Application Guide

AT THE HEART OF POWER ELECTRONICS
Solutions for specific Applications

LEM solutions for electrical measurements

LEM has been the market leader in providing innovative and high quality solutions for measuring electrical parameters for the last 40 years. Its core products - current and voltage transducers - are used in a broad range of applications including drives & welding, renewable energies & power supplies, traction, high precision, conventional and green vehicle businesses.
With higher accuracy and speed, the feedback signal from LEM transducers enables smoother control and energy consumption reduction of many electrical systems.

At the heart of … DRIVES

In most lifts installed worldwide, LEM transducers prevent the doors closing on passengers. They keep the cabin stable when people enter, and ensure that the lift rides smoothly by adjusting the torque of the motor.

DRIVES & WELDING MARKET

Today, the transducer market has two main technology drivers: first, the desire for a greater degree of comfort and finer regulation, and second, the need to save energy. This means that more and more applications that used to be mechanical are changing to fully electronic control which provides increased reliability, improved regulation and higher energy efficiency.
Today, about 15 % of all motors have an inverter control. This inverter can save 50 % of the total energy consumed, which is a huge potential for savings.
The inverter control used in these newer systems requires reliable, accurate current measurement to enable engineers to develop a system with isolated current measurement directly on the motor phases.
LEM products are already used among a broad spectrum of power electronics applications such as industrial motor drives, UPS, welding, robots, cranes, cable cars, ski lifts, elevators, ventilation, air-conditioning, power supplies for computer servers, and telecom.
This trend towards more involved power electronics happens in a general manner in the industrial world, for example, in lighting, domestic appliances, computers and telecom applications. Power electronics increases efficiency by delivering the correct type of power at the most efficient voltage, current and frequency.

At the heart of … RENEWABLE ENERGIES

LEM transducers, specifically designed for renewable power systems, control the flow and waveform of energy sent to the grid from photovoltaic and other renewable energy systems. They measure the current to help the windmills and solar installations to work at their maximum efficiency.

RENEWABLE ENERGIES & POWER SUPPLIES MARKET

Energy savings are the key words today and this includes the exploitation of the wind and the sun as alternate energies. To use these renewable sources in the most energy efficient way, the use of power electronics is a must and is essential to drive and control energy in industrial applications.
Modern systems are becoming more complex and require precise coordination between the power semiconductors, the system controller, mechanics, and the feedback sensors.

Transducers provide the necessary information from the load to fulfill that function. We can compare the use of transducers to adding “eyes” to the system. They can supply the “brain” of the system, in real time, with information regarding the condition of the controller.

At the heart of … TRACTION

Regardless of whether a train is powered by diesel or electricity, traction is provided by electric motors driven by inverters that are relying on LEM transducers to measure, optimize and adjust the power that is sent to the motors, improving both performance and reliability.

TRACTION & TRACKSIDE MARKET

Today, high speed trains, city transit systems (metro, trams, and trolleybuses) and freight trains are the solutions against pollution and interstate traffic immobility, and provide significant energy savings.
Power electronics is essential to drive and control energy in these transportation systems.
LEM has been the market leader in traction power electronics applications and development for the last 40 years and leverages this vast experience to supply solutions for isolated current and voltage measurements.
LEM transducers provide control and protection to power converters and inverters that regulate energy to the electric motors (for propulsion) and to the auxiliaries (for air conditioning, heating, lighting, electrical doors, ventilation, etc.). This includes the incoming monitoring of the voltage network (changing by crossing European borders) to make the power electronics work accordingly.
Although this is true for on-board applications, LEM has also provided the same control and protection signals for wayside substations.
The rail industry is under constant change and evolution. As a recent example, the privatization of the rail networks raised new requirements for which LEM provides: the onboard monitoring of power consumption (EM4T II Energy Meter), solutions for trackside applications, rail maintenance and the monitoring of points (switches) machines or signaling conditions with some new transducers families.

At the heart of … HIGH PRECISION APPLICATIONS

The current transducer used has a direct impact on the image and if the transducer is not precise enough this will lead to a blurred and illegible image. LEM current transducers set a standard for accuracy and are the most precise industrial products in the market today. The transducers provide levels of stability and precision, at about 1–3 parts per million, which makes them references in calibration test benches or in laboratories.

HIGH PRECISION MARKET

Certain power-electronics applications require such high performance in accuracy, drift and/or response time that is necessary to switch to other technologies to achieve these goals. The validation of customer equipment is made through recognized laboratories using high-performance test benches supported by high-technology equipment including extremely accurate current transducers. These transducers are still in need today for such traditional applications but are more and more in demand in high-performance industrial applications, specifically medical equipment (scanners, MRI, etc.), precision motor controllers, and metering or accessories for measuring and test equipment. LEM has been the leader for years in producing transducers with high performance and competitive costs for these markets.

The 2009 acquisition of the Danish company, Danfysik ACP A/S, as being the world's leader in the development and manufacturing of very-high precision current transducers, reinforced this position.

To achieve this challenging target of accuracy and performance, LEM's current transducers for the high precision market use an established and proven technology, the Fluxgate technology deployed in different alternatives.
Thanks to this technology we can claim accuracies in the parts per million (PPMs) of the nominal magnitude giving an idea about the performance achieved.

The high-accuracy product range covers transducers for nominal current measurements from 12.5 A to 24 kA while providing overall accuracies at ambient temperatures (25°C) of only a few PPM. Thermal offset drifts are extremely low, only a few PPM per Kelvin (K).

At the heart of … AUTOMOTIVE

In electric and hybrid vehicles, LEM transducers monitor energy levels to and from the battery and are critical in the control of the electric motors.

AUTOMOTIVE MARKET

In the automotive market, LEM works with all the major car manufacturers and Tier-1 suppliers in the world, and supplies galvanically-isolated electronic transducers that measure currents in battery-management and motor-control applications.

The ever more stringent requirements for energy efficiency and reduced CO2 emissions lead car manufacturers to increasingly depend on on-board electrical components. From electric power-steering and stop-start technologies to on-board navigation and infotainment systems, these components put an additional load on the electrical circuits and particularly the battery, making it essential to control the energy generated and consumed by the various on-board systems. In collaboration with its customers and with the help of powerful simulation techniques, LEM uses the most-appropriate technology (from Hall-cell to fluxgate) to measure the currents entering and leaving the car's battery and/or the alternator. This allows an intelligent management of available power that leads to the increased efficiency of today's internal-combustion engines. More importantly still, the hybrid- and electric-vehicles entering the market today depend on accurate measurement of battery-pack currents to determine the available driving range and recharging strategy. LEM has the technology.
Not only must battery currents be accurately measured in hybrid- and electric-vehicles, but the electric motors driving the wheels of this new generation of automobiles also need to be precisely controlled to allow smooth operation. Electric motor phase-current sensing has been LEM's core competency since its beginning and remains today a major application for its technology. LEM has a dedicated product range for measuring phase-currents in motors and DC-DC converters essential to all hybrid- and electric-vehicles.

It is our business to provide you with both standard and customised products to optimize your applications all around the world. We have regional sales offices and production facilities in Switzerland, Europe (including Russia and Bulgaria) and Asia (China and Japan).

ABC OF TRANSDUCERS

Transducers are hidden at the heart of power electronics applications. Without noticing it, you probably walk by and even use several LEM transducers every day. They are present in trains, buses, elevators, and all sorts of technical equipment such as industrial drives on motors, welders, inverters, electric vehicles and battery-backed uninterruptible power supplies (UPS) in computer servers.

The function of a transducer is not, as with an ammeter, to take a measurement and record it, but to supply an isolated signal indicating the exact value of a constantly varying current. Used as a feedback for control purposes, this signal allows accurate and smooth adjustment of equipment operation. LEM transducers provide the feedback signal needed for controlling and monitoring complex currents and voltages from 0.25 A (e.g. in a drilling machine) to 24000 A (e.g. in current monitoring for electrolysis) and up to 4200 V (e.g. in the traction network for railways) in various technologies in a wide range of applications.

