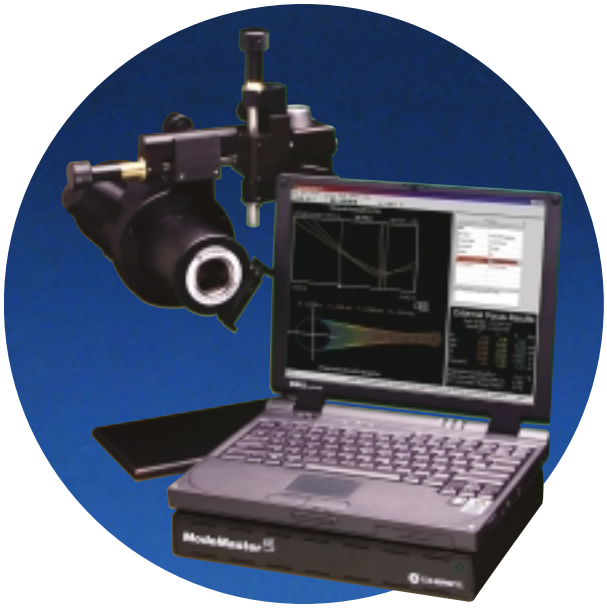
ModeMaster PC

M^2 Beam Propagation Analyzer

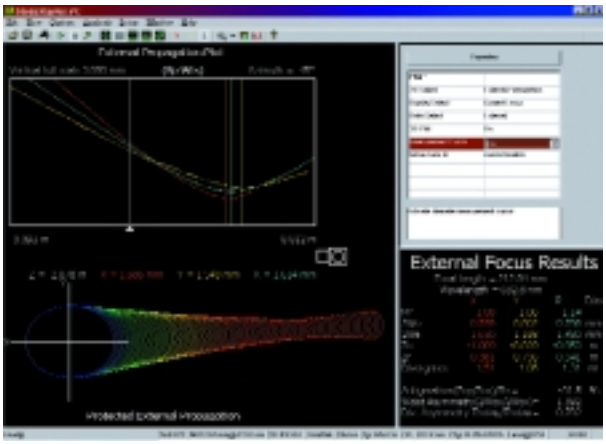
- *Measurement and display of CW laser divergence, M^2 (or k) and astigmatism*
- *Beam sizes 0.2 mm to 25 mm*
- *Wavelengths from 220 nm to 15 µm*
- *Determination of waist location and diameters (including $D4\sigma$ diameter) and Rayleigh Range*
- *Angular and translational beam-pointing stability*



Coherent pioneered M^2 beam propagation analysis with the ModeMaster system a decade ago. Now, Coherent introduces the ModeMaster™ PC, the newest version of the ModeMaster line of M^2 Laser Beam Propagation Analyzers. The ModeMaster PC combines all the ISO-compliant accuracy and powerful features for measuring M^2 and other beam propagation analysis functions for CW lasers. It also provides the added flexibility and value of using a personal computer to provide optimum user control, data processing, storage and results display.

The ModeMaster PC includes a Universal Serial Bus (USB) Control/Interface Console and Windows software for operation with the latest MS Windows-based PC computers supporting a USB interface (for MS Windows® 98, ME, 2000 or XP). The ModeMaster PC is also compatible with all existing ModeMaster systems, allowing current users to easily upgrade their system for use on a supported PC computer.

Beam Propagation Display



Easy Beam Alignment

The ModeMaster PC precision 5-axis head mount and beam position display provides easy angular alignment and translational centering of the lens and scan axis to the beam propagation path.

Second Moment Diameters

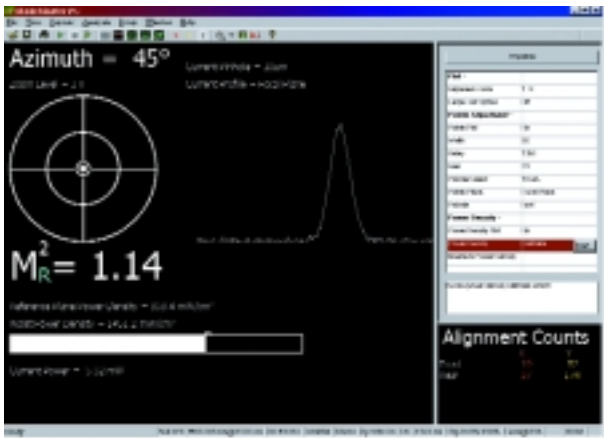
Beam diameter is a critical parameter in beam propagation measurements. Second moment diameters ($D4\sigma$) give the best theoretical answers for beam propagation calculations. The ModeMaster PC measures second moment diameters directly. The ModeMaster PC software also includes conversion algorithms from its knife-edge measurements to second moment diameter measurements that are valid for stable resonator modes with M^2 of 1 to 4 (covering most commercially available lasers). Also included are conversions to D86 and slit diameters to allow comparison to other measurements.

