FS84/FS85C

Fail-safe system basis chip with multiple SMPS and LDO

Rev. 10 — 17 November 2023 **Product data sheet**

1 General description

The FS85/FS84 device family is developed in compliance with ASIL D process, FS84 is ASIL B capable and FS85 is ASIL D capable. All device options are pin to pin and software compatible.

The FS85/FS84 is an automotive functionally safe multi-output power supply integrated circuit, with focus on Radar, Vision, ADAS domain controller, Radio, and Infotainment applications. It includes multiple switch mode and linear voltage regulators. It offers external frequency synchronization input and output, for optimized system EMC performance.

The FS85/FS84 includes enhanced safety features, with fail-safe output, becoming a full part of a safety-oriented system partitioning, covering both ASIL B and ASIL D safety integrity level. It is developed in compliance with ISO 26262 standard and is qualified in compliance with AEC-Q100 rev H (Grade1, MSL3).

Several device versions are available, offering choice in number of output rails, output voltage setting, operating frequency and power up sequencing, to address multiple applications.

2 Features and benefits

- 60 V DC maximum input voltage for 12 V and 24 V applications
- VPRE synchronous buck controller with external MOSFETs. Configurable output voltage, switching frequency, and current capability up to 10 A peak.
- Low voltage integrated synchronous BUCK1 converter, dedicated to MCU core supply with SVS capability. Configurable output voltage and current capability up to 3.6 A peak.
- **Based on device options (see Table 1)**: low voltage integrated synchronous BUCK2 converter. Configurable output voltage and current capability up to 3.6 A peak. Multi-phase capability with BUCK1 to extend the current capability up to 7.2 A peak on a single rail. Static voltage scaling capability.
- **Based on device options (see Table 1)**: low voltage integrated synchronous BUCK3 converter. Configurable output voltage and current capability up to 3.6 A peak.
- BOOST converter with integrated low-side switch. Configurable output voltage and max input current up to 1.5 A peak.
- EMC optimization techniques including SMPS frequency synchronization, spread spectrum, slew rate control, manual frequency tuning
- 2x linear voltage regulators for MCU IOs and ADC supply, external physical layer. Configurable output voltage and current capability up to 400 mA DC.
- OFF mode (power down) with very low quiescent current (10 µA typ)
- 2x input pins for wake-up detection and battery voltage sensing
- Device control via 32 bits SPI or I2C interface with CRC
- Power synchronization pin to operate 2x FS85 devices or FS85 plus an external PMIC
- Scalable portfolio from ASIL B to ASIL D with independent monitoring circuitry, dedicated interface for MCU monitoring, simple and challenger watchdog function, power good, reset and interrupt, built-in self-test, fail-safe output
- Configuration by OTP programming. Prototype enablement to support custom setting during project development in engineering mode.

3 Simplified application diagram

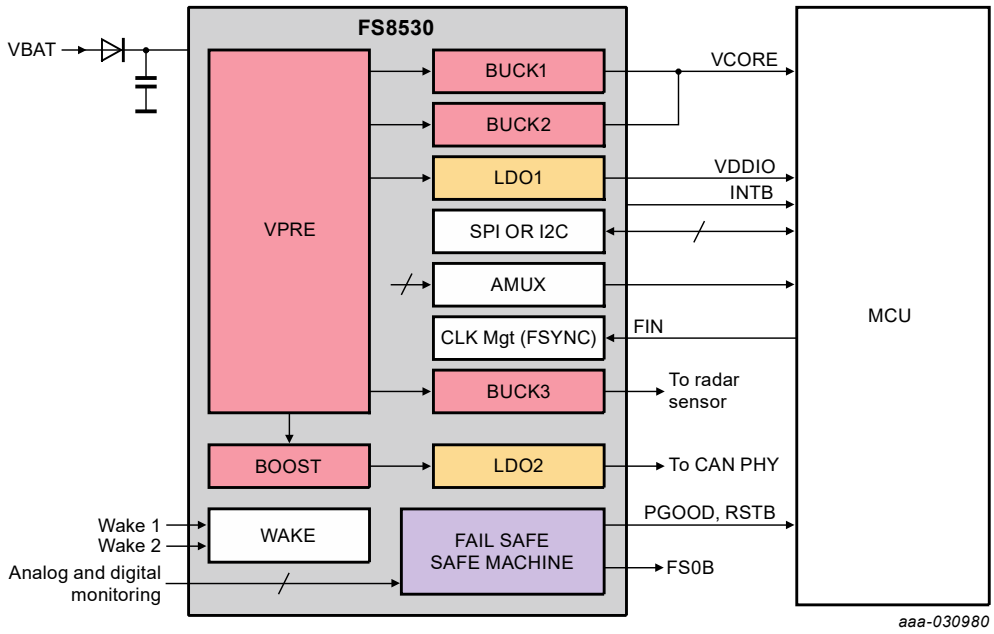


Figure 1. FS8530 superset device of the family

4 Ordering information

Table 1. Device options

Device options	BUCK1	BUCK2	BUCK3	FCCU	VMONx	ASIL [1]
FS8400	Yes	No	No	No	up to 2	B
FS8405	Yes	No	No	Yes	up to 4	B
FS8410	Yes	No	Yes	No	up to 2	B
FS8415	Yes	No	Yes	Yes	up to 4	B
FS8420	Yes	Yes	No	No	up to 2	B
FS8425	Yes	Yes	No	Yes	up to 4	B
FS8430	Yes	Yes	Yes	No	up to 2	B
FS8435	Yes	Yes	Yes	Yes	up to 4	B
FS8500	Yes	No	No	Yes	up to 4	D
FS8510	Yes	No	Yes	Yes	up to 4	D
FS8520	Yes	Yes	No	Yes	up to 4	D
FS8530	Yes	Yes	Yes	Yes	up to 4	D

[1] See Table 104 for recommended ASIL B versus ASIL D safety features.

Table 2. Ordering information

Part number [1] [2][3]	Application target	Package		
		Name	Description	Version
MC33FS8400G0ES MC33FS8400G0KS	Superset covering FS8400 configurations	HVQFN56	plastic thermal enhanced very thin quad flat package; no leads; wettable flank, 56 terminals; 0.5 mm pitch, 8 mm x 8 mm x 0.85 mm body See Section 34 "Package outline" for differences.	SOT684-23
MC33FS8400G5ES MC33FS8400G5KS	Camera			
MC33FS8405G0ES MC33FS8405G0KS	Superset covering FS8405 configurations			
MC33FS8410G0ES MC33FS8410G0KS	Superset covering FS8410 configurations			
MC33FS8410G3ES MC33FS8410G3KS	Radar with NXP S32R274 MCU			
MC33FS8410G6ES MC33FS8410G6KS	Gateway with NXP MPC5748G MCU			
MC33FS8415G0ES MC33FS8415G0KS	Superset covering FS8415 configurations			
MC33FS8415GJES MC33FS8415GJKS	For Radar with NXP S32R294 + TEF810x for 12 V/24 V application [4]			
MC33FS8415GYES MC33FS8415GYKS	For Radar with NXP S32R294 + TEF810x/TEF82xx for 12 V/24 V application			
MC33FS8420G0ES MC33FS8420G0KS	Superset covering FS8420 configurations			
MC33FS8425G0ES MC33FS8425G0KS	Superset covering FS8425 configurations			
MC33FS8430G0ES MC33FS8430G0KS	Superset covering FS8430 configurations			
MC33FS8430G1ES MC33FS8430G1KS	Camera with NXP S32V MCU and PF8x PMIC			
MC33FS8430G2ES MC33FS8430G2KS	Camera with NXP S32V MCU			
MC33FS8430G4ES MC33FS8430G4KS	Camera			
MC33FS8435G0ES MC33FS8435G0KS	Superset covering FS8435 configurations			
MC33FS8500A0ES	Superset covering FS8500 configurations			

Table 2. Ordering information*...continued*

Part number [1] [2][3]	Application target	Package		
		Name	Description	Version
MC33FS8500A0KS				
MC33FS8510A0ES MC33FS8510A0KS	Superset covering FS8510 configurations			
MC33FS8510A2ES MC33FS8510A2KS	Domain controller			
MC33FS8510D3ES MC33FS8510D3KS	Battery monitoring system			
MC33FS8520A0ES MC33FS8520A0KS	Superset covering FS8520 configurations			
MC33FS8530A0ES MC33FS8530A0KS	Superset covering FS8530 configurations			
MC33FS8530A1ES MC33FS8530A1KS	Camera			
MC33FS8530A4ES MC33FS8530A4KS	Imaging radar with NXP S32R MCU			

[1] To order parts in tape and reel, add the R2 suffix to the part number.
[2] Step-cut wettable flank for part numbers ending in ES
Dimple wettable flank for part numbers ending in KS
[3] The part numbers with KS suffix are recommended for new designs.
[4] FS8415GY part is recommended for new designs

A0 and G0 parts are non-programmed OTP configurations. Pre-programmed OTP configurations (other than BUCK regulators and ASIL level) are managed through part number extension: A1 to FZ for FS85 and G1 to LZ for FS84.

For a custom OTP configuration, contact a local NXP sales representative.

4.1 Main OTP flavors

	MC33FS8530A1	MC33FS8510A2	MC33FS8510D3	MC33FS8530A4	MC33FS8430G1	MC33FS8430G2	MC33FS8410G3	MC33FS8430G4	MC33FS8400G5	MC33FS8410G6	MC33FS8415GJ	MC33FS8415GY
VPRE												
Output voltage	3.3 V	3.3 V	5.0 V	4.1 V	4.1 V	5.0 V	3.3 V	4.1 V	3.3 V	3.3 V	3.3 V	3.3 V
Slope compensation	60 mV/µs	140 mV/µs	60 mV/µs	70 mV/µs	70 mV/µs	70 mV/µs	140 mV/µs	100mV/µs	60mV/µs	60 mV/µs	50 mV/µs	50 mV/µs
Current limitation	120 mV	120 mV	50 mV	150 mV	150 mV	150 mV	120 mV	80 mV	150 mV	120 mV	80 mV	80 mV
High-side slew rate	PU/PD/900 mA	PU/PD/900 mA	PU/PD/900 mA	PU/PD/130 mA	PU/PD/130 mA	PU/PD/130 mA	PU/PD/130 mA	PU/PD/900 mA	PU/PD/130 mA	PU/PD/130 mA	PU/PD/900 mA	PU/PD/900 mA
Switching frequency	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)	455 kHz (Force PWM)
Phase shifting	delay 0	delay 0	delay 0	delay 0	delay 0	delay 0	delay 3	delay 0	delay 0	delay 0	delay 0	delay 0
Turn OFF delay	250 µs	250 µs	250µs	250 µs	32 ms	250 µs	250 µs	250 µs	250 µs	250 µs	32 ms	32 ms
VBOOST												
Enabled	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Output voltage	5.0 V	5.0 V	5.74 V	5.0 V	5.0 V	5.74 V	5.74 V	5.74 V	5.74 V	5.0 V	5.0 V	5.0 V
Slope compensation	160 mV/µs	79 mV/µs	125 mV/µs	125 mV/µs	160 mV/µs	160 mV/µs	160 mV/µs	125 mV/µs	160 mV/µs	160 mV/µs	125 mV/µs	125 mV/µs
Slew rate	500 V/µs	500 V/µs	300 V/µs	500 V/µs	500 V/µs	500 V/µs	500 V/µs	500 V/µs	500 V/µs	500 V/µs	500 V/µs	500 V/µs
Compensation resistor	750 kΩ	750 kΩ	750 kΩ	750 kΩ	750 kΩ	750 kΩ	750 kΩ	750 kΩ	750 kΩ	750 kΩ	750 kΩ	750 kΩ
Compensation capacitor	125 pF	125 pF	125 pF	125 pF	125 pF	125 pF	125 pF	125 pF	125 pF	125 pF	125 pF	125 pF
Switching frequency	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz
Phase shifting	delay 1	delay 0	delay 1	delay 0	delay 0	delay 0	delay 0	delay 7	delay 0	delay 3	delay 0	delay 0
Behavior in case of TSD	BOOST shutdown + DFS	BOOST shutdown + DFS	BOOST shutdown + DFS	BOOST shutdown	BOOST shutdown	BOOST shutdown	BOOST shutdown	BOOST shutdown	BOOST shutdown	BOOST shutdown	BOOST shutdown	BOOST shutdown
BUCK1												
Output voltage	1.35 V	1.025 V	1.3 V	1.1 V	1.8 V	1.1 V	1.25 V	1.03125 V	1.25 V	1.2 V	0.825 V	0.825 V
Current limitation	2.6 A	2.6 A	2.6 A	4.5 A	4.5 A	4.5 A	4.5 A	4.5 A	2.6 A	2.6 A	4.5 A	4.5 A
Inductor	1.5 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH
Compensation network	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM
Switching frequency	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz
Phase shifting	delay 3	delay 0	delay 2	delay 0	delay 0	delay 0	delay 0	delay 0	delay 0	delay 2	delay 6	delay 6
Behavior in case of TSD	BUCK1 shutdown + DFS	BUCK1 shutdown + DFS	BUCK1 shutdown + DFS	BUCK1 shutdown	BUCK1 shutdown	BUCK1 shutdown	BUCK1 shutdown	BUCK1 shutdown + DFS	BUCK1 shutdown + DFS	BUCK1 shutdown	BUCK1 shutdown	BUCK1 shutdown
Power sequencing slot	Regulator Start and Stop in Slot 1	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 6	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 6	Regulator Start and Stop in Slot 1	Regulator Start and Stop in Slot 4	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 3	Regulator Start and Stop in Slot 3
DVS (Soft start)	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs
BUCK2												
Enabled	Yes	No	No	Yes	No	Yes	No	Yes	No	No	No	No
Output voltage	1.8 V	1.25 V	1.35 V	1.8 V	1.25 V	1.8 V	1.25 V	1.03125 V	1.25 V	1.2 V	1.8 V	1.8 V
Current limitation	4.5 A	4.5 A	4.5 A	4.5 A	4.5 A	4.5 A	4.5 A	4.5 A	4.5 A	4.5 A	4.5 A	2.6 A
Inductor	1.5 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH
Compensation network	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM	65 GM
Switching frequency	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz
Multiphase with Buck1	No	No	No	No	No	No	No	Yes	No	No	No	No
Phase shifting	delay 2	delay 0	delay 4	delay 0	delay 0	delay 0	delay 3	delay 4	delay 4	delay 7	delay 0	delay 0

	MC33FS8530A1	MC33FS8510A2	MC33FS8510D3	MC33FS8530A4	MC33FS8430G1	MC33FS8430G2	MC33FS8410G3	MC33FS8430G4	MC33FS8400G5	MC33FS8410G6	MC33FS8415GJ	MC33FS8415GY
Behavior in case of TSD	BUCK2 shutdown + DFS	BUCK2 shutdown	BUCK2 shutdown + DFS	BUCK2 shutdown	BUCK2 shutdown	BUCK2 shutdown	BUCK2 shutdown	BUCK2 shutdown + DFS	BUCK2 shutdown	BUCK2 shutdown	BUCK2 shutdown	BUCK2 shutdown
Power sequencing slot	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 0	Regulator does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 4	Regulator does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 2	Regulator Does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 4	Regulator does not Start (Enabled by SPI)	Regulator does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 1	Regulator Start and Stop in Slot 0
DVS (Soft start)	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs	7.81 mV/µs
BUCK3												
Enabled	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Output voltage	1.2 V	1.8 V	3.3 V	3.3 V	3.3 V	3.3 V	2.3 V	1.35 V	1.8 V	1.8 V	2.3 V	2.5 V
Inductor	1.5 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH	1 µH
Current limitation	2.6 A	2.6 A	2.6 A	4.5 A	4.5 A	4.5 A	4.5 A	2.6 A	4.5 A	2.6 A	4.5 A	4.5 A
Compensation resistor	Default	Default	Default	Default	Default	Default	Default	Default	Default	Default	Default	Default
Gain control	Default	Default	Default	Default	Default	Default	Default	Default	Default	Default	Default	Default
Switching frequency	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz	2.22 MHz
Phase shifting	delay 7	delay 0	delay 3	delay 0	delay 0	delay 0	delay 0	delay 2	delay 0	delay 4	delay 3	delay 3
Behavior in case of TSD	BUCK3 shutdown + DFS	BUCK3 shutdown + DFS	BUCK3 shutdown + DFS	BUCK3 shutdown	BUCK3 shutdown	BUCK3 shutdown	BUCK3 shutdown	BUCK3 shutdown + DFS	BUCK3 shutdown	BUCK3 shutdown	BUCK3 shutdown	BUCK3 shutdown
Power sequencing slot	Regulator Start and Stop in Slot 6	Regulator Start and Stop in Slot 6	Regulator Start and Stop in Slot 1	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 5	Regulator Does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 0
DVS (Soft start)	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs	10.41 mV/µs
LDO1												
Output voltage	2.5 V	5.0 V	5. 0 V	1.8 V	1.8 V	1.2 V	3.3 V	3.3 V	5.0 V	1.8 V	1.8 V	1.8 V
Current limitation	400 mA	400 mA	150 mA	400 mA	400 mA	400 mA	150 mA	400 mA	400 mA	400 mA	400 mA	400 mA
Behavior in case of TSD	LDO1 shutdown + DFS	LDO1 shutdown	LDO1 shutdown + DFS	LDO1 shutdown	LDO1 shutdown	LDO1 shutdown	LDO1 shutdown	LDO1 shutdown + DFS	LDO1 shutdown	LDO1 shutdown	LDO1 shutdown	LDO1 shutdown
Power sequencing slot	Regulator Start and Stop in Slot 5	Regulator Does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 2	Regulator Start and Stop in Slot 2	Regulator Does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 4	Regulator Start and Stop in Slot 2	Regulator Start and Stop in Slot 6	Regulator Start and Stop in Slot 1	Regulator does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 2	Regulator Start and Stop in Slot 2
LDO2												
Output voltage	3.3 V	5.0 V	5.0 V	1.2 V	3.3 V	1.8 V	5.0 V	5.0 V	5.0 V	3.3 V	3.3 V	3.3 V
Current limitation	400 mA	400 mA	150 mA	400 mA	400 mA	400 mA	150 mA	150 mA	150 mA	400 mA	400 mA	400 mA
Behavior in case of TSD	LDO2 shutdown + DFS	LDO2 shutdown	LDO2 shutdown + DFS	LDO2 shutdown	LDO2 shutdown	LDO2 shutdown	LDO2 shutdown	LDO2 shutdown	LDO2 shutdown	LDO2 shutdown	LDO2 shutdown	LDO2 shutdown
Power sequencing slot	Regulator Start and Stop in Slot 2	Regulator Start and Stop in Slot 0	Regulator Start and Stop in Slot 3	Regulator Start and Stop in slot 1	Regulator does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 2	Regulator Start and Stop in Slot 1	Regulator Start and Stop in Slot 3	Regulator does not Start (Enabled by SPI)	Regulator does not Start (Enabled by SPI)	Regulator Start and Stop in Slot 1	Regulator Start and Stop in Slot 1
Other												
PSYNC	Disabled	Disabled	Disabled	Disabled	1x FS85 and 1x PF82	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
PLL enabled	Yes	No	No	Yes	No	No	Yes	No	No	Yes	Yes	Yes
TSlot	250 µs	250 µs	250 µs	250 µs	250 µs	250 µs	250 µs	250 µs	250 µs	250 µs	1000 µs	1000 µs
Deep Fail-safe (autoretry)	Infinite	Infinite	Infinite	Infinite	Infinite	Infinite	x15	x15	x15	x15	Infinite	Infinite
VSUP power-up threshold	4.9 V	4.9 V	6.2 V	4.9 V	4.9 V	4.9 V	4.9 V	4.9V	4.9 V	4.9 V	4.9 V for V_{PRE} < 4.5 V	4.9 V for V_{PRE} < 4.5 V
Regulator assigned to VDDIO	LDO2	VPRE	LDO1	BUCK3	BUCK3	External regulator	VPRE	LDO1	VPRE	VPRE	VPRE	VPRE
I2C address	0x24	0x20	0x20	0x20	0x20	0x20	0x20	0x20	0x20	0x20	0x20	0x20
Device ID	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	00000001	00000001

4.2 Fail-safe OTP flavors

	MC33FS8530A1	MC33FS8510A2	MC33FS8510D3	MC33FS8530A4	MC33FS8430G1	MC33FS8430G2	MC33FS8410G3	MC33FS8430G4	MC33FS8400G5	MC33FS8410G6	MC33FS8415GJ	MC33FS8415GY
VCOREMON												
Monitoring voltage	1.35 V	1.025 V	1.3 V	1.1 V	1.8 V	1.1 V	1.25 V	1.03125 V	1.25 V	1.2 V	0.825 V	0.825 V
OVTH	112 %	109 %	110 %	112 %	112 %	112 %	112%	106%	110 %	110 %	104.5 %	104.5 %
UVTH	88 %	88.5 %	90 %	88 %	88 %	88%	88%	94%	90 %	95 %	95.5 %	95.5 %
OV_DGLT	45 µs	25 µs	45 µs	25 µs	25 µs	45 µs	25 µs	45 µs	25 µs	25 µs	25 µs	25 µs
UV_DGLT	40 us	5 µs	40 µs	5 µs	15 µs	40 µs	15 µs	40 µs	15 µs	15 µs	25 µs	25 µs
SVS_CLAMP	No SVS	No SVS	No SVS	No SVS	No SVS	No SVS	No SVS	No SVS	No SVS	No SVS	No SVS	No SVS
VDDIOMON												
Monitoring voltage	3.3 V	3.3 V	5.0 V	3.3 V	3.3 V	3.3 V	3.3 V	3.3 V	3.3 V	3.3 V	3.3 V	3.3 V
OVTH	112 %	106.5 %	110%	112 %	112 %	112 %	112 %	107 %	110 %	106.5 %	105 %	105 %
UVTH	88 %	93 %	90 %	88 %	88 %	88 %	88 %	93.5 %	90 %	95 %	95 %	95 %
OV_DGLT	45 µs	25 µs	45 µs	25 µs	25 µs	45 µs	25 µs	45 µs	25 µs	25 µs	25 µs	25 µs
UV_DGLT	40 µs	5 µs	40 µs	5 µs	15 µs	40 µs	15 µs	40 µs	15 µs	15 µs	25 µs	25 µs
VMON1												
OVTH	112 %	108.5 %	110 %	112 %	112 %	112 %	112 %	107 %	112 %	109 %	106 %	106 %
UVTH	88 %	91.5 %	90 %	88 %	88 %	88 %	88 %	92.5 %	88 %	95.5 %	94 %	94 %
OV_DGLT	45 µs	25 µs	45 µs	25 µs	25 µs	45 µs	25 µs	45 µs	25 µs	25 µs	25 µs	25 µs
UV_DGLT	40 µs	5 µs	40 µs	5 µs	15 µs	40 µs	15 µs	40 µs	15 µs	15 µs	25 µs	25 µs
VMON2												
OVTH	112 %	108.5 %	110 %	112 %	112 %	112 %	112 %	107 %	108 %	110 %	106 %	106 %
UVTH	88 %	91.5 %	90 %	88 %	88 %	88 %	88 %	92.5 %	92 %	90 %	94 %	94 %
OV_DGLT	45 µs	25 µs	45 µs	25 µs	25 µs	45 µs	25 µs	45 µs	25 µs	25 µs	25 µs	25 µs
UV_DGLT	40 µs	5 µs	40 µs	5 µs	15 µs	40 µs	15 µs	40 µs	15 µs	15 µs	25 µs	25 µs
VMON3												
OVTH	112 %	107 %	110 %	112 %	112 %	112 %	112 %	104.5 %	112 %	112 %	106 %	106 %
UVTH	88 %	91.5 %	90 %	88 %	88 %	88 %	88 %	95.5 %	88 %	88 %	94 %	94 %
OV_DGLT	45 µs	25 µs	45 µs	25 µs	25 µs	45 µs	25 µs	45 µs	25 µs	25 µs	25 µs	25 µs
UV_DGLT	40 µs	5 µs	40 µs	5 µs	15 µs	40 µs	15 µs	40 µs	15 µs	15 µs	25 µs	25 µs
VMON4												
OVTH	112 %	107.5 %	110 %	112 %	112 %	112 %	11 2%	104.5 %	112 %	112 %	106 %	106 %
UVTH	88 %	91 %	90 %	88 %	88 %	88 %	88 %	95.5 %	88 %	88 %	94 %	94 %
OV_DGLT	45 µs	25 µs	45 µs	25 µs	25 µs	45 µs	25 µs	45 µs	25 µs	25 µs	25 µs	25 µs
UV_DGLT	40 µs	5 µs	40 µs	5 µs	15 µs	40 µs	15 µs	40 µs	15 µs	15 µs	25 µs	25 µs
PGOOD												
VCOREMON	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
VDDIOMON	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
VMON1	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
VMON2	No	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
VMON3	Yes	No	No	Yes	No	No	No	No	No	No	Yes	Yes
VMON4	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes
RSTB	No	No	No	No	No	Yes	No	No	No	No	No	No

	MC33FS8530A1	MC33FS8510A2	MC33FS8510D3	MC33FS8530A4	MC33FS8430G1	MC33FS8430G2	MC33FS8410G3	MC33FS8430G4	MC33FS8400G5	MC33FS8410G6	MC33FS8415GJ	MC33FS8415GY
ABIST1												
VCOREMON	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VDDIOMON	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VMON1	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
VMON2	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VMON3	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
VMON4	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
Safety enable												
VMON1	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
VMON2	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VMON3	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
VMON4	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
FCCU	Yes	No	No	Yes	No	No	No	No	No	No	Yes	Yes
ERRMON	No	No	Yes	Yes	No	No	No	No	No	No	No	No
WATCHDOG	Challenger WD	Challenger WD	Challenger WD	Simple WD	Simple WD	Simple WD	Simple WD	Simple WD	Simple WD	Simple WD	Simple WD	Simple WD
FLT_RECOVERY	Yes	No	No	No	No	No	No	No	No	No	Yes	Yes
Other												
I2C address	0x21	0x21	0x21	0x21	0x21	0x21	0x21	0x21	0x21	0x21	0x21	0x21

5 Applications

- Radar (corner radar, imaging radar, ...)
- Vision (mono camera, stereo camera, night vision, ...)
- ADAS domain controller
- Infotainment
- V2x

6 Block diagram

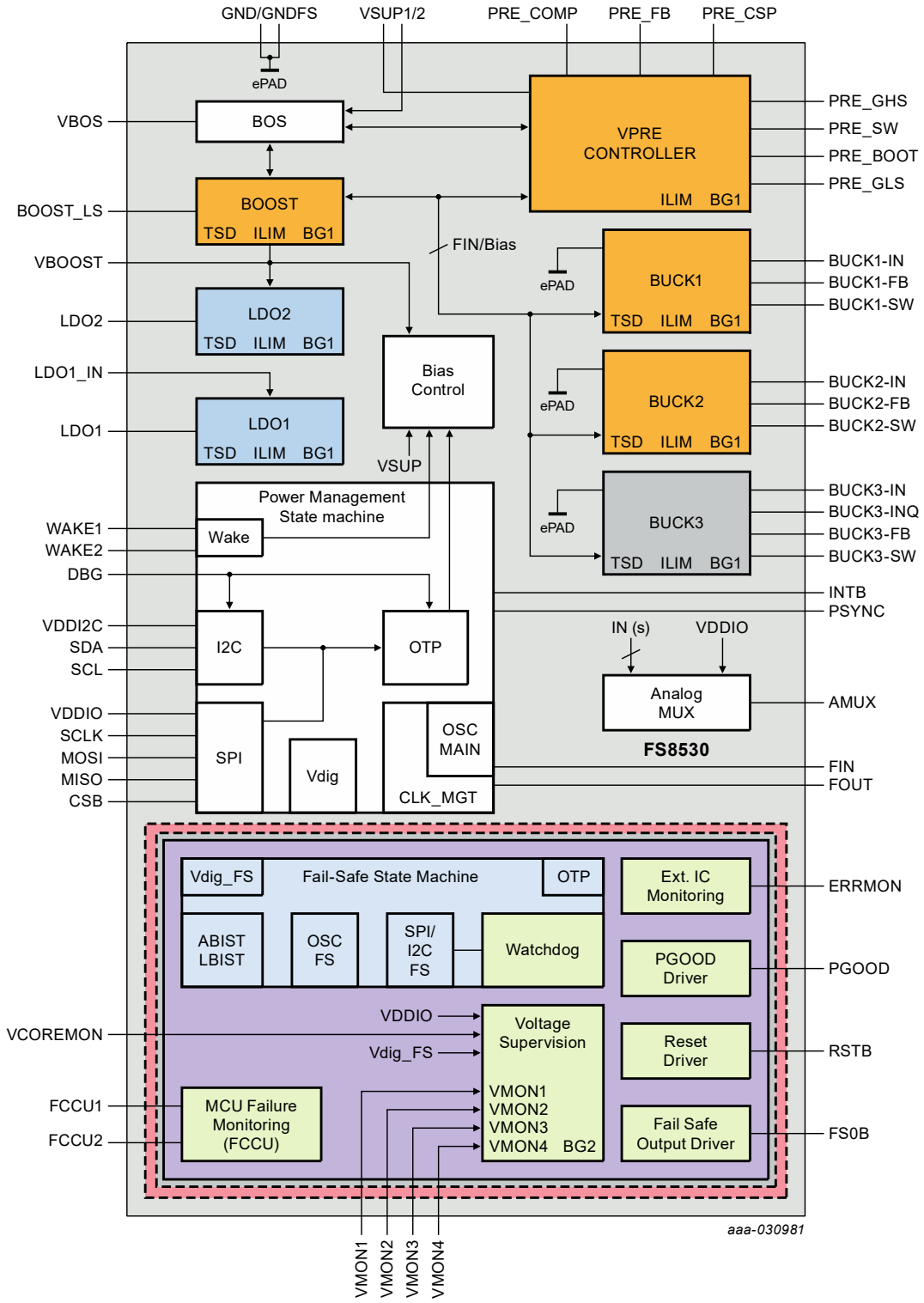


Figure 2. Block diagram

7 Pinning information

7.1 Pinning

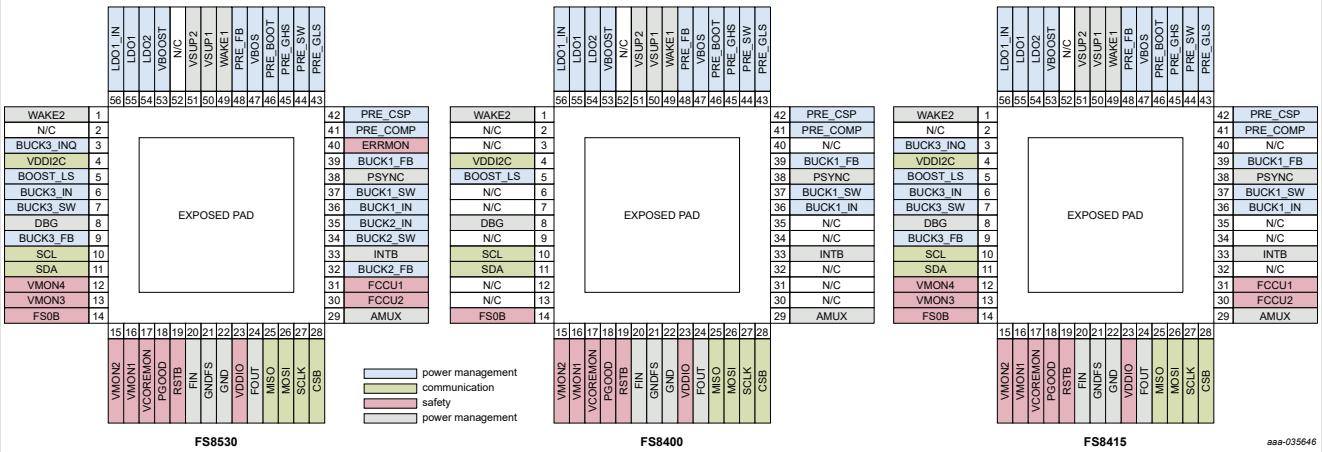


Figure 3. Pin configuration

7.2 Pin description

Table 3. Pin description

Symbol	Pin	Type	Description [1]
WAKE2	1	A_IN / D_IN	Wake-up input 2 An external serial resistor is required if WAKE2 is a global pin
N/C	2	N/C	Not connected pin
BUCK3_INQ	3	A_IN	Low voltage Buck3 quiet input voltage
VDDI2C	4	A_IN	Input voltage for I2C buffers
BOOST_LS	5	A_IN	Boost low-side drain of internal MOSFET
BUCK3_IN	6	A_IN	Low voltage Buck3 input voltage
BUCK3_SW	7	A_OUT	Low voltage Buck3 switching node
DBG	8	A_IN	Debug mode entry
BUCK3_FB	9	A_IN	Low voltage Buck3 voltage feedback
SCL	10	D_IN	I2C bus Clock input
SDA	11	D_IN/OUT	I2C bus Bidirectional data line
VMON4	12	A_IN	Voltage monitoring input 4
VMON3	13	A_IN	Voltage monitoring input 3
FS0B	14	D_OUT	Fail-safe output 0 Active low Open drain structure
VMON2	15	A_IN	Voltage monitoring input 2
VMON1	16	A_IN	Voltage monitoring input 1
VCOREMON	17	A_IN	VCORE monitoring input: Must be connected to Buck1 output voltage

Table 3. Pin description*...continued*

Symbol	Pin	Type	Description [1]
PGOOD	18	D_OUT	Power good output Active low Pull up to VDDIO mandatory
RSTB	19	D_OUT	Reset output Active low The main function is to reset the MCU. Reset input voltage is monitored to detect external reset and fault condition. Pull up to VDDIO mandatory
FIN	20	D_IN	Frequency synchronization input
GNDFS	21	GND	Fail-safe ground
GND	22	GND	Main ground
VDDIO	23	A_IN	Input voltage for SPI, FOUT and AMUX buffers Allow voltage compatibility with MCU I/Os
FOUT	24	D_OUT	Frequency synchronization output
MISO	25	D_OUT	SPI bus Master input slave output
MOSI	26	D_IN	SPI bus Master output slave Input
SCLK	27	D_IN	SPI bus Clock input
CSB	28	D_IN	Chip select (active low)
AMUX	29	A_OUT	Multiplexed output to connect to MCU ADC Selection of the analog parameter through SPI or I2C
FCCU2	30	D_IN	MCU error monitoring input 2
FCCU1	31	D_IN	MCU error monitoring input 1
BUCK2_FB	32	A_IN	Low voltage Buck2 voltage feedback
INTB	33	D_OUT	Interrupt output
BUCK2_SW	34	A_OUT	Low voltage Buck2 switching node
BUCK2_IN	35	A_IN	Low voltage Buck2 input voltage
BUCK1_IN	36	A_IN	Low voltage Buck1 input voltage
BUCK1_SW	37	A_OUT	Low voltage Buck1 switching node
PSYNC	38	D_IN/OUT	Power synchronization input/output
BUCK1_FB	39	A_IN	Low voltage Buck1 voltage feedback
ERRMON	40	D_IN	External IC error monitoring input
PRE_COMP	41	A_IN	VPRE compensation network
PRE_CSP	42	A_IN	VPRE positive current sense input
PRE_GLS	43	A_OUT	VPRE low-side gate driver for external MOSFET
PRE_SW	44	A_IN	VPRE switching node
PRE_GHS	45	A_OUT	VPRE high-side gate driver for external MOSFET
PRE_BOOT	46	A_IN/OUT	VPRE bootstrap capacitor
VBOS	47	A_OUT	Best of supply output voltage
PRE_FB	48	A_IN	VPRE voltage feedback and negative current sense input

Table 3. Pin description...*continued*

Symbol	Pin	Type	Description [1]
WAKE1	49	A_IN / D_IN	Wake up input 1 An external serial resistor is required if WAKE1 is a global pin
VSUP1	50	A_IN	Power supply 1 of the device An external reverse battery protection diode in series is mandatory
VSUP2	51	A_IN	Power supply 2 of the device An external reverse battery protection diode in series is mandatory
N/C	52	N/C	Not connected pin
VBOOST	53	A_IN	VBOOST voltage feedback
LDO2	54	A_OUT	Linear regulator 2 output voltage
LDO1	55	A_OUT	Linear regulator 1 output voltage
LDO1_IN	56	A_IN	Linear regulator 1 input voltage
EP	57	GND	Expose pad (BUCK1, BUCK2 and BUCK3 low-side GNDs are connected to the expose pad) Must be connected to GND

[1] See Section 8 for connection of unused pins.

8 Connection of unused pins

Table 4. Connection of unused pins

Pin	Name	Type	Connection if not used
1	WAKE2	A_IN / D_IN	External pull down to GND
2	N/C	N/C	Open
3	BUCK3_INQ	A_IN	Open
4	VDDI2C	A_IN	Open
5	BOOST_LS	A_IN	See Section 21.5 "VBOOST not populated"
6	BUCK3_IN	A_IN	Open
7	BUCK3_SW	A_OUT	Open
8	DBG	A_IN	**Connection mandatory**
9	BUCK3_FB	A_IN	Open – 1.5 MΩ internal resistor bridge pull down to GND
10	SCL	D_IN	External pull down to GND
11	SDA	D_IN/OUT	External pull down to GND
12	VMON4	A_IN	Open – 2 MΩ internal pull down to GND, OTP_VMON4_EN = 0
13	VMON3	A_IN	Open – 2 MΩ internal pull down to GND, OTP_VMON3_EN = 0
14	FS0B	D_OUT	Open – 2 MΩ internal pull down to GND
15	VMON2	A_IN	Open – 2 MΩ internal pull down to GND, OTP_VMON2_EN = 0
16	VMON1	A_IN	Open – 2 MΩ internal pull down to GND, OTP_VMON1_EN = 0
17	VCOREMON	A_IN	**Connection mandatory**
18	PGOOD	D_OUT	**Connection mandatory**
19	RSTB	D_OUT	**Connection mandatory**
20	FIN	D_IN	External pull down to GND
21	GNDFS	GND	**Connection mandatory**
22	GND	GND	**Connection mandatory**
23	VDDIO	A_IN	**Connection mandatory**
24	FOUT	D_OUT	Open – push pull structure
25	MISO	D_OUT	Open – push pull structure
26	MOSI	D_IN	Open – 450 kΩ internal pull up to VDDIO
27	SCLK	D_IN	External pull down to GND
28	CSB	D_IN	Open – 450 kΩ internal pull up to VDDIO
29	AMUX	A_OUT	Open
30	FCCU2	D_IN	Open – 200 kΩ internal pull up to VDDIO
31	FCCU1	D_IN	Open – 800 kΩ internal pull down to GND
32	BUCK2_FB	A_IN	Open – 1.5 MΩ Internal resistor bridge pull down to GND
33	INTB	D_OUT	Open – 10 kΩ internal pull up to VDDIO
34	BUCK2_SW	A_OUT	Open
35	BUCK2_IN	A_IN	Open
36	BUCK1_IN	A_IN	**Connection mandatory**
37	BUCK1_SW	A_OUT	**Connection mandatory**
38	PSYNC	D_IN/OUT	External pull up to VBOS

Table 4. Connection of unused pins...*continued*

Pin	Name	Type	Connection if not used
39	BUCK1_FB	A_IN	**Connection mandatory**
40	ERRMON	D_IN	External pull down to GND
41	PRE_COMP	A_IN	See Section 20.7 "VPRE not populated"
42	PRE_CSP	A_IN	See Section 20.7 "VPRE not populated"
43	PRE_GLS	A_OUT	See Section 20.7 "VPRE not populated"
44	PRE_SW	A_OUT	See Section 20.7 "VPRE not populated"
45	PRE_GHS	A_OUT	See Section 20.7 "VPRE not populated"
46	PRE_BOOT	A_IN/OUT	See Section 20.7 "VPRE not populated"
47	VBOS	A_OUT	**Connection mandatory**
48	PRE_FB	A_IN	See Section 20.7 "VPRE not populated"
49	WAKE1	A_IN / D_IN	External pull down to GND
50	VSUP1	A_IN	**Connection mandatory**
51	VSUP2	A_IN	**Connection mandatory**
52	N/C	N/C	Open
53	VBOOST	A_OUT	See Section 21.5 "VBOOST not populated"
54	LDO2	A_OUT	Open – power sequence slot 7, OTP_LDO1S[2:0] = ‘111’
55	LDO1	A_OUT	Open – power sequence slot 7, OTP_LDO2S[2:0] = ‘111’
56	LDO1_IN	A_IN	Open
57	EP	GND	**Connection mandatory**

9 Maximum ratings

Table 5. Maximum ratings

All voltages are with respect to ground, unless otherwise noted. Exceeding these ratings may cause a malfunction or permanent damage to the device.

Symbol	Parameter	Conditions	Min	Max	Unit
Voltage ratings					
VSUP1/2	DC voltage	power supply VSUP1,2 pins	−0.3	60	V
WAKE1/2	DC voltage	WAKE1,2 pins; external serial resistor mandatory	−1.0	60	V
PRE_SW	DC voltage	PRE_SW pin	−2.0	60	V
	Transient voltage < 20 ns		−3.0	60	V
VMONx, FS0B	DC voltage	VMON1,2,3,4, VCOREMON, FS0B pins	−0.3	60	V
PRE_GHS, PRE_BOOT	DC voltage	PRE_GHS, PRE_BOOT pins	−0.3	65.5	V
DBG	DC voltage	DBG pin	−0.3	10	V
BOOST_LS	DC voltage	BOOST_LS pin	−0.3	8.5	V
VBOOST, LDO1_IN	DC voltage	VBOOST, LDO1_IN pins	−0.3	6.5	V
BUCKx_IN	DC voltage	BUCK1_IN, BUCK2_IN, BUCK3_IN, BUCK3_INQ	−1.0	5.5	V
BUCKx_IN	Transient voltage < 3 µs	BUCK1_IN, BUCK2_IN, BUCK3_IN, BUCK3_INQ	−1.0	6.5	V
BUCKx_SW	Transient voltage < 20 ns	BUCK1_SW, BUCK2_SW, BUCK3_SW	−3.0	6.5	V
All other pins	DC voltage	at all other pins	−0.3	5.5	V
Current ratings					
I_WAKE	Maximum current capability	WAKE1,2	−5.0	5.0	mA
I_SUP	Maximum current capability	VSUP1,2	−5.0	—	mA

10 Electrostatic discharge

10.1 Human body model (JESD22/A114)

The device is protected up to ±2 kV, according to the human body model standard with 100 pF and 1.5 kΩ. This protection is ensured at all pins.

10.2 Charged device model

The device is protected up to ±500 V, according to the AEC Q100 - 011 charged device model standard. This protection is ensured at all pins.

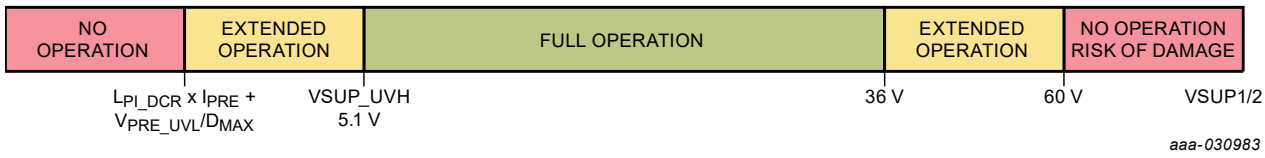
10.3 Discharged contact test

The device is protected up to ±8 kV, according to the following discharged contact tests.

Discharged contact test (IEC61000-4-2) at 150 pF and 330 Ω
Discharged contact test (ISO10605.2008) at 150 pF and 2 kΩ
Discharged contact test (ISO10605.2008) at 330 pF and 2 kΩ

This protection is ensured at VSUP1, VSUP2, WAKE1, WAKE2, FS0B pins.

11 Operating range



Assumptions

L_{PI_DCR} = 30 mΩ
D_{MAX} = 98.18 % with F_{PRE_SW} = 455 kHz and $T_{PRE\_OFF\_MIN}$ = 40 ns
I_{PRE} = 3.0 A
V_{RBD} = 0.56 V
VBAT_min = 3.4 V when VPRE = V_{PRE_UVL}

Figure 4. Operating range

- Below VSUP_UVH threshold, the extended operation range depends on VPRE output voltage configuration and external components.
  - When VPRE is configured at 5.0 V, VPRE may not remain in its regulation range
  - VSUP minimum voltage depends on external components (L_{PI_DCR}) and application conditions (I_{PRE}, F_{PRE_SW})
- When VPRE is switching at 455 kHz, the FS85/FS84 maximum continuous operating voltage is 36 V. It is validated at 48 V for limited duration of 15 minutes at room temperature to satisfy the jump start requirement of 24 V applications. It can sustain 58 V load dump without external protection.
- When VPRE is switching at 2.2 MHz, the FS85/FS84 maximum continuous operating voltage is 18 V. It is validated at 26 V for limited duration of 2 minutes at room temperature to satisfy the jump start requirement of 12 V applications and 35 V load dump.

12 Thermal ratings

Table 6. Thermal ratings

Symbol	Parameter	Conditions	Min	Max	Unit
$R_{\theta JA}$	Thermal resistance junction to ambient	2s2p circuit board [1] • Step-cut wettable flank • Dimple wettable flank	 — —	 32 32	°C/W
$R_{\theta JA}$	Thermal resistance junction to ambient	2s6p circuit board [1] • Step-cut wettable flank • Dimple wettable flank	 — —	 24 24	°C/W
$R_{\theta JB}$	Thermal resistance junction to board	2s2p circuit board [1] • Step-cut wettable flank • Dimple wettable flank	 — —	 16 16	°C/W
$R_{\theta JB}$	Thermal resistance junction to board	2s6p circuit board [1] • Step-cut wettable flank • Dimple wettable flank	 — —	 11 11	°C/W
$R_{\theta JC\_BOT}$	Thermal resistance junction to case bottom	between the die and the solder pad on the bottom of the package [1] • Step-cut wettable flank • Dimple wettable flank	 — —	 1.5 1.5	°C/W
$R_{\theta JP\_TOP}$	Thermal resistance junction to package top	between package top and the junction temperature [1] • Step-cut wettable flank • Dimple wettable flank	 — —	 4 4	°C/W
T_A	Ambient temperature (Grade 1)		−40	125	°C
T_J	Junction temperature (Grade 1)		−40	150	°C
T_{STG}	Storage temperature		−55	150	°C

[1] per JEDEC JESD51-2 and JESD51-8

13 Characteristics

Table 7. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
Power supply					
I_{SUP_NORMAL}	Current in Normal mode, all regulators ON (I_{OUT} = 0)	—	15	25	mA
$I_{SUP\_STANDBY}$	Current in Standby mode, all regulators OFF except VBOS	—	5	10	mA
I_{SUP_OFF1}	Current in OFF mode (Power Down), T_A < 85 °C	—	10	15	µA
I_{SUP_OFF2}	Current in OFF mode (Power Down), T_A = 125 °C	—	—	25	µA
V_{SUP_UV7}	VSUP undervoltage threshold (7.0 V)	7.2	7.5	7.8	V
V_{SUP_UVH}	VSUP undervoltage threshold high (during power up and Vsup rising) OTP_VSUP_CFG = 0	4.7	—	5.1	V
	VSUP undervoltage threshold high (during power up and Vsup rising) OTP_VSUP_CFG = 1	6.0	—	6.4	V
V_{SUP_UVL}	VSUP undervoltage threshold low (during power up and Vsup falling) OTP_VSUP_CFG = 0	4.0	—	4.4	V
	VSUP undervoltage threshold low (during power up and Vsup falling) OTP_VSUP_CFG = 1	5.3	—	5.7	V
T_{SUP_UV}	V_{SUP_UV7}, V_{SUP_UVH} and V_{SUP_UVL} filtering time	6.0	10	15	µs

14 Functional description

The FS85/FS84 device has two independent logic blocks. The main state machine manages the power management, the Standby mode and the wake-up sources. The fail-safe state machine manages the monitoring of the power management, the monitoring of the MCU and the monitoring of an external IC.

14.1 Simplified functional state diagram

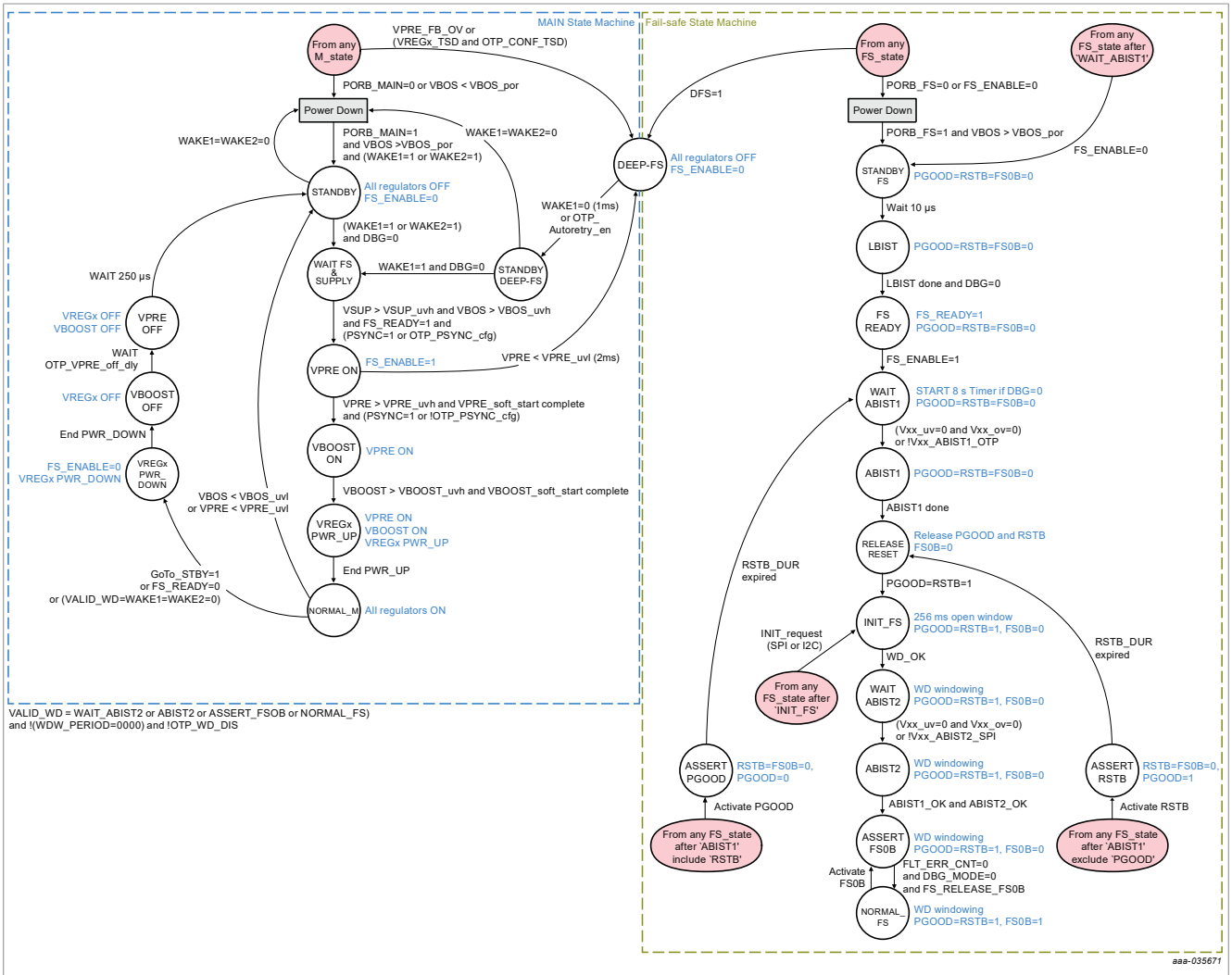


Figure 5. Simplified functional state diagram

VALID_WD = 0

- when the WD is disabled by OTP
  OR
- when the WD period = 0
  OR
- when the device is in INIT_FS sate

VALID_WD = 1

- when the WD period is different than 0

AND

- when the device is in one of the following states: WAIT_ABIST2 or ABIST2 or ASSERT_FS0B or NORMAL_FS

14.2 Main state machine

The FS85/FS84 starts when VSUP > V_{SUP_UVH} and WAKE1 or WAKE2 > $WAKE12_{VIH}$ with VBOS first, followed by VPRE, VBOOST and the power up sequencing from the OTP programming for the remaining regulators if PSYNC pin is pulled up to VBOS. If during the power up sequence VSUP < V_{SUP_UVL}, the device goes back to Standby mode. When the power up is finished, the main state machine is in Normal_M mode which is the application running mode with all the regulators ON and V_{SUP_UVL} has no effect even if VSUP < V_{SUP_UVL}. See Figure 4 for the minimum operating voltage.

The power up sequence can be synchronized with another PMIC using the PSYNC pin in order to stop before or after VPRE is ON and wait for the PMIC feedback on PSYNC pin before allowing FS85/FS84 to continue its power up sequence. See Section 27.3 "PSYNC for two FS85" for more details on PSYNC pin. If the power up sequence from VPRE ON to NORMAL_M is not completed within 1 second, the device goes back to Standby mode. VPRE restarts when VSUP > V_{SUP_UVH} and WAKE1 or WAKE2 > $WAKE12_{VIH}$.

The device goes to Standby mode by a SPI/I2C command from the MCU. If the WD is disabled by OTP_WD_DIS bit, for an application without MCU, the device goes to Standby mode when both WAKE1 and WAKE 2 = 0. The device goes to Standby mode following the power down sequence to stop all the regulators in the reverse order of the power up sequence. VPRE shutdown can be delayed from 250 µs to 32 ms by OTP_VPRE_off_dly bit in case VPRE is supplying an external PMIC to wait its power down sequence completion.

In case of loss of VPRE (VPRE < V_{PRE_UVL}) or loss of VBOS (VBOS < V_{BOS_UVL}), the device stops and goes directly to Standby mode without power down sequence. VPRE restarts when VSUP > V_{SUP_UVH} and WAKE1 or WAKE2 > $WAKE12_{VIH}$.

In case of VPRE_FB_OV detection, or TSD detection on a regulator depending on OTP_conf_tsd[5:0] bits configuration, or deep fail-safe request from the fail-safe state machine when DFS = 1, the device stops and goes directly to DEEP-FS mode without power down sequence.

Exit of DEEP-FS mode is only possible by WAKE1 = 0 or after 4 s if the autoretry feature is activated by OTP_Autorety_en bit. The number of autroretry can be limited to 15 or infinite depending on OTP_Autoretry_infinite bit. VPRE restarts when VSUP > V_{SUP_UVH} and WAKE1 > $WAKE12_{VIH}$.

14.3 Fail-safe state machine

The fail-safe state machine starts with LBIST execution when VBOS > V_{BOS_POR}. When the LBIST is done, the 8 s timer monitoring the RSTB pin starts and the ABIST1 is automatically executed when all the regulators assigned to ABIST1 have passed their undervoltage threshold and remain under their overvoltage threshold. When the ABIST1 is done, RSTB and PGOOD pins are released and the initialization of the device is opened for 256 ms. If the WD is not correctly refreshed within the 256 ms window, RSTB is asserted and the fault error counter is increased by 1. ABIST1 fail does not prevent RSTB and PGOOD release but maintains FS0B asserted.

The first good watchdog refresh closes the INIT_FS. Continuous watchdog refresh is now required. The device waits for the regulators assigned to ABIST2 in FS_I_OVUV_SAFE_REACTION1 register during INIT_FS to be started. When the ABIST2 is done and pass, the fault counter must be cleared with the appropriate number of good watchdog refresh to release the FS0B pin per the procedure described in Section 32.9.4 "FS0B release".

When FS0B pin is released, the device is ready for application running mode with all the selected monitoring activated. From now on, the FS85/FS84 reacts by asserting the safety pins (PGOOD, RSTB and FS0B)

according to its configuration when a fault is detected. The safety pins hierarchical priority is 1-PGOOD, 2-RSTB, 3-FS0B.

14.4 Power sequencing

VPRE is the first regulator to start automatically, followed by the BOOST, before the SLOT_0. The other regulators are starting from the OTP power sequencing configuration. Seven slots are available to program the start-up sequence of BUCK1, BUCK 2, BUCK 3, LDO1 and LDO2 regulators. The delay between each slot is configurable to 250 µs or 1 ms by OTP using OTP_Tslot bit to accommodate the different ramp up speed of BUCK1, BUCK2 and BUCK3.

