Multiplexers and Signal Switches Glossary

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About This Multiplexers and Signal Switches Glossary

This glossary provides a brief overview and introduction to the terminology, features, and parameters for multiplexers and signal switches. The entire switches and multiplexers portfolio can be found at *www.ti.com/switches*.

For components used to manage power rails, TI offers a power switch and power multiplexer portfolio which can each be found at *www.ti.com/powerswitch*.

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1. Introduction to Multiplexers and Signal Switches

Signal switch — An integrated circuit (IC) used for connecting and disconnecting an electrical circuit. For more information, see the *Switches and muxes: What are switches & multiplexers?* training video from *TI Precision Labs*.

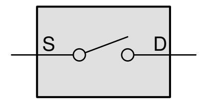


Figure 1. Ideal 1:1 SPST Switch

Multiplexer (Mux) — An integrated circuit that connects a selected signal path to a single line.

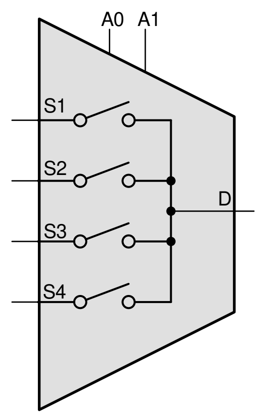


Figure 2. Ideal 4:1 Mux

Analog switches and multiplexers — These devices are used for switching and multiplexing analog and digital signals up to 500 mA in applications such as:

- Precision data acquisition
- GPIO expansion and diagnostics
- System communication and bus isolation
- System protection and power sequencing
- General-purpose signal switching

Protocol-specific switches and multiplexers — These devices are defined to support specific protocol applications such as USB, HDMI, LAN, MIPI, audio, memory and so forth.

Power multiplexer — These devices are a set of electronic switches used to select and transition between two or more input power paths to a single output.

Power switch — These devices manage power distribution for paths typically greater than 500 mA between a voltage source to a load. They can be used to limit inrush current, enable power sequencing, provide protection from overvoltage or overcurrent events, and more.

Precision — These devices minimize offset error and signal distortion in a high-accuracy measurement system.

Protection — These devices isolate I/O signal paths and protect the system using powered-off, overvoltage and undershoot protection.

Low voltage — These devices support I/O signals ≤ ±24 V

Mid voltage — These devices support I/O signals > ±24 V

Configuration — Defines the number of signals that can be selected. Table 1 shows the typical configurations.

Channel — Defines the number of configurations (circuits) in a single device. Table 1 shows the 1- and 2- channel configurations, but the number of channels may exceed 2.

Table 1. Configurations and Channels

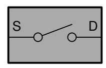
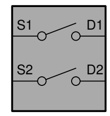
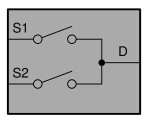
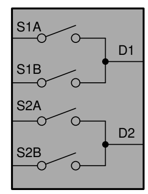
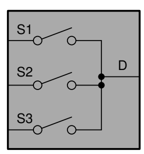
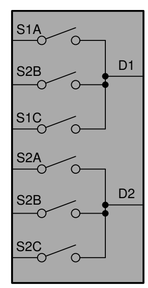
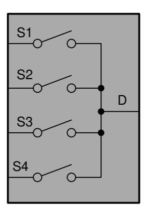
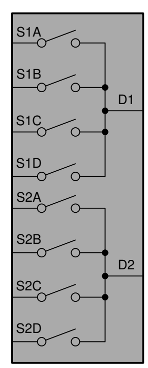
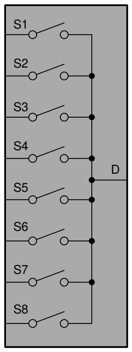
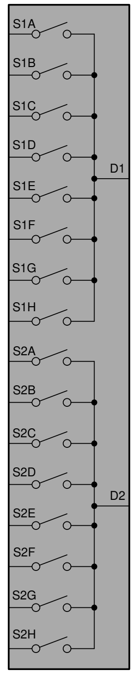
		1-Channel	2-Channel
Configuration	1:1		
	2:1		
	3:1		
	4:1		

Table 1. Configurations and Channels (continued)

		1-Channel	2-Channel
Configuration	**8:1**		

2. Operation of Multiplexers and Signal Switches

Absolute maximum ratings — These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under the *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. Stresses beyond those listed under the *Absolute Maximum Rating* may cause permanent damage to the device.

