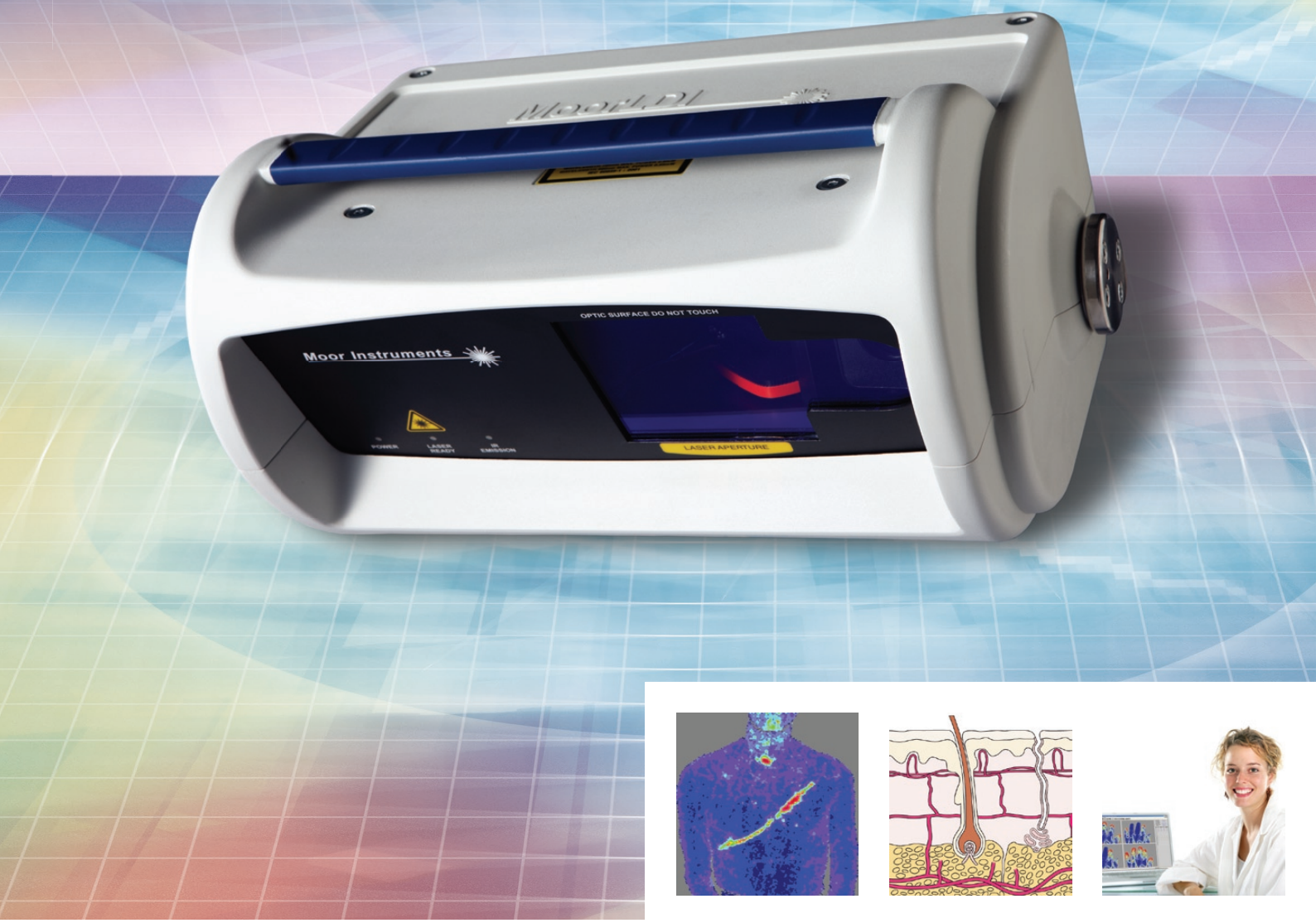
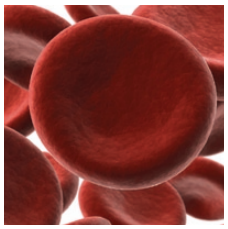
Large area, high resolution blood flow imaging