The power up sequence starts at SLOT_0 and ends at SLOT_7 while the power down sequence is executed in reverse order. This means that all regulators set to SLOT_7 and powered up by SPI/I2C, will be stopped first during the power down sequence. All the SLOTs are executed even if there is no regulator assigned to a SLOT. The regulators assigned to SLOT_7 are not started during the power up sequence. They can be started (or not) later in NORMAL_M mode with a SPI/I2C command to write in M_REG_CTRL1 register if they were enabled by OTP.

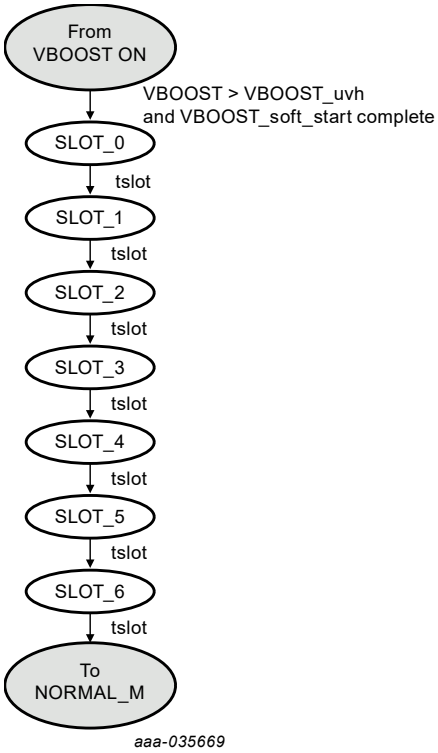


Figure 6. Power sequencing (VREGx PWR_UP)

Each regulator is assigned to a SLOT by OTP configuration using OTP_VB1S[2:0] for BUCK1, OTP_VB2S[2:0] for BUCK2, OTP_VB3S[2:0] for BUCK3, OTP_LDO1S[2:0] for LDO1 and OTP_LDO2S[2:0] for LDO2.

The different soft start duration of the BUCKs and the LDOs should be considered in the SLOT assignment to achieve the correct sequence.

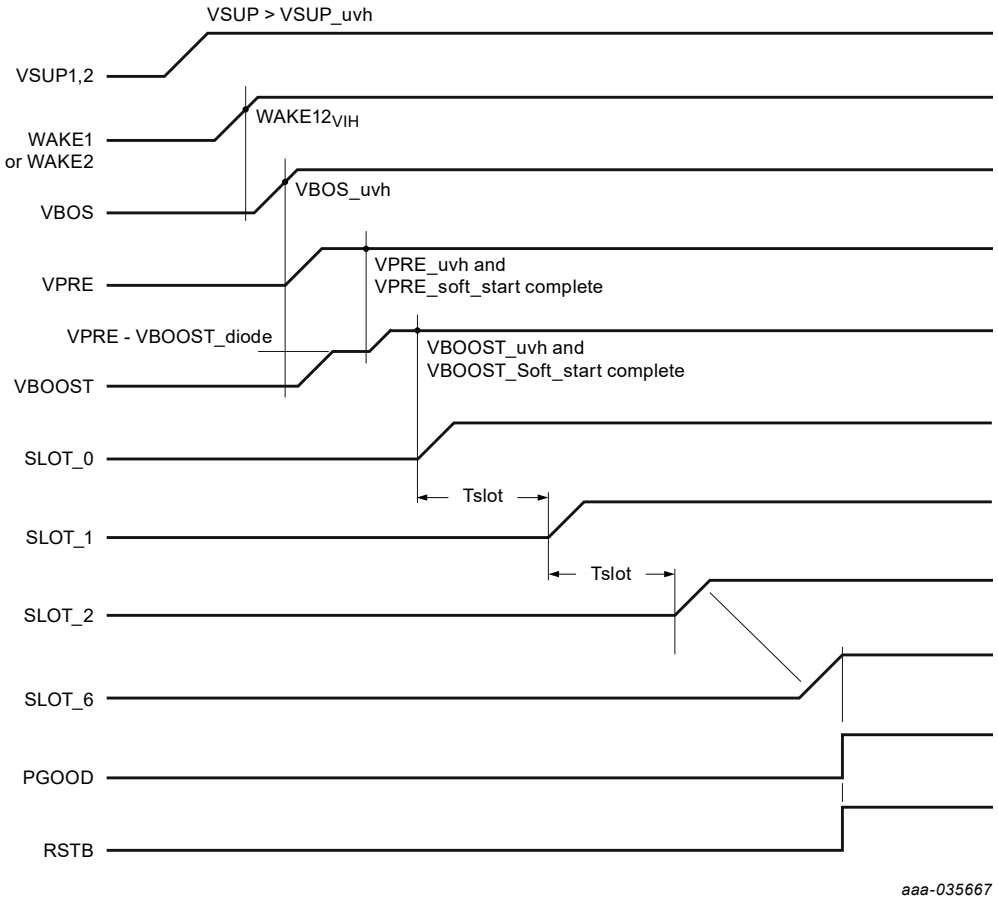


Figure 7. Power up sequence example

PGOOD and RSTB release depends on the combination of the power up sequence and what regulator is assigned to PGOOD and ABIST1 through the voltage monitoring connection (VCOREMON, VDDIOMON and VMONx). The FS85_FS84_OTP_Config file used to generate the OTP configuration of the device draws the power up sequence of an OTP configuration in the OTP_conf_summary sheet.

14.5 Debug mode

The FS85/FS84 enters in Debug mode with the sequence described in Figure 8:

1. DBG pin = V_{DBG} and VSUP > V_{SUP_UVH}
2. WAKE1 or WAKE2 > $WAKE12_{VIH}$

V_{DBG} and VSUP can come up at the same time as long as WAKE1 or WAKE2 comes up the last.

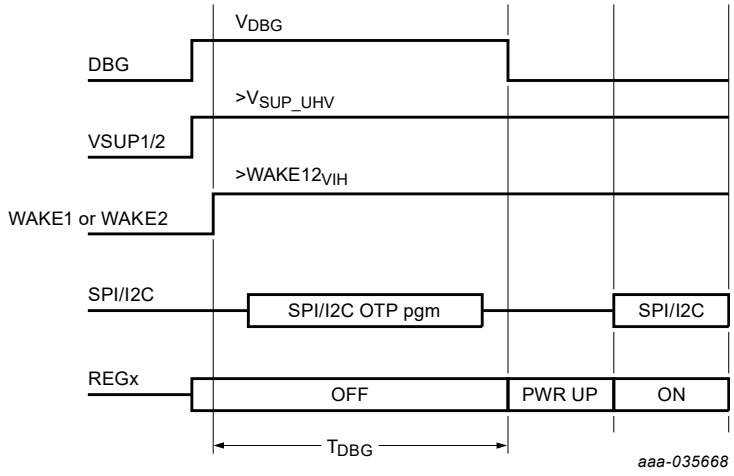


Figure 8. Debug mode entry

When the DBG pin is asserted low after T_{DBG} without SPI/I2C command access, the device starts with the internal OTP configuration.

If V_{DBG} voltage is maintained at DBG pin, a new OTP configuration can be emulated or programmed by SPI/I2C communication using NXP FlexGUI interface and NXP socket EVB. When the OTP process is completed, the device starts with the new OTP configuration when DBG pin is asserted low. The OTP emulation/programming is possible during engineering development only. The OTP programming in production is done by NXP only.

In OTP Debug mode (DBG = 5.0 V), the I2C address is fixed to 0x20 for the main digital access and 0x21 for the fail-safe digital access.

In Debug mode, the watchdog window is fully opened, the deep fail-safe request from the fail-safe state machine (DFS = 1) is masked, the 8 s timer monitoring of RSTB pin is disabled, the fail-safe output pin FS0B cannot be released, and the OTP emulation and programming of a raw device by SPI/I2C is possible.

In Debug mode, no watchdog refresh is required. It allows an easy debug of the hardware and software routines (i.e. SPI/I2C commands). However, the whole watchdog functionality is kept on (seed, LFSR, WD refresh counter, WD error counter...). WD errors are detected and counted with reaction on RSTB pin.

To release FS0B without taking care of the watchdog window, disable the watchdog window with WDW_PERIOD[3:0] = ‘0000’ in FS_WD_WINDOW register before leaving the Debug mode. To leave Debug mode, write DBG_EXIT bit = ‘1’ in FS_STATES register.

Refer to AN12333 for more details on Debug mode entry implementation.

Table 8. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
V_{DBG}	Debug mode entry threshold	4.5	5	5.5	V
T_{DBG}	Debug mode entry filtering time (minimum duration of DBG = V_{DBG} after VSUP > V_{SUP_UVH} and WAKE1 or WAKE2 > WAKE12$_{VIH}$	7	—	—	ms

14.6 Flow charts

The flow charts describe how the device starts and what to do when the RSTB pin is released.

14.6.1 Application flow chart

In application mode, the Debug pin is connected to GND and watchdog refresh is required as soon as INIT_FS is closed.

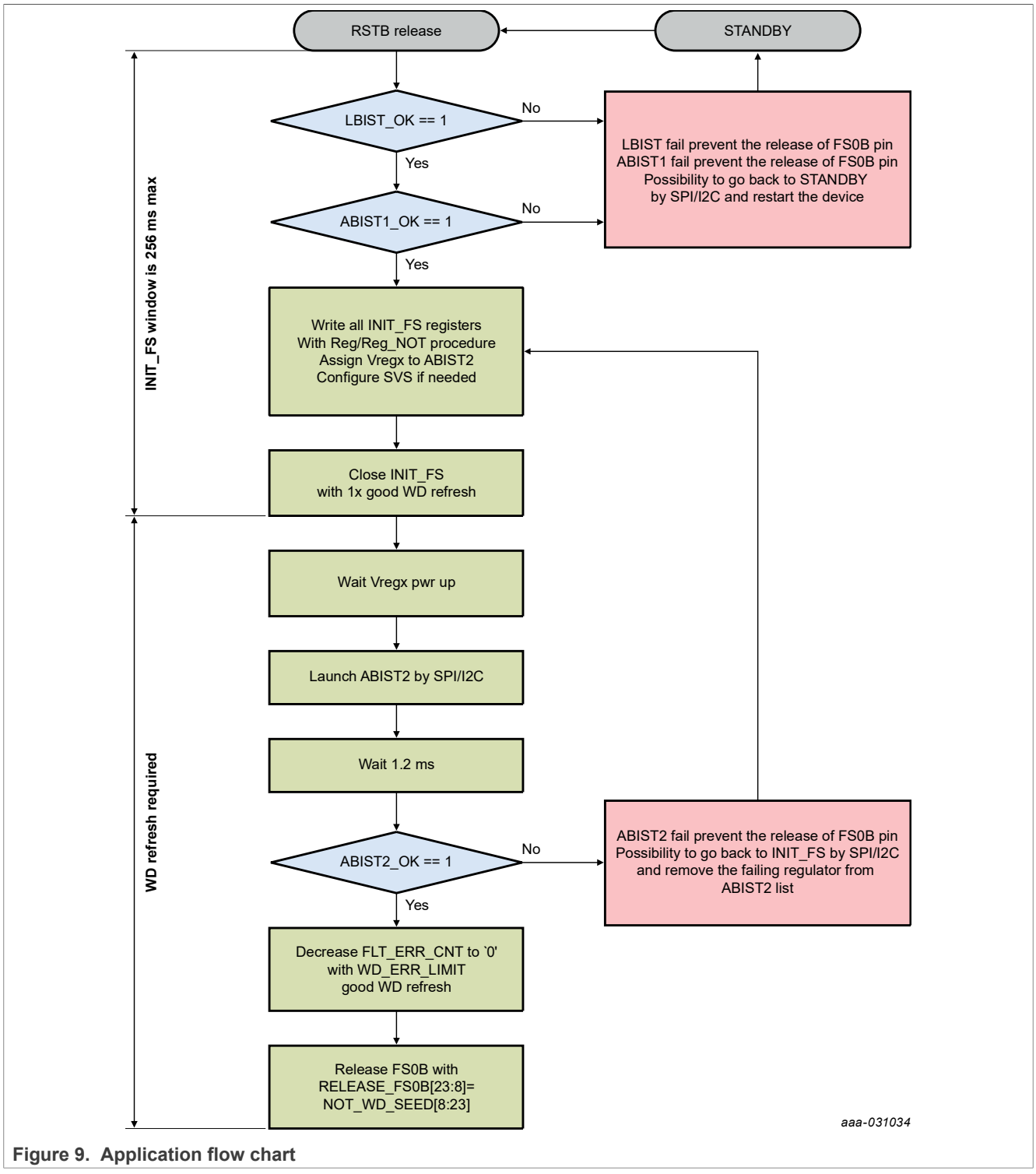


Figure 9. Application flow chart

14.6.2 Debug flow chart

In Debug mode, the Debug pin is managed according to Section 14.4 "Power sequencing" description. The watchdog window is fully opened, and the watchdog refresh is not required.

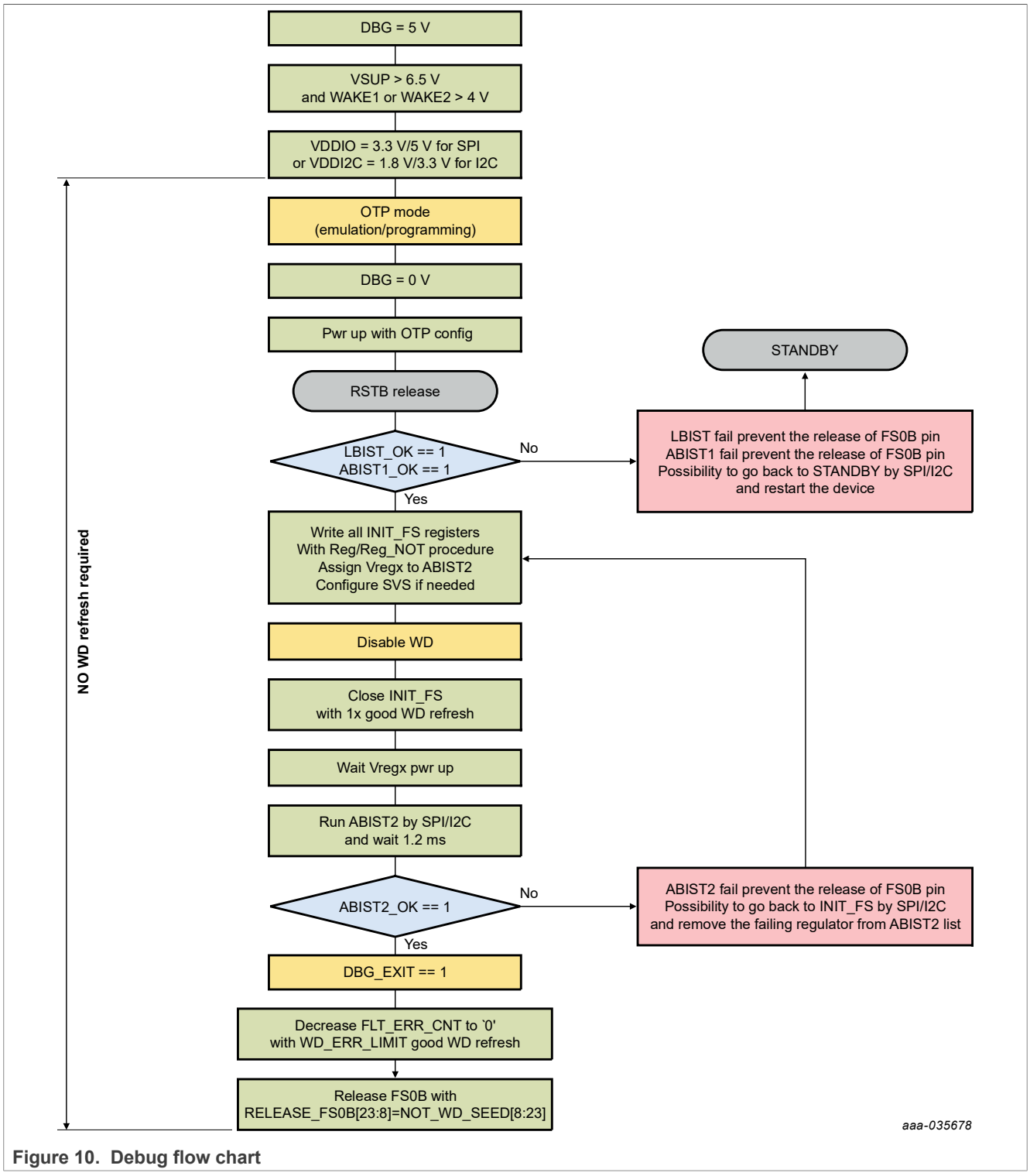


Figure 10. Debug flow chart

Note: *Disabling the watchdog before INIT_FS closure and Debug mode exit by SPI/I2C allows FS0B release. Otherwise, FS0B is stuck low in Debug mode.*

15 Register mapping

Register	M/FS	Address						R/W SPI	R/W I2C	Read / Write	Reference
		Adr_5	Adr_4	Adr_3	Adr_2	Adr_1	Adr_0				
M_FLAG	0	0	0	0	0	0	0	0/1	1/0	Read / Write	Section 16.3
M_MODE	0	0	0	0	0	0	1	0/1	1/0	Read / Write	Section 16.4
M_REG_CTRL1	0	0	0	0	0	1	0	0/1	1/0	Read / Write	Section 16.5
M_REG_CTRL2	0	0	0	0	0	1	1	0/1	1/0	Read / Write	Section 16.6
M_AMUX	0	0	0	0	1	0	0	0/1	1/0	Read / Write	Section 16.7
M_CLOCK	0	0	0	0	1	0	1	0/1	1/0	Read / Write	Section 16.8
M_INT_MASK1	0	0	0	0	1	1	0	0/1	1/0	Read / Write	Section 16.9
M_INT_MASK2	0	0	0	0	1	1	1	0/1	1/0	Read / Write	Section 16.10
M_FLAG1	0	0	0	1	0	0	0	0/1	1/0	Read / Write	Section 16.11
M_FLAG2	0	0	0	1	0	0	1	0/1	1/0	Read / Write	Section 16.12
M_VMON_REGX	0	0	0	1	0	1	0	0/1	1/0	Read / Write	Section 16.13
M_LVB1_SVS	0	0	0	1	0	1	1	0	1	Read only	Section 16.14
M_MEMORY0	0	1	0	0	0	1	1	0/1	1/0	Read / Write	Section 16.15
M_MEMORY1	0	1	0	0	1	0	0	0/1	1/0	Read / Write	Section 16.16
M_DEVICEID	0	1	0	0	1	0	1	0	1	Read only	Section 16.17
FS_GRL_FLAGS	1	0	0	0	0	0	0	0	1	Read only	Section 17.3
FS_I_OVUV_SAFE_REACTION1	1	0	0	0	0	0	1	0/1	1/0	Write during INIT then Read only	Section 17.4
FS_I_NOT_OVUV_SAFE_REACTION1	1	0	0	0	0	1	0	0/1	1/0	Write during INIT then Read only	
FS_I_OVUV_SAFE_REACTION2	1	0	0	0	0	1	1	0/1	1/0	Write during INIT then Read only	Section 17.5
FS_I_NOT_OVUV_SAFE_REACTION2	1	0	0	0	1	0	0	0/1	1/0	Write during INIT then Read only	
FS_I_WD_CFG	1	0	0	0	1	0	1	0/1	1/0	Write during INIT then Read only	Section 17.6
FS_I_NOT_WD_CFG	1	0	0	0	1	1	0	0/1	1/0	Write during INIT then Read only	
FS_I_SAFE_INPUTS	1	0	0	0	1	1	1	0/1	1/0	Write during INIT then Read only	Section 17.7
FS_I_NOT_SAFE_INPUTS	1	0	0	1	0	0	0	0/1	1/0	Write during INIT then Read only	
FS_I_FSSM	1	0	0	1	0	0	1	0/1	1/0	Write during INIT then Read only	Section 17.8
FS_I_NOT_FSSM	1	0	0	1	0	1	0	0/1	1/0	Write during INIT then Read only	
FS_I_SVS	1	0	0	1	0	1	1	0/1	1/0	Write during INIT then Read only	Section 17.9
FS_I_NOT_SVS	1	0	0	1	1	0	0	0/1	1/0	Write during INIT then Read only	
FS_WD_WINDOW	1	0	0	1	1	0	1	0/1	1/0	Read / Write	Section 17.10
FS_NOT_WD_WINDOW	1	0	0	1	1	1	0	0/1	1/0	Read / Write	
FS_WD_SEED	1	0	0	1	1	1	1	0/1	1/0	Read / Write	Section 17.11
FS_WD_ANSWER	1	0	1	0	0	0	0	1	0	Write only	Section 17.12
FS_OVUVREG_STATUS	1	0	1	0	0	0	1	0/1	1/0	Read / Write	Section 17.13
FS_RELEASE_FS0B	1	0	1	0	0	1	0	0/1	1/0	Read / Write	Section 17.14
FS_SAFE_IOS	1	0	1	0	0	1	1	0/1	1/0	Read / Write	Section 17.15
FS_DIAG_SAFETY	1	0	1	0	1	0	0	0/1	1/0	Read / Write	Section 17.16
FS_INTB_MASK	1	0	1	0	1	0	1	0/1	1/0	Read / Write	Section 17.17
FS_STATES	1	0	1	0	1	1	0	0/1	1/0	Read / Write	Section 17.18

16 Main register mapping

16.1 Main writing registers overview

Table 9. Main writing registers overview

Logic	Register name	bit 23	bit 22	bit 21	bit 20	bit 19	bit 18	bit 17	bit 16
		bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8
Main	M_FLAG	0	0	0	0	0	0	0	0
		0	0	0	SPI_M_CLK	SPI_M_REQ	SPI_M_CRC	I2C_M_CRC	I2C_M_REQ
	M_MODE	0	0	0	0	0	0	0	0
		0	EXT_FIN_DIS	0	0	0	W2DIS	W1DIS	GoTo_STBY
	M_REG_CTRL1	VPRE_PD_DIS	VPDIS	BOOSTDIS	BUCK1DIS	BUCK2DIS	BUCK3DIS	LDO1DIS	LDO2DIS
		0	VPEN	BOOSTEN	BUCK1EN	BUCK2EN	BUCK3EN	LDO1EN	LDO2EN
	M_REG_CTRL2	VBSTSR[1:0]		BOOSTT SDCFG	BUCK1TSDCFG	BUCK2TSDCFG	BUCK3TSDCFG	LDO1TSDCFG	LDO2TSDCFG
		0	0	0	VPRESRLS		0	VPRESRHS	
	M_AMUX	0	0	0	0	0	0	0	0
		0	0	RATIO	AMUX[4:0]				
	M_CLOCK	MOD_CONF	FOUT_MUX_SEL[3:0]				FOUT_PHASE[2:0]		
		FOUT_ CLK_SEL	EXT_FIN_SEL	FIN_DIV	MOD_EN	CLK_TUNE[3 :0]			
	M_INT_MASK1	0	VPREOC_M	0	BUCK1OC_M	BUCK2OC_M	BUCK3OC_M	LDO1OC_M	LDO2OC_M
		0	0	BOOSTTSD_M	BUCK1TSD_M	BUCK2TSD_M	BUCK3TSD_M	LDO1TSD_M	LDO2TSD_M
	M_INT_MASK2	0	0	0	0	VBOOSTOV_M	VBOSUVH_M	COM_M	VPRE_ FB_OV_M
		VBOOST_ UVH_M	VSUPUV7	0	VPREUVH	VSUPUV	VSUPUVH	WAKE1_M	WAKE2_M
	M_FLAG1	VBOSUVH	VBOOSTUVH	VPREOC	BUCK1OC	BUCK2OC	BUCK3OC	LDO1OC	LDO2OC
		0	VBOOSTOV	VBOOSTOT	BUCK1OT	BUCK2OT	BUCK3OT	LDO1OT	LDO2OT
	M_FLAG2	VPRE_FB_OV	VSUPUV7	0	0	0	0	0	0
		VPREUVL	VPREUVH	VSUPUVL	VSUPUVH	0	0	WK2FLG	WK1FLG
	M_VMON_REGX	0	0	0	0	VMON4_REG[2:0]			VMON3_REG[2]
		VMON3_REG[1:0]		VMON2_REG[2:0]			VMON1_REG[2:0]		
	M_MEMORY0	MEMORY0[15:0]							
	M_MEMORY1	MEMORY1[15:0]							

16.2 Main reading registers overview

Table 10. Main reading registers overview

Logic	Register name	bit 23	bit 22	bit 21	bit 20	bit 19	bit 18	bit 17	bit 16
		bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8
Main	M_FLAG	COM_ERR	WU_G	VPRE_G	VBOOST_G	VBUCK1_G	VBUCK2_G	VBUCK3_G	VLDO1_G
		VLDO2_G	0	0	SPI_M_CLK	SPI_M_REQ	SPI_M_CRC	I2C_M_CRC	I2C_M_REQ
	M_MODE	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	PLL_LOCK_RT
		EXT_FIN_ SEL_RT	RESERVED	MAIN_NORMAL	RESERVED	RESERVED	W2DIS	W1DIS	RESERVED
	M_REG_CTRL1	VPRE_PD_DIS	VPDIS	BOOSTDIS	BUCK1DIS	BUCK2DIS	BUCK3DIS	LDO1DIS	LDO2DIS
		0	VPEN	BOOSTEN	BUCK1EN	BUCK2EN	BUCK3EN	LDO1EN	LDO2EN
	M_REG_CTRL2	VBSTSR[1:0]		BOOSTT SDCFG	BUCK1TSDCFG	BUCK2TSDCFG	BUCK3TSDCFG	LDO1TSDCFG	LDO2TSDCFG
		RESERVED	RESERVED	RESERVED	VPRESRLS		RESERVED	VPRESRHS	
	M_AMUX	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
		RESERVED	RESERVED	RATIO	AMUX[4:0)				
	M_CLOCK	MOD_CONF	FOUT_MUX_SEL[3:0]				FOUT_PHASE[2:0]		
		FOUT_ CLK_SEL	RESERVED	FIN_DIV	MOD_EN	CLK_TUNE[3 :0]			
	M_INT_MASK1	RESERVED	VPREOC_M	RESERVED	BUCK1OC_M	BUCK2OC_M	BUCK3OC_M	LDO1OC_M	LDO2OC_M
		RESERVED	RESERVED	BOOSTTSD_M	BUCK1TSD_M	BUCK2TSD_M	BUCK3TSD_M	LDO1TSD_M	LDO2TSD_M
	M_INT_MASK2	RESERVED	RESERVED	RESERVED	RESERVED	VBOOSTOV_M	VBOSUVH_M	COM_M	VPRE_ FB_OV_M
		VBOOST_ UVH_M	VSUPUV7	RESERVED	VPREUVH	VSUPUV	VSUPUVH	WAKE1_M	WAKE2_M
	M_FLAG1	VBOSUVH	VBOOSTUVH	VPREOC	BUCK1OC	BUCK2OC	BUCK3OC	LDO1OC	LDO2OC
		CLK_FIN_ DIV_OK	VBOOSTOV	VBOOSTOT	BUCK1OT	BUCK2OT	BUCK3OT	LDO1OT	LDO2OT
	M_FLAG2	VPRE_FB_OV	VSUPUV7	BOOST_ST	BUCK1_ST	BUCK2_ST	BUCK3_ST	LDO1_ST	LDO2_ST
		VPREUVL	VPREUVH	VSUPUVL	VSUPUVH	WK2RT	WK1RT	WK2FLG	WK1FLG
	M_VMON_REGX	RESERVED	RESERVED	RESERVED	RESERVED	VMON4_REG[2:0]			VMON3_ REG[2:0]
		VMON3_REG[1:0]		VMON2_REG[2:0]			VMON1_REG[2]		
	M_LVB1_SVS	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
		RESERVED	RESERVED	RESERVED	LVB1_SVS[4:0]				
	M_MEMORY0	MEMORY0[15:0]							
	M_MEMORY0	MEMORY1[15:0]							
	M_DEVICEID	FM_REV[3:0]				MM_REV[3:0]			
		DEVICEID[7:0]							

16.3 M_FLAG register

When the device starts up, it is recommended to clear all the flags by writing 1s on all bits.

Table 11. M_FLAG register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	0	0	0	0	0	0	0	0
Read	COM_ERR	WU_G	VPRE_G	VBOOST_G	VBUCK1_G	VBUCK2_G	VBUCK3_G	VLDO1_G
Reset	0	1	1	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	0	0	SPI_M_CLK	SPI_M_REQ	SPI_M_CRC	I2C_M_CRC	I2C_M_REQ
Read	VLDO2_G	0	0	SPI_M_CLK	SPI_M_REQ	SPI_M_CRC	I2C_M_CRC	I2C_M_REQ
Reset	0	0	0	0	0	0	0	0

Table 12. M_FLAG register bit description

Bit	Symbol	Description
23	COM_ERR	Report an error in the Communication (SPI or I2C) **COM_ERR** = SPI_M_CRC or SPI_M_CLK or SPI_M_REQ or I2C_M_CRC or I2C_M_REQ or FS_COM_G
		0 No failure
		1 Failure
		Reset condition: Real time information - cleared when all individual bits are cleared
22	WU_G	Report a wake-up event by WAKE1 or WAKE2 **WU_G** = WK1FLG or WK2FLG
		0 No wake event
		1 Wake event
		Reset condition: Real time information - cleared when all individual bits are cleared
21	VPRE_G	Report an event on VPRE (status change or failure) **VPRE_G** = VPREOC or VPREUVH or VPREUVL or VPRE_FB_OV
		0 No event
		1 Event occurred
		Reset condition: Real time information - cleared when all individual bits are cleared
20	VBOOST_G	Report an event on VBOOST (status change or failure) **VBOOST_G** = VBOOSTOT or BOOSTOV
		0 No event
		1 Event occurred
		Reset condition: Real time information - cleared when all individual bits are cleared
19	VBUCK1_G	Report an event on BUCK1 (status change or failure) **VBUCK1_G** = BUCK1OC or BUCK1OT
		0 No event
		1 Event occurred
		Reset condition: Real time information - cleared when all individual bits are cleared

Table 12. M_FLAG register bit description*...continued*

Bit	Symbol	Description
18	VBUCK2_G	Report an event on BUCK2 (status change or failure) **VBUCK2_G** = BUCK2OC or BUCK2OT
		0 No event
		1 Event occurred
		Reset condition: Real time information - cleared when all individual bits are cleared
17	VBUCK3_G	Report an event on BUCK3 (status change or failure) **VBUCK3_G** = BUCK3OC or BUCK3OT
		0 No event
		1 Event occurred
		Reset condition: Real time information - cleared when all individual bits are cleared
16	VLDO1_G	Report an event on LDO1 (status change or failure) **VLDO1_G** = LDO1OC or LDO1OT
		0 No event
		1 Event occurred
		Reset condition: Real time information
15	VLDO2_G	Report an event on LDO2 (status change or failure) **VLDO2_G** = LDO2OC or LDO2OT
		0 No event
		1 Event occurred
		Reset condition: Real time information
12	SPI_M_CLK	Main domain SPI SCLK error detection
		0 No error
		1 Wrong number of clock cycles (<32 or >32)
		Reset condition: POR / clear on Write (write ‘1’)
11	SPI_M_REQ	Invalid main domain SPI access (wrong Write or Read, Write to INIT registers in normal mode, wrong address)
		0 No error
		1 SPI violation
		Reset condition: POR / clear on Write (write ‘1’)
10	SPI_M_CRC	Main domain SPI communication CRC issue
		0 No error
		1 Error detected in the SPI CRC
		Reset condition: POR / clear on Write (write ‘1’)
9	I2C_M_CRC	Main domain I2C communication CRC issue
		0 No error
		1 Error detected in the I2C CRC
		Reset condition: POR / clear on write (write ‘1’)
8	I2C_M_REQ	Invalid main domain I2C access (wrong Write or Read, Write to INIT registers in normal mode, wrong address)
		0 No error
		1 I2C violation
		Reset condition: POR / clear on Write (write ‘1’)

16.4 M_MODE register

Table 13. M_MODE register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	0	0	0	0	0	0	0	0
Read	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	PLL_ LOCK_RT
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	EXT_ FIN_DIS	0	0	0	W2DIS	W1DIS	GoTo_STBY
Read	EXT_FIN_ SEL_RT	RESERVED	MAIN_ NORMAL	RESERVED	RESERVED	W2DIS	W1DIS	RESERVED
Reset	0	0	1	0	0	0	0	0

Table 14. M_MODE register bit description

Bit	Symbol	Description
16	PLL_LOCK_RT	Real time status of the PPL
		0 PLL not locked
		1 PLL locked
		Reset condition: POR
15	EXT_FIN_SEL_RT	Real time status of FIN clock selection
		0 Internal clock oscillator is selected
		1 External FIN clock is selected
		Reset condition: POR
14	EXT_FIN_DIS	Disable request of EXT FIN selection at PLL input
		0 No effect
		1 Disable FIN selection
		Reset condition: POR
13	MAIN NORMAL	Main state machine status
		0 Main state machine is not in Normal mode
		1 Main state machine is in Normal mode
		Reset condition: POR
10	W2DIS	WAKE2 wake up disable
		0 wake up enable
		1 wake up disable
		Reset condition: POR
9	W1DIS	WAKE1 wake up disable
		0 Wake up enable
		1 Wake up disable
		Reset condition: POR

Table 14. M_MODE register bit description*...continued*

Bit	Symbol	Description
8	GoTo_STBY	Standby mode request
		0 Device remains in current state
		1 Device enters in Standby mode
		Reset condition: POR

16.5 M_REG_CTRL1 register

Table 15. M_REG_CTRL1 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	VPRE_ PD_DIS	VPDIS	BOOSTDIS	BUCK1DIS	BUCK2DIS	BUCK3DIS	LDO1DIS	LDO2DIS
Read	VPRE_ PD_DIS	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	VPEN	BOOSTEN	BUCK1EN	BUCK2EN	BUCK3EN	LDO1EN	LDO2EN
Read	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
Reset	0	0	0	0	0	0	0	0

Table 16. M_REG_CTRL1 register bit description

Bit	Symbol	Description
23	VPRE_PD_DIS	Force disable of VPRE pull down
		0 No effect (VPRE pull down is automatically controlled by the logic)
		1 VPRE pull down disable request
		Reset condition: POR
22	VPDIS	Disable request of VPRE
		0 No effect (regulator remains in existing state)
		1 VPRE disable request
		Reset condition: POR
21	BOOSTDIS	Disable request of BOOST
		0 No effect (regulator remains in existing state)
		1 BOOST disable request
		Reset condition: POR
20	BUCK1DIS	Disable request of BUCK1
		0 No effect (regulator remains in existing state)
		1 BUCK1 disable request
		Reset condition: POR

Table 16. M_REG_CTRL1 register bit description*...continued*

Bit	Symbol	Description
19	BUCK2DIS	Disable request of BUCK2
		0 No effect (regulator remains in existing state)
		1 BUCK2 disable request
		Reset condition: POR
18	BUCK3DIS	Disable request of BUCK3
		0 No effect (regulator remains in existing state)
		1 BUCK3 disable request
		Reset condition: POR
17	LDO1DIS	Disable request of LDO1
		0 No effect (regulator remains in existing state)
		1 LDO1 disable request
		Reset condition: POR
16	LDO2DIS	Disable request of LDO2
		0 no effect (regulator remains in existing state)
		1 LDO2 disable request
		Reset condition: POR
14	VPEN	Enable request of VPRE
		0 No effect (regulator remains in existing state)
		1 VPRE enable request (after a VPDIS request)
		Reset condition: POR
13	BOOSTEN	Enable request of BOOST
		0 No effect (regulator remains in existing state)
		1 BOOST enable request
		Reset condition: POR
12	BUCK1EN	Enable request of BUCK1
		0 No effect (regulator remains in existing state)
		1 BUCK1 enable request
		Reset condition: POR
11	BUCK2EN	Enable request of BUCK2
		0 No effect (regulator remains in existing state)
		1 BUCK2 enable request
		Reset condition: POR
10	BUCK3EN	Enable request of BUCK3
		0 No effect (regulator remains in existing state)
		1 BUCK3 enable request
		Reset condition: POR
9	LDO1EN	Enable request of LDO1
		0 No effect (regulator remains in existing state)
		1 LDO1 enable request
		Reset condition: POR

Table 16. M_REG_CTRL1 register bit description*...continued*

Bit	Symbol	Description
8	LDO2EN	Enable request of LDO2
		0 no effect (regulator remains in existing state)
		1 LDO2 enable request
		Reset condition: POR

16.6 M_REG_CTRL2 register

Table 17. M_REG_CTRL2 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	VBSTSR[1:0]		BOOSTT SDCFG	BUCK1 TSDCFG	BUCK2 TSDCFG	BUCK3 TSDCFG	LDO1 TSDCFG	LDO2 TSDCFG
Read	VBSTSR[1:0]		BOOSTT SDCFG	BUCK1 TSDCFG	BUCK2 TSDCFG	BUCK3 TSDCFG	LDO1 TSDCFG	LDO2 TSDCFG
Reset	OTP	OTP	OTP	OTP	OTP	OTP	OTP	OTP

Bit	15	14	13	12	11	10	9	8
Write	0	0	0	VPRESRLS[1:0]		0	VPRESRHS[1:0]	
Read	RESERVED	RESERVED	RESERVED	VPRESRLS[1:0]		RESERVED	VPRESRHS[1:0]	
Reset	0	0	0	1	1	0	OTP	OTP

Table 18. M_REG_CTRL2 register bit description

Bit	Symbol	Description
23 to 22	VBSTSR[1:0]	VBOOST low-side slew rate control
		00 50 V/µs - slow
		01 100 V/µs – medium
		10 300 V/µs – fast
		11 500 V/µs – ultra fast
		Reset condition: POR
21	BOOSTTSDCFG	BOOST behavior in case of TSD
		0 Regulator shutdown
		1 Regulator shutdown and state machine transition to DEEP-FS
		Reset condition: POR
20	BUCK1TSDCFG	BUCK1 behavior in case of TSD
		0 Regulator shutdown
		1 Regulator shutdown and state machine transition to DEEP-FS
		Reset condition: POR
19	BUCK2TSDCFG	BUCK2 behavior in case of TSD
		0 Regulator shutdown
		1 Regulator shutdown and state machine transition to DEEP-FS
		Reset condition: POR

Table 18. M_REG_CTRL2 register bit description*...continued*

Bit	Symbol	Description
18	BUCK3TSDCFG	BUCK3 behavior in case of TSD
		0 Regulator shutdown
		1 Regulator shutdown and state machine transition to DEEP-FS
		Reset condition: POR
17	LDO1TSDCFG	LDO1 behavior in case of TSD
		0 Regulator shutdown
		1 Regulator shutdown and state machine transition to DEEP-FS
		Reset condition: POR
16	LDO2TSDCFG	LDO2 behavior in case of TSD
		0 Regulator shutdown
		1 Regulator shutdown and state machine transition to DEEP-FS
		Reset condition: POR
12 to 11	VPRESRLS[1:0]	VPRE low-side slew rate control
		00 130 mA typical drive capability - slow
		01 260 mA typical drive capability - medium
		10 520 mA typical drive capability - fast
		11 900 mA typical drive capability - ultra fast
		Reset condition: POR
9 to 8	VPRESRHS[1:0]	VPRE high-side slew rate control
		00 130 mA typical drive capability - slow
		01 260 mA typical drive capability - medium
		10 520 mA typical drive capability - fast
		11 900 mA typical drive capability - ultra fast
		Reset condition: POR

16.7 M_AMUX register

Table 19. M_AMUX register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	0	0	0	0	0	0	0	0
Read	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	0	RATIO	AMUX[4:0)				
Read	RESERVED	RESERVED	RATIO	AMUX[4:0)				
Reset	0	0	0	0	0	0	0	0

Table 20. M_AMUX register bit description

Bit	Symbol	Description
13	RATIO	Selection of divider ratio for Vsup, Wake1 and Wake 2 inputs
		0 Ratio = 7.5 when Vsup is selected, 7.45 when WAKE1 or WAKE2 are selected
		1 Ratio = 14 when Vsup is selected,13.85 when WAKE1 or WAKE2 are selected
		Reset condition
12 to 8	AMUX[4:0]	See Table 89

16.8 M_CLOCK register

Table 21. M_CLOCK register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	MOD_CONF	FOUT_MUX_SEL[3:0]				FOUT_PHASE[2:0]		
Read	MOD_CONF	FOUT_MUX_SEL[3:0]				FOUT_PHASE[2:0]		
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	FOUT_ CLK_SEL	EXT_ FIN_SEL	FIN_DIV	MOD_EN	CLK_TUNE[3 :0]			
Read	FOUT_ CLK_SEL	RESERVED	FIN_DIV	MOD_EN	CLK_TUNE[3 :0]			
Reset	0	0	0	0	0	0	0	0

Table 22. M_CLOCK register bit description

Bit	Symbol	Description
23	MOD_CONF	Modulation configuration of main oscillator
		0 range ± 5 % 23 kHz
		1 range ± 5 % 94 kHz
		Reset condition: POR
22 to 19	FOUT_MUX_SEL[3:0]	See Table 87
18 to 16	FOUT_PHASE[2:0]	FOUT phase shifting configuration (see Section 25.2 "Phase shifting")
		000 No shift
		001 Shifted by 1 clock cycle of CLK running at 20 MHz
		010 Shifted by 2 clock cycle of CLK running at 20 MHz
		011 Shifted by 3 clock cycle of CLK running at 20 MHz
		100 Shifted by 4 clock cycle of CLK running at 20 MHz
		101 Shifted by 5 clock cycle of CLK running at 20 MHz
		110 Shifted by 6 clock cycle of CLK running at 20 MHz
		111 Shifted by 7 clock cycle of CLK running at 20 MHz
		Reset condition: POR

Table 22. M_CLOCK register bit description*...continued*

Bit	Symbol	Description
15	FOUT_CLK_SEL	FOUT_clk frequency selection (CLK1 or CLK2)
		0 FOUT_clk = CLK1
		1 FOUT_clk = CLK2
		Reset condition: POR
14	EXT_FIN_SEL	Enable request of EXT FIN selection at PLL input
		0 No effect
		1 FIN selection request
		Reset condition: POR
13	FIN_DIV	FIN input signal divider selection
		0 Divider by 1
		1 Divider by 6
		Reset condition: POR
12	MOD_EN	Modulation activation of main oscillator
		0 Modulation disabled
		1 Modulation enabled
		Reset condition: POR
11 to 8	CLK_TUNE[3:0]	See Table 86

16.9 M_INT_MASK1 register

Table 23. M_INT_MASK1 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	0	VPREOC_M	0	BUCK1 OC_M	BUCK2 OC_M	BUCK3 OC_M	LDO1OC_M	LDO2OC_M
Read	RESERVED	VPREOC_M	RESERVED	BUCK1 OC_M	BUCK2 OC_M	BUCK3 OC_M	LDO1OC_M	LDO2OC_M
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	0	BOOSTTSD_M	BUCK1 TSD_M	BUCK2 TSD_M	BUCK3 TSD_M	LDO1TSD_M	LDO2TSD_M
Read	RESERVED	RESERVED	BOOSTTSD_M	BUCK1 TSD_M	BUCK2 TSD_M	BUCK3 TSD_M	LDO1TSD_M	LDO2TSD_M
Reset	0	0	0	0	0	0	0	0

Table 24. M_INT_MASK1 register bit description

Bit	Symbol	Description
22	VPREOC_M	Inhibit INTERRUPT for VPRE overcurrent
		0 INT not masked
		1 INT masked
		Reset condition: POR

Table 24. M_INT_MASK1 register bit description*...continued*

Bit	Symbol	Description
20	BUCK1OC_M	Inhibit INTERRUPT for BUCK1 overcurrent
		0 INT not masked
		1 INT masked
		Reset condition: POR
19	BUCK2OC_M	Inhibit INTERRUPT for BUCK3 overcurrent
		0 INT not masked
		1 INT masked
		Reset condition: POR
18	BUCK3OC_M	Inhibit INTERRUPT for BUCK3 overcurrent
		0 INT not masked
		1 INT masked
		Reset condition: POR
17	LDO1OC_M	Inhibit INTERRUPT for LDO1 overcurrent
		0 INT not masked
		1 INT masked
		Reset condition: POR
16	LDO2OC_M	Inhibit INTERRUPT for LDO2 overcurrent
		0 INT not masked
		1 INT masked
		Reset condition: POR
13	BOOSTTSD_M	Inhibit INTERRUPT for BOOST overtemperature shutdown event
		0 INT not masked
		1 INT masked
		Reset condition: POR
12	BUCK1TSD_M	Inhibit INTERRUPT for BUCK1 overtemperature shutdown event
		0 INT not masked
		1 INT masked
		Reset condition: POR
11	BUCK2TSD_M	Inhibit INTERRUPT for BUCK2 overtemperature shutdown event
		0 INT not masked
		1 INT masked
		Reset condition: POR
10	BUCK3TSD_M	Inhibit INTERRUPT for BUCK3 overtemperature shutdown event
		0 INT not masked
		1 INT masked
		Reset condition: POR
9	LDO1TSD_M	Inhibit INTERRUPT for LDO1 overtemperature shutdown event
		0 INT not masked
		1 INT masked
		Reset condition: POR

Table 24. M_INT_MASK1 register bit description*...continued*

Bit	Symbol	Description
8	LDO2TSD_M	Inhibit INTERRUPT for LDO2 overtemperature shutdown event
		0 INT not masked
		1 INT masked
		Reset condition: POR

16.10 M_INT_MASK2 register

Table 25. M_INT_MASK2 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	0	0	0	0	VBOOSTOV_M	VBOSUVH_M	COM_M	VPRE_FB_OV_M
Read	RESERVED	RESERVED	RESERVED	RESERVED	VBOOSTOV_M	VBOSUVH_M	COM_M	VPRE_FB_OV_M
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	VBOOST_UVH_M	VSUPUV7_M	0	VPREUVH_M	VSUPUVL_M	VSUPUVH_M	WAKE1_M	WAKE2_M
Read	VBOOST_UVH_M	VSUPUV7_M	RESERVED	VPREUVH_M	VSUPUVL_M	VSUPUVH_M	WAKE1_M	WAKE2_M
Reset	0	0	0	0	0	0	0	0

Table 26. M_INT_MASK2 register bit description

Bit	Symbol	Description
19	VBOOSTOV_M	Inhibit INTERRUPT for VBOOST_OV any transition
		0 INT not masked
		1 INT masked
		Reset condition: POR
18	VBOSUVH_M	Inhibit INTERRUPT for VBOS_UVH any transition
		0 INT not masked
		1 INT masked
		Reset condition: POR
17	COM_M	Inhibit INTERRUPT for COM any transition
		0 INT not masked
		1 INT masked
		Reset condition: POR
16	VPRE_FB_OV_M	Inhibit INTERRUPT for VPRE_FB_OV
		0 INT not masked
		1 INT masked
		Reset condition: POR

Table 26. M_INT_MASK2 register bit description*...continued*

Bit	Symbol	Description
15	VBOOSTUVH_M	Inhibit INTERRUPT for VBOOST_UVH
		0 INT not masked
		1 INT masked
		Reset condition: POR
14	VSUPUV7_M	Inhibit INTERRUPT for VSUP_UV7
		0 INT not masked
		1 INT masked
		Reset condition: POR
12	VREUVH_M	Inhibit INTERRUPT for VPRE_UVH
		0 INT not masked
		1 INT masked
		Reset condition: POR
11	VSUPUVL_M	Inhibit INTERRUPT for VSUP_UVL
		0 INT not masked
		1 INT masked
		Reset condition: POR
10	VSUPUVH_M	Inhibit INTERRUPT for VSUP_UVH
		0 INT not masked
		1 INT masked
		Reset condition: POR
9	WAKE1_M	Inhibit INTERRUPT for WAKE1 any transition
		0 INT not masked
		1 INT masked
		Reset condition: POR
8	WAKE2_M	Inhibit INTERRUPT for WAKE2 any transition
		0 INT not masked
		1 INT masked
		Reset condition: POR

16.11 M_FLAG1 register

When the device starts up, it is recommended to clear all the flags by writing 1s on all bits.

Table 27. M_FLAG1 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	VBOSUVH	VBO OSTUVH	VPREOC	BUCK1OC	BUCK2OC	BUCK3OC	LDO1OC	LDO2OC
Read	VBOSUVH	VBO OSTUVH	VPREOC	BUCK1OC	BUCK2OC	BUCK3OC	LDO1OC	LDO2OC
Reset	1	1	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	VBOOSTOV	VBOOSTOT	BUCK1OT	BUCK2OT	BUCK3OT	LDO1OT	LDO2OT
Read	CLK_FIN_DIV_OK	VBOOSTOV	VBOOSTOT	BUCK1OT	BUCK2OT	BUCK3OT	LDO1OT	LDO2OT
Reset	0	0	0	0	0	0	0	0

Table 28. M_FLAG1 register bit description

Bit	Symbol	Description
23	VBOSUVH	VBOS undervoltage high event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
22	VBOOSTUVH	VBOOST undervoltage high event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
21	VPREOC	VPRE overcurrent event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
20	BUCK1OC	BUCK1 overcurrent event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
19	BUCK2OC	BUCK2 overcurrent event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
18	BUCK3OC	BUCK3 overcurrent
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
17	LDO1OC	LDO2 overcurrent
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
16	LDO2OC	LDO1 overcurrent
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)

Table 28. M_FLAG1 register bit description*...continued*

Bit	Symbol	Description
15	CLK_FIN_DIV_OK	CLK_FIN_DIV monitoring
		0 Not OK: FIN_{ERR_LONG} < CLK_FIN_DIV deviation < FIN_{ERR_SHORT}
		1 OK: FIN_{ERR_SHORT} < CLK_FIN_DIV deviation < FIN_{ERR_LONG}
		Reset condition: Real time information
14	VBOOSTOV	VBOOST overvoltage protection event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
13	VBOOSTOT	VBOOST overtemperature shutdown event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
12	BUCK1OT	BUCK1 overtemperature shutdown event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
11	BUCK2OT	BUCK2 overtemperature shutdown event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
10	BUCK3OT	BUCK3 overtemperature shutdown event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
9	LDO1OT	LDO1 overtemperature shutdown event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
8	LDO2OT	LDO2 overtemperature shutdown event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)

16.12 M_FLAG2 register

When the device starts up, it is recommended to clear all the flags by writing 1s on all bits.

