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# Power GreenPAK™ with Low Drop Out Regulators (LDO)

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## Abstract

This white paper addresses the challenges of power system design for mobile and wearable devices, focusing on reducing size and weight while extending battery life. Renesas introduces Flexible Power Islands (FPIs) to divide complex power systems into localized regions, each with dedicated power control, sequencing, and regulation. FPIs enhance performance and efficiency, offering fully customizable solutions for diverse system needs. The SLG46580 device exemplifies FPIs by integrating power monitoring, sequencing, reset, and switching functions in a compact package. It features four programmable LDO regulators with advanced options for slew-rate selection and fault detection. Benefits of the Power GreenPAK with LDOs include high integration, reduced board size, and versatile tri-mode LDO regulators. Taking advantage of the included configurable macrocells such as analog comparators and asynchronous state machines (ASM) enhances the power sequencing flexibility of the SLG46580. This white paper explores FPIs with the SLG46580(/82/83/85) as an example, demonstrating their potential to meet modern power system design requirements.

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# 1. Introduction

Power system design in the age of mobile devices (and especially wearable devices) is much more challenging than it has ever been. The end users of these devices want them to be smaller and lighter while also having longer battery life. These opposing goals and a need to reduce the cost and the circuit board size are just a few of the challenges a power system designer faces. Figure 1 shows even more of the challenges facing designers of mobile device power systems.

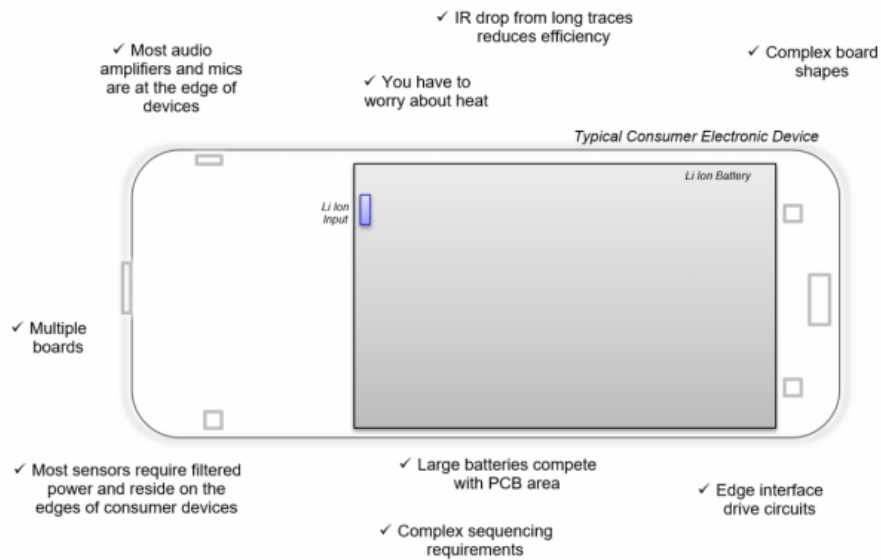


Figure 1. Power System Challenges

To overcome these challenges, Renesas has developed the concept of Flexible Power Islands (FPIs). Using FPIs, designers can divide their complex power systems into some number of smaller local power regions (or islands). Each region (island) incorporates the power control, power sequencing, and power regulation needed to support power loads in its immediate vicinity. This technique results in higher performance and a more efficient solution that can be flexibly tailored to the requirements of each individual system.



Figure 2. GreenPAK Flexible Power Island

## Power GreenPAK™ with Low Drop Out Regulators (LDO)

In some cases, using an FPI can be very useful for augmenting the functions included in a power management IC (PMIC). In this use case, an FPI can support local point-of-load regulation, sequencing, and power monitoring. This can result in a simpler layout, as well as improved energy and thermal efficiency.

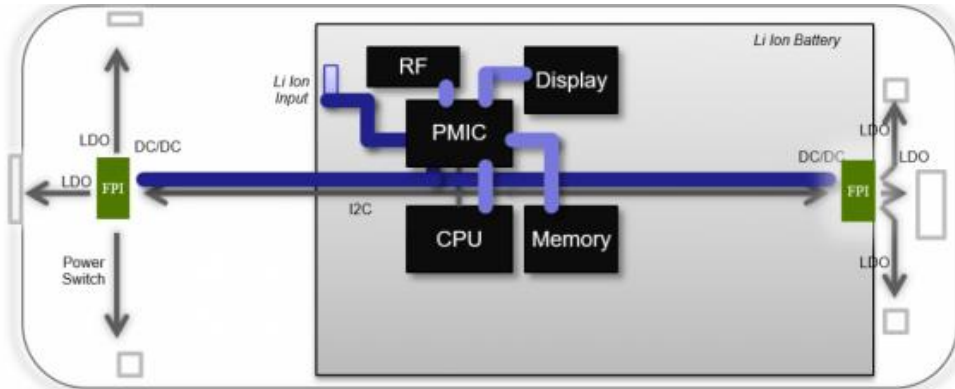


Figure 3. Typical Consumer Electronic Device

For smaller and simpler systems (which have up to six power rails), the FPI concept can provide most or all of the power system functions needed. In this case, an FPI can serve as a “ $\mu$ PMIC”, but with the added benefit of greater levels of flexibility and customization, with no requirements for additional NRE.

