ISLKU060DEMO1Z

Renesas Rad Hard Power Management Reference Design for AMD's Space Grade XQRKU060

Over the last decade satellites and spacecrafts have seen an exponential increase in the need for on-board data processing and storage demands. Additionally, major satellite manufacturers have recently announced their latest satellites to be modular, fully digital, and capable of in-orbit reconfigurability. To meet these demands, satellite and payload manufacturers are using high-end FPGAs, ASICs, and processors. AMD's Kintex XQRKU060 FPGA is a radiation hardened FPGA that has comparable performance to commercial counterparts in demanding computing applications. The Kintex XQRKU060 requires a complex power solution with multiple low voltage supply rails that can deliver high currents and a need for power supply sequencing to eliminate high inrush currents. In collaboration with AMD and Ibeos, Renesas offers a Kintex XQRKU060 development board with the FPGA powered by Renesas' Radiation Hardened products.

Features

- Radiation hardened QMLV power solution by Renesas (MIL-PRF-38535)
- Radiation tolerant AMD Kintex XQRKU060 FPGA
- 4x 4GB DDR3 Memory
- 512MB SPI Flash Memory
- RJ45 interface for 10/100/1000 Gigabit Ethernet
- DB9 RS-485 Communication Port
- JTAG Configuration Header

Power Supply Specifications

- $5V_{DC}$ ±10% (Banana Jack Connectors)

Related Information

- ISL70002SEH, ISL70001ASEH, ISL75051ASEH, ISL70005SEH, ISL70321SEH and ISL70244SEH device pages
- AMD Radiation Tolerant Kintex FPGA Overview
- AMD Radiation Tolerant Kintex FPGA Datasheet

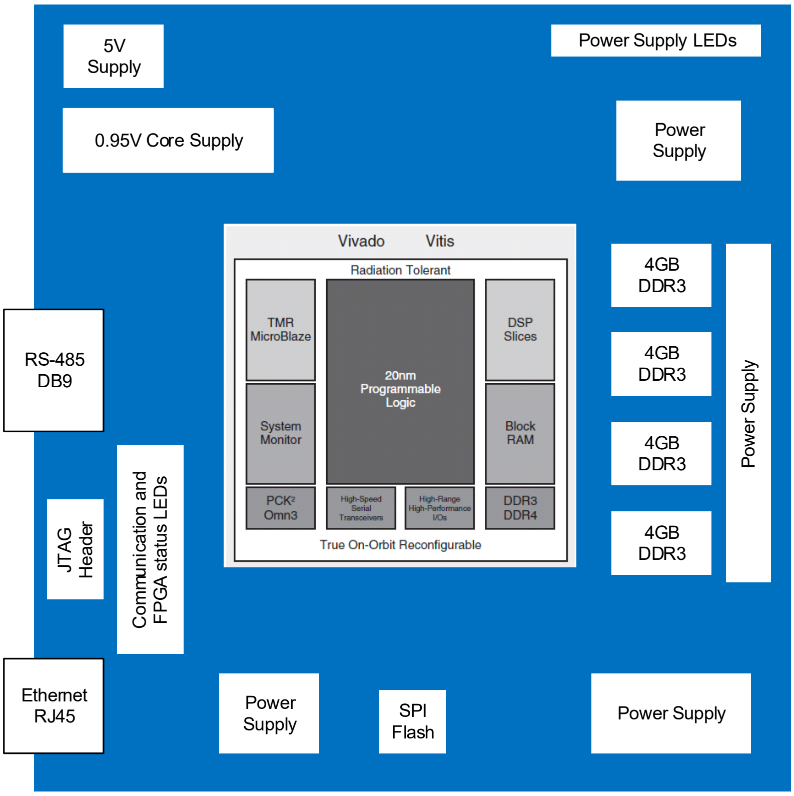


Figure 1. ISLKU060DEMO1Z Block Diagram

Contents

1. Functional Description

The ISLKU060DEMO1Z development platform allows users to prototype and evaluate the performance of the FPGA in different applications. Figure 1 shows a block diagram of the development board. The board includes 4x 4GB Double Data Rate 3 (DDR3) memory and 2x 256MB SPI flash memory, a Gigabit Ethernet (GbE) port, RS-485 communication port and a JTAG header for programming. On-board DC/DC Point-of-Load (PoL) Converters power the FPGA and peripherals from a 5V power supply input.

1.1 Getting Started

1. Power Switch SW1 switches power to the ISLKU060DEMO1Z. Before making connections, ensure it is in the down (OFF) position.
2. Apply +5VDC to the banana connectors J5 and J6. J5 is positive terminal and J6 is GND.
3. Move SW1 to the up (ON) position to power on board.
4. The LED indicators in the upper right sequence on to indicate power sequencing to the FPGA.
5. When the FPGA is properly powered and configured successfully, the FPGA_PROG_B, FPGA_INIT_B and FPGA_DONE LEDs in the lower left hand corner of the board illuminate green.
6. Visit the AMD Kintex Ultrascale website to download the Vivado Design Suite and get started on the design.

1.2 Kintex XQRKU060 Power Solution

Table 1 summarizes the Renesas part numbers, descriptions and operation conditions of the various DC-DC converters used in the space grade design.

Table 1. Renesas Power Management Solution for Kintex RT XQRKU060

Part Number	Description	Input Voltage	Output Voltage	Function
ISL70002SEH	Radiation Hardened and SEE Hardened 22A Synchronous Buck Regulator with Current Sharing	5V	0.95V[1]	VCC Core
ISL70001ASEH	Radiation and SEE Tolerant 3V to 13.2V, 9A Buck Regulator	5V	2.5V	FPGA VCCO Ethernet AVDD and I/O
			1.8V	Auxiliary VCC, Auxiliary I/O and SYSMON ADC
			3.3V	VCC 3.3V I/O and SPI Flash
ISL75051ASEH	3A, Radiation Hardened, Positive, Ultra-Low Dropout Regulator	2.5V	1.0V	Ethernet DVDD
			1.0V	GTH Analog VCC
			1.2V	GTH Termination VTT
			1.8V	GTH Auxiliary VCC
ISL70005SEH	Radiation Hardened Dual Output Point-of-Load, Integrated Synchronous Buck and Low Dropout Regulator	5V	1.35V	DDR VDDQ
		1.35V	0.675V	DDR VTT

1. A mechanical potentiometer, labeled R4781, is available to tune the VCC Core voltage across a range of 0.95V to 0.98V. This feature allows adjusting to a specific core voltage as determined by the AMD Power Estimator (XPE) tool when configuring the Kintex XQRKU060.

In addition to the power management ICs in Table 1, two ISL70321SEH quad power supply sequencers and an ISL70062SEH NMOS load switch control the power-up and power-down sequences of the eight power supply rails. An ISL70244SEH Radiation Hardened Op-Amp is also used for buffering the VREF of the DDR3 VTT supply.

Figure 2 shows the power tree connections from the two ISL70321SEH sequencer outputs to the enable inputs of the various DC-DC converters.

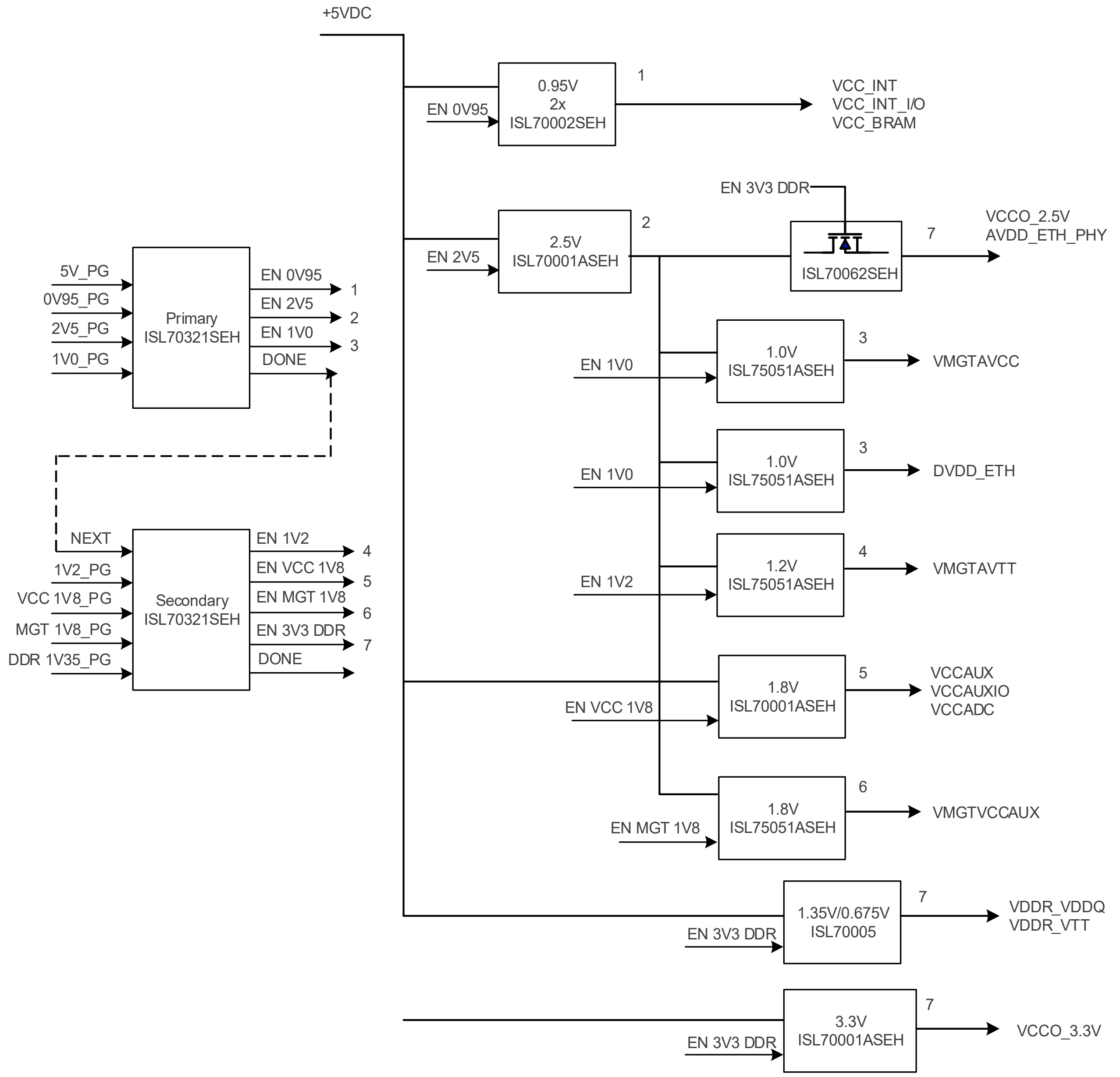


Figure 2. ISLKU060DEMO1Z Power Tree and Sequencing

The power-up sequence of the power supplies is summarized below:

1. The external 5V supply is monitored by the ISL70321SEH and when it reaches 4.3V, it enables the two ISL70002SEH set up in current-sharing configuration to provide 0.95V to the FPGA core.
2. When the 0.95V supply reaches 0.8V, an ISL70001ASEH is enabled to provide 2.5V for four down-stream ISL75051ASEH LDOs.
3. When the 2.5V supply reaches 2.1V, two ISL75051ASEHs are enabled. One provides 1.0V for the DVDD to the Ethernet controller. The other provides 1.0V for the GTH transceiver Analog VCC. To minimize power dissipation in the LDO, the ISL75051ASEH input voltage comes from the 2.5V rail.

4. When the 1.0V supply reaches 0.87V, an ISL75051ASEH is enabled to provide 1.2V for the GTH transceiver Termination VTT. To minimize power dissipation in the LDO, the ISL75051ASEH input voltage comes from the 2.5V rail.
5. When the 1.2V supply reaches 1.0V, an ISL70001ASEH is enabled to provide 1.8V for the Auxiliary VCC, Auxiliary I/O and to the SYSMON ADC supply.
6. When the 1.8V supply reaches 1.5V, an ISL75051ASEH is enabled to provide 1.8V for the GTH transceiver Auxiliary VCC. To minimize power dissipation in the LDO, the ISL75051ASEH input voltage comes from the 2.5V rail.
7. When the second 1.8V supply rail reaches 1.5V, the final two supply rails are enabled. An ISL70001ASEH is enabled to provide 3.3V for the VCC I/O and for the SPI Flash Memory. The ISL70005SEH is enabled to provide 1.35V for the VDDQ and 0.675V for the VTT of the DDR3 memory. The 0.675V before the VTT rail is also buffered by an ISL70244SEH op-amp to provide VREF for the DDR3 memory. There is also an ISL70062SEH NMOS load switch that is turned on by the second 1.8V supply rail, which provides 2.5V for the FPGA VCC I/O, Ethernet AVDD and I/O.

Figure 3 shows the power-up sequence of the ISLKU060DEMO1Z board.

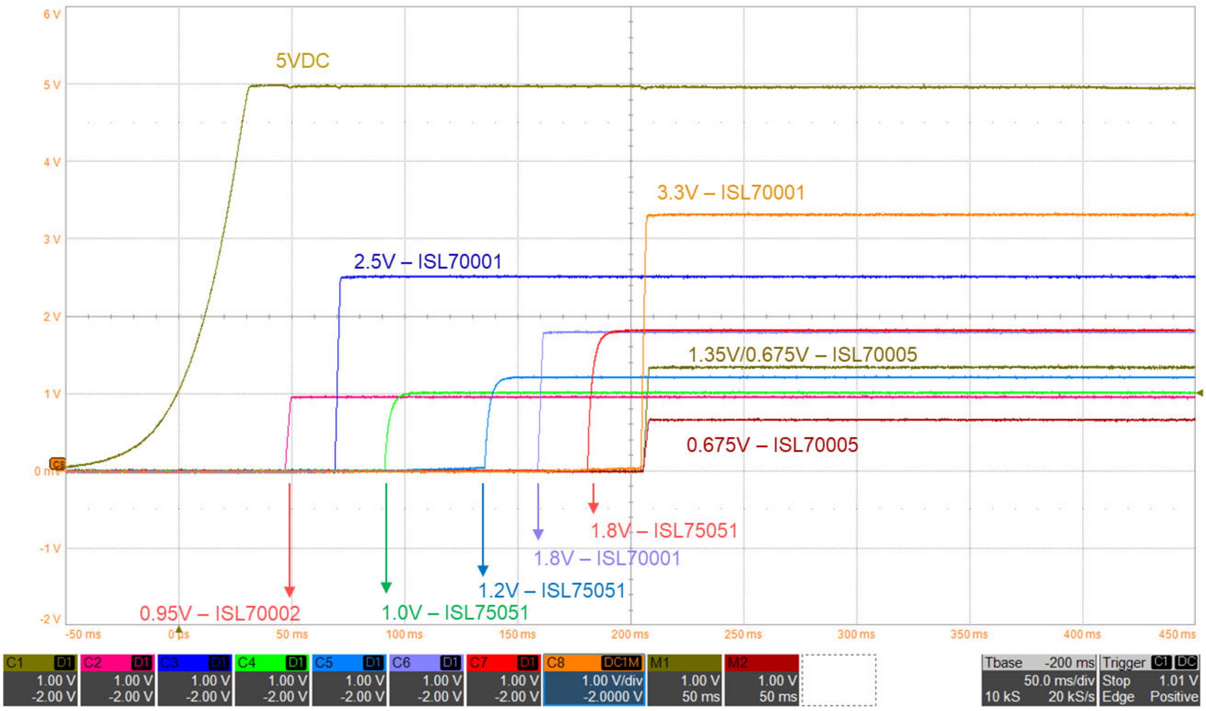


Figure 3. ISLKU060DEMO1Z Power-Up Sequencing

2. Typical Performance Graphs

Typical performance curves for Figure 9 through Figure 13 are derived from the datasheet of the associated part. Actual performance on the ISLKU060DEMO1Z may be different due to test conditions.