Table 29. M_FLAG2 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	VPRE_ FB_OV	VSUPUV7	0	0	0	0	0	0
Read	VPRE_ FB_OV	VSUPUV7	BOOST_ST	BUCK1_ST	BUCK2_ST	BUCK3_ST	LDO1_ST	LDO2_ST
Reset	0	1	1	1	1	1	1	1

Bit	15	14	13	12	11	10	9	8
Write	VPREUVL	VPREUVH	VSUPUVL	VSUPUVH	0	0	WK2FLG	WK1FLG
Read	VPREUVL	VPREUVH	VSUPUVL	VSUPUVH	WK2RT	WK1RT	WK2FLG	WK1FLG
Reset	1	1	1	1	0	1	0	1

Note: *Reset value for FS8530, wake up by Wake1, all regulators started by default during power up sequence.*

Table 30. M_FLAG2 register bit description

Bit	Symbol	Description
23	VPRE_FB_OV	VPRE_FB_OV event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
22	VSUPUV7	VSUP_UV7 event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
21	BOOST_ST	BOOST state
		0 Regulator OFF
		1 Regulator ON
		Reset condition: Real time information
20	BUCK1_ST	BUCK1 state
		0 Regulator OFF
		1 Regulator ON
		Reset condition: Real time information
19	BUCK2_ST	BUCK2 state
		0 Regulator OFF
		1 Regulator ON
		Reset condition: Real time information
18	BUCK3_ST	BUCK3 state
		0 Regulator OFF
		1 Regulator ON
		Reset condition: Real time information

Table 30. M_FLAG2 register bit description*...continued*

Bit	Symbol	Description
17	LDO1_ST	LDO1 state
		0 regulator OFF
		1 regulator ON
		Reset condition: Real time information
16	LDO2_ST	LDO2 state
		0 regulator OFF
		1 regulator ON
		Reset condition: Real time information
15	VPREUVL	VPRE_UVL event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
14	VPREUVH	VPRE_UVH event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
13	VSUPUVL	VSUP_UVL event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
12	VSUPUVH	VSUP_UVH event
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
11	WK2RT	Report event: WAKE2 real time state
		0 WAKE2 is low level
		1 WAKE2 is high
		Reset condition: Real time information
10	WK1RT	Report event: WAKE1 real time state
		0 WAKE1 is low level
		1 WAKE1 is high
		Reset condition: Real time information
9	WK2FLG	WAKE2 wake up source flag
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)
8	WK1FLG	WAKE1 wake up source flag
		0 No event
		1 Event occurred
		Reset condition: POR / Clear on Write (write ‘1’)

16.13 M_VMON_REGx register

Table 31. M_VMON_REGx register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	0	0	0	0	VMON4_REG[2:0]			VMON3_REG[2]
Read	RESERVED	RESERVED	RESERVED	RESERVED	VMON4_REG[2:0]			VMON3_REG[2]
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	VMON3_REG[1:0]		VMON2_REG[2:0]			VMON1_REG[2:0]		
Read	VMON3_REG[1:0]		VMON2_REG[2:0]			VMON1_REG[2:0]		
Reset	0	0	0	0	0	0	0	0

Table 32. M_VMON_REGx register bit description

Bit	Symbol	Description
19 to 17	VMON4_REG[2:0]	Regulator assignment to VMON4
		000 External regulator
		001 VPRE
		010 LDO1
		011 LDO2
		100 BUCK2
		101 BUCK3
		11x External regulator
		Reset condition: POR
16 to 14	VMON3_REG[2:0]	Regulator assignment to VMON3
		000 External regulator
		001 VPRE
		010 LDO1
		011 LDO2
		100 BUCK2
		101 BUCK3
		11x External regulator
		Reset condition: POR

Table 32. M_VMON_REGx register bit description*...continued*

Bit	Symbol	Description
13 to 11	VMON2_REG[2:0]	Regulator assignment to VMON2
		000 External regulator
		001 VPRE
		010 LDO1
		011 LDO2
		100 BUCK2
		101 BUCK3
		11x External regulator
		Reset condition: POR
10 to 8	VMON1_REG[2:0]	Regulator assignment to VMON1
		000 External regulator
		001 VPRE
		010 LDO1
		011 LDO2
		100 BUCK2
		101 BUCK3
		11x External regulator
		Reset condition: POR

16.14 M_LVB1_SVS register

Table 33. M_LVB1_SVS register bit allocation

Bit	23	22	21	20	19	18	17	16
Read	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Read	RESERVED	RESERVED	RESERVED	LVB1_SVS[4:0]				
Reset	0	0	0	0	0	0	0	0

Table 34. M_LVB1_SVS register bit description

Bit	Symbol	Description
12 to 8	LVB1_SVS[4:0]	Static voltage scaling negative offset
		00000 0 mV
		00001 −6.25 mV
		00010 −12.50 mV
		00011 −18.75 mV
		00100 −25 mV
		00101 −31.25 mV
		00110 −37.5 mV
		00111 −43.75 mV
		01000 −50 mV
		01001 −56.25 mV
		01010 −62.5 mV
		01011 −68.75 mV
		01100 −75 mV
		01101 −81.25 mV
		01110 −87.5 mV
		01111 −93.75 mV
		10000 −100 mV
		Reset condition: POR

16.15 M_MEMORY0 register

Table 35. M_MEMORY0 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	MEMORY0[15:8]							
Read	MEMORY0[15:8]							
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	MEMORY0[7:0]							
Read	MEMORY0[7:0]							
Reset	0	0	0	0	0	0	0	0

Table 36. M_MEMORY0 register bit description

Bit	Symbol	Description
23 to 8	MEMORY0[15:0]	Free memory field for data storage
		0... 16 bits free memory ...1
		Reset condition: POR

16.16 M_MEMORY1 register

Table 37. M_MEMORY1 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	MEMORY1[15:8]							
Read	MEMORY1[15:8]							
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	MEMORY1[7:0]							
Read	MEMORY1[7:0]							
Reset	0	0	0	0	0	0	0	0

Table 38. M_MEMORY1 register bit description

Bit	Symbol	Description
23 to 8	MEMORY1[15:0]	Free memory field for data storage
		0… 16 bits free memory
		…1
		Reset condition: POR

16.17 M_DEVICEID register

Table 39. M_DEVICEID register bit allocation

Bit	23	22	21	20	19	18	17	16
Read	FMREV[3:0]				MMREV[3:0]			
Reset	0	0	1	1	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Read	DEVICEID[7:0]							
Reset	0	0	0	0	0	0	0	0

Table 40. M_DEVICEID register bit description

Bit	Symbol	Description
23 to 20	FMREV[3:0]	Full mask revision
		Full mask revision configured by metal connection
		Reset condition: POR
19 to 16	MMREV[3:0]	Metal Mask Revision
		Metal mask revision configured by metal connection
		Reset condition: POR
15 to 8	DEVICEID[7:0]	Device ID
		x…x Device ID from OTP_DEVICEID[7:0] bits
		Reset condition: POR

17 Fail-safe register mapping

17.1 Fail-safe writing registers overview

Table 41. Fail-safe writing registers overview

Logic	Register name	bit 23	bit 22	bit 21	bit 20	bit 19	bit 18	bit 17	bit 16
		bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8
Fail-safe	FS_I_OVUV_ SAFE_REACTION1	VCOREMON_OV_FS_IMPACT[1:0]		VCOREMON_UV_FS_IMPACT[1:0]		0	VCOREMON_ ABIST2	VDDIO_ABIST2	VMON1_ ABIST2
		VMON2_ ABIST2	VMON3_ ABIST2	VMON4_ ABIST2	0	VDDIO_OV_FS_IMPACT[1:0]		VDDIO_UV_FS_IMPACT[1:0]	
	FS_I_OVUV_ SAFE_REACTION2	VMON4_OV_FS_IMPACT[1:0]		VMON4_UV_FS_IMPACT[1:0]		VMON3_OV_FS_IMPACT[1:0]		VMON3_UV_FS_IMPACT[1:0]	
		VMON2_OV_FS_IMPACT[1:0]		VMON2_UV_FS_IMPACT[1:0]		VMON1_OV_FS_IMPACT[1:0]		VMON1_UV_FS_IMPACT[1:0]	
	FS_I_WD_CFG	WD_ERR_LIMIT[1:0]		0	WD_RFR_LIMIT[1:0]		0	WD_FS_IMPACT[1:0]	
		0	0	0	0	0	0	0	0
	FS_I_SAFE_ INPUTS	FCCU_CFG[1:0]		0	FCCU12_ FLT_POL	FCCU1_ FLT_POL	FCCU2_ FLT_POL	0	FCCU12_ FS_IMPACT
		FCCU1_ FS_IMPACT	FCCU2_ FS_IMPACT	0	ERRMON_ FLT_POL	ERRMON_ACK_TIME[1:0]		ERRMON_ FS_IMPACT	0
	FS_I_FSSM	FLT_ERR_CNT_LIMIT[1:0]		0	FLT_ERR_IMPACT[1:0]		0	RSTB_DUR	0
		FS0B_SC_ HIGH_CFG	0	CLK_MON_DIS	DIS_8s	0	0	0	0
	FS_I_SVS	SVS_OFFSET[4:0]					0	0	0
		0	0	0	0	0	0	0	0
	FS_WD_WINDOW	WDW_PERIOD [3:0]				0	WDW_DC[2:0]		
		0	0	0	0	WDW_RECOVERY[3:0]			
	FS_WD_SEED	WD_SEED[15:8]							
		WD_ SEED[7:0]							
	FS_WD_ANSWER	WD_ANSWER[15:8]							
		WD_ANSWER[7:0]							
	FS_OVUVREG_ STATUS	VCOREMON_ OV	VCOREMON_ UV	VDDIO_OV	VDDIO_UV	VMON4_OV	VMON4_UV	VMON3_OV	VMON3_UV
		VMON2_OV	VMON2_UV	VMON1_OV	VMON1_UV	0	FS_DIG_ REF_OV	FS_OSC_DRIFT	0
	FS_RELEASE_FS0 B	RELEASE_FS0B[15:8]							
		RELEASE_FS0B[7:0]							
	FS_SAFE_IOS	PGOOD_DIAG	PGOOD_ EVENT	0	EXT_RSTB	0	0	RSTB_EVENT	RSTB_DIAG
		RSTB_REQ	0	0	FS0B_DIAG	FS0B_REQ	GOTO_INITFS	0	0
	FS_DIAG_SAFETY	FCCU12	FCCU1	FCCU2	ERRMON_ACK	ERRMON	0	BAD_WD_DATA	BAD_WD_ TIMING
		0	0	SPI_FS_CLK	SPI_FS_REQ	SPI_FS_CRC	I2C_FS_CRC	I2C_FS_REQ	0
	FS_INTB_MASK	0	0	0	0	0	0	INT_INH_ VMON4_OV_UV	INT_INH_ VMON3_OV_UV
		INT_INH_ VMON2_OV_UV	INT_INH_ VMON1_OV_UV	INT_INH_ VDDIO_OV_UV	INT_INH_ VCOREMON_ OV_UV	INT_INH_BAD_ WD_REFRESH	INT_INH_ ERRMON	INT_INH_ FCCU2	INT_INH_ FCCU1
	FS_STATES	0	DBG_EXIT	0	0	OTP_ CORRUPT	0	REG_ CORRUPT	0
		0	0	0	0	0	0	0	0

17.2 Fail-safe reading registers overview

Table 42. Fail-safe reading registers overview

Logic	Register name	bit 23	bit 22	bit 21	bit 20	bit 19	bit 18	bit 17	bit 16
		bit 15	bit 14	bit 13	bit 12	bit 11	bit 10	bit 9	bit 8
Fail-safe	FS_GRL_FLAGS	FS_COM_G	FS_WD_G	FS_IO_G	FS_REG_OVUV_G	RESERVED	RESERVED	RESERVED	RESERVED
		RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
	FS_I_OVUV_SAFE_REACTION1	VCOREMON_OV_FS_IMPACT[1:0]		VCOREMON_UV_FS_IMPACT[1:0]		RESERVED	VCOREMON_ABIST2	VDDIO_ABIST2	VMON1_ABIST2
		VMON2_ABIST2	VMON3_ABIST2	VMON4_ABIST2	RESERVED	VDDIO_OV_FS_IMPACT[1:0]		VDDIO_UV_FS_IMPACT[1:0]	
	FS_I_OVUV_SAFE_REACTION2	VMON4_OV_FS_IMPACT[1:0]		VMON4_UV_FS_IMPACT[1:0]		VMON3_OV_FS_IMPACT[1:0]		VMON3_UV_FS_IMPACT[1:0]	
		VMON2_OV_FS_IMPACT[1:0]		VMON2_UV_FS_IMPACT[1:0]		VMON1_OV_FS_IMPACT[1:0]		VMON1_UV_FS_IMPACT[1:0]	
	FS_I_WD_CFG	WD_ERR_LIMIT[1:0]		RESERVED	WD_RFR_LIMIT[1:0]		RESERVED	WD_FS_IMPACT[1:0]	
		RESERVED	WD_RFR_CNT[2:0]			WD_ERR_CNT[3:0]			
	FS_I_SAFE_INPUTS	FCCU_CFG[1:0]		RESERVED	FCCU12_FLT_POL	FCCU1_FLT_POL	FCCU2_FLT_POL	RESERVED	FCCU12_FS_IMPACT
		FCCU1_FS_IMPACT	FCCU2_FS_IMPACT	RESERVED	ERRMON_FLT_POL	ERRMON_ACK_TIME[1:0]		ERRMON_FS_IMPACT	RESERVED
	FS_I_FSSM	FLT_ERR_CNT_LIMIT[1:0]		RESERVED	FLT_ERR_IMPACT[1:0]		RESERVED	RSTB_DUR	RESERVED
		FS0B_SC_HIGH_CFG	RESERVED	CLK_MON_DIS	DIS_8s	FLT_ERR_CNT[3:0]			
	FS_I_SVS	SVS_OFFSET[4:0]					RESERVED	RESERVED	RESERVED
		RESERVED	RESERVED	reserved	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
	FS_WD_WINDOW	WDW_PERIOD[3:0]				RESERVED	WDW_DC[2:0]		
		RESERVED	RESERVED	RESERVED	RESERVED	WDW_RECOVERY[3:0]			
	FS_WD_SEED	WD_ SEED[15:8]							
		WD_ SEED[7:0]							
	FS_WD_ANSWER	WD_ANSWER[15:8]							
		WD_ANSWER[7:0]							
	FS_OVUVREG_STATUS	VCOREMON_OV	VCOREMON_UV	VDDIO_OV	VDDIO_UV	VMON4_OV	VMON4_UV	VMON3_OV	VMON3_UV
		VMON2_OV	VMON2_UV	VMON1_OV	VMON1_UV	RESERVED	FS_DIG_REF_OV	FS_OSC_DRIFT	RESERVED
	FS_RELEASE_FS0B	RELEASE_FS0B[15:8]							
		RELEASE_FS0B[7:0]							
	FS_SAFE_IOS	PGOOD_DIAG	PGOOD_EVENT	PGOOD_SNS	EXT_RSTB	RSTB_DRV	RSTB_SNS	RSTB_EVENT	RSTB_DIAG
		RESERVED	FS0B_DRV	FS0B_SNS	FS0B_DIAG	RESERVED	RESERVED	FCCU2_RT	FCCU1_RT
	FS_DIAG_SAFETY	FCCU12	FCCU1	FCCU2	RESERVED	ERRMON	ERRMON_STATUS	BAD_WD_DATA	BAD_WD_TIMING
		ABIST1_OK	ABIST2_OK	SPI_FS_CLK	SPI_FS_REQ	SPI_FS_CRC	I2C_FS_CRC	I2C_FS_REQ	LBIST_OK
	FS_INTB_MASK	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	INT_INH_VMON4_OV_UV	INT_INH_VMON4_OV_UV
		INT_INH_VMON2_OV_UV	INT_INH_VMON1_OV_UV	INT_INH_VDDIO_OV_UV	INT_INH_VCOREMON_OV_UV	INT_INH_BAD_WD_REFRESH	INT_INH_ERRMON	INT_INH_FCCU2	INT_INH_FCCU1
	FS_STATES	RESERVED	RESERVED	DBG_MODE	RESERVED	OTP_CORRUPT	RESERVED	REG_CORRUPT	RESERVED
		RESERVED	RESERVED	RESERVED	FSM_STATE[4:0]				

17.3 FS_GRL_FLAGS register

Table 43. FS_GRL_FLAGS register bit allocation

Bit	23	22	21	20	19	18	17	16
Read	FS_COM_G	FS_WD_G	FS_IO_G	FS_REG_OVUV_G	RESERVED	RESERVED	RESERVED	RESERVED
Reset	0	0	0	1	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Read	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
Reset	0	0	0	0	0	0	0	0

Table 44. FS_GRL_FLAGS register bit description

Bit	Symbol	Description
23	FS_COM_G	Report an issue in the communication (SPI or I2C) **FS_COM_G** = SPI_FS_CLK or SPI_FS_REQ or SPI_FS_CRC or I2C_FS_CRC or I2C_FS_REQ
		0 No failure
		1 Failure
		Reset condition: Real time information - cleared when all individual bits are cleared
22	FS_WD_G	Report an issue on the watchdog refresh **FS_WD_G** = BAD_WD_DATA or BAD_WD_TIMING
		0 Good WD refresh
		1 Bad WD refresh
		Reset condition: Real time information - cleared when all individual bits are cleared
21	FS_IO_G	Report an issue in one of the fail-safe IOs **FS_IO_G** = PGOOD_DIAG or RSTB_DIAG or FS0B_DIAG
		0 No failure
		1 Failure
		Reset condition: real time information - cleared when all individual bits are cleared
20	FS_REG_OVUV_G	Report an issue in one of the voltage monitoring (OV or UV) **FS_REG_OVUV_G** = VCOREMON_OV or VCOREMON_UV or VDDIO_OV or VDDIO_UV or VMON4_OV or VMON4_UV or VMON3_OV or VMON3_UV or VMON2_OV or VMON2_UV or VMON1_OV or VMON1_UV
		0 No failure
		1 Failure
		Reset condition: real time information - cleared when all individual bits are cleared

17.4 FS_I_OVUV_SAFE_REACTION1 register

Table 45. FS_I_OVUV_SAFE_REACTION1 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	VCOREMON_OV_FS_IMPACT[1:0]		VCOREMON_UV_FS_IMPACT[1:0]		0	VCOREMON_ABIST2	VDDIO_ABIST2	VMON1_ABIST2
Read	VCOREMON_OV_FS_IMPACT[1:0]		VCOREMON_UV_FS_IMPACT[1:0]		RESERVED	VCOREMON_ABIST2	VDDIO_ABIST2	VMON1_ABIST2
Reset	1	1	0	1	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	VMON2_ABIST2	VMON3_ABIST2	VMON4_ABIST2	0	VDDIO_OV_FS_IMPACT[1:0]		VDDIO_UV_FS_IMPACT[1:0]	
Read	VMON2_ABIST2	VMON3_ABIST2	VMON4_ABIST2	RESERVED	VDDIO_OV_FS_IMPACT[1:0]		VDDIO_UV_FS_IMPACT[1:0]	
Reset	0	0	0	0	1	1	0	1

Table 46. FS_I_OVUV_SAFE_REACTION1 register bit description

Bit	Symbol	Description
23 to 22	VCOREMON_OV_FS_IMPACT[1:0]	Table 117
21 to 20	VCOREMON_UV_FS_IMPACT[1:0]	Table 117
18	VCOREMON_ABIST2	VCOREMON ABIST2 configuration
		0 No ABIST
		1 VCOREMON BIST executed during ABIST2
		Reset condition: POR
17	VDDIO_ABIST2	VDDIO ABIST2 configuration
		0 No ABIST
		1 VDDIO BIST executed during ABIST2
		Reset condition: POR
16	VMON1_ABIST2	VMON1 ABIST2 configuration
		0 No ABIST
		1 VMON1 BIST executed during ABIST2
		Reset condition: POR
15	VMON2_ABIST2	VMON2 ABIST2 configuration
		0 No ABIST
		1 VMON2 BIST executed during ABIST2
		Reset condition: POR
14	VMON3_ABIST2	VMON3 ABIST2 configuration
		0 No ABIST
		1 VMON3 BIST executed during ABIST2
		Reset condition: POR

Table 46. FS_I_OVUV_SAFE_REACTION1 register bit description...*continued*

Bit	Symbol	Description
13	VMON4_ABIST2	VMON4 ABIST2 configuration
		0 No ABIST
		1 VMON4 BIST executed during ABIST2
		Reset condition: POR
11 to 10	VDDIO_OV_FS_IMPACT[1:0]	Table 120
9 to 8	VDDIO_UV_FS_IMPACT[1:0]	Table 120

17.5 FS_I_OVUV_SAFE_REACTION2 register

Table 47. FS_I_OVUV_SAFE_REACTION2 register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	VMON4_OV_FS_IMPACT[1:0]		VMON4_UV_FS_IMPACT[1:0]		VMON3_OV_FS_IMPACT[1:0]		VMON3_UV_FS_IMPACT[1:0]	
Read	VMON4_OV_FS_IMPACT[1:0]		VMON4_UV_FS_IMPACT[1:0]		VMON3_OV_FS_IMPACT[1:0]		VMON3_UV_FS_IMPACT[1:0]	
Reset	1	1	0	1	1	1	0	1

Bit	15	14	13	12	11	10	9	8
Write	VMON2_OV_FS_IMPACT[1:0]		VMON2_UV_FS_IMPACT[1:0]		VMON1_OV_FS_IMPACT[1:0]		VMON1_UV_FS_IMPACT[1:0]	
Read	VMON2_OV_FS_IMPACT[1:0]		VMON2_UV_FS_IMPACT[1:0]		VMON1_OV_FS_IMPACT[1:0]		VMON1_UV_FS_IMPACT[1:0]	
Reset	1	1	0	1	1	1	0	1

Table 48. FS_I_OVUV_SAFE_REACTION2 register bit description

Bit	Symbol	Description
23 to 22	VMON4_OV_FS_IMPACT[1:0]	See Table 122
21 to 20	VMON4_UV_FS_IMPACT[1:0]	
19 to 18	VMON3_OV_FS_IMPACT[1:0]	
17 to 16	VMON3_UV_FS_IMPACT[1:0]	
15 to 14	VMON2_OV_FS_IMPACT[1:0]	
13 to 12	VMON2_UV_FS_IMPACT[1:0]	
11 to 10	VMON1_OV_FS_IMPACT[1:0]	
9 to 8	VMON1_UV_FS_IMPACT[1:0]	

17.6 FS_I_WD_CFG register

Table 49. FS_I_WD_CFG register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	WD_ERR_LIMIT[1:0]		0	WD_RFR_LIMIT[1:0]		0	WD_FS_IMPACT[1:0]	
Read	WD_ERR_LIMIT[1:0]		RESERVED	WD_RFR_LIMIT[1:0]		RESERVED	WD_FS_IMPACT[1:0]	
Reset	0	1	0	0	0	0	1	0

Bit	15	14	13	12	11	10	9	8
Write	0	0	0	0	0	0	0	0
Read	RESERVED	WD_RFR_CNT[2:0]			WD_ERR_CNT[3:0]			
Reset	0	0	0	0	0	0	0	0

Table 50. FS_I_WD_CFG register bit description

Bit	Symbol	Description
23 to 22	WD_ERR_LIMIT[1:0]	See Table 107
20 to 19	WD_RFR_LIMIT[1:0]	See Table 108
17 to 16	WD_FS_IMPACT[1:0]	See Table 109
14 to 12	WD_RFR_CNT[2:0]	Reflect the value of the watchdog refresh counter
		000 0
		001 1
		010 2
		011 3
		100 4
		101 5
		110 6
		111 7
		Reset condition: POR
11 to 8	WD_ERR_CNT[3:0]	Reflect the value of the watchdog error counter
		0000 0
		0001 1
		0010 2
		0011 3
		0100 4
		0101 5
		0110 6
		0111 7
		1000 8
		Reset condition: POR

17.7 FS_I_SAFE_INPUTS register

Table 51. FS_I_SAFE_INPUTS register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	FCCU_CFG[1:0]		0	FCCU12_ FLT_POL	FCCU1_ FLT_POL	FCCU2_ FLT_POL	0	FCCU12_ FS_IMPACT
Read	FCCU_CFG[1:0]		RESERVED	FCCU12_ FLT_POL	FCCU1_ FLT_POL	FCCU2_ FLT_POL	RESERVED	FCCU12_ FS_IMPACT
Reset	0	1	0	0	0	0	0	1

Bit	15	14	13	12	11	10	9	8
Write	FCCU1_ FS_IMPACT	FCCU2_ FS_IMPACT	0	ERRMON_ FLT_POL	ERRMON_ACK_TIME[1:0]		ERRMON_ FS_IMPACT	0
Read	FCCU1_ FS_IMPACT	FCCU2_ FS_IMPACT	RESERVED	ERRMON_ FLT_POL	ERRMON_ACK_TIME[1:0]		ERRMON_ FS_IMPACT	RESERVED
Reset	1	1	0	0	0	1	1	0

Table 52. FS_I_SAFE_INPUTS register bit description

Bit	Symbol	Description
23 to 22	FCCU_CFG[1:0]	See Table 111
20	FCCU12_FLT_POL	See Table 112
19	FCCU1_FLT_POL	See Table 114
18	FCCU2_FLT_POL	See Table 114
16	FCCU12_FS_IMPACT	See Table 113
15	FCCU1_FS_IMPACT	See Table 115
14	FCCU2_FS_IMPACT	See Table 115
12	ERRMON_FLT_POL	See Table 124
11 to 10	ERRMON_ACK_TIME[1:0]	See Table 125
9	ERRMON_FS_IMPACT	See Table 126

17.8 FS_I_FSSM register

Table 53. FS_I_FSSM register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	FLT_ERR_CNT_LIMIT[1:0]		0	FLT_ERR_IMPACT[1:0]		0	RSTB_DUR	0
Read	FLT_ERR_CNT_LIMIT[1:0]		RESERVED	FLT_ERR_IMPACT[1:0]		RESERVED	RSTB_DUR	RESERVED
Reset	0	1	0	1	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	FS0B_SC_ HIGH_CFG	0	CLK_ MON_DIS	DIS_8s	0	0	0	0
Read	FS0B_SC_ HIGH_CFG	RESERVED	CLK_ MON_DIS	DIS_8s	FLT_ERR_CNT[3:0]			
Reset	1	0	0	0	0	0	0	1

Table 54. FS_I_FSSM register bit description

Bit	Symbol	Description
23 to 22	FLT_ERR_CNT_LIMIT[1:0]	See Table 128
20 to 19	FLT_ERR_IMPACT[1:0]	See Table 129
17	RSTB_DUR	RSTB pulse duration configuration
		0 10 ms
		1 1.0 ms
		Reset condition: POR

Table 54. FS_I_FSSM register bit description*...continued*

Bit	Symbol	Description
15	FS0B_SC_HIGH_CFG	Assert RSTB in case of a short to high detected on FS0B
		0 RSTB is not asserted
		1 RSTB is asserted
		Reset condition: POR
13	CLK_MON_DIS	Disable clock monitoring
		0 Clock monitoring enabled
		1 Clock monitoring disabled
		Reset condition: POR
12	DIS_8s	Disable 8 s timer
		0 RSTB low 8 s counter enabled
		1 RSTB low 8 s counter disabled
		Reset condition: POR
11 to 8	FLT_ERR_CNT[3:0]	Reflect the value of the fault error counter
		0000 0
		0001 1
		0010 2
		0011 3
		0100 4
		0101 5
		0110 6
		0111 7
		1000 8
		1001 9
		1010 10
		1011 11
		1100 12
		Reset condition: Real time information

17.9 FS_I_SVS register

Table 55. FS_I_SVS register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	SVS_OFFSET[4:0]					0	0	0
Read	SVS_OFFSET[4:0]					RESERVED	RESERVED	RESERVED
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	0	0	0	0	0	0	0
Read	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
Reset	0	0	0	0	0	0	0	0

Table 56. FS_I_SVS register bit description

Bit	Symbol	Description
23 to 19	SVS_OFFSET[4:0]	Static voltage scaling negative offset
		0 0000 0 mV
		0 0001 −6.25 mV
		0 0010 −12.50 mV
		0 0011 −18.75 mV
		0 0100 −25 mV
		0 0101 −31.25 mV
		0 0110 −37.5 mV
		0 0111 −43.75 mV
		0 1000 −50 mV
		0 1001 −56.25 mV
		0 1010 −62.5 mV
		0 1011 −68.75 mV
		0 1100 −75 mV
		0 1101 −81.25 mV
		0 1110 −87.5 mV
		0 1111 −93.75 mV
		1 0000 −100 mV
		Reset condition: POR

17.10 FS_WD_WINDOW register

Table 57. FS_WD_WINDOW register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	WDW_PERIOD [3:0]				0	WDW_DC[2:0]		
Read	WDW_PERIOD[3:0]				RESERVED	WDW_DC[2:0]		
Reset	0	0	1	1	0	0	1	0

Bit	15	14	13	12	11	10	9	8
Write	0	0	0	0	WDW_RECOVERY[3:0]			
Read	RESERVED	RESERVED	RESERVED	RESERVED	WDW_RECOVERY[3:0]			
Reset	0	0	0	0	1	0	1	1

Table 58. FS_WD_WINDOW register bit description

Bit	Symbol	Description
23 to 20	WDW_PERIOD[3:0]	See Table 105
18 to 16	WDW_DC[2:0]	See Table 106
11 to 8	WDW_RECOVERY[3:0]	See Table 110

17.11 FS_WD_SEED register

Table 59. FS_WD_SEED register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	WD_SEED[15:8]							
Read	WD_ SEED[15:8]							
Reset	0	1	0	1	1	0	1	0

Bit	15	14	13	12	11	10	9	8
Write	WD_ SEED[7:0]							
Read	WD_ SEED[7:0]							
Reset	1	0	1	1	0	0	1	0

Table 60. FS_WD_SEED register bit description

Bit	Symbol	Description
23 to 8	WD_SEED [15:0]	Watchdog LFSR value
		0… 0x5AB2 default value at startup …1
		Reset condition: POR

17.12 FS_WD_ANSWER register

Table 61. FS_WD_ANSWER register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	WD_ANSWER[15:8]							
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	WD_ANSWER[7:0]							
Reset	0	0	0	0	0	0	0	0

Table 62. FS_WD_ANSWER register bit description

Bit	Symbol	Description
23 to 8	WD_ANSWER[15:0]	Watchdog answer value from the MCU
		0… Challenger WD answer = (NOT(((LFSR x 4)+6)–4))/4 (see Section 32.4.1) …1 Simple WD answer = 0x5AB2 (see Section 32.4.2)
		Reset condition: POR

17.13 FS_OVUVREG_STATUS register

Table 63. FS_OVUVREG_STATUS register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	VCOREMON_OV	VCOREMON_UV	VDDIO_OV	VDDIO_UV	VMON4_OV	VMON4_UV	VMON3_OV	VMON3_UV
Read	VCOREMON_OV	VCOREMON_UV	VDDIO_OV	VDDIO_UV	VMON4_OV	VMON4_UV	VMON3_OV	VMON3_UV
Reset	0	1	0	1	0	1	0	1

Bit	15	14	13	12	11	10	9	8
Write	VMON2_OV	VMON2_UV	VMON1_OV	VMON1_UV	0	FS_DIG_REF_OV	FS_OSC_DRIFT	0
Read	VMON2_OV	VMON2_UV	VMON1_OV	VMON1_UV	RESERVED	FS_DIG_REF_OV	FS_OSC_DRIFT	RESERVED
Reset	0	1	0	1	0	0	0	0

Table 64. FS_OVUVREG_STATUS register bit description

Bit	Symbol	Description
23	VCOREMON_OV	Overvoltage monitoring on VCOREMON
		0 No overvoltage
		1 Overvoltage reported on VCOREMON
		Reset condition: POR / clear on write (write ‘1’)
22	VCOREMON_UV	Undervoltage monitoring on VCOREMON
		0 No undervoltage
		1 Undervoltage reported on VCOREMON
		Reset condition: POR / clear on write (write ‘1’)
21	VDDIO_OV	Overvoltage monitoring on VDDIO
		0 No overvoltage
		1 Overvoltage reported on VDDIO
		Reset condition POR / clear on write (write ‘1’)
20	VDDIO_UV	Undervoltage monitoring on VDDIO
		0 No undervoltage
		1 Undervoltage reported on VDDIO
		Reset condition: POR / clear on write (write ‘1’)
19	VMON4_OV	Overvoltage monitoring on VMON4
		0 No overvoltage
		1 Overvoltage reported on VMON4
		Reset condition: POR / clear on write (write ‘1’)
18	VMON4_UV	Undervoltage monitoring on VMON4
		0 No undervoltage
		1 Undervoltage reported on VMON4
		Reset condition: POR / clear on write (write ‘1’)

Table 64. FS_OVUVREG_STATUS register bit description*...continued*

Bit	Symbol	Description
17	VMON3_OV	Overvoltage monitoring on VMON3
		0 No overvoltage
		1 Overvoltage reported on VMON3
		Reset condition: POR / clear on write (write '1')
16	VMON3_UV	Undervoltage monitoring on VMON3
		0 No Undervoltage
		1 Undervoltage reported on VMON3
		Reset condition: POR / clear on write (write '1')
15	VMON2_OV	Overvoltage monitoring on VMON2
		0 No overvoltage
		1 Overvoltage reported on VMON2
		Reset condition: POR / clear on write (write '1')
14	VMON2_UV	Undervoltage monitoring on VMON2
		0 No undervoltage
		1 Undervoltage reported on VMON2
		Reset condition: POR / clear on write (write '1')
13	VMON1_OV	Overvoltage monitoring on VMON1
		0 No overvoltage
		1 Overvoltage reported on VMON1
		Reset condition: POR / clear on write (write '1')
12	VMON1_UV	Undervoltage monitoring on VMON1
		0 No undervoltage
		1 Undervoltage reported on VMON1
		Reset condition: POR / clear on write (write '1')
10	FS_DIG_REF_OV	Overvoltage of the internal digital fail-safe reference voltage
		0 No overvoltage
		1 Overvoltage reported of the internal digital fail-safe reference voltage
		Reset condition: POR / clear on write (write '1')
9	FS_OSC_DRIFT	Drift of the fail-safe OSC
		0 No drift
		1 Oscillator drift
		Reset condition: POR / clear on write (write '1')

17.14 FS_RELEASE_FS0B register

Table 65. FS_RELEASE_FS0B register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	RELEASE_FS0B[15:8]							
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	RELEASE_FS0B[7:0]							
Reset	0	0	0	0	0	0	0	0

Table 66. FS_RELEASE_FS0B register bit description

Bit	Symbol	Description
23 to 8	RELEASE_FS0B [15:0]	Secure 16-bits word to release FS0B
		0... Depend on WD_SEED value and calculation. See Section 32.9.4 "FS0B release".
		...1
		Reset condition: POR

17.15 FS_SAFE_IOs register

Table 67. FS_SAFE_IOS register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	PGOOD_ DIAG	PGOOD_ EVENT	0	EXT_RSTB	0	0	RSTB_ EVENT	RSTB_DIAG
Read	PGOOD_ DIAG	PGOOD_ EVENT	PGOOD_ SNS	EXT_RSTB	RSTB_DRV	RSTB_SNS	RSTB_ EVENT	RSTB_DIAG
Reset	0	1	0	0	0	0	1	0

Bit	15	14	13	12	11	10	9	8
Write	RSTB_REQ	0	0	FS0B_DIAG	FS0B_REQ	GOTO_ INITFS	0	0
Read	RESERVED	FS0B_DRV	FS0B_SNS	FS0B_DIAG	RESERVED	RESERVED	FCCU2_RT	FCCU1_RT
Reset	0	0	0	0	0	0	0	0

Table 68. FS_SAFE_IOS register bit description

Bit	Symbol	Description
23	PGOOD_DIAG	Report a PGOOD Short to High
		0 No failure
		1 Short circuit HIGH
		Reset condition: POR / clear on write (write ‘1’)
22	PGOOD_EVENT	Report a Power GOOD event
		0 No Power GOOD
		1 Power GOOD event occurred
		Reset condition: POR / clear on write (write ‘1’)
21	PGOOD_SNS	Sense of PGOOD pad
		0 PGOOD pad sensed low
		1 PGOOD pad sensed high
		Reset condition: Real time information

Table 68. FS_SAFE_IOS register bit description*...continued*

Bit	Symbol	Description
20	EXT_RSTB	Report an external RESET
		0 No external RESET
		1 External RESET
		Reset condition: POR / clear on write (write '1')
19	RSTB_DRV	RSTB driver – digital command
		0 RSTB driver command sensed low
		1 RSTB driver command sensed high
		Reset condition: Real time information
18	RSTB_SNS	Sense of RSTB pad
		0 RSTB pad sensed low
		1 RSTB pad sensed high
		Reset condition: Real time information
17	RSTB_EVENT	Report a RSTB event
		0 No RESET
		1 RESET occurred
		Reset condition: POR / clear on write (write '1')
16	RSTB_DIAG	Report a RSTB short to high
		0 No failure
		1 Short circuit high
		Reset condition: POR / clear on write (write '1')
15	RSTB_REQ	Request assertion of RSTB (Pulse)
		0 No assertion
		1 RSTB assertion (pulse)
		Reset condition: POR
14	FS0B_DRV	FS0B driver – digital command
		0 FS0B driver command sensed low
		1 FS0B driver command sensed high
		Reset condition: Real time information
13	FS0B_SNS	Sense of FS0B pad
		0 FS0B pad sensed low
		1 FS0B pad sensed high
		Reset condition: Real time information
12	FS0B_DIAG	Report a failure on FS0B
		0 No failure
		1 Short circuit high
		Reset condition: POR / clear on write (write '1')
11	FS0B_REQ	Request assertion of FS0B
		0 No assertion
		1 FS0B assertion
		Reset condition: POR

Table 68. FS_SAFE_IOS register bit description*...continued*

Bit	Symbol	Description
10	GOTO_INITFS	Go back to INIT fail-safe request
		0 No action
		1 Go back to INIT_FS
		Reset condition: POR
9	FCCU2_RT	Report FCCU2 pin level
		0 LOW level
		1 HIGH level
		Reset condition: Real time information
8	FCCU1_RT	Report FCCU1 pin level
		0 LOW level
		1 HIGH level
		Reset condition: Real time information

17.16 FS_DIAG_SAFETY register

Table 69. FS_DIAG_SAFETY register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	FCCU12	FCCU1	FCCU2	ERRMON_ ACK	ERRMON	0	BAD_ WD_DATA	BAD_WD_ TIMING
Read	FCCU12	FCCU1	FCCU2	RESERVED	ERRMON	ERRMON_ STATUS	BAD_ WD_DATA	BAD_WD_ TIMING
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	0	SPI_FS_CLK	SPI_FS_REQ	SPI_FS_CRC	I2C_FS_CRC	I2C_FS_REQ	0
Read	ABIST1_OK	ABIST2_OK	SPI_FS_CLK	SPI_FS_REQ	SPI_FS_CRC	I2C_FS_CRC	I2C_FS_REQ	LBIST_OK
Reset	1	0	0	0	0	0	0	1

Table 70. FS_DIAG_SAFETY register bit description

Bit	Symbol	Description
23	FCCU12	Report an error in the FCCU12 input
		0 No error
		1 Error detected
		Reset condition: POR / clear on write (write ‘1’)
22	FCCU1	Report an error in the FCCU1 input
		0 No error
		1 Error detected
		Reset condition: POR / clear on write (write ‘1’)

Table 70. FS_DIAG_SAFETY register bit description*...continued*

Bit	Symbol	Description
21	FCCU2	Report an error in the FCCU2 input
		0 No error
		1 Error detected
		Reset condition: POR / clear on write (write '1')
20	ERRMON_ACK	Acknowledge ERRMON failure detection from MCU
		0 No effect
		1 Acknowledge ERRMON failure detection
		Reset condition: POR
19	ERRMON	Report an error in the ERRMON input
		0 No error
		1 Error detected
		Reset condition: POR / clear on write (write '1')
18	ERRMON_STATUS	Report ERRMON pin level
		0 LOW level
		1 HIGH level
		Reset condition: Real time information
17	BAD_WD_DATA	WD refresh status - Data
		0 Good WD refresh
		1 Bad WD refresh, error in the DATA
		Reset condition: POR / clear on write (write '1')
16	BAD_WD_TIMING	WD refresh status - Timing
		0 Good WD refresh
		1 Bad WD refresh, wrong window or in timeout
		Reset condition: POR / clear on write (write '1')
15	ABIST1_OK	Diagnostic of Analog BIST1
		0 ABIST1 FAIL
		1 ABIST1 PASS
		Reset condition: Real time information
14	ABIST2_OK	Diagnostic of Analog BIST2
		0 ABIST2 FAIL or NOT EXECUTED
		1 ABIST2 PASS
		Reset condition: Real time information
13	SPI_FS_CLK	Fail-safe SPI SCLK error detection
		0 No error
		1 Wrong number of clock cycles (<32 or >32)
		Reset condition: POR / clear on write (write '1')
12	SPI_FS_REQ	Invalid fail-safe SPI access (wrong write or read, write to INIT registers in Normal mode, wrong address)
		0 No error
		1 SPI violation
		Reset condition: POR / clear on write (write '1')

Table 70. FS_DIAG_SAFETY register bit description*...continued*

Bit	Symbol	Description
11	SPI_FS_CRC	Fail-safe SPI communication CRC issue
		0 No error
		1 Error detected in the CRC
		Reset condition: POR / clear on write (write '1')
10	I2C_FS_CRC	Fail-safe I2C communication CRC issue
		0 No error
		1 Error detected in the CRC
		Reset condition: POR / clear on write (write '1')
9	I2C_FS_REQ	Invalid fail-safe I2C access (wrong write or read, write to INIT registers in normal mode, wrong address)
		0 No error
		1 I2C violation
		Reset condition: POR / clear on write (write '1')
8	LBIST_OK	Diagnostic of Logical BIST
		0 LBIST FAIL
		1 LBIST PASS
		Reset condition: Real time information

17.17 FS_INTB_MASK register

Table 71. FS_INTB_MASK register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	0	0	0	0	0	0	INT_INH_VMON4_OV_UV	INT_INH_VMON3_OV_UV
Read	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	INT_INH_VMON4_OV_UV	INT_INH_VMON4_OV_UV
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	INT_INH_VMON2_OV_UV	INT_INH_VMON1_OV_UV	INT_INH_VDDIO_OV_UV	INT_INH_VCOREMON_OV_UV	INT_INH_BAD_WD_REFRESH	INT_INH_ERRMON	INT_INH_FCCU2	INT_INH_FCCU1
Read	INT_INH_VMON2_OV_UV	INT_INH_VMON1_OV_UV	INT_INH_VDDIO_OV_UV	INT_INH_VCOREMON_OV_UV	INT_INH_BAD_WD_REFRESH	INT_INH_ERRMON	INT_INH_FCCU2	INT_INH_FCCU1
Reset	0	0	0	0	0	0	0	0

Table 72. FS_INTB_MASK register bit description

Bit	Symbol	Description
17	INT_INH_VMON4_OV_UV	Inhibit INTERRUPT on VMON4 OV and UV event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
16	INT_INH_VMON3_OV_UV	Inhibit INTERRUPT on VMON3 OV and UV event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
15	INT_INH_VMON2_OV_UV	Inhibit INTERRUPT on VMON2 OV and UV event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
14	INT_INH_VMON1_OV_UV	Inhibit INTERRUPT on VMON1 OV and UV event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
13	INT_INH_VDDIO_OV_UV	Inhibit INTERRUPT on VDDIO OV and UV event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
12	INT_INH_VCOREMON_OV_UV	Inhibit INTERRUPT on VCOREMON OV and UV event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
11	INT_INH_BAD_WD_REFRESH	Inhibit INTERRUPT on bad WD refresh event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
10	INT_INH_ERRMON	Inhibit INTERRUPT on ERRMON event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
9	INT_INH_FCCU2	Inhibit INTERRUPT on FCCU2 event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR
8	INT_INH_FCCU1	Inhibit INTERRUPT on FCCU1 event
		0 Interruption NOT MASKED
		1 Interruption MASKED
		Reset condition: POR

17.18 FS_STATES register

Table 73. FS_STATES register bit allocation

Bit	23	22	21	20	19	18	17	16
Write	0	DBG_EXIT	0	0	OTP_ CORRUPT	0	REG_ CORRUPT	0
Read	RESERVED	RESERVED	DBG_MODE	RESERVED	OTP_ CORRUPT	RESERVED	REG_ CORRUPT	RESERVED
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
Write	0	0	0	0	0	0	0	0
Read	RESERVED	RESERVED	RESERVED	FSM_STATE |4:0]				
Reset	0	0	0	0	0	1	1	0

Table 74. FS_STATES register bit description

Bit	Symbol	Description
22	DBG_EXIT	Leave DEBUG mode
		0 No action
		1 Leave DEBUG mode
		Reset condition: POR
21	DBG_MODE	DEBUG mode status
		0 NOT in DEBUG mode
		1 In DEBUG mode
		Reset condition: Real time information
19	OTP_CORRUPT	OTP bits corruption detection (5 ms cyclic check)
		0 No error
		1 OTP CRC error detected
		Reset condition: POR / clear on write (write ‘1’)
17	REG_CORRUPT	INIT register corruption detection (real time comparison)
		0 No error
		1 INIT register content error detected (mismatch between FS_I_Register / FS_I_NOT_ Register)
		Reset condition: POR / clear on write (write ‘1’)
12 to 8	FSM_STATE[3:0]	Report fail-safe state machine current state
		0 0110 INIT_FS
		0 0111 WAIT_ABIST2
		0 1000 ABIST2
		0 1001 ASSERT_FS0B
		0 1010 NORMAL _FS
		Reset condition: Real time information

18 OTP bits description

18.1 Main OTP Overview

Table 75. Main OTP_REGISTERS

Name [1]	Address	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
OTP_CFG_VPRE_1	14	0	0	VPREV[5:0]					
OTP_CFG_VPRE_2	15	0	0	VPRESC[5:0]					
OTP_CFG_VPRE_3	16	VPREILIM[1:0]		1	0	1	1	**VPRESRHS[1:0]**	
OTP_CFG_BOOST_1	17	0	0	VPRE_MODE	0	VBSTV[3:0]			
OTP_CFG_BOOST_2	18	BOOSTEN	VBSTTONTIME[1:0]		VBSTSC[4:0]				
OTP_CFG_BOOST_3	19	0	0	0	0	0	1	**VBSTSR[1:0]**	
OTP_CFG_BUCK1_1	1A	VB1V[7:0]							
OTP_CFG_BUCK1_2	1B	0	0	0	VB1INDOPT[1:0]		VB1SWILIM[1:0]		VB12 MULTIPH
OTP_CFG_BUCK2_1	1C	VB2V[7:0]							
OTP_CFG_BUCK2_2	1D	0	VB2INDOPT[1:0]		BUCK2EN	VB2SWILIM[1:0]		0	0
OTP_CFG_BUCK3_1	1E	BUCK3EN	VB3INDOPT[1:0]		VB3V[4:0]				
OTP_CFG_BUCK3_2	1F	VB2GMCOMP[2:0]			VB1GMCOMP[2:0]			VB3SWILIM[1:0]	
OTP_CFG_LDO	20	LDO2ILIM	LDO2V[2:0]			LDO1ILIM	LDO1V[2:0]		
OTP_CFG_SEQ_1	21	0	0	VB2S[2:0]			VB1S[2:0]		
OTP_CFG_SEQ_2	22	0	0	LDO2S[2:0]			LDO1S[2:0]		
OTP_CFG_SEQ_3	23	DVS_BUCK12[1:0]		DVS_BUCK3[1:0]		Tslot	VB3S[2:0]		
OTP_CFG_CLOCK_1	24	0	0	VPRE_ph[2:0]			1	0	0
OTP_CFG_CLOCK_2	25	0	0	BUCK1_ph[2:0]			VBST_ph[2:0]		
OTP_CFG_CLOCK_3	26	0	0	BUCK3_ph[2:0]			BUCK2_ph[2:0]		
OTP_CFG_CLOCK_4	27	BUCK3_ clk_sel	BUCK2_ clk_sel	BUCK1_ clk_sel	VBST_clk_sel	VPRE_clk_sel	PLL_sel	1	0
OTP_CFG_SM_1	28	0	0	**conf_TSD[5:0]**					
OTP_CFG_SM_2	29	0	0	0	VPRE_off_dly	Autoretry_ infinite	Autoretry_en	PSYNC_CFG	PSYNC_EN
OTP_CFG_VSUP_UV	2A	0	0	0	0	0	0	0	VSUPCFG
OTP_CFG_I2C	2B	0	0	0	0	M_I2CDEVADDR[3:0]			
OTP_CFG_OV	2C	0	0	0	0	0	VDDIO_REG_ASSIGN[2:0]		
OTP_CFG_DEVID	2D	DeviceID[7:0]							

[1] Regulator behavior in case of TSD, VPRE and VBOOST slew rate parameters in bold can be changed later by SPI/I2C.

18.2 Main OTP bit description

Table 76. Main OTP bit description

Address	Register	Bit	Symbol	Value	Description
14	OTP_CFG_VPRE_1	5 to 0	VPREV[5:0]		VPRE output voltage
				0 01111	3.3 V
				010100	3.8 V
				0 10111	4.1 V
				1 00000	5.0 V

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
15	OTP_CFG_VPRE_2	5 to 0	VPRESC[5:0]		VPRE slope compensation
				000100	40 mV/µs
				000101	50 mV/µs
				0 00110	60 mV/µs
				0 00111	70 mV/µs
				001000	80 mV/µs
				001001	90 mV/µs
				0 01010	100 mV/µs
				0 01110	140 mV/µs
				0 10001	170 mV/µs
				0 10100	200 mV/µs
				0 11000	240 mV/µs
16	OTP_CFG_VPRE_3	7 to 6	VPREILIM[1:0]		VPRE current limitation threshold
				00	50 mV
				01	80 mV
				10	120 mV
				11	150 mV
		1 to 0	VPRESRHS[1:0]		VPRE high-side slew rate control
				00	PU/PD/130 mA
				01	PU/PD/260 mA
				10	PU/PD/520 mA
				11	PU/PD/900 mA
17	OTP_CFG_BOOST_1	5	VPRE_MODE		VPRE mode (PWM , APS)
				0	Force PWM for 455 kHz setting
				1	Automatic Pulse Skipping (APS) for 2.2MHz setting
		3 to 0	VBSTV[3:0]		VBOOST output voltage
				0110	5.0 V
				1101	5.74 V
18	OTP_CFG_BOOST_2	7	BOOSTEN		BOOST enable
				0	Disabled
				1	Enabled
		6 to 5	VBSTTONTIME[1:0]		BOOST minimum ON time
				00	60 ns
				01	50 ns
		4 to 0	VBSTSC[4:0]		VBOOST slope compensation
				0 0110	160 mV/µs
				0 1100	125 mV/µs
				0 1110	79 mV/µs
19	OTP_CFG_BOOST_3	1 to 0	VBSTSR[1:0]		VBOOST low-side slew rate control
				10	300 V/µs
				11	500 V/µs

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
1A	OTP_CFG_BUCK1_1	7 to 0	VB1V[7:0]		VBUCK1 output voltage
				0100 0000	0.8 V
				0100 0100	0.825 V
				0101 0000	0.9 V
				0101 1000	0.95 V
				0110 0000	1.0 V
				01100100	1.025 V
				0110 0101	1.03125 V
				0111 0000	1.1 V
				1000 0000	1.2 V
				1000 1000	1.25 V
				1001 0000	1.3 V
				1001 1000	1.35 V
				1010 0000	1.4 V
				1011 0000	1.5 V
				1011 0001	1.8 V
1B	OTP_CFG_BUCK1_2	4 to 3	VB1INDOPT[1:0]		BUCK1 inductor selection
				00	1 µH
				01	0.47 µH
				10	1.5 µH
		2 to 1	VB1SWILIM[1:0]		BUCK1 current limitation
				01	2.6 A
				11	4.5 A
		0	VB12MULTIPH		VBUCK1 and VBUCK2 multiphase operation enable
				0	Disabled
				1	Enabled
1C	OTP_CFG_BUCK2_1	7 to 0	VB2V[7:0]		VBUCK2 output voltage
				0100 0000	0.8 V
				0100 0100	0.825 V
				0101 0000	0.9 V
				0101 1000	0.95 V
				0110 0000	1.0 V
				01100100	1.025 V
				0110 0101	1.03125 V
				0111 0000	1.1 V
				1000 0000	1.2 V
				1000 1000	1.25 V
				1001 0000	1.3 V
				1001 1000	1.35 V
				1010 0000	1.4 V
				1011 0000	1.5 V
				1011 0001	1.8 V

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
1D	OTP_CFG_BUCK2_2	6 to 5	VB2INDOPT[1:0]		BUCK2 inductor selection
				00	1 µH
				01	0.47 µH
				10	1.5 µH
		4	BUCK2EN		BUCK2 enable
				0	Disabled
				1	Enabled
		3 to 2	VB2SWILIM[1:0]		BUCK2 current limitation
				01	2.6 A
				11	4.5 A
1E	OTP_CFG_BUCK3_1	7	BUCK3EN		BUCK3 enable
				0	Disabled
				1	Enabled
		6 to 5	VB3INDOPT[1:0]		BUCK3 inductor selection
				00	1 µH
				01	0.47 µH
				10	1.5 µH
		4 to 0	VB3V[4:0]		VBUCK3 output voltage
				0 0000	1.0 V
				0 0001	1.1 V
				0 0010	1.2 V
				0 0011	1.25 V
				0 0100	1.3 V
				0 0101	1.35 V
				0 0110	1.5 V
				0 0111	1.6 V
				0 1000	1.8 V
				0 1110	2.3 V
				1 0000	2.5 V
				1 0001	2.8 V
				1 0101	3.3 V

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
1F	OTP_CFG_BUCK3_2	7 to 5	VB2GMCOMP[2:0]		BUCK2 compensation network
				001	16.25 GM
				010	32.5 GM
				011	48.75 GM, Default to use
				100	65 GM
				101	81.25 GM
				110	97.5 GM
		4 to 2	VB1GMCOMP[2:0]		BUCK1 compensation network
				001	16.25 GM
				010	32.5 GM
				011	48.75 GM, Default to use
				100	65 GM
				101	81.25 GM
				110	97.5 GM
		1 to 0	VB3SWILIM[1:0]		BUCK3 current limitation
				01	2.6 A
				11	4.5 A
20	OTP_CFG_LDO	7	LDO2ILIM		VLDO2 current limitation
				0	400 mA
				1	150 mA
		6 to 4	LDO2V[2:0]		VLDO2 output voltage
				000	1.1 V
				001	1.2 V
				010	1.6 V
				011	1.8 V
				100	2.5 V
				101	2.8 V
				110	3.3 V
				111	5.0 V
		3	LDO1ILIM		VLDO1 current limitation
				0	400 mA
				1	150 mA
		2 to 0	LDO1V[2:0]		VLDO1 output voltage
				000	1.1 V
				001	1.2 V
				010	1.6 V
				011	1.8 V
				100	2.5 V
				101	2.8 V
				110	3.3 V
				111	5.0 V

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
21	OTP_CFG_SEQ_1	5 to 3	VB2S[2:0]		BUCK2 sequencing slot
				000	Regulator start and stop in Slot 0
				001	Regulator start and stop in Slot 1
				010	Regulator start and stop in Slot 2
				011	Regulator start and stop in Slot 3
				100	Regulator start and stop in Slot 4
				101	Regulator start and stop in Slot 5
				110	Regulator start and stop in Slot 6
				111	Regulator does not start (enabled by SPI)
		2 to 0	VB1S[2:0]		BUCK1 sequencing slot
				000	Regulator start and stop in Slot 0
				001	Regulator start and stop in Slot 1
				010	Regulator start and stop in Slot 2
				011	Regulator start and stop in Slot 3
				100	Regulator start and stop in Slot 4
				101	Regulator start and stop in Slot 5
				110	Regulator start and stop in Slot 6
				111	Regulator does not start (enabled by SPI)
22	OTP_CFG_SEQ_2	5 to 3	LDO2S[2:0]		LDO2 sequencing slot
				000	Regulator start and stop in Slot 0
				001	Regulator start and stop in Slot 1
				010	Regulator start and Stop in Slot 2
				011	Regulator start and stop in Slot 3
				100	Regulator start and stop in Slot 4
				101	Regulator start and stop in Slot 5
				110	Regulator start and stop in Slot 6
				111	Regulator does not start (enabled by SPI)
		2 to 0	LDO1S[2:0]		LDO1 sequencing slot
				000	Regulator start and stop in Slot 0
				001	Regulator start and stop in Slot 1
				010	Regulator start and stop in Slot 2
				011	Regulator start and stop in Slot 3
				100	Regulator start and stop in Slot 4
				101	Regulator start and stop in Slot 5
				110	Regulator start and stop in Slot 6
				111	Regulator does not start (enabled by SPI)
23	OTP_CFG_SEQ_3	7 to 6	DVS_BUCK12[1:0]		BUCK1 and BUCK2 soft start/stop configurability
				00	7.81 mV/µs
				01	3.13 mV/µs
				10	2.6 mV/µs
				11	2.23 mV/µs
		5 to 4	DVS_BUCK3[1:0]		BUCK3 soft start/stop configurability
				00	10.41 mV/µs
				01	3.47 mV/µs
				10	2.6 mV/µs

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
				11	2.08 mV/µs
		3	Tslot		Power up/down slot duration
				0	250 µs
				1	1 ms
		2 to 0	VB3S[2:0]		BUCK3 sequencing slot
				000	Regulator start and stop in Slot 0
				001	Regulator start and stop in Slot 1
				010	Regulator start and Stop in Slot 2
				011	Regulator start and stop in Slot 3
				100	Regulator start and stop in Slot 4
				101	Regulator start and stop in Slot 5
				110	Regulator start and stop in Slot 6
				111	Regulator does not start (enabled by SPI)
24	OTP_CFG_CLOCK_1	5 to 3	VPRE_ph[2:0]		VPRE phase (delay) selection
				000	no delay
				001	delay 1
				010	delay 2
				011	delay 3
				100	delay 4
				101	delay 5
				110	delay 6
				111	delay 7
25	OTP_CFG_CLOCK_2	5 to 3	BUCK1_ph[2:0]		VBUCK1 phase (delay) selection
				000	no delay
				001	delay 1
				010	delay 2
				011	delay 3
				100	delay 4
				101	delay 5
				110	delay 6
				111	delay 7
		2 to 0	VBST_ph[2:0]		VBOOST phase (delay) selection
				000	no delay
				001	delay 1
				010	delay 2
				011	delay 3
				100	delay 4
				101	delay 5
				110	delay 6
				111	delay 7

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
26	OTP_CFG_CLOCK_3	5 to 3	BUCK3_ph[2:0]		VBUCK3 phase (delay) selection
				000	no delay
				001	delay 1
				010	delay 2
				011	delay 3
				100	delay 4
				101	delay 5
				110	delay 6
				111	delay 7
		2 to 0	BUCK2_ph[2:0]		VBUCK2 phase (delay) selection
				000	no delay
				001	delay 1
				010	delay 2
				011	delay 3
				100	delay 4
				101	delay 5
				110	delay 6
				111	delay 7
27	OTP_CFG_CLOCK_4	7	BUCK3_clk_sel		BUCK3 clock selection
				0	CLK_DIV1 = 2.22 MHz
		6	BUCK2_clk_sel		BUCK2 clock selection
				0	CLK_DIV1 = 2.22 MHz
		5	BUCK1_clk_sel		BUCK1 clock selection
				0	CLK_DIV1 = 2.22 MHz
		4	VBST_clk_sel		VBOOST clock selection
				0	CLK_DIV1 = 2.22 MHz
		3	VPRE_clk_sel		VPRE clock selection
				0	CLK_DIV1 = 2.22 MHz
				1	CLK_DIV2 = 455 kHz
		2	PLL_sel		PLL enable
				0	Disabled
				1	Enabled

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
28	OTP_CFG_SM_1	5 to 0	conf_TSD[5]		BOOST behavior in case of TSD
				0	BOOST shutdown
				1	BOOST shutdown + DFS
			conf_TSD[4]		BUCK1 behavior in case of TSD
				0	BUCK1 shutdown
				1	BUCK1 shutdown + DFS
			conf_TSD[3]		BUCK2 behavior in case of TSD
				0	BUCK2 shutdown
				1	BUCK2 shutdown + DFS
			conf_TSD[2]		BUCK3 behavior in case of TSD
				0	BUCK3 shutdown
				1	BUCK3 Shutdown + DFS
			conf_TSD[1]		LDO1 behavior in case of TSD
				0	LDO1 shutdown
				1	LDO1 shutdown + DFS
			conf_TSD[0]		LDO2 behavior in case of TSD
				0	LDO2 shutdown
				1	LDO2 shutdown + DFS
29	OTP_CFG_SM_2	4	VPRE_off_dly		Delay to turn OFF VPRE at device power down
				0	250 µs
				1	32 ms
		3	Autoretry_infinite		Deep fail-safe infinite autoretry enable
				0	Disabled
				1	Enabled
		2	Autoretry_en		Deep fail-safe autoretry enable
				0	Disabled
				1	Enabled
		1	PSYNC_CFG		Power up synchronization
				0	2x FS85
				1	1x FS85 and 1x ext. PMIC
		0	PSYNC_EN		Synchronization with two devices
				0	Disabled
				1	Enabled
2A	OTP_CFG_VSUP_UV	0	VSUP_CFG		VSUP undervoltage threshold configuration
				0	4.9 V for Vpre < 4.5 V
				1	6.2 V for Vpre > 4.5 V
2B	OTP_CFG_I2C	3 to 0	M_I2CDEVADDR[3:0]		Device I2C address
				0000	Address D0
				…	...
				1111	Address D15

Table 76. Main OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
2C	OTP_CFG_OV	2 to 0	VDDIO_REG_ASSIGN[2:0]		Regulator assigned to VDDIO
				000	External regulator
				001	VPRE
				010	LDO1
				011	LDO2
				100	BUCK3
				101	External regulator
				110	External regulator
				111	External regulator
2D	OTP_CFG_DEVID	7 to 0	DeviceID[7:0]		Device ID

