User Guide

BOOT user guide

NSING Technologies Pte. Ltd.
Add: NSING, Teletech Park #02-28, 20 Science Park Road,
Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

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Add: NSING, Teletech Park #02-28, 20 Science Park Road, Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

CONTENTS

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Tel: +65 69268090
Email: sales@nsing.com.sg

1. Overview

BOOT brief description

The firmware program of the chip, namely BOOT, mainly provides functions such as user program download, API and other functions.

This document describes the functions, implementation, and usage of the N32G031 series MCU BOOT in detail. The N32G031 series MCU have a maximum of 64KB of Flash memory, 3KB of BOOT memory, and 8KB of SRAM.

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Singapore 117674
Tel: +65 69268090
Email: sales@nsing.com.sg

1.1. BOOT Function Definition

- **User program download function**
  - Supports USART (USART1, using GPIO PA9-TX and PA10-RX; the default initial baud rate is 9600bps; supports baud rate setting by command; supported baud rates: 4800bps, 9600bps, 14400bps, 19200bps, 38400bps, 57600bps, 115200bps, 128000bps, 256000bps, 576000bps, 923076bps);
  - Supports CRC32 check for downloaded data;
  - Supports software reset chip;
  - Supports jump to user program.

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Email: sales@nsing.com.sg

2. BOOT Flow and Command Processing

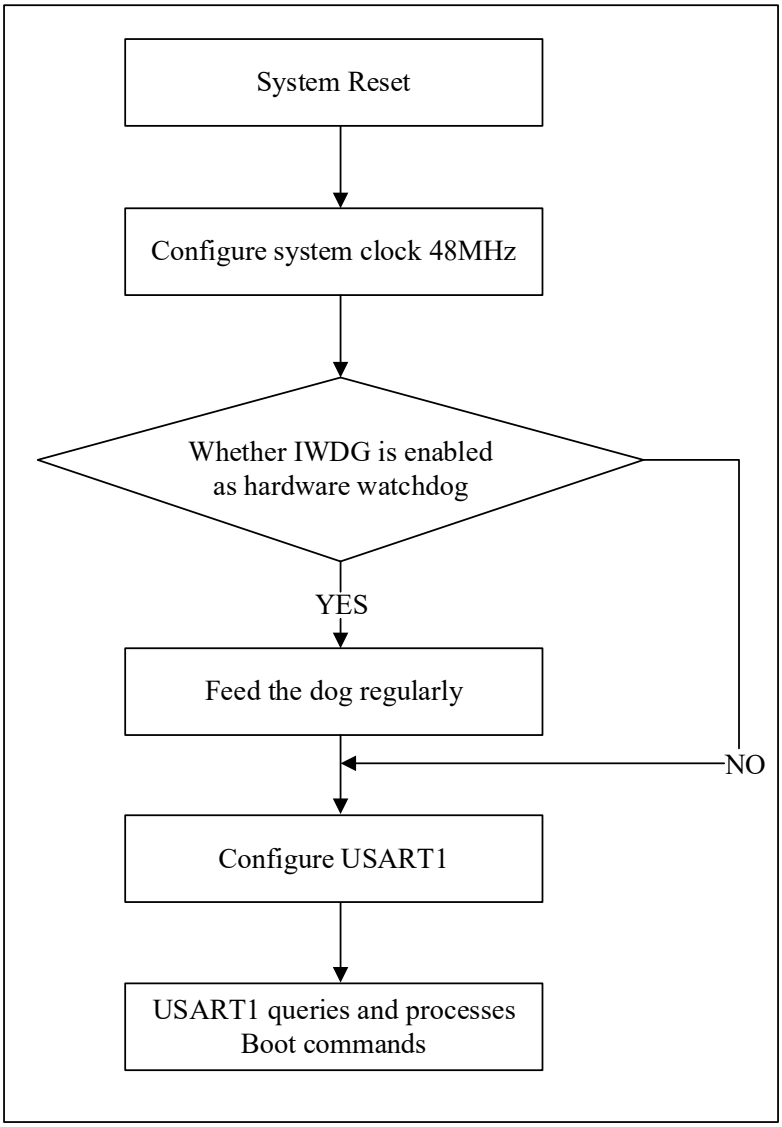
The firmware program BOOT of N32G031

series chip supports downloading user programs and data through the USART interface.

