MagniV in 24V Applications

Enabling MagniV for Truck Applications

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1 Introduction

The MagniV devices are designed for automotive 12V applications.

This application note introduces some considerations on how to enable MagniV family devices for 24V applications. In particular cases, the common PCB design can be used for both 12V and 24V applications (e.g. cars and trucks).

This consideration takes into account the device power supply chain, I/O pins and the communication physical layer. The key approach is to add selected external components that extend the device's operational voltage range.

These considerations are based on the ISO16750-1, ISO16750-2, ISO7637-2 and ISO7637-3 norms.

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2 MagniV

Freescale S12 MagniV portfolio simplifies system design and reduces time to market with integrated mixed-signal microcontrollers (MCUs) for automotive and industrial applications. Offering single-die solutions, the S12 MagniV MCUs are complete system-in-package (SiP) solutions built on proven S12 technology, enabling software and tool compatibility across the entire portfolio.

The MagniVtechnology offers to combine in single-die solution the MCU, +5V voltage regulator, LIN or CAN physical layer, high side driver (HSD), low side driver (LSD), gate driver unit (GDU) and high voltage input (HVI).

The MagniV family introduces products as follows:

- S12ZVM for electrical motor applications with LIN and CAN (e.g. water, oil or fuel pumps)
- S12ZVR for DC motor relay based control with LIN (e.g. window lift)
- S12ZVH for cluster applications with LIN and CAN (e.g dashboard)
- S12ZVL for general purpose applications with LIN (e.g. switch panel, RGB LED node)
- S12ZVC for sensor based applications with CAN

More information can be found at [5].

3 Norms Pick

An essential norms pick follows in order to understand the system state of the art. The following norms are considered:

- Power supply chain (ISO16750-1, ISO16750-2, ISO7637-2)
- Connectivity physical layer solution (ISO16750-1, ISO7637-3)
- 24V I/O solution (ISO16750-1, ISO7637-3)

A detailed study of the norms is recommended to understand the use cases and test cases.

3.1 ISO16750-1 Norm

Norm [1] pick, as follows:

- Operating modes:
  — mode 2.2, vehicle engine shut-off, U_B = 24V
  — mode 3.2, vehicle engine running, U_A = 28V
- Functional status classification:
  — class A, all functions of the device/system operate during and after the test
  — class C, some functions of the device/system do not perform during the test, but return automatically to normal operation after the test

3.2 ISO16750-2 Norm

Norm [2] pick, as follows:

- Code E selected: power supply voltage varies from $U_{S\ min}$ = 10V to $U_{S\ max}$ = 32V
- Superimposed alternating voltage: sinewave $10V_{PP}$ superposed, 32V max
- Discontinues in power supply: voltage drop from $U_{S\ min}$ to 9V, pulse duration100ms
- Reset behavior at voltage drop: the number of successive voltage drops
- Motor starting profile: functional status class A, starting profile level I, U_S = 10V, pulse duration100ms
- Reversed voltage: power supply -28V for 60s

3.3 ISO7637-2 Norm

Norm [3] pick, as follows:

- Set of test pulses from -600V to +200V, period max 1ms
- Load dump: +174V, duration 350ms

3.4 ISO7637-3 Norm

Norm [4] specifies the set of pulses injected into the harness via the coupling clamp module (galvanic isolation).

4   Power Supply Line

The power supply line topology can be seen in Figure 1. The module is powered from a 24V network, where the positive pole is marked +B and the negative pole is marked -B. The fuse F1 protects the battery and load from a short circuit. The reverse battery protection is managed by diode D1.

The power line pulses are suppressed by the combination of decoupling capacitors C1, C2 and C3. The load dump protection is realized by a method of disconnecting from the power supply. To keep the module running in the case of a load dump, the energy reservoir is added.

The pre-regulator drops the power supply voltage down to a level acceptable by the MagniV family devices.