Real-Time Power Density Adjustment

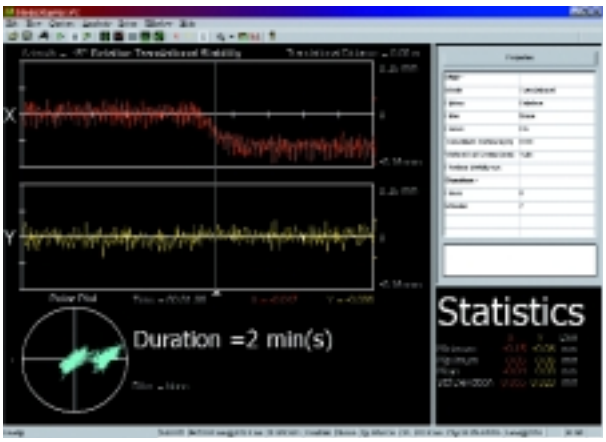
In most laser applications, it's not laser power that does the work, it's power density. Using the ModeMaster PC, the point of maximum power density can be quickly located. The ModeMaster PC's convenient power density tuning screen displays power density as a pseudo analog "tune bar," giving real-time feedback as the laser mirrors are adjusted.

ModeMaster PC

Real-Time Display



Pointing Stability Display



Real-Time M^2 and Beam Profiles
The ModeMaster PC provides real-time measurement and display for fine tuning of M^2 and many other beam propagation parameters, along with the near-field or far-field pinhole intensity beam profiles.

Beam Pointing and Translational Stability
ModeMaster is able to measure and display both translational (parallel to the beam axis) or angular (from a pivot point) beam movement over a period of 2 minutes to 24 hours. The angular pivot point of the beam axis (often a single optical surface) can be located along the beam path. Statistical analysis of the beam axis location and angle are displayed for both the X and Y axes. Three levels of filtering reduce noise and increase the sensitivity of pointing stability measurements.

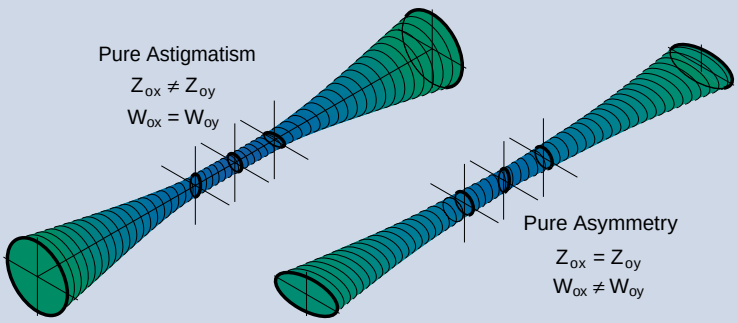
Expanded On-line Help
The ModeMaster PC provides complete on-line help. Help messages are also displayed when beam parameter limits are exceeded and messages suggest corrective measures.

Upgrading to the ModeMaster PC
All previous versions of the ModeMaster systems can be upgraded to the ModeMaster PC by replacing the original console unit and the LabMaster display with the ModeMaster PC Control/Interface Module and Software installed in a user-supplied compatible PC computer (see requirements below). All original ModeMaster Scan Heads are fully compatible and can be plugged into the ModeMaster PC Control/Interface Module, which can be ordered separately and includes the software.

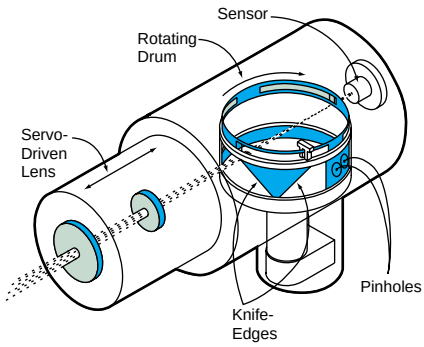
RS-232 Interface
The ModeMaster PC can provide measured beam data, analysis results and focus scan control through the RS-232 interface for remote data logging, results monitoring and measurement control.

