Digital power conversion basics: from analog to digital control

XMC™ microcontrollers

May 2016

Agenda

1. Why digital control in power conversion?
2. What to expect when moving from analog to digital control
3. Basics of digital control
4. XMC™ power conversion peripherals
5. Development steps vs. XMC™ support
6. Development tools and software
7. General information

Agenda

1. Why digital control in power conversion?
2. What to expect when moving from analog to digital control
3. Basics of digital control
4. XMC™ power conversion peripherals
5. Development steps vs. XMC™ support
6. Development tools and software
7. General information

Digital control is a natural evolution

Evolution


*

Would you get stock in the past?

*(Source: Freepik)

Benefits of digital control

Adaptability

- Allow full performance by tuning SW to specific design
- Programmable operation limits
- Scalable to different designs
- Programmable fault handling

Advance control

- Adaptive control
- Multimode operation: CCM, DCM
- Auto calibration
- Non lineal control
- System linearization

Security

- Implement and protect your own IP from read access
- Embedded HW protections in case of SW fault

Communications

- Housekeeping: diagnostics, metering & reporting
- Remote SW update
- Remote controllable, i.e. diming

Agenda

1. Why digital control in power conversion?
2. What to expect when moving from analog to digital control
3. Basics of digital control
4. XMC™ power conversion peripherals
5. Development steps vs. XMC™ support
6. Development tools and software
7. General information

What to expect when moving from analog to digital control?

*


*

The major problem that digital control has is:
freedom!

Together with freedom comes:
responsibility!

Don’t panic! XMC™ ecosystem will provide you with what you need!

*(Source: Pixabay)

What to expect when moving from analog to digital control?

XMC™

XMC™ + SW example + demo board

Extra steps

› Adapt SW parameters for new design

Empty µC (without SW)

