# Optical Scanners

Our broad range of closed loop galvanometer-based optical scanning components and systems offer the systems integrator the maximum galvanometer-based performance for any positioning or scanning requirement. Our superior positioning performance comes from advanced actuator designs, innovative patented position detection techniques, the consistency of our high quality manufacturing process and our continued commitment to advancing the state of galvo technology. With our extensive range of scanning options, application expertise and world-wide technical support, we are ready to be your partner in scientific and OEM optical system applications.

Just as important as our superior positioning system performance is the product reliability, lifetime and support that you need for long term system and market success. Superior product lifetime and reliability result from disciplined design technique and simulation, the best in bearing and component technology and quality manufacturing processes and workmanship. We take great pride in the performance and the extensive lifetime of our products. These high standards in our manufacturing processes guarantee the performance consistency that you need to design the high calibre systems demanded in today's competitive marketplace.

We offer a complete range of closed loop galvanometers, servo drivers and system options for the maximum in price/performance options, system design flexibility and ease of integration.

## Galvanometers

- Proprietary Moving Magnet Actuator Technology for the highest positioning speed.
- Proprietary Moving Coil Actuator Technology for the highest positioning accuracy.
- Patented Capacitive Position Detector Technology for the highest positioning accuracy and stability
- Patented Optical Position Detector Technology offers positioning accuracy at lower cost.
- Product Consistency and Reliability for extended system lifetimes and uptime.
- A Broad Range of Products sized for optimum performance for apertures from 1mm to 50mms.

These galvo technologies are offered in three families of optical scanning products .

- The Moving Magnet Scanners with Advanced Optical Position Detector (Model 6200, 6210, 6220, 6230)
- The Moving Magnet Scanners with Optical Position Detector (Model 6800HP/L, 6810P/L, 6850P/L)
- The Moving Magnet Scanners with Capacitive Position Detector (Model 6860, 6870, 6880)
- The Moving Coil Scanners with Capacitive Position Detector (Model 6350, 6450, 6650, 6900, 6400)

## Servo Drivers

The key Servo Driver Technologies and offerings include:

- Surface Mount Technology (SMT) driver boards for compact system size.
- Proprietary Class 1 Integrating Servo Drivers for the highest positioning accuracy and stability.
- Proprietary Class 0 Non-Integrating Servo Drivers for the highest speed and lowest cost.
- System Control and Interface Features for ease of system integration.

These servo technologies are offered in several formats and performance capabilities.

- The Class 0 Non-Integrating Driver Boards (Models 678XX, 658XX).
- The Class 1 Integrating Driver Boards (Models 670XX, 650XX, 653XX).
- The Rack Mount Driver Boxes (Models 602XX, 603XX).

## System Options

For more complete levels of system integration and solutions, we also provide the following system components and solutions:

- Standard Two Axis X/Y Mounts and Mirrors Sets from 3mm to 50mm apertures.
- Standard and Custom Mirrors for all galvos.
- Standard and Custom Interface Cables.
- PositionProtm PC-based Hardware and Software Galvo Control.

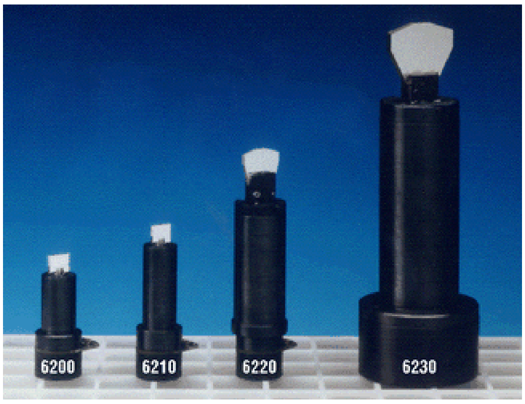
# Galvanometers

- The combination of our Moving Magnet Actuator technology and our innovative patented Advanced Optical Position Detector design offers the highest positioning speed and excellent accuracy in the smallest, lower cost closed loop galvanometers. Scanning system applications can be designed and optimized for speed, size, cost and accuracy with typical beam diameters in the 1 to 3mm range.

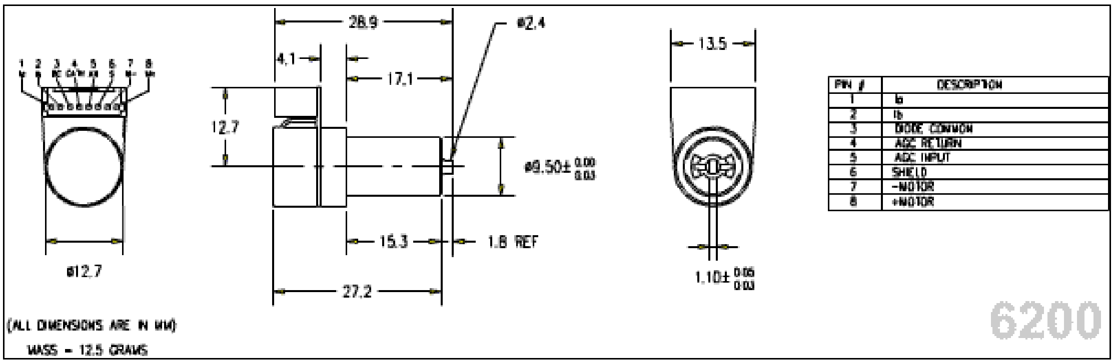
- The Moving Magnet Scanner's Positioning Speed comes from advanced galvanometer and actuator design for the highest system resonant frequency and RMS power capability. The higher resonant frequency of our moving magnet actuator design, the intense magnetic field strength of state of the art neodymium-iron-boron magnets and our advanced servo driver options allow superior system bandwidths, step response times and repetition rates with excellent wobble and jitter performance.

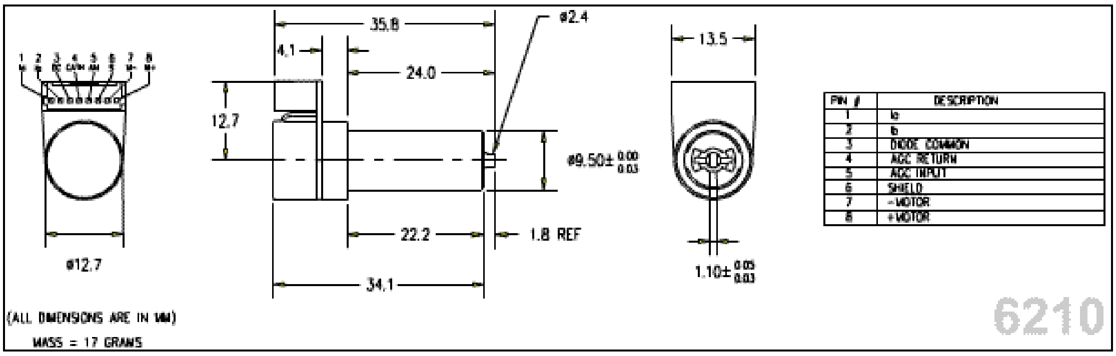
- Our newly patented advanced optical position detector design coupled with the positioning precision of the moving magnet actuator provides excellent repeatability and accuracy . The advanced optical position detector is designed to provide high positioning linearity, repeatability and stability over time and temperature, and lower closed loop galvo cost in the smallest, most compact package.

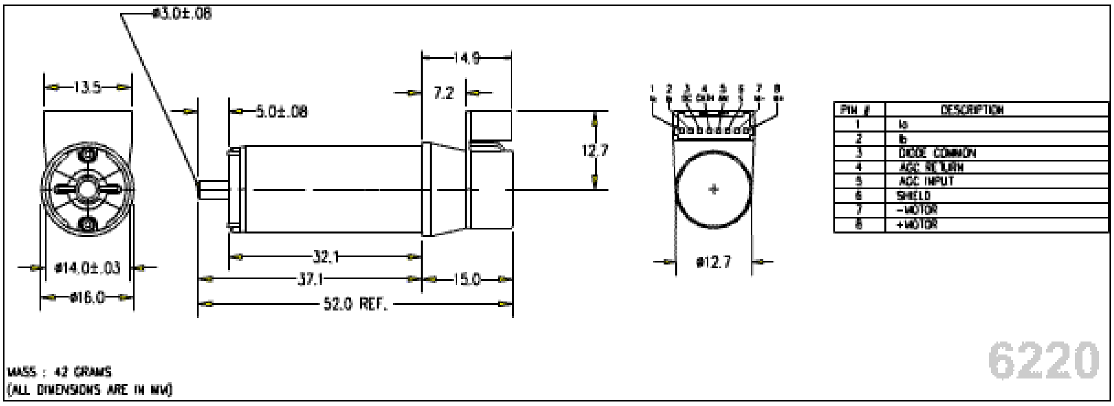
- Superior product lifetime and reliability result from disciplined design technique, the best in bearing technology and quality manufacturing processes and workmanship. We take great pride in the performance of our products. Our scanner designs are computer modelled and have been life-test proven to billions of cycles of operation. Our high standards of manufacturing quality guarantees the performance consistency that you need to design the high quality systems demanded in today's competitive marketplace.

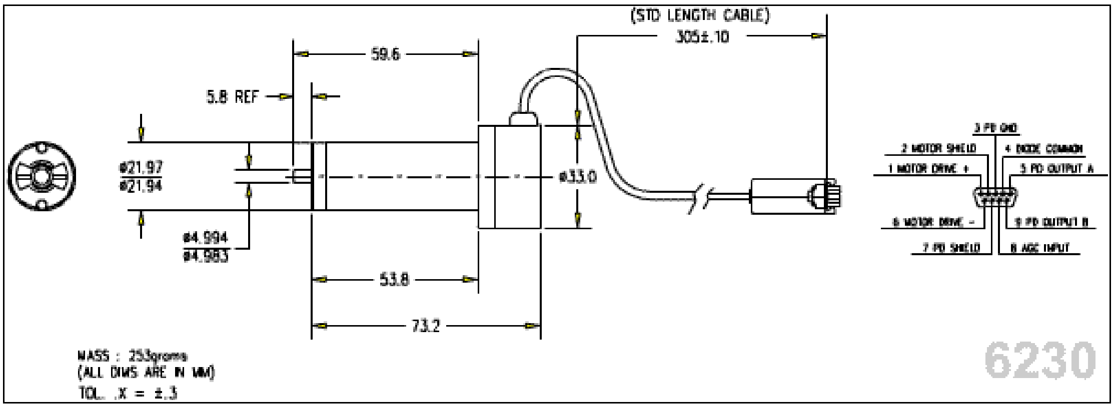



| **Specifications** | 6200 | 6210 | 6220 | 6230 | Units & Tolerances |
|---|---|---|---|---|---|
| Optical apertures supported, two-axis | 3 | 3 | 5 | 10 | mm |
| Maximum recommended load | 0.12 | .2 | 1.4 | 10 | gm*cm$^2$, +/-10% |
| **Mechanical Specifications** | | | | | |
| Rotor inertia | 0.012 | 0.02 | 0.14 | 1.0 | gm*cm$^2$, +/-10% |
| Torque constant | 1.08 | 2.5 | 5.7 | 11.4 | x10$^4$ dyne-cm/A, ±10% |
| **Electrical specifications** | | | | | |
| Coil resistance | 2.4 | 4.1 | 3.4 | 1.4 | ohms, +/-10% |
| Current, RMS | 1.6 | 1.6 | 2.6 | 5.4 | A, Maximum |
| Small angle step response | 0.175 | 0.175 | 0.25 | 0.3 | mS, with balanced inertia matched load |
| Linearity | 99.5 | 99.5 | 99.5 | 99.5 | %, min, over 40 degrees |
| Repeatability | 15 | 15 | 15 | 15 | Microradians, Maximum |

