

# Non-Isolated DC/DC Solutions for Alder Lake in Notebook Computing Applications



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## ABSTRACT

Notebook, desktop, and industrial computers serve to improve business continuity, enhance consumer entertainment, and streamline industrial process control. Texas Instruments provides performance power-management solutions for these applications to improve performance and extend battery life. Advanced processors and platforms, such as the Intel® Alder Lake micro-architecture, need point-of-load (POL) solutions for memory, low-power CPU rails, and 3.3 V and 5 V rail requirements from an array of rechargeable batteries, or a 12 V input bus. This document intends to highlight DC/DC converters and describe their features addressing general Alder Lake power requirements. For specific information about Intel processors and their power requirements, log on to the Intel Resource and Design Center. Contact TI for information about multiphase controllers and power stages designed specifically for the Intel Mobile Voltage Positioning (IMVP) requirements.

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## 1 Suggested Point-of-Load Solutions

**Table 1-1** highlights the latest POL DC/DC converters with integrated MOSFETs and controllers suitable for Alder Lake applications. The suggested devices are selected to accommodate different input voltage and control mode requirements over a wide range of output current. The featured devices in the left column accommodate a maximum input voltage of 22 V or greater, and are designed to achieve fast load-transient response with an adaptive on-time control mode, high light and full-load efficiency, and low quiescent current.

Several devices include an integrated programmable voltage identification (VID) supporting the processor's adaptive voltage requirements. The alternate devices in the right column employ fixed-frequency current-mode control with frequency synchronization useful in noise-sensitive industrial applications, and operate up to a 17 V input. If VID is required with alternative devices, consider the LM10011 VID voltage programmer in addition to the converter's resistor divider network.

**Table 1-1. Suggested DC/DC Controllers and Converters for Alder Lake**

| Featured P/N <sup>(1)</sup>             | Rail                  | Current Capability            | Type                        | Note                                 | Alternate P/N <sup>(2)</sup>                     |
|-----------------------------------------|-----------------------|-------------------------------|-----------------------------|--------------------------------------|--------------------------------------------------|
| <a href="#">TPS51285A</a>               | V5A                   | ≤20A + 100mA LDO<br>each rail | Dual Controller & 2<br>LDOs | System Power                         | <a href="#">TPS51220A</a>                        |
|                                         | V3P3                  |                               |                             |                                      |                                                  |
| <a href="#">TPS51395</a>                | V5A                   | ≤8A + 100mA LDO               | Converter & LDO             | System Power                         | <a href="#">TPS54A24</a>                         |
| <a href="#">TPS51393</a>                | V3P3                  |                               |                             |                                      |                                                  |
| <a href="#">TPS51215A</a>               | V <sub>CCIN_AUX</sub> | ≤32A                          | Controller                  | I/O power, 2-bit VID (0V<br>support) | -                                                |
| <a href="#">TPS566335</a>               | V1P8A                 | ≤6A                           | Converter                   |                                      | <a href="#">TPS543620</a>                        |
| <a href="#">TPS51372</a>                | Optional<br>Bypass    | ≤6.5A                         | Converter                   | 2-bit VID                            | -                                                |
| <b>General Purpose DC/DC Converters</b> |                       |                               |                             |                                      |                                                  |
| <a href="#">TPS51367</a>                | Various               | 12A                           | Converter                   | General                              | <a href="#">TPS54A24</a>                         |
| <a href="#">TPS51397A</a>               | Various               | 10A                           | Converter                   | General                              | <a href="#">TPS54A24</a>                         |
| <a href="#">TPS51396A</a>               | Various               | 8A                            | Converter                   | General                              | <a href="#">TPS543820</a>                        |
| <a href="#">TPS566335</a>               | Various               | 6A                            | Converter                   | General                              | <a href="#">TPS543620</a>                        |
| <a href="#">TPS56339</a>                | Various               | 3A                            | Converter                   | General                              | <a href="#">TPS543320</a>                        |
| <b>DDR Memory Power Solutions</b>       |                       |                               |                             |                                      |                                                  |
| <a href="#">TPS51486A</a>               | V <sub>DDQ</sub>      | ≤8A                           | Multi-Channel<br>Converter  | DDR4 Memory                          | <a href="#">TPS65295</a>                         |
|                                         | V <sub>PP</sub>       | ≤1A                           |                             |                                      |                                                  |
|                                         | V <sub>TT</sub>       | ±1A                           |                             |                                      |                                                  |
|                                         | V <sub>TT_REF</sub>   | 10mA                          |                             |                                      |                                                  |
| <a href="#">TPS51487XA</a>              | V <sub>DD1</sub>      | ≤8A                           | Multi-Channel<br>Converter  | LPDDR4/X Memory                      | <a href="#">TPS65296</a>                         |
|                                         | V <sub>DD2</sub>      | ≤1A                           |                             |                                      |                                                  |
|                                         | V <sub>DDQ_TX</sub>   | ≤1.5A                         |                             |                                      |                                                  |
| <a href="#">TPS51397A</a>               | V <sub>DD2H/L</sub>   | ≤10A                          | Converter                   | LPDDR5 Memory                        | Consider general device<br>for more/less current |
| <a href="#">TLV62084A</a>               | V <sub>DD1</sub>      | ≤2A                           | Converter                   |                                      | <a href="#">TPS543320</a>                        |
| <a href="#">TLV62084A</a>               | V <sub>DDQ</sub>      | ≤2A                           | Converter                   |                                      | <a href="#">TPS543320</a>                        |

