AN14422

FS86 NXP PMIC solution for S32K3 processor

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Document information

Information	Content
Keywords	Power solution, S32K3, FS86
Abstract	This application note presents how to use an NXP power management integrated circuit (PMIC) FS86 to power the S32K3 processor system.

1 Scope of the document

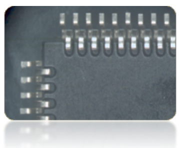
This application note shows the power solution using an NXP power management integrated circuit (PMIC) FS86 to power NXP S32K3 devices. Users learn how to use FS86 to accomplish the power solution design including power rails configuration and functional safety features. This application note also provides a general description of the functional safety interconnection between FS86 and S32K3.

2 S32K3 and FS86 PMIC overview

2.1 S32K3 overview

The S32K3 is targeted at automotive applications. Given the high number of power rails required, S32K3 systems present a power challenge. NXP's flexible PMIC FS86 offers a power solution that meets S32K3 power and safety requirements in a way that simplifies design and development.

Table 1. S32K3

	S32K3
Performance	1-5 M7 @ 120-320 MHz Single-core, multicore, or lockstep-core
Memory	512KB-12MB P-Flash 128 KB-2.25 MB* RAM
Security and OTA	HSE-B: Sym and asym ciphers; 100+ keys, side-channel protection Seamless OTA (RWW, memory remapping for A/B swap, FW rollback option) Compliant with ISO 21434
Safety	ASIL B/D
Key peripherals	Up to 2x1Gbps Ethernet (TSN, AVB), up to 12 CAN FD eMIOS, BCTU, LCU for motor control Advanced peripherals I3C, enhanced FlexIO
Packaging	BGA  HDQFP  LQFP 

The S32K3xx product series, Table 1, further extends the highly-scalable portfolio of Arm ® Cortex ® - M0+/ M4F S32K1xx chips in the automotive industry with the Arm Cortex-M7 core at higher frequency, more memory, ASIL B/ASIL D rating, and advanced security module. With a focus on automotive environment robustness, the S32K3xx product series devices are well suited to a wide range of applications in electrical harsh environments, and are optimized for cost-sensitive applications offering new, space saving package options. The S32K3xx series offers a broad range of memory, peripherals, and performance options. Devices in this series share common peripherals and pin-out, allowing developers to migrate easily within a chip series or among other chip series to take advantage of more memory or feature integration.

S32K3 boards include a high-voltage PMIC. PMICs that can be directly connected to Vbat are high-voltage PMICs or system basis chips (SBCs).

NXP provides a complete portfolio of safety PMICs with embedded system features. The NXP FS26 is the PMIC that supports the S32K3 series, but the FS86 can also be selected as an option of the high-voltage PMIC.

2.2 FS86 PMIC overview

The FS86 device family, which is software compatible with the FS84/85 family, expands the power capability, the safety integration and the system scalability of domain controller applications to address the multiple MCU requirements present in ADAS, radar, and electrification applications.

The FS86 includes multiple switch mode and linear voltage regulators, and enhanced safety features with fail-safe outputs. The latest NXP HV buck architecture features a 15 A capability with e-fuse protection to shut down the system power, to prevent any damage during a harmful event. The ability to monitor ten voltages with ±1 % accuracy extends the system safety concept by allowing QM rails from other components to be monitored.

The FS86 is part of a complete family of devices that offer scalability in power and safety, and provide pin-to-pin and software compatibility. It is developed in compliance with the ISO 26262 standard and is qualified according to AEC-Q100 requirements.

2.2.1 Operating range

- 60 V DC maximum input voltage for 24 V battery network applications
- 36 V DC maximum input voltage for 12 V battery network applications
- Support operating voltage range down to 4.5 V battery voltage with VPRE = 3.3 V
- Low-power off mode with low-sleep current (10 µA typ.)

