

Traction Inverter Motor Control Enhancement Using Logic and Translation

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ABSTRACT

Logic and translation devices can be found in a majority of the systems which control a *Traction Inverter Motor*. The control systems integrate numerous sub-systems, such as motor driver circuitry, which require high drive strength and extended noise immunity that a microcontroller output is generally unable to provide making logic devices necessary. Sensors such as weight and proximity sensors often operate at a different voltage than the system controller and hence, translation must be used. All of the use cases shown in the [Block Diagram](#) and [Logic and Translation Use Cases](#) sections of this document are commonly seen in the *Control Unit* designs.

Logic gates, voltage translators, and other logic devices are utilized for many purposes throughout modern electronic systems. This document provides example solutions for common design challenges that can be solved using logic and translation. Not all of the solutions here appear in every system; however, all solutions shown are commonly used and effective.

There are dozens of logic families available from Texas Instruments, and it can be difficult to select the right one for the application. Control unit of Traction Inverter Motor generally prefer low-power solutions, which makes it easier to identify an appropriate family for this application. See [Recommended Logic and Translation Families for Traction Inverter Motor Control](#) for help finding the right logic family for your use case.

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1 Block Diagram

For the purpose of this report, a simplified system block diagram is used to illustrate the logic and translation use cases, see Figure 1. For a more complete view, see the interactive online end equipment reference diagram for *Traction inverter motor control*.

