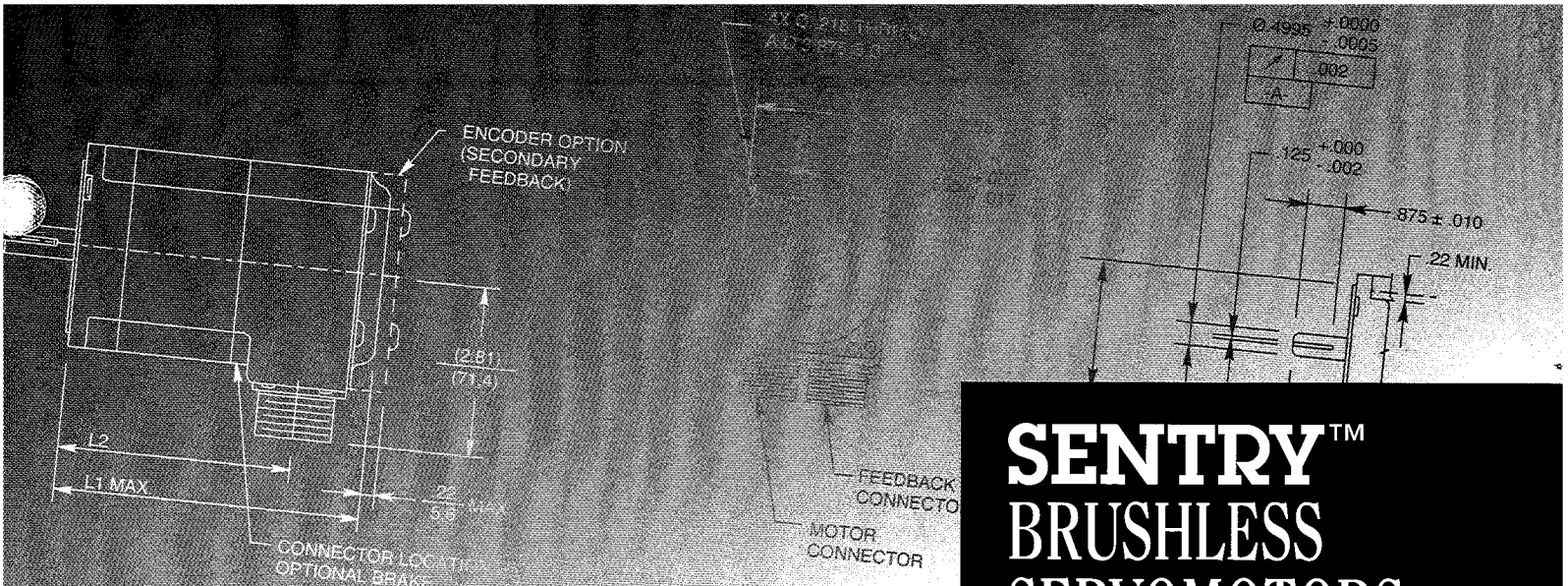
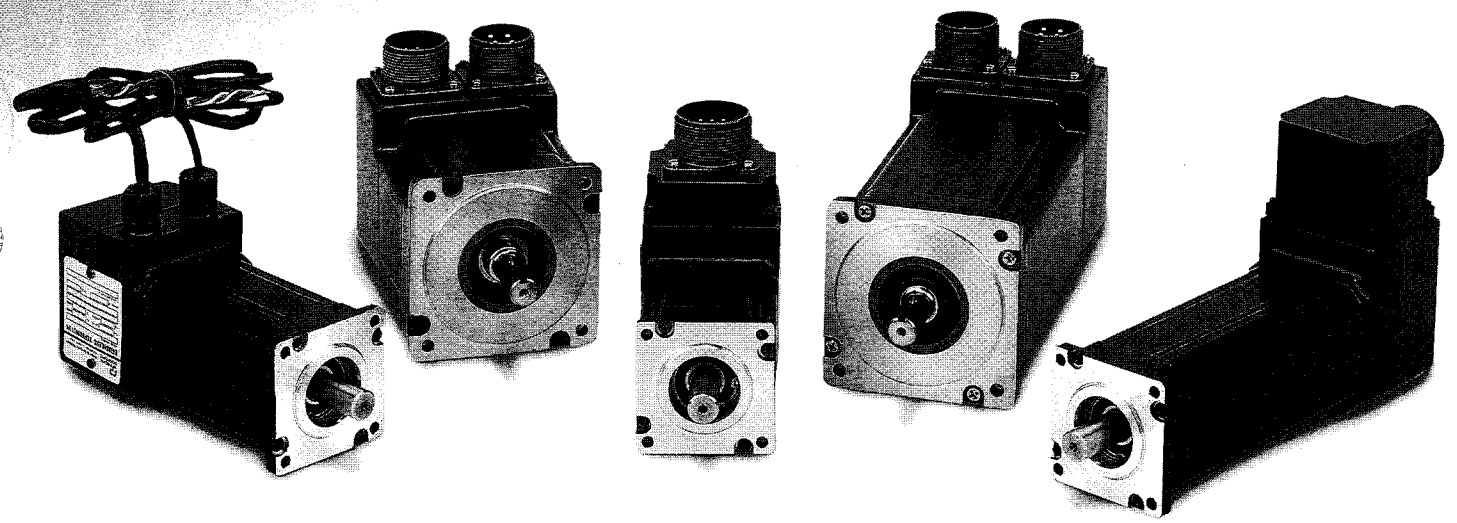


SENTRY™ BRUSHLESS SERVOMOTORS



- NEMA 23 & 34 frame sizes... metric mounting also available
- Highest torque per frame size in the industry
- Medium motor inertia for improved load inertia matching

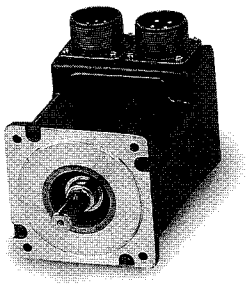
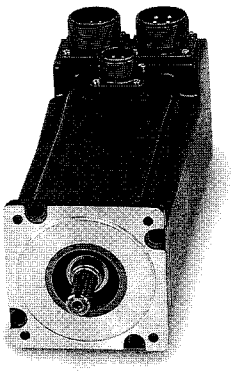
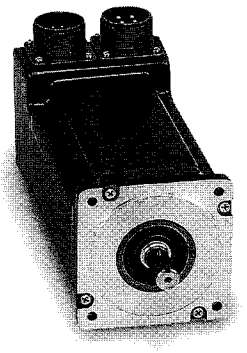
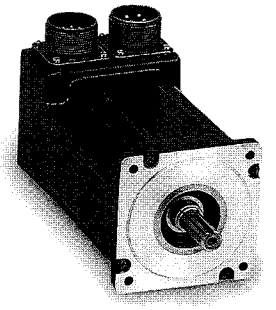
PACIFIC SCIENTIFIC
AUTOMATION TECHNOLOGY GROUP

MOTOR PRODUCTS DIVISION

February, 1997

ISO 9001

SENTRY™ BRUSHLESS SERVOMOTORS

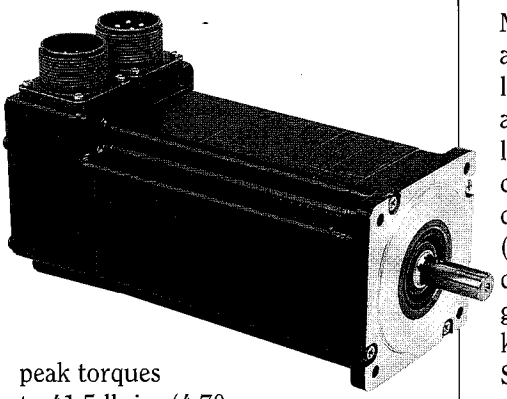
Broad Section

The new **SENTRY** Series NEMA 23 and 34 frame brushless servomotors extend Pacific Scientifics' offering of high performance, reliable brushless servomotors. **SENTRY** complements the existing **REGAL™** series of low inertia products by adding a new medium inertia, high performance family.

High Performance

Designed for demanding torque, velocity and/or positioning applications, the unique **SENTRY** features the industry's highest torque per frame size plus medium rotor inertia for improved load matching.

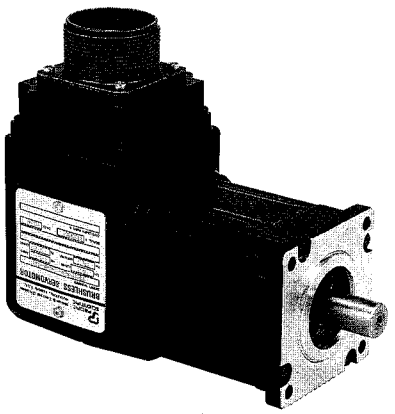
High torque per frame size provides important application advantages. The **SENTRY** Series provides continuous stall torques up to 13.8 lb-in. (1.56 Nm) for the NEMA 23 frame and 45 lb-in. (5.2 Nm) for the NEMA 34 frame. The NEMA 23 frame provides

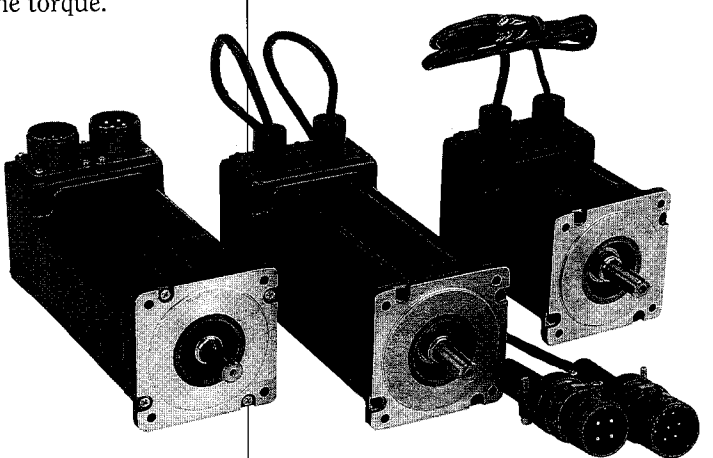


peak torques to 41.5 lb-in. (4.70 Nm) and 131 lb-in. (15.6 Nm) in the NEMA 34 frame. **SENTRY**'s increased torque enhances system performance without increasing the motor frame size and the size of the machine or equipment. A compact motor like **SENTRY** can possibly reduce the size of the machine while providing the same torque.

Load Matching

Medium rotor inertia also provides application advantages. Most closed loop brushless servomotor applications require closely matched load to motor inertias to achieve compliant system stability and the desired system response (bandwidth). Whether coupled directly to the load or through gearing, these considerations are key to the desired result. The **SENTRY** Series medium inertia design permits a closer load inertia match in a broad range of applications. In some applications, **SENTRY** can eliminate the need for gear reduction. Gear reducers are sometimes used to achieve better load matching, but can increase system cost, take up additional space and reduce system reliability.





