

## The Actuator for High-Speed CD/DVD Rewritable System

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**Key Words** : Optical Pick-Up, Actuator, Tilt, Digital Versatile Disc, Compact Disc, Rewritables, Readability

### ABSTRACT

There has been lower the tilt margin by the increase of coma aberration due to the reduction of wave-length and the increase of numerical aperture for high density recording. The RF signal degradation is increased as the decrease of tilt margin. To compensate the tilt margin, the optical pick-up actuator for high-speed CD/DVD re-writable system should be able to drive the radial-tilt motion. We announce that the 3-axis drive actuator for high-speed CD/DVD rewritable system. And what was more, the DC/AC sensitivities of this actuator are suitable for the low-speed playability, the high-speed readability and the high-speed rewritability.

### 1. Design Concept

It need high DC sensitivity and the compensation of tilt that the guarantee for the readability of Compact Disc-Player(CD-P) and Digital Video Disc-Player(DVD-P) even though the worst condition of various disc. And the readability of high-speed Compact Disc-Read Only Memory(CD-ROM) and Digital Versatile Disc-Read Only Memory(DVD-ROM) are subject to the AC sensitivity and the control of tilt. Moreover the AC tilt values for rotational-frequencies for respective speed mode are restricted within narrow limit by tilt margin. The accessing quality of Digital Versatile Disc-Random Access Memory(DVD-RAM) are subject to the control of tilt. Therefore, it is a difficult problem of the optical pick-up actuator for high-speed CD/DVD rewritable system that how can realize high DC/AC sensitivity with securing the tilt margin enough to cover all of the worst condition.

To achieve high DC/AC sensitivity and low AC tilt or the capability of tilt control, we adopted the 4-polarized magnet and the fine-pattern-coil(FP coil) of two-layer as the magnetic circuit system of new type actuator. The prominent effect of polarized magnet is the increase of maximum B-flux which can derive higher thrust than non-polarized magnet (see Fig1). The FP coil can be achieved the simplicity of magnetic circuit, so that the size of actuator can be fitted on various optical pick-up, such as CD-RW, DVD-ROM, DVD-RAM, COMBO, RAMBO (see Fig2); moreover, asynchronous tilt-drive can be easily achieved by adoption of FP coil (see Fig1).

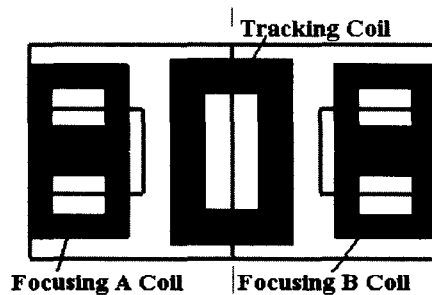


Fig1. The 4-polarized magnet and FP coil layout

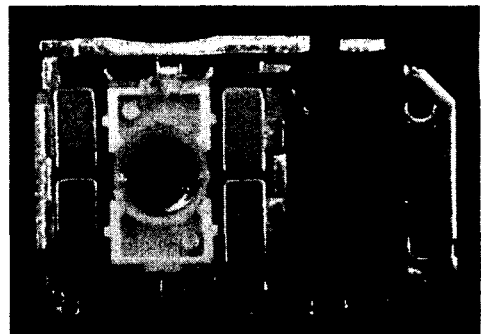


Fig2. The actuator for CD-RW X40 & DVD X16

Since a certain kind of system does not support tilt-servo, the actuator should have to be converted to 2-axis drive by minor changes. If the system does not compensate AC tilt, the 2-axis-drive actuator should have minimum AC tilt value about broad ranges of rotational frequencies since the AC tilt causes signal degradation.

