

How to Tighten PMBus Output Current Measurement Accuracy



George Lakkas

Enterprise servers and switches, storage attach networks and base stations are increasingly using power supplies with PMBus to easily configure, control and monitor critical voltage rails such as high-current ASICs, DSPs, FPGAs and DDR memory core without software programming.

Monitoring output voltage, current and temperature is useful for board characterization and real-time, remote monitoring of high-power data centers. DC/DC converters such as TI's 20A [TPS544B20](#) and 30A [TPS544C20](#) provide this capability. These devices are able to sense the average output current using an internal MOSFET sensor. The sensor carries a scaled-down version of the current through the main power MOSFET to enable current monitoring and better overcurrent threshold accuracy compared to inductor DCR current sensing. As well, there is minimal temperature variation and dependence on the inductor power loss thus enabling the end user to select a lower DCR inductor to improve efficiency even further, while reducing cost and size.

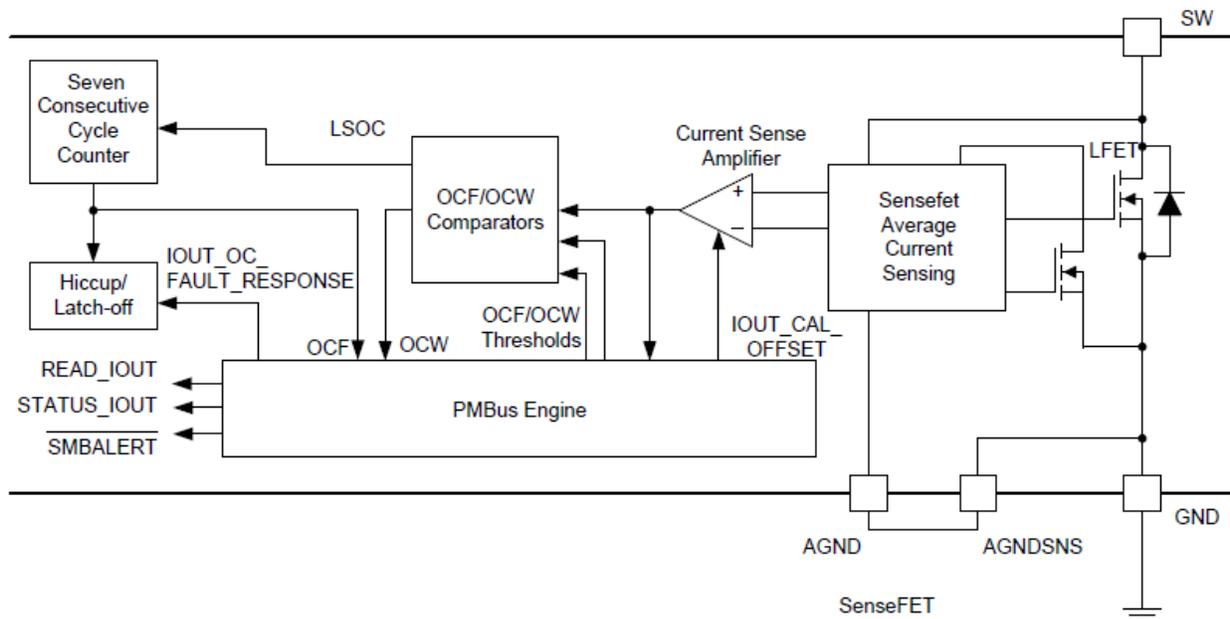


Figure 1. TPS544B20 and TPS544C20 MOSFET Current Sensing

When the power supply is assembled on the board, there can be layout-related systemic errors that introduce additional variation in the output current sense and measurement accuracy. Fortunately, the [TPS544B20](#) and [TPS544C20](#) include a PMBus command "IOUT_CAL_OFFSET" that can be used to improve current sensing and measurement accuracy post assembly.

