PM0012
Programming Manual

AT32 Bootloader I2C Protocol

Introduction

This application note describes the I2C protocol used in the AT32 microcontroller bootloader and details each supported command.

For more information about the I2C hardware resources and requirements for your device bootloader, refer to the *PM0007_AT32_Bootloader_Program_Manual*.

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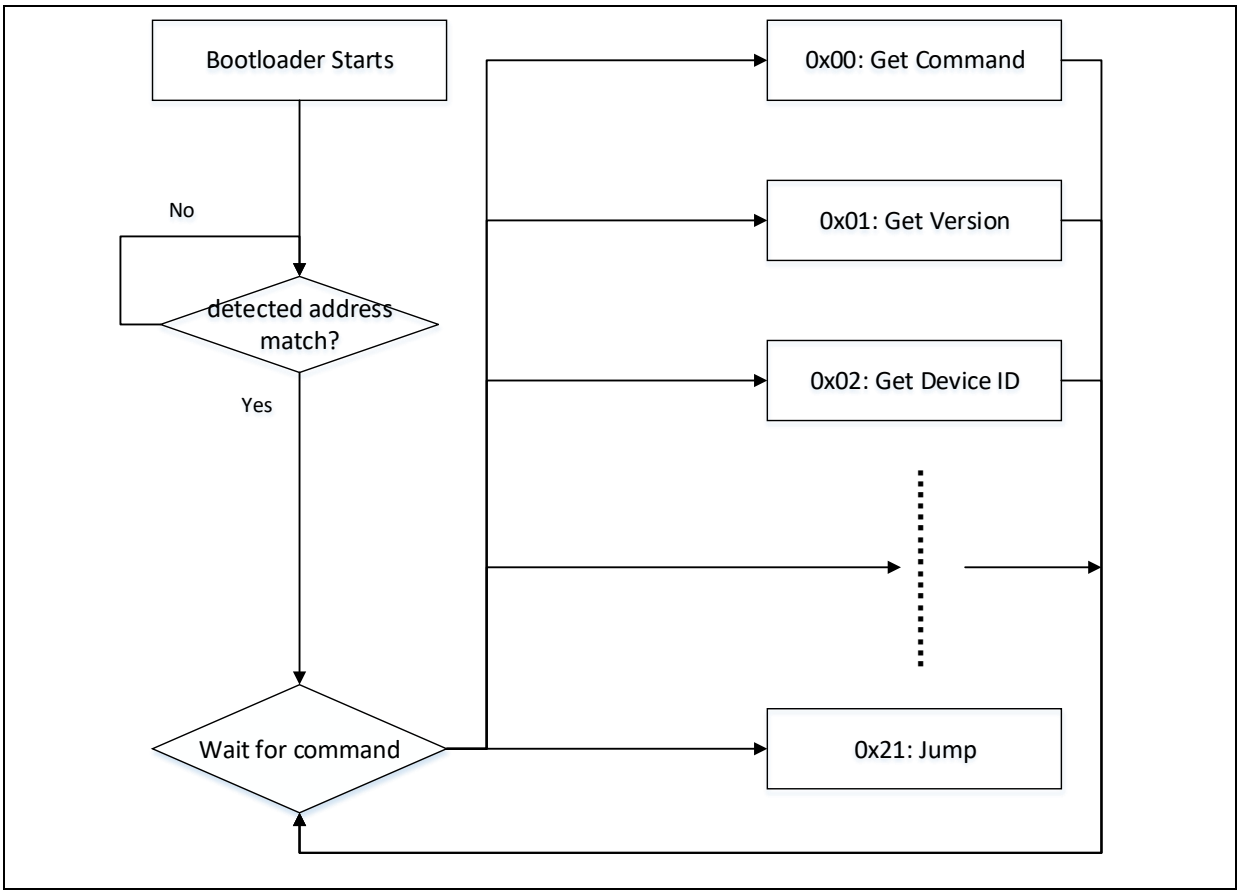
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1 I2C bootloader code sequence

Once the system memory boot mode has been entered, the bootloader begins to scan the I2C_SDA to detect its own address on the bus. Once detected and matched (address 0x3C 0b0011101), the I2C bootloader begins waiting for host commands.

Figure 1 Bootloader Main Loop



2 Bootloader command set

The number of supported commands varies between microcontroller series. For the same commands, however, they are compatible across the entire microcontroller series, such as read, write, and erase operations.

ACK=0x79, indicates that the bootloader accepts the command.
NACK=0x1F, indicates that the bootloader does not accept the command.
I2C uses slave 7-bit address: 0b0011101x
I2C bootloader commands

Commands	Command code	Command description	Supported product series
Get Commands	0x00	Gets the commands supported by the current version of the protocol	Product series with I2C feature
Get Version	0x01	Get the bootloader version	Product series with I2C feature
Get Device ID	0x02	Get the device ID	Product series with I2C feature
Read memory	0x11	Read memory starting from an address specified by the application	Product series with I2C feature
Jump	0x21	Jump to application code located in the specified flash memory	Product series with I2C feature
Write memory	0x31	Write to the memory starting from an address specified by the application	Product series with I2C feature
Erase	0x44	Erase memory	Product series with I2C feature
Erase and program protect	0x63	Enable Erase and program protection	Product series with I2C feature
Erase and program unprotect	0x73	Disable Erase and program protection	Product series with I2C feature
Access Protect	0x82	Enable Access protection	Product series with I2C feature
Access Unprotect	0x92	Disable Access protection	Product series with I2C feature
Firmware CRC	0xAC	Sector CRC Compute CRC of a given sector	Product series with I2C feature
Enable sLib	0xD0	Enable sLib	Product series with I2C feature
Disable sLib	0xD1	Disable sLib	Product series with I2C feature
Get sLib Status	0xD2	Get sLib Status	Product series with I2C feature
Reset Device	0xD4	Reset Device	Product series with I2C feature
Advanced Access Protect	0xD6	Enable Advanced Access Protect	Product series with I2C feature

3 Bootloader command descriptions

This chapter describes the role and operating methods of each supported command from a perspectives of the host side and the device side.

3.1 Get Commands

This command is used to get the protocol version and the supported commands. The number of the supported commands depends on the MCU series.
When the bootloader receives the command, it transmit an “ACK” byte to the host. After the transmission of the ACK byte, the bootloader sends the number of bytes (one byte) to the host, the protocol version and the supported commands and then transmits an ACK byte.
This command is allowed and executed when the access protection is enabled

3.1.1 Flow chart on host and device sides

Figure 2 Get Commands: host side

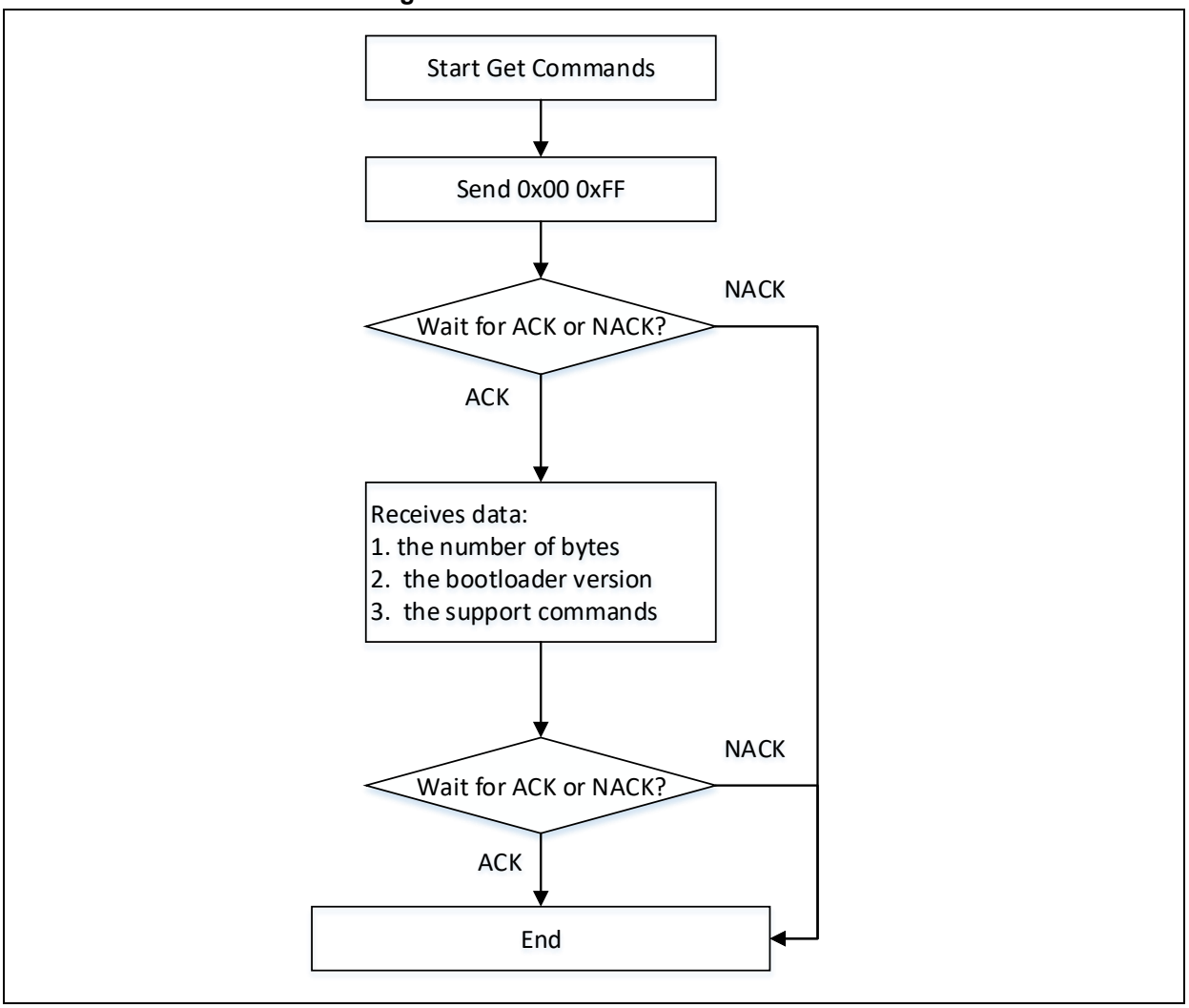
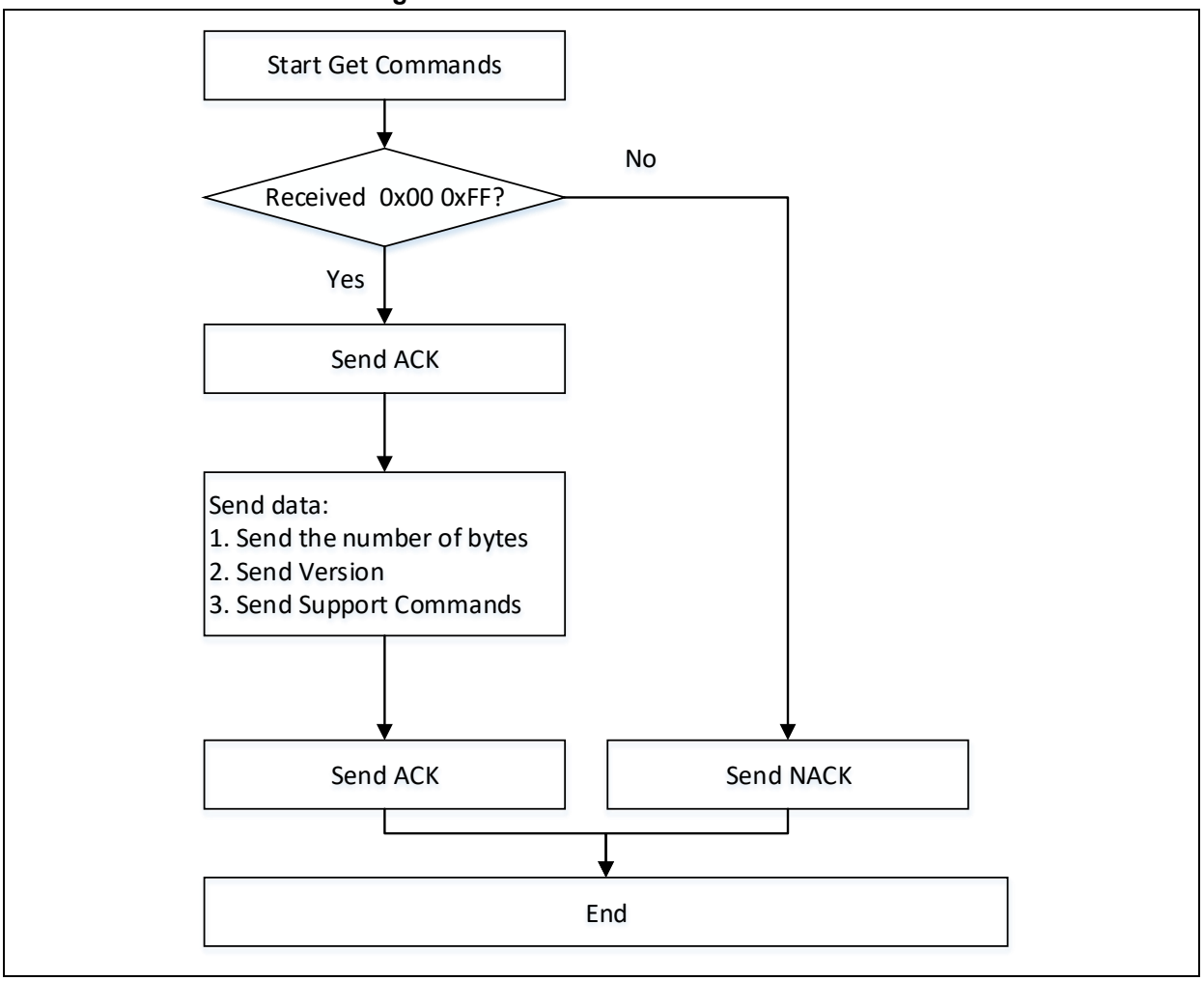


Figure 3 Get Commands: device side



3.1.2 Data transmit on host side

Send	Receive	Data	Description
1		0x00	
2		0xFF	
	1	ACK/NACK	When an NACK is received, it represents the end of the command.
	2	n	It represents the number of data to be received.
	3	*	The protocol version of the bootloader
	4	0x00	First command: Get Commands
	5	0x01	Second command: Get Version
	…	…	…
	n+2	*	N command
	n+3	ACK	End of command

3.2 Get Version

This command is used to get the version of the bootloader. When the device receives the command, it transmits an ACK byte to the host. After the transmission of the ACK byte, the device sends the bootloader protocol version (1 byte) and the bootloader version code (BID, two bytes). After this operation, the device transmits the ACK byte to the host signaling the end of the command.

This command is allowed and executed when the access protection is enabled.

3.2.1 Flow chart on host and device sides

Figure 4 Get Version: host side

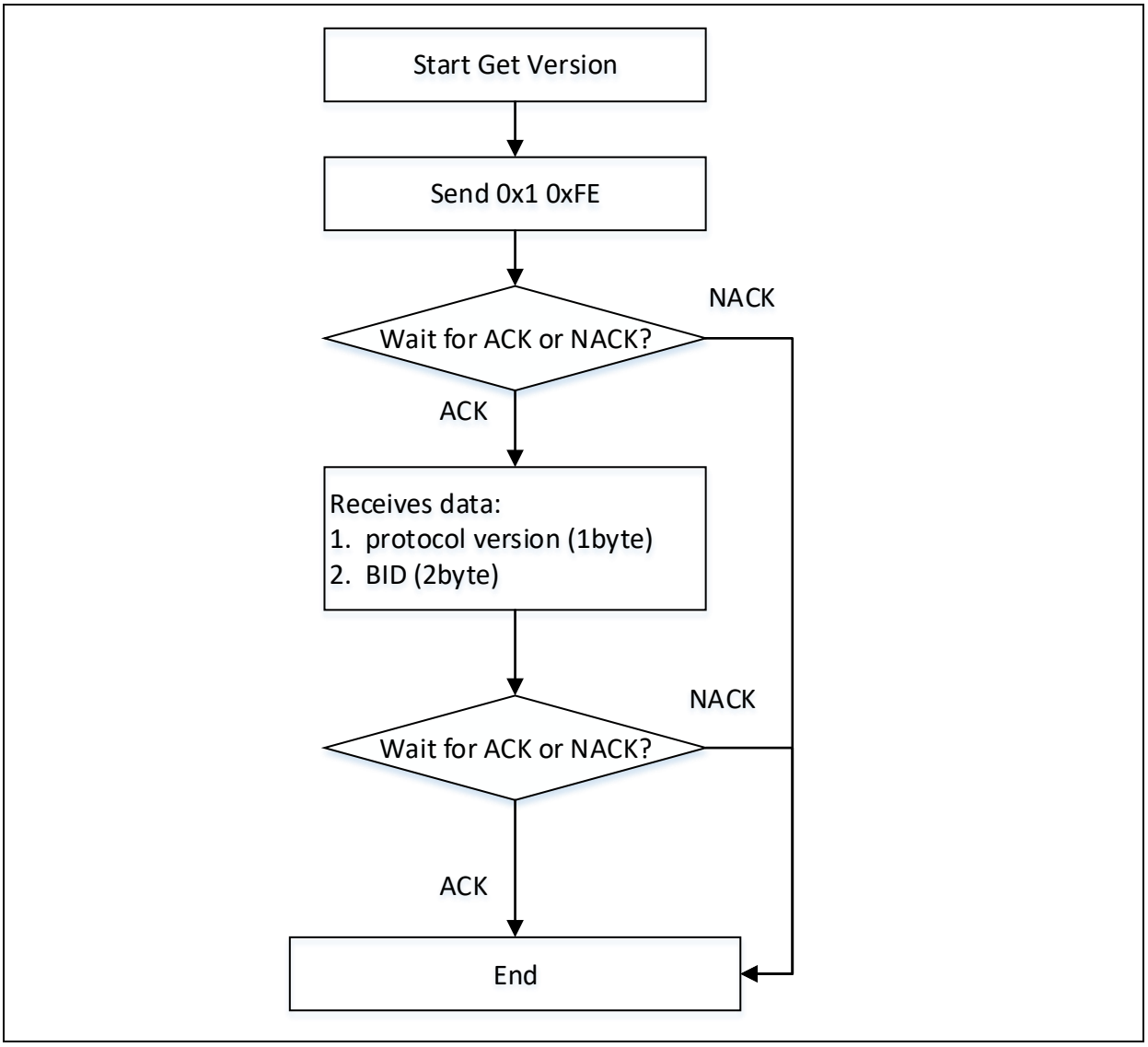
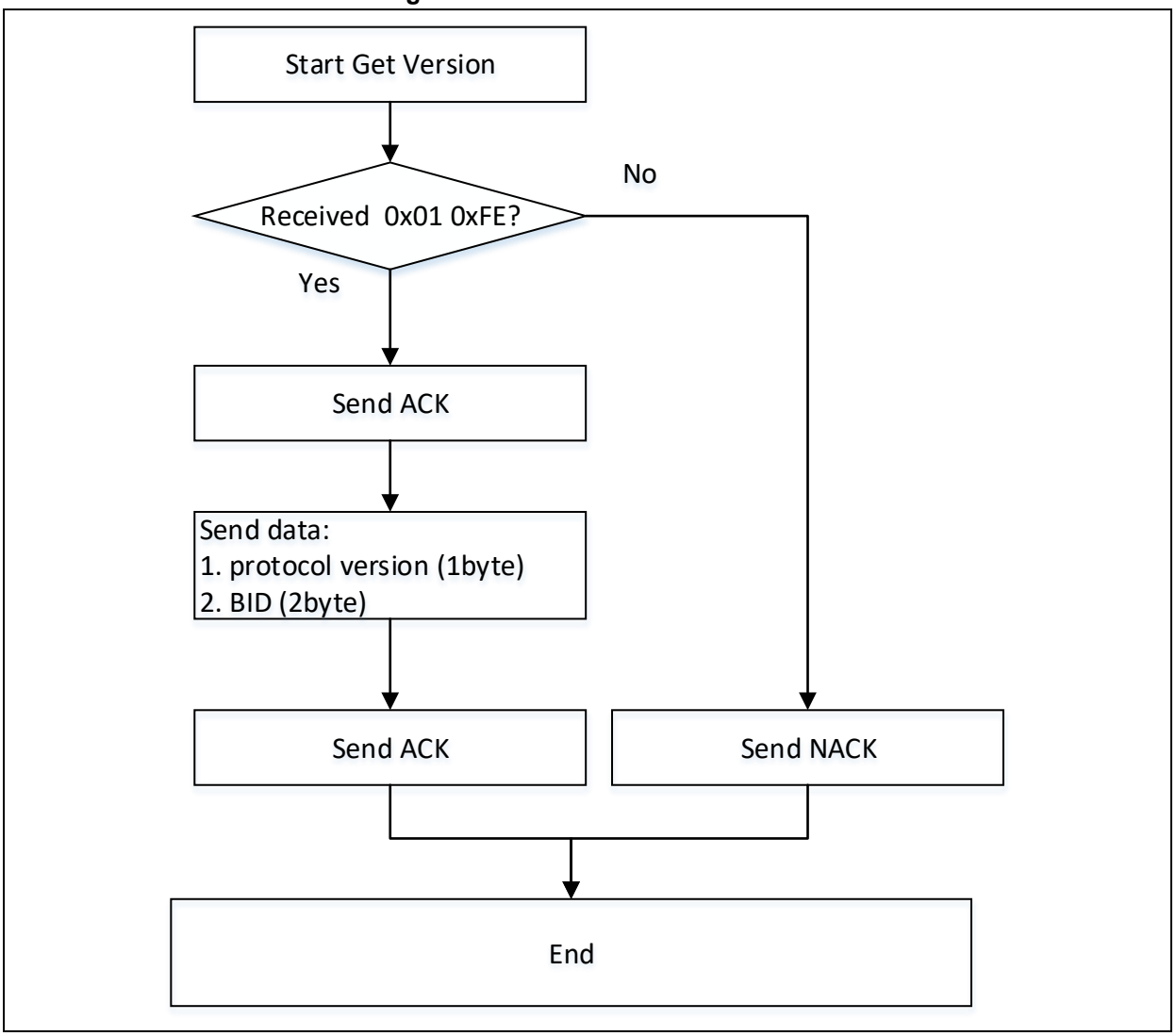


