Three-Axis Helmholtz Coil Systems

Triple-Nested 3D Vector Magnet Systems · Water-Cooled AC/DC Operation · Custom Power Supply up to 1000Hz · Vector Fields up to 500mT

COMPLETE 3D VECTOR CONTROL · Triple-nested geometry · Three independent axes · AC field synthesis · Custom high-frequency power supply

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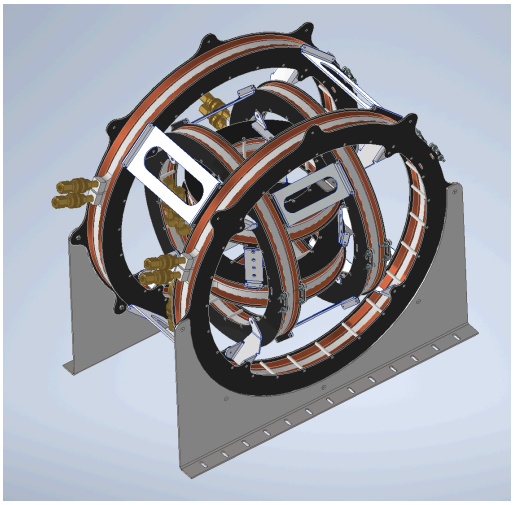
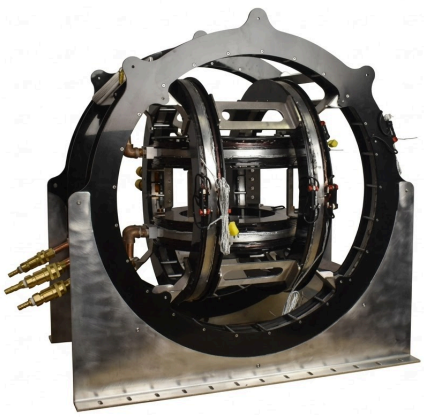
Complete 3D Vector Magnetic Field Control



Woodruff Engineering's Three-Axis Helmholtz Coil Systems provide complete 3D vector magnetic field control with three mutually orthogonal nested coil pairs, enabling arbitrary field direction and magnitude from 30mT to 200mT per axis for advanced vector magnetometry, 3D magnetic field mapping, and directional materials characterization requiring full spatial field control. Built as triple-nested water-cooled Helmholtz coils with X, Y, and Z axes mutually perpendicular, these systems generate combined vector fields up to 346mT (200mT × √3) with complete spherical angular coverage, serving research laboratories and metrology facilities requiring precise three-dimensional magnetic field synthesis.

Triple-Nested Geometry and Continuous Operation



The triple-nested geometry ranges from compact systems with innermost coils of 100mm diameter to large installations with outermost coils exceeding 1000mm, providing working volumes from 40mm to 200mm diameter spheres with <1% departure from peak field along all three axes simultaneously. Each axis features independent water-cooled hollow copper windings and dedicated power channels, enabling continuous operation at 100mT per axis (173mT vector magnitude) and pulsed operation to 200mT per axis with appropriate duty cycles.

Advanced AC-Capable Power Supply and Control

Unlike standard DC-only Helmholtz systems, Woodruff Engineering designs and manufactures custom AC-capable power supplies with H-bridge topology supporting frequencies up to 1000Hz, enabling time-varying rotating fields, AC susceptibility measurements in arbitrary orientations, and complex 3D field waveform synthesis for specialized materials research and advanced sensor calibration applications. The six-channel synchronized power supply delivers independent current control to each coil pair with ±0.5% regulation, closed-loop feedback, and programmable waveform generation supporting DC, sinusoidal, triangular, and arbitrary field profiles on each axis. Control modes include both Cartesian coordinates (Bx, By, Bz) for independent axis programming and (optional) spherical coordinates (B, θ, φ) for intuitive vector magnitude and direction specification, with (optional) real-time 3D vector magnetometer feedback ensuring accuracy better than 0.1% in magnitude and 0.5° in angular orientation.

