CAN SIC transceivers: Taming reflections in CAN FD networks

(Source: Adobe Stock)

CAN SIC (signal improvement capability) is a physical-layer enhancement for CAN FD networks. It actively improves the normally recessive transition for a limited time, reducing ringing caused by reflections. The protocol and CAN FD frame format remain unchanged, but the transceiver timing and arbitration limits must be included in the network design.

CAN is often introduced as a robust two-wire differential network that tolerates distributed nodes and an imperfect real-world wiring. That description remains valid, but it becomes incomplete as the data-phase bit rate increases. At higher edge rates, cable sections, connectors, stubs, and termination no longer behave like a single lumped load. Their impedance discontinuities create reflections, and those reflections can appear as overshoot, undershoot, or ringing on the differential bus signal. For explanatory reasons we use the network topology as shown in Figure 1. However, using this network topology in real-world systems is not recommended.

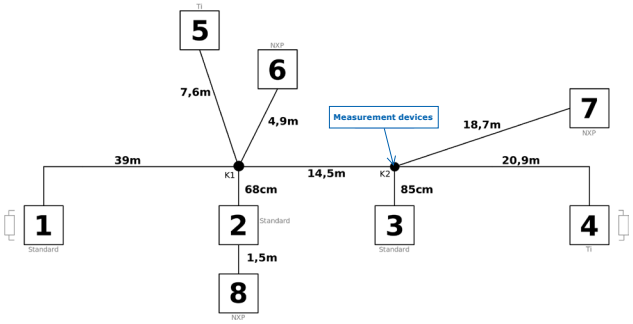

Figure 1: Structure of the example CAN network (Source: Microcontrol)

Conventional CAN high-speed (HS) transceivers are designed around a simple electrical principle: they actively drive the dominant state and release the bus for the recessive state. This behavior is fundamental to arbitration. It is also one reason why a dominant-to-recessive transition can be comparatively slow and vulnerable to the energy returning from the network. This “ringing” is shown in Figure 2, which depicts the CAN signal from node 7 during transmission.

The CAN signal improvement capability (CAN SIC) addresses this physical-layer problem without changing the CAN controller or the frame format.

Why high-speed CAN needs more than a faster transceiver

In a CAN CC (classic) network using CAN high-speed transceivers, a dominant bit is produced by driving a differential voltage onto CAN_H and CAN_L lines. A recessive bit is produced by releasing the bus so that the termination network brings the two lines back toward the common recessive level. The network is therefore not driven with the same impedance in recessive and dominant states.

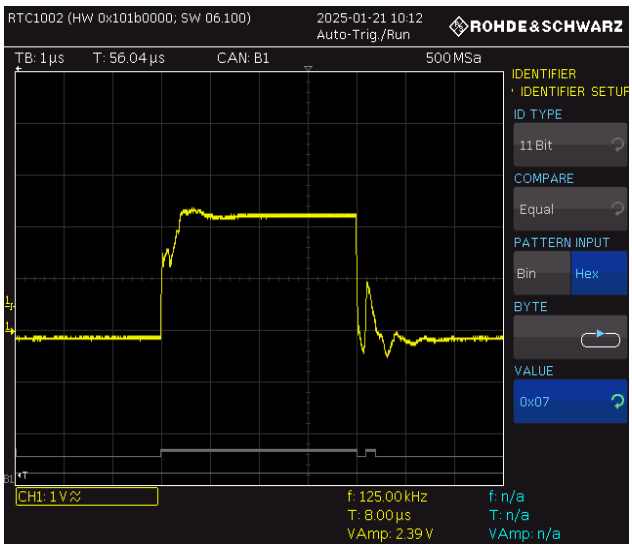

Figure 2: CAN signal ringing during transmission from node 7 (Source: Microcontrol)

That asymmetry is normally an advantage because it enables a non-destructive arbitration: a dominant bit overrides a recessive bit. However, the physical waveform does not change instantaneously. When a transmitter releases the bus, the signal propagates through the cable and encounters branches, connectors, and other loads. If the topology is not electrically well matched to the cable, a part of the signal is reflected. At a sufficiently high data-phase bit rate, the reflection can still be present when the receiver samples the bit.

The result is not necessarily a complete communication failure. More commonly, the system loses the timing margin. A receiver may see a delayed threshold crossing, a shortened or extended bit, or a series of spurious crossings that appear as glitches at the RxD output. The same physical network that works comfortably at 250 kbit/s may therefore become difficult to operate at 500 kbit/s, even if the nominal cable length has not changed.

