The Digital Piezo Translator

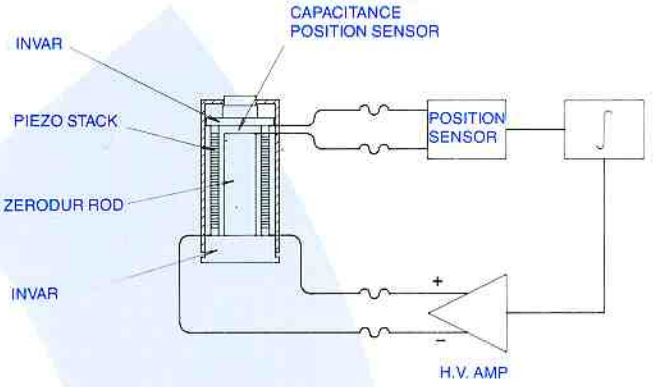
Repeatable positioning to better than a Nanometer

FROM
Queensgate Instruments

How Digital Piezos Work

The key to the outstanding positioning accuracy and repeatability achieved by the DPT is Queensgate's unique capacitance sensor technology. Each DPT contains a capacitance position sensor which has picometer sensitivity. Changes in the length of the DPT are detected by this sensor and used to control its length.

The DPT's are made of Zerodur (a low thermal expansion coefficient glass) and Invar to minimize temporal and thermal drift. The DPT operates in a closed servo-loop incorporating an almost perfect integrator stage – as a result the DPT is extremely stiff. As loads on the device change its length so the servo loop responds, changing the voltage on the PZT stack to correct for these perturbations. The DPT has a slew rate of $1\mu m\ ms^{-1}$, and a noise level of less than 1 nanometer rms.



The capacitance sensors developed for the DPT are now also available as separate units, for other applications which demand the highest possible position sensitivity. Please contact us for further information.

PRODUCT FAMILY

There are five parts to the DPT-C product family:

Translators

Control Modules

Host Units

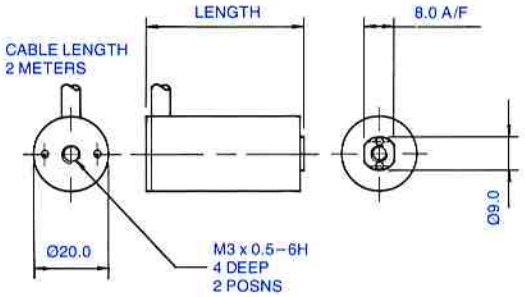
Interfaces

and Accessories

The minimum basic components required are a DPT-C and a Control Module. For manual control, display facilities and computer interfaces the Control Module can be mounted in one of a variety of Host units. Accessories include mirrors, end pieces, mounting blocks and extension cables. Vacuum compatible and non-magnetic DPT-Cs are also available.

Translators

The DPT-C is constructed of Zerodur and Invar. It is preloaded in a 20mm diameter stainless steel housing, with M3 threaded end pieces and a 2 meter long flying lead. Each DPT-C is individually calibrated, and a calibration curve supplied. The DPT-C is repeatable to better than 1 nanometer.



	DPT-C-S	DPT-C-M	DPT-C-L
Range (μm)	15	35	70
Length (mm)	42.2	76.7	127.8
Diameter (mm)	20	20	20
Mass (gms)	70	110	170
Linearity (%)	0.1	0.15	0.15
Temp Coeff (nm °C^{-1})	15	25	35 (typical)
Tilt (arcsecs μm^{-1})	0.5	0.5	0.5 (typical)

Specifications marked (typical) are for information and guidance and are not guaranteed in normal production.

Vacuum Compatible Option: These special translators are made from very low outgassing materials and can be baked out up to 100°C. For high vacuum applications specify – VAC (eg DPT-C-S-VAC). Specify -UVAC for applications which demand Kapton cables (rather than PTFE). Vacuum operation is not possible for intermediate or partial vacuums due to spark discharge problems. Vacuums must be better than 0.01 Torr. The system must be switched off during evacuation. A standard DPT-C should not be operated in a vacuum since damage will result. The Control Module is not vacuum compatible. VGCON is a VG ZEFT19 UHV compatible feedthrough connector, wired to the DPT.

