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SRV02-Series

Rotary Servo Plant

User Manual

SRV02-(E;EHR)(T)

Rotary Servo Plant

User Manual

1. Description

The plant consists of a DC motor in a solid aluminum frame. The motor is equipped with a gearbox. The gearbox output drives external gears. The basic unit is equipped with a potentiometer to measure the output/load angular position.

2. Purchase Options

The product can be equipped with an optional tachometer and an optional quadrature encoder. The tachometer measures motor speed and the encoder measures output/load shaft angle. A high resolution encoder option is also available.

Model / Option	Description
SRV02	Basic Unit – Potentiometer, Motor and Gearbox
(**E**) Option	Potentiometer, 1024 line Quadrature Encoder and Motor
(**EHR**) Option	Potentiometer, 2048 line Quadrature Encoder and Motor
(**T**) Option	Potentiometer, Tachometer and Motor

Table 1 SRV02 Options

2.1 Modular Options

Quanser values itself for the modularity of its experiments. The SRV02 rotary plant module serves as the base component for the rotary family of experiments. This modular philosophy facilitates the change from one experimental setup to another with relative ease of work and a valuable savings in cost. The following table lists the experiments currently available in the rotary family of products utilizing the SRV02 as the base.

Module Name	Description
Ball & Beam	The Ball & Beam experiment requires the user to manipulate the position of a rolling ball on a beam.
Flexible Link	The Flexible Link experiment requires the user to command a *tip* position of the flexible link attached to the SRV02.
Flexible Joint	A rigid beam is mounted on a flexible joint that rotates via the SRV02 and the user is to command the tip position of this beam.
Gyro/Stable Platform	The purpose is to maintain the line of sight of an instrument mounted on a rotating platform (SRV02).
Inverted Pendulum	The purpose is to balance the inverted pendulum through a rotary motion arm (SRV02).
Double Inverted Pendulum	The double inverted problem adds to the complexity of the single pendulum by introducing a 2^{nd} pendulum.
2 DOF robot module	This experiment requires the x-y positioning of the “end effector”.
2 DOF Rotary Gantry	This experiment requires the control of the swing of a x-y gantry crane using a 5 DOF linkage.
2 DOF inverted pendulum	Balance a pendulum that is free to fall in 2 directions. The pendulum is attached to the tip of the 2 DOF robot.

Table 2 Rotary Family Modules

3. System Nomenclature and Components

Refer to the following figures below to associate the *components* with their corresponding photographs.

1	Top Plate	**13**	Tachometer
2	Bottom Plate	**14**	Bearing Block
3	Posts	**15**	Potentiometer Connector
4	Standard Motor Gear – 72 teeth	**16**	S2 Connector
5	Output Gear	**17**	Encoder Connector
6	Potentiometer Anti-Backslash Gear	**18**	Tachometer Connector
7	Anti-Backslash Springs	**19**	Motor Connector
8	Output Shaft / Load Shaft	**20**	Motor Gear – 24 teeth
9	Motor	**21**	Load Gear – 120 teeth
10	Gearbox		
11	Potentiometer		
12	Encoder		