Figure 5 Get Version: device side



3.2.2 Data transmit on host and device sides

Send	Receive	Data	Description
1		0x01	
2		0xFE	
	1	ACK/NACK	When an NACK is received, it represents the end of the command.
	2	*	Bootloader protocol version
	3	*	Bootloader version ID（BID）
	4	*	Bootloader version ID（BID）
	5	ACK	End of command

3.3 Get Device ID

This command is used to get the identification code of the device. This ID data includes a 4-byte product ID and a 1-byte project ID. The “project ID” is used to identify which MCU series is being used, and the “product ID” is used to get the exact part number of the current MCU series in use. When the device receives this command, it transmits an “ACK” byte to the host. After the transmission of the ACK byte, the device sends a 1-byte data length indicating the number of data to be transmitted-- the value is the transmitted length minus 1 (for example, the transmitted data size is 5, then the value is 4), then sends another 4-byte product ID and 1-byte project ID. After this operation, the device transmits an ACK byte to the host.
This command is allowed and executed when the access protection is enabled.

3.3.1 Flowchart on host and device sides

Figure 6 Get Device ID: host side

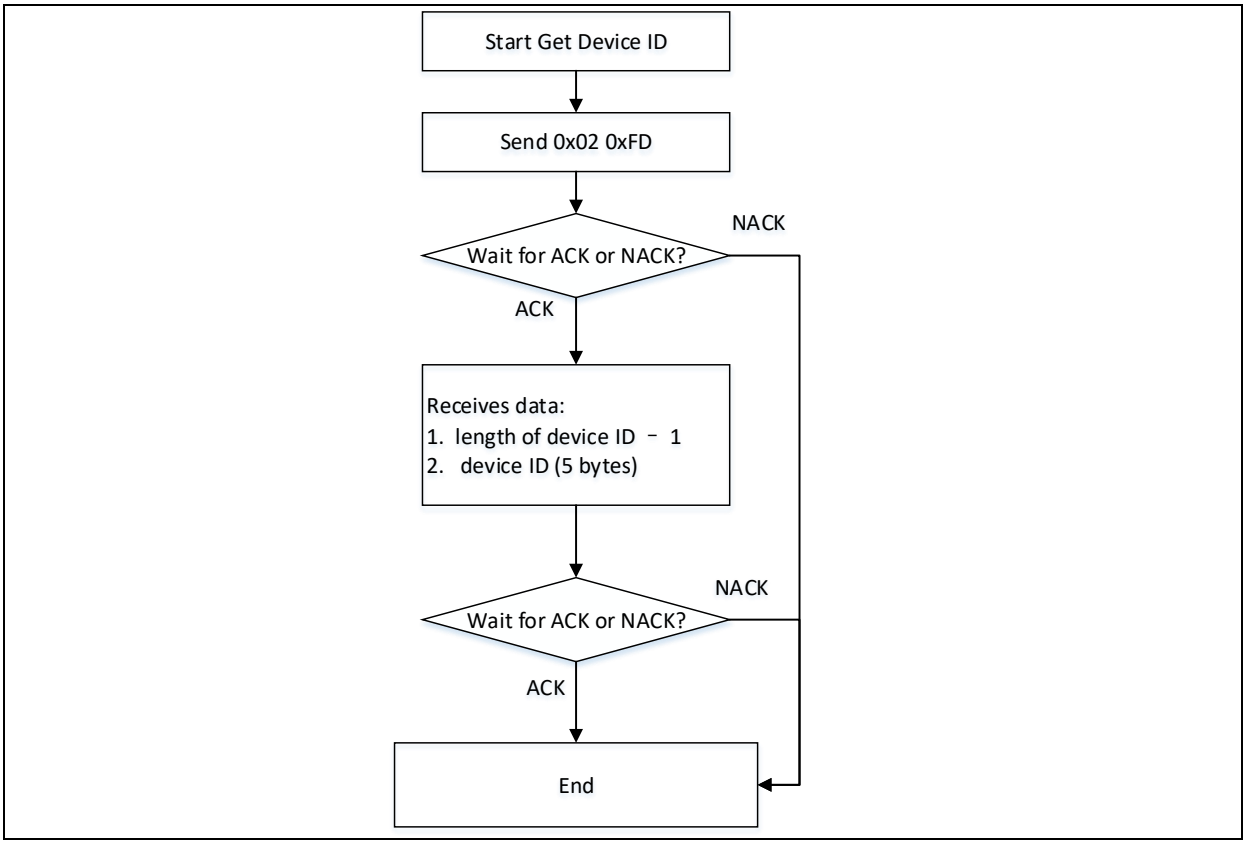
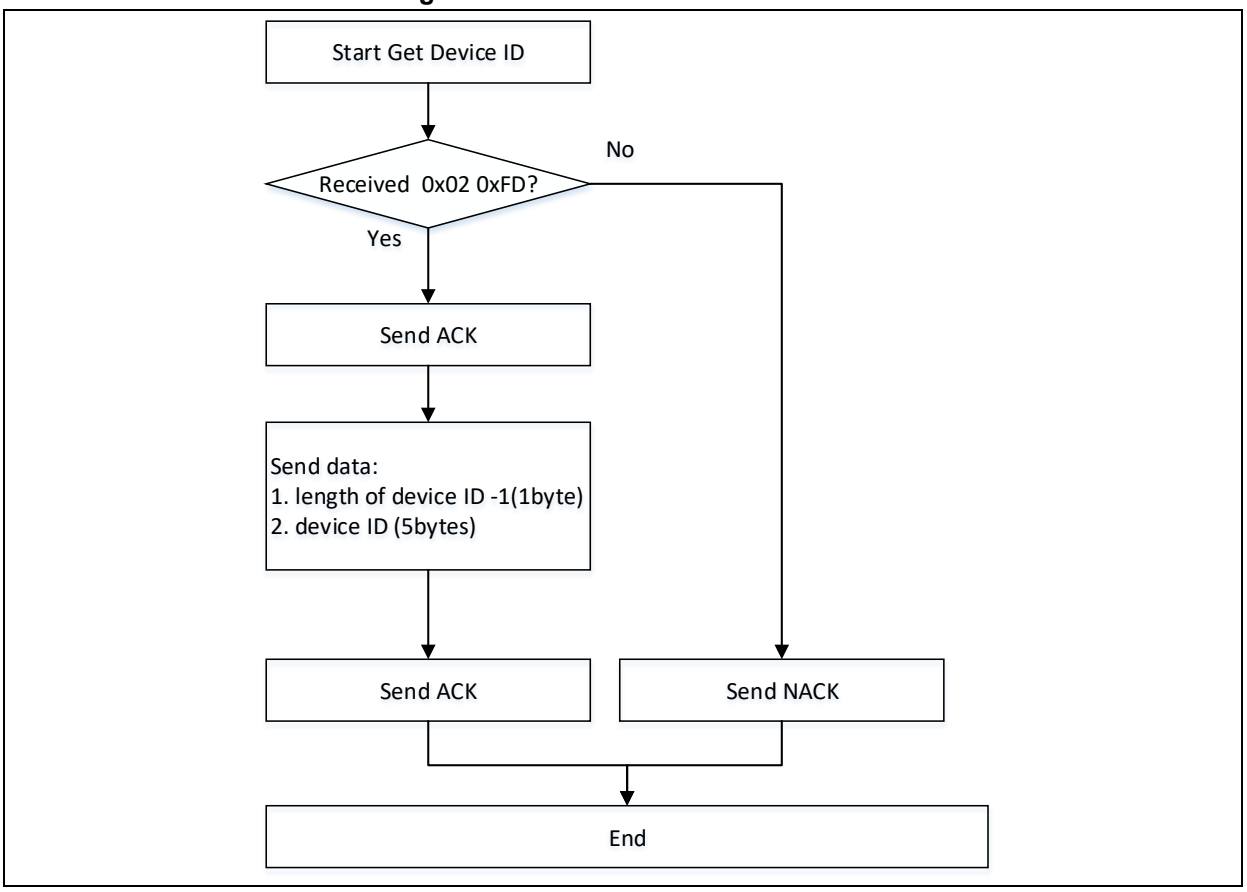


Figure 7 Get Device ID: device side



3.3.2 Data transmit on host side

Send	Receive	Data	Description
1		0x02	
2		0xFD	
	1	ACK/NACK	When an NACK is received, it represents the end of the command.
	2	0x04	Device ID length minus 1
	3	*	Product ID [8-15]
	4	*	Product ID [0-7]
	5	*	Product ID [24-31]
	6	*	Product ID [16-23]
	7	*	Project ID
	8	ACK	End of command

3.4 Read Memory

This command is used to read data from any valid memory address (refer to the product datasheets) in SRAM, boot memory and in the user system data area. For those MCUs with SPIM feature, SPIM must be enabled first (send Enable SPIM command) to read data from it.
When the device receives the command, if the access protection is not enabled, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device waits for an address (four bytes) and a checksum byte. If the Checksum is correct and the valid is valid, the devices transmits an ACK byte, and then waits for the number of bytes to be read (1 byte) and for a checksum byte. The number of byte to read is the actual read data length -1(for example, to read 10 bytes, the value here is 9). If the checksum is correct, the devices sends an ACK before starting to send the needed data.
This command is not allowed and executed when the access protection is enabled.

3.4.1 Flowchart on host and device sides

Figure 8 Read Memory: host side

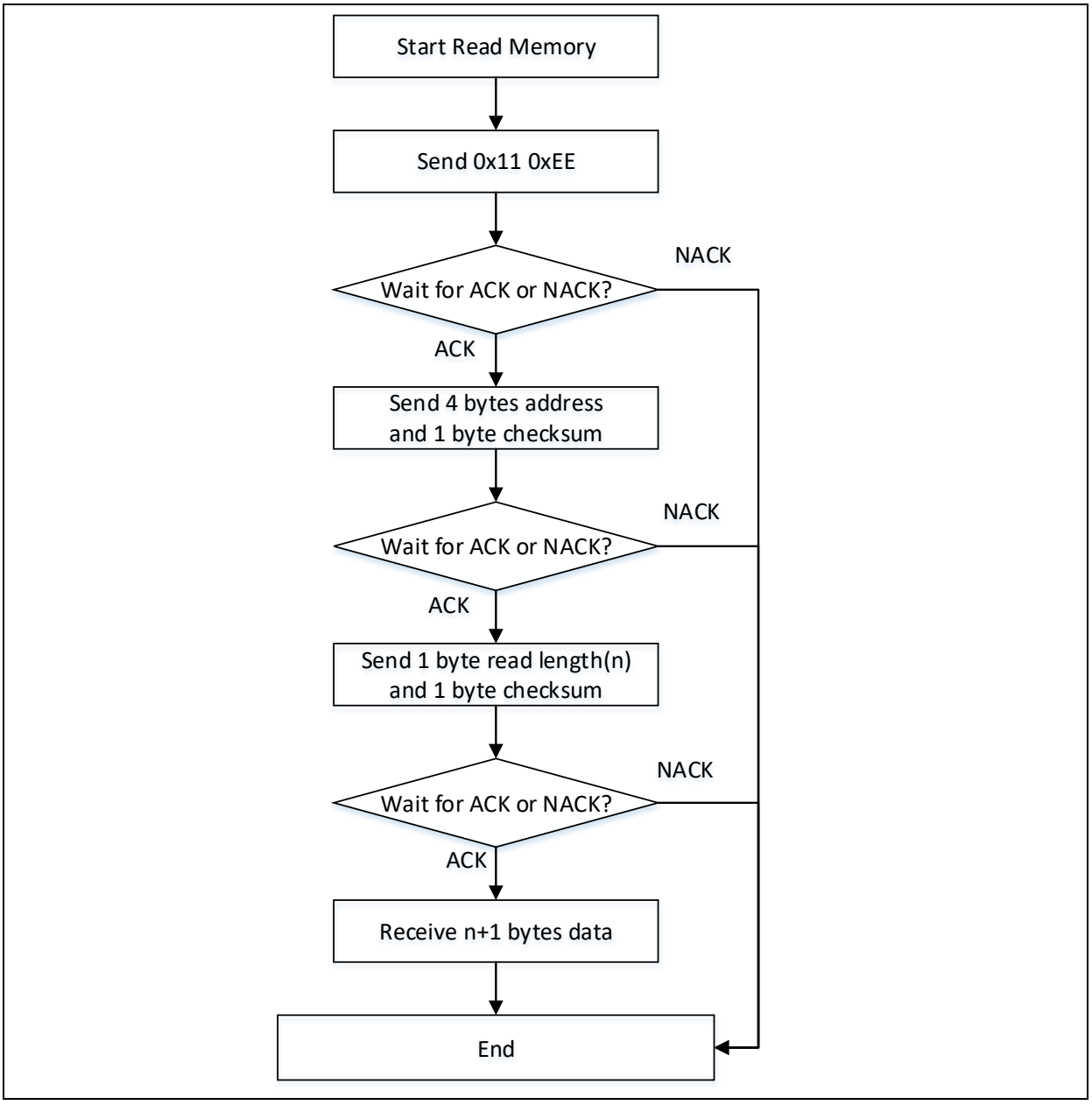
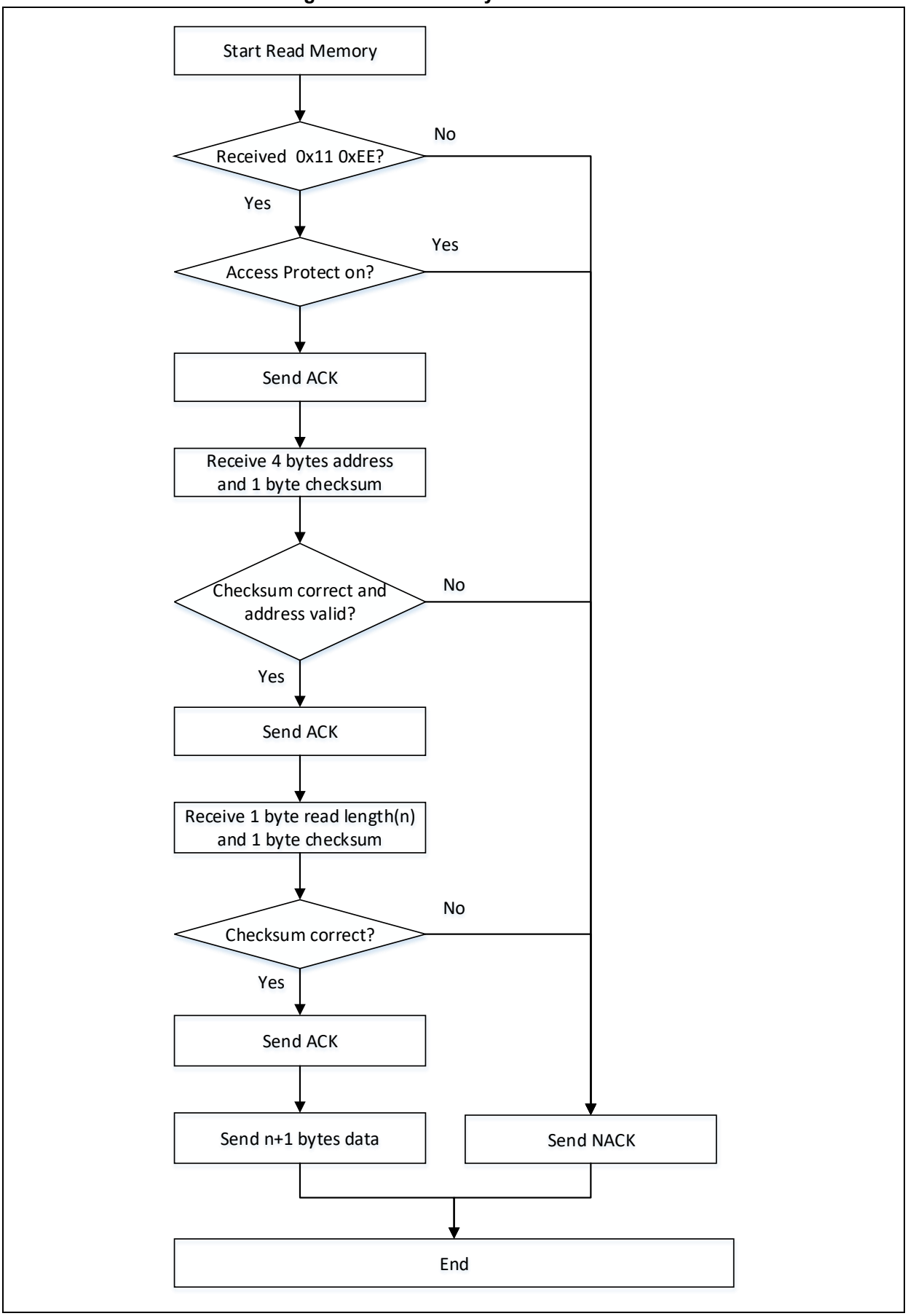


Figure 9 Read Memory: device side



3.4.2 Data transmit on host side

Send	Receive	Data	Description
1		0x11	
2		0xEE	
	1	ACK/NACK	When an NACK is received, it represents that the access protection is enabled, and the end of the command.
3		*	Address MSB
4		*	
5		*	
6		*	Address LSB
7		*	Checksum：XOR（address byte3~byte6）
	2	ACK/NACK	When an NACK is received, it represents the end of the command.
8		*	Read data length – 1 (n)
9		*	Checksum: 0xFF XOR byte8
	3	ACK/NACK	When an NACK is received, it represents the end of the command.
	4	*	Destination address data
	…	…	Destination address data
	4+n+1	*	Destination address data

3.5 Jump

This command is used to execute the code in a specified address. It can jump to main memory or SRAM to execute code. The address must be valid, which depends on the MCU series.
When the device receives the command, if the access protection is not enabled, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device waits for an address (four bytes) and a checksum byte, then it checks the received address. If the address is valid and the checksum is correct, the devices transmits an ACK byte, and jumps to the memory location.
This command is not allowed and executed when the access protection is enabled.