Recommended operating conditions — The operating conditions for which the device has been characterized.

Single power supply — Device with only positive power supply pins with reference to ground. The voltage applied is labeled as V_{DD}, V_{CC}, V_+ and so forth.

Dual power supply — Device with positive and negative supply pins with reference to ground. Voltage applied at the positive pin is labeled as V_{DD}, V_{CC}, V_+, and so forth, and at the negative pin is labeled as V_{SS}, V_{EE}, V_-, and so forth.

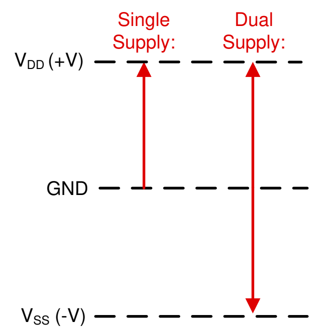


Figure 3. Single and Dual Supply

Switch control signal levels (V_{IH}, V_{IL}) — Voltage levels required on the control pins (EN, SEL, IN, and so forth) required for the switch to change the internal signal path.

- **V_{IH}** – The minimum voltage for the input control signal to achieve a logic "1"*high* value
- **V_{IL}** – The maximum voltage for the input control signal to remain a logic "0"*low* value

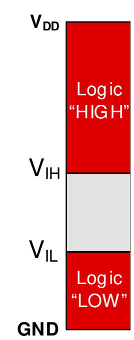


Figure 4. Switch Control Signal Levels

Rail-to-rail — A common term meaning that a device will support $V_{I/O}$ voltage range between the most positive and most negative power supply *rails*.

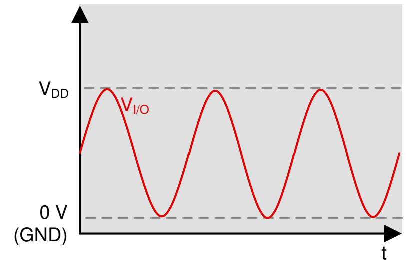


Figure 5. Rail-to-Rail

Input/Output voltage beyond supply – The switch can support voltage range beyond the supply rail to $V_{I/O(MAX)}$as indicated by the recommended operating conditions.

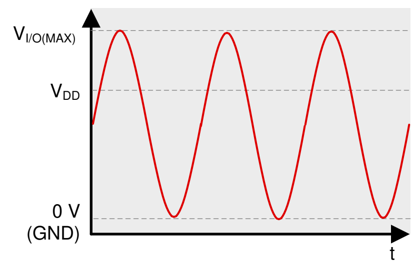


Figure 6. I/O Voltage Beyond Supply

Bidirectional signal path – The switch conducts equally well from source (S) to drain (D) or from drain (D) to source (S). Each channel has very similar characteristics in both directions and supports both analog and digital signals. TI analog switches and multiplexers are typically bidirectional. See the *Switches and muxes: Are switches & multiplexers bidirectional?* training video from *TI Precision Labs*.

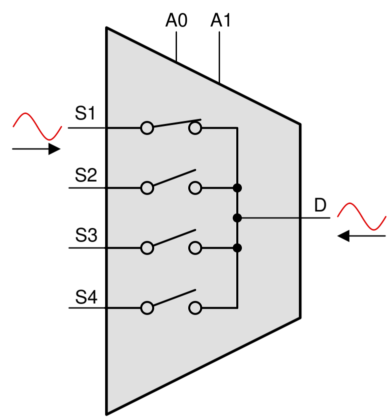


Figure 7. Bidirectional Signal Path

3. Additional Features

1.8-V control logic – Switches with this feature have a built-in voltage translator to prevent voltage mismatch between the supply rail and the control logic. V_{IH} and V_{IL} levels are compatible with the 1.8-V logic levels at any voltage supply. See the *Simplifying Design With 1.8 V logic MUXes and Switches Tech Note* for more information.

Fail-safe logic – Ensures the switch stays off and the voltage on the logic pin (V_{SEL}) does not back-power V_{DD} when V_{SEL} is greater than V_{DD}. See the *Switches and muxes: What is fail-safe logic?* training video from *TI Precision Labs*.

