Smart Actuators - The Intelligent Choice

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Modern cars contain more than 130 motors to control everything from HVAC systems, coolant and refrigerant valves, headlights and seat adjustments to grille shutters, vehicle security and trunks. Most automotive actuators are comprised of an electric motor and gearbox assembly packaged in a housing. They take an electrical signal and convert it into rotary or linear motion, resulting in a physical change to a component on the vehicle.

Smart actuators are a relatively new innovation in the automotive industry. They combine actuators with local drive electronics and internal or external sensors to make dynamic adjustments to automobile systems, reducing weight and drag and increasing efficiency. Smart actuators are capable of performing diagnostics and include learning capabilities and memory functions.

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CO_2

The worldwide harmonized light vehicle test cycle (WLTC) and worldwide light vehicle test procedures (WLTPs) will be introduced in September 2017 and will apply to all cars by September 2018. The WLTC and WLTPs replace the New European Driving Cycle (NEDC) and define a globally harmonized standard for measuring pollutant levels, CO_2 emissions and fuel consumption for light-duty vehicles. They close the gap between test stand emission and field emission, and cover higher driving speeds as well as special features and tires. The European Union (EU) has set goals of 95 gCO_2/km for 95 percent of all new cars by 2020, and for 100 percent of all new cars by 2021.

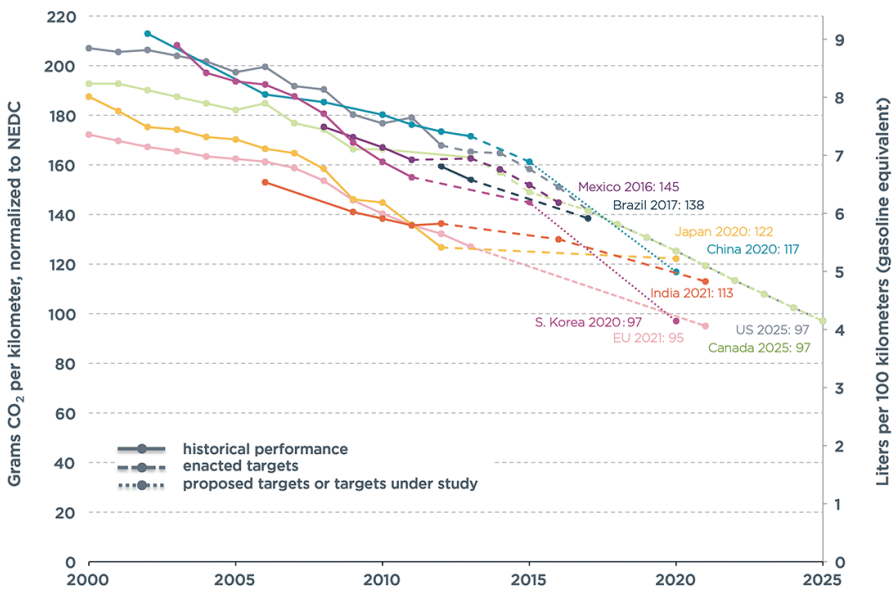

Figure 1: International emissions goals. (Source: International Council on Clean Transportation)

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OEMs within the EU gain super credits if they reduce CO_2 emissions; these credits allow manufacturers to consider ultra-low carbon vehicles (ULCVs) as more than one vehicle, thereby artificially lowering their emission average. In 2012-2013, each ULCV was counted as 3.5 vehicles. This was lowered to 2.5 in 2014, 1.5 in 2015 and 1 in 2016-2019. Super credits also apply to the second stage of emission reductions to .35 g/km in 2020-2022. Each low-emitting car in this time period will be counted as 2 vehicles in 2020, 1.67 in 2021, 1.33 in 2022 and 1 in 2023.

Aerodynamic features are a cost-effective way to reduce CO_2 emissions. A car's aerodynamics (C_w value) avoid lift-up from under the car, reduce drag and contribute to the total energy cycle of the car by as much as 42.2 percent for city cars. There is a trend visible of automakers incorporating these features into the designs of cars. However, there are many areas where this isn't possible. These cases present opportunities for the implementation of active aerodynamic solutions.