Non Magnetic Option: For translators made entirely from non magnetic materials specify -SS (eg DPT-C-S-SS). In this case the Invar ends are replaced with stainless steel (AISI 316 Martensitic) end pieces. This increases the coefficient of thermal expansion of the translators by 180nm°C^{-1}.

Cryogenic Option: Translators can be made which operate at liquid Nitrogen temperatures. Please call for further details.

Control Modules

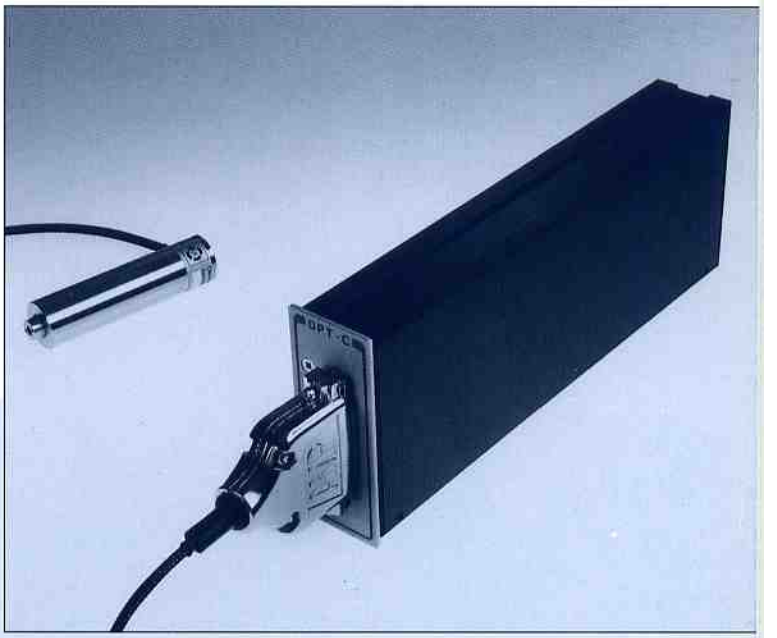
The Control Module contains the position sensing electronics and piezo drive amplifiers necessary to drive the DPT-C. It can operate standalone from ± 15V DC and has a 14 bit TTL parallel digital interface, an analog input, Position Monitor and Ready Signal. A separate Control Module is required to drive each DPT-C.

Position Monitor and Ready Signal: Since it takes a finite time for the translator to move from one position to another, there will be a difference between the demand position and the actual position while the translator is slewing. The Position Monitor signal (POSMON) indicates the demand position of the translator. A Ready Signal (READY) is provided which shows when the translator has actually reached the demand position within 10nm.

Low Drift Option: By incorporating selected, very low drift electronic components the thermal drift specification of the Control Module can be improved dramatically, from $0 \pm 25 nm°C^{-1}$ to $0 \pm 5\ nm°C^{-1}$. This option is useful when warm-up drift must be minimized or when the Control Module is operated in an environment where the temperature is changing rapidly. Order Code: CM-LD

Low Noise Option: This option gives an improved noise specification (<0.5nm rms) over the standard module, and in addition provides the capability to drive the DPT-C over long extension cables without increasing the noise level. Order Code: CM-LN

Both LN and LD options may be specified on the same Control Module if required.
Order Code: CM-LN-LD