What CAN SIC transceiver changes

A CAN SIC transceiver changes the electrical behavior of the recessive transition. Instead of immediately switching to a very high impedance, the transmitter actively drives the recessive level for a limited interval. The source impedance is approximately 100 Ohm in the commonly described implementation, rather than the tens of k-Ohms associated with a released output. This temporary low-impedance drive absorbs energy and reduces the amplitude and duration of reflections.

After the signal-improvement interval, the transceiver returns to the normal released state. That time limit is essential. The improvement function must help the recessive edge to settle, but it must not prevent a different node from asserting a dominant bit during arbitration. In addition to transmit-side ringing suppression, the ISO-defined family of signal-improvement functions also includes receive-side approaches that filter or reject ringing at the receiver. This difference is shown in Figure 3. Here, the transceiver from node 7 has been changed from a CAN HS transceiver to a CAN SIC transceiver.

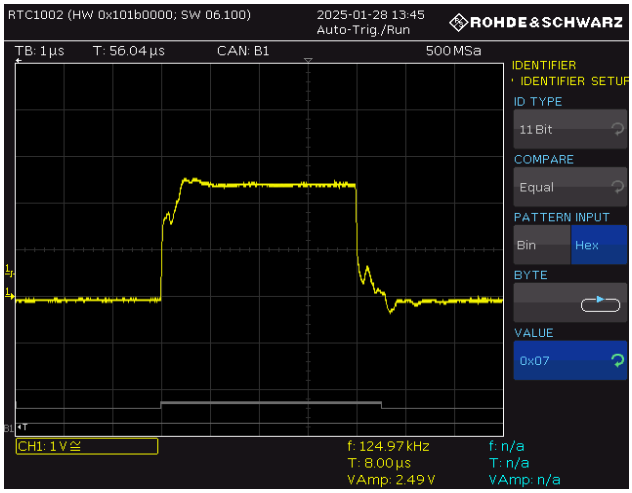

Figure 3: Impact of CAN SIC transceiver from node 7 (Source: Microcontrol)

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Table 1: Timing parameters for CAN SIC transceivers (Source: Microcontrol, ISO)

Parameter	Meaning	Why it matters
Signal improvement time	Time during which signal improvement remains active after a dominant-to-recessive transition at TxD.	It improves the edge, but its duration contributes to arbitration-phase limits when several nodes release the bus at once.
Transmitted bit-width variation	Difference between the bit width generated at TxD and the bit width appearing on the bus.	It describes timing distortion through the transmit path.
Received bit-width variation	Difference between the received bit width at RxD and the original TxD bit width.	It captures the complete loop-delay effect through the transceiver.
Receiver timing symmetry	Difference between the bit width on the bus and the bit width reconstructed at RxD.	It separates receive-path distortion from the bus waveform itself.
Propagation delay	Delay from TxD to the bus and from the bus to RxD, specified separately for dominant and recessive states.	It consumes the phase margin and constrains the cable length, bit rate, and sample-point choices.
Standards note: *The numerical limits in the internal timing sheet reflect the former CiA 601-4 / ISO 11898-2:2016 comparison. Compliance work should use the licensed, current ISO 11898-2:2026 text.*		

The important distinction is that SIC is not a new CAN data link layer (ISO OSI layer 2) protocol. A CAN FD controller still transmits and receives the same dominant and recessive bits, using the same frame structure and nominal bit coding. The change is in the physical medium attachment (PMA) implemented by the transceiver.

The timing trade-off

Active driving of the recessive state improves the waveform, but it also introduces a new electrical condition during which the bus is being driven by more than one node. Imagine that several nodes transmit recessive bits at the same time while another node transmits a dominant bit. The dominant driver has to override the active-recessive drivers. The more nodes are active at the same time, the greater the load that has to be overcome.

For that reason, the signal-improvement interval is bounded and the arbitration phase cannot simply be treated as an 8-Mbit/s link. The standard specifies CAN SIC transceivers as supporting data-phase bit rates up to 8 Mbit/s, while also warning that the arbitration phase may be limited to approximately 667 kbit/s when all CAN-Identifier values are considered. The exact usable value depends on the transceiver implementation, cable, topology, propagation delay, bit timing, and the required arbitration margin.

