BLUMLEIN LINE GENERATION OF LONG-PULSE, PRECISELY "REGULATED" WAVESHAPES FOR NONLINEAR RESISTIVE LOADS

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ABSTRACT

This paper describes the criteria utilized in the design of a long-pulse, "offset-tuned" Blumlein line. It is capable of 100-μs, medium repetition rate (1kC), 200-kV pulses for nonlinear loads (such as klystrons), with a total load power deviation of less that 0.5% (ripple, overshoot, and droop, inclusive).

The offset-tuned Blumlein line consists of two Type E Guillemin networks with identical element values of capacitance and self inductance. The networks are offset-tuned by each utilizing a slightly different value of the inductor's coefficient of coupling. As each network has slightly different filter characteristics, this results in a smoothing of the output pulse.

A 20-section, 30-μs Blumlein line was modeled utilizing NET2 circuit routines for use on a high-power cathode modulated klystron. The klystron is modeled as a nonlinear resistance to account for the gun perveance. Figure 1 depicts the klystron power pulse; and Fig. 2 details the flattop portion, indicating a 0.36% power deviation (0.085% voltage deviation). Figures 3, 4, 5, and 6 indicate a good match over a wide range of voltage (thus load impedance) and still maintain less than 0.5% power deviation. Figures 7, 8, and 9 indicate the expected results when utilizing two identical Type E Guillemin networks for the Blumlein line.

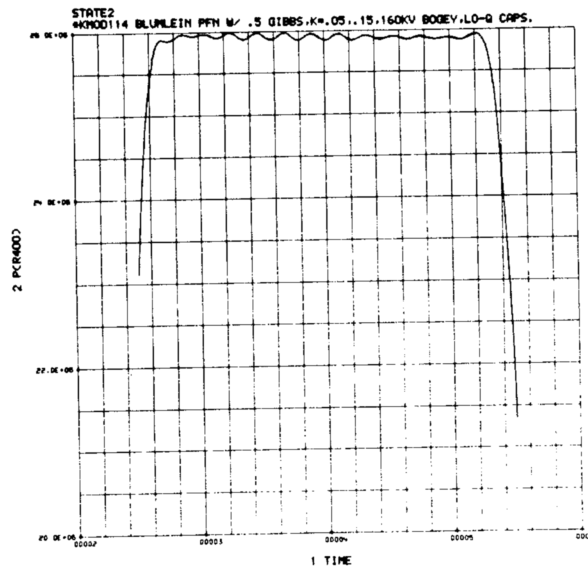

Fig. 2. Detail of flattop for Fig. 1 2 μs/div. horizontal, 500 kW/div. vertical.

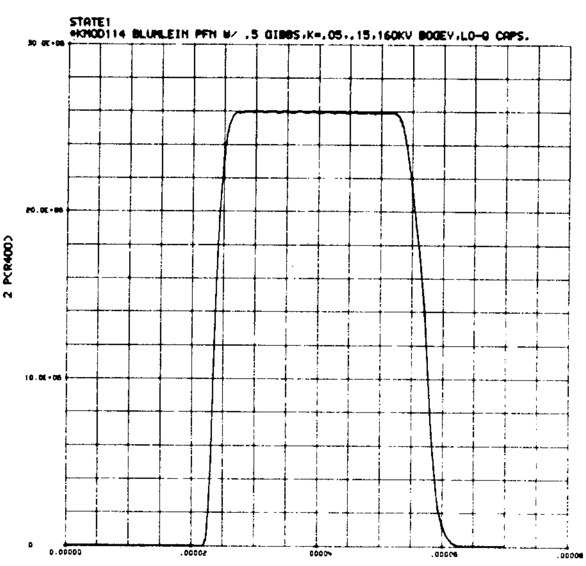

Fig. 1. Klystron power pulse at 160 kV bogey 5 μs/div. horizontal, 2 MW/div. vertical.