Control Module:
37 pin D-type connector

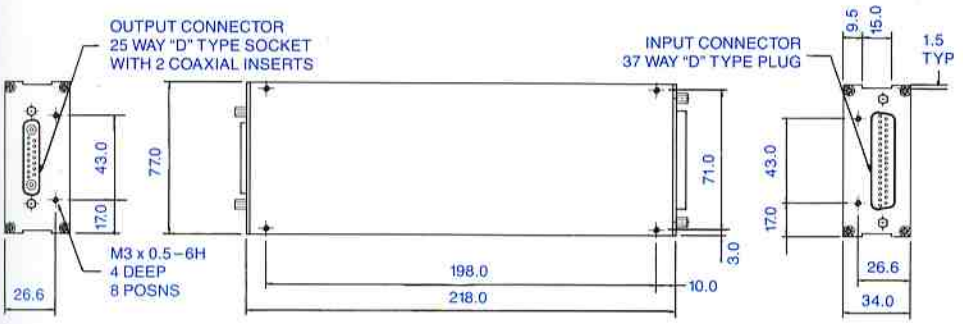
Pin#	Designation
1	+15V
2	−15V
3	0V
4	0V
5	Bargraph References (for use by AX101/AX301)
6	Range Output (for use by AX101/AX301)
7	0V (Analogue)
8	+ve Analogue Input
9	0V (Analogue)
10	0V (Digital)
11	Ready Signal (TTL level)
12	D13 (Most Significant Bit)
13	D12
14	D11
15	D10
16	D9
17	D8
18	D7
19	WR (data valid on low)
20	+15V
21	−15V
22	0V
23	Integrator Output
24	Position Monitor
25	0V (Analogue)
26	−ve Analogue Input
27	0V (Analogue)
28	0V (Digital)
29	Out of Range (TTL Level)
30	D0 (Least Significant Bit)
31	D1
32	D2
33	D3
34	D4
35	D5
36	D6
37	CS (module select on low)

CS and WR are internally connected to 0 V via 100KΩ resistors.

Control Module Specifications

Slew Rate	1 micron ms^{-1}
Response time (variable)	1ms
Temp Coeff CM	$0 \pm 25 nm°C^{-1}$
CM-LD	$0 \pm 5 nm°C^{-1}$
Noise CM	<1nm rms for all translators
CM-LN	<0.5nm rms for all translators
Size	218 x 77 x 34mm

Power: + 15V (±0.5V) at 500mA max (210mA quiescent)
− 15V (±0.5V) at 500mA max (210mA quiescent)



Host Units

A Control Module is required to operate a DPT-C. The Control Module can, if desired, be mounted in one of a variety of Host Units, which run on line voltage and provide position display, manual control and IEEE-488 or RS232 interfaces.

AX101

The AX101 is a single channel Host Unit capable of driving one Control Module.

Size	258 x 312 x 104mm
Power	50 W
Weight	5Kg
Mains voltage	95-130 VAC or 190-260 VAC at 50/60 Hz (selectable)

Analog Input (±10V differential)
10 turn Manual control
4½ digit position display
Bargraph piezo voltage display
Optional IEEE-488 or RS232 interface
Position Monitor (±5V)
Out of Range (TTL)

The AX101-ND is similar to the AX101 but without the position display, bargraph display or manual offset control. This is the most economical way of operating through an IEEE-488 or RS232 interface, which can be mounted in either the AX101 or AX101-ND. (see panel for further details on interfaces.)

AX301

The AX301 is a triple channel Host Unit capable of driving up to three Control Modules.

Size	258 x 312 x 104mm
Power	90 W
Weight	6Kg
Mains voltage	95-130 VAC or 190-260 VAC at 50/60 Hz (customer selectable)

3 x Analog Input (±10V differential)
3 x 10 turn Manual control
Switchable 4½ digit position display
Switchable Bargraph piezo voltage display
Optional IEEE-488 or RS232 interface
3 x Position Monitor (±5V)
3 x Out of Range (TTL)

The AX301-ND is similar to the AX301 but without the position display, bargraph display or manual offset control. This is the most economical way of operating 2 or 3 DPT-C's through an IEEE-488 or RS232 interface, which can be mounted in either the AX301 or AX301-ND. (see below for further details on interfaces.)

The AX301-NDZ is a version of the AX301-ND which includes a parallel interface designed to be used with the PC DIO 24 PC expansion card (National Instruments).

Interfaces

Both RS232 and IEEE-488 interfaces are available as optional extras for the Host Units. Each interface is organised as 12 4-bit ports. Four of these ports are used for the 14-bit data word which is the position input. The other ports are used for reading back the Ready Signal, the Out of Range signal, and for module selection and Data Valid signals.