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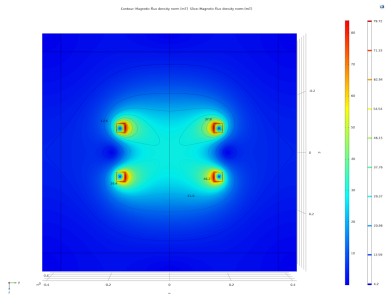
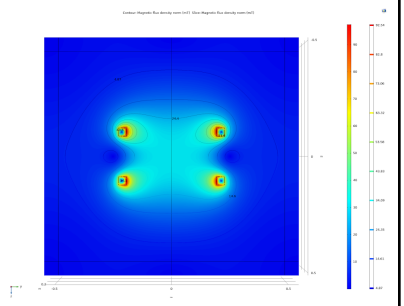
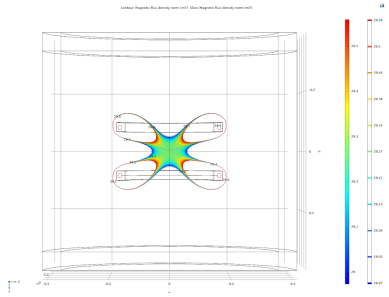
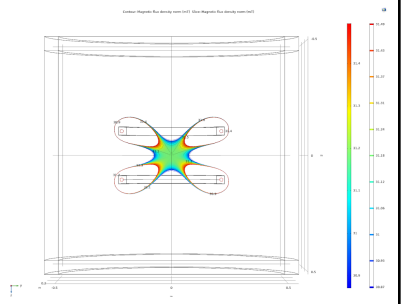
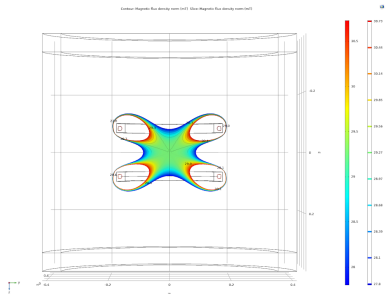
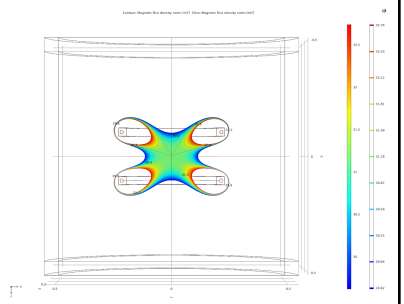
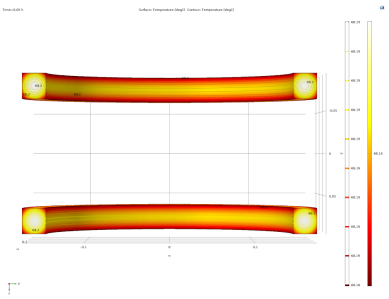
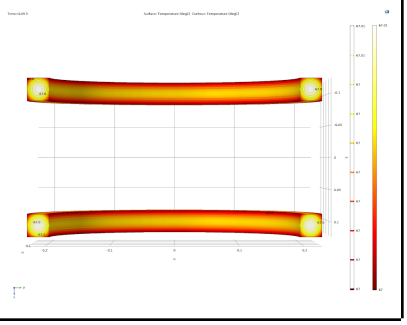
COMSOL simulations of the nested 3 axis HH coil set