2.2.2 Power supplies

- VPRE: Synchronous high voltage buck controller with external FETs
  - Configurable output voltage from 3.3 V to 5.0 V and current capability up to 15 A DC
  - Selectable switching frequency in force PWM with APS
- BOOST: Low-voltage boost converter with integrated low-side FET
  - Configurable output voltage from 5 V to 6 V and current capability up to 1 A DC
- BUCK: Low-voltage integrated synchronous BUCK converter
  - Configurable output voltage from 1.0 V to 3.3 V and current capability up to 2.5 A DC
- LDO1: Low-voltage LDO regulator for MCU I/O and system peripheral support with load-switch capability
  - Configurable output voltage from 1.5 V to 5.0 V and current capability up to 400 mA DC
- LDO2: Medium-voltage LDO regulator for MCU I/O and system peripheral support
  - Configurable output voltage from 1.1 V to 5.0 V and current capability up to 400 mA DC

2.2.3 Functional safety

- Scalable portfolio to fit for ASIL B to ASIL D automotive safety systems
- Independent voltage monitoring circuitry
- Up to ten voltage monitoring inputs for FS86 and external PMIC voltage rails with 1 % target accuracy
- Dedicated interface for MCU monitoring with simple or challenger watchdog monitoring
- MCU hardware failure monitoring with PWM monitoring capability (FCCU)
- External IC failure monitoring (ERRMON)
- Logical and analog built-in self-test (LBIST, ABIST)
- Safety outputs with latent fault detection mechanism (PGOOD, RSTB, FS0B)

