

# AN14551

## Power management solution for headset applications

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Application note

### Document information

Information	Content
Keywords	wireless, headset, power solution, smart watch, smart band, PMIC, battery charging, small size, high efficiency, flexible OTP, PCA9420, PCA9421, PCA942x
Abstract	This application note introduces NXP PMIC solutions for headset applications, including wireless headsets and hearing aid headsets. It demonstrates key features and a typical PMIC design for long battery life that fits small form factor requirements. Flexible one-time programmable PMIC functions ease customer design, allowing one type of PMIC for various headset platforms.



## 1 Introduction

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In recent years, headphone technology has ushered in a revolutionary development. The popularity of wireless headphones, especially wireless headphones, has completely liberated users and freed them from the constraints of cables. The availability of high-quality audio coding technology has also greatly improved the sound quality of wireless headphones. Intelligence is also an important direction in recent development of headphone technology. Many headphones can now be controlled by touch or even operated by voice assistants. Looking to the future, headphone technology will continue to develop towards higher sound quality, smarter operation, and a more comfortable wearing experience. With the integration of artificial intelligence and Internet of Things technologies, future headphones may become an extension of personal assistants, providing not only high-fidelity music, but also real-time language translation, health data monitoring, and virtual reality experience.

As technology continues to evolve, headphones will be more in line with user needs and become an important bridge connecting the real world and the digital world. Therefore, high-performance products are needed to match the growing demand. The power management system is also complex and diverse, including battery charging management technology, requirements for power rails of various specifications, load switch requirements, and system power-on and power-off sequence requirements.. These requirements can be met with the help of power management ICs (PMICs).

## 2 Differing requirements of wireless headsets and hearing-aid headsets

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Although wireless headsets and hearing aids are similar in some ways, they have significant differences in terms of functionality and design.

Hearing aids collect sound information, analyze it, reduce noise, then amplify and conduct the sound, so digital signal processing (DSP) is generally required for data processing. Traditional wireless headsets simply do signal reception and release, and their main functions are just a loudspeaker and a Bluetooth receiving module.

Wireless headsets cannot be used as hearing aids, but the new generation of hearing aids with integrated Bluetooth functions can also be used as wireless headsets. At the same time, the new generation of headsets are integrated with wireless charging, touch control, and other functions. All of these new functions contain sensors with different power rail requirements. As the performance increases, the power consumption of each channel also increases, so efficiency and small-size design requirements are getting more crucial.

NXP power management IC PCA942x series solutions, especially with their efficiency and small size, can be well adapted to various headphones, even wireless headphones and hearing aid headphones.

### 3 Headset power requirements

#### 3.1 Power requirements for hearing aid headsets

##### Power supply requirements

Voltage: typically, hearing aid headsets require a voltage supply between 1.2 V and 3.7 V.

Current: the current requirement depends on the specific headset and its features, but typical values range from 1 mA to 10 mA.

Power consumption: hearing aid headsets typically consume between 1 mW to 10 mW of power.

##### Battery life

Typical battery life: 5 to 7 days of continuous use

Standby time: Up to 30 days of standby time

Charging time: 2 to 4 hours to fully charge the battery

##### Power supply options

Battery: most hearing aid headsets use rechargeable batteries, such as zinc-air or nickel-metal hydride (NiMH).

Rechargeable batteries: some headsets use rechargeable batteries, such as lithium-Ion (Li-ion) or nickel-cadmium (NiCd).

Disposable batteries: some headsets use disposable batteries, such as zinc-carbon or alkaline.

Wireless charging: some headsets support wireless charging, using technologies such as power factor correction (PFC).

##### Power Management

Low-power mode: many headsets have a low-power mode that reduces power consumption when not in use.

Auto power off: some headsets have an auto power off feature that turns off the headset after a period of inactivity.

Power saving features: some headsets have power-saving features, such as reducing the transmission power or using a low-power codec.

Figure 1 is a typical hearing aid headset block diagram. The PCA9420 can be used with a wireless charging module to charge the battery, and can provide all power rails for the system, including DSP\BLE\Mic\NFMI.

