# GREENPAK™

## INTRODUCTION

18. APRIL 2024
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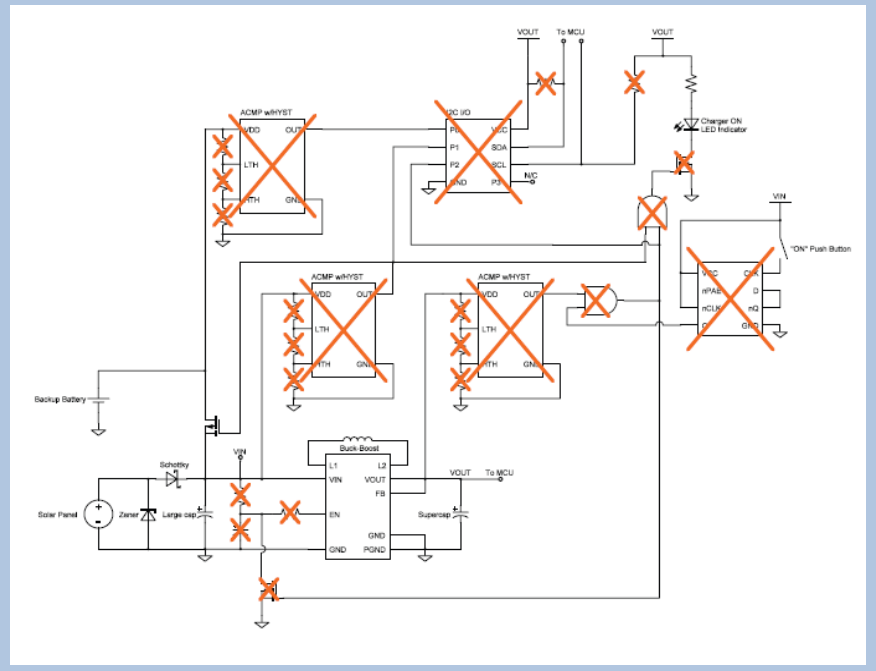
POWER & ANALOG PRODUCTS
RENESAS ELECTRONICS CORPORATION

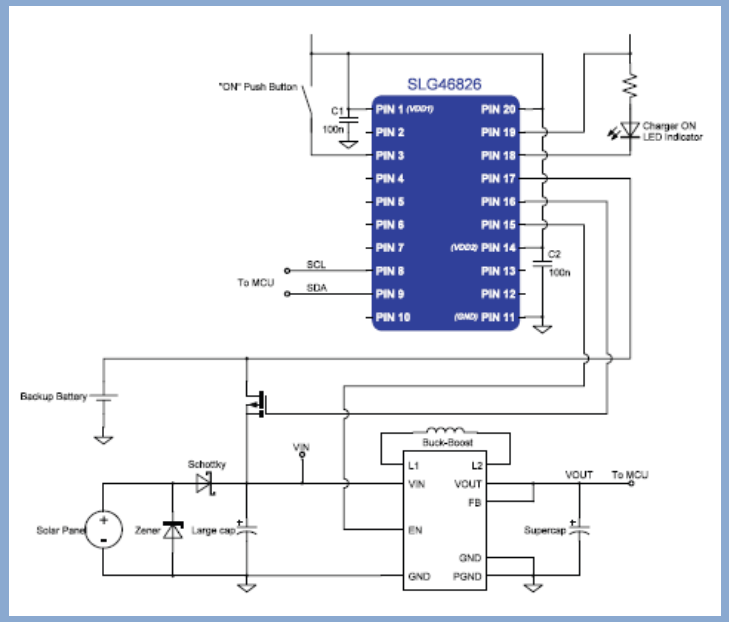
# AGENDA

- What is GreenPAK?
- *GreenPAK Development Boards*
- *GreenPAK Simulation Software*
- Designing with *GreenPAK*
- *GreenPAK Macro Cells (Examples)*
- *GreenPAK Resources*
- Design Security
- Wrap-Up

# WHAT IS GREENPAK™? – A CONCEPTUAL APPROACH

## Configurable Mixed-Signal IC




**Design reduced by:**

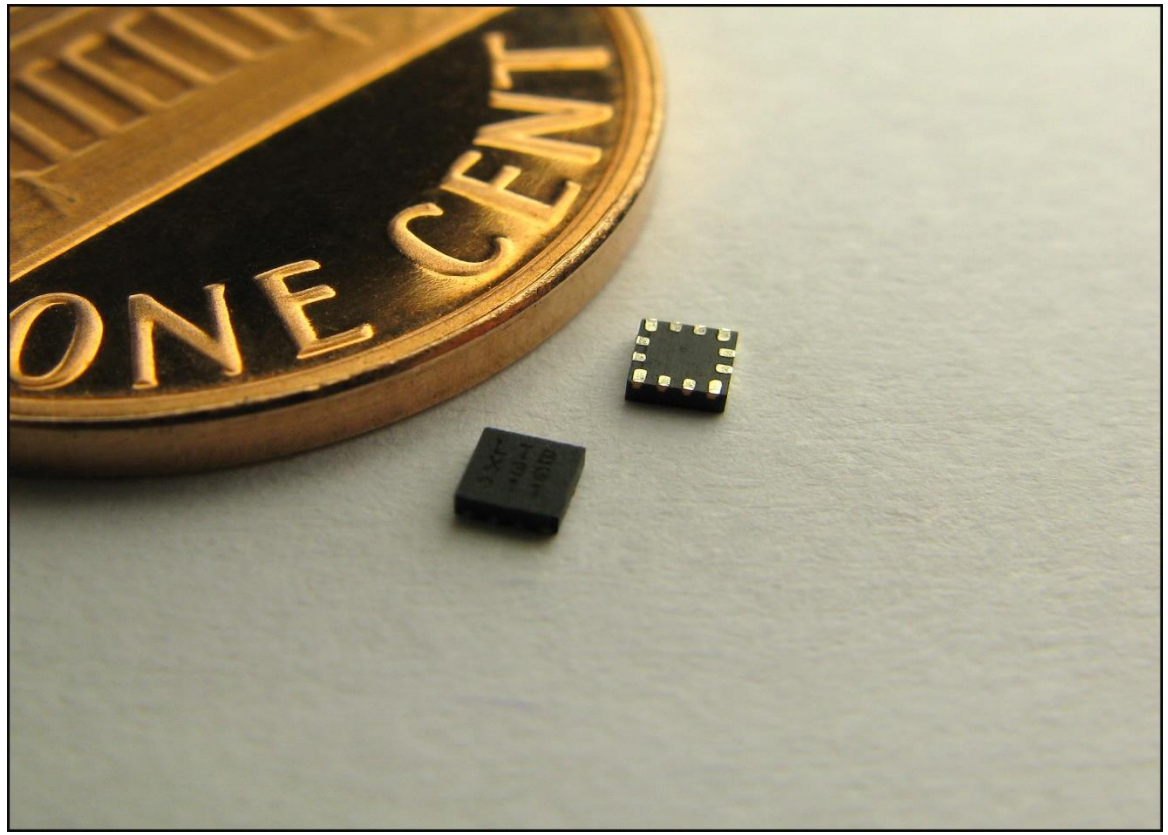
- 5 ICs
- 2 NMOS transistors
- 14 passive components

**Customer Benefits:**

- Integration
- Configurability
- Reliability
- Safety
- Lower power consumption

# WHAT IS GREENPAK?

**The World's 1st Custom Mixed-signal IC (CMIC) Family**




- Roughly 60 ICs, each with a unique set of features
- Customizable with simple, free software
- Very small package, down to 1.2mm$^2$
- Low power solution
- Can be used in a myriad of applications…

# 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

Design in minutes Prototype in hours

No NRE

No Production Commitment

14 Week Production Lead-time

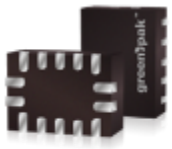
Custom Datasheet

### Easy & fast development tools

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

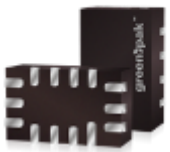
1.0 mm x 1.2 mm
0.4 mm pitch
STQFN
8-pin package

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

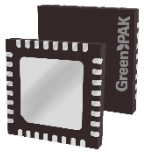
2.0 mm x 2.2 mm
0.4 mm pitch
STQFN
14-pin package



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

# WHAT ARE KEY BENEFITS OF GREENPAK?

- **Faster time to market** – Average lead time is **8-weeks for production qty.** Sample qty in 14 days
  - Parts are preprogrammed (Assembly bank) -> Customer parts are programmed, tested, marked accordingly, & packaged -> shipped out to customer
- **Adaptable & flexible design**
- **Design security**
  - Parts can be locked -> Black Box from outside
  - Customer specific part number & custom datasheet -> part number can only be ordered by customer owning part number
- **BOM & design size reduction**
- **Lower cost consideration for designs**
  - No coding required
  - No additional costs for programming
  - MOQ is one reel (3k or 6k parts; depending on Greenpak part)

# 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

# WHAT CAN I DO WITH GREENPAK™?

## GreenPAK Functions

- Level Translation
- ADC
- Glue Logic (IN5, IN4, IN3, IN2, IN1, 5-bit LUT)
- Pulse Width Modulator
- Voltage Monitor
- H-/Half-Bridge
- Finite State Machine (S1, S2)
- Op Amp
- Counters / Delays
- Rheostat / Potentiometer

## Example Applications

- Supervisory Circuits
- System Reset
- LED Control
- Motor & Fan Control
- Power Sequencing
- Voltage Detection
- Frequency Detection
- Sensor Interface
- Port Detection
- Temperature Control
- Battery Monitor
- See COOKBOOK for more!

**Not for Automotive qualified GreenPAK*

★ **Multiple functions & applications can be combined into one IC** ★

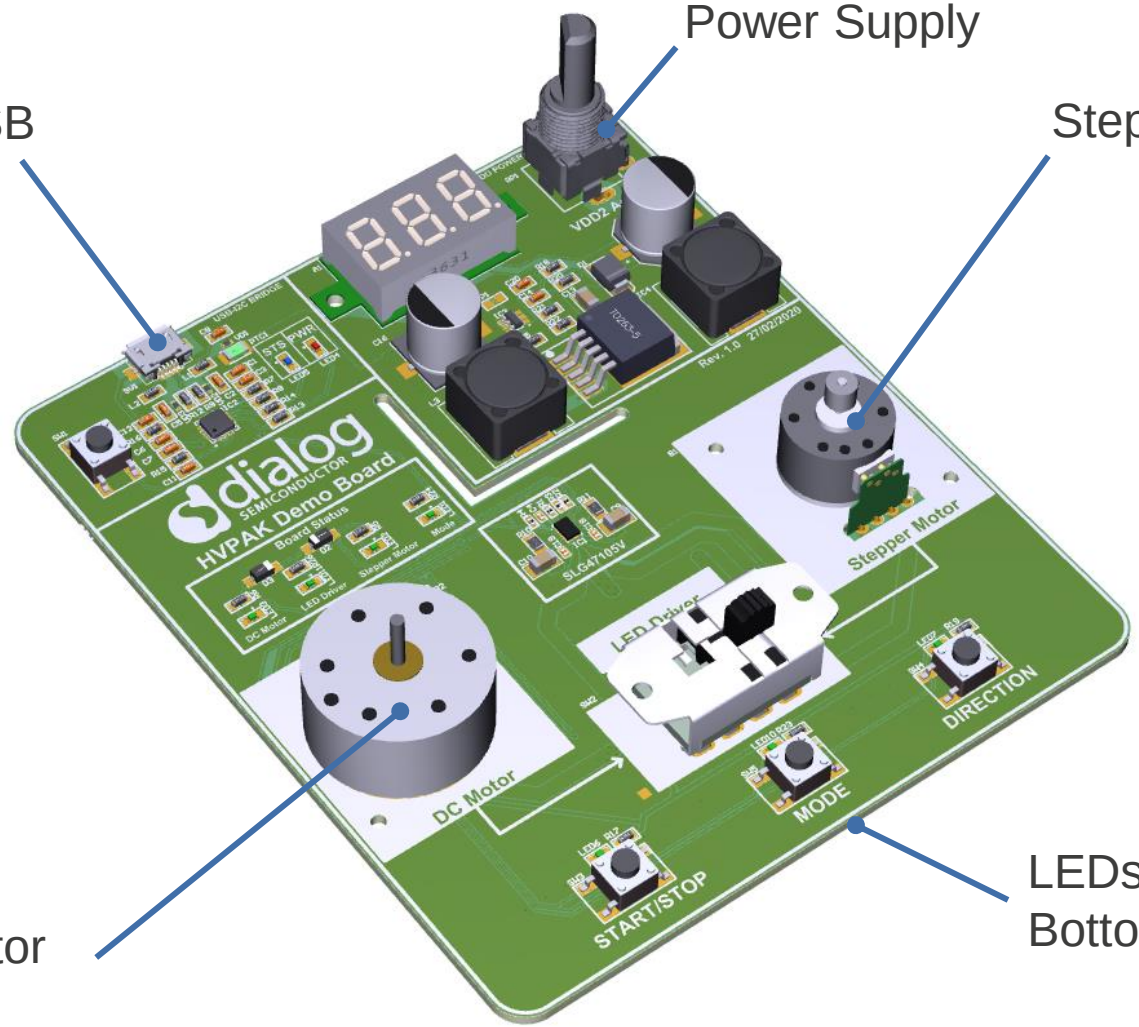
# HVPAK DEMO BOARD

**SLG47105 Demo Board**
allows the User to get acquainted
with SLG47105's functionality,
especially the H-Bridge and Half-Bridge functions,
and demonstrates the power part of the chip

More info

**Demo Board Video**

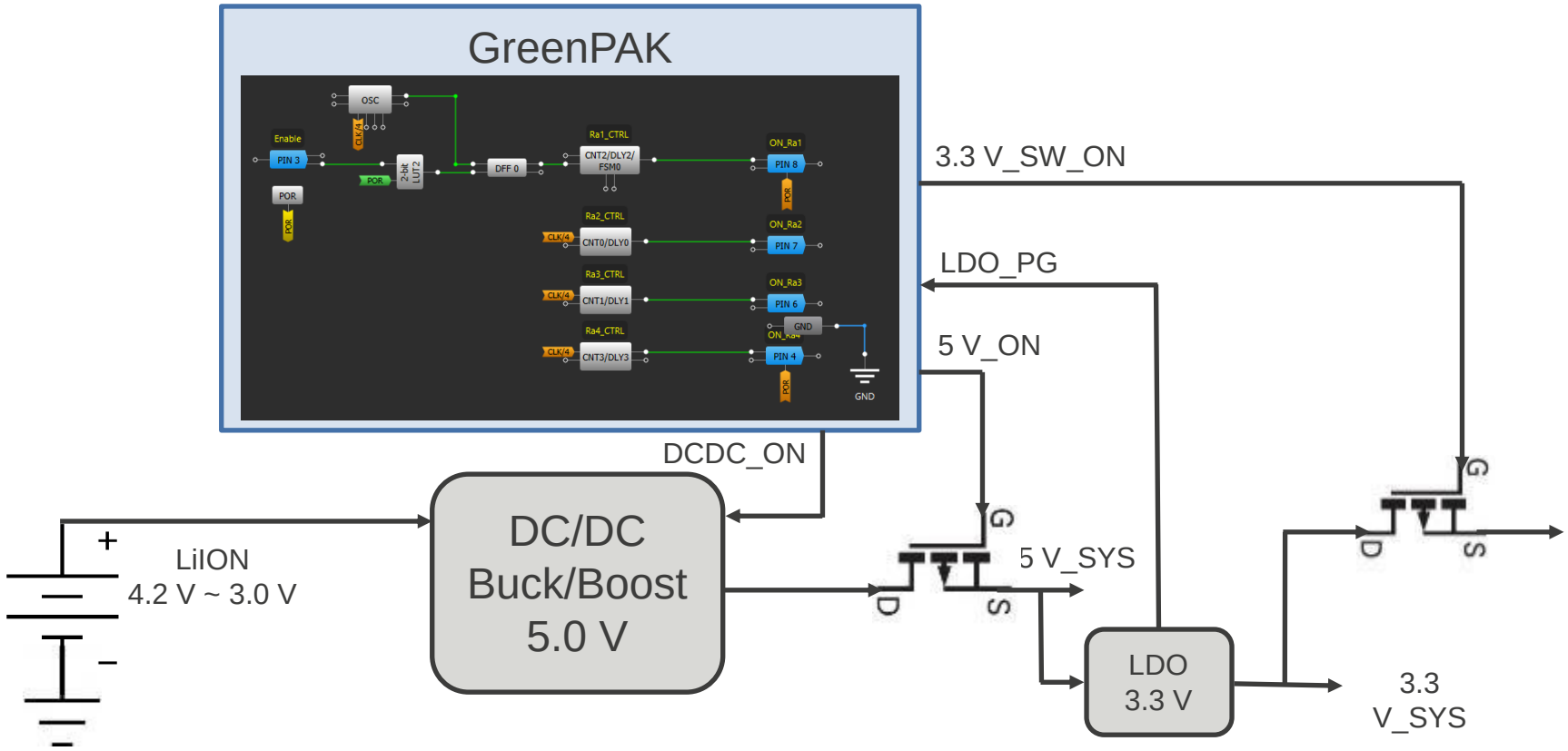
YouTube



# GREENPAK APPLICATION EXAMPLES

## Power Rail Sequencing

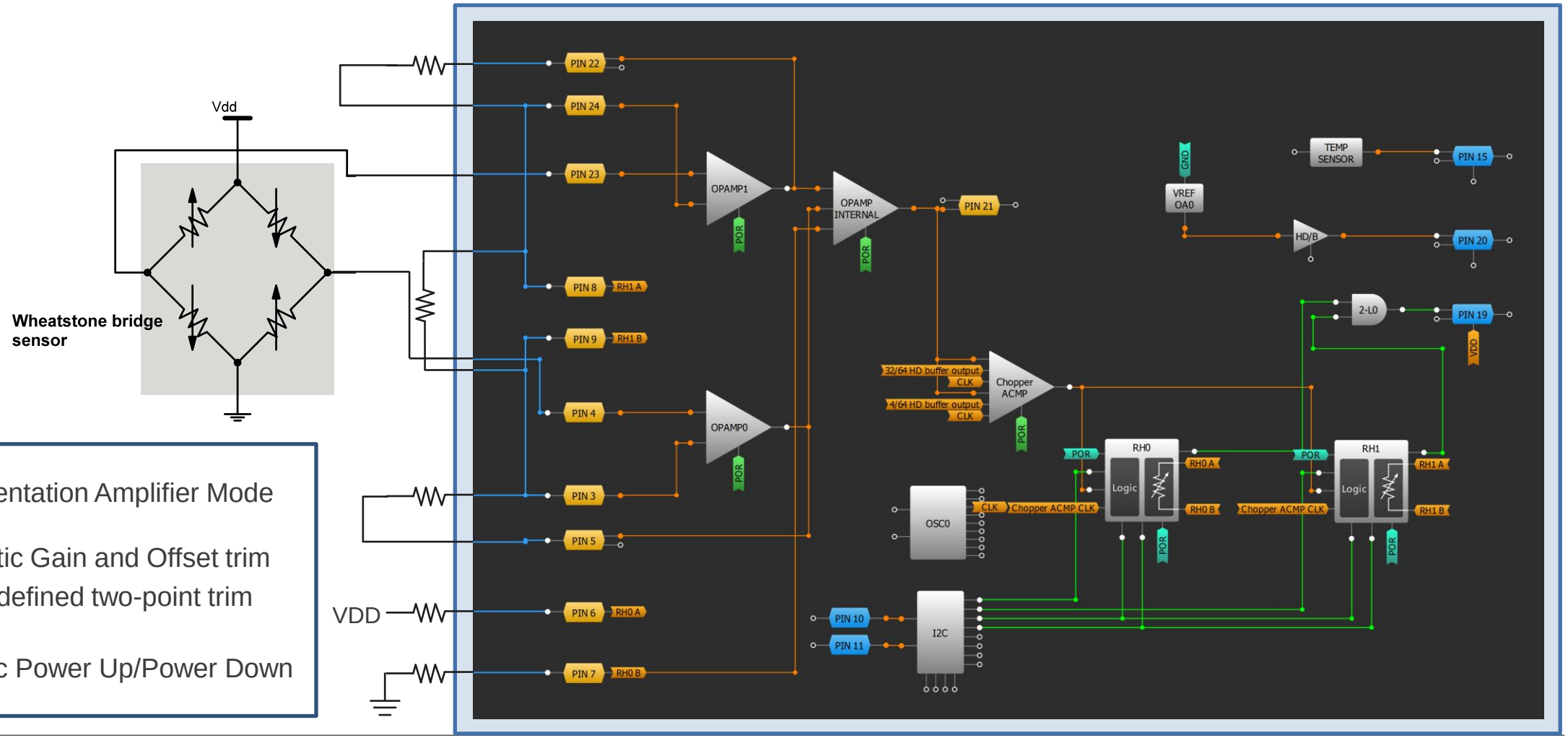
- Can be implemented in any GreenPAK silicon
- Inputs:  logic signals, PGs, voltage levels
- Outputs:  load switch OEs, LDO OEs, DC/DC OEs, MOSFET gates



# GREENPAK APPLICATION EXAMPLES

## Wheatstone Bridge Sensors Interface Using AnalogPAK SLG47004

AnalogPAK



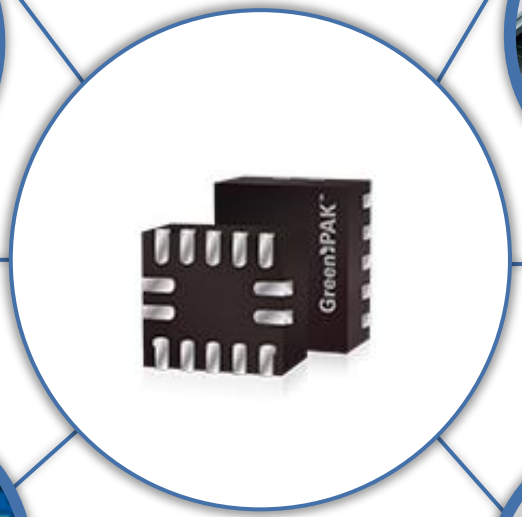

- Instrumentation Amplifier Mode
- Automatic Gain and Offset trim or user-defined two-point trim
- Dynamic Power Up/Power Down

# GREENPAK TARGET MARKETS

Computing & Storage

Consumer Electronics

Smart Home




Networking & Comms

Industrial

Medical

# GREENPAK IS COST EFFECTIVE

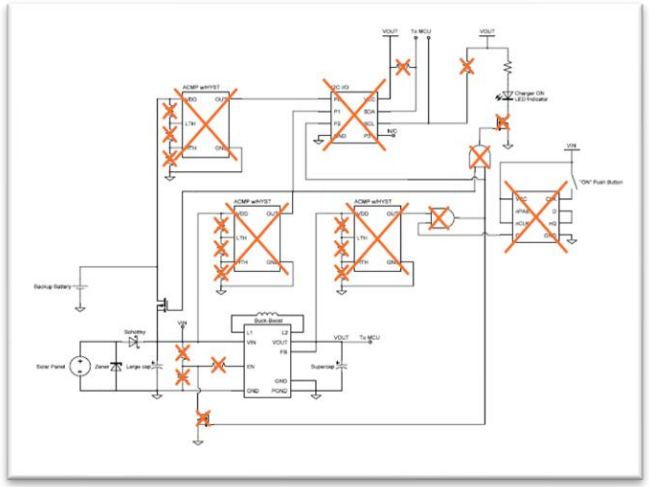
**Integrating multiple discrete ICs & passives into GreenPAK lowers design cost**

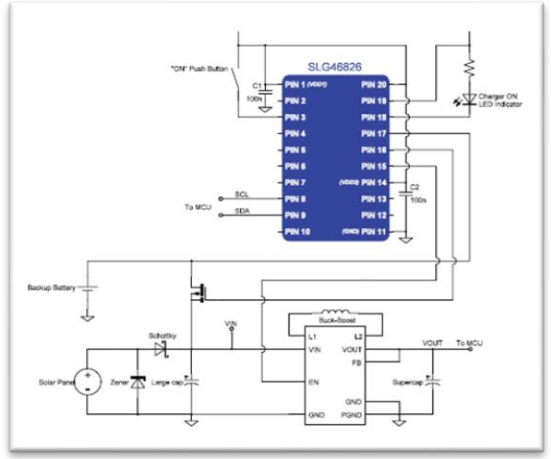
## GreenPAK IC Costs

- Entire portfolio designed to be cost effective
- Fit as much as you can into GreenPAK*
- Average pricing between **~$0.10 - $0.50****
- Auto GreenPAK between **~$0.35 - $0.70****

## Other Costs Benefits

- *No coding required* – streamlined design time
- Reduced prototyping time
- Reduces need for additional components
- Design changes are quick and inexpensive






**Simple or Small Design** ⟷ **More Complex Designs / Higher Integration**

* Cost independent of circuit design

** Volume dependent

# SELECTING RIGHT GREENPAK FOR DESIGN

## Best GreenPAK for application dependent on design requirements

### Picking Right Base Die

- Number of GPIO? (6 to 28)
- What is VDD? (1.0V to 5.5V)
- Need for VDD2? (Yes or No)
- SPI or I2C? (Yes, or not required)
- MTP (Multiple-Time Programmable) or OTP?
- Number of voltage rails being monitored?

### What Functions / Features?

- With many use cases for GreenPAK it is important to determine which functions and features would be utilized. Examples Include:

| Analog | | Digital | |
|---|---|---|---|
| Analog switch | OpAmp | Control | Level shifting |
| Battery charge indicator | Over-temp detection | Deserialization/serialization | Motor driving |
| Comparators | Potentiometer | Frequency detection | Pattern generator |
| Current sense/limiter | Rheostat | Frequency divider | PWM generation |
| LDOs | Voltage level detection | GPIOs (6-28) | Sequencer |
| Low voltage indicator | Wake/sleep function | H-/Half-Bridge | SPI or I²C Communication |
| Logic (Mux, gates, etc.) | and More | I²C expansion | System reset |
| | | Interrupt | Watchdog timer |
| | | LED driving/pattern | and More |

### Selecting GreenPAK

- Filter by parametric search on web
- Reach out to Distribution FAE /Renesas FAE for support

**Simple or Small Design** ⟷ **More Complex Designs / Higher Integration**

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0.4 mm pitch
STQFN
8-pin package

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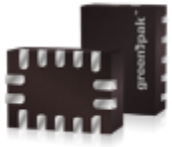

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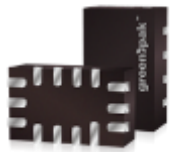

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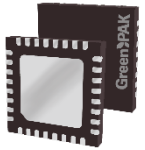

4.0 mm x 4.0 mm
0.4 mm pitch
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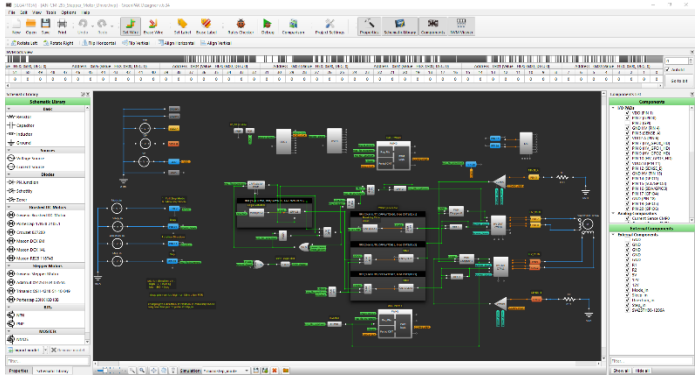
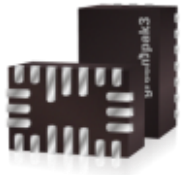
# GREENPAK DESIGN DEVELOPMENT PROCESS

- 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

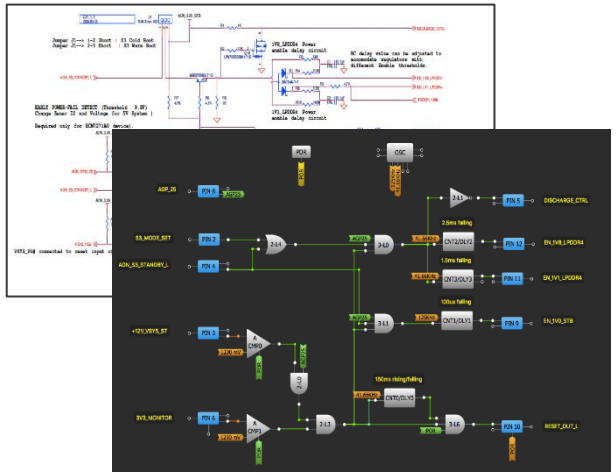
## Program at Your Desk

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

## Production Samples Process Covered on Next Slide

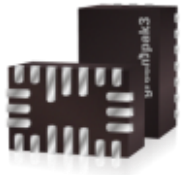
# GREENPAK SAMPLE & PRODUCTION FLOW

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



72 Hours

7-14 Days



8 weeks

Design Revisions?

Design Finalized?

Production

**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

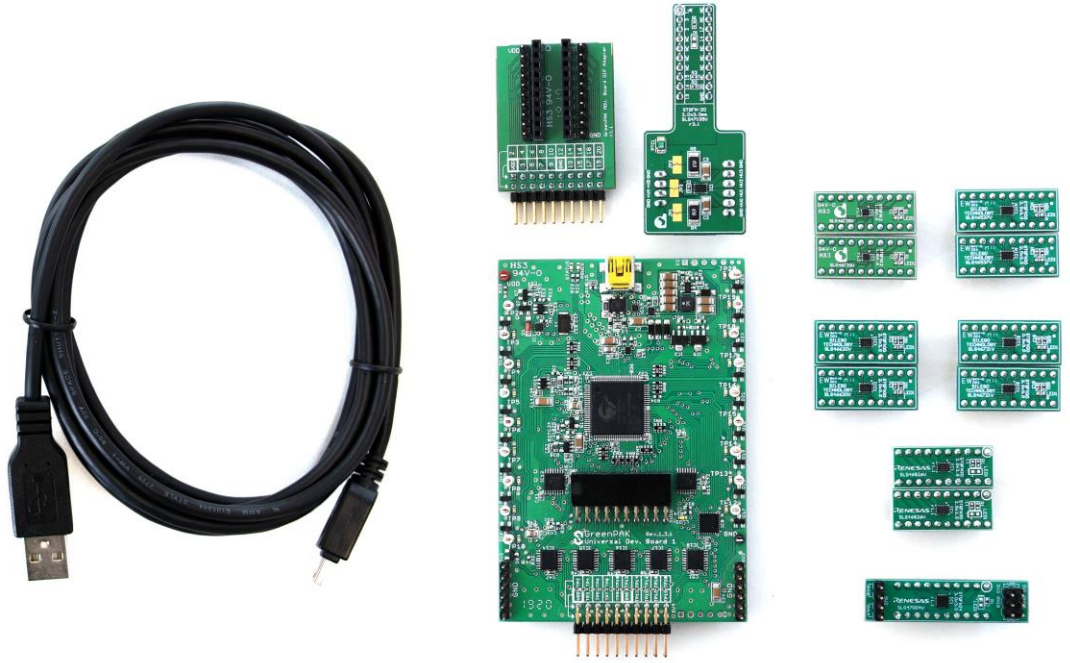
**Purchase Production Parts**
8 Week Lead Time

# GREENPAK DEVELOPMENT BOARDS

# GREENPAK DEVELOPMENT TOOLS – STARTING WITH HARDWARE

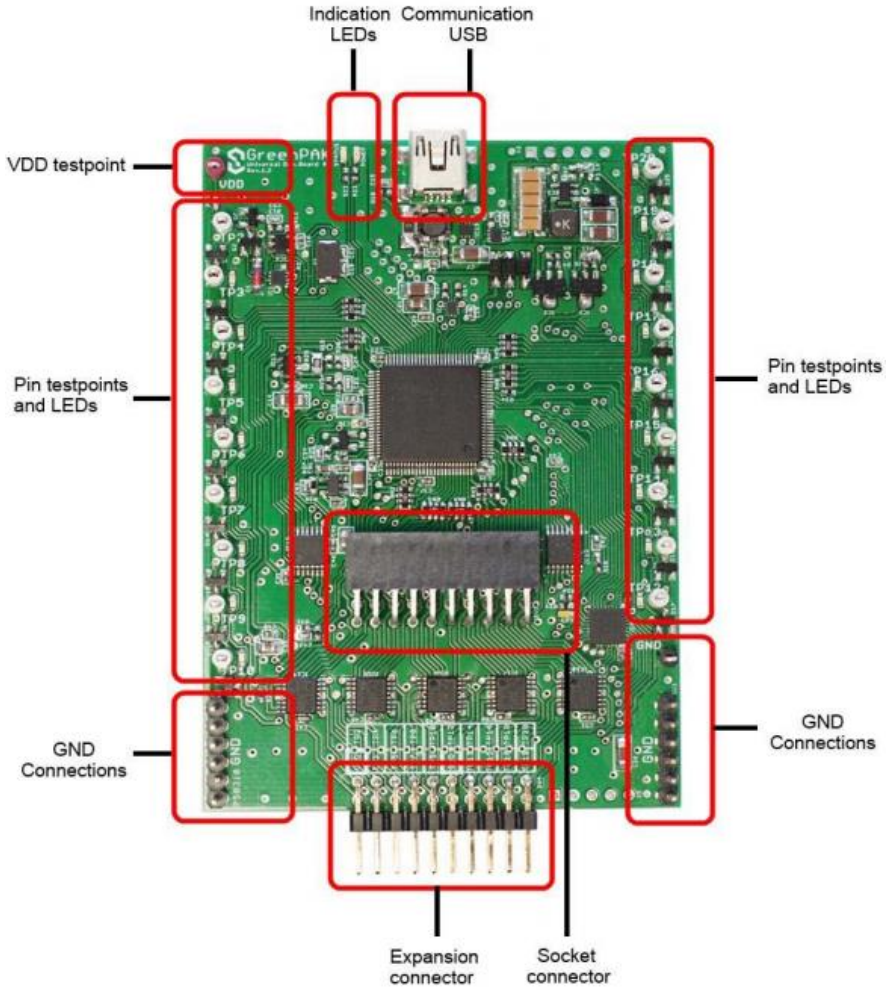
## Where to start with hardware:

- If hardware is required Renesas FAE or GreenPAK product line can provide feedback on which tools / devices to begin design with
- Another option is the **SLG4DVKINTRO – GreenPAK Introduction Kit** which includes:
  - 1x Universal Development Board (this might later change to the Lite board, but for now it is Advanced Dev Board)
  - 1x USB cable
  - 1x SLG4SADIP
  - 2x SLG46120V-DIP
  - 2x SLG46721V-DIP
  - 2x SLG46620V-DIP
  - 2x SLG46537V-DIP
  - 2x SLG46826V-DIP
  - 1x SLG47105V-DIP
  - 1x SLG47004V-DIP



# GREENPAK DEVELOPMENT HARDWARE

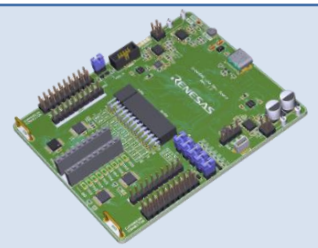
## Advanced Development Platform




### Provides Full Programming, Emulation and Testing Functionality:

- On Board Signal and Logic Generators
- Socket Connection for GreenPAK Socket Adapters
- USB Mini-b Connector for GreenPAK Software Designer Interface
- LEDs and Test Points for each GPIO
- Expansion Connector for Signal Injection

# GREENPAK DEVELOPMENT HARDWARE

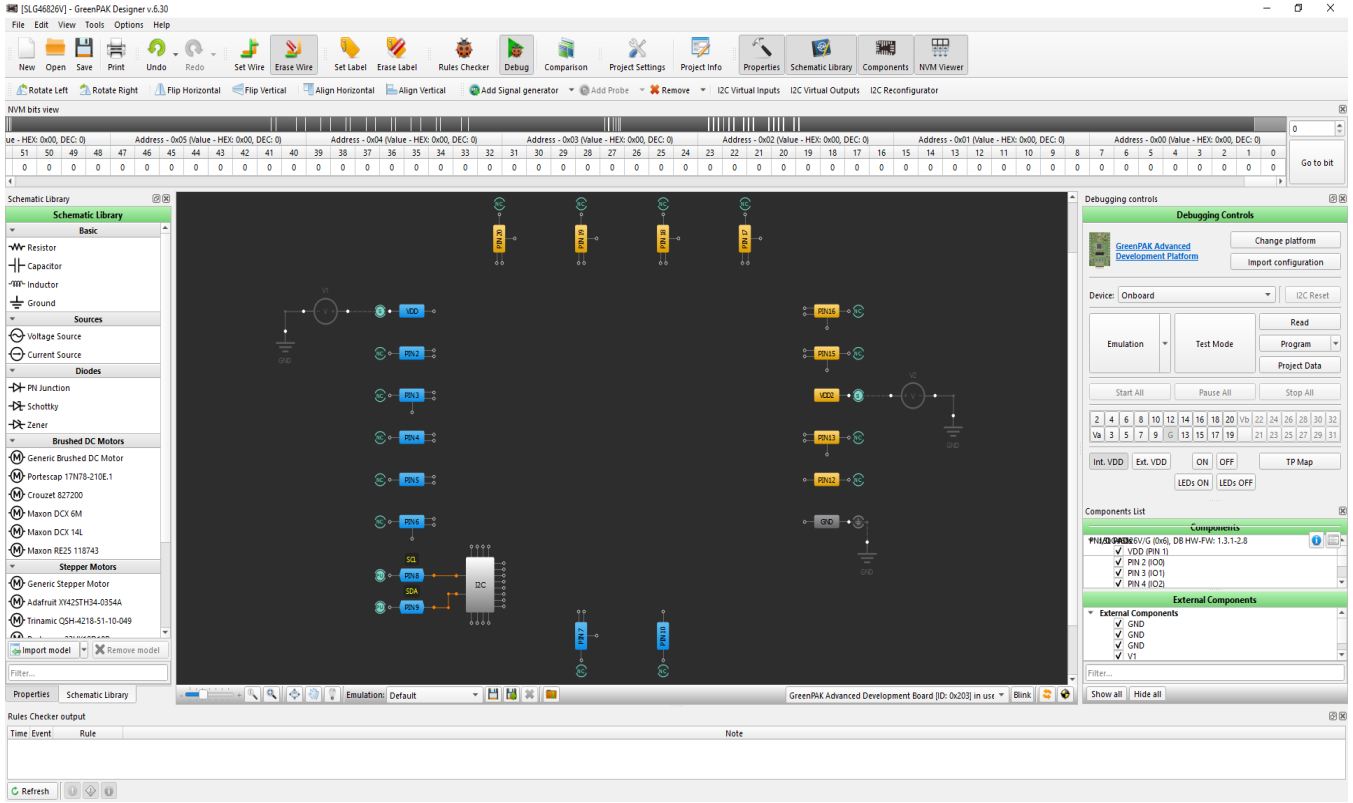
| Board/Functions | Features | |
|---|---|---|
| **GreenPAK Advanced Development Platform**<br>Program custom samples in minutes using any GreenPAK device. | ▪ USB interface<br>▪ MacOS, Windows and Linux compatible<br>▪ Programming and Emulation<br>▪ Gated expansion header for connection to external test equipment<br>▪ Integrated signal and logic generators<br>▪ LEDs and Test Points for each GPIO |  |
| **GreenPAK Serial Debugger Board (GSD)**<br>Serial debugging for all GreenPAK parts with I²C. | ▪ USB interface for power and control<br>▪ 4 pin header with I²C interface to target system<br>▪ MacOS, Windows and Linux compatible<br>▪ GSD supports serial programming for SLG46827 |  |
| **GreenPAK Development Board Lite**<br>Supports Programming and Emulation for Breadboarding and Fast Prototyping | ▪ USB interface<br>▪ MacOS, Windows and Linux compatible<br>▪ Gated expansion header for connection to external test equipment<br>▪ LEDs for visual indication<br>▪ Real-time power monitor function |  |
| **GreenPAK DIP Development Platform**<br>Perfect for breadboarding and fast prototypes | ▪ USB interface<br>▪ MacOS, Windows and Linux compatible<br>▪ Programming and Emulation<br>▪ Gated expansion header for connection to external test equipment |  |

Available online from local/global distribution partners!