18.3 Fail-safe OTP Overview

Table 77. Fail-safe OTP_REGISTERS

Name	Address	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
OTP_CFG_UVOV_1	0A	VCORE_V[7:0]							
OTP_CFG_UVOV_2	0B	VDDIOOVTH[3:0]				VCOREOVTH[3:0]			
OTP_CFG_UVOV_3	0C	0	0	VDDIO_V	VCORE_SVS_CLAMP[4:0]				
OTP_CFG_UVOV_4	0D	VMON2OVTH[3:0]				VMON1OVTH[3:0]			
OTP_CFG_UVOV_5	0E	VMON4OVTH[3:0]				VMON3OVTH[3:0]			
OTP_CFG_UVOV_6	0F	VDDIOUVTH[3:0]				VCOREUVTH[3:0]			
OTP_CFG_UVOV_7	10	VMON2UVTH[3:0]				VMON1UVTH[3:0]			
OTP_CFG_UVOV_8	11	VMON4UVTH[3:0]				VMON3UVTH[3:0]			
OTP_CFG_PGOOD	12	0	PGOOD_ RSTB	PGOOD_ VMON4	PGOOD_ VMON3	PGOOD_ VMON2	PGOOD_ VMON1	PGOOD_ VDDIO	PGOOD_ VCORE
OTP_CFG_ABIST1	13	0	0	ABIST1_ VMON4	ABIST1_ VMON3	ABIST1_ VMON2	ABIST1_ VMON1	ABIST1_ VDDIO	ABIST1_ VCORE
OTP_CFG_ASIL	14	WD_DIS	WD_Selection	ERRMON_EN	FCCU_EN	VMON4_EN	VMON3_EN	VMON2_EN	VMON1_EN
OTP_CFG_I2C	15	0	0	0	FLT_ RECOVERY_ EN	FS_I2CDEVADDR[3:0]			
OTP_CFG_DGLT_DUR_1	16	0	0	VCORE_UV_DGLT[1:0]		VCORE_ OV_DGLT	VDDIO_UV_DGLT[1:0]		VDDIO_ OV_DGLT
OTP_CFG_DGLT_DUR_2	17	0	0	0	0	0	VMONx_UV_DGLT[1:0]		VMONx_ OV_DGLT

18.4 Fail-safe OTP bit description

Table 78. Fail-safe OTP bit description

Address	Register	Bit	Symbol	Value	Description
0A	OTP_CFG_UVOV_1	7 to 0	VCORE_V[7:0]		VCORE (VBUCK1) monitoring voltage
				0100 0000	0.8 V
				0100 0100	0.825 V
				0101 0000	0.9 V
				0101 1000	0.95 V
				0110 0000	1 V
				01100100	1.025 V
				0110 0101	1.03125 V
				0110 0000	1.1 V
				1000 0000	1.2 V
				1000 1000	1.25 V
				1001 0000	1.3 V
				1001 1000	1.35 V
				1010 0000	1.4 V
				1011 0000	1.5 V
				1011 0001	1.8 V

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
0B	OTP_CFG_UVOV_2	7 to 4	VDDIOOVTH[3:0]		VDDIO overvoltage threshold configuration
				0000	104.5 %
				0001	105 %
				0010	105.5 %
				0011	106 %
				0100	106.5 %
				0101	107 %
				0110	107.5
				0111	108 %
				1000	108.5 %
				1001	109 %
				1010	109.5 %
				1011	110 %
				1100	110.5 %
				1101	111 %
				1110	111.5 %
				1111	112 %
		3 to 0	VCOREOVTH[3:0]		VCOREMON overvoltage threshold configuration
				0000	104.5 %
				0001	105 %
				0010	105.5 %
				0011	106 %
				0100	106.5 %
				0101	107 %
				0110	107.5
				0111	108 %
				1000	108.5 %
				1001	109 %
				1010	109.5 %
				1011	110 %
				1100	110.5 %
				1101	111 %
				1110	111.5 %
				1111	112 %
0C	OTP_CFG_UVOV_3	5	VDDIO_V		VDDIO voltage selection
				0	3.3 V
				1	5 V
0C	OTP_CFG_UVOV_3	4 to 0	VCORE_SVS_CLAMP[4:0]		SVS max value allowed (mask)
				00000	No SVS
				00001	2 steps available
				00011	4 steps available
				00111	8 steps available
				01111	16 steps available

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
0D	OTP_CFG_UVOV_4	7 to 4	VMON2OVTH[3:0]		VMON2 overvoltage threshold configuration
				0000	104.5 %
				0001	105 %
				0010	105.5 %
				0011	106 %
				0100	106.5 %
				0101	107 %
				0110	107.5
				0111	108 %
				1000	108.5 %
				1001	109 %
				1010	109.5 %
				1011	110 %
				1100	110.5 %
				1101	111 %
				1110	111.5 %
				1111	112 %
		3 to 0	VMON1OVTH[3:0]		VMON1 overvoltage threshold configuration
				0000	104.5 %
				0001	105 %
				0010	105.5 %
				0011	106 %
				0100	106.5 %
				0101	107 %
				0110	107.5
				0111	108 %
				1000	108.5 %
				1001	109 %
				1010	109.5 %
				1011	110 %
				1100	110.5 %
				1101	111 %
				1110	111.5 %
				1111	112 %

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
0E	OTP_CFG_UVOV_5	7 to 4	VMON4OVTH[3:0]		VMON4 overvoltage threshold configuration
				0000	104.5 %
				0001	105 %
				0010	105.5 %
				0011	106 %
				0100	106.5 %
				0101	107 %
				0110	107.5
				0111	108 %
				1000	108.5 %
				1001	109 %
				1010	109.5 %
				1011	110 %
				1100	110.5 %
				1101	111 %
				1110	111.5 %
				1111	112 %
		3 to 0	VMON3OVTH[3:0]		VMON3 overvoltage threshold configuration
				0000	104.5 %
				0001	105 %
				0010	105.5 %
				0011	106 %
				0100	106.5 %
				0101	107 %
				0110	107.5
				0111	108 %
				1000	108.5 %
				1001	109 %
				1010	109.5 %
				1011	110 %
				1100	110.5 %
				1101	111 %
				1110	111.5 %
				1111	112 %

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
0F	OTP_CFG_UVOV_6	7 to 4	VDDIOUVTH[3:0]		VDDIO undervoltage threshold configuration
				0000	95.5 %
				0001	95 %
				0010	94.5 %
				0011	94 %
				0100	93.5 %
				0101	93 %
				0110	92.5 %
				0111	92 %
				1000	91.5 %
				1001	91 %
				1010	90.5 %
				1011	90 %
				1100	89.5 %
				1101	89 %
				1110	88.5 %
				1111	88 %
		3 to 0	VCOREUVTH[3:0]		VCOREMON undervoltage threshold configuration
				0000	95.5 %
				0001	95 %
				0010	94.5 %
				0011	94 %
				0100	93.5 %
				0101	93 %
				0110	92.5 %
				0111	92 %
				1000	91.5 %
				1001	91 %
				1010	90.5 %
				1011	90 %
				1100	89.5 %
				1101	89 %
				1110	88.5 %
				1111	88 %

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
10	OTP_CFG_UVOV_7	7 to 4	VMON2UVTH[3:0]		VMON2 undervoltage threshold configuration
				0000	95.5 %
				0001	95 %
				0010	94.5 %
				0011	94 %
				0100	93.5 %
				0101	93 %
				0110	92.5 %
				0111	92 %
				1000	91.5 %
				1001	91 %
				1010	90.5 %
				1011	90 %
				1100	89.5 %
				1101	89 %
				1110	88.5 %
				1111	88 %
		3 to 0	VMON1UVTH[3:0]		VMON1 undervoltage threshold configuration
				0000	95.5 %
				0001	95 %
				0010	94.5 %
				0011	94 %
				0100	93.5 %
				0101	93 %
				0110	92.5 %
				0111	92 %
				1000	91.5 %
				1001	91 %
				1010	90.5 %
				1011	90 %
				1100	89.5 %
				1101	89 %
				1110	88.5 %
				1111	88 %

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
11	OTP_CFG_UVOV_8	7 to 4	VMON4UVTH[3:0]		VMON4 undervoltage threshold configuration
				0000	95.5 %
				0001	95 %
				0010	94.5 %
				0011	94 %
				0100	93.5 %
				0101	93 %
				0110	92.5 %
				0111	92 %
				1000	91.5 %
				1001	91 %
				1010	90.5 %
				1011	90 %
				1100	89.5 %
				1101	89 %
				1110	88.5 %
				1111	88 %
		3 to 0	VMON3UVTH[3:0]		VMON3 undervoltage threshold configuration
				0000	95.5 %
				0001	95 %
				0010	94.5 %
				0011	94 %
				0100	93.5 %
				0101	93 %
				0110	92.5 %
				0111	92 %
				1000	91.5 %
				1001	91 %
				1010	90.5 %
				1011	90 %
				1100	89.5 %
				1101	89 %
				1110	88.5 %
				1111	88 %

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
12	OTP_CFG_PGOOD	6	PGOOD_RSTB		RSTB assignment to PGOOD
				0	Not assigned
				1	Assigned
		5	PGOOD_VMON4		VMON4 assignment to PGOOD
				0	Not assigned
				1	Assigned
		4	PGOOD_VMON3		VMON3 assignment to PGOOD
				0	Not assigned
				1	Assigned
		3	PGOOD_VMON2		VMON2 assignment to PGOOD
				0	Not assigned
				1	Assigned
		2	PGOOD_VMON1		VMON1 assignment to PGOOD
				0	Not assigned
				1	Assigned
		1	PGOOD_VDDIO		VDDIO assignment to PGOOD
				0	Not assigned
				1	Assigned
		0	PGOOD_VCORE		VCORE (BUCK1) assignment to PGOOD
				0	Not assigned
				1	Assigned
13	OTP_CFG_ABIST1	5	ABIST_VMON4		VMON4 assignment to ABIST1
				0	Not assigned
				1	Assigned
		4	ABIST_VMON3		VMON3 assignment to ABIST1
				0	Not assigned
				1	Assigned
		3	ABIST_VMON2		VMON2 assignment to ABIST1
				0	Not assigned
				1	Assigned
		2	ABIST_VMON1		VMON1 assignment to ABIST1
				0	Not assigned
				1	Assigned
		1	ABIST_VDDIO		VDDIO assignment to ABIST1
				0	Not assigned
				1	Assigned
		0	ABIST_VCORE		VCORE assignment to ABIST1
				0	Not assigned
				1	Assigned

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
14	OTP_CFG_ASIL	7	WD_DIS		Watchdog monitoring enable
				0	Enabled
				1	Disabled
		6	WD_SELECTION		Watchdog mode selection
				0	Simple WD
				1	Challenger WD
		5	ERRMON_EN		ERRMON monitoring enable
				0	Disabled
				1	Enabled
		4	FCCU_EN		FCCU monitoring enable
				0	Disabled
				1	Enabled
		3	VMON4_EN		VMON4 monitoring enable
				0	Disabled
				1	Enabled
		2	VMON3_EN		VMON3 monitoring enable
				0	Disabled
				1	Enabled
		1	VMON2_EN		VMON2 monitoring enable
				0	Disabled
				1	Enabled
		0	VMON1_EN		VMON1 monitoring enable
				0	Disabled
				1	Enabled
15	OTP_CFG_I2C	4	FLT_RECOVERY_EN		Fault recovery strategy enable
				0	Disabled
				1	Enabled
		3 to 0	FS_I2CDEVADDR[3:0]		Device I2C address
				0000	Address D0
				…	…
				1111	Address D15

Table 78. Fail-safe OTP bit description*...continued*

Address	Register	Bit	Symbol	Value	Description
16	OTP_CFG_DGLT_DUR_1	5 to 4	VCORE_UV_DGLT[1:0]		VCORE undervoltage filtering time
				00	5 µs
				01	15 µs
				10	25 µs
				11	40 µs
		3	VCORE_OV_DGLT		VCORE overvoltage filtering time
				0	25 µs
				1	45 µs
		2 to 1	VDDIO_UV_DGLT[1:0]		VDDIO undervoltage filtering time
				00	5 µs
				01	15 µs
				10	25 µs
				11	40 µs
		0	VDDIO_OV_DGLT		VDDIO overvoltage filtering time
				0	25 µs
				1	45 µs
17	OTP_CFG_DGLT_DUR_2	2 to 1	VMONx_UV_DGLT[1:0]		VMONx undervoltage filtering time
				00	5 µs
				01	15 µs
				10	25 µs
				11	40 µs
		0	VMONx_OV_DGLT		VMONx overvoltage filtering time
				0	25 µs
				1	45 µs

19 Best of supply

19.1 Functional description

VBOS regulator manages the best of supply from VSUP, VPRE and VBOOST to efficiently generate 5.0 V output to supply the internal biasing of the device. VBOS is also the supply of VPRE high-side and low-side gate drivers and VBOOST low-side gate driver.

VBOS undervoltage may not guarantee the full functionality of the device. Consequently, VBOS_UVL detection powers down the device.

V_{SUP_UV7} undervoltage threshold is used to enable the path from VSUP to VBOS when VSUP < V_{SUP_UV7} to have a low drop path from VSUP, while VPRE is going low and to power up the device when VPRE is not started. When VSUP > V_{SUP_UV7}, VBOS is forced to use either VPRE or VBOOST to optimize the efficiency.

19.2 Electrical characteristics

Table 79. Best of supply electrical characteristics

T_A = –40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
Best of supply					
V_{BOS}	Best of supply output voltage	3.3	5.0	5.25	V
V_{BOS_UVH}	VBOS undervoltage threshold high (VBOS rising)	4.1	—	4.5	V
V_{BOS_UVL}	VBOS undervoltage threshold low (VBOS falling)	3.2	—	3.4	V
T_{BOS_UV}	V_{BOS_UVH} and V_{BOS_UVL} filtering time	6.0	10	15	µs
V_{BOS_POR}	VBOS power on reset threshold	—	—	2.5	V
T_{BOS_POR}	V_{BOS_POR} filtering time	0.5	—	1.5	µs
I_{BOS}	Best of supply current capability	—	—	60	mA
C_{OUT_BOS}	Effective output capacitor	4.7	—	10	µF
	Output decoupling capacitor		0.1	—	µF

20 High voltage buck: VPRE

20.1 Functional description

VPRE block is a high voltage, synchronous, peak current mode buck controller. VPRE is working with external logical level NMOS in force PWM mode at 455 kHz and in Automatic Pulse Skipping (APS) mode at 2.22 MHz. The APS mode helps to maintain the correct output voltage at high input voltage by skipping some turn ON cycles of the HS FET below the minimum duty cycle. VPRE input voltage is naturally limited to $V_{SUP} = L_{PI\_DCR} \times I_{PRE} + V_{PRE\_UVL} / D_{MAX}$ with $D_{MAX} = 1 - (F_{PRE\_SW} \times T_{PRE\_OFF\_MIN})$.

A bootstrap capacitor is required to supply the gate drive circuit of the high-side NMOS. The output voltage is configurable by OTP from 3.3 V to 5.0 V, and the switching frequency is configurable by OTP at 455 kHz for 12 V and 24 V transportation applications or 2.22 MHz for 12 V automotive applications. The stability is ensured by an external Type 2 compensation network with slope compensation.

The output current is sensed via an external shunt in series with the inductor and the maximum current capability is defined by the external components (NMOS gate charge, inductor, shunt resistor), the gate driver current capability and the switching frequency. An overcurrent detection is implemented to protect the external MOSFETs. If an overcurrent is detected after the HS minimum TON time, the HS is turned OFF and will be turned ON again at the next rising edge of the switching clock. The overcurrent induces a duty cycle reduction that could lead to the output voltage gradually dropping, causing an undervoltage condition on VPRE and/or one of the cascaded regulators.

The maximum input voltage is 60 V and allows operation in 24 V truck applications without external protection to sustain ISO 16750-2:2012 load dump pulse 5b. VPRE must be the input supply of the BOOST and BUCK1,2. VPRE can be the input supply of BUCK3 and LDO1. VPRE can be the supply of local loads remaining inside the ECU.

By default, VPRE switching frequency is derived from the internal oscillator, and can be synchronized with an external frequency signal applied at FIN input pin. The change from internal oscillator to external clock or vice versa is controlled by SPI/I2C.

V_{PRE_UVH}, V_{PRE_UVL} and $V_{PRE\_FB\_OV}$ thresholds are monitored from PRE_FB pin and manage some transitions of the main state machine described in Section 14.1 "Simplified functional state diagram". These monitoring are not safety related.

20.2 Application schematic

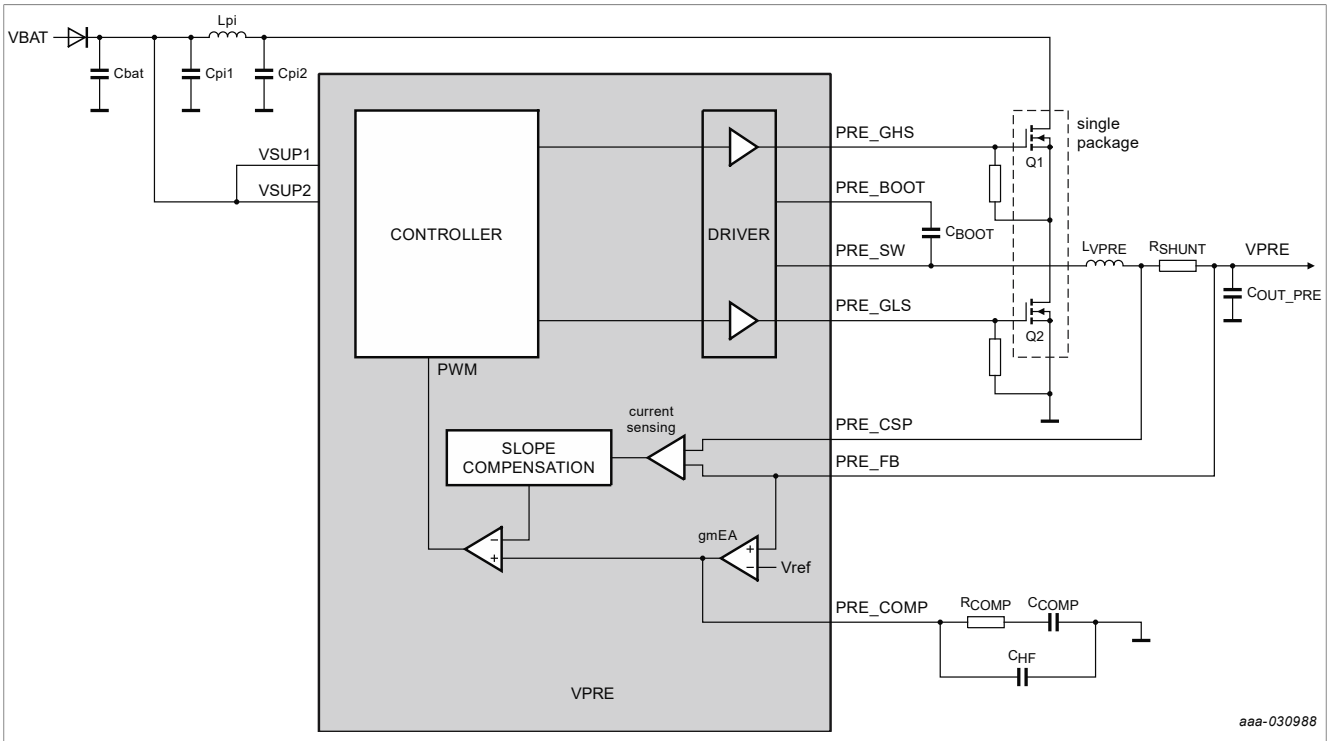


Figure 11. VPRE schematic

A PI filter, with F_{RES} = 1 / [2π x √(LCpi1)] and calculated for Fres < F_{PRE_SW} / 10, is required to filter VPRE switching frequency on the battery line. VSUP1, 2 pins must be connected before the PI filter for a clean biasing of the device. Cpi1 capacitor shall be implemented close to VSUP1,2 pins. Cpi2 capacitor shall be implemented close to Q1. The bootstrap capacitor value should be sized to be >10 times the gate source capacitor of Q1. Gate to source resistor on Q1 and Q2 is recommended in case of pin disconnection to guarantee a passive switch OFF of the transistors.

20.3 Compensation network and stability

The external compensation network, made with R_{COMP}, C_{COMP} and C_{HF} shall be calculated for best compromise between stability and transient response, based on below conceptual plot of Type 2 compensation network transfer function.

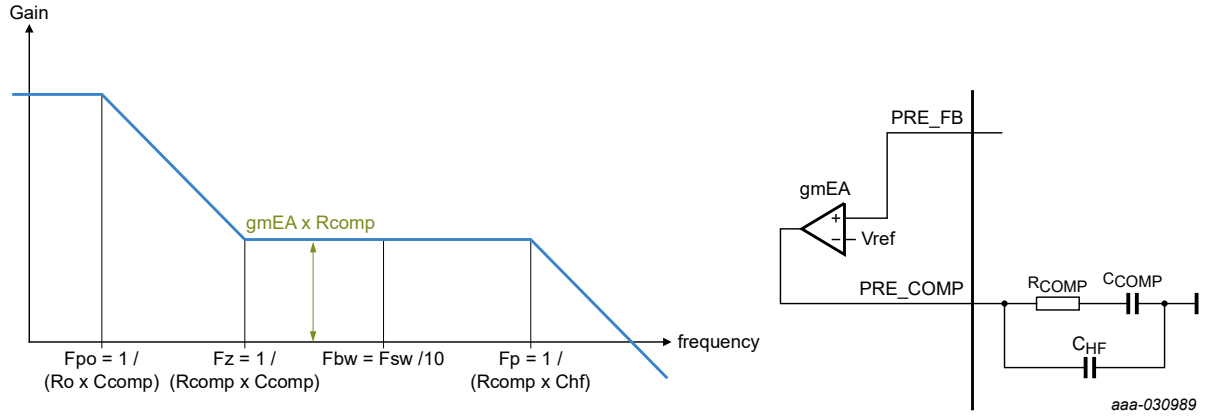


Figure 12. Type 2 compensation network concept

Calculation guideline:

- System bandwidth for VPRE = 455 kHz: $F_{bw} = F_{PRE\_SW} / 10$
- System bandwidth for VPRE = 2.22 MHz: $F_{bw} = F_{PRE\_SW} / 15$
- Compensation zero: $Fz = F_{bw} / 10$
- Compensation pole for VPRE = 455 kHz: $Fp = F_{PRE\_SW} / 2$
- Compensation pole for VPRE = 2.22MHz: $Fp = F_{PRE\_SW} / 4$
- $F_{GBW} = 1 / (2\pi \times R_{SHUNT} \times V_{PRE\_LIM\_GAIN} \times C_{OUT\_PRE})$
- Error amplifier gain: $EA\_gain = (V_{REF} / V_{PRE}) \times gmEA_{PRE} \times R_{COMP} = 10 \text{ ^ } LOG (F_{BW} / F_{GBW})$
- $V_{REF} = 1.0$ V, $R_{COMP} = V_{PRE} \times (EA\_gain / gmEA_{PRE})$
- $C_{COMP} = 1 / (2\pi \times Fz \times R_{COMP})$
- $C_{HF} = 1 / (2\pi \times Fp \times R_{COMP})$
- Slope compensation: $Se > (V_{PRE} / L_{VPRE}) \times R_{SHUNT} \times V_{PRE\_LIM\_GAIN}$

The compensation network can be automatically calculated with the sheet FS85_VPRE_VBOOST_Components in the FS85_FS84_OTP_Config.xlsm file which is using the same formulas. A Simplis simulation is recommended to verify the Phase and Gain Margin with normalized components.

Use case calculation with $V_{PRE} = 4.1$ V, $L_{VPRE} = 6.8$ µH, $F_{PRE\_SW} = 455$ kHz, $C_{OUT\_PRE} = 66$ µF, $R_{SHUNT} = 10.0$ mΩ:

- System bandwidth: $F_{bw} = 45$ kHz
- Compensation zero: $Fz = 4.5$ kHz
- Compensation pole: $Fp = 227.5$ kHz
- $F_{GBW} = 53$ kHz
- Error amplifier gain: $EA\_gain = 10 \text{ ^ } LOG (F_{BW} / F_{GBW}) = 0.86$
- $R_{COMP} = 2.34$ kΩ = 2.2 kΩ
- $C_{COMP} = 15.9$ nF = 16 nF
- $C_{HF} = 318$ pF = 330 pF
- Slope compensation: Se > 30 mV/µs

Use case stability verification:

- Phase margin target PM > 45° and gain margin target GM > 6dB.

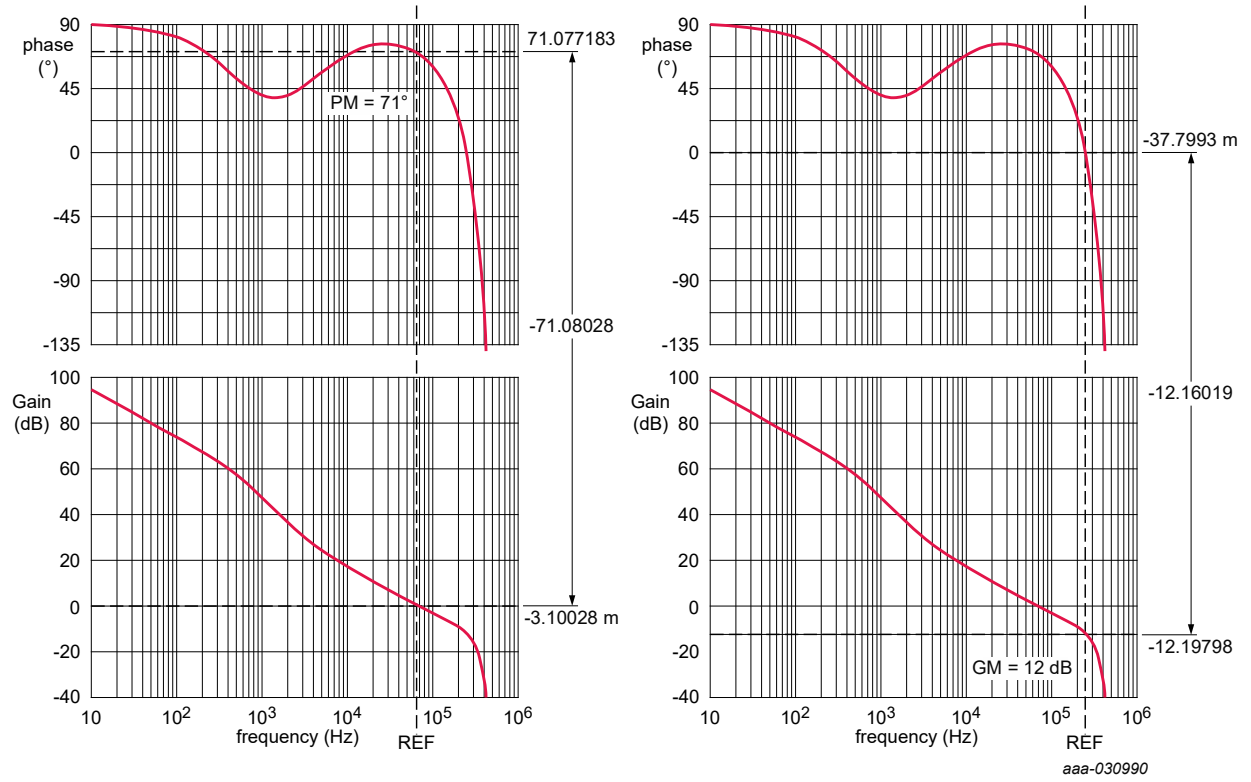


Figure 13. Phase and gain margin simulation

Use case transient response verification:

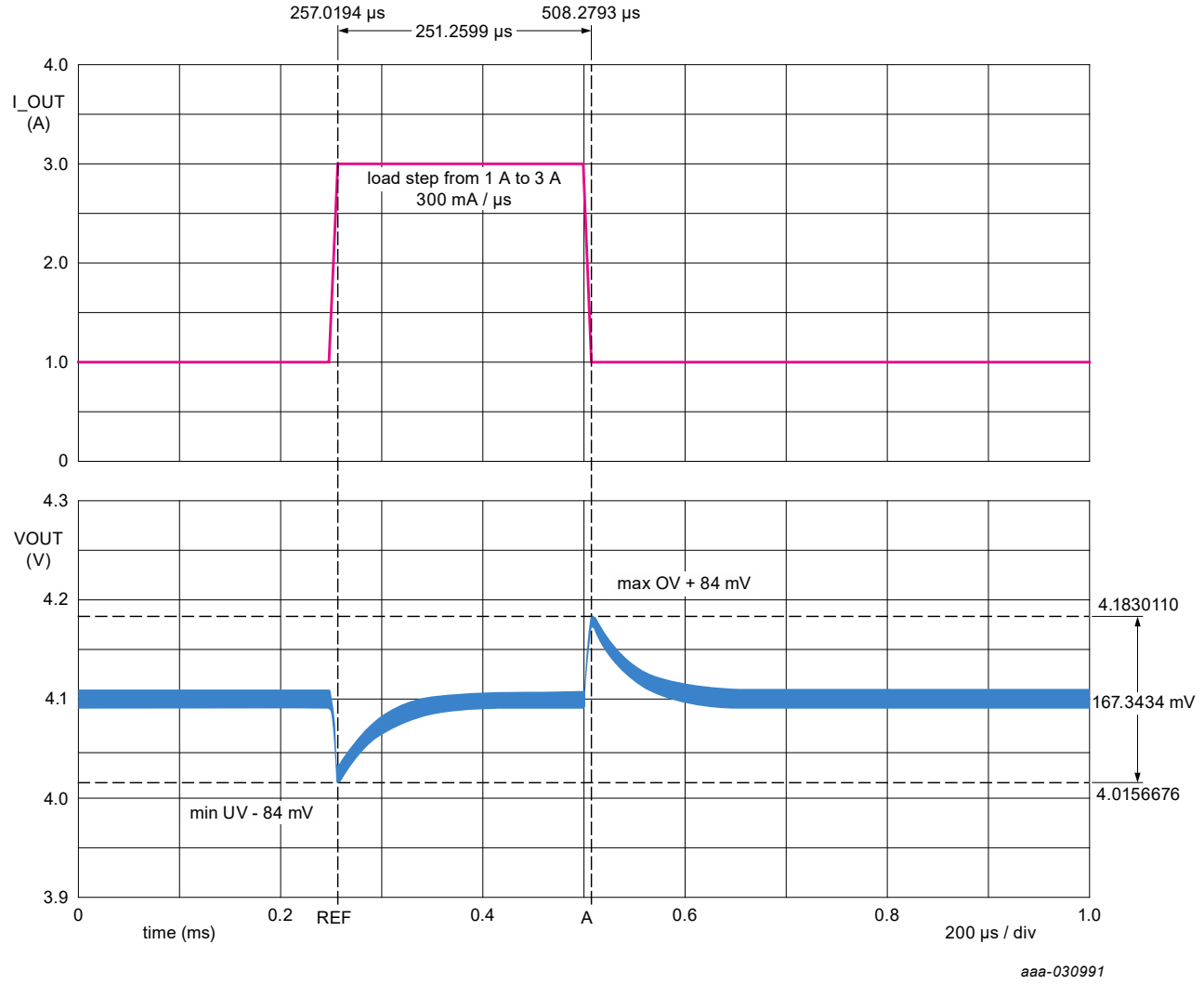


Figure 14. Transient response simulation

20.4 Electrical characteristics

Table 80. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
VPRE					
V_{PRE}	Output voltage (OTP_VPREV[5:0] bits)	3.2	3.3	3.4	V
		3.68	3.8	3.92	V
		3.98	4.1	4.22	V
		4.85	5.0	5.15	V
$V_{PRE\_SOFT\_START}$	Output voltage from 10 % to 90 %	250	450	650	µs
	Digital DAC soft start completion	—	—	1.35	ms
$V_{PRE\_STARTUP}$	Overshoot at startup	—	—	3	%
$V_{PRE\_FB\_OV}$	Over voltage threshold protection	5.5	6.0	6.5	V

Table 80. Electrical characteristics...*continued*

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
$T_{PRE\_FB\_OV}$	$V_{PRE\_FB\_OV}$ filtering time	1	2	3	µs
V_{PRE_UVH}	Under voltage threshold high	2.9	—	3.1	V
V_{PRE_UVL}	Under voltage threshold low	2.5	—	2.7	V
T_{PRE_UV}	V_{PRE_UVH} and V_{PRE_UVL} filtering time	6.0	10	15	µs
F_{PRE_SW}	Switching frequency range (OTP_VPRE_clk_sel bit)	430	455	480	kHz
		2.1	2.22	2.35	MHz
L_{VPRE}	Typical inductor value for F_{PRE_SW} = 455 kHz	4.7	6.8	10	µH
	Typical inductor value for F_{PRE_SW} = 2.22 MHz	1.5	2.2	4.7	µH
$V_{PRE\_LINE\_REG\_455k}$	Transient line regulation at 455 kHz VSUP = 6.0 V to 18 V and VSUP = 12 V to 36 V (Cin = 47uF + PI filter, L_{VPRE} = 6.8 µH, C_{OUT_PRE} = 66 µF, dv/dt = 100 mV/µs)	-3	—	3	%
$V_{PRE\_LINE\_REG\_2.2M}$	Transient line regulation at 2.22 MHz VSUP = 6.0 V to 18 V (Cin = 47uF + PI filter, L_{VPRE} = 2.2 µH, C_{OUT_PRE} = 44 µF, dv/dt = 100 mV/µs)	-3	—	3	%
$V_{PRE\_LOAD\_REG\_455k}$	Transient load regulation at 455 kHz VSUP = 6.0 V to 36 V (L_{VPRE} = 6.8 µH, C_{OUT_PRE} = 66 µF, from 1.0 A to 3.0 A, di/dt = 300 mA/µs)	−3	—	3	%
$V_{PRE\_LOAD\_REG\_2.2M}$	Transient load regulation at 2.22MHz VSUP = 6.0 V to 18 V (L_{VPRE} = 2.2 µH, C_{OUT_PRE} = 44 µF, from 1.0 A to 3.0 A, di/dt = 300 mA/µs)	-3	—	3	%
$V_{PRE\_RIPPLE\_455k}$	Ripple at 455 kHz VSUP = 12 V and VSUP = 24 V (L_{VPRE} = 6.8 µH, C_{OUT_PRE} = 66 µF, V_{PRE} = 3.3 V and 5.0 V, I_{PRE} = 4A)	-1	—	1	%
$V_{PRE\_RIPPLE\_2.2M}$	Ripple at 2.22 MHz VSUP = 12 V (L_{VPRE} = 2.2 µH, C_{OUT_PRE} = 44 µF, V_{PRE} = 3.3 V and 5.0 V, I_{PRE} = 2A)	-0.5	—	0.5	%
$T_{PRE\_ON\_MIN}$	HS minimum ON time	15	25	35	ns
$T_{PRE\_OFF\_MIN}$	HS minimum OFF time	20	40	60	ns
R_{SHUNT}	Current sense resistor (±1 %)	10	—	20	mΩ
$V_{PRE\_LIM\_GAIN}$	Current sense amplifier gain	4.5	5	5.5	
$V_{PRE\_LIM\_TH1}$	Current sense amplifier peak detection threshold (OTP_VPREILIM[1:0] bits) Note: 150mV setting is not available for 2.22 MHz	37	50	63	mV
		60.8	80	99.2	mV
		93.6	120	146.4	mV
		117	150	183	mV
I_{LIM_PRE}	I_{LIM_PRE} = $V_{PRE\_LIM\_TH}$ / R_{SHUNT} Inductor peak current limitation range (R_{SHUNT} = 10 mΩ, $V_{PRE\_LIM\_TH1}$ = 50 mV)	3.75	5	6.25	A
	Inductor peak current limitation range (R_{SHUNT} = 10 mΩ, $V_{PRE\_LIM\_TH1}$ = 150 mV)	12	15	18	A

Table 80. Electrical characteristics...*continued*

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
	To be recalculated for different R_{SHUNT} and different $V_{PRE\_LIM\_TH}$				
V_{PRE_DRV}	HS and LS gate driver output voltage	—	VBOS	—	V
$I_{PRE\_GATE\_DRV}$	HS and LS gate driver pull up and pull down current capability (OTP_VPRESRHS[1:0] bits by default + VPRESRHS[1:0] and VPRESRLS[1:0] bits by SPI/I2C)	60	130	220	mA
		120	260	430	mA
		220	520	860	mA
		420	900	1490	mA
C_{OUT_PRE}	Effective output capacitor for F_{PRE_SW} = 455 kHz	40	66	220	µF
	Effective output capacitor for F_{PRE_SW} = 2.22 MHz	20	44	110	µF
	Output decoupling capacitor	—	0.1	—	µF
C_{IN_PRE}	Effective input capacitor (Cpi2)	20	—	—	µF
	Input decoupling capacitor	—	0.1	—	µF
I_{PRE_DRV}	Combined HS + LS gate driver average current capability $I_{PRE\_DRV} < F_{PRE\_SW} \times (QC_{HS} + QC_{LS})$ with QC_{HS} = gate charge of Q2 at VBOS with QC_{LS} = gate charge of Q1 at VBOS	—	—	30	mA
$gmEA_{PRE}$	Error amplifier transconductance	1.0	1.5	2.1	mS
V_{PRE_SLOPE}	Slope compensation (OTP_VPRESC[5:0] bits)	29	40	51	mV/µs
		36	50	64	mV/µs
		43	60	77	mV/µs
		51	70	89	mV/us
		58	80	102	mV/µs
		65	90	115	mV/µs
		73	100	127	mV/µs
		102	140	178	mV/µs
		124	170	216	mV/µs
		146	200	254	mV/µs
		175	240	305	mV/µs
$T_{PRE\_UV\_DFS}$	V_{PRE_UVL} filtering time to go to DEEP-FS during VPRE start up	1.8	2	2.2	ms
T_{PRE_DT}	Dead time to avoid cross conduction (this timing does not take into account the external FET turn ON/OFF times)	20	30	40	ns
VPRE_OFF_DLY	Wait time between VBOOST OFF and VPRE OFF (OTP_VPRE_off_dly bit)	—	250	—	µs
		—	32	—	ms
R_{PRE_DIS}	Discharge resistor (when VPRE is disabled)	250	500	1000	Ω
$I_{PRE\_SW\_LKG}$	PRE_SW leakage	—	—	10	µA
R_{DRV_OFF}	HS and LS gate driver pull down resistor when VPRE is disabled	5	—	35	kΩ
R_{BOOT_OFF}	PRE_BOOT pull down resistor when VPRE is disabled	1.2	—	2.6	kΩ

Table 80. Electrical characteristics...*continued*

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
I_{BOOT_LKG}	PRE_BOOT leakage	—	—	10	µA

20.5 VPRE external MOSFETs

MOSFETs selection:

- Logical level NMOS, gate drive comes from VBOS (5.0 V)
- VDS > 60 V for 24 V truck, bus applications
- VDS > 40 V for 12 V automotive applications
- Qg < 15 nC at Vgs = 5.0 V is recommended for 455 kHz
- Qg < 7 nC at Vgs = 5.0 V is recommended for 2.22MHz
- Recommended references

Applications	Fpre	Ipre < 2.0 A	Ipre < 4.0 A	Ipre < 6.0 A	Ipre < 10 A
12 V	455 kHz	BUK9K25-40E, BUK9K18-40E	BUK9K25-40E, BUK9K18-40E	BUK9K18-40E	BUK9K18-40E, NVTFS5C471NLWFTAG, HS = BUK9M9R5-40H, LS = BUK9M3R3-40H
	2.22 MHz	BUK9K25-40E, BUK9Y29-40E	BUK9K25-40E, BUK9Y29-40E	BUK9K25-40E, BUK9Y29-40E	N/A
24 V	455 kHz	BUK9K35-60E, BUK9K52-60E	BUK9K35-60E, BUK9K52-60E	BUK9K35-60E	BUK9K12-60E

Other MOSFETs are possible but should have similar performances than the recommended references. The maximum current at 2.22 MHz is limited to 6 A for which the efficiency is equivalent to 10 A at 455 kHz. Above, the power dissipation in the external MOSFETs become important and the junction temperature may rise above 175 °C.

VPRE switching slew rate can be configured by SPI/I2C to align with external MOSFET selection, VPRE switching frequency, and to optimize power dissipation and EMC performance. It is recommended to configure the maximum slew rate by OTP and reduce it later by SPI/I2C if needed. FS85/FS84 is using current source to drive the external MOSFET so adding an external serial resistor with the gate will not affect the slew rate. It is recommended to change the current source selection by SPI/I2C to change the slew rate.

VPRE MOSFET switching time can be estimated to $T_{SW} = (Q_{GD} + Q_{GS} / 2) / I_{PRE\_GATE\_DRV}$ using the gate charge definition from Figure 15. Q_{GD} and Q_{GS} can be extracted from the MOSFET data sheet.

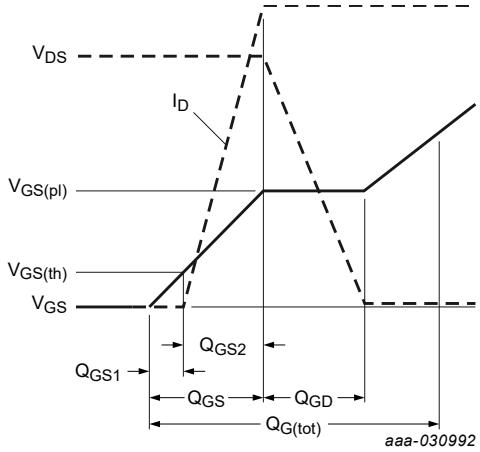


Figure 15. MOSFET gate charge definition

20.6 VPRE efficiency

VPRE efficiency versus current load is given for information based on external component criteria provided and VSUP voltage 14 V. If the conditions change, it has to be recalculated with the FS85_PDTCAL tool. The real efficiency has to be verified by measurement at the application level.

VRPE at 455 kHz: BUK9K18-40E
VPRE at 2.2 MHz: BUK9K25-40E

Ext. C and L			
Fpre	455	2220	kHz
Cin	47	47	µF
ESR Cin	30	30	mΩ
Cout	60	44	µF
ESR Cout	10	10	mΩ
L coil	6.8	2.2	µH
DCR coil	25	25	mΩ
Rshunt	10	10	mΩ

Ext. MOSFET's			
GHS_drive	5	5	V
HS_Rdson	17	24	mΩ
HS_QGtot	7	5	nC
HS_QGD	3	2.4	nC
HS_QGS	2	1.4	nC
HS_Igate	900	900	mA
THS_sw	5	4	ns
GLS_drive	5	5	V
LS_Rdson	17	24	mΩ
LS_QGtot	7	5	nC
LS_QGD	3	2.4	nC
LS_QGS	2	1.4	nC
LS_QRR	16	7.6	nC
LS_Igate	900	900	mA
TLS_sw	5	4	ns

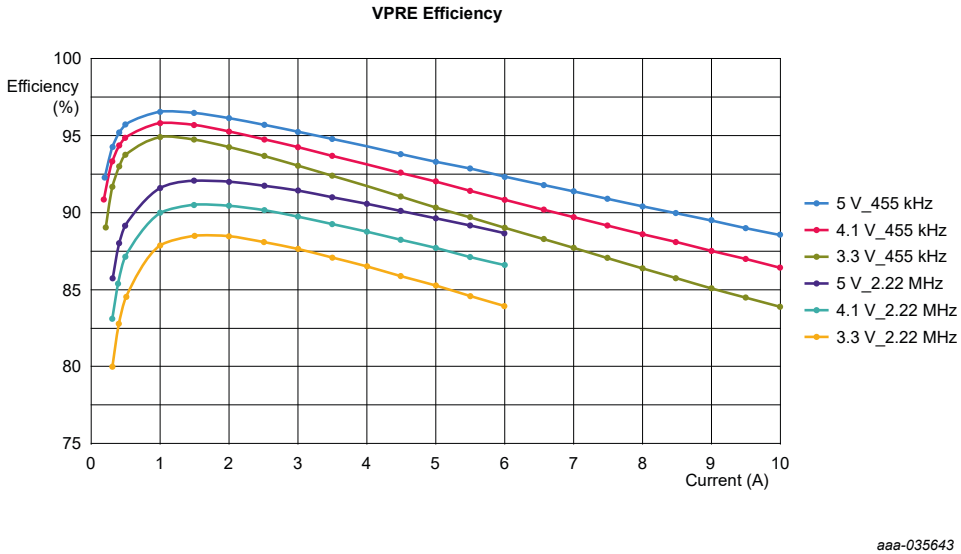


Figure 16. VPRE theoretical efficiency

20.7 VPRE not populated

When two FS85/FS84 are used, only one VPRE may be required. It is possible to not populate the external components of the second VPRE to optimize the bill of material.

In that case, specific connection of the VPRE2 pins is required:

- PRE_FB2 must be connected to PRE_FB1
- PRE_CSP2 must be connected to PRE_FB1
- PRE_COMP2 must be left open
- PRE_SW2 must be connected to GND
- PRE_BOOT2 must be connected to VBOS2
- PRE_GHS2 and PRE_GLS2 must be left open

After the start-up phase, VPRE2 shall be disabled by SPI/I2C with VPDIS bit.

21 Low voltage boost: VBOOST

21.1 Functional description

VBOOST block is a low voltage, asynchronous, peak current mode boost converter. VBOOST works in PWM and uses an external diode and an internal low-side FET. VBOOST enters Skip mode to maintain the correct output voltage in light load condition. The output voltage is configurable by OTP at 5.0 V or 5.74 V, the switching frequency is 2.22 MHz and the output current is limited to 1.5 A peak input current. The input of the boost is connected to the output of VPRE. This block is intended to supply LDO1, LDO2, BUCK3 or an external regulator. The stability is ensured by an internal Type 2 compensation network with slope compensation.

By default, VBOOST switching frequency is derived from the internal oscillator, and can be synchronized with an external frequency signal applied on FIN input pin. The change from internal oscillator to external clock or vice versa is controlled by SPI/I2C.

An overcurrent detection and a thermal shutdown are implemented to protect the internal MOSFET. If an overcurrent is detected after the LS minimum TON time, the LS is turned OFF and will be turned ON again at the next rising edge of the switching clock. The overcurrent induces a duty cycle reduction that could lead to the output voltage gradually dropping, causing an undervoltage condition on one of the cascaded regulators.

Since the current limitation is on the input current, Table 81 summarizes the expected output current capability depending on VPRE and VBOOST voltage configurations and L = 4.7 µH.

Table 81. Output current capability

VPRE	VBOOST	IBOOST_OUT
3.3 V	5.0 V	800 mA
	5.74 V	700 mA
4.1 V	5.0 V	1 A
	5.74 V	900 mA
5.0 V	5.74 V	1.1 A

An overvoltage protection is implemented on BOOST_LS pin. When V_{BOOST_OV} is detected during two consecutive turn ON cycles, VBOOST is disabled. A SPI/I2C command is required to enable it again. This monitoring is not safety related.

21.2 Application schematic

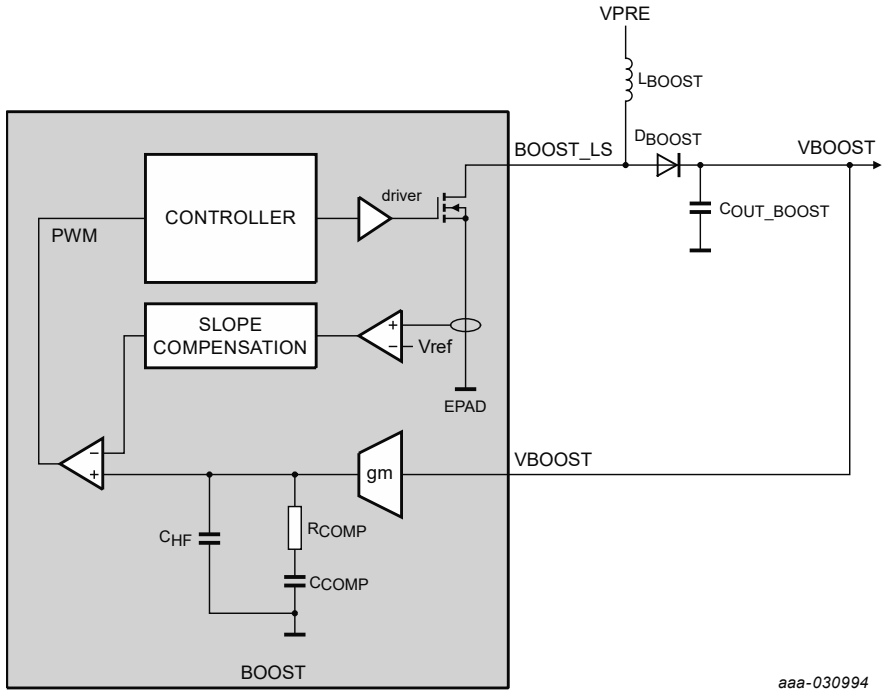


Figure 17. BOOST schematic

It is recommended to select a Schottky diode for D_{BOOST} to limit the impact on the SMPS efficiency.

21.3 Compensation network and stability

The internal compensation network, made with R_{COMP}, C_{COMP} and C_{HF} is optimized for best compromise between stability and transient response with R_{COMP} = 750 kΩ, C_{COMP} = 125 pF and C_{HF} = 2.0 pF.

Use case with V_{BOOST} = 5.74 V, L_{VBOOST} = 4.7 µH, F_{BOOST_SW} = 2.22 MHz, C_{OUT_BOOST} = 22 µF

Use case stability verification:

- Phase margin target PM > 45° and gain margin target GM > 6 dB.

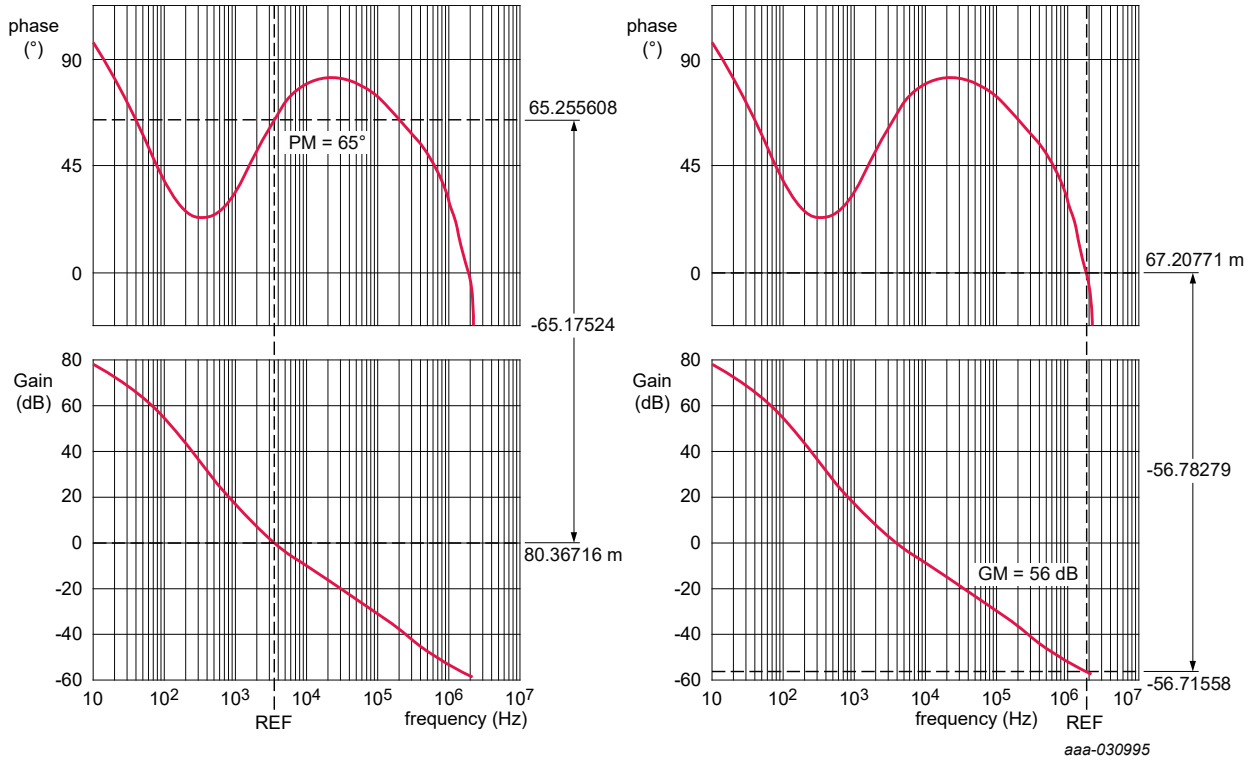


Figure 18. Phase and gain margin simulation

Use case transient response verification:

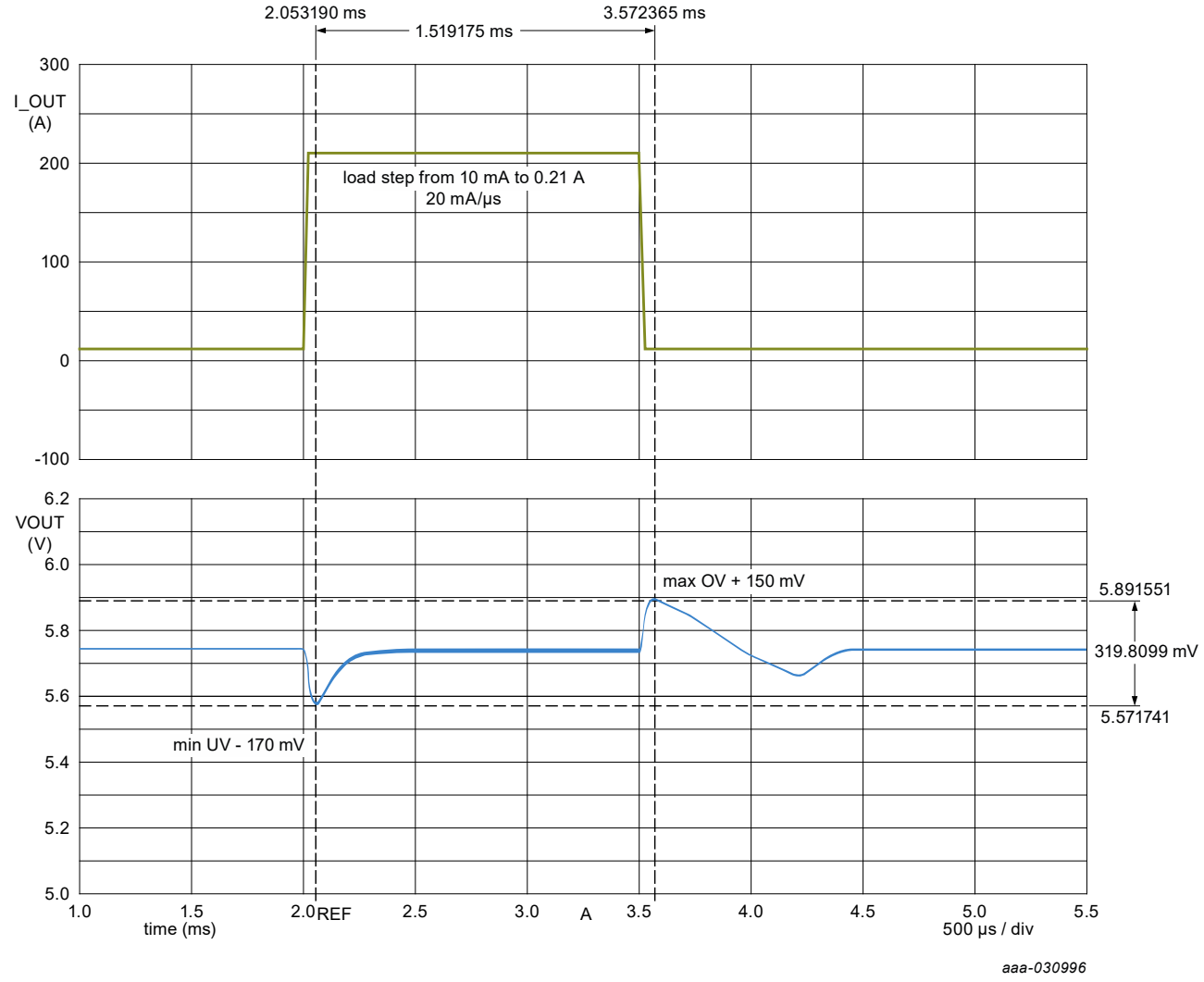


Figure 19. Transient response simulation

21.4 Electrical characteristics

Table 82. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
VBOOST					
V_{BOOST}	Output voltage (OTP_VBSTV[3:0] bits)	5.57	5.74	5.91	V
		4.85	5.0	5.15	V
$V_{BOOST\_SOFT\_START}$	Output voltage from 10 % to 90 %	—	500	—	µs
	Digital DAC soft start completion	—	—	825	µs
$V_{BOOST\_STARTUP}$	Overshoot at startup	—	—	3	%
V_{BOOST_UVH}	Undervoltage threshold high	3.3	—	3.7	V
T_{BOOST_UVH}	V_{BOOST_UVH} filtering time	6	10	15	µs
V_{BOOST_OV}	Overvoltage protection threshold	7.4	—	7.9	V
F_{BOOST_SW}	Switching frequency range	2.1	2.22	2.35	MHz
L_{BOOST}	Typical inductor value	2.2	4.7	6.8	µH
C_{OUT_BOOST}	Effective output capacitor	22	—	66	µF
$V_{BOOST\_LOAD\_REG}$	Transient load regulation (C_{OUT_BOOST} = 22 µF, from 10 mA to 400 mA, di/dt = 200 mA/µs)	—	—	750	mV
$V_{BOOST\_LOAD\_REG}$	Transient load regulation (C_{OUT_BOOST} = 22 µF, from 1.0 mA to 20 mA, di/dt = 200 mA/µs)	—	—	500	mV
I_{LIM_BOOST}	Inductor peak current limitation range (OTP_VBSTILIM[1:0] bits)	1.5	2	2.75	A
$T_{BOOST\_ON\_MIN}$	LS minimum ON time (OTP_VBSTTONTIME[1:0] bits)	40	60	90	ns
		30	50	80	ns
R_{BOOST_RON}	LS NMOS RDSon	—	150	280	mΩ
T_{BOOST_SR}	Switching output slew rate (OTP_VBSTSR[1:0] bits by default + VBSTSR[1:0] bits by SPI/I2C)	—	500	1500	V/µs
		—	300	750	V/µs
$gmEA_{BOOST}$	Error amplifier transconductance	3.5	7	9	µS
V_{BOOST_SLOPE}	Slope compensation (OTP_VBSTSC[3:0] bits)	40	79	110	mV/µs
		70	125	190	mV/µs
		90	160	230	mV/µs
R_{COMP}	Compensation network resistor	500	750	1200	kΩ
		250	500	1000	kΩ
C_{COMP}	Compensation network capacitor	90	125	175	pF
TSD_{BOOST}	Thermal shutdown threshold	160	—	—	°C
TSD_{BOOST_HYST}	Thermal shutdown threshold hysteresis	—	9	—	°C
T_{BOOST_TSD}	Thermal shutdown filtering time	3	5	8	µs

21.5 VBOOST not populated

It is possible to not use the VBOOST when VPRE is configured at 4.1 V or 5.0 V. In this case, the external VBOOST components can be unpopulated to optimize the bill of material. The OTP_BOOSTEN bit shall be programmed to 0 and VBOOST pin must be connected to VPRE. BOOST_LS pin must be left open.

