Mirror Systems

FMB Oxford

High Stability Systems

In general, many factors will be used to determine the overall specification of a mirror and its system. The mirror shape, cooling, length, and quality are defined by the source characteristics, beamline layout, and application. The mirror may be fitted with a bender; to optimise focusing or adjust for different experimental requirements. The systems themselves (vessel and manipulator) broadly fall into two categories; conventional and hexapod mounts.

The high stability style offers two (one at either end) or three (two at one end and one at the other) vertical jacks mounted on a rigid support base (typically synthetic granite). These jacks are isolated from the vacuum vessel through bellows and support an optic mounting plate inside the vessel. The vacuum vessel itself can be mounted on the same synthetic granite support block or on a separate frame. The three jack system will offer three degrees of freedom; height, pitch and roll, or stripe selection, yaw and roll depending on the orientation of the mirror (vertical or horizontal deflection). Five-degrees of freedom is offered by the addition of two horizontal slides in vacuum on the mirror support plate that provide stripe selection and yaw or pitch and 'height', again depending on the orientation of the mirror.

Where space is at a premium it is possible to reduce the footprint of the system by fixing the mirror within a smaller vacuum vessel and moving both as a single unit and if roll is required then this can be offered as an in-vacuum or 'through vacuum' system to prevent wind up of bellows. Alternatively the vertical jacks can be mounted on translation stages fixed to the synthetic support block.

Specifications

Vacuum performance	< 5 x 10^{-10} mbar
Helium leak rate	< 1 x 10^{-9} mbar l/sec
Maximum bakeout temperature	150ºC (unless fitted with DPT for fine motion)
Mirror length	300 to 1700 mm
Vertical drive resolution	Encoded at 0.05 µm
Horizontal drive resolution	Typically up to 40 mm in all directions
Number of degrees of freedom for mirror positioning system	Up to 5 motorised axes
Vertical actuator type	Stepper motor with gearbox
Horizontal actuator type	Stepper motor with gearbox
Encoders and Limit switches	Fitted to all motorised motions
Number of degrees of freedom for manual stand adjustments	6

KB Mirror System for MAX IV BioMAX

HRM for DLS I09

Mirror Systems

FMB Oxford

Hexapod Systems

The Hexapod mount is ideal for mounting small mirror systems (although the load capacity can be up to 500 kg). It delivers high performance with outstanding precision, resolution, and repeatability in six degrees of freedom. The unique feature of the hexapod, compared to other mirror mounts, is the ability to move around any centre point the user defines, using parallel kinematics – all of the struts are involved in each degree of freedom. This allows total control of the exact area of illumination of the optical element. The centre of rotation is definable in software, and does not necessarily have to coincide with any item of hardware.

FMB can offer special systems with very low vibration levels for Infra Red mirrors, and Optical Diagnostics on the storage ring as well as special KB mirror pairs, multiple mirrors in a single vessel and other complex optical arrangements. These are often based on our standard modules and techniques.

Specifications

Load Capacity	Up to 500 kg
Vertical range	±25 mm with 0.1 μm encoder resolution
Lateral range	±25 mm with 0.1 μm encoder resolution
Angular range	±2° (±40 mrad) about each axis with 1 μrad resolution

Linear repeatability	±0.4 μm
Linear accuracy	<1 μm
Rotational accuracy	<1 μrad
Rotational repeatability	±1 μrad

Fine pitch motion can be offered on any axis by incorporating a flexure mount and Digital Piezo Transducer. Most commonly these are mounted in vacuum to provide fine pitch corrections. These can be integrated with an appropriate beam position monitor and control system to provide fast feedback on beam position. Angular resolution depends on the lever arm offered by the support flexure.

