Ford Fiesta with Micro Hybrid Drive

- **Ford Fiesta with micro hybrid drive at Ford Research Center Aachen**
- **Optimized energy management and stop-start function**
- **MicroAutoBox, ControlDesk, CalDesk, and TargetLink used**

The Ford Research Center Aachen, Germany, is intensively engaged in developing operating strategies and energy management concepts for hybrid drive structures. A Ford Fiesta is being used as the experimental vehicle for testing and optimizing a micro hybrid drive, focusing on control strategies for hybrid-drive-specific functions such as stop/start and regenerative braking. Ford is using a MicroAutoBox, the ControlDesk test software, and the CalDesk calibration software for this task.

Developing vehicles with a variety of hybrid drive concepts is currently a major focus at automobile manufacturers. One reason is customers' demands for systems with more power, and for greater safety and comfort. Legislation on exhaust reduction (Euro 5 emission standard) and the industry's voluntary commitment to reducing CO_2 emissions (ACEA agreement) also necessitate new propulsion concepts.

The bandwidth of hybrid drives ranges from what are called micro hybrid drives to mild, medium, and even full hybrid concepts:

- Micro hybrid drives are defined as a combination of stop/start functions, regenerative braking in which the battery is recharged by the generator in deceleration phases, and sometimes also restricted electric propulsion support during acceleration.
- Full hybrid drives have at least one powerful electric motor and a traction battery which allows completely electrical propulsion, plus the functions listed above. Regenerative braking and propulsion support during acceleration are performed at a suitably high performance level.
- Mild and medium hybrid structures are between micro und full hybrid in functionality and features.

▼ *The Ford Fiesta demonstration vehicle with micro hybrid drive.*

Micro hybrid drives are considerably less expensive than full hybrid drives. The ratio of additional costs to achievable fuel consumption reduction means they can compete with other vehicle-related CO_2 reduction measures. Micro hybrid concepts are therefore an interesting alternative for the mass market. As well as the stop/start and regenerative braking functions, they also have a function known as stall recovery. This restarts the engine automatically if it stalls. The

core component representing this function is a belt-driven, integrated starter-generator (B-ISG), which replaces the conventional generator in the vehicle.

Stop/Start Function

The stop/start function switches the engine off when it is idle. This avoids CO_2 and other emissions, and also saves fuel, for example, while the vehicle is waiting at traffic lights. The engine is then automatically restarted by the B-ISG machine. It is not possible, or desirable, to switch off the engine in every case, so the state of the vehicle and its subsystems is monitored and analyzed. This is done by a MicroAutoBox, which receives its data from various sensors distributed throughout the vehicle, and from the CAN bus networks in the vehicle. The MicroAutoBox is also the bus master in a LIN bus installation, serving an intelligent battery monitoring system. The operating strategy that was implemented prevents the combustion engine from being switched off, for example, during the warm-up phase of engine and catalytic converter, or if the battery is low.

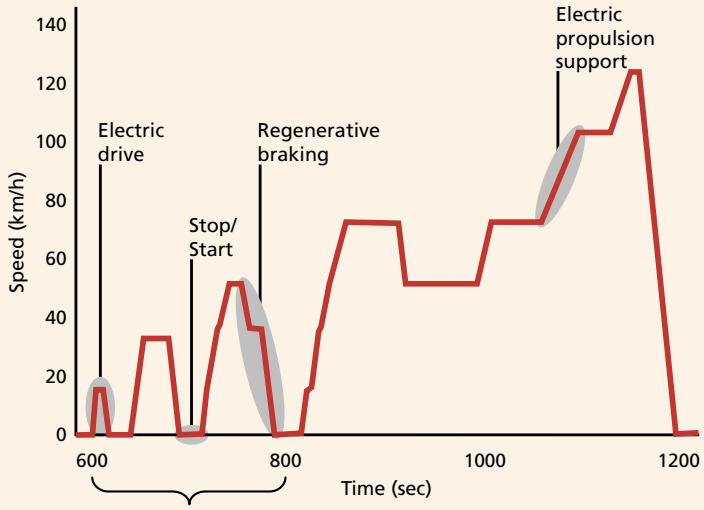
"CalDesk has considerable advantages in terms of simple handling and fast switching of different parameter sets."

Holger Jung

Regenerative Braking

Another potential fuel saving with the micro hybrid drive is when the vehicle decelerates. During deceleration, part of the vehicle's kinetic energy is converted into electrical energy by means of the B-ISG machine. The MicroAutoBox controls the B-ISG power electronics via a CAN bus. The generated energy is stored in the battery and made available whenever generating electrical energy is fuel-intensive or even impossible, for example, during acceleration phases or engine shutdown.

