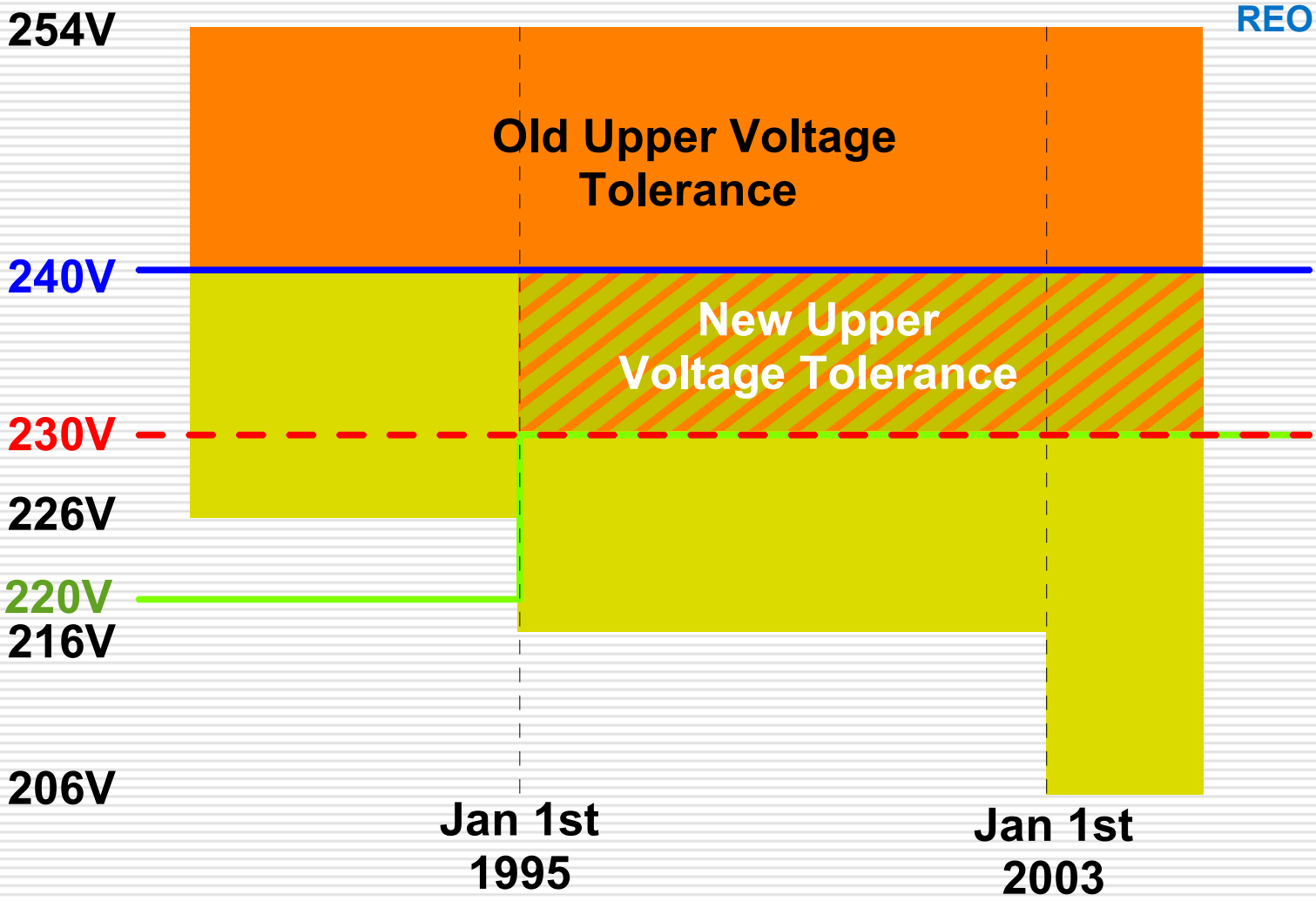
REO

REO (UK) LTD

Power Quality

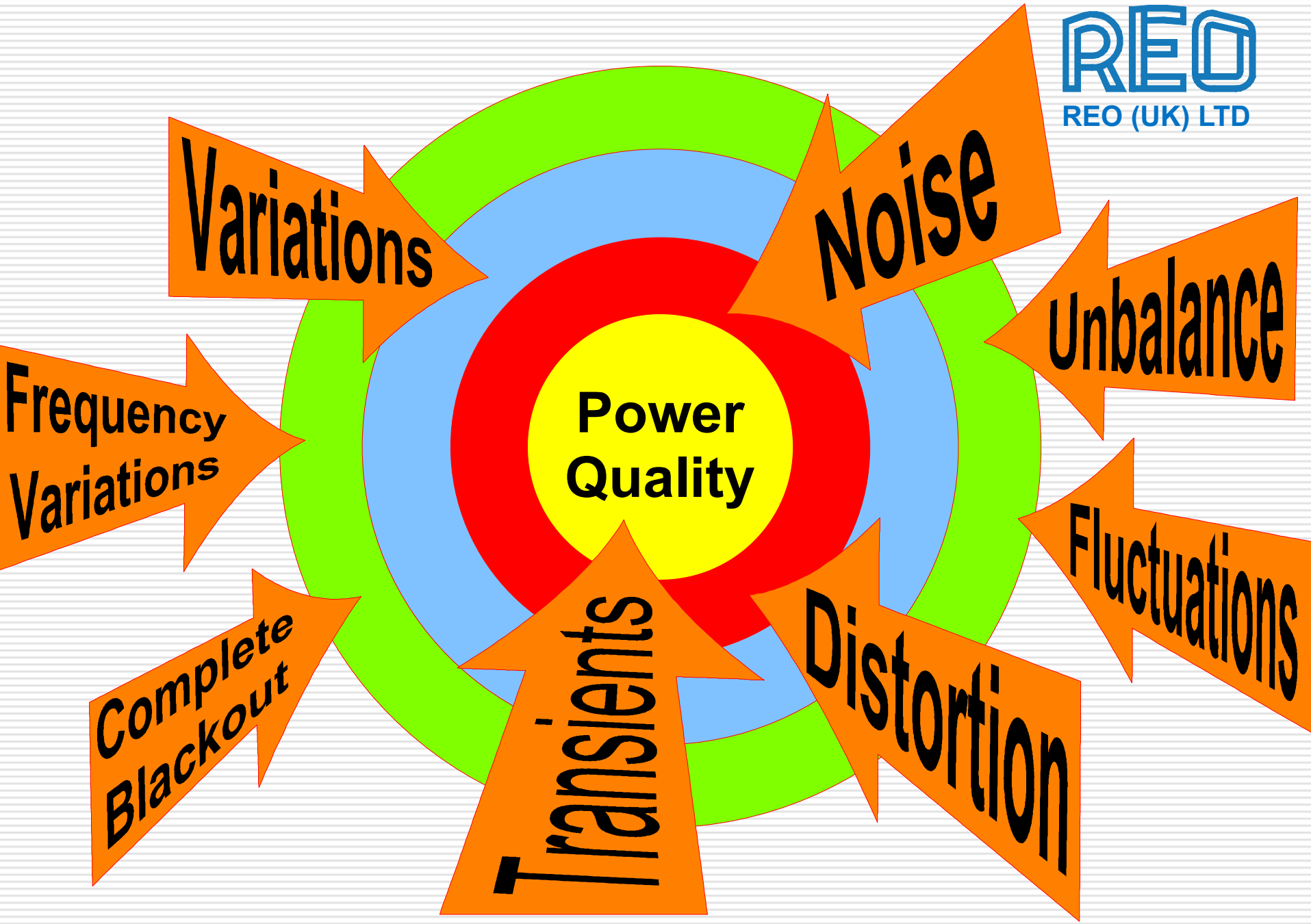
REO (UK) LTD



Moving the supply voltage goalposts

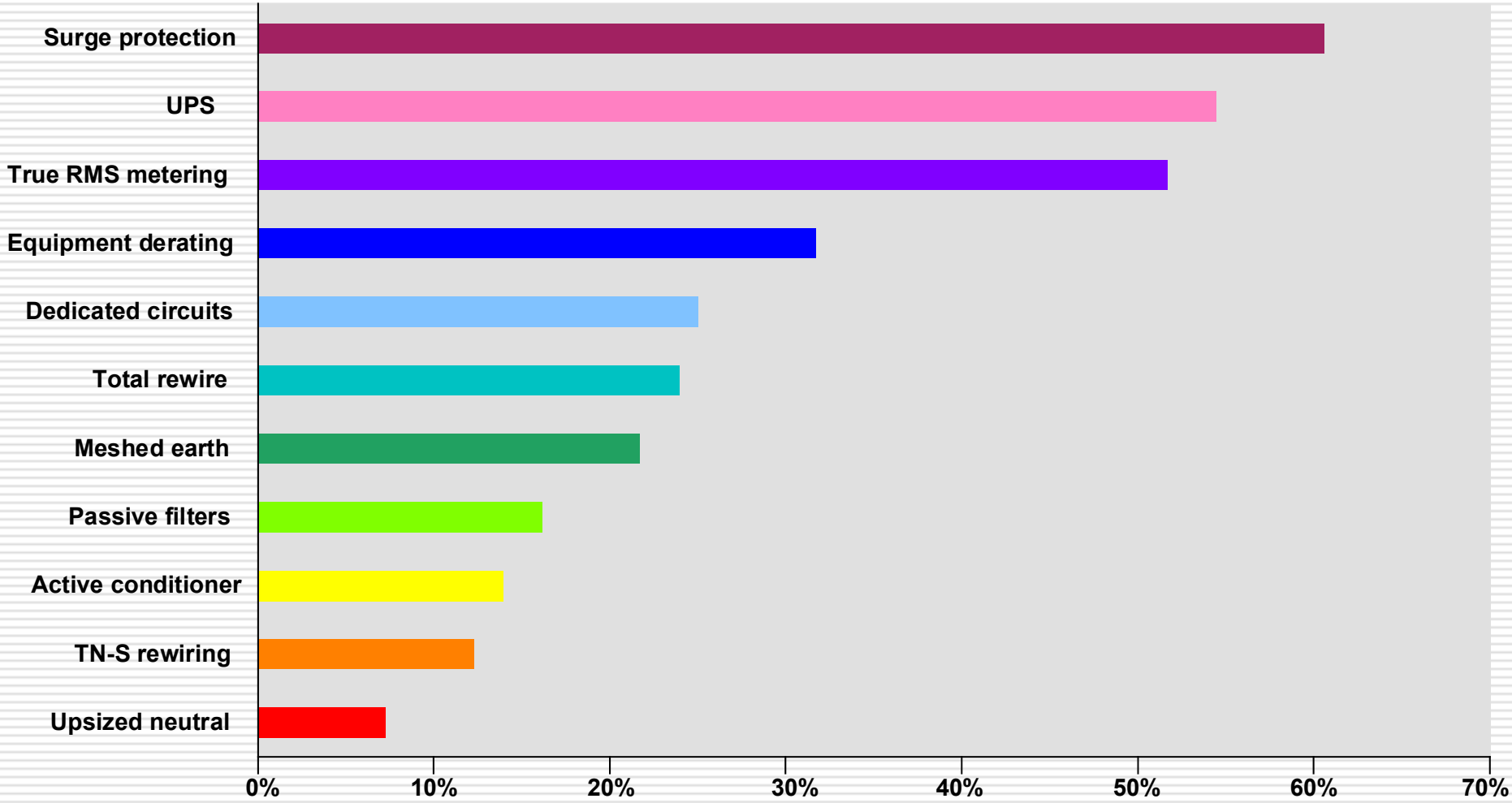
REO

REO (UK) LTD

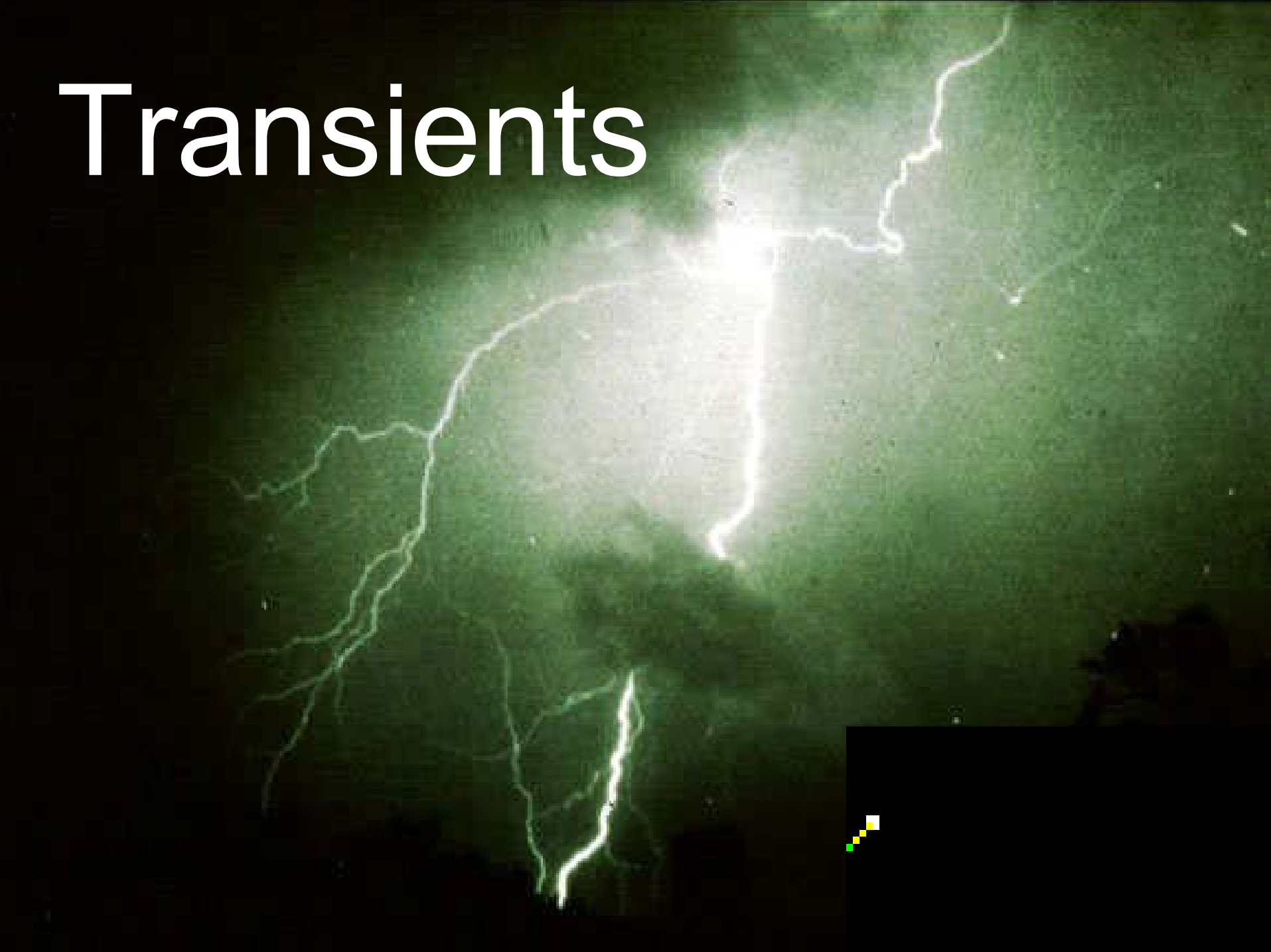

REO
REO (UK) LTD
Variations
Noise
Unbalance
Frequency Variations
Power Quality
Fluctuations
Complete Blackout
Transients
Distortion

The most widely used Power Quality Solutions from a survey of 1400 sites in 8 countries

REO (UK) LTD



Transients



REO (UK) LTD

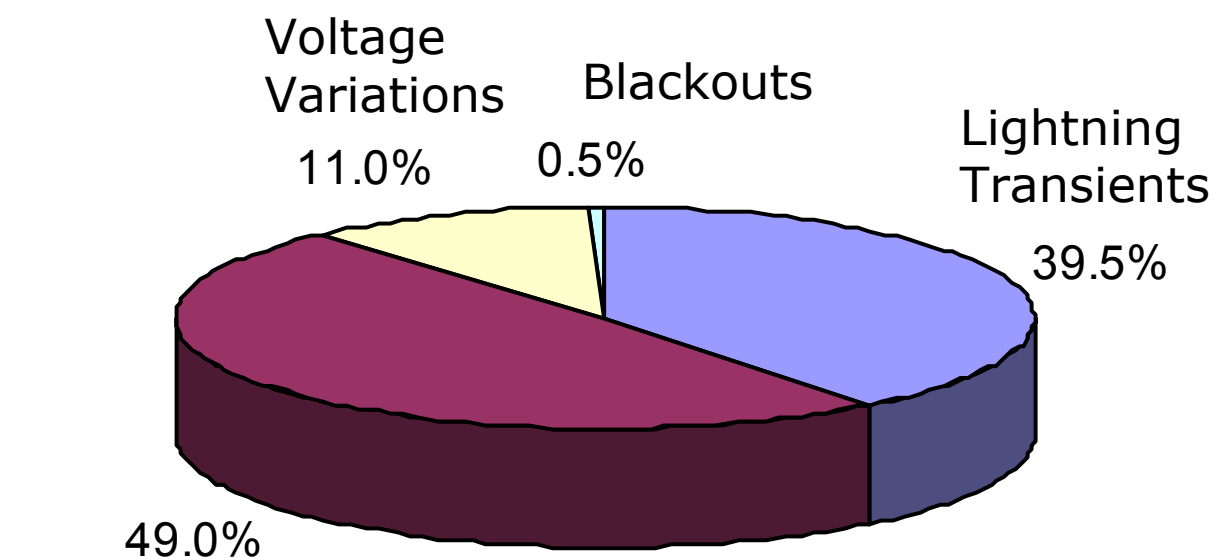
Transients can be caused by:-

- Lightning
- Switching on the mains supply network
- Switching of any load (even relays !)
- Sags
- Arc welding

Transients are often referred to as surges, particularly in standards

IBM Survey of incidence rates of harmful power disturbances causing computer equipment failures (Allen & Segall)

REO (UK) LTD



NB: 88.5% due to transients

Some interesting facts about lightning

REO (UK) LTD

- There are about 300,000 ground strikes every year in Britain
- 30 – 60 people are struck by lightning each year and on average 3 may be killed

Source: Tornado and Storm Research Organisation www.torro.org.uk

- The Met Office monitors radio waves emitted from lightning flashes. These have a frequency of about 50 kHz and in principle can travel from the other side of the World with very little loss in strength.