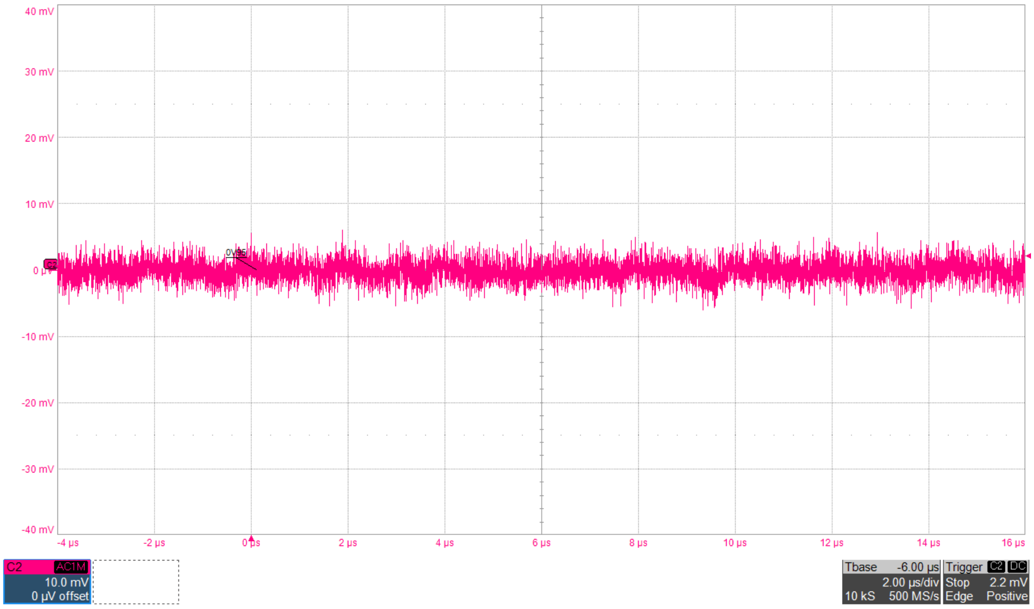


Figure 4. Output Ripple of ISL70002SEH for the FPGA VCCINT Core Voltage

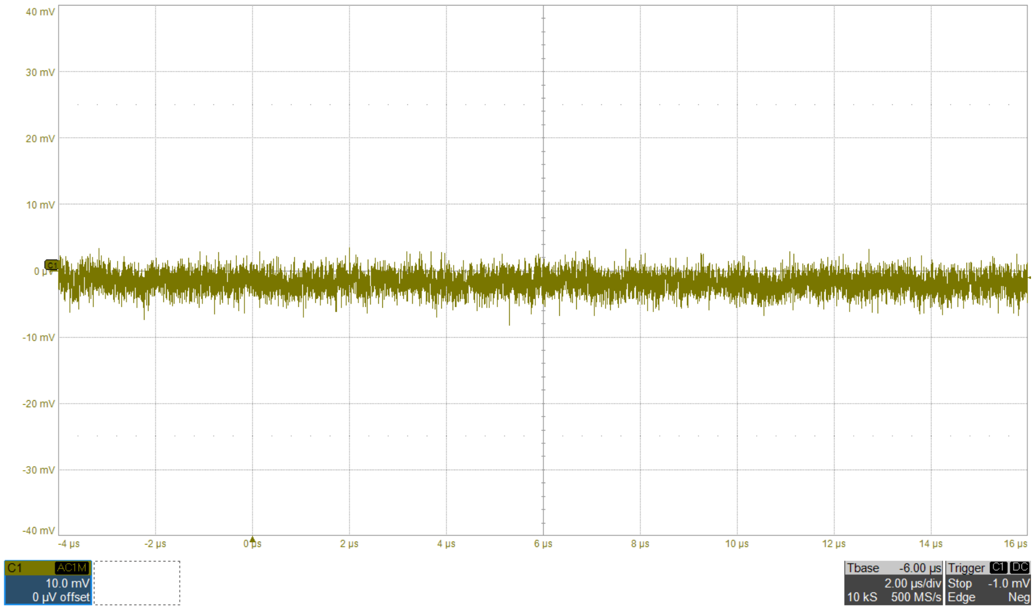


Figure 5. Output Ripple of ISL75051ASEH for the FPGA 1.0V VMGTAVCC Voltage

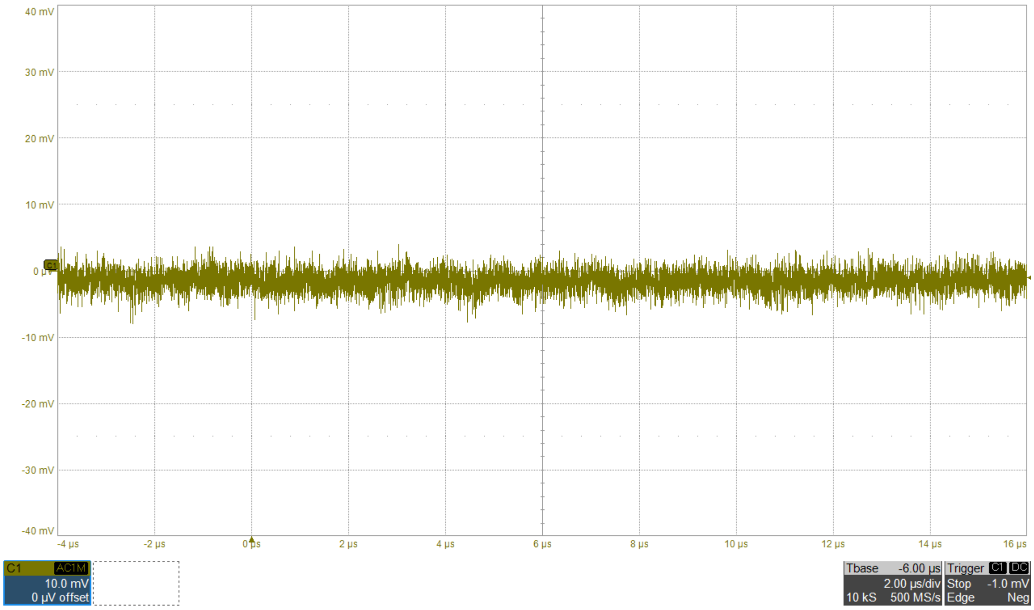


Figure 6. Output Ripple of ISL75051ASEH for the FPGA 1.2V VMGTAVTT Voltage

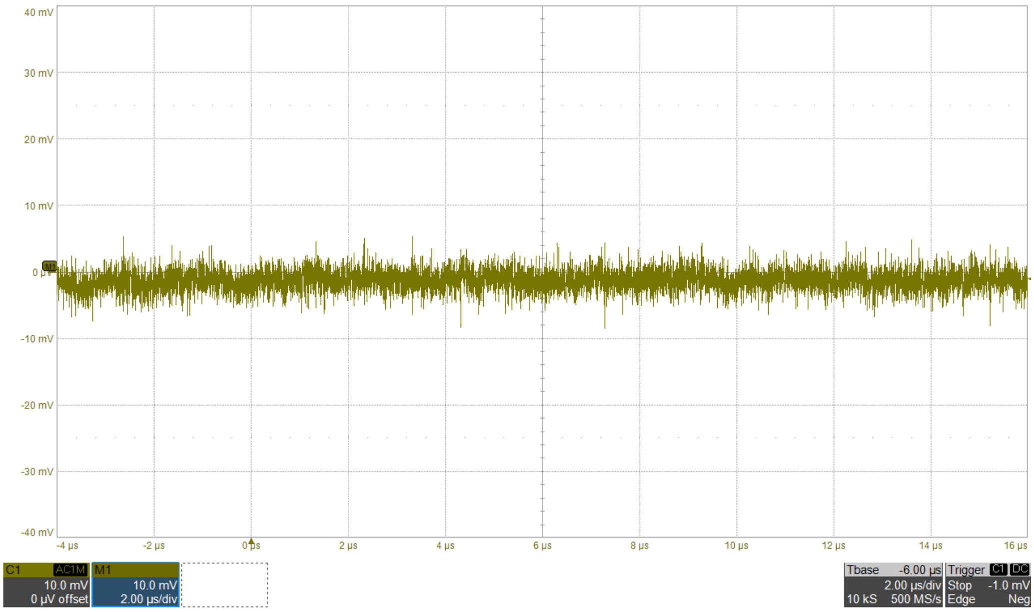


Figure 7. Output Ripple of ISL75051ASEH for the FPGA 1.8V VMGTACCAUX Voltage

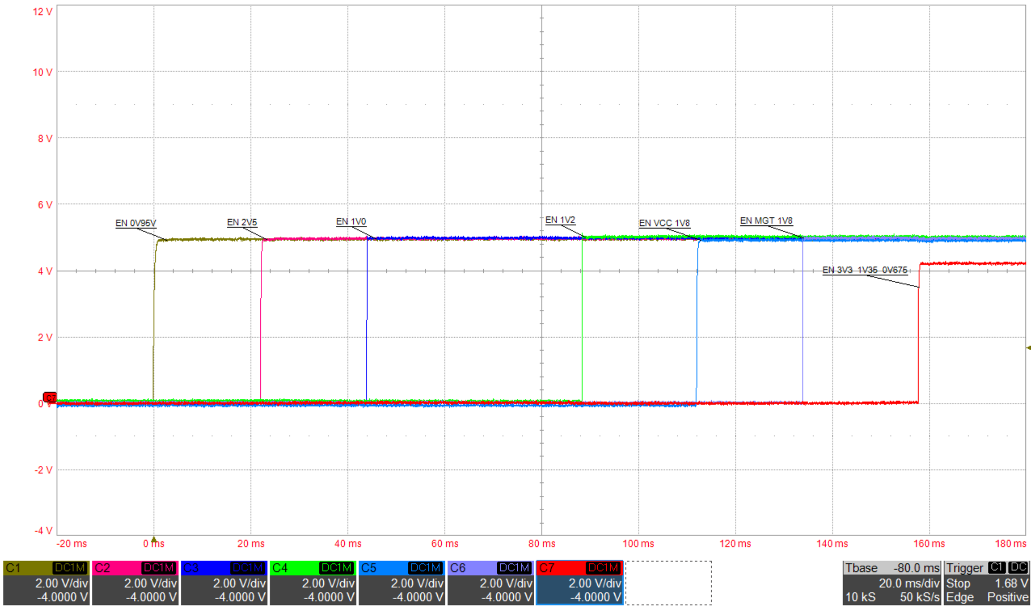


Figure 8. ISL70321SEH Power Sequencing Enable

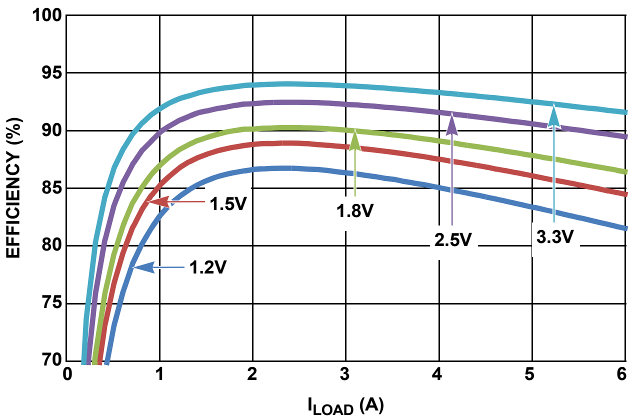


Figure 9. Efficiency vs Load, V_{IN} = 5.0V

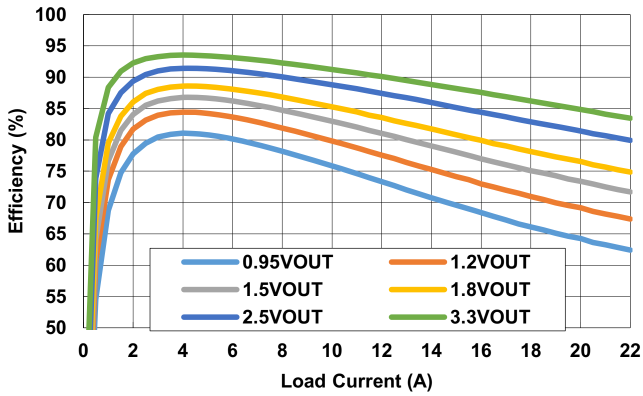


Figure 10. ISL70002SEH Efficiency, V_{IN} = 5V, 500kHz

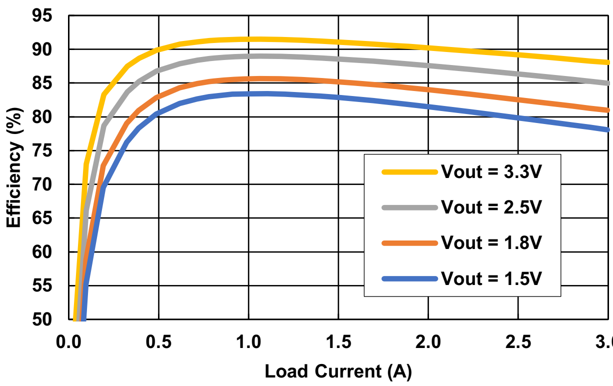


Figure 11. ISL70005SEH Buck Efficiency, V_{IN} = 5V, 1MHz

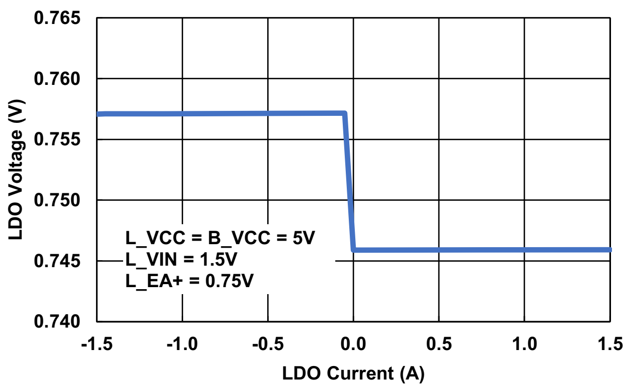


Figure 12. ISL70005SEH LDO Load Regulation

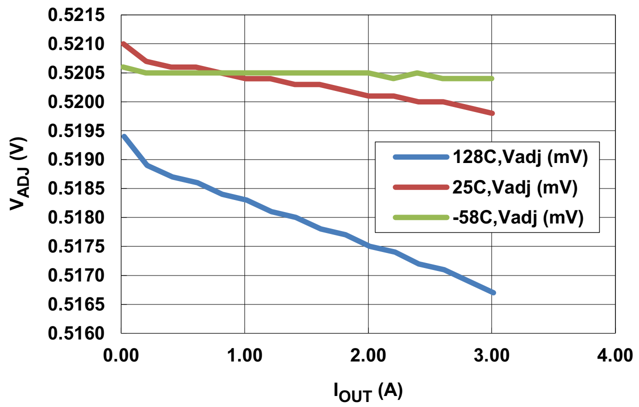


Figure 13. ISL75051ASEH Load Regulation, VADJ vs I_{OUT}

3. Board Design

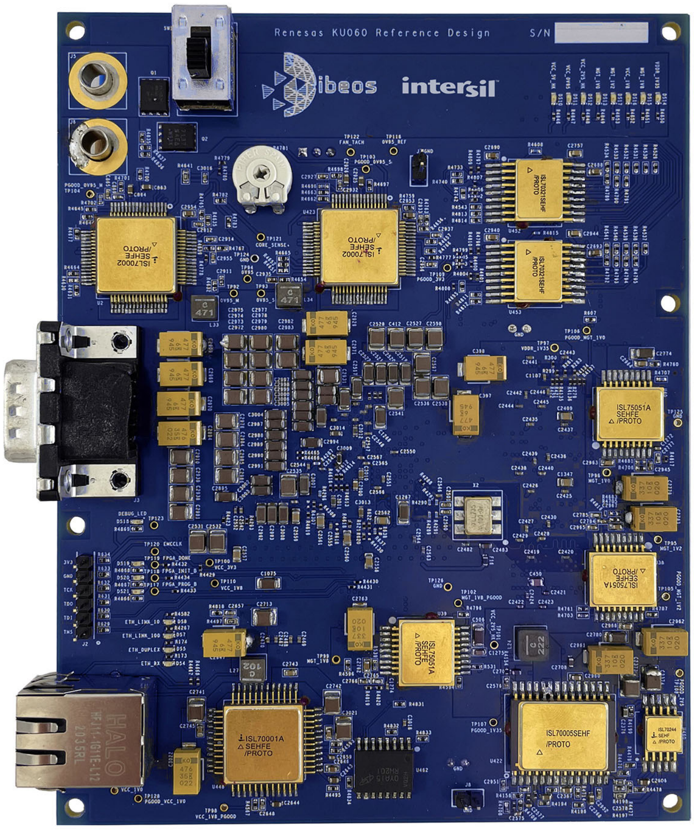


Figure 14. Top of Board

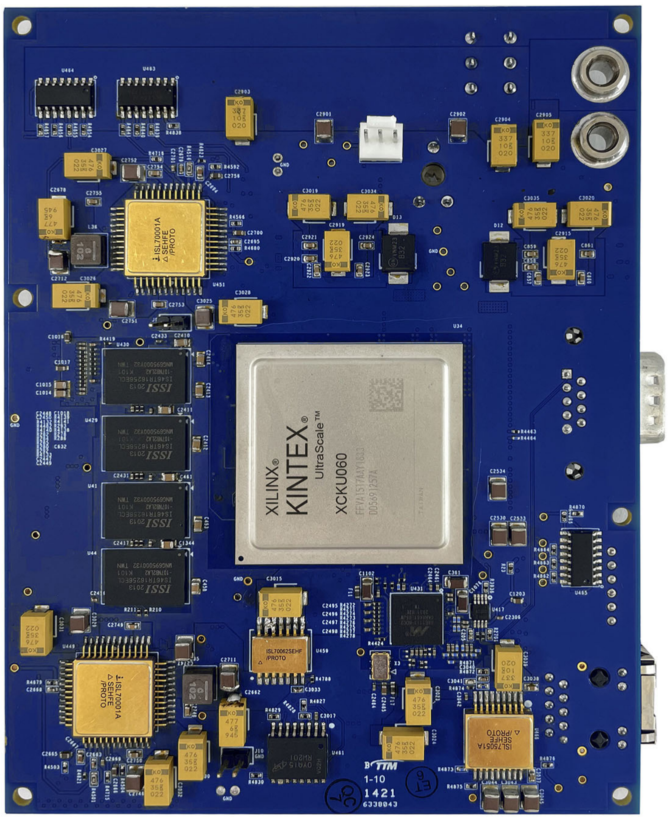


Figure 15. Bottom of Board

3.1 Layout Guidelines

As the AMD Kintex XQRKU060 is a high-performance FPGA, careful consideration must be taken with regards to the layout for the power management ICs. Per the FPGA datasheet for recommended operating conditions for each of the supply rails, it can be seen they must operate with the tolerances described. In addition to choosing the right components for the design, the layout is equally as critical in maintaining the electrical performance within the tolerance window. The load current transitions from one DC/DC regulator can cause voltage spikes across the interconnecting impedances and parasitic circuit elements. These voltage spikes can degrade efficiency, radiate noise into the circuit and lead to device overvoltage stress. Proper component layout and printed circuit board design minimizes these voltage spikes. Below are general recommended guidelines for proper layout:

- Ground planes have two important uses. They should be used to shield the switch node of Buck regulators to contain radiated EMI. Ground planes are also used to provide low impedance returns for the supply currents.
- Signal routing should be on dedicated layers. Avoid routing signals on every layer without regard to how layers above and below may interact with the signal. Typically, the top and bottom layer of the board are dedicated for signals. Always shield the layer above and below signal layers with ground planes.
- Keep the signal and power grounds for each IC separate but have them tied together in a low noise area of the PCB. **Note:** Be careful that noise or high current paths from the power supply grounds does not disrupt the signal ground. Avoid placing signal and sensitive analog grounds in the paths of these noise and high current grounds.
- Place low ESR ceramic bypass capacitors directly at the power supply inputs of DC/DC regulators. These capacitors are necessary to filter out any high frequency noise on the power supply traces.
- Provide enough PCB trace width to carry the power supply currents. This is especially important for the core rail which provides very high currents. Route the power dissipation across the PCB trace in such a way the thermal dissipation can be properly carried away from the board.
- For DC/DC regulator ICs that have a back side EPAD, expose the PCB solder mask to provide proper thermal transfer from the IC to the PCB. In addition, include the proper amount of vias to maximize thermal performance. The vias should connect to all ground layers to spread out the heat.

