AN14770

Using SmartDMA for Keyscan on MCX A Series MCU

Rev. 1.0 — 30 July 2025 Application note

Document information

Information	Content
Keywords	AN14770, Pmod header, SmartDMA, keyscan, MCX A
Abstract	This application note introduces the keyscan solution for MCX A series MCU.

1 Introduction

This application note introduces the keyscan solution for MCX A series MCU. It includes the introduction of the keyscan solution, its features and API routines, and a demo.

All MCX A series MCUs include a SmartDMA coprocessor, which can effectively reduce the load on the Arm core and perform fast I/O operations.

2 Target application

As the name suggests, the keyscan solution is used in key scanning applications, such as in a computer keyboard. However, it can also be used in other scenarios, such as in a requirement where continuous scanning of IO port input is required.

3 Keyscan interfaces

The keyscan scheme has no fixed interface. It can be used for matrix scanning and for row or column scanning. The number of scanned keys can be one or from one to two hundreds.

If it is a commonly used computer keyboard, it is generally 101 keys, 104 keys, or 87 keys. If it is a small keyboard, it is 4x4 to get 16 keys generally. It can also be used for irregular button matrix. In short, the button layout and the number of buttons can be customized.

This document uses a 4x4 matrix keyboard, however, the interface is not fully compatible. It only supports the determination of 2x4 with a total of 8 keys. To achieve the determination of 16 keys, rework the hardware with some wires.

4 Features of keyscan solution

The features of the keyscan solution are as follows:

- 4 x 4 keyscan
- Superfast key scan without Arm core intervention (>= 8 kHz report rate)
- Programmable debounce time
- Easy to support 8 x 16 or other size
- Easily portable to other platforms

5 Functional description

This section describes the functional description of the keyscan solution.

5.1 Keyscan engine

SmartDMA, functioning as a coprocessor for the MCX A series MCU, is designed for highly efficient instruction execution. It can quickly and efficiently complete key scanning operations. During the scanning process of button operations, the Arm core need not intervene. An interrupt is sent to the Arm core only when there is a change in the key value. The Arm core must only read the key value from the RAM.

5.1.1 Keyscan driver lib

The instructions of SmartDMA use the type of machine code. The code implements the functions of the keyscan solution and is released in a C array. Some API routines are provided in this application. You can use API routines to initialize the engine and configure the pins, start, or stop keyscan.

5.2 System clock

The keyscan engine shares the system clock with the Arm core. Lowering the system clock frequency reduces the speed at which SmartDMA executes code.

5.3 Memory usage

The code of SmartDMA must be loaded and executed at a fixed location, which in this application is 0x04000000. Changing the execution instruction location requires regeneration of the instruction code array.

5.4 Hardware description

Connect the PmodKYPD board with the FRDM-MCXA346 board, as shown in Figure 1.

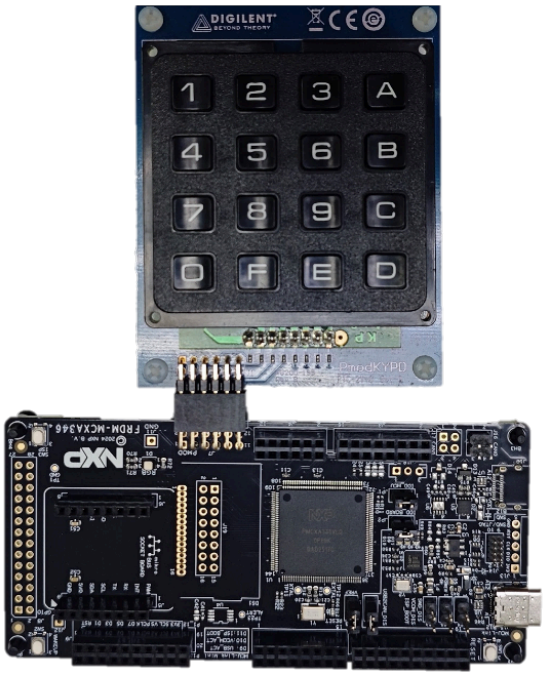

Figure 1. Hardware connection

Note: *The PmodKYPD board can be purchased from here.*

Figure 2 shows the PmodKYPD schematic.

