MEMS mirror

S12237-03P

Ultra-miniature, high performance Electromagnetically driven laser scanning MEMS mirror

The S12237-03P is an electromagnetically driven mirror that incorporates our unique MEMS (micro-electro-mechanical systems) technology. We achieved an ultra-miniature scale by mounting the magnet beneath the mirror. Within a magnetic field generated by the magnet, electrical current flowing in the coil surrounding the mirror produces a Lorentz force based on Fleming's rule that drives the mirror. Hamamatsu MEMS mirrors offer a wide optical deflection angle and high mirror reflectivity as well as low power consumption.

Features

- **Low current operation**
- **Ultra-miniature size**
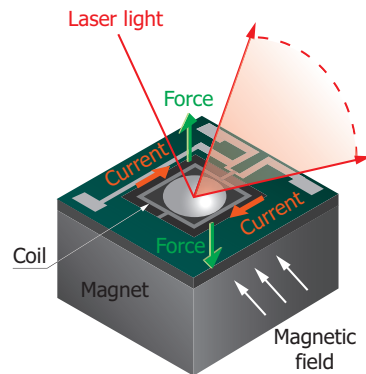- **Wide optical deflection angle**

Applications

- **Laser scanner unit**
- **Light switch**

Structure and principle

In a MEMS mirror, a metallic coil is formed on a single-crystal silicon, a mirror is formed inside the coil through MEMS processing, and a magnet is arranged beneath the mirror. Within a magnetic field generated by the magnet, electrical current flowing in the coil surrounding the mirror produces a Lorentz force based on Fleming's rule that drives the mirror tilt angle in one dimension. The path of the laser light incident on the mirror surface is varied in this way to scan and project. Compared to the electrostatic or piezoelectric driven mirrors, electromagnetically driven MEMS mirrors are smaller, lower voltage driven, and lower power consuming.

▷ Structure diagram

KOTHC0058EB

Absolute maximum ratings (Tcase=25 °C unless otherwise noted)

Parameter	Symbol	Condition	Value	Unit
Drive current	Is		±20	mA
Optical deflection angle*1	θs		±18	degrees
Operating temperature*2	Tcase	No dew condensation*3	-40 to +80	°C
Storage temperature	Tstg	No dew condensation*3	-40 to +85	°C
Soldering conditions	-	Using a soldering iron*4	260 °C max., within 10 s	-

*1: Angle at which the mirror makes contact with the magnet, damaging the mirror
*2: Case temperature (temperature of the metal frame on back side of case)
*3: When there is a temperature difference between a product and the surrounding area in high humidity environment, dew condensation may occur on the product surface. Dew condensation on the product may cause deterioration in characteristics and reliability.
*4: The magnetic force of the mirror built into this product degrades if the mirror is exposed to high temperature. Do not use reflow soldering on this product.
Note: As there is no window material on the S12237-03P, be sure to take measures to prevent dust adhesion and measures against moisture. Exceeding the absolute maximum ratings even momentarily may cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

Structure

Parameter	Condition	Min.	Typ.	Max.	Unit
Mirror size		φ2.59	φ2.60	φ2.61	mm
Mirror material		Aluminum			-
Operation mode		Linear mode			-

Recommended operating conditions

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating temperature*5	Tcase	No dew condensation	-20	+25	+70	°C
Optical deflection angle*6 *7	θs		-15	-	+15	degrees
Drive frequency	fs		DC*8	-	100	Hz

*5: Case temperature
*6: The optical deflection angle is twice the mechanical deflection angle.
*7: If a drive current is not applied, the optical deflection angle is defined to be 0°.
*8: Using the mirror with only one side (positive or negative) of the optical deflection angle is not recommended, as it can shorten the service life.