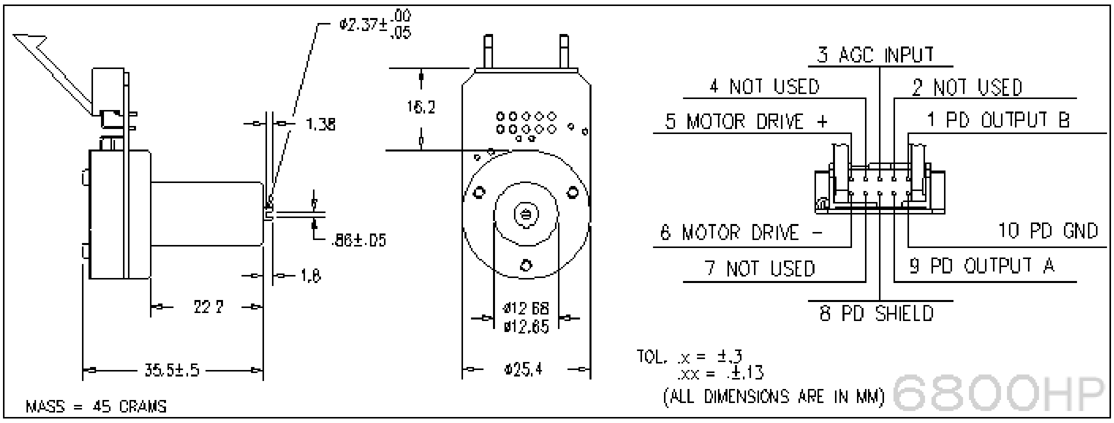

28.9
ø2.4
4.1
17.1
13.5
12.7
ø9.50± 0.00 0.03
15.3
1.8 REF
27.2
ø12.7
1.10± 0.05 0.03
PIN #
DESCRIPTION
1 Ia
2 Ib
3 DIODE COMMON
4 AGC RETURN
5 AGC INPUT
6 SHIELD
7 -MOTOR
8 +MOTOR
(ALL DIMENSIONS ARE IN MM)
MASS = 12.5 GRAMS
6200

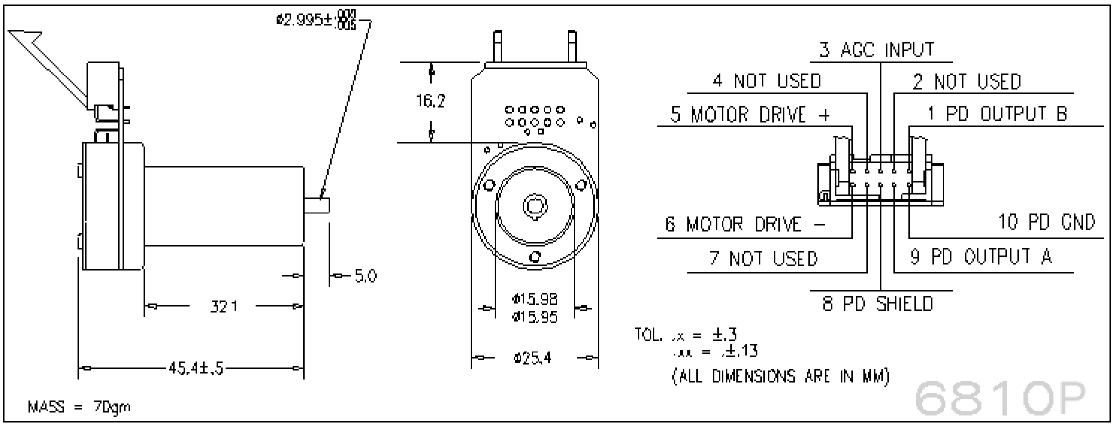

35.8
ø2.4
4.1
24.0
13.5
12.7
ø9.50± 0.00 0.03
22.2
1.8 REF
34.1
ø12.7
1.10± 0.05 0.03
PIN #
DESCRIPTION
1 Ia
2 Ib
3 DIODE COMMON
4 AGC RETURN
5 AGC INPUT
6 SHIELD
7 -MOTOR
8 +MOTOR
(ALL DIMENSIONS ARE IN MM)
MASS = 17 GRAMS
6210

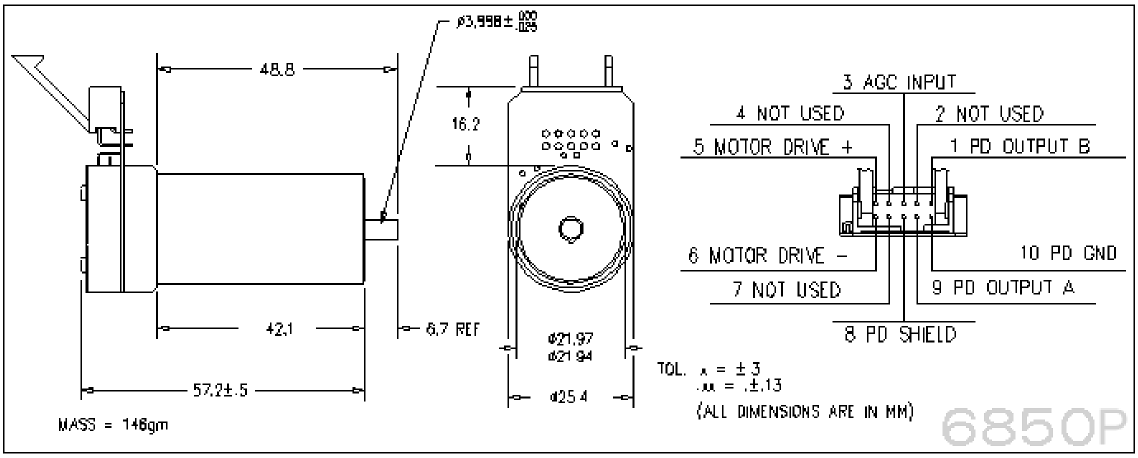

ø3.0±.08
14.9
13.5
7.2
5.0±.08
12.7
32.1
37.1
15.0
52.0 REF.
ø14.0±.03
ø16.0
ø12.7
PIN #
DESCRIPTION
1 Ia
2 Ib
3 DIODE COMMON
4 AGC RETURN
5 AGC INPUT
6 SHIELD
7 -MOTOR
8 +MOTOR
MASS : 42 GRAMS
(ALL DIMENSIONS ARE IN MM)
6220


(STD LENGTH CABLE)
305±.10
59.6
5.8 REF
ø21.97
ø21.94
ø33.0
ø4.994
ø4.983
53.8
73.2
3 PD GND
2 MOTOR SHIELD
4 DIODE COMMON
1 MOTOR DRIVE +
5 PD OUTPUT A
6 MOTOR DRIVE -
9 PD OUTPUT B
7 PD SHIELD
8 AGC INPUT
MASS : 253grams
(ALL DIMS ARE IN MM)
TOL. .X = ±.3
6230


| Specifications | 6800HP | 6810P | 6850P | Units & Tolerances |
|---|---|---|---|---|
| Optical apertures supported, two-axis | 3 | 5 | 10 | mm |
| Maximum recommended load | 0.18 | 1 | 5 | gm*cm$^2$, +/-10% |
| **Mechanical specifications** | | | | |
| Rotor inertia | 0.018 | 0.1 | 0.5 | gm*cm$^2$, +/-10% |
| Torque constant | 2.5 | 5.7 | 9.5 | x10$^4$ dyne-cm/A, ±10% |
| **Electrical specifications** | | | | |
| Coil resistance | 4.2 | 3.4 | 1.5 | ohms, +/-10% |
| Current, RMS | 1.6 | 2.6 | 4.3 | A, Maximum |
| Small angle step response | 0.3 | 0.4 | 0.5 | mS, with balanced inertia matched load |
| Linearity | 98 | 98 | 98 | %, min, over 40 degrees |
| Repeatability | 20 | 20 | 20 | Microradians, Maximum |




ø3,998± .000 .025
48.8
16.2
42,1
6,7 REF
ø21.97
ø21.94
57,2±.5
ø25.4
MASS = 146gm
3 AGC INPUT
4 NOT USED
2 NOT USED
5 MOTOR DRIVE +
1 PD OUTPUT B
6 MOTOR DRIVE -
10 PD GND
7 NOT USED
9 PD OUTPUT A
8 PD SHIELD
TOL. .x = ± 3
.xx = .±.13
(ALL DIMENSIONS ARE IN MM)
6850P

## Model 6210H Moving Magnet Closed Loop Galvanometer Based Optical Scanner

Supports apertures of 3mm, 4mm, 5mm, 6mm, and 7mm. Shown here with A connecter and 3mm Y mirror.

**Galvanometer Specifications**
All Position Detector specifications apply with our servo driver after a 30 second warm-up. All angles are in mechanical degrees. Consult manual for complete operating instructions.

**Mechanical**

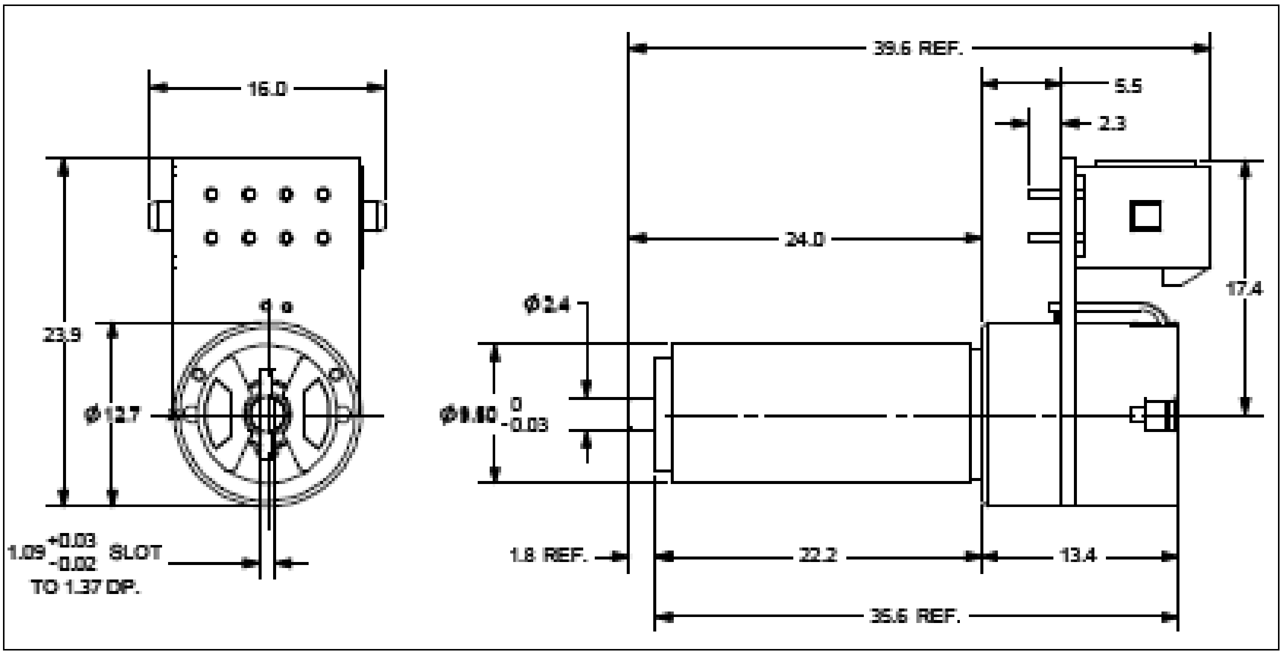
| | |
|---|---|
| Rated Angular Excursion: | 40° |
| Rotor Inertia: | 0.018 gm $cm^2$ , +/-10% |
| Torque Constant: | $2.79 \times 10^4$ dyne cm/amp, +/-10% |
| Maximum Rotor Temperature: | 110° C |
| Thermal Resistance (Coil to Case): | 2° C/Watt, Max |

