XMC™ protections in digitally controlled SMPS

XMC™ Microcontrollers

June 2016

Agenda

1. Protections in SMPS
2. Hardware protection: ultra-fast protections
3. Hardware protection: fast protections
4. Software protection: slow protections
5. General information

Agenda

1. Protections in SMPS
2. Hardware protection: ultra-fast protections
3. Hardware protection: fast protections
4. Software protection: slow protections
5. General information

Protections in SMPS
Introduction

- SMPS systems requires protections to prevent system parameter to go beyond reliability limits
- Many times, this protections are calibrated during production of final product
- Typical examples are:
  - Overcurrent protection (**OCP**):
    - very fast reaction required: less than 100 nsec
  - Overvoltage protection (**OVP**):
    - Fast till relative slow reaction is allowed: in the range of usec to msec
  - Over temperature protection (**OTP**):
    - Very slow reaction: msec to seconds
    - Might require multilevel for warning
  - Overpower protection (**OPP**):
    - Fast till relative slow
    - Not easy with HW → SW approach is simpler

Protections in SMPS
Overview of protections with XMC™

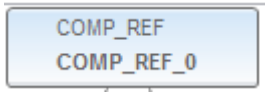
Type of protection		Characteristic						
		Typical reaction time	**HW used**	**SW**	**Typical reaction to protection**	**Typical use case**	**Available in following devices**	**Comment**
Faster reaction	**Ultra-fast protection** Analog comparator	**30-70 ns**	XMC1000→ Analog comparators XMC4000→CSG	No	PWM switch off and/or interrupt routine	OCP, OVP	XMC13/14 XMC41/42/44	10 bit DAC reference in XMC4000
	Fast protection Analog comparator	**100-300 ns**	ORC (Out of range comparators)	No	PWM switch off and/or interrupt routine	OVP, OTP	XMC12,13,14 All XMC4000	Reference is fixed to VAREF (ADC ref)
	Fast protection ADC fast compare	**150 ns + 30-60 ns**	VADC fast compare mode	No	PWM switch off and/or interrupt routine, modulation, warning	OVP, OTP	All	Requires typically to spend a full ADC group for this function
	Fast protection ADC boundaries	**600 ns – 1500 ns**	VADC limit checking (boundary feature)	No	PWM switch off and/or interrupt routine, modulation, warning	OVP, OTP	XMC12,13,14 All XMC4000	Useful for variables that are anyhow measured for control purposes
	Slow protection Software	**1 us - ms**	No HW, only SW	Yes	Any possible	OVP, OTP, OPP, any	All	

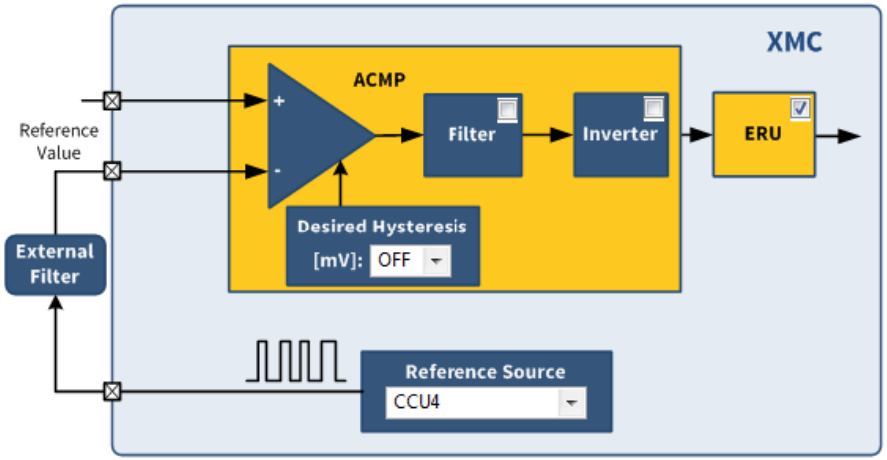
Agenda

1. Protections in SMPS
2. Hardware protection: ultra-fast protections
3. Hardware protection: fast protections
4. Software protection: slow protections
5. General information

Hardware protection - ultra-fast protection
Analog comparator in XMC1000

- Implemented in XMC1000 with "analog comparator" peripheral
- Comparator reference can be generated by XMC™ with a PWM signal adding a capacitor to the pin
- Supported in **COMP_REF** App in DAVE™ and XMC Lib



