Green Cementech 2010

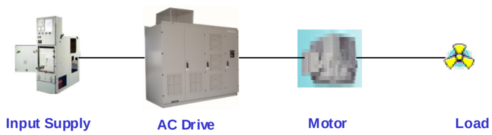
13th & 14th May 2010

Energy Saving
Medium Voltage Drives
For
Cement Industry

BKM

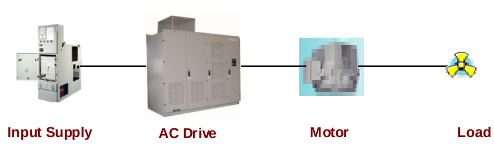
Date: 12.05.10, Rev 1

MV AC Drives : What are the concerns?



- Voltage & Current Harmonic Distortion
  Power factor
- Reliability
  Maintainability
  Efficiency
  Technology
- Harmonic heating
  Insulation stress
  Additional bearing current
- Rotational torque oscillations

MV AC Drives : What are the concerns?



Voltage & Current Harmonic Distortion

Power factor

Harmonic Distortion

Effect of Harmonic Distortion

- Poor Power factor, i.e., High current for given power
- Excessive heating of Motors
- High Acoustic noise from Transformers, Switch gear, bus bar etc,
- Abnormal heating of Transformer & Power Cables
- Damage of Power factor correction Capacitors

Harmonic Regulations

IEEE 519 – 1992 recommended practices are followed globally for Harmonics .

The philosophy of developing harmonic limits in this recommended practice is to

1. Limit the harmonic injection from individual customers so that they will not cause unacceptable voltage distortion levels for normal system characteristics
2. Limit the overall harmonic distortion of the system voltage supplied by the utility

The objectives of the current limits are to limit the maximum individual frequency voltage harmonic to 3% of the fundamental and the voltage THD to 5% for systems without a major parallel resonance at one of the injected harmonic frequencies.

Below Table indicates the system classification and distortion Limits

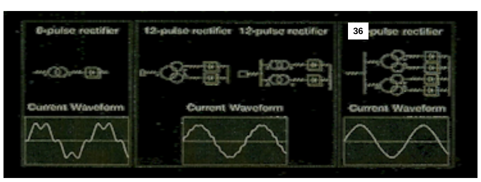
	Special Application	General System	Dedicated System
Voltage THD	3%	5%	10%

Harmonic Regulations

Current Distortion Limits for General Distribution Systems (120 V Through 69 000 V)						
Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_L	<11	11<=*h*<17	17<=*h*<23	23<=*h*<35	35<=*h*	TDD
<20	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

where
I_{sc} = maximum short-circuit current at PCC.
I_L = maximum demand load current (fundamental frequency component) at PCC.
TDD = Total Demand Distortion

High Pulse Rectification : Most effective Harmonics Mitigation Technique



- Harmonics 6n ± 1
- Predominant 5th, 7th, 11th, 13th, 17th, 19th, 23rd, 25th ……
- Amplitude of 5th is 1/5 i.e. 20% , 7th is 13% of fundamental
- Overall Current TDD ~ 35% -45%

→

- Harmonics 12n ± 1
- Predominant 11th, 13th, 23rd, 25th ……
- Predominant harmonics i.e. 5th , 7th, 17th , 19th are non existent
- Overall Current TDD ~ 13% -15%

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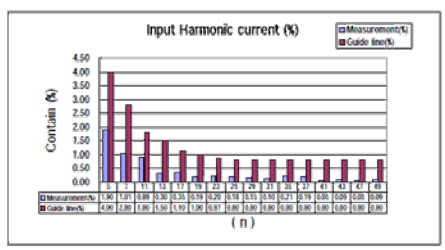
- Harmonics keeps on getting reduced as we go higher pulse rectification
- Overall Current TDD for 36 Pulse rectifier is as low as 1% - 3%

High Pulse Rectification : Only way to meet the guidelines



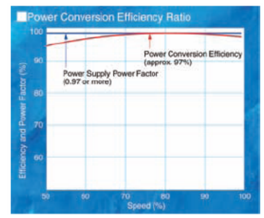
36 Pulse configuration reduces harmonic currents at primary side of Input transformer.