3.5.1 Flowchart on host and device sides

Figure 10 Jump: host side

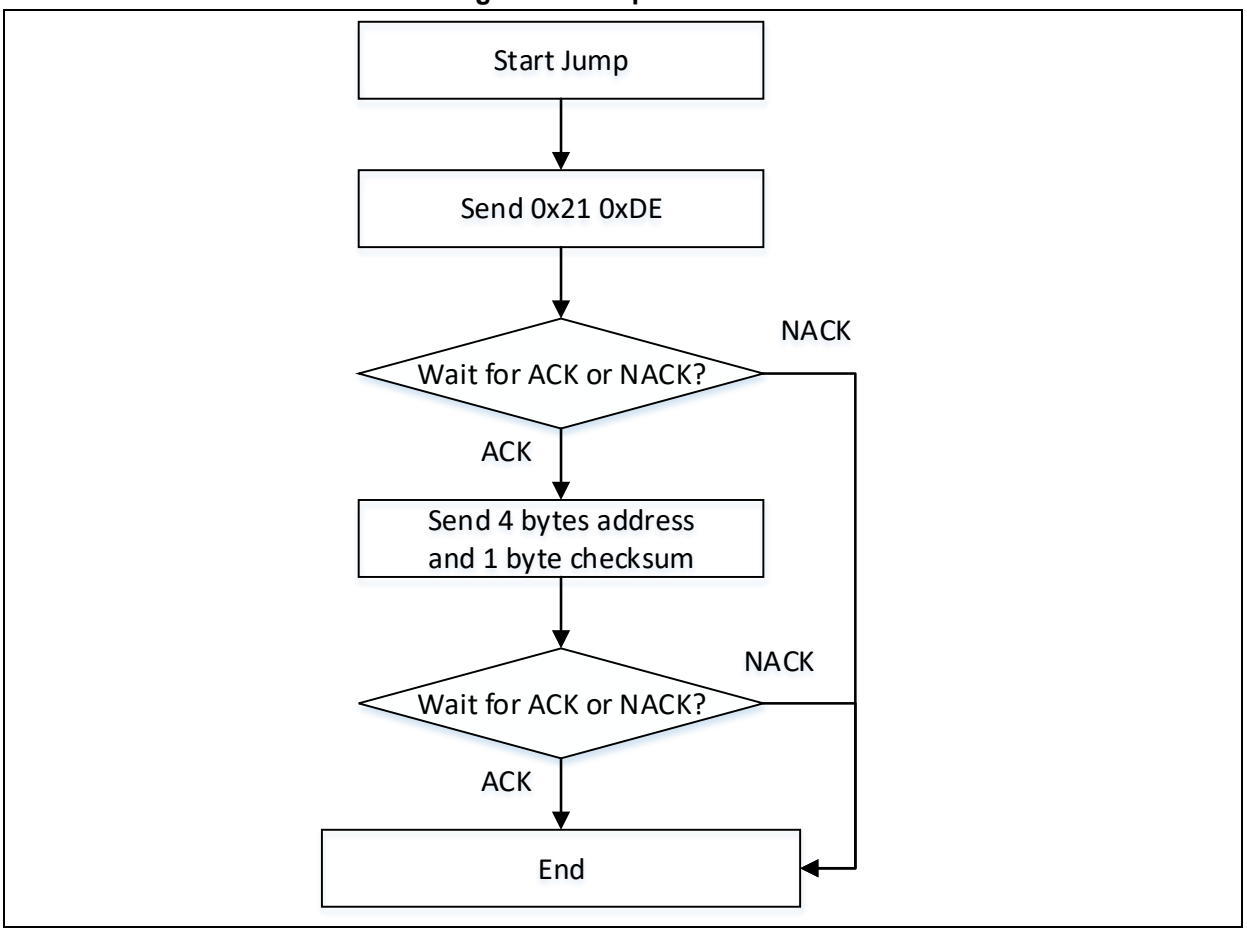
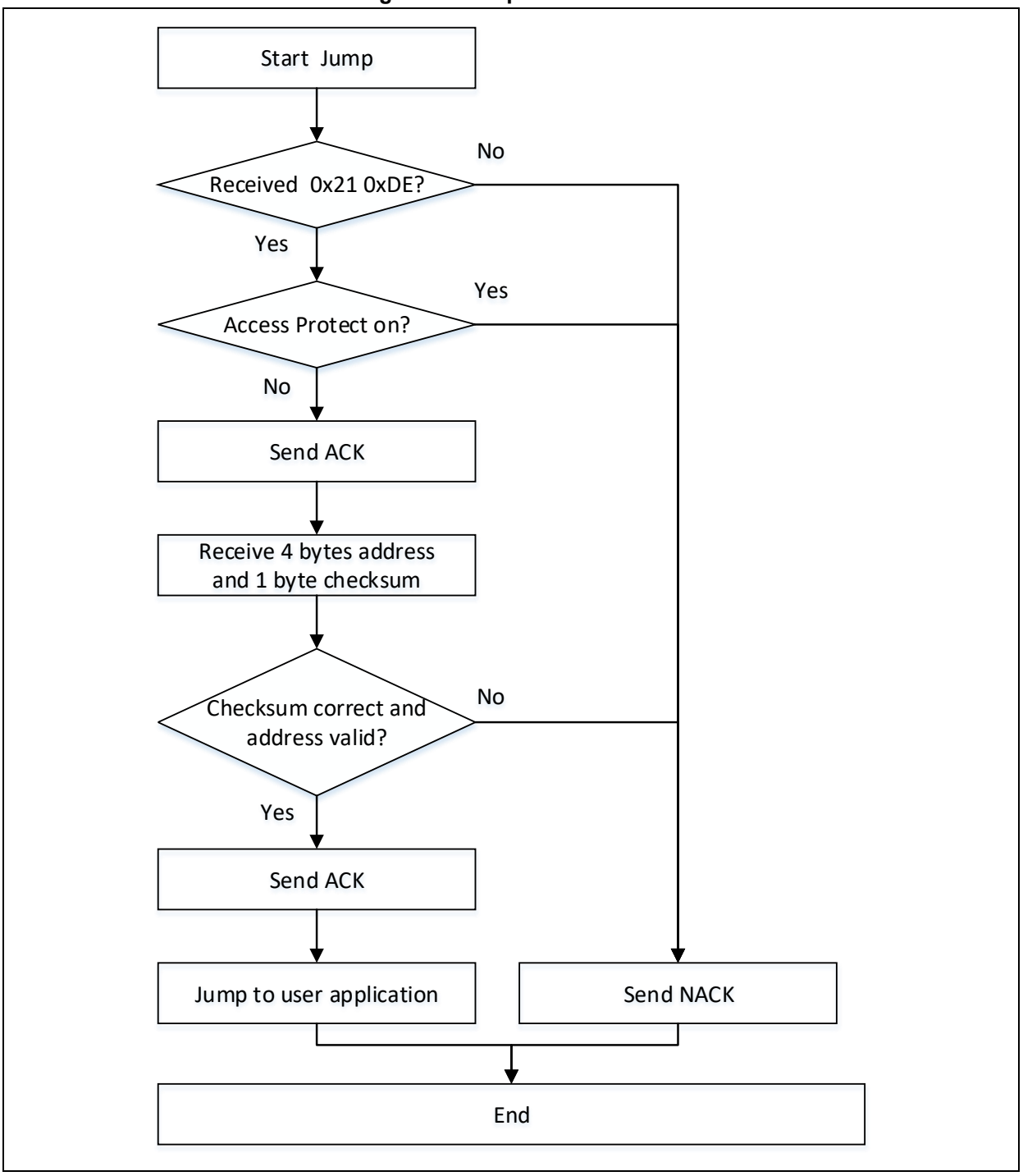


Figure 11 Jump: device side



3.5.2 Data transmit on host side

Send	Receive	Data	Description
1		0x21	Jump
2		0xDE	Jump
	1	ACK/NACK	When an NACK byte is received, it indicates that the access protection is enabled, and the end of the command.
3		*	Address MSB
4		*	
5		*	
6		*	Address LSB
7		*	Checksum：XOR（address byte3~byte6）
	2	ACK/NACK	

3.6 Write Memory

This command is used to write data to any valid memory address (depending on the product series) such as Flash memory, SRAM, or user system data area.

If the Write Memory command is issued to the Flash memory, all bytes are erased before writing the new values.

The size of the user system data area depends on the product series:

- User system data area smaller than 256 bytes
  Only a single Write Memory command is issued by the host to write data to the user system data area. When the device receives the command, it erases all bytes in the user system data area before writing to it and then performing a system reset.
- User system data area greater than 256 bytes
  Multiple Write Memory commands are issued by the host to write data to the user system data area.
  When the device receives the command, if the received address to write is the start address of the user system data area, the address is erased before written.
  If it is not the start address of the user system data area, no erase operation is performed and data are directly written.
  After the write operation (after all of data are written), a system reset is performed automatically.

When the device receive the “Write Memory” command, if the access protection is not enabled, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device waits for an address (four bytes) and a checksum byte. If the received address is valid and the checksum is correct, the device transmits an ACK byte. After the transmission of the ACK byte, the device waits for an address (one byte) and a checksum byte. The value is the actual written length minus 1 (for example, to write 10 bytes, the value here is 9). If the checksum is correct, the device writes data to the received address and then transmits an ACK byte to the host.

This command is not allowed and executed when the access protection is enabled.

3.6.1 Flowchart on host and device sides

Figure 12 Write Memory: host side

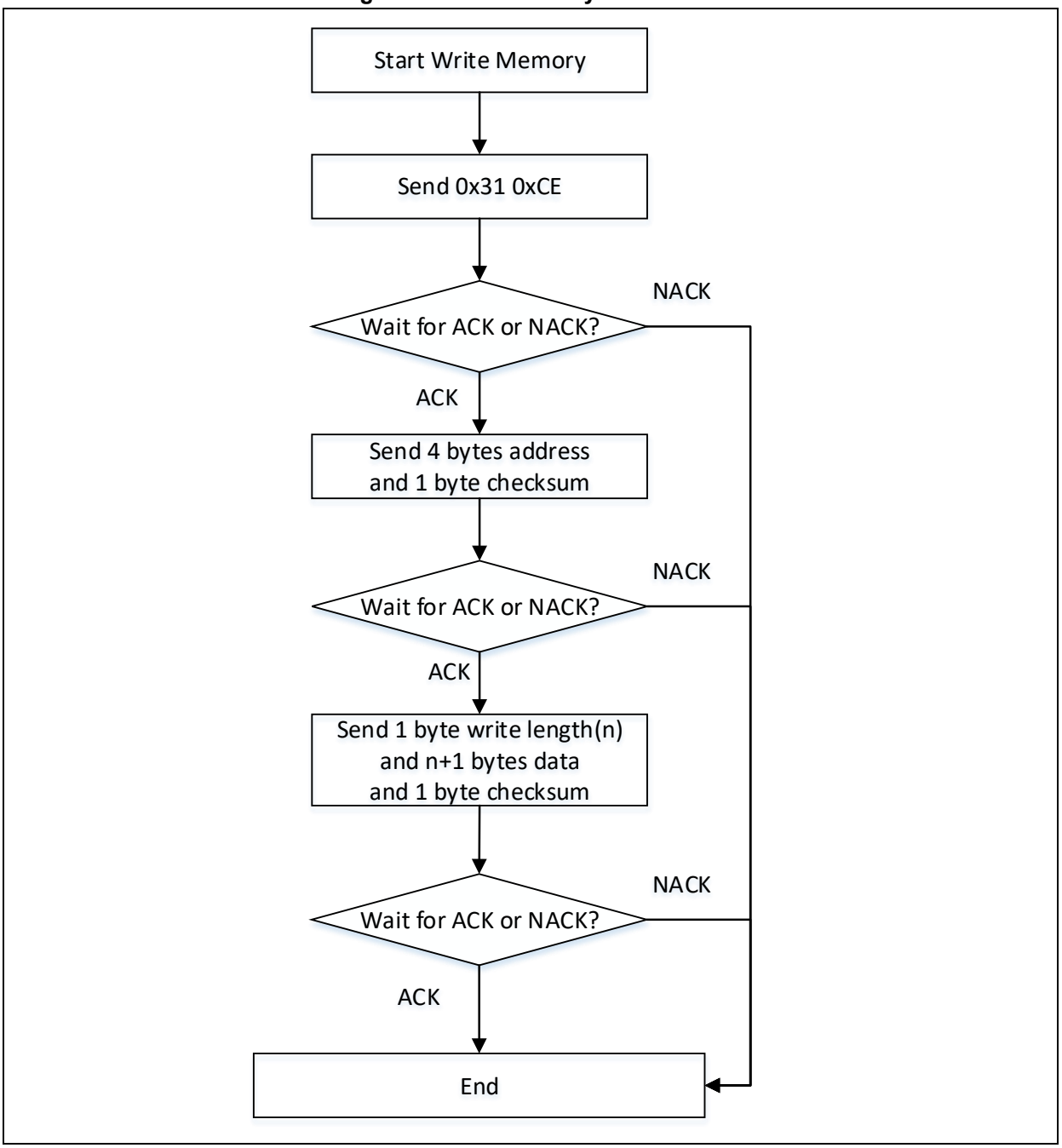
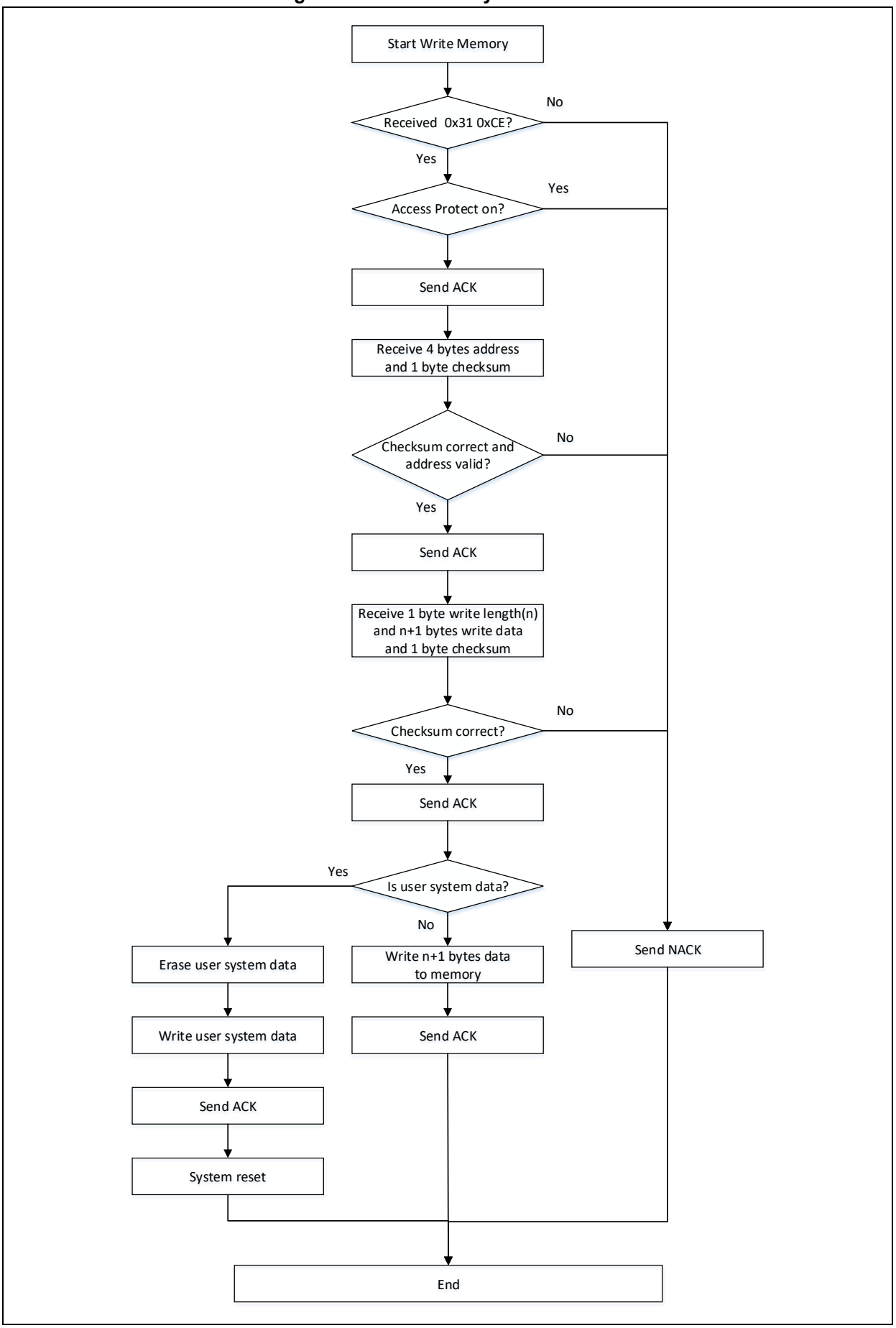


Figure 13 Write Memory: device side



3.6.2 Data transmit on host side

Send	Transmit	Data	Description
1		0x31	Write Memory
2		0xCE	Write Memory
	1	ACK/NACK	When an NACK byte is received, it indicates the access protection is enabled, and the end of the command.
3		*	Address MSB
4		*	
5		*	
6		*	Address LSB
7		*	Checksum：XOR（address byte3~byte6）
	2	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
8		*	The number of data to be written n - 1
9		*	Write data
…		…	Write data
9+n		*	Write data
			Checksum：XOR byte8 - byte9+n
	3	ACK/NACK	End of command

3.7 Erase

This command allows the host to erase Flash memory pages. It supports sector erase (sector size depends on the product series) and mass erase.

