

Power Supply Design for Semidrive G9H (G9V/Q/X Compatible) Using LP87565V-Q1 and LP875230C-Q1



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ABSTRACT

This document details the design considerations of a power design for the Semidrive G9H SoC (system-on-chip) power rails using the LP87565V-Q1 and LP875230C-Q1 power management ICs. This power design is compatible for the entire Semidrive G9 series (G9V, G9Q, and G9X).

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1 Introduction

This application note details the design considerations of a power design for the Semidrive G9H SoC (system-on-chip) power rails using the LP87565V-Q1 and LP875230C-Q1 power management ICs (PMICs). An additional TPS74501-Q1 LDO and TPS6281120-Q1 buck converter are used for the peripheral rails. Safety rails are powered by the LP873248-Q1 PMIC. This power design assumes an input voltage of 5V (+/-5%). If the system input voltage is higher, for example a car battery, a buck converter as a pre-regulator with high enough current capability can be used to generate a supply voltage of 5V.

The LP87565V-Q1 has four buck converters configured to work as dual 2-phase converters. LP875230C-Q1 is configured to work as 2-phase converter for the GPU rail and then additional two single phase rails for the peripherals. LP873248-Q1 is used for the safety power rails. These devices are OTP programmable, meaning default register values are set in TI production line to desired values for this platform without further need for customers to change settings through I²C bus. Full orderable part numbers for these OTP spins are LP87565VRNFRQ1, LP875230CRNFRQ1, and LP873248RHDRQ1. See the Technical Reference Manuals for the specific part numbers for more details on the OTP settings.

This power design is an example of how the Semidrive G9H required rails can be powered with TI PMICs. Sequencing is handled through programmable startup/shutdown delays of the PMICs and GPIOs and only requires a single Enable signal from the system to initiate the sequencing. This power design is possible to customize and optimize based on the actual use case regarding current requirements, used peripherals, and so forth.

2 Design Parameters

Table 2-1 shows the power rails, load requirements and [Measurements](#) shows typical performance data.

Table 2-1. Design Parameters

	VOLTAGE (V)	RAIL NAME	MAX LOAD (A)	LOAD CAPABILITY (mA)	SOURCE
AP	0.8	VDD_AP_0V8	8000	8000	LP87565V-Q1 B0+B1
	0.85	VDD_CPU_0V8	4000	8000	LP87565V-Q1 B2+B3
	0.85	VDD_GPU_0V8	5000	6000	LP875230C-Q1 B0+B1
	1.1	VDDQ_DRAM_1V1	1750	2000	LP875230C-Q1 B2
	1.8	VDD_1V8	1000	2000	LP875230C-Q1 B3
	1.8	VDDA_MIPI_1V8	50	2000	LP875230C-Q1 B3
	0.6	VDDQLP_DRAM	500	1000	TPS6281120-Q1 (BUCK)
Safety	1.8	VDD_LP4_1V8	200	500	TPS74501-Q1 (LDO)
	0.8	VSFT_0V8	1500	2000	LP873248-Q1 B0
	1.8	VDDA_SAF	720	2000	LP873248-Q1 B1
	3.3	VDDIO_GPIO	300	300	LP873248-Q1 LDO0
	3.3	VDDIO_GPIO	300	300	LP873248-Q1 LDO1

3 Power Design

Figure 3-1 shows power tree with LP87565V-Q1, LP875230C-Q1, TPS6281120-Q1, and TPS74501-Q1 devices powering the G9H AP rails.

