

Robicon Perfect Harmony

Medium Voltage AC Drives



industrial

POWER CONTROL



SIEMENS

Rely on the Number One Source for Medium Voltage AC Drives

Siemens has the largest installed base of medium voltage AC drives. We serve all segments of the market, as we're the only company that offers drives from 300 to 160,000 HP (225 to 120,000 kW).

Selecting the right drive system for your application – no matter what the industry or application – means your maintenance costs go down while your production numbers stay high. The right system even means lower operating costs when your new drive allows you to build a more energy efficient process.

The Perfect Harmony drive from Siemens is the world's best-selling medium voltage AC drive. And there is good reason it should be your drive. For most applications, installing a Perfect Harmony Variable Frequency Drive can immediately slash energy costs, improve productivity and protect the environment.

Unlike conventional power control technology, the Perfect Harmony AC drive is easy to use and maintain. Plus, the soft start features of the Perfect Harmony decrease stresses that can limit the life of your equipment.

The Business Behind a Variable Frequency Drive

If you haven't installed a VFD yet, you're letting thousands of dollars of energy costs eat away at your bottom line every month.

The culprit? An inefficient process.

The US Department of Energy (DOE) says that industrial motors consume over a billion kilowatt hours of energy each year – 50 percent of the world's energy usage. System improvements such as improved sizing and proper matching to load, use of more efficient drive trains, and use of adjustable speed drives will help drive energy usage down, according to the DOE. That means the right drive helps you drive cost out of your operation.



Getting the Right Service and Support Helps, Too

The Siemens difference is apparent from the first meeting. Our experts have tailored thousands of systems. So you'll see right away that we have the right level of power conversion experience to help select the right drives to streamline your process.



The Perfect Harmony of Performance, Process and Technology

Designed for Maximum Versatility, Efficiency and Reliability

The patented, integrated design of the Perfect Harmony drive ensures a level of reliability, efficiency and versatility that is unmatched in the power controls industry. The Perfect Harmony is designed to withstand failures that would overwhelm conventional drive systems.

Proven Solutions for Every Industry

The most successful medium voltage drive ever built, the Perfect Harmony is used in thousands of applications around the world. From water treatment to power generation to oil and gas production, we can provide a custom-engineered Perfect Harmony drive to maximize your process.

Setting the Standard in Power Conversion

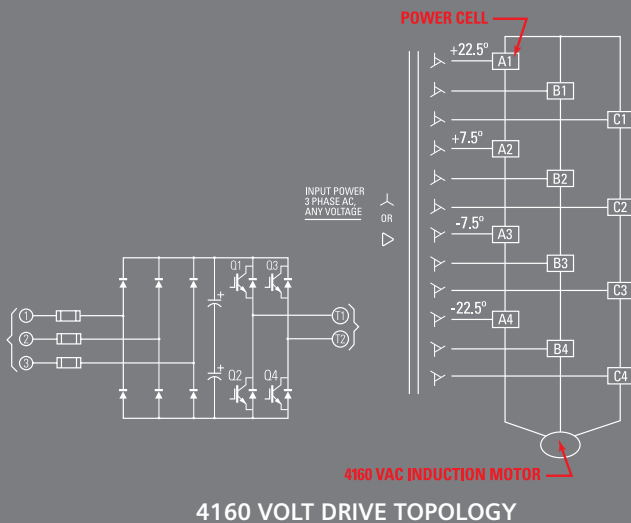
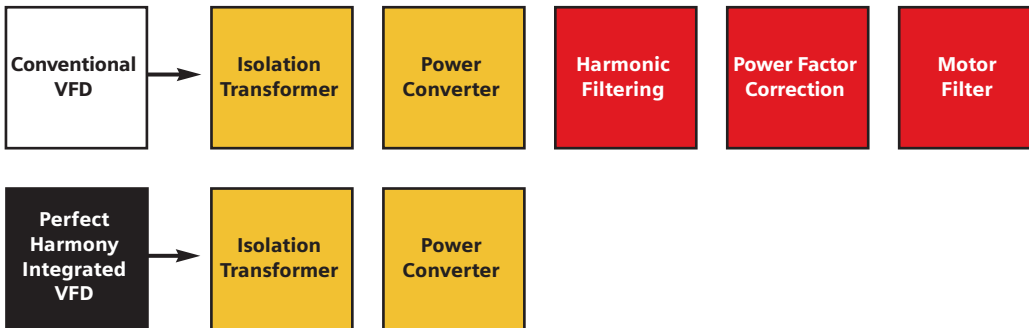
Since its introduction in 1994, the Perfect Harmony drive has revolutionized power conversion and continues to set industry standards for reliability and innovation. However, advances are made without “reinventing the wheel” like other drive manufacturers. We have maintained the Perfect Harmony’s core topology and continue to advance its capability, ensuring life-cycle product support. The Perfect Harmony of today represents an evolution founded on experience garnered from our huge installation base.