3.2 Schematic Diagrams

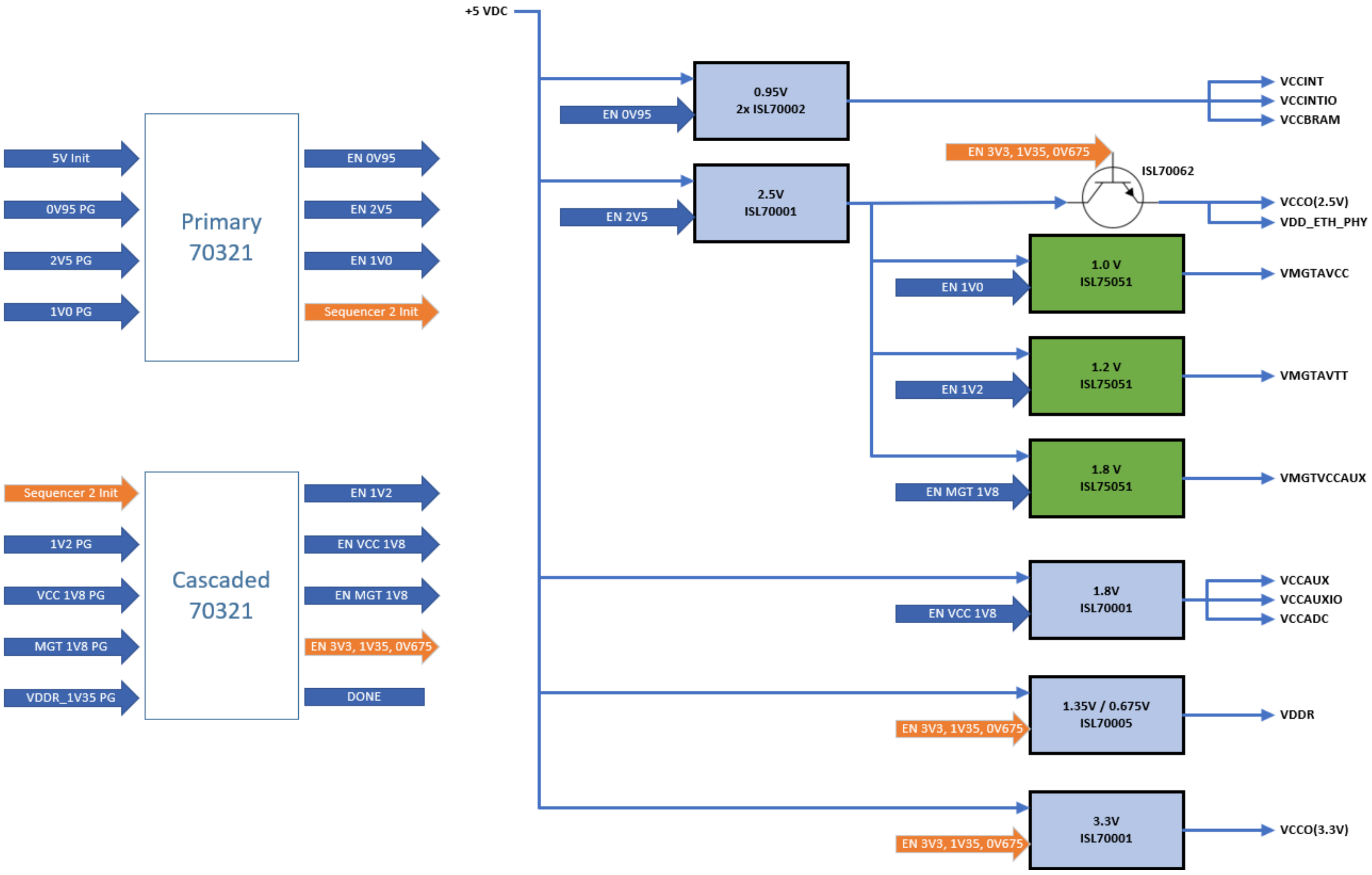


Figure 16. Schematic Page 1

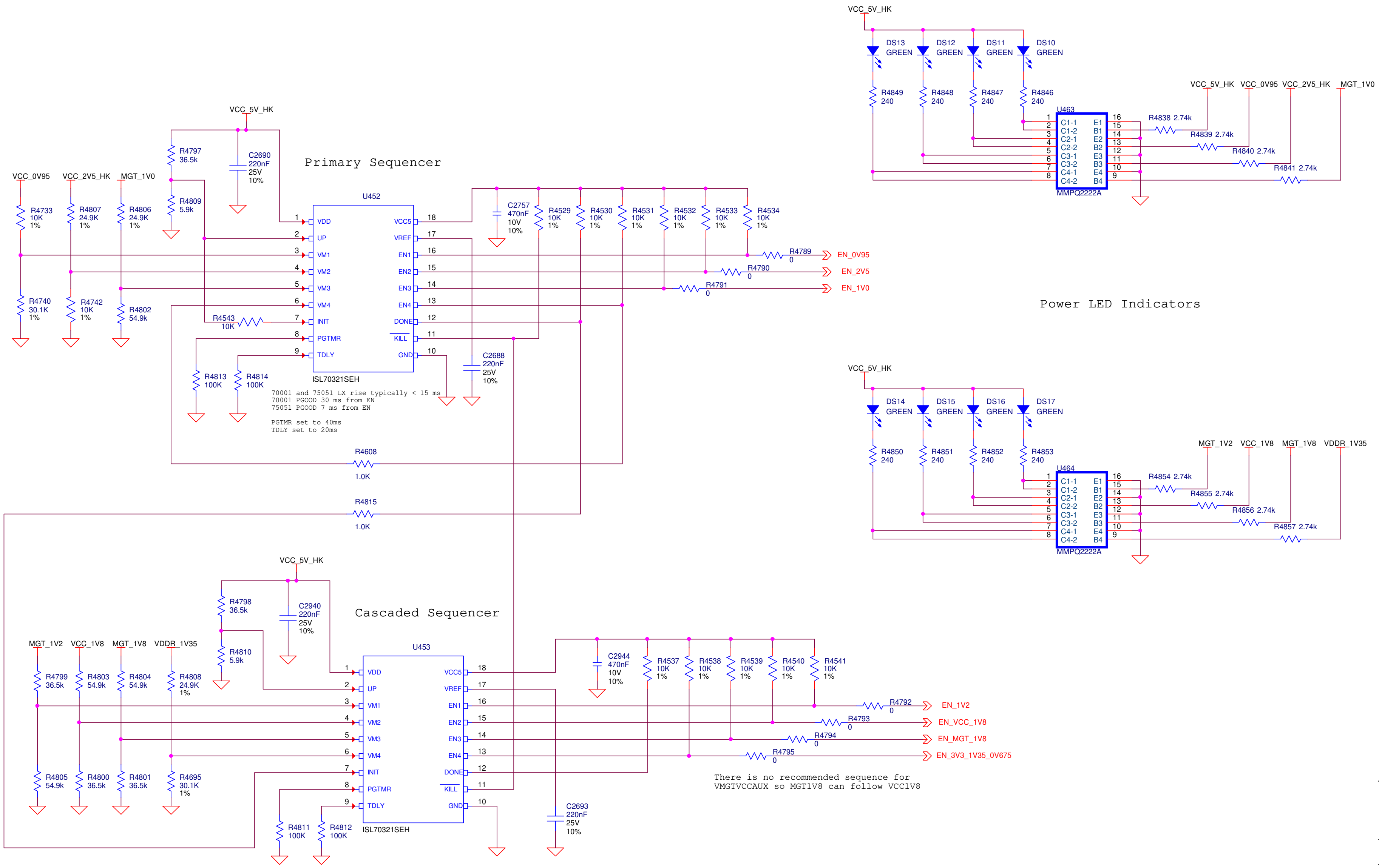


Figure 17. Schematic Page 2

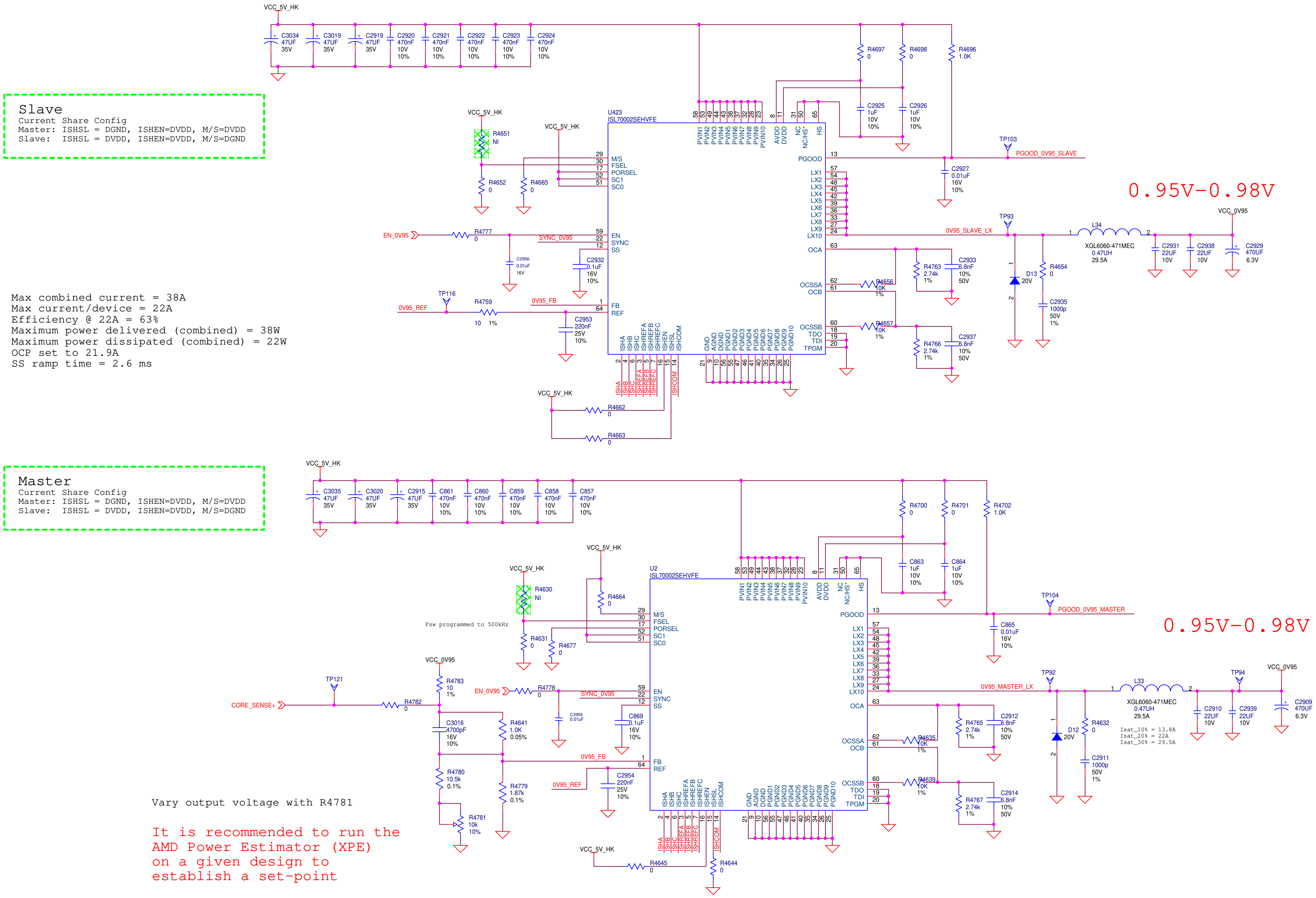


Figure 18. Schematic Page 3

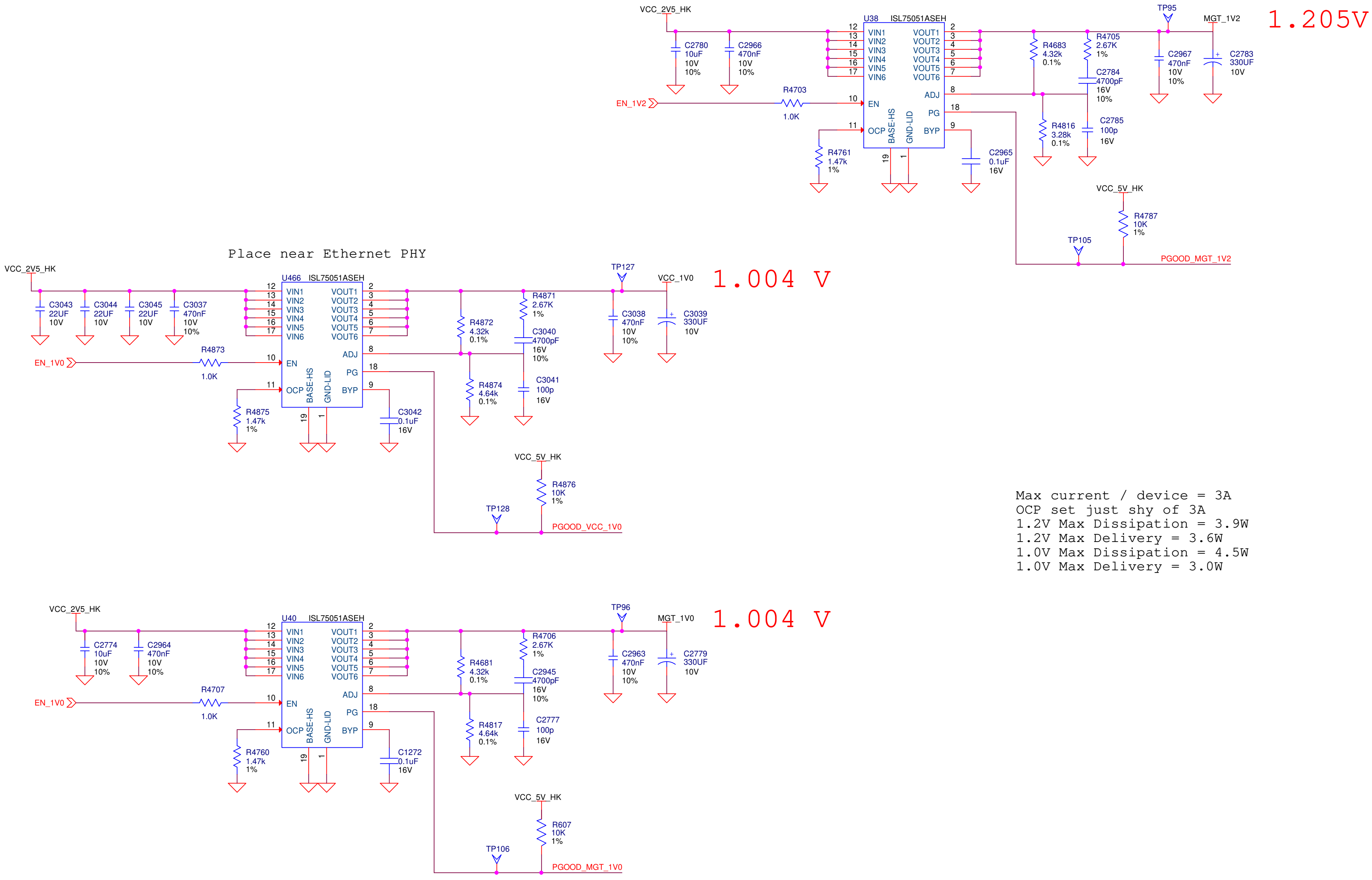


Figure 19. Schematic Page 4

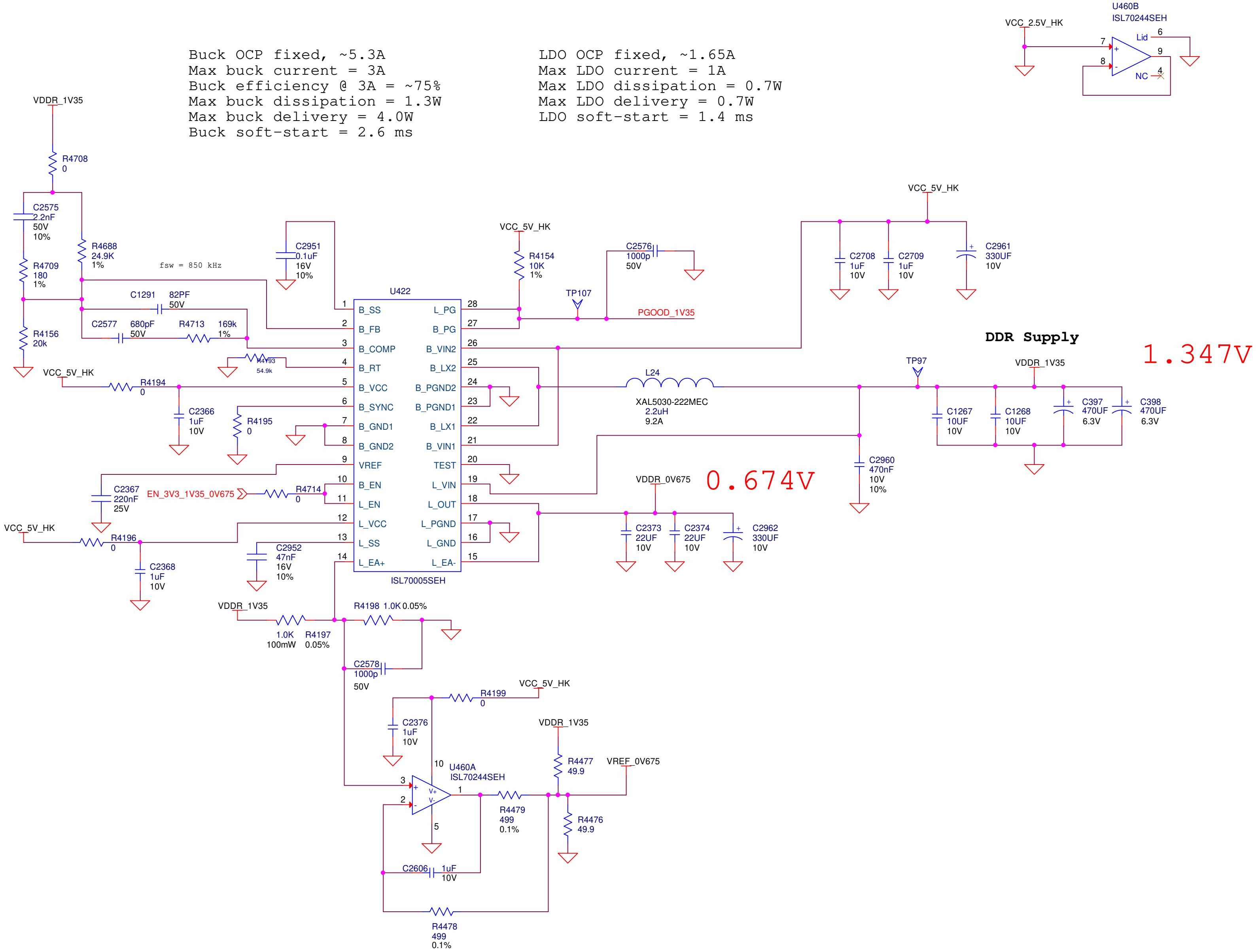


Figure 20. Schematic Page 5

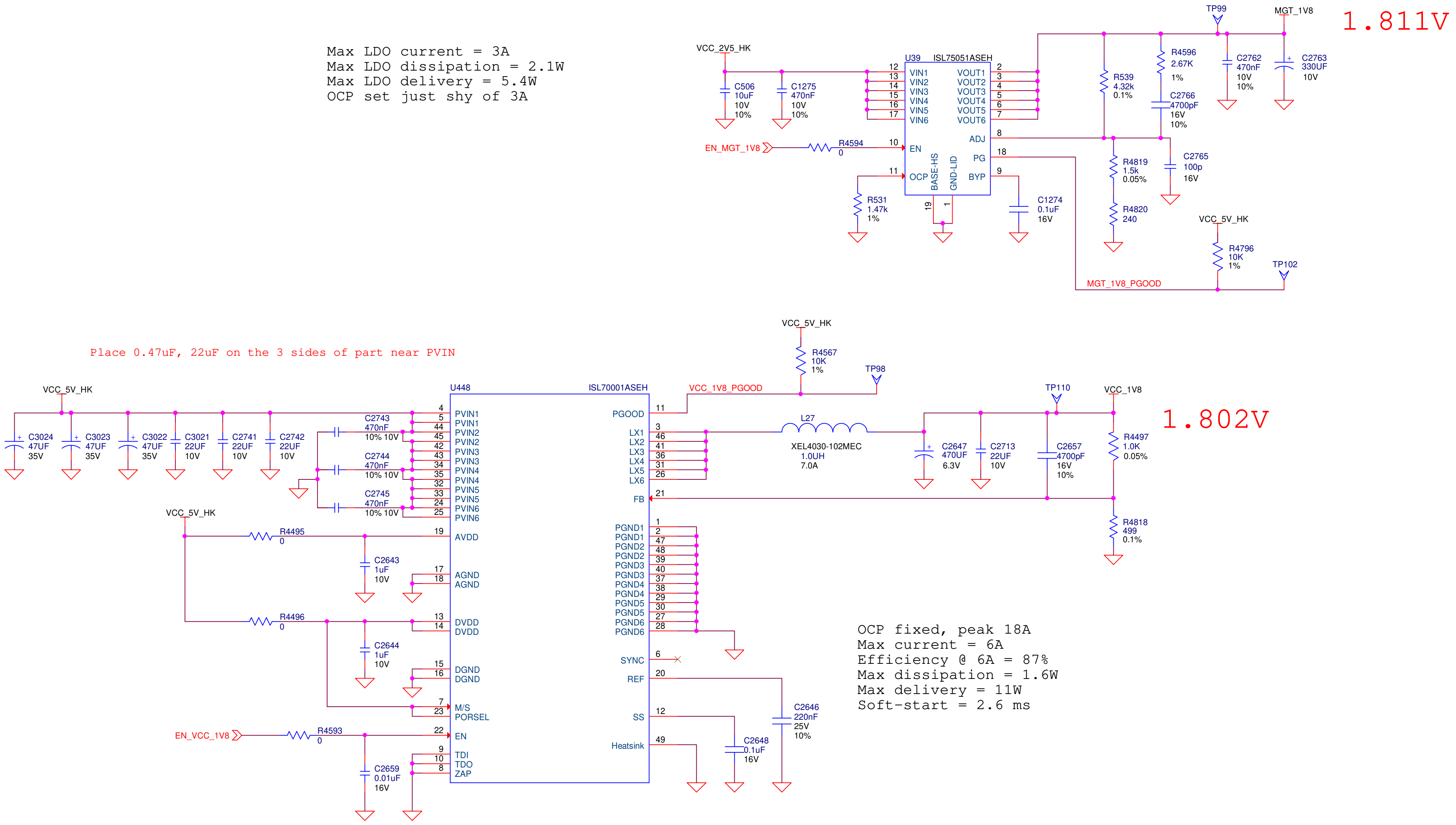


Figure 21. Schematic Page 6

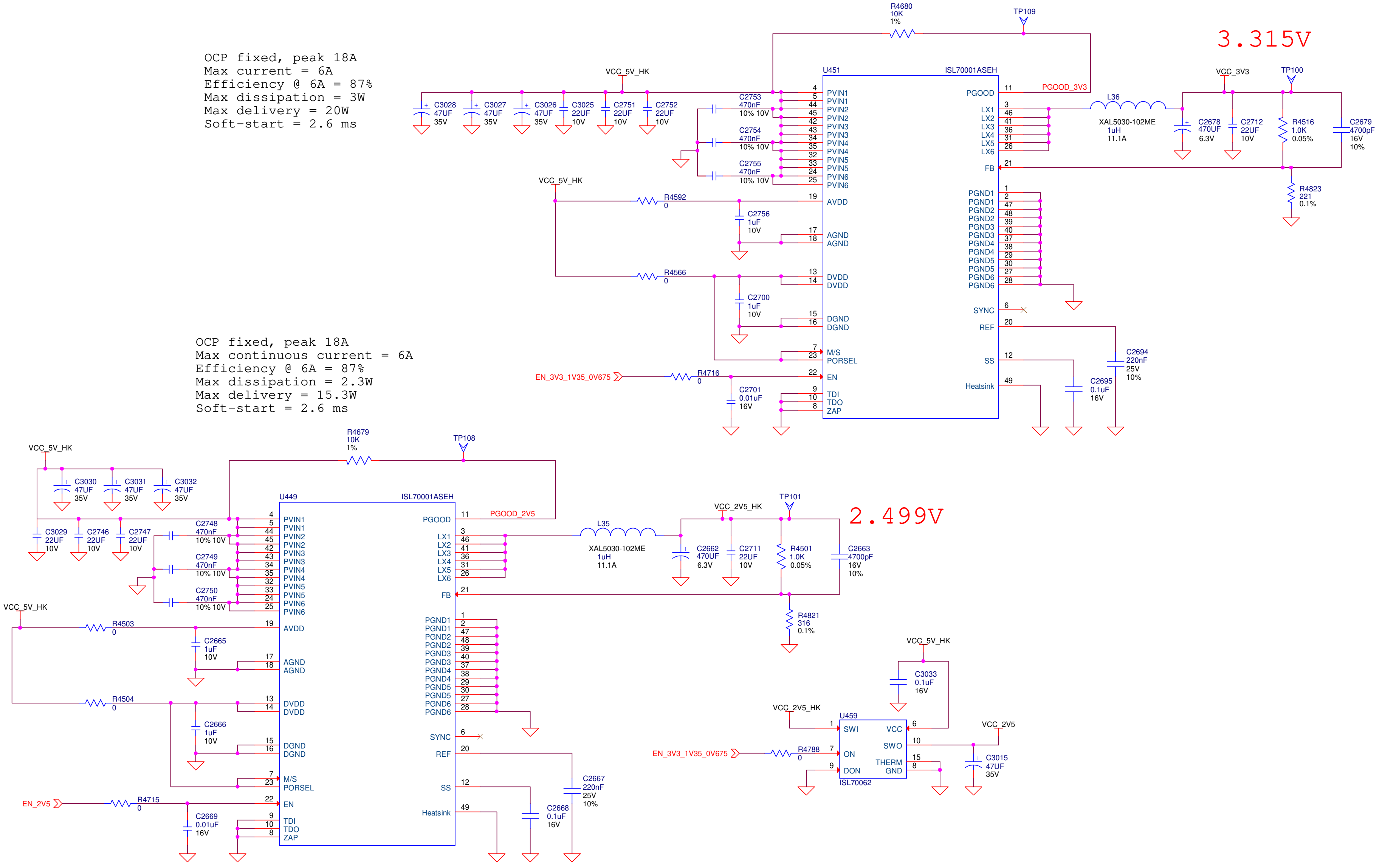
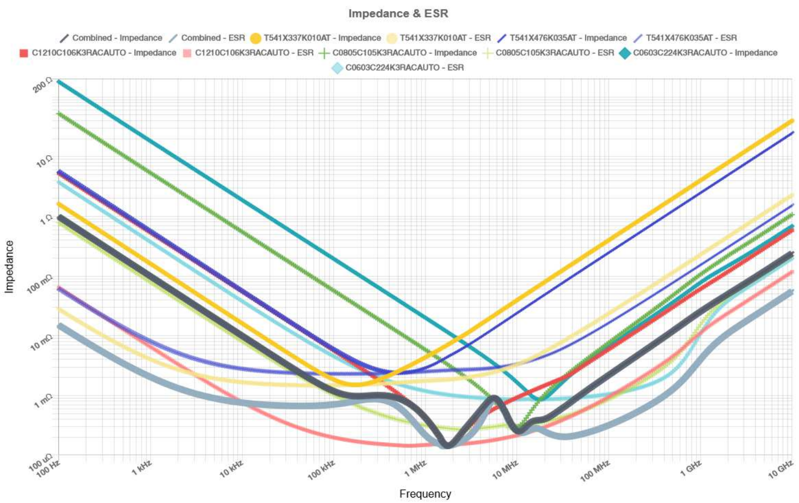
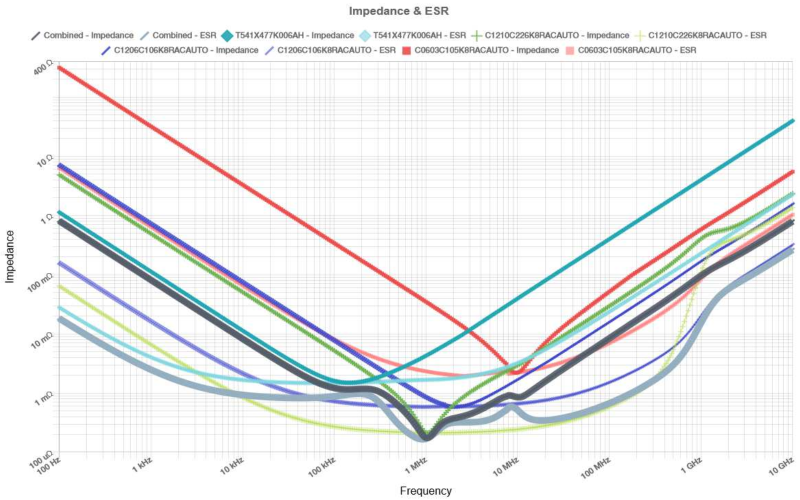


Figure 22. Schematic Page 7

AMD Reference Decoupling Network Impedance:



BOM-Optimized Decoupling Network Impedance:



Decoupling designed to a 6A load step

Recommended PCB Capacitors per Device

Example decoupling capacitor quantities for the XQRKU060-CNA1509 device are listed in Table 77 to Table 81. The optimized quantities of PCB decoupling capacitors assume that the voltage regulators have stable output voltages and meet the regulator manufacturer's minimum output capacitance requirements. These recommendations assume a regulator (DC) tolerance of ±2% and an AC tolerance of ±1%, except for V_{CCINT} which assumes an AC tolerance of ±2%. The total of the DC and AC tolerances must be within the recommended operating conditions specified in Table 9.

Table 77: **Decoupling Capacitor Quantities for V_{CCINT} with Sample Step Currents**

VCCINT/VCCBRAM/VCCINT_IO Combined or VCCINT/VCCINT_IO Combined(1)					
Step current (A)	**330 µF**	**47 µF**	**10 µF**	**1.0 µF**	**0.22 µF**
6	3	6	30	30	40
5	2	5	19	21	25
4	1	4	16	16	16
3	1	2	8	8	8
2	1	1	3	3	3

