

Lenz PowerKat[®] System for BMW M1



1. The BMW M1

At the debut of the Paris Salon in 1978 the BMW M1 became the absolute public magnet. The design unmistakably carries the handwriting of Giorgio Giugiaro. With a tubular frame, composite body and a technically complex six cylinder engine construction, the potential was put in the cradle for the star as a high carat racing instrument in Group 4 (Gran Tourism) and Group 5 (special production cars) to take up the inheritance of the celebrated CSL.

With 453 copies built at Lamborghini the necessary homologation number of 400 was reached, and at the price of a Ferrari 512 BB the exclusivity was guaranteed.

The M1 had high-quality technology to offer, beginning with the brilliant M88 engine. The straight six cylinder with two overhead cam shafts, four-valve head, cam controlled Bosch mechanical injection and dry sump lubrication developed from 3,5 liters displacement at 6500 U/min moderate, but in dynamometer runs 277 HP guaranteed. On this basis in the race version M88/1 490 HP were realized, in the M88/2 with two KKK turbochargers even 1000 HP. Well maintained M1s are sought after and obtain top prices today. In respect to contemporary pollutant behavior and unrestricted mobility also during ozone alarm, the question of a technically adequate catalyst retrofit is of current interest.

The newly-developed Lenz PowerKat[®] system offers to connect optimized pollutant behavior with clearly improved performance development using most modern technology in comparison to the base engine of the BMW M1.

2. The conception of the Lenz PowerKat[®] system

The Lenz PowerKat[®] system is conceived as an uncompromising high end catalyst retrofit system particularly for high performance engines. Developed on the basis of an efficient digital engine management, with components specially matched to the engine and using a metal catalyst, this system achieves optimal pollutant values with clearly improved engine performance. As pollutant standard, the guideline 91/441 is effective at present, with which the retrofit vehicles are absolutely equivalent in comparison to today's state of the art. By classification as low-pollutant, the BMW M1 equipped with the Lenz PowerKat[®] system is excluded from driving bans during ozone alarms (ozone plaque) and is taxed according to the Euro 1-tax rate at present 10.84 € /100 ccm.

3. The technical implementation

The substantial idea with the adaptation of the Lenz PowerKat[®] system for the BMW M1 exists in the systematic and consistent use of most modern engine technology for performance optimization in connection with a regulated metal catalyst. The inaccurate cam controlled mechanical injection is replaced by an exact electronic injection. Principle item of the Lenz PowerKat[®] system is the digital engine management Lenz KatTronic[®], with which injection and ignition can be controlled extremely precisely. The clearly improved performance results from the more effective engine control, as well as an optimized vibration behavior of the exhaust system. New components such as an alpha / n air measurement system, a metal catalyst as well as an electro-pneumatic valve system for the exhaust are used.

4. Performance optimization

Only through the efficiency of modern engine controls can the constructional potential of a sport engine be effectively used. The performance-related bottlenecks of the BMW M1 engine are essentially; the ignition control parameters of the Weber-Marelli system, which through a fixed degree of ignition over 5500 rpms gives away a large portion of the performance, as well as, a relatively mild cam as concession to the difficult calibration of the mechanical injection control cam in partial load range. With the conversion to electronic injection and use of engine control for injection and ignition, outstanding preconditions for an increase in performance are realized.