Electrical and optical characteristics (recommended operating conditions unless otherwise noted)

Parameter	Symbol	Condition			Min.	Typ.	Max.	Unit
Drive current	Is	Tcase=25 °C, fs=DC	θs=-15°		-17	-15	-13	mA
			θs=+15°		+13	+15	+17	
Optical deflection angle accuracy*9	dθs	Tcase=25 °C	fs≤50 Hz	m=1	-0.8	-	+0.8	degrees
				m=3	-0.3	-	+0.3	
			fs≤100 Hz	m=1	-1.0	-	+1.0	
				m=3	-0.5	-	+0.5	
Temperature coefficient of optical deflection angle*10	α	Tcase=-20 to +70 °C, θs=±15°			-	-0.095	-	%/°C
		Tcase=-20 to +25 °C, θs=±15°			-	-0.085	-	
		Tcase=25 to 70 °C, θs=±15°			-	-0.105	-	
Resonant frequency	fS-R	Tcase=25 °C, Is=0.6 mAp-p			500	530	560	Hz
Quality factor	Q	Tcase=25 °C, Is=0.6 mAp-p, 1 atm			30	34	38	-
Coil resistance	Rs	Tcase=25 °C, Is=0.1 mA			135	165	195	Ω

*9: Deviation between specified optical deflection angle θc(t) and actual optical deflection angle θs(Is(t)) [equation (1)]

$$d\theta s = \theta s(Is(t)) - \theta c(t) \ \ldots (1)$$

θc(t): optical deflection angle of sine wave for drive frequency fs and amplitude Ac [equation (2)]
θs(Is(t)): actual optical deflection angle for drive current Is(t) calculated from equation (3)

$$\theta c(t) = Ac \cdot \sin(2\pi fs \cdot t) \ \ldots (2)$$

$$Is(t) = \sum_{n=0}^{m}\left[a(m,n) \cdot \left\{ Ac\left[1 - \left(\frac{fs}{fs\text{-}R}\right)^2\right]\sin(2\pi fs \cdot t + \phi)\right\}^n\right] \ \ldots (3)$$

a(m, n): correction factor, where m is the order. The correction factor is indicated on the final inspection sheet.
φ: Phase deviation [equation (4)]

$$\phi = \tan^{-1}\left[\frac{1}{Q} \cdot \frac{\frac{fs}{fs\text{-}R}}{1 - \left(\frac{fs}{fs\text{-}R}\right)^2}\right] \ \ldots (4)$$
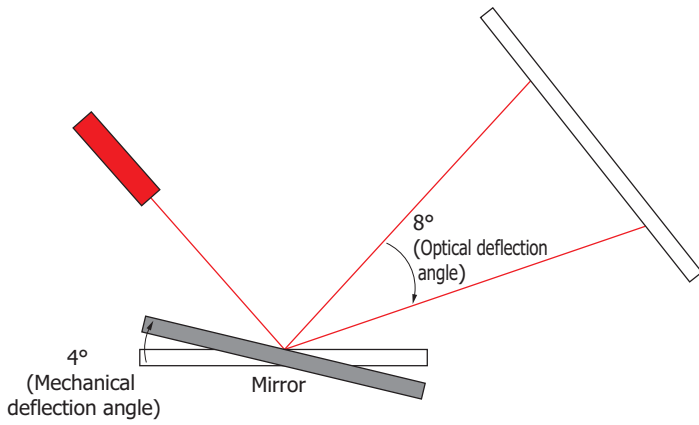
*10: Temperature dependency of optical deflection angle when the drive current is constant [equation (5)]

$$\alpha = \frac{\theta s(Is, T_2) - \theta s(Is, T_1)}{T_2 - T_1} \times 100 \ \ldots (5)$$

