N9H20 NAND Loader Reference Guide

Document Information

Abstract	Introduce the steps to build and launch NAND Loader for the N9H20 series microprocessor (MPU).
Apply to	N9H20 series

Table of Contents

1 Introduction

The NAND loader is a firmware stored at the NAND Flash chip for booting purpose. It will set the system clock, initialize the relevant modules, and then load the next firmware to DRAM to execute.

The NAND loader supports the following features:

- Initialize more modules such as SPU, RTC, and so on.
- Load Logo image to DRAM if it existed at NAND Flash chip.
- Load next firmware to DRAM if it existed at NAND Flash chip.
- Execute next firmware. Normally, it should be NVT loader.

Nuvoton provides NAND loader source code within the N9H20 series microprocessor (MPU) BSP. There are three NAND loader projects, which can meet the part numbers of three different DRAM sizes.

- N9H20K5 with 32 MB DRAM
- N9H20K3 with 8 MB DRAM
- N9H20K1 with 2 MB DRAM

2 NAND Loader BSP Directory Structure

This chapter introduces the NAND loader related files and directories in the N9H20 BSP.

2.1 Loaders\NANDLoader

GCC\	The GCC project files for the NAND loader.
KEIL\	The KEIL project files for the NAND loader.
USER_DEFINE\	The sample codes supports user defined feature.
NandLoader.c	The main function for the NAND loader.
NandLoader_N9H20K5.scf	The scatter file for the N9H20K5 NAND loader
NandLoader_N9H20K3.scf	The scatter file for the N9H20K3 NAND loader
NandLoader_N9H20K1.scf	The scatter file for the N9H20K1 NAND loader
NandDrv.c	NAND Flash driver of N9H20.
Other files	System driver of N9H20.

2.2 Loaders\Binary

N9H20K5_NANDLoader_xxx.bin	The binary file of the N9H20K5 NAND loader for different project targets.
N9H20K3_NANDLoader_xxx.bin	The binary file of the N9H20K3 NAND loader for different project targets.
N9H20K1_NANDLoader_xxx.bin	The binary file of the N9H20K1 NAND loader for different project targets.

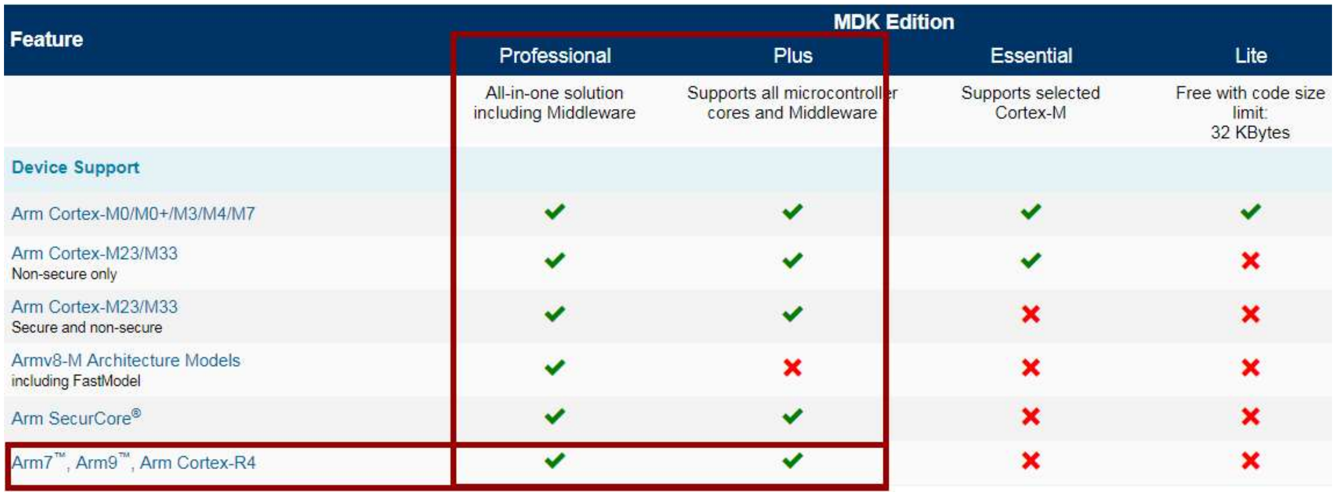
3 NAND Loader Source Code

Complete source codes are included in the *N9H20 BSP Loaders\NANDLoader* directory:

3.1 Development Environment

Keil IDE and Eclipse are used as Non-OS BSP development environment, which uses J-Link ICE or ULINK2 ICE (optional) for debugging. This document uses Keil IDE to describe the project structure. To support ARM9, MDK Plus or Professional edition shall be used.

Note that Keil IDE and ICE need to be purchased from vendor sources.



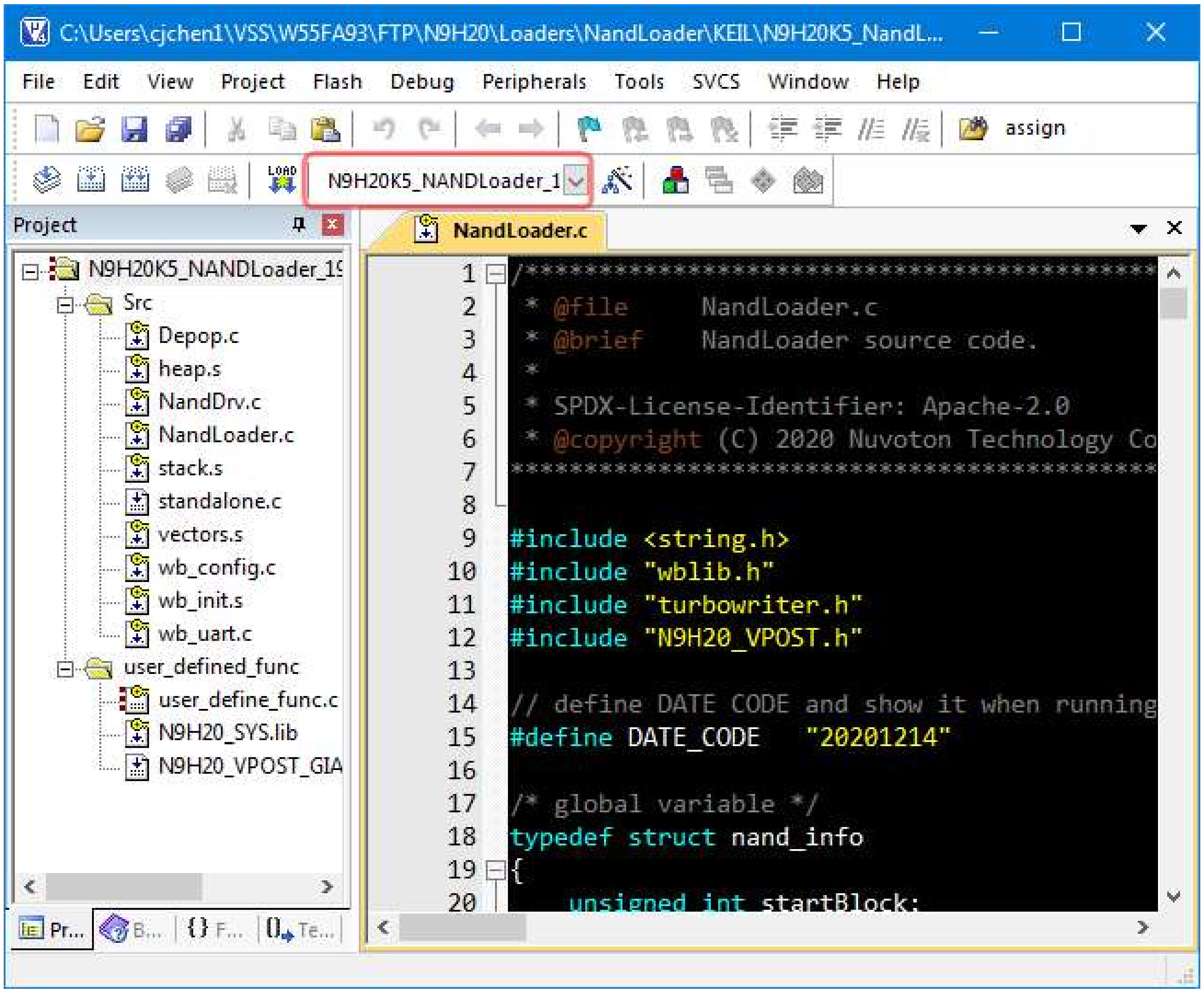
Feature	MDK Edition			
	Professional	Plus	Essential	Lite
	All-in-one solution including Middleware	Supports all microcontroller cores and Middleware	Supports selected Cortex-M	Free with code size limit: 32 KBytes
Device Support				
Arm Cortex-M0/M0+/M3/M4/M7	✓	✓	✓	✓
Arm Cortex-M23/M33 Non-secure only	✓	✓	✓	✗
Arm Cortex-M23/M33 Secure and non-secure	✓	✓	✗	✗
Armv8-M Architecture Models including FastModel	✓	✗	✗	✗
Arm SecurCore®	✓	✓	✗	✗
Arm7™, Arm9™, Arm Cortex-R4	✓	✓	✗	✗