Inner	Middle	Outer
Field strength		
1% uniformity		
5% uniformity		
Thermal		

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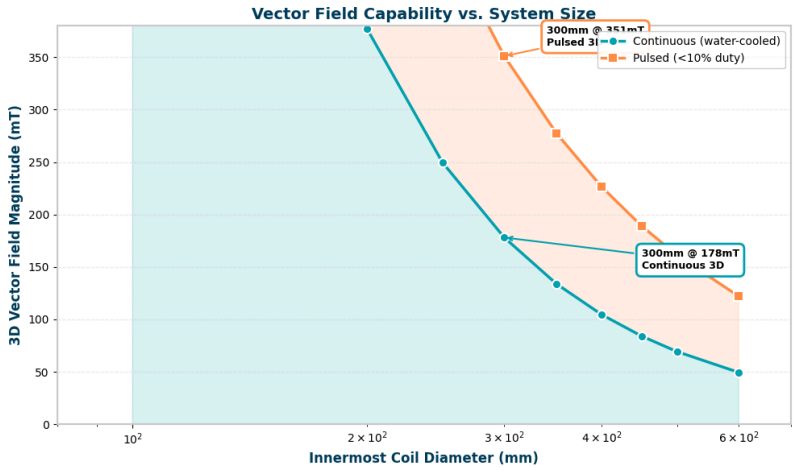
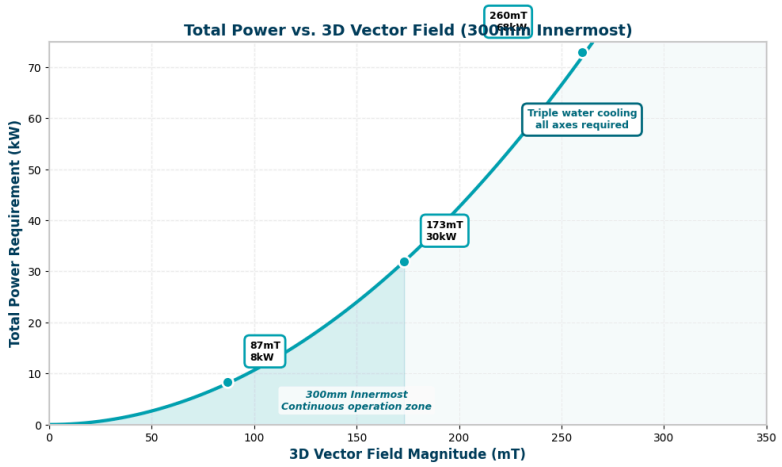
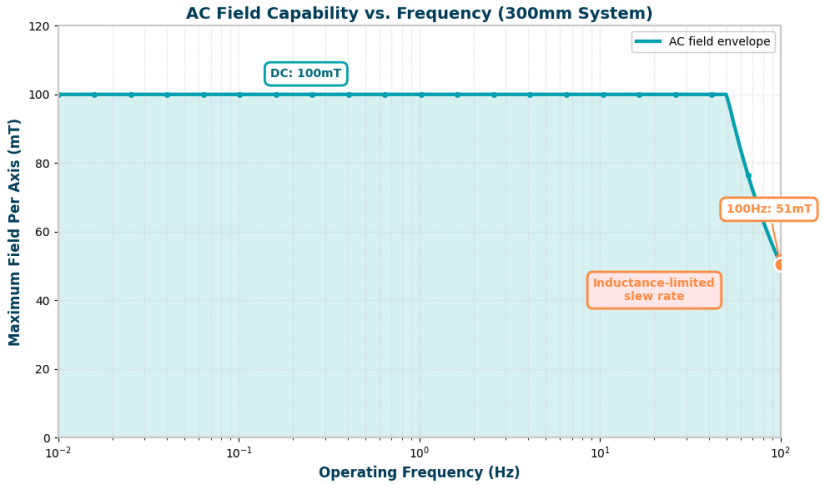
Production datasheet reviewed & accepted requirements.

Parameter space plots of the nested 3 axis HH coil set







Plots generated with a python script.

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SYSTEM SPECIFICATIONS

Field Strength Per Axis	30–500 mT (300–5000 G) *Continuous: 30–100mT; Pulsed: up to 500mT per axis*
3D Vector Field Magnitude	Up to 866 mT (500√3 mT) *Maximum when all three axes aligned at 500mT per axis*
Innermost Coil Diameter	100mm to 500mm *Defines working volume access*
Outermost Coil Diameter	200mm to 1000mm *Typically 2× innermost diameter*
Field Uniformity	<1% deviation from peak field over central ~30% of innermost coil *All three axes independently uniform*
Angular Coverage	Full 4π steradians *Complete spherical field control*

AC/DC OPERATION

Operating Modes	DC and AC up to 1000Hz *Custom WE power supply required*
Frequency Range	DC to 1000 Hz per axis *Independent frequency per axis*
Field Ramp Rate	0.1–100 mT/s (frequency dependent) *Limited by inductance at high frequency*
Waveform Types	DC, sine, triangle, arbitrary *Programmable per axis*
Phase Control	Independent phase per axis *Rotating field synthesis*

