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Design of a 700-kV Modulator for High-Power Radiofrequency Sources above 200 GHz

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The availability of a high-power radiofrequency (RF) source above 200 GHz would introduce a remarkable progress in many applications, as in nuclear fusion plasma heating and diagnostics, in high-gradient accelerators, in RF undulators.
For this reason, ENEA is running a project for the realization of a Cyclotron Auto Resonance Maser (CARM). The operational parameters of the CARM were selected taking into account the expected requirements of the future DEMO reactor. Since the DEMO electron cyclotron frequency should exceed 200 GHz with an optimal range 230-280 GHz, the frequency was fixed at 250 GHz, that is also suitable to perform second-harmonic tests in the FTU tokamak.
This frequency can be produced by a beam power supply (PS) up to 700 kV. Its input electrical power is at least 4 MW with an efficiency ≈30%, leading to ≈1 MW of useful RF power.
The first CARM prototype will be supplied by a specific high voltage modulator able to generate pulses in the range 500-700 kV with a rise time ≈1 μs and with a flat-top within ±0.1% (including stability and droop) longer than 5 μs. The final stage of the modulator is a pulse transformer immersed in an oil tank together with a ballast/dummy load. The CARM load can be regarded as a resistance (capacitance <5 pF) depending only on the filament temperature (controlled by a dedicated ≈27 kW PS). The very low calculated perveance ($<10^{-7}$) does not help the limitation of the overshoot that shall be <2%. A current increasing up to 100 A is being evaluated to reach the RF power necessary in accelerators and in short-wavelength undulators for X-ray free electron lasers.
After the success of the first phase of the project, a new PS design will be adopted to achieve long (up to continuous wave) and amplifier-mode operations.

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