- Some featured 24-V devices require Mysecure access to download the data sheet. Click the device link to request access. Users will require their my.ti.com account information.
- Alternate converters operate up to 17 V input with a fixed-frequency control mode

## 2 Light Load Efficiency (Eco-Mode™) and Low Quiescent Current (ULQ™)

The POL regulators generating low voltages from an array of batteries must employ an energy-saving pulse-skipping technique now referred to as Eco-Mode. The inductor current in a synchronous-buck converter is a triangle wave. As the output current decreases from a heavy-load condition, the inductor current is reduced and the rippled valley of the triangle wave eventually touches the zero level at the boundary between continuous conduction-mode (CCM) and discontinuous conduction mode (DCM).

With Eco-Mode, the rectifying MOSFET is turned off when the converter detects zero current in the inductor. As the load current further decreases, the on-time is held nearly constant so that the off-time is extended, and the switching frequency is reduced to maintain regulation. As a result, the power MOSFETs and inductor are idle for longer time periods and conduction losses are greatly reduced. DC/DC converters and controllers with low quiescent current will have improved light-load efficiency performance and extended battery run-time, since less power is dissipated within the IC. The TPS51825A features Ultra Low Quiescent current (ULQ) of 25- $\mu$ A for longer battery life in system stand-by mode.

Figure 2-1 shows 90% efficiency with 7.4-V input and 5-V output at 1-mA, illustrating the combined affects of Eco-Mode and ULQ.

