Dynamic Analysis of Linear Resonant Actuator Driven by DC Motor

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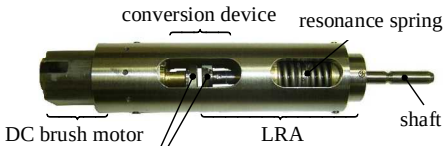
Introduction

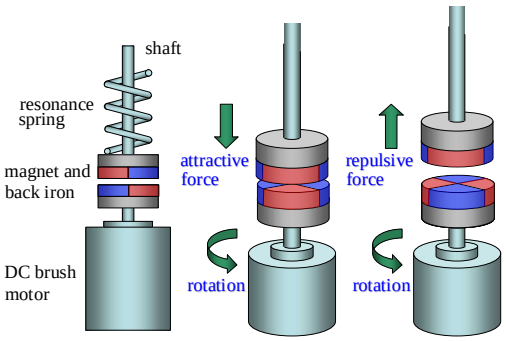
We developed a new structured linear resonant actuator (LRA) that can convert the rotation into the linear actuation by the attractive and repulsive force of a couple of multi-poles permanent magnets which are connected to the armature and DC brush motor, respectively.

The effects of the contact resistance on the dynamic oscillation characteristics of the LRA are quantitatively clarified. The usefulness of the use of appropriate contact resistance is clarified through the comparison with the measured results.



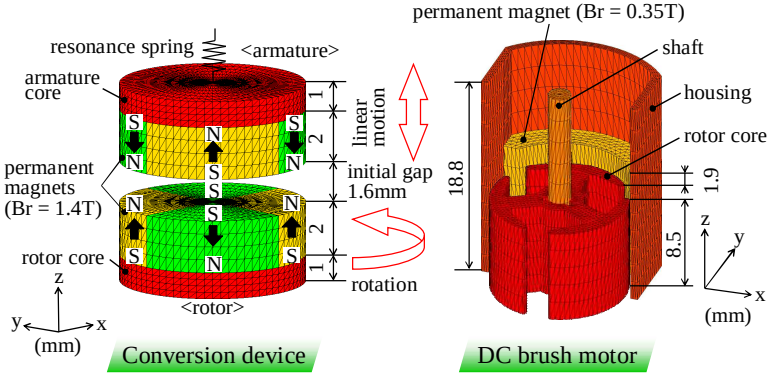
Linear resonant actuator

Principle of Operation



The armature moves linearly in the direction of z-axis as the attractive and repulsive force acts on the armature according to the rotation of the rotor. Because the armature is restricted to linear motion by the sliding guide, it reciprocates twice while the rotor goes round.

FEM Model



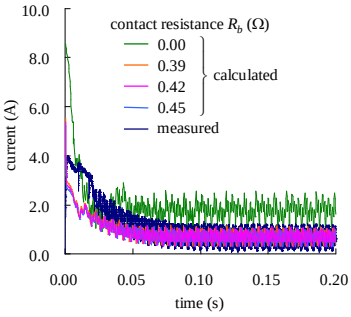
Conversion device

DC brush motor

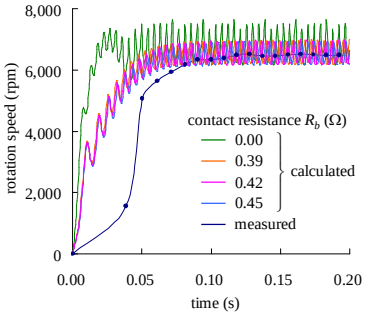
Analysis Conditions

Conversion device	Mass of armature (g)		11.55
	Spring constant (N/mm)		26.3
	Viscous damping coefficient (N·s/m)		0.025
	Dynamic friction force (N)		1.0
DC brush motor	Moment of inertia (kg·m^2)		1.571×10^{-7}
	Coil	Number of turns (turn)	24
		Resistance (Ω/phase)	0.216
		Contact resistance between brush and commutator (Ω/phase)	0.00, 0.39, 0.42, 0.45

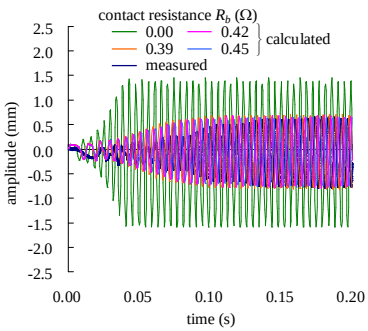
Time Variations of Current of DC Brush Motor



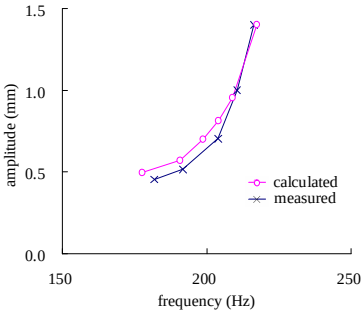
Time Variations of Rotation Speed of Rotor



Time Variations of Armature Amplitude of LRA



Characteristics of Amplitude versus Operating Frequency



Discretization Data and CPU Time

	Conversion device	DC brush motor
Number of elements	214,272	232,128
Number of nodes	38,049	42,185
Number of edges	256,856	281,240
Number of unknown variables	243,248	260,458
Number of time steps	800	
Total CPU time (hours)	185.1	

Computer used : Pentium 4 (3.0GHz) PC

Conclusion

The influences of the contact resistance on the dynamic oscillation characteristics of the LRA are quantitatively clarified.

The calculated results with contact resistance of 0.42Ω agree well with the measured ones. The usefulness of the use of appropriate contact resistance is clarified.