HOW2POWER TODAY
Your Power Design Newsletter

Exclusive Technology Feature

ISSUE: June 2011

Add A Black Box To Your Big (Or Small) Box

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Everyone is familiar with the terminology “black box.” Ask someone what a black box is, and invariably they will tell you it is the device that provides all the clues as to why a plane crashed. The airplane’s black box collects numerous data points about the operating conditions of the aircraft like altitude, speed, flap and rudder positions. It also records what the pilots were doing and saying right before the accident. This running log of what transpired just before a crash can be critical in determining the root cause of the incident.

As an aside, the term black box is a misnomer. The equipment used in aircraft is never black—it is orange so that it can be easily located. The proper avionic terminology for the device is an “event data recorder.”

Of course, the engineering community will also understand a black box to be a device where the inputs and outputs are known, but the internal operation of the box is unknown. That type of black box is not the subject of this article.

Adding a black box to electronic equipment other than aircraft can prove extremely valuable. Called a complex system manager in electronic equipment, black-box functionality provides fault logging in networking, industrial control, medical, and communications equipment. The principal benefit of fault logging is quite straightforward: faster, more definitive failure analysis. This article explains how to implement such a function, and outlines the benefits that can be realized from nonvolatile fault logging.

Power-Management Schemes

From a power-management perspective, the inner workings of most systems look very similar. This is true for “big box” systems such as servers as well as “small box” systems (more commonly called pizza boxes) such as network switches. Whether the box is a router, a server, a base station, an optical multiplexer, a programmable logic controller (PLC), or a magnetic resonance imager (MRI), they all contain an array of switched-mode and linear power supplies that require monitoring for voltage, current, temperature, and possibly fan speed (Fig. 1.)

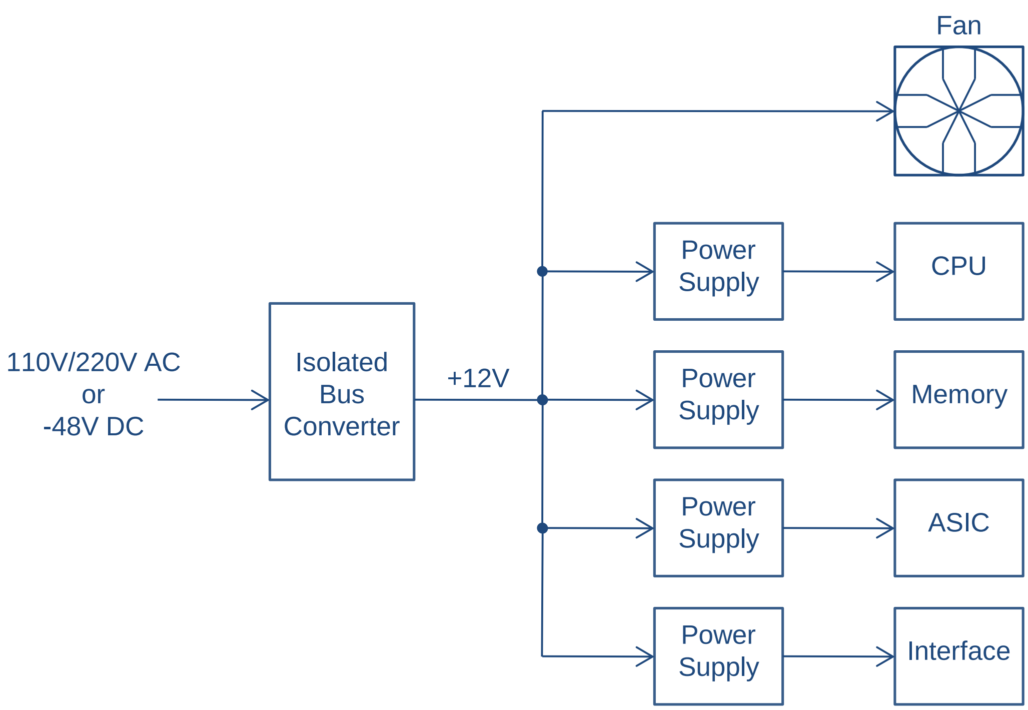

Fig. 1. A typical power-supply arrangement.