Table 3 Component Names

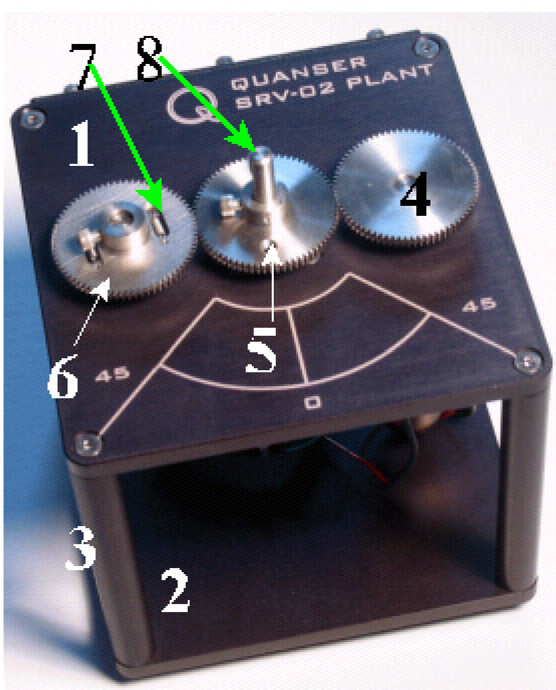


Figure 1 SRV02 Front View

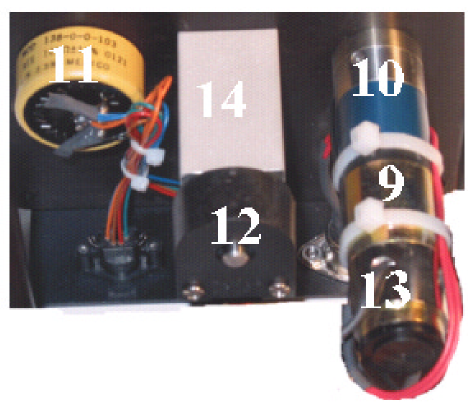


Figure 2 SRV02 Under the Top Plate

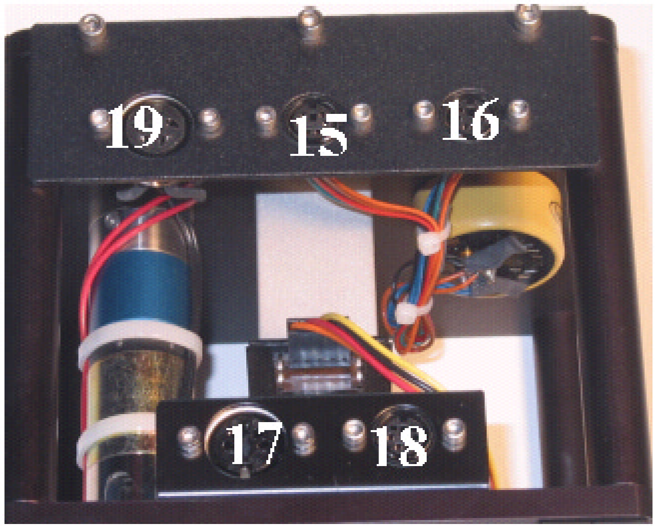


Figure 3 SRV02 Connections View

4. System Configuration and Assembly

The external gear can be reconfigured in two configurations:

4.1 Low Gear Ratio

This is the recommended configuration to perform the position and speed control experiments with no other module attached to the output. The only loads that are recommended for this configuration are the bar and circular loads supplied with the system.

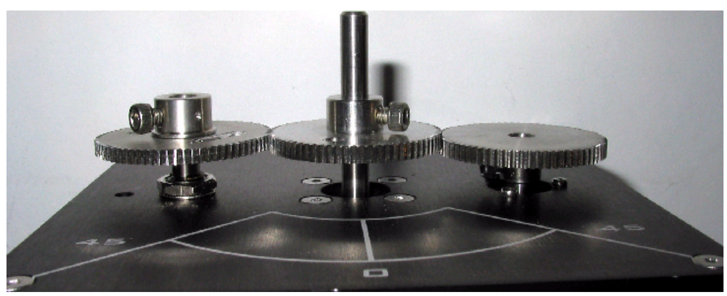


Figure 4 Low Gear Configuration

4.2 High Gear Ratio

This is the recommended configuration for all other experiments that require an additional module such as the ball and beam, gyro, rotary inverted pendulum, etc.

