AN13554

NXP PMIC solution for SAMA5Dx series processor

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Application note

Document information

Information	Content
Keywords	power solution, PMIC, battery charging, PF1550, PF1510, SAMA5Dx
Abstract	This document demonstrates one complete, highly integrated, cost optimized power management solution for the Microchip/Atmel SAMA5Dx series processors using an NXP PF1550/PF1510 Power Management IC (PMIC).

Table 1. Revision history

Rev	Date	Description
1	20220428	Initial version

1 Introduction

SAMA5 are high-performance, ultra-low power ARM Cortex-A5 core based microprocessors (MPUs) supporting multiple memories, including DDR3, LPDDR3 and QSPI Flash. They are fit for various applications like control panels/HMI, secure IoT gateways, connectivity, barcode scanners, printers and POS terminal applications. The low-power features and small packages are ideal for wearables and other battery-operated consumer devices.

PF1550/PF1510 have multiple power supply, battery charging and power mode optimizations that are compatible with SAMA5 based applications. This application note introduces one typical power solution with PF1550/PF1510 to enable and power a SAMA5x MPU, which can simplify system design and save customer effort.

2 PF1550 and PF1510

PF1550/PF1510 features three high-efficiency buck converters, three linear regulators, a DDR reference and an always-on power supply, it is an optimized solution for low-power portable, smart wearable and Internet-of-Things (IoT) applications. PF1550 and PF1510 are pin-to-pin compatible with the space-saving 5x5mm QFN package.

The difference between PF1550 and PF1510 is that PF1550 integrates one linear 1 A Li+ battery charger, and it can be powered with a Li battery or a 5 V USB, AC adaptor. PF1510 does not have a battery charger and only supports 5 V USB, AC adaptor input.


Figure 1. PF1550 block diagram

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3   Power solution

This section details a PF1550A6 and PF1510A6 power solution for the SAMA5D2 MPU specifically. The PF1510A6 could power a SAMA5D2 if a lithium battery is not required. PF1550 and PF1510 have other part numbers that are able to power a SAMA5Dx with diverse peripherals based on actual requirements. The customer could refer to the PF1550/PF1510 datasheet to get the detailed configuration of each part number.

Figure 2 shows a PF1550A6 connection with SAMA5D2. Three switchers, three low dropouts (LDOs) and one always-on regulator VSNVS from PF1550 provide power supply to the MPU and DDR3L. The power supply default voltage and power-up sequence configuration is managed by the PF1550 one time programmable (OTP) functionality, which saves system complexity and customer development time. One battery charger is integrated within PF1550, which supports charging of a Li-ion or LiPo battery. PF1550 features various power modes to optimize current consumption.

Figure 2. PF1550 power solution for SAMA5D2
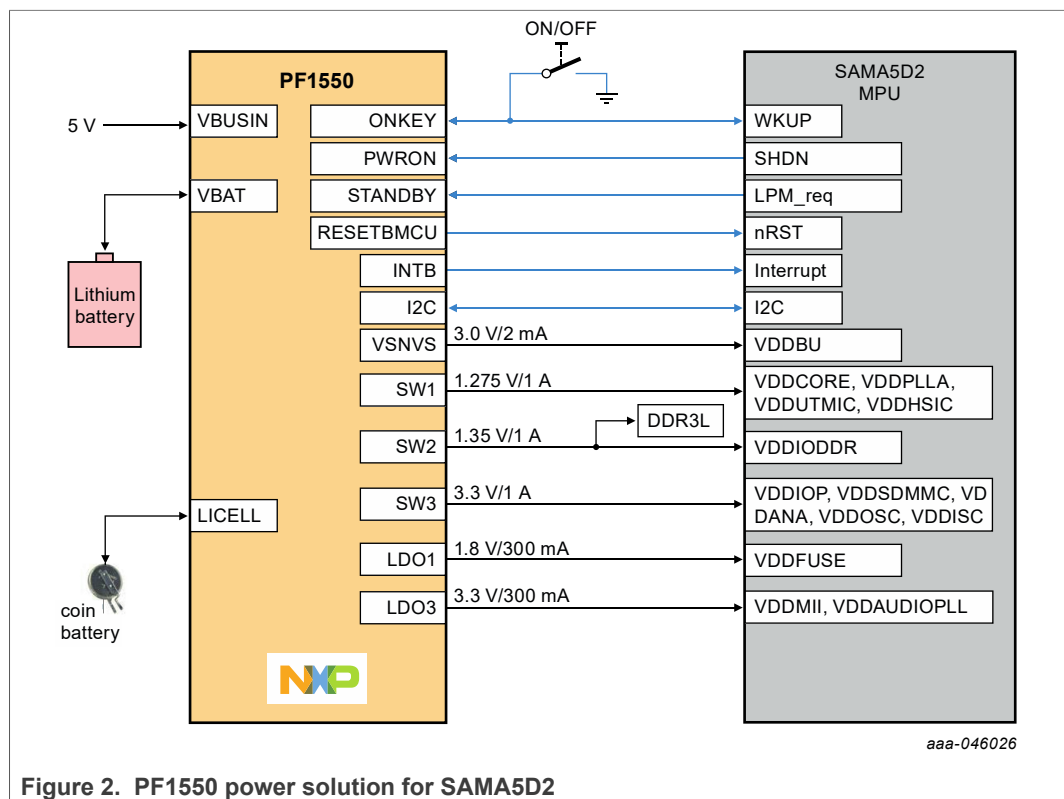
3.1   Power supply

