

GreenPAK Applications in VR and AR Headsets

Terms and Definitions

AR	Augmented Reality
DFF	D Flip-Flop
GPIO	General-Purpose Input/Output
I/O	Input/Output
LUT	Look Up Table
VR	Virtual Reality

Introduction

The demand for immersive virtual reality (VR) and augmented reality (AR) experiences continues to accelerate, driven by advancements in display technology, sensor integration, and low-latency processing. Figure 1 shows the market size for VR and AR headsets, collectively referred to as extended reality devices, over recent years and their projected growth in future years.

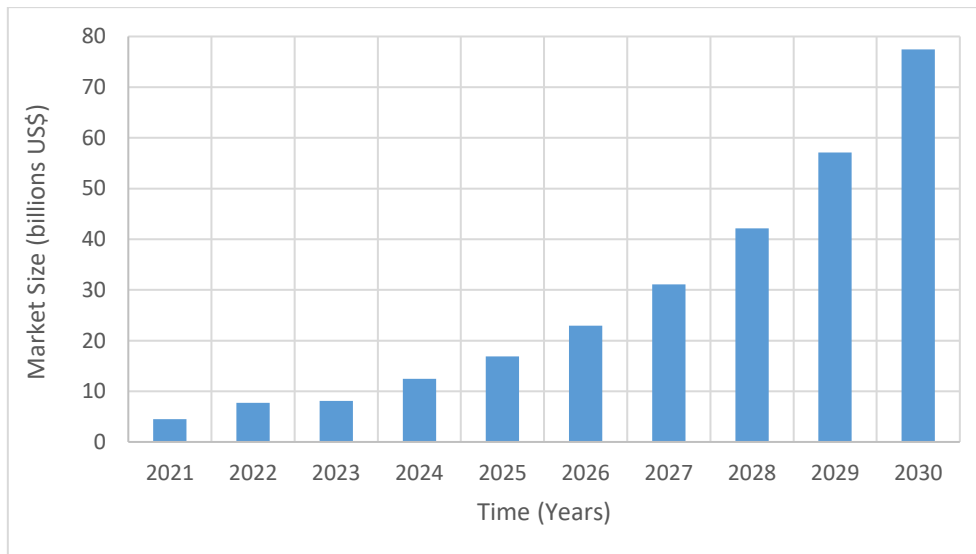


Figure 1. AR and VR Headsets Market Size*

* Source: <https://www.precedenceresearch.com/ar-and-vr-headsets-market>

Headset manufacturers face ever-increasing challenges in delivering compact, power-efficient, and responsive hardware with high-performance features while also maintaining comfort and extended battery life.

GreenPAK™ programmable mixed-signal devices provide a versatile platform for addressing these challenges. By integrating logic, timing, power sequencing, interface translation, and sensor control into a single, highly configurable IC, GreenPAK reduces component count, board space, and power consumption – key factors in next-generation VR/AR designs. This paper explores the role of GreenPAK technology in enabling the design of more efficient and more cost-effective VR/AR headsets, highlighting GreenPAK’s ability to streamline system design and while also improving both reliability and user experience.

1. Data Communication and Protocol Conversion

One important application of GreenPAK in extended reality devices is in data communication. Wearable devices are typically limited by their size and it is often necessary to convert data from parallel output to serial input and vice versa to enable communication across different components. In some cases, this involves converting more than a dozen lines of data into a single serial stream. Protocol conversion is also a common requirement as specialized protocols are often required.

GreenPAK can use its dedicated I²C or SPI macrocells to convert up to 16 data lines into the required format and also enables the implementation of custom data communication protocols (e.g. protocols such as OneWire).

For more details, refer to the Renesas application notes [I²C to SPI Converter using SLG47011V](#) and [SPI Serial to Parallel Converter](#).

2. I/O Expander

An I/O expander is a type of circuit that makes additional general-purpose input/output (GPIO) pins available to a microcontroller, processor, or SoC when the device's native GPIO count is insufficient. Instead of redesigning hardware around a larger MCU, engineers can connect a GPIO expander over a standard serial bus (most often I²C or SPI) to instantly gain additional configurable pins. These pins can be configured as either inputs or outputs, with extra features such as programmable pull-ups/pull-downs for easier signal handling and low-voltage operation, which are especially useful for battery-powered designs.