Minimum Computer Requirements
- *MS Windows 98, ME, 2000 or XP*
- *USB port available*
- *Laptop or desktop PC with 586 (Pentium II) 233 MHz processor or better*
- *64-Mb of RAM*
- *30-Mb of free hard disk space*
- *SVGA graphics card and display (800 x 600 recommended)*
- *Serial communication port (for remote operation)*

Beam Astigmatism and Asymmetry
Changes in shape of a propagating beam can be astigmatic, asymmetric or both. The beam shown at the near right has pure astigmatism; the waists (Wo) in the horizontal and vertical directions are the same size, but occur at different propagation distances (Zo). In asymmetric beams (far right), the two waists occur together, but are of different diameters. The ModeMaster PC provides complete analysis of these beam characteristics.



Complete Geometric Beam Characterization Along the Laser Beam Path



Beam propagation is concerned with the energy distribution in a beam and the change of that distribution along the beam path. The ModeMaster Beam Propagation Analyzer established an entirely new laser beam quality parameter, M^2, which has now become an ISO measurement standard. M^2 describes how close to "perfect-Gaussian" a laser beam is, and it can be used to predict the beam size, beam shape and the smallest spot that can be created from the beam further down range.

How Does It Work?

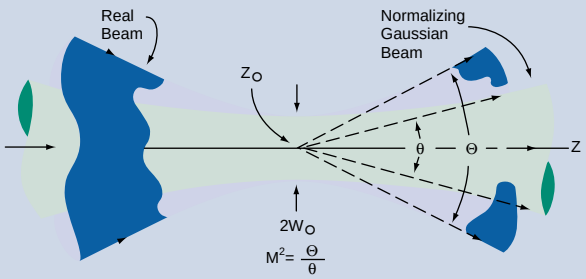
The ModeMaster PC head is a dual knife-edge beam profiler integrated with a diffraction-limited precision scanning lens, which is translated along the beam propagation axis. The lens focuses the beam to create an internal beam waist and the two orthogonal knife edges (X and Y), mounted on a rotating drum, measure the beam diameter and beam axis location at 256 planes along the beam waist as the lens is translated. The powerful ModeMaster PC software then derives the M^2 factor, the size and location of the beam waist, the far-field divergence angle, the pointing direction, astigmatism, asymmetry and the Rayleigh Range. Measurements also include ISO D4σ, second moment, knife-edge, slit and D86 beam diameters. This entire process occurs in less than 30 seconds.

The ModeMaster PC also provides special weighting functions to help eliminate effects on measurement accuracy due to intermittent beam noise, vignetting or other transients during the focus scan. Additionally, real-time displays allow laser peaking or adjustment for minimum M^2, divergence, maximum power density, far-field pinhole profiles and pointing angle.

- Beam Quality – M^2
- Beam Diameter
- Waist Diameter & Location
- Divergence Angle
- Rayleigh Range
- Pointing Stability
- Power Density
- Beam Profiles
- Second Moment Diameters
- Astigmatism
- Waist Asymmetry
- Divergence Asymmetry

Laser Beam Quality

The closer a real laser beam is to diffraction-limited, the more tightly it can be focused, the greater the depth of field, and the smaller the diameter of beam-handling optics needed to transmit the beam. M^2 is the ratio of the divergence of the real beam to that of a theoretical diffraction-limited beam of the same waist size in the TEM_{00} mode. Thus, the angular size of the beam in the far field will be M^2 larger than calculated for a perfect Gaussian beam.



$\Theta = M^2 \times 2\lambda / (\pi W_o)$, for a beam waist diameter $2W_o$.

Power/Energy Selection Guide
Power/Energy Meters
Power Sensors
Energy Sensors
Custom & OEM
Calibration & Service
Power/Energy Accessories
Beam Diagnostics
Spectral Analysis
Index

Selecting a ModeMaster PC System Configuration

The ModeMaster PC systems are available in eight standard configurations (including scanning head, 5-axis mount, USB Control/Interface Console, cables, PC software and manual). These configurations provide measurements in four wavelength ranges, with two divergence ranges (high divergence and low divergence) within each wavelength range. Use the following steps, along with the Selection Nomogram Chart and Configuration Table (below), to select a ModeMaster PC configuration.