Passive Input Harmonic Filters : Not a long term solution

- L-C circuit are common harmonic filters which traps harmonic frequencies mainly 5th harmonic
- Over the period Capacitance i.e. C value changes due to aging resulting in de-tuning of these filters and thus leaving them in-effective
- Future addition of non-linear loads becomes a problem. Need to re-design with every new addition
- May trap harmonics from other sources, thereby causing overheating of the filter
- To be designed for additional bandwidth to take care of Input Frequency variation of +/- 5%. Unless designed with proper Bandwidth they become less effective during frequency variation
- In many instances the trap filter will sink currents from different parts of the plant. This may cause random circuit breaker tripping and blown fuses

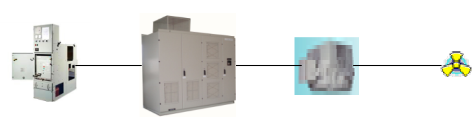
High Efficiency & Power factor

- **Direct medium-voltage inverter - No o/p transformer-power conversion efficiency of approx. 97%**
- **Power supply factor- kept at 0.97 or more**
- **Power factor improvement capacitor not required**



Efficient Use of Energy

MV AC Drives : What are the concerns?



Input Supply **AC Drive** **Motor** **Load**

Voltage & Current Harmonic Distortion

Power factor

Reliability

Maintainability

Efficiency

Technology

MV Inverter Construction : Compact and Maintenance Friendly

Transformer Section

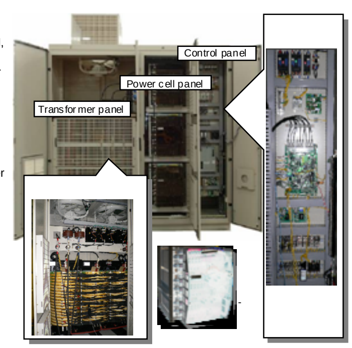
- Power supply lead-in terminal, output terminal section, and input multi-phase transformer stored.
- Air-cooled, dry-type transformer employed.

Power Cell Section

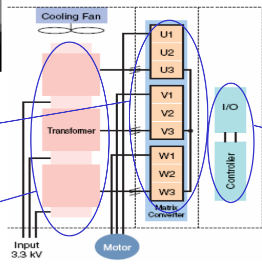
- 6 cells connected in series per Inverter output phase.
- Output phase star-connected to output 6 kV class directly.

Control Section

- Control board for multiple PWM control stored.
- Communication with power cells using noise resistant optical communications.



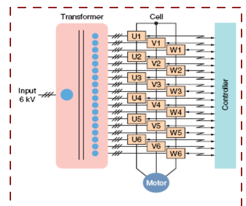
MV Inverter Construction : Compact and Maintenance Friendly



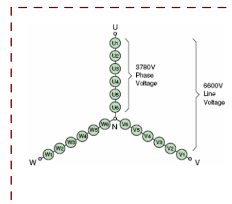
- Modular, Rack-out Construction
- Status LEDs available on the top
- Can be replaced within few Minutes
- Dry Type, Insulation Class 'H'
- 3 Wire in/ 3 Wire out
- Power Cells to Transformer winding connection Firm, Short & Factory tested
- State of Art based controls
- Each Cell is connected to controller on Fibre link
- Detailed diagnostics available on Digital Display

MV Inverter Configuration : Removable Cellular Technology

The modern day MV drives employ PWM control with multi-output connected in a series which connects 6 power cells per phase (phase inverter).



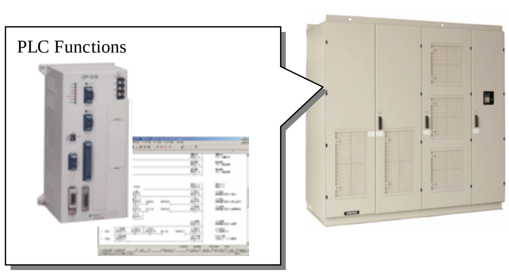
6.6 kV Example



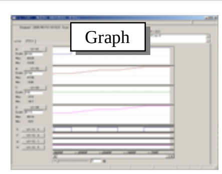
6.6 Power Cells per Phase

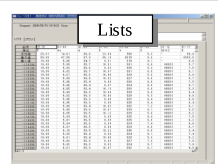
Intelligent Drive Functionality

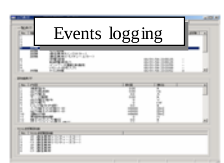
Using Built-in PLC function supports, Intelligent drives can be easily built