I/O expanders are widely used in space-constrained systems such as VR/AR headsets, where PCB area and MCU pin count are limited.

GreenPAK is well-suited for this application by taking advantage of its I²C macrocell. Access to the GreenPAK pin state is accomplished by a read command, and up to 16 pins can be used to increase the number of GPIOs available. Optionally, a pin can be implemented as an interrupt for continuous pin monitoring.

For a deeper dive into this particular GreenPAK application, refer to the Renesas application note [GPIO Expander/Single Wire Interface](#).

3. PCB Routing Simplification and Error Fix

In regards to PCB Routing, using GreenPAK helps to reduce the number of required PCB layers and, in general, simplifies overall PCB complexity. The Renesas GreenPAK IC enables routing of complex interconnections through its Connection Matrix which only requires a minimal PCB footprint and incurs little to no additional delay. One other advantage is that PCB errors can be corrected in the GreenPAK design rather than on the board, eliminating the need for expensive redesigns.

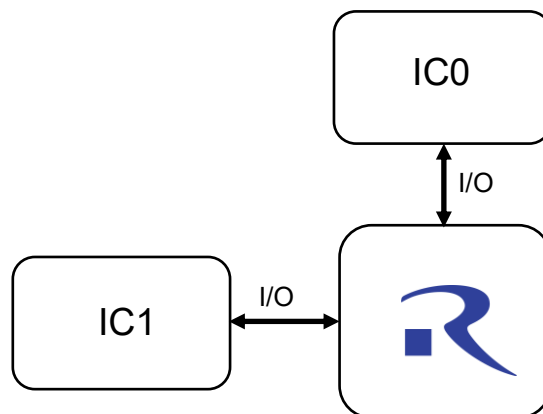


Figure 2. Block Diagram of GreenPAK as PCB Router and Error Fixer

4. Camera Noise Management

Cameras are another critical subsystem in many VR and AR headsets, providing the sensing capabilities required for accurate tracking, depth perception, and real-time environment mapping. These devices are often referred to as mixed reality systems. Camera performance directly impacts latency, field of view, resolution, and power efficiency, all of which can negatively affect the overall user experience if not accounted for.

Cameras are highly sensitive to noise, as even small fluctuations in power delivery or electromagnetic interference can degrade image quality, tracking accuracy, as well as system stability. The Renesas application note [Noise Component Role in Forming Image Quality](#) illustrates this phenomenon in detail.

Integration of multiple high-resolution sensors in compact, lightweight designs further increases the challenge of managing power integrity while also adhering to heat and space constraints. [Figure 3](#) demonstrates a conventional multi-IC solution compared to using a Power GreenPAK solution.