2.2.4 FS86 internal block diagram

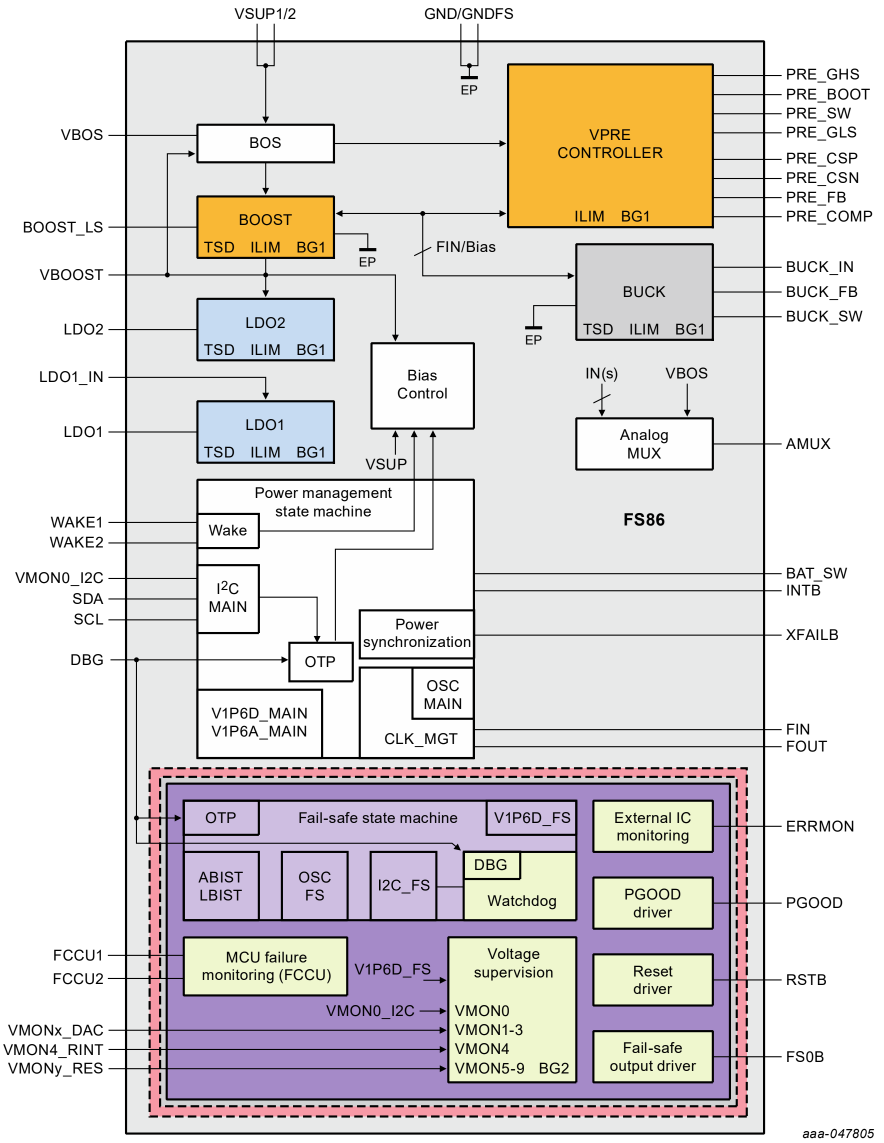


Figure 1. FS86 block diagram

3 S32K3 power solution introduction

To implement an alternative power solution for S32K3, the high-voltage PMIC FS86 solution can be suitable for S32K3 in automotive application.

Figure 2 shows the block diagram of FS86 power solution for S32K3. The FS86 integrates a battery-connected HV BUCK controller with external FETs and the current capability can achieve 15 A. This HV BUCK supplies power to FS86 regulators, which supply the S32K3.