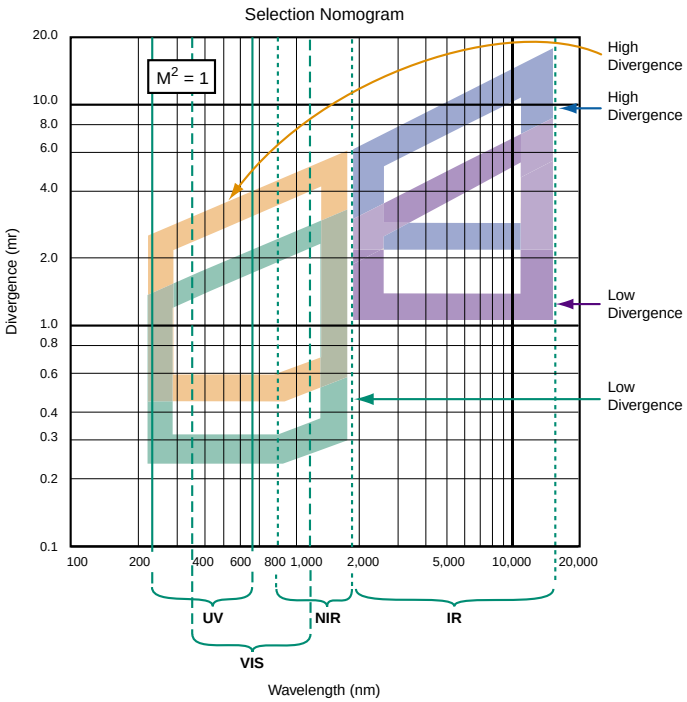
1. Choose between the four spectral ranges: UV (220 - 680 nm), VIS (340 - 1,000 nm), NIR (800 - 1,800 nm) and IR (1,800 - 15,000 nm).

2. Determine the approximate divergence of your laser beam and use the Selection Nomogram (Divergence vs. Wavelength) Chart to select the low divergence or high divergence configuration.

3. Confirm your beam size is <25 mm diameter for the low divergence configuration or <12 mm for the high divergence configuration.

4. Use the table below to determine the selected ModeMaster PC configuration part number and verify all other beam specifications.

5. If more than one ModeMaster PC configuration is indicated to cover all needed beam parameter ranges, optional Scanning Head Modular Components can be ordered to change the configuration of the ModeMaster PC system to cover other ranges (see back page for details).



STANDARD CONFIGURATIONS		UV Low Divergence	UV High Divergence	VIS Low Divergence	VIS High Divergence	NIR Low Divergence	NIR High Divergence	IR High Divergence	IR Low Divergence
Part Number		33-1843-000	33-2106-000	33-2221-000	33-2239-000	33-2387-000	33-2395-000	33-2429-000	33-2437-000
Model	**MM**	-1	-1 S	-2	-2S	-3	-3S	-4	-5
Spectral Range		0.22-0.68 µm		0.34-1.00 µm		0.80-1.80 µm		1.80-15 µm	
Detector Type		Silicon				Germanium		Pyroelectric	
INPUT BEAM REQUIREMENTS AT TEST WAVELENGTH									
Test Wavelength[a]		351 nm		514 nm		1.06 µm		10.6 µm	
Minimum Power[b]		7.5 mW[c]		2.5 mW[c]		2.5 mW		400 mW	
Maximum Power[b]		10W[c]		25W[c]		2.5W		20W	
Noise		<2% RMS and <5% peak-to-peak							
Min. Divergence (mrad)		0.24	0.46	0.24	0.46	0.25[e]	0.47[e]	2.7	1.3
Max. Divergence (mrad)[d]		1.7	3.2	2.0	3.6	2.7	5.0	14	7.2
Max. Beam Dia. (mm)[f]		25	12	25	12	25	12	12	25

[a] Wavelength-dependent quantities are input power levels, and minimum and maximum divergence (see notes b, e, f).

[b] Power levels are proportional to the inverse of the spectral response of the detector. The silicon detector peaks at 900 nm and is at half-peak sensitivity at 510 nm and 1050 nm. The germanium detector peaks at 1500 nm and is at half-peak sensitivity at 1100 nm and 1650 nm. The pyroelectric detector has a flat spectral response.

[c] These limits can be reduced by a factor of 10 (higher sensitivity) by user-removal of the light-restricting aperture in front of detector.

[d] The maximum divergence limit is fixed by the inability to accurately locate the internal waist when the internal beam diameter growth (over the span of the drum) is too slight. Limits shown are for $M^2 = 1$ and test wavelength; limits scale as the square root of M^2 (test wavelength).

[e] Minimum divergence in this wavelength range scales as the square root of M^2 (test wavelength).

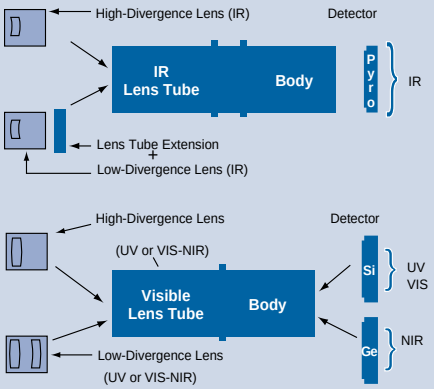
[f] Diameters are approximate; divergence takes precedence in choosing options. Refer to nomogram.

