Power Quality for Mission Critical Manufacturing





Venue: Novotel Apollo Singapore
405 Havelock Road, Singapore 169633
Date: 23 March 2004
Time: 9am to 5pm

Jointly organized by:

Precicon D&C Pte. Ltd.

PSL Power Standards Laboratory

efi ELECTRONICS



Precicon D&C Pte. Ltd.
a member of Lim Kim Hai Group

Mission | General | Milestone | Goal | Business | Segment | PCM

Schedule of the day

9.00	*Registration*
9.30	*Welcome Speech, Mr Colin Koh (PD&C)*
9.35	*A New Approach to Power Quality, Mr Alex McEachern (PSL)*
10.30	*Tea Break*
11.00	*Continue… A New Approach to Power Quality*
12.00	*Lunch*
2.00	*Continue… A New Approach to Power Quality*
3.00	*Tea Break*
3.30	*Electromagnetic Compatibility (EMC), Mr Eric Lim (efi)*
4.00	*Semi F47 Solutions & Case Studies Mr. Francis Phang (PD&C)*
4.30	*Q&A*

PSL *Power Standards Lab*

A New Approach To Power Quality

Alex McEachern
Power Standards Laboratory

March, 2004

Power Standards Lab

- Emeryville, California - near San Francisco



(Sorry – no visitors allowed – too many confidential projects...)

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Power Standards Lab customers

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- Siemens
- Schlumberger
- Tokyo Electron (U.S.)
- ThermaWave
- Verteq
- ReadRite
- WaferTech
- WasteTech
- Portland General Electric
- And many, many more...

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Power Standards Lab has defined a new approach to power quality.

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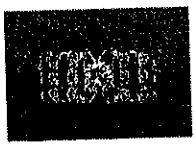
Old approach to power quality: "Difference from perfection"





Is electric power more like a jewel, or a laptop, or a marriage?

- Old approach: Power quality was defined by smooth, consistent sine wave
- Anything else was "bad quality power"

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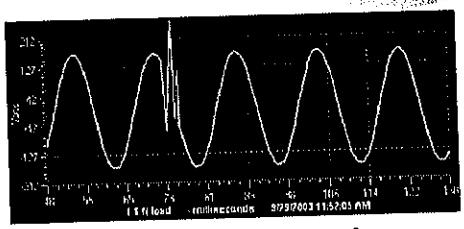
Old approach: impulses



Lightning strikes, inductive loads, power factor capacitors

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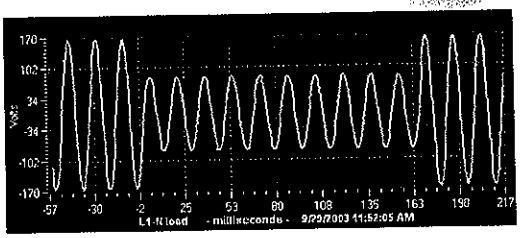
Old approach: voltage sags



Sags are <u>the</u> most common problem: faults, overloads

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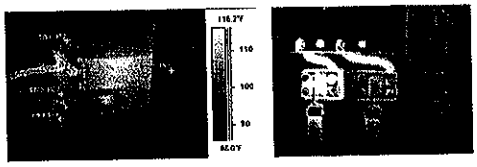
Why voltage sags happen

Only two causes:

- Either increase in source impedance (less common), or
- <u>Big</u> increase in current (very common)



Examples of increase in source impedance during earthquakes

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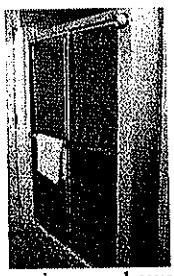
Why voltage sags happen





Voltage sag in your shower:

Water pressure = voltage, water flow = current

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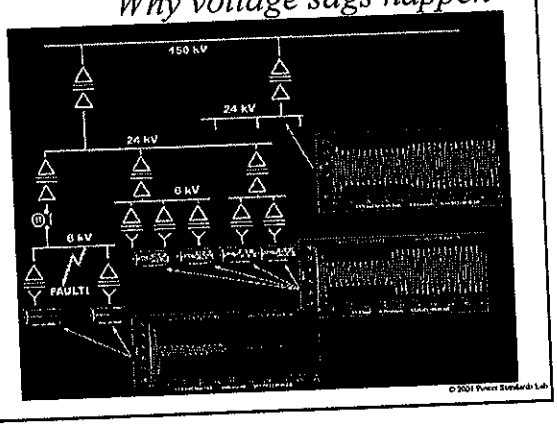
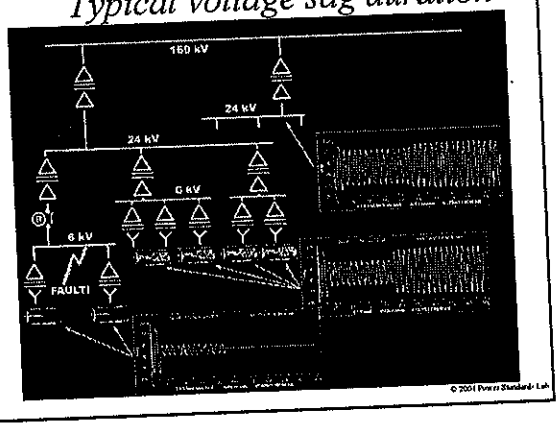
Why voltage sags happen



Typical voltage sag duration



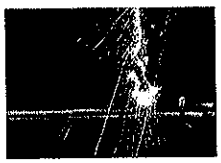
Why voltage sags happen



Construction accidents…

Why voltage sags happen





Birds…

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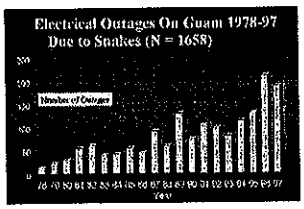
Why voltage sags happen







Snakes…

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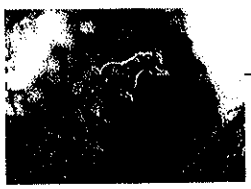
Why voltage sags happen







Squirrel outages are fairly common," says Jack Suggs, director of the Electric Department. "Squirrels like to use the distribution system, the wires, as their highway system."

Squirrels and rats…

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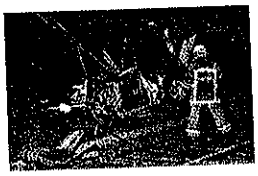
Why voltage sags happen







Car and truck crashes…

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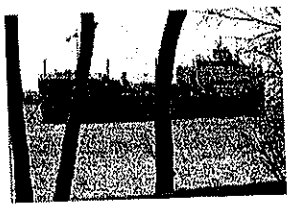
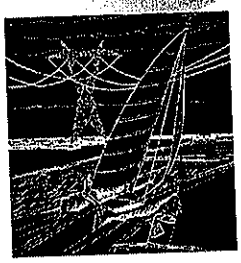
Why voltage sags happen





Ships and boating…

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Why voltage sags happen



Ice storms…

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Why voltage sags happen



Trees or vegetation…

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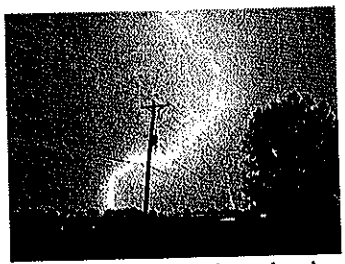
Why voltage sags happen



Lightning, and lightning-related maintenance…

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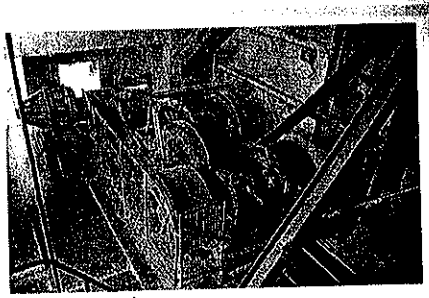
~80% of sags are caused inside the building, not by utility



Motor starting…

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~80% of sags are caused inside the building, not by utility



Intermittent loads…

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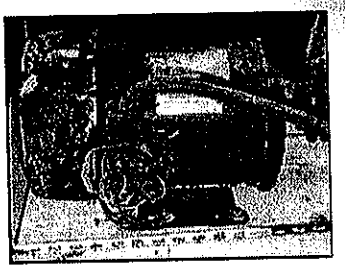
~80% of sags are caused inside the building, not by utility



Accidents and errors…

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~80% of sags are caused inside the building, not by utility



Accidents and errors…

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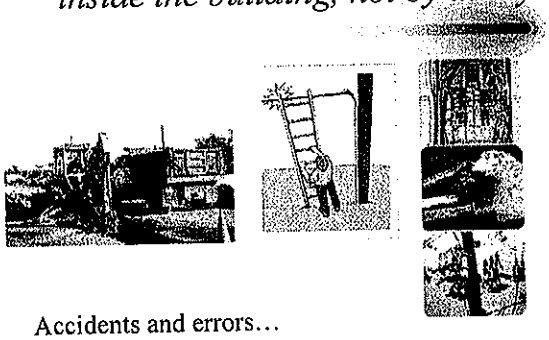
~80% of sags are caused inside the building, not by utility



Accidents and errors…

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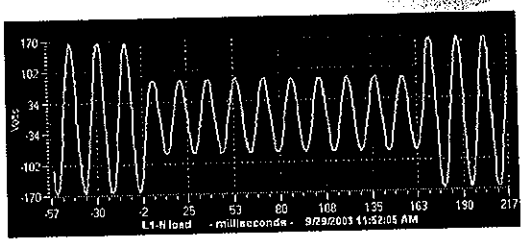
Voltage sags do happen, and will continue, no matter what.



Sags are the most common problem: faults, overloads

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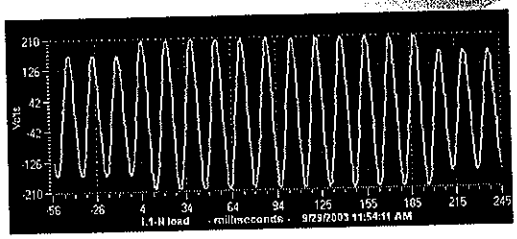
Old approach: Voltage swells



Voltage swells are rare, but do occur

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Old approach: Other disturbances



- Flicker
- Harmonics – current
- Harmonics – voltage
- Mains signalling
- Interruptions
- All defined, in old approach, by difference from perfection

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Problem with old approach to Power Quality:

- Disturbances happen. They cannot be avoided.
- Power company is responsible for power quality.
- Success is technically impossible.

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What if cars were engineered like this?



Note: requires road that is +/-10% smooth. Otherwise, wheels may fall off.



Aftermarket road-smoothers are readily available.

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Basic idea behind PSL's new approach to Power Quality

- Power quality is <u>compatibility</u> between source and load, <u>not</u> perfection of source
- There are always two solutions to compatibility
- Either improve the power, <u>or</u> make the loads tougher.
- How to choose?