For those products that contain bank 1 and bank 2, this command can be used to erase bank 1 and bank 2.

For those with SPIM feature, it support erase operation on Bank 3.

Note that this command is used to erase any valid memory address, depending on the product series.

When the device receives the command, if the access protection is not enabled, it transmits the ACK byte to the host. After the transmission of the ACK byte, the devices receives two bytes data and check which erase operation is performed based on the received data type.

- If it is Sector erase, the received data indicates the number of the sectors to be erased. Then the device receives the index of N sectors to be erased. After receiving the index, the device starts erasing the corresponding sector and then transmits an ACK byte to the host.
- If it is mass erase or bank erase, the device directly performs erase operation and then transmits the ACK byte to the host after the erase operation.

This command is not allowed and executed when the access protection is enabled.

Table 1 List of erase type

Erase type	Erase index	Erase area
Sector erase	0x00 0x00	Sector0
	0x00 0x01	Sector1
	…	…
	0x80 00	Bank3 Sector0
	0x80 01	Bank3 Sector1
	…	…
	0x8F 0xFF	Bank3 Sector4096
Mass erase	0xFF 0xFF	All Flash
Bank erase	0xFF 0xFE	Bank1 Erase
	0xFF 0xFD	Bank2 Erase
	0xFF 0xFC	Bank3 Erase

Note: the sector size is dependent on the product series.

3.7.1 Flowchart on host and device sides

Figure 14 Erase: host side

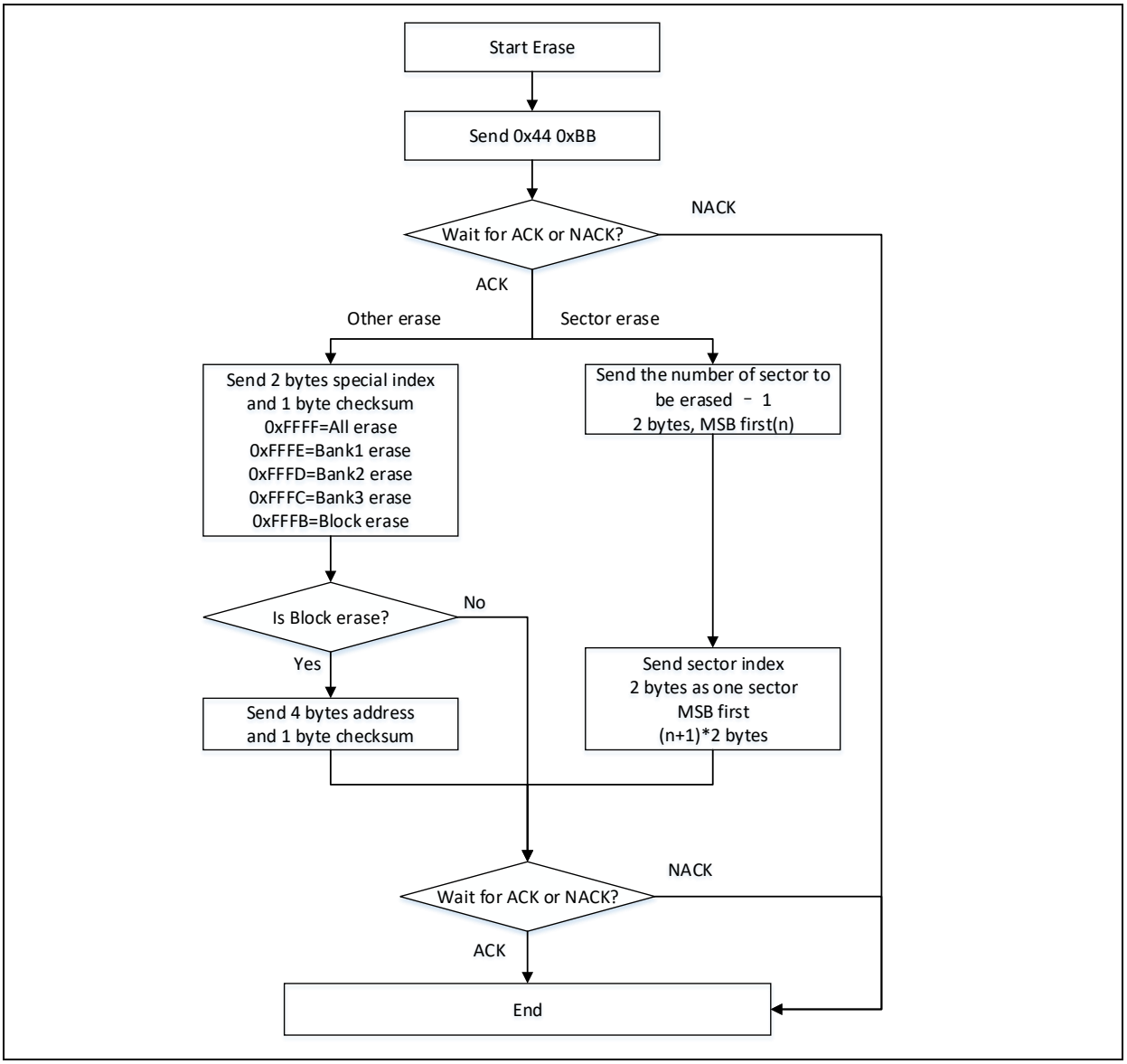
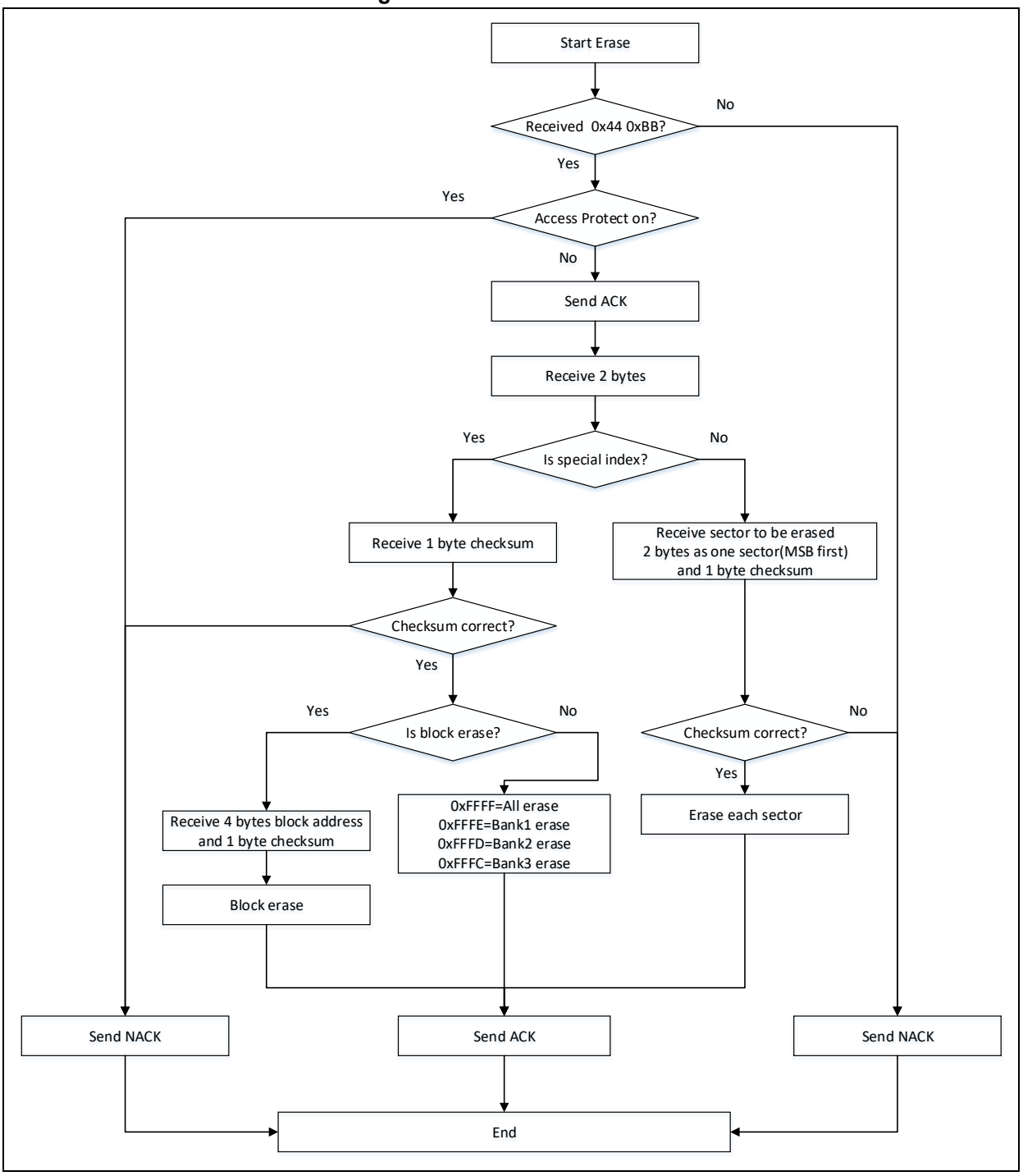


Figure 15 Erase: device side



3.7.2 Data transmit on host side

Sector erase

Send	Receive	Data	Description
1		0x44	Erase
2		0xBB	Erase
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
3		*	Erase sector number – 1 (n) MSB
4		*	Erase sector number – 1 (n) LSB
5		*	First Sector index (MSB)
6		*	First Sector index (LSB)
…		*	X Sector index (MSB)
…		*	X Sector index (LSB)
7+2(n+1)		*	Checksum：XOR (byte 3~6+2(n+1))
	2	ACK	

Bank or mass erase

Send	Receive	Data	Description
1		0x44	Erase
2		0xBB	Erase
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
3		0xFF	Mass erase or Bank erase index (MSB)
4		*	Mass erase (0xFF) or Bank erase (0xFE, 0xFD, 0xFC) index (LSB)
5		*	Checksum：XOR（byte 3~4）
	2	ACK	

3.8 Erase and Program Protect

This command is used to enable erase/program protection for the specified sectors.

When the device receives the command, if the access protection is not enabled, it transmits an ACK byte to the host. After the transmission of the ACK byte, it waits for one-byte length-1 (n), and then receives the index bit corresponding to the erase/program protection (n+1 bytes) ---refer to the corresponding product datasheet for more details about the bit definition --- and a checksum byte. If the checksum is correct, the device erases the user system data area (those data other than erase/program protect bytes are reserved), and writes the settings for erase/program protection, and transmits the ACK byte to the host before performing a system reset.

Note: The index bit (0, 1, 2…n) for erase/program protection corresponds to the bit (0-N) of the erase/program protection byte of the user system data area. See the corresponding product sheet for more details about the user system data area.

This command is not allowed and executed when the access protection is enabled.

3.8.1 Flowchart on host and device sides

Figure 16 Erase and Program Protect: host side

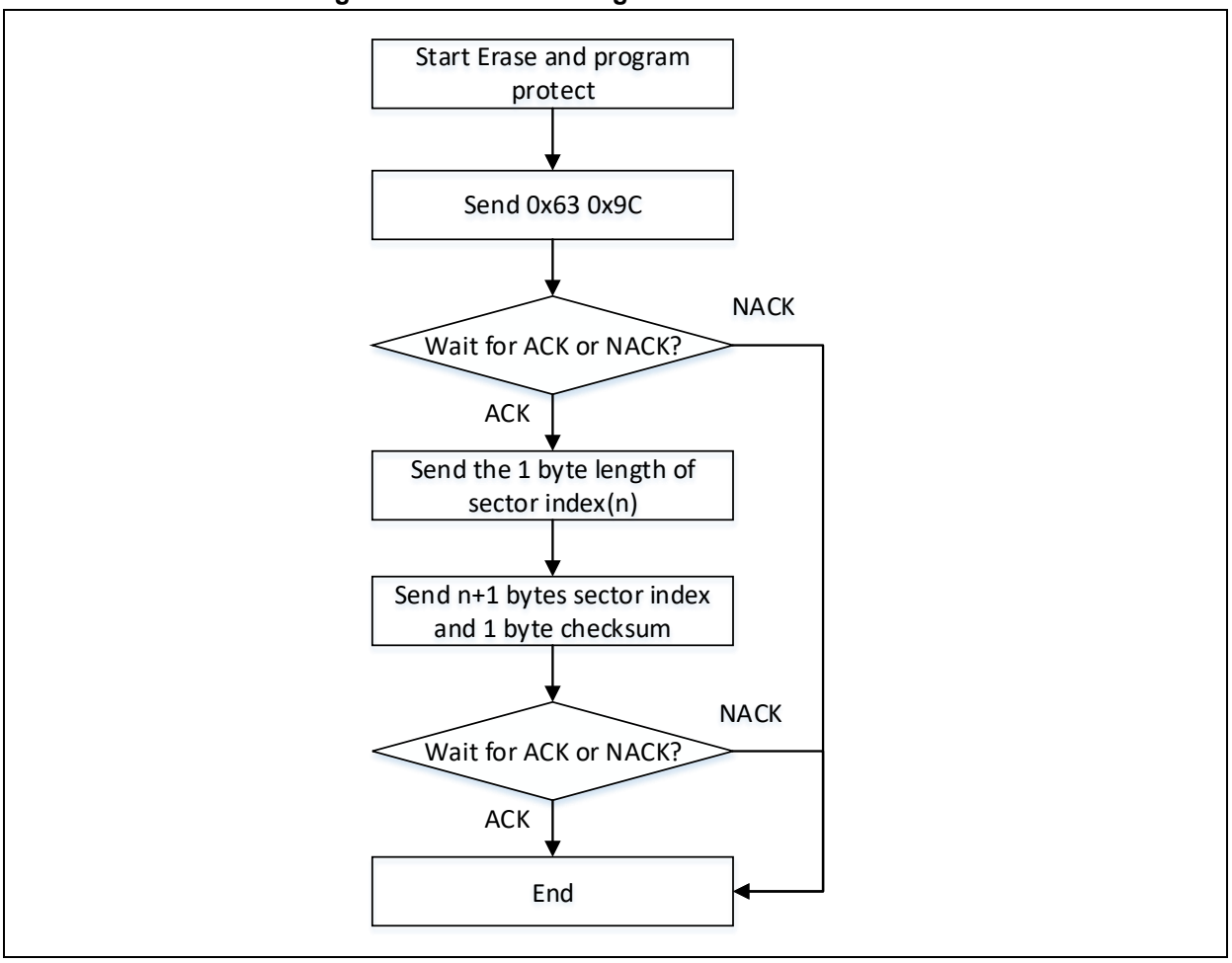
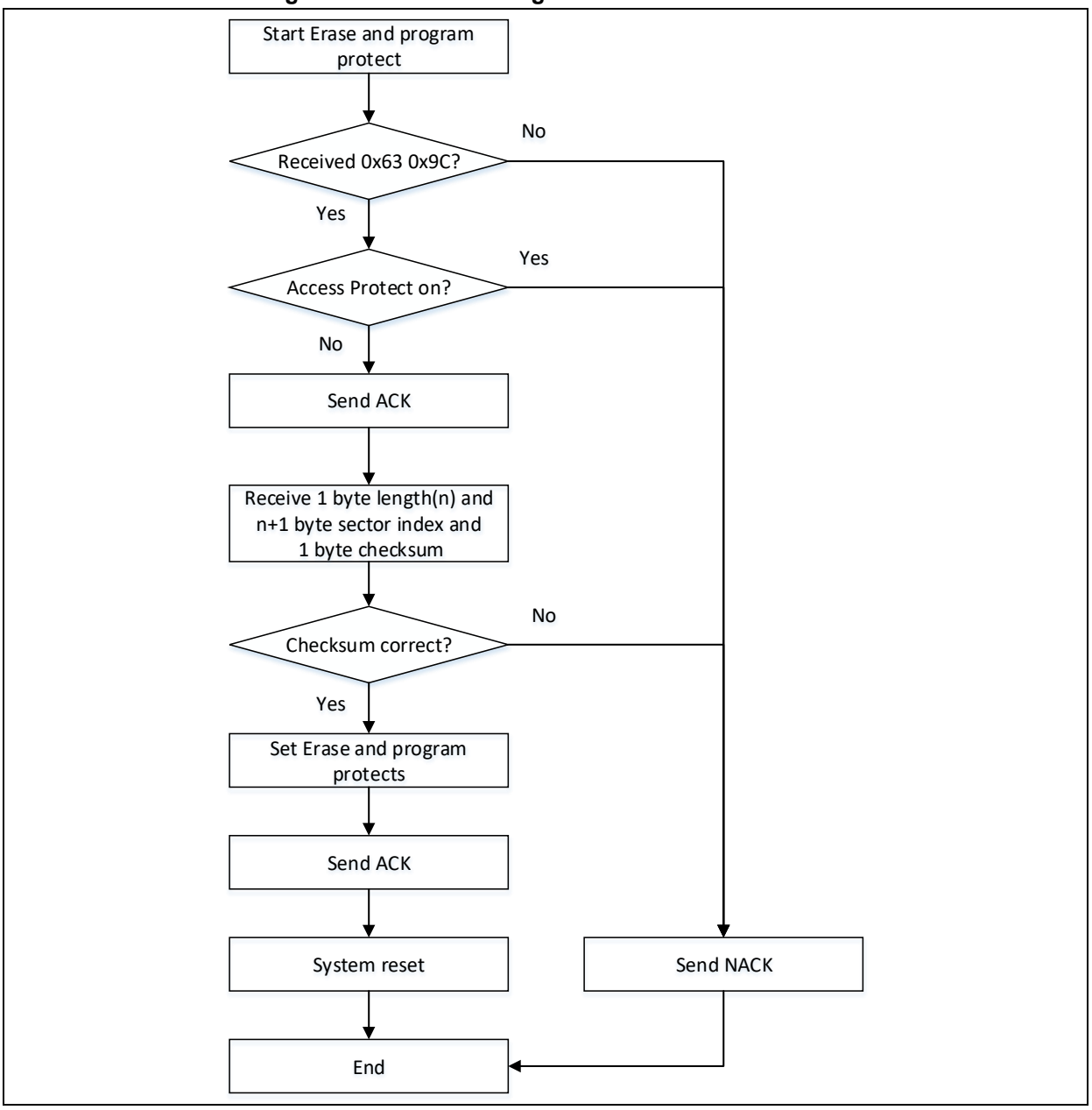


Figure 17 Erase and Program Protect: device side



3.8.2 Data transmit on host side

Send	Receive	Data	Description
1		0x63	Erase and program protect
2		0x9C	Erase and program protect
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
3		*	Protection byte--1 (n)
…		…	The index to be protected
5+n+1		*	Checksum: XOR（byte 3~4+n+1）
	2	ACK	

3.9 Erase and Program Unprotect

This command is used to disable the erase/program protection of memory.
When the device receives the command, if the access protection is not enabled, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device disables the erase/program protection of all the flash memory sectors. After the unprotect ion operation, the device transmits the ACK byte and performs a system reset.
This command is not allowed and executed when the access protection is enabled.