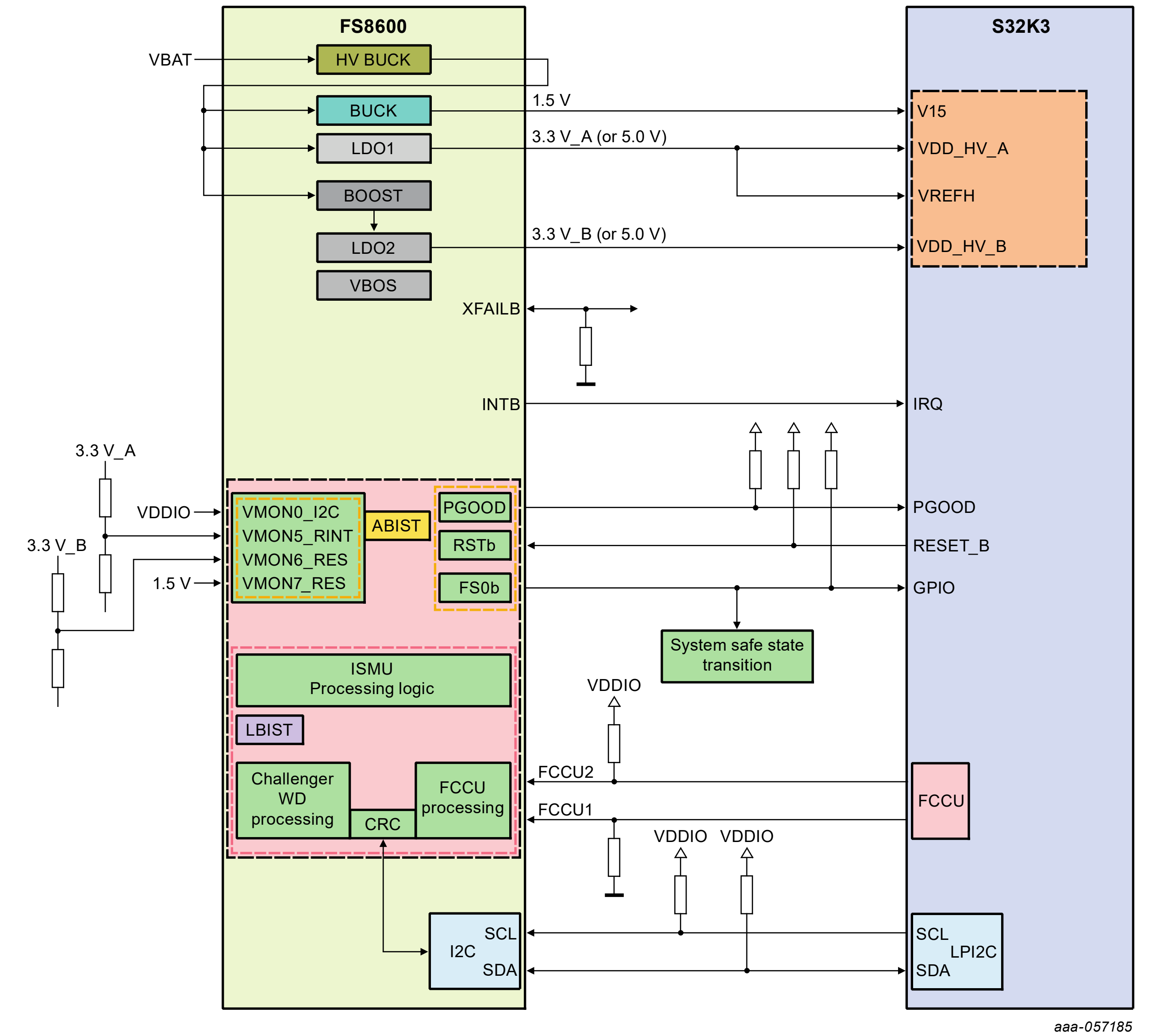


Figure 2. FS86 power solution for S32K3

3.1 FS86 regulators characteristics

Table 2 shows the FS86 regulators' output-voltage configurations and output-current capability. Refer to the product data sheet for more details.

Table 2. FS86 regulators' characteristics

PMIC regulator	Voltage (V)	Max load (A)
VPRE	3.3 to 5	6 (at 2.22 MHz) or 15 (at 455 kHz)
BUCK	1 to 3.3	2.5
LDO1	1.5 to 5	0.4
LDO2	1.1 to 5	0.15 or 0.4 (OTP configurable)
BOOST	5 to 6	Refer to Table 150 from FS86 datasheet

4 Functional safety

Functional safety is normally required for automotive applications. The FS86 is an ASIL B/D-configurable SBC. The PMIC here is developed in compliance with the ISO 26262 standard, and is appropriate for this architecture.