PF1550 and PF1510 support two input sources with 5 V through VBUSIN or lithium battery (PF1510 only). A 5 V USB or AC adaptor could power the system and charge the battery at the same time, if a valid voltage is present at VBUSIN.

Table 2 shows the PF1550A6 and PF1510A6 default voltage configuration. SW1/SW2/SW3 works in PWM mode in high current load, and adaptive variable frequency pulse skip mode in light load, which could save current consumption. SW1 also integrates a dynamic voltage scaling (DVS) module to support output voltage adjustment with SAMA5D2 core requirements. The VDDFUSE function is the fuse box for programming, and its valid voltage is 2.25 to 2.75 V. The LDO1 default voltage is 1.8 V, and the voltage

could be changed to 2.5 V through an I2C command once fuse box programming is needed.

VSNVS is the always-on power supply for VDDBU of SAMA5D2. The VSNVS input could be from either VBUSIN, VBAT, or a coin cell battery.

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Table 2. PF1550A6/PF1510A6 power supply configuration

PF1550\PF1510 output channel	Voltage/V	Current capability/A	Power up sequence	SAMA5D2 power rail	Function
SW1	1.275	1	3	VDDCORE,VDDPLLA,VDDUTMIC,VDDHSIC	Core,PLL and USB BU
SW2	1.25	1	3	VDDIODDR	DDR3L interface IO
SW3	3.3	1	3	VDDIOP,VDDSDMMC,VDDANA,VDDOSC,VDDISC	Peripheral IO
LDO1	1.8	0.3	3	VDDFUSE	Fuse box for programming
LDO2	3.3	0.4	2	reserved	N.A
LDO3	3.3	0.3	3	VDDMII,VDDAUDIOPLL	USB, Audio
VSNVS	3	3	1	VDDBU	Slow Clock Oscillator for low power mode

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Table1, PF1550A6/PF1510A6 power supply configuration

