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Low Cost High Efficiency Magnetrons for Accelerator Applications

Cooperative Research and Development Agreement Final Report

CRADA Number: FRA-2015-0008

Fermilab Technical Contact: Ralph Pasquinelli

Summary Report
9/24/2019

NOTICE

In accordance with Requirements set forth in Article X of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

CRADA number: FRA-2015-0008

CRADA Title: Low Cost High Efficiency Magnetrons for Accelerator Applications

Parties to the Agreement: Calabazas Creek Research and Fermi Research Alliance, LLC

Abstract of CRADA work:

High efficiency, low cost RF sources are required for proton, ion, and muon accelerators. These sources must be compact and provide precise control of the output power and phase. Currently only large, expensive klystrons can provide this performance. Calabazas Creek Research Inc. proposes to develop a phase locked magnetron-based system that has phase and amplitude control via a low power amplifier. The system uses phase modulation to control the RF power. The efficiency can exceed 80% and the cost is expected to be less than $3/Watt, significantly lower than other high power amplifiers. CCR originally proposed to develop a magnetron with a grid for control of phase and amplitude. Detailed simulations showed that this was not a promising approach. The grid was found to be viable only in magnetrons with low duty cycle, and amplitude control was demonstrated; but the grid was found to be not effective for phase locking. Attention was turned to a concept from Fermilab, which is very promising for both amplitude and phase control and does not require a grid. CCR will develop an RF system providing phase and amplitude control of a 100 kW peak, 10 kW average 1.3 GHz magnetron. Procedures and techniques will be applicable to design of systems at other frequencies and power levels. The program will include development of the magnetron and locking electronics. The system will be tested at Fermilab. Commercial Applications and Other Benefits Magnetrons can provide high levels of RF power at very high efficiency at low cost. As oscillators, however, their applications are limited. Magnetrons with more precise control of the output power and control of the phase could find wide application in accelerators and colliders. They would also provide improved performance for high resolution radar.

Summary of Research Results:

We have demonstrated a high-efficiency magnetron system capable of phase and amplitude control for driving high-*Q* accelerator cavities. The system produced 100 kW at 1.3 GHz with 1.5-ms pulses. A locking bandwidth of 0.9 MHz was obtained with a drive signal 25 dB below the magnetron output power. Consequently, the system can be controlled at full power with a 316-W locking signal, readily available from

commercial, solid-state sources. The demonstrated average power was about 300 W, which was limited only by the available test time. The design was scaled from a 100-kW, 915-MHz device, so there is high confidence that 10 kW of average power can be achieved.

Related Reports, Publications, and Presentations:

A 100-kW 1300-MHz Magnetron With Amplitude and Phase Control for Accelerators

Michael Read; R. Lawrence Ives; Thuc Bui; George Collins; David Marsden; Brian Chase; John Reid; Chris Walker; Jeff Conant;
IEEE Transactions on Plasma Science

FERMILAB-CONF-16-685-AD

Subject Inventions listing:

NONE

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