P-Channel PowerPath Controllers & Ideal Diodes Frequently Asked Questions

The following is a compilation of common general customer questions about the LTC441x family of P-channel PowerPath controllers and Ideal Diodes and how to use or better understand them. The Ideal Diode control scheme is also commonly present in many of our standard and all of our Smart battery chargers, making this information very useful for comprehensive understanding of these products at a system level.

Q: Why use P-channel MOSFETs?

A: P-channel control requires far less driver current overhead when driving a FET. Fundamental semiconductor physics states that an NMOS requires the gate to be driven *above* the source voltage (Vgsth>0V), universally requiring a charge pump for high-side switching applications. Whereas, a PMOS needs to have its gate voltage pulled down sufficiently *below* its source voltage (i.e. Vgsth<0V) to turn it “on”. This only requires a current sink from the gate, saving significant quiescent current. This is inherently beneficial for coaxing maximum runtime from a battery-powered design, but can also be helpful with systems striving for lowest possible standby current for “green” power applications. Turning a path off simply requires the gate to be shorted to the source or the highest available voltage source.

Q: What are the tradeoffs for using P- vs. N-channel products?

A: The above explanation of gate drive current is in favor of the P-channel family. N-channel parts (currently) tend to be capable of stronger drive, higher (automotive, telecom, etc.) voltages, and greater MOSFET options. Sometimes the quiescent current is the only motivation to choose a P-channel part, but if other factors are a concern, please contact your local Field Sales representative.

Q: How does the PowerPath/Ideal Diode enable/disable a path?

A: The enable logic signals must first be set to the proper levels for the respective paths. Once power has been supplied, the IC senses the initial drain-to-source body diode drop of the FET. When the comparator detects a sufficient drop, the logic enables the gate driver to drive the gate voltage until the DC forward regulation point is reached, on the order of 20mV or less depending on the product. Conversely, when a path must be switched off, the enable signal can be changed or the IC can automatically disable a path once the reverse threshold (often given as a negative voltage) has been detected by the comparator. Often it is recommended that a local bypass is placed physically very close the IC’s two comparator inputs to prevent noisy sources from generating false switching behavior.

Q: Can I use my PowerPath controller at a higher input source range?

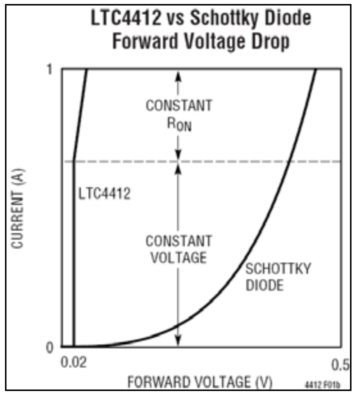
A: Yes. Please refer to AN107: Extending the Input Voltage Range of PowerPath Circuits for Automotive and Industrial Applications.

Q: If I rapidly turn on/off a path or physically unplug my input supply, I see a large transient that sometimes electrically over-stresses the PowerPath/Ideal Diode part or other portions of my circuit. How can I prevent this?

A: What is happening is a problem outside the confines of the part’s ability to control the FET. This issue is due to a path suddenly going high-impedance along with the use of low-ESR bypass caps in the circuit. The solution is discussed in AN88 - Ceramic Input Capacitors Can Cause Overvoltage Transients.

Q: What is the difference between a traditional diode and an Ideal Diode, in other words, why bother using something more complicated?

A: The fundamental problems with a traditional diode are a lack of control and the forward voltage drop. The need for prioritization and smarter switching of paths is inherently answered by the Ideal Diode or PowerPath control scheme. The forward drop is significantly reduced by the control regulation capability and the proper choice of FET on resistance. The forward drop comparison between a traditional diode and a PowerPath controller controlling an external FET is shown below:



Q: Isn't the FET oriented the wrong way in the reference circuit?

A: No. The objective of a PowerPath controller or Ideal Application used in a diode-OR manner is that a FET so oriented will block the primary source or load from back-powering the auxiliary source or vice-versa. Take for example the figure below, a typical use of LTC4414.

From an intuitive standpoint, upon loss of the wall adapter input, the battery needs to take over supplying the load. If the input source collapses to 0V, without a means of blocking the path with a diode or Ideal Diode element, the battery will be shorted or back-power the input to the charger or other up-stream converters. All of our switching battery chargers include this feature, often called the INFET, the input Ideal Diode gate control, to prevent this unwanted behavior.

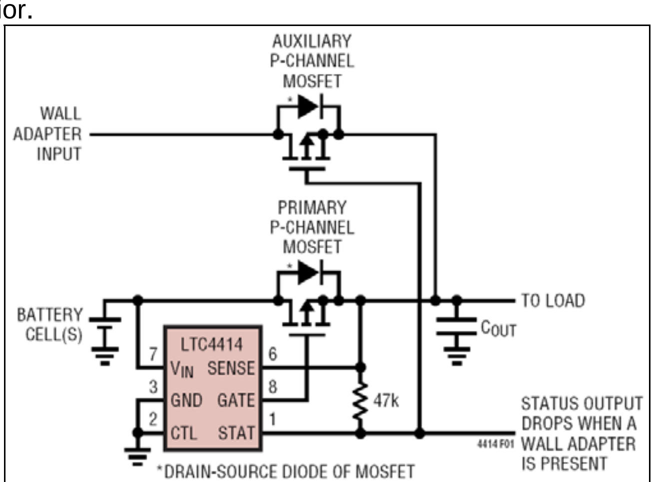
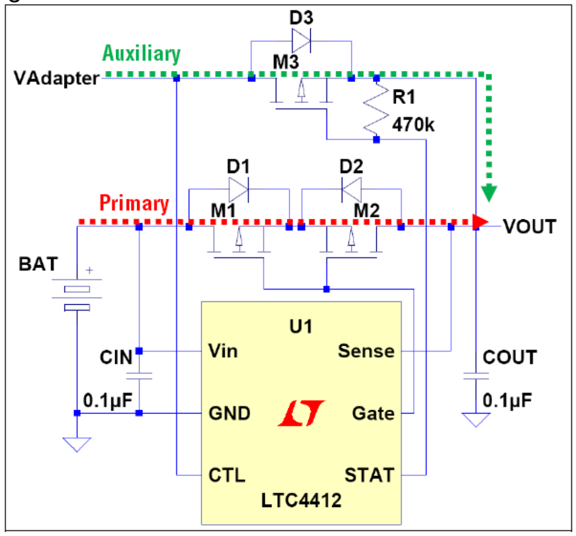


Figure 1. Automatic Switchover of Load Between a Battery and a Wall Adapter with Auxiliary P-Channel MOSFET for Lowest Loss

Q: Can I use a lower voltage “primary” input source and a higher voltage auxiliary?

A: Yes. This requires logic control of the PowerPath enable signal and at least one path with back-to-back FETs as shown below. Please contact the factory or your local Field Sales representative to receive a soft copy of “Automatic Battery-Override Using LTC441x PowerPath™ Controllers” for further details.



Q: How can I charge more than one battery with a single standard battery charger?

A: See circuit example below. For charging multiple Smart Batteries, LTC carries two products, LTC1960 & LT1760 which serve this purpose. Please contact the factory or your local Field Sales representative to receive a soft copy of “LTC4411/12/13/14/16 Parallel Battery Application Circuits”. This solution is applicable to LTC4415 as well, though not shown in the article.