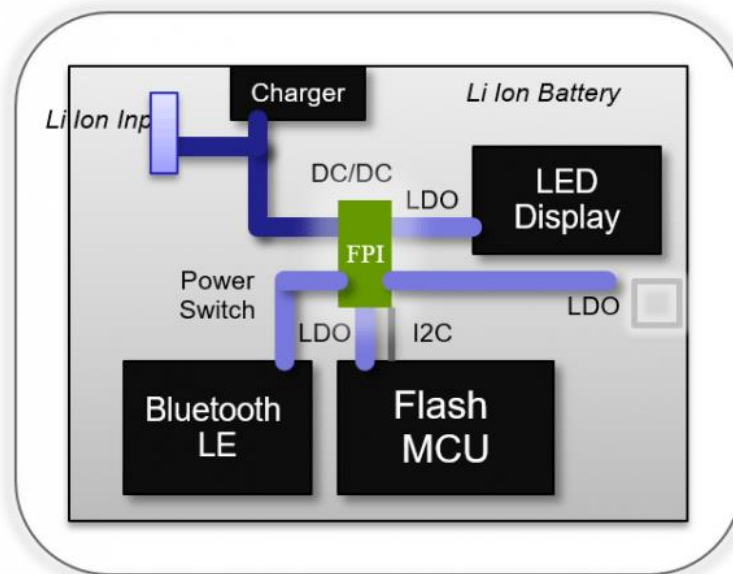


Figure 4. Tiny Consumer Electronic Device

## 2. Power GreenPAK: an Integrated Power Management Solution

The Power GreenPAK platform by Renesas provides a versatile and efficient approach to power management and control. These integrated solutions vastly simplify the design process, bringing power management and control to the fast and easy-to-use GreenPAK platform.

Power GreenPAK is an ideal solution for various power management needs, featuring:

- **Efficient Power Management:** the platform includes LDO and DC-DC converters based on Renesas' successful GreenPAK programmable ASIC platform, ensuring efficient power regulation and conversion.
- **Robust Power Control:** Power GreenPAK features load switches designed for power protection, distribution, and sequencing, offering robust control over power flows.
- **Customizable System:** the platform is easily configurable to meet specific system requirements, providing flexibility in the power system design.
- **Fast-to-Market Solutions:** Power GreenPAK enables the development of customized integrated power solutions that are compact, efficient, and quick to deploy.

These capabilities make Power GreenPAK an ideal choice for a wide range of applications, ensuring efficient, reliable, and customizable power management solutions for modern electronic devices.

The most popular representative of the Power GreenPAK family with LDOs is SLG46580/82/83/85. Let's take a closer look at SLG46580. It is a low-power component commonly used to integrate mixed-signal functions under the control of an asynchronous state machine. The SLG46580 encompasses many of the necessary power system functions, including power monitoring, sequencing, reset, and power switching - all in a tiny 2.0 mm x 3.0 mm 20-pin fully encapsulated plastic package. Using Renesas' easy-to-use GUI-based [Go Configure™ Software Hub](#) along with the associated GreenPAK development hardware, designers can quickly and easily implement their unique configuration of the device, thereby customizing the functions to match their unique power requirements.

The SLG46580 has four LDOs, each with a maximum output current of 150 mA. Each LDO has a programmable output voltage level that can be set to one of 32 different values from 0.9 V to 4.35 V. Each LDO also has programmable options for slew-rate selection and fault detection.

The FPI concept is widely used across a range of end markets, such as:

- Handheld devices
- Wearable electronics
- Computing and storage
- Consumer electronics
- Smart home
- Networking and communications
- Medical and industrial

## 3. Benefits of GreenPAK with LDOs

One of the most obvious benefits of the GreenPAK with LDOs is that the GreenPAK ensures high integration. It includes many components typically found in power systems, such as power control, power sequencing, power monitoring, and power regulation. Let's take a look at one example of the Power GreenPAK family SLG46580/82/83/85.

