Understanding One Shot Edge Accelerators in Auto Direction Level Translators

AND90452/D

Understanding transient drive with the **onsemi** NL3X5004 and NL5X4002.

WHY A SHORT BURST OF DRIVE HELPS

An auto-direction level translator transfers a logic signal between two supply-voltage domains without a direction-control pin. Each channel responds to the side being driven. The challenge is to switch quickly while keeping the steady-state drive modest enough for an external driver to take control when the direction changes.

A one-shot, also called a monostable circuit, solves this tradeoff by producing a brief internal pulse when it detects an edge. That pulse enables a stronger drive path to charge or discharge the load capacitance. When the pulse ends, the extra drive turns off. The output can remain at its new logic level; the internal pulse is not the duration of the data bit.

Figure 1 expands the NL3X5004 four channel auto directional translator into its two directions. Each direction has separate rising- and falling-edge one-shots that briefly bypass the 1 kΩ DC path with stronger drive.

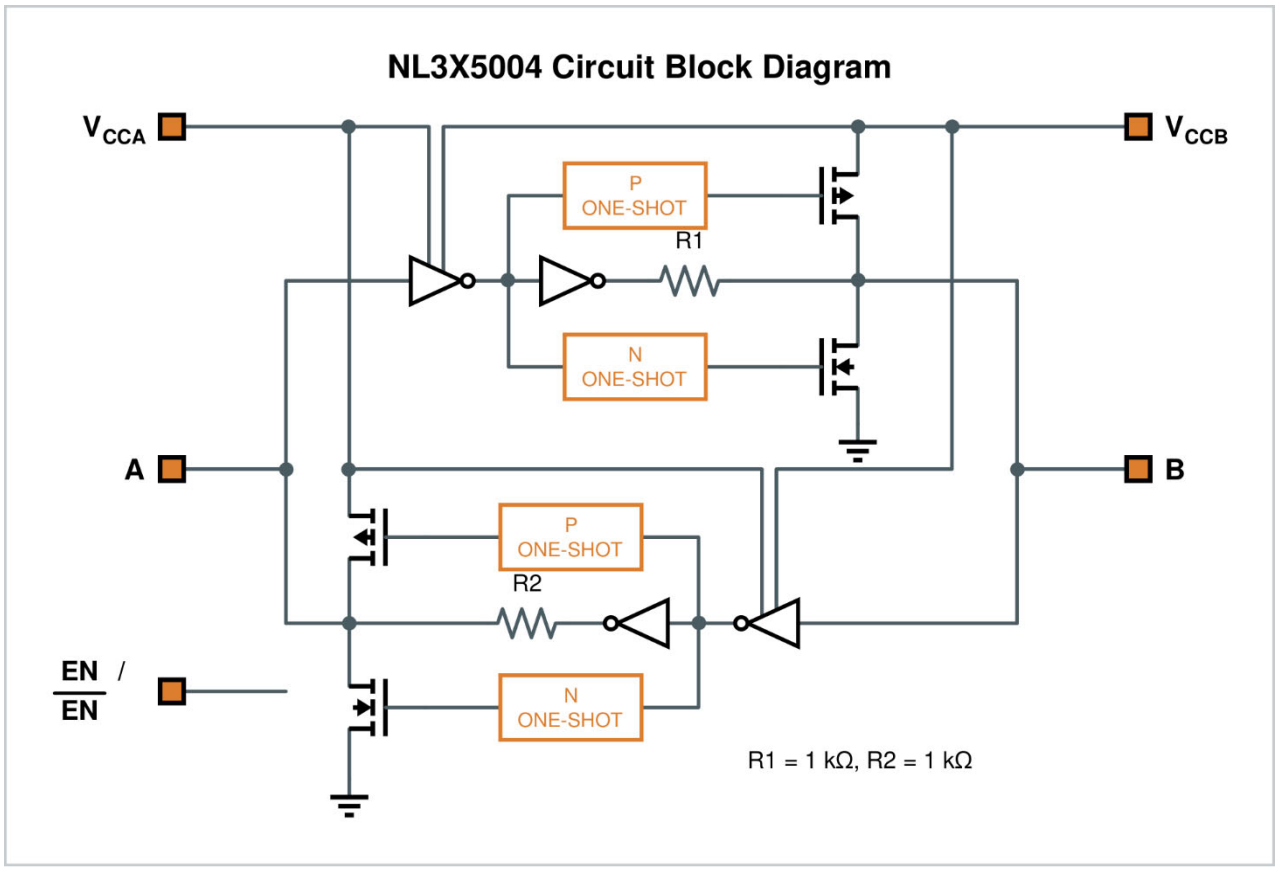


Figure 1. NL3X5004 Circuit Block Diagram

© Semiconductor Components Industries, LLC, 2026

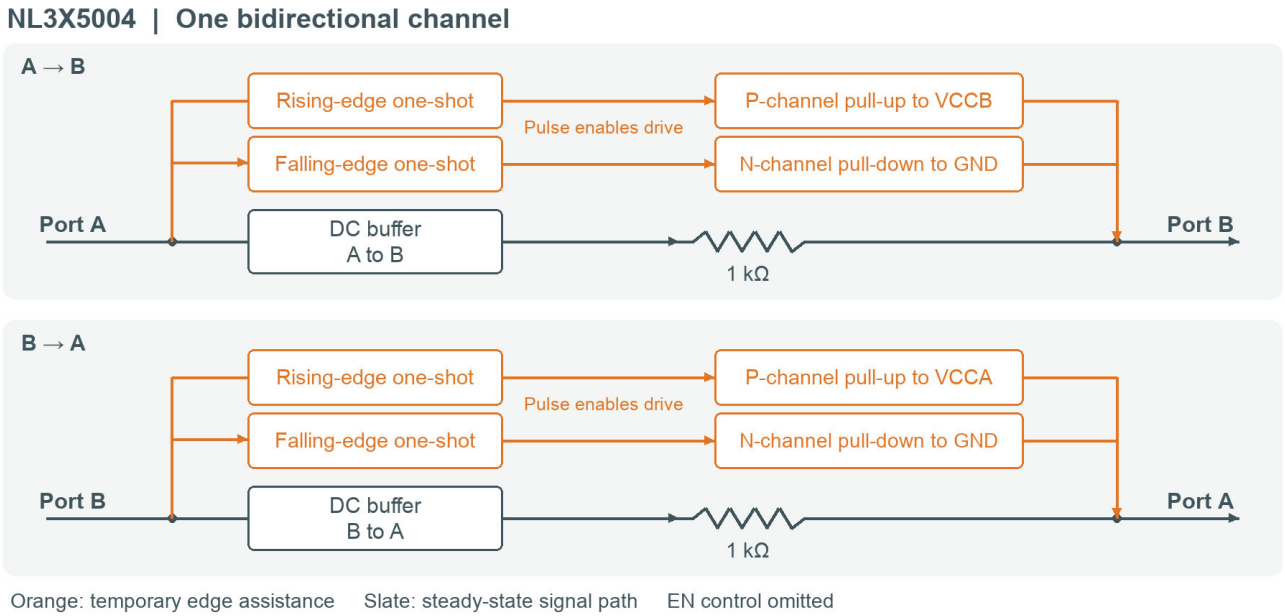


Figure 2. NL3X5004 Architecture, Simplified. The Two Rows Show Opposite Directions of the Same A–B Channel, Not Separate Channels. En and Internal Inversions Are Omitted.

