Contribution ID: **56** Type: **Remote presentation**

System-on-Chip Technology Application on Millimeter Wave Reflectometers

Tuesday 14 May 2024 16:30 (30 minutes)

The microwave reflectometer serves as a crucial diagnostic tool for plasma density measurements. In modern large-scale, high power fusion plasma facilities, reflectometers require lengthy millimeter-wave transmission lines to shield the microwave transmitting/receiving systems from harsh radiation environments, thereby ensuring the diagnostic system's integrity. Enhancing the output power of the transmitting module and the conversion gain of the receiving module is essential to compensate for transmission line losses. Leveraging advancements in semiconductor technology, System-on-Chip (SoC) microwave transmitter and receiver modules have been developed and implemented in magnetic confinement fusion diagnostic equipment. The inclusion of millimeter-wave low-noise power amplifiers in both transmitting and receiving components directly improves the signal-to-noise ratio of reflectometer measurements while minimizing back-end electronics noise. These microwave chips, scaled down to square millimeter dimensions, are enclosed individually in shielding enclosures, occupying only about 150 cubic centimeters. This compact design, coupled with high power output and conversion gain, facilitates easy installation, and broadens the application potential of microwave reflectometers. In 2023, the successful development of the GaN-based W-band receiver chip marked a significant milestone. The utilization of wide bandgap materials like GaN promises enhanced radiation tolerance for millimeter-wave electronics, a pivotal advancement in the realm of fusion reactor microwave diagnostics.

This work is supported by the US Department of Energy under US DoE grants DE-SC0021353, DE-FG02-99ER54518, DE-FG02-99ER54531, DE-SC0023500.

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Session Classification: Talks

Track Classification: Day 2 - Scientific Contributions: Technology development