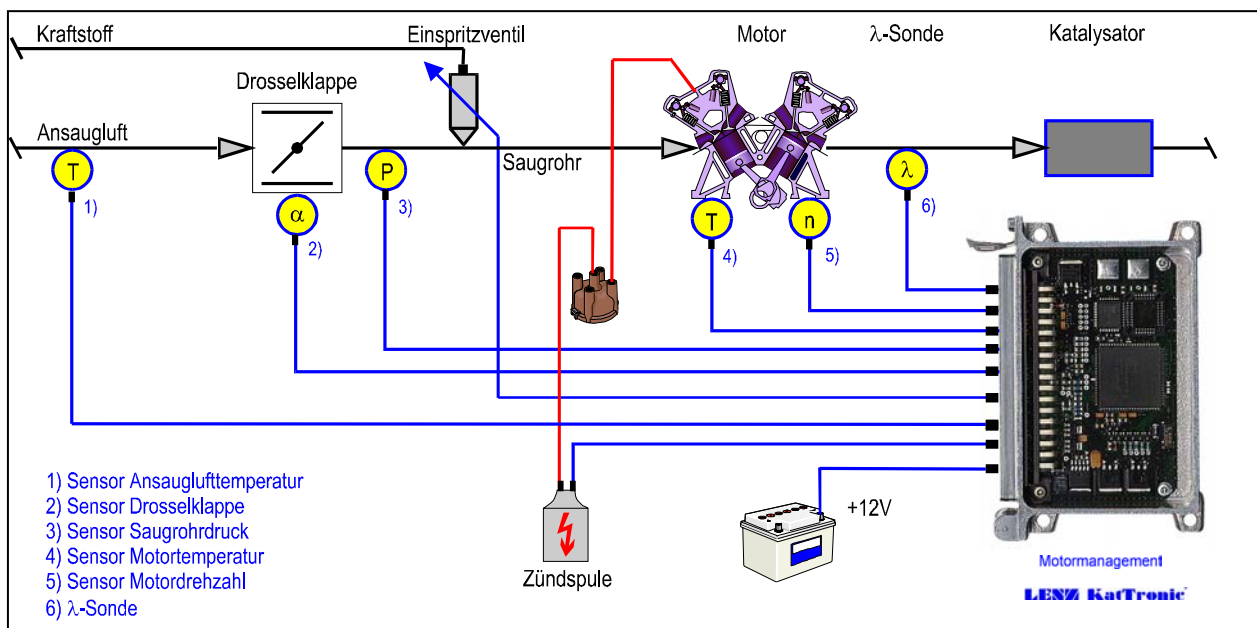
Base of the development is a careful analysis of the vibration response of the engine on the intake and the exhaust side. For this, extensive measurements on the Lenz engine dynamometer were performed. Thereupon the basic adjustment of the system components took place in stationary operation. The dynamic behavior of the engine was optimized in numerous measuring runs. From the analysis of data recorded while driving (data-recording) substantial information about improvement potentials in the dynamic behavior could be won, which were transferred to engine control on the software level. Experiences of many years in motor sport flowed into the development, which resulted altogether in a performance-optimized total system.

For the BMW M1 the system was in particular optimized regarding; throttle response, engine performance, accelerating power and specific consumption.

5. System structure

The engine-specific adaptation of the Lenz KatTronic[®] is effected through specially developed and adapted sensor/actuator components. For the precise measurement of the operating dimensions of the engine, high-quality, select sensors are used.

System structure Lenz PowerKat[®] and Adaptation Lenz KatTronic[®] to BMW M1



6. The Lenz KatTronic[®] engine management

The Lenz KatTronic[®] is a modern, modular structured digital engine management for injection and ignition with the Infineon Microcontroller C537A as CPU. The storage of the data tables / maps and control parameters takes place in flash memories. A special, hardware-supported signal processing enables the ultra fast and highly exact processing of the sensor data and a high system throughput. The system software operates real-time, i.e. calculates each injection and ignition phase up to the maximum permissible engine speed in real time from the sensor data and operating dimensions. The result is a delay-free adjustment of the engine control to the respective operating condition.

Special algorithms are implemented in the software management for the optimization of the dynamic behavior. The lambda regulation operates according to a modified PID rule algorithm practically delay-free over the entire load/rpm spectrum, the reference is derived from a lambda data table / map with additional specific corrections. The regulation operates adaptively, i.e. from the measured values of the lambda sensors parameters are derived, which are stored in an adaptation data table / map. The signals of both lambda sensors are processed in 2 separate

control loops and selectively effect the injectors of both cylinder groups (stereo lambda regulation) whose injection duration is calculated by separate injection data tables.