VBOOST must be used when VPRE is configured at 3.3 V or 3.8 V to supply VBOS.

22 Low voltage buck: BUCK1 and BUCK2

22.1 Functional description

BUCK1 and BUCK2 blocks are low voltage, synchronous, valley current mode buck converters with integrated HS PMOS and LS NMOS. BUCK1 and BUCK2 work in force PWM and the output voltage is configurable by OTP from 0.8 V to 1.8 V, the switching frequency is 2.22 MHz and the output current is limited to 3.6 A peak . The input of these blocks must be connected to the output of VPRE. The stability is ensured by an internal Type 2 compensation network with slope compensation.

By default, BUCK1 and BUCK2 switching frequency is derived from the internal oscillator and can be synchronized with an external frequency signal applied on FIN input pin. The change from internal oscillator to external clock or vice versa is controlled by SPI/I2C.

BUCK2 is part number dependent according to OTP_BUCK2EN bit. BUCK1 and BUCK2 can work independently or in Dual phase mode to double the output current capability. When BUCK1 and BUCK2 are used in dual phase, they must have the same output voltage configuration. Any action like TSD, OV, disable by SPI/I2C, on BUCK1 affects BUCK2 and vice versa.

An overcurrent detection and a thermal shutdown are implemented on BUCK1 and BUCK2 to protect the internal MOSFETs. The overcurrent induces a duty cycle reduction that could lead to the output voltage gradually dropping, causing an undervoltage condition.

The ramp up and ramp down of BUCK1 and BUCK2 when they are enabled and disabled is configurable with OTP_DVS_BUCK12[1:0] bits to accommodate multiple MCU soft start requirements. Static Voltage Scaling (SVS) feature is available to decrease the output voltage after power up during INIT_FS. Programmable phase shift control is implemented, see Section 25 "Clock management".

22.2 Application schematic: Single phase mode

In this configuration, BUCK1 and BUCK2 are configured as independent outputs, working independently. Each output is configured and controlled independently by SPI/I2C.

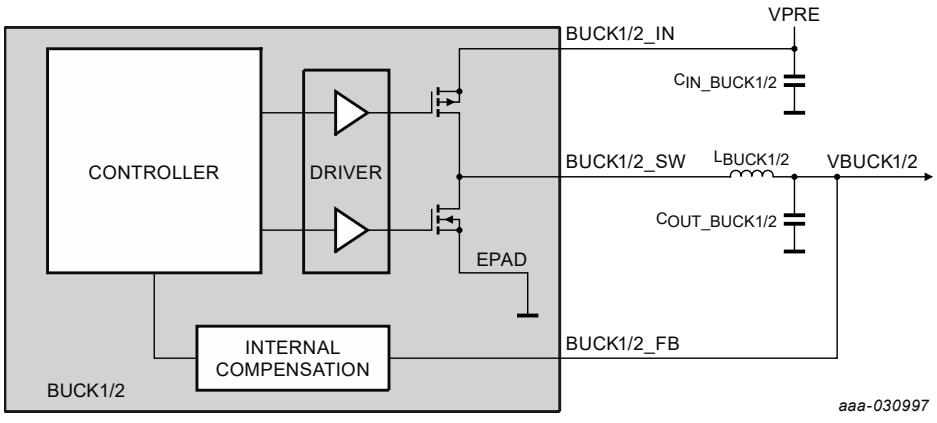


Figure 20. BUCK1/2 standalone schematic

22.3 Application schematic: Dual phase mode

In this configuration, BUCK1 and BUCK2 are configured in dual phase mode to double the output current capability. The dual phase mode is enable with OTP_VB12MULTIPH bit. The PCB layout of BUCK1 phase and BUCK2 must be symmetric for optimum EMC performance.

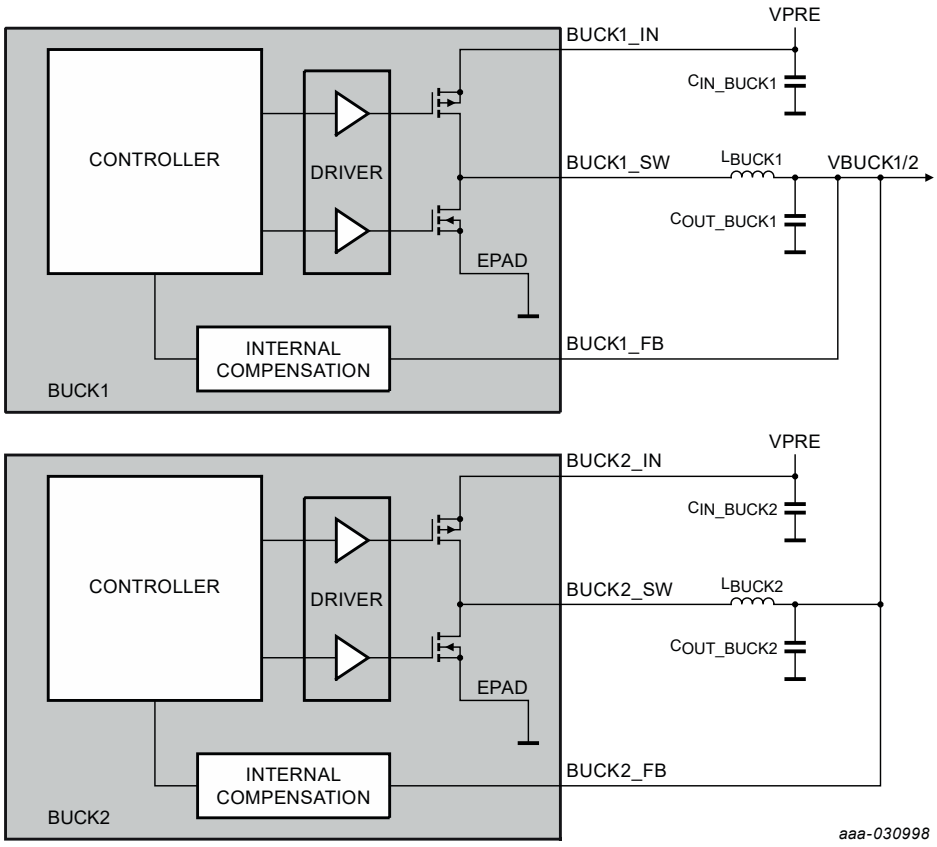


Figure 21. BUCK1/2 multiphase schematic

22.4 Compensation network and stability

The internal compensation network ensures the stability and the transient response performance of the buck converter. The error amplifier gain is configurable with OTP_VBxGMCOMP[2:0] bits for each BUCK 1 and BUCK2 regulators. It is recommended to use the default value that covers most of the use cases.

Decreasing the gain reduces the regulation bandwidth and increase the phase and gain margin but transient performance is degraded. Increasing the gain enlarges the regulation bandwidth and improves the transient performance but the phase and gain margin is degraded.

OTP_VBxINDOPT[1:0] scales the slope compensation and the zero cross detection according to the inductor value. 1.0 µH is the recommended inductor value for BUCK1 and BUCK2.

Use case with V_{PRE} = 3.3 V, V_{BUCK1} = 1.0 V, L_{VBUCK1} = 1.0 µH, V_{BUCK1_SW} = 2.22 MHz, C_{OUT_BUCK1} = 44 µF, default Err Amp gain

Use case stability verification:

- Phase margin target PM > 45° and gain margin target GM > 6 dB.

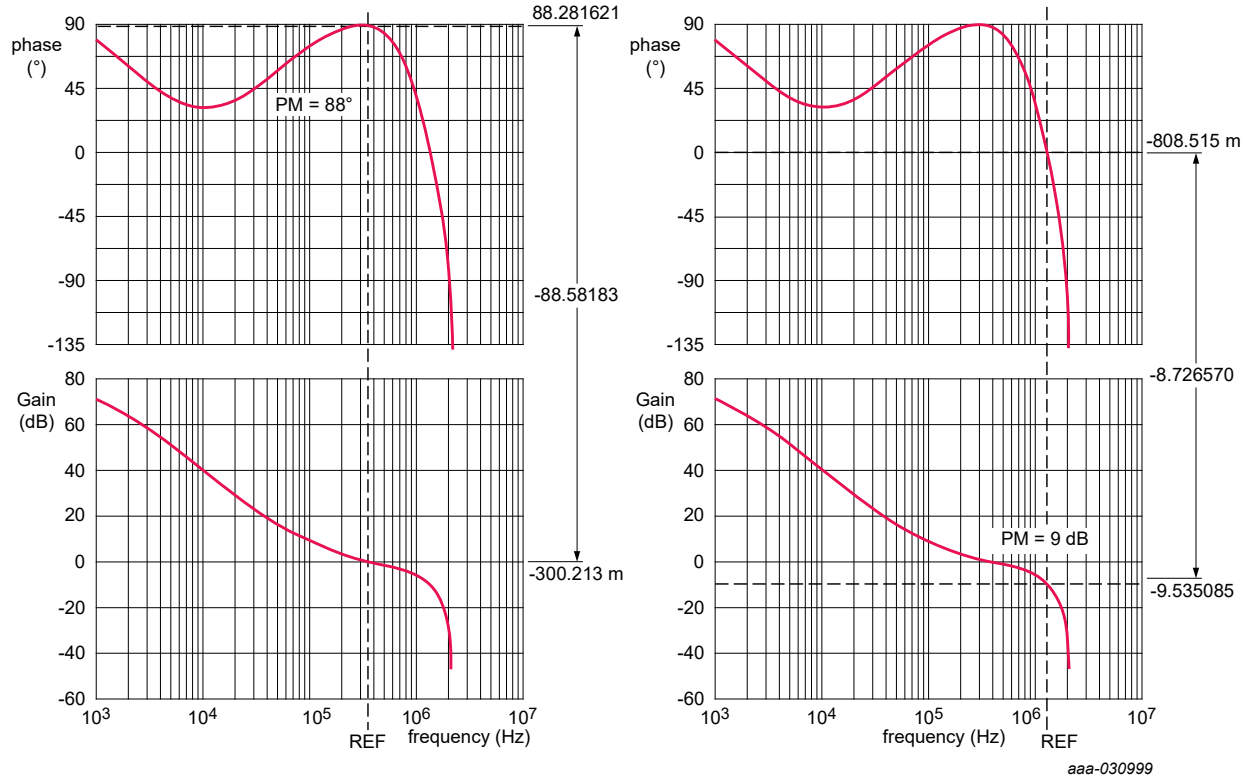


Figure 22. Phase and gain margin simulation

Use case transient response verification:

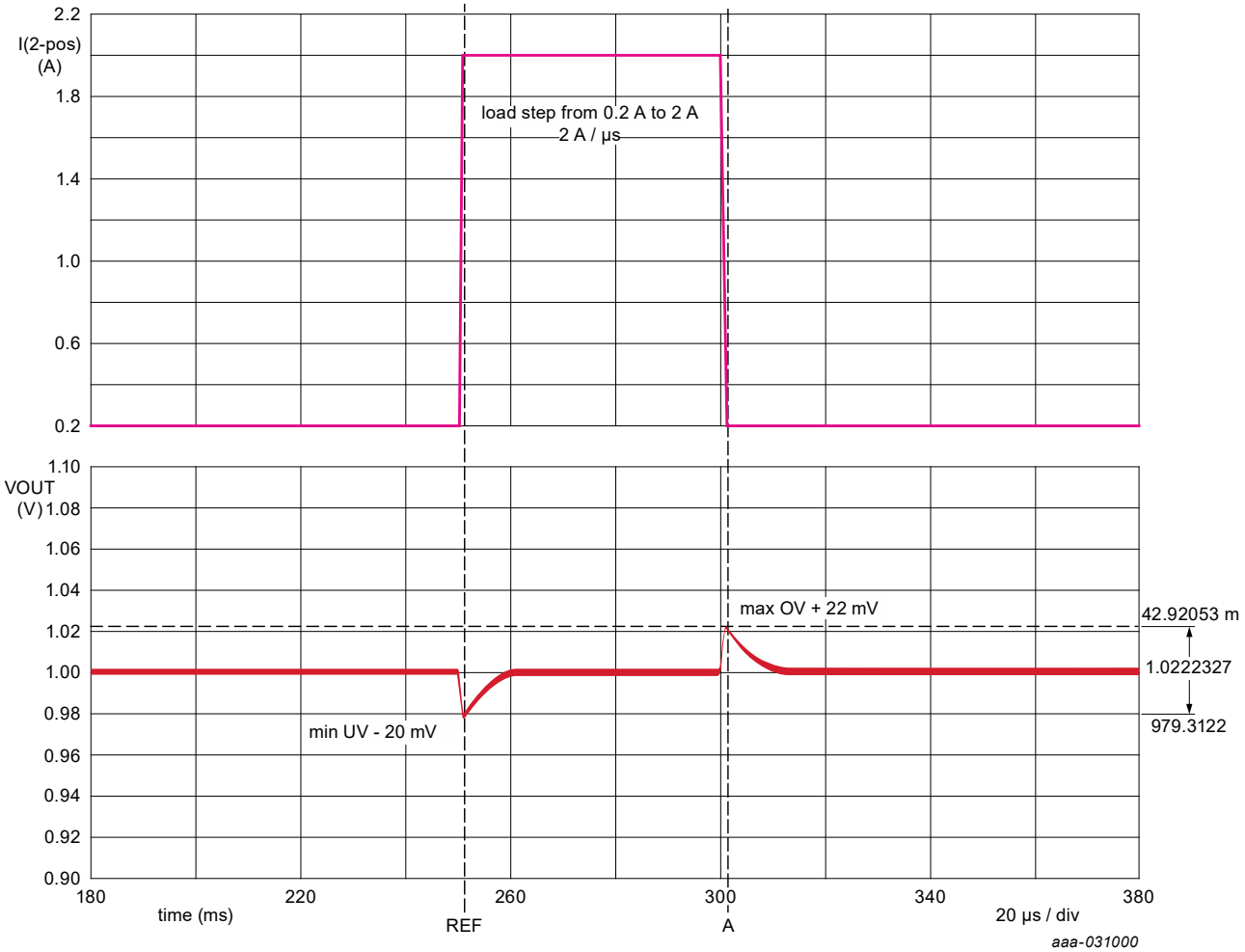


Figure 23. Transient response simulation

22.5 Electrical characteristics

Table 83. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
BUCK1 and BUCK2					
VBUCK12_IN	Input voltage range	2.5	—	5.5	V
VBUCK12	Output voltage (OTP_VB1V[7:0] and OTP_VB2V[7:0] bits) 0.8 V, 0.825 V, 0.9 V, 0.95 V, 0.975 V, 1.0 V, 1.025 V, 1.03125 V, 1.075 V, 1.0875 V, 1.09375 V, 1.1 V, 1.11875 V, 1.1375 V, 1.2 V, 1.25 V, 1.3 V, 1.35 V, 1.4 V, 1.5 V, 1.8 V	0.8	—	1.8	V
I_{BUCK12}	DC output current capability (one phase)	—	2.5	—	A
V_{BUCK12_ACC}	Output voltage accuracy (Iout < 2.5 A)	−1.5	—	+1.5	%
F_{BUCK12_SW}	Switching frequency range	2.1	2.22	2.35	MHz
L_{BUCK12}	Typical inductor value (OTP_VB1INDOPT[1:0] and OTP_VB2INDOPT[1:0] bits)	0.47	1.0	1.5	µH
C_{OUT_BUCK12}	Effective output capacitor	40	—	160	µF
	Output decoupling capacitor	—	0.1	—	µF

Table 83. Electrical characteristics*...continued*

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
C_{IN_BUCK12}	Effective input capacitor (close to BUCK1_IN and BUCK2_IN pins)	4.7	—	—	µF
	Input decoupling capacitor (close to BUCK1_IN and BUCK2_IN pins)	—	0.1	—	µF
V_{BUCK12_TLR}	Transient load regulation for VBUCK12 < 1.2 V (Cout = 40 µF, from 200 mA to 1.0 A, di/dt = 2.0 A/µs for mono phase configuration) (Cout = 40 µF, from 400 mA to 2.0 A, di/dt = 4.0 A/µs for dual phase configuration)	−25	—	+25	mV
	Transient load regulation for VBUCK12 >1.2V (Cout = 40 µF, from 200 mA to 1.0 A, di/dt = 2.0 A/µs for mono phase configuration) (Cout = 40 µF, from 400 mA to 2.0 A, di/dt = 4.0 A/µs for dual phase configuration)	−3	—	+3	%
I_{LIM_BUCK12}	Inductor peak current limitation range for one phase (OTP_VB1SWILIM[1:0] bits and OTP_VB2SWILIM[1:0])	2.0	2.6	3.1	A
		3.6	4.5	5.45	A
$V_{BUCK12\_DVS\_UP}$ (for V_{BUCK12} up to 1.5 V)	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 00	5.86	7.81	9.77	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 01	2.34	3.13	3.91	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 10	1.95	2.60	3.26	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 11	1.67	2.23	2.79	mV/µs
$V_{BUCK12\_DVS\_UP\_1p8}$ (for V_{BUCK12} = 1.8 V)	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 00	7.33	9.763	12.21	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 01	2.93	3.91	4.89	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 10	2.44	3.25	4.08	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 11	2.09	2.79	3.49	mV/µs
$V_{BUCK12\_DVS\_DOWN}$ (for V_{BUCK12} up to 1.5 V	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 00	3.91	5.21	6.51	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 01	2.34	3.13	3.91	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 10	1.95	2.6	3.26	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 11	1.67	2.23	2.79	mV/µs
$V_{BUCK12\_DVS\_DOWN\_1p8}$ (for V_{BUCK12} = 1.8 V)	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 00	4.89	6.51	8.14	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 01	2.93	3.91	4.89	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 10	2.44	3.25	4.08	mV/µs
	Ramp up and ramp down speed, OTP_DVS_BUCK12[1:0] = 11	2.09	2.79	3.49	mV/µs
$T_{BUCK12\_SOFT\_START}$	$V_{BUCK12\_SOFT\_START}$ = V_{BUCK12} / $V_{BUCK12\_DVS\_UP}$ Soft start for V_{BUCK12} = 1.2 V and OTP_DVS_BUCK12[1:0] = 00	122.9	153.6	204.8	µs
	Soft start for V_{BUCK12} = 1.2 V and OTP_DVS_BUCK12[1:0] = 11 To be recalculated for different V_{BUCK12} and different $V_{BUCK12\_DVS\_UP}$	430.1	538.1	718.5	µs

Table 83. Electrical characteristics...*continued*

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
$V_{BUCK12\_STARTUP}$	Overshoot at startup	—	—	50	mV
$T_{BUCK12\_OFF\_MIN}$	HS minimum OFF time	9	30	54	ns
T_{BUCK12_DT}	Dead time to avoid cross conduction	0.01	3	20	ns
$R_{BUCK12\_HS\_RON}$	HS PMOS RDSon	—	—	135	mΩ
$R_{BUCK12\_LS\_RON}$	LS NMOS RDSon	—	—	80	mΩ
R_{BUCK12_DISCH}	Discharge resistance (when BUCK1,2 is disabled)	250	500	1000	Ω
TSD_{BUCK12}	Thermal shutdown threshold	160	—	—	°C
TSD_{BUCK12_HYST}	Thermal shutdown threshold hysteresis	—	9	—	°C
T_{BUCK12_TSD}	Thermal shutdown filtering time	3	5	8	µs

22.6 BUCK1 and BUCK2 efficiency

BUCK1 and BUCK2 efficiency versus current load is given for information based on external component criteria provided and VPRE voltage 4.1 V. If the conditions change, it has to be recalculated with the FS85_PDTCAL tool. The real efficiency has to be verified by measurement at the application level.

Ext. C and L		
Cin	60	µF
ESR Cin	10	mΩ
Cout	44	µF
ESR Cout	10	mΩ
L coil	1	µH
DCR coil	20	mΩ
Int. MOSFETs		
HS_Rdson	135	mΩ
QHS	0.5	nC
THS_sw	3	ns
GHS_drive	5	V
LS_Rdson	80	mΩ
QLS	0.5	nC
TLS_sw	3	ns
GLS_drive	5	V

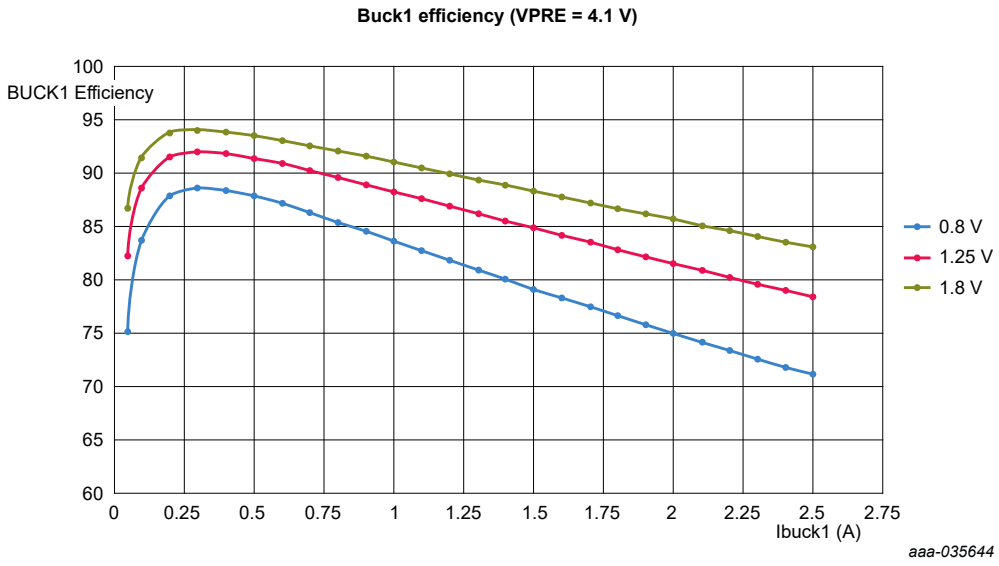


Figure 24. BUCK1 and BUCK2 theoretical efficiency

23 Low voltage buck: BUCK3

23.1 Functional description

BUCK3 block is a low voltage, synchronous, peak current mode buck converter with integrated HS PMOS and LS NMOS. BUCK3 works in force PWM and the output voltage is configurable by OTP from 1.0 V to 3.3 V, the switching frequency is 2.22 MHz and the output current is limited to 3.6 A peak . The input of this block can be connected to the output of VPRE or VBOOST when VBOOST = 5.0 V only. The stability is ensured by an internal Type 2 compensation network with slope compensation.

By default, BUCK3 switching frequency is derived from the internal oscillator, and can be synchronized with an external frequency signal applied on FIN input pin. The change from internal oscillator to external clock or vice versa is controlled by SPI/I2C.

An overcurrent detection and a thermal shutdown are implemented on BUCK3 to protect the internal MOSFETs. The overcurrent induces a duty cycle reduction that could lead to the output voltage gradually dropping, causing an undervoltage condition.

BUCK3 is part number dependent according to OTP_BUCK3EN bit. BUCK3_INQ pin, used to bias internal BUCK3 driver, must be connected to the same source than BUCK3_IN , either on VBOOST either on VPRE. See Application schematic. The ramp up and ramp down of BUCK3 when it is enabled and disabled is configurable with OTP_DVS_BUCK3[1:0] bits to accommodate multiple MCU soft start requirements.

Programmable phase shift control is implemented, see Section 25 "Clock management".

23.2 Application schematic

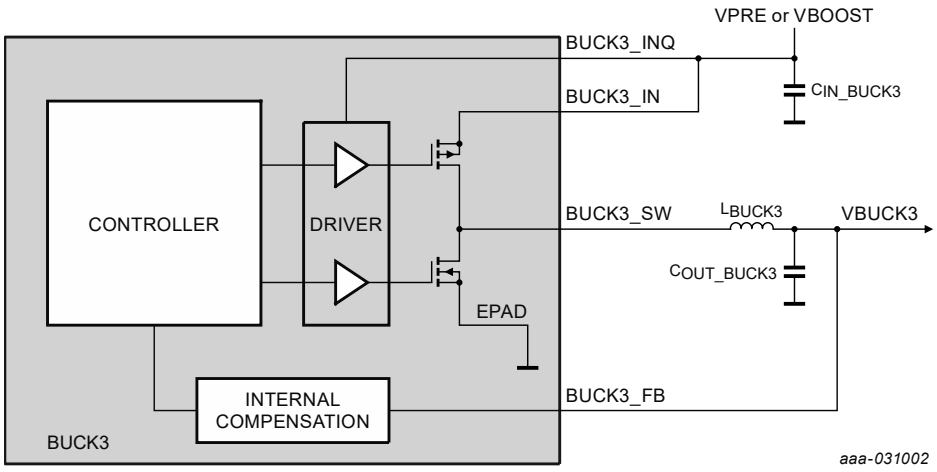


Figure 25. BUCK3 schematic

23.3 Compensation network and stability

The internal compensation network ensures the stability and the transient response performance of the buck converter. OTP_VB3INDOPT[1:0] scales the slope compensation and the zero cross detection according to inductor value. 1.0 µH is the recommended inductor value for BUCK3.

Use case with V_{PRE} = 3.3 V, V_{BUCK3} = 2.3 V, L_{VBUCK3} = 1.0 µH, F_{BUCK3_SW} = 2.22 MHz, C_{OUT_BUCK3} = 44 µF

Use case stability verification:

- Phase margin target PM > 45° and gain margin target GM > 6 dB.

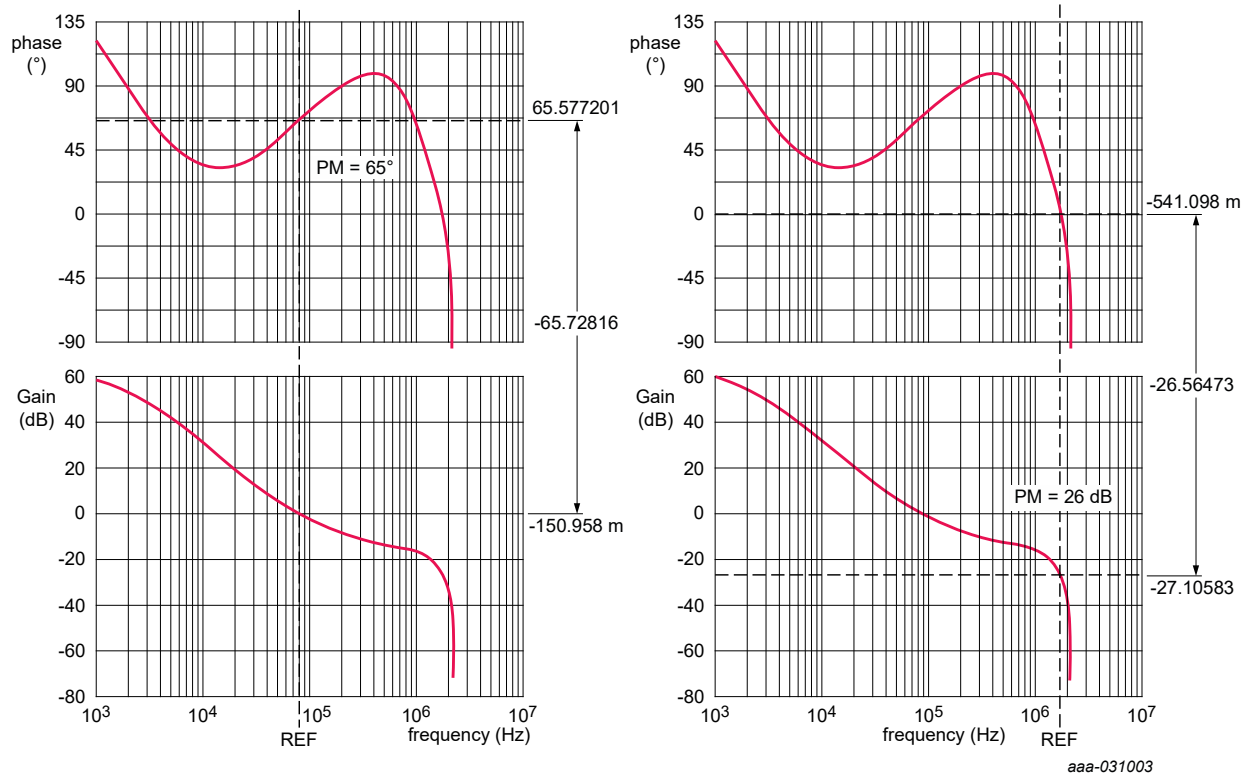


Figure 26. Phase and gain margin simulation

Use case transient response verification:

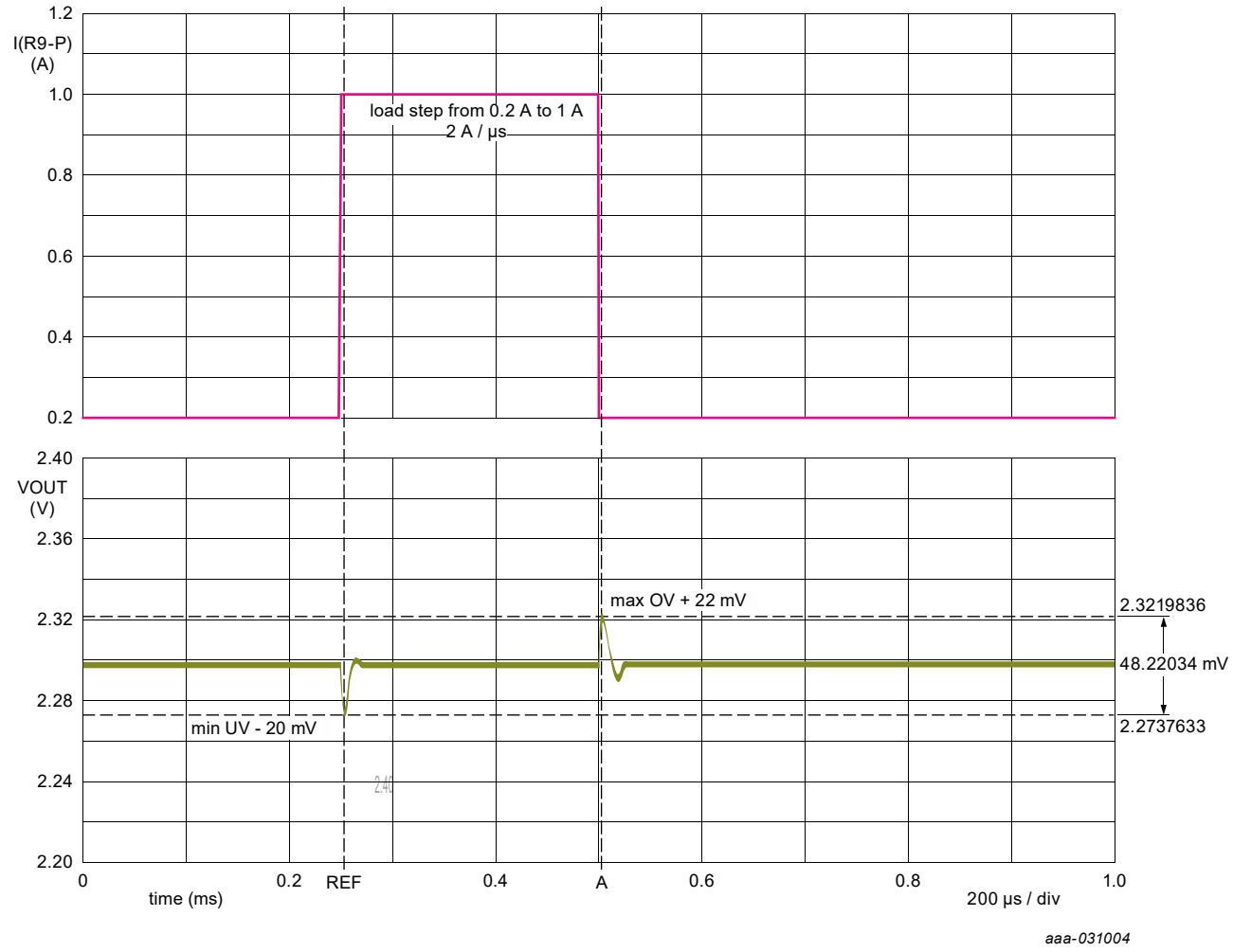


Figure 27. Transient response simulation

23.4 Electrical characteristics

Table 84. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
BUCK3					
V_{BUCK3_IN}	Input voltage range	2.5	—	5.5	V
V_{BUCK3}	Output voltage (OTP_VB3V[4:0] bits) 1.0 V, 1.1 V, 1.2 V, 1.25 V, 1.3 V, 1.35 V, 1.5 V, 1.6 V, 1.8 V, 2.3 V, 2.5 V, 2.8 V, 3.3 V	1.0	—	3.3	V
I_{BUCK3}	DC output current capability	—	2.5	—	A
V_{BUCK3_ACC}	Output voltage accuracy (Iout < 2.5 A)	−1.5	—	+1.5	%
F_{BUCK3_SW}	Switching frequency range	2.1	2.22	2.35	MHz
L_{BUCK3}	Typical inductor value (OTP_VB3INDOPT[1:0] bits)	0.47	1.0	1.5	µH

Table 84. Electrical characteristics*...continued*

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
C_{OUT_BUCK3}	Effective output capacitor	40	—	120	µF
	Output decoupling capacitor	—	0.1	—	µF
C_{IN_BUCK3}	Effective input capacitor (close to BUCK3_IN pin)	4.7	—	—	µF
	Input decoupling capacitor (close to BUCK3_IN pin)	—	0.1	—	µF
V_{BUCK3_TLR}	Transient load regulation (Cout = 40 µF, from 200 mA to 1.0 A, di/dt = 2.0 A/µs)	−50	—	+50	mV
I_{LIM_BUCK3}	Inductor peak current limitation range (OTP_VB3 SWILIM[1:0] bits)	2.0	2.6	3.1	A
		3.6	4.5	5.45	A
$T_{BUCK3\_ON\_MIN}$	HS minimum ON time	5	50	80	ns
$V_{BUCK3\_DVS\_UP\_DOWN}$	Ramp up and ramp down speed, OTP_DVS_ BUCK3[1:0] = 00	7.81	10.42	13.02	mV/µs
	Ramp up and ramp down speed, OTP_DVS_ BUCK3[1:0] = 01	2.6	3.47	4.34	mV/µs
	Ramp up and ramp down speed, OTP_DVS_ BUCK3[1:0] = 10	1.95	2.6	3.26	mV/µs
	Ramp up and ramp down speed, OTP_DVS_ BUCK3[1:0] = 11	1.56	2.08	2.60	mV/µs
$T_{BUCK3\_SOFT\_START}$	$V_{BUCK3\_SOFT\_START}$ = V_{BUCK3} / $V_{BUCK3\_DVS\_UP\_DOWN}$ Soft start for V_{BUCK3} = 1.1 V and OTP_DVS_ BUCK3[1:0] = 00	84.8	105.6	140.8	µs
	Soft start for V_{BUCK3} = 1.1 V and OTP_DVS_ BUCK3[1:0] = 11 To be recalculated for different V_{BUCK3} and different $V_{BUCK3\_DVS\_UP\_DOWN}$	422.4	528	704	µs
$V_{BUCK3\_STARTUP}$	Overshoot at startup	—	—	50	mV
T_{BUCK3_DT}	Dead time to avoid cross conduction	0.01	3	20	ns
$R_{BUCK3\_HS\_RON}$	HS PMOS RDSon	—	—	135	mΩ
$R_{BUCK3\_LS\_RON}$	LS NMOS RDSon	—	—	80	mΩ
R_{BUCK3_DISCH}	Discharge resistance (when BUCK3 is disabled)	250	500	1000	Ω
TSD_{BUCK3}	Thermal shutdown threshold	160	—	—	°C
TSD_{BUCK3_HYST}	Thermal shutdown threshold hysteresis	—	9	—	°C
T_{BUCK3_TSD}	Thermal shutdown filtering time	3	5	8	µs

23.5 BUCK3 efficiency

BUCK3 efficiency versus current load is given for information based on external component criteria provided and VPRE voltage 4.1 V. If the conditions change, it has to be recalculated with the FS85_PDTCAL tool. The real efficiency has to be verified by measurement at the application level.

Ext. C and L		
Cin	60	µF
ESR Cin	10	mΩ
Cout	44	µF
ESR Cout	10	mΩ
L coil	1	µH
DCR coil	20	mΩ
Int. MOSFETs		
HS_Rdson	135	mΩ
QHS	0.5	nC
THS_sw	3	ns
GHS_drive	5	V
LS_Rdson	80	mΩ
QLS	0.5	nC
TLS_sw	3	ns
GLS_drive	5	V

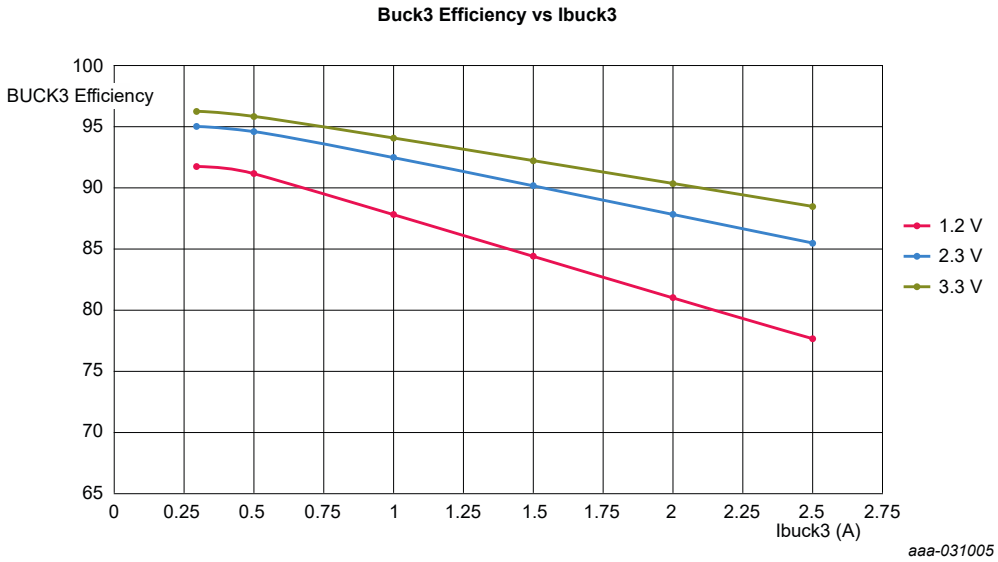


Figure 28. BUCK3 theoretical efficiency

24 Linear voltage regulator: LDO1, LDO2

24.1 Functional description

LDO1 and LDO2 blocks are two linear voltage regulators. The output voltage is configurable by OTP from 1.1 V to 5.0 V. A minimum voltage drop is required depending on the output current capability (0.5 V for 150 mA and 1.0 V for 400 mA). The LDO current capability is linear with the voltage drop and can be estimated to I(mA) = 500 x V_{LDO12_DROP} -100 for intermediate voltage drop between 0.5 V and 1.0 V.

LDO1 input supply is externally connected to VPRE, VBOOST, or another supply. LDO2 input supply is internally connected to the output of VBOOST. An overcurrent detection and a thermal shutdown are implemented on LDO1 and LDO2 to protect the internal pass device.

24.2 Application schematics

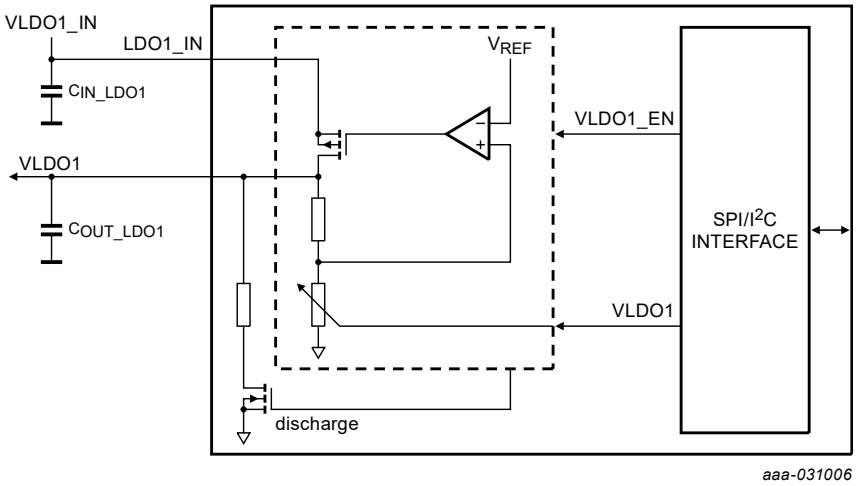


Figure 29. LDO1 block diagram

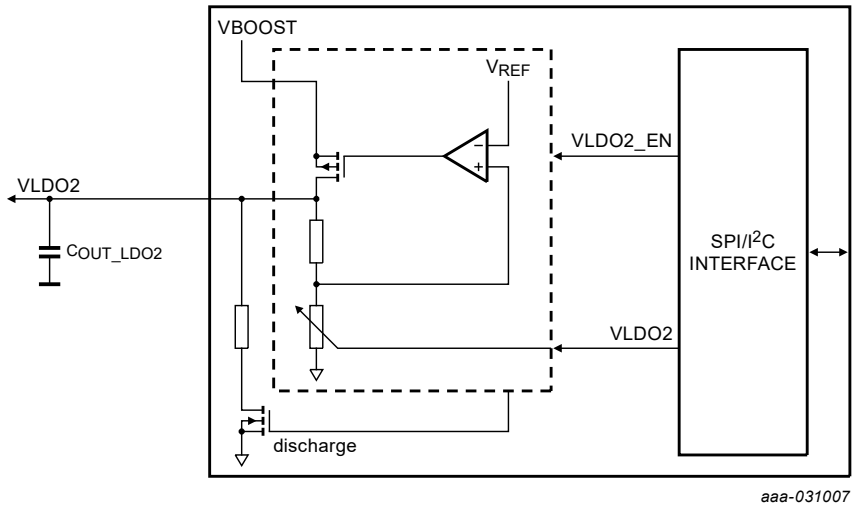


Figure 30. LDO2 block diagram

24.3 Electrical characteristics

Table 85. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
LDO1 and LDO2					
V_{LDO12_IN}	Input voltage range	2.5	—	6.5	V
V_{LDO12}	Output voltage (OTP_VLDO1V[2:0] and OTP_LDO2V[2:0] bits) 1.1 V, 1.2 V, 1.6 V, 1.8 V, 2.5 V, 2.8 V, 3.3 V, 5.0 V	1.1	—	5.0	V
$V_{LDO12\_ACC\_150}$	Output voltage accuracy, 150 mA current capability	−2	—	+2	%
$V_{LDO12\_ACC\_400}$	Output voltage accuracy, 400 mA current capability	−3	—	+3	%
$V_{LDO12\_DROP\_150}$	Minimum value between input and output to guarantee the LDO parametrics at 150 mA current capability	0.5	—	—	V
$V_{LDO12\_DROP\_400}$	Minimum value between input and output to guarantee the LDO parametrics at 400 mA current capability	1.0	—	—	V
$V_{LDO12\_DO\_mode\_150}$	Maximum voltage between input and output when LDO is in dropout mode for 150 mA current	—	—	0.3	V
$V_{LDO12\_DO\_mode\_400}$	Maximum voltage between input and output when LDO is in dropout mode for 400 mA current	—	—	0.8	V
C_{IN_LDO1}	Input capacitor (close to LDO1_IN pin)	1.0	—	—	µF
$C_{OUT\_LDO12\_150}$	Output capacitor, 150 mA current capability	4.7	—	10	µF
$C_{OUT\_LDO12\_400}$	Output capacitor, 400 mA current capability	6.8	—	10	µF
C_{OUT_LDO12}	Output decoupling capacitor	0.1	—	—	µF
$V_{LDO12\_LTR\_150}$	Transient load regulation (from 10 mA to 150 mA in 2.0 µs)	−4	—	+4	%
$V_{LDO12\_LTR\_400}$	Transient load regulation (from 10 mA to 400 mA in 4.0 µs)	−5	—	+5	%
V_{LDO12_LR}	Line regulation	—	—	0.5	%
$V_{LDO12\_ILIM\_150}$	Current limitation, 150 mA current capability (OTP_LDO1ILIM and OTP_LDO2ILIM bits)	200	280	500	mA
$V_{LDO12\_ILIM\_400}$	Current limitation, 400 mA current capability (OTP_LDO1ILIM and OTP_LDO2ILIM bits)	430	560	800	mA
$V_{LDO12\_SOFT\_START}$	Soft start (enable to 90 %)	—	1.0	1.3	ms
$V_{LDO12\_STARTUP}$	Overshoot at startup	—	—	2	%
R_{LDO12_DISCH}	Discharge resistance (when LDO1,2 is disabled)	10	20	60	Ω
TSD_{LDO12}	Thermal shutdown threshold	160	—	—	°C
TSD_{LDO12_HYST}	Thermal shutdown threshold hysteresis	—	9	—	°C
T_{LDO12_TSD}	Thermal shutdown filtering time	3	5	8	µs

25 Clock management

25.1 Clock description

The clock management block is made of the Internal oscillator, the Phase Locked Loop (PLL) and multiple dividers. This block manages the clock generation for the internal digital state machines, the switching regulators and the external clock synchronization.

The internal oscillator is running at 20 MHz by default after start up. The frequency is programmable by SPI/I2C and a spread spectrum feature can be activated by SPI/I2C to reduce the emission of the oscillator fundamental frequency.

VPRE switching frequency is coming from CLK2 (455 kHz) or CLK1 (2.22 MHz). BUCK1,2,3 and BOOST switching frequency is coming from CLK1 (2.22 MHz). The switching regulators can be synchronized with an external frequency coming from FIN pin. A dedicated watchdog monitoring is implemented to verify and report the correct FIN frequency range. Different clocks can be sent to FOUT pin to synchronize an external IC or for diagnostic.

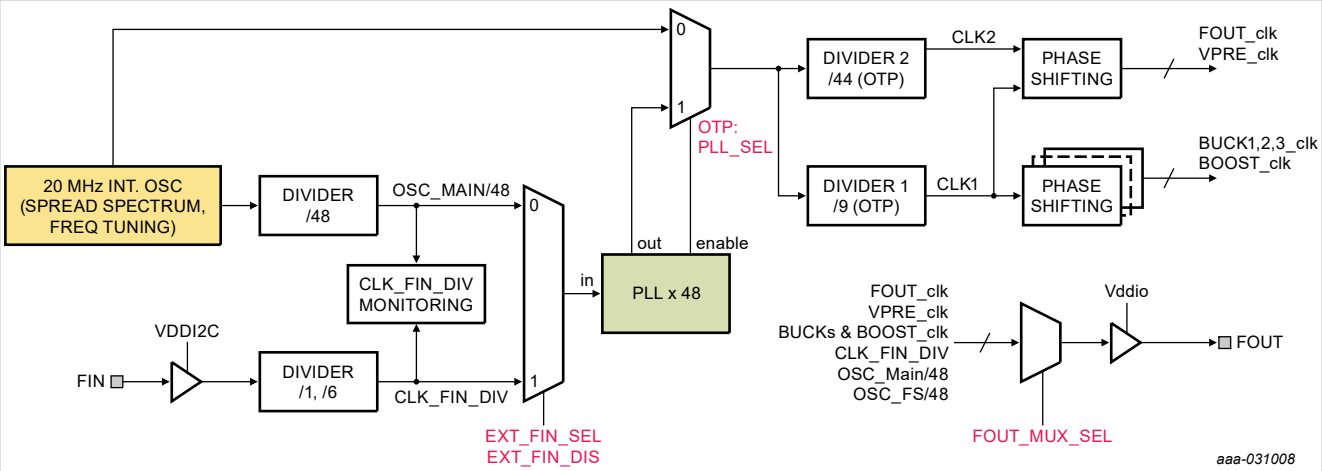


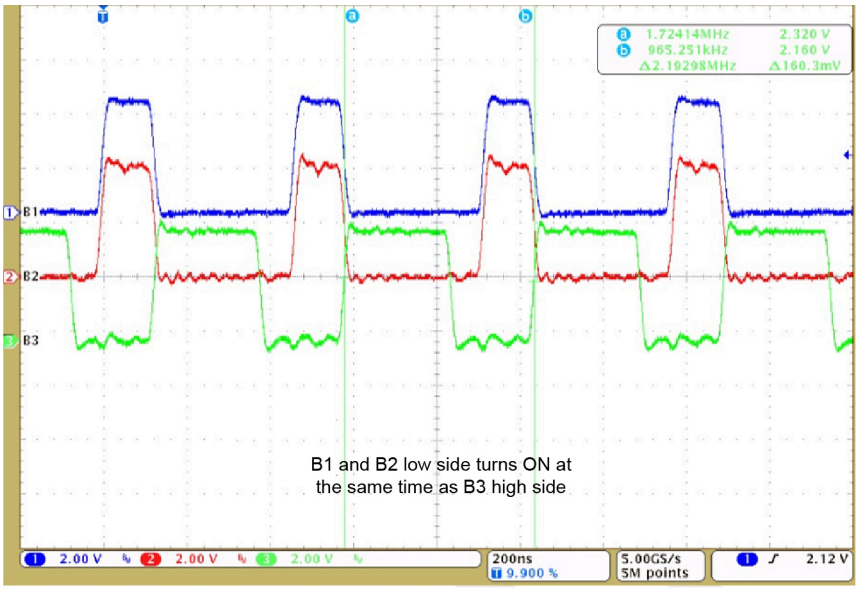
Figure 31. Clock management block diagram

25.2 Phase shifting

The clocks of the switching regulators (VPRE_clk, BOOST_clk, BUCK1_clk, BUCK2_clk and BUCK3_clk) can be delayed in order to avoid all the regulators to turn ON at the same time to reduce peak current and improve EMC performance.

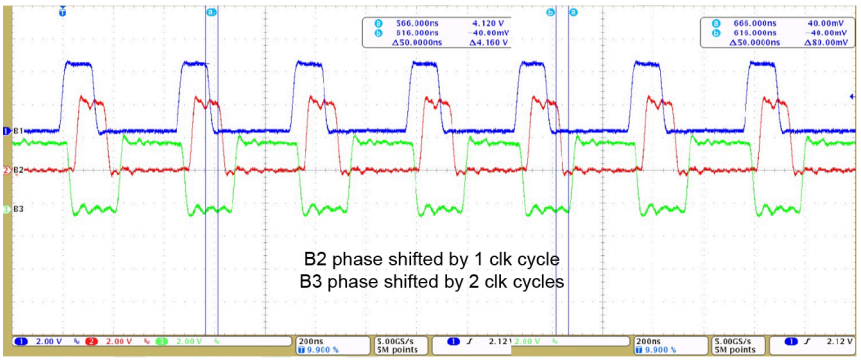
Each clock of each regulator can be shifted from 1 to 7 clock cycles of CLK running at 20 MHz what corresponds to 50 ns. The phase shift configuration is done by OTP configuration using OTP_VPRE_ph[2:0], OTP_VBST_ph[2:0], OTP_BUCK1_ph[2:0], OTP_BUCK2_ph[2:0] and OTP_BUCK3_ph[2:0].

VPRE and BUCK3 have a peak current detection architecture. The PWM synchronizes the turn ON of the high-side switch. BUCK1 and BUCK2 have a valley current detection architecture. The PWM synchronizes the turn ON of the low-side switch.



aaa-031009

Figure 32. BUCK1,2,3_clk = 2.22 MHz without clock phase shifting



aaa-031010

Figure 33. BUCK1,2,3_clk = 2.22 MHz with clock phase shifting

25.3 Manual frequency tuning

The internal oscillator frequency, 20 MHz by default, can be programmed from 16 MHz to 24 MHz with 1.0 MHz frequency step by SPI/I2C. The oscillator functionality is guaranteed for frequency increment of one step at a time in either direction, with a minimum of 10 µs between two steps. For any unused code of the CLK_TUNE [3:0] bits, the internal oscillator is set at the default 20 MHz frequency.

To change the internal oscillator frequency from 20 MHz to 24 MHz, four SPI/I2C commands are required with 10 µs wait time between each command (21 MHz – wait 10 µs – 22 MHz – wait 10 µs – 23 MHz – wait 10 µs – 24 MHz). To change the internal oscillator frequency from 24 MHz to 16 MHz, eight SPI/I2C commands are required with 10 µs wait time between each command (23 MHz – wait 10 µs – 22 MHz – wait 10 µs – 21 MHz – wait 10 µs – 20 MHz – wait 10 µs – 19 MHz – wait 10 µs – 18 MHz – wait 10 µs – 17 MHz – wait 10 µs – 16MHz).

Table 86. Manual frequency tuning configuration

CLK_TUNE [3:0]	Oscillator frequency [MHz]
0000 (default)	20
0001	21
0010	22
0011	23
0100	24
1001	16
1010	17
1011	18
1100	19
Reset condition	POR

25.4 Spread spectrum

The internal oscillator can be modulated with a triangular carrier frequency of 23 kHz or 94 kHz with ±5 % deviation range around the oscillator frequency. The spread spectrum feature can be activated by SPI/I2C with the MOD_EN bit and the carrier frequency can be selected by SPI/I2C with the MOD_CONF bit. By default, the spread spectrum is disabled. The spread spectrum and the manual frequency tuning functions cannot be used at the same time.

The main purpose of the spread spectrum is to improve the EMC performance by spreading the energy of the internal oscillator and VPRE frequency on VBAT frequency spectrum. It is recommended to select 23 kHz carrier frequency when VPRE is configured at 455 kHz and 94 kHz when VPRE is configured at 2.2 MHz for the best performance.

25.5 External clock synchronization

To synchronize the switching regulators with an external frequency coming from FIN pin, the PLL shall be enabled with OTP_PLL_SEL bit. The FIN pin accepts two ranges of frequency depending on the divider selection to always have CLK clock at the output of the PLL in the working range of the digital blocks from 16 MHz to 24 MHz. When FIN_DIV = 0, the input frequency range must be between 333 kHz and 500 kHz. When FIN_DIV = 1, the input frequency range must be between 2.0 MHz and 3.0 MHz.

After the FIN clock divider configuration with FIN_DIV bit, the FIN clock is routed to the PLL input with EXT_FIN_SEL bit. The CLK clock changes from the internal oscillator to FIN external clock with EXT_FIN_SEL bit. So, the configuration procedure is FIN_DIV first, then apply FIN and finally set EXT_FIN_SEL.