HIGHEST TORQUE PER FRAME SIZE IN THE INDUSTRY–SENTRY™

FEATURES	BENEFITS
Highest torque per frame size in the industry	Maximum performance in small envelope. Reduce space required for motor or get more torque in same space
Medium rotor inertia for improved load matching	Obtain not only an optimized system response (time), but a stable system response...eliminates gearing sometimes used to achieve better load matching
Standard NEMA and Metric mounting, UL and European Compliance rating	Satisfy broad end use requirements
Peak torque rated at three times continuous current plus good torque linearity beyond continuous ratings	Move loads fast–operate above peak ratings in intermittent duty applications to move loads even faster
Choice of Hall sensor, resolver or encoder feedback	To meet broad drive and system requirements
Compatible with 6-step or sine drives–can furnish special windings for specific drive parameters and torque/speed requirements	Versatile
600 V UL winding insulation system	Maintain motor integrity at higher bus voltages
NEMA 23 & 34 frame sizes- 4.3 to 45 lb-in. continuous stall torque	Addresses wide range of torque requirements
Rugged "housingless" square frame	Efficient use of volume for optimal magnetic circuit
Sealed per IP65 and NEMA specifications	For washdown requirements
Brake option	Improved machine safety
Two year warranty	Quality and reliability
Anti-cog magnet design	Smooth low speed performance
Long life bearing system	Longer motor life for reduced machine downtime
Over temperature thermistor (PTC)	Protection against motor damage

INDEX

How to use this selection guide

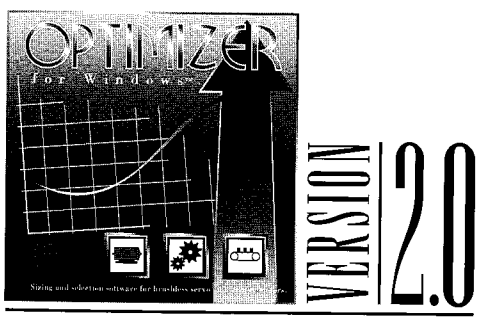
Select the proper motor using one of the following procedures.

- If you are already familiar with these motors and the available options, refer to the Model Number Codes on page 4 (NEMA 23) and page 8 (NEMA 34) to verify the coded information prior to ordering.

- If you are not familiar with these motors and the available options:
  -refer to the General Specifications on page 3 and/or the Index at the right. Note that each frame size is covered separately and the Technical Data applies to all motors. Construct a model number after all the technical parameters, including options, are determined.
  -Use OPTIMIZER™ Version 2.0, our Windows® compatible sizing and selection software for both brushless servo and stepper motors. Call or fax us for your free program disk. A complete model number will be selected.

Additional technical information available on request

- Motion Control Mechanics
- Sizing a Servomotor for your Application
- Optimizer – Sizing and Selection Software



Sizing and selection software for brushless servomotors and hybrid steppers. Ask for a FREE copy.

SENTRY™ SERIES BRUSHLESS SERVOMOTORS

FEATURES

- Troublefree, brushless construction
- Highest torque per frame size
- Medium rotor inertia for improved load inertia matching
- Low thermal resistance for maximum power rating per frame size
- High torque over wide speed range
- Location flexibility, with no need to provide brush maintenance access
- Reduced EMI through elimination of brushes and brush arcing
- Anti-cog magnet design for smooth low speed performance
- Rugged TENV, NEMA and IP65 construction for washdown requirements
- 2 year warranty
- High voltage insulation – contact application engineering

PRIMARY FEEDBACK OPTIONS

- Hall sensors
- Frameless resolver, transmitter type

SECONDARY FEEDBACK OPTIONS

- 1000-, and 1024-line optical incremental encoders

OTHER OPTIONS

- NEMA or metric mounting and shaft configurations
- Shaft seals
- High-speed/high-power (low torque constant) or low-speed/low-power (high torque constant) windings

PERFORMANCE

Series	Continuous stall torque–lb-in. (Nm)	Peak torque–lb-in. (Nm)
S 20, NEMA 23	up to 13.8 (1,56)	up to 41.5 (4,70)
S 30, NEMA 34	up to 45 (5,1)	up to 131 (14,8)

GENERAL SPECIFICATIONS

Number of poles	6
Winding	3 phase wye
Magnet type	Neodymium-iron-boron
Sealed housing construction (all motors)	TENV, NEMA and IP65, See P. 24
Terminations	MS connectors, Flying Leads, Flying Leads w/ MS connectors at end, Terminal Box (NEMA 34 only)
Thermal protection	positive-temperature-coefficient (PTC) thermistor
Frame construction	
S 20, NEMA 23 Series (2.28" width/height)	square
S 30, NEMA 34 Series (3.25" width/height)	square

Additional information

SENTRY™ S20 SERIES
NEMA 23 Frame
2.28" square

MODEL NUMBER CODE

To construct a motor listing, select the combination of features required and put all the coded information in the proper sequence. Please account for all entries. The model number shown is an example of a properly specified motor.

S 22 G N N A - H G N L - 00

Motor Series
S = SENTRY
6 pole Neodymium

Motors
S 21
S 22
S 24

Frame Size
2 = NEMA 23

Stack Length
1 = 1 Stack
2 = 2 Stack
4 = 4 Stack

Winding
G
H

Shaft & Mounting
N= NEMA 23 Frame
M= Metric mounting

Holding Brake Option
N= No brake
A= 24 Vdc brake
B= 100 Vdc brake

Factory Preassigned

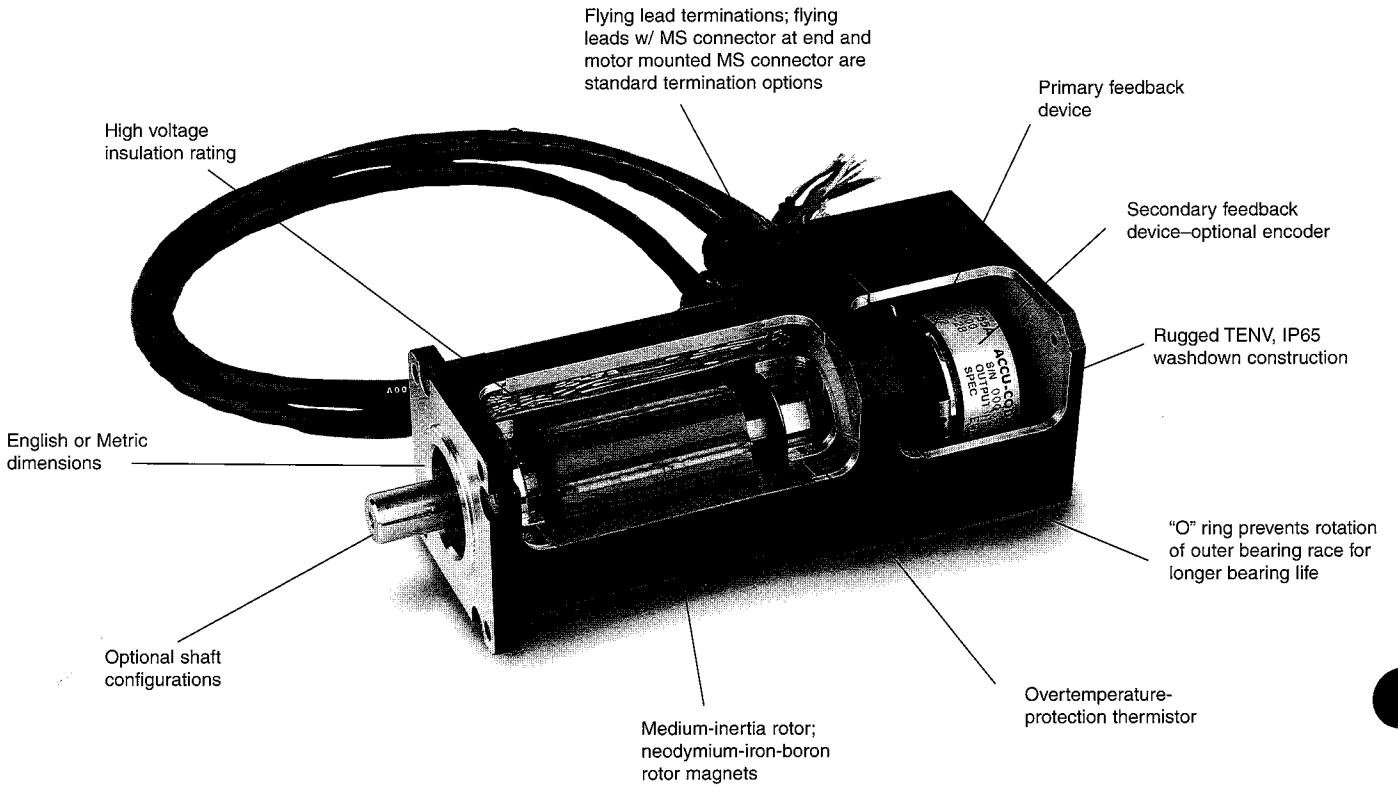
Primary Feedbacks
H= Hall Sensor
R= Size 21 frameless resolver
N= No primary

Secondary Feedbacks
(Standard encoder secondary options apply with Hall sensor primary feedback only. Contact factory for other combinations.)
F= 1000 ppr, line driver encoder
G= 1024 ppr, line driver encoder
N= no secondary

Shaft Sealing
N= No shaft seal
V= Viton shaft seal

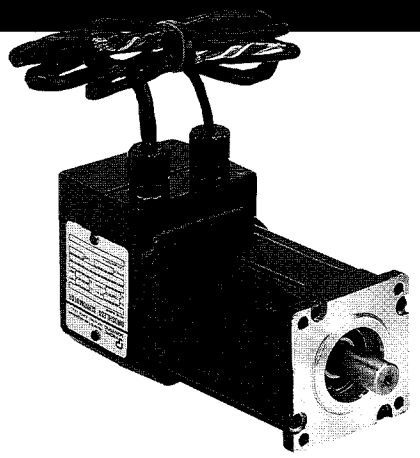
Terminations
C = 18" Flying leads with MS connectors
L = 18" Flying leads
M = Motor mounted MS connectors
5 = MS connector facing shaft
6 = MS connector facing rear

Sequence Number
00 = Standard Listing



SENTRY™ S20 SERIES
NEMA 23 Frame
2.28" square

4.3 to 13.8 lb-in. (.49 to 1.6 Nm) continuous (stall) torque; 12.3 to 41.5 lb-in. (1.39 to 4.7 Nm) peak torque



PERFORMANCE FEATURES

- 6 Pole Design
- Troublefree brushless construction
- Long life bearing system
- High energy Neodymium-iron-boron magnets for maximum torque in a small package
- Medium rotor inertia for better load matching
- Full torque over wide speed range
- Anti-cog magnet design for smooth low speed performance
- Built in thermal protection
- NEMA 23 mounting standard
- High torque per frame size

SENTRY Series brushless servomotors deliver excellent torque, speed and/or position control.

Neodymium magnets, long life bearings and brushless construction assure maximum performance and service life.