Figure 3-1 Keil MDK License Chart

3.2 Project Structure

The NAND loader project includes one main function file and some driver files of N9H20. It doesn't link any driver library in order to shrink the binary code size.

Please note that the binary code size of the NAND loader MUST less than (page size * (page number per block - 2)) of the NAND Flash chip on board.



```
/*****************************************************
 * @file      NandLoader.c
 * @brief     NandLoader source code.
 *
 * SPDX-License-Identifier: Apache-2.0
 * @copyright (C) 2020 Nuvoton Technology Co
*****************************************************

#include <string.h>
#include "wblib.h"
#include "turbowriter.h"
#include "N9H20_VPOST.h"

// define DATE CODE and show it when running
#define DATE_CODE    "20201214"

/* global variable */
typedef struct nand_info
{
    unsigned int startBlock;
```

Figure 3-2 NAND Loader Project Tree on Keil MDK

The NAND loader project includes some targets that can be used in different situations.

- **N9H20K5_NANDLoader_192MHz**: Set system core clock to 192MHz. This is the official standard target.
- **N9H20K5_NANDLoader_192MHz_Logo**: Set system core clock to 192MHz and support user defined feature. Please refer to section 3.5 for further information.
- **N9H20K5_NANDLoader_120MHz**: Set system core clock to 120MHz.
- **N9H20K5_NANDLoader_96MHz**: Set system core clock to 96MHz.

3.3 System Initialization

The system initialization code is located in main function, including system code clock setting, SPU setting, and UART debug port setting. It also initializes some necessary peripherals during the boot process.

```
int main()
{
    NVT_NAND_INFO_T image;
    int count, i;

    /* Clear Boot Code Header in SRAM to avoid booting fail issue */
    outp32(0xFF000000, 0);

    spuDacOn(2);
    /* PLL clock setting */
    initClock();

    uart.uiFreq = sysGetExternalClock()*1000;       /*Use external clock*/
    uart.uiBaudrate = 115200;
    uart.uiDataBits = WB_DATA_BITS_8;
    uart.uiStopBits = WB_STOP_BITS_1;
    uart.uiParity = WB_PARITY_NONE;
    uart.uiRxTriggerLevel = LEVEL_1_BYTE;
    sysInitializeUART(&uart);
    sysprintf("N9H20 Nand Boot Loader entry (%s).\n", DATE_CODE);

    sysGetSystemClock(&eSrcClk, &u32PllKHz, &u32SysKHz, &u32CpuKHz, &u32HclkKHz,
&u32ApbKHz);
    sysprintf("System clock = %dKHz\nAHB clock = %dKHz\nREG_SDTIME = 0x%08X\n",
               u32SysKHz, u32HclkKHz, inp32(REG_SDTIME));

     /* Omit some source code in document. */
}
```

