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Flash Core Voltage Supply

Requirements and Considerations

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Contents

1 Introduction

The voltage supply for Freescale's on-chip flash memory (NVM) is a particularly important supply and if it is not controlled correctly, the internal microcontroller circuitry can be damaged, leaving the flash memory unusable. Though this application note takes a look at the flash memory supply requirements and some other considerations, its recommendations can also apply generally to other power supply connections.

2 Supply Requirements

The specific flash core voltage (VFLASH) is required to power the flash memory and related circuitry.

Switching circuitry (MOS devices) are more susceptible to electrical overstress (EOS) events when voltages get elevated above max operating supply voltage than non-switching circuits; therefore, extra care should be taken to maintain voltage level requirements for switching circuit power supplies.

The requirements are detailed in the electrical specification for the particular microcontroller.

C90 (for example, MPC56xx) technology flash core voltage is typically 3.3 V. See Table 1 below for minimum and maximum rating and operating conditions.

Table 1. Flash specifications

	Maximum ratings		Operating conditions	
Flash technology	**Minimum**	**Maximum**	**Minimum**	**Maximum**
C90	–0.3 V	3.6 V	3.0 V	3.6 V

Additionally, a higher voltage is allowed for a limited time only:

- 5.3 V for 10 hours cumulative time, 3.3 V +10% for time remaining.

It is imperative that these specs are not violated. Bench evaluations found that EOS damage occurs when units are operating with VFLASH ~5.8 V. Damage can also occur as low as 5.25 V. See Appendix A, Characterization data, for some basic characterization data.

3 Considerations

Spikes or voltage overshoot can cause damage on the 3.3 V supply, mostly in the NVM pump clock circuitry (or some 3.3 V related pins). This can cause a dead NVM pump clock and, hence, no NVM operation will work.

It is imperative to ensure that out-of-spec overshoots do not happen.

3.1 Internal regulator

Some devices include a 3.3 V internal regulator, if supplied by a larger voltage like 5 V. This 3.3 V supply should always be used to power the flash memory and related circuitry, since the 3.3 V supply includes internal protection.

3.2 External protection

If there is no internal 3.3 V supply available, or for other reasons an external 3.3 V supply is used, it is highly recommended to implement some protection circuitry to ensure the specification is not violated.

Additionally, if an external supply is used, it is still recommended to use the internal 3.3 V supply for the flash memory.

4 Protection Solutions

This section details some potential solutions, depending on other requirements.

4.1 Use internal and external supply combination

Some devices like MPC5668x and MPC564xA have an internal voltage regulator that supplies 3.3 V in a 5 V input mode. This 3.3 V internal supply should be the input to the flash core voltage in the system design.

If an external 3.3 V is chosen in the system design, it is still recommended to connect the internal 3.3 V supply to the flash core voltage. Other supplies like clocks and analog can be connected to an external 3.3 V supply.

4.2 Use external supply with protection

Freescale offers Power System Basis Chip (SBC) devices that provide over-voltage detection and protection, as well as current limiting, and under-voltage protection. They additionally support CAN and LIN interfaces.

These can be used to supply the MCU with 5 V or 3.3 V depending on requirements.

The key features are:

- Buck converter—VCORE core supply
  - Configurable from 0.9 V to 5 V
- Linear regulator—VAUX
  - 1.8 V, 3.3 V, 5 V (+/– 3%), SPI configuration
- Linear regulator—VCCA
  - 5 V or 3.3 V pin selectable
- Linear regulator—VCAN
- Robust HSCAN and LIN interface
- Analog multiplexer including voltage reference
- Power management state machine and failsafe state machine
  - Independent supply
  - Independent oscillator
  - Independent reference
  - Failsafe outputs
  - Failsafe inputs
- Configurable I/Os with MCU monitoring

See Appendix B, PowerSBC device summary, for further information. The part numbers are:

- MC33909 (CANopy)
- MC33907/8 (PowerSBC10/20)
- MC33906 (PowerSBC5)

See Figure 1 for an example simplified application diagram connecting MC33909 to an MCU.