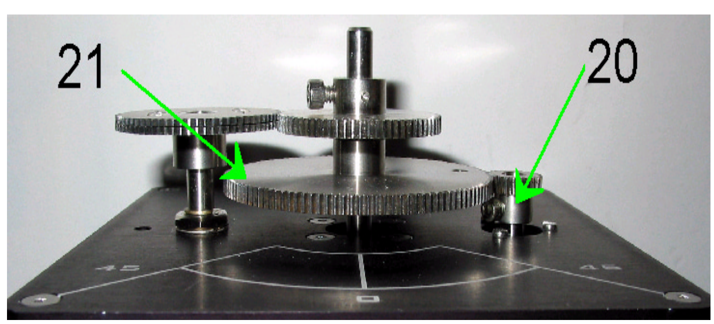


Figure 5 High Gear Configuration

4.3 Assembly

The SRV02 system is already pre-assembled. The one manual assembly needed is changing the gear configuration.

4.3.1 Changing Gear Ratios

- Each SRV02 system is shipped with 2 gear configurations (as seen in Figure 4 and Figure 5). Use the appropriate allen key (shipped with system) to loosen the screws on the gear hubs and remove them from the shafts.

- Insert the new gears as shown depicted in one of the configurations above. Tighten the screws with the same allen key used before.

- The potentiometer gear is an **anti-backlash** gear (*Component 6*). In order to insert it properly, you must rotate its two faces against each other such that the springs are partially pre-loaded. Do not fully extend the springs when you pre-load the gears.

4.3.2 Attaching External Loads

The SRV02 comes with two external loads to be attached to your system. Loads should be attached to the load gear with the provided 8-32 screws. **Do not apply a load greater than 5kg at any time**. Make sure all the screws are properly tightened before operating the servo.

For directions in attaching one of the many Quanser modular experiments, please refer to each experiments individual user manual for detailed instructions.

5. Wiring and Operation Procedure

5.1 DC Motor (*component 9*)

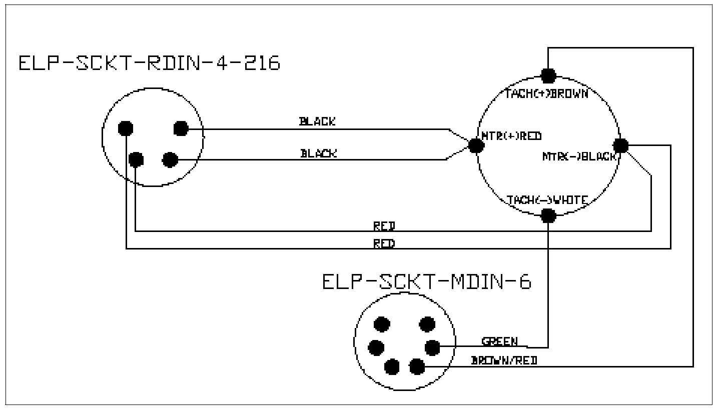
The SRV02 incorporates a *MicroMo Coreless DC Motor (2338S006).* This model is a high efficiency low inductance motor resulting in a much faster response than a conventional DC motor.

The motor connection is a 4-pin DIN connector (*component 19*) configured to be driven by a Quanser Universal Power Module. For a complete schematic and spec. sheet of the motor, refer to Appendix B at the end of this manual.

WARNING: *High Frequency signals applied to a motor will eventually damage the gearbox and/or the brushes. The most likely source for high frequency noise is derivative feedback. If the derivative gain is too high, a noisy voltage will be fed into the motor. To protect your motor, you should always band limit your signal (especially derivative feedback) to a value of **50Hz**.*

5.2 Tachometer (*component 13*)

The SRV02 (T) option comes fully equipped with a *MicroMo (2356S006) Motor and Tach Combination.* The tachometer is attached directly to the motor so there are no latencies in the timing of the response and the speed of the motor is accurately measured. The following Schematic 1 is the wiring diagram of the tachometer. The 4-pin DIN connector (*component 19*) shown is the actual input signal driving the motor (from UPM). The 6-pin mini DIN is the tachometer connector (*component 18*) and is typically connected to *S3* on the UPM. For a complete schematic and spec. sheet on the tachometer, refer to Appendix C at the end of this manual.

