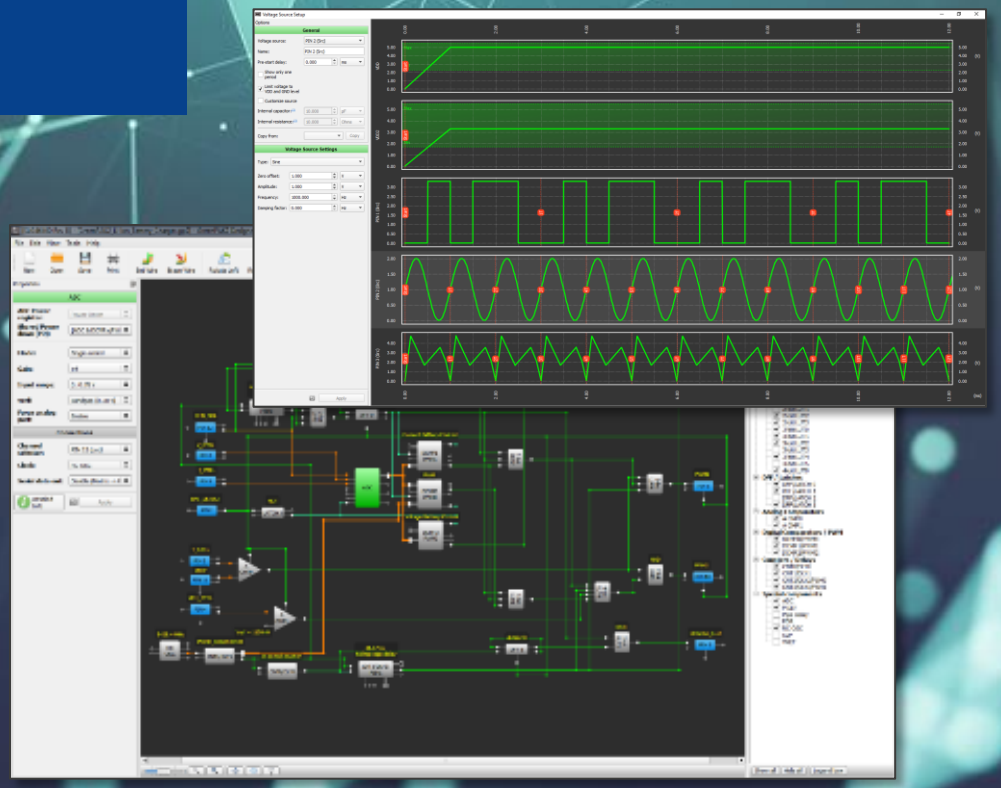
WEBINAR: GREENPAK™

PROGRAMMABLE MIXED-SIGNAL MATRIX TECHNOLOGY

FREE WEBINAR BY RENESAS AND TELSYS

APRIL 2024
SHAI BERMAN
SR. DIGITAL FIELD APPLICATION ENGINEER
RENESAS ELECTRONICS CORPORATION



WHO WE ARE

Renesas Electronics Corporation is a global semiconductor company delivering trusted **embedded design innovation with complete semiconductor solutions** that enable billions of connected, intelligent devices to enhance the way people work and live.

A **global** leader in **microcontrollers, analog, power, and SoC products**, Renesas provides comprehensive solutions for a broad range of **automotive, industrial, infrastructure, and IoT applications** that help shape a limitless future.

Headquarters

Tokyo, Japan

With strong center of gravity in Silicon Valley

Approx. 21,000 employees*

Global with >50% outside of Japan

Operating in

30+ countries

1,502.7 billion yen

In top 10 semi ranking

18% CAGR since 2019, 30% FCF

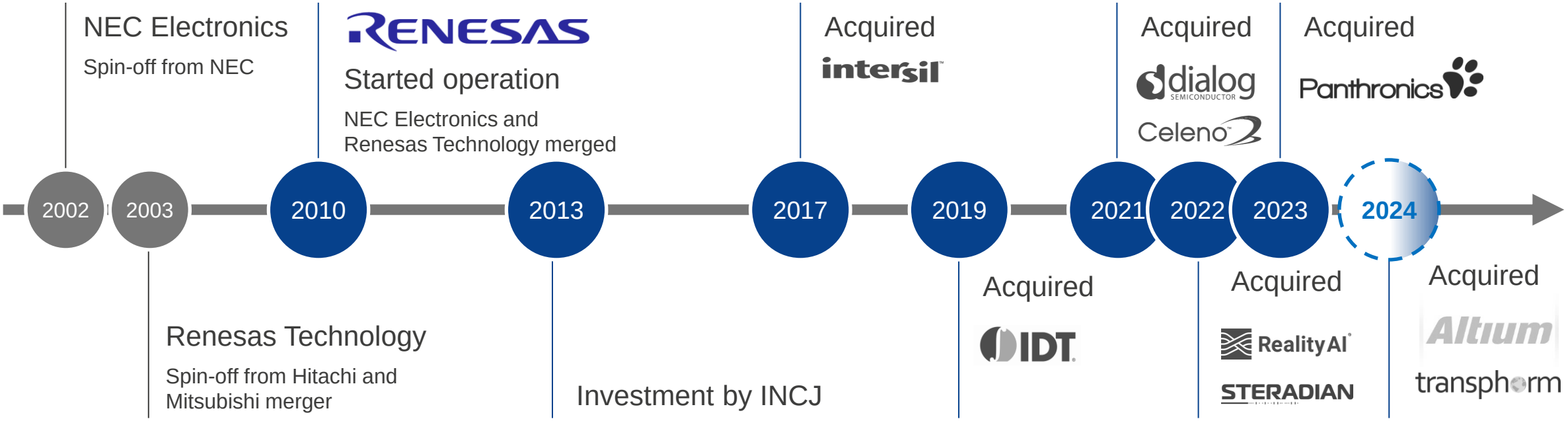
16% R&D investment

Approx. 20,000 patents & pending applications

SoC: System-on-a-chip * Consolidated, as of December 31, 2021

OUR HISTORY

Renesas is built on the foundation that combines the rich culture of technology and innovation of Hitachi, Mitsubishi and NEC. Since 2017, we have expanded our analog product portfolio through many acquisitions including Intersil, IDT, and Dialog. Renesas will continue to grow as a global leader in embedded solutions for high-growth markets: automotive, industrial/infrastructure and IoT.



Intersil: Intersil Corporation, IDT: Integrated Device Technology, Inc., Dialog: Dialog Semiconductor Plc, Celeno: Celeno Communications, Reality AI: Reality Analytics, Inc., Steradian: Steradian Semiconductors Private Limited

WHAT WE DO

Renesas delivers a vast array of semiconductor products, from sensors to actuators, across the whole signal chain to help our customers realize complete embedded systems.

Focus verticals

- Automotive
- Industrial
- Infrastructure
- IoT

Sense

- Sensor:
  optical, flow, humidity, gas, CO_2, temperature, thermopile, position, radar transceiver
- Sensor signal conditioner (SSC)

Move / Store

- Bluetooth
- Wi-Fi
- Cellular
- 6LoWPAN
- RF, RF for 5G
- Timing
- Optical
- Memory interface
- High bandwidth memory (HBM)
- NVDIMM
- Audio CODEC

Compute

- MCU
- MPU
- SoC
- ADAS / AD platform
- Gateway
- DRP / e-AI

Actuate

- Motor solution
- OIS servo-controller
- PMIC
- BMIC
- Low Iq
- Wireless power
- IGBT / MOSFET
- Programable mixed signal device / FPGA
- Haptics driver

OIS: Optical Image Stabilizer. PMIC: Power Management IC, BMIC: Battery Management IC

RENESAS POSITIONING

Microcontrollers & Microprocessors, System-on-Chips (SoCs)

RENESAS RA
Advanced 32-bit MCUs
Arm ecosystem, Advanced security, Intelligent IoT

RENESAS RZ
High-end 32/64-bit MPUs
High-resolution HMI, IoT Gateway, Vision AI
Industrial network & real-time control

RISC-V products
General-purpose 64-bit MPUs (RZ/Five)
Application-specific 32-bit MCUs

RENESAS RX
High Power Efficiently 32-bit MCUs
Motor control, Capacitive touch, Functional safety, GUI

RENESAS RL78
Ultra-low Energy 8/16-bit MCUs
Bluetooth® Low Energy, SubGHz, LoRa®-based Solutions
Automotive actuators & sensors, Low-end ECUs

RENESAS RH850
Automotive 32-bit MCUs
Rich functional safety and embedded security features

RENESAS R-Car
Automotive SoCs
Next generation of automotive computing

Analog and Power Devices

- Analog products
- Clocks & Timing
- Interface & Connectivity
- Memory & Logic
- Power & Power management
- Programmable Mixed-signal, ASIC, & IP products
- RF products
- Sensor products
- Space & Harsh environment

- Timing
- Wireless Power
- Battery Management
- Power Devices
- Power Management
- Sensors
- Video & Display