# GREENPAK DEVELOPMENT SOFTWARE

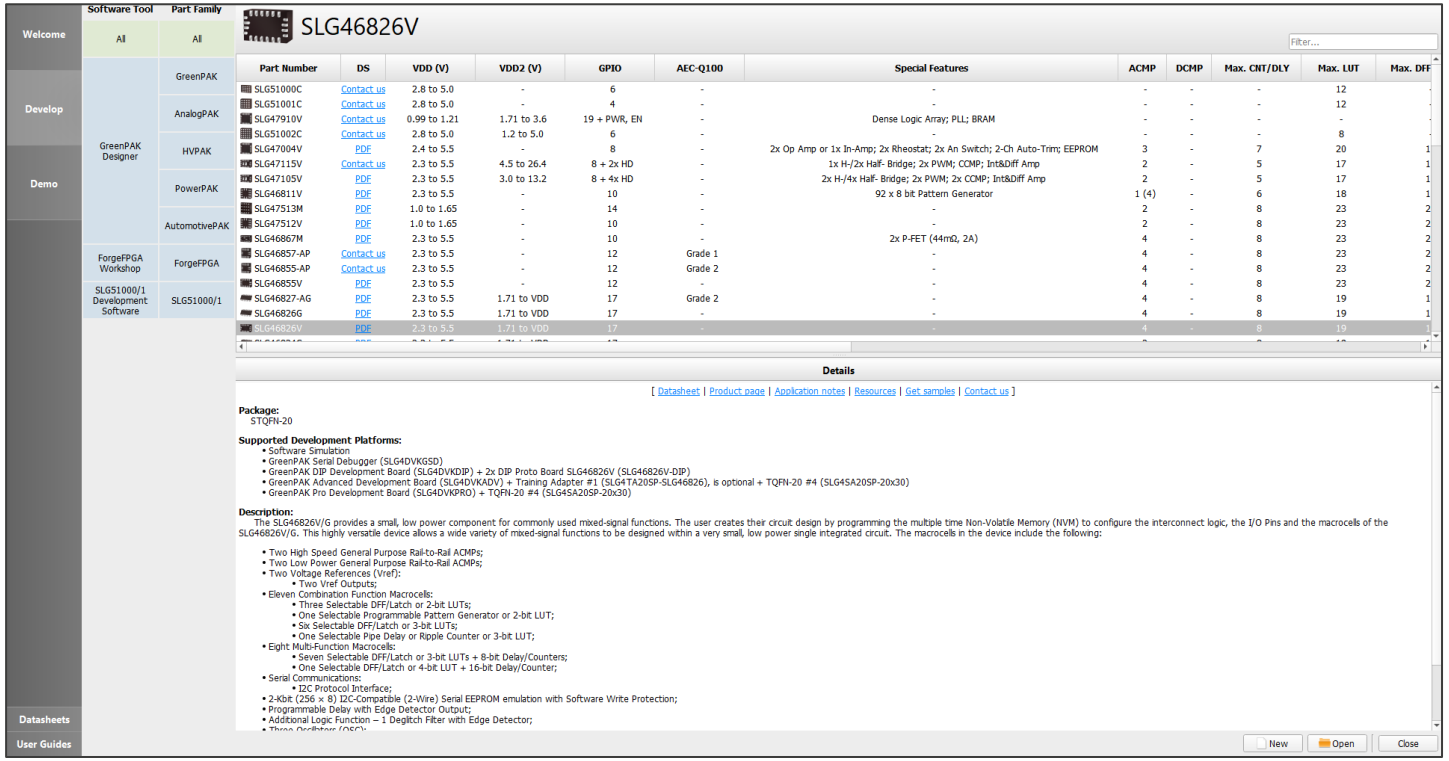
# GREENPAK SOFTWARE

- Create custom solutions, simulate circuit
- Debug, program ICs,
- EVK hardware is **NOT** needed to get started



# GREENPAK DEVELOPMENT SOFTWARE

## Go Configure Software Hub




### Tabs

- Welcome: Design Tips, Links to Product Brochures, Application Notes, and Training Videos
- Develop: Table of GreenPAK ICs with their PCB Footprint and Logic Resource Availability
- Demo: List of Common GreenPAK Applications
- Datasheets
- User Guides

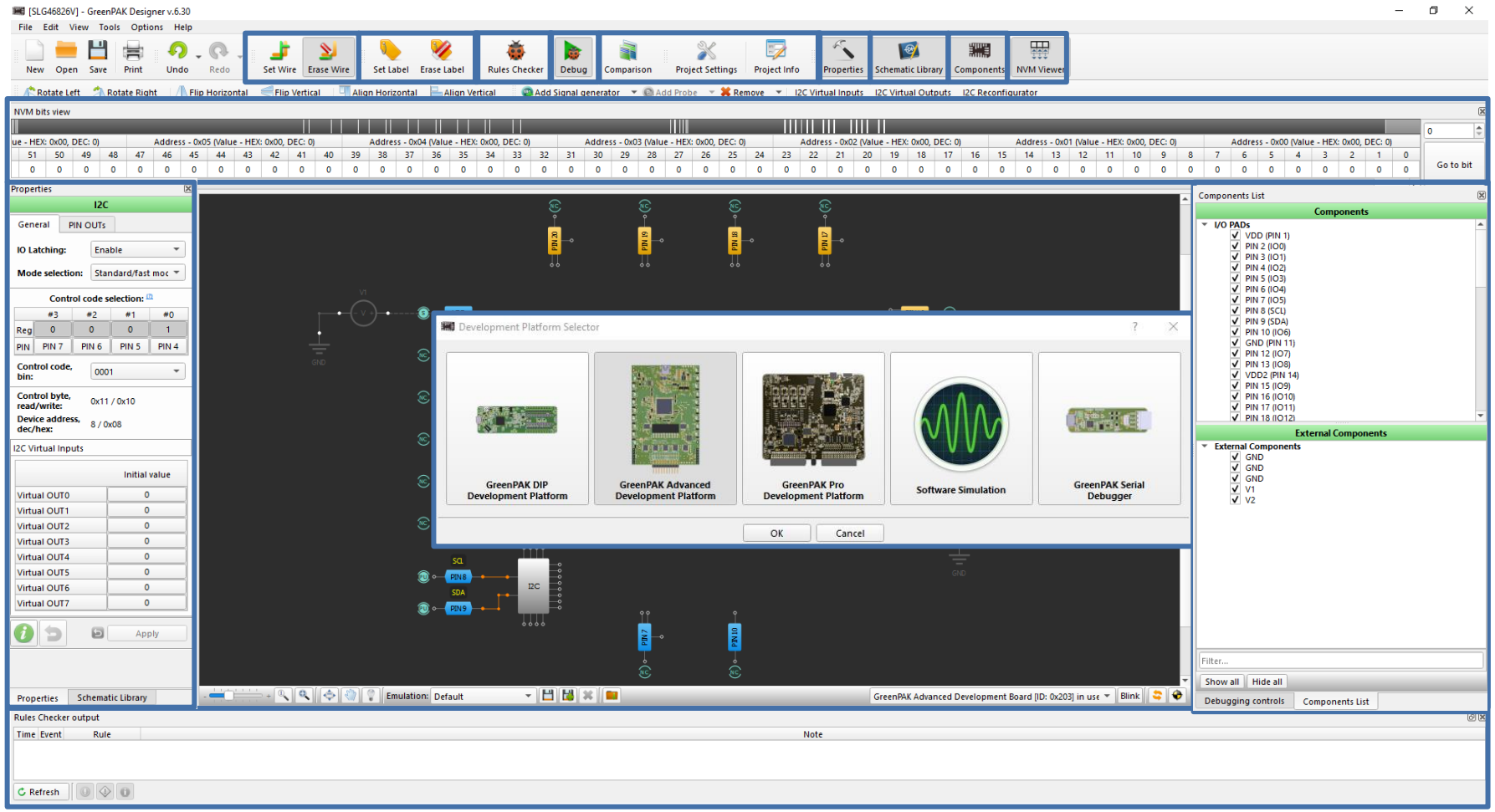
[Go Configure Software Hub - GreenPAK Designer | Renesas]

# GREENPAK DEVELOPMENT SOFTWARE

## GreenPAK Designer

### Tool Bar

- Set / Erase Wire
- Set / Erase Label
- Rules Checker
- Debug
- Project Settings
- Project Info
- Properties
- Schematic Library
- Components
- NVM Viewer
- Change platform

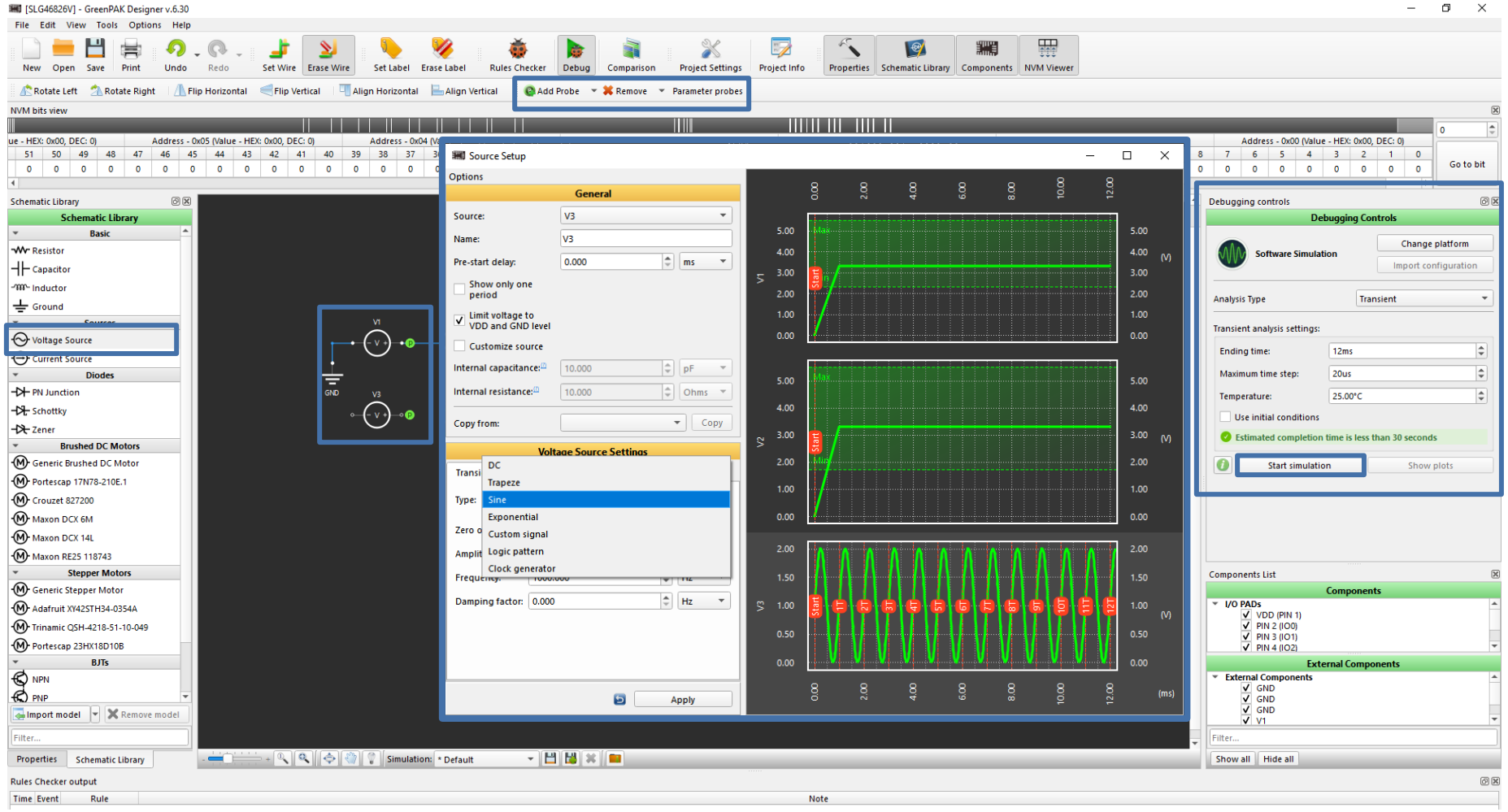


# GREENPAK DEVELOPMENT SOFTWARE

## GreenPAK Designer

### Software Simulation

- Voltage Source
- Add Probe
- Remove
- Debugging Controls

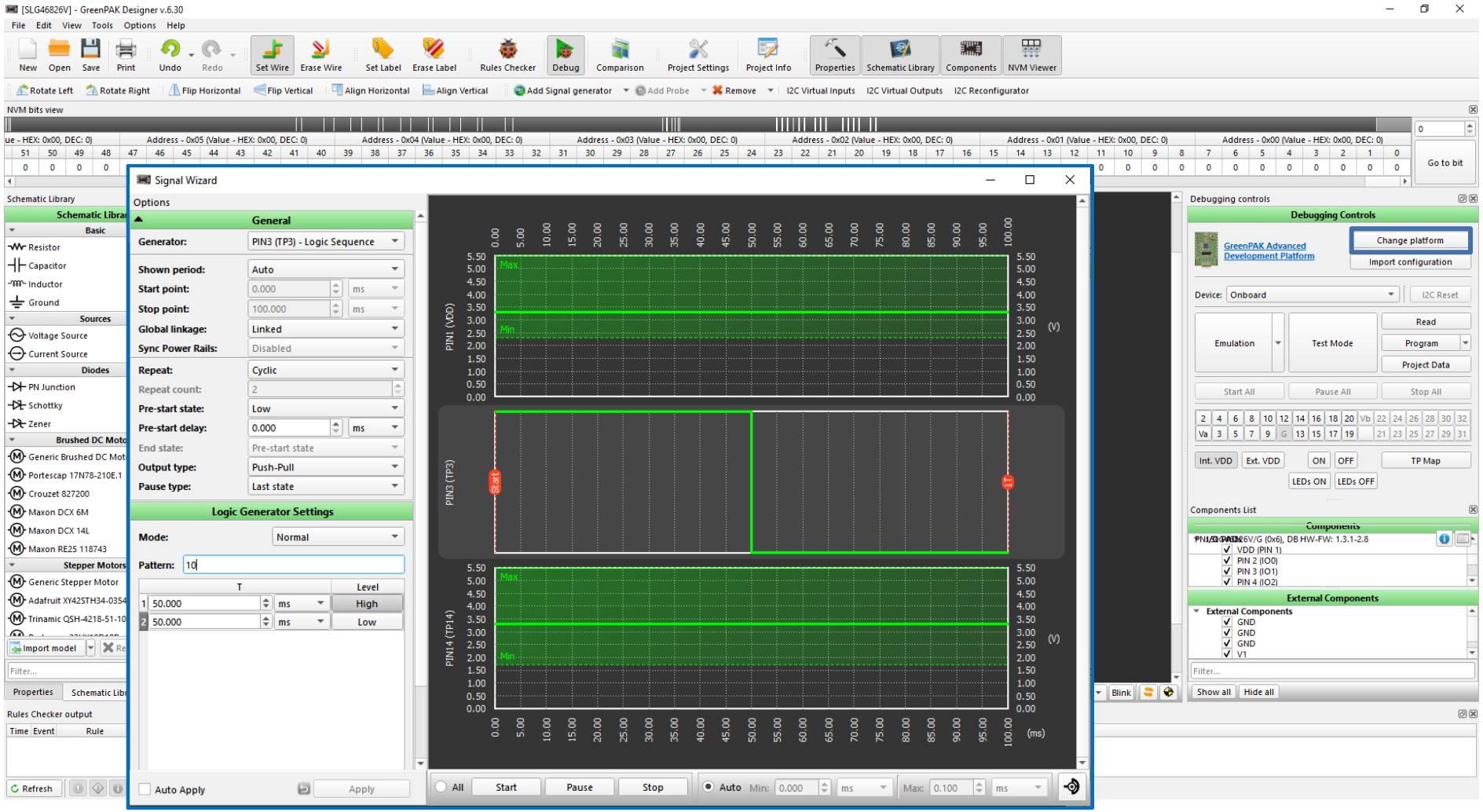


# GREENPAK DEVELOPMENT SOFTWARE

## GreenPAK Designer

### Debug with Hardware

- Logic generator
- Signal generator
- I2C generator



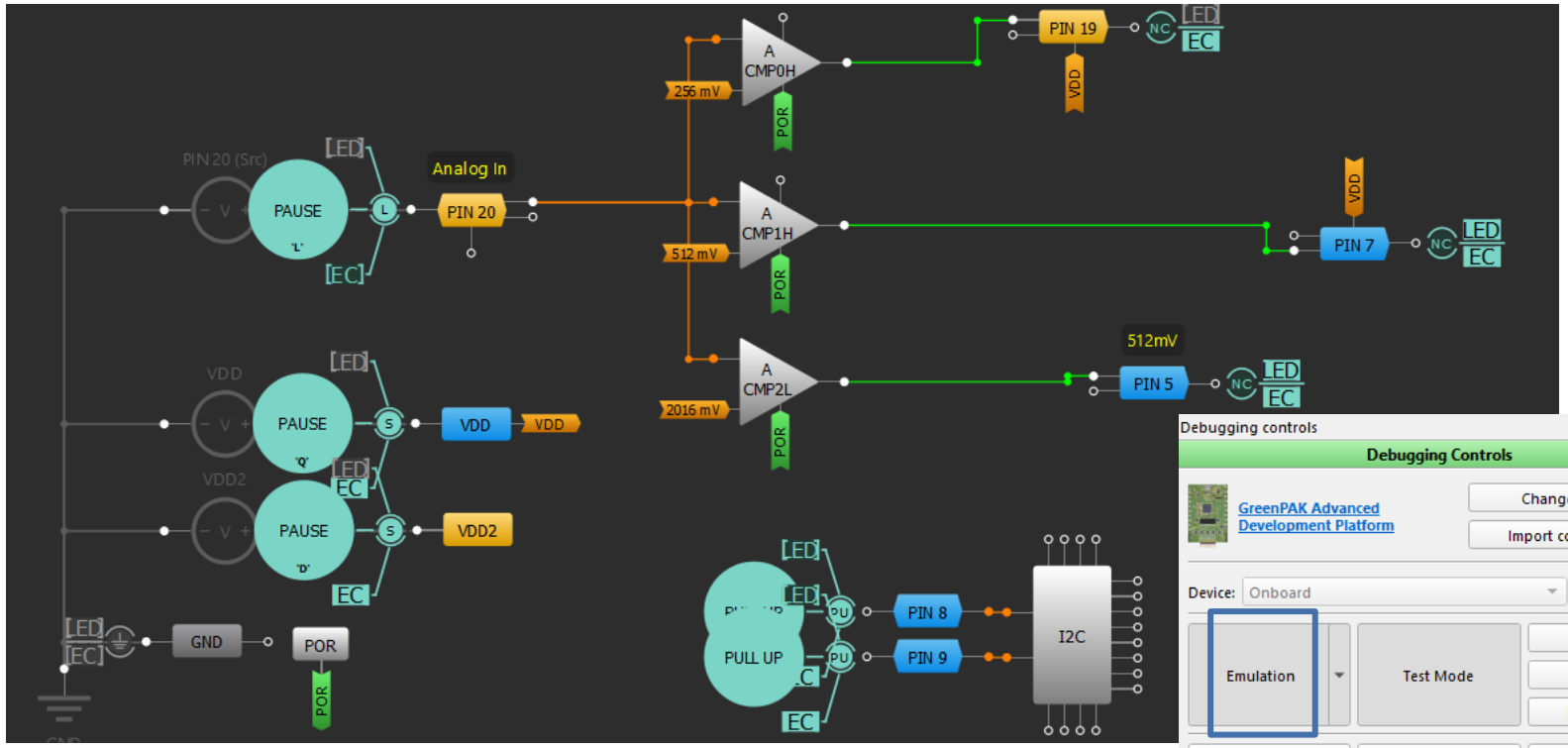
# GREENPAK DEVELOPMENT SOFTWARE

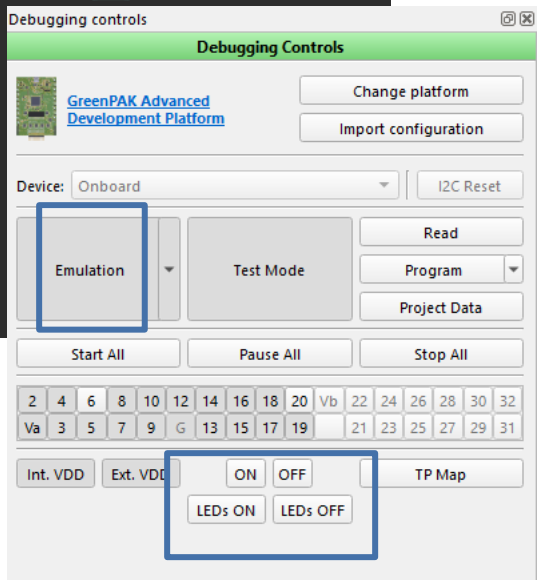
## GreenPAK Designer

### Emulation Mode together with Evaluation Boards

- Add Logic Generator
- Add I2C Generator
- Add Signal generator

- **Debug with Hardware**
- Test your Greenpak Programming on Evaluation Board
- LEDs at Test Points can be turned ON /OFF for better debugging



# GREENPAK FOR LED CONTROL

# WHY IS GREENPAK GOOD FOR LED CONTROL APPLICATIONS?

- High drive strength I/Os on GreenPAK allow for direct LED drive
- Multiple output modes allow for your choice in LED drive
- LED dimming and LED breathing can be implemented without any processor overhead
- Can use $I^2C$ to remotely control LEDs – very easy to implement
- You can customize any way you want

# DESIGN DEMONSTRATION #1

- Usage of AMPs to create three different control pins for an RGB-LED
- Goal to switch LEDs when input voltage is higher than ACMP’s threshold
- ACMP has different references applied to IN-
- By increasing the voltage at PIN20, the outputs will go HIGH

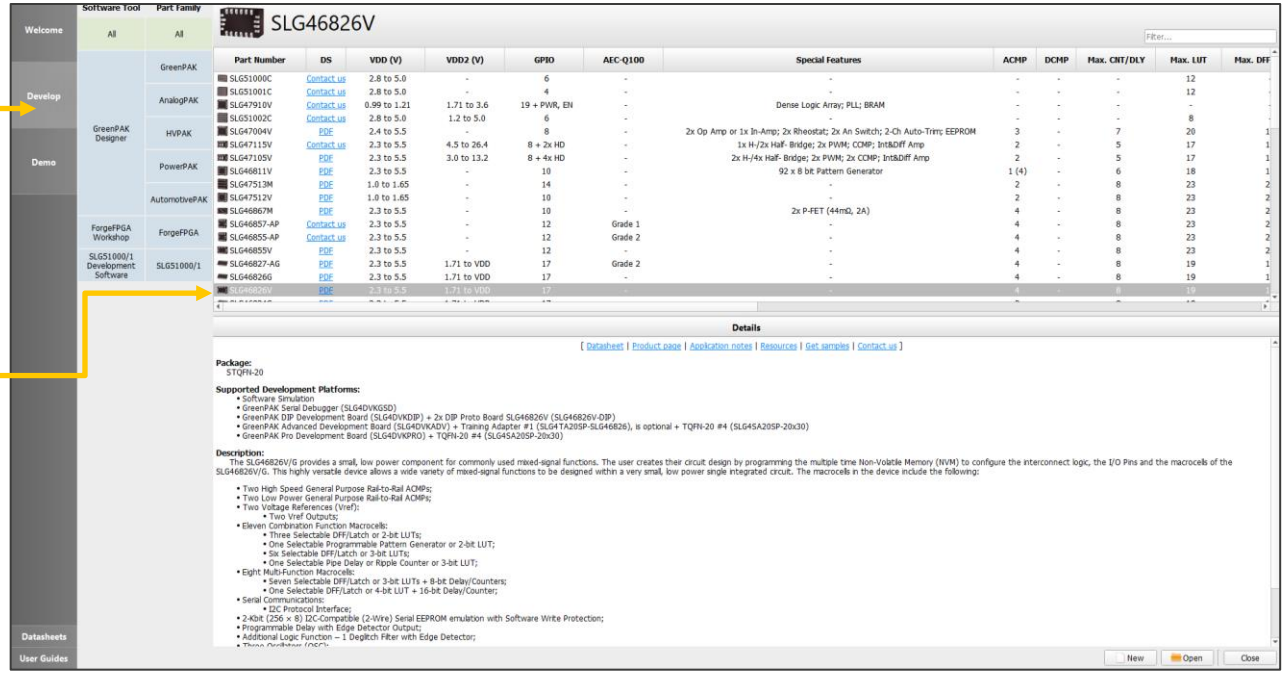
# STARTING THE PROCESS

## Launch GreenPAK Designer

- After you have installed GoConfigure Software Hub, open up the program
  - Click the Windows button in the bottom left corner of your screen
  - Scroll to the GoConfigure Software Hub icon and click once to open it
  - Click the GoConfigure Software Hub


- The first time you launch GoConfigure Software Hub, you will land on the Welcome page.
  Click the “Develop” page next.

- This will give you a window that shows the selection of GreenPAK parts available
  - Single click the SLG46826V to highlight it
  - Double click on SLG46826V to launch the designer for this silicon



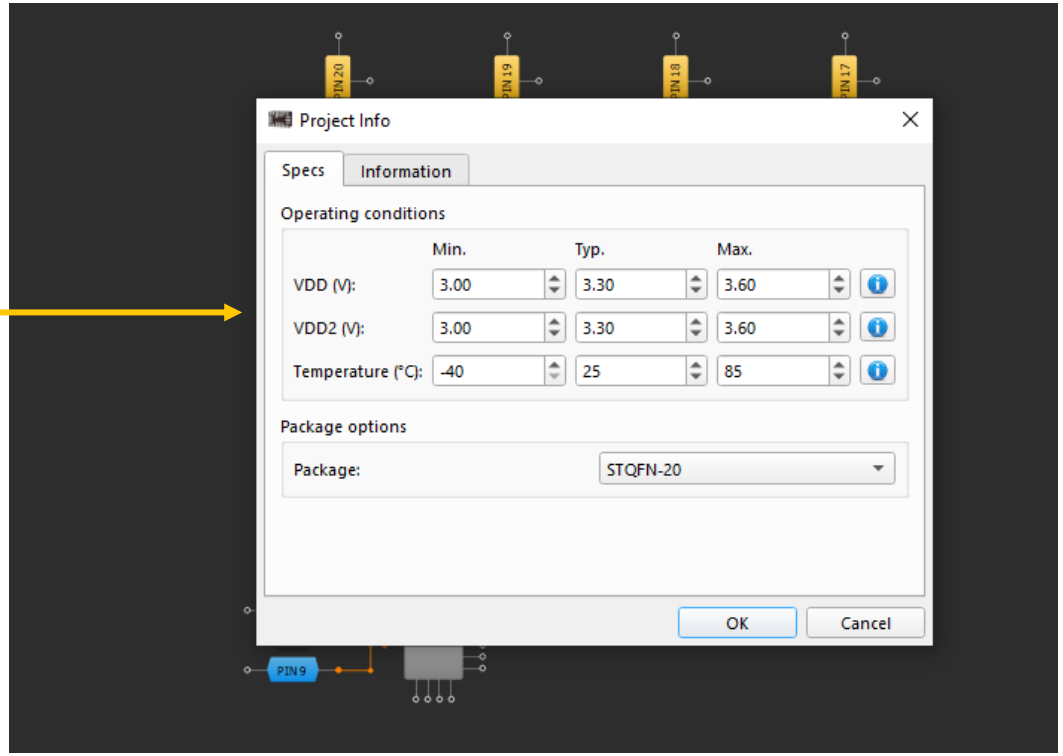
# SETTING UP PROJECT INFO

## Entering VDD, VDD2 and Temperature Information

- You will get a window with “Project Info” that opens automatically

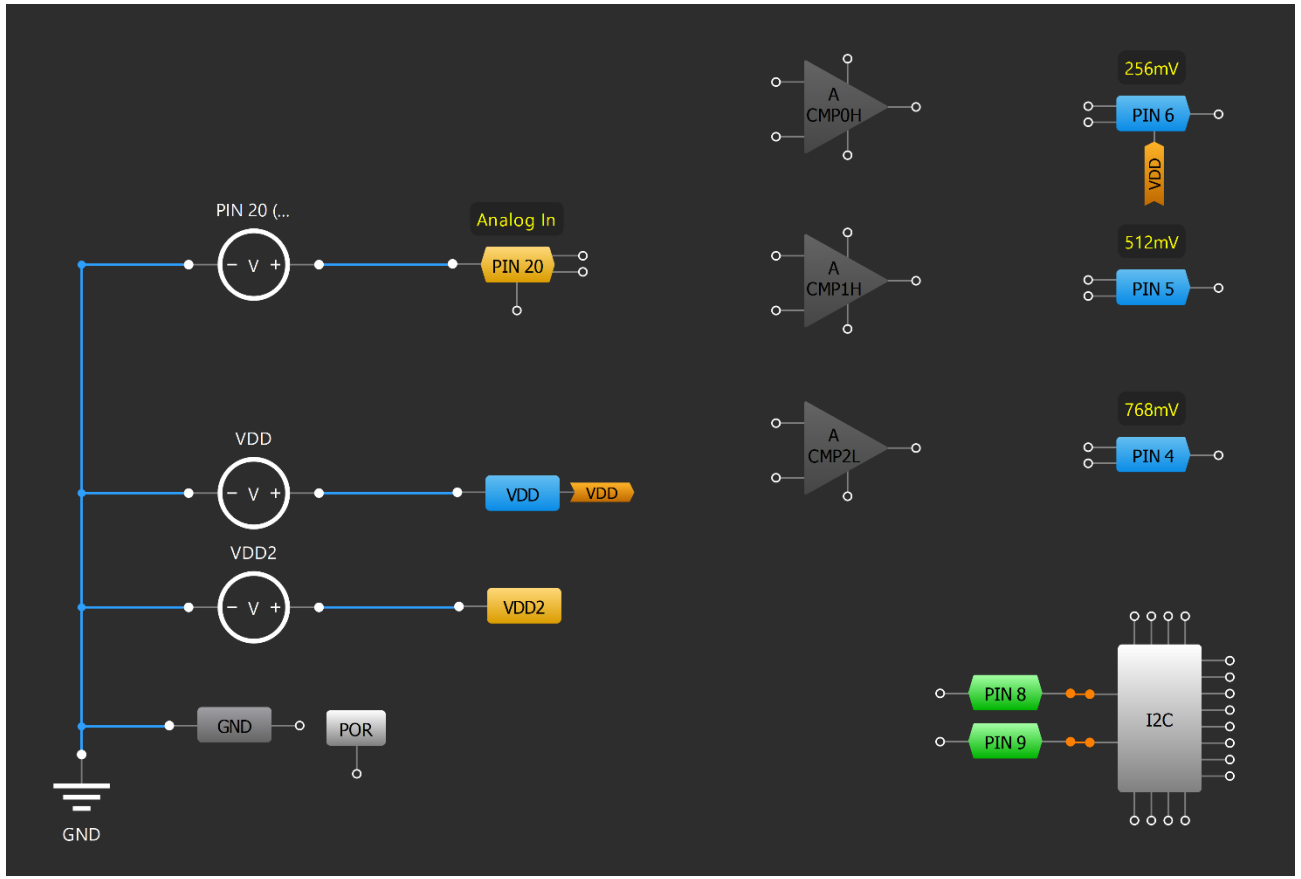
- Set:
  - VDD to 3.0, 3.3, 3.6
  - VDD2 to 3.0, 3.3, 3.6
  - Temp to -40, 25, 85

- This information will be used when we want to test or simulate the design



# DESIGN DEMONSTRATION #1

## Usage of AMPs to create three different control levels for an RGB-LED



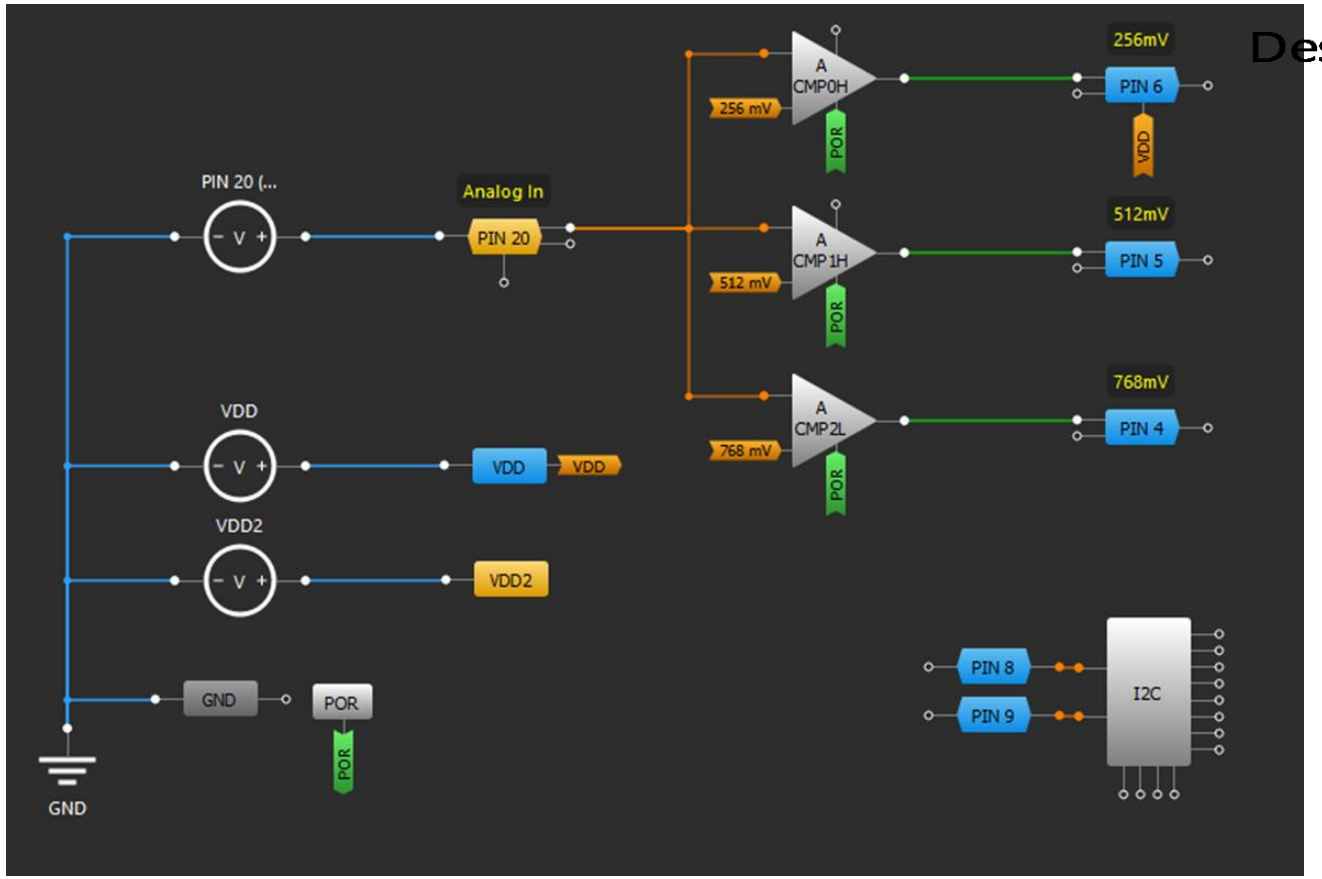

GP6

Design_Demonstration_2.gp6

- Goal to switch LEDs when input voltage is higher than ACMP's threshold
- ACMP has different references applied to IN-
- By increasing the voltage at PIN20, the outputs will go HIGH

