Dynamic Voltage Restorer for a critical Manufacturing Facility

Most common cause of voltage dips

- Single phase ground faults
Case Study DVR

Site Conditions 1999:

Semiconductor Plant in Israel

Up to 15 sags a night

Over 150 sags a year

Faults: 1-phase sags seen as 2-phase sags at plant

Ready for chip manufacturing September 2000
Case Study DVR

Main Data

- Medium Voltage: 22kV / 50Hz
- Protected Load: 22.5 MVA
- 3-phase compensation: 35%
- 1-phase compensation: 50%
- Multiple sags: possible
- Duration: 500ms
- Response time: 1 ms
- Energy storage: 3.1 MJ
Case Study DVR

Operating principle

Booster Transformer

Utility

Converter

Energy Storage

Load
Case Study DVR
Case Study DVR

Compensation capability

- 1-phase %
- 2-phase %
- 3-phase %

Graph showing compensation capability against time (F[ms]) for 1-phase, 2-phase, and 3-phase systems.
Case Study DVR

- Hardware platform IGCT – PEBB (three level – IGCTs)
Case Study DVR

Dynamic Voltage Restorer
Case Study DVR

DVR Container
# Case Study DVR

## Project Information

<table>
<thead>
<tr>
<th></th>
<th>Date</th>
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<tbody>
<tr>
<td>Order Date</td>
<td>January 6 2000</td>
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<tr>
<td>Delivered EXW</td>
<td>June 15 2000</td>
</tr>
<tr>
<td>In Service DVR-1B</td>
<td>September 3 2000</td>
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<tr>
<td>In Service DVR-1A</td>
<td>September 18 2000</td>
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Case Study DVR
Case Study DVR
Case Study DVR

Since the installation of two ABB DVR systems (22,5 MVA each) in 2000 all sags have been compensated resulting in a significant:

- Increase in plant availability
- Decrease in consequential damages
- Higher operational efficiency

<table>
<thead>
<tr>
<th></th>
<th>Sags</th>
<th>Compensated</th>
<th>Success rate</th>
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<tr>
<td>DVR-1B:</td>
<td>151</td>
<td>151</td>
<td>100%</td>
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<tr>
<td>DVR-1B</td>
<td>168</td>
<td>168</td>
<td>100%</td>
</tr>
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</table>
Case Study DVR

Voltage sag events at a critical site

Events which were successfully compensated by a DVR

Number of Voltage Sags

Case Study DVR

all sags compensated!
ABB delivered a proven solution
High compensation capability
Low maintainance
100% succes rate
Reduced operation cost due to high efficiency
Increased Customers Productivity

SATISFACTION
Consequences of voltage sags

Highly automated continuous processes can experience disturbances

Quotations from manufacturers about money lost per event

- Textile: US $ 35’000. —
- Pharmaceutics: US $ 1’000’000.—
- Semiconductors: US $ 500’000. —
- Plastic products: US $ 80’000. —

very much dependent on plant size
Theoretical US market volume

<table>
<thead>
<tr>
<th>Factories per industry</th>
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<tbody>
<tr>
<td>Semiconductor</td>
<td>1082</td>
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<tr>
<td>Pulp &amp; Paper</td>
<td>293</td>
</tr>
<tr>
<td>Yarn Spinning</td>
<td>411</td>
</tr>
<tr>
<td>Broad woven</td>
<td>838</td>
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<tr>
<td>Plastic resin</td>
<td>532</td>
</tr>
<tr>
<td>Plastic products</td>
<td>8608</td>
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11,764

Source: www.laruscorp.com/isokera.htm

Isokeraunic Map of United States
## Semiconductor manufacturers acc. to US census