Notes:
1. VCCINT_IO is tied internally in the CNA1509 package to VCCINT.
2. Step current is typically a fraction of dynamic current; roughly 15–33%.

Table 78: **Decoupling Capacitor Quantities for V_{CCBRAM}**

V_{CCBRAM}	
47 µF	**10 µF**
1	1

Table 79: **Decoupling Capacitor Quantities for V_{CCAUX}/V_{CCAUX_IO}**

V_{CCAUX}/V_{CCAUX_IO} (combined)	
47 µF	**10 µF**
1	1

Notes:
1. Based on 2.0A of I_{CCAUX} + I_{CCAUX_IO} dynamic current.

Table 80: **Decoupling Capacitor Quantities for V_{CCO} per Bank**

V_{CCO_HP} (per bank) or V_{CCO_HR} (per bank)	
47 µF	**10 µF**
1	1

Notes:
1. When combining banks, one 47 µF can power up to four connected banks.

Table 81: **Decoupling Capacitor Specifications and Sample Part Numbers**

Value (µF)	Case	Type	ESR (mΩ)	ESL (nH)	Sample Part Number
330	D	Tant Poly	5.84	1.90	Kemet T541X337M010ATE
47	D	Tant Poly	15.22	1.90	Kemet T541D476M3.5ATE
10	1210	X7R	20	1.62	
1.0	0805	X7R	19	2.50	
0.22	0603	X7R	12	2.50	

Decoupling methods other than those presented in these tables can be used, but the decoupling network should be designed to meet or exceed the performance of the simple decoupling networks presented here. The impedance of the alternate network is recommended to be less than or equal to that of the recommended network across frequencies from 100 kHz to approximately 10 MHz.

Using KEMET's K-SIM capacitor simulation software we find that the AMD design has peak impedance of about 1.5 mOhm over frequency. Iterating in the same tool we derive a network with a similar figure, but fewer components. This reduces the BOM and simplifies PCB layout.

Both designs are under Ztarget = 3mOhm.