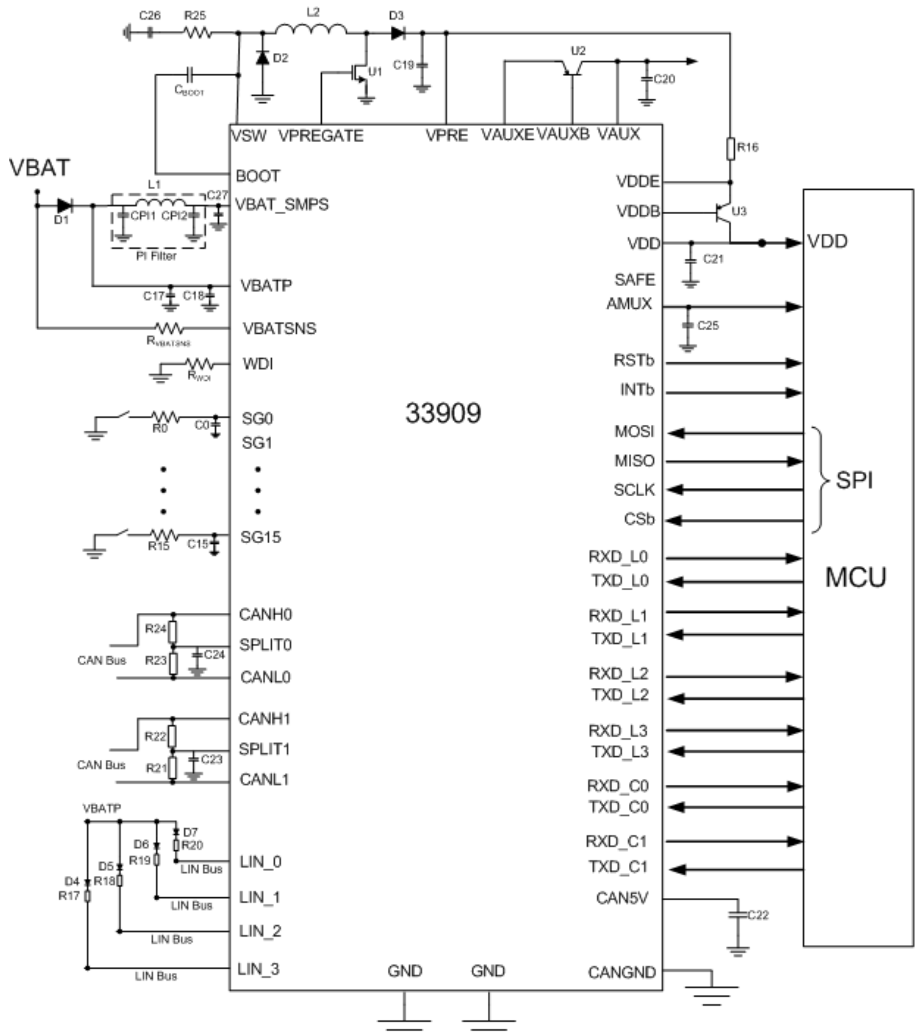

Figure 1. MC33909 simplified application diagram

Other similar devices may be available. The latest information can be found at freescale.com.

4.3 Use diodes

There are a number of diodes available to protect against surges in power supplies. Table 2 compares three options:

Table 2. Diode comparison

Zener Diode	Transient Voltage Suppression Diode (TVS)	Schottky Diode
Stronger resistance to surge than ceramic capacitors	Stronger resistance to surge than ceramic capacitors	Protects limited parts of a PCB
High clamping voltage and heat dissipation is slow	Low clamping heat	Low clamping voltage
	Available in small packages	Surface-mount packaging

The only issue with diodes is that they do not protect against nanosecond events that may include some voltage spikes; however, it may be good practice to include these into hardware designs.

