




Gowin_EMPU_M1 Download **Reference Design**

IPUG532-1.8E, 07/21/2021

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Revision History

Date	Versi	Description
02/19/2019	1.0E	Initial version published.
07/18/2019	1.1E	<ul style="list-style-type: none"> ● Supports the automated merging tool used for MCU hardware design and software programming design; ● MCU supports off-chip SPI-Flash downloading and startup.
08/18/2019	1.2E	<ul style="list-style-type: none"> ● MCU hardware design and software programming design support extended peripheral: DD3 Memory; ● Fixed known issues of ITCM, DTCM Size and IDE.
09/27/2019	1.3E	The description of software configuration updated.
01/16/2020	1.4E	<ul style="list-style-type: none"> ● MCU hardware design and software programming design supports PSRAM; ● Updated MCU compiling software GMD V1.0; ● RTOS reference design updated; ● Hardware and software reference design of AHB2 and APB2 extension
03/03/2020	1.5E	<ul style="list-style-type: none"> ● Known issues of ITCM, DTCM Size and IDE fixed; ● The FPGA devices of GW2A-18C/GW2AR-18C/GW2A-55C supported.
06/12/2020	1.6E	<ul style="list-style-type: none"> ● MCU supports External instruction memory; ● MCU supports External data memory; ● 6 AHB bus interfaces extended; ● 16 APB bus interfaces extended; ● GPIO supports multiple interface types; ● I²C supports multiple interface types; ● Merge_bit tool supports GowinSynthesis[®] to parse the rules of naming.
01/25/2021	1.7E	<ul style="list-style-type: none"> ● The reference design of GW1N-9C, GW2A-18C, GW2A-55C (Version C) updated; ● The download auxiliary tools called Merge_bit and make_hex updated; ● The reference design and the version of Gowin Software updated.
07/21/2021	1.8E	<ul style="list-style-type: none"> ● GW1N-9C/GW1NR-9C supports embedded UserFlash as instruction memory; ● Merge_bit tool updated; ● The synthesis tool, SynplifyPro, deleted; ● The version of FPGA and MCU software updated.

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1 Download Methods

Gowin_EMPU_M1 provides four download methods of hardware design and software programming design:

1. Use the mapping files generated by software programming design as the ITCM initial value of hardware design.
 - a) Use Gowin_EMPU_M1 software programming design to generate BIN files in a binary format in software design;
 - b) Use make_hex tool to convert the BIN files in a binary format in software design to four mapping files in a hexadecimal format: itcm0, itcm1, itcm2, and itcm3;
 - c) Use itcm0, itcm1, itcm2, and itcm3 as the ITCM initial value files in hardware design to read in;
 - d) Synthesis, place & route to generate the bitstream files in hardware design including software programming design and hardware design;
 - e) Use Programmer, the download tool, to download the bitstream files in hardware design.
2. Merge the BIN files in a binary format in software design generated by software programming design and the BIN files in a binary format in hardware design generated by hardware design.
 - a) Use Gowin_EMPU_M1 hardware design to generate bitstream files in hardware design.
 - b) Use Gowin_EMPU_M1 software programming design to generate BIN files in a binary format in software design;
 - c) Use merge_bit tool to merge the BIN files in a binary format in software design and bitstream files in hardware design;
 - d) Generate new bitstream files in hardware design after merging the software design and the hardware design;
 - e) Use Programmer, the download tool, to download the bitstream files in hardware design after merging.
3. Use off-chip SPI-Flash to download the BIN files in a binary format generated by software programming design.

- a) In Gowin_EMPU_M1 hardware design, configure ITCM Size and select different bootload as the initial value of ITCM according to ITCM Size.
 - b) In Gowin_EMPU_M1 hardware design, generate bitstream files in hardware design with the off-chip SPI-Flash that provides download functions.
 - c) Use Programmer, the download tool, to download the bitstream files in hardware design generated by hardware design.
 - d) Use Gowin_EMPU_M1 software programming design to generate BIN files in a binary format in software design;
 - e) Use Programmer, the download tool, to download the BIN files in a binary format generated by software programming design.
4. Use embedded UserFlash to download the BIN files in a binary format generated by software programming design.
- a) In Gowin_EMPU_M1 hardware design, ITCM Select is configured as External Instruction Memory;
 - b) UserFlash Controller (GW1N-9C/GW1NR-9C FLASH608K) which instantiates Memory Map function is the instruction memory of Gowin_EMPU_M1;
 - c) Synthesize, place, and route Gowin_EMPU_M1 hardware design to generate bitstream files in hardware design;
 - d) Build and link Gowin_EMPU_M1 software programming design to generate BIN files in a binary format in software design;
 - e) Use Programmer, the download tool, to download the bitstream files in hardware design and BIN files in a binary format in software design.

2 Software Programming Output as ITCM Initialization Value

2.1 Tools

Gowin_EMPU_M1\tool\make_hex\bin\make_hex.exe

Access the above software tools via this link:

http://cdn.gowinsemi.com.cn/Gowin_EMPU_M1.zip

2.2 Command Parameters

make_hex.exe bin-file

2.3 Software Configuration

Use software programming design to generate BIN files in a binary format in software design.