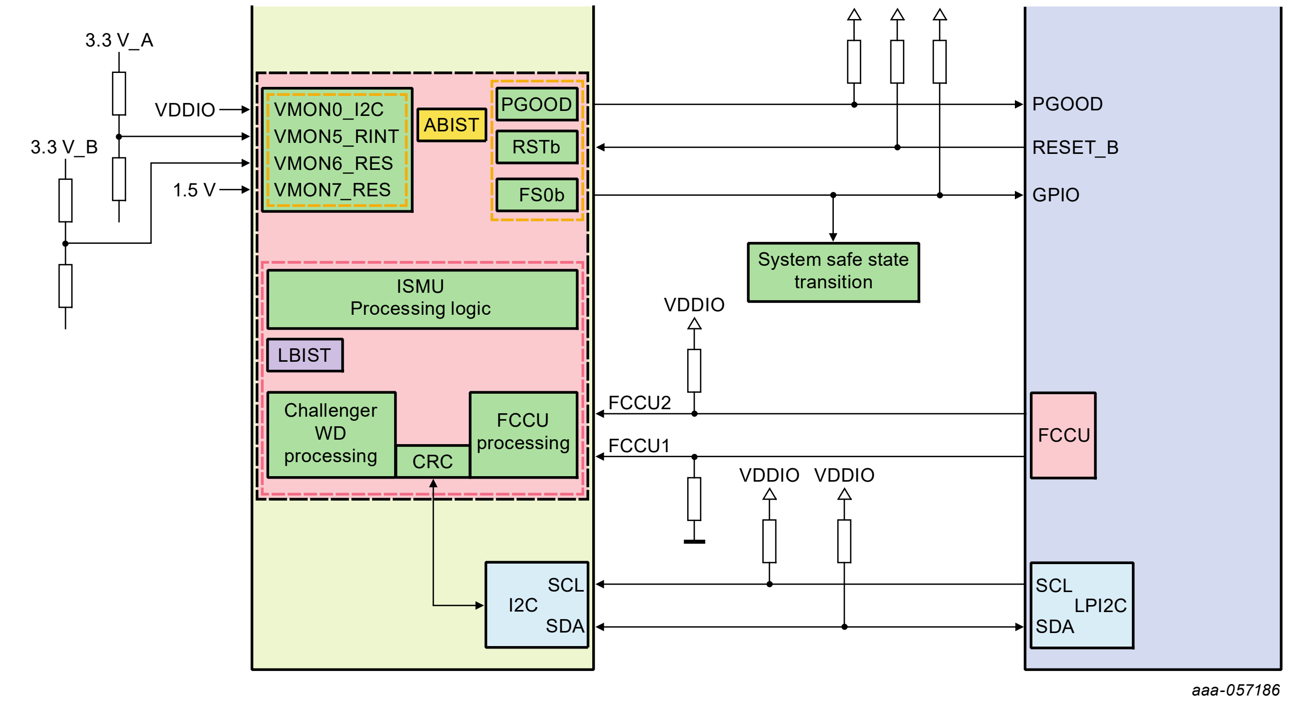


Figure 3. Functional signal connection between PMIC and S32K3

Figure 3 shows the recommended functional signal connections between PMIC and S32K3 processor. The FS86 family implement embedded safety mechanisms that include the functional safety features as follows:

- **Independent voltage monitoring and fault detection:** FS86 features independent fault monitoring per regulator. The PMIC fault monitor block monitors three types of faults (undervoltage (UV), overvoltage (OV), and overcurrent (OC)). The PMIC can indicate the output state per regulator through PGOOD.
- **I²C CRC and write protection:** I²C secure write protection protects the secure registers against faulty operation using a dedicated safety mechanism.
- **Analog built-in self-test (ABIST):** When power to the system is turned on, the PMIC automatically tests all output voltage monitors prior to the power up sequence. ABIST checks the state of the voltage monitoring block (OV/UV) per regulator, whether it's normal or not. If a failure on the OV/UV monitor is detected during ABIST, the PMIC asserts the corresponding ABIST flag.
- **Functional safety output:** When the PMIC detects a critical fault, such as an incorrect regulator output or watchdog (WD) failure, the fail-safe output 0 (FS0B) pin from the FS86 is used to transition the system into a Safe state.
- **Logic built-in self-test (LBIST):** LBIST verifies the correct functionality of the safety logic monitoring. FS86 performs LBIST after power on or upon wakeup from Standby mode.
- **External voltage monitor:** The FS86 can monitor up to ten voltages, including FS86 supply rails or external regulators. Depending on the safety requirements, voltage monitoring (VMON) can be used to monitor not only FS86 rails but also other external regulators, to reach the corresponding safety level for the system.
- **MCU failure monitoring:** The FS86 features two input pins (FCCU1/2) in charge of monitoring hardware failures of the safety MCU. Fault collection and control unit (FCCU) pins can be connected to the FCCU pins

of the MCU. When the FS86 detects a hardware failure from MCU through FCCU, the FS86 FS0B\RSTB pin can be asserted.

- **External IC monitoring:** The FS86 features the ERRMON input pin, in charge of monitoring an external safety IC on the application.
- **Watchdog monitoring:** The watchdog function is based on a question/answer strategy to monitor the safety MCU. It can be configured to simple or to challenger watchdog.