As always, Renesas provides an efficient product in a tiny 2.0 mm x 3.0 mm STQFN packaging for a small board area. Not only does it reduce the board size, but also saves additional space by including 150 mA LDO regulators that can operate in three modes:

- Mode 0: 150 mA output with quiescent current at ~60  $\mu$ A
- Mode 1: 100  $\mu$ A output with quiescent current at ~6  $\mu$ A
- Bypass Mode: acts like a load switch.

In addition, the GreenPAK ensures the flexibility with its assortment of configurable macrocells, such as analog comparators, combination function macrocells, asynchronous state machine (ASM), and I<sup>2</sup>C slave protocol interface, among others.

#### 4. Using the Asynchronous State Machine for Power Sequencing

The asynchronous state machine (ASM) macrocell is perfect for driving a flexible power-sequencing architecture. The graphic user interface (GUI) based development tools allow the user to quickly identify the operating states, the allowed transitions between states, and the links between signals that drive each state transition. Using additional GreenPAK macrocells allows the user to easily perform time-based state transitions (using delay macrocells) and logic functions (using look-up tables). The example state machine in Figure 5 is the one used in a demo project that drives both the power sequencing signals for six power rails, as well as the signals to turn on four LDOs in sequence.

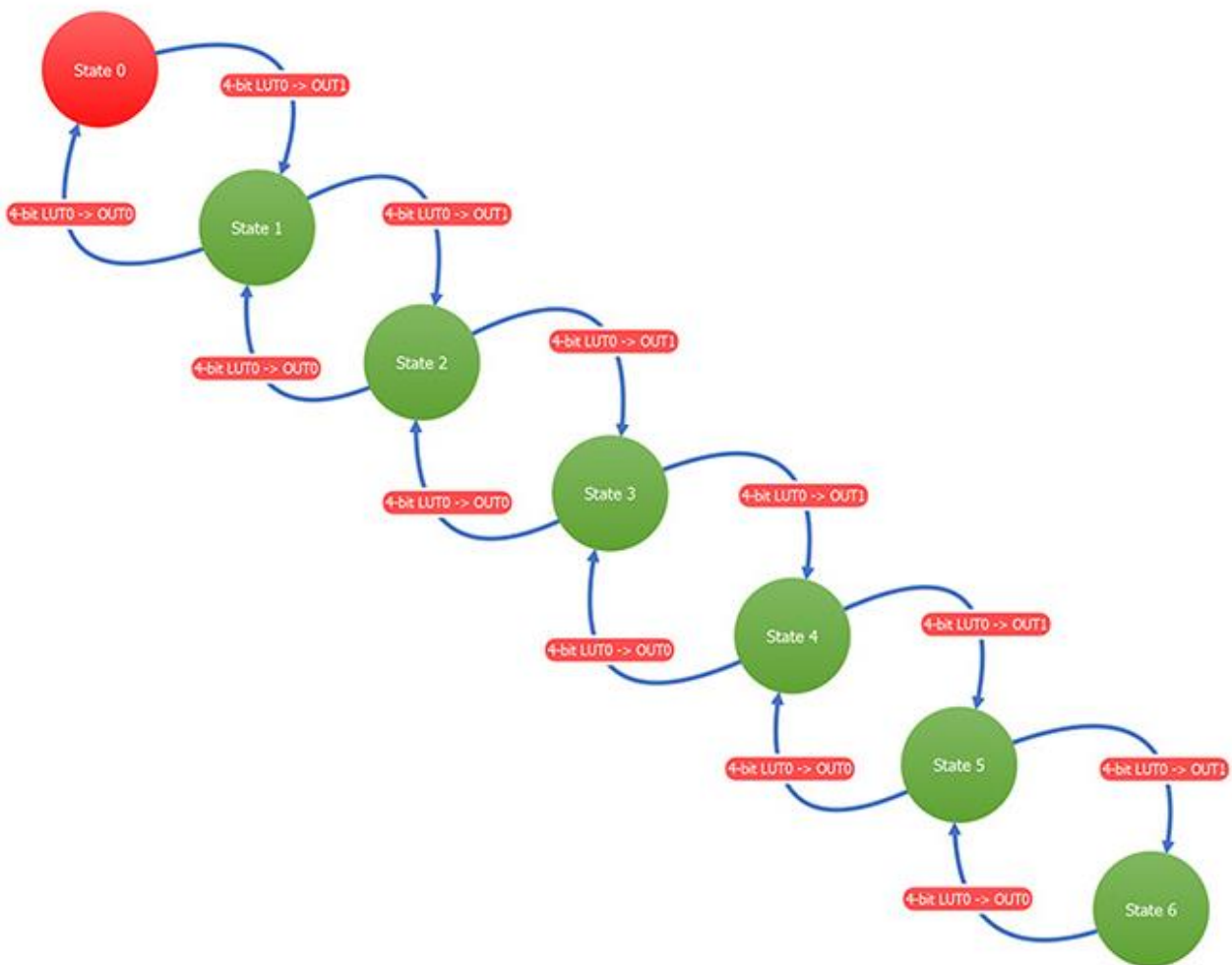


Figure 5. Asynchronous State Machine Example

## 5. Controlling LDOs with GreenPAK Resources

The LDOs included in any GreenPAK device allow the user to control many aspects of the output dynamically, during operation.

First, the user can control the output voltage. Each LDO can support two output voltages, which are user-selectable. There is an internal signal coming from the Connection Matrix that can switch the output voltage of each LDO during operation.

