Is Digital Power the Right Choice?

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Experienced digital power users are normally well aware of the benefits of digital power system management. However, for those who are considering whether it makes sense for their products, its benefits may not be so obvious. Typical questions being asked are: Will our time-to-market be longer when incorporating digital power? How difficult is it to implement? How long is the learning curve? What is the additional cost? Will our customers value digital power? Will this technology open up new markets? Will we be left behind if we don't incorporate digital power into our product portfolio? The answers to these questions need to be understood to help determine if digital power is a good choice in the end application.

Why Digital Power?

Having digital control over analog power supplies with a simple PC connection is especially valuable during the development stage where designers need to get their systems up and running quickly. There can be as many as 30 point-of-load (POL) voltage rails and users need to be able to easily monitor and adjust supply voltages, sequence supplies up/down, set operating voltage limits, and read parameters like voltage, current and temperature as well as access detailed fault logging via a digital interface. High accuracy is extremely important in these systems to maintain tight control over the rails and achieve the maximum performance.

In data centers, a key challenge is to reduce overall power consumption by rescheduling the work flow and moving jobs to underutilized servers, thereby enabling shutdown of other servers. To meet these demands, it is essential to know the power consumption of the end-user equipment. A properly designed digital power management system can provide the user with power consumption data, allowing for smart energy management decisions to be made.

Knowing the condition and operating status of a voltage regulator is perhaps the last remaining "blind spot" in today's modern electronic systems, since they normally do not have the means for directly configuring or remotely monitoring key operating parameters. It can be critical for reliable operation that a regulators output voltage drift over time or an over temperature condition be detected and acted on before a potential failure event occurs. A well designed digital dower system can monitor the performance of a voltage regulator and report back on its health in so that corrective action can be taken prior to it going out of specification or even failure.

In order to protect expensive ASICs from the possibility of an over voltage condition, high-speed comparators must monitor the voltage levels of each rail and take immediate protective action if a rail goes out of its specified safe operating limits. In a digital power system, the host can be notified when a fault occurs via the PMBus alert line and dependant rails can be shut down to protect powered devices such as an ASIC. Achieving this level of protection requires excellent accuracy and very fast response times.