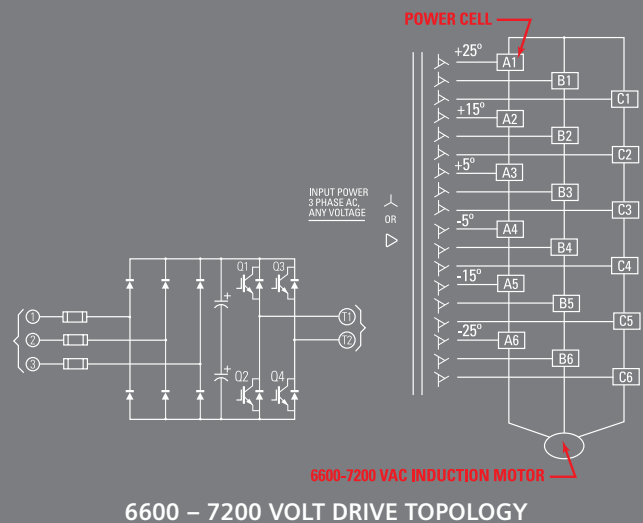
Designed for Maximum Versatility, Efficiency and Reliability

What is an Integrated Variable Frequency Drive (VFD)?

A traditional VFD features up to five separate components, such as harmonic filter, power factor correction, transformer, power converter, and motor filter. However, the Perfect Harmony's topology integrates these elements so an isolation transformer and power converter are the only major components required. The integrated system allows for quick, easy and less expensive installations and start-ups. Shortening your outages and process downtime gives you more project flexibility.



4160 VOLT DRIVE TOPOLOGY



6600 - 7200 VOLT DRIVE TOPOLOGY

Perfect Harmony Topology Structure

In the Perfect Harmony, a series of low voltage cells are linked together to build the medium voltage power output of the drive system. This patented configuration gives the Perfect Harmony many advantages when it comes to maintenance, power quality and reliability. It also provides the basis for one of its most most important advantages – increased reliability through the advanced cell bypass option.

Versatility

The proven technology of the Robicon Perfect Harmony drive meets the needs of customers in many industries, from water treatment to energy production to chemical processing. Siemens is the only industrial power controls manufacturer to offer this level of system versatility to its customers.

And when it comes to retrofits, the Perfect Harmony upholds its reputation as the world's most versatile medium voltage drive. The Perfect Harmony is compatible with existing motor systems, regardless of age, brand or voltage/frequency – even synchronous motors.

You can be sure that the Perfect Harmony is compatible with your power system as it meets the most stringent IEEE 519 1992 requirements for voltage and current harmonic distortion.

The Perfect Harmony can accept many different input voltages and can provide motor output voltages up to 13,800 volts, putting it in a class by itself.

Efficiency

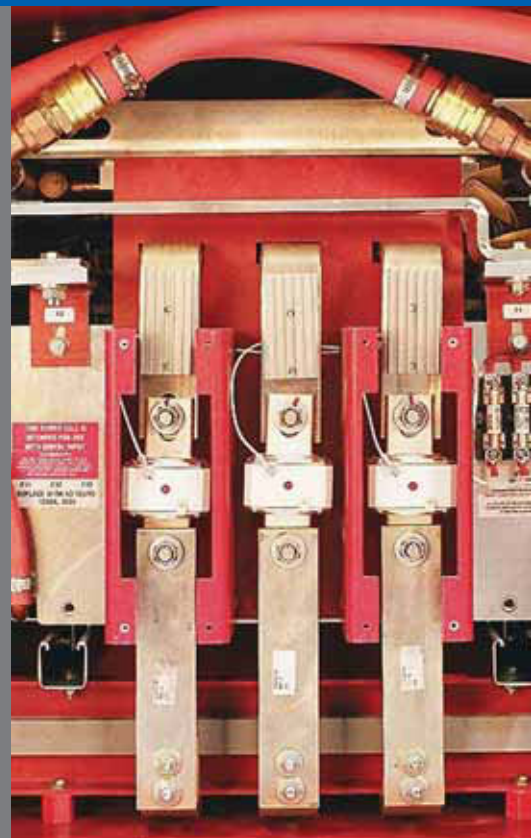
The integrated Perfect Harmony maximizes efficiency in a number of critical areas. Integration helps provide quick and reliable start-ups, a smaller footprint and allows for the addition of power conversion redundancy. It all adds up to a smaller, more efficient and reliable system.

System Performance

The Perfect Harmony exceeds .95 power factor at normal operating speeds without external power-factor correction capacitors. It also provides more than 98 percent VFD efficiency and 97 to 96.5 percent total drive system efficiency.