SUMMARY

ROBOTS

A robot is an electromechanical machine that is guided by computer and electronic programming. Robots can be autonomous, semi-autonomous or remotely controlled. Robots range from humanoids such as ASIMO and TOPIO to nanorobots and industrial robots.

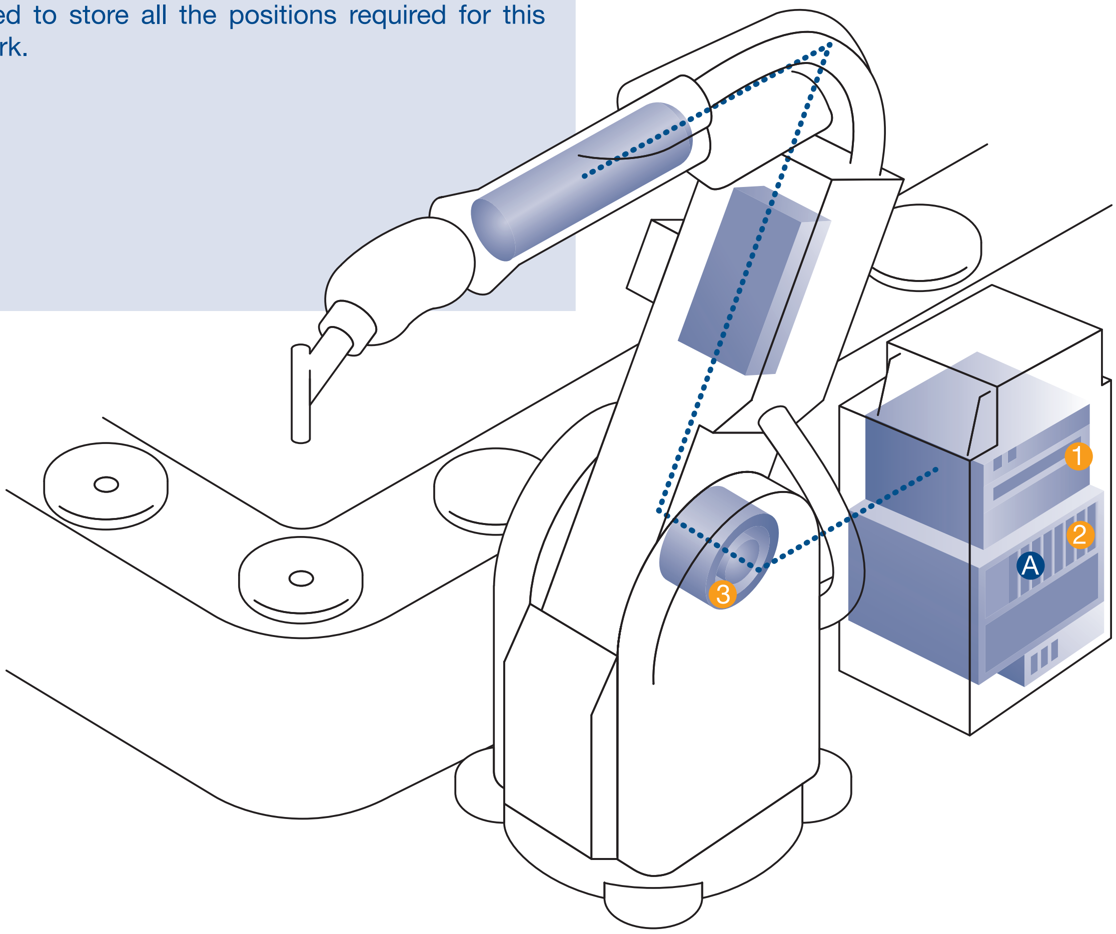
Industrial robots usually require movements in 3-6 axes in order to move the end of the arm in every position. Typical applications of robots include welding, painting, assembly, pick-and-place (such as packaging, palletizing and SMT), product inspection, and testing; all accomplished with high endurance, speed, and precision.

The robot arm is moved by electrical motors: usually one motor for each axis. The motors are controlled by a power inverter that receives its signal from a motion control unit. In order to control the arm, the power inverter drives the motor from one position to the next and stops precisely in position. To do so, an accurate measurement of the current is needed.

Transducers are used to measure the current and, together with the position sensor, they are responsible for controlling the fast movement and the precision to stop the arm in the new position. The motion control unit also contains the memory used to store all the positions required for this work.

CASR

1 Control Unit
2 Inverter
3 Motor
A CASR



PLASMA CUTTING

How do you cut steel or other metals? There are different methods to do it: besides mechanical methods, for example sawing, the industry also uses gas or laser techniques.

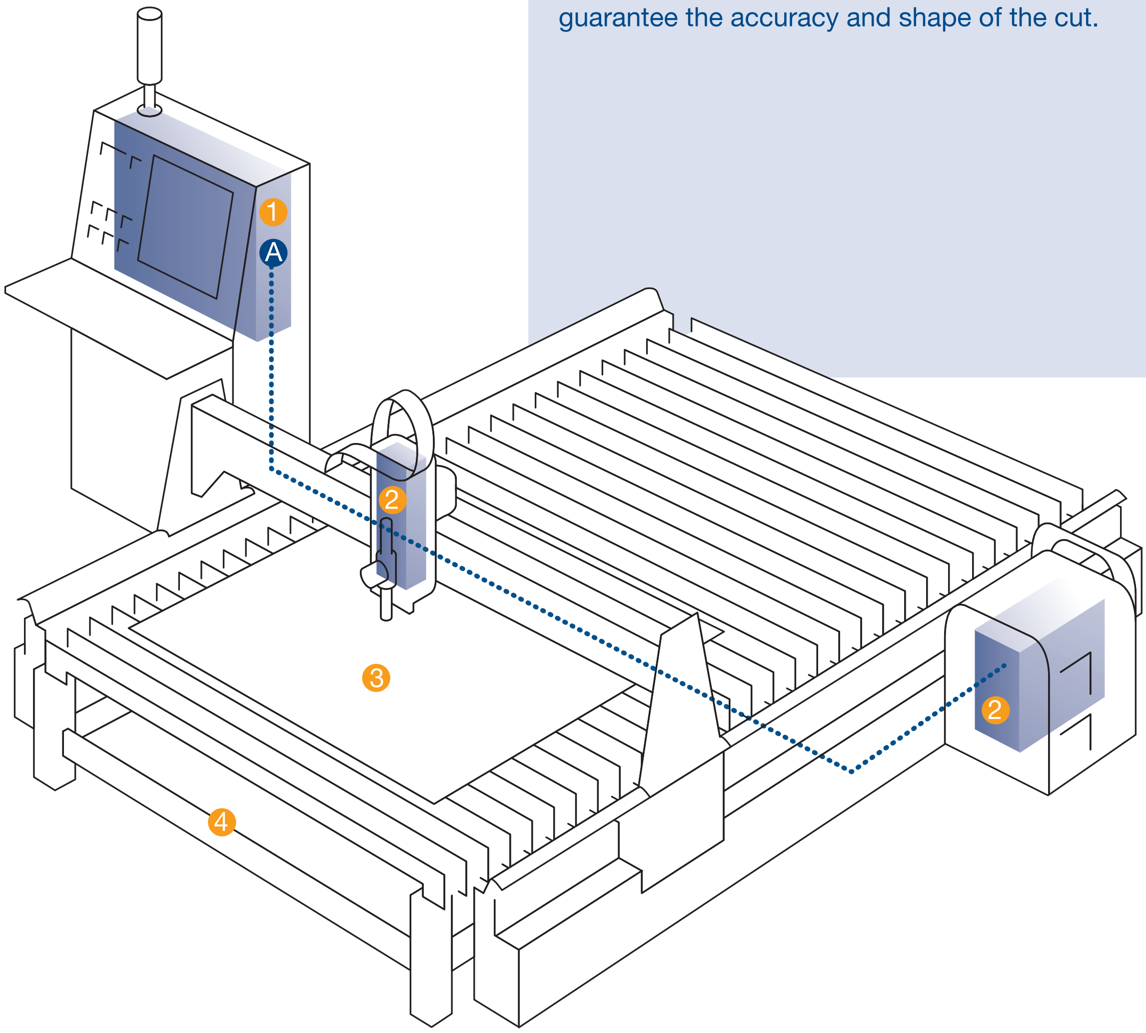
Plasma cutting uses a “plasma torch”. In this process, an inert gas (in some units, compressed air) is blown at high speed out of a nozzle; at the same time an electrical arc is formed through that gas from the nozzle to the surface being cut, turning some of that gas to plasma. The plasma is hot enough to melt the metal being cut and moves sufficiently fast to blow molten metal away from the incision.