The following describes the command processing flow.

2.1. BOOT Startup Flow

Figure 2-1 BOOT Startup Flow



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Serial port startup process:

1) The default initial baud rate is 9600bps. The host computer uses the command CMD_SET_BR to transmit the baud rate set by the user (for example, 115200bps) to the MCU at 9600bps.

2) After receiving the CMD_SET_BR command, the MCU responds and sets the baud rate of the serial port to the value set by the user (for example, 115200bps).

3) The host computer sets the baud rate of the serial port to the value set by the user (for example, 115200bps), and then communicates normally.

2.2. Commands and Data Structure

2.2.1. The List of Commands

Table 2-1 Command Definition

Name of The Command	Value	Commands
CMD_SET_BR	0x01	Set the baud rate of the serial port (valid only when serial ports are used)
CMD_GET_INF	0x10	Read chip model index, BOOT version number, chip ID
CMD_FLASH_ERASE	0x30	Erase Flash
CMD_FLASH_DWNLD	0x31	Download user programs to Flash
CMD_DATA_CRC_CHECK	0x32	CRC check for downloaded user program
CMD_OPT_RW	0x40	Read/configure option bytes (including read protection level, Flash page write protection, DATA0/1 configuration,)
CMD_SYS_RESET	0x50	The system reset
CMD_APP_GO	0x51	Jump to user area to execute the program

2.2.2. Data Structure

This section describes some conventions described in the following sections. "<>" represents fields that must be included, and "()" represents the fields that included according to different commands.

Upper and lower commands data structure

1. Upper command structure:

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<CMD_H + CMD_L + LEN + Par> + (DAT).

CMD_H indicates the level-1 command field, and CMD_L indicates the level-2 command field. LEN indicates the length of data to be sent. Par represents a four-byte command parameter; DAT represents the specific data sent from the upper level command to the lower level;

2. Lower response structure:

< CMD_H + CMD_L + LEN > + (DAT) + <CR1+CR2>.

CMD_H indicates the level-1 command field, and CMD_L indicates the level-2 command field. The command fields at the lower level response structure are the same as those at the upper level command structure. LEN indicates the length of data to be sent. DAT indicates the specific data that the lower level responds to the upper level. CR1+CR2 indicates the command execution result returned to the upper level. If the level-1 and level-2 command fields do not belong to any command, BOOT responds with CR1=0xBB and CR2 = 0xCC.

Command data structures supported by the serial port:

1. The host computer transmits the upper command:

STA1 + STA2 + {Upper command structure} + XOR.

STA1 and STA2 are the start bytes of commands sent through the serial port. STA1=0xAA and STA2=0x55. STA1 and STA2 are used for chip identification of host computer to transmit serial data stream.

XOR represents the XOR operation value of the previous command byte (STA1 + STA2 + {Upper command structure}).

2. The host computer receives the lower response:

STA1 + STA2 + {Lower response structure} + XOR.

STA1 and STA2 are the start bytes of commands sent through the serial port. STA1=0xAA and STA2=0x55. STA1 and STA2 are used for the host computer to identify serial port data stream transmitted by chip.

XOR represents the XOR operation value of the previous command byte (STA1 + STA2 + {Lower response structure}).

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Note: in BOOT V1.0 (for the command of obtaining version information, see section 2.3.2), XOR does not operate on CR2 but only on bytes preceding CR2, that is (STA1 + STA2 + {< CMD_H + CMD_L + LEN > + (DAT) + <CR1 >})

2.3. Command Description

2.3.1. CMD_SET_BR

This command is used to change the baud rate of the serial port.

Upper command:

Table 2-2 Upper Command of CMD_SET_BR

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x01 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data: 0x00,0x00							
4~7(Par)	Par[0~3] : Set baud rate parameters							
(DAT)	None							

- Par[0~3], the serial port baud rate can be set to a typical value.