Hexapod Mirror System for DLS I06

Toroid Hexapod for NSLS II CSX Beamline

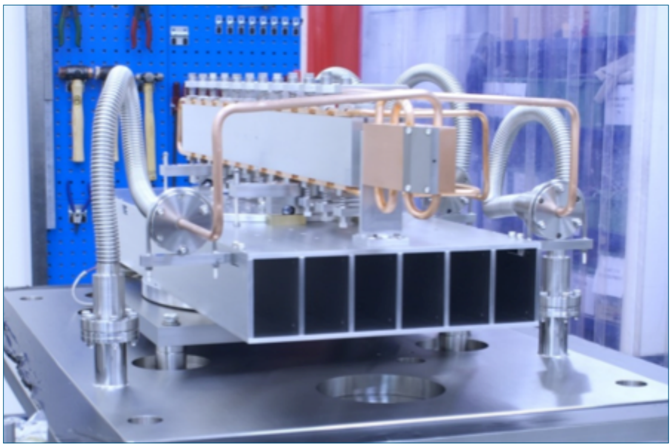
Mirror Systems

FMB Oxford

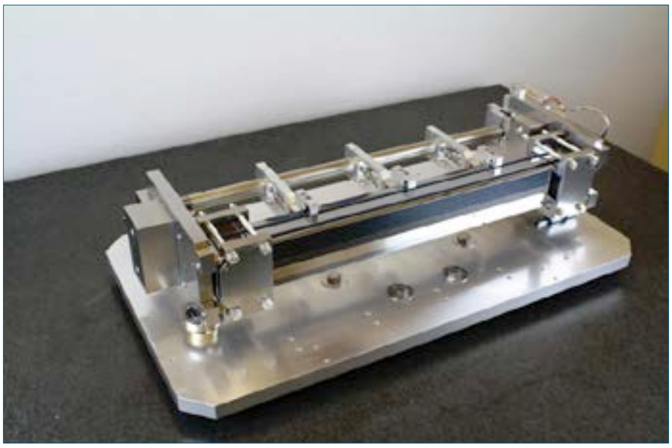
Optics - Cooling and Bending

The demands placed on optical systems have risen dramatically in recent years as the performance of storage rings has improved. Smaller source sizes and higher brilliance drive optical quality, power handling and stability. Figure errors can now be reduced using remediation techniques such as coating deposition or surface etching. Conventional polishing techniques can deliver much smaller errors. However, as optical quality improves then mounting techniques and system stability become ever more critical. FMB offers best practise learned over more than 100 systems in recent years.

Cooling options vary from direct cooled units, through slot cooling to side cooling. Each application is carefully assessed and the specific cooling arrangement discussed with the customer to ensure optimal beamline performance.

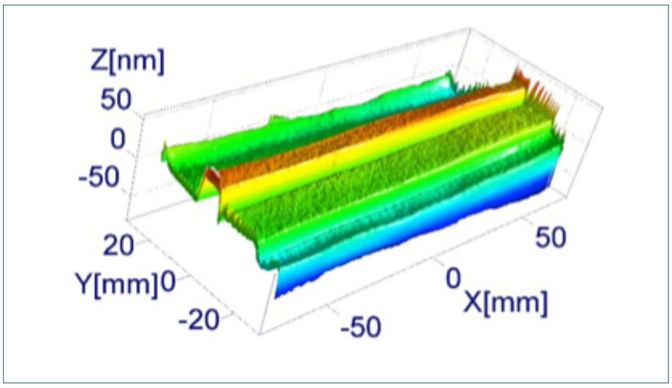


DLS I13LC Mirror



HFM for MAX IV NanoMAX

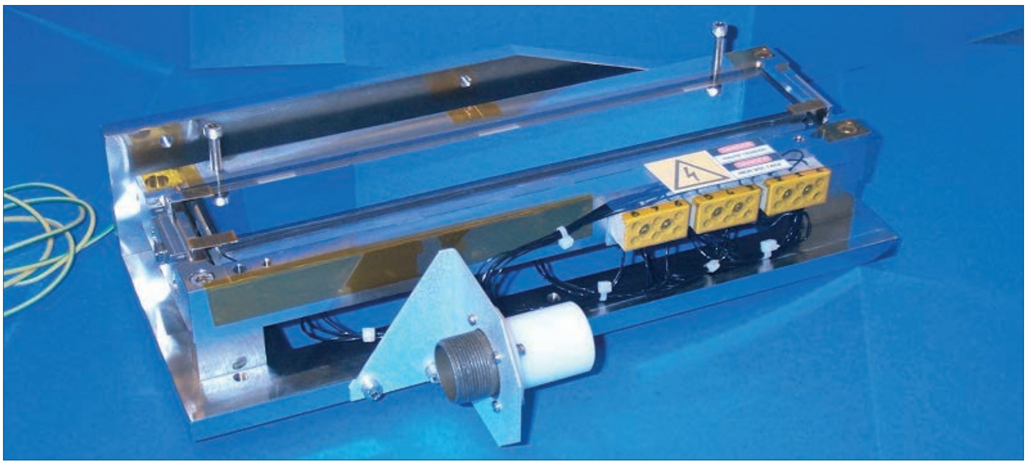
FMB Oxford offers a range of options from various vendors - bounce up, bounce down and side bounce - for fixed optics through cylindrical benders all the way to full elliptical bending. 3rd party verification of bender performance by recognized facilities is included in the standard offering.