OPTIONAL THERMAL MANAGEMENT

Cooling Method	Water-cooled all three axes *Independent cooling circuits per axis*
Total Coolant Flow Rate	3–30 L/min (size dependent) *Distributed across six coil pairs*
Pulsed Operation	500mT per axis *10% duty cycle, brief pulses*
Thermal Time Constant	5–15 minutes to steady-state *Size dependent*
Cooling System	Triple manifold with flowmeters *Independent monitoring per axis*

CUSTOM POWER SUPPLY

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Topology	Six-channel H-bridge *Two channels per axis (push-pull)*
Current Per Channel	Up to 50A continuous *Higher for large coils*
Feedback Control	Closed-loop current regulation *High-speed digital control is optional*
Interface	Ethernet/RS-232, analog inputs *Lab automation compatible*

GEOMETRIC CONFIGURATION

Coil Arrangement	Triple-nested orthogonal pairs *X, Y, Z axes mutually perpendicular*
Working Volume	Sphere ~40% of innermost coil *All three axes uniform*
Coil Former Material	G-10 fiberglass or aluminum *Non-magnetic, low thermal expansion*
Weight Range	10–1500 kg (size dependent) *Three complete Helmholtz pairs*

VECTOR FIELD CONTROL

Control Modes	Cartesian (Bx,By,Bz) or Spherical (B,θ,φ) *Software-selectable coordinates*
Static 3D Vectors	Any direction in 4π steradians *Programmable field orientation*
Rotating Fields	0.001–100 Hz in any plane *Great circles, arbitrary rotation axes*
Field Monitoring	3-axis vector magnetometer *Real-time vector field measurement at a single point*

SYSTEM INTEGRATION

Power Supply	Custom WE six-channel unit *19" rack-mount, integrated with coils*
Control Software	LabVIEW/Python API included *Vector field programming interface*
Safety Interlocks	Water flow, temperature, current *Automatic shutdown all axes*
Calibration	3D field mapping can be provided *Certified uniformity report as option*

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Three-Axis Helmholtz Coil Systems — Product Variants

MODEL	CONFIG	PER-AXIS (CONT)	PER-AXIS (PULSED)	3D VECTOR	VOLUME	POWER	APPLICATIONS	LEAD
WE-HC3-100/200/300-LF	100/200/300mm Ultra-low field	2–10 mT Air-cooled	20 mT Brief pulses	3.5 / 35 mT Cont./Pulsed	~40mm<1% uniform	0.1–1 kW Low power	Earth field cancellation, biomagMinimal power	16 wks
WE-HC3-150/300/450-LF	150/300/450mm Low field	2–15 mT Air-cooled	25 mT Brief pulses	3.5 / 43 mT Cont./Pulsed	~60mm<1% uniform	0.2–1.5 kW Low power	Mag shielding test, low-field NMRPrecision low-field	16 wks
WE-HC3-200/350/500-LF	200/350/500mm Low-mid field	2–25 mT Forced air	40 mT 10% duty	3.5 / 69 mT Cont./Pulsed	~80mm<1% uniform	0.5–3 kW Forced air	Sensitive sensors, field mappingWide low range	18 wks
WE-HC3-100/200/300	100/200/300mm Ultra-compact	30–80 mT Water-cooled	140 mT 10% duty	52 / 242 mT Cont./Pulsed	~40mm<1% uniform	2–8 kW Water cooling	Compact sensor cal, 3D testingMinimal footprint	18 wks
WE-HC3-150/300/450	150/300/450mm Std benchtop	30–80 mT Water-cooled	130 mT10% duty	52 / 225 mT Cont./Pulsed	~60mm<1% uniform	4–12 kW Water cooling	3-axis Hall arrays, IMU calGood balance	18 wks
WE-HC3-180/300/420	180/300/420mm Std spec	2–35 mT AC to 100Hz	60 mT 10% duty	3.5 / 104 mT Cont./Pulsed	~72mm<1% uniform	0.5–6 kW Custom AC PSU	AC susceptibility, rotating fieldsHigh-freq AC	20 wks
WE-HC3-200/350/500	200/350/500mm Std research	10–70 mT Water-cooled	120 mT 10% duty	17 / 208 mT Cont./Pulsed	~80mm<1% uniform	3–20 kW Water cooling	Vector magnetometry, full-sphere calVersatile	20 wks
WE-HC3-300/500/700 ⭐	300/500/700mm Most common	10–65 mT Water-cooled	110 mT 10% duty	17 / 190 mT Cont./Pulsed	~120mm<1 % uniform	8–45 kW High-power	Advanced materials, 3D mappingIndustry std	22 wks
WE-HC3-400/650/900	400/650/900mm Large volume	10–60 mT Water-cooled	100 mT 10% duty	17 / 173 mT Cont./Pulsed	~160mm<1 % uniform	5–50 kW Facility-scale	Large assembly, multi-sensor arraysSignificant access	24 wks
WE-HC3-500/800/1100	500/800/1100m mMax volume	10–50 mT Water-cooled	80 mT 10% duty	17 / 139 mT Cont./Pulsed	~200mm<1 % uniform	8–60 kW Dedicated facility	Aerospace component testingMaximum volume	26 wks