Load (%)	VFD Efficiency (%)	Total Drive System Efficiency (%) (VFD & Transformer)	Power Factor
25	97.5 - 93.4	97.0 - 96.5	.96
50	98.0 - 95.0	97.2 - 96.8	.96
75	98.5 - 97.5	97.2 - 96.8	.96
100	98.6 - 98.0	97.0 - 96.5	.95

Efficiency and power factor values are based on centrifugal load characteristics for torque and speed.



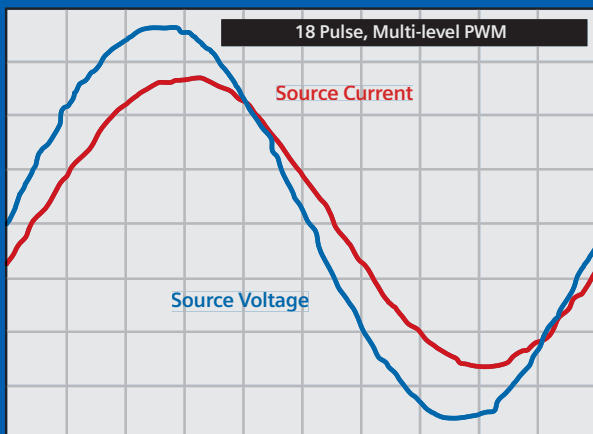
Clean Power Input

The Robicon Perfect Harmony drive meets the most stringent harmonic requirements for voltage and current distortion.

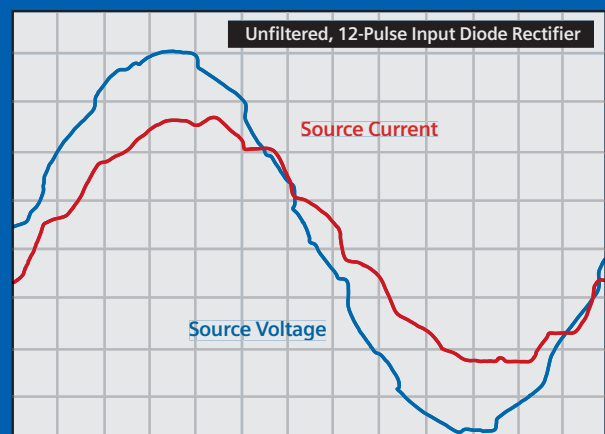
- Protects other on-line equipment from harmonic disturbance (computers, telephones, lighting ballast)
- Prevents "cross-talk" with other sensitive control and variable frequency drives
- Avoids costly harmonic filters and associated resonance problems



Harmonic Comparison of Typical 1,000 HP
12-Pulse PWM Inverter vs. Perfect Harmony Series
1,100KVA, 5.75% Impedance Source

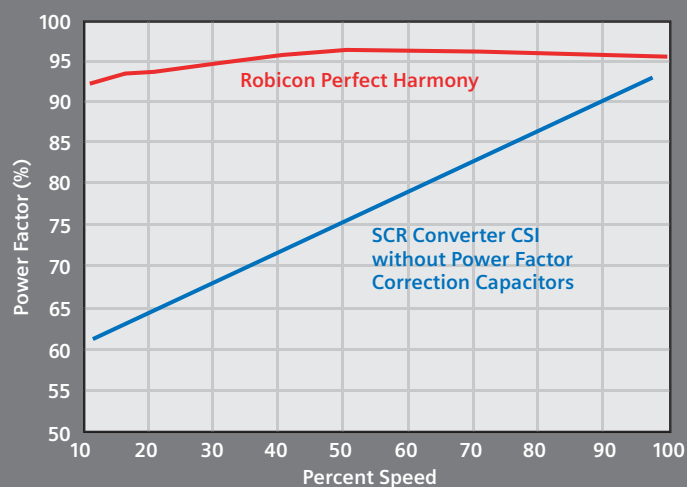


Perfect Harmony Series Waveform
less than 3% total voltage distortion
less than 5% total current distortion
Meets IEEE 519-1992 at the input to the isolation transformer



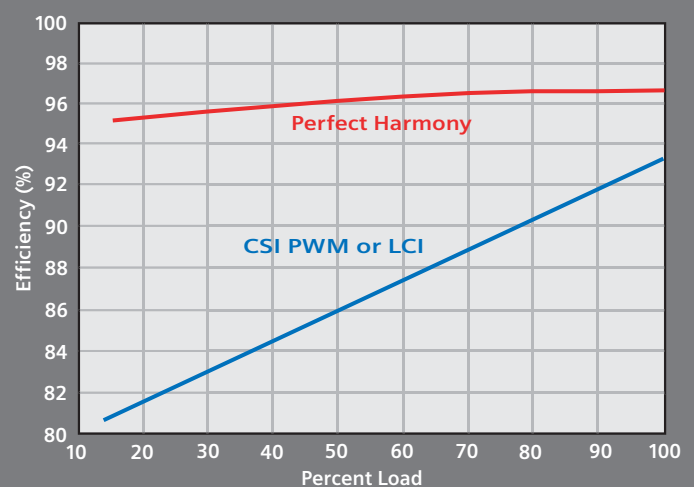
12-Pulse Harmonic Waveform
5.9% total voltage distortion
8.8% total current distortion

Measured Power Factor



Total power factor includes distortion and displacement power factor.

