High Power Test of X-band Accelerator Cavity Powered by Solid State RF Source

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Overwhelming demand for high energy particle beams in science and medicine has substantially stimulated the application of radio frequency linear accelerators (linacs) in rapidly growing technologies including X-ray medical diagnostics; X-ray or electron beam therapy; industrial non-destructive testing, geophysical and terrestrial imaging. We focus on the requirements of the linear accelerator as a scientific instrument installed in a space satellite with its unique challenges including payload and electrical power requirement [Nanni *et al.*, SLAC-R-1058. SLAC National Accelerator Laboratory (SLAC), 2016]. Conventional radio-frequency linacs are powered by such vacuum-tube based radio-frequency sources as klystrons or magnetrons, which come with unique burdens for airborne applications. An attractive approach for meeting this challenge, especially for moderate to low-gradient linacs with accelerating gradients of about 1 MV/m, is the use of solid state power amplifiers (SSPAs) to drive the linac. Main idea is to feed each accelerating cavity separately thus increasing operational flexibility of the linac while avoiding penalty of radio-frequency losses in a power combining circuit.

Such a technique promises a cost-efficient power source with large scale integration capability, the absence of high voltage power supplies and significantly lower weight for airborne applications compared to conventional drivers. In this paper we describe high power test results of an X-band 100-W solid state amplifier chain for linac applications. Moreover, the performance of solid state amplifiers when driving an accelerating cavity is investigated. Commercially available, matched and fully-packaged GaN on SiC HEMTs are utilized, comprising a wideband driver stage and two power stages to generate a 100 W with variable duty cycle. The amplifier chain has a high power-added-efficiency and is able to supply up to ~1.2 MV/m field gradient at 9.2 GHz in the test cavity, with a peak power exceeding 100 W. We also observed radio-frequency breakdown events inside the air-filled accelerating cavity due to such high gradient. Furthermore, we demonstrate the design and test of highly-efficient Class-F power amplifiers circuit boards designed in-house using unmatched GaN dies and operating at 11.4 GHz.