with moorLDI2™





moor instruments
laser Doppler blood flow assessment

moorLDI2™ - Laser Doppler Imaging Systems

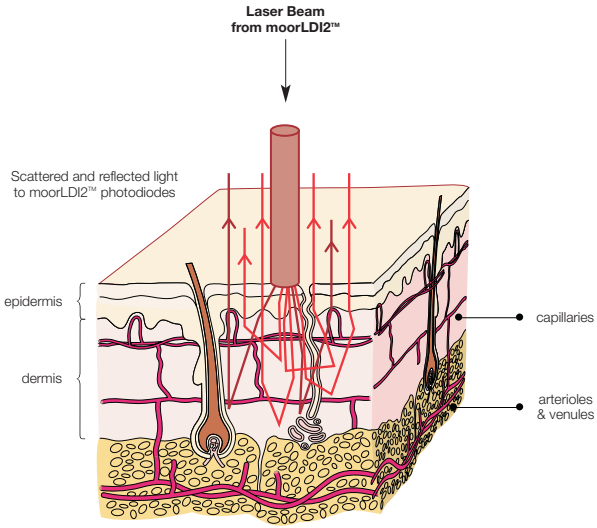
The moorLDI2™ laser Doppler imaging systems offer a proven, high specification solution to your blood flow mapping application for clinical or research use. In routine use worldwide, all models employ a unique, patented, optical design and high quality signal processing to offer rapid, high quality imaging.

- **Non Contact;** images are obtained by scanning a low power laser beam across a tissue surface, with up to 1 metre between surface and scanner.
- **Daylight Operation;** unique optical design enables operation even in high ambient room lighting.
- **Single Image Mode;** capture single images quickly and effectively. Group single images into one file to ease analysis.
- **Repeat Image Mode;** evolving responses can be imaged and quantified with automatic analysis functions.
- **Line Scanning Mode;** capture and analyse extremely rapid changes not possible with full imaging.
- **In-Built Colour Digital Camera;** eases scan set-up and provides photographs of scan region. Optical zoom maintains image quality for smaller subjects.
- **High Resolution;** up to 256 x 256 individual measurements: resolutions from 0.2mm to 2.0mm per pixel (0.1mm for moorLDI2-HR™).
- **Flexible Scan Sizes;** up to 50cm x 50cm.
- **Choice Of Laser Wavelengths;** to assess different vascular beds, dual wavelength option offers simultaneous deep and shallow assessments.
- **User Friendly Vista Compatible Software;** now 5th generation, developed in conjunction with clinicians and researchers by Moor software engineers. Eases scan setup and allows for convenient statistical analysis.

The Laser Doppler Technique

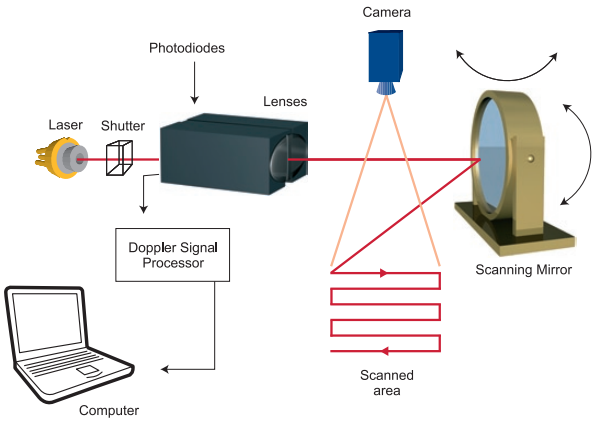
The moorLDI2™ laser Doppler imager scans a low power laser beam in a raster pattern over skin or other tissue surfaces (Ref 1).

Moving blood in the microvasculature causes a Doppler frequency shift of the scattered laser light, which is photodetected and then processed to build a colour coded map of blood flow.



A digital camera records a colour clinical photograph at the same time, corresponding closely with the blood flow image in size and aspect.

The measurement is non-contact and can quantify differences in flow over an area of tissue or, using the repeat scan mode to repetitively assess evolving flow patterns over time.



moorLDI2™ Variants - Your Choice!