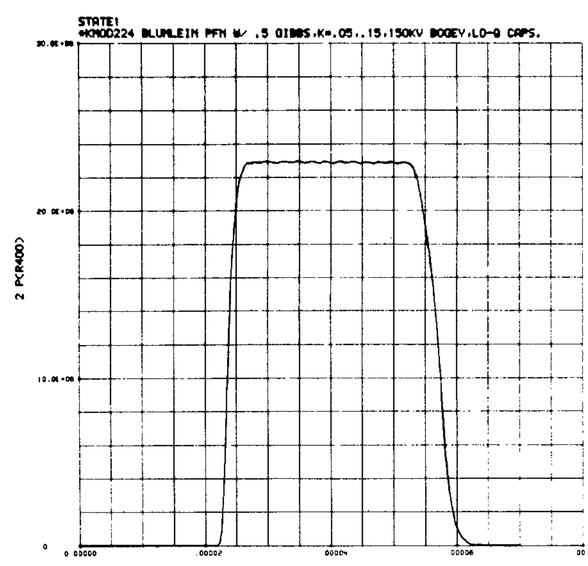

Fig. 3. Klystron power pulse at 150 kV 5 μs/div. horizontal, 2 MW/div. vertical.

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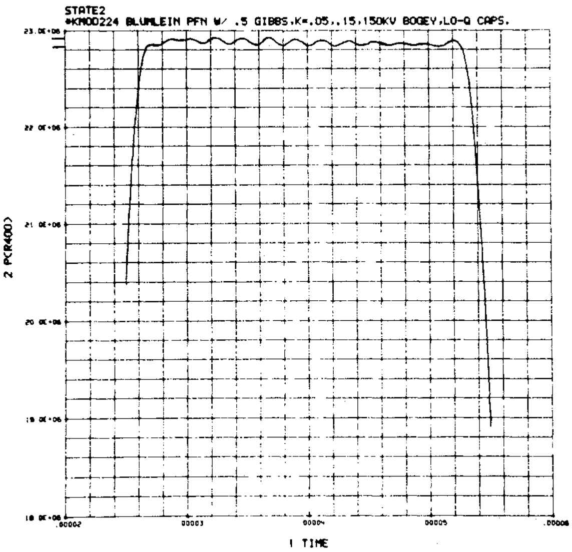

Fig. 4. Detail of flattop for Fig. 3
2 μs/div. horizontal, 200 kW/div. vertical.

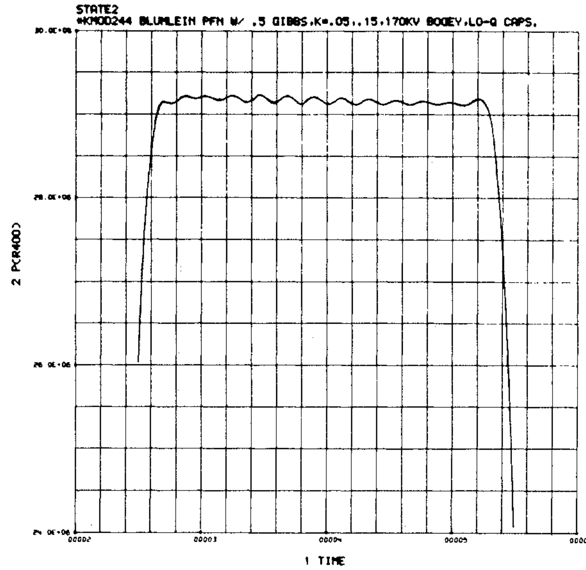

Fig. 6. Detail of flattop for Fig. 5
2 μs/div. horizontal, 500 kW/div. vertical.

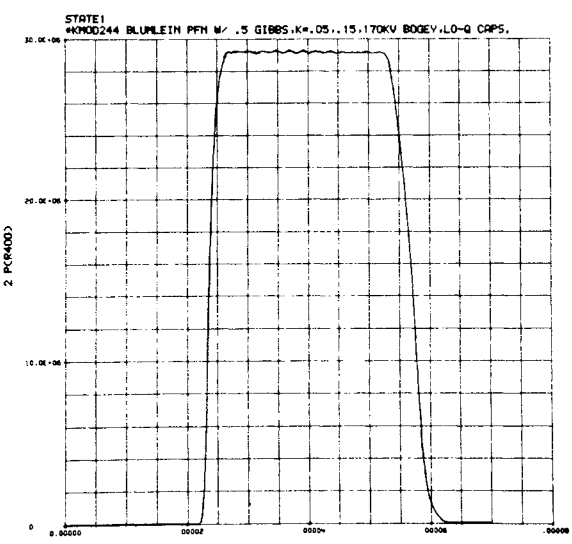

Fig. 5. Klystron power pulse at 170 kV
5 μs/div. horizontal, 2 MW/div. vertical.