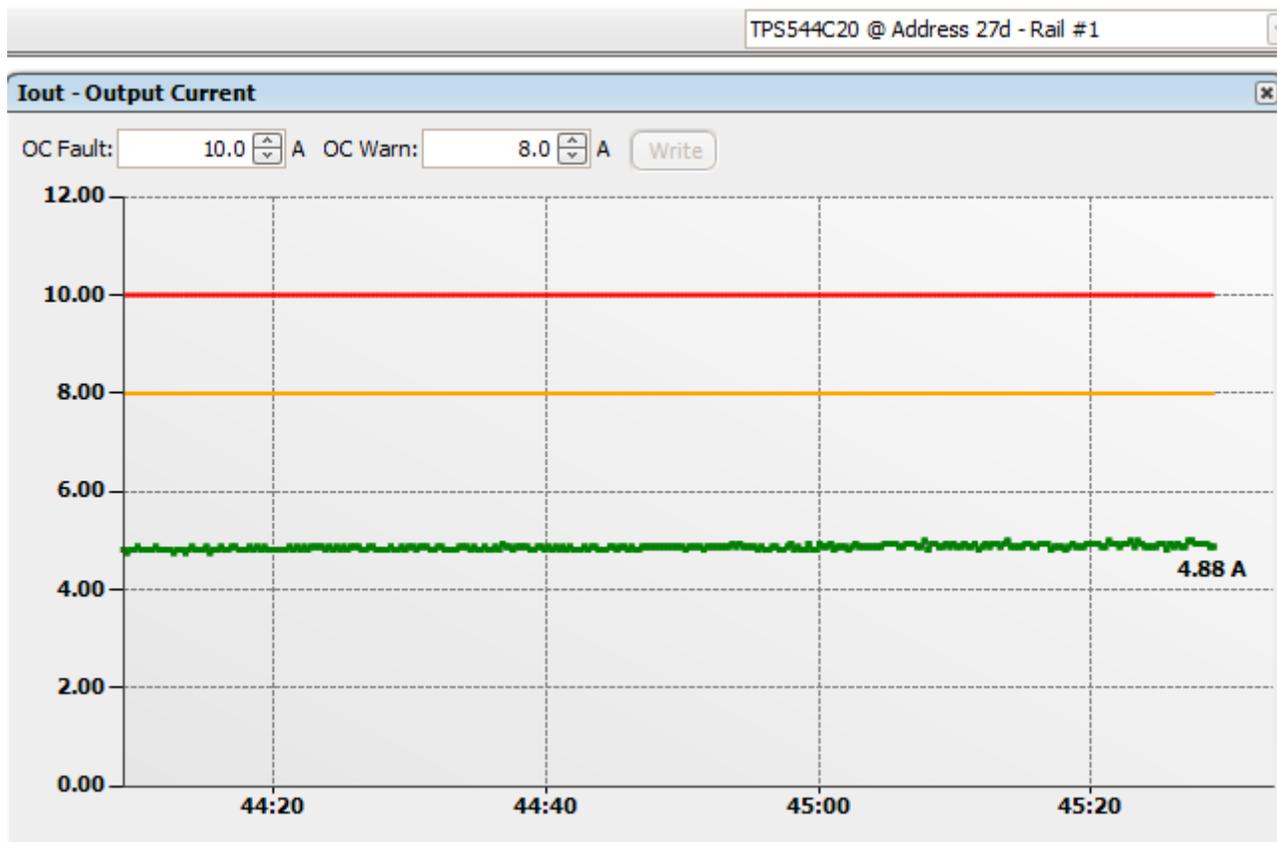


Figure 2. TPS544B20 and TPS544C20 Output Current Monitoring via TI Fusion Digital Power™ Gui

The current sense error has two components: Gain and Offset. Gain is a multiplicative factor (i.e. $IOUT \times 0.98 = \text{gain}$ is 2% low). Offset is an additive factor (i.e. $READ_IOUT = IOUT + 1A$). As the name implies, `IOUT_CAL_OFFSET` adjusts the offset. In reality, the device has both gain and offset error. Using the `IOUT_CAL_OFFSET` command allows the end user to “center” the output current reading at a certain point, which mitigates the cumulative effect of a gain error. The best place to calibrate is in the center of the design’s operating range. The `IOUT_CAL_OFFSET` command is used to compensate for offset errors in the `READ_IOUT` results and the `IOUT_OC_FAULT_LIMIT` and `IOUT_OC_WARN_LIMIT` thresholds. The default setting is 0A (amperes). The resolution of this command is 62.5mA (milliamperes) and the range is +3937.5mA to -4000mA. The contents of this register can be stored to the [TPS544B20](#) or [TPS544C20](#) non-volatile memory using The `STORE_USER_ALL` command.