Customer requirements have led us to develop variants of the standard moorLDI2™ for specific applications. The variants include;

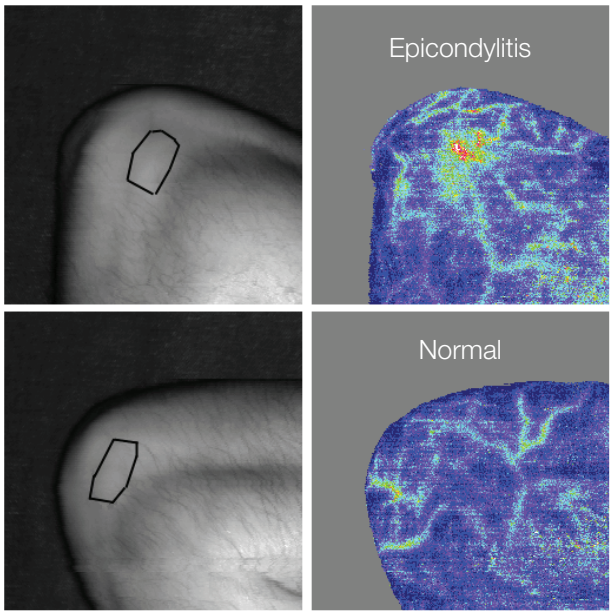
Near Infra-Red System

The moorLDI2-IR™ is the most popular, flexible, all round performer for a wide range of physiological studies and clinical research applications. Of all the moorLDI2™ variants it offers an excellent selection of scan area, spatial resolution and scan speed. The system uses a near Infra-Red laser beam (with a coaxial Visible Red aiming beam) to map tissue blood flow over areas up to 50cm x 50cm with 256 x 256 individual measurements; over 64,000 measurements are made in approximately 5 minutes. Spatial resolution of 0.2mm can be achieved.

Dual Wavelength System

The moorLDI2-2λ™ is used to compare flow from different vascular beds simultaneously. The moorLDI2-2λ™ uses a short wavelength 633nm Visible Red laser combined with a long wavelength near Infra-Red 830nm laser.

Optical filtering and two sets of photo detectors are used to ensure that the signals from both lasers can be separated and displayed as two time-matched images.

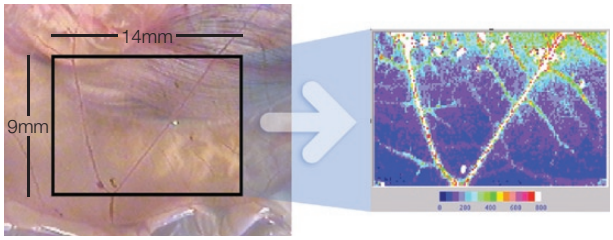


Images reproduced with kind permission of Dr W R Ferrell, Centre for Rheumatic Diseases, Royal Infirmary, Glasgow

High Resolution System

The moorLDI2-HR™ offers the highest spatial resolution available of the moorLDI2™ variants. A laser beam focused to a small spot size of approximately 0.1mm diameter is used. Coupled with high-resolution encoders, it enables a maximum pixel density of 10,400 pixels per cm^2 compared with the 2,600 pixels per cm^2 of a standard moorLDI2™ imager.

For stability and the short working distances used for high resolution measurements we recommend the DS2 stand for this system. The DS2 stand has a ratchet movement for easy and accurate adjustment of the working distance and a yoke support for two axis rotational adjustment.



The image above shows the formation of new vessels in the surface of a chick egg yolk sac

Visible Red Systems

The moorLDI2-VR™ and the Class 2 moorLDI2-II™ are used for more superficial measurements as the penetration depth is related to the shorter wavelength being used. By using a laser with the shorter wavelength, capillary flow in the superficial skin layer contributes proportionally more to the measured blood flow.

Accessories

A full range of accessories are available, including stands for bench top use (BS1 and DS2) and a mobile stand (MS2) for clinical use. Dedicated software and hardware is available to enable control of iontophoresis and skin heating protocols. Please refer to the iontophoresis controller and skin heater brochures for further information.

