Application Note

Power Supply and Monitoring Solution for C2000 MCU Automotive Applications

Susmitha Bumadi

ABSTRACT

This application note provides insight into Power Design for C2000™ MCUs with Safety or non-Safety Requirements. The figures illustrate the power trees based on power source monitoring for Core, 3.3V rail and VREFHI. The application note walks through all the steps like the selection of LDO/Buck converter, voltage monitors, reference voltage sources for ADC and watchdog timer needed for Power and monitoring solution based on functional aspect.

Table of Contents

List of Figures

Trademarks

1 C2000 Power Supply and Monitoring Solution

Power supply and voltage monitoring requirements vary widely depending on the application. Figure 1-1 classifies these requirements into safety and non-safety applications. The blocks on the left are safety focused and the blocks on the right are non-safety and low cost focused.

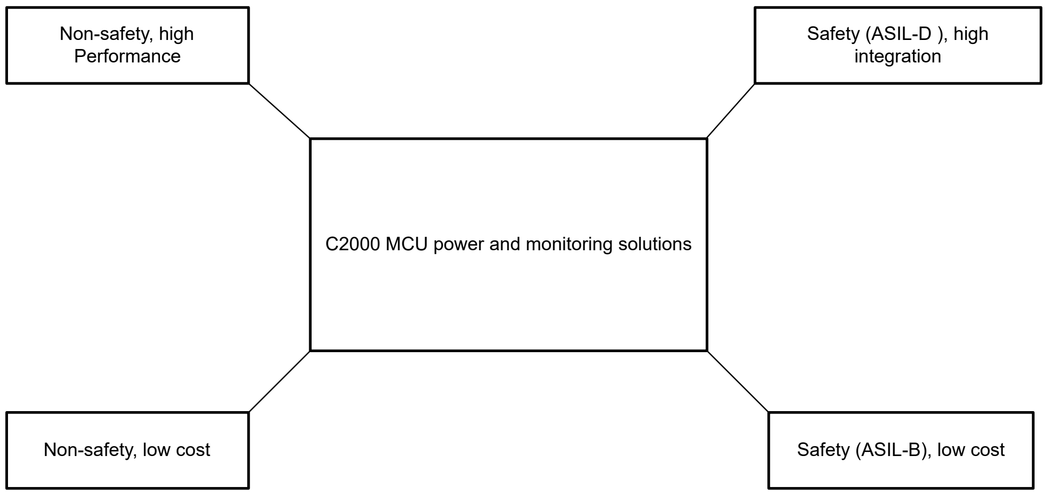

Figure 1-1. C2000 Power Supply and Monitoring Solution

2 Power Supply Solution for Safety Applications

The ISO 26262 standard was originally published in 2011 to help address the functional safety of electrical and electronic systems. This standard uses a risk classification scheme called Automotive Safety Integrity Levels (ASILs) that express the capability of a safety-related function. The four ASILs identified by the standard are ASIL A, ASIL B, ASIL C and ASIL D, with ASIL A dictating the lowest capability and ASIL D being the most stringent.

2.1 ASIL-D Requirements

ASLIL-D functional safety has several voltage monitoring and CPU health requirements that are beyond the scope of this application report. There are various methods to meet these requirements. One approach is to use a power management IC that not only delivers power to the MCU, but also integrates various voltage monitoring and watchdog features needed to meet ASIL-D requirements. The PMIC selected to meet the ASIL-D requirements should meet all the following criteria.

2.1.1 PMIC Solution

- The integrated PMIC should be qualified for automotive applications.
- It should have Built-In Self-Test on voltage monitors
- The diagnostic percentage is 90%
- It should monitor Under/overvoltage and current-limit on all output supply rails
- It should have Watchdog (window or Q&A) for diagnostic coverage of MCU CPU health
- Current Limit and Temperature protection for all Supply Rails
- Error Signal Monitor (ESM) for monitoring MCU hardware fault diagnostic output

You can either use internal/external VREF for MCU. Figure 2-1 and Figure 2-2 show the respective solution.

