



Innovation That Drives Industries™

High-speed Motor Generators, Power Electronics
and Magnetic Bearings



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Since our inception in 1998, Calnetix Technologies has developed and introduced numerous disruptive innovations in motor generators, power electronics and magnetic bearings for a wide variety of applications and industries. Most of the innovations have been for large original equipment manufacturers (OEMs) for whom we continue to manufacture and provide components, and several of these innovations have become the foundation of entirely new companies.

Calnetix's innovative high-speed motor technologists have repeatedly provided path-bending advances in technology to customers in a broad range of industries, enabling companies all over the world to drive market growth.



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Total In-House, High-Speed System Offering: Motor Generators, Power Electronics and Magnetic Bearings

Calnetix Technologies specializes in high-performance, high-speed motor generators and best-in-class power electronics and advanced magnetic bearings. Innovation in these disciplines is driven by our competitive spirit and our significant investment in research and development activities, which have led to perpetual technical advancements and numerous patents in our core products that continue to keep us ahead of the competition.

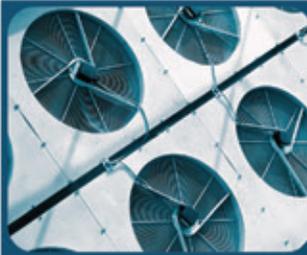
Vast Array of Designs Across a Broad Range of Industries

Calnetix Technologies currently designs, develops and manufactures products for the aerospace, air and liquid processing, automotive, chemical, communications, defense, energy, food, HVACR, marine, medical, pharmaceutical, semiconductor and other industries. Our technology is being used in applications, such as blowers, dryers, pumps, test stands, turbochargers/superchargers, compressors, UAVs, satellites, gas turbines and turboexpanders. Our customers are often large global organizations seeking innovative and highly efficient product enhancements or new products altogether.



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Existing Custom Product Range

<p>▶ Products</p> <p>→ Applications</p>	<p>▶ Custom High-Speed Permanent Magnet Motors</p>						
	<p>↓ Blowers</p>	<p>↓ Dryers</p>	<p>↓ Pumps</p>	<p>↓ Test Stands</p>	<p>↓ Turbochargers/ Superchargers</p>	<p>↓ Compressors</p>	<p>↓ UAVs / Satellites</p>
							
<p>→ Industries</p> <p>→ Performance Data and Features</p>	<p>Defense Energy Industrial Semiconductors</p>	<p>Chemical Food Pharmaceutical</p>	<p>Medical</p>	<p>Automotive Defense</p>	<p>Automotive Marine</p>	<p>Defense Energy HVACR Marine</p>	<p>Aerospace Communications Defense</p>
	<p>Power: Up to 75 kW Speed: Up to 90,000 RPM Bearings: Air, Oil-Lubricated, Powerflux™</p>	<p>Power: Up to 250 kW Speed: Up to 18,000 RPM Bearings: Powerflux™</p>	<p>Power: Up to 10 Watts Speed: Up to 13,500 RPM Bearings: Glass Bead</p>	<p>Power: Up to 1,500 kW Speed: Up to 200,000 RPM Bearings: Oil-Lubricated, Powerflux™</p>	<p>Power: Up to 100 kW Speed: Up to 200,000 RPM Bearings: Oil-Lubricated</p>	<p>Power: Up to 1,200 kW Speed: Up to 130,000 RPM Bearings: Air, Oil-Lubricated, Powerflux™</p>	<p>Power: Up to 40 kW Speed: Up to 250,000 RPM Bearings: Air, Oil-Lubricated, Powerflux™</p>

<p>▶ Custom High-Speed Permanent Magnet Generators</p>		
<p>↓ Gas Turbines</p>	<p>↓ Turbochargers</p>	<p>↓ Turboexpanders</p>
		
<p>Energy</p>	<p>Automotive Defense Energy Marine</p>	<p>Air Processing Energy</p>
<p>Power: Up to 1,500 kW Speed: Up to 120,000 RPM Bearings: Oil-Lubricated</p>	<p>Power: Up to 750 kW Speed: Up to 110,000 RPM Bearings: Oil-Lubricated</p>	<p>Power: Up to 350 kW Speed: Up to 38,000 RPM Bearings: Powerflux™</p>

