REFERENCE DESIGN

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CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

1.0 Introduction

CAES Quad Voltage Supervisors (UT04VS33P, UT04VS50P) find broad applications in voltage monitoring, voltage sequencing, and Fault Detection, Isolation and Recovery (FDIR). The voltage sequencing function is important for FPGA and ASIC designs that require a fixed order of voltage power-up for the core, high-speed I/O, and low-speed I/O power supplies to prevent contention and anomalously high currents. In the same way, they also often require a power down sequence that reverses the forward order of power up. Stand-alone CAES Quad Voltage Supervisors define the order for power-up sequencing and maintain this same order during power-down. This Reference Design provides a simple method of using a minimal number of 8-bit (8-b) MSI logic gates with CAES Quad Channel Voltage Supervisors to create the CASE Intelligent Power Sequencer Reference Design that powers-down system power rails in the reverse order of power up.

2.0 Device Features and Demonstration Board

The CAES Intelligent Power Sequencer as described in this Reference Design document generates forward power-up and reverse power-down voltage sequences useful in power systems design. The block diagram is shown as Figure 1. There are four primary functional parts of the design:

1) The 8-b MSI Power Sequencing Logic, consisting of three required logic ICs: a) CAES UT54ACS/ACTS02E Quad 2-Input NOR Gate , b) CAES UT54ACS/ACTS04E Hex Inverters , and c) CAES UT54ACS/ACTS08E Quad 2-Input AND Gate. One additional, supplemental logic/driver IC is included for driving the discrete LED display.

2) Four identical Voltage Regulator ICs for generating the four system-level power rails.

3) One CAES UT04VS33P Quad Voltage Supervisor IC for voltage monitoring and as part of the overall voltage sequencing logic.

4) One 5.0V to 3.3V Voltage Regulator is also included, representing a stable, system-level power supply that generates VDD=3.3V for the 8-b RHMSI Logic and the UT04VS33P Voltage Supervisor. The CAES Intelligent Power Sequencer Demonstration Board is shown in Figure 2.

Voltage comparators in the UT04VS33P Quad Voltage Supervisor generate "voltage good" enable logic signals (VOUTx) to sequence a series of four voltage regulators. The Quad Supervisor VOUTx signals serve as flags indicating that each monitored system voltage is within tolerance, which are 3.3V, 2.5V, 1.8V, and 1.5V nominal voltages in this application. The Quad Supervisors RESET/RESETB outputs provide final reset de-assert after all system voltages are within tolerance.

The CAES Intelligent Power Sequencer provides all hardware necessary for demonstrating the capabilities of forward order power-up, and reverse order power-down voltage sequencing via a visual display of four each of green and red light-emitting diodes (LEDs) turning on and off in the correct sequence, along with suitable time delays. The green LEDs indicate that the corresponding power rail is enabled, active, and on, while the red LEDs indicate that the corresponding power rail is disabled, inactive, and off. The board circuit design components, with the exception of the CAES UT04VS33P Voltage Supervisor (U10), are implemented with commercial grade integrated circuits (ICs), and discrete components, since voltage regulators and logic gates are typically standard functions and pinouts. The board is intended to show the power-up/down sequencing function, and is intended for terrestrial use only in non-radiation, benign environments. For a sequencer design suitable for radiation or other harsh environments, the user would substitute the CAES 8-b RHMSI logic parts listed above, and in the Reference Design schematics for the necessary logic, along with all other ICs, such as voltage regulators, and discrete components as determined by the user to meet their particular system-level environmental requirements.

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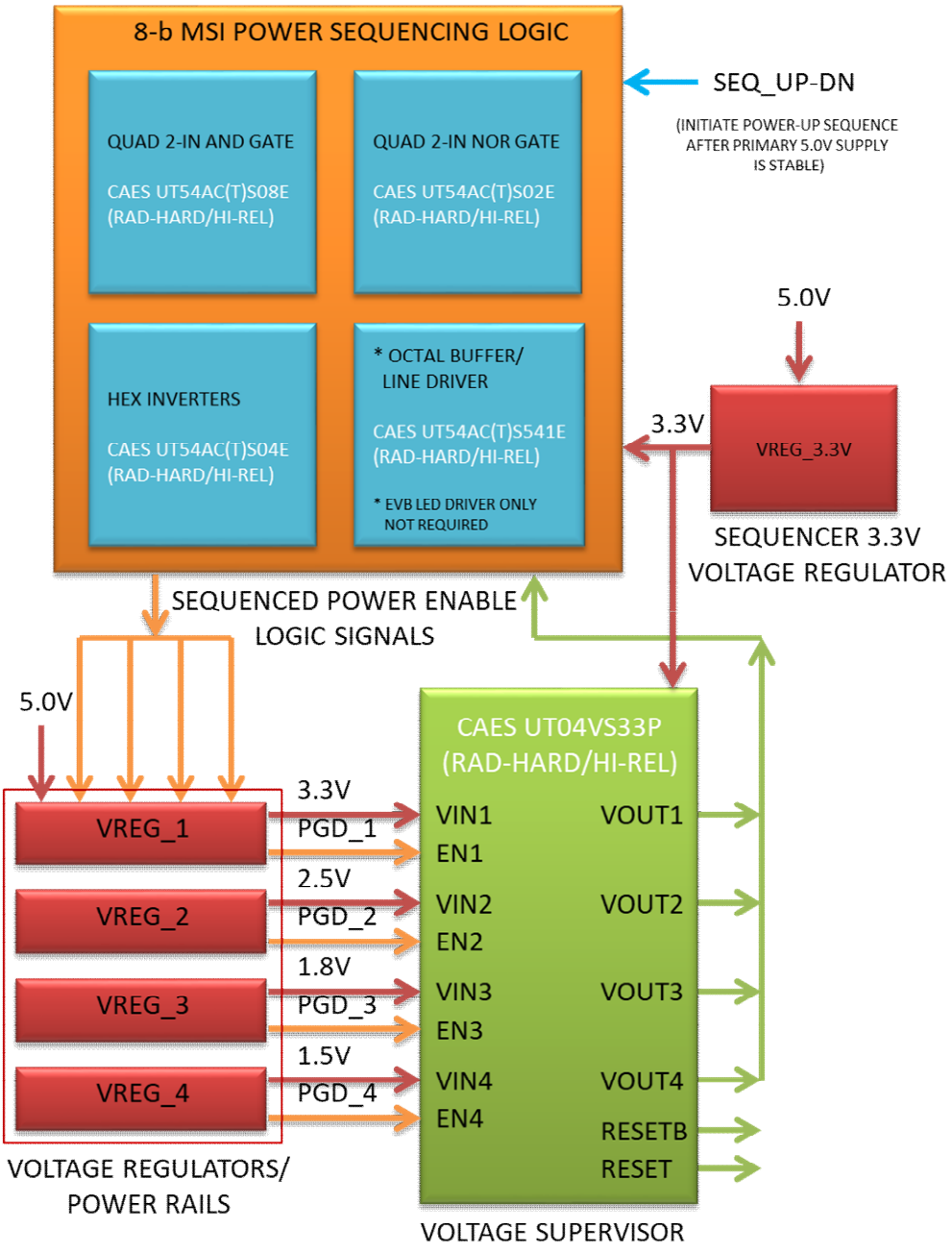

