



SIEMENS

Ingenuity for life



SIMINE Haul Truck

How to execute material transport
at lowest cost per ton

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Maximum profitability needs maximum power

Your challenge:

In highly competitive global mining markets, operators of open-pit mines are well advised to choose the most powerful and best performing haul trucks with a proven track record of low maintenance and high reliability. These features depend heavily on the truck's drive system as the key element in a critical value-added chain.

The main goal of mining corporations is primarily aimed at reducing the cost per ton of bulk material to be handled over the life cycle of the assets, under consideration of tighter environmental, work safety and health legislations. To accomplish this, it requires operating large, reliable haul trucks which are able to cope with extreme climate conditions: from + 45°C in central Africa to – 40°C in Canada. Dust, shock and vibrations as well as soil conditions and mine profiles have to be taken into consideration too when it comes to choose the right truck for the right application.





Good reasons for SIMINE Truck

- Low operating costs
- Proven reliability
- Less maintenance
- Higher productivity
- Safe and environmentally friendly
- High degree of integration

Our solution:

To achieve maximum performance, the Siemens AC truck drive system efficiently channels all available diesel engine power. With higher diesel engine power utilization than pure mechanical drives can offer, the electric-driven truck pulls hard at stall to move away from the shovel, moves fast on grade up the ramp. With an onboard driving capacity of up to 4,800 kW, haul trucks equipped with Siemens AC drive systems are able to master uphill and downhill hauls at higher speeds than DC trucks and provide smooth, effortless electric braking all the way to standstill.

In addition, proven converter technology and innovative remote monitoring and management tools minimize the total cost of ownership (TCO). Better performance, higher availability, and significant reductions in operating and maintenance costs – it all adds up to more tons of material moved at lower costs. All this added up offers the most powerful electric truck drive system available on the market.

Truck drive systems based on Siemens converter technology including IGBT components provide high torque and enable the vehicle to accelerate quickly when carrying heavy loads or driving on soft roads, even from a standstill. Thanks to their high power

output, improved electric braking characteristics are also provided by the drive system. As a result, there is less wear on the mechanical brake. Siemens water-cooled IGBT converters are characterized by their high efficiency and reliability.

Apart from this, they feature unique control qualities as well as a higher degree of operational safety and reliability.

Good reasons for SIMINE Truck

Low operating costs

Our AC motors are more efficient than DC motors or mechanical drives. They also save you money on brushes and periodic commutator rebuilds. The differential torque control increases the life of tires and brakes. SIRAS remote diagnosis and MIDAS system analysis and management tools help prevent repairs and downtimes. In addition, sophisticated cooling technologies provide very high power levels in a compact package. Due to the fact that equipment weighs substantially less than DC drive systems, which leads to significantly less operating costs.

Proven reliability

In many industries worldwide, Siemens AC drives are renowned for their outstanding quality features and enhanced performance. Our AC drive systems represent the worldwide standard for variable-speed industrial applications. Advantages of Insulated Gate Bipolar Transistors (IGBT) include less weight and volume as well as increased efficiency and proven reliability.

Less maintenance

With Siemens AC drives, truck operators and mining companies achieve their goal to minimize maintenance expenditures. Without commutators or brushes, all that has to be done to maintain these motors is to lubricate them once a year. The power electronics at the heart of the drive system are essentially maintenance-free, having no power contactors or components that are subject to wear. The drive system also features state-of-the-art diagnostics and a modular structure that simplifies repairs and minimizes the mean time to repair.

Higher productivity

SIMINE truck drive systems provide high tractive forces at stall and enable the truck to move quickly, even on ramps, to transport more material in less time. SIMINE truck drive systems can be used with a trolley assist to overcome the limitations of engine power and increase speed on a gradient. By tapping into overhead electric lines, the drive system can boost speed by up to 80 percent, even while the engine idles.



High degree of integration

Mining companies value mobile mining equipment that in terms of reliability, cost and efficiency performs above average and therefore invest particularly in excavation and transportation technologies which meet their increased production demands best.

Integrated Drive Systems meet these particular requirements in an optimal way as individual system components are matched to each other. Siemens Integrated Drive Systems improve the truck performance through precisely integrated motors, traction drives, control systems and gearboxes. Having one trusted partner that delivers a complete drive system also simplifies the design and procurement processes, reducing the required production time and total cost. Augmented by a comprehensive suite of performance monitoring software and services, Siemens Integrated Drive Systems deliver additional benefits compared to purchasing separate drive components.