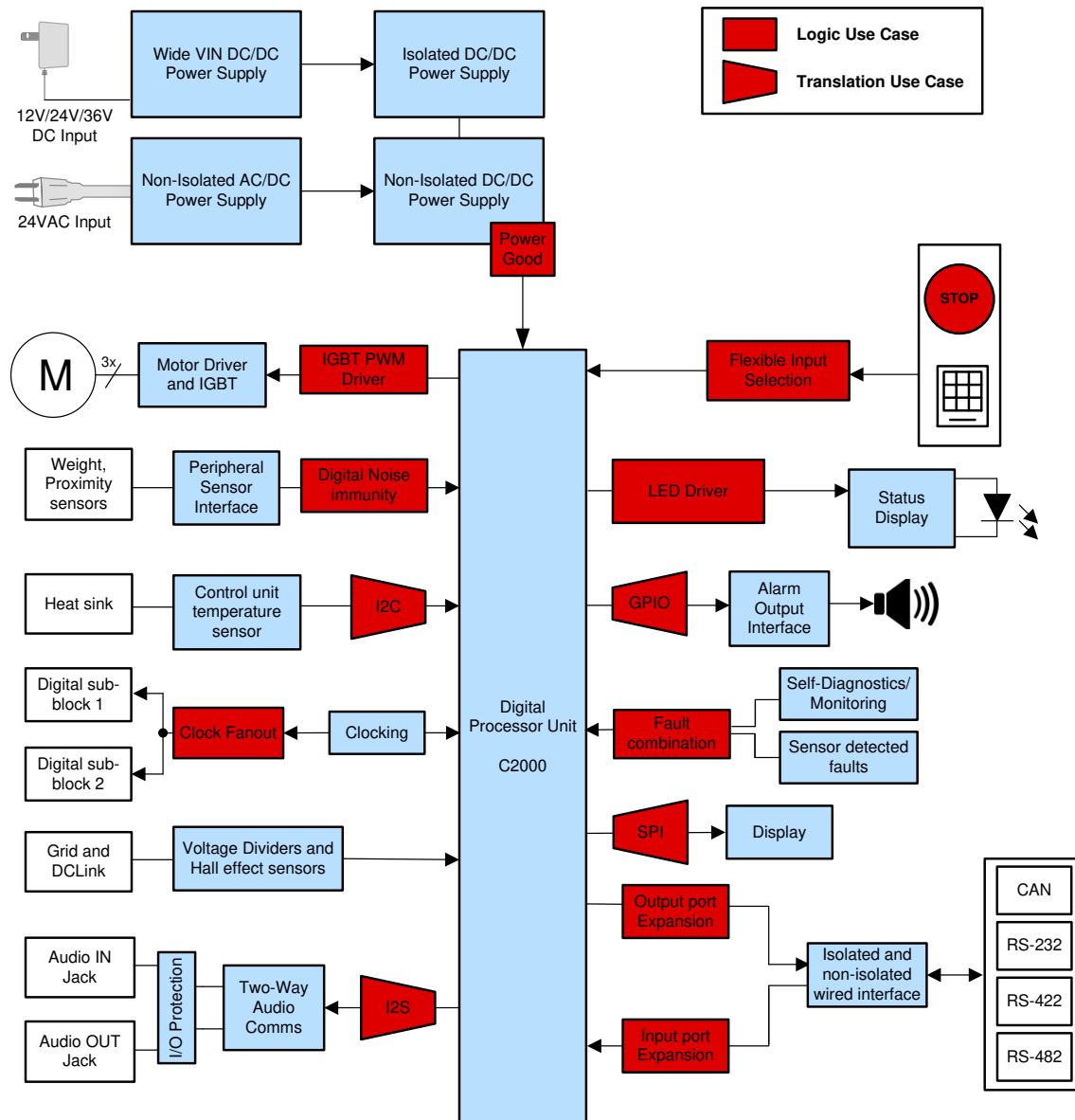


Figure 1. Simplified Block Diagram for Traction Inverter Motor Control

2 Optimizing Fault Circuitry With Logic Devices

Control units of modern elevators and escalators with traction inverter motor require continuous monitoring and predictive maintenance to reduce downtime and service costs. Logic devices play a prime role to combine the fault signals to alert the MCU for appropriate action. Further, on fault detection, the PWM input to the IGBT driver of the motor is connected to the enable pin of the tristate buffer to allow soft shutdown, disabling the drive stage and turning off the IGBT slowly.

Both of these use cases pertaining to fault signal circuitry are illustrated in this section.

2.1 Combine Fault Signals

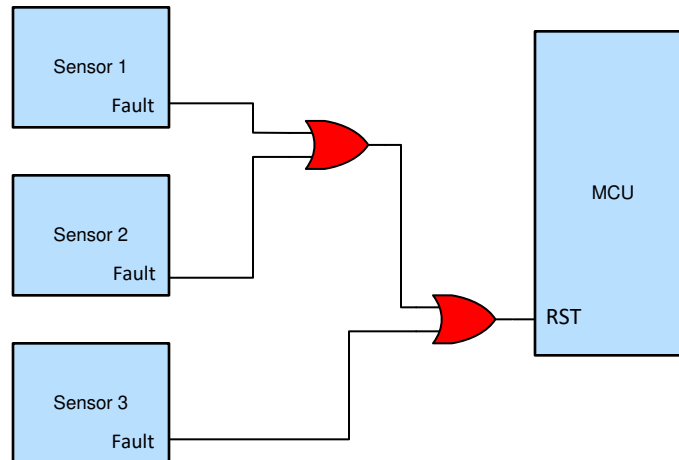


Figure 2. Using Logic to Combine Multiple Fault Signals

- Detects multiple fault events on the basis of which action is required
- Reduces number of signals to the system controller
- Increases safety by rapidly responding to the changes in one or many fault signals
- See more about this use case in *The Logic Minute* video [Use Fewer Inputs to Monitor Error Signals](#)
- Find the right OR gate through the [online parametric search tool](#)

2.2 IGBT PWM Driver

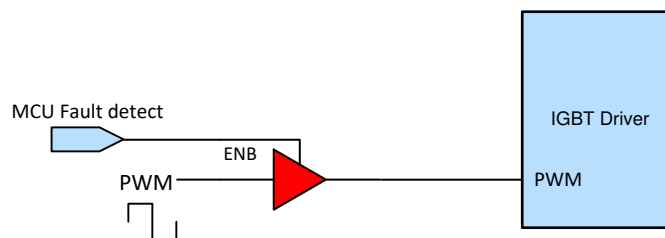


Figure 3. Using Logic to Produce High Impedance Required for Soft Shutdown

- Tri-state buffer can produce high impedance state (Hi-Z) equivalent to an open circuit
- Useful to drive IGBT gate driver for soft shutdown, if a fault is detected
- Increases current drive strength capability
- Buffers allow isolation of gates or circuits from each other
- Find the right buffer with the [online parametric search tool](#)