3.4 NAND Flash Initialization

One of the major tasks of the NAND loader is to copy the next firmware on the NAND Flash to DRAM for execution. To initialize the NAND Flash driver, both fmiInitDevice() and sicSMInit() must be called in source code.

```
    /* Initial DMAC and NAND interface */
    fmiInitDevice();
    sicSMInit();
    memset((char *)&image, 0, sizeof(NVT_NAND_INFO_T));
    /* read physical block 0 - image information */
    for (i=0; i<4; i++)
    {
        if (!sicSMpread(0, i, pSM0->uPagePerBlock-2, imagebuf))
        {
            if (((*(pImageList+0)) == 0x574255aa) && ((*(pImageList+3)) == 0x57425963))
            {
                sysprintf("Get image information from block 0x%x ..\n", i);
                break;
            }
        }
    }
```

3.5 User Defined Feature

The NAND loader allows the user to execute user defined functions before the NAND loader executes the next firmware. For example, the NAND loader can display a Logo on the LCD panel as soon as possible after booting.

Please select project target "**N9H20K5_NANDLoader_192MHz_Logo**" to enable this feature.

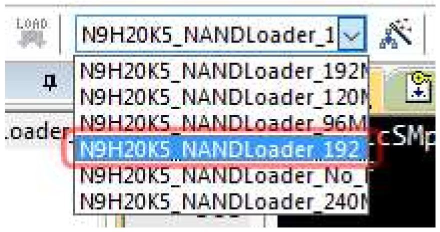
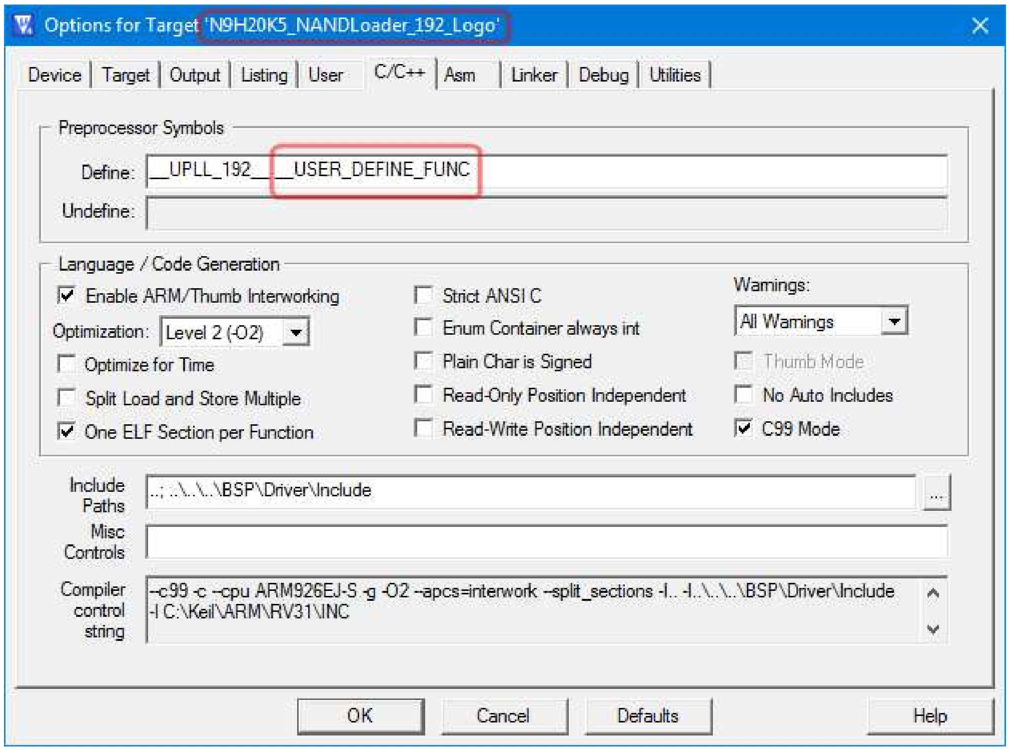


