The MEG and the Villari Effect

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This paper investigates how the anomalous OU performance of the MEG may be explained by the Villari effect.

Examination of the MEG circuit shows the low power drive into the primary coils is square wave (provided by switching transistors) but the high power output is sinusoidal. There are two possible explanations for this, either (a) there exists a high Q resonant circuit that filters out the square wave harmonics or (b) there is a sinusoidal voltage source within the system. Examination of the likely self-capacitance of the output coils and hence the Q of this circuit tells us that this cannot account for (a), the Q is far too low. Also magnetic domain analysis shows that for conservation of flux there has to be an anomalous sinusoidal mmf (or H field) generator somewhere within the system, hence (b) applies. It is this "internal" source of AC power that gives the MEG its over-unity characteristic, and there has to be some resonance phenomenon responsible for the sine waves. The analysis prompted a search for such a resonance, and this was found to be ultrasonic resonance of the Metglas C cores. The Metglas material used for the cores has magneto-strictive properties, so electrically driving the system at the resonant frequency of each C core will excite that mechanical resonance: standing wave stresses in the core will then induce (via the Villari effect) changes of reluctance that, when biased by the permanent magnet, provide the anomalous source of alternating mmf to explain the OU.

The resonance considered here is a longitudinal (along the magnetic field direction) expansion and contraction of the core material. Materials that are mechanically excited in this manner will exhibit a resonance determined among other things by the speed of longitudinal (acoustic) stress waves in the material. Thus a rod will resonate at frequencies where the length is close to integer multiples of a half wavelength. In this respect it behaves like an electromagnetic dipole. Considering the half wave dipole, the expansion/contraction is (like voltage in the EM dipole) a maximum at the ends while a minimum at the center, and the stress (as for current) is minimum at the ends while being maximum at the center. The expansion/contraction resonance still occurs if the rod is bent into a U shape. Mechanical excitation is via magneto-striction, the core expands/contracts along the magnetization direction in response to changes of magnetic field.

The Villari effect is the reverse of magneto-striction, i.e. externally driven expansion/contraction changes the magnetization hence alters the permeability and the core reluctance.

The presence of the MEG permanent magnet has several effects:

1. It biases each C core into a region where magneto-striction is maximum.
2. It enables the Villari effect to create anomalous mmf within the magnetic ring circuit. By having the small AC flux superimposed on a large value of static flux, small changes in permeability synchronized with the AC flux generate large vales of mmf (imagine a DC current flowing through a resistor whose value is changing say by 1%. The change of voltage across that resistor will

be proportional to the value of DC current, the larger the current the greater the AC voltage).

Magnetic Domain Analysis.

There are pictures on the web showing the drive coils alternately switching the magnet flux from one side of the core to the other. This is unreal. Using the measured output voltage and frequency, and knowing the number of turns, the AC flux is easily determined to be tiny compared to the DC magnet flux, it is in the order of one thousandth! Also those same pictures assume the magnet flux to be uniformly distributed across the core cross-section area, and again this is untrue. The flux lines from the magnet enter the core at right angles to the laminations: in this direction the core bulk material has very low permeability. The flux lines take the lowest reluctance path along the laminations and the net result is the magnet flux is concentrated within the innermost laminations closest to the poles of the magnet. These innermost laminations are magnetically saturated, hence they cannot carry the small AC flux. Figure X is an FEMM plot demonstrating this feature. FEMM cannot handle laminations following the curved corners, hence this plot was performed using X and Y laminations which meet at the corners (with thanks to Stan Zuwala for this plot).

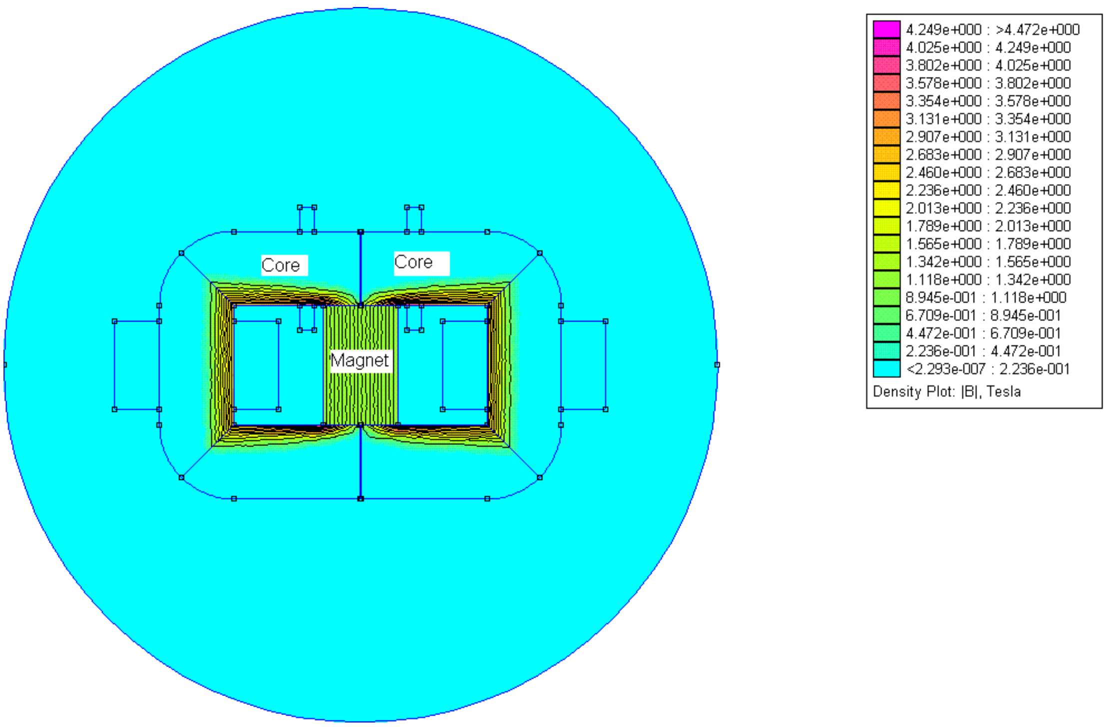

Figure X. FEMM plot showing magnet flux within innermost laminations.

Thus the core can be divided into two regions, the innermost region carrying only magnet flux and the outermost region carrying only small AC flux. This division is crucial to the operation of the MEG, since one region acts as the magnetostrictive driver to excite the mechanical resonance and the other region acts as the Villari effect transducer to create the anomalous mmf.