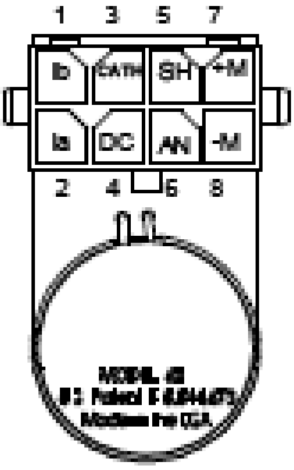
**Electrical/Drive Mechanism**

| | |
|---|---|
| Coil Resistance: | 3.72 Ohms, +/-10% |
| Coil Inductance: | 109 µH, +/-10% |
| Back EMF Voltage: | 48.7 µV/degree/sec, +/-10% |
| RMS Current: | 2.4 Amperes at Tcase of 50° C, Max |
| Peak Current: | 8 Amperes, Max |
| Small Angle Step Response Time: | 100 µs, with 3mm, Y mirror, settled to 99% |

**Position Detector**

| | |
|---|---|
| Linearity: | 99.9 %, Minimum, over 20 degrees, 99.5% Typical, over 40 degrees |
| Scale Drift: | 50 PPM/° C, Maximum |
| Zero Drift: | 15 µrad/° C, Maximum |
| Repeatability, Short Term: | 8 microradians |
| Output Signal, Common Mode: | 155 µA with AGC current of 30mA, +/-20% |
| Output Signal, Differential Mode: | 12 µA/°, at common mode current of 155 µA, +/-20% |




| PIN # | DESCRIPTION |
|---|---|
| 1 | Ib |
| 2 | Ia |
| 3 | AGC RETURN |
| 4 | DIODE COMMON |
| 5 | SHIELD |
| 6 | AGC INPUT |
| 7 | + MOTOR |
| 8 | - MOTOR |

(ALL DIMENSIONS ARE IN mm)

TOL: .X = ±.3

MASS = 18.8 GRAMS

## Model 6230H Moving Magnet Closed Loop Galvanometer Based Optical Scanner

The 6230H galvanometer can be designed and optimized for speed, size, cost and accuracy with typical beam diameters of 8mm, 10mm, 12mm, and 15mm. It is shown here with a 10mm Y mirror.

**Galvanometer Specifications**
All Position Detector specifications apply with our servo driver after a 30 second warm-up. All angles are in mechanical degrees. Consult manual for complete operating instructions.

**Mechanical Specifications**

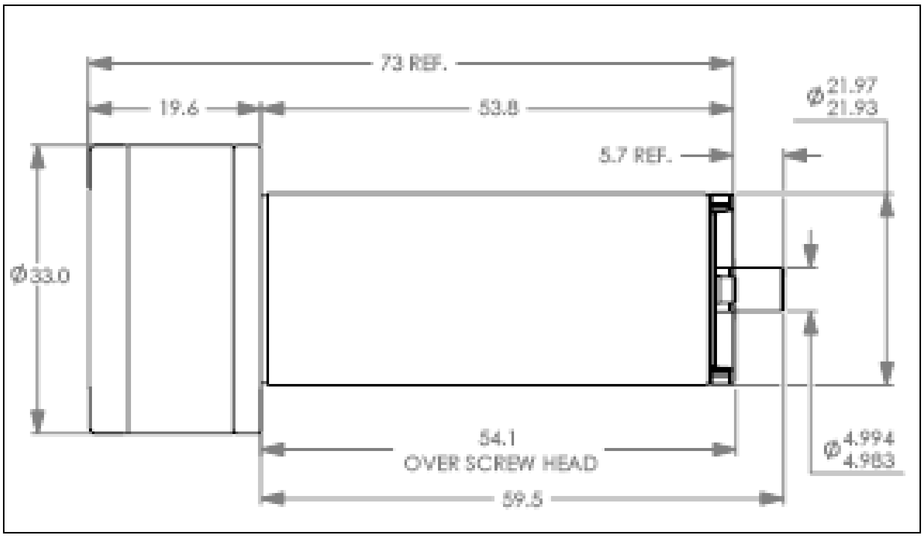
| | |
|---|---|
| Rated Angular Excursion: | 40° |
| Rotor Inertia: | 0.97 gm $cm^2$, +/-10% |
| Torque Constant: | $1.31x10^5$ dyne cm/amp, +/-10% |
| Maximum Rotor Temperature: | 110°C Thermal |
| Resistance (Rotor to Case): | 0.80°C/Watt, Max |

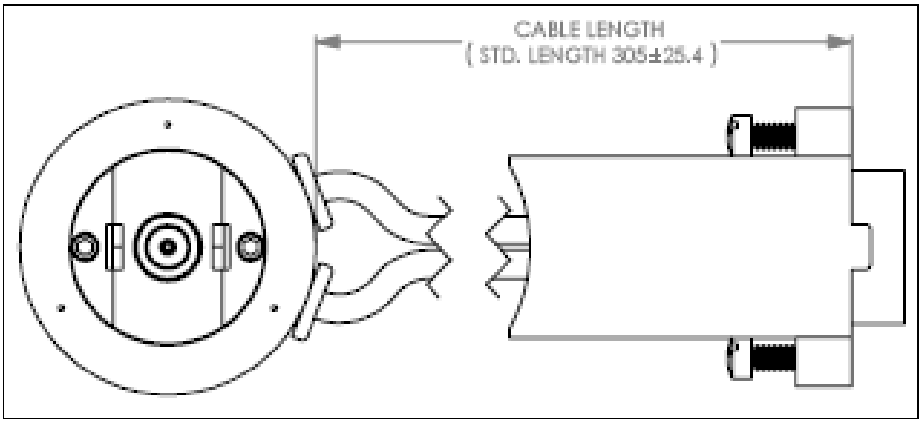
**Electrical Specifications/Drive Mechanism**

| | |
|---|---|
| Coil Resistance: | 1.07 Ohms, +/-10% |
| Coil Inductance: | 173 uH, +/-10% |
| Back EMF Voltage: | 229 µV/degree/sec, +/-10% |
| RMS Current: | 7.1 Amperes at Tcase of 50°C, Max |
| Peak Current: | 25 Amperes, Max |
| Small Angle Step Response Time: | 250 µs, with 8mm Y Mirror, settled to 99% 250 µs, with 10mm Y mirror, settled to 99% |

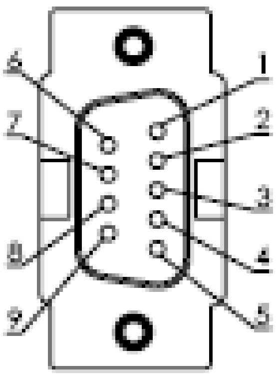
**Position Detector**

| | |
|---|---|
| Linearity: | 99.9 %, Minimum, over 20 degrees, 99.5% Typical, over 40 degrees |
| Scale Drift: | 50 PPM/°C, Maximum |
| Zero Drift: | 15 µrad/°C, Maximum |
| Repeatability, Short Term: | 8 microradians |
| Output Signal, Common Mode: | 155 µA with AGC current of 30mA, +/-20% |
| Output Signal, Differential Mode: | 11.7 µA/°, at common mode current of 155 µA, +/-20% |




(ALL DIMS ARE IN mm)
TOL. .X±.4
.XX±.13
MASS : 267 grams




| | |
|---|---|
| 1 | MOTOR + |
| 2 | MOTOR SHIELD |
| 3 | PD GND |
| 4 | DIODE COMMON |
| 5 | PD OUTPUT A |
| 6 | MOTOR - |
| 7 | PD SHIELD |
| 8 | AGC |
| 9 | PD OUTPUT B |

## Model 6231HC Moving Magnet Closed Loop Galvanometer Based Optical Scanner

The 6231H supports apertures of 8mm, 10mm, 12mm, and 15mm. It is shown here with the C connector and a 10mm Y mirror.

**Galvanometer Specifications**
All Position Detector specifications apply with our servo driver after a 30 second warm-up. All angles are in mechanical degrees. Consult manual for complete operating instructions.

**Mechanical**

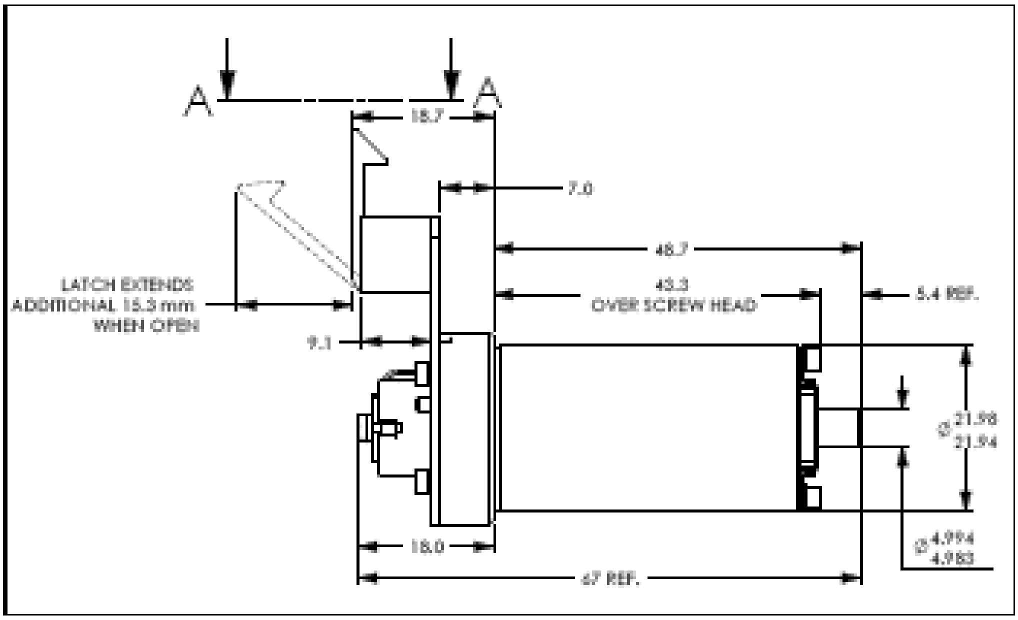
| | |
|---|---|
| Rated Angular Excursion: | 40° |
| Rotor Inertia: | 0.82 gm $cm^2$ , +/-10% |
| Torque Constant: | $1.11x10^5$ dyne cm/amp, +/-10% |
| Maximum Rotor Temperature: | 110° C |
| Thermal Resistance (Rotor to Case): | 1° C/Watt, Max |

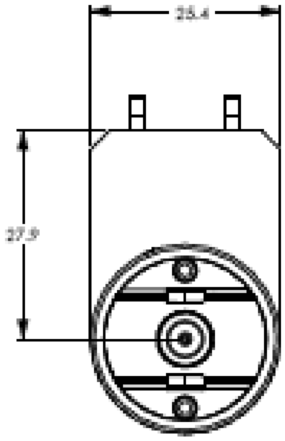
**Electrical/Drive Mechanism**

| | |
|---|---|
| Coil Resistance: | 1.27 Ohms, +/-10% |
| Coil Inductance: | 176 µH, +/-10% |
| Back EMF Voltage: | 195 µV/degree/sec, +/-10% |
| RMS Current: | 5.8 Amperes at Tcase of 50° C, Max |
| Peak Current: | 25 Amperes, Max |
| Small Angle Step Response Time: | 250 µs, with balanced load of 0.3 $gm*cm^2$ |

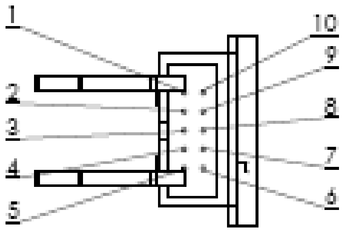
**Position Detector**

| | |
|---|---|
| Linearity: | 99.9 %, Minimum, over 20 degrees, 99.5% Typical, over 40 degrees |
| Scale Drift: | 50 PPM/° C, Maximum |
| Zero Drift: | 15 µrad/° C, Maximum |
| Repeatability, Short Term: | 8 microradians |
| Output Signal, Common Mode: | 155 µA with AGC current of 30mA, +/-20% |
| Output Signal, Differential Mode: | 11.7 µA/°, at common mode current of 155 µA, +/-20% |




(ALL DIMENSIONS ARE IN mm)
TOL: .X ±.4
.XX ±.13
MASS = 144 grams




A-A

| PIN | DESCRIPTION |
|---|---|
| 1 | PD OUTPUT B |
| 2 | PD GND |
| 3 | AGC |
| 4 | PD SHIELD |
| 5 | MOTOR + |
| 6 | MOTOR - |
| 7 | PD SHIELD |
| 8 | PD SHIELD |
| 9 | PD OUTPUT A |
| 10 | PD GND |

## Model 6240H Moving Magnet Closed Loop Galvanometer Based Optical Scanner

The 6240H galvanometer can be designed and optimized for speed, size, cost and accuracy with typical beam diameters of 12mm, 15mm, 20mm, 25mm, and 30mm. It is shown here with a 12mm Y mirror.

