White Paper

Eliminating Power Supply Design Complexity with ‘Simple Digital’ Modules

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Abstract

This document introduces the ‘Simple Digital’ power module family from Renesas and its benefits and ease of use for designing power supply solutions.

Introduction

Step-down (buck) regulators are used industrywide to convert power from a distributed bus to the individual point-of-loads (POLs) in industrial and infrastructure systems. These buck converters need to handle increasingly larger load current requirements from modern FPGAs and ASICs, with POL voltages decreasing progressively, but still satisfy demands for tighter regulation and reduced noise performance.

A major challenge for power supply designers is to meet these daunting demands while delivering maximum efficiency and peak performance with a reduced BOM cost and a minimum overall size. Power modules offer these advantages by integrating the controller, synchronous MOSFETs, inductor, compensation network, and protection circuitry together into one compact package. This makes power modules a ready-to-use, reliable solution with only a few input and output capacitors needed to finish the design. With the presence of both analog and digital power modules in the market, every design engineer must have faced the dilemma whether to go the analog or digital route. The goal is to achieve the right balance between functionality and cost effectiveness.

Digital power modules use advanced digital control techniques and provide systems with more flexibility and intelligence. System performance can be greatly improved with real-time telemetry and fault detection via a digital interface such as PMBus™, I2C, or SPI. This makes way for easy debugging and timely corrective actions. In a larger and more complex system comprised of multiple power rails, having an option to save and load different configurations in non-volatile memory can allow for much faster integration and superior management.

Analog, being the tried-and-trusted solution even before the advent of digital control in power supplies, still provides such benefits as ease-of-use and design simplicity. The designer does not need to have the know-how for programming or communication protocols as required with digital control. These benefits, however, come with limited flexibility. For instance, a feedback compensation loop cannot be optimized for different conditions without changing the physical components.

There is a need for a solution that combines the merits of both analog and digital domains without incurring additional cost and complexity to the design. The 'Simple Digital' family of parts and their fit between the spheres of true analog and full-featured digital power modules provide such a solution.

Simple Digital: A simple solution

The Simple Digital power module family bridges the gap between the analog and digital domains. Simple Digital power modules provide the design-in experience along the lines of an analog power module, while retaining the digital PMBus interface for telemetry and configuration during real-time operation.

Simple Digital power modules offer the full benefits and flexibility of a digital control architecture, and can be fully configured via pin-strap settings like traditional analog power products. A programmability option with pin-strap resistors provides for a plug-and-play solution.

The unprecedented ease of design with a real-time system monitoring capability and control via the industry-standard PMBus interface makes the Simple Digital module a unique solution. Full power supply telemetry, including output voltage, output current, fault status, and thermal management, is supported, which improves reliability and system uptime. Customers can utilize the PMBus interface to validate their designs without the inconvenience of switching passives (resistors and capacitors) every time a functionality needs to be adjusted or modified, reducing the development time and overall cost of implementation.

Ease of Use

Simple Digital modules do away with RC time constants, which are used to set delay and ramp times in traditional analog controllers. External capacitors are not required to configure the control loop for stability since the inherent digital control framework allows for a compensation-free design, eliminating the need for intricate calculations and stability analysis. The total component count is considerably reduced as compared to an analog power supply, leading to a highly integrated and cost-effective solution.

One of the disadvantages of analog power products is the lack of system monitoring during run time. Management of multiple voltage rails and currents in an elaborate and intricate system can be quite challenging and costly, requiring additional components (voltage supervisors, current shunt monitors, etc.), which take up valuable real estate on the printed circuit board. Simple Digital modules leverage the telemetry available in digital controllers and provide the capability to monitor critical data for early fault detection, creating a more robust and reliable solution. Temperature monitoring can safeguard against thermal failures by identifying hot spots and improving the overall thermal management of the system.

Digital controllers offer the flexibility to program the configuration of the power supply by storing the parameters in onboard non-volatile memory while also allowing programming through external resistors for a small number of features. When using such a full digital controller, the system designer must program the majority of the configuration parameters and store them in NVM. Simple Digital power modules bypass the digital programming by providing a comprehensive selection of resistor pin-straps for configuring the power module. The system designer simply needs to select a resistor to program features like output voltage, frequency, input UVLO, ramp times, and soft-start/stop, as well as sophisticated features like voltage tracking, external clock synchronization, and phase-spreading.

A PMBus interface for a Simple Digital power supply can offer a huge advantage during the development phase by rigorously testing for various combinations of output voltages, switching frequency, ramp times, and soft-start/stop without the inconvenience of changing hardware (resistors and capacitors). This reduces the time required for testing considerably, while simultaneously ensuring that the design integrity is not compromised. Fault protection limits of input UVLO, output over/under voltage, and over current can be easily adjusted via the PMBus interface, allowing the designer to validate multiple test case combinations in a short time. NVM

access for fault logging can make it much easier to troubleshoot the system by reading the captured data after a fault event.