TWO DEVICES WITH DIFFERENT EDGE ASSISTANCE

Device	Accelerated edges	Steady-state behavior
NL3X5004 4 channels 0.9–3.6 V per rail	Rising and falling edges Temporary pull-up and pull-down drive	Buffer paths with 1 kΩ series resistors in the functional diagram
NL5X4002 2 channels 1.65–5.5 V per rail	Rising edges Useful when an open-drain driver releases the line	Internal 10 kΩ pull-ups on the I/O lines

Share Feedback
Your Opinion Matters

RISING EDGE ASSISTANCE IN AN OPEN DRAIN CHANNEL

The NL5X4002 uses a different architecture. In Figure 3, a bidirectional pass FET links A and B. Each port has a 10 kΩ pull-up and a temporary pull-up branch. A rising edge at A triggers the one-shot driving PU2 on B; a rising edge at B triggers PU1 on A. The gate-bias block controls the pass FET.

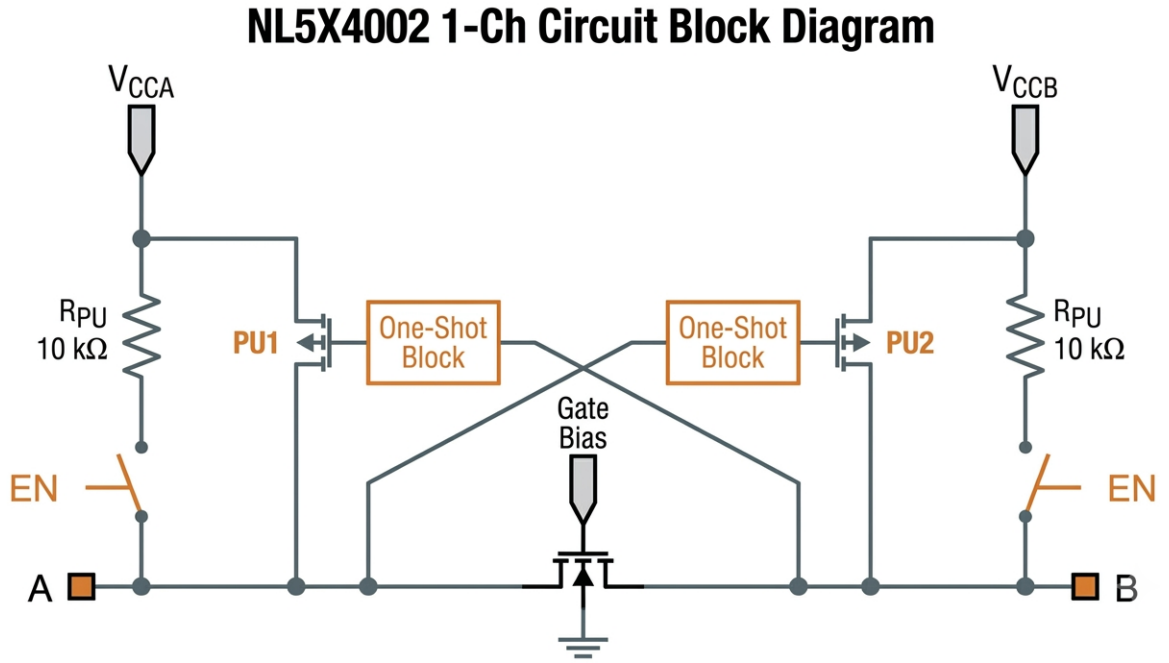


Figure 3. NL5X4002 1-Ch Circuit Block Diagram

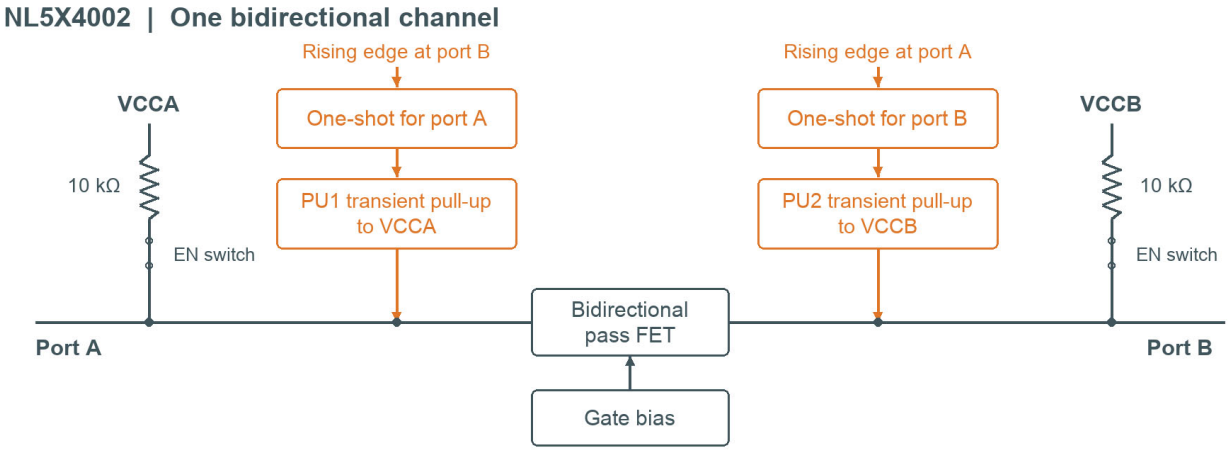


Figure 4. NL5X4002 Architecture, Redrawn as Functional Blocks. PU1 and PU2 Are Transient Pull-Ups. The En-Controlled Pull-Up Paths Are Shown Enabled; Other Enable Circuitry Is Omitted.