Bimorph Mirrors

Bimorph mirror are constructed such that the bending mechanism is intrinsic to the mirror, via a series of piezoelectric elements mounted on the sides of the substrate. The bending is made by applying voltages to the individual elements, providing adaptive zonal control of the mirror reflecting surface. There are no moving parts.

The advantage of the bimorph is that with the multiple bending elements it is possible to act on the high spatial frequencies, and thereby correct for optical defects from other elements in the beamline.



www.fmb-oxford.com | sales@fmb-oxford.com

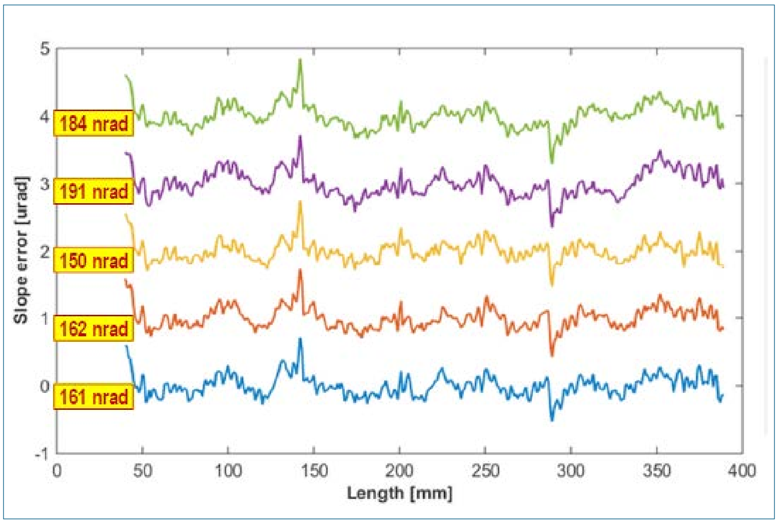
Mirror Systems

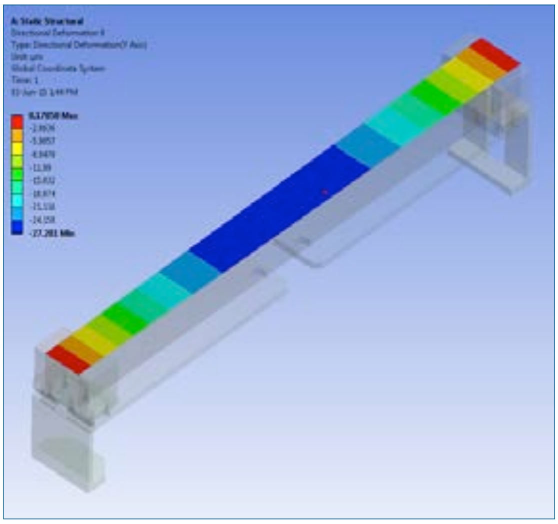
Analysis and Testing

As the polishing and metrology of x-ray optics continues apace, new scientific opportunities are unearthed. FMB Oxford is partnering with world-leading optics suppliers to satisfy the most stringent demands being placed upon optical instruments for FELS and ultra-brilliant storage rings.

Our engineers and scientists have extensive experience developing high end optical mounts, cooling systems and mirror benders. The performance we have been able to obtain is the result of our highly collaborative approach working with our customers on their specific experimental requirements. Input from different points of view and areas of expertise is encouraged and in that way the whole x-ray instrument field moves forward.

FMB Oxford provides optimized benders from different sources based upon specific product requirements. The substrate geometry, bending philosophy and optical clamping arrangements are all verified by finite element analysis, then verified by high end optical metrology from recognized 3rd party suppliers.