Extra steps

› Design control algorithms

› Resources assignment: pins, PWM, ADC…

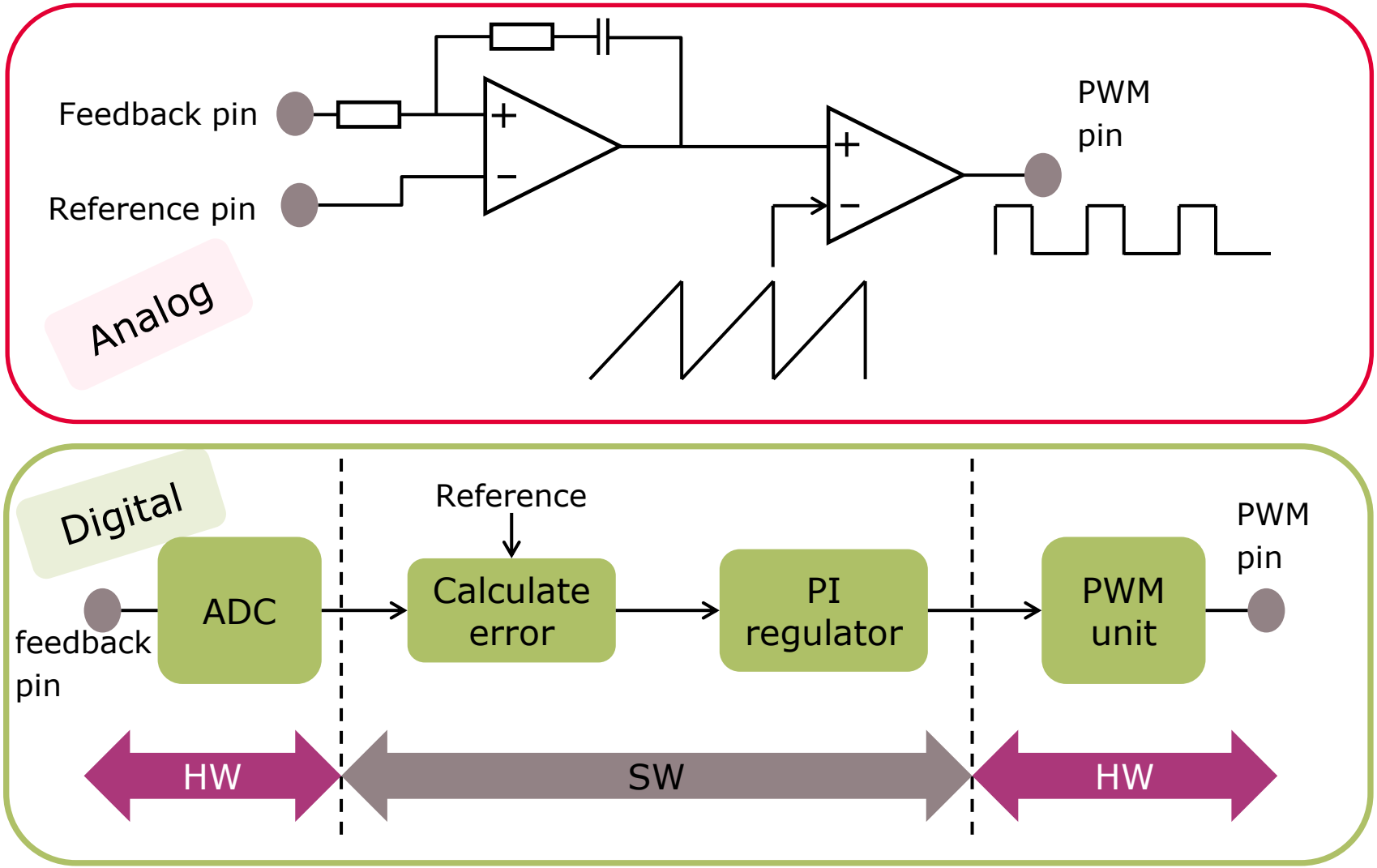
› Code algorithms

› Debug

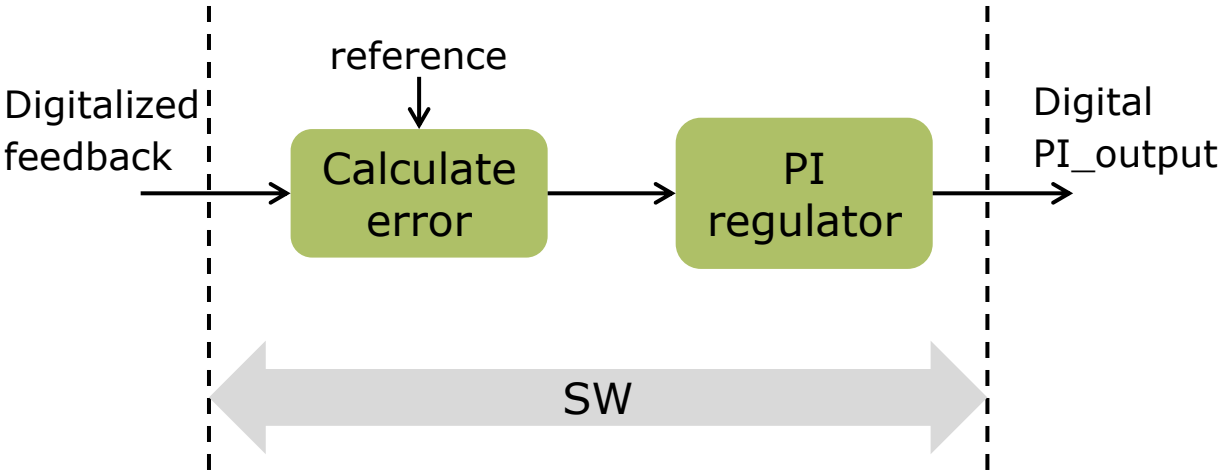
Agenda

1. Why digital control in power conversion?
2. What to expect when moving from analog to digital control
3. Basics of digital control
4. XMC™ power conversion peripherals
5. Development steps vs. XMC™ support
6. Development tools and software
7. General information

Simple PI regulator: Analog vs. digital



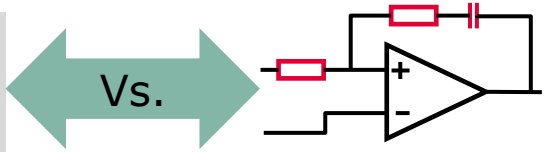
Digital PI regulator in C code



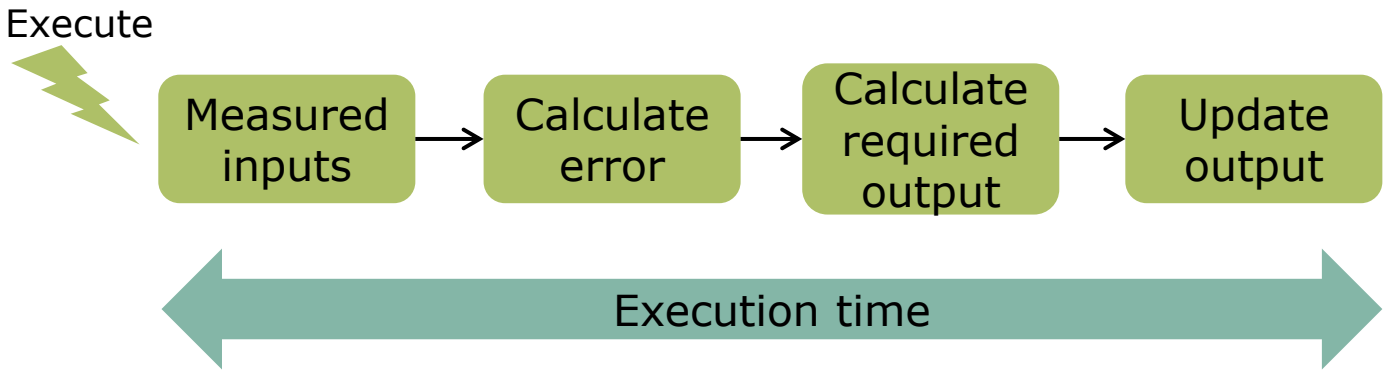

```
error = reference - feedback;
PI_storage = (error * PI_ki) +
PI_storage_1;
PI_storage_1 = PI_storage;

PI_output = (error * PI_kp) + PI_storage;
```

Where are the
PI parameters?