Table 2-3 Baud Rate Configuration Value

Par[0~3]	Toggle Specified Baud Rate (bps)
0x000E15C4	923076
0x0008CA00	576000
0x0003E800	256000
0x0001F400	128000
0x0001C200	115200
0x0000E100	57600
0x00009600	38400
0x00004B00	19200
0x00003840	14400

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0x00002580	9600
0x000012C0	4800

- Reserved value: 0x00.

Lower response:

Table 2-4 Lower Response of CMD_SET_BR

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x01 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data: 0x00,0x00							
(DAT)	None							
4(CR1)	Status byte 1							
5(CR2)	Status byte 2							

- Status bytes (CR1 and CR2) are divided into the following types according to command execution:

1. Return success: status flag bits (0xA0, 0x00).
2. Return failure: status flag bits (0xB0, 0x00).

2.3.2. CMD_GET_INF

The function provided by this command is to read the BOOT version number, chip model index, and chip ID.

Upper command:

Table 2-5 Upper Command of CMD_GET_INF

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x10 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3 (LEN)	Length of transmit data							
4~7(Par)	Reserved							

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(DAT)	None

- Reserved value: 0x00.
- LEN represents transmit data length: 0x00(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] +(LEN[1]<<8).

Lower response:

Table 2-6 Lower Response of CMD_GET_INF

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x10 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3 (LEN)	The length of the data							
4~54(DAT)	BOOT version, chip model index, chip ID							
55(CR1)	Status byte 1							
56(CR2)	Status byte 2							

- The procedure byte (CMD_H) corresponds to the CMD_H in the upper command.
- LEN is the data length: 0x33(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] + (LEN[1]<<8).
- DAT[0] : 0x01, reserved bit
- DAT[1] : 0xXY, BOOT version (BCD code)
- DAT[2] : BOOT command version
- DAT[3~50] : 48 bytes
  - DAT[3~18] : 16 bytes UCID (for details about the UCID, refer to the user manual).
  - DAT[19-30] : 12 bytes MCU ID(UID) (for details, refer to the user manual).
  - DAT[31~34]: 4 bytes DBGMCU_IDCODE (for details about DBGMCU_IDCODE, refer to the user manual).
  - DAT[35~50] : 16 bytes other information
- Status bytes (CR1 and CR2) are divided into the following types according to command execution:

1. Return success: status flag bits (0xA0, 0x00).

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2. Return failure: status flag bits (0xB0, 0x00).

2.3.3. CMD_FLASH_ERASE

BOOT provides the function of erasing Flash in units of pages. The erasure page address number and page number are provided by the user. The Flash space to be erased cannot exceed the entire Flash space, and at least 1 page (512Byte) is to be erased.

Upper command:

Table 2-7 Upper Command of CMD_FLASH_ERASE

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x30 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data (0)							
4~7(Par)	Page address number (2 bytes): 0 to 255 Page Number (2 bytes) :1 to 256							
(DAT)	None							

- CMD_L: partition number of the Flash space to be erased

  0x00

- LEN is the transmit data length: 0x10(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] + (LEN[1]<<8).

- The address and range of Flash to be erased consist of four bytes in the Par field

  Par[0~1] : 2 bytes for page address number (0~255)

  Page address number = Par [0] + Par [1]<<8;

  Par[2~3] : 2 bytes for page number (1~256)

  Page number = Par [2] + Par [3]<<8;

  The first address of page 0 is 0x0800_0000. For each subsequent page, the page address increments by 1 and the first address in the page increments by 0x200.

