User's Guide
SLVUAB1–September 2014

Discrete Power Solution for AM437x

This document details the implementation of a BOM-optimized discrete power solution for the AM437x processor with a minimal number of discrete ICs and basic feature set. The solution represents a baseline for a discrete power solution that can be extended for additional features of the AM437x processor.

The high-performance AM437x processor requires 4 different voltage rails with specific power-on and power-off sequences. The TLV family of devices offers a low cost power solution for the AM437x with simple RC delays to handle the required sequencing. The TLV62565 step-down converter provides the 3.3-V rail and the TLV62080 provides the 1.1-V rail, while two TLV702xx low drop out regulators (LDOs) provide the 1.5-V and 1.8-V rails. A TLV803M voltage supervisor is also included in the power solution to keep the processor in reset until all rails are operational and to reset the processor when input power is lost.

This document provides a reference for connectivity between these discrete ICs and the AM437x.

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1 Power Requirements

The discrete power solution is designed for the following system requirements:

- AM437x simplified power sequencing with RTC feature disabled
- VDD_MPU and VDD_CORE: OPP100
- No dynamic voltage and frequency scaling (DVFS)
- MPU clock frequency up to 600 MHz
- Dual voltage IO VDDSHVx: 3.3 V

Figure 1 shows a block diagram of the TLV family of devices and AM437x interface. A detailed circuit schematic detailing the power solution and sequence is found in Figure 3.

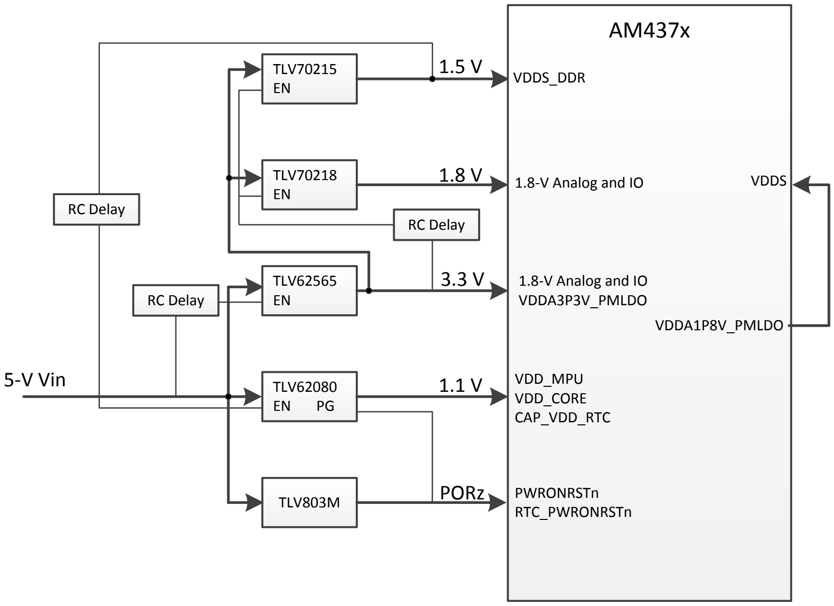

Figure 1. Functional Block Diagram Powering AM437x

The AM437x power requirements are listed in Table 1.

Table 1. AM437x Power Requirements

Discrete ICs						AM437x			
Power-Up Sequence	Power-Down Sequence	Power Supply	V_{OUT} (V)	I_{OUT} (mA)	Output Voltage (V)	Power Supply	Nominal Rating	Grouping	Max Current (mA)
1	3	TLV62565	Adjustable	1500	3.3	VDDA3P3V_USB0/1, VDDS3P3V_IOLDO, VDDSHV1~11	3.3 V ±5%	3.3-V Analog and IO	630
2	2	TLV70215	1.5	300	1.5	VDDS_DDR	1.5 V ±5%	1.5-V Analog	250
2	2	TLV70218	1.8	300	1.8	VDDS_RTC, VDDA_ADC0/1, VDDS_SRAM_CORE_BG, VDDS_SRAM_MPU_BB, VDDS_PLL_DDR, VDDS_PLL_CORE_LCD, VDDS_PLL_MPU, VDDS_OSC, VDDA1P8V_USB0/1	1.8 V ±5%	1.8-V Analog and IO	150
3	1	TLV62080	Adjustable	1200	1.1	VDD_CORE, VDD_MPU, CAP_VDD_RTC	1.1 V ±4%	1.1-V Core	1002

