BAUMA 2013
AC Mining Haul Trucks –

April, 15-21th in Munich, Germany
Safety is our top priority

- Safety
- Reliability
- Productivity
Derived from locomotive traction systems, mobile mining motors and inverters offer a reliable high-power drive system, suitable for the rough environmental conditions of surface mining.

Integrated drive train – Gearbox matched with motor and inverter to allow toughest duty cycles for trucks and achieve high gradability.

**Customer value**

- High reliability
- Proven train technology for extreme environmental conditions
- High mean time between failure (mtbf) and low mean time to repair (mttr) for high availability
- Global service network for quick response
- Low Lifecycle Cost (LCC)
Siemens Powered Mining Trucks
History

1998: Prototype GTO trucks for Hitachi and Liebherr released

2005: AC IGBT water cool system released

2007: Direct trolley system for IGBT System released

Working with several OEMs to produce truck drive systems size from 240t to 400t

2000: Diesel boost trolley system developed
### Truck Portfolio

**Ultra Class Market**
- Before 2010
  - 200st: X
  - 240st: X
  - 280st: ✔
  - 320st: ✔
  - 360st: ✔
  - 400st: ✔

**Small Class Market**
- After 2010
  - 200st: ✔
  - 240st: ✔
  - 280st: ✔
  - 320st: ✔
  - 360st: ✔
  - 400st: ✔

- Complete drive train with gear box available for 260t & 330t (Siemens)
- Complete Trolley solution available for all sizes
And the World’s Largest AC Electric Truck – 500t
Mobile Mining WW Population
Trucks (714 – Ultra Class) Shovels (200) Draglines (8)
Benefits of Siemens AC Trucks
Benefits

- IGBT inverter system (simple and easy to maintain)
  - more efficient than previous GTO design
  - lightweight
  - easy to troubleshoot
- Inverter Cooling
  - Ultraclass (300t and above) – Liquid cooled
  - Small truck (240t and below) – Air cooled
- Dynamic Retarding – Higher Capacity than DC
  - Electrical Braking to ZERO speed.
  - IGBT Choppers are used instead of DC contractors
- Designed for typical operation on 12% total grades versus DC systems 10% capability
Benefits

- Higher maximum speed capability
  - AC – 64.4 km/h (40 mph)
  - DC – 48.8 km/h (30.3 mph)
- No commutator or brushes in an AC wheel motor
- Higher thermal limitations in an AC wheel motor
- Main blower and grid blower motors – AC
- System Cooling independent of Engine Speed – Fuel Savings

Insulated-Gate Bipolar Transistor (IGBT)
Smaller, lighter electronics package
Highest inverter reliability
- Fewer control components
- Less complex component
- Simpler control – easier to fault find
Showcasing the “Small Truck”
System Configuration – 240 st

**Major Components:**

- Alternator
- Inverter / Control Cabinet with two compact inverters, control unit (TCU), rectifier, alternator field regulator
- Main Blower
- Two traction motors
- One complete grid box with braking resistors and grid cooling blower
- Spindle with transmission
- Remote Diagnostics – MIDAS Reports - Optional
Alternator

- 3 Φ two main windings and an auxiliary winding (isolated) brushless AC generator
- Bearing and windings temperature monitoring
- 95 % efficient
Rectifier

Main Rectifier
- Two identical main rectifier for each winding of alternator and compact inverter
- Mounted inside cabinet, heat sink cooled by dirty air
- Junction temperature <90 deg C at worse case

Auxiliary Rectifier
- 3 ФAC 250V to 500V.
- Mounted inside cabinet, heat sink cooled by dirty air
- Junction temperature <85 deg C at worse case
Traction Motor

**Rated Data**
- 6 pole motor

**Peak Torque**
- 26000 NM propel

**Weight**
- 3385 kg / 7464lbs
- Single sided forced cooled
- Speed and Temperature signal combined in 1 plug
- Produced in Germany
Compact Inverter (2 units / truck)
Main Blower

- Identical blowers
- One is for inverter cabinet and alternator, the other is for motor
- Variable Speed Drive to adjust according to ambient temperature and altitude
- Lower maintenance, low noise
- Produced in USA
Grid Box

- The grid box is an assembly that is used to dissipate energy from the inverter system during braking (retard) of the mining truck.