Title	Renesas KU060 Reference Design
Size	Document Number

Figure 23. Schematic Page 8

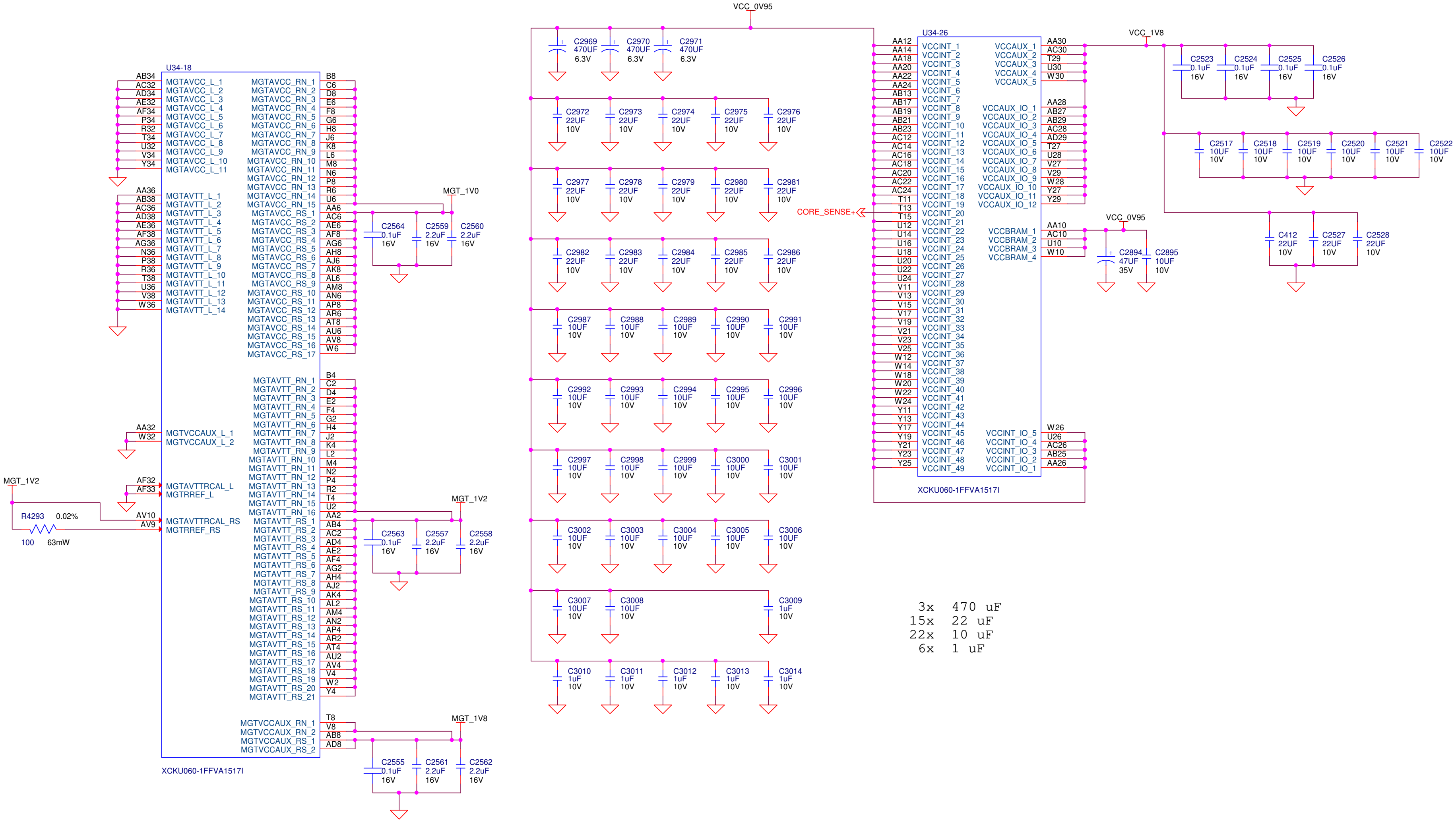


Figure 24. Schematic Page 9

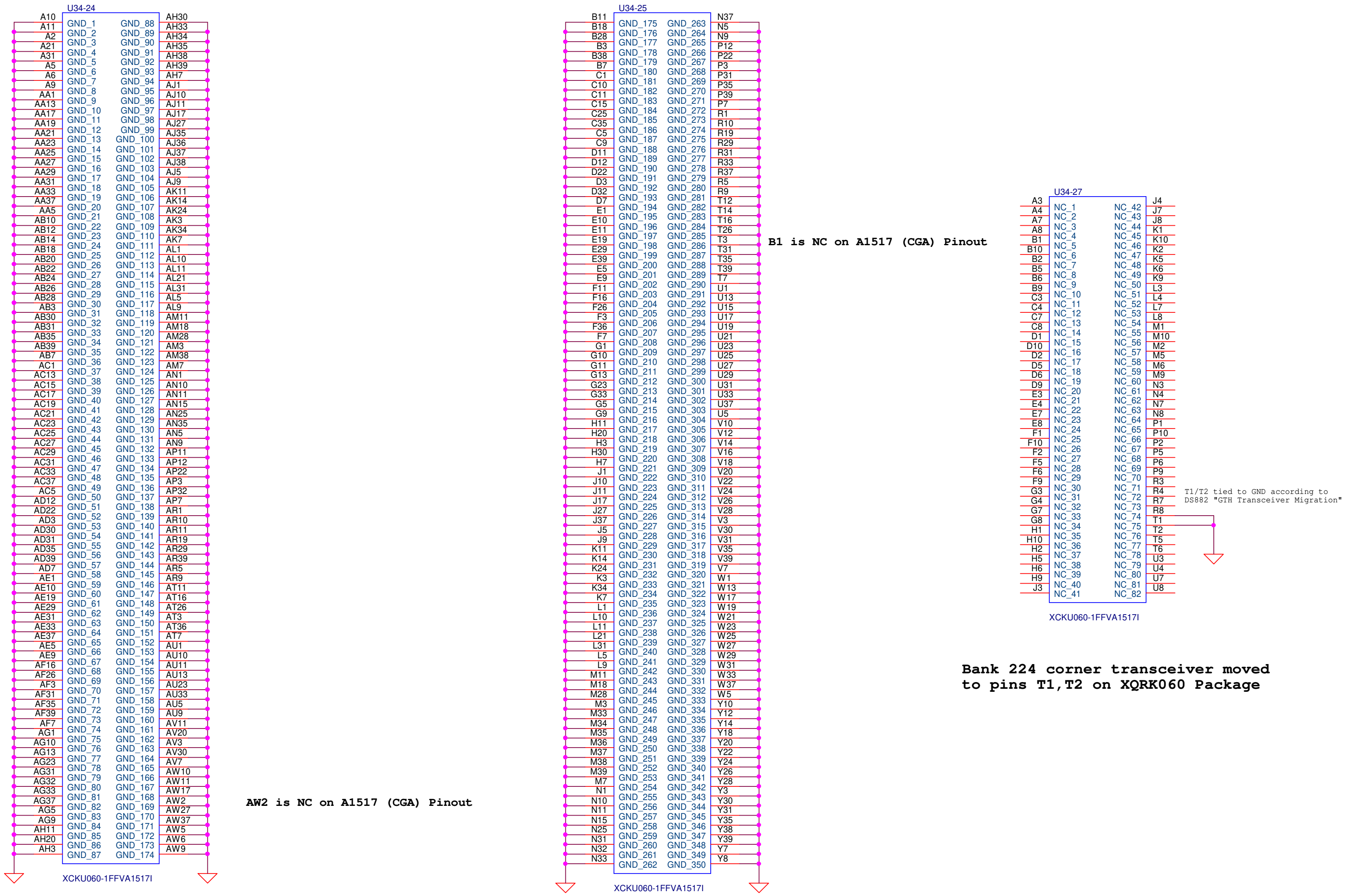


Figure 25. Schematic Page 10

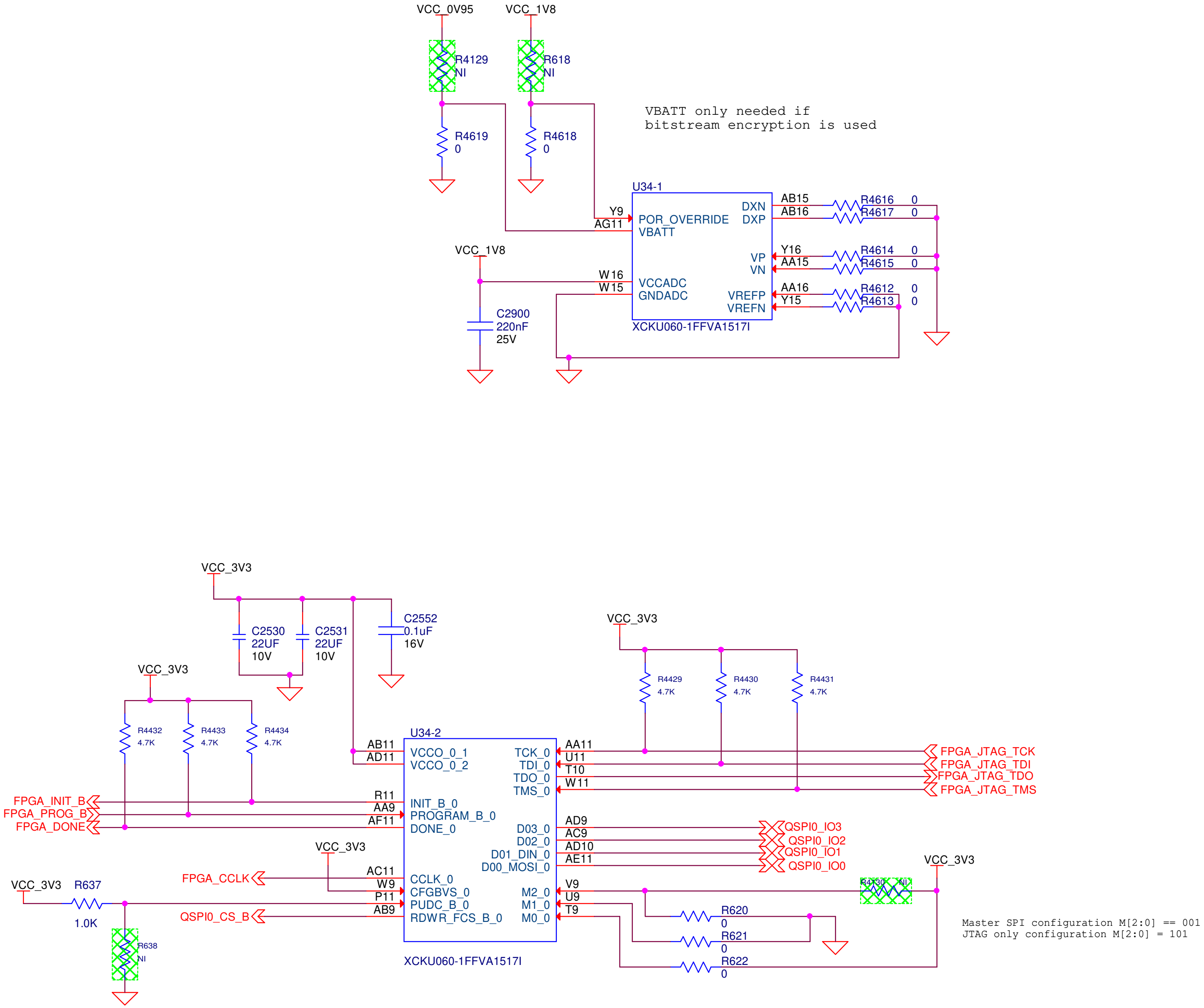


Figure 26. Schematic Page 11

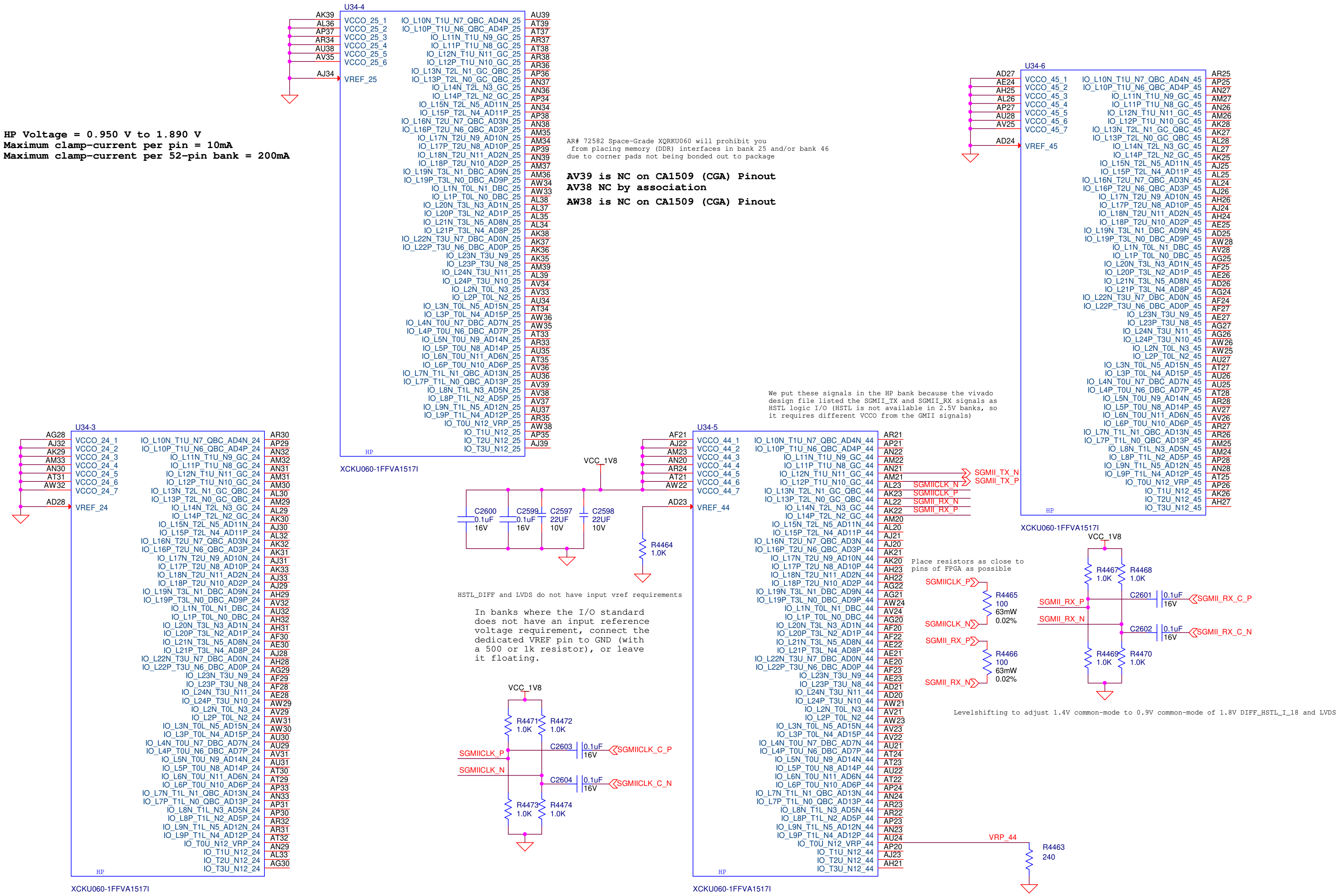


Figure 27. Schematic Page 12

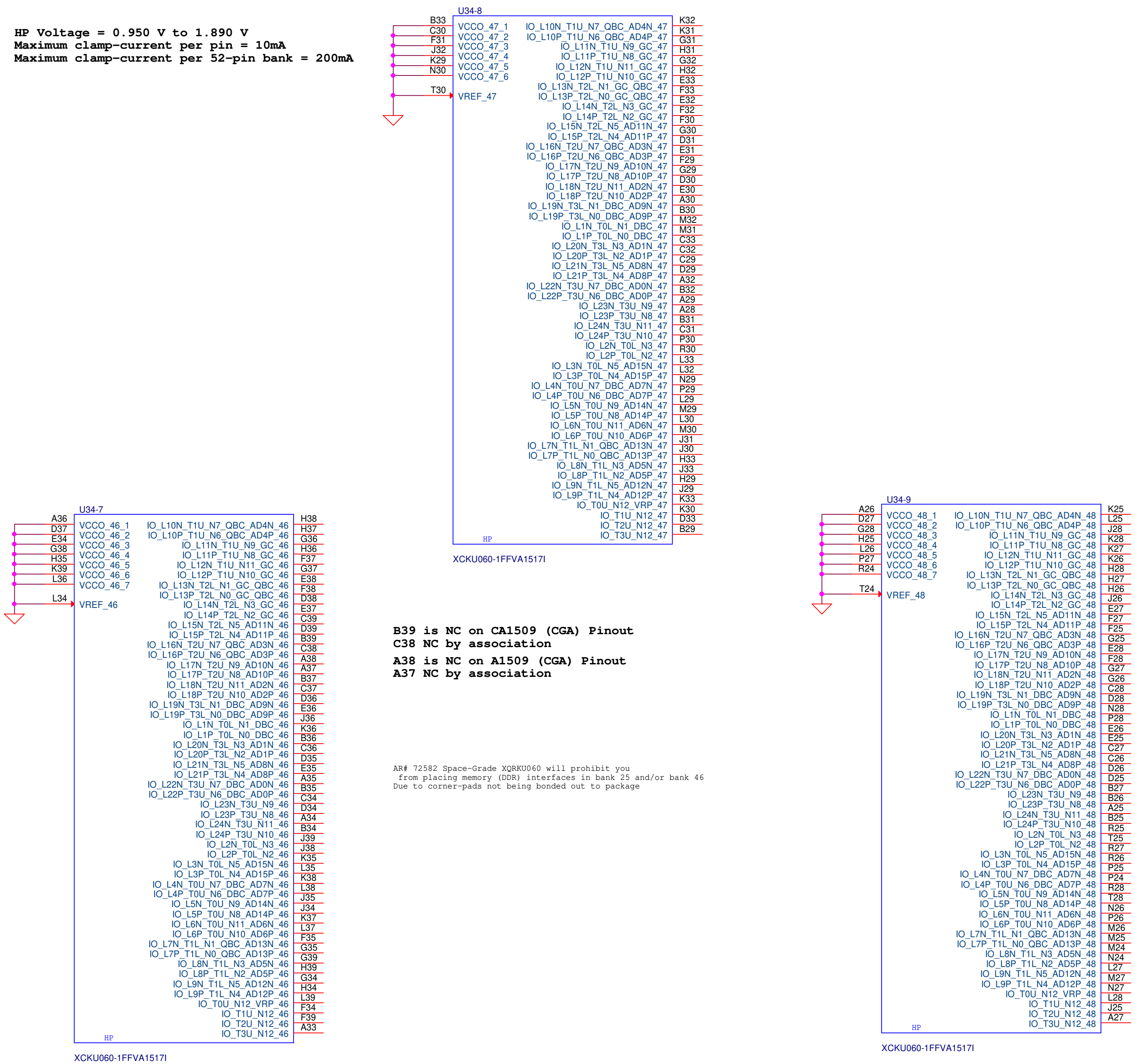


Figure 28. Schematic Page 13

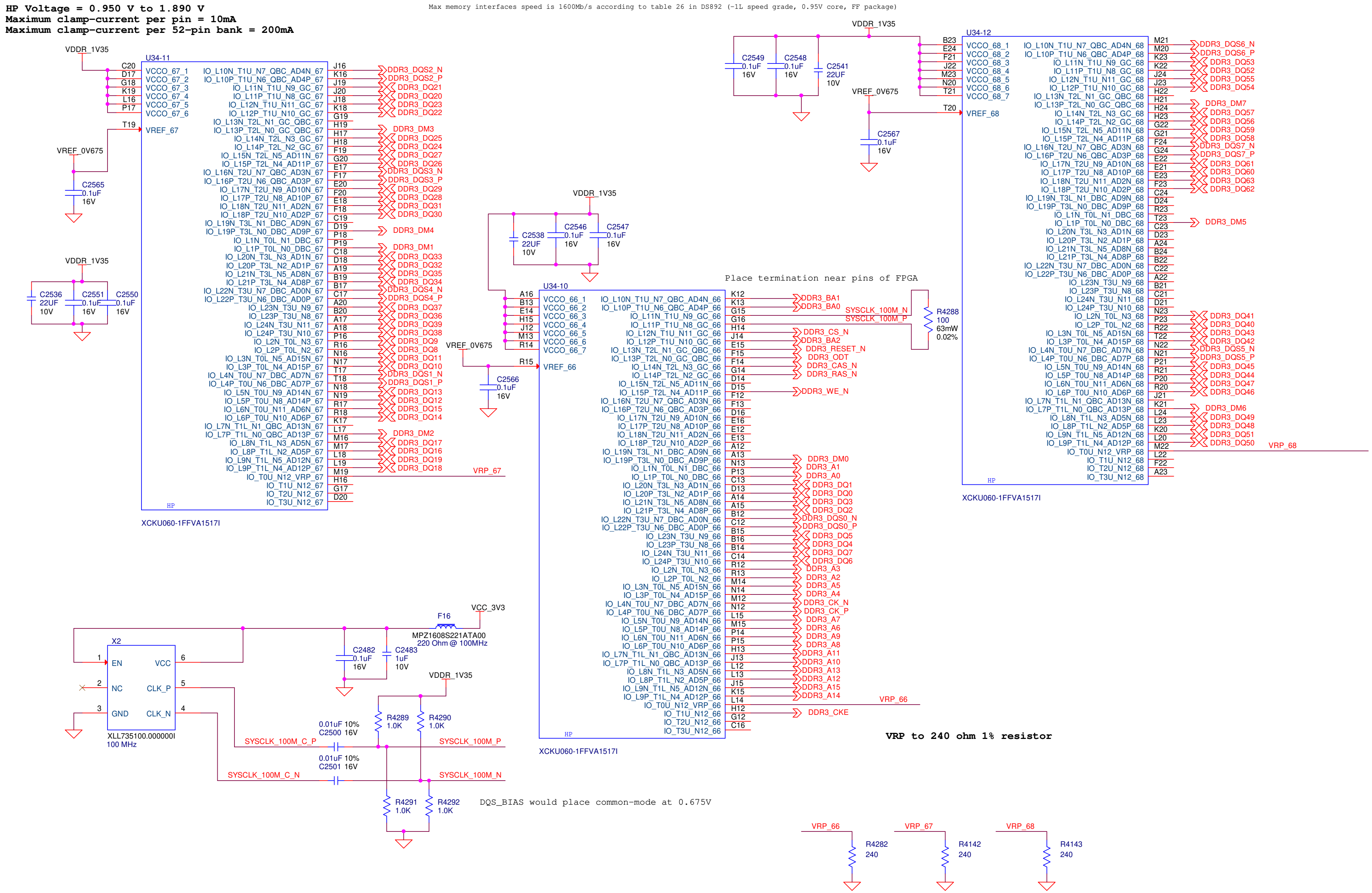


Figure 29. Schematic Page 14

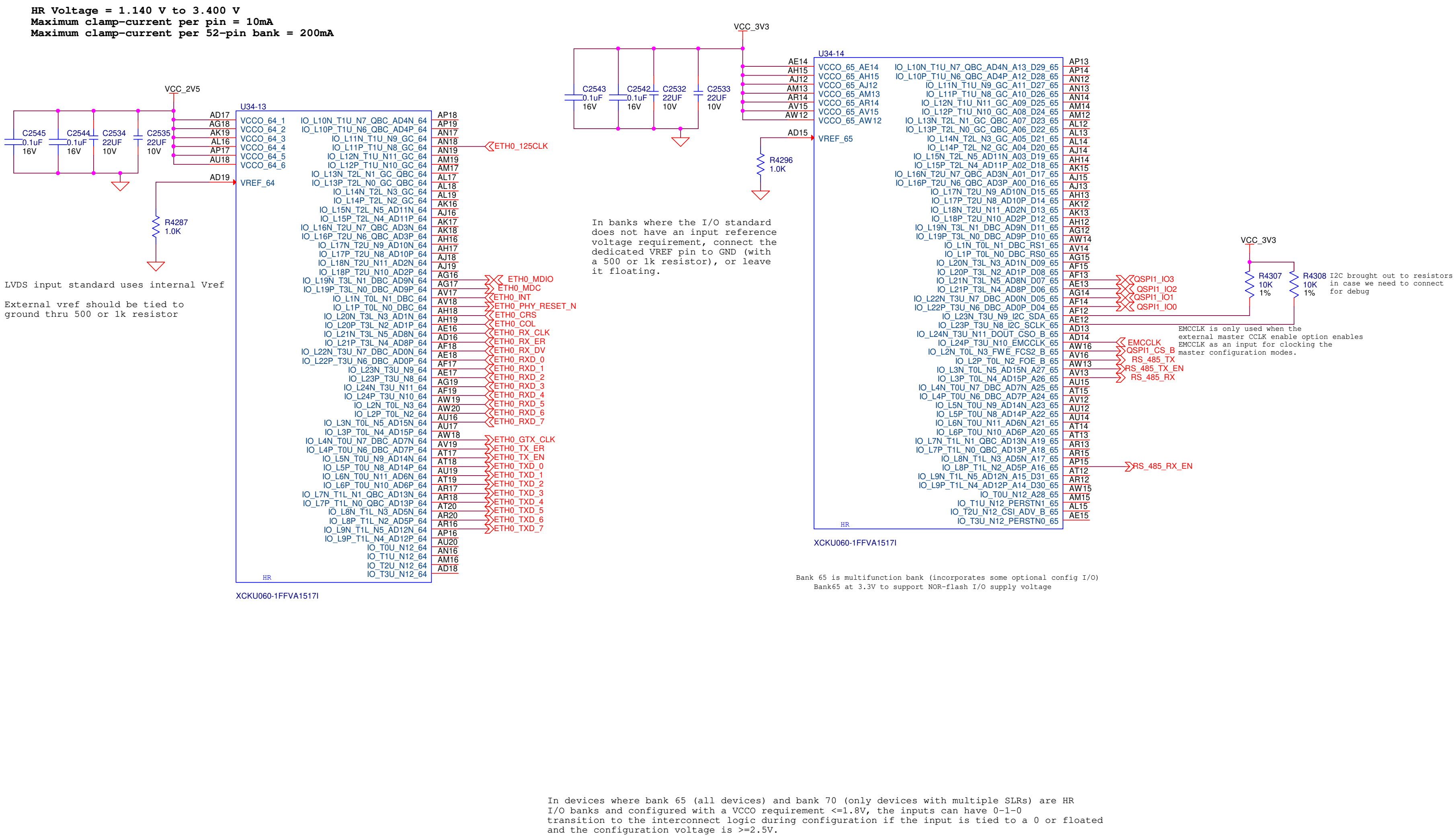


Figure 30. Schematic Page 15

Figure 31. Schematic Page 16

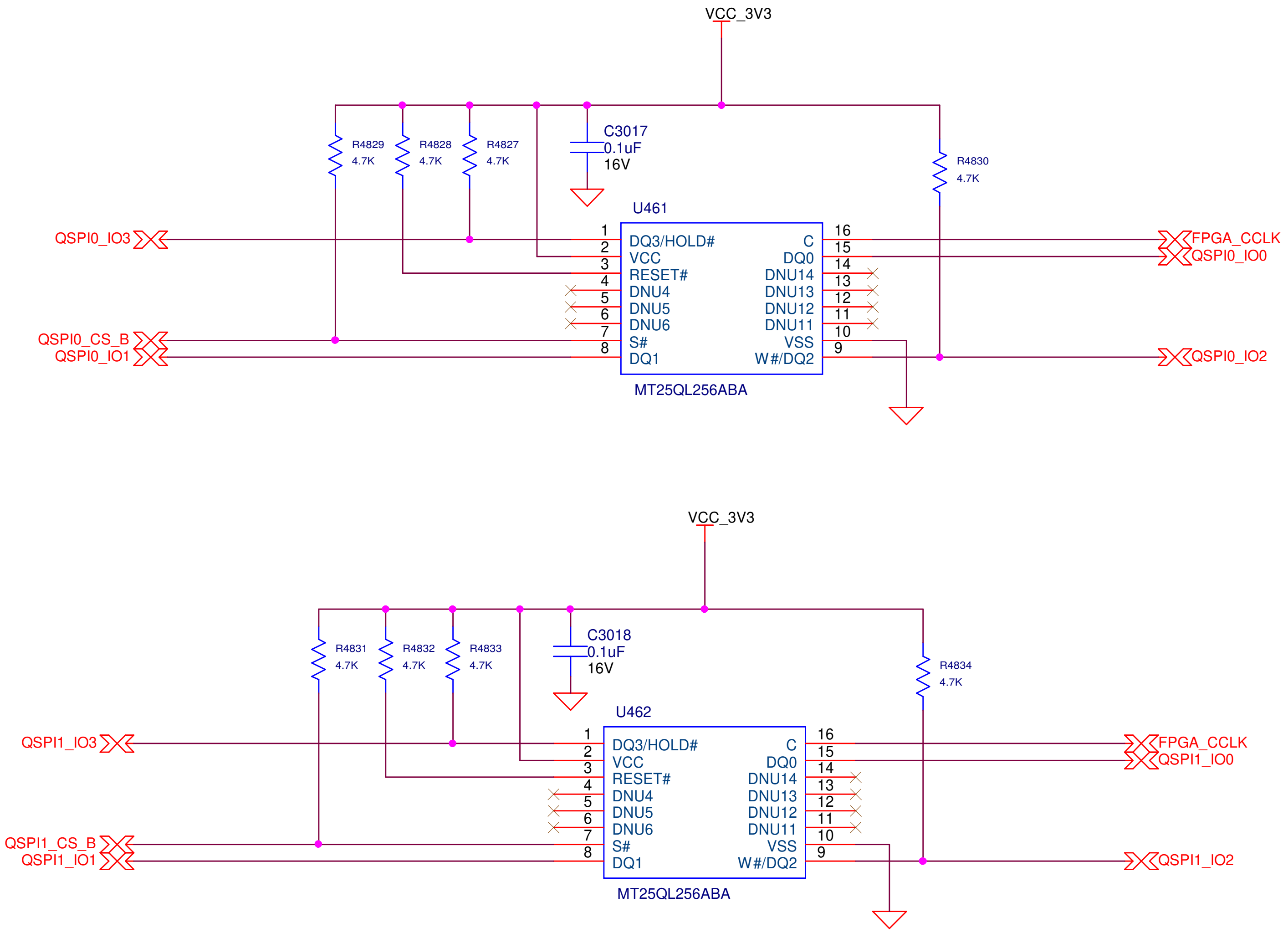


Figure 32. Schematic Page 17

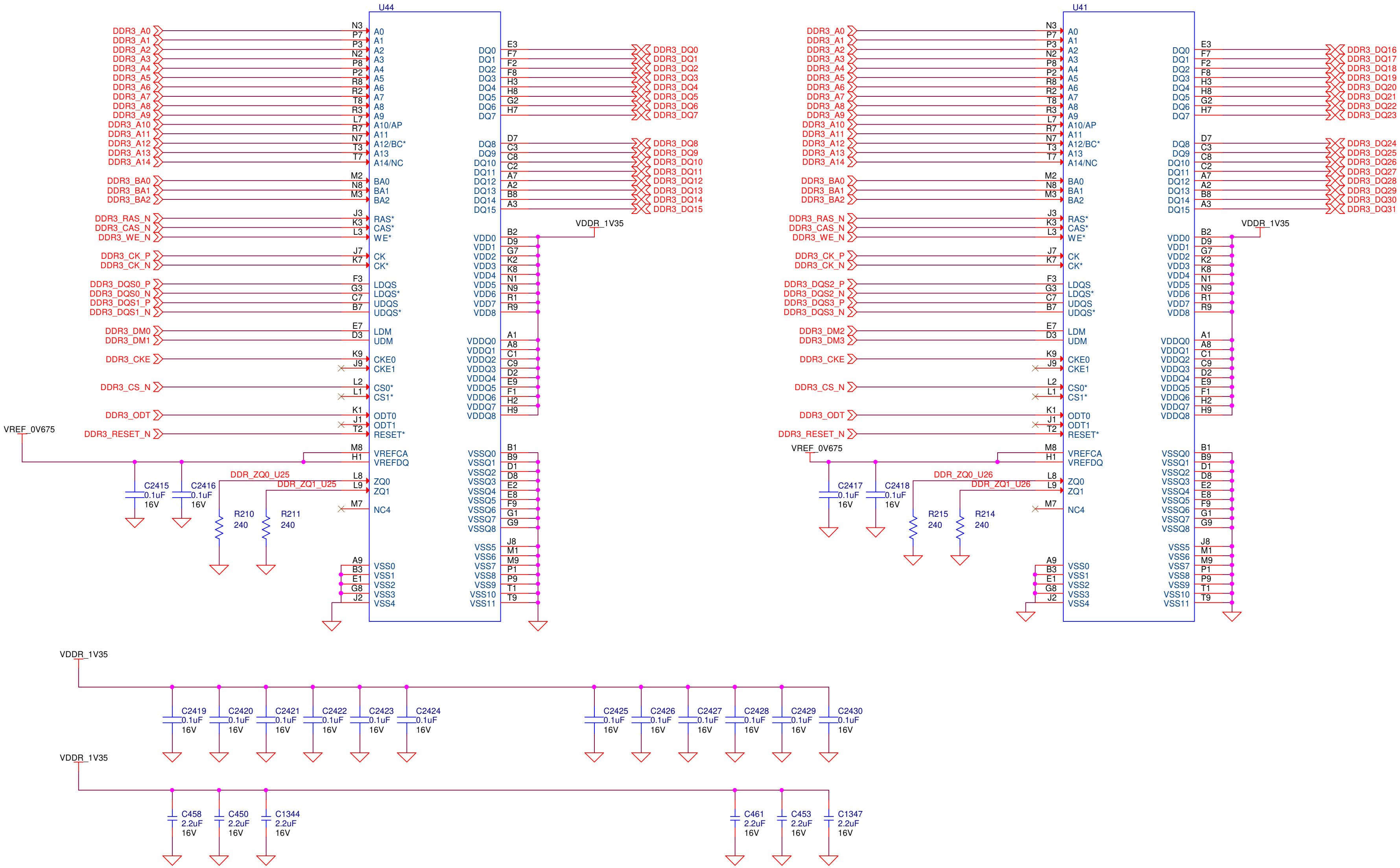


Figure 33. Schematic Page 18

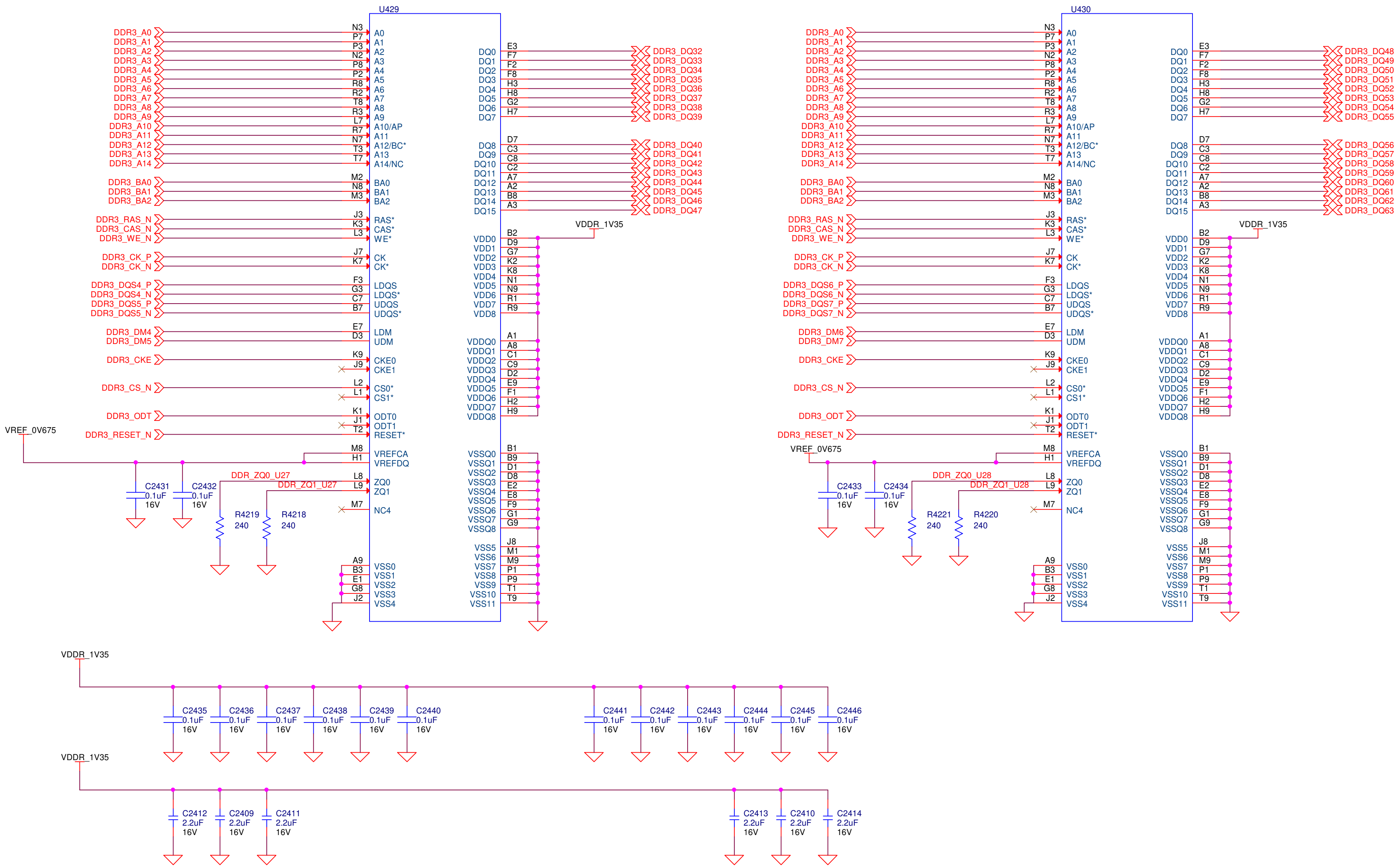


Figure 34. Schematic Page 19