3.9.1 Flowchart on host and device sides

Figure 18 Erase and Program Unprotect: host side

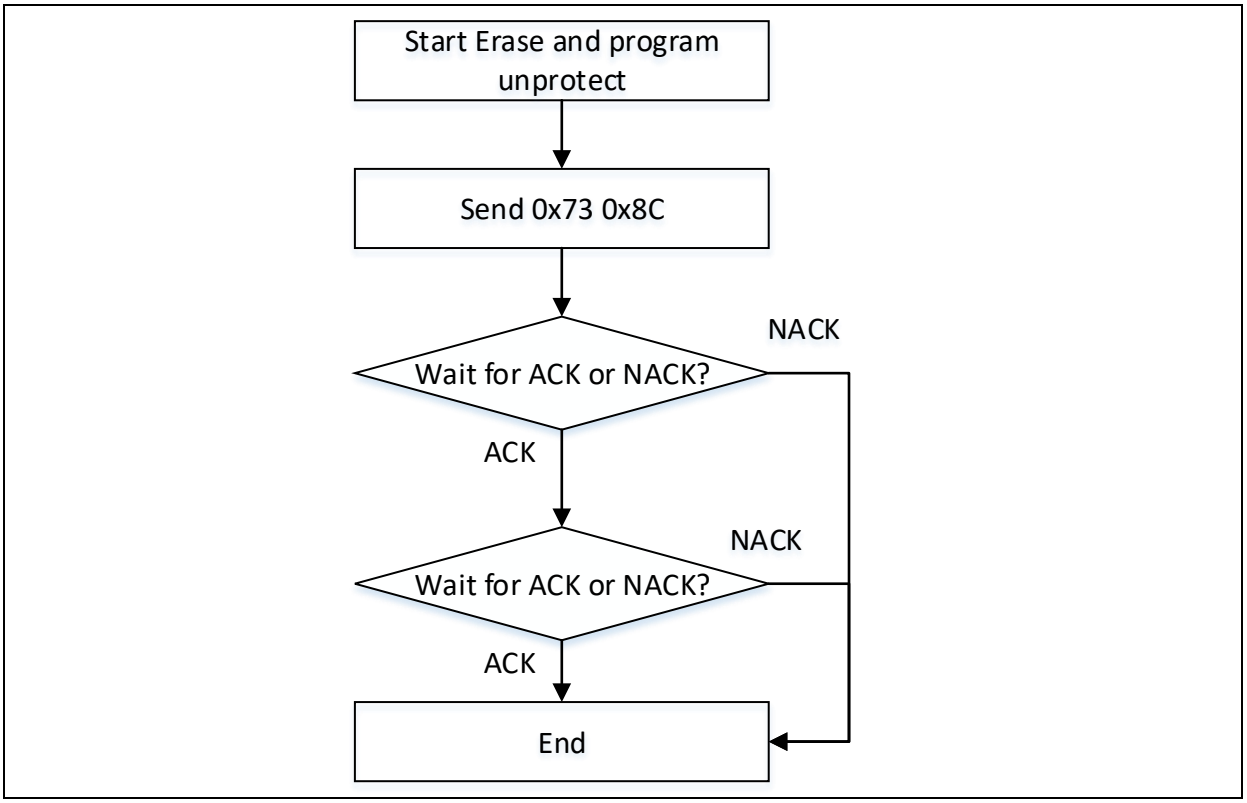
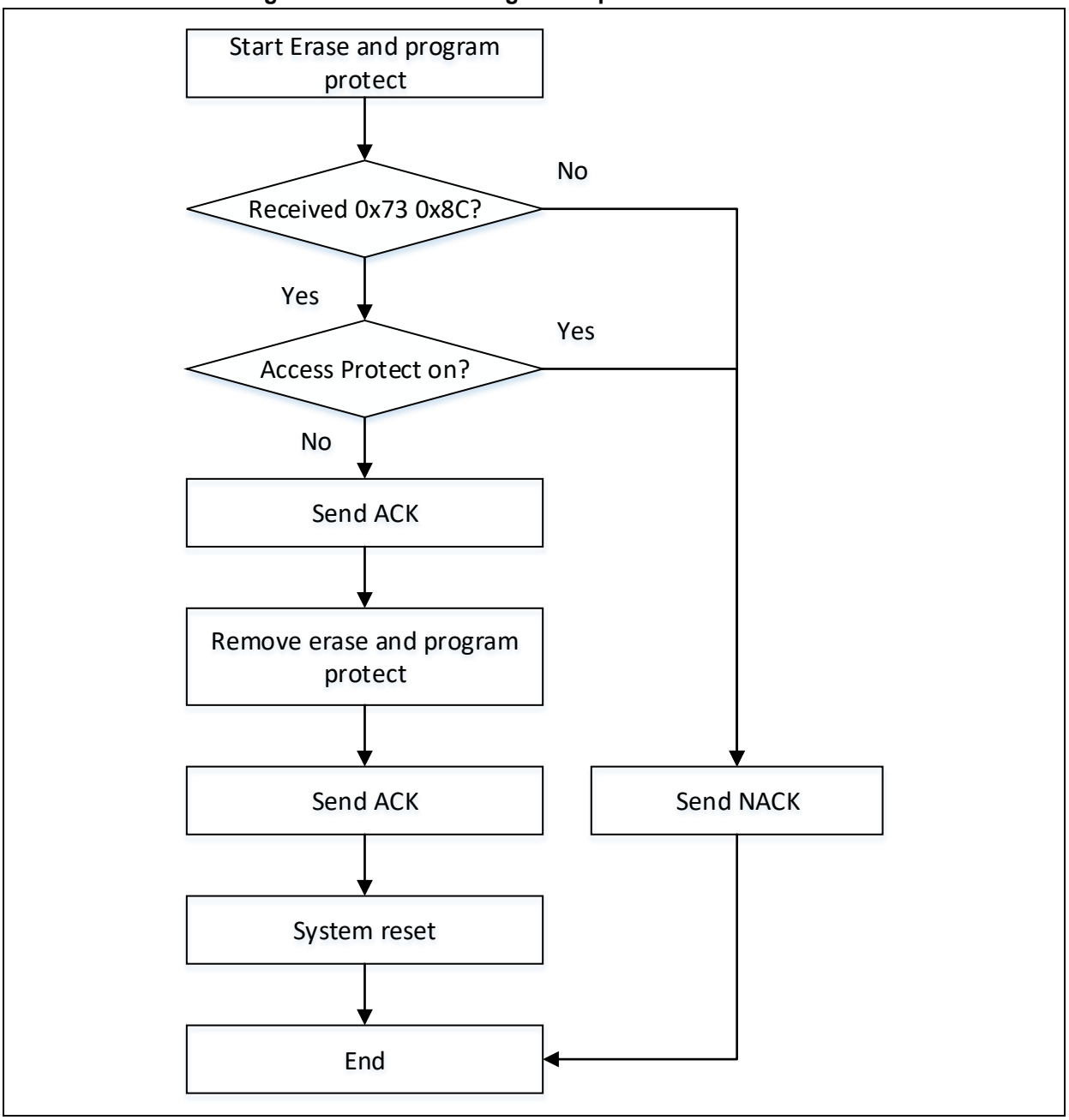


Figure 19 Erase and Program Unprotect: device side



3.9.2 Data transmit on host side

Send	Receive	Data	Description
1		0x73	Erase and program unprotect
2		0x8C	Erase and program unprotect
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
	2	ACK	

3.10 Access Protect

This command is used to enable the flash memory access protection. After this command is enabled, it is not allowed to read data from flash memory.

When the device receives the command, if the access protection is not enabled, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device enables the access protection for the flash memory. After the protection operation, the device transmits the ACK byte to the host and then performs a system reset.

This command is not allowed and executed when the access protection is enabled.

3.10.1 Flowchart on host and device sides

Figure 20 Access Protect: host side

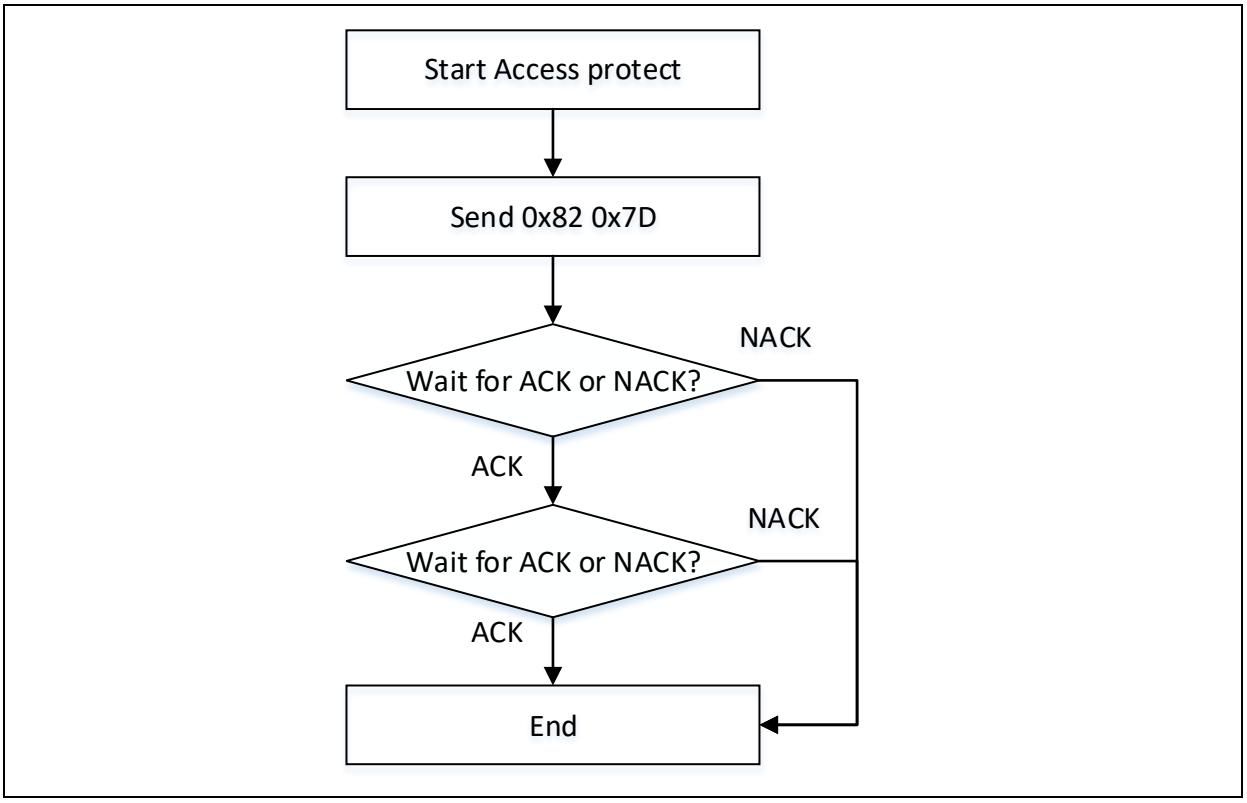
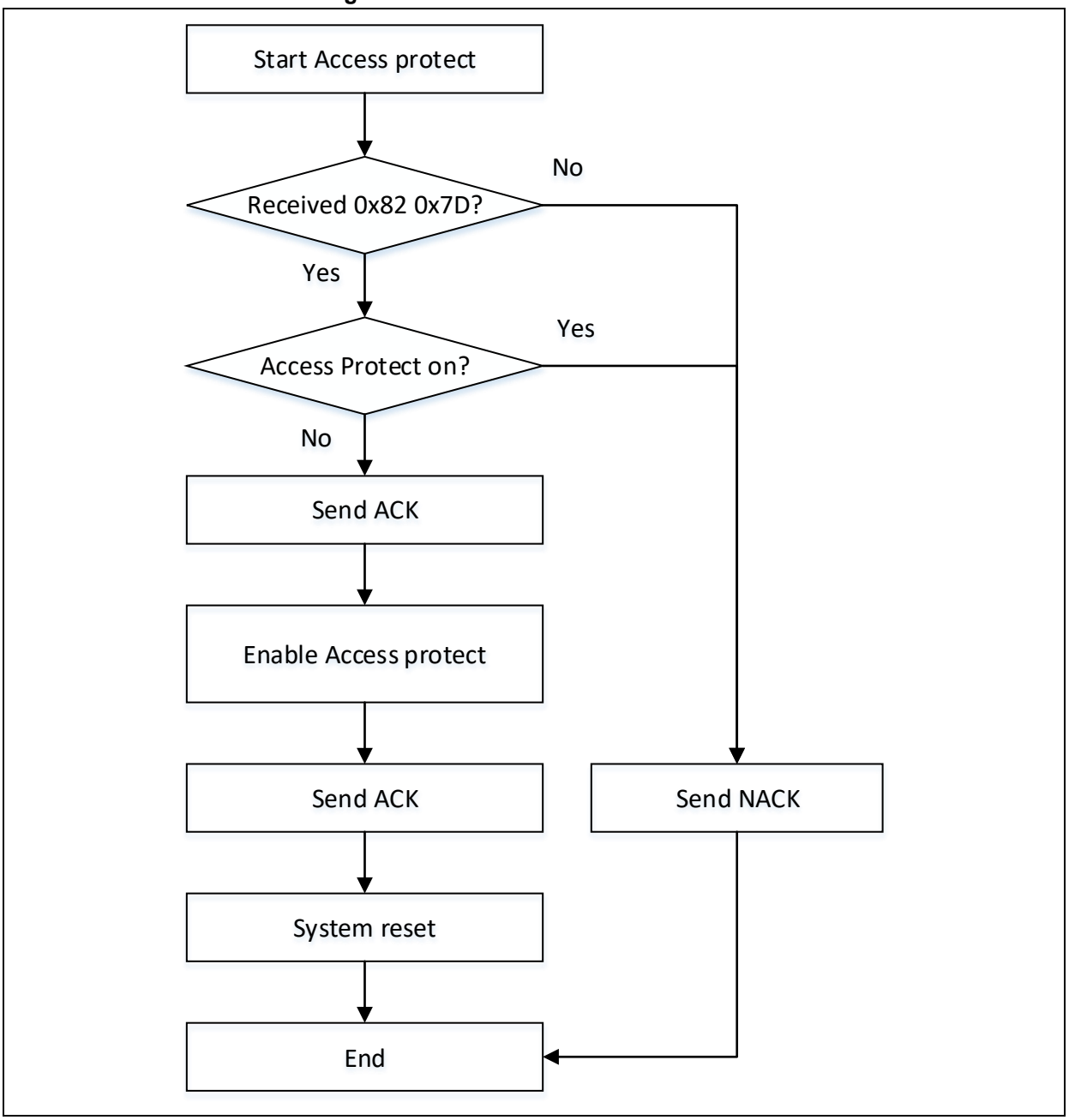


Figure 21 Access Protect: device side



3.10.2 Data transmit on host side

Send	Receive	Data	Description
1		0x82	Access protect
2		0x7D	Access protect
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
	2	ACK	

3.11 Access Unprotect

This command is used to disable the flash memory access protection. If the device is in Access protection mode, this command operation induces a mass erase of the flash memory.
When the device receives the command, it transmits the ACK byte to the host. After the transmission of the ACK byte, the devices disables the access protection of the flash memory. After the unprotect ion operation, the device transmits the ACK byte to the host and then performs a system reset.

