Technical information

Valve Control Management (VCM®)
Flexibility to meet future challenges
At the heart of the engine

The ability to control valve timing and valve lift on combustion engines brings a range of benefits in terms of engine operating performance, emissions and fuel consumption. It is an enabling technology for a number of measures on four-stroke diesel and gas engines which target lower emissions, improved engine efficiency, increased power density and enhanced transient behavior.

Proven technology
Anticipating this demand, in 2009 ABB Turbocharging agreed a collaboration with one of the leading exponents of variable valve timing in the automotive sector, German engine component specialist Schaeffler Technologies GmbH & Co. KG. The agreement centers on the development of the UniAir® variable valve train system for automotive engines to suit applications on large four-stroke diesel and gas engines with power outputs above 400 kW.

VCM
The result of the cooperation is VCM
V = Valve
C = Control of timing and/or lift
M = Management in steady or transient mode

Like UniAir®, it uses electro-hydraulic technology to achieve progressive variation of timing/lift of the inlet or exhaust valve.

VCM offers the following features:
Quick and stepless: Unlike purely mechanical systems, e.g. those which vary the positions of the fulcrums of cam followers to change the timing of valve actuation and valve stroke, VCM offers a wider range of fully proportional control of valve timing/lift. Compact and add-on: The VCM system combines all elements in a single module which can be readily installed on four-stroke engines. The majority of VCM equipment is located under the valve cover, and by using the engine lube oil as its hydraulic fluid and a simple solenoid valve as its control organ, only two control/supply connections are required. The system also requires no major changes to engine architecture and the modules are readily fitted during the assembly process at the engine builder’s works.
VCM in action

**Flexibility**
The stepless variation in valve timing and lift achievable with VCM represents a versatile tool for:

- Varying Miller cycles on forthcoming generations of low emissions diesel and gas engines
- Closely adapting engine performance to the operating profile of a given engine application, e.g. switching from emissions to fuel optimized modes
- Potential for realizing internal exhaust gas recirculation on four-stroke engines

**Enabling Miller timing**
Indeed, ABB Turbocharging sees VCM's foremost application as one of the major enabling technologies for engine builders seeking to exploit strong Miller cycles as a route to far lower emissions of NOx. The Miller cycle is a clever way of cooling the cylinder charge of diesel engines to eliminate the combustion chamber temperature peaks responsible for over 90 percent of NOx formation. On gas engines, the technique can be used to substantially increase power density.

**Miller cycle principle**
On four-stroke engines, substantial cooling of the engine intake air is achieved by the internal expansion of the trapped mass. The earlier the induction ends, the cooler the charge becomes. These advanced Miller timings are only possible with two-stage turbocharging with its high pressure ratio and turbocharging efficiency capabilities. However, strong Miller cycles call for turbocharging efficiency at its Maximum Continuous Rating (MCR). At lower loads, longer valve opening is needed to avoid emissions of smoke and particulate matter, as well as poor engine response to load changes due to intake air deficiency.

**VCM solution**
With its capability to vary valve timing, VCM provides engine builders with a powerful tool for adapting the strength of Miller cycles across the complete operating load and speed ranges of four-stroke diesel and gas engines.

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**Early Miller cycle and standard induction at the moment of inlet valve closure.**

Shifting the curve – fuel consumption and NOx reduction potential using two-stage turbocharging to achieve strong Miller Cycles on further developed diesel engines.
VCM achieves stepless variation in valve timing by interposing a high pressure oil chamber in the engine valve train between the valve and its mechanical actuation system. A solenoid valve varies the filling of the chamber with engine lube oil pressurized by a camshaft-actuated pump. This enables both the timing of the opening and closing of the valve to be varied as well as the valve lift. The pump also feeds a brake unit to limit forces when the valve contacts its seat.

<table>
<thead>
<tr>
<th>Full lift</th>
<th>Early closure</th>
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<tbody>
<tr>
<td>Late opening/early closure, limited lift</td>
<td>Double opening</td>
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ABB Turbocharging
A unique partner for advanced engine performance.

VCM is designed as a flexible solution to enable precise, fast and cylinder-individual control of high performance gas and diesel engines. It delivers greater benefits for engine builders and operators, compared to conventional turbocharged four-stroke engines.

VCM is a major element in ABB Turbocharging’s growing portfolio of products and services for engine builders and engine end users. Their common aim is to optimize the performance, economy, reliability, availability, life cycle costs and not least the exhaust emissions of diesel and gas engines.

Benefits of VCM for operators

<table>
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<tr>
<th>Benefits of VCM for operators</th>
<th>Leading to reduced fuel consumption, lower CO₂ emissions, and lower thermal load which results in reduced total cost of ownership (TCO).</th>
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<tr>
<td>Improved efficiency</td>
<td>Enables fast load pick-up and power availability.</td>
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<td>Improved transient behavior</td>
<td>Leading to lower first costs and lower TCO.</td>
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<tr>
<td>Broader application and</td>
<td>Lower raw emissions lead to reduction in costs for emissions abatement equipment and operation.</td>
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<td>operation range</td>
<td>First cost is reduced through engine downsizing.</td>
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Benefits of VCM and Power2®
Fitting perfectly with VCM is ABB Turbocharging’s Power2 two-stage turbocharging system. These complementary technologies represent essential enablers of variable Miller cycles on large four-stroke engines.

Combining the capability for VCM to control air intake with the increased turbocharging efficiency of a two-stage turbocharging solution, additional engine efficiency gains are possible. Together, two-stage turbocharging and VCM gives a gas engine, for example, the power density of a diesel engine. This ultimately enables higher output and a number of key benefits for operators. These include: adaptability to different operation profiles and to fuel types; reduced emissions through further advanced Miller timings; and improved transient response.

Unique development partner
With these technologies, ABB Turbocharging is a unique partner for two of the major on-engine systems required by diesel and gas engine builders to prepare their products for the new era of strict global emissions limitations.
Emissions compliance
IMO Tier III and EPA Tier

IMO Tier III
The third stage of marine engine emissions legislation issued by the International Maritime Organisation builds on IMO Tier II. In 2016 the generally applicable 20 percent reduction in NO\textsubscript{x} emissions regarding IMO Tier I (introduced in 2000) continues to govern NO\textsubscript{x} emissions on the high seas. However, IMO Tier III demands an 80 percent reduction in NO\textsubscript{x} emissions from vessels operating in Emissions Control Areas (ECA).

ECAs are, broadly, coastal waters close to areas of population or environmentally sensitive locations. ECAs already designated are the complete East and West Coasts of the USA and Canada, straits like the English Channel, landlocked seas like the Baltic and numerous port approaches.

EPA Tier 4 standards
Emissions standards issued by the USA’s Environmental Protection Agency cover NO\textsubscript{x} emissions from water borne, mobile and stationary engines of all sizes used in a wide range of applications. The EPA Tier 4 standard now requires NO\textsubscript{x} emissions to be reduced by around 90 percent compared to the 2008 Tier 1 baseline.
An attractive solution
VCM delivers more benefits and offers new possibilities for advanced high performance four-stroke engines.
ABB Turbocharging Service network

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