High-Speed Electric Motor Generators

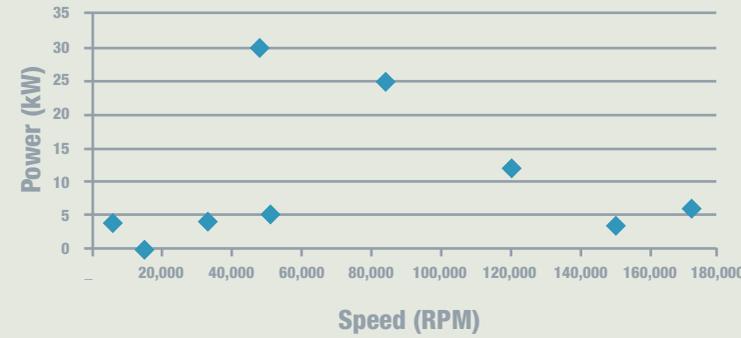
Calnetix Technologies' **Magnaforce™ Permanent Magnet (PM)**

Motor Generators range from only a few watts to megawatt power levels with speeds ranging from 4,000 RPM to 450,000 RPM.

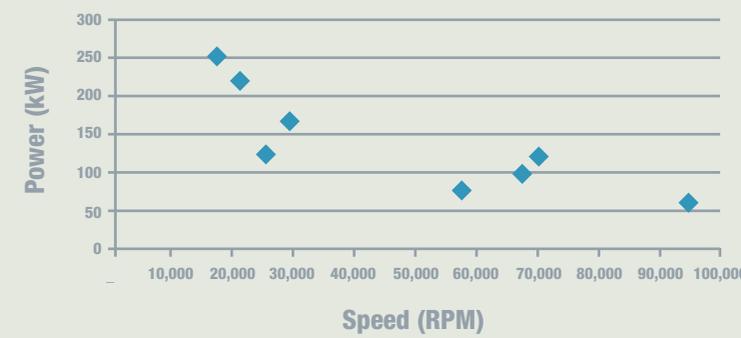
Whether converting mechanical power to electrical or converting electrical power to mechanical, Calnetix PM motor generators offer:

- » High-speed operation
- » High system efficiency
- » Optimized magnetic performance
- » High-temperature operation
- » Customization for targeted applications
- » Direct variable speed drive to eliminate gearboxes
- » Very compact size
- » High availability and reliability
- » Low noise and vibration
- » Very cost-effective operation and lifetime costs

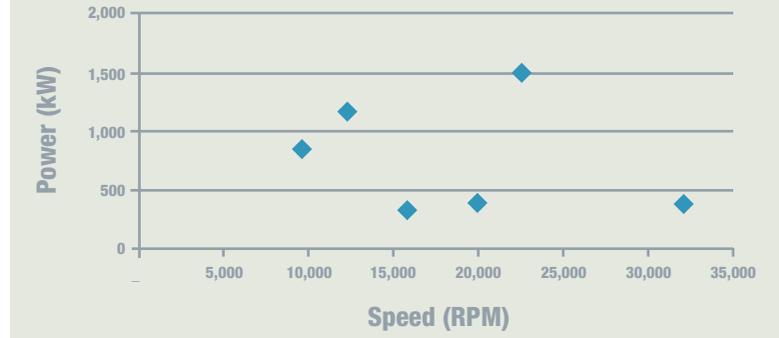
A Selection of Existing Custom Machines (1 Watt - 30 kW)



A Selection of Existing Custom Machines (30 kW - 250 kW)



A Selection of Existing Custom Machines (250 kW - 1,500 kW)



Calnetix's Magnaforce™ machines are comprised of PM rotors and companion stators for constant torque applications. Smaller rotors feature metal sleeve construction, while large units employ Calnetix's proprietary composite sleeve technology. Each companion stator is optimized to provide trouble-free service over an extended lifetime.

