HIVECTOL L-HVI

Medium Voltage Multi-level IGBT Drives
Over 80 Years of Experience in Variable Speed Drives

Based on lengthy experience in drive systems for steel rolling mills, Hitachi supplies AC drive systems to various industry applications including mixers and extruders for the plastics and rubber industry, induced and forced draft fans for thermal power plants, pumps for water purification plants and water and waste water treatment facilities, and fans and blowers for general applications.

Mega power AC drives also have applied to wind mill power converters, dump truck drives for mining industry, compressor drives for oil & gas industry and propulsion drives for ice breaker ships.

HIGHLIGHTS

1933
Ward Leonard Drives
for steel rolling mills

1958
Mercury-arc Rectifier
applied Ward Leonard
Drives for steel rolling
mills

1973
DC drive controls,
HILECTOL

1982
The world’s first Digital
Thyrister Leonard Drives

1986
Medium Voltage AC Drives
for steel rolling mills

1930-1960

1970

1980

1910
The first products of Hitachi

Hitachi was founded in 1910 as an electrical repair shop for a mining company and succeeded in the first domestic manufacture of three 5 HP motors as the company’s first products.
Direct Inverter Controls

- **1995**: 20MVA GTO Drives for steel rolling mills
- **1999**: Medium Voltage Multi-level IGBT Drives, HIVECTOL-HVI
- **2001**: 8MVA HIVECTOL-HVI for utility thermal power plants
- **2007**: 30MVA IGBT Drives for steel rolling mills
- **2004**: Multi-level IGBT drive production started in China
- **2009**: 30MVA 5-Level water cooled IGBT Drives

**Features**

**Power Source and Machine Friendly**
- Current harmonic at the power source conforms the IEEE 519-1992 guidelines without line side harmonic filters.
- Multi-level PWM approximates output waveforms to sine curves and reduces motor insulation stress.
- Multi-winding isolation transformer and diode converter help achieve a power factor of 0.95 or better.

**State-of-the-art Technology and High Performance**
- Stable operation is assured for applications needing high starting torque and high intermittent torque.
- Patented "external pre-charging method" helps reduce the parts count and down time.
- Automatic restarting function helps continuous operation in cases of instant power failure.
- Motor Speed accuracy is ±0.5% at the rated 100% speed without a speed sensor device. (±0.1% with speed sensor device)

**High Reliability**
- IGBT, the most reliable, available and widely installed power semiconductors in industry are used.
- Quality production in manufacturing eliminates human error during manufacturing.
- "Realtime simulator" helps prevent axial vibration and minimize the commissioning period.

**Operator Friendly**
- Large touch-screen panel shows easy-to-understand information and assures user friendly operation.
- Windows® PC based maintenance software is supplied by Hitachi for user friendly operation.
HIVECTOL HVI Hardware Overview

Main components of HIVECTOL-HVI are the “Transformer Section”, “Inverter Section” and “Control Section”. Inverter Section is composed of a series-connected “Inverter Cell”. Isolation Transformer is a phase shifted multi-winding type. Control Unit has functions such as IGBT inverter switching, an interface to external equipment, etc.
Power Source and Machine Friendly

Inverter Cell is composed of a diode converter and IGBT inverter. Each Inverter Cell is fed from a separate secondary winding of the isolation transformer. These Inverter Cells are connected in series and are operated in multiplexed mode. This mode of operation generates a stepped voltage output which approximates sine waveforms. This allows the direct inverter to be used not only with new inverter motors, but with existing standard motors as well. In addition, the phase shifted multi-winding transformer effects reduction of current harmonics to the power supply well below the levels admitted under the IEEE 519-1992 guidelines.

- **Line-side current distortion content**
  - Output wave forms are very smooth resulting in reduction of electrical and mechanical stress of the motor.
  - [Graph showing harmonic content and guideline comparison]

- **AC voltage output wave form**
  - [Graph showing AC voltage output wave form]

**Diagram**

- Power supply 2~11kV class
- Isolation transformer
- Inverter section
- U1, U9
- V1, V9
- W1, W9
- Control unit
- PWM (Pulse width modulation)
- Diode converter
- Inverter cell
- IGBT inverter
- IM
State-of-the-art Technology and High Performance

**Best Fits for High Torque Application**
Robust speed sensor-less vector control technology prevents over current conditions and operates machines in a safe and continuous mode when the impact load reaches 200%. HIVECTOL-HVI is capable of driving a heavy starting load (200% torque) and can not only match but excel in performance compared to a DC motor. HIVECTOL-HVI best fits mixers and extruders for rubber and plastic industries.

