Power Management

Solution for Xilinx ZYNQ Ultrascale+ RFSoC

Abstract

This document provides a power management reference solution for the Xilinx Zynq® Ultrascale+™ RFSoC. The Zynq® UltraScale+™ RFSoC family integrates multi-gigasample RF data converters into an SoC platform that contains a 64-bit quad-core Arm® Cortex™-A53 and dual-core Arm Cortex-R5 based processing system. The reference design is suitable for the ZU21DR, ZU25DR, ZU27DR, ZU28DR, and ZU29DR devices. Target applications are 4G and 5G remote wireless infrastructure and test and measurement. Figure 1 shows the power supply rails for the device.

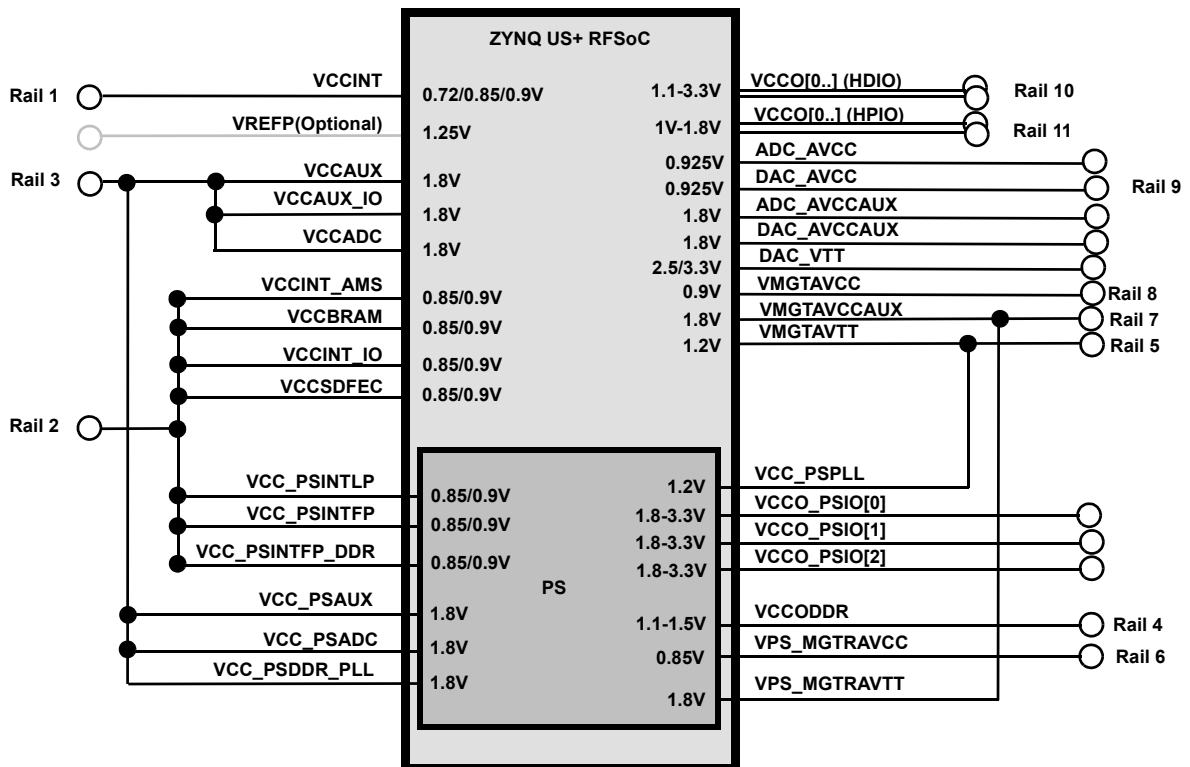Figure 1. Power Rail Consolidation for the Xilinx Zynq US+ RFSoC

Related Literature

For a full list of related documents, visit our website:

- ISL68124, ISL99227, ISL91211AIK, ISL91211BIK, ISL8024, ISL80019 device pages

1. Specifications

Table 1 lists the specifications for each rail required for the RFSoC. The ADC and DAC supply rails request low voltage ripples; therefore, additional LC low-pass filters are added after the DC/DC converters. Table 2 lists the voltage ripple requirements for the ADC and DAC supply rails. There are two proposed solutions in this applications note:

• Use discrete integrated FET controllers (ISL8024) to generate ADC and DAC supply rails

• Use a PMIC (ISL91211BIK) and a discrete integrated FET controller (ISL80019)

Table 1.   Rail Specifications for RFSoC

Rail Name	ZYNQ US+ RFSoC Power Supply Rails	Voltage (V)	Current (A)	Device	Device
Rail 1	VCCINT	0.72/0.85/0.9	45	ISL68124	ISL68124
Rail 2	VCCINT_AMS, VCCBRAM, VCCINT_IO, VCCSDFEC, VCC_PSINTLP, VCC_PSINTFP, VCC_PSINTFP_DDR	0.85/0.9	20.15		
Rail 3	VCCAUX, VCCAUX_IO, VCCADC, VCC_PSAUX, VCC_PSDDR_PLL, VCC_PSADC	1.8	2.04	ISL91211BIK	ISL91211BIK
Rail 4	VCCODDR	DDR	0.5A+	ISL91211AIK	ISL91211AIK
Rail 5	VMGTAVTT	1.2	4.1		
Rail 6	VMGTRAVCC	0.85	0.3		
Rail 7	VMGTAVCCAUX	1.8	0.3	ISL91211BIK	ISL91211BIK
Rail 8	VMGTAVCC	0.9	2	ISL91211BIK	ISL91211BIK
Rail 9	ADC_AVCC	0.925	2	ISL8024	ISL91211BIK
Rail 10	ADC_AVCCAUX	1.8	1.3	ISL8024	
Rail 11	DAC_AVCC	0.925	2.2	ISL8024	
Rail 12	DAC_AVCCAUX	1.8	0.25	ISL8024	
Rail 13	DAC_AVTT	2.5/3	0.6	ISL8024	ISL80019

