# AN13815

## Programming LPC800 Using USART ISP

**Rev. 0 — 5 May 2023**                                               **Application note**

**Document Information**

| Information | Content |
|---|---|
| Keywords | AN13815, ISP, LPC553x, LPC800 |
| Abstract | This document describes how to upgrade or program the LPC800 using USART ISP |

# 1   Introduction

The LPC800 series offers a range of low-power, space-efficient, and low-pin-count options for basic microcontroller applications.

In some application scenarios, when the pins of the main processor are insufficient or other functions must be expanded, an LPC800 is an excellent solution. As shown in Figure 1, the host MCU/MPU connects with LPC800 via USART, and LPC800 connects to and controls other $I^2C$, SPI, and other components.
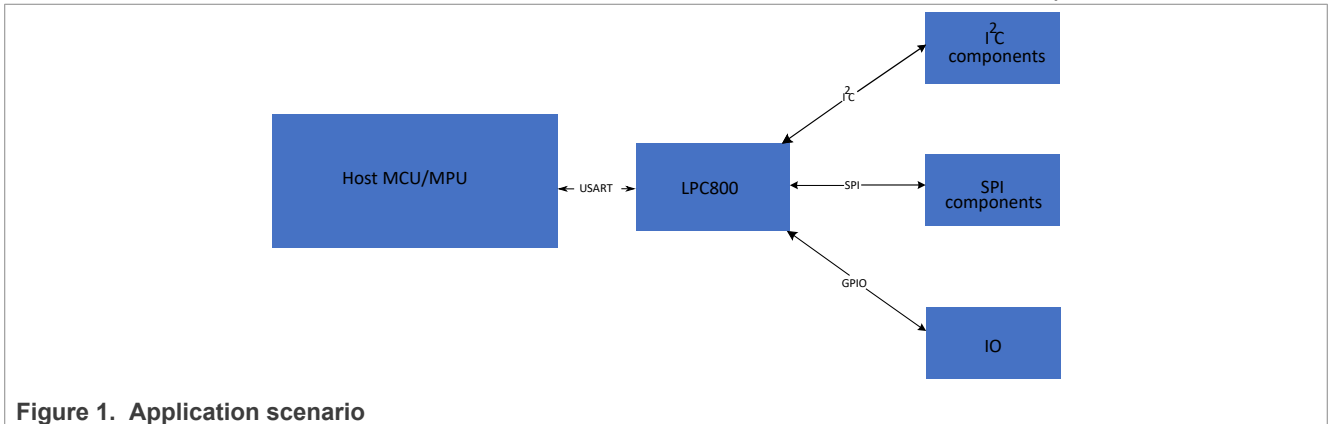


**Figure 1.  Application scenario**

In addition to other functions, all LPC800 devices include ROM-based services for programming and reading flash memory. In-System Programming (ISP) works on an unprogrammed or previously programmed device using one from a selection of hardware interfaces.

This document introduces a way to program or upgrade LPC800 using USART ISP in the field.

# 2   LPC800 USART ISP

The ISP command handler accepts the commands listed in Table 1. For further information, see the corresponding *LPC8xx User Manual*.

**Table 1.  ISP command**

| ISP Command | Usage |
|---|---|
| Unlock | U <unlock code> |
| Set baud rate | B <baud rate> <stop bit> |
| Echo | A <setting> |
| Write to RAM | W <start address> <number of bytes> |
| Read memory | R <address> <number of bytes> |
| Prepare sectors for write operation | P <start sector number> <end sector number> |
| Copy RAM to flash | C <flash address> <RAM address> <number of bytes> |
| Go | G <address> <mode> |
| Erase sector | E <start sector number> <end sector number> |
| Erase page | X <start page number> <end page number> |
| Blank check sector | I <start sector number> <end sector number> |
| Read Part ID | J |
| Read boot code version | K |

AN13815

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**Application note**

**Rev. 0 — 5 May 2023**

**2 / 10**

**Table 1. ISP command**...*continued*

| ISP Command | Usage |
|---|---|
| Compare | M <address1> <address2> <number of bytes> |
| Read UID | N |
| Read CRC checksum | S <address> <number of bytes> |
| Read flash signature | Z |

All USART ISP commands must be sent as single ASCII strings. Strings must be terminated with Carriage Return (CR) and/or Line Feed (LF) control characters. Extra `<CR>` and `<LF>` characters are ignored. All ISP responses are sent as `<CR><LF>` terminated ASCII strings. Data is sent and received in plain binary format.

