ARUN MICROELECTRONICS LTD

Magnetic Leakage Fields of AML Stepper Motors

APPLICATION NOTES

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1. Magnetic Leakage Fields

AML stepper motors are hybrid types and contain an axially-magnetised permanent magnet in the rotor. D-series motors are magnetised with the north-seeking pole at the flanged end of the motor. A small proportion of the total magnetic flux leaks out of the motor, which behaves as a very weak bar magnet. The leakage fields of typical samples are shown below. These were measured inside a cylindrical magnetic shield with its axis at right angles to the horizontal component of the earth's magnetic field, which was 48 µT at the test location. The screening became ineffective at displacements of 150 mm along the motor axis.

D35.1		
	Flux density µT	
Disp. mm	On axis	On side
40	50	15
60	16	5.5
80	6	2.2
100	2.8	1.1
120	1.8	0.6
140	1.2	0.3

D42.1		
	Flux density µT	
Disp. mm	On axis	On side
40	40	20
60	13	8
80	5	3
100	3	1.5
120	2	0.8
140	1.4	0.4

D57.1		
	Flux density µT	
Disp. mm	On axis	On side
40	n/a	100
60	90	40
80	30	16
100	16	8
120	11	4
140	6	2

During operation, the magnetic field is modulated by an alternating field at the stepping frequency. This is not usually as significant as the steady field, for a combination of reasons. The amplitude of the stepping-frequency field reduces with increasing step frequency and is only comparable to the steady field below a few hundred Hz. At low step rates, it is normal (for mechanical reasons) to use micro-stepping, which produces a sinusoidal flux waveform. Above a few hundred Hz it is normal to use full-step drive, which attempts to produce a rectangular flux waveform. However, the filtering action of the winding inductance progressively reduces the amplitudes of all frequency components of the field above a few hundred Hz so that the alternating component of the leakage field at a stepping frequency can be considered sinusoidal for all practical purposes. Most modern stepper motor drives achieve current regulation in the windings with a switching action, which also modulates the magnetic leakage field. The amplitude of this is usually very small compared to the steady and step-frequency components of the field, typically less than 10%. In most situations, the switching is disabled for the first few milliseconds after each step and is therefore not present at all above step rates of 500 Hz. Stepping motors achieve their greatest electromechanical efficiency between 500 Hz and 1 kHz step rates and it is standard practice to design motorised vacuum mechanisms to slew at these rates, in order to minimise the total energy input and hence the outgassing. It is fortunate that this also reduces the alternating components of the leakage flux.

Vacuum motorised mechanisms should be designed to hold their rest position without the need for the motors to be powered. This is desirable for a number of reasons, including the reduction of outgassing. If the analysis or process within the vacuum system is only active when the mechanism is stationary, then the alternating components of leakage fields need not be considered.

The axial fields of motors are about three times greater than the radial fields at a given displacement. This and the presence of the shaft means that the fields can be screened more easily at the sides of the motors. Where possible, the optimum orientation for the motor is with the shaft at right angles to the line between the motor and the point where the field is to be minimised and at the maximum displacement. If there are several motors in the mechanism some field-cancellation can be achieved by mounting them in pairs, aligning their axes in opposing directions. Where motors are to be screened using Mumetal or other material it is more effective to place the screens much closer to the motors than to the volume where the field is to be minimised. Where significant torques and minimal leakage flux are required in the same installation it is better to use D35 or D42 motors and reduction gears than D57 motors.