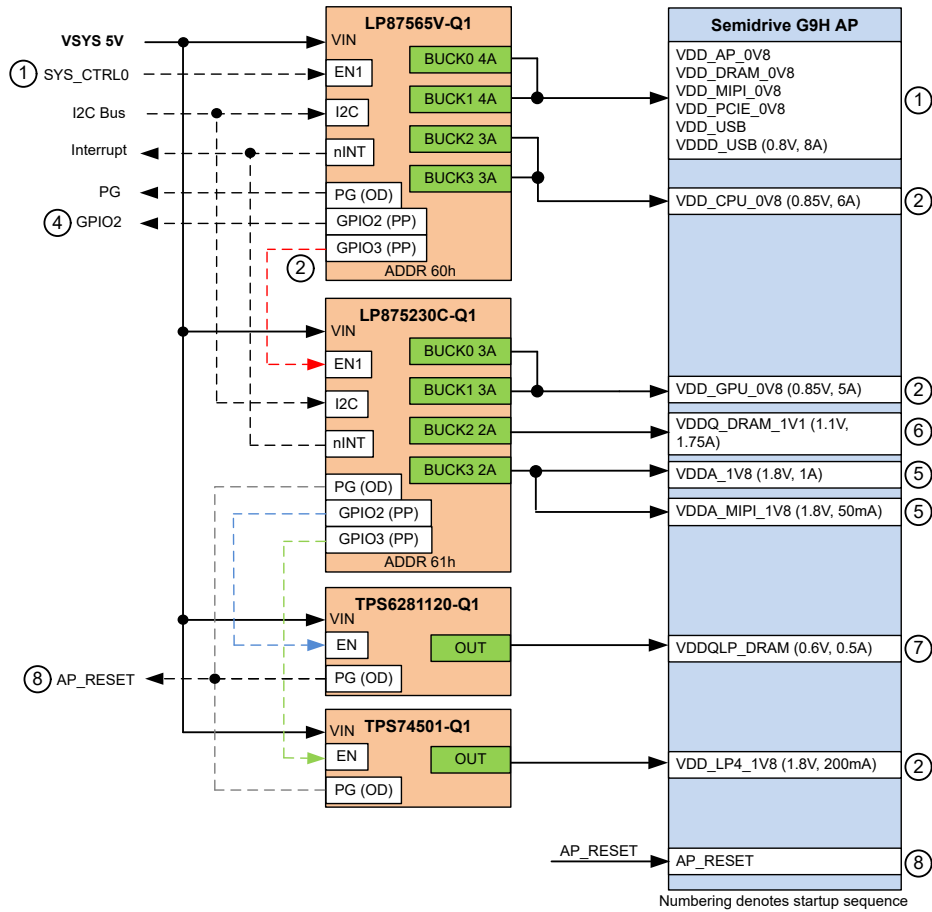


Figure 3-1. Semidrive G9H AP Power Design Block Diagram

Main features:

- 5V supplied from pre-regulator.
- After the devices are powered, the microcontroller can set the SYS_CTRL0 pin high to initiate the start-up sequence.
- Start-up delays are controlled internally in the LP87565V-Q1 and LP875230C-Q1 sequencer and discrete DC-DCs are controlled with PMIC GPIOs.
- I²C can be used to read status registers and reset interrupts.
- PMIC devices have dedicated I²C address so the devices can share the same I²C bus.
- PG signal from TPS6281120-Q1 act as AP_RESET signal for the SoC. LP875230C-PG and TPS74501-Q1 PG can be combined with this signal to allow SoC reset if any of these rails have failure.

Figure 3-2 shows power design with LP873248-Q1 powering the G9H safety rails.

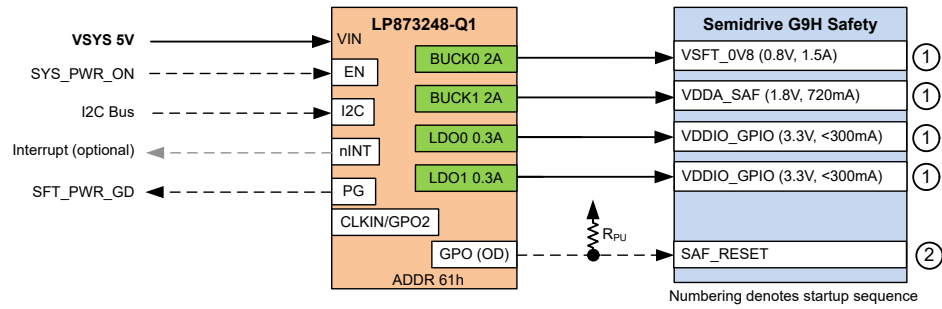


Figure 3-2. Semidrive G9H Safety Power Design Block Diagram

Main features:

- 5V supplied from pre-regulator
- One SYS_PWR_ON signal controls start-up and shutdown sequences for all the rails
- PGOOD or GPO can be used for the RESET signal

4 Sequencing

4.1 Start-up

Figure 4-1 shows start-up timing of the power rails and corresponding signals.