Magnaforce™ Rotor



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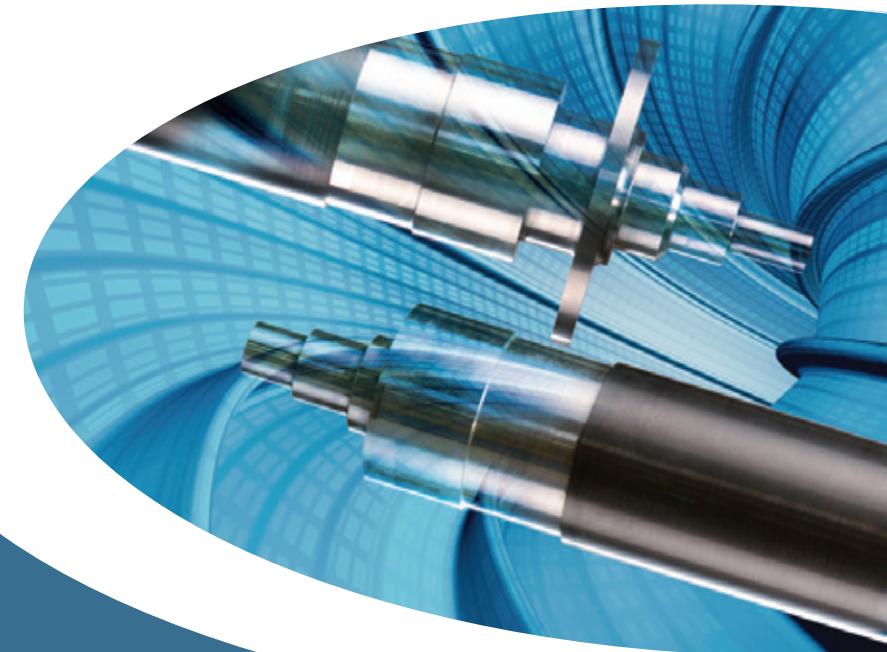
Magnaforce™ Stator



Magnaforce™ Motor Generator
Power: 25 kW, Speed: 84,000 RPM



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Power Electronics

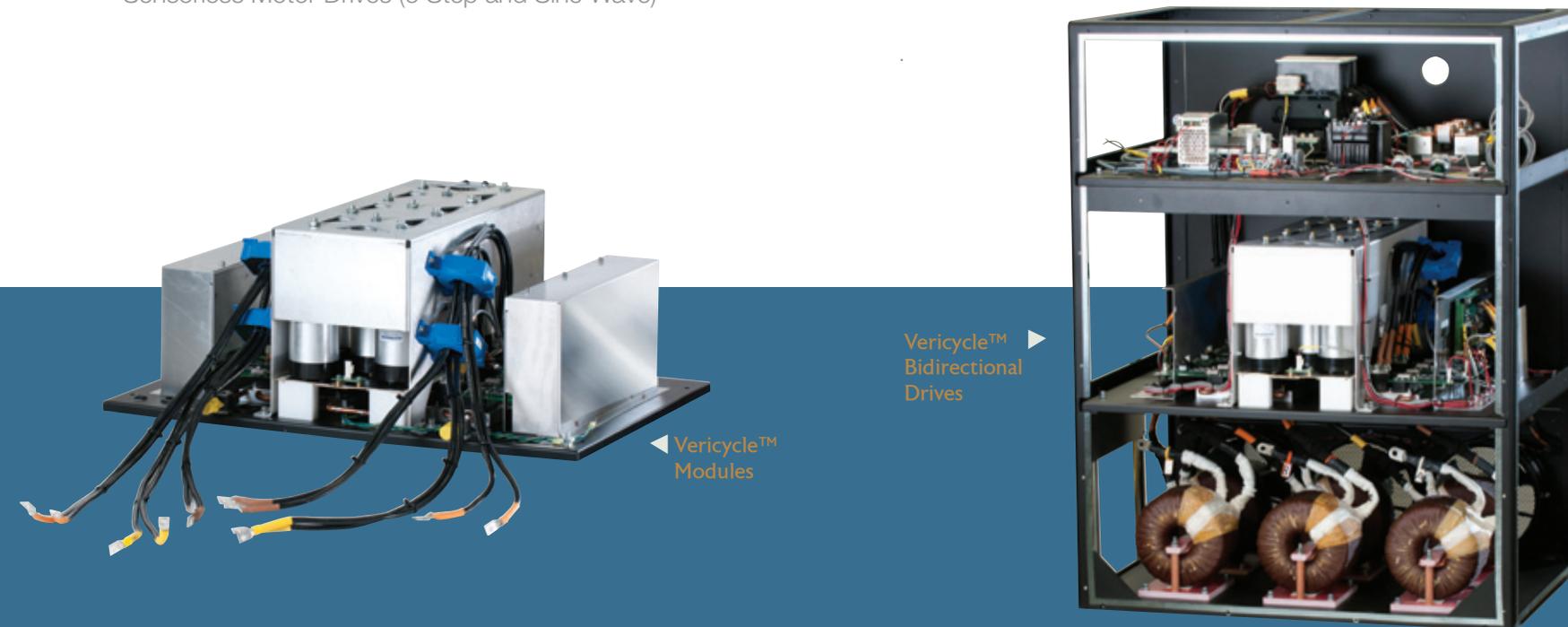
Whether developing, integrating or manufacturing the necessary power electronics, Calnetix always designs with the system and application in mind. **Vericycle™ Bidirectional Drives** are the ideal choice for any turbomachinery system.