Figure 1. CAES Intelligent Power Sequencer Block Diagram

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

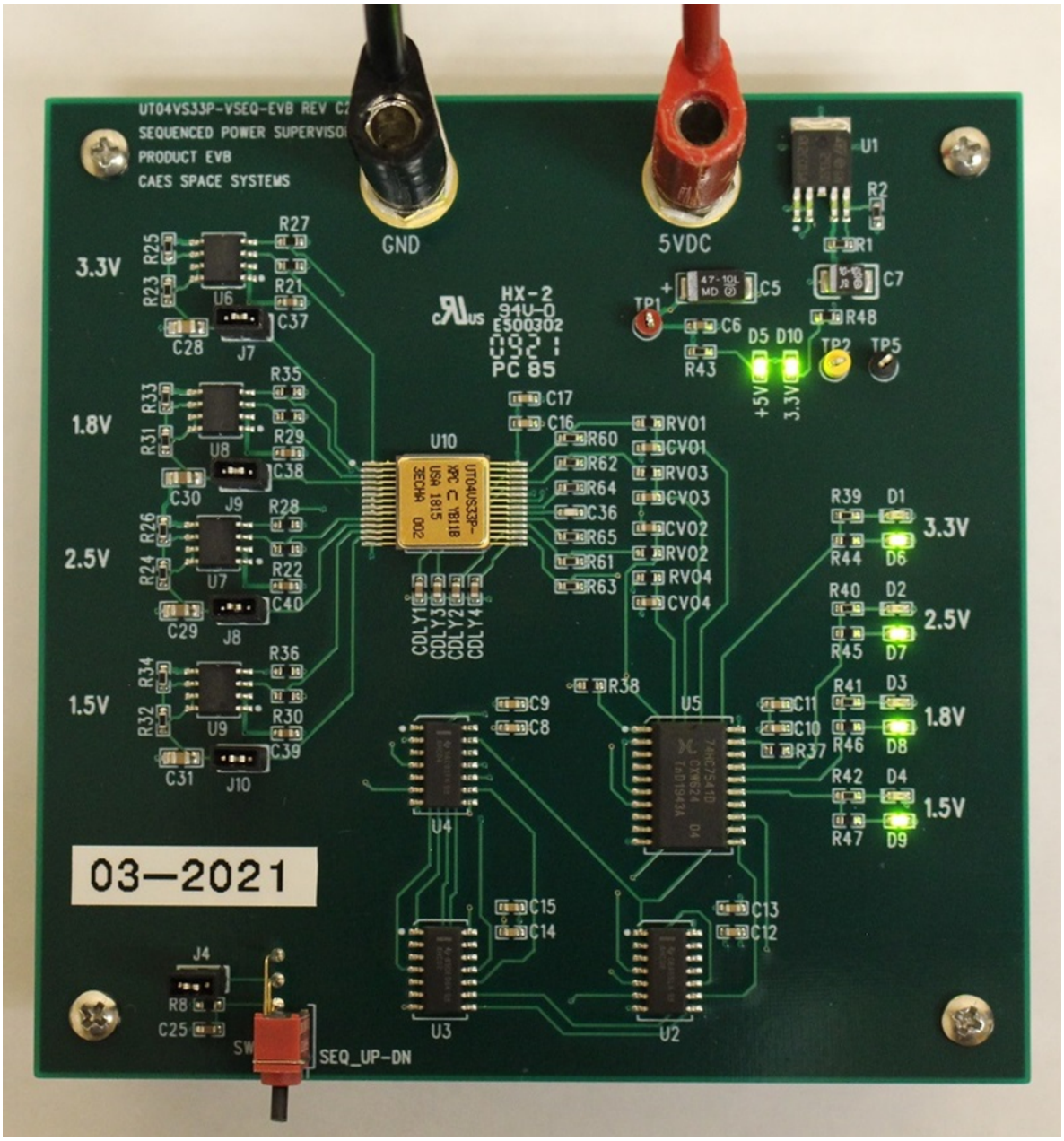

Figure 2. CAES Intelligent Power Sequencer Demonstration Board, Top View

3.0 Intelligent Power Sequencing Application

Demonstration Board operation: Toggling the two position SEQ_UP-DN SPDT switch from a logic 0 to a logic 1 initiates the power-up sequence. The time delay for power-up sequencing is set by the external CDLY capacitor value. The Demonstration Board uses CDLYx values of 1µF for approximately 1s of delay. Voltage comparators in the UT04VS33P Quad Supervisor create a series of enable signals to start the monitored voltages and sequence them up in order of VOUT1, VOUT2, VOUT3, VOUT4. The comparators in the Quad Supervisor verify each voltage rail is within tolerance before enabling the next rail. All four green LEDs illuminated indicates that the power-up sequence is complete.

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

Toggling the SEQ_UP-DN switch from logic 1 to logic 0 initiates the Voltage Supervisor and MSI Logic to disable the voltage regulators in the reverse order of the power-up sequence. The Voltage Supervisor disables each power rail as the logic waterfall occurs. Since it's desirable from a system-level to power-down the power supply rails quickly in the event of a fault, this shutdown normally occurs in 40µs or less. However, the Demonstration Board uses a simple 1MΩ/1µF R-C network at each of the UT04VS33P VOUTx logic outputs to add an approximate 1s delay in order to provide sufficient time for observable LED sequencing. All four red LEDs illuminated indicates that the power-down sequence is complete.

Since this R-C delay at the VOUTx outputs affects both rising and falling VOUTx edges, it will be combined with the power-up sequence CDLY delay to yield an approximate 2s total delay vs. an approximate 1s delay for power-down sequencing. The voltage sequencing and delays are shown in the oscilloscope voltage vs. time plots of Figures 3, 4, and 5, below, where "time" is the x-axis and "voltage" is the y-axis. These waveforms were measured at the four voltage regulator output pins on the Demo. Board (J7-J10) using high impedance, 1MΩ oscilloscope probes, with a horizontal (time) scale of either 1s/div., or 2s/div. The vertical (voltage) axis scale is 1.0V/div. Figure 6 shows the core CAES Intelligent Power Sequencer logic signals and logic implementation, without delay elements or LED display circuits. The Demonstration Board schematics are provided as Figures 7-11.

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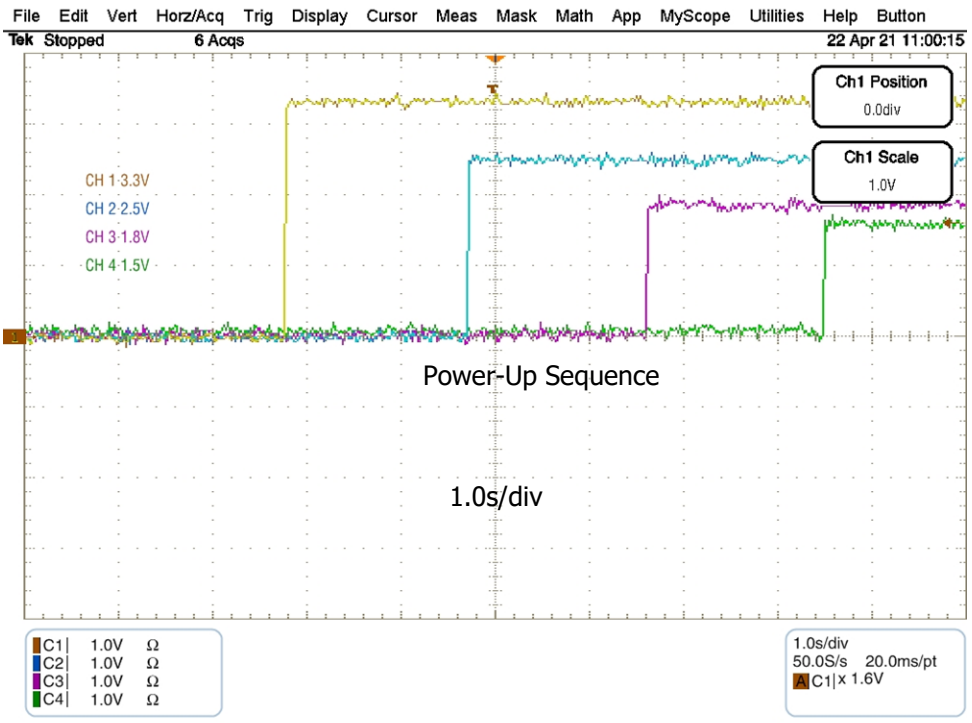