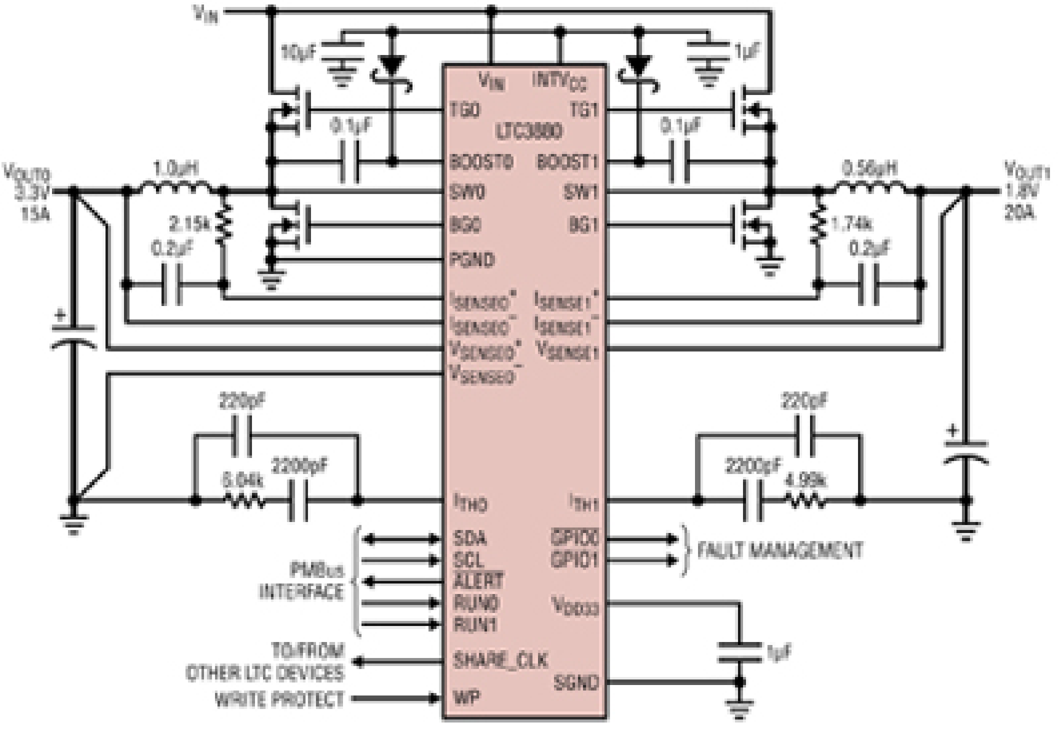

Figure 1. LTC3880 applications schematic.

Digital power management is being adopted because of its ability to provide accurate information about the power system and its ability to autonomously control and supervise dozens of voltages with ease. It can be very difficult to probe around and monitor 30 POL voltages on a complex system board. System designers don't have to write a single line of code unless they want their host processor to read telemetry and do simple fault intervention. It is clear that manufacturers need to provide cost-effective parts tailored and targeted at specific niches that can be easily implemented by new, as well as experienced users.

Digital Power Done Right

Recently released dual output high efficiency synchronous step-down DC/DC controllers are available with an I2C-based PMBus interface for digital power system management, and combine desirable analog switching regulator performance with precision mixed signal data conversion for ease of power system design and management. Software development support includes an easy-to-use graphical user interface (GUI).

Linear Technology's LTC3880 and LTC3880-1, for instance, allow for digital programming and read back for real-time control and monitoring of critical point-of-load converter functions. Programmable control parameters include output voltage, margining and current limits, input and output supervisory limits, power-up sequencing and tracking, switching frequency and identification and traceability data. On-chip precision data converters and EEPROM allow for the capture and nonvolatile storage of regulator configuration settings and telemetry variables, including input and output voltages and currents, duty cycle, temperature and fault logging.

The LTC3880/-1 has an analog control loop for best loop stability and fastest transient response without the quantization effects commonly found in slower digital control loops. This device can provide two independent outputs or be configured for a two phase single output. Up to six phases can be interleaved and paralleled for accurate sharing among multiple ICs, minimizing input and output filtering requirements for high current and/or multiple output applications. An integrated amplifier provides true differential remote output voltage sensing, enabling high accuracy regulation, independent of board IR voltage drops. Figure 1 shows a typical application using the LTC3880 to develop 1.8 V at 20 A and 3.3 V at 15 A from a 12-V bus voltage.

Configurations are easily saved to internal EEPROM over the device’s I2C serial interface using GUI-based development software. Onboard memory allows for specific user settings. In addition, this controller can power up autonomously without burdening the host processor. Default settings can be optionally configured by external resistor dividers for output voltage, switching frequency, phase and device address. The LTC3880/-1 has an onboard 16-bit ADC that provides best in class programmability and telemetry read-back.

Digital System Management for Real-Life Applications

A large multirail power board is normally comprised of an isolated intermediate bus converter, which converts a 48 V, 24 V or other voltage from the backplane to a lower intermediate bus voltage (IBV), typically 12V that is distributed around the PC card. Individual point-of-load (POL) DC-DC converters step down the IBV to the required rail voltages, which normally range from 0.6 V to 5 V with currents ranging from 0.5 A to 120 A. Figure 2 shows how a multi-rail system can be controlled with various controllers and DC/DC converters. The point of load DC/DC’s can be self-contained modules, monolithic devices or solutions comprised of DC-DC controller ICs with associated L’s, C’s and MOSFETs. These rails normally have strict requirements for sequencing, voltage accuracy, over current and over voltage limits, margining and supervision.