AGENDA

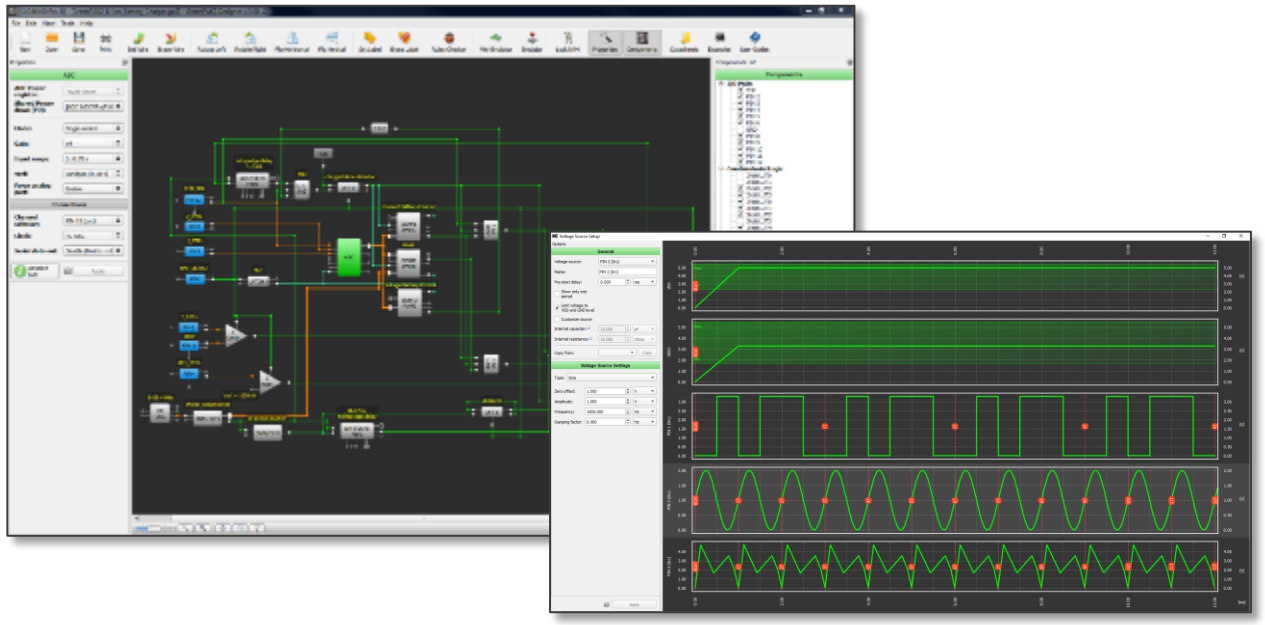
- Introduction to GreenPAK
- Great Tools, Great IDE. Design Fast.
- Applications & Support
- A Wide Family of Products
- ForgeFPGA (just a bit)
- Roadmap
- Live demonstration and Q/A

GREENPAK

Integrate Many System Functions to Minimize Components, Reduce PCB Space, and Lower Power

GreenPAK is ideal for

- Functional replacement of popular mixed-signal standard products and stand-alone discrete circuits
- Providing reliable hardware supervisory functions for devices such as SoCs and Microcontrollers

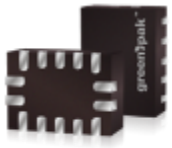


Easy & fast development tools

- GUI-based GreenPAK Designer software
- Development Kits for circuit emulation and IC programming

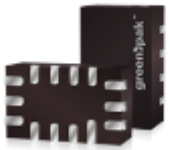
1.0 mm x 1.2 mm
0.4 mm pitch
STQFN
8-pin package

1.6 mm x 1.6 mm
0.4 mm pitch
STQFN
12-pin package



1.6 mm x 2.0 mm
0.4 mm pitch
STQFN
14-pin package

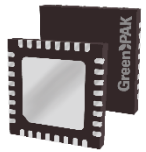
2.0 mm x 2.2 mm
0.4 mm pitch
STQFN
14-pin package



1.6 mm x 2.5 mm
0.4 mm pitch
STQFN
14-pin package

2.0 mm x 3.0 mm
0.4 mm pitch
STQFN
20-pin package

2.0 mm x 2.2 mm
0.4 mm pitch
MSTQFN
22-pin package

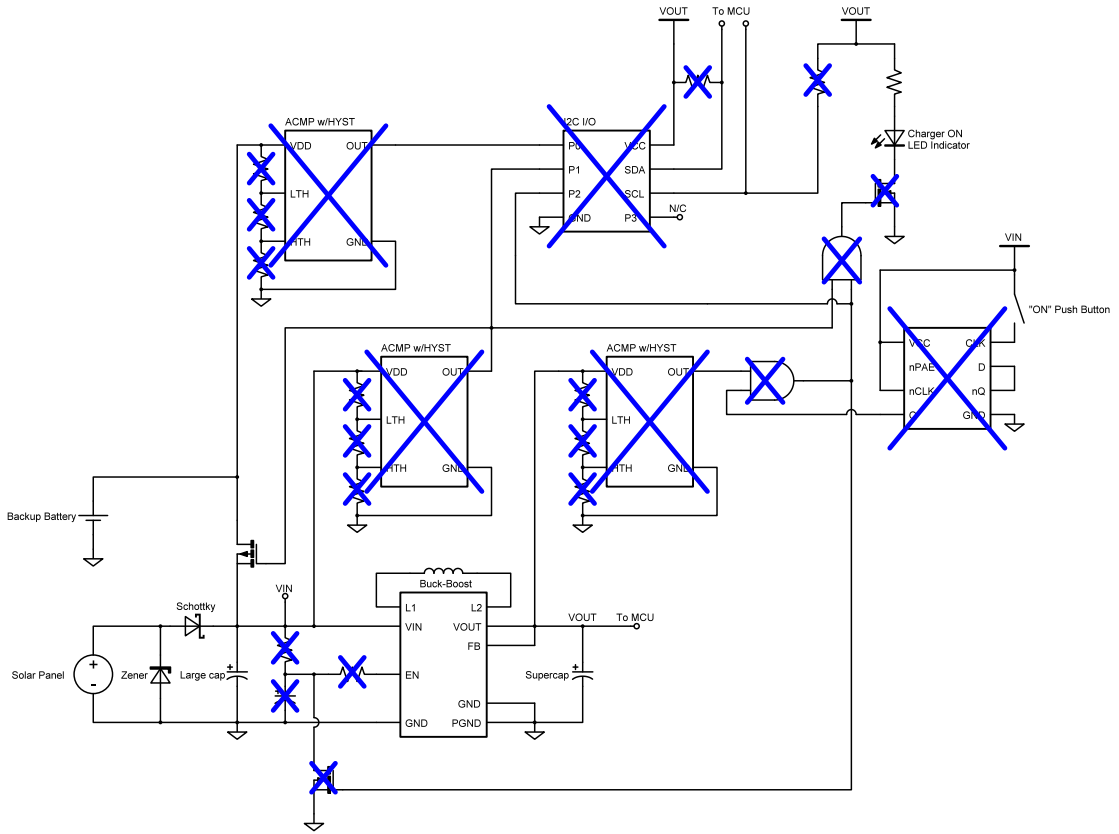


4.0 mm x 4.0 mm
0.4 mm pitch
STQFN
32-pin package

THE GREENPAK APPROACH

Example: IOT Power Charger

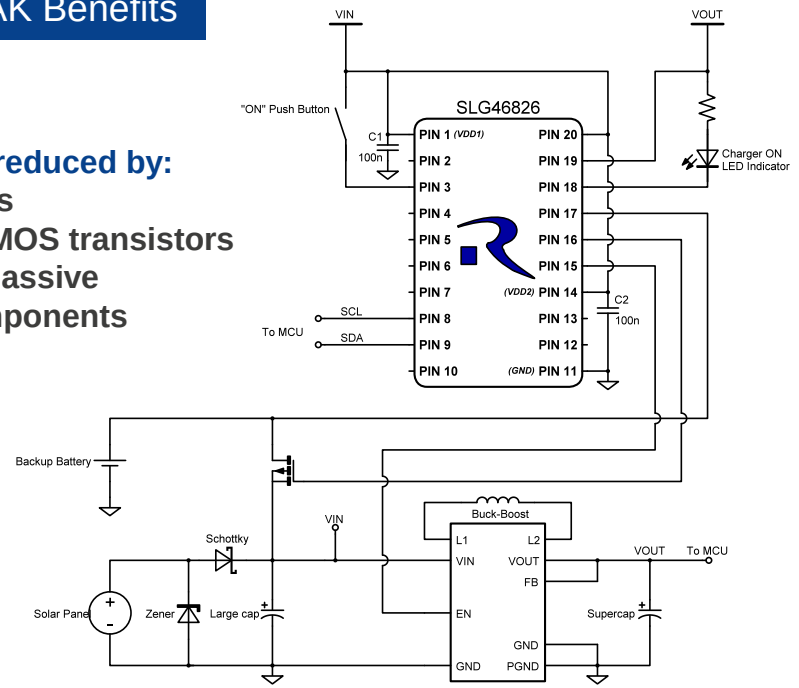
Original Design



GreenPAK Benefits

Design reduced by:

- 5 ICs
- 2 NMOS transistors
- 14 passive components



Value	Approx. savings with GreenPAK
Layout Size	17.8 mm^2
Cost Savings	$ 1.33

WHAT ARE THE GREENPAK BENEFITS?