In long-term operation performance data are maintained by up-dating of engine electronics on a constant level. On board diagnostic routines permanently monitor the function of the sensor technology and store abnormal operating conditions as well as implausible sensor data for diagnostic purposes. A fail-safe program permits driving in the event of an error. A temperature-dependent speed limiter protects the engine during the warming-up phase against excessive wear by too high rpms.

The development line of the Lenz KatTronic® is based on the Lenz TurboTronic®, a complex, professional engine management system, which was used among other things successfully in formula 1 (BMW engine). From it the Lenz TurboTronicLight® (TTL) is derived, which was conceived as the more economical version of the Lenz TurboTronic® for a broader application in motor sport (DTM) and for the production series applications. The Lenz KatTronic® is a current advancement of the TTL toward pollutant optimization for the application in production vehicles with catalyst.

TurboTronic®, TurboTronicLight® and KatTronic® are developments of Lenz Motorentechnik and as trademarks are legally protected.

The Lenz KatTronic® Engine Management System



**Picture of
Controller**

The engine management is plug and pin-compatible to the standard Bosch Motronic controller. The structure is executed in modern SMD technique according to EMV guidelines.

Overview of the Lenz KatTronic® Engine Management

Input Values	Output Values	Data Tables / Maps	Data Table Drivers
Intake Manifold Pressure Engine Temperature	Idle Injection	Injection Ignition degree	Lambda Sensor Engine Temperature
Air Temperature Lambda Sensors Exhaust Gas Temperature Throttle Butterfly position Rpm Sensor Knock Sensor	Ignition Fuel Pump Boost Regulation	Lambda value Lambda regulation Load evaluation Adaptation Boost Pressure	Air Temperature Warm Up Start Quantity After-Start Faktor Voltage Correction

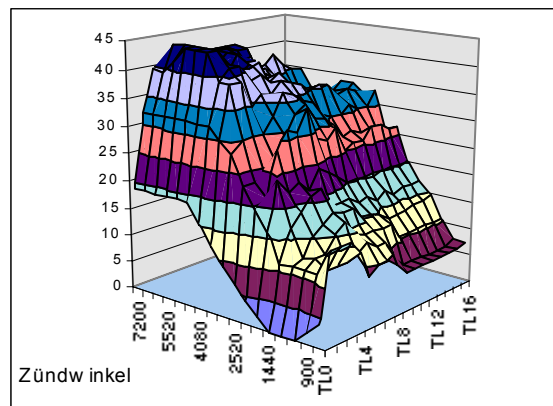
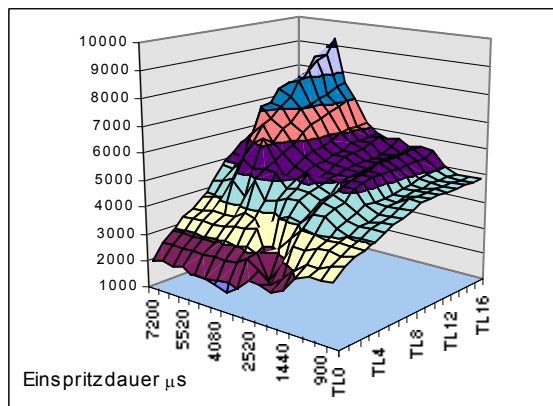
Base Functions

- Warm Up
- Idle Regulation
- Temperature dependent thrust reduction
- Temperature Compensation
- Dynamic Transition Compensation
- Boost pressure regulation
- Asymmetrical PID lambda Regulation

Monitoring Functions

- Error Memory
- Fail-safe Program
- Extreme value Memory
- Sensor monitoring
- Operating hour counter
- Serial Interface (RS-232)
- Temperature dependent speed limiter

