Short overview

Perfect Harmony

ROBICON

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System overview

Product features

- Truly Scaleable Technology
- 300 kW to 30 MW (Single Channel)
- Large Number of Framesizes
- Most Motor Voltages Supported
- Low Harmonic Input
- High Efficiency and Power Factor
- Line Disturbance Immune
- New or Existing Motors
- Negligible Pulsating Torques
- High Availability
System overview
The Harmony concept: provide an integrated VFD system

<table>
<thead>
<tr>
<th>Feature</th>
<th>Perfect Harmony</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation Transformer</td>
<td>Included</td>
</tr>
<tr>
<td>Harmonic Filtering</td>
<td>Inherent</td>
</tr>
<tr>
<td>Power Factor Correction</td>
<td>Inherent</td>
</tr>
<tr>
<td>Power Converter</td>
<td>Included</td>
</tr>
<tr>
<td>Motor Filter</td>
<td>Inherent</td>
</tr>
</tbody>
</table>

- Easy engineering
- Simple installation
- Lower installed cost.
## System overview

### Product history

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product introduction</td>
<td>1994</td>
</tr>
<tr>
<td>Increased output to 6.6 KV&lt;br&gt;(690 V cells)</td>
<td>1995</td>
</tr>
<tr>
<td>Gen II: Options program</td>
<td>1996</td>
</tr>
<tr>
<td>UL/CSA</td>
<td>1996</td>
</tr>
<tr>
<td><strong>ProToPS™</strong></td>
<td>1998</td>
</tr>
<tr>
<td>Gen III Harmony&lt;br&gt;CE Mark&lt;br&gt;Fast Bypass</td>
<td>1998&lt;br&gt;1999&lt;br&gt;1999</td>
</tr>
<tr>
<td>Increased max power to 19,000 kVA&lt;br&gt;(1250 A – 690 V cells)</td>
<td>2000</td>
</tr>
<tr>
<td>Introduced Harmony HV for 13.8 KV motors</td>
<td>2003</td>
</tr>
<tr>
<td>Largest PWM VFD 45/60 MW with AFE</td>
<td>2004</td>
</tr>
<tr>
<td>3000 Perfect Harmony units sold</td>
<td>2005</td>
</tr>
<tr>
<td>Introduced Gen IV – smallest air-cooled MV VFD</td>
<td>2006</td>
</tr>
</tbody>
</table>
Perfect Harmony Topology

Typical Power Section Schematic

4160 Volt Drive (750 V Power Cells)
Perfect Harmony Topology

Principle of Operation

These cells are in phase at zero degrees electrical.

These cells are in phase at 120 degrees electrical.

These cells are in phase at 240 degrees electrical.
# System performance

## Isolation transformer

<table>
<thead>
<tr>
<th>Features</th>
<th>Customer benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation transformer: included</td>
<td>Prevents risk of motor damage by common mode voltages</td>
</tr>
<tr>
<td>No motor common mode voltage issues</td>
<td>Enhances the retrofit capability</td>
</tr>
<tr>
<td>Continued operation with one earth fault possible</td>
<td>Avoids expensive motor modifications or the need for a new motor</td>
</tr>
<tr>
<td>Isolation transformer built into drive cubicle</td>
<td>Increased system availability</td>
</tr>
<tr>
<td>Easy plug-and-play installation: Three cables in, three cables out</td>
<td>Perfect for retrofit projects</td>
</tr>
</tbody>
</table>
System performance
Input power quality

Features
Harmonic filter inherent:
- “Clean power” sinusoidal converter
- Near zero harmonics

Customer benefits
- Meets all new requirements of IEEE 519 1992 for both current and voltage distortion
- Eliminates needs to do harmonic analysis
- Eliminates costly harmonic filters required for distortion control

Robicon "Perfect Harmony" Drive

1000 HP / 750 KW VFD, 1100 kVA 5.75% Impedance Source
System performance
Loss of power supply

Continued operation when line voltage lost

- Restored operation with no trip for 5 cycle power interruption
- Restart Into spinning load with no load or line disturbance as long as motor flux is present
## System performance

### Motor compatibility

<table>
<thead>
<tr>
<th>Features</th>
<th>Customer benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor filter inherent:</td>
<td></td>
</tr>
<tr>
<td><strong>No common mode motor insulation stress</strong></td>
<td>▪ Drive is compatible with both new and existing motors</td>
</tr>
<tr>
<td></td>
<td>▪ Torque ripple 1% or less on driven load at all operating frequencies</td>
</tr>
<tr>
<td><strong>No additional VFD induced motor heating</strong></td>
<td>▪ Drive can be safely applied to 1.0 service factor motors</td>
</tr>
<tr>
<td><strong>No dv/dt problems</strong></td>
<td>▪ Drive creates no motor voltage insulation stress</td>
</tr>
<tr>
<td></td>
<td>▪ Motor does not require reinforced insulation</td>
</tr>
</tbody>
</table>
System performance
Motor compatibility

Output Waveforms @ 60 HZ and 30 HZ

Wave forms remain high quality at lower speeds due to multi-level PWM output.
System performance
Output harmonics

Output Harmonics - Robicon Perfect Harmony Series
@ 30 HZ, Full Load

Less Than 2% VFD Induced Torque Ripple on Driven Load
Output Harmonics - Robicon Perfect Harmony motor operating from Generator vs. Perfect Harmony

Recirc Pump Motor 2B Temperature Rise  
(Based on 3 hour Averages)

-10 0 10 20 30 40 50 60 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600

Temp Rise (degF)

Speed (RPM)