PI_ki
PI_kp



The impact of the execution time



Consider

- Execution time add a delay to the control loop
- Due to execution time we may not be able to "regulate" the system every switching cycle
- The faster the CPU the faster we can close the loop
- Executing the control loop faster than switching frequency may not help

Fix point vs. floating point

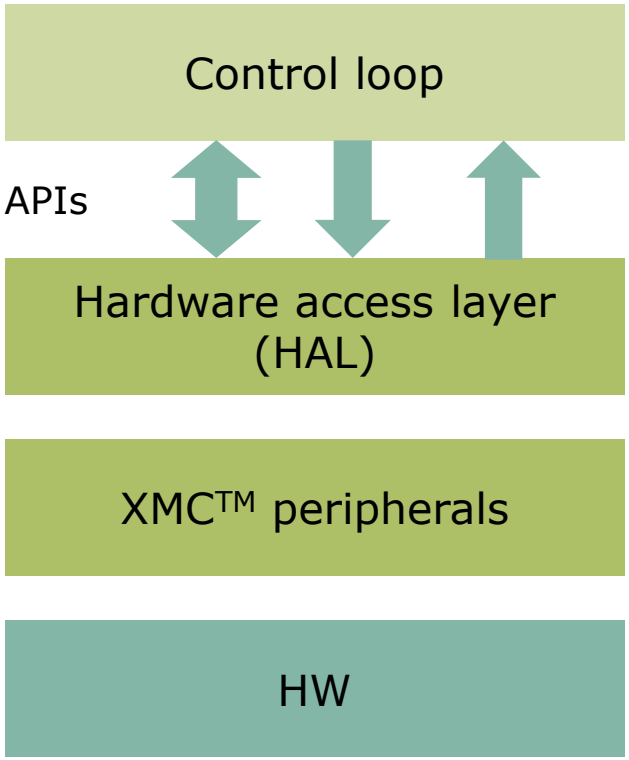
Fix point

- Cheaper HW
- Faster execution (in general)
- Danger of operations overflow
- May required scaling factors

Floating point

- Do not need variables scaling
- Low overflow risk
- Easy coding and easy to understand
- Higher code reusability
- More expensive HW (or slow execution)
- Type conversion to access HW registers

XMC™ examples SW architecture



Target: Ensure code reusability and reliability by isolating control loops from HW

Options

- Low level drivers
- DAVE™ APPs (based on LLDs)
- Custom
- Combination of previous

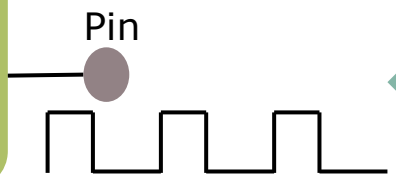
Agenda

1. Why digital control in power conversion?
2. What to expect when moving from analog to digital control
3. Basics of digital control
4. XMC™ power conversion peripherals
5. Development steps vs. XMC™ support
6. Development tools and software
7. General information

How key peripherals help? CPU usage

- Peripherals are state machines which can run independently and interact with the CPU or with other peripherals

PWM unit
- Frequency
- Duty cycle



Vs.

```
While(1)
{  signal_high= 100;
   while (signal_high--);
   set_pin_low();
   signal_low= 200;
   while (signal_low--);
   set_pin_high();
}
```

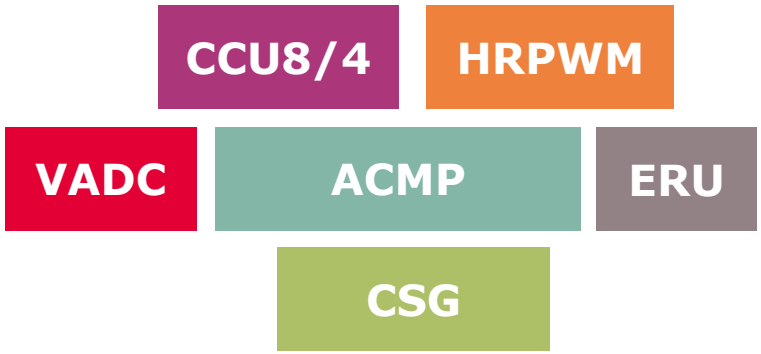
- Precise
- CPU is free

- Block CPU
- It is unprecise

Key peripherals are a must to enable high performance control

Key peripherals

Peripherals for power conversion applications



Highlights

Analog front end together with full configurability allows most advanced power supply control

With the support of ARM® Cortex® cores and high resolution PWM (150 ps), accurate and fast control loops execution are possible for improved figure of merits in power supply design