Note: *The only S32K3 versions that have PGOOD are S32K358, S32K348, S32K338, S32K328, and S32K388. If no PGOOD is used, FS86 PGOOD pin must be left open.*

5 Other solutions for S32K3

The next figures show some other power solutions for S32K3 with FS86 PMIC. Figure 4 shows a power solution with VDD_HV_A and VDD_HV_B supplied by the same regulator when both require the same voltage and together demand less current (just the current that can be supplied by a single LDO).

Figure 5 shows a power solution for the case in which just VDD_HV_A is used.

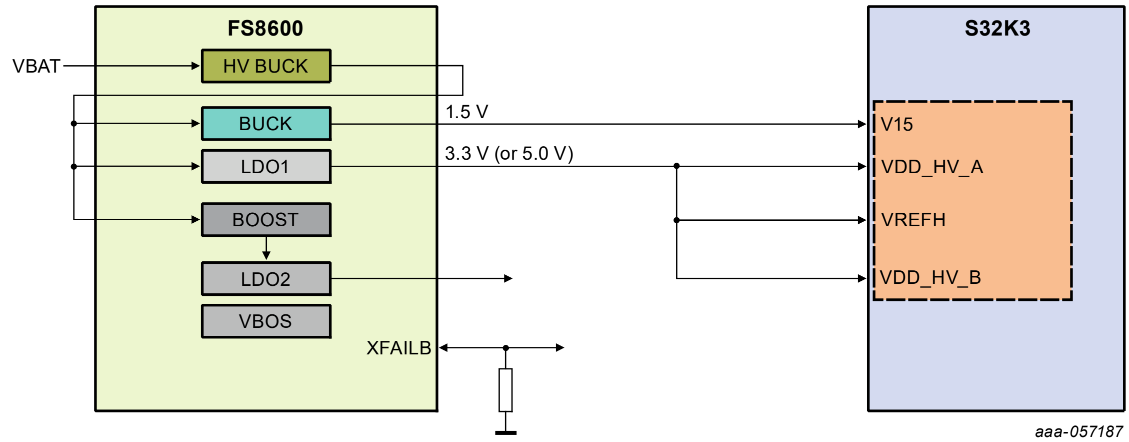


Figure 4. FS86 power solution for S32K3 with a single supply for VDD_HV_x

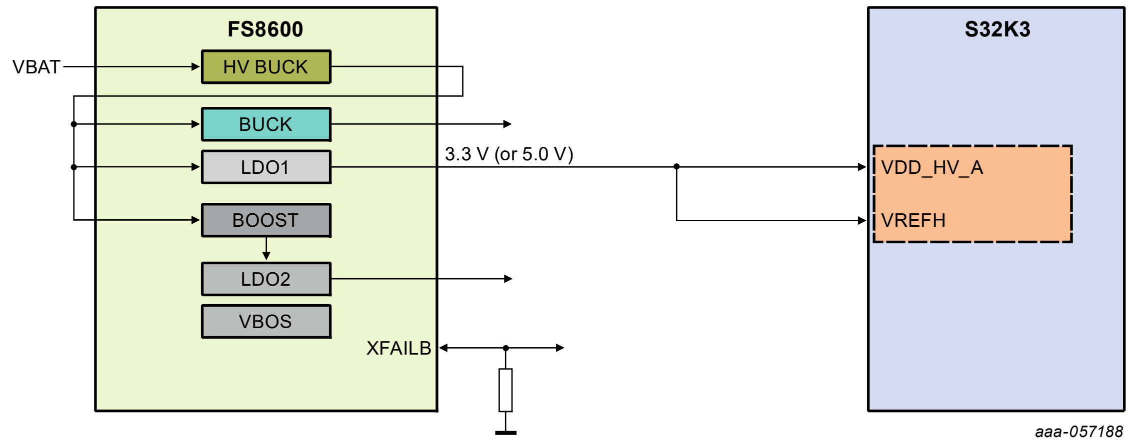


Figure 5. FS86 power solution for S32K3 with just VDD_HV_A

Figure 6 and Figure 7 show the same power solutions for S32K3, but for applications with an external transistor for V15.