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Consequences of PSL's new approach to Power Quality

- Power quality is a <u>shared</u> responsibility:
  - electric company must deliver some level of quality, but <u>not</u> perfection
  - Customer must buy equipment that <u>tolerates</u> normal disturbances.



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PSL's new approach: <u>Use</u> bad quality power.

- Engineers design (or re-design) their equipment to tolerate typical power disturbances.



- Use power disturbance generators to make bad quality power.



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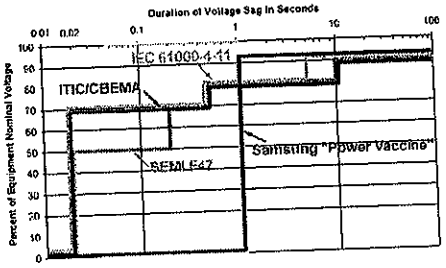
New approach: What should be tolerated?



What is "typical" disturbance?

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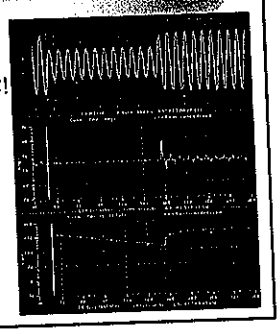
How to fix the problem?

- Software
- Energy storage – DC, not AC!
- Tiny, local power back-up
- More…



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Fix with low-cost Power Quality sensors.

- In some cases, sensors can replace power conditioners at less than 1% of cost.
- "Power Quality Judo"
- Sensors can be used as a defense against power disturbances.



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New approach to power quality began in semiconductor industry, is spreading.



Using a PSL *Industrial Power Corruptor* in Semiconductor Industry.

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New approach to Power Quality in world-wide standards.

- IEC
  - Chair of 61000-4-30 (PQ measurements); 61000-4-11 and 61000-4-34 (voltage dip immunity)
- IEEE
  - Co-author of IEEE 519 (harmonics), past Chair of IEEE 1159.1
- Country-specific
  - For example, Canada "Grades of Power Quality"
- Industry-specific
  - For example, SEMI F42 (voltage sag immunity)
- Military / Security

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Example projects with new approach(1)

- Make semiconductor equipment immune to voltage sags, for almost zero cost



August 2000 – Voltage sag correctors
$30k per system
200V 3-phase 175 amps per phase



December 2003 – same system, re-designed
$0 per system

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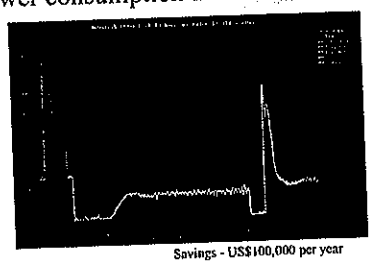
Example projects with new approach (2)

- Reduce power consumption in semiconductor equipment



Savings - US$100,000 per year

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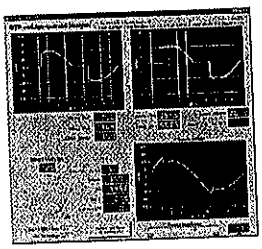
Example projects with new approach(3)

- Stabilize semiconductor equipment – line impedance



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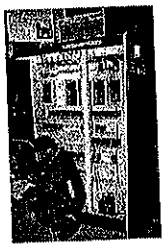
Example projects with new approach (4)

- Fire alarm control panel – automobile plant – power quality problem?



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More information about new approach to Power Quality

- www.PowerStandards.com
- Free technical papers
- Download free software



- E-mail

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A New Approach To Power Quality

Alex McEachern
Power Standards Laboratory

March, 2004

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Power Quality Sensor

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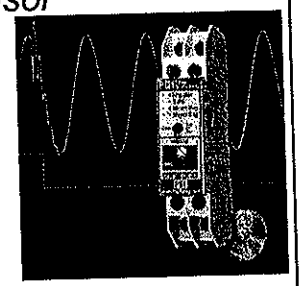

World's simplest, tiniest power quality sensor: AC in, relay contacts out.

□□□□□□□□□□□□□□□□□□□□
AC□□□□□□□□□□

Simple, easy, low cost power quality monitor

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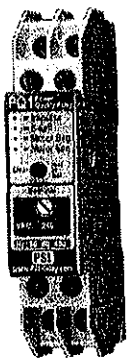


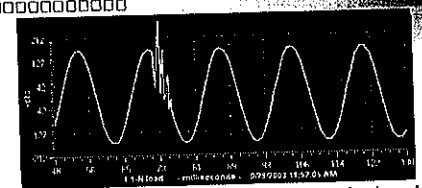
- Front panel LED's and button for simplest user interface
  □□**LED**□□□□□□□□□□□□□□
- Three relay contact outputs
  3□□□□□□□□
- No computer required. No software required. No network or phone line required.
  □□□□□□□□□□□□□□□

Automatically adapts to 50 Hz, 60 Hz, and 400 Hz

□□□□ **50Hz,60Hz,400Hz**

Detects all power line disturbances

□□□□□□□□□□□□□



- **Voltage sags**
  □□□□
- **Voltage swells**
  □□□□
- **Interruptions**
  □□□□
- **High frequency impulses/transients, with fast 500 nanosecond response**
  □500ns□□□□□□□□□□□□□□(□□)/□□□

World-wide approvals

□□□□□□



Data sheets in English, Deutsch, Español, Français, Português, Svenska, Italiano, Hrvatski…
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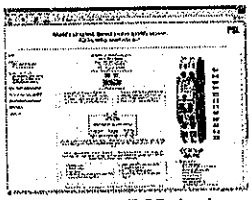
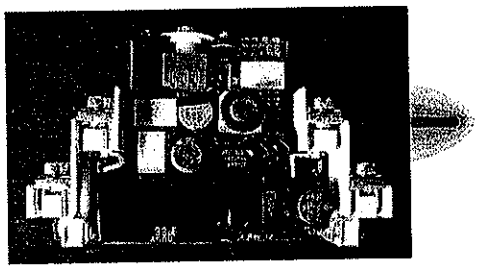


□□□□□ www.PowerStandards.com/PQRelay.htm

Inside the PQ1

PQ1□□□□□□□



High voltage circuits, switches (front side)
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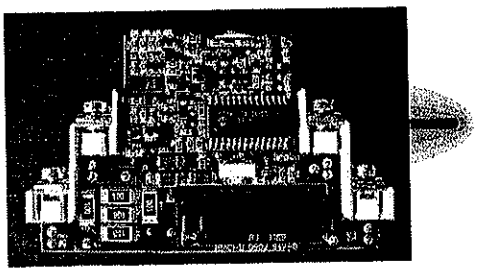
Inside the PQ1

PQ1□□□□□□□



Intelligence, LEDs, and energy storage (back side)
□□□**LED**□□□□□□□□□□□

Simple intelligent thresholds

□□□□□□□□□



- **Minor sag contacts: 10% below nominal**
  □□□□□□□□□□□□□□□10%
- **Swell/impulse contacts: 10% above nominal or more than 450V peak for 500 nanoseconds**
  □□□□/□□□□□□□□□□□10%□□□□□□450V,□□500□□
- **Major sag contacts: sophisticated depth-duration curves (ITIC, CBEMA, SEMI F47, etc.)**
  □□□□□□□□□□□□□□□□□□□ITIC, CBEMA, SEMI F47□□□□□□□
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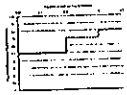
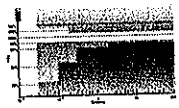
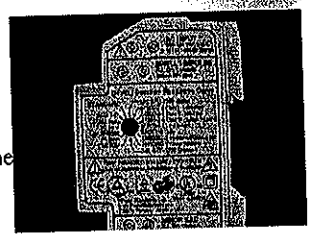




Thresholds pre-programmed to international standards:

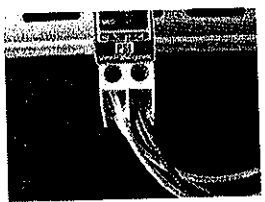
□□□□□□□□□□□□□

- SEMI F47
- ITIC
- CBEMA
- IEC
- Samsung Power Vaccine
- MIL-STD
- **And more!**



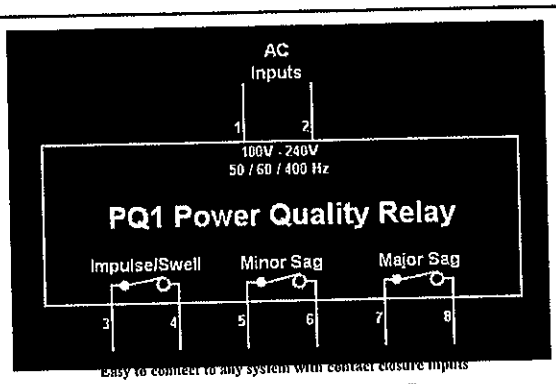
Easy to install!

□□□□





- **Choose a standard and set the threshold switch.**
  □□□□□□□□□□□□□□□
- **Set the nominal voltage switch.**
  □□□□□□□□
- **Mount to DIN-rail or Chassis-mount.**
  □□□□□□□□□
- **Connect AC power.**
  □□□□□□
5. **Connect the normally-closed relay contacts.**
   □□□□□□□□□□□



Easy to connect to any system with contact closure inputs

□□□□□□□□□□□□□□□□□□□

What can you connect to the normally-closed relay contacts?