Key feature

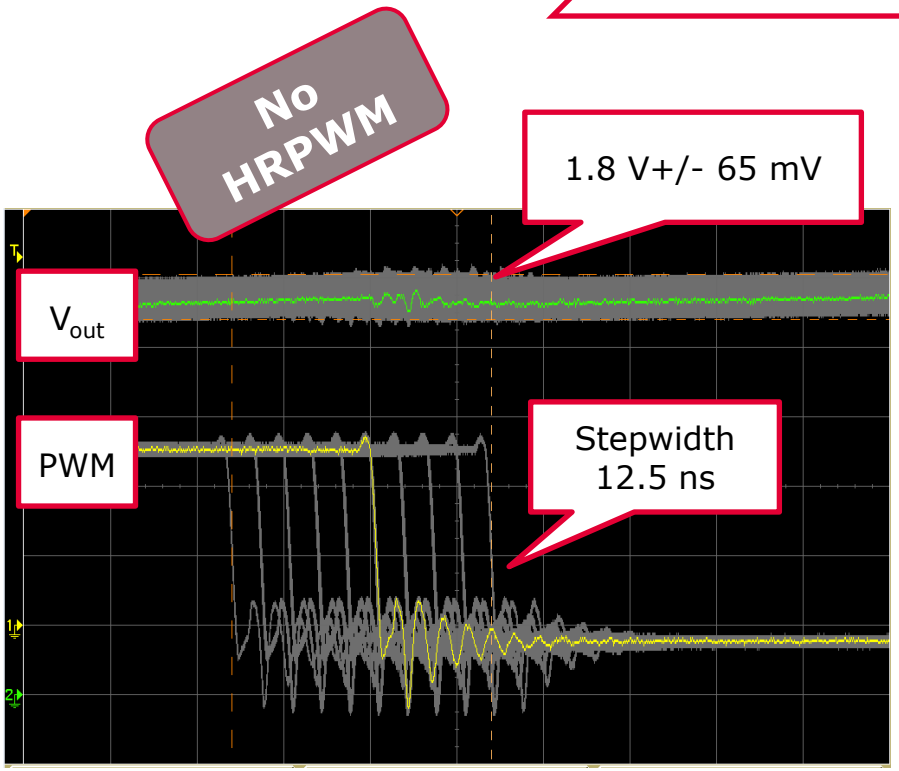
- High resolution PWM (150 ps)
- Smart analog comparators
- Fast and flexible ADC and timers

Customer benefits

- Regulate voltages/current with higher accuracy
- Analog comparators with smart features such as slope compensation
- Permit complex PWM patterns and sophisticated measure sequences

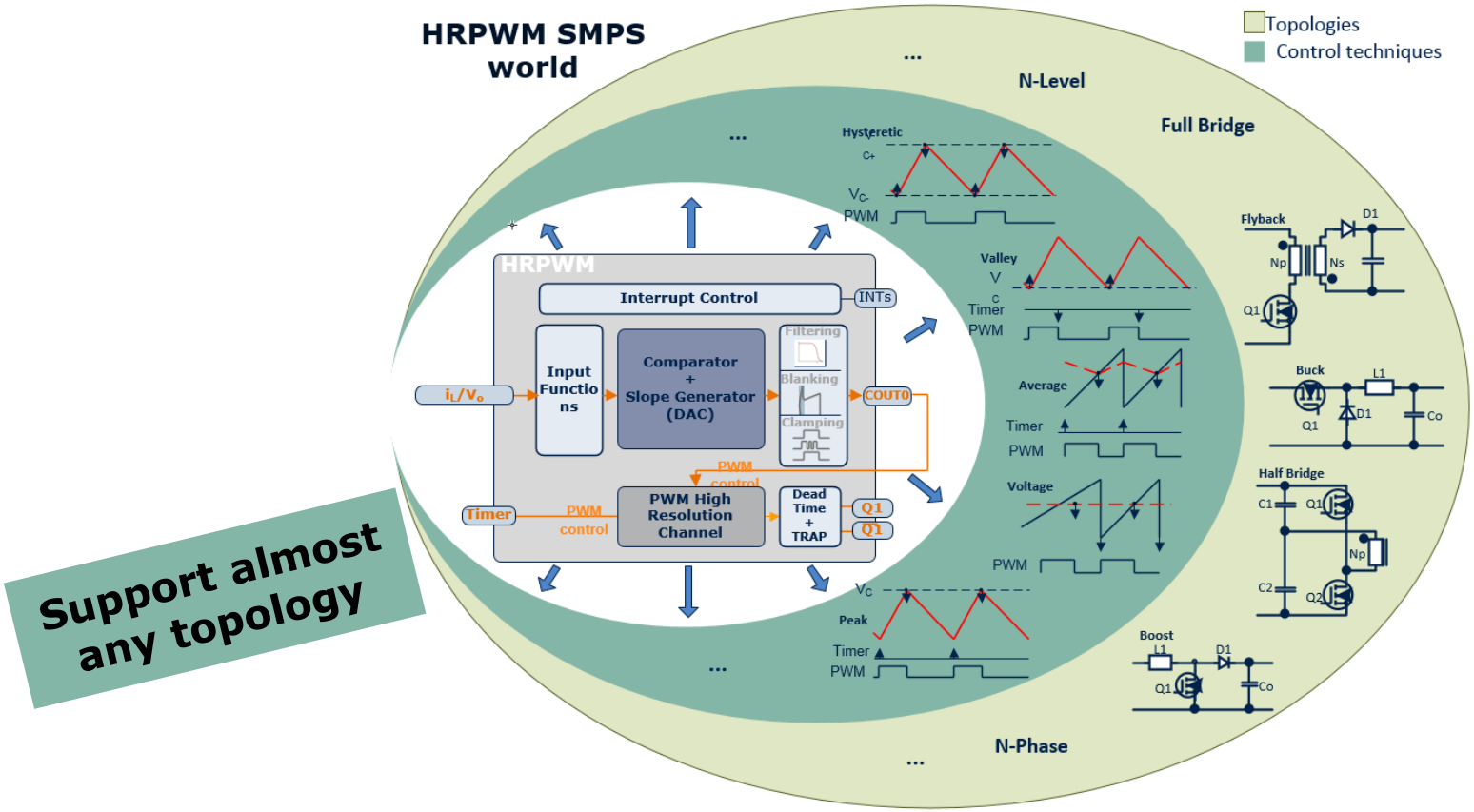
Key peripheral example 1: High Resolution PWM