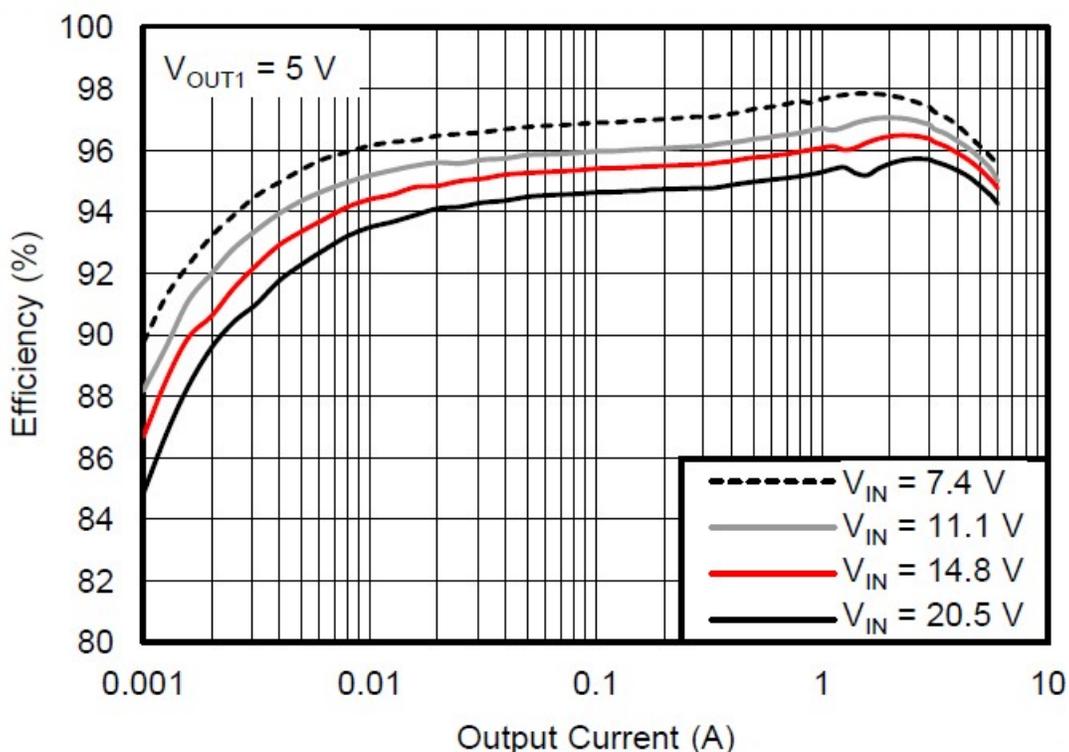


Figure 2-1. TPS51825A Efficiency Plot

### 3 Voltage Identification (VID) Capability with TPS51215A

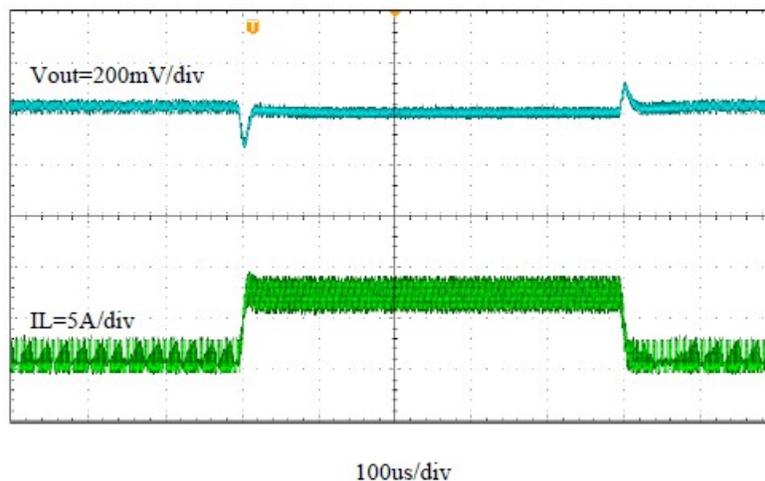
The TPS51215A supports a 2-bit VID and Low Power Mode(LPM) to dynamically change the output voltage to satisfy Intel IMVP8/9 applications for VCCIN\_AUX, VCCIO\_0, and VCCIO\_1\_2 rails. A fixed 0V output voltage and up to three voltage levels can be programmed externally with a voltage divider circuit. The device can also be configured to provide a 1-bit VID output voltage. Please see the [TPS51215A Single Phase, D-CAP2™ Controller with 2-Bit VID Control and Low Power Mode](#) data sheet for more information.

