CONTROL LOADING SOLUTIONS

Rev. E, November 2024

A FULL RANGE OF CONTROL LOADING SOLUTIONS FOR FIXED AND ROTARY WING

MOOG | Shaping the way our world moves™

TAKE YOUR CONTROL LOADING SYSTEMS TO NEW HEIGHTS

Moog has over 40 years' experience in the design and manufacture of control loading systems for a wide range of military and commercial fixed-wing and rotary-wing aircraft simulators. Thousands of control loading systems are in the field around the world effectively meeting the needs of our customers.

Our unique model-follower force-loop technology forms the basis for all our control loading systems. Combined with highly responsive electric actuators and sophisticated software models, Moog control loading systems deliver an unsurpassed level of performance, fidelity and reliability.

ADVANTAGES

- Highest level of design flexibility and unique expertise, with proven reliability in critical loading applications around the world for flight simulation and other applications
- Turnkey control loading solutions are fully tailored to customer requirements. A typical set-up could include base frame, interconnecting linkages, replica controls and integration of control loading hardware and software
- Optimal solution for all control loading requirements, from basic flight training to high fidelity full flight simulation to the highest level of certification from the US Federal Aviation Administration (FAA), European Union Aviation Safety Agency (EASA) or military equivalent
- All actuators are based on brushless permanent magnet servomotors and digital control electronics for smooth and dependable performance
- Provides a wide range of services including mechanical linkage design and manufacturing, software development, aircraft control response measurement, tuning and acceptance, installation support, training, spares and repair services

ELECTRIC ROTARY CONTROL LOADERS HIGH DYNAMIC

These actuators are based on high torque servomotors in a direct-drive setup, capable of generating an output torque of up to 200 Nm (1,770 lb in) continuously. They are designed for primary controls with high fidelity requirements in applications related to high fidelity control force simulation. High dynamic is provided through high torque and velocity.

Model *	CL-R-E/HD/50Nm	CL-R-E/HD/100Nm	CL-R-E/HD/150Nm	CL-R-E/HD/200Nm
Continuous Output Torque	45 Nm (73.8 ft-lb)	100 Nm (885 lb in)	150 Nm (1,325 lb in)	200 Nm (1,770 lb in)
Output Torque < 30 sec	55 Nm (88.5 ft-lb)	120 Nm (1,050 lb in)	175 Nm (1,550 lb in)	250 Nm (2,210 lb in)
Output Torque Peak < 1 sec	80 Nm (177 ft-lb)	240 Nm (2,125 lb in)	300 Nm (2,650 lb in)	350 Nm (3,100 lb in)
Output Stroke	Multi-turn	+/- 45 °	+/- 45 °	+/- 45 °
Output Mechanical Interface	Flange with 6 holes for sprocket or lever	M8 rod-end	M8 rod-end	M8 rod-end
Maximum Velocity (1 x 208-230 VAC)	2,500 °/s	600 °/s	590 °/s	500 °/s
Weight	20 kg (44.1 lb)	28 kg (61.7 lb)	37 kg (81.6 lb)	42 kg (92.6 lb)
Dimensions of Motor (LxWxH)	263 x 232 x 241 mm (10.4 x 9.1 x 9.5 in)	341 x 332 x 223 mm (13.4 x 13.1 x 8.8 in)	341 x 332 x 248 mm (13.4 x 13.1 x 9.8 in)	341 x 332 x 273 mm (13.4 x 13.1 x 10.7 in)
CE Marking	Yes	Yes	Yes	Yes
Operating Temperature	0 - 45 °C (273 - 318 K)	0 - 45 °C (273 - 318 K)	0 - 45 °C (273 - 318 K)	0 - 45 °C (273 - 318 K)
Storage Temperature	-25 - 70 °C (248 - 343 K)	-25 - 70 °C (248 - 343 K)	-25 - 70 °C (248 - 343 K)	-25 - 70 °C (248 - 343 K)
Humidity	<85% (operating); < 95% (storage) non-condensing	<85% (operating); < 95% (storage) non-condensing	<85% (operating); < 95% (storage) non-condensing	<85% (operating); < 95% (storage) non-condensing

ELECTRIC ROTARY CONTROL LOADERS MEDIUM DYNAMIC

These actuators comprise compact servomotor gearbox combinations capable of generating an output torque of up to 100 Nm (885 lb in) continuously. They are mainly used for secondary controls and medium fidelity primary controls in applications related to control force simulation. Medium dynamic is provided through medium torque and velocity.

