High-Power, Plasma-Switched, Lumped-Element Reconfigurable Impedance Tuner for Radar Transmitter Applications

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With recent S-Band frequency reallocations in the United States requiring sharing between incumbent radar systems and fifth-generation (5G) wireless communications, radar systems will need to be frequency-agile. To maximize output power, and hence radar detection range, while operating flexibly in a congested environment, a radar transmitter will need to adapt in real-time when a new interferer presents itself. As the frequency of a radar transmitter is changed, the optimum load impedance for maximizing output power from the transmitter power amplifier also changes. To further complicate the problem, the impedance presented by the antennas of the array elements change with changes in array scan angle. The output matching network should be designed to provide a good power match over all frequency and array scan angle changes. Since the Bode-Fano critierion shows that any fixed matching network is limited in its ability to provide high gain over a wide range of frequencies, a reconfigurable output matching network can provide an advantage over a fixed matching network, as long as the reconfiguration time is fast enough for the application.

While many previously available tuners have been designed to either reconfigure quickly or handle high power levels, few tuner designs have demonstrated both fast reconfiguration times and high power handling. Design and simulation of a novel high-power reconfigurable 2-4 GHz impedance tuner is presented. The tuner is shown to have broad Smith Chart coverage and low loss, while completing a search-based reconfiguration within hundreds of microseconds. Unlike previous plasma-switch tuner designs, this tuner uses inductors and capacitors terminated to ground off of the main transmission line and high-power semiconductor plasma chiplet switches to change the state of the tuner. Through switching the plasma chiplets, different combinations of shunt inductors and capacitors are presented to a series transmission line, adjusting the impedance presented to the amplifier. With a wide range of impedances that the tuner can reach, a real-time, measurement-based search algorithm is used to determine the tuner state for maximum output power. Simulations show that this design covers a significant portion of the Smith Chart and has many reconfiguration options with reasonable loss over the entire octave operating band. The majority of the states in the tuner design have a loss less than 2dB, with loss observed as low as a 0.5dB at 2GHz. This tuner design holds promise for use in radar and other high-power transmitter applications to quickly adjust for maximum output power while varying its operating frequency and scan angle in a congested spectral environment.