**Galvanometer Specifications**
All Position Detector specifications apply with our servo driver after a 30 second warm-up. All angles are in mechanical degree. Consult manual for complete operating instructions.

**Mechanical Specifications**

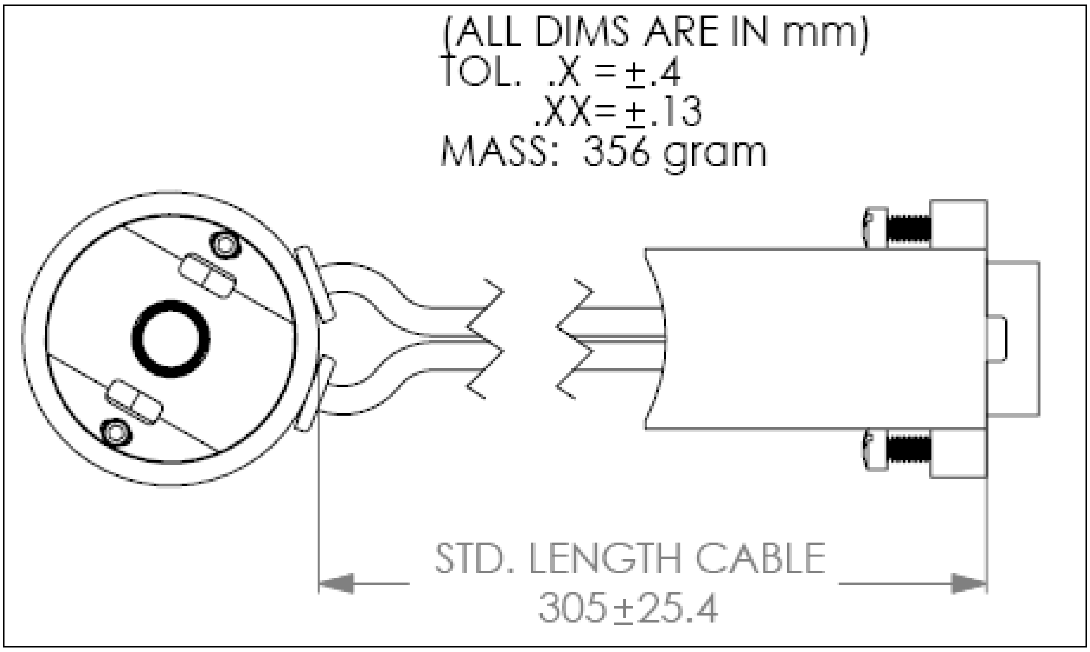
| | |
|---|---|
| Rated Angular Excursion: | 40° |
| Rotor Inertia: | 2.4 gm $cm^2$, +/-10% |
| Torque Constant: | $2.0x10^5$ dyne cm/amp, +/-10% |
| Maximum Coil Temperature: | 110°C |
| Thermal Resistance (Coil to Case): | 0.62°C/Watt, Max |

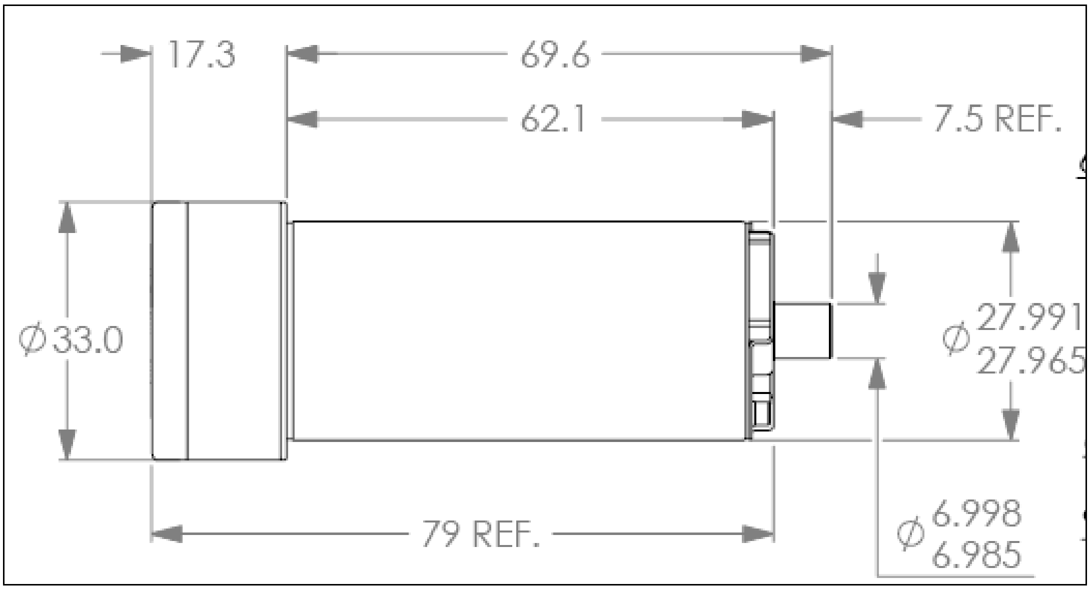
**Electrical Specifications/Drive Mechanism**

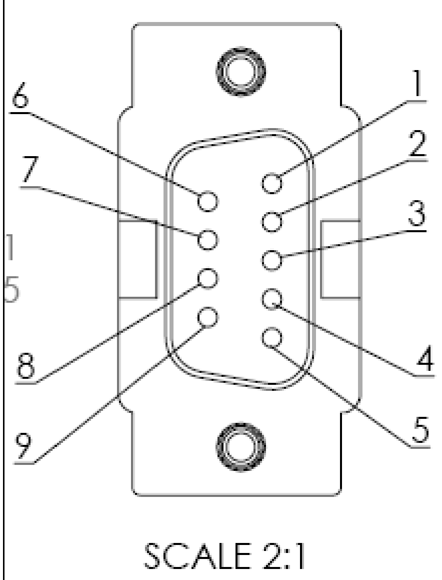
| | |
|---|---|
| Coil Resistance: | 1.03 Ohms, +/-10% |
| Coil Inductance: | 350µH, +/-10% |
| Back EMF Voltage: | 346 µV/degree/sec, +/-10% |
| RMS Current: | 8.2 Amperes at Tcase of 50°C, Max |
| Peak Current: | 25 Amperes, Max |
| Small Angle Step Response Time: | 300 µs, with 12mm Y mirror, settled to 99%<br>350µs, with 15mm Y mirror, settled to 99%<br>650 µs, with 20mm Y mirror, settled to 99% |

**Position Detector**

| | |
|---|---|
| Linearity: | 99.9 %, Minimum, over 20 degrees, 99.5% Typical, over 40 degrees |
| Scale Drift: | 50 PPM/°C, Maximum |
| Zero Drift: | 15 µrad/°C, maximum |
| Repeatability, Short Term: | 8 microradians |
| Output Signal, Common Mode: | 155 µA with AGC current of 30mA, +/-20% |
| Output Signal, Differential Mode: | 11.7 µA/°, at common mode current of 155 µA, +/-20% |




| | |
|---|---|
| 1 | MOTOR + |
| 2 | MOTOR SHIELD |
| 3 | PD GND |
| 4 | DIODE COMMON |
| 5 | PD OUTPUT A |
| 6 | MOTOR - |
| 7 | PD SHIELD |
| 8 | AGC |
| 9 | PD OUTPUT B |

## Model 6870 Moving Magnet Capacitive Position Detector Optical Scanner

Supports 12mm and 15mm beam apertures.

**Galvanometer Specifications**
All Position Detector specifications apply with our servo driver after a 30 second warm-up. All angles are in mechanical degree. Consult manual for complete operating instructions.

**Mechanical Specifications**

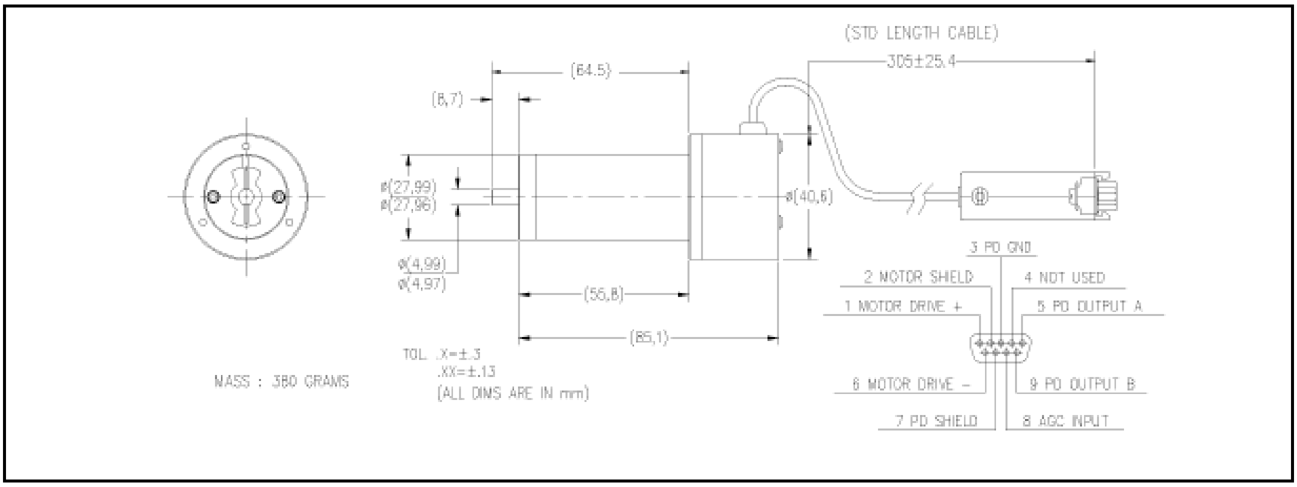
| | |
|---|---|
| Rated Angular Excursion: | 40° |
| Rotor Inertia: | 2.0 gm*cm$^2$, +/-10% |
| Torque Constant: | 1.8X10$^5$dyne-cm/amp, +/-10% |
| Maximum Coil Temperature: | 110°C |
| Thermal Resistance (Coil to Case): | 1.0°C/Watt, Max |

**Electrical Specifications/Drive Mechanism**

| | |
|---|---|
| Coil Resistance: | 1.4 Ohms, +/-10% |
| Coil Inductance: | 275uH, +/-10% |
| Back EMF Voltage: | 0.3mV/degree/sec, +/-10% |
| RMS Current: | 5.3 Amperes at Tcase of 50°C, Max |
| Peak Current: | 25 Amperes, Max |
| Small Angle Step Response Time: | 0.7ms, with balanced 2.0gm*cm$^2$ load |

**Position Detector**

| | |
|---|---|
| Linearity: | 99.9%, Minimum, over 40 degrees |
| Scale Drift: | 50PPM/°C, Maximum |
| Zero Drift: | 15 microradians/°C, Maximum |
| Repeatability, Short Term: | 8 microradians |
| Output Signal, Common Mode: | 585 microamperes with AGC voltage of 10VDC, +/-20% |
| Output Signal, Differential Mode: | 14.5 µA/degree, at common mode current of 585 µA, +/-20% |



## Model 6880 Moving Magnet Capacitive Position Detector Optical Scanner

Supports 20 mm and 30 mm beam apertures.