### 4 Fast Load Transient Response with D-CAP3™ and D-CAP2™ Control

Since the load profile can change dramatically in Notebook and Desktop PC applications, it is important to consider AC transient performance. Choosing a DC/DC converter with a fast transient response using non-linear control techniques, such as constant on-time or D-CAP3™, allows a fast transient response with minimal output capacitance. A converter using D-CAP3 control mode has three primary considerations for deciding the value of the output capacitance: transient (which includes load step and slew rate of the load step) output ripple, and stability.

In applications where the load transient is stringent, the output capacitance is predominantly driven by the transient requirement. For a D-CAP3 based design, there is a minimum capacitance requirement in terms of small signal stability. This requirement prevents subharmonic, multiple-pulsing behavior in the modulator.

Figure 4-1 shows the transient performance of the 8-A TPS51395 with a 5-V output, less than 100mV overshoot, and less than a 30µs recovery with output capacitance of 0.1 µF and 4x22 µF. The 0.8-A to 7.2-A load step has a slew rate of 2.5-A/µs.



**Figure 4-1. TPS51395 Transient Waveform**

The TPS51215A supplying VCCIN\_AUX features adaptive on-time D-CAP2™ control allowing ceramic output capacitors and achieves a fast load transient response shown in Figure 4-2 under the noted conditions below the waveform. The over-voltage and under-voltage test results also meet the target design specification, and the results are shown in Table 4-1 under the same conditions as the TPS51215A load transient waveform. The TPS51215A waveform conditions are  $V_{IN}=12.6V$ , slew rate=12A/µs,  $F_{SW}=600k\Omega$ ,  $L=0.22\mu H$ , and  $C_{OUT}=220\mu F + 22*12\mu F$ .