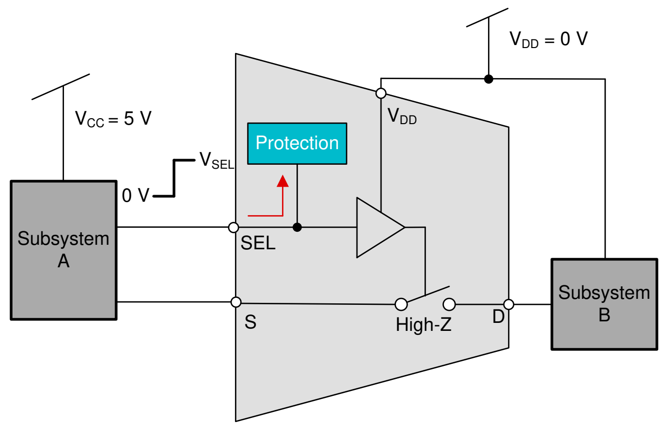


Figure 8. Fail-Safe Logic

Injection current control — Allows signals on disabled (high-Z) signal paths to exceed the supply voltage without affecting the signal of the enabled signal path. For example, if current is injected into a disabled signal path, raising the voltage at the pin above the supply, the signal on the enabled signal path will not be affected. See the *Switches and muxes: Prevent crosstalk with injection current control* training video from *TI Precision Labs*.

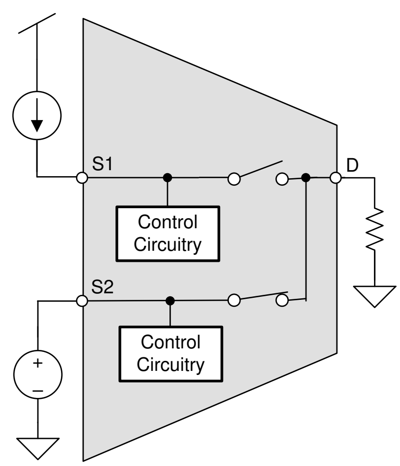


Figure 9. Injection Current Control

Integrated pulldown resistor on logic pin – Internal weak pulldown resistors to GND to ensure the logic pins are not floating.

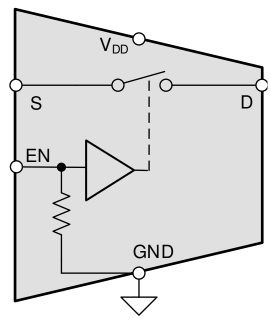


Figure 10. Integrated Pulldown Resistor on Logic Pin

Latch-up immunity – Devices that are latch-up immune are built in a Silicon On Insulator (SOI) process and will not latch-up when exposed to current injection or overvoltage events. See the *Switches and muxes: What is latch-up immunity?* training video from *TI Precision Labs*.

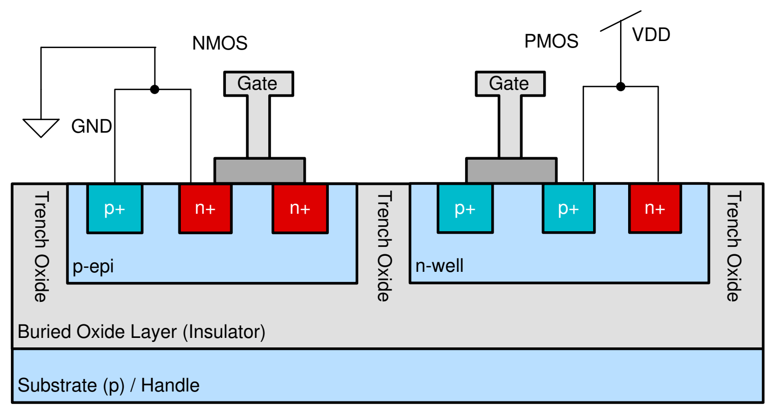


Figure 11. Latch-Up Immunity With SOI Process

Overvoltage protection – When the input voltage $V_{I/O}$ exceeds the defined threshold voltage, V_{TH}, the switch enters the high impedance state, isolates signal path, and protects downstream components.