Source: www.met-office.gov.uk

REO (UK) LTD

EN 61000-4-5: Testing and measurement techniques-Surge immunity test

- This standard defines the test levels for various classifications of equipment. The most stringent test (interconnections through outdoor cables) calls for a 4kV surge test.
- In reality surges in excess of 10kV can be expected, particularly in North and South America and the Pacific Rim.

REO (UK) LTD

Locations near to power lines are particularly vulnerable to transients, typically 10kV ten times a year. Whereas an office in town could expect up to 3kV ten times a year.

Source: Manufacturing Systems Magazine

Last Updated: Tuesday, 29 April, 2003, 13:31 GMT 14:31 UK

Email this to a friend Printable version

Power cut hits commuters

Power cuts in Belfast have caused disruption for road and rail travellers.

Supplies were affected after the substation fire

It follows a serious fire at an electricity substation on the Glen Road in west Belfast.

The power failure hit about 0700 BST on Tuesday, causing problems for commuters as traffic lights and train signals were also affected.

Northern Ireland Electricity said major customers were affected but its domestic customers still had power.

An investigation is under way to find out what went wrong at the Hannahstown substation.

There may have been a power surge caused by a fault in the voltage switching system overnight.

The fire service was called to the scene and on arrival they found ceramic insulators still smouldering.

Homes next to the substation were unaffected but the power

WATCH AND LISTEN

BBC NI's Rosy Billingham:
"The power surge caused considerable disruption right across Belfast"
VIDEO

SEE ALSO:
- Electricity attacks warning
  24 Apr 03 | Northern Ireland
- Power restored to NI homes
  24 Feb 02 | Northern Ireland
- Storms cut power supplies
  20 Feb 02 | Northern Ireland

RELATED INTERNET LINKS:
- Northern Ireland Electricity
- Translink

The BBC is not responsible for the content of external internet sites

TOP NORTHERN IRELAND STORIES NOW
- Efforts intensify to break impasse
- UDA's 'spokesmen vendetta'
- Man killed in road accident
- Partygoer in arson inquiry

TOP UK STORIES NOW

REO (UK) LTD

Transients can cause:-

- Equipment failure
- Premature ageing of components e.g semiconductors (especially power components such as rectifiers)
- Disruption of a process
- Fire

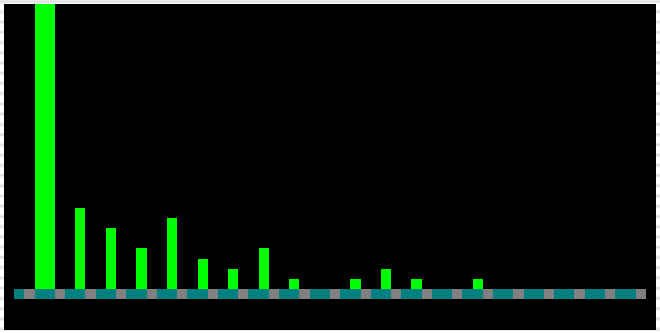
Some devices for protection against transients

REO (UK) LTD

Gas discharge tube, essentially just a spark-gap, slow but very high power and negligible leakage

Metal-oxide varistor, a bulk semi-conductor, fast and less rugged than a GDT

Also avalanche devices (zener type action) and thyristor devices

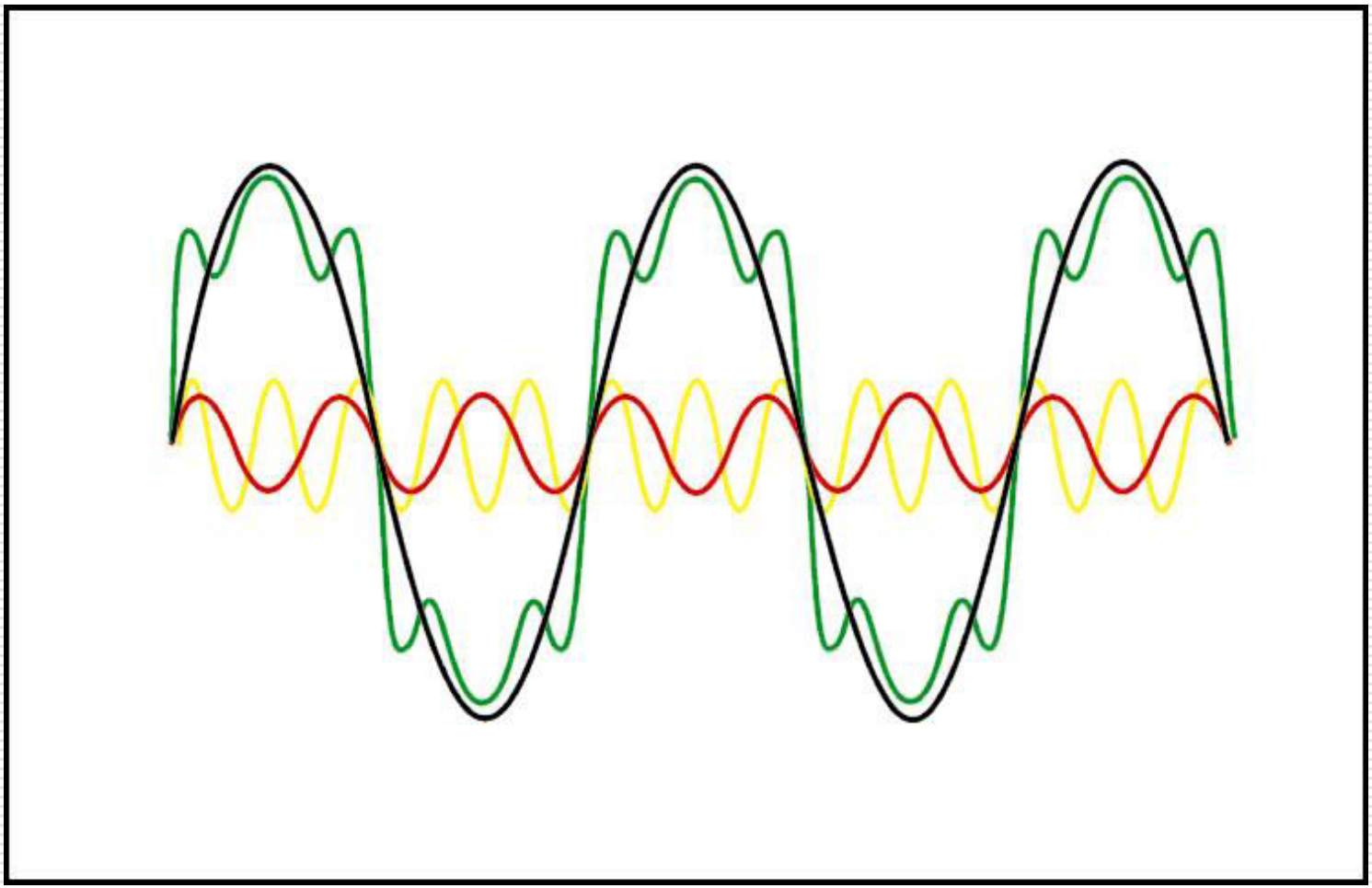


REO (UK) LTD

Harmonics

- Sinusoidal components of a non- linear periodic waveform with a frequency that is a whole multiple of the fundamental frequency
- Symmetrical waveforms – odd harmonics only
- Asymmetrical waveforms – both odd and even harmonics