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## 2. Performance

The DC sensitivity of focusing actuator is  $1.1\text{mm/V}$  and the AC sensitivity at  $200\text{Hz}$  is  $80\mu\text{m/V}(18\text{G/V})$ . The DC sensitivity of tracking actuator is  $1.3\text{mm/V}$  and the AC sensitivity at  $200\text{Hz}$  is  $90\mu\text{m/V}(20\text{G/V})$  (See Fig3). The acceleration level of track actuator can cover the acceleration caused by warped or eccentric disc; for example, the CD-RW 48 multiple-speed system on Zoned-Constant Linear Velocity (Zone-CLV) mode can drive spindle motor as  $11,000\text{rpm}$ , therefore, its acceleration by warped disc and eccentric disc is very large. The eccentric acceleration and the wobble acceleration are about  $70\text{ m/s}^2 (=7.14\text{G})$  at  $200\text{Hz}$  in CD-RW X48 (See Fig4). Therefore, the AC sensitivity at  $200\text{Hz}$  is very important factor for high-speed CD/DVD rewritable system. The 3-axis-drive actuator is  $13.2\text{G/V}(\text{focus})$ ,  $13.1\text{G/V}(\text{track})$  and the 2-axis-drive actuator is  $12.9\text{G/V}(\text{focus})$ ,  $14.5\text{G/V}(\text{track})$ .

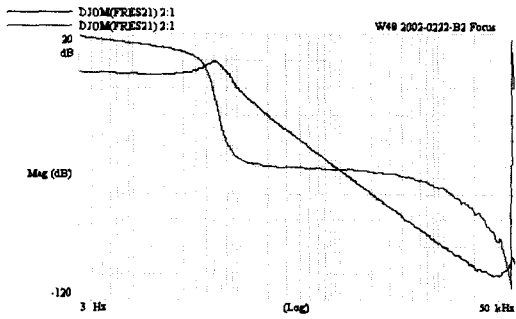


Fig3. (A) Frequency response function about focusing actuator (2-axis model)

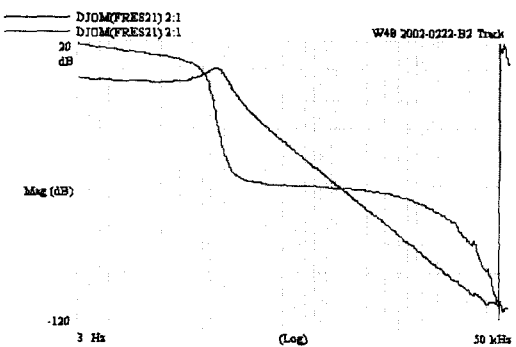


Fig3. (B) Frequency response function about tracking actuator (2-axis model)

The frequency of 2nd resonance peak of the tracking actuator is about  $42\text{kHz}$ . Moreover, the gain margin from the gain at  $1\text{kHz}$  to the 2nd resonance peak is  $61\text{dB}$  or its over. And the cross-over frequency which means that the

frequency crosses gain and 2nd resonance peak, horizontally, is about  $38\text{kHz}$ . Physical meaning of cross-over frequency of track actuator is an index of the cut-off frequency in open-loop transfer function including actuator, drive IC, digital equalizer and RF module. In case of DVD-ROM 16 multiple-speed drive, the cut-off frequency in open-loop transfer function is about  $6.6\text{kHz}$  at maximum speed. Therefore, it is impossible to resonate which is caused by system instability due to 2nd resonance or subsidiary resonance.

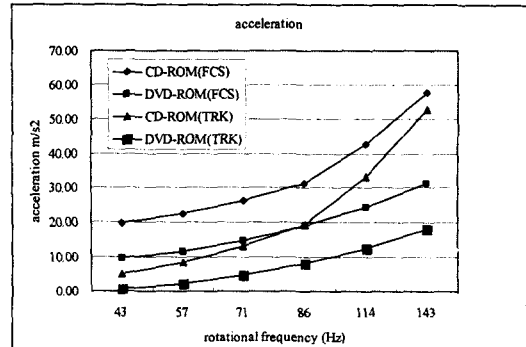


Fig4. The axial and eccentric acceleration by disc speed for standard warped(CD:  $\pm 0.5\text{mm}$ , DVD:  $\pm 0.3\text{mm}$ ) and eccentric(CD:  $\pm 70\mu\text{m}$ , DVD:  $\pm 35\mu\text{m}$ ) media