For high torque applications such as rubber mixers, extruders, and agitators, Hitachi uses a method that controls the output voltage by adjusting current flux component using measurement of overload current. Smooth torque control in the operating speed range and high torque at the startup is achieved by sensor-less vector control by using calculated required current for torque and excitation for the given load. A sensor-less vector control scheme needs no speed feedback device (speed sensor) and it improves system reliability and maintainability.

**Lower Parts Count Enhances Reliability**
In order to reduce inrush current when the main power is turned on, a pre-charging circuit is required to charge DC capacitors. Hitachi uses its patented external pre-charging circuit and pre-charging is done by a separate power supply. The other method is to use a pre-charging circuit with each Cell Inverter. Comparing between the two pre-charging methods, the external pre-charging method is very simple and reduces the parts count.

**Patented Pre-Charging method**
Pre-charging circuit charges the DC capacitor before the input medium voltage breaker is turned on. This is done in order to prevent the inrush current when the medium voltage main power supply turns on. HIVECTOL-HVI uses a separate LV power source for pre-charging. This power supply is switched on for about 20 seconds, during which capacitors in the inverter cells charge. Once capacitor charging is completed, the LV supply is disconnected and the medium voltage breaker for main supply is turned on. Compared to a pre-charging circuit that uses a thyristor switch and a resistor in each cell unit, the arrangement of separated pre-charging circuit is simple and easy to maintain. This design leads to high reliability in inverter operation. Separated pre-charging circuit method has been patented by Hitachi Ltd (Patent No.3,535,477).
User Friendly

**Easy Analysis and Diagnostics**

The operator touch-screen panel with a large LCD is easy to see and easy to operate. Operator can see various kinds of helpful information such as the operation status and alarm information.

**Easy Maintenance**

Hitachi provides a maintenance software tool which helps maintain the drive system easier. The software is designed for Windows® PC. The major functions of the maintenance tool are as follows:

- Memory Read/Write Function
- Display Diagnostic Message and Trend Data
- Selection of Analog Output Signal
- File Read/Write Function
- Bar Graph Display Function

**Instantaneous Voltage Drop Measure**

**Automatic Restart upon Instantaneous Power Failure**

After input power recovery, the automatic restart function maintains continuous operation in the case of instantaneous power failure. The coasting motor can be reaccelerated to the reference speed automatically.
Quality

Axial Vibration Prevention
Hitachi has developed a real-time simulator, which simulates the physical control system in real time. The simulation models cover the main circuits of the drive motor and driven mechanical load. For example, axial vibration happens to be generated by resonant frequency from the load. Prior to shipment of the drives for such applications, Hitachi evaluates the resonance effects to prevent axial vibration. This real-time simulator works not only to improve reliability, but also to shorten the commissioning period on site.

Quality Production
Hitachi has implemented a production data management system which displays on a video terminal the last updated or the new schematics and the Bills of Materials (BOM). Visual assistance helps the manufacturing work force to prevent human error and to improve quality. No paper schematics are used in the wiring and assembly process.

Why does Hitachi choose IGBT?
Hitachi applies IGBT power semiconductors for all product lines of variable frequency drives. The reliability of IGBT has been proven in a variety of application environments such as steel rolling mills, traction drives, generator converters, and general purpose drives. Compared to the other types of power semiconductors, IGBT is a more commonly used power device. From this viewpoint, IGBT parts are more availability.
External Interfaces

External interfaces allow user specific or plant specific signals to be coordinated for operation of the inverter in the plant environment. These signals can be interlocking signals, monitoring signals or process control signals that are connected to the inverter so that it works in a synchronized fashion with the machine and the process.

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Digital Input:
- Inverter run
- Inverter stop
- Inverter running Interlock

Digital Output:
- Inverter running
- Inverter ready to run
- Inverter alarm
- Inverter fault / trip

Analog Input:
- Rotating speed reference (4-20mA)

Analog Output:
- Speed feedback (4-20mA)
- Torque current feedback (4-20mA)

Control power (100~220V)
Pre-charging power (380~440V)

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*CELL : Cell Inverter
(The number changes depends on the output voltage.)

