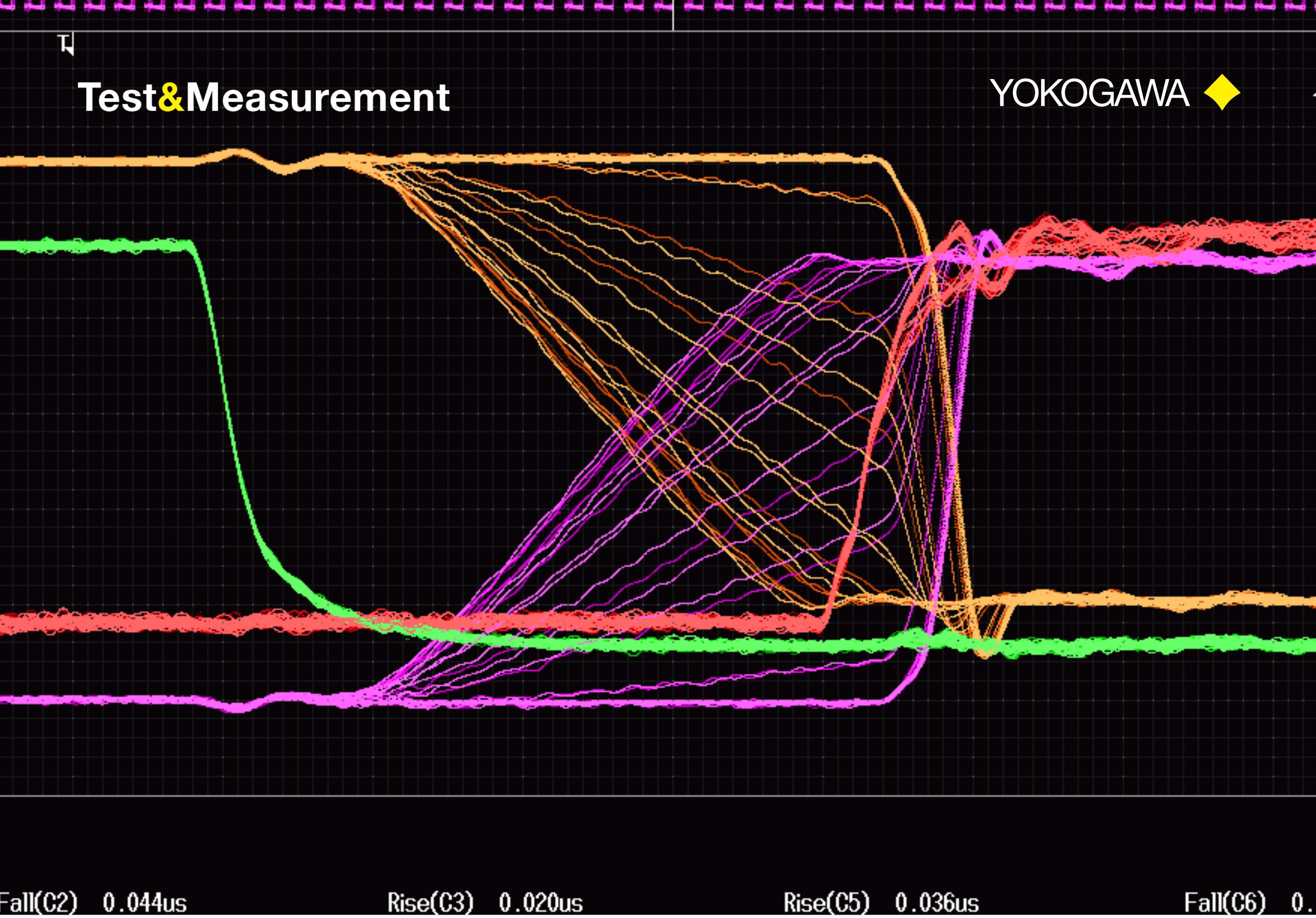
Test&Measurement

YOKOGAWA



Multichannel Measurement for SiC Inverter Voltage Waveforms

Introduction

Research and development using silicon carbide (SiC) power devices is proving to be immensely important in the design and creation of significant energy saving instruments.