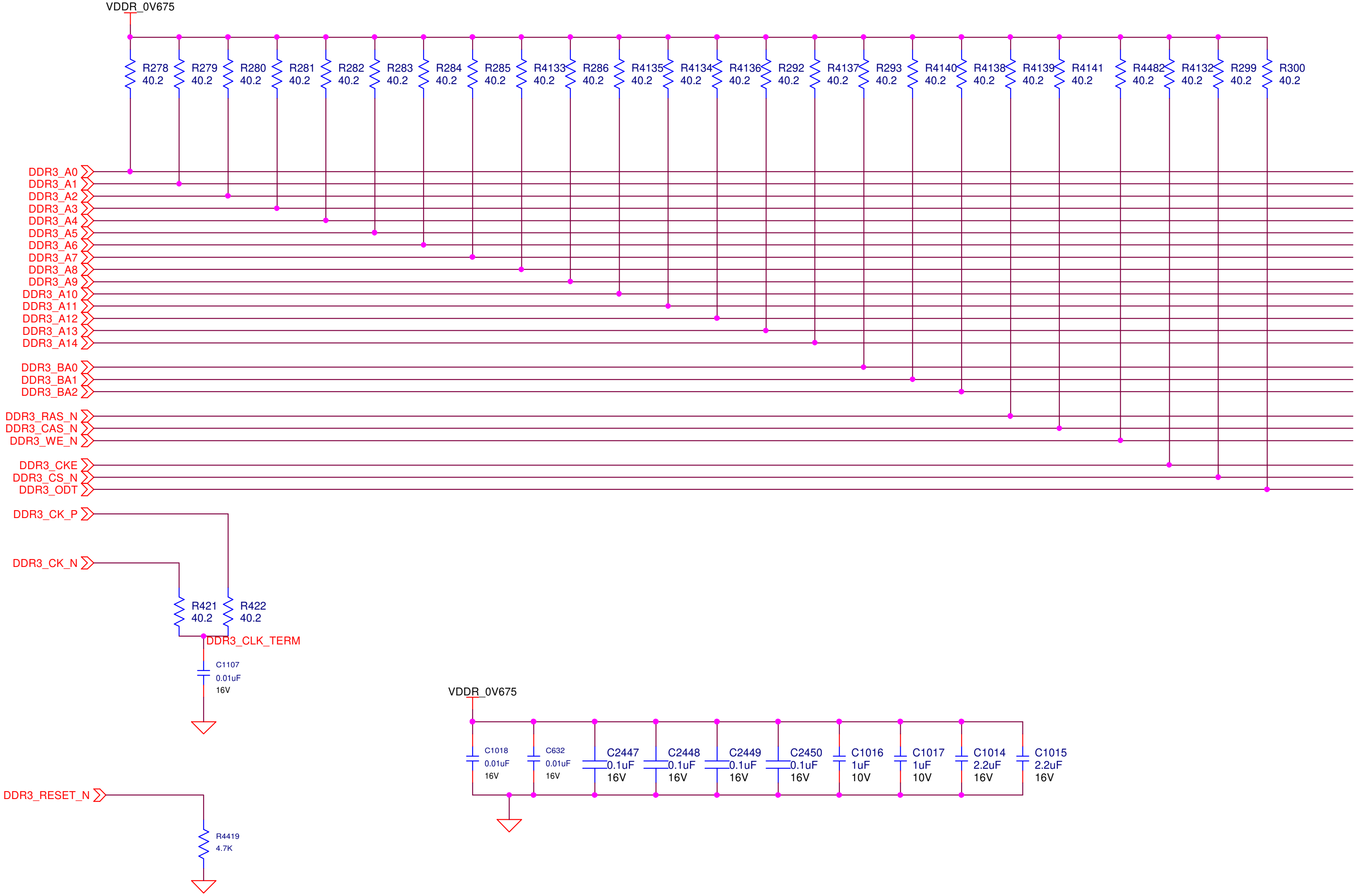


Figure 35. Schematic Page 20

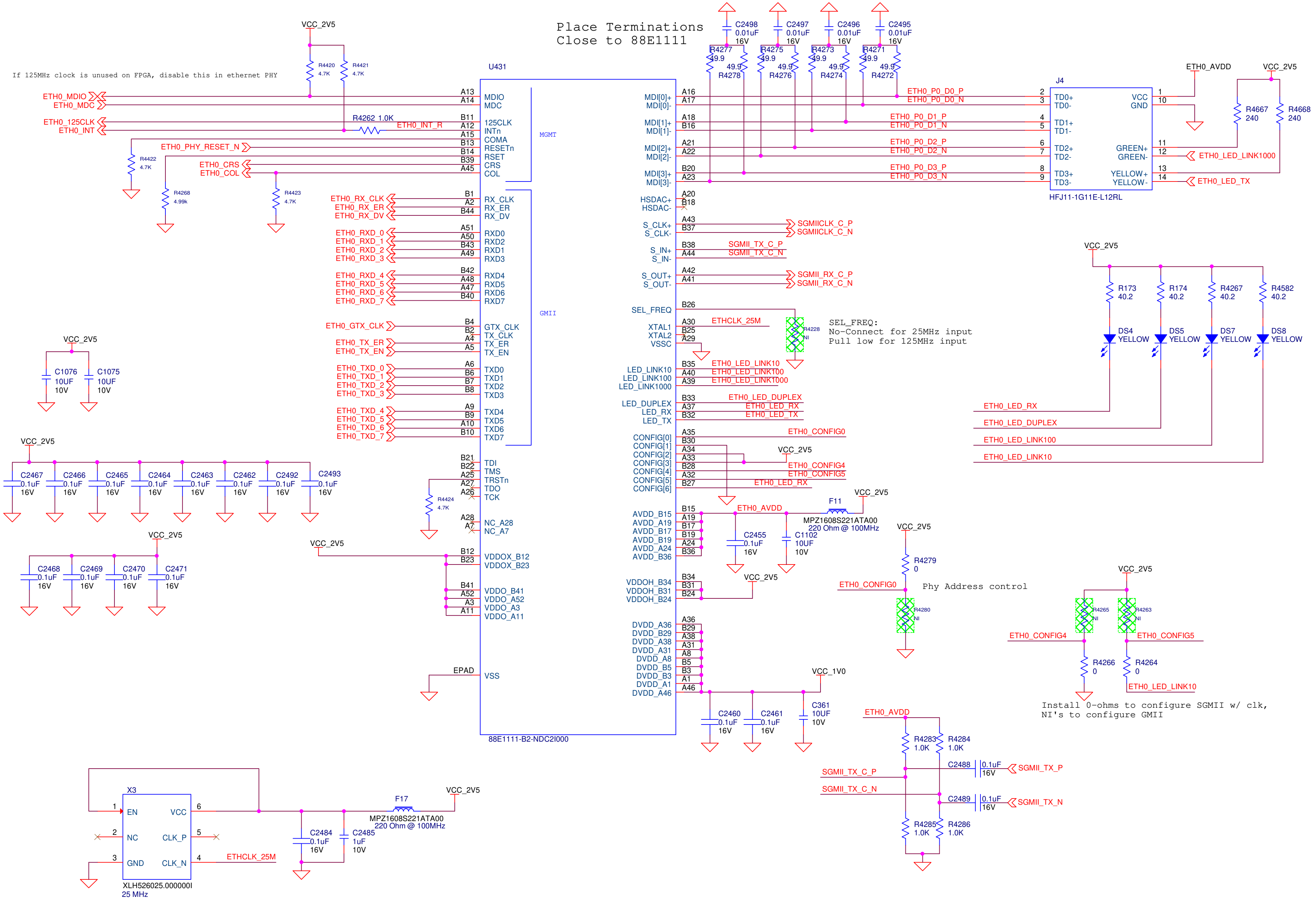


Figure 36. Schematic Page 21

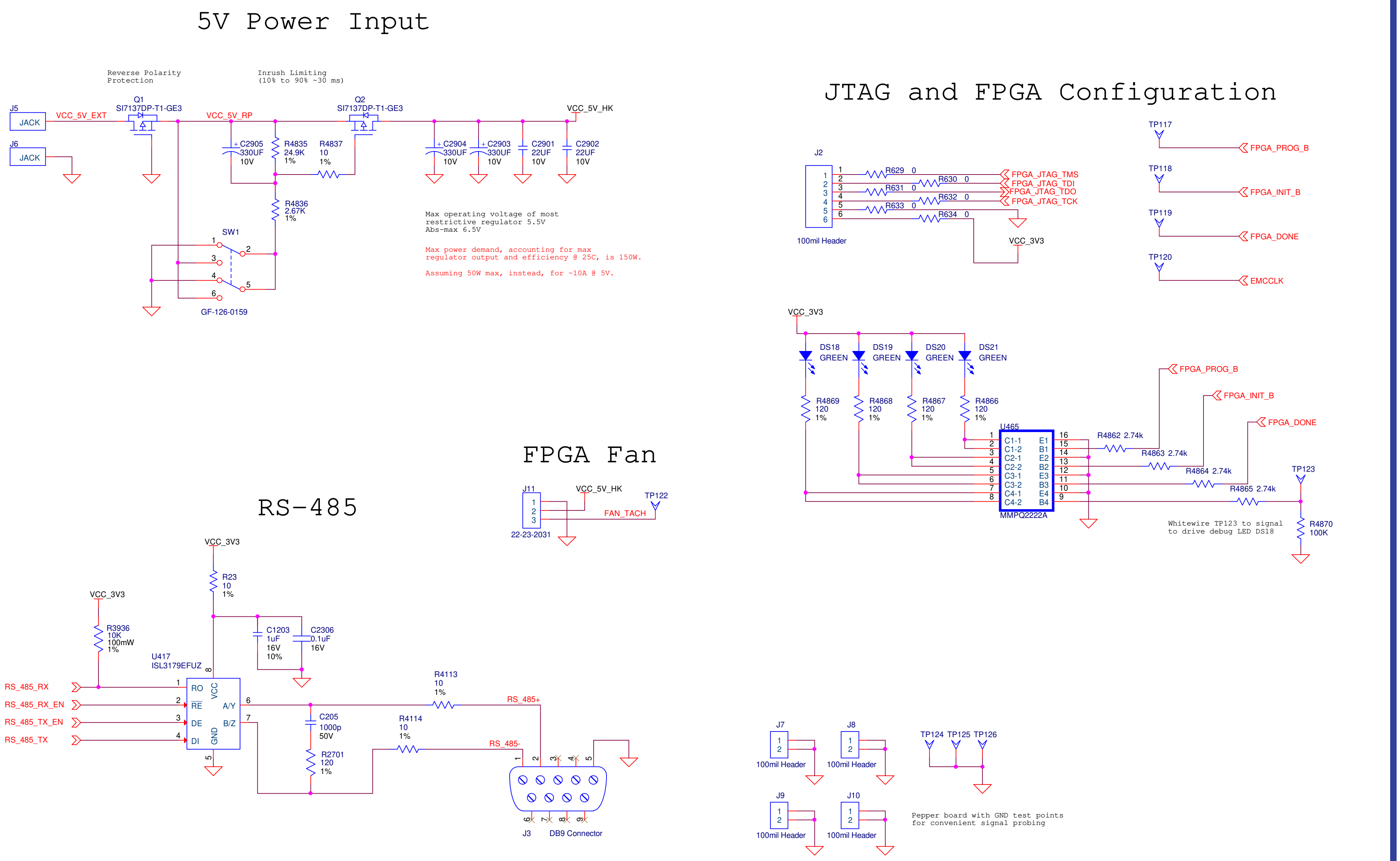


Figure 37. Schematic Page 22

3.3 Bill of Materials

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
1		PWB-PCB, ISLKU060DEMO1Z, REVA, ROHS	Imagineering Inc	ISLKU060DEMO1ZREVAPCB
4	C2765, C2777, C2785, C3041	CAP, SMD, 0402, 100pF, 16V, 10%, C0G/NP0, ROHS	Kemet	C0402C101K4GACTU
5	C205, C2576, C2578, C2911, C2935	CAP-AEC-Q200, SMD, 0402, 1000pF, 50V, 5%, C0G/NP0, ROHS	Kemet	C0402C102J5GACAUTO
16	C632, C865, C1018, C1107, C2495, C2496, C2497, C2498, C2500, C2501, C2659, C2669, C2701, C2927, C2955, C2956	CAP-AEC-Q200, ESD, SMD, 0402, 0.01µF, 16V, 10%, X7R, ROHS	Kemet	C0402C103K4RECAUTO
