



Mining Shovels SIMINE^{CIS} SH

Higher reliability and lower costs –
with AC Drive Systems for Mining Shovels

Mining Technologies

SIEMENS

How to maximize productivity and minimize operating costs

The challenge

Mines must look for the lowest cost per ton of material moved to remain profitable. This means moving the highest possible payload per hour while minimizing operating costs over the lifetime of the machine. Reliability in the harsh open-pit mining environment is of utmost importance. Machine availability of above 98%, including scheduled maintenance, is expected. This means high Mean Time Between Failures (MTBF) and a Mean Time To Repair (MTTR) of less than one hour. Power distribution systems in open-pit mines are often weak and overloaded, resulting in high voltage fluctuations at the shovel terminals. Finally, many mines are located in very remote areas such as the Andes mountains, the tar sands of northern Canada, or the deserts of Africa and central Australia.

Our solution

SIMINE^{CIS} SH is our drive and automation solution for large electric mining shovels. It combines over 25 years of Siemens AC shovel drive experience with innovative IGBT (Insulated Gate Bipolar Transistor) technology for the most reliable shovel solution with higher productivity and lower operating costs.

Higher productivity

Mining shovels with AC drives can operate faster than their counterparts with DC drives. AC induction motors allow higher stall torque, faster acceleration, and higher speeds in field weakening. This results in a larger area under the speed/torque curve and shorter machine cycle times.

Benchmark reliability

Our IGBT shovel drive systems operate routinely at above 98% availability. MTBF is in the thousands of hours and MTTR is typically less than one hour. We are

supporting our customers to keep these benchmark values high over the life of the machine. There is not a more reliable system on the market.

Less maintenance with Siemens technology

The excavator squirrel cage AC induction motors require only minimal attention – grease the bearings every six months and keep on digging. AC motors, unlike DC, have no brushes or commutators to wear out or to be maintained. IGBT power and digital SIBAS™ control modules require no routine maintenance. They come from our traction equipment line and are built to meet traction and military specifications. The modules are interchangeable between motions, as well as between different machine models.

Excellent distribution system compatibility

Today's large electric mining shovels represent peak loads of more than 3.5 MW to an often "weak" mine distribution system. Our system uses active IGBT rectifiers, also called Active Front Ends (AFEs) in place of conventional SCR rectifiers. This ensures uninterrupted operation even during line voltage fluctuations and provides unity machine power factor and a total harmonic distortion of less than 5% while improving dynamic machine performance.