Safe and environmentally friendly

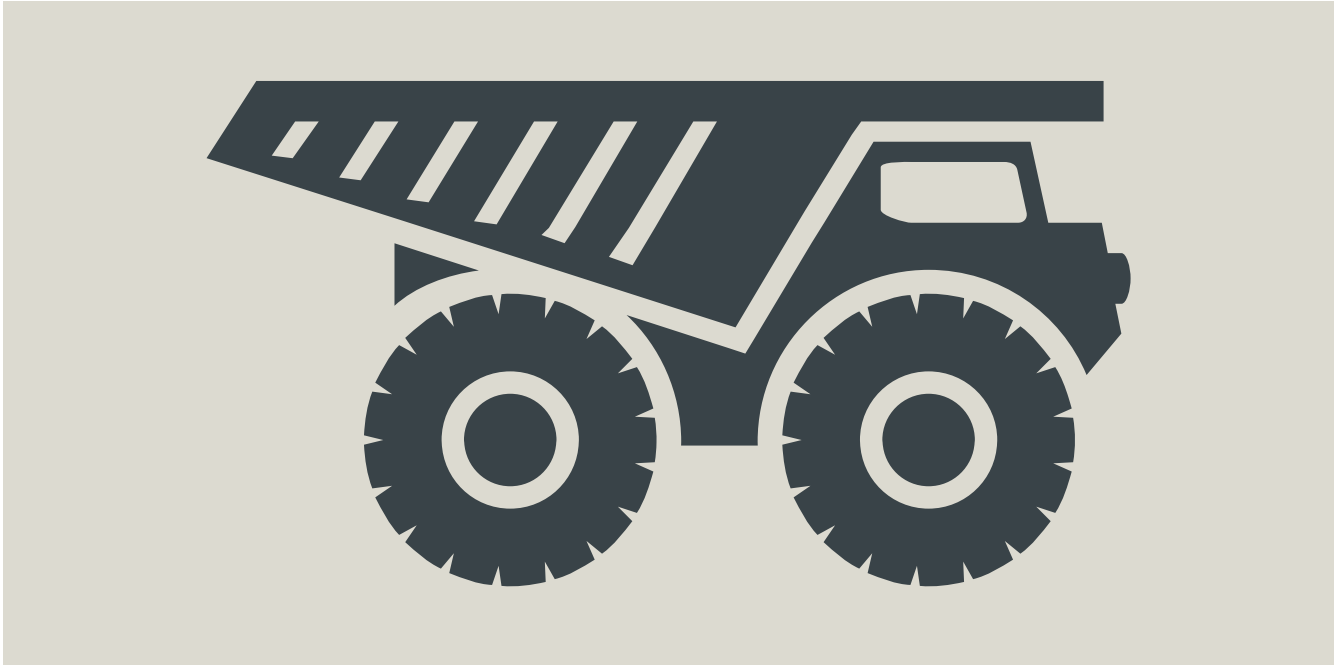
Enhanced control techniques and software features guarantee operational safety and drive system efficiency. In addition, the systems are designed to be both intrinsically secure and environmentally friendly. Furthermore, using the trolley system, the drive system consumes significantly less fuel, runs with higher efficiency and drastically reduces exhaust and noise emissions.



Faster, smoother, more efficient – the AC drive system

AC drive technology is the perfect choice for open-pit mining because it offers increased performance, low maintenance, and excellent compatibility with the harsh environment.





Higher performance

AC drive technology yields 6 – 7% higher efficiency than DC drives at higher power levels and provides significant improvements in control functions. Automatic brake blending, for example, delivers seamless, single-pedal slowing and stopping while slip / slide control maximizes traction. An automatic retard function keeps the truck within mine speed limits at all times. Anti-rollback provides one-pedal control on hills and cruise control functions in both propel and retard operating modes. Finally, a differential torque control enhances turning and reduces tire wear.

Less maintenance, lower operating costs

AC drive technology means no power contactors or degradable components. Except for periodic bearing lubrication, the system is inherently maintenance-free. Power slowing to standstill all but eliminates wear on the mechanical service brakes.

How it works – propulsion:

The traction alternator converts the mechanical energy of the diesel engine into DC current, charging the DC bus capacitors. The electric power passes the DC link to two inverters, which produce AC current for the traction motors. The output frequency and voltage of the inverters are controlled to provide precise motor torque and speed.

How it works – retardation:

In retardation mode, the motors apply braking torque by generating electricity which is converted to DC by the inverters. Braking choppers, connected to the inverters, channel that power straight into a resistor grid that continuously dissipates the energy until the truck reaches standstill. So braking is smooth, like driving a car, but without mechanical brake wear.

AC drive system – the perfect fit for Haul Trucks

The power unit

Diesel engine, alternator, and rectifier: AC power from the alternator is rectified to 1,800V DC and transferred to the motors via the traction inverters.

Braking choppers and resistor grids

Maintenance-free electric braking choppers are used in place of mechanical contactors to connect the powerful grid resistors. The retard pedal initiates immediate and smooth braking action. Capable of dissipating up to 6,000 horsepower, the braking system improves control and greatly reduces mechanical brake wear.

IGBT inverters and control

The inverters, motors, and alternator are cooled by a dedicated electric blower that operates independently of vehicle speed or engine rpm. This maximizes cooling performance and system reliability.

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 truck 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 transmitted to the motors. This means the drives require no snubbers, and smaller, less complex gate drivers.

IGBTs have a high overload capability, which enables electronic protection circuits without fuses, resulting in greatly increased reliability.