3.11.1 Flowchart on host and device sides

Figure 22 Access Unprotect: host side

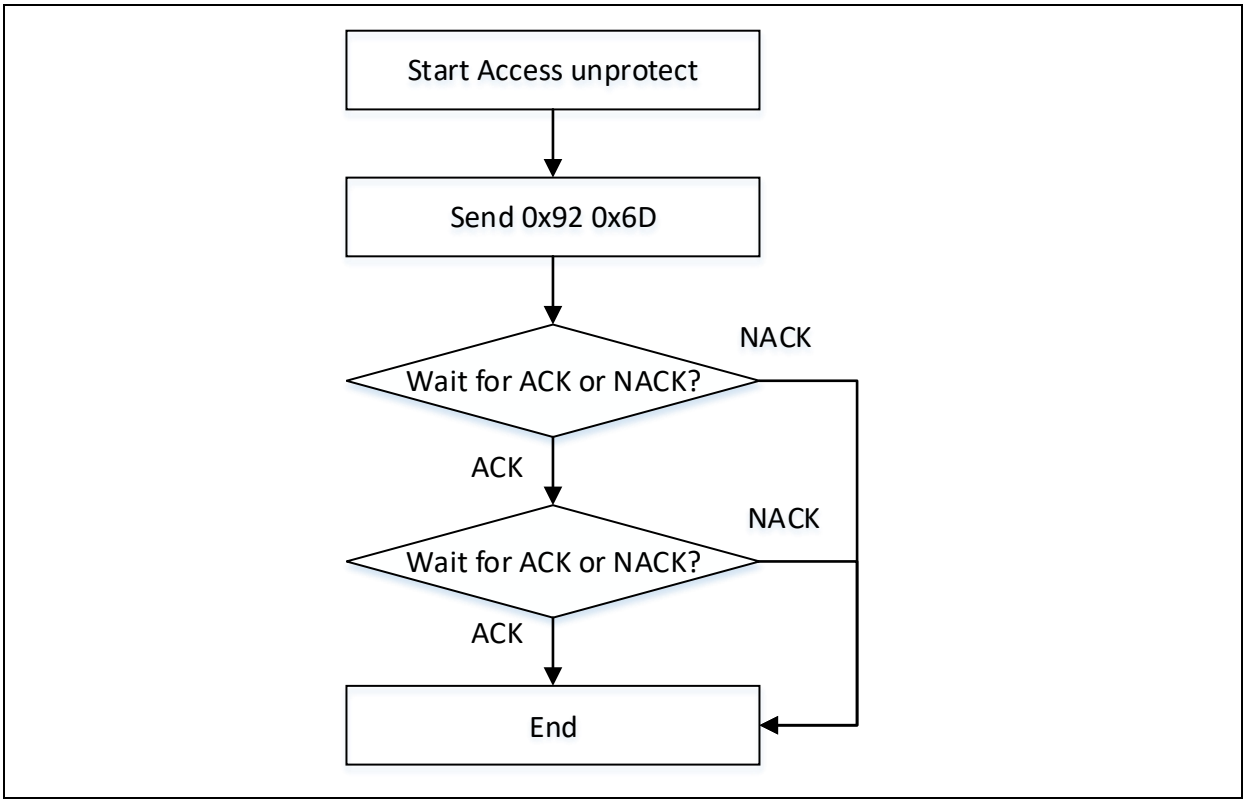
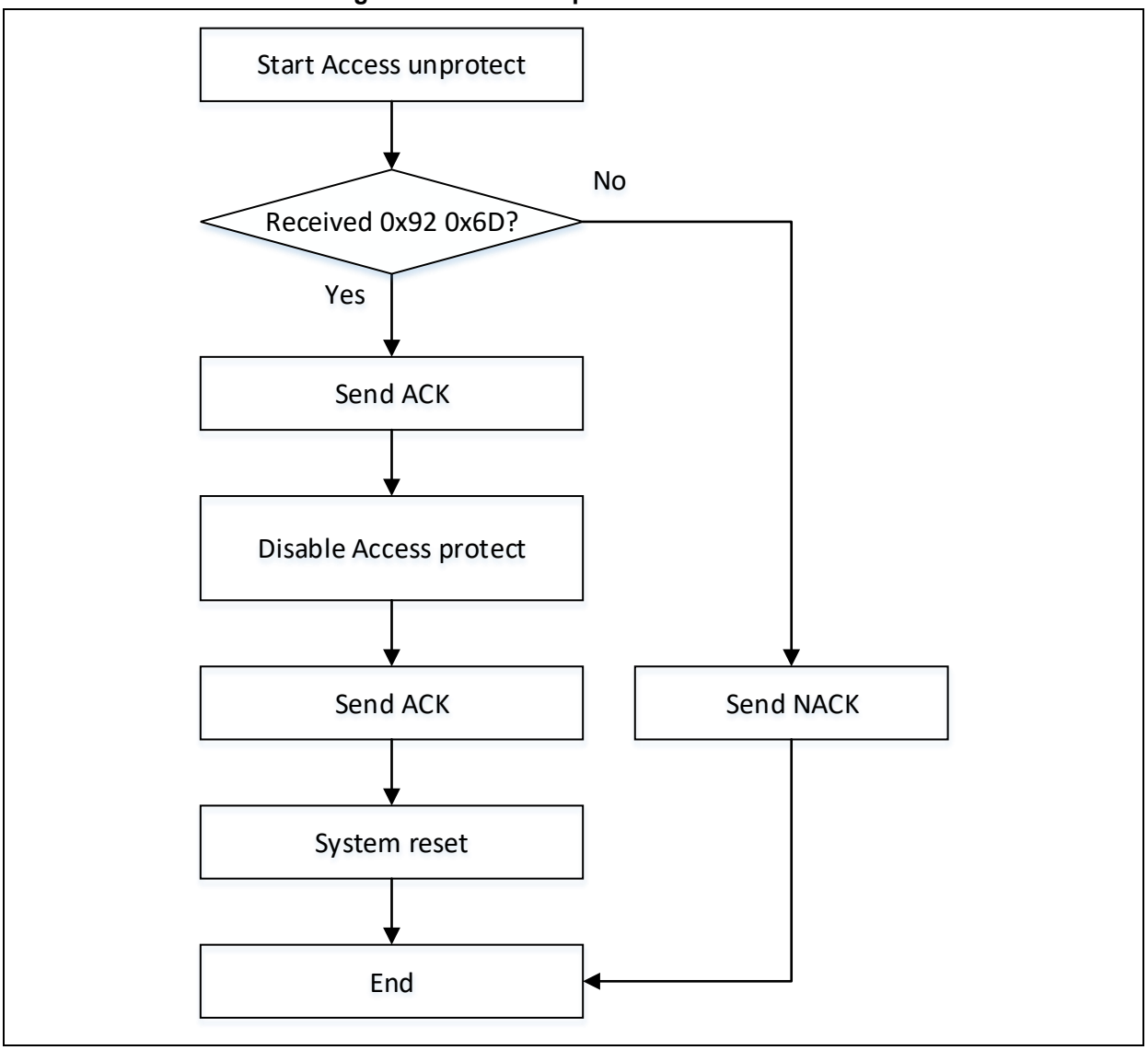


Figure 23 Access Unprotect: device side



3.11.2 Data transmit on host side

Send	Receive	Data	Description
1		0x92	Access unprotect
2		0x6D	Access unprotect
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command
	2	ACK	

3.12 Firmware CRC

This command is used to check whether memory data is correct. The memory area is specified by the host but must be expressed in sector unit and its start address must be aligned with a sector. When the device receives the command, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device waist for the start address (four bytes) and a checksum byte. If the received address and the checksum are all valid, the device transmits the ACK byte to the host. Then the device waits for the number of sectors (two bytes) to be computed -1 (n) and a checksum byte. If the checksum is correct, the device transmits an ACK byte to the host and starts computing CRC value. After the computing operation, the device sends back a four-byte CRC value to the host.

The Firmware CRC adopts the MPEG-2 CRC algorithm.

3.12.1 Flowchart on host and device sides

Figure 24 Firmware CRC: host side

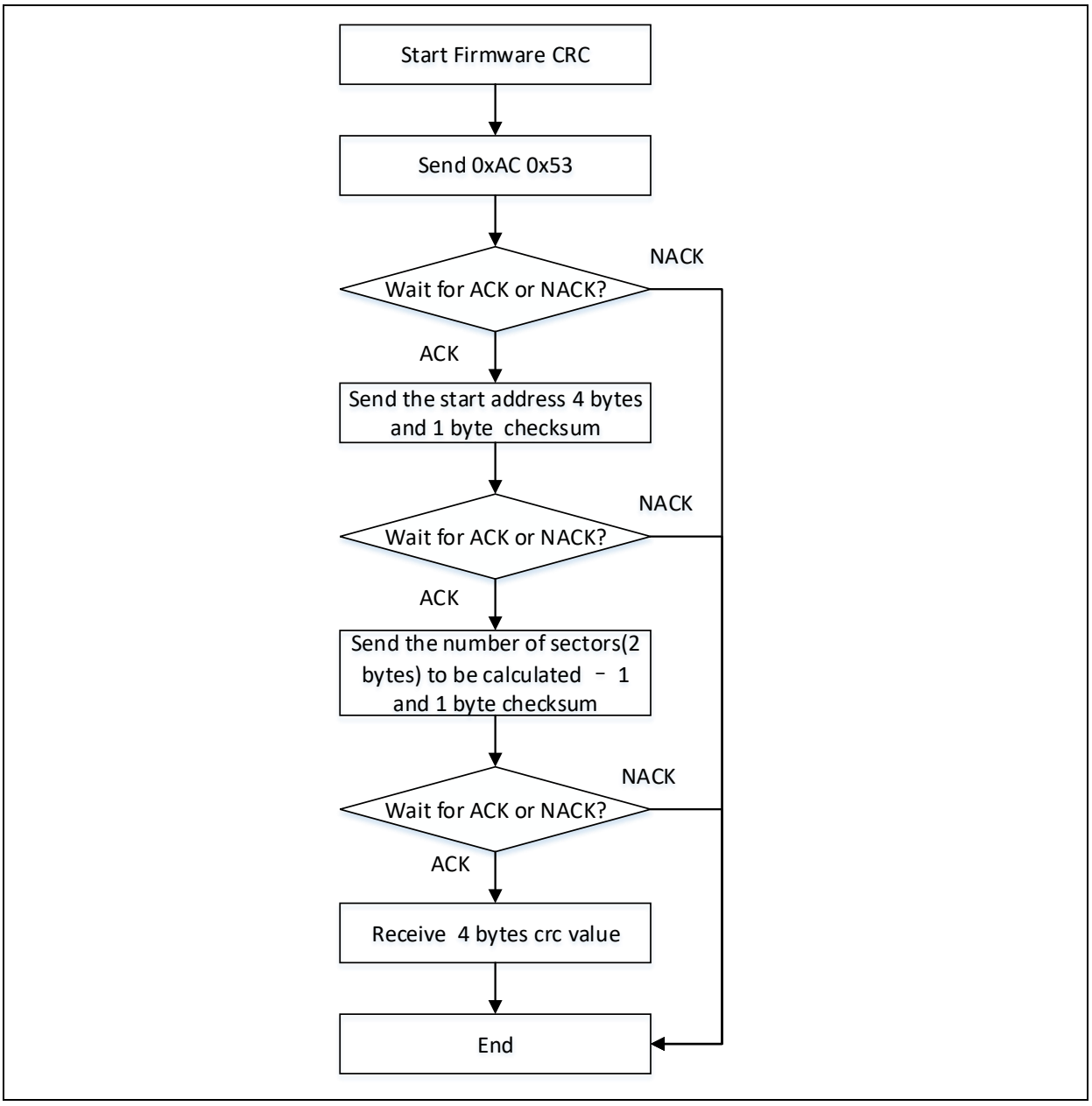
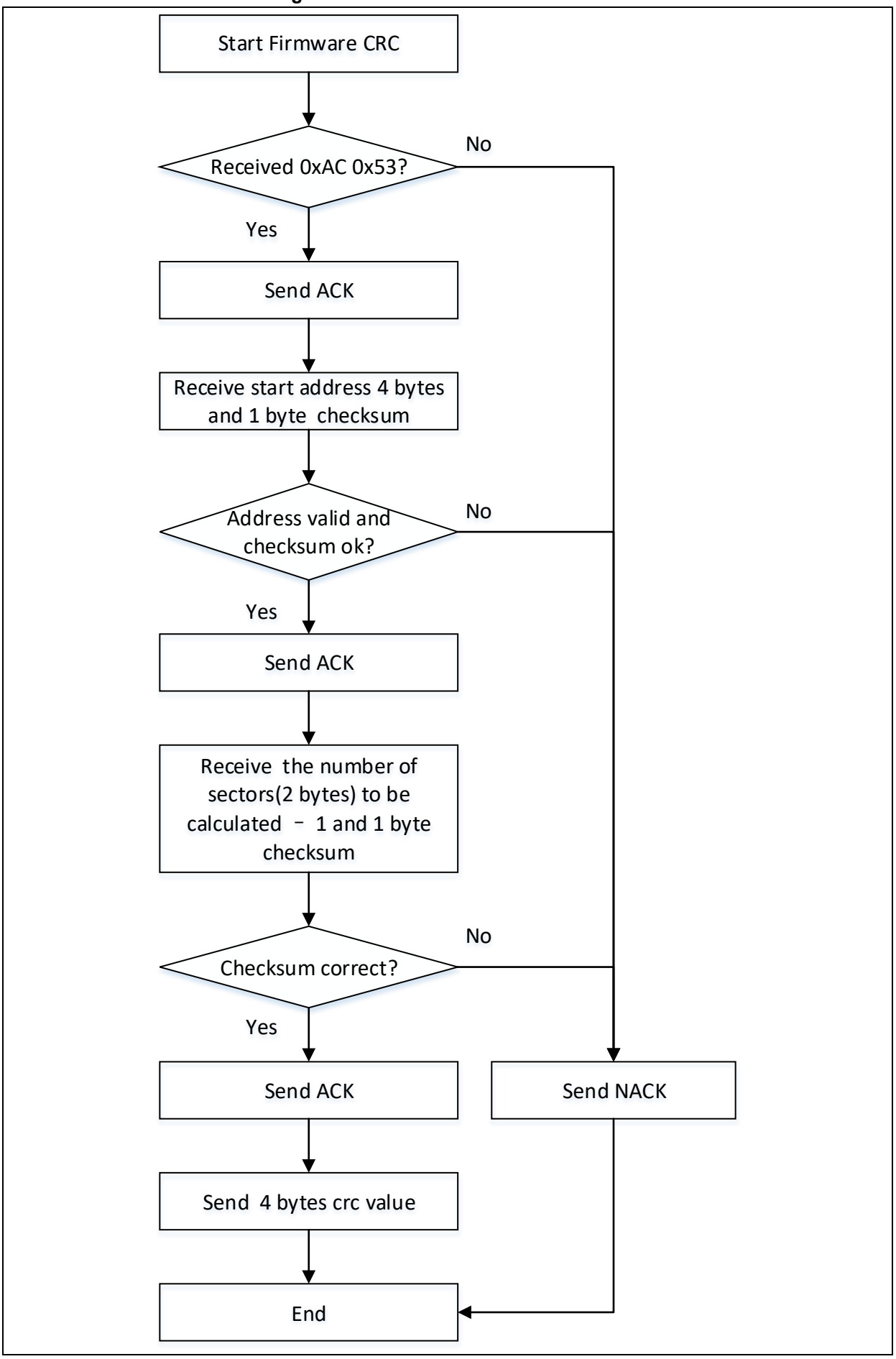


Figure 25 Firmware CRC: device side



3.12.2 Data transmit on host side

Send	Receive	Data	Description
1		0xAC	Firmware CRC
2		0x53	Firmware CRC
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
3		*	Address (MSB)
4		*	Address
5		*	Address
6		*	Address (LSB)
7		*	Checksum XOR (byte 3~6)
	2	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
8		*	Number of sectors – 1 MSB (n)
9		*	Number of sectors – 1 LSB (n)
10		*	Checksum XOR (byte 8~9)
	3	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
	4	*	CRC value (MSB)
	5	*	CRC value
	6	*	CRC value
	7	*	CRC value (LSB)

3.13 Enable sLib

This command is used to enable security library (also called sLib). Refer to the sLib use manual for more details about it.

When the device receives the command, if the access protection is not enabled, it transmits an ACK byte to the host. After the transmission of the ACK byte, the device waits for the sLib password (four bytes), sLib start sector (two bytes), sLib data/instruction start sector (two bytes), sLib end sector (two bytes) and a checksum byte. If the checksum is valid, the device configures sLib, and then returns the setting status (one byte). After this operation, the device transmits the ACK byte to the host.

Note that a system reset has to be done for the sLib settings to take into account.

This command is not allowed and executed when the access protection is enabled.

sLib state:

- 1: sLib is enabled
- 0: sLib configuration success

3.13.1 Flowchart on host and device sides

Figure 26 Enable sLib: host side

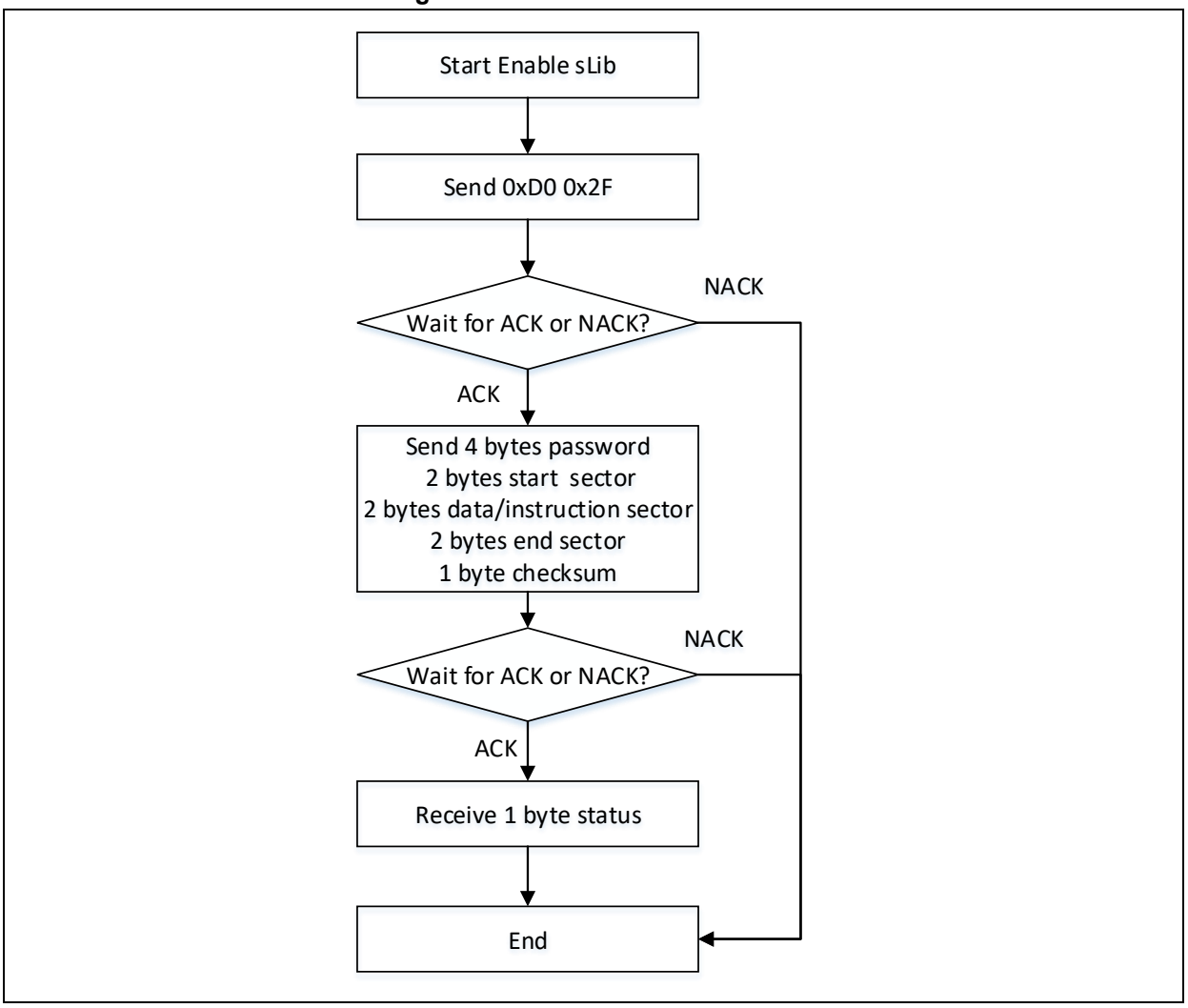
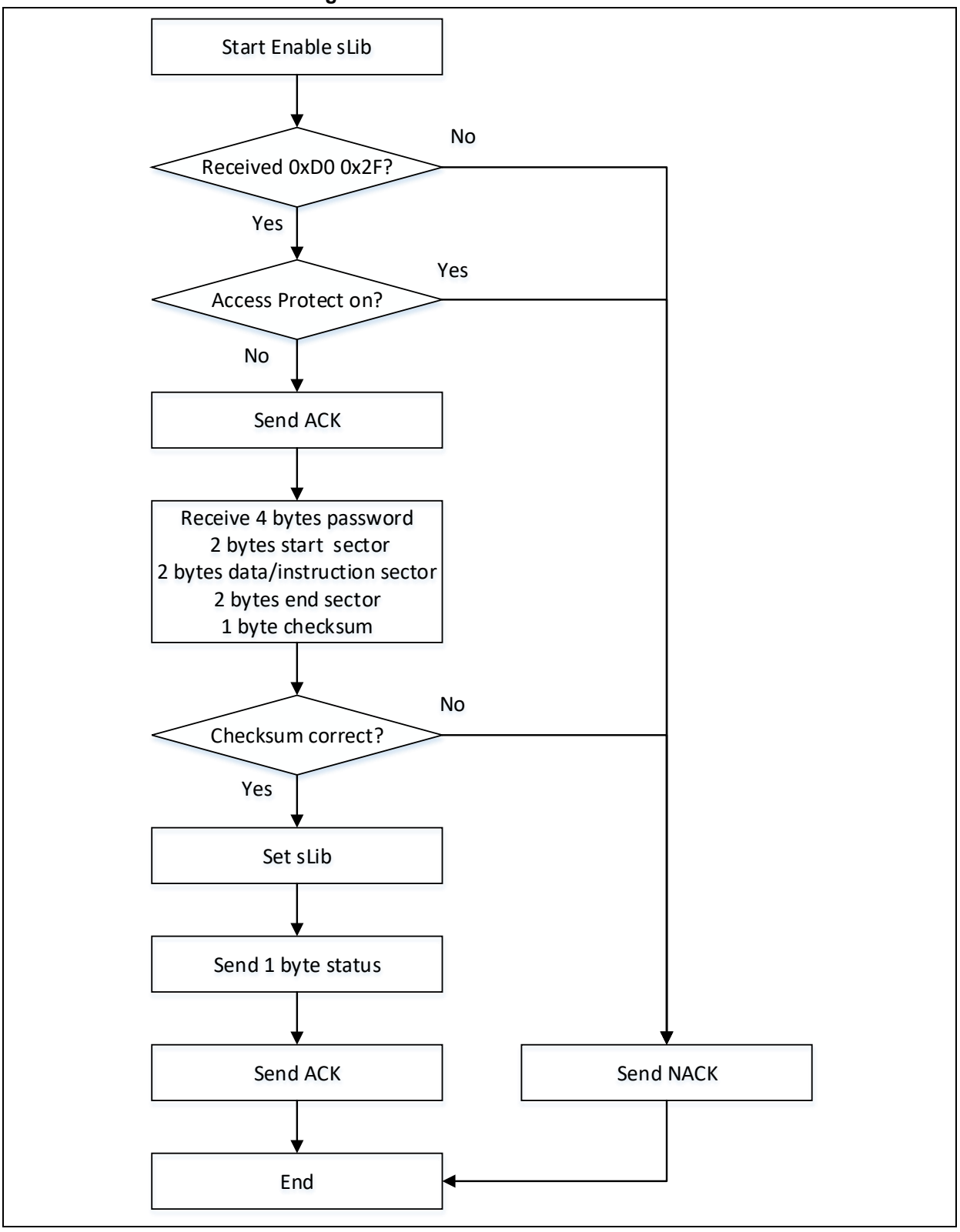