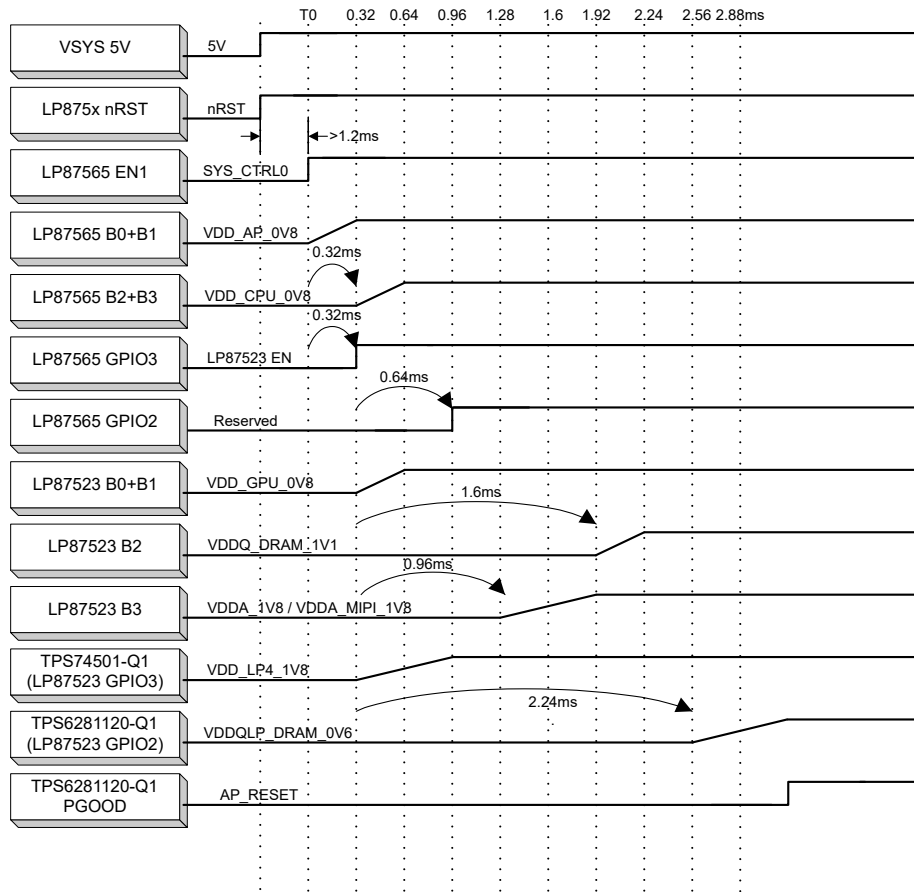


Figure 4-1. Semidrive G9H Power Start-up Timing Diagram

4.2 Shutdown

Figure 4-2 shows an example of shutdown timing of the power rails and corresponding signals.

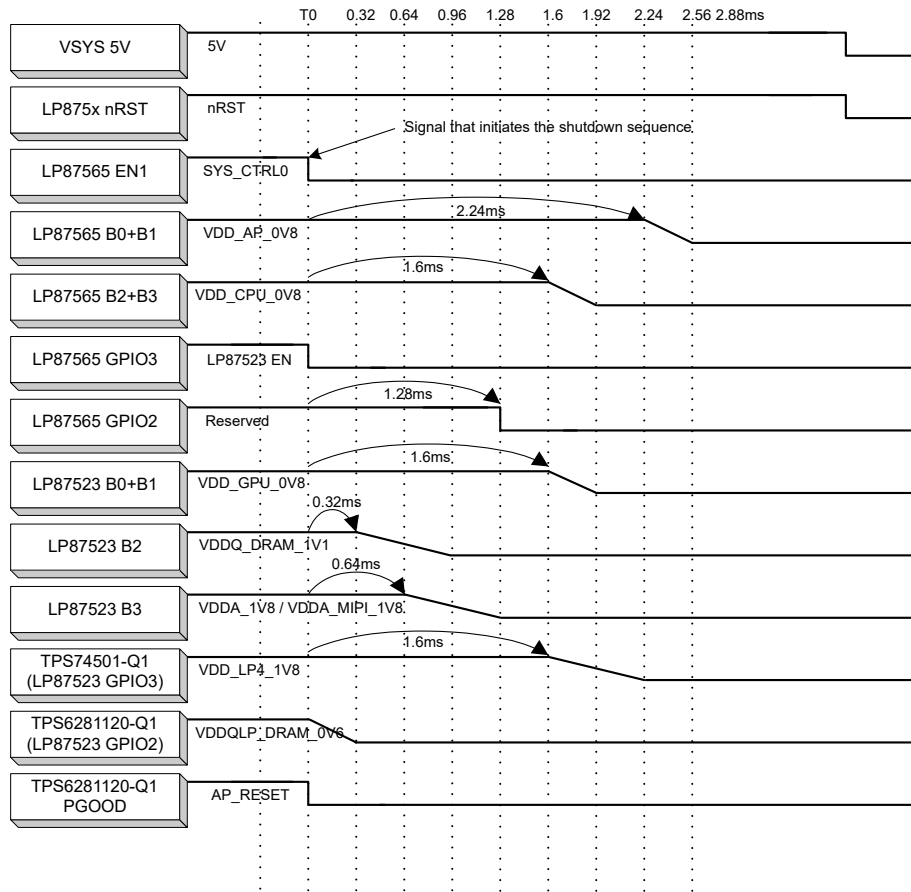


Figure 4-2. Semidrive G9H Power Shutdown Timing Diagram

5 Schematics

Figure 5-1 through Figure 5-6 show the Semidrive G9H power tree schematic with critical components.

For guidance on layout, please refer to the data sheet application section and EVM user guide for the particular device.

