



Innovative front wheel suspension
for SAME specialty tractors

Perfect Grip, Perfect Grapes

To give the specialty tractors of the Frutteto series the best possible driving safety and maneuverability, SAME developed the new Frutteto S/V Active-Drive series featuring an electronically controlled front wheel suspension with independent arms. The production code was generated with TargetLink.



“The TargetLink Data Dictionary was a great help in centrally managing the high number of model variables and parameters of the ActiveDrive project.”

Andrea Degiorgi, SDF R&D Department

Nothing gets wine connoisseurs more excited than a good vintage. But all too often, the most excellent drops grow on the most challenging terrains. Steep hills, loose ground, and narrow paths require specialty tractors to cultivate and harvest the grapes. However, these tractors' narrow track and their high center of gravity bring additional challenges, as they make it difficult to ensure a good grip and safe propulsion in all situations.

Active Control Ensures Grip and Propulsion

To master these challenges, SAME developed the new Frutteto S/V ActiveDrive, equipped with a novelty in the specialized tractor market – an adaptive hydro-pneumatic front suspension with independent arms. Its electronic control ensures constant grip by automatically detecting wheel slip and activating a differential lock accordingly. It also uses two hydraulic cylinders to always keep the two arms of the independent suspension in an optimal position, even when connected equipment adds extra weight to the tractor. This means the tractor's weight distribution is continuously being optimized. In combination with a lower center of gravity, this gives the tractor more stability and ensures stable propulsion, even at the maximum steering angle of 53° or when driving in parallel to a hill. The numerous sensors for position, speed, steering angle, suspension, braking status, etc. open

up even more possibilities for the control software to improve safety. For example, “Anti-Dive” prevents the front wheel suspension from diving when the tractor brakes, while “Anti-Rolling” automatically adjusts the stiffness of the suspension to the driving speed and steering wheel angle. This improves stability and grip both in the field and on the road. ActiveDrive therefore gives the Frutteto series a level of safety and ride comfort that had previously been unique to high-performance tractors.