If FIN is out of range, CLK clock moves back to the internal oscillator and reports the error using the CLK_FIN_DIV_OK bit. When FIN comes back in the range, the configuration procedure described above shall be executed again.

The FOUT pin can be used to synchronize an external device with the FS85/FS84. The frequency sent to FOUT is selected by SPI/I2C with the FOUT_MUX_SEL [3:0] bits.

Table 87. FOUT multiplexer selection

FOUT_MUX_SEL [3:0]	FOUT multiplexer selection
0000 (default)	No signal, FOUT is low
0001	VPRE_clk

Table 87. FOUT multiplexer selection*...continued*

FOUT_MUX_SEL [3:0]	FOUT multiplexer selection
0010	BOOST_clk
0011	BUCK1_clk
0100	BUCK2_clk
0101	BUCK3_clk
0110	FOUT_clk (CLK1 or CLK2 selected with FOUT_CLK_SEL bit)
0111	OSC_MAIN/48 (when PLL is enabled by OTP)
1000	OSC_FS/48
1001	CLK_FIN_DIV
Others	No signal, FOUT is low
Reset condition	POR

25.6 Electrical characteristics

Table 88. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
20 MHz internal oscillator					
F_{20MHz}	Oscillator nominal frequency (programmable)	—	20	—	MHz
F_{20MHz_ACC}	Oscillator accuracy	−6	—	+6	%
T_{20MHz_step}	Oscillator frequency tuning step transition time	—	10	—	µs
Spread spectrum					
FSS_{MOD}	Spread spectrum frequency modulation (MOD_CONF SPI/I2C configuration)	—	23	—	kHz
		—	94	—	kHz
FSS_{RANGE}	Spread spectrum range (around the nominal frequency)	−5	—	+5	%

Table 88. Electrical characteristics*...continued*

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
Clock synchronization (FIN)					
V_{FIN_IN}	Input voltage range	—	VDDI2C	—	V
DC_{FIN_FOUT}	FIN and FOUT duty cycle	40	50	60	%
FIN_{RANGE}	FIN input frequency range (FIN_DIV SPI/I2C configuration)	333	417	500	kHz
		2.25	2.5	2.75	MHz
FIN_{VIL}	FIN low voltage threshold	0.3 x V_{DDI2C}	—	—	V
FIN_{VIH}	FIN high voltage threshold	—	—	0.7 x V_{DDI2C}	V
FIN_{HYST}	FIN hysteresis	0.1	—	—	V
FIN_{IPD}	FIN internal pull down current source	7	10	13	µA
FIN_{DLY}	FIN input buffer propagation delay	—	—	8	ns
FIN_{ERR_LONG}	CLK_FIN_DIV monitoring, long deviation detection	5	—	—	µs
FIN_{ERR_SHORT}	CLK_FIN_DIV monitoring, short deviation detection	—	—	1.5	µs
FIN_{TLOST}	Time to switch to internal oscillator when FIN is lost	—	—	3	µs
Clock synchronization (FOUT)					
V_{FOUT_OUT}	Output voltage range	—	VDDIO	—	V
$FOUT_{VOL}$	FOUT low voltage threshold at 2.0 mA	—	—	0.5	V
$FOUT_{VOH}$	FOUT high voltage threshold at −2.0 mA	V_{DDIO} − 0.5	—	—	V
I_{FOUT}	Tri-state leakage current (VDDIO = 5.0 V)	−1.0	—	1.0	µA
$FOUT_{TRISE}$	FOUT rise time (from 20 % to 80 % of VDDIO, Cout = 30 pF)	—	—	20	ns
$FOUT_{TFALL}$	FOUT fall time (from 80 % to 20 % of VDDIO, Cout = 30 pF)	—	—	20	ns
PLL_{TLOCK}	PLL lock time	—	—	90	µs
PLL_{TSET}	PLL settling time (from EXT_FIN_DIS enable to ±1 % of output frequency)	—	—	125	µs

26 Analog multiplexer: AMUX

26.1 Functional description

The AMUX pin delivers 32 analog voltage channels to the MCU ADC input. The voltage channels delivered to AMUX pin can be selected by SPI/I2C. The maximum AMUX output voltage range is VDDIO. External Rs/Cout components are required for the buffer stability.

26.2 Block diagram

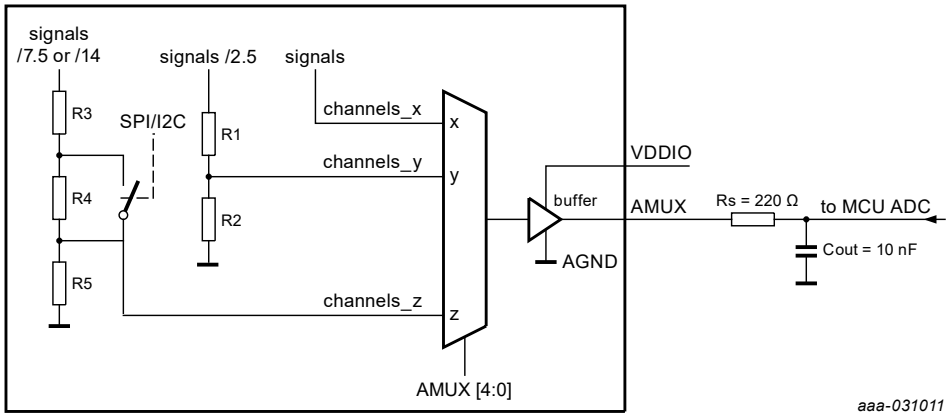


Figure 34. AMUX block diagram

26.3 AMUX channel selection

Table 89. AMUX output selection

AMUX[4:0]	Signal selection for AMUX output
00000 (default)	GND
00001	VDDIO voltage
00010	Temperature sensor : T(°C) = [(V_{AMUX} – V_{TEMP25}) / V_{TEMP_COEFF}] + 25
00011	Bandgap main: 1.0 V ±1 %
00100	Bandgap fail-safe: 1.0 V ±1 %
00101	VBUCK1 voltage
00110	VBUCK2 voltage
00111	VBUCK3 voltage divided by 2.5
01000	VPRE voltage divided by 2.5
01001	VBOOST voltage divided by 2.5
01010	VLDO1 voltage divided by 2.5
01011	VLDO2 voltage divided by 2.5
01100	VBOS voltage divided by 2.5
01101	Reserved
01110	VSUP1 voltage divided by 7.5 or 14 (SPI/I2C configuration with bit RATIO)
01111	WAKE1 voltage divided by 7.45 or 13.85 (SPI/I2C configuration with bit RATIO)

Table 89. AMUX output selection*...continued*

AMUX[4:0]	Signal selection for AMUX output
10000	WAKE2 voltage divided by 7.45 or 13.85 (SPI/I2C configuration with bit RATIO)
10001	Vana: internal main analog voltage supply: 1.6 V ±2 %
10010	Vdig: internal main digital voltage supply: 1.6 V ±2 %
10011	Vdig_fs: internal fail-safe digital voltage supply: 1.6 V ±2 %
10100	PSYNC voltage
Others	Same as default value (00000): GND

26.4 Electrical characteristics

Table 90. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
AMUX					
V_{AMUX_VDDIO}	Minimum VDDIO operating voltage for AMUX	3.2	—	—	V
V_{AMUX_IN}	Input voltage range for VSUP, WAKE1, WAKE2 • Ratio 7.45 and 7.5 • Ratio 13.85 and 14	 2.25 4.2	 — —	 22.5 42	V
I_{AMUX}	Output buffer current capability	—	—	2.0	mA
V_{AMUX_OFF}	Offset voltage (Iout = 1.0 mA)	−7	—	+7	mV
V_{AMUX_RATIO}	Ratio accuracy • Ratio 1 • Ratio 2.5 • Ratio 7.5 for VSUP1 • Ratio 7.45 for WAKE12 • Ratio 14 for VSUP1 • Ratio 13.85 for WAKE12	 −0.5 −1.5 −2.0 −2.0 −2.0 −2.0	 — — — — — —	 0.5 1.5 2.0 2.0 2.0 2.0	%
V_{AMUX_BRIDGE}	VSUP1, WAKE1, WAKE2 resistor bridge	0.75	1.5	3	MΩ
V_{TEMP25}	Temperature sensor voltage at 25 °C	2.01	2.07	2.12	V
V_{TEMP_COEFF}	Temperature sensor coefficient	−6.25	−6	−5.75	mV/°C
T_{AMUX_SET}	Settling time (from 10 % to 90 % of V_{DDIO}, Rs = 220 Ω, Cout = 10 nF)	—	—	10	µs
Rs	Output resistor	—	220	—	Ω
Cout	Output capacitor	—	10	—	nF

26.5 1.8 V MCU ADC input use case

FS85/FS84 AMUX buffer is referenced to VDDIO, 3.3 V or 5.0 V. In case the MCU requires a 1.8 V ADC input voltage, an external resistor bridge R1/R2 can be added in between AMUX output and ADC input as shown in Figure 35. It is recommended to use 0.1 % resistor accuracy to limit the conversion error impact.

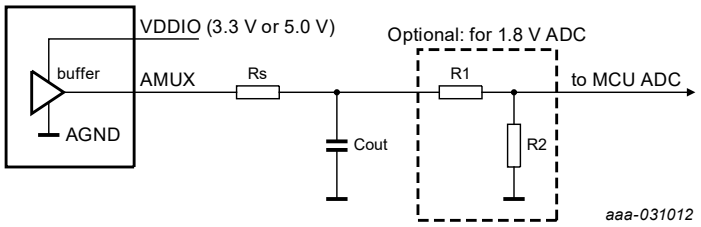


Figure 35. Optional 1.8 V ADC use case

The total resistor bridge value (R1 + R2) shall consume between min 10x ADC input current and max 1mA at AMUX output to neither disturb the AMUX output buffer nor the ADC input. A good estimate is to calculate the resistor bridge value for 200 µA current consumption at VDDIO = 3.3 V.

Target R1 + R2 = 20 kΩ

For VDDIO = 3.3 V, R2 / (R1 + R2) = 1.8 / 3.3 = 0.545

After calculation, R2 = 11 kΩ and R1 = 9.3 kΩ

27 I/O interface pins

27.1 WAKE1, WAKE2

WAKE pins are used to manage the internal biasing of the device and the main state machine transitions.

- When WAKE1 or WAKE2 is > $WAKE12_{VIH}$, the internal biasing is started and the equivalent digital state is '1'
- When WAKE1 or WAKE2 is < $WAKE12_{VIL}$, the equivalent digital state is '0'
- When WAKE1 and WAKE2 are < $WAKE12_{AVIL}$, the internal biasing is stopped if the device was in Standby mode

WAKE1 and WAKE2 are level based wake-up input signals with analog measurement capability thru AMUX. WAKE1 can be for example connected to a switched VBAT (KL15 line) and WAKE2 to the wake-up output of a CAN or FlexRay transceiver. When a WAKE pin is used as a global pin, a C - R - C protection is required (see Section 31 "Application information").

Table 91. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
WAKE1, WAKE2					
$WAKE12_{AVIL}$	Analog low input voltage threshold	1	—	—	V
$WAKE12_{VIL}$	Digital low input voltage threshold	2	—	—	V
$WAKE12_{VIH}$	Digital high input voltage threshold	—	—	4	V
I_{WAKE12}	Input current leakage at WAKE12 = 36 V	—	—	100	µA
	Input current leakage at WAKE12 = 60 V	—	—	300	µA
T_{WAKE12}	Filtering time	50	70	100	µs

27.2 INTB

INTB is an open drain output pin with internal pull up to VDDIO. This pin generates a pulse when an internal interrupt occurs to inform the MCU. Each interrupt can be masked by setting the corresponding inhibit interrupt bit in M_INT_MASK registers.

Table 92. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
Interrupt pin					
$INTB_{PULL-up}$	Internal pull-up resistor to VDDIO	5.5	10	15	kΩ
$INTB_{VOL}$	Low output level threshold (I = 2.0 mA)	—	—	0.5	V
$INTB_{PULSE}$	Pulse duration (without manual frequency tuning)	90	100	110	µs

Table 93. List of interrupts from main logic

Interrupt main	Description
VSUP_UV7	VSUP undervoltage 7.0 V
VSUP_UVH	VSUP undervoltage high

Table 93. List of interrupts from main logic*...continued*

Interrupt main	Description
VSUP_UVL	VSUP undervoltage low
VBOS_UVH	VBOS undervoltage high
VPRE_OC	VPRE overcurrent
VPRE_FB_OV	VPRE overvoltage protection
VPRE_UVH	VPRE undervoltage high
BUCK1_TSD	BUCK1 overtemperature shutdown event
BUCK1_OC	BUCK1 overcurrent
BUCK2_TSD	BUCK2 over temperature shutdown event
BUCK2_OC	BUCK2 overcurrent
BUCK3_TSD	BUCK3 overtemperature shutdown event
BUCK3_OC	BUCK3 overcurrent
BOOST_TSD	BOOST overtemperature shutdown event
VBOOST_OV	BOOST overvoltage
VBOOST_UVH	BOOST undervoltage high
LDO1_TSD	LDO1 overtemperature shutdown event
LDO1_OC	LDO1 overcurrent
LDO2_TSD	LDO2 overtemperature shutdown event
LDO2_OC	LDO2 overcurrent
WAKE1	WAKE1 transition
WAKE2	WAKE2 transition
COM	SPI/I2C communication error

Table 94. List of interrupts from fail-safe logic

Interrupt fail-safe	Description
FCCU12	FCCU12 bi-stable error detected
FCCU1	FCCU1 single error detected
FCCU2	FCCU2 single error detected
ERRMON	External IC error detected
VCOREMON_OV	VCOREMON overvoltage detected
VCOREMON_UV	VCOREMON undervoltage detected
VDDIO_OV	VDDIO overvoltage detected
VDDIO_UV	VDDIO undervoltage detected
VMONx_OV	VMONx overvoltage detected
VMONx_UV	VMONx undervoltage detected
WD_BAD_DATA	Wrong watchdog refresh – wrong data
WD_BAD_TIMING	Wrong watchdog refresh – CLOSED window or timeout

27.3 PSYNC for two FS85

PSYNC function allows to manage complex start up sequence with multiple power management ICs like two FS85/FS84 (OTP_PSYNC_CFG = 0) or one FS85/FS84 plus one PF82 (OTP_PSYNC_CFG = 1). This function is enabled with the OTP_PSYNC_EN bit.

When PSYNC is used to synchronize two FS85/FS84, PSYNC pin of each device shall be connected together and pulled up to VBOS pin of the FS85/FS84 master device as shown in Figure 36. In this configuration, FS85#1 state machine stops before FS85#1_VPRE starts and waits for FS85#2 to synchronize FS85#2_VPRE start.

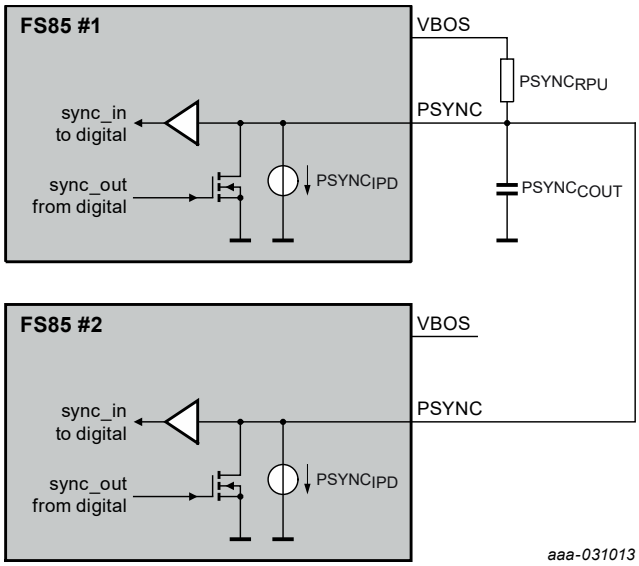


Figure 36. Synchronization of two FS85/FS84

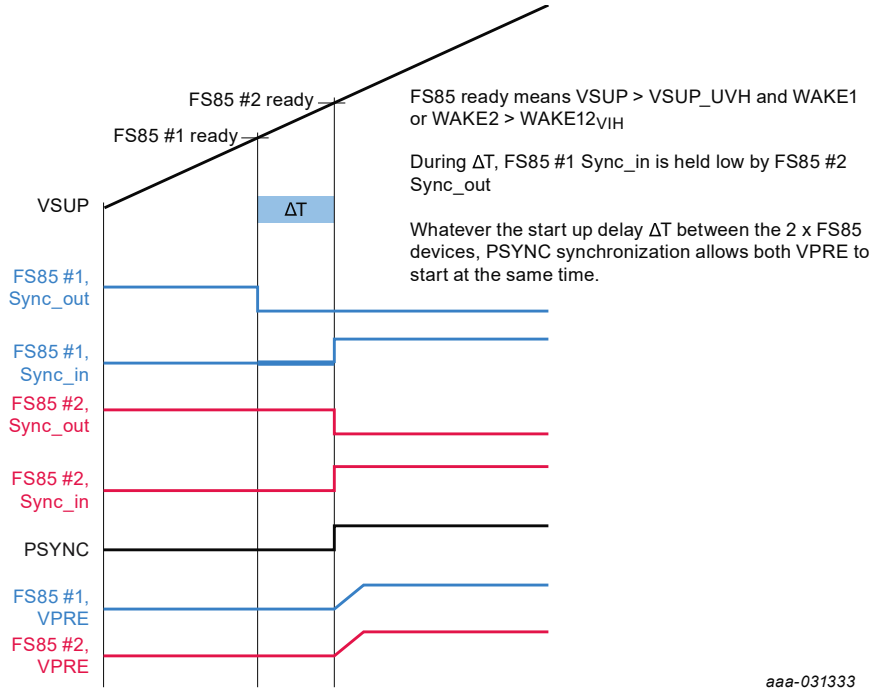


Figure 37. Two FS85/FS84 synchronization timing diagram

27.4 PSYNC for FS85 and external PMIC

When PSYNC is used to synchronize one FS85/FS84 and one external PMIC, PSYNC pin of FS85/FS84 shall be connected to PGOOD pin of the external PMIC. When the external PMIC is PF82 from NXP, it can be pulled up to VSNVS pin of PF82. In this configuration, FS85 state machine stops after VPRE starts and waits for the PGOOD pin of the external PMIC to be released to continue its own power sequencing. It allows to synchronize the power up sequence of both devices.

During power down sequence, FS85 should wait the external PMIC power down sequence completion before turning OFF VPRE (VPRE is powering the external PMIC). OTP_VPRE_off_dly bit shall be configured to extend VPRE turn OFF delay from 250 µs default value to 32 ms.

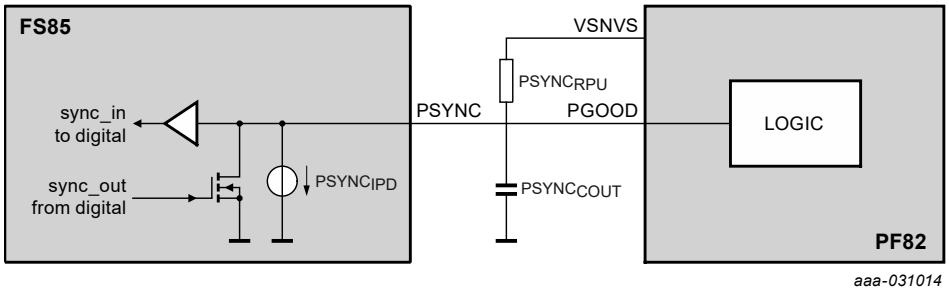


Figure 38. Synchronization of one FS85/FS84 and one external PMIC (PF82)

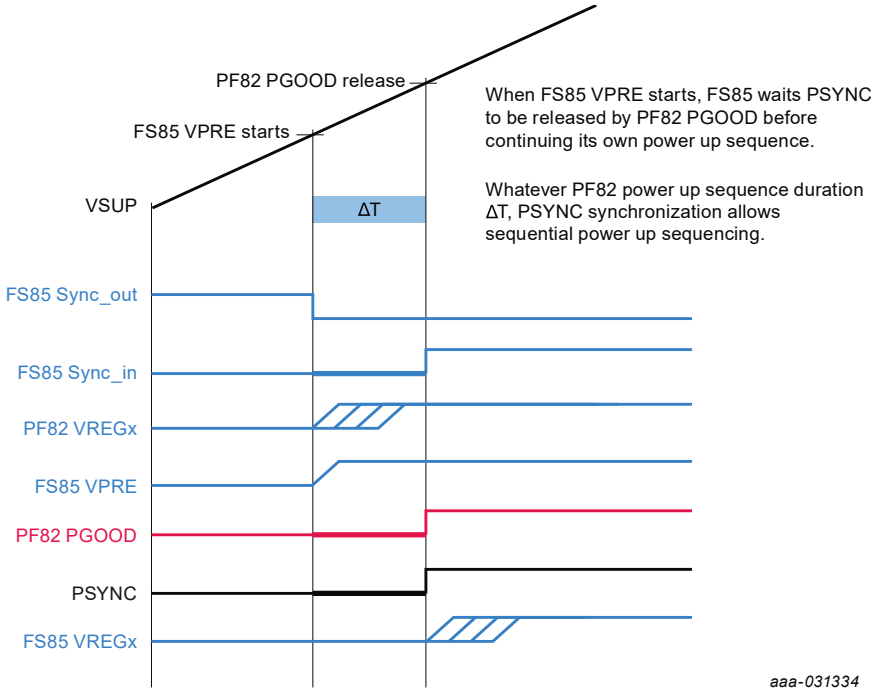


Figure 39. FS85/FS84 and one external PMIC (PF82) synchronization timing diagram

Table 95. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
PSYNC					
$PSYNC_{VIL}$	Low level input voltage threshold	1	—	—	V
$PSYNC_{VIH}$	High level input voltage threshold	—	—	2	V
$PSYNC_{HYST}$	Hysteresis	0.1	—	—	V
$PSYNC_{VOL}$	Low level output threshold (I = 2.0 mA)	—	—	0.5	V
$PSYNC_{IPD}$	Internal pull down current source	7	10	13	µA
$PSYNC_{RPU}$	External pull up resistor to VBOS	—	10	—	kΩ
$PSYNC_{COUT}$	External decoupling capacitor	—	0.1	—	µF
$PSYNC_{TFB}$	Feedback filtering time	6	10	15	µs

28 Cyclic Redundant Check generation

An 8 bit CRC is required for each Write and Read SPI and I2C command. Computation of a cyclic redundancy check is derived from the mathematics of polynomial division, modulo two.

The CRC polynomial used is compatible with SAEJ 1850 CRC8 standard: x^8+x^4+x^3+x^2+1 (identified by 0x1D) with a SEED value of hexadecimal '0xFF'.

The following is an example of CRC encoding HW implementation:

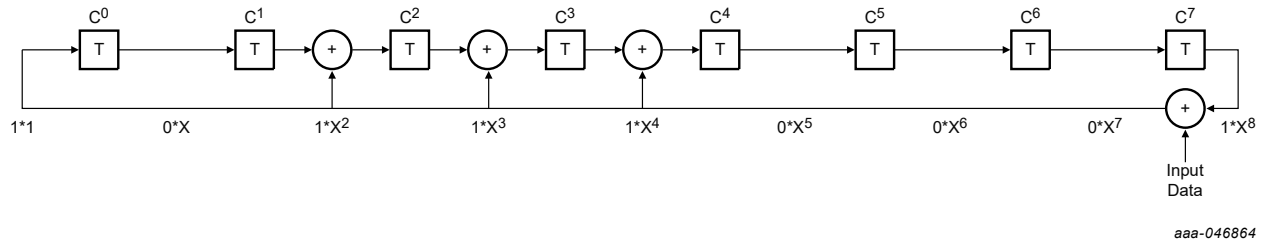


Figure 40. CRC encoder example

The effect of CRC encoding procedure is shown in the following table. The seed value is appended into the most significant bits of the shift register.

Table 96. Data preparation for CRC encoding (SPI format)

Seed	M/FS	Reg_ Address	Read/Write	Data_MSB	Data_LSB
0xFF	Bits[31]	Bit[30:25]	BIT[24]	Bit[23:16]	Bits[15:8]

Seed…	…padded with the message to encode…	…padded with 8 zeros

1. Using a serial CRC calculation method, the transmitter rotates the seed and data into the least significant bits of the shift register.
2. During the serial CRC calculation, the seed and the data bits are XOR compared with the polynomial data bits. When the MSB is logic 1, the comparison result is loaded in the register, otherwise the data bits are simply shifted. It must be noted the 32-bit message to be processed must have the bits corresponding to the CRC byte all equal to zero (00000000).
3. Once the CRC is calculated, it replaces the CRC byte initially set to all zeros and is transmitted.

Following is the procedure for the CRC decoding:

1. The seed value is loaded into the most significant bits of the receive register.
2. Using a serial CRC calculation method, the receiver rotates the received message and CRC into the least significant bits of the shift register in the order received (MSB first).
3. When the calculation on the last bit of the CRC is rotated into the shift register, the shift register contains the CRC check result.
   - If the shift register contains all zeros, the CRC is correct.
   - If the shift register contains a value other than zero, the CRC is incorrect.

29 SPI interface

29.1 SPI interface overview

The FS85/FS84 uses a 32-bit SPI, with the following arrangement:

- MOSI, Master Out Slave In bits:
  - Bit 31: main or fail-safe registers selection
  - Bit 30 to 25: register address
  - Bit 24: read/write
  - Bit 23 to 8: control bits
  - Bit7 to 0: cyclic redundant check (CRC)
- MISO, Master In Slave Out bits:
  - Bit 31-24: general device status
  - bits 23 to 8: extended device status, or device internal control register content or device flags
  - Bit7 to 0: cyclic redundant check (CRC)

The digital SPI pins (CSB, SCLK, MOSI, MISO) are referenced to VDDIO.

Table 97. SPI message arrangement

	B31	B30	B29	B28	B27	B26	B25	B24								
MOSI	M/FS	Adr_5	Adr_4	Adr_3	Adr_2	Adr_1	Adr_0	R/W								
MISO	COM_ERR	WU_G	VPRE_G	VBOOST_G	VBUCK1_G	VBUCK2_G	VBUCK3_G	VLDO_G								
	B23	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8
MOSI	Data_15	Data_14	Data_13	Data_12	Data_11	Data_10	Data_9	Data_8	Data_7	Data_6	Data_5	Data_4	Data_3	Data_2	Data_1	Data_0
MISO	Data MSB								Data LSB							
									B7	B6	B5	B4	B3	B2	B1	B0
MOSI									CRC_7	CRC_6	CRC_5	CRC_4	CRC_3	CRC_2	CRC_1	CRC_0
MISO									CRC_7	CRC_6	CRC_5	CRC_4	CRC_3	CRC_2	CRC_1	CRC_0

The MCU is the master driving MOSI and FS85/FS84 is the slave driving MISO. The MISO data is latched at the SCLK rising edge and MOSI data is latched at the SCLK falling edge. In write command, MISO [23:8] bits are the previous register bits and MISO [7:0] is the CRC of the message sent by the FS85/FS84. In read command, MOSI [23:8] bits are all 0 and MOSI [7:0] is the CRC of the message sent by the MCU. Refer to AN12333 for more details.

29.2 SPI CRC calculation and results

CRC calculation using XOR:

Table 98. CRC calculation using XOR

CRC_7 = XOR (B31, B24, B23, B22, B20, B17, B13, B12, B11, 1, 1)

CRC_6 = XOR (B31, B30, B23, B22, B21, B19, B16, B12, B11, B10, 1, 1)

CRC_5 = XOR (B30, B29, B22, B21, B20, B18, B15, B11, B10, B9, 1, 1)

CRC_4 = XOR (B29, B28, B21, B20, B19, B17, B14, B10, B9, B8, 1, 1)

CRC_3 = XOR (B28, B27, B24, B23, B22, B19, B18, B17, B16, B12, B11, B9, B8, 1, 1, 1)

CRC_2 = XOR (B27, B26, B24, B21, B20, B18, B16, B15, B13, B12, B10, B8, 1, 1, 1)

CRC_1 = XOR (B26, B25, B24, B22, B19, B15, B14, B13, B9, 1, 1, 1)

CRC_0 = XOR (B25, B24, B23, B21, B18, B14, B13, B12, B8, 1, 1)

CRC results examples:

Table 99. CRC results examples

M/FS, Register address, R/W, 8 bit (Hex)	Data MSB, 8 bit (Hex)	Data LSB, 8 bit (Hex)	CRC, 8 bit (Hex)
0x05	0x00	0x00	0x87
0x83	0xD0	0x0D	0x54

29.3 Electrical characteristics

Table 100. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
SPI					
F_{SPI}	SPI operation frequency (50 % DC)	0.5	—	10	MHz
t_{CLH}	Minimum time SCLK = HIGH	50	—	—	ns
t_{CLL}	Minimum time SCLK = LOW	50	—	—	ns
t_{PCLD}	Propagation delay (SCLK to data at 10 % of MISO rising edge)	—	—	30	ns
t_{CSDV}	CSB = low to data at MISO active	—	—	70	ns
t_{SCLCH}	SCLK low before CSB low (setup time SCLK to CSB change H/L)	70	—	—	ns
t_{HCLCL}	SCLK change L/H after CSB = low	70	—	—	ns
t_{SCLD}	SDI input setup time (SCLK change H/L after MOSI data valid)	35	—	—	ns
t_{HCLD}	SDI input hold time (MOSI data hold after SCLK change H/L)	35	—	—	ns
t_{SCLCL}	SCLK low before CSB high	90	—	—	ns
t_{HCLCH}	SCLK high after CSB high	90	—	—	ns
t_{PCHD}	CSB L/H to MISO at high-impedance	—	—	75	ns
t_{ONCSB}	CSB min. high time	500	—	—	ns
SPI_{VIL}	CSB, SCLK, MOSI low level input voltage threshold	0.3 x V_{DDIO}	—	—	V
SPI_{VIH}	CSB, SCLK, MOSI high level input voltage threshold	—	—	0.7 x V_{DDIO}	V
I_{CSB_MOSI}	CSB, MOSI Input leakage current	—	—	1.0	µA
$SCLK_{IPD}$	SCLK internal pull down current source	7	10	13	µA
$MISO_{VOH}$	MISO high output voltage (I = 2.0 mA)	V_{DDIO}-0.4	—	—	V
$MISO_{VOL}$	MISO low output voltage (I = 2.0 mA)	—	—	0.4	V
I_{MISO}	Tri-state leakage current (VDDIO = 5.0 V)	−1.0	—	1.0	µA
$SPI_{PULL-up}$	CSB, MOSI internal pull-up (pull-up to VDDIO)	200	450	800	kΩ
C_{SPI}	Input capacitance at MOSI / MISO / SCLK / CSB	—	—	10	pF

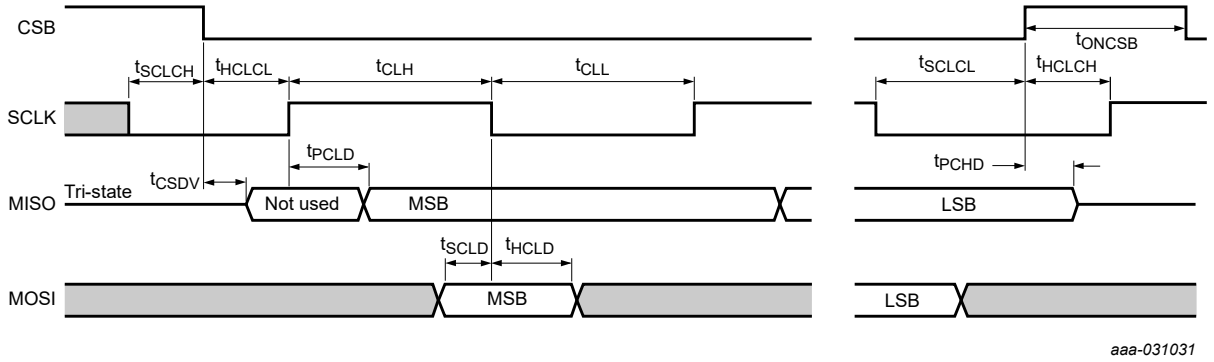


Figure 41. SPI timings

30 I2C interface

30.1 I2C interface overview

The FS85/FS84 uses an I2C interface following the high-speed mode definition up to 3.4 Mbit/s. I2C interface protocol requires a device address for addressing the target IC on a multi-device bus. The FS85/FS84 has two device addresses: one to access the main logic and one to access the fail-safe logic. These two I2C addresses are set by OTP.

The I2C interface is using a dedicated power input pin VDDI2C and it's compatible with 1.8 V / 3.3 V input supply. Timing, diagrams, and further details can be found in the NXP I^2C specification UM10204 rev6.

Table 101. I2C message arrangement

B39	B38	B37	B36	B35	B34	B33	B32	B31	B30	B29	B28	B27	B26	B25	B24
ID_6-0							0	0	0	Adr_5-0					
Device address							Read/ Write			Register address					
B23	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8
Data_15	Data_14	Data_13	Data_12	Data_11	Data_10	Data_9	Data_8	Data_7	Data_6	Data_5	Data_4	Data_3	Data_2	Data_1	Data_0
Data MSB								Data LSB							
								B7	B6	B5	B4	B3	B2	B1	B0
								CRC_7	CRC_6	CRC_5	CRC_4	CRC_3	CRC_2	CRC_1	CRC_0
								CRC_7	CRC_6	CRC_5	CRC_4	CRC_3	CRC_2	CRC_1	CRC_0

30.2 Device address

The FS85/FS84 has two device address: one to access the Main logic and one to access the Fail-safe logic.

B39	B38	B37	B36	B35	B34	B33
0	1	OTP	OTP	OTP	OTP	M/FS

The I2C addresses have the following arrangement:

- Bit 39: 0
- Bit 38: 1
- Bit 37 to 34: OTP value
- Bit 33: 0 to access the main logic, 1 to access the fail-safe logic

30.3 I2C CRC calculation and results

CRC calculation using XOR:

CRC_7 = XOR (B38, B35, B32, B31, B24, B23, B22, B20, B17, B13, B12, B11, 1, 1, 1)

CRC_6 = XOR (B37, B34, B23, B22, B21, B19, B16, B12, B11, B10, 1, 1)

CRC_5 = XOR (B39, B36, B33, B30, B29, B22, B21, B20, B18, B15, B11, B10, B9, 1, 1, 1)

CRC_4 = XOR (B39, B38, B35, B32, B29, B28, B21, B20, B19, B17, B14, B10, B9, B8, 1, 1, 1, 1)

CRC_3 = XOR (B37, B35, B34, B32, B28, B27, B24, B23, B22, B19, B18, B17, B16, B12, B11, B9, B8, 1, 1, 1, 1)

CRC_2 = XOR (B39, B38, B36, B35, B34, B33, B32, B27, B26, B24, B21, B20, B18, B16, B15, B13, B12, B10, B8, 1, 1, 1, 1, 1, 1, 1)

CRC_1 = XOR (B37, B34, B33, B26, B25, B24, B22, B19, B15, B14, B13, B9, 1, 1, 1)

CRC_0 = XOR (B39, B36, B33, B32, B25, B24, B23, B21, B18, B14, B13, B12, B8, 1, 1, 1, 1)

CRC results examples:

- Main I2C device address: 0x20
- Fail-safe I2C device address: 0x21

Table 102. CRC results examples

Device address, R/W, 8 bit (Hex)	00, Register address, 8 bit (Hex)	Data MSB, 8 bit (Hex)	Data LSB, 8 bit (Hex)	CRC, 8 bit (Hex)
0x40	0x02	0x00	0x00	0x31
0x42	0x01	0xD0	0x0D	0x8C

30.4 Electrical characteristics

Table 103. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
I2C					
VDDI2C	I2C interface power input	1.62	1.8	1.98	V
		2.97	3.3	3.63	V
F_{SCL}	SCL clock frequency	—	—	3.4	MHz
$I2C_{VIL}$	SCL, SDA low level input voltage threshold	0.3 x V_{DDI2C}	—	—	V
$I2C_{VIH}$	SCL, SDA high level input voltage threshold	—	—	0.7 x V_{DDI2C}	V
SDA_{VOL}	Low level output voltage at SDA pin (I = 20 mA)	—	—	0.4	V
C_{I2C}	Input capacitance at SCL / SDA	—	—	10	pF
t_{SPSCL}	SCL pulse width filtering time, when 50 ns filter selected (fast speed, fast speed plus)	50	—	150	ns
t_{SPSDA}	SDA pulse width filtering time, when 50 ns filter selected (fast speed, fast speed plus)	50	—	150	ns
t_{SPHSCL}	SCL pulse width filtering time, when 10 ns filter selected (high speed)	10	—	25	ns
t_{SPHSDA}	SDA pulse width filtering time, when 10 ns filter selected (high speed)	10	—	25	ns

31 Application information

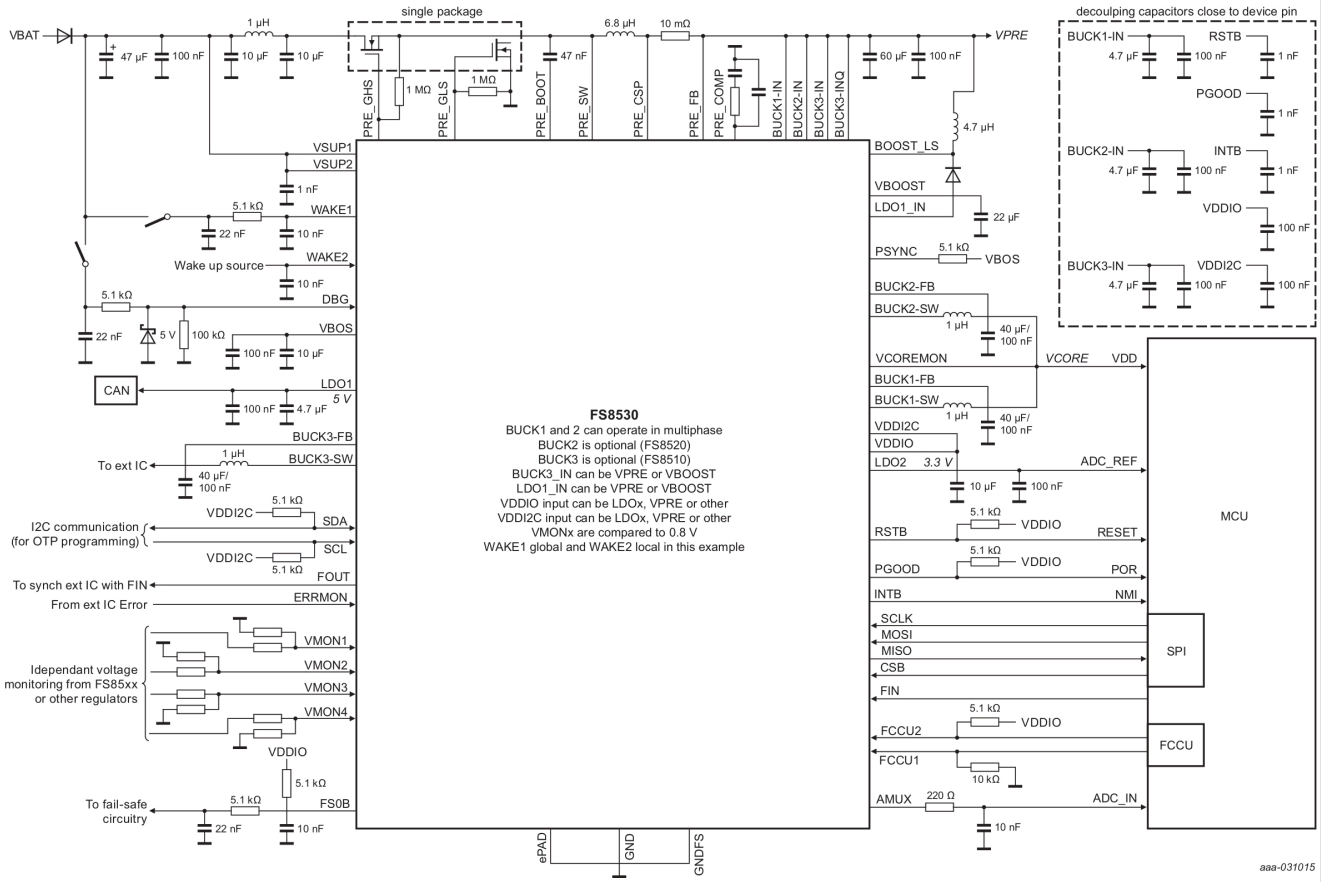


Figure 42. Application diagram

31.1 FS8400 / MR3003 radar application example

Note: *This FS8400 / MR3003 radar application is an example. Other configurations are possible.*

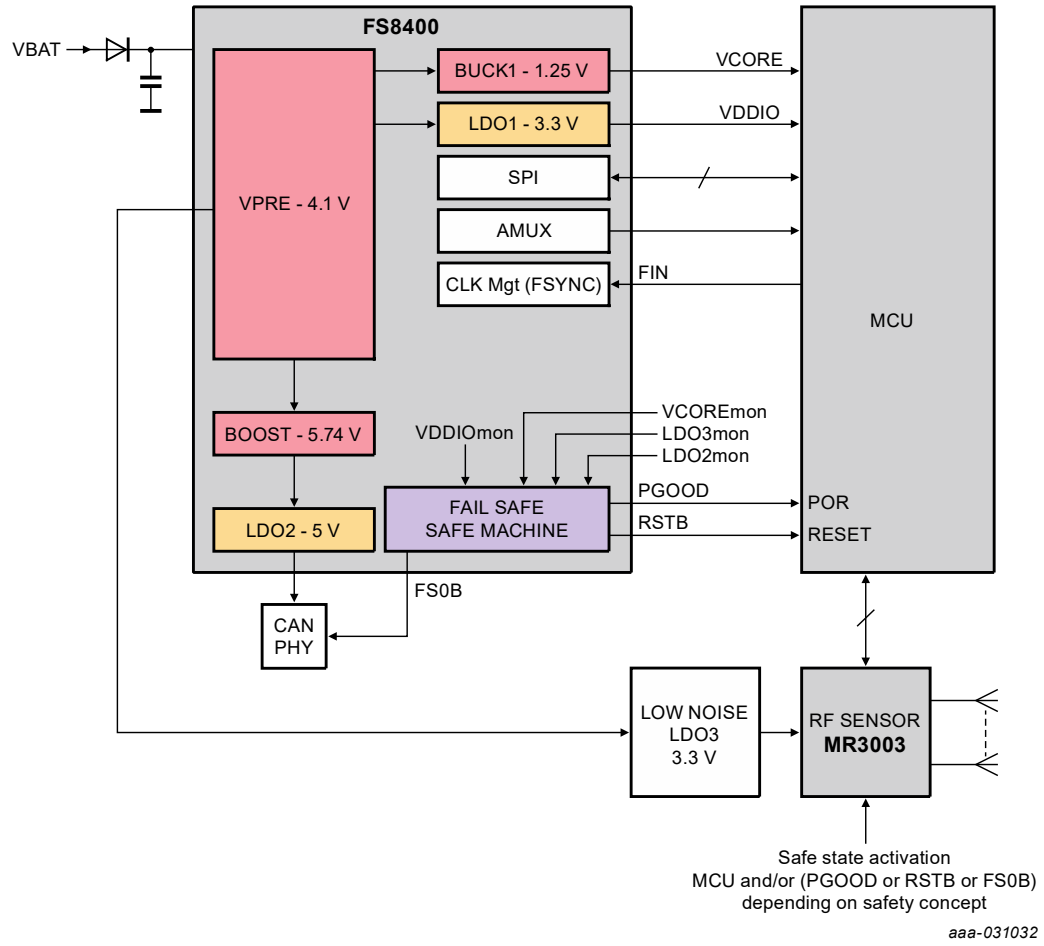


Figure 43. Simplified application diagram for FS8400 / MR3003 radar application example

31.2 FS8410 / TEF810X radar application example

Note: *This FS8410 / TEF810X radar application is an example. Other configurations are possible.*

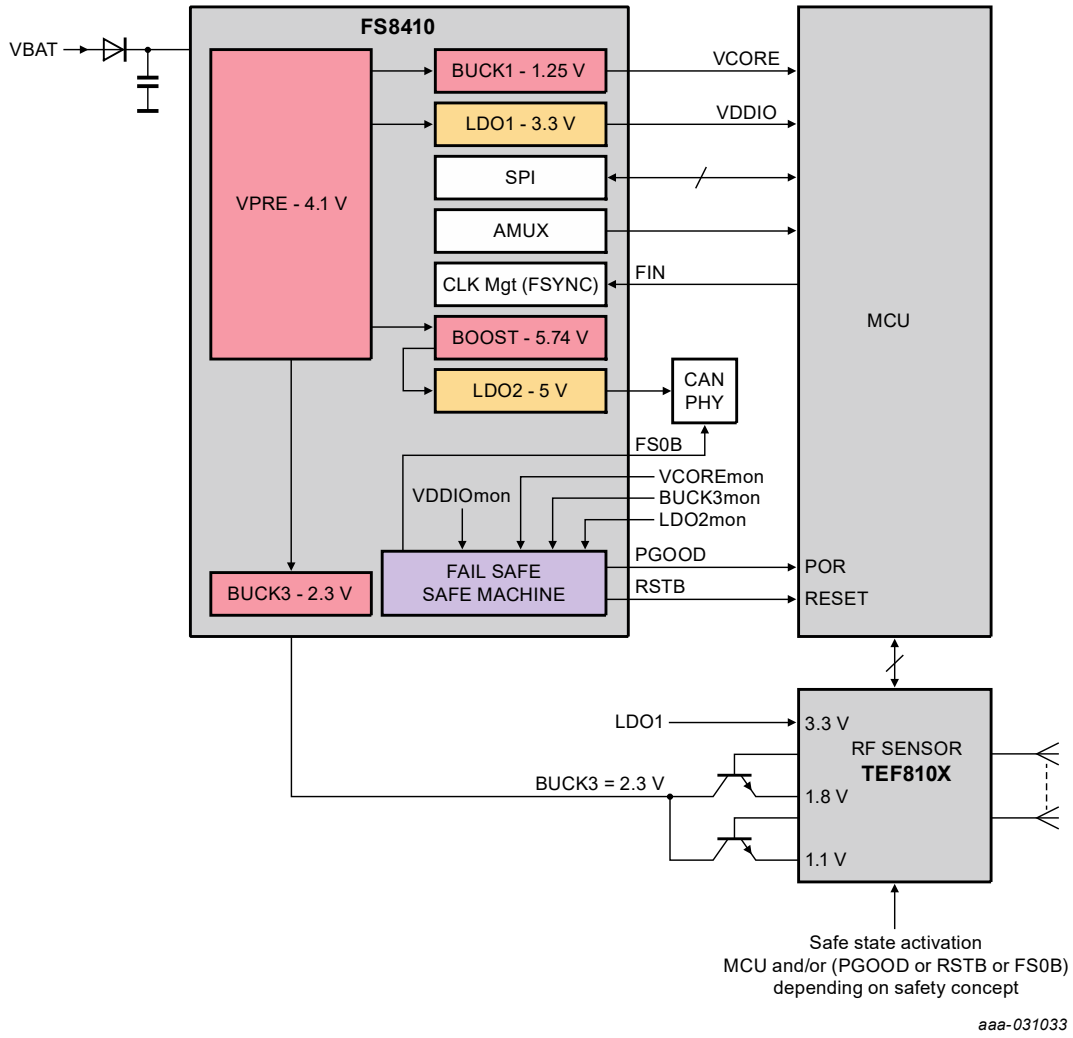


Figure 44. Simplified application diagram for FS8410 / TEF810X radar application example

32 Functional safety

32.1 Functional description

The fail-safe domain is electrically independent and physically isolated. The fail-safe domain is supplied by its own reference voltages and current, has its own oscillator, has duplicated analog path to minimize the common cause failures and has LBIST/ABIST to cover latent faults. The fail-safe domain offers ASIL B or ASIL D compliance depending on device part number. The fail-safe timings are derived from the fail-safe oscillator with ±6 % accuracy unless otherwise specified.

All fail-safe OTP bits are described in detail in the safety manual.

The fail-safe domain and the dedicated pins are represented in Figure 45:

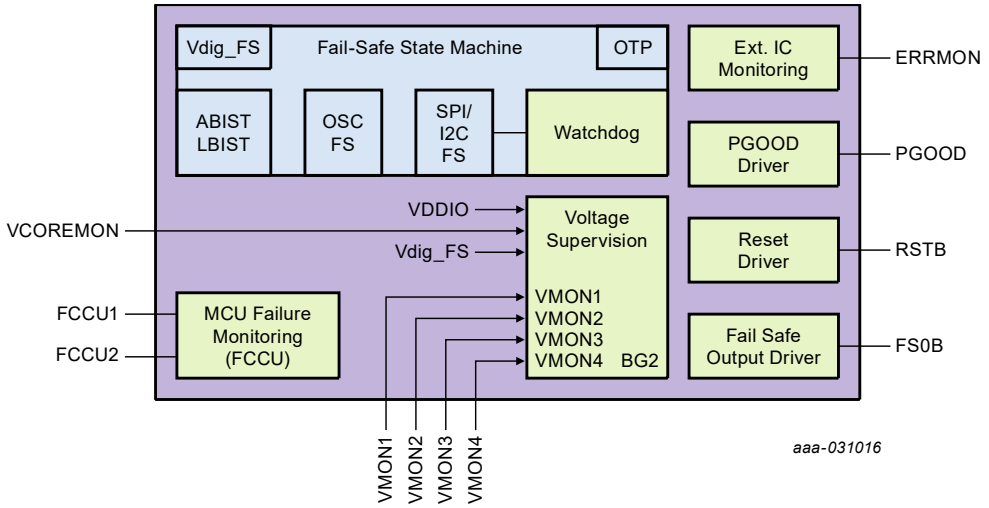


Figure 45. Fail-safe block diagram

32.2 ASIL B versus ASIL D

Table 104. Recommended ASIL B vs ASIL D safety features

Safety features	ASIL B (FS84)	ASIL D (FS85)
PGOOD output pin	Yes	Yes
RSTB output pin	Yes	Yes
FS0B output pin	Yes	Yes
VCORE voltage monitoring (VCOREMON)	Yes	Yes
VDDIO voltage monitoring	Yes	Yes
Voltage monitoring (VMONx)	2 to 4	up to 4
Watchdog monitoring	Simple WD	Challenger WD
FCCU monitoring	Optional	Yes
MCU fault recovery strategy	No	Yes
External IC monitoring (ERRMON)	No	Yes
Analog BIST (ABIST)	Yes	Yes
Logical BIST (LBIST)	No	Yes

32.3 Fail-safe initialization

After POR or wake up from Standby, when the RSTB pin is released, the fail-safe state machine enters in INIT_FS phase for initialization. To secure the writing process during INIT_FS phase, in addition to CRC computation during SPI/I2C transfer, it is requested for the MCU to perform the following sequence for all INIT_FS registers:

1 - Write the desired data in the FS_I_Register_A (DATA)

2 - Write the opposite in the FS_I_NOT_Register_A (DATA_NOT)

As an example, if the data of FS_I_Register_A = 0xABCD, the data not of FS_I_NOT_Register_A = 0x5432. A real-time comparison process (XOR) is performed by the FS85/FS84 to ensure DATA FS_I_Register_A = DATA_NOT FS_I_NOT_Register_A. Only the utility bits must be inverted in the DATA_NOT content. The RESERVED bits are not considered and can be written at ‘0’. If the comparison result is correct, then the REG_CORRUPT is set to ‘0’. If the comparison result is wrong, then the REG_CORRUPT bit is set to ‘1’. The REG_CORRUPT monitoring is active as soon as the INIT_FS is closed by the first good watchdog refresh.

INIT_FS must be closed by the first good watchdog refresh before 256 ms timeout.

After INIT_FS closure, it is possible to come back to INIT_FS with the GoTo_INITFS bit in FS_SAFE_IOS register, from any FS_state after INIT_FS. It is recommended to send the GoTo_INITFS command just after a good watchdog refresh.

32.4 Watchdog

The watchdog is a windowed watchdog for the Simple and the Challenger watchdog. The first half of the window is said CLOSED and the second half is said OPEN. A good watchdog refresh is a good watchdog answer during the OPEN window. A bad watchdog refresh is a bad watchdog answer during the OPEN window, no watchdog refresh during the OPEN window or a good watchdog answer during the CLOSED window. After a good or a bad watchdog refresh, a new window period starts immediately for the MCU to keep the synchronization with the windowed watchdog.

The first good watchdog refresh closes the INIT_FS. Then the watchdog window is running and the MCU must refresh the watchdog in the OPEN window of the watchdog window period. The duration of the watchdog window is configurable from 1.0 ms to 1024 ms with the WDW_PERIOD [3:0] bits. The new watchdog window is effective after the next watchdog refresh. The watchdog window can be disabled during INIT_FS only. The watchdog disable is effective when the INIT_FS is closed.

The watchdog configuration requires to write in FS_WD_WINDOW and FS_NOT_WD_WINDOW registers like INIT registers.

Table 105. Watchdog window period configuration

WDW_PERIOD [3:0]	Watchdog window period
0000	DISABLE (during INIT_FS only)
0001	1.0 ms
0010	2.0 ms
0011 (default)	**3.0 ms**
0100	4.0 ms
0101	6.0 ms
0110	8.0 ms
0111	12 ms
1000	16 ms
1001	24 ms
1010	32 ms
1011	64 ms
1100	128 ms
1101	256 ms
1110	512 ms
1111	1024 ms
Reset condition	POR

The duty cycle of the watchdog window is configurable from 31.25 % to 68.75 % with the WDW_DC [2:0] bits. The new duty cycle is effective after the next watchdog refresh.

Table 106. Watchdog window duty cycle configuration

WDW_DC [2:0]	CLOSED window	OPEN window
000	31.25 %	68.75 %
001	37.5 %	62.5 %
010 (default)	**50 %**	**50 %**
011	62.5 %	37.5 %
100	68.75 %	31.25 %
Others	50 %	50 %
Reset condition	POR	

32.4.1 Challenger watchdog

The Challenger watchdog monitoring feature is enabled by OTP_WD_SELECTION bit. The Challenger watchdog is based on a question/answer process with the MCU. A 16-bits pseudo-random word is generated by implementing a Linear Feedback Shift Register (LFSR) in the FS85. The MCU can send the seed of the LFSR or use the LFSR generated by the FS85 during the INIT_FS phase and performs a pre-defined calculation. The result is sent through the SPI/I2C during the OPEN watchdog window and verified by the FS85. When the result is right, the watchdog window is restarted and a new LFSR is generated. When the result is wrong, the WD error counter is incremented, the watchdog window is restarted and the LFSR value is not changed.

During the initialization phase (INIT_FS), the MCU sends the seed for the LFSR, or uses the default LFSR value generated by the FS85 (0x5AB2), available in the WD_SEED register. Using this LFSR, the MCU performs a simple calculation based on below formula and sends the results in the WD_ANSWER register.

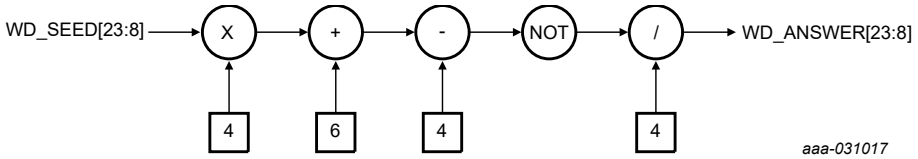


Figure 46. Challenger watchdog formula

In Challenger watchdog configuration, it is impossible to write 0x0000 in WD_SEED register. A communication error is reported in case of 0x0000 write tentative and the configuration is ignored.

32.4.2 Simple watchdog

The Simple watchdog monitoring feature is enabled by OTP_WD_SELECTION bit. The Simple watchdog uses a unique seed. The MCU can send its own seed in WD_SEED register or uses the default value 0x5AB2. This seed must be written in the WD_ANSWER register during the OPEN watchdog window. When the result is right, the watchdog window is restarted. When the result is wrong, the WD error counter is incremented and the watchdog window is restarted. In Simple watchdog configuration, it is impossible to write 0xFFFF and 0x0000 in WD_SEED register. A communication error is reported in case of 0x0000 and 0xFFFF write tentative and the configuration is ignored.

32.4.3 Watchdog error counter

The watchdog error strategy is available for the Challenger watchdog and the Simple watchdog. The watchdog error counter is implemented in the device to filter the incorrect watchdog refresh. Each time a watchdog failure occurs, the device increments this counter by 2. The watchdog error counter is decremented by 1 each time the watchdog is properly refreshed. This principle ensures a cyclic ’OK/NOK’ behavior converges to a failure detection.