□□□*PQ1*□□□□□□□□□□□□□□□□□□□

- **Alarms – bells, flashing lights, etc.**
  □□□ – □□□□□□□□□
- **Counters**
  □□□
- **EMO Circuit**
  □□□□□□
- **Local or Networked monitoring systems**
  □□□□□□□□□
- **Local PLC's**
  □□PLC□□
- **Digital inputs on any computer system**
  □□□□□□□□□□□
- **Relays to control larger loads**
  □□□□□□□□□□□

Applications

□□

- **Notify service engineers when PQ limits are exceeded (medical equipment, for example)**
  □□□□□□□□□□□□□□□□□□□□□□□□□□□□□
- **Turn equipment off before it gets damaged (textile automation, for example)**
  □□□□□□□□□□□□□□□□□□□□□
- **Eliminate expensive power conditioning – have the computer re-set components that were disturbed, then re-start (semiconductor equipment)**
  □□□□□□□□□□□□□ – □□□□□□□□□, □□□□□□(□□□□□)

Applications□□



- **Semiconductor manufacturing tools**
  □□□□□□□□□
- **Medical laboratory equipment**
  □□□□□□□
- **Elevator controls**
  □□□□
- **Machine tools, HVAC controls, ASD's**
  □□□□□□□□□□□□□□□□□□□
- **Ultra-low-cost substation power quality monitoring**
  □□□□□□□□□□□□□□□□

- **Data centers, servers, telecom centers**
  □□□□□□□□□□□□□
- **Add power quality information to error log files**
  □□□□□□□□□□□□□□□
- **Identify hard-to-duplicate intermittent problems**
  □□□□□□□□□□□□□□□
- **Reduce unproductive service calls**
  □□□□□□□□□□
- **Correctly assign responsibility**
  □□□□□□

PQ1
Power Quality Sensor



PSL **Power Standards Laboratory**
www.PowerStandards.com

3908 Adeline Street
Emeryville, California, 94608
U.S.A.

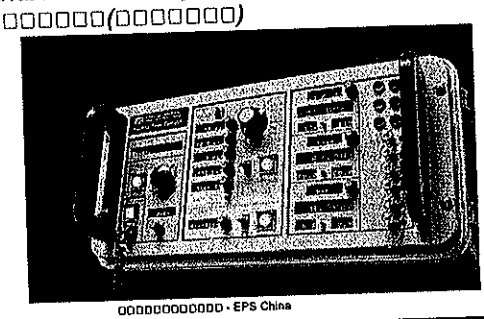
TEL ++1-510-658-9600
FAX ++1-510-658-9688

PSL Power Standards Laboratory **EPS**□□□□

IPC □□□□□□□□□□

Industrial Power Corruptor

□□□□□□□□□□(□□□□□□□)



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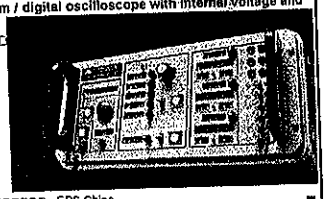
Industrial Power Corruptor:□□□□□□□□□□□□□□

- Voltage sags and swells, from 0% to 125% of nominal, from 200 µSec to 30 seconds.
  □□□□/□□ □□□□□□□0% - 125%□□□□200 µSec - 30 seconds
- 100 Vrms to 480 Vrms nominal. True phase-to-phase sags and swells – no neutral required.
  □□□□□□□□100V-480V. □□□□-□□□□□/□□□□□□□
- Built-in standards: SEMI F47, SEMI E6, IEC 61000-4-11, IEC 61000-4-34, SAMSUNG, FAA, MIL SPEC, CBEMA, ITIC, and more.
  □□□□□SEMI F47, SEMI E6, IEC 61000-4-11, IEC 61000-4-34, SAMSUNG, FAA, MIL SPEC, CBEMA, ITIC, □□
- Built-in 28-channel data acquisition system / digital oscilloscope with internal voltage and current sensors.
  □□28□□□□□□□□ / □□□□□□□□□□□□□□□□



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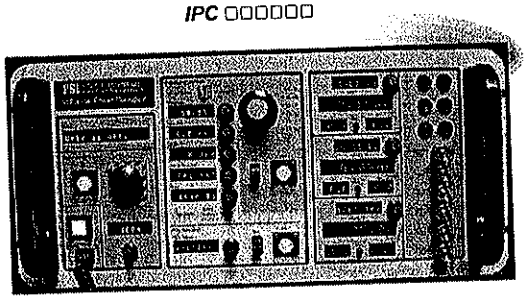
IPC Front Panel

IPC □□□□□□



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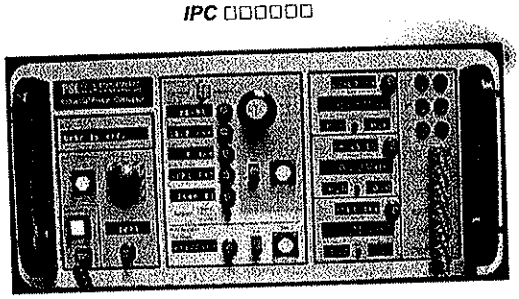
IPC Front Panel

IPC □□□□□□



Status Display □□□□

- **Shows status of IPC, alarms, etc.** □□**IPC**□□□,□□□

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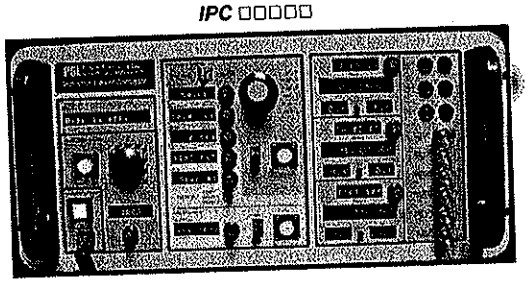
IPC Front Panel

IPC □□□□□



Main Circuit Breaker controls □□□□□□

- Emergency Off (EMO) □□□□□□**EMO**□□
- C.B. on (with CBMO option) □□□□□**CBMO**□□□
- C.B. Trip setting □□□□□□□

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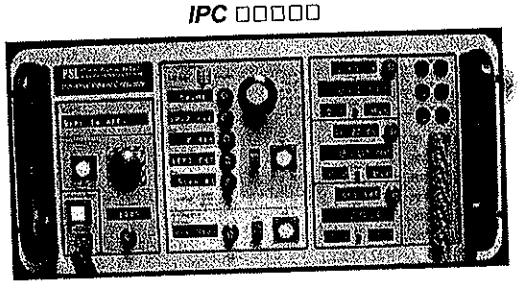
IPC Front Panel

IPC □□□□□



- IPC ON/OFF switch **IPC**□/□ □□
- Serial Port for PC Interface **PC**□□□□

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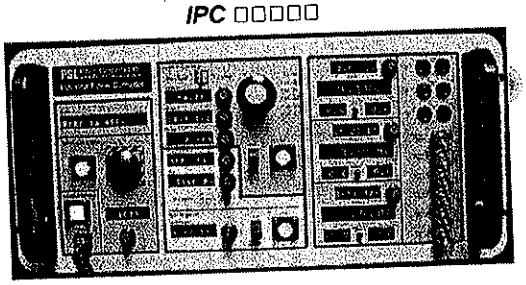
IPC Front Panel
IPC □□□□□



Disturbance Settings □□□□
- Depth & Duration □□ & □□□□
- Angle □□
- Phase □□
- Arm & Fire □□ & □□

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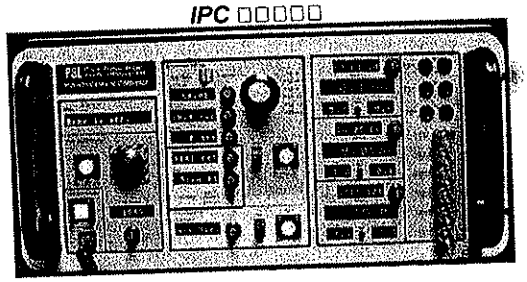
IPC Front Panel
IPC □□□□□



Pre-programmed standards □□□□□□
- Select international standard, step, and test margin
  □□□□□□□□□□□□□□

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IPC Front Panel
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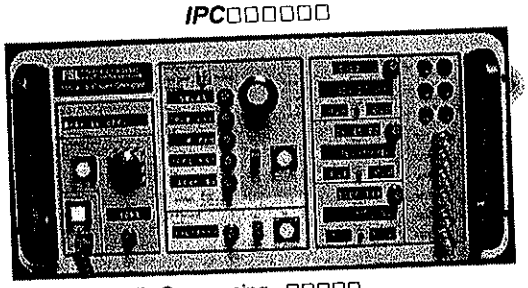

Semi-Automatic Sequencing □□□□□
- Automatically step through each step of selected standard
  □□□□□□□□□□□□□

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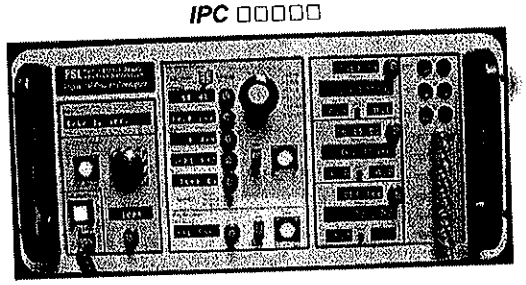
IPC Front Panel
IPC □□□□□



Meters □□□
- 3 sets of meters 3□□□□
- Each monitors up to 42 parameters □□□□□□□42□□□
- Max/Min recorders with reset buttons □□/□□□□□□□□□

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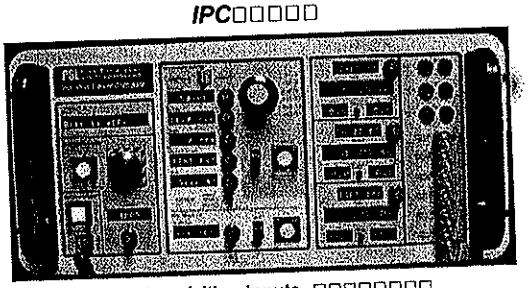
IPC Front Panel
IPC□□□□□□



External Data Acquisition Inputs □□□□□□□□
- 3 ± 600V channels □ 3 ± 600V □□
- 6 ± 100V channels□□□□□□6 ± 100V □□

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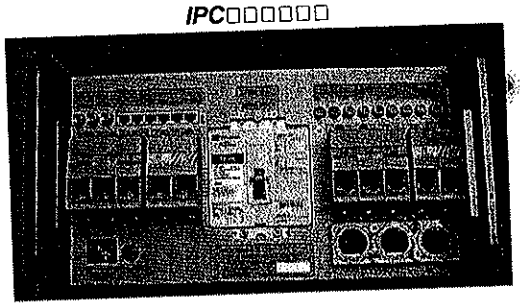
IPC Rear Panel
IPC□□□□□□



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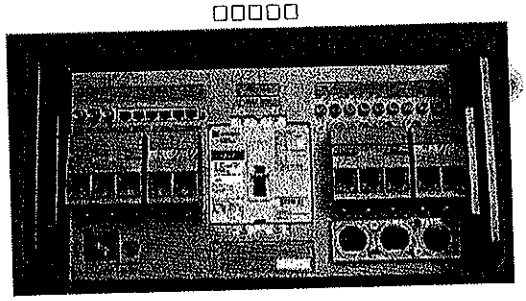
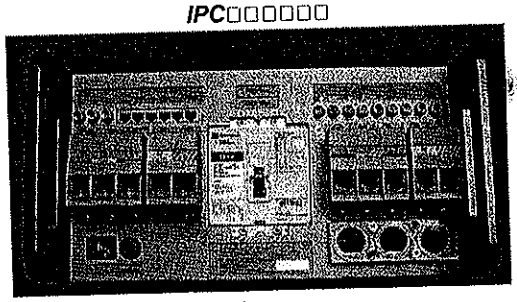
IPC Rear Panel
□□□□□



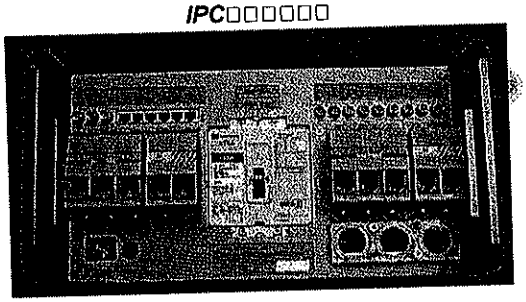
Instrument Power □□□□
• 100-240Vac in.□ 100-240Vac □□