Figure 3-3 The NAND loader project target for user defined feature


Options for Target 'N9H20K5_NANDLoader_192_Logo'

Preprocessor Symbols
Define: __UPLL_192__ __USER_DEFINE_FUNC
Undefine:

Language / Code Generation
[✓] Enable ARM/Thumb Interworking
Optimization: Level 2 (-O2)
[ ] Optimize for Time
[ ] Split Load and Store Multiple
[✓] One ELF Section per Function
[ ] Strict ANSI C
[ ] Enum Container always int
[ ] Plain Char is Signed
[ ] Read-Only Position Independent
[ ] Read-Write Position Independent
Warnings: All Warnings
[ ] Thumb Mode
[ ] No Auto Includes
[✓] C99 Mode

Include Paths: ..; ..\..\..\BSP\Driver\Include
Misc Controls:
Compiler control string:

```
--c99 -c --cpu ARM926EJ-S -g -O2 --apcs=interwork --split_sections -I.. -I..\..\..\BSP\Driver\Include
-I C:\Keil\ARM\RV31\INC
```

Figure 3-4 The NAND loader project definition for user defined feature

Within main() function, the **user_define_func()** is called to execute user defined function before load next firmware.

```
#ifdef __USER_DEFINE_FUNC
        //--- call user define function before jump to next application.
        user_define_func();
#endif

        /* load execution file */
        pImageList = pImageList+4;
        for (i=0; i<count; i++)
        {
            if (((*(pImageList) >> 16) & 0xffff) == 1)  // execute
            {
                image.startBlock = *(pImageList + 1) & 0xffff;
                image.endBlock = (*(pImageList + 1) & 0xffff0000) >> 16;
                image.executeAddr = *(pImageList + 2);
                image.fileLen = *(pImageList + 3);
                MoveData(&image, TRUE);
                break;
            }
            /* pointer to next image */
            pImageList = pImageList+12;
        }
```

Within source code file *NANDLoader\USER_DEFINE\user_define_func.c*, the function user_define_func() can be implemented to do the user defined function.

```
#ifdef __USER_DEFINE_FUNC
#include "user_define_func.h"

/*-----------------------------------------------------------------------------------*/
/* The entry point of User Define Function that called by NandLoader.                */
/*-----------------------------------------------------------------------------------*/
void user_define_func()
{
    /* Do something here for user defined function */
}

#else

/*-----------------------------------------------------------------------------------*/
/* The entry point of User Define Function that called by NandLoader.                */
/*-----------------------------------------------------------------------------------*/
void user_define_func()
{
    //--- Keep empty if user define nothing for User Define Function.
}

#endif  // end of #ifdef __USER_DEFINE_FUNC
```

3.6 Build NAND Loader Project

Normally, the NAND loader doesn't need to modify. If the NAND loader is modified, clicking the **Rebuild** icon as shown below or press **F7** function key to rebuilt it in Keil MDK.

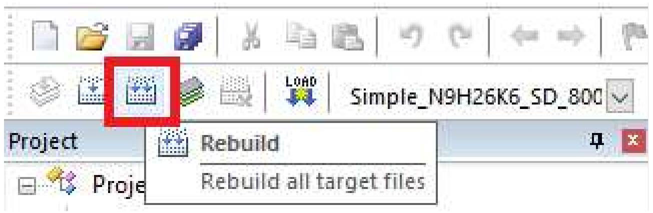


Figure 3-5 Shortcut Icon to Rebuild the NAND Loader on Keil MDK

The binary file of NAND loader will be copied to the *Loaders\Binary* folder with the file name *N9H20K5_NANDLoader_xxx.bin*. The “*xxx*” is depend on the project target. For the **N9H20K5_NANDLoader_192MHz** project target, the binay file name is *N9H20K5_NANDLoader_192MHz.bin*.