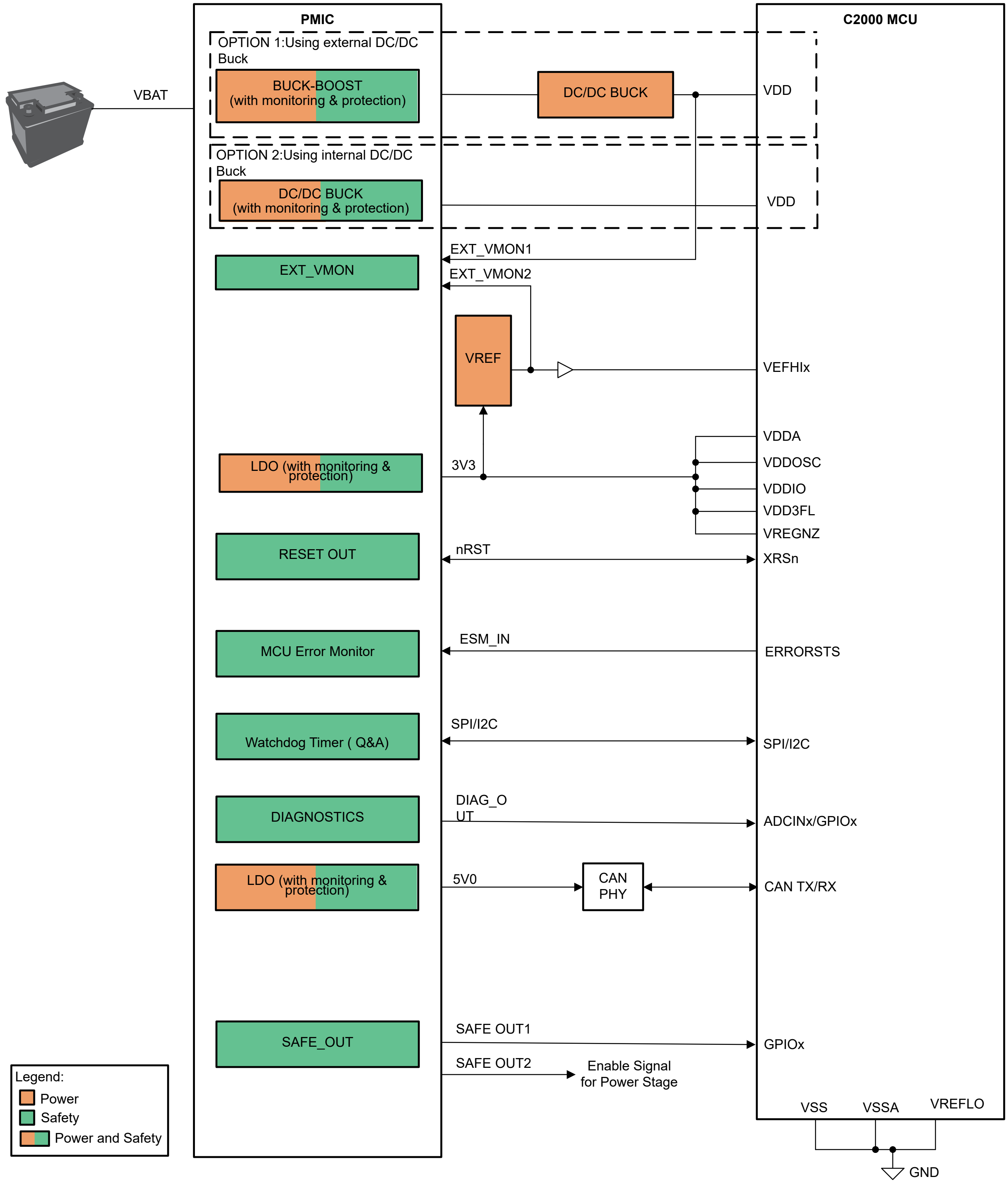

Figure 2-1. ASILD: MCU With External VREFHI and External VREG

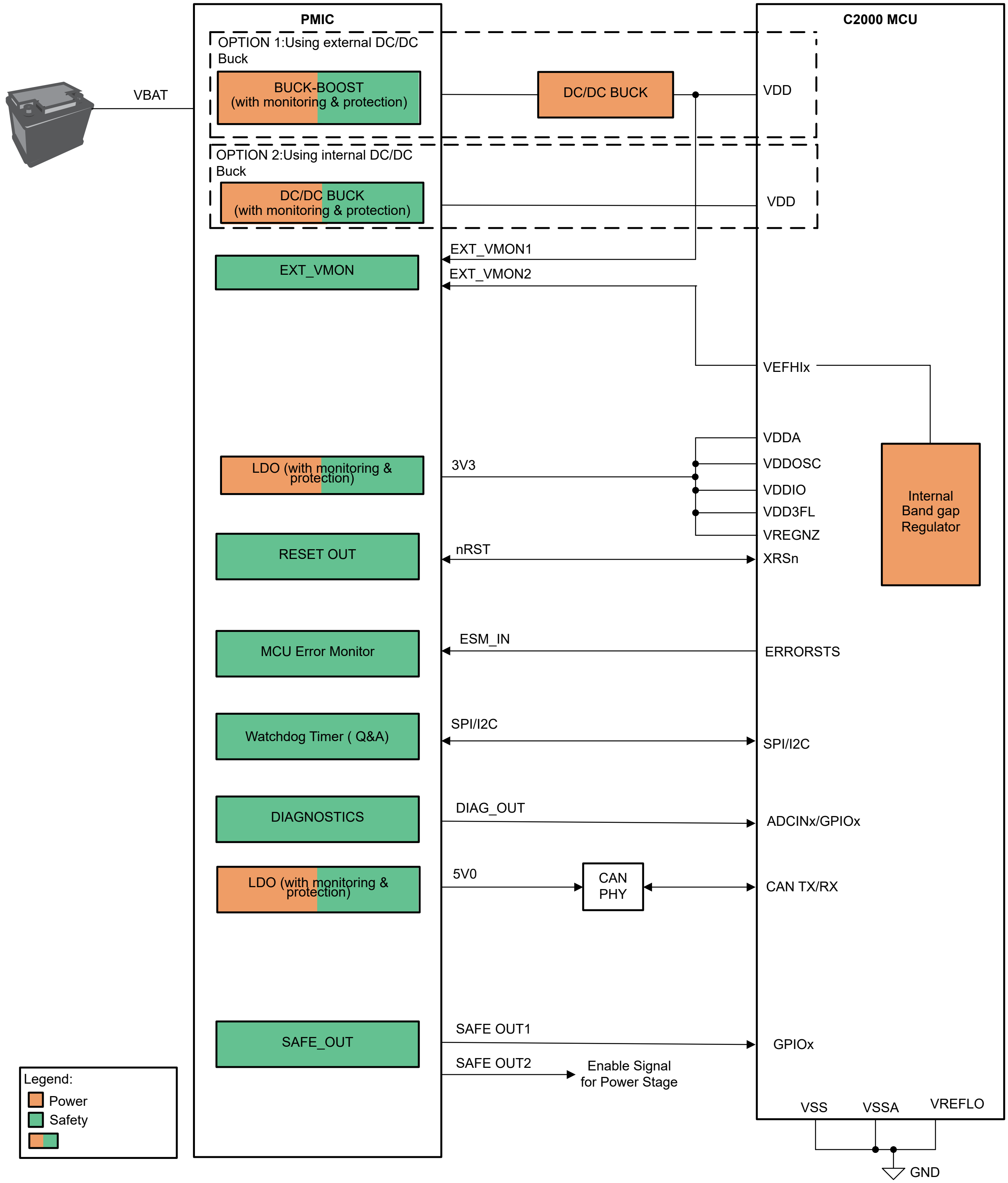

Figure 2-2. ASILD: MCU With Internal VREFHI and External VREG

2.2 ASIL-B: Requirements

With ASIL-B functional safety requirements, you can go either with PMIC or discrete solution.

