Engine signal simulator for ECU

The pistons of an engine are connected to the crankshaft by a connecting rod. So one rotation of the crankshaft means an up-and-down movement of each piston. Most engines in the automotive sector have four strokes, which means that the piston goes up and down two times. However, the camshafts, which control valves of the cylinders, rotate only once in those four strokes. There are several camshafts in one engine.

One of the keys to a working engine control unit is sensing the position of the crankshaft and camshaft. If the engine control unit does not know these positions, it does not know when there should be injection and ignition. The ECU/ECM receives this information by sensors which detect the position of the crankshaft and camshaft.

The **µLC Test System** is a compact hardware in the loop test system including software for the simulation of most sensor signals in the automotive sector. There is a focus on the simulation of crankshaft and camshaft. The user-friendly utilization makes it very easy to realize functional tests for ECUs even in early development phases.

Top Features

- Import of A2L / Hex files or simple manual configuration of signals
- Wide range for RPM simulation (up to 20 000 rpm)
- Support of many kinds of sensors such as Hall sensor, inductive sensor, DG23i and TL4953
- Camshaft adjustment and error simulation

Figure 1: µLC Test System - Compact HIL

Signal simulation of camshaft and crankshaft

Among other things, the **µLC Test System** is also able to simulate signals from crankshaft and camshaft sensors. These signals are used by engine control units to detect speed and position. Many processes within the engine control units, such as the injection, run in a speed-synchronous manner. Therefore, the simulated signals have to meet ambitious real-time requirements.

The module for speed generation is one of the most important in the **µLC Test System**. The rpm is dependent on various factors such as the number of teeth, the type of sensor, a forward / reverse rotational engine and active cylinder pressure simulation. The maximum speed of the module is 20,000 revolutions per minute (rpm).

The number of teeth can be selected between 10 and 220, the length of the gap is limited to 0 to 10 teeth. The adjustable range for the phase difference of the crankshaft angle is -360 ° to 360 °. The phase of the camshafts (relative to the crankshaft) can be shifted independently during operation.