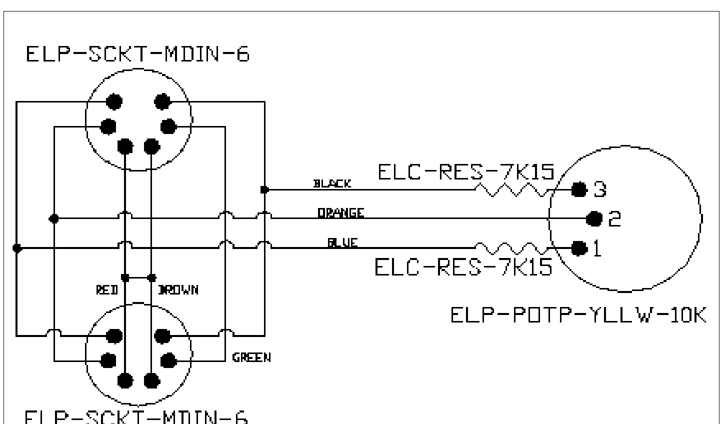


Schematic 1 Tachometer Wiring

5.3 Potentiometer (*Component 11*)

All SRV02 models come with a potentiometer already assembled. The model used is a *Vshay Spectrol model 132* potentiometer. It is a single turn, 10k Ohm sensor with no physical stops. Its electrical range is 352 degrees. It is biased such that a +/- 12 V supply results in a +/- 5 V range over the full range of 352 degrees. Under normal operations, terminal three should measure +5 V while terminal 1 should measure -5 V. The actual signal is available at terminal 2.

It is wired to two 6-pin mini DIN sockets in parallel and its signal is typically available on *S1* when connected to a Quanser UPM. The second mini DIN Connector (*S2*) is used to connect to other rotary modules. The two 6-pin mini connectors seen in Schematic 2 are *components 15 & 16* respectively.

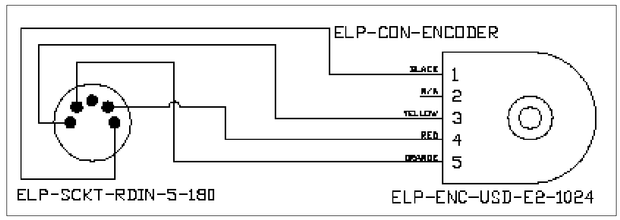


Schematic 2 Potentiometer Wiring

5.4 Encoder (*Component 12*)

The SRV02 (E) and (EHR) options come with an optical encoder used to measure the load shaft angular position. The model used in the SRV02 is a US Digital Optical Kit Encoder. It offers high resolution (4096 counts in quadrature – 8192 for EHR), and measures the *relative* angle of the shaft (as opposed to the potentiometer which only measure an *absolute* angle from a pre-defined 0° location).

The Encoder sends a digital signal and should be directly connected to a Quanser terminal board using a standard 5-pin DIN cable. **DO NOT connect the encoder signal to the UPM**. Is the wiring diagram of the encoder. The 5-pin DIN connector shown in Schematic 3corresponds to *component 17* on the SRV02.