Share Feedback
Your Opinion Matters

From Edge Detection to a Short Burst of Drive

When an open-drain transmitter releases the line, the pull-ups start the rise and the one-shot speeds it. There is no corresponding falling-edge one-shot in this device. The low-driving endpoint and pass path establish a low. By comparison, the NL3X5004 architecture in Figure 1 assists both polarities, as illustrated in Figure 5.

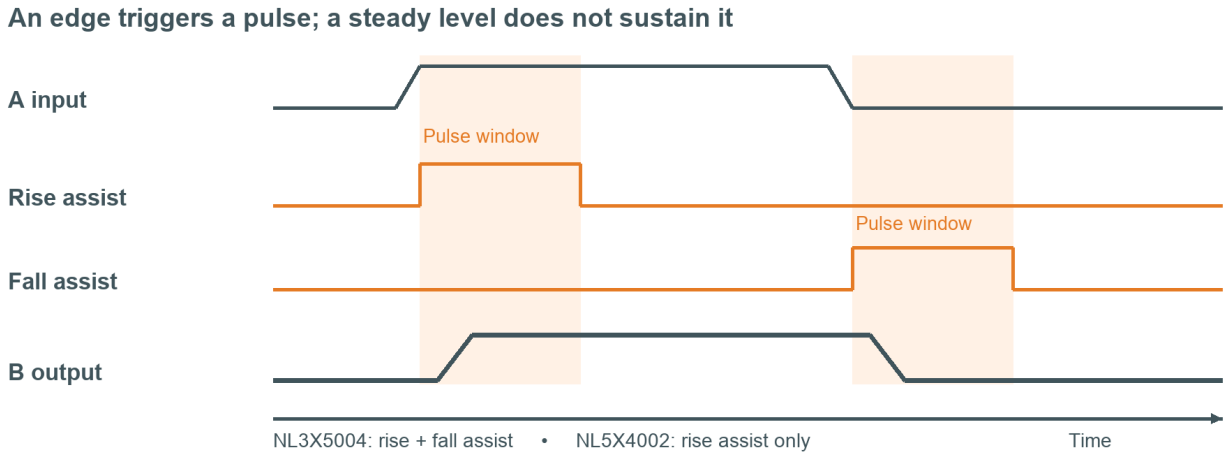


Figure 5. Qualitative A-to-B Timing for the Nl3x5004. High on an Assist Trace Means “Enabled,” Not Transistor-Gate Polarity. The Nl5x4002 Has Rising-Edge Assistance Only. Timing Is Not to Scale.

What Remains After the Pulse

The extra drive turns off after its pulse, but the new logic level can remain. The NL3X5004 retains its modest DC buffer path; the NL5X4002 retains its pull-ups. Pulse timeout does not put the whole port in high impedance. EN low is the separate control that disables the I/O ports.

