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## Making a Difference – BODAS and Mobile Electronics

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### Abstract

Increasing efficiency remains one of the key requirements in the market for mobile working machines and continues to be the central theme of all development activities at Bosch Rexroth. For years we have been successful in developing solutions that offer our customers optimal components and systems for efficient operation. However, solutions at Bosch Rexroth mean more than just ready-to-use components - they also include concepts that meet customer needs for individual system and legal requirements. Bosch Rexroth responds to these market requirements not only with its portfolio of hydraulics, but also with solutions such as based on networking of hydraulic and mobile electronics. The BODAS Mobile Electronics system in particular “makes the difference”.

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## The **Bosch Rexroth Design and Application System – BODAS**

Today's and future working machines present an array of diverse challenges. For a long time, the focus has been on the mere function and the price of the working machine, but today a number of additional aspects play an increasingly important role for machine manufacturers: functional safety, emission regulations e.g. TIER 4 final, Total Cost of Ownership, fuel consumption, noise optimization, dynamics improvements and even greater comfort (Fig. 1). In this context, solutions based on Mobile Electronics and for Energy Efficiency "4EE" respectively with the focus on energy system design for optimized power management are gaining in significance.

BODAS stands out for its consistent modular design and tailored interfaces. Every component can easily be integrated and expanded, making it possible to develop effective machine controls in a quick and cost-effective way. Existing solutions can be upgraded with additional functions with minimal effort. The optimal compatibility of BODAS components with Rexroth hydraulic systems simplifies mechanical integration and boosts efficiency of the working machine as a whole.

At the heart of the BODAS system (Fig. 2) are freely programmable controllers that have been developed based on Bosch technology specifically for use in mobile working machines. Sensors, displays and joysticks complete the BODAS system. BODAS thus represents a one-stop solution for all components of a complete electro-hydraulic drive system and vehicle management. But BODAS is not to be regarded as a mere hardware modular system, since it also offers all the necessary development and service tools to program and maintain the hardware in question. The BODAS-design programming system for controllers plays a central role in this regard. Based on IEC EN 61131-3, it contains a comprehensive instruction set for very straightforward hardware abstractions. As a service tool, BODAS-service offers a wide range of diagnostic functions for commissioning and maintenance work. Additional tools such as measuring adapters and test kits complete the system. The BODAS system has benefited greatly from the close collaboration between Bosch Rexroth and Bosch. The "Bosch factor" in development, testing and automotive mass production results in exceptionally high and reliable product quality, which in turn leads to high system availability of machines in day-to-day work.

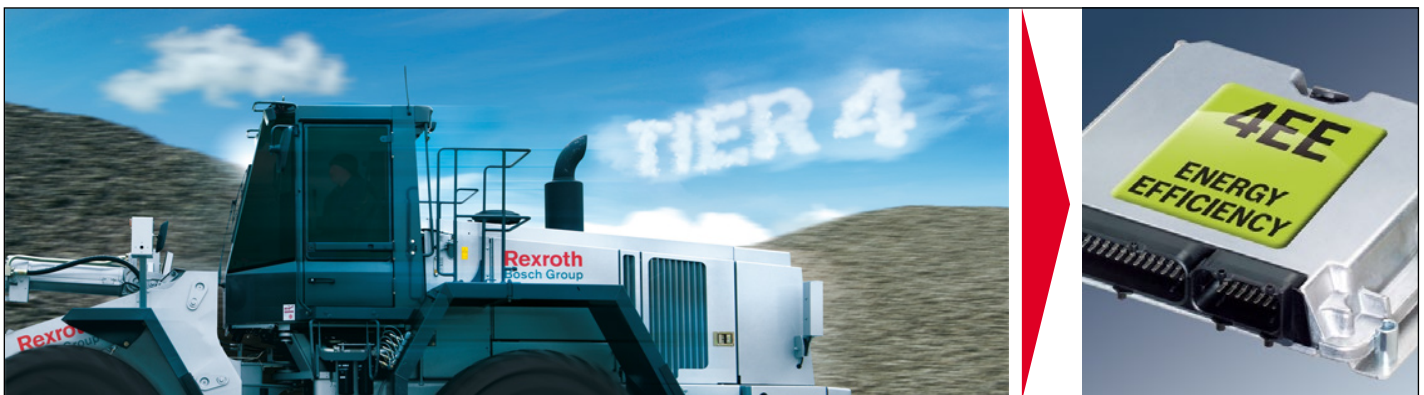


Fig. 1: Solutions for challenges like TIER 4 with "4EE" for Energy Efficiency BODAS Electronics



Fig. 2: Mobile Electronics @ Bosch Rexroth = BODAS

This is just one aspect of Mobile Electronics at Bosch Rexroth. In an effort to increase the level of electronic control in mobile working machines, designers are relying more heavily on integrated solution concepts such as On-Board-Electronics (OBE), for example in the hydraulic pump or valve block. In this context, BODAS also represents a starting point for the closer integration of hydraulic and electronic systems. But this is merely the hardware perspective.