Now that it has progressed from the R&D stage to practical use, engineers are adopting SiC power devices in the production of motor drive inverters for railways and EVs.

To best utilize SiC devices for improved energy efficiency in equipment, it is important to optimize the internal device peripheral circuits in the inverter according to the device characteristics. In both the R&D and evaluation stages, this means accurately measuring surge voltage, switching time, and high-speed changing voltage signals at multiple locations is the priority.

Mitigating Potential Measurement and Design Challenges

There are multiple benefits to employing SiC devices in the production process, including incredibly fast switching and improved energy efficiency. Even so, there are several measurement and design challenges that must be considered.

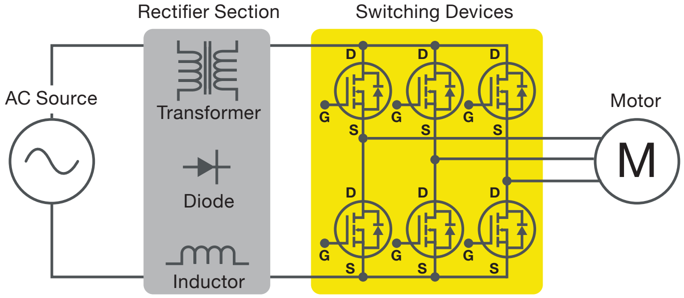


Figure 1. Motor drive inverter circuit

Check the gate-source voltage

A SiC power device greatly reduces switching loss, as the switching speed is very high. However, rapid changes in voltage can generate surge due to stray inductance and capacitive components on the circuit. These rapid changes in the current cause electromagnetic noise, as a result of alterations in magnetic flux. If adequate measures are not taken, the equipment may malfunction or encounter durability problems because of the stress applied to part of the circuit.

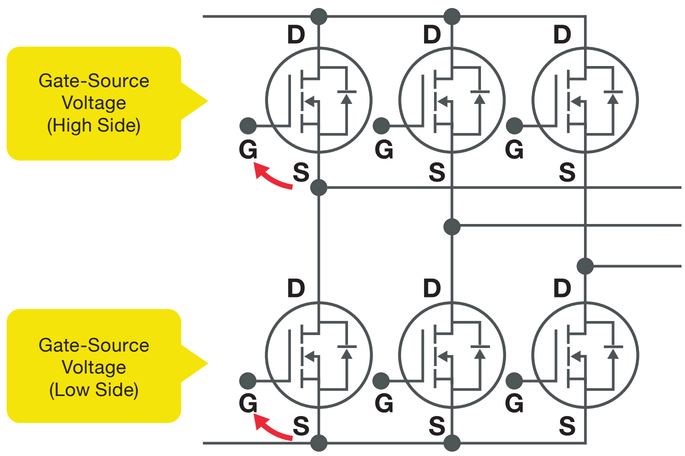


Figure 2. Switching devices

Optimize deadtime between the high side and low side

If devices at the high and low side are turned on simultaneously, a short circuit current occurs that causes serious harm to devices, making dead time essential. To reduce switching loss, it is necessary to employ dead time, though minimally.

As each device has variations, consider delay and jitter due to transient characteristics.

Measurement at multiple channels simultaneously

A three-phase motor inverter consists of six switching devices. A typical four-channel oscilloscope cannot simultaneously measure them, therefore more channels are required.