2.2.1 PMIC Solution

The PMIC selected to meet the ASIL-B requirements should meet all the following criteria:

- The integrated PMIC should be qualified for automotive applications.
- It should have Built-In Self-Test on voltage monitors
- The diagnostic percentage is 60%
- It should monitor Under/overvoltage and current-limit on all output supply rails
- It should have Watchdog (window or Q&A)

2.2.2 Discrete Solution

With Discrete solution, make sure to have following criteria met to ensure ASIL-B requirement.

1. System power requirements

   This is one of the important steps when we want to design a power supply and monitoring solution for the MCU and the rest of the system. Calculate the maximum current consumption value of IDD and IDDIO for MCU from its data sheet and include all the current consumption of other components on each rail.
2. Selection of LDO /Buck converters
   a. When selecting an LDO as a power supply for VDD and VDDIO, make sure they are functional safety capable, auto qualified and have good accuracy (1% or better is recommended)
   b. When selecting a Buck converter as a power supply for VDD or VDDIO, make sure they are functional safety capable and auto qualified
   c. When selecting a Dual Buck converter as a power supply for VDD or VDDIO, make sure they are functional safety capable and auto qualified
   d. To choose the appropriate regulator for specific applications, parameters such as the input voltage, required output voltage, maximum load current, size, efficiency, frequency and power rating need to be considered to maximize regulator characteristics. If efficiency is not your priority, heat is not a concern, the current necessary is very small, or Vin is only slightly higher than Vout, an LDO can be used. But, if efficiency and performance are your utmost concern even if it is more complex and likely to be more expensive, then a buck converter is the ideal choice.

      As for electrical noise, LDOs can reach a lower noise floor than buck converters. This is because buck converters (and other switching power supplies) use inductors that have the tendency to produce significant noise.
3. Selection of monitors

   Select an IC that can monitor VDD and VDDIO Supply rails. Use either the single Multichannel Supervisor or separate supervisor for each of the power rails. Select ICs that are functional safety complaint and auto qualified. For the monitoring of VDD, see the device-specific data sheet.
4. Selection of external VREF for ADC

   Make sure IC selected is functional safety capable and auto qualified.

   VREF can be supplied externally or internally. Using the internal reference for the ADC provides better accuracy compared to an external reference using a supply rail. If external VREF is used, use the buffer to minimize the noise on the rail. Based on the functional safety goals of the application, voltage monitoring of ADC VREF may be required.
5. Selection of Watchdog

   You can use an external watchdog or supervisor with integrated window/Q&A watchdog.