3 Logic and Translation Use Cases

3.1 Logic Use Cases

3.1.1 Noise Immunity of Digital Signals

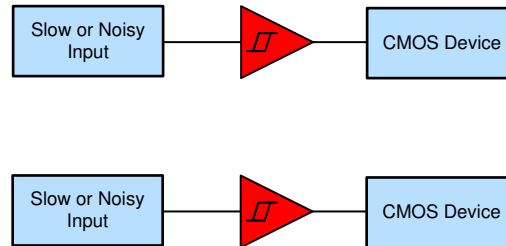


Figure 4. Using Logic to Gain Noise Immunity or Remove Slow Edges From Signals

- Ensures clean digital signal outputs in all system components
- Increases reliability of I/O pins
- Adds current drive strength to drive more outputs
- See more about this use case in *The Logic Minute* video [Eliminate Slow or Noisy Input Signals](#)
- Find the right Schmitt Trigger Buffer through the [online parametric search tool](#)

3.1.2 Input Signal Selection

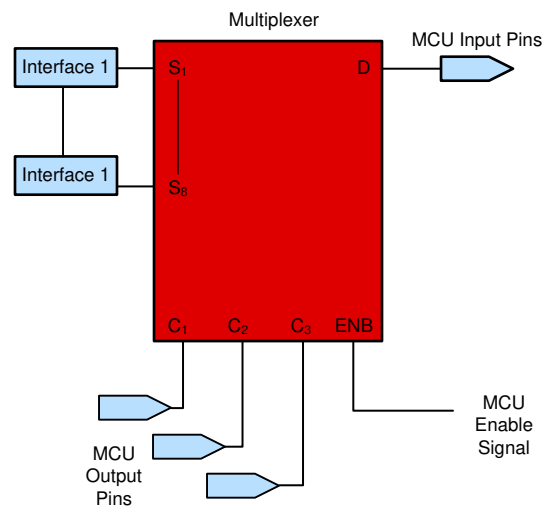


Figure 5. Using Logic to Select Required Input

- Allows selection from multiple input options
- Reinforces configurability and reuse of system blocks
- Low on-resistance ensures minimal propagation delay
- Find the right multiplexer through the [online parametric search tool](#)

3.1.3 Drive Indicator LEDs

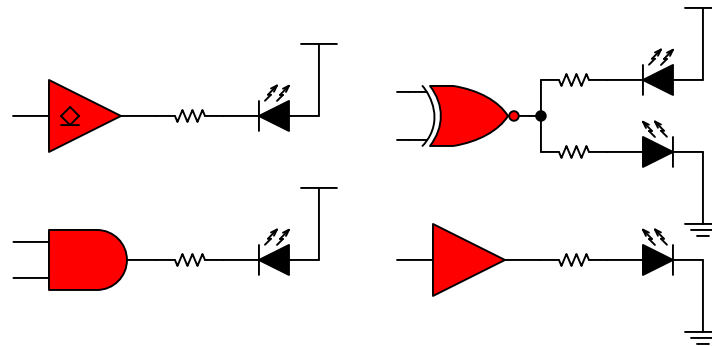


Figure 6. Using Logic as Indicator LED Driver Application Examples

- Add system indicators without controller interaction required.
- Most logic gates can drive low-current indicator LEDs (1 to 25 mA).
- Logic functions add configurability.
- Disable indicator LEDs as desired.
- Find the right logic solutions through the [online parametric search tool](#).

3.1.4 Combine Power Good Signals

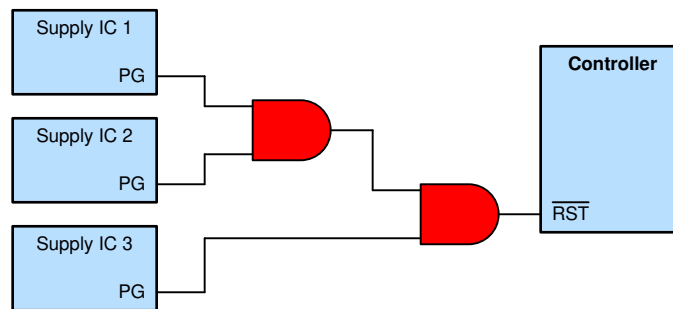


Figure 7. Using Logic to Combine Multiple Power-Good Signals

- Combine power good signals to drive an active low reset
- Add power indicator LEDs without software or system controller interaction
- See more about this use case in *The Logic Minute* video [Combining Power Good Signals](#)
- Find the right AND gate through the [online parametric search tool](#)