Table 2.   Voltage Ripple Requirements for the ADC and DAC Supply Rails

Rail Name	ZYNQ US+ RFSoC Power Supply Rails	Voltage (V)	Current (A)	Voltage Ripple
Rail 9	ADC_AVCC	0.925	2	$<0.25mV_{P-P}$
Rail 10	ADC_AVCCAUX	1.8	1.3	$<10mV_{P-P}$
Rail 11	DAC_AVCC	0.925	2.2	$<0.40mV_{P-P}$
Rail 12	DAC_AVCCAUX	1.8	0.25	$<2mV_{P-P}$
Rail 13	DAC_AVTT	2.5/3	0.6	$<8mV_{P-P}$

2. Functional Description

The block diagrams are shown in Figures 2 and 3. The VCCINT and VCCBRAM rails are converted directly from the 12V input, while the remaining rails are converted from an intermediate 3.3V bus, which is generated by ISL68201+ISL99227B. The ADC/DAC rails require low voltage ripple so additional low-pass filters are needed. Figure 2 shows the solution using all switching regulators, ISL8024 for all ADC/DAC rails. Figure 3 shows the solution using a PMIC, ISL91211BIK for DAC_AVCC, DAC_ACCAUX, ADC_AVCC, and ADC_ACCAUX rails.
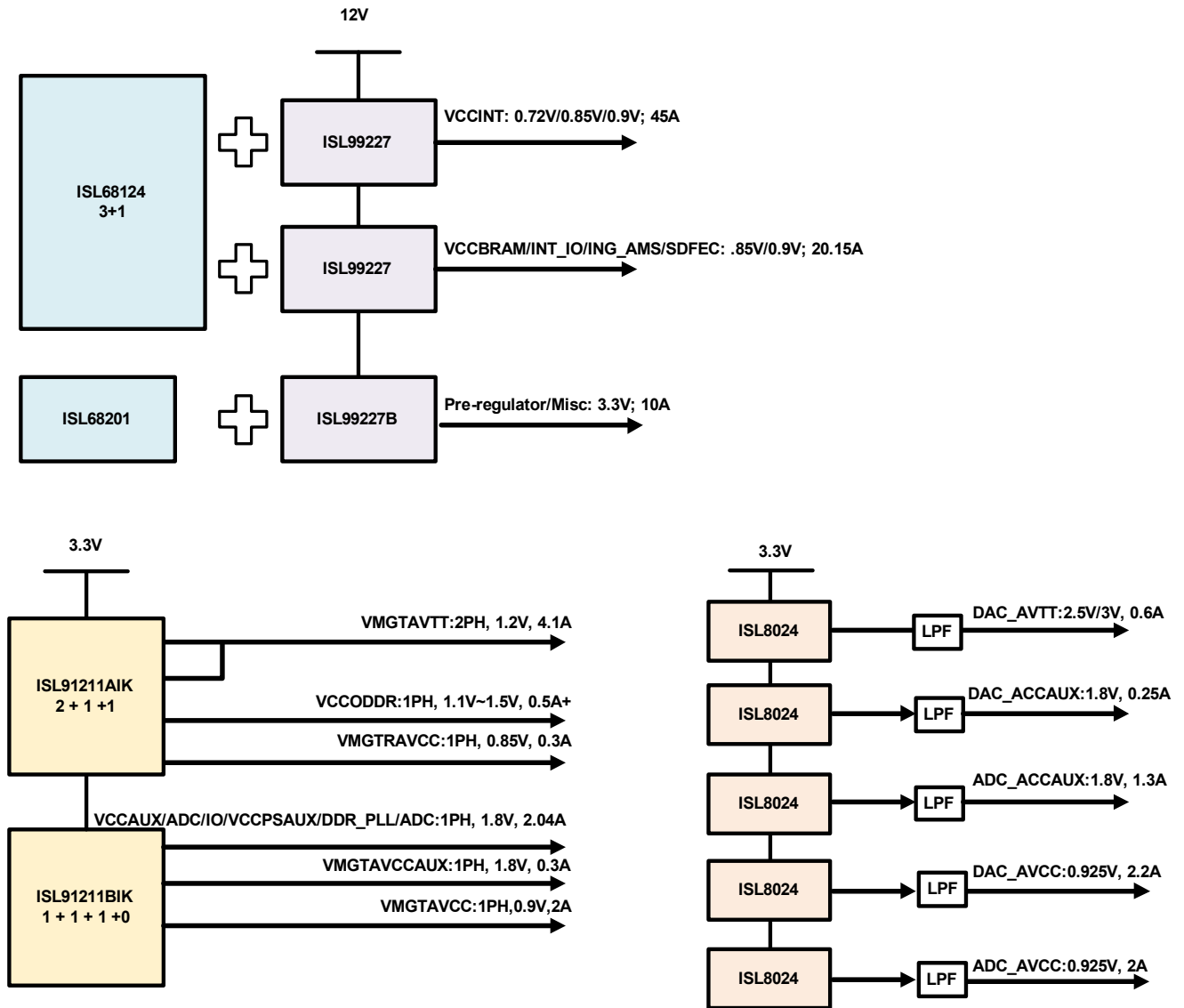
12V