**Galvanometer Specifications**

All Position Detector specifications apply with our servo driver after a 30 second warm-up. All angles are in mechanical degrees. Consult manual for complete operating instructions.

**Mechanical Specifications**

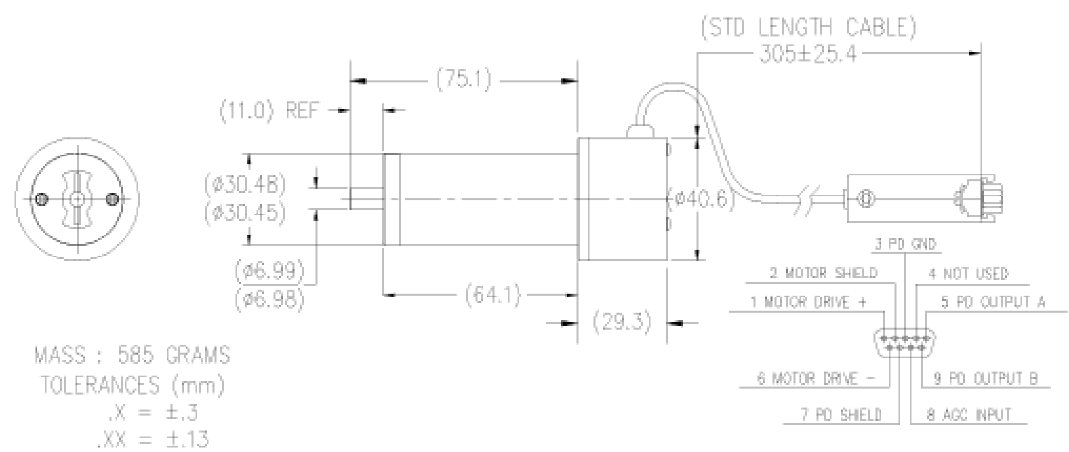
| | |
|---|---|
| Rated Angular Excursion: | 40° |
| Rotor Inertia: | 6.4 gm*cm$^2$, +/-10% |
| Torque Constant: | 2.54X10$^5$dyne-cm/amp, +/-10% |
| Maximum Coil Temperature: | 110°C |
| Thermal Resistance (Coil to Case): | 0.75°C/Watt, Max |

**Electrical Specifications/Drive Mechanism**

| | |
|---|---|
| Coil Resistance: | 1.0 Ohms, +/-10% |
| Coil Inductance: | 280uH, +/-10% |
| Back EMF Voltage: | 0.44mV/degree/sec, +/-10% |
| RMS Current: | 7.5 Amperes at Tcase of 50°C, Max |
| Peak Current: | 25 Amperes, Max |
| Small Angle Step Response Time: | 0.9ms, with balanced inertia matched load |

**Position Detector**

| | |
|---|---|
| Linearity: | 99.9%, Minimum, over 40 degrees |
| Scale Drift: | 50PPM/°C, Maximum |
| Zero Drift: | 10 microradians/°C, Maximum |
| Repeatability, Short Term: | 8 microradians |
| Output Signal, Common Mode: | 970 microamperes with AGC voltage of 10VDC, +/-20% |
| Output Signal, Differential Mode: | 22 µA/degree, at common mode current 970 µA, +/- 20% |



## Model 6400 Moving Coil Capacitive Position Detector Optical Scanner

Supports apertures greater than 50 mm.

**Mechanical Specifications**

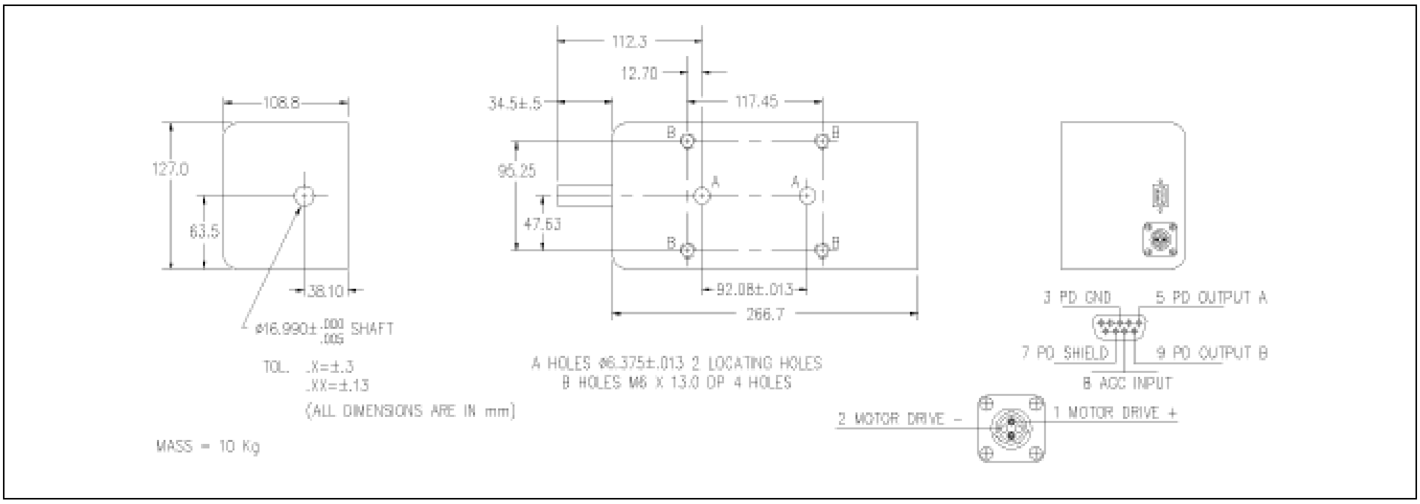
| | |
|---|---|
| Rated Angular Excursion: | 40° |
| Rotor Inertia: | 1300 gm*cm$^2$, +/-10% |
| Torque Constant: | 4.5X10$^6$dyne-cm/amp, +/-10% |
| Maximum Coil Temperature: | 150°C |
| Thermal Resistance (Coil to Case): | 0.45°C/Watt, Max |

**Electrical Specifications/Drive Mechanism**

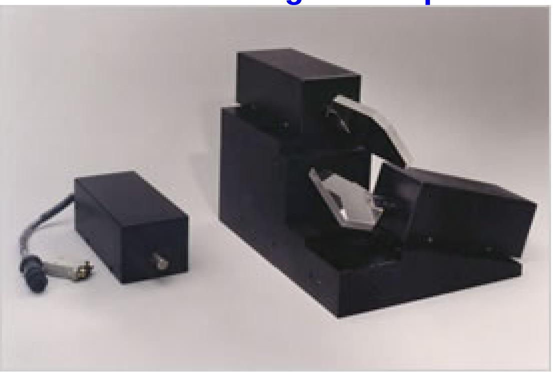
| | |
|---|---|
| Coil Resistance: | 0.9 Ohms, +/-10% |
| Coil Inductance: | 4500uH, +/-10% |
| Back EMF Voltage: | 9.2mV/degree/sec, +/-10% |
| RMS Current: | 14 Amperes at Tcase of 50°C, Max |
| Peak Current: | 60 Amperes, Max |
| Small Angle Step Response Time: | 8.0ms, with balanced inertia matched load |

**Position Detector**

| | |
|---|---|
| Linearity: | 99.9%, Minimum, over 40 degrees |
| Scale Drift: | 50PPM/°C, Maximum |
| Zero Drift: | 15 microradians/°C, Maximum |
| Repeatability, Short Term: | 2 microradians |
| Output Signal, Common Mode: | 1570 microamperes with AGC voltage of 10VDC, +/-20% |
| Output Signal, Differential Mode: | 26.5 µA/degree, at common mode current of 1570 µA, +/-20% |



## Model 6900 Moving Coil Capacitive Position Detector Optical Scanner



Supports 50 mm apertures.

**Mechanical Specifications**

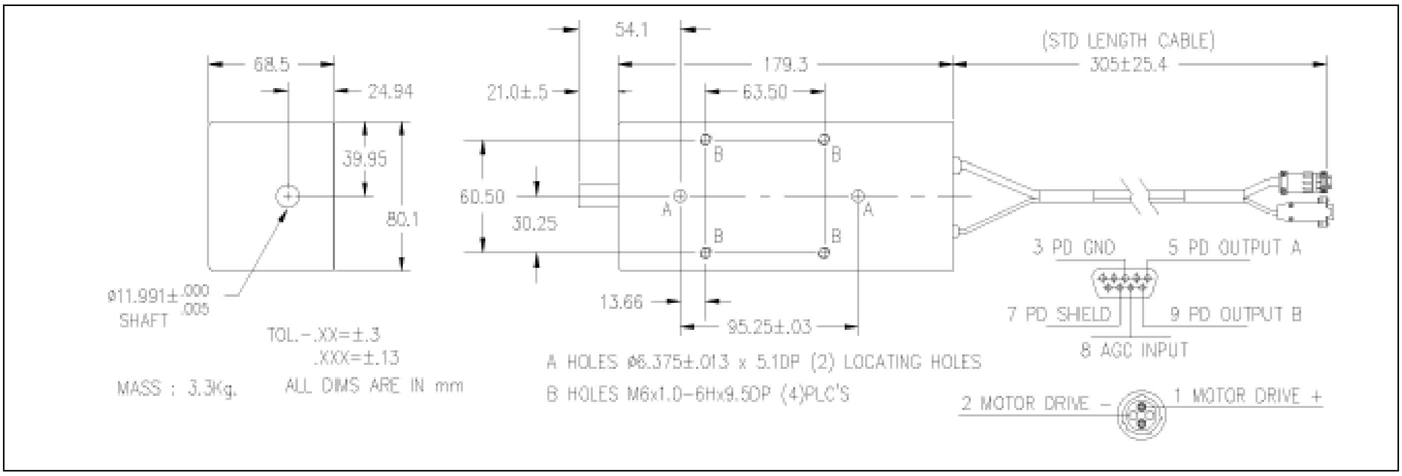
| | |
|---|---|
| Rated Angular Excursion: | 40° |
| Rotor Inertia: | 70 gm*cm$^2$, +/-10% |
| Torque Constant: | 1.63X10$^6$dyne-cm/amp, +/-10% |
| Maximum Coil Temperature: | 150°C |
| Thermal Resistance (Coil to Case): | 1.25°C/Watt, Max |

**Electrical Specifications/Drive Mechanism**

| | |
|---|---|
| Coil Resistance: | 2.2 Ohms, +/-10% |
| Coil Inductance: | 750uH, +/-10% |
| Back EMF Voltage: | 2.85 mV/degree/sec, +/-10% |
| RMS Current: | 5.0 Amperes at Tcase of 50°C, Max |
| Peak Current: | 25 Amperes, Max |
| Small Angle Step Response Time: | 6.0ms, with balanced inertia matched load |

**Position Detector**

| | |
|---|---|
| Linearity: | 99.9%, Minimum, over 40 degrees |
| Scale Drift: | 50PPM/°C, Maximum |
| Zero Drift: | 10 microradians/°C, Maximum |
| Repeatability, Short Term: | 1.5 microradians |
| Output Signal, Common Mode: | 1730 microamperes with AGC voltage of 5.4VDC, +/-20% |
| Output Signal, Differential Mode: | 48 µA/degree, at common mode current of 1730 µA, +/-20% |



## Servo Electronics

We offer several high performance, board level and rack mount drive electronics configurations. The use of advanced automatic gain control (AGC) and low noise damping found in our complete line of drivers provide high quality and stable positioning. Designed with flexibility in mind, each driver can be configured for operation with most of our extensive line of precision closed loop galvanometer based optical scanners. All of our drivers operate from an analogue command input of up to +/-10V which can be scaled to up to +/-20 mechanical degrees scanner rotation. Digital input options are also available on many of our products. The servo options include several package and feature sets including both Class 1 Integrating and Class 0 Non-integrating configurations.