# DESIGN DEMONSTRATION #1

**Usage of AMPs to create three different control levels for an RGB-LED**



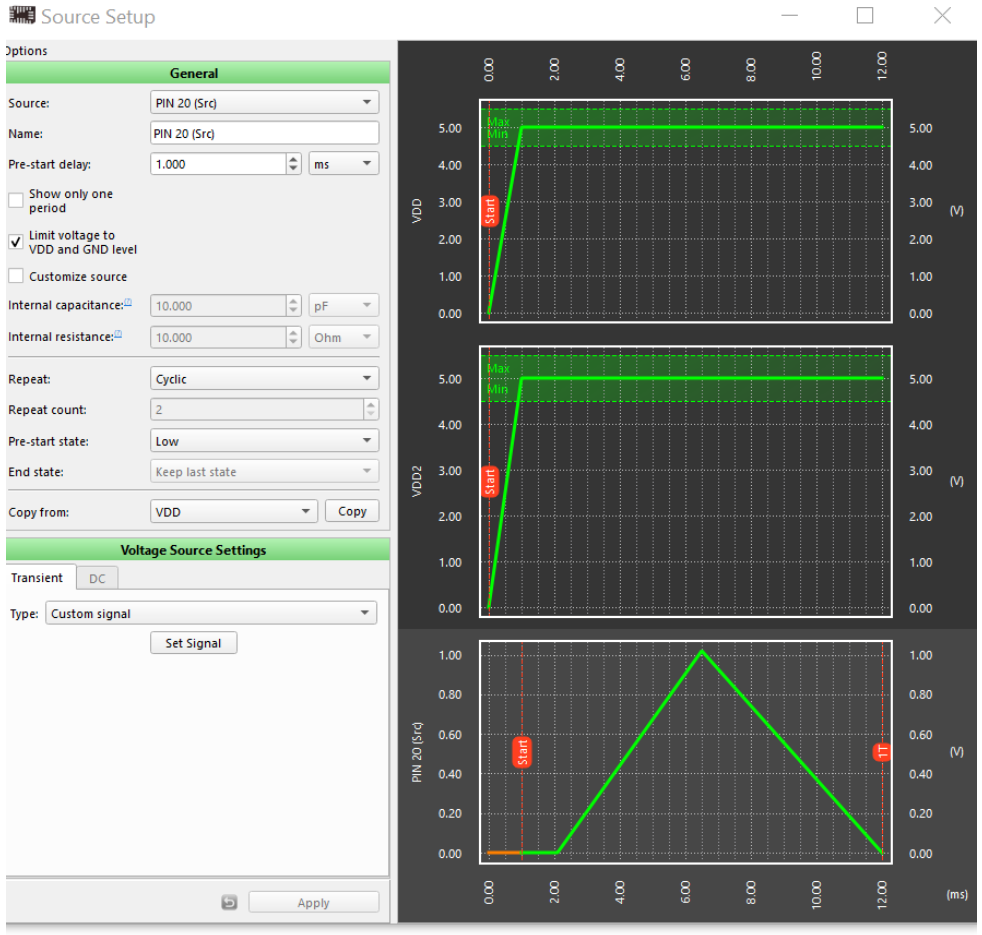

GP6

Design_Demonstration_2_finished.gp

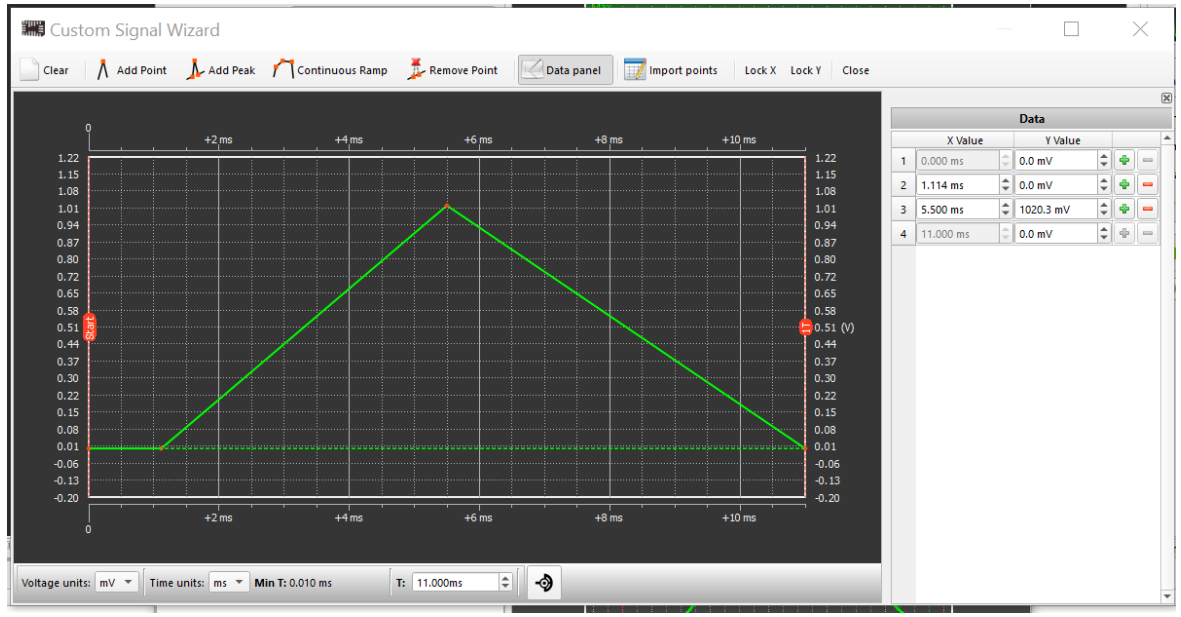
- Power Up the ACMP by connecting POR to PWR UP input
- Change the reference in each ACMP to the given value

# DESIGN DEMONSTRATION #1: SIMULATION SETUP

## Voltage source setup

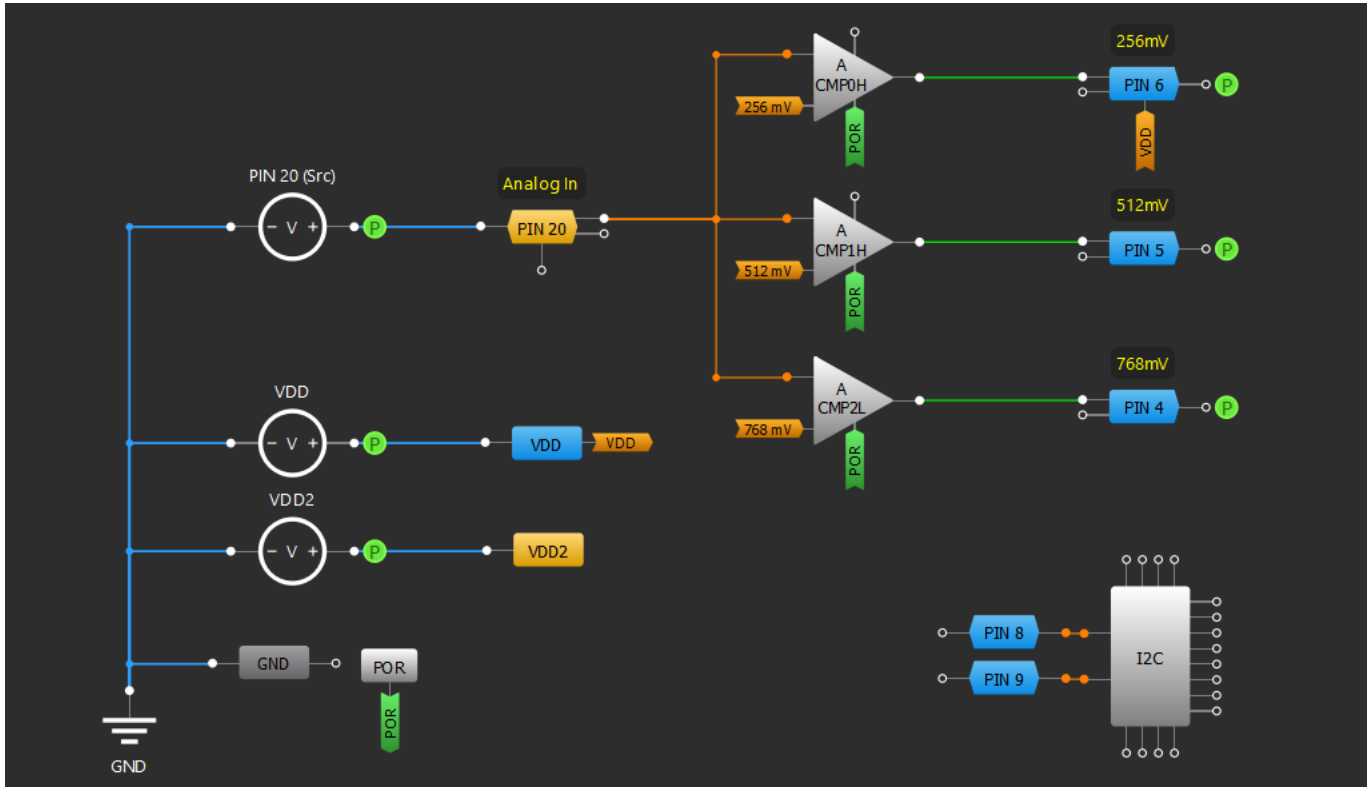



- VDD = VDD2 = 5V
- V(Pin 20) = triangle



# DESIGN DEMONSTRATION #1: ADDING PROBES FOR TESTING

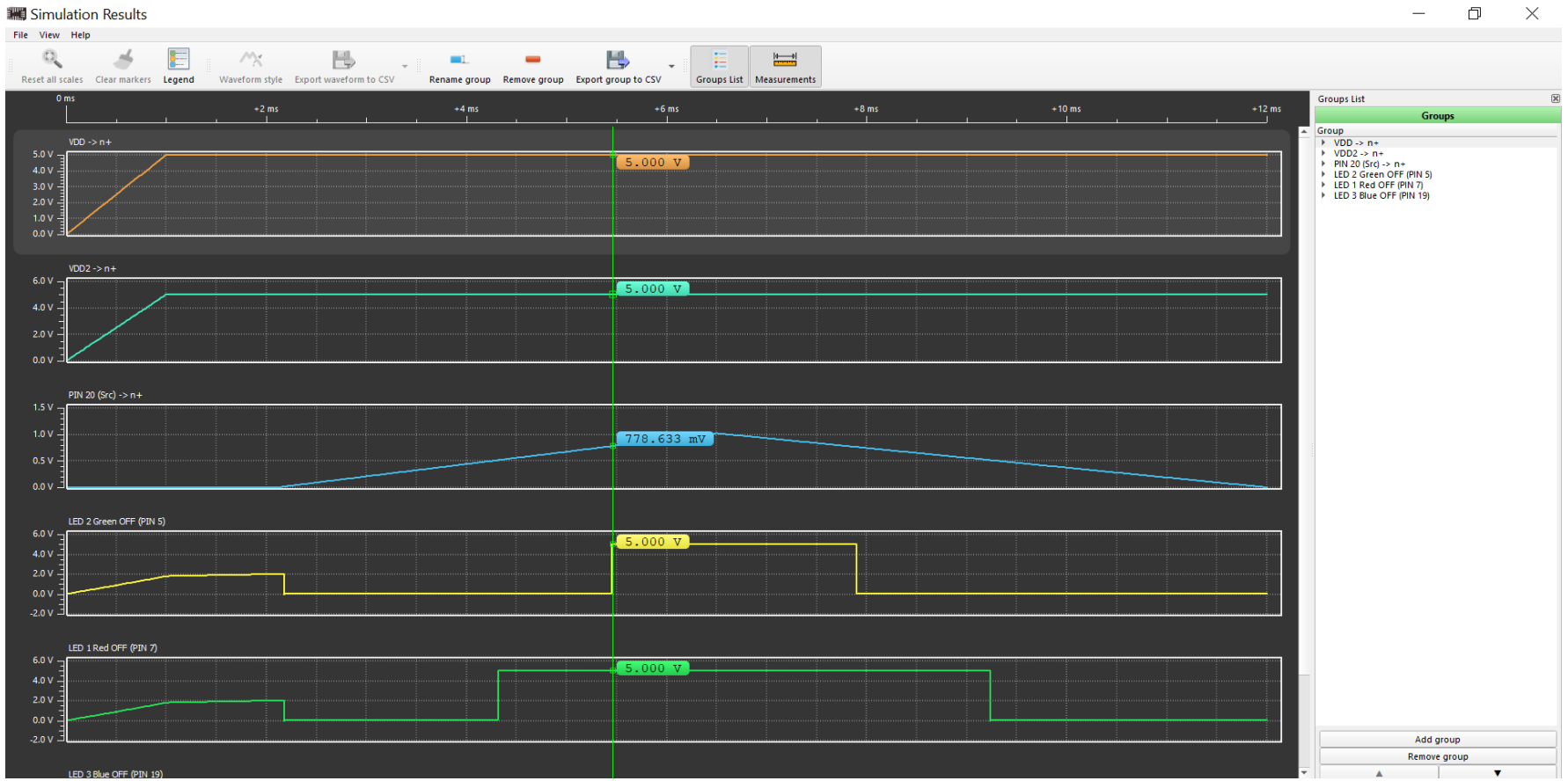
## Add probes




- Add probes where you want to see waveforms
- Parametric probes allow you to see counter states (can right-click on probe symbol to add)

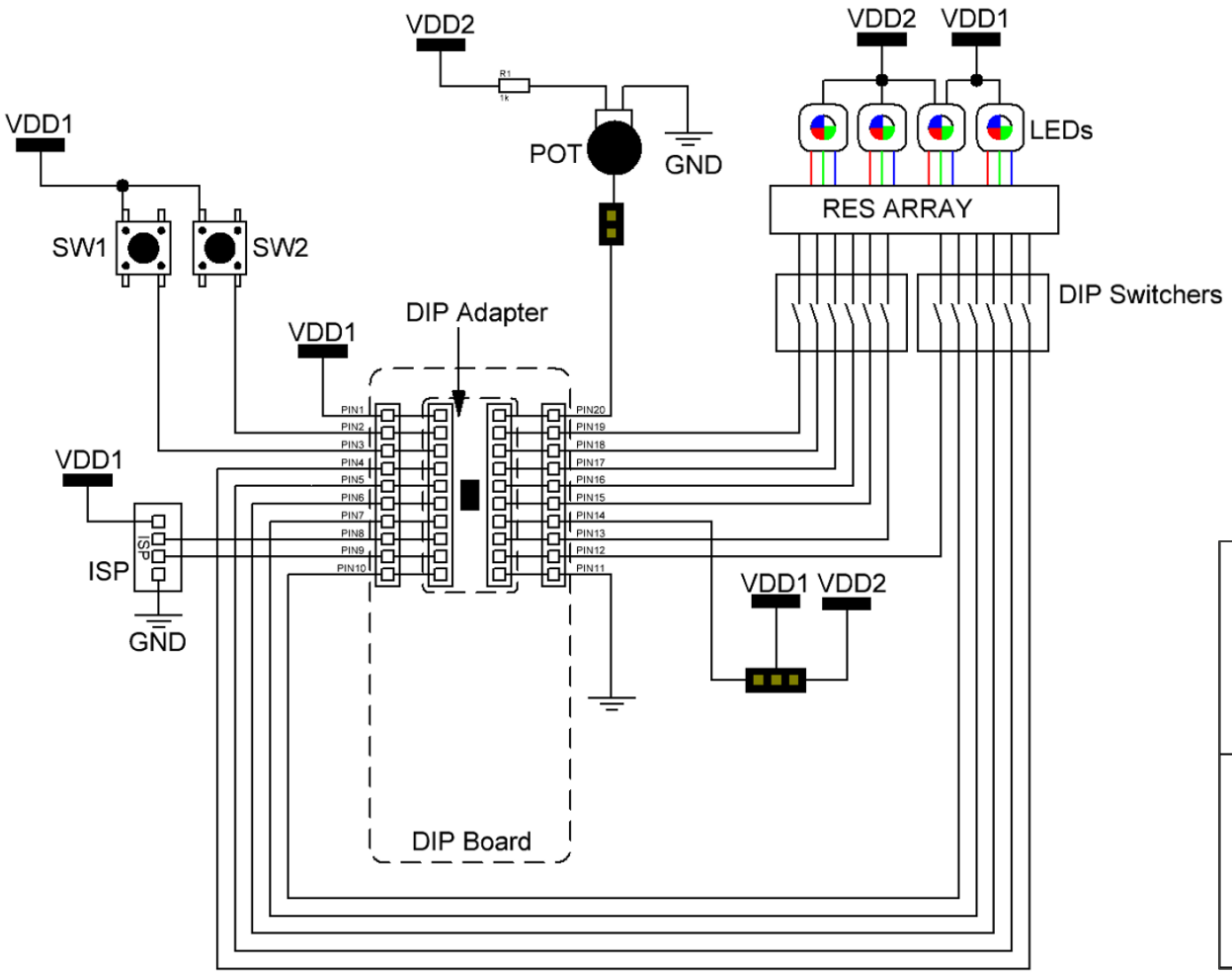
# DESIGN DEMONSTRATION #1: SPICE SIMULATION

## ACMPs and Spice Simulation




- Read out values with Markers

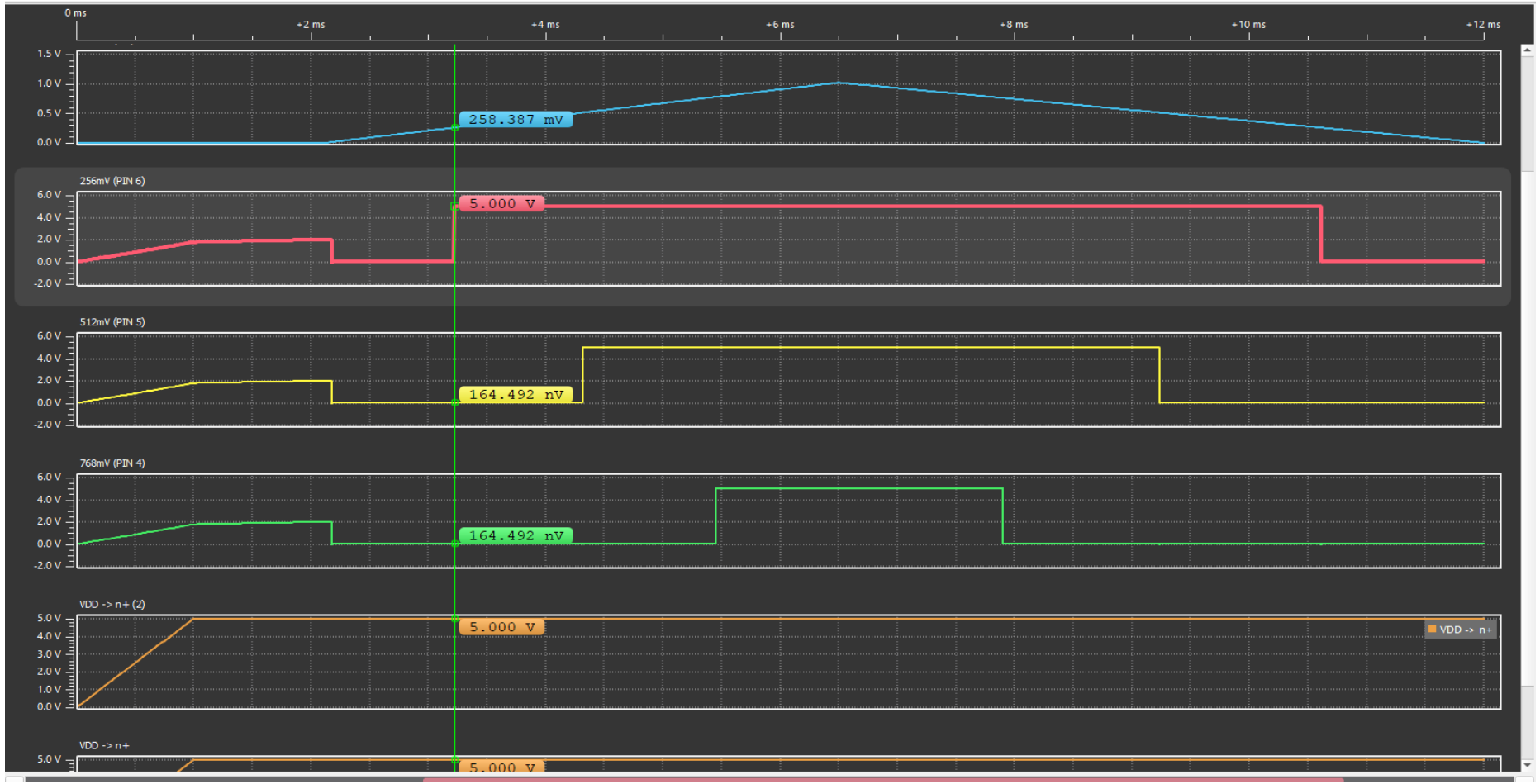
# SCHEMATIC AND MAPPING FOR TRAINING BOARD




| | | | | |
|---|---|---|---|---|
| SW4 | 1 | LED1 | Blue | PIN12 |
| | 2 | | Green | PIN10 |
| | 3 | | Red | PIN7 |
| | 4 | LED2 | Blue | PIN6 |
| | 5 | | Green | PIN5 |
| | 6 | | Red | PIN4 |
| SW3 | 1 | LED3 | Blue | PIN19 |
| | 2 | | Green | PIN18 |
| | 3 | | Red | PIN17 |
| | 4 | LED4 | Blue | PIN16 |
| | 5 | | Green | PIN15 |
| | 6 | | Red | PIN13 |

# DESIGN DEMONSTRATION #1 WITH REAL HARDWARE

## Simulation Results with Markers

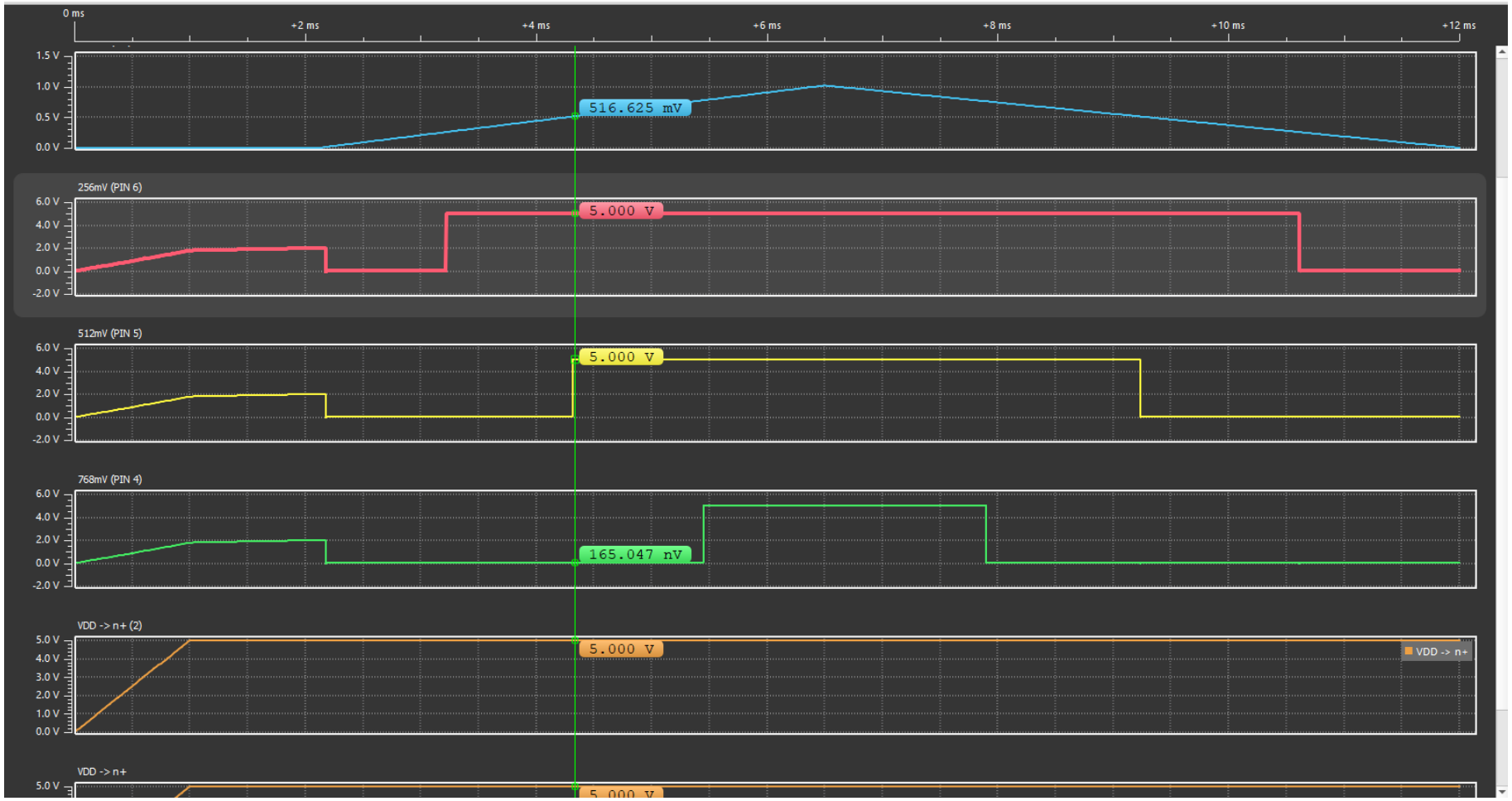



Simulation results

- VIN > 256 mV
- V (PIN 6) = 5 V
- V (PIN 5) = 0 V
- V (PIN 4) = 0 V
- Green LED ON @Training Board
- TP6 LED is ON

# DESIGN DEMONSTRATION #1 WITH REAL HARDWARE

## Simulation Results with Markers

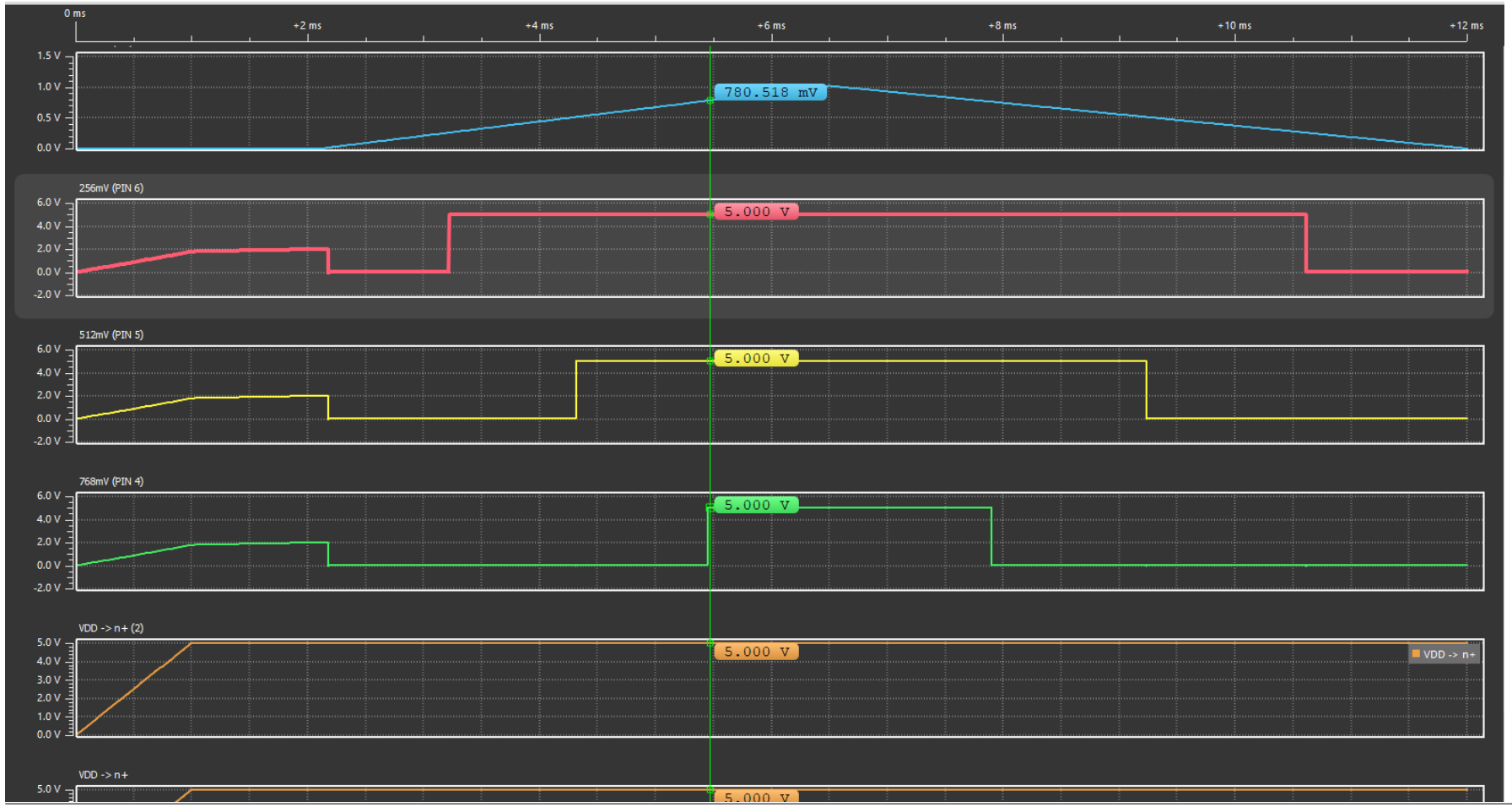



Simulation results

- VIN > 512 mV
- V (PIN 6) = 5 V
- V (PIN 5) = 5 V
- V (PIN 4) = 0 V
- Red LED ON @ Training Board
- TP6 LED is ON
- TP5 LED is ON

# DESIGN DEMONSTRATION #1 WITH REAL HARDWARE

## Simulation Results with Markers

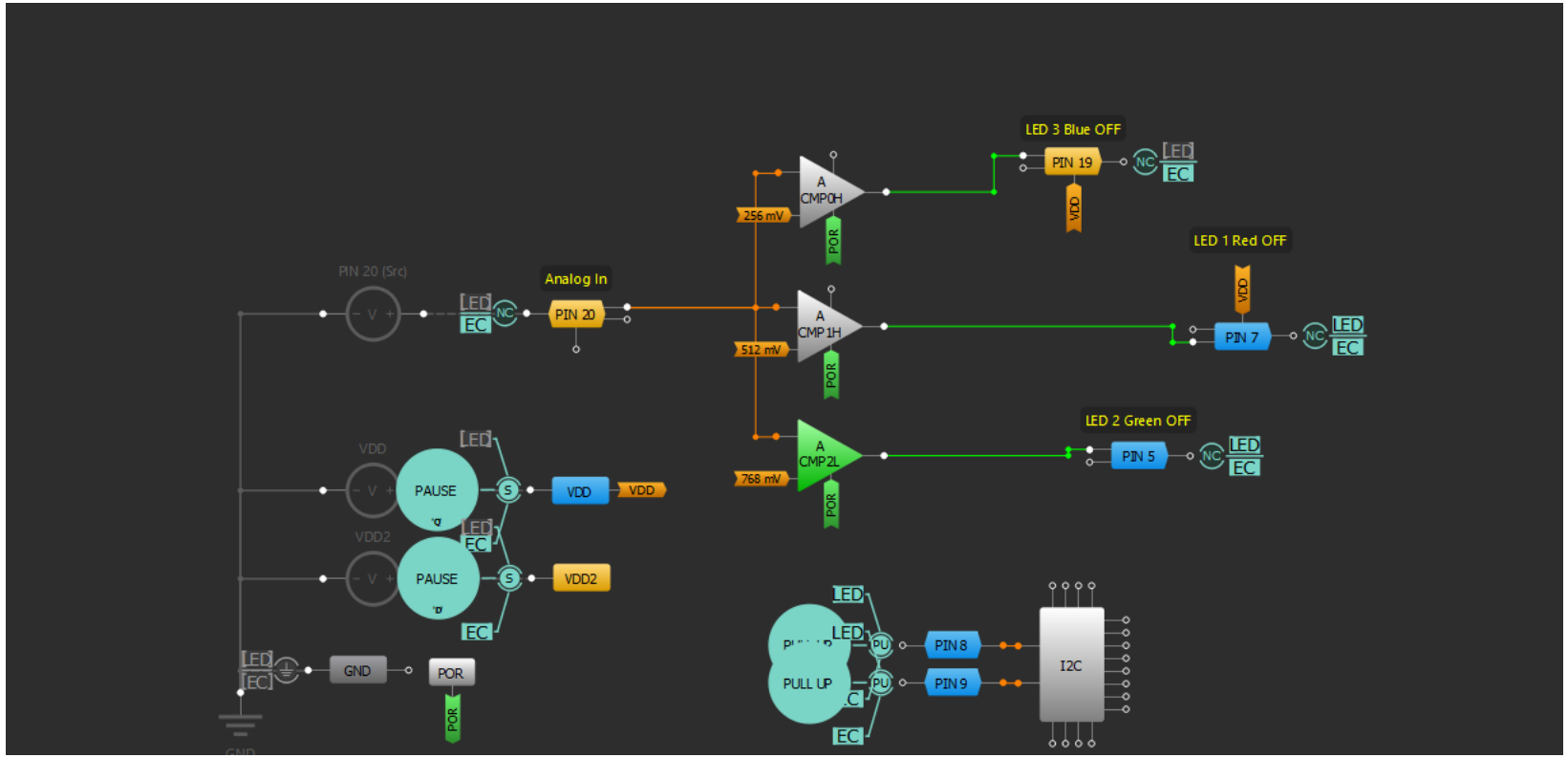



Simulation results

- VIN > 768 mV
- V (PIN 6) = 5 V
- V (PIN 5) = 5 V
- V (PIN 4) = 5 V
- No LED ON @ Training Board
- TP6 LED is ON
- TP5 LED is ON
- TP4 LED is ON

# DESIGN DEMONSTRATION #2 WITH REAL HARDWARE

## Linking the PINs to other LEDs (Emulation Mode)



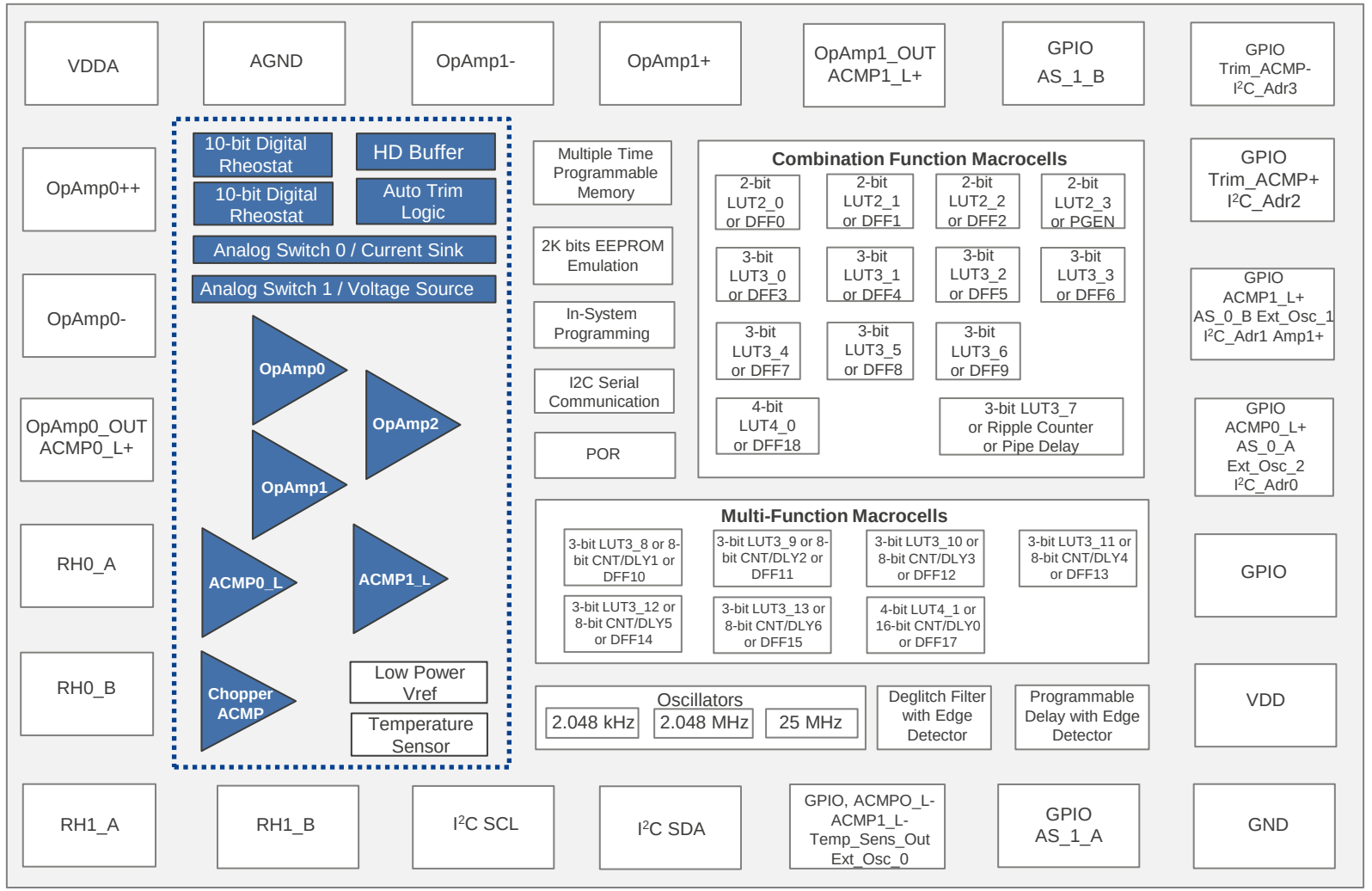

PIN 19 = LED 3 Blue OFF
PIN7 = LED2 Green OFF
PIN5 = LED1 Red OFF

- TP7 LED is ON
- TP5 LED is ON

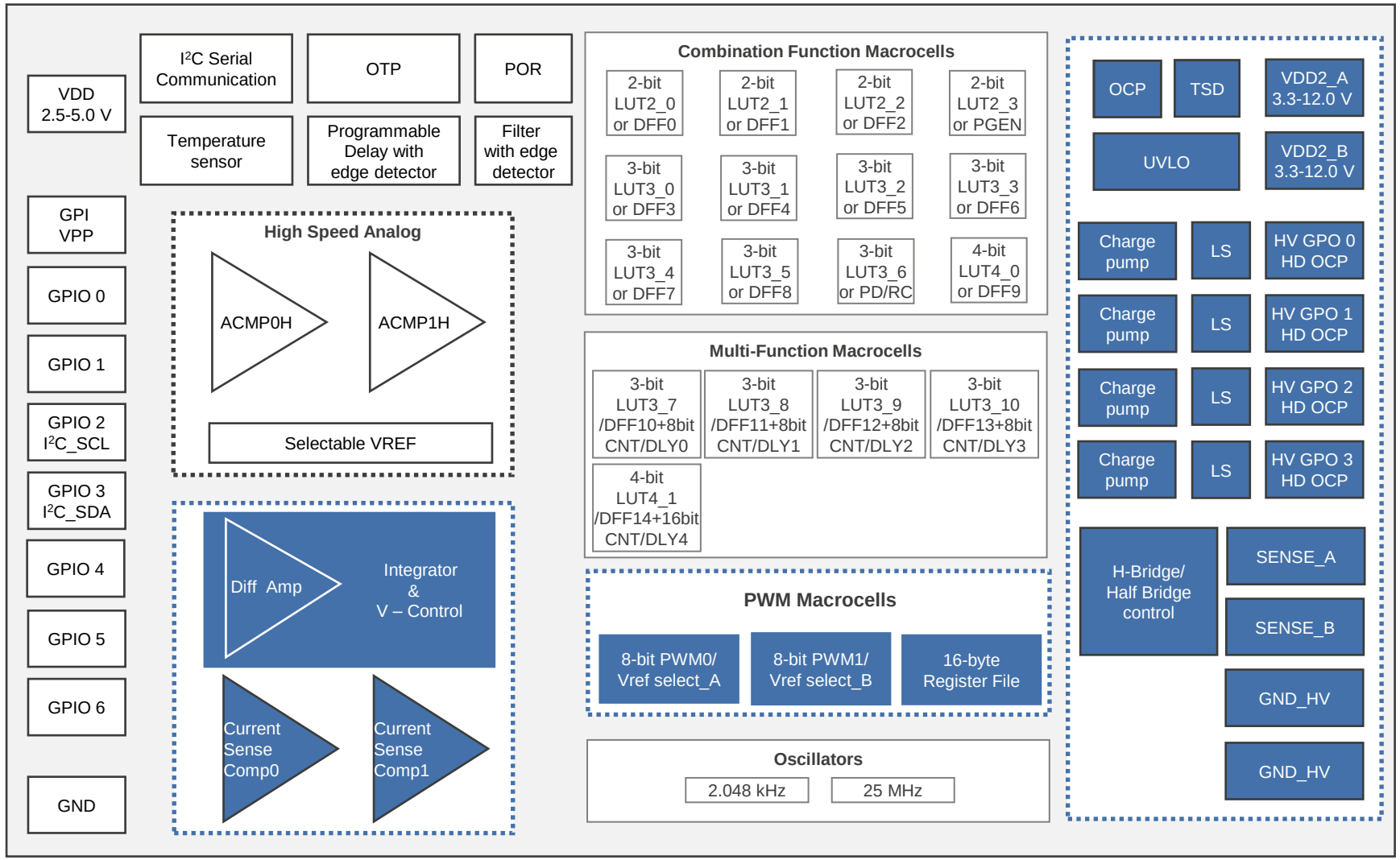
Input PIN 20 is variable (POTI)