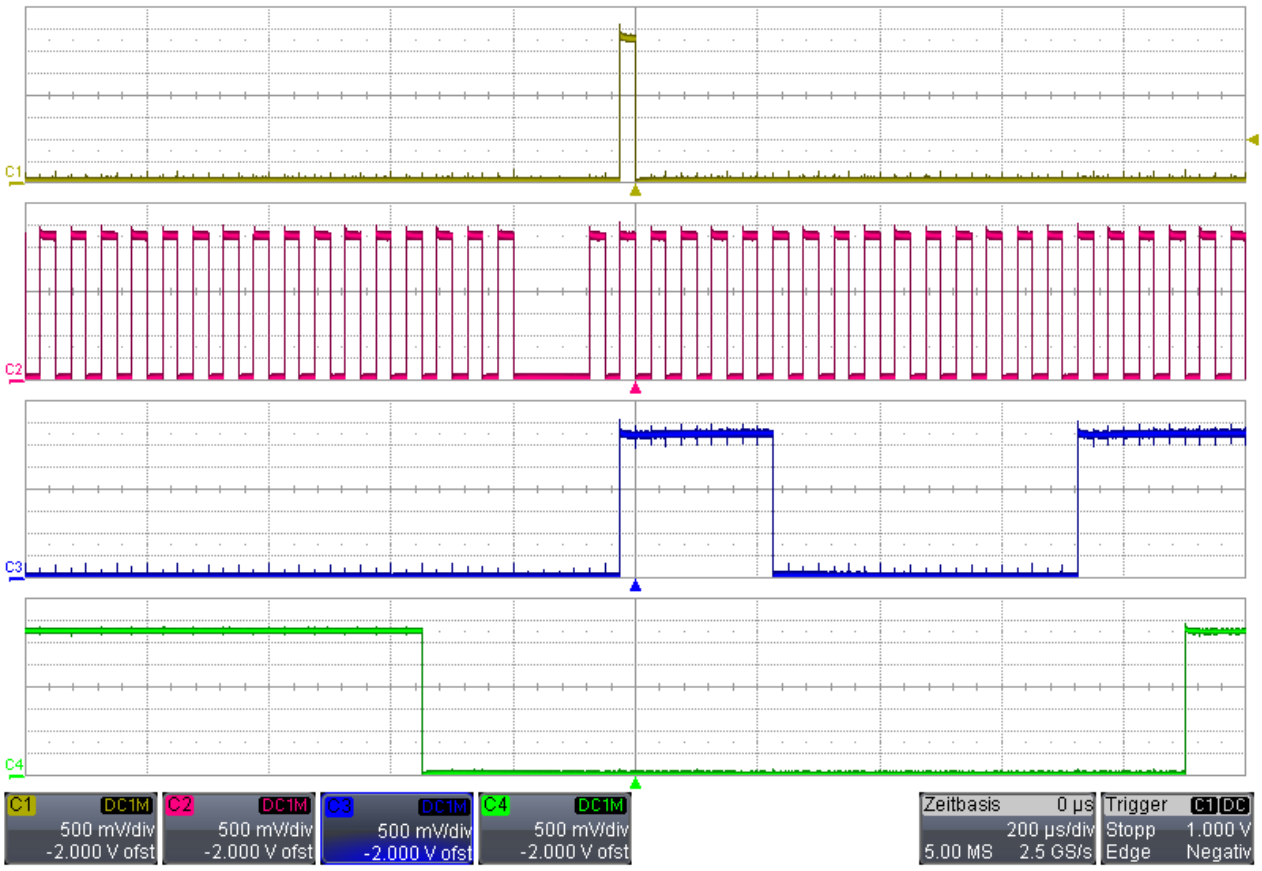


Figure 2: Illustration of the simulated crankshaft and camshaft signals shown on the oscilliscope

Crankshaft and camshaft – Signal form out of A2l/hex

The signal form shown in the configurator corresponds to the crankshaft or camshaft sprocket wheels. Signals from camshafts with individual segment lengths as well as z + 1 encoder wheels can be generated from A2L / Hex files. The crankshafts can generate standard 60-2 sensor wheel signals as well as 60-x multipolar sensor wheel signals with a 12 ° gap.

Crankshaft and camshaft – Sensors

There are four different kinds of sensors which can be simulated with our device.

Hall sensor simulation

- Tooth head: The output level of the signal is 5 V
- Tooth base: The output level of the signal is 0 V

Inductive sensor simulation

- Tooth head: The output level of the signal is 12 V
- Tooth base: The output level of the signal is -12 V

DG23i sensor simulation

- Signal level is always at 5 V (even at a standstill)
- If a declining tooth flank is detected (transition from tooth head to tooth base), the signal level is 0 V for exactly 45 µs if the crankshaft rotates forward. If the crankshaft rotates backward, then it is 90 µs.

TL4953 sensor simulation

- The signal level is always at 0 V (even at a standstill)
- If a rising tooth flank is detected (transition from tooth head to tooth base), the signal level is 5 V for exactly 60 µs if the crankshaft rotates forward. If the crankshaft rotates backward, then it is 120 µs.

Crankshaft and camshaft configurator

The signals from the crankshafts, camshafts and the trigger signal can be adapted via the crankshaft/camshaft configurator. For this purpose various tools are available in the upper section. In the lower section, there are further functions, for example, to quickly generate the signal of a gearwheel or to generate a pattern from an A2L / HEX file.

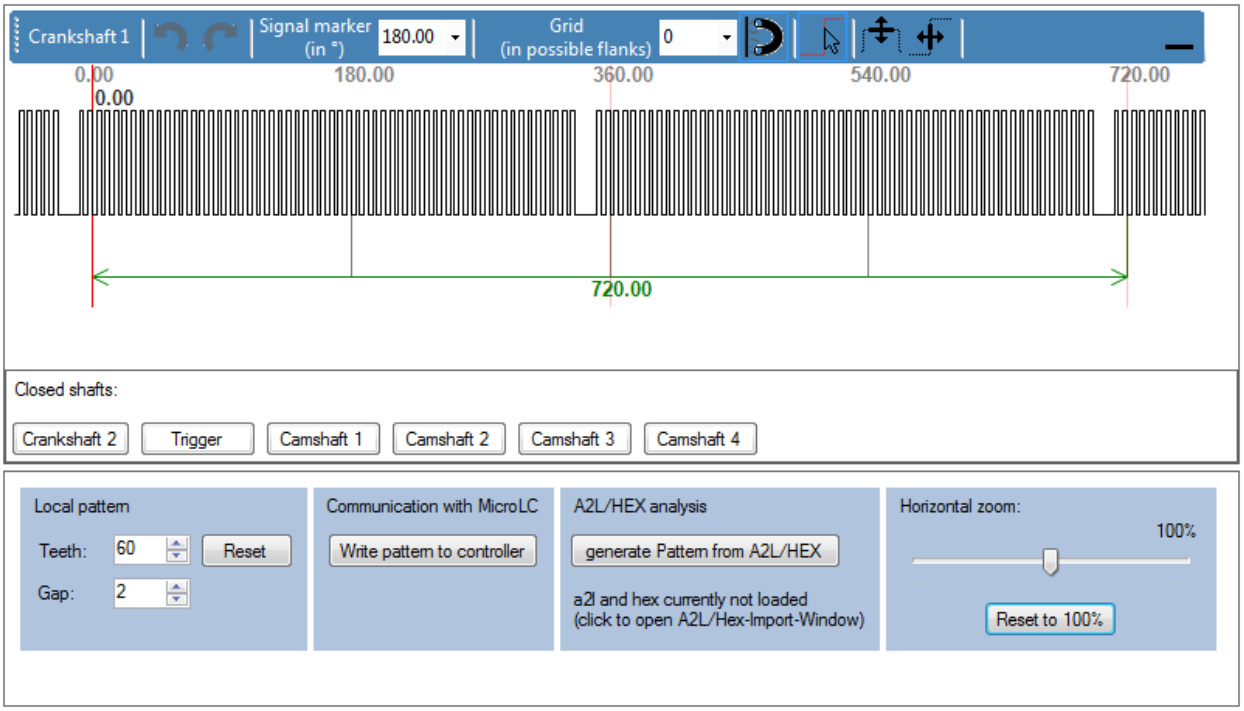


Figure 3: MicroLC Software - Illustration of crankshaft signal

Processing signals

Above the signal path, various functions are arranged which simplify the processing of the signal.