Higher accuracy
Better control
stability



Key peripheral example 2: Smart analog comparators

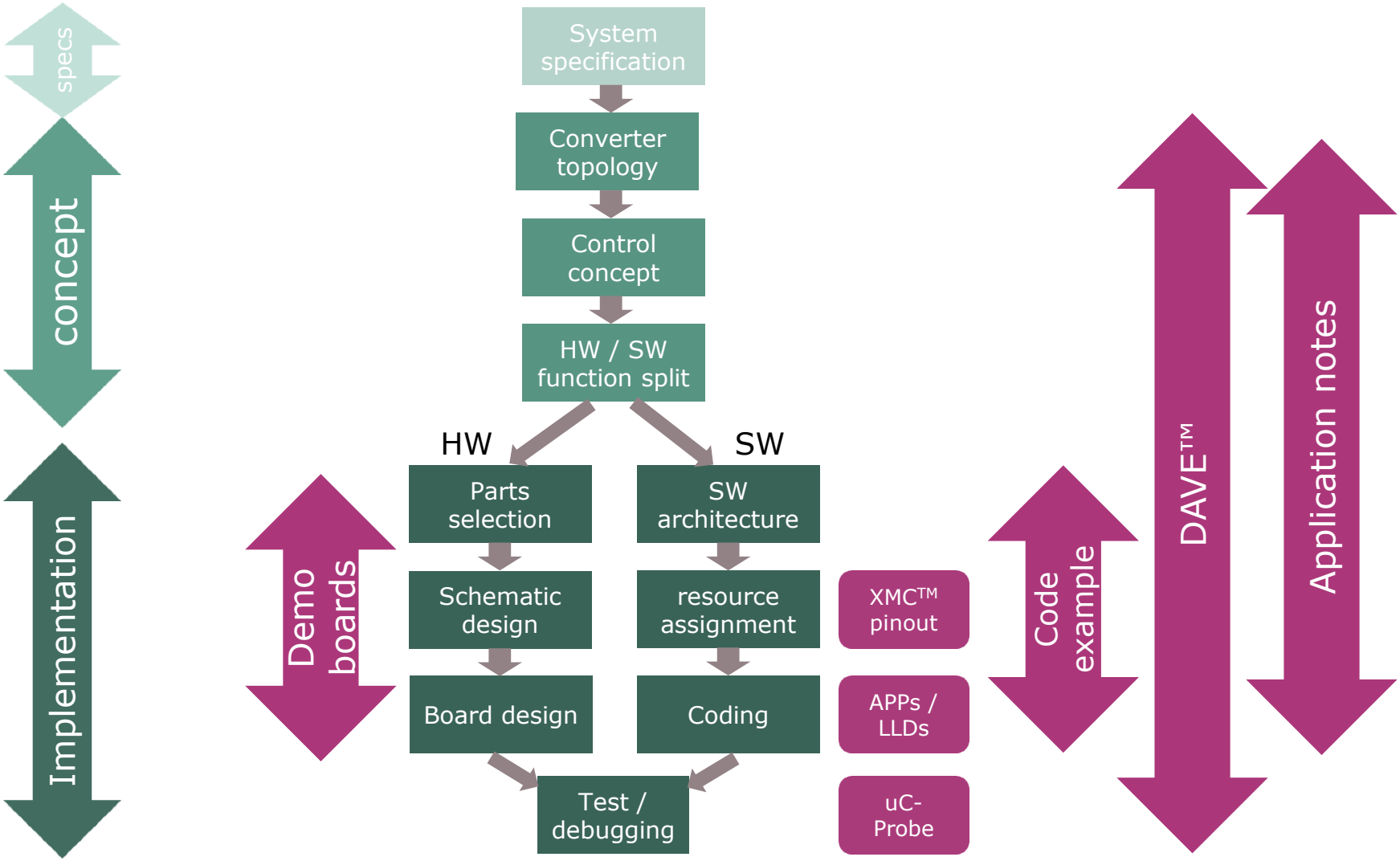
- XMC4000 comparators include **filtering, blanking and clamping** capabilities as well as a **DAC** for automatic reference or slope generation
- XMC1000 comparators can configure **hysteresis** and output **filtering**



Agenda

1. Why digital control in power conversion?
2. What to expect when moving from analog to digital control
3. Basics of digital control
4. XMC™ power conversion peripherals
5. Development steps vs. XMC™ support
6. Development tools and software
7. General information

