

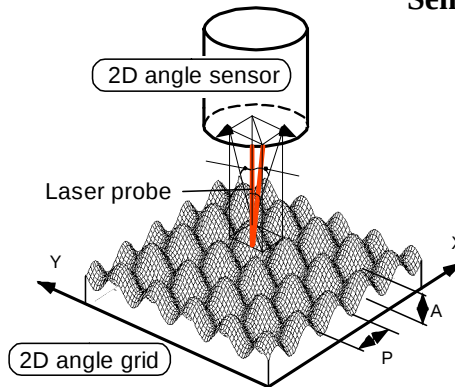
A surface encoder for 5DOF position measurement

JPPN 2005-315649

Principle of XY-measurement

Characteristics

- Two elements; angle grid and sensor unit
- MDOF measurement
- Non-contact measurement

Sensor output m_x, m_y

$$m_x(x, y) = \frac{\partial H(x, y)}{\partial x} = \frac{2\pi A}{P} \cos\left(\frac{2\pi}{P} x\right)$$

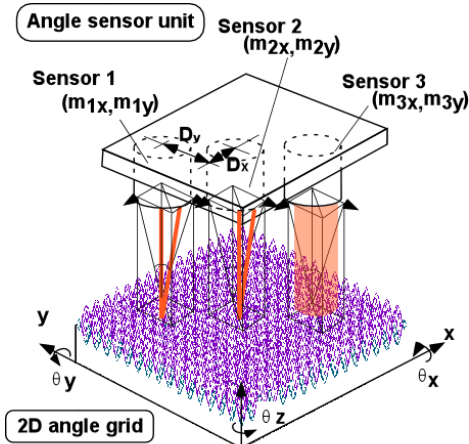
$$m_y(x, y) = \frac{\partial H(x, y)}{\partial y} = \frac{2\pi A}{P} \cos\left(\frac{2\pi}{P} y\right)$$

XY measurement

Profile of angle grid $H(x, y)$

$$H(x, y) = A \sin\left(\frac{2\pi}{P} x\right) + A \sin\left(\frac{2\pi}{P} y\right)$$

5DOF measurement by two sensors

XY $\theta_x\theta_y\theta_z$ measurement

XY

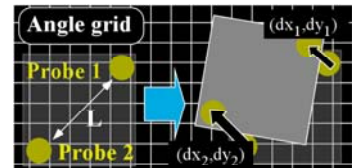
$$x = \frac{P}{\pi} \tan^{-1} \frac{m_{2x}}{m_{1x}} + n_x P$$

$$y = \frac{P}{\pi} \tan^{-1} \frac{m_{2y}}{m_{1y}} + n_y P$$

 θ_x, θ_y

$$\theta_x = m_{3x}$$

$$\theta_y = m_{3y}$$

 θ_z 

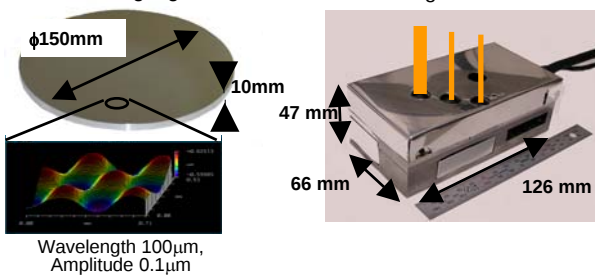
$$dx_{1x} = \frac{P}{2\pi} \cos^{-1}\left(\frac{P}{2\pi} m_{1x}\right) \quad dx_{2x} = \frac{P}{2\pi} \cos^{-1}\left(\frac{P}{2\pi} m_{2x}\right)$$

$$dy_{1y} = \frac{P}{2\pi} \cos^{-1}\left(\frac{P}{2\pi} m_{1y}\right) \quad dy_{2y} = \frac{P}{2\pi} \cos^{-1}\left(\frac{P}{2\pi} m_{2y}\right)$$

$$\theta_z = \frac{\sqrt{dx_1^2 + dy_1^2} - \sqrt{dx_2^2 + dy_2^2}}{L} \quad (L = \sqrt{D_x^2 + D_y^2})$$

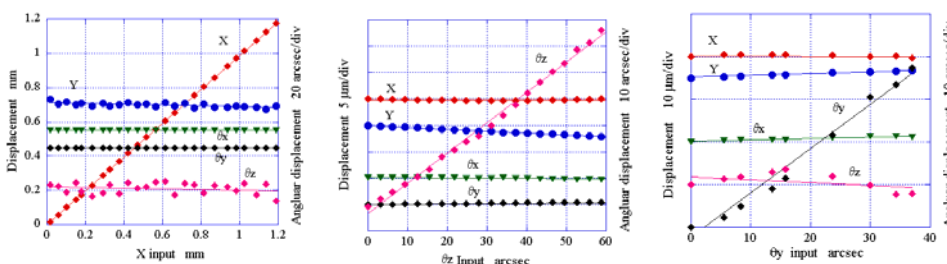
2D angle grid

2D angle sensor unit

Wavelength 100μm,
Amplitude 0.1μm

Results

MDOF measurement results



Specifications

DOF	5	(XY $\theta_x\theta_y\theta_z$)
Range	XY	100 mm
	$\theta_x\theta_y$	16 arcsec
	θ_z	120 arcsec
Resolution	XY	30 nm
	$\theta_x\theta_y$	0.01 arcsec
	θ_z	0.3 arcsec
Speed		550 mm/s