TYPICAL APPLICATIONS

- Clamping
- Coil Winders
- Electronic insertion machinery
- Fluid Metering
- Gauging
- In-Feed / Out-Feed conveyors
- Mail handling equipment
- Material handling
- Packaging machinery
- Robotics
- Test equipment
- X-Y tables

RATINGS AND CHARACTERISTICS

Motor parameters and winding data

		ENGLISH				METRIC				
Parameters	**Symbol**	**Units**	**S21**	**S22**	**S24**	**Symbol**	**Units**	**S21**	**S22**	**S24**
Continuous stall torque ⚠1	T_{CS}	lb-in.	4.3	8.4	13.8	T_{CS}	Nm	,49	,95	1,56
Peak Torque ⚠1	T_{PK}	lb-in.	12.3	24.3	41.5	T_{PK}	Nm	1,39	2,75	4,70
Inertia (motor only) ⚠3	J_M	lb-in-sec²	.000196	.000384	.000706	J_M	$kgm^2 \times 10^{-3}$	,022	,043	,080
Static friction (max.)	T_f	lb-in.	.07	.09	.22	T_f	Nm	,008	,010	,025
Viscous Damping coefficient	K_{DV}	lb-in/Krpm	.03	.05	.11	K_{DV}	Nm/Krpm	,003	,006	,012
Thermal resistance ⚠5	R_{TH}	°C/Watt	2.2	1.7	1.29	R_{TH}	°C/Watt	2,2	1,7	1,29
Thermal time constant	τ_{TH}	min.	5	11	15	τ_{TH}	min.	5	11	15
Weight (motor only)	W	lbs.	3.1	4.2	6.0	M (mass)	kg	1,4	1,9	2,7

Winding data	**Symbol**	**Units**	**G H**	**G H**	**G H**	**Symbol**	**Units**	**G H**	**G H**	**G H**
Torque Constant ⚠1 **(line-line)**	K_T peak	lb-in/A	2.5 1.3	5.1 2.5	5.4 2.7	K_T peak	Nm/A	,28 ,14	,57 ,28	,61 ,31
Voltage Constant ⚠2 **(line-line)**	K_E peak	V/Krpm	30 15	60 30	64 32	K_E peak	V/rad/sec	,28 ,14	,57 ,28	,61 ,31
Continuous stall current ⚠1	I_{CS}	A	1.9 3.8	1.8 3.5	3.2 6.3	I_{CS}	A	1.9 3.8	1,8 3,5	3,2 6,3
Current at peak torque ⚠1	I_{PK}	A	5.7 11.4	5.4 10.5	9.6 18.9	I_{PK}	A	5,7 11,4	5,4 10,5	9,6 18,9
Resistance (line-line)	R_C cold	Ohms	12.0 3.0	16.2 4.2	6.8 1.8	R_C cold	Ohms	12,0 3,0	16,2 4,2	6,8 1,8
Resistance (line-line) ⚠4	R_H hot	Ohms	18.1 4.5	24.5 6.3	10.3 2.7	R_H hot	Ohms	18,1 4,5	24,5 6,3	10,3 2,7
Inductance (line-line)	L	mH	14.4 3.7	22.1 5.7	9.3 2.2	L	mH	14,4 3,7	22,1 5,7	9,3 2,2

Note: All values at 25°C unless otherwise noted.

⚠1 Windings at 155°C. Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum heat sink.

⚠2 Peak value of a sinusoidal waveform.

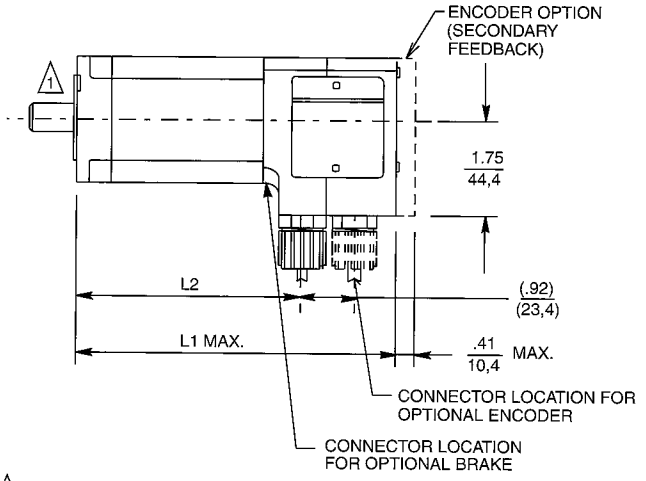
⚠3 Add feedback and if applicable, holding brake for total inertia.

⚠4 Caution: For peak torques or peak currents greater than 3X the continuous rating, consult the factory for thermal considerations.

⚠5 Motor in 25°C ambient mounted to a 10" x 10" x 1/4" aluminum heat sink.

DIMENSIONS . . . S20 Series, NEMA 23 Frame...metric mounting also available

See p. 16 for termination options



1 In addition to the standard options shown below, custom shaft and mounting provisions are readily available. See worksheet p. 26.

NEMA (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
S21	4.88	(3.10)
S22	5.88	(4.10)
S24	7.88	(6.10)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

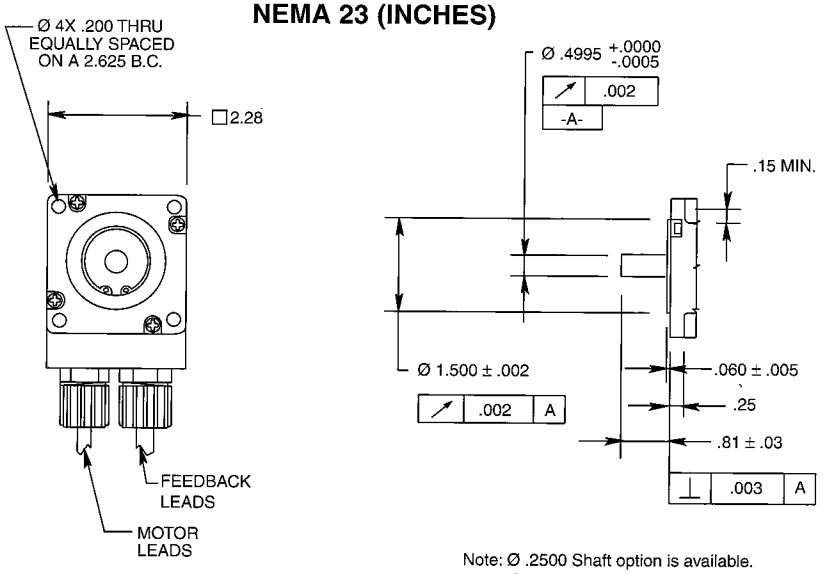
MODEL NUMBER	L1 MAX.*	L2 REF.*
S21	124,0	(78,7)
S22	149,4	(104,1)
S24	200,2	(154,9)

Note: L1 includes primary feedback device.

*Add 2.41 in. (61,2 mm) for brake option.

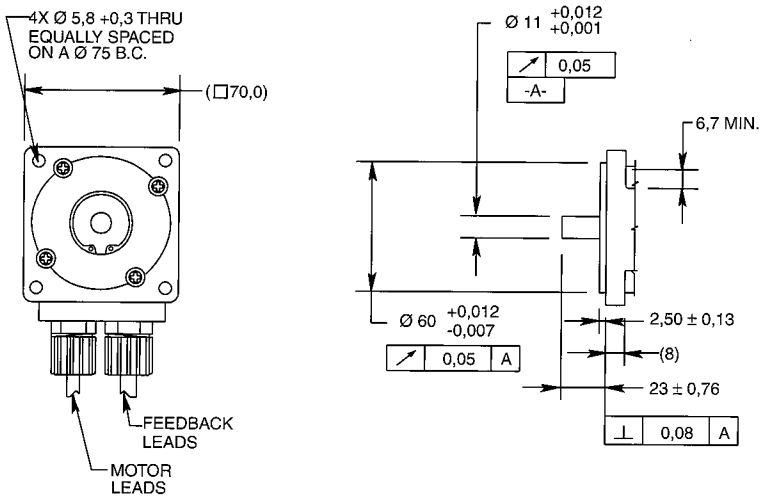
MOUNTING AND SHAFT OPTIONS

NEMA 23 (INCHES)



Note: Ø .2500 Shaft option is available. Consult application engineering.

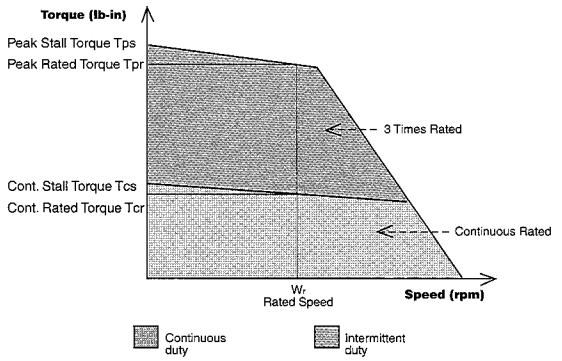
METRIC (MILLIMETERS)



SENTRY™ S20 SERIES
NEMA 23 Frame
2.28" square

Test Conditions
- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" Aluminum heat sink.
- 25° C. ambient
- 320 Vdc bus, trapezoidal commutation applied.

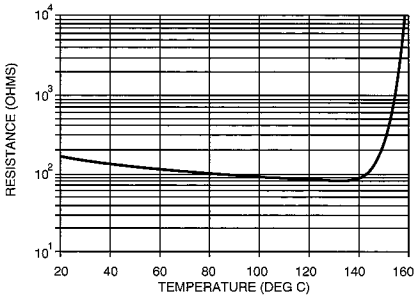
NOTE: Maximum no-load speed not to exceed 14,000 rpm. Consult Application Engineering.



The speed-torque curve example and all motor curves shown reflect peak rated torque at 3 times the motor's continuous rated torque. Motors are capable of higher peak torques. Consult brushless application engineering at (815) 226-3100.

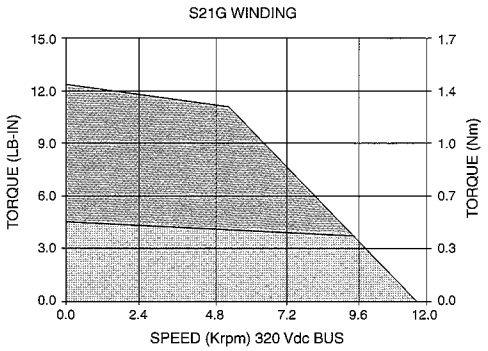
TYPICAL THERMISTOR CHARACTERISTICS, ALL MOTORS

The protective, positive-temperature-coefficient (PTC) thermistors in all motors operate with the characteristics shown here.
Caution: For peak currents or peak torques greater than 3 times continuous motor rating, consult application engineering (815) 226-3100, for thermal considerations.