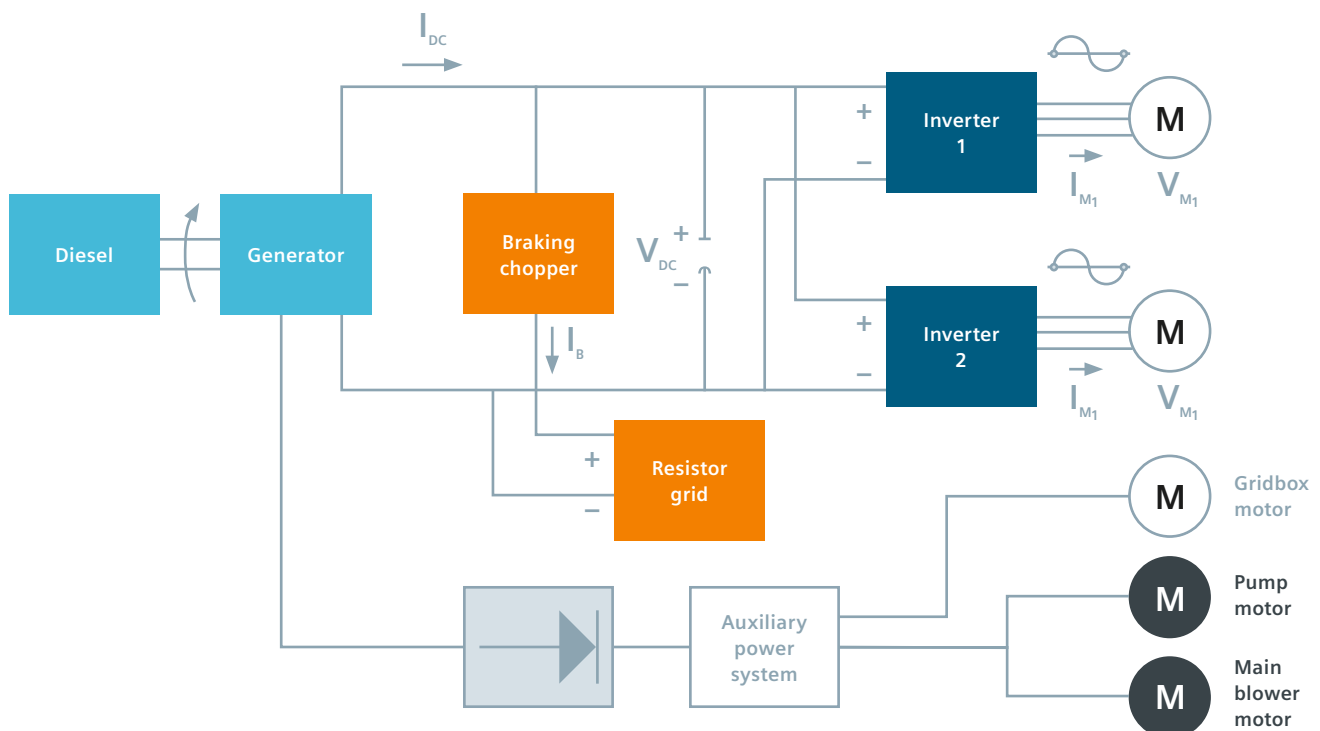
Traction motors and final drive

The cooling system is completely self-contained. The speed and cooling are controlled by numerous sensors.

The liquid pump circulates coolant to / from the radiator while the air heat exchanger equalizes the coolant temperature with the cabinet temperature. The high power density, closed cycle cooling, and standardized modules optimize the system's capability, reliability, and efficiency.

Auxiliary power system

The Siemens control unit along with high-quality engineering design makes the current power system one of the best. Our improved, high performance power system is lightweight, compact, and quiet. Maximum cooling can be reached even when the engine is at idle speed and minimum cooling is controlled when temperature is low. A smooth start of the motor without inrush current thereby increases the motor's life.



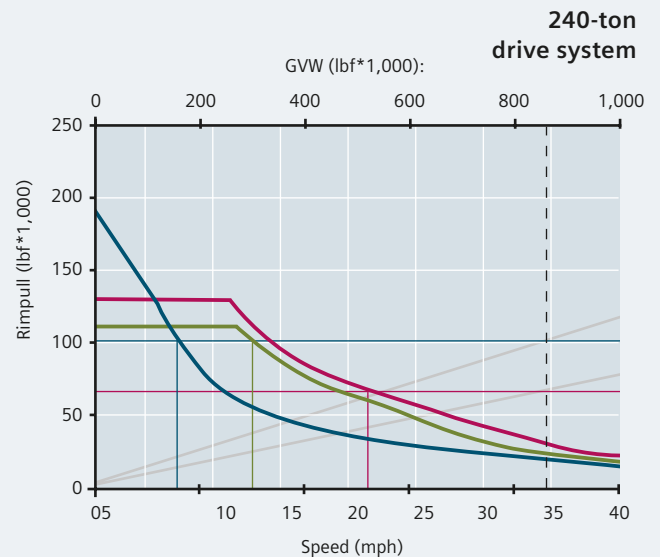
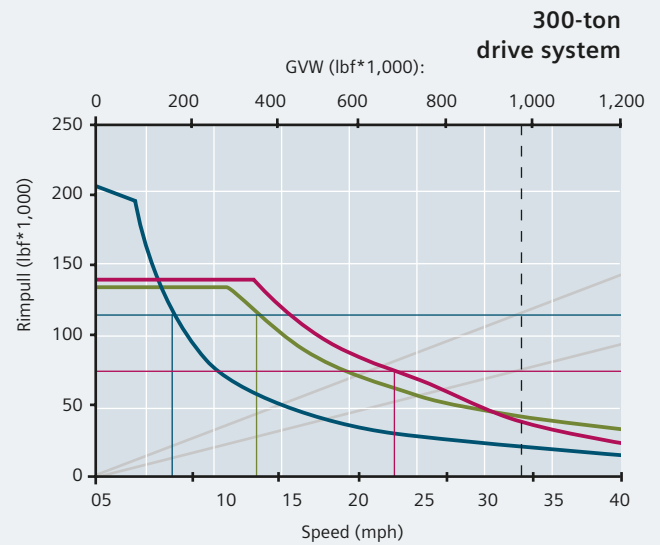
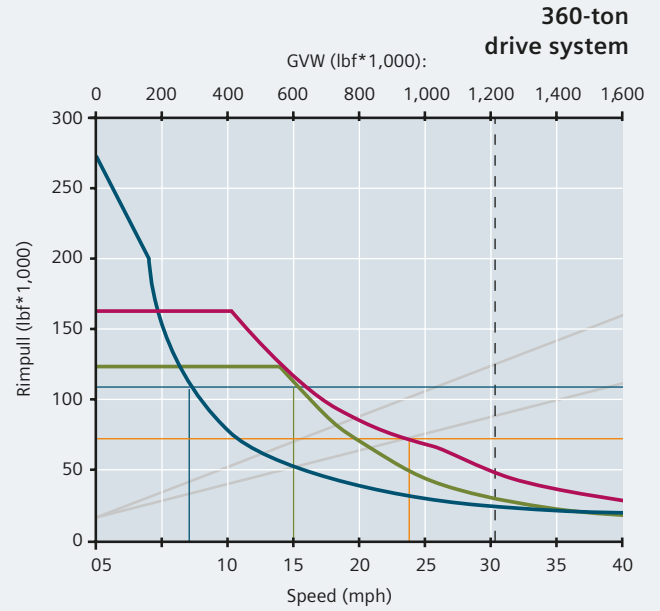
Water cooling system

The cooling system is completely self-contained. The speed and cooling are controlled by numerous sensors. The liquid pump circulates coolant to / from the radiator while the air heat exchanger equalizes the coolant temperature with the cabinet temperature. The high power density, closed cycle cooling, and standardized modules optimize the system's capability, reliability, and efficiency.



