Press News

DC motors – reliable, rugged actuators in the vehicle

EC Motors, the extended arm of automotive electronics

Safety and reliability are of prime importance in automobile construction and, for this reason, auxiliary and accessory equipment has in practice till now also been driven mechanically from the driving machine (motor). The disadvantage of this solution lies in the increased fuel consumption and mechanical losses. A further aspect to be considered is the limitations placed on freedom of design by the inherent necessity of the coupling. Belt, chain or gear drives can only be fitted to certain areas of the engine. The external shape of the engine bonnet (hood) cover and thus the air-drag coefficient is subjected to these constraints. Increasingly the automotive sector is therefore resorting to discrete drives, a trend, which has long been established in the rest of machine building. Electro-motors are ideal as discrete drives, especially as electronically commutated (EC) DC motors work reliably even under the harshest operating conditions. Reliability was also the reason why motor manufacturers were loath to move to direct (gearless) drives. Modern EC motors designed for the application now reliably meet the specified requirements.

The basic trend in automotive construction highlights the increasing use of electronics, with around 30% of development costs flowing into this area. Whether one is talking about motor management, chassis design, safety or climate control and navigation, the interaction of all the components must be ensured. Electronics however is directed to operating elements, commonly called 'actuators', in order to implement mechanical tasks.

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Due to problems with electromagnetic compatibility, conventional DC motors with carbon brushes can only be used in limited circumstances, or require high EMC protection. "Lightning flash storms" on the collector with their resulting noise spikes, as well as the control components that are also required, do not go to make for integration into sophisticated on-board or bus systems. Electronically commutated motors offer an ideal alternative here. They too can be powered from the DC supply, but thanks to their commutating electronics are simple to control and can be integrated without any problems into a bus system.

Because of the planned increase in vehicle power supplies to 42 V, contact controlled relay switches, with their high contact erosion, will to a great extent be replaced by electronic components. EC motors however have no need for any additional "load electronics" – just a bus connection. Moreover, with careful choice of materials for the magnets and with the new higher voltage, motors can be optimised with regard to their power density and overall size so that the traditional drive configuration can be greatly out-performed! The motors can be produced either as external or internal rotor motors, which means that even from the design stage they can be adapted to suit the operating requirements.

EC External Rotor Motor

In external rotor motors the turning rotor sits outside over the excitation winding. This offers the advantage of high torque and at the same time good synchronous operation. The freely accessible rotor is ideally suited for example to carry various impeller blades as a fan drive. The motor and fan specialist ebm-papst of St. Georgen, Germany, specially manufactures therefore a variety of different fans for the automotive industry. It is important to note that there is a strict differentiation between products for the consumer or PC markets and those for the automotive sector. So for example the temperature range that vehicle motors operate at, from - 40 ° up to + 95 °C, is very wide. It has to be ensured that bearings, lifetime lubrication as well as the control electronics can stand up to this. As well as the more stringent EMC specifications that apply to automobiles, a safety immobilisation function has to be built into the electronics in case of fusing. The integration of motors into a control system by means of a built-in interface is now already standard.

In a similar way it is now expected that operating noise be almost inaudible and the speed be perfectly controlled. It is also important that the bearings be protected against shock and vibration – a rule of thumb is at least 4 g shock tolerance, this being the norm for components installed inside a vehicle. Naturally these must operate reliably as well.

Use in motor vehicles – a challenging task

If one compares these requirements with those for PCs or other consumer devices, then one quickly realises that the two kinds of fans are not comparable. Tasks that appear similar differ however drastically in their requirements. A PC does not move from its spot. A navigation device with radio and CD changer is just as highly integrated a component as a PC and also needs cooling. But simple PC cooling fans would fail after only a short period. However fans that have been specifically designed for automotive use live up to expectations. Of all the millions of radio/navigation devices in use, not one has so far failed due to cooling problems. The design of the fan is also crucial in ensuring it meets the demands placed on it. A high amount of pressure is for example needed for cooling compact electronic boxes, booster ventilators in the long, narrow air ducts of a climate control system or for blowers that cool various areas of the instrument panel via ducting. As a specialist in fans, ebm-papst St. Georgen can select the most suitable fan from its wide range to meet these particular automotive requirements (fig 1) This could be a radial fan delivering a higher pressure flow, an axial version for seat ventilation or specialist sensor fans for climate control – just about any customer requirement can be quickly answered.

EC Internal Rotor Motors – the dynamic ones

For functional drives, internal rotor motors are better suited than external ones. The low moment of inertia of the small internally located rotor allows fast rotating speeds or quick changes of direction. Moreover, thanks to the careful selection of materials as well as miniaturised electronics, a high power density is possible. This type of motor opens up a range of opportunities for use with auxiliary equipment and accessories.

The most well known example is the ECI motor (fig 2) for steering support in automobiles. The properties of this motor demonstrate the problems which automotive applications bring:

Throughout the entire service life, speeds of between 0 and 6,000 rpm have to be endured. For unobtrusive steering support, the sensitive, almost stepper motor like operation and the dynamic run-up operation are called for in quick succession. Used in vehicles, the motor is continuously loaded in 4-quadrant operation. The ebm-papst solution is based on the principle of a three-phase synchronous internal rotor motor, excited by a permanent magnet, and a sinusoidal current feed, i.e. the motor comprises a six-slot stator and a four-pole rotor. Doing without any kind of skewing in the stator and rotor results in cost-efficient manufacture. Cuboidal permanent magnets made of a high-quality neodymium- iron-boron material are embedded in the rotor package. A targeted widening of the air-gap in the rotor surface modulates the sinusoidal shape of the voltage. This on the one hand means that a very small static detent torque can be achieved, and on the other a high uniform torque when current is applied.

