

White Paper

Scalable Digital Point-of-Load Solutions

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Abstract

Scalable Point-of-Load (POL) offers a design flexibility that addresses a wide range of load-current requirements for modern day electronic loads. Combined with benefits derived from digital power management, the scalable digital POL can provide flexible and cost-effective solutions. This paper outlines the benefits of the latest digital PWM controllers from Renesas for scalable POL designs.

Introduction

Point-of-load (POL) regulators represent an important component in today's power systems for communications and computing infrastructure applications. The POL regulates DC bus voltage to lower output voltages with high precision while supplying the dynamic loads. Demand for POLs to provide high current/low voltage to power-hungry FPGAs, ASICs, SoCs and microprocessors, efficiently and reliably, is increasing.

FPGA and SoC vendors often provide various grades of their products to address the end application's requirements. As a result, the current requirement can range widely from tens to hundreds of amperes. The scalable POL approach offers flexibility and a shorter design cycle. For example, if the 30A current is required, the power supply designer can design a single-phase POL solution. If the current requirement is increased to 60A, paralleling two of the single-phase POLs can offer ease of design. However, paralleling POL requires a current sharing mechanism to ensure proper circuit operations.

The digital power management controller provides systems with real-time intelligence and flexibility. It can also facilitate communication with other digital processing ICs through a standardized protocol such as PMBus to enhance the system's performance. Additionally, digital power management allows for extensive power-supply fault detection, diagnostics, and recovery functions. The controller can detect a power train fault, report the problem to the host processor, and take corrective actions. All these benefits from the digital controller enable fast design-cycles and easy debugging.

This paper will discuss the general approach for scalable POL design and introduce the ISL68300 and ISL68301 digital PWM buck controllers from Renesas, highlighting their benefits for scalable POL designs.

Scalable Digital PWM Controllers

The ISL68300 and ISL68301 are single-phase digital PWM buck controllers that provide a scalable solution for one to eight phases to address multiple power requirements. The ISL68301 is a PWM buck controller for use with the smart power stage module (i.e., ISL99227B) or DrMOS (i.e., ISL99140, ISL99135B, and ISL99125B). The ISL68300 is a PWM buck controller with integrated gate drivers for use with discrete N-Channel MOSFETs. Both are fully digital power management controllers with PMBus v1.3 compliance.

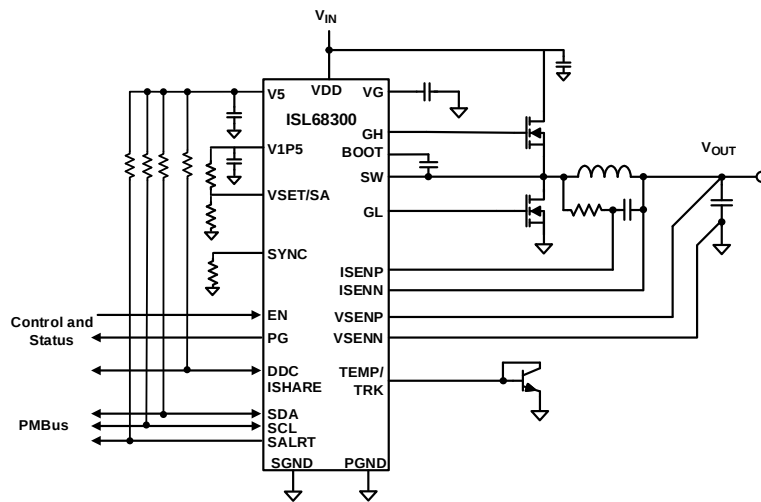


Figure 1: ISL68300 typical application circuit

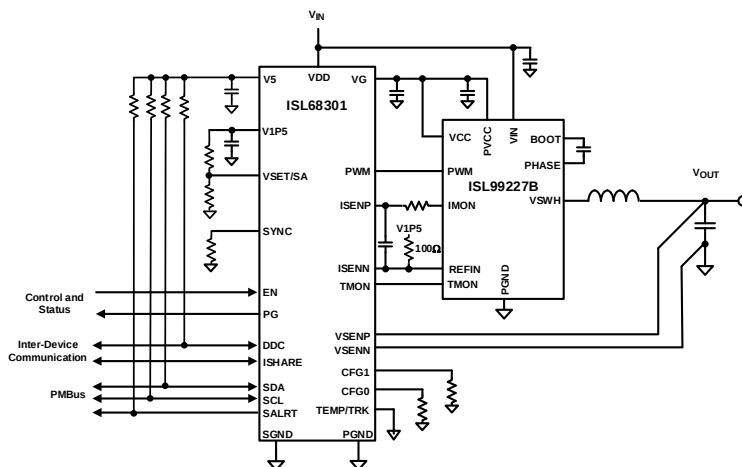


Figure 2: ISL68301 with SPS (ISL99227B) typical application circuit.