Figure 3 shows the PF1550A6 and PF1510A6 power-up sequence and power-down sequence. PF1550/PF1510 manages power up for all regulators automatically. Time slot 0 and slot 1 are not applied to any regulators, but still executed with fixed times. SAMA5D2 can boot up when RESETBMCU is released, after all regulators finish powering up. All PF1550/PF1510 switchers and LDOs support soft start with a 2 ms typical value.
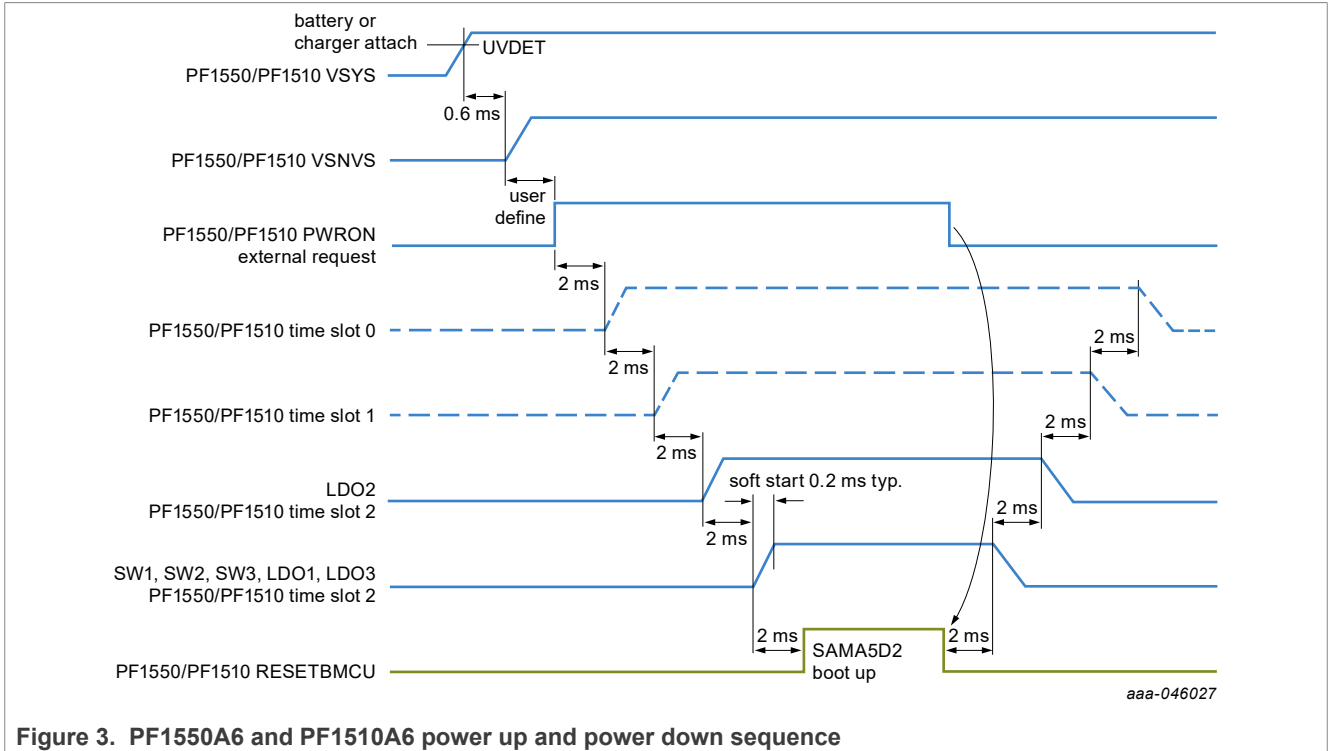

Figure 3. PF1550A6 and PF1510A6 power up and power down sequence

3.2 Power modes

PF1550/PF1510 configurable power modes can satisfy various SAMA5D2 power requirements in normal, backup and DDR/self-refresh modes. Figure 4 and Table 3 illustrate PF1550 and SAMA5D2 connections and functions to enable various power mode controls.
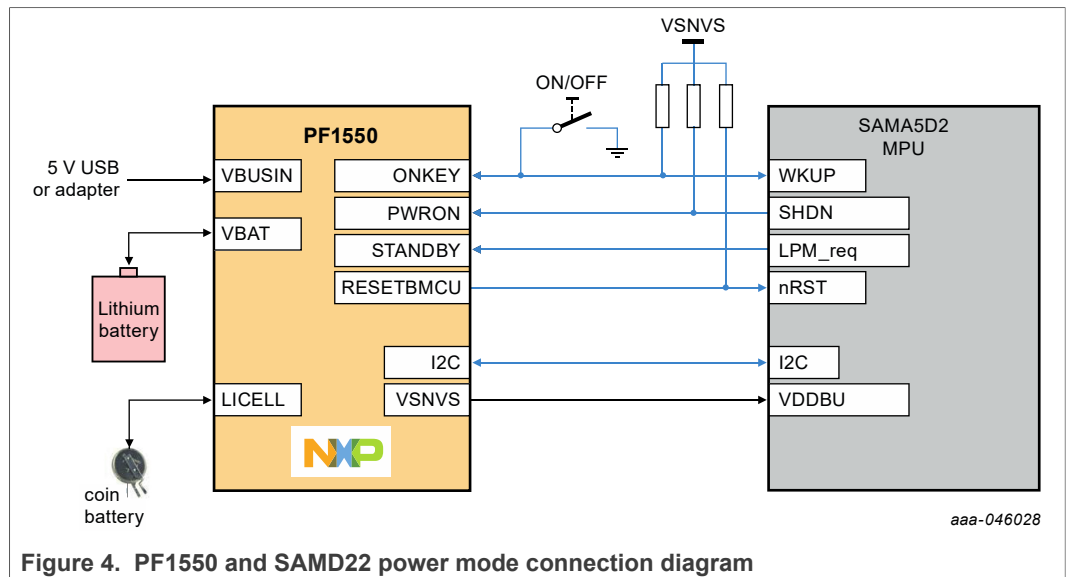
Figure 4. PF1550 and SAMD22 power mode connection diagram