Power, rimpull, and truck speed:

Each drive system has very high traction forces (rimpull) for pulling away in soft ground and fully utilizes all available engine horsepower. Additional power available during trolley assist translates into higher speed on a gradient. Retard utilizes the full power capability of the AC drive system for the highest safe downhill speeds.



Keep things running with top-notch service

Siemens' service supports customers in maintaining peak machine performance throughout the entire life cycle. To this end, we provide professional service from the design stage through installation, commissioning, and in-field optimization, including advanced diagnostic tools that can be used for predictive maintenance and trend analysis.

From online monitoring to intervention to troubleshooting – we offer flexible service concepts and highly qualified service personnel to maximize your trucks' availability.



Never far from the mine

Centrally located service resources plus a worldwide and regional service presence are indispensable. That's why you can find us wherever trucks operate in open-pit mines – with our numerous Siemens service centers worldwide, and with specialized haul truck service personnel in the USA, Chile, Russia, India, Canada, Australia, and China.

Maintenance at its best

For complete peace of mind we offer remote monitoring and customized maintenance and repair contracts (MARC) together with the truck OEMs / distributors with parts-and-labor options. For example, your contract could include parts only, labor, supplementing the existing maintenance staff, or even complete coverage with all parts and labor.



MIDAS / SIRAS / SiCOM remote diagnostics and data analysis

More reliability and remote access

To achieve high uptime and short mean time to repair, we offer one of the most advanced and user-friendly maintenance hard- and software packages in the industry. Our sophisticated tools show the electrician where the problem is, and which part is needed to fix it.

SIRAS – bridging distances

SIRAS remote diagnostics hardware and software use well-advanced technology to “keep the factory on the machine.” Siemens service technicians and other experts can log on from around the world and do the same work as the electrician aboard the truck, except for physically tightening a screw, for example. Vital signs can be monitored for trends, and maintenance can be planned before failures occur. Software upgrades can be downloaded to the truck and installed during the truck’s downtime. The net result is a substantial reduction in mean time to repair, greater system availability, and reduced maintenance costs.

MIDAS – a new lever

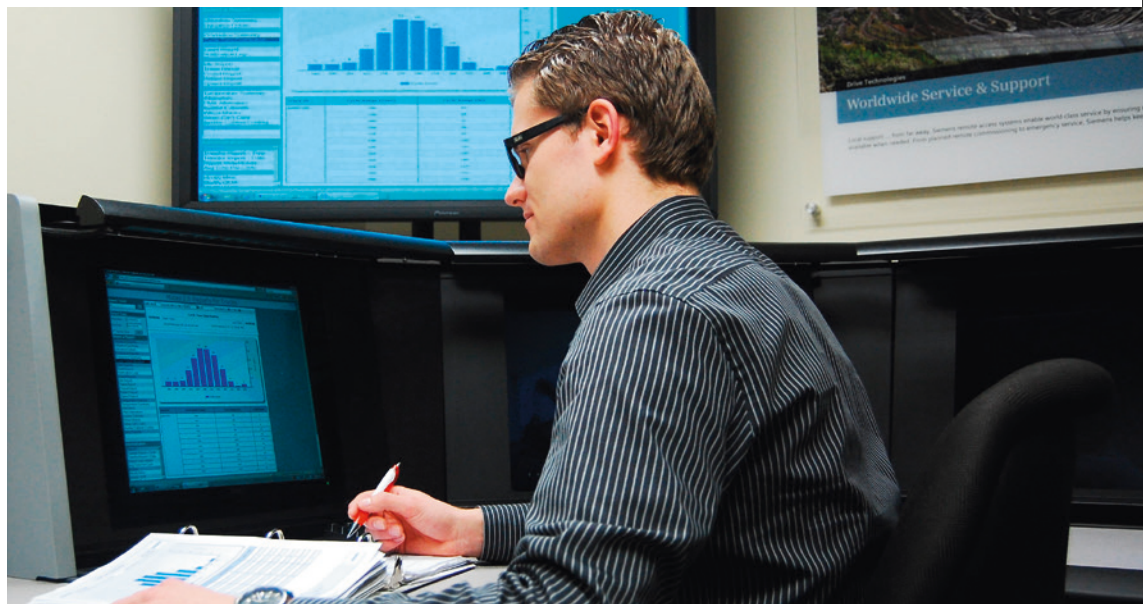
Investment in large earth-moving machinery can be leveraged by determining how to use it more effectively. MIDAS (from monitoring, interaction, diagnostics, analysis and service) is such a lever. It collects data during ongoing operation and uses this data to carry out analyses of production and to optimize systems.

This enables service engineers to gain access at all times to the key process, electrical and mechanical data of all the system components. As a result, a maintenance schedule can be drawn up in advance. The analysis of machine performance and productivity is carried out with the help of a plant information system.

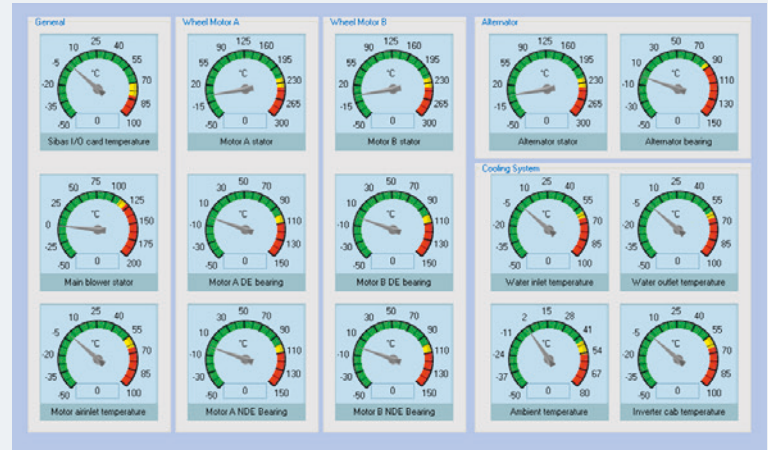
By integrating the MIDAS system into daily planning and monitoring habits, the end user gains more insight into the machine and how it is operated. In addition, new ways emerge how to use the machine more effectively and how to maximize production capability.