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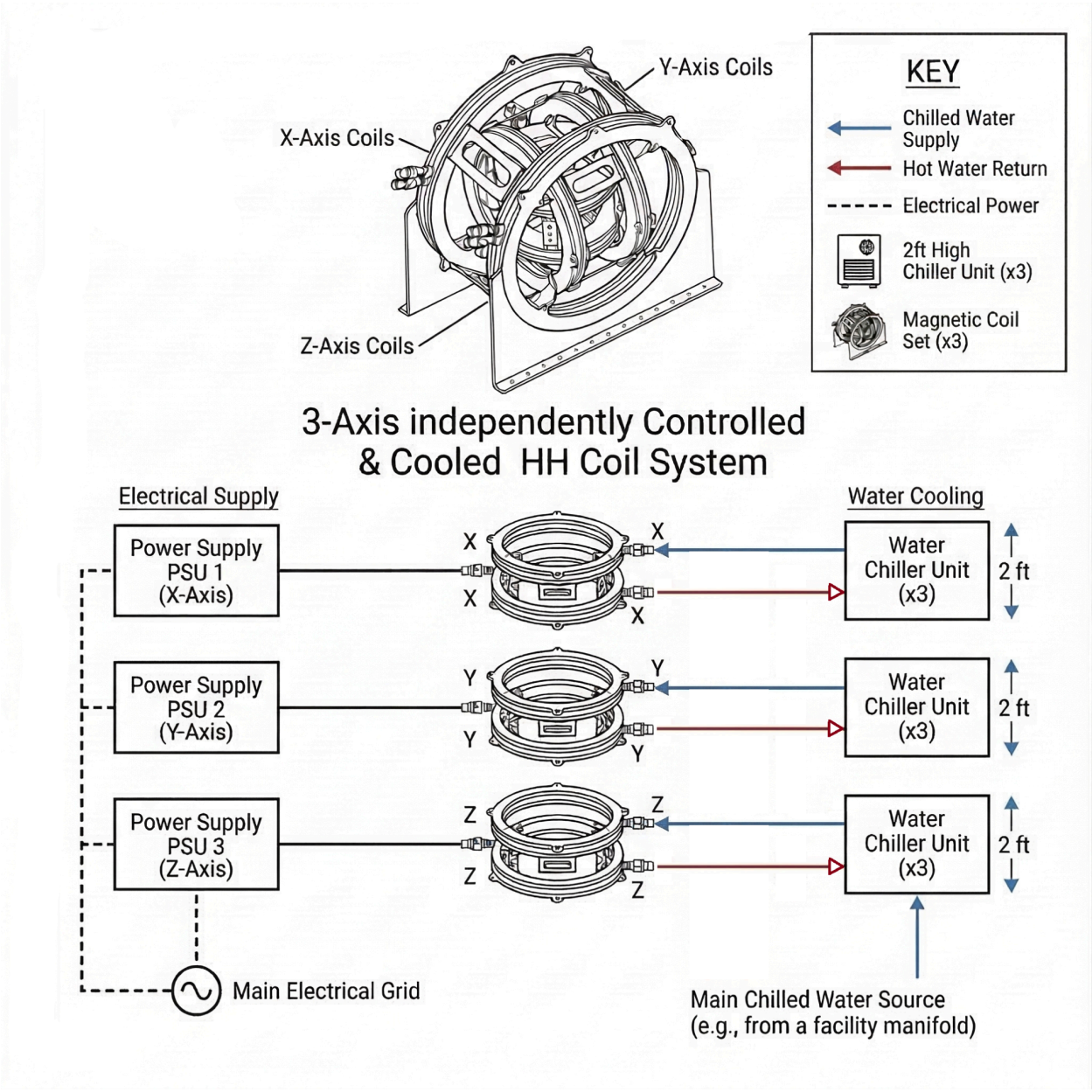
Connection schematic of the nested 3 axis HH coil set