**ISL68124
3+1**

ISL99227 — VCCINT: 0.72V/0.85V/0.9V; 45A

ISL99227 — VCCBRAM/INT_IO/ING_AMS/SDFEC: .85V/0.9V; 20.15A

ISL68201

ISL99227B — Pre-regulator/Misc: 3.3V; 10A

3.3V

**ISL91211AIK
2 + 1 +1**
- VMGTAVTT:2PH, 1.2V, 4.1A
- VCCODDR:1PH, 1.1V~1.5V, 0.5A+
- VMGTRAVCC:1PH, 0.85V, 0.3A

VCCAUX/ADC/IO/VCCPSAUX/DDR_PLL/ADC:1PH, 1.8V, 2.04A

**ISL91211BIK
1 + 1 + 1 +0**
- VMGTAVCCAUX:1PH, 1.8V, 0.3A
- VMGTAVCC:1PH,0.9V,2A

3.3V

ISL8024 — LPF — DAC_AVTT:2.5V/3V, 0.6A

ISL8024 — LPF — DAC_ACCAUX:1.8V, 0.25A

ISL8024 — LPF — ADC_ACCAUX:1.8V, 1.3A

ISL8024 — LPF — DAC_AVCC:0.925V, 2.2A

ISL8024 — LPF — ADC_AVCC:0.925V, 2A

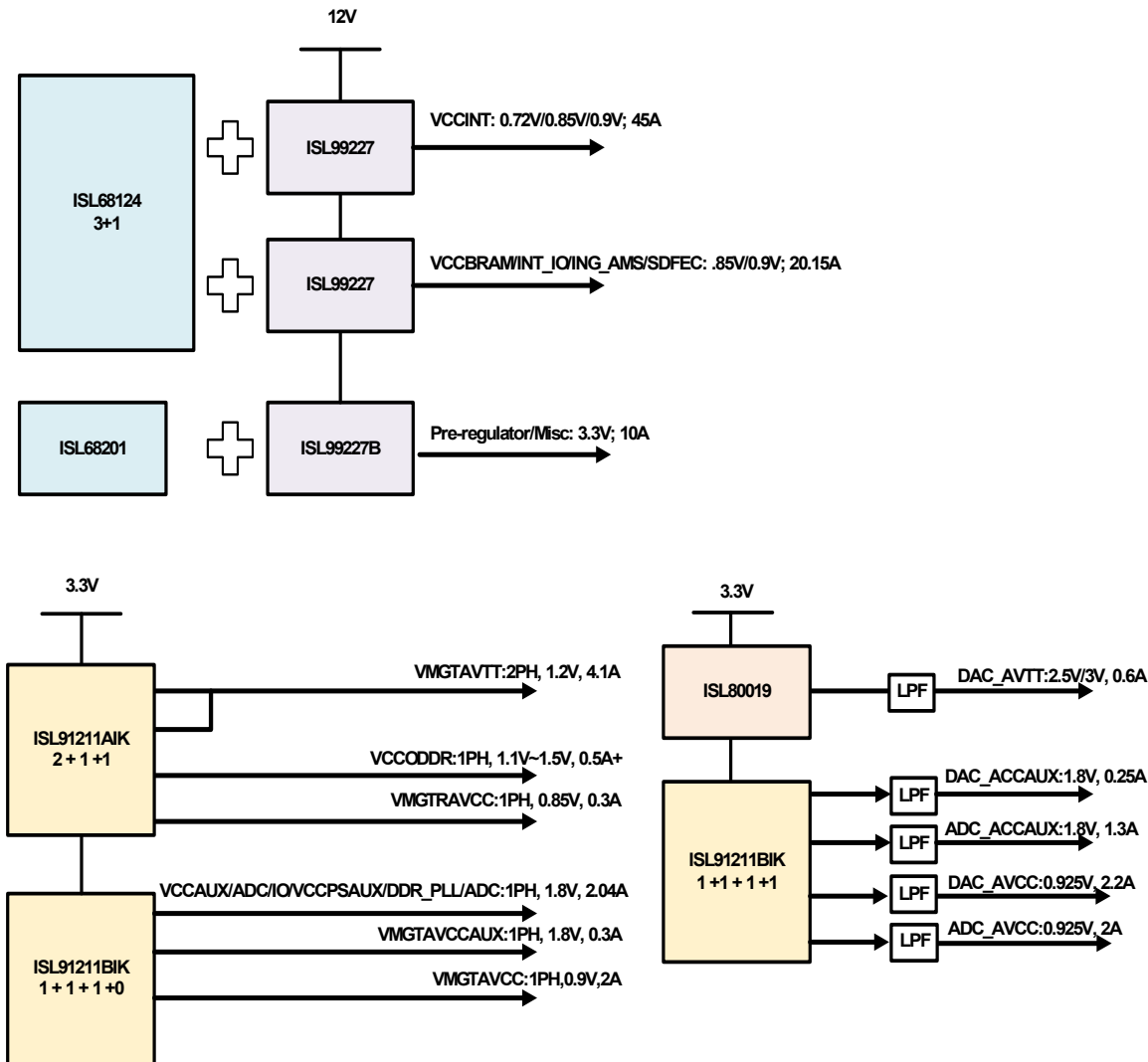**Figure 2. Block Diagram - Solution using Switching Regulators**

Figure 3. Block Diagram - Solution using a PMIC

2.1 Digital Multiphase Controller

The ISL68124 is a digital dual output, flexible multiphase (X+Y ≤ 4) PWM controller supporting the latest PMBus V1.3 specifications. Either of the outputs can be configured to support any desired phase assignments up to a maximum of four phases across the two outputs (X+Y). For example, 3+1, 2+2, or even a single output operation as a 4+0 configuration are supported. The ISL68124 uses the Renesas proprietary linear synthetic digital current modulation scheme to achieve the industry-best combination of transient response and ease of tuning while addressing the challenges of modern multiphase designs.

