Smart Actuators – The Future of Automotive Systems

A close look on the automotive supply chain shows clearly, that there are many problems that need to be solved; restricted space, thermal conductivity and high power density are challenging issues. Therefore, smart actuators could be an alternative to meet these challenges, creating additionally some benefits.

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Introduction to Smart Actuators

First of all, smart actuators may not be suitable for all kind of automotive application. At least, there is not automatically a need of replacement. There may exist many reasons for not choosing the highly integrated solution; one of them is the cost of development. A "normal" solution may fit for low quantities, since the development is often cheaper and there are more suppliers available.

To manufacture a smart actuator is not easy. System integrators with experience and having an appropriate network of partnerships along the supply chain are needed. Highly integrated systems like smart valves or power packs have the advantage that they require less weight and space than conventional alternatives. They also reduce EMC problems but the interfaces of the different parts need to fit together. The system integrator should have the ability and the deep understanding of all main components being able to design them in close cooperation with the relevant partners to finally get a completed and optimized system.

Thermoset overmolding of electronics

To get an integrated system the housing design especially for the electronics is a very critical issue. There are many points that need to be covered accordingly like size, weight, thermal conductivity, mounting points, connectors and integrated bearing shields. All this and more is possible in one part if you overmold the electronics with thermoset. This has the advantage that there is no air gap between the components on the PCBA and the housing. A very good thermal connection between the power components and outside can be archived with a thermal connectivity of about 0.5 to 2.0 W/mK, even up to 10 W/mK is possible but more expensive. A method to avoid hitting the limits in point of price or thermal conductivity of thermoset is to insert metal inlays to get heat guides to external heat sinks.

Figure 1 2K molded housing with features

Another point of consideration is that if you overmold the electronics with thermoset using proper connectors and materials you get oil and even gas tight parts. This is because the thermoset gets into a molecular connection with few other materials. Finally the question is why not simple use the well known thermoplast for overmolding the electronics? Thermoplast shows high molding temperature and pres-

sure whereas thermoset has a molding temperature of about 180°C with under 10 bar injection pressure. So overmolding electronic PCBs is only possible with thermoset but not every supplier can provide this service.

Figure 2
Thermoset overmolded electronics

Valves in automotive applications

In a modern car there are plenty of valves grouped on one electronic control unit (ECU) but sometimes there are only a few valves were an external ECU is oversized. In these cases an integrated valve is a good solution. The advantage of inserting the ECU into a valve is remarkable: Despite of space savings, weight reduction and EMC problems, some interesting software features are possible as well, e.g. to calibrate the hysteresis of the valve and store it into the internal microcontroller to remove the production tolerances. With Flowtronic there is a valve available that works with 12 Volt with CAN communication on two connector pins. The output of the proportional valve is a controlled pressure up to 40 bar with a coil-current of 3 Ampere all inside a valve with 30 millimeter diameter.

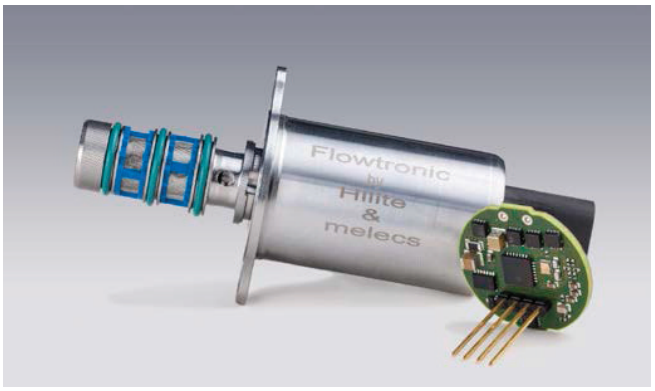

Figure 3 Smart valve Flowtronic [Ø30x80mm]

Power packs for gearbox applications

Small 12 Volt motors are commonly used in powertrain applications mainly with external ECU's. This was the common way of doing it because the electronic housing and components were not small or in the small package not powerful enough. With thermoset housings it is possible to solve that complexity of the housing in point of mounting and internal features, getting thermal assistance for the PCBA components as well. The Micro Power Pack (MPP) features a 12 Volt supply (150W) with CAN communication. The BLDC motor has a speed of 3000 RPM with 0.5 Nm. It is also possible to integrate the motor winding interconnections for parallel winded motors into the PCB which saves unit space and reduces EMC and eliminates an additional lead frame.