Secondly, it is possible to control the power consumption of each LDO. Each LDO regulator can operate in MODE 0 (standard active mode supporting full 150 mA output), as well as MODE 1 (low power mode with maximum 100 µA output), with reduced quiescent current consumption.

Lastly, the user can make the selection to have the LDO operate in load switch mode. Each LDO has a user-selectable option where the LDO no longer regulates power and instead, the power MOSFET is turned on as a power switch, passing the voltage applied to VIN directly to VOUT.

Changing the LDO behavior via I<sup>2</sup>C is also possible with little effort. All the control features mentioned above can also be changed via I<sup>2</sup>C commands.

## 6. Power GreenPAK with LDO Feature Set

Renesas offers a wide range of PowerGreenPAK products with LDOs. Below is a comparison table with the representatives of this product line and their features.

Part Number	SLG51000	SLG51001	SLG51002	SLG46580	SLG46582	SLG46583	SLG46585
<b>General Parameters</b>							
Memory Type	OTP	OTP	OTP	OTP	OTP	OTP	OTP
# of Pins / # of GPIOs	20 / 6	16 / 4	25 / 6	20 / 9	20 / 9	20 / 9	29 / 7
Operating Voltage (V)	2.8V - 5.0V	2.8V - 5.0V	2.8V - 5.0V	2.3V - 5.5V	2.3V - 5.5V	2.3V - 5.5V	2.5V - 5.5V
Communication Interface Type	I2C	I2C	I2C	I2C	I2C	I2C	I2C
Communication Interface Voltage	1.2V - 1.8V	1.2V - 1.8V	1.2V - 1.8V	1.2V - 5.5V	1.2V - 5.5V	1.2V - 5.5V	1.2V - 5.5V
GPIO Voltage	1.2V to 1.8V	1.2V to 1.8V	1.2V to 5.0V	1.2V to 5.5V	1.2V to 5.5V	1.2V to 5.5V	1.2V to 5.5V
Package Type	WLCSP	WLCSP	WLCSP	TQFN	TQFN	TQFN	TQFN
Package Size	1.675 mm x 2.075 mm	1.675 mm x 1.675 mm	1.992 mm x 1.992 mm	2 mm x 3 mm	2 mm x 3 mm	2 mm x 3 mm	3 mm x 3 mm
Operating temperature	-40°C to 85°C	-40°C to 85°C	-40°C to 85°C	-40°C to 85°C	-40°C to 85°C	-40°C to 85°C	-40°C to 85°C
<b>Combinatorial logic</b>							
Analog Comparators	–	–	–	4	4	4	4
Max. Look Up Tables (LUTs) / DFF	12 / -	12 / -	8 / 8	15 / 9	15 / 9	15 / 9	16 / 9
Pipe Delay	–	–	–	16 - stage	16 - stage	16 - stage	16 - stage
Internal Oscillator (Hz)	8M	8M	8M	1.73k / 25k / 2M	25k / 2M	25k / 2M	25k / 2M
Max Counters / Delays	–	–	1 / 4	5	5	5	5