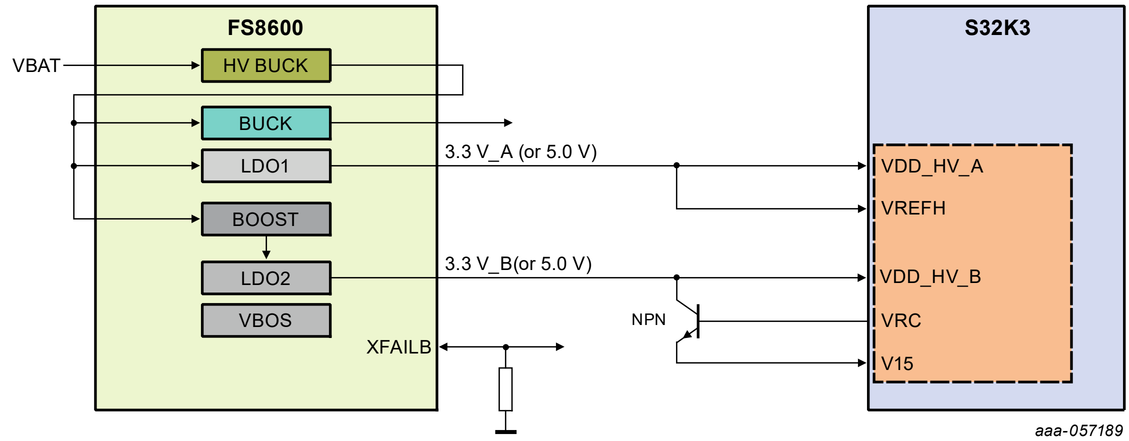


Figure 6. FS86 power solution for S32K3 with external transistor for V15

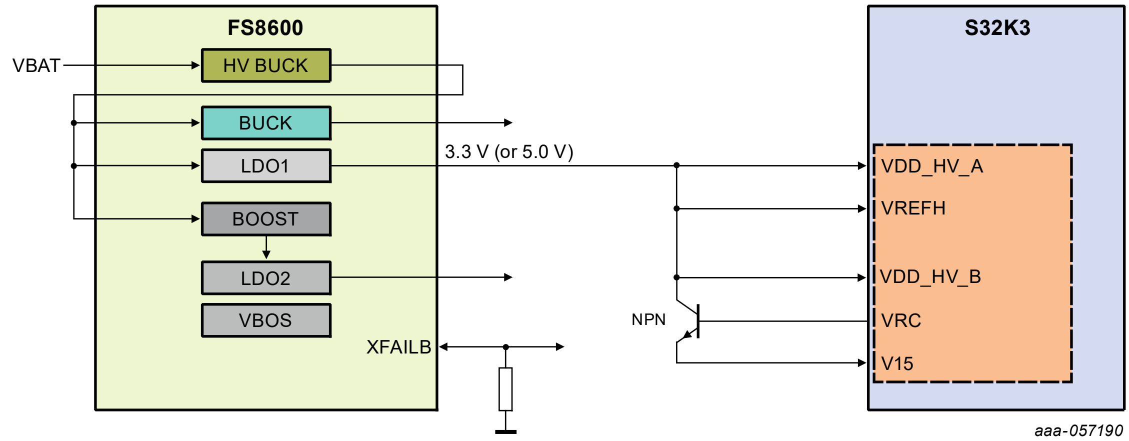


Figure 7. FS86 power solution for S32K3 with a single supply for VDD_HV_x and external transistor for V15

6 References

[1] FS86 product summary page: FS86 Safety System Basis Chip For Domain Controller, Fit For ASIL B and D | NXP Semiconductors

[2] S32K3 product summary page: S32K3 Microcontrollers for Automotive General Purpose | NXP Semiconductors

7 Revision history

Table 3. Revision history

Document ID	Release date	Description
AN14422 v.1.0	03 October 2024	Initial version

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