

120 App up to 150 kHz: Ripple Testing per ISO 21498-2

By Enrico Neumann, Head of Product Management at IAV · October 2026

A ripple generator delivering up to 120 App of ripple current across 300 Hz to 150 kHz. On the datasheet, that reads like a solvable problem. The single component exists, the specification is fixed, and procurement is underway.

In practice, it often looks different. We know this from many projects in our Stollberg test facility. Between the final component delivery and the first standard-compliant test setup, there are often several months. Sometimes, it takes years.

This article shows where the real pitfalls of the voltage ripple test lie and how we solved them. Some of it transfers directly to your own test setup.



The IAV Auros Iso in the test facility.

What ISO 21498-2 requires of the ripple test in detail

ISO 21498-2 covers electrical tests for high-voltage components in electrically propelled road vehicles. They are meant to ensure safe, interference-free operation of several HV components in the vehicle's HV network. Sections 6.5 and 6.6 cover voltage ripple.

Section 6.5 addresses Generated Voltage Ripple. The DUT (device under test) is operated at typical operating points. These include load variation as well as upper, nominal, and lower operating voltage.

It must not exceed a frequency-dependent ripple voltage curve. Evaluation takes place in both the time and frequency domains. It ensures that the physically inherent disturbances caused by the DUT's power electronics stay within a permissible range.

Section 6.6 addresses Immunity to Voltage Ripple. Here the ripple is modulated onto the operating voltage (HV DC voltage) as a sinusoidal voltage wave. The amplitude is specified and depends on the frequency.

This reproduces the operation of another HV component in the HV onboard network that causes standard-compliant disturbances. Under these boundary conditions, the full functionality of the DUT must be maintained.

Both tests place high demands on the measurement equipment. Alongside communication with the DUT via CAN, which allows sampling rates of at most 100 Hz, detecting ripple frequencies up to 250 kHz requires separate data acquisition devices for current and voltage.



HV power supply inside the IAV Auros Iso. The DC component comes from the power supply, the AC component from the ripple generator.

The measurement challenge and our solution

Voltage class B permits voltages up to 1500 V. In practice, HV vehicles use nominal operating voltages of 400 V or 800 V. For commercial vehicles, 1200 V is also common. Intermediate values are possible as well.

Depending on the application, the currents are measured with contactless current sensors. This applies to frequencies up to 250 kHz. The standard requires it this way.

For this purpose, we integrated the high-frequency measurement equipment that we use in our own test facility. The Dewetron PA8 power analyzer has a modular design and offers up to 32 measurement channels. Sampling rates of up to 10 MS/s per channel are possible. This leaves headroom for higher demands and functional applications.

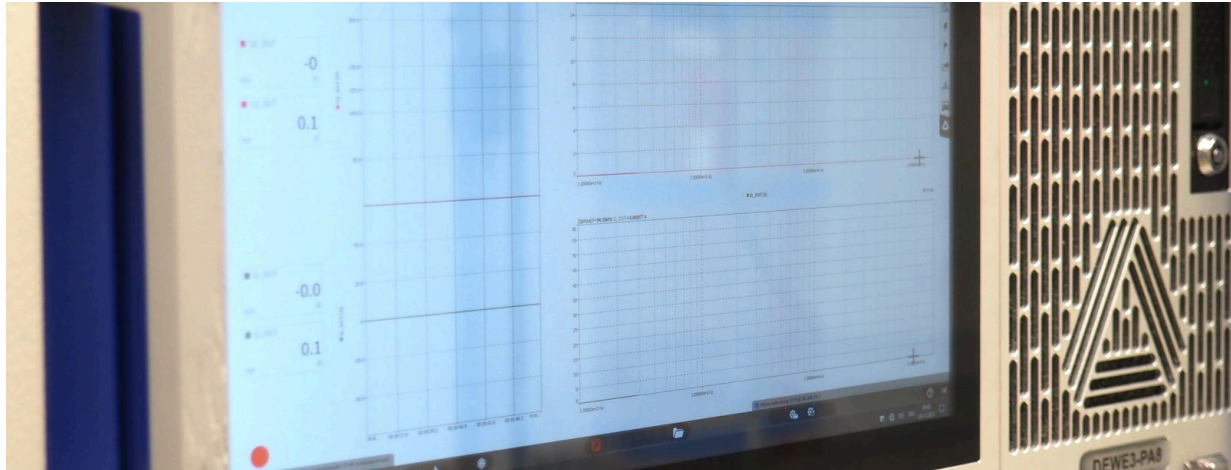
ISO 21498-2 requires sampling rates of ≥ 1 MS/s for the ripple tests. Bidirectional data exchange with peripheral devices is supported via CAN and network interfaces.

The "Immunity to Voltage Ripple" test calls for dedicated hardware. Only a few providers have this equipment and are able to perform the test at all. That makes it something special within ISO 21498-2.

The voltage signal from the HV power supply has to be superimposed with the required sinusoidal current signals. This applies to a frequency band from 10 Hz under the old ISO standard up to 150 kHz. In ISO 21498-2:2024, the frequency band begins at 100 Hz.

Why a single ripple generator covers only half the ripple test

Frequencies up to 1 kHz are modulated directly onto the DC voltage by a modern power supply such as the Regatron G5. For higher frequencies, a ripple generator is used. It works with a ripple control unit (RCU) and a connection box from IMP.



The Dewetron PA8 power analyzer captures current and voltage at up to 10 MS/s per channel.