In this design, the ISL68124 is used to generate VCCINT rail and VCCBRAM rail. shows the ISL68124 schematic. Three phases are assigned for the VCCINT rail to provide 45A current, and one phase is assigned to VCCBRAM rail to provide 20A current.
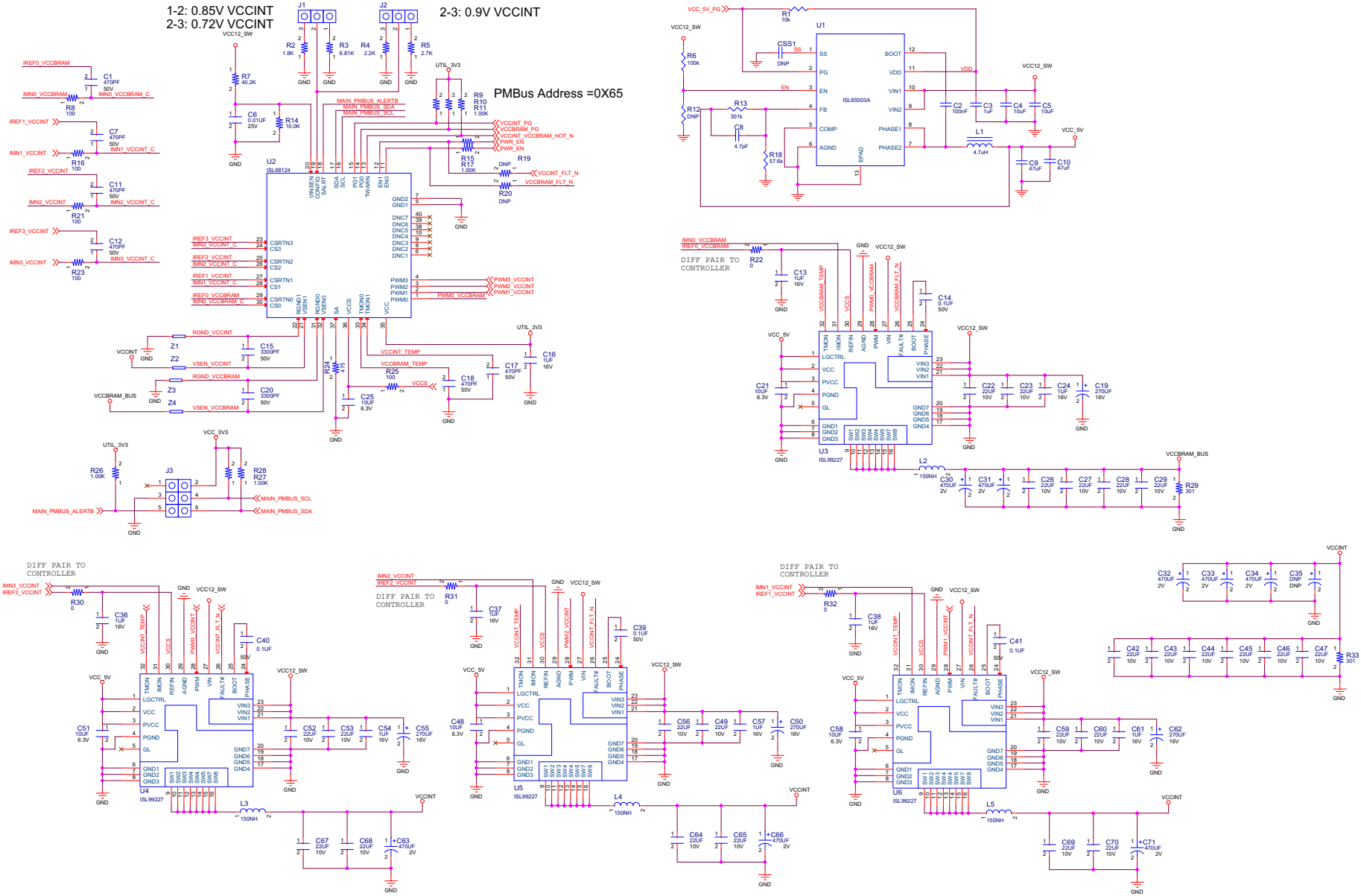
Figure 4. ISL68124 Schematic

2.2 Digital Hybrid PWM Controller

The ISL68201 is a single-phase, synchronous buck PWM controller featuring the Renesas proprietary R4™ Technology. It supports a wide 4.5V to 24V input voltage range and a wide 0.5V to 5.5V output range. Integrated LDOs provide controller bias voltage, allowing for single supply operation. The ISL68201 includes a PMBus/SMBus/I^{2}C interface for device configuration and telemetry (V$_{IN}$, V$_{OUT}$, I$_{OUT}$, and temperature) and fault reporting. In this design, the ISL68201 is used for generating an intermediate 3.3V bus. Figure 5 shows the ISL68201 schematic.
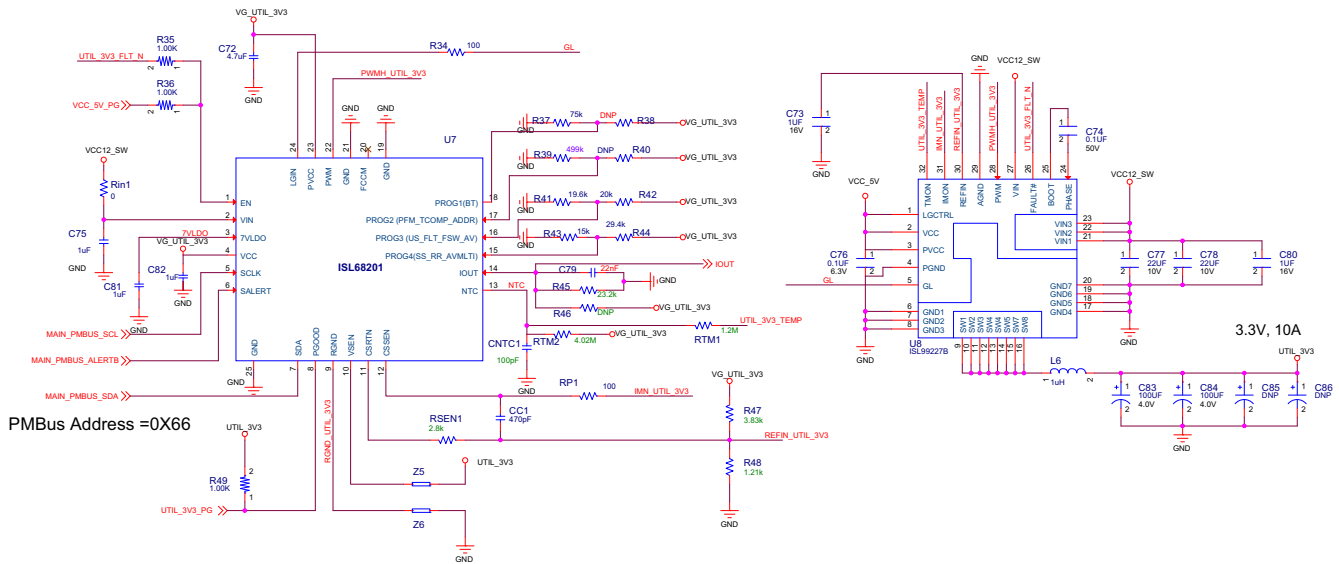