**SMT Drivers**

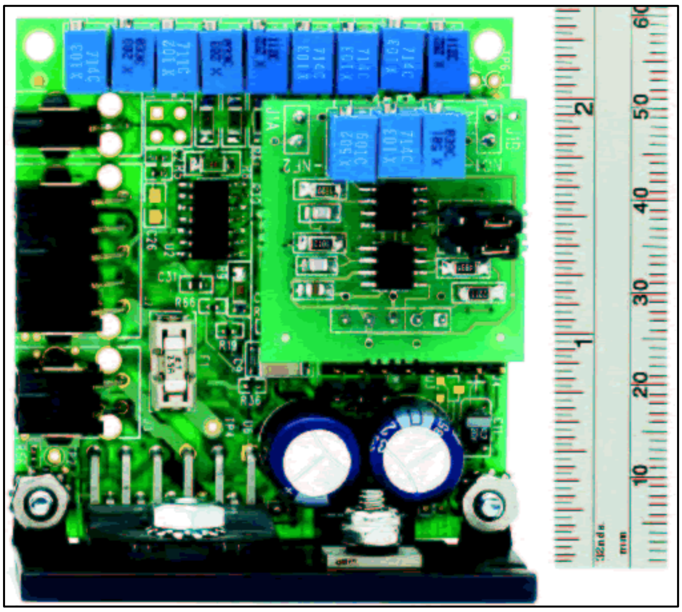
The Surface Mount Technology (SMT) design and packaging of our MicroMax drivers yield high performance operation in extremely compact packages and very attractive OEM prices. Integral mounting hardware, convenient placement of system tuning and setup adjustments and overall servo size further support compact system designs and ease of integration. Optional bandwidth enhancement modules extend system bandwidth and positioning speeds to new levels. The MicroMax series offers two available models.

### *The MicroMax 670XX Driver Board*

Our advanced servo topology and Class 1 error integration provides excellent positioning repeatability, accuracy and stability in a compact single axis configuration. High stability components provide excellent time and temperature stability. Built-in system conditioning and status monitoring ensures complete and reliable system control during integration and operation.

### MicroMax® Model 677XX

Board level single axis driver electronics



**FEATURES:**

- Smallest Servo Driver For Compact, Low Cost System Integration
- Position, Error and Velocity Output Signals
- Input Scale and Offset Adjustment
- On Board Protection Circuitry

The MicroMax Model 677XX driver provides an extremely compact, high performance and fully featured servo package at a very attractive price. At just 2 inches in width and 2.5 in length it is among the smallest servo drivers commercially available, bringing easier integration to your scanning solution. Featuring automatic gain control (AGC), low noise system damping, linearity compensation and high stability components, the 677XX servo provides high quality and stable positioning.

Designed with flexibility in mind, the MicroMax Model 677XX features differential analogue inputs, flexible power supply configurations and positioning control allowing for optimization of system positioning angles, speed and accuracy. System position, velocity and error output signals make integrations into complex scanning system applications easy and accurate. Integral mounting hardware, low profile connectors and the overall small size allow for compact system designs with easy integration.

The New Smaller Size MicroMax 677XX single axis servo driver can be configured for optimal performance with our 6200 and 6800 line of closed loop, galvanometer based optical scanners. Used with our patented position detection galvanometer technology, the MicroMax 677XX provides improved time and temperature stability without the need for thermal compensation. On board protection circuitry ensures reliable system control during integration and operation. To guarantee safe operation and extended product lifetime, the MicroMax 677XX monitors and controls galvanometer rms power and features a socketed fuse for added system protection. It also utilizes servo signal conditioning to maintain controlled performance within rated angular excursion limits. This combination of size, flexibility and price make the MicroMax Model 677XX the ideal choice where high levels of speed and performance are required in the most compact environment.

**Specifications:**

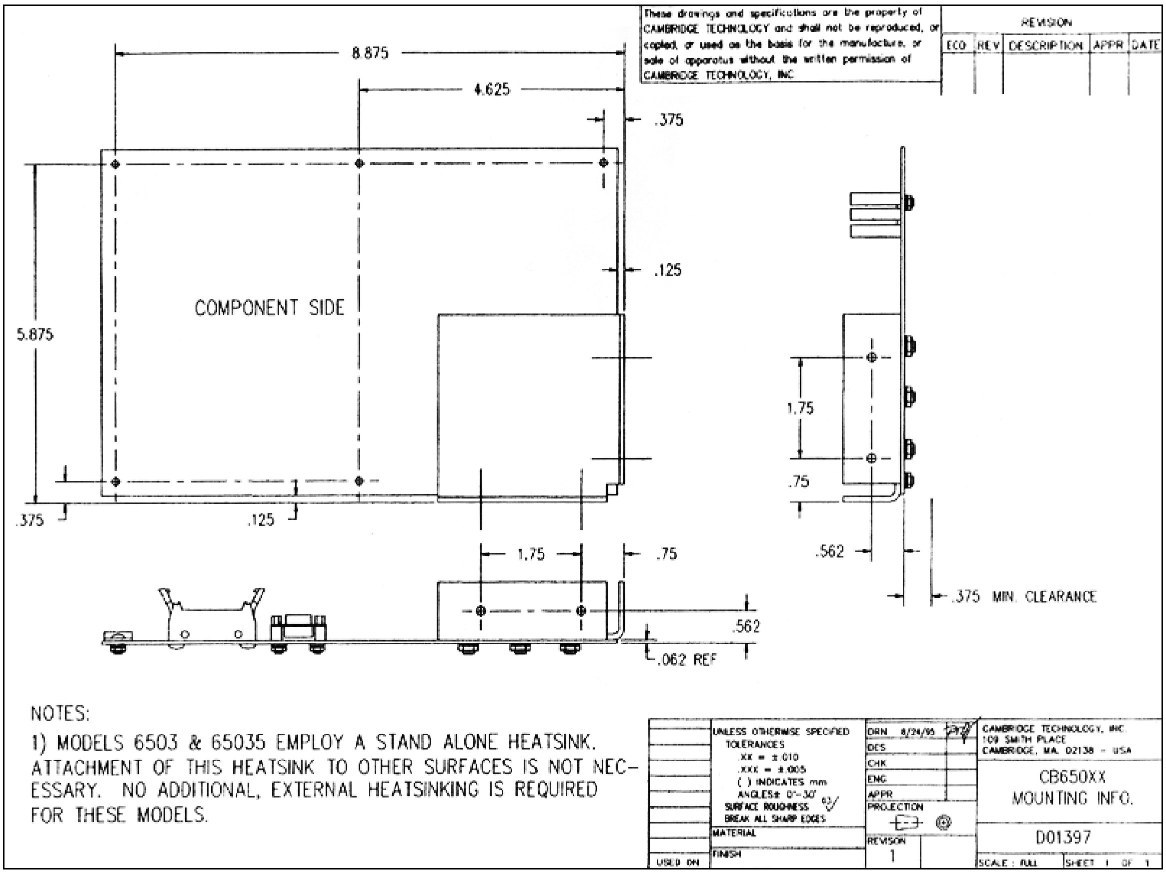
| | |
|---|---|
| Analog Input Impedance | 400K +/-1% ohms (Differential)<br>200K +/-1% ohms (Single Ended) |
| Analog Output Impedance | 1K +/-1% ohms (for all other observation outputs) |
| Position Input Scale Factor | 0.5 volt/mechanical degree (40$^o$ System), 0.67 volt/degree (30$^o$ System) |
| Position Input Range | +/-10 volts, maximum |
| Position Offset Range | +/-10 volts |
| Position Output Scale Factor | 0.5 volt/degree |
| Error Output Scale Factor | 0.5 volt/degree |
| Velocity Output Scale Factor | Analog output (scaled by position differentiator gain) |
| Power Supply Requirements | +/-15 to +/-28VDC configurations available |
| Maximum Drive Current Limit | 10 amps peak<br>5 amps rms (power supply and load dependent) |
| Operating Temperature Range | 0 -50 oC |
| Size | 5.08 cm x 6.35 cm x 2.69 cm |

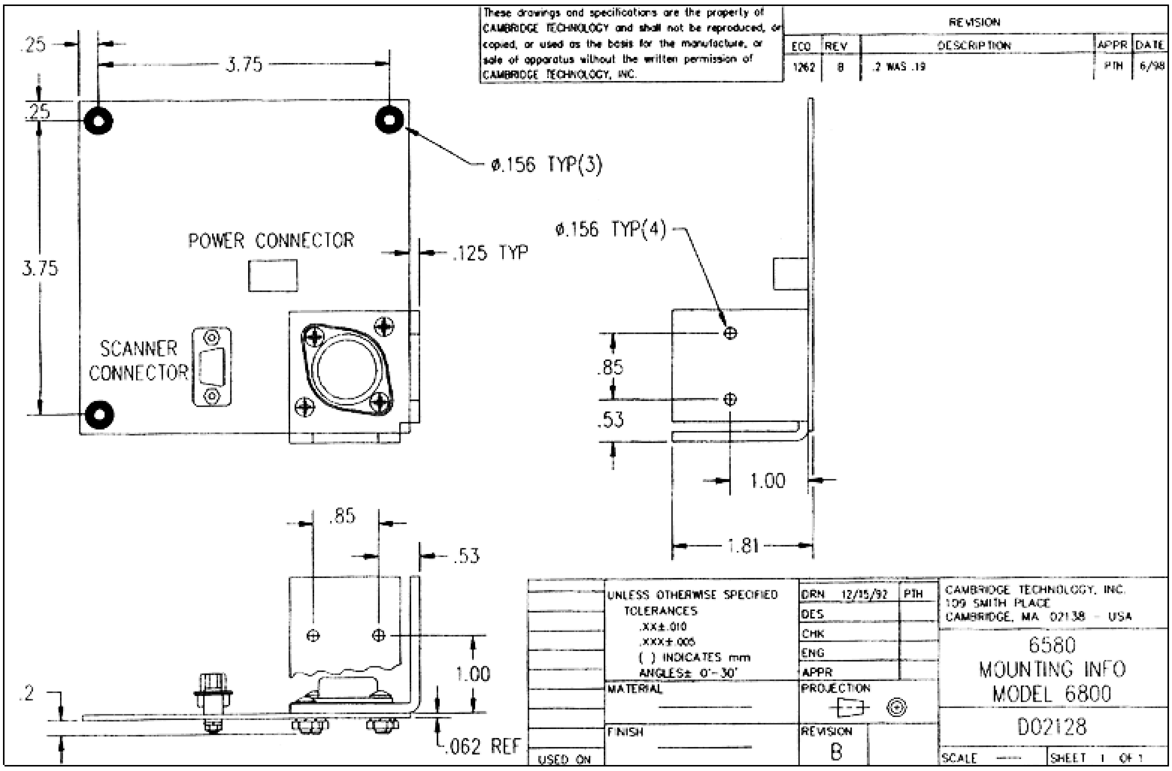
## The MicroMax 678XX Driver Board

Our advanced Class 0 non-integrating servo topology provides the highest positioning speed and lowest cost in a compact single axis configuration. Differential analogue inputs, flexible power supply configurations and positioning control allow for optimization of system positioning angle, speed, accuracy and cost. Servo signal conditioning, and continuous power monitoring and adjustment maintain controlled performance within the rated angular excursion limits.