# GREENPAK MACRO CELLS (EXAMPLES)

# EXAMPLE: ANALOGPAK: SLG47004: BLOCK DIAGRAM

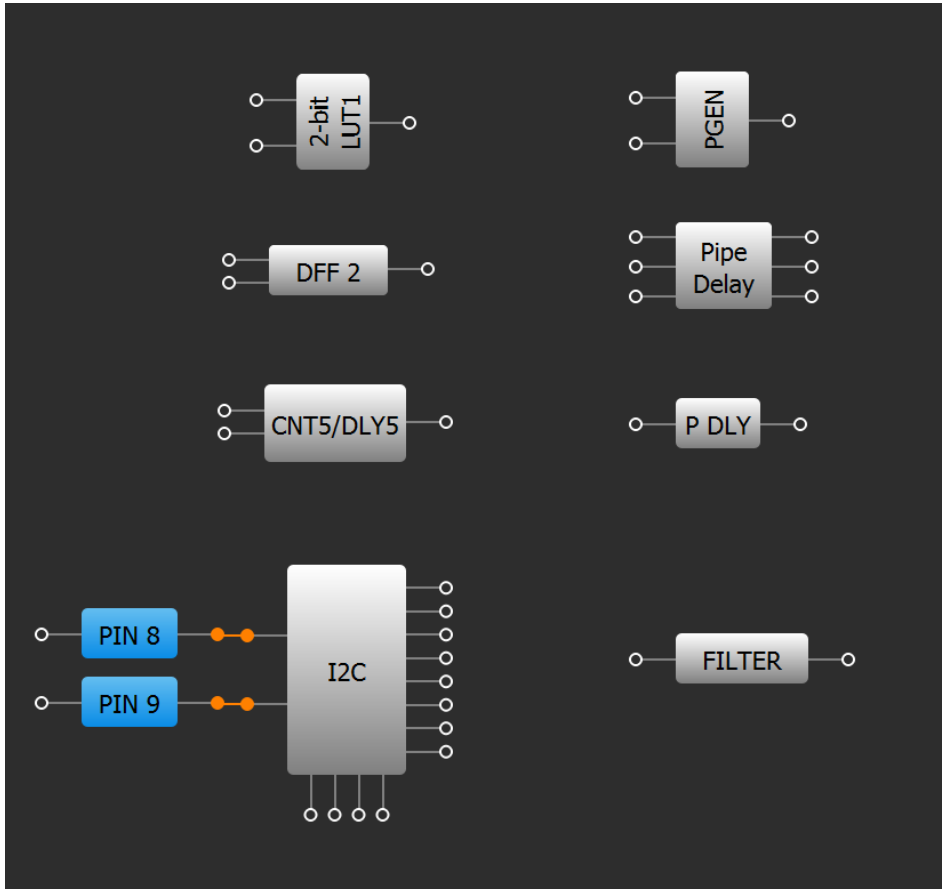


# EXAMPLE: HVPAK:SLG47105 BLOCK DIAGRAM



# DIGITAL MACROCELLS

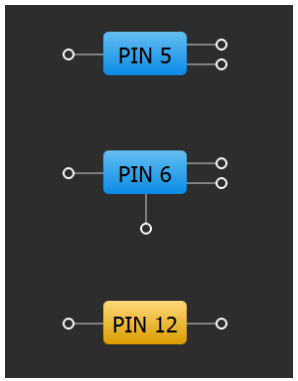
- Common Digital Macro cells
  - Look-Up Tables (LUTs)
  - D Flip-Flop (DFF) / Latch
  - Counter / Delay (CNT/DLY)
- Communication
  - $I^2C$ (many devices)
  - SPI (select devices)
- Less Common
  - Pattern Generator (PGEN)
  - Pipe Delay
  - Programmable delay (PDLY)
  - Filter / Edge Detector



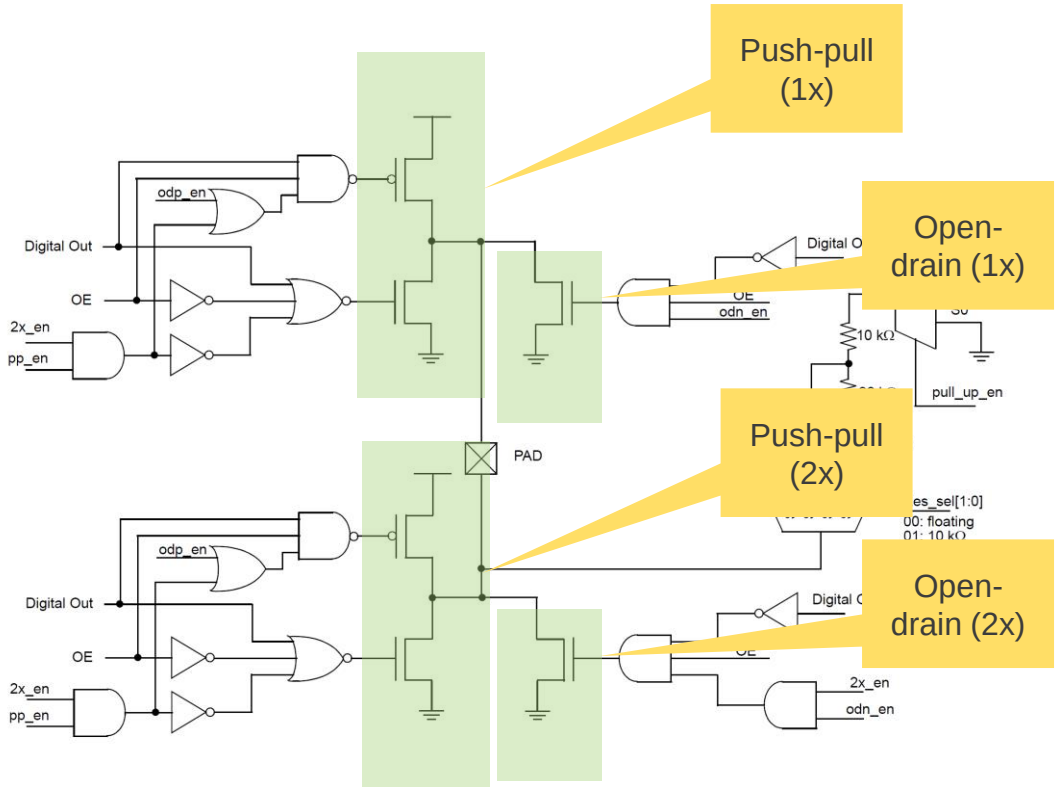
# I/Os

## Most I/Os in GreenPAK devices are very flexible

- Various output modes [Push-pull (1x or 2x), Open-drain (1x or 2x) or Analog-Output]
- Various input modes [Digital-In, Digital-In with Schmitt trigger, Low Voltage Digital-In and Analog-In]
- Some I/Os support Output Enable
- Some I/Os support level shifting

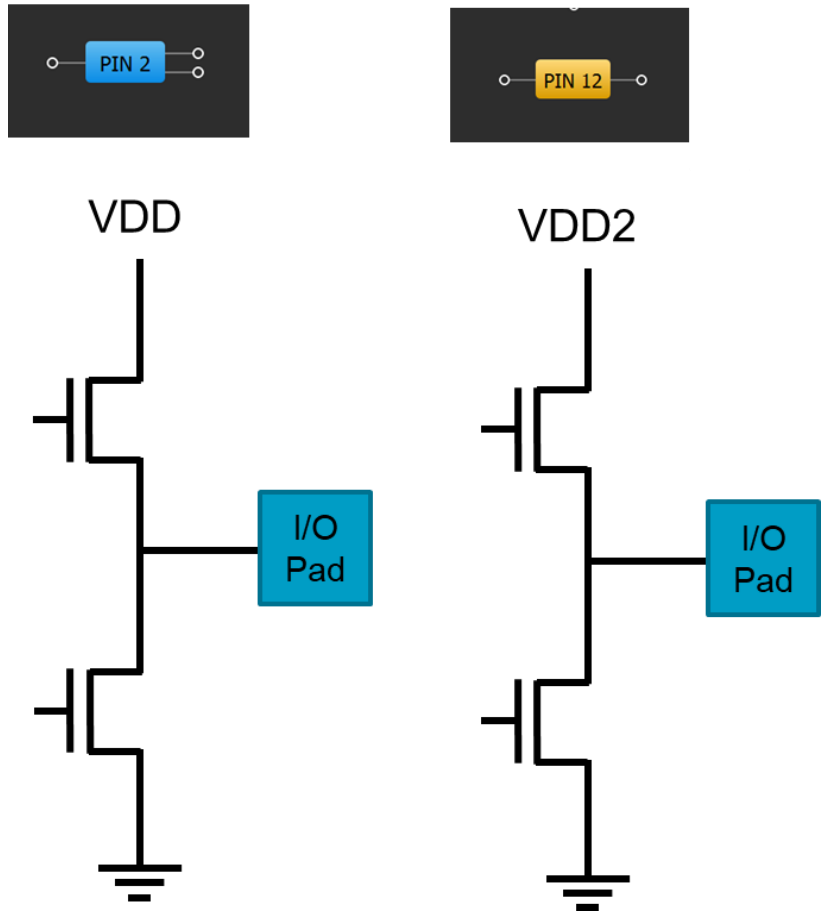



## Typical I/O Structure



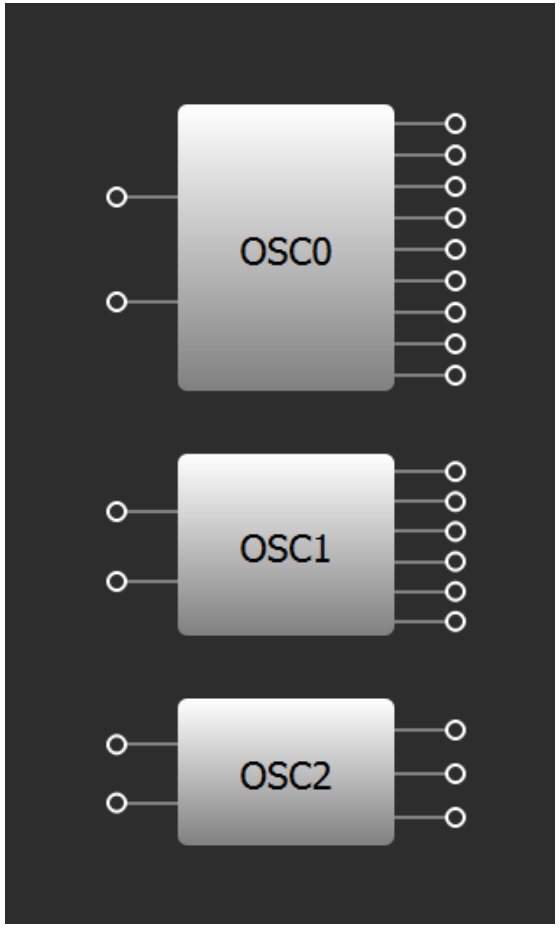
# LEVEL SHIFTING

- GreenPAK devices with VDD2 have some I/O pins tied to VDD2
  - You can see this by the color of the Pin icon
- This makes level shifting applications very easy to implement
- Some of the devices have VDD2



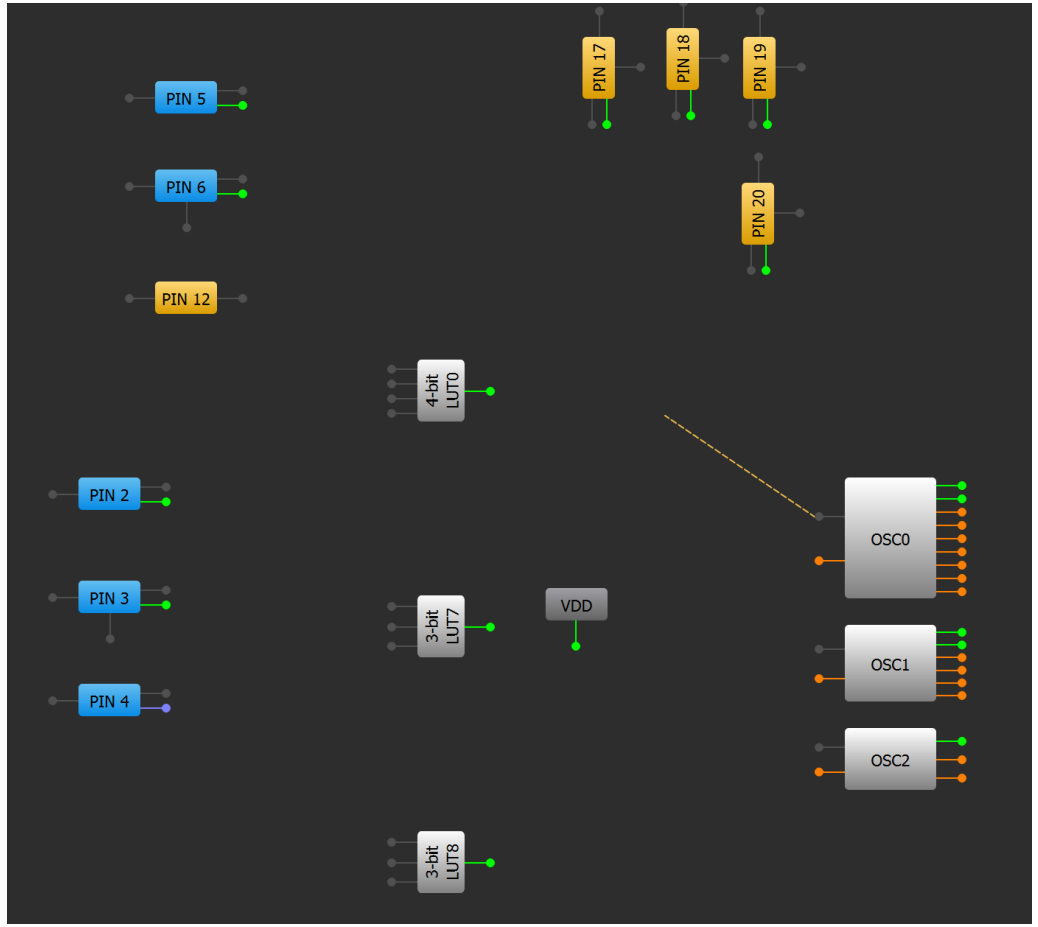
# OSCILLATORS

- Most GreenPAK devices have at least two oscillators
- Newest devices have three oscillators, i.e., SLG46824/826 have three oscillators
  - 2KHz low speed, low power oscillator
  - 2MHz medium speed
  - 25MHz high speed
- Auto-power on option allows you to turn off the oscillator when the clock is not needed
  - Great way to save power
- Oscillator outputs have several pre-dividers to allow you flexibility in clocking



# INTERCONNECTIONS

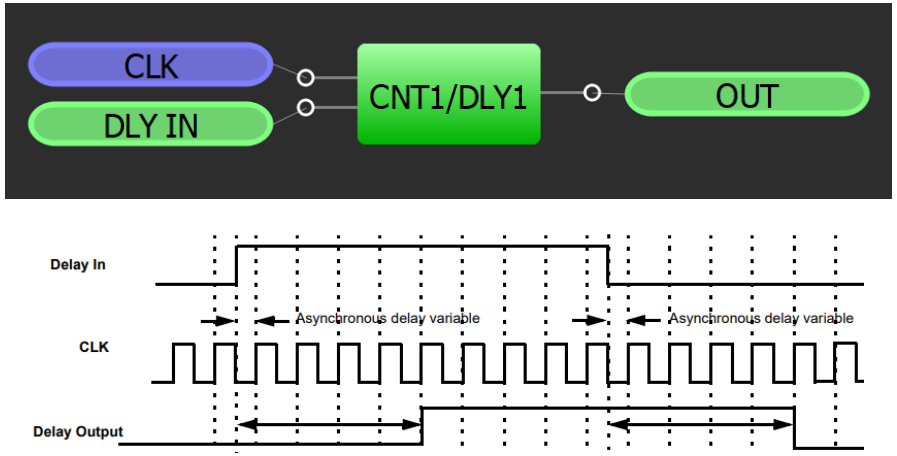
- Interconnection is easy
- System will guide you on which connections you can make
- When you click on any connection point, the system:
  - Highlights all available connections in green
  - Gives you a “rubber band” connection that you can stretch to any of these green connection
  - This results in a green wire to show you interconnections you have made



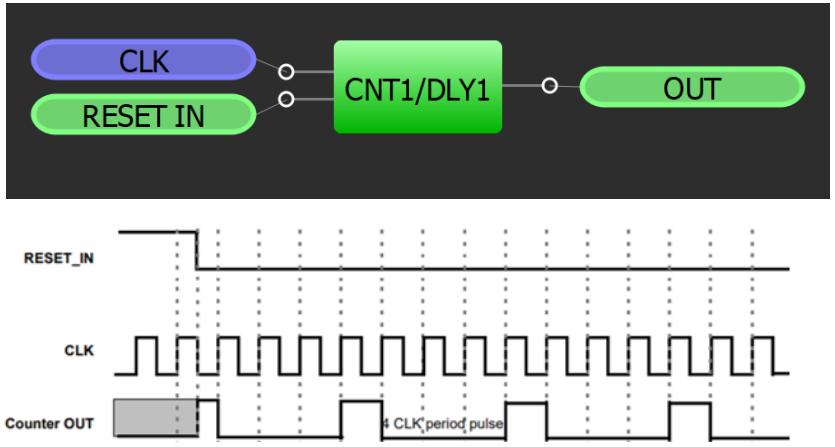
# COUNTER DELAY (CNT/DLY) BLOCKS

- CNT/DLY macrocells allow diverse customization of timing sequences
- Configuration modes to match unique behavior
  - Delays
  - One-shot
  - Frequency Detect
  - Reset Counter
  - Edge Detect
  - Delayed Edge Detect

### Delay Mode (Both Edges)

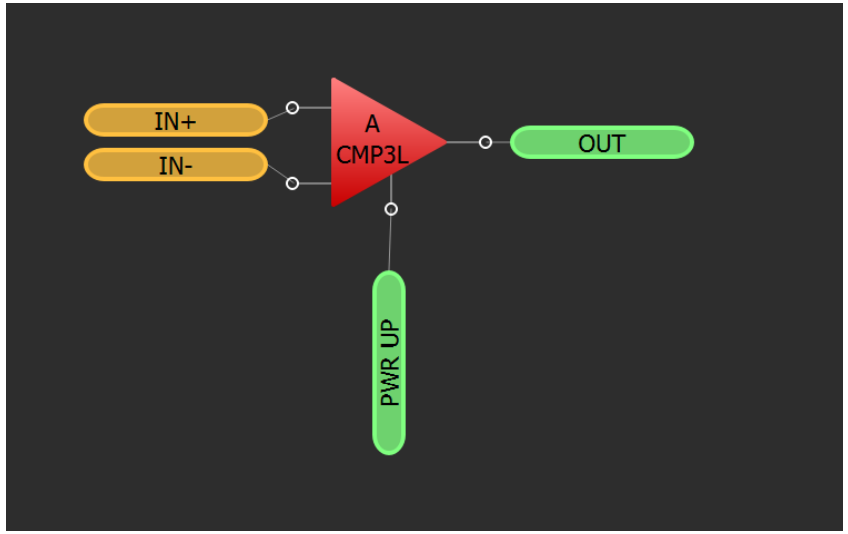


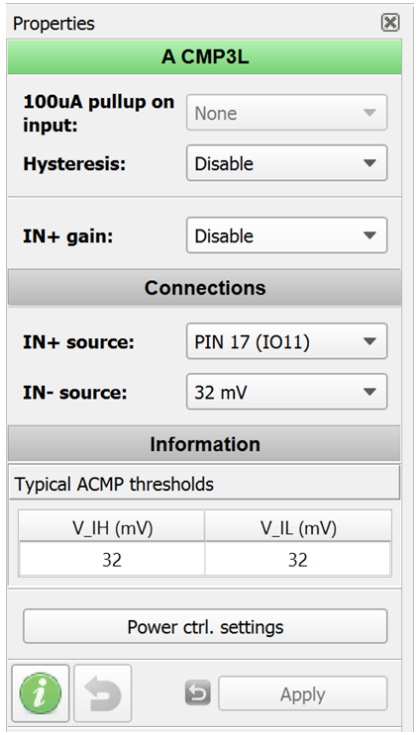

### Reset Counter Mode (High-level Reset)



# ACMPs

- ACMPs offer easy and integrated way to include analog input functions in your GreenPAK design
  - ACMPs in GreenPAK optimized high integration – including selectable internal voltage references
  - Power Up (PWR UP) signal input allows for powers savings by turning off the ACMPs



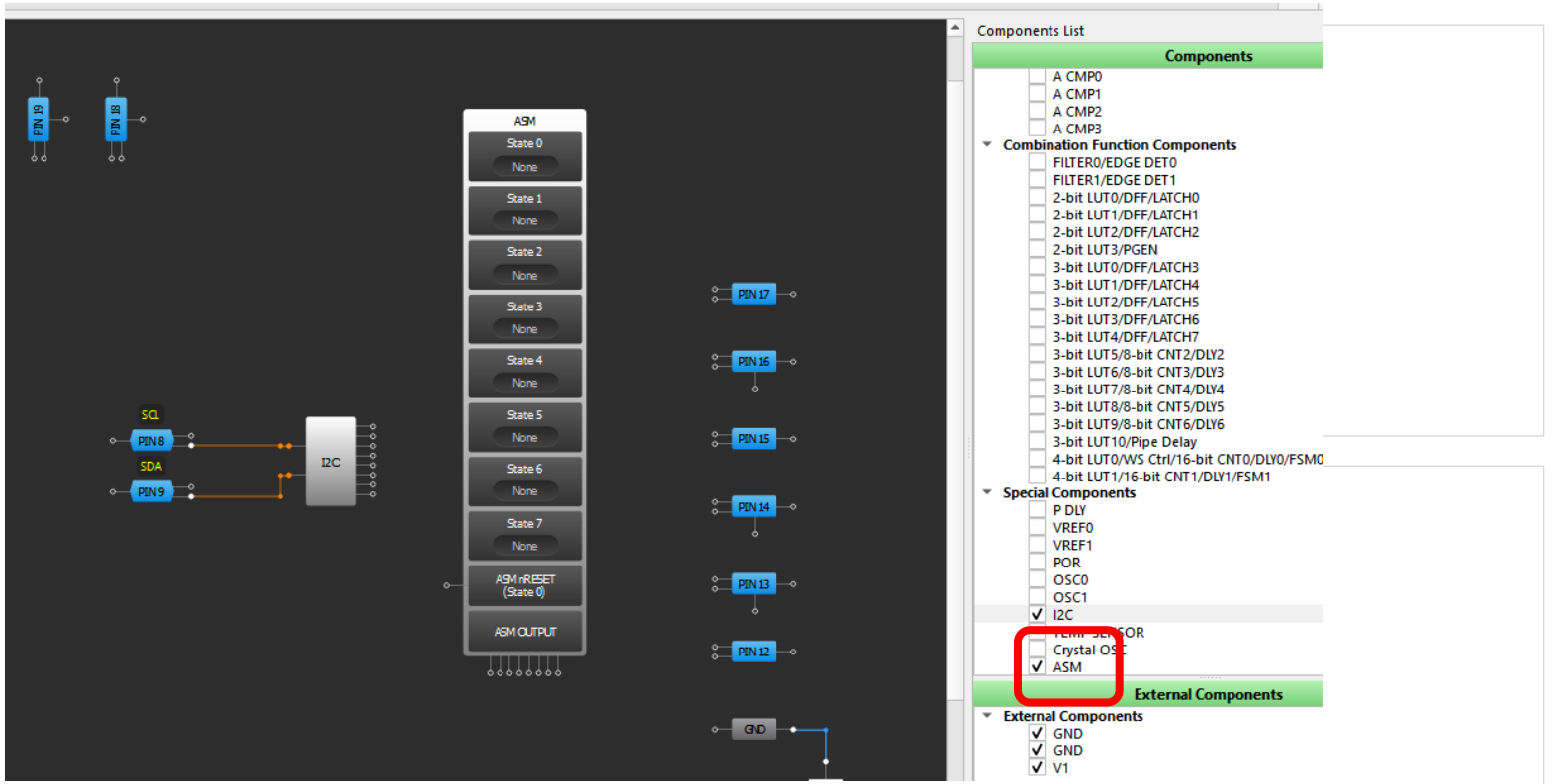



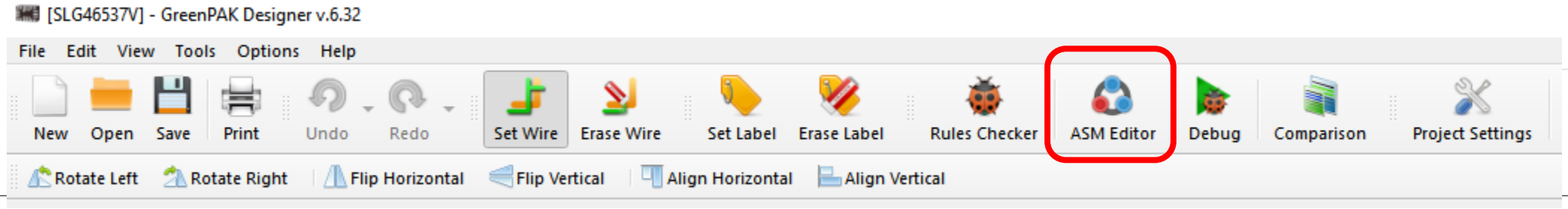

- 100µA pullup on input
- Hysteresis
- Gain
- In+ Source
- In- Source
- Internal voltage reference goes from 32mV to 2016mv
  - Step size is 32 mV
- External voltage reference is also an option

# ASYNCHRONOUS STATE MACHINE

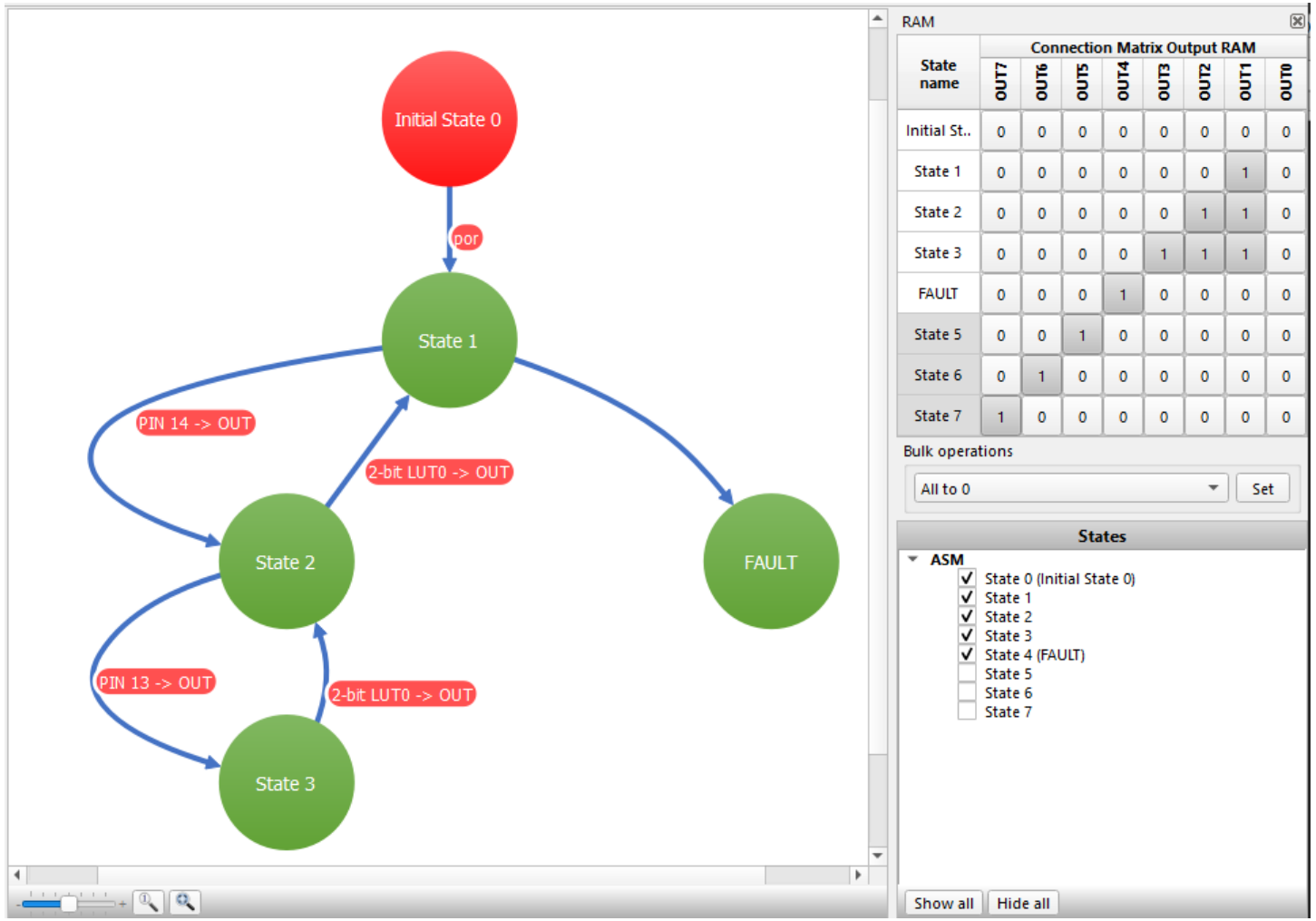
Some Greenpaks features an ASM (asynchronous state machine) block (e.g. SLG46537)

The ASM is convenient way to create power sequencer function.



# ASYNCHRONOUS STATE MACHINE: DESIGN VIEW




RAM

| State name | Connection Matrix Output RAM OUT7 | OUT6 | OUT5 | OUT4 | OUT3 | OUT2 | OUT1 | OUT0 |
|---|---|---|---|---|---|---|---|---|
| Initial St.. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| State 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| State 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| State 3 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| FAULT | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| State 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| State 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| State 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Bulk operations

All to 0 | Set

States

ASM
- [x] State 0 (Initial State 0)
- [x] State 1
- [x] State 2
- [x] State 3
- [x] State 4 (FAULT)
- [ ] State 5
- [ ] State 6
- [ ] State 7

Show all | Hide all

Define your states with Look up tables and in a flow chart

# DESIGN SECURITY

# DESIGN SECURITY

- Greenpaks allows a portion or the entire Register and NVM to be inhibited from being read or written/erased
- Customer specific designs can be “hidden” inside a Greenpak,
- looks like a “Black Box” from outside
- It’s up to the customer’s choice how much he would like to “hide” of his specific design
- Impedes “Reverse Engineering” of your design
- Can be easily done in “Project Settings” in the Go Configure Software Hub

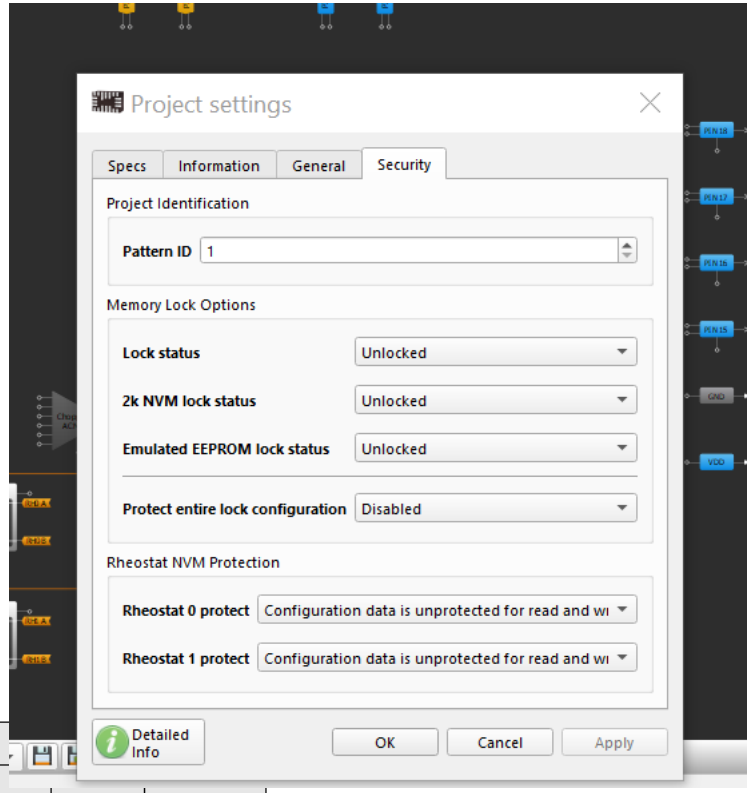


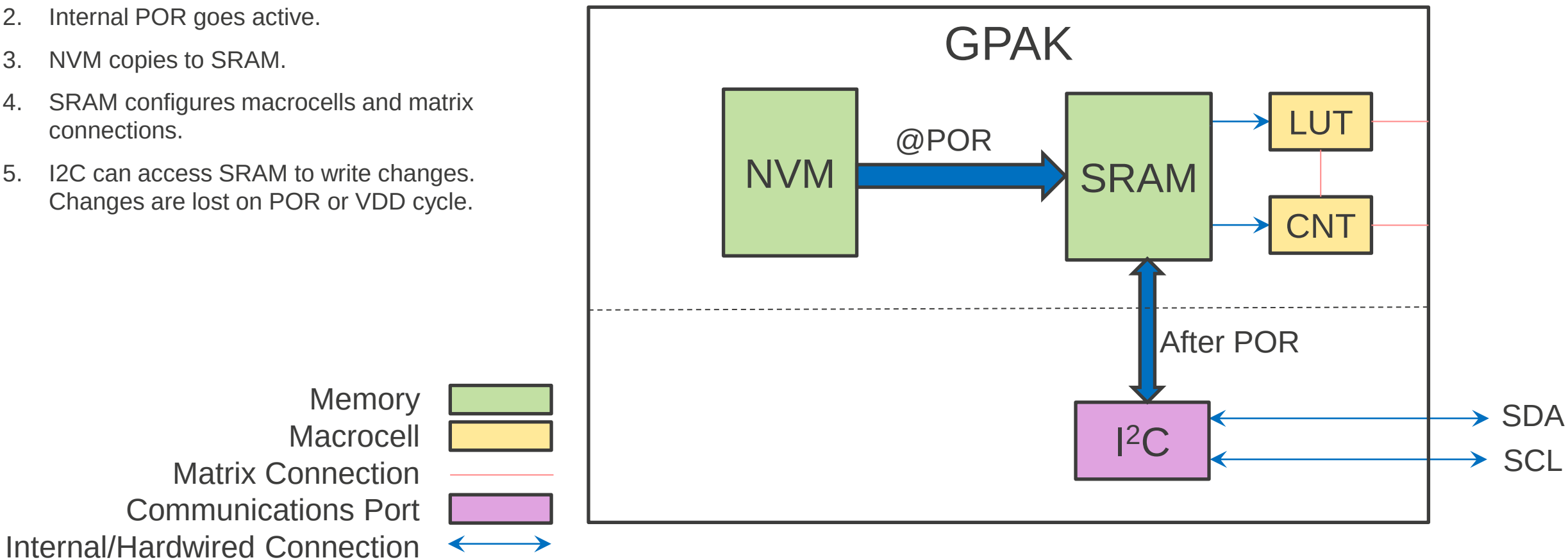

**Table 65: Read/Write Register Protection Options**

| Configurations | Protection Modes Configuration | | | | | | | | | Test Mode | Register Address |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unlock | Partly Lock Read | Partly Lock Write | Partly Lock Read/ Write | Partly Lock Read & Lock Write | Lock Read & Partly Lock Write | Lock Read | Lock Write | Lock Read/ Write | | |
| RPR[1:0] | 00 | 01 | 00 | 01 | 01 | 10 | 10 | 00 | 10 | | |
| RPR[3:2] | 00 | 00 | 01 | 01 | 10 | 01 | 00 | 10 | 10 | | |

# GREENPAK – I2C BLOCK PRESENT

## Power Up Sequence

1. Apply VDD.
2. Internal POR goes active.
3. NVM copies to SRAM.
4. SRAM configures macrocells and matrix connections.
5. I2C can access SRAM to write changes. Changes are lost on POR or VDD cycle.



