# The Introduction of Randomizer Feature on Macronix MX30xFxG28AD and MX35xFxG24AD

1. Introduction

This application note introduces the Randomizer feature of Macronix MX30xFxG28AD and MX35xFxG24AD NAND devices. For those extremely unbalanced data patterns on the distribution of zeros and ones which might potentially lead to data error for high program/erase endurance blocks, the randomizer feature may help on such applications.

The following illustration shows the sensitive user data pattern which may lead to data error for high program/erase endurance blocks (as the ✖). After we apply the randomizer function, the user data is scrambled before being written to the chip. The scrambled data is random and the data will be still correct for high program/erase endurance blocks (as the ✔).
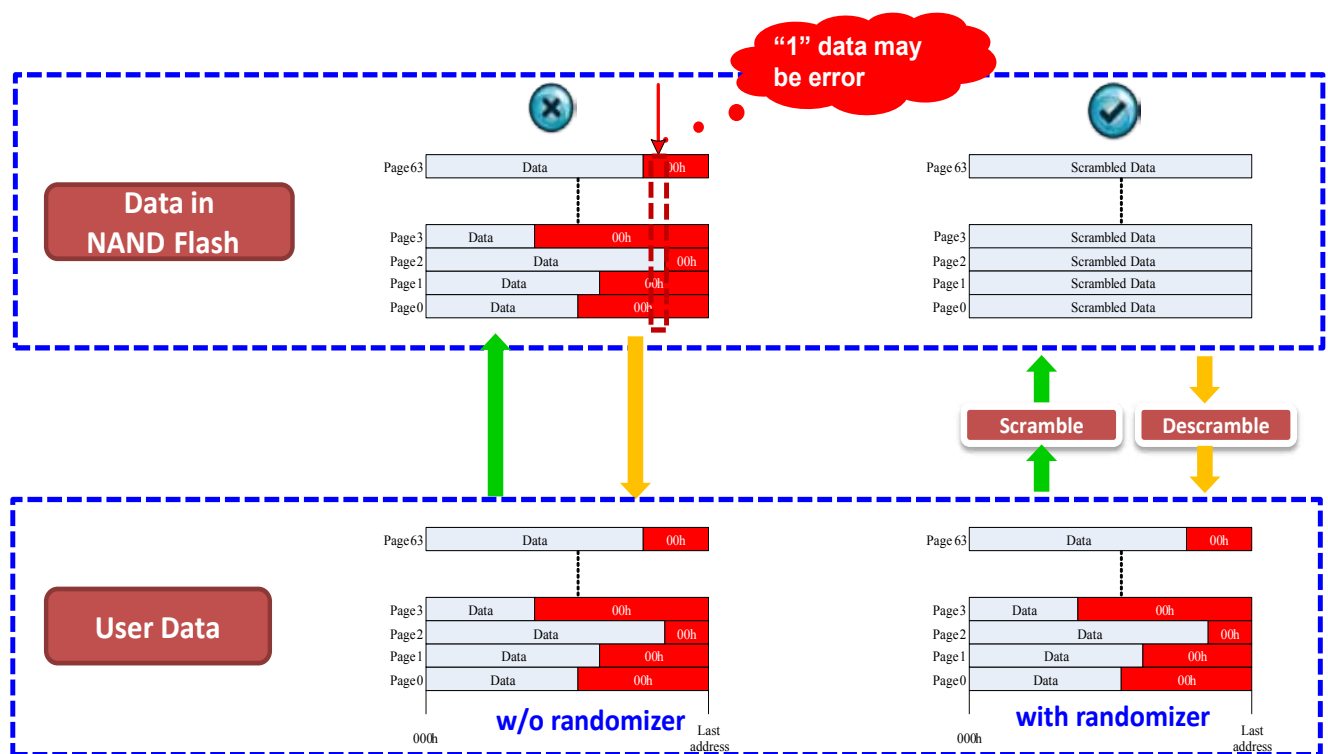
2. Randomizer Operation

When the randomizer function is enabled on the NAND device, the user data and OTP area (if the user will use the Secure OTP (One-Time-Programmable) Feature) is scrambled in a random pattern before being written to the NAND device. When attempting to use the randomizer function, it is necessary to enable the randomizer function prior to programming data in the main array and OTP area. The randomizer function is enabled by RANDEN bit through the "set feature" operation (as *"Table 2-1: Sub-Feature Parameter Table of Feature Address – B0h (Configuration)"*).