  For example:

  The first address of page 1 is 0x0800_0000 + 1*0x200 = 0x0800_0200

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The first address of page 2 is 0x0800_0000 + 2*0x200 = 0x0800_0400

Calculation of the entire address range to be erased:

For example, the page address is 0x01 and the number of pages is 0x02

Erasing address range:

(0x0800_0000 + 1*0x200) ~ (0x0800_0000 + 1*0x200 + 2*0x200)

That is, (first address of the page number) to (first address of the page number + (number of pages)*(page size))

Lower response:

Table 2-8 Lower Response of CMD_FLASH_ERASE

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x30 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data							
(DAT)	None							
4(CR1)	Status byte 1							
5(CR2)	Status byte 2							

- LEN is transmit data length: 0x00(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] + (LEN[1]<<8).
- Status bytes (CR1 and CR2) are divided into the following types according to command execution:

1. Return success: status flag bits (0xA0, 0x00).
2. Return failure: status flag bits (CR1, CR2).
   a) (0xB0, 0x00): return failure;
   b) (0xB0, 0x30): the erased Flash page is protected by RDP;
   c) (0xB0, 0x31): the erased Flash page is protected by WRP;
   d) (0xB0, 0x32): erase Flash page is protected by partition;
   e) (0xB0, 0x33): erase Flash page range across partitions;
   f) (0xB0, 0x34): the Flash address range is out of bounds (that is, it exceeds the size of the entire Flash);

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Tel: +65 69268090
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g) (0xB0, 0x35): download Flash start address is not 16 bytes aligned;

h) (0xB0, 0x36): the downloaded Flash data length is not a multiple of 16;

i) (0xB0, 0x37): failed to erase the Flash.

2.3.4. CMD_FLASH_DWNLD

This command allows the user to download code into the specified Flash. Data length must be 16 bytes aligned (0x00 automatically added by the host computer when the length is less than 16 bytes.). Data are all provided by upper-level commands. The downloaded data is plaintext.

Upper command:

Table 2-9 Upper Command of CMD_FLASH_DWNLD

Byte / Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x31 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data							
4~7(Par)	Start address for downloading the Flash							
8~23+N(DAT)	DAT[16~16+N] : data that downloaded DAT[16+N+1~16+N+4] : 4 bytes CRC32 check value of data							

- CMD_L: the partition number of the Flash to be downloaded

  0x00.

- LEN is transmit data length: 0xXX(LEN[0]), 0xXX(LEN[1]), LEN = LEN[0] + (LEN[1]<<8)

- Par [0 ~ 3]: download the starting address of the Flash, the synthesizing rules is Address = Par[0] | Par[1]<<8 | Par[2]<<16 | Par[3]<<24.

- DAT[0~15]: reserved, all are 0x00

- DAT[16~16+N]: the data to be downloaded, total number is N+1

  USART: can contain a maximum of 128 bytes. 15<=N<=143. N+1 must be a multiple of 16.

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DAT[16+N+1~16+N+4]: 4 byte CRC32 check value of data

Lower response:

Table 2-10 Lower Response of CMD_FLASH_DWNLD

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x31 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2(LEN)	Length of transmit data							
(DAT)	None							
3(CR1)	Status byte 1							
4(CR2)	Status byte 2							
5(XOR)	XOR result							

- LEN is transmit data length: 0x00(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] + (LEN[1]<<8).
- Status bytes (CR1 and CR2) are divided into the following types according to command execution:

1. Download success: status flag bits (0xA0, 0x00).
2. Download failed: status flag bits (CR1, CR2).
   a) (0xB0, 0x00): return failure;
   b) (0xB0, 0x30): the downloaded Flash address is protected by RDP;
   c) (0xB0, 0x31): the downloaded Flash address is protected by WRP;
   d) (0xB0, 0x32): the downloaded Flash address is protected by partition
   e) (0xB0, 0x33): download Flash address range across partitions;
   f) (0xB0, 0x34): download Flash address range is out of bounds (refers to beyond the size of the entire Flash);
   g) (0xB0, 0x35): download Flash start address is not 16 bytes aligned;
   h) (0xB0, 0x36): the downloaded Flash data length is not a multiple of 16;
   i) (0xB0, 0x37): failed to program the Flash.

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2.3.5. CMD_DATA_CRC_CHECK

This command is used to check whether the downloaded data is correct. Considering the download speed and low probability of download failure, the CRC check is performed after the downloaded data is complete. The upper command must provide the CRC value, start address, and check length of the downloaded data.