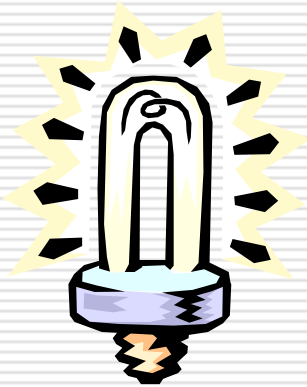
REO (UK) LTD



A sine wave distorted by third and fifth harmonics

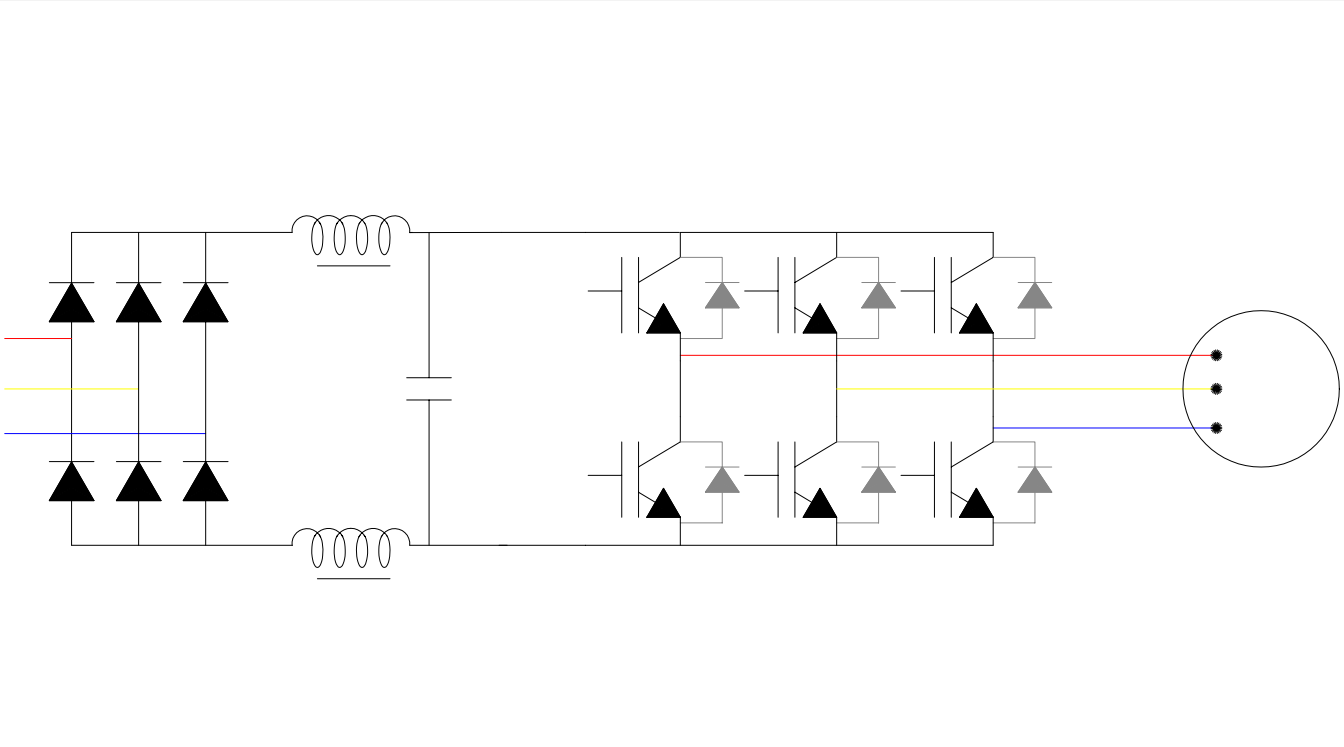
REO (UK) LTD

Harmonics are caused by:-



- Fluorescent Lighting (energy saving bulbs)
- Televisions and computers
- Switch mode power supplies
- Variable speed drives
- Air conditioning equipment
- IT equipment
- Phase-angle power controllers