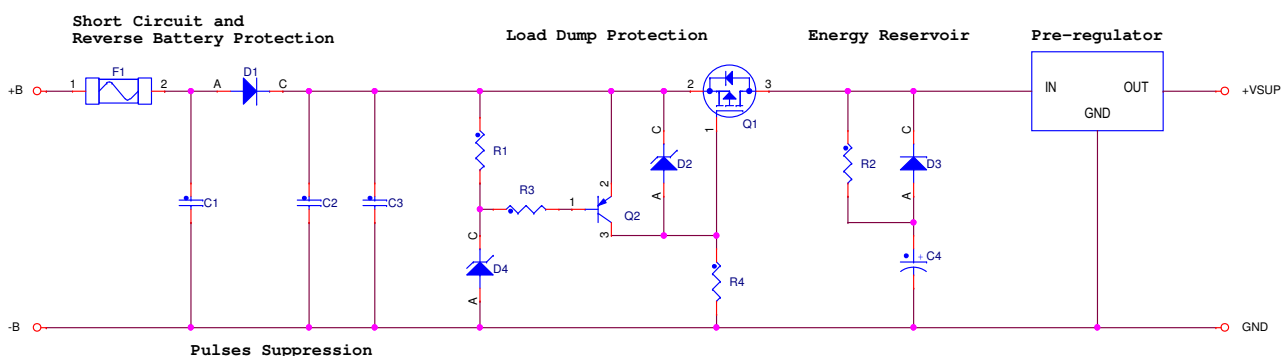The blocks are discussed in detail in following sections.

Figure 1. Power supply line topology

4.1   Short Circuit Protection

In the case of a power supply line short circuit condition, the automotive blade fuse F1 opens and protects the battery, wiring and on-board electronics against burn-out. Use the fuse time-current characteristic curves and select the fuse value based on the module continuous current and the desired fuse turn-OFF time.

4.2   Reverse Battery

The ISO16750-2 norm, see Section 3.2, "ISO16750-2 Norm", specifies the reverse battery voltage -28V for 60s. The ISO7637-2 norm, see Section 3.3, "ISO7637-2 Norm", specifies pulses down to -600V, duration 1ms.

The diode D1 protects the on-board electronics from negative voltages. The diode has to have a low leakage current and reverse voltage higher than 600V (e.g. GS1M).

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4.3　Pulses Suppression

The ISO7637-2 norm, see Section 3.3, "ISO7637-2 Norm", specifies the test pulses. The capacitors C1, C2 and C3 suppress the pulses voltage by accumulating the pulse energy. The typical values of the C1 and C2 capacitors are hundreds of nF. The C3 value is around 100pF.

The capacitor value selection is an object of investigation for each particular case. The PCB design influences the design compliance with the norm.

4.4　Load Dump Protection

The ISO7637-2 norm, see Section 3.3, "ISO7637-2 Norm", specifies the load dump test pulse 5: +174V, duration 350ms.

In the case of a load dump condition, the Q1 P-MOSFET turns OFF and disconnects the power supply line. Whenever the C3 voltage rises above 32V, the zener diode D4 opens and the Q2 turns OFF the Q1. If the C3 voltage drops down below 32V, the Q2 turns ON the Q1.

The diode D2 limits the Q1 gate-to-source voltage.

4.5　Energy Reservoir

The C4 capacitor value is related to the module functional status classification, see Section 3.1, "ISO16750-1 Norm".

In the case of class C, the C4 capacitor is used for decoupling only and the R2 and D3 components are removed.

In the case of class A, the energy reservoir C4 delivers energy where there is a load dump, motor start, temporary loss of battery voltage, etc. The resistor R2 reduces the capacitor C4 charging current pulse. The R2 typical value equals 100Ohms. The diode D3 bypasses the resistor R2, when C4 supplies the current.

