scienlab
electronic systems

Testing the common rail injection system

Comprehensive testing in development and production

Testing actuators and injectors in the common rail system

The aim of the automotive industry and its suppliers is to make extremely energy-efficient combustion engines. Common rail technology offers the saving potential to do so. Further requirements are reduced CO_2 and pollutant emissions. The injectors ensure precise delivery of fuel to the engine. Fundamental to that process are the electrically triggered actuators integrated in the injectors.

These are crucial for the functionality of the injectors, which makes faultless triggering especially important. Scienlab offers testing options for injectors and actuators at every stage of development and production. Requirements such as interfaces or output parameters (current/voltage) can be comprehensively covered in customer-specific tests.

Testing options in the common rail field

	Actuator			Injector			Overall common rail system
Development	✓	✓	–	✓	✓	–	✓
Production monitoring	✓	✓	–	✓	✓	–	✓
Production	✓	–	✓	✓	–	✓	–
Scienlab Test Solution	DICU	Durability Test System	Quality Assurance System	DICU	DICU Basic	Charge Amplifier	Durability Test System

Technical data of the common rail products

	DICU Basic	DICU				Charge Amplifier	Quality Assurance System	Durability Test System	
		piezoelectric		electromagnetic				Resonant Power Stage	Class D amplifier
		Analog amplifier	Class D amplifier	Half-bridge amplifier	Full-bridge amplifier				
Output voltage	-12...200 V	-150...250 V	0...400 V	-80...130 V	-120...120 V	95...205 V	0...220 V (Peak)	130...350 V	180...600 V
Output current	±16 A	±25 A/± 50 A	±25 A	0...15 A	-10...30 A	100 mA	±3 A (Peak)	25 A	35 A
Output power (continuous)	10 VA	25/50/75 VA	50 VA	–	–	–	75 VA	30 VA	50 VA
Number of channels	1	1 to 4	1 to 6	1 to 4	1 to 4	6	1 to 6	108	108
Device interface	–	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet
Connection to Ausys	–	✓	✓	✓	✓	✓	✓	–	Optional
Triggering	Internal/ external	Internal/ external	Internal/ external	Internal/ external	Internal/ external	External	Internal/ external	Internal	Internal
Number of injections	Single	Multiple	Multiple	Multiple	Multiple	Single	–	Multiple	Multiple
Analog input	Optional	Optional	Optional	Optional	Optional	–	–	Optional	Optional
Interferometer integration	–	Optional	–	–	–	–	–	–	–
Signal shape	Fixed	Parameter-izable	Parameter-izable	Parameter-izable	Parameter-izable	Parame-terizable	Parame-terizable	Parame-terizable	Parame-terizable
Test equipment verification unit	–	–	–	–	–	–	–	Optional	Optional
Operator software	Operation on the de-vice	Injector Discover	Injector Discover	Injector Discover	Injector Discover	–	–	Piezo Discover II	Piezo Discover II
Current/voltage monitor	✓	✓	✓	✓	✓	–	✓	–	–
Measuring equipment capability	–	✓	–	–	–	–	✓	–	–

DICU Basic: replacing the triggering of injectors

Component level testing before the overall system is available delivers significant time and quality gains in the development process. It is therefore beneficial in the field of fuel injection to start optimizing piezo injectors before the control unit is available. Common requirements within the framework of these tests are emulating different series-production amplifiers, using customer-specific signal shapes and freely defining the injection curves of the injectors.

The benefits of the Direct Injection Control Unit (DICU) Basic at a glance:

- Transparent analysis of the combustion process through replacement of the control unit
- Easy examination of the spray pattern
- Ensure quality in development and production through ongoing analyses
- Quality assurance and specification of piezo injectors using the high-precision amplifier concept
- Integrated, digital signal processing
- Flexible use: standalone system with operation directly on the device or integration into an existing test bench automation system

Direct Injection Control Unit (DICU) Basic

DICU: flexible testing options for actuators and injectors

There are numerous advantages to replacing the series-production control unit, for example conducting flexible tests in order to characterize actuators and injectors independently of the series-production control unit.

The Direct Injection Control Unit (DICU) from Scienlab is designed for this purpose and, depending on the customer's requirement, can be used as an individual unit or integrated into an automation system. It permits flexible triggering of the actuators and injectors, both on the test bench and with the combustion engine running, using multiple injection or operation with internal, external or crankshaft angle-based triggers. The DICU can be optionally equipped with the Scienlab software InjectorDiscover for user-friendly parameterization and evaluation of the tests.

Testing the piezoelectric actuator and injector

In order to trigger the piezoelectrically operated injectors and thus generate injection profiles, the control unit is designed during the development phase to give injector and engine developers the greatest possible degrees of freedom. This permits targeted optimization of the injectors and engines before the series-production control unit is available.

The charge-based precision amplifier concept of the DICU enables developers to ensure quality during production by simultaneously triggering and analyzing the actuators and injectors. It also makes it possible to specify the actuators at the test bench during an early stage of development. By using data records any current curves can be easily and flexibly transferred to the DICU and be modified there.The actuators and injectors can be triggered in both normal and inverse mode.

Direct Injection Control Unit (DICU) – piezoelectric

Testing the electromagnetic actuator and injector
Comprehensive testing of the electromagnetically operated actuators (the so-called solenoid injectors) is important in all stages of development from characterization through to end-of-line testing in production. The DICU can replace the control unit of the electromagnetic injectors here. The DICU can be used, for example, in assuring the quality of injectors or engines in production as well as in developing injectors and control units.