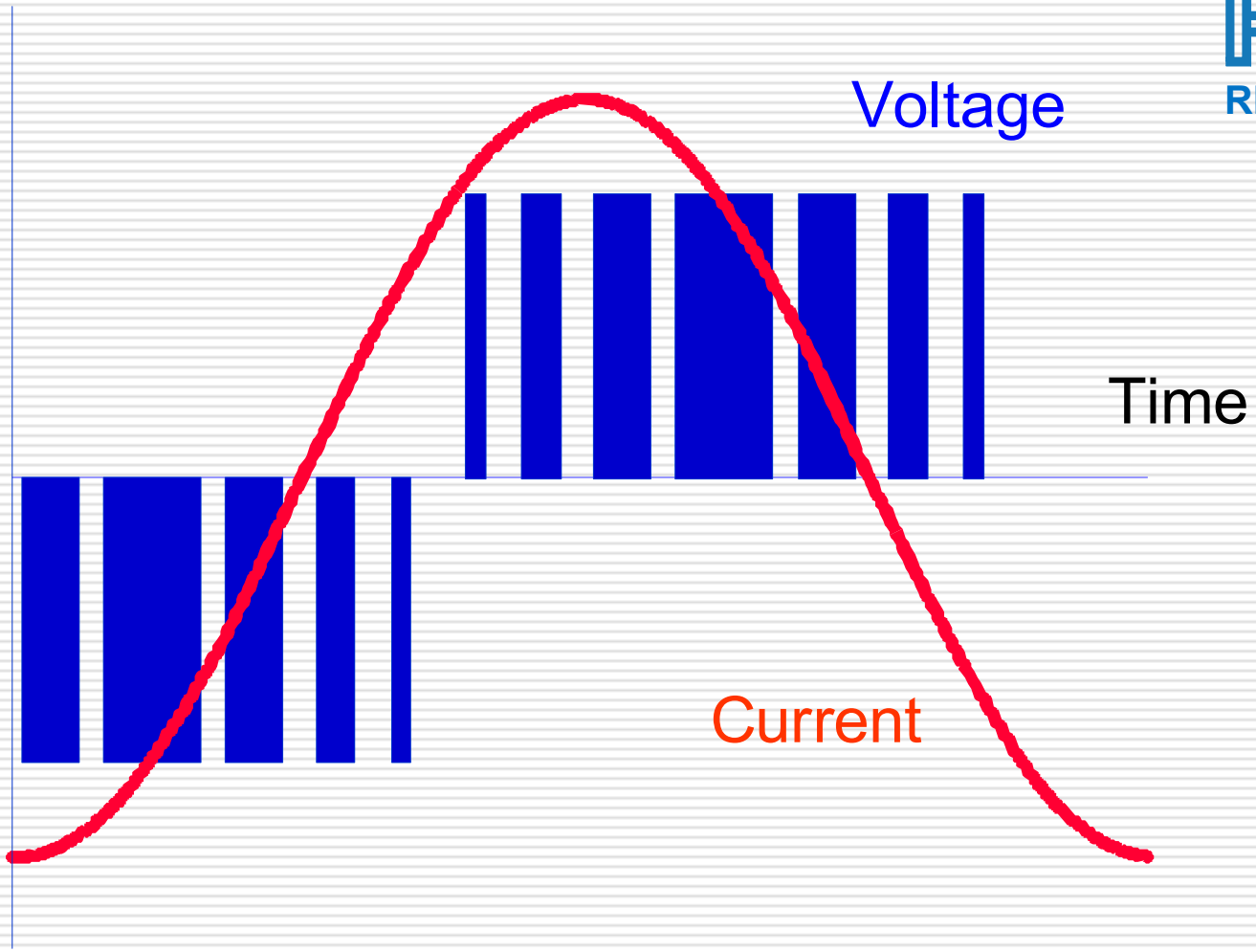
REO (UK) LTD



A Variable Speed Drive (VSD) comprises three main components:-

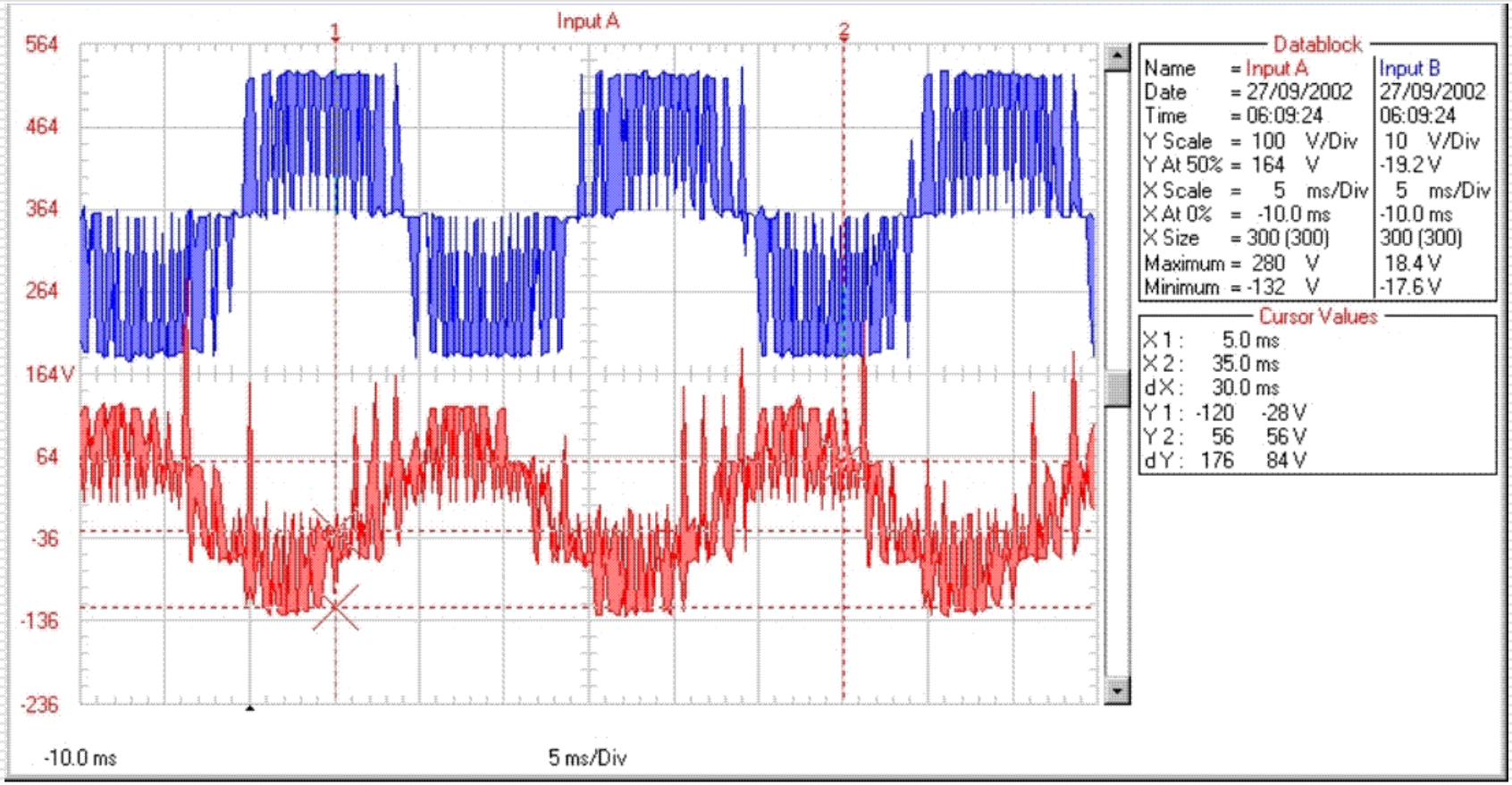
- A RECTIFIER to convert the mains supply into DC
- The DC LINK incorporating chokes and capacitors for maintaining a steady DC voltage
- An OUTPUT STAGE using Insulated Gate Bipolar Transistors (IGBT's) for generating a 3-phase, variable frequency output to control the motor

REO (UK) LTD

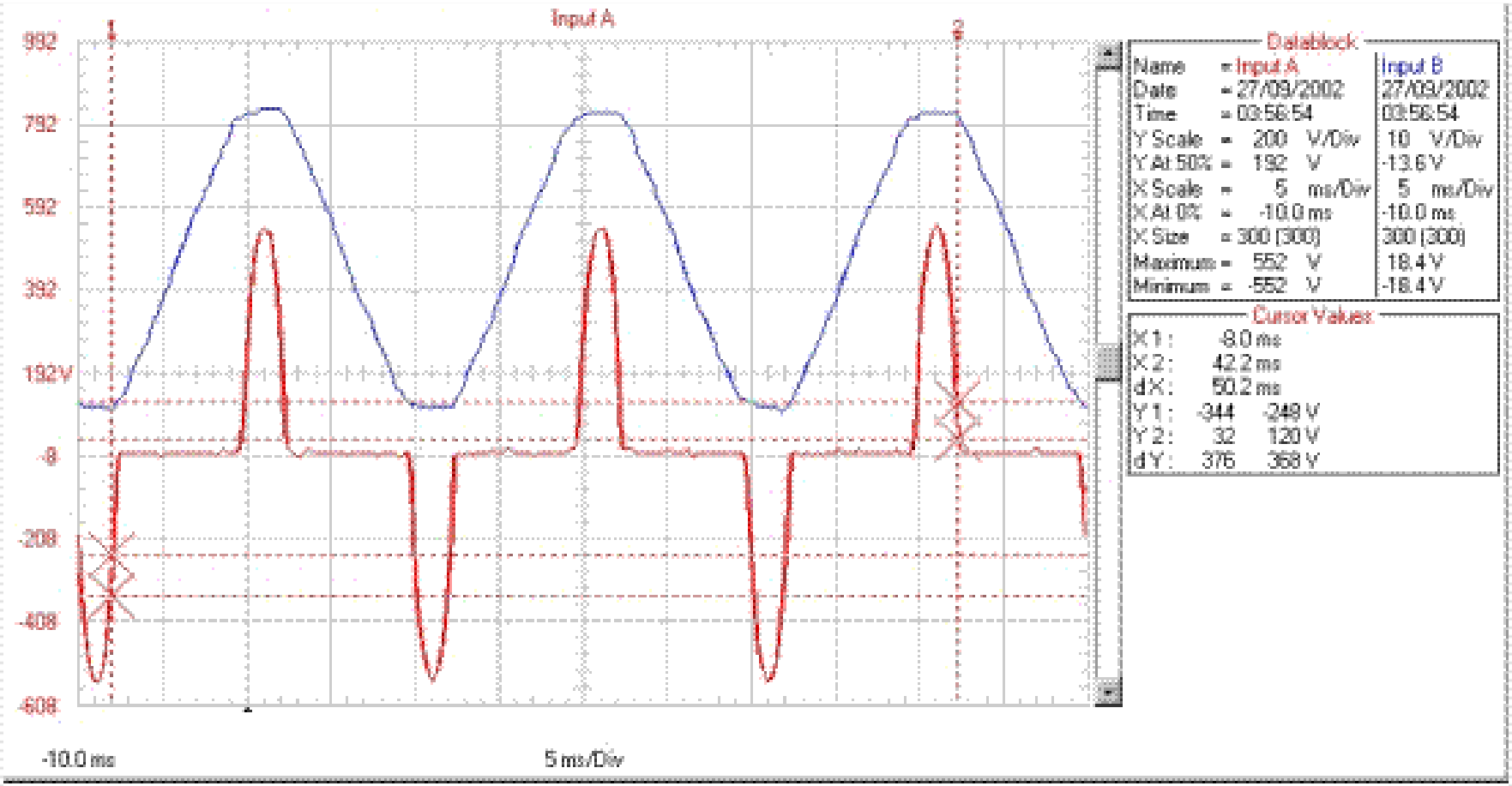


Simplified diagram showing the pulse width modulated output from an inverter drive.