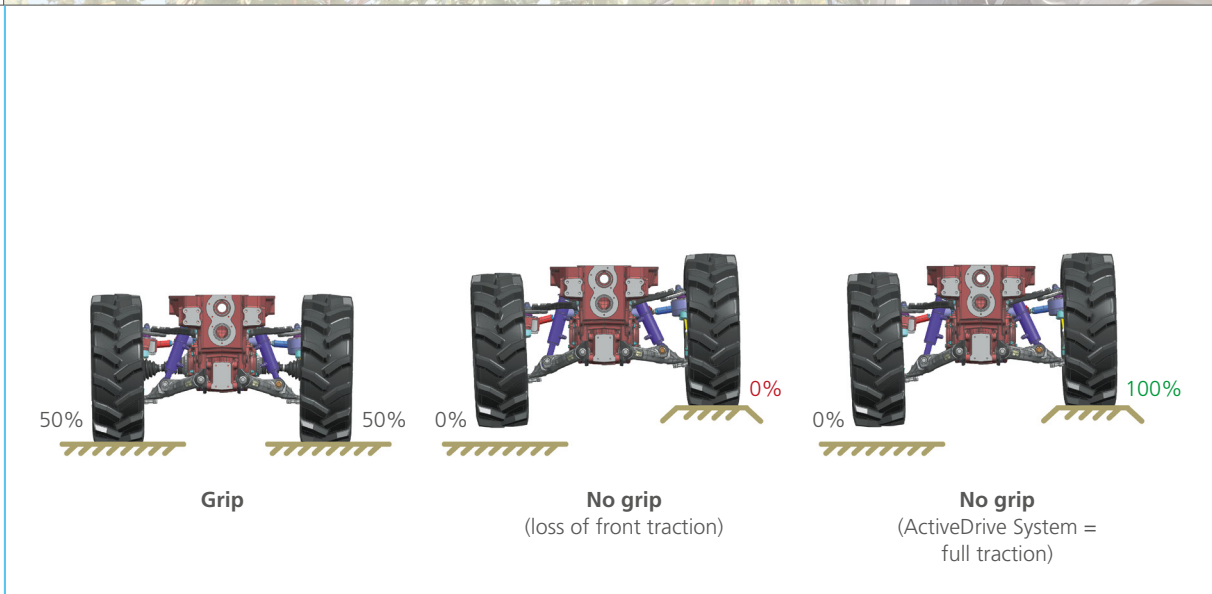
Smart Controller Concept

ActiveDrive is controlled on the basis of input variables such as the steering angle, driving speed, angular velocity of each front wheel, position of the hydraulic cylinders, status of the brakes and all-wheel drive, and the mode selected by the driver. The control variables calculated by the controller are translated into commands for the solenoid valves, which adjust the locking effect of the axle differential as well as the oil flow and pressure in the two hydraulic cylinders of the axle suspension. This not only makes it possible to slide the cylinders in and out, but the closed loop control also adjusts the damping and stiffness to each driving situation.

Central Management of Variables and Parameters

The controller was developed in a model-based MATLAB®/Simulink®/Stateflow® environment and with

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Front wheel suspension of an all-wheel tractor: Usually, the drive force is distributed between the front wheels. If one wheel loses ground contact, the entire drive force is lost due to the lifted wheel. The differential control of the Frutteto S/V ActiveDrive detects these states, rapidly activates the differential lock, and thus harnesses the entire drive force to the wheel that is touching the ground.

the production code generator dSPACE TargetLink®, which SAME had already used in some of its development projects since 2005. To manage the approximately 120 variables and parameters of the controller mode centrally, efficiently, and in a structured way, the developers extensively used the TargetLink Data Dictionary. Due to automatic code generation, the production code for ActiveDrive was available much sooner than usual and SAME achieved a markedly higher consistency between the code and the model than with handwritten code.

Comprehensive Simulation Options

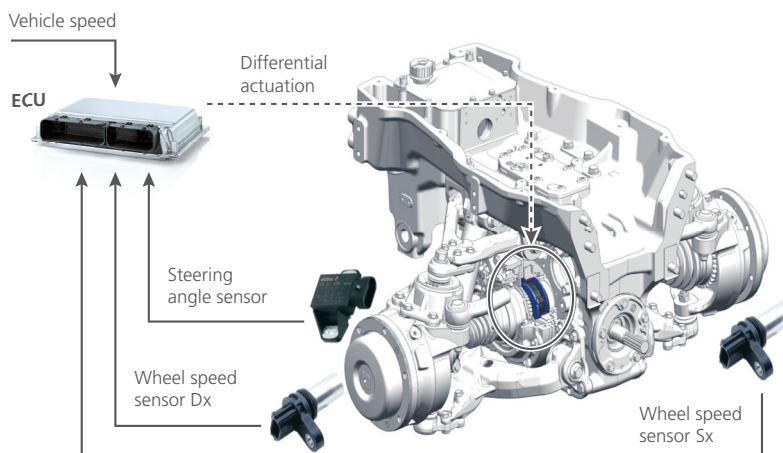
Further improvements in development time and efficiency were made possible by TargetLink's three-stage simulation and verification concept, which allows for a quick and easy run through different simulation modes (model-in-the-loop, software-in-the-loop, and processor-in-the-loop) at the click of a button, thus ensuring early validation. Therefore, the software generated with TargetLink has a high level of maturity even before a mechanical prototype is available. At the same time, it was easy for SAME to integrate software vari-

ants, e.g., for different subsystems or parameter sets. Here, too, the developers benefited from the simple use of defined variables with the TargetLink Data Dictionary. Furthermore, they were able to test the control strategies of the Frutteto S/V ActiveDrive series together with models of the entire vehicle and the environment, making it possible to execute meaningful closed-loop simulations of the entire system behavior.