Model *	CL-R-E/MD/40Nm	CL-R-E/MD/100Nm
Continuous Output Torque	40 Nm (354 lb in)	100 Nm (885 lb in)
Output Torque < 30 sec	50 Nm (443 lb in)	120 Nm (1,062 lb in)
Output Torque Peak < 1 sec	80 Nm (708 lb in)	200 Nm (1,770 lb in)
Output Stroke	+/- 45 °	+/- 45 °
Maximum Velocity	300 °/s	300 °/s
Weight	7 kg (15.4 lb)	11 kg (24.3 lb)
Output Mechanical Interface	M6 rod-end	M8 rod-end
CE Marking	Yes	Yes
Dimension of Motor (LxWxH)	334 x 94 x 135 mm (13.1 x 3.7 x 5.3 in)	364 x 136 x 181mm (14.3 x 5.3 x 7.1 in)
Operating Temperature	Yes	Yes
Storage Temperature	0 - 45 °C (273 - 318 K)	0 - 45 °C (273 - 318 K)
Humidity	-25 - 70 °C (248 - 343 K)	-25 - 70 °C (248 - 343 K)
Humidity	<85% (operating); < 95% (storage) non-condensing	<85% (operating); < 95% (storage) non-condensing

* See page 4 for the explanation of the ordering code

ELECTRIC LINEAR CONTROL LOADER

These actuators are compact with servo-ballscrew combinations capable of generating an output force of up to 2,400 N (539 lbf) continuously. Their primary use is for heavily loaded primary control force simulation. They are compact and provide high performance.

Model	CL-L-E/2.2kN
Stroke Length	127 mm (5.0 in)
Lubrication	Oil Lubrication-Lifetime Lubrication
Finish	Paint Flat Black
Position Feedback	Encoder (Absolute)
Static Design Load	4 kN (899 lbf)
Weight	13 kg (28.7 lb)
CE Marking	Yes
Actuator Continuous Force Capability	2.2 kN (495 lbf)
Actuator Peak Velocity Set by Controller	609 mm/s (24.0 in/s)
Actuator Screw Lead	20 mm/rev (0.79 in/rev)
Total Actuator Inertia	0,006 in-lb-s2 (Rotor, Screw, Interface of Bearings, Nute, Keyways)
Actuator Design Life	Dynamic Load Rating of Screw 19.5 kN (4,383 lbf)
L10 Life	10.8 million m (426 million in) of Travel at 1.1 N (250 lbf) Cubic Mean Load

CONTROL FORCE MEASUREMENT SYSTEM (CFM)

The CFM facilitates accurate force-position measurements of aircraft flight controls for the development of type-specific software models and verification/validation of the flight control responses in simulators.

KEY FEATURES

- High precision force/position measurement
- Extensive data analysis
- Position or angle measurements by rate-gyro. In combination with the stringpot, cross coupling measurement is possible
- Pedal plates, with sensors for measuring of heel and toe forces

ORDERING INFORMATION

Control Loader (CL)	Rotary or Linear (R or L)	Electric (E)	High Dynamic or Medium Dynamic (HD or MD)	Torque or Force (values as indicated in this brochure) ## Nm/kN

EXAMPLE

CL-R-E/HD/200Nm

MODULAR CONTROL LOADING SYSTEMS

The Moog Modular Control Loading units have been designed to support the easy and fast development and deployment of next-generation Flight Training Devices (FTDs). These compact modules have been developed for cost-effective, ready-to-use applications where installation volume constraints matter, making them an ideal solution for mobile trainers and quick-dispatch FTDs.

The Moog Modular Control Loading units are provided with the following components and features:

- Common software base
- Common user interface
- Highest fidelity and performance available
- Proven reliability and support

Moog offers three compact modules that can be implemented in rotary wing and fixed wing applications with a cyclic or center stick, pedals and collective unit. Each Modular Control Loading can be delivered with generic controls (as shown in the picture), or without controls so that custom controls can be mounted.