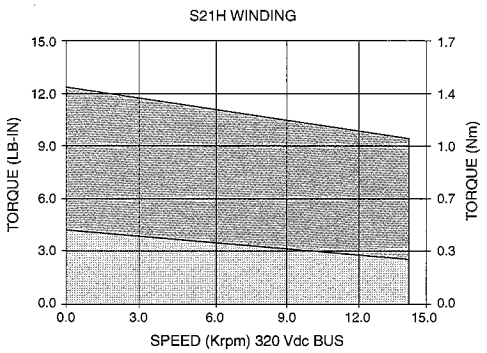
S21G MOTOR

Reference Points	
T_{PS}	12.0
T_{PR}	11.0
T_{CS}	4.3
T_{CR}	4.0
W_R	5,000
I_{cs}	1.9
I_{pk}	5.7



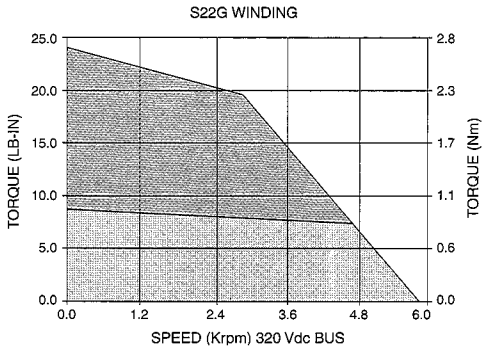
S21H MOTOR

Reference Points	
T_{PS}	12.0
T_{PR}	11.0
T_{CS}	4.3
T_{CR}	3.1
W_R	10,000
I_{cs}	3.8
I_{pk}	11.4



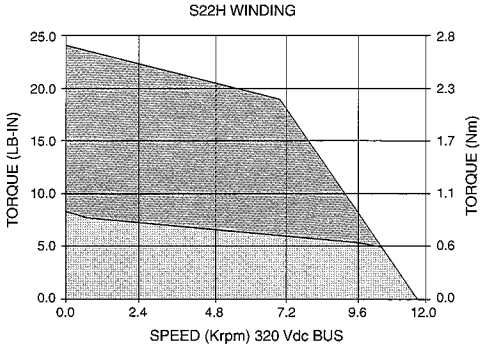
S22G MOTOR

Reference Points	
T_{PS}	24.0
T_{PR}	21.0
T_{CS}	8.4
T_{CR}	8.0
W_R	2,500
I_{cs}	1.8
I_{pk}	5.4



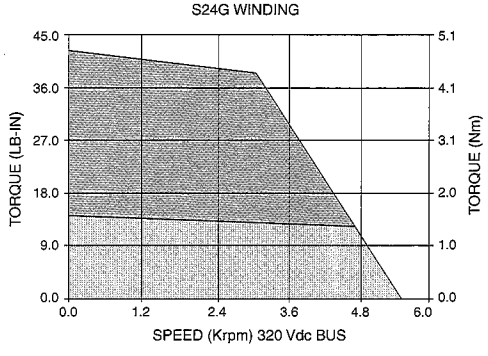
S22H MOTOR

Reference Points	
T_{PS}	24.0
T_{PR}	19.0
T_{CS}	8.4
T_{CR}	6.0
W_R	7,000
I_{cs}	3.5
I_{pk}	10.5



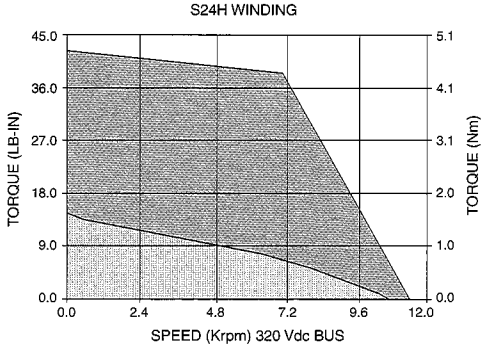
S24G MOTOR

Reference Points	
T_{PS}	42.0
T_{PR}	39.0
T_{CS}	13.8
T_{CR}	12.6
W_R	3,000
I_{cs}	3.3
I_{pk}	9.6



S24H MOTOR

Reference Points	
T_{PS}	42.0
T_{PR}	38.0
T_{CS}	13.8
T_{CR}	6.3
W_R	7,000
I_{cs}	6.3
I_{pk}	18.9



SENTRY™ S30 SERIES
NEMA 34 Frame
3.38" square

MODEL NUMBER CODE

To construct a motor listing, select the combination of features required and put all the coded information in the proper sequence. Please account for all entries. The model number shown is an example of a properly specified motor.

S 3 2 G N N A - H G N M - 0 0

Motor Series
S = SENTRY
6 pole Neodymium

Motors
S 31
S 32
S 33

Frame Size
3 = NEMA 34

Stack Length
1 = 1 Stack
2 = 2 Stack
3 = 3 Stack

Winding
G
H

Shaft & Mounting
N= NEMA 34 Frame
M= Metric mounting

Factory Preassigned

Holding Brake Option
N= No brake
A= 24 Vdc brake
B= 100 Vdc brake

Primary Feedbacks
H= Hall Sensor
R= Size 21 frameless resolver
N= No primary

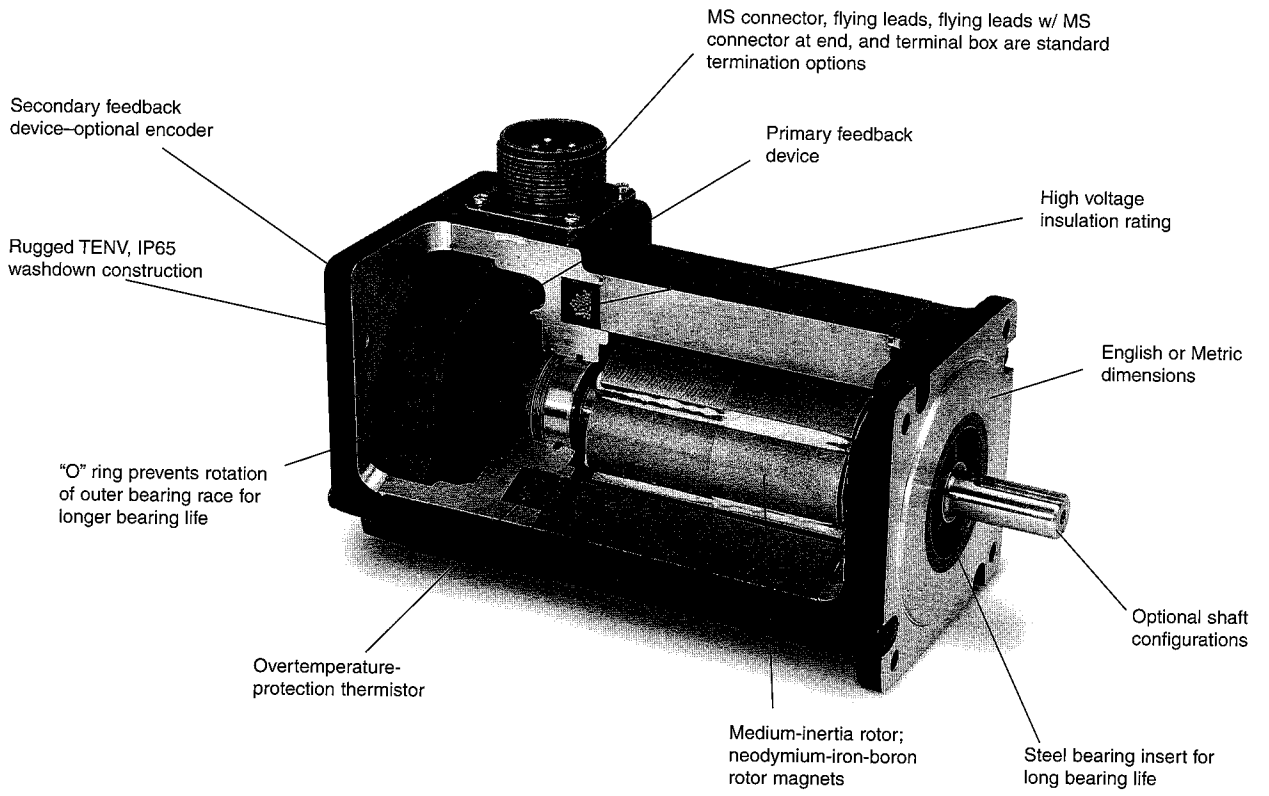
Secondary Feedbacks
(Standard encoder secondary options apply with Hall sensor primary feedback only. Contact factory for other combinations.)
F= 1000 ppr, line driver encoder
G= 1024 ppr, line driver encoder
N= no secondary

Shaft Sealing
N= No shaft seal
V= Viton shaft seal

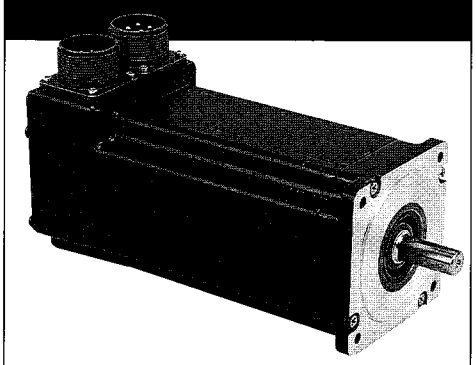
Terminations
C= 18" Flying leads with MS connectors at end
L= 18" Flying leads
M= Motor mounted MS connectors
⚠ 1= Terminal box, feedback MS connector facing shaft
⚠ 2= Terminal box, feedback MS connector facing rear
⚠ 5= Terminal box with MS connectors facing shaft
⚠ 6= Terminal box with MS connectors facing rear

Sequence Number
00 = Standard Listing

⚠ Terminal Box options 1 & 2 have a terminal block for motor power, brake, and ground connections with a standard MS connector for feedback(s), and PTC connections with front or rear facing orientation. Terminal box options 5 & 6 provide standard MS connectors for motor power, feedback(s), PTC, and brake connections with front or rear facing orientation. See termination options beginning on p. 16.



SENTRY™ S30 SERIES
NEMA 34 Frame
3.38" square



19 to 45 lb-in. (2.2 to 5.1 Nm) continuous (stall) torque; 56 to 131 lb-in. (6.3 to 14.8 Nm) peak torque

PERFORMANCE FEATURES

- 6 Pole Design
- Troublefree brushless construction
- Long life bearing system
- High energy Neodymium-iron-boron magnets for maximum torque in a small package
- Medium rotor inertia for better load matching
- Full torque over wide speed range
- Anti-cog magnet design for smooth low speed performance
- Built in thermal protection
- NEMA 34 mounting standard
- High torque per frame size

SENTRY Series brushless servomotors deliver excellent torque, speed and/or position control.

Neodymium magnets, long life bearings and brushless construction assure maximum performance and service life.

