

# Innovation

**SBIR Topic Number:**  
AF06-003

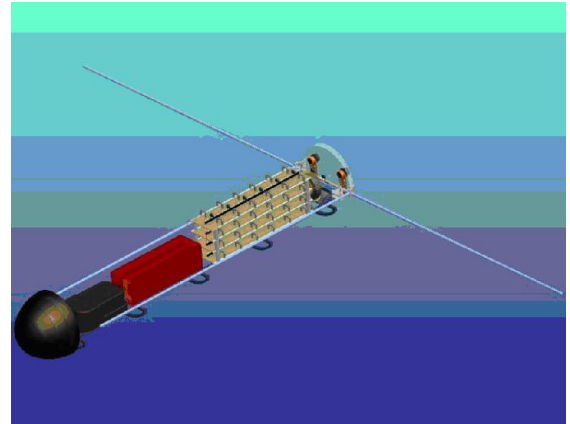
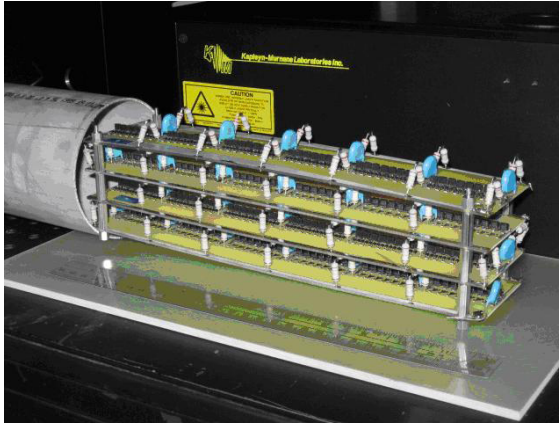
**SBIR Title:**  
Traveling Wave  
Marx Generator

**Contract Number:**  
FA9451-07-C-0026

**SBIR Company Name:**  
Physical Optics  
Corporation,  
Torrance, CA

**Technical Project Office:**  
AFRL Directed Energy  
Directorate, Kirtland AFB,  
NM

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



**Left: Physical Optics Corporation's 3rd generation solid-state mini-Marx (SSMM), capable of generating maximum power of 50 kilovolts (kV) x 100 A from the size of 3"x 4"x12", and fits in tube of 4" diameter as shown above. Right: Artist view of the SSMM as an electromagnetic interference (EMI) source in the air with a nose cone for the soft landing. Battery operated 4 kV DC-to-DC converters are behind the cone.**

## Solid-State Mini-Marx Generator

- The Air Force needed to improve the performance of small Marx generators since they are the lightest way to achieve high voltages
- Physical Optics Corporation (POC) developed a Solid-State Mini-Marx (SSMM) lightweight pulsed-power generator
- This technology will have a significant potential impact on the Air Force's development of airborne and ground-based radar systems and high-power microwave systems
- In addition, POC's high-power switches are directly useful as a modulator for a klystron microwave source that will emit even above 10 gigahertz (GHz), with an immediate potential application as an electromagnetic interference (EMI) nonlethal

RD-09-0993

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## Air Force Requirement

The Air Force needed to improve the performance of small Marx generators since they are the lightest way to achieve high voltages. The technology application needs to be capable of producing a 150-250 kilovolts (kV) damped sine wave between 100 MHz and 1 GHz. One can array several Marx generators, but the desired size is 12-in. long and 3-in. in diameter.

## SBIR Technology

Physical Optics Corporation (POC) developed a Solid-State Mini-Marx (SSMM) lightweight pulsed-power generator. This 11.5-in. long and 4-in. diameter mini-Marx generator is comprised of 24 stages, based on an array of avalanche bipolar junction transistors as an ultrafast solid-state switch.