Reducing Time to Market

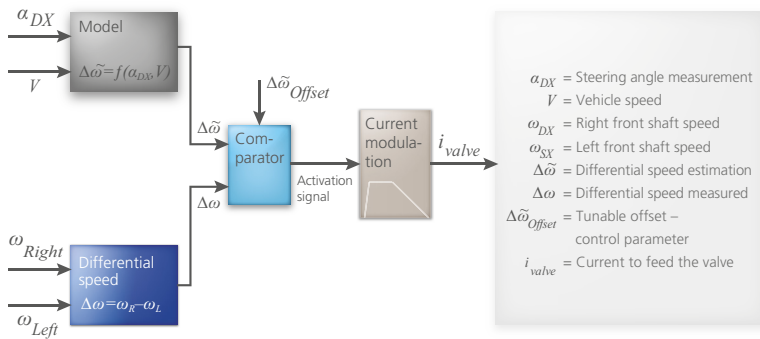
The simulation results were successfully validated on the test bench, on

Sensor arrangement: The control of the differential lock depends on the steering angle and the respective angular velocities of the front wheels.



a tiltable platform, and in real test drives. In all these stages of validation, the Frutteto S/V ActiveDrive again proved that it is much more stable than conventional specialty tractors. Even at steep inclines with angles over 40° as well as on wet and loose ground, the tractor did not exhibit any weaknesses. As a result, the Frutteto S/V ActiveDrive achieved market maturity much faster than usual, not least due to automatic code generation with TargetLink. With this positive experience in mind, SAME plans to shift its future in-house software design processes entirely to a model-based environment and to use TargetLink for the transition to series production. But development efficiency and cost effectiveness were not the company's only achievements: Agriculture experts awarded the Frutteto S/V ActiveDrive with the Tractor of the Year 2016 award in the category "Best of Specialized". It seems like SAME has also created an excellent vintage. ■

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Excerpt of the control architecture: The calculated control variables are output as commands for the solenoid valves (in this case of the differential).

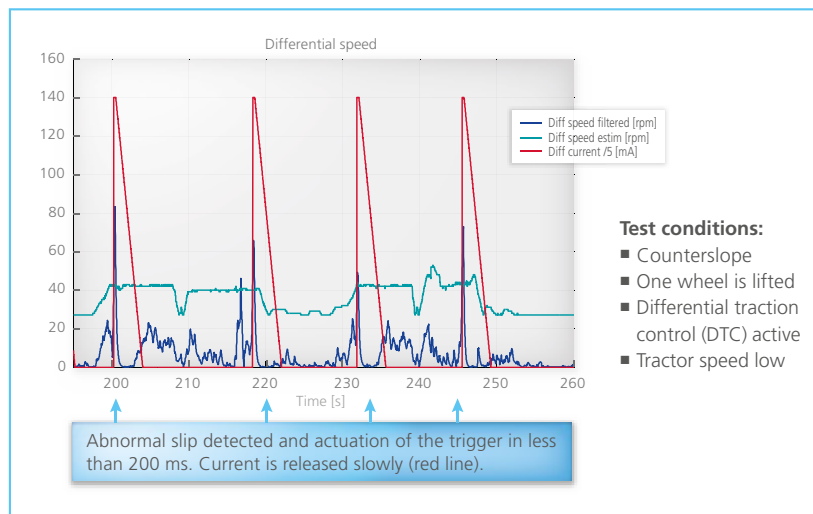
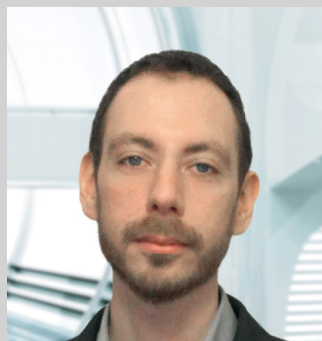


Diagram from the extensive test program for the Frutteto S/V ActiveDrive: The sensors detect an approaching wheel slip early on and activate the differential lock in less than 200 ms.

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