Applications and Analysis

Many applications take advantage of the speed, scan area and resolution of moorLDI2™ imaging; for example, in the assessment of tissue expansion and flap viability, quantification of irritant and allergic reactions, ischaemia/ reperfusion studies, wound healing and angiogenesis. The moorLDI2™ is routinely used in the following areas: -

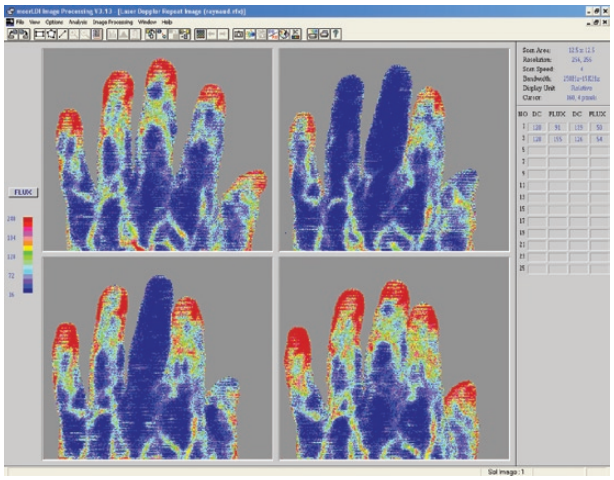
- Angiogenesis
- Inflammation
- Cerebral Ischemia
- Dermatology
- Diabetes
- Oncology
- Patch Testing
- Plastic Surgery
- Rheumatology
- Anastomotic Patency
- Burn Assessment - refer to the moorLDI2-BI™ brochure for this application.

Detailed 'Application Notes' are available on request. Refer to the contact details on back page.

Rheumatology

Many painful conditions involve changes in skin blood flow. For example the vasospastic disorder Raynaud's phenomenon involves blood flow changes that are easily observed by laser Doppler imaging. The spatial distribution of low or absent perfusion is mapped for further analysis. Repeat scan and multi-point functions extend use into dynamic testing.

The images below show baseline measurement and recovery following cold water immersion.

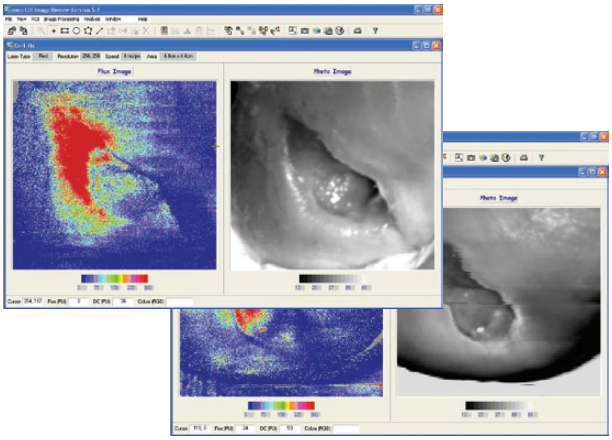


Baseline (top left), post cold water immersion (top right), 7.5 minutes recovery (bottom left) and 15 minutes recovery (bottom right)

Ischaemic Ulcer

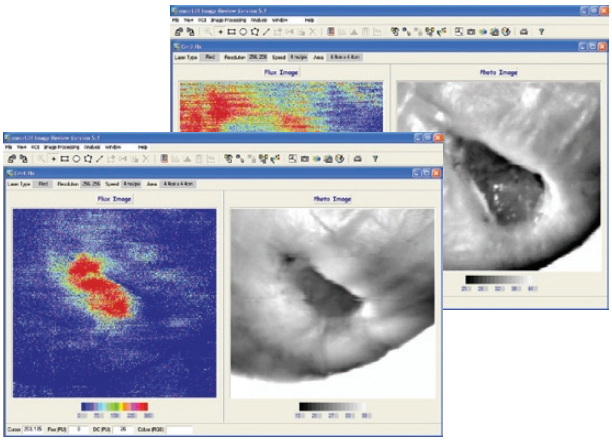
This sequence shows blood flow images relating to a healing ischaemic ulcer on the heel. The ulcer was imaged pre-treatment and 4, 8, 12 weeks post-treatment with Dermagraft™ (Smith & Nephew), human fibroblast derived dermis replacement dressing. The slowest region to heal showed initial low flow which increased during the healing process.