IPC Rear Panel
IPC□□□□□□□



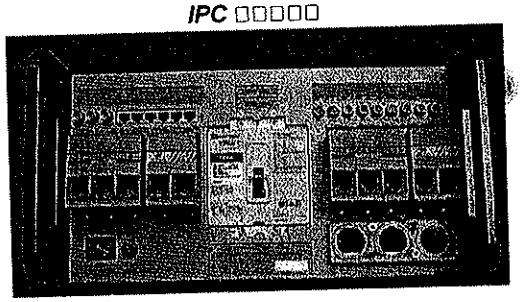
CBMO Connection CBMO□□
• For connection to optional CB Motor Operator.
□□□□□□**CB**□□□□

IPC Rear Panel
IPC□□□□□□□



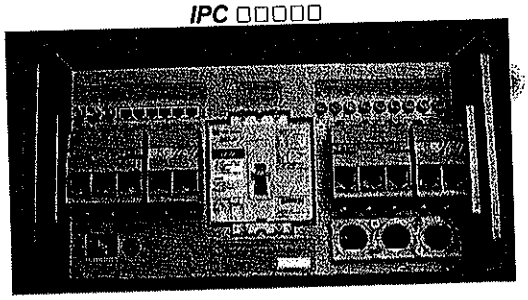
"From Source" Terminal Blocks "□□□"□□□
• Connections from power source. □□□□□

IPC Rear Panel
IPC □□□□□



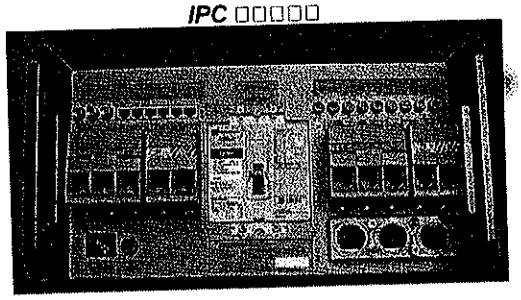
"To Load" Terminal Blocks "□□□" □□□□
• Connections to equipment under test. □□□□□□□□

IPC Rear Panel
IPC □□□□□



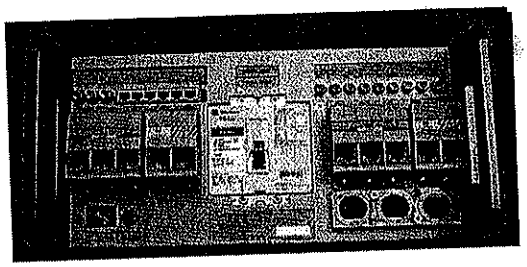
Circuit Breaker □□□
• Tripped by CB curve, IPC hardware / firmware.
CBCIPC□□□/ □□□□□□□□□

IPC Rear Panel
IPC □□□□□



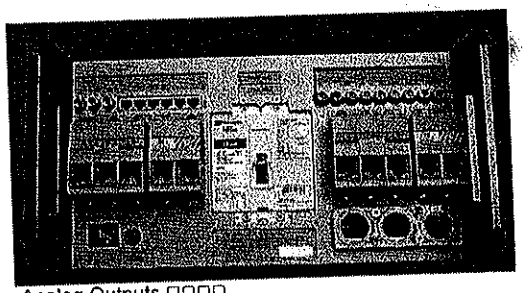
Future Option □□□□
• Impulse Generator connections. □□□□□□□

IPC Rear Panel
IPC □□□□□



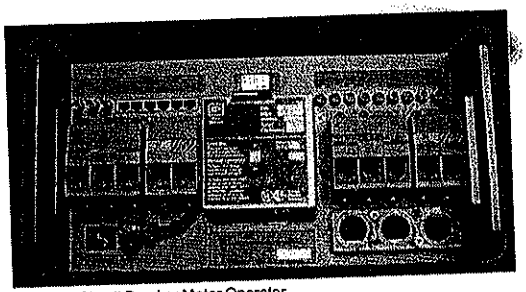
External triggers and
Specialized communication ports
□□□□□□□□□□□

IPC Rear Panel
IPC □□□□□



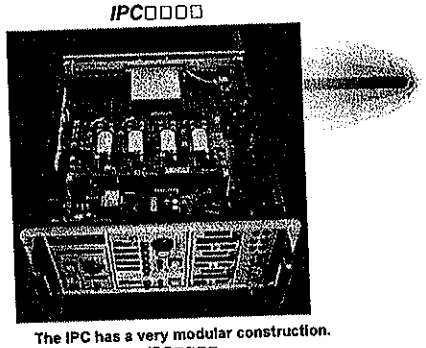
Analog Outputs □□□□
• 10V full scale Voltage and Current measurement outputs
10V□□□□□/□□□□□

IPC Rear Panel
IPC□□□□□□



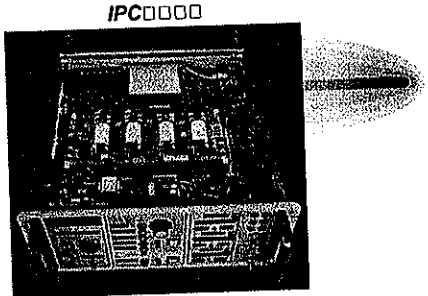
Optional Circuit Breaker Motor Operator
□□□□□□□□□□
• Allows front panel control of CB.
□□□□□□□□CB

Inside the IPC
IPC□□□□



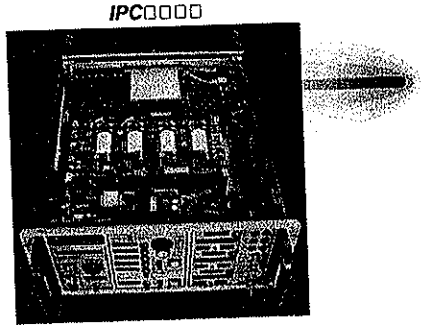
The IPC has a very modular construction.
IPC□□□□

Inside the IPC
IPC□□□□



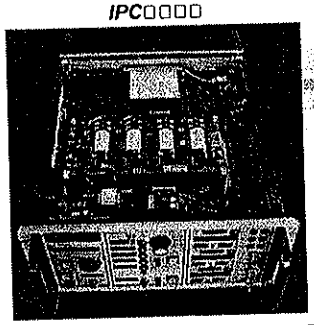
The IGBT Module (insulated gate bipolar transistor)
IGBT□□□□□□□□□□□□□□
• Uses 1200 volt, 400 amp bipolar transistors to perform precision power transitions.
□1200V,400amp□□□□□□□□□□□□□□

Inside the IPC
IPC□□□□



DAQ Board Assembly□DAQ □□□□
• 28 channels of Voltage, Current, and Temperature data acquisition.
28□□/□□□□□□□□□□

Inside the IPC
IPC□□□□



The Power Supply Board Assembly□□□□□□□
- Power storage / distribution □□□□/□□□
- Trouble shooting indicators □□□□□□

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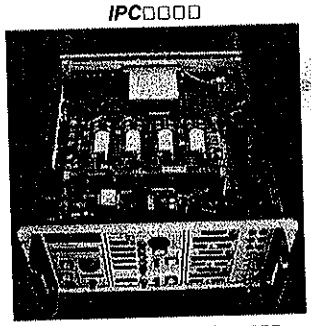
Inside the IPC
IPC□□□□



The Power Supply Assembly□□□□□
- 100-240Vac in, 24Vdc out□□100-240 VAC □□□24VDC □□□□

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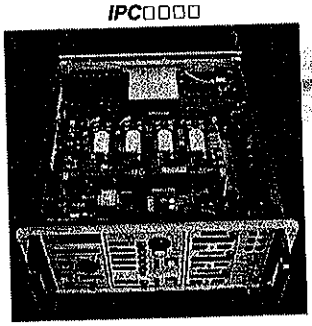
Inside the IPC
IPC□□□□



The Cooling System□□□□□□
- Cooling Fans maintain optimum internal temperature □□□□□□□□□□

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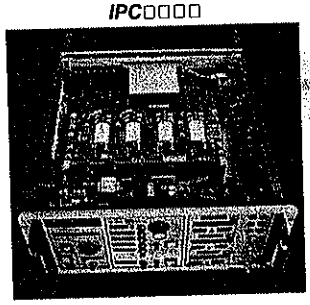
Inside the IPC
IPC□□□□



The Front Panel Assembly□□□□□□
- External user interface controls □□□□□□□
- Control and Display printed circuit boards. □□□□□□□

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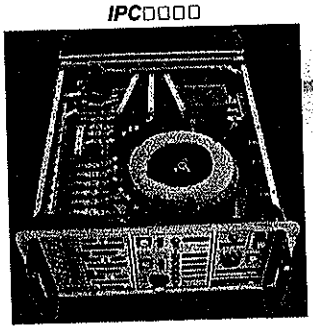
Inside the IPC
IPC□□□□



□□□□□□□□□□□□ - EPS China

Inside the IPC
IPC□□□□



Patent-Pending Multi-Tap Transformer Assembly□ □□□□□□□□□□□□□
- allows sags and swells in 2.5% increments. □□□□/□□□□2.5%□□□□

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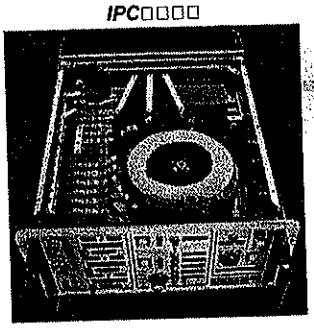
Inside the IPC
IPC□□□□



Tap Relay Assembly□□□□□□
- Configures transformer outputs to required percentage levels
□□□□□□□□□□□□□□□

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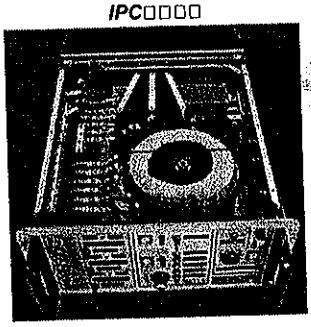
Inside the IPC
IPC□□□□



Rear Panel Assembly□□□□□□□
- IPC interface along with Voltage / Current sensors and 16 configuration relays
IPC□□□□/□□□□□□16□□□□□□□

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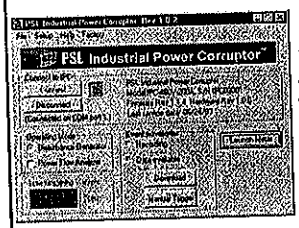
Standard IPC Control Software
□□□ IPC □□□□