Integrate and Differentiate

Implement new features and functionality in one device as small as 1.0 mm x 1.2 mm

Shrink PCB Footprint

Fewer components and less routing complexity

Reduce Power Consumption

Extend battery life by powering fewer discrete devices and dynamically managing power within the GreenPAK

Adapt Design as Needed

Adapt to changing requirements quickly and spin new prototypes in minutes

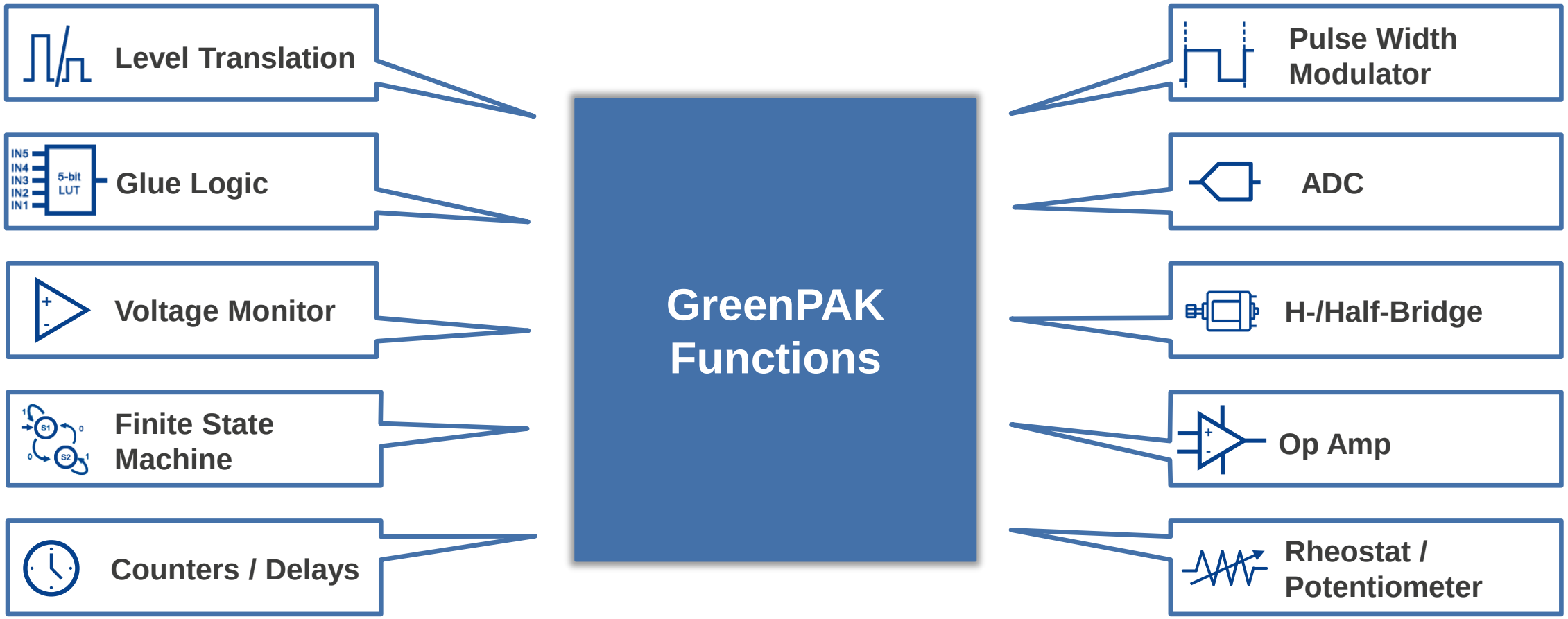
Faster Time to Market

Development tools exploit the power of silicon without NRE charges and long lead times

Secure

Circuit implementation is not visible to competition

WHAT CAN I DO WITH GREENPAK?

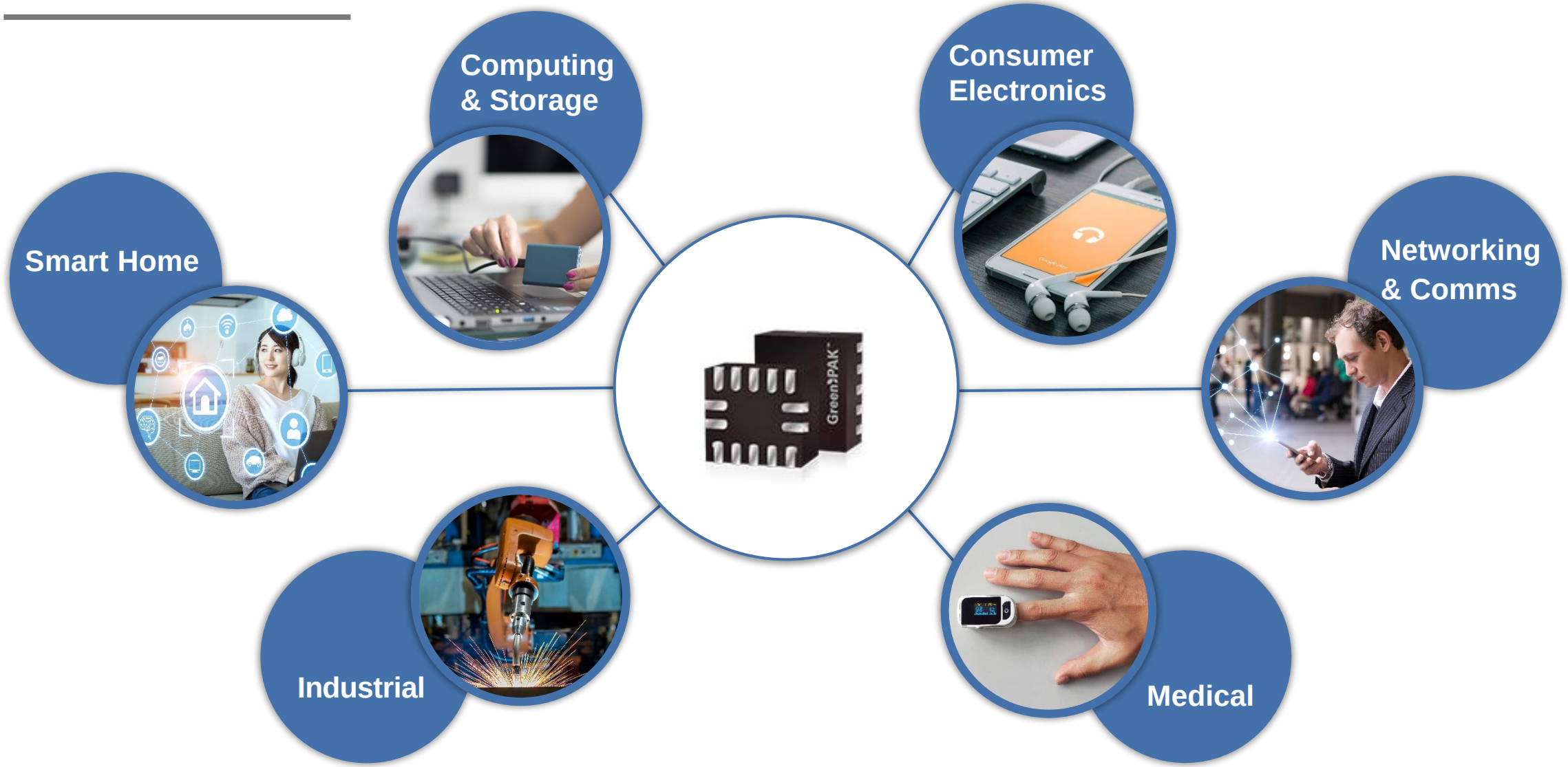


WHAT CAN I DO WITH GREENPAK? - APPLICATIONS

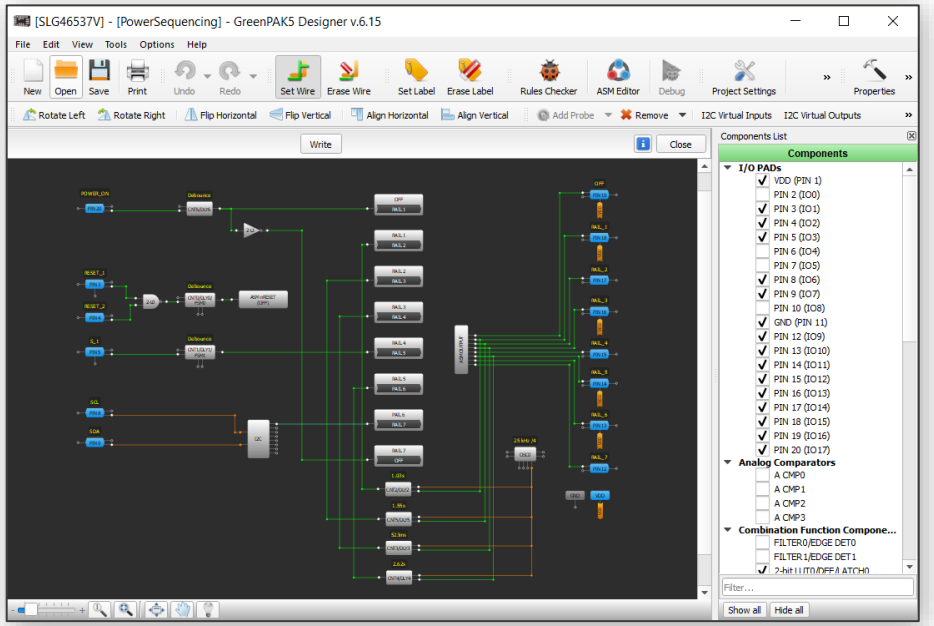
- Power Sequencing
- Supervisory Circuits
- System Reset
- Voltage Detection
- LED Control
- Motor & Fan Control

- Frequency Detection
- Sensor Interface
- Port Detection
- Temperature Control
- Coulomb Counter