Figure 3. UT04VS33P-VSEQ-EVB Oscilloscope Voltage Power-Up Sequence Waveforms

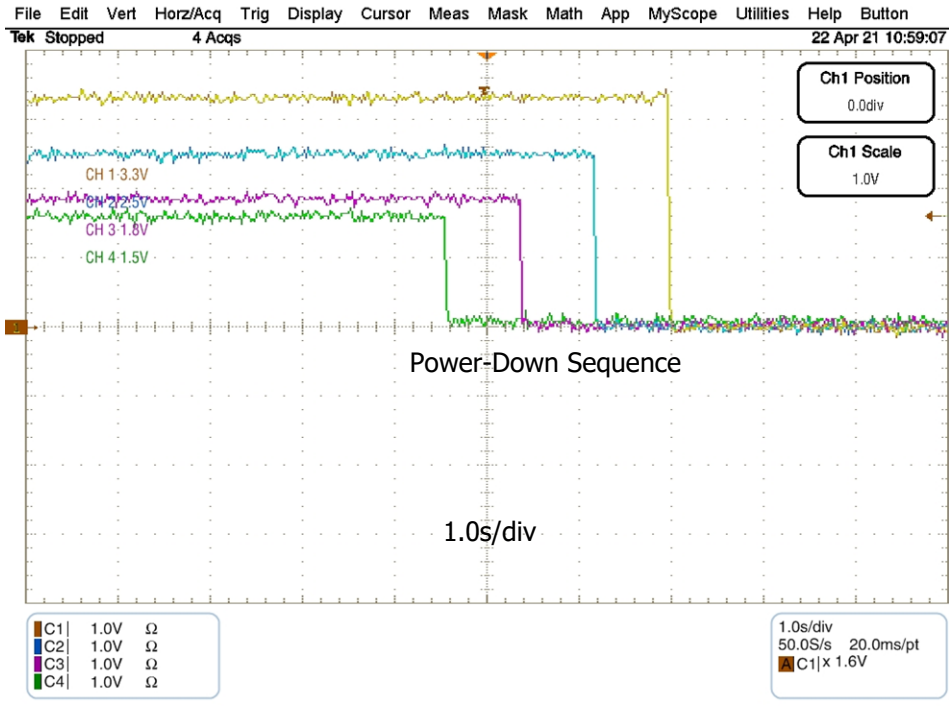

Figure 4. UT04VS33P-VSEQ-EVB Oscilloscope Voltage Power-Down Sequence Waveforms

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

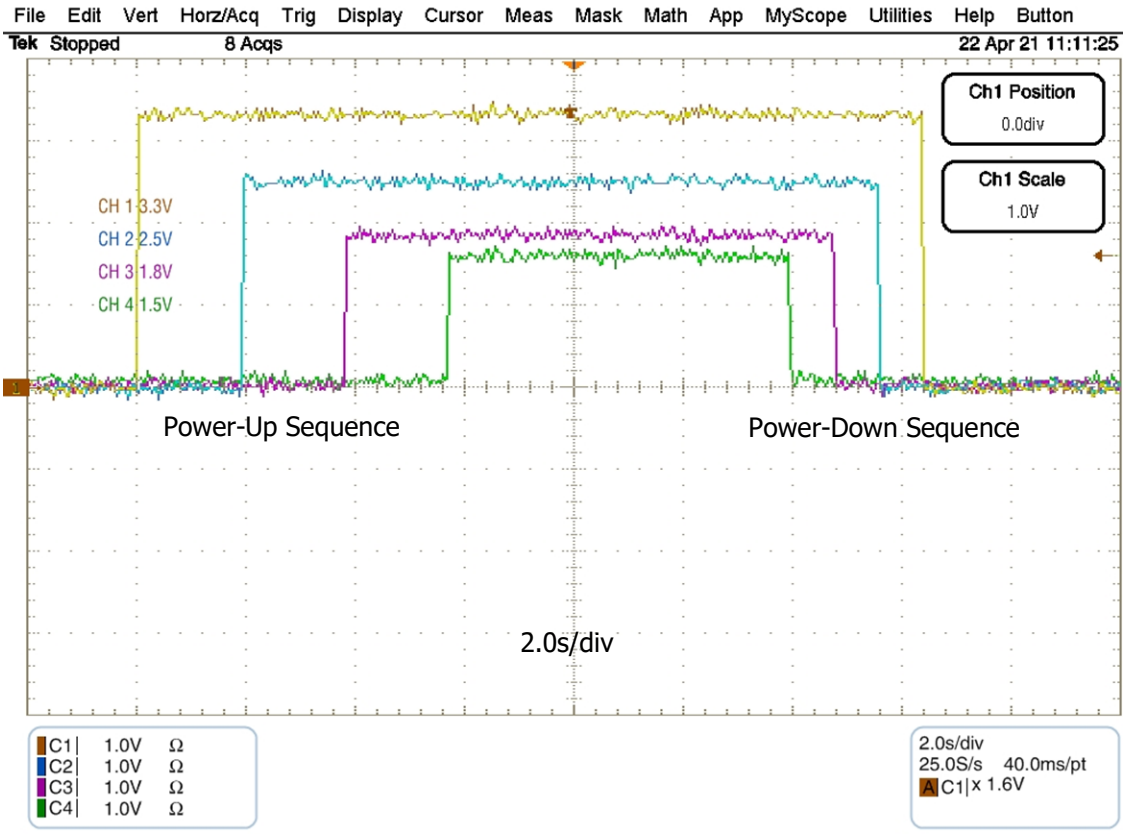

Figure 5. UT04VS33P-VSEQ-EVB Oscilloscope Combined Voltage Power-Up/Down Sequence Waveforms