DESIGNING AROUND THE FINITE ASSIST WINDOW

A load needs charge to change voltage: $Q = C \times \Delta V$. A larger capacitance or voltage swing needs more charge. The one-shot supplies extra current for only a limited interval, so a heavily loaded node can still be settling when that interval ends. The weaker steady-state path then finishes the transition, potentially leaving a slow tail. Figure 6 illustrates this behavior; it is not a simulation or measured device waveform.

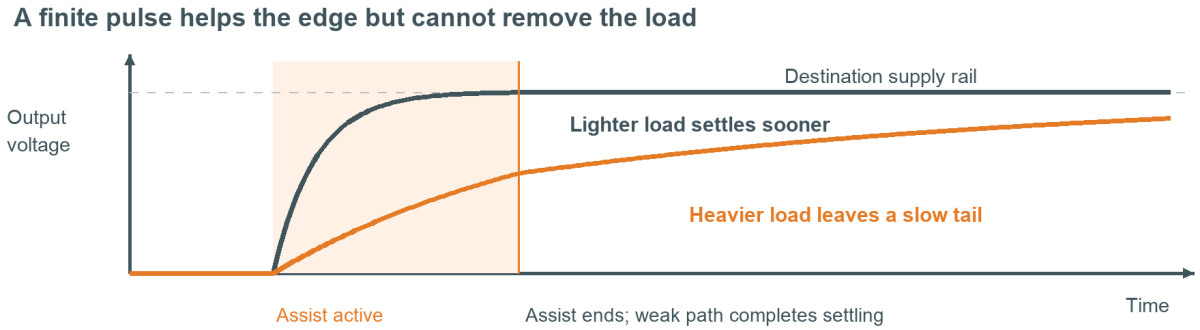


Figure 6. Illustrative Rising Edges With Different Loads and the Same Assist Window. The End of Assistance Is Not a Guarantee That the Receiver Has Reached a Valid High Level.

Neither data sheet specifies a guaranteed one-shot pulse duration or retriggering interval. Use the published switching limits and their test conditions to budget timing.

Apply the Distinction to a Real Interface

In Figure 4, adding an external pull-up in parallel with an internal resistor reduces the effective resistance: R effective = 10 kΩ M || R external. It can improve passive charging but also increases the current that every low-driving endpoint must sink. Check the low-level voltage and sink-current budget on both voltage domains.

For an NL3X5004 interface, check that the source can supply the specified 5.0 mA peak drive and that the total load matches the switching-table conditions. Treat short, clean interconnects and low-capacitance probing as part of the load budget. High transient drive capability does not imply equally strong continuous DC drive.

Share Feedback
Your Opinion Matters

What to Check on the Bench

Observe both ports with low-capacitance probes. Check rise and fall times, valid logic levels, propagation delay and settling at the actual receiving pin. Repeat in both directions and at the intended supply and load extremes. A shoulder after the fast part of an edge can indicate that the assist has ended before the load settles. Ringing or repeated threshold crossings deserve investigation rather than an assumption that the one-shot will filter them.

For open-drain links, also test line release and acknowledge or turnaround intervals. For push-pull links, release the previous driver before enabling the next: one-shot assistance does not arbitrate between opposing drivers. For more information on **onsemi** voltage level translation devices please visit **onsemi**'s level translation landing page on **onsemi**.com.

Share Feedback
Your Opinion Matters

REVISION HISTORY

Revision	Description of Changes	Date
0	Initial document release.	11/2/2026

Share Feedback
Your Opinion Matters

onsemi, , and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent−Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as−is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

ADDITIONAL INFORMATION

TECHNICAL PUBLICATIONS:
Technical Library: www.onsemi.com/design/resources/technical−documentation
onsemi Website: www.onsemi.com

ONLINE SUPPORT: www.onsemi.com/support
For additional information, please contact your local Sales Representative at www.onsemi.com/support/sales