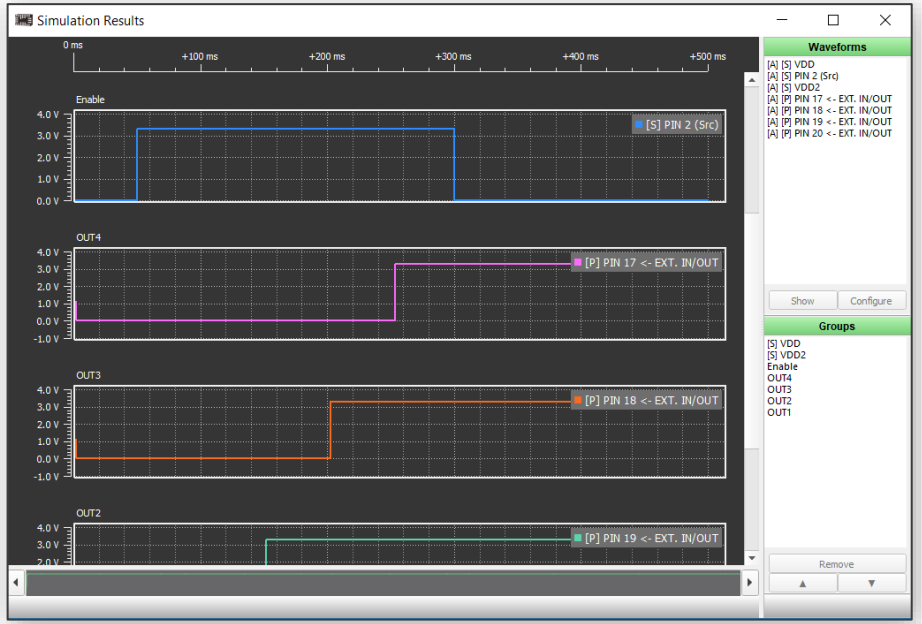
GREENPAK TARGET MARKETS



CREATE DESIGNS QUICKLY & EFFICIENTLY



- ✓ Supports design creation, emulation & IC programming
- ✓ GUI-based schematic capture approach to design entry
- ✓ Allows real-time design iterations



- ✓ SPICE simulation available for select families
- ✓ Software configurable function generators for design validation

Download for free at [Go Configure™ Software Hub | Renesas]

GREENPAK DESIGN DEVELOPMENT PROCESS

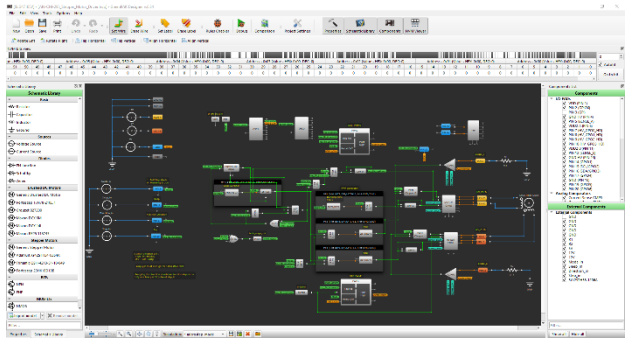
Design in minutes
Prototype in hours

No NRE

- Development with GreenPAK is **FAST**
- Create a custom design and debug with Evaluation Kit, or program individual ICs at your fingertips

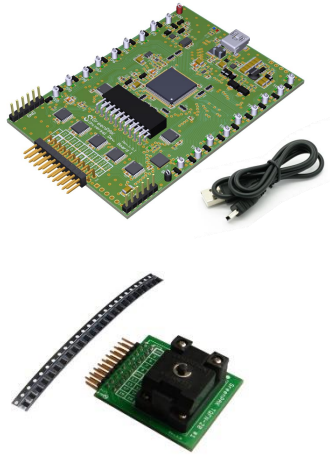
Design Revisions?

Ready for Production Samples?

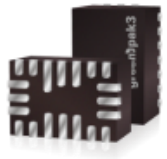


GreenPAK Design Created
Design in as little as a few minutes with the FREE Go Configure Software Hub.

Circuit design is done via SW
No EVK needed for creation of design!



Can Use EVK to Test & Debug*
Custom design can be tested with EVK or **FREE** samples requested from Renesas



Program at Your Desk
Can program prototype ICs at your fingertips or ask Renesas for **FREE** programmed samples

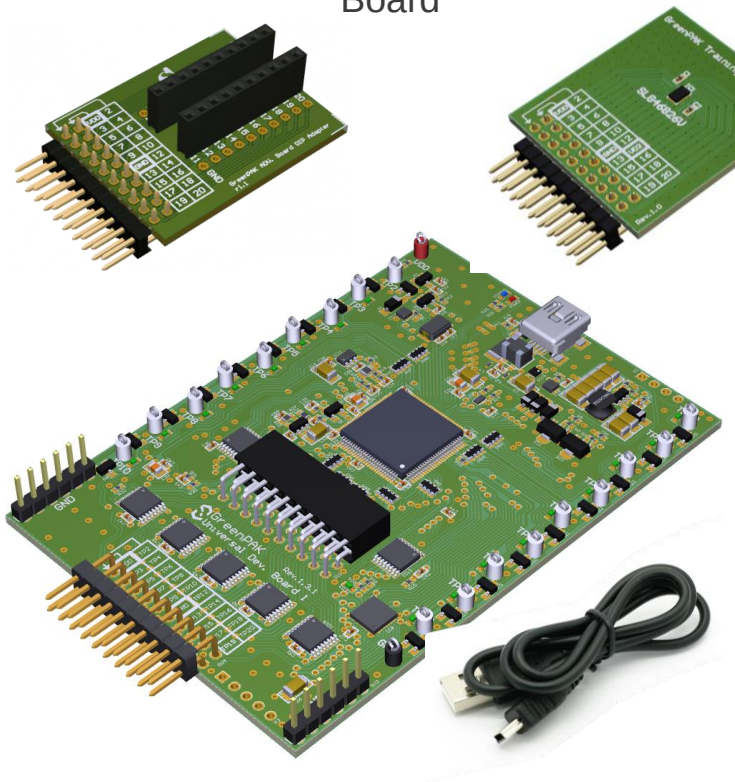
Production Samples Process Covered on Next Slide

GREENPAK DEVELOPMENT HARDWARE OPTIONS

- USB interface
- MacOS, Windows and Linux compatible
- Expansion header for connection to external test equipment*
- Integrated signal and logic generators*
- LEDs for visual indication*
- DIP form or Sockets for easy programming**

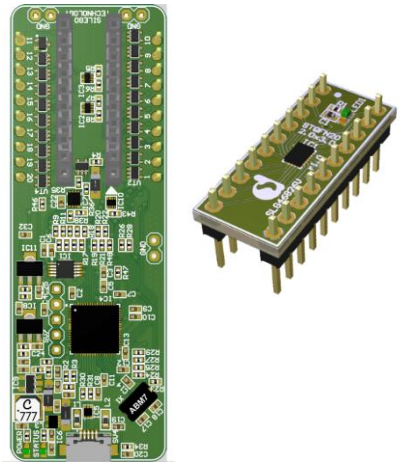
* Features only in Advanced Development Board
** Features only in DIP Development Board

Advanced Development Board



or

DIP Development Board and DIP Adapter



Available online from local/global distribution partners!

GREENPAK SAMPLE & PRODUCTION FLOW

Custom Datasheet

No Production Commitment

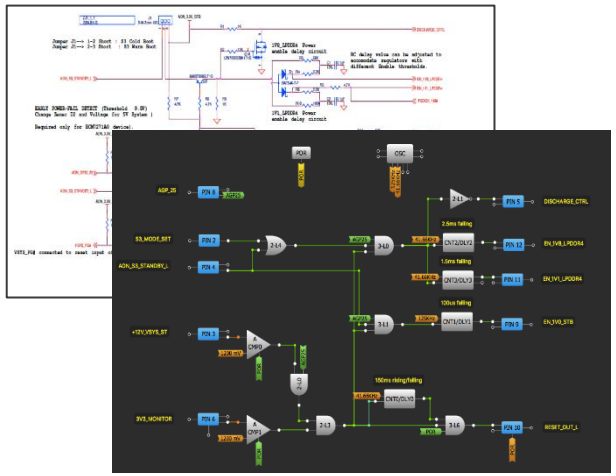
8 Week Production Lead-time

- Design changes can be made throughout the development cycle
- Datasheet revision and part top markings reflect different versions of the device through development

Design Revisions?

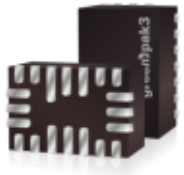
Design Finalized?

Production



72 Hours

7-14 Days



8 weeks

GreenPAK Design Created
Submit design to Renesas

Datasheet Generated
Customer specific part number & datasheet generated

Need Samples?
FREE Programmed samples arrive within 7-14 days

Purchase Production Parts
8 Week Lead Time

A WIDE FAMILY OF PRODUCTS FOR MANY APPLICATIONS

Overview of Existing Subfamilies

GreenPAK

- Dual Supply GreenPAK
- GreenPAK with Load Switches
- GreenPAK with Asynchronous State Machine
- GreenPAK with Low Drop Out Regulators
- GreenPAK with In-System Programmability
- PN*: SLG46*xxx* and SLG47*xxx*

More Info

HVPAK

- Programmable Mixed-Signal ASIC with High Voltage Features
- Integrated High Voltage up to 26.4 V and High Current up 3 A Output Drivers
- PN: SLG471*xx*

More Info

AnalogPAK

- Programmable Mixed-Signal ASIC with Analog Features
- Rich set of analog blocks (OpAmp's, digital rheostats, etc.)
- MTP NVM with in-system programmability
- PN: SLG470*xx*

More Info

Automotive GreenPAK

- Cost-effective NVM programmable devices allowing to integrate many system functions into a single AEC-Q100 qualified IC
- PN: SLG46*xxx*-A

More Info

PowerPAK

- High PSRR, low noise multi-output LDO IC for advanced camera and sensor systems
- PN: SLG5100*x*