The IPC software package runs on Windows® computers
IPC□□□□□□Windows® □□□□□

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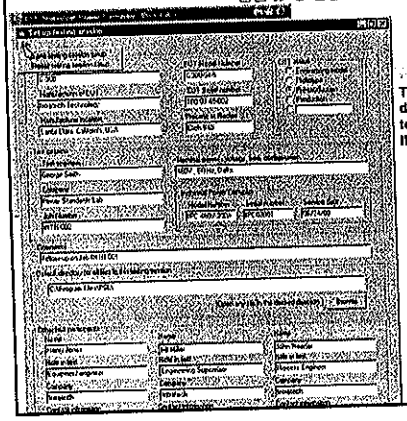
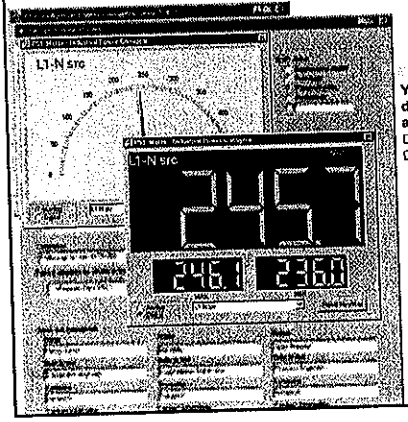
Standard IPC Control Software
□□ IPC □□□□



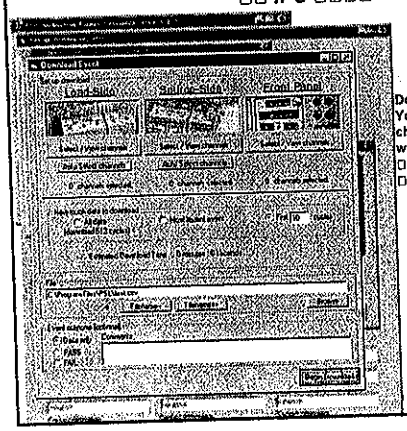
The IPC Software helps you document every aspect of your testing
IPC□□□□□□□□□□□

Standard IPC Control Software
□□ IPC □□□□



You can choose an analog or digital meter to display the data acquisition channels on your PC
□□□□□□□□□□□□□□□□□□□□□
□□□□□□

Standard IPC Control Software
□□ IPC □□□□



Downloading is simple. You can choose which channels, how much data, and where to download.
□□□□□
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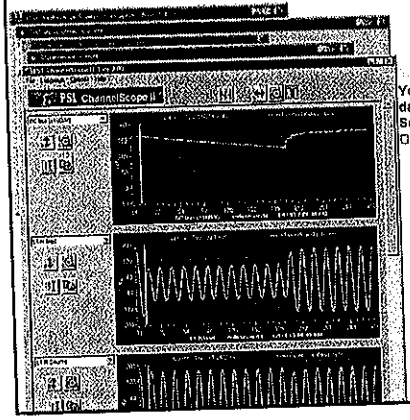
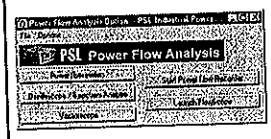
Standard IPC Control Software
□□ IPC □□□□



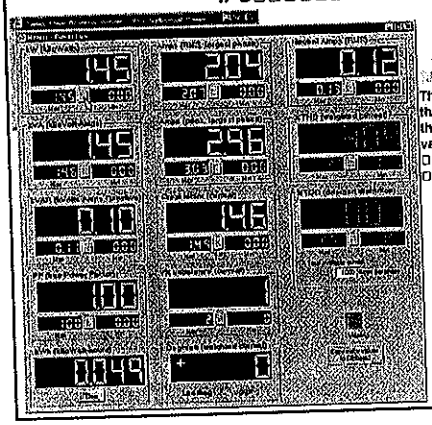
You can view the downloaded data with the included ChannelScope software.
□□□ChannelScope□□□□□□□

IPC□□□□□□□□□



The Power Flow Analysis Option allows you to analyze power flow on the load side of the IPC
□□□□□□□□□□IPC□□□□□□□□

IPC□□□□□□□□□



The power flow meters show the present value, as well as the minimum and maximum value, for each parameter.
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□□□□/□□□

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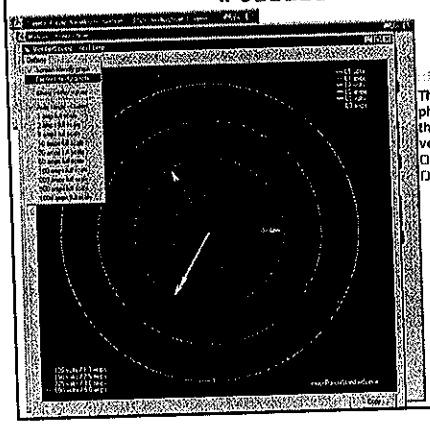
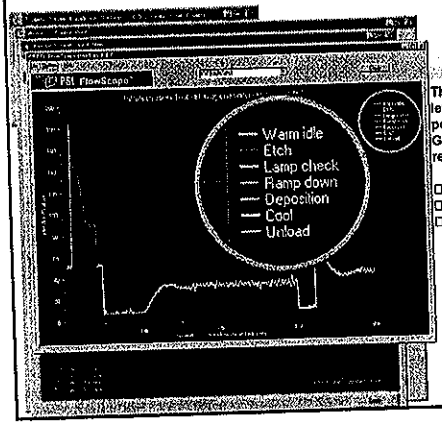


The VectorScope can verify phase rotation and check the angles and balance of voltages and currents.
□□□□□□□□□□□□□□□□□□
□□□/□□□□

IPC□□□□□□□□□



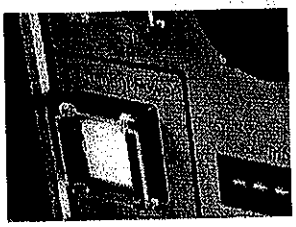
The FlowScope software lets you analyze and graph power flow parameters. Great for SEMI E6 reporting!
□□□□□□□□□□□□□□□□□
□□□□□□□□SEMI E6 □□□
□

How to test with your IPC
□□□IPC□□



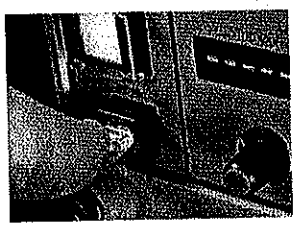
- Plug in the IPC □□□□

How to test with your IPC
□□□*IPC*□□



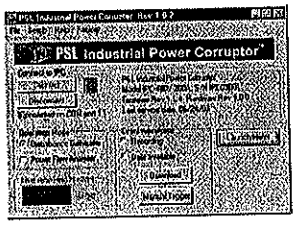
- Plug in the IPC□□□□□□
- Turn it on □□□□

How to test with your IPC
□□□*IPC*□□



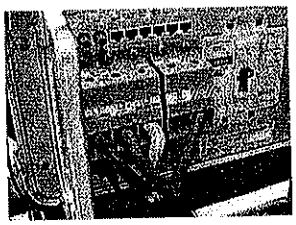
- Plug in the IPC□□□□□□
- Turn it on□□□□□□
- Connect to PC □□PC

How to test with your IPC
□□□*IPC*□□



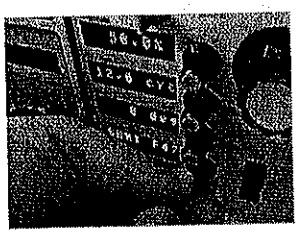
- Plug in the IPC□□□□□□
- Turn it on□□□□□□
- Connect to PC□□□PC
- **Start Software** □□□□

How to test with your IPC
□□□*IPC*□□



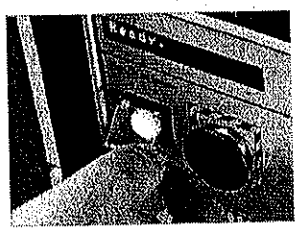
- Plug in the IPC□□□□□□
- Turn it on□□□□□□
- Connect to PC□□□PC
- Start Software□□□□□
- **Make source/load connections** □□□□□□□

How to test with your IPC
□□□*IPC*□□



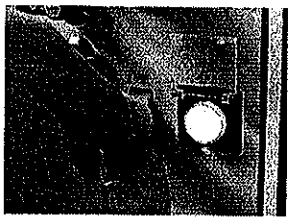
- Plug in the IPC□□□□□□
- Turn it on□□□□□□□□
- Connect to PC□□□PC
- Start Software□□□□□
- Make source/load connections□ □□□□□□□
- **Select settings** □□□□

How to test with your IPC
□□□*IPC*□□



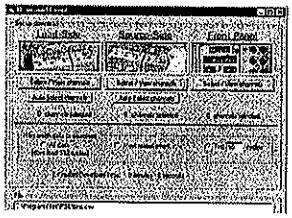
- Plug in the IPC□□□□□□
- Turn it on□□□□□□□□
- Connect to PC□□□PC
- Start Software□□□□□
- Make source/load connections □□□□□□□
- Select settings □□□□
- **Turn on the CB □□CB**

How to test with your IPC
□□□*IPC*□□



- Plug in the IPC□□□□□
- Turn it on□□□□□□□□
- Connect to PC□□□PC
- Start Software□□□□□
- Make source/load connections
- Select settings□□□□
- Turn on the CB□□CB
- Arm and Fire □□□□

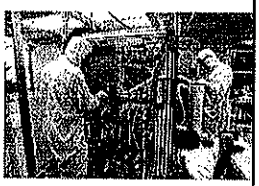
How to test with your IPC
□□□*IPC*□□



- Plug in the IPC□□□□□
- Turn it on□□□□□□□□
- Connect to PC□□□PC
- Start Software□□□□□
- Make source/load connections
- Select settings □□□□
- Turn on the CB □□CB
- Arm and Fire □□□□
- **Observe / Download results** □□□□□□□

Typical IPC Users
IPC□□□□

Semiconductor tool manufacturers, and their component suppliers, use the Industrial Power Corruptor to test and design for SEMI F47 compliance and completing data sheet 400 of the SEMI E6 standard.
□□□□□□□□□□□□□□□□□□□□□IPC□□□□□□□□SEMI F47□□□□□□□



Typical IPC Users
□□□□

University and national research labs use the Industrial Power Corruptor for training, research projects, and pre-testing critical equipment for voltage sag and swell sensitivity. Typical standards include IEEE 1100 (CBEMA).

**□□□□□□□□□IPC□□□□□□□□□□□□□□□□□□□

Typical IPC Users

□□□□

Compliance engineers and test labs use the Industrial Power Corruptor to verify compliance with IEC standards, including IEC 61000-4-11 and 61000-4-34, and other national and international voltage sag immunity standards.

□□□□□□□□IPC□□□□IEC□□□□□IEC 61000-4-11□61000-4-34□□□□□□□□□□□□□□□□□□□□□□



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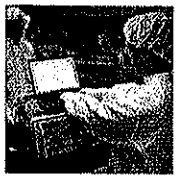
IPC Testing, and you!