### *Servo Drivers*

For existing and specific OEM and system applications, the model 650XX Integrating and 658XX Non-integrating servos based on our proven Class 1 and Class 0 servo architectures offer excellent positioning performance. These servo capabilities are also offered in the model 653XX dual axis servo board.




### *Rack Mount Drivers*

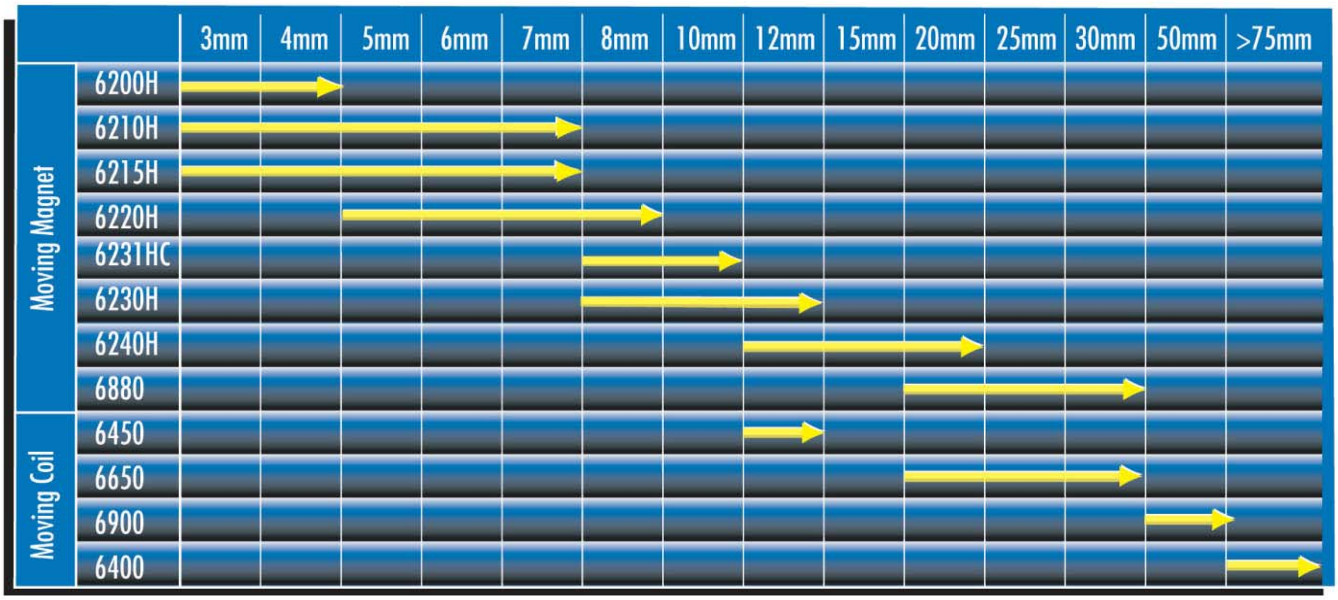
Rack Mount Driver Boxes are also available for those applications requiring proven Class 1 and Class 0 servo driver capability and/or the highest peak galvo drive capability in a fully integrated and packaged servo control unit. Only a structured command input signal and AC power are required. The Rack Mount Drivers are available in both the model 602XX single axis and the model 603XX dual axis configurations.

## Galvo Selection Guide

| Galvo Model | Step Response Time with mirror | Current RMS Max at 50º C | Torque Constant Dyne-cm/Amp ± 10% | Scale Drift ppm per °C | Zero Drift µrad per °C | Linearity | Short Term Repeatability µrad |
|---|---|---|---|---|---|---|---|
| 6200H | 130us/3mm | 2.3 | $1.2 \times 10^4$ | 50 | 15 | 99.9% | 8 |
| 6210H | 100us/3mm | 2.4 | $2.79 \times 10^4$ | 50 | 15 | 99.9% | 8 |
| 6215H | 175us/6mm | 4.1 | $3.78 \times 10^4$ | 50 | 15 | 99.9% | 8 |
| 6220H | 195us/5mm | 3.9 | $6.17 \times 10^4$ | 50 | 15 | 99.9% | 8 |
| 6231HC | 210us/8mm | 5.8 | $1.11 \times 10^5$ | 50 | 15 | 99.9% | 8 |
| 6230H | 250us/10mm | 7.1 | $1.31 \times 10^5$ | 50 | 15 | 99.9% | 8 |
| 6240H | 350us/15mm | 8.2 | $2.00 \times 10^5$ | 50 | 15 | 99.9% | 8 |
| 6880 | 0.9ms/20mm | 7.5 | $2.54 \times 10^5$ | 50 | 10 | 99.9% | 8 |
| 6450 | 2ms/12mm | 1.8 | $.045 \times 10^6$ | 50 | 15 | 99.9% | 2 |
| 6650 | 3.5ms/20mm | 2.8 | $0.65 \times 10^6$ | 50 | 10 | 99.9% | 1.5 |
| 6900 | 6ms/50mm | 5 | $1.63 \times 10^6$ | 50 | 10 | 99.9% | 1.5 |
| 6400 | 8ms/75mm | 14 | $4.5 \times 10^6$ | 50 | 15 | 99.9% | 2 |

**Recommended Galvos by Beam Aperture**

We have the widest range of galvos available in the market giving our customers the flexibility to select a galvo to optimize price, performance, and footprint requirements of their application. Each galvo model, although ideally suited for a particular aperture, will also operate mirror sets larger and smaller than the optimum mirror set. In some applications, the user may choose to implement a smaller, less expensive galvo to operate a larger mirror set as a cost-saving strategy while other users may opt for a galvo with "undersized" mirrors to maximize the rotor stiffness for positioning performance considerations. The chart below lists the popular range of mirror apertures for each galvo model. Of course, some users also go outside these ranges to fully optimize their application.



**3mm Beam Aperture Galvanometers**

In selecting a galvanometer, many factors determine the best solution for a specific application. Whether it is speed, accuracy, size or price, these factors must be weighted against each other depending on your design goals. We however make this process easier by offering the broadest range of closed loop galvanometers in the world.

We offer three different galvanometers in the 3mm beam diameter scanning range. Each one designed specifically to meet the high demands of speed, accuracy, size and cost. Below each galvanometer features are highlighted and a comparison chart is also provided detailing the specifications of each scanner.

| 6200H | 6210H | 6800HP |
|---|---|---|
| Moving Magnet with Advanced Optical Detector | Moving Magnet with Advanced Optical Detector | Moving Magnet with Dual Optical Detector |
| High Speed | Highest Speed possible | High Speed |
| High Accuracy | High Accuracy | High Accuracy |
| Smallest Footprint available | Higher Torque Constant than 6200H | Not recommended for new designs |
| Lowest Cost | | |

**5mm Beam Aperture Galvanometers**

We offer five galvanometers in the 5mm Beam Diameter scanning range. Each one designed specifically to meet the high demands of speed, accuracy, size and cost. Below each galvanometer features are highlighted and a comparison chart is also provided detailing the specifications of each scanner.

| 6215H | 6220H | 6810P | 6860 | 6350 |
|---|---|---|---|---|
| Moving Magnet with Advanced Optical Position Detector | Moving Magnet with Advanced Optical Detector | Moving Magnet with Optical Detector | Moving Magnet with Capacitive Rear Detector | Moving Coil with Capacitive Front Detector |
| Highest Speed Available | High Speed | High Speed | Slower Speed than 6220, 6810P | Slower Speed than 6215H,6220H, 6810P |
| High Accuracy | High Accuracy | High Accuracy | Higher Accuracy | Highest Accuracy |
| Best cost per performance Galvo | | Not recommended for new designs | | Best Torque/Watt |

**8mm Beam Aperture Galvanometers**

In the 8mm Beam Diameter scanning range, we offer the 6220. This galvo model is designed specifically to meet the high demands of speed, accuracy, size and cost and has been proven to give an optimal performance in applications requiring 8mm beam diameter scanning.  Our engineers will work with you to determine the best product for your unique applications and requirements.

**10mm Beam Aperture Galvanometers**

We offer four galvanometers in the 10mm beam diameter scanning range. Each one designed specifically to meet the high demands of speed, accuracy, size and cost. Below each galvanometer features are highlighted and a comparison chart is also provided detailing the specifications of each scanner.

| 6220H | 6230H | 6850P | 6860 | 6350 |
|---|---|---|---|---|
| Moving Magnet with Advanced Optical Detector | Moving Magnet with Advanced Optical Detector | Moving Magnet with Optical Detector | Moving Magnet with Capacitive Rear Detector | Moving Coil with Capacitive Front Detector |
| Acceptable speed for many applications | Highest Speed Available | High Speed | Higher Accuracy than 6230, 6850P | Highest Accuracy |
| High Accuracy | High Accuracy | High Accuracy | Slower Speed than 6220 | Slower Speed than 6230, 6850P, 6860 |
| Lowest cost 10mm solution | Best cost per performance Galvo | Not recommended for new designs | Legacy favourite | Best Torque/Watt |

**12mm Beam Aperture Galvanometers**

We offer three galvanometers in the 12mm beam diameter scanning range. Each one designed specifically to meet the high demands of speed, accuracy, size and cost. Below each galvanometer features are highlighted and a comparison chart is also provided detailing the specifications of each scanner.

| 6240 | 6870 | 6450 |
|---|---|---|
| Moving Magnet with Advanced Optical Detector | Moving Magnet with Capacitive Detector | Moving Coil with Capacitive Detector |
| Highest Speed Available | High Speed | Highest Accuracy |
| High Accuracy | High Accuracy | Best Torque/Watt |
| Newest Product | Only recommended for certain applications | Not recommended for new designs |
| Best cost per performance | | |

**15mm Beam Aperture Galvanometers**

We offer two galvanometers in the 15mm beam diameter scanning range. Each one designed specifically to meet the high demands of speed, accuracy, size and cost. Below each galvanometer features are highlighted and a comparison chart is also provided detailing the specifications of each scanner.

| 6240 | 6870 |
|---|---|
| Moving Magnet with Advanced Optical Detector | Moving Magnet with Capacitive Detector |
| Highest Speed Available | High Speed |
| High Accuracy | High Accuracy |
| Newest Product | Only recommended for certain applications |
| Best cost per performance | |
| | |

**20mm Beam Aperture Galvanometers**

We offer two galvanometers in the 20 mm beam diameter scanning range. Each one designed specifically to meet the high demands of speed, accuracy, size and cost. Below each galvanometer features are highlighted and a comparison chart is also provided detailing the specifications of each scanner.

| | | |
|---|---|---|
| 6240 | 6880 | 6650 |
| Moving Magnet with Advanced Optical Detector | Moving Magnet with Capacitive Detector | Moving Coil with Capacitive Detector |
| Highest Speed Available | High Speed | Highest Accuracy |
| High Accuracy | High Accuracy | Best Torque/Watt |
| Newest Product | Compact Footprint | |
| Best cost per performance | | |

**30mm Beam Aperture Galvanometers**

We offer two galvanometers in the 30mm beam diameter scanning range. Each one designed specifically to meet the high demands of speed, accuracy, size and cost. Below each galvanometer features are highlighted and a comparison chart is also provided detailing the specifications of each scanner.

| | |
|---|---|
| 6880 | 6650 |
| Moving Magnet with Capacitive Detector | Moving Coil with Capacitive Detector |
| Highest Speed | Highest Accuracy |
| High Accuracy | Best Torque/Watt |
| Compact Footprint | |
| Best price per performance | |

**50mm Beam Aperture Galvanometers**

We offer two galvanometers in the 50mm beam diameter scanning range. Each one designed specifically to meet the high demands of speed, accuracy, size and cost. Below each galvanometer features are highlighted and a comparison chart is also provided detailing the specifications of each scanner.

| | |
|---|---|
| 6900 | 6400 |
| Moving Coil with Capacitive Detector | Moving Coil with Capacitive Detector |
| Highest Speed | Highest Accuracy |
| Highest Accuracy | More Available Torque |
| Lower cost than 6400 | Can handle mirrors up to 75mm beam diameter |
| Smaller footprint | |

# Choosing the Right Galvanometer and Servo for the Job

Galvanometer-based optical scanners are the preferred positioning solution for an increasingly broad range of industrial, scientific, imaging, and medical laser applications. While a number of scanning approaches are available, galvanometer-based scanners — commonly called "galvos" — offer flexibility, speed and accuracy at an attractive cost. While many imaging applications take advantage of the galvo's ability to provide a constant velocity for superior image quality, other vector-based scanning applications benefit from the fast step response times of modern galvos. With continued advances in galvo and servo technology, the devices today offer closed loop bandwidths of several kilohertz even for larger beams, step-response times in the 100-&s range, max rms frequency >2kHz, single microradian- level positioning resolution, lower costs per axis and flexible positioning control to describe a variety of motions across wide angles.