Development flow vs. Infineon support



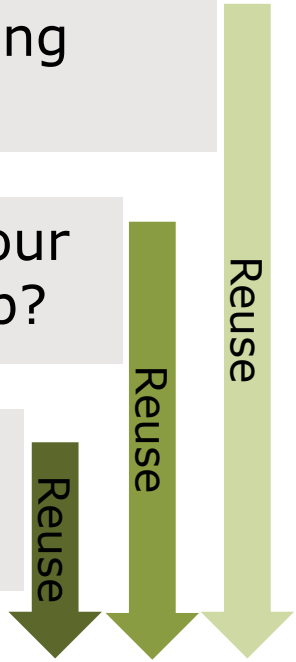
Shorten your development time

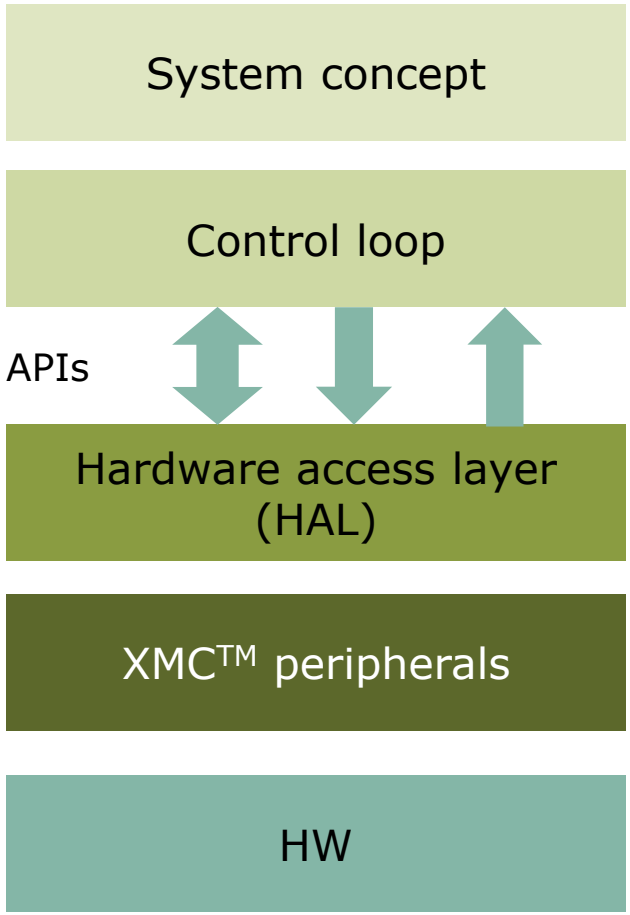
Which entry point do your target?

Want to reuse SW from a running system?

Want to code your own control loop?

Want to configure MCU peripherals?

