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## Implementation of Design Changes Towards a More Reliable, Hands-off Magnetron Ion Source

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As the main  $H^-$  ion source for the accelerator complex, magnetron ion sources have been used at Fermilab since the 1970's. At the offline test stand, new R&D is carried out to develop and upgrade the present magnetron-type sources of  $H^-$  ions of up to 80 mA and 35 keV beam energy in the context of the Proton Improvement Plan. The aim of this plan is to provide high-power proton beams for the experiments at FNAL. In order to reduce the amount of tuning and monitoring of these ion sources, a new electronic system consisting of a current-regulated arc discharge modulator allow the ion source to run at a constant arc current for improved beam output and operation. A solenoid-type gas valve feeds  $H_2$  gas into the source precisely and independently of ambient temperature. This summary will cover several studies and design changes that have been tested and will eventually be implemented on the operational magnetron sources at Fermilab. Innovative results for this type of ion source include cathode geometries, solenoid gas valves, current controlled arc pulser, cesium boiler redesign, gas mixtures of hydrogen and nitrogen, and duty factor reduction, with the aim to improve source lifetime, stability, and reducing the amount of tuning needed. In this summary, I will highlight the advances made in ion sources at Fermilab and will outline the directions of the continuing R&D effort.

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