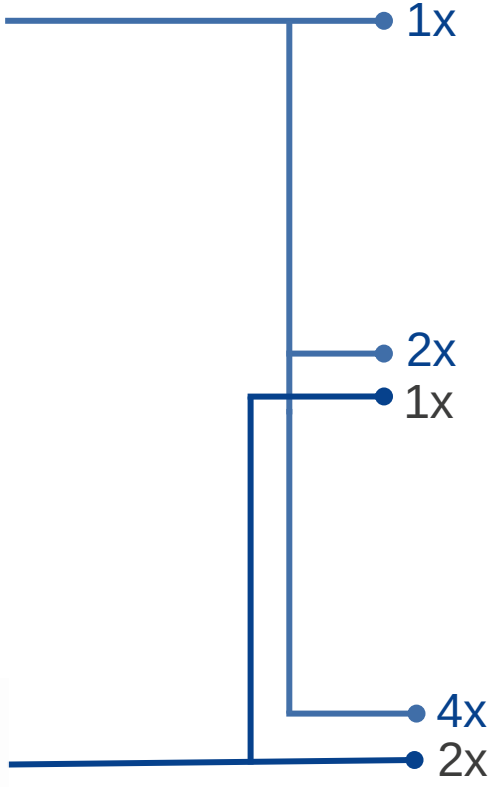
More Info

* PN stands for part number

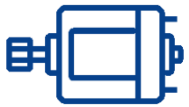
GET YOUR MOTOR RUN WITH HVPAK

- **4** High Voltage High Current Outputs
- Power Supply Voltage up to **13.2 V**
- Up to **2 A** Current per Output

- **2** High Voltage High Current Outputs
- Power Supply Voltage up to **26.4 V**
- Up to **3 A** Current per Output



Stepper Motor:
- Full-, Half-, Microstep Mode
- Configurable Current Limit
- Configurable Fault Monitor
- Sleep Mode

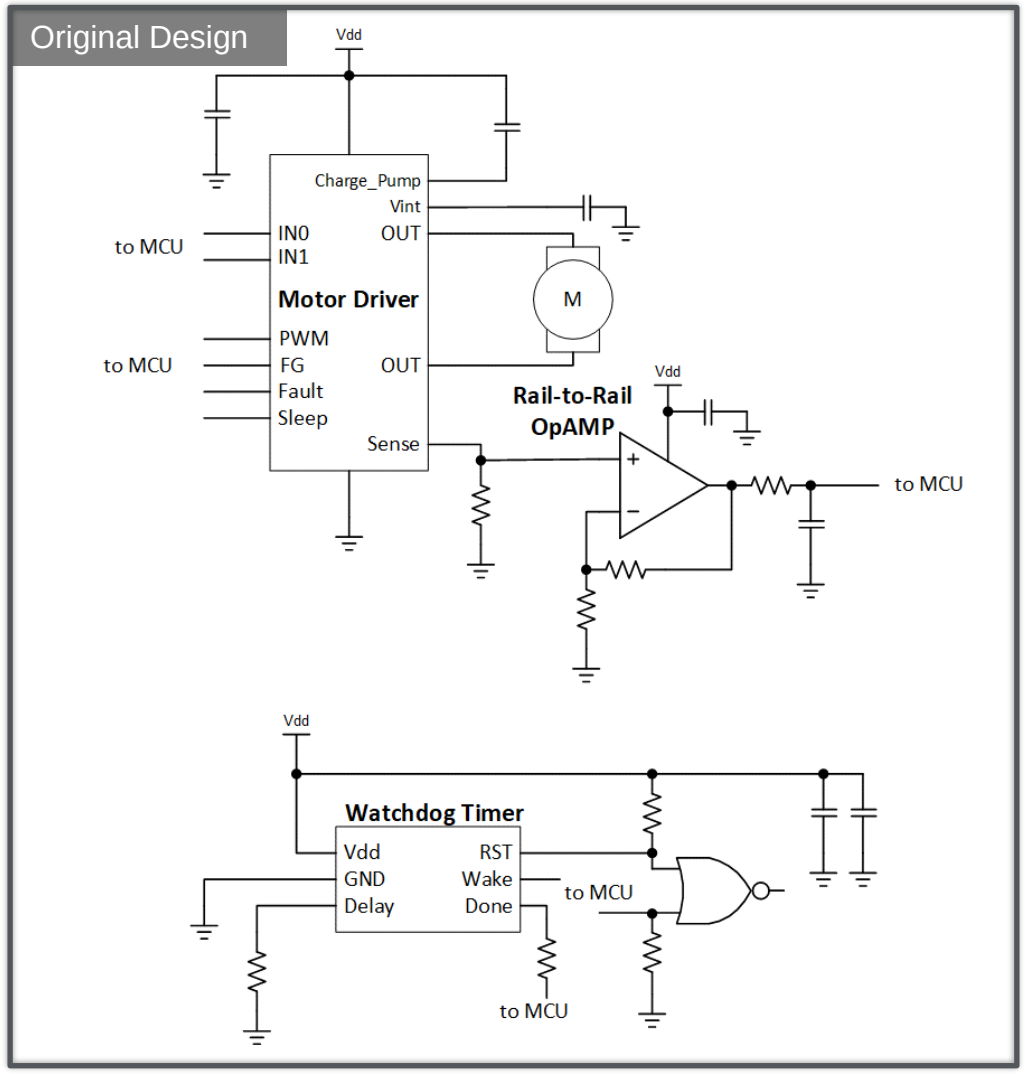


DC Motors:
- Constant Voltage Mode
- Constant Current Mode
- Custom Current Sensing
- Custom Fault Monitor
- PWM Soft start

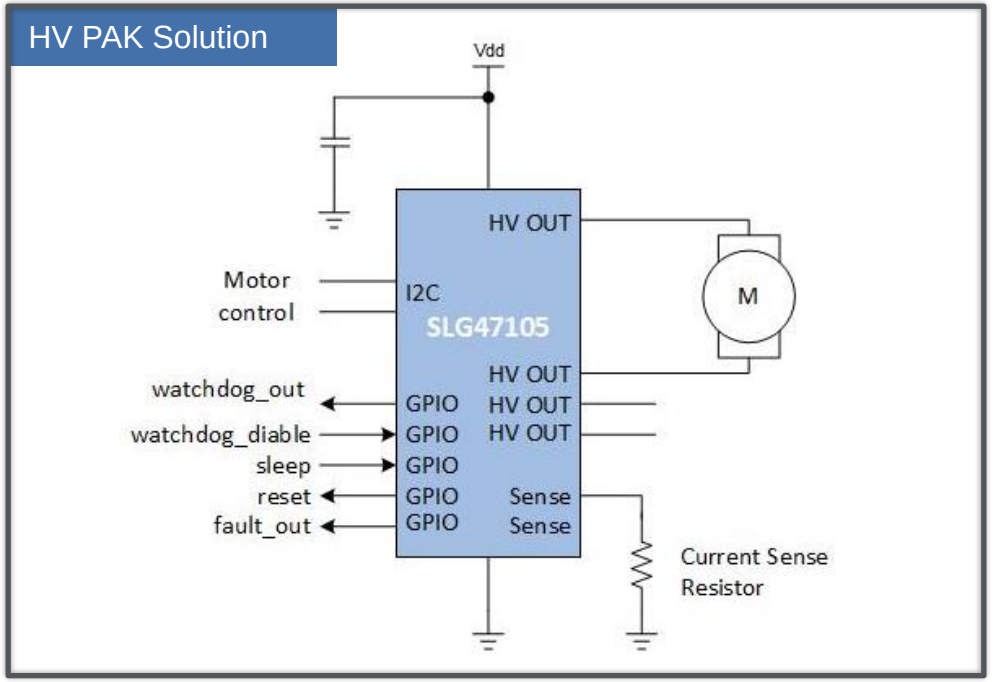
Solenoids:
- Don’t need external diode for relay coil
- Multi-drivers
- Zero-Crossing Detection

HVPAK APPROACH: SMART LOCK DESIGN

Original Design



HV PAK Solution

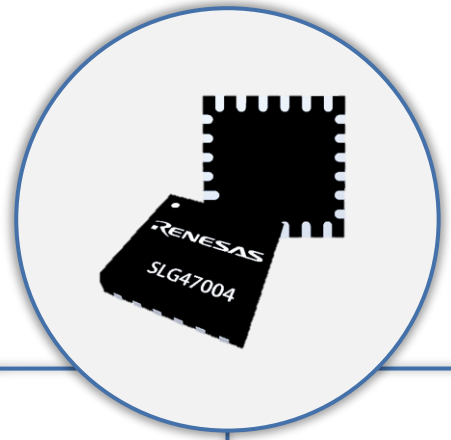


Design reduced by:

- 4 ICs
- 14 passive components
- reduced current consumption by four times

WHAT IS ANALOGPAK?