Calculate the C4 value using Eqn. 1:

$$C4 = \frac{T}{R \times abs\left(\ln\left(1 - \frac{dU}{U}\right)\right)} \qquad \textbf{\textit{Eqn. 1}}$$

where:

- T— period when C4 delivers energy [s]
- R— load resistance [Ohm]
- U— nominal power supply voltage [V]
- dU— voltage drop during period T [V]
- abs(x)— absolute value of variable x

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4.6 Pre-Regulator

The MagniV devices can operate from 5.5V to 18V. The MagniV devices include a +5V regulator, so there is no need to regulate the voltage precisely.

Considering the minimal operating voltage of 10V (see Section 3.2, "ISO16750-2 Norm"), and keeping the pre-regulator and MagniV on-chip regulator power dissipation at a reasonable level, the pre-regulator output voltage is regulated to 8V.

The discrete or integrated linear pre-regulator is recommended to use for power supply currents below 50mA. The higher currents are managed by a switch mode pre-regulator, see Figure 2.
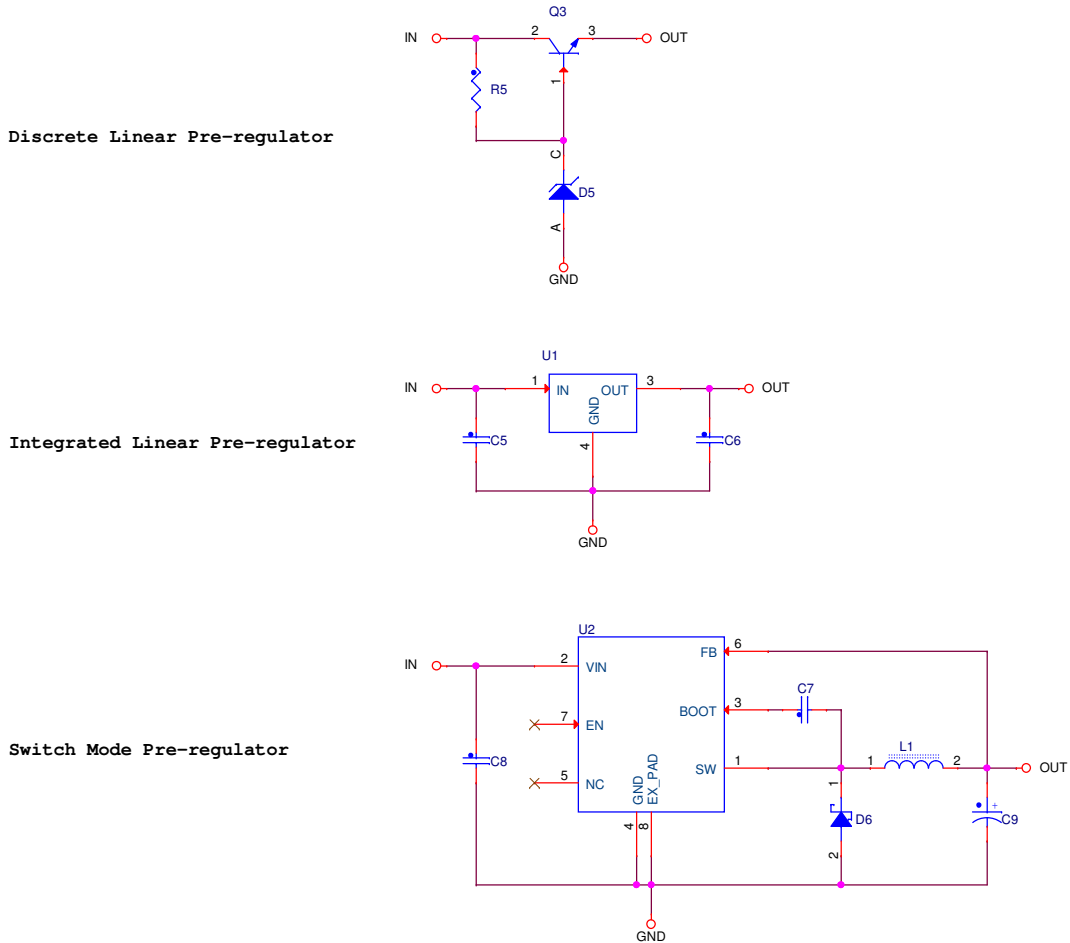
Figure 2. Pre-regulator topology

5 Communication Physical Layer

The first option is to use communication physical layer qualified for operation in a 24V automotive environment.