How do you form an electrical arc? You make a contact by touch to the metal and then move a few millimetres away from the metal. In that way the arc is formed and can melt the metal.

To maintain the arc continuously, the current through the arc is measured by a current transducer that feeds the value of the current back to a control unit, which regulates it using modern IGBTs (Isolated Gate Bipolar Transistors) to ensure the current intensity of the arc. The accuracy of the measurement is important to guarantee the accuracy and shape of the cut.

LAH

1 Electronic
2 Motor
3 Torch
4 XY-table
A LAH



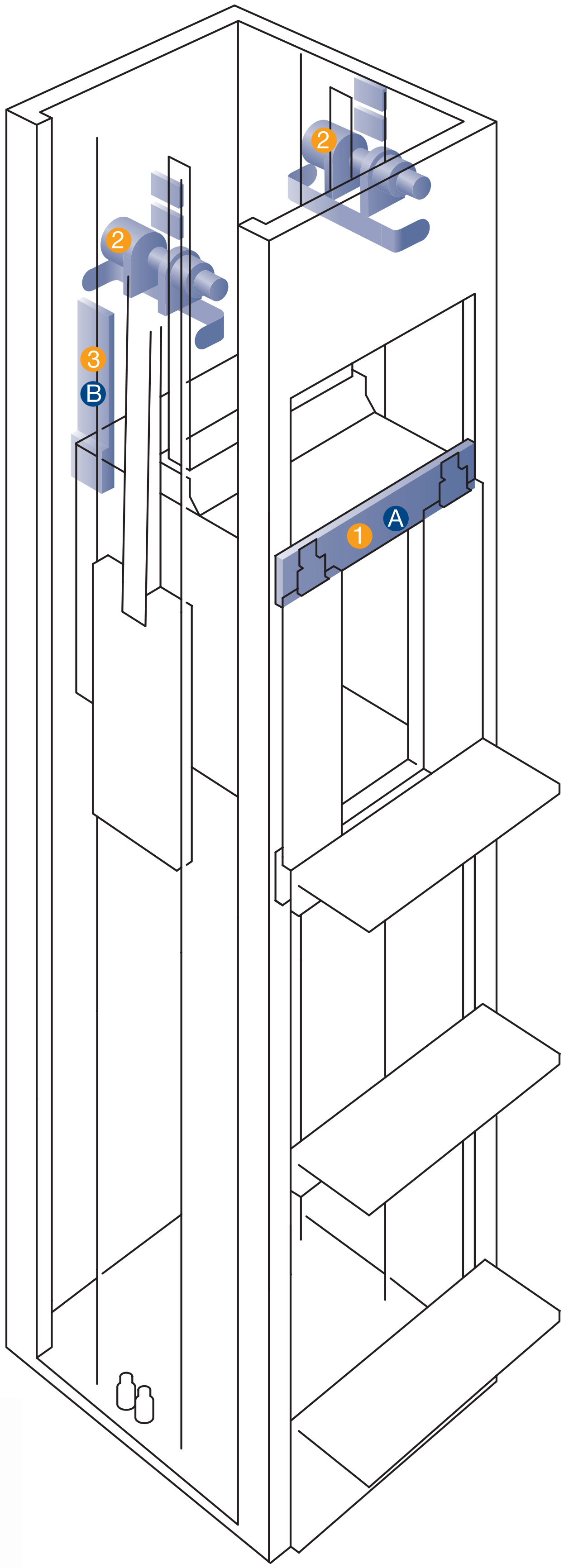
ELEVATOR

Elevators are generally powered by electric motors that either drive traction cables or counterweight systems like a hoist.

Machine room-less elevators are designed so that most of the components fit within the shaft containing the elevator car.
A small cabinet houses the elevator controller and the motors.

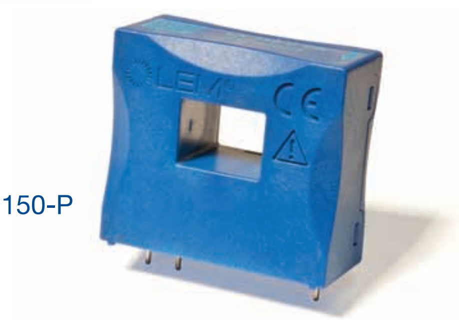
The motor (2) is controlled by an inverter and a controller (3).
As soon as someone pushes a button to request the elevator, the controller gives the necessary signals to the inverter. It then moves the motor in the right direction and lets it stop exactly at the right position to the floor ground independent of the weight in the elevator car. The current transducers take care that the motor is powered with the correct current.

Elevator doors protect riders from falling into the shaft. The most common configuration is to have two panels that meet in the middle and slide open laterally.
The doors are controlled by a control unit (1) that integrates the motors of the sliding doors and the protection of the riders. The current transducer measures the current in the motors for two purposes: to run the panels smoothly and to discover if something (e.g., a finger, a leg) obstructs the doors in which case the closing would be stopped.



LTS

1 Door control unit
2 Motor
3 Controller
A LTS
B LA 150-P



LA 150-P

ITL 900-T

1 Gradient coils
2 Magnet & Shim
3 Generator
4 Gradient amplifier
5 Shim control
6 Radio frequency coil
7 Radio frequency amplifier
8 CPU & Display
A ITL 900-T