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* CB(52) Status answer back
* CB(52) Turn on command
* CB(52) Turn off command
## Specifications (For Reference)

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Output Volt[V]</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Line-up</td>
<td>Capacity[kVA]</td>
<td>2,400 — — 360 530 800 1,060 1,600 2,130 2,900 3,630</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>3,000 — 330 450 660 1,000 1,330 2,000 2,670 3,650 4,550</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>3,300 — 360 500 730 1,100 1,460 2,200 2,930 4,000 5,000</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>4,160 310 460 630 920 1,380 1,850 2,770 3,700 5,040 6,300</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>6,000 450 660 900 1,330 2,000 2,670 4,000 5,340 7,300 9,100</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>6,600 500 730 1,000 1,460 2,200 2,930 4,400 5,870 8,000 10,000</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>10,000 750 1,110 1,510 2,220 3,330 4,450 6,670 8,900 12,100 15,200</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>11,000 830 1,220 1,660 2,440 3,670 4,890 7,340 9,790 13,300 16,700</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Rated Output Current [A]</td>
<td>43.7 64.2 87.5 128.5 192.8 257.1 385.6 514.2 707 875</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Output Frequency [Hz]</td>
<td>50 / 60Hz (Max.75Hz)</td>
</tr>
<tr>
<td>11</td>
<td>Power Supply</td>
<td>Input Voltage</td>
<td>AC2,400V / 3,000V / 3,300V / 4,160V / 6,000V / 6,600V / 10,000V / 11,000V</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Input Frequency</td>
<td>50 / 60Hz</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Power supply for control</td>
<td>AC100 / 110 / 200 / 220 / 230 / 240V 1 Phase (Standard) or DC100/110V (Option)</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Pre-charge power supply</td>
<td>AC400 / 415 / 440V (Standard) AC220 / 200V or other low voltage (option) 3 Phase</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Voltage fluctuation</td>
<td>within +/-10% (Working without fault although the output power become lower)</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Frequency fluctuation</td>
<td>within +/-5% (Guarantee output power)</td>
</tr>
<tr>
<td>17</td>
<td>Structure</td>
<td>Cubicle</td>
<td>Forced air cooled self-standing cubicle type</td>
</tr>
<tr>
<td>18</td>
<td>Control</td>
<td>Transformer</td>
<td>In-built dry type (Oil-immersed Transformer as option)</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>Protection</td>
<td>IP21 (Higher degrees of protection as option)</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>Type</td>
<td>Medium Voltage Multi-level IGBT Inverter</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>Control Method</td>
<td>Sensor less Vector Control / Vector Control with Sensor (Option)</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>Driving Method</td>
<td>2 quadrant Operation</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>Deceleration</td>
<td>Natural Deceleration</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>Speed Control Range</td>
<td>1%~100% speed</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>Accuracy</td>
<td>+/-0.5% at 100% speed without sensor / +/-0.05% at 100% speed with sensor</td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>Overload</td>
<td>125% 60sec</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>Efficiency</td>
<td>approximately 97% (including Transformer)</td>
</tr>
<tr>
<td>28</td>
<td></td>
<td>Power factor</td>
<td>above 95%</td>
</tr>
<tr>
<td>29</td>
<td></td>
<td>Interface</td>
<td>Analog / Field network (DeviceNet / Profibus / Modbus / CAN)</td>
</tr>
<tr>
<td>30</td>
<td>Protection</td>
<td>Momentary Over Current</td>
<td>Detected output AC side</td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>Over voltage of DC circuit</td>
<td>Detected DC over voltage of each cell</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>Power drop for Driver board</td>
<td>Detected power drop of each cell</td>
</tr>
<tr>
<td>33</td>
<td></td>
<td>PT CT failure</td>
<td>Comparing drive frequency with voltage/current feed back</td>
</tr>
<tr>
<td>34</td>
<td></td>
<td>Ground fault</td>
<td>Detected current flow into earthing resistor</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>Power failure</td>
<td>Detected at quenemiy voltage of multiplex winding transformer</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>Abnormal Cooling Fan</td>
<td>Detected by thermal or MCCB trip</td>
</tr>
<tr>
<td>37</td>
<td>Indication</td>
<td>Charging</td>
<td>Indicate until main DC voltage to 50V</td>
</tr>
<tr>
<td>38</td>
<td></td>
<td>Speed / Current / etc.</td>
<td>Indication Bar chart on Graphic Panel</td>
</tr>
<tr>
<td>39</td>
<td></td>
<td>Fault</td>
<td>Indication on Graphic Panel</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>Trace Back Data</td>
<td>Read out to the Maintenance tool</td>
</tr>
<tr>
<td>41</td>
<td>Others</td>
<td>Cable entrance</td>
<td>Bottom / Upper (Option)</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>Restart after instantaneous power failure</td>
<td>Option (Need UPS power supply)</td>
</tr>
<tr>
<td>43</td>
<td></td>
<td>Restart while the motor rotating</td>
<td>Option</td>
</tr>
<tr>
<td>44</td>
<td></td>
<td>Standards</td>
<td>IEC / JIS / IEC / JEM</td>
</tr>
</tbody>
</table>