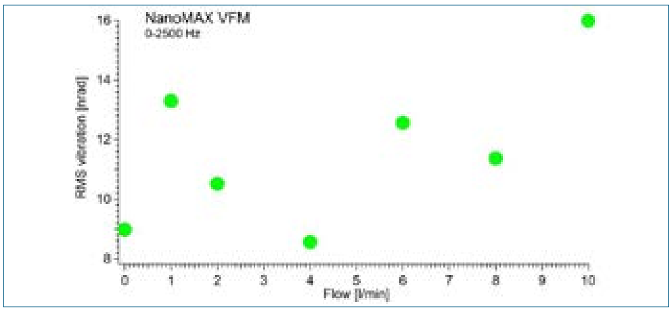




Slope Error Measurements of mirror in bender

Various methods of mirror cooling are available from internally-cooled substrates, to Indium-Gallium-filled slots in the substrate, through to notched substrates and side clamping arrangements. New cooling practices are being investigated to examine potential benefits.

NanoMAX Mirror and Cooling

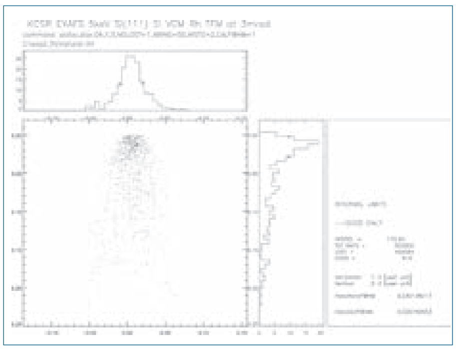


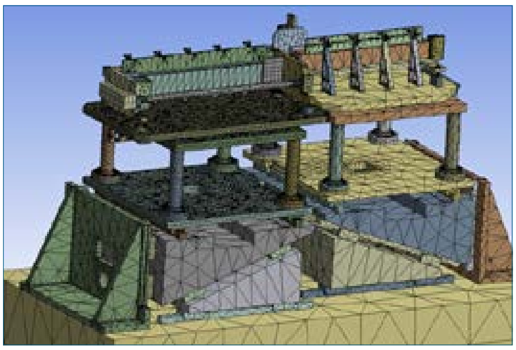
Flow-Induced Vibration on NanoMAX Mirror

The performance of the mirror optics must be matched by the system and support and mechanisms are also analysed to ensure they meet the vibration and drift requirements placed upon them by the experimental requirements.

Free vibration testing provides the lowest natural frequency of the system, an important measure of its susceptibility to external vibration sources. Dynamic testing is performed to determine the performance of the optic coupled to the mirror system under simulated operational conditions.

The effect of the resultant theoretical deformed optical surface is a primary input for raytracing programs (e.g. Shadow) to determine the end effect on the beam at the experimental location. These analyses can then be repeated with actual measured surface data from the 3rd party metrology laboratories prior to installation.



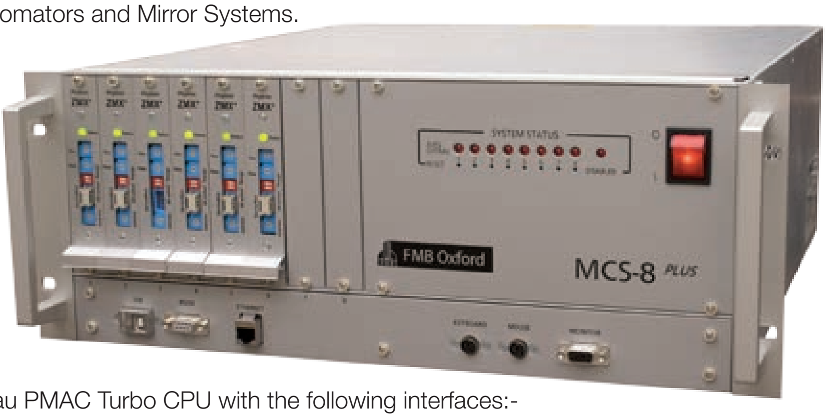


Mesh for Analysis of Dynamic Performance

Controls

MCS-8 Motion Controls

FMB Oxford offers a comprehensive control system design and implementation service. We can provide integration with EPICS, TANGO, SPEC, and Labview experimental controls systems, and have developed a range of hardware and software solutions specifically for Monochromators and Mirror Systems.