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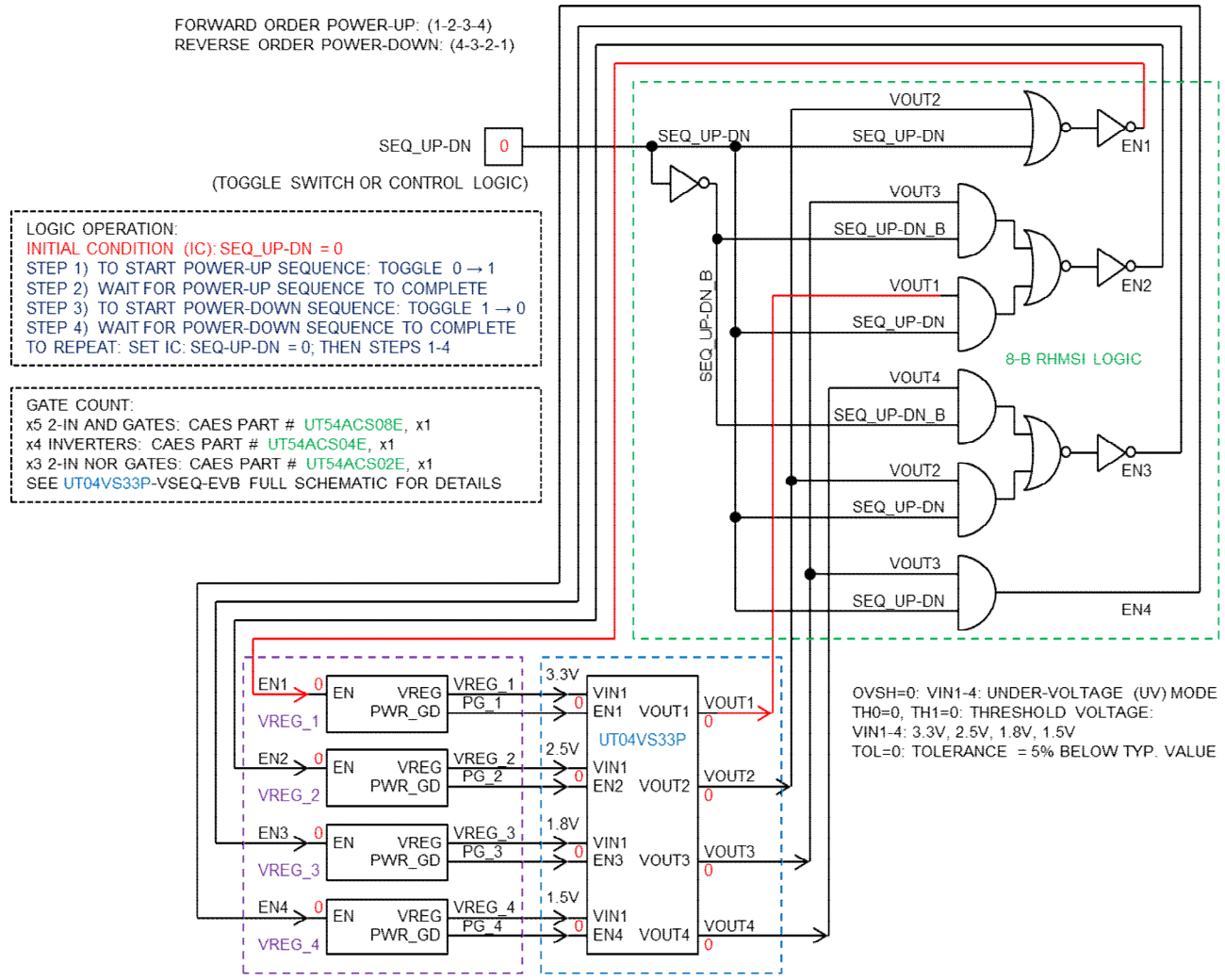

Figure 6. Core Logic Signal Connections +MSI Logic Schematic

4.0 Conclusion

The CAES Intelligent Power Sequencer uses the UT04VS33P Quad Voltage Supervisor in combination with a small number of 8-b RHMSI logic gates to sequence voltage rails in any order with adjustable delays for each rail. This design provides a solution to FPGA and ASIC sequenced power-up and power down requirements. The CAES Quad Voltage Supervisors power-down implementation sequences quickly, which allows for emergency shutdowns. However, if power-down delays are necessary, a simple R-C network connected to the voltage supervisor ENx, or VOUTx pins is an option, as shown in this Reference Design. Please see schematics and bill of materials (BoM) included below for additional information.

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CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

Table 1. Demonstration Board Reference Design Bill of Materials (BoM)