Schematic 3 Encoder Wiring

5.5 Typical Connections for the SRV02

From...	*To...*	*Cable*	*Description*
Potentiometer (*Component 16*)	*S1* Connector on *UPM.*	6-pin mini DIN to 6-pin mini DIN.	This cable results in delivering a ±12V bias to the potentiometer and measuring the wiper voltage on *S1*.
Tachometer (*Component 18*)	*S3* Connector on *UPM.*	6-pin mini DIN to 6-pin mini DIN.	This cable results in the tachometer signal being measured on *S3* on the *UPM.*
Encoder (*Component 17*)	*Encoder 0* connector on the terminal board.	5-pin Stereo DIN to 5-pin Stereo DIN.	The terminal board should supply the encoder with the +5V and ground. The terminal will then measure the A & B signals on the *Encoder 0* channel.
Motor (*Component 19)*	*'To Load'* Connector on *UPM.*	4-pin DIN to 6-pin DIN.	This connects the output of the amplifier to the motor. You can use a variety of cables resulting in a different gain from input to output. The cables available are Gain=1, Gain=3, Gain=5.
Analog Signals (*To A/D)*	Analog input channels 0-3 on the DAC.	5-pin DIN to 4x RCA.	From the *UPM,* connect all the analog sensor signals to the terminal board such that *S1* is measured on channel 0.
UPM input (*From D/A)*	Analog output channel 0 on the DAC.	5-pin DIN to RCA.	This is the output of the terminal board that needs to be amplified and drive the motor.

6. Testing and Trouble-Shooting the SRV02

This section describes functional tests to determine if your SRV02 is operating normally. It does **not** cover any performance tests. All these tests require an understanding of Simulink (or Labview), WinCon (or equivalent), and MultiQ (or equivalent data acquisition board you are using). You should be able to *"build"* a controller that can measure and apply desired signals.

In the following sections, it is also assumed that the SRV02 is connected as described in the *Typical Connections* table in *Section 5.5* above.

6.1 Testing the Motor

- Apply a voltage to analog output channel 0 of the terminal board (use Simulink and WinCon or equivalent).
- A positive voltage should result in a counter-clockwise rotation of the motor shaft and a negative voltage should result in a clockwise rotation. You should note that the motor shaft and the load shaft turn in opposite directions.

6.1.1 **Trouble-Shooting the Motor**

If the motor is not responding to any signals applied, you should:

- Check that the power amplifier is functional.
- Check that the MultiQ is functional. The LED on the board should be on.
- Check that the voltage is actually reaching the motor terminals (use an oscilloscope).
- If the motor terminals are receiving the signal and the motor is still not turning, your motor might be damaged and will need to be repaired. Please refer to our support section for information on contacting Quanser.

6.2 Testing the Potentiometer

- Wire the potentiometer to the *S1* connector on the *UPM*. Ensure that the *S1* signal is connected to analog input channel 0 on the terminal board.
- Measure the channel 0 signal using Simulink and WinCon (or equivalent).
- Rotating the shaft counter-clockwise should result in a positive change in the signal gradually increasing to +5V. You will then reach the discontinuity at which point the signal will abruptly change to -5V and begin to increase again.

6.2.1 **Trouble-Shooting the Potentiometer**

If the potentiometer does not measure correctly, you should:

- Measure the voltage across the potentiometer. It should be powered with ±12V at the DIN connector and ±5V at the potentiometer terminals. If the voltage from the wiper does not change when you rotate the potentiometer shaft, your potentiometer needs to be replaced. Refer to our Support section for additional information on replacing your potentiometer.

6.3 Testing the Tachometer

- Connect the tachometer to the *S3* connector on the *UPM.* Measure the tachometer voltage on analog input channel 2 of your terminal board.
- Apply a voltage to your Motor.
- The faster the motor turns, the higher the tachometer signal should be.
- Applying a voltage of +2V to the motor, should result in a tachometer measurement of approximately 3 volts.

6.3.1 **Trouble-Shooting the Tachometer**

If you are receiving any signal from your tachometer, and you have checked all the wiring, your tachometer may be damaged and need replacement. Please refer to our support section on information to contact Quanser.

6.4 Testing the Encoder

- Connect the encoder to one of the encoder channels on the terminal board and construct a controller that measures the signal from the encoder channel.
- Rotating the shaft for one rotation should result in the measurement of 4096 counts (8192 for EHR option).