* The output rated voltage shall be guaranteed within the above mentioned voltage fluctuation.
* More options are available. Please inquire for more details.
* All specifications are subject to change without notice.
* DeviceNet is trademark of Open DeviceNet Vendor Association (ODVA), Inc.
* Profibus is a registered trademark of Profinz Nutzerorganisation e. V.
* Modbus is a registered trademark of AEG Schneider Automation Inc.
* HIVECTOL is a registered trademark of Hitachi, Ltd.
### Dimensions (For reference)

1. **Note:** The dimensions and weight mentioned above are only for reference. Please ask to our sales network and confirm it by technical specifications.
2. Differences may occur due to some factors like: options, components, modifications, installation condition. Please contact us for more details.
3. Please inquire about weight and dimensions for transformer (dry type or oil-filled type) separation.
4. Less clearance space in back can be available. Please inquire for more details.
5. Dimensions are subject to change without notice.

<table>
<thead>
<tr>
<th>Voltage (kV)</th>
<th>kVA</th>
<th>Outline</th>
<th>Dimensions (mm)</th>
<th>Weight (kg)</th>
<th>(mm) (at least)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Width (W)</td>
<td>Depth (D)</td>
<td>Height (H)</td>
</tr>
<tr>
<td>2.4</td>
<td></td>
<td>Fig-1</td>
<td>2,700</td>
<td>1,200</td>
<td>2,700</td>
</tr>
<tr>
<td>3.3</td>
<td></td>
<td>Fig-1</td>
<td>2,700</td>
<td>1,200</td>
<td>2,700</td>
</tr>
<tr>
<td>4.16</td>
<td></td>
<td>Fig-1</td>
<td>2,700</td>
<td>1,200</td>
<td>2,700</td>
</tr>
<tr>
<td>6.6</td>
<td></td>
<td>Fig-1</td>
<td>2,700</td>
<td>1,200</td>
<td>2,700</td>
</tr>
<tr>
<td>11.0</td>
<td></td>
<td>Fig-1</td>
<td>2,700</td>
<td>1,500</td>
<td>3,000</td>
</tr>
</tbody>
</table>

Note: Please inquire about weight and dimensions for transformer (dry type or oil-filled type) separation.
Trusted in various industrial fields

Rubber and Plastic
Hitachi has delivered more than one hundred HIVECTOL inverters for rubber mixer drive systems to major tire manufacturers. Major tire manufacturers in the world enjoy higher productivity and profitability. Hitachi has also delivered more HIVECTOL inverters for agitators, pelletizers, extruders and more applications which require high starting torque and high intermittent torque in their operation.

Water and Waste Water
Hitachi has delivered hundreds of drives for variable speed control of pumps in water and waste water treatment facilities.

Metals
Hitachi has delivered hundreds of rolling mill drives all over the world. Their high reliability and performance are proven and well known in the metal industry. Hitachi has delivered a number of fan drives for energy saving in this industry.
Oil and Gas
Replacing a mechanical drive with an AC motor drive for compressors. A motor drive is well suited for energy and maintenance cost savings and delivers better performance with precise drive control.

Cement
HIVECTOL inverters are used not only for various fan drives but also for rotary kiln drives in the cement industry. HIVECTOL inverters help slash energy and maintenance costs.

Thermal Power Generation
Optimization of drive speeds of ID Fans and FD Fans for boiler combustion facilities significantly save energy consumption. Hitachi has delivered HIVECTOL inverters for such applications to large utilities for many years.

Nuclear Power Generation
Hitachi has delivered reactor internal pump drives for years.