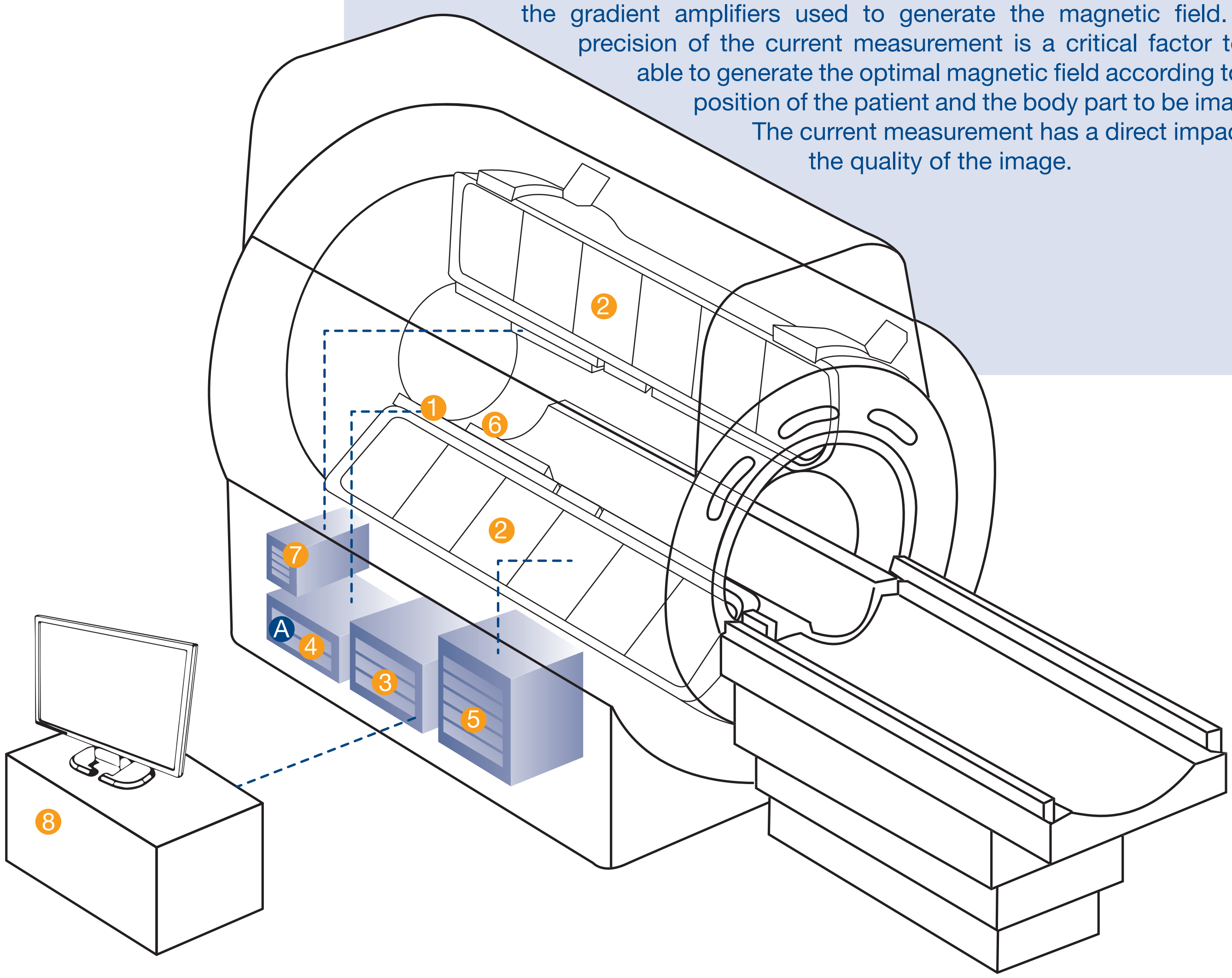
MEDICAL SCANNERS

Magnetic resonance imaging (MRI) is a medical imaging technique most commonly used to visualize the detailed internal structure of the body. One advantage of an MRI scan is that it is harmless to the patient. It uses strong magnetic fields and non-ionizing radiation in the radio frequency range, unlike CT scans and traditional X-rays which both make use of ionizing radiation.

The body is largely composed of water molecules which each contain two hydrogen nuclei or protons. When a person goes inside the powerful magnetic field of the scanner, the magnetic moments of these protons align with the direction of the field. A radio frequency electromagnetic field is then briefly turned on, causing the protons to alter their alignment relative to the field. When this field is turned off the protons return to the original magnetization alignment.
These alignment changes create a signal which can be detected by the scanner. The frequency at which the protons resonate depends on the strength of the magnetic field. The position of protons in the body can be determined by applying additional magnetic fields during the scan which allows an image of the body to be built up. These are created by turning gradient coils on and off which creates the knocking sounds heard during an MRI scan.

The magnetic field is generated by 3 gradient amplifiers that increase the energy signal before it reaches the gradient coils. They are capable of creating a precise magnetic field that will need to vary depending on the location. The 3 coils are perpendicular to each other in order to reproduce a 3 dimensional image. One LEM ITL 900 transducer is used for each gradient amplifier.

The ITL 900 measures and assures the precise level of electric current going to the gradient amplifiers used to generate the magnetic field. The precision of the current measurement is a critical factor to be able to generate the optimal magnetic field according to the position of the patient and the body part to be imaged. The current measurement has a direct impact on the quality of the image.



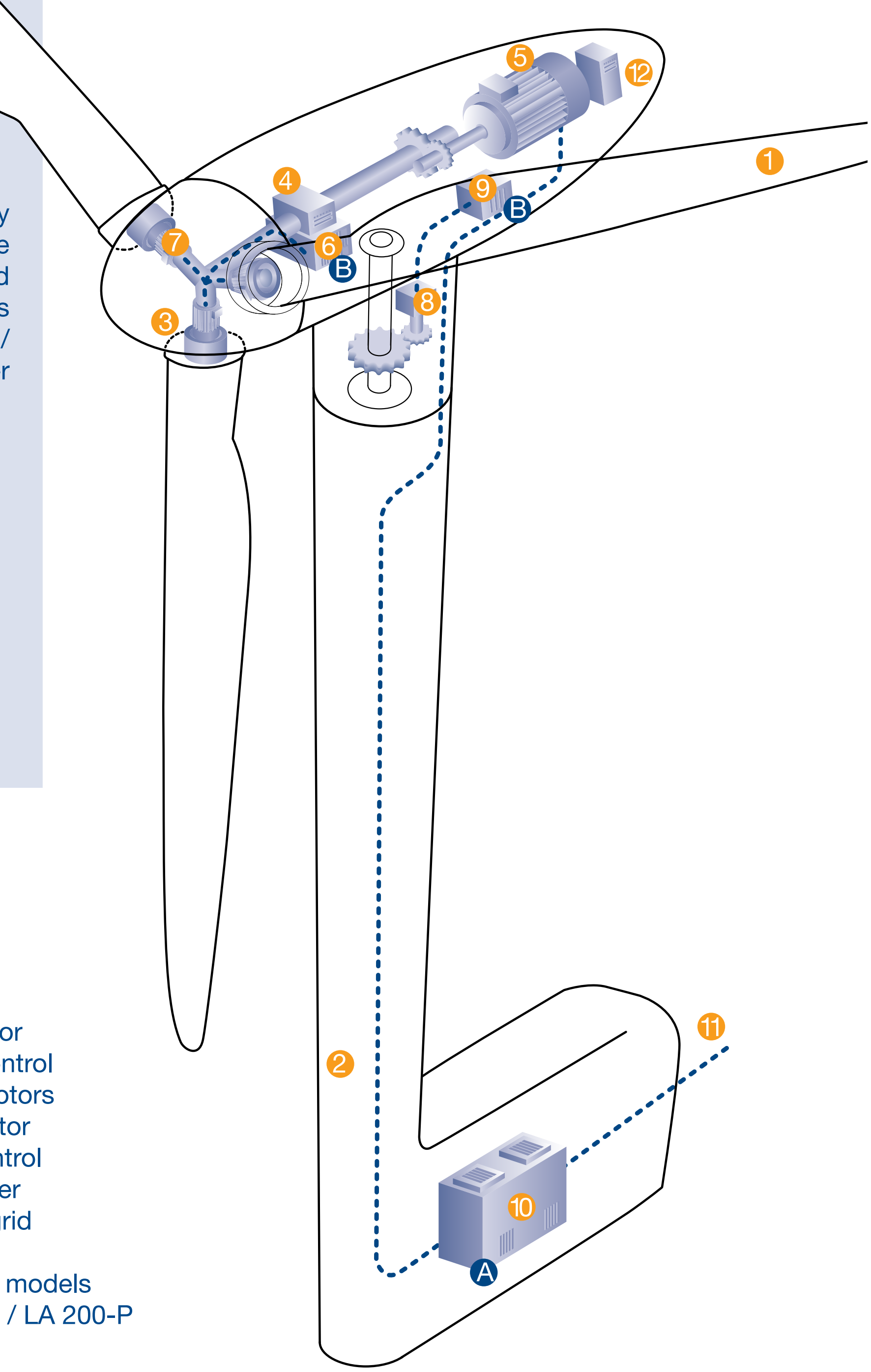
WINDMILLS

Modern onshore and offshore wind energy turbines drive a generator that converts the mechanical energy from the turning blades into electricity.
LEM transducers contribute in two ways to improve safety and efficiency of wind turbines.

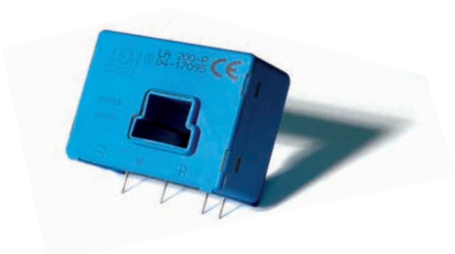
1. To ensure the generators work most efficiently, electric motors turn the nacelle and the rotor into the wind. In addition, an active power control system adjusts the rotor blades within their longitudinal axis. LEM's transducers in the power converters continuously measure the current in order to optimally position the turbine.