Smart Actuator Applications for Active Aerodynamics

Self-adjusting front or rear spoilers and grille shutters—which automatically open when engine compartment temperatures rise and close when they drop—are examples of active aerodynamics. Active aerodynamics help to lower a car's drag coefficient without compromising performance or safety.

The accompanying table displays some of the many opportunities for active aerodynamics.

Location	*Critical areas*	*Features possibility*
Overbody	Fascia / air intake (cooler)	Active grille shutter
	Car back upper side	Active spoiler Active back retraction
	Other features	Active sun roof air deflector
Underbody	Fascia lower side	Active air dam
	Tires	Active speed lips
	Axles	Active air deflector
	Features causing turbulences	Active air deflector
	Car back lower side	Active diffuser flaps

Table 1: Active Aerodynamic Opportunities. (Source: NMB Technologies Corporation)

In experiments conducted by Audi in 2016, the drag coefficient of an Audi A4 improved from 0.26 to 0.231 C_w by optimizing the fascia and mirrors using speed lips as well as optimizing the underbody. These tests showed that underbody optimization is an important and often overlooked area. Of the 0.031 C_w reduction, 69 percent was attributed to underbody optimization. Applying active aerodynamic features to the underbody opens up many possibilities for improving efficiency. For example, the forward side of the front tires is a source of great turbulence. Placing an active speed lip in front of the tire to reduce turbulence is an opportunity for active aerodynamics. Additional underbody active aerodynamic possibilities include active air dams and an active air diffuser. Placed at the location where air from the underbody and over-body come together, the active air diffuser steers air flow dependent on the car's speed.

NMB Technologies Corporation is part of the MinebeaMitsumi group of companies, a world leader in the design and manufacture of electro-mechanical components. MinebeaMitsumi leveraged their PMDM GmbH division's expertise in brushless DC (BLDC) motors to develop the PA241x and PA242x BLDC active grille actuator (AGA) series and the stepper-driven HAL actuator for HVAC applications.

PA241x and PA242x BLDC—Smart Actuators

NMB Technologies Corporation smart actuators incorporate drive electronics and a motor into the actuator housing. They find their main application in active grille shutter (AGS) systems.

Figure 2: PA241X Actuator (Source: NMB Technologies Corporation)

Every car has a radiator and a grille. Air streams through the grille and into the engine compartment, causing turbulence. The grille shutter consists of vanes that can close the air stream down and block the air from entering the engine compartment. This reduces turbulence, which decreases drag and increases fuel economy. The vehicle's electronic control unit (ECU) decides whether the grille shutter needs to be open or closed based on the engine and outside temperature, driving conditions and other factors. The actuators open and close the grille shutter as needed, allowing the car to operate efficiently without the risk of overheating. The integrated electronics drive and control the BLDC motor and communicate with the vehicle's ECU via LIN interface to receive commands and provide feedback about its status and events such as actuator position, temperature, over-current or over-voltage report and many others. Additionally, it stores crucial events aiding continuous quality control.

Active grille shutter actuators (AGA) feature a three-phase BLDC motor and have several advantages over actuators with stepper motors. Stepper motors provide the same torque during operation, while the BLDC motors supply torque on demand and only provide the torque needed based on the sensed force, reducing power consumption and stress. The actuators also adjust the current to pull at different temperature levels to ensure that torque is always the same, even if the temperature drops below freezing. BLDC motors exhibit a soft landing (torque reduction before the end-stop),

resulting in less stress for end-stops and benefits for high-torque setups. Due to direct torque control, the actuator features immediate blockage detection. BLDC actuators also offer no loss of calibration during boost mode, while stepper motors lose calibration.