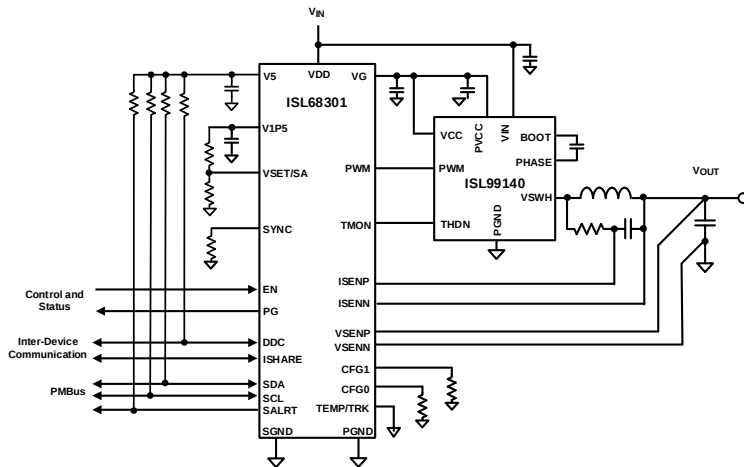


Figure 3: ISL68301 with DrMOS (ISL99140) typical application circuit

Both the ISL68300 and ISL68301 implement Renesas' ChargeMode™ control, which provides an inherently stable control loop with no external compensation. ChargeMode control uses a multi-rate sampling technique that samples the output voltage and computes the modulation signal multiple times during each switching cycle. This technique significantly reduces delay and, therefore, supports very high bandwidth operation. Typically, it only takes one switching cycle to charge the inductor current to the steady state level upon load turn-on.

For scalability, the ISL68300 and ISL68301 provide a dedicated current-sharing (ISHARE) pin for load-current sharing. The integrated current-sharing control enables parallel operation of the POLs to deliver a high current to the loads. The load current is, thus, evenly distributed among the POLs, reducing thermal stress and improving reliability. Each phase delivers up to 40A of output current based upon MOSFET selection. Designers determine the number of ISL68300 and ISL68301 controllers required based on the number of voltages and output current levels that need to be generated.

Current Sharing

The current-sharing technique is critical for paralleling POL to ensure that the load current is shared evenly among the POLs. When the load current and power dissipation are distributed evenly among the POLs, the stresses on the electrical components are reduced, extending the lifetime of the power supplies.

Several current-sharing schemes can be implemented in the POL's paralleling operation. The basic current-sharing techniques can be categorized into two classes:

- 1) Droop current-sharing method
- 2) Active current-sharing method.

The main drawback of the droop method is the poor load regulation, which makes it impractical for the applications that require tight output voltage regulation. On the other hand, the active current-sharing method

provides excellent dynamic performance in addition to steady-state performance. The active current-sharing technique typically utilizes at least one connection (current-sharing bus) among each module to provide current information.

The ISL68300 and ISL68301 digital PWM controllers feature proprietary active current-sharing technology, enabling up to eight devices in parallel, for improved cost efficiency for a variety of specific design needs. The current-sharing method implemented in these devices is based on the master-slave technique. The master device provides its current information through the ISHARE bus. The slave devices use the current information from the master device as the reference and regulate their currents to match with the reference current.

Figure 4 demonstrates the connections of the ISL68300 and ISL68301 in the parallel operation. The current-sharing (ISHARE) bus provides the current information to be communicated across the devices. The SYNC pins allow all devices to be operated at the same switching frequency. Phase interleaving is set, by default, based on the number of devices in the rails. The DDC bus provides communications across devices such as fault spreading.

