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# Electronics in Combine Harvesters

*In spite of the comprehensive introduction of further monitoring and control systems, requirements on controlling combine harvesters are still high. The latest developments by manufacturers and by research institutions which support operators and improve machine efficiency were presented at the VDI-MEG conference Landtechnik Ag Eng 2007 and at the Agritechnica.*

Assistant systems for the operator in combine harvesters facilitate to monitor and to adjust the machine. The demands on the operators are still high due to the unbroken increase in performance of the machines and due to the distance to the working processes by the comfort of the cabins. For almost all models graphical displays are offered by the manufacturers. So, the information overload for the operator can be reduced and only the relevant data for the actual context will be displayed. Further displays are in the panel, in the A-pillar, under the cabin roof or are integrated in additional terminals, according to the specific manufacturers.

### Information and Operation Systems

With the introduction of the first graphical displays nearly 20 years ago [1], the displaying devices and the operator controls in the machines have been fundamentally revised. The cabins presented themselves tidy and additional functionalities could be integrated in these new concepts. Improved and more ergonomic multi-functional handles enabled the increasing number of controllable functions [2]. Additional demands for machine monitoring and control, for farm management and Precision Farming require additional displays and operating units. They cannot always be integrated meaningfully into the existing systems but they will complement them, e.g. by further displays and buttons.

*Fig. 1: John Deere display and control unit for combine harvester S690i (courtesy of John Deere)*

A topical analysis and evaluation at the Institute of Agricultural Engineering in Hohenheim of displays and of operator controls in combine harvesters shows the partial necessity of a revision and adjustment of these systems. For new models or face-lifts all manufacturers use the revision of the cabins to improve their concepts for displays and operating units.

In the revised combine S690i John Deere keeps the display area in the A-pillar. In three specific displays grain losses and return load, control of cutter bar and reel, and configurable driving speed, adjustments and revolutions of the main working units are shown. The automatic machine adjustment for the specific crops is now integrated into the graphical display Command Center, attached to the panel (*Fig. 1*). The operation of this display is done with five function keys directly above the screen, as well as with an incremental encoder and a keypad with four function keys in the panel. The incremental encoder changes between the active areas of the display and can be used for inputs and for adjusting values. The function keys are used to confirm, to cancel, to call a sub-menu and to change the control to the second and optional graphical display at the cabin roof above the A-pillar. In this second display functions for Precision Farming and automatic steering are integrated. In the panel, 15 further buttons and some open fields for optional and future functions are included.

For the new introduced combine series Tucano, Claas has revised the display and control system Cebis. The operation via keypad with cursor keys, buttons for confirmation, cancel, plus or minus, and for a context-sensitive help function was maintained. The direct access to important display and control functions via a rotary switch with twelve positions has been revised. The labels on the switch are eliminated and will be shown on the display itself when using the rotary switch. Consequently, all relevant information is concentrated on one display and shown in a context sensitive way. The revision of the graphical user interface and the modest use of colour contribute to keep the clarity of this system.

### Sensors

For all manufacturers the measurement and mapping of yield and moisture is state of the art. The load on the separation and cleaning units is registered with the so-called loss sensors, which are good indicators of changes in the harvesting process. Sensors for the return measure the amount of return without further information about its composition. New Holland presented a new system to register grain damage and the purity. For this deve-

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lopment together with the University of Leuven, Belgium, they use the bypass for the moisture measurement at the grain elevator. In addition to the moisture sensor a viewing window for a monochromatic camera and a lighting facility is integrated. By LEDs with selected wavelengths, the sample is sequentially illuminated. The images recorded at different wavelengths enable after some calculations a good distinction between grain, grain breakage and impurity. The result will be indicated to the driver as a percentage value and assist him to optimize manually the machine settings [3].

*Fig. 2: Claas display and control unit for combine harvester Tucano (courtesy of Claas)*

### Closed Loop Control Systems

The hitherto offers of throughput control systems for combine harvesters, by adjusting the driving speed to the loads of the machines, which are registered in different ways by the different manufacturers, have been described before [4]. Newly added is the throughput control system, developed also from the University of Leuven, Belgium, for New Holland. For this system the driving torque of cutter bar and feeder house is used as the load signal. The force on the tension pulley of the drive belt is measured by a bending beam. Extensive calibrations eliminate fluctuations around the zero point by changes of the mechanical loads e.g. by friction or variations of the chain tension in the feeder house. Even an exchange of the cutter bar by an appropriate calibration is possible. Published measurements demonstrate the suitability of this throughput controller.

As for the 3D-cleaning unit from Claas, now New Holland also offers a hillside compensation by overlayed transverse vibrations on the cleaning sieves. Claas controls the transverse vibration by a hydraulic, which keeps a pendulum vertically and moves by this the linkage of a rocker arm. New Holland moves the linkage by an electric motor. The size of the transverse vibration is influenced by the side slope and additionally by the setting of the fan speed. By this the density of grain is, according to the manufacturer, also taken into account.

### Teleservice

The best utilization of the machines can be achieved by the use of electronic systems. Additional effort is needed to reduce the downtime of combines and to use all the available hours for harvesting. On the one hand teleservice enables the recording of machine data and the transfer to a central server. From there, these data are available for the analysis of the use and the settings of the machine via Internet. By graphics of the performance several machines in use can be compared. The superposition of the position of the machines on worldwide available maps like Google Earth visualizes the location. Teleservice also enables the connection of a machine to a diagnostic system for the online analysis of the machine condition [6]. The results are reliable failure analysis and short downtimes for any necessary repairs. These teleservice systems have particularly high acceptance in very large structured regions. The overview for the owner of the machines on the current operating conditions is very difficult there. In the case of service the times on the road can be reduced to a minimum by good remote diagnosis of the damage.

### Basic electronic structure

Since the mid-90s of the previous century, the use of CAN-bus systems in combine harvesters has started. The extent of this, often only for one series designed system, has grown rapidly. The limits of these systems regarding busload (number of messages on the bus), processor performance, number of CAN nodes, and of the costs have soon been reached. By the example of one series of combine harvesters, the number of electronic controllers (ECU) increased fivefold within 15 years, by surely also increased computing power per controller [7]. The developers were forced to restructure these systems fundamentally and to use them for all ranges of machines of one manufacturer. Today, by the reuse of functional components in different series, costs can be reduced and also the user interface can be standardized. The reuse of software and hardware components can be achieved by structuring of the electronics design process. Using standard software for operating systems, drivers and communications protocols, and the use of software development tools enables the single development of software functionalities and their multiple uses in different terminals or controllers.

### Summary

The use of electronics in agricultural machines has become naturally since several years. The fundamental revision of existing systems is already completed. Continuously new applications and application areas are coming-up. As long as the complexity for manufacturers, distributors and service remains manageable, and as long there is a cost advantage and a functional benefit for the operator, this development will continue. First comprehensive control systems in combine harvesters, which integrate various parameters of different units in the machine for a throughput regime, have already been proven in the market. The optimization of the machine setting remains a big challenge. So far, the operator is only informed on process parameters such as throughput, losses, purity and grain breakage. The modification of the machine setting still remains the task of the operator.

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