The following feature bits RANDEN and RANDOPT are related to the randomizer function (as *"Table 2-1: Sub-Feature Parameter Table of Feature Address – B0h (Configuration)"*). To enable the randomizer function, RANDEN bit must be set to "1", RANDOPT can be set to "0" or "1" depending on the user choice (as *"Table 2-2: The definition of RANDOPT bit for the randomized area per page (as grey color)"*).

Table 2-1: Sub-Feature Parameter Table of Feature Address – B0h (Configuration)

Sub Feature Parameter	Definition		I/O7	I/O6	I/O5	I/O4	I/O3	I/O2	I/O1	I/O0	Value
P1	Configuration	Disable (Default)	Reserved (0)					0	0	0	00h
		Randomizer Operation						RANDOPT (Randomizer option)[Note1, Note2, Note3]	RANDEN (Enable Randomizer)[Note1, Note3]	ENPGM (Enable RANDOPT and RANDEN Program)	
P2			Reserved (0)								
P3			Reserved (0)								
P4			Reserved (0)								

Notes:

1. The values of RANDOPT and RANDEN are Volatile type (V2 type). The V2 type where the value is volatile type; however, the default value of these V2 volatile feature bits can be changed once by the Flowchart of RANDEN and RANDOPT Bits Program Operation.

2. The value is defined in "Table 2-2: The definition of RANDOPT bit for the randomized area per page (as grey color)". The definition of RANDOPT bit for the randomized area per page (as grey color).

3. The ENPGM bit is a volatile bit

Table 2-2: The definition of RANDOPT bit for the randomized area per page (as grey color)

Density	RANDOPT	Main	Spare 0	Spare 1	Remark
1Gb	0	0000h~07FFh	0800h-081Fh	0820h~087Fh	NOP=1 for Main/Spare 0/Spare 1
	1	0000h~07FFh	0800h-081Fh	0820h~087Fh	NOP=1 for Main/Spare 1
2Gb	0	0000h~07FFh	0800h-081Fh	0820h~087Fh	NOP=1 for Main/Spare 0/Spare 1
	1	0000h~07FFh	0800h-081Fh	0820h~087Fh	NOP=1 for Main/Spare 1
4Gb	0	0000h~0FFFh	1000h-101Fh	1020h~10FFh	NOP=1 for Main/Spare 0/Spare 1
	1	0000h~0FFFh	1000h-101Fh	1020h~10FFh	NOP=1 for Main/Spare 1

Both RANDEN and RANDOPT feature bits are V2-type volatile bits with default values that can be changed once as shown in *"Figure 2-1: Flowchart of RANDEN and RANDOPT Bits Program Operation"*. The RANDEN and RANDOPT bits will return to their default value after a power cycle. The RANDEN and RANDOPT bits program flowchart is shown in *"Figure 2-1: Flowchart of RANDEN and RANDOPT Bits Program Operation"*.

To enable the program sequence, ENPGM feature bit must be set to "1". After the program is finished, ENPGM feature bit must be set to "0" as shown in the flow.

After the RANDEN and RANDOPT feature bits are programmed, users can issue the Get Feature command to check whether the RANDEN and RANDOPT feature bits are programmed successfully or not.

RANDOPT bit: considering the needs of different applications; there are two options of randomizer coverage provided as shown in grey color in *"Table 2-2: The definition of RANDOPT bit for the randomized area per page (as grey color)"*. The grey data area is covered by the randomizer function for each option; whereas the white area is not.

Note: the NOP=1 for the randomizer-covered data area.