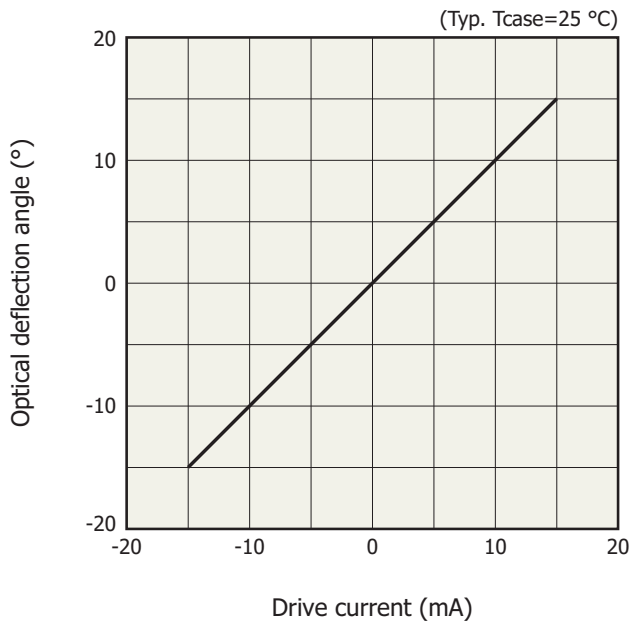T_1, T_2: Any temperature in the operating temperature range
θs(I, T): optical deflection angle for drive current I and temperature T
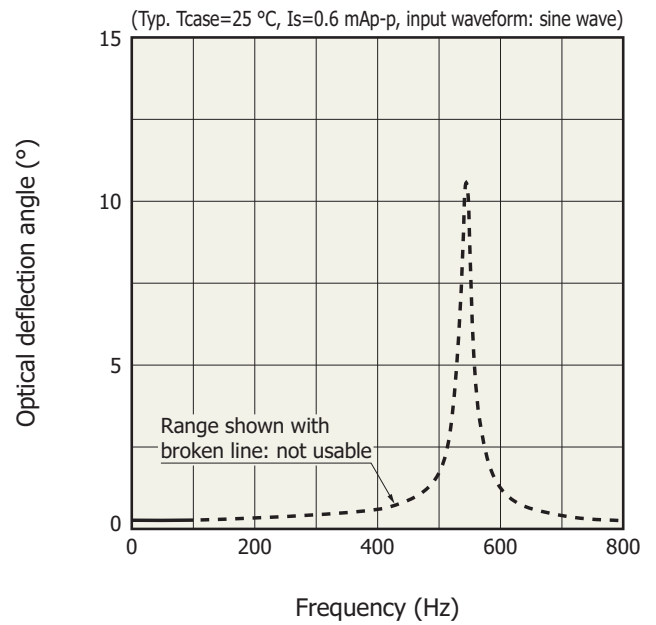
Optical deflection angle

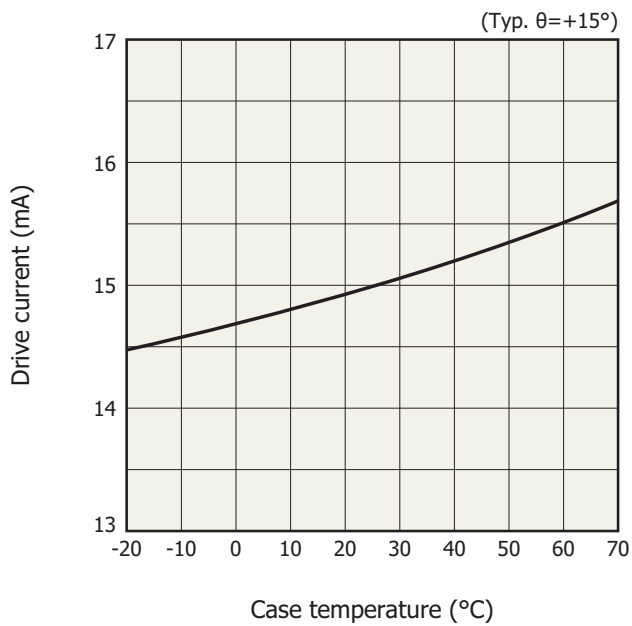KOTHC0070EA

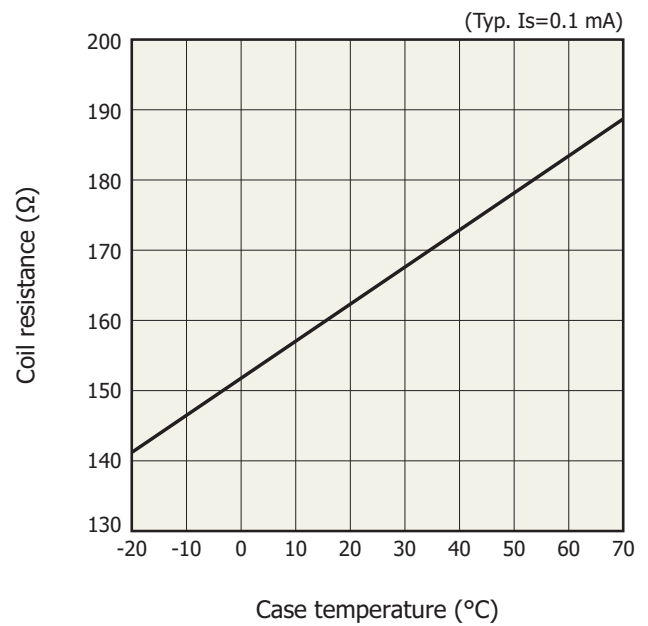## Optical deflection angle vs. drive current