# DESIGN SECURITY: CUSTOM PART NUMBER: BASE PART VS CUSTOMER PART

RENESAS Datasheet

SLG47115

GreenPAK Programmable Mixed-Signal Matrix with High Voltage Features

The SLG47115 provides a small, low power component for commonly used Mixed-Signal and Full Bridge functions. The user creates their circuit design by programming the one time programmable (OTP) Non-Volatile Memory (NVM) to configure the interconnect logic, the IO Pins, the High Voltage Pins, and the macrocells of the SLG47115.

Configurable PWM macrocells in combination with Special High Voltage outputs will be useful for a motor drive or load drive applications. High Voltage pins allow to design smart level translators or to drive the high voltage high current load.

**Features**

- Two Power Supply Inputs:
  - 2.5 V (±8 %) to 5.0 V (±10 %) $V_{DD}$
  - 5.0 V (±10 %) to 24.0 V (±10 %) $V_{DD2}$
- Two High Voltage High Current Drive GPOs
  - Full Bridge Driver Option
  - Dual/Single Half Bridge Driver Option
  - Slew Rate Modes:
    - Motor Driver Mode
    - Pre-Driver (MOSFET Driver) Mode
  - High Drive GPOs with Sleep Function
  - Low $R_{DS(ON)}$ High-side + Low-side resistance = 0.5 Ω typical
  - 3 A Peak, 1.5 A RMS per Full Bridge[1]
  - Current up to 3 A Peak, 1.5 A RMS per GPO/Half Bridge and up to 6 A Peak, 3 A RMS for two HV GPOs Connected in Parallel[1]
  - Integrated Over Current/Short Circuit/Undervoltage-Lockout Protections
  - SENSE Input that is connected to the Current Comparator for Current Control
  - Fault Signal Indicator (OCP/UVLO/TSD/)
- Differential Amplifier with Integrator and Comparator for Motor Speed Control Function
- Current Sense Comparator with Dynamical Vref Mode
- Two High-Speed General Purpose ACMPs
  - Modes: UVLO, OCP, TSD, Voltage Monitor, Current Monitor
- One Voltage Reference (Vref) Output
- Five Multi-Function Macrocells
- Four Selectable DFF/LATCH/3-bit LUTs + 8-bit Delay/Counters
- One Selectable DFF/LATCH/4-bit LUT + 16-bit Delay/Counter
- Twelve Combination Function Macrocells
  - Three Selectable DFF/LATCH or 2-bit LUTs
  - One Selectable Programmable Pattern Generator or 2-bit LUT
  - Six Selectable DFF/LATCH or 3-bit LUTs
  - One Selectable Pipe Delay or Ripple Counter or 3-bit LUT
  - One Selectable DFF/LATCH or 4-bit LUT
- Two PWM Macrocells
  - Flexible 8-bit/7-bit PWM Mode with the Duty Cycle Control
  - 16 Preset Duty Cycle Registers Switching Mode for PWM Sine or Other Waveforms[2]
- Serial Communications
  - I²C Protocol Interface
- Programmable Delay with Edge Detector Output
- Additional Logic Function – One Deglitch Filter with Edge Detectors
- Two Oscillators (OSC)
  - 2.048 kHz Oscillator
  - 25 MHz Oscillator
- Analog Temperature Sensor with ACMP Connected Output
- POR
- One Time Programmable Memory
- Operating Temperature Range: -40 °C to 85 °C
- RoHS Compliant/Halogen-Free
- 20-pin STQFN: 2 mm x 3 mm x 0.55 mm, 0.4 mm pitch

**Applications**

- Smart Locks
- Personal Computers and Servers
- Consumer Electronics
- Motor Drivers
- Toys
- HV MOSFET Drivers
- Video Security Cameras
- LED Matrix Dimmers

[1] Power dissipation and thermal limits must be observed. See Section 3.3 Recommended Operating Conditions.
[2] For all PWM features see Section 13. Pulse Width Modulation Macrocell.

R19DS0118EU0111 Rev.1.11
Sep 23, 2022

RENESAS

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RENESAS

SLG4BF45665

GreenPAK ™

Camera shutter Module

**General Description**

The SLG4BF45665 provides a small, low power component for commonly used Mixed-Signal and H-Bridge functions.
The SoC is housed in a 2mm x 3mm STQFN package which is optimal for using with small devices.
Configurable PWM macrocells in combination with Special High Voltage outputs will be useful for a motor drive or load drive applications. High Voltage pins allow to design smart level translators or to drive the high voltage high current load.

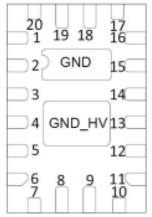
**Features**

- Low Power Consumption
- Pb - Free / RoHS Compliant
- Halogen - Free
- STQFN - 20 Package
- Four High Voltage High Current Drive GPOs
- Current up to 1.5A RMS per GPO/ H-Bridge
- Differential Amplifier with Integrator
- Two Current Sense Comparators
- Two PWM Macrocells

**Output Summary**

2 Outputs - High Drive Push Pull

**Pin Configuration**




STQFN-20L
(Top View)

**Pin name**

| Pin # | Pin name | Pin # | Pin name |
|---|---|---|---|
| 1 | VDD | 11 | VDD2_B |
| 2 | NC | 12 | PGND |
| 3 | NC | 13 | GND |
| 4 | GND | 14 | NC |
| 5 | PGND | 15 | SCL |
| 6 | VDD2_A | 16 | SDA |
| 7 | OUT1 | 17 | NC |
| 8 | OUT2 | 18 | GND |
| 9 | NC | 19 | NC |
| 10 | NC | 20 | NC |

SLG4BF45665_DS_r010
SLG4BF45665_GP_r001

RENESAS
*Preliminary*

Rev 0.10
Revised March 25, 2022

- **Base device IC datasheet on left**
  - Base datasheets have default device information
- **Customer specific part number & custom datasheet right**
  - Customer specific part number is unique to GreenPAK IC design
- **Customizable datasheet**
  - Tailored to customer request (i.e. remove or add specific data such as tables or figures)
- **Purchasable only by customer**
  - Only customer who owns design can purchase part
  - Need approval from customer to sell to non-customer entity (CM, 3rd parties, etc.)

# GREENPAK RESOURCES

# PRODUCT SELECTION TABLE

## Product Selection Table

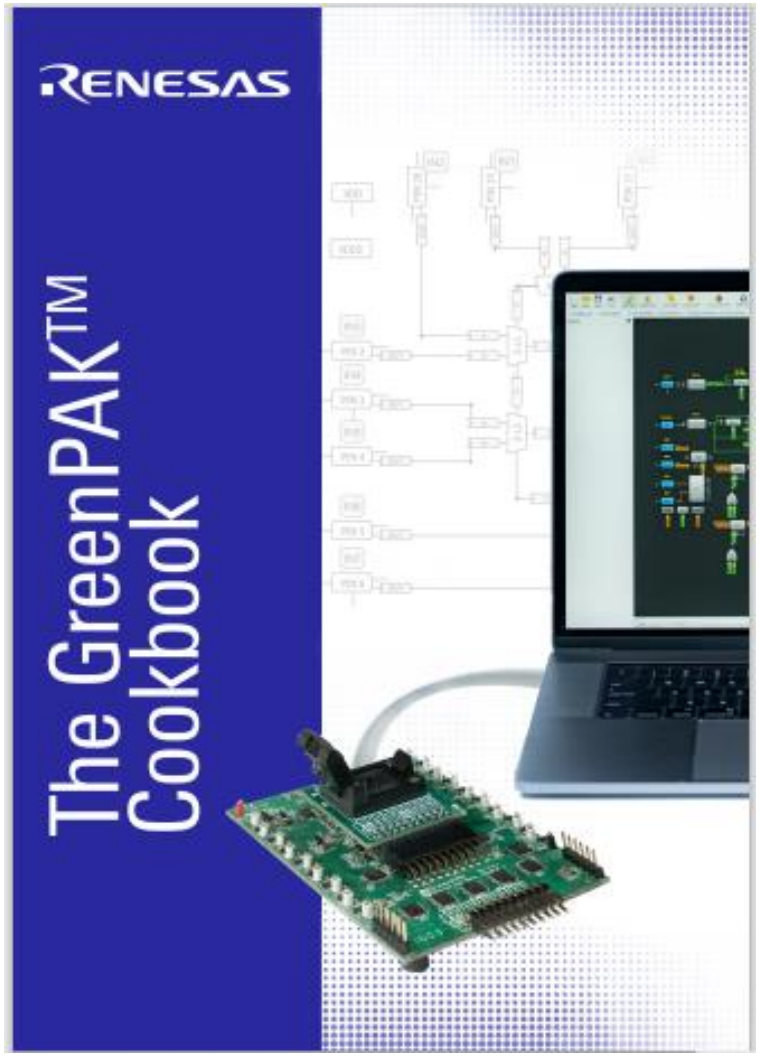
Hide Filters | Reset | Full Screen | Export | Tips

| Part Number | Special Features | GPIOs (#) | Nor |
|---|---|---|---|
| **Part Count: 7**<br>(46) Featured Products<br>(0) Additional Products<br>Automotive | 1x H-/2x Half- Bridge, 2x PWM, CCMP, Int&Diff Amp, Pattern Generator<br>2x H-/4x Half- Bridge, 2x PWM, 2x CCMP, Int&Diff Amp, Pattern Generator<br>2x Op Amp or 1x In-Amp, 2x Rheostat, 2x An Switch, 2-Ch Auto-Trim, EEPROM, Pattern Generator<br>2x P-FET (44Ω, 2A)<br>OR | ≤ 28<br>≥ 0 | OR |
| SLG46538-A<br>Automotive GreenPAK™ Programmable ... | ASM (8 states), Pattern Generator | 17 | |
| SLG46620-A<br>Automotive GreenPAK Programmable M... | 3x PWM, ADC (8-bit, SAR), 2x DAC, Pattern Generator | 18 | |
| SLG46625-A<br>Automotive GreenPAK Programmable M... | 3x PWM, ADC (8-bit, SAR), 2x DAC, Pattern Generator | 18 | |
| SLG46827-A<br>Automotive GreenPAK™ Programmable ... | Pattern Generator | 17 | |

[GreenPAK™ Programmable Mixed-signal Products | Renesas]

# GREENPAK COOKBOOK

- Our Cookbook has **OVER 90** applications & techniques references for design with GreenPAK
- The design files are downloadable
- Greenpak Cookbook
- Good Approach to start your design
- Search for the application and extent your design with the building blocks needed

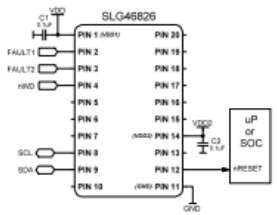


# GREENPAK COOKBOOK AND APPLICATION NOTES

The GreenPAK Cookbook

## Application: System Reset

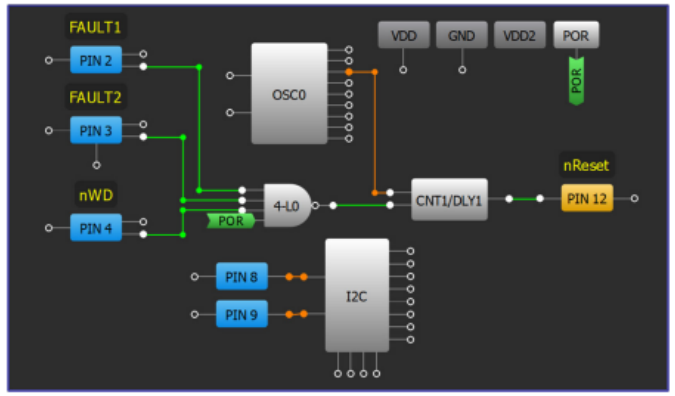
System Reset ICs are used to provide a reset to a microprocessor during faults, manual resets, brown-outs and more.




### Ingredients

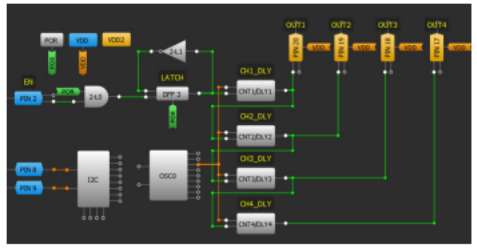
- Any GreenPAK
- No other components are needed

### GreenPAK Diagram

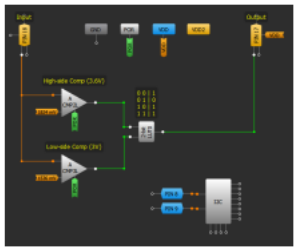



### Design Steps

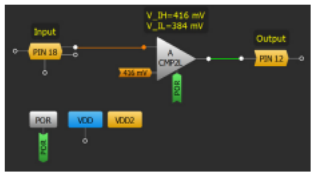
1. Configure an I/O as an input for each input signal.
2. Add LUT logic to create a HIGH signal when any of the lines are active. The logic is dependent on whether each signal is active-high or active-low.
3. Configure a CNT/DLY block to "One shot" mode, with Edge select configured to "Rising." Set the Counter data to create the desired length of pulse. For an active-low pulse change the Output polarity to "Inverted (nOUT)."
4. Connect the CNT/DLY block's output to an output pin.



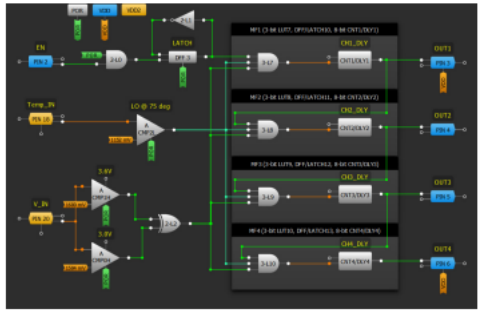
Power Sequencing



Window Comparator



Overtemperature Detection



Unique Solution

**Both can be used together to create**

- New features
- New applications

# EXAMPLES FOR APPLICATION NOTES

## Adjustable Filter

**Low Pass Filter Solution:**

- Sallen-Key Topology
- Cutoff Frequency
  - $F_{C1}$ = 100 kHz
  - $F_{C2}$ = 1 MHz
- Manual Trim Controlled by GreenPAK Digital Logic

Application Note

## Tracking ADC

**I²C Controlled ADC:**

- Potentiometer Mode Configuration
- $V_{IN}$ Tracking using the Auto-Trim Feature
- I²C-Accessible Digital Value

Application Note

## Sigma-Delta ADC


**Precision ADC:**

- 16-bit resolution
- 0.5 mV offset, 0.009% gain error, 2LSB (max) INL
- 1.95 sps
- I²C-Accessible Digital Value

Application Note

## Pressure Sensor

**Wheatstone Bridge AFE:**

- Auto-Trim Algorithm for Gain Tuning and Offset Compensation
- $V_{AN}$ & 2.048V Reference Solutions
- Error Analysis

Application Note

## Heart Rate Monitor

**Transimpedance (TIA) Amplifier for Photodiode Sensing:**

- LED Driving
- Sample & Hold Circuit
- AC Coupling with DC Bias Ambient Light Compensation
- Non-Inverting Amplification

Application Note

# HVPAK APPLICATION NOTES

## Smart Home

- AN-CM-296 **Smart Lock** Motor Driver with Voltage Regulation
- AN-CM-298 **Smart Lock** Motor Driver with Battery Discharge Compensation
- AN-CM-301 **LED Lamp Driver**
- AN-CM-316 Automatic **Air Freshener**
- AN-CM-332 Smart PWM **Fan Driver**
- AN-CM-339 Ultrasonic **Humidifier**
- AN-CM-340 **Brightness-Controlled Lamp** with Motion Sensor
- AN-CM-344 Remote TX and RX Control System for **Toys**
- AN-CM-345 Ultrasonic **Dog Chaser** with Repelling Strobe Light
- AN-CM-353 Induction **Heater** with Variable Power Output
- AN-CM-359 **Portable Washing Machine**

## Power

- AN-CM-321 **Class D Power Amplifier** Using HV PAK
- AN-CM-322 Universal **Class D (UcD) Power Amplifier**
- AN-CM-337 Monolithic **Battery Charger**

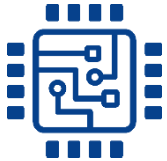
## Industrial/Consumer

- AN-CM-295 **Stepper Motor Driver**
- AN-CM-315 High Voltage **Zero-Crossing Relay Driver**
- AN-CM-323 Simultaneous **Dual Motor Control**
- AN-CM-330 Ultrasonic Qualitative **Distance Estimation Sensor**
- AN-CM-342 Power Saving **Solenoid Driver**

# DESIGN RESOURCES - USEFUL LINKS

## Go Configure™ Software

Schematic capture-like tool allowing design, configuration, and programming



## GreenPAK Cookbook

Outlines different techniques and provides completed applications for reference

## Application Notes

Resource of hundreds of design ideas

Collection of application specific collateral documenting design process for various solutions using GreenPAK

## GreenPAK Forum

is part of the Renesas Engineering Community

Online community for questions and support on GreenPAK

## GreenPAK Partners

Certified experienced GreenPAK third-party design partners


## FAQs

Knowledge base addressing common questions

# DESIGN RESOURCES - USEFUL LINKS

**Renesas Academy**
You will find there GreenPAK Courses and Go Configure™ Software Hub Courses

## Non – Renesas Web sites

**Hackster.io Greenpak Projects**
On Hackster IO Webside you will find 76 Greenpak projects

**Hackaday IO**
On Hackaday IO Webside you will find 79 Greenpak projects

**Greenpak Blog**

# DESIGNING WITH GREENPAK

# HOW TO GET STARTED

## Create a design on your own


Download our free Go Configure Software Hub — Link


Download our GreenPAK Cookbook — Link


Watch our training videos to get familiar with GreenPAK design — Link


Search our database for hundreds of example design files and app notes — Link


Program parts in minutes using the GreenPAK development board


Send us your design files for higher volume sampling

## Let us do the work, if you got stucked


Send your Disti FAE /Renesas FAE your IC requirements or system schematics and we will design a custom IC to suit your needs.

# WRAP-UP

# WHY IS GREENPAK POPULAR?

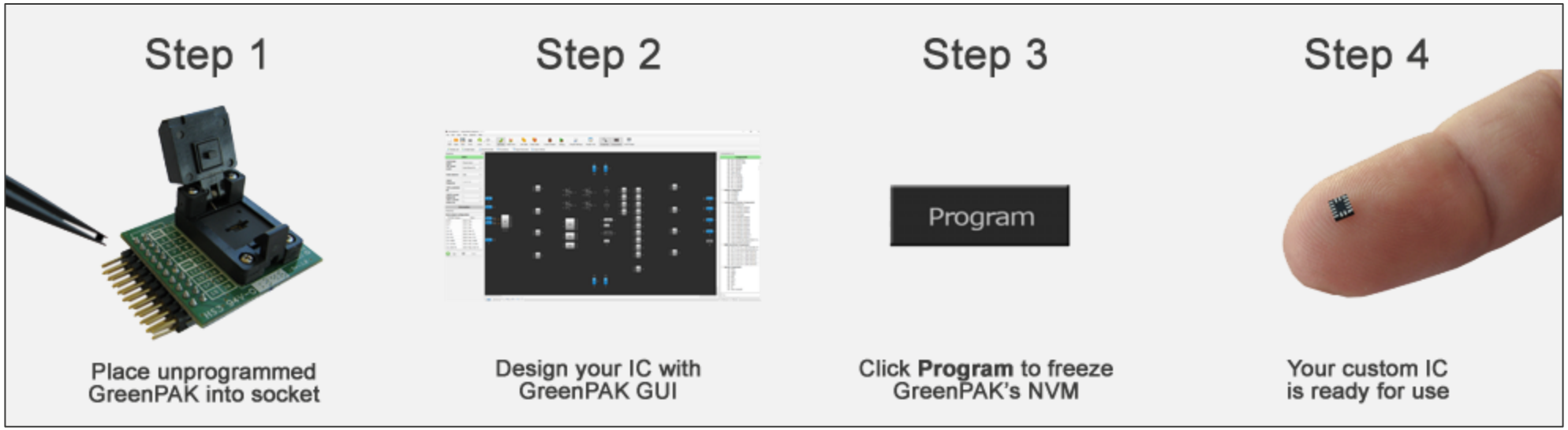
Design in minutes
Prototype in hours

No NRE

No Production
Commitment

14 Week
Production
Lead-time

Custom
Datasheet



# WHERE CAN GREENPAK BE USED?

**Many functions in many applications in many markets! Its universal…**

## Functions

- Finite State Machine
- Timing Delays
- Counters
- Pulse Width Modulator
- Comparators
- Voltage Monitor
- Voltage Reference
- ADC
- Glue Logic
- Level Translation

## Applications

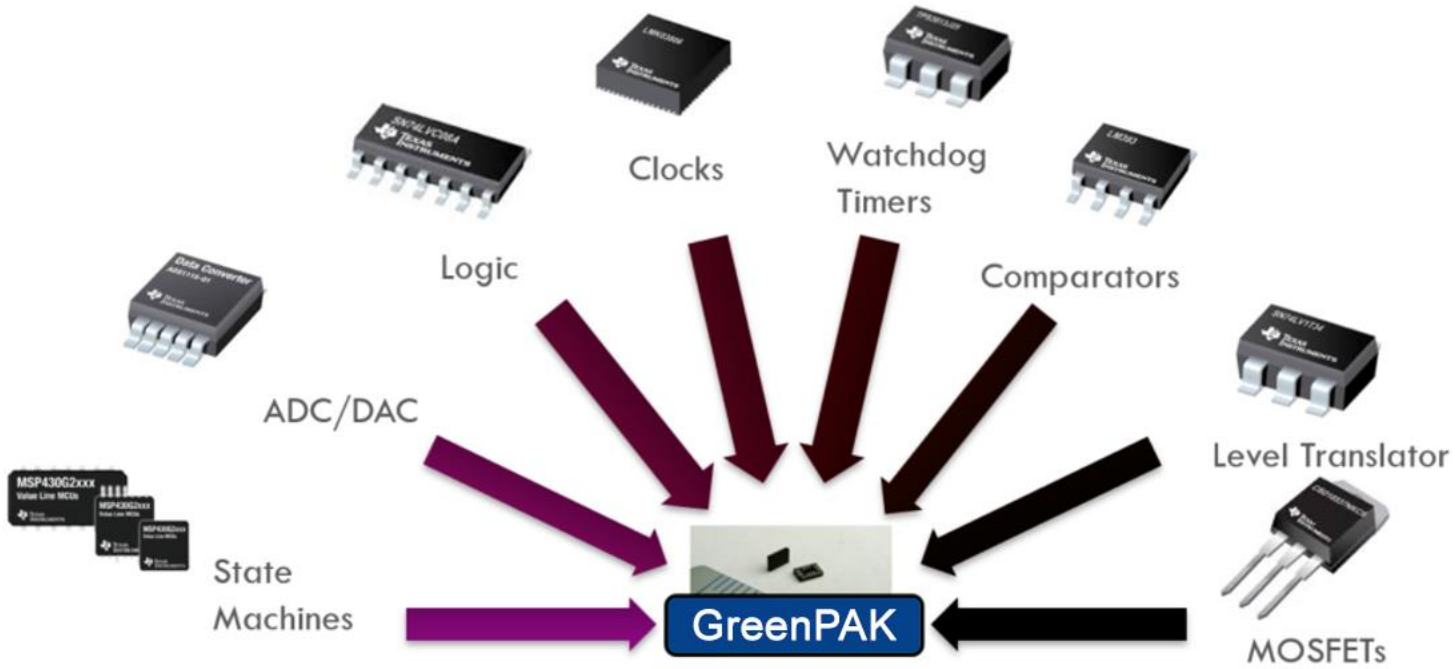
- Supervisory Circuits
- System Reset
- LED Control
- Motor & Fan Control
- Power Sequencing
- Voltage Detection
- Frequency Detection
- Sensor Interface
- Port Detection
- Temperature Control
- Coulomb Counter

## Markets

- Handheld Devices
- IoT / Wearable Electronics
- Computing & Storage
- Consumer Electronics
- Smart Home
- Networking & Communications
- Medical
- Industrial

# WHAT DOES GREENPAK REPLACE?

GreenPAK can replace simple discrete logic , analog comparators, low end 8-bit ADC's, etc.
It can be used to implement non-standard variations of reset IC's and other ASSP's without tooling or NRE.
This can support new variations of applications for customers who run into design issues.



# 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

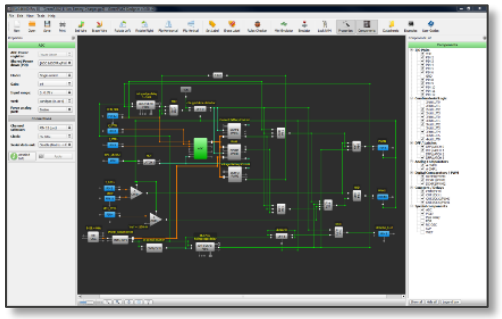
Development tools exploit the power of silicon without NRE charges and long lead times

## Secure

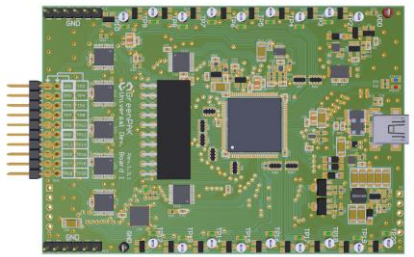
Circuit implementation is not visible to competition

# GREENPAK SOLUTION PLATFORM

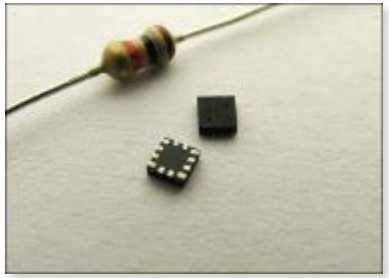
Design in MINUTES



Prototype in HOURS



Production in DAYS



The Choice is Yours


**Customers create solutions & program samples**

- Renesas provides un-programmed GreenPAK ICs
- Customer retains design control

**Renesas creates designs and provides samples**

- Customers communicate design requirements
- Design feedback and datasheet within 72 hours (typical)
- Custom part numbers assigned
- Delivery of programmed samples and tested production units

Renesas.com

# BACK UP SLIDES

# PRODUCTION GREENPAK FEATURE SETS

| | SLG46108 | SLG46127 | SLG46116/7 | SLG46110 | SLG46120 | SLG46140 | SLG46169 | SLG46170 |
|---|---|---|---|---|---|---|---|---|
| # of GPIOs | 6 | 6 | 7 | 8 | 10 | 12 | 12 | 12 |
| Operating Voltage (V) | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 |
| Dual Supply (VDD2 1.8 V to VDD) | - | - | - | - | SLG46121[1] | - | - | - |
| 8-bit SAR ADC | - | - | - | - | - | 1 | - | - |
| Analog/Digital Comparators | - | 2/0 | 2/0 | 2/0 | 2/0 | 2/3 | 2/0 | - |
| Look Up Tables (LUTs) | 4 | 4 Total | 4 Total | 4 Total | 5 Total | 8 Total | 9 Total | 15 Total |
| 2-bit LUT | 2 | 2 | 2 | 2 | 1 | 4 | 2 | 5 |
| 3-bit LUT | 2 | 2 | 2 | 2 | 4 | 4 | 7 | 9 |
| 4-bit LUT | - | - | - | - | - | - | - | 1 |
| Combination Function Macro-cells | 6 Total | 6 Total | 6 Total | 6 Total | 11 Total | 8 Total | 9 Total | 2 Total |
| Selectable LUT/DFF/Latch | 4 | 4 | 4 | 4 | 8 | 4 | 6 | 1 |
| Selectable LUT/Pipe Delay | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Selectable LUT/CNT/DLY | 1 | 1 | 1 | 1 | 2 | 2 | 2 | - |
| Selectable LUT/Pattern Gen | - | - | - | - | - | 1 | - | - |
| PWMs | - | - | - | - | - | 3 | - | - |
| Counters/Delays | 3 | 3 | 3 | 3 | 2 | 2 | 5 | 8 |
| DFF / Latch | - | - | - | - | - | 2 | - | 6 |
| Pipe Delay | - | 8-stage | 8-stage | 8-stage | 8-stage | 16-stage | 16-stage | 16-stage |
| Programmable Delay | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Internal Oscillator (Hz) | 25k/2M | 25k/2M | 25k/2M | 25k/2M | 25k/2M | 1.7k/25k/ 2M/27M | 25k/2M | 25k/2M |
| Load Switch | - | 2 x 2 A P-FET | 1.25 A P-FET | - | - | - | - | - |
| Asynchronous State Machine | - | - | - | - | - | - | - | - |
| Communication Interface | - | - | - | - | - | SPI | - | - |
| TQFN Part Number | SLG46108V | - | SLG46116V SLG46117V | SLG46110V | SLG46120V SLG46121V | SLG46140V | SLG46169V | SLG46170V |
| TQFN Package Size (mm) | 1.0 x 1.2 | - | 1.6 x 2.5 | 1.6 x 1.6 | 1.6 x 1.6 | 1.6 x 2.0 | 2.0 x 2.2 | 2.0 x 2.2 |
| MSTQFN Part Number | - | SLG46125M SLG46127M | - | - | - | - | - | - |
| MSTQFN Package Size (mm) | - | 1.6 x 2.0 | - | - | - | - | - | - |

# PRODUCTION GREENPAK FEATURE SETS

| | SLG46534 | SLG46536 | SLG46517 | SLG46533 | SLG46537 | SLG46620 | SLG46721 | SLG46722 |
|---|---|---|---|---|---|---|---|---|
| # of GPIOs | 12 | 12 | 16 | 18 | 18 | 18 | 18 | 18 |
| Operating Voltage (V) | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 | 1.8 to 5.0 |
| Dual Supply (VDD2 1.8 V to VDD) | SLG46535ǂ | - | - | - | SLG46538ǂ | SLG46621ǂ | - | - |
| 8-bit SAR ADC | - | - | - | - | - | 1 | - | - |
| Analog/Digital Comparators | 3/0 | 3/0 | 4/0 | 4/0 | 4/0 | 6/3 | 4/0 | - |
| Look Up Tables (LUTs) | - | - | - | - | - | 25 Total | 9 Total | 15 Total |
| 2-bit LUT | - | - | - | - | - | 8 | 2 | 5 |
| 3-bit LUT | - | - | - | - | - | 16 | 7 | 9 |
| 4-bit LUT | - | 1 | - | 1 | - | 1 | - | 1 |
| Combination Function Macro-cells | 17 Total | 24 Total | 17 Total | 24 Total | 17 Total | 1 Total | 9 Total | 2 Total |
| Selectable LUT/DFF/Latch | 8 | 15 | 8 | 15 | 8 | - | 6 | 1 |
| Selectable LUT/Pipe Delay | 1 | 1 | 1 | 1 | 1 | - | 1 | 1 |
| Selectable LUT/CNT/DLY | 7 | 7 | 7 | 7 | 7 | - | 2 | - |
| Selectable LUT/Pattern Gen | 1 | 1 | 1 | 1 | 1 | 1 | - | - |
| PWMs | - | - | - | - | - | 3 | - | - |
| Counters/Delays | - | - | - | - | - | 10 | 5 | 8 |
| DFF / Latch | - | - | - | - | - | 12 | - | 6 |
| Pipe Delay | 16-stage | 16-stage | 16-stage | 16-stage | 16-stage | 2 x 16-stage | 16-stage | 16-stage |
| Programmable Delay | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| Internal Oscillator (Hz) | 25k/2M/25M | 25k/2M/25M | 25k/2M/25M | 25k/2M/25M | 25k/2M/25M | 1.7k/25k/ 2M/27M | 25k/2M | 25k/2M |
| Load Switch | - | - | 2 x 2 A P-FET | - | - | - | - | - |
| Asynchronous State Machine | 8-state | - | 8-state | - | 8-state | - | - | - |
| Communication Interface | I²C | I²C | I²C | I²C | I²C | SPI | - | - |
| TQFN Part Number | SLG46534V SLG46535V | SLG46536V | - | SLG46533V | SLG46537V SLG46538V | SLG46620V SLG46621V | SLG46721V | SLG46722V |
| TQFN Package Size (mm) | 2.0 x 2.2 | 2.0 x 2.2 | - | 2.0 x 3.0 | 2.0 x 3.0 | 2.0 x 3.0 | 2.0 x 3.0 | 2.0 x 3.0 |
| MSTQFN Part Number | - | - | SLG46515M SLG46517M | SLG46533M | SLG46537M SLG46538M | - | - | - |
| MSTQFN Package Size (mm) | - | - | 2.0 x 3.0 | 2.0 x 2.2 | 2.0 x 2.2 | - | - | - |

# PARAMETRIC TABLE EXAMPLE

In-System Programmable

| | SLG47105 | SLG47115 | SLG46824/SLG46826 | SLG47004V | SLG47512/SLG47513 |
|---|---|---|---|---|---|
| # of Pins / # of GPIOs | 20/8 + 4 x HD | 20/8 + 2 x HD | 20/17 | 24/8 | SLG47512 – 12/10<br>SLG47513 – 16/14 |
| Operating Voltage, VDD (V) | 2.3 to 5.5 | 2.3 to 5.5 | 2.3 to 5.5 | 2.3 to 5.5 | 1.0 to 1.65 |
| Dual Supply, VDD2 (V) | 3.0 to 13.2 | 4.5 to 26.4 | 1.71 to VDD | - | - |
| Dual Supply Version | - | - | - | - | - |
| Analog/Digital Comparators | 4/0 | 3/0 | 4(2)/0 | 3(2)/0 | 2/0 |
| Voltage Reference | Trimmed | Trimmed | Trimmed | Trimmed | Trimmed |
| Combo Function Macro-cells | 12 Total | 12 Total | 11 Total | 13 Total | 15 Total |
| Multi-Function Macro-cells | 5 Total | 5 Total | 8 Total | 7 Total | 8 Total |
| PWMs | 2 | 2 | - | - | - |
| Special Features | - | - | SLG46826: 2-kbit $I^2C$ compatible serial EEPROM emulation | 2 Op Amps, 2 Rheostats, 2 analog switches, EEPROM | - |
| Counters/Delays | 5 | 5 | - | - | - |
| DFF / Latch | 15 | 15 | - | - | - |
| 3-Output Pipe Delay | 16-stage | 16-stage | 16-stage | 16-stage/0 | -/14 |
| Programmable Delay | Yes | Yes | Yes | Yes | Yes |
| Internal Oscillator (Hz) | 2k/25M | 2k/25M | q2k/2M/25M | 2k/2M/25M | 2k/25M |
| Power Switch | - | - | - | - | - |
| LDO | - | - | - | - | - |
| DC/DC | - | - | - | - | - |
| Asynchronous State Machine | - | - | - | - | - |
| Temp Sensor | Yes | Yes | Yes (SLG46826) | Yes | Yes |
| Crystal Oscillator Cell | - | - | - | - | - |
| Communication Interface | $I^2C$ | $I^2C$ | $I^2C$ | $I^2C$ | $I^2C$ |
| Package Size (mm) | 2.0 x 3.0 | 2.0 x 3.0 | 2.0 x 3.0 | 3.0 x 3.0 | 1.6 x 1.6 |
| Package Type | STQFN | STQFN | STQFN & TSSOP | STQFN | STQFN |