SiCOM

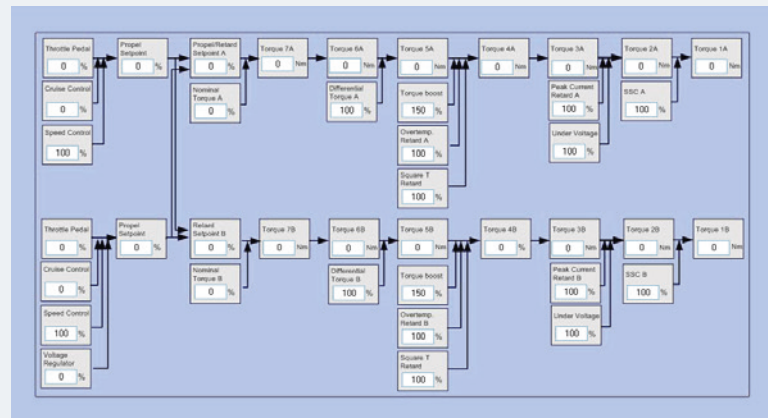
With SiCOM, mine technicians have a simpler interface to the SiBAS drive control system. Never before has it been so easy to download statistics and monitor signals online. In addition, SiCOM automates testing routines and streamlines commissioning.



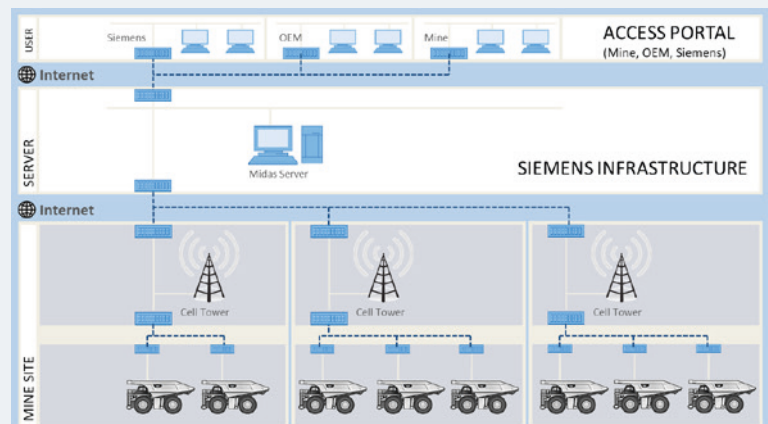
MIDAS enables precise monitoring of all relevant drive system parameters and provides full transparency to the operator.
Example: temperatures



With MIDAS real-time and recorded in-depth information about the operational status is displayed. This function supports trouble-shooting and is the basis for optimized system application and optimized TCO.



Consistent data acquisition and evaluation throughout the entire fleet enables precise monitoring and optimization of the truck fleet operation.



Trolley systems – the revival of efficiency and productivity

In the past, trolley systems were replaced by other truck systems. Now they are coming back. Normally, speed on a gradient is limited by diesel engine horsepower. If a truck could get more power by connecting to an overhead electric line while going uphill, it could climb faster.

The engine would be idling, and fuel consumption would be reduced by 95 percent. Noise and emissions would diminish, and productivity and engine life would rise significantly.



Higher speeds, shorter cycle times, leaner fleets

Can be used with trolley assist to overcome the limitations of engine power and to increase speed on a gradient. By tapping into overhead electric lines, the drive system can boost speed by up to 80 percent, even while the engine idles. Offering significant advantages over DC trolley assist systems, trucks with Siemens AC trolley assist can handle a wide range of line voltages and run on the line at any speed and payload.

Taking the line

In contrast to trucks with DC drives, trucks with Siemens AC drives can connect to a trolley at any speed, independent of the trolley line voltage. In addition, trucks can operate at existing line voltages of 1,400V – 1,800V DC or on new, more efficient, 1,800V lines. Even operating in mines with mixed systems is possible. The system automatically detects the line voltage when the operator “takes the line,” and switches to either high-voltage direct trolley operation or low-voltage diesel boost trolley operation.

Reduced operating and maintenance costs

Loaded travel on uphill grades typically accounts for 70 – 80 percent of a truck’s total fuel consumption. In addition, with engine operating and maintenance costs tied directly to fuel consumption, trolley assist further lowers your cost per ton of output because the time between engine overhauls may increase to double or more.

One-stop trolley shopping

Siemens can perform a site-specific evaluation – including haul profile data, cycle times, production requirements and energy prices – and create a cost-benefit analysis for possible trolley scenarios in your mine. Experience has shown that the higher productivity and reductions in energy and maintenance costs lead to an attractive IRR and payback time of one to three years. In addition, we can supply all trolley equipment and services – on the truck as well as in the mine. That includes pantographs, overhead lines, substations, and line position sensors, together with financing, maintenance, and service support.

Trolley wire position sensor

To ease trolley operation, Siemens offers a driver assist system. The indication of the pantograph position under the overhead line will be shown with an LED panel mounted above the driver’s dashboard. This way, the driver doesn’t have to look up, and keeps the truck right on track.

Environmentally friendly technology

The trolley system doesn’t use fuel, and it provides an even better efficiency factor than AC drives powered by fuel, so a minimal environmental impact with very low noise and diesel exhaust emissions is guaranteed.

System overview

The extreme conditions under which dump trucks have to operate around the clock in the mines pose high demands on operational reliability. Rough terrain with constantly changing mining roads, deficient infrastructure and high gross vehicle weights call for a reliable and flexible power supply system.

A trolley assist package co-developed by Siemens to supplement diesel-electric drives, the Truck Trolley System has established a fine track record in open-cast mines in a number of countries. This system enables the truck to operate on low-cost electricity.