IPC□□□□



PSL's Testing Partner program is a simple, low-cost way to certify compliance with several standards, including SEMI F47, SEMI E6, and IEEE 1000. It is based on PSL's latest generation of test equipment, which – if you allow it to – lets us look over your shoulder electronically while you perform the tests.

PSL□□□□□□□□□□□□□□□□□□□□□□IEEE1000,SEMI F47,SEMI E6□□□□□□

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Power Quality for
Mission Critical Manufacturing

EMC
ELECTROMAGNETIC
COMPATIBILITY

Seminar Index

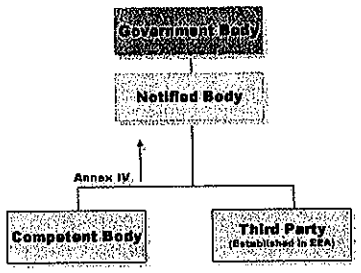
1 Introduction
2 EMC Norms
  2.1 Emission Norms (EN61000-6-4)
  2.2 Immunity Norms (EN61000-6-2)
3 Problems and Solutions
  3.1 Conducted noise
  3.2 Radiated noise
  3.3 Immunity Problems
4 Documentation
5 SUMMARY

1.- Introduction to the EMC

EMC: a must to obtain CE mark

- To obtain the CE Mark, and therefore sell products legally in the European Community, three Directives must be accomplished:
- EMC Directive 89/336/EC (since 1.1.1996)
- General Machinery Directive 89/392/EC (since 1.1.1995).
- Low Voltage Directive 73/23/EC

The Route to CE Compliance



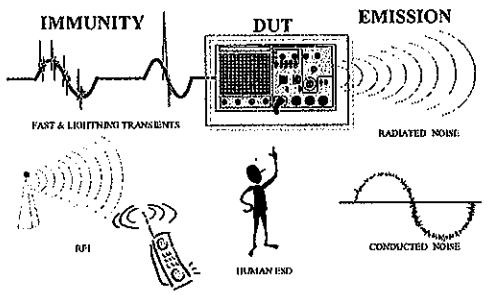
¿ What is EMC ?

- EMC is defined as the capability of an electronic equipment to operate in its electromagnetic environment without producing interferences to other equipment and not being affected by other equipment disturbances.

¿ What is EMC ?

- Emission:Machines can not generate radiated nor conducted electromagnetic interference that can alter the normal function of any other electronic equipment in the network.
- Immunity:Machines must not alter their normal function when submitted to radiated or conducted electromagnetic interference.

Example:



Is EMC mandatory ?

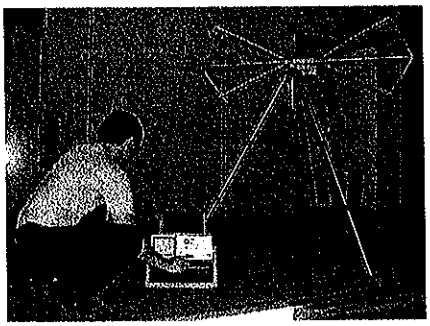
- By 1st January 1996 all Machines installed in the European Union must accomplish the 89/336/EEC Directive.
- Non accomplishment of Law could imply penalty charges to Directors of Manufacturing, Import, Sales, Installation and Users Companies as high as 200,000 Euros

2.- EMC NORMS

EMC Norms

- EMC Directive: 89/336/EEC.
- Industrial equipment must be understood and tested as a unit, not as a combination of different electronic parts that each require individual testing.

EMC Testing in Progress



EMC Norms

- EMISSION NORMS
  - EN61000-6-4, General Emission Norm, Industrial Environment (Old EN50081-2)
    - EN55011: Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) equipment.
    - EN55014: Limits and Methods of measurement of radio interference of household electrical appliances, portable tools and similar apparatus.
    - EN55022:Limits and methods of measurement of radio interference characteristics of information equipment.

Machines Classification

- Machines definition: All industrial, scientifical and medical equipments are understood as machines in general.
- EN 55011: Limits of electromagnetic disturbance of Industrial equipment & Environment.
  - Group 1: electromagnetic interference is generated unintentionally.
  - Group 2: e.m. interference is generated intentionally for material treatment.
  - Class A: Industrial environment.
  - Class B: Light Ind.& Domestic environment.

Machines Classification

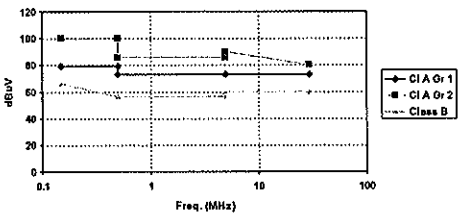
- Classification examples:
  - Class A Group 1
    - Lathes, Packaging machines, Semiconductors machines, Textile machines, Environmental Control Systems
    - class A Group 2
    - Electro-Discharge machines (EDM), Wire-Cut machines, Arc Welding machines ...
  - Class B
    - Laboratory equipment, Cash Registers ...

Conducted Noise Limits

FREQUENCY (MHz)	Class A Group 1 Quasi-Peak LIMIT (dBµV)	Class A Group 1 Average LIMIT (dBµV)	Class A Group 2 Quasi-Peak LIMIT (dBµV)	Class A Group 2 Average LIMIT (dBµV)	Class B Quasi-Peak LIMIT (dBµV)	Class B Average LIMIT (dBµV)
0,15-0,5	79	66	100	90	66 Decreasing	56 Decreasing
0,5-5	73	60	86	76	56	46
5-30	73	60	90 Decreasing	80 Decreasing	60	50

Conducted Noise Limits

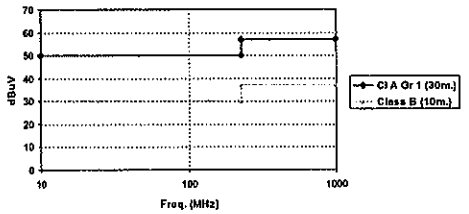
QUASI-PEAK LIMITS



Radiated Noise Limits

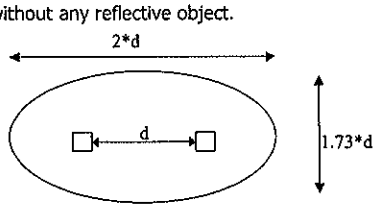
FREQUENCY (MHz)	Class A Group 1 LIMIT (dBµV/m)	Class A Group 1 Measurement Distance	Class B LIMIT (dBµV/m)	Class B Measurement Distance
30 – 230	30	30 m.	30	10 m.
230 - 1000	37	30 m.	37	10 m.

Radiated Noise Limits



PROCESS

- Place of measurements:
  - area without any reflective object.
  - ellipse



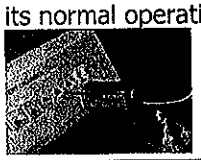
- In situ: The place where the machine is.

EMC Norms

- IMMUNITY NORMS
  - EN61000-6-2, General Immunity Norm, Industrial Environment (EN50082-2)
    - EN61000-4-1:General Immunity Norm
    - EN61000-4-2: Immunity to ESD
    - EN61000-4-3: Immunity to Radio Electromagnetic Field
    - EN61000-4-4: Immunity to fast transients
    - EN61000-4-5: Immunity to lightning transients
    - EN61000-4-6: Immunity to Radiated Electromagnetic Field
    - EN61000-4-8: Immunity to Magnetic fields
    - EN61000-4-11: Immunity to Voltage Dips, Short Interruptions and Voltage fluctuations.

Immunity to ESD

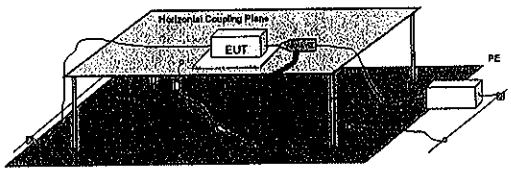
- EN61000-4-2
- 10 Discharges have to be applied.
- The Severity Level depends on the environment.
- The machine tested must not show any change in its normal operation .



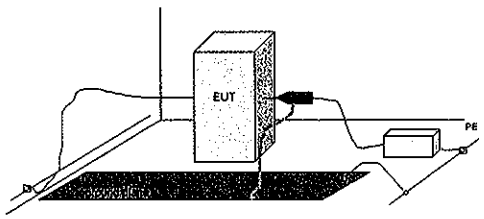
Test points according EN61000-4-2

- **Direct Discharge**
  - all accessible points (operation and maintenance)
  - housing, displays, switches, buttons, plugs etc.
- **Indirect Discharge**
  - VCP to all edges of the EUT
  - HCP at 10 cm distance of the EUT

ESD Direct discharge



ESD test for post-installations



Immunity to Radio Electromagnetic Fields

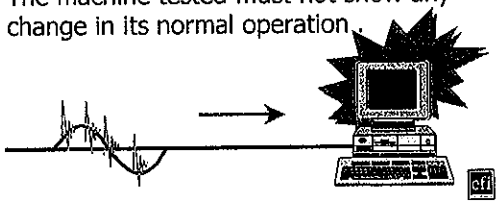
- EN61000-4-3
- Accomplished empirical test of radiated disturbance of severity Class 1-3 (1-10V/m) in the electrical-electronic board of the Device, at frequencies range from 80-1000MHz.
- Test must be conducted in an anechoic lab as generating these frequencies in open is illegal.
- Practical approach to this test is to use spot frequency listed in IEC 1000-6

Immunity to Radioelectromagnetic Fields

LEVELS OF TESTING ACCORDING TO THE EN61000-4-3 (80MHz- 1000 MHz)	
Level	Field intensity in V/m
1	1
2	3
3	10

Immunity to Fast Transients

- EN61000-4-4
- The Severity Level depends on the environment.
- The machine tested must not show any change in its normal operation.



Burst pulses

- **Single spike**

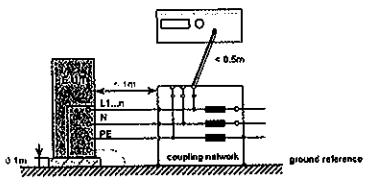


- **Burst**



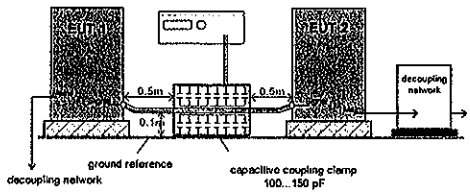
Coupling test and set-up

- **Coupling onto mains supply lines**



Coupling test and set-up

- Coupling onto signal and data lines



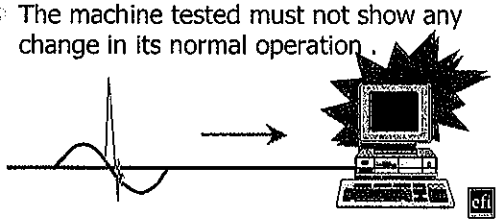
Test Levels

- Test levels for burst tests

Level	mains supply lines		I/O lines	
1	500V	5kHz	250V	5kHz
2	1000V	5kHz	500V	5kHz
3	2000V	5kHz	1000V	5kHz
4	4000V	2.5kHz	2000V	5kHz

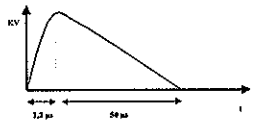
Immunity to Lightning Transients

- EN61000-4-5
- The Severity Level depends on the environment.
- The machine tested must not show any change in its normal operation.