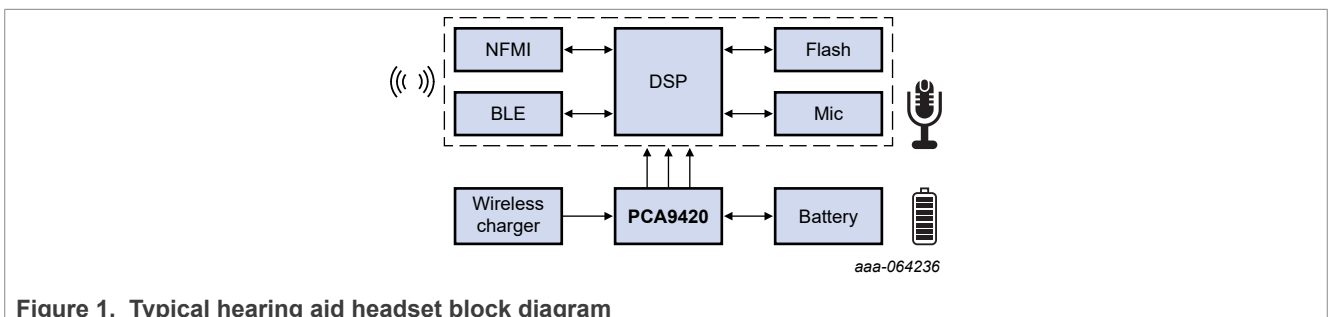


Figure 1. Typical hearing aid headset block diagram

#### 3.2 Power requirements for wireless headsets

##### Power supply requirements

Voltage: typically, wireless headsets require a voltage supply between 2.5 V and 5 V.

Current: the current requirement depends on the specific headset and its features, but typical values range from 10 mA to 100 mA.

Power consumption: wireless headsets typically consume between 10 mW to 100 mW of power.

**Battery Life**

Typical Battery Life: 8-12 hours of continuous use

Standby Time: Up to 200 hours of standby time

Charging Time: 2-4 hours to fully charge the battery

**Power Supply Options**

Battery: Most wireless headsets use rechargeable batteries, such as Lithium-Ion (Li-ion) or Nickel-Metal Hydride (NiMH).

USB Power: Some headsets can be powered via USB, either from a computer or a wall adapter.

Wireless Charging: Some headsets support wireless charging, using technologies like PFC.

**Power Management**

Low-power mode many headsets have a low-power mode that reduces power consumption when the device is not in use.

Auto power off: some headsets have an auto power off feature that turns the headset off after a period of inactivity.

Power saving features: some headsets have power-saving features, such as reducing the transmission power or using a low-power codec.

Figure 2 is a typical wireless headset block diagram. PCA9420 can be used with a wireless charging module to charge the battery, and all power rails can meet the power supply needs of the SOC, the MCU and the peripheral sensors.