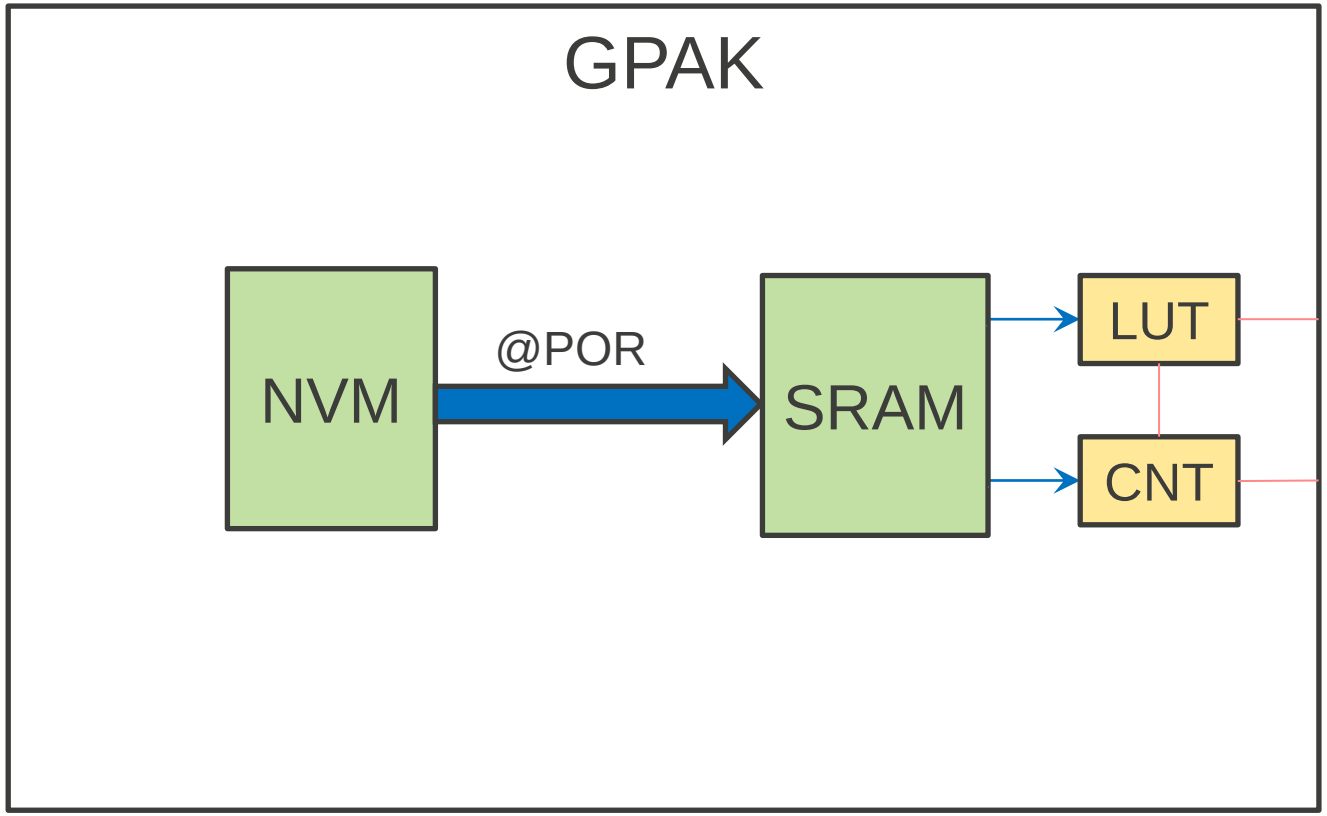
# BACK UP SLIDES

# GREENPAK POWER UP SEQUENCE

# GREENPAK – NO I2C BLOCK PRESENT

## Power Up Sequence

1. Apply VDD.
2. Internal POR goes active.
3. NVM copies to SRAM.
4. SRAM configures macrocells and matrix connections.

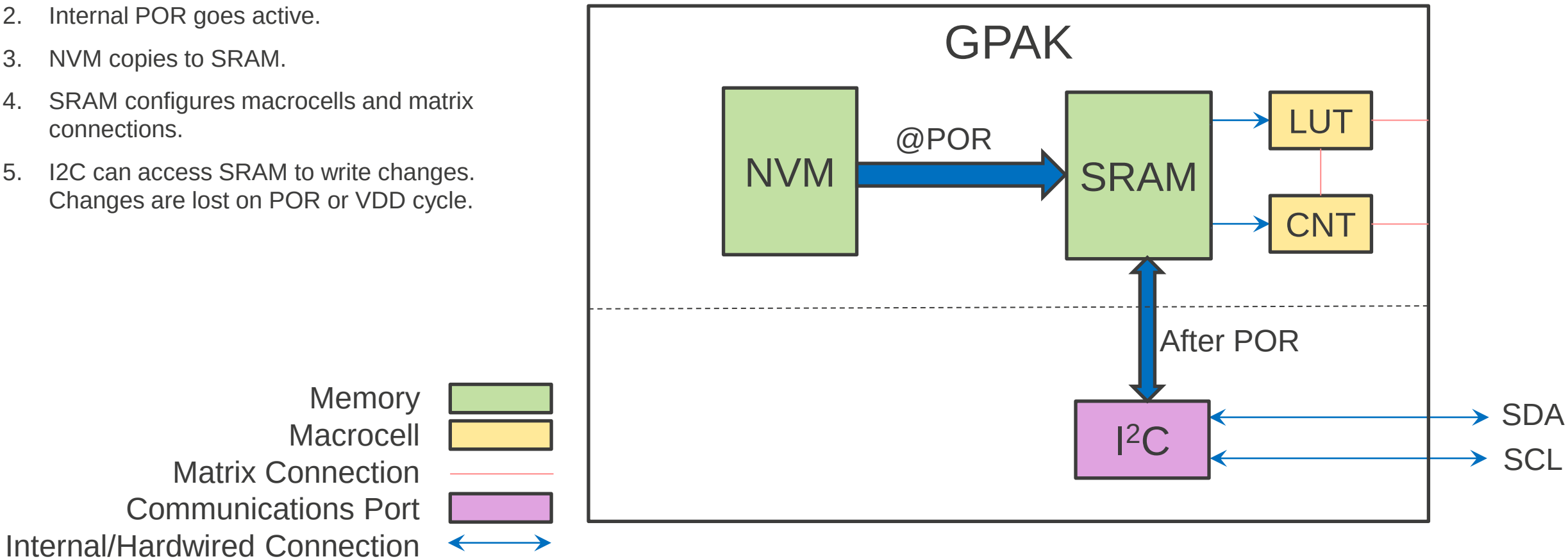



Memory
Macrocell
Matrix Connection
Communications Port
Internal/Hardwired Connection

# GREENPAK – I2C BLOCK PRESENT

## Power Up Sequence

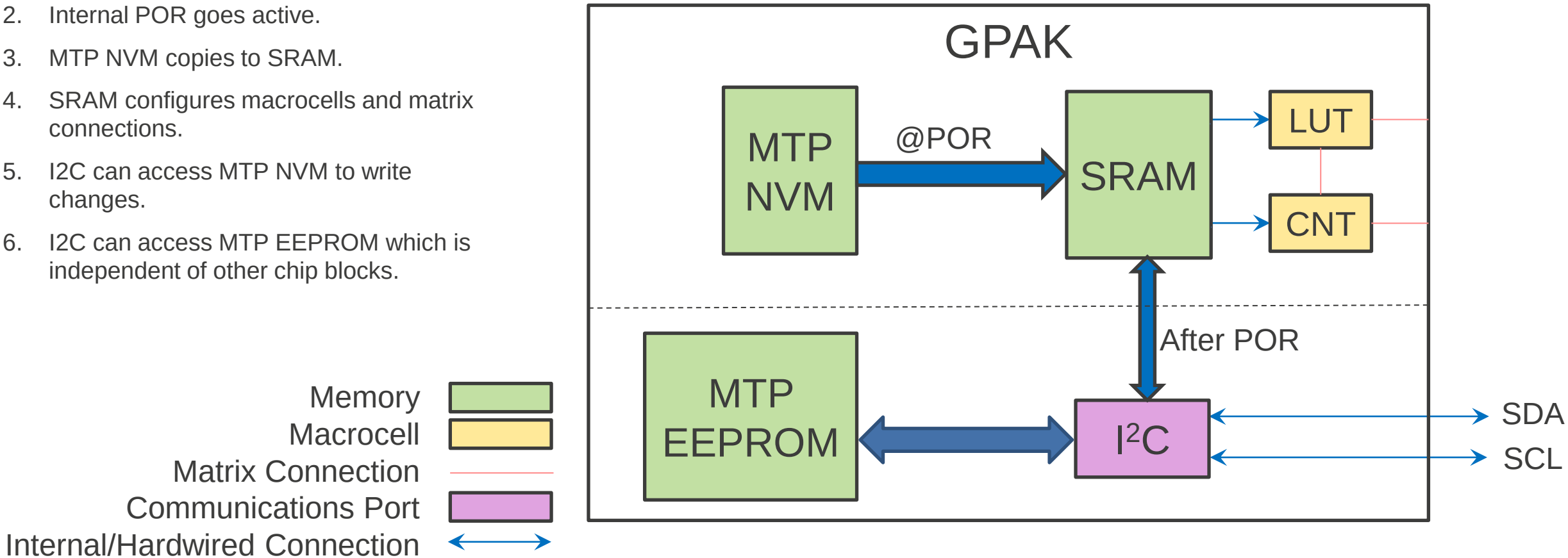
1. Apply VDD.
2. Internal POR goes active.
3. NVM copies to SRAM.
4. SRAM configures macrocells and matrix connections.
5. I2C can access SRAM to write changes. Changes are lost on POR or VDD cycle.



# GREENPAK – I2C BLOCK PRESENT AND IN SYSTEM PROGRAMMABLE

## Power Up Sequence

1. Apply VDD.
2. Internal POR goes active.
3. MTP NVM copies to SRAM.
4. SRAM configures macrocells and matrix connections.
5. I2C can access MTP NVM to write changes.
6. I2C can access MTP EEPROM which is independent of other chip blocks.



# BACK UP SLIDES

# AUTOMOTIVE GREENPAK

# GreenPAK™ PROGRAMMABLE MIXED-SIGNAL ASIC - SLG46XXX-A, SLG47XXX-A

## Value Proposition & Features

- Automotive grade, **AEC-Q100** compliant (Grade 2 available now, Grade 1 on the roadmap)
- Cost effective NVM programmable IC containing **digital and analog**
- Fewer parts = lower FIT, **less qualification** & **less sourcing** issues

## Solution Example

Infotainment/Cluster, xEV, MCS, …

Power sequence, Voltage/Current/Temp detector, PWM, I/O expander, Button debounce/Glitch filter, Sensor AFE Watchdog, Reset control, Level shift/Buffer, Glue logic

## Benefit

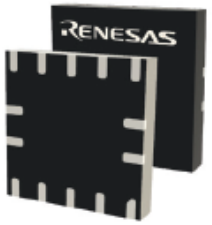
- Automotive grade, AEC-Q100 compliant
- Combine multiple discrete ICs into one small package
- Small-scale custom IC without NRE, 18 weeks for MP
- GUI design tool available

Production
Sampling

# ROADMAP FOR GREENPAK AEC-Q100 QUALIFICATION

## Scalable Solutions to Reduce Solution Size, Cost & Power


6.5 mm x 6.4 mm
20-pin TSSOP
0.65 mm pitch




3.0 mm x 3.0 mm
14-pin FCQFN
0.65 mm pitch

**SLG46620-A**
Analog Rich GreenPAK w/ ADC, PWM
TSSOP-20, Grade 2
MP: Now

**SLG46827-A**
Dual supply GreenPAK w/ 2 Vdd
TSSOP-20, Grade 2
MP: Now

**SLG46855-A**
Ultra-Low Power GreenPAK, Smallest Package
FCQFN-14, Grade 2
MP: Now

**SLG46880-A**
ASM GreenPAK w/ 12-state ASM, 2 Vdd,
TQFN-32, Grade 1
MP: Now

*SLG46625-A**
Analog Rich GreenPAK w/ ADC, PWM
TQFN-20, Grade 1
MP: Now

**SLG46538-A**
ASM GreenPAK w/ 8-state ASM, 2 Vdd
TQFN-20, Grade 1
WS, ES: Q3 '23, CS: Q2 '24, MP: Q4 '24

**SLG46857-A**
Ultra-Low Power GreenPAK Smallest Package
FCQFN-14, Grade 1
WS: Now, ES: Q2, '24, CS: Q4 '24, MP: Q4 '24

**SLG47004-A**
AnalogPAK w/ 2 OPAMPs, rheostats
TSSOP-24, Grade 1
WS: Q3 '23, ES: Q4, '23, CS: Q3 '24, MP: Q3 '24

**Current Generation GreenPAK Automotive Devices**

# GREENPAK AUTOMOTIVE PARTS

| | SLG46620-A | SLG46827-A | SLG46855-A | SLG46625-A |
|---|---|---|---|---|
| Status | Production | Production | Production | Sampling |
| # of GPIOs | 20/18 | 20/17 | 14/12 | 20/18 |
| Operating Voltage (V) | 1.71 to 3.6 | 2.3 to 5.5 | 2.3 to 5.5 | 1.71 to 5.0 |
| Dual Supply | | 1.71 to Vdd | - | - |
| In-System Debug | No | Yes | No | No |
| 8-bit SAR ADC | 1 | - | - | 1 |
| Analog/Digital Comparators | 6/3 | 4/0 | 4/0 | 6/3 |
| Look Up Tables (LUTs) | 25 | 0 | 0 | 25 |
| Combinational Function Macro-cells | 1 Total | 11 Total | 15 Total | 1 Total |
| Multifunction Macrocells | 0 | 8 | 8 | 0 |
| PWMs | 3 | - | - | 3 |
| Counter/Delays | 10 | - | - | 10 |
| DFF/Latch | 12 | - | - | 12 |
| Pipe Delay | 2 x 16-stage | 16-stage | 16-stage | 2 x 16-stage |
| Programmable Delay | 2 | 1 | 1 | 2 |
| Internal Oscillator (Hz) | 1.7 k/25 k/2 M/27 M | 2 k/2 M/25 M | 2 k/2 M/25 M | 1.7 k/25 k/2 M/27 M |
| Load Switch | - | - | - | - |
| LDO | - | - | - | - |
| Asynchronous State Machine | - | - | - | - |
| Communication Interface | SPI | $I^2C$ | $I^2C$ | SPI |
| Package | 6.4 mm x 6.5 mm TSSOP-20 | 6.4 mm x 6.5 mm TSSOP-20 | 3.0 mm x 3.0 mm FCQFN -14 | 3.5 mm x 3.5 mm TQFN-20 |
| Package Pitch | 0.65 | 0.65 | 0.65 | 0.5 |
| Temperature Grade | 2 | 2 | 2 | 1 |

# GREENPAK AUTOMOTIVE PARTS

| | SLG46857-A | SLG46880-A | SLG46538-A | SLG47004-A |
|---|---|---|---|---|
| Status | Sampling | Sampling | Sampling | Sampling |
| # of GPIOs | 14/12 | 32/28 | 20/17 | 24/20 |
| Operating Voltage (V) | 2.3 to 5.5 | 2.3 to 5.5 | 1.71 to 5.5 | 2.4 to 5.5 |
| Dual Supply | - | 2.3 to VDD | 1.71 to 5.5 | - |
| In-System Debug | No | No | No | Yes |
| 8-bit SAR ADC | - | - | - | - |
| Analog/Digital Comparators | 4/0 | 5/0 | 4/0 | 3/0 |
| Look Up Tables (LUTs) | 0 | - | - | 0 |
| Combinational Function Macro-cells | 15 Total | 12 Total | 17 Total | 13 Total |
| Multifunction Macrocells | 8 | 0 | 0 | 7 |
| PWMs | - | - | - | - |
| Counter/Delays | - | - | - | - |
| DFF/Latch | - | - | - | - |
| Pipe Delay | 16-stage | 16-stage | 16-stage | 16-stage |
| Programmable Delay | 1 | 1 | 1 | 1 |
| Internal Oscillator (Hz) | 2 k/2 M/25 M | 2 k/2 M/25 M | 25 k/2 M/25 M | 2 k/2 M/25 M |
| Load Switch | - | - | - | - |
| LDO | - | - | - | - |
| Asynchronous State Machine | - | 12-state | 8-state | - |
| Communication Interface | $I^2C$ | $I^2C$ | $I^2C$ | $I^2C$ |
| Package | 3.0 mm x 3.0 mm FCQFN -14 | 5.0 mm x 5.0 mm TQFN - 32 | 3.5 mm x 3.5 mm TQFN-20 | 4.0 mm x 4.0 mm TSSOP-24 |
| Package Pitch | 0.65 | 0.5 | 0.5 | 0.5 |
| Temperature Grade | 1 | 1 | 1 | 1 |

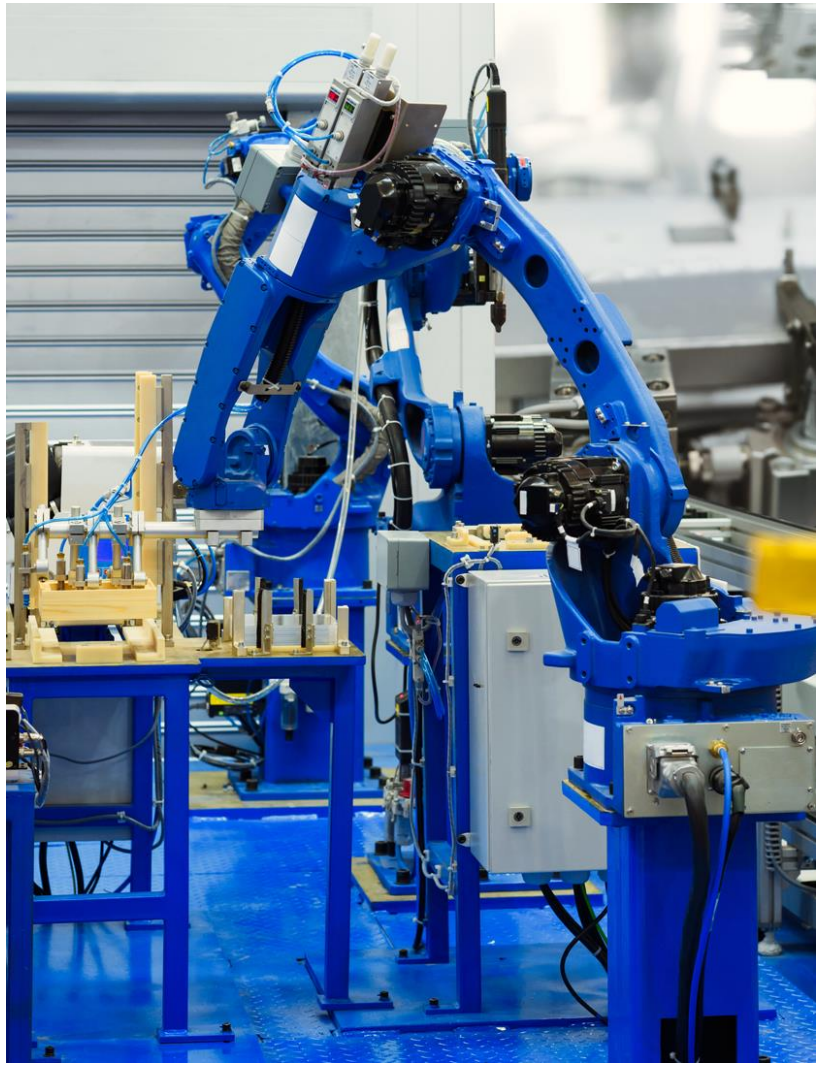
# RENESAS MANUFACTURING ADVANTAGES

## Device Level Features

- **Ambient Operating Temperature Range:** -40 °C to 105 °C (grade 2) or -40 °C to 125 °C (grade 1)
- **Moisture Sensitivity Level:** 1 (Unlimited)
- **ESD Protection:** 2 kV HBM, 500+ V CDM
- **Quality Management:** ISO9001:2010 certified, AEC-Q100 qualified
- **Failure Rate:** < 10 DPPM
- **Long Product Lifecycles:** Driven by customer requirements
- **Environmental:** All subcons ISO14001, RoHS Compliant , Halogen-Free

## Design Benefits

- Higher Reliability
- Design Security
- Tested Solution



# DESIGN PORTION OF DEMO

## USING GREENPAK DESIGNER (PART OF GO CONFIGURE SOFTWARE HUB)

## CREATING A SIMPLE RESET CIRCUIT

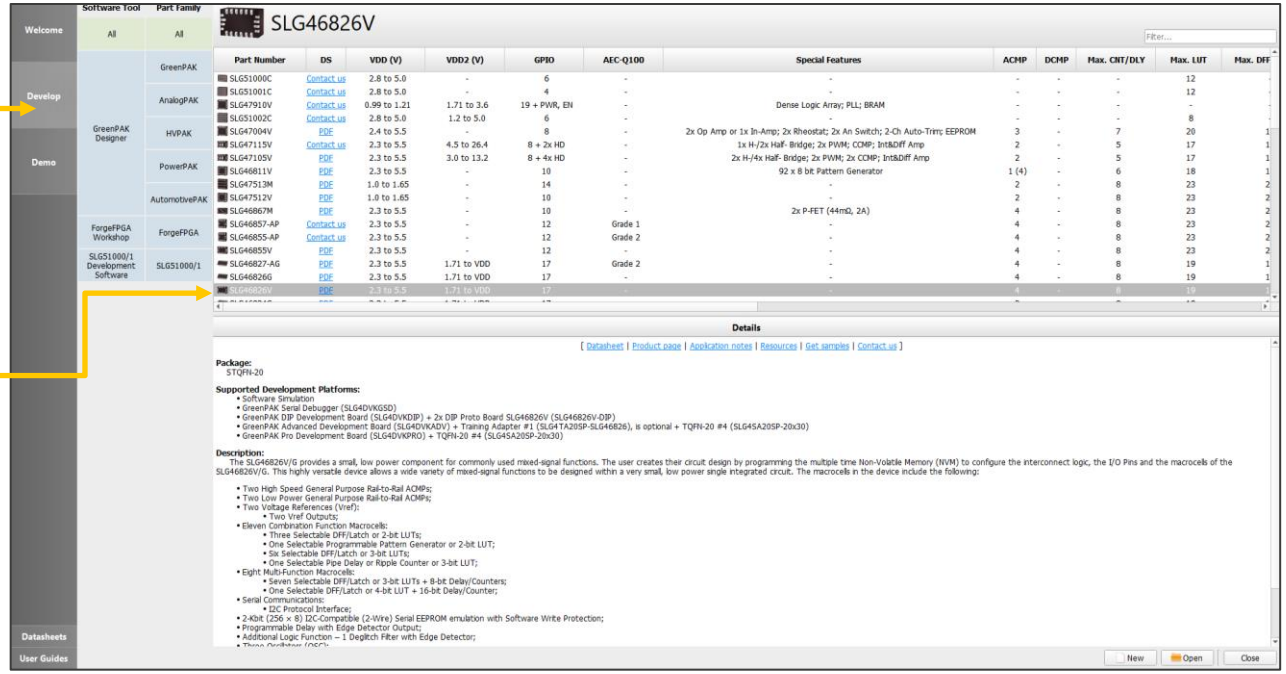
# STARTING THE PROCESS

## Launch GreenPAK Designer

- After you have installed GoConfigure Software Hub, open up the program
  - Click the Windows button in the bottom left corner of your screen
  - Scroll to the GoConfigure Software Hub icon and click once to open it
  - Click the GoConfigure Software Hub


- The first time you launch GoConfigure Software Hub, you will land on the Welcome page.
  Click the “Develop” page next.

- This will give you a window that shows the selection of GreenPAK parts available
  - Single click the SLG46826V to highlight it
  - Double click on SLG46826V to launch the designer for this silicon



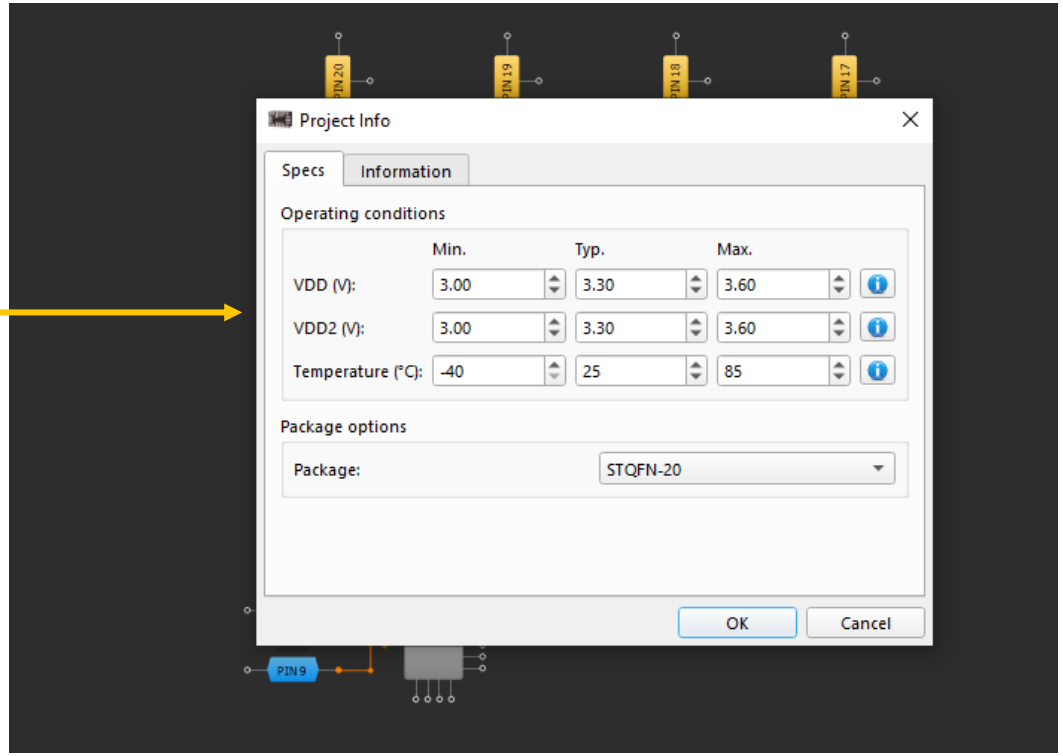
# SETTING UP PROJECT INFO

## Entering VDD, VDD2 and Temperature Information

- You will get a window with “Project Info” that opens automatically

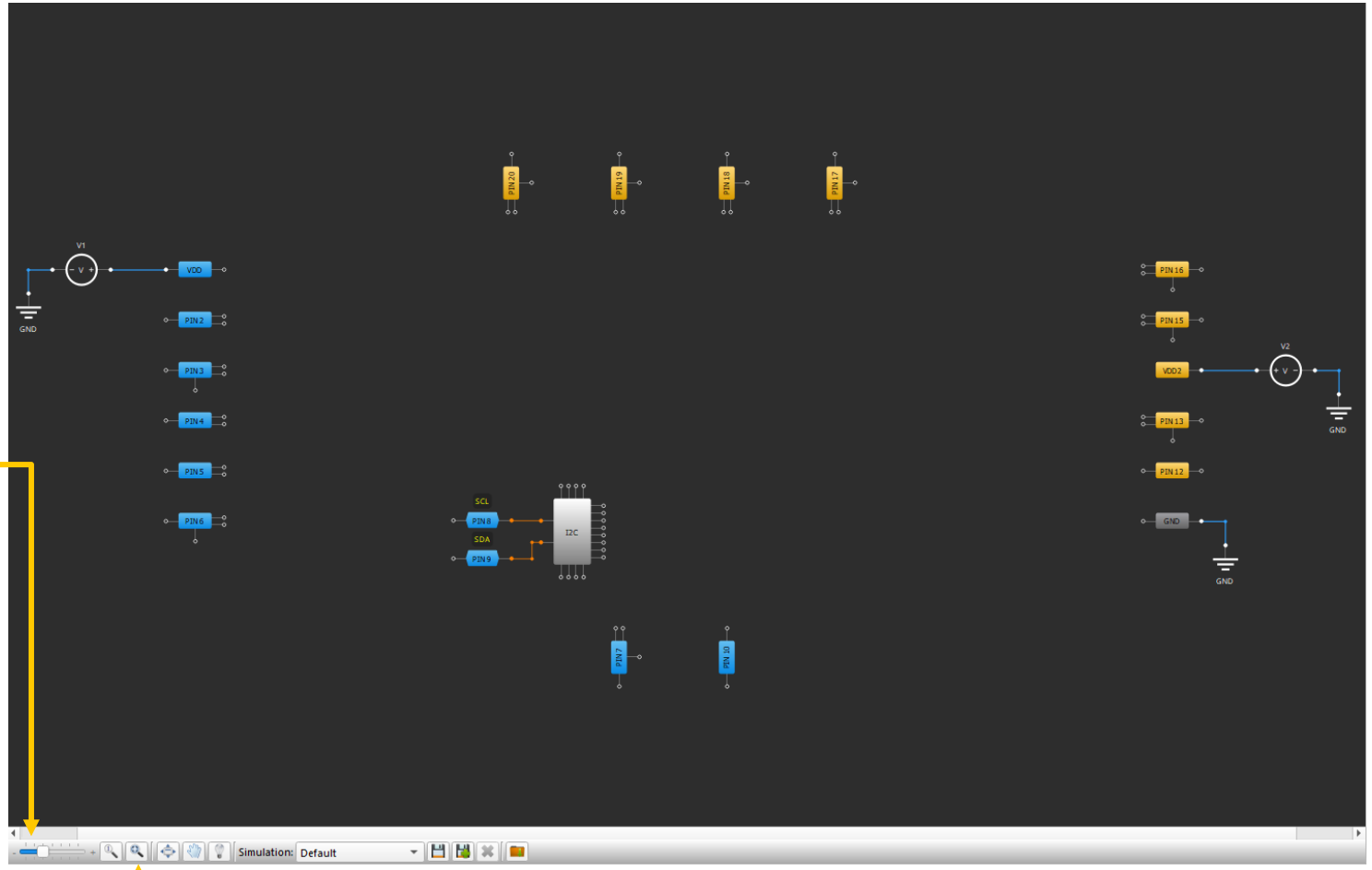
- Set:
  - VDD to 3.0, 3.3, 3.6
  - VDD2 to 3.0, 3.3, 3.6
  - Temp to -40, 25, 85

- This information will be used when we want to test or simulate the design



# RESIZING MAIN WINDOW

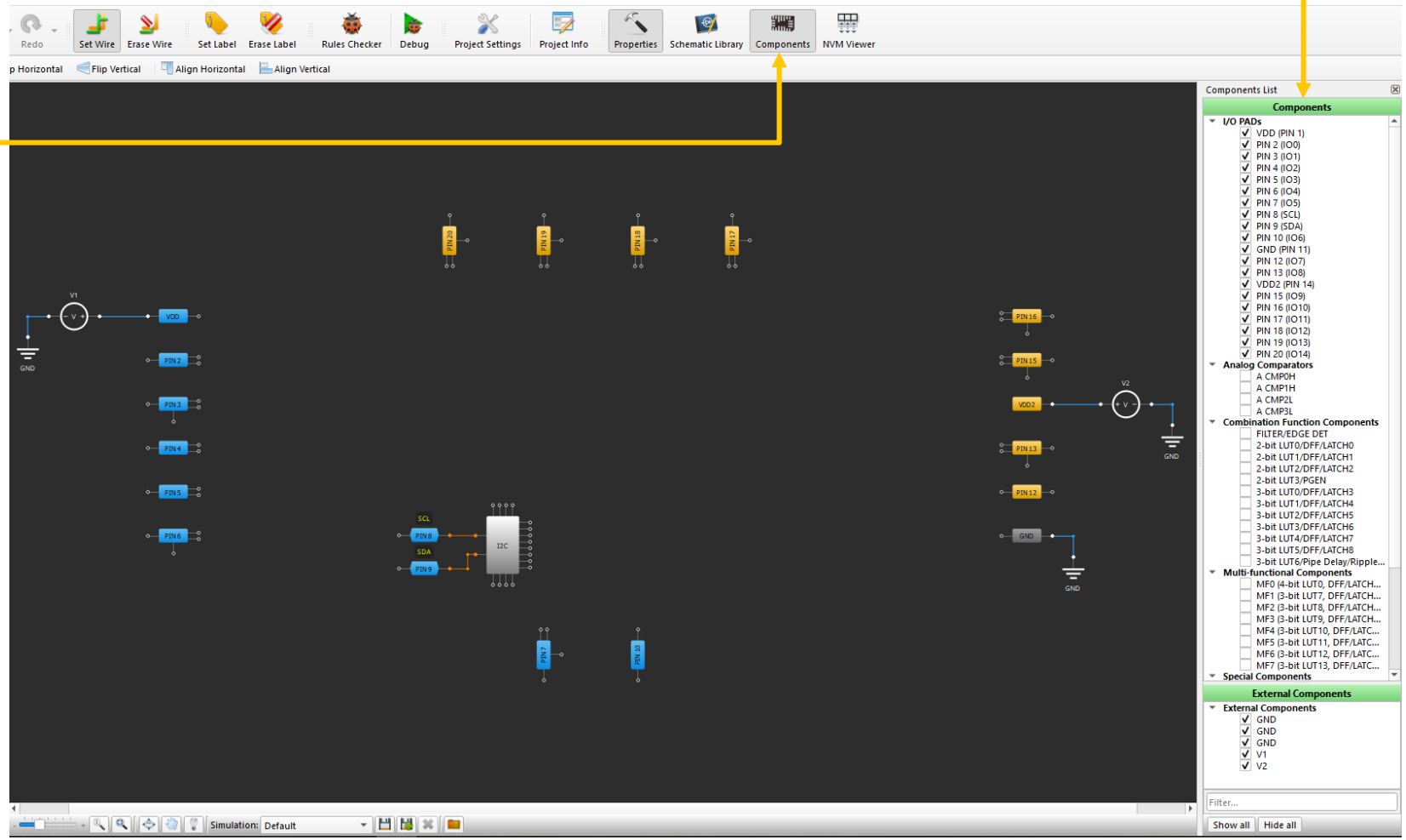
- Use slider bar here to adjust view to show all pins (should look like this when you are done)
  - Alternatively, you can select the “Fit Work Area” button to auto scale the view




- Pins shown have two types:
  - Blue pins connected to VDD
  - Gold pins connected to VDD2
  - These are available on all dual-supply parts

# COMPONENTS WINDOW

- Components list should be shown on right hand side
- If it is not showing, click on Components button to make it show
- The components window shows the available circuit components
- The components in each base device are different, therefore the components window is unique for each device type



# OUR GOAL IS TO DESIGN A SIMPLE RESET CIRCUIT

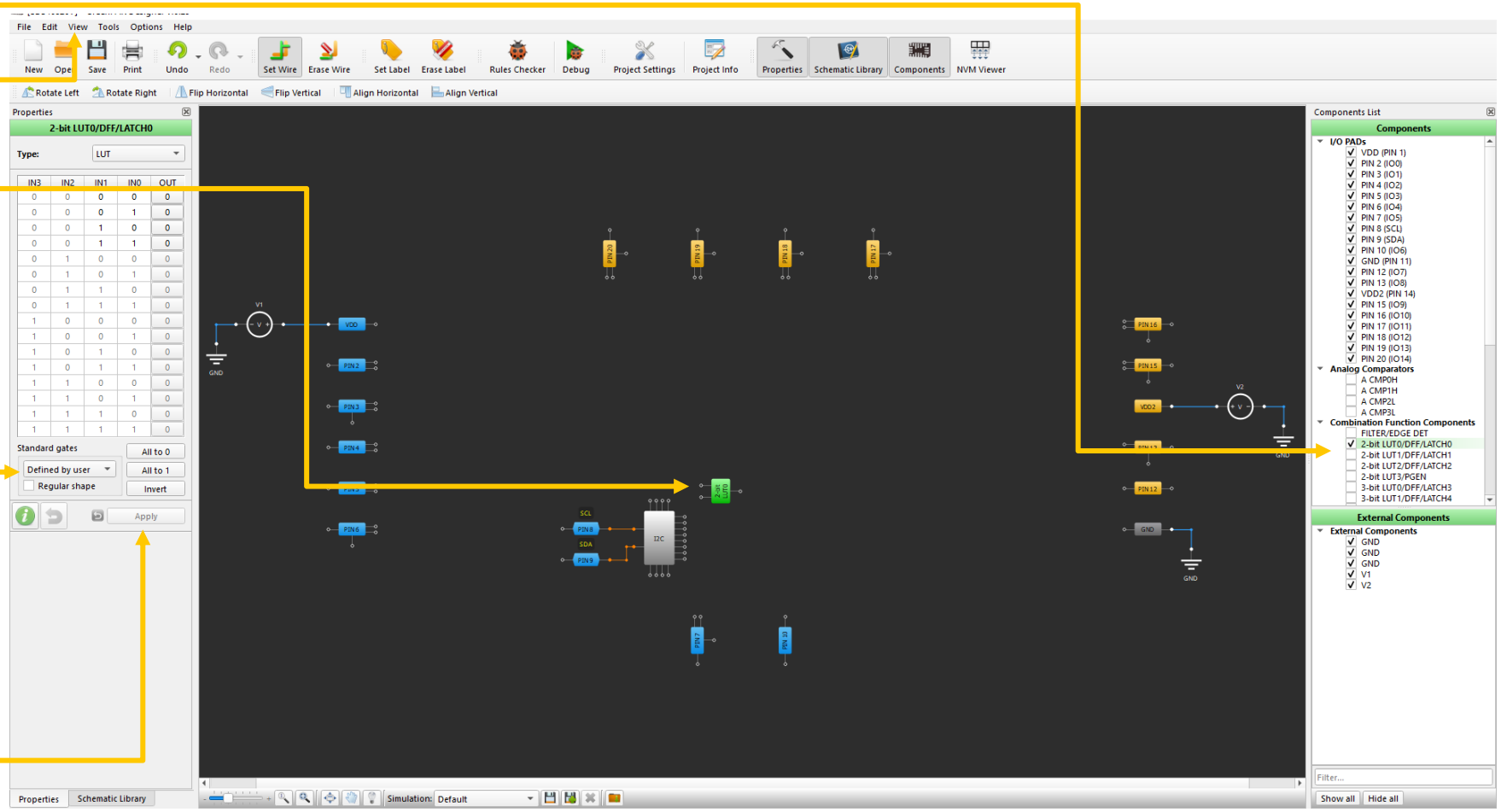
## Three Functions in the Design

- This design will issue an output pulse that can trigger a reset of a system
- This function has three components in this example:
  - Logic “OR” gate
  - Analog comparator (ACMP)
  - One shot (pulse generator)
- Let’s review what each component does in this example:
  - One shot – this is the output pulse that a monitoring device will use to reset the system
  - ACMP – this will monitor a voltage rail (for example a main power rail)
  - “OR” gate – this will be used to monitor two possible signals that can trigger a reset
    - ACMP output for the case where the power rail goes too low
    - Digital logic input for the case where another device wants to trigger a reset
- The signal flow looks like this: digital logic “OR” ACMP → One shot

# SELECTING A COMPONENT (LOGIC GATE)

## Configuring the Gate

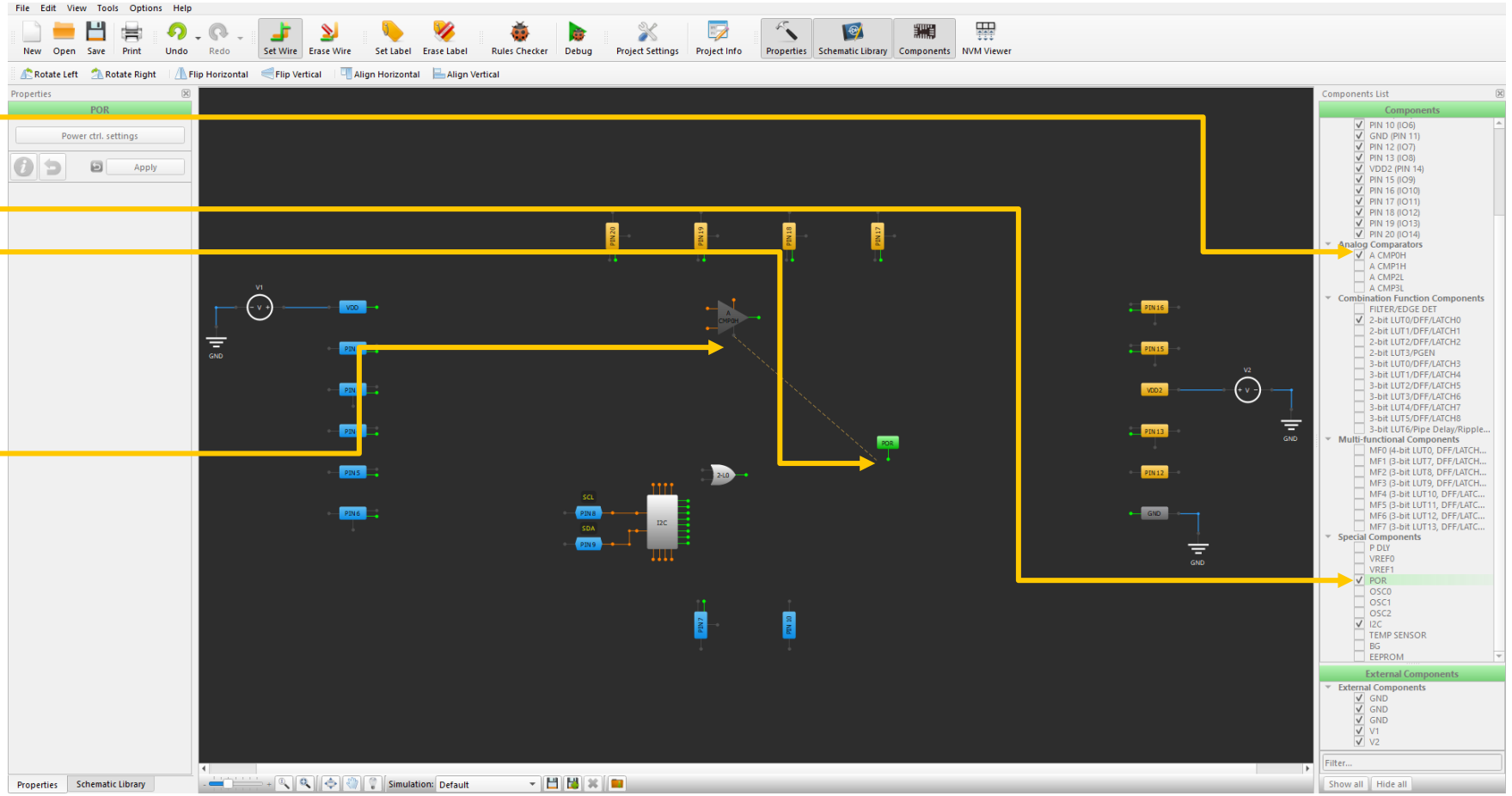
- Click on 2-bit LUT0
  - Check the box next to the name of the block
- Make sure the block is highlighted green
  - If it's not, click the item once
  - Click "View" "Properties if necessary
- Set the logic block to be an "OR" gate
  - From the drop-down menu, select "OR"
- Click "Apply" to keep the changes