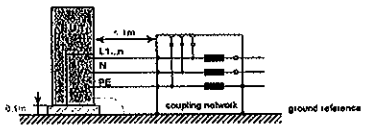
Immunity to Lightning Transients

Severity Class	Test Voltage	Environment
1	0,5K V	Highly Protected
2	1 KV	Protected
3	2 KV	Normal Industry
4	4 KV	Heavy Industry
X	Especial	Special Locations



Immunity to Radiated Electromagnetic fields coupled into Power/data lines

- EN61000-4-6
- It has been coupled 10V in the Power Lines and in the Data lines through the whole range of frequencies (150 kHz-80 MHz) according to the standard



Immunity to Radiated Electromagnetic fields coupled into Power/data lines

LEVELS OF TESTING ACCORDING TO THE EN61000-4-6 (150 kHz-80 MHz)		
Level	Level of Induced Voltage	
	U_o [dB(μV)]	U_o [V]
1	120	1
2	130	3
3	140	10

Immunity to Magnetic Fields

- EN61000-4-8.
- The severity level depends on the environment.
- The machine tested must not show any change in its normal operation.
- The EUT will be tested according the immersion method and in the three axis.

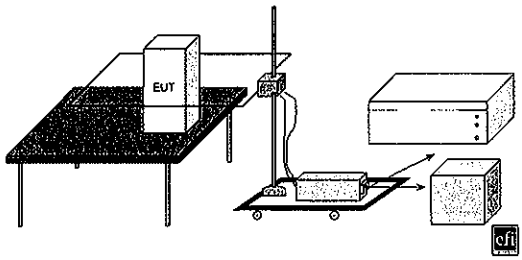
Test Levels

- **Test levels for Magnetic Field Immunity test**

Severity Class	Magnetic field Intensity
1	1 A/m
2	3 A/m
3	10 A/m
4	30 A/m
5	100 A/m

Magnetic field Test

- Power magnetic field 50 / 60 Hz



Immunity to Voltage Dips, Short interruptions and Voltage Variations

- EN61000-4-11
- Test Levels

Level of the Test (% Ut)	Voltage Dips and Short Interruptions (% Ut)	Duration (in periods)
0	100	0,5 1
40	60	5 10
70	30	25 50
		x

3.- Problems and Solutions

Conducted Noise

- Come from the machine and go through the cable to another machines.
- Problems
  - **Can affect other machines by entering by the line voltage.**
  - **Create logic problems and systems hang-up**
- Sources of conducted noise
  - **Switching Power Supplies...**
  - **Inverters, Drives ...**
  - **Starters, Power Relays ...**

Conducted Noise

- Countermeasures
  - Noise Filter
  - Filter-Suppressors
  - Isolation Transformers



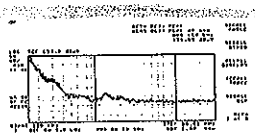
EFI Noise Filter
Power-Pro Series



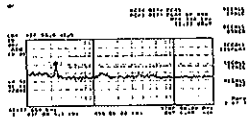
EFI Filter-Suppressor
TITAN 65DR Series

EXAMPLE OF CONDUCTED EMISSIONS

Conducted noise generated by the machine



Conducted noise after installing an EFI line filter



Radiated Noise

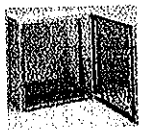
- Come from the machine and go trough the air.
- Problems
  - **Can affect other machines by coupling them in electromagnetic fields, and affecting its normal operation.**
- Sources of Radiated noise
  - **Inverters, Drives...**
  - **High current cables**

Radiated Noise

- Countermeasures
  - wiring rules
  - Shielded cables
  - EMC Enclosures (panels, cabinets ...)
  - Shield Rooms



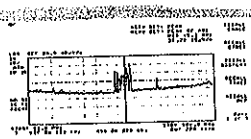
SHIELDED CABLES



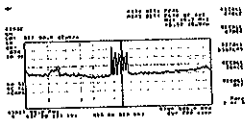
EMC ENCLOSURES

EXAMPLE OF RADIATED EMISSIONS

Environmental noise captured by the machine with the biconical antenna.
(Machine stopped)



Radiated noise with the machine at full operation.



Immunity to ESD

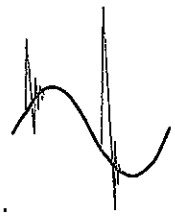
- Problems
  - **Malfunction**
  - **Systems hang-up**



- The ESD comes from the Operator
- Countermeasures
  - **Special Anti-Static materials**
  - **Good grounding**

Immunity to Transients

- Problems
  - **Malfunction**
  - **Systems hang-up**
  - **Hardware damage**
- Sources of Transients
  - Lightning
  - Switching motors, printers ...



Immunity to Transients

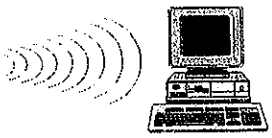
- Countermeasures
  - **Suppressors**
  - **Hybrid Suppressors (TVSS)**





Immunity to Magnetic Fields

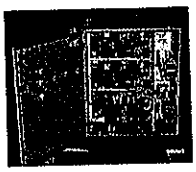
- Problems
  - Malfunction
  - Flickering
  - Health problems
- Countermeasures
  - Magnetic shielding enclosures



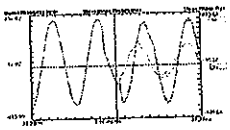


Immunity to Voltage Dips and short interruptions

- Problems
  - Malfunction
  - system hang_up
  - Data Loss



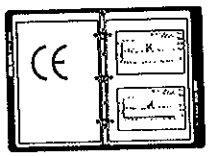
- Countermeasures
  - UPS´s
  - Sag Corrector



4.- DOCUMENTATION

EMC Documentation needed

- EMC testing documents (graphs,...).
  - Emission: Conducted Noise test.
  - Emission: Radiated Noise test.
  - Immunity test.



EMC Documentation needed

- Information to be sent together with the machine
  - **EMC Accomplishment Document, mentioning norms used, machine model and series number.**
  - **Incoming power supply requirements.**
  - **Environment conditions.**
  - **Installation and connection guide.**
  - **Operating and Maintenance Manuals.**
  - **Part list**

EMC Documentation needed

- Technical Construction file (TCF)
  - **The manufacturer and the European Importer must keep a copy of the TCF.**
  - **The TCF includes the following:**
    - **A copy of all the information sent with the Machine**
    - **Mechanical description**
    - **All electrical schematics and diagrams**
    - **All tests done, including EMC tests, accuracy tests ...**
    - **All changes applied with the description and reason of the change**

THANK YOU VERY MUCH FOR YOUR ATTENDANCE

Precicon D&C Pte. Ltd.

SEMI F47 Compliance Solution



Precicon D&C Pte. Ltd.

SEMI F47 : Compliance Concept

- Better equipment design and component quality
- Reduce or eliminate battery storage device



Precicon D&C Pte. Ltd.

SEMI F47, What We Really Care

a) Reduced the impact of Voltage Sag to the plant operation.

b) Minimized the call back and repair rate.

c) Established electricity supply standard.



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The Steps to Voltage Sag Immunity

Step 1: Conduct detail study of the system and devise a compliance strategy.

Step 2: Carry out a SEMI F47 test to ascertain the vulnerability of the system, and identified weak links.

Step 3: Replaced weak links with components that can better withstand voltage sag.

Example i) Replaced normal DC Power Supply with wide voltage input model
ii) Made used of DC type contactor
iii) Select F47 certified VSD

Step 4: Protect the rest of the weak links with battery-less voltage sag corrector

Precicon D&C Pte. Ltd.

Case Study on Industrial Process Pump System

Overview

- A new high tech plant has specified SEMI F47 for all critical production support facility system to be installed in the plant.
- An industrial process pump system has been identified as a critical system which required voltage sag ride through capability.
- No prior study has been carried out on the pump system.

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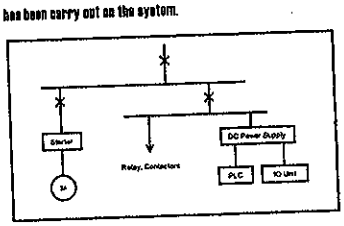
Case Study on Industrial Process Pump System

- A detail study has been carry out on the system.



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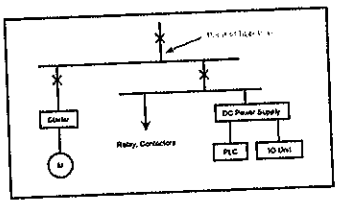
Case Study on Industrial Process Pump System

- A SEMI F47 test has been carried out.
- Wide input DC Power Supply has been used.



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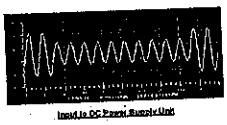
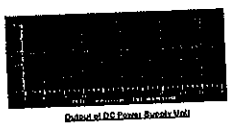
Case Study on Industrial Process Pump System

Observations:

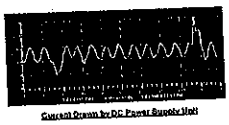
- Contactors trip at below the SEMI F47 curve.
- Wide input DC power supply unit gave regulated DC output throughout the test.



Input to DC Power Supply Unit



Output of DC Power Supply Unit



Current Drawn by DC Power Supply Unit

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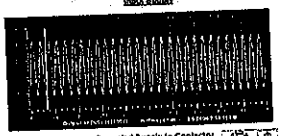
Case Study on Industrial Process Pump System

Enhancement:

- A battery-less Dynamic Sag Corrector is used to hardened the contactor circuit
- The system ride through the SEMI F47 requirement in engineering mode.



Input Supply



Corrected Supply to Contactor Circuit

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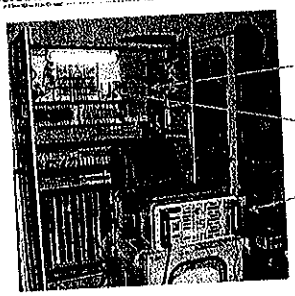

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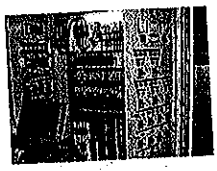



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DySC

Dynamic Sag Corrector

"the off-the-shelf SEMI F47 Solution"

SoftSwitching

Precicon D&C Pte. Ltd.