The TLV62565 and TLV62080 step-down converters and the TLV702xx LDOs meet the power requirements. In order to power up the AM437x in the right sequence, RC delay circuits are implemented between the 3.3-V rail and 1.5-V/1.8-V rail as well as between the 1.5-V and 1.1-V rail.

1.1 Power-On Sequence

According to the AM437x data sheet (SPRS851), with RTC feature disabled and dual-voltage IOs configured as 3.3 V, the power up sequence should be as shown in Figure 2.

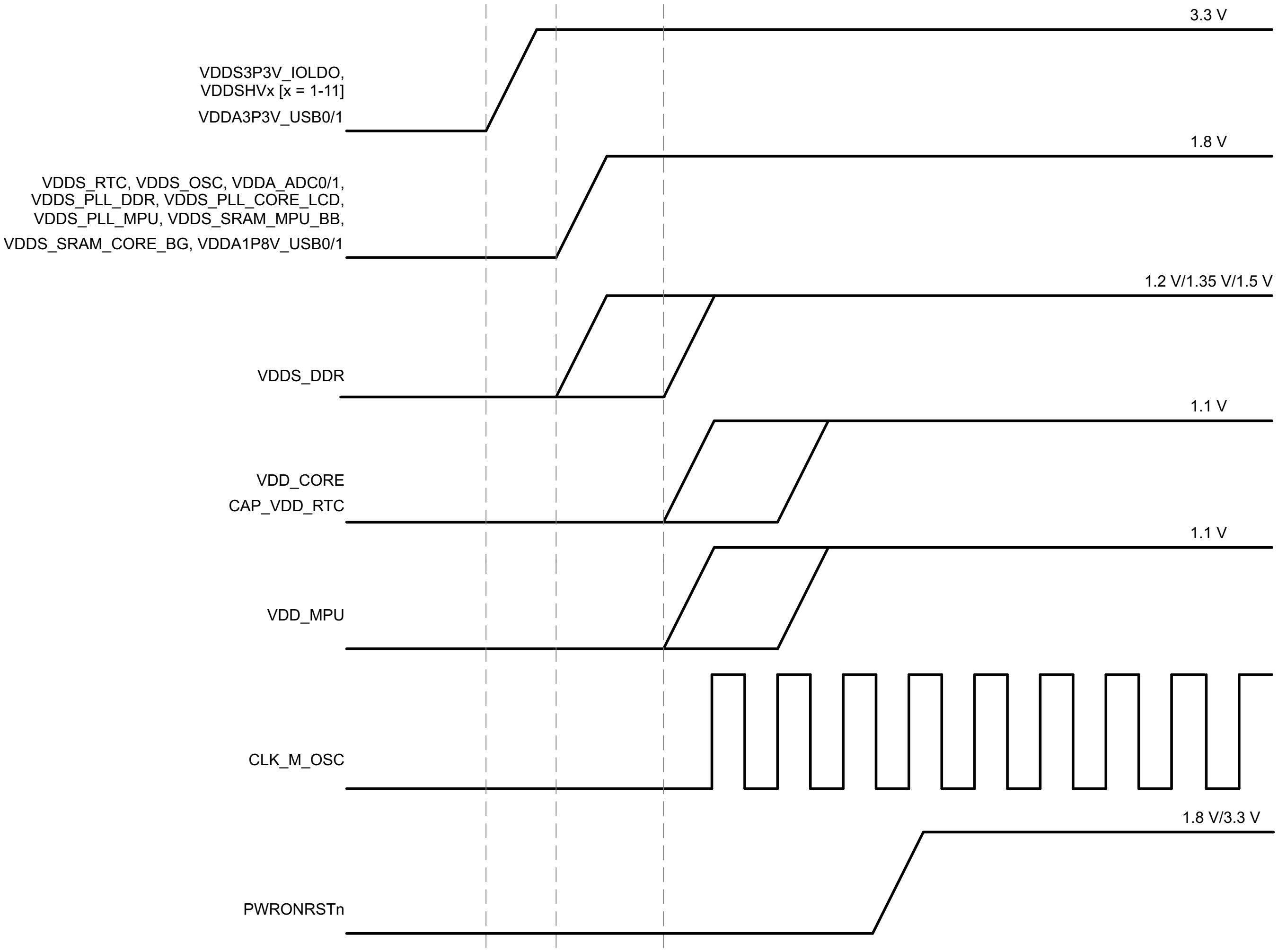

Figure 2. Power-On Sequence for AM437x

The proper connections for this power-on sequencing are shown in Figure 3. When the 5-V rail is on, R4 and C6 provide an RC delay to the EN pin of the TLV62565. After the TLV62565 starts up, the 3.3-V output rail is connected to another RC delay, R7 and C8, which provides the EN signal for both LDOs. When the EN signal ramps up to the threshold voltage of the TLV70215 and TLV70218, these two ICs begin to start up. In this way, the 3.3-V rail and 1.5-V/1.8-V rails are powered on in the right sequence. Lastly, the EN pin of the TLV62080 is connected to the output of the 1.5-V rail by an RC delay, R8 and C10. In this way, the 1.1-V rail is powered on after the 1.5-V/1.8-V rails.

1.2 Power-Off Sequence

As shown in the AM437x data sheet, the preferred way to sequence power off is to have all the power supplies ramped down sequentially in the exact reverse order of the power-on sequence. In other words, the power supply that has been ramped up first should be the last one that is ramped down. This ensures no spurious current paths during the power-off sequence.

When using the simplified power-down sequence, there is no power-off requirement between the VDDS, VDDS_CLKOUT and VDDSHVx supplies. All supplies are ramped down together without any reliability concern.

The proper connections for this power-off sequencing are shown in Figure 3.

2 Schematic

Figure 3 shows the circuit schematic detailing the external components required by the optimized discrete solution to achieve the 3.3-, 1.5-, 1.8- and 1.1-V power rails required by the AM437x. In addition, Figure 3 shows the sequencing circuits with RC delays that achieve the proper power-on, power-off, and PWRONRSTn sequencing required by the AM437x.

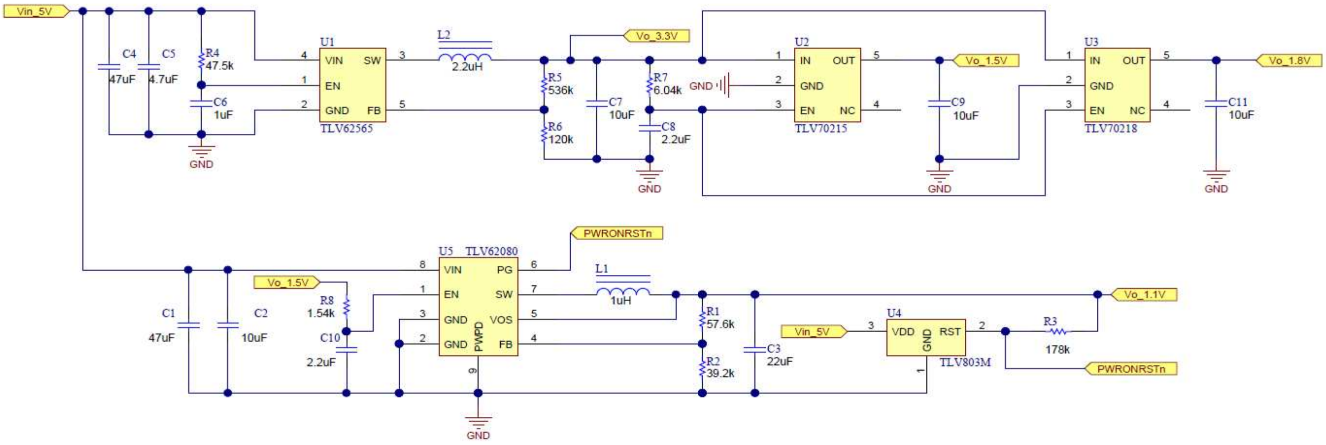

Figure 3. Powering and Sequencing Circuit for AM437x Requirements

3 Waveforms

The following waveforms demonstrate that the power-on and power-off sequences of the discrete devices meet the requirements of the AM437x.

Figure 4 shows the power-on sequence for the 5-V, 3.3-V, 1.5-V and 1.1-V voltage rails.

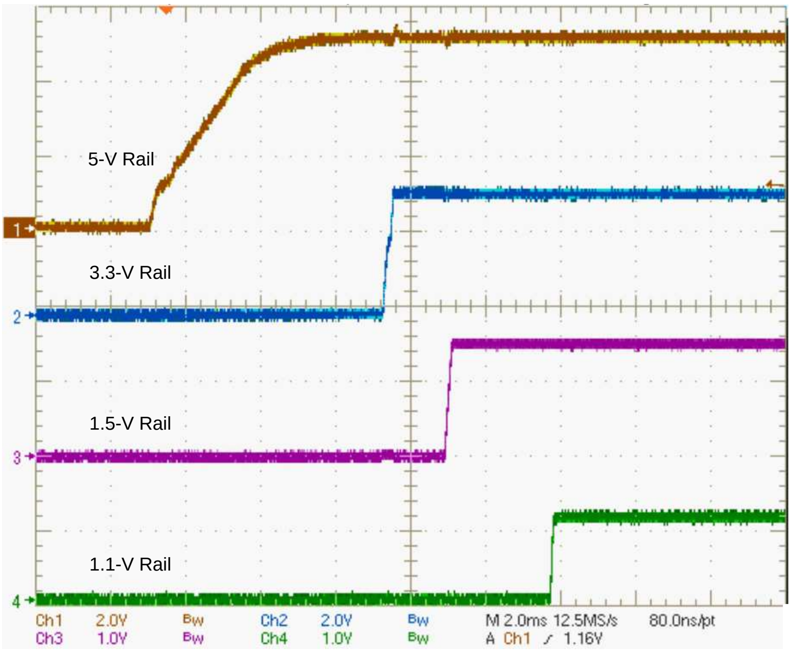

Figure 4. Power-On Sequence with Converter Rails

Figure 5 shows the power-on sequence for all the required power supplies for AM437x.

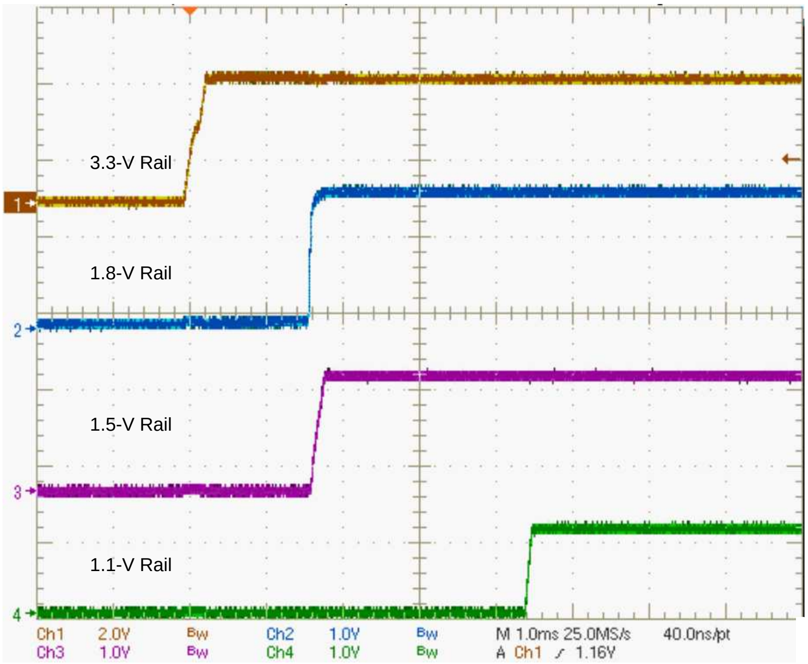

Figure 5. Power-On Sequence for AM437x

After all the power rails are on, the PORZn signal is pulled high about 200 ms later, as shown in Figure 6.

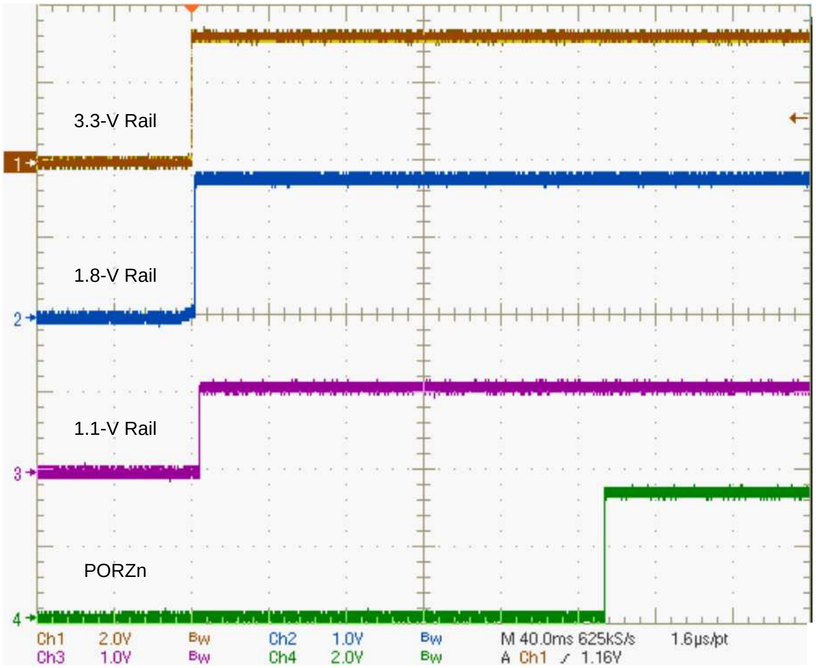

Figure 6. Power-On Sequence with PORZn Signal

Figure 7 shows the power-off sequence of the voltage rails with the PORZn signal. When the PORZn signal goes low, the processor enters the reset state and all rails are safe to turn off as their input voltage drops.

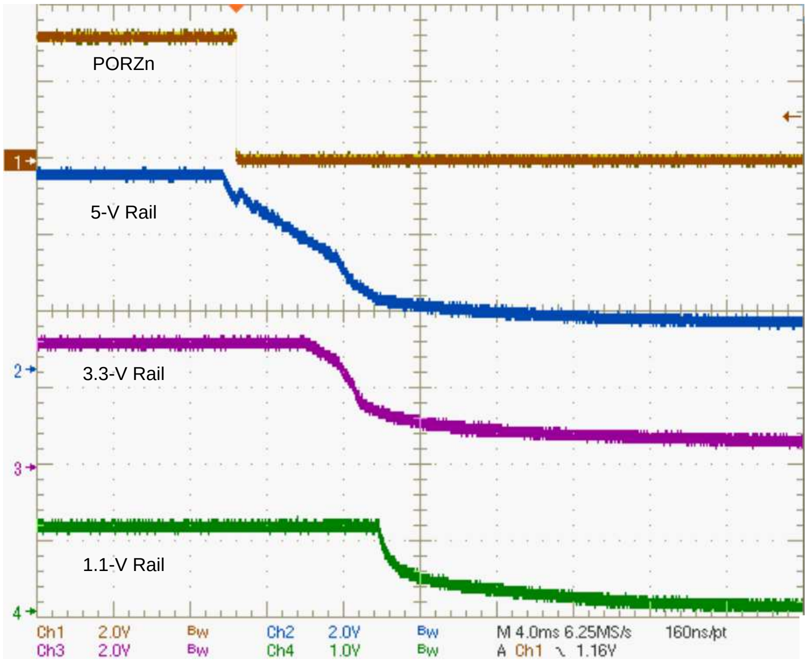

Figure 7. Power-Off Sequence with PORZn Signal

The voltage rail’s power-off sequence is shown in Figure 8.

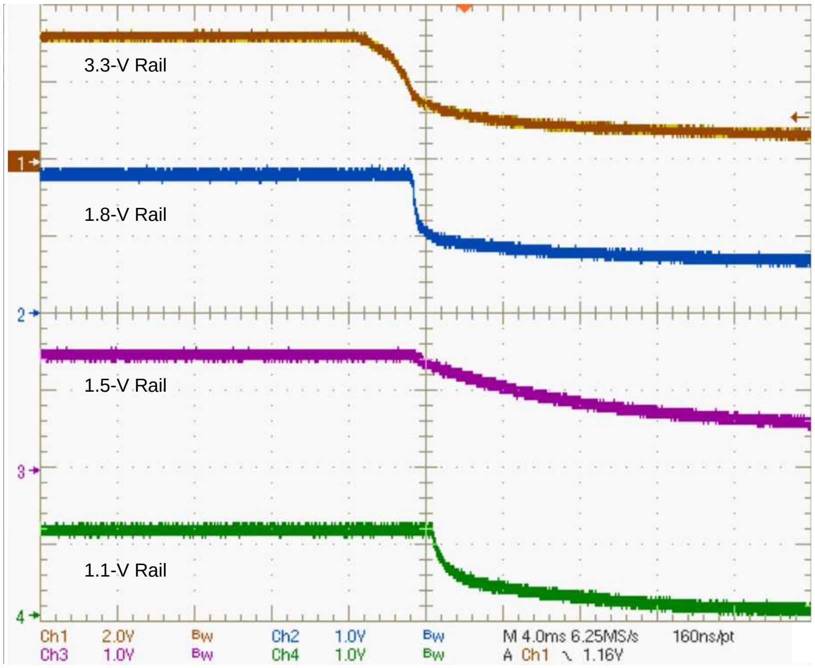

Figure 8. Power-Off Sequence with All Power Supply Rails

4 Bill of Materials

The bill of materials for the BOM-optimized discrete power solution is listed in Table 2.

Table 2. Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
2	C1, C4	47uF	Capacitor, ceramic, 6.3-V, X5R, 20%	0805	Std	Std
4	C2, C7, C9, C11	10uF	Capacitor, ceramic, 6.3-V, X5R, 20%	0603	Std	Std
1	C3	22uF	Capacitor, ceramic, 6.3-V, X5R, 20%	0805	GRM21BR60J226ME39L	Murata
1	C5	4.7uF	Capacitor, ceramic, 6.3-V, X5R, 20%	0603	GRM188R60J475ME84	Murata
1	C6	1uF	Capacitor, ceramic, 10-V, X5R, 20%	0603	GRM188R61A105KA61	Murata
2	C8, C10	2.2uF	Capacitor, ceramic, 6.3-V, X5R, 20%	0603	GRM188R61A225KE34	Murata
1	R1	57.5kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R2	39.2kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R3	178kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R4	47.5kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R5	536kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R6	120kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R7	6.04kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	R8	1.54kΩ	Resistor, chip, 1/16W, 1%	0603	Std	Std
1	L1	1uH	Inductor, power, 2.2-A, ±20%	3.05 mm 3.05mm	XFL3012-102MEB	Coilcraft
1	L2	2.2uH	Inductor, LQH44PN_SERIES, ± 20%	1515	LQH44PN2R2MP0	Murata
1	U1	TLV62565	IC, 1.5A High Efficiency Step Down Converter	SOT-23-5	TLV62565DBV	TI
1	U2	TLV70215	IC, 300mA low drop regulator	SOT-23-5	TLV70215DBV	TI
1	U3	TLV70218	IC, 300mA low drop regulator	SOT-23-5	TLV70218DBV	TI
1	U4	TLV803M	IC, 3pin voltage supervisors	SOT-23-3	TLV803ZDBZ	TI
1	U5	TLV62080	IC, 1.2-A sync. step-down converter	SON-8	TLV62080DSG	TI

5 Power-Up Sequence for TLV70215 and TLV70218

There could be a small difference of startup time between the TLV70215 and TLV70218, but this is unimportant for the AM437x. Though they are from the same LDO family (TLV702xx) and share the same EN signal, it cannot be ensured that the TLV70215 and TLV70218 start simultaneously.

There are two factors leading to the different startup time of the two devices. The first factor is the different EN threshold voltages of the two devices. Though the TLV70215 and TLV70218 are from the same LDO family, parameter variation leads to possibly different EN thresholds, as shown in Figure 9.

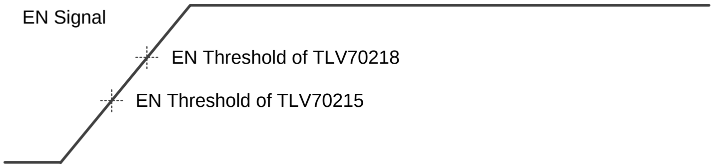

Figure 9. Potentially Different EN Thresholds of the two Devices

Secondly, the delay time after receiving the EN signal is also different. With a very sharp EN signal, the influence of different EN thresholds is insignificant. However, even with the same EN signal and without any threshold difference, the delay time of the TLV70215 (Delay1) and the TLV70218 (Delay2) is possibly different, as shown in Figure 10.

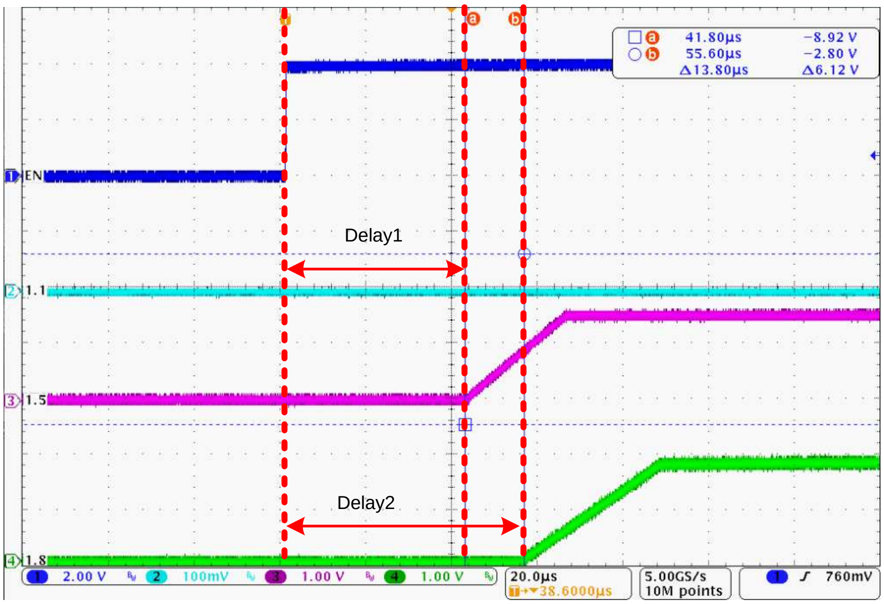

Figure 10. Potentially Different Delays with Sharp EN Signal

These two factors create the small startup time difference between the TLV70215 and TLV70218. It is very difficult to eliminate the different startup time since parameter variation between the devices cannot be controlled accurately. However, this small difference has no influence on the power-on sequence for the AM437x.

6 Slew Rate Requirement

To maintain the safe operating range of the internal ESD protection devices, it is recommended to limit the maximum slew rate of all supplies to be less than 1.0E +5 V/s.

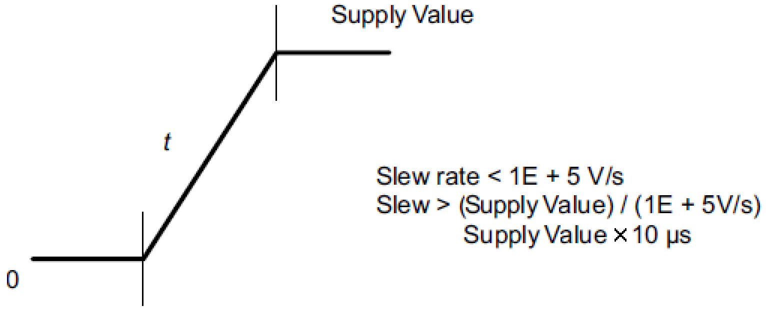

Figure 11. Power Supply Slew Rate Requirement

The TLV62565 for the 3.3-V rail has a fixed startup time of about 250 µs. The TLV62080 for the 1.1-V rail has a fixed soft start time of 100 µs. Both meet the requirement of a slew rate < 1E +5 V/s.

The 1.8-V and 1.5-V rails only have current limit during startup and not a controlled slew rate. The slew rate of the output voltage is decided by the output capacitor and current limit. On the 1.8-V rail for example, the startup time should be greater than 18 µs. From the data sheet of the TLV70218 (SLVSAG6), the maximum current limit is 860 mA. According to the following equation, using an output capacitor larger than 8.6 µF at the 1.8-V output meets the slew rate requirement.

$$\frac{I_{Current\_limit}}{C_{OUT}} = \frac{V_{OUT}}{\text{Slew Rate}} \qquad (1)$$

Thus, the minimum output capacitor for TLV702xx is calculated according to Equation 1.

7 Supporting AM437x 1-GHz Operation

The AM437x Sitara processors support up to 1000-MHz CPU frequency. For running the processor at 1 GHz with the discrete power solution, the VDD_MPU power supply should be powered by a 1.325-V power supply. Figure 12 shows the block diagram of supporting 1-GHz processor operation. The VDD_MPU power supply is powered at 1.325-V by an additional TLV62565 step-down converter. The same enable signal from the RC delay output of 1.5-V DDR power supply can be used for enabling the TLV62565.

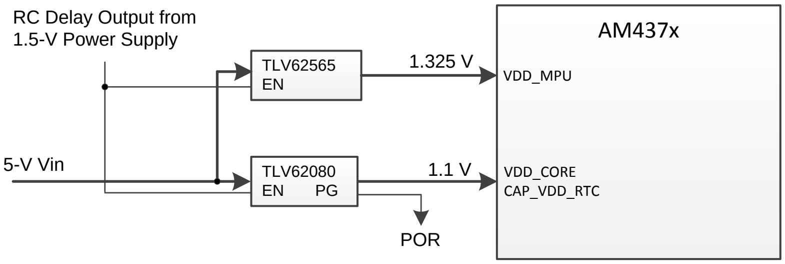

Figure 12. Block Diagram of 1-GHz Mode Support

8 Conclusion

The TLV62565 and TLV62080 step-down converters combined with the TLV70218 and TLV70215 LDOs provide a BOM-optimized, discrete power solution for the AM437x. This reference design demonstrates the external components of the discrete ICs to provide the required voltage rails and RC delay circuits that meet the power-on and power-off sequencing requirements of the AM437x processor. This document can be used as a reference for choosing a series of discrete devices for powering the AM437x.

9 References

1. TLV62565, 1.5-A High Efficiency Step-Down Converter in SOT23-5 Package data sheet (SLVSBC1)
2. TLV62080, 1.2 A High Efficient Step-Down Converter in 2x2 mm SON Package data sheet (SLVSAK9)
3. TLV702xx, 300-mA, Low-IQ, Low-Dropout Regulator data sheet (SLVSAG6)
4. TLV803M, 3-Pin Voltage Supervisors with Active-Low, Open-Drain Reset data sheet (SBVS157)
5. AM437x, AM437x Sitara Processors data sheet (SPRS851)

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