# SELECTING A COMPONENT (ANALOG COMPARATOR)

## Configuring the ACMP

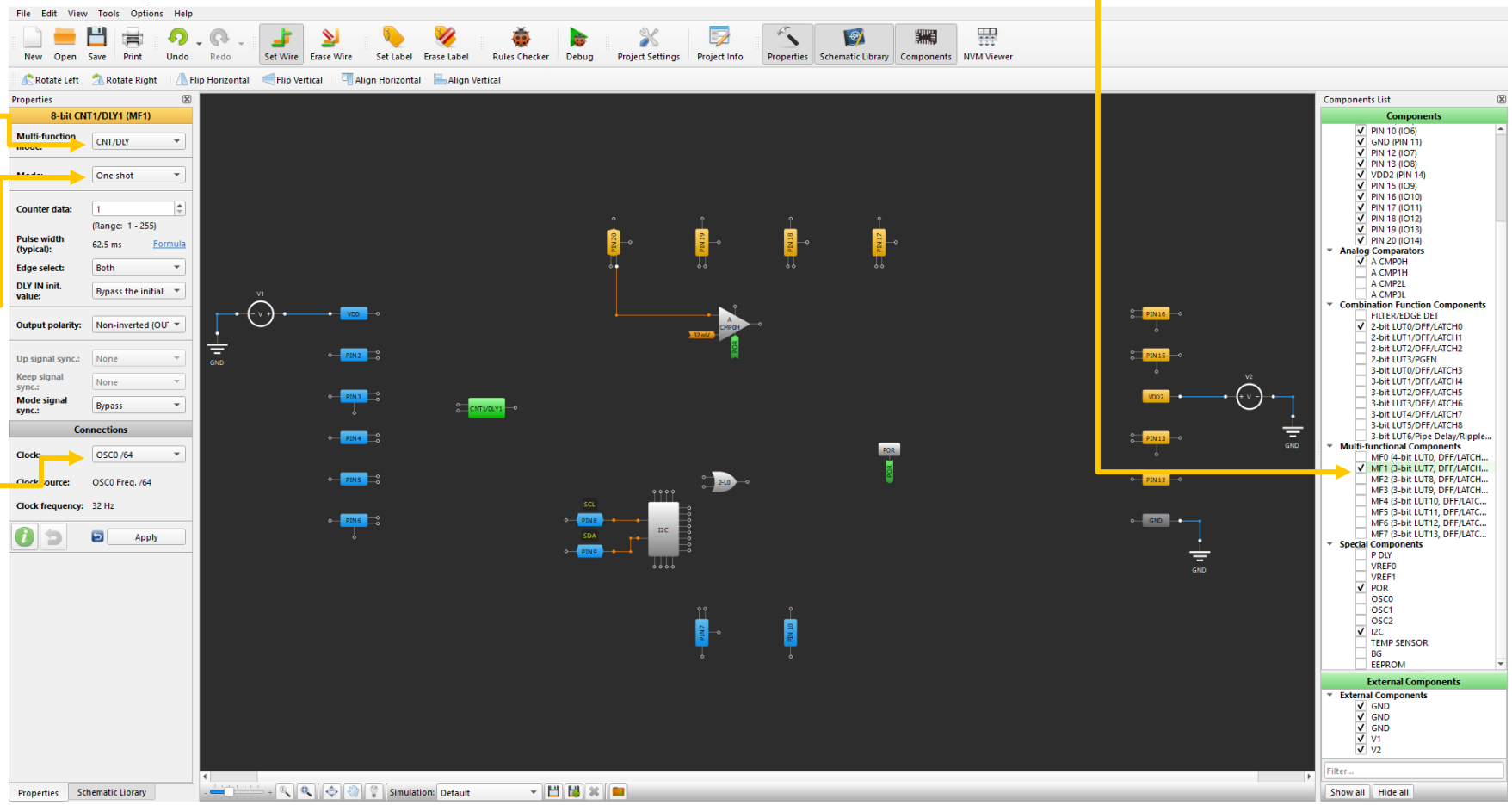
- Click on ACMP0H
  - Check the box next to the name of the block
- Click on POR
- Click the pin of POR so that you start a “wire” connection
- Connect the wire to the “power” pin of the ACMP
- This powers the ACMP whenever the POR is on
- Pin 20 will default to an analog input and connect to IN+ of the ACMP



# SELECTING A COMPONENT (ONE SHOT)

## Configuring the Counter Block as a One Shot

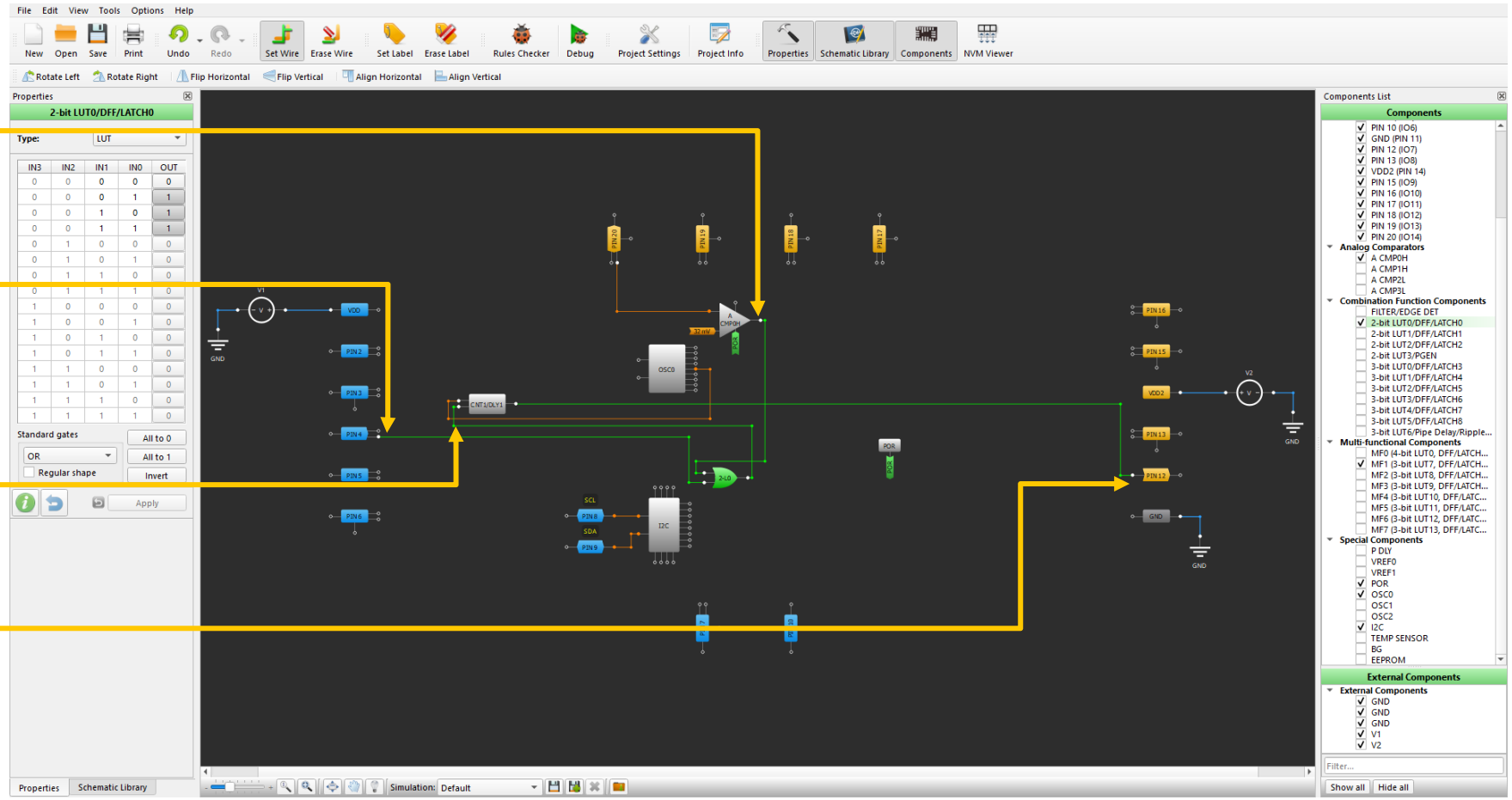
- Click on MF1 block
  - MF = Multi-Function
- Use the drop-down menu to change it to a counter
- Click “Apply” and “Yes”
- Use 2nd drop-down menu and change to One Shot
- Click “Apply”
- Select OSC0/64 from the drop-down menu for oscillator
- Click “Apply”
- OSC0 appears with an orange wire to CNT1



# CONNECTING BLOCKS TOGETHER

## Using Wires

- Use a wire to connect ACMP output to IN1 of “OR” gate
- Wire Pin 4 output to IN0 of “OR” gate
- Wire “OR” gate output to CNT1 “DLY IN”
- Wire CNT1 one shot output to Pin 12



# WHAT DOES THIS DESIGN DO SO FAR?

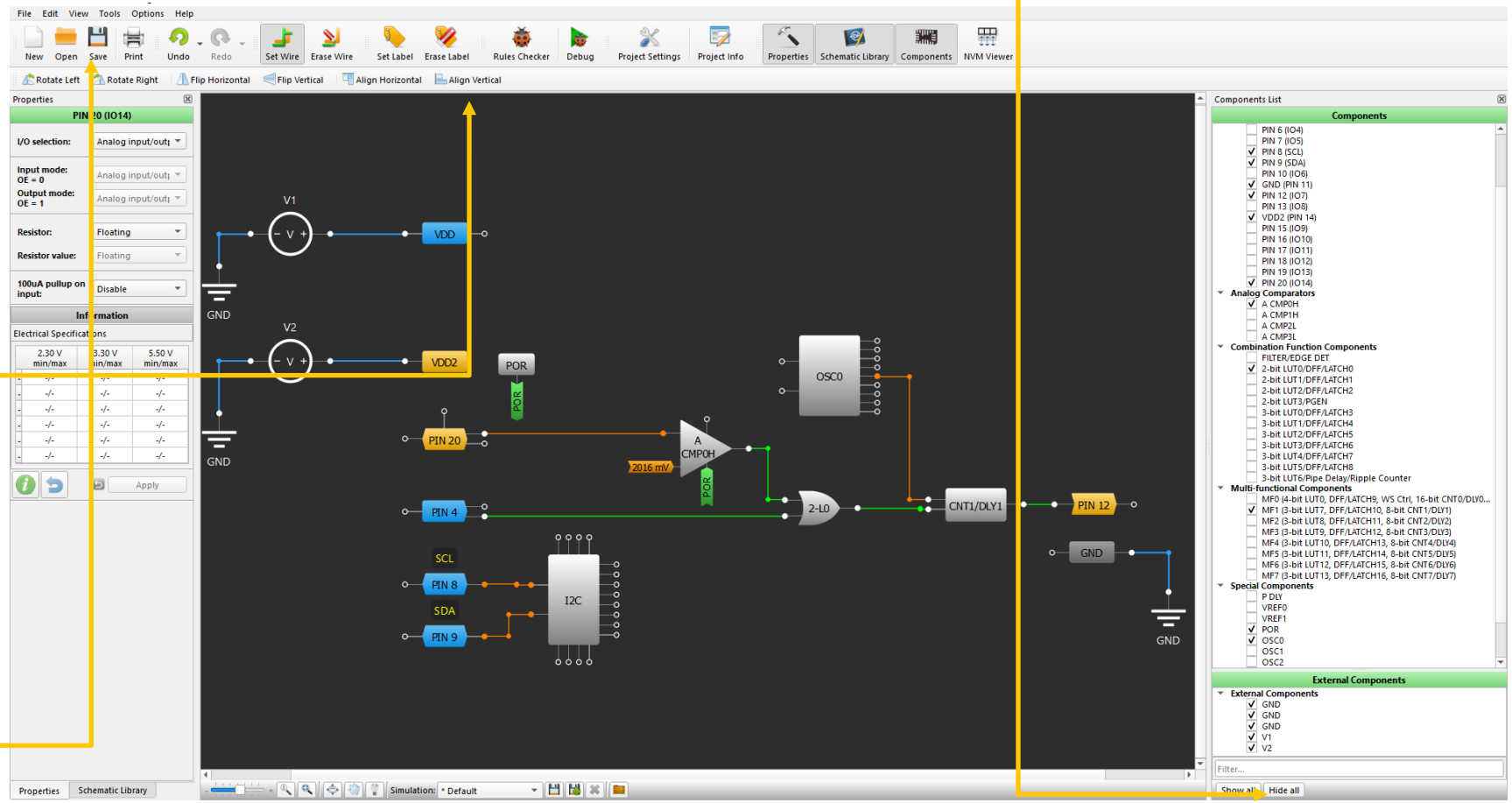
## Design Operation

- If Pin 4 goes to a logic high, OR Pin 20 goes above the ACMP VREF (currently defaulted to 32 mV), then the output of the OR gate will go HI.
- Upon a HI or LO from the OR gate the CNT1 one shot trigger. The one shot pulse is currently set to be a 62.5 msec, HI pulse (output polarity = not inverted).
- Let's say that Pin 20 is tied to the VDD of an S.O.C. When the SOC VDD goes HI, the output of the OR gate will go HI, triggering the one shot output pulse. Since an SOC takes some time to power up, we might cause a reset of the SOC mid-power up. We can fix this by changing the CNT1 edge to "Falling".
- Also, 32 mV might be a little low to compare the VDD value to so let's change that to 2016 mV (2.016 mV). This is now configured as a much better "brownout" detector.

# CLEANING UP THE LAYOUT

## Rearrange and Remove Unused Pins

- To remove unused pins, click “Hide All”.
- To move blocks around, click and hold a block to drag them around the screen. This is shown by a hand-shaped cursor.
- To align pins vertically, drag a highlighted box around Pins 4, 8, 9 and 20. Then click the “Align Vertical” button.
- To rotate a block, click it once, then right click and rotate it.
- Save early, save often!

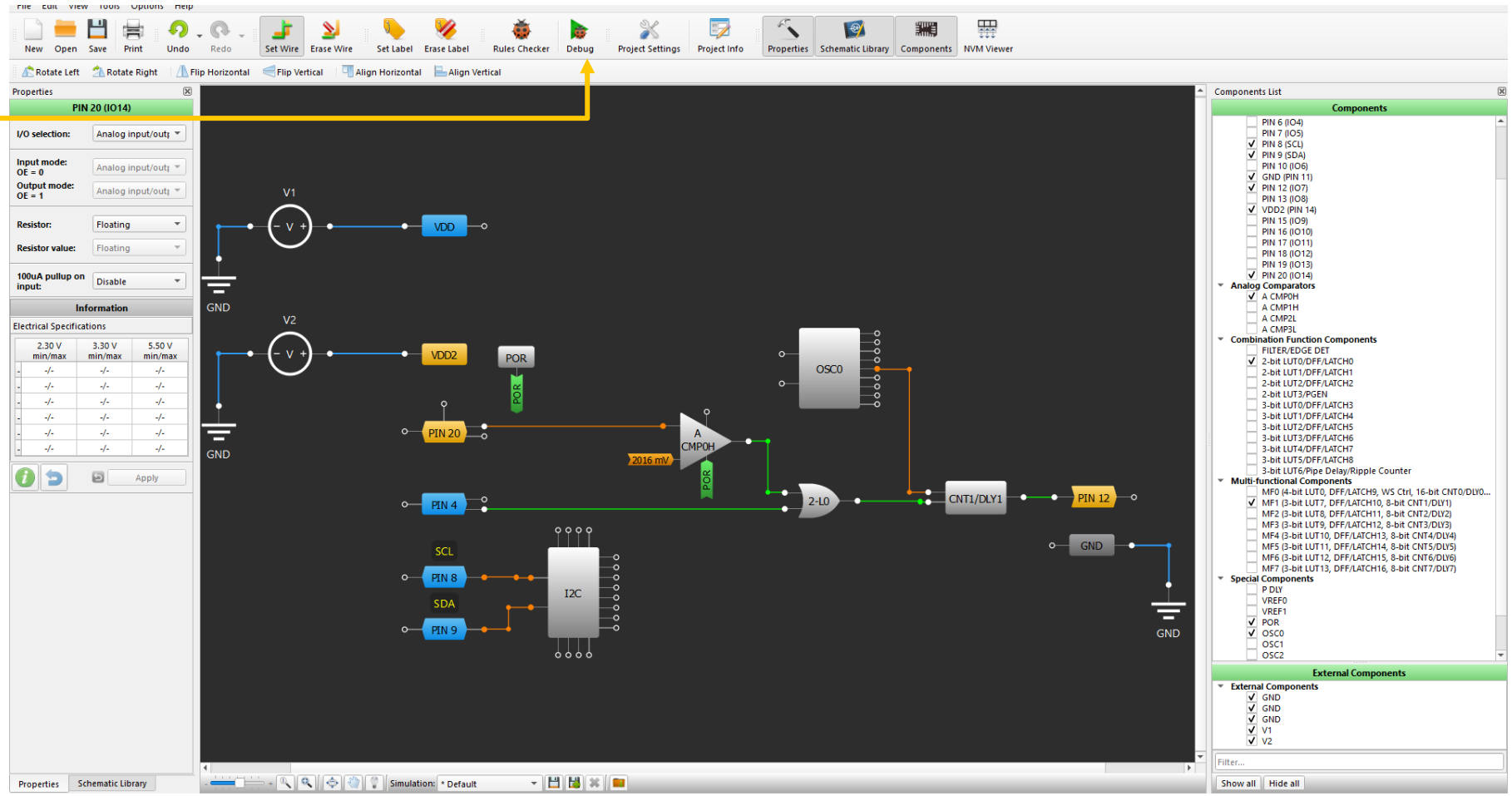


# SIMULATION PORTION OF DEMO

# OPEN THE DEBUGGER

## This is How to Access the Built-In Simulator (SPICE)

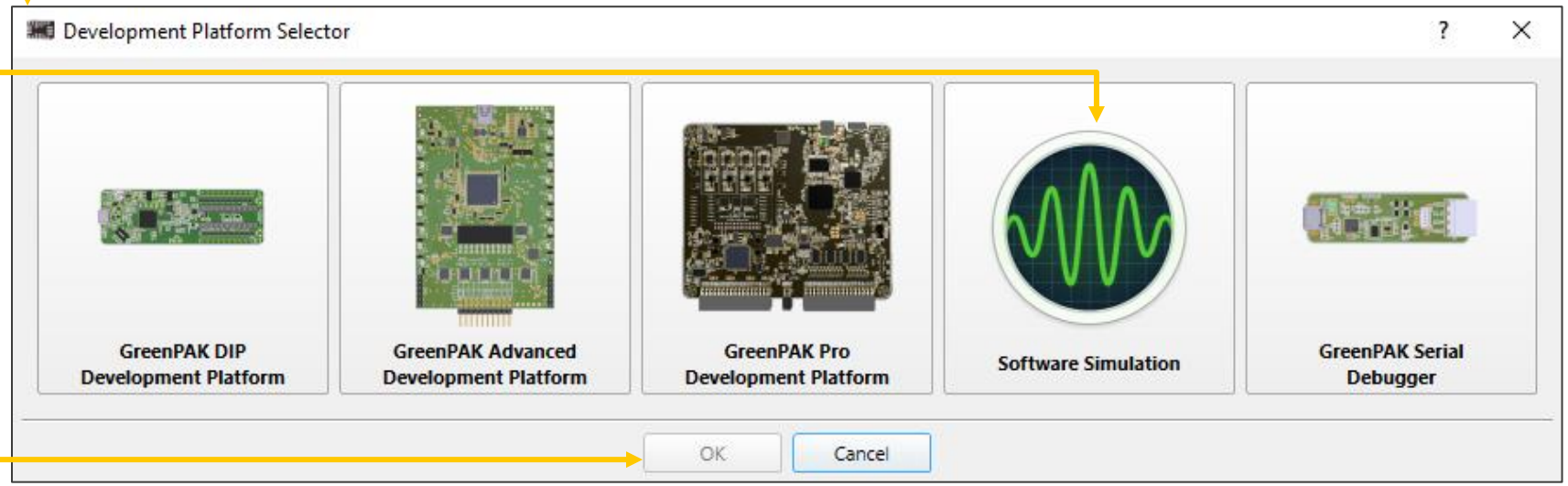
- Click the “Debug” button to access the SPICE simulator
- This is also how to access the emulator for the various hardware development kits



# DEVELOPMENT PLATFORM SELECTOR WINDOW

## Accessing the SPICE Software Simulation Tool

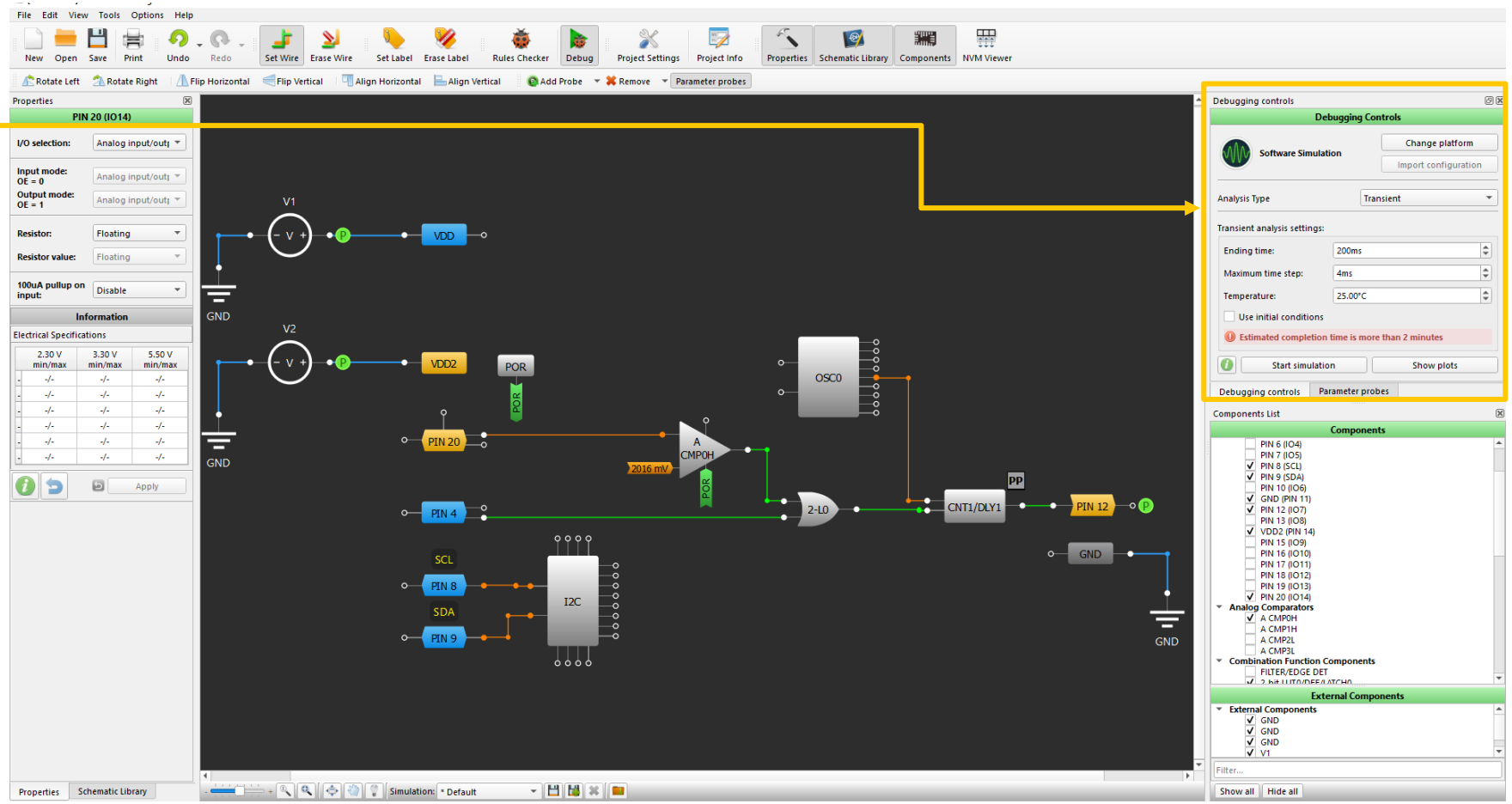
- The Development Platform Selector window should be visible
- We want to use the Software Simulator to test the design, so select it
- Click OK



# THE DEBUGGER CONTROLS WINDOW

## Setting Simulation Parameters

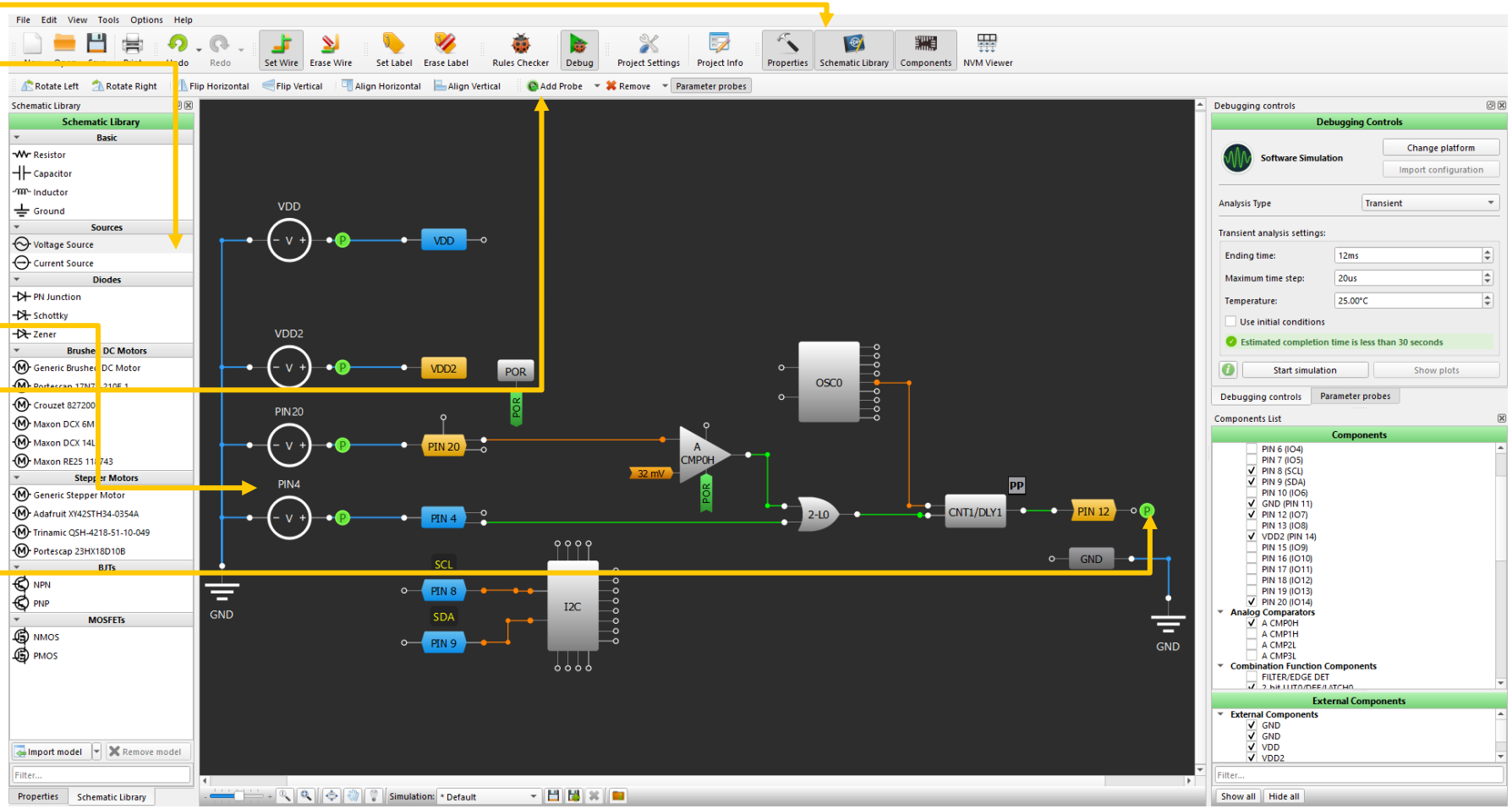
- This window allows you to define the parameters of the simulation run
- Before we run the simulation, we need to set input signals and choose probe points (circuit connection points where the simulation software will track the outputs)



# ADD VOLTAGE SOURCE AND PROBE POINT

## For Both Input Pins and the Output Pin

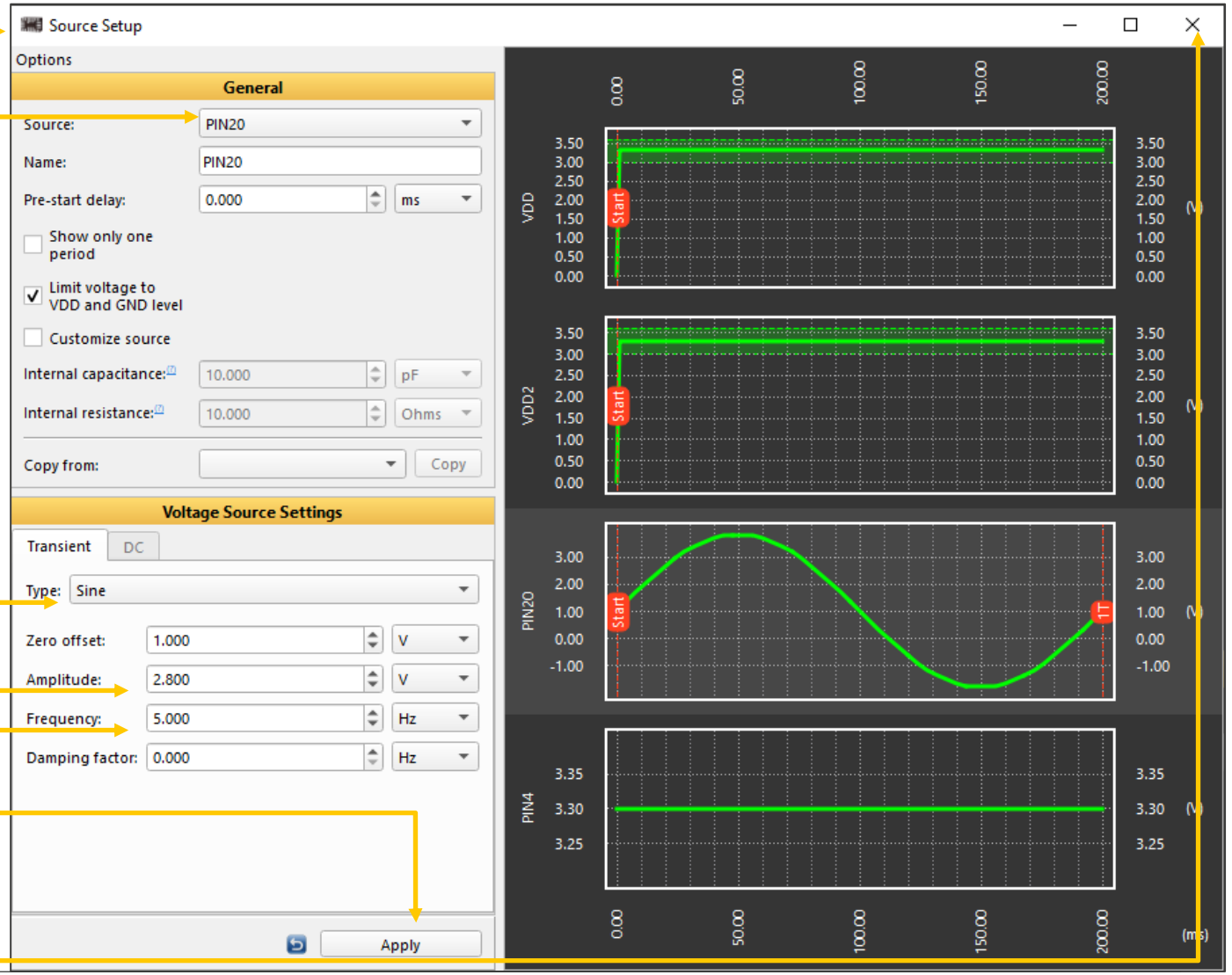
- Click „Schematic Library”, then “Voltage Source”
- Add voltage sources to VDD, VDD2, Pin 4, and Pin 20
- Click “Add Probe”
- Click the external connection for Pin 12
- Green probe appears



# EDIT AND CONFIGURE THE SOURCE

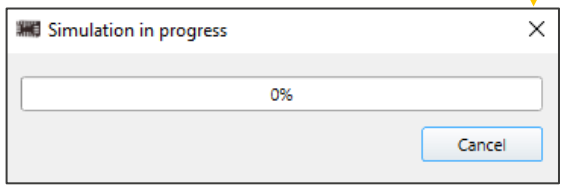
## Setting Source Simulation Parameters

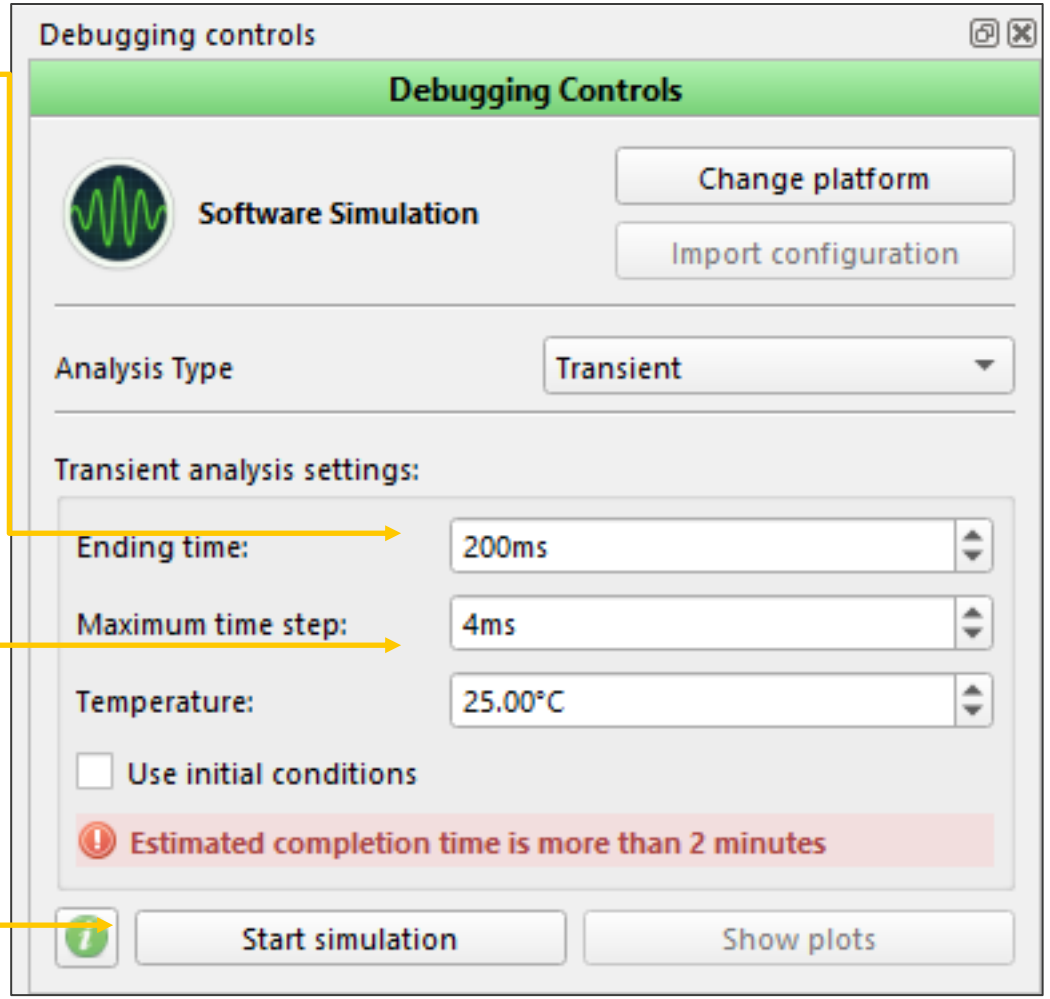
- Double click the source for Pin 20
- You should see this window pop-up
- Note that we are looking at the source for Pin 20
- Change its type to sine
- Change the amplitude to 2.8 V
- Change the frequency to 5 Hz
- Click “Apply”
- Close the window