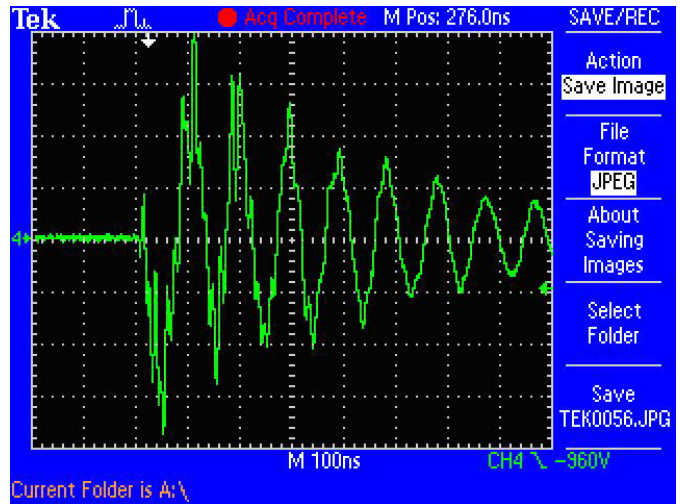
Just a single trigger on the very first transistor of the first stage sets the switches of all stages firing like a traveling wave, thus eliminating the jitter problem completely.

A typical risetime of 2.5 ns or 100 MHz is routinely achievable. An intermediate voltage of 51.6 kV-pp (limited by the high voltage probe capability) was achieved at the 12th stage of the generator, although over 100 kV-pp is expected at the 24th stage.

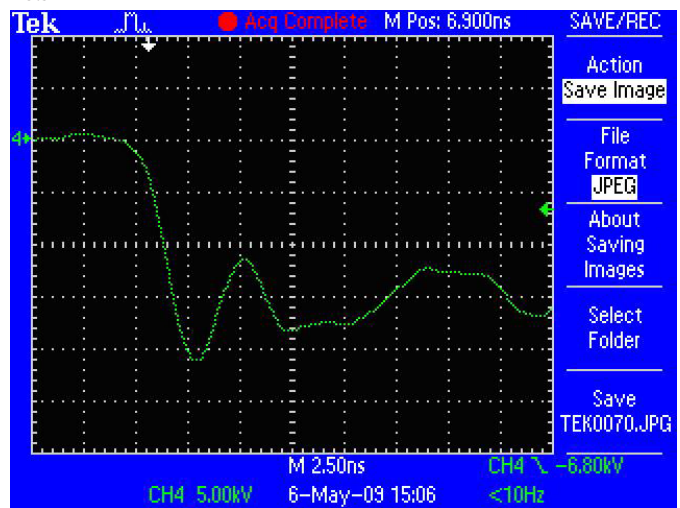
## Potential Air Force Application

This technology will have a significant potential impact on the Air Force's development of airborne and ground-based radar systems and high-power microwave systems. The POC-developed nanosecond high voltage (HV) impulse is useful for ultra-broadband radar. It can also generate a high-power microwave pulse in the GHz range once a sub-nanosecond risetime is achieved.

In addition, POC's high-power switches are directly useful as a modulator for a klystron microwave source that will emit even above 10 GHz. An immediate potential application for the Air Force is as an electromagnetic interference (EMI) nonlethal weapon, since the 4-in. diameter 12-in. height mini-Marx generator can produce 50-kV amplitude (100 kV peak-peak), 100-MHz sine waves at 10 A. An extra 12 inches in height can accommodate an 18V battery, a 4kV-30 mA DC-DC power supply, and a 100-MHz dipole antenna. The system is re-usable, being equipped with a soft-landing nose cone for use in an airborne weapon. These have an upgrading potential in terms of the power, cost, and size, adhering to the Air Force requirements.



SSMM generating 10 MHz damped sinusoidal wave with peak-to-peak voltage of 15.5 kV



SSMM switching speed 2.5 ns or 100 MHz demonstrated for the high-voltage of 21.6 kV and current of approximately 25 A (not shown)

## Company Impact

The Air Force SBIR program enabled POC to apply its unique capabilities as a technology-based small systems integrator. POC was able to apply its experience with a number of related electronic and high voltage technologies, together with certain project specific novel innovations, to create a solution for the Air Force customer. The SSMM is an important development for multiple systems solutions that have the potential for widespread government and commercial applications. This project directly fits with POC's product development and commercialization plans and is expected to materially contribute to the growth and success of the company.



# SBIR/STTR

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