Data tables / Maps for Injection duration and ignition degree

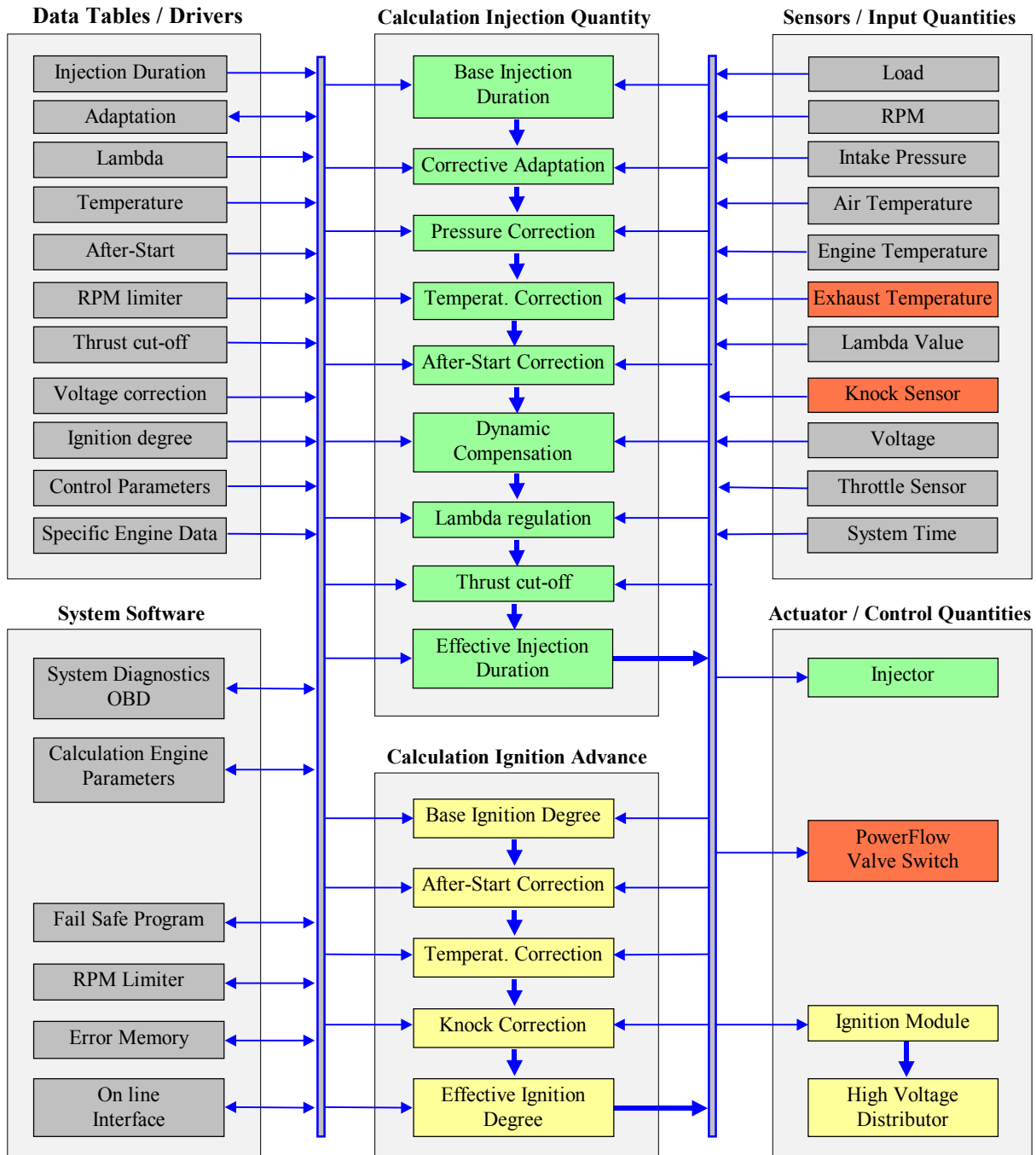


7. The software for the Lenz KatTronic®

A singular feature of the Lenz KatTronic® is the integrated serial interface to standard PC (operating system MSDOS) executable software. In the standard version important system data can be displayed on-line in current driving conditions on a graphic display (e.g. laptop with MSDOS) and diagnostic data for service purposes can be read-out. For the professional application an extended version is available. This contains functions for system calibration as well as the on-line editing of the data tables / maps and system parameters, with which an individual fine tuning is possible on the respective engine. Further measuring data can be recorded (data recording). In the extended version all functions can be used also over radio data transmission (cell phone with GSM Card) from a stationary PC (telemetry).