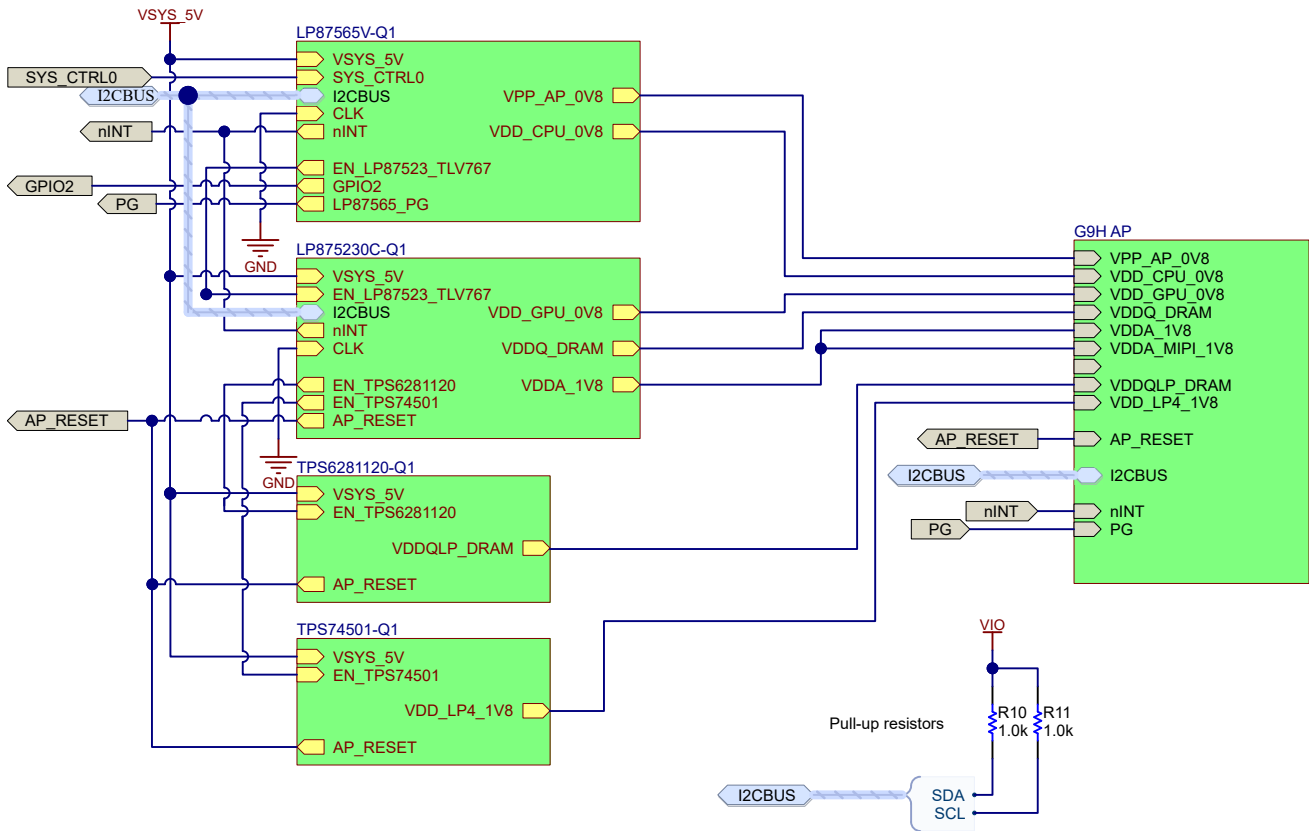


Figure 5-1. G9H Top Level Schematic

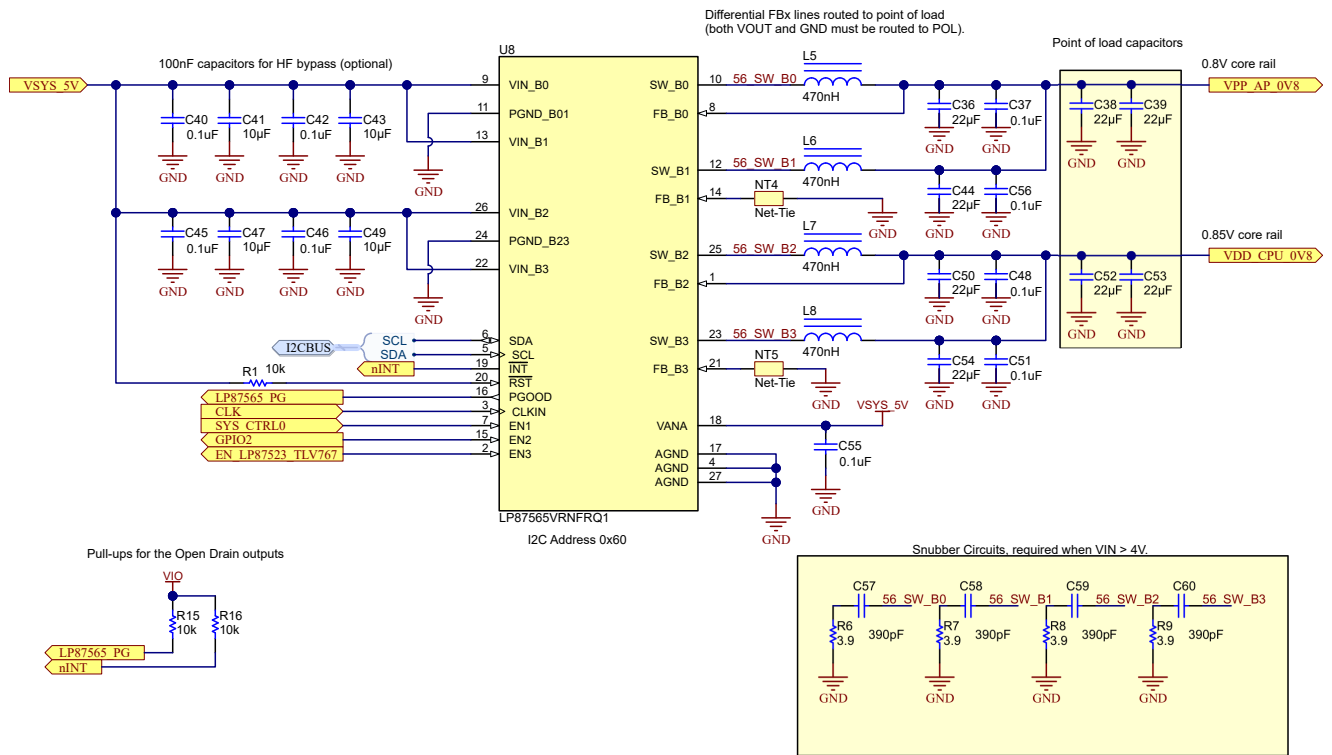


Figure 5-2. LP87565V-Q1 Schematic

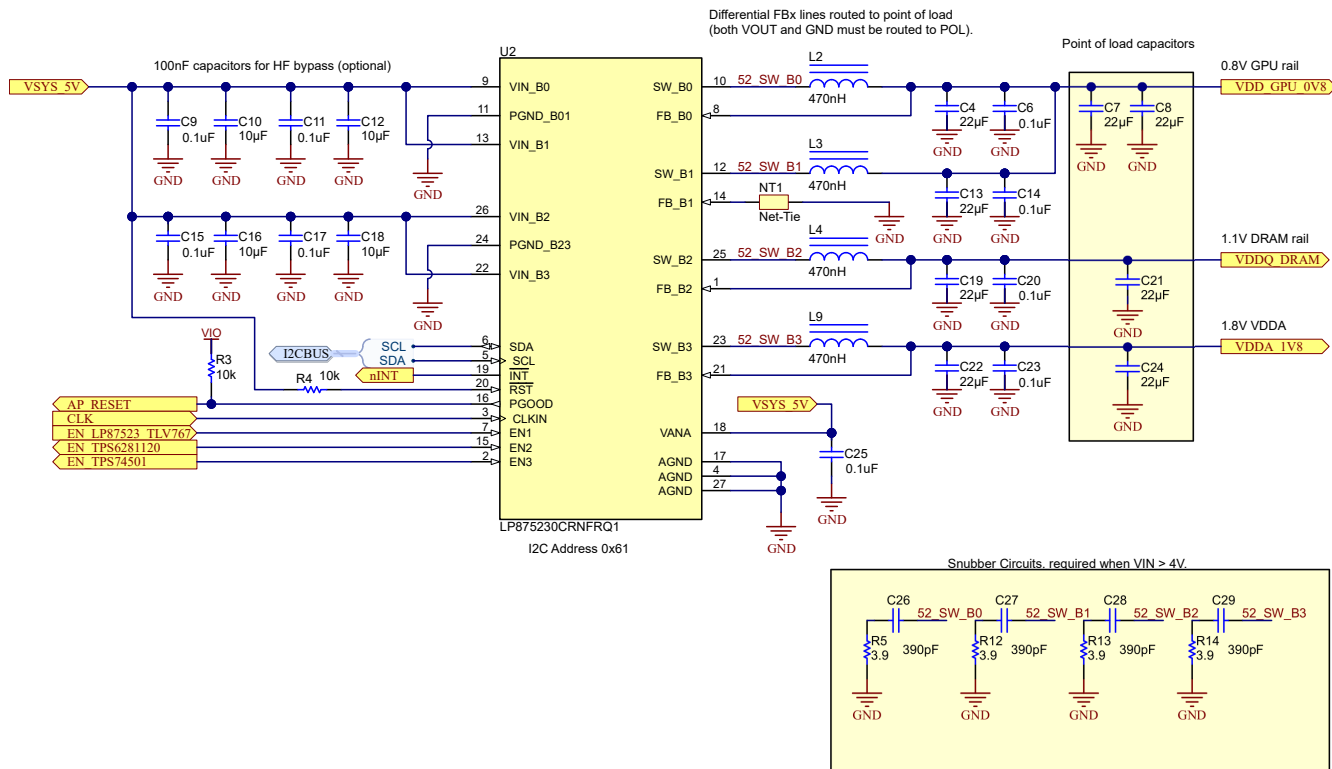


Figure 5-3. LP875230C-Q1 Schematic

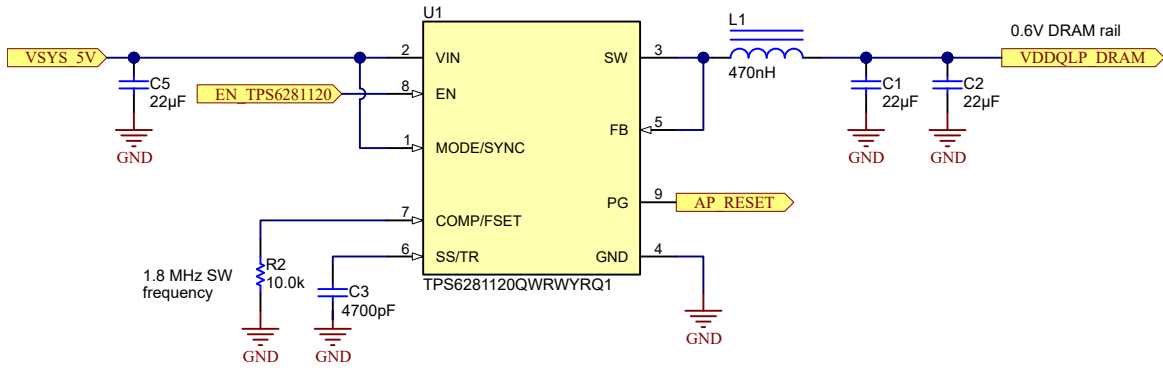