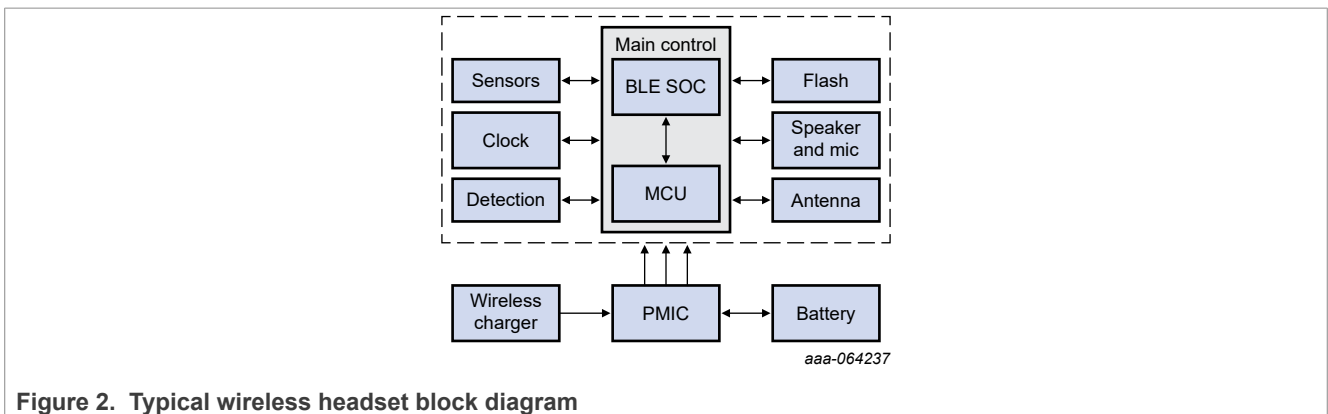


Figure 2. Typical wireless headset block diagram

## 4 NXP power solutions

NXP power management IC PCA9420/PCA9421 series solutions are appropriate for various headsets applications. This product portfolio offers various power management functions in one PMIC, including battery charging, multiple DC/DC converters and LDOs, load switch, and power mode control. [Figure 3](#) is a block diagram of PCA9420 and PCA9421. They are pin-to-pin compatible. The two devices differ in that PCA9421 does not have a battery charging function.

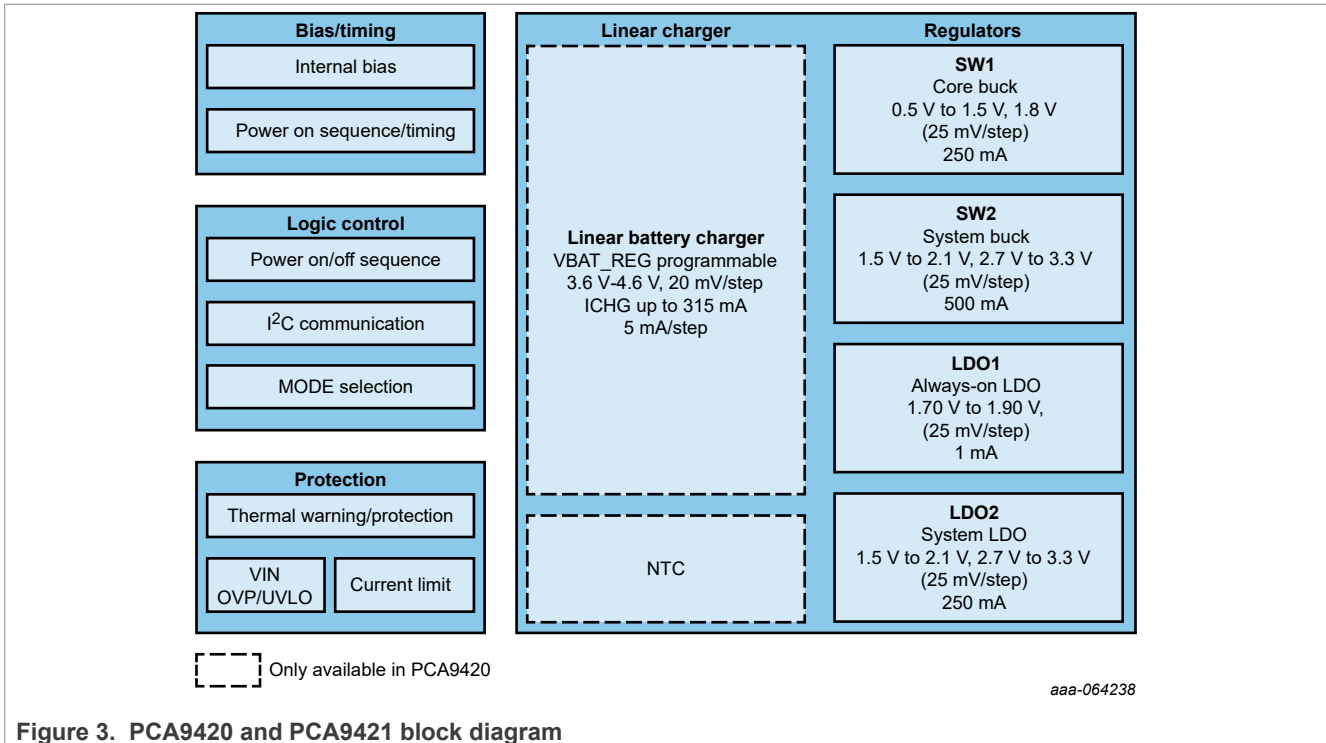


Figure 3. PCA9420 and PCA9421 block diagram

PCA9420/PCA9421 has these features that can meet the requirements of headset applications:

- Highly efficient power delivery for extended battery life
- Ultra-low-power Quiescent Current mode
- Ship mode – 125 nA
- Standby mode (2xDCDC, 2XLDO enabled no load) –3 μA
- Highly integrated solution
- 4x supply rails, integrated linear battery charger with JEITA temperature control, fully programmable
- 20 V input voltage tolerance level
- ON-pin recovery from Ship/OFF mode and reset
- Various protection and watchdog integrated functionality
- Power sequence and features are MTP configurable
- Supports four work mode transitions
- Very small package size – 2.1 mm x 2.1 mm 5 x5 bump WLCSP or 3 mm x 3 mm 24-pin QFN
- PCA9421 as no-battery selection with P2P compatibility

### 4.1 Mode setting and selection

When the MCU operates in different modes such as Overdrive Run mode or Low-power mode, it may require the power supply to operate in different settings accordingly (for example, enabling/disabling each rail and output voltage of each rail) to achieve better performance and efficiency.

On the PCA9420, there are four register modes (Mode Setting 0/1/2/3) to accommodate such requirements from MCU, where Mode Setting A is the default mode setting (that is, the initial mode setting upon initial power up). Depending on the user's preference, switching among different mode settings can be controlled by either the external signal (ON pin), external pins (MODESEL0/1), or I<sup>2</sup>C.

### 4.2 Flexible OTP configuration

PCA942x series PMICs support customized OTP definition, which means the PMIC default regulators' output voltage, power-up sequence and system functions are configurable to fit different system requirements. This allows the designer to use one PMIC as the power management solution in multiple platforms, from low-end platforms to high-end watch and band, which saves design effort.

For example, [Figure 4](#) is the power tree of PCA9420 + BLE ( NxH3675/2004 ) + LPC55xx MCU. This can also be the power rail set for a headset demo. For the detailed design, refer to [AN12593](#).

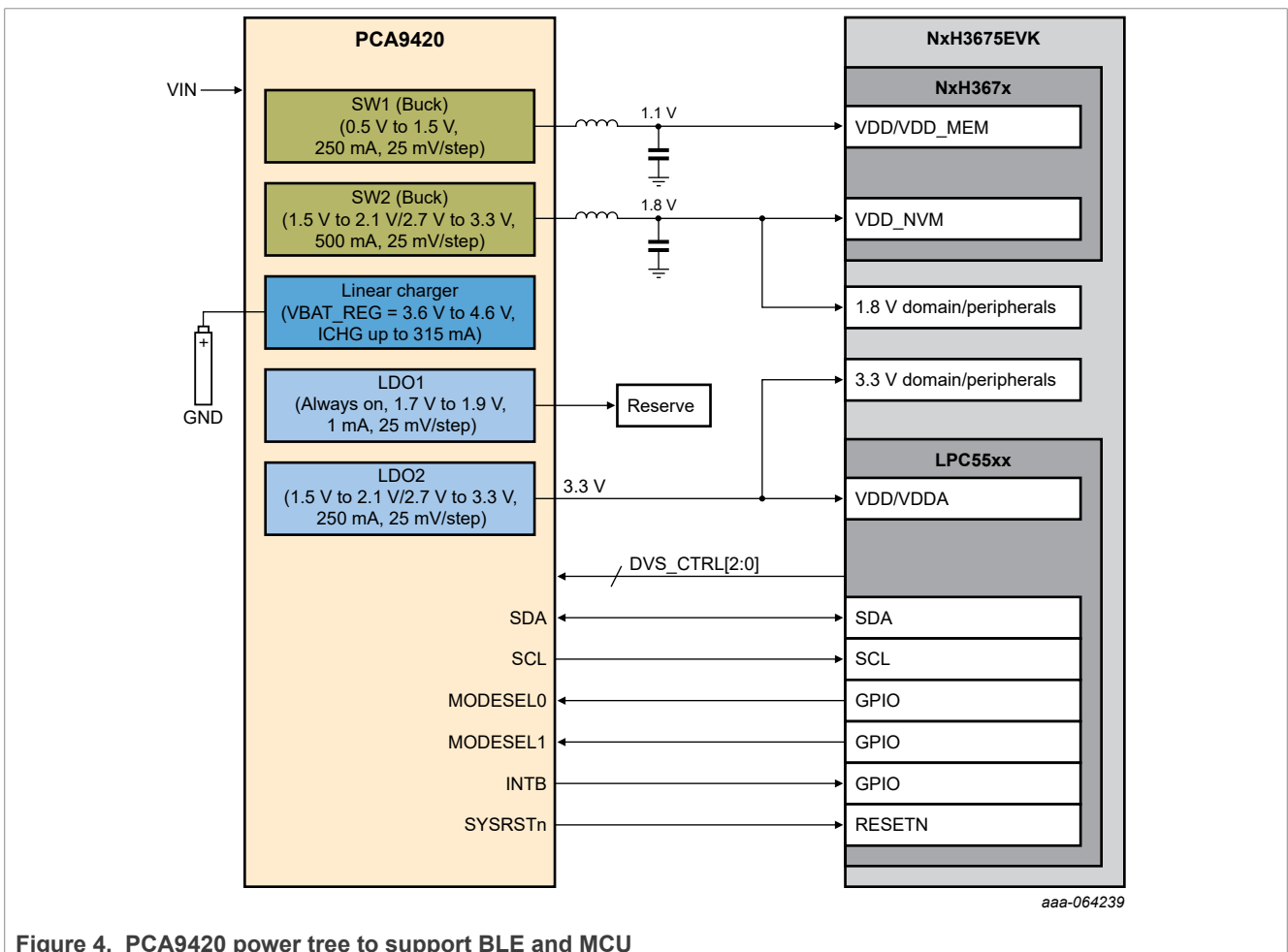


Figure 4. PCA9420 power tree to support BLE and MCU

### 4.3 Ship mode feature

PCA9420 features a *Ship mode* in which the chip provides the lowest quiescent consumption at the nA level. Ship mode is designed to operate only from VBAT. Ship mode should not be entered when both VIN and VBAT are present. Ship mode has a higher priority over any conditions and operations.

Upon a request to enter Ship mode while the device is running in active mode, a power-down sequence should take place before entering Ship mode. Once the device enters Ship mode, all the I<sup>2</sup>C register values are reset to their default settings.

### 4.4 Small form factor

PCA9420/1 has a WLCSP25 package, which is 2.09 mm x 2.09 mm x 0.525 mm, and their QFN24 is 3.00 mm x 3.00 mm x 0.85 mm. Their small footprint has an advantage from a space saving perspective compared with discrete solutions.

Figure 5 is one example of a comparison with a discrete power solution (Switcher, LDO and Charging IC) and PCA9420. The total number of components is greatly reduced, and PCB size is reduced ~40 % using PCA9420.