Currently, Calnetix utilizes both sensor-based and sensorless motor drive technology based on the needs of the system.

A few of the products Calnetix has delivered include:

- » Hall Effect Sensor-based Motor Drives (6 Step and Sine Wave)
- » Encoder Feedback Motor Drives (Sine Wave)
- » Sensorless Motor Drives (6 Step and Sine Wave)

Calnetix's Vericycle™ Bidirectional Drive Modules include identical and interchangeable three-phase active front-end and grid-tie inverters connected through a common DC bus. The inverters consist of Insulated Gate Bipolar Transistors (IGBTs) mounted on a liquid-cooled cold plate. The modules meet the most stringent utility and grid requirements and are available with maximum current ratings of up to 900A.



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Active Magnetic Bearings

Magnetic bearings offer a non-contact rotor support system with extremely low friction and wear. Calnetix Technologies specializes in active magnetic bearings and offers **Powerflux™ Magnetic Bearings** in radial and combination configurations for mainstream applications and **Xcelflux™ High Performance Magnetic Bearings** in a side by side combination configuration for today's most challenging applications.

Xcelflux™ side-by-side combination (combo) magnetic bearings provide best-in-class axial bandwidth and superior rotodynamics. These units are smaller than any other combo bearing on the market and much smaller than any arrangement of radial and axial bearings. With its easier machine assembly and improved axial bandwidth, Xcelflux™ is perfect for compressor and expander applications. Its simpler construction and highly configurable envelop contribute directly to lower cost and higher reliability.

To operate magnetic bearing systems, Calnetix has developed and deployed a line of advanced controllers called **Insight™ Magnetic Bearing Controllers**. Key subsystems include a digital signal processor (DSP) board with sensor demodulation electronics, power electronics and DC power supplies. These very compact controllers interact with the magnetic bearing actuators and shaft position sensors, which are located within the PM-driven machine. Calnetix believes that its latest magnetic bearing controller, Insight™ 3600, is the most advanced and compact controller available on the market today.



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A Trusted Partner for Over a Decade

Product Development and System Integration

If you are looking for a technological edge to optimize your system or reduce the size of your product offering, withstand special operating conditions, improve maintainability, or simply decrease operating and/or maintenance costs, Calnetix can help.



Calnetix offers customers two convenient ways to employ our core competencies in developing the most advanced energy efficient products.

» Calnetix will provide a comprehensive turnkey **system integration** solution to a customer specified challenge using all of Calnetix's technology – our PM motor generators, power electronics designs and magnetic bearing capabilities.