AnalogPAK Product Introduction



- Integration of New Analog Resources:
  - Two Op Amps (3-opamp InAmp)
  - Two 10-bit Rheostats
  - Two Analog Switches

- Traditional Features:
  - Configurable Digital Logic Cells, Oscillators, ACMPs
  - I^2C Communication
  - Multi-Time Programmable Memory (NVM + EEPROM)

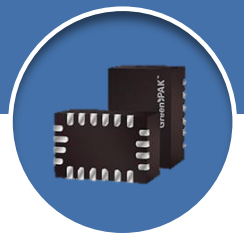
- Unique Auto-Trim Solution:
  - Tunable Amplifiers & Filters
  - Tolerance, Drift, & Error Compensation

GREENPAK ICS NEW FEATURES

- Low current consumption (200 nA – 300 µA)
- In-system programmable
  through I^2C port (ISP) in SLG46824 and SLG46826
- Temperature range up to 105 °C (for automotive ICs)
- LDO up to 4 x 150 mA / Load Switches 2 x 2 A / DC/DC
- State machine up to 12 states –
  zero current consumption, no clock needed

STAND OUT FEATURES OF SLG46824/SLG46826 AND SLG47004

SLG46824/SLG46826 Features

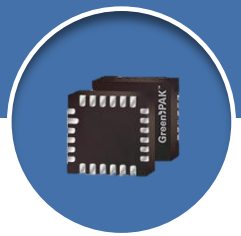


- Two low power ACMPs and two high speed ACMPs
- In-System Programmable through I2C port (ISP)
- Multi-Time Programmable (MTP / 1K Erase/Write cycles)
- 2k bits of memory for independent customer use (EEPROM emulation)
- Analog temperature sensor
- Multi-Function Macrocells
- 2.0 mm x 3.0 mm, 20-pin TQFN

Very Low Current Consumption

- VDD applied, no blocks active: 80 nA
- Lower power consumption for ACMPs:
  - Each of these devices includes two ACMPs optimized for low power
- AnalogPAK OpAmps power consumption depends on selectable bandwidth:
  - 33/90/237/611 µA
- Low power 2.048 kHz oscillator:
  - 370 nA typical when VDD = 3.3 V

AnalogPAK™ SLG47004 Features



- Rich set of analog blocks (op amps, in amp mode, digital rheostats etc.)
- Unique Auto-Trim Feature
- EEPROM, multi-time programmable NVM, and in-system programmability
- Three fully configurable Op Amps
- Two 10-bit 100 kOhm digital rheostats
- Power saving features for all blocks
- 3.0 mm x 3.0 mm, 24-pin STQFN

NEW ROADMAP DEVICES SLG46880/1 AND SLG46855 HIGHLIGHTS

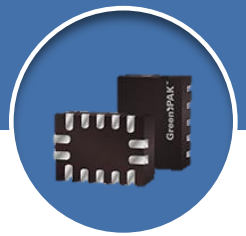
SLG46880 and SLG46881 Features

- 12 state ASM with 84 possible state transitions
- Two low power ACMPs and two high speed ACMPs
- (f1) computation macrocell
- Analog temperature sensor
- 4.0 mm x 4.0 mm, 32-pin TQFN

Very Low Current Consumption

- VDD applied, no blocks active: 80 nA
- Lower power consumption for ACMPs:
  - Each of these devices includes two ACMPs optimized for low power
  - 1.9 µA typical for one ACMP with internal VREF
  - 1.0 µA typical for one ACMP with external VREF
- Low power 2.048 kHz oscillator:
  - 370 nA typical when VDD = 3.3 V

SLG46855 Features



- Two low power ACMPs and two high speed ACMPs
- Multi-Function Macrocells
- Analog temperature sensor
- 1.6 mm x 2.0 mm, 14-pin STQFN

NEW ROADMAP DEVICES SLG4658X AND SLG46585 HIGHLIGHTS

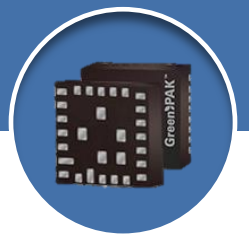
SLG46580, SLG46582 and SLG46583 Features

- Integrated, programmable LDOs
  - Four 150 mA channels (SLG46580)
  - Two 300 mA channels (SLG46582)
  - One 600 mA channel (SLG46583)
  - Each channel can be programmed as a load switch
  - Low power modes available
- 8-state ASM
- Analog temperature sensor
- 2.0 mm x 3.0 mm, 20-pin STQFN

Very Low Current Consumption

- VDD applied, no blocks active: 80 nA
- Low power 2.048 kHz oscillator:
  - 370 nA typical when VDD = 3.3 V

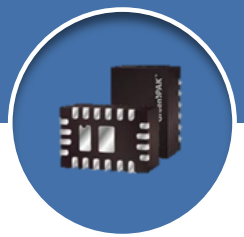
SLG46585 Features



- 1 A DC/DC Buck Converter with programmable output voltage
- Integrated, programmable LDOs
  - Four 150 mA channels
  - Each channel can be programmed as a load switch
  - Low power modes available
- 8-state ASM
- Analog temperature sensor
- 3.0 mm x 3.0 mm, 29-pin MSTQFN

HVPAK™ HIGHLIGHTS

SLG47105 Features

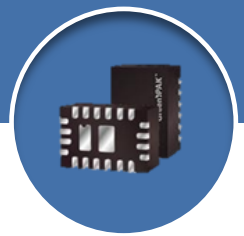


- **4** High Voltage Hight Current Outputs
- Power Supply Voltage up to **13.2 V**
- Up to 2 A Current per Output
- 8 Configurable General Purpose In/Out
- 20-pin STQFN package

Very Low Current Consumption

- VDD applied, no blocks active: 80 nA
- Low power 2.048 kHz oscillator:
  - 370 nA typical when VDD = 3.3 V

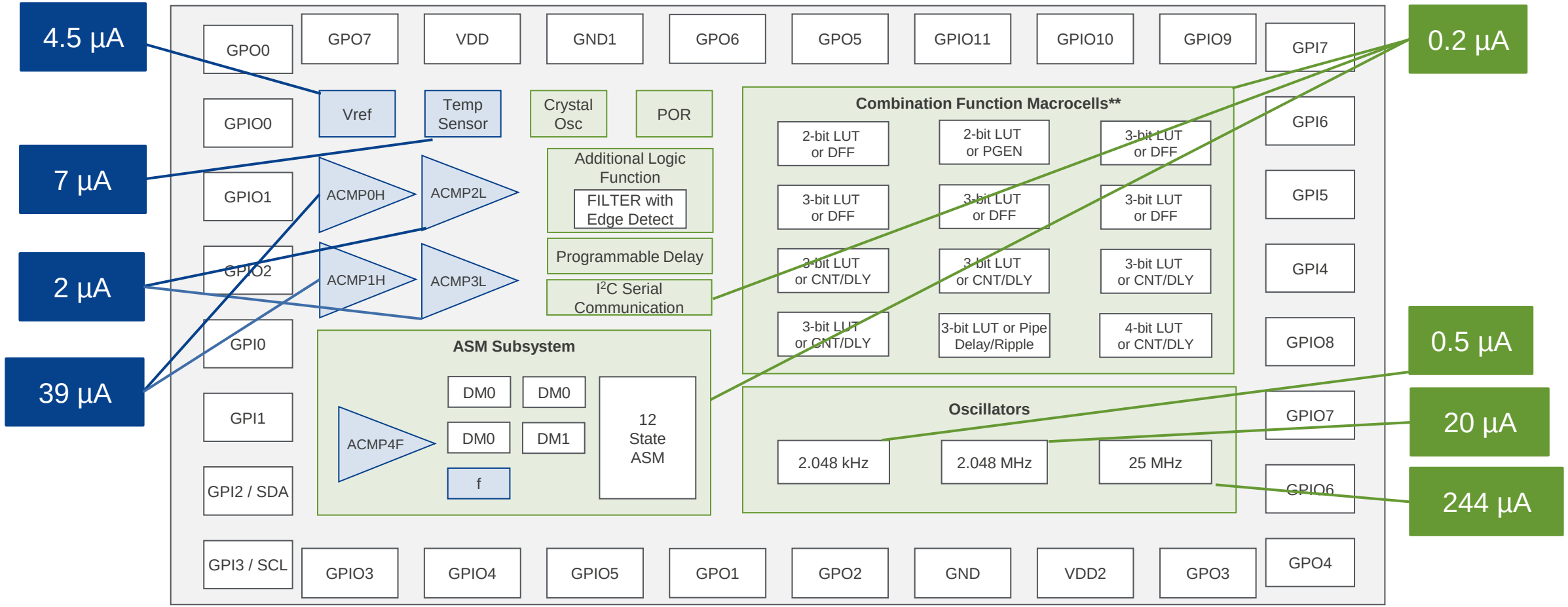
SLG47115 Features



- **2** High Voltage Hight Current Outputs
- Power Supply Voltage up to **26.4 V**
- Up to 3 A Current per Output
- 8 Configurable General Purpose In/Out
- 20-pin STQFN package