TYPICAL APPLICATIONS

- Assembly equipment
- Coil Winders
- Electronic insertion machinery
- Machine tools
- Mail handling equipment
- Material handling
- Packaging machinery
- Press feeds
- Robotics
- Specialty test equipment
- Spindles
- X-Y tables

RATINGS AND CHARACTERISTICS

Motor parameters and winding data

		ENGLISH					METRIC				
Parameters	**Symbol**	**Units**	**S31**	**S32**	**S33**	**Symbol**	**Units**	**S31**	**S32**	**S33**
Continuous stall torque △1	T_{CS}	lb-in.	19	34	45	T_{CS}	Nm	2,2	3,8	5,1
Peak Torque △4	T_{PK}	lb-in.	56	99	131	T_{PK}	Nm	6,3	11,2	14,8
Inertia (motor only) △3	J_M	lb-in-sec^2	.0014	.0028	.0041	J_M	kgm^2 x 10^{-3}	,15	,32	,46
Static friction (max.)	T_f	lb-in.	.56	1.31	1.5	T_f	Nm	,063	,150	,170
Viscous Damping coefficient	K_{DV}	lb-in/Krpm	.15	.35	.42	K_{DV}	Nm/Krpm	,016	,039	,047
Thermal resistance	R_{TH}	°C/Watt	1.23	.97	.87	R_{TH}	°C/Watt	1,23	,97	,87
Thermal time constant △5	τ_{TH}	min.	14	24	27	τ_{TH}	min.	14	24	27
Weight (motor only)	W	lbs.	7.1	10.7	14.2	M (mass)	kg	3,2	4,9	6,5

Winding data	**Symbol**	**Units**	**G H**	**G H**	**G H**	**Symbol**	**Units**	**G H**	**G H**	**G H**
Torque Constant △2 **(line-line)**	K_T peak	lb-in/A	10.2 5.1	10.0 5.0	14.8 7.4	K_T peak	Nm/A	1,15 ,58	1,13 ,57	1,67 ,84
Voltage Constant △2 **(line-line)**	K_E peak	V/Krpm	120 60	118 59	174 87	K_E peak	V/rad/sec	1,15 ,58	1,13 ,57	1,67 ,84
Continuous stall current △1	I_{CS}	A	2.1 4.1	3.8 7.5	3.4 6.9	I_{CS}	A	2,1 4,1	3,8 7,5	3,5 6,9
Current at peak torque △4	I_{PK}	A	6.21 12.3	11.3 22.5	10.4 20.7	I_{PK}	A	6,2 12,3	11,3 22,5	10,4 20,7
Resistance (line-line)	R_C cold	Ohms	16.4 4.1	6.2 1.6	8.4 2.1	R_C cold	Ohms	16,4 4,1	6,2 1,6	8,4 2,1
Resistance (line-line) △1	R_H hot	Ohms	24.4 6.1	9.2 2.3	12.8 3.2	R_H hot	Ohms	24,4 6,1	9,2 2,3	12,8 3,2
Inductance (line-line)	L	mH	41.2 10.3	18 4.5	25.2 6.3	L	mH	41,2 10,3	18 4,5	25,2 6,3

Note: All values at 25°C unless otherwise noted.

△1 Windings at 155°C. Motor in 25°C ambient and mounted to a 10" x 10" x 1/4" aluminum heat sink.

△2 Peak value of a sinusoidal waveform.

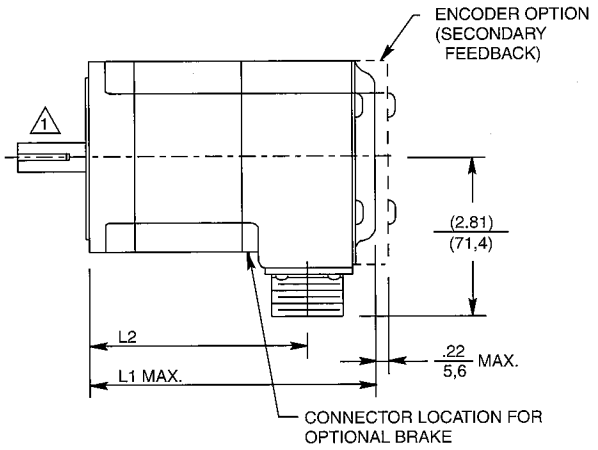
△3 Add feedback and if applicable, holding brake for total inertia.

△4 Caution: For peak torques or peak currents greater than 3X the continuous rating, consult the factory for thermal considerations.

△5 Motor in 25°C ambient mounted to a 10" x 10" x 1/4" aluminum heat sink.

DIMENSIONS . . . S30 Series, NEMA 34 Frame

See p. 16 for termination options



1 In addition to the standard options shown below, custom shaft and mounting provisions are readily available. Contact factory. See worksheet p. 26.

ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
S31	5.13	(3.84)
S32	6.63	(5.34)
S33	8.13	(6.84)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

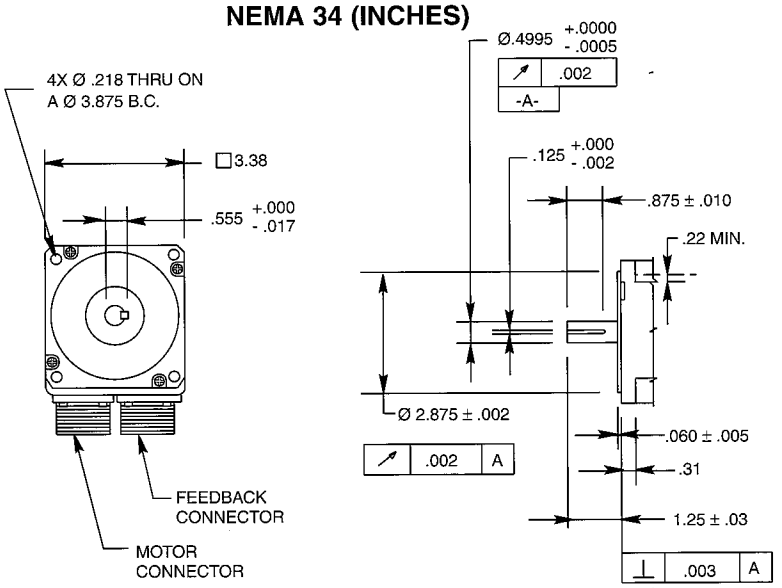
MODEL NUMBER	L1 MAX.*	L2 REF.*
S31	130,3	(97,5)
S32	168,4	(135,6)
S33	206,5	(173,7)

Note: L1 includes primary feedback device.

* Add 2.66 in. (67,5 mm) for brake option.

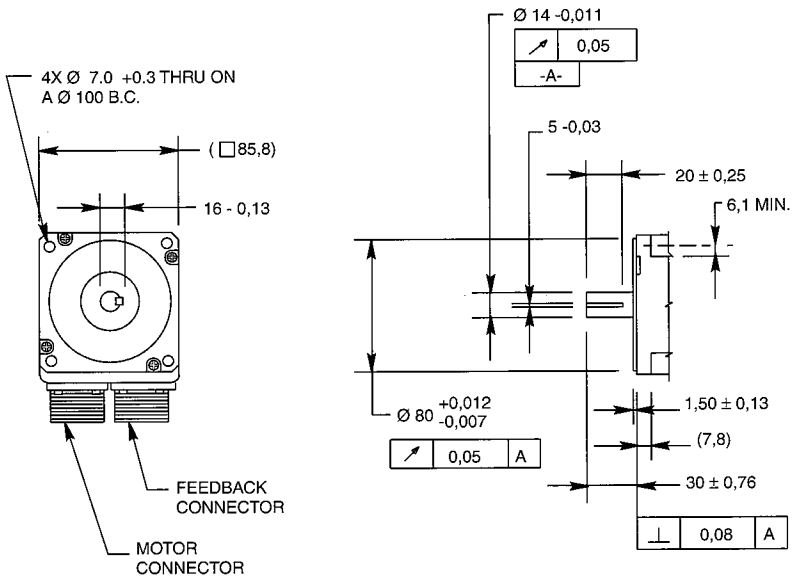
MOUNTING AND SHAFT OPTIONS

NEMA 34 (INCHES)



NOTE: .375 shaft option available consult application engineering.

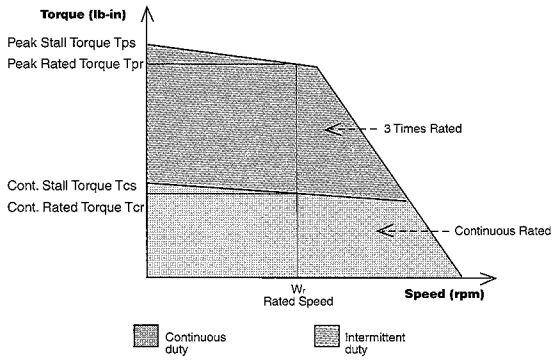
METRIC (MILLIMETERS)



SENTRY™ S30 SERIES
NEMA 34 Frame
3.38" square

Test Conditions
- Motor operated at rated winding temperature, mounted to a 10" x 10" x 1/4" Aluminum heat sink.
- 25°C ambient
- 320 Vdc bus applied

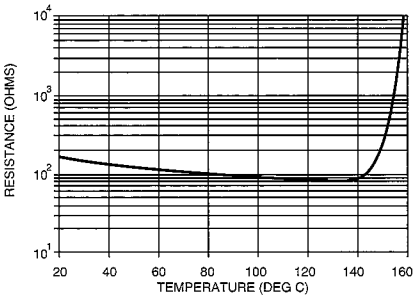
NOTE: Maximum no-load speed not to exceed 14,000 rpm. Consult Application Engineering.



The speed-torque curve example and all motor curves shown reflect peak rated torque at 3 times the motor's continuous stall current. Motors are capable of higher peak torques. Consult brushless application engineering at (815) 226-3100

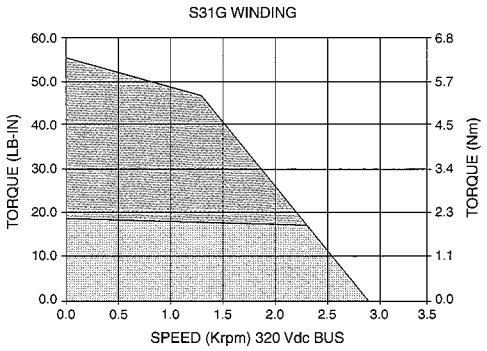
TYPICAL THERMISTOR CHARACTERISTICS, ALL MOTORS

The protective, positive-temperature-coefficient (PTC) thermistors in all motors operate with the characteristics shown here.
Caution: For peak currents or peak torques greater than 3 times continuous motor rating, consult application engineering (815) 226-3100, for thermal considerations.