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Table 3. PF1550/PF1510 and SAMA5D2 power mode connections

PF1550\ PF1510	SAMA5D2	Function
ONKEY	WKUP	Power on\off and power mode control through ON\OFF button pressing timing detection
PWRON	SHDN	SAMA5D2 control PF1550\PF1510 powering on\off or entering sleep mode
STANDBY	LPM_req	SAMA5D2 control PF1550\PF1510 for standby mode
RESETBMCU	nRST	Reset connection
I2C	I2C	SAMA5D2 configure and read PF1550\PF1510 I2C register
VSNVS	VDD3P3_RTC	PF1550\PF1510 always on LDO for SAMA5D2 Back up mode
LICELL	NA	Back up power supply input for Vsvns once Vbat and Vbusin is not valid

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[Figure 5](#) is a power mode transition and condition diagram:

RUN: All PF1550/PF1510 regulators are on and SAMA5D2 is in normal mode with all features available.

STANDBY: First-level low-power mode with PF1550/PF1510 regulators on or off, with voltage configured by SAMA5D2.

SLEEP: Second-level low-power mode with PF1550/PF1510 regulators on or off, with voltage configured by SAMA5D2.

POWER OFF: Third-level low-power mode with PF1550/PF1510 regulators off, except VSNVS is on.

SHIP(PF1550 only): All PF1550 regulators and VSNVS are off, current consumption is lowest value to save battery life.
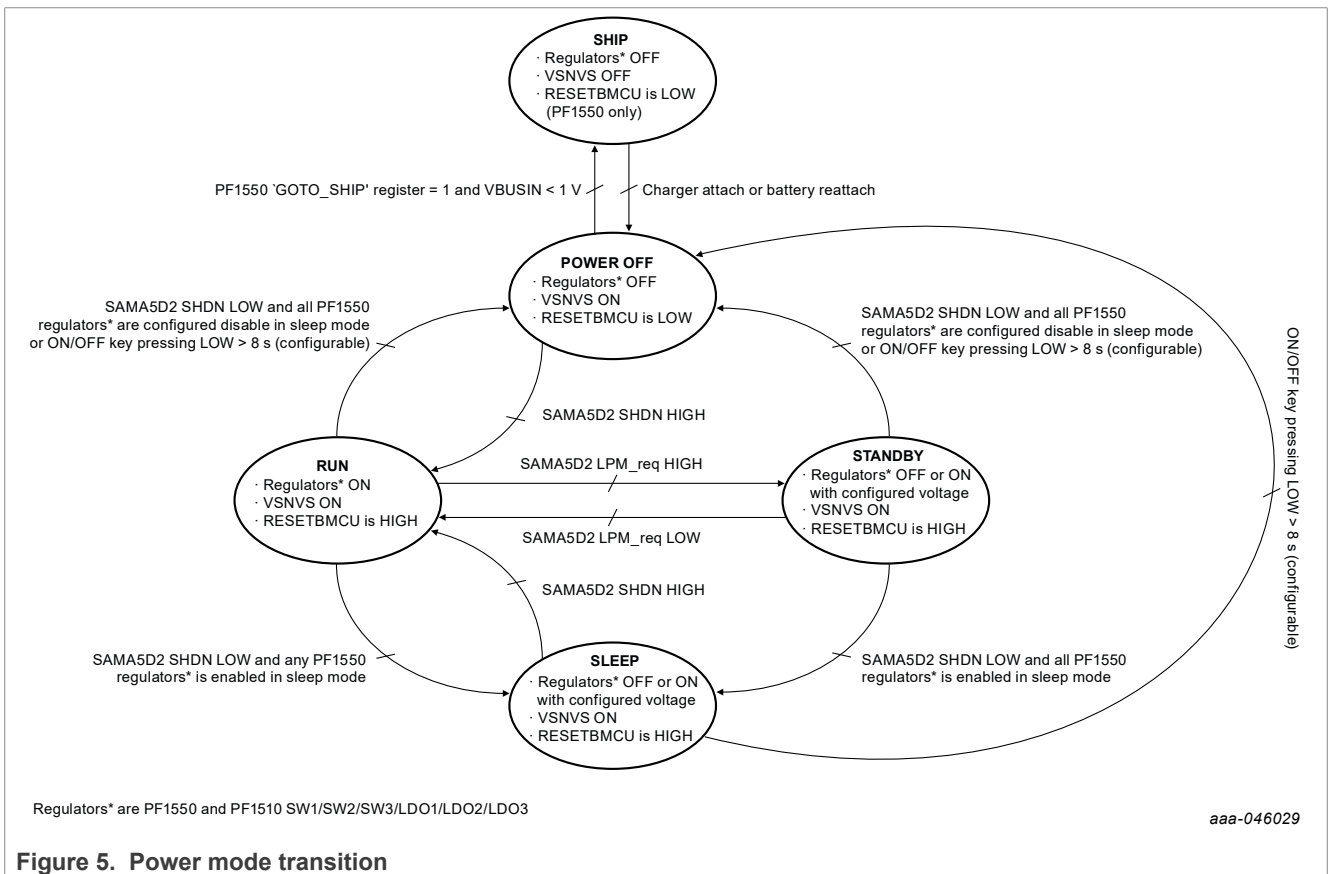
Figure 5. Power mode transition