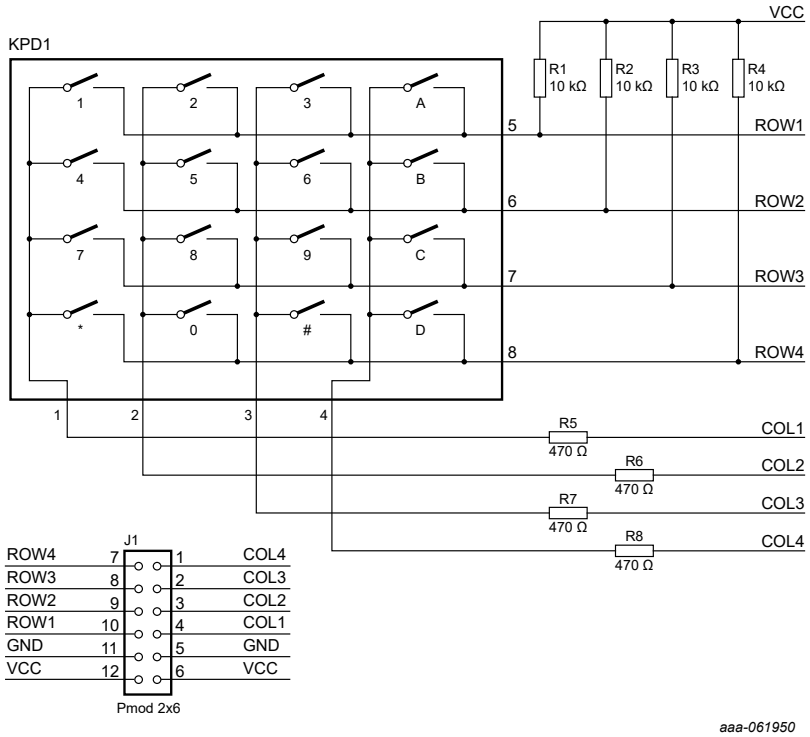

Figure 2. Keyscan schematic

Figure 3 shows the schematic of Pmod header on the FRDM-MCXA346 board.

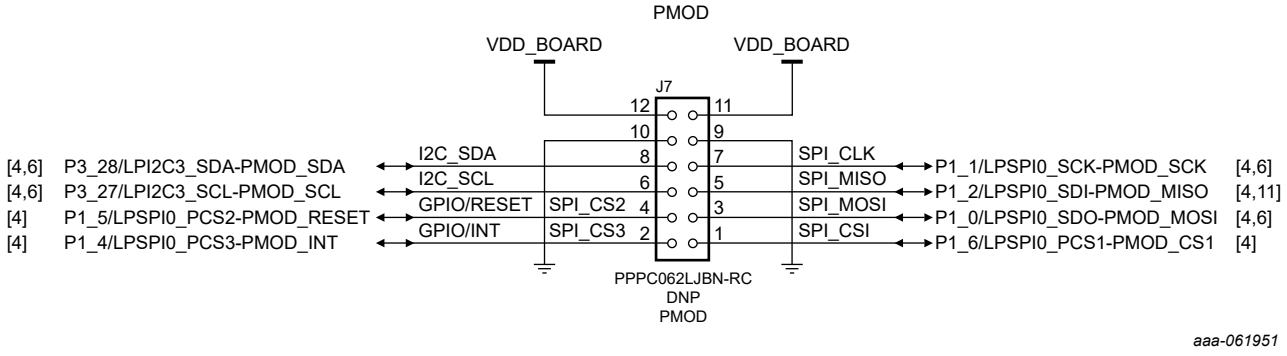

Figure 3. PMOD interface signals

5.4.1 Pin description

Figure 4 shows how to connect the PmodKYPD board with the FRDM-MCXA346 board.