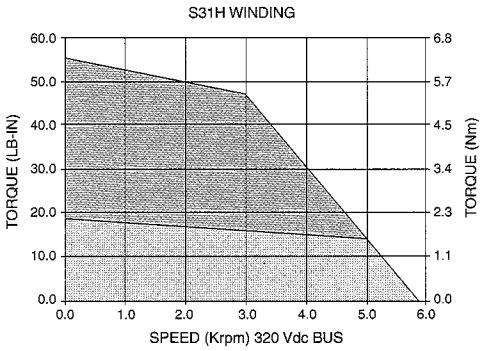
S31G MOTOR

Reference Points	
T_{PS}	56.0
T_{PR}	46.0
T_{CS}	19.0
T_{CR}	18.0
W_R	1,300
I_{cs}	2.1
I_{pk}	6.3



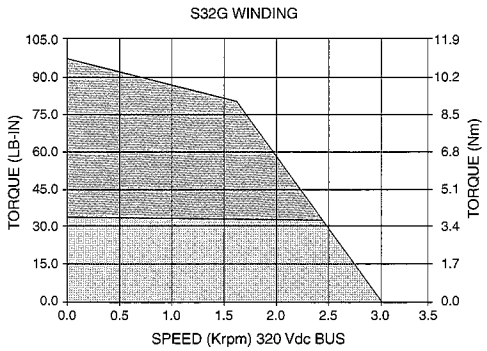
S31H MOTOR

Reference Points	
T_{PS}	56.0
T_{PR}	48.0
T_{CS}	19.0
T_{CR}	17.0
W_R	3,000
I_{cs}	4.1
I_{pk}	12.3



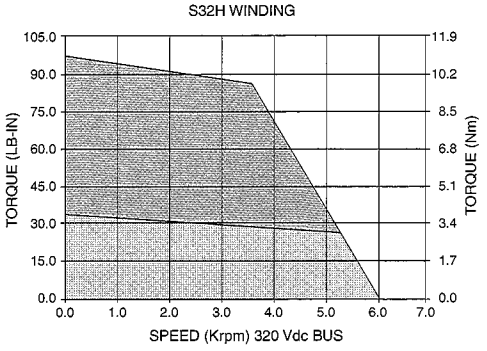
S32G MOTOR

Reference Points	
T_{PS}	99.0
T_{PR}	87.0
T_{CS}	34.0
T_{CR}	30.0
W_R	1,500
I_{cs}	3.8
I_{pk}	11.4



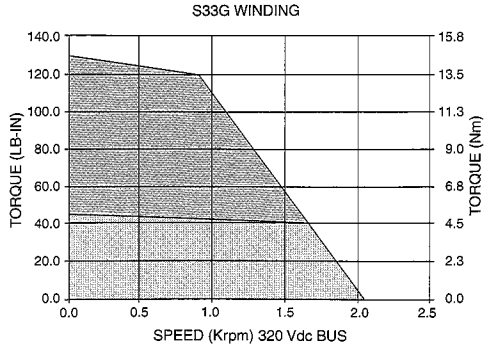
S32H MOTOR

Reference Points	
T_{PS}	99.0
T_{PR}	87.0
T_{CS}	34.0
T_{CR}	26.0
W_R	3,400
I_{cs}	7.5
I_{pk}	22.5



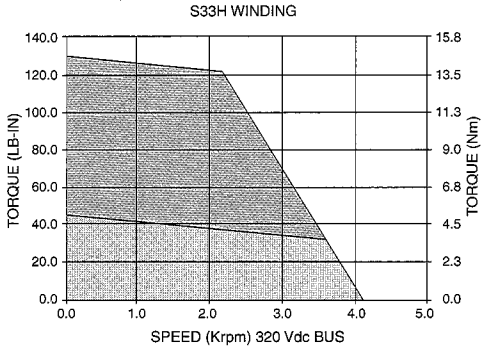
S33G MOTOR

Reference Points	
T_{PS}	131.0
T_{PR}	120.0
T_{CS}	45.0
T_{CR}	42.0
W_R	900
I_{cs}	3.4
I_{pk}	10.2



S33H MOTOR

Reference Points	
T_{PS}	131.0
T_{PR}	122.0
T_{CS}	45.0
T_{CR}	37.0
W_R	2,100
I_{cs}	6.9
I_{pk}	20.7



SENTRY™ SERIES DEFINITIONS

VOLTAGE (K_E) AND TORQUE (K_T) CONSTANTS

All Pacific Scientific motors are 3-phase WYE connected. The phase-to-phase (line-line) back EMF approximates a sinusoidal waveform. The back-EMF constant, or voltage constant, is measured while driving the motor as a generator at 1000 rpm and is expressed as a peak value. The motor's torque constant may then be calculated from the voltage constant measurement.

Two types of controls are typically used to drive the motor; either 6-step (DC or trapezoidal) or sinusoidal (AC or continuous commutation). The relationship of the motor's peak voltage constant and peak torque constant to their effective values depends on which type of drive is used.

A 6-step control puts current in 2 phases at a time, commutating every 60 electrical degrees. The amplifier current is usually specified as the DC portion of the square wave output, and the motor's effective K_T and K_E are the average values through the 60° commutation zone, or .95 x the peak values.

A sinusoidal control puts a sinusoidally varying current in all three phases. The amplifier current is usually specified as either a peak value or as an RMS value.

For a peak current specification, the motor's effective K_T is .86 x K_T peak.

For an RMS current specification, the motor's effective K_T is 1.22 x K_T peak.

The motor's K_E expressed in VRMS/KRPM is .707 x K_E peak.

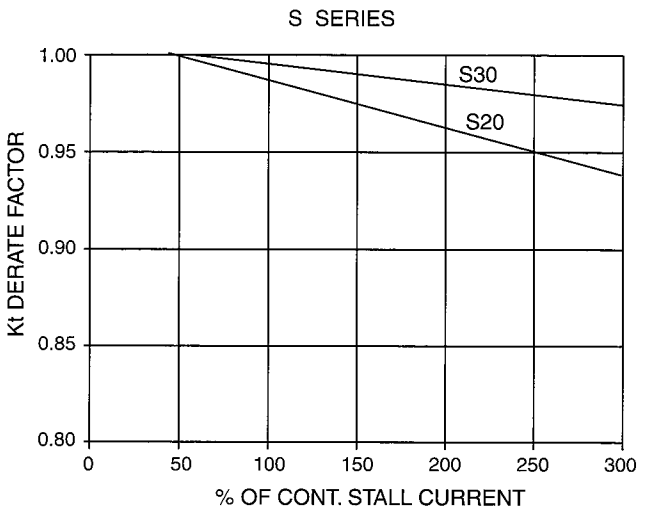
The same conversion methods apply to metric values.

TORQUE LINEARITY

Maximum Linear Torque (10% loss in K_T)

The torque/current relationship of any permanent-magnet motor changes as more current is applied. This change is the result of the degree of saturation of the motor's magnetic circuit.

At low current levels, the torque/current relationship is quite linear. As more current is applied, torque is increasingly non-linear. The maximum linear torque value is expressed at that point where torque has dropped 10% from a theoretical linear relationship. Note that additional torque can be produced beyond this point but a disproportionate amount of current must be applied.



HOLDING BRAKE

The holding brake is designed to provide a static holding torque to the motor shaft with the brake coil de-energized. The brake must first be released (coil energized) prior to commanding motor rotation as determined by its "drop-out time". **The holding brake is limited to applying holding torque to a non-rotating motor and must not be used in applications to stop a motor.**

BRAKE DATA		S20 SERIES NEMA 23 Frame		S30 SERIES NEMA 34 Frame	
Voltage	DC	+24	+100	+24	+100
Current	Amps	.38	.1	.72	.21
Static Holding Torque	lb-in.	10	10	32	32
	Nm	1,1	1,1	3,6	3,6
Inertia	lb-in-sec^2	.045 x 10^{-3}	.045 x 10^{-3}	.025 x 10^{-3}	.025 x 10^{-3}
	Kgm^2 x 10^{-3}	,005	,005	,0028	,0028
Pull-in Time	msec	40	40	10	10
Drop-out Time	msec	25	25	30	30
Max Speed	RPM	5000	5000	5000	5000
Weight Adder	lbs.	1.1	1.1	2.5	2.5
	Kg	,5	,5	1,1	1,1

Notes;

1. All voltage and current values have ±10% tolerance
2. **Pull-in time** is the nominal brake engagement time.
3. **Drop-out time** is the nominal brake release time.
4. **Max. Speed** is the mechanical limiting speed of the brake.

SENTRY™ BRUSHLESS SERVOMOTOR FEEDBACK COMBINATIONS

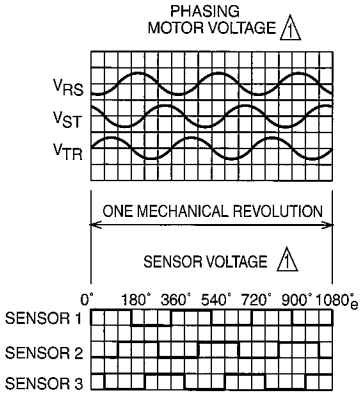
Primary Feedback Devices	Secondary Feedback Devices
Hall sensors • Commutation signals Resolver, transmitter type • Commutation signals • Analog position information • Velocity data	Digital Optical Encoders • Digital position • Velocity data

A selection of feedback configurations are available for the Sentry Series. Options include motors equipped with primary-only, primary and secondary, and secondary feedback only.

Described below are the feedback options available. Any one of the two primary feedback devices may be factory-installed by Pacific Scientific on the Sentry Series motor of your choice. The secondary-feedback device can be factory-installed on the same motor.

PRIMARY FEEDBACK DEVICES. . .TECHNICAL DATA

Hall Sensors (H) for Sentry Series

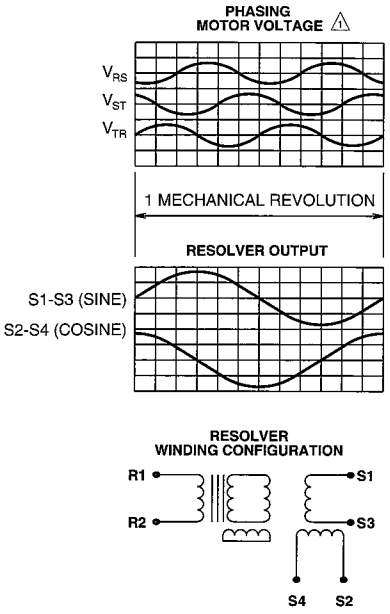


Typical output @ 25°C

Parameter	Units	Value
Commutation outputs:		See phasing diagram
No. of poles		6
No. of phases		3
Output volts, max.	volts	DC Supply
Power supply required	volts	+ 4.5 to 24 VDC
	mA	20 mA max
Rotor inertia	lb-in-sec^2 x 10^{-3}	.049
Weight	lb	.08

⚠ For clockwise motor rotation.

Frameless Resolvers (R)



Typical output @ 25°C

Parameter	Units	R
Frame size		21
Type		Transmitter
Primary		Rotor
Speed		1
Input voltage	V_{RMS}	4.0
Frequency	kHz	5
Input current, max.	mA	25
Transformation ratio		0.5
Max. electrical error	Minutes	±21
Rotor inertia Max.	lb-in-sec^2 x 10^{-3}	.18
Weight	lb	.56

⚠ For clockwise motor rotation.

SENTRY™ BRUSHLESS SERVOMOTOR FEEDBACK COMBINATIONS

SECONDARY FEEDBACK DEVICES...TECHNICAL DATA

Optical Encoders

Typical performance @ 25° C

S20 SERIES, NEMA 23 Frame

Parameter	F	G
Pulses per revolution	**1000**	**1024**
Type	Incremental	
Supply voltage	+5 Vdc ±5% @160 mA typical	
Output format	Dual-channel quadrature and index with complements	
Output type	26LS31 TTL Differential Line Driver (RS422A)–short-circuit protected	
Frequency response	125 kHz	
Rotor inertia	1.4 x 10^{-5} lb-in-sec^2	
Weight	.22 lbs.	