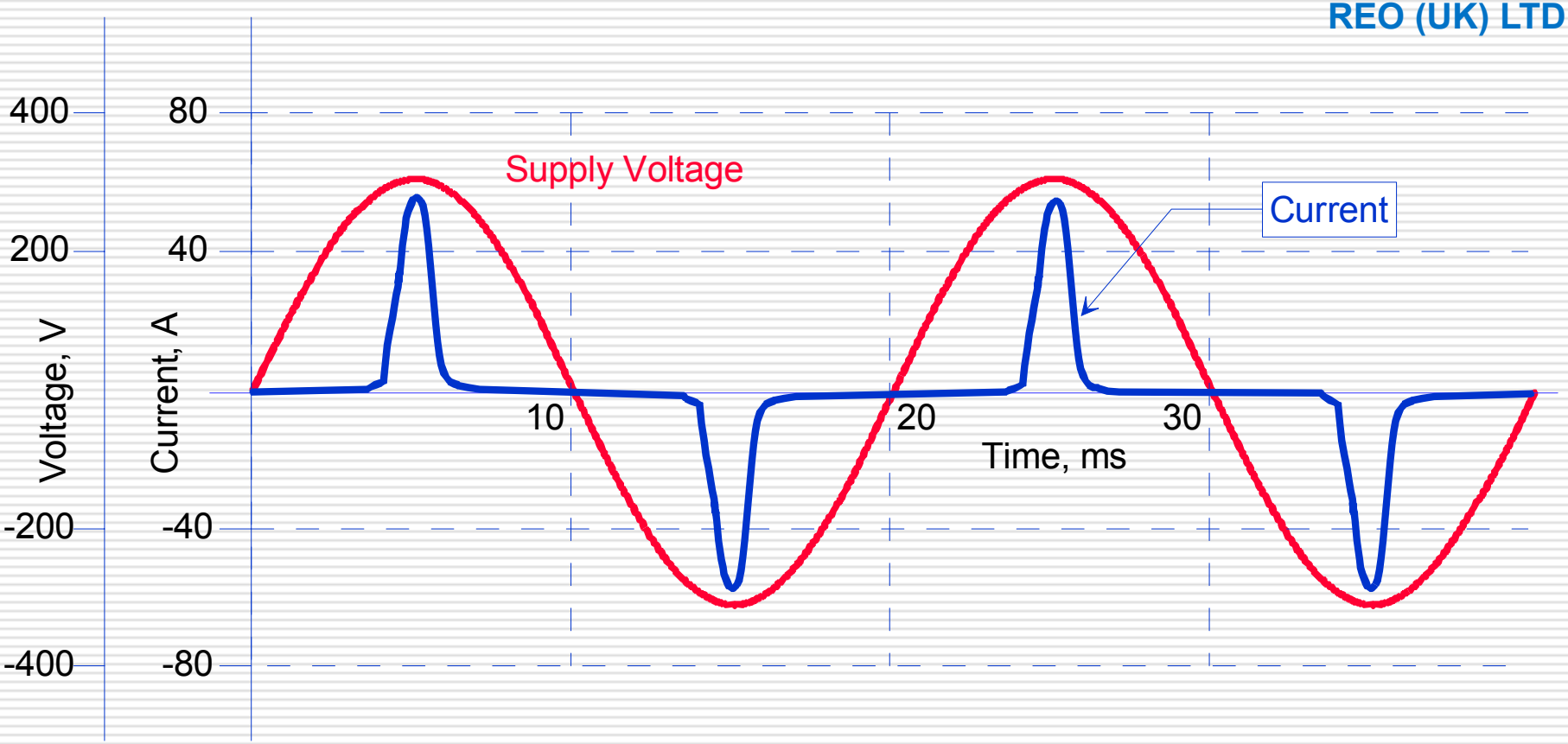
REO (UK) LTD


Input A
1
2
564
464
364
264
164 V
64
-36
-136
-236
-10.0 ms
5 ms/Div
Datablock
Name = Input A | Input B
Date = 27/09/2002 | 27/09/2002
Time = 06:09:24 | 06:09:24
Y Scale = 100 V/Div | 10 V/Div
Y At 50% = 164 V | -19.2 V
X Scale = 5 ms/Div | 5 ms/Div
X At 0% = -10.0 ms | -10.0 ms
X Size = 300 (300) | 300 (300)
Maximum = 280 V | 18.4 V
Minimum = -132 V | -17.6 V
Cursor Values
X 1 : 5.0 ms
X 2 : 35.0 ms
dX : 30.0 ms
Y 1 : -120 -28 V
Y 2 : 56 56 V
dY : 176 84 V

REO (UK) LTD

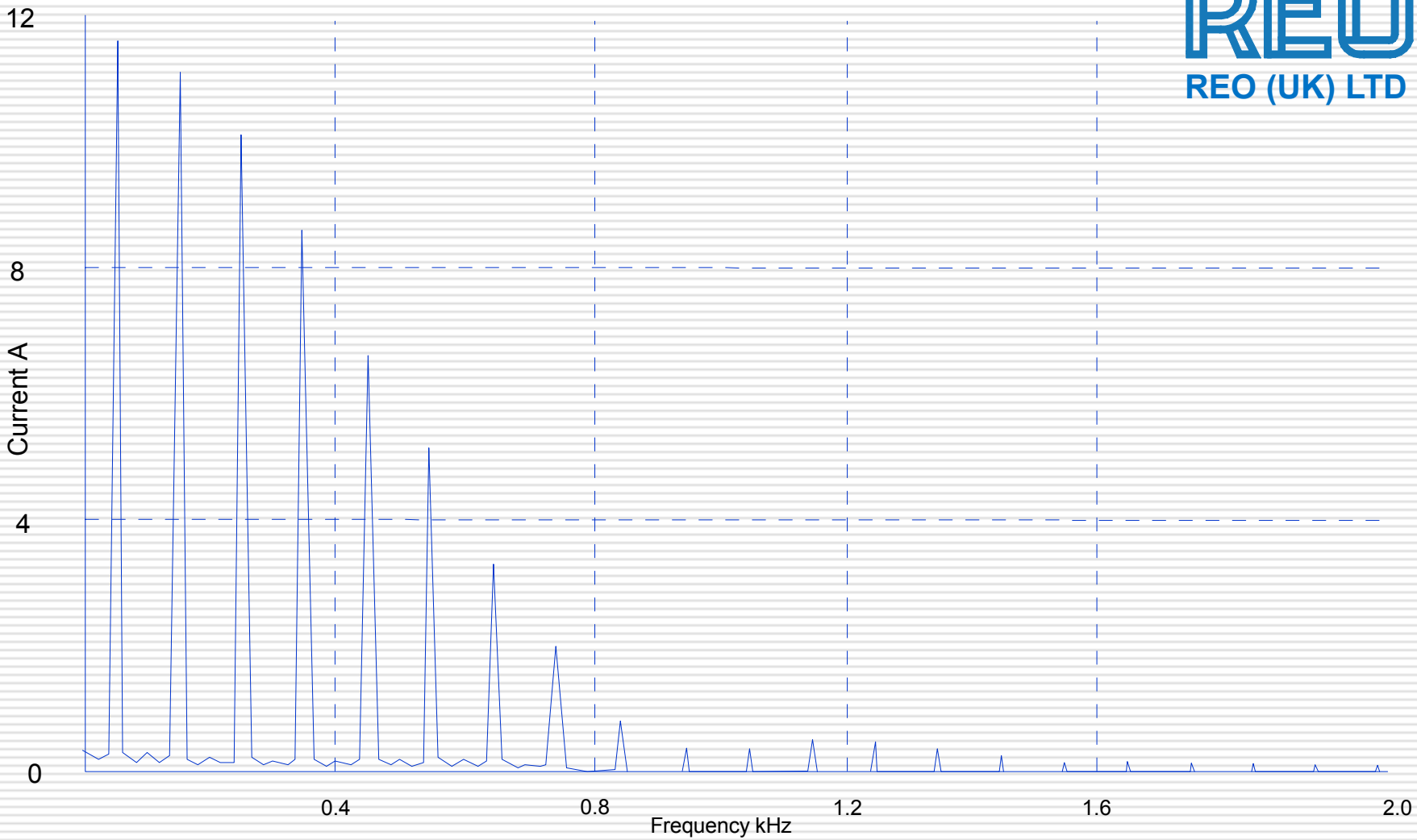

Input A
992
792
592
392
192V
-8
-208
-408
-608
-10.0 ms
5 ms/Div
Datablock
Name = Input A
Date = 27/09/2002
Time = 03:56:54
Y Scale = 200 V/Div
Y At 50% = 192 V
X Scale = 5 ms/Div
X At 0% = -10.0 ms
X Size = 300 (300)
Maximum = 552 V
Minimum = -552 V
Input B
27/09/2002
03:56:54
10 V/Div
-13.6 V
5 ms/Div
-10.0 ms
300 (300)
18.4 V
-18.4 V
Cursor Values
X1: -8.0 ms
X2: 42.2 ms
dX: 50.2 ms
Y1: -344 -249 V
Y2: 32 120 V
dY: 376 368 V

REO (UK) LTD



Typical input current waveform for a 1.5 kW PWM drive

REO (UK) LTD



Spectrum showing harmonic content of current waveform for 1.5kW PWM drive

Harmonics can cause:-

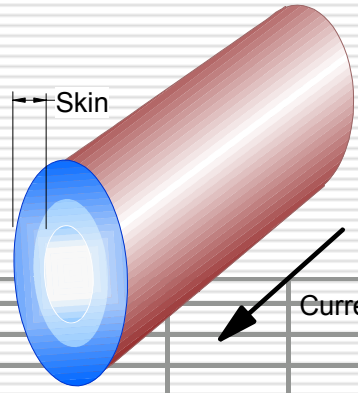
REO (UK) LTD

- High neutral currents i.e can be 1.7 x phase current when there are a lot of single phase loads because triplens are additive
- Problems with half-size neutrals in older buildings
- Nuisance tripping
- Overheating and fire hazards
- Overheating of Power Factor Correction Capacitors
- Extra losses in transformers
- Losses in power cables (skin effect)