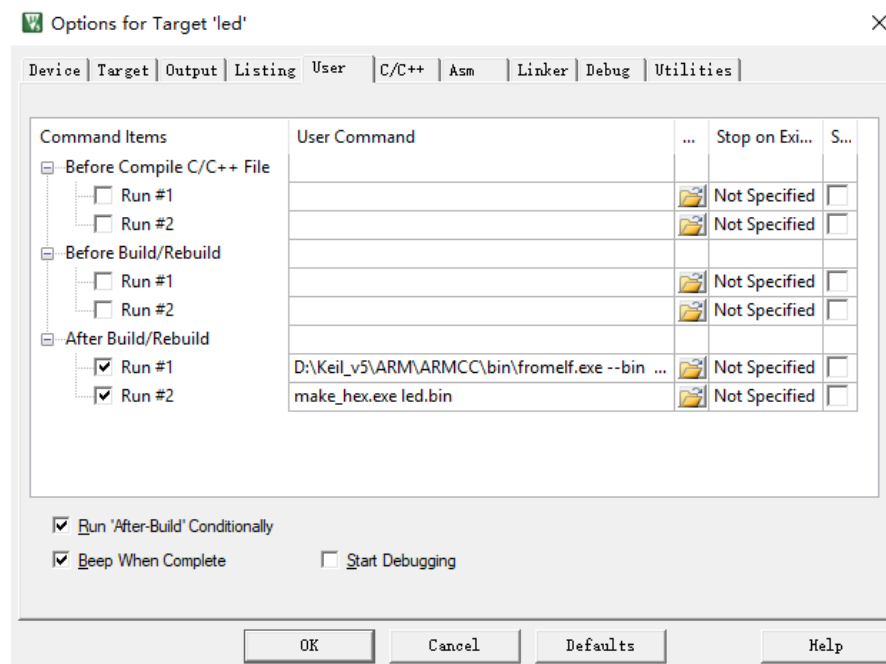
Use make_hex tool to convert the BIN files in a binary format in software design to four mapping files in a hexadecimal format: itcm0, itcm1, itcm2, and itcm3.

In ARM Keil MDK (V5.26 and above), configure make_hex.exe as external tool, as shown in Figure 2-1.

- Run #1: fromelf.exe --bin -o bin-file axf-file
- Run #2: make_hex.exe bin-file

Automatically call make_hex.exe tool to generate the BIN files in a binary format in software design to four mapping files in a hexadecimal format.

Figure 2-1 Configure External Tool

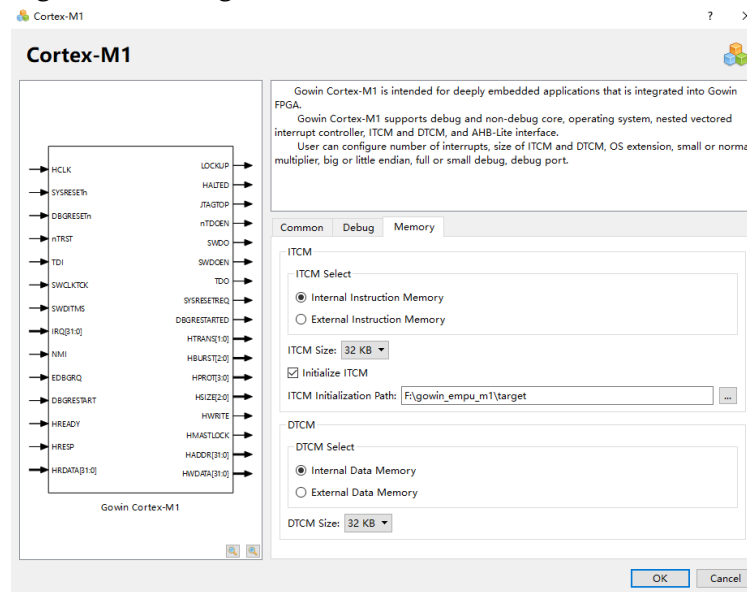


2.4 Hardware Configuration

In IP Core Generator in Gowin Software:

- Select “Cortex-M1 > Memory > ITCM > ITCM Select > Internal Instruction Memory”;
- Select “Cortex-M1 > Memory > ITCM > Initialize ITCM”;
- Select “Cortex-M1 > Memory > ITCM > ITCM Initialization Path” and import the path of the four mapping files in a hexadecimal format of itcm0, itcm1, itcm2, and itcm3 as the initial value of ITCM, as shown in Figure 2-2;
- Import itcm0、itcm1、itcm2、itcm3 as the initial value of ITCM, as well as Gowin_EMPU_M1 hardware design generated after the external tool configuration of Cortex-M1 and AHB/APB in IP Core Generator. The hardware design includes software programming design.

Figure 2-2 Configure ITCM Initialization



2.5 Design Flow

1. Use the software programming design of ARM Keil MDK (V5.26 and above) and GOWIN MCU Designer (V1.1 and above) to compile four mapping files in a hexadecimal format of itcm0, itcm1, itcm2, and itcm3;
2. Use IP Core Generator in Gowin Software to generate Gowin_EMPU_M1 hardware design; and itcm0, itcm1, itcm2, and itcm3 generated by software programming design are used as the initial value of ITCM in hardware design;
3. Instantiate Gowin_EMPU_M1 Top Module, and connect user design;
4. Add physical and timing Constraints;
5. Use GowinSynthesis[®] as the synthesis tool to synthesize;
6. Use Place & Route tool to generate the bitstream files in hardware design including software programming design;
7. Use Programmer, the download tool, to download the bitstream files in hardware design.

