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A Novel Planar Switched Reluctance Motor for Industrial Applications.

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I. INTRODUCTION
The authors propose a 2D direct-drive, low cost, easy to manufacture machine based on switched reluctance principle for perspective industrial applications[1]. This motor consists of the following major components,
1. Aluminum base with multiple, laminated silicon-steel blocks
2. Six laminated si-steel slots with coils with an arrangement that any one slot and the its adjacent neighbor are responsible for perpendicular axis of motion
3. Two pairs of supporting mechanical slides holding the moving platforms and maintain the air gap
4. Optical encoders to detect and feedback its position information.
Fig.1 shows its overall structure from top and side views.
II. MACHINE CONSTRUCTION
This motor derives from a former design of a linear switched reluctance motor in our laboratory. This LSRM is targeted on accurate position control with 1-um of precision. This planar motor incorporates the design advantages of the previous LSRM for precise 2D position control applications (Table I).
The moving platform consists of two sets of 3-phase windings. Six movers together and coils have the same dimension and ratings. The arrangement has the following features,
a. Individual mover slot with coil simplifies winding scheme
b. Zero mutual-inductance between each adjacent mover
c. Long travel distance can be accomplished easily
The stator contains multiple laminated 0.5mm si-steel blocks held together, an aluminum base plate to support them firmly fixed and sliding supports to hold the platform and maintain the air gap[1]. This unique stator structure not only reduces eddy currents, but the “building element”concept makes mass production and flexible modifications of any size feasible.
III. SYSTEM FORMULATION
The equations that govern the entire system model can be described in a general state-space form. Inductance and resistance are 6×6 diagonal matrix since mutual inductance between any movers are zero.
IV. SYSTEM CHARACTERISITCS VERIFICATION
To precisely represent the model in finite element (FE) analysis, three dimensional models have been constructed. Then corresponding experimental measurement are carried out to verify simulated results.
1. Mutual inductance effect
A mover with its closet neighbor is chosen to inspect the couplings (Fig.2). Magnetic field merely distributes within the short magnetic path among the mover with its coil, the stator and the air gap between them. An experiment on the mutual effect has already been carried out in article[2].
Different current values are input to the coil and forces are calculated at every movement. Also he force is measured from the loadcell mounted on the mover. Overall the data from FEM and experiment correlate with each over satisfactorily after the friction is considered.
3. Inductance
After flux density from every FEs are obtained, the relationship between inductance and position is derived. Flux-linkage measurement from different positions has been carried out[2] and inductance can be calculated accordingly.
4. Force disparity in Z-axis
For the analysis of force disparity, fully aligned position(x) of the motor is considered. From the result of PID control proposed in[2], the slight variation from z directiondoes not affect dynamic performances.
N.C.Cheung,J.F.Pan and J.M.Yang,”Two dimensional variable reluctance planar motor”, U.S. Patent
N.C.Cheung, J.F.Pan and J.M.Yang,”High-Precision Position Control of a Novel Planar Switched Reluctance Motor”,IEEE Transactions on Industrial Electronics,Vol.52,No.6, December 2005

Mover mass (X)	8.75 Kg (Mx)
Mover mass (Y)	15 Kg (My)
Size of base plate	450×450mm
Travel distance	300×300mm
Air gap	0.55mm (z)
Number of turns per phase	160 (N)
Phase resistance	1.5Ω (R)
Pole pitch	6 mm (p)
Pole width	6mm (d)
Pole slot	6mm (q)
Encoder precision	0.5 µm

Table I. motor specifications

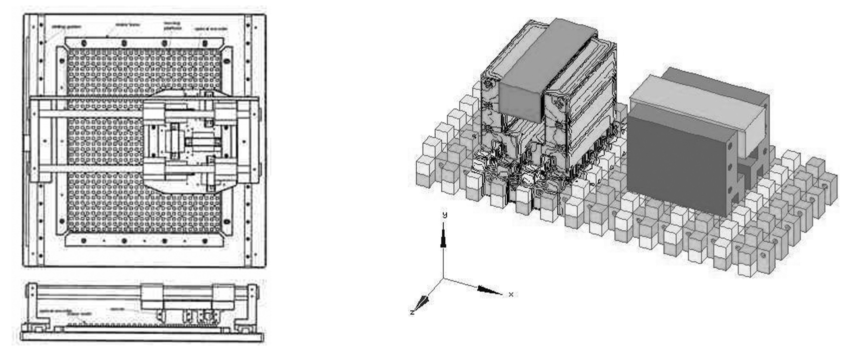

Fig.1 overall structure of PSRM