Nonvolatile Fault Logging

In both large big-box systems and smaller pizza-box systems, a complex system manager's primary function is to control and monitor a number of power supplies and fans. Monitoring includes looking for system fault events such as voltages that are either too high or too low, currents that are too high, temperatures that are out of range, and fans that are not spinning at the proper speed. Checking for faults could be as simple as examining the parameter for excursion beyond a threshold. If real-time data is collected while the system operates and is stored to nonvolatile memory when a fault occurs, an event-data-recorder function can be created. Fig. 2 shows just such a system.

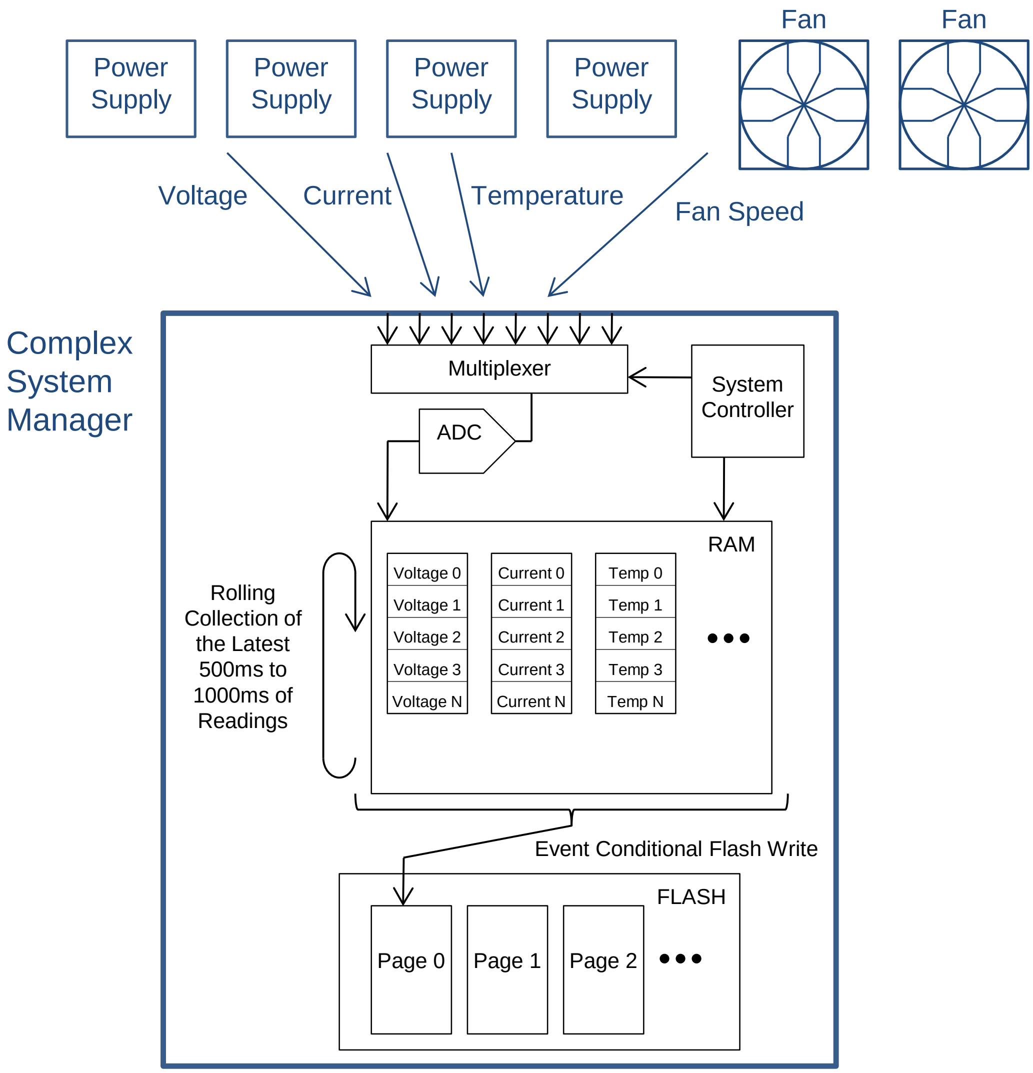

Fig. 2. Functional diagram of a nonvolatile fault logging system for a number of power supplies and fans.

In Fig. 2, the complex system manager continuously collects data on the numerous system voltages, currents, temperatures, and fan speeds. Similar to the black box in an aircraft, the most recent parametric data (for example, the last 500 ms to 1 s of data) is continuously collected on a rolling basis. Then when a fault occurs, a snapshot of the system at that time is permanently recorded.