Item #	Qty.	Description	Reference Number	Mfr.	Mfr. Part #	PCB Footprint	Comp. Value	Digi-Key	Digi-Key Part #
1	12	CAP CER 1UF 16V X7R 0603	CVO1,CDLY1,CVO2,CDLY2, CVO3,CDLY3,CVO4,CDLY4, C37,C38,C39,C40	Samsung	CL10B105KO8VPNC	SMT0603	1uF	Digi-Key	1276-6613-1-ND
2	1	CAP TANT 47UF 10V 10% 2312	C5	Vishay Sprague	293D476X9010C2TE3	C_CASE / 2312 / 0.236"L x 0.126"W (6.00mm x 3.20mm)	47UF	Digi-Key	718-1087-1-ND
3	1	CAP CER 0.33UF 16V X7R 0603	C6	Murata	GRM188R71C334KA01D	SMT0603	0.33UF	Digi-Key	490-3294-1-ND
4	1	CAP TANT 10UF 10V 10% 1411	C7	Vishay Sprague	293D106X9010B2TE3	B_CASE / 1411 / 0.138"L x 0.110"W (3.50mm x 2.80mm)	10UF	Digi-Key	718-1122-1-ND
5	5	CAP CER 0.1UF 10V X7R 0603	C8,C10,C12,C14,C16	Kemet	C0603C104K8RACTU	SMT0603	0.1UF	Digi-Key	399-1095-6-ND
6	5	CAP CER 10000PF 25V X7R 0603	C9,C11,C13,C15,C17	Samsung	CL10B103KA8WPNC	SMT0603	0.01UF	Digi-Key	1276-6531-1-ND
7	1	CAP CER 2.2UF 10V X7R 0603	C25	Murata	GRM188R71A225KE15D	SMT0603	2.2UF	Digi-Key	490-4520-1-ND
8	4	CAP CER 4.7UF 16V X7R 0805	C28,C29,C30,C31	Murata	GRM21BR71C475KE51L	SMT0805	4.7UF	Digi-Key	490-14466-1-ND
9	1	CAP CER 68PF 16V C0G/NP0 0603	C36	Kemet	C0603C680J4GAC7867	SMT0603	68PF	Digi-Key	399-15418-1-ND
10	4	LED RED CLEAR 0603 SMD	D1,D2,D3,D4	Lite-On	LTST-C190CKT	LED_0603	RED	Digi-Key	160-1181-1-ND
11	6	LED GREEN CLEAR 0603 SMD	D5,D6,D7,D8,D9,D10	Lite-On	LTST-C190GKT	LED_0603	GREEN	Digi-Key	160-1183-1-ND
12	2	HDWR BANANA JACK UNINS	J1,J2	Pomona	3267	MH256_PLATED	BANANA JACK	Digi-Key	501-1115-ND
13	5	CONN HEADER VERT 2POS .100 "	J4,J7,J8,J9,J10	Sullins	PRPC002SAAN-RC	2x1_HEADER	HEADER 2	Digi-Key	S1011EC-02-ND
14	5	CONN JUMPER/SHUNT SHORTING 2POS .100"	J4,J7,J8,J9,J10	Sullins	QPC02SXGN-RC	2x1_JUMPER-SHUNT	JUMPER-SHUNT 2	Digi-Key	S9337-ND
15	4	RES SMD 1M OHM 1% 1/10W 0603	RVO1,RVO2,RVO3,RVO4	Vishay Dale	CRCW06031M00FKEA	SMT0603	1M	Digi-Key	541-1.00MHCT-ND
16	1	RES SMD 24.9K OHM 1% 1/10W 0603	R1	Panasonic	ERJ-3EKF2492V	SMT0603	24.9K	Digi-Key	P24.9KHCT-ND
17	1	RES SMD 14.7K OHM 1% 1/10W 0603	R2	Panasonic	ERJ-3EKF1472V	SMT0603	14.7K	Digi-Key	P14.7KHCT-ND
18	1	RES SMD 1K OHM 1% 1/10W 0603	R8	Vishay Dale	CRCW06031K00FKEA	SMT0603	1K	Digi-Key	541-1.00KHCT-ND
19	4	RES SMD 100K OHM 1% 1/10W 0603	R21,R22,R29,R30	Vishay Dale	CRCW0603100KFKEA	SMT0603	100K	Digi-Key	541-100KHCT-ND
20	3	RES SMD 35.7K OHM 1% 1/10W 0603	R23,R24,R31	Panasonic	ERJ-3EKF3572V	SMT0603	35.7K	Digi-Key	P35.7KHCT-ND
21	1	RES SMD 11.5K OHM 1% 1/10W 0603	R25	Panasonic	ERJ-3EKF1152V	SMT0603	11.5K	Digi-Key	P11.5KHCT-ND
22	1	RES SMD 16.9K OHM 1% 1/10W 0603	R26	Panasonic	ERJ-3EKF1692V	SMT0603	16.9K	Digi-Key	P16.9KHCT-ND
23	6	RES SMD 10K OHM 1% 1/10W 0603	R27,R28,R35,R36,R37,R38	Vishay Dale	CRCW060310K0FKEA	SMT0603	10K	Digi-Key	541-10.0KHCT-ND
24	1	RES SMD 41.2K OHM 1% 1/10W 0603	R32	Panasonic	ERJ-3EKF4122V	SMT0603	41.2K	Digi-Key	P41.2KHCT-ND
25	1	RES SMD 28.7K OHM 1% 1/10W 0603	R33	Panasonic	ERJ-3EKF2872V	SMT0603	28.7K	Digi-Key	P28.7KHCT-ND
26	1	RES SMD 47.5K OHM 1% 1/10W 0603	R34	Panasonic	ERJ-3EKF4752V	SMT0603	47.5K	Digi-Key	P47.5KHCT-ND
27	4	RES SMD 220 OHM 1% 1/10W 0603	R39,R40,R41,R42	Panasonic	ERJ-3EKF2200V	SMT0603	220	Digi-Key	P220HCT-ND
28	1	RES SMD 150 OHM 1% 1/10W 0603	R43	Panasonic	ERJ-3EKF1500V	SMT0603	150	Digi-Key	P150HCT-ND
29	5	RES SMD 60.4 OHM 1% 1/10W 0603	R44,R45,R46,R47,R48	Vishay Dale	CRCW060360R4FKEA	SMT0603	60	Digi-Key	541-60.4HCT-ND
30	6	RES SMD 3K OHM 1% 1/10W 0603	R60,R61,R62,R63,R64,R65	Panasonic	ERJ-3EKF3001V	SMT0603	3K	Digi-Key	P3.00KHCT-ND
31	1	SWITCH TOGGLE SPDT 0.4VA 20V	SW1	E-Switch	200USP1T1A1M7RE	200USP1T1A1M7RE	200USP1T1A1M7RE	Digi-Key	EG4916-ND
32	1	TEST POINT PC MINI 0.040"D RED	TP1	Keystone	5000	TP_40D	TESTPOINT	Digi-Key	36-5000-ND
33	1	TEST POINT PC MINI 0.040"D YELO	TP2	Keystone	5004	TP_40D	TESTPOINT	Digi-Key	36-5004-ND
34	1	TEST POINT PC MINI 0.040"D BLACK	TP5	Keystone	5001	TP_40D	TESTPOINT	Digi-Key	36-5001-ND
35	1	IC REG LDO ADJ 1.5A PPAK	U1	ST Microelectronics	LD29150PTR	ppak5	LD29150	Digi-Key	497-4250-1-ND
36	1	IC GATE AND QUAD 2-IN 14-SOIC	U2	Texas Instruments	SN74AHC08DR	14-SOIC_8.65x3.9x1.27mm	SN74AHC08DR	Digi-Key	296-4523-1-ND
37	1	IC GATE NOR QUAD 2-IN 14-SOIC	U3	Texas Instruments	SN74AHC02DR	14-SOIC_8.65x3.9x1.27mm	SN74AHC02DR	Digi-Key	296-4511-1-ND
38	1	IC INVERTER HEX 1-IN 14-SOIC	U4	Texas Instruments	SN74AHC04DR	14-SOIC_8.65x3.9x1.27mm	SN74AHC04DR	Digi-Key	296-4516-1-ND
39	1	IC BUFFER NON-INVERT S-T INPUTS 2-6V 20-SOIC	U5	Nexperia	74HC7541D	20-SOIC_12.8x7.5x1.27mm	74HC7541D	Digi-Key	1727-6344-1-ND
40	4	IC REG LINEAR POS ADJ 1.2A 8SOP	U6,U7,U8,U9	Diodes Inc	AP7167-SPG-13	8soic_1o27mm_3o9x4o9m m_pad_2o4x3o3mm	AP7167	Digi-Key	AP7167-SPGDICT-ND
41	4	HEX STAND-OFF #4-40 ALUMINUM 1"	N/A	RAF Electronic Hardware	2112-440-AL	0.125" dia. drill hole, 4 corners	Screw Thread #4-40 Stand-Off L=1"	Digi-Key	1772-1052-ND
42	4	MACHINE SCREW PAN PHILLIPS 4-40	N/A	Keystone Electronics	9900	0.125" dia. drill hole, 4 corners	Screw Thread #4-40 Screw Thread L=0.25"	Digi-Key	36-9900-ND
43	1	VOLTAGE SUPERVISOR 3.3V 4-CH.	U10	Cobham	UT04VS33P	cfp28p25mil	UT04VS33P	Cobham	N/A

Notes:

1) For radiation or other harsh environment designs, the three required CAES Space-grade 8-b RHMSI Logic parts are listed here with the equivalent Commercial-grade BoM 8-b MSI Logic parts.

Space-grade: CAES UT54ACS/ACTS08E Quad 2-Input AND Gate — Commercial-grade: BoM Item #36, U2, IC QUAD 2-IN AND GATE
Space-grade: CAES UT54ACS/ACTS02E Quad 2-Input NOR Gate — Commercial-grade: BoM Item #37, U4, IC QUAD 2-IN NOR GATE
Space-grade: CAES UT54ACS/ACTS04E Hex Inverters — Commercial-grade: BoM Item #38, U3, IC HEX INVERTERS

2) The Space-grade logic parts all share a common package and footprint: 14-L Ceramic FP. The Commercial-grade logic parts all share a common package and footprint: 14-L Plastic SOIC. Both space-grade and commercial 8-b MSI Logic package footprint types are available from CAES along with the UT04VS33P Quad Voltage Supervisor in a 28-L CFP package. The package pinouts are identical between these Space-grade and Commercial-grade logic parts, for the respective logic function.