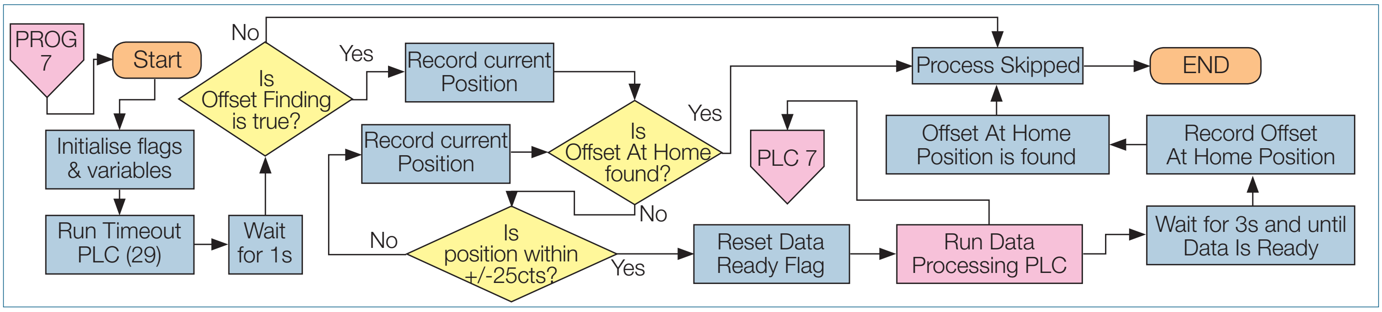
The unit uses a Delta Tau PMAC Turbo CPU with the following interfaces:-

- 100Mbps Ethernet TCP/IP Communication Interface
- USB2.0 Communication Interface
- RS-232 Serial Communication Interface
- Quadrature encoder inputs A, B, C, channels with differential/single-ended drivers
- Axes Flags for all channels

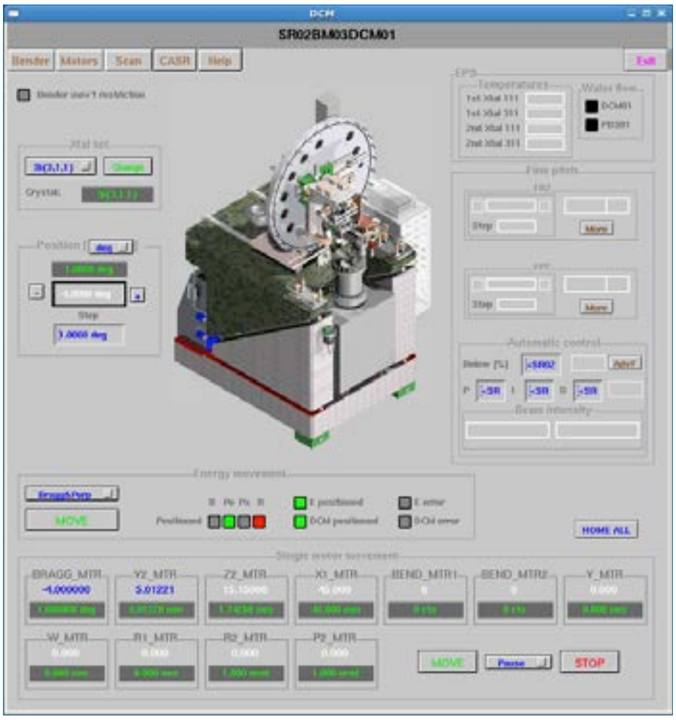
FMB Oxford is a recognized partner of Delta Tau and is recognized as such on its website http://www.deltatau.co.uk/oxford.html

For standard DCMs FMB Oxford offers dual loop control algorithms specifically for the high resolution goniometer to provide excellent Bragg performance and improve settling times by a factor of 3-5.