96	C869, C1272, C1274, C2306, C2415, C2416, C2417, C2418, C2419, C2420, C2421, C2422, C2423, C2424, C2425, C2426, C2427, C2428, C2429, C2430, C2431, C2432, C2433, C2434, C2435, C2436, C2437, C2438, C2439, C2440, C2441, C2442, C2443, C2444, C2445, C2446, C2447, C2448, C2449, C2450, C2455, C2460, C2461, C2462, C2463, C2464, C2465, C2466, C2467, C2468, C2469, C2470, C2471, C2482, C2484, C2488, C2489, C2492, C2493, C2523, C2524, C2525, C2526, C2542, C2543, C2544, C2545, C2546, C2547, C2548, C2549, C2550, C2551, C2552, C2555, C2563, C2564, C2565, C2566, C2567, C2599, C2600, C2601, C2602, C2603, C2604, C2648, C2668, C2695, C2932, C2951, C2965, C3017, C3018, C3033, C3042	CAP-AEC-Q200, SMD, 0402, 0.1µF, 16V, 10%, X7R, ROHS	Kemet	C0402C104K4RACAUTO
1	C2575	CAP-AEC-Q200, SMD, 0402, 2200pF, 50V, 10%, X7R, ROHS	Kemet	C0402C222K5RACAUTO
8	C2657, C2663, C2679, C2766, C2784, C2945, C3016, C3040	CAP-AEC-Q200, SMD, 0402, 4700pF, 16V, 10%, X7R, ROHS	Kemet	C0402C472K4RACAUTO