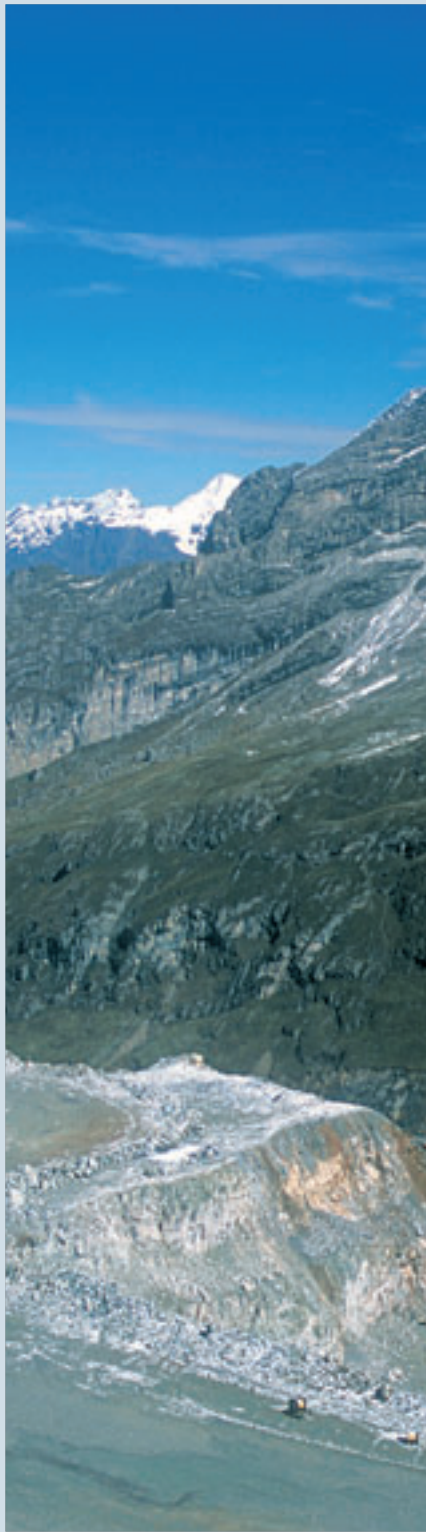
Lower life-cycle operating cost

Increased AC system efficiency combined with unity or leading power factor reduces energy costs. This, plus maintenance savings and smart controls, lowers machine operating costs over the complete life cycle.

Proven experience

We have provided AC shovel drive systems for more than 25 years. They operate from the Arctic Circle to the central Australian desert. Nobody can beat this wealth of experience.