Typical System Efficiency Robicon "Perfect Harmony" Series vs. CSI PWM or LCI

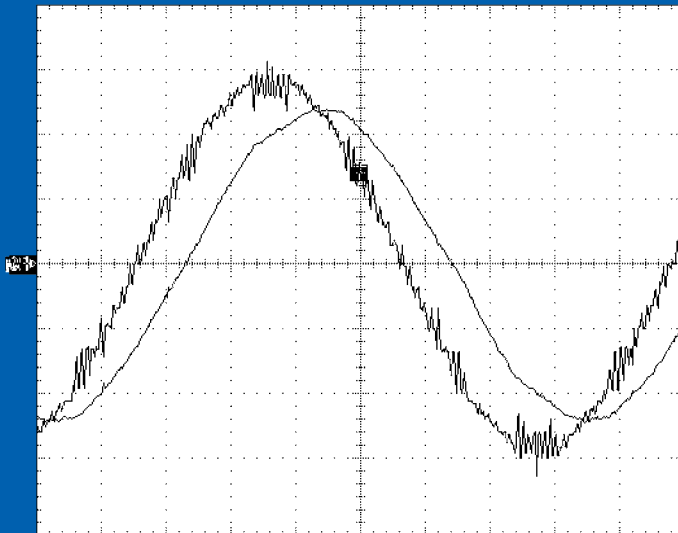


System efficiency includes isolation transformer, harmonic filter, power factor correction and drive.

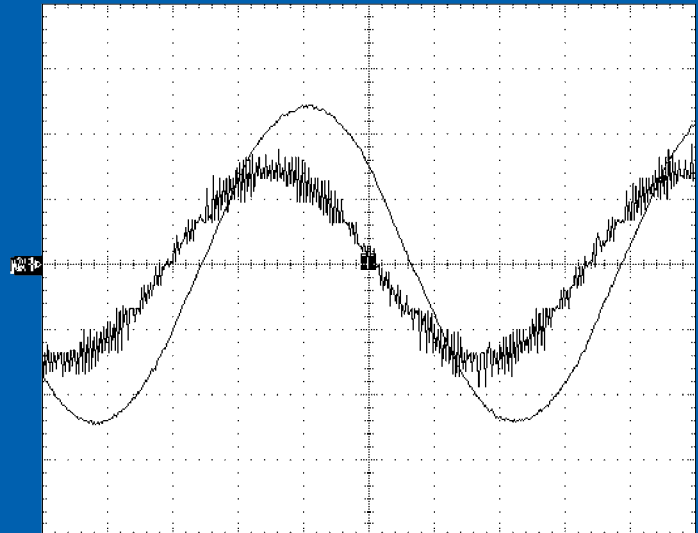
Power Quality Output

- No common mode motor insulation stress
 - Perfect Harmony includes an isolation transformer integral in common mode dissipation
 - Motor does not require 10 to 13 kV insulation
- Drive is compatible with both new and existing 1.0 service factor induction or synchronous motors from any manufacturer without any special design considerations
- No significant VFD induced torque pulsations – even at low speeds
- No need for expensive flexible couplings
- No additional VFD induced motor heating
- No cable length restrictions
- Allows standard motor insulation – decreasing the motor insulation requirements to less than an across-the-line start motor

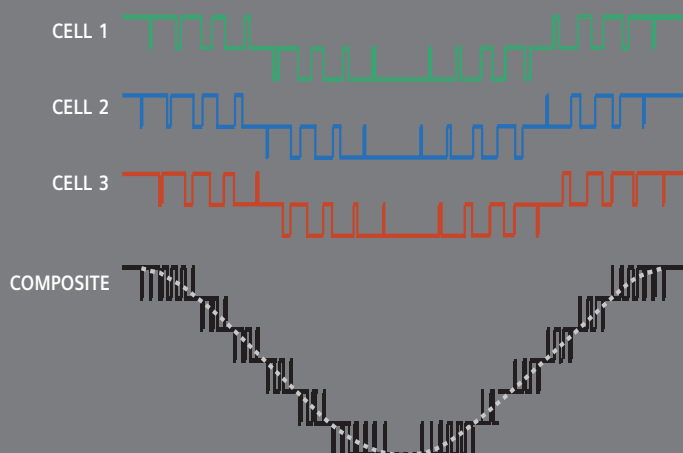
Perfect Harmony
Output Waveforms at 100% Speed



Perfect Harmony
Output Waveforms at 50% Speed



Multi-Level, Pulse-Width Modulated,
Output-Voltage Waveform



Maximizes Uptime Through Redundancy and ProToPS™ Process Control

Reliability

The reliability of the Perfect Harmony drive is second to none due to Siemens' common-sense approach to component selection and design. Traction grade insulated Gate Bipolar Transistors (IGBTs) form the backbone of the Perfect Harmony drive. Built-in high volumes and serving as a proven power device across the industrial power control industry, IGBT technology has been in existence for more than a decade. The stability and availability of IGBTs give you reliable, long-term, life-cycle confidence. But that's just the start of our forward-thinking design.