You should *Note* that some data acquisition systems do not measure in quadrature in which case you will receive ¼ of the expected counts; and thus less resolution. Other data acquisition systems **DO** measure in quadrature but increment the count by 0.25. You should know how the system you are using works. Standard Quanser counters measure a total of 4x # of lines per rotation. Therefore a 1024 line encoder results in a total count from 0 to 4095 for 1 full revolution.

6.4.1 **Trouble-Shooting the Encoder**

If the encoder doesn't measure properly, you should:

- Check the fuse on the data acquisition board. Replace if burnt.
- Check that the A & B signals are present on the encoder. Use an oscilloscope.

7. Technical Support

For technical support referring to any of the SRV02 components, please visit us on the web at: www.Quanser.com.

Under our *Technical Support* section, please fill out a *technical support form* indicating your problem in detail and one of our engineers will be happy to respond to your request.

Appendix A: System Parameters

The following table is listing of all the system parameters associated with the SRV02.

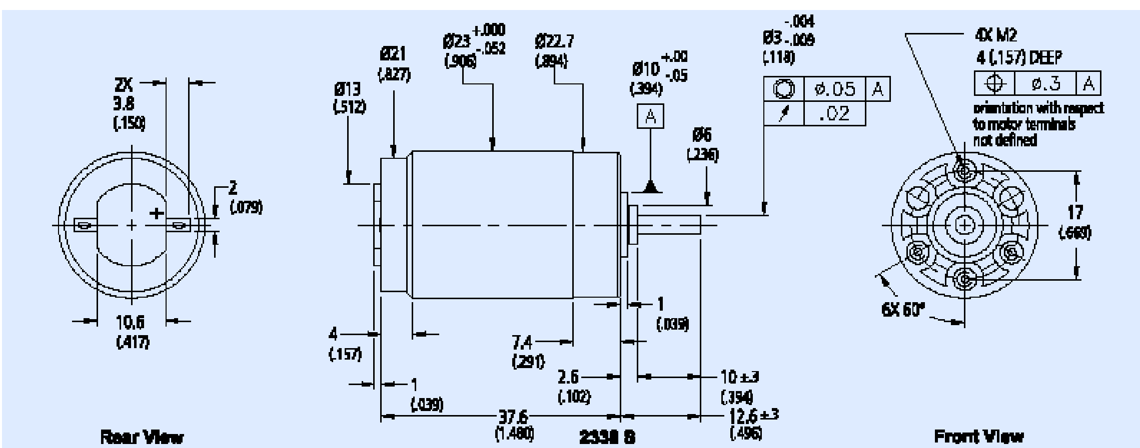
Symbol	Name	Value	Units	Variation
K_t	Motor Torque Constant	**0.00767**	N·m	±12%
K_m	Back EMF Constant	**0.00767**	V/(rd/s)	±12%
R_m	Armature Resistance	**2.6**	Ω	±12%
K_{gi}	Gearbox Ratio (Internal)	**14:1**	N/A	
K_{ge-low}	External Low Gear Ratio	**1:1**	N/A	
$K_{ge-high}$	External High Gear Ratio	**5:1**	N/A	
J_m	Motor Inertia	**3.87 e-7**	$kg \cdot m^2$	±10%
J_{tach}	Tachometer Inertia	**0.7 e-7**	$kg \cdot m^2$	±10%
Jeq_{low}	Equivalent Low Gear Inertia	**9.3 e-5**	$kg \cdot m^2$	±10%
Jeq_{high}	Equivalent High Gear Inertia	**2.0 e-3**	$kg \cdot m^2$	±10%
Beq_{low}	Viscous Damping Coefficient (Low)	**1.5 e-3**	N·m/(rd/s)	±20%
Beq_{high}	Viscous Damping Coefficient (High)	**4.0 e-3**	N·m/(rd/s)	±20%
Eff_g	Gearbox Efficiency	**0.85**	N/A	±10%
Eff_m	Motor Efficiency	**0.69**	N/A	±5%
K_{pot}	Potentiometer Sensitivity	**35.2**	Deg/V	±2%
K_{Enc}	Encoder Resolution (E option)	**4096**	Counts/rev.	
K_{EncH}	Encoder Resolution (EHR option)	**8192**	Counts/rev.	
K_{tach}	Tachometer Sensitivity	**1.5**	V/1000RPM	±2%
M_{max}	Maximum Load on Output Shaft	**5**	kg	
f_{max}	Maximum Input Frequency	**50**	Hz	
V_{rated}	Rated Motor Voltage	**6**	V	