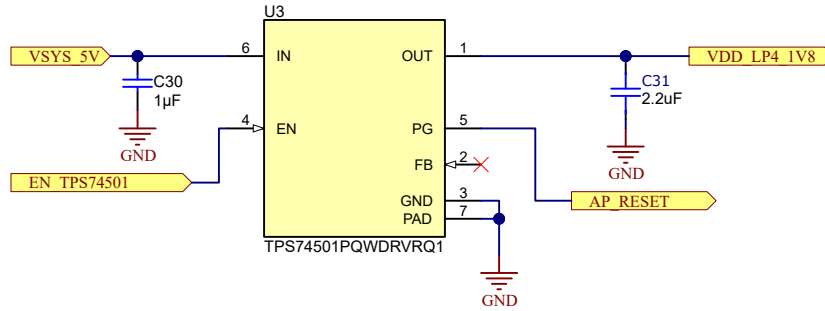


Figure 5-4. TPS6281120-Q1 Schematic



Note: For fixed voltage version the FB pin can be left floating

Figure 5-5. TPS74501-Q1 Schematic

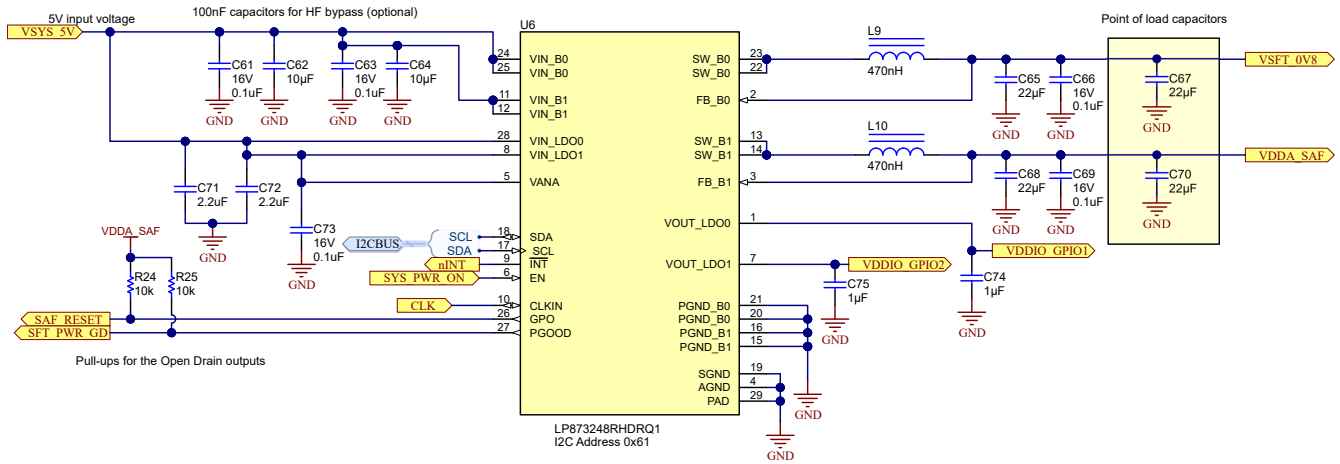


Figure 5-6. LP873248-Q1 Schematic

6 Compatibility with G9V/Q/X

This power supply design is also compatible with Semidrive G9V, G9Q, and G9X. The difference between the platforms is the number of physical layers (PHY). Since the power design is pin-to-pin compatible between the different platforms, the same ICs can be used to lessen re-design effort.

