Advantages of Digital Power and PMBus

Power-supply concepts have been well established for many years in the consumer segment, including laptop and desktop PCs, are now increasingly adopted in more industrial applications. The following article gives a detailed description of the advantages provided by digital power supplies, with a special emphasis on the possibilities offered by the PMBus interface. **Hans-Günter Kremser, Principal Field Application Engineer, Texas Instruments, Munich, Germany**

For many years, digital power supplies have been a hot topic in technical discussions held with customers. The most frequently asked questions are around the advantages provided by this technology and the customers that are already using it.

In spite of all skepticism, more and more customers decide to use a digital power supply for the following reasons:

- FPGA and processor suppliers demand a dynamic adjustment of the core supply voltage using adaptive voltage scaling (AVS) or dynamic voltage scaling (DVS). This enables dynamic performance increases or reductions depending on the individual processing load with the goal to achieve a lower power consumption.
- Remote monitoring of the power supply is required (for instance in cellular base stations).
- It is desirable to log the currents and voltages of the different output voltage paths (more information enables faster troubleshooting).
- Flexible sequencing when powering up and down the different output voltage paths during the prototyping phase.

Different concepts

For instance, semiconductor manufacturers promote their analog switching converters featuring a PMBus™ interface. However, it is debatable whether these converters can be called 'digital' because the communication interface is the only digital element. Solutions are available for isolated and non-isolated power supplies based on common topologies. The portfolio includes converters featuring the current-mode, voltage-mode, constant-on-time, or DCAP (Direct connection to the Output CAPacitor) control schemes.

In addition, a number of switching converters featuring a PMBus interface digitize the feedback signal, compute the compensation using a processor or a hardware block and adjust the PWM signal accordingly.

Advantages of this concept include the digital compensation and the reduced influence of temperature and aging effects. For instance, it is possible to dynamically adjust the compensation during operation, for instance if an inductive load is replaced by a capacitive load. Even the compensation mode can be varied by modifying specific coefficients (e. g. for the second-order IIR filter included in the UCD9244). For instance, users can select whether the output voltage should be regulated to its desired value faster after a load step or if a low-pass behavior should be preferred for safety reasons. It is important to note