The DC sensitivity of radial-tilt actuation is  $3.29\text{deg/V}$  and the AC sensitivity of this is  $0.29\text{deg/V}$ . The higher DC gain of radial-tilt becomes the lower consumption of power to compensate radial-tilt in case of asynchronous drive (see Fig5). The maximum value of AC tilt (rolling) with the sine-sweep of focus or track by the shift in direction of track or focus is  $0.35\text{deg}$  at  $100\text{Hz}$ . The condition of AC tilt measurement is that the magnitude of sweep in tracking direction is  $\pm 0.2\text{mm}$  and the magnitude of offset in focusing direction is  $\pm 0.4\text{mm}$ . The 2-axis-type actuator should have minimum AC tilt value about broad ranges of rotational frequencies. The FP coil guarantees the endurance for high temperature by over-current. This system can endure DC  $700\text{mA}$  current for 60 seconds. At this time, the surface temperature of FP coil is about  $240^\circ\text{C}$ .

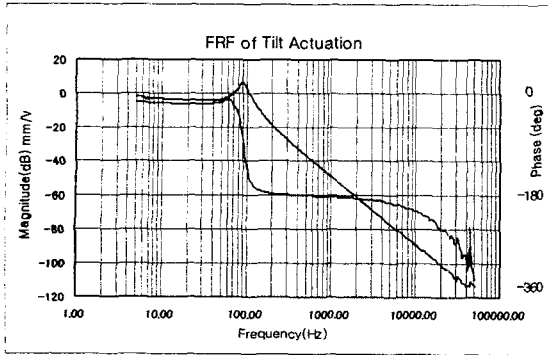


Fig5. Frequency Response Function about Tilt Actuation

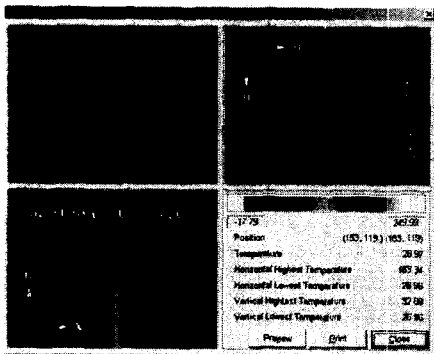


Fig6. Temperature at DC700mA, 60 sec.

Table1. Dynamic Characteristics of The Actuator (3-axis model and 2-axis model)

ITEM	UNIT	3-axis model			2-axis model	
		FCS	TRK	TLT	FCS	TRK
DC Sensitivity	mm/V	1.0	1.2	4.29	1.0	1.1
AC Sensitivity	G/V	13.2	13.1		12.9	14.5
	um/V	82	81	1.29	80	90
Resistance	Ohm	3.9	3.3	3.9	3.4	3.4
1st Resonance Freq.	Hz	65	69	110	65	67
1st Resonance Q factor	dB	5.0	5.0	8.0	5.0	5.0
2nd Resonance Freq.	kHz	45	45		44	44
Cross-over Freq.	kHz	16.2	38.4		16.2	38.4
Phase Delay (10 kHz)	deg	-28	-30		-28	-30
Moving Range	mm	2.55	1.6	1.0	2.55	1.6
Moving Mass	mg	440			400	
AC Tilt (max)	deg	±0.20			±0.05	

Note1. The unit of 'DC/AC sensitivity' is deg/V and that of 'moving range' is deg.

Note2. The condition of AC tilt measurement is that the magnitude of sweep in tracking direction is ±0.2mm and the magnitude of offset in focusing direction is ±0.4mm at rolling frequency.

### 3. Conclusion

- Our results are recapitulated below. By the use of 4-polarized magnet and FP coil, we can achieve;
- (1) High DC/AC gain of focusing and tracking for readability at low speed and high speed as well.
  - (2) High DC/AC gain of tilting for the compensation of tilt and for the low consumption of power.
  - (3) Low AC tilt for system adopted non-tilt servo
  - (4) Assurance for over-current
  - (5) Fitting on various optical pick-up platform

### Reference

- (1) Technical Document, "Performance of New-Type Actuator", P/U-ACT-053, OMS Division, Samsung Electronics Co., Ltd., 2002