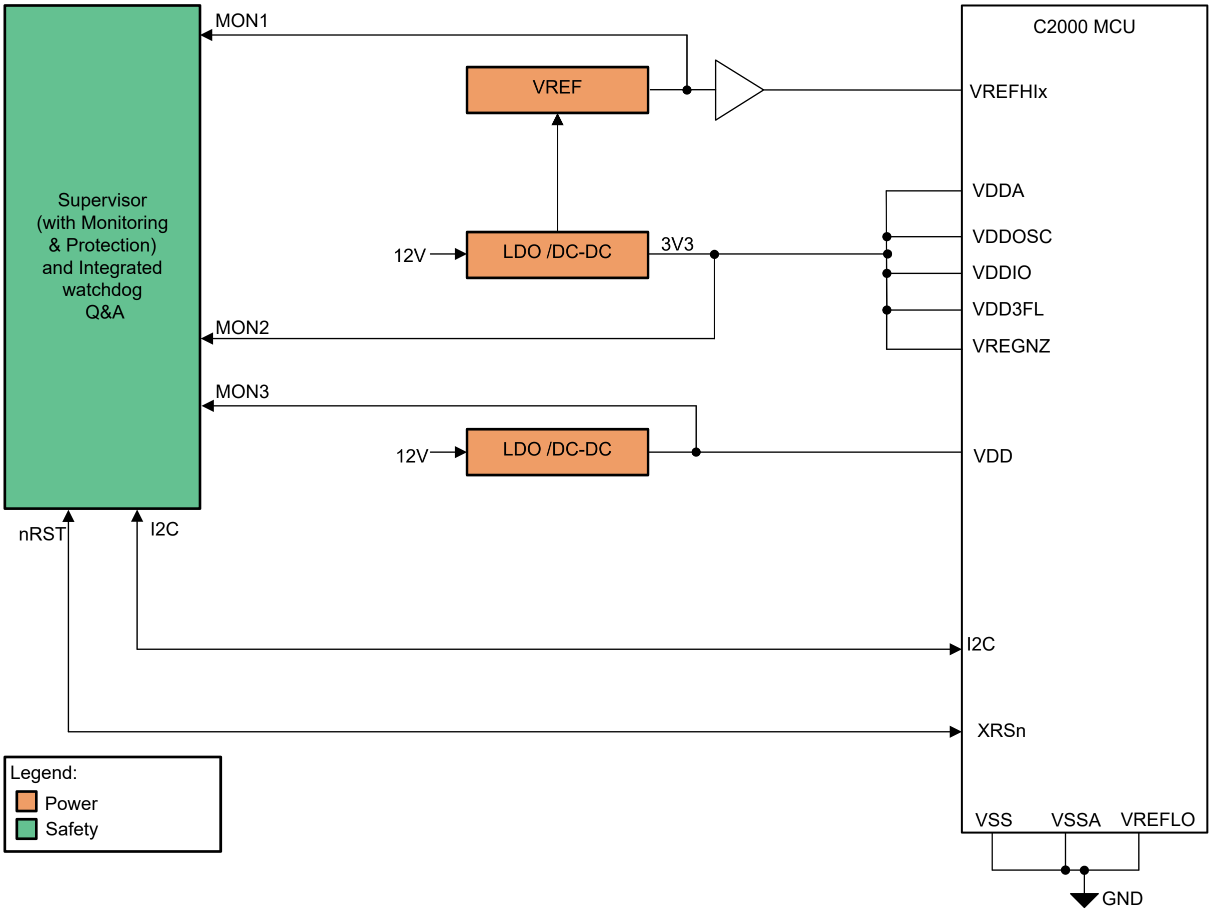

Figure 2-3. ASILB: MCU With External VREFHI and External VREG

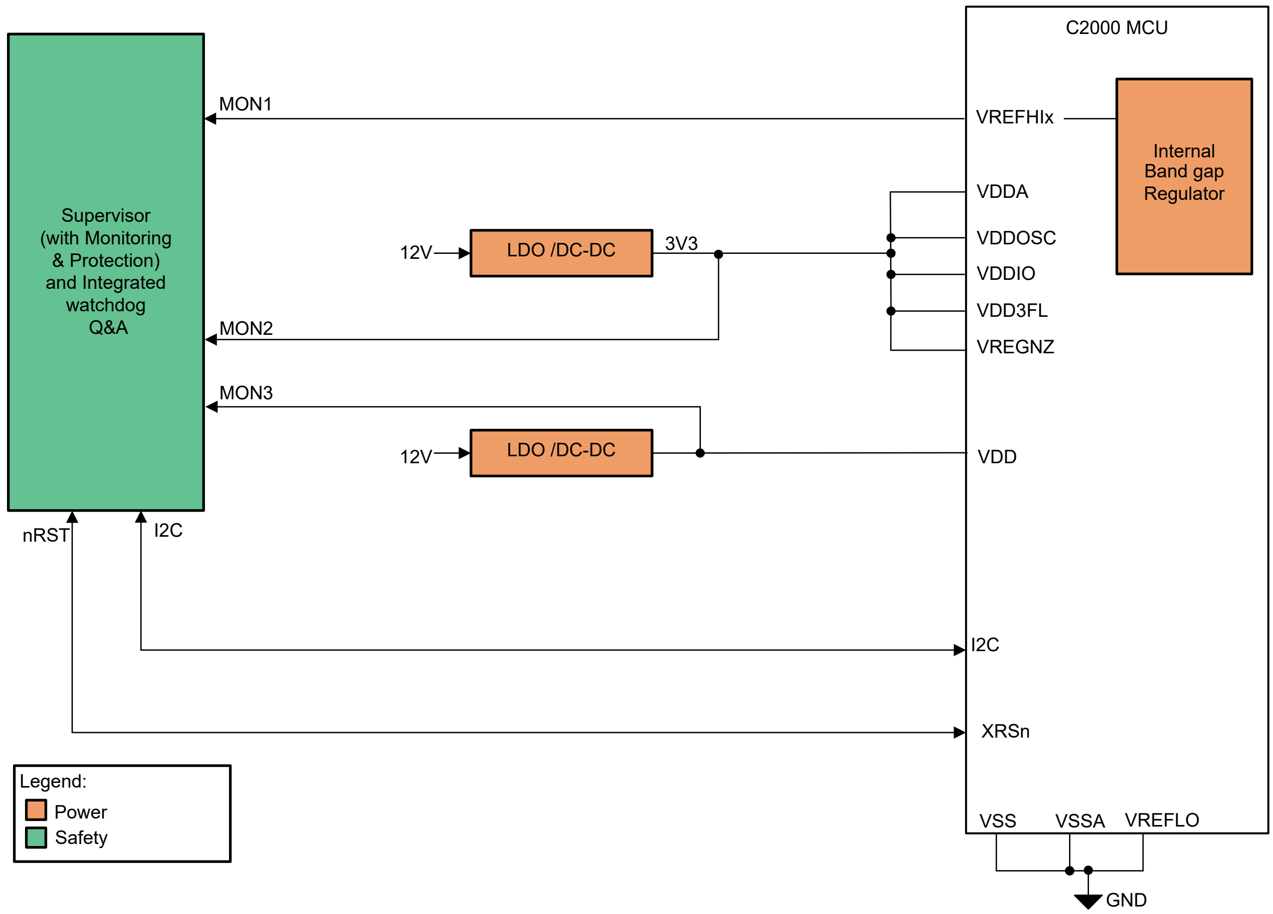

Figure 2-4. ASILB: MCU With Internal VREFHI and External VREG

3 Power Supply Solution for Non-Safety Applications

In this solution, regulators are needed that can provide VDD and VDDIO to MCU. It is not required to have supervisors to monitor the voltage rails.

1. System Power requirements

   This is one of the important steps when you want to design a power supply and monitoring solution for the MCU and the rest of the system. Calculate the maximum current consumption value of IDD and IDDIO for MCU from the device-specific data sheet and include all the current consumptions of other components on each rail.
2. Selection of LDO /Buck converters
   a. When selecting an LDO as a power supply for VDD and VDDIO, make sure they are auto qualified and accuracy (>1%)
   b. When selecting a Buck converter as a power supply for VDD and VDDIO, make sure they have regulated outputs as 1 and auto qualified
   c. When selecting a Dual Buck converter as a power supply for VDD and VDDIO, make sure they have regulated outputs as 2 and auto qualified

   For the Selection of LDO/Buck converter, see Step 2 in Section 2.2.2.
3. Selection of monitors (Optional)

   Select an IC that can monitor VDD and VDDIO Supply rails. Use either the single Multichannel Supervisor or separate supervisor for each of the power rails. Select ICs that are auto qualified. For the monitoring of VDD, see the device-specific data sheet.
4. Selection of external VREF for ADC (Optional)

   Make sure IC selected is auto qualified.
5. Selection of Watchdog (Optional)

   An external watchdog or supervisor is used with integrated window/Q&A watchdog.