Upper command:

Table 2-11 Upper Command of CMD_DATA_CRC_CHECK

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x32 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data							
4~7(Par)	32-bit CRC check value							
8~31(DAT)	DAT [0~15]: reserved DAT[16~19]: start address of the CRC check DAT[20~23]: length of CRC check(in bytes, minimum length is 512B)							

- CMD_L: indicates the partition number to be checked by CRC

  0 x00.

- LEN is transmit data length: 0x18(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] + (LEN[1]<<8).

- Par [0 ~ 3]: 32 bit CRC checksum value, the synthetic rules for CRC32 = CRC32 = Par[0] | Par[1]<<8 | Par[2]<<16 | Par[3]<<24.

- CMD_L = 0x00:16 bytes are all 0x00.

- DAT [0~15]: reserved, all is 0

- DAT [16 ~ 19]: check the starting Address, the synthesizing rule is Address = DAT [16] | DAT [17] < < 8 | DAT [18] < < 16 | DAT [19] < < 24, the Address can only be in the range of the Flash.

- DAT [20 ~ 23]: check length, its synthesizingrule is CRC_LEN = DAT [20] | DAT [21] < < 8 | DAT [22] < < 16 | DAT [23] < < 24. CRC_LEN is only within the effective range. Length is larger than 2 KB, and is a multiple of 16.

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Lower response:

Table 2-12 Lower Response of CMD_DATA_CRC_CHECK

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x32 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data							
(DAT)	None							
4(CR1)	Status byte 1							
5(CR2)	Status byte 2							

- LEN is transmit data length: 0x00(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] + (LEN[1]<<8).
- Status bytes (CR1 and CR2) are divided into the following types according to command execution:

1. Check succeeded: status flag bits (0xA0, 0x00).
2. Check failure: status flag bits (CR1, CR2)
   a) (0xB0, 0x00): return failure;
   b) (0xB0, 0x32): CRC check addresses are protected by partitions.
   c) (0xB0, 0x33): CRC check address range crosses partitions;
   d) (0xB0, 0x34): CRC check address range is out of bounds (refers to the size of the entire Flash);
   e) (0xB0, 0x35): CRC check address is not 16-byte alignment;
   f) (0xB0, 0x36): The CRC check length is not a multiple of 16 or less than 512 bytes.
   g) (0xB0, 0x38): CRC check failed.

2.3.6. CMD_OPT_RW

This command is used for option bytes reading and writing (including read protection level, Flash page write protection, data0/1 configuration, and USER configuration).

Upper command:

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Table 2-13 Upper Command of CMD_OPT_RW

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x40 Level-1 command field							
1(CMD_L)	Level-2 command field							
2~3(LEN)	Length of transmit data							
4~7(Par)								
8~23(DAT)	16 bytes option byte configuration							

- CMD_L Level-2 command field:
  a) 0x00: gets option bytes.
  b) 0x01: configuration option byte.
  c) 0x02: configuration option byte, reset again.
- LEN is transmit data length: 0x14(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] + (LEN[1]<<8).
- DAT[0~15]: 16 bytes option bytes
  RDP, nRDP, USER, nUSER, Data0, nData0, Data1, nData1, WRP0, nWRP0, WRP1, nWRP1, RDP2, nRDP2, Reserved, nReserved;
  a) CMD_L = 0x00: all values of option bytes are 0x00.
  b) CMD_L = 0x01/0x02: option bytes are the values to be written.

Lower response:

Table 2-14 Lower Response of CMD_OPT_RW

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x40 Level-1 command field							
1(CMD_L)	Level-2 command field							
2~3(LEN)	Length of transmit data							
4~19(DAT)	16 bytes option bytes configuration							
24(CR1)	Status byte 1							
25(CR2)	Status byte 2							

- LEN is transmit data length: 0x14(LEN[0]), 0x00(LEN[1]), LEN = LEN[0] + (LEN[1]<<8).