- The energy is dissipated in the form of heat.

- The grid box consists of an air cooled motor and a fan assembly which is used to generate sufficient air flow to prevent overheating of the braking resistor banks that are connected in series.

- The grid blower fan is metal.

- The grid blower speed is adjusted according to the altitude and power.

- The grid blower motor is powered by ELFA inverter.
Grid Box Blower

- Dual fans driven by dual shaft motor
- Lower maintenance, low noise
- Four separated banks operated with IGBT choppers
- Rated speed 1750 to 2150 rpm
- Soft start: controlled by ELFA
- Produced in USA
Traction Control Unit (SiBAS)

- Si - Siemens
- B - Bahn (Train)
- A - Automation
- S - System

- Easy configuration, small interface card
- Sibas 32s interface between ZR and Compact Inverters
- Produced in Germany to meet strict traction drive control requirements.
- SII extended its use to trucks
Siemens Gear Box
Operational Features
**Temperature protection**

- **Automatic power reduction (APRS)**
  - Only for an over temperature compact inverter or alternator
  - Power is reduced to 75%
  - Driver is informed when APRS is activated

- **Shutdown limit**
  - Temperature limit where inverter is shut off, (pulse blocked)
  - Truck goes to limp mode (max 12 kph) if it’s from one side of drive
  - Driver is informed to stop truck

- **Reset limits**
  - Temperature restriction only resets when temp decreases
  - Even if reset occurs driver should get the over temperature investigated / repaired
Operational Features

**Shift lever validation**
- Drive system must always see only 1 selection (out of 5 possible)
- The last valid position is held while the truck is in motion
- Shift lever direction changes are ignored at speeds >5 kph
- Torque “plugging” will occur with direction changes <5 kph
- Service brake to “stand still” should be applied during direction changes

**Park brake**
- must be released before torque will be applied to the traction motors

**Brake lock**
- Must be released before torque is applied (unless D.O.S. is activated)
- Same truck solenoid used by drive system for zero speed retard
Operational Features

**Retard to zero speed (Service brake blending)**
- Torque is applied down to standstill
- Brake lock solenoid is turned on at <0.5 kph when retard/ brake pedal is >75 %

**Automatic hill start (Anti roll)**
- Activates when truck motion, opposite to the shift lever direction is detected or when shift level is at neutral
- Energizes brake lock solenoid to hold truck on grade
- Releases brake once sufficient torque has built up, no rolling back
- Release torque value based on load and grade (via PLM & inclinometer)
- Going to Neutral will cancel anti roll feature after park brake is on for 3 s
- Truck will roll in the direction of shift lever position
- Manual hill start is also available, if the override switch is used
### Operational Features

#### Slip slide control
- Used to maximize traction torque
- Slip or slide condition are calculated from rear wheel speeds
- Reduces torque for a short period to maintain traction
- Can be turned off with Traction Control switch in cab or disabled with a service PC
- Requires front wheel speed sensors

#### Cruise control
- 2 different modes available, propel & retard or retard only
- Familiar automotive type control
- Torque is ramped in and out to maintain speed, very little overshoot
- Truck will retard to keep speed as necessary
- Function is enabled/disabled via a service PC
Operational Features

Pedal Inputs

- Retard pedal provides braking torque (overrides throttle)
- Both pedal inputs are monitored for broken wires
- Independently fused 5 V supply power
- Could be calibrated via monitor program

Rest mode

- Commanded by a rocker switch in the operator cab
- Turns off blowers and discharges DC line to < 30 V
- Chopper set point maintained at < 30 V
- Still allows the engine speed to be controlled by the throttle
Operational Features