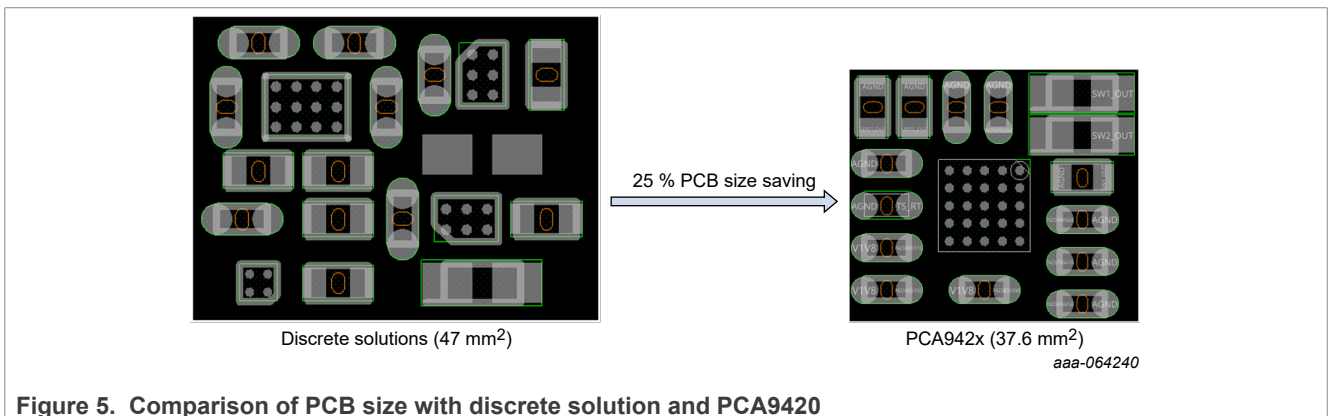


Figure 5. Comparison of PCB size with discrete solution and PCA9420

- Discrete solutions (47 mm<sup>2</sup>)
- PCA942x (37.6 mm<sup>2</sup>)

### 4.5 Extended battery life

The PCA9420/1 series PMICs provide several switchers and LDOs. The combination of these in one chip allows the user flexibility to select the most efficient solution for processors or peripherals. The switcher has PFM and PWM modes with 94 % maximum efficiency, designed primarily for high current loads. LDOs are primarily used for low current and noise-sensitive loads. The LDO also has a load switch mode which could cut off a load completely when needed to reduce power consumption.

NXP PMICs enable battery life extension not only from their own integrated features, but also from system-level interaction with processors. All the regulator voltages in the PMIC are adjustable through I<sup>2</sup>C on the fly. The switcher also supports Dynamic Voltage Scaling, which enables a processor to run in a different frequency to save power. To ease system power mode adjustment, the PMICs also have IO pins to quickly change power mode with different pre-configured regulator voltages.

### 4.6 Safe battery management

PCA9420 integrates a single Li-battery charging with 5 V typical input. The charging current and voltage are configurable through I<sup>2</sup>C. The maximum charging current of the PCA9420 linear charger is 315 mA. If a

customer has a higher battery charging requirement, they could select a discrete charging IC plus a PCA9421 without the charging function.

Multiple safe battery protection features are embedded in these PMICs:

- Input overvoltage protection
- Battery overcurrent protection
- Thermal protection
- JEITA compliant for charging
- Battery temperature protection

## 5 Conclusion

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Wireless headset technology has been evolving quickly and will continue to integrate more functionality. This brings challenges for power management design. This AN presents NXP PMIC solutions implementing multiple regulators, charging functions, and power mode controls. These features are appropriate for applications requiring long battery life and small form factor. Flexible OTP features also enable customers to use one PMIC for different headset system designs, saving time and cost.

## 6 Typical schematic and BOM

Figure 6 is a typical schematic for the PF9420, and Table 1 contains a typical BOM.