Pre-treatment



4 weeks post-treatment

8 weeks post-treatment

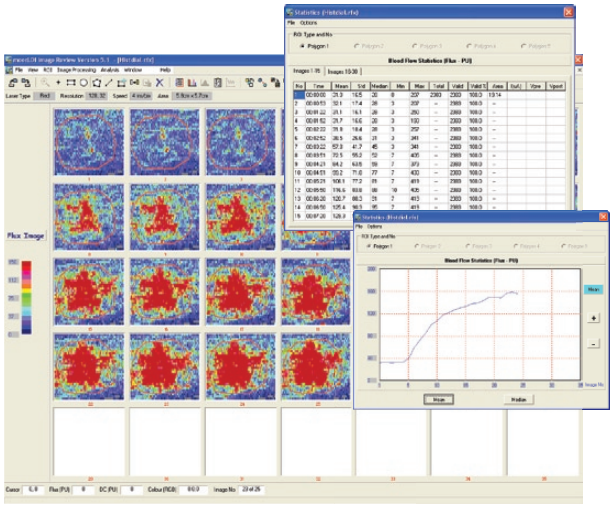


12 weeks post-treatment

Images reproduced with kind permission of Dr Faisel Khan and Dr David Newton, Ninewells Hospital, Dundee

Irritant/ Inflammatory Responses

Repeat scanning allows the quantification of irritant and allergic reactions as well as reperfusion studies. Once a region of interest has been defined, 'single click' analysis provides both tabulated and graphical display of mean flow over the time course. Illustrated is a wheal and flare response to microdialysis of Histamine in the forearm (Ref 2).



Images reproduced with kind permission of Professors Martin Church and Geraldine Clough, Southampton General Hospital

Dermatology/ Psoriasis

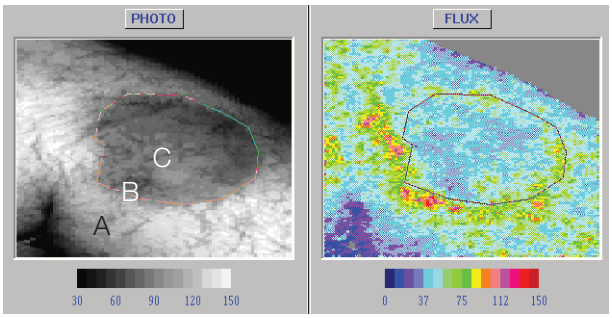
The moorLDI2™ can be used to assess dynamic changes at individual or multiple points by positioning the beam at any site within the scan region. The moorLDI2™ has been used in this way to investigate temporal characteristics of perfusion at three points relative to a coal tar treated psoriatic plaque (Ref 3).

Key:

A = uninvolved tissue

B = region close to visible edge

C = tissue within plaque



Inflammation and Patch Tests

The moorLDI2™ can be used to quantify inflammatory conditions. Analyses include area of involvement, profiling tool, histogram analysis and statistics: mean, min, max, median and standard deviation of LD flow values within a user defined region of interest. Repeat imaging of the area of involvement enables the time course of acute inflammatory responses to be quantified.

Illustrated below is the dose response to the injection of monosodium urate (2.5, 1.25, 0.625, 0.31mg), each in 200 microlitres of sterile saline. The image was taken at 24 hours post injection.

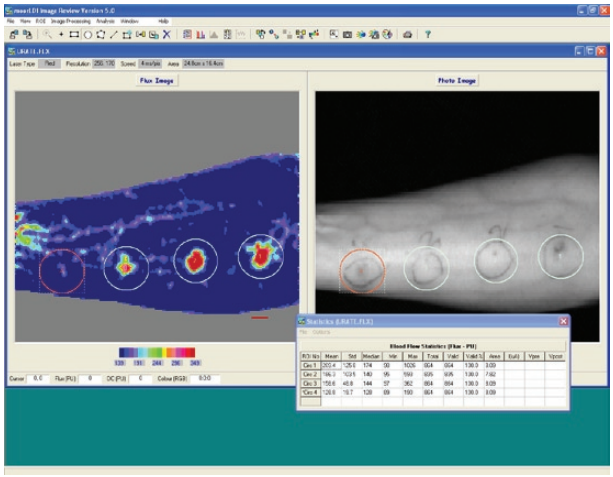


Image reproduced with kind permission of Professor Dorian Haskard, Imperial College, London

References

(1) A laser Doppler scanner for imaging blood flow in skin. T.J.H. Essex and P.O. Byrne. Journal of Biomedical Eng. May 1991, Vol 13, 189-194.

(2) Scanning laser Doppler imaging and dermal microdialysis in the investigation of skin inflammation. M.K. Church and G.F. Clough. Allergy and Clinical Immunology Int. March/April 1997, Vol 9(2), 41-46.