2.6 Devices Supported

- GW1N-9/GW1NR-9/GW1N-9C/GW1NR-9C/GW2AN-9X
- GW2A-18/GW2A-18C/GW2AR-18/GW2AR-18C/GW2ANR-18C/GW2AN-18X
- GW2A-55/ GW2A-55C/ GW2AN-55C

2.7 Reference Design

Access the [reference design](#) via this link:

Gowin_EMPU_M1\tool\make_hex\example

3 Merge Results of Software Design and Hardware Design

3.1 Tools

Gowin_EMPU_M1\tool\merge_bit\bin\merge_bit.bat

Access the above software tools via this link:

http://cdn.gowinsemi.com.cn/Gowin_EMPU_M1.zip

3.2 Command Parameters

Software commands and parameters:

call make_loc.exe -i posp-file -s itcm_size [-d] -t synthesis_tool

call merge_bit.exe bin-file itcm.loc fs-file

For the description of commands and parameters, please refer to Table 3-1.

Table 3-1 merge_bit Commands and Parameters

Parameter	Description
make_loc.exe	Input posp-file and generate itcm.loc file, the ITCM layout information.
-i	Post-Place File, generated by configure "Place & Route > General > Generate Post-Place File" in Gowin Software.
-s	ITCM Size, configured according to Gowin_EMPU_M1 hardware design
-d	Optional If configure Enable Debug, then enable -d; If configure Disable Debug, then disable -d.
-t	Specify the synthesis tool: gowin_syn.
merge_bit.exe	Merge Gowin_EMPU_M1 software design and hardware design.
bin-file	Use Gowin_EMPU_M1 software programming design to generate BIN files in a binary format in software design.
itcm.loc	Itcm.loc file, ITCM layout information generated by make_loc.exe.
fs-file	Bitstream files in hardware design generated by Gowin_EMPU_M1 hardware design.

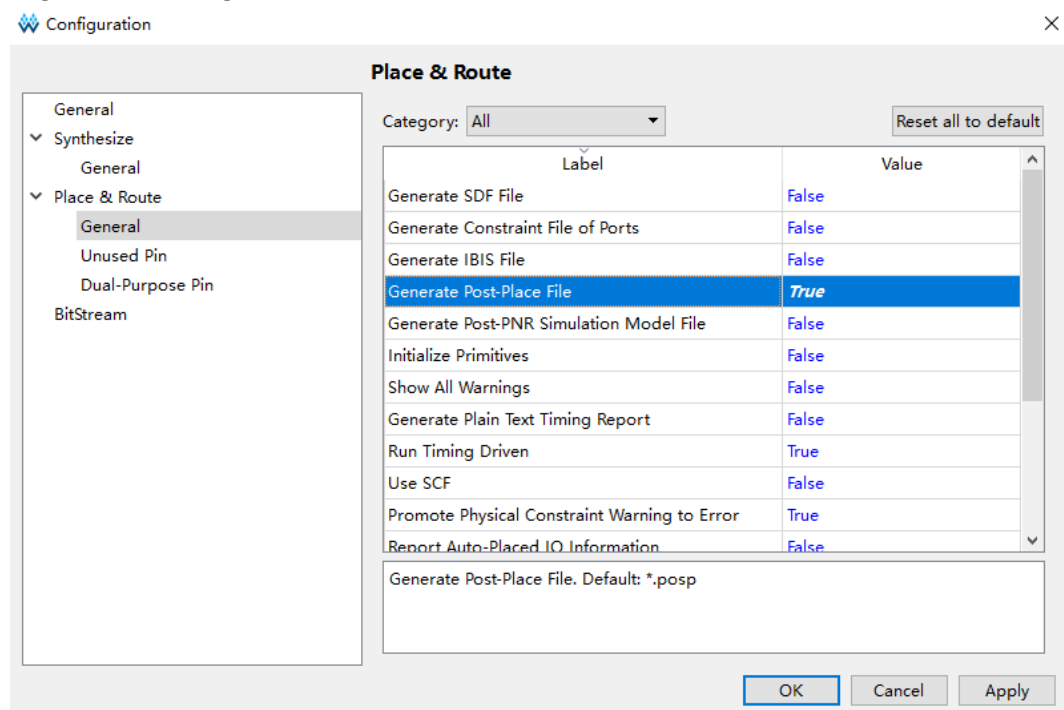
Merge the BIN files in a binary format in software design generated by software programming design and the bitstream files in hardware design generated by hardware design.

During the use of merge_bit.bat, you can modify the parameters, such as -i posp-file, -s itcm_size, -d bin-file, fs-file, according to your requirements.

3.3 Hardware Configuration

In Gowin Software configuration options, select "Place & Route > General > Generate Post-Place File", and set "True" to generate Post-Place File as the posp input file of make_loc.exe -i parameter, as shown in Figure 3-1.

Figure 3-1 Configure Post-Place File



3.4 Design Flow

3.4.1 Merge

1. Use Gowin_EMPU_M1 hardware design to generate bitstream files in hardware design and Post-Place File;
2. Use Gowin_EMPU_M1 software programming design to generate BIN files in a binary format in software design;
3. Perform merge_bit.bat, merge the bitstream files in hardware design generated by hardware design and the BIN files in a binary format in software design generated by software programming design to generate new bitstream files, as shown in Figure 3-2.