The modular design of the individual system components facilitates the conversion of existing diesel trucks. An existing fleet of trucks can be converted with minimum effort thanks to a modular design incorporating field-proven standard components.

High flexibility is the hallmark of this logically-structured system – a feature which ensures easy adaption of the system to any customer requirements. Individual aspects of a mine's operation and the existing infrastructure can be channeled into the system during the design phase. Standard components ensure not only cost-efficient stocking of spare parts but also immediate removal of any faults that occur. The entire Truck Trolley System can be expanded, dismantled or moved without any difficulty, even after many years of operation.

The power supply via overhead contact lines increases the speed of the trucks, especially on gradients. With the standard motors available today, it is possible with this system to attain significantly higher operating speeds, which also means quicker turn-around times for the trucks and therefore increased haulage.

Previous experience has shown that the Truck Trolley System is a real economical and technical alternative, even in around-the-clock mining operations. The alternative supply of power from the overhead contact line instead of the diesel unit results in fuel savings of approximately 95% during operation on the trolley line. The electricity supplied through the catenary system is generated at lower cost and with minimal environmental impact.

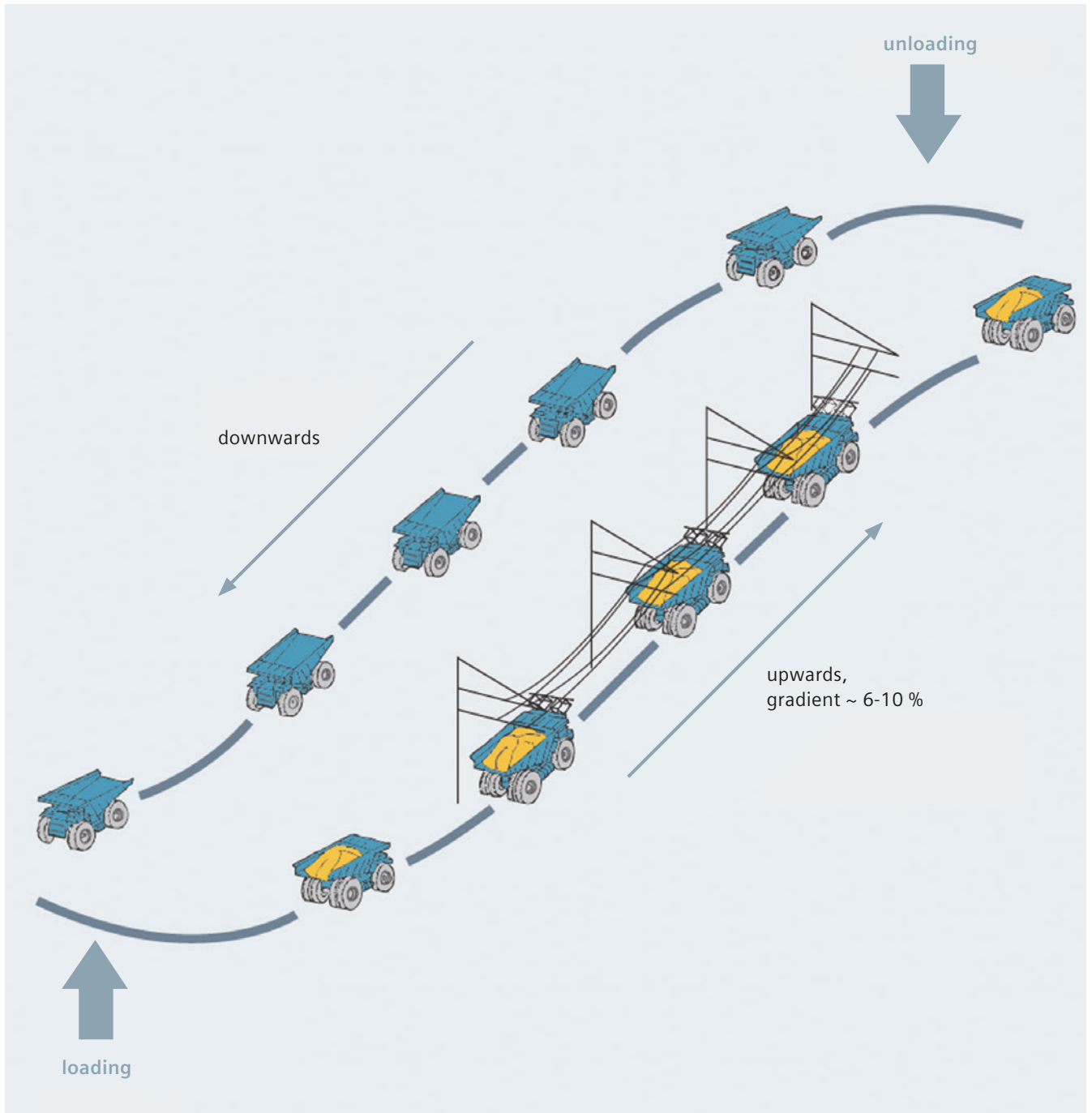
The design of the heavy-duty dump trucks is based on a diesel-electric diesel-electric systems which powers the wheel motors of the rear axles.

To permit truck trolley operation, the vehicle is equipped with a conversion package which comprises a control unit with electric and electronic components, two pantographs with corresponding support frame, and the necessary cabling. The completely preassembled control unit is mounted in a cubicle.

Carbon strips establish the contact between the pantographs and the overhead contact wires and ensure optimum current collection with minimum contact wire wear. The power necessary for electric operation is supplied via overhead contact lines. The vehicle changes over from diesel-electric operation to full electric drive as soon as the raised pantographs make contact with the catenaries. This modal changeover occurs automatically when the control system installed in the dump truck detects the specified parameters such as contact wire voltage and minimum speed of the truck.

The Truck Trolley System is most economical on the ramps, where most of the total energy is consumed. Therefore, the trolley is normally installed on the uphill stretch where the benefits of fuel savings and increased speed are greatest.