CENTER STICK UNIT

Installation Volume *Dimensions*		
Length (direction of flight)		404 mm (15.91 in)
Width		385 mm (15.16 in)
Depth below floor level		182 mm (7.17 in)
Performance Data *Specifications*	*Pitch*	*Roll*
Torque (continuous)	102 Nm (905 in-lb)	69 Nm (611 in-lb)
Torque (max. peak)	204 Nm (1810 in-lb)	138 Nm (1222 in-lb)
Force (cont. at grip)	180 N (40 lb)	107 N (24 lb)
Force (peak at grip) <1 sec	360 N (80 lb)	214 N (48 lb)
Travel	± 22 (8.4 inch)	± 22 (9.5 inch)
Velocity (max.)	210 deg/s	330 deg/s
Interface Diameter (inner diameter mounting socket) *Dimensions*		
Interface diameter		35 mm (1.38 in)*

COLLECTIVE UNIT

Installation Volume *Dimensions*	
Length (direction of flight)	195 mm (7.68 in)
Width	250 mm (9.84 in)
Depth below floor level	140 mm (5.51 in)
Performance Data *Specifications*	*Collective*
Torque (continuous)	95 Nm (844 in-lb)
Torque (max. peak)	190 Nm (1688 in-lb)
Force (cont. at grip)	164 N (37 lb)
Force (peak at grip) <1 sec	328 N (74 lb)
Travel	± 22 (8.6 inch)
Velocity (max.)	230 deg/s
Interface Diameter (inner diameter mounting socket) *Dimensions*	
Interface diameter	35 mm (1.38 in)*

PEDAL UNIT

Installation Volume *Dimensions*	
Length (direction of flight)	447 mm (17.60 in)
Width	486 mm (19.13 in)
Depth below floor level	167 mm (6.57 in)
Performance Data *Specifications*	*Yaw*
Torque (continuous)	99 Nm (876 in-lb)
Torque (max. peak)	188 Nm (1752 in-lb)
Force (cont. at grip)	314 N (70 lb)
Force (peak at grip) <1 sec	628 N (140 lb)
Travel	± 22 (4.7 inch)
Velocity (max.)	220 deg/s
Interface Diameter (inner diameter mounting socket) *Dimensions*	
Interface diameter	30 mm (1.18 in)*

TANDEM OPERATION

For a Pilot and Co-Pilot configuration, it's possible to couple the controls in two ways:

- Moog Force Control Loop allows very stiff virtual coupling by installing modules at both sides and couple the controls within the software models.
- Pedals and Cyclic modules are designed for mechanical interconnection by installing the modules on one side (for example Pilot) and connect to Co-Pilot side by mechanical push-pull rods. Due to its size, the Collective modules cannot be coupled mechanically and will therefore have the software coupling between pilot and co-pilot module. While offering a little less flexibility, it lowers acquisition cost.

* Smaller diameter controls can be accommodated by adding a shim bus, or adding bushings for the pedals.
The Cyclic and Collective units allow for a separate control neutral angle adjustment, independent of the motor position. The adjustmant is ± 25°.

MOOG THRUST LEVER

Our state-of-the-art active control systems are designed to meet the highest standards of fidelity and performance. The Moog Thrust Lever integrates seamlessly into a complete system with our range of control loading products, ensuring a cohesive and unparalleled experience.

KEY BENEFITS

- Adjustable Sensing Characteristics: Customize the sensing parameters to suit specific needs.
- Real-Time Control: Ensure immediate and precise responses to inputs.
- Adaptable: Capable of seamless connection and integration.

The Moog Control Loading Systems leverage programmability, real-time control, and flexibility to optimize performance and user experience.

CONTROL LOADING SOFTWARE

All Moog control loading systems are delivered with a basic model, allowing the operator to use the system with limited parameters (spring, damping and friction).

The Moog generic model represents a typical flight control system and is suitable for medium fidelity training devices. This software is available for fixed wing or rotary wing aircraft simulation.

Seamless integration with the host computer over ethernet utilizing the UDP protocol for communication.

The Moog aircraft-specific model replicates the controls of the simulated aircraft. This software model is used by customers to obtain the highest level of certification from the FAA, EASA or military equivalent.

All Moog Simulation products, utilize the software ControllerMiddleware framework running on a realtime Linux operating system on a dedicated computer.

The interface to this framework is established by webbased Graphical User Interface to monitor, control and diagnose all individual components of the control loading system.

MODEL DEVELOPMENT ENVIRONMENT

Moog offers a model development environment to program/model the behavior of the control loader. The Model Development Environment provides the possibility to develop and deploy own aircraft specific models so that they can run on Moog RT control loading computer. One of the advantages will be that the model and force-loop will run at a high frequency rate and the interface can run at a low frequency.

NOTES

TAKE A CLOSER LOOK

Motion System Solutions from Moog are available around the world. For more information, visit our web site or contact one of the locations below.

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