# Simulations of an AC Quadrupole for Power-line Ripple Correction at the AGS Booster

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## Abstract

The AGS Booster delivers slow-extracted beam to the NASA Space Radiation Laboratory by exciting a third integer resonance with [1]. To correct oscillations of the orbit from the power-line ripple, an active filter on the main magnet power supply [2]. This corrects the ripple in the dipoles and four of five windings in the quadrupoles. To correct residual ripple on the quadrupoles, a corrector quadrupole has been installed and connected to an AC circuit to drive the quadrupole at the frequency of the observed ripple. Simulations of the effects of power-line ripple on the quadrupoles are shown, with and without the AC quadrupole corrector, and their effects on the dynamics of slow extracted beam [3].

## The Power-line Ripple

The option for a time varying magnetic field has previously been installed in Zgoubi to support simulations of AC dipoles [4]. Recently, a similar scaling has been installed for simulations of PS ripple on magnets. For these simulations, the ripple on all quadrupoles follows:

$$B_{quad} = B_{quad}(0)(1 + K \sin 2\pi\nu_{ripple} t) \quad (1)$$

with K the ripple amplitude, $\nu_{ripple}$ is the tune of the ripple as observed by the beam, and t is the turn number.

A single corrector AC quadrupole was added to compensate for the ripple powered with a pure sine-wave, following

$$B_{ACQ} = B_{ACQ,o} \sin 2\pi\nu_{ripple} t \quad (2)$$

The installed magnet has an excitation of 11.67 G/A, which would correspond to 6 A to correct a 0.025% ripple for 1.5 GeV protons.

| Parameter | Value |
|---|---|
| $B\rho$ | 7.6 Tm |
| $B_{quad}(0)$ | 0.348 T |
| $\nu_{ripple}$ | $4.3664\times10^{-5}$ |
| K | 0.025% |
| $B_{ACQ,o}$ | 7.1 mT |

| | |
|---|---|
| Top plot | the FFT measured tune with a large bin width and resulting poor accuracy. The corrected tunes are relatively constant. |
| Middle plot | the left and right plots are separated by $\nu_{ripple}/2$ where the shape for the compensated scenario remains relatively constant compared to the uncorrected case. |
| Bottom plot | the particles location in phase space is fit to a circle. A comparison to the deviation of particle trajectories from the best fit circle radius is plotted as the residual, which shows the shape of the corrected case is constant and the uncorrected is not. |

The power supply is in development and is expected before the end of 2025. Comissioning will being shortly after the PS is ready.

## Acknowledgements

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## References

[1] K. Brown et al. "Design of a Resonant Extraction System for the AGS Booster," in proceedings PAC1999, 1999.

[2] K. Brown et al. "Commissioning results of Slow Extraction of Heavy Ions from the AGS Booster," in proceedings PAC2003, 2003.

[3] K. Brown, "Third Integer Resonant Extraction: Ripple Compensation and Bunched Beams," CA/AP Tech Note 645, 2021.

[4] F. Meot, "Zgoubi User's Guide," 2021.

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