This is a central design message: SIC can make the data phase faster and more tolerant of ringing, but it does not remove the fundamental timing relationship between arbitration, bus length, and propagation delay. A CAN FD frame can therefore combine a conservative arbitration bit rate with a much faster data phase, provided that all nodes and the physical network are qualified for the selected settings.

SIC timing parameters

The original SIC engineering discussions use several timing parameters (see Table 1) to separate the effects of the transmitter, the bus, and the receiver. Keeping those effects separate is useful when moving from an oscilloscope waveform to a bit-timing calculation.

These parameters matter because CAN FD sampling is a phase-margin problem. The receiver does not merely need to detect the correct voltage; it needs to detect it within the permitted sample window after accounting for oscillator tolerance, controller delay, transceiver asymmetry, cable propagation, reflections, and the selected sample point. A transceiver data sheet that only advertises a headline bit rate is therefore not enough to qualify a network.

What SIC improves and what not

SIC is most valuable when the limiting problem is ringing caused by the network topology rather than by a fundamentally unsuitable cable or a missing termination. It can provide an additional margin in systems with longer branches, hybrid layouts, connectors, or other impedance discontinuities that would be difficult or expensive to eliminate mechanically. It is particularly relevant when the CAN FD data phase is above 1 Mbit/s and the network needs more flexibility than a point-to-point arrangement allows.

SIC does not turn an arbitrary wiring into a valid CAN network. The cable still needs an appropriate differential impedance, the main line still needs a correct termination, and stubs still have a finite electrical length. Common-mode behavior, electromagnetic compatibility, ground offsets, supply decoupling, and protection against bus faults remain the system responsibilities. A CAN SIC transceiver is a margin-improvement tool, not a substitute for the topology analysis, which should include the following steps:

- Start with the physical network: cable type, characteristic impedance, total length, stub lengths, connector transitions, and termination.
- Separate the arbitration-phase requirements from the CAN FD data-phase requirements.
- Use the transceiver's dominant-to-recessive and recessive-to-dominant propagation data in the bit-timing calculation.
- Check both differential ringing and common-mode disturbances at representative nodes, not only at the transmitter.
- Verify interoperability when different suppliers' CAN SIC transceiver implementations are mixed in one network.

From CiA 601-4 to ISO 11898-2

The former CiA 601-4 specification is a historical reference for the CAN SIC concept. Its content moved into the ▷

ISO standardization process and was incorporated into ISO 11898-2:2024. This edition was later replaced by ISO 11898-2:2026, which is the current normative reference for CAN SIC transceiver requirements.

The withdrawal of CiA 601-4 should therefore not be interpreted as a withdrawal of the CAN SIC technology. It reflects the normal transition from an industry specification to an international standard. CiA also issued an interim corrigendum proposal, CiA 140, because some comments and corrections were not reflected in the ISO 11898-2:2024. CiA later withdrew the CiA 140 document as the ISO revision has been progressing.

Conclusion

CAN SIC transceivers address a very practical weakness in high-speed CAN networks: the energy that a conventional transceiver leaves behind when it releases the bus. By actively shaping the recessive transition for a controlled interval, SIC reduces ringing and can make more demanding CAN FD topologies feasible. The gain comes with a timing trade-off, especially in the arbitration phase, so the improvement must be considered together with the propagation delay, sample-point margin, and network topology.

For engineers accustomed to CAN high-speed transceivers, the migration concept is straightforward: the controller and frames remain familiar, while the physical-layer qualification becomes more detailed. The key question is not simply whether a transceiver is advertised as supporting a certain bit rate. The key question is whether the complete network – transceivers, cable, connectors, termination, controller timing, and EMC environment – remains inside the limits of the current ISO-defined PMA behavior. ◀

References

[1] ISO 11898-2:2026, Road vehicles – Controller area network (CAN) – Part 2: High-speed physical medium attachment (PMA) sublayer. It is the current normative reference for CAN SIC transceivers and related PMA options.

[2] CiA: Physical-layer options. Overview of CAN HS, CAN FD, CAN SIC, and CAN SIC XL transceiver categories and their practical bit-rate/topology context.

[3] CiA 601 series: CAN FD guidelines and recommendations. CiA website explaining that SIC handling formerly specified in CiA 601-4 is now specified in ISO 11898-2. The text also points to the related design calculations.

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