

AMTI

FORCE AND MOTION



The ADL Force 5 configured for knee testing

ADL Force 5

Specifications



ADL-Force 5 specifications

General ^[1]		
Base DOF	Specification	Comment
Vertical load	±4500N(±1000lb)	±25 mm (±1 inch)
Flexion	±100 degrees	45 N-m (400 in-lb)
IE rotation	±100 degrees	45 N-m (400 in-lb)
AP translation	±25 mm (±1 inch)	±4500N(±1000lb)
Additional DOF for knee configuration ^[2]	Specification	Comment
ML translation	±6 mm	Tibial tray, not controlled
Valgus rotation	±7 degrees	Tibial tray, not controlled
Additional DOF for hip configuration	Specification	Comment
Abduction	±9 degrees	3.4 N-m (30 in-lb)
High torque option	±9 degrees	6.8 N-m (60 in-lb)
Actuator type	Specification	Comment
Vertical load	Servo-hydraulic	
Flexion	Servo-hydraulic	
IE rotation	Servo-hydraulic	
AP translation	Servo-hydraulic	
Abduction	Brushless servo-motor	Removable abduction head
Control feedback	Typical method	Alternate method
Vertical load	Fz load cell	Position sensor
Flexion	Angle sensor	
IE rotation	Angle sensor	Mz load cell
AP translation	Position sensor	Fy load cell
Load cell (two included)	Specification	Comment
Channels	6 DOF	Fx, Fy, Fz, Mx, My, Mz
Type	Strain gage	Amplifier included in controls
Physical specifications	Specification	
Length	86 cm (34 in)	
Width	66 cm (26 in)	
Height	180 cm (70 in)	
Weight	550 kg (1200 lbs)	
Hydraulic system	Specification	Comment
Type	Integral pump & motor	Built into machine
Pressure	800 psi	Constant pressure
Capacity	7 GPM	
Installation requirements ^[3]	Specification	Comment
Power	240 VAC, 7 kva	3 phase, 50/60 Hz
Temp control	Modulating valve	Requires cooling water
Cooling	5 hp (3.7 kW)	1 gpm (4.2 L/m) - 16 °C

Dynamic performance			
	Maximum repetition rate		
Item	(repetitions/second) ^[4]	Maximum frequency (Hz) ^[5]	
Controller	30 Hz	30 Hz	
	Typical repetition rate		RMS error
DOF	(repetitions/second) ^[4]	Maximum frequency (Hz) ^[5]	(% FS) ^[6]
Vertical load	2.0 Hz	10 Hz	< 1%
Flexion extension	2.0 Hz	10 Hz	< 1%
IE rotation	2.0 Hz	10 Hz	< 1%
AP Translation	1.5 Hz	12 Hz	< 2%
	Typical repetition rate		RMS error
Additional DOF for hip	(repetitions/second) ^[4]	Maximum frequency (Hz) ^[5]	(% FS) ^[6]
Abduction			
High torque option	1.0 Hz	1 Hz	< 2%



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Measurement instrumentation			
Data acquisition	Channel	Range	Comment
Data rate	All channels	10-2000 samples/sec	User selection
Resolution	All channels	16 bit ADC	
Digital filters	All channels	10-1000Hz	User selection
Anti-aliasing filters	All channels	360 Hz	
Strain gage conditioning	Channel	Range	Comment
Gain	All channels	1000, 2000, 4000, 8000	User selection
Excitation	All channels	0-10 Volt	User selection
Filters	All channels	10-1000 Hz	User selection
Multi-axis load cell – hip	Channel	Range	Sensitivity
Axial load	Fz	4400 N	0.34 $\mu\text{V}/\text{V}\cdot\text{N}$
AP force	Fy	1100 N	1.35 $\mu\text{V}/\text{V}\cdot\text{N}$
ML force	Fx	1100 N	1.35 $\mu\text{V}/\text{V}\cdot\text{N}$
Flexion moment	Mx	56 Nm	70.8 $\mu\text{V}/\text{V}\cdot\text{Nm}$
Abduction moment	My	56 Nm	70.8 $\mu\text{V}/\text{V}\cdot\text{Nm}$
Axial moment	Mz	28 Nm	53.1 $\mu\text{V}/\text{V}\cdot\text{Nm}$
Multi-axis load cell – knee	Channel	Range	Sensitivity
Axial load	Fz	8800 N	0.09 $\mu\text{V}/\text{V}\cdot\text{N}$
AP force	Fy	4400 N	0.35 $\mu\text{V}/\text{V}\cdot\text{N}$
ML force	Fx	4400 N	0.35 $\mu\text{V}/\text{V}\cdot\text{N}$
Flexion moment	Mx	200 Nm	18 $\mu\text{V}/\text{V}\cdot\text{Nm}$
Valgus moment	My	200 Nm	18 $\mu\text{V}/\text{V}\cdot\text{Nm}$
Axial moment	Mz	100 Nm	13 $\mu\text{V}/\text{V}\cdot\text{Nm}$
Angle and position	Channel	Range	~Resolution
Vertical position	VP	50 mm	0.1 mm
Flexion	Flex	$\pm 100^\circ$	0.1°
IE rotation	IE	$\pm 100^\circ$	0.1°
AP translation	AP	50 mm	0.1 mm
Abduction (hip configuration)	AD	$\pm 9^\circ$	0.1°
Other sensors	Channel	Comment	
Serum temperature			
Oil temperature			
Fluid level			
Hydraulic pressure			
Thermocouple			
Cal amp input			