The host sends a `'?' (0x3F)` as a synchronization character and waits for a response. The host side serial port settings are 8 data bits, one stop bit, and no parity. The auto-baud routine programs the baud rate of the serial port generator by measuring the bit time of the received synchronization character in terms of its frequency. It also sends an ASCII string (`Synchronized<CR><LF>`) to the host. In response to this action, the host sends back the same string (`Synchronized<CR><LF>`).

The auto-baud routine looks at the received characters to verify synchronization. If synchronization is verified, the `Synchronized<CR><LF>OK<CR><LF>` string is sent to the host ("echo" is enabled by default). The host responds by sending the crystal frequency (in kHz) at which the part is running. The response is required for backward compatibility of the bootloader code and is ignored. The `OK<CR><LF>` string is sent to the host after receiving the crystal frequency. If synchronization is not verified, the auto-baud routine waits again for a synchronization character.

Once the crystal frequency is received, the part initializes, and the ISP command handler invokes. For safety reasons, an "Unlock" command is required before executing the commands resulting in flash erase/write operations and the "Go" command. The rest of the commands are executed without the unlock command. Execute the "Unlock" command once per ISP session.

# 3 ISP programming flow

The host device requires several steps to communicate and program LPC800. In short, the host device requires synchronization with LPC800, then unlock the erase/program operation, erase the flash, and finally program the flash. The following sections use flowcharts to describe this process in further detail.

The flow shown in Figure 2 provides only an example and should not be precisely adhered to. It can be adjusted suitably in practice to meet the requirements.

*Note: The demo shown in Figure 2 considers 64 kB flash LPC800 as an example. For different flash sizes of LPC800, it is necessary to modify the corresponding sector parameters.*
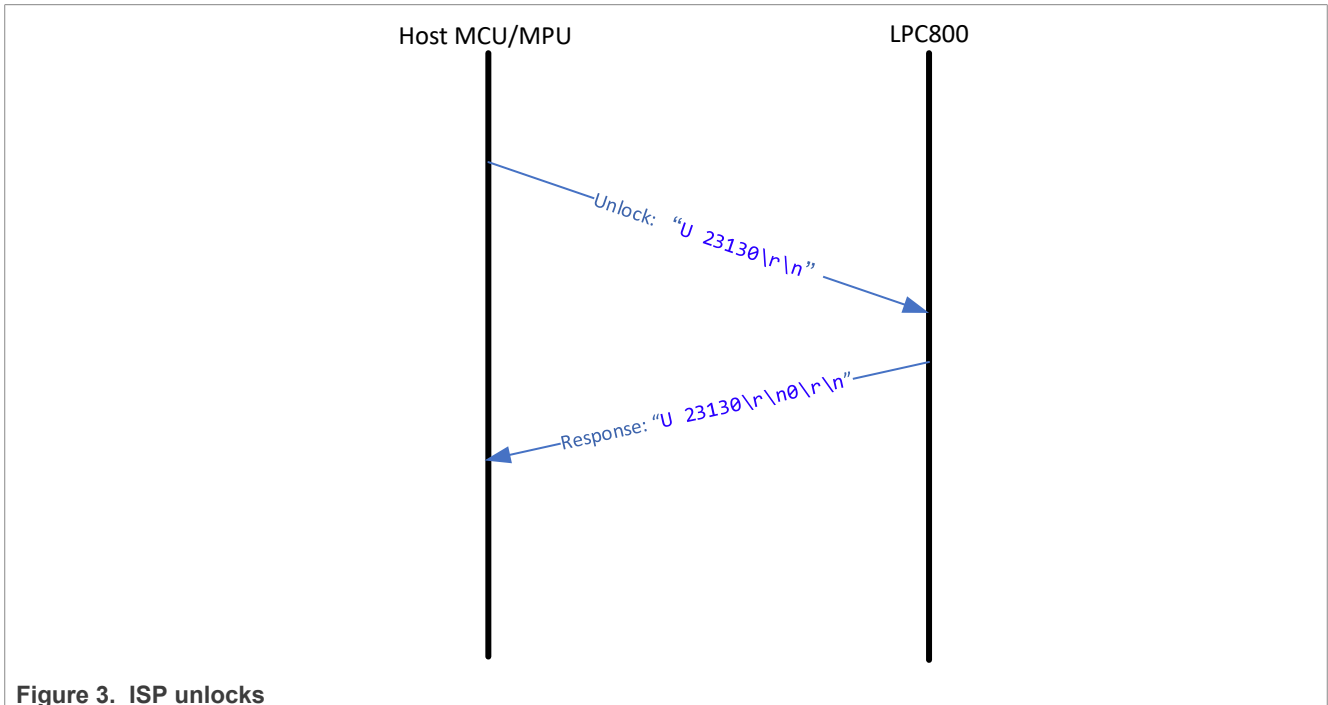
## 3.1 Synchronize