*All illustrations in this paragraph are used only for commentary purposes*
### Order sheet

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Application (Facility Name)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Load Machine Name</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Load Machine Character</td>
<td></td>
</tr>
<tr>
<td></td>
<td>☐Square Reduction Torque ☐Constant Torque ☐Proportional Torque ☐Power Constant ☐Others</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Starting Torque: ___%  Overload: ___% ___ s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GD(^2) (Motor Axis Conversion): ___kg-m(^2)  Natural Deceleration Time: ___ s</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Regenerative Operation</td>
<td>☐No. ☐Yes.(Regenerative type Inverter required)</td>
</tr>
<tr>
<td>5</td>
<td>Motor Specification</td>
<td>☐Existing ☐New-Built ☐Squirrel Cage Induction Motor ☐Winding Induction Motor</td>
</tr>
<tr>
<td></td>
<td>☐Non Explosion Protection ☐Explosion Protection(Safety Increase, Pressure Proof, Inner Pressure)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output: ___ kW  Voltage: ___ V  Current: ___ A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency: ___ Hz  Number of Poles: ___ p  Rotational Speed: ___ min(^{-1})</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Efficiency: ___%  Power Factor: ___%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Rotational Speed Range</td>
<td></td>
</tr>
<tr>
<td></td>
<td>_____ min(^{-1}) - _____ min(^{-1})  Stall Torque: ☐Yes ☐No</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Acceleration, Deceleration Time</td>
<td>☐Set(Acceleration Time: ___ s, Deceleration Time: ___ s) ☐Unset</td>
</tr>
<tr>
<td>8</td>
<td>Speed Sensor</td>
<td>☐Sensorless Control ☐Sensor Control</td>
</tr>
<tr>
<td>9</td>
<td>Commercial Bypass Drive</td>
<td>☐Necessary(Automatic Switch, Manual Switch) ☐Unnecessary</td>
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<tr>
<td>10</td>
<td>Signal Interface</td>
<td>☐PIO Interface / ☐DeviceNet ☐Profibus ☐Modbus ☐CAN</td>
</tr>
<tr>
<td>11</td>
<td>Main Circuit Power Supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage: ___ kV  Frequency: ___ Hz  Short Circuit Current: ___ kA</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Main Power Supply Transformer</td>
<td>☐Oil ☐Mold ☐H type Dry System ☐Any</td>
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<tr>
<td>13</td>
<td>Control Power Supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage: ___ V  Frequency: ___ Hz  Capacity: ___ kVA</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Installation Requirements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>City/Country:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ambient Temperature: _____ - _____ °C</td>
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</tr>
<tr>
<td></td>
<td>Humidity: _____ - _____ %RH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Altitude: _____ m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas: _____ ppm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dust: ☐No ☐Yes(Class: _____ thousand)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Inverter Capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inverter: _____ kVA</td>
<td>Inverter Capacity(kW) = Motor Capacity(kW) / Motor Eff.(PU)*Motor PF(PU)</td>
</tr>
</tbody>
</table>

* For other specifications, please describe here.
HIVECTOL HVI

Medium Voltage Multi-level IGBT Drives

U.S.A.
Hitachi America, Ltd.
(Industrial and Infrastructure Systems Division)
(New York Office)
50 Prospect Avenue,
Tarrytown, NY 10591
Phone:<1>(914)631-0600
Fax: <1>(914)332-3672
URL: www-hitachi.us
(Houston Office)
9700 Richmond Avenue,
Houston, TX 77042
Phone:<1>(713)782-0529
Fax: <1>(713)782-0981

Canada
Hitachi (Canada) Ltd.
(Toronto Office)
5750 Explorer Drive suite 301,
Mississauga, Ontario
Phone:<1>(905)629-9300
Fax: <1>(905)290-0141
(Headquarters, S&IC)
<1>(905)814-0848(Digital Media)
(Calgary Office)
Suite 460, 10655 Southport Road S.W.,
Calgary, Alberta T2G 4Y1
Phone:<1>(403)278-1881
Fax: <1>(403)278-1810

Mexico
Hitachi Mexico, S.A. de C.V.
(Mexico Office)
Andres Bello No.10 Piso 10
Col.Chapultepec Polanco
11560, Mexico, D.F.
Phone:<1>(55)5282-9040
Fax: <1>(55)5282-9042

Brazil
Hitachi Brazil Representacoes Ltda.
(Headquarters)
Av. Paulista, 854-7^ And-Cj.72
Edificio Top Center,
CEP 01310-913-Sào Paulo-S.P.
Phone:<55>(11)3284-0922
Fax: <55>(11)287-2781

U.K.
Hitachi Europe Ltd.
Whitebrook Park
Lower Cookham Road
Maidenhead Berkshire SL6 8YA
Phone:<44>(1628)585000
Fax: <44>(1628)585988

Russian Federation
Hitachi, Ltd.
(Moscow Office)
Millennium House, 12, Trubnaya
Moscow, 103045
Phone:<7>(095)787-4020
Fax: <7>(095)787-4021

Germany
Hitachi Europe GmbH
Am Seestern 18(Euro-Center)
D-40547 Düsseldorf
(Mailing Address)
P.O. Box 11 05 36
40505 Düsseldorf
Phone:<49>(211)5283 0(HEG)
Fax: <49>(211)52915 0(HSE)
<49>(211)5283 530, 091(HEG)
<49>(211)52915 0(HSE)

Egypt
Hitachi, Ltd.
Nile Hilton Commercial Center
Tahrir Square, Cairo, 11111
Phone:<20>(2)574-3322
Fax: <20>(2)574-1414

U. A. E
Hitachi, Ltd., Middle East Branch
Office No. 1205 Al Masraf Tower, Banvios
Road, Deira P. O. Box 5561, Dubai, U.A.E
Phone:<971>(4)228-3617

Australia
Hitachi Australia Ltd,
(Head Office)
Level3, 82 Waterloo Road,
North Ryde NSW 2113
Phone:<61>(2)9888-4100
Fax: <61>(2)9888-4952

China
Hitachi China, Ltd.
(Beijing Headquarters)
Beijing Fortune Building, 5 Dong San Han
Bei-Lu Chao Yang District, Beijing 100004
Phone:<86>(10)6590-8111
Fax: <86>(10)6590-8110

(Shanghai Regional Office)
Rui jin Building, No.205 Maoming Road(S),
Shanghai, 200020
Phone:<86>(2)6472-1002
Fax: <86>(2)6472-4990

(Taipei Branch)
3rd Floor, Hung Kuo Building No.167
Tun-Hwa North Road, Taipei(105)
Taiwan
Phone:<886>(2)2718-8777/2718-3666
Fax: <886>(2)2718-8180

(Hong Kong Headquarters)
4th Floor, North Tower
World Finance Centre, Harbour City
Canton Road, Tsim Sha Tsui, Kowloon
Hong Kong
Phone:<852>2735-9218
Fax: <852>2375-3192

India
Hitachi India Pvt. Ltd.
Units 304-306, 3rd Floor, ABW Elegance
Tower, Jasola District Centre, New Delhi
110 025, India
Phone:<91>(11)4060-5252
Fax: <91>(11)4060-5253

Indonesia
Hitachi Asia Ltd.
(Jakarta Office)
24th Floor, Mid Plaza 1, Jl. Jend.
Sudirman Kav. 10-11, Jakarta 10220
Phone:<62>(21)574-4313
Fax: <62>(21)574-4312

Malaysia
Hitachi Asia(Malaysia)Sdn.Bhd.
Suite 17.3, Level 17 Menara IMC
(Letter Box No. 5)
No.8 Jalan Sultan Ismail
50250 Kuala Lumpur
Phone:<60>(3)2031-8751
Fax: <60>(3)2713-2855

Singapore
Hitachi Asia Ltd.
Headquarters
7 Tampines Grande, #08-01
Hitachi Square, Singapore 528736
Phone:<65>6535-2100
Fax: <65>6535-1533

Thailand
Hitachi Asia(Thailand)Co., Ltd.
18th Floor, Ramiland Building
952 Rama IV Road, Bangrak,
Bangkok 10500
Phone:<66>(2)632-9292
Fax: <66>(2)632-9299

Vietnam
Hitachi Asia Ltd. Ho Chi Minh City Office
The Landmark, 4th Floor, 5B Ton Duc Thang
Street, Dist. 1, HCMC, Vietnam
Phone:<84>(8)3829-9725
Fax: <8>(3829)-9729

Germany
Hitachi Europe GmbH
Am Seestern 18(Euro-Center)
D-40547 Düsseldorf
(Mailing Address)
P.O. Box 11 05 36
40505 Düsseldorf
Phone:<49>(211)5283 0(HEG)
Fax: <49>(211)52915 0(HSE)
<49>(211)5283 530, 091(HEG)
<49>(211)52915 0(HSE)

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Infrastrructure Systems Company
Akibahara Daihiru Building,
18-13, Soto-Kanda, 1-chome, Chiyoda-ku, Tokyo, 101-8608
Tel: <81>(3)4584-5539 Fax: <81>(3)4584-4738

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