ModeMaster PC

Components for Other Wavelength and Divergence Ranges

The body design of the ModeMaster PC scanning head has modular lens and detector sets that allow quick changes to other wavelength or divergence ranges to suit your measurement needs.

The IR body can only be used with the IR (Pyroelectric - Pyro) detector and either the low- or high-divergence IR heads. But, the UV-VIS-NIR body can be used in any of the UV, VIS or NIR spectral regions, with the appropriate detector (Silicon - Si for the UV and VIS; Germanium - Ge for the NIR) and low- or high-divergence lenses. The UV lens can be used with the Silicon detector and the VIS-NIR lens can be used with either the Silicon or Germanium Detectors.

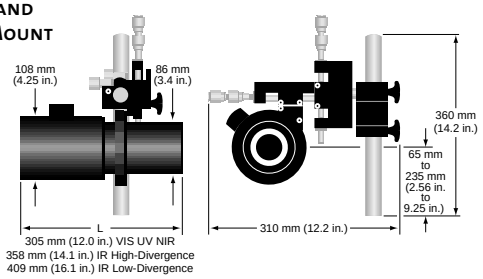


Part Number	Spectral Region(s)	Description
33-2072-000	UV, VIS	Silicon Detector (0.22-1.0 µm)
33-2080-000	NIR	Germanium Detector (0.8-1.8 µm)
33-2098-000	IR	Pyroelectric Detector (1.8-20 µm)
33-2114-000	UV	High-Divergence Lens Kit (UV-VIS-NIR Body Only)
33-2130-000	UV	Low-Divergence Lens Kit (UV-VIS-NIR Body Only)
33-2122-000	VIS, NIR	High-Divergence Lens Kit (UV-VIS-NIR Body Only)
33-2148-000	VIS, NIR	Low-Divergence Lens Kit (UV-VIS-NIR Body Only)
33-2155-000	IR	High-Divergence Lens Kit (IR Body Only)
33-2166-000	IR	Low-Divergence Lens Kit (IR Body Only)

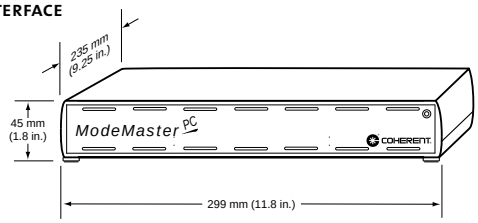
SPECIFICATIONS

Accuracies	
Waist Diameter	±2%
Waist Location	±8% of input beam Rayleigh Range
Beam Quality - M^2	±5%
Divergence	±5%
Beam Translation	±[5% of waist diameter +0.1 mm]
Pointing Angle	±[5% of divergence +0.04 mrad]
Azimuth Angle Readout	±2°(10-200°)
Knife-Edge Clip Levels	User-adjustable 0% to 100% in 1.5% steps
ModeMaster PC Control/ Interface Module Update Rate	<8 Hz (M^2, divergence, power density, waist diameter, profiles)
Analog Outputs	Detector signal output, 0-13V maximum. A/D control signal out, 0-5V pulse. Trigger (syncs to drum rotation), 0-5V pulse.
Digital Outputs	RS-232 interface. Front and back knife-edge widths and pinhole profiles available in digitized form via RS-232.
Power	100-240 VAC, 47 to 63 Hz, 40W maximum

Scan Head and Precision Mount



Control/Interface Console



ModeMaster PC M^2 Beam Propagation Analyzer (Standard System Configuration)

Part Number	Description
33-1843-000	ModeMaster PC Scan Head, Mount, Control/Interface Console and Software for UV, Low-Divergence Beams
33-2106-000	ModeMaster PC Scan Head, Mount, Control/Interface Console and Software for UV, High-Divergence Beams
33-2221-000	ModeMaster PC Scan Head, Mount, Control/Interface Console and Software for VIS, Low-Divergence Beams
33-2239-000	ModeMaster PC Scan Head, Mount, Control/Interface Console and Software for VIS, High-Divergence Beams
33-2387-000	ModeMaster PC Scan Head, Mount, Control/Interface Console and Software for NIR, Low-Divergence Beams
33-2395-000	ModeMaster PC Scan Head, Mount, Control/Interface Console and Software for NIR, High-Divergence Beams
33-2429-000	ModeMaster PC Scan Head, Mount, Control/Interface Console and Software for IR, High-Divergence Beams
33-2437-000	ModeMaster PC Scan Head, Mount, Control/Interface Console and Software for IR, Low-Divergence Beams
33-1710-000	ModeMaster PC Control/Interface Console and Software