BODAS stands out for solution concepts regarding hardware and software for mobile working machines. Our customers are offered system solutions that result from the detailed, specific knowledge accumulated by Bosch Rexroth over many years combined with the expertise of the Bosch automotive division.

As a system solution, the sophisticated combination of Rexroth components is intended to create added value for our customers with the utilization of intelligent control technology. This can be illustrated well using the example of the High Level Braking (HLB) developed by Bosch Rexroth. Here standard hydraulic variable pumps and motors are connected in such a way and expanded with a HLB control concept. As a result, mobile working machines can now achieve appropriate braking performance even without mechanical brakes and with TIER 4 motors. The example of Diesel Hydraulic Control (DHC) takes system solution concepts one step further. With DHC, not only separate components are expanded with a control concept, but also the diesel engine, meaning that Bosch expertise can be integrated in the control and regulation strategies for driving and working operations. This approach makes it possible to further reduce the fuel consumption of the machine with no compromise to performance, and in some cases even improved performance.

## Mobile innovation

Market trends and market developments indicate that future mobile working machines will be considerably different to the machines of today. A change of such magnitude will be the result of technological innovations – products and solutions that customers will perceive as new and beneficial.

However, innovation can only come about if the right technology and the right products are provided at the right time for a specific application. The consequences of failing to spot an innovation at the right time or to bring it to market has been seen lately in the mobile telecommunications industry (Fig. 3). A manufacturer that was for many years the uncontested number one in the market is now struggling to survive. It missed the essential leap to the next level of technology.

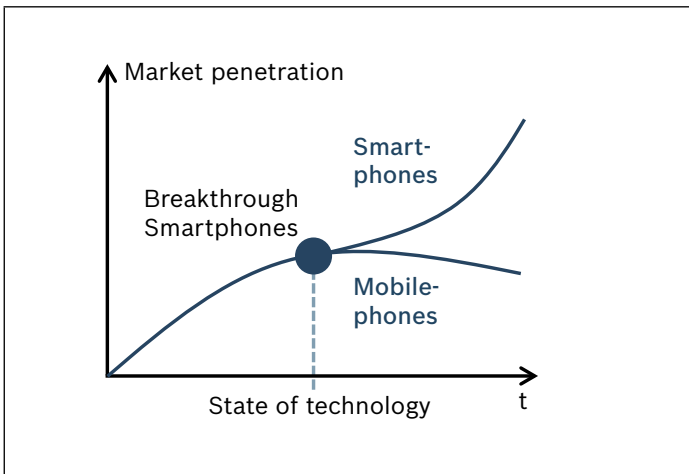


Fig. 3: Technological development of mobile- and smartphones

This example cannot be carried over entirely into the world of mobile working machines. However, a consideration of the ratio of purely hydraulic (HST) to electro-hydraulic systems (eHST) in the past and today points to an obvious transition (Fig. 4). As a result of topics that have been partly driven by new legislation, such as the introduction of the new machinery directive in 2009 and the TIER 4 emissions standards, a clear trend can be

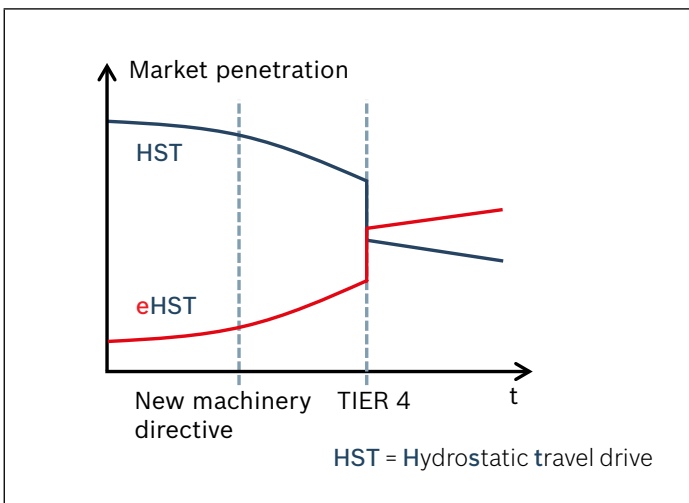


Fig. 4: Market development for hydraulic systems (HST) and electro-hydraulic systems (eHST)