This has enabled new levels of performance in laser marking and other material processing applications, via drilling, high resolution print and imaging applications, DNA analysis and drug discovery systems, and low cost biomedical systems that bring screening and detection capabilities from the research lab to the doctor's office. The design requirements of each application, however, place varying emphasis on speed, accuracy, size and cost.

Fortunately, the many galvo configurations and capabilities enable system designers to select the optimal product for the requirements of the target application.

**Components and Technology**

A galvo system consists of three main components: the galvanometer, the mirror (or mirrors) and the servo driver that controls the system. As galvo systems offer higher speeds and performance, the correct design and proper selection among these components becomes increasingly important to achieving maximum performance. As galvo systems have reached 100-&s step times and rms frequencies have reached >2kHz, many of the design rules and principles that applied when system-positioning performance was measured in milliseconds are no longer adequate.

**The Galvanometer**

The galvo itself has two major parts: the actuator that manipulates the mirror load and the integral position detector that provides mirror position information to the closed loop system.

Two actuator configurations commonly serve today's high-performance systems. The moving magnet, in which the magnet is part of the rotor and the coil is part of the stator, provides the highest system-resonant frequencies because of its uniform rotor design. The moving coil, in which the coil is integral to the rotor and in which the magnet is part of the stator, offers the highest torque-to-inertia ratio and the highest torque efficiency.

In the two common types of position detectors, the detector element moves as part of the galvo rotor structure. In the moving dielectric capacitive design, a radiofrequency source drives two variable capacitors, and the resulting rectified differential currents report the position of the galvo actuator and mirror. In the new optical position detector designs, a light source illuminates parts of four photocells. Between the light source and the receivers, a moving butterfly like shape casts more or less shadow onto pairs of the receiver cells. The resulting currents report the position of the galvo actuator and mirror.

The design of the positioning detector greatly defines the positioning accuracy of the system, and its inertial and resonant frequency characteristics affect the speed of the system. The compact, low-noise and low inertia features of our patented optical position detectors provide higher speed, smaller size, and
reduced cost compared with capacitive devices, without sacrificing accuracy or stability. Moreover, some capacitive detectors can emit RF electrical noise that can interfere with nearby electronics in the

system
and this noise is eliminated with optical position detectors.

**The Mirror**

The mirror is an important component of the system, particularly at increased speeds. Its design can make or break the design goals for speed and accuracy.

At the most basic level, a mirror or mirrors must hold the required beam diameter over the required angular range specified in the typical application. The mirror thickness, profile, cross section and materials (most commonly synthetic fused silica, silicon or beryllium) are all important. They influence the system's inertia as well as the stiffness and resonant frequency of the actuator and mirror assembly.

Increases in stiffness and resonant frequency that do not greatly add to total system inertia enable faster response times and higher bandwidth. Therefore, the mirror design affects not only the optical path and cost of the galvo system, but also the speed and accuracy of the overall system.

In two-axis steered-beam systems, a distance between the axes of rotation and the available angular range of the design usually requires the second mirror in the system to be larger than the first. Because of this, the second mirror can be the component that limits the speed of the entire two axis system, making its design and construction critical. In an optimized two-axis design, the second mirror in such a system will provide only slight limits to system speed, as compared with the first mirror.

**The Servo Driver**


The final component of the galvo system is the servo circuitry that drives the galvo and controls the position of the mirror. The servo demodulates the position detector's current output signals, compares them with the commanded position signal and drives the actuator to bring the galvo to the desired position, forcing error between the signals nearly to zero.

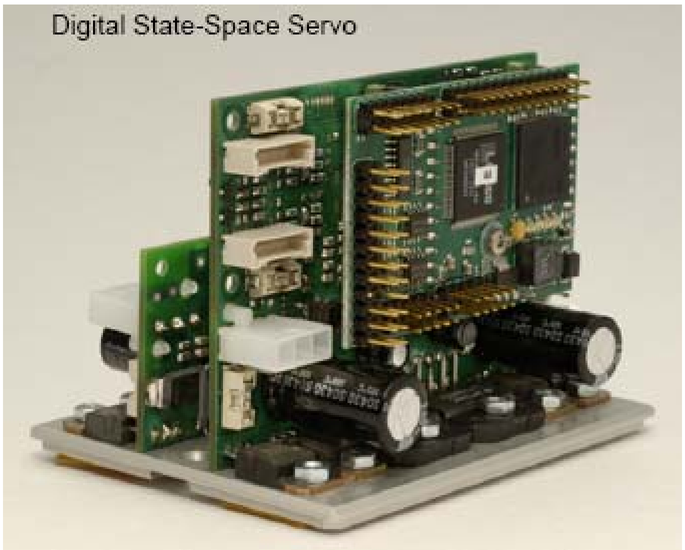
Typical servos use a combination of the detected position, galvo drive current, angular velocity, and error or integral-of-error signals to enable closed-loop system control at the desired positioning speed and accuracy. Just as there have been many advances in the design of actuators and position detectors, ongoing developments in servo electronics have been critical to taking the fullest advantage of galvo advances in bandwidth and rms capability. New digital servo architectures such as State-Space, have pushed galvo performance beyond what was achievable with analog or digital PID servos.

**Analog Servo Configurations**

Two analog servo configurations commonly optimize or balance the speed and accuracy requirements, which often compete in importance. An integrating servo, referred to as Class 1, or PID (Proportional-Integral-Derivative), uses integrated position error to settle to the highest level of positioning accuracy with the least angular error. Applications that value precision over speed often rely on integrating Class 1
servo controllers. A non-integrating servo, or Class 0, can provide higher system speeds because it avoids the integration time. This configuration is used when some precision (up to approximately 100 &rad) is sacrificed to increase the speed, often by 10 percent or more. Many of the highest-speed applications rely on non-integrating Class 0 servos.

**Beyond PID Servos**

New digital state-space servo architectures have optimized the performance of galvos by substantially reducing or eliminating the "tracking error" that is prevalent in PID (analog or digital) servos. Reduced tracking error allows users to eliminate software delays in their motion programs that were inserted to compensate for the time variations caused by tracking error, and the overall galvo performance (primarily in vector type applications) is greatly improved. In laser marking applications, it is typical to see marking speeds increase 2x to 4x once this tracking error is eliminated. Other advantages of digital servos often include self-tuning or computer-assisted tuning.




**Motion Categories**

While there are many types of beam positioning motions or command structures employed in laser systems, most can be classified as either random or repetitive in nature. Of these, the most common are vector, raster and step-and-hold positioning motions. An appreciable ingredient in successful laser system design today is the intelligent command and control of the signals given to the scanner system.

**Vector Positioning**

In vector-positioning applications such as laser marking and other forms of industrial materials processing, beam motion may be structured into a series of small angular vectors or steps for process consistency and maximum material throughput. The use of small steps maximizes efficiency by minimizing the settling time variation, and delays associated with large-angle movements, which may be limited by voltage or current restrictions, galvo torque, thermal limitations or electrical saturation within the servo control loop. Success is often measured in characters, vectors or steps executed per second.

In the fastest vector-positioning applications, the system rarely is stationary between vectors. In meeting these demands, it is often not limited by galvo torque, Galvo power dissipation constraints, power supply levels, etc. Rather, the critical limiting parameter is the closed-loop bandwidth, defined and limited by the resonant frequencies of the combined mirror and galvo, as well as by the servo's ability to control and suppress the system's naturally occurring resonant frequencies.

**Raster Positioning**

For raster-style applications such as printing, scanning laser microscopy, and image capture, the beam or aperture is moved at a constant velocity during the active imaging, forming active lines that are joined by an often faster retrace. During this active imaging time, acceleration (and thereby the current through the galvo coil) is nearly zero. During flyback, the acceleration is high, so current through the galvo coil is
high.

The overall operating frequency of the galvo system is limited by the fly back portion of the scan period and its relationship to the active imaging time, also described as the duty cycle or efficiency of the scan. Although it may not be obvious, a more relaxed efficiency often enables a higher operating frequency. When more time is allowed for fly back, current in the scanner is lower, the operating frequency may be higher, and more lines may be printed or gathered per second without thermally limiting the system.

Raster applications typically employ less laser power, and the pixel or spot size and the path length define the beam diameter and mirror/ galvo size requirements. The ability to execute large-angle steps with low cross-scan mirror wobble and timing jitter, together with high galvo power handling capacity, are critical as extreme levels of repeatability from scan to scan at high repetition rates are required. The rigid structure of the moving-magnet actuator, along with its low thermal resistance from coil to case, as in the 62xxH family of galvos, makes it an excellent choice for many raster applications.

A remaining consideration in this application group is the structure of the command waveform(s) sent to the galvo system. A cycloidal command waveform is recommended to manage position, velocity and acceleration discontinuities that can simultaneously limit the image quality and operating frequency. A smooth, “acceleration managed” input aids system performance by limiting the frequency content that is passed to the galvo system. This tends to avoid excitation of the system’s natural resonances, enabling greater image quality. It also lowers the acceleration in the fly back phase, which reduces power in the system. These two factors often allow a better repeatability at a higher operating frequency than is possible using simpler saw tooth shape inputs.

**Step-And-Hold Positioning**

Step-and-hold positioning varies from vector positioning in that the system is commanded to a fixed angle and held as still as possible while the operation is performed. These positioning moves range in frequency and amplitude, though highly accurate and repeatable beam placement is typically required.

The most critical galvo system parameters in this type of positioning are an accurate and stable position detector and an efficient, high-torque but low-inertia actuator for fast acceleration and settling to the commanded position. Depending on the goals of the application and, as in raster positioning, managing the command signal to limit the frequency content that is passed on to the scanner system can enhance the step-and-hold result.

Such positioning is available in optical clear apertures ranging from 3- to 50-mm beam diameters across all laser system applications. The moving-coil class of galvo, which features single-microradian repeatability, position detector linearity >99.9 percent and uncompensated scale drift of 50 ppm per degree of temperature change, best serves these applications.

**Optimizing Performance**

The closed-loop galvanometer offers the system designer a powerful combination of speed, accuracy and low cost, as well as a flexibility that is not possible with other scanner technologies. The range of galvos attributes satisfies a variety of applications. Advances in this technology, along with advances in laser technology, continue to widen the galvanometer’s application range, enabling new performance levels, applications and markets. Deriving the highest possible performance in any galvo application requires an understanding of the most critical parameters for positioning speed and accuracy, along with the proper design and selection of the galvo, mirror, and servo driver.