Technical Article

Output Accuracy Varies with Temperature – 1% Is Not Always 1%

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The Industrial Internet of Things (IIoT) and Industry 4.0 are creating a stronger push toward smaller computing systems with increased performance. This is being driven by semiconductor process geometries declining to 10nm or below, making power supply for applications such as industrial PCs more challenging than ever before. This is shown in Figure 1's examples of supply requirements for selected field-programmable gate arrays (FPGAs) that have incredibly low core voltages and tight tolerances. With these additional challenges, it becomes increasingly important for engineers like you to pay attention to the details: not all 1% accuracy specifications are equal.

FPGA model	Core voltage range (tolerance), V	Auxiliary voltage range (tolerance), V	I/O voltage range (tolerance), V
Spartan-7	1.0 (50 mv)	1.8 (5%)	1.2 to 3.3 (5%)
Spartan-7 (-1LI)	0.95 (30 mv)	1.8 (5%)	1.2 to 3.3 (5%)
Artix-7	1.0 (50 mv)	1.8 (5%)	1.2 to 3.3 (5%)
Artix-7 (-2LE)	0.9 (30 mv)	1.8 (5%)	1.2 to 3.3 (5%)
Kintex-7 (-2LI)	0.95 (20 mv)	1.8 (5%)	1.2 to 3.3 (5%)
Arria II-GX	0.9 (30 mv)	2.5 (VCCA_PLL) 0.9 (VCCD_PLL)	1.2 to 3.3 (5%)
Stratix IV-GX	0.9 (30 mv)	2.5 (VCCA_PLL) 0.9 (VCCD_PLL)	1.2 to 3.0 (5%)
Cyclone IV	1.2 (50 mv)/ 1.0 (30 mv)	2.5 (VCCA_PLL) 1.2/1.0 (VCCD_PLL)	1.2 to 3.3 (5%)

Figure 1. Supply Voltage Requirements for Selected FPGAs

Additional Considerations That Factor into Output Accuracy.

Processors, FPGAs or system on chips (SoC)/application-specific integrated circuits (ASICs) using ultra-small process geometries offer high functional integration and extreme performance levels, but they also require high accuracy on their power-supply rails. Designing for 1.0V core voltages and below requires careful calculations of all DC specifications, as well as AC transients of corner spreads and process variations, to avoid false resets, unreliable operation or malfunction in single-board computer or industrial PCs.

Using 0.1% resistors to set the output voltage and adding multiple output capacitors can help fulfill the typical ±5% supply accuracy requirement even at low voltages, but these resistors add cost and take up board space. Choosing a power supply with a 1% feedback voltage accuracy specification gives you more flexibility and potential cost reductions when selecting the output-voltage-setting resistor divider and output capacitors.

Figure 2 shows an example of the tolerance stack-up with a 1% reference voltage and 1% resistor accuracy, summing up to ±1.8% DC variations.

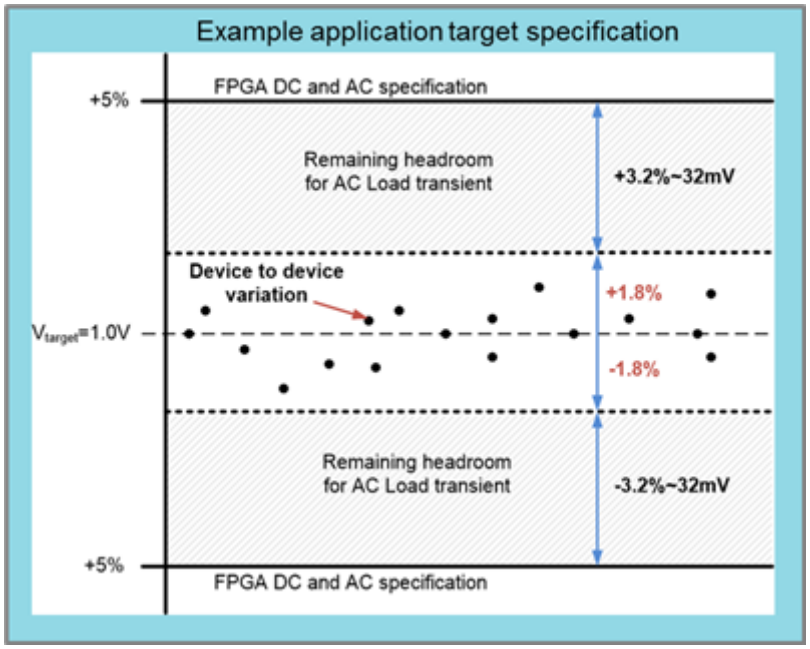

Figure 2. Target Specification with 5% Variation at a 1.0V Core Supply

Don't Forget about Temperature Variation!

But always remember to look at the details, not all 1% accuracy specifications are comparable. Temperature variations and dependency on input voltages are common variables whose influences are sometimes not included in the 1% value. Some semiconductor suppliers show 1% accuracy on the first page of the data sheet. But this critical electrical parameter is often defined only at one given temperature and one input voltage point (for example, a 25°C room temperature and 3.6V input voltage).

Enter our new low-power families of DC/DC buck converters for 12V supply rains (TPS62147/TPS62148/TPS62135/TPS62136) and 5V supply rails (TPS62821/TPS62822/TPS62823/TPS62825/TPS62826/TPS62827). These parts can help solve the challenges that come with a 1% feedback voltage accuracy (or an output-voltage accuracy for fixed output-voltage options) **specified over the full junction temperature range from -40°C to +125°C** and over the full input voltage range of 3V to 17V or 2.4V to 5.5V. These DC/DC converters are also specified at high output accuracy and offer small solution size; for example: 1.5x1.5mm QFN for 2A, 3A or 4A (5V supply), or 2x3mm QFN for 2A or 4A (up to 17V supply).

Conclusion

It is becoming increasingly difficult to adhere to tight output tolerances driven by smaller and smaller process geometries employed in Industry 4.0 applications. Multiple factors need to be taken into considerations when determining your true output accuracy; it doesn't help that accuracy specifications over temperature aren't true to the value on the front page of the datasheet. This blog aims to shed light on understanding your true output accuracy and introduces a new family of DC/DC buck converters that will give you 1% accuracy, no matter how rugged your industrial application.

For more information, visit our new Power Management for FPGAs and Processors web page.

Additional Resources

- Watch the video, “How to meet an FPGA’s DC voltage accuracy and AC load transient specification?”
- Check out the webinar, “How to Reduce the Total Size of FPGA Solutions.”
- Download the Small Efficient Flexible Power Supply Reference Design for NXP iMX7 Series Application Processors.
- Read the blog post, “Oh yes! My FPGA application is safe.”

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