seen towards the use of electro-hydraulic systems. This is connected with an strongly expected step towards electronically controlled diesel engines. Since electronics are now an absolute necessity in machines, there is a demand for greater innovation in mobile working machine systems. Certainly this creates a degree of freedom for the inclusion of additional functions that would significantly improve the Total Cost of Ownership (TCO).

The new machine functions that result are thus innovations in the market. The way in which such innovative functions are manifested in the solutions offered by Bosch Rexroth can be seen in the following example of an energy system design for optimized power management.

### BODAS software solutions: the next generation driving

At Mobile 2009, the innovative system solution Diesel Hydraulic Control (DHC) was presented for the first time. The aim of DHC is to optimize efficiency with no compromise to the dynamics of the machine – or even an improvement in performance (Fig. 5).



Fig. 5: Diesel Hydraulic Control (DHC)

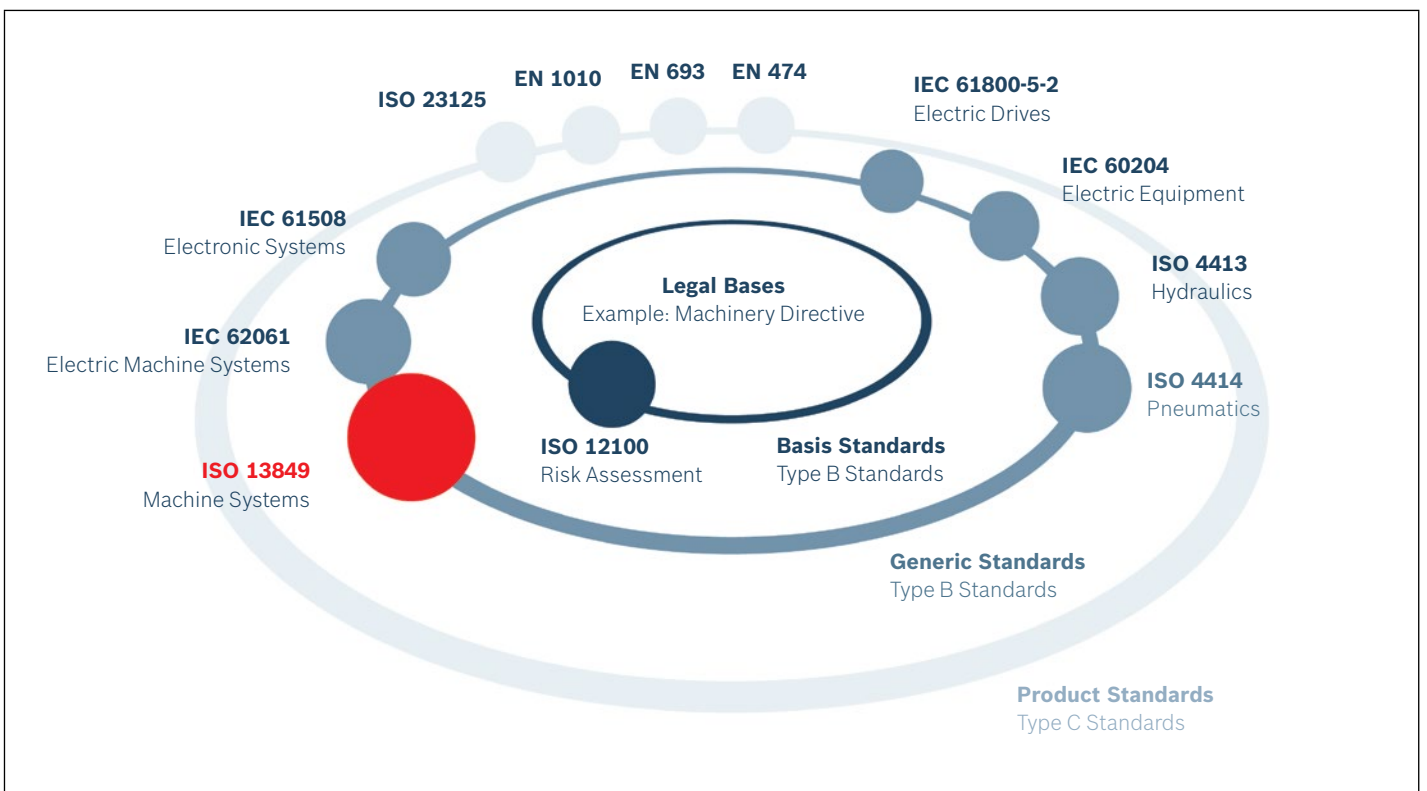


Fig. 6: Machinery directive and miscellaneous safety standards

DHC with energy system design for optimized power management represents enhanced integration of control electronics for working and drive hydraulics and control electronics for the combustion engine. The results are fuel savings, lower emissions, optimized mechanical performance and improved dynamics, even with TIER 4 motors. Now, three years later, Bosch Rexroth has a wide range of applications based on DHC technology, and in particular the DHC Eco Drive, in series production.

The following observations can be reported on this front:

The DHC Eco Drive with optimized dynamics improves fuel consumption by up to 20% with better performance in most cases – without the addition of any significant components and thus added costs.

With the aim of reacting even more quickly on individual customer requirements, Bosch Rexroth is focusing its development even more on the modularization of the software solutions. The goal is to make it possible to customize DHC travel drive solutions for individual requirements by parameterization and without the need to develop. This service is to be performed either by Bosch Rexroth, one of its partners in the global BODAS network or the customer itself.

Additionally, the new-generation travel drive with DHC Eco Drive will take into account the increasingly important criterion of standard functional safety management (Fig. 6).

This means that solutions will conform to requirements such as those of EN/ISO 13849 up to performance level “d”. For this to be possible, BODAS offers a standardized safety concept with appropriate safety planning guidelines. Based on these directives, customers can either independently or in cooperation with Bosch Rexroth realize the safety requirements as per EN/ISO 13849 up to performance level “d”. This safety concept is found, for example, in the new generation of travel drives with DHC applications and is implemented in line with legal requirements.

This safety concept does not only center on safety issues, but also takes into consideration the availability and flexibility of the machine.

**BODAS software** makes the difference in machine performance and efficiency with a comprehensive range of modular functions.

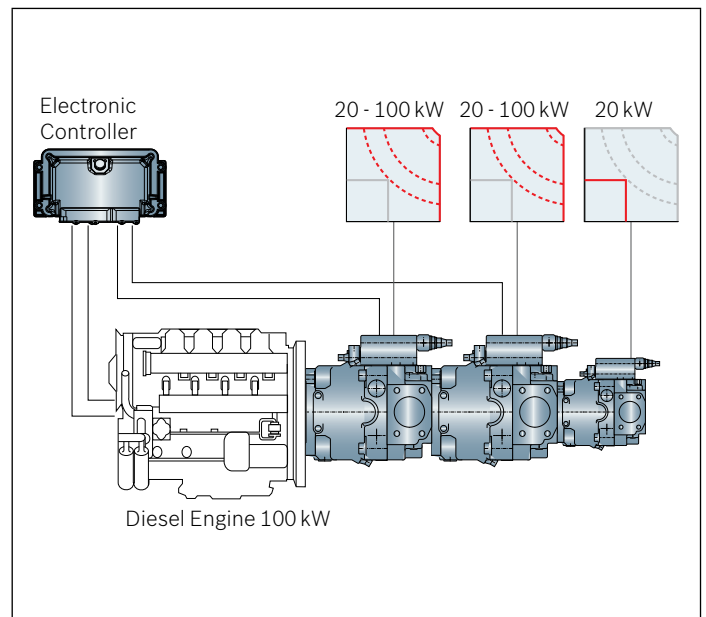


Fig. 7: Configuration of a system with Load Limiting Control (LLC) (example)