Accessories

Front Surfaced Plane Mirrors

These are available in either 12.5mm diameter or 25mm diameter, mounted in a special holder which screws straight into the M3 end piece of the DPT-C. The mirrors are ⅒th wave and made from fused silica. They are coated with protected Aluminium. Other coatings are available on request. Please call us with details of your requirements.
Order Code: 12.5mm Diameter: -FS12.5
Order Code: 25mm Diameter: -FS25

Corner Cube

This is a 10.5mm aperture corner cube, made of fused silica, with <5 arcsecs deviation, mounted in a special holder which screws directly into either of the M3 end pieces of a DPT-C.
Order Code: -CC

Ball End Pieces (5mm diameter)

A stainless steel hemisphere, 5mm diameter, which screws directly into either of the M3 end pieces of the DPT-C.
Order Code: -BEP5

V Groove End Piece (3mm deep)

A 90 degree V groove, stainless steel end piece, which screws directly into either of the M3 end pieces of the DPT-C. This end piece can be used in kinematic mounting schemes. It is designed to take a 5mm diameter ball, giving a clearance of 0.535mm to a 5mm hemisphere mounted on a plane surface.
Order Code: -VEP3

Plane End Piece

An Invar plane end piece 10mm in diameter which screws directly into either of the M3 end pieces of the DPT-C. It provides a flat surface which can be used to bond the DPT in position, as part of a kinematic mounting scheme, or to bond mirrors or other substrates to.
Order Code: -PEP

Magnetic End Piece

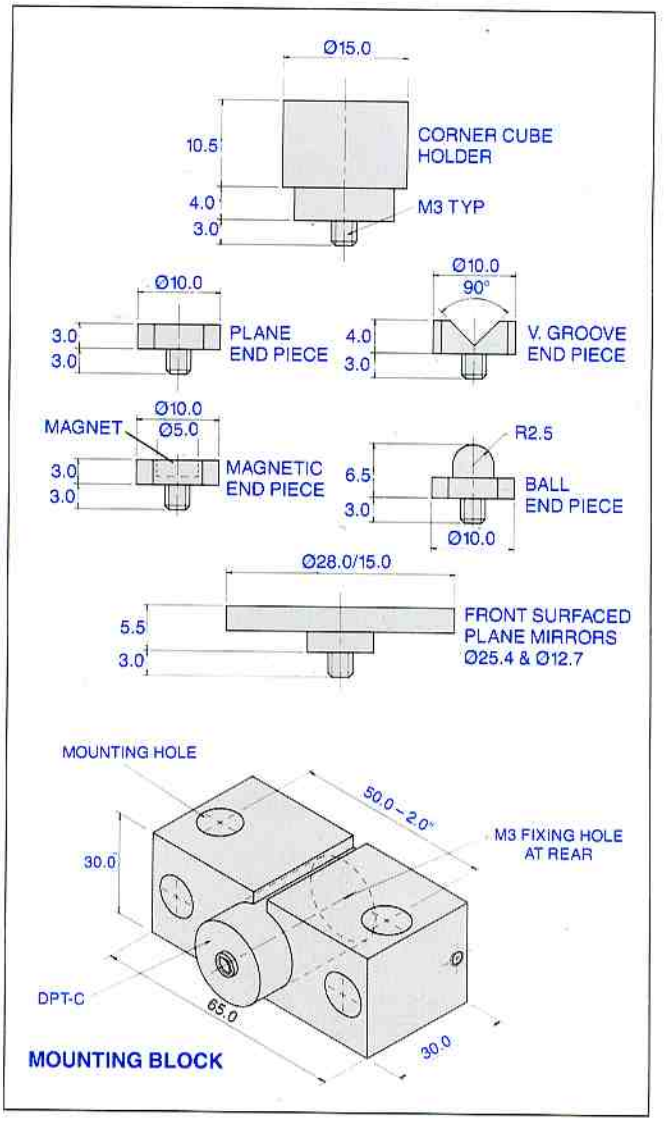
An Invar end piece incorporating a Samarium Cobalt magnet, which screws directly into either of the M3 end pieces of the DPT-C.
Order Code: -MEP

Mounting Block

A block, made either of Invar or Aluminium, which allows a DPT-C to be mounted onto translation stages or optical tables. The design accommodates both 1 inch and 25mm hole pitch. The DPT can be mounted either vertically or horizontally, and provision is made to attach preloading springs for attaching large masses to the DPT.
Order Code: -MBI Invar -MBA Aluminium

Extension Cables

Bulkhead mountable extension cables for connecting the DPT-C to the Control Module are available in three lengths, 3 meters, 5 meters or 8 meters. Please note that using longer cables will result in higher noise levels. The noise increases by 1nm rms for every 2 meters of cable with the standard Control Module. Using the Low Noise version of the Control Module the noise increases by 0.2nm rms per meter. It is not recommended to use cable lengths of more than 10 meters.
Order Code: -EC3 -EC5 -EC8



Applications

Phase Shifting Interferometry: to provide an accurate, linear and repeatable shifting of the fringe pattern in phase shifting interferometry.