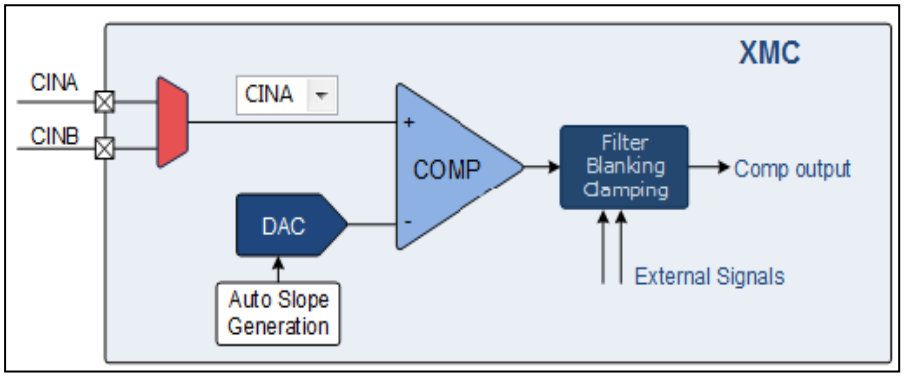


- Example connectivity of comparator 0 output in XMC1400

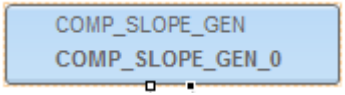
ACMP0.OUT	O	P0.10 P2.10 P3.3 P4.3 ERU0.0A0 BCCU0.IN5 BCCU0.IN6 CCU40.IN0AS CCU40.IN3AR CCU80.IN2AR CCU80.IN3AS ERU1.3A0 CCU41.IN0AS CCU41.IN3AR CCU81.IN0AS CCU81.IN2AR	output of ACMP0

Hardware protection - ultra-fast protection
Analog comparator in XMC4000

- Implemented in XMC4000 with comparator rand slope generation module (CSG)
- CSG integrates a 10 bit DAC that generates the level at which the protection is triggered



- Can blank, filter or clamp the comparator output with external signals
- Supported in **COMP_SLOPE_GEN** App in DAVE™



- Example connectivity of comparator 0 output in XMC4200

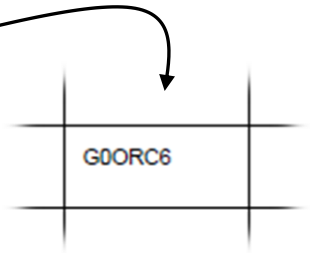
HRPWM0.C0O	O	CCU80.IN0M; CCU80.IN3P; CCU41.IN0G; HRPWM0.SC0IM; ERU1.2B3	Comparator Output

Agenda

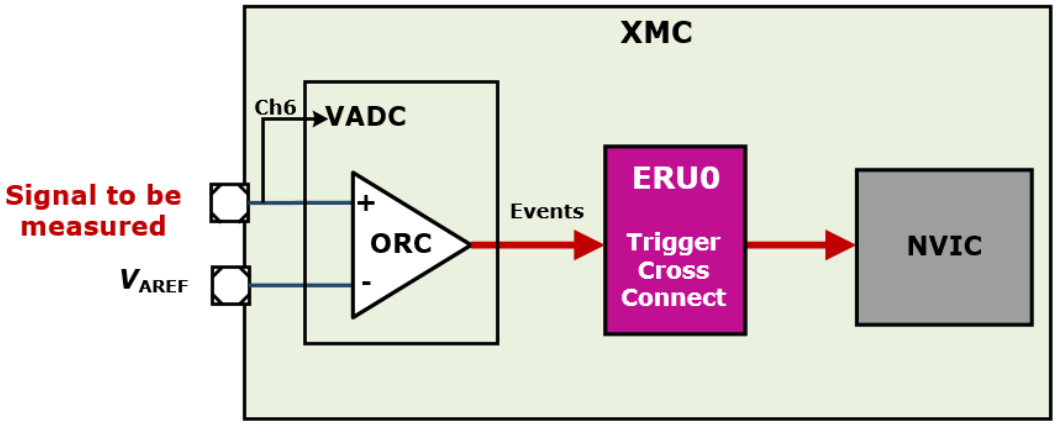
1. Protections in SMPS
2. Hardware protection: ultra-fast protections
3. Hardware protection: fast protections
4. Software protection: slow protections
5. General information

Hardware protection: fast protections
Analog comparator-Out of Range Comp. (ORC)