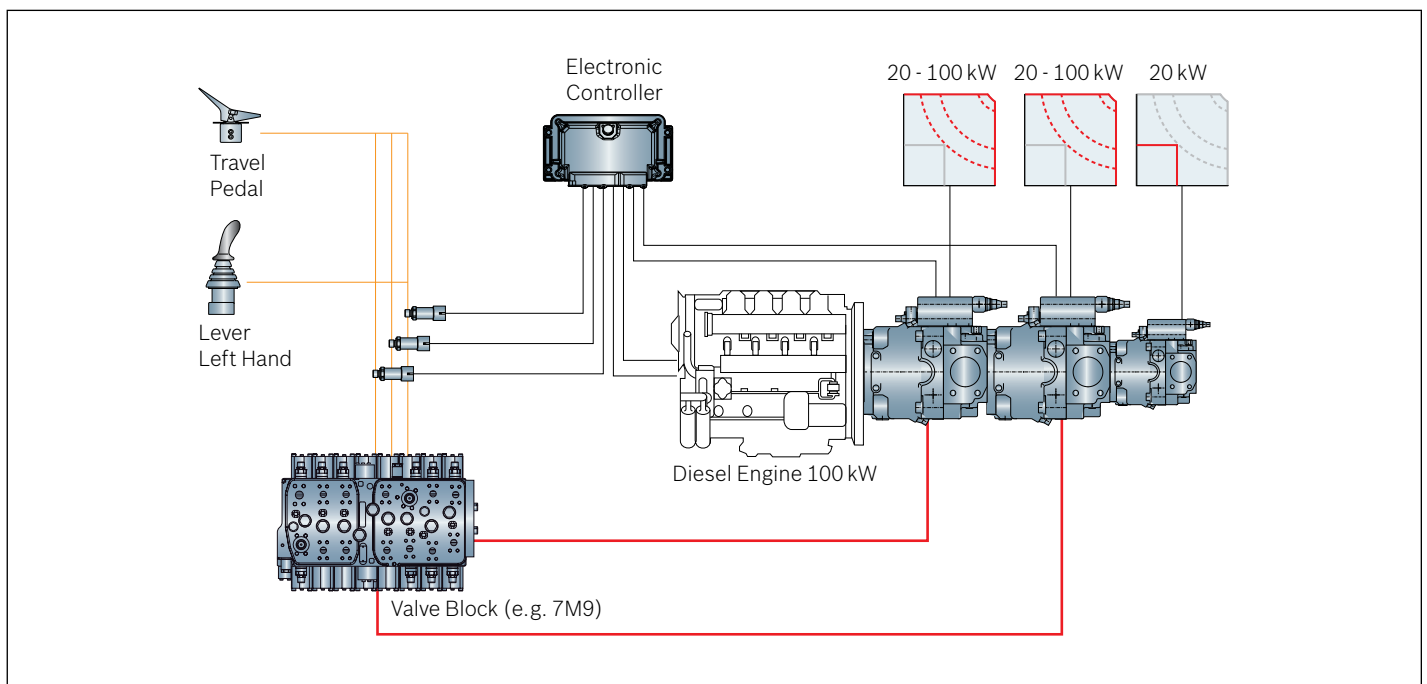


Fig. 8: Configuration of a system with Load Limiting Control (LLC) inclusive active power management (example)

## BODAS application solution: the next generation Load Limiting Control

A further example for energy system design for optimized power management is the Load Limiting Control (LLC) in e.g. excavators. The LLC (Fig. 7) has already been used in Europe and America for decades to tackle the unbalanced power and system dynamics between diesel engines and hydraulics. The primary aim of the LLC is to prevent the engine from stalling. However, today's requirements in this field are once again vastly different from those of yesterday. As a result of regionally specific traits, an LLC with torque control, also called "active power management" (Fig. 8) has developed from a pure LLC. This advancement can be traced back to a mastery of dynamics, hydraulics and the diesel engine with the aim of creating added value for customers with a load-optimized strategy. The new generation of LLC systems thus not only helps to prevent the engine from stalling but has also been integrated into the strategy to optimize dynamics and fuel consumption for the main function of excavation.

The **application solution BODAS LLC** with active power management combines Rexroth components and understanding of the application with "Bosch diesel know-how" in order to improve the Total Cost of Ownership (TCO) and to enhance the dynamics of the machine. Thus BODAS application solutions make the difference.

## BODAS makes it yours: specific requirements with HVT

In order to illustrate the topic of energy system design for optimized power management, it will be useful to take a look at the innovative Hydromechanical Variable Transmission (HVT) system by Dana Rexroth Transmission Systems. HVT represents a combination of components from Rexroth and Dana with HVT control and regulation software.