A suppression diode operates in a similar manner to a Zener diode. Suppression diodes have a higher current-carrying capacity and are considerably faster. They very quickly become conductive above a defined breakdown voltage and hence short-circuit the overvoltage. However, their current-carrying capacity is not very high. On the other hand, they exhibit an extremely fast response time, in the picoseconds range. The low protection level of suppression diodes is another advantage. Unidirectional and bidirectional versions are available. See Figure 2 for an example of the desired effect.

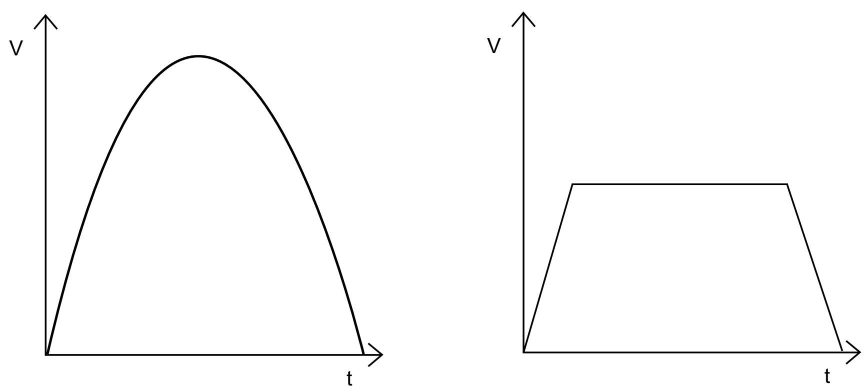

Figure 2. Suppression diode effect

4.4 Use capacitors

Decoupling or bypass capacitors can also be used to shunt noise through the capacitors. The capacitor works as the device's local energy storage. It should be placed as close as possible to the supply pin, connecting it to ground via the capacitor or capacitors.

The value of the capacitor depends on the load the MCU has to drive. The input capacitance for a given device is parameter C_{IN} in the device data sheet/electrical specification. Here is an example calculation:

Voltage = 3.3 V

C_{IN} = 2 pF

Rise time = 1 nS

The current required is:

$$I = C \cdot \left(\frac{dV}{dt}\right)$$

$$I = 2pF \cdot \left(\frac{3.3V}{1ns}\right) = 6.6mA$$

If the voltage increases to 3.6 V, or an increase of 300 mV, the required capacitor then equals:

$$C = I \,/ \left(\frac{dV}{dt}\right)$$

$$C = 6.6mA / \left(\frac{300mV}{1ns}\right) = 22pF$$

The more current the device needs to supply, the larger the capacitor should be. It is also good practice to increase the number of same-value capacitors.

The standard bypass capacitor is the ceramic type, since they have low Equivalent Series Resistance (ESR) and they are small, but Tantalum electrolytic type capacitors also have a low ESR. Aluminium electrolytic capacitors are special low ESR types. PCB space may determine the type of capacitor used. Figure 3 shows the capacitor connection in layout and highlights the noise path.

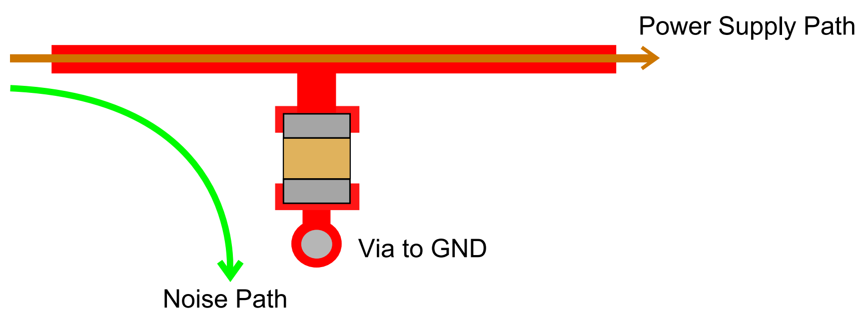

Figure 3. Simplified bypass capacitor diagram

5 Conclusion

There are a number of ways to protect the flash, and other, supplies from voltage overshoots, but it is your choice for the best option for your application that remains within Freescale's specification.