Clearly, the sophistication of power management is increasing and it’s not uncommon for a circuit board to have over 30 rails. These types of boards are densely

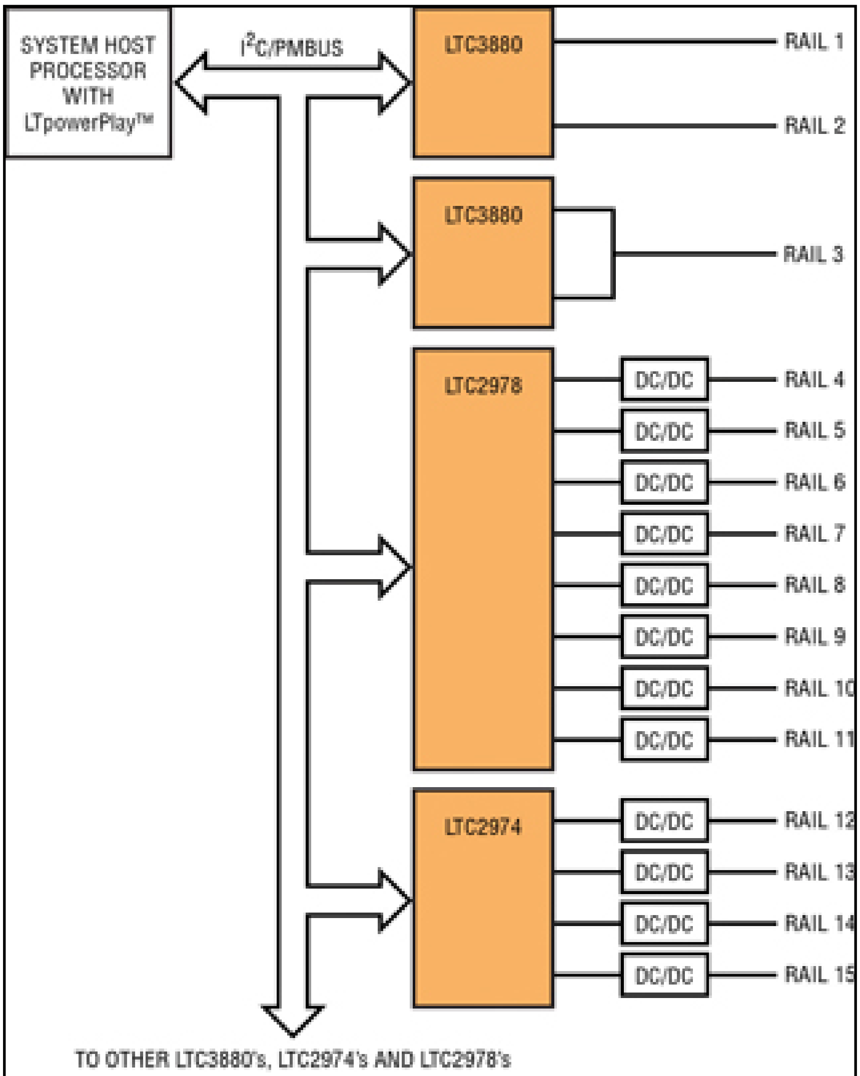

Figure 2. Block diagram on how to control 15 rails via an I2C/PMBus.

populated, and the digital power system management circuitry must not take up too much board space. It must be easy to use and be able to control a high number of rails. Linear Technology's LTC2978, for example, combines all the necessary features to work in conjunction with the LTC3880/1 and LTC2874 to control up to 72 voltages on a single segment of an I2C bus. The LTC3880/-1 controls, monitors and generates up to two high current rails. The LTC2978 controls and monitors up to eight rails, and the LTC2974 controls and monitors up to 4 rails. Such solutions must operate autonomously or communicate with a system host processor for command, control and to report telemetry. Figure 3 shows an example of one channel of an LTC2978 controlling a DC/DC converter.