2. The electricity produced needs to be fed safely into the power grid, meaning it needs to be supplied with continuous power at a controlled frequency and voltage. LEM's current transducers enable optimal control and protection of the AC/DC (Alternating Current/Direct Current) converter to feed the power grid.

LF xx10 models



LA 55-P
LA 200-P



1 Blades
2 Tower
3 Rotor
4 Brake
5 Generator
6 Pitch control
7 Pitch motors
8 Yaw motor
9 Yaw control
10 Converter
11 Power grid
12 Yaw
A LF xx10 models
B LA 55-P / LA 200-P

HLSR

CAS

CASR

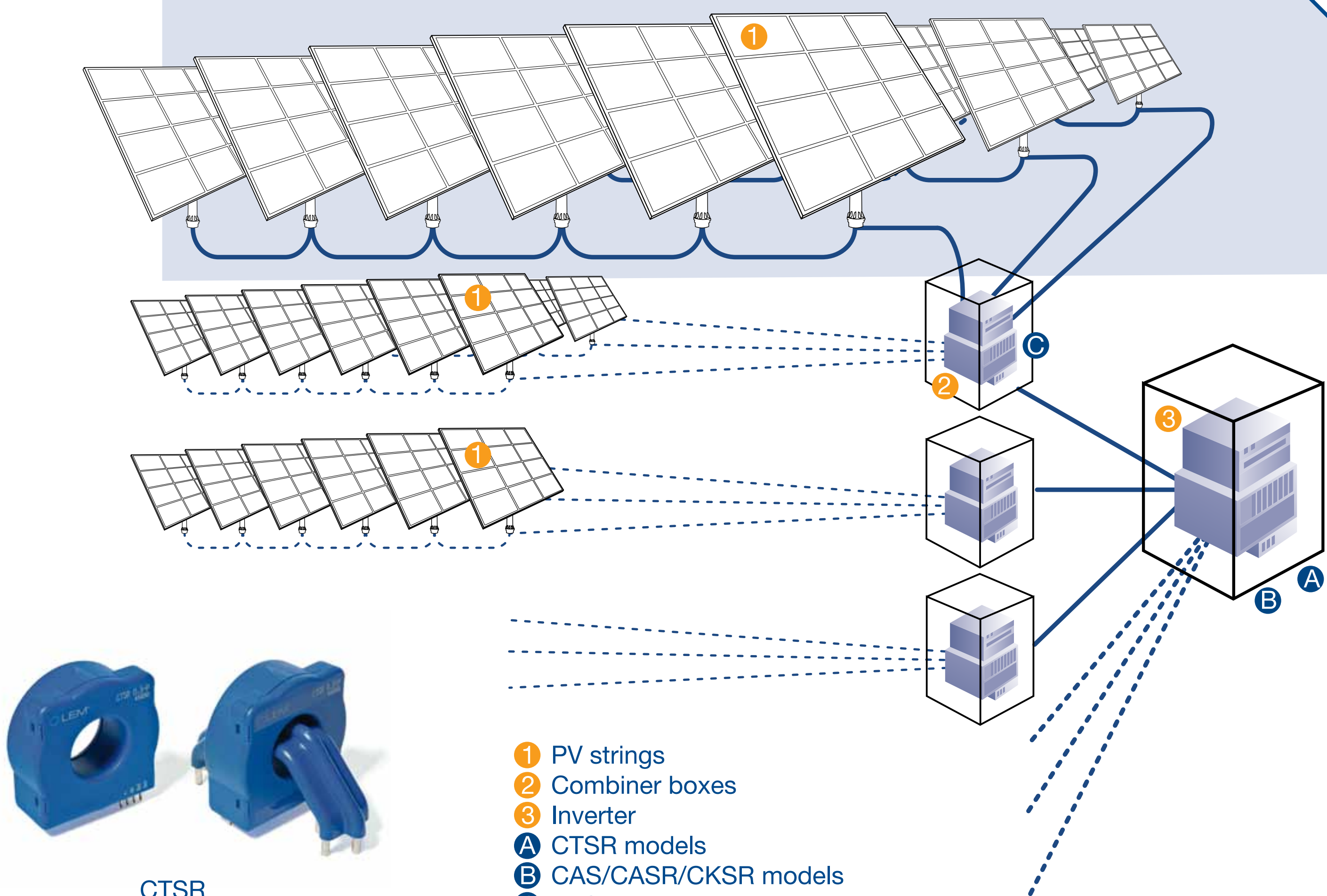
CKSR

SOLAR

In solar panels, the generated electricity can be used for autonomous installations, remote from the distribution grid, which charge a battery. This is commonly referred to as an “offgrid system”. In contrast, the grid-connected system feeds energy back into the grid. In photovoltaic panels, transducers control the energy flow to the grid and are used for ensuring the safety of equipment and people.

Thousands of solar panels are required to build a solar plant, and the performance of the overall installation has to be monitored in order to maximize its efficiency. The inverter used for the conversion of the power to the grid will ensure a part of this efficiency by tracking if the Maximum Power Point (MPP) for the generated current and voltage is reached for the total installation. In order to be the most efficient, the current has to be measured. This will allow adapting the parameters to adjust the Maximum Power Point for the generated current and voltage, but also to detect any defective solar panel (CAS/CASR/CKSR models). Furthermore it is vital to the employees’ safety to be able to detect any earth leakage current potentially happening, as this would be a safety hazard. The transducers measure the current to ensure that the circuits are not loosing any current anywhere (CTSR models).

In a solar plant, a simple way to detect a defective solar panel is to check the current produced by each PV string. A comparison of the current generated by each PV string allows evaluating if they each produce the same level. Some levels of unbalance between PV strings can be set to trigger an alarm if they are reached. In order to be the most efficient, the current has to be measured on each PV string.
This will allow adapting the parameters to adjust the MPP of the respective solar string, but also to detect any defective solar panel that is part of the solar string (reducing the efficiency of the solar string substantially). For solar plants that are equipped with motorized panels, the current control will also allow the solar panel orientation tracking versus the sun position; this will give the best yield. Boxes for the parallel connection of the PV strings are used. They are often called “combiner boxes” (but also “smart combiner boxes” or “array boxes”) integrating the current and voltage measurements for each string and checking several PV strings (HLSR models).



CTSR

1 PV strings
2 Combiner boxes
3 Inverter
A CTSR models
B CAS/CASR/CKSR models
C HLSR models

TRACTION-LOCOMOTIVE

A locomotive obtains energy from the line over the pantograph (1) on the roof. Usually in Europe this is 15kV or 25kV AC voltage. The second connection is on earth connected over the wheels to the locomotive.

Some locomotives are able to run in different systems. The Eurostar, for example, is able to run with four different voltages: 25kV/AC/50Hz, 3kV DC, 1.5kV DC, and 750V DC. From the pantograph the energy flows into a transformer (2), which transforms the voltage to 2.8kV or lower. After, a rectifier transforms the voltage from AC to DC.

Voltage and current transducers are used to measure the current and the voltage on the secondary side of the transformer and on the DC-side. Inverters (3) are used to transform the energy into the right voltage and current to drive the motors (4), usually one motor per axis or every second axis. Special differential transducers are implemented at the secondary side of the transformer to detect any leakage current flowing in the train.