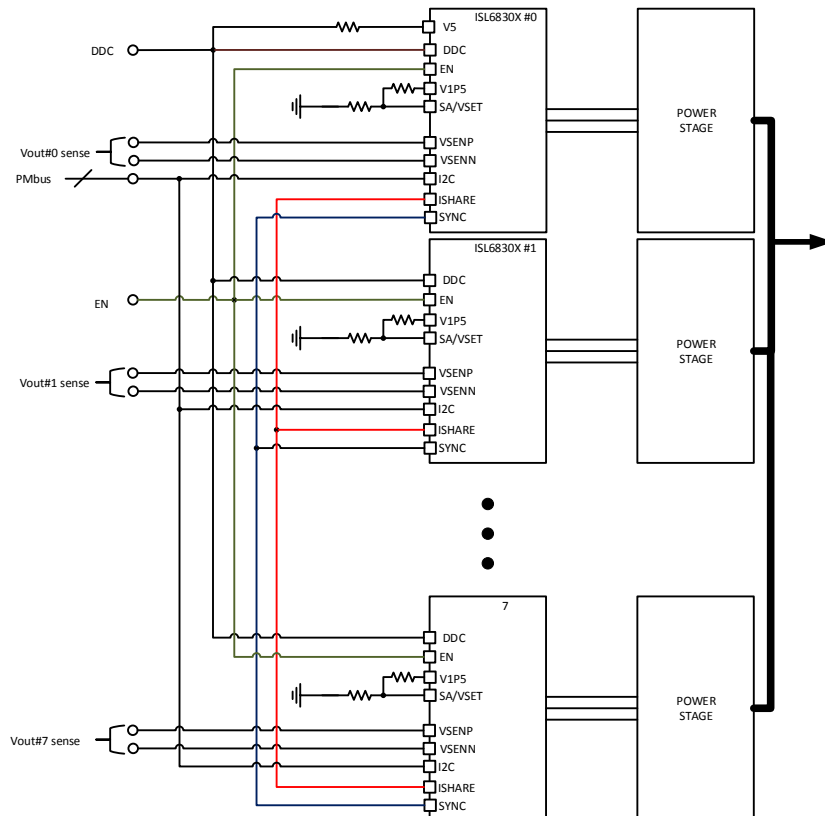


Figure 4: Simplified Block Diagram of ISL68300/ISL68301 Parallel Operation

Figure 5 and 6 show inductor current and output voltage waveforms of the converters with eight of the ISL68300 in parallel operation. During load transients, the ISL68300 can keep the inductor currents well balanced while sharing the load current.

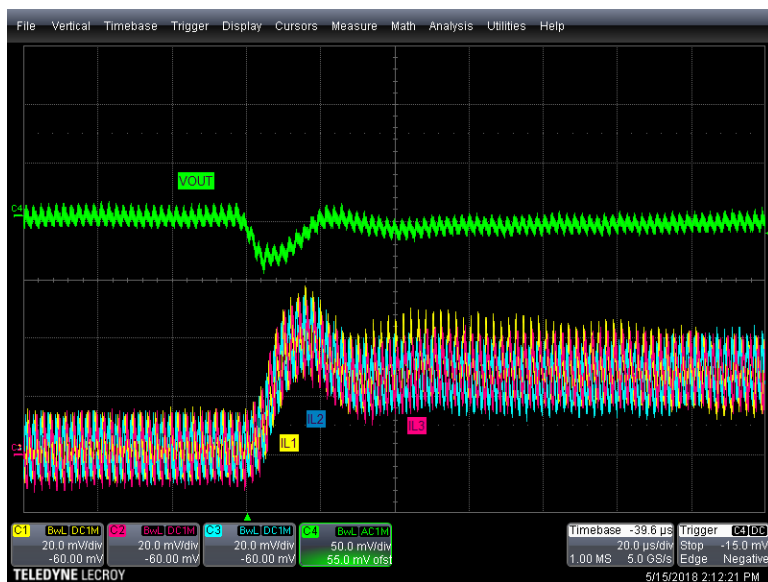


Figure 5: Current sharing during load application



Figure 6: Current sharing during load release

Key Features

With the benefits of the mixed-signal circuit design, the ISL68300 and ISL68301 PWM buck controllers provide excellent 0.5% output voltage accuracy over line, load, and temperature. These devices also provide several features that ease the POL design without external components.

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- True differential remote:

The differential remote sensing helps compensate for the droop due to the load on the positive and negative rails, maintaining high system accuracy.

- Soft-start/stop with programmable ramp times and delay times:

Delay and ramp times of the soft-start and soft-stop can be set independently. This feature yields flexible power-up and power-down sequencing. In addition, the ISL68300 and ISL68301 also support pre-biased startup.

- Voltage tracking:

The ISL68300 and ISL68301 support both coincidental and ratiometric tracking modes, enabling the proper start-up and shut down of the sensitive multi-rail systems.

- External temperature sensing

The devices can be used with an external NPN transistor for external temperature sensing. The external temperature information can be used in telemetry data and fault operation. The ISL68301 also provides an option to sense SPS's temperature through the TMON pin.

- Comprehensive protection function and monitoring

The ISL68300 and ISL68301 support various protection functions, including power input UV/OV, two levels of output current UC/OC (average and peak), output voltage UV/OV, and temperature UT/OT. Each protection has both a fault limit and warning limit, which can be set independently. The user can set the corresponding fault limit value easily through PMBus commands. A wide variety of system parameters and statuses can be monitored through PMBus commands.

- Configurable fault responses

The user can select the fault response, latch or retry, for each fault source independently. For the retry fault response, the retry time interval can also be programmed through the PMBus command.

Conclusion

To meet the requirements necessary in scalable POL designs for a wide range of load current, the latest digital controllers from Renesas, the ISL68300 and ISL68301, offer several advantages such as ChargeMode control for inherently stable control loop and fast transient response, a dedicated current-share bus for paralleling up to eight devices in a current-share configuration, and scalability for supporting a wide range of load currents. The ISL68300 and ISL68301 enable a cost-efficient, simpler design process for designing various applications.

Related Resources

- [ISL68300/01 product information](#)
- [ISL68301 datasheet](#)
- [PowerNavigator™ GUI software](#)

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