To allow flexibility in the application, the maximum value of this counter is configurable with the WD_ERR_LIMIT[1:0] bits during the INIT_FS phase.

Table 107. Watchdog error counter configuration

WD_ERR_LIMIT[1:0]	Watchdog error counter value
00	8
01 (default)	**6**
10	4
11	2
Reset condition	POR

The watchdog error counter value can be read by the MCU for diagnostic with the WD_ERR_CNT[3:0] bits.

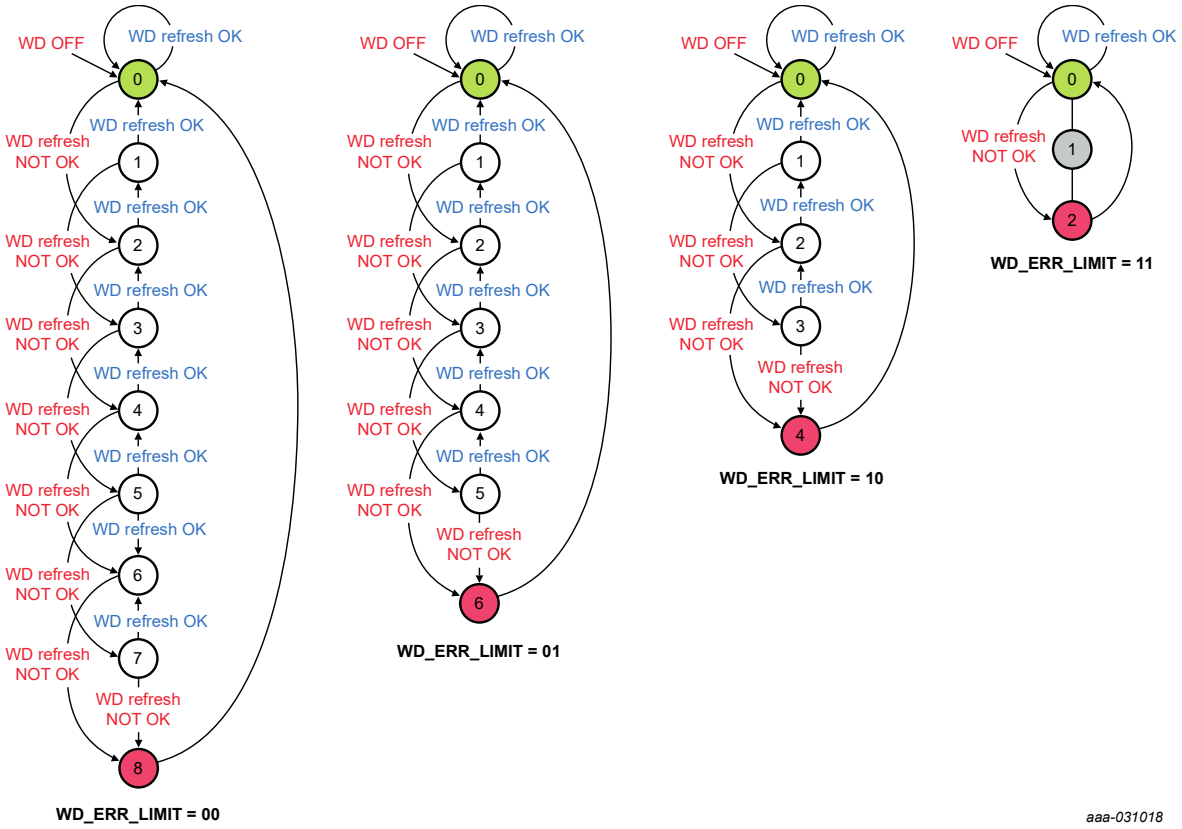


Figure 47. Watchdog error counter configurations

32.4.4 Watchdog refresh counter

The watchdog refresh strategy is available for the Challenger watchdog and the Simple watchdog. The watchdog refresh counter is used to decrement the fault error counter. Each time the watchdog is properly refreshed, the watchdog refresh counter is incremented by ’1’. Each time the watchdog refresh counter reaches its maximum value (‘6’ by default) and if next WD refresh is also good, the fault error counter is decremented by ’1’. Whatever the position the watchdog refresh counter is in, each time there is a wrong refresh watchdog, the watchdog refresh counter is reset to ’0’.

To allow flexibility in the application, the maximum value of this watchdog refresh counter is configurable with the WD_RFR_LIMIT[1:0] bits during the INIT_FS phase.

Table 108. Watchdog refresh counter configuration

WD_RFR_LIMIT[1:0]	Watchdog refresh counter value
00 (default)	**6**
01	4
10	2
11	1
Reset condition	POR

The watchdog refresh counter value can be read by the MCU for diagnostic with the WD_RFR_CNT[2:0] bits.

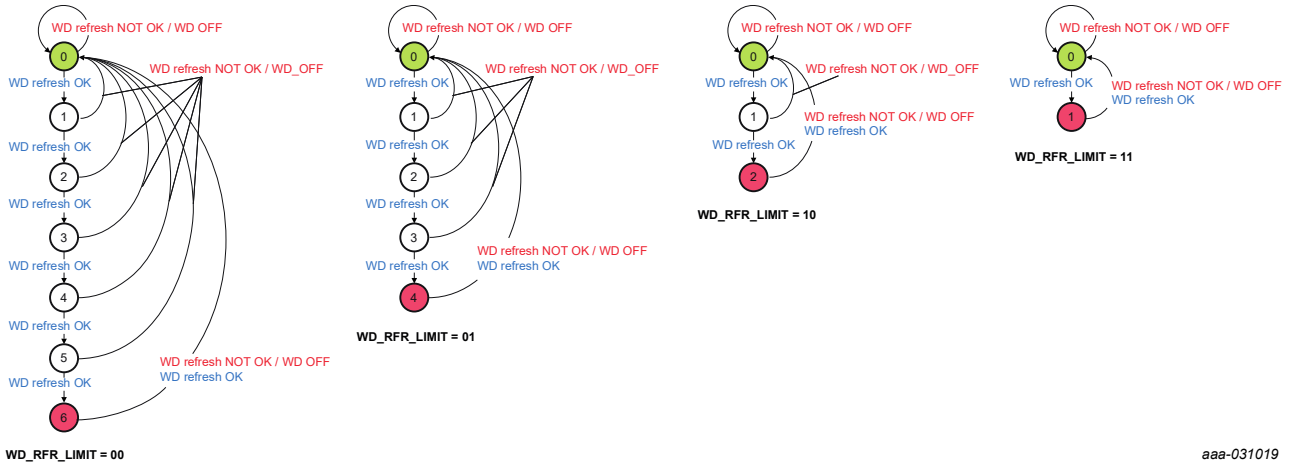


Figure 48. Watchdog refresh counter configurations

32.4.5 Watchdog error impact

When the watchdog error counter reaches its maximum value, the fail-safe reaction on RSTB and/or FS0B is configurable with the WD_FS_IMPACT[1:0] bits during the INIT_FS phase.

Table 109. Watchdog error impact configuration

WD_FS_IMPACT[1:0]	Watchdog error impact on RSTB/FS0B
00	No action on RSTB and FS0B
01	FS0B only is asserted if WD error counter = WD_ERR_ LIMIT[1:0]
1x	**FS0B and RSTB are asserted if WD error counter = WD_ ERR_LIMIT[1:0]**
Reset condition	POR

32.4.6 MCU fault recovery strategy

The fault recovery strategy feature is enabled by OTP_FLT_RECOVERY_EN bit. This function extends the watchdog window to allow the MCU to perform a fault recovery strategy. The goal is to not reset the MCU while it is trying to recover the application after a failure event. When a fault is triggered by the MCU via its FCCU pins, the FS0B pin is asserted by the device and the watchdog window duration becomes automatically an open window (no more duty cycle). This open window duration is configurable with the WDW_RECOVERY [3:0] bits during the INIT_FS phase.

Table 110. Watchdog window in fault recovery configuration

WDW_RECOVERY [3:0]	Watchdog window duration when the device is in fault recovery strategy
0000	DISABLE
0001	1.0 ms
0010	2.0 ms
0011	3.0 ms
0100	4.0 ms
0101	6.0 ms
0110	8.0 ms
0111	12 ms
1000	16 ms
1001	24 ms
1010	32 ms
1011(default)	**64 ms**
1100	128 ms
1101	256 ms
1110	512 ms
1111	1024 ms
Reset condition	POR

The transition from WDW_PERIOD to WDW_RECOVERY happens when the FCCU pin indicates an error and FS0B is asserted. If the MCU send a good watchdog refresh before the end of the WDW_RECOVERY duration, the device switches back to the WDW_PERIOD duration and associated duty cycle if the FCCU pins does not indicate an error anymore. Otherwise, a new WDW_RECOVERY period is started. If the MCU does not send a good watchdog refresh before the end of the WDW_RECOVERY duration, then a reset pulse is generated, and the fail-safe state machine moves back to INIT_FS.

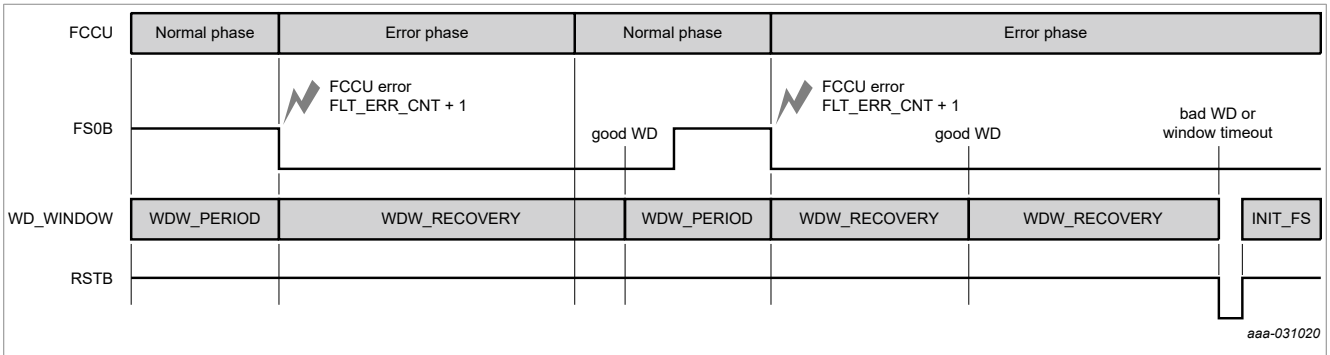


Figure 49. Fault recovery strategy principle

32.5 FCCU monitoring

The FCCU monitoring feature is enabled by OTP_FCCU_EN bit. The FCCU input pins are in charge of monitoring HW failure from the MCU. The FCCU input pins can be configured by pair, or single independent

inputs. The FCCU monitoring is active as soon as the INIT_FS is closed by the first good watchdog refresh. The FCCU input pins are configured by pair, or single independent inputs with the FCCU_CFG[1:0] bits.

Table 111. FCCU pins configuration

FCCU_CFG[1:0]	FCCU pins configuration
00	No monitoring
01 (default)	**FCCU1 and FCCU2 monitoring by pair (bi-stable protocol)**
10	FCCU1 or FCCU2 input monitoring
11	FCCU1 input monitoring only
Reset condition	POR

32.5.1 FCCU12 monitoring by pair

When FCCU12 are used by pair, the bi-stable protocol is supported according to Figure 50:

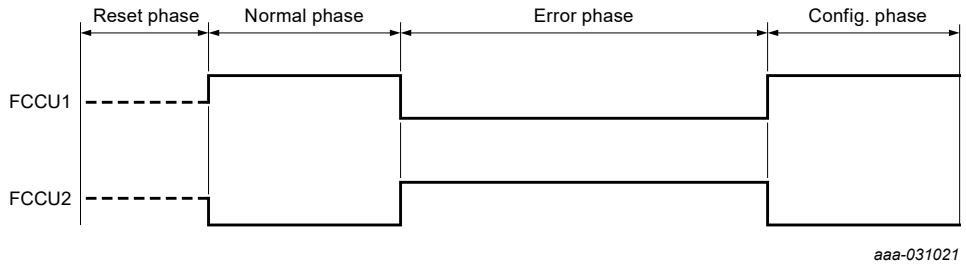


Figure 50. FCCU bi-stable protocol

The polarity of the FCCU fault signals is configurable with FCCU12_FLT_POL bit during the INIT_FS phase.

Table 112. FCCU12 polarity configuration

FCCU12_FLT_POL	FCCU12 polarity
0 (default)	**FCCU1=0 or FCCU2=1 level is a fault**
1	FCCU1=1 or FCCU2=0 level is a fault
Reset condition	POR

When FCCU fault is detected, the fail-safe reaction on RSTB and/or FS0B is configurable with the FCCU12_FS_IMPACT bit during the INIT_FS phase

Table 113. FCCU12 error impact configuration

FCCU12_FS_IMPACT	FCCU12 impact on RSTB/FS0B
0	FS0B only is asserted
1 (default)	**FS0B and RSTB are asserted**
Reset condition	POR

32.5.2 FCCU12 independent monitoring

When FCCU1 and/or FCCU2 are used independently, the FCCU inputs can monitor two different and independent error signals. For each input the polarity of the FCCU fault signal is configurable with FCCUx_FLT_POL bits during the INIT_FS phase.

Table 114. FCCUx polarity configuration

FCCU1_FLT_POL	FCCU1 polarity
0 (default)	**FCCU1 low level is a fault**
1	FCCU1 high level is a fault
Reset condition	POR

FCCU2_FLT_POL	FCCU2 polarity
0 (default)	**FCCU2 low level is a fault**
1	FCCU2 high level is a fault
Reset condition	POR

When FCCU fault is detected, the fail-safe reaction on RSTB and/or FS0B is configurable with the FCCUx_FS_IMPACT bits during the INIT_FS phase.

Table 115. FCCUx error impact configuration

FCCU1_FS_IMPACT	FCCU1 impact on RSTB/FS0B
0	FS0B only is asserted
1 (default)	**FS0B and RSTB are asserted**
Reset condition	POR

FCCU2_FS_IMPACT	FCCU2 impact on RSTB/FS0B
0	FS0B only is asserted
1 (default)	**FS0B and RSTB are asserted**
Reset condition	POR

32.5.3 FCCU12 electrical characteristics

Table 116. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
FCCU1,2					
$FCCU12_{TERR}$	FCCU1,2 filtering time	4.0	—	8.0	µs
$FCCU12_{VIH}$	FCCU1,2 high level input voltage threshold	—	—	0.7 x V_{DDIO}	V
$FCCU12_{VIL}$	FCCU1,2 low level input voltage threshold	0.3 x V_{DDIO}	—	—	V
$FCCU12_{HYST}$	FCCU1,2 input voltage hysteresis	0.1 x V_{DDIO}	—	1.85	V
$FCCU12_{ILKG}$	Input leakage current	—	—	1.0	µA
$FCCU1_{RPD}$	FCCU1 internal pull down resistor	400	800	1300	kΩ
$FCCU2_{RPU}$	FCCU2 internal pull up resistor to VDDIO	100	200	400	kΩ
$FCCU12_{RATIO}$	FCCU1/2 internal resistor ratio ($FCCU1_{RPD}$ / $FCCU2_{RPU}$)	3.5	4	4.5	—

32.6 Voltage supervisor

The voltage supervisor is in charge of overvoltage and undervoltage monitoring of VCOREMON, VDDIO and VMONx input pins. When an overvoltage occurs on a FS85/FS84 regulator monitored by one of these pins, the associated FS85/FS84 regulator is switched off till the fault is removed. The voltage monitoring is active as soon as FS_ENABLE=1 and UV/OV flags are then reported accordingly.

32.6.1 VCOREMON monitoring

VCOREMON input pin is dedicated to BUCK1 or BUCK1 and BUCK2 in case of multiphase operation. When overvoltage or undervoltage fault is detected, the fail-safe reaction on RSTB and/or FS0B is configurable with the VCOREMON_OV/UV_FS_IMPACT[1:0] bits during the INIT_FS phase.

Table 117. VCOREMON error impact configuration

VCOREMON_OV_FS_IMPACT[1:0]	VCOREMON OV impact on RSTB/FS0B
00	No effect on RSTB and FS0B
01	FS0B only is asserted
1x (default)	**FS0B and RSTB are asserted**
Reset condition	POR
VCOREMON_UV_FS_IMPACT[1:0]	**VCOREMON UV impact on RSTB/FS0B**
00	No effect on RSTB and FS0B
01 (default)	**FS0B only is asserted**
1x	FS0B and RSTB are asserted
Reset condition	POR

Table 118. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
VCOREMON					
VCOREMON_OV_min	Overvoltage threshold minimum	—	+4.5	—	%
VCOREMON_OV_max	Overvoltage threshold maximum	—	+12	—	%
VCOREMON_OV_step	Overvoltage threshold step (OTP_ VCOREOVTH[7:0] bits)	—	+0.5	—	%
VCOREMON_OV_acc	Overvoltage threshold accuracy	−2	—	2	%
TCOREMON_OV	Overvoltage filtering time (OTP_VCORE_OV_ DGLT bit)	20	25	30	µs
		40	45	50	µs
VCOREMON_UV_min	Undervoltage threshold minimum	—	−4.5	—	%
VCOREMON_UV_max	Undervoltage threshold maximum	—	−12	—	%
VCOREMON_UV_step	Undervoltage threshold step (OTP_ VCOREUVTH[7:0] bits)	—	−0.5	—	%
VCOREMON_UV_acc	Undervoltage threshold accuracy	−2	—	2	%
TCOREMON_UV	Undervoltage filtering time (OTP_VCORE_UV_ DGLT[1:0] bits)	2.5	5	7.5	µs
		10	15	20	µs
		20	25	30	µs
		35	40	45	µs

32.6.2 Static voltage scaling (SVS)

A static voltage scaling function is implemented to allow the MCU to reduce the output voltage initially configured at start-up of BUCK1 (and BUCK2 if used in multiphase). The SVS configuration must be done in INIT_FS phase. The offset value is configurable by SPI/I2C with the SVS_OFFSET[4:0] bits and the exact complemented value shall be written in the NOT_SVS_OFFSET[4:0] bits.

Table 119. SVS offset configuration

SVS_OFFSET[4:0]	NOT_SVS_OFFSET[4:0]	Offset applied to BUCK1 (and BUCK2 if used in multiphase)
00000 (default)	**11111**	**0 mV**
00001	11110	−6.25 mV
- - - - -	- - - - -	−6.25 mV step per bit
10000	01111	−100 mV
Reset condition	POR	

The BUCK1/2 output voltage transition starts when the NOT_SVS_OFFSET[4:0] SPI/I2C command is received and confirmed good. If the NOT_SVS_OFFSET[4:0] SPI/I2C command is not the exact opposite to the SVS_OFFSET[4:0] SPI/I2C command, the SVS procedure is not executed and the BUCK1 output voltage remains at its original value. The OV/UV threshold changes immediately when the NOT_SVS_OFFSET[4:0] SPI/I2C command is received and confirmed good. The BUCK1 output voltage transition last less than TCOREMON_OV, preventing a false OV detection.

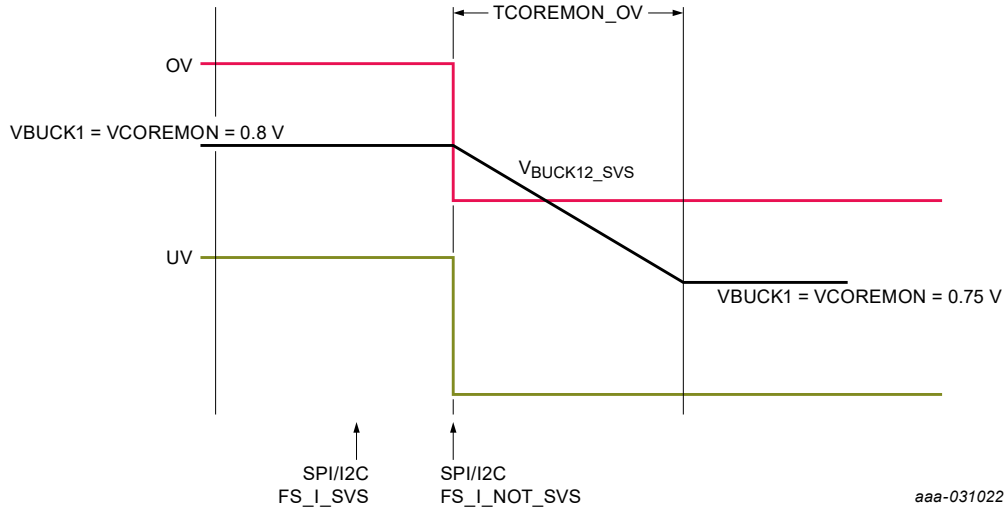


Figure 51. SVS principle

32.6.3 VDDIO monitoring

VDDIO input pin can be connected to VPRE, LDO1, LDO2, BUCK3 or an external regulator. The regulator connected to VDDIO must be at 3.3 V or 5.0 V to be compatible with overvoltage and undervoltage monitoring thresholds. In order to turn OFF the regulator in case of overvoltage detection, the configuration of which regulator is connected to VDDIO is done with OTP_VDDIO_REG_ASSIGN[2:0] bits. If an external regulator (not delivered by the FS85/FS84) is connected to VDDIO, this regulator cannot be turned OFF, but the overvoltage flag is reported to the MCU which can take appropriate action. In all cases, the fail-safe reaction on RSTB and/or FS0B configured with VDDIO_OV/UV_FS_IMPACT[1:0] bits is guaranteed.

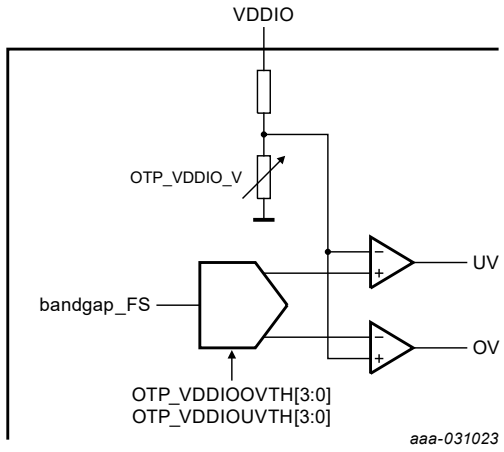


Figure 52. VDDIO monitoring principle

When overvoltage or undervoltage fault is detected, the fail-safe reaction on RSTB and/or FS0B is configurable with the VDDIO_OV/UV_IMPACT[1:0] bits during the INIT_FS phase.

Table 120. VDDIO error impact configuration

VDDIO_OV_FS_IMPACT[1:0]	VDDIO OV impact on RSTB/FS0B
00	No effect on RSTB and FS0B
01	FS0B only is asserted
1x (default)	**FS0B and RSTB are asserted**
Reset condition	POR

VDDIO_UV_FS_IMPACT[1:0]	VDDIO UV impact on RSTB/FS0B
00	No effect on RSTB and FS0B
01 (default)	**FS0B only is asserted**
1x	FS0B and RSTB are asserted
Reset condition	POR

Table 121. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
VDDIO					
VDDIO_OV_min	Overvoltage threshold minimum	—	+4.5	—	%
VDDIO_OV_max	Overvoltage threshold maximum	—	+12	—	%
VDDIO_OV_step	Overvoltage threshold step (OTP_VDDIOOVTH[7:0] bits)	—	+0.5	—	%
VDDIO_OV_acc	Overvoltage threshold accuracy	−2	—	2	%
TVDDIO_OV	Overvoltage filtering time (OTP_VDDIO_OV_DGLT bit)	20	25	30	µs
		40	45	50	µs
VDDIO_UV_min	Undervoltage threshold minimum	—	−4.5	—	%
VDDIO_UV_max	Undervoltage threshold maximum	—	−12	—	%
VDDIO_UV_step	Undervoltage threshold step (OTP_VDDIOUVTH[7:0] bits)	—	−0.5	—	%
VDDIO_UV_acc	Undervoltage threshold accuracy	−2	—	2	%
TVDDIO_UV	Undervoltage filtering time (OTP_VDDIO_UV_DGLT[1:0] bits)	2.5	5	7.5	µs
		10	15	20	µs
		20	25	30	µs
		35	40	45	µs

32.6.4 VMONx monitoring

Each VMONx monitoring feature is enabled by OTP. VMONx input pin can be connected to VPRE, LDO1, LDO2, BUCK3, BUCK2 (in case BUCK2 is not used in multiphase) or even an external regulator. In order to turn OFF the regulator in case of Overvoltage detection, the configuration of which regulator is connected to VMONx is done by SPI/I2C in the register M_VMON_REGx. If an external regulator (not delivered by the FS85/FS84) is connected to VMONx, this regulator cannot be turned OFF, but the Overvoltage flag is reported to the MCU which can take appropriate action. In all cases, the fail-safe reaction on RSTB and/or FS0B configured with VMONx_OV/UV_FS_IMPACT[1:0] bits is guaranteed.

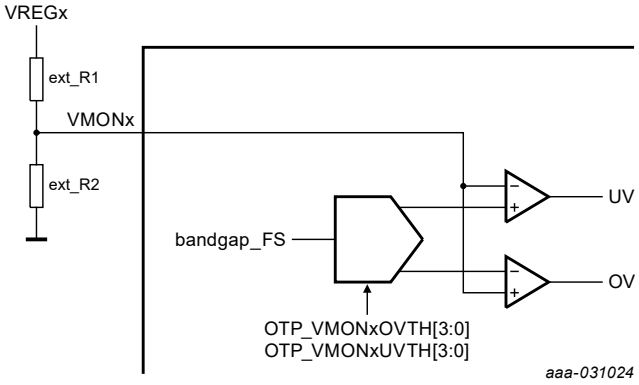


Figure 53. VMONx monitoring principle

The external resistor bridge connected to VMONx shall be calculated to deliver a middle point of 0.8V. It is recommended to use ±1 % or less resistor accuracy. When overvoltage or undervoltage fault is detected, the fail-safe reaction on RSTB and/or FS0B is configurable with the VMONx_OV/UV_FS_IMPACT[1:0] bits during the INIT_FS phase.

Table 122. VMONx error impact configuration

VMONx_OV_FS_IMPACT[1:0]	VMONx OV impact on RSTB/FS0B
00	No effect on RSTB and FS0B
01	FS0B only is asserted
1x (default)	**FS0B and RSTB are asserted**
Reset condition	POR

VMONx_UV_FS_IMPACT[1:0]	VMONx UV impact on RSTB/FS0B
00	No effect on RSTB and FS0B
01 (default)	**FS0B only is asserted**
1x	FS0B and RSTB are asserted
Reset condition	POR

Table 123. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
VMONx (without ext resistor accuracy)					
VMONx_OV_min	Overvoltage threshold minimum	—	+4.5	—	%
VMONx_OV_max	Overvoltage threshold maximum	—	+12	—	%
VMONx_OV_step	Overvoltage threshold step (OTP_VMONxOVTH[7:0] bits)	—	+0.5	—	%
VMONx_OV_acc	Overvoltage threshold accuracy	−2	—	2	%
TMONx_OV	Overvoltage filtering time (OTP_VMONx_OV_DGLT bit)	20	25	30	µs
		40	45	50	µs
VMONx_UV_min	Undervoltage threshold minimum	—	−4.5	—	%
VMONx_UV_max	Undervoltage threshold maximum	—	−12	—	%
VMONx_UV_step	Undervoltage threshold step (OTP_VMONxUVTH[7:0] bits)	—	−0.5	—	%
VMONx_UV_acc	Undervoltage threshold accuracy	−2	—	2	%
TMONx_UV	Undervoltage filtering time (OTP_VMONx_UV_DGLT[1:0] bits)	2.5	5	7.5	µs
		10	15	20	µs
		20	25	30	µs
		35	40	45	µs
VMONx_PD	Internal passive pull down	1	2	4	MΩ

32.7 External IC monitoring (ERRMON)

The external IC monitoring feature is enabled by OTP_ERRMON_EN bit. The ERRMON input pin is in charge to monitor an external IC on the application, neither the FS85, nor the MCU. The ERRMON monitoring is active as soon as the INIT_FS is closed by the first good watchdog refresh

A transition detected at ERRMON pin indicates an error from the external IC. The polarity of the ERRMON fault signal is configurable with ERRMON_FLT_POL bit during the INIT_FS phase.

Table 124. ERRMON polarity configuration

ERRMON_FLT_POL	ERRMON polarity
0 (default)	**Negative edge at ERRMON pin is a fault**
1	Positive edge at ERRMON pin is a fault
Reset condition	POR

The acknowledge timing from the MCU is configurable with the ERRMON_ACK_TIME[1:0] bits.

Table 125. ERRMON timing configuration

ERRMON_ACK_TIME[1:0]	ERRMON acknowledgement timing
00	1 ms
01 (default)	**8 ms**
10	16 ms
11	32 ms
Reset condition	POR

The acknowledgement by the MCU is done through SPI/I2C communication according to Figure 54.

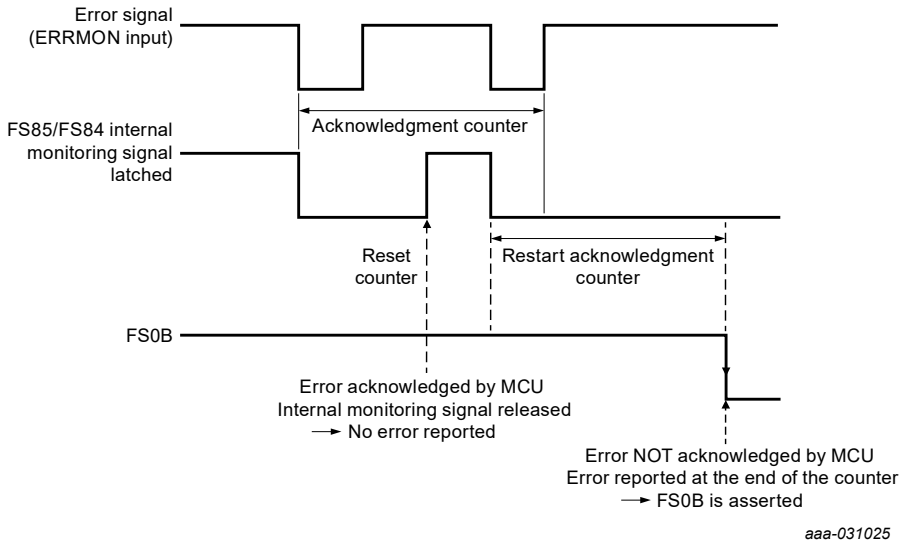


Figure 54. ERRMON principle

When ERRMON fault is detected, the fail-safe reaction on RSTB and/or FS0B is configurable with the ERRMON_FS_IMPACT bit during the INIT_FS phase.

Table 126. ERRMON error impact configuration

ERRMON_FS_IMPACT	ERRMON impact on RSTB/FS0B
0	FS0B only is asserted when ERRMON fault is detected
1 (default)	**FS0B and RSTB are asserted when ERRMON fault is detected**
Reset condition	POR

Table 127. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
ERRMON					
$ERRMON_{TACK\_ACC}$	Acknowledgement counter accuracy	−10	—	10	%
$ERRMON_{TERR}$	Filtering time	4.0	—	8.0	µs
$ERRMON_{VIH}$	High level input voltage threshold	—	—	2.0	V
$ERRMON_{VIL}$	Low level input voltage threshold	1.0	—	—	V
$ERRMON_{HYST}$	Input voltage hysteresis	100	—	500	mV
$ERRMON_{IPD}$	Internal pull down current source	7	10	13	µA

32.8 Fault management

32.8.1 Fault error counter

The FS85/FS84 integrates a configurable fault error counter which is counting the number of faults related to the device itself and also caused by external events. The fault error counter starts at level "1" after a POR or resuming from Standby. The final value of the fault error counter is used to transition in DEEP-FS mode. The maximum value of this counter is configurable with the FLT_ERR_CNT_LIMIT[1:0] bits during the INIT_FS phase.

Table 128. Fault error counter configuration

FLT_ERR_CNT_LIMIT[1:0]	Fault error counter max value configuration	Fault error counter intermediate value
00	2	1
01 (default)	**6**	**3**
10	8	4
11	12	6
Reset condition	POR	

The fault error counter has two output values: intermediate and final. The intermediate value can be used to force the FS0B activation or generate a RSTB pulse according to the FLT_ERR_IMPACT[1:0] bits configuration.

Table 129. Fault error counter impact configuration

FLT_ERR_IMPACT[1:0]	Fault error counter intermediate value impact on RSTB/FS0B
00	No effect on RSTB and FS0B
01	FS0B only is asserted if FLT_ERR_CNT=intermediate value
1x (default)	**FS0B is asserted if FLT_ERR_CNT=intermediate value** **RSTB is asserted for each value of FLT_ERR_CNT>=intermediate value**
Reset condition	POR

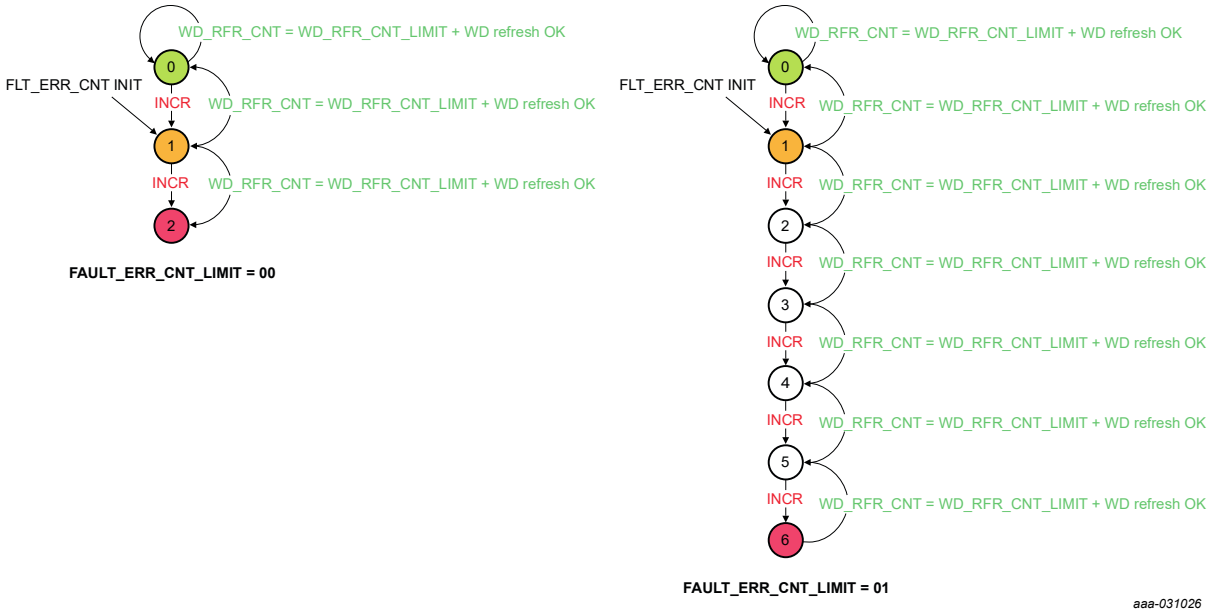


Figure 55. Fault error counter max value = 2 or 6

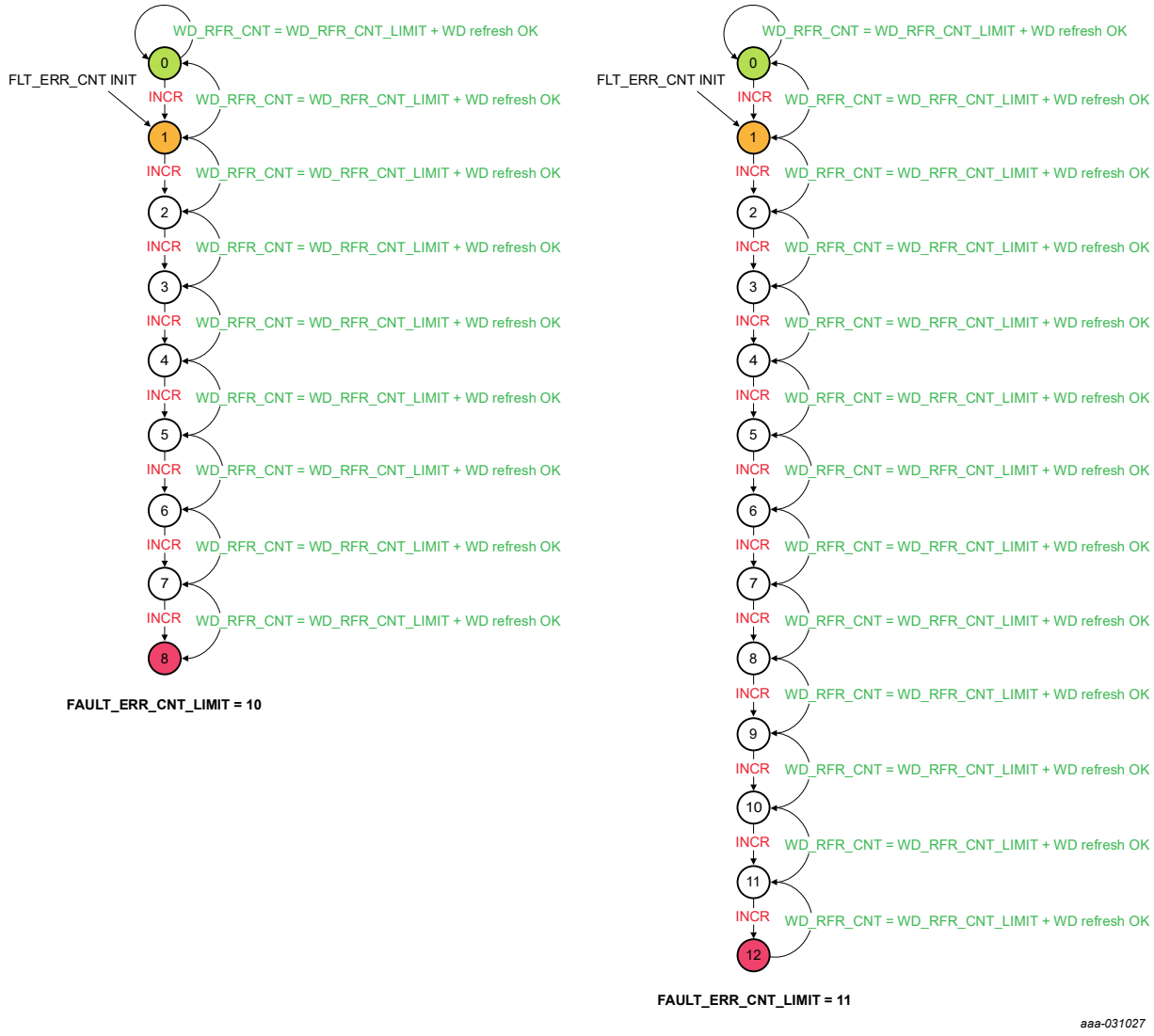


Figure 56. Fault error counter max value = 8 or 12

32.8.2 Fault source and reaction

In normal operation when FS0B and RSTB are released, the fault error counter is incremented when a fault is detected by the FS85/FS84 fail-safe sate machine. Table 130 lists the faults and their impact on PGOOD, RSTB and FS0B pins according to the device configuration. The faults that are configured to not assert RSTB and FS0B will not increment the fault error counter. In that case, only the flags are available for MCU diagnostic. The fault error counter is incremented by 1, each time the RSTB and/or FS0B pin is asserted. When FS0B is asserted, the fault error counter continues to be incremented by +1 each time the WD error counter reach its maximum value.

Table 130. Application related fail-safe fault list and reaction

In Orange, the reaction in not configurable.

In Green, the reaction is configurable by OTP for PGOOD and by SPI/I2C for RSTB/FS0B during INIT_FS.

Apps related fail-safe faults	FLT_ERR_CNT increment	FS0B assertion	RSTB assertion	PGOOD assertion
VCOREMON_OV	+1	VCOREMON_OV_FS_IMPACT[0]	VCOREMON_OV_FS_IMPACT[1]	OTP_PGOOD_VCORE
VDDIO_OV	+1	VDDIO_OV_FS_IMPACT[0]	VDDIO_OV_FS_IMPACT[1]	OTP_PGOOD_VDDIO
VMONx_OV	+1	VMONx_OV_FS_IMPACT[0]	VMONx_OV_FS_IMPACT[1]	OTP_PGOOD_VMONx
VCOREMON_UV	+1	VCOREMON_UV_FS_IMPACT[0]	VCOREMON_UV_FS_IMPACT[1]	OTP_PGOOD_VCORE
VDDIO_UV	+1	VDDIO_UV_FS_IMPACT[0]	VDDIO_UV_FS_IMPACT[1]	OTP_PGOOD_VDDIO
VMONx_UV	+1	VMONx_UV_FS_IMPACT[0]	VMONx_UV_FS_IMPACT[1]	OTP_PGOOD_VMONx
FCCU12 (pair)	+1	FCCU12_FS_IMPACT	FCCU12_FS_IMPACT	No
FCCU1 (single)	+1	FCCU1_FS_IMPACT	FCCU1_FS_IMPACT	No
FCCU2 (single)	+1	FCCU2_FS_IMPACT	FCCU2_FS_IMPACT	No
ERRMON	+1	ERRMON_FS_IMPACT	ERRMON_FS_IMPACT	No
WD error counter = max value	+1	WD_FS_IMPACT[0]	WD_FS_IMPACT[1]	No
Fault error counter impact at intermediate value	No	FLT_ERR_IMPACT[0]	FLT_ERR_IMPACT[1]	No
Wrong WD refresh in INIT_FS	+1	Yes	Yes	No
No WD refresh in INIT_FS	+1	Yes	Yes	No
External RESET (falling edge)	+1	No [1]	Yes (low externally)	No
RSTB pulse request by MCU	No	No [1]	Yes	No
RSTB short to high	+1	Yes	No (high externally)	No
FS0B short to high	No	No (high externally)	FS0B_SC_HIGH_CFG	No
FS0B request by the MCU	No	Yes	No	No
REG_CORRUPT = 1	+1	Yes	No	No
OTP_CORRUPT = 1	+1	Yes	No	No
GOTO_INITFS request by MCU	No	Yes	No	No

[1] By cascaded effect, the FSOB is asserted low because of INIT_FS state.

If OTP_PGOOD_RSTB = ‘0’ (default configuration), RSTB and PGOOD pins work independently according to Table 130.

If OTP_PGOOD_RSTB = ‘1’, RSTB and PGOOD pins work concurrently and all the faults asserting RSTB will also assert PGOOD except in case of External RESET detection.

32.9 PGOOD, RSTB, FS0B

These three safety output pins have a hierarchical implementation in order to guarantee the safe state.

- PGOOD has the priority one. If PGOOD is asserted, RSTB and FS0B are asserted.
- RSTB has the priority two. If RSTB is asserted, FS0B is asserted but PGOOD may not be asserted.

- FS0B has the priority three. If FS0B is asserted, RSTB and PGOOD may not be asserted.

RSTB release is managed by the fail-safe state machine and depends on PGOOD release and ABIST1 execution.

Voltage monitoring assigned to PGOOD and to ABIST1 determines when RSTB is released. This configuration is done by OTP.

32.9.1 PGOOD

PGOOD is an open-drain output that can be connected in the application to the PORB of the MCU. PGOOD requires an external pull up resistor to VDDIO and a filtering capacitor to GND for immunity. An internal pull down RPD ensures PGOOD low level in Standby and Power down mode. BUCK1, VDDIO, VMONx can be assigned to PGOOD by OTP.

PGOOD is asserted low by the FS_LOGIC when any of the assigned regulators are in undervoltage or overvoltage. When PGOOD is asserted low, RSTB and FS0B are also asserted low. An internal pull up on the gate of the low-side MOS ensure PGOOD low level in case of FS_LOGIC failure.

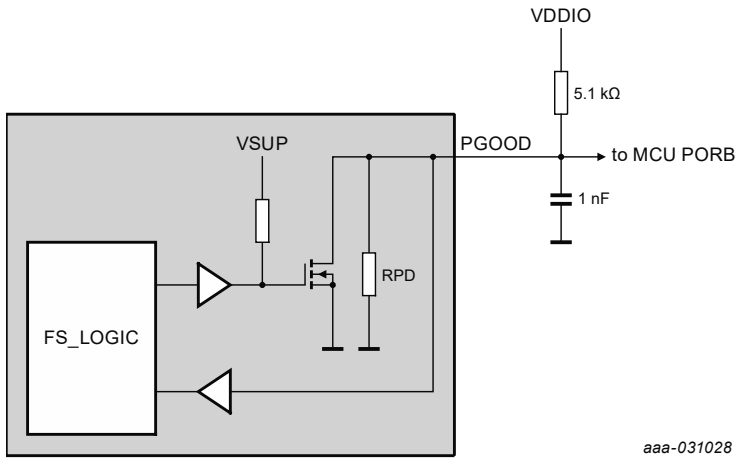


Figure 57. PGOOD pin implementation

Table 131. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
PGOOD					
$PGOOD_{VIL}$	Low level input voltage threshold	1.0	—	—	V
$PGOOD_{VIH}$	High level input voltage threshold	—	—	2.0	V
$PGOOD_{HYST}$	Input voltage hysteresis	100	—	—	mV
$PGOOD_{VOL}$	Low level output voltage (I = 2.0 mA)	—	—	0.5	V
$PGOOD_{RPD}$	Internal pull down resistor	200	400	800	kΩ
$PGOOD_{ILIM}$	Current limitation	4.0	—	20	mA
$PGOOD_{TFB}$	Feedback filtering time	8.0	—	15	µs

32.9.2 RSTB

RSTB is an open-drain output that can be connected in the application to the RESET of the MCU. RSTB requires an external pull up resistor to VDDIO and a filtering capacitor to GND for immunity. An internal pull

down RPD ensure RSTB low level in Standby and Power down mode. RSTB assertion depends on the device configuration during INIT_FS phase. When RSTB is asserted low, FS0B is also asserted low. An internal pull up on the gate of the low-side MOS ensures RSTB low level in case of FS_LOGIC failure. When RSTB is stuck low for more than $RSTB_{T8S}$, the device transitions in DEEP-FS mode.

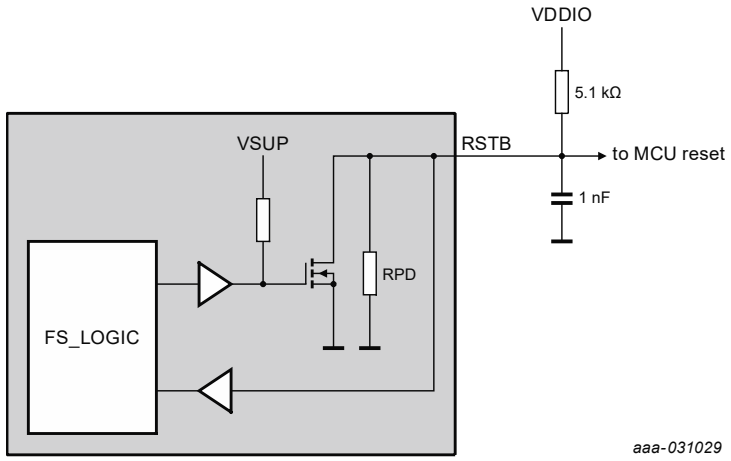


Figure 58. RSTB pin implementation

Table 132. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
RSTB					
$RSTB_{VIL}$	Low level input voltage threshold	1.0	—	—	V
$RSTB_{VIH}$	High level input voltage threshold	—	—	2.0	V
$RSTB_{HYST}$	Input voltage hysteresis	100	—	—	mV
$RSTB_{VOL}$	Low level output voltage (I = 2.0 mA)	—	—	0.5	V
$RSTB_{RPB}$	Internal pull-down resistor	200	400	800	kΩ
$RSTB_{ILIM}$	Current limitation	4.0	—	20	mA
$RSTB_{TFB}$	Feedback filtering time	8.0	—	15	µs
$RSTB_{TSC}$	Short to high filtering time	500	—	800	us
$RSTB_{TLG}$	Long pulse (configurable with RSTB_DUR bit)	9.0	—	11	ms
$RSTB_{TST}$	Short pulse (configurable with RSTB_DUR bit)	0.9	—	1.1	ms
$RSTB_{T8S}$	8 second timer	7.0	8.0	9.0	s
$RSTB_{TRELEASE}$	Time to release RSTB from Wake-up or POR with all regulators started in Slot 0	—	8	—	ms

32.9.3 FS0B

FS0B is an open-drain output that can be used to transition the system in safe sate. FS0B requires an external pull up resistor to VDDIO or VSUP, a 10 nF filtering capacitor to GND for immunity when FS0B is a local pin, and an additional RC network when FS0B is a global pin to be robust against ESD GUN and ISO 7637 transient pulses. An internal pull down RPD ensure FS0B low level in Standby and Power down mode. FS0B assertion depends on the device configuration during INIT_FS phase. An internal pull up on the gate of the low-side MOS ensure FS0B low level in case of FS_LOGIC failure.

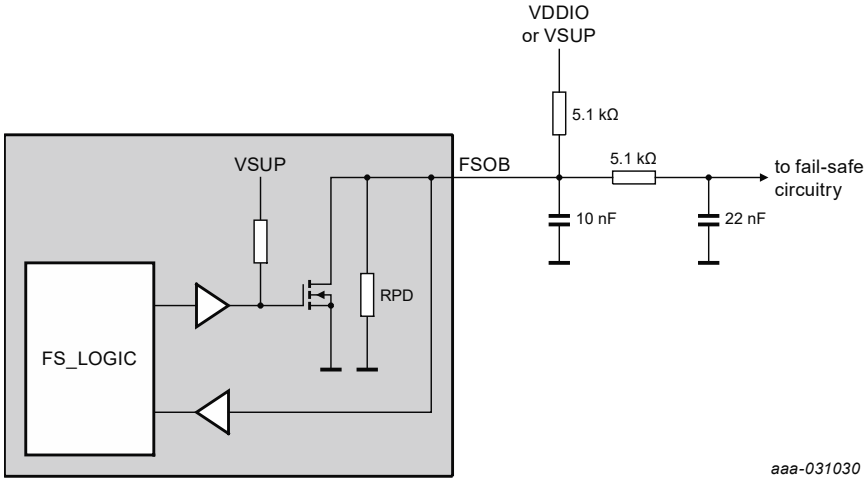


Figure 59. FS0B pin implementation

Table 133. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
FS0B					
$FS0B_{VIL}$	Low level input voltage threshold	1.0	—	—	V
$FS0B_{VIH}$	High level input voltage threshold	—	—	2.0	V
$FS0B_{HYST}$	Input voltage hysteresis	100	—	—	mV
$FS0B_{VOL}$	Low level output voltage (I = 2.0 mA)	—	—	0.5	V
$FS0B_{RPD}$	Internal pull down resistor	1	2	4	MΩ
$FS0B_{ILIM}$	Current limitation	4.0	—	20	mA
$FS0B_{TFB}$	Feedback filtering time	8.0	—	15	µs
$FS0B_{TSC}$	Short to high filtering time	500	—	800	µs

32.9.4 FS0B release

When the fail-safe output FS0B is asserted low by the device due to a fault, some conditions must be validated before allowing these pins to be released by the device. These conditions are:

- LBIST_OK = ABIST1_OK = ABIST2_OK = 1
- Fault Error Counter = 0
- RELEASE_FS0B register filled with ongoing WD_SEED reversed and complemented

Table 134. RELEASE_FS0B register based on WD_SEED value

WD_SEED[23:16]	B23	B22	B21	B20	B19	B18	B17	B16
RELEASE_FS0B[23:16]	**Not(B8)**	**Not(B9)**	**Not(B10)**	**Not(B11)**	**Not(B12)**	**Not(B13)**	**Not(B14)**	**Not(B15)**
WD_SEED[15:8]	B15	B14	B13	B12	B11	B10	B9	B8
RELEASE_FS0B[15:8]	**Not(B16)**	**Not(B17)**	**Not(B18)**	**Not(B19)**	**Not(B20)**	**Not(B21)**	**Not(B22)**	**Not(B23)**

32.10 Built-in self-test (BIST)

32.10.1 Logical BIST

The fail-safe state machine includes a logical built-in self-test (LBIST) to verify the correct functionality of the safety logic monitoring. The LBIST is performed after each POR, or after each wake up from Standby. In case of LBIST fail, RSTB and PGOOD are released but FS0B remains stuck low and cannot be released. The flag LBIST_OK is available through SPI/I2C for MCU diagnostic. The typical LBIST duration is 4.2 ms and the maximum LBIST duration is 6.0 ms.

32.10.2 Analog BIST

The fail-safe state machine includes two analog built-in self-test (ABIST) to verify the correct functionality of the safety analog monitoring. ABIST1 is executed automatically after each POR, or after each wake up from Standby. The assignment of which regulator is checked during ABIST1 is done by OTP.

ABIST2 is executed after INIT_FS is closed with a good WD refresh and the regulators assigned to ABIST2 in FS_I_OVUV_SAFE_REACTION1 register during INIT_FS are started and they crossed their UV. In case of ABIST fail, RSTB and PGOOD are released but FS0B remains stuck low and cannot be released. The flags ABIST1_OK and ABIST2_OK are available through SPI/I2C for MCU diagnostic.

Table 135. ABIST coverage

Parameter	Overvoltage	Undervoltage	Short to high	Low speed	High speed	ABIST1	ABIST2
VCOREMON	X	X				OTP	SPI/I2C
VDDIO	X	X				OTP	SPI/I2C
VMONx	X	X				OTP	SPI/I2C
OSC				X	X	X	
V1p6D_FS	X					X	
PGOOD			X			X	
RSTB			X			X	
FS0B			X			X	

Table 136. ABIST2 execution bit

VCOREMON_ABIST2	VCOREMON BIST executed during ABIST2
0 (default)	**No ABIST2**
1	VCOREMON BIST executed during ABIST2
Reset condition	POR

VDDIO_ABIST2	VDDIO BIST executed during ABIST2
0 (default)	**No ABIST2**
1	VDDIO BIST executed during ABIST2
Reset condition	POR

VMONx_ABIST2	VMONx BIST executed during ABIST2
0 (default)	**No ABIST2**
1	VMONx BIST executed during ABIST2
Reset condition	POR

Table 137. Electrical characteristics

T_A = −40 °C to 125 °C, unless otherwise specified. VSUP = VSUP_UVH to 36 V, unless otherwise specified. All voltages referenced to ground.

Symbol	Parameter	Min	Typ	Max	Unit
ABIST					
$ABIST1_{TDUR}$	ABIST1 duration • MIN with **no** voltage monitoring assigned by OTP • MAX with **all** voltage monitoring assigned by OTP	0.2	—	1.2	ms
$ABIST2_{TDUR}$	ABIST2 duration • MIN with **no** voltage monitoring selected by SPI/I2C • MAX with **all** voltage monitoring selected by SPI/I2C	0.2	—	1.2	ms

33 Package information

FS85/FS84 package is a QFN (sawn), thermally enhanced wettable flanks, 8 x 8 x 0.85 mm, 0.5 mm pitch, 56 pins.