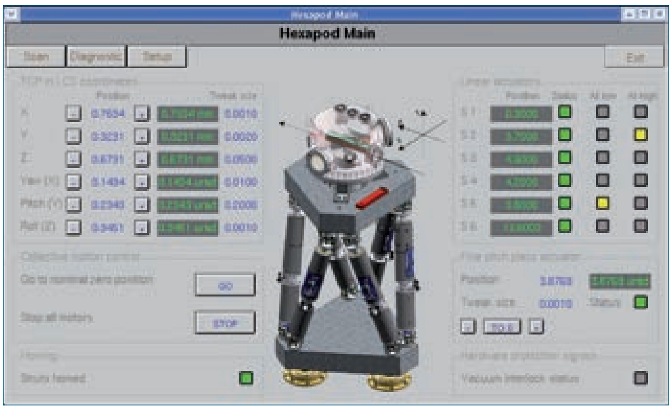
For direct drive DCMs using a brushless servo motor without any gearing for ultimate Bragg performance, a specialized system is provided where the controls are closely matched to the motor and load.



Motion Controls Programs for Optimised Monochromator Performance



The hexapod controls is delivered with the inverse kinematics algorithm embedded as it is a specialist requirement for operating parallel kinematics machines.



Controls

FMB Oxford

Nano Beam Position Monitor (NanoBPM)

Features

- In-vacuum detector head
- <100nm resolution (beam size and intensity dependant)
- Low Z material, amorphous scatterer
- Image processing unit (B100) and control computer (rack mount or desk top)
- FMB Oxford exclusively licences this technology from the University of Manchester

Applications

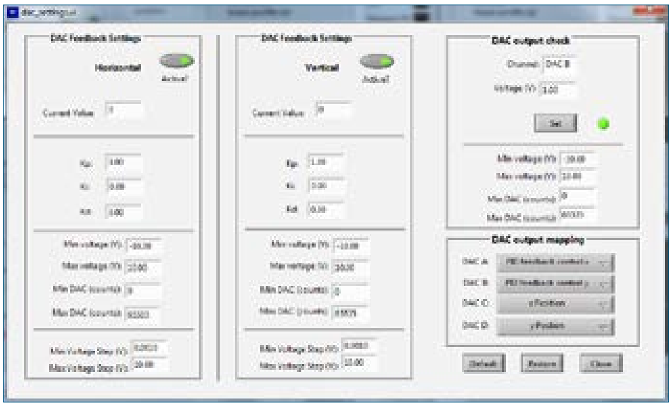
- Beam position monitoring
- Beam profile monitoring
- Motion feedback on monochromators or mirror systems