MG Set  
VFD
## System performance
### Factory integration

### Features

<table>
<thead>
<tr>
<th>Factory integration:</th>
<th>Customer benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fully integrated at Siemens A&amp;D LD A</strong></td>
<td><strong>Fast and safe commissioning at customer site</strong></td>
</tr>
</tbody>
</table>
| **Complete In-factory test -tested as complete systems in our plant** | **Comprehensive proof of performance**
| | **Enhances reliability by weeding out early failures** |
ProToPS™
Advanced Cell Bypass

Advanced Cell Bypass Results
**ProToPS™**

Bypass Contactor and Control

- **Traction DC Contactor**
  - Automatic bypass of a failed power cell in 250 ms
  - Completely redundant bypass control: Physically separate from cell
  - Allows bypass down to (1) one cell per phase
  - Allows unequal number of active cells per phase
  - U.S. Patent No. 5,986,909 issued November 16, 1999

![Bypass Contactor](image)

**Cell Bypass Control Logic**
Open Loop Sensorless Vector Control

- Motor-mounted encoder NOT required
- Duplicates two-quadrant DC operation
- Provides precision speed/torque control
- Features fast dynamic response
- Has low speed/high torque capability

Auto Tuning

- Provides motor information to optimize control
- Is a two-stage process
  - Stage 1: Stator resistance, leakage inductance
  - Stage 2: Motor no-load current, inertia
Control Interface

Power monitoring

Can determine and display information about input waveform and drive output

Input display parameters

- Input voltage
- Input voltage harmonics (one at a time)
- Input current
- Input current harmonics (one at a time)
- Input PF
- Input power (kW)
- Input reactive power (kVAR)
- Input kW-Hr
- Input phase sequence
- Loss of phase
- Low voltage
- Transformer overload
- Output power (kW)
- kW-Hr
- Output current – RMS
- Output voltage – RMS
- VFD efficiency
- Motor torque
- Motor speed (RPM)
- Motor slip (%)
- Drive output frequency (Hz)
- Magnetizing current
- Torque current
- Motor flux
Control Interface
Control Drive Tool

- Provides Windows-based graphical user interface
- Provides full drive functionality
- Features same structure as keypad interface
- Has multiple language support
# Motors
The perfect products for a broad spectrum of motors

<table>
<thead>
<tr>
<th>H-compact PLUS</th>
<th>H-compact IEC</th>
<th>Series 1R.5/S.5</th>
<th>H-modyn IEC, ANEMA</th>
<th>Special motors</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC, ANEMA</td>
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<td>IEC, ANEMA</td>
<td>ANEMA</td>
</tr>
<tr>
<td>1000 - 7000 kW</td>
<td>1340 - 9390 HP</td>
<td>7000 - 10000 kW</td>
<td>7000 - 50000 kW</td>
<td>2000 - 65000 kW</td>
</tr>
<tr>
<td>2 - 12 pole</td>
<td>2 - 12 pole</td>
<td>3.3 - 13.2 kV</td>
<td>6 - 13.2 kV</td>
<td>690 V - 13.2 kV</td>
</tr>
<tr>
<td>Squirrel cage</td>
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<td>2 - 12 pole</td>
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</tr>
<tr>
<td>Cast iron housing with cooling ribs</td>
<td>Cast iron-/ Steel housing, cooler assembly IP23, IP55, WP II</td>
<td>slip ring rotor</td>
<td>synchronous</td>
<td>synchronous</td>
</tr>
<tr>
<td>IP55</td>
<td>IP55, WP II</td>
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<td>150 - 2500 HP</td>
<td>2000 - 65000 kW</td>
<td>ANEMA</td>
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<td>0.2 – 11 kV</td>
<td>690 V - 13.2 kV</td>
<td>2000 - 65000 kW</td>
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<td>2 - 16 pole</td>
<td>Squirrel cage</td>
<td>ANEMA</td>
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<tr>
<td>Squirrel cage</td>
<td>Squirrel cage</td>
<td>Retrofit</td>
</tr>
<tr>
<td>Cast iron housing with cooling ribs</td>
<td>Cast iron housing</td>
<td>• Existing motors with standard windings</td>
</tr>
<tr>
<td>IP55/TEFC</td>
<td>cooler assembly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ODP, WP I, WP II, TEAAC/TEWAC</td>
<td></td>
</tr>
</tbody>
</table>

- **ANEMA**
  - 150 - 2500 HP
  - 0.2 – 11 kV
  - 2 - 16 pole
  - Squirrel cage
  - Cast iron housing with cooling ribs
  - IP55/TEFC

- **ANEMA**
  - 200 - 10000 HP
  - 0.2 – 13.8 kV
  - 2 - 16 pole
  - Squirrel cage
  - Cast iron housing
  - cooler assembly
  - ODP, WP I, WP II, TEAAC/TEWAC

- **ANEMA**
  - 1000 - 7000 kW
  - 1340 – 9390 HP
  - 2 - 12 pole
  - Squirrel cage
  - Cast iron housing with cooling ribs
  - IP55

- **ANEMA**
  - 7000 - 10000 kW
  - 3.3 - 13.2 kV
  - 2 - 12 pole
  - Squirrel cage
  - Cast iron-/ Steel housing, cooler assembly IP23, IP55, WP II

- **ANEMA**
  - 7000 - 50000 kW
  - 6 - 13.2 kV
  - 2 - 12 pole
  - Squirrel cage
  - Synchronous
  - Cast iron-/ Steel housing, cooler assembly IP55, WP II

- **H-modyn**
  - 2000 - 65000 kW
  - 690 V - 13.2 kV
  - Squirrel cage
  - Synchronous
  - Example: Highspeed compressor drive

- **Retrofit**
  - • Existing motors with standard windings
Applications
The perfect products for all applications