This command is used to synchronize the baud rate between host and LPC800 via USART.

**Figure 2. ISP sync**
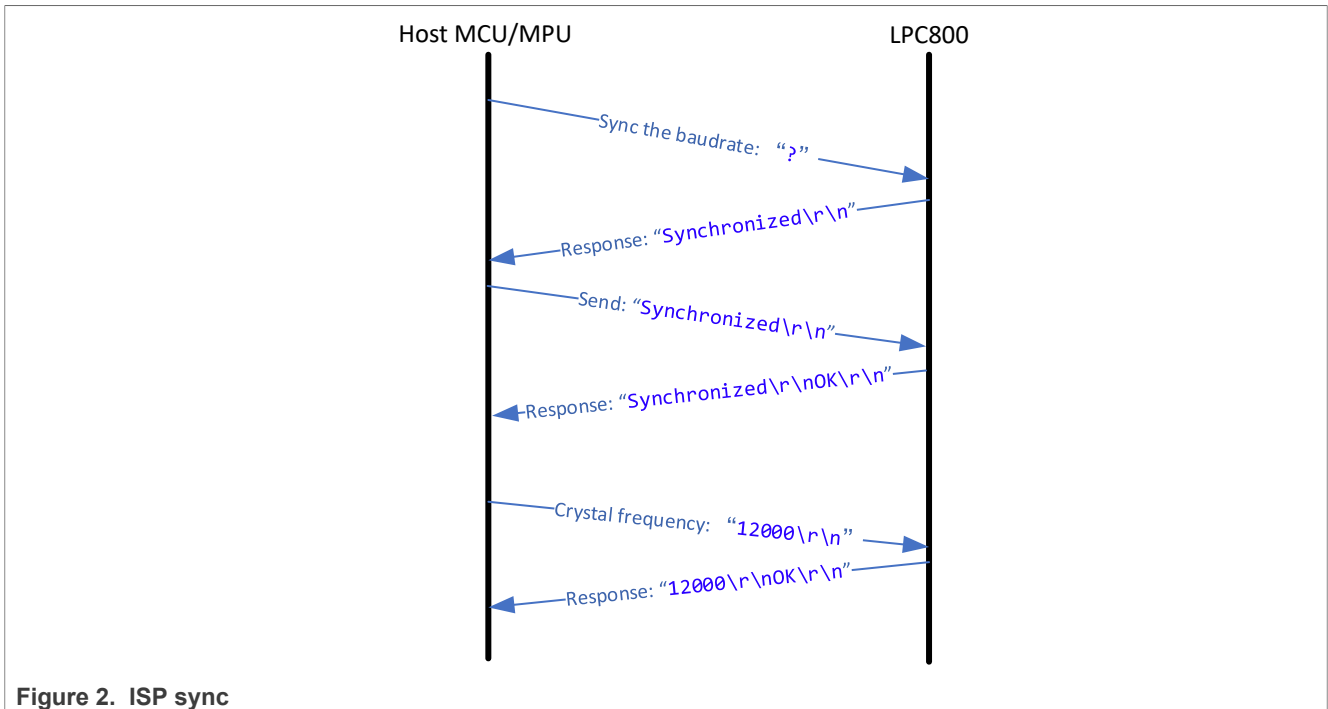
## 3.2 Unlock

This command is used to unlock flash "Write", "Erase", and "Go" commands.