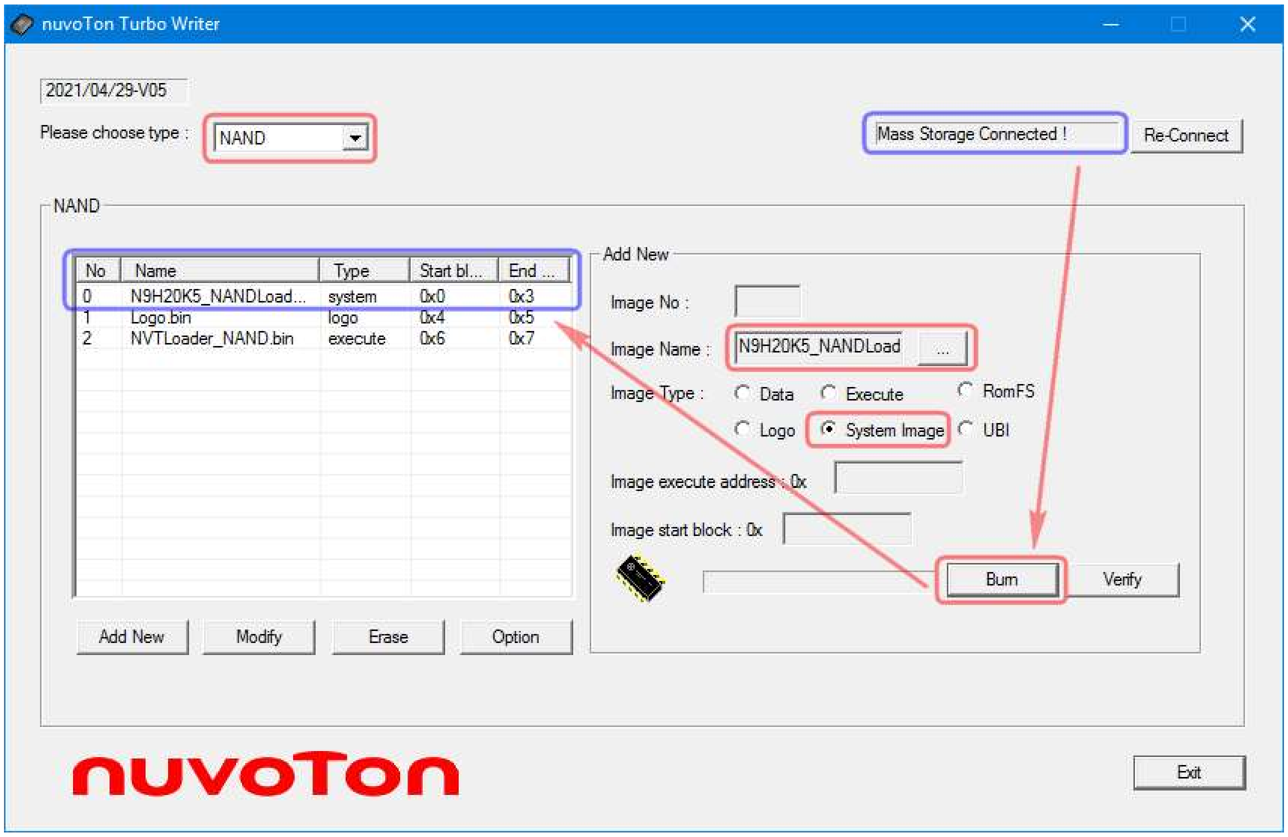
Please note that the binary code size of the NAND loader MUST less than (page size * (page number per block - 2)) of the NAND Flash chip on board.