Figure 5. ISL68201 Schematic

2.3 Power Management IC (PMIC)

The ISL91211AIK and ISL91211BIK have four independently OTP programmable voltage settings for each buck controller, which can set the output voltage. The ISL91211AIK and ISL91211BIK are highly efficient, dual or single output, synchronous multiphase buck switching regulators that can deliver up to 3.5A per-phase continuous output current.

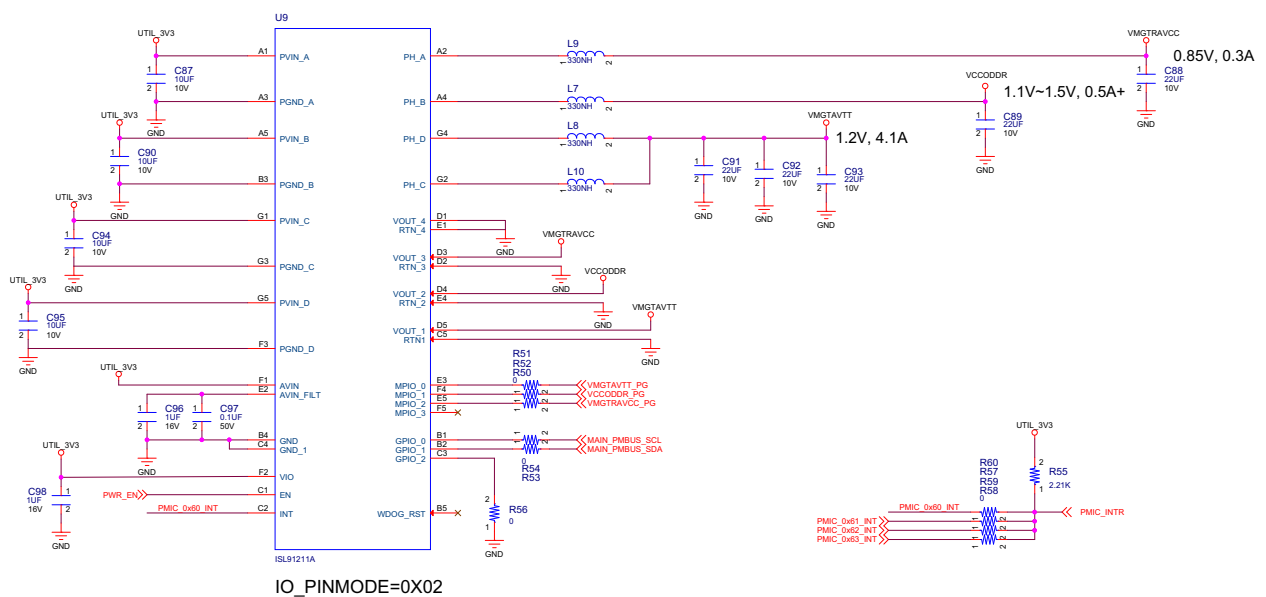Figure 6 shows the ISL91211AIK schematic which generates VMGVVTT, VCCODDR and VMGTRAVCC rails.

Figure 6. ISL91211AIK Schematic

shows the ISL91211BIK schematic which generates VCCAUX/ADC/IO, VMGTVCCAUX, and VMGTAVCC rails.
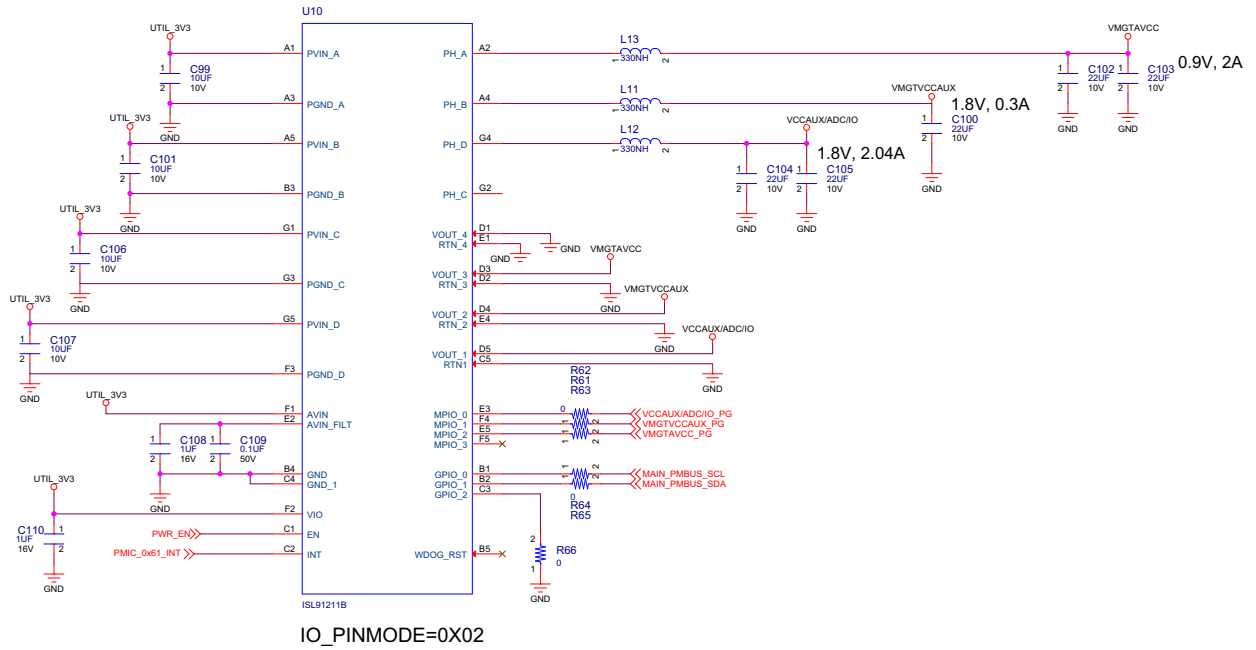

Figure 7. ISL91211BIK Schematic

3. ADC/DAC Supply Rails

For the first solution, which uses discrete switch regulators (ISL8024) to generate ADCAVCC, DACAVCC, and DACAVTT rails, see UG187 for details.

Figures 8 shows the ISL91211BIK and ISL80019 schematic, which generates DAC_ACCAUX, ADC_ACCAUX, DAC_AVCC, ADC_AVCC, and DAC_AVTT rails.
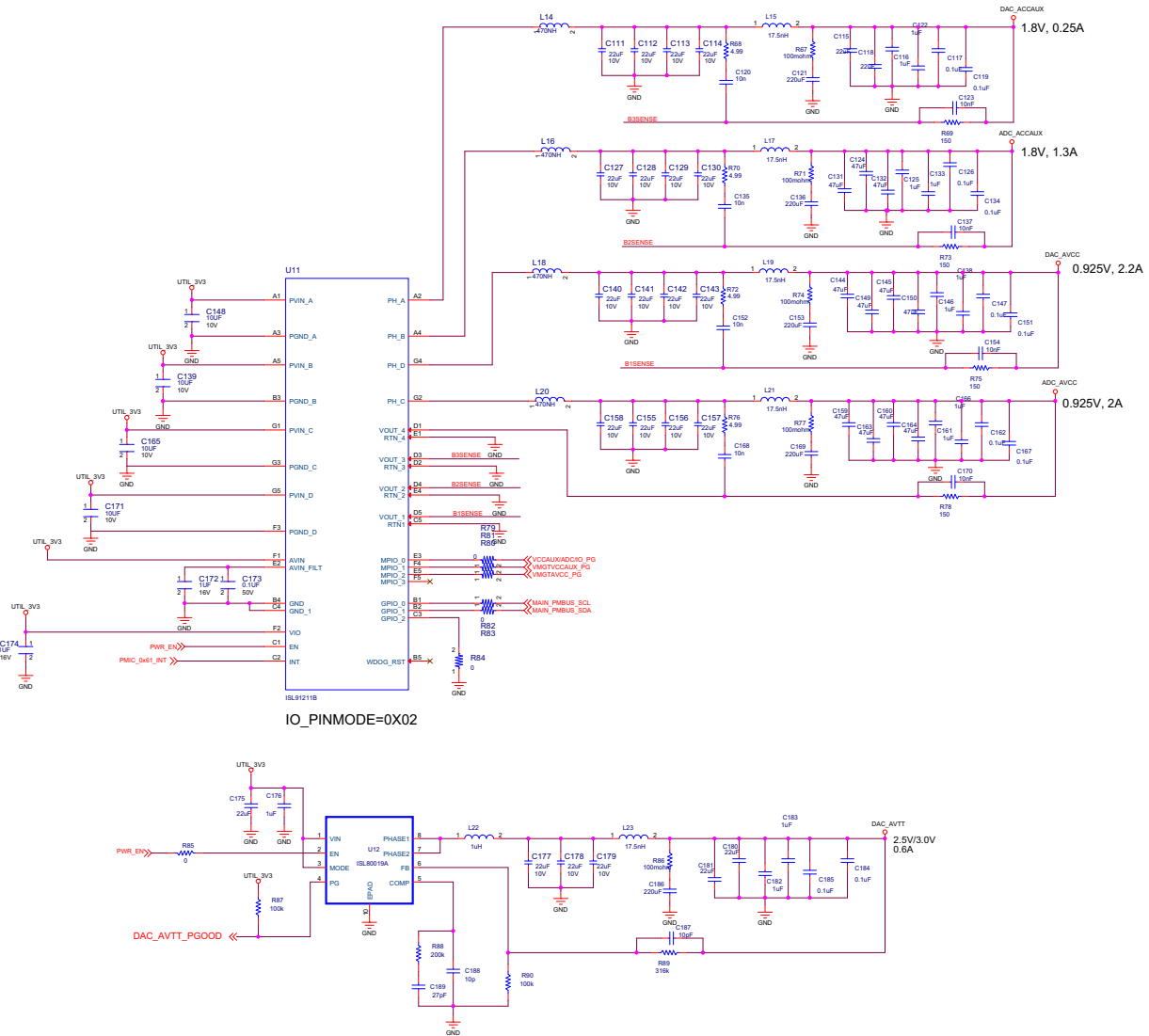

Figure 8. ISL91211BIK and ISL80019 Schematic for ADC/DAC Supply Rails

4. Bill of Materials

Qty	Reference Designator	Description	Mfr	Manufacturer Part Number
ISL68124 Schematic				
6	C1, C7, C11, C12, C17, C18	CAP CER 470pF 50V X7R 0402	Various	
1	C2	CAP CER 0.1µF 10V X7R 0603	Various	
1	C3	CAP CER 1µF 16V X7R 0603	Various	
2	C4, C5	CAP CER 10µF 25V X7R 1206	Various	
1	C6	CAP CER 10000pF 25V X7R 0402	Various	
1	C8	CAP, SMD, 0402, 4.7pF, 50V, 5%, NP0, ROHS	Various	