The circuit setup and the switchover threshold are implemented internally. No reconfiguration is therefore needed. The test runs through in a single pass.

For low-power DUTs, the DUT impedance at low frequencies can be higher than that of the power supply. The ripple current injected through the connection box would then flow into the power supply. It would fail to produce the intended voltage rise in the DUT. To counter this, a frequency-dependent switchable additional inductance (choke) is built in.

Two current sources operate during the ripple test. The power supply provides the DC component and ensures the function of the DUT. The ripple generator provides only the AC component.

Because the DUT impedance changes with frequency, a different ripple current is needed at each frequency step. This is how the ripple voltage required by the test specification is reached. The RCU measures the ripple voltage continuously and frequency-selectively and regulates the ripple current accordingly.

A resonance range is usually swept through, formed by the inductance and resistance of the HV cable to the DUT and the capacitance of the DC-link capacitor. Up to the impedance maximum of the test setup, an ever-larger current is needed for the same ripple voltage.

To protect the DUT, the RCU limits the maximum ripple current in U/I control mode (voltage control with current limiting). The voltage thus stays on the target curve across the entire frequency range. Around the resonance frequency, the typical dip in peak-to-peak voltage occurs. With this, the boundary conditions for the standard-compliant Immunity to Voltage Ripple test are met.

Evaluation is based on the operational status of the DUT, which must not enter a fault state. It is also based on quantities such as the delivered torque, which the ripple must not affect.

The ripple generator in the IAV Auros Iso delivers 120 App or 200 App at up to 80 Vpp. The units are designed for SiC power electronics. SiC operates at higher switching frequencies and with steeper switching edges than conventional IGBT technology.

In tests that evaluate the DUT's effect on the HV onboard network (for example Generated Voltage Ripple and Generated Voltage Slope), the test specifications call for HV resistors (for example 100 mΩ) in the hardware setup. They replicate the resistance of the HV battery and the conductor and limit the current flow. This can lead to steeper and higher voltage rises.

The hardware resistors provided for this are exchangeable and air-cooled. They behave linearly, so that any control in the power supply does not affect the test result.

For the HV power supply, the focus was on transient behavior. The “Immunity to Load Dump Voltage” test calls for voltage gradients of ≥ 250 V/ms. The voltage swing here is around 50 to 80 V. This is maintained for loads up to 22 kW.

For the integration of all VW 80300 tests, we meet the demanding requirement of 3000 V/ms when the boundary conditions are known. These include system voltage, DC-link capacitance, and voltage swing.



Is there still a gap between the datasheet and a running test?

Are you building such a setup yourself right now, and the gap between the datasheet and a running test is still wider than you would like? Then reach out to us directly. Whether it is a quick technical question about a single test or a broader exchange about the complete setup, I am glad to go through it with you. And anyone who would rather see it on the running hardware is always welcome at our test facility in Stollberg.

[Book a slot with Enrico Neumann](#)

Why the ripple test is not an isolated problem

The IAV Auros Iso is designed so that the DUT is connected at the HV output. All boundary conditions required by the standard regarding inductances and capacitances are met.

The typical interconnections between the HV source and the DUT are established internally via a switch box. The paths are switched without load. The “Generated Load Dump Voltage” and “Short Circuit” tests require switching under load. The corresponding switching elements are dimensioned for this and can be replaced when worn.

As a result, the DUT is connected only once, and the HV acceptance of the test setup is needed only once. All ISO 21498-2 tests then run automatically one after another, in any order. Under given boundary conditions, they can also run unattended and overnight.

Without such a concept, the test object is connected to the ripple generator and the measurement equipment for the ripple test. For the next test, the wiring has to be changed. Every rewiring alters contact resistances and cable lengths, and with them the electrical boundary conditions. Across 15 tests, these changes add up and erode measurement quality.

The interplay is the real task

Each individual problem is solvable on its own, and the right components are in every catalog. The interplay is in none of them.

The real challenge: accommodating all the solutions at once in a single setup that maps the eleven tests of ISO 21498-2 in an audit-proof way.

Automation takes the final step. Only when the test sequences run reproducibly, safely, and with complete documentation does a collection of individual devices become a reliable test system.

We brought this coordination and automation work together over the course of years. The ISO 21498-2 tests are covered completely and without reconfiguration between tests; the same tests are at the same time part of more comprehensive OEM standards such as VW 80300.

Let us talk about your setup

Are you fine-tuning individual parameters? Would you like to exchange ideas about the complete setup? We would be glad to receive a message or a visit to our Stollberg test facility.

[Arrange a meeting](#)



About the author: Enrico Neumann

Head of Product Management at IAV, responsible for the IAV Auros Iso product

The practical experience described in this article comes from the daily operation of the IAV test facility in Stollberg. There, our HV test system has been in use for customer projects for years.

enrico.neumann@iav.de · Phone: +49 5371 80-51724

More about IAV Auros Iso

All information on the test system for electrical tests per ISO 21498-2, VW 80300 and MBN 11123:
www.iav.com/products-and-services/iav-auros-iso

Contacts

Enrico Neumann
Head of Product Management
enrico.neumann@iav.de

Marco Ullrich
Product Manager
marco.ullrich@iav.de

Thomas Beyer
Sales Manager
thomas.beyer@iav.de

IAV GmbH Ingenieurgesellschaft Auto und Verkehr · Carnotstraße 1 · 10587 Berlin · www.iav.com