The formula for the depth of skin effect in copper is:-

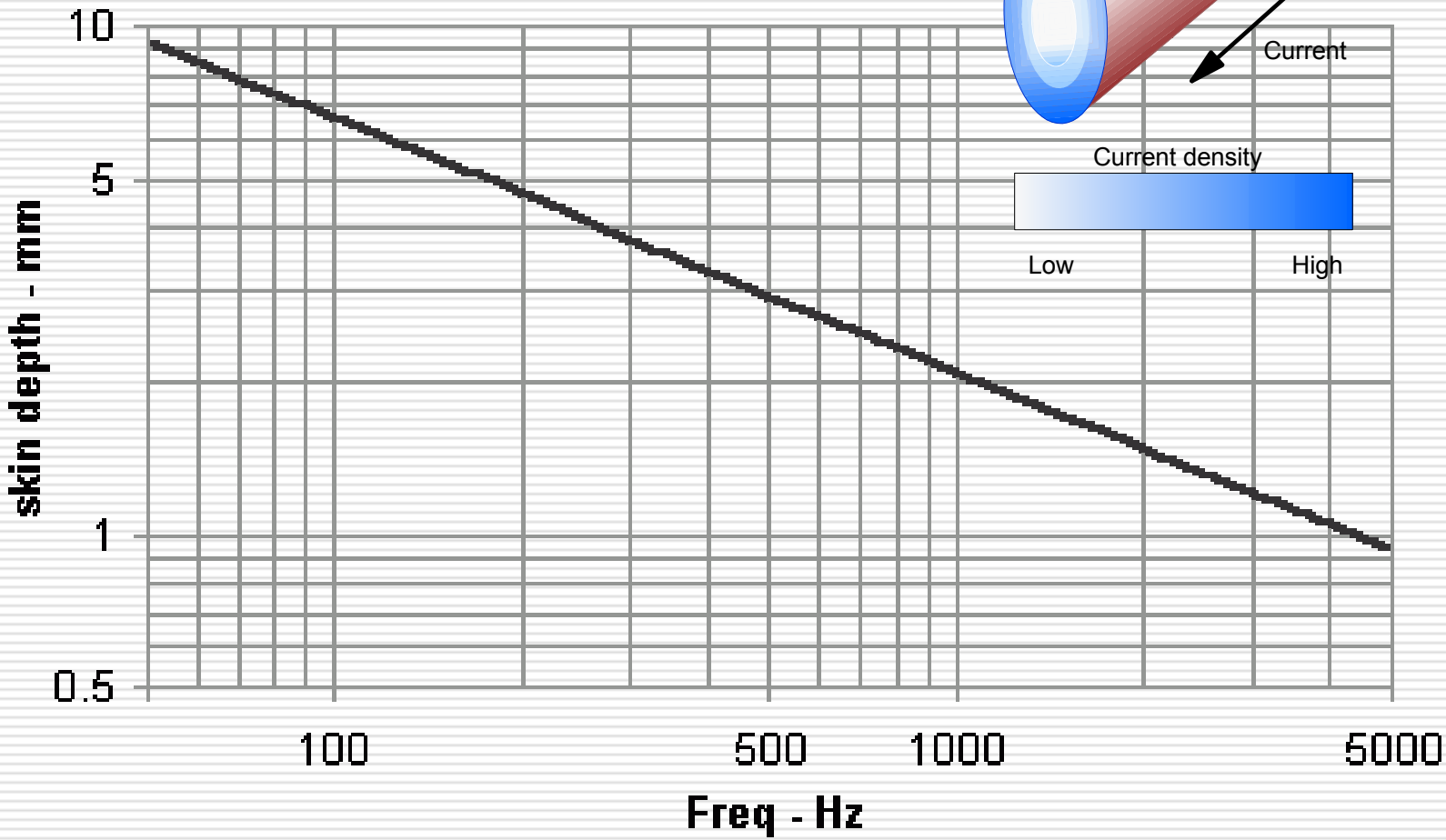
$$Depth\ (mm) = \frac{66.04}{\sqrt{f}}$$

REO (UK) LTD



Current density

Low High



REO (UK) LTD

Standards and Recommendations

- EN 61000-3-2

  Up to 16A/phase

  For Lighting Equipment > 25 W

  For Other Equipment > 75 W

- G5/4 Recommendations

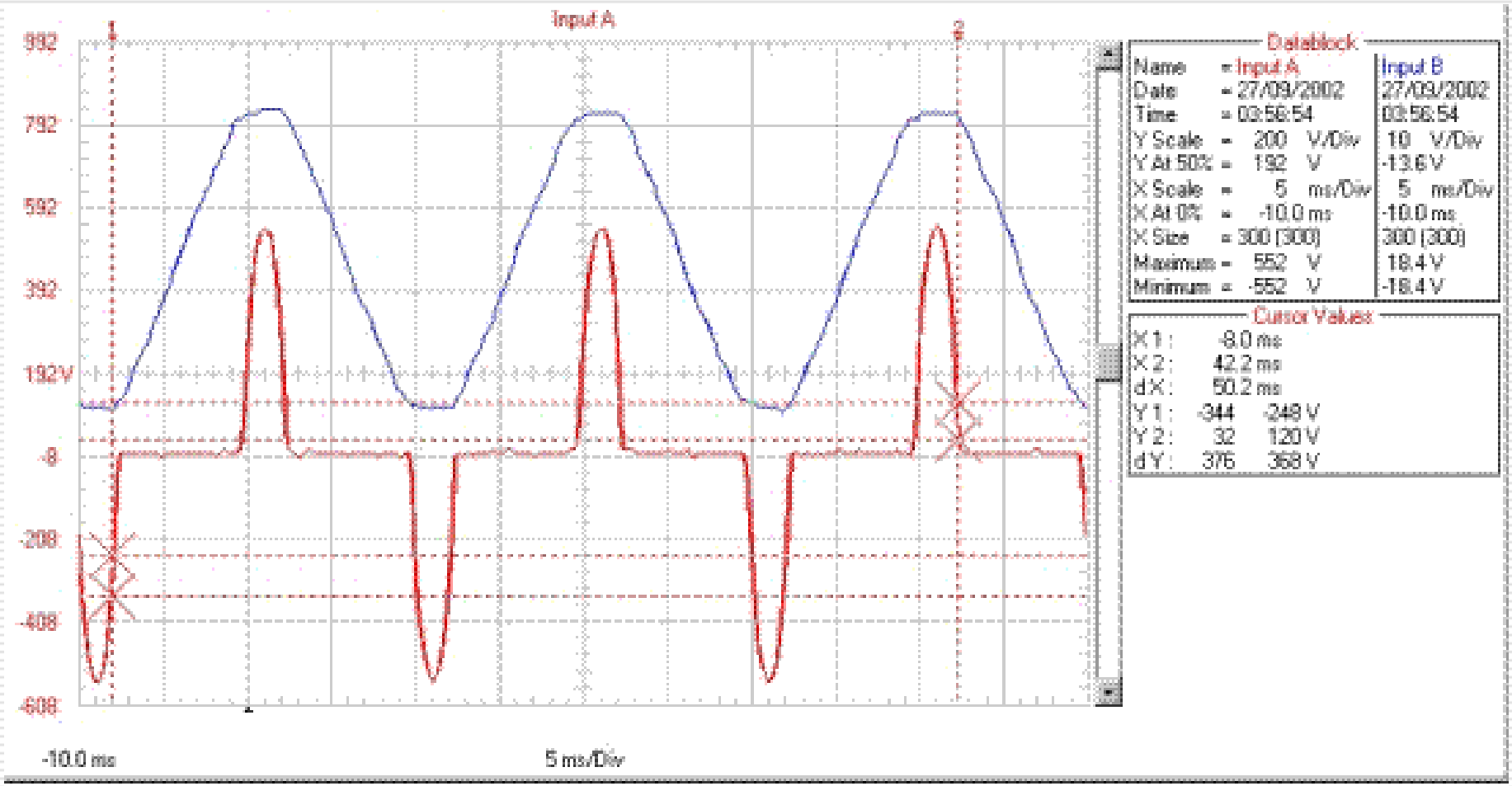
REO (UK) LTD

Harmonic distortion reduction techniques (medium power range)

- Line reactors or DC link reactors
- Star/Delta 12 pulse systems
- Active PFC
- PWM control of power transistors instead of using rectifiers
- Transformers with a high leakage inductance
- UPS that doesn’t generate harmonics
- Dedicated LV transformer

The effect of adding a 4% line reactor

REO (UK) LTD



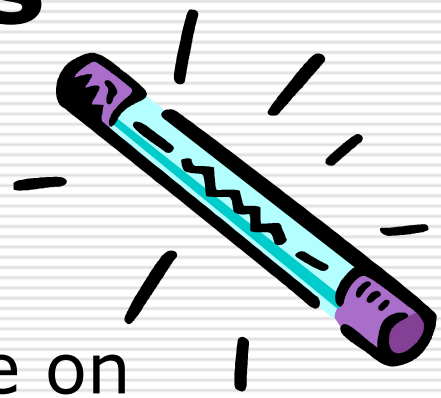
REO

REO (UK) LTD

Voltage variations

Dips, dropouts and interruptions (short duration of less than 1 min)