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Helmholtz Coil System

Technical Specification Form

Please complete all sections below. This information will be used to prepare a detailed quotation and ensure the system meets your requirements. If you have questions about any specification, contact us at sales@woodruffeng.com

CUSTOMER INFORMATION

Organization / Institution	
Contact Name	
Email Address	
Phone Number	
Shipping Address	

SYSTEM CONFIGURATION

Number of Axes	☐ 1-axis (single coil pair) ☐ 2-axis (X-Y planar) ☐ 3-axis (X-Y-Z)
Innermost Coil Diameter	_____ mm (Typical range: 100–1000mm)
For multi-axis systems:	Outermost coil diameter: _____ mm
Coil separation	☐ Standard Helmholtz (d = R) ☐ Custom (specify): _____

FIELD REQUIREMENTS

Maximum Field Per Axis(Continuous Operation)	_____ mT (Typical range: 10–200mT continuous)
Peak Field Per Axis(Pulsed, if needed)	_____ mT at _____ % duty cycle
Maximum Vector Field(for multi-axis systems)	_____ mT (2-axis: √2 × per-axis; 3-axis: √3 × per-axis)

WORKING VOLUME & UNIFORMITY

Required Uniform Volume(diameter or radius)	_____ mm (Typically 30–50% of innermost coil diameter)
Field Uniformity Specification	☐ <0.5% ☐ <1% ☐ <2% ☐ Other: _____%
Uniformity measured over:	☐ Central sphere ☐ Central cylinder (1-axis) ☐ Other:

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OPERATING FREQUENCY & POWER SUPPLY

Operating Mode	☐ DC only ☐ AC capable ☐ Both
If AC capable, frequency range:	DC to _____ Hz (Typical: DC–100Hz or DC–1000Hz)
Waveform Requirements	☐ DC ☐ Sine ☐ Triangle ☐ Square ☐ Arbitrary
For multi-axis, rotating fields?	☐ Not required ☐ Yes (specify rotation rate): _____ Hz
Power Supply Preference	☐ Woodruff Engineering supply ☐ Customer-provided
If customer-provided:	Current capability: _____ A Voltage: _____ V

COOLING & INSTALLATION

Cooling Method	☐ Air-cooled ☐ Water-cooled ☐ Forced air
If water-cooled:	Available water flow: _____ L/min Pressure: _____ PSI
Mounting Configuration	☐ Benchtop ☐ Floor-standing ☐ Custom frame
Access requirements	☐ Horizontal bore ☐ Vertical bore ☐ Both (3-axis)

SPECIAL REQUIREMENTS & NOTES

Computer Control Interface	☐ Not required ☐ USB ☐ Ethernet ☐ RS-232
Control Software	☐ Standalone GUI ☐ LabVIEW compatible ☐ Python API
Field Sensors / Feedback	☐ Open-loop ☐ Closed-loop (Hall probe feedback)
Coordinate system control	☐ Cartesian (Bx, By, Bz) ☐ Spherical (B, θ, φ)
Budget Range (optional)	$ _____ to $ _____
Target Delivery Date	_____ (Typical lead times vary between 8–26 weeks)

Additional Requirements or Notes:

_____

_____

_____

_____

SUBMISSION

Please email this completed form to: sales@woodruffeng.com

We will review your specifications and provide a detailed quotation within 3–5 business days. If clarification is needed on any requirements, we will contact you directly.

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