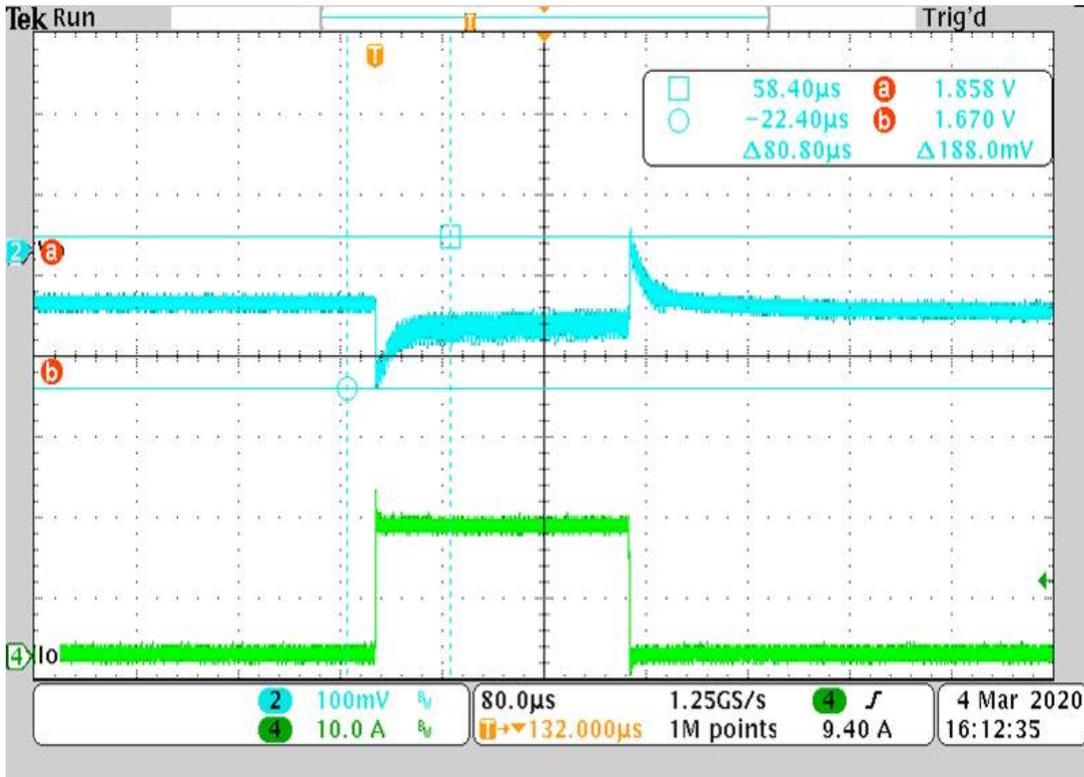


Figure 4-2. TPS51215A Load Transient Waveform

Table 4-1. TPS51215A Load Transient Test Results

| Voltage Rail | Type       | Load Transient | Validation Result (V) | Target (V) |
|--------------|------------|----------------|-----------------------|------------|
| 0.8 V        | Undershoot | 0 A to 16 A    | 1.67                  | 1.62       |
|              | Overshoot  | 16 A to 0 A    | 1.858                 | 1.89       |
| 1.8 V        | Undershoot | 17 A to 29 A   | 1.678                 | 1.62       |
|              | Overshoot  | 29 A to 17 A   | 1.882                 | 1.89       |

## 5 Small IC Packaging

Integrated circuit packaging technology must keep pace with semiconductor wafer fabrication as process technology advances. TI released flip-chip on leadframe packaging that reduce package footprint, power loss, and parasitic effects. Traditional bond wires are replaced with copper posts attached directly to the leadframe which shortens current path from the IC to the lead frame, which allows a larger die in the small package cavity, reduced package resistance, and reduced parasitic package inductance loops. Consider the 6-A TPS566335, housed in a small 2x3mm QFN package.

Figure 5-1 shows ample pins for power conversion and I/O features while maintaining a 0.5mm pin pitch, allowing simplified circuit board manufacturing.

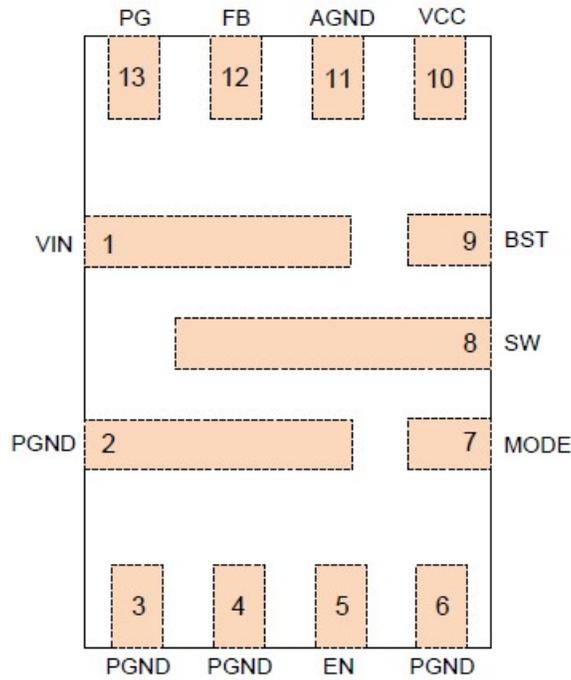


Figure 5-1. TPS566335 in 2x3mm QFN Package

## 6 Conclusion

Performance processors, such as the Alder Lake platform in Notebook and Industrial PCs, need DC/DC converters that offer fast transient response, small packaging, low quiescent current, and high light and full-load efficiency. TI offers high performance point-of-load solutions to address these requirements while lowering the total system cost.

## 7 Resources

- Texas Instruments, [LM10011 VID Programmer](#) data sheet.
- Texas Instruments, [Accuracy-Enhanced Ramp-Generation Design for D-CAP3 Modulation](#) application report.
- Texas Instruments, [Power tips: Iq \(quiescent current\) and Light Load Efficiency](#) training video.
- Texas Instruments, [HotRod QFN Package PCB Attachment](#) application note.

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