Being able to examine the previous 500 ms to 1 s of system operation before a fault occurs is critical information for understanding what caused the fault and what the resulting effects on the system were. From examining the data, a timeline can be reconstructed and the interdependencies determined.

Ideally, the complex system manager should record multiple fault occurrences. Due to tightly coupled system interdependencies, it is likely that a fault will cause multiple system faults to occur in succession. To find the root cause of the failure, it is thus important that all of the data be captured. Moreover, a large amount of nonvolatile storage allows the system to store events that may not be deemed catastrophic but merely indicate when the system is operating outside the specified range. The storage of this data can be important for enforcing warranty compliance.

An Example

Consider the scenario shown in Fig. 3. A power supply fails (Step 1) and the fault is detected by one of the complex system managers that is constantly monitoring voltages, currents, and temperatures. The manager immediately notifies the other managers in the system so they can take action as needed (Step 2). The complex system managers then sequence off the power supplies and fans in concert as the system requires (Step 3). All of the recent data on system voltages, currents, temperatures, and fan speeds is then logged into the onboard black box in each complex system manager (Step 4). Since the data is stored in nonvolatile memory, a host can pull the data anytime in the future (even after it is returned from the field) to determine what caused the failure (Step 5).

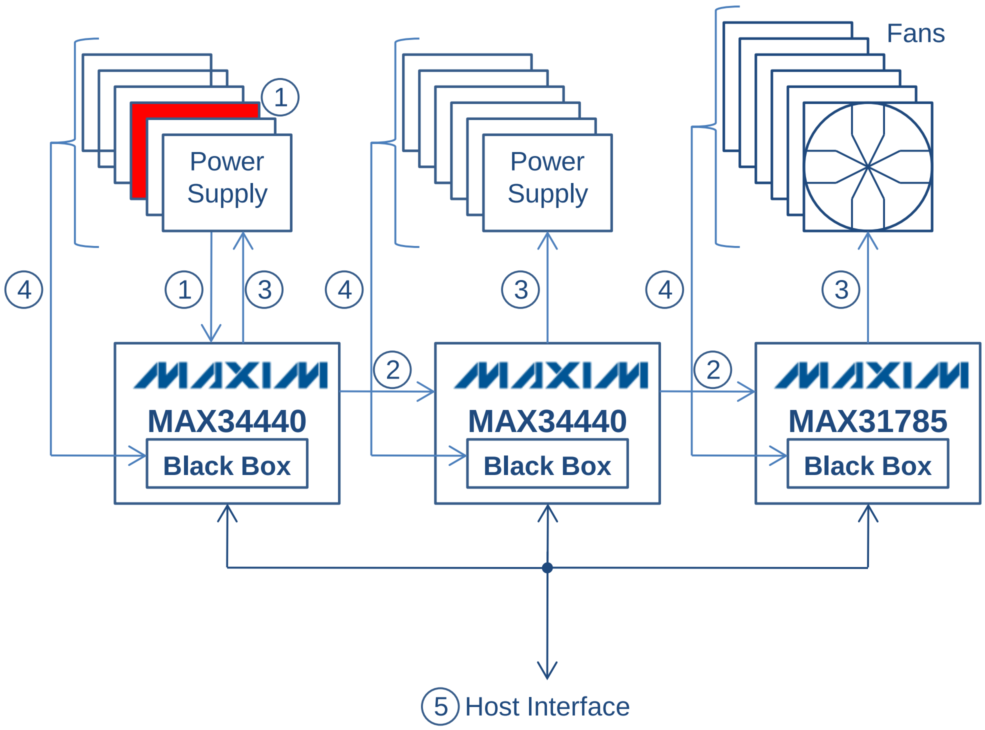

Fig. 3. Black-box fault logging scenario.

Benefits Of Nonvolatile Fault Logging

Nonvolatile fault logging has a number of benefits. If the equipment can track what transpired during the field failure, the failure analysis team can quickly analyze and accurately determine the root cause of the failure. This troubleshooting improves customer relationships, since the users inevitably want to know quickly why the equipment failed. Also, the quicker a manufacturer can realize a potential liability, the quicker they can rectify the issue and save the costs of potential future failures. Once again, this keeps customers satisfied and improves the overall reliability of their equipment.