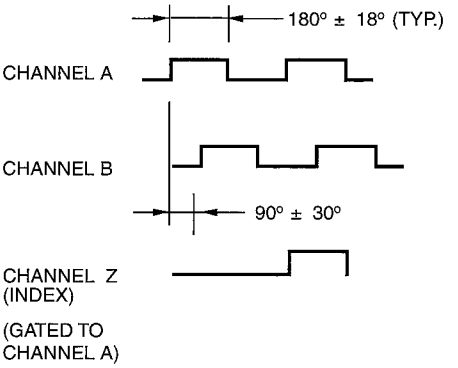
S30 SERIES, NEMA 34 Frame

Parameter	F	G
Pulses per revolution	**1000**	**1024**
Type	Incremental	
Supply voltage	+5 Vdc ±10% @165 mA typical	
Output format	Dual-channel quadrature and index with complements	
Output type	26LS31 TTL Differential Line Driver (RS422A)–short-circuit protected	
Frequency response	100 kHz	
Rotor inertia	.7 x 10^{-5} lb-in-sec^2	
Weight	.22 lbs. ⚠	

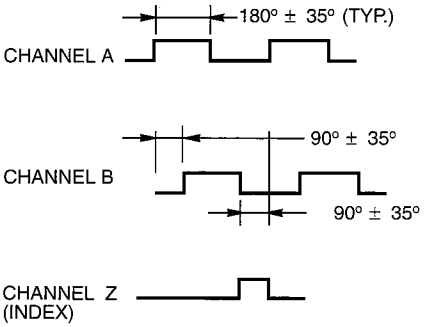
⚠ Includes weight of additional end cover.

Encoder Output

FOR CW DIRECTION OF ROTATION WHEN VIEWED FROM DRIVE SHAFT END (COMPLEMENTS NOT SHOWN)

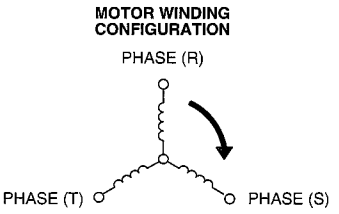


FOR CW DIRECTION OF ROTATION WHEN VIEWED FROM DRIVE SHAFT END (COMPLEMENTS NOT SHOWN)



PHASING DIAGRAM—ALL MOTORS

Shown here is the phasing diagram for CW rotation as viewed from the drive-shaft end of the motor.



See overview of feedback devices on the following pages.

OVERVIEW OF FEEDBACK DEVICES

A wide variety of feedback devices are used in DC servo systems and brushless servo systems. This section outlines the devices, their uses, and their merits in a brushless servo system. The tables on the following page summarize the information.

HALL-EFFECT SENSORS

Hall-effect devices are used to sense magnetic fields. They are used in some brushless servo systems to provide commutation information to the brushless servo controller.

For three phase brushless servo motors, three Hall-effect devices are used to provide commutation signals. In some motors, a magnetized wheel is attached to the rear of the motor shaft. In other motors, the actual rotor magnets are used in lieu of a magnetized wheel. The three Hall-effect devices sense the magnet field of the wheel or the rotor magnets as the motor shaft rotates and produce three square wave signals phased 120° apart. These three signals are used by the brushless controller to generate currents in the proper motor phases for optimum torque production.

The Hall-effect device itself is an electronic component and has a temperature rating of 155°C.

DC TACHOMETER (brush-type)

The DC tachometer is used to sense motor velocity. It generates an analog DC voltage that is proportional to shaft velocity. The polarity of the output voltage is determined by the direction of rotation. The tachometer can be viewed as a DC servo motor operated as a DC generator. Brushes and a commutator couple the output voltage from the rotating winding to the stationary terminal connections.

The DC tachometer is an electromagnetic device and contains no electronics.

BRUSHLESS TACHOMETER

Like the DC tachometer, this device is used to sense motor velocity. It provides an analog DC voltage proportional to speed with its polarity determined by the direction of rotation. However, unlike the DC tachometer, the brushless tachometer does not have brushes or a commutator. Commutation is done electronically which eliminates brushes and their potential problems.

The commutation electronics are typically located in the tachometer package mounted on the rear of the motor. The brushless tachometer was developed specifically for use with brushless motors.

RESOLVER

The resolver is an electromagnetic device that is excited with a high frequency carrier signal. The resolver output is a two phase, amplitude modulated signal. These signals are processed by a resolver-to-digital converter (RDC) located in the controller. There are no electronics located in the resolver package mounted on the motor.

The RDC produces an analog velocity signal and a digital position word. The digital position word is used for motor commutation and can also be used for motor positioning. The resolver is functionally equivalent to Hall-effect sensors plus brushless tachometer plus absolute encoder.

SYNCHRO

The synchro is essentially a three phase version of the resolver. Synchro signals can be processed by an RDC by first running the three phase synchro signals through a Scott-T transformer. This transformer converts the three phase signals to two phase signals which can be used by the RDC.

In industrial servo applications, the resolver is far more prevalent than the synchro. This is due primarily to the lower cost of the resolver and its ability to directly interface to the RDC electronics. Synchros require the Scott-T transformer to interface to the RDC which adds cost and complexity.

ENCODER

An encoder is an electro-optical position sensor. It is available in absolute or incremental versions with the incremental version more commonly used.

An incremental encoder consists of a glass, mylar, or metal disk with alternating opaque and transparent stripes. Light from an LED or lamp is passed through the disk onto a photosensor which detects the alternating opaque and transparent stripes. Encoder outputs are typically two phase digital signals in quadrature (90° out of phase). Rotational direction information is obtained by sensing which output phase is leading. Absolute encoders operate on similar principles but have multiple tracks to generate absolute position information.

The processing electronics used to convert the optical signals to digital signals are contained in the encoder package mounted on the motor.

COMMUTATION ENCODER

The commutation encoder is a self contained device that offers both commutation tracks for brushless motor commutation and tracks for velocity, and/or position sensing. Motor commutation is accomplished by adding additional data tracks to the encoder disk with the correct electrical spacing similar to the hall-effect feedback device. A typical commutation encoder has an additional 3 tracks which produce square waves that are phased 120° apart and can be aligned to a brushless motor's back EMF. The commutation information is used at the drive end to steer the current into the required motor winding(s). Standard encoder data tracks for velocity, and/or position found on the other tracks typically consist of square wave 2 channel quadrature with index.

The processing electronics used to convert the optical to digital signals are contained in the encoder package mounted to the motor. These devices have typically been designed to commutate 4, 6, and 8 pole motors.

OVERVIEW OF FEEDBACK DEVICES...SUMMARY

In general, it is good design practice to keep electronics and optics out of the motor since motors are designed to operate at high winding temperatures, i.e., 155°C. When the motor is operated at its rated continuous torque, the temperature around the feedback device mounted on the motor can reach 110°C or more. This temperature is well beyond the operating range of commercial and industrial grade electronic components. To solve the temperature sensitivity problem, more expensive military grade components must be used or the motor must be derated to reduce the winding temperature to an acceptable level. Either solution introduces added cost to the system.

The Hall effect, and resolver offer a solution to the temperature problem since these devices are rated to a 155°C motor winding operating temperature and their processing electronics are located in the controller rather than on the motor.

The inherent ruggedness of the Hall effect, and resolver is important when considering other environmental issues such as shock, vibration, and motor sealing. Optical encoders can be especially susceptible to these environmental hazards.

FEEDBACK DEVICES

Device	Technology	Parameter(s) Measured	Function
⚠ Hall effect	Electronic-magnetic	Coarse rotor position	Brushless motor commutation, limited velocity feedback.
DC Tachometer	Electromagnetic	Motor velocity	Analog velocity feedback.
Brushless Tachometer	Electronic	Motor velocity	Analog velocity feedback.
⚠ Resolver	Electromagnetic	Coarse rotor position, Motor velocity, Fine rotor position	Brushless motor commutation, Analog velocity feedback, Digital position feedback.
Synchro	Electromagnetic	Coarse rotor position, Motor velocity, Fine rotor position	Brushless motor commutation, Analog velocity feedback, Digital position feedback.
⚠ Encoder	Electro-optical	Fine rotor position	Digital position feedback, limited velocity feedback.

⚠ Standard Pacific Scientific Brushless Servomotor feedbacks.

STANDARD PACIFIC SCIENTIFIC SERVOMOTOR CONFIGURATIONS

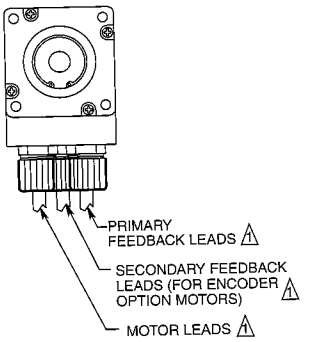
Typical Configurations	Standard Feedback Device(s) Used	Function
Torque Control	Hall effect Sensors	Sensors provide motor commutation information to an amplifier.
Velocity Control	Hall effect Sensors & Encoder	Provides motor commutation and digital velocity feedback and position information.
Position Control	Resolver	Resolver provides motor commutation, analog velocity, and digital position information to a controller (with electronics in the controller).

MOTOR CONNECTORS

FLYING LEADS (STANDARD)

(22 GA. SHIELDED CABLE, 18" LONG)

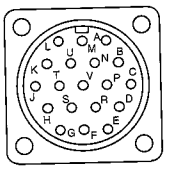
Lead Color	Function
Blue	Phase R
Brown	Phase S
Violet	Phase T
Green/Yellow	Ground (Frame)
----------	Shield



⚠ Standard length of cables is 18.0 in. (457,2 mm) minimum measured from rear end bell. Wires are stripped.

MOTOR MOUNTED MS CONNECTOR (STANDARD OPTION)

MS3102E22-14P

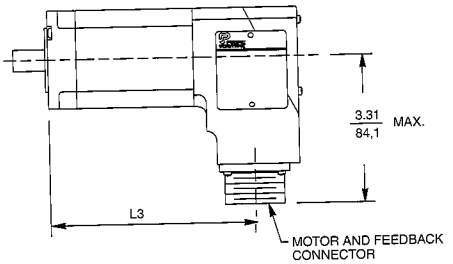


PINOUTS ⚠

Connector Pin	Function
A	Phase R
B	Phase S
C	Phase T
N	Ground (Frame)

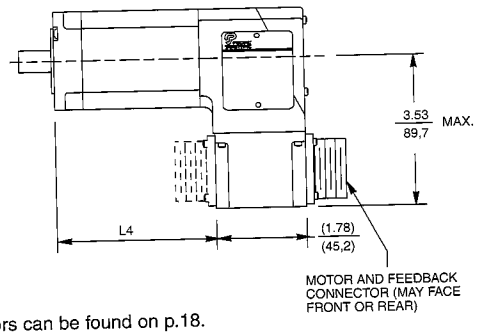
SUGGESTED MATING CONNECTOR AND CLAMP

MATING CONNECTOR	CLAMP
MS3106A22-14S	MS3057-12A-1
PACIFIC SCIENTIFIC	PACIFIC SCIENTIFIC
P/N CZ00075	P/N CE00003



ENGLISH (INCHES)

MODEL NUMBER	L3 REF.	L4 REF.
S21	(3.94)	(3.02)
S22	(4.94)	(4.02)
S24	(6.94)	(6.02)



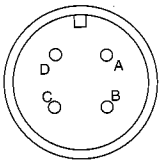
METRIC (MILLIMETERS)

MODEL NUMBER	L3 REF.	L4 REF.
S21	(100,1)	(76,7)
S22	(125,5)	(102,1)
S24	(176,3)	(152,9)

⚠ Complete Pinout information for S20 series motors can be found on p.18.