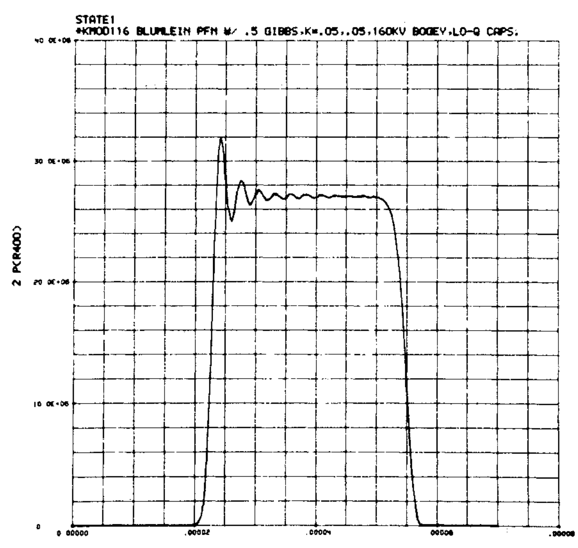

Fig. 7. Klystron power pulse of Blumlein line with inductor coupling coefficient of 0.05 for each network.

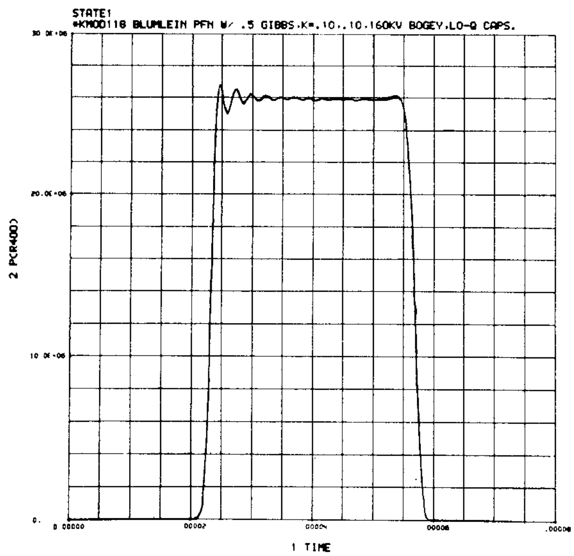

Fig. 8. Klystron power pulse of Blumlein line with inductor coupling coefficient of 0.1 for each network.

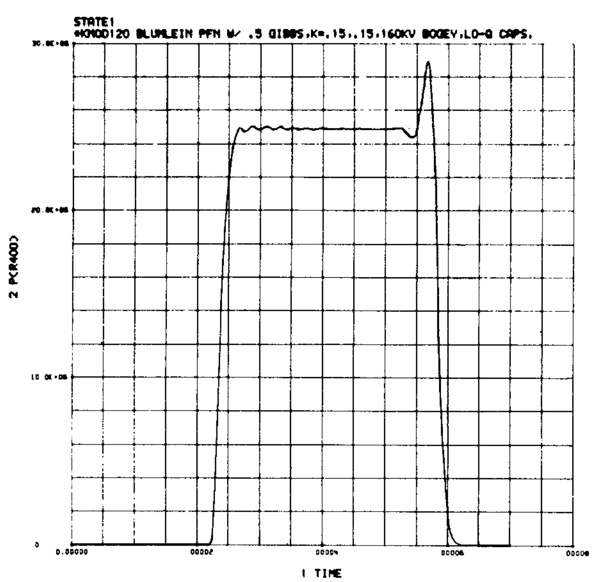

Fig. 9. Klystron power pulse of Blumlein line with inductor coupling coefficient of 0.15 for each network.

The offset-tuned Blumlein line would be particularly advantageous for long-pulse applications necessitating outstanding pulse fidelity, such as those requiring excellent rf load power and phase stability (i.e., multistage and RFQ linacs). In the 100-μs time regime, pulse transformers could be expected to have a few percent of voltage overshoot and droop, with up to 10-15% power deviation in nonlinear loads (i.e., klystrons). With the advent of the ceramic high-voltage, fast-recovery, gradient-grid thyratrons (i.e., EG&G HY5613, 250 kV, TR ~30 μs), the offset-tuned Blumlein line would be a practical modulator typically limited by the switch tube characteristics. Operation could easily meet the 200-kV bogey load voltage level and multikilohertz pulse repetition frequency. There would also be economies in size and weight as compared to lower impedance pulse transformer designs due to the pulse transformer system's larger PFN and resonant charge capacitances.

The offset-tuned Blumlein line can be characterized as capable of generating extremely high-power, high-voltage pulses with outstanding fidelity over a wide range of voltage driving a nonlinear resistive load.

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