Figure 27 Enable sLib: device side



3.13.2 Data transmit on host side

Send	Receive	Data	Description
1		0xD0	Enable sLib
2		0x2F	Enable sLib
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
3		*	Password (MSB)
4		*	Password
5		*	Password
6		*	Password (LSB)
7		*	sLib start sector (MSB)
8		*	sLib start sector (LSB)
9		*	sLib data/instruction start sector (MSB)
10		*	sLib data/instruction start sector (LSB)
11		*	sLib end sector (MSB)
12		*	sLib end sector (LSB)
13		*	Checksum XOR byte (3~12)
	2	0/1	sLib configuration state
	3	ACK	

3.14 Disable sLib

This command is used to disable sLib. This operation induces mass erase of the memory.
When the device receives the command, if the access protection is not enabled, it transmits an ACK byte to the host. After the transmission of the ACK byte, the device waits for the password (four bytes) and a checksum byte. If the checksum is valid, the device erases sLib, and returns the current state (one bytes). After the operation, the device transmits the ACK byte to the host.
sLib disable state:

- 1: sLib password wrong
- 0: sLib is disabled.

This command is not allowed and executed when the access protection is enabled.

3.14.1 Flowchart on host and device sides

Figure 28 Disable sLib: host side

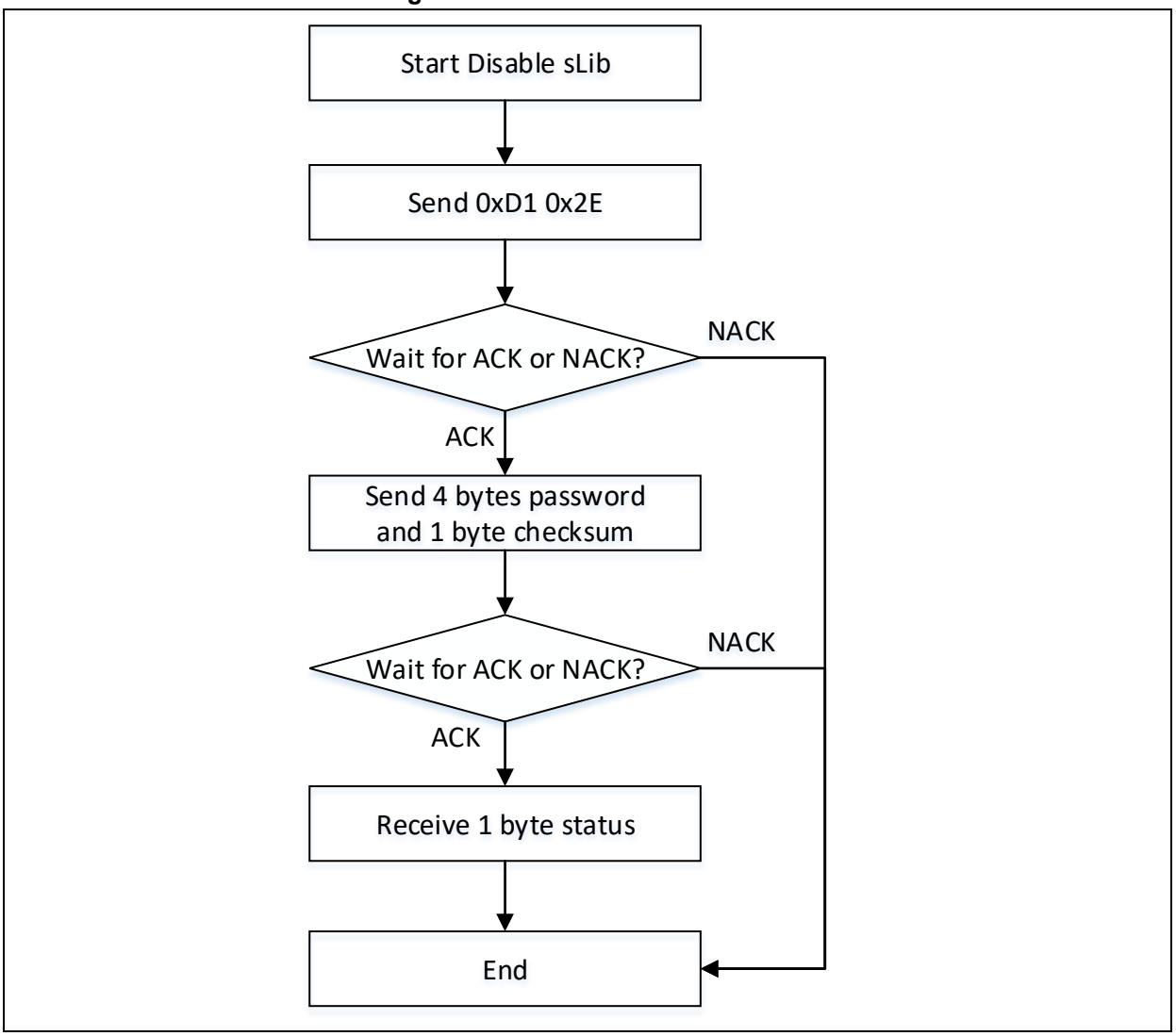
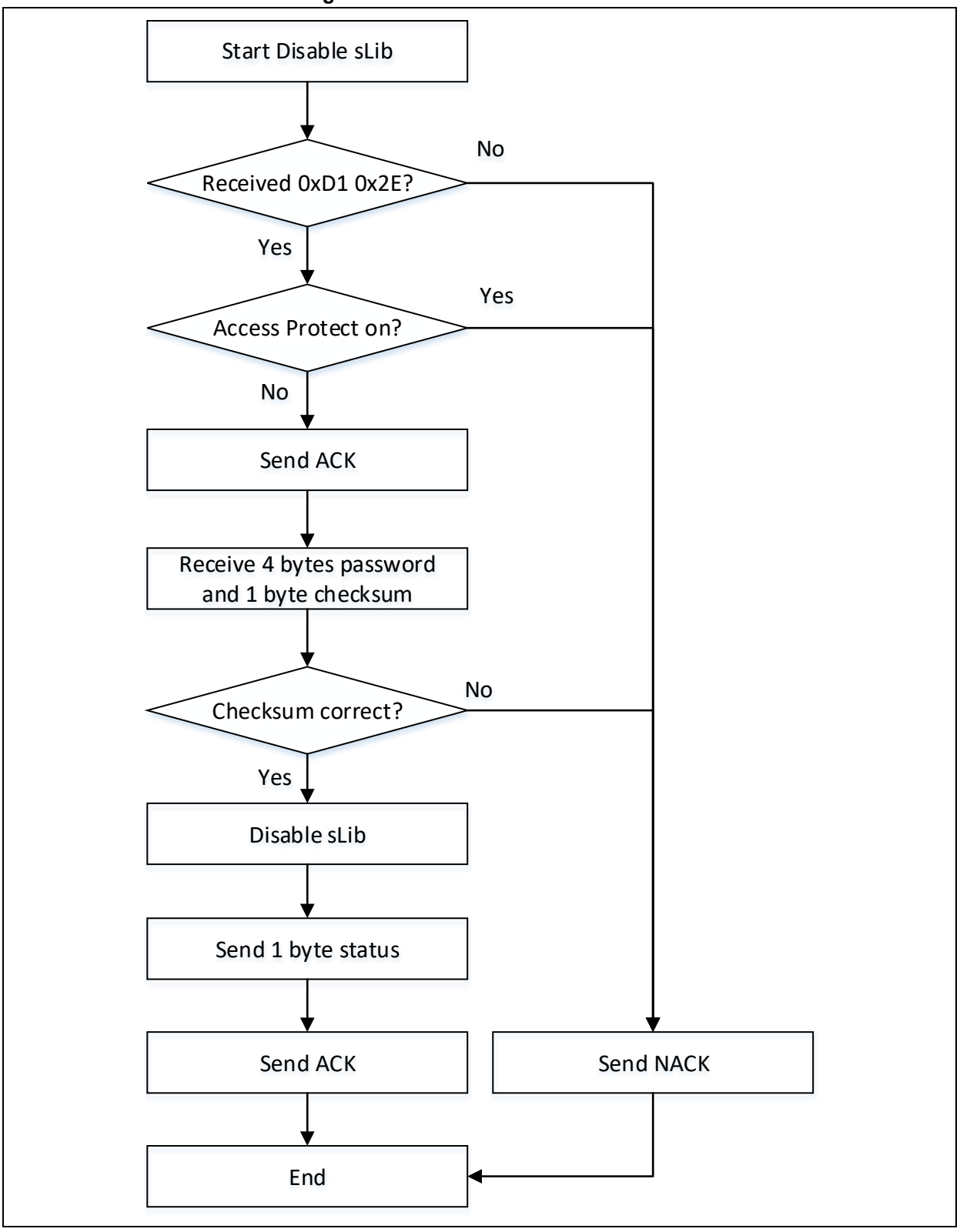


Figure 29 Disable sLib: device side



3.14.2 Data transmit on host side

Send	Receive	Data	Description
1		0xD1	Disable sLib
2		0x2E	Disable sLib
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
3		*	Password（MSB）
4		*	Password
5		*	Password
6		*	Password（LSB）
	2	0/1	sLib disable state
	3	ACK	

3.15 Get sLib status

This command is used to get the current sLib state. It returns the corresponding sLib register value. For more details about the sLib, see the corresponding product datasheet.

AT32F435xx/AT32F437xx: (send 16 bytes data)
When the device receives the command, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device sends the values of the SLIB_STS0 register (four bytes), the SLIB_STS1 register (four bytes), the SLIB_STS2 register (four bytes) and SLIB_MISC_STS register (four bytes). After the operation, the device transmits the ACK byte to the host.

Other product series (send 12 bytes data)
When the device receives the command, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device sends the values of the SLIB_STS0 register (four bytes), the SLIB_STS1 register (four bytes) and the SLIB_MISC_STS register (four bytes). After the operation, the device transmits the ACK byte to the host.

Note: For AT32F403A, AT32F407 and AT32F413 series, this command is not allowed and executed when the access protection is enabled. For other product series, this command is still active when the access protection is enabled.

3.15.1 Flowchart on host and device sides

Figure 30 Get sLib status: host side

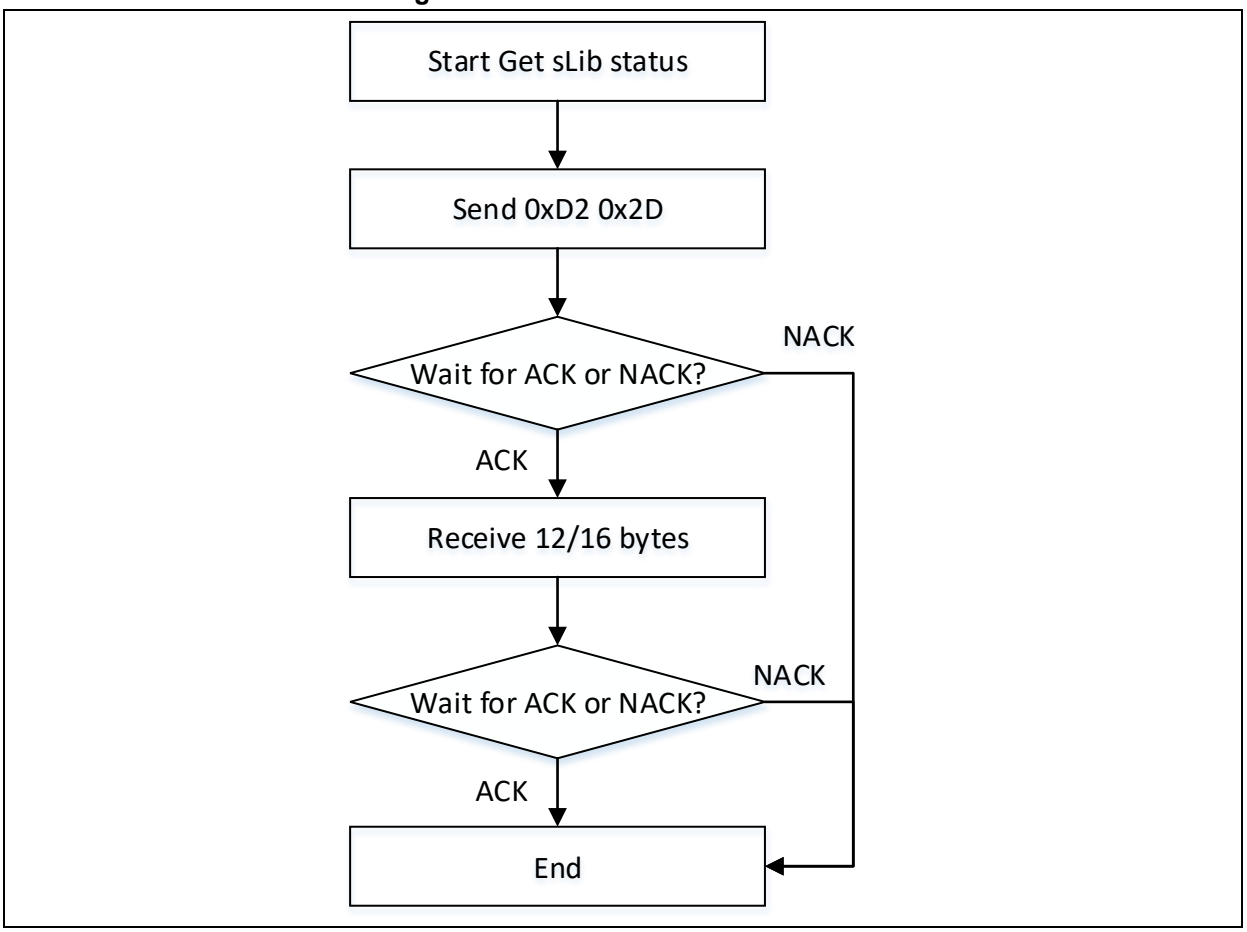
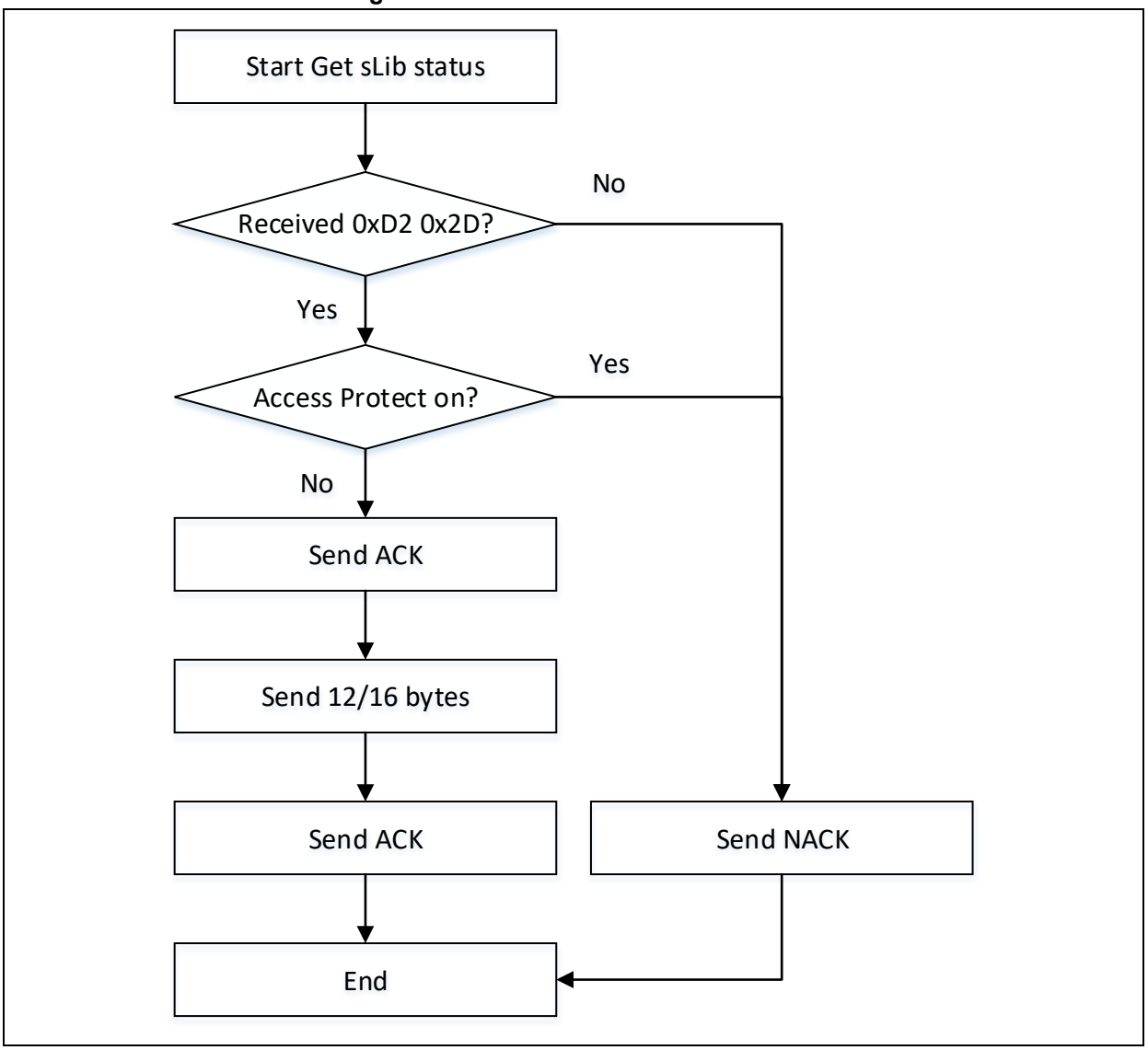


Figure 31 Get sLib status: device side



3.15.2 Data transmit on host side

AT32F435xx/AT32F437xx:

Send	Receive	Data	Description
1		0xD2	Get sLib status
2		0x2D	Get sLib status
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
	2	*	SLIB_STS0 (MSB)
	3	*	SLIB_STS0
	4	*	SLIB_STS0
	5	*	SLIB_STS0 (LSB)
	6	*	SLIB_STS1 (MSB)
	7	*	SLIB_STS1
	8	*	SLIB_STS1
	9	*	SLIB_STS1 (LSB)
	10	*	SLIB_STS2 (MSB)

Send	Receive	Data	Description
	11	*	SLIB_STS2
	12	*	SLIB_STS2
	13	*	SLIB_STS2 (LSB)
	14		SLIB_MISC_STS (MSB)
	15		SLIB_MISC_STS
	16		SLIB_MISC_STS
	17		SLIB_MISC_STS (LSB)
	18	ACK	

Other product series:

Send	Receive	Data	Description
1		0xD2	Get sLib status
2		0x2D	Get sLib status
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
	2	*	SLIB_STS0 (MSB)
	3	*	SLIB_STS0
	4	*	SLIB_STS0
	5	*	SLIB_STS0 (LSB)
	6	*	SLIB_STS1 (MSB)
	7	*	SLIB_STS1
	8	*	SLIB_STS1
	9	*	SLIB_STS1 (LSB)
	10	*	SLIB_MISC_STS (MSB)
	11	*	SLIB_MISC_STS
	12	*	SLIB_MISC_STS
	13	*	SLIB_MISC_STS (LSB)
	14	ACK	

3.16 Reset Device

This command is used to enable a system reset.

When the device receives the command, it transmits the ACK byte to the host in two times and then performs a system reset.

3.16.1 Flowchart on host and device sides

Figure 32 Reset Device: host side

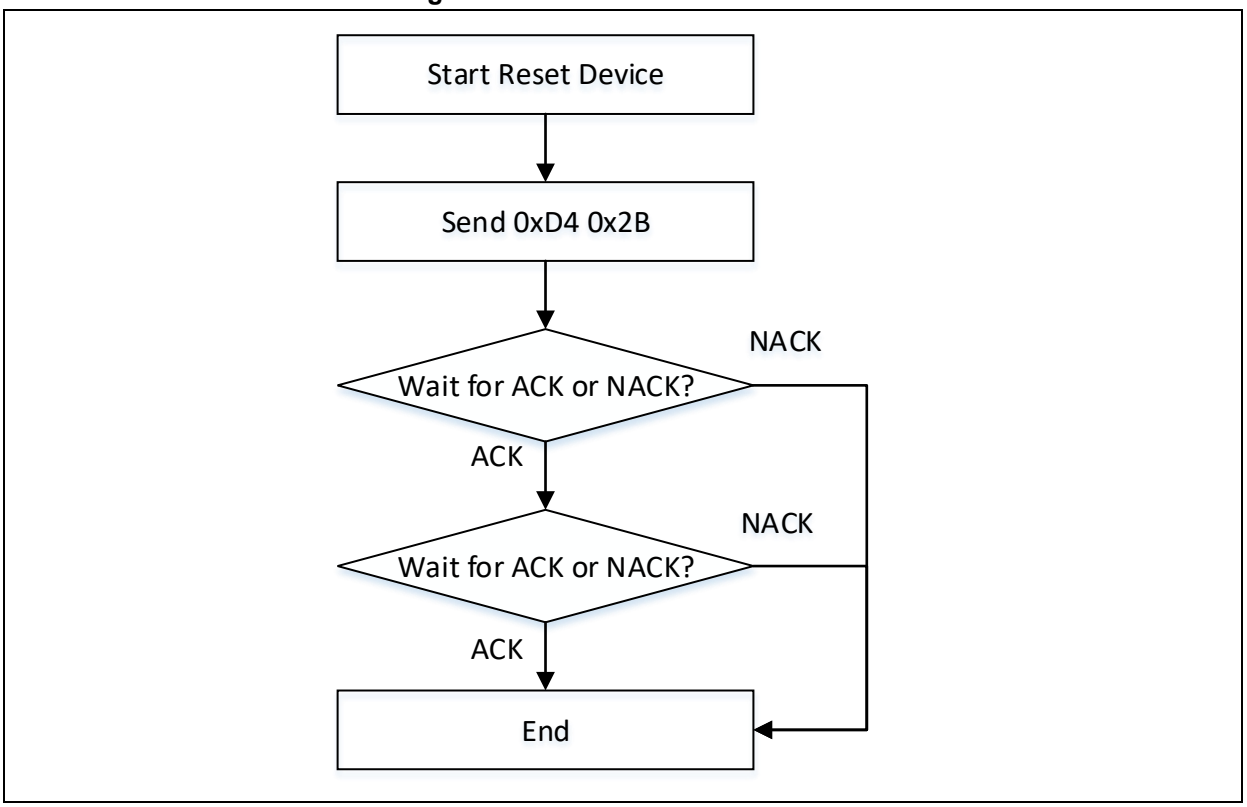
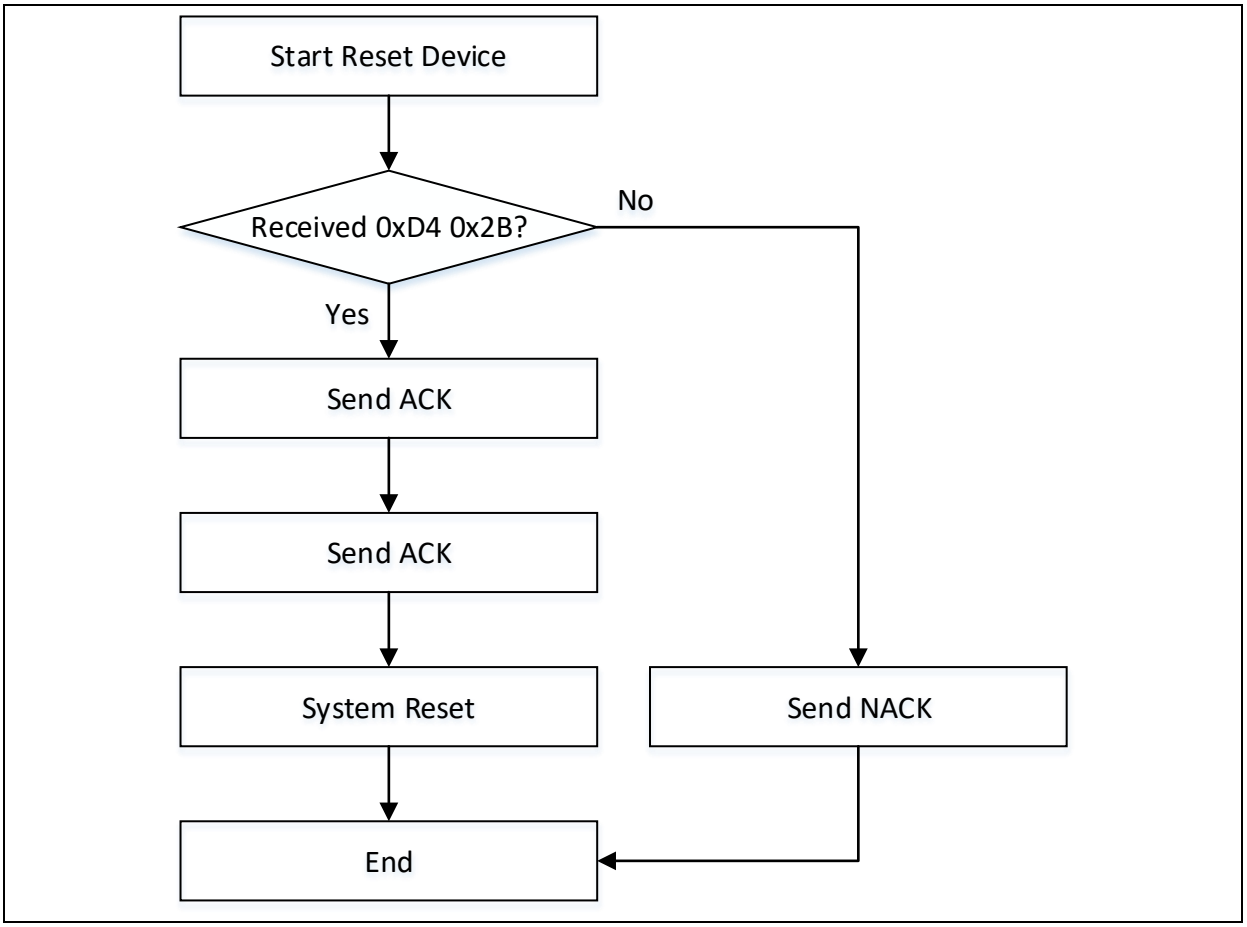


Figure 33 Reset Device: device side



3.16.2 Data transmit on host side

Send	Receive	Data	Description
1		0xD4	Reset Device
2		0x2B	Reset Device
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
	2	ACK	

3.17 Advanced Access Protect

This command is used to enable advanced access protection. Refer to the corresponding product datasheet for more details about this protection.

When the device receives the command, if the access protection is not enabled, it transmits the ACK byte to the host. After the transmission of the ACK byte, the device waits for the advanced access protection flag (two bytes, flag can be any value). Then it starts configuring the advanced access protection and transmits the ACK byte to the host before performing a system reset.

This command is not allowed and executed when the access protection is enabled.

Note: the advanced access protection cannot be disabled for some product series. For details, refer to the corresponding user manual.

3.17.1 Flowchart on host and device sides

Figure 34 Advanced Access Protect: host side

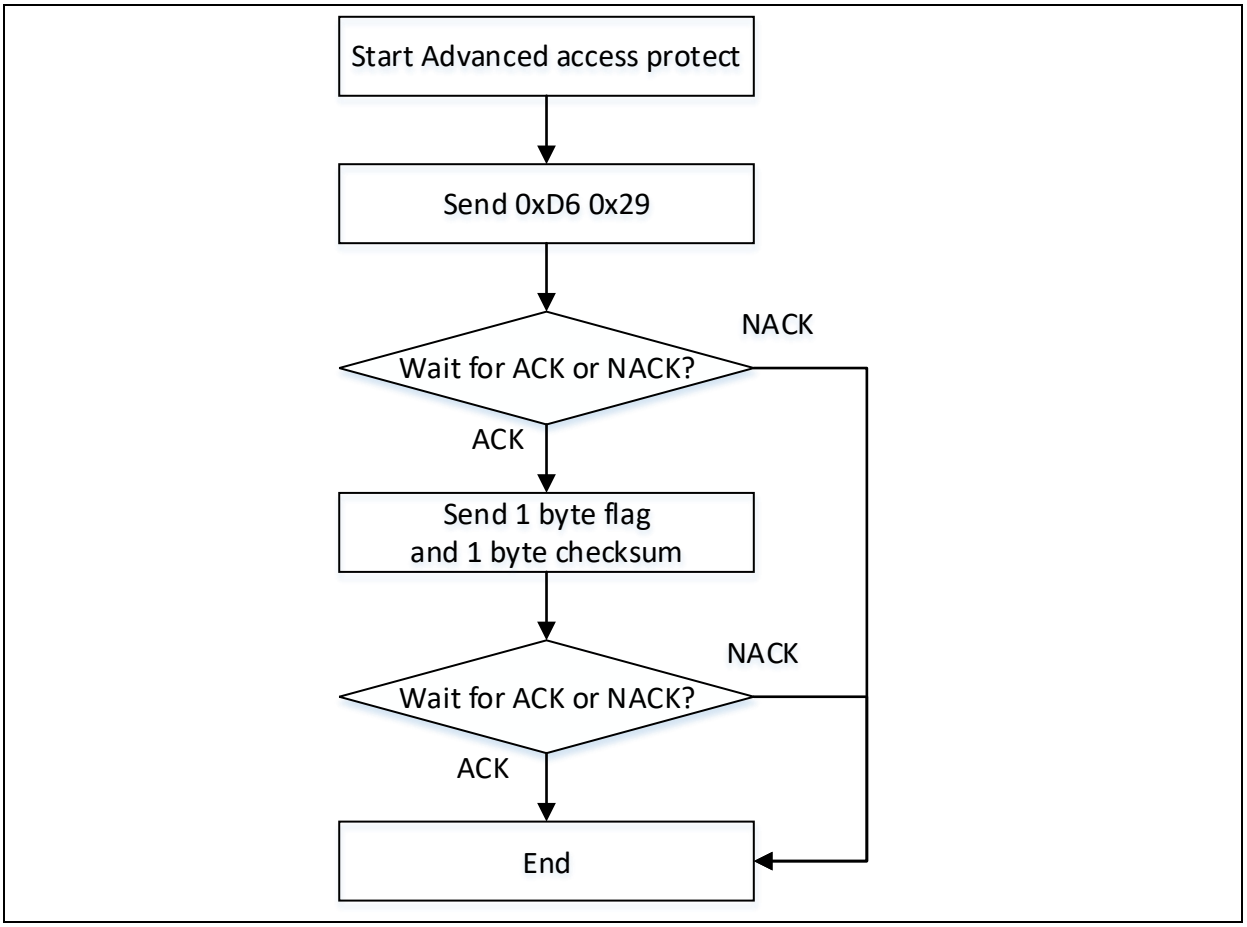
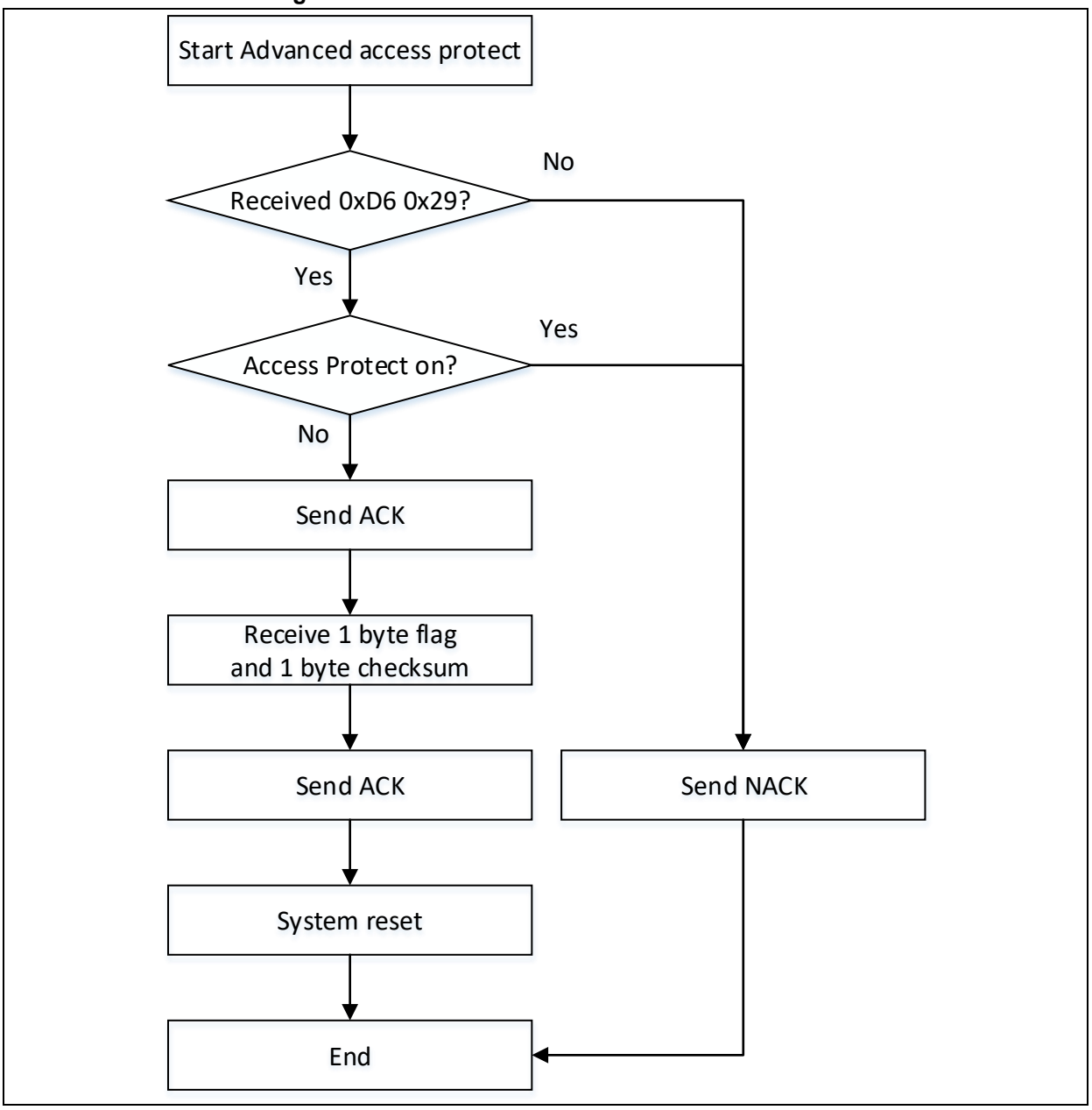


Figure 35 Advanced Access Protect: device side



3.17.2 Data transmit on host side

Send	Receive	Data	Description
1		0xD6	Advanced access protect
2		0x29	Advanced access protect
	1	ACK/NACK	When an NACK byte is received, it indicates the end of the command.
3		*	flag
4		*	Checksum XOR byte3
	2	ACK	

4 Revision history

Table 2 Document revision history

Date	Revision	Changes
2023.06.30	2.0.0	Initial release
2024.04.28	2.0.1	1. Update supported product list 2. Update supported command list

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