CURRENT CONSUMPTION

Digital (Green) Versus Analog (Blue) Blocks Current Consumption*

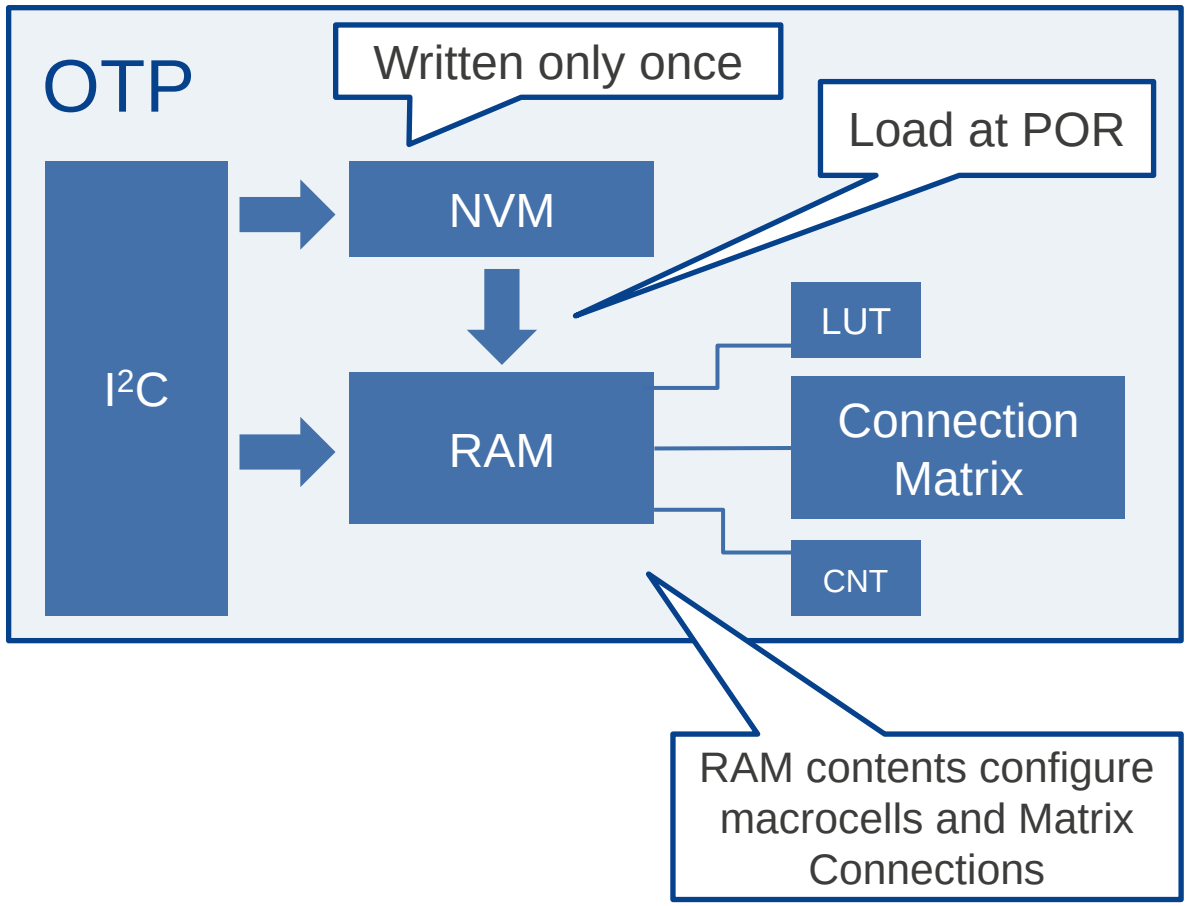


*current consumption of SLG46880 and SGL46881 under V_{DD} = 5 V

** Combination Function Macrocells current consumption equals to 0 µA

STRUCTURE OF THE GREENPAK IC MEMORY

How IC Memory Works in OTP and MTP/ISP Circuits



- During start NVM memory is emulated to RAM.
- Inside the NVM, there is a specifically dedicated protection page, MTP enables to change security settings.

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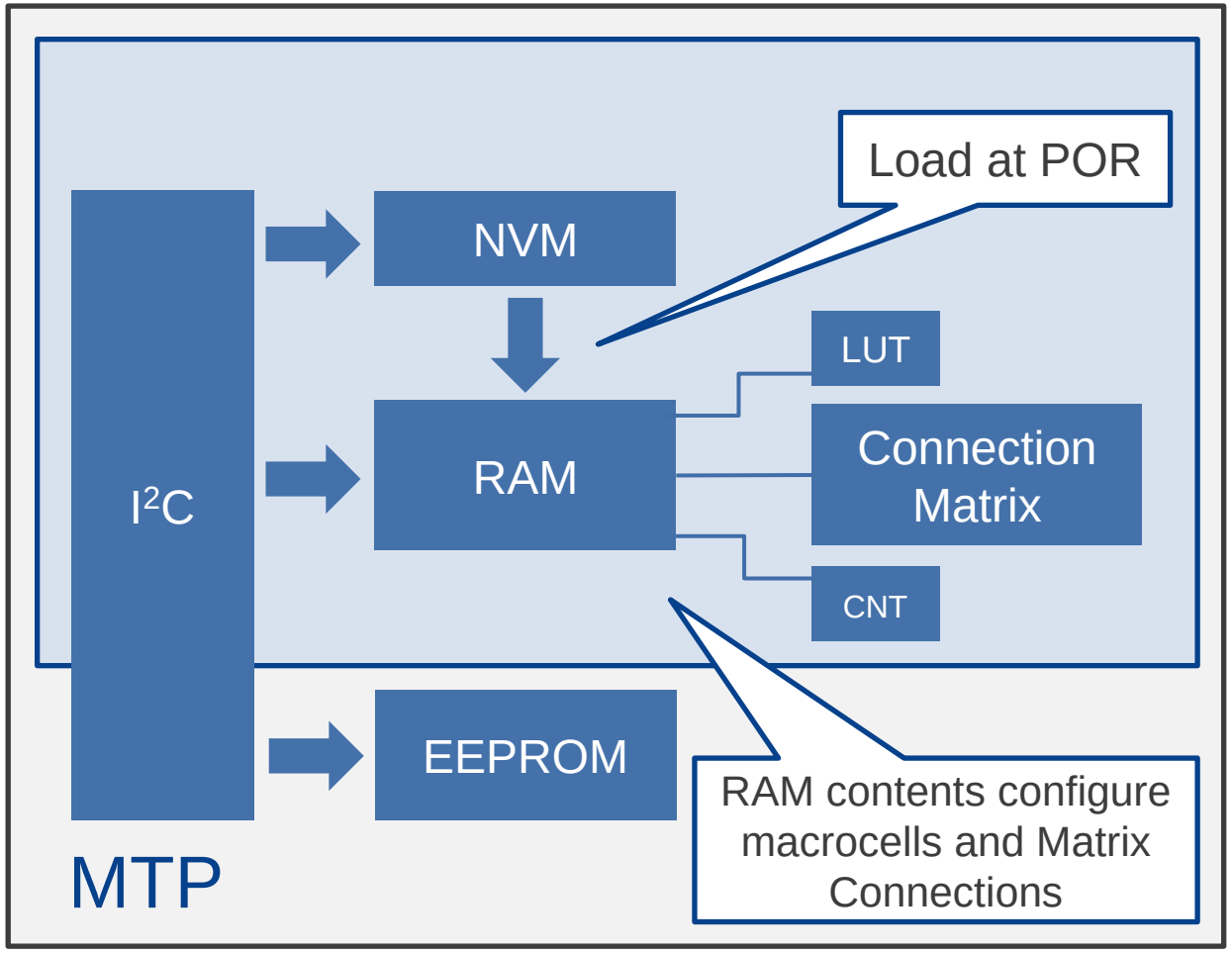


- During start NVM memory is emulated to RAM.
- Inside the NVM, there is a specifically dedicated protection page, MTP enables to change security settings.

WHAT IS THE DIFFERENCE BETWEEN OTP AND ISP DEVICES?

Discover What Fits Your Expectations

Comparison Area	One Time Programmable	Multiple Time / In-System Programmable
Optimized for:	Lower per unit cost	Greatest flexibility
Most popular programming scenario	Programmed in Renesas factory (sold in custom-tested and custom-marked form)	Programmed by customer during final test using I^2C connection (sold in unprogrammed form)
Other programming options	No other options available	Programmed in Renesas factory Programming upgrade in the filed (requires other components in system to provide programming information)
Additional benefits		Programming can be changed in previously programmed devices (avoids inventory obsolescence)

DEPENDABLE HIGH-VOLUME PRODUCTION

Over 5 Billion
GreenPAK and GreenFET™ ICs Delivered!

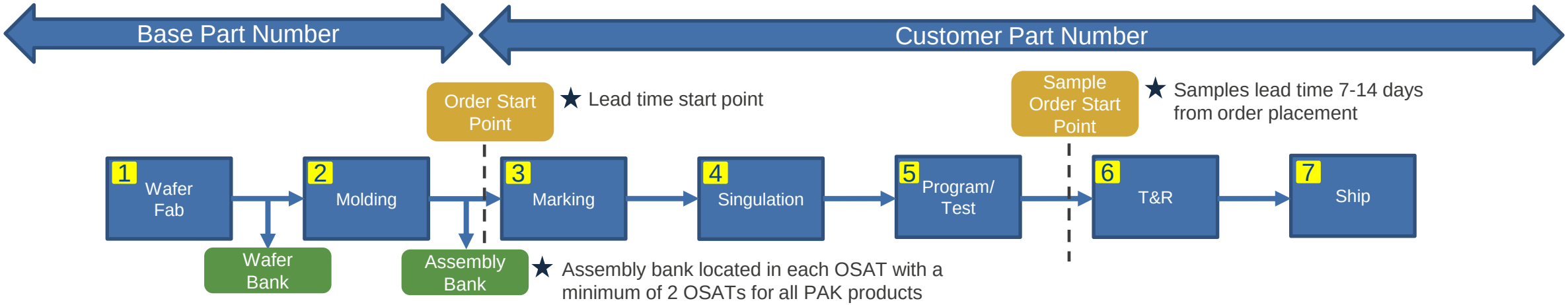
Availability and Continuity of Supply

- Standard CMOS and packaging with a flexible inventory system
- Rapidly expanding product offering to achieve a wide range of price points
- Engineering support centers and distributor hubs located globally

Custom Silicon at Commodity Prices

- BOM, board space, cost and vendor reduction
- Cost effective analog solution by trimming for operating condition

PRODUCTION&SAMPLE GREENPAK DEVICES – SUPPLY CHAIN FLOW



1: Wafer Fab & Wafer Bank

- TSMC 180 Mixed Signal wafer process
- Mature wafer process – not going anywhere & not constrained
- Wafer banks hold prepared wafers
- Very large inventory of wafers
- We do not wait on new wafer fabs for new orders – grab from bank
- Millions of devices in bank ready for molding

2: Molding & Assembly Bank

- Molded into large sheets for processing (QFN)
- Tens of thousands devices per sheet
- Very large inventory of molded sheets in Assembly Bank
- Millions of blank ready-to-go devices
- Ready for customer orders
- Quoted lead time is from Assembly Bank (step 2) to Ship (step 7)