Advanced Cell Bypass

The Perfect Harmony is engineered to withstand failures that would overwhelm conventional drives because

we've added redundancy options into the system. Our patented, cell-based configuration maximizes uptime and simplifies modifications. Through a redundant bypass control that is completely separated from each power cell, the Perfect Harmony ensures automatic bypass of a failed power cell in 250 milliseconds (less than 1/4 of a second).

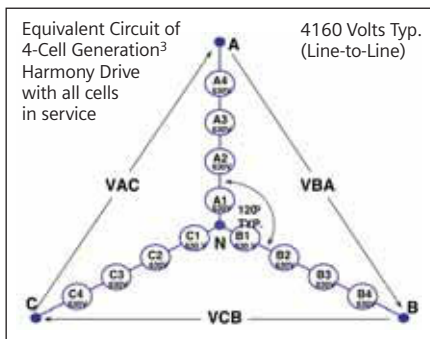


Another feature that bolsters the Perfect Harmony's reliability is its control strategy. Our Process Tolerant Protection Strategy (ProToPS™) is a groundbreaking process control system available exclusively from Siemens. Instead of tripping the drive and automatically shutting down the system due to a malfunction, ProToPS provides a hierarchical system of warnings. This control strategy allows time to evaluate

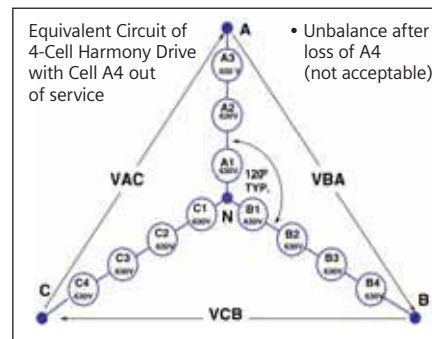
the situation and respond appropriately to avoid a system shutdown. ProToPS has proved invaluable for many of our Perfect Harmony customers, including strategic power plants, refineries, water and wastewater facilities, and process plants.

Factory System Test

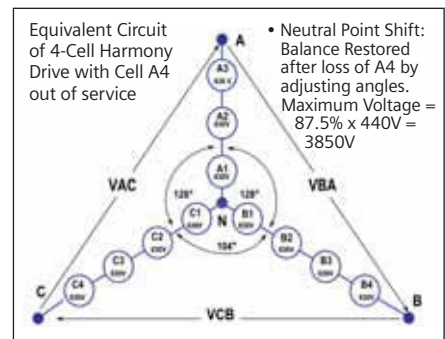
Upon delivery, you can be confident that the Perfect Harmony will get your process running because we have the ability to test every product as a complete system at full load. At our factory, we test every transformer and power converter together so that any imperfections can be identified and corrected before the product is shipped. In addition, factory testing allows accurate efficiency measurements. We also verify sequence of operation and protection to ensure that the Perfect Harmony system matches your needs.



Advanced Power Cell Bypass



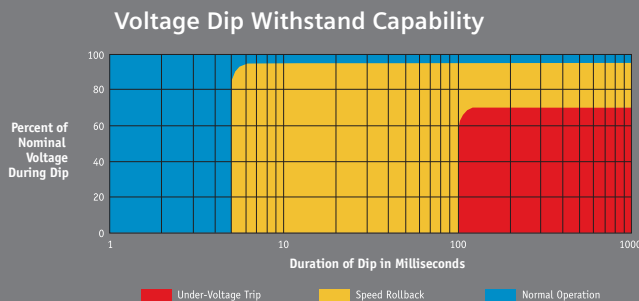
Advanced Power Cell Bypass



Advanced Power Cell Bypass

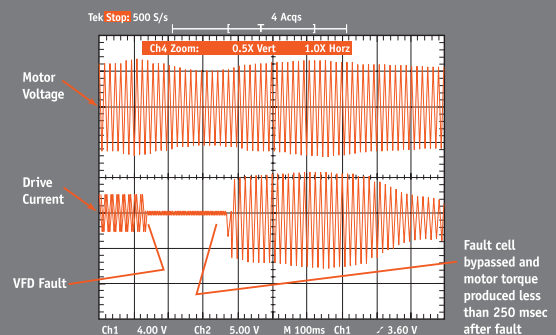
Voltage Dip Withstand Capability during Full Load, Nominal Voltage

The Perfect Harmony operates continuously, even during a 30 percent voltage dip.