**Engine load testing**

- Used to test the engine power output
- Run using a service PC
- NO cable changes required
- All power from engine is pumped into the grids, both choppers are controlled to dissipate the power into resistor bank according to power setting.
- Truck can not be driven in this mode, test always done at stand still.
- Useful tool for troubleshooting the problem from engine, alternator, grid box, chopper circuit and field regulator.
Operational Features

Speed limits

Active Speed limits
- Can be adjusted up to system max via service PC
- Truck speed is regulated by drive system if driver’s input does not keep truck below the limit
- 7 different speed limits can be set
- Transitions are ramped prevent sudden changes

System speed limits
- Are meant to protect the truck and driver
- Maintain maximum permitted wheel motor rotation = 3600 rpm
- Certain system events will limit the maximum speed to < 16 kph
- Truck overloaded (not adjustable) & can not be optioned out!
- Hot Rotating Equipment
- Hot Inverters
Service
Siemens Value

- **MMP – Motor Management Programme** – Maximized Motor Reliability, Optimised Efficiency and Maintenance Costs and reduced Inventory Investment.
  - ✔ 30 % Improvement in Motor Reliability
  - ✔ 7 % to 15 % less downtime
  - ✔ 30 % reduction inventory holding levels
  - ✔ 10 % to 30 % reduction in motor maintenance costs

- Dedicated Siemens **Factory Motor Specialists** will be located within our Facility in Perth.

- **Global Network** leveraging from 253 Repair Facilities and more than 1300 Engineers.

- Siemens have **locally (9) Senior Engineers** with extensive experience in large LNG Projects.
MMDC Service Agreements

Premium Support 24h/8h
- Highest Priority Support
- Results within 2 hrs
- Rapid response save time & cost

Personal Contract Management
- Personal facilitation of your Services
- Presentation of the services delivery
- Performance against key metrics

Preventive Maintenance
- Minor, major & annual services (3, 6, 12 mths)
- Experienced service engineers that understand the instruments' functionality & apply to your process

Remote Diagnostics
- Faster problem diagnosis
- Worldwide skill-pool
- Lower travel cost
- Secure access

Customer Asset Evaluation
- Knowing status of your assets
- Equipment and spares status
- Identify spares requirement

Block of Service
- Facilitate rapid resolution of problems
- Enable service to be delivered at short notice e.g. Late at night

Motor Management Program
- 30% Improvement in Motor Reliability
- 7 to 15% less downtime
- 30% reduction inventory holding levels
- 10 to 30% reduction in motor maintenance cost

On-Site Part Service
- Replacement parts to suit your maintenance strategy
- Reduce capital outlay
- Reduce plant downtime
- Quarterly availability & quality check
Siemens Truck, shovels and draglines Worldwide Service Support

Rotation Eq.
Repair Centers
San Francisco, CA
Australia
Nuremberg
Johannesburg, SA
Indonesia
Chile
Canada

Canada
Ft. McMurray 1,
(4*) Kitchener(2)
USA
Alpharetta, GA 7 (5*)
Wyoming 1
Colombia
Cerrejon 3
Chile
Santiago 4
Zambia
Lumwana 1
South Africa
Johannesburg 2
Australia
Hunter Valley 2
Lake Lindsey 1
Russia
Indonesia
Mumbai 4
Jakarta 4
Brasil
Belohorizonte 2
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Siemens can deliver the appropriate solution to manage the primary systems from an E2E.

- Variable Speed Drives and Inverters
- HV and MV Motors
- Motor Management Program
- Remote Services Capability
- Data Acquisition, Management and Reporting
- Predictive Based Services not Reactive

Total System Approach
Summary

- Siemens has long experience with AC drive systems for haul trucks – more than 600 trucks in operation worldwide.
- Trolley assist is a proven technology – Increased power, speed, productivity, reduced energy costs, GREEN
- Reduced engine wear and greatly extended engine service intervals
- Mitigates risk for future carbon taxes
- Siemens offers feasibility studies for
  - Electrical truck drives, trolley equipment, conversion kit for trolley assists
  - Mine trolley electrification with substations and catenary system
  - Global service and support structure
  - Optional: erection, commissioning, relocations, maintenance, turnkey systems
Thank you for your attention!