The user needs as much flexibility as possible during final inspection of combustion engines in order to trigger the operated magnetic valves and generate injection profiles. The DICU makes it possible to optimize the actuators and engines even before the series-production control unit is manufactured. Multiplexer technology enables up to 12 injectors to be triggered with one power amplifier.

Direct Injection Control Unit (DICU) – electromagnetic

Charge Amplifier: testing functional capability

The production process ends with functional testing of the common rail system, which by now is already installed in the engine. This includes checking the injectors in a defined sequence and checking the opening times. This is done by triggering the injectors in the engine and examining their behavior. Up to eight piezoelectric injectors can be triggered simultaneously e.g. for rinse, hot or cold testing during end-of-line testing in engine production.

The Charge Amplifier has the appropriate interfaces for integration into the testing concept of the automation system. Current/voltage trigger patterns can be defined via a multiplexer input and the output switches of the amplifier triggered in accordance with the pattern.

Charge Amplifier

Quality Assurance System: fully ensuring the quality of actuators

In order to exploit the piezoelectric effect of the piezo actuators, the piezo ceramic must be polarized by aligning the electrical dipole moments. Automated tests are conducted using the Quality Assurance System so that the actuator can be polarized and the mechanical strength of the actuators tested. The actuator is impinged with a sinusoidal current in a freely oscillating configuration, i.e. without mechanical preload, and at the same time adjusted to a medium voltage via the voltage channel. Triggering takes place via the Quality Assurance System combined testing and analysis instrument using a hybrid power amplifier. The system ensures consistently high quality, which greatly reduces the probability of a failure in the field.


Quality Assurance System

Durability Test System: endurance test for actuators and overall system

Testing the actuators

Durability and performance capability are also decisive for the high quality of actuators. Therefore, endurance tests are conducted during series production and the tolerances of certain parameters monitored.

The Durability Test System supports this process with accelerated aging and durability tests of the DUT. It emulates the control unit by simulating the output currents of common series control units within the framework of a test program. Due to the high flexibility of the hardware and software components, the test procedure can be adapted to different injectors and ECU strategies. The Durability Test System is controlled and param eterized via the intuitive Scienlab software PiezoDiscover II. The integration of a climate chamber or the extension of a test equipment verification unit to perform a fully automated test of all relevant measuring and control functions is possible on request.

Testing the overall system

As well as testing individual components, overall system testing is decisively important when it comes to testing to standards or testing of individually defined driving cycles.

The Durability Test System developed and produced by Scienlab verifies the complete fuel injection system, including injectors, common rail and high pressure pump, with the aid of the Scienlab software PiezoDiscover II. In addition to this, all amplifiers can be operated synchronously and asynchronously and additional control variables such as rail pressure and temperature can be integrated in the system. On request it is possible to use a climate chamber and also to integrate the test system in a comprehensive test bench automation system.

Durability Test System

50 million automotive piezo actuators tested

The German and European market leaders in the area of piezo-electric injection technology have been using Scienlab test systems for more than a decade. More than 50 million actuators for gasoline and diesel engines were tested since using Scienlab technology – from development to production support to the last test before installing the engines in the vehicles. Over 10 million vehicles in total have been delivered with Scienlab-tested injectors since 2003. No case of failure in the field has been reported. Another plus for the car manufacturers and their suppliers: the Scienlab systems are energy-efficient and practically maintenance-free even after years of continuous operation. They thus make a contribution to cost efficiency.

What makes Scienlab stand out

For the testing of injectors and actuators in the common rail system, Scienlab offers test solutions for the entire development and production process. Numerous corporations, medium-sized companies and research institutes all over the world place their trust in the know-how of Scienlab for development and testing of their products.

Extensive test systems for the electric drive train

At Scienlab, the products for testing of actuators and injectors are based on long-standing expertise. Scienlab continuously expands its testing range to put our customers' products of tomorrow to the test already today. In the Scienlab laboratory, test systems are produced for a range of industrial products as well as for automotive components used in electric drive trains. This includes test systems for:

- Inverters, DC/DC converters
- Charging technology and infrastructure
- Energy storage (i.e. also fuel cells)
- Network configurations of several components

As a development partner and engineering service provider, Scienlab also realizes customer-specific solutions. These include, for example, analog and digital measuring and circuit technology as well as control units in small production series for different automotive and industrial applications.

Everything from one source – from the idea through to on-site commissioning

The employees at Scienlab are the guarantee for individual engineering services of the highest standard: all products are developed and produced at the Bochum location – from hardware production and software development through to system acceptance. The company has other locations in Munich and Shenyang (China). Scienlab has a deep understanding of user needs. This is further developed in a continual dialog with customers and forms the basis for products that allow our customers to perform their tasks with maximum efficiency and reliability. The resultant high-end solutions provide our customers with a decisive competitive edge.

Scienlab is a problem-solver for its customers
and makes it possible to develop innovative technologies to market readiness more quickly.

Scienlab is full of ideas,
which are realized in new products by the Scienlab team – premium solutions to ensure that our customers are always one step ahead.

Scienlab works on a partnership basis
and attaches high value to long-term business relationships with our customers and partners. Together, we realize successes and technological progress that are reflected in innovative products.

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