Command	Code	Value/Edit	Hex/Edit
▼ Calibration			
<code>IOUT_CAL_OFFSET</code>	0x39	0.2000 A	0xE003
<code>MFR_04 (VREF_TRIM)</code>	0xD4	0.039 V	0x0014

Figure 3. TPS544B20 and TPS544C20 `IOUT_CAL_OFFSET` PMBus Command in TI Fusion Digital Power GUI

To “calibrate” the current measurement in ICT using the `IOUT_CAL_OFFSET` command, force a known load current to the output of the [TPS544B20](#) or [TPS544C20](#) and use `IOUT_CAL_OFFSET` to adjust `READ_IOUT` until it matches the known load value. For example, the end user might force a 20A load current with a resistor

or DC load, read READ_OUT through the Fusion Digital Power GUI and get 22A. They could then apply IOUT_CAL_OFFSET = -2A to set the READ_IOUT to the actual IOUT of 20A.

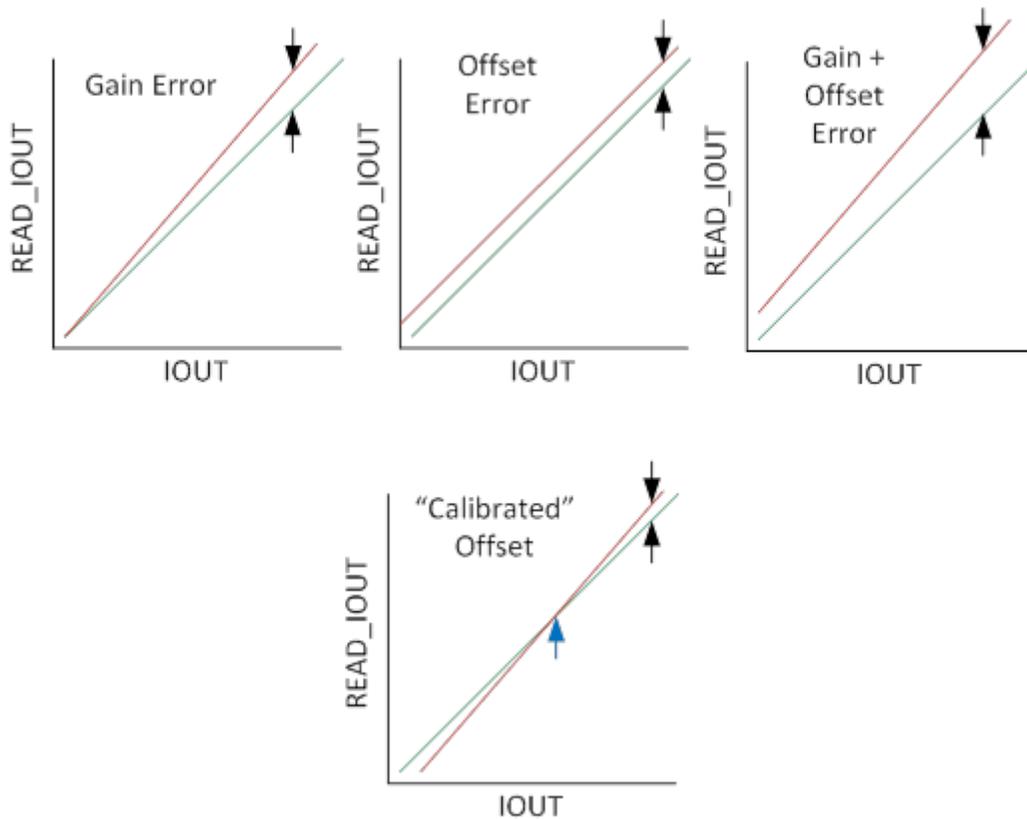


Figure 4. READ_IOUT Gain and Offset Errors before and after Calibrating the READ_IOUT Offset

With this PMBus command, the user can tighten the output current measurement accuracy through the [TPS544B20](#) or [TPS544C20](#) PMBus interface eliminating any post-assembly errors.

Download the TI Design, [High density 30W DC/DC buck converter with the inductor mounted over the converter to save space](#) to get started on your design.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated