Application Note

Power Supply Design for Semidrive X9H Using LP875230C-Q1 and LP87565V-Q1

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ABSTRACT

This document details the design considerations of a power solution for the Semidrive X9H SoC (system-on-chip) power rails using the LP87565V-Q1 and LP875230C-Q1 power management ICs. Additional TLV76733-Q1, TPS74518-Q1 LDOs and TPS6281120-Q1 buck converter are used for the peripheral rails. This power solution assumes an input voltage of 5 V (+/-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 should be used to generate a supply voltage of 5 V.

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. 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 customer to change settings through I^2C bus. Full orderable part numbers for these OTP spins are LP87565VRNFRQ1 and LP875230CRNFRQ1. See the Technical Reference Manuals for the specific part numbers for more details on the OTP settings.

This power solution is an example how Semidrive X9H required rails can be powered with TI PMICs. Sequencing is handled through programmable startup/shutdown delays of the PMICs and GPIOs and it only requires a single Enable signal from the system to initiate the sequencing. This power solution is possible to customize and optimize based on the actual use case regarding current requirements, used peripherals, and so forth.

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Trademarks

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1 Design Parameters

Table 1-1 shows the power rails, load requirements and Measurements shows typical performance data.

Table 1-1. Design Parameters

VOLTAGE (V)	RAIL NAME	MAX LOAD (A)	LOAD CAPABILITY (mA)	SOURCE
0.8	VCC0V8_VDD_AP	8000	8000	LP87565 B0+B1
0.85	VCC0V85_CPU	6000	8000	LP87565 B2+B3
0.85	VCC0V85_GPU	5000	6000	LP87523 B0+B1
1.1	VCC1V1_VDDQ_DRAM	1750	2000	LP87523 B2
1.8	VCC1V8	1000	2000	LP87523 B3
1.8	VDDA_MIPI_1V8	50	2000	LP87523 B3
3.3	VDDH_EMMC	450	1000	TLV76733-Q1 (LDO)
0.6	VDDQLP_DRAM	500	1000	TPS6281120-Q1 (BUCK)
1.8	VDD_LP4_1V8	100	500	TPS74518-Q1 (LDO)

2 Power Solution

Figure 2-1 shows power tree with LP87565V-Q1, LP875230C-Q1, TLV76733-Q1, TPS6281120-Q1, and TPS74518-Q1 devices powering the X9H rails.

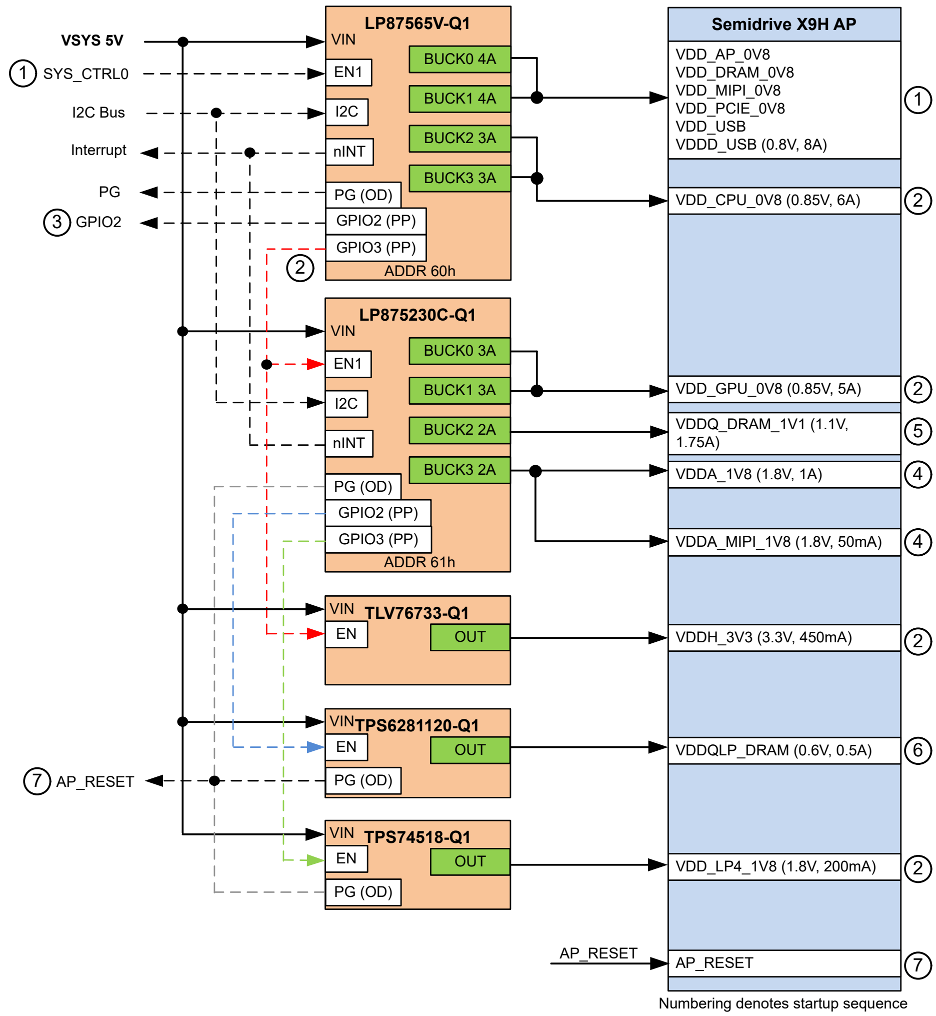


Figure 2-1. Semidrive X9H Power Solution Block Diagram

Main features:

- 5 V supplied from pre-regulator
- After the devices are powered, the microcontroller can set the SYS_CTRL0 pin high to initiate the startup sequence.
- Startup delays are controlled internally in the LP87565V-Q1 and LP875230C-Q1 sequencer and discrete DC-DCs are controlled with PMIC GPIOs.
- I^{2}C can be used to read status registers and reset interrupts.
- PMIC devices have dedicated I^{2}C address so they can share the same I^{2}C bus.
- PG signal from TPS6281120-Q1 act as AP_RESET signal for the SoC. LP875230C and TPS74518-Q1 PG can be combined with this signal to allow SoC reset if any of these rails have failure.

3 Sequencing

3.1 Startup

Figure 3-1 shows startup timing of the power rails and corresponding signals.

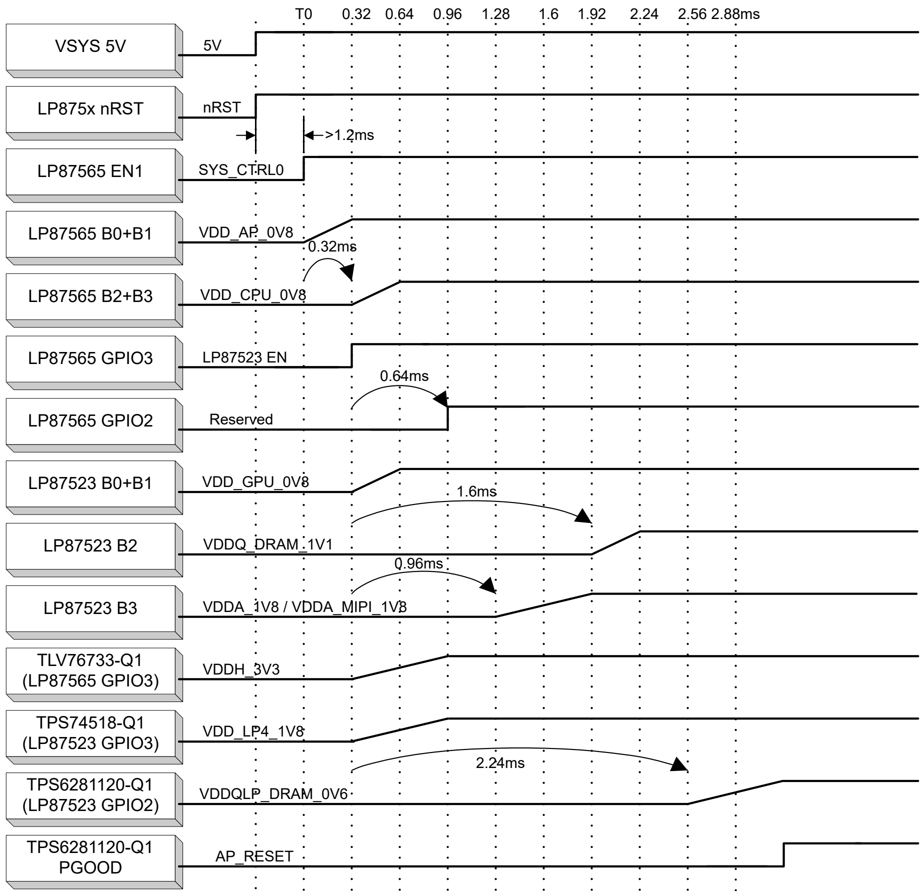


Figure 3-1. Semidrive X9H Power Startup Timing Diagram

3.2 Shutdown

Figure 3-2 shows an example of shutdown timing of the power rails and corresponding signals.

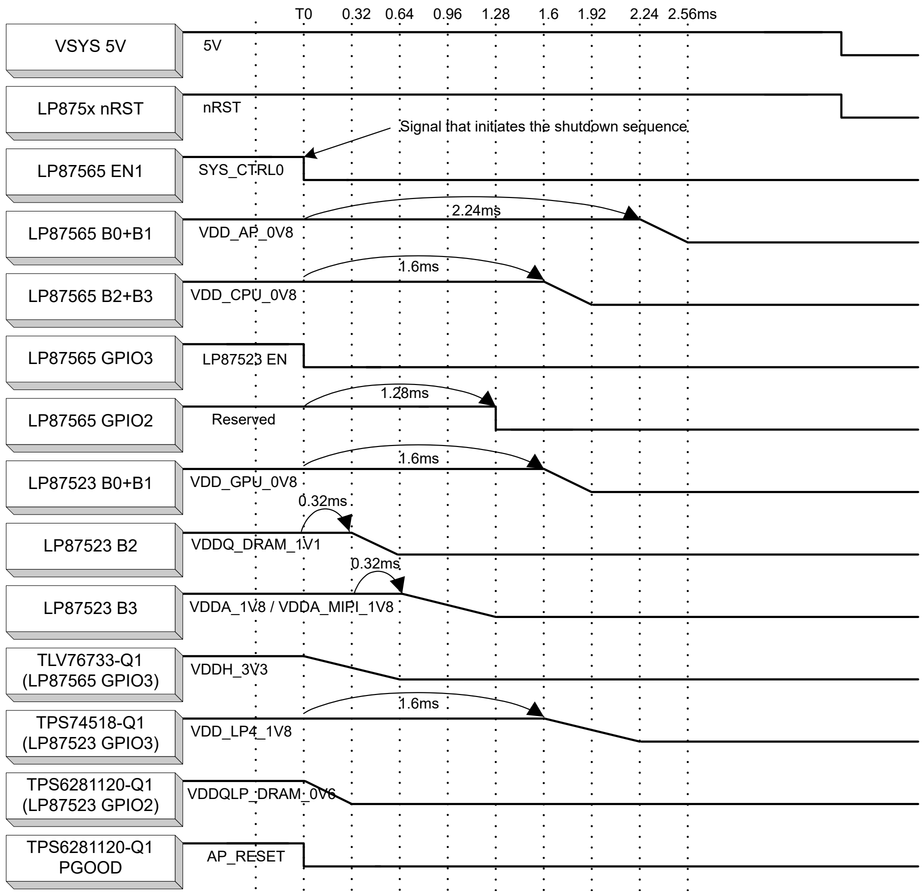


Figure 3-2. Shutdown Timing Diagram

4 Schematic

Figure 4-1 through Figure 4-6 show the Semidrive X9H 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.

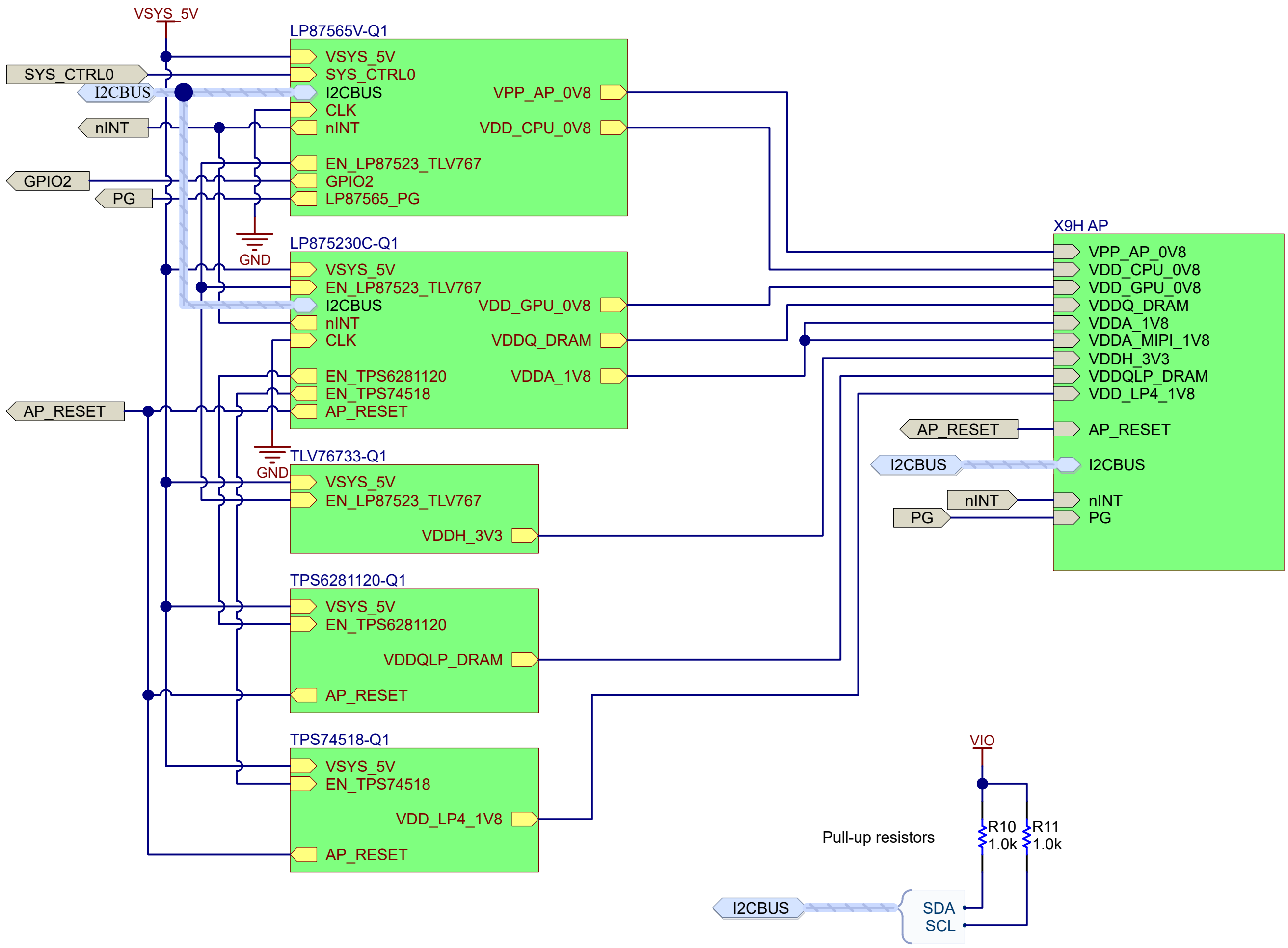


Figure 4-1. X9H Top Level Schematic

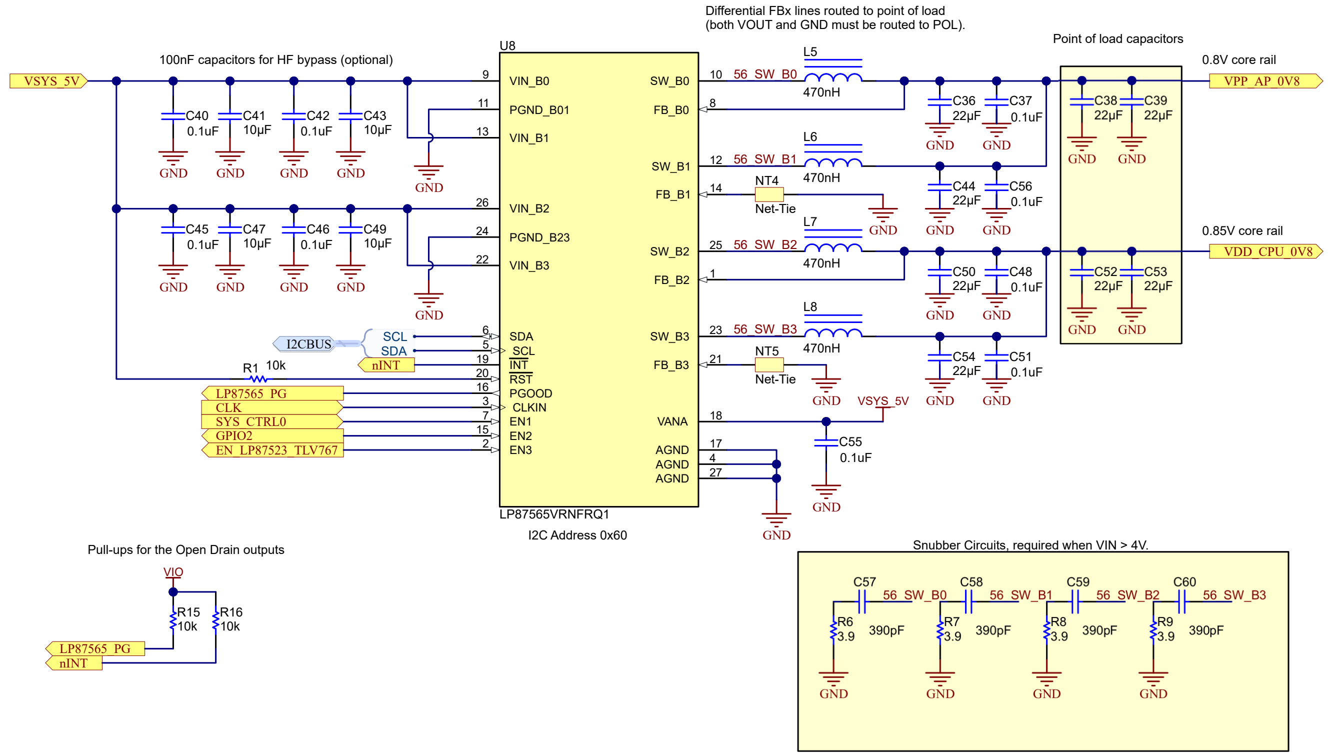


Figure 4-2. LP87565V-Q1 Schematic

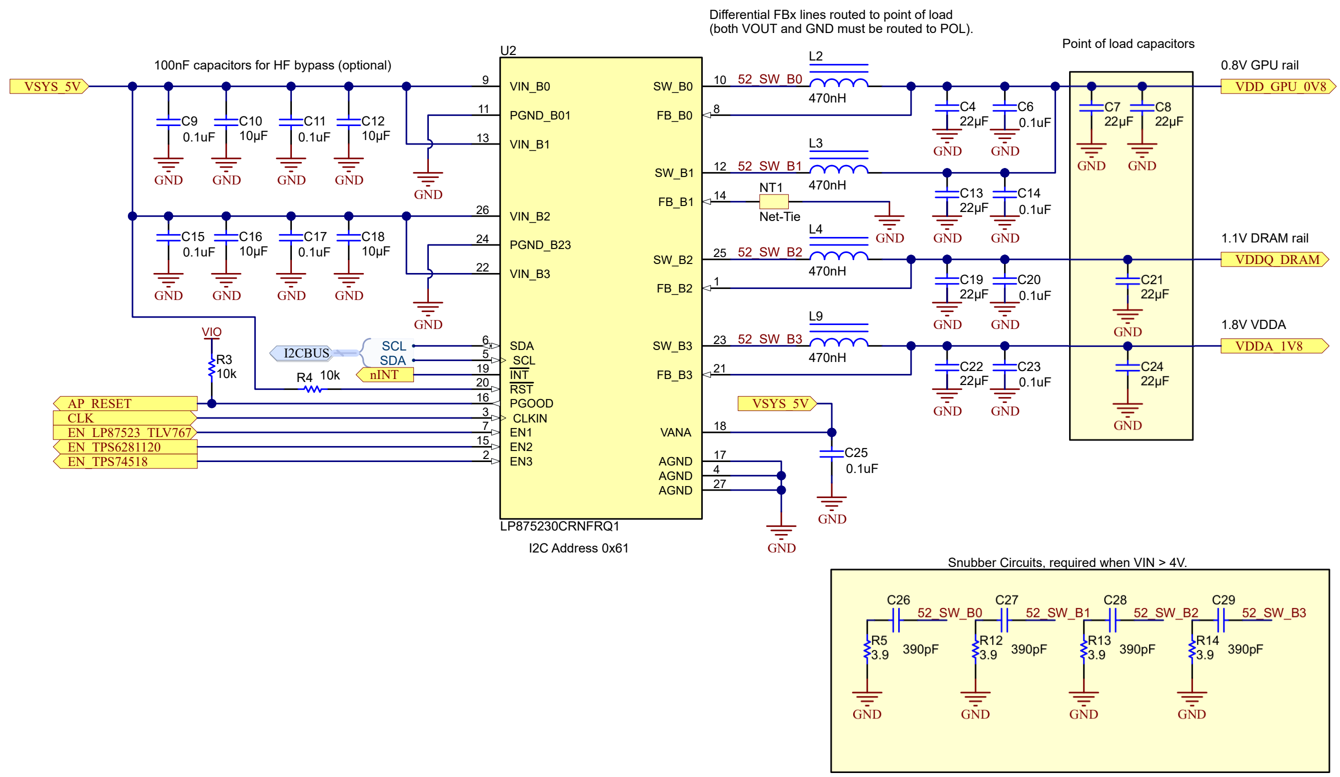


Figure 4-3. LP875230C-Q1 Schematic

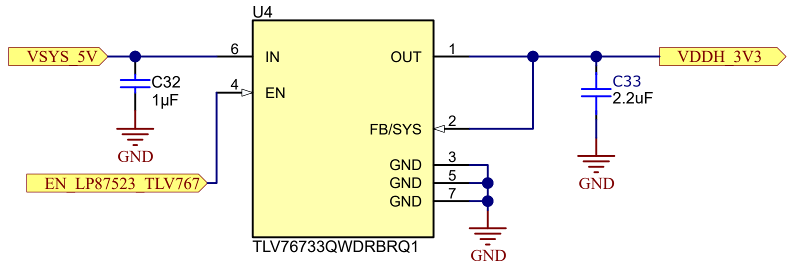