Other Smart Applications

Figure 3: PA241X Actuator (Source: NMB Technologies Corporation)

Initially developed for active grille shutters, the PA242x and PA241x actuators can be incorporated into virtually any active aerodynamic application. Beyond aerodynamics, reliability and durability make the actuators feasible for many other automotive applications. Originally developed for vehicle seat adjustment and rear spoiler systems, NMB Technologies Corporation smart actuators allow communication with each other to operate on a master/slave principle. The actuator in the first position is designated as the master and communicates with the vehicle's ECU, while the other actuator is the slave. This technology allows OEMs to drive certain features in a precise synchronized fashion and to replace applications where one motor drives two linkages connected over distance by a rod bar.

The introduction of local drive electronics allows the actuators to respond without receiving a command from the vehicle's control system. They receive one signal from the car's ECU and execute a program that makes decisions based on signals and sensory input for monitoring temperature, load and other conditions. The sensors can connect directly to the smart actuator's local drive electronics.

Due to NMB Technologies Corporation's modular technology approach, a variety of actuators and BLDC motors can be equipped with smart driving technology.

AGA Actuator Specifications

PA2410

General Information	Options	Features
Motor: Three-phase BLDC	LIN Interface: 1.2 / 2.x	Single Output Shaft
Sensorless Positioning	PWM Interface: PWM	High Power-to-Volume Ratio
Position Memory Even in Boost	Digital Interface: ON/OFF	Various Control Interfaces
Weight: <70 g	Connector: MLK (a,b) / WDP	High Reliability
Radial Play: <4°		

Table 2: PA2410 AGA Specifications. (Source: NMB Technologies Corporation)

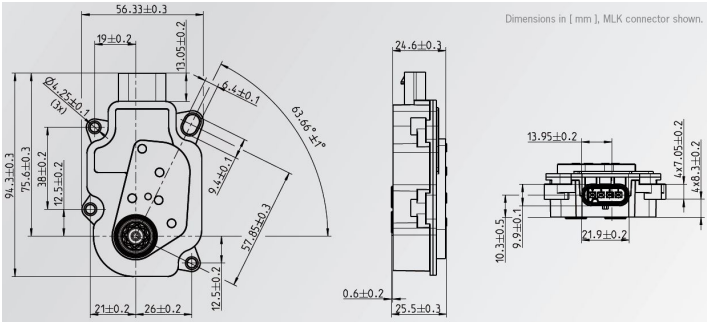

Figure 4: PA2410 Illustration. (Source: NMB Technologies Corporation)

PA242x

General Information	Options	Features
Motor: Three-phase BLDC	LIN Interface: 2.x	Dual Output Shaft
Sensorless Positioning	Mounting: Adujstable	High Power-to-Volume Ratio
Position Memory Even in Boost	Connector: MLK (b) / WDP	Various Control Interfaces
Weight: <90 g		Torque Control Mode
Radial Play: <5°		

Table 3: PA242x AGA Specifications. (Source: NMB Technologies Corporation)

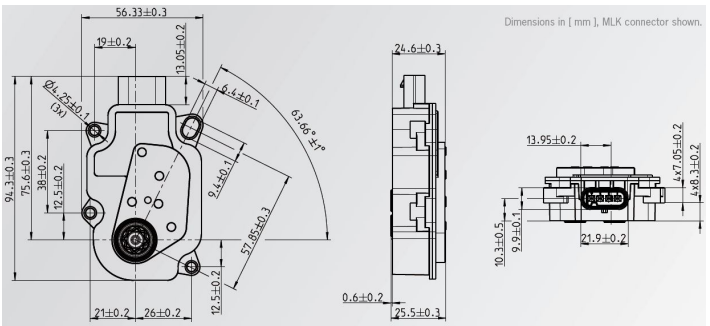

Figure 5: PA242x Illustration. (Source: NMB Technologies Corporation)

HAL Actuators for HVAC

NMB Technologies Corporation's HVAC actuator with LIN interface (HAL) is a stepper-motor-driven actuator designed for automotive air conditioning system applications. Each car uses three to 12 actuators for mode change, air inlets and outlets and air mix.

Figure 6: HAL HVAC Acuator.(Source: NMB Technologies Corporation)

The HAL is the latest NMB Technologies Corporation HVAC actuator development that began in 2003 as the VHB30 series and includes the HAD series from 2012. What sets it apart from traditional stepper-driven actuators is the

incorporation of an onboard ECU and LIN interface that allows two or more actuators to communicate with the ECU and to move independently. As with the AGA line of smart actuators, HAL actuators can operate as a master/slave relationship. The master is located in the control panel and all other actuators are slaves; they do not control other actuators.