4 Download and Run

4.1 Download NAND Loader Binary to NAND Flash

The NAND loader binary on NAND Flash can be programmed by the tool *TurboWriter* and here are the steps. Further information about *TurboWriter* can be found at BSP *Tools/PC_Tools/TurboWriter Tool User Guide.pdf*.

1. Power off device.
2. Plug in USB cable to PC/NB.
3. Power on device under Recovery mode.
4. Run TurboWriter for N9H20 version on PC/NB.
5. Wait for the TurboWriter message to change to "**Mass Storage Connected !**". If not, press the "**Re-Connect**" button to reconnect the device.
6. Select "**NAND**" on the option "**Please choose type**".
7. Select NAND loader binary file on the option "**Image Name**".
8. Select "**System Image**" on the option "**Image Type**".
9. Press "**Burn**" button to burn the NAND loader binary into NAND Flash.
10. After burning completed, check the NAND loader information in the left table.



No	Name	Type	Start bl...	End ...
0	N9H20K5_NANDLoad...	system	0x0	0x3
1	Logo.bin	logo	0x4	0x5
2	NVTLoader_NAND.bin	execute	0x6	0x7

Figure 4-1 Programmed NAND Loader by TurboWriter

11. Remove USB device safely.
12. Plug out USB cable from PC/NB.
13. Reset the device under Normal mode.

4.2 Run NAND Loader

N9H20 has built-in 16K bytes IBR (Internal Booting ROM) where is the boot loader to initialize chip basically when power on, and then try to find out the next stage loader from different type of storage. It could be SD card, NAND Flash, SPI Flash, or USB storage. The booting sequence by the IBR as Figure 4-2.