Existing Solutions

- Constant Voltage Transformer(CVT) / Voltage Regulators
  - Medium cost
  - Plants with sensitive electronic equipment
  - Provides voltage regulation against sustained brownouts
  - No regulation for deep voltage sags i.e. 50% drop) or momentary loss of power
- Uninterruptible Power Supplies
  - High cost
  - Protects against momentary power loss and voltage sags
  - High maintenance and high costs

Precicon D&C Pte. Ltd.

Key Decision: Point-of-Pain vs. Facility Wide Protection

	Point of Pain Protection	Facility Wide Protection
Positives	Cost-effective, protects sensitive loads only Can be staged, highest impact loads first – budget friendly Standard product based, rugged and reliable	Protects all loads (but more expensive $/kVA of protected loads) Installation may be simpler, (but may require outside trailer/facility)
Negatives	Installation may be more complex	Requires major budget commitment and engineering effort, also higher $/kVA of protected load. Custom product, difficult to protect at MV level

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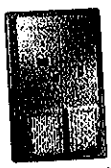
Dynamic Sag Corrector ™ (DySC™)



MINIDySC™





PRODySC™





Precicon D&C Pte. Ltd.

What make the [redacted] the Ideal SEMI F47 Voltage Sag Solution ?

Precicon D&C Pte. Ltd.

The MiniDySC Comparison

Features	CVT	Battery UPS	MiniDySC
Cover Shallow Sags – 20%	Yes	Yes	Yes
Covers Deep Sags – 50%	No	Yes	Yes
Covers Momentary Power Loss	No	Yes	Yes
Battery Free	Yes	No	Yes
Handles Dynamic Loads	No	No	Yes
Operating Cost	High	High	Low
Mount in Control Enclosure	No	Yes	Yes

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The PRODySC Comparison

Features	Flywheel UPS	Battery UPS	PRODySC
Covers Deep Sags – 50%	Yes	Yes	Yes
Covers Momentary Power Loss	Yes	Yes	Yes
Small Equipment Footprint	No	No	Yes
Equipment First Cost	High	High	Low
Handles Dynamic Loads	Yes	No	Yes
Operating Cost	High	High	Low
Designed for Plant Floor (No HVAC requirement)	No	Yes	Yes
Easy Installation (No floor preparation requirement)	No	Yes	Yes
Free of moving parts and vibration	No	Yes	Yes

Precicon D&C Pte. Ltd.

DySC™ Competitive Advantages

- Proven Off-the-Shelve Solution
- Uses only power electronics to cover over 92% of all power quality events
- Significant size, efficiency, and cost advantages over other competitive solutions
- Patent protected in over 10 countries
- Lowest cost of ownership

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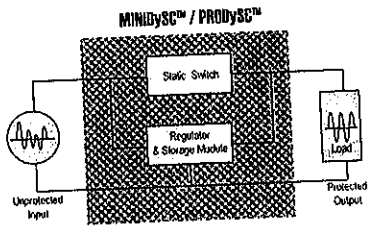
Block Diagram



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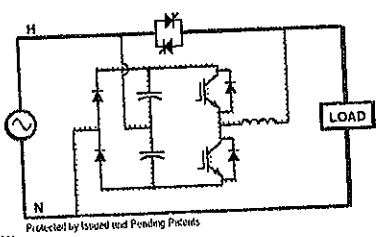
The *DySC* Circuit

Normal Operation
- Power Electronics Off Line
- No Thermal Cycling
- Capacitors Stay Charged
- Very Long Life Design
- Low maintenance
- Highly efficient (>99%)

- 1-2 ms sag detection
- Static switch force commuted off, Power electronics 'on'
- Additional Current drawn from line for sags down to 50%
- Energy from capacitors for total power loss (3-12 cycles)



Protected by Issued and Pending Patents

Precicon D&C Pte. Ltd.

MiniDySC Specification





- Single Phase
- 110V, 120V, 208V, 220V, 230V, 240V
- Current Rating: 1A, 2A, 3A, 12.5A, 25A, 50A
- up to 50% sag for 2 sec cumulative over a 60 sec period.
- 50% to 100% for 3 cycle for standard product.
- Response time: 1/8 cycle

Precicon D&C Pte. Ltd.

ProDySC Specification



- Three Phase
- 208V, 380V, 400V, 415V, 480V
- Current rating: 25A, 50A,100A, 200A, 400A, 800A
- up to 50% sag for 2 sec cumulative over a 60 sec period.
- 50% to 100% for 3 cycle for standard product.
- Response time: 1/8 cycle

Precicon D&C Pte. Ltd.

DySC™ Cost Advantage

- Point of use solution, protects against utility and internal faults
- Wide power range for maximum flexibility
- No batteries, no moving parts, minimal maintenance
- Lowest first cost and operational cost
- SEMI F47 compatible

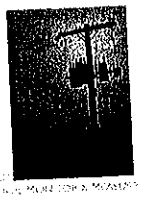
Cost Comparison for 1.0 MW Load

	DySC™	Battery UPS	Flywheel
Estimated Initial Price	$280,000	$400,000	$400,000
Energy Cost Over 5 Yrs	$62,500	$420,000	$368,000
Maintenance Cost	Low	High	Medium
HVAC Initial Cost	None	Yes	Yes
HVAC Operating Cost	None	High	High

Precicon D&C Pte. Ltd.

DySC™ Product

- Ratings from 1.5kVA to 2500kVA
- Over 400 units sold, great field experience
- Industries using the DySC™:



Semiconductors
Automobiles
Fiber Optics
Telecom
Plastics
Food Processing
Cement
Paper
Lighting
CNC Machining



Precicon D&C Pte. Ltd.

CNC Machining Application

CASE STUDY

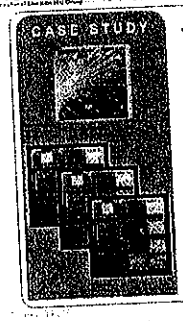


- Application: CNC machining of large steel axles and rotors(15' Lg., 4' Diam.)
- Events: 10 to 15 per year
- Losses: Up to 24 hours of production loss, expensive rotors scrapped, delayed shipments
- Collaboration: AEP and EPRI collaborated with the customer to deploy solution
- Solution: 300 kVA PRODySC for main CNC Machines, HID lighting, and Office load
- Results:- Downtime and scrap material has been virtually eliminated.
  - Office computer re-boot and data re-storage problems eliminated.
  - Customer not considering re-locating business.
  - Approximately 3 years of operation

Precicon D&C Pte. Ltd.

Fiber Optic Cable Manufacturing

CASE STUDY



- Application: Fiber Optic Cable Sheathing extrusion lines. Integrated DC & AC drives, and PLC extruder controls 2 mile long cables, over 500 individual fibers per cable
- Events: 8 to 10 voltage sags per year
- Losses: $150,000 to $600,000 per event!
- Collaboration: Over 5 years of PQ data recorded indicating only sag events. Utility feed from transmission grid
- Solution: Over 3500 kVA of PRODySC units installed as part of cable lines
  - Ratings include 180 kVA, 330 kVA & 500 kVA
  - Capability to add capacitive energy storage for additional ride through
- Results: In the first 3 months two definite saves recorded on two lines the investment on each line paid for itself in first event.

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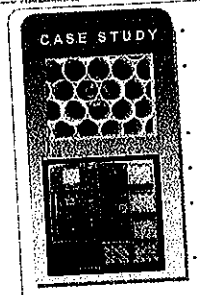
Plastics Extrusion Manufacturing

CASE STUDY



- Application: Manufacturer of large dia PV plastics extrusion products
- Events: Multiple sag and momentary loss of power due to being in lightning belt. At time of installation, only computer on shop floor monitored weather. During storms within 50 mile radius, all off-site staff on standby for clean-up and re-starting lines.
- Losses: Major production losses, up to 8 hrs of clean up & restart time after event. Significant scrap material. Delayed shipments.
- Collaboration: TVA and EPRI-PEAC collaborated with the customer to deploy solution.
- Solution: 300 kVA PRODySC to protect 5 of eight lines.
  Unit equipped with 15 cycle extended outage for momentary loss of power
- Results: Many recorded saves of connected lines.
  Lines not protected shut down.

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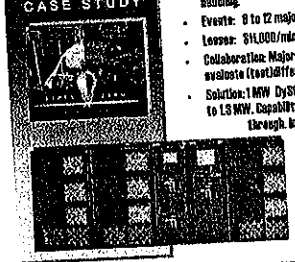
Automotive Application

CASE STUDY



- Application: Body Shop robot welding systems, PLC controls, material handling.
- Events: 9 to 12 major events per year
- Losses: $11,000/min; 2-4 hrs production loss
- Collaboration: Major East Coast Utility collaborated with the customer to evaluate (test) different solutions & recommendation.
- Solution: 1 MW DySC for Body Shop power distribution panel, expandable to 1.5 MW. Capability to add capacitive energy storage for additional ride-through. Installed I-Sense™ Power Monitors at Input & output

Results:

Several saves recorded where body shop kept running when other parts of plant shut down. I-Sense e-mail reports verified protection by the PRODySC.

Customer preparing to install a larger unit for plant expansion.

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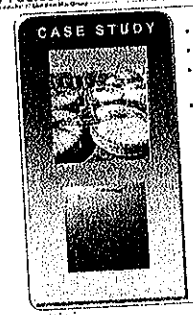
Chemical Plant Application

CASE STUDY



- Application: Chemical plant based on Jurong Island, Singapore
- Events: Process interruptions due to voltage sag events
- Losses: The sag typically caused the contactor circuit in the Motor Control Centre to drop-off, resulting in interruption of operation.
- Limitations: Battery storage devices were not ideal
  because 1) Singapore's premium grid minimize outages, and
  2) prolonged ride-through by a battery storage device during an extended power outage event would in any case require a shut down of the entire process.
- Solution: To save the contactor from tripping, a single phase DySC was applied.
- Results: the DySC has since saved the company from several voltage dip events and prevented tripping of the motors.

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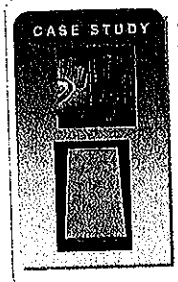
Disk Drive Manufacturing Application



- Application: Major disk drive manufacturer
- Events: Sputter machine would trip during a voltage sag or dip.
- Losses: Unscheduled downtime costing about S$40,000 per machine per event
- Limitations: The clean-room had very limited space to install a battery storage system.
- Collaboration: A study was conducted identifying the EMO circuit, PLC, and the servo driver to be the weak link.
- Solution: A specially design DySC, which incorporated a single phase and 3 system, was supplied to mitigate the voltage sag problem.
- Results: The system is now installed and running, not since make several saves

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Question & Answer