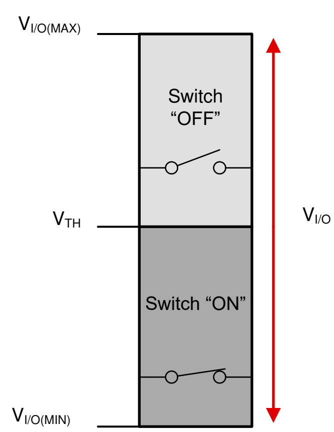


Figure 12. Overvoltage Protection

Powered-off protection – Protects switch and isolates signal path when signals are present at the I/O pins and VDD = 0 V. See the *Switches and muxes: Simplify power sequencing with powered-off protection* training video from *TI Precision Labs*and the *Eliminate Power Sequencing With Powered-off Protection Signal Switches Tech Note* for more information.

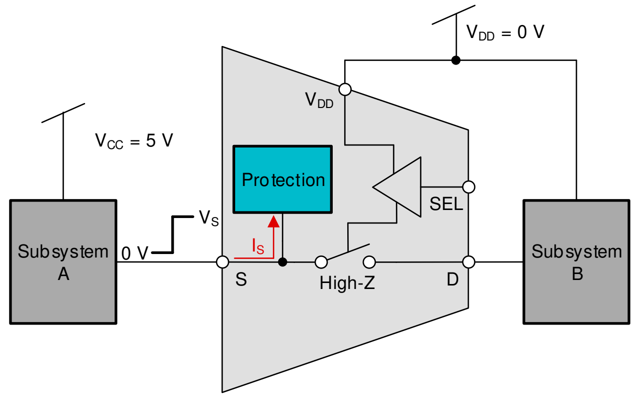


Figure 13. Powered-Off Protection

4. DC Characteristics

For more parameter information, see the device data sheet.

On-resistance (R_{ON}) — The resistance inserted into the signal path as a result of the switch path being turned on.

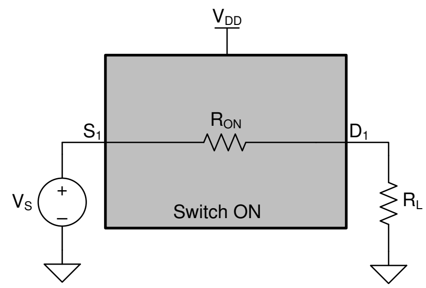


Figure 14. On-Resistance

On-resistance flatness ($R_{ON\ FLAT}$) — Difference between the maximum and minimum value of Ron in a channel over the V_D or V_S voltage range.

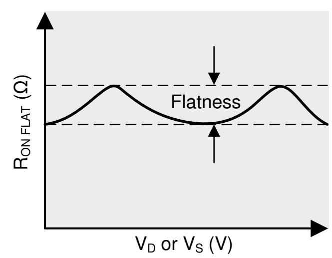


Figure 15. On-Resistance Flatness

OFF leakage current ($I_{D(OFF)}$, $I_{S(OFF)}$) — Leakage current measured at the input port, with the corresponding channel output in the OFF state under worst-case input and output conditions.

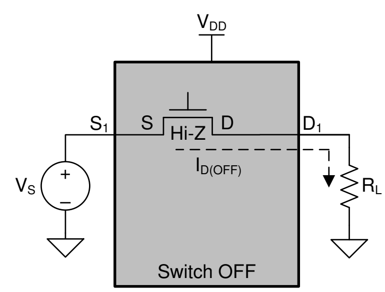


Figure 16. OFF Leakage Current

Powered-off I/O pin leakage current (I_{POFF}) — The leakage current flowing into or out of the source pin when the device is powered off (V_{DD} = 0V).

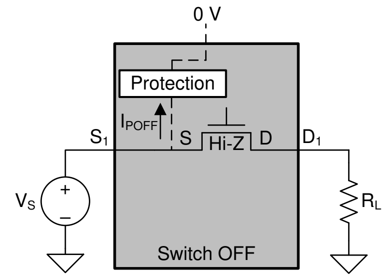


Figure 17. Powered-Off I/O Pin Leakage Current

ON leakage current ($I_{D(ON)}$, $I_{S(ON)}$) — Leakage current measured at the input port in the ON state, with the corresponding output port in the ON state and the output being open.