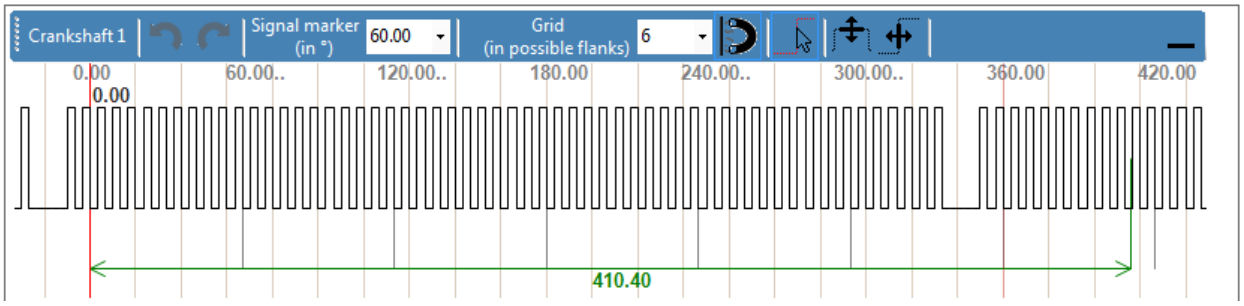
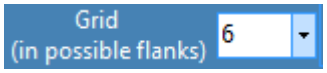


Figure 4: MicroLC Software - Illustration of crankshaft signal and editing possibilities

The name of the signal is displayed in the upper left corner, here Crankshaft 1.

These arrows can be used to undo changes or to restore undone changes.

With this the distance (in °) between two illustrated guidelines can be adjusted. In this example, 6 guide lines are displayed over a full revolution. To hide the guidelines, an angle of 0 ° must be set.



Here, the distance of the grid lines can be set in flanks. A range of 0 to 200 edges is available. To hide the grid lines, zero must be set.

If this function is active, the cursor is locked to the grid. If the grid is deactivated, the cursor locks on the flanks and jumps from flank to flank.

With this function, a signal can be drawn freely and the length of the pulses can be changed.

With this function, the flanks can be raised or lowered. You can only switch between high and low level.

With this function, the length of the pulses can be changed.

With this function, the wave can be minimized. It can be recalled via a button in the area "closed waves".

For camshafts, the offset to the crankshaft (in °) can be adjusted. This is freely selectable depending on the tooth width. Preset values are +/- 30 °, 60 °, 90 °, 180 ° crankshaft.

Additional function

More functions are placed below the signal curve.

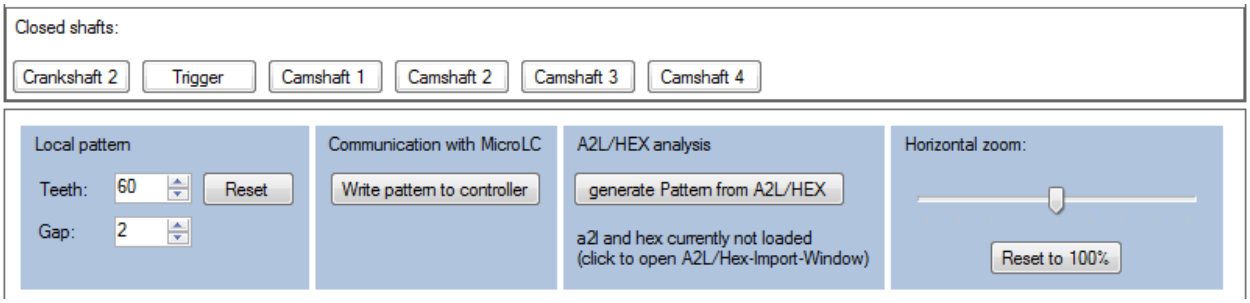


Figure 5: MicroLC Software - Extract of user interface

Closed waves

Here, those waves are displayed which are not shown at the moment. By clicking on a certain wave, it can be opened and edited.

Local pattern

With this function, a processed signal can be reset to a constant signal from teeth and gaps.

Communication with the Micro LC

By clicking on the "Transfer pattern to controller" button, the generated patterns are transferred to the **µLC Test System**.

A2L/HEX interpretation

With this function, a pattern for a wave can be created from an A2L / Hex file.

Horizontal zoom

The zoom can be used to enlarge the signal profile.

For further information about µLC Test System please check our product catalog on www.bosch-motorsport.de, category "electronics/test system“ or contact us via motorsport@bosch.com.