FLYING LEADS WITH MS CONNECTOR AT END (STANDARD OPTION)

MS3101A20-4P

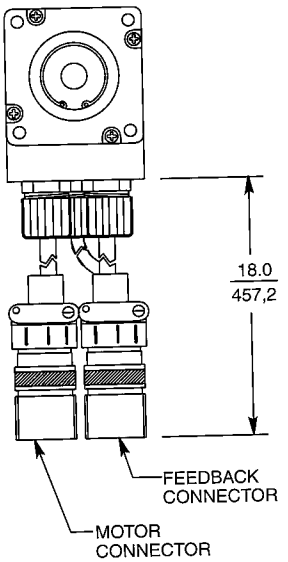


PINOUTS

Connector Pin	Function
A	Phase R
B	Phase S
C	Phase T
D	Ground (Frame)

SUGGESTED MATING CONNECTOR AND CLAMP

MATING CONNECTOR	CLAMP
MS3106A20-4S	MS3057-12A-1
PACIFIC SCIENTIFIC	PACIFIC SCIENTIFIC
P/N CZ00007	P/N CE00003

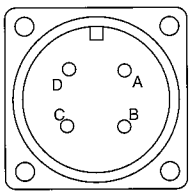


STANDARD TERMINATION OPTIONS...S30 Series, NEMA 34 Frame

MOTOR CONNECTORS

MOTOR MOUNTED MS CONNECTOR (STANDARD)

MS3102E20-4P

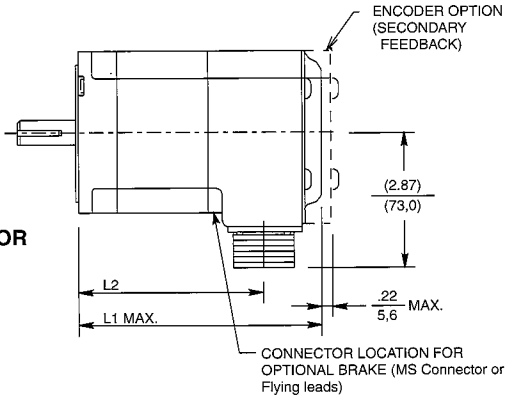


PINOUTS

Connector Pin	Function
A	Phase R
B	Phase S
C	Phase T
D	Ground (Frame)

SUGGESTED MATING CONNECTOR AND CLAMP

MATING CONNECTOR	CLAMP
MS3106A20-4S	MS3057-12A-1
PACIFIC SCIENTIFIC	PACIFIC SCIENTIFIC
P/N CZ00007	P/N CE00003



ENGLISH (INCHES)

MODEL NUMBER	L1 MAX.*	L2 REF.*
S31	5.13	(3.84)
S32	6.63	(5.34)
S33	8.13	(6.84)

Note: L1 includes primary feedback device.

METRIC (MILLIMETERS)

MODEL NUMBER	L1 MAX.*	L2 REF.*
S31	130,3	(97,5)
S32	168,4	(135,6)
S33	206,5	(173,7)

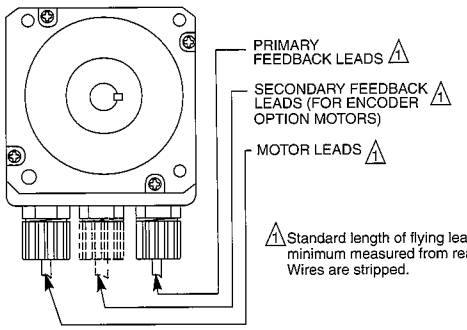
Note: L1 includes primary feedback device.

*Add 2.66 in. (67,5mm) for brake option.

FLYING LEADS (STANDARD OPTION)

(18 GA. SHIELDED CABLE, 18" LONG)

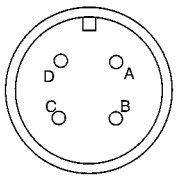
Lead Color	Function
Blue	Phase R
Brown	Phase S
Violet	Phase T
Green/Yellow	Ground (Frame)
---------	Shield



1 Standard length of flying leads is 18.0 in. (457,2 mm) minimum measured from rear end bell. Wires are stripped.

FLYING LEADS WITH MS CONNECTOR AT END (STANDARD OPTION)

MS3101A20-4P

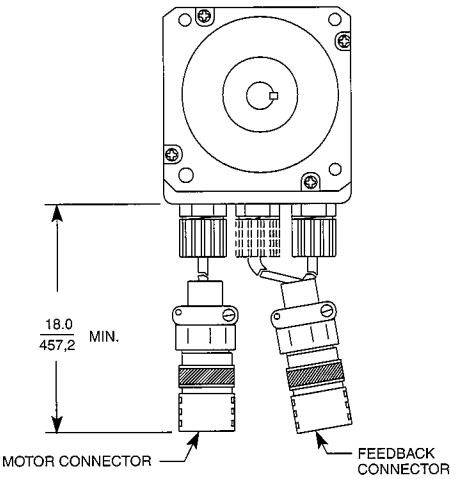


PINOUTS

Connector Pin	Function
A	Phase R
B	Phase S
C	Phase T
D	Ground (Frame)

SUGGESTED MATING CONNECTOR AND CLAMP

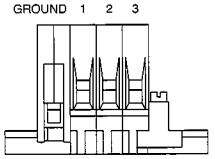
MATING CONNECTOR	CLAMP
MS3106A20-4S	MS3057-12A-1
PACIFIC SCIENTIFIC	PACIFIC SCIENTIFIC
P/N CZ00007	P/N CE00003



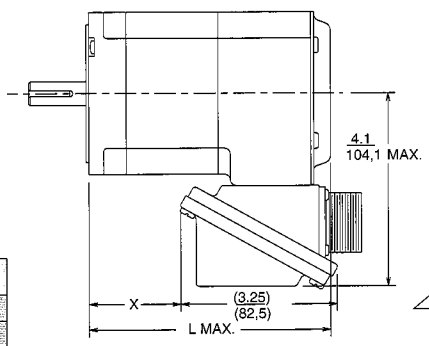
TERMINAL BOX (STANDARD OPTION)

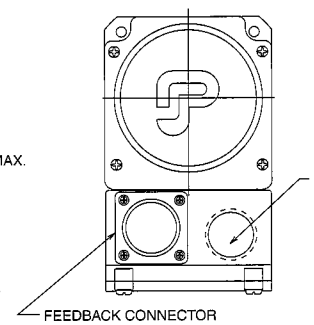
(terminal strip shown)

Available in combination with MS connector only (not flying leads) when MS connector is used for primary or primary and secondary feedback termination.



Screw Terminal Connections	Function
1	Phase R
2	Phase S
3	Phase T
⏚	Ground





1/2" NPT FOR TERMINAL STRIP ACCESS (Motor power connection and brake option. Special fittings available on request.)

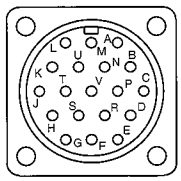
MODEL NUMBER	L MAX.	X
S31	5.13	(1.91 / 48.5)
S32	6.63	(3.41 / 86.6)
S33	8.13	(4.91 / 124.7)

STANDARD TERMINATION OPTIONS...S20 & S30 SERIES

PRIMARY FEEDBACK

MOTOR MOUNTED MS CONNECTOR (S20 SERIES)

MS3102E22-14P



STANDARD PINOUTS

Connector Pin	Motor and Resolver Feedback	Motor and Hall Sensor Feedback
A	Phase R	Phase R
B	Phase S	Phase S
C	Phase T	Phase T
D	N/C	N/C
E	S4 (-cosine)	Sensor 1
F	S3 (-sine)	Sensor 2
G	S2 (+cosine)	Sensor 3
H	S1 (+sine)	N/C
J	N/C	N/C
K	Thermistor ⚠	Thermistor ⚠
L	Thermistor ⚠	Thermistor ⚠
M	N/C	N/C
N	Ground (Frame)	Ground (Frame)
P	N/C	N/C
R	R1 (Excitation)	+Vdc
S	R2 (Excitation RTN)	Vdc RTN
T	N/C	N/C
U	N/C	N/C
V	N/C	N/C

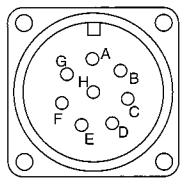
⚠ Optional Thermostat available for S 30 series only.

SUGGESTED MATING CONNECTOR AND CLAMP

MATING CONNECTOR	CLAMP
MS3106A22-14S	MS3057-12A-1
PACIFIC SCIENTIFIC	PACIFIC SCIENTIFIC
P/N CZ00075	P/N CE00003

MOTOR MOUNTED MS CONNECTOR (S30 SERIES)

MS3102E20-7P



PINOUTS

Connector Pin	Resolver	Hall Sensors
A	S4 (-cosine)	+Vdc
B	S3 (-sine)	Vdc RTN
C	S2 (+ cosine)	Sensor 1
D	S1 (+sine)	Sensor 2
E	R1 (Excitation)	Sensor 3
F	R2 (Excitation RTN)	N/C
G	Thermistor	Thermistor
H	Thermistor	Thermistor

SUGGESTED MATING CONNECTOR AND CLAMP

CONNECTOR	CLAMP
MS3106A20-7S	MS3057-12A-1
PACIFIC SCIENTIFIC	PACIFIC SCIENTIFIC
P/N CZ00008	P/N CE00003

FLYING LEADS (S20 & S30 SERIES)

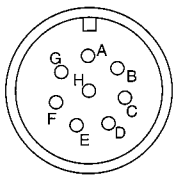
(22 GA. SHIELDED CABLE, 18" LONG)

Lead Color	Resolver	Hall Sensors
Green	S4 (-cosine)	Sensor 1
Black	S3 (-sine)	Supply Return
Brown	S2 (+cosine)	Sensor 2
Red	S1 (+sine)	+4.5 to 24 Vdc
Red/White	R1 (Excitation)	N/C
Black/White	R2 (Excitation Return)	N/C
Yellow	Thermistor	Thermistor
Blue	Thermistor	Thermistor
Yellow ⚠	N/C	Sensor 3
------	Shields	Shields

⚠ Yellow conductor from the brown, yellow and green triad.

FLYING LEADS W/ MS CONNECTOR AT END (S20 & S30 SERIES)

MS3101A20-7P



PINOUTS

Connector Pin	Resolver	Hall Sensors
A	S4 (-cosine)	+Vdc
B	S3 (-sine)	Vdc RTN
C	S2 (+ cosine)	Sensor 1
D	S1 (+sine)	Sensor 2
E	R1 (Excitation)	Sensor 3
F	R2 (Excitation RTN)	N/C
G	Thermistor	Thermistor
H	Thermistor	Thermistor

SUGGESTED MATING CONNECTOR AND CLAMP

CONNECTOR	CLAMP
MS3106A20-7S	MS3057-12A-1
PACIFIC SCIENTIFIC	PACIFIC SCIENTIFIC
P/N CZ00008	P/N CE00003