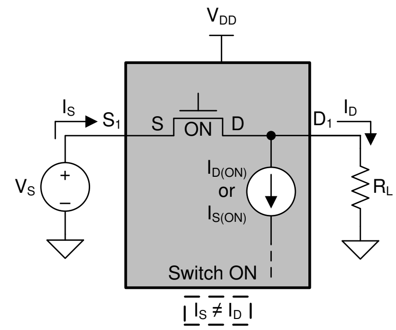


Figure 18. ON Leakage Current

Control input leakage (I_{SEL} or I_{EN}) — Leakage measured at the switch control pins.

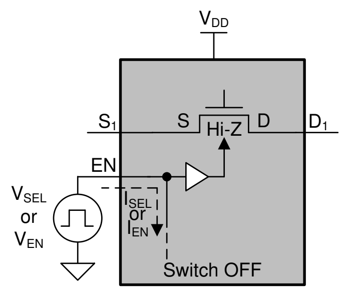


Figure 19. Control Input Leakage

5. Dynamic Characteristics

For detailed information of dynamic characteristics, see the *Multiplexers: Bandwidth, Channel-to-Channel Crosstalk, Off-Isolation and THD+Noise* training video from *TI Precision Labs*.

For more parameter information, see the device data sheet.

Off capacitance source and drain (C_{OFF}) — The capacitive loading when a switch path is in the high-impedance state.

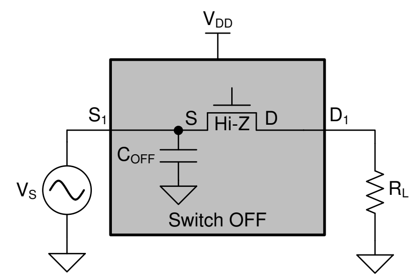


Figure 20. Source and Drain Off Capacitance

On capacitance source and drain (C_{ON}) — The capacitive loading when a switch path is in the low-impedance state.

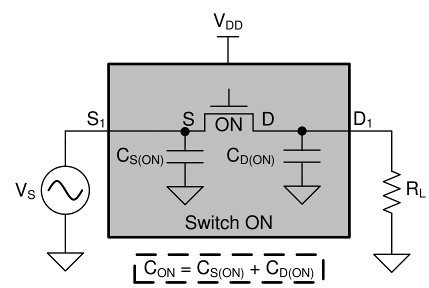


Figure 21. Source and Drain On Capacitance

Charge injection (Q_C) — Charge injection is a measurement of unwanted signal coupling from the control (EN) input to the analog output. This is measured in coulomb (C) and measured by the total charge induced due to switching of the control input.

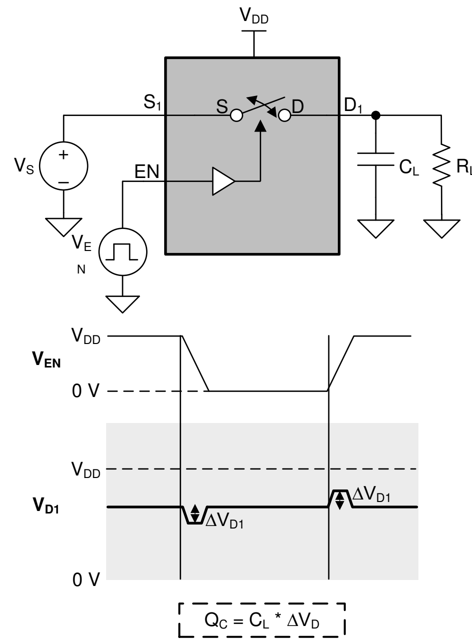


Figure 22. Charge Injection

Off-isolation (O_{ISO}) — A measurement OFF-state switch impedance. This is the ratio of V_{D1} to V_{S1} measured in dB at a specific frequency, with the corresponding channel in the OFF state.

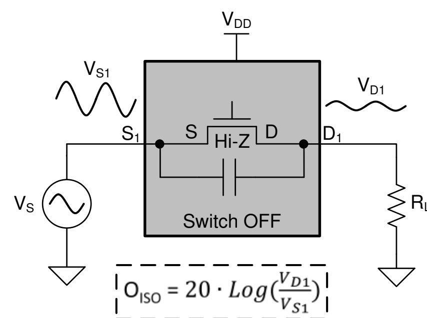


Figure 23. Off-Isolation

Channel-to-channel crosstalk (X_{TALK}) — A measurement of unwanted signal coupling from an ON channel to an OFF channel. This is the ratio of V_{S2} to V_{S1} measured in dB at a specific frequency.