The drawing shows the normal case, the trucks drive up the ramp with a high gradient from the loading point to the place where they dump the load. Then they drive down the same gradient or ramp empty.



Simplified example of truck operation with the Truck Trolley System

Truck conversion

The illustration shows the additional equipment necessary for trolley assisted operation. Two pantographs are mounted parallel to the front of the truck, so that electric power can be collected from overhead lines. Additional control devices are added to the truck, so that power from the overhead contact lines can be transmitted correctly to the wheel motors.

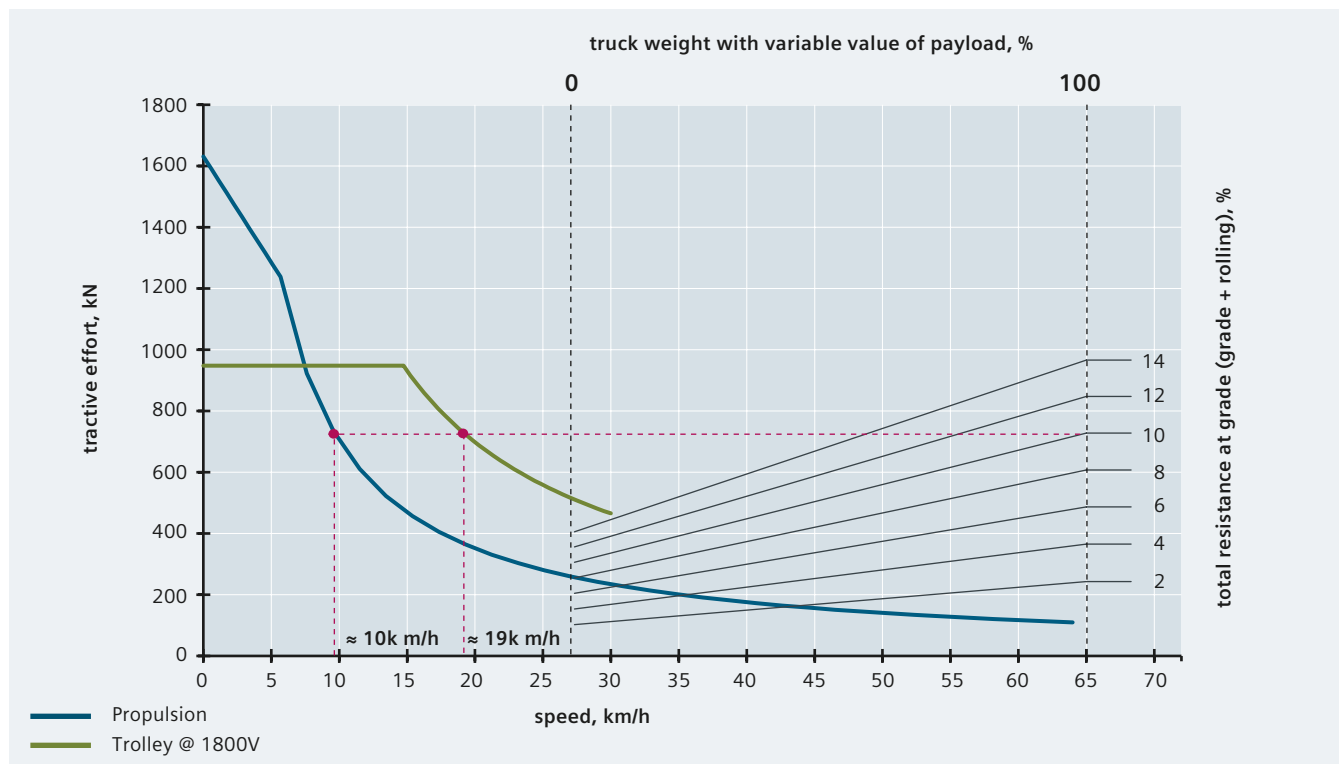
When the truck is connected to the trolley line, the diesel engine and alternator are not used for propulsion. The engine automatically drops to idling speed, with all the power for propulsion coming from the overhead lines. The system is designed to provide the highest possible line voltage which the drive and motors can safely handle, so that the truck will operate at the highest possible speed.

The speed of a diesel-powered truck is limited by its engine horsepower, but the speed of a trolley truck is only limited by the capabilities of its drive traction motors. The truck speed performance chart shows the tractive effort characteristic of different operation modes. The blue curve (diesel operation) shows the limitation of traction capacity given

