Application Report

Power Supply Design for AC8015 Using LP87522E-Q1 and LP873244-Q1

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ABSTRACT

This document details the design considerations of a power solution for the AutoChips AC8015 automotive SoC (system-on-chip) power rails using the LP87522E-Q1 and LP873244-Q1 power management ICs. Additional discrete buck TPS62813-Q1 is used to power 3.3V rail. 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 should be used to generate a supply voltage of 5 V. LM25141-Q1 can be used as a pre-regulator when powered directly from car battery.

The LP87522E-Q1 has four buck converters configured to work as single 3-phase converter and a separate single phase converter. LP873244-Q1 has two 2 A buck converters and two 300 mA LDOs. These devices are OTP programmable, meaning default register values are set in TI production line to desired values and it is also possible to control registers through I^2C after power-up. Contact TI sales for samples with specific OTP settings.

TPS62813-Q1 is a discrete buck converter with up to 6V input voltage and output voltage ranging from 0.6V to 5.5V. TPS62813-Q1 has maximum output current of 3A and this product family has also other pin-to-pin compatible options ranging from 1A to 4A current capability. This makes it easy change the part to different version depending on the use case requirements.

This power solution is an example how AutoChips AC8015 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.

I^2C control allows diagnostic and control of the PMICs. For error handling and control this solution also has PGOOD output, Interrupt output, and Reset output for the SoC.

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1 Design Parameters

Table 1-1 shows the power rails, load requirements, and startup/shutdown sequencing requirements and Section 7 shows typical measurement data.

Table 1-1. Design Parameters

VOLTAGE (V)	RAIL NAME	MAX LOAD (mA)	SOURCE	STARTUP DELAY (trigger)	SHUTDOWN DELAY (trigger)
0.9V	0V9_AON	900	LP8732 BUCK0	0ms (LP8732 EN high)	0ms (LP8732 EN low)
	0V9_SW	8500	LP87522 BUCK0..2	0ms (LP87522 EN1 high)	3ms (LP87522 EN1 low)
1.1	DDRV_AON	250	LP8732 BUCK1	3ms (LP8732 EN high)	0ms (LP8732 EN low)
	DDRV_SW	200	LP8732 BUCK1	3ms (LP8732 EN high)	0ms (LP8732 EN low)
1.8	1V8_AON	35	LP8732 LDO0	1ms (LP8732 EN high)	2ms (LP8732 EN low)
	1V8_SW	400	LP87522 BUCK3	2ms (LP87522 EN1 high)	2ms (LP87522 EN1 low)
3.3	3V3_AON	1	LP8733 LDO1	2ms (LP8732 EN high)	1ms (LP8732 EN low)
	3V3_SW	300	TPS62813	4ms (LP87522 EN1 high)	0ms (LP87522 EN1 low)
IO	RESET_N	-	LP8732 GPO	15ms (LP8732 EN high)	0ms (LP8732 EN low)
IO	PWR_GOOD	-	LP87522 GPIO2	30ms (LP87522 EN high)	0ms (LP87522 EN low)

2 Power Solution

Figure 2-1 shows an example block diagram of LP87522E-Q1, LP873244-Q1, and TPS62813-Q1 devices powering the AC8015 power rails. LM215141-Q1 is used as a pre-regulator to generate 5V input voltage for the PMICs and TPS62813-Q1 buck regulator.

LP87522E-Q1 and LP873244-Q1 are specific part numbers for this platform and have the output voltages, sequencing etc. pre-programmed to the OTP memory. Please refer to the Technical Reference Manual for these part numbers for details on the OTP settings.

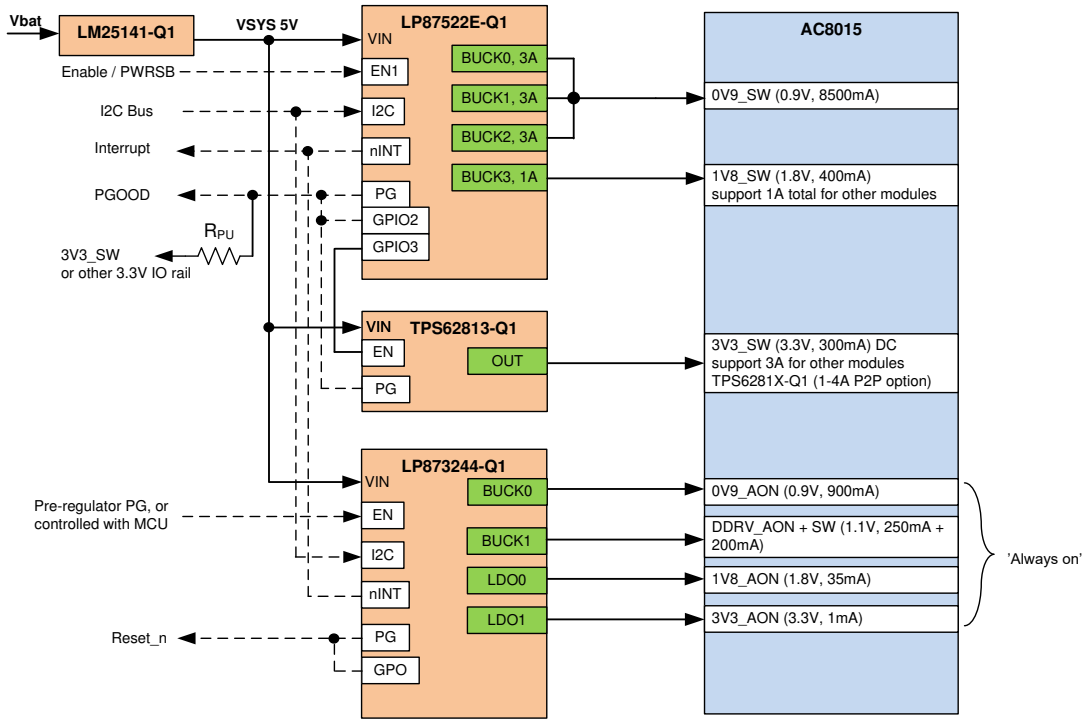

Figure 2-1. AC8015 Power Solution Block Diagram

Main features:

- After the devices are powered, the microcontroller can control the EN signals of LP873244-Q1 and LP87522E-Q1. LP873244-Q1 can be enabled/disabled with the pre-regulator powergood signal as well.
- Startup delays are controlled internally in the LP87522E-Q1 and LP873244-Q1 logic and TPS62813-Q1s is controlled with LP87522E-Q1 GPIO3. Section 3 has more details about the startup/shutdown sequence.
- I^2C can be used to read status registers and reset interrupts. Since interrupt lines are connected together, both PMIC fault registers should be read/cleared in case of interrupt goes low.
- All PMIC devices have dedicated I^2C address so they can share the same I^2C bus.
- LP873244-Q1 GPO signals act as nRESET signal for the SoC and LP87522E-Q1 GPIO2 signal is used as PGOOD indication. Note the PGOOD functionality is disabled in the PMIC configuration, although it can be enabled through I^2C bus.

3 Sequencing

3.1 Startup

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

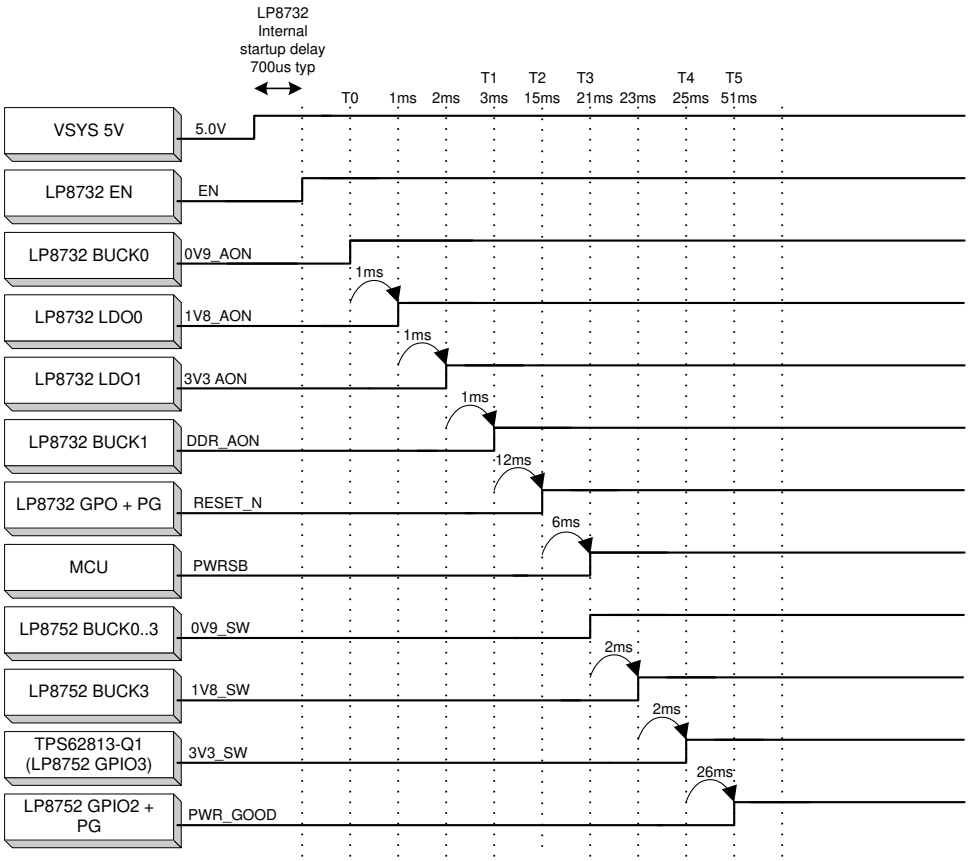

Figure 3-1. AC8015 Power Startup Timing Diagram

3.2 Shutdown

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

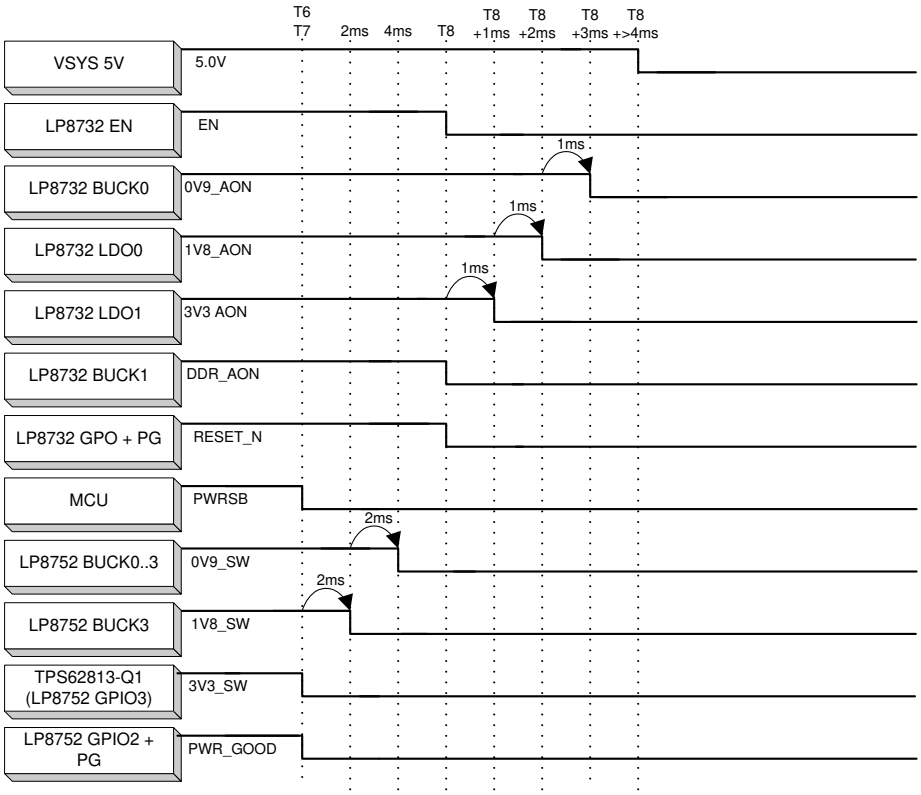

Figure 3-2. AC8015 Shutdown Timing Diagram

4 Schematic

Figure 4-1through Figure 4-3 show the AC8015 power tree schematic with critical components. Snubbers are needed for LP87522E-Q1 when input voltage of the system is >4 V, otherwise they are optional.

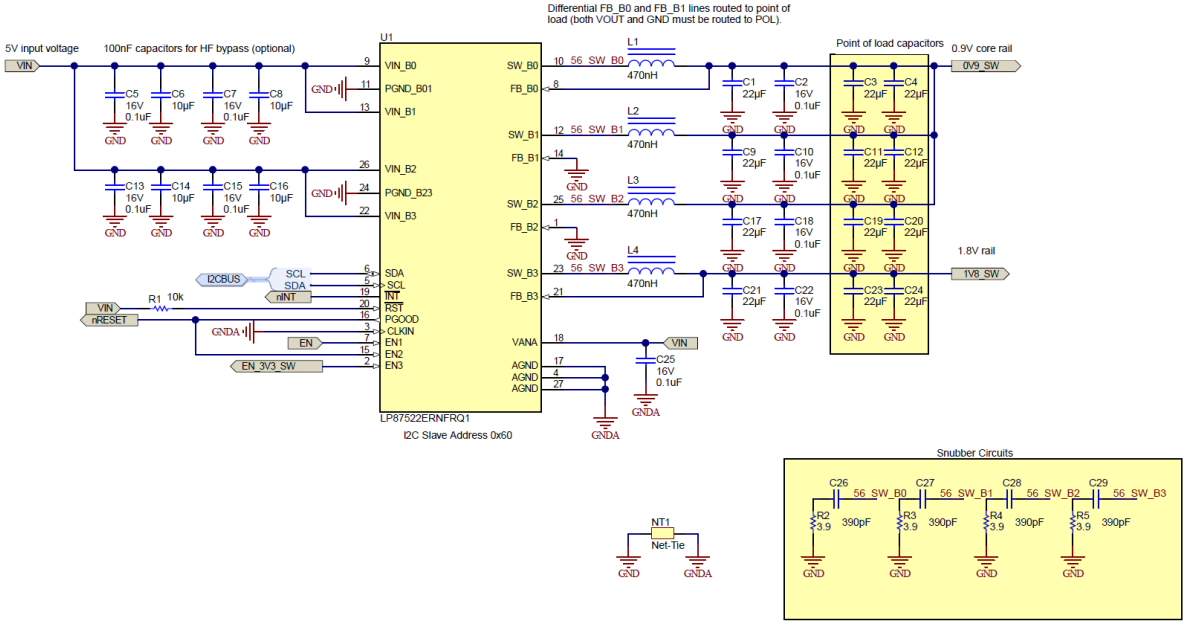

Figure 4-1. LP87522E-Q1 Schematic

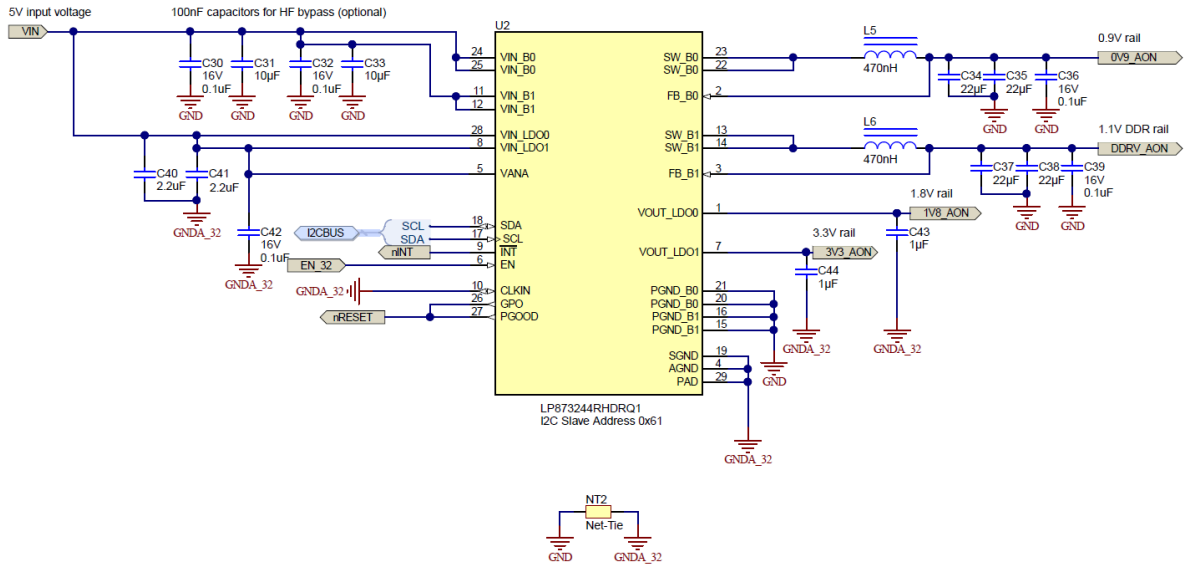

Figure 4-2. LP873244-Q1 Schematic

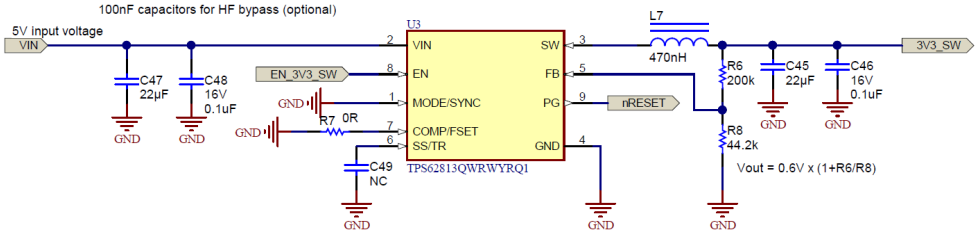

Figure 4-3. TPS62813-Q1 Schematic

5 Software Drivers

Linux drivers for the LP875x and LP873x are available in public git repository. These can be used to help integrate the LP875x / LP873x control to system software:

LP8756x

- https://github.com/torvalds/linux/blob/master/drivers/mfd/lp87565.c
- https://github.com/torvalds/linux/blob/master/drivers/regulator/lp87565-regulator.c
- https://github.com/torvalds/linux/blob/master/drivers/gpio/gpio-lp87565.c

LP873x

- https://github.com/torvalds/linux/blob/master/drivers/mfd/lp873x.c
- https://github.com/torvalds/linux/blob/master/drivers/regulator/lp873x-regulator.c
- https://github.com/torvalds/linux/blob/master/drivers/gpio/gpio-lp873x.c

Note: Every header file is in the “include” folder starting from the root directory. So once in “include folder”, you can navigate to the relevant header file. For example, here is the LP87565.h file: https://github.com/torvalds/linux/blob/master/include/linux/mfd/lp87565.h.

6 Recommended External Components

Table 6-1 shows the recommended external components to use in this solution with the LP87522E-Q1, LP873244-Q1, and TPS62813-Q1. It also shows the total solution size, including the PMIC device and the external components. Note this is done for the minimum solution size in mind and depending on the requirements the actual components can be different. Please see application note Stability Considerations for LP8756x-Q1 and LP8752x-Q1, LP8752x-Q1 datasheet, LP8732xx-Q1 datasheet, and TPS6281x-Q1 datasheet for more details.

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)
1	TI	LP87522E-Q1	Configurable 4-phase Buck	4.00	4.50	0.90	27.50	27.50
4	TOKO	DFE252012PD-R47M	LP8752x Inductor 0.47uH, Imax 4.0A, Rdc typ 21mOhm	2.50	2.00	1.20	10.50	42.00
4	Murata	GCM21BR71A106KE22	LP8752x SMPS Input Capacitor 10uF, 10V, 10%	2.00	1.25	1.25	6.75	27.00
8	Murata	GCM21BD70J226ME35	LP8752x SMPS Output Capacitor 22uF, 10V, 10%	2.00	1.25	1.25	6.75	54.00
1	Murata	GCM155R71C104KA55D	LP8752x Input Capacitor 0.1uF, 16V, 10%	1.00	0.50	0.50	3.00	3.00
4	TDK	CGA2B2C0G1H391J050BA	LP8752x Snubber capacitor, 390pF	1.00	0.50	0.50	3.00	12.00
4	Vishay-Dale	CRCW04023R90JNED	LP8752x Snubber resistor, 3R9	1.00	0.50	0.50	3.00	12.00
1	TI	LP873244-Q1	Configurable 2 Bucks and 2 LDOs	5.00	5.00	0.90	36.00	36.00
2	TOKO	DFE252012PD-R47M	LP8732x Inductor 0.47uH, Imax 4.0A, Rdc typ 21mOhm	2.50	2.00	1.20	10.50	21.00
2	Murata	GCM21BR71A106KE22	LP8732x SMPS Input Capacitor 10uF, 10V, 10%	2.00	1.25	1.25	6.75	13.50
4	Murata	GCM21BD70J226ME35	LP8732x SMPS Output Capacitor 22uF, 10V, 10%	2.00	1.25	1.25	6.75	27.00
2	Murata	GCM188R70J225KE22	LP8732x LDO Input Capacitor 2.2uF, 6.3V, 10%	1.60	0.80	0.90	4.68	9.36
2	Murata	GCM155C71A105KE38	LP8732x LDO Output Capacitor 1.0uF, 16V, 10%	1.00	0.50	0.50	3.00	6.00
1	Murata	GCM155R71C104KA55D	LP8732x Input Capacitor 0.1uF, 16V, 10%	1.00	0.50	0.50	3.00	3.00
1	TI	TPS62813-Q1	Adjustable Step-down converter	3.00	2.00	0.90	12.00	12.00
4			Setup resistors for TPS62813-Q1 output voltage etc.	1.00	0.50	0.50	3.00	12.00
1	TOKO	DFE252012PD-R47M	Inductor 0.47uH, Imax 4.0A, Rdc typ 21mOhm	2.50	2.00	1.20	10.50	10.50
1	Murata	GCM21BD70J226ME35	Input Capacitor 22uF, 10V, 10%	2.00	1.25	1.25	6.75	6.75
2	Murata	GCM21BD70J226ME35	Output Capacitor 22uF, 10V, 10%	2.00	1.25	1.25	6.75	13.50
							TOTAL	348.11 mm^2
							Routing area calculated with 0.3 routing factor	149.19 mm^2
							Total area	497.30 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 *LP8752x-Q1 Datasheet*, *LP8732xx-Q1 Datasheet*, and *TPS6281x-Q1 Datasheet.*

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

Measurements were taken on the LP87522Q1EVM and LP8732Q1EVM with default components.

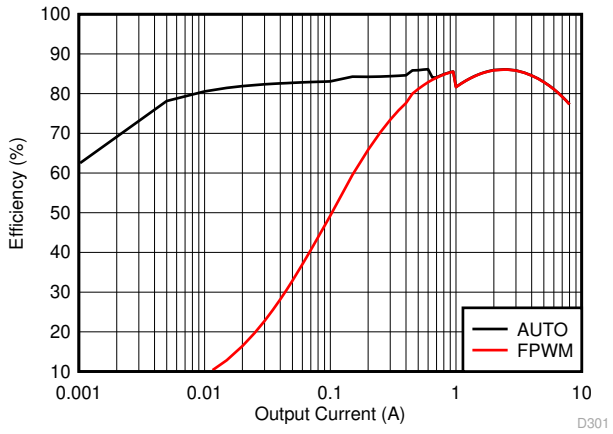

Figure 7-1. LP87522E-Q1 Efficiency with Vin = 5 V, Vout = 0.9V 25°C

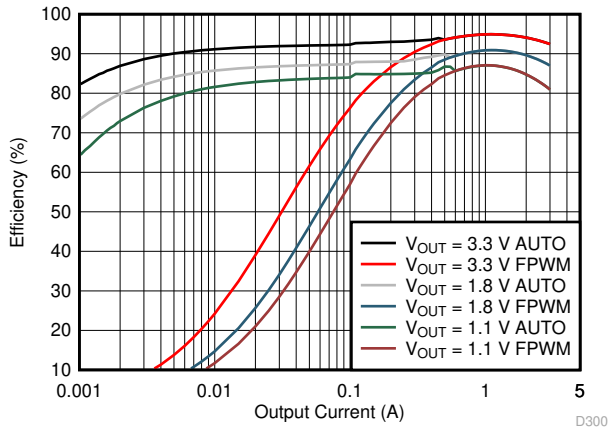

Figure 7-2. LP873244-Q1 Efficiency with Vin = 5 V, 25°C

8 Summary

With this presented solution with the LP87522E-Q1, and LP873244-Q1 PMICs and TPS62813-Q1 buck converter, it is possible to meet power requirements for AC8015 SoC while maintaining good efficiency. Sequencing is handled in PMICs and with minimal control needed from the controller. Solution is compact due to minimum number of external components.

9 References

See these references for additional information:

1. Texas Instruments, *LP8752x-Q1 10A Buck Converter With Integrated Switches Data Sheet* (SNVSB23)
2. Texas Instruments, *LP8732xx-Q1 Dual High-Current Buck Converter and Dual Linear Regulator Data Sheet* (SNVSB63)
3. Texas Instruments, *TPS6281x-Q1 2.75-V to 6-V Adjustable-Frequency Step-Down Converter* (SLVSDU1)
4. Texas Instruments, *Stability Considerations for LP8756x-Q1 and LP8752x-Q1* (SNVA881)
5. Texas Instruments, *LP8756x and LP8752x Design Checklist* (SNVR480)

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