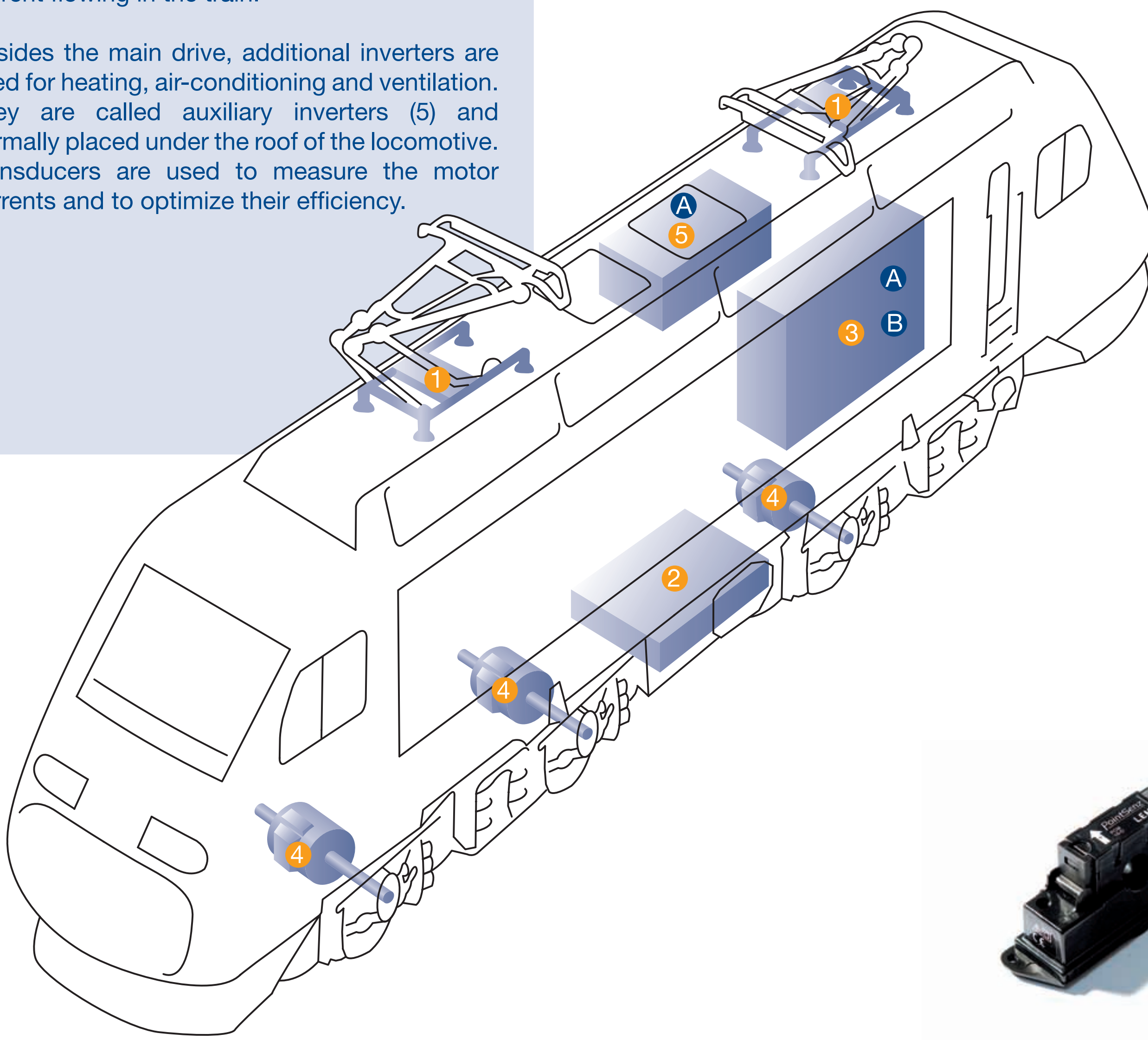
Besides the main drive, additional inverters are used for heating, air-conditioning and ventilation. They are called auxiliary inverters (5) and normally placed under the roof of the locomotive. Transducers are used to measure the motor currents and to optimize their efficiency.

LTC 1000

DVL

1. Pantograph
2. Transformer
3. Inverters
4. Motors
5. Auxiliary inverter

A. LTC 1000
B. DVL



PCM

CASR

LTSR

LA 25-NP

TRACKSIDE

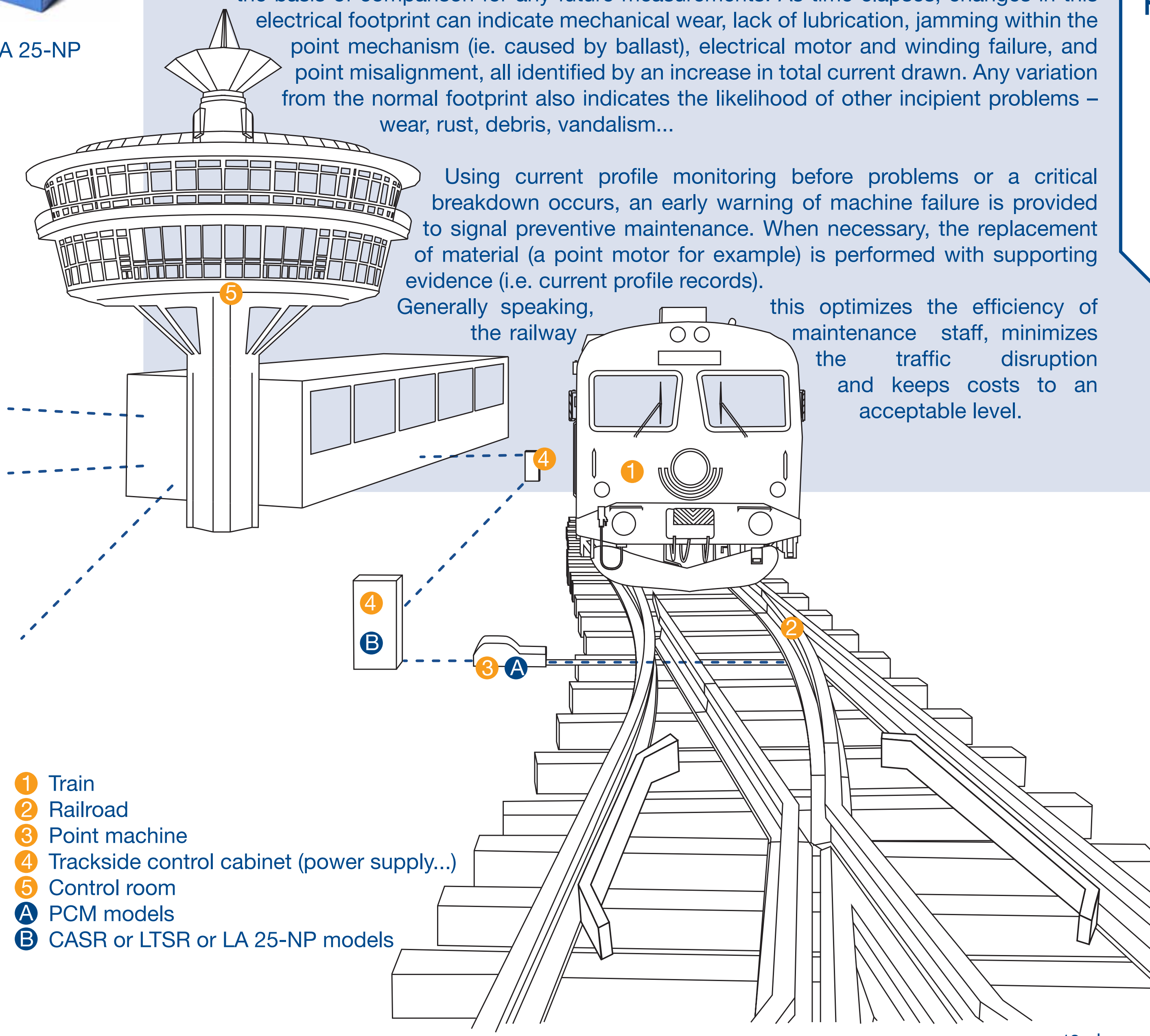
The increasing separation of infrastructure and railway responsibilities within the rail system underlines, among other things, the importance of trackside monitoring. This serves to optimize the capital investment and maintenance costs of track equipment such point machines, crossing gates, signaling… while ensuring satisfactory levels of safety and operational performance through conditioned monitoring methods.