Figure 3-2 Merge Software Programming Design and Hardware Design

```

----- GOWIN Merge Tool -----
Read bit stream file gowin_empu_m1.fs ...
Build bsram init value fusemap...
Reading original bsram init value map...
Location file itcm.loc reading...
Bsram R46[0] init value convert to fusemap success.
Bsram R46[1] init value convert to fusemap success.
Bsram R46[2] init value convert to fusemap success.
Bsram R46[3] init value convert to fusemap success.
Bsram R28[5] init value convert to fusemap success.
Bsram R46[4] init value convert to fusemap success.
Bsram R28[6] init value convert to fusemap success.
Bsram R28[7] init value convert to fusemap success.
Bsram R28[8] init value convert to fusemap success.
Bsram R28[9] init value convert to fusemap success.
Bsram R10[11] init value convert to fusemap success.
Bsram R28[10] init value convert to fusemap success.
Bsram R10[12] init value convert to fusemap success.
Bsram R10[13] init value convert to fusemap success.
Bsram R10[14] init value convert to fusemap success.
Bsram R10[15] init value convert to fusemap success.
Replace new bsram init value map to file new_gowin_empu_m1.fs...
Build bsram init value replace completed.

```

3.4.2 Download

After merging, use Programmer, the download tool, to download the new bitstream files in hardware design.

For the usage of Gowin Programmer, please see [SUG502](#), *Gowin Programmer User Guide*.

3.5 Devices Supported

- GW2AN-9X
- GW2A-18/GW2A-18C/GW2AR-18/GW2AR-18C/GW2ANR-18C/GW2AN-18X
- GW2A-55/ GW2A-55C/ GW2AN-55C

3.6 Application Software

Gowin_V1.9.8 Beta and above

3.7 Reference Design

Access the [reference design](#) via this link:

Gowin_EMPU_M1\tool\merge_bit\example

4 Off-chip SPI-Flash Download Method

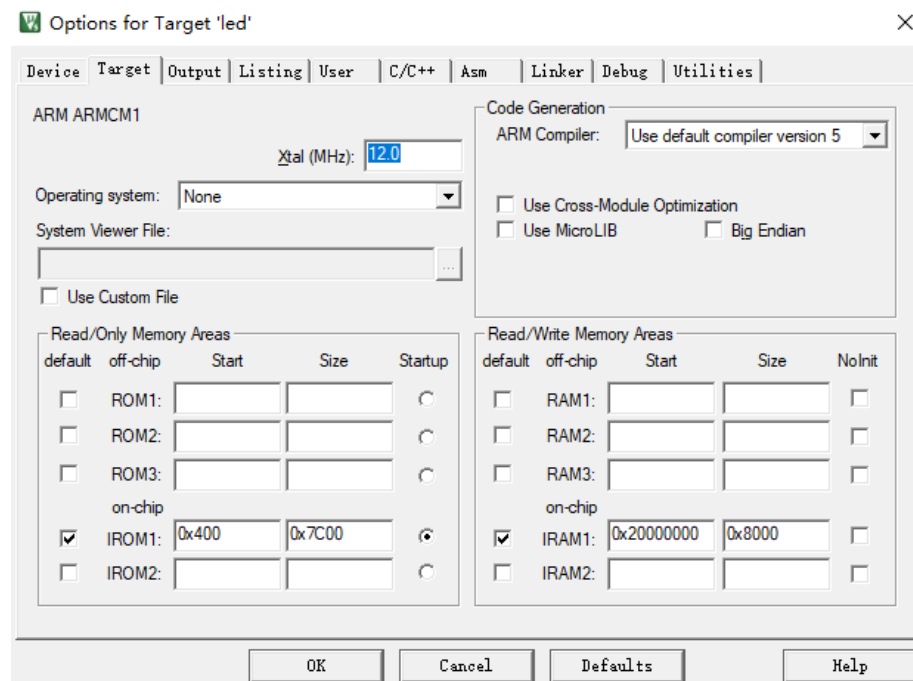
4.1 Software Configuration

In Gowin_EMPU_M1 Software Programming Design:

If you use ARM Keil MDK (V5.26 and above) software development environment, set the IROM1 start address to 0x400 and set the IROM1 Size according to the actual ITCM Size hardware configuration.

Taking DK-START-GW2A18 V2.0 reference design in SDK for an instance, set IROM1 to 0x7C00, as shown in Figure 4-1.

Figure 4-1 ROM Start Address and Size Configuration



If you use GOWIN MCU Designer (V1.1 and above) software development environment, change the Flash start address of the Flash linker GOWIN_M1_flash.ld to 0x00000400.