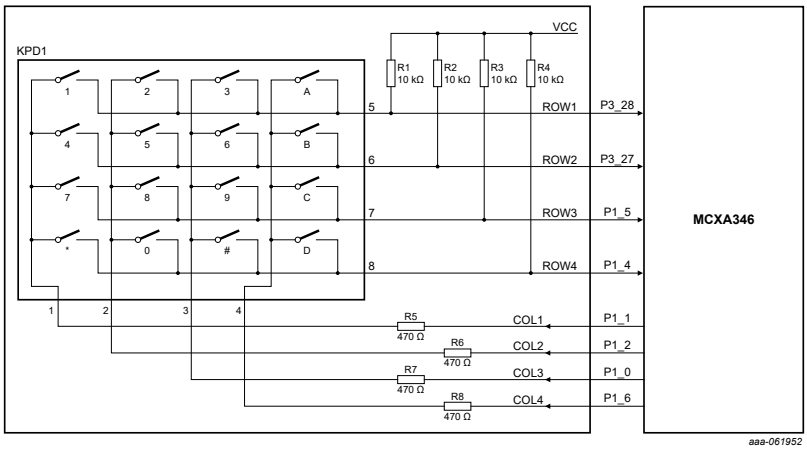

Figure 4. Hardware connection`

5.5 Keyscan timings

When a key is not pressed, the SmartDMA continuously outputs waveforms on each column line. However, when a key is pressed, the row where the key is located has the same waveform as the column where it is located. In this way, it can locate which button is pressed.

6 Software description

This section describes the SmartDMA keyscan example and the functions to implement it.

6.1 Demo example introduction

The config tool generates the demo code in this example as a standalone "Hello World" project. Based on this project, I/O initialization code and SmartDMA driver code are added.

6.2 SmartDMA function array

The SmartDMA keyscan API can be found in the file fsl_smartdma_mcxn.h:

```
/*!
* @brief The API index when using s_smartdmaKeyscanFirmware
*/
enum _smartdma_keyscan_api
{
/*!using Smartdma to control GPIO . */
kSMARTDMA_Keyscan_4x4 = 0U,
};
```

In the fsl_smartdma_mcxn.c file, there is an array called s_smartdmaKeyscanFirmware, which contains the implementation of SmartDMA keyscan functions. The purpose of encapsulating the SmartDMA functions into an array is to reduce the research cost for users. This approach allows them to use pre-implemented module functions directly, enabling faster development of application features.

6.3 SmartDMA initialization

Table 1 lists the functions that implement the SmartDMA initialization.

Table 1. API routines

Routine	Description
`SMARTDMA_InitWithoutFirmware`	Initialize the SmartDMA
`SMARTDMA_InstallFirmware`	Install the firmware
`SMARTDMA_InstallCallback`	Install the complete callback function
`SMARTDMA_Boot`	To run the program, boot the SmartDMA
`SMARTDMA_Deinit`	Deinitialize the SmartDMA
`SMARTDMA_Reset`	Reset the SmartDMA
`SMARTDMA_HandleIRQ`	SmartDMA IRQ
`SmartDMA_keyscan_callback`	SmartDMA interrupt callback

6.3.1 Init SmartDMA

To enable SmartDMA, perform the following operations:

- Clear reset of SmartDMA
- Enable the clock for SmartDMA
- Enable the IRQ for SmartDMA

6.3.2 Install SmartDMA firmware

The function module of SmartDMA must be placed at a fixed memory address to work properly. In this application, it must be placed at 0x04000000.

For example:

```
/*! @brief The firmware used for keyscan. */
extern const uint8_t s_smartdmaKeyscanFirmware[];
/*! @brief The s_smartdmaKeyscanFirmware firmware memory address. */
#define SMARTDMA_KEYSCAN_MEM_ADDR 0x04000000U
/*! @brief Size of s_smartdmacameraFirmware */
#define SMARTDMA_KEYSCAN_FIRMWARE_SIZE (s_smartdmaKeyscanFirmwareSize)
/*! @brief Size of s_smartdmacameraFirmware */
extern const uint32_t s_smartdmaKeyscanFirmwareSize;
```

The process of installing SmartDMA firmware is essentially copying the code array of SmartDMA function modules to a specified RAM address.