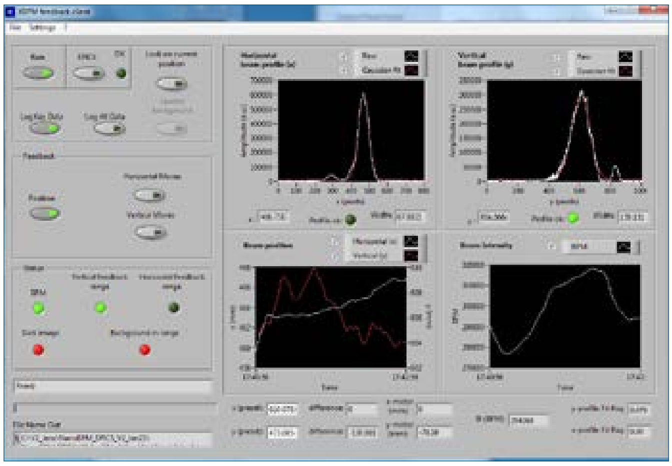
Specifications

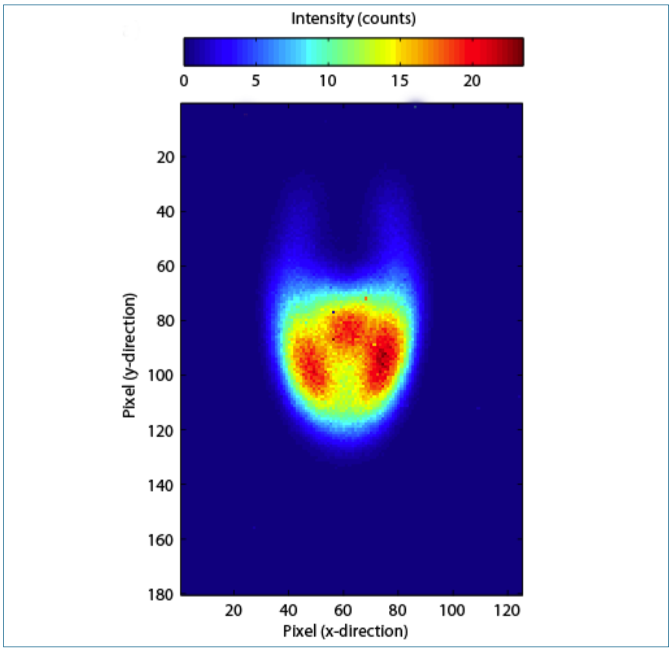
Operating principal	Low Z scatterer, pinhole focussed CMOS imager
External accuracy	< 100 nm (200 µm beam, 10^{12} photons/sec)
Integration time	0.02 - 5 seconds
Digitization	16 bit
Power input	12 V DC
Operating environment	10-40 C

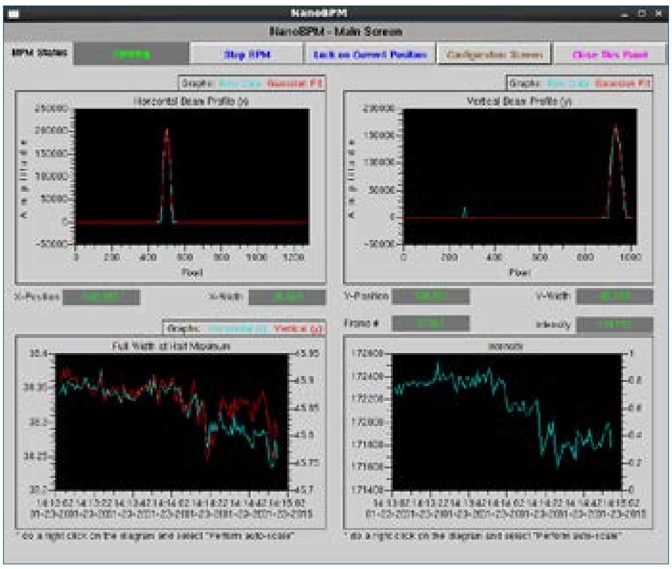
Ordering Information

Description	Part Number
NanoBPM system	AHQ2402









F-460 Fast Feedback Electronics

The F460 offers very fast current measurement and is equivalent to four high spec independent converters in one box, at a very competitive price.

Features

- 4 input channels - each with independent gain and offset control
- 0.1 nA to 1 mA (bipolar) measurement range - 4 independently selectable ranges per channel
- +/- 0.1% full scale absolute accuracy
  - maintained by integrated calibration sources
- 16 bit digitisation per measurement range - signal to noise ratio maintained on each scale
- 1 Hz to 250 kHz simultaneous sampling speed
- 4 output channels - analogue (16 bit DAC, +/- 10V) or digital (TTL levels into 50Ω)
- Digital filtering - box car averaging up to 250,000 samples
- Buffering - 50,000 contiguous samples at any sample rate
- External triggering - start, pause and stop acquisition

Applications

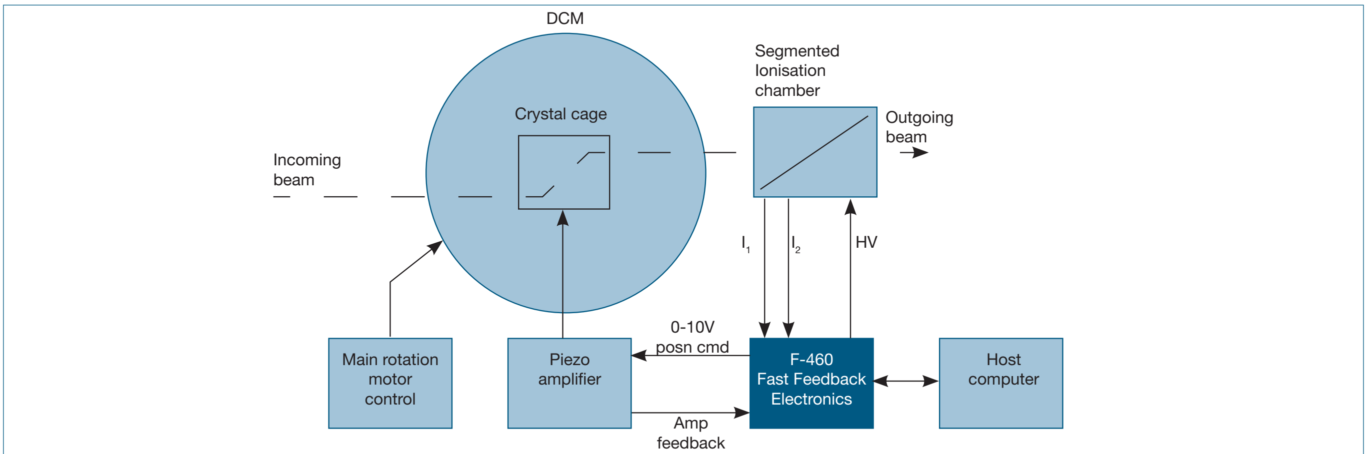
- Quadrant photodiode readout
- Beam position monitors
- Low current and charge measurement
- Servo control based on current measurement