(3) Erythemal and therapeutic response of psoriasis to PUVA using high dose UVA. E.L. Speight and P.M. Farr. British Journal of Dermatology 1994, Vol 131, 667-672.

About Moor Instruments

Moor Instruments, established in 1987, is a world leader in the design and manufacture of laser Doppler systems, used for the monitoring and imaging of blood flow in the microvasculature.

First hand experience of laser Doppler research and development within Moor dates back to 1978 and with this we have the breadth of knowledge to help with your application and the enthusiasm to help with answers to any of your questions.

By giving priority to performance, quality and service we strive to be our customers' number one choice.

Our dedicated design team are involved with a number of development projects for other partners and manufacturers. Whatever your needs, as a researcher, clinician or manufacturer, Moor will work harder for you.

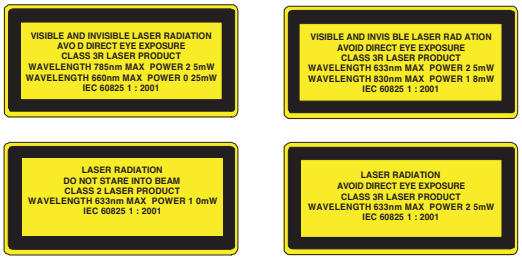
moorLDI2™ with optional panel PC and MS2 mobile stand

Specifications:

Quality Control
Moor Instruments is certified to ISO 13485: 2003. The moorLDI2™ is CE certified.

Laser Source
moorLDI2-IR; 785nm, Max 2.5mW, 1mm beam (target beam 660nm, Max 0.25mW)
moorLDI2-HR; 830nm, Max 2.5mW, 0.1mm beam (target beam 660nm, Max 0.25mW)
moorLDI2-2λ; 633nm, Max 2.5mW, 830nm, Max 1.8mW, 1mm beam
moorLDI2-VR; 633nm, Max 2.5mW, 1mm beam
All above models are Class 3R per IEC 60825-1:2001

moorLDI2-II; 633nm, Max 1.0mW, 1mm beam
Class 2 per IEC 60825-1:2001



Stand Options
There are three stands available for the moorLDI2™, MS2, DS2 and BS1;

MS2 mobile stand, vertical adjustment provided by ratchet winding handle. Positioning provided towards and away from the vertical twin support pillars to enable 'reaching' over a bed. Yoke style scan head holder to allow positioning and rotation to any angle. Stand fully mobilised on wheels. Rear Container with built in control box, power supply and isolation transformer.

DS2 desktop stand, easy vertical adjustment provided by ratchet winding handle. Yoke style scan head holder to allow positioning and rotation in two axis.

BS1 desktop stand, manual vertical adjustment. Angular rotation in one axis.

Software
Dedicated Windows™ based software for measurement, processing and analysis supplied with each system.

CCD Camera
10 x Optical zoom, 4 x digital zoom, 752 x 582 pixel resolution, auto focus.

Bandwidth
Low frequency cut-off (3db) 20Hz, 100Hz or 250Hz.
High frequency cut-off (0.1db) 3kHz, 15kHz or 22kHz.

Spatial Resolution
Up to 256 x 256 pixels.
Standard system: 0.2mm/pixel at 20cm, 2mm/pixel at 100cm.
High resolution system: 0.1mm/pixel at 20cm.

Scan Speed
Scan speed is approximately 4ms/pixel, 10ms/pixel or 50ms/pixel (at maximum resolution). Scan duration is typically 40 seconds for a 12.5cm x 12.5cm image at 64 x 64 pixel resolution.

General
Power source: Universal voltage, 84-264V AC, 50VA, 50 to 60Hz.
Dimensions: *W* x *H* x *D* mm, Weight: *kg*.
Control Box: 305 x 115 x 260, 4.5kg.
Scan Head: 426 x 244 x 300, 8kg.
Operating environment: Clinic or laboratory, excluding domestic.
Operating temperature: 15-30ºC.

Safety Standards
Complies with:
IEC 60601-1:2005, IEC 60601-1-2:2007, IEC 60825-1:2001.
Medical devices directive 93/42/EEC.
FDA Laser Notice No. 50; dated July 26, 2001.

Moor Instruments reserves the right to change specifications without notice.

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