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
1	C2952	CAP-AEC-Q200, SMD, 0402, 0.047µF, 25V, 10%, X7R, ROHS	Kemet	C0402C473K3RACAUTO
1	C2577	CAP-AEC-Q200, SMD, 0402, 680pF, 50V, 10%, X7R, ROHS	Kemet	C0402C681K5RACAUTO
4	C2912, C2914, C2933, C2937	CAP-AEC-Q200, SMD, 0402, 6800pF, 50V, 10%, X7R, ROHS	Kemet	C0402C682K5RACAUTO
1	C1291	CAP-AEC-Q200, SMD, 0402, 82pF, 25V, 5%, C0G/NP0, ROHS	Kemet	C0402C820J3GACAUTO
27	C863, C864, C1016, C1017, C1203, C2366, C2368, C2376, C2483, C2485, C2606, C2643, C2644, C2665, C2666, C2700, C2708, C2709, C2756, C2925, C2926, C3009, C3010, C3011, C3012, C3013, C3014	CAP, SMD, 0603, 1.0µF, 16V, 10%, X7R, ROHS	Kemet	C0603C105K4RACTU
11	C2367, C2646, C2667, C2688, C2690, C2693, C2694, C2900, C2940, C2953, C2954	CAP-AEC-Q200, SMD, 0603, 0.22µF, 25V, 10%, X7R, ROHS	Kemet	C0603C224K3RACAUTO
30	C857, C858, C859, C860, C861, C1275, C2743, C2744, C2745, C2748, C2749, C2750, C2753, C2754, C2755, C2757, C2762, C2920, C2921, C2922, C2923, C2924, C2944, C2960, C2963, C2964, C2966, C2967, C3037, C3038	CAP-AEC-Q200, SMD, 0603, 0.47µF, 16V, 10%, X7R, ROHS	Kemet	C0603C474K4RACAUTO
20	C450, C453, C458, C461, C1014, C1015, C1344, C1347, C2409, C2410, C2411, C2412, C2413, C2414, C2557, C2558, C2559, C2560, C2561, C2562	CAP-AEC-Q200, SMD, 0805, 2.2µF, 16V, 10%, X7R, ROHS	Kemet	C0805C225K4RACAUTO721
38	C361, C506, C1075, C1076, C1102, C1267, C1268, C2517, C2518, C2519, C2520, C2521, C2522, C2774, C2780, C2895, C2987, C2988, C2989, C2990, C2991, C2992, C2993, C2994, C2995, C2996, C2997, C2998, C2999, C3000, C3001, C3002, C3003, C3004, C3005, C3006, C3007, C3008	CAP-AEC-Q200, SMD, 1206, 10µF, 16V, 10%, X7R, ROHS	Kemet	C1206C106K4RACAUTO

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
52	C412, C2373, C2374, C2527, C2528, C2530, C2531, C2532, C2533, C2534, C2535, C2536, C2538, C2541, C2597, C2598, C2711, C2712, C2713, C2741, C2742, C2746, C2747, C2751, C2752, C2901, C2902, C2910, C2931, C2938, C2939, C2972, C2973, C2974, C2975, C2976, C2977, C2978, C2979, C2980, C2981, C2982, C2983, C2984, C2985, C2986, C3021, C3025, C3029, C3043, C3044, C3045	CAP-AEC-Q200, SMD, 1210, 22µF, 10V, 10%, X7R, ROHS	Kemet	C1210C226K8RACAUTO
9	C2763, C2779, C2783, C2903, C2904, C2905, C2961, C2962, C3039	CAP-TANT, SMD, 7.3x4.3x4.3, 330µF, 10V, 20%, 5mΩ ESR, COTS, ROHS	Kemet	T541X337M010AH6510
17	C2894, C2915, C2919, C3015, C3019, C3020, C3022, C3023, C3024, C3026, C3027, C3028, C3030, C3031, C3032, C3034, C3035	CAP-TANT, SMD, 7.3x4.3x4.3, 47µF, 35V, 20%, 60mΩ ESR, COTS, ROHS	Kemet	T541X476M035AH6510
10	C397, C398, C2647, C2662, C2678, C2909, C2929, C2969, C2970, C2971	CAP-TANT, SMD, 7.3x4.3, 470µF, 6.3V, 20%, 10mΩESR, COTS, ROHS	Kemet	T541X477M006AH6710
2	L35, L36	COIL-PWR INDUCTOR, AEC-Q200, SMD, 5.2x5.4mm, 1µH, 20%, 14A, ROHS	Coilcraft	XAL5030-102MEB
1	L24	COIL-PWR INDUCTOR, SMD, 5.2x5.4mm, 2.2µH, 20%, 9.2A, 13.2mΩ, ROHS	Coilcraft	XAL5030-222MEB
1	L27	COIL-PWR INDUCTOR, AEC-Q200, SMD, 4mm, 1µH, 20%, 9A, ROHS	Coilcraft	XEL4030-102MEB
2	L33, L34	COIL-PWR INDUCTOR, AEC-Q200, SMD, 6.1x5mm, 0.47µH, 20%, 22A, ROHS	Coilcraft	XGL6060-471MEB
1	J11	CONN-HEADER, 1x3, SOLID, 2.54mm, FRICTION LOCK, ROHS	Molex	22-23-2031
2	J5, J6	CONN-JACK, MINI BANANA, 0.175 PLUG, NICKEL/BRASS, ROHS	Keystone	575-4

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
4	J7, J8, J9, J10	CONN-HEADER, 1x2, 2.54mmCENTER, 0.236X0.118in., ROHS	Wurth Elektronik	61300211121
1	J2	CONN-HEADER, 1x6, BREAKAWAY, 2.54mmPITCH, 0.236inx0.118in, ROHS	Wurth Elektronik	61300611121
1	J4	CONN-MODULAR, FEMALE JACK, ETHERNET, RJ45, TH, 1PORT, R/A, ROHS	Halo Electronics	HFJ11-1G11E-L12RL
1	J3	CONN-D-SUB, MALE PLUG, TH, 9POSITION, R/A, ROHS	Amphenol/FCI	LD09P13A4GX00LF
2	D12, D13	DIODE-RECTIFIER, SMD, SMC, 2P, 20V, 3A, ROHS	On Semiconductor	MBRS320T3G
12	DS10, DS11, DS12, DS13, DS14, DS15, DS16, DS17, DS18, DS19, DS20, DS21	LED, SMD, 0603, GREEN/DIFFUSED, 2.2V, 20mA, 18MCD, 565nm, ROHS	Lumex	SML-LX0603GW-TR
4	DS4, DS5, DS7, DS8	LED, SMD, 0603, YELLOW/DIFFUSED, 2.1V, 20mA, 14MCD, 585nm, ROHS	Lumex	SML-LX0603YW-TR
3	F11, F16, F17	FERRITE CHIP, SMD, 0603, 50mΩ, 2.2A, 220Ω at 100MHz, ROHS	TDK	MPZ1608S221ATA00
4	U41, U44, U429, U430	IC-DRAM MEMORY, 3.3V, DDR3, 256Mx16, SMD, 96P, BGA, AUTOMOTIVE, ROHS	ISSI (Lumissil Microsystems)	IS46TR16256ECL-107NB2LA2 IS46TR16256BL-107MBLA2 (alternative p/n; Non error correction code (ECC) version)
3	U448, U449, U451 *Sub ISL70001ASEHFE/MS	IC-PROTO, RAD/SEE HARD 6A REGULATOR, 48P, CQFP, W/HEATSINK, ROHS	Renesas Electronics America	ISL70001ASEHFE/PROTO
2	U2, U423 *Sub ISL70002SEHFE/MS	IC-12A SYNC BUCK REGULAT, 64P, CQFP, W/HEATSINK, ROHS	Renesas Electronics America	ISL70002SEHFE/PROTO
1	U422 *Sub ISL70005SEHF/MS	IC-RAD HARD LDO REGULATOR, SMD, 28P, CFP, ROHS	Renesas Electronics America	ISL70005SEHF/PROTO
1	U459 *Sub ISL70062SEHF/MS	IC-RAD HARD, LOW VOLT SWITCH, 14P, CFP, ROHS	Renesas Electronics America	ISL70062SEHF/PROTO
1	U460 *Sub ISL70244SEHF/MS	IC-19MHz RAD HARD R/R OP AMP, 10P, FP, ROHS	Renesas Electronics America	ISL70244SEHF/PROTO
2	U452, U453 *Sub ISL70321SEHF/MS	IC-RADHARD QUAD SEQUENCER, 18P, FLATPAK, ROHS	Renesas Electronics America	ISL70321SEHF/PROTO

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
4	U38, U39, U40, U466 *Sub ISL75051ASEHFE/MS	IC-RADHARD, CMOS 3A LDO REGULATOR, 18P, CFP, ROHS	Renesas Electronics America	ISL75051ASEHFE/PROTO
2	U461, U462	IC-AEC-Q100, NOR FLASH MEMORY, 256Mb, SMD, 16P, SOP2, ROHS	Micron Technology	MT25QL256ABA8ESF-0AAT
1	U34 *Sub XQDAISY-CNA1509	IC-FPGA, FLIP-CHIP, 624 I/O, SMD, 1517P, BBGA, ROHS	AMD	XCKU060-1FFVA1517I
3	U463, U464, U465	IC-TRANSISTOR-4 NPN, 40V, 0.5A, 16P, SOIC, ROHS	On Semiconductor	MMPQ2222A
2	Q1, Q2	TRANSISTOR-MOS, P-CHANNEL, 8P, PWRPAK, -20V, -60A, ROHS	Vishay/Siliconix	SI7137DP-T1-GE3
1	X3	OSC-CRYSTAL, 25MHz XO, HCMOS, 2.5V, SMD, 6P, 5.15x3.35mm, ROHS	Renesas Electronics	XLH526025.000000I
1	X2	OSC-CRYSTAL, 100MHz XO, LVDS, 3.3V, SMD, 6P, 7.5x5.2mm, ROHS	Renesas Electronics	XLL735100.000000I
1	R4781	POT-TRIM, CERMET, TH, 10.3x4.8, 10K, 1/3W, 10%, 1 TURN, TOP ADJ, ROHS	AMP-Piner	PTC10LV10-103A1010
1	R4780	RES-AEC-Q200, SMD, 0402, 10.5K, 1/16W, 0.1%, TF, ROHS	Panasonic	ERA-2AEB1052X
1	R4779	RES-AEC-Q200, SMD, 0402, 1.87K, 1/16W, 0.1%, TF, ROHS	Panasonic	ERA-2AEB1871X
1	R4823	RES-AEC-Q200, SMD, 0402, 221Ω, 1/16W, 0.1%, TF, ROHS	Panasonic	ERA-2AEB2210X
1	R4821	RES-AEC-Q200, SMD, 0402, 316Ω, 1/16W, 0.1%, TF, ROHS	Panasonic	ERA-2AEB3160X
3	R4478, R4479, R4818	RES-AEC-Q200, SMD, 0402, 499Ω, 1/16W, 0.1%, TF, ROHS	Panasonic	ERA-2AEB4990X
2	R4817, R4874	RES-AEC-Q200, SMD, 0402, 4.64K, 1/16W, 0.1%, TF, ROHS	Panasonic	ERA-2APB4641X
1	R4156	RES-AEC-Q200, SMD, 0402, 20K, 1/16W, 0.1%, TF, ROHS	Panasonic	ERA-2ARB203X
1	R4268	RES-AEC-Q200, SMD, 0402, 4.99K, 1/16W, 0.1%, TF, ROHS	Panasonic	ERA-2ARB4991X

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
1	R4819	RES-AEC-Q200, SMD, 0402, 1.5K, 1/10W, 0.5%, THINFILM, ROHS	Panasonic	ERA-2VRW1501X
62	R620, R621, R622, R629, R630, R631, R632, R633, R634, R4194, R4195, R4196, R4199, R4264, R4266, R4279, R4495, R4496, R4503, R4504, R4566, R4592, R4593, R4594, R4612, R4613, R4614, R4615, R4616, R4617, R4618, R4619, R4631, R4632, R4644, R4645, R4652, R4654, R4662, R4663, R4664, R4665, R4677, R4697, R4698, R4700, R4701, R4708, R4714, R4715, R4716, R4777, R4778, R4782, R4788, R4789, R4790, R4791, R4792, R4793, R4794, R4795	RES-AEC-Q200, SMD, 0402, 0Ω, 1/10W, ROHS	Panasonic	ERJ-2GE0R00X
28	R637, R4262, R4283, R4284, R4285, R4286, R4287, R4289, R4290, R4291, R4292, R4296, R4464, R4467, R4468, R4469, R4470, R4471, R4472, R4473, R4474, R4608, R4696, R4702, R4703, R4707, R4815, R4873	RES-AEC-Q200, SMD, 0402, 1K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF1001X
29	R607, R3936, R4154, R4307, R4308, R4529, R4530, R4531, R4532, R4533, R4534, R4537, R4538, R4539, R4540, R4541, R4543, R4567, R4635, R4639, R4656, R4657, R4679, R4680, R4733, R4742, R4787, R4796, R4876	RES-AEC-Q200, SMD, 0402, 10K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF1002X
5	R4811, R4812, R4813, R4814, R4870	RES-AEC-Q200, SMD, 0402, 100K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF1003X
4	R531, R4760, R4761, R4875	RES-AEC-Q200, SMD, 0402, 1.47K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF1471X
1	R4713	RES-AEC-Q200, SMD, 0402, 169K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF1693X

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
1	R4709	RES-AEC-Q200, SMD, 0402, 180Ω, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF1800X
23	R210, R211, R214, R215, R4142, R4143, R4218, R4219, R4220, R4221, R4282, R4463, R4667, R4668, R4820, R4846, R4847, R4848, R4849, R4850, R4851, R4852, R4853	RES-AEC-Q200, SMD, 0402, 240Ω, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF2400X
5	R4688, R4806, R4807, R4808, R4835	RES-AEC-Q200, SMD, 0402, 24.9K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF2492X
5	R4596, R4705, R4706, R4836, R4871	RES-AEC-Q200, SMD, 0402, 2.67K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF2671X
16	R4763, R4765, R4766, R4767, R4838, R4839, R4840, R4841, R4854, R4855, R4856, R4857, R4862, R4863, R4864, R4865	RES-AEC-Q200, SMD, 0402, 2.74K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF2741X
2	R4695, R4740	RES-AEC-Q200, SMD, 0402, 30.1K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF3012X
5	R4797, R4798, R4799, R4800, R4801	RES-AEC-Q200, SMD, 0402, 36.5K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF3652X
30	R173, R174, R278, R279, R280, R281, R282, R283, R284, R285, R286, R292, R293, R299, R300, R421, R422, R4132, R4133, R4134, R4135, R4136, R4137, R4138, R4139, R4140, R4141, R4267, R4482, R4582	RES-AEC-Q200, SMD, 0402, 40.2Ω, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF40R2X
20	R4419, R4420, R4421, R4422, R4423, R4424, R4429, R4430, R4431, R4432, R4433, R4434, R4827, R4828, R4829, R4830, R4831, R4832, R4833, R4834	RES-AEC-Q200, SMD, 0402, 4.7K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF4701X
10	R4271, R4272, R4273, R4274, R4275, R4276, R4277, R4278, R4476, R4477	RES-AEC-Q200, SMD, 0402, 49.9Ω, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF49R9X
5	R4193, R4802, R4803, R4804, R4805	RES-AEC-Q200, SMD, 0402, 54.9K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF5492X

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part
2	R4809, R4810	RES-AEC-Q200, SMD, 0402, 5.9K, 1/10W, 1%, TF, ROHS	Panasonic	ERJ-2RKF5901X
6	R23, R4113, R4114, R4759, R4783, R4837	RES-AEC-Q200, SMD, 0402, 10Ω, 1/5W, 1%, TF, ROHS	Panasonic	ERJ-PA2F10R0X
5	R2701, R4866, R4867, R4868, R4869	RES-AEC-Q200, SMD, 0402, 120Ω, 1/5W, 1%, TF, ROHS	Panasonic	ERJ-PA2F1200X
4	R4288, R4293, R4465, R4466	RES-AEC-Q200, SMD, 0402, 100Ω, 1/16W, 0.02%, THINFILM, ROHS	Susumu	RG1005V-101-P
6	R4197, R4198, R4497, R4501, R4516, R4641	RES-AEC-Q200, SMD, 0603, 1K, 1/10W, 0.05%, THINFILM, ROHS	Susumu	RG1608N-102-W-T1
4	R539, R4681, R4683, R4872	RES, SMD, 0402, 4.32K, 1/16W, 0.1%, THINFILM, ROHS	Yageo	RT0402BRD074K32L
1	R4816	RES-AEC-Q200, SMD, 0402, 3.28K, 1/10W, 0.1%, Thin Film, ROHS	Vishay/Dale	TNPW04023K28BEED
1	SW1	SWITCH-SLIDE, TH, 6P, DPDT, 3A, 125V, ROHS	CW Industries	GF-126-0159
4	Four corners	SCREW, 4-40X1/4in, PHILLIPS, PANHEAD, STAINLESS, ROHS	Building Fasteners	PMSSS 440 0025 PH
4	Four corners	STANDOFF, 4-40X3/4in, F/F, HEX, ALUMINUM, 0.25 OD, ROHS	Keystone	2204
1	U431	TRANSCEIVER-ETHERNET, SMD, 96P, aQFN, INDUSTRIAL, ROHS	Marvell	88E1111-B2-NDC2I000
0	R618, R638, R4129, R4130, R4228, R4263, R4265, R4280, R4630, R4651	DO NOT POPULATE OR PURCHASE		
0	TP92, TP93, TP94, TP95, TP96, TP97, TP98, TP99, TP100, TP101, TP102, TP103, TP104, TP105, TP106, TP107, TP108, TP109, TP110, TP116, TP117, TP118, TP119, TP120, TP121, TP122, TP123, TP124, TP125, TP126, TP127, TP128	DO NOT POPULATE OR PURCHASE		
1	U417	IC-TRANSCEIVER, 3.3V HALF DUPLEX, RS-485/RS-422, ROHS	Renesas Electronics	ISL3179EFUZ

4. Ordering Information

Part Number	Description
ISLKU060DEMO1Z	Rad Hard Power Management KU060 Reference Design

5. Revision History

Revision	Date	Description
1.02	Jul 25, 2024	Changed Xilinx to AMD throughout document.
1.01	Oct 18, 2022	Updated Figure 2.
1.00	Oct 15, 2021	Initial release

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