**Figure 3. ISP unlocks**

## 3.3 Erase and prepare the flash for programming

The `P <Start Sector Number> <End Sector Number>\r\n` is used to prepare sectors before erase and program.

AN13815

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**Application note**

**Rev. 0 — 5 May 2023**

**4 / 10**

The `E <Start Sector Number> <End Sector Number>\r\n` is used to erase one or more sectors of on-chip flash memory.

For subsequent flash programming operations, use the command `P <Start Sector Number> <End Sector Number>\r\n` to prepare the flash sectors again.

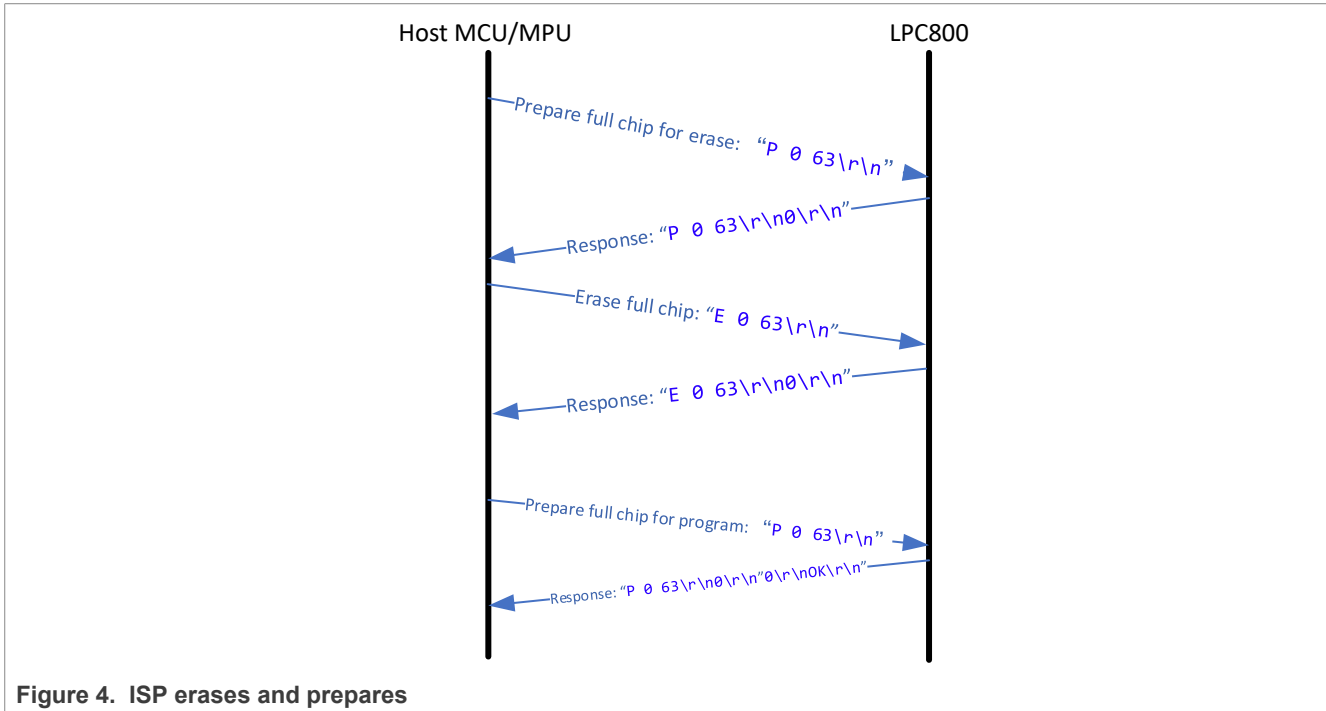*Note:* *The example in* *Figure 4* *performs a full chip erase.*