Protecting Process Quality

If a power cell is bypassed, there is minimal degradation of the motor's output power quality, as the Perfect Harmony's advanced power cell bypass system ensures that your process is uninterrupted.



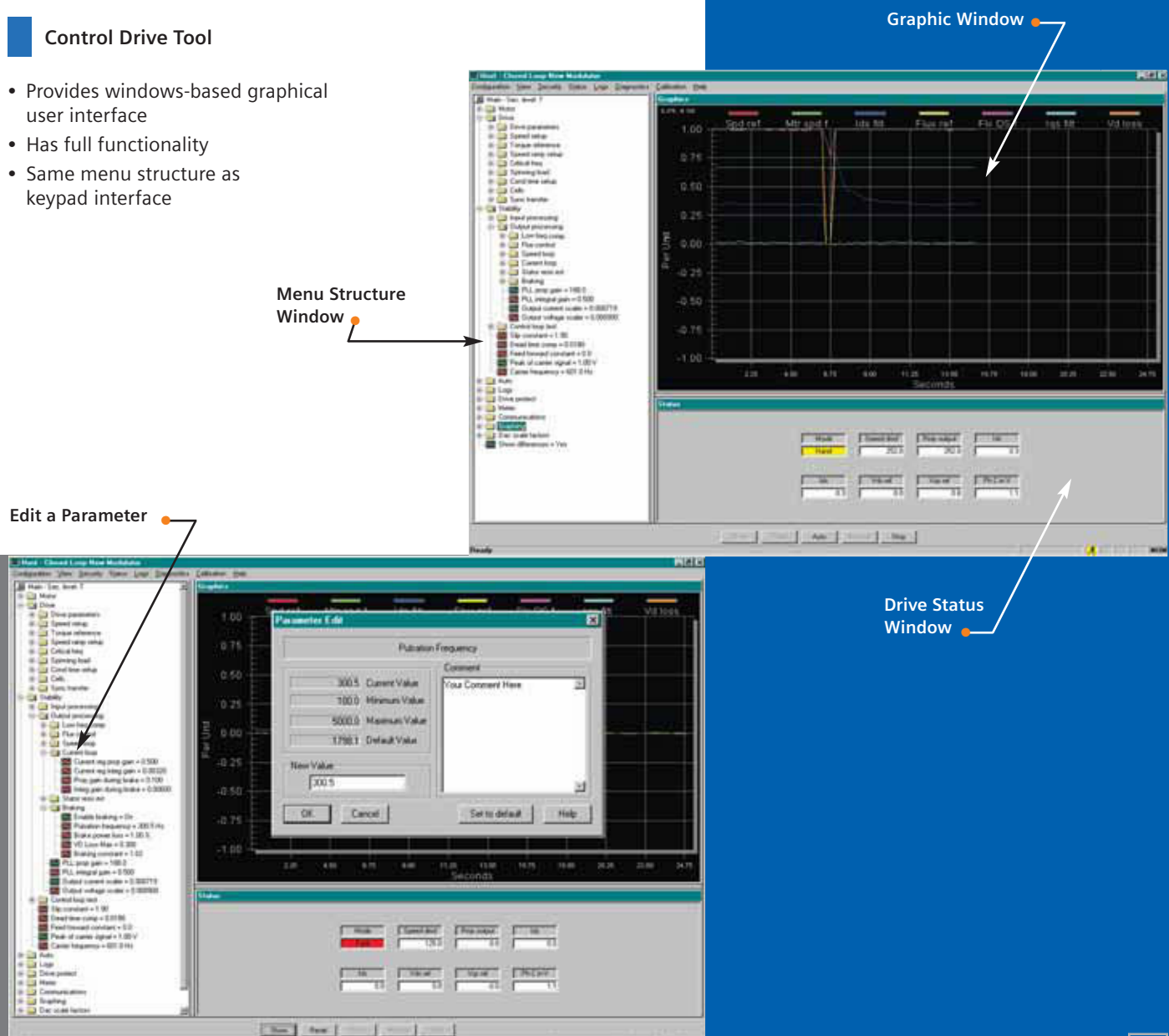
Advanced Cell Bypass Results

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Control Drive Tool

- Edi

Edit a Parameter



Trusted in the Most Demanding Applications

The Perfect Harmony is regularly applied by the most reliability and quality conscious industries and their most demanding applications.

Oil and Gas

ESP's – offshore and onshore for powering electrical submersible pumps at cable lengths up 35 km (22 miles) without complicated output filters.

High Speed Compressors - process critical high speed applications for liquefied natural gas and refineries consistently choose the Perfect Harmony because it

delivers sinusoidal power at output frequencies of 330 hertz and beyond making these systems less complicated, more efficient and lowering their life cycle maintenance.