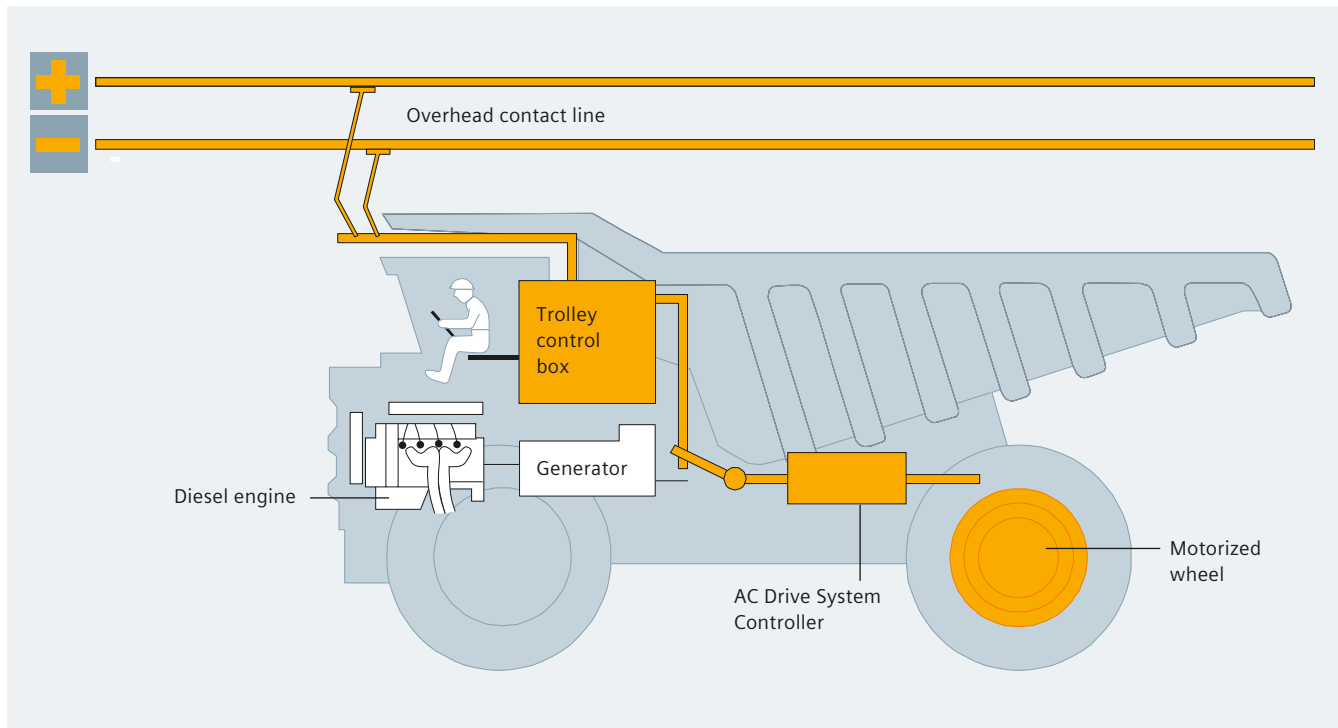
by the diesel engine. For retarding (red line) the dimensioning of the AC-drive system enables full power capacity and highest safety at the same time. When fed from a trolley line, the higher capacity of the drive system is usable for traction purposes as long term capacity. This can double the speed of a loaded truck on an uphill ramp. The reduced truck cycle time leads to higher productivity using the same number of trucks.

Power supply from a trolley line reduces expenses for maintenance, especially for the diesel engine. Furthermore the diesel consumption will be decreased in a significant manner. This leads to less environmental impacts and prevents operation restrictions because of dust limitations in mines.

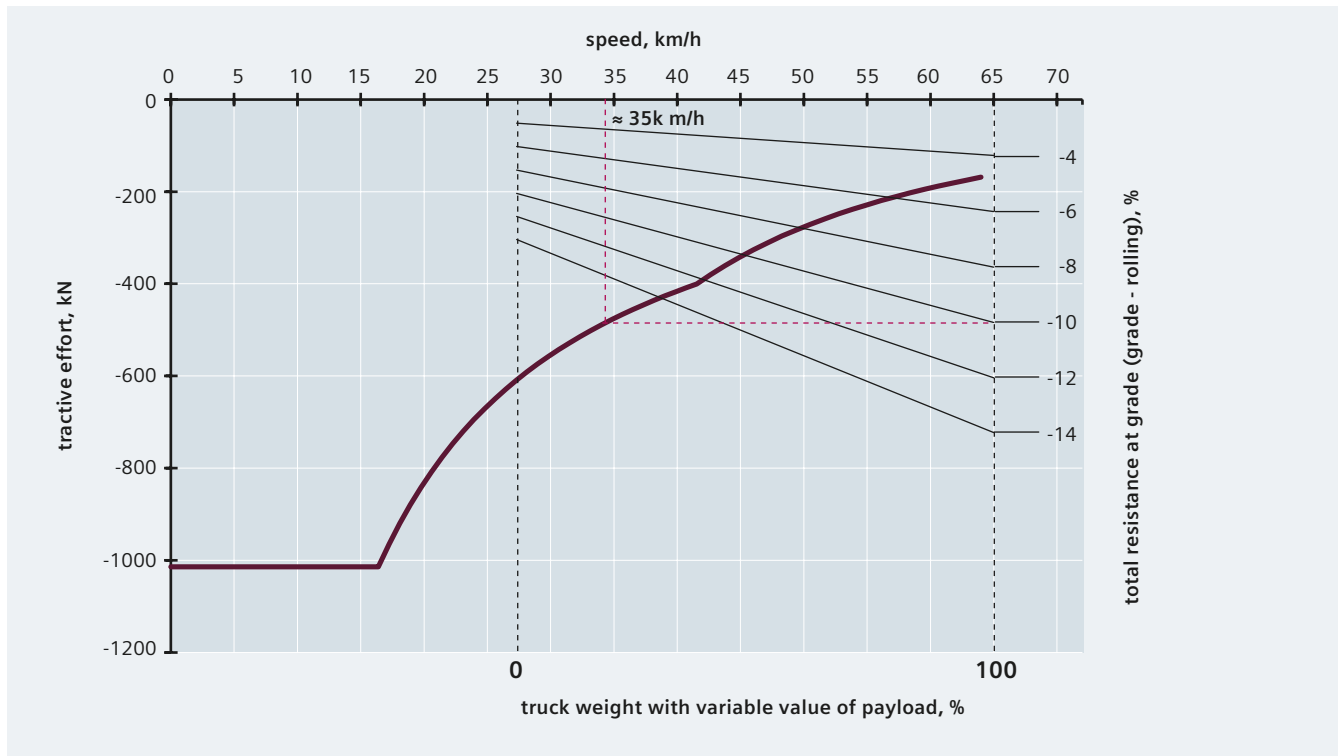
Using an AC drive system, there is no speed limit for a truck entering / connecting to the trolley lines. Combining an AC drive system with a Siemens trolley feeding system maximizes the operation flexibility and efficiency.



Propulsion performance characteristics of dump truck with nominal 400 short tons (360 metric tons) payload with MMT400 drive system, 59 80R63 type tires and 38.05:1 gear ratio.



Schematic view of converted truck



Retard performance characteristics of dump truck with nominal 400 short tons (360 metric tons) payload with MMT400 drive system, 59 80R63 type tires and 38.05:1 gear ratio.

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