**Figure 4. ISP erases and prepares**

## 3.4 Disable the echo

The `A 0 \r\n` turns echo OFF. The default setting for echo command is ON. When ON, the ISP command handler sends the received serial data back to the host.
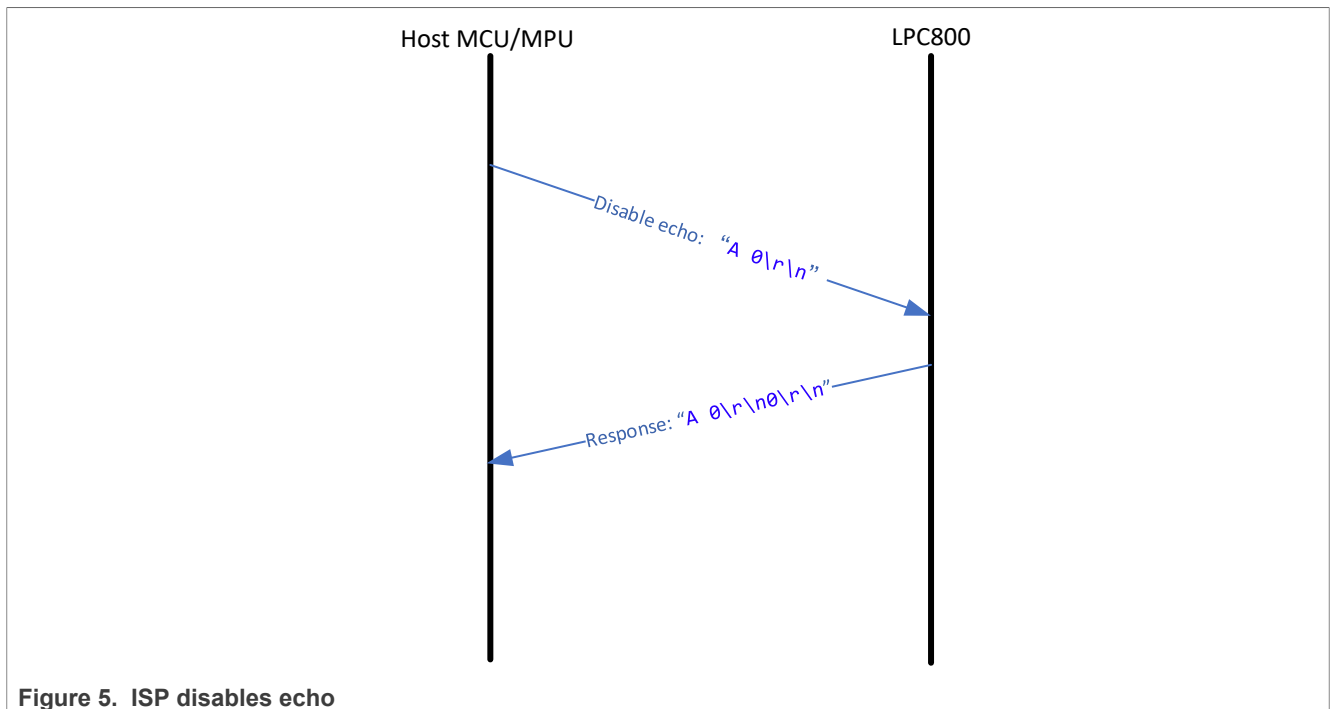
**Figure 5. ISP disables echo**

## 3.5 Program the image into flash

The `W <Start Address> <Number of Bytes>\r\n` is used to download data to RAM. After that, the host sends the plain binary code.

The `C <Flash address> <RAM address> <number of bytes>\r\n` is used to copy the content in RAM to the flash memory. Number of bytes to be written should be 64 | 128 | 256 | 512 | 1024. The destination address should be a 64 byte boundary.

This process must be repeated until the entire target image is downloaded.