- Integrated in some input channels in ADC (check data sheet "Port I/O Functions table-GxORCy), XMC™ devices integrate analog comparators that **connects to interconnection matrix (ERU)**

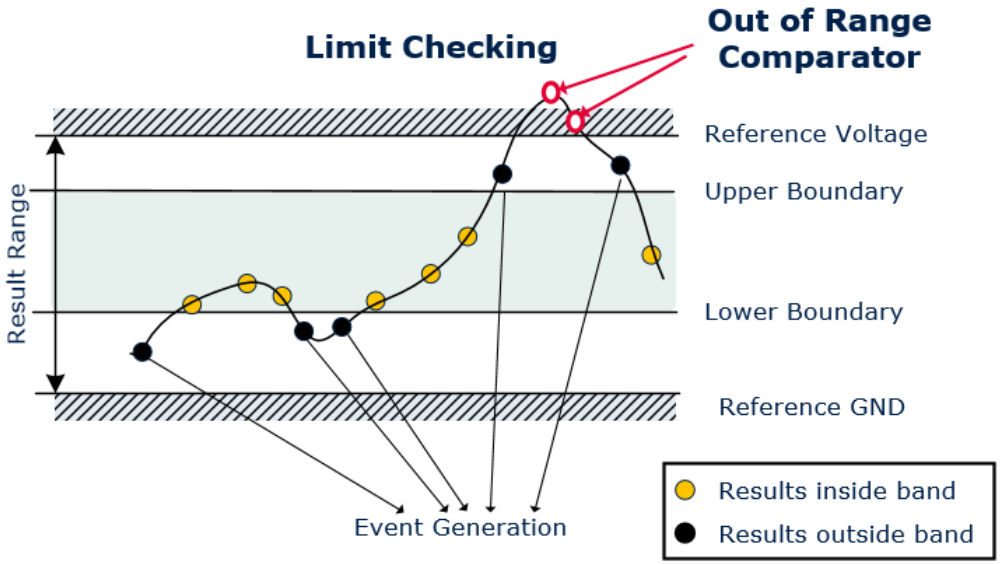


- The **reference is fixed** to VADC analog reference - VAREF
- ERU can route the signal **to other peripherals or trigger and interrupt** routine
- In ERU, the output of the comparator can be **logic AND, OR**, etc, to other signals to implement blanking as an example



Hardware protection: fast protections
Analog comparator-Out of Range Comp. (ORC)

- Typical use case of ORC together with limit checking (boundary of VADC-explained in next slides)



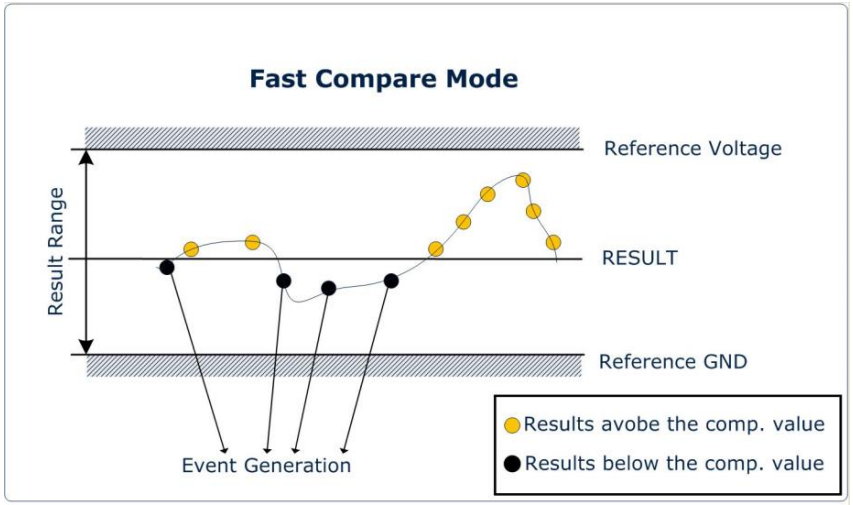
- Connectivity of ORC output of comparator 6 as input in ERU in XMC4200 (SCU section)

