

# Development and Magnetic Analysis of Stirling Converter Assembly Linear Alternators

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Infinia Corporation is working with NASA Glenn Research Center to evolve the Infinia Technology Demonstration Converter into a lower mass, higher efficiency design. As part of the effort, the linear alternator has been re-designed and analyzed using a 3-D finite element analysis (FEA) software package. The linear alternator is the most massive component of the Stirling converter assembly and offers the highest potential for mass reduction and corresponding gains in power density. The 3-D MAXWELL software package was applied to determine the demagnetization margin for permanent magnets and to map the detailed magnetic field of the laminations to maximize the use of lamination iron, which is not provided by the empirical, in-house design code. Initial evaluation shows that substantial weight reduction can be achieved with a compact, moving-magnet linear alternator design. The improved linear alternators employ more compact copper coils and stator/mover iron and higher operation frequency to achieve significant overall weight reduction. This paper presents some of the analysis results and discusses areas for future improvement.

## Nomenclature

|             |   |                                    |
|-------------|---|------------------------------------|
| <i>FPSE</i> | = | Free-Piston Stirling Engine        |
| <i>CHP</i>  | = | Combined Heat and Power            |
| <i>GRC</i>  | = | Glenn Research Center              |
| <i>SCA</i>  | = | Stirling Converter Assembly        |
| <i>FEA</i>  | = | Finite Element Analysis            |
| <i>MTI</i>  | = | Mechanical Technology Incorporated |
| <i>CTCP</i> | = | Component Test Power Converter     |
| <i>SBIR</i> | = | Small Business Innovative Research |

## I. Introduction

Recently Infinia, supported through a NASA Glenn Research Center (GRC) task order contract, undertook a design study to reduce Stirling Converter Assembly (SCA) mass. Particular attention was paid to the converter assembly and the linear alternator, which constitutes 70% of the overall SCA mass. Several new, low-mass alternator configurations were designed and evaluated, from which a smaller, lighter, moving-magnet configuration was chosen as a promising upgrade over the Infinia legacy, moving-iron linear alternator. Other analyses of the general linear alternator design have identified significant potential mass savings through optimization of magnetic flux distribution, improved topologies, and coil/lamination usage. This paper provides some details regarding the new linear alternator designs, as well as results of analyses performed using 3-D MAXWELL.

## II. Advanced Low-Mass Alternator

Moving-iron alternators, such as those used in legacy SCA systems, contribute significantly to overall mass. Reducing the overall stator diameter will be a key focus of the new design, considering that mass and volume both scale with the square of the diameter. Figure 1 provides an illustration of the current Infinia moving-iron linear

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