3.1.5 Clock Fanout

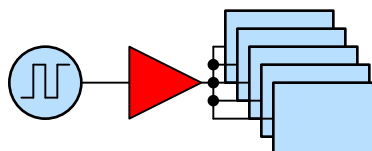


Figure 8. Using Logic to Propagate Clock Signals to Multiple Blocks

- Buffer increases drive strength of low-frequency (approximately 20 MHz) digital clock output
- Capable of driving multiple digital blocks, combined load up to 70 pF
- Establishes clean clock signals to all sub-systems
- Find the right buffer through the [online parametric search tool](#)

3.1.6 Input Port Expansion

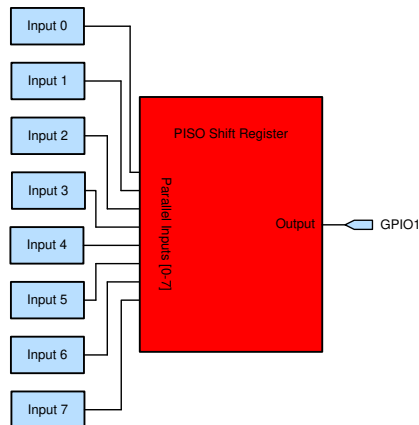


Figure 9. Using Logic to Increase Number of Usable Input Ports of Microcontroller

- Different configurations of shift registers reduces IO pin requirements
- Parallel-In Serial-Out Shift registers increase the number of inputs to the microcontroller
- Lower cost system realization by reducing the size of microcontroller required
- See more about this use case in *The Logic Minute* video [Increase the Number of Inputs on a Microcontroller](#)
- Find the right Shift Register through the [online parametric search tool](#)

3.1.7 Output Port Expansion

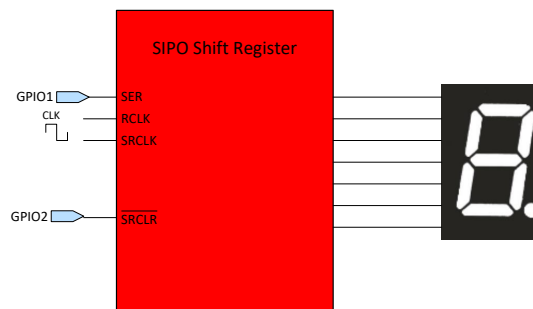


Figure 10. Using Logic to Increase Number of Usable Output Ports of Microcontroller

- Different configurations of shift registers reduces IO pin requirements
- Serial-In Parallel-Out Shift registers increase the number of outputs driven by the microcontroller
- Lower cost system realization by reducing the size of microcontroller required
- See more about this use case in *The Logic Minute* video [Increase the number of outputs on a microcontroller](#)
- Find the right Shift Register through the [online parametric search tool](#)

3.2 Voltage Translation Use Cases

3.2.1 SPI Communication

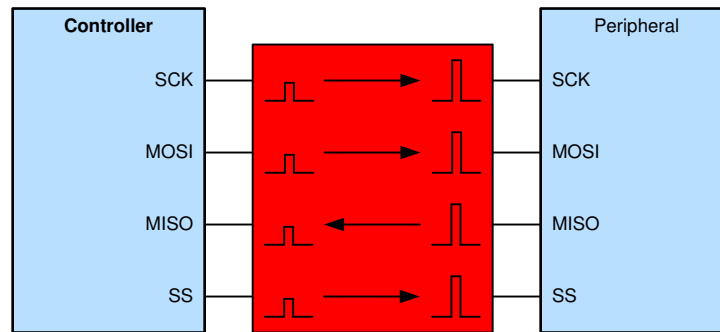


Figure 11. Using Voltage Translation With an SPI-Communication Bus

- Conform to requirements of communication interfaces for control unit
- Enable communication when devices have mismatched logic voltage levels
- Prevent damage to devices that cannot support higher voltage inputs
- Improve data rates over discrete translation solutions
- Find the right voltage level translator through the [online parametric search tool](#)