34 Package outline

34.1 Step-cut wettable flank

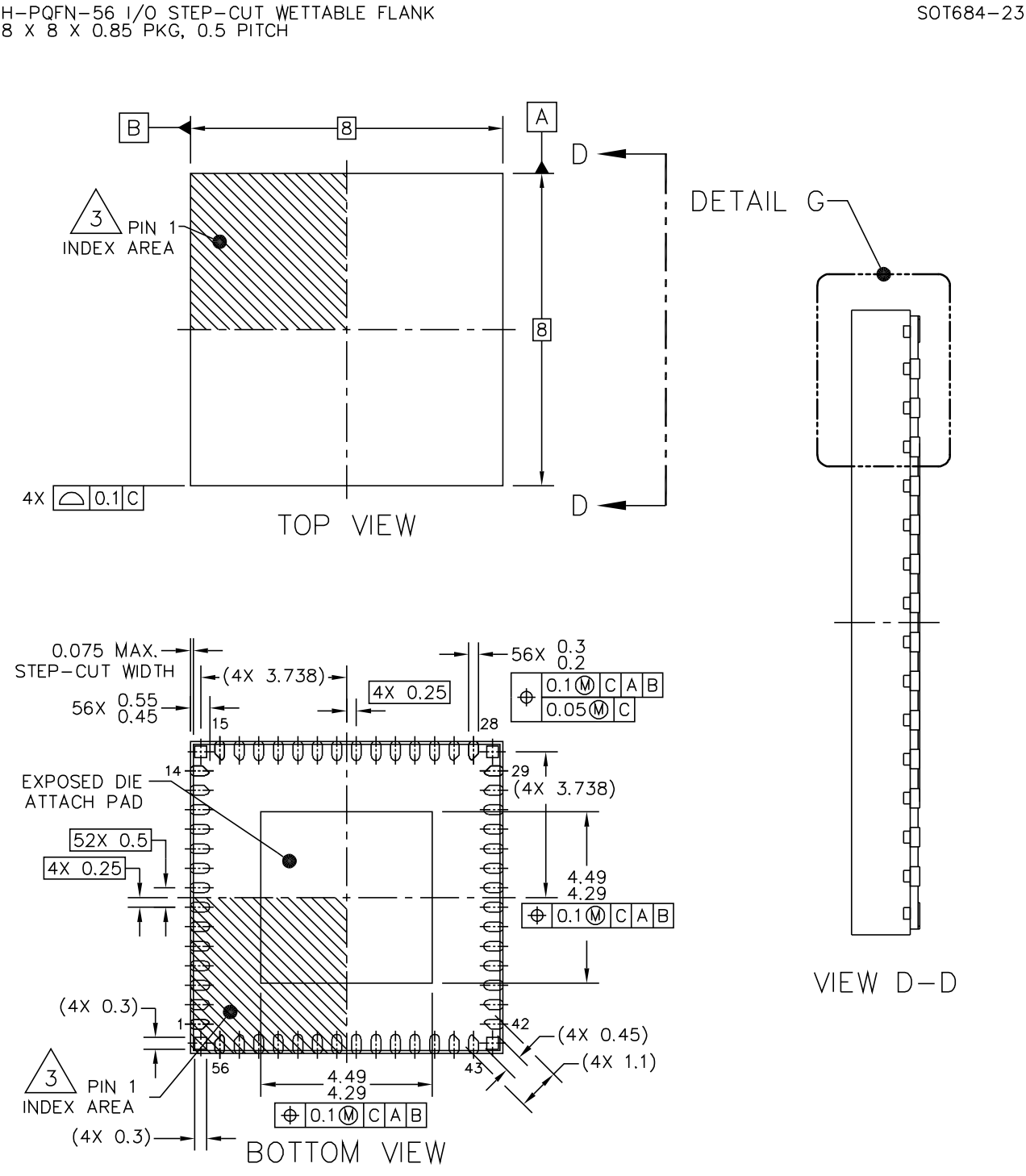


Figure 60. Package outline for HVQFN56 (SOT684-23, Step-cut)

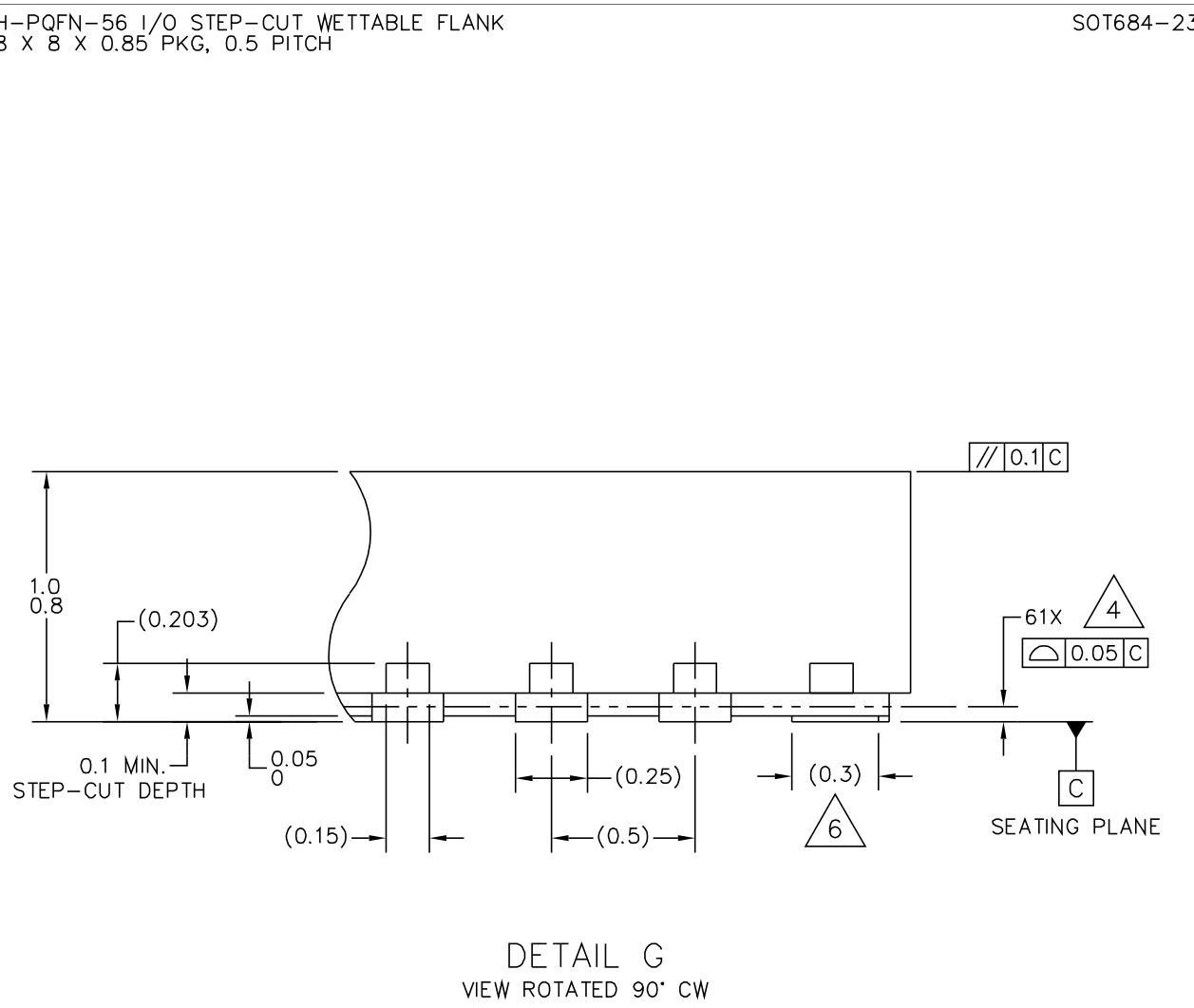


Figure 61. Package outline detail for HVQFN56 (SOT684-23, Step-cut)

34.2 Dimple wettable flank

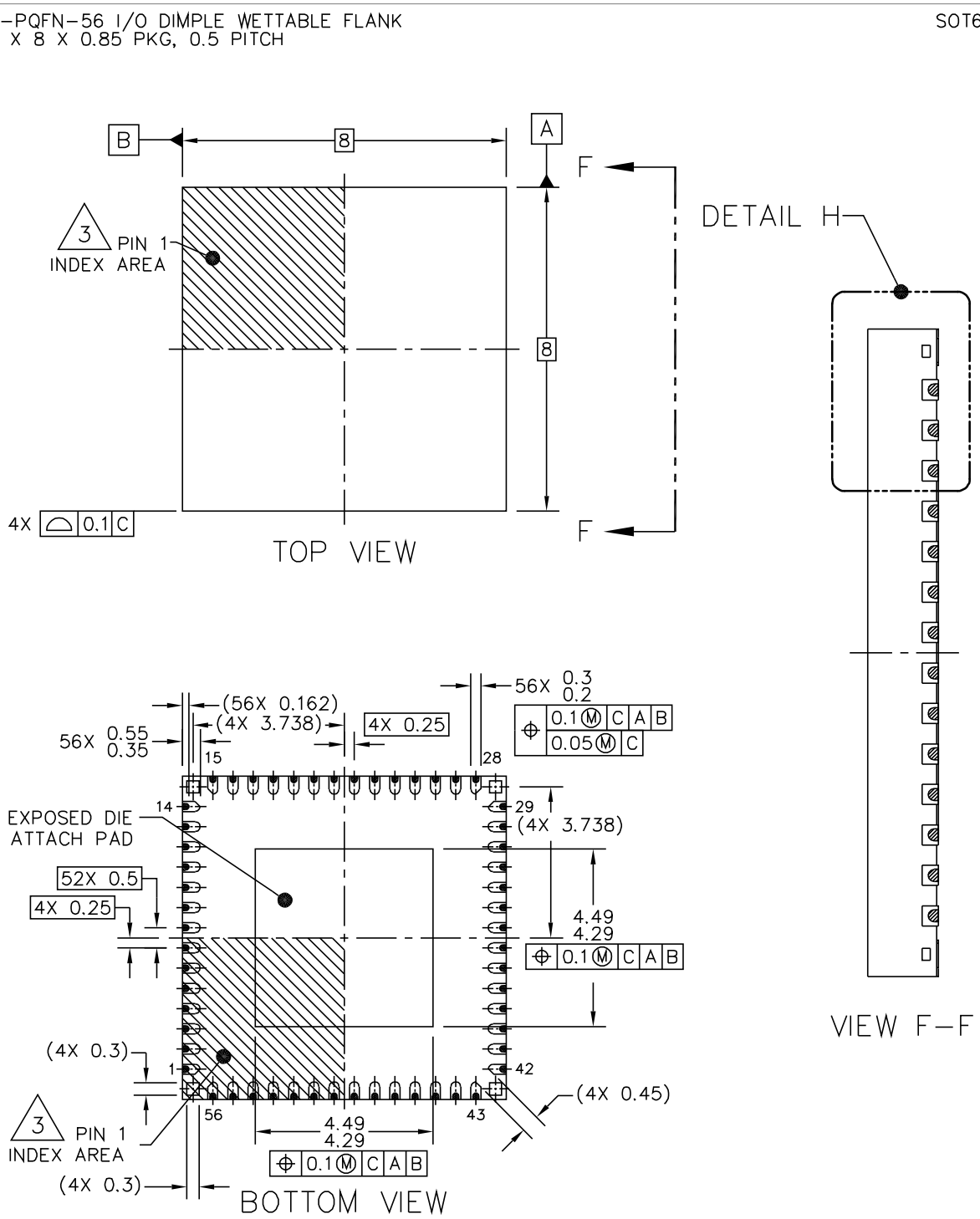


Figure 62. Package outline for HVQFN56 (SOT684-23, Dimple)

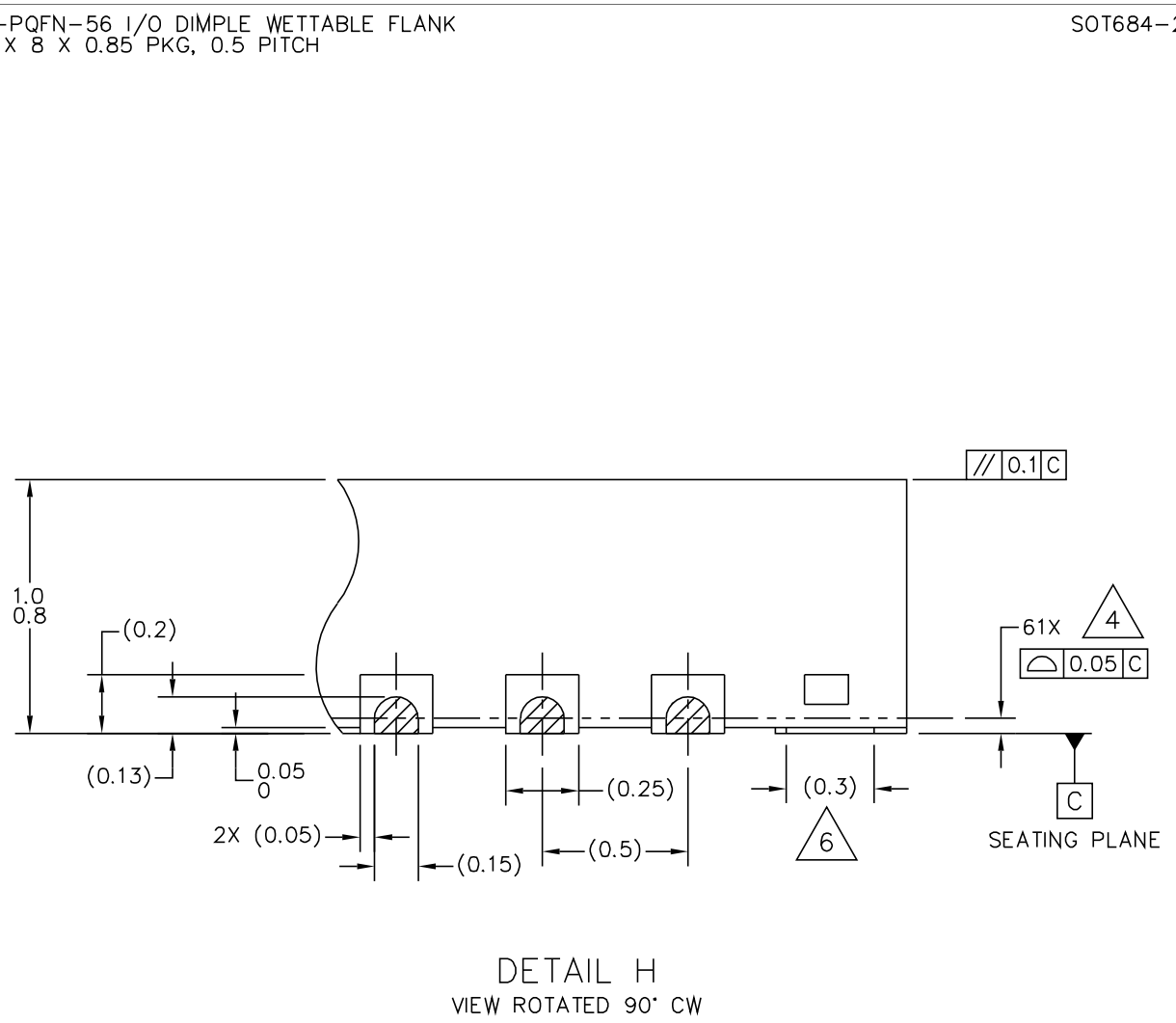


Figure 63. Package outline detail for HVQFN56 (SOT684-23, Dimple)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994.
3. PIN 1 FEATURE SHAPE, SIZE AND LOCATION MAY VARY.
4. COPLANARITY APPLIES TO LEADS, DIE ATTACH FLAG AND CORNER NON–FUNCTIONAL PADS.
5. MIN. METAL GAP SHOULD BE 0.25 MM.
6. ANCHORING PADS.

Figure 64. Package outline notes for HVQFN56 (SOT684-23)

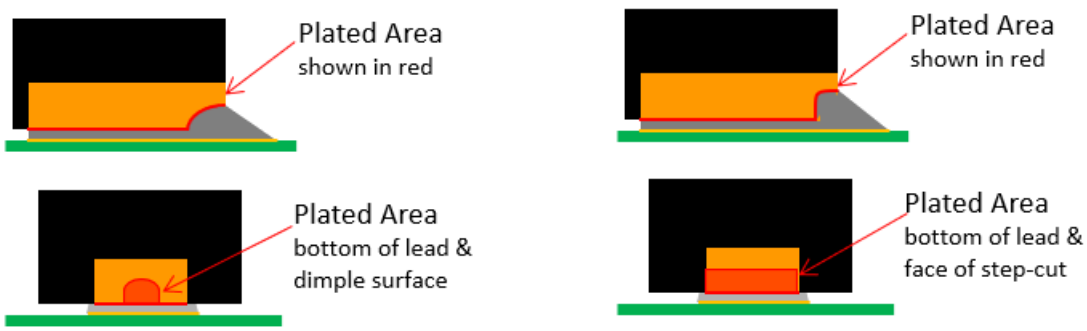
34.3 Package comparison

Table 138. Package comparison

Item	Dimple wettable flank	Step-cut wettable flank
Package size (x,y,z)	8x8x0.85 mm3	8x8x0.85 mm3

Table 138. Package comparison*...continued*

Item	Dimple wettable flank	Step-cut wettable flank
Package	QFN56 8*8	QFN56 8*8
Epoxy	EN4900G*	EN4900G*
Wire	AuPdCu Wire 1.3mil	AuPdCu Wire 1.3mil
Compound	CEL-9240HF10AN4	G700LA fine catalyst
Lead frame	PPF+RT	SN Plated
Wettable flank	Dimple solution	Step Cut
Part number	MC33FS85XXXXKS	MC33FS85XXXXES
MSL / Reflow ℃	3 / 260	3 / 260



35 Layout and PCB guidelines

35.1 Landing pad information

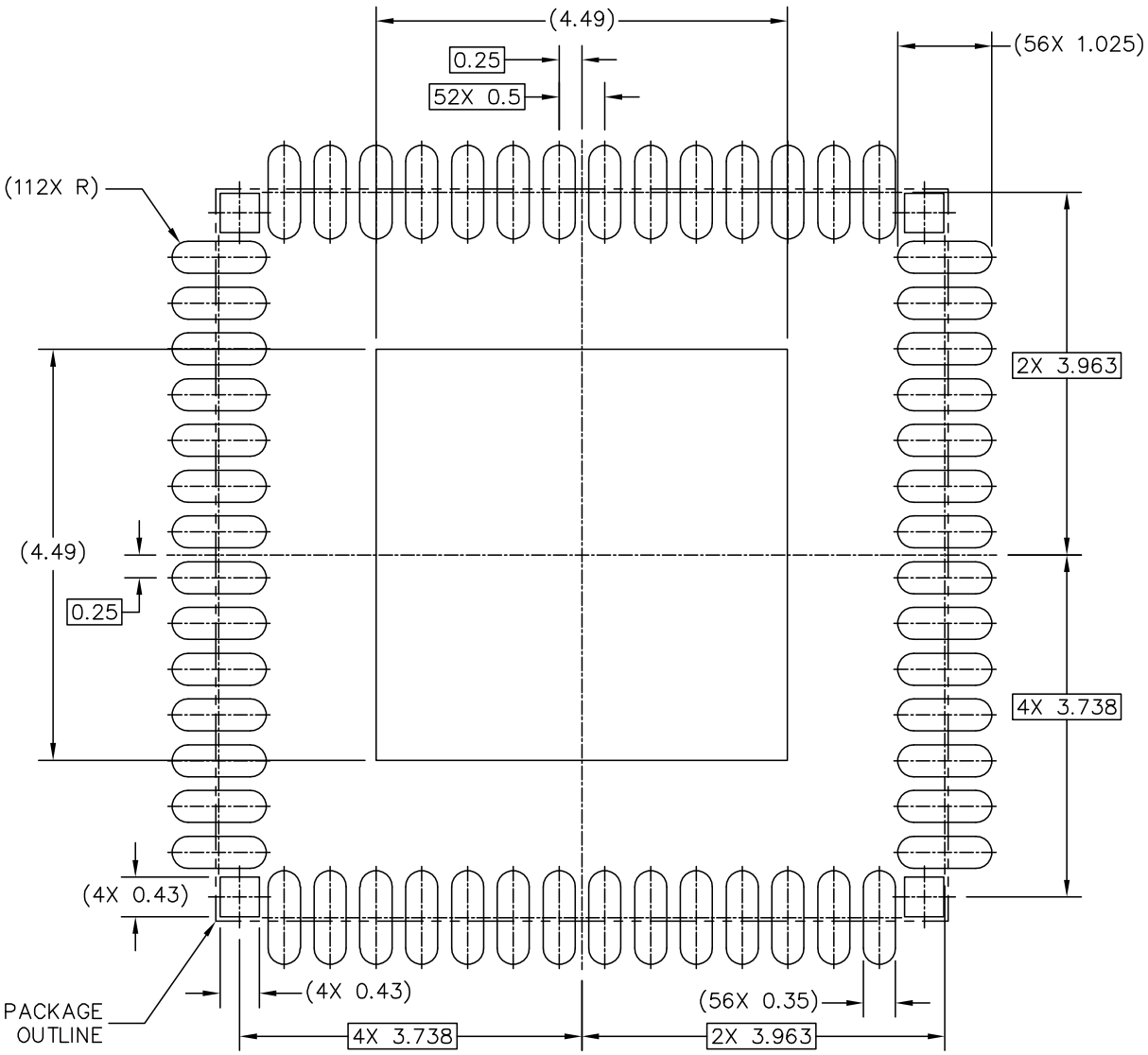


Figure 65. Solder mask pattern

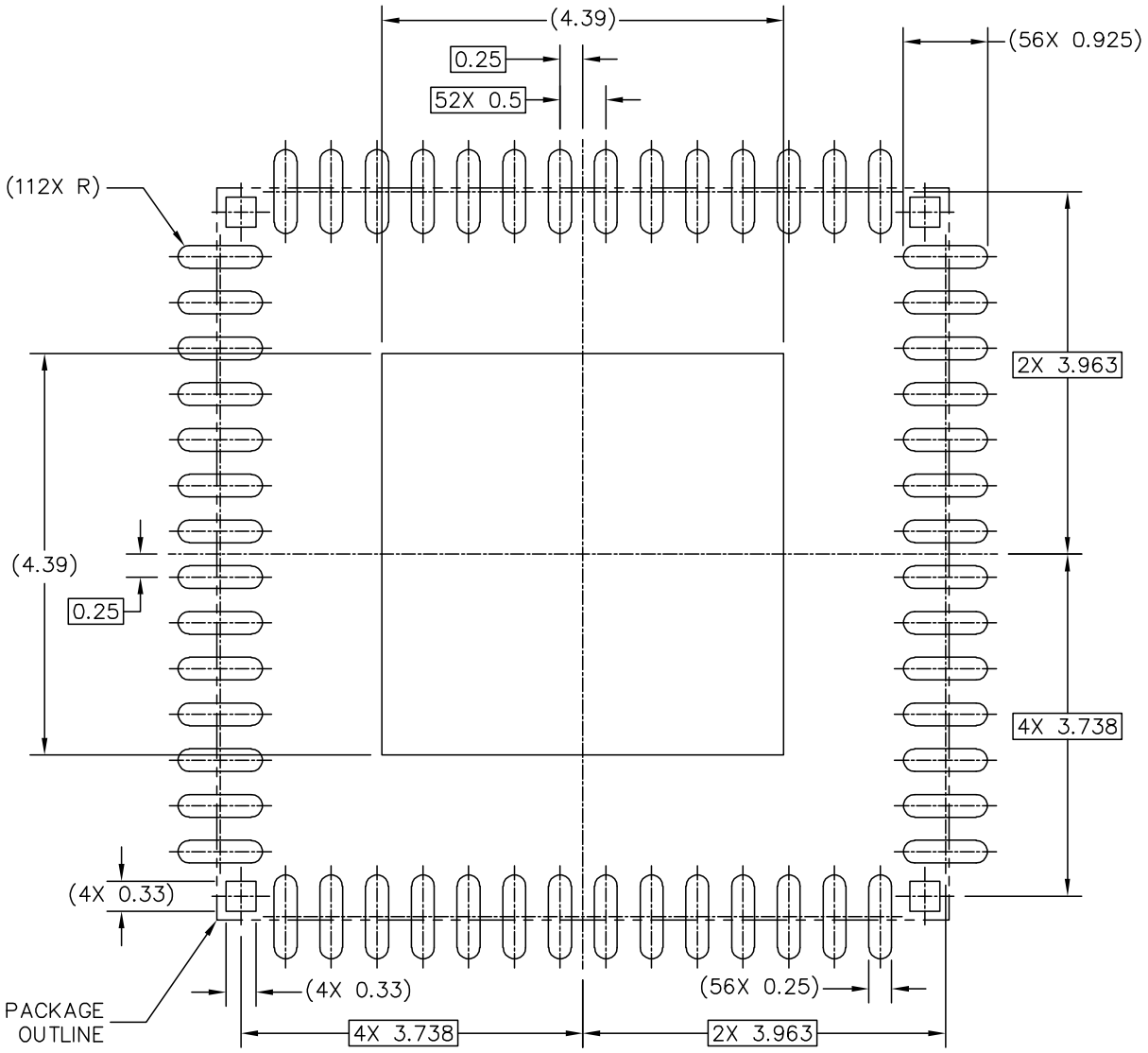


Figure 66. I/O pads and solderable area

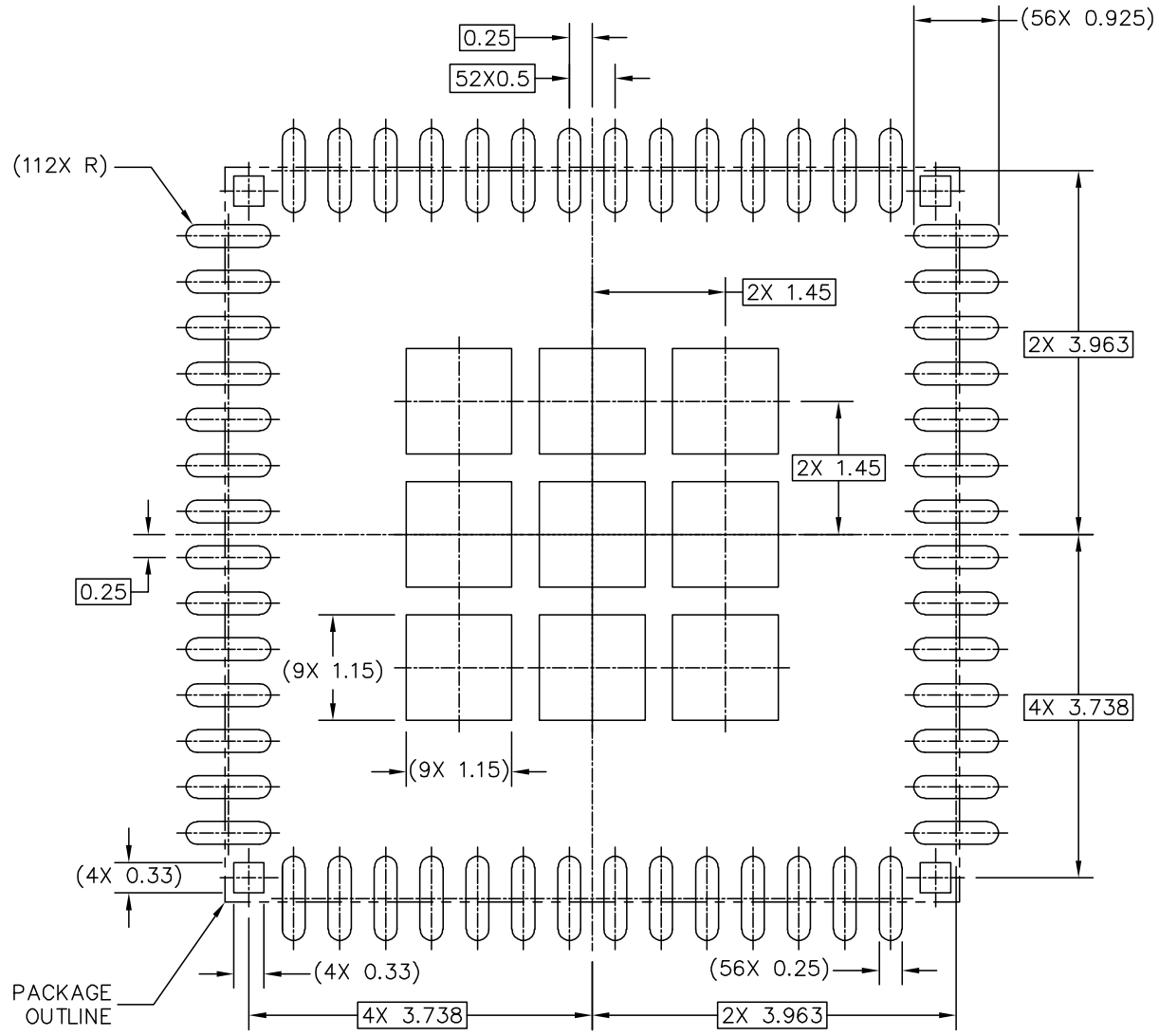


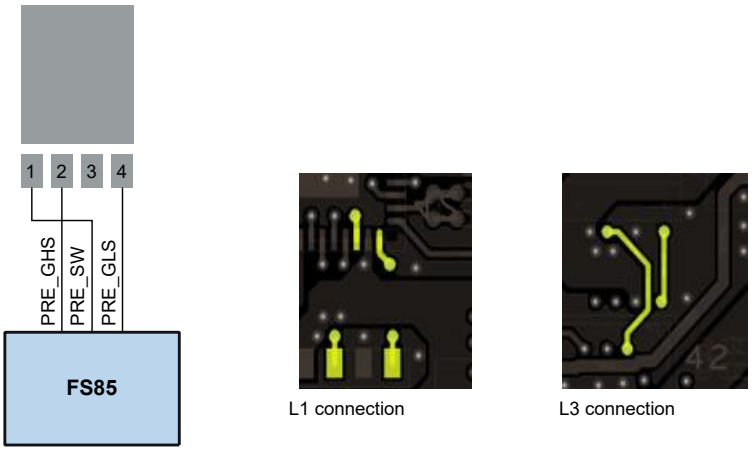
Figure 67. Solder paste stencil

35.2 Component selection

- SMPS input and output capacitors shall be chosen with low ESR (ceramic or MLCC type of capacitors). X7R ceramic type is preferred. Input decoupling capacitors shall be placed as close as possible to the device pin. Output capacitor voltage rating shall be selected to be 3x the voltage output value to minimize the DC bias degradation.
- SMPS inductors shall be shielded with ISAT higher than maximum inductor peak current.

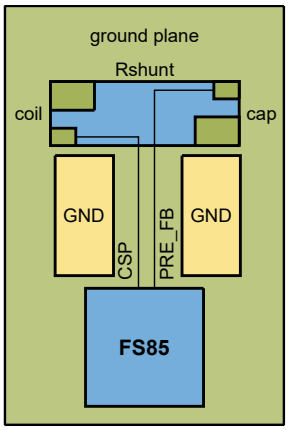
35.3 VPRE

- Inductor charging and discharging current loop shall be designed as small as possible.
- Input decoupling capacitors shall be placed close to the high-side drain transistor pin.
- The boot strap capacitor shall be placed close to the device pin using wide and short track to connect to the external low-side drain transistor.
- PRE_GLS, PRE_GHS and PRE_SW tracks shall be wide and short and should not cross any sensitive signal (current sensing, for example).



Implementation
Note: L2 is system ground.

- PRE_FB used as voltage feedback AND current sense shall be connected to R_{SHUNT} and routed as a pair with CSP.

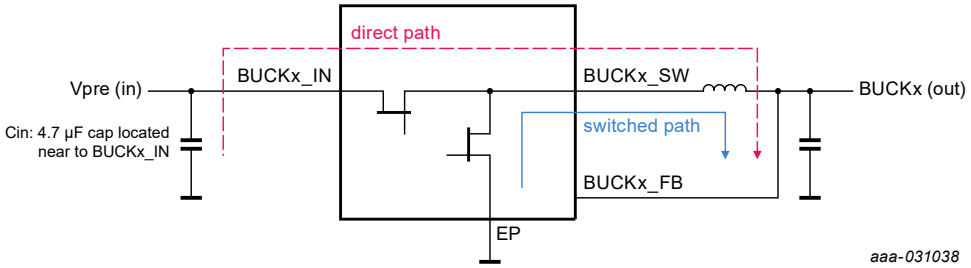


layout as a pair
do not cross any noisy signal

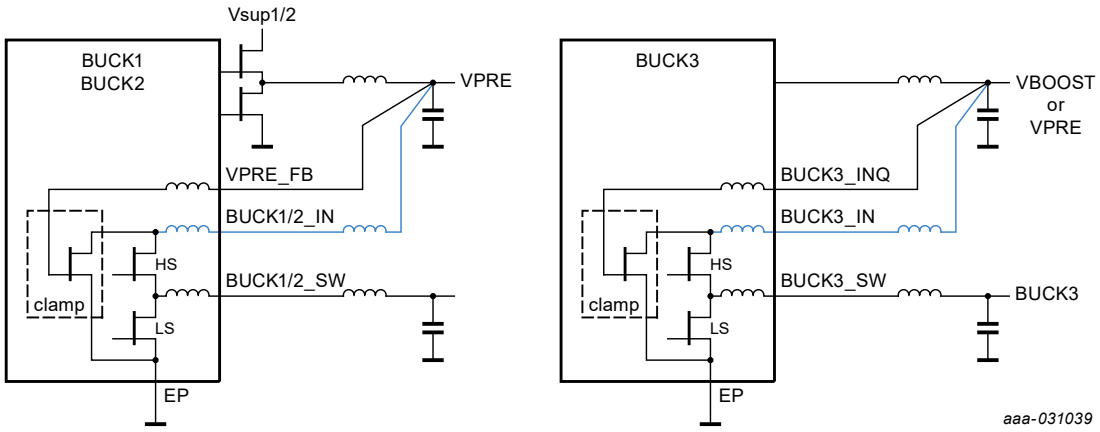
- The external transistor thermal shape should be in the range of 25 x 25 mm for optimum Rth.
- See LFPAK56 application note for more details: http://assets.nexperia.com/documents/application-note/AN10874.pdf

35.4 VBUCKx

- Inductor charging and discharging current loop shall be designed as small as possible.



- Input decoupling capacitors shall be placed close to BUCKx_IN pins.
- BUCK3_IN and BUCK3_INQ pins shall be tied to the same capacitor, VPRE or VBOOST output capacitor depending on BUCK3_IN supply selected (in the blue path below). On the PCB, the coil is parasitic from tracks. In the package, the coil is parasitic from the bonding.



36 EMC compliance

The FS85/FS84 EMC performance will be verified against BISS generic IC EMC test specification version 2.0 from 07.2012 and FMC1278 electromagnetic compatibility specification for electrical/electronic components and subsystems from 2016 with the following specific conditions:

- Conducted emission: IEC 61967-4
  - Global pins: VBAT (Vsup1 and Vsup2), WAKE1/2, FS0B, 150 Ohm method, 12-M level
  - Local pins: VPRE, BUCK1/2/3, LDO1/2, VBOOST, 150 Ohm method, 10-K level
- Conducted immunity: IEC 62132-4
  - Global pins: VBAT (Vsup1 and Vsup2), 36 dBm, Class A (no state change on FS0B, RSTB, PGOOD and all regulators in spec)
  - Global pins: WAKE1, WAKE2, FS0B, 30 dBm, Class A (no state change on FS0B, RSTB, PGOOD and all regulators in spec)
  - Local pins: RSTB, PGOOD, VDDIO, VDDI2C, VBOS, 12 dBm, Class A (no state change on FS0B, RSTB, PGOOD and all regulators in spec)
  - Supply pins: VPRE, BUCK1/2/3, LDO1/2, 12 dBm, Class A (no state change on FS0B, RSTB, PGOOD and all regulators in spec)
- Radiated emission: FMC1278 from July 2015
  - Compliance with FMC1278 RE310 Level 2 requirement in Normal mode
- Radiated immunity: FMC1278 from July 2015
  - Injection level per FMC1278 RI112 Level 2 requirement in Normal mode, FS0B released and no assertion
  - Injection level per FMC1278 RI112 Level 2 requirement in Normal mode, FS0B asserted and no release
  - No wake up when injecting FMC1278 RI112 Level 2 requirement in Standby mode

Table 139. Regulators setup for the EMC tests

VPRE	Output voltage	3.3 V
	Switching frequency	455 kHz
	Output current	3 A
BUCK1	Output voltage	1.25 V
	Switching frequency	2.22 MHz
	Output current	1.2 A
BUCK2	Output voltage	0.8 V
	Switching frequency	2.22 MHz
	Output current	1.2 A
BUCK3	Output voltage	2.3 V
	Switching frequency	2.22 MHz
	Output current	1.2 A
BOOST	Output voltage	5 V
	Switching frequency	2.22 MHz
	Output current	275 mA
LDO1	Output voltage	2.5 V
	Output current	75 mA

Table 139. Regulators setup for the EMC tests*...continued*

LDO2	Output voltage	1.1 V
	Output current	200 mA

37 References

[1] **FS8400** — Safety System Basis Chip for S32 Microcontrollers, fit for ASIL B
http://www.nxp.com/FS8400

[2] **FS8500** — Safety System Basis Chip for S32 Microcontroller, fit for ASIL D
http://www.nxp.com/FS8500

[3] **FS85_PDTCALC** — VPRE compensation network calculation and power dissipation tool (Excel file)
https://www.nxp.com/downloads/en/calculators/FS85-PDTCALC.xlsx

[4] **FS85_FMEDA** — FMEDA analysis [1]

[5] **FS85_VPRE_Simplis_Model** Simplis model for stability and transient simulations [1]

[6] **KITFS85FRDMEVM** — detailed information on this board, including documentation, downloads, and software and tools
http://www.nxp.com/KITFS85FRDMEVM

[7] **KITFS85SKTEVM** — detailed information on this board, including documentation, downloads, and software and tools
http://www.nxp.com/KITFS85SKTEVM

[8] **KITFS85AEEVM** — detailed information on this board, including documentation, downloads, and software and tools
http://www.nxp.com/KITFS85AEEVM

[9] **AN12333** — FS84, FS85 product guidelines application note
https://www.nxp.com/webapp/sps/download/mod_download.jsp?colCode=AN12333

[10] **FS85_FS84_OTP_Config.xlsm** — OTP configuration file
https://www.nxp.com/webapp/Download?colCode=FS85-FS84-OTP

[11] **FS85_FS84SMUGC** — Safety manual [1]

[1] Contact NXP sales representative.

38 Revision history

Table 140. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
FS84_FS85C v.10.0	20231117	Product data sheet	CIN 202309011I	FS84_FS85C v.9.0
Modifications	• Table 1: Revised all occurences of "optional" to "Yes". • Revised Figure 5 • Table 26, revised as follows: – Bit 12's Description changed from "Inhibit INTERRUPT for VSUP_UVH" to "Inhibit INTERRUPT for VPRE_UVH". – Bit 10's Description changed from "Inhibit INTERRUPT for VPRE_UVH" to "Inhibit INTERRUPT for VSUP_UVH". • Table 75, revised as follows: – OTP_CFG_CLOCK_4 Bit1 changed from "0" to "1" – OTP_CFG_CLOCK_4 Bit1 changed from "1" to "0" • Table 76: Revised Address 1F Description for VB2GMCOMP[2:0] and VB1GMCOMP[2:0] from "48.75 GM" to "48.75 GM, Default to use" • Revised Figure 40 • Revised Figure 42 • Table 130, revised as follows: – "External RESET (out of extended RSTB)" changed to "External RESET (falling edge)" – "OTP_PGOOD_RSTB" changed to "No" – FLT_ERR_CNT increment for "OTP_PGOOD_RSTB" changed from "+1" to "No"			
FS84_FS85C v.9.0	20220115	Product data sheet	CIN 202201016I	FS84_FS85C v.8.0
Modifications	• Section 4.1, revised Regulator assigned to VDDIO for column titled "MC33FS8415GJ" and "MC33FS8415GY' from "LOD2" to "VPRE". • Section 4.2, revised as follows: – VDDIOMON OVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "104.5 %" to "105 %". – VDDIOMON UVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "95.5 %" to "95 %". – VMON1 OVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "105 %" to "106 %". – VMON1 UVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "95 %" to "94 %". – VMON2 OVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "104.5 %" to "106 %". – VMON2 UVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "95.5 %" to "94 %". – VMON3 OVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "104.5 %" to "106 %". – VMON3 UVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415G" from "95.5 %" to "94 %". – VMON4 OVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "104.5 %" to "106 %". – VMON4 UVTH: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY' from "95.5 %" to "94 %". – PGOOD VMON4: revised values for column titled "MC33FS8415GJ" and "MC33FS8415GY" from "No' to "Yes". – ABIST1 VMON4: revised the value for column titled "MC33FS8415GJ" from "No" to "Yes".			
FS84_FS85C v.8.0	20211001	Product data sheet	CIN 202110002I	FS84_FS85C v.7.0
Modifications	• Table 6: updated table to include step-cut and wettable flank values • Table 78: updated description for OTP_CFG_UVOV_3 register • Section 35.4: replaced "BUCK3_FB" by "BUCK3_IN"			
FS84_FS85C v.7.0	20210427	Product data sheet	CIN 202104044I	FS84_FS85C v.6.0
Modifications	• Table 2: replaced "HPQFN56" by "HVQFN56", updated part numbers, and added note "The part numbers with KS suffix are recommended for new designs" • Table 3: updated pin type for PRE_SW (replaced A_OUT by A_IN) • Section 4.1: added OTP flavors for MC33FS8415GJ and MC33FS8415GY • Section 4.2: added OTP flavors for MC33FS8415GJ and MC33FS8415GY • Table 9: corrected typo (replaced "VMON1_REG[2]" by "VMON1_REG[2:0]" • Table 31: replaced "VMON2_REG[1:0]" by "VMON2_REG[2:0]" • Table 64: Bit 9 changed to Bit 10 and Bit 8 changed to Bit 9 • Table 83: updated description for V_{BUCK12} and updated output voltage accuracy (replaced 2 % by 1.5 %) • Table 84: updated output voltage accuracy (replaced 2 % by 1.5 %) • Section 23.5: updated Figure 28 • Section 24.3: added values for $V_{LDO12\_DO\_mode\_150}$ and $V_{LDO12\_DO\_mode\_400}$ and updated description for $V_{LDO12\_DROP\_150}$ and $V_{LDO12\_DROP\_400}$ • Section 28: replaced "The CRC polynomial used is x^8+x^4+x^3+x^2+1 (identified by 0x1D) with a SEED value of hexadecimal 0xFF" by "The CRC polynomial used is compatible with SAEJ 1850 CRC8 standard: x^8+x^4+x^3+x^2+1 (identified by 0x1D) with a SEED value of hexadecimal 0xFF" • Table 100: added values for SPI input capacitance • Section 34: replaced "HPQFN56" by "HVQFN56" and added drawings for dimple wettable flank			
FS84_FS85C v.6.0	20200811	Product data sheet	202007042I	FS84_FS85C v.5.0

Table 140. Revision history...*continued*

Document ID	Release date	Data sheet status	Change notice	Supersedes
Modifications	• Table 2: added new part numbers (MC33FS8500A0ES, MC33FS8510A0ES, MC33FS8520A0ES, MC33FS8400G0ES, MC33 FS8405G0ES, MC33FS8410G0ES, MC33FS8415G0ES, MC33FS8420G0ES, MC33FS8425G0ES, MC33FS8435G0ES) • Section 4.1: updated OTP configurations for MC33FS8530A4ES, MC33FS8430G2ES, MC33FS8410G3ES, and MC33FS8400 G5ES – VBOOST - slope compensation (MC33FS8530A4ES): replaced 160 mV/µs by 125 mV/µs – BUCK2 - output voltage (MC33FS8530A4ES): replaced 1.2 V by 1.8 V – LDO2 - output voltage (MC33FS8530A4ES): replaced 5.0 V by 1.2 V – LDO2 - power sequencing slot (MC33FS8530A4ES): replaced "Regulator does not Start (Enabled by SPI)" by "Regulator Start and Stop in slot 1" – VBOOST - slope compensation (MC33FS8430G2ES): replaced 140 mV/µs by 160 mV/µs – VPRE - switching frequency (MC33FS8410G3ES): replaced delay 0 by delay 3 – LDO1 - current limitation (MC33FS8400G5ES): replaced 150 mA by 400 mA • Section 4.2: updated OTP configurations for MC33FS8530A4ES – VCOREMON, VDDIOMON, VMON1, VMON2, VMON3, VMON4 - OV_DGLT: replaced 45 µs by 25 µs – VCOREMON, VDDIOMON, VMON1, VMON2, VMON3, VMON4 - UV_DGLT: replaced 40 µs by 5 µs – PGOOD - RSTB: replaced "Yes" by "No" – Watchdog: replaced Challenger WD by Simple WD • Table 5: added new row under PRE_SW for Transient voltage < 20 ns • Table 28: Updated description for VBOSUVH and VBOOSTUVH (deleted "falling") • Table 130: added footnote "By cascaded effect, the FSOB is asserted low because of INIT_FS state" • Section 32.8.2: updated first paragraph (added "The fault error counter is incremented by 1, each time the RSTB and/or FS0B pin is asserted")			
FS84_FS85C v.5.0	20200129	Product data sheet	201912015I	FS84_FS85C v.4.0
Modifications	• Section 4, Table 2, revised "MC33FS8030G5ES" to "MC33FS8400G5ES". • Section 22.5, Table 83, revised as follows: – Revised the parameter description for V_{BUCK12} to include "0.975 V". – Moved "2.5" from "Max" value to "Typ" value for I_{BUCK12}. – Revised I_{LIM_BUCK12} parameter description and added new row with new min, typ, and max values. Revised "$V_{BUCK12\_SOFT\_START}$" to "$T_{BUCK12\_SOFT\_START}$". • Section 23.4, Table 84, revised as follows: – Revised "I_{BUCK12}" to "I_{BUCK3}". – Revised the first parameter description for $T_{BUCK3\_SOFT\_START}$ from "$V_{BUCK12\_SOFT\_START}$ = V_{BUCK12} / $V_{BUCK12\_DVS\_UP}$ Soft start for VBUCK3 = 1.8 V and OTP_DVS_BUCK3[1:0] = 00" to "$V_{BUCK3\_SOFT\_START}$ = V_{BUCK3} / $V_{BUCK3\_DVS\_UP\_DOWN}$ Soft start for VBUCK3 = 1.1 V and OTP_DVS_BUCK3[1:0] = 00" – Revised the second parameter description for $T_{BUCK3\_SOFT\_START}$ from "Soft start for V_{BUCK3} = 1.8 V and OTP_DVS_ BUCK3[1:0] = 11 To be recalculated for different V_{BUCK3} and different $V_{BUCK3\_DVS\_UP\_DOWN}$" to "Soft start for V_{BUCK3} = 1.1 V and OTP_DVS_BUCK3[1:0] = 11 To be recalculated for different V_{BUCK3} and different $V_{BUCK3\_DVS\_UP\_DOWN}$"			
FS84_FS85C v.4.0	20191205	Product data sheet	201912015I	FS84_FS85 v.3.0
Modifications	• changed "V_{BOOST_SW}" to "F_{BOOST_SW}" throughout document • Section 4, – Table 2: removed part number PC33FS8510A3ES; added part number MC33FS8510D3ES; updated orderable part numbers — replaced "PC" with "MC" – Table 1: removed part number PC33FS8510A3ES; added part number MC33FS8510D3ES; updated orderable part numbers — replaced "PC" with "MC" • Section 4.1: removed VPRE low-side slew rate row; removed part number PC33FS8510A3ES; added part number MC33FS8510 D3ES; updated orderable part numbers — replaced "PC" with "MC" • Section 4.2: column heading changed from MC33FS8510A 3ES to MC33FS8510D 3ES • Section 5: updated radar and vision applications • Section 7.2, Table 3: updated EP description • Section 9, Table 5 – "All other pins", Min changed from –1.0 to –0.3 – Added BUCKx_SW | Transient voltage<20ns | BUCK1_SW, BUCK2_SW, BUCK3_SW | -3.0 | 6.5 | V | • Section 10: updated ESD Charged device model • Section 11: updated content starting with paragraph "When VPRE is switching..." • Section 12, Table 6 – changed T_A parameter from "Ambient temperature" to "Ambient temperature (Grade 1)" – changed T_J parameter from "Junction temperature" to "Junction temperature (Grade 1)" • Section 14.1: updated Figure 5 • Section 14.2, final paragraph: replaced "WAKE1 or WAKE2 > $WAKE12_{VIH}$" with "WAKE1 > $WAKE12_{VIH}$" • Section 14.3, updated first and second paragraph			

Table 140. Revision history...*continued*

Document ID	Release date	Data sheet status	Change notice	Supersedes
	• Section 14.4: updated first and second paragraphs • Section 14.5 – added paragraph "Refer to AN12333 for more details on Debug mode entry implementation." – Table 8: updated T_{DBG} • Section 15: updated FS_WD_ANSWER register • Section 16.1 – M_MODE register, changed field name "GOTOSTBY" to "GoToSTBY" – M_MEMORYx registers, changed field names "M_MEMORYx" to "MEMORYx" • Section 16.2 – M_MEMORYx registers, changed field names "M_MEMORYx" to "MEMORYx" – updated M_DEVICEID register • Section 16.4: changed field name "GOTOSTBY" to "GoToSTBY"; changed GoToSTBY reset condition from "n.a." to "POR"			
	• Section 16.6: changed VPRESRLS[1:0] bit reset values from "OTP" to "1" • Section 16.7: updated RATIO field value = 0 description and value =1 description • Section 16.11: changed VBOSUVH field reset value from "0" to "1"; changed VBOOSTUVH field reset value from "1" to "0" • Section 16.15: changed field names "M_MEMORY0" to "MEMORY0" • Section 16.16: changed field names "M_MEMORY1" to "MEMORY1"; changed bits 23 to 16 field name from MEMORY1[15:0] to MEMORY1[15:8]; changed bits 15 to 8 field name from MEMORY1[15:0] to MEMORY1[7:0] • Section 16.17: updated fields and descriptions • Section 17.15: changed PGOOD_EVENT reset value from "0" to "1"; changed RSTB_EVENT reset value from "0" to "1" • Section 18.1, Table 75: changed OTP_CFG_BOOST_1 bit 5 to "VPRE_MODE"; changed OTP_CFG_SEQ_3 bit[7:6] to DVS_BUCK12[1:0], bit[5:4] to DVS_BUCK3[1:0], bit[3] to Tslot • Section 18.2, Table 76: added descriptions for OTP_CFG_BOOST_1; updated OTP_CFG_SEQ_3 register; updated OTP_CFG_SM_2 register PSYNC_CFG field description • Section 18.4: OTP_CFG_UVOV_3 register: changed "(12.5mV)" to "(-12.5 mV)"; changed "(25mV)" to "(-25 mV)"; changed "(50mV)" to "(-50 mV)"; changed "(100mV)" to "(-100 mV)" • Section 19.2: updated C_{OUT_BOS} • Section 20.1: updated first and second paragraph • Section 20.3: updated content with changes to the calculation guideline • Section 20.4 – updated $V_{PRE\_SOFT\_START}$, F_{PRE_SW}, L_{VPRE}, $V_{PRE\_LOAD\_REG\_455k}$, $V_{PRE\_LIM\_TH1}$, I_{LIM_PRE}, $I_{PRE\_GATE\_DRV}$, C_{OUT_PRE}, C_{IN_PRE}, I_{PRE_DRV}, $gmEA_{PRE}$, T_{PRE_DT} – added $V_{PRE\_LINE\_REG\_455k}$, $V_{PRE\_LINE\_REG\_2.2M}$, $V_{PRE\_LOAD\_REG\_2.2M}$, $V_{PRE\_RIPPLE\_455k}$, $V_{PRE\_RIPPLE\_2.2M}$ • Section 20.5: updated content • Section 20.6; updated Figure 16 • Section 21.4: updated C_{OUT_BOOST}, I_{LIM_BOOST}, $T_{BOOST\_ON\_MIN}$, $gmEA_{BOOST}$, R_{COMP} • Section 22.1: updated final paragraph • Section 22.5: updated V_{BUCK12}, I_{BUCK12}, C_{OUT_BUCK12}, C_{IN_BUCK12}, V_{BUCK12_TLR}, V_{BUCK12_TLR}, V_{BUCK12_TLR}, I_{LIM_BUCK12}, $V_{BUCK12\_DVS\_UP}$ (for V_{BUCK12} up to 1.5V), $V_{BUCK12\_DVS\_UP\_1p8}$ (for V_{BUCK12} = 1.8V), $V_{BUCK12\_DVS\_DOWN}$(for V_{BUCK12} up to 1.5V), $V_{BUCK12\_DVS\_DOWN\_1p8}$ (for V_{BUCK12} = 1.8V), $V_{BUCK12\_SOFT\_START}$, T_{BUCK12_DT} • Section 22.6: updated Figure 24 • Section 23.1: updated paragraph starting "BUCK3 is part number dependent..." • Section 23.4: updated C_{OUT_BUCK3}, C_{IN_BUCK3}; added $V_{BUCK3\_DVS\_UP\_DOWN}$, $T_{BUCK3\_SOFT\_START}$, T_{BUCK3_DT} • Section 23.5: updated Figure 28 • Section 25.1, third paragraph: changed "VPRE switching frequency is coming from CLK2 (455 kHz)" to "VPRE switching frequency is coming from CLK2 (455 kHz) or CLK1 (2.22 MHz)" • Section 25.4, second paragraph: changed "It is recommended to select 23 kHz carrier frequency when VPRE is configured at 455 kHz." to "It is recommended to select 23 kHz carrier frequency when VPRE is configured at 455 kHz and 94 kHz when VPRE is configured at 2.2 MHz for the best performance." • Section 25.5: first paragraph: removed "If FIN is out of range, CLK clock moves back to internal oscillator and report the error using the CLK_FIN_DIV_OK bit."; added paragraph starting "If FIN is out of range," • Section 25.6: updated FIN_{RANGE} • Section 26.3: updated 00100 row: changed "T(°C) = (V_{AMUX} – V_{TEMP25}) / V_{TEMP_COEFF} + 25" to T(°C) = [(V_{AMUX} – V_{TEMP25}) / V_{TEMP_COEFF}] + 25 • Section 27.1: paragraph starting "WAKE1 and WAKE2 are level based": changed "WAKE1 can be for example connected to VBAT " to "WAKE1 can be for example connected to a switched VBAT (KL15 line) ", changed "When a WAKE pin is used as a global pin, a CRC protection" to "When a WAKE pin is used as a global pin, a C - R - C protection" ; Table 91: undated I_{WAKE12} • Section 27.2 Table 93: removed VPRE_UVL and BOOST_OC • Section 27.4: updated paragraphs and figure titles to reference external PMIC instead of PF82; changed "VSNS pin of PF82" to "VSNVS pin of PF82" • Section 28: first paragraph: changed "An 8 bit CRC is required for each Write and Read SPI command." to "An 8 bit CRC is required for each Write and Read SPI and I2C command. "; updated second and third paragraphs for clarity; updated Figure 40; changed Table 96 title from "Data preparation for CRC encoding" to "Data preparation for CRC encoding (SPI format)" • Section 29.1, updated paragraph starting with "the MCU is the master driving …"			

Table 140. Revision history...*continued*

Document ID	Release date	Data sheet status	Change notice	Supersedes
	• Section 29.2: changed topic title from "SPI CRC calculation" to "SPI CRC calculation and results"; added title to Table 98; added Table 99 • Section 29.3 Table 100: removed t_{CBS_MIN} • Updated Section 30.3 • Replaced section titled "29.3 Cyclic redundant check" with Section 30.3 "I2C CRC calculation and results" • Section 31: updated Figure 42 • Section 32.3: added paragraph starting with "After INIT_FS closure, …." • Section 32.8.2: updated final paragraph starting with "If OTP_GOOD_RSTB = '1', …." • Section 32.10.2: updated second paragraph starting with "ABIST2 is executed after INIT_FS…." • Updated Section 35.3 • Updated Section 35.4 • Section 37: updated reference [11]: changed "FS84_FS84SMUG" to "FS84_FS84SMUGC", removed reference [12] ES_FS84_FS85—Errata sheet • Section 32.5.3: updated $F_{CCU12RATIO}$		
FS84_FS85 v.3.0	20190409	Product data sheet	-	FS84_FS85 v.2.0
Modifications	• Section 10.2: updated description • Section 15: renamed column R/W to R/W SPI and added a column R/W I2C			
FS84_FS85 v.2.0	20190315	Product data sheet	-	FS84_FS85 v.1.0
Modifications	• Section 4: added part numbers and corresponding OTP flavors • Section 11: updated Figure 4, assumptions and description • Global: corrected minor typos • Table 67: replaced FCCU1_RT by FCCU2_RT for bit 9 and FCCU2_RT by FCCU1_RT for bit 8 • Section 34 and Section 35: updated case outline • Table 5: added parameters for BUCKx_IN • Table 76: replaced CLK_DIV1 by 2.22 MHz • Table 76: updated the value and description for OTP_CFG_CLOCK_4 register bit 3 (replaced 0 by 1 and 2.22 MHz by 455 kHz) • Section 20.1: replaced "$V_{SUP} = V_{PRE} / (T_{PRE\_ON\_MIN} \times F_{PRE\_SW})$" by "$V_{SUP} = L_{PI\_DCR} \times I_{PRE} + V_{PRE\_UVL} / D_{MAX}$ with $D_{MAX} = 1 - (F_{PRE\_SW} \times T_{PRE\_OFF\_MIN})$" • Figure 16: deleted 2.22 MHz curves		
FS84_FS85 v.1.0	20190122	Preliminary data sheet	-	-

Legal information

Data sheet status

Document status[1][2]	Product status[3]	Definition
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Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.
[2] The term 'short data sheet' is explained in section "Definitions".
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