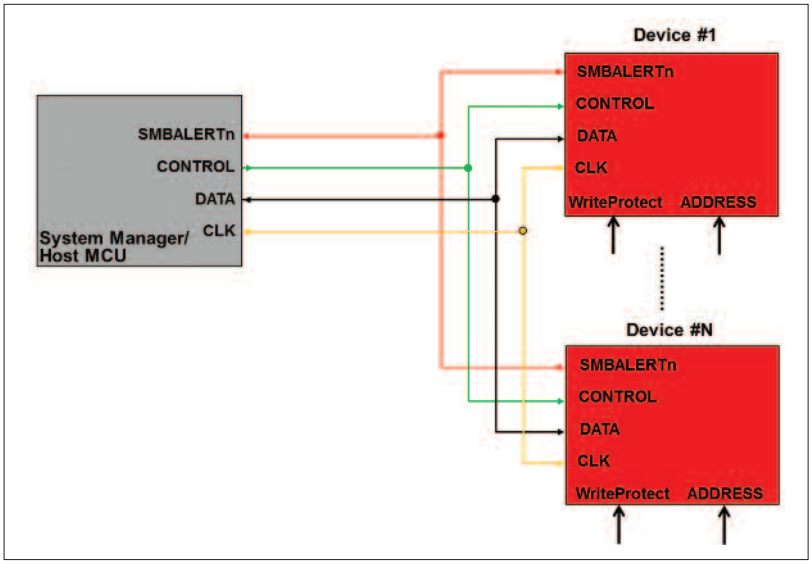

Figure 1: Block diagram of a PMBus-based power supply

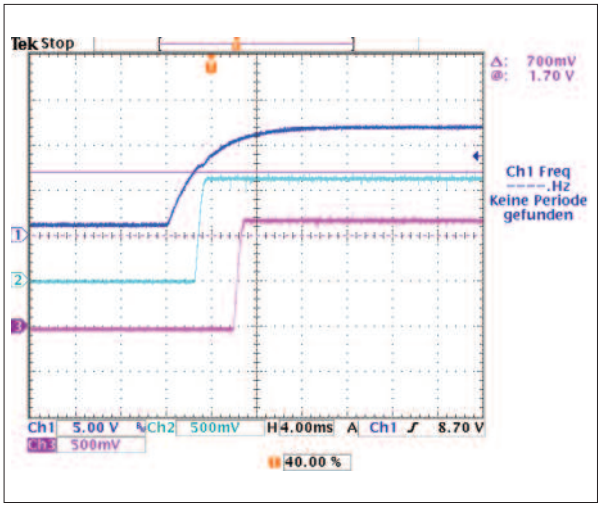

Figure 2: Core supply is powered up before the I/O supply

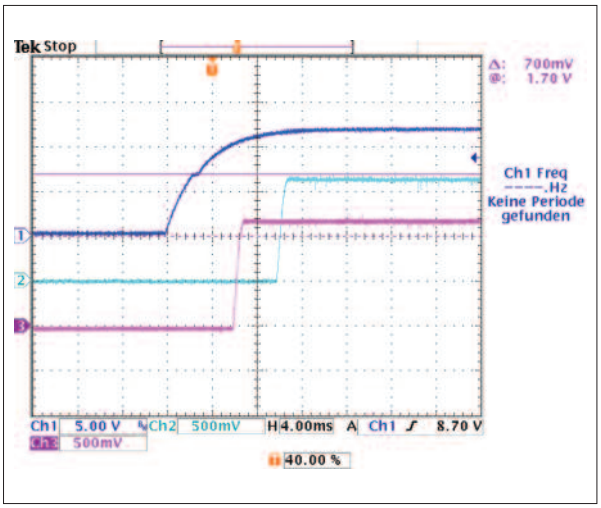

Figure 3: **Core supply is powered up after the I/O supply**

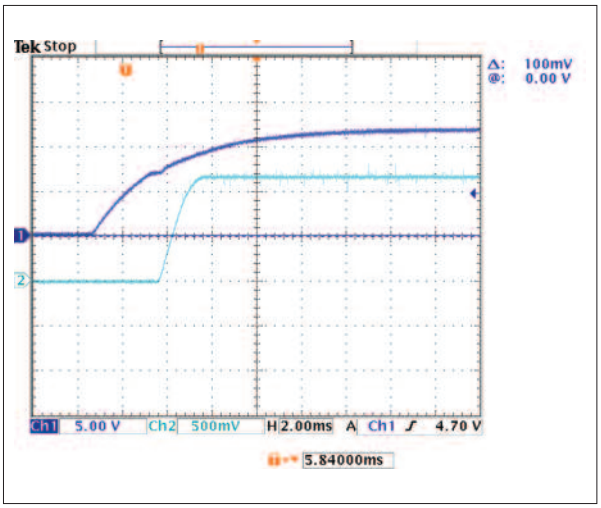

Figure 4: **Soft start in approximately 2 ms**

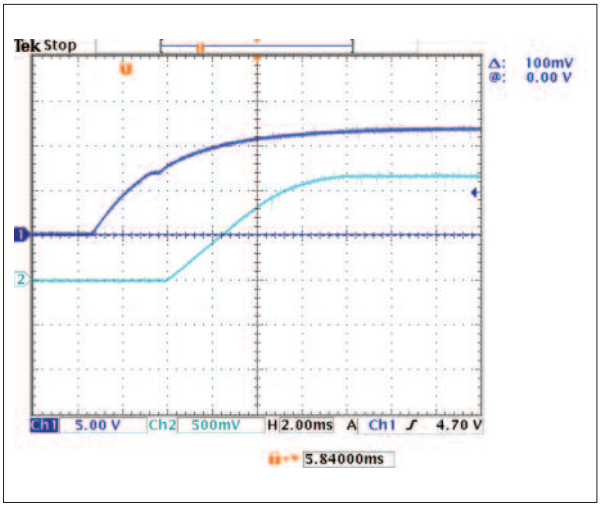

Figure 5: **Soft start in approximately 8 ms**

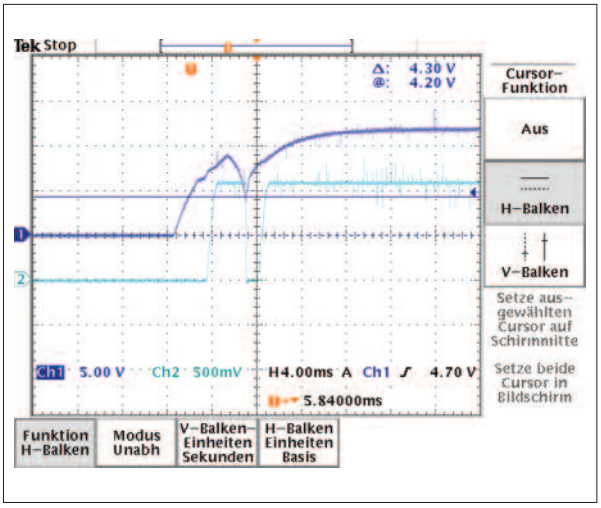

Figure 6: **Hiccup mode**

that no programming skills are required for this device. Instead, the required parameters can be easily specified via a graphical user interface. Of course, entirely processor-based power supplies are also available. Among others, TI provides libraries with the relevant functional blocks for its C2000 processors.

The PMBus

Based on the I²C interface protocol, the PMBus protocol is designed for the purpose of controlling and monitoring power supplies. Figure 1 illustrates the structure of a typical PMBus system. The PMBus interface consists of clock and data lines and the SMBALERT connection. The CONTROL lines enable additional functions including powering up and down the bus-connected switching converters. The physical address of each converter is permanently set via hardware. Using the WRITE_PROTECT command, the settings of the converter can be protected from inadvertent overwriting. Some manufacturers also provide an optional WriteProtect pin as an additional safety mechanism. All converters must be able to start up without communicating with the host MCU. As the entire set of PMBus commands is not supported by all converters, it is necessary to consult the manufacturer's data sheet.

Both concepts provide the advantages outlined above. For the two solutions shown below, two TPS53915 12A regulators were connected to a computer and configured via a graphical user interface called Fusion Digital Power Designer. Figures 2 and 3 show oscilloscope plots of different power-on sequences of the core and I/O supply (for instance for a microcontroller). As the power-on sequence can be easily modified via software, this is very helpful for circuit designs based on initial prototypes. As shown in Figures 4 and 5, it is also possible to adjust the slope of the power-up edges.

The ability to set warning and alert levels is another important feature. For instance, output voltages and currents can be monitored within pre-defined ranges. Furthermore, the switching frequency can also be set.

Figure 6 depicts the behavior of the output voltage in the event of a short circuit (input voltage drop). It is possible to select whether the voltage should remain switched off after an overload event or whether it should automatically be powered up again (hiccup mode).

Without the digital PMBus interface, all the features described above would require additional hardware, and some could not be implemented at all.

Customers do not have to pay any licensing fees when using PMBus ICs. The specifications and additional useful information can be downloaded for free at www.pmbus.org.