<table>
<thead>
<tr>
<th>SIC 3674</th>
<th>plants</th>
<th>employee</th>
<th>YoS</th>
<th>red values are calculated, black values are copied from economic census</th>
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<tbody>
<tr>
<td>semiconductor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Geographic Region | Plants | Employees | YoS |  
|-------------------|--------|-----------|-----|---|
| United States     | 1182   | 198,119   | 2,100,364 | |
| California        | 410    | 54,377    | 1,094,742 | |
| Texas             | 213    | 36,139    | 1,996,937 | |
| Massachusetts     | 73     | 5,517     | 1,941,020 | |
| Pennsylvania      | 52     | 7,916     | 4,142,733 | |
| Arizona           | 47     | 18,070    | 1,059,716 | |
| New Jersey        | 41     | 1,194     | 3,371,171 | |
| New York          | 41     | 7,900     | 1,167,765 | |
| Colorado          | 31     | 4,656     | 1,141,521 | |
| Florida           | 30     | 3,481     | 805,877  | |
| Oregon            | 28     | 8,930     | 7,959,672 | |
| Illinois          | 25     | 4,07      | 57,360   | |
| Washington        | 21     | 3,104     | 703,783  | |
| Connecticut       | 19     | 755       | 1,152,290 | |
| New Mexico        | 16     | 3,348     | 803,977  | |
| Virginia          | 16     | 11,00     | 751,116  | |
| Michigan          | 15     | 311       | 369,009  | |
| Minnesota         | 15     | 2,038     | 3,729,036 | |
| North Carolina    | 14     | 1,796     | 3,553,600 | |
| New Hampshire     | 13     | 1,400     | 2,734,206 | |
| Ohio              | 17     | 1,380     | 2,992,852 | |
| Maryland          | 9      | 1,540     | 884,156  | |
| Missouri          | 9      | 0         | 0       | |
| Wisconsin         | 9      | 0         | 0       | |
| Utah              | 7      | 813       | 51,720   | |
| Idaho             | 6      | 8,439     | 2,086,948 | |
| Indiana           | 5      | 0         | 0       | |
| Kansas            | 5      | 189       | 1,373,830 | |
| Vermont           | 4      | 0         | 0       | |
| Maine             | 3      | 0         | 0       | |
| Oklahoma          | 3      | 0         | 0       | |
| Rhode Island      | 3      | 0         | 0       | |
| Tennessee         | 3      | 0         | 0       | |
| South Carolina    | 7      | 0         | 0       | |
| North Dakota      | 1      | 0         | 0       | |

**avg Value of Shipments / plant**

**Electricity intensity = energy/value added**
? The big question mark ?

- Voltage dip compensating devices exist

- Why are not hundreds of them in operation?
Possible answers

- They do not operate satisfactorily

- The expected pay back time is unrealistically low

- The figures stated by manufacturers represent theoretical loss of sales, but real volume of sales is far below plant capacity
Our approach

- We expect increased demand for voltage dip compensating devices
  - Smaller units than usually built so far
  - Installed at low voltage distribution level
- We developed the SVR (Series Voltage Restorer)
SVR, Series Voltage Restorer

- Protection of loads at low voltage level with ratings in the range of typical industrial low voltage feeder loads

- Voltage sag compensation at nominal load
  - Single-phase sags of 50% for 1000 ms
  - Three-phase sags of 38% for 1000 ms

- Larger sags or longer duration for partial loads

- Response time until voltage is back to normal (amplitude and vector angle position) about 1 ms

- No energy storage

- Additional user benefits
SVR, Series Voltage Restorer

- Additional user benefits
  - Constant Voltage Regulation
  - Reactive Power Compensation
  - Provision of UPS functionality if required in the future

- Potential future options, if there is a demand
  - Load Balancing
  - Active Filter performance
SVR, Series Voltage Restorer

- PCS for voltage sag compensation in low voltage systems (SVR)

1 ... Booster – Converter
2 ... Charger – Converter
3 ... DC Link
4 ... Charger - Transformer
SVR, Series Voltage Restorer

Diagram showing the connections and components of a Series Voltage Restorer:
- Grid (A B C N)
- A' B' C' Load
- Crowbar
- Isolating Switch 1
- Bypass Switch
- Isolating Switch 2
- Charger Transformer
- Charger Converter
- DC Link
- Booster Converter

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SVR, Series Voltage Restorer

- Hardware platform IGBT – PEBB (two level – IGBTs)
  - Latest hardware platform with ABB LoPak IGBT modules
    – The PowerPak
SVR, Series Voltage Restorer
SVR, Series Voltage Restorer

- PCS for voltage sag compensation in low voltage systems (SVR)

- 400 to 600 V

- 500 A

- 1500 A

- 2500 A
SVR, Series Voltage Restorer

- PCS for voltage sag compensation in low voltage systems (SVR)
  - 400 to 600 V, 1500 A
SVR, Series Voltage Restorer

SVR, dimensions

right side view

front view

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SVR, Series Voltage Restorer

- PCS for voltage sag compensation in low voltage systems (SVR)

The SVR compensates a 30% three-phase sag (top) for 6 cycles, such that it has no effect on a sensitive load (bottom).
SVR, Series Voltage Restorer