Drive current (mA)

KOTHB0004EC

Frequency response

Frequency (Hz)

KOTHB0016EC

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Drive current vs. case temperature

(Typ. θ=+15°)

Drive current (mA) vs. Case temperature (°C)

KOTHB0017EB

Coil resistance vs. case temperature

(Typ. Is=0.1 mA)

Coil resistance (Ω) vs. Case temperature (°C)

KOTHB0018EB

Resonant frequency vs. case temperature

(Typ. Is=0.6 mAp-p)

Resonant frequency (Hz) vs. Case temperature (°C)

KOTHB0019EB

Reflectivity vs. wavelength

(Typ. Ta=25 °C)

Reflectivity (%) vs. Wavelength (nm)

KOTHB0020EB

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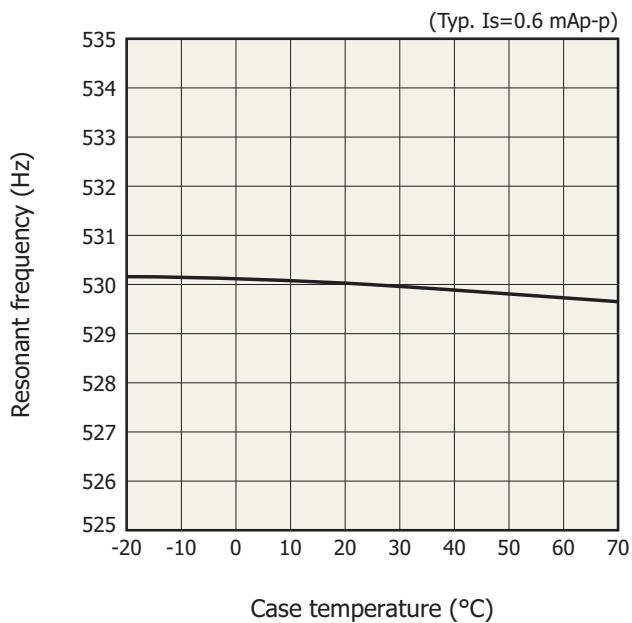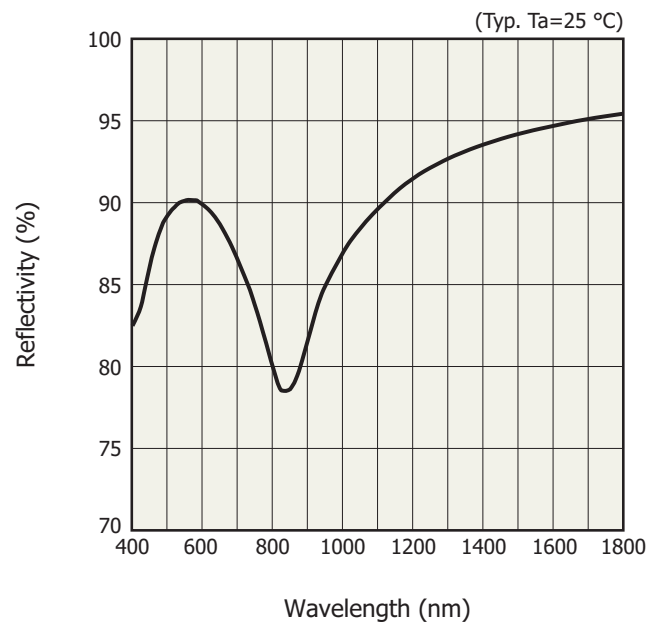
Quality factor vs. case temperature

