Compact Module for Complementary-Channel Terahertz Pulse Slicing

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OTHER INFORMATION

CATEGORIZED AS

- **Semiconductors**
  - Other

RELATED CASES

2024-858-0

BACKGROUND

High-power, narrow-band terahertz waves are crucial for heating plasmas in fusion reactors, wireless communications with ultra-high data rates, radar with mm-range spatial resolution, electron beam accelerators, and coherent manipulation of quantum states. For all these applications, complex THz waveforms are desirable; however, scaling them to high frequencies is challenging. The leading technique for modulating such waveforms is laser-driven semiconductor switching (LDSS) with switching powers up to 1MW. Electronic modulation of such high-power THz sources is also possible but is complicated by the low damage threshold of such modulators. An important application for high contrast pulse modulation is high field electron spin resonance (ESR), where even a small fraction of leaked pulse power reduces spectroscopic resolution. In recent decades, ESR at frequencies above 95 GHz has grown in popularity because spectral resolution is greater, new phenomena can be accessed, and the increased polarizability of electrons can be transferred to nuclei to enhance the signal strength of high field nuclear magnetic resonance spectroscopy through dynamic nuclear polarization (DNP). This growth in popularity demonstrates the need for waveform generated quasi CW THz radiation with greatly relaxed power limitations.

DESCRIPTION

Researchers at the University of California, Santa Barbara have designed a quasi-optical modular pulse slicer designed for use at terahertz frequencies. It consists of identical modules with two inputs and two outputs, allowing stacking of modules combining two outputs of each module with two inputs of the next module. The pulse slicer is capable of flexible pulse durations (>1 ns) with customizable start and stop timings over a broad range of frequencies (>150 GHz). The design incorporates a laser-driven silicon switch at Brewster's angle to incoming terahertz radiation to limit undesired reflections in the "off" state and ensure that terahertz power is only transmitted when the switch is "on". Further, an "off" switch ensures that no power is leaked after the pulse and that the switching profile is sharp. The slicer's small footprint (48x72x162 mm) and small insertion loss (1.2 dB at 320 GHz) as well as high switching efficiency (>65%) allows pulse slicers to be stacked to create complex pulse sequences. An additional feature of the pulse slicer is splitting of the laser pulses generating pulses 2, 3, etc. and directing a part of the radiation to the preceding switches maintaining a high reflection in the on state thus overcoming limitations imposed on times between pulses due to the carrier's relaxation in the switch material. This design will enable more complex kW-power pulse sequences than existing pulse slicers for free electron laser or gyrotron-powered pulsed ESR and has potential applications for pulsed DNP.

ADVANTAGES

- Allows for complex pulse sequences
- Electronically controlled customizable pulse length
- High on-off contact and low insertion loss
- Offers inter-pulse phase control and spatial mode filtering
- Compact, modular design
- Simple construction makes the slicer inexpensive to produce

APPLICATIONS

- Fusion power
- Wireless communications
- Manufacturing
- Medical research
- Radar systems
- Quantum mechanics

PATENT STATUS

Country	Type	Number	Dated	Case
Patent Cooperation Treaty	Published Application	2025/198646	09/25/2025	2024-858

Additional Patent Pending

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- A Cavity-Free Self-Referencing Frequency Comb

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