

System Evaluation

SE-1

We are using a lateral shear interferometer to measure the MTF of an $f/4$ optical system for a spatial frequency of 100 l/mm and a wavelength of 500 nm. It can be shown that

$$\frac{\text{MTF}[\nu]_{\text{actual}}}{\text{MTF}[\nu]_{\text{max theoretical}}} = f[\phi_{\text{rms}}]$$

where $f[\phi_{\text{rms}}]$ is a function involving the rms of the wavefront difference function for a shear corresponding to a spatial frequency of 100 l/mm. What is $f[\phi_{\text{rms}}]$?

SE-2

- a) An $f/10$ optical system is defocused $\lambda/2$. Using only geometrical optics, calculate the MTF at spatial frequencies of 10, 30, and 50 lines/mm. Assume the wavelength is $0.5 \mu\text{m}$.
- b) A target having an intensity distribution of the form

$$b \left(1 + \frac{15}{23} \sum_{n=0}^2 \frac{1}{2n+1} \cos[2\pi(2n+1)\nu_o x] \right)$$

where $\nu_o = 10$ lines/mm is imaged by an optical system which over the spatial frequency region of interest has an OTF which can be approximated by the equation

$$H[\nu] = \left(1 - \left(\frac{\nu}{\nu_{oo}} \right)^2 \right) \exp \left[i 2\pi 5 \left(\frac{\nu}{\nu_{oo}} \right)^2 \text{Sign}[\nu] \right]$$

where $\nu_{oo} = 100$ lines/mm. Give an analytical expression for the resulting image and give the physical distance each frequency component is shifted.

- c) What wavefront error is present in an optical system which has an OTF given by

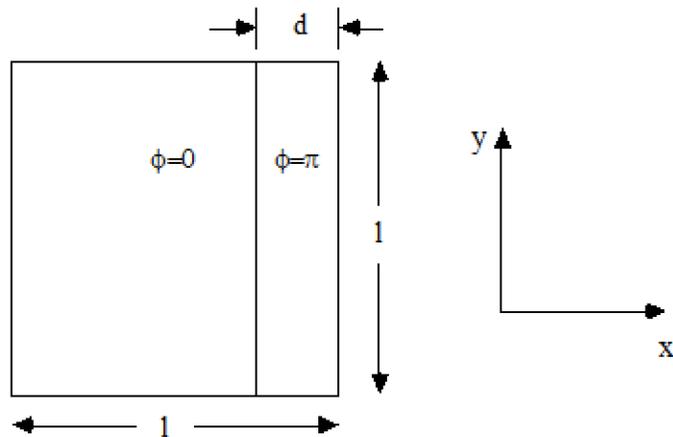
$$H[\nu] = [\text{Diffraction limited MTF}] e^{i 2\pi(\nu/\nu_{oo})}$$

where ν_{oo} is a constant?

SE-3

An optical system with the square aperture shown below is used to image an incoherently illuminated object. The pupil function has a 180° phase step as shown in the figure.

- a) If $l = 0.5$ meter, $d = 0.1$ meter, and the wavelength is 500 nm, what is the cutoff frequency in units of lines/radian in the x and y directions?
- b) Give equations for the MTF as a function of spatial frequency in the x and y directions.
- c) Sketch the MTF in the x and y directions.



SE-4

A lateral shear interferometer is used to measure the MTF of a lens having a 100 mm focal length operating at a wavelength of 500 nm. The lens is used to image a target located at infinity. How much shear should be introduced to measure the MTF for a frequency of 50 lines/mm if

- the lens has a 20 mm diameter?
- the lens has a 30 mm diameter?

SE-5

A 20 mm diameter lens having a 200 mm focal length operating at a wavelength of 500 nm is used to image a target.

- What is the cutoff frequency of the modulation transfer function in image space for incoherent illumination if
 - the target is at infinity?
 - the target is 400 mm from the lens?
- A lateral shear interferometer is used to measure the MTF of the lens for a target at infinity. How much shear should be introduced to measure the MTF for a frequency of 50 lines/mm?