Power Generation

Induced and forced draft boiler fans – when the power has to be delivered the Perfect Harmony has been the overwhelming choice of the U.S. power generation market because of the Siemens' engineering expertise and the remarkable reliability that each and every installation has shown.

Water

In more than 20 countries, the Perfect Harmony drive is the medium voltage drive of choice for all types of critical clean water and wastewater pumping applications.

Adding to the versatility of the Perfect Harmony drive, it is available with forced-air-cooling (bottom) or self-contained, closed-loop, water-cooling (top). Redundant pumps are standard on water-cooled units. Redundant blowers are a standard option for air-cooled units. The multi-cell design allows quick rack in/out of power cells, making maintenance of the Perfect Harmony very quick and simple. A hydraulic "cell lifter cart" is an option for larger cell designs.



Marine

The Perfect Harmony helps our marine customers reduce costs and enhance power quality and reliability, while maximizing space. Additionally, the Perfect Harmony offers regeneration capability that many marine customers demand. Through Siemens' alliances with ship owners, designers and leading component suppliers, we can product comprehensive electrical systems for all types of marine applications.

Paper

Through an advanced control strategy called sensorless or closed-loop vector control, the Perfect Harmony drive provides precise torque and speed control to a wide range of demanding applications in the pulp and paper industry.



Through Siemens' alliances with ship owners, designers and leading component suppliers, we can provide comprehensive electrical systems for all types of marine applications, including complete ship propulsion and thruster systems for merchant, naval and scientific ships; drilling and exploration platforms; passenger ships; and waterway ferries.



A History of Continuous Improvement

Siemens has consistently led the industry in innovation and quality. As power switching device technology advances and increases output voltage capability, Siemens improves each generation of the Perfect Harmony in three key areas: fewer parts, increased efficiency and a smaller drive footprint.

Moving forward, Siemens will remain on the leading edge of medium voltage technology with the following features on future Perfect Harmony drives:

- Intuitive interface systems to make the Perfect Harmony drive more user friendly
- Installation wizards for quick and easy start-up

- Remote monitoring and control to allow customers or Siemens to operate the drive, manage its performance or diagnose service concerns from any global location
- Intelligent diagnostics to empower the Perfect Harmony drive to independently and automatically correct service concerns
- Parallel redundant control systems to provide peace of mind to customers requiring maximum reliability through redundancy of all drive functions to help prevent disruptions

Siemens' investments in emerging technologies will culminate as these features are introduced in upcoming generations of the Perfect Harmony drive.



Cinergy Corporation Inc., the largest non-nuclear electric supplier in the U.S., is improving the efficiency of its Cinergy/PSI Gibson Generation Station in Owensville, Ind., by installing 15 sets of 6600 V Perfect Harmony drives and Robicon motors as part of an environmental compliance project. The total capacity of the new drives and motors will be more than 150,000 HP, which will contribute to the site's overall capacity of 3,380 megawatts. Gibson Station is the third largest coal-fired generating station in the country, generating approximately 20,000,000 net megawatt hours annually.

Setting the Standard in High-Power Conversion

At Siemens, we lead the way with industry "firsts" in medium voltage drive technology. Since its introduction in 1994, the Perfect Harmony drive has set the standard for medium voltage technology and continues to innovate. We constantly solicit customer

feedback and use it to guide product enhancements. Advances, however, are made without "reinventing the wheel." While others change their drive topology, Siemens maintains the same topology from generation to generation. Our customers have

the option to easily upgrade their drives with the latest available technology and features. By keeping the same topology, our customers see a reduction in maintenance and spare parts, as well as an increase in quality and reduced life-cycle costs.

1994

- Developed cell-based modular technology, making medium voltage drives easier to scale and service, while providing a smaller footprint
- First IGBT-based drive at medium voltage
- First fully integrated medium voltage drive to meet all IEEE 519 compliance standards without optional equipment
- First filterless, standard, motor-compatible, medium voltage drive
- First extended cable-length medium voltage drive to power an electrical submersible pump motor

1995

- First IGBT-based 6.6 kV drive without an output transformer

1996

- First IGBT-based drive above 10000 horsepower (7500 kW)



2005

- Introduced the smallest footprint medium voltage VFD in the world – Robicon MicroHarmony

2004

- Largest pulse width modulated drive ever built – 80,000 HP

2003

- First high voltage 13.8 kV drive capable of operating motors from 4000 HP to 90000 HP (3000 kW – 67000 kW), connected direct at 13.8 kV

2002

- 1500th Perfect Harmony drive installed

2001

- 1000th Perfect Harmony drive installed

2000

- First voltage-fed drive to operate a medium voltage synchronous motor

1999

- First drive to provide process-transparent, cell-bypass capability and neutral-point shift

1998

- First drive to offer a process tolerant protection strategy (ProToPS™)
- 500th Perfect Harmony drive installed

Protecting Our Customers' Investments with Superior Service and Support

Siemens' service and support network is never more than a phone call away. Representatives are ready 24 hours a day, seven days a week, to assist customers with immediate technical support geared to handle every phase of installation, startup, maintenance and troubleshooting.