The other option is to use MagniV internal communication physical layer and design external circuitry (using common choke, capacitors, resistors and transils) to pass the ISO7637-3 based device testing.

6 HVI and VSENSE Pins

The HVI and VSENSE pins are designed for operation in a 12V system. Additional external circuitry is needed when the requested operation as in the 24V system.

The HVI/VSENSE pin circuity topology depicted in Figure 3 is a good starting point for further investigation. The 24V HVI/VSENSE and 24V GND pins interface to the 24V network. The HVI/VSENSE and GND pins are connected to the MagniV device.
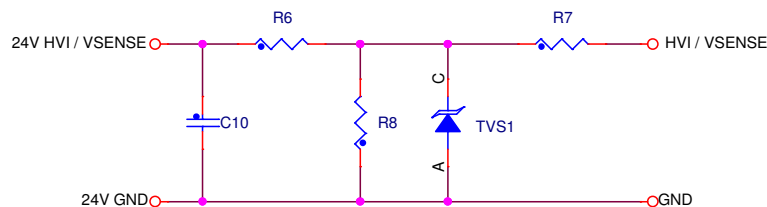
Figure 3. HVI and VSENSE pins

The capacitor C10 suppresses the 24V network's shortest pulses. The C10 value equals units of nF. The resistor divider R6, R8 divides the 24V HVI/VSENSE input voltage by two to fit the HVI/VSENSE pin voltage range. The resistor values typically equal 10kOhm. The unidirectional transil TVS1 limits the pulses voltage. The TVS1 reverse stand-off voltage equals 20V. The resistor R7, value 10kOhm, protects the HVI/VSENSE pin.

7 Driving Load

The MagniV device is a 5V I/O device. The output pins can drive a voltage from 0V to 5V. Driving the load in a 24V system requires an external buffer.

7.1 Discrete Solution

The bipolar junction or MOSFET low side driver transistor can be driven directly by MCU pin. If the high side, push-pull output, 2-phase bridge or 3-phase bridge is required, the integrated solution might be the best solution.