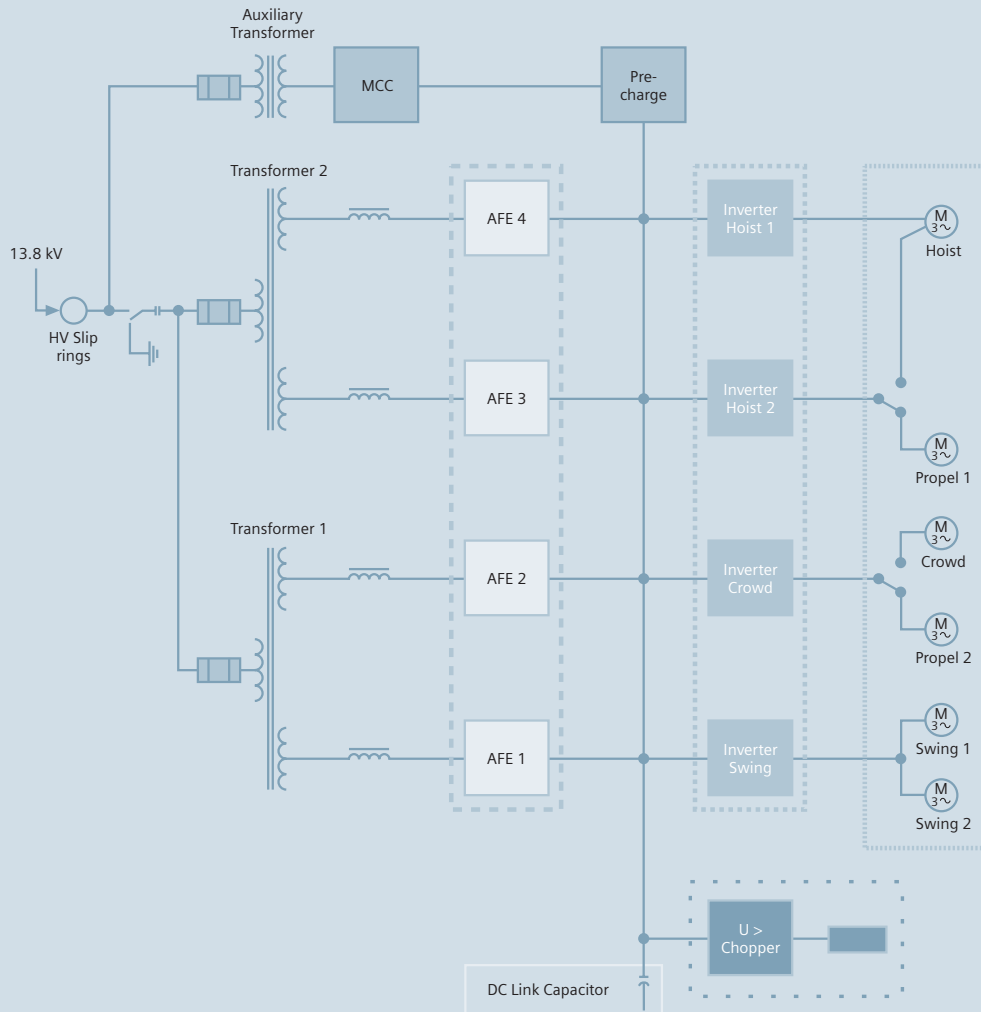


Good reasons for SIMINE^{CIS} SH

- Higher productivity
- Benchmark reliability
- Less maintenance with Siemens technology
- Excellent distribution system compatibility
- Lower life-cycle operating costs
- Proven experience

BI 495BII at 15,000 ft in the Peruvian Andes

More productive, more reliable: AC Drive System – how it works



System block diagram

Incoming AC power is fed from the slip rings via a high-voltage contactor and two 1-MVA power transformers with four 900-V secondaries to four active IGBT rectifiers, also called Active Front Ends (AFEs). The AFEs provide constant voltage for the DC bus capacitors, which filter the voltage and supply magnetizing current to the drive motors. A common DC bus for all drives enables exchange of energy between motoring and regenerating drives. Only one size of IGBT inverter is used to power the individual motions. The inverters are air-cooled or

water-cooled and use IGBTs to convert DC power into AC. A single inverter has an application rating of 1 MW, and an output voltage of 0 to 1,400 V. The Hoist drive uses two parallel inverters to power either the 1,670-kW/2,240-hp Hoist or the 522-kW/700-hp Propel motor. The Crowd inverter is switched between a 522-kW/700-hp Crowd motor and the second Propel motor. And the fourth inverter provides power for two 377-kW/505-hp Swing motors (Drive Specification BI-495BII HR).

Common skid design

One common welded inverter/control cabinet is used to accommodate all power and control electronics. The cabinet has been specially designed to withstand the shocks, vibrations and dusty atmosphere of the mining environment and features separate cooling circuits for control and power modules. Power and control wiring is prefabricated and pretested to reduce installation time and maximize reliability. The complete inverter/control unit undergoes a full functional and burn-in test before leaving the factory.



One common skid holds all IGBT power and control components.



Mining-duty Hoist motor with speed sensor

AFEs

Active IGBT rectifiers (AFEs) are used in place of self-commutated SCR rectifiers. The AFE is practically an inverter “turned around”. While the inverter uses a constant DC bus voltage as input and produces a 3-phase variable output voltage with variable frequency, the AFE uses the 3-phase line voltage as input and produces a constant DC bus voltage. The AFE control is set to regulate unity or even a leading power factor. This can be used to minimize voltage fluctuation in the mine’s distribution system. Due to forced commutation and high pulsing rate, the total harmonic current distortion (THD) is very low – typically less than 5%. In addition, AFEs improve dynamic response to load changes and are extremely robust against power grid disturbances.

IGBT inverters and control

The IGBT inverters, controlled by a SIBAS control unit, transform DC power at constant voltage into AC power at variable frequency and voltage to drive the shovel motors. During braking, the inverters send power from the motors back to the DC link. IGBTs have significant advantages: They allow high switching frequencies, which improves the current quality to the motors, require no snubbers and smaller, less complex gate drivers. They have a high overload capability, which enables electronic protection circuits without fuses. This has greatly increased reliability. Both AFEs and inverters use the same power modules with the same IGBT devices.

Motors

The squirrel-cage induction motors are specially designed for harsh excavator duty. Proven in all environments from arctic to tropical, they feature:

- fabricated steel frames
- heavy-duty bearings
- inside and outside bearing seals
- specially braced coils
- special shaft material

The electrical design is based on the excavator’s duty cycle and the IGBT inverter power supply. For cooling independently of the motor speed, the motors are force-ventilated. Heavy-duty digital pulse generators, which provide precise speed feedback to the control system, are mounted directly on the motor shafts.