4.2 Hardware Configuration

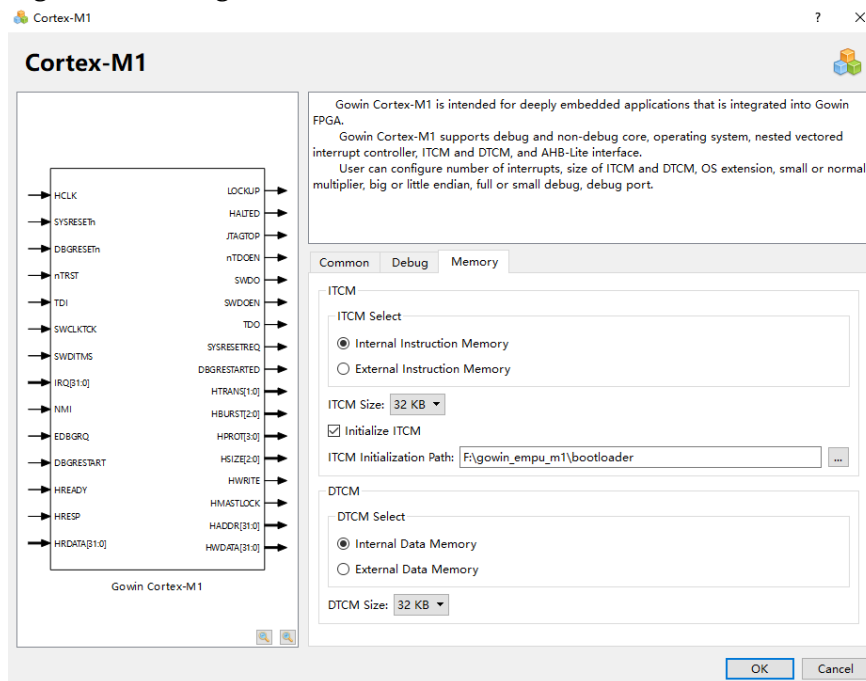
4.2.1 ITCM Initialization Configuration

Use IP Core Generator tool in Gowin Software to configure and generate Gowin_EMPU_M1 hardware design:

- Select Internal Instruction Memory as the instruction memory of Gowin_EMPU_M1;
- Select ITCM Size;
- Select Initialized ITCM;
- Select different bootload as the initial value of ITCM according to ITCM Size. Import bootload path to ITCM Initialization Path.

Configure ITCM Initialization as shown in Figure 4-2.

Figure 4-2 Configure ITCM Initialization Path



The bootload corresponding to different ITCM Size are as show in Table 4-1.

Table 4-1 Bootload Corresponding to ITCM Size

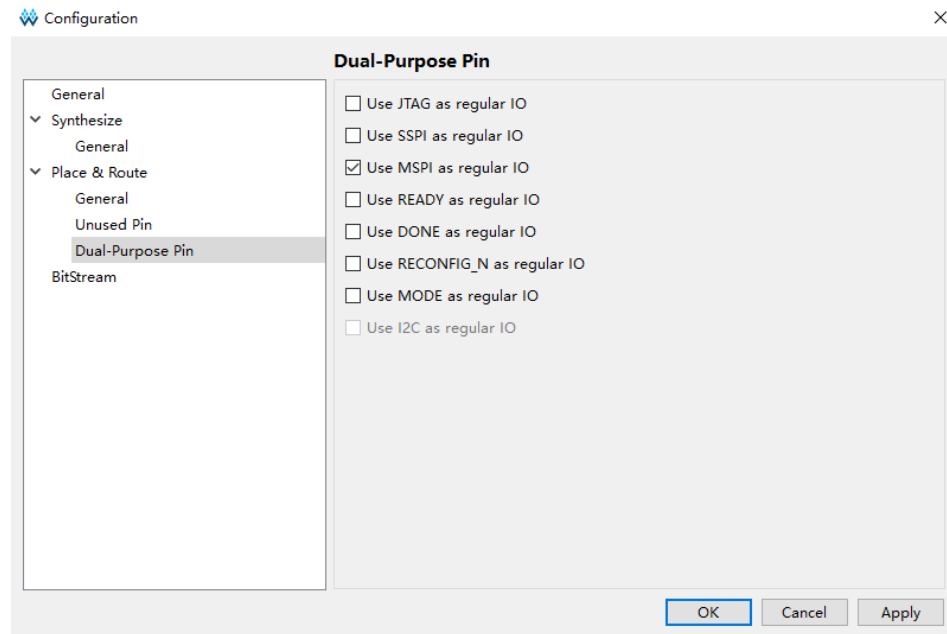
ITCM Size (KByte)	bootload
2	Gowin_EMPU_M1\bootload\boot\ITCM_Size_2KB
4	Gowin_EMPU_M1\bootload\boot\ITCM_Size_4KB
8	Gowin_EMPU_M1\bootload\boot\ITCM_Size_8KB
16	Gowin_EMPU_M1\bootload\boot\ITCM_Size_16KB
32	Gowin_EMPU_M1\bootload\boot\ITCM_Size_32KB
64	Gowin_EMPU_M1\bootload\boot\ITCM_Size_64KB
128	Gowin_EMPU_M1\bootload\boot\ITCM_Size_128KB

ITCM Size (KByte)	bootload
256	Gowin_EMPU_M1\bootload\boot\ITCM_Size_256KB

4.2.2 Dual-Purpose Pin Configuration

In Gowin Software configuration options, select “Place & Route > Dual-Purpose Pin” to configure MSPI as universal IO, as shown in Figure 4-3.

Figure 4-3 Onfiure Dual-Purpose Pin



4.3 Design Flow


1. Gowin_EMPU_M1 hardware design configuration:
 - Select Internal Instruction Memory;
 - Select ITCM Size;
 - Select Initialized ITCM;
 - Select different bootload as the initial value of ITCM according to ITCM Size.
2. Generate Gowin_EMPU_M1 hardware design;
3. Synthesize, place & route to generate bitstream files in hardware design with the off-chip SPI-Flash that provides download functions.
4. Configure Device configuration with Programmer, the download tool, to download the bitstream files in hardware design.
5. Use Gowin_EMPU_M1 software programming design to generate BIN files in a binary format in software design;
6. Configure Device configuration in Programmer, the download tool, to download the BIN file in binary format in software design.