**Figure 6. ISP programs the image**
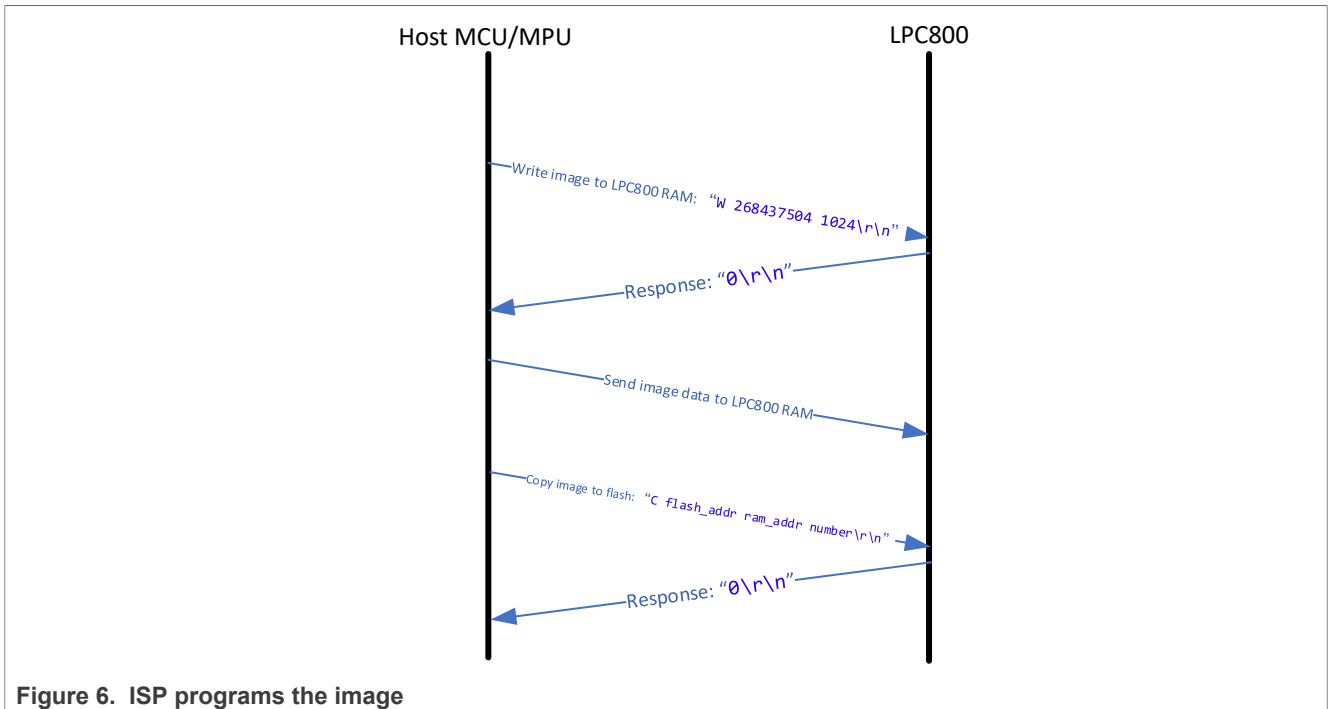
# 4 Demonstration and example

This application note attaches a demo code that uses LPC55S36 EVK as the host device and LPCXpresso860-MAX board as the target MCU.

1. Import the demo example project to MCUXpresso IDE, compile, and then download into LPC55S36 EVK.
2. Open a serial terminal software. The default setting is 115200/8/1/N.
3. Connect LPC55S36 EVK and LPCXpresso860-MAX board as shown in Table 2.

Table 2. Board-to-board connection

| LPC55S36 EVK | LPCXpresso860-MAX board |
|---|---|
| J7-3(P1_24 FC2 RX) | J2-4(P0_25 ISP TX) |
| J7-4(P1_25 FC2 TX) | J2-2(P0_24 ISP RX) |
| J7-8(GND) | J1-14(GND) |

**Note:** *The power supply voltage of LPC55S36 and LPC86x must be the same, that is, 3.3 V.*
Use the buttons on the board to force the chip into ISP mode because the LPCXpresso860-MAX board does not lead out ISP pins.
To force LPC86x into ISP mode, follow the steps below:
   a. Press **ISP** and **RESET** buttons at the same time.
   b. Release the **RESET** button.
   c. Release the **ISP** button.
4. To erase or program the device, follow the log in the terminal as shown in Figure 7.

AN13815

**Application note**

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**Rev. 0 — 5 May 2023**

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**7 / 10**

```
Please make sure LPC800 has entered ISP mode!!
Please input a character to erase or program LPC800, 'E' means erase
only, other character means erase and program:
1
image size is 4072, aligned size is 4096
Programming is complete, please re-enter ISP mode for further operation!
```

**Figure 7.  Terminal**

# 5 Revision history

The Table 3 lists the substantive changes done to this document since the initial release.

**Table 3.  Revision history**

| Revision number | Date | Substantive changes |
|---|---|---|
| 0 | 05 May 2023 | Initial release |

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**Application note**
**Rev. 0 — 5 May 2023**

**9 / 10**

# Contents