SOLID-STATE HIGH VOLTAGE MODULATOR WITH OUTPUT CONTROL UTILIZING SERIES-CONNECTED IGBTS

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The design of a solid-state high voltage modulator has been developed that uses series-connected IGBTs to control the output voltage. Although having many potential applications, this high voltage modulator was designed to meet, at a minimum, the requirements of one of the power supplies required for depressed collector gyrotrons being used in electron cyclotron systems on devices performing experiments for fusion energy. Depending on the specific gyrotron, the output voltage is required to vary up to -80 kV with currents up to 100 A. In addition, square-wave modulation at frequencies up to 1 kHz is required. Four IGBTs are configured into a 2.4 kV IGBT module, and the number of IGBT modules that are connected in series is adjusted to meet the output voltage requirement. IGBT modules were successfully built and tested to verify the performance of the topology at 2.4 kV. The design of a -80 kV, 100 A modulator has been developed. The design is easily scalable for different applications and output voltages. A conceptual design was also developed for a -90 kV, 120 A power supply that has multiple intermediate taps to energize a multi-stage depressed collector gyrotron. This concept has twenty-four 4.5 kV, 120 A power supply modules that are connected in series. Each power supply module has three 2.4 kV IGBT modules, which provides sufficient voltage margin to support the additional voltage headroom needed for regulation and AC line fluctuations. If all of the power supply modules were equally sharing the total output voltage of -90 kV, then each module would be operating at -3.75 kV. The extra 18 kV of voltage margin adds the capability of reaching -90 kV with some of the modules putting out less than -3.75 kV. The description of the design of the IGBT modules and of the -80 kV, 100 A modulator will be presented. An overview of its adaptation to the concept for the power supply of the multi-stage depressed collector gyrotron will also be presented.