Qty	Reference Designator	Description	Mfr	Manufacturer Part Number
2	C9, C10	CAP CER 47µF 10V X7R 1210	Various	
9	C13, C16, C24, C36, C37, C38, C54, C57, C61	CAP CER 1µF 16V X6S 0402	Various	
4	C14, C39, C40, C41	CAP CER 0.1µF 50V X7R 0402	Various	
2	C15, C20	CAP CER 3300pF 50V X7R 0402	Various	
4	C19, C50, C55, C62	CAP ALUM POLY 270µF 20% 16V T/H	Nichicon	RS81C271MDN1
5	C21, C25, C48, C51, C58	CAP CER 10µF 6.3V X6S 0402	Various	
24	C22, C23, C26, C27, C28, C29, C42, C43, C44, C45, C46, C47, C49, C52, C53, C56, C59, C60, C64, C65, C67, C68, C69, C70	CAP CER 22µF 10V X5R 0603	Various	
8	C30, C31, C32, C33, C34, C63, C66, C71	CAP ALUM POLY 470µF 20% 2V SMD	Panasonic Electronic Components	EEF-GX0D471R
2	J1, J2	CONN HEADER VERT 36POS 2.54MM	Sullins	PBC36SAAN
1	J3	CONN HEADER R/A 6POS 2.54MM	Amphenol ICC	68021-406HLF
1	L1	COIL-PWR CHOKE, SMD, 7x6.9, 4.7µH, 20%, 6A, 19.5mΩ, ROHS	WURTH ELECTRONIC	744311470
4	L2, L3, L4, L5	FIXED IND 150NH 51A 0.29 MΩ	Eaton	FP0906R1-R15-R
1	R1	RES, SMD, 0402, 10k, 1/16W, 1%, TF, ROHS	Various	
1	R2	RES, SMD, 0402, 1.8k, 1/16W, 1%, TF, ROHS	Various	
1	R3	RES, SMD, 0402, 6.81k, 1/16W, 1%, TF, ROHS	Various	
1	R4	RES, SMD, 0402, 2.2k, 1/16W, 1%, TF, ROHS	Various	
1	R5	RES, SMD, 0402, 2.7k, 1/16W, 1%, TF, ROHS	Various	
1	R6	RES, SMD, 0402, 100k, 1/16W, 1%, TF, ROHS	Various	
1	R7	RES, SMD, 0402, 40.2k, 1/16W, 1%, TF, ROHS	Various	
5	R8, R16, R21, R23, R25	RES, SMD, 0402, 100Ω, 1/16W, 1%, TF, ROHS	Various	
8	R9, R10, R11, R15, R17, R26, R27, R28	RES, SMD, 0402, 1k, 1/16W, 1%, TF, ROHS	Various	
1	R13	RES, SMD, 0402, 301k, 1/16W, 1%, TF, ROHS	Various	
1	R14	RES, SMD, 0402, 10k, 1/16W, 1%, TF, ROHS	Various	
1	R18	RES, SMD, 0402, 57.6k, 1/16W, 1%, TF, ROHS	Various	
4	R22, R30, R31, R32	RES, SMD, 0402, 0Ω, 1/16W, 1%, TF, ROHS	Various	
1	R24	RES, SMD, 0402, 475Ω, 1/16W, 1%, TF, ROHS	Various	
2	R29, R33	RES, SMD, 0402, 301Ω, 1/16W, 1%, TF, ROHS	Various	
1	U1	IC REG BUCK ADJUSTABLE 3A 12DFN	Renesas	ISL85003A
1	U2	IC REG CTRLR PMBUS 40TQFN	Renesas	ISL68124
4	U3, U4, U5, U6	IC MODULE SPS 3.3V 32-PQFN	Renesas	ISL99227
4	Z1, Z2, Z3, Z4	RES, SMD, 0402, 0Ω, 1/16W, 1%, TF, ROHS	Various	
0	CSS1, R12, R19, R20, C35, J1, J2	Do Not Populate		
ISL68201 Schematic				
1	CC1	CAP CER 470pF 50V X7R 0402	Various	
1	CNTC1	CAP CER 100pF 50V X7R 0402	Various	
1	C72	CAP CER 4.7µF 10V X7R 0603	Various	
2	C73, C80	CAP CER 1.0µF 16V X5R 0402	Various	
2	C74, C76	CAP CER 0.1µF 50V X7R 0402	Various	
3	C75, C81, C82	CAP CER 1.0µF 10V X5R 0402	Various	