Environmental conditioning for specimens		
Specimen fluid recirculation	Specification	Comment
Pump	100 ml/min	60 RPM peristaltic pump with #25 silicone tubing
Reservoir	500 ml	Stainless steel tank
Fluid level	On/off	Magnetic sensor
Specimen fluid temperature	Specification	Comment
Temperature controller		Resistance heating
Specimen fluid	Specification	
Suitable fluids	Bovine serum, saline solution, water	



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Control system			
NetControl interface	Specification	Comments	
Supplied computer hardware		Windows XP PC, monitor, keyboard, mouse	
Ethernet connection	10 mbps	Coaxial cable	
Real-time controller	Channels	Range	Comments
DSP controller		AD 2181	
Update rate		2000 Hz	
Output channels	8	± 10 volt	
Input channels	6	Bridge inputs	Strain gage
Analog inputs	8	± 10 volt	High-level analog
Digital inputs	4	TTL	Digital I/O
Control modes	Channels		
PID	8		
Gain scheduling	8		
Adaptive Control	8		
Virtual Soft Tissue	4		
Nested loops	4		
Waveform generator	Channels	Range	Comments
Channels	4-8		
Repetition rate		0.01 to 30 Hz	
Programmable		256 points	Interpolated
Event monitor	Channels	Specification	Comments
Threshold trigger	16		Rising or falling edge
Response time	All channels	0.0005 seconds	
Programmable response	All channels		Soft stop, hold, shut down
Digital outputs	Channels	Update rate	
Reference waveforms	4-8	2000 Hz	
Servo drive signals	4-8	2000 Hz	
Soft tissue constraint	4	2000 Hz	
Sum signals	4	2000 Hz	
Digital loop filters	Channels	Update rate	
	8	30-1000 Hz	

[1] Specifications may change without notice.

[2] The Force 5 can be configured for many different types of testing, including the evaluation of hip, spine, and knee implants. The standard quotation is for the knee simulator configuration, which includes the additional load cell and tibial tray mechanism necessary for knee testing.

[3] The system is normally delivered configured for the indicated power requirements. If your available power differs in phase or voltage, please contact AMTI. The system requires cooling water for operation. This is usually available from your laboratory's infrastructure – if not available, please contact AMTI for additional information on manufacturers of suitable chillers.

[4] The repetition rate corresponds to the maximum rate at which satisfactory performance will be achieved running the ISO standard gait cycle waveforms for hip and knee testing. This is a somewhat subjective indication of dynamic performance. Typically, overall tracking performance is reduced with higher frequency of operation.

[5] The ISO waveforms contain spectral content in considerable excess of the fundamental driving frequency. Analysis of these waveforms indicates that tracking performance at a 1 Hz repetition rate is excellent up to the indicated frequency.

[6] The RMS error provides a measure of the simulator's tracking performance (the extent that the machine's outputs differ from the target inputs). These values are typical for testing at a 1 Hz repetition rate while running the ISO waveforms and represent standard results while evaluating conventional prosthetics using AMTI's Adaptive Control Technology (iterative learning control algorithm). Different prosthetic devices or conditions may result in an increased or decreased tracking error.