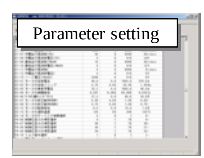


PC Based Diagnostic Tools

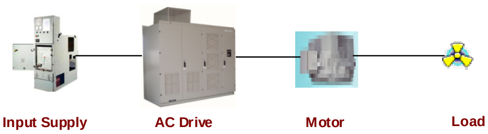








MV AC Drives : What are the concerns?



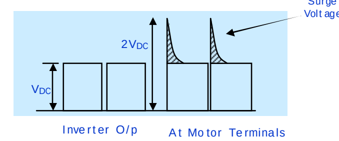
- Voltage & Current Harmonic Distortion
- Power factor

- Reliability
- Maintainability
- Efficiency
- Technology

- Harmonic heating
- Insulation stress
- Additional bearing current

Output Waveform reduces Motor Life

Effect of Reflecting Wave Phenomenon Due to High Cable Distance



Multi Level PWM ~ Motor Friendly Waveform

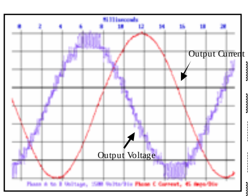
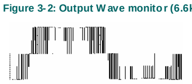


Figure 3-2: Output Wave monitor (6.6kV)



Multiple PWM control produce a sinusoidal waveform output voltage.

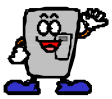
- External filters are not required.
- No appreciable audible motor noise
- Can be applied to existing normal motor
- Low torque pulsations even at low speed.
- Reducing the stress on mechanical equipment.
- Common mode voltage stress and dV/dt stress are minimized.

Multi Level PWM ~ No de-ration of Motor

Multi-level PWM Technology

- Multi-level PWM
  - Output Current close to Sine Wave → Operation at full original motor kW
  - Eliminates harmful Voltage Surges → No abnormal insulation stress
- → No Motor De-ration For Retrofitting

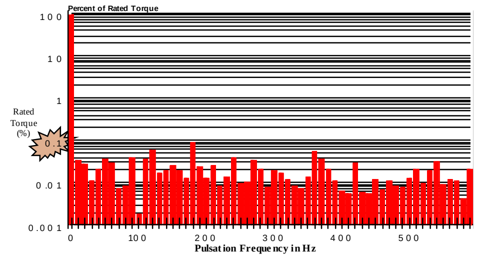
Multi Level PWM ~ Even Old Motors no problem



1. Reduction of Harmonic Current
2. Low surge voltage
   Suppresses surge voltage the motor, eliminating the need for surge voltage protection for the motor.
3. Electrolytic corrosion of motor bearings due to shaft voltage
4. Low electrical noise
   Significantly reduce conduction (power supply) noise and radiated noise caused by inverter drives, minimizing effects on peripheral devices.
5. Leakage current are greatly reduced.
6. Low acoustic noise
   Provides low acoustic noise, difficult to achieve with conventional designs.

Multi Level PWM ~ Least Torque Pulsations

Motor Compatibility –
Torque Pulsations with multiple PWM MV Inverter



Typical Torque Pulsations

MV Inverters - Summarizing Benefits

Clean Power Input

Sinusoidal input waveform
- Meet IEEE519 1992 Guideline
- Current distortion: 1 ~ 3%
- Voltage distortion: 1 ~ 2%
- No harmonics filter and active filter are not required

Energy Saving
- High Efficiency/High Power Factor
- Convert efficiency 97% or more
- Power factor 0.95 or more at all speed

On the Sinusoidal Path
- Sinusoidal output current
- Nearly Perfect Sinusoidal Output Voltage
- No resonance surge voltage
- Lowtorque ripple
- Noise is the same level as commercial power operation
- Existing motors and wiring be used

Maintainability
- Integrated Dry Type Transformer
- Rack-in Rack-out Cell construction
- Air Cooled
- PC Based Maintenance tool
- High Speed Trace Function