Among the goals have been to decrease train service interruptions due to failures, to improve the punctuality and to reduce potentially strong penalties. Also, the availability of the railway network is becoming more and more crucial. Existing infrastructure must be exploited more efficiently, which is why monitoring crucial track objects (points, crossing gates, signaling…) is an indispensable tool in this context. Online monitoring makes it possible to take preventive actions before abnormalities lead to failures.

About 25 % of disturbances causing trains delays are due to the point (switch) machines along the tracks. Their preventive maintenance, with potential replacement prior to failure, is a way of improvement thanks to their conditioned monitoring.

The output from a transducer measuring the DC (or AC) current drawn by the point (switch) motor is logged to produce an operational profile of current against time. This is then stored within a data logging system and used as the control characteristic. This “footprint” forms the basis of comparison for any future measurements. As time elapses, changes in this electrical footprint can indicate mechanical wear, lack of lubrication, jamming within the point mechanism (ie. caused by ballast), electrical motor and winding failure, and point misalignment, all identified by an increase in total current drawn. Any variation from the normal footprint also indicates the likelihood of other incipient problems – wear, rust, debris, vandalism...

Using current profile monitoring before problems or a critical breakdown occurs, an early warning of machine failure is provided to signal preventive maintenance. When necessary, the replacement of material (a point motor for example) is performed with supporting evidence (i.e. current profile records).
Generally speaking, this optimizes the efficiency of the railway maintenance staff, minimizes the traffic disruption and keeps costs to an acceptable level.



1 Train
2 Railroad
3 Point machine
4 Trackside control cabinet (power supply...)
5 Control room
A PCM models
B CASR or LTSR or LA 25-NP models

CONVENTIONAL & HYBRID ELECTRIC VEHICLES

In cars, features such as air conditioning, electric windows, the entertainment system, lights, heated seats, clocks as well as computers require energy. Computers even function when the car is not running.
All these sources must have enough energy to run. And the battery management system in the car is important to ensure its optimal function. The status of the battery's energy level can be measured by a transducer such as the DHAB which will be able to detect the level of energy that is flowing into and out of the battery. This information is fed into the car's computer and will enable various calculations and operations to ensure an optimal battery management.

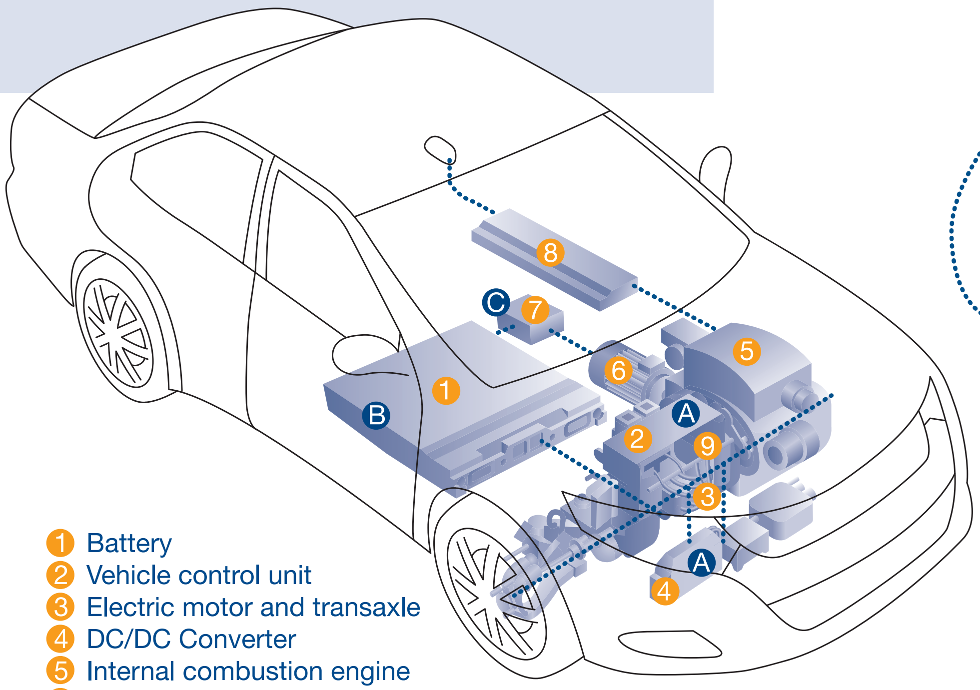
HEV Hybrid Electric Vehicles are cars that have both a conventional internal combustion engine (ICE) and an electric motor which is powered by batteries.
Modern HEVs can significantly reduce fuel consumption by up to 50% and air pollution emissions by up to 90%. These reductions are due primarily to the use of three mechanisms:
-Reducing wasted energy during idle and low speeds, by turning the internal combustion engine (ICE) off
-Recapturing waste energy by regenerative braking to recharge the battery
-Reducing the size and power of the ICE engine and using the better torque response of electric motors.

Here again, the transducers measure the status of the batteries charge, allowing the on-board computer to know the exact energy level of the battery. This helps the computers to make the most energy efficient decision about using the electric or ICE engine.

HAH1

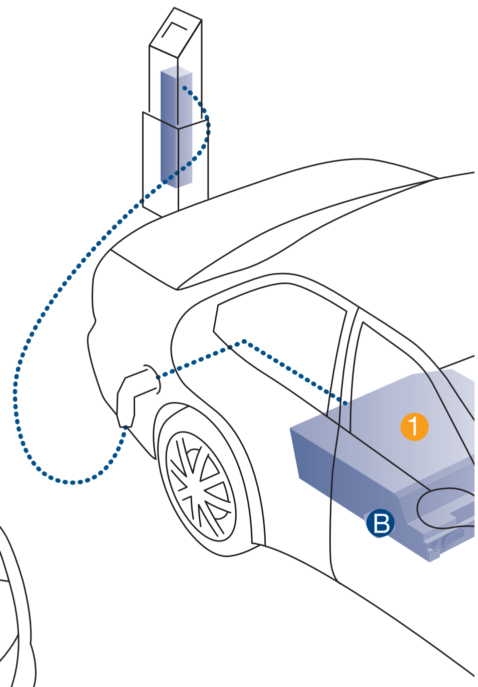
DHAB

HC5F



1 Battery
2 Vehicle control unit
3 Electric motor and transaxle
4 DC/DC Converter
5 Internal combustion engine
6 Starter-generator
7 Rectifier
8 Fuel tank
9 Electric motor controller

A HAH1
B DHAB
C HC5F



1 High-voltage battery
2 Vehicle control unit
3 Charger
4 Motor controller
5 Electric motor and transaxle
6 DC/DC converter
7 Electric power steering

ELECTRIC PLUG-IN CARS

BATTERY MANAGEMENT

The sensor is the key element to measure the autonomy of the car. It measures the current in and out of the battery pack and hence the units of energy available to be consumed. This information helps to calculate the remaining distance that can be driven based on the current battery charge.

ELECTRIC MOTOR MANAGEMENT

These sensors are used to manage the converter and/or inverter. The information provided by these sensors is used to adjust the drive performance to the speed required by the driver.

CHARGER MANAGEMENT

The sensor is used as a safety part of the car; it is the key element of the DC circuit breakers. It measures the leakage current that could occur during the charging phase. The same sensor may also be used for battery pack measurement. Due to its high accuracy it can provide much better information and thereby help to increase the autonomy of the car or reduce the cost of the battery pack.