3.3 Lithium battery charging (PF1550 only)

PF1550 integrates one one-cell battery charger with a single VBUSIN power input. See [Figure 6](#) for a simplified block diagram. VBUSIN operates from 4.0 V to 6.5 V. The PF1550 internally blocks power from the battery when no valid VBUSIN is present. The charger supports three battery charging modes: precharge, fast charge constant current (CC), and fast charge constant voltage (CV). The precharge current, constant current, and constant voltage are programmable via the I2C-bus. The CC value is configurable from 100 mA to 1000 mA, and the CV value is configurable from 3.5 V to 4.44 V.

The PF1550 includes a temperature control function that conforms to the recommendations specified in the Japan Electronics and Information Technology Association (JEITA). JEITA guidelines help to improve safety when charging the lithium batteries. The charger is able to adjust battery charging current and voltage automatically, based on the battery temperature, which is measured by the thermistor. Other safety functions to protect the battery and charger are implemented inside the Li_battery charger: charging timer, battery overvoltage protection, battery overcurrent limit, VBUSIN voltage regulation control, VBUSIN current limitation, and thermal regulation.
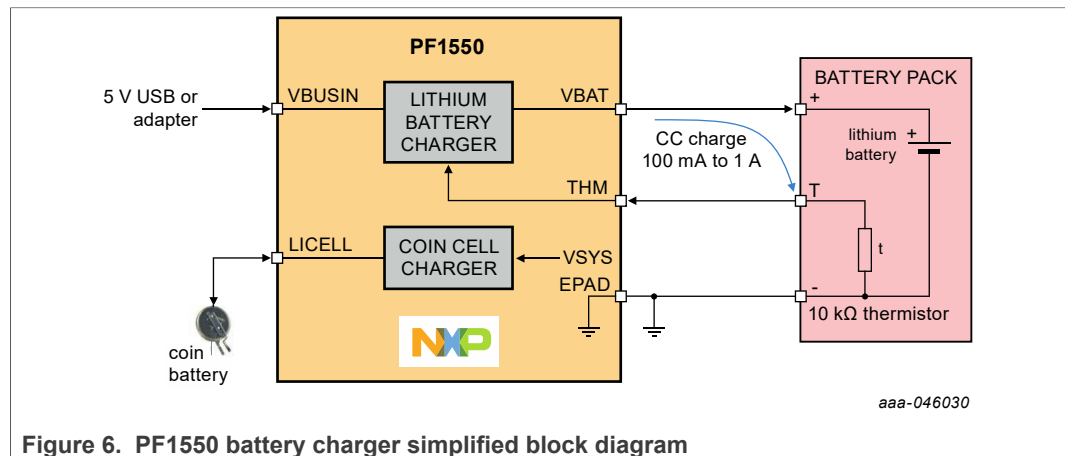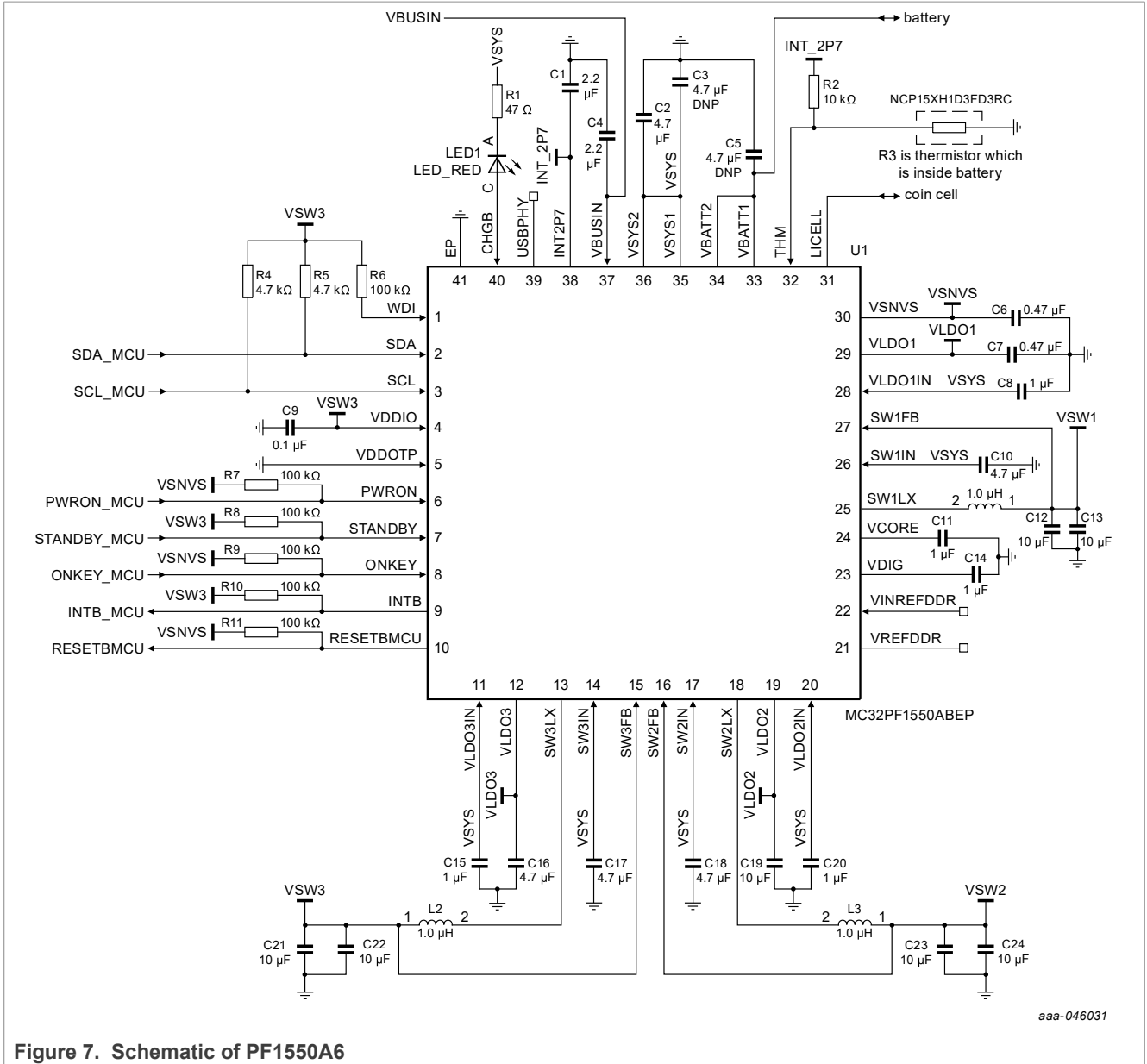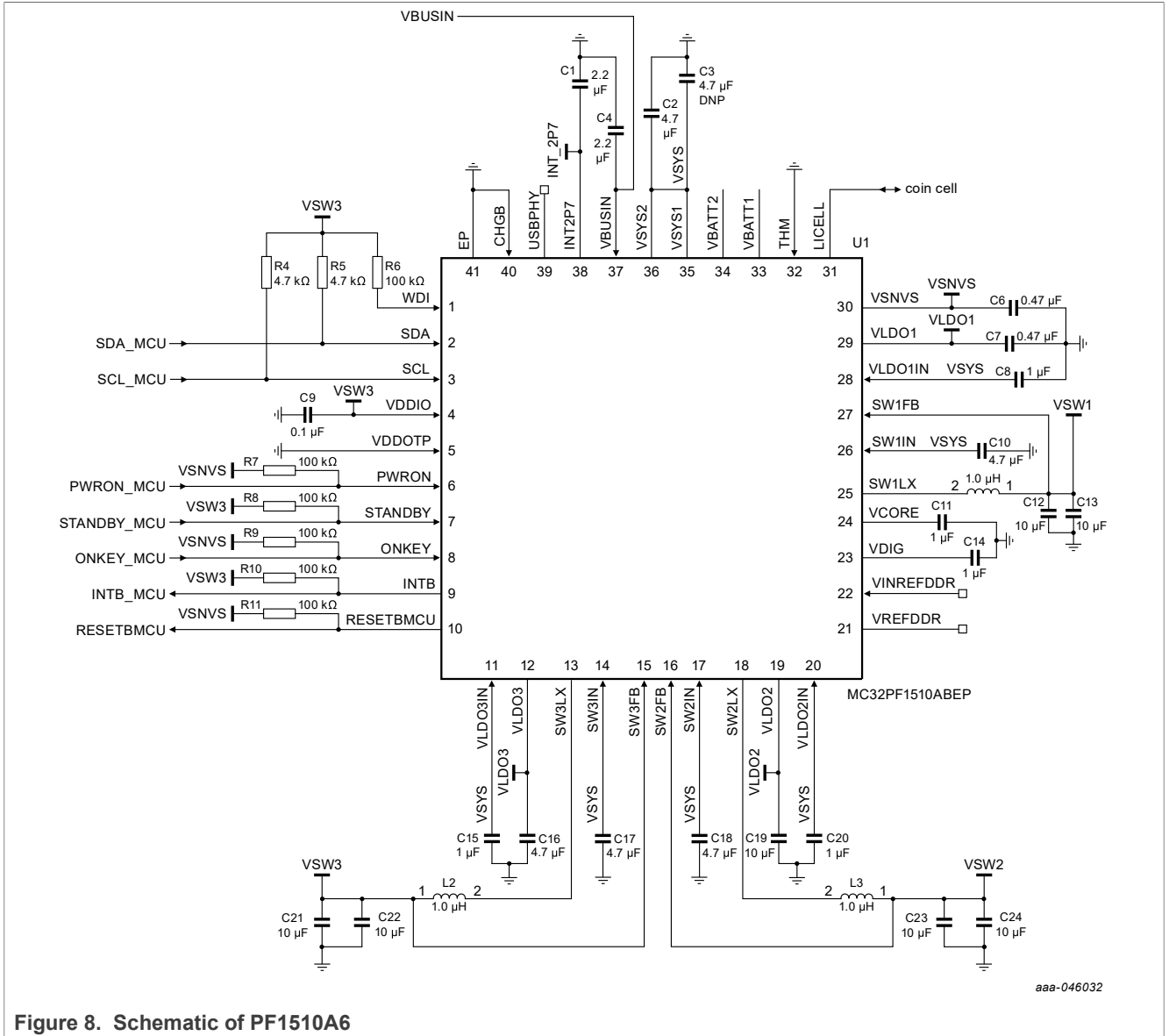