(Typ. Is=0.6 mAp-p)
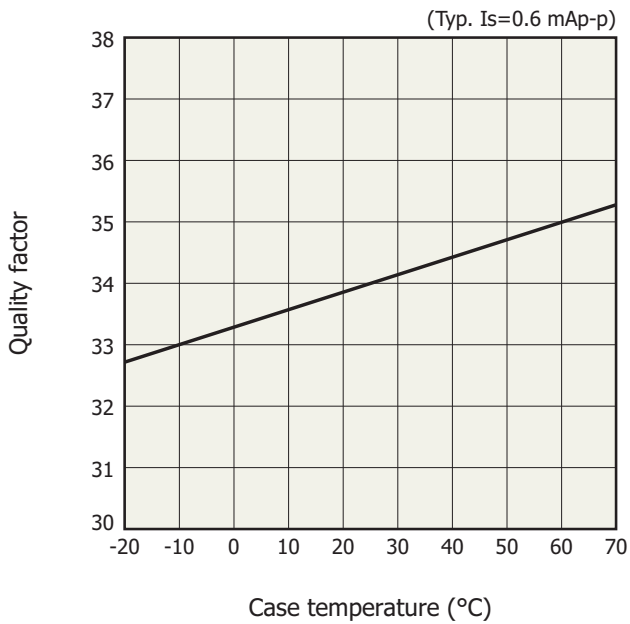
KOTHB0036EA

Temperature characteristics of optical deflection angle

(Typ. AC drive current at Tcase=25 °C, θs=15°)

- -20 °C
- 0 °C
- 25 °C
- 40 °C
- 70 °C
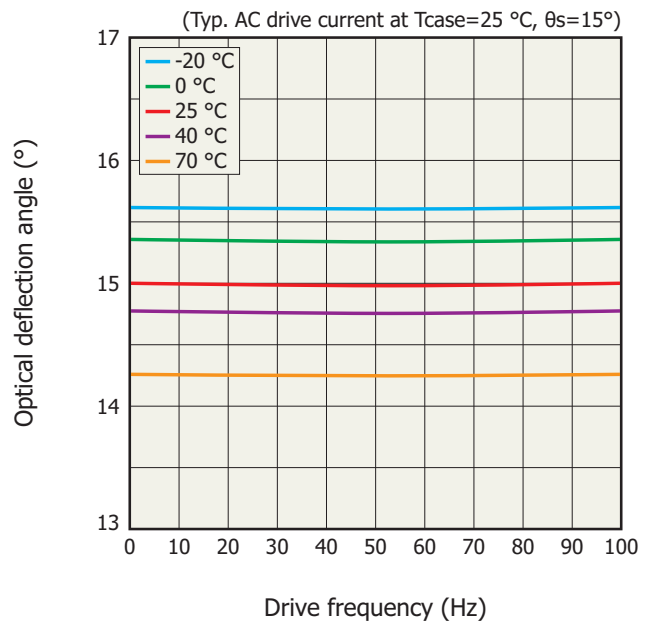
KOTHB0037EB

Dimensional outline (unit: mm)

① NC
② Coil2
③ Coil1
④ NC
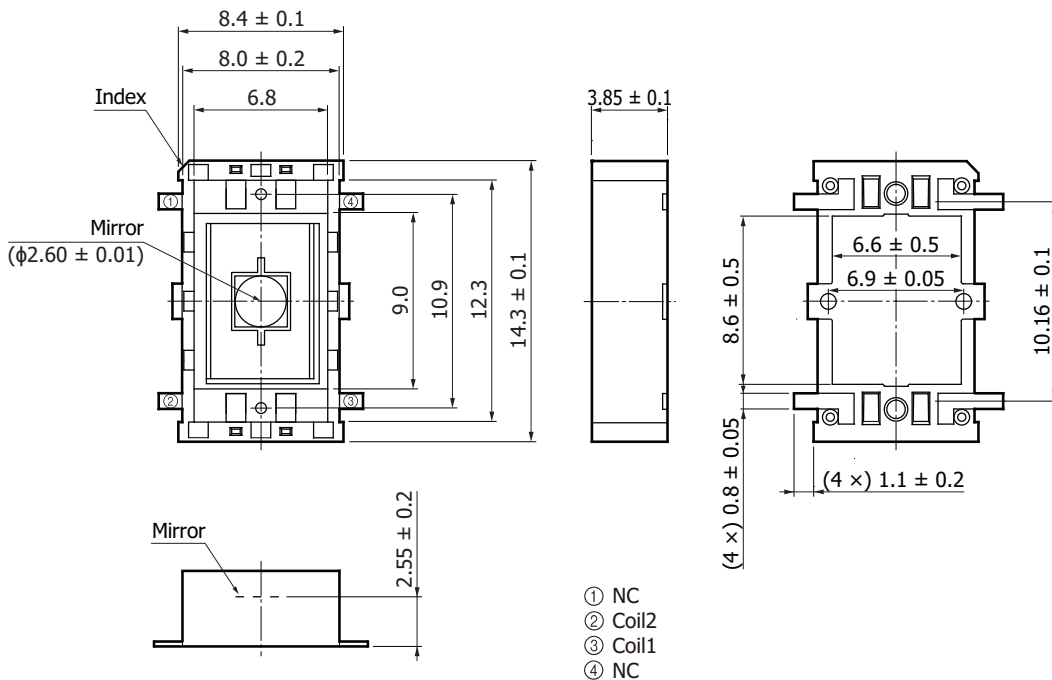
Position accuracy of mirror relative to package center: ±0.15