RTC and safety power supply for both MCUs are the same, so the same power trees for G9H shown in the [Power Design](#) section can be reused for the G9 series in powering G9V/G9Q/G9X.

7 Software Drivers

This design supports control through I²C bus.

Linux drivers for the LP875x-Q1 and LP8732-Q1 are available in public git repository. These can be used to help integrate the LP875x and LP8732 controls to system software:

LP8756x-Q1:

- [Torvalds/Linux/Drivers/mfd/lp87565.c](#)
- [Torvalds/Linux/Drivers/regulator/lp87565-regulator.c](#)
- [Torvalds/Linux/Drivers/gpio/gpio-lp87565.c](#)

LP8732-Q1:

- [Torvalds/Linux/Drivers/mfd/lp873x.c](#)
- [Torvalds/Linux/Drivers/regulator/lp873x-regulator.c](#)
- [Torvalds/Linux/Drivers/gpio/gpio-lp873x.c](#)

Note: Every header file is in the *include* folder starting from the root directory. So once in *include folder*, the user can navigate to the relevant header file. For example, the LP87565.h file: [Torvalds/Linux/include/linux/mfd/lp87565.h](#).

8 Recommended External Components

Table 8-1 shows the recommended external components to use in this design with the LP87565V-Q1, LP875230C-Q1, LP873248-Q1, TPS6281120-Q1, TLV76733-Q1, and TPS74501-Q1. The Bill of Materials also shows the total design size, including the PMIC device and the external components.

Table 8-1. Bill of Materials

COUNT	VENDOR	PART NUMBER	SYSTEM COMPONENT	W (mm)	L (mm)	H (mm)	UNIT AREA ⁽¹⁾	TOTAL BOARD AREA ⁽¹⁾
2	TI	LP875x-Q1	Configurable 4-phase Buck	4.00	4.50	0.90	27.50	55.00
8	Murata	DFE252012PD-R47M	LP875x Inductor 0.47μH, I _{max} 4.0A, R _{dc} typ 21mΩ	2.50	2.00	1.20	10.50	84.00
8	Murata	GCM21BR71A106KE22	LP875x SMPS Input Capacitor 10μF, 10V, 10%	2.00	1.25	1.25	6.75	54.00
16	Murata	GCM21BD70J226ME35	LP875x SMPS Output Capacitor 22μF, 10V, 10%	2.00	1.25	1.25	6.75	108.00
2	Murata	GCM155R71C104KA55D	LP875x Input Capacitor 0.1μF, 16V, 10%	1.00	0.50	0.50	3.00	6.00
1	TI	TPS74501-Q1	Low Dropout Regulator	2.00	2.00	0.80	9.00	9.00
1	Murata	GCM188R71C105KA64D	Input Capacitor 1μF	1.00	0.50	0.50	3.00	3.00
1	Murata	GRT155C71A225KE13	Output Capacitor 2.2μF	1.00	0.50	0.50	3.00	3.00
1	TI	TPS6281120-Q1	Buck Converter	3.00	2.00	0.80	12.00	12.00
1	Murata	DFE252012PD-R47M	Inductor 0.47μH, I _{max} 4.0A, R _{dc} typ 21mΩ	2.50	2.00	1.20	10.50	10.50
1	Murata	GCM21BD70J226ME35	Input Capacitor 22μF, 10V, 10%	2.00	1.25	1.25	6.75	6.75
2	Murata	GCM21BD70J226ME35	Output Capacitor 22μF, 10V, 10%	2.00	1.25	1.25	6.75	13.50
1	Murata	GRT155R71H472KE01	CSS capacitors	1.00	0.50	0.50	3.00	3.00
1			Frequency set resistor, 10kΩ	1.00	0.50	0.50	3.00	3.00
1	Murata	GCM21BR71A106KE22	Output Capacitor 10μF, 10V, 10%	2.00	1.25	1.25	6.75	6.75
1	TI	LP8732-Q1	Configurable 2 Bucks and 2 LDOs	5.00	5.00	1.00	36.00	36.00
2	Murata	DFE252012PD-R47M	LP8732 Inductor 0.47 μH, I _{max} 4.0A, R _{dc} typ 21mΩ	2.50	2.00	1.20	10.50	21.00

Table 8-1. Bill of Materials (continued)