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

3) Links to CAES 8-b RHMSI product Data Sheet pages here:

https://caes.com/sites/default/files/documents/Datasheet-UT54ACxS08E.pdf

Quadruple 2-Input AND Gates UT54ACS08E/UT54ACTS08E

https://caes.com/sites/default/files/documents/Datasheet-UT54ACxS02E.pdf

Quadruple 2-Input NOR Gate UT54ACS02E/UT54ACTS02E

https://caes.com/sites/default/files/documents/Datasheet-UT54ACS04E.pdf

Hex Inverters UT54ACS04E (The UT54ACTS04E Data Sheet is available separately.)

Table 2. Printed Circuit Board (PCB) Specifications

Generic Specifications		
Board Dimensions	4.0" × 4.0" (10.16cmx10.16cm), 0.062" Overall Thickness	
Board Maximum Weight	NA	
Number of Layers:	4	
Dielectric Material	FR-4	
Dielectric Thickness	NA	
Outer Layer Copper Weight	1oz	
Inner Layer Copper Weight	1oz	
Differential Line Spacing	NA	
Default Trace Width	12 mil	
Voltage Rails	**Voltage (V)**	**Current (A)**
Input	5.0	0.1
Internal Rail 1	3.3	0.1
Output 1	3.3	0.1
Output 2	2.5	0.1
Output 3	1.8	0.1
Output 4	1.5	0.1
Layer Definition	**Name**	**Type**
Layer 1	Top	Components + Signal Routing
Layer 2	GND	GND=VSS=0V
Layer 3	VDD Split Plane	VDD=5.0V, 3.3V
Layer 4	Bottom	Signal Routing