The PMBus command language was developed to address the needs of large multirail systems. In addition to a well-defined set of standard commands, PMBus compliant devices can also implement their own proprietary commands to provide innovative value-added features. The standardization of the majority of the commands and the data format is a great advantage to OEMs producing these types of system boards. The protocol is implemented over the industry-standard SMBus serial interface and enables programming, control, and real-time monitoring of power conversion products. Command language and data format standardization allows for easy firmware development and reuse by OEMs, which results in reduced time-to-market for power systems designers. For more information, see http://pmbus.org [1].

With over 75 PMBus standard command functions, users can take full operational control of their power system using one of the most popular open standard power-management protocols. Users can also generate interrupt requests for the system controller by asserting an ALERT pin in response to supported PMBus faults. Linear Technology’s LTpowerPlay GUI gives users easy access to the LTC3880/-1’s operations and settings.

Conclusion

Digital power creates a new design environment for power supplies which adds value in several areas. First, having digital control over analog power supplies with a simple PC connection is valuable during the development stage enabling designers to get their systems up and running quickly. Designers of high rail count systems need an easy way to monitor, control and adjust supply voltages, limits and sequencing. Production margin testing is easier to perform than traditional methods since the entire test can be controlled by a couple of standard commands over an I2C/PMBus bus.

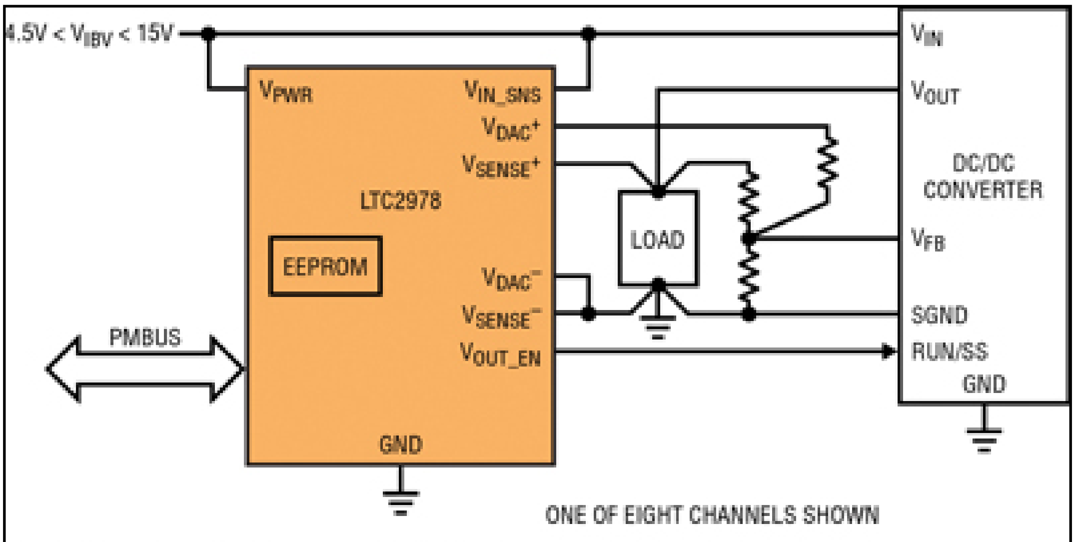

Figure 3. LTC2978 controlling an external DC/DC converter.

Power system data can be sent back to the OEM about the power supplies health, effectively opening up the blind spot with regards to a DC/DC converters well being. If a board is returned, the fault log can be read back to determine which fault occurred, the board temperature and the time of the fault. This data can be used to quickly determine root cause, to determine if the system was operated outside of its specified operating limits or to improve the design of future products.

A properly designed digital power management system provides the user with power consumption data, allowing for smart energy management decisions to be made, which can be used to reduce overall power consumption. Digital power is not all things to all people; however, for high rail count complex systems and OEM’s who want to keep track of their power systems status it is a very powerful tool.

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