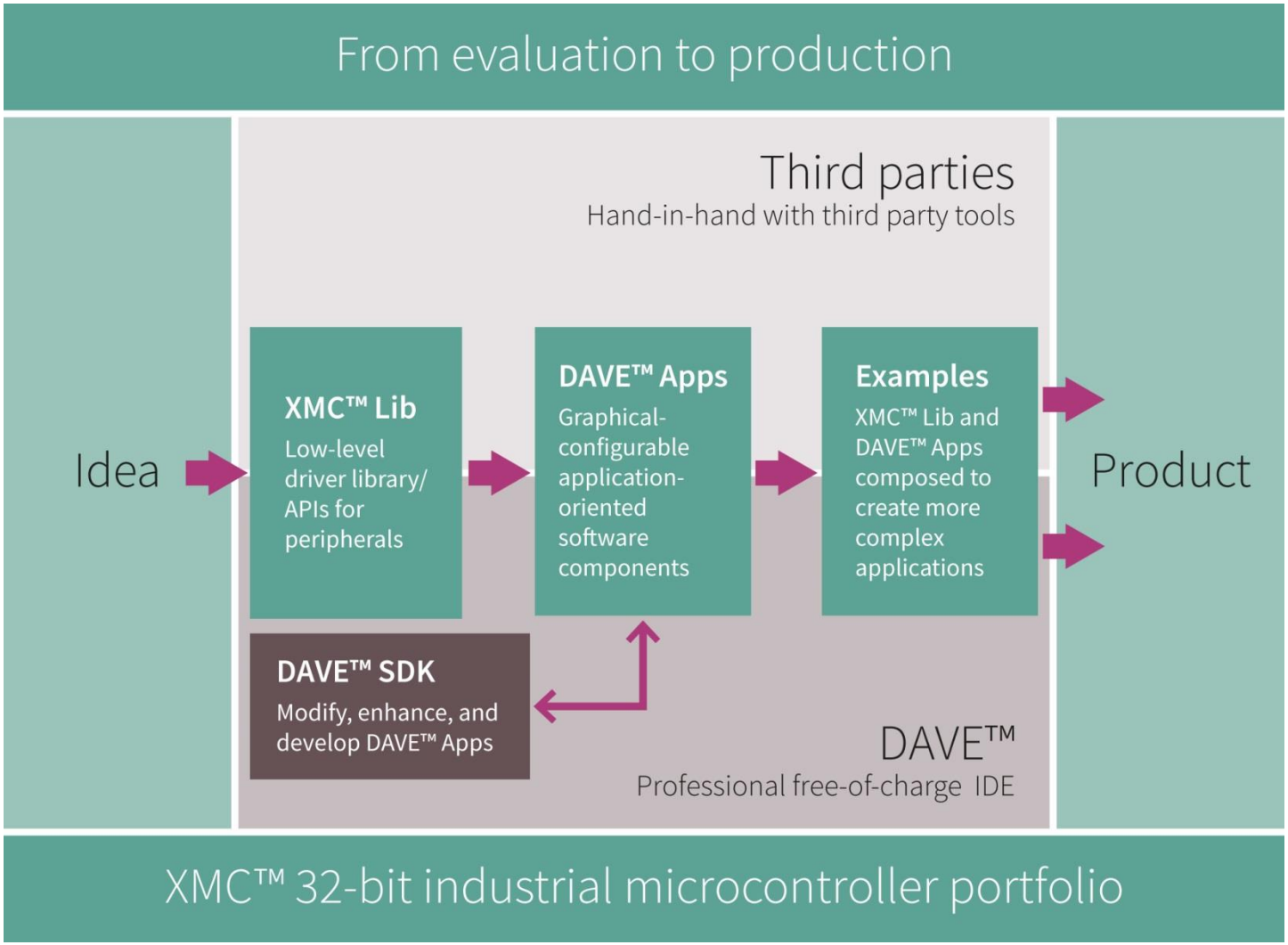




Agenda

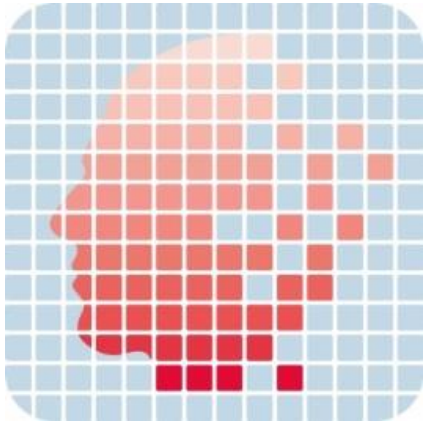
1. Why digital control in power conversion?
2. What to expect when moving from analog to digital control
3. Basics of digital control
4. XMC™ power conversion peripherals
5. Development steps vs. XMC™ support
6. Development tools and software
7. General information

Development tools and software
DAVE™– software development made easy



Development tool and software

- DAVE™ – Free development platform for code generation
  - Eclipse IDE
  - Compiler
  - Debugger
  - Application library and examples
  - Software can be used with 3rd party tools



- For download and support:

DAVE™ website

µC/Probe™: Read/write your data on the fly without code modification!