Violating the specification can cause damage to the internal circuitry of the MCU.

6 References

Freescale Semiconductor, "Qorivva/5xxx Power Architecture® Automotive MCUs,"
http://www.freescale.com/webapp/sps/site/homepage.jsp?code=POWER_ARCH_5XXX

———, "System Basis Chip,"
http://www.freescale.com/webapp/sps/site/taxonomy.jsp?code=SYSBASISCHIP

Lee, Benny, "An Overview of ESD Protection Devices," *Compliance Engineering*, http://www.ce-mag.com/archive/01/Spring/Lee.html

Murata Manufacturing, *Application Manual for Power Supply Noise Suppression and Decoupling for Digital ICs*, http://www.murata.com/products/catalog/pdf/c39e.pdf

Polulu Robotics and Electronics, "Understanding Destructive LC Voltage Spikes," http://www.pololu.com/docs/0J16/all

Semtech, "What Are TVS Diodes," http://www.semtech.com/images/promo/What_are_TVS_Diodes.pdf

Weidmuller, "The Basics of Overvoltage Protection," http://www.elektrospoji.si/uploads/menu_download/file_276_vse_o_prenapetostni_zasciti.pdf

Appendix A Characterization data

DUT 1

VFLASH (V)	3.3	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25
ARRAY READ (p/f)	pass	pass	pass	pass	pass	pass	pass	pass	fail	fail	fail	fail	fail

DUT 2

VFLASH (V)	3.3	3.5	3.75	4	4.25	4.5	4.75	5	5.25	5.5	5.75	6	6.25
ARRAY READ (p/f)	pass	pass	pass	pass	pass	pass	pass	pass	pass	pass	fail	fail	fail

DUT 3

VFLASH (v)		3.5	3.75	4	4.25	4.5	4.76	5	5.25	5.5	5.75	6	6.25
ARRAY READ (p/f)		pass	pass	pass	pass	pass	pass	pass	pass	fail	fail	fail	fail

Appendix B
PowerSBC device summary

Part Number	MC33909	MC33906	MC33907	MC33908
	CANopy	PowerSBC05	PowerSBC10	PowerSBC20
Pre-regulator 5%	1.0A (B-B_440 kHz)	1.0A (B-B_440 kHz)	1.5A (B-B_440 kHz)	2A (B-B_440 kHz)
MCU core supply VCore / 2%	0.5A (Linear)	0.5A (Linear)	0.8A (B_2.4 MHz)	1.5A (B_2.4 MHz)
MCU I/O / ATD supply VCCA /1%	No	No	100 mA (int) +/–1% or 300 mA (ext.) +/–3%	100 mA (int) +/–1% or 300 mA (ext.) +/–3%
Auxiliary ECU supply Vaux / 3%	200 mA	Up to 300 mA	Up to 300 mA	Up to 300 mA
Can_5V Supply - VCAN	200 mA	100 mA	100 mA	100 mA
CAN Interfaces	2	1	1	1
LIN Interfaces	4	1	1	1
IOs	16	6 (incl. F/S inputs)	6 (incl. F/S inputs)	6 (incl. F/S inputs)
Watchdog	Timeout, window, random configurable	Challenger	Challenger	Challenger
LowQ Voff/Von	50 µA	25 µA	25 µA	25 µA
AMUX & Battery Sense	Yes	Yes	Yes	Yes
Fail Safe	Output (Static/Dynamic)	Independent I&O	Independent I&O	Independent I&O
Package	LQFP64eP	LQFP48eP	LQFP48eP	LQFP48eP

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