Figure 4-4. TLV76733-Q1 Schematic

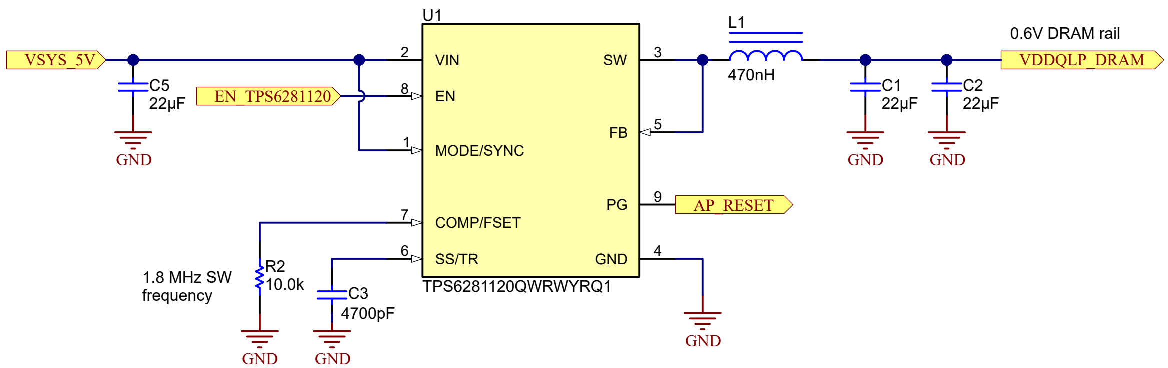
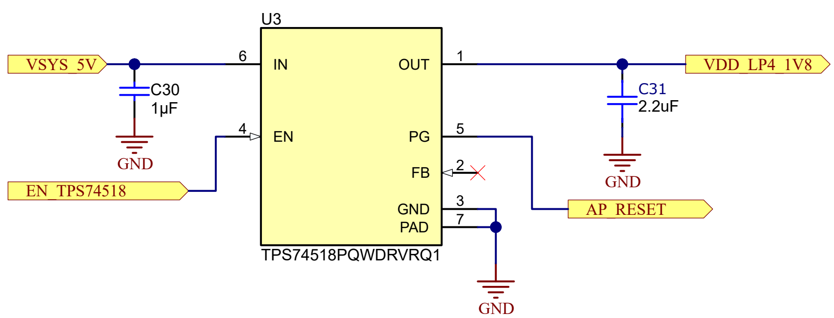