The aim of the HVT system is to combine mechanical and hydrostatic drive to increase the dynamics of the travel drive and to boost machine efficiency. This is only possible with a specific concept on the side of Bosch Rexroth Mobile Electronics. The focus here is not only on the specific HVT software, but also on the system-specific Special Rexroth Controller SRC (Fig. 9). To realize the HVT concept and an optimized HVT system, new hardware and software requirements were defined and implemented in a new model of SRC and are now in use in the framework of the HVT. Generally if customized solutions are realized, the focus is also on the modularization of function blocks, so that this new technology can be easily transferred into the multi-functional BODAS RC world. In this way, the advantages associated with an SRC project can also be offered in the standard BODAS RC program.

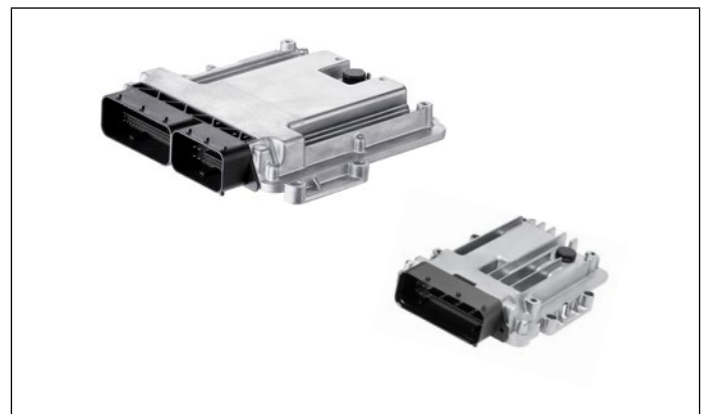


Fig. 9: Examples of Special Rexroth Controllers SRC

**BODAS** makes the difference with **standard or tailored solutions** for software and hardware based on Bosch automotive technology.

## Summary

BODAS represents the basis for mobile working machine solutions and aims to master the dynamics of individual components and the system as a whole (Fig. 10).

The BODAS Mobile Electronics system offers:

- Multifunctional, modular, easy to use and comprehensive building set for standard but also individual solutions

- Integrated Bosch expertise in hardware and software

- A flexible solution for functional safety requirements in line with international standards as EN/ISO 13849 for solutions up to performance level „d“

- A wide range of TIER 4 relevant application solutions

With this comprehensive system and the additional functions that have been realized considering already the challenges of tomorrow, Mobile Electronics is the key for future success and supports manufacturers to meet market requirements in terms of functional safety, TIER 4 final solutions, Total Cost of Ownership, optimization, improved dynamics and greater convenience.

BODAS makes the difference!

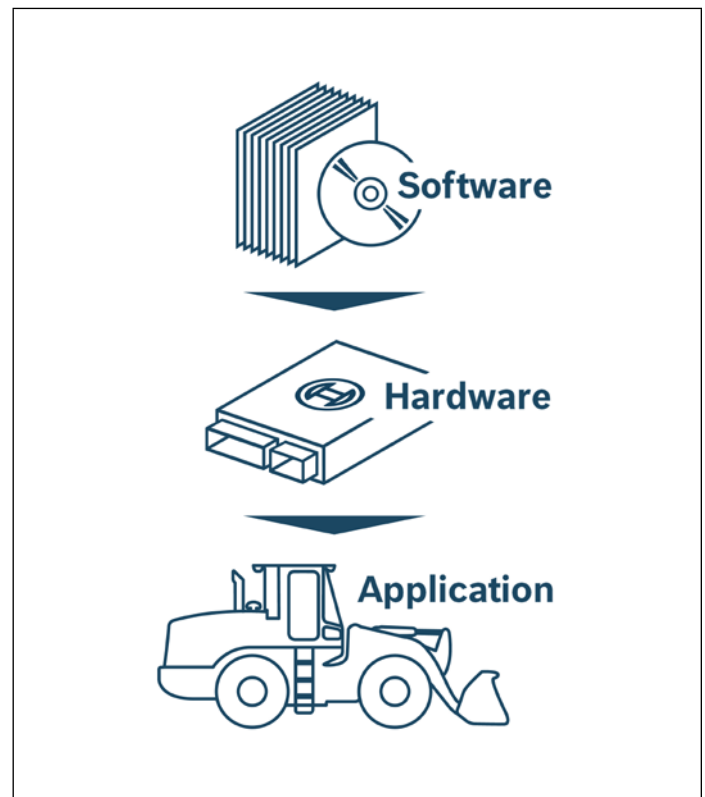


Fig. 10: From the application software to the application solution