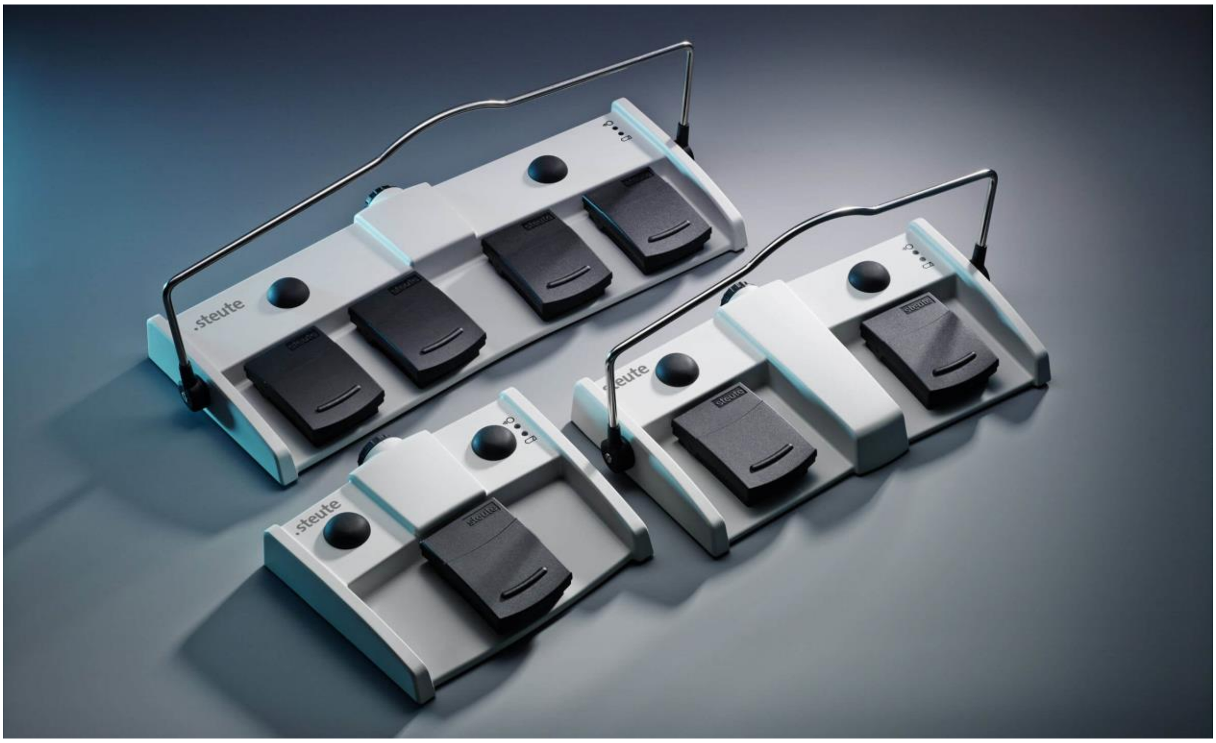
Technical article, published in: etz (11/2022)



01 steute wireless controls for medical devices are used, for example, in the OR. Due to the strict hygiene regulations they must comply with protection class IPX8

# Sensors and antennas are best when integrated

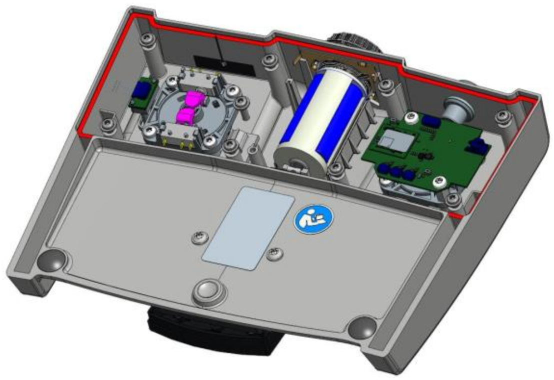
**In a project by the cluster of excellence it´s OWL, steute is currently testing the integration of sensors and antennas in the enclosures of control systems and user interfaces for industrial, as well as medical applications. A combination of laser-direct structuring and additive manufacturing is being used. The results are extremely promising.**

Laser-direct structuring (LDS) can be crucial, for example facilitating some laptop and smart phone functions. This process makes it possible to integrate three-dimensional circuit board traces, sensors and antennas directly in the plastic enclosure of the device in question. A special plastic enriched with metallic additives is used for the injection moulding process. A laser "writes" the electrical layout onto the plastic component. This activates the additives, which in the subsequent chemical bath then bond with the copper. In the activated areas, three-dimensional circuit paths form and are preserved with a layer of nickel or gold and maybe painted over. The last step is dependent on the application and whether the conductive layer should remain on the upper surface or be protected.