» Calnetix will provide **integration support** services to meld selected portions of our core technologies with customer designated hardware and software, working closely with customer engineering teams to arrive at an advanced application solution.

Magnaforce™ Motor Generator
Power: 3.7 kW, Speed: 4,600 RPM

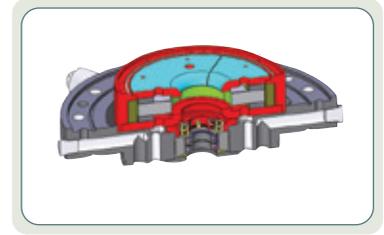
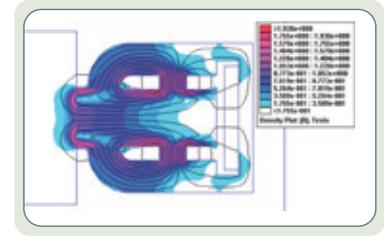


[10]

Calnetix Technologies' highly accomplished product development team is committed to a comprehensive design process that balances magnetic, thermal and structural factors to ensure an optimal design solution. Our **in-house design and analysis capabilities** include:

» Electromagnetic Analysis and Design

Calnetix utilizes both closed-form mathematical modeling and finite element method modeling. For motor generator designs, closed form computer models developed at Calnetix, based on permanent magnet synchronous machine theory, provide fast and accurate tradeoff studies of machine parameters, such as number of poles, stator configuration, material selection and machine aspect ratios. Magnetic Bearing design and analysis software is based on a proprietary approach utilizing both analytical closed-form modeling and finite element analysis in tandem to generate an optimal electromagnetic design and accurately predict its performance parameter



» Mechanical Analysis

Calnetix utilizes Solidworks as a software-based platform for mechanical design. Complete systems are modeled in this 3D design package to ensure optimum mechanical integration of our high-performance technology. During the design process, our customers approve interface control drawings to ensure that the designed system meets all of their mechanical interface requirements. Designs are validated in supporting analysis, and upon completion, the design is released and fabricated per ISO9001 requirements.



Magnaforce™ Motor Generator
Power: 3 kW, Speed: 100,000 RPM



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» Rotordynamic Analysis

Calnetix offers complete rotordynamic analysis using in-house-developed, finite-element-based rotordynamic analysis tools for motor generators and magnetic bearing systems (MBS). For motor generators, this analysis determines critical rotor characteristics for high-speed performance; these characteristics are either passed onto the customer for use in system integration or used internally for the modeling of a Calnetix-designed system (including customer specified bearings, rotor components and structural support). For magnetic bearing systems, this approach allows coupling of the MBS control equations to the rotor and housing structural models for complete system analysis. The rotordynamic analysis allows the overall system design to be optimized for bearing and position sensor location.