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Figure 6. PF1550 battery charger simplified block diagram

4   Schematics

Figure 7. Schematic of PF1550A6

Figure 8. Schematic of PF1510A6

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5   Bill of materials

Table 4. BOM for PF1550A6

Value	Quantity	Part number	Description	Vendor	Part Reference
2.2 µF	1	02016D225MAT2A	CAP CER 2.2 µF 6.3 V 20% X5R 0201	AVX	C1
47 µF	1	GRM21BR61A476ME15L	CAP CER 47 µF 10 V 10% X5R 0805	TDK	C2
4.7 µF	7	C1005X5R0J475M050BC	CAP CER 4.7 µF 6.3 V 20% X5R 0402	TDK	C3,C5,C7,C10,C16,C17,C18
2.2 µF	1	C1005X5R1E225M050BC	CAP CER 2.2 µF 25 V 20% X5R 0402	TDK	C4
0.47 µF	1	C0603X5R0J474M030BC	CAP CER 0.47 µF 6.3 V 20% X5R 0201	TDK	C6
1 µF	5	02016D105MAT2A	CAP CER 1 µF 6.3 V 20% X5R 0201	AVX	C8,C11,C14,C15,C20
0.1 µF	1	GRM033R60J104KE19D	CAP CER 0.1 µF 6.3 V 10% X5R 0201	MURATA	C9
10 µF	7	C1005X5R0J106M050BC	CAP CER 10 µF 6.3 V 20% X5R 0402	TDK	C12,C13,C19,C21,C22,C23,C24
LED_RED	1	LS L29K-G1J2-1-Z	LED RED SGL 20 mA 0603 NRND	OSRAM	LED1
1.0 µH	3	DFE201208S-1R0M=P2	IND PWR 1.0 µH@1MHz 2.7 A 20% 2012	TOKO INC.	L1,L2,L3
47 Ω	1	RC73L2Z470JTF	RES MF 47 OHM 1/16 W 5% 0402	SMEC	R1
10 kΩ	1	RC0402FR-1310KL	RES MF 10K 1/16 W 1% 0402	yageo	R2
10 kΩ	1	NCP15XH103F03RC	thermistor, 100 mW, 10 kΩ, ±1 %, 0402	Murata	R3
4.7 kΩ	2	RK73B1HTTC472J	RES MF 4.7 K 1/20 W 5% 0201	KOA SPEER	R4,R5
100 kΩ	6	RK73B1ETTP104J	RES MF 100 K 1/1 6 W 5% 0402	KOA SPEER	R6,R7,R8,R9,R10,R11
PF1550	1	PC32PF1550A6	IC PWR MANAGEMENT -- QFN40	NXP	U1

Table 5. BOM for PF1510A6

Value	Quantity	Part number	Description	Vendor	Part Reference
2.2 uF	1	02016D225MAT2A	CAP CER 2.2 µF 6.3 V 20% X5R 0201	AVX	C1
47 UF	1	GRM21BR61A476ME15L	CAP CER 47 µF 10 V 10% X5R 0805	TDK	C2
4.7 uF	6	C1005X5R0J475M050BC	CAP CER 4.7 µF 6.3 V 20% X5R 0402	TDK	C3,C7,C10,C16,C17,C18
2.2 uF	1	C1005X5R1E225M050BC	CAP CER 2.2 µF 25 V 20% X5R 0402	TDK	C4
0.47 uF	1	C0603X5R0J474M030BC	CAP CER 0.47 µF 6.3 V 20% X5R 0201	TDK	C6
1 uF	5	02016D105MAT2A	CAP CER 1 µF 6.3 V 20% X5R 0201	AVX	C8,C11,C14,C15,C20
0.1 UF	1	GRM033R60J104KE19D	CAP CER 0.1 µF 6.3 V 10% X5R 0201	MURATA	C9

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Table 5. BOM for PF1510A6...*continued*

10 uF	7	C1005X5R0J106M050BC	CAP CER 10 µF 6.3 V 20% X5R 0402	TDK	C12,C13,C19,C21,C22,C23,C24
1.0 UH	3	DFE201208S-1R0M=P2	IND PWR 1.0 µH@1 MHz 2.7 A 20% 2012	TOKO INC.	L1,L2,L3
4.7 K	2	RK73B1HTTC472J	RES MF 4.7 K 1/20 W 5% 0201	KOA SPEER	R4,R5
100 K	6	RK73B1ETTP104J	RES MF 100 K 1/16 W 5% 0402	KOA SPEER	R6,R7,R8,R9,R10,R11
PF1510	1	PC32PF1510A6EP	IC PWR MANAGEMENT -- QFN40	NXP	U1

6   References

[1] PF1550 data sheet https://www.nxp.com/docs/en/data-sheet/PF1550.pdf

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