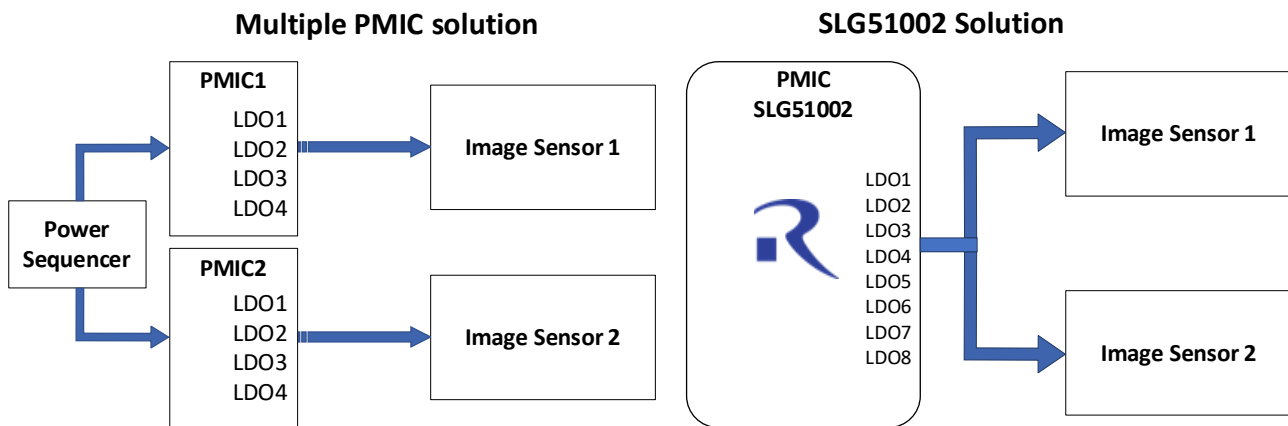


Figure 3. Comparison of Multiple PMIC Solutions with SLG51002

The Power GreenPAK subfamily of devices offers an efficient solution to these challenges by improving thermal performance, minimizing thermal noise, and ensuring that clean, stable power is available for image sensors while also meeting the stringent size, efficiency, and performance requirements of next-generation wearable systems. Additional advantages include integrated EMI filtering, low-noise operation, and simplified system integration through selectable I²C slave addresses via pin configuration. These features can be used to help streamline the design process, especially in VR and AR headsets implementing multi-camera setups where multiple PMICs may need to be used, reducing the risk of address conflicts and ensuring reliable communication with the system’s main controller.

5. Other Applications

In addition to the applications mentioned previously, GreenPAK can also be used in immersive extended reality devices as glue logic, level shifters, watchdog timers, power sequencers, voltage monitors, ship mode controllers, and many other components.

A Ship mode controller acts as an ultra-low-power button monitor that can save battery life while the product is not yet with the end user, such as while it is in transit or being “shipped” to the end user. This enables a better first experience for the user as the battery will still have charge available upon arrival. [Figure 4](#) illustrates a basic schematic of a ship mode controller based on using a GreenPAK IC (SLG46826), and [Figure 5](#) shows the internal GreenPAK design.

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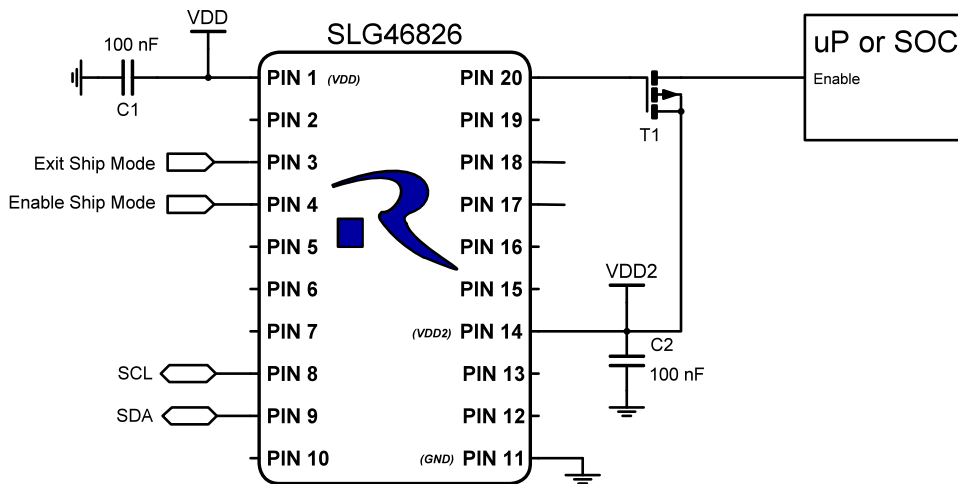