» Stress Analysis

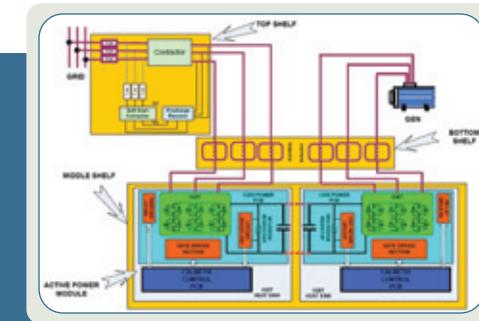
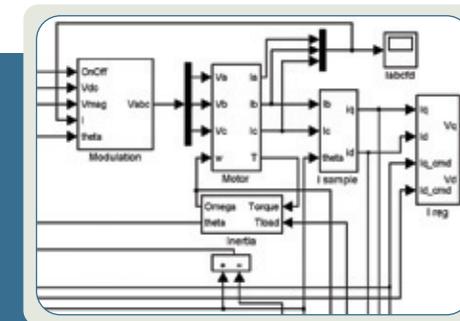
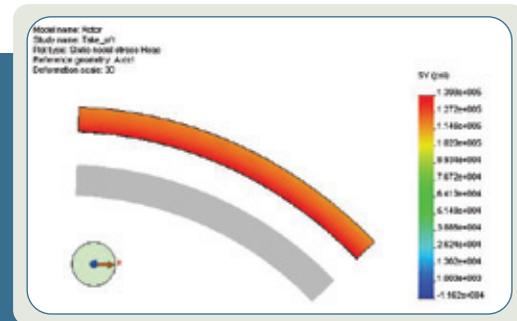
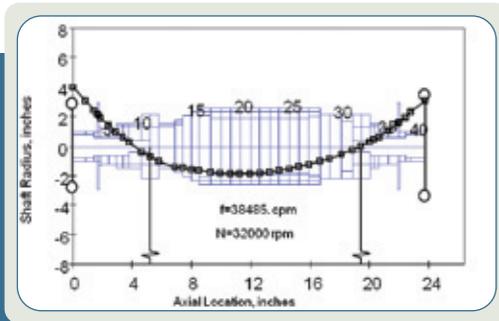
To achieve a sound rotor design with low vibration and robust stability control, Calnetix builds and analyzes a finite element structural dynamics model of the rotating assembly. This model is used to identify the rotor's natural frequencies and mode shapes and to adjust them if necessary and possible to achieve smooth (low vibration) operation. This rotor model is coupled with a state space magnetic bearing model, a housing structural dynamics model, where applicable, and any bearing or seal rotordynamic coefficients required for system operation. The magnetic bearing model is created and analyzed to ensure low vibration and robust stability control over the range of expected machine operating speeds, temperatures, over-speed conditions and other machine parameters required by the application.

» Embedded Control System Design

Calnetix Magnetic Bearing Controllers and Motor Drives employ embedded controls to perform dedicated control functions specific to Calnetix designed motor generator and bearing performance needs. Calnetix develops its own embedded hardware and associated software to address the needs of complex electrical, mechanical and system design and integration requirements. Calnetix employs two development platforms based on the Texas Instruments (TI) DSP and the Motorola Freescale DSP for its magnetic bearing controllers and motor drives. These embedded controllers feature high-speed DSP, PWM drives, analog and digital I/Os, and on-board flash and RAM. The user can control and monitor the embedded controllers by using Modbus through RS485/232, or digital/analog I/Os. Ethernet or USB port interfaces are also available.

» Power Electronics/Motor Controller Design

Calnetix's Sine Wave drives utilize space vector controls with interleaving switching to reduce the current harmonics in the motor. Motors are designed with these harmonics in mind to ensure that the system will operate at peak performance. For power generation, Calnetix has delivered both generators and inverters for stand-alone and grid-tie applications. Besides the existing line of drives and inverters, Calnetix designs and manufactures custom electronics for niche applications in various industries.



Manufacturing

Calnetix is **ISO (International Standards Organization) 9001:2008 certified for design and manufacturing**. Our robust quality system ensures that all products meet design requirements, regulatory requirements and user needs. All of Calnetix's production lines are designed to be scalable, with production staff cross trained for further flexibility in factory floor loading. Calnetix's 7+ acre headquarters and assembly facility is located in Cerritos, CA. Our **in-house manufacturing capabilities** include:

- » Vacuum impregnation varnish system, potting and housing capabilities for stator manufacturing
- » Metal and carbon sleeving
- » Magnetization of rare earth magnets for high-performance rotor fabrication
- » Custom fixturing and high-speed spin and load testing for motor assembly and testing
- » Complete mechanical system assembly for rotor/stator/magnetic bearing technologies
- » Comprehensive electronic assembly and test facilities for power electronics and magnetic bearing controllers, including wire harness fabrication and automated burn in
- » The latest generation of analyzers for electrical testing and mechanical inspection
- » Advanced scheduling and purchasing systems to ensure on-time, cost-effective deliveries



Calnetix Technologies stands ready to help you innovate and become more competitive. Contact us today and discover how our products and services can create new opportunities for your business.



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Calnetix Technologies
16323 Shoemaker Avenue
Cerritos, CA 90703
+1 562 293 1660
info@calnetix.com
www.calnetix.com

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