4.4 Download

For the usage of Gowin Programmer, please see [SUG502](#), *Gowin Programmer User Guide*.

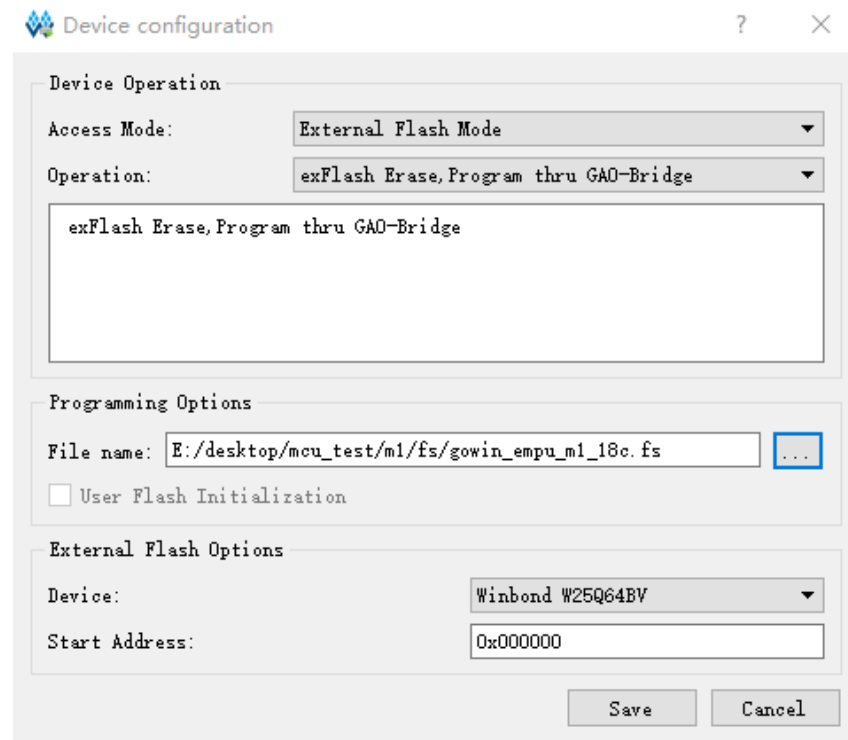
4.4.1 Download Bitstream Files in Hardware Design

Gowin_EMPU_M1 hardware design generates bootloader as the initial value of ITCM and bitstream files with the off-chip SPI-Flash that provides download functions. Use Programmer, the download tool, to download the bitstream files in hardware design.

Select "Tools > Programmer" in the menu bar or "Programmer" () in the tool bar in Gowin Software to open Programmer, the download tool.

Select "Edit > Configure Device" in the menu bar or "Configure Device" () in the tool bar to open the "Device configuration".

- Select "External Flash Mode" in "Access Mode" drop-down list.
- Select "exFlash Erase, Program thru GAO-Bridge" or "exFlash Erase, Program, Verify thru GAO-Bridge" in "Operation" drop-down list.
- Import the hardware design bitstream file required to download in "Programming Options > File name" option.
- Select "External Flash Options > Device" based on the on-board Flash chip types (such as on-board Winbond W25Q64BV of DK-START-GW2A18 V2.0).
- Select "External Flash Options > Start Address" to set the start address as 0x000000.
- Click "Save" to configure the download of bitstream files in hardware design, as shown in Figure 4-4.


Figure 4-4 Device configuration for Hardware Download

After device configuration, click “Program/Configure” () in the Programmer tool bar to download bitstream files in hardware design.

4.4.2 Download BIN File in Binary Format in Software Design

After downloading the bitstream files in Gowin_EMPU_M1 hardware design, download the BIN files in binary format in software design with Programmer, the download tool.

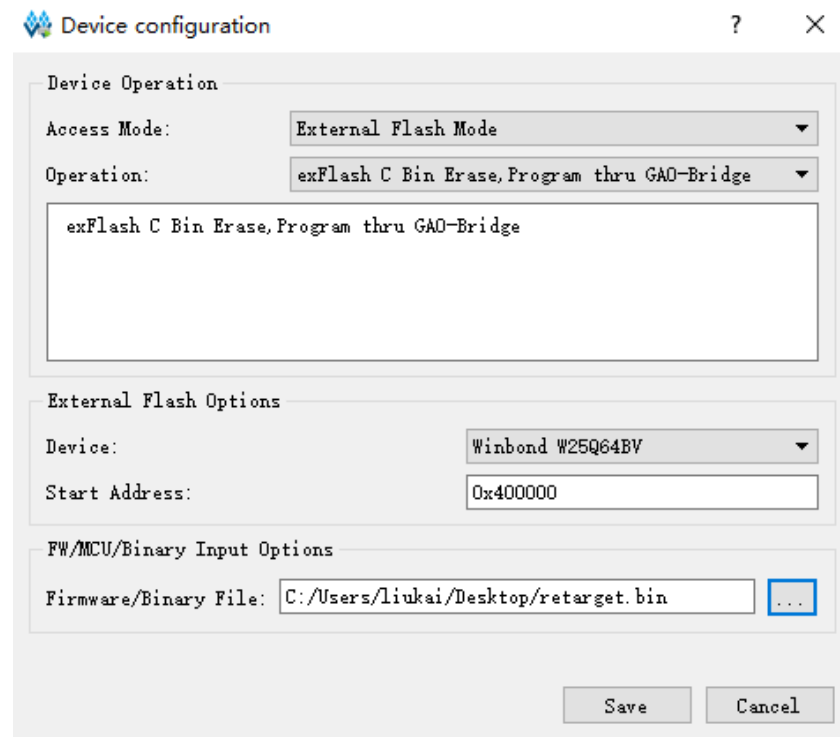
Open Programmer, the download tool, in Gowin Software or under the software installation path.


