband Microwave Frequency Synthesizer", pp. 142-145, IEEE 1998

[3] P. Heymann, R. Doerner, and M. Rudolph, "Multiharmonic Generators for Relative Phase Calibration of Nonlinear Network Analyzers", IEEE Transactions on Instrumentation and Measurement", Vol. 50, No. 1, pp. 129-134, February 2001

[4] S. Hamilton and R. Hall, "Shunt Mode Harmonic Generation Using Step Recovery Diodes", Microwave Journal, pp. 69-78, April 1967

[5] M.J.W. Rodwell, M. Kamegawa, R. Yu, M. Case, E. Carman, and K.S. Giboney, "GaAs Nonlinear Transmission Lines for Picosecond Pulse Generation and Millimeter-Wave Sampling", IEEE Transactions on Microwave Theory and Techniques, Vol. 39, No. 7, pp. 1194-1204, July 1991