Appendix A SRV02 System Parameters

Appendix B: Motor Specification Sheet

Series 2338 ... S

		2338 S	4.5 S	006 S	009 S	012 S	018 S	024 S	
1	Nominal voltage	U_N	4.5	6	9	12	18	24	Volt
2	Terminal resistance	R ± 12%	1.4	2.6	5.7	10.0	23.5	38.0	Ω
3	Output power	$P_{2\,max.}$	3.39	3.23	3.29	3.31	3.18	3.50	W
4	Efficiency	$\eta_{max.}$	70	69	67	66	67	67	%
5	No-load speed	n_o ± 12%	7,200	7,200	7,400	7,800	7,400	7,600	rpm
6	No-load current (with shaft ø 0.12 in)	I_o ± 50%	0.100	0.080	0.060	0.050	0.030	0.025	A
7	Stall torque	M_H	2.55	2.42	2.41	2.29	2.32	2.49	oz-in
8	Friction torque	M_R	0.082	0.086	0.095	0.099	0.095	0.102	oz-in
9	Speed constant	k_n	1,650	1,240	855	678	428	330	rpm/V
10	Back-EMF constant	k_E	0.606	0.804	1.170	1.470	2.340	3.030	mV/rpm
11	Torque constant	k_M	0.818	1.088	1.586	1.997	3.158	4.107	oz-in/A
12	Current constant	k_I	1.222	0.919	0.630	0.501	0.317	0.244	A/oz-in
13	Slope of n-M curve	$\Delta n/\Delta M$	2,824	2,975	3,071	3,406	3,190	3,052	rpm/oz-in
14	Rotor inductance	L	100	180	380	630	1,400	2,600	µH
15	Mechanical time constant	τ_m	20	17	17	17	17	17	ms
16	Rotor inertia	J	$6.797 \cdot 10^{-5}$	$5.523 \cdot 10^{-5}$	$5.240 \cdot 10^{-5}$	$4.815 \cdot 10^{-5}$	$5.098 \cdot 10^{-5}$	$5.381 \cdot 10^{-5}$	oz-in-sec²
17	Angular acceleration	$\alpha_{max.}$	38	44	46	48	46	47	$\cdot 10^3$rad/s²
18	Thermal resistance	$R_{th\,1} / R_{th\,2}$	3 / 24						°C/W
19	Thermal time constant	τ_{w1} / τ_{w2}	5.7 / 645						s
20	Operating temperature range:								
	– motor		– 30 to +85 (– 22 to +185)						°C (°F)
	– rotor, max. permissible		+125 (+257)						°C (°F)
	Note: Special operating temperature models for		–55°C to +125°C (– 67°F to +257°F) available on request.						
21	Shaft bearings		sintered bronze sleeves		ball bearings		ball bearings, preloaded		
22	Shaft load max.:		(standard)		(optional)		(optional)		
	– with shaft diameter		0.1181		0.1181		0.1181		in
	– radial at 3,000 rpm (0.12 in from bearing)		9		72		72		oz
	– axial at 3,000 rpm		1.08		7.2		7.2		oz
	– axial at standstill		72		72		72		oz
23	Shaft play:								
	– radial	≤	0.0012		0.0006		0.0006		in
	– axial	≤	0.0079		0.0079		0		in
24	Housing material		steel, zinc galvanized and passivated						
25	Weight		2.47						oz
26	Direction of rotation		clockwise, viewed from the front face						
Recommended values									
27	Speed up to	$n_{e\,max.}$	6,000	6,000	6,000	6,000	6,000	6,000	rpm
28	Torque up to	$M_{e\,max.}$	0.566	0.566	0.566	0.566	0.566	0.566	oz-in
29	Current up to (thermal limits)	$I_{e\,max.}$	1.380	1.000	0.680	0.510	0.330	0.260	A