Flexible and able to be retrofitted

These requirements and characteristics apply extensively to all electro-motors in vehicles. Sometimes more emphasis is placed on absolute quiet running like with motors within the vehicle cabin, for example for seat adjustment, whereas at other times a “finely dispensed” amount of stepper motor operation is the priority, as is the case with control actuators for brake linings or cooling discs and spoiler drives. Thanks to the use of EC motors, comfort and optimised fuel consumption can be combined in the areas of steering, clutch and gear-change. The driver can choose the point in time or a program, following which the actual clutch engagement or gear change is carried out by a rugged EC motor connected to the bus of the motor management system. Acceleration, clutch and gear-change are thus optimally synchronised with the minimum of wear.

Currently in use as the preliminary stage to a direct drive is for example a hydraulic pump that is driven by the electro-motor (fig 3). This has the advantage of doing away with the belt transmission, with its heavy wear and constant need for intervention, as well as reducing the fuel consumption. Furthermore the hydraulic pump can now be installed independently of the engine at a suitable location in the vehicle. By continuing to use the actuator hydraulics, the final control elements previously used can be kept, with the added advantage that any costs for a re-design are minimal.

Constructively matched to the needs of automobile operation, electronically commutated DC motors present the manufacturer with a wide variety of new opportunities. The individual drives have the flexibility to be installed as desired on site, have a compact construction thanks to their high power density and are easy to control. The reliability of modern EC motors lies way above that of belt or chain drives and they need absolutely no maintenance. This not only increases the safety of the vehicle owner but also his satisfaction. Inspection intervals are less frequent and the number of items needing to be checked is drastically reduced. In cooperation with the increasing use of electronics in the automotive industry these individually controlled and operated electro-motors, acting as the “extended arm” of those electronics, offer user-friendly cost saving solutions throughout the vehicle.

PAP049_Intro1.jpg

PAP049_Intro2.jpg

Intro 1 & 2: Modern DC motors with electronic motor commutation

PAP049_fig1.jpg

Fig 1: Selection of fans with properties specially chosen for automotive use, guaranteeing long-term reliable operation – here, for example, sensor fans

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Fig 2: ECI steering support motors – compact and dynamic, with a high-performance construction that defies every adversity in vehicle operation

PAP049_fig3a.jpg

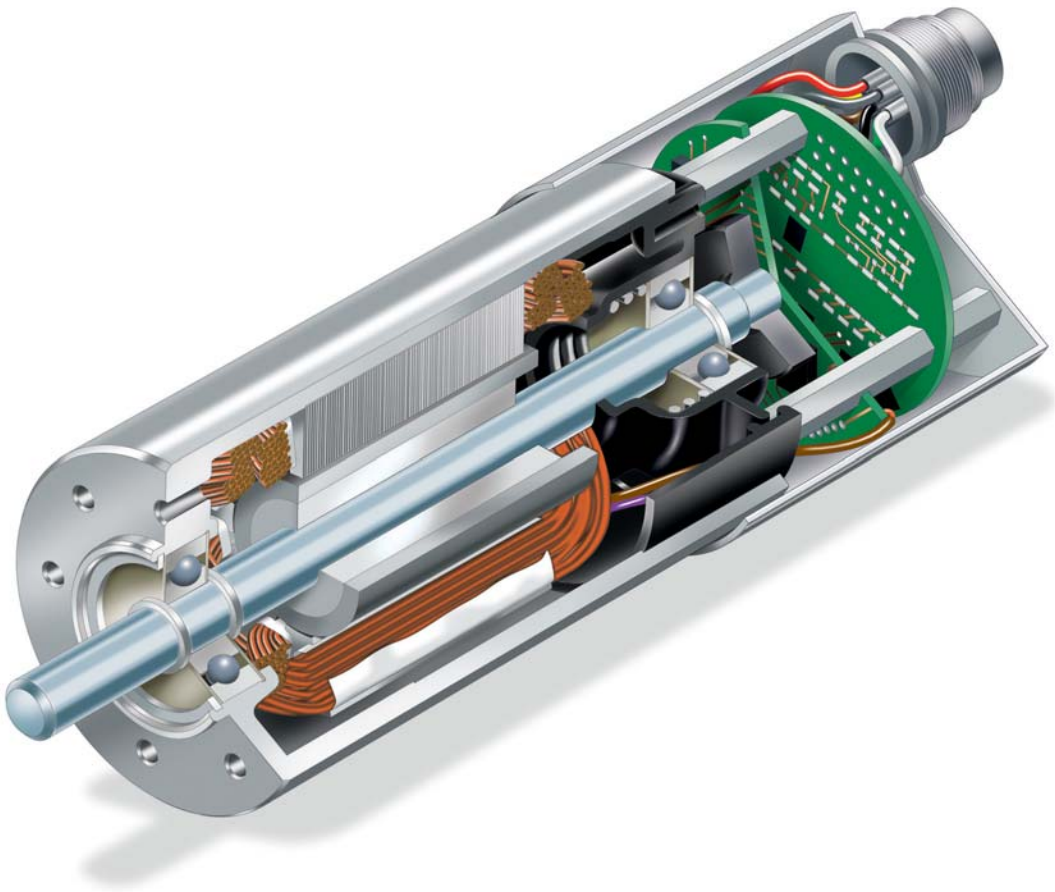

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Fig 3a & 3b: EC internal rotor motors for dynamic tasks. Reliability and power density are the prime requisites