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- DAT[0~15]: 16 bytes current option bytes configuration
  RDP, nRDP, USER, nUSER, Data0, nData0, Data1, nData1, WRP0, nWRP0, WRP1, nWRP1, RDP2, nRDP2, Reserved, nReserved;
- Status bytes (CR1 and CR2) are divided into the following types according to command execution:

1. Return success: status flag bits (0xA0, 0x00).
2. Check failure: status flag bits (CR1, CR2)
   a) (0xB0, 0x00): return failure;
   b) (0xB0, 0x39): the matched area is sealed and the read protection level is not allowed to be reduced from L1 to L0;

2.3.7. CMD_SYS_RESET

This command is used to reset the BOOT program.

Upper command:

Table 2-15 Upper Command of CMD_SYS_RESET

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x50 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data							
4~7(Par)	Reserved							
(DAT)	None							

- Reserved value: 0x00;

Lower response:

Table 2-16 Lower Response of CMD_SYS_RESET

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x50 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data							

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(DAT)	None
4(CR1)	Status byte 1
5(CR2)	Status byte 2

- Status bytes (CR1 and CR2) are divided into the following types according to command execution:

1. Return success: status flag bits (0xA0, 0x00).
2. Return failure: status flag bits (0xB0, 0x00).

2.3.8. CMD_APP_GO

This command is used to jump to the entry address (0x0800_0000) of USER1 reset program and execute after the BOOT program is downloaded to the Flash.

Upper command:

Table 2-17 Upper Command of CMD_APP_GO

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x51 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3(LEN)	Length of transmit data							
4~7(Par)	Reserved							
(DAT)	None							

- Reserved value: 0x00;

Lower response:

Table 2-18 Lower Response of CMD_APP_GO

Byte \ Bit	b7	b6	b5	b4	b3	b2	b1	b0
0(CMD_H)	0x51 Level-1 command field							
1(CMD_L)	0x00 Level-2 command field							
2~3 (LEN)	Length of transmit data							
(DAT)	None							
4(CR1)	Status byte 1							

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5(CR2)	Status byte 2

- Status bytes (CR1 and CR2) are divided into the following types according to command execution:

1. Return success: status flag bits (0xA0, 0x00).
2. Return failure: status flag bits (0xB0, 0x00).

2.4. The Returned Status Word Description

2.4.1. Return Success Status Word

Return success: status flag bits (0xA0, 0x00). The command from the upper level is successfully executed, and the success status is displayed.
Contains the success return value of the read, update, configure, and other commands.

2.4.2. Return Failure Status Word

Return failure: status flag bits (0xB0, 0x00). It indicates that the command delivered by the upper level fails to be executed due to other reasons (such as incorrect received command format or timeout). Then failure status is returned.

2.4.3. Other Return Status Words

The following return status words also indicates failure. The second byte of status word indicates different error types.

1. (0xB0, 0x30): erase/download Flash page protected by RDP;
2. (0xB0, 0x31): erased/downloaded Flash page is protected by WRP;
3. (0xB0, 0x32): erase/download/CRC check address is protected by partition;
4. (0xB0, 0x33): erase/download/CRC check address range cross partitions;
5. (0xB0, 0x34): the address range of erase/download/CRC is out of bounds (refers to the size of the entire Flash);
6. (0xB0, 0x35): erase/download /CRC start address is not 16-byte alignment;
7. (0xB0, 0x36): the length of the download /CRC check data is not a multiple of 16;

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data length indicates the length of erasing Flash, or the length of downloading code to Flash, or the length of Flash to be CRC checked;

8. (0xB0, 0x37): failed to erase/download Flash programming;
9. (0xB0, 0x38): CRC check fails;
10. (0xB0, 0x39): partition sealing has been configured, and read protection level is not allowed to be reduced from L1 to L0;
11. (0xBB, 0xCC): the level-1 and level-2 command fields do not belong to any command.

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3. Version History

Version	Date	Changes
V1.0	2021.09.24	Initial release
V1.1.0	2022.06.17	1. Delete CMD_USER_SEAL boot command; 2. Modify notice description, header and footer; 3. Modify the error of URART in the second chapter brief description, and correct it to USART; 4. Section 2.2.2. Add the note of XOR operation;

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Add: NSING, Teletech Park #02-28, 20 Science Park Road,
Singapore 117674
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Email: sales@nsing.com.sg

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