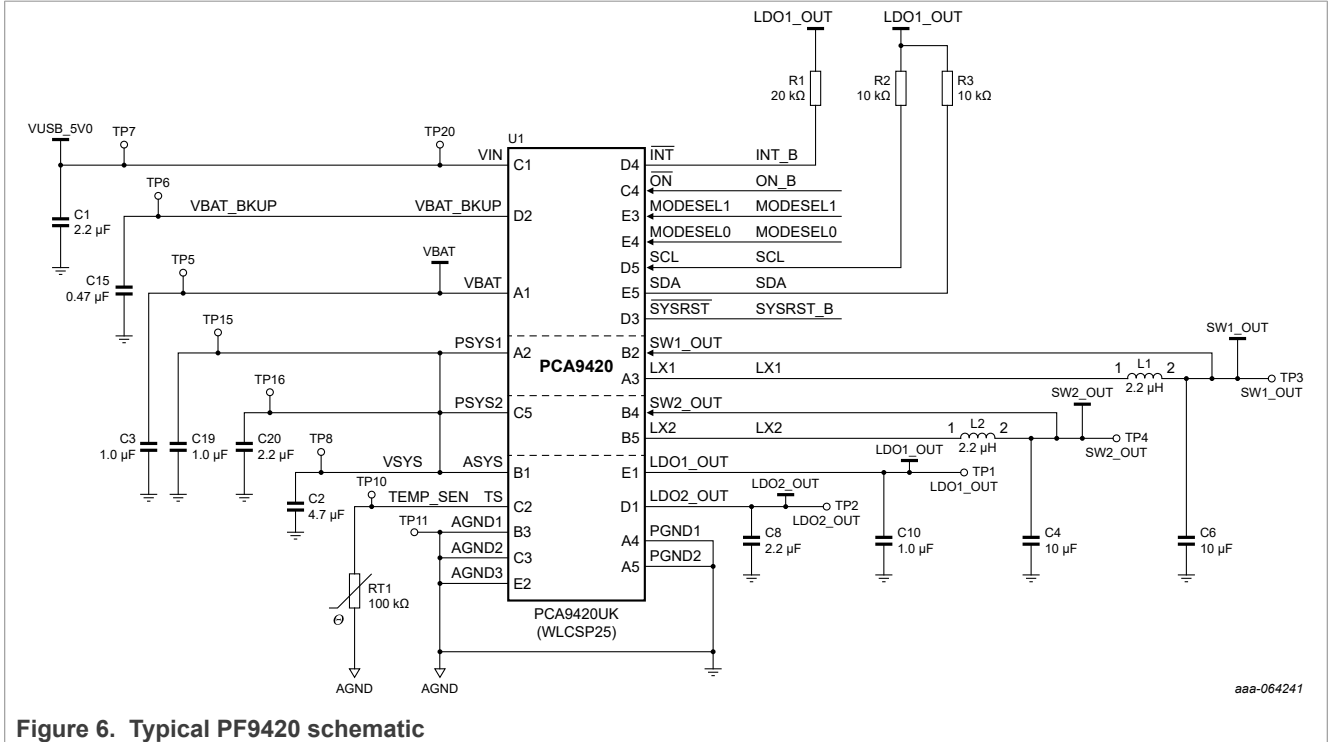


Figure 6. Typical PF9420 schematic

Table 1. Typical bill of material

Reference	Part	MPN	Quantity
C1, C8, C20	2.2 μF	GRM188Z71C225KE43	3
C2	4.7 μF	GRM188Z71C475KE21	1
C3, C10, C19	1.0 μF	GRM188R71C105KE15	3
C4, C6	10 μF	GRM21BZ71C106KE15	2
C15	0.47 μF	GCM188R71C474KA55D	1
L1, L2	2.2 μH	CIGT201610EH2R2MNE	2
RT1	100 KΩ	NCP15WF104F03RC	1
R1	20.0 KΩ	CR0603-FX-2002ELF	1
R2, R3	10.0 KΩ	RC0603FR-0710KL	2
U1	PCA9420UK	PCA9420UK_WLCSP25	1

## 7 Abbreviations

Abbreviation	Description
BLE	Bluetooth low energy
DSP	digital signal processing
DVS	dynamic voltage scaling
JEITA	Japan Electronics and Information Technology Industries Association
Li-ion	lithium-ion
MCU	microprocessor control unit
mic	microphone
MTP	multi-time programmable
NFMI	near-field magnetic induction
NiCd	nickel-cadmium
NiMH	nickel-metal hydride
P2P	pin-to-pin
PMIC	power management integrated circuit
PWM	pulse-width modulation
SOC	system on chip

## 8 Reference resources

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PCA9420 and PCA9421 information and tools can be found at this link: <https://www.nxp.com/products/power-management/pmics-and-sbcs/pmics/pmic-for-low-power-applications:PCA9420-PCA9421>

## 9 Revision history

Table 2. Revision history

Document ID	Release date	Description
AN14551 v. 1.0	14 April 2026	Initial release

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