Key features of the HAL actuators are the compact footprint, low noise, good EMC characteristics and high-durability design. An ASIC flash version is available and a ROM version is planned for the future.

The diagram below illustrates typical actuator locations in an automotive HVAC system.

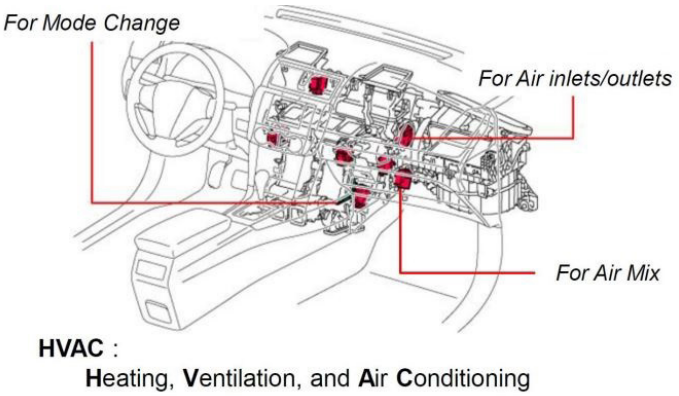

Figure 7: Automotive HVAC actuators. (Source: NMB Technologies Corporation)

MinebeaMitsumi manufactures three different versions of the HAL actuator: the HAL 1.3X, the HALL 2.x and the HALG-480. The main difference between the three models is their LIN protocols.

General Specification			HAL - 480	HALL - 480	HALG - 480
Nomenclature			HAL-480	HALL-480	HALG-480
LIN Protocol			LIN 1.3	LIN 2.x	SAE LIN
Mechanical Dimension			65x49x25	65x49x25	65x49x25
PIN Details			1- Gnd 2- LIN Bus In 3- LIN Bus Out 4- Vbat	1- Gnd 2- LIN Bus In 3- LIN Bus Out 4- Vbat	1- Gnd 2- LIN 3- Addrs 4- Vbat
LIN Bus Protocol			Cooling (LIN 1.3)	Ver 2.0/2.1	Ver 2.0 (SAE LIN)
Weight			<57 g	<57 g	<57 g
Operating Temperature			-40° C to 85° C	-40° C to 85° C	-40° C to 85° C
Operating Voltage			9.0 V to 16.0 V	9.0 V to 16.0 V	9.0 V to 17.0 V
Pull-In Torque	@-40° C, 9.7 V	Speed 0	≥40 Ncm	≥40 Ncm	≥40 Ncm
Speed			Speed can be controlled by a LIN bus command and has up to five different settings, including auto speed.		

Table 4: HAL Series Comparison. (Source: NMB Technologies Corporation)

Conclusion

As CO_2 emission regulations continue to tighten, automotive OEMs are looking for ways to reduce weight and drag and avoid lift-up to increase car efficiency. Incorporating active aerodynamics into designs is a cost-effective approach to achieve these goals. Active grilles and air dams, as well as underbody solutions such as active speed lips, will become commonplace, and smart actuators from NMB Technologies Corporation are a wise choice for these applications. The integrated local device controls, LIN communication protocol and BLDC motor technology, offer unparalleled performance and functionality.

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ABOUT NMB TECHNOLOGIES CORPORATION

NMB Technologies Corporation, a MinebeaMitsumi Group company, is a volume leader in the design and manufacture of a broad range of high precision electro-mechanical components and advanced technologies. NMB products include miniature ball bearings, cooling fans, small motors, smart actuators, sensors, LED lighting solutions and resonant devices, as well as smart cities management solutions. NMB and MinebeaMitsumi products can be found in the automotive, medical, and consumer electronics industry, as well as in telecommunications and industrial markets. For more information visit: http://www.nmbtc.com and http://www.minebeamitsumi.com