Future pollutant standards as well as performance improvements in the course of continuing development can be realized as updates to the operational software problem-free. Therefore the Lenz KatTronic® is a future-safe investment.

Functional Structure of the Lenz Katronic® Engine Management System



View of Measurement Data Display

General	Data Tables / Maps	Load	Save	Measurement Data	Print
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RPM	0 U/min	Ignition Data —BMW_M1.ZKF—			
Throttle Position.....	0 %	Start Ignition Degree	0.0 °		
Intake Manifold Pressure:	956 hPa	After Start Correction Factor ..	5.3 °		
Load / RPM Coordinate.:	1.6 / 840	Engine Temperature Correction :	0.0 °		
		Effective Ignition Degree	5.3 °		
Battery Voltage	12.57 V	Injection Data —BMW_M1.EKF—			
Load time Ignition Coil.:	3.1 ms	Start Ignition Value	6000 µs		
Spannungskorr. EV.....	1.8 ms	After Start Correction Factor ..	1.00		
Engine Temperature ...:	47 °C	Engine Temperature Correction :	1.00		
Air Temperature.....:	20 °C	Air Temperature Correction ...:	1.00		
		Pressure Correction	1.00		
		Effective Injection Duration ... :	6.00 ms		
			0.00 ms		
		Injection Amout	0.00 g / s		
Speed	0 km/h	G: 0	Lam 1 0.80 [---]	(deakt.)	
		S: 0		(deakt.) AKF	
			Lam 2 0.80	(deakt.)	
P4.5 HI P4.7 HI				1.00 Fak. B2	
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8. System components

The Lenz PowerKat® system for the BMW M1 consists of the following components

- 6 electric injectors
- 2 heated lambda sensors
- new additional wiring harness
- pressure and temperature sensors
- Lenz KatTronic® engine management
- PowerFlow-System integrated into the existing muffler
- sport metal catalyst integrated into the existing muffler
- alpha / n air measurement system (with high resolution linear potentiometer)

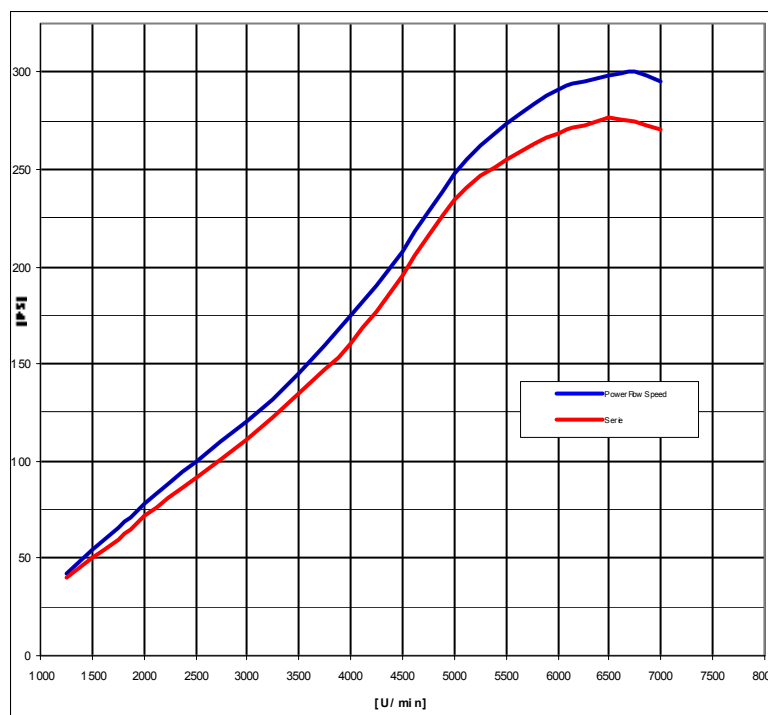
9. Results P – C - P

❑ Performance increase

The Lenz PowerKat® system for the BMW M1 clearly improves the response mode (throttle response), the performance and accelerating power compared to the base engine, and this, in connection with a catalyst. The torque development through the entire rpm range is fuller, and the response especially at higher rpms is significantly more pronounced than the series engine. The rpm limit is increased to the clubsport special model level.