This is how the antennas of smart phones or other smart devices are created. Devices with



steute Technologies GmbH & Co. KG
Brückenstr. 91
32584 Löhne, Germany
Phone: + 49 5731 745-0
Fax: + 49 5731 745-200
info@steute.com
www.steute.com



02 Damp monitoring inside enclosures is a good option for user interfaces in the OR – and a research topic for the it´s OWL Merlin project

03 Flexible circuit boards and sensors can be integrated in three-dimensional enclosures

selectively metallated surfaces are also known as MID: moulded integrated devices or mechatronic integrated devices.

**Aim: to integrate circuit board traces in conjunction with small quantities**

This tried-and-tested technology is highly in demand, not least with regard to IoT, integration and increasingly compact terminal devices. Since it is based on injection moulding, however, it cannot be used economically for smaller series or one-off products.

For a company producing, for example, switchgear or drive elements in small to medium quantities, the questions therefore arise: Is it possible to attach circuit board traces to plastic enclosures or integrate circuit board traces in the enclosures and in this way produce MID? And can the benefits of LDS also be used in combination with other production technologies?

Finding answers to these questions is the task of the project "Smart wireless MID sensor systems for IoT applications" (Merlin) within the "Intelligent technical systems – it´s OWL" cluster of excellence. Two research partners (Fraunhofer IEM, Paderborn, and OWL University of Applied Sciences, Lemgo), as well as three industrial companies (Berg Spannsysteme, Lenze and steute), have been working together in this project since it began in March 2021. It is supported by the state of NRW with funding from the Ministry of Economic Affairs, Innovation, Digitalisation and Energy.

**Development goal: measurement of damp inside OR foot control**

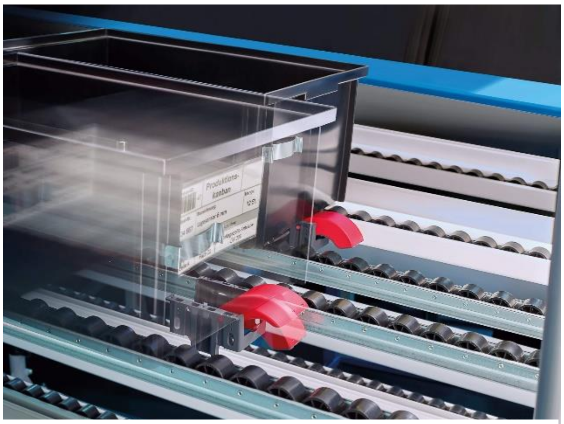
From the point of view of steute, one of the most interesting potential applications is in its business unit Meditec. Here the company develops and manufactures foot controls as human-machine interfaces for medical devices used in the OR (Fig. 1). In order to meet the strict hygiene requirements, the switches regularly undergo intensive cleaning and therefore need to be extremely well sealed. The required standard is protection class IPX8. Each individual switch is tested for leakage at the end of the assembly process.

Should wet or damp have penetrated the switch despite all precautions, the corresponding medical device could no longer be operated. It is therefore an understandable goal to wish to monitor damp inside the foot controls – as simply yet reliably, and as affordably as possible.



steute Technologies GmbH & Co. KG
Brückenstr. 91
32584 Löhne, Germany
Phone: + 49 5731 745-0
Fax: + 49 5731 745-200
info@steute.com
www.steute.com

04 An integrated capacitive damp sensor printed onto the surface was also tested



05 The it´s OWL project also investigated the integration of antennas in 3D-printed actuating elements of wireless sensors

**Prerequisite: a combination of LDS and additive manufacturing**

Fundamentally, the LDS process is suitable for the abovementioned application case. However, the foot controls in question are only produced in relatively small quantities. The prerequisite if LDS is still to be used comes from a process developed and patented by the Fraunhofer Institut IEM. It combines LDS with additive manufacturing, whereby an additive plastic powder is used to print the three-dimensional component. Similarly to LDS for injection-moulded parts, the laser "burns" the layout onto the surface of the component and metallises it using copper ions. Here, too, the conductive layer can be coated and protected with a layer of paint.