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

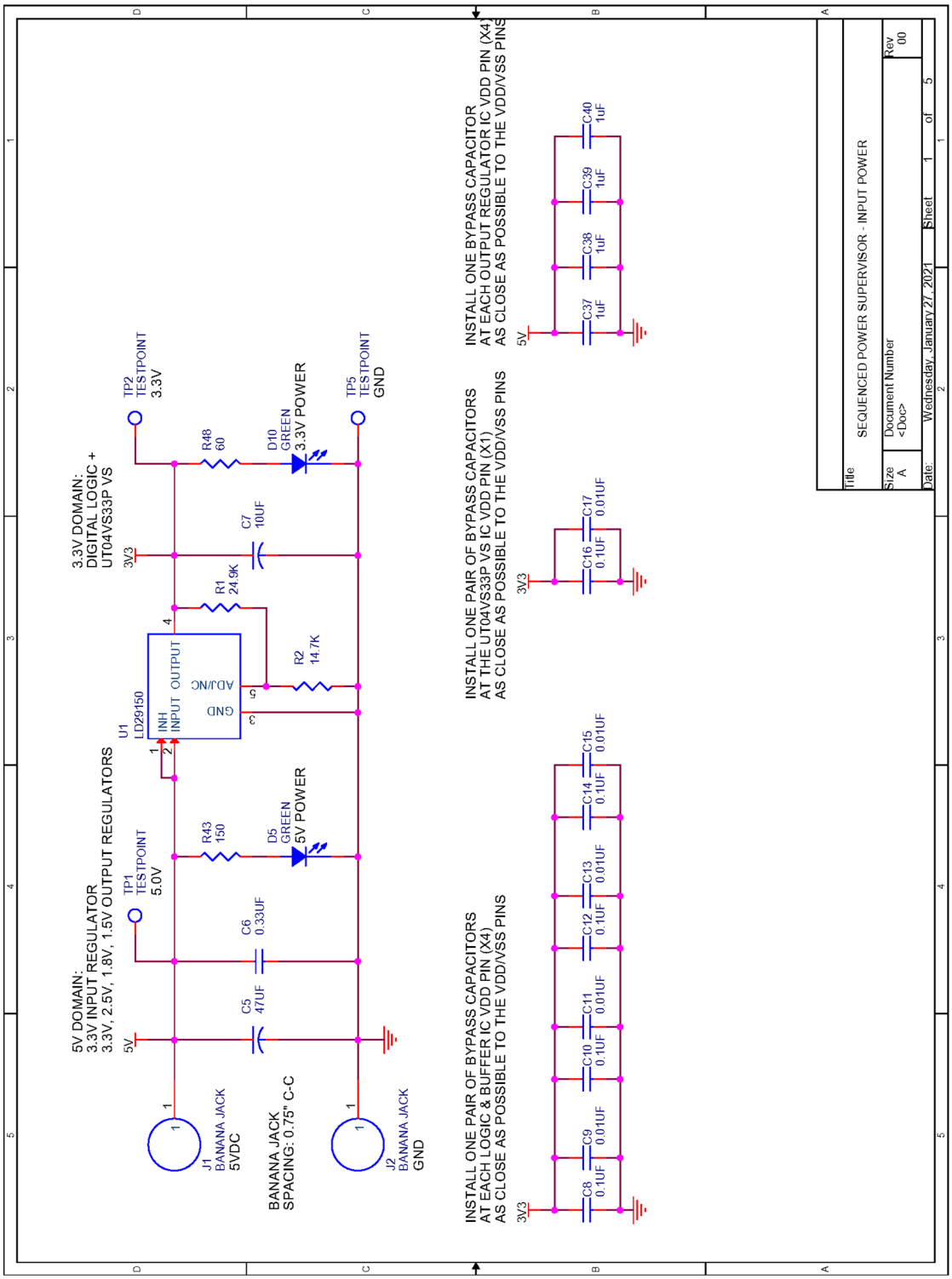

Figure 7. Schematic – Page 1 of 5: Input Power

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

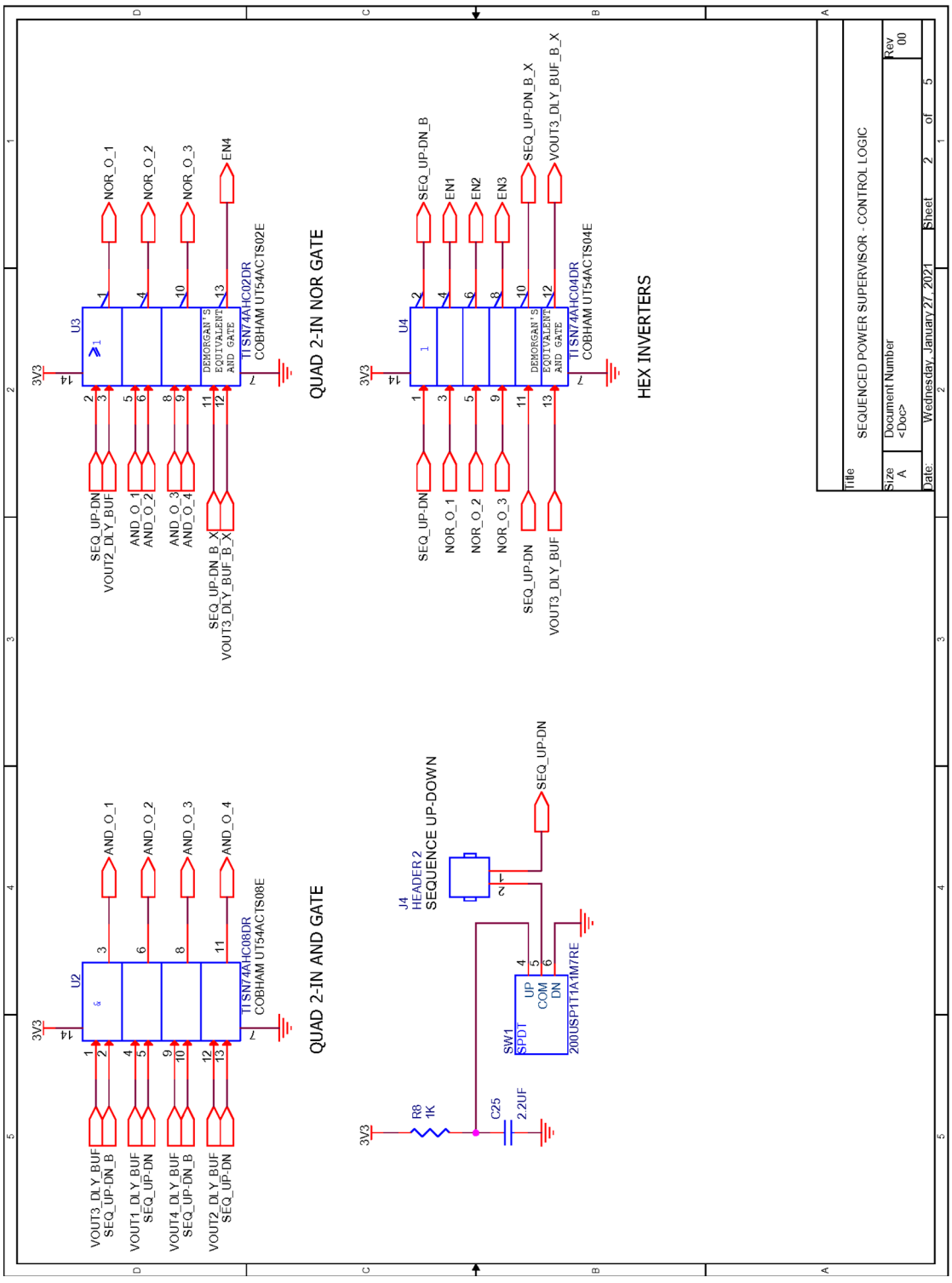

Figure 8. Schematic – Page 2 of 5: Control Logic

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

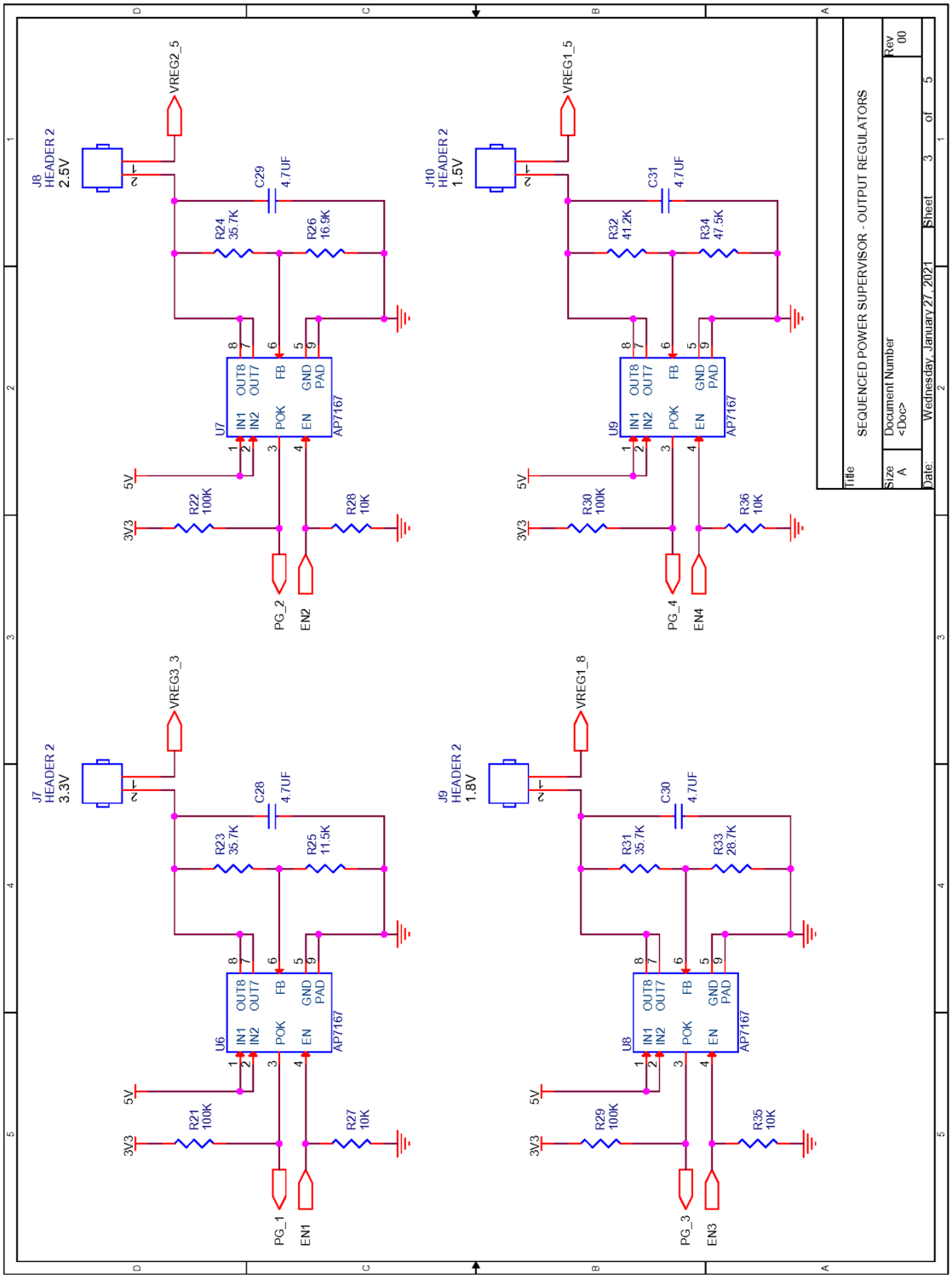

Figure 9. Schematic – Page 3 of 5: Output Regulators

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

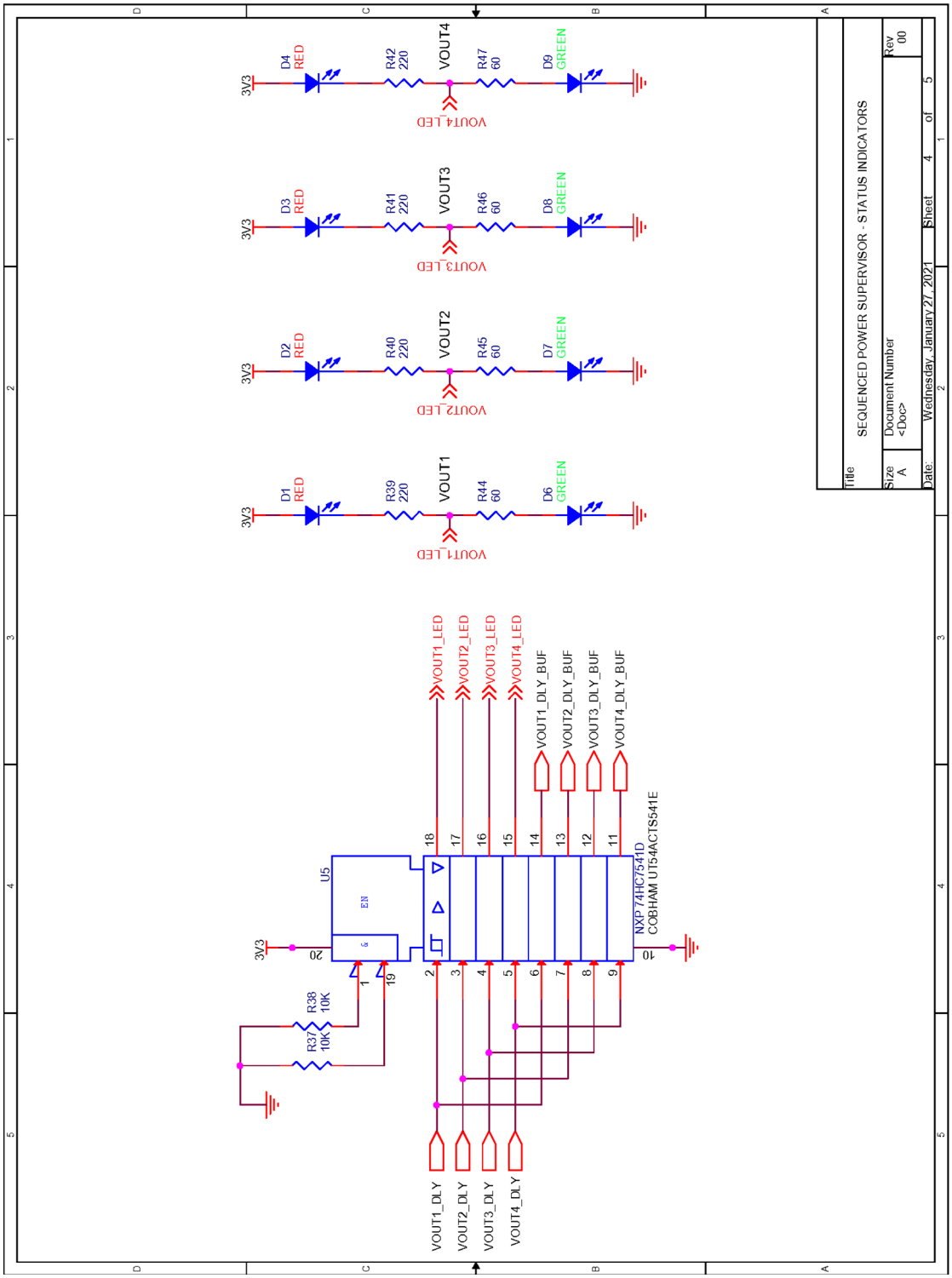

Figure 10. Schematic – Page 4 of 5: Status Indicators

CAES Intelligent Power Sequencer Using the UT04VS33P Quad Voltage Supervisor