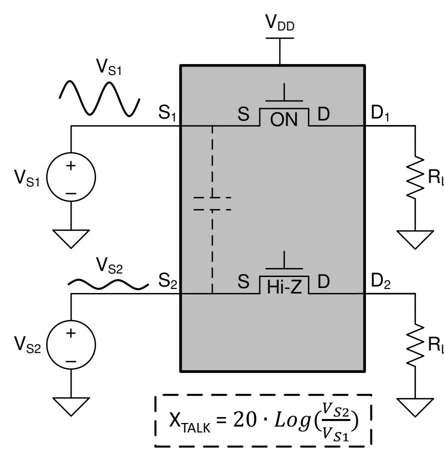


Figure 24. Channel-to-Channel Crosstalk

Bandwidth (BW) — The frequency range of signals that can pass through the switch with no more than 3 dB of attenuation.

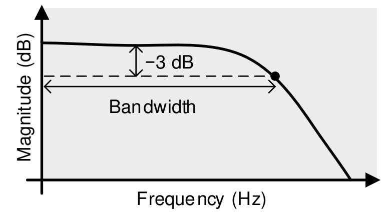


Figure 25. Bandwidth

6. Timing Characteristics

For detailed information, see the *Switches and muxes: What are timing characteristics?* training video from *TI Precision Labs*.

For more parameter information, see the device data sheet.

Transition time (t_{TRAN}) — The time taken by the switch output to rise or fall within a given percentage of the final value after the address signal has risen or fallen past the logic threshold.

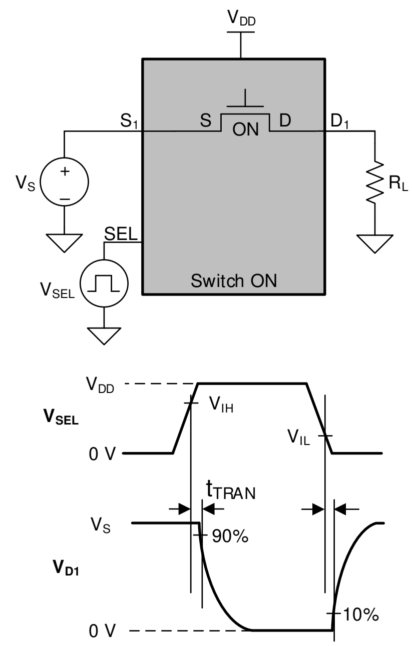


Figure 26. Transition Time

Device turn on time from enable pin ($t_{ON(EN)}$ and $t_{OFF(EN)}$) — The time taken by the switch output to rise or fall within a given percentage of the final value after the enable has risen or fallen past the logic threshold.

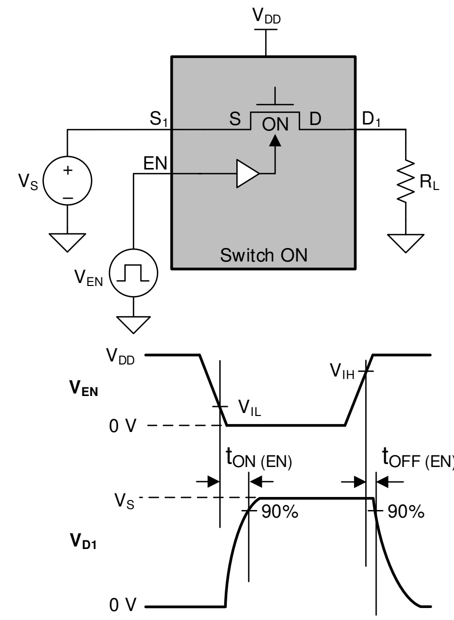


Figure 27. Device Turn on Time From Enable Pin

Break-before-make time ($t_{OPEN\ (BBM)}$) — Ensures that in a multiplexer, two multiplexer paths are never electrically connected when the signal path is changed by the select input.