REO (UK) LTD



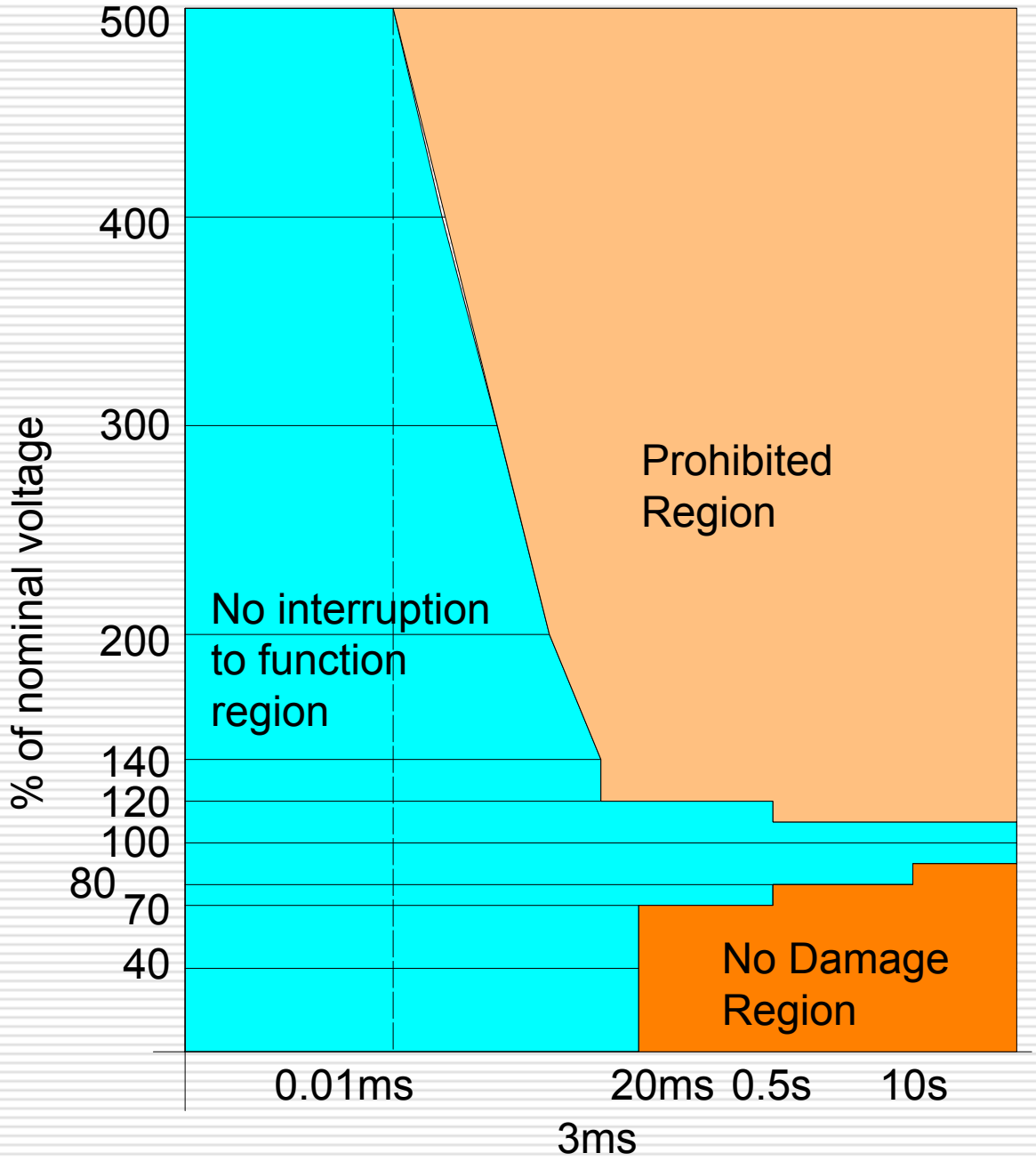
These are caused by:-

- Load switching and fault clearance on the mains network
- Switching to emergency power supplies such as a UPS
- Starting of large loads (motors can draw up to six times their full load current))

REO (UK) LTD

Dips, dropouts and interruptions can cause:-

- Domestic timers to stop
- Electromechanical devices, relays, contactors and solenoids to malfunction
- Protective circuits to close down
- Data loss on IT equipment



REO (UK) LTD

CBEMA Curve

Reproduced with permission from the Information Technology Industry Council (ITI)

REO (UK) LTD

Number of disturbances per annum caused by faults or switching operations in the public supply systems

(Source: International Union of Producers and Distributors of Electrical Energy (UNIPEDE): 1991, No. 50.02.)

Depth %	Duration			
	10 ms to <100 ms	100 ms to <500 ms	500 ms to <1s	1s to < 3s
10 to < 30	61	66	12	6
30 to < 60	8	36	4	1
60 to < 100	2	17	3	2
100	0	12	24	5

Source: EN 61000-4-11

BS EN 50160:2000 Voltage characteristics of electricity supplied by public distribution systems - permits

REO (UK) LTD

- Short term dips under 85% and less than 1 minute = 10 to 1000 times/year
- Interruptions under 1% and longer than 3 minutes = 10 to 50 times/year
- Transients up to 6 kV Line to Earth

Swells

REO (UK) LTD

Not so common but can be caused by:-

- Temporary voltage rise on non-faulty phases during a single line-to-ground fault
- Energising of a large capacitor bank

REO (UK) LTD

Over and under voltages (long duration)

- Can affect the performance of equipment
- Relays and contacts can drop-out
- Equipment can shut-down for protection e.g drives
- Can shorten the life of electrical goods
- More critical where supplies are less reliable or in remote areas.

REO (UK) LTD

Solutions for voltage variation problems

- Voltage stabilisers
- Constant voltage transformers
- Uninterruptible Power Supplies
- Multi-tapped transformers
- Switch-mode power supplies use their mark-space ratio to hold up the voltage but draw more current.

Blackout

Trains back after power surge

Rail services in the West Midlands are returning to normal after a power surge caused chaos for passengers at Birmingham New Street station.

The incident caused disruption to commuters.

Passengers faced major delays for several hours after the surge caused a power failure and disrupted signals just after 1330 BST on Friday.

Thousands of homes were briefly affected and some city centre shops had to move customers out when their lights failed.

An investigation has been launched into the incident.

A Network Rail spokeswoman said on Friday: "It affected the whole of Birmingham. Shops like Rackhams had to throw everyone out because they had no lights.

"There was a fluctuation that knocked out quite a lot of our equipment including the signalling which is the most important aspect.

ws Front Page
World
UK
England
thern Ireland
Scotland
Wales
Business
Politics
Health
Education
ience/Nature
Technology
ntertainment
Have Your Say
Magazine
Country Profiles
In Depth
Programmes
RELATED SITES
BBC SPORT
BBC WEATHER
BBC news
BBC ON THIS DAY

News Front Page
World
UK
England
Northern Ireland
Scotland
Wales
Business
Market Data
Your Money
E-Commerce
Economy
Companies
Fact Files
Politics
Health
Education
Science/Nature
Technology
Entertainment
Have Your Say
Magazine

Last Updated: Saturday, 16 August, 2003, 00:08 GMT 01:08 UK

E-mail this to a friend
Printable version

Firms struggle to resume business

Financial markets have recovered quickly from the effects of widespread power blackouts in the US and Canada, but transport problems still hit factories and offices.

The daily commute proved tricky

Many companies have been disrupted, especially in the vulnerable aviation sector.

Airlines have cancelled hundreds of flights and analysts say this may cost the industry tens of millions of dollars.

The New York Stock Exchange opened as usual on Friday, although trading was light as many people struggled to get into work.

In New York, Mayor Michael Bloomberg urged non-essential workers to take the day off, warning that the subway system

WATCH AND LISTEN
The BBC's John Terrett
"In the business and financial hub of the United States people have been jumpy ever since 9/11"
VIDEO

NORTH AMERICA BLACKOUT
KEY STORIES
Blackout 'originated in Ohio'
Bush urges US grid upgrade
Firms struggle to resume business
Net survives power outage

EYEWITNESS REPORTS

Homeward struggle
A young British intern describes her experiences in New York's blackout

Toronto's novel ways to cope
Initial fears of terror in New York

REO (UK) LTD

Stand-by power

- Uninterruptible Power Supplies
- Flywheel Generators
- Fuel Cells
- Diesel Generators

REO (UK) LTD

In conclusion

- If you design electrical equipment it is not adequate to rely purely on standards
- It is very likely that power quality (reliability) will worsen
- The authorities will continue to tighten-up on voltage distortion limits
- There are many power quality issues that engineers may not be aware of

REO

REO (UK) LTD

Free Guides!

Email:

main@reo.co.uk