3.2.2 GPIO Communication

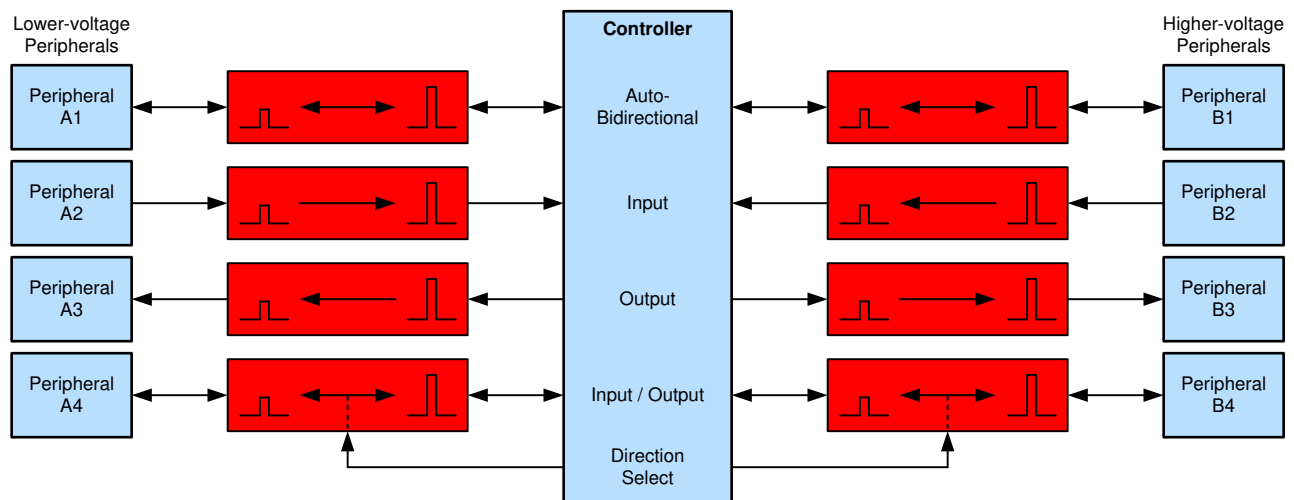


Figure 12. Using Voltage Translation With GPIO Communications

- Sensors can operate at different voltage levels from microcontroller GPIO pins
- Enable communication when devices have mismatched logic voltage levels
- Prevent damage to devices that cannot support higher voltage inputs
- Improve data rates over discrete translation solutions
- Provides protection from disconnected peripherals
- Find the right voltage level translator through the [online parametric search tool](#)

3.2.3 I²C Communication

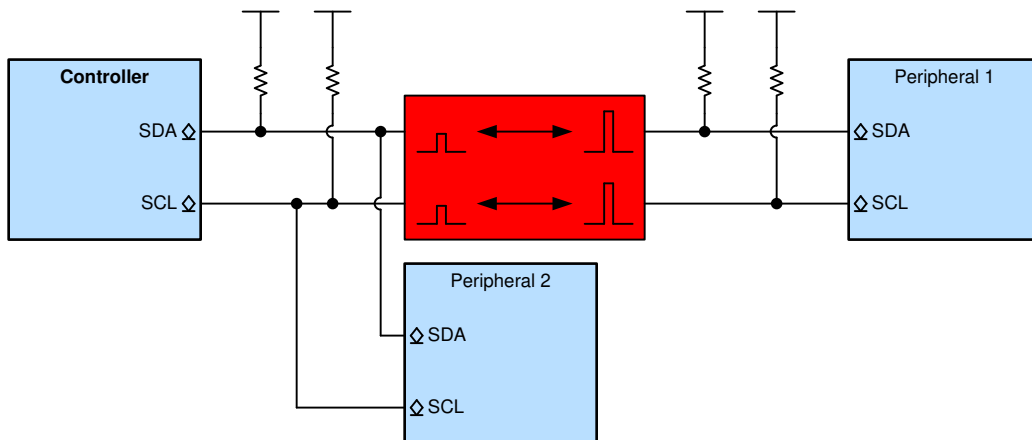


Figure 13. Using Voltage Translation With an I²C Communication Bus

- Conform to requirements of communication interfaces for control unit
- Enable communication when devices have mismatched logic voltage levels
- Prevent damage to devices that cannot support higher voltage inputs
- Improve data rates over discrete translation solutions
- Find the right voltage level translator through the [online parametric search tool](#)