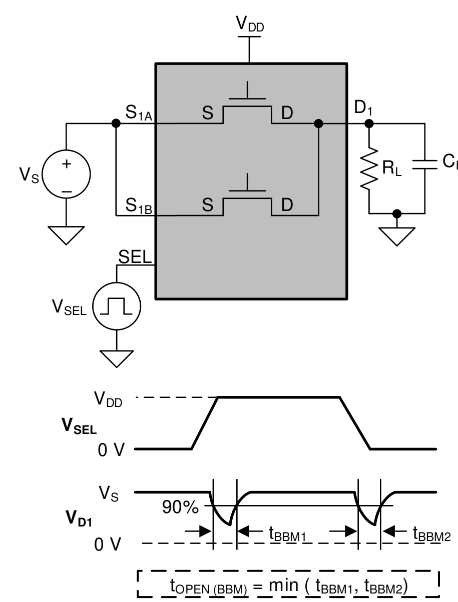


Figure 28. Break-Before-Make Time

Make-before-break time ($t_{CLOSED\ (MBB)}$) — Ensures that in a multiplexer, two multiplexer paths are never electrically disconnected when the signal path is changed by the select input.

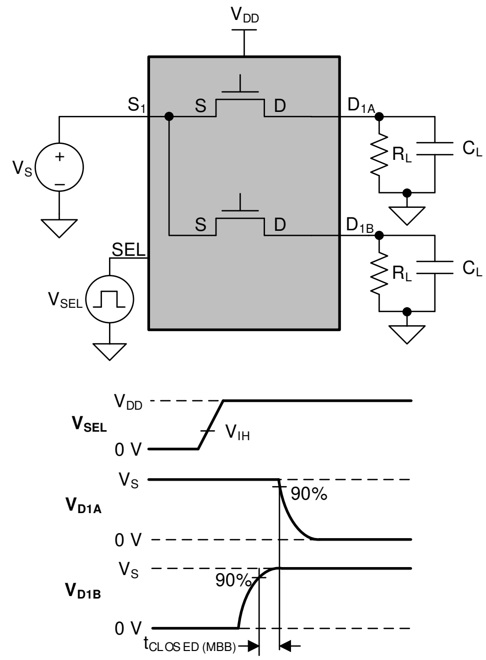


Figure 29. Make-Before-Break Time

Output-to-output skew (t_{SK}) — The maximum difference between the propagation delays of different outputs due to different internal paths.

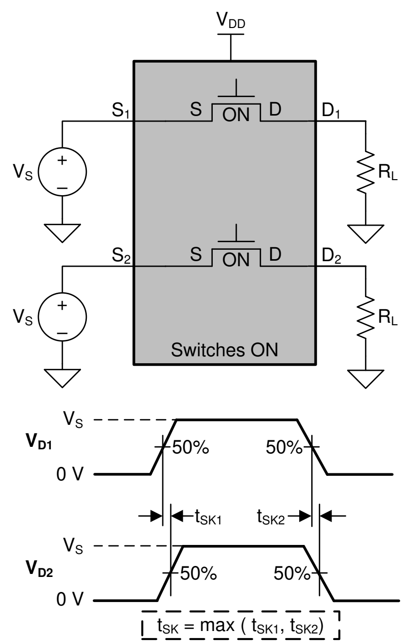


Figure 30. Output-to-Output Skew

Propagation delay through the switch (t_{pd}) — The time required for a signal to pass from the input signal pin to the respective output signal pin.

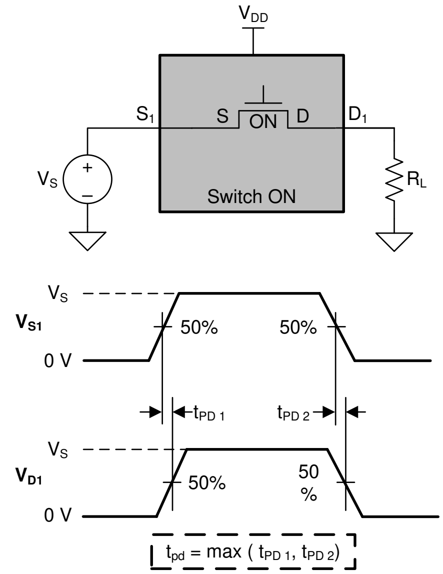


Figure 31. Propagation Delay Through the Switch