# SET AND RUN THE SIMULATION

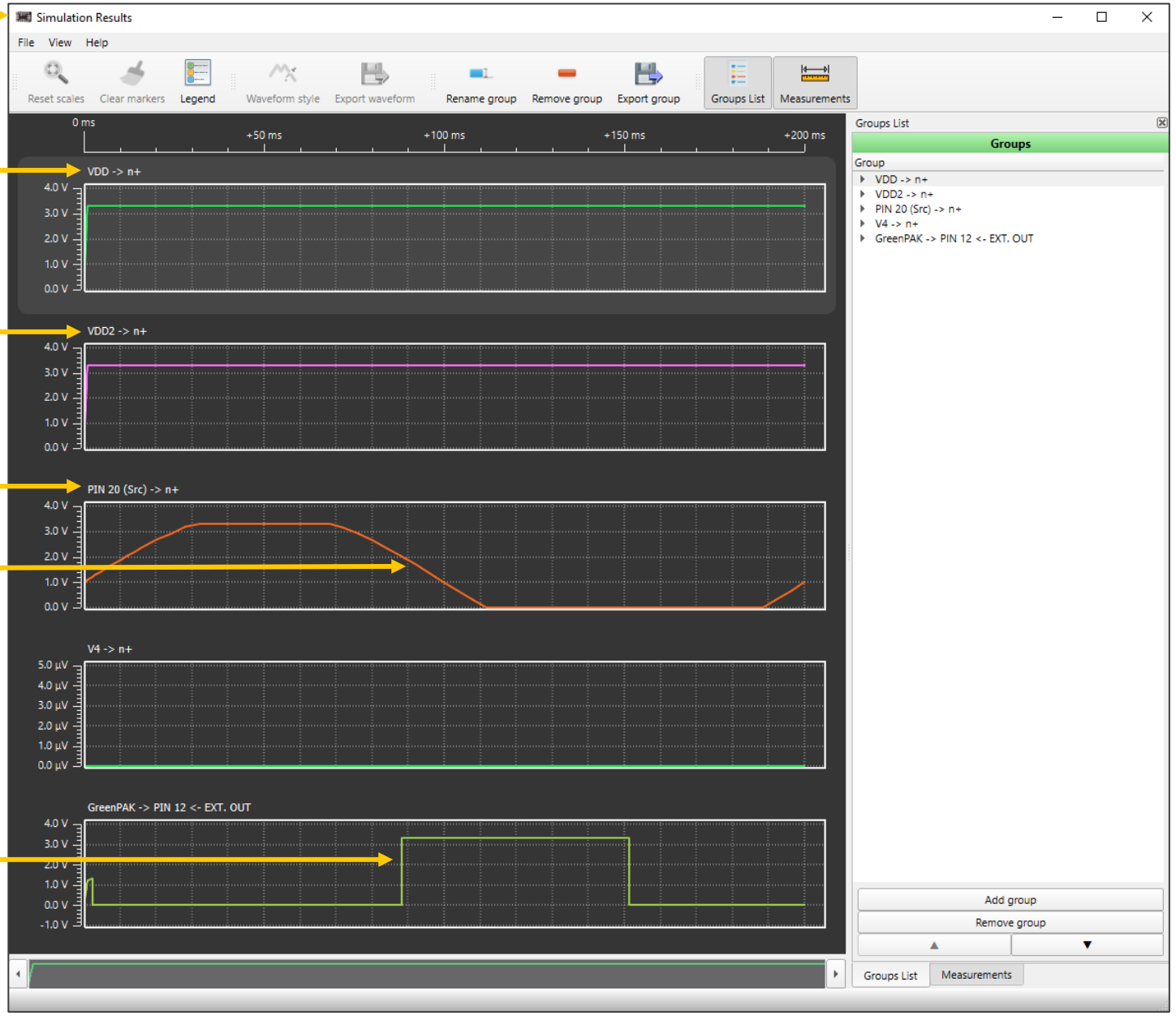
- Change the Ending Time to 200 ms
- Change the Maximum time step to 4 ms
- Note that the default is in µs
- Push this button to start the simulation
- A warning pop-up may appear to show a long simulation time, it's ok to dismiss
- This pop-up window shows the progress



# SIMULATION RESULTS

- Results show in a new window
- VDD voltage for 200 ms
- VDD2
- Input voltage on Pin 20
- Since the one shot trigger was set to falling edge, as the sine wave input falls below 2.016 V, we will cause the one shot pulse to be output
- Note the pulse width is 62.5 ms as designed

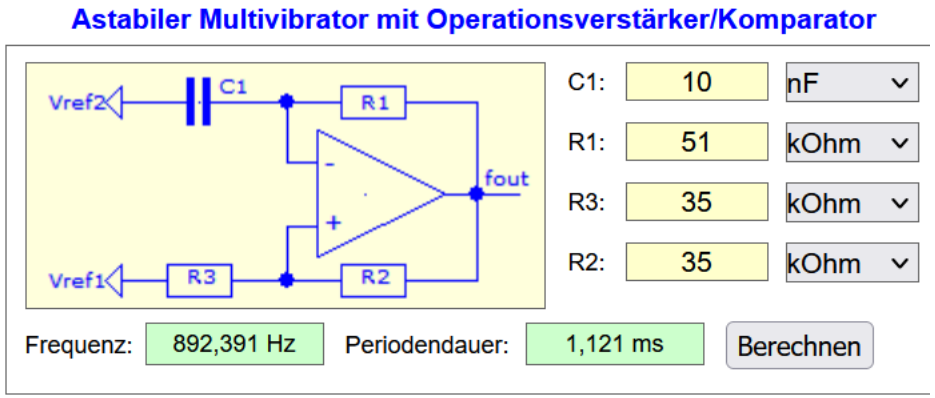


# BACK UP SLIDES ADDITIONAL APPLICATIONS EXAMPLES

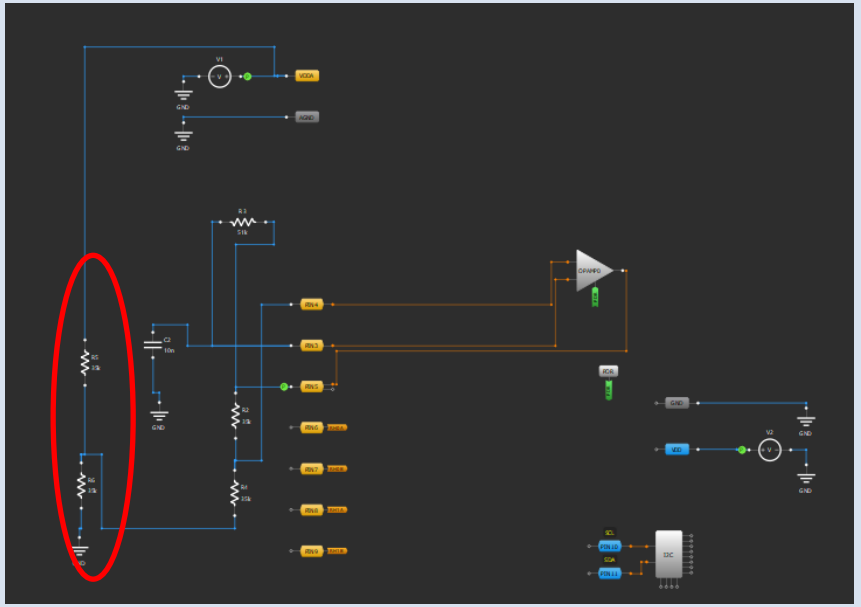
# GREENPAK APPLICATION EXAMPLES

## Multivibrator (Op Amp Design)

- Uses the OPAMP0 in SLG47004V
- As there is no negative Supply voltage for the Op AMP
  - Set Input voltage on Vref 1 = Vdd/2
  - Include additional voltage divider (1:1)

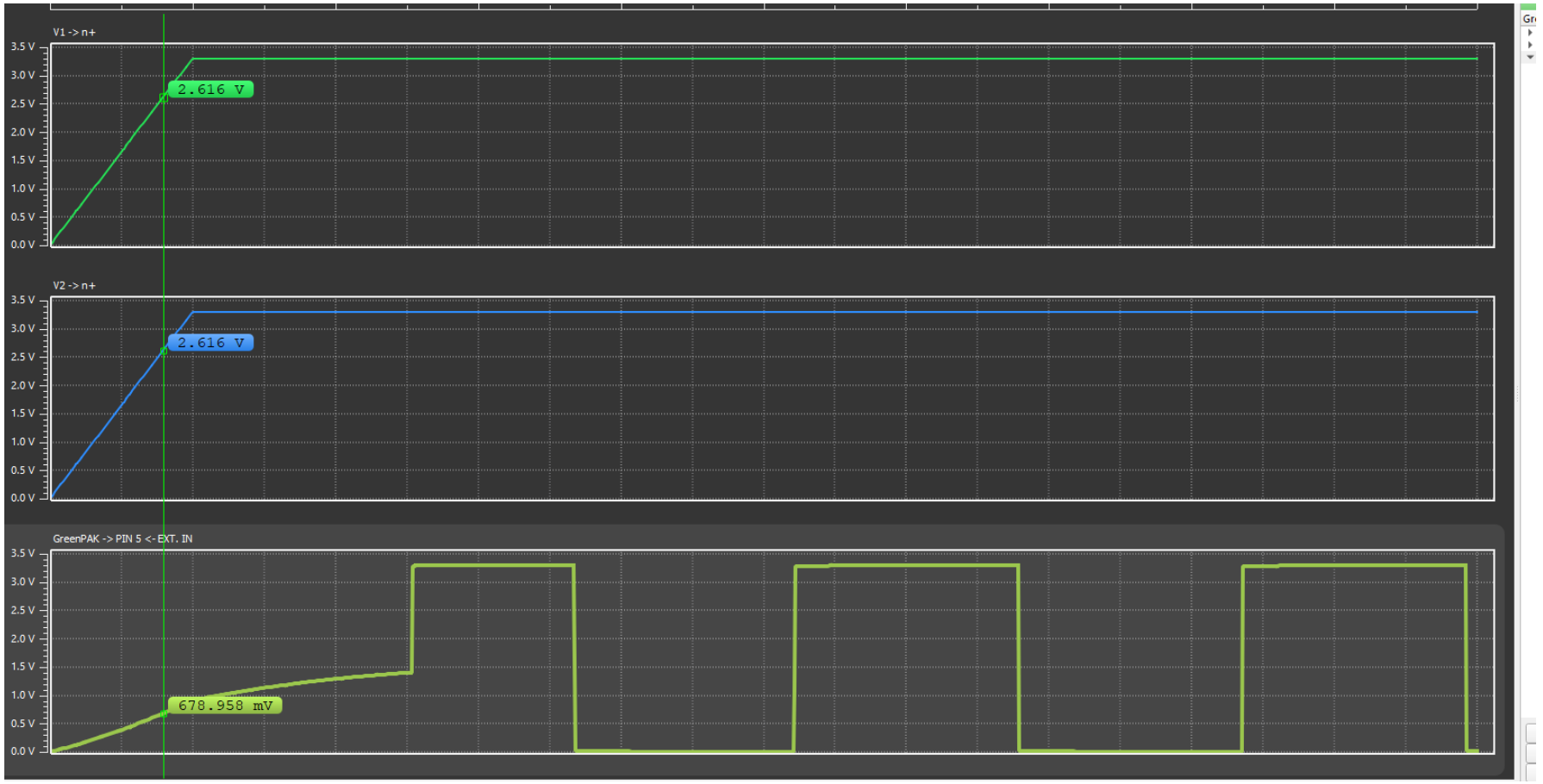



GreenPAK



# GREENPAK APPLICATION EXAMPLES

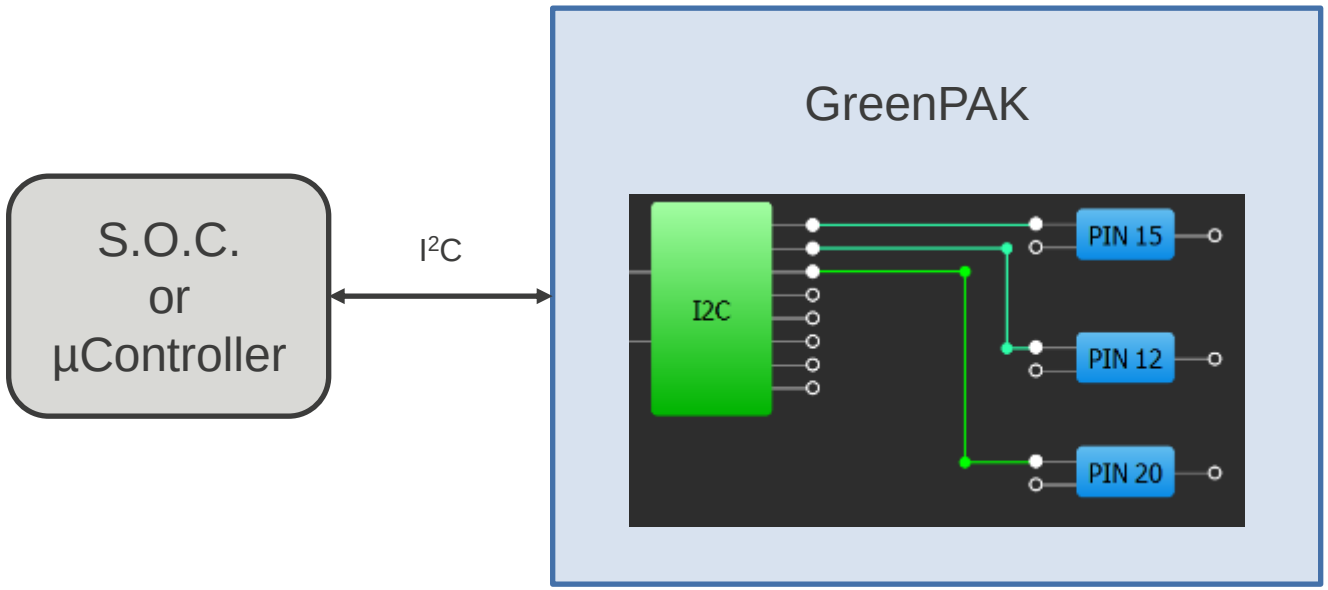
## Multivibrator (Op Amp Design)



# GREENPAK APPLICATION EXAMPLES

## GPIO Expander

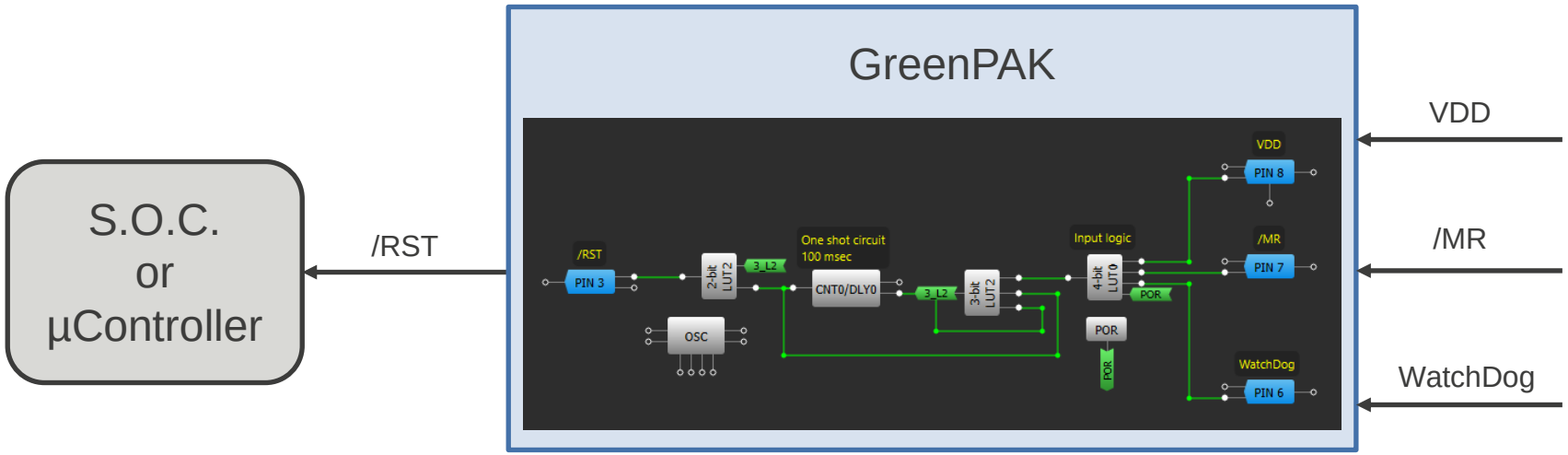
- Uses the I²C port in SLG4653xV
- Access GreenPAK pin state by a read command
  (up to 16 pins with SLG46533/SLG46537/SLG46538V)
- Optional /INT pin can be implemented for continuous pin monitoring



# GREENPAK APPLICATION EXAMPLES

## System Reset

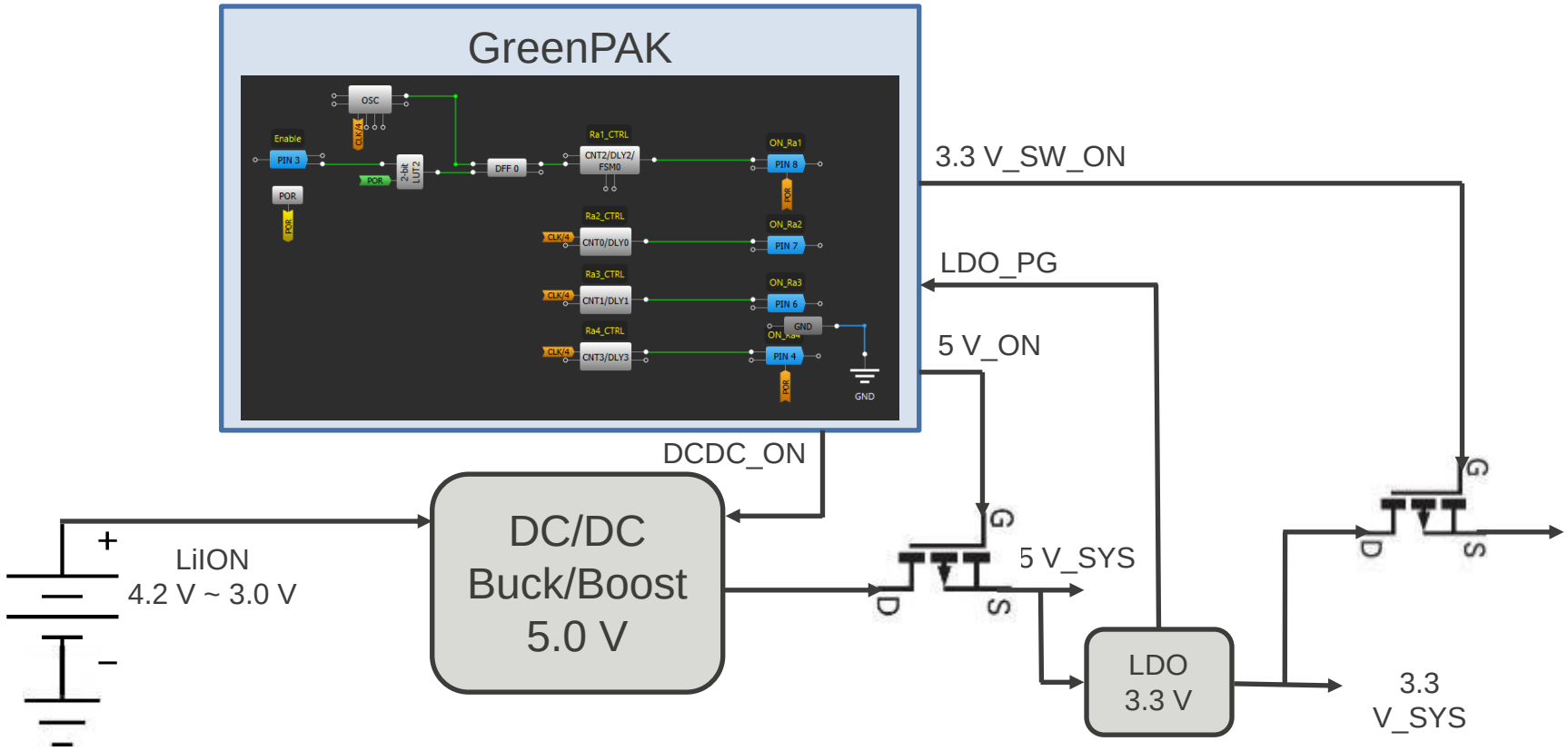
- Can be implemented in any GreenPAK silicon
- Inputs:  /MR, VDD, WatchDog, voltage rail, logic signal
- Output:  one shot pulse of almost any time length, level shifted logic



# GREENPAK APPLICATION EXAMPLES

## Power Rail Sequencing

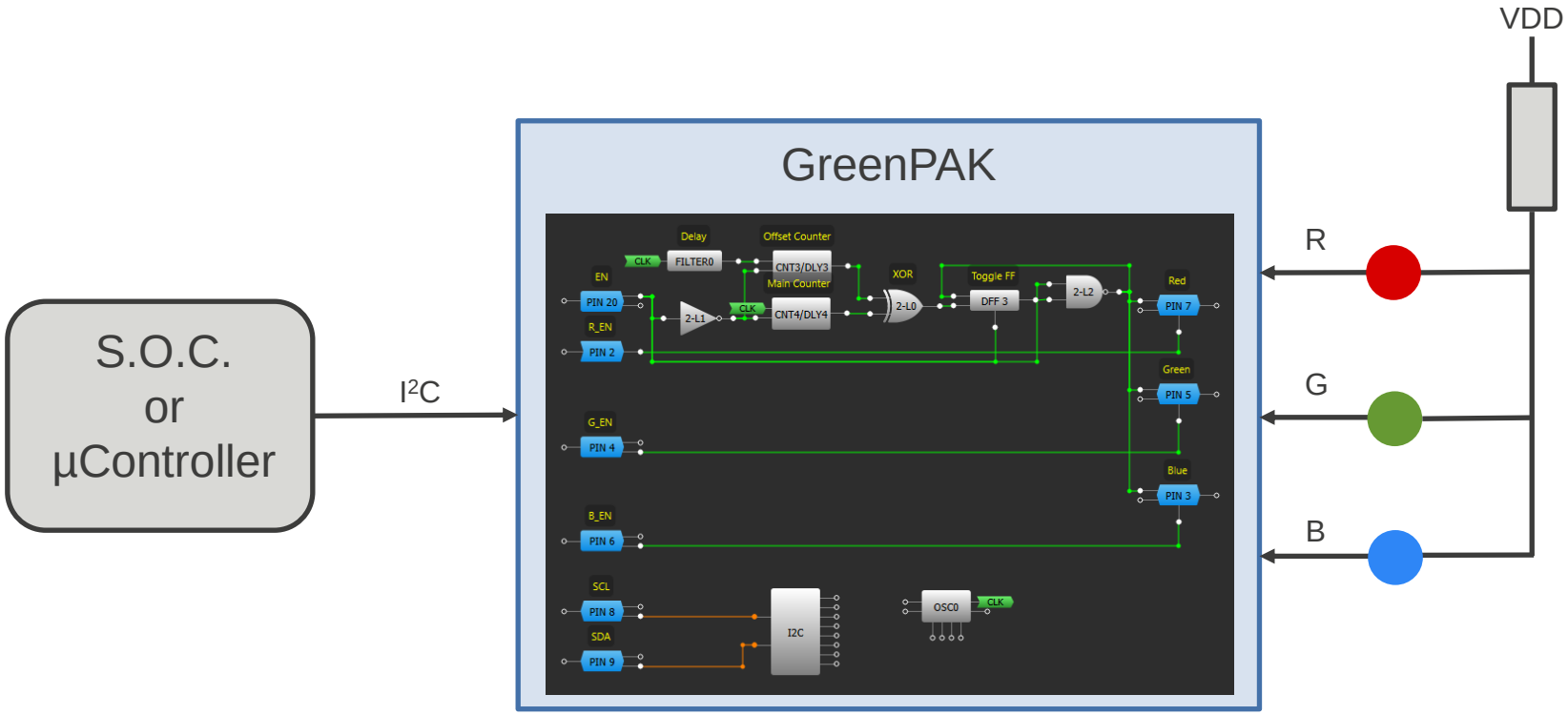
- Can be implemented in any GreenPAK silicon
- Inputs:  logic signals, PGs, voltage levels
- Outputs:  load switch OEs, LDO OEs, DC/DC OEs, MOSFET gates



# GREENPAK APPLICATION EXAMPLES

## RGB LED Driver

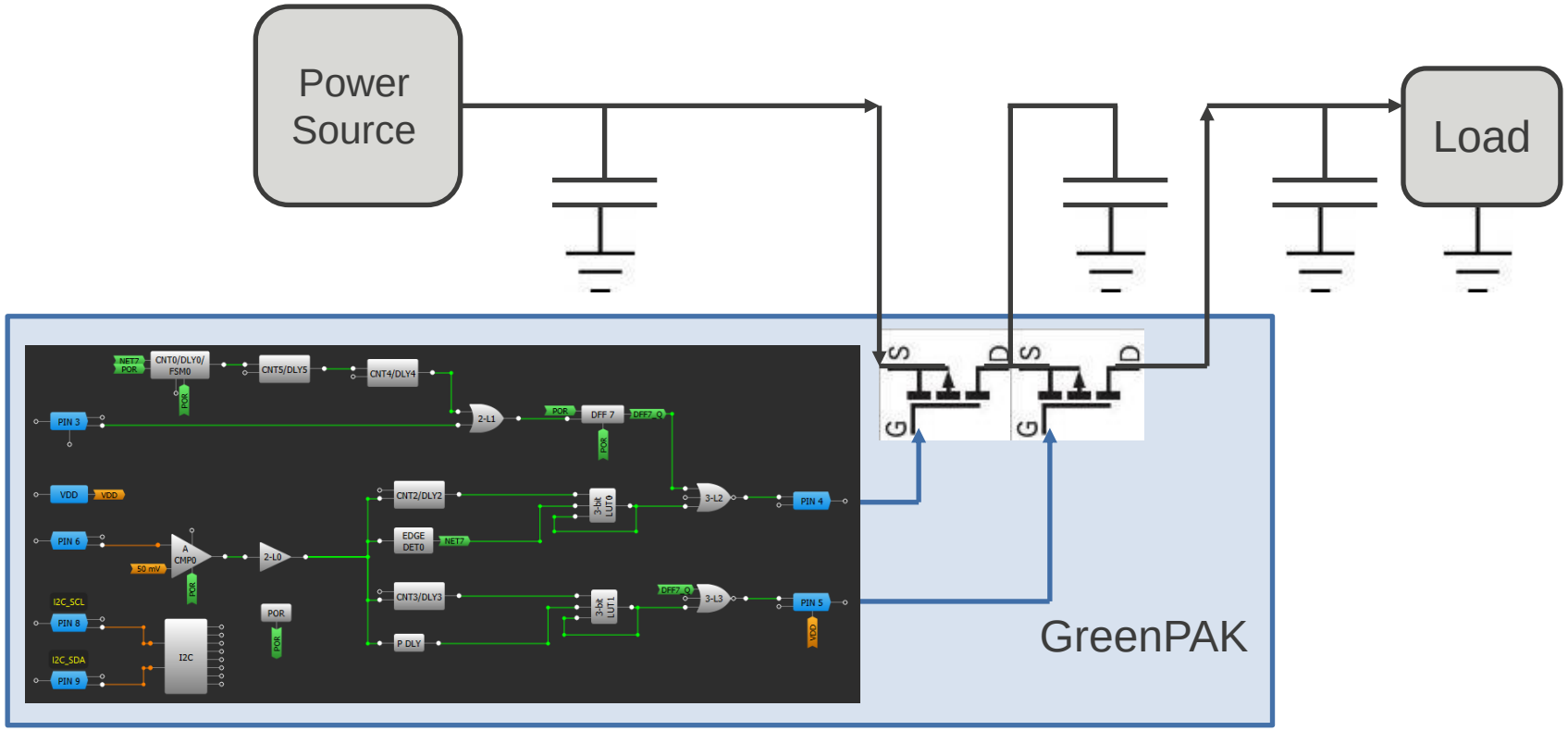
- Uses the I2C port in SLG4653xV, can be implemented with SPI in other GreenPAKs
- Inputs:  write command for color, flashing time, pulsing time, breath time
- Output:  PWM signal with timing to drive RGB diode(s)



# GREENPAK APPLICATION EXAMPLES

## Coulomb Counter

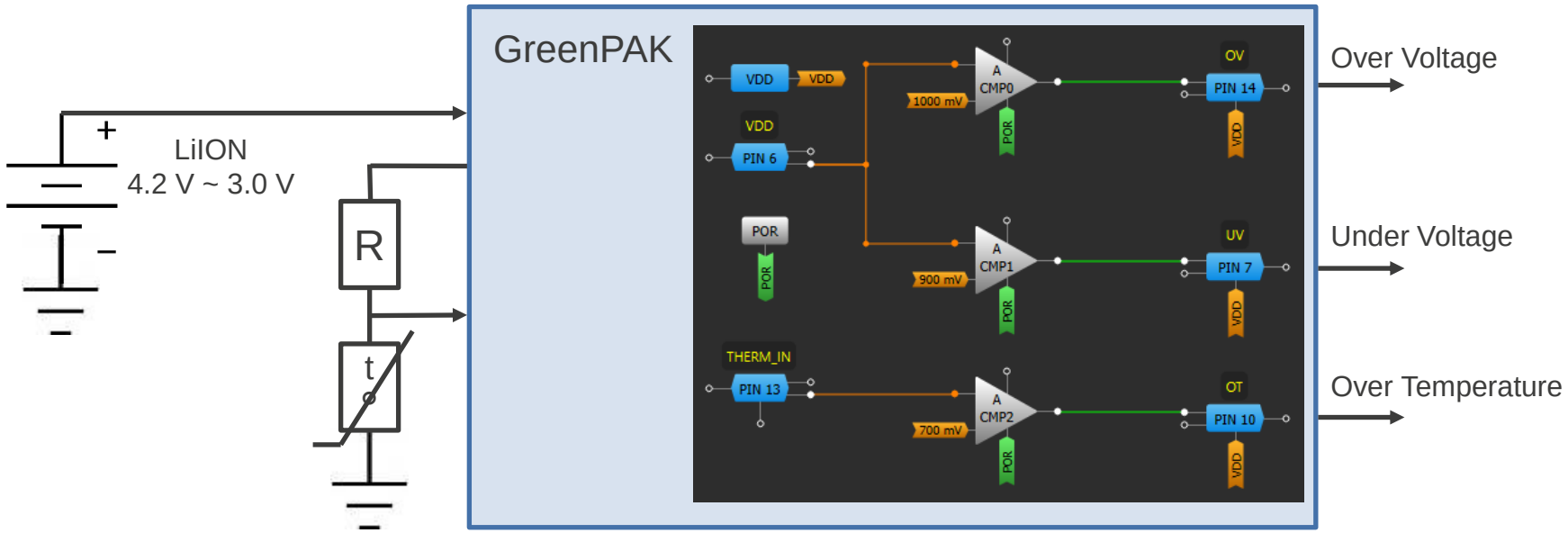
- 2 uA power consumption; linear for power switch currents from uA to mA
- Inputs:  Current through power switches
- Output:  Frequency proportional to current through switches or I2C counter read



# GREENPAK APPLICATION EXAMPLES

## Safety Features

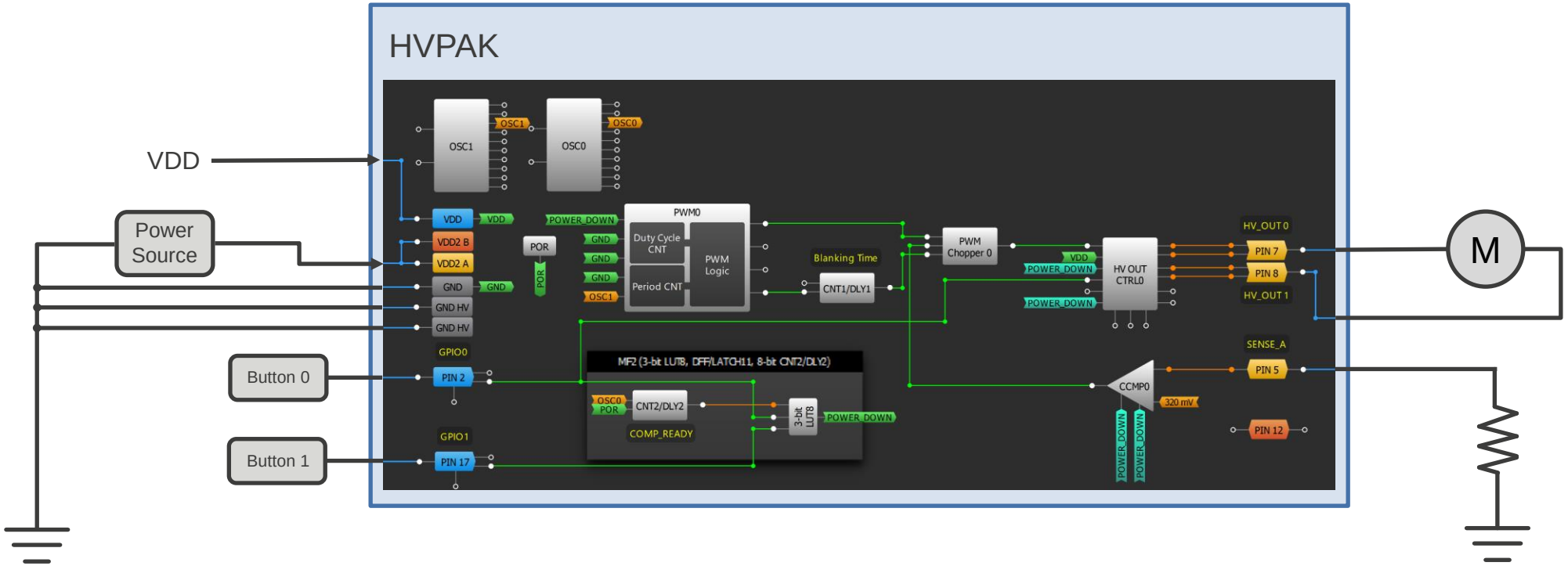
- Can be implemented in any GreenPAK silicon with ACMPs
- Inputs:  VDD, voltage rails, thermistors, other sensing elements
- Outputs:  over/under voltage indication, over temperature



# GREENPAK APPLICATION EXAMPLES

## HVPAK Motor Driver with Current Limiting Application

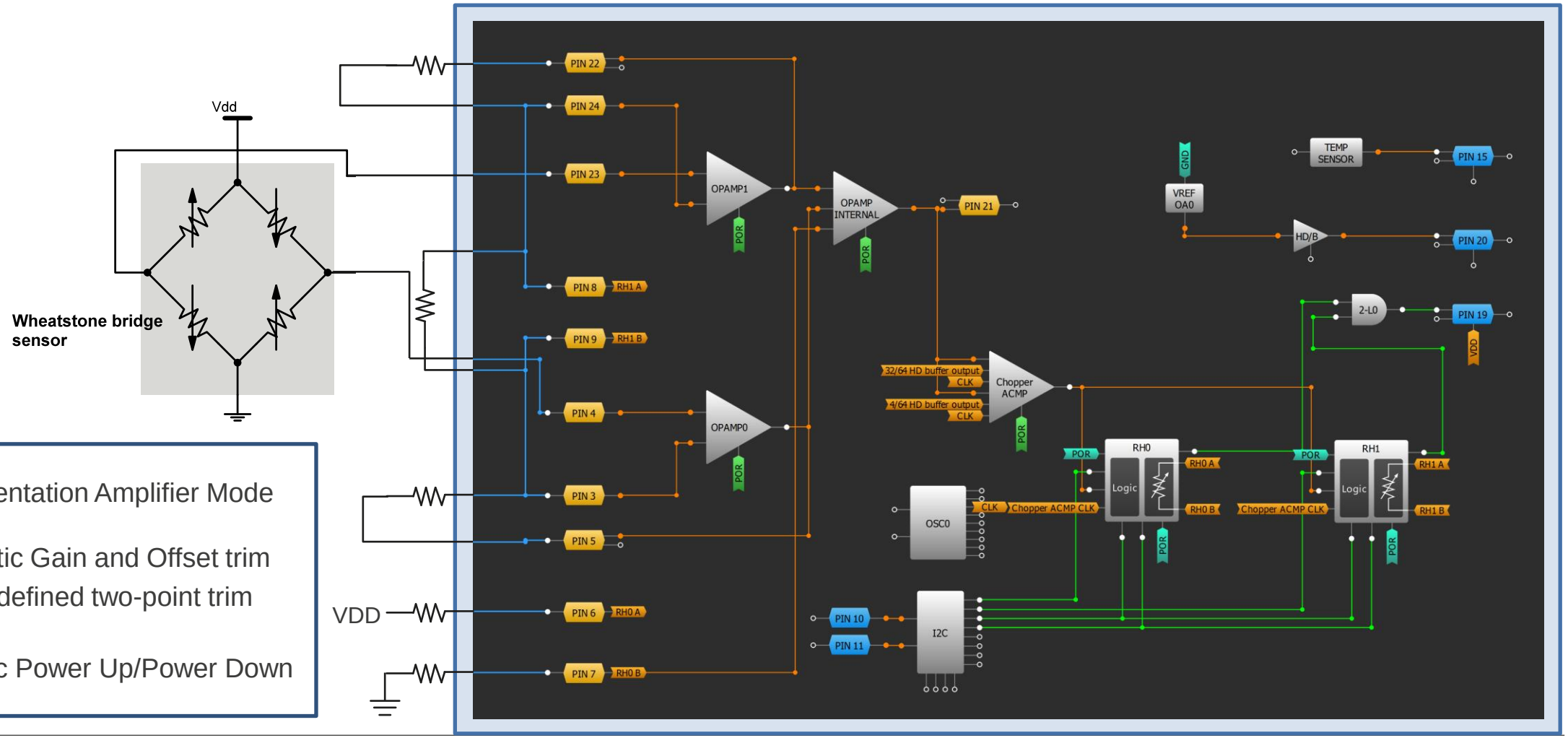
- Can be implemented using HVPAK family ICs
- Inputs: VDD, power source, two buttons
- Outputs: custom motor control with over current protection



# GREENPAK APPLICATION EXAMPLES

## Wheatstone Bridge Sensors Interface Using AnalogPAK SLG47004

AnalogPAK




- Instrumentation Amplifier Mode
- Automatic Gain and Offset trim or user-defined two-point trim
- Dynamic Power Up/Power Down

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