3.2.4 I²S Communication

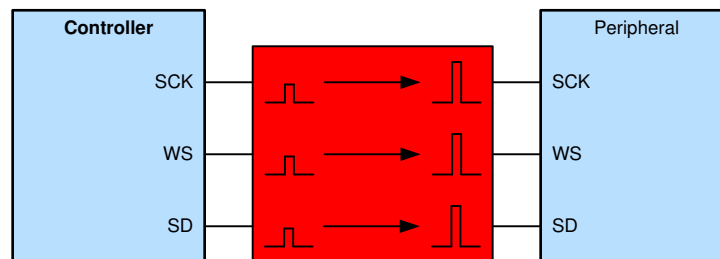


Figure 14. Using Voltage Translation With an I²S Communication Bus

- Conform to requirements of communication interfaces for control unit
- Enable communication when devices have mismatched logic voltage levels
- Prevent damage to devices that cannot support higher voltage inputs
- Improve data rates over discrete translation solutions
- Protect controller while peripheral is not connected
- Find the right voltage level translator through the [online parametric search tool](#)

4 Recommended Logic and Translation Families for Traction Inverter Motor Control

4.1 HCS: Schmitt-Trigger Integrated High-Speed CMOS

Key Features:

- Schmitt trigger inputs
- Low power consumption: Maximum $I_{CC} = 2 \mu\text{A}$
- Low propagation delay: Typical $T_{PD} = 7 \text{ ns}$ at 6 V @ $C_L = 50 \text{ pF}$
- $\pm 7.8\text{-mA}$ output drive at 5 V
- Low input current: Maximum Input Leakage Current = $1 \mu\text{A}$
- Wide voltage operating range of 2 V to 6 V
- Packaging Options:
 - SOIC
 - TSSOP
- 4-kV HBM, 1.5-kV CDM

Find the right HC family voltage level translation devices through the [online parametric search tool](#).

4.2 HC: High-speed CMOS Logic

Key Features:

- Huge portfolio of logic functions
- 4+ channels per package
- Inputs and output include positive and negative clamp diodes
- Wide voltage operating range of 2 V to 6 V
- Up to 140-Mbps operation
- Packaging Options:
 - PDIP
 - SO
 - SOIC
 - SSOP
 - TSSOP

Find the right HC family voltage level translation devices through the [online parametric search tool](#).

4.3 LVC: Low-Voltage CMOS Logic and Translation

Key Features: SN74LVCxxxx

- Huge portfolio of logic functions
- LVC: 4+ channels per package
- Overvoltage tolerant inputs allow unidirectional down-translation with any function
- High-drive outputs (up to 32 mA)
- Up to 250-Mbps operation
- I_{off} supports partial-power-down mode operation
- Packaging Options:
 - SOIC
 - TSSOP
 - VQFN
 - SOP
 - SSOP

Key Features: SN74LVCxGxxxx

- Put one, two, or three channels of any logic function right where they are needed
- Configurable gates available: ('57, '58, '97, '98, '99 functions)
- Overvoltage tolerant inputs allow unidirectional down-translation with any gate or buffer
- High-drive outputs (up to 32 mA)
- Up to 250-Mbps operation
- I_{off} supports partial-power-down mode operation
- Packaging Options:
 - SOT-23
 - SC70
 - X2SON
 - SOT-5X3
 - SON
 - DSBGA

Key Features: SN74LVCxTxxxx

- LVCxT: Up and down translation across 1.65 V to 5.5 V
- 1, 2, 8, or 16 channels per device
- High-drive outputs (up to 32 mA)
- Up to 250-Mbps operation
- I_{off} supports partial-power-down mode operation

Find the right LVC family logic and voltage level translation devices through the [online parametric search tool](#).

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