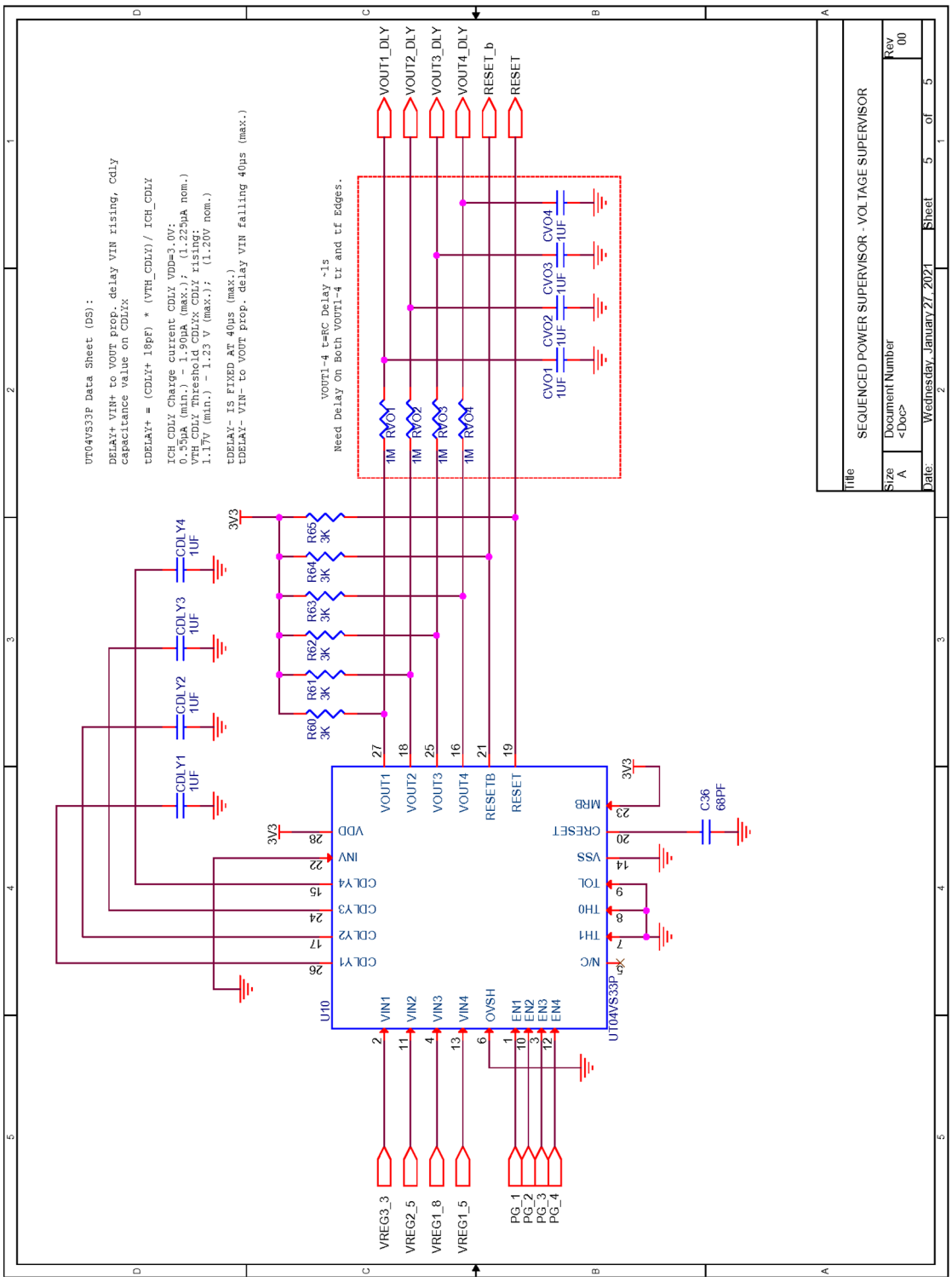

Figure 11. Schematic – Page 5 of 5: Voltage Supervisor

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REVISION HISTORY

Date	Revisions	Author	Change Description
12-12-2014	0.0.1	CB	Initial Release
04-29-2021	1.0.0	BM	Reduced Logic Gate Count

The following United States (U.S.) Department of Commerce statement shall be applicable if these commodities, technology, or software are exported from the U.S.: These commodities, technology, or software were exported from the United States in accordance with the Export Administration Regulations. Diversion contrary to U.S. law is prohibited.