Nonvolatile fault logging can also be used to determine if the customer was using the equipment outside the specified operating range, an action that can violate the product warranty. Over time, the collection of field failure data can improve future product reliability by identifying poor suppliers or weak design practices.

Complex System Managers

Maxim Integrated Products offers a number of complex system managers that include extensive nonvolatile fault logging for both big-box systems and pizza-box designs. See Figs. 4 and 5.

The MAX34440 controls and monitors up to six power supplies (Fig. 4). It provides power-supply sequencing, margining, and monitoring for voltage, current and temperature faults. Multiple MAX34440 devices can be paralleled to handle all of the power supplies that exist in a system. The MAX31785 controls and monitors up to six fans. Like the MAX34440, multiple MAX31785 devices can be used to support as many fans as required.

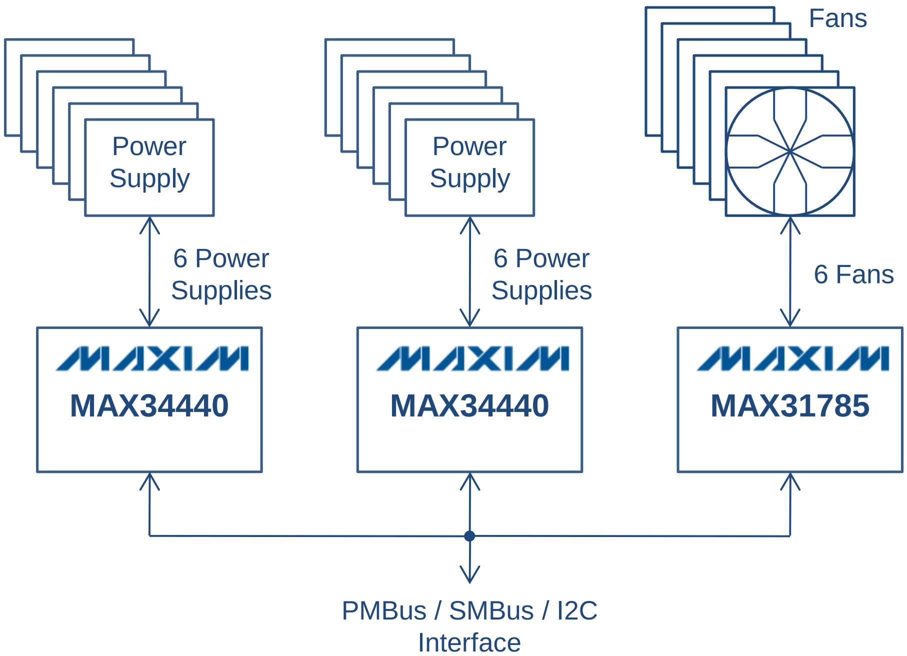

Fig. 4. A big-box system design uses the MAX34440 and MAX31785 to control and monitor power supplies and fans.

Maxim also offers complex system managers that support smaller pizza-box designs like network switches. The MAX34441 supports up to five power supplies plus a fan (Fig. 5). To maximize design flexibility, multiple MAX34441 devices can be paralleled or used in conjunction with multiple MAX34440 and MAX31785 devices.

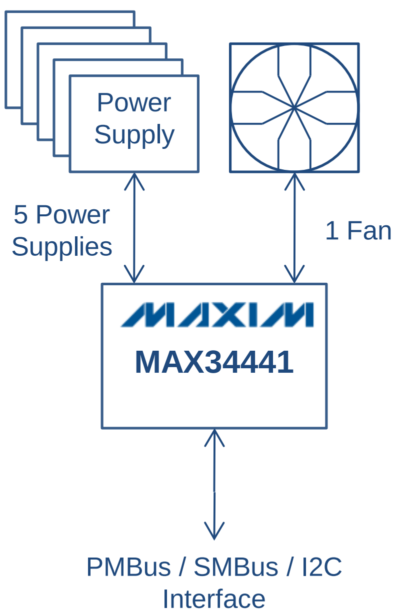

Fig. 5. A pizza-box system design using the MAX34441.

A Value Proposition

Black-box fault logging in networking, industrial control, medical, and communications equipment results in faster, more definitive failure analysis. This, in turn, yields higher customer satisfaction with faster reaction times and in the long term, better product reliability.

About The Author

Dewight Warren is a product definer in the Mixed-Signal Business Unit at Maxim Integrated Products. He has a BSEE from the University of Florida and an MBA from the University of Texas at Dallas.