HAH3


CAB


HAB

START-STOP SYSTEMS

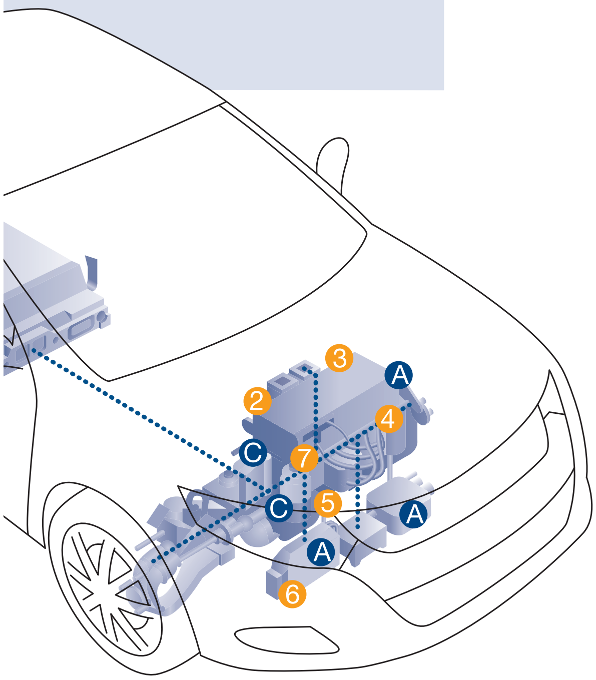
Over the past few years, an increasing number of new car models are available with a system that automatically shuts off the engine while stopped in traffic, and restarts it as soon as the driver engages a gear or presses the accelerator. These so-called start-stop systems reduce the amount of time the engine spends idling, thereby lowering fuel consumption, and gas emissions. To function safely and efficiently, these start-stop systems need a careful measurement of the electric energy available in the batteries.

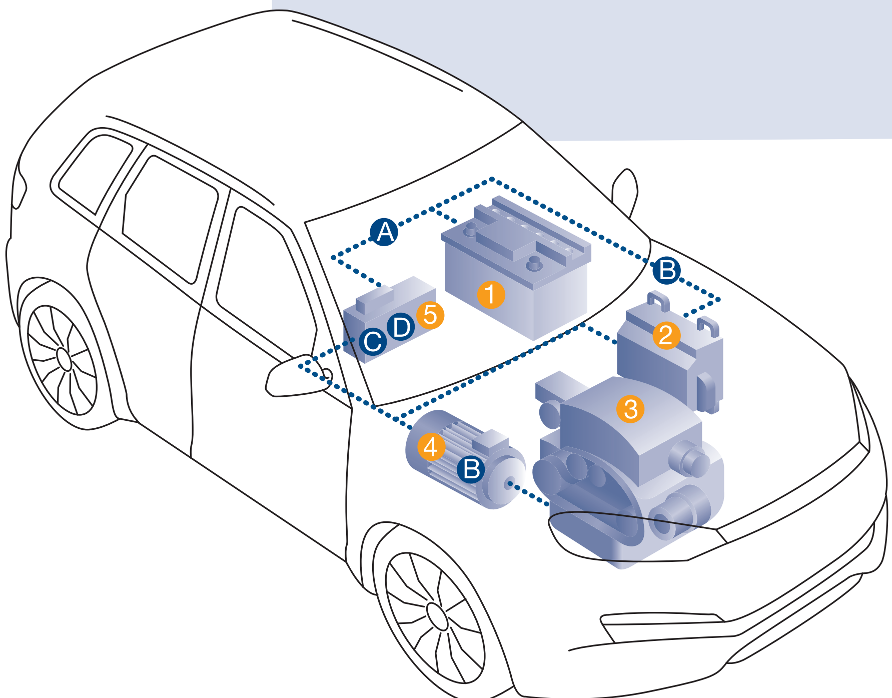
BATTERY MANAGEMENT

The current sensors (HAB, CAB) allow the battery management system to decide if enough energy is available in the battery to operate the accessories (such as air-conditioning, headlights, and radio) while the engine is off, and still have ample charge left to restart the engine.

“POWER-CONTROL UNIT” AND “STARTER-GENERATOR” MANAGEMENT

The “power-control unit” will instruct the “starter-generator” to restart the engine or recharge the battery, as needed, and current sensors (HC5F, HAH3) used in the converters and inverter modules allow it to operate smoothly, improving the driver experience while helping the environment.



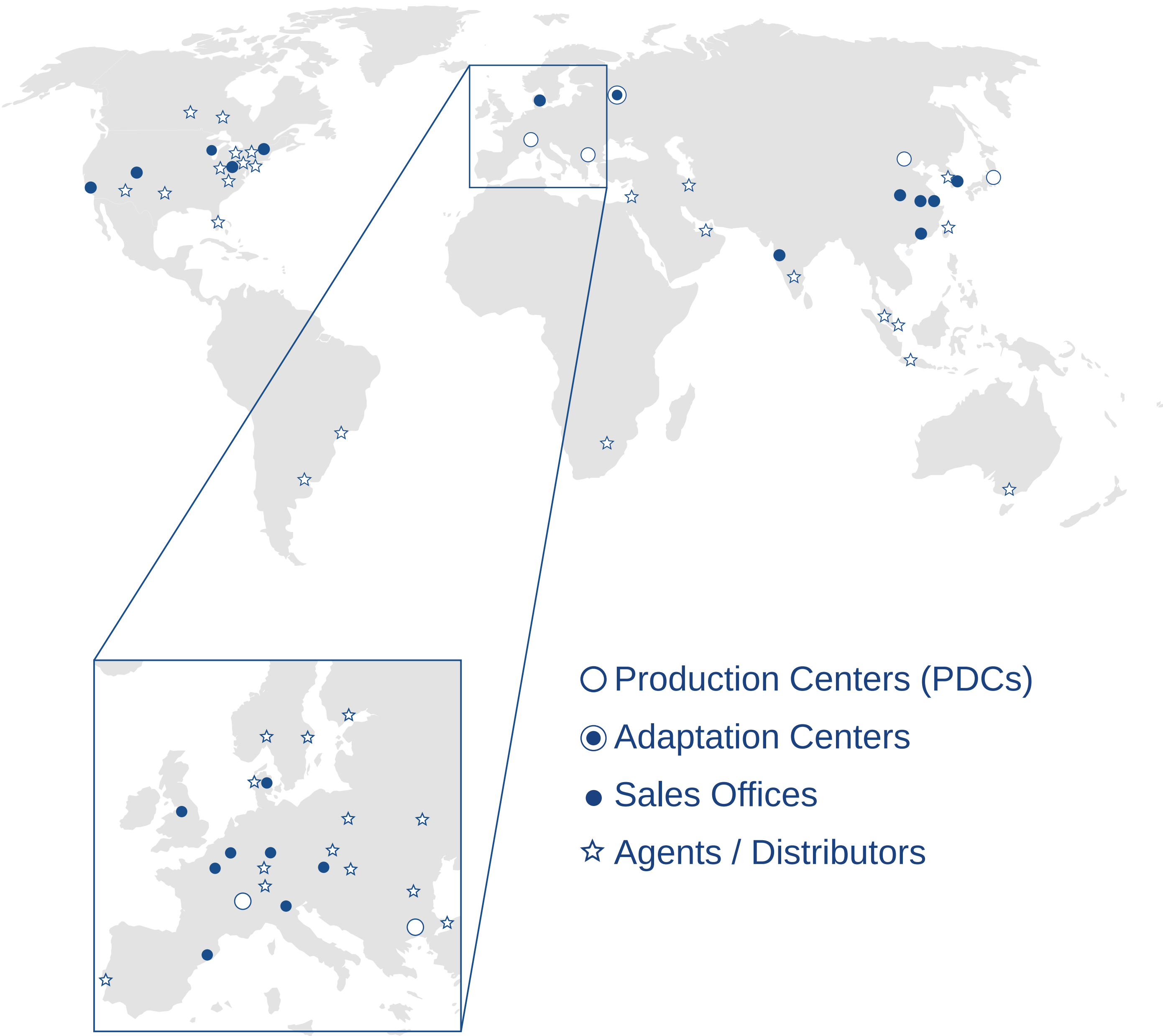


A HAH1
B CAB
C HC5F

1 Battery
2 Power-control unit
3 Internal combustion engine
4 Starter-generator
5 Rectifier

A CAB
B HAB
C HC5F
D HAH3

LEM International Sales Representatives



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