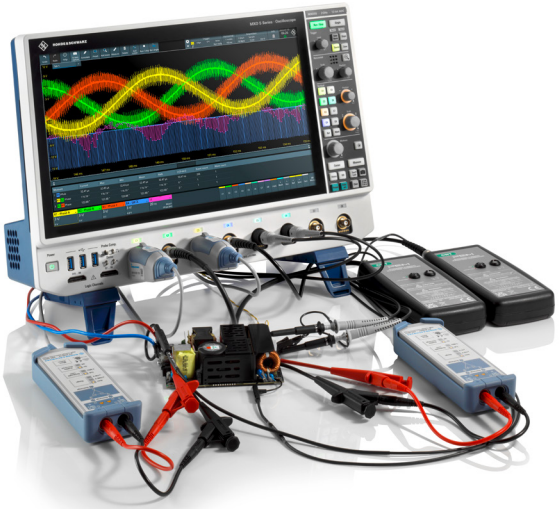
OPTIMIZING ELECTRIC DRIVETRAINS WITH MXO OSCILLOSCOPES

The automotive industry is undergoing a transformative shift towards electrification. Precise measurement and analysis of electric drivetrains are vital to improved performance, efficiency and reliability. MXO oscilloscopes have become an essential test tool for these measurements, with real-time insight into voltage and current waveforms that let engineers and technicians explore the intricate mechanisms to improve drivetrain performance and efficiency.



MXO with probe interface for high voltage differential and current probes used in drivetrain analyses

Your task

Drivetrain performance characterization is multi-faceted and ensures seamless integration and optimal functionality. Voltage and current waveform analysis is required at key points within the drivetrain to determine power conversion in different stages along with the efficiency and power factor to find areas for improvement. Motor control algorithms must be validated for accurate and responsive motor behavior in line with control input. Transient analysis helps determine the drivetrain response to sudden changes in load or power conditions. Identifying and mitigating harmonic system distortions helps improve power quality and overall drivetrain reliability. The comprehensive approach ensures thorough understanding of drivetrain behavior and helps optimize drivetrain performance.

Rohde&Schwarz solution

Different equipment is needed for precise results when dealing with such varied measurement requirements. Power analyzers, low frequency vector analyzers or bus decoders can all help with accurate measurements. Oscilloscopes also play a unique role by visualizing time and amplitude relationships, while offering many tools such as FFT, math functions, harmonics analysis, digital communications protocol decoding and frequency response analysis.

As a next generation oscilloscope, the MXO series excels at electric drivetrain optimization by providing basic time analysis, the fastest available waveform acquisition, 18-bit HD resolution, ultra-fast FFT spectrum capabilities and very deep record lengths. The MXO 3 and MXO 5 series are the first eight-channel oscilloscope for three-phase analysis where voltage and current are measured concurrently.

Benefits

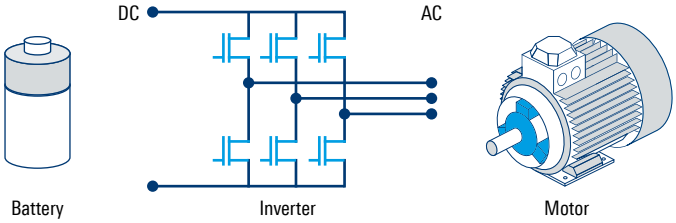
- 4.5 million waveforms/s: highest capture rate up to 99%
- 18-bit HD mode: most precise and accurate available
- 125/400/500 Mpoints per channel: maintain high sample rates for longer
- 45000 FFT/s: responsive spectrum for EMI analysis
- Digital trigger: highest available trigger sensitivity of 0.0001 div

Inverter drive control needs more channels

The conversion of DC battery power to AC electric motor drive power is a main element of drivetrains. To improve efficiency, properly timed inverter gates (totem-pole) switch DC pulses into different widths with pulse-width modulation (PWM) filtered into AC forms to drive the

motor. Three-phase electric motors need three sets of inverter gates, whose switching logic and timing will affect driving performance. Voltage and current are measured in each inverter phase. Sensors measuring torque and motor drive speeds provide insights. The MXO 3 and MXO 5 series have more channels to help capture a comprehensive view of the inverter drive controls.

Inverter switches DC power into three-phase AC power



MXO with track function can visualize PWM into traces for analysis

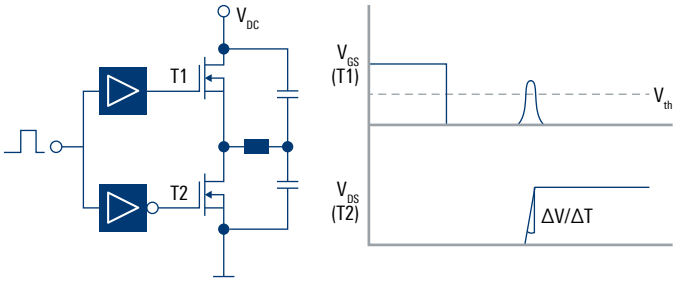
Switching gate issue

For better efficiency and faster drivetrain response, designs with insulated-gate bipolar transistors (IGBT) are shifting to transistors that use wide bandgap technology (e.g. silicon carbide; SiC), which provide faster switching. More importantly, the transistors have lower dynamic-on resistance for better conductive efficiency.

Faster rising/falling edges are a design challenge because they can introduce EMI noise in a system. Parasitic signals can intensify ringing and cause damaging shoot-through events when both high-side and low-side gates are turned on. Additional timing analysis is needed for the transistors and inverter circuits.

The MXO series digital trigger is very useful at detecting glitches in transistor gates. The 18-bit HD resolution has a high precision triggerable waveform with high trigger sensitivity to help debug designs. The fast FFT helps detect EMI emissions and improves circuit filter designs.

Glitch in T1 transistor gate causes shoot-through events if T2 is turned on.



The MXO digital trigger is useful when analyzing the scenario and helps make sure designs have enough dead-time between the switching of high-side and low-side gates.

Summary

Electric drivetrain improvements demand different testing approaches, from high level three-phase harmonic improvements to gate driver switching analysis. Unlike power analyzers meant for high precision sepecification measurements, oscilloscopes can provide a timing view that helps users understand time-variant behavior for different timing controls. The oscilloscopes are also very versatile with test capabilities in the time and frequency domains for electric power efficiency measurements, EMI debugging, harmonic analysis and bus decoding.

MXO series oscilloscopes come with standard deep record lengths that make them ideal for electric drivetrains, since they typically have slow responses. The digital trigger, HD precision, measurement track, fast spectrum analysis and eight channel capability open up endless measurement possibilities when evaluating electric drivetrain performance.

See also

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Data without tolerance limits is not binding | Subject to change