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What Is the Modulation Transfer Function?

The modulation transfer function, or MTF, is a parameter used to evaluate the performance of a lens. MTF provides a quantitative and standardized way to characterize optical systems, so the metric is used by optical designers and microscopists alike to compare lenses and determine the best one for an imaging system.

Optical MTF data is used for a range of instruments, including DNA sequencers, cell analyzers, disk scanners, and industrial inspection equipment. To help assist the optical design process, this white paper will explore MTF in detail and explain the different ways it can be used.

Understanding MTF Measurement

Both resolution and contrast are essential for an image to appear sharp. In simple terms, resolution is the ability to transfer details, while contrast is the ability to distinguish between light and dark areas. Even if resolution is high, a low contrast will inhibit your ability to clearly see sample details. High-quality optics transfer more contrast at higher frequencies (i.e., at a higher resolution), so it is important to measure this ability in optics when designing an imaging system. This can be done through MTF.

MTF measures a lens' ability to transfer the contrast of a sample to an image using spatial frequency (resolution). Spatial frequency indicates the number of line pairs (i.e., one black and one white line) per millimeter (lp/mm). Generally, various charts with equally spaced, alternating black and white lines (Figure 1) are used to measure the MTF of a lens. The contrast is then plotted on an MTF chart against the spatial frequency, as shown in Figure 2 below.



Figure 1. Examples of different spatial frequencies.

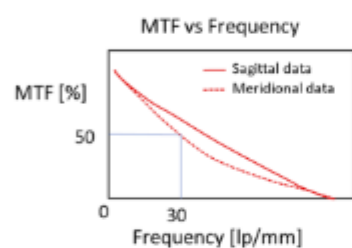


Figure 2. Olympus MTF chart showing contrast (MTF) vs. spatial frequency. The chart shows 50% contrast at a spatial frequency of 30 lp/mm.

What Is the Modulation Transfer Function?

This whitepaper describes Modulation Transfer Function (MTF) in depth. It covers MTF measurements compared with the ideal diffraction limit, how MTF can be used to compare objective lens performance and considerations for its application in optical design for scientific instruments.

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