Figure 4-5. TPS6281120-Q1 Schematic



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

Figure 4-6. TPS74518-Q1 Schematic

5 Software Drivers

This solution supports control through I^2C bus.

Linux drivers for the LP875x are available in public git repository. These can be used to help integrate the LP875x control to system software:

- Torvalds/Linux/Drivers/mfd/lp87565.c
- Torvalds/Linux/Drivers/regulator/lp87565-regulator.c
- Torvalds/Linux/Drivers/gpio/gpio-lp87565.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.

6 Recommended External Components

Table 6-1 shows the recommended external components to use in this solution with the LP87565V-Q1, LP875230C-Q1, TPS6281120-Q1, TLV76733-Q1, and TPS74518-Q1. It also shows the total solution size, including the PMIC device and the external components.

Table 6-1. 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, Imax 4.0A, Rdc typ 21mOhm	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	TPS74518-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, Imax 4.0A, Rdc typ 21mOhm	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, 10kOhm	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	TLV76733-Q1	Low Dropout Regulator	3.00	3.00	1.00	16.00	16.00
1	Murata	GCM188R71C105KA64D	Input Capacitor 1µF	1.00	0.50	0.50	3.00	3.00
1	Murata	GCM188R71C105KA64D	Input Capacitor 1µF	1.00	0.50	0.50	3.00	3.00
							TOTAL	399.50 mm^2
							Routing area calculated with 0.3 routing factor	171.21 mm^2
							Total area	570.71 mm^2

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

7 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*
- *TLV767-Q1 1-A, 16-V Linear Voltage 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 and LP87523Q1EVM with default components.

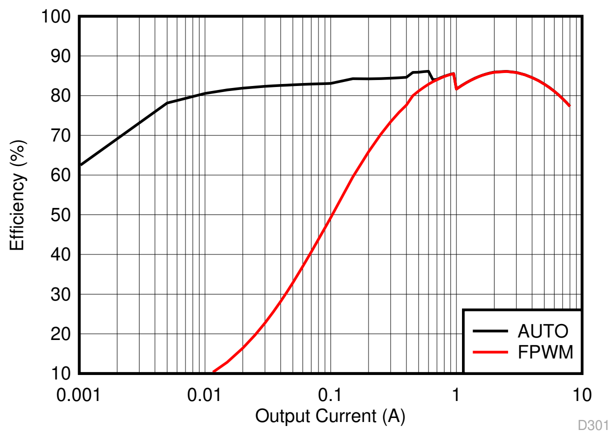


Figure 7-1. LP87565-Q1/LP87523-Q1 Dual Phase Efficiency with Vin = 5 V, 25°C, Vout = 0.85 V

8 Summary

With this presented solution with the LP87565V-Q1, LP85230C-Q1 PMICs + discrete DC-DCs, it is possible to meet power requirements for Semidrive X9H application processor while maintaining good efficiency. Sequencing is handled in PMICs and only one EN signal is needed from the controller. Solution is compact due to minimum number of external components. I^2C control allows diagnostic and PMIC control if needed.

9 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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