The Lenz PowerFlow® system is available as an optional stage of increased performance. With this system it concerns a variable adjustable exhaust system which uses specially coordinated resonance and flow characteristics and in particular minimizes the exhaust back pressure in the upper rpm range. In connection with a sport camshaft a considerable performance increase is offered. Additionally the Lenz PowerFlow® system offers particularly attractive sound qualities: the sound spectrum ranges from reservedly quiet at idle and partial load to noticeably sporty at higher rpms and higher performance.

Full load curve Lenz PowerKat® for BMW M1 compared to series engine



❑ Consumption optimization

The precise adherence to the ideal values for injection amount and ignition degree and the measurement of the operating condition with high-quality sensors result in a specific consumption particularly favorable in comparison to the series engine. The lambda regulation operates over the entire load and rpm spectrum as a dynamically regulated system of high quality. Thus in mixed driving favorable values consumed are obtained.

❑ **Pollutant reduction**

With the Lenz KatTronic[®] system, the BMW M1 fulfills the EC guideline 91/441 and is therefore classified as low-pollution equivalent to Euro-standard I. Thus an engine equipped with the Lenz PowerKat[®] system does not fall under a driving ban during ozone alarm, and the ozone plaque can be issued for the vehicle.

10. TÜV certification

The Lenz PowerKat[®] system was certified by the TÜV Munich for the BMW M1. In the test report the performance and pollutant values, maximum speed and sound levels were documented. With the available TÜV certification, an entry of the Lenz KatTronic[®] into the title / registration papers is possible, problem-free.

11. Installation, sut up, maintenance and guarantee

A substantial advantage of the Lenz PowerKat[®] system is the lack of mechanical interventions into the engine. The components can be installed by the manufacturer or in authorized workshops problem-free. If necessary, the vehicle at relatively small expenditure can be returned back again to the original state. Under normal conditions the Lenz PowerKat[®] system is maintenance-free. The special software necessary for the diagnosis and adjustment of the engine control Lenz KatTronic[®] is available only from the manufacturer or in authorized workshops.

For the installation and initial set-up, the instructions in the installation and operating manual absolutely must be followed. Incorrect assembly of the components can cause malfunctions or damage, in this case the guarantee for the system components expires.

If the vehicle was previously operated with leaded gasoline, then the tank as far as possible must be run dry and before installation, the vehicle absolutely must be driven with a full tank of unleaded fuel in order to exclude damage to the catalyst by lead. Relevant investigations by car manufacturers (Mercedes Benz) regarding lead free operation of engines with not-hardened valve seats conclusively show that as a result of prior long-term actual operating time with leaded gasoline sufficient lead diffuses into the valve seats (memory effect), so that no negative effects are to be expected on the life span of the valve seats. We recommend nevertheless the use of suitable lead replacement additives, which have proven innocuous for emission control systems (e.g. Castrol).

Basic condition for optimal functionality of the Lenz PowerKat[®] system is naturally a mechanically intact, not worn engine, which was maintained according to the factory specifications. Only in this case can a guarantee for the indicated performance data be made. On the components of the Lenz PowerKat[®] system, a 1 year warranty starting from delivery date is made.

The price for the system Lenz PowerKat[®] includes expressly only the components of the catalyst retrofit kit and their assembly. Additionally necessary service work and the exchange of defective or worn components are charged for as incurred.

The technical specifications refer - if nothing different is mentioned - to the basic version of the Lenz PowerKat[®] - system for the BMW M1.

Technical changes remain reserved.

Dez 2002

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