Click "Edit > Configure Device" in the menu bar or "Configure Device" () in the tool bar to open the "Device configuration".

- Select "External Flash Mode" in "Access Mode" drop-down list.
- Select “exFlash C Bin Erase, Program thru GAO-Bridge” or "exFlash C Bin Erase, Program, Verify thru GAO-Bridge” in “Operation” drop-down list.
- Select “FW/MCU Input Options > Firmware/Binary File” to import the BIN files in binary format in software design to download.
- Select “External Flash Options > Device” based on the on-board Flash chip types (such as on-board Winbond W25Q64BV of DK-START-GW2A18 V2.0).
- Select “External Flash Options > Start Address” to set the start address as 0x400000.
- Click “Save” to configure the download of BIN files in binary format in

software design, as shown in Figure 4-5.

Figure 4-5 Device Configuration for Software Download



After device configuration, click “Program/Configure” () in the Programmer tool bar to download BIN files in binary format in software design.

4.5 Devices Supported

- GW2AN-9X
- GW2A-18/GW2A-18C/GW2AR-18/GW2AR-18C/GW2ANR-18C/GW2AN-18X
- GW2A-55/ GW2A-55C/ GW2AN-55C

4.6 Reference Design

Access the [reference design](#) via this link:

Gowin_EMPU_M1\bootload\example

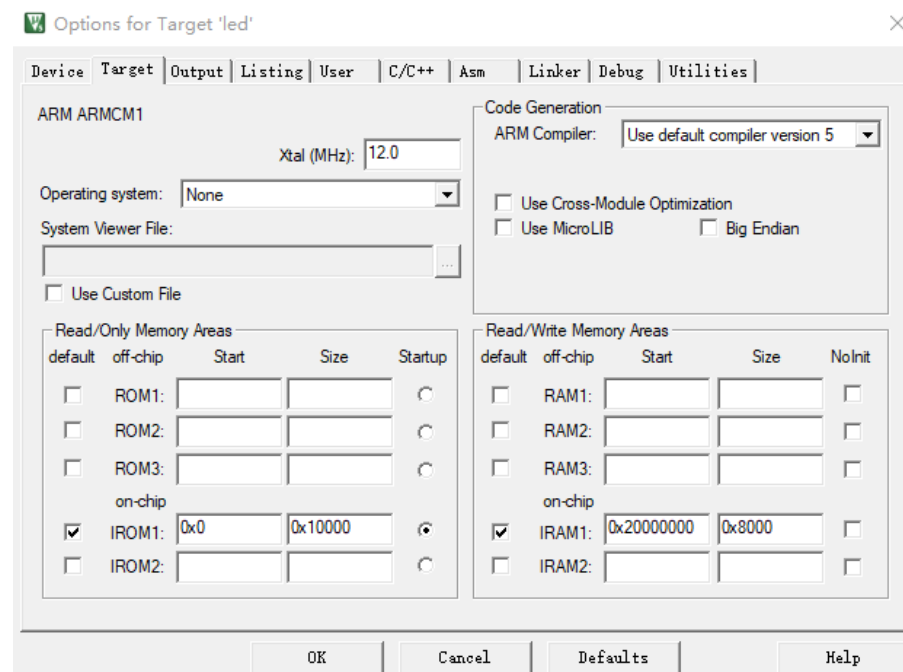
5 Embedded UserFlash Download Methods

5.1 Software Configuration

Take DK-START-GW1N9 V1.1 reference design in SDK for an instance:

If you use ARM Keil MDK (V5.26 and above) software development environment, set the IROM1 start address to 0x0 and set the IROM1 Size to 0x10000 (64KB), as shown in Figure 5-1.