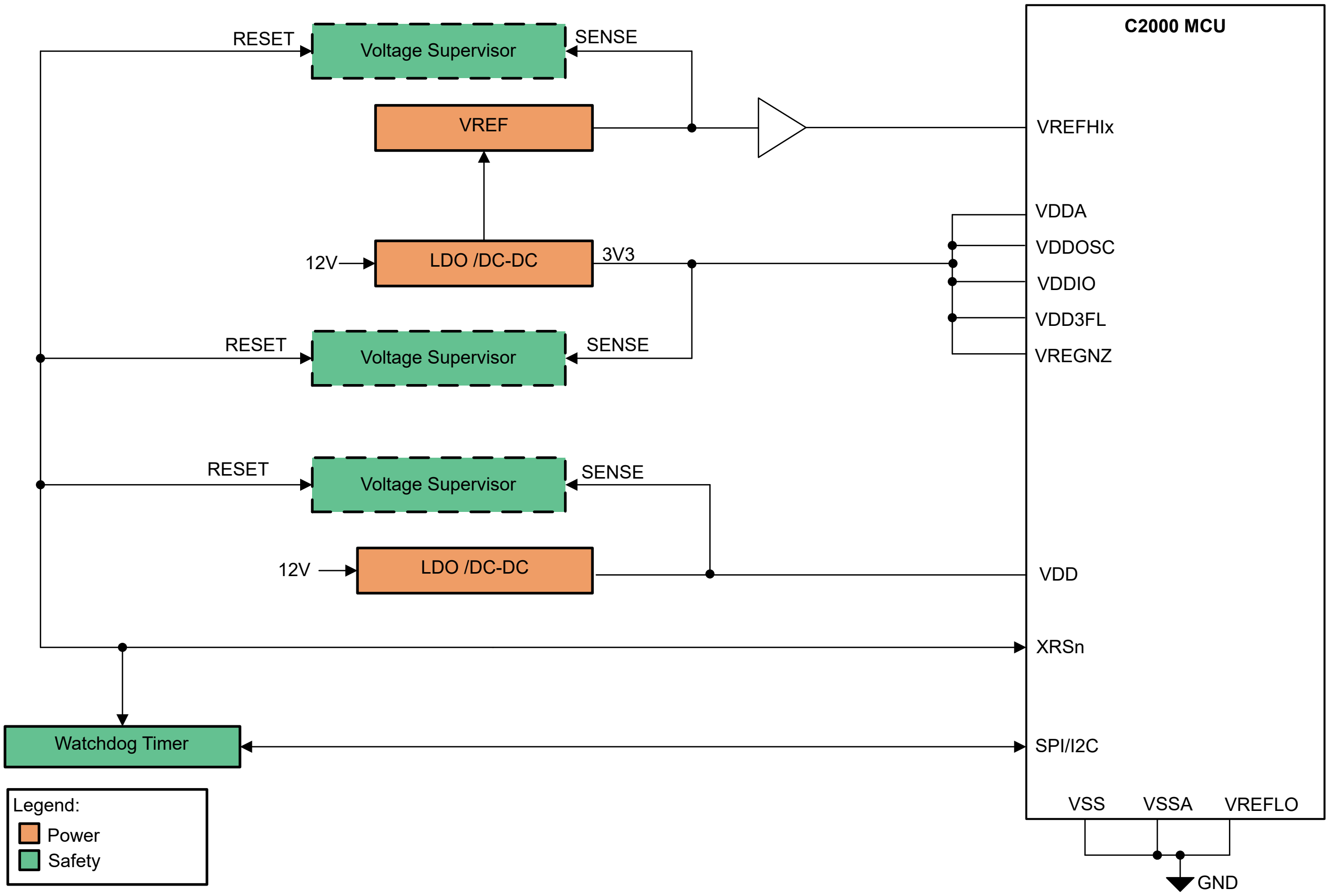

Figure 3-1. Non-Safety: MCU With External VREFHI and External VREG

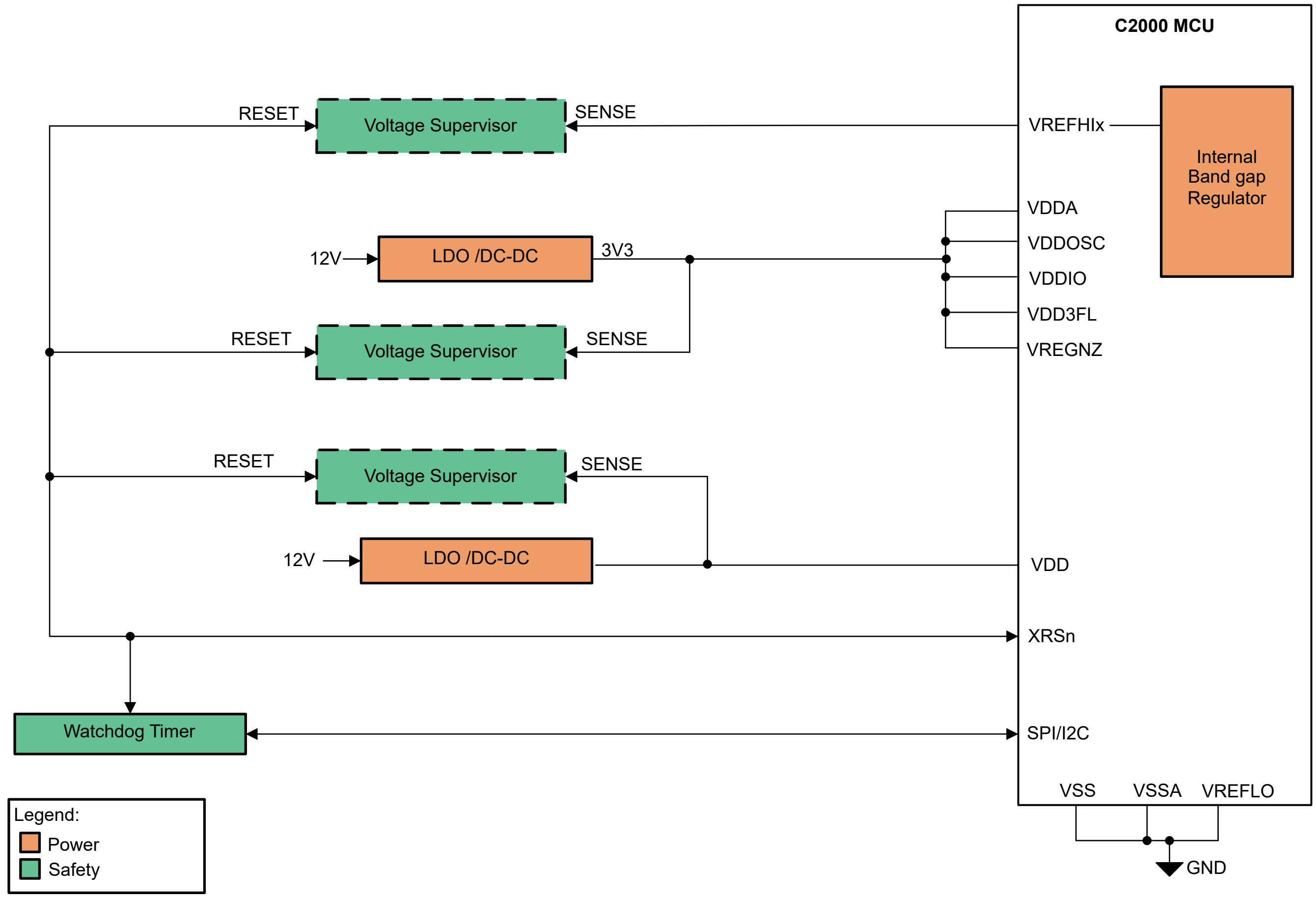

Figure 3-2. Non-Safety: MCU With Internal VREFHI and External VREG

4 Summary

This document details the use of buck Converters and voltage supervisor monitoring all the critical rails to provide a power and cost optimized power design. The publication also provides details of the required external components for the discrete ICs to meet ASIL-B requirements of the system.. This document can be used as a reference to propose power supply solution for safety and non-safety Applications.

5 References

- *Using voltage supervisors for rail monitoring in functional safety applications*
- *Designing a Power Supply for a Safety MCU to Meet Functional Safety ASIL*
- *How voltage references and supervisors help achieve ASIL functional safety goals*

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265