Ordering Information

Description	Part Number
F-460 Fast Feedback Electronics	F460

Specifications

Operating principle	Gated integrators with choice of feedback capacitor and integration period.
Feedback capacitors	Two on each channel, default values 30 pF and 2700 pF
Input impedance	≤ 40 ohm
Noise	< 100 fA + 1 fA per pF input load up to 100 pF (1 sec integration on 30 pF)
Integration period	100 µsec to 1 second
Stability	Output drift < 200 fA C-1 hour-1
External accuracy	< 0.5% of nominal full scale with selected capacitor and integration.
Current source	Internal precision calibration sources, 500 nA, used for automatic calibration. Calibration factors stored in flash memory.
Digitization	16 bit successive approximation bipolar, 250 kHz, fully parallel.
Accumulation	Charge accumulation provided via numeric integration.
Sensor compensation	Independent gain and offset factors provided for sensor compensation. Stored in flash memory.
Data buffering	On-board buffering of up to 50000 contiguous samples at any data rate up to maximum.
Triggering	External trigger line can start, pause and stop acquisition via TTL level signal to gate input. Input impedance 2.5 kohm.
HV bias supply	Factory option) 0 to 200/500/1000/2000/3000V programmable (polarity and maximum voltage factory selectable), 1 watt max output. Noise and ripple < 0.1% (up to 2000V), <0.2% (3000V)
Analog inputs	Two, 16-bit ± 10 V. Accuracy better than ± 0.5% of full scale.
Analog outputs	Four, 16 bit ± 10V (used for servo and monitor outputs). Accuracy better than ± 0.1% of full scale.
Digital outputs	Four, TTL levels into 50 ohms (used for monitor outputs).
Displays	Four status LEDs, “HV on” LED.
Power input	+24V (± 2V) DC, 300mA typ, 500mA max. PTC fuse 500 mA.



DCM Components

FMB Oxford

RXM Bimorph Power Supply

The Multi-Channel Bipolar Power Supply is designed to drive piezo-electric cells in a bimorph X-ray optic. The power supply is designed to operate the latest generation of bimorph mirrors where the piezos are mounted on the sides of the optical substrate as well as the “older” type where the piezos are sandwiched between fused silica/silicon layers.

The power supply is populated with cards of 8 channels and can have a maximum of 32 channels. The power supply can operate two separate optics by selecting independent banks using dip switches. Changing the output voltages of the channels in a bank this can be done in two ways: A) All channels slew at the same rate. B) The channel that has the largest difference between its current voltage and the desired voltage is identified and the slew rate of the remaining channels is adjusted automatically such that all channels reach their desired voltage at the same time. The former is useful during commissioning and the latter provides advantages for normal operation.

The power supply communicates over Ethernet and RS232 and is available with both a browser based control interface and an EPICS IOC and GUI.

Specifications

Range	± 2000 V
Channels	32
Resolution	< 76 mV
Ripple	< 10 mV
Slew rate	Up to 100 V/s
Temperature coefficient	< 40 ppm °C^{-1}
Stability	< 50 ppm over 8 h, 0.1% after 1000 h
Software	Browser based GUI and EPICS IOC/GUI