Solutions for Every Point-of-Load

Renesas offers a rich, comprehensive portfolio of Simple Digital point-of-load power modules to address the needs of the wide-input voltage range and load-current range of infrastructure systems.

The pin-strap-configurable step-down PMBus-compliant DC/DC power supply modules are suitable for various power train architectures, specifically around FPGAs, DSPs, and microcontrollers from 25A to 70A point of loads, providing similar high-power densities for multi-rail applications to what the full digital modules deliver. Because of these modules' thermally-enhanced HDA packaging technology, the need for airflow or additional heat sinking is eliminated, further reducing the system cost and size. The RAA210xxx family simplifies configuration and control of Renesas' digital power technology while offering an upgrade path to full PMBus configuration through the pin-compatible ISL827xM family.

The proprietary ChargeMode™ control architecture provides fast transient response and achieves best-in-class conversion efficiencies. A single-clock cycle response to load-step transient reduces the amount of capacitance required at the output, leading to cost and board space savings. Due to a multi-rate sampling technique, any extraneous delay between the error-sampling instant and the moment the PWM is generated is reduced significantly. Simple Digital control technology provides unprecedented ease of design with real-time system monitoring capability and control via an industry-standard PMBus interface. It supports full power supply telemetry, including output voltage, output current, and fault-status monitoring for improved reliability and system uptime.

The RAA210925 is a dual-channel module that can greatly enhance the support to various power architectures, specifically around FPGAs, DSPs, and microcontrollers. The RAA210925 complements Renesas' single channel offering, covering up to 25A per channel and providing high-power density for multi-rail applications.

Table: Mapping the Simple Digital family of parts to the existing full-featured Digital ISL827XM series of modules from Renesas.

	ISL827xM Full Digital Family	**RAA210xxx Simple Digital Family**
Pin-to-Pin Compatibility	ISL8277M: 25A ISL8278M: 33A ISL8272M: 50A ISL8273M: 80A ISL8274M: Dual Channel 30A	RAA210825: 25A RAA210833: 33A RAA210850: 50A RAA210870: 70A RAA210925: Dual Channel 25A
Vin (V)	4.5-14	4.5-14
Vout(V)	0.6-5	0.6-5
Fsw (kHz)	296-1067	296-1067
Digital PMBus programmability for configuration of modules	All PMBus commands supported. NVM access to store module configuration.	Configuration of modules supported via pin-strap resistors. Digital programmability supports configuration changes during run-time operation with a subset of PMBus commands. No NVM access to store module configuration.
Power Navigator support	Yes	Yes
SYNC capability	Yes	Yes
Current sharing multi-modules	Yes	No
DDC Pin (inter-device communication)	Yes	No

All digital power modules from Renesas are supported by the PowerNavigator™ GUI, which is a user-friendly tool to help support PMBus communication. Setting operating parameters through pin-strap resistors/PMBus and testing and debugging allows for a very simplified design flow for power designers. Other supported ancillary tools like PowerCompass™ and iSIM offer a powerful and holistic means for analyzing the system requirements early in the design stage, performing high-level analysis, and helping to generate the starting point for a customer's circuit. PowerCompass has built-in templates for popular ASICs and FPGAs, thereby making it easier to build a complete system-level application schematic and BOM. It can provide system efficiency and power dissipation projections for systems that use both digital and analog power solutions. Detailed instructions and video tutorials are available online to help the user get started easily on these tools.

Conclusion

Simple Digital power modules leverage the inherent advantages of a digitally-controlled power supply by offering telemetry and configuration using the PMBus interface. A digital interface supports real-time monitoring of output voltage, current, and temperature, which supports the powertrain architectures required by FPGAs, ASICs, DSPs, and microcontrollers. A compensation-free design implemented in software eliminates the sensitivity to component tolerances due to aging and provides excellent transient performance. Fault logging provides a powerful tool for faster troubleshooting and correction. A minimal component count creates a power-dense footprint and a reliable solution.

The simplified approach in configuring the modules by using pin-strap resistors eliminates any intricacies involved with programming. Renesas' ChargeMode control architecture responds to transient load step in a single switching cycle, saving cost and board space by reducing the amount of capacitance. A highly integrated solution, the RAA210xxx power modules only require a few external components to operate. Advanced HDA packaging technology provides an excellent thermal performance over a wide range of operating temperatures without the need for airflow or heatsink. Online design support tools, including PowerNavigator, PowerCompass, and SIMPLIS models, lead to fast time-to-market powertrain development and optimization.