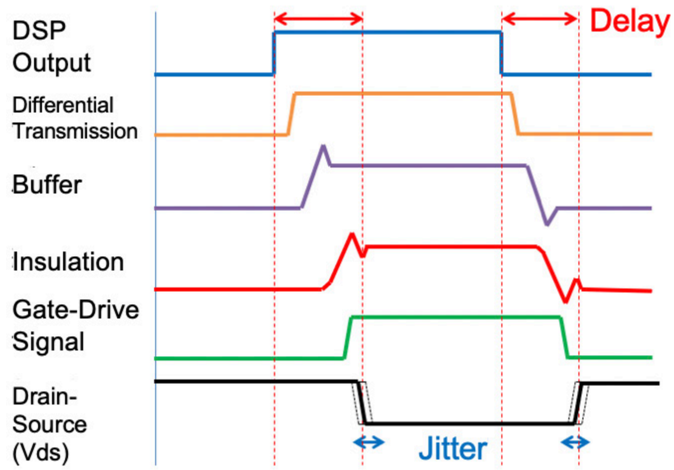


Figure 3. Output from switching devices measured with an oscilloscope

Remove the effects of common mode noise

Because the potential on the high side of a bridge circuit moves, a differential probe or an isolated input measuring instrument are required. To accurately measure floating signals like an inverter, high CMRR performance at high frequencies is needed.

Sic Inverter Measurement Example

Of the six switching devices (SiC MOSFET) in the three-phase inverter, a pair of upper and lower arms for the gate-drive signal and drain-source voltage signal is measured.

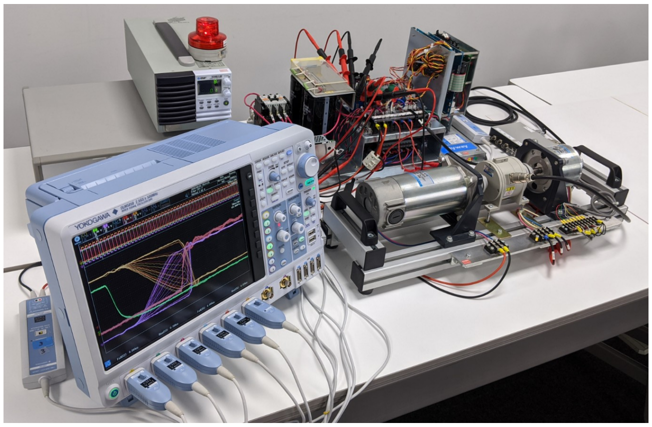


Figure 4. Test setup with switching devices being measured via oscilloscope

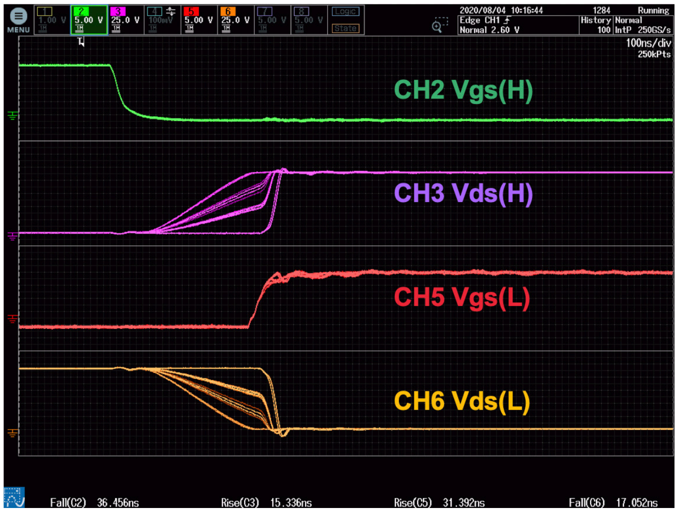


Figure 5. Zoomed-in waveforms of high and low gate-source and drain-source

Energy Efficiency Solutions

High-speed, simultaneous multichannel measurement of floating voltage signals

Combining the eight-channel, high voltage DLM5000 Mixed Signal Oscilloscope with high-frequency differential probes produces accurate simultaneous measurements for each voltage signal of the inverter internal circuit. This results in the ability to more efficiently check surge voltage and switching operation timing.