Our services include:

- Around-the-clock field service
- Preventative maintenance
- Product refurbishment
- Training
- After-market spare parts
- Upgrades
- Repairs and exchanges
- Specialty services

Our Commitment

Siemens is proud of its reputation for long-term service of its products, including the Perfect Harmony. We are committed to providing complete life-cycle support. We never relinquish the responsibility for servicing our products to the full satisfaction of our customers, regardless of the age of the product. To extend the lifespan and increase the functionality of the drive, the Siemens refurbishment program provides our customers with the opportunity to upgrade their Perfect Harmony drive with new technology as it becomes available.

Local Convenience

Because we are accustomed to providing on-site service for all of our customers, we have the extensive reach of a dedicated, global service force. Each of our service representatives is fully trained in variable frequency drives. We are committed to growing our sales and service staff and branching out into new regions to support the growth of our installed base.

All Siemens LD-R service representatives are fully trained in medium voltage variable frequency drives, giving Siemens the largest medium voltage service organization in the world!



Output Parameters

Rated Motor Voltage Single Drive Configuration

2.3 kV		3.3 kV		4.16 kV		6.0 kV		6.6 kV		11 kV	
Output Current	Output kVA	Output Current	Output kVA	Output Current	Output kVA	Output Current	Output kVA	Output Current	Output kVA	Output Current	Output kVA
70	300	70	400	70	500	70	700	70	800	500	8000
100	400	100	600	100	700	100	1000	100	1000	800	15000
140	500	140	800	140	1000	140	1500	140	1500	1400	25000
200	800	200	1000	200	1500	200	2000	200	2000	13.8 kV	
260	1000	260	1500	260	1750	260	2500	260	3000		
315	1250	315	1750	315	2000	315	3000	315	3500	Output Current	Output kVA
375	1500	375	2000	375	2500	375	4000	375	4000		
500	2000	500	2500	500	3500	500	5000	500	5500	500	10000
660	2500	660	3500	660	4500	660	7000	660	7500	800	18000
		880	5000	880	6500	880	9000	880	9500	1400	31000
		1250	7000	1250	9000	1250	13000	1250	14000		

Maximum output frequency — 330 Hz (with derating). Speed-control range — 1:1000 (with encoder).

Technical Specifications

General		Cooling Type	
Power semiconductors	IGBTs; diodes	Air-cooled	Forced-air cooling with integrated fans
Line-side converter	18- to 36-pulse diode rectifier (standard)	Permissible ambient and cooling, medium temperature	
Motor-side converter	Multi-level converter (PWM) with IGBT power modules	- In operation	0°C to + 40°C: 100% load capability +40°C to 50°C: current derating
Closed-loop control	Sensorless closed-loop control, fully digital with signal processor	- During storage	-25°C to +55°C
Drive quadrants	Driving: 2 directions of rotation (2 quadrant), 4 quadrant option	- During transport	-25°C to +70°C
Potential separation: Power section	Fiber-optic cable	Water-cooled	Deionized water with integrated water-to-water heat exchanger
- Open- and closed-loop control		Permissible ambient temperature	
Permissible humidity rating	Relative air humidity < 95% non-condensing	- In operation	+0°C to + 40°C
Noise level	Approx. 75 dB (A)	- During storage	-25°C to + 55°C (without deionized water)
Efficiency (standard version)	96% at the rated operating point including transformer	- During transport	-25°C to + 70°C (without deionized water)
Regulations compliances	IEEE, ANSI, NEMA, UL, CSA, CE	Permissible cooling medium temperature (raw water)	
Paint finish	ANSI 61 Gray	- Intake	+5°C to 35°C
Degree of protection	Acc. to DIN VDE 0470, IEC 60529, EN 60529	- Outlet	Max. +40°C
- Standard	IP31 (air-cooling) IP52 (water-cooling) NEMA 1 (air-cooling) NEMA 12 (water-cooling)	Supply Data	
- Optional	IP42 (air-cooling)	Standard	2.3 to 15 kV
		Special option	< 2.3 and > 12 kV
		Control voltage	1 Ph, 120 VAC or integrated to auxiliary supply

ProToPS™ Alarm and Trip Examples (All Configurable)			
Alarms	Meanings	Alarms	Meanings
Overspeed	Alarm speed threshold reached	Underload	Underload alarm
Overcurrent	Alarm current threshold reached	Single-input phasing	Loss of one input phase
Motor temperature	Alarm motor temperature threshold reached	Ride through	Drive in ride-through operation (input voltage dip)
Network failure	Communication problem		
Speed reference signal loss	Loss of speed feedback signal		