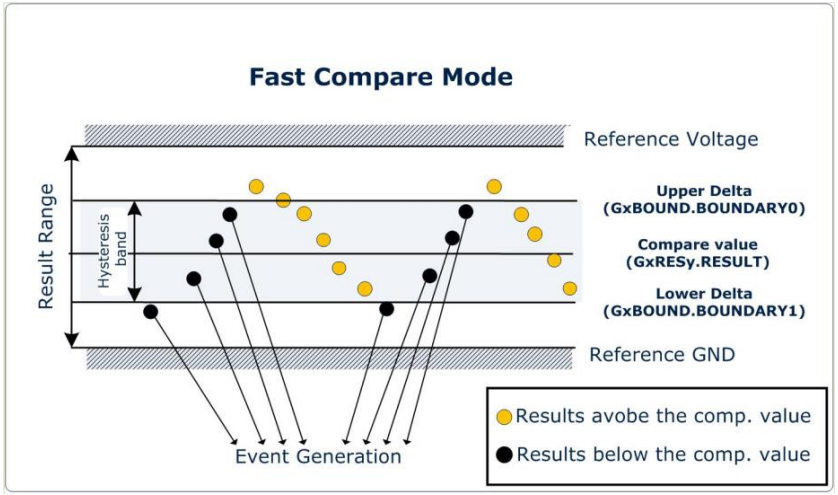
Table 4-8 ERU0 Pin Connections

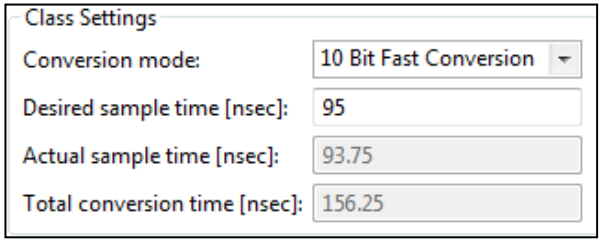
Global Inputs/Outputs	I/O	Connected To
ERU0.0A0	I	PORTS
ERU0.0A1	I	PORTS
ERU0.0A2	I	PORTS
ERU0.0A3	I	SCU.G0ORCOUT6

Hardware protection: fast protections
ADC fast compare

- 1 bit ADC conversion that happens in only 150 ns (min. conversion time)
- The result informs whether the signal is **above or below a given 10 bits value** (result register)
- A boundary flag connecting to other peripherals or NVIC can be generated in fast compare mode
- **Hysteresis** can be added in most XMC™ devices using boundaries to provide robustness to the protection detection
- Supported in **ADC_QUEUE/SCAN** Apps in DAVE™ and XMC Lib by class settings selection







Agenda

1. Protections in SMPS
2. Hardware protection: ultra-fast protections
3. Hardware protection: fast protections
4. Software protection: slow protections
5. General information

Software protection: slow protections

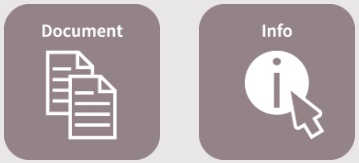
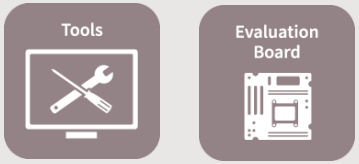
- Software running in XMC™ handles values of voltages, currents, temperatures for the right control and monitoring of the power supply.
- It can calculate power as well
- Those values can be easily and flexibly **controlled to certain target values**
- **Averaging** is very common to avoid miss-triggering of protections
- Many times multilevel protection is implemented and reaction is to mitigate the root cause until warning levels or trespassed
- Example code snippet of an overvoltage protection in a PFC stage with averaging

```
vout_avg_st = vout_avg_st - (vout_avg >> VOUT_AVG_SHIFT) + vout;

vout_avg = vout_avg_st >> VOUT_AVG_SHIFT;        //Average Vout

if (vout_avg>VOUT_OVP_VALUE))                    //Check threshold

{

    PFC_Stop(SW_OVERVOLTAGE);                    //Stop PFC stage if protection is triggered

}
```

Agenda

1. Protections in SMPS
2. Hardware protection: ultra-fast protections
3. Hardware protection: fast protections
4. Software protection: slow protections
5. 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

ADC	Analog Digital Converter
DAVE™	Free development IDE for XMC™
PWM	Pulse Width Modulation
OVP	Over Voltage Protection
OCP	Over Current Protection
OTP	Over Temperature Protection
OPP	Over Power Protection
ORC	Out of Range Comparator
PFC	Power Factor Corrector stage
ERU	External Request Unit (connection matrix)
HW-SW	Hardware-Software

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.

Part of your life. Part of tomorrow.

Infineon