FILE NO. DST/TSG/NTS/2005/28

Project Title: Development of Rare Earth Permanent Magnet Stepper Motor.

Part A – Summary Report

1. Project Objectives

Objective as per the approved Project	Fully Achieved/Partially Achieved (Indicate Shortfall)	Reason for Partial Achievement
This research project aims at bringing about an innovation in stepper motor technology in India. Accordingly, it aims at developing indigenous know-how in the area of design of Permanent magnet - stepper motors using rare earth permanent magnets.	Fully Achieved	
Computer software for implementing the design algorithm will also be developed.	Fully Achieved	
Typical REPHM stepper motors employed in typical high performance high volume applications such as computer peripherals, and/or CNC machine tools and robotics, will be designed utilizing the design software.	Fully Achieved	
Electronic controllers based on microcontrollers or FPGA' s will be designed for the motors designed.	Fully Achieved	
Fabrication of both the stepper motors and their controllers will be undertaken, preferably in collaboration with industry.	Partially Achieved	Stepper Motor fabrication is pending, due to fabrication process constraint in stator coil & Disc rotor.

2. Deliverables

Deliverable as per the approved Project	Fully/Partially/Not Achieved	Reason for Partial/Non Achievement
Technology Document	Fully Achieved	----------
Prototype Controller	Fully Achieved	----------
Prototype motor	Partially Achieved	Our collaborator firm M/s. Martin Frank Motion Control is unable to fabricate Stepper motor particularly Stator coil & Disc rotor of the motor.

3. Specific benefits/ Outcome

I. Patent if any: Nil
II. Product/Developed/: Micro-stepping Drive for the Stepper motor.

III. List of Publications arising from the project:

Part B- Comprehensive Report

- **Project Title:** "Development of Rare Earth Permanent Magnet Stepper Motor"
- **Project/Process as an outcome of the project, identify beneficiaries:**
  - Technology document; on know how design of disc rotor stepper motor micro-stepping controller.
  - Micro—stepping controller for disc rotor type stepper motor.

  Potential beneficiaries are manufacturers of hybrid stepper motors, and the end users of the disc rotor type stepper motor.

- **Scientific description of the project/ process, given Specification /Standards for the same:**

  When precise motion over a fixed distance or fixed angle, then stepper motors are required. In Stepper motor rotation occurs because of magnetic interaction between rotor pole and poles of sequentially energized stator winding. Rotor has salient magnetized pole instead of winding. In permanent magnet stepper motor the torque is high out the presence of permanent magnet increases cogging. A high power to weight ratio stepper motor with better dynamic responses requires to overcome this. Therefore new motor is called the disc rotor type permanent magnet stepper motor has been developed.

  As far as India is concerned, only variable reluctance, permanent magnet and permanent magnet hybrid stepper motors are manufactured. The technology of disc magnet stepper
  motor is not available in India, and according to the information available only one company in Switzerland manufacture disc magnet stepper motor.

  The objective of this work is to design and develop a disc rotor type stepper motor to allow for truly exceptional dynamic performance. The rotor of these motors consists of a rare ,
  earth magnet having the shape of a tnin disc which is axially magnetized. A particular
  magnetization method allows for a high number of magnetic poles, giving much smaller
  step angles than conventional two-phase permanent magnet stepper motors. Such a rotor design has a very low moment of inertia, resulting in outstanding acceleration an dynamic behavior. These features, together with high peak speeds, mean that any incremental movement is carried out in the shortest possible time. Low inertia also means high start/stop frequencies allowing to save time during the first step and to solve certain motion problems without applying a ramp. These motors are specially designed for micro stepping feature a sinusoidal torque function with very low harmonic distortion and low detent torque. Excellent static and dynamic accuracy is obtained for any position and under any load or speed conditions**.**

4. Methodology Adopted for the development of the project.

Following methodology steps have been adopted in this project.

1. Analytical design

Using a Finite Element Analysis tool the design of disc rotor type stepper motor and controller was prepared and verified for analytical performance.

2. **Modeling & Optimization:**
   After designing, a 3D model of disc rotor type stepper motor using software, it was checked for performance. Based on the result the model has been changed for optimum performance. Similarly simulation results have been checked for the micro-stepping controller using simulation software.
3. **Fabrication of Controller and Stepper motor**
   Fabrication of Controller's PCB has been done as per design. Components soldered on the PCB.
   Different components of the disc rotor type stepper motor fabricated as per design. Only stator coil winding and rotor disc magnetization is pending due to manufacturing process constraints.

4. **Specific/technology formulation giving underlying basis:**
   Here performance prediction and design optimization is done through FEM analysis. Torque angle profile and inductance profile are calculated using FEM method. Thereafter a 10.8 kg-cm, 1.8 step angle, 2phase disk rotor Permanent magnet stepper motor was designed. The 3D model of the design was made and performance prediction was carried out using FEM package. Further a two phase bipolar micro stepping drive for disc rotar type stepper motor was designed. The micro stepping control system improves the positioning accuracy and eliminates controller 24V DC with upto 1/32 steps for the above stepper motor drive has been designed, simulated and fabricated. Which is better than imported (1/16 steps).