Scanning Probe Microscopy: Scanning the tip in X,Y and Z in tunnelling, atomic force and magnetic force microscopy.

Semiconductor Manufacture: controlling the position, focus and rotation of wafers and reticles, accurate positioning of samples and masks in sub-micron lithography.

Adaptive Optics: controlling deformable or segmented mirrors at high bandwidth to achieve accurate wavefront correction.

Precison Beam Steering: guiding laser beams in Inter-Satellite communication systems and providing super precision angular rotation in auto-collimators.

Interferometry: controlling the position of mirrors in Fabry-Perot and Fourier Transform Interferometers to produce linear, hysteresis-free scanning.

Microscopy: moving stages or samples in X-ray or optical microscopes.

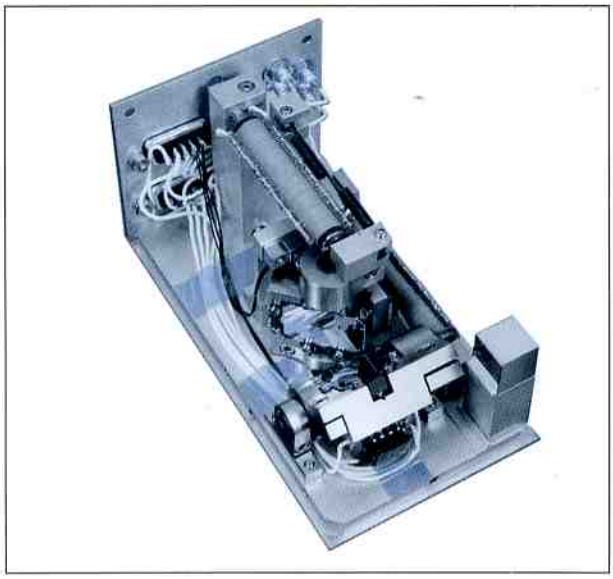
Disc Drives: testing the alignment of read and write heads. Research into high density recording media.

Applications Engineering

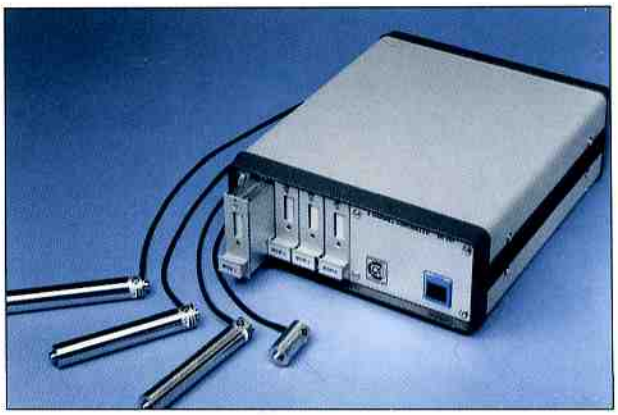
At Queensgate we have the capacity and experience to modify our products to meet the particular needs of our customers. Please contact us to discuss your requirements and your problems. Our wide expertise in optics and electronics allows us to offer innovative and cost effective solutions.

Examples of application engineered products:

A DPT with an integral pre-amplifier, part of a 75 channel system for an adaptive mirror.