## Power GreenPAK™ with Low Drop Out Regulators (LDO)

Part Number	SLG51000	SLG51001	SLG51002	SLG46580	SLG46582	SLG46583	SLG46585
Combination Function Macrocells	–	–	8	15	15	15	15
State Machine	Power Sequencer	Power Sequencer	Power Sequencer	8-state ASM	8-state ASM	8-state ASM	8-state ASM
Flexible Timing & Event-Triggered Sequencer	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<b>Power Parameters</b>							
# LDOs	7	6	8	4	2	2	4
VIN total range	0.8V - 5.0V	0.8V - 5.0V	0.8V - 5.0V	2.3V - 5.5V	2.3V - 5.5V	2.3V - 5.5V	2.5V - 5.5V
VOU total range	0.5V - 3.75V	0.5V - 3.75V	0.5V - 3.75V	0.9V to 4.35V	0.9V to 4.35V	0.9V to 4.35V	0.9V to 4.2V
Output Current Max	0,8	1	1,3	0,15	0,3	0,6	0,15
Max Iout_LDO1	475mA (High PSRR)	475mA (High PSRR)	500mA	150mA	300mA	600mA	150mA
Max Iout_LDO2	475mA (High PSRR)	500mA	500mA	150mA	300mA	–	150mA
Max Iout_LDO3	500mA	500mA	500mA	150mA	–	–	150mA
Max Iout_LDO4	500mA	500mA	500mA	150mA	–	–	150mA
Max Iout_LDO5	800mA	500mA	500mA	–	–	–	–
Max Iout_LDO6	800mA	1000mA	1A	–	–	–	–
Max Iout_LDO7	500mA	–	1 A	–	–	–	–
Max Iout_LDO8	–	–	1.3 A	–	–	–	–
# of Load Switches	2	1	5	4	2	1	1
Vdropout	80 mV @ 0.8A (LV LDO)	100mV @1A (LV LDO)	130mV @1.3A (LV LDO)	250mV	250mV	250mV	250mV
PSRR	87 dB @ 100kHz (HP LDO)	87 dB @ 100kHz (HP LDO)	65 dB @ 100kHz (HV LDO)	50 dB @ 100Hz to 100kHz	50 dB @ 100Hz to 100kHz	50 dB @ 100Hz to 100kHz	50 dB @ 100Hz to 100kHz
Output Noise	13 uV @ 10Hz to 100kHz (HP LDO)	13 uV @ 10Hz to 100kHz (HP LDO)	152 uV @ 10Hz to 100kHz (HV LDO)	75 uV @ 10Hz to 100kHz	75 uV @ 10Hz to 100kHz	75 uV @ 10Hz to 100kHz	75 uV @ 10Hz to 100kHz
Current limit	Startup & Functional (Programmable)	Startup & Functional (Programmable)	Startup & Functional (Programmable)	Over-current & Short-Circuit Detection Current Limit	Over-current & Short-Circuit Detection Current Limit	Over-current & Short-Circuit Detection Current Limit	Over-current & Short-Circuit Detection Current Limit
Protection Features	ESD, OCL, OTP, UVLO	ESD, OCL, OTP, UVLO	ESD, OCL, OTP, UVLO	ESD, OCL, SCD, OTP, Read Lock	ESD, OCL, SCD, OTP, Read Lock	ESD, OCL, SCD, OTP, Read Lock	ESD, OCL, SCD, OTP, Read Lock



## 7. Conclusion

The rapid evolution of mobile and wearable devices has placed unprecedented demands on power system design, necessitating innovative solutions that can simultaneously reduce size and weight while extending battery life. Renesas' Flexible Power Islands (FPIs) represent a groundbreaking approach to these challenges, enabling designers to segment complex power systems into localized regions with dedicated control, sequencing, and regulation. This modularity enhances both performance and efficiency, allowing for highly customizable solutions tailored to specific application needs.

The SLG46580/82/83/85 device is a prime example of the FPI concept in action, which integrates essential power functions, such as monitoring, sequencing, reset, and switching within a remarkably compact 2.0 mm x 3.0 mm package. With its four programmable LDO regulators, the SLG46580 offers advanced options for slew-rate selection and fault detection, ensuring precise and reliable power management. The GreenPAK™ GUI-based Go Configure™ Software Hub simplifies the customization process further, empowering designers to quickly and easily adapt the device to their unique requirements.

The Power GreenPAK SLG46580 device is applicable across a wide range of markets, from handheld devices and wearable electronics to computing, consumer electronics, smart home applications, networking, communications, medical, and industrial sectors. The GreenPAK in combination with versatile tri-mode LDO regulators ensures high integration and reduced board size, delivering significant benefits in terms of efficiency and design flexibility. Configurable macrocells, such as analog comparators and asynchronous state machines (ASM), provide additional capabilities for power sequencing and control.

To summarize, the Power GreenPAK SLG46580/82/83/85 device offers a robust and flexible solution to the power system design challenges of modern mobile and wearable devices. By embracing these innovative technologies, designers can achieve higher performance, improved efficiency, and greater customization, meeting the ever-evolving demands of the market. Renesas remains committed to driving innovations in this field, providing tools and technologies needed to overcome the challenges of today and tomorrow.



## 8. Revision History

Revision	Date	Description
1.00	Jul 2, 2024	Initial release.

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