Figure 2-1: Flowchart of RANDEN and RANDOPT Bits Program Operation
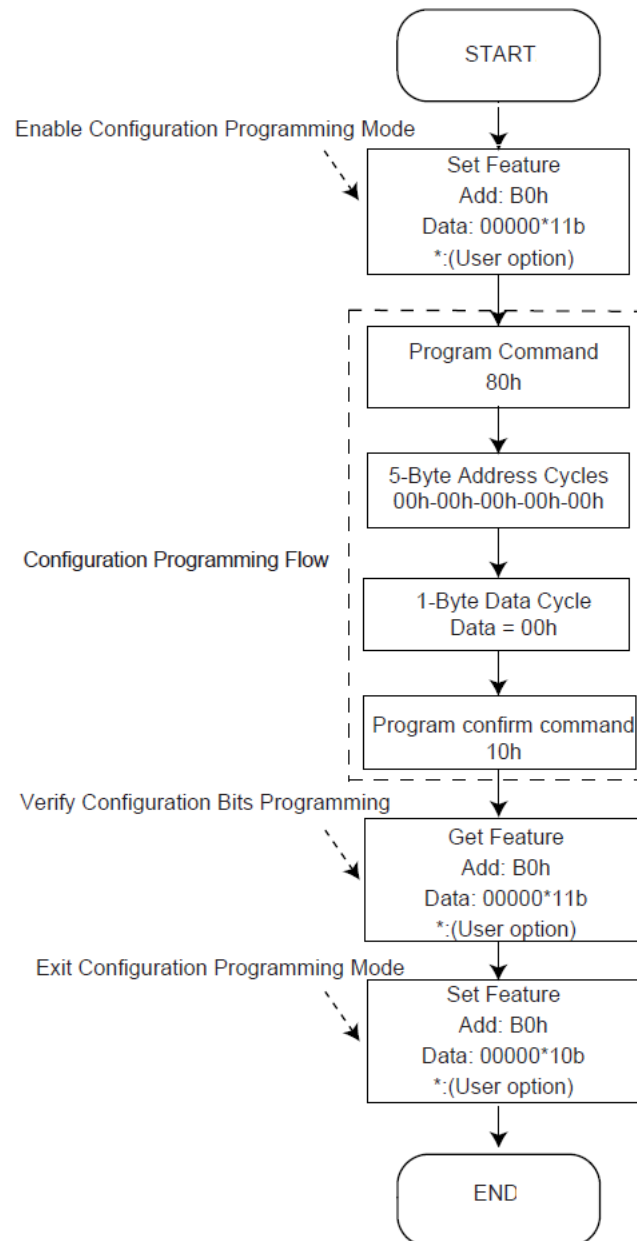
3. Related Parameter Timing Specs

The corresponding parameter timing specifications are shown in *"Table 3-1: Corresponding parameter timing specifications"*.

Table 3-1: Corresponding parameter timing specifications

Symbol	Parameter	Typ.	Max.	Unit
tPROG_RAND	Page programming time (Randomizer enabled)	360	740	us
tCBSY_RAND (Program)	Busy time for cache program (Randomizer enabled)	30	740	us
tDP_RAND	CE# high to deep power-down mode with randomizer enable (Idle/Read/Program/Erase)		1/25/740/5000	us

4. Supporting Measures

To use Randomizer correctly, you need to pay attention to the following supporting measures:

1. The values of the RANDOPT register and the RANDEN register are of Volatile type (V2 type). V2 type, its value is volatile and returns to the default state after power-on. The default value can be changed once, and then the user can still use the "setting function" to change the values of these two bits because they are volatile types, but they will return to the default state after the next power-on.

2. The OTP area is also scrambled if the randomizer function is enabled.

3. The NOP=1 for the randomizer-covered data area.

4. There will be some parameter timing spec getting longer at Randomizer operation: page program time(tPROG_RAND) will be 360us(typical) and 740us(max.), Cache program busy time (tCBSY_RAND) will be 30us(typ.) and 740us(max.), the tDP_RAND (CE# high to deep power-down mode with randomizer enable on Idle/Read/Program/Erase) will be 1/25/740/5000

5. Reference Documents

"Table 5-1: Datasheet Version" shows the datasheet versions used in this application note. For the most current, detailed Macronix specification, please contact Macronix Sales and distributors.

Table 5-1: Datasheet Version

Datasheet	Location	Date Issued	Versions
MX30UF1G_2G_4G28AD	Macronix Web site	August 04, 2022	Rev. 1.2
MX30LF1G_2G_4G28AD	Macronix Web site	August 04, 2022	Rev. 1.3
MX35UF1G_2G_4G24AD	Macronix Web site	October 07, 2022	Rev. 1.2
MX35LF1G_2G_4G24AD	Macronix Web site	February 21, 2022	Rev. 1.2

6. Revision History

Revision No.	Description	Page	Date
Rev. 1	Initial Release	ALL	November 02, 2023

For the contact and order information, please visit Macronix's Web site at: http://www.macronix.com