An additional possibility: The OWL University of Applied Sciences (Lemgo) uses a powder paint which permits organisation of circuitry on any metal plates. Here, too, the LDS process can therefore be used.

**Two strategies for measuring damp inside switch enclosures: resistive and capacitive**

Within the Merlin project, steute and its two research partners tested two options for measuring damp inside switch enclosures (Fig. 2). In a demonstrator, parallel but unconnected circuit board traces are fixed to the main plate of the enclosure. Following the principle of resistive measurement, a penetrating drop of water makes a connection between proximate circuit board traces and creates a short circuit. This is apparent as a drop in voltage: a clear signal for the penetration of damp.

In a second demonstrator, the principle of capacitive damp measurement was applied, and a sensor created by laser activation of applied paint (Figs. 3 and 4). From the change in the dielectric constant, conclusions can be drawn about the entry of damp, but the results are less reliable compared to those from resistive measurement. The reason for this is probably that individual drops only have a small impact when measuring capacities across a large surface area. This could be helped by using an absorbent fleece laid over the capacitive sensor surface.

The results of this sub-project show that the combination of LDS and additive manufacturing in the described application case is fundamentally promising. There is a high probability that they will be adopted in the serial manufacture of medical user interfaces at steute.



steute Technologies GmbH & Co. KG
Brückenstr. 91
32584 Löhne, Germany
Phone: + 49 5731 745-0
Fax: + 49 5731 745-200
info@steute.com
www.steute.com

**Second MID application: integration of an antenna in a wireless sensor enclosure**

In a second sub-project, the combination of technology fields AM and MID was examined using the example of a wireless sensor from the steute business unit nexy. nexy is a wireless network which monitors and controls material flow across the entire shop floor. Elimination of cables permits the detection of boxes in moving Kanban racks. Sensors also monitor dollies and tugger trains at their transfer points, aiding in-house material replenishments.

The nexy hardware components include a tilting sensor which monitors the occupancy of eKanban racks (Fig. 5). Several hundred such tilting sensors can be used within a single nexy installation. A two-dimensional metal antenna is located below the plastic rocker, which is manufactured using injection moulding. In practice that functions well, but when the antenna features an improved radiation pattern and extended range, the number of Access Points as receiver units in the field can be reduced. That was the aim of this project, integrating the antenna in the rocker and also guiding it three-dimensionally over the front surface of the rocker.

The simulation was first performed using a 2.4-GHz-wireless system, the frequency used by steute for its medical technology. Because the antenna is more compact, it is easier to realise. In a second step, the results are then to be translated to the 868-MHz-frequency used in the nexy wireless technology. Following the concept of combining LDS and additive manufacturing, the three-dimensional antenna is integrated in the surface of the rocker, thus considerably increasing the range of the antenna and its radiation pattern. This project is still ongoing; final results are not yet available.

**A fast way to access new technologies**

The conclusion steute is able to draw: the very good collaboration with the two research institutes and the two other industrial partners in the Merlin-project opens up new perspectives, helps to unlock innovative technologies and accelerates implementation. In the short to mid-term, it will potentially mean that steute can use the MID technology in two of its business units and in two different application fields (damp measurement in HMI-enclosures, and integration of antennas in sensors).


Authors:

**Julia Mönks**
Product Manager MMI
steute Technologies

**Marc Schmidt**
Head of Development Software & Electronics
steute Technologies


Images: steute Technologies GmbH & Co. KG




steute Technologies GmbH & Co. KG
Brückenstr. 91
32584 Löhne, Germany
Phone: + 49 5731 745-0
Fax: + 49 5731 745-200
info@steute.com
www.steute.com