www.infineon.com/ucProbeXMC

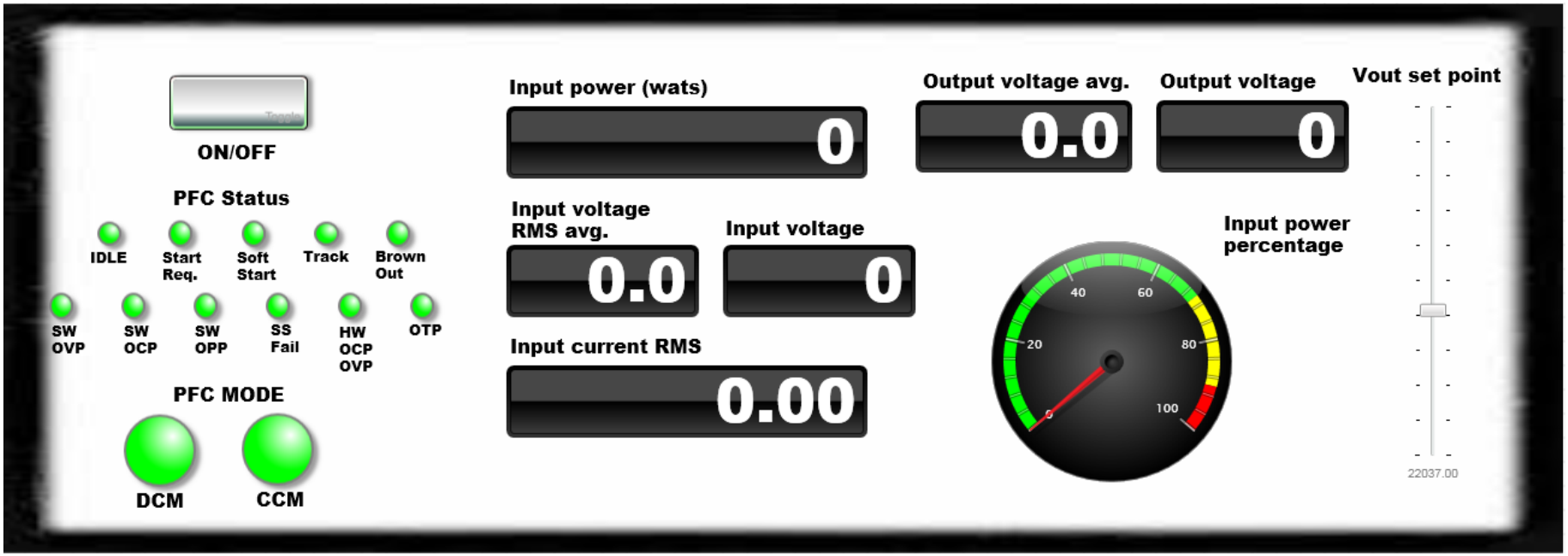
Debug

Built your own GUI

Parametrize your system

Digital scope*

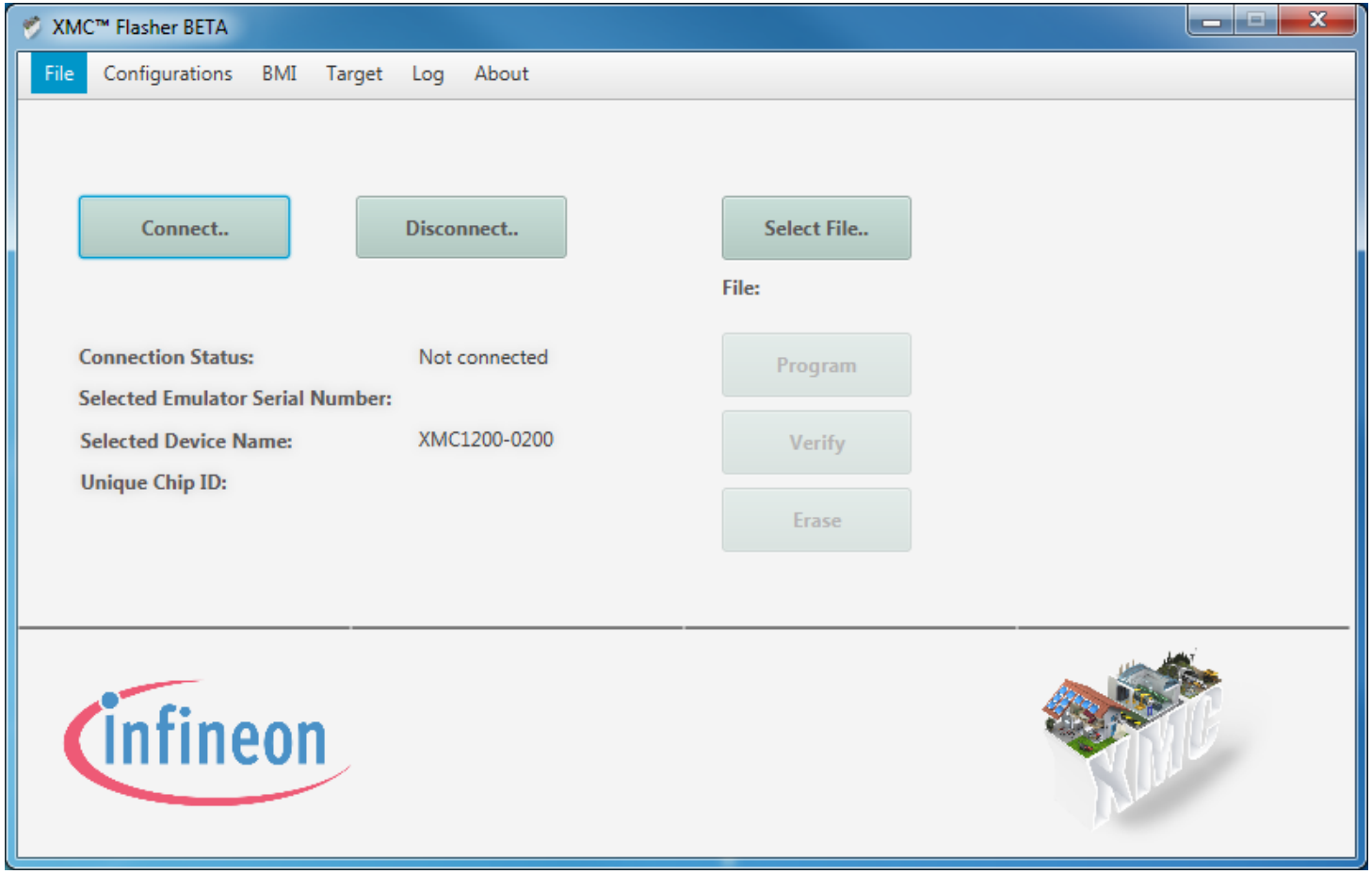
› PFC example GUI:



* Digital scope functionality requires adding of debug code

XMC™ Flasher

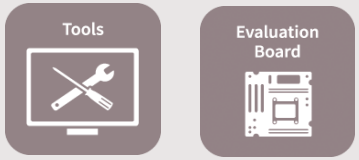
- Easy code download to your XMC™



Agenda

1. Why digital control in power conversion?
2. What to expect when moving from analog to digital control
3. Basics of digital control
4. XMC™ power conversion peripherals
5. Development steps vs. XMC™ support
6. Development tools and software
7. General information

Support material:

Collaterals and Brochures 	› Product Briefs › Selection Guides › Application Brochures › Presentations › Press Releases, Ads	› www.infineon.com/XMC
Technical Material 	› Application Notes › Technical Articles › Simulation Models › Datasheets, MCDS Files › PCB Design Data	› www.infineon.com/XMC › Kits and Boards › DAVE™ › Software and Tool Ecosystem
Videos 	› Technical Videos › Product Information Videos	› Infineon Media Center › XMC Mediathek
Contact 	› Forums › Product Support	› Infineon Forums › Technical Assistance Center (TAC)

Glossary abbreviations

VADC	Versatile Analog Digital Converter
CCU	Capture Compare Unit
ACMP	Analog Comparator
PWM	Pulse Width Modulation
HRPWM	High Resolution Pulse Width Modulation
DAVE™	Free development IDE for XMC
CSG	Comparator & Slow Generator
ERU	Event Request Unit
PFC	Power Factor Correction

Part of your life. Part of tomorrow.

Infineon

Disclaimer

The information given in this training materials is given as a hint for the implementation of the Infineon Technologies component only and shall not be regarded as any description or warranty of a certain functionality, condition or quality of the Infineon Technologies component.

Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including without limitation warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this training material.

The images were designed by Freepik and Pixabay, see footer.