3-5: Prepared Blank ICs

- Material taken from Assembly Bank
- **3:** Sheets divided into individual ICs
- **4:** All ICs individually tested & verified for function
- **5:** Devices packaged into tape & reel

6 & 7: Sample Order Point

- **6:** Parts are programmed, tested, marked accordingly, & packaged
- **7:** Sample parts shipped to customer
- Approximate timeline for **PROGRAMMED** samples is 7-14 days

FORGEFPGA (SLG47910)

GOING BEYOND GREENPAK

Renesas has had HUGE success selling GreenPAK

GreenPAK customers

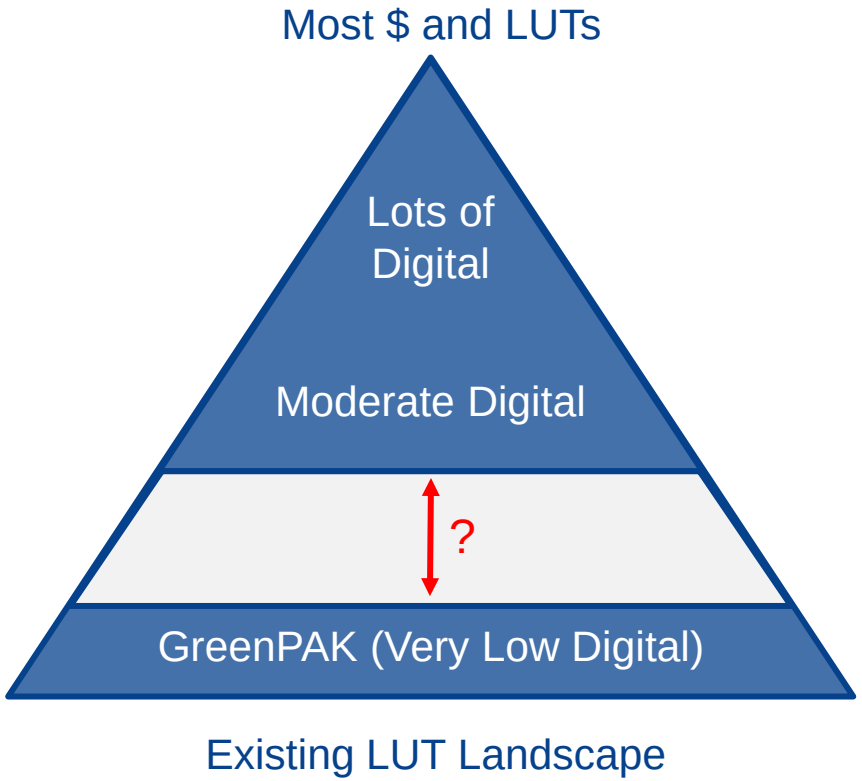
"This part is great, but I also want…

…more low-power data buffering …

… A different (or custom) interface…

… digital processing my sensors…

…and keep it cheap!"



- We will support customers with logic resources above existing GreenPAK.
- A small, cheap FPGA fills the digital resource gap between GreenPAK and larger, more expensive solutions.

SLG47910 OVERVIEW (1K FPGA)

Development

Sampling Now

1k Digital Logic Core

- 900 4-bit LUT equivalents
- 1.8k DFFs
- 5kb distributed memory
- 32kb EBRAM
- OTP Non-Volatile Memory
- 19 Digital GPIO

Power Supply

- VDDIO: 1.71 V to 3.6 V
- VDDCore: 1.1 V (+-10%)
- Power Gating Structure & Data Retention

High-Freq 50MHz Oscillator

- 3.4 MHz Low-power Mode

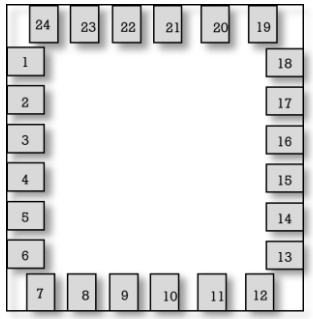
Phase-Locked Loop (PLL)

- Input from OSC or external source

Less than $0.50 in high volume

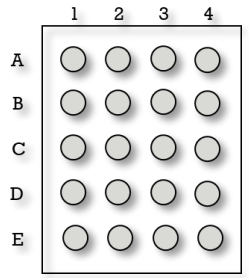
Package Options

SLG47910V



24-pin MSTQFN 0.4P
3.0 mm x 3.0 mm

SLG47910C



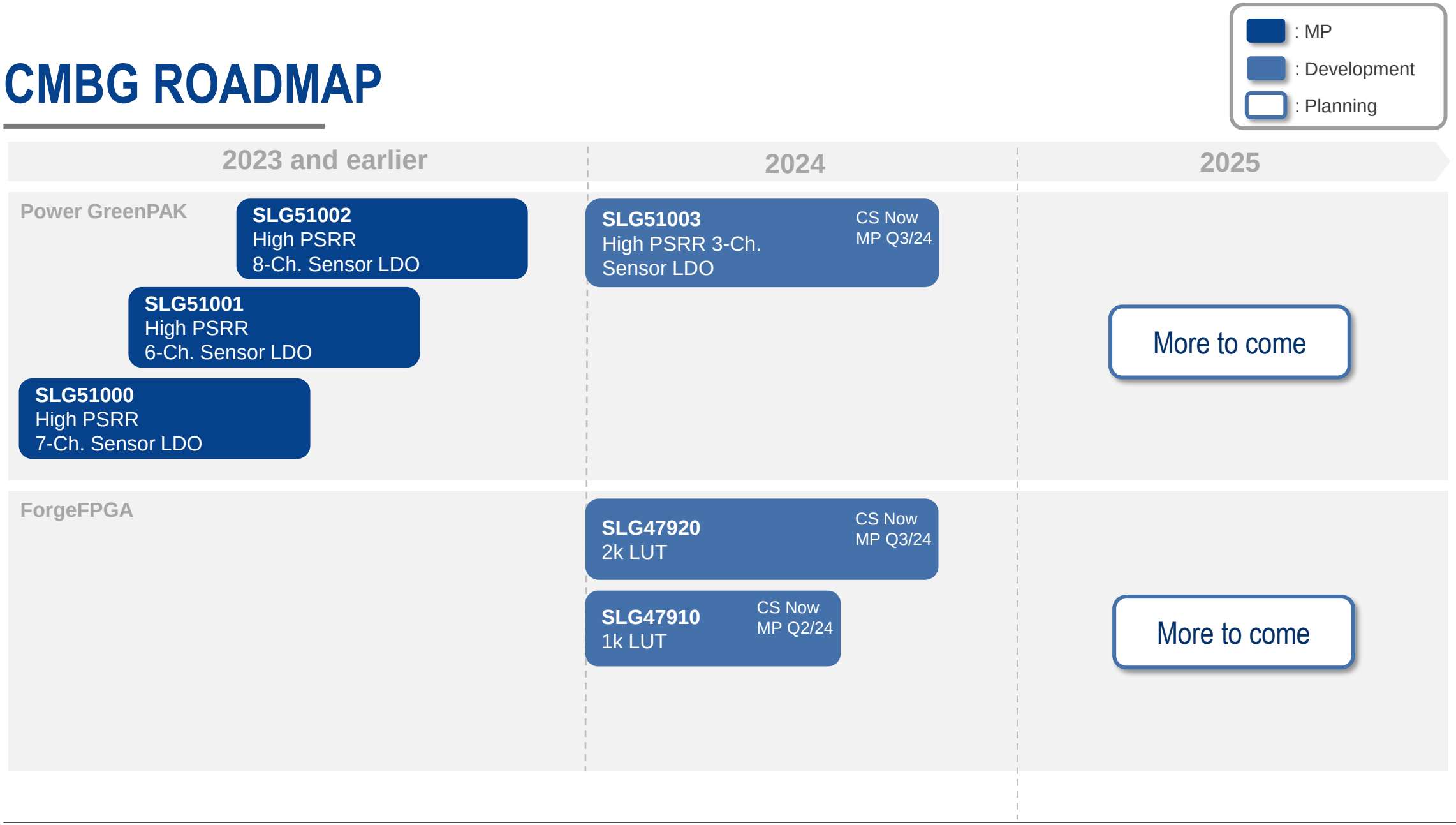
20-pin WLCSP 0.35P
1.85 mm x 1.6 mm

CMBG ROADMAP

: MP
: Development
: Planning

	2023 and earlier	2024	2025
AnalogPAK: Advanced Analog	**SLG47004** 3xOp-Amps, 2x10-bit Rheostats, MTP NVM	**SLG47011** CS Now, MP Q3/24 14-bit ADC, PGA, PWM/DCMP, Buffer, MathCore, 12-bit DAC **SLG47001/003** CS Now, MP Q3/24 2xUltra-Low Offset OpAmps, 2x10-bit Rheostats, EPG	More to come
HVPAK: Motor/Power	**SLG47115** Two Driver OUTs 26.4 V and up to 3 A per OUT **SLG47105** Four Driver OUTs 13.2 V and up to 2 A per OUT	**SLG47125** CS Now, MP Q3/24 BLDC Control, Three Driver OUTs 26.4 V and up to 5 A per OUT	More to come
GreenPAK with New Features	**SLG47512/513** Low Voltage GreenPAK VDD= 1.0 V - 1.65 V **SLG46811** Smallest GreenPAK with I2C Interface on board and Extended Pattern Generator	**SLG47525/528** CS Now, MP Q2/24 Dual Supply GreenPAK with ASM,VDD1=1.71V - 5.5V, VDD2=0.95V - 1.89V	More to come

CMBG ROADMAP



LIVE DEMO AND Q/A

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