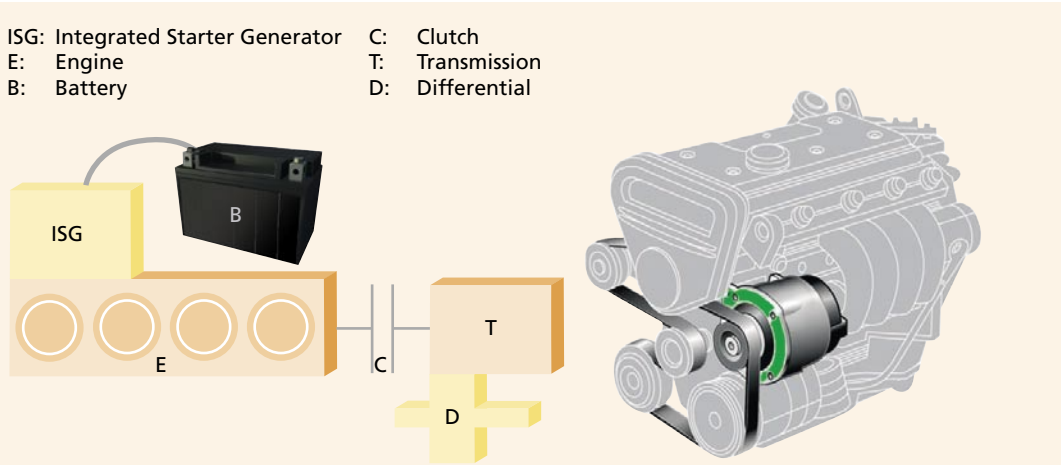
When a vehicle is used mainly in city traffic, these functions cut fuel consumption by up to 15%.



▲ *The New European Drive Cycle (NEDC) shows the phases in which fuel can be saved by means of hybrid components.*

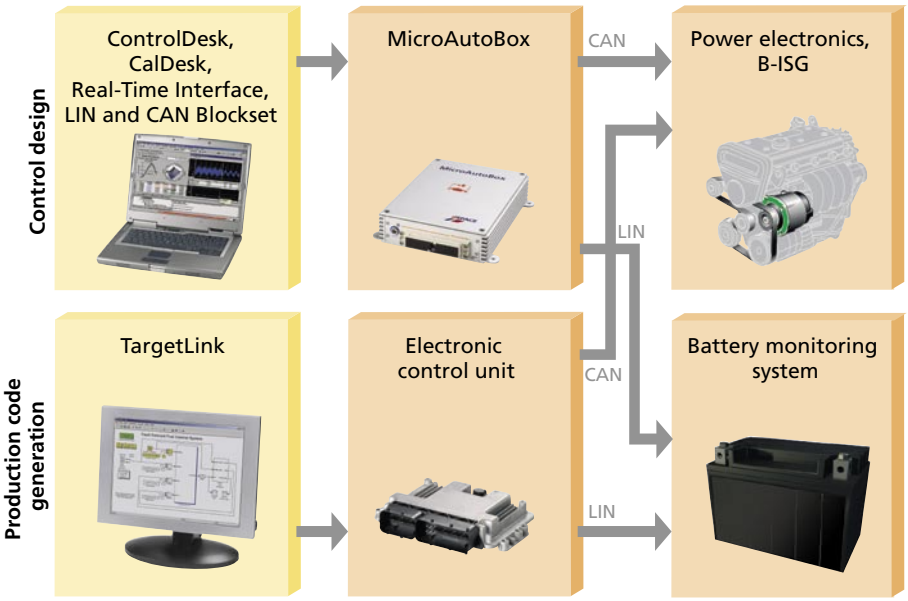
Development with the dSPACE Tool Chain

The stop-start strategy and the control strategy for regenerative braking in the Fiesta were developed from the beginning with MATLAB®/Simulink® and implemented on the MicroAutoBox via dSPACE's Real-Time Interface (RTI) and the LIN and CAN Blocksets. With a view to later portation to a potential target platform, only TargetLink-compatible blocks were used in the actual strategy. This ensures that when development work using TargetLink is completed, production-ready ECU code can be generated



◀ *Schematic of the engine with starter-generator (B-ISG).*

dSPACE Product	Application Area
Real-Time Interface, LIN/CAN-Blockset	Implementing the control strategy on MicroAutoBox
MicroAutoBox	Developing the control strategy by rapid control prototyping
ControlDesk	Testing and managing control strategies
CalDesk	Managing parameter sets, switching between calibrated parameter sets, Testing and managing the control strategy
TargetLink	Generating production code for the ECU



▲ *Schematic of the development process with the products used and their application areas.*

from the model. At the start, ControlDesk was used to calibrate the strategy. Later on, the team switched to CalDesk. To do so, first some of the blocks in the independent TargetLink library had to be modified so that parameters with useful names (variable names from the data dictionary) were available in CalDesk. As we see it, using CalDesk as early as the rapid control prototyping phase with the MicroAutoBox has considerable advantages in terms of easy handling and fast switching of different calibrated parameter sets. Moreover, recorded measurements can be directly analyzed in the original displays, which saves time. Last but not least, CalDesk allows seamless transition to tests on the target processor. Both the tests using MicroAutoBox and the tests on the target processor are performed in the vehicle.

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Glossary

B-ISG (belt-driven integrated starter-generator) –
Combines the functions of the starter and the generator.

New European Drive Cycle (NEDC) –
Legally defined drive cycle used to determine levels of toxic emissions and consumption.