Common IGBT platform – for shovels, draglines, and trucks

Common IGBT platform for shovels, draglines, and trucks

We will use a single drive design platform for powering shovels, draglines, and haul trucks. This common drive platform will substantially reduce costs associated with operations, training, maintenance and support. As a building block, we will use the proven IGBT power modules, air- or water-cooled with options to configure them into both OEM and retrofit applications for AC or DC motor control. Commonality of drive platforms in all three major pieces of equipment can significantly impact costs and productivity in a mining operation. Shovels, trucks and draglines typically contain multiple sub-systems from multiple vendors, requiring numerous solutions to handle power requirements, harmonics, motion control, automation, displays, and more. As equipment manufacturers and end users drive migration to AC controls with their inherent benefits – more efficiency, higher speeds, fewer parts, less maintenance, adjustable power factor and lower harmonics – a single drive design platform is the next logical step to reduce system complexity, training and maintenance requirements, and spare part inventories.

Intelligent Diagnostics Onboard Maintenance Computer

Our onboard Maintenance Computer allows the electrician to monitor all machine functions and to find and eliminate a fault quickly and easily without additional instrumentation. Faulty components identify themselves with location, part number, and exchange instructions. Active logic screens visualize the signal flow so the electrician can easily determine, for example, why the main contactor does not want to close.

SIMINE^{cis} SIRAS remote diagnostics

With SIMINE^{cis} SIRAS remote diagnostics, we can “keep the factory on the machine” to minimize downtime. Remote-access hardware and software connects the drive system to the Internet and allows Siemens service technicians, as well as other experts, to log on to the shovel from around the world for monitoring, troubleshooting and maintenance. SIMINE^{cis} SIRAS supports full two-way read/write communication so the remote expert can do exactly the same thing as the electrician on board – except for tightening a screw. Software upgrades can be downloaded to the shovel and installed during lunch breaks. The net result is a substantial reduction in MTTR, greater system availability, and reduced maintenance costs.

MIDAS™ productivity analysis

The MIDAS software package allows the user to monitor the performance of the shovel in real time or through a past log file. The data is relevant to multiple departments within the mine, including production, operator training, and maintenance. The concept is simple: “This is how my machine is behaving. How can I make it better?” MIDAS creates a continuous record of all important external input and output signals and presents them in a meaningful manner. This data can then

be viewed by multiple users at the same time. Log files allow the users to go “back in time” to analyze what was happening at the very second a fault occurred. A 2D model of the shovel is provided so users can see the machine in motion. A graphic operator interface allows to see what the machine operator was doing to make the shovel behave that way. Max/Min gauges monitor power section module temperatures, motor temperatures, reactor temperatures as well as air pressure and lube system pressure. With the addition of the Bearing Temperature option, all motor and gearbox bearing temperatures are also monitored.

With the **Load Weigh** option, real-time production data can be ascertained, including how much material is moved by each bucket, each truck, and each shift. The Siemens Load Weigh system measures the weight of the bucket indirectly, using no additional sensors. It does not require frequent recalibrations, as is required on most truck load weigh systems. Therefore, it is not only accurate within +/- 5%, but also very reliable and consistent.

The built-in **Report Generator** gives users the best/worst cycle times during a shift, and can be used to pin down what makes one operator perform better than another. Operator trainers can use this information to train their personnel, resulting in more tons per shift. In short, this powerful program can show how the machine behaves in its environment. Users from different camps can quickly see data relevant to their jobs and use it to produce precise documentation regarding system performance.

From online monitoring to special reports to troubleshooting – we offer flexible service concepts and highly qualified service personnel to maximize your shovel’s availability.

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