KOTHA0004EE

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► Mechanical deflection direction of mirror due to drive current

The direction of the mirror's mechanical deflection varies depending on the direction of the drive current flowing through ③Coil1 and ②Coil2.

Applies negative current to ③Coil1

No drive current

Applies positive current to ③Coil1

Mirror

②Coil2   ③Coil1
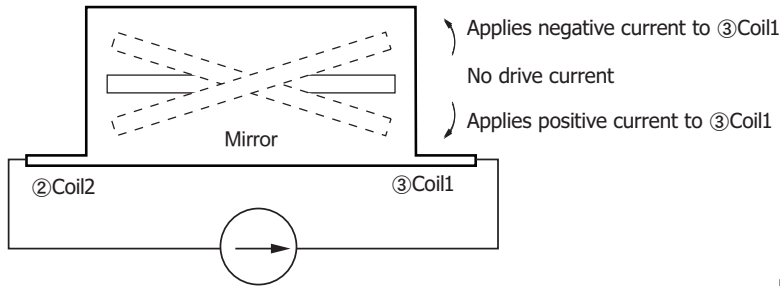
KOTHC0071EC

► Test result (reference)

(1) Operating conditions: Input waveform: sine, optical deflection angle: ±15 degrees, continuous operation
(2) Ambient environment: Temperature: 23 °C, humidity: 45%, clean room cleanliness: class 10000

For (1) and (2), it has been confirmed that characteristics do not change after 12,000,000,000 operations. Note that this data is for reference. It does not guarantee the reliability.

► Precautions

■ Handling

· MEMS mirrors (hereafter called "the product") are unsealed products. Use the product in an environment where dust and blemish do not adhere to it. The inside of the product is prone to damage. As such, do not apply air blower or wipe the product even if dust or blemish adheres to it.

· A powerful magnet is inside the product. Do not bring metallic items (screws, screwdrivers, etc.) near the product. Doing so may damage the mirror area.

· Do not use the product in a strong magnetic field environment. The operating characteristics of the product may degrade due to the magnetic field.

· When carrying several products together, prevent each product from making contact with each other due to the attraction force of magnets, such as by fixing the products in place with space between them inside the container.

· Bringing the product near a person with electronic medical equipment (e.g., pacemaker) is dangerous. Never do so.

· Do not bring the product near magnetic tapes, prepaid cards, and the like. They may become unusable, or the magnetic recording may be corrupted.

· Bringing the product near electronic control equipment may affect instrument boards or control boards and may lead to failures or accidents. If you want to use the product with electronic control equipment, check that the equipment does not fail or cause accidents due to the magnet inside the product.

· The product may fail due to the damage that it receives when it is mounted. Be sure to inspect the product after mounting, and check that the product is working properly.

■ Soldering

· Do not use reflow soldering on this product. Exceeding the absolute maximum temperature rating will cause the product's characteristics to change.

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▪ Related information

www.hamamatsu.com/sp/ssd/doc_en.html

■ Precautions
· Disclaimer

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