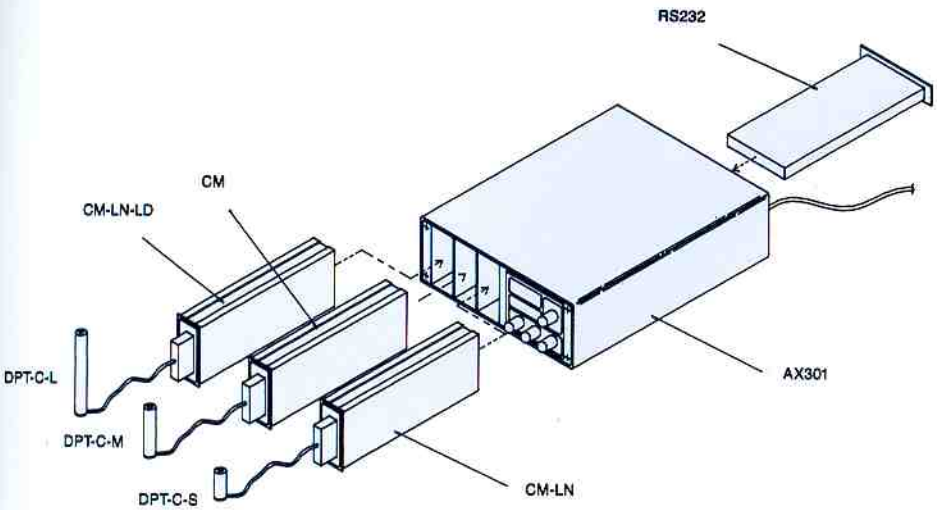


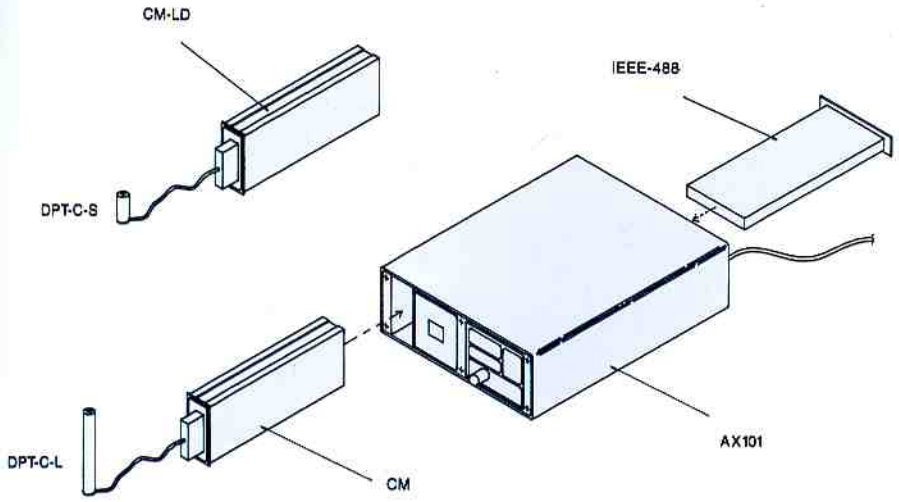
A fine-pointing mechanism developed by Queensgate for the Semiconductor-laser Inter-satellite Link EXperiment (SILEX) project for the European Space Agency.



4 channel DPT system custom engineered for an application in semi-conductor manufacture.

Ordering Information





Product Code Summary

Translators

DPT-C-S	15µm range closed loop translator
DPT-C-M	35µm range closed loop translator
DPT-C-L	70µm range closed loop translator
options	-UVAC UHV compatible
	-VAC vacuum compatible
	-SS non-magnetic

Control Modules

CM	Standard Control Module
options	-LD low drift
	-LN low noise

Host Units

AX101	single channel Host Unit
AX101-ND	single channel Host Unit with no display or manual control facilities
AX301	three channel Host Unit
AX301-ND	three channel Host Unit with no display or manual control facilities
AX301-NDZ	AX301-ND with parallel interface

Interfaces

IEEE-488	interface suitable for AX101 or AX301
RS232	interface suitable for AX101 or AX301

Accessories

FS12.5	Front Surface mirror 12.5mm diameter
FS25	Front Surface mirror 25mm diameter
CC	Corner Cube
BEP5	Ball End Piece
PEP	Plane End Piece
VEP3	V groove End Piece
MBI	Invar Mounting Block
MBA	Aluminium Mounting Block
MEP	Magnetic End Piece
EC3	3 meter Extension Cables
EC5	5 meter Extension Cables
EC8	8 meter Extension Cables
VGON	wired with VAC feedthrough