Qty	Reference Designator	Description	Mfr	Manufacturer Part Number
2	C77, C78	CAP CER 22µF 10V X5R 0603	Various	
1	C79	CAP CER 22nF 50V X7R 0402	Various	
2	C83, C84	CAP ALUM POLY 220µF 20% 6.3V SMD	Panasonic	6TPF220M5L
1	L6	FIXED IND 1U 28A 5 MΩ	Coilcraft	XAL7030-102ME
2	RP1, R34	RES, SMD, 0402, 100Ω, 1/16W, 1%, TF, ROHS	Various	
1	RSEN1	RES, SMD, 0402, 2.8k, 1/16W, 1%, TF, ROHS	Various	
1	RTM1	RES, SMD, 0402, 1.2MΩ, 1/16W, 1%, TF, ROHS	Various	
1	RTM2	RES, SMD, 0402, 4.02MΩ, 1/16W, 1%, TF, ROHS	Various	
1	Rin1	RES, SMD, 0402, 0Ω, 1/16W, 1%, TF, ROHS	Various	
3	R35, R36, R49	RES, SMD, 0402, 1kΩ, 1/16W, 1%, TF, ROHS	Various	
1	R37	RES, SMD, 0402, 75kΩ, 1/16W, 1%, TF, ROHS	Various	
1	R39	RES, SMD, 0402, 499k, 1/16W, 1%, TF, ROHS	Various	
1	R41	RES, SMD, 0402, 19.6k, 1/16W, 1%, TF, ROHS	Various	
1	R42	RES, SMD, 0402, 20k, 1/16W, 1%, TF, ROHS	Various	
1	R43	RES, SMD, 0402, 15k, 1/16W, 1%, TF, ROHS	Various	
1	R44	RES, SMD, 0402, 29.4k, 1/16W, 1%, TF, ROHS	Various	
1	R45	RES, SMD, 0402, 23.2k, 1/16W, 1%, TF, ROHS	Various	
1	R47	RES, SMD, 0402, 3.83k, 1/16W, 1%, TF, ROHS	Various	
1	R48	RES, SMD, 0402, 1.21k, 1/16W, 1%, TF, ROHS	Various	
1	U7	IC REG CTRLR BUCK PMBUS 24QFN	Renesas	ISL68201
1	U8	IC MODULE SPS 5V 32-PQFN	Renesas	ISL99227B
2	Z5, Z6	RES, SMD, 0402, 0Ω, 1/16W, 1%, TF, ROHS	Various	
3	R38, R40, R46, C85, C86	Do Not Populate		
ISL91211AIK Schematic				
4	C87, C90, C94, C95	CAP CER 10µF 10V X5R 0603	Various	
5	C88, C89, C91, C92, C93	CAP CER 22µF 10V X5R 0603	Various	
2	C96, C98	CAP CER 1.0µF 10V X6S 0402	Various	
1	C97	CAP CER 0.1µF 50V X7R 0402	Various	
4	L7, L8, L9, L10	FIXED IND 330NH 5.1A 19 MΩ	Murata	DFE252012F-R33M
10	R50, R51, R52, R53, R54, R56, R57, R58, R59, R60	RES, SMD, 0402, 0Ω, 1/16W, 1%, TF, ROHS	Various	
1	R55	RES, SMD, 0402, 2.21kΩ, 1/16W, 1%, TF, ROHS	Various	
1	U9	IC REG BCK PROG 10A/5A/5A TRPL	Renesas	ISL91211AIK
ISL91211BIK Schematic				
4	C99, C101, C106, C107	CAP CER 10µF 10V X5R 0603	Various	
5	C100, C102, C103, C104, C105	CAP CER 22µF 10V X5R 0603	Various	
2	C108, C110	CAP CER 1.0µF 10V X6S 0402	Various	
1	C109	CAP CER 0.1µF 50V X7R 0402	Various	
3	L11, L12, L13	FIXED IND 330NH 5.1A 19 MΩ	Murata	DFE252012F-R33M
6	R61, R62, R63, R64, R65, R66	RES, SMD, 0402, 0Ω, 1/16W, 1%, TF, ROHS	Various	
1	U10	IC REG BUCK PROG 5A/5A/5A/5A QUAD	Renesas	ISL91211BIK
DAC/ADC Supply Schematic				
24	C111, C112, C113, C114, C115, C118, C127, C128, C129, C130, C140, C141, C142, C143, C155, C156, C157, C158, C175, C177, C178, C179, C180, C181	CAP CER 22µF 10V X5R 0603	Various	

Qty	Reference Designator	Description	Mfr	Manufacturer Part Number
13	C116, C122, C125, C133, C138, C146, C161, C166, C172, C174, C176, C182, C183	CAP CER 1.0µF 10V X6S 0402	Various	
11	C117, C119, C126, C134, C147, C151, C162, C167, C173, C184, C185	CAP CER 0.1µF 50V X7R 0402	Various	
8	C120, C123, C135, C137, C152, C154, C168, C170	CAP CER 10nF 50V X7R 0402	Various	
5	C121, C136, C153, C169, C186	CAP CER 220µF 6.3V X5R 1206	Various	
11	C124, C131, C132, C144, C145, C149, C150, C159, C160, C163, C164	CAP CER 47µF 6.3V X5R 0603	Various	
4	C139, C148, C165, C171	CAP CER 10µF 10V X5R 0603	Various	
2	C187, C188	CAP CER 10pF 50V COG 0402		
1	C189	CAP CER 27pF 50V COG 0402		
4	L14, L16, L18, L20	FIXED IND 470nH 4.9A 23MΩ	Murata	DFE252012F-R47M
5	L15, L17, L19, L21, L23L15, L17, L19, L21, L23	FIXED IND 17.5nH 3.5A 4.5MΩ	Abracon LLC	AIAC-2712C-17N5J-T
1	L22	FIXED IND 1µH 2.5A 75 MΩ SMD	Wurth	74438323010
5	R67, R71, R74, R77, R86	RES, SMD, 0603, 0.1Ω, 1/16W, 1%, TF, ROHS	Various	
4	R68, R70, R72, R76	RES, SMD, 0402, 4.99Ω, 1/16W, 1%, TF, ROHS	Various	
4	R69, R73, R75, R78	RES, SMD, 0402, 150Ω, 1/16W, 1%, TF, ROHS	Various	
7	R79, R80, R81, R82, R83, R84, R85	RES, SMD, 0402, 0Ω, 1/16W, 1%, TF, ROHS	Various	
2	R87, R90	RES, SMD, 0402, 100kΩ, 1/16W, 1%, TF, ROHS	Various	
2	R87, R90	RES, SMD, 0402, 200kΩ, 1/16W, 1%, TF, ROHS	Various	
1	R89	RES, SMD, 0402, 316kΩ, 1/16W, 1%, TF, ROHS	Various	
1	U11	IC REG BUCK PROG 5A/5A/5A/5A QUAD	Renesas	ISL91211BIK
1	U12	IC-500mA BUCK REGULATOR, 12P, DFN, 3x4, ROHS	Renesas	ISL80019A

5.   Revision History

Rev.	Date	Description
1.00	Mar.4.20	Initial release

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

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