Figure 4. Basic Schematic of Ship Mode Controller

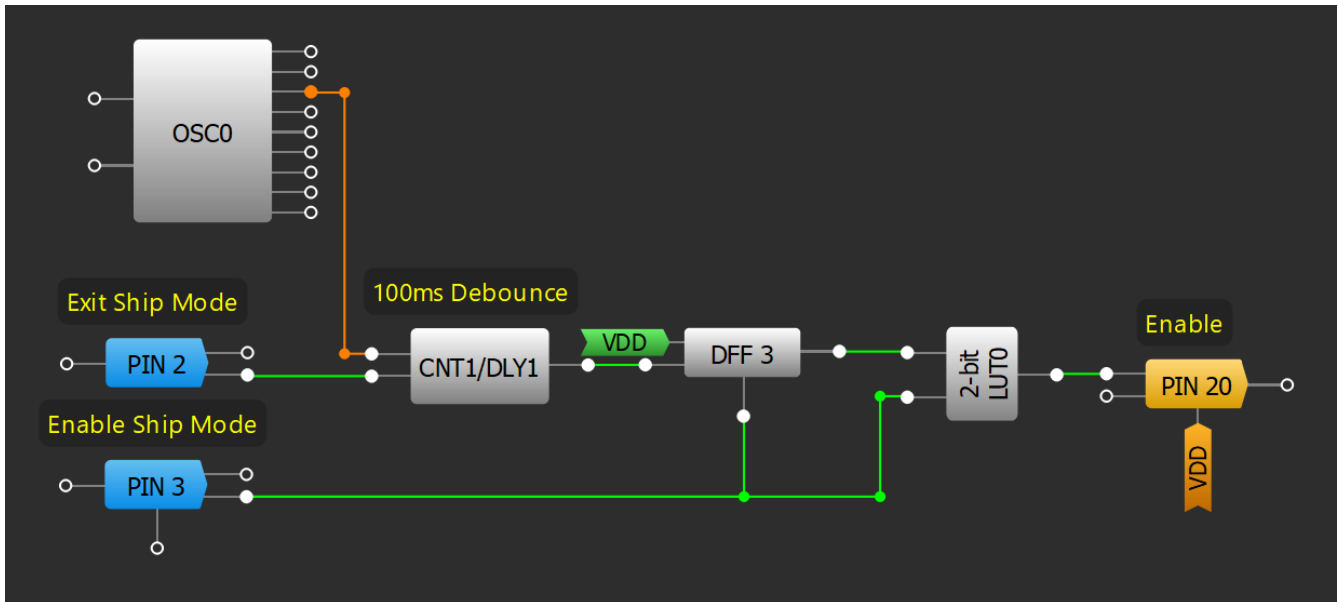


Figure 5. GreenPAK Design of a Ship Mode Controller

When a device with ship mode functionality arrives at the end user, both the Enable Ship Mode and Exit Ship Mode signals are HIGH, and the device power is disabled. Once the device's button (usually the power button) is pressed for the first time, Pin 2 is pulled LOW. After debounce macrocell filtering and inversion, DFF3 triggers on the rising edge and outputs a HIGH-level signal, which then causes LUT3 to output a HIGH-level signal, turning on the external transistor T1 and thus enabling power.

Implementing a level shifter with GreenPAK is discussed in detail in the white paper [Level Shifter Circuits - Design Basics and Applications](#).

The GreenPAK platform offers a flexible process to design a fully customizable system reset IC. Other complex, code-based integrated circuits are often vulnerable to lock-ups, which may cause issues such as reduced user satisfaction, hardware damage, safety risks, and even negative impacts on product sales. To address this, Renesas provides detailed instructions on how to implement a reset IC solution, available through the following resource: [GreenPAK Reset IC](#).

All of these applications and much more are available in the Renesas [GreenPAK Cookbook](#).

Conclusions

The rapid evolution of VR and AR headsets continues to push the boundaries of performance, power efficiency, and user experience. GreenPAK technology provides a highly flexible and cost-effective platform that addresses many of the design challenges in these types of devices.

GreenPAK is a perfect fit for VR and AR headsets, due to its PCB space efficiency and power consumption optimization. By integrating functions and their wide range of combinations, such as sensor interfacing, power sequencing, and system monitoring into a compact programmable device, GreenPAK reduces component count, minimizes board space, and lowers overall system cost.

The GreenPAK IC's flexibility not only leads to faster development cycles but also enables designers to fine-tune headset features to differentiate their extended reality devices in a highly competitive market.

By leveraging the versatility of GreenPAK, next-generation immersive technologies can deliver higher performance, extended battery life, and improved user comfort – key factors in driving widespread adoption and shaping the future of extended reality.

For more information, visit our [GreenPAK™](#) page on the Renesas website.

Revision History

Revision	Date	Description
1.00	Feb 24, 2025	Initial release.