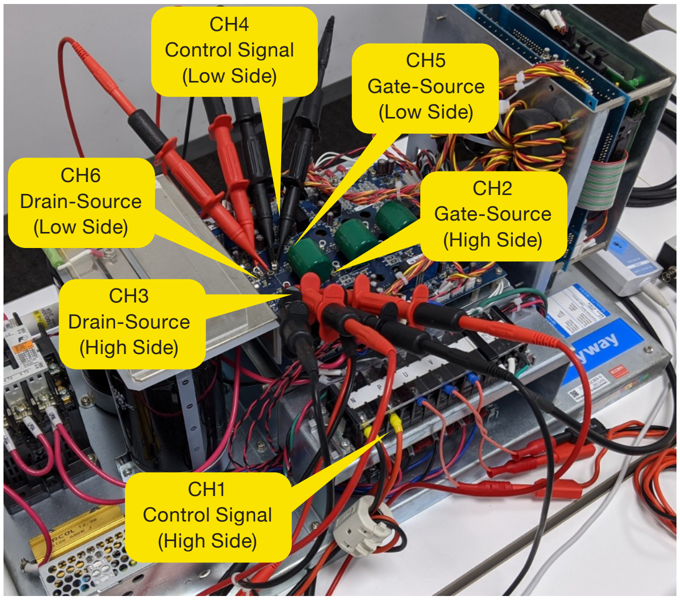


Figure 6. Differential probes connected to the high and low side of the drain-source, control signal, and gate-source

Increase the number of channels with *DLMsync*

When eight channels are not enough, two DLM5000s can be connected via *DLMsync* to enable synchronous measurement of up to 16 analog channels.

Increased efficiency of variability evaluation

Using the History function on the DLM5000, users can save up to 100,000 previously captured waveforms in the acquisition memory. In addition, the DLM5000 enables statistical analysis of repetitive waveform parameters and is effective for jitter measurement and level fluctuation.

DLM5000 Series Mixed Signal Oscilloscope

- Eight analog channels, up to 32 bits logic input in one unit
- 2.5 GS/s for all eight analog channels
- 350 MHz/500 MHz frequency bandwidth
- Maximum 500 Mpoints-long memory
- USB 3.0

Figure 7. Adaptable mixed signal oscilloscopes allow for more efficient and effective measurement and analysis of electrical signals

701927 150 MHz High-Voltage Differential Probe

- Power supply: Yokogawa interface
- Frequency band: DC to 150 MHz (-3 dB)
- CMRR (typical): -80 dB (60 Hz), -50 dB (1 MHz)
- Input attenuation ratio: 50:1 and 500:1, user-selectable
- Maximum allowed differential voltage: ±1400 V (DC + Acpeak) (500:1)

Figure 8. High-voltage differential probes enable the detection and floating measurement of the difference between non-grounded signals

Yokogawa's global network of 114 companies spans 62 countries. Founded in 1915, the US $3.7 billion company engages in cutting-edge research and innovation. Yokogawa is active in the industrial automation and control (IA), test and measurement, and aviation and other businesses segments.

Yokogawa has been developing measurement solutions for 100 years, consistently finding new ways to give R&D teams the tools they need to gain the best insights from their measurement strategies. The company has pioneered accurate power measurement throughout its history and is the market leader in digital power analyzers.

Yokogawa instruments are renowned for maintaining high levels of precision and for continuing to deliver value for far longer than the typical shelf-life of such equipment. Yokogawa believes that precise and effective measurement lies at the heart of successful innovation - and has focused its own R&D on providing the tools that researchers and engineers need to address challenges great and small.

Yokogawa takes pride in its reputation for quality, both in the products it delivers - often adding new features in response to specific client requests - and the level of service and advice provided to clients, helping to devise measurement strategies for even the most challenging environments.

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