Figure 5-1 ROM Start Address and Size Configuration

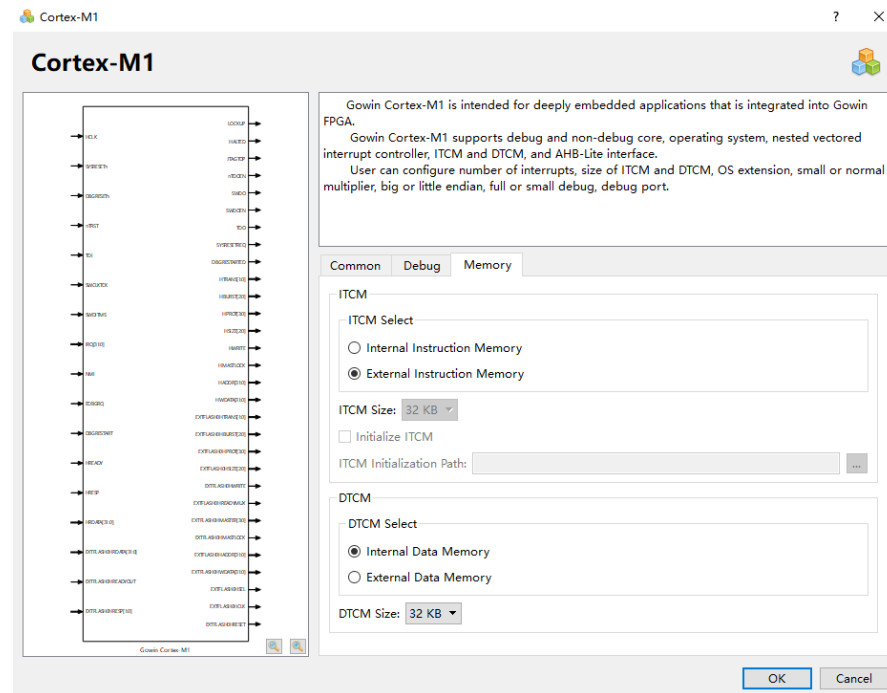


If you use GOWIN MCU Designer (V1.1 and above) software development environment, set "FLASH ORIGIN", the Flash start address of the Flash linker GOWIN_M1_flash.ld to 0x00000000, and set Flash Size "LENGTH" to 64K.

5.2 Hardware Configuration

Use IP Core Generator tool of Gowin Software to configure and generate Gowin_EMPU_M1 hardware design. In this process, select External Instruction Memory as the instruction memory of Gowin_EMPU_M1 in ITCM Select options, as shown in Figure 5-2.

Figure 5-2 ITCM Select Configuration





5.3 Design Flow

1. In Gowin_EMPU_M1 hardware design configuration, configure ITCM Select as External Instruction Memory;
2. IP Core Generator generates Gowin_EMPU_M1 hardware designs;
3. UserFlash Controller (GW1N-9C/GW1NR-9C FLASH608K) which instantiates Memory Map function is the instruction memory of Gowin_EMPU_M1;
4. Software programming designs synthesize, place, and route Gowin_EMPU_M1 hardware design to generate bitstream files in hardware design;
5. Software programming design build, andlink to generate BIN files in a binary format in software design;
6. Use Programmer, the download tool, to download the bitstream files in Gowin_EMPU_M1 hardware design and BIN files in a binary format in Gowin_EMPU_M1 software design.

5.4 Download

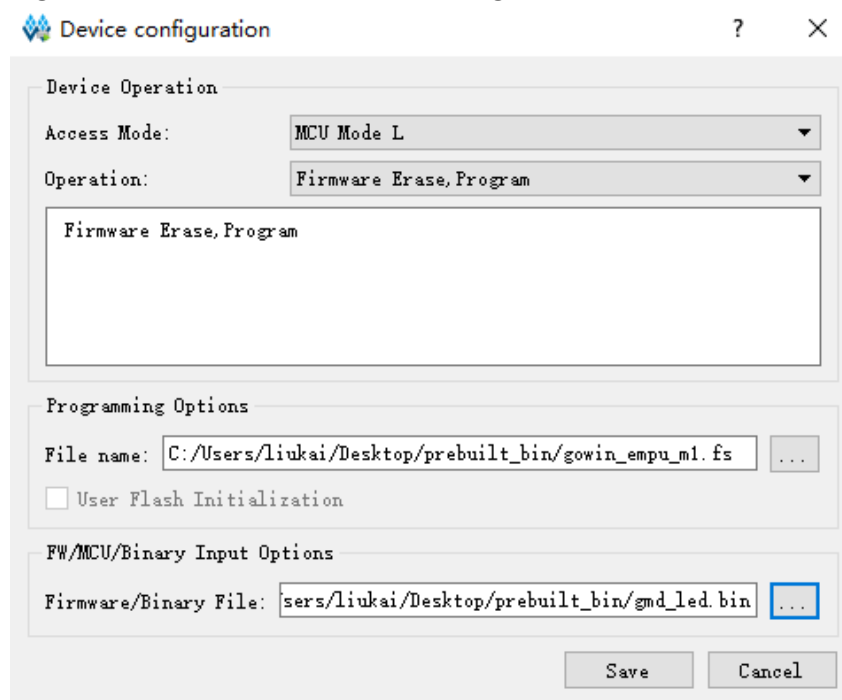
For the usage of Gowin Programmer, please see [SUG502](#), *Gowin Programmer User Guide*.


Select “Tools > Programmer” in the menu bar or “Programmer” () in the tool bar in Gowin Software to open Programmer, the download tool.

Select "Edit > Configure Device" in Programmer menu bar or "Configure Device " () in the tool bar to open the "Device configuration", as shown in Figure 5-3.

- Select "MCU Mode L" in “Access Mode” drop-down list.
- Select “Firmware Erase, Program” or "Firmware Erase, Program, Verify” in “Operation” drop-down list.
- Import the hardware design bitstream file required to download in “Programming Options > File name” option.
- Select “FW/MCU/Binary Input Options > Firmware/Binary File” to import the BIN files in a binary format in software programming design required to download.
- Click “Save” to complete the download configuration of the bitstream files in hardware design and BIN files in a binary format in software design.

Figure 5-3 GW1N(R)-9C Device Configuration



After device configuration, click “Program/Configure” () in the Programmer tool bar to download the bitstream files in hardware design and the BIN files in binary format in software programming design at the same time.

5.5 Devices Supported

- GW1N-9C
- GW1NR-9C

5.6 Reference Design

Access the [reference design](#) via this link:

Gowin_EMPU_M1\ref_design\FPGA_RefDesign\Debug_RefDesign\
K_START_GW1N9_V1.1