Appendix B DC Motor Specification Sheet

Appendix C: Tachometer Specification Sheet

Series 2251 … S

Tachogenerator		1.5 G	
EMF constant	K_E	1.5	mV/rpm
		14.325	mV/rad s^{-1}
Tolerance of EMF constant		± 2	%
Load resistance	R_L	≥ 25	kΩ
Operating speed, max. continuous	$n_{e\ max.}$	≤ 5,000	rpm
Terminal resistance	R	260	Ω
Ripple, peak-peak, typical		7	%
Ripple frequency, cycles		14	per turn
Linearity, without load,			
between 500 and 5,000 rpm		± 0.2	%
Reversion error		± 0.2	%
Temperature coefficient of EMF		0.02	% / °C
Temperature coefficient of armature resistance		0.4	% / °C
Rotor inductance	L	3,000	µH
Direction of rotation		reversible	
Polarity		dependent on direction of rotation	

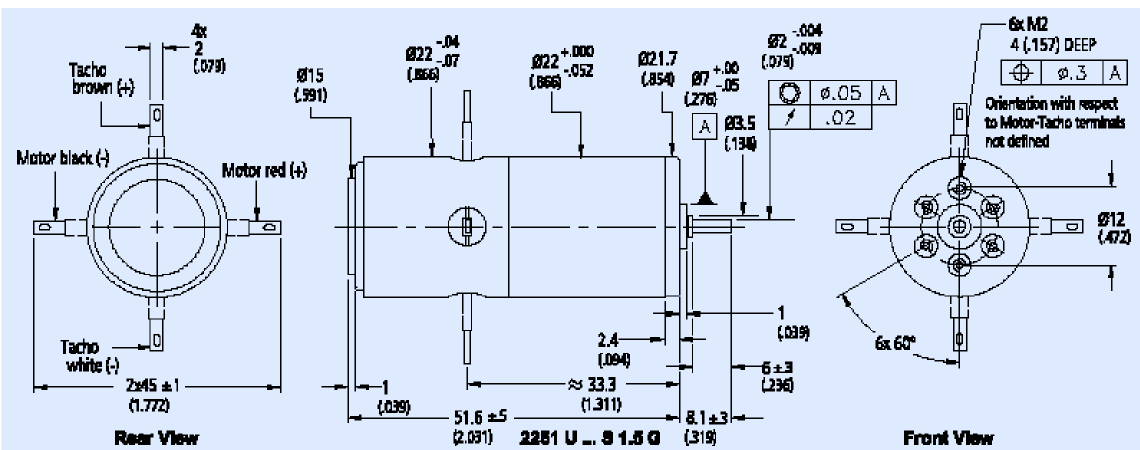
Features

Mono-axis design
Motor and tachogenerator feature the patented skew wound ironless rotors (System FAULHABER®).
The mono-axis design with the two commutator systems, facing each other in a patented arrangement, mounted on a single solid shaft, has excellent torsion characteristics and the highest frequency response possible.

Commutation system
The commutators and brushes are made of high quality precious metal alloy and provide a minimized but constant contact resistance as well as insensibility to changes in environment.

Operating temperature ranges:

Motor-Tacho, standard	–30 ... +85°C (–22 … +185°F)
Motor-Tacho, optional	–30 ... +125°C (–22 … +257°F)
Rotor, max. permissible	+125°C (+257°F)



Appendix C Tachometer Specification Sheet