7.2 Integrated Solution

The example of integrated solution is in following picture. The Figure 4 displays the 3-phase bridge solution for electrical motor applications using S12ZVM MCU and MC33937 pre-driver [6].
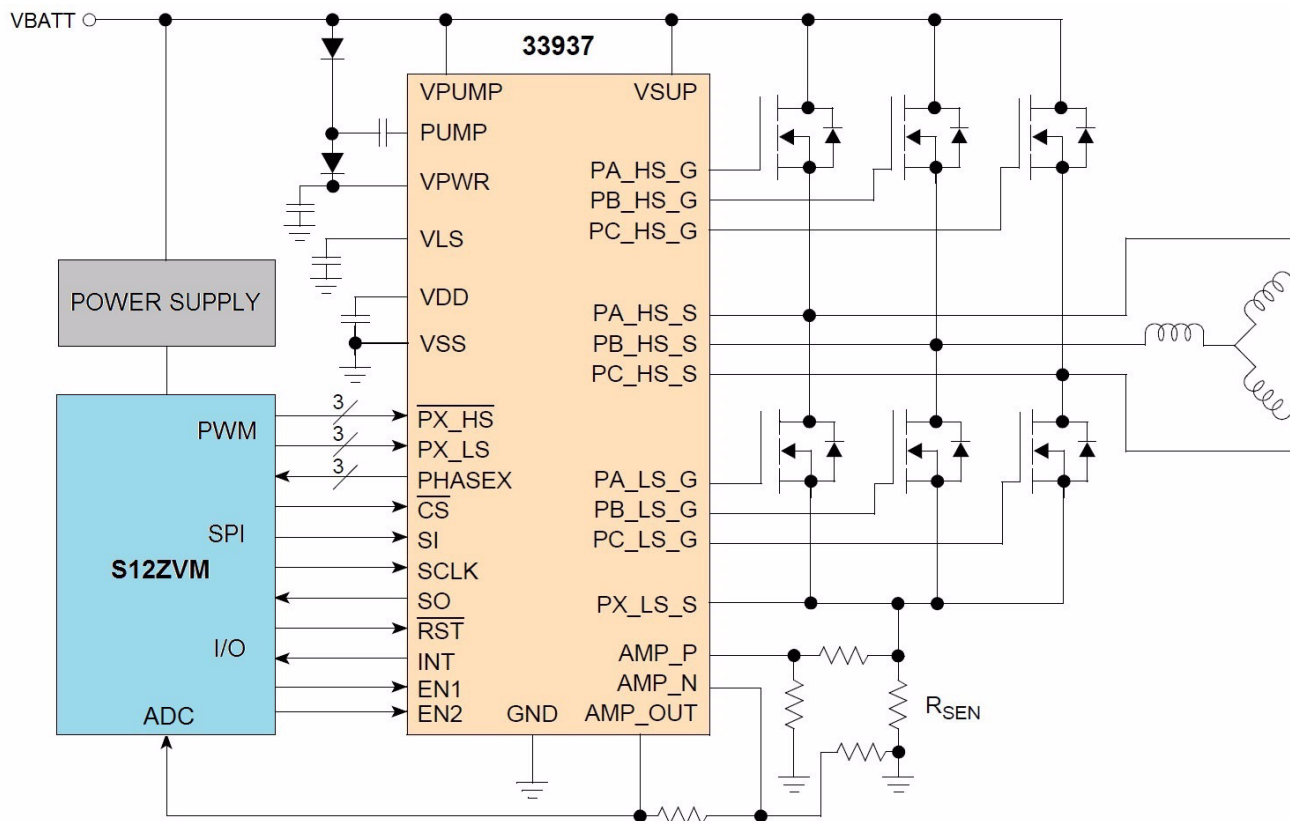

Figure 4. S12ZVM 3-Phase Bridge for Electrical Motor Applications

8   Summary

The MagniV family devices can be used in 24V applications. The key enablement are the external components, extending the device operational voltage range.

The Table 1 sums-up typical use cases for each MagniV family member.

Table 1. MagniV Selector Guide

Device	External Pre-Regulator	External Physical Layer	Other
S12ZVL	Linear	-	-
S12ZVC	Linear	CAN	-
S12ZVH	Switch Mode	CAN	-
S12ZVR	Linear/Switch Mode	-	-
S12ZVM	Switch Mode	CAN	External MOSFET Pre-driver MC33937

Note: The external components are rated for operation in 24V applications.

9 References

1. ISO16750-1: Road vehicles – Environmental conditions and testing for electrical and electronic equipment – General, ISO16750-1:2006(E)

2. ISO16750-2: Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Electrical Loads, ISO16750-2:2006(E)

3. ISO7637-2: Road vehicles – Electrical disturbances from conduction and coupling - Electrical transient conducting along supply lines only, ISO7637-2:2004(E)

4. ISO7637-3: Road vehicles – Electrical disturbances from conduction and coupling - Electrical transient transmission by capacitive and inductive coupling via lines other than power supply, ISO7637-3:2004(E)

5. www.freescale.com/MagniV

6. www.freescale.com

10   Acronyms

DC	Direct Current
CAN	Controller Area Network
HVI	High Voltage Input
LIN	Local Interconnect Network
MCU	Microcontroller Unit
SMPS	Switch Mode Power Supply
VSUP	Voltage Supply

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