Figure 4 MPP100 with demo pump mounted [Ø66x70mm]

Hydraulic smart actuators

If thermoset overmolded electronics seems to be too expensive or the customer prefers to stay within the well known manufacturing processes, a "normal" assembly will be suitable. Housing made of aluminum has the advantage of a good thermal connection from the PCB to the heat sink, which is mostly not the air around the housing but the mounting on the gearbox itself. The disadvantage is that an electrical isolation from PCB to the housing is needed. This could be done in many ways; one of them is to inserting isolation material between the two parts. This adds part costs and width. Therefore, Melecs uses its patented design which includes electrical isolation into the PCB layer stack and saves costs and assembly time.

This consequently leads into developing a Micro Hydraulic Power Pack (MHP) which results in a tiny product with dimensions of 155x80x93mm, including an inverter for 24 or 12 Volt supply within the same

electronic PCBA design. The whole system needs 200W of power and has an output of up to 450 l/h with 8 bar of pressure. All this gets paired with an ECU that is capable of CAN wake-up and KL15 wake-up to have simultaneous possibilities of enabling and disabling the system. With this feature the system have the opportunity of an intelligent limp home mode in case the CAN bus or the KL15 has a faulty behavior.

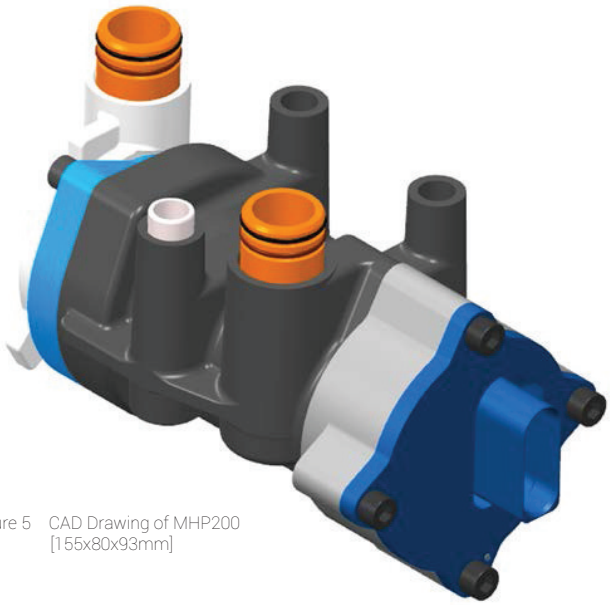

Figure 5 CAD Drawing of MHP200 [155x80x93mm]

High power applications in cars

When the power ratings are higher and the installation space does not expand, there are many problems that need to be solved. For example, the PCB layer stack looks different for logic or power board with two possible solutions. The first one is to make a mixed layer stack in one PCB for logic and power part. Unfortunately, this solution has not the best internal construction available but fits both needs with one single PCB. The second – and by the way – better solution is to split the PCB and make one logic board and one power board with an internal connector. The result is an optimum PCB stack for each one. Additionally, by splitting the PCB the cost savings are noteworthy as the logic board needs more layers then the power board. On this way, a small multi layer logic board with e.g. eight layers can easily be combined with a bigger power board with more copper in each of the four layers. This has also the advantage that a generic logic PCBA is available which can be reused for multiple upcoming projects. At input powers of up to 3000W at 48 Volt special supply connectors are needed. Therefore, splitting the power supply and the logic connector, like the PCBAs, is the best way to go.

In 48V systems most OEM's require "splitted grounds". This means, there are no connections allowed between 48 to 12 Volt bord grid. Having to separate grounds is not as simple as it seems to be. It is not only the two separated pins; it is also the fact that you need a communication between the boards and should not have the same grounding. So one way is to use inductive couplers, which raises the system costs. The second problem: If the logic unit is turned off, electrical power need to be provided to the CAN transceiver ensuring CAN wake-up features. So with an intelligent design it is possible to get a Hydraulic Power Pack that has the ability of generating 100bar with a flow rate of 12 l/min with only 117x117x216mm in dimension.

Figure 6 CAD Drawing of HPP3000 [117x117x216mm]

Conclusion

Finally, the recommendation to everybody who wants to design a smart actuator is to have a detailed look at the application, while considering if a smart actuator is the right solution. Also important is to ponder whether the company has the possibilities and the network of partner companies being able to develop and manufacture such complex systems accordingly. We at Melecs are convinced that smart actuators are the future of many applications all around the car but they need to be tailored precisely to the requirements of the application, installation space and environmental conditions around the smart product.

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