COUNT	VENDOR	PART NUMBER	SYSTEM COMPONENT	W (mm)	L (mm)	H (mm)	UNIT AREA ⁽¹⁾	TOTAL BOARD AREA ⁽¹⁾
2	Murata	GCM21BR71A 106KE22	LP8732 Input Capacitor 10 μ F, 10V, 10%	2.00	1.25	1.25	6.75	13.50
4	Murata	GCM21BD70J 226ME35	LP8732 Output Capacitor 22 μ F, 10V, 10%	2.00	1.25	1.25	6.75	27.00
2	Murata	GRT155C71A2 25KE13	LP8732 Input Capacitor 2.2 μ F, 6.3V, 10%	1.00	0.50	0.50	3.00	6.00
2	Murata	GCM155C71A 105KE38	LP8732 Output Capacitor 1 μ F, 16V, 10%	1.00	0.50	0.50	3.00	6.00
3	Murata	GCM155R71C 104KA55D	LP8732 Input Capacitor 0.1 μ F, 16V, 10%	1.00	0.50	0.50	3.00	9.00
TOTAL								496.00mm ²
Routing area calculated with 0.3 routing factor								212.57mm ²
Total area								708.57mm ²

(1) Assuming 1mm keep-out around each component, and multiplying by component count

9 Measurements

Test data can be found in the Application Curves section of the following data sheets:

- [LP8756x-Q1 16A Buck Converter With Integrated Switches](#)
- [LP8752x-Q1 10-A Buck Converter With Integrated Switches](#)
- [LP8732-Q1 Dual High-Current Buck Converter and Dual Linear Regulator](#)
- [TPS6281x-Q1 2.75-V to 6-V Adjustable-Frequency Step-Down Converter](#)
- [TPS745-Q1 500-mA LDO With Power-Good in Small Wettable Flank WSON Packages](#)

Additional bench test data for efficiency in specific conditions for this power tree can be seen in this section.

Measurements were taken on the LP87565Q1EVM, LP87523Q1EVM, and LP87320Q1EVM with default components.

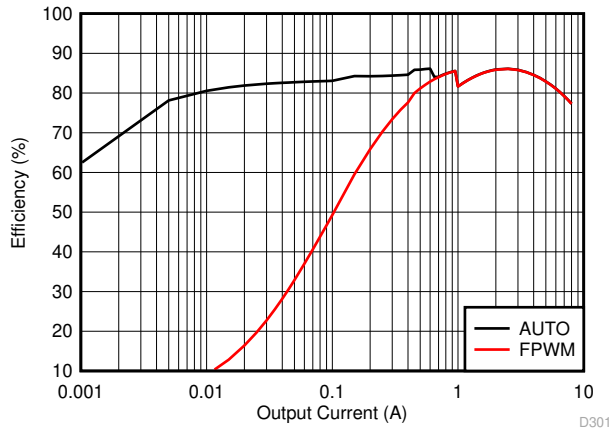


Figure 9-1. LP87565-Q1/LP87523-Q1 Dual Phase Efficiency with $V_{in} = 5V$, $25^{\circ}C$, $V_{out} = 0.85V$

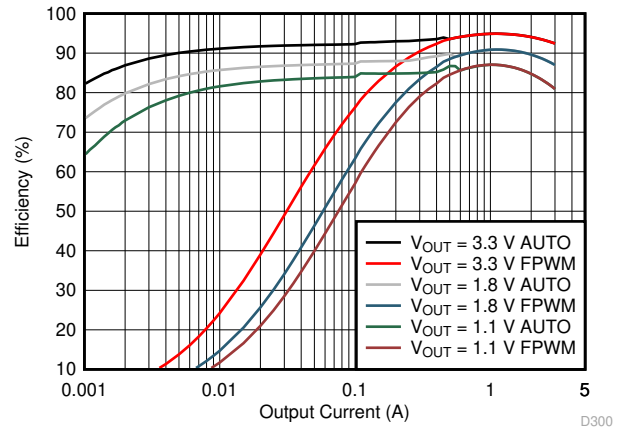


Figure 9-2. LP873248-Q1 Efficiency with $V_{in} = 5V$, $25^{\circ}C$

10 Summary

With this presented design with the LP87523-Q1, LP87565-Q1 PMICs, and discrete DC-DCs, meeting power requirements for Semidrive G9H application processor is possible while maintaining good efficiency. The design also demonstrates how to apply LP87324-Q1 PMIC to meet the power requirements for Semidrive G9H safety. Sequencing is handled in PMICs and only one EN signal is needed from the controller. The design is compact due to minimum number of external components. I²C control allows diagnostic and PMIC control if needed.

11 References

See these references for additional information:

1. Texas Instruments, [LP8756x-Q1 16A Buck Converter With Integrated Switches](#) data sheet.
2. Texas Instruments, [LP87565V-Q1 Technical Reference Manual](#).
3. Texas Instruments, [LP8752x-Q1 10-A Buck Converter With Integrated Switches](#).
4. Texas Instruments, [LP875230C-Q1 Technical Reference Manual](#).
5. Texas Instruments, [TLV767-Q1 1-A, 16-V Linear Voltage Regulator](#).
6. Texas Instruments, [TPS6281x-Q1 2.75-V to 6-V Adjustable-Frequency Step-Down Converter](#).
7. Texas Instruments, [TPS745-Q1 500-mA LDO With Power-Good in Small Wettable Flank WSON Packages](#).

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