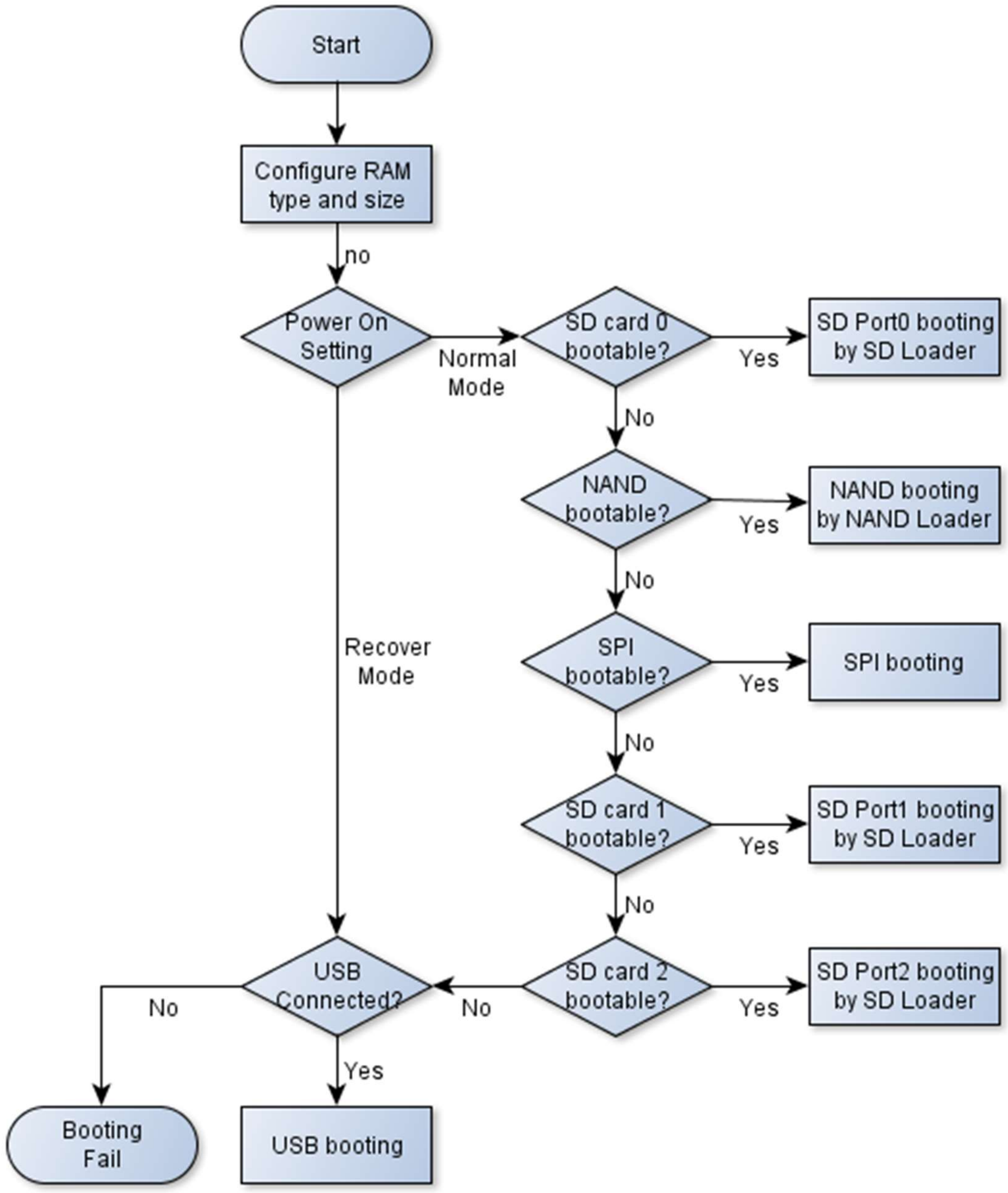
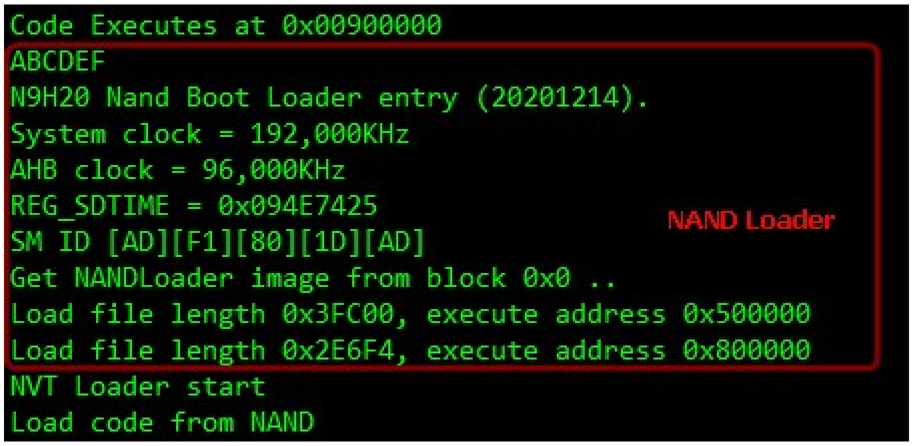


Figure 4-2 IBR Booting Sequence after Power On

The IBR will execute the NAND loader if SD loader on SD card 0 is invalid.



```
Code Executes at 0x00900000
ABCDEF
N9H20 Nand Boot Loader entry (20201214).
System clock = 192,000KHz
AHB clock = 96,000KHz
REG_SDTIME = 0x094E7425
SM ID [AD][F1][80][1D][AD]
Get NANDLoader image from block 0x0 ..
Load file length 0x3FC00, execute address 0x500000
Load file length 0x2E6F4, execute address 0x800000
NVT Loader start
Load code from NAND
```

Figure 4-3 The NAND Loader Runs on N9H20

5 Supporting Resources

The N9H20 system related issues can be posted in Nuvoton's forum:

- ARM7/9 forum at: http://forum.nuvoton.com/viewforum.php?f=12.

Revision History

Date	Revision	Description
2021.6.21	1.01	1. Modify document structure.
2018.5.4	1.00	1. Initially issued.