The following snippet is the related code:

```
SMARTDMA_InitWithoutFirmware();
```

```
SMARTDMA_InstallFirmware(SMARTDMA_KEYSCAN_MEM_ADDR,s_smartdmaKeyscanFirmware,
 SMARTDMA_KEYSCAN_FIRMWARE_SIZE);
```

6.3.3 SmartDMA callback routine

SmartDMA can actively trigger an interruption in the Arm core, such as after the end of data transfer.

SmartDMA has a related interrupt number (SMARTDMA_IRQHandler) in the Arm vector table. In the configuration phase of SmartDMA, a callback function can be installed.

The following snippet is the related code:

```
SMARTDMA_InstallCallback(SmartDMA_keyscan_callback, NULL);
```

In the callback function, the Arm core can read the pressed key value and print the log.

6.3.4 Boot SmartDMA API

In the application, define a structure to set parameters related to SmartDMA. These parameters include the address of the data buffer, the length of data transfer, and the address of SmartDMA stack space. The most important thing is to find an API that must be executed from the SmartDMA function block code.

The following snippet is the related code:

```
smartdmaParam.smartdma_stack = (uint32_t*)g_samrtdma_stack;
smartdmaParam.p_gpio_reg = (uint32_t*)g_keyscan_gpio_register;
smartdmaParam.p_keyvalue = (uint32_t*)KeyValue; smartdmaParam.p_keycan_interval
 = (uint32_t*)&g_keyscan_interval; SMARTDMA_Boot(kSMARTDMA_Keyscan_4x4,
 &smartdmaParam, 0x2);
```

The boot process involves assigning the address of the corresponding API to the program counter of SmartDMA after which it begins to execute the function block.

7 Download and run demo based on FRDM-MCXA346

This section describes how to prepare and run the demo that is based on the FRDM-MCXA346 board. The demo can be found in the software package SDK_25_06_00_FRDM-MCXA346.

The example path: SDK_25_06_00_FRDM-MCXA346\boards\frdmmcxa346\demo_apps\

7.1 Prepare the demo

To prepare the demo, perform the following steps:

1. Connect the USB Type-C to micro-USB cable between the PC host and the USB port on the board.
2. Open a serial terminal on a PC for the serial device with the following settings:
   Baud rate = 115200
   Data bits = 8
   Parity = None
   Stop bit = One
   Flow control = None
3. Download the program to the target board.

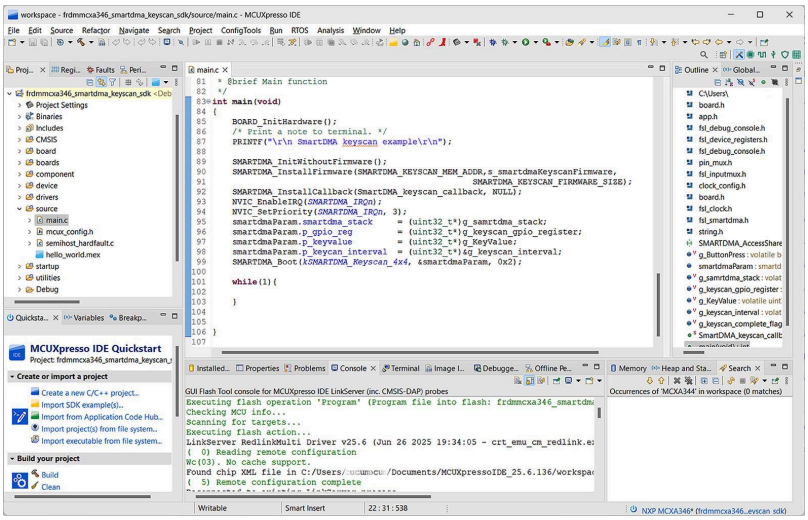

Figure 5. Project

4. To begin running the demo, either press the reset button on your board or launch the debugger in your IDE.

7.2 Run the demo

To run the demo, perform the following steps:

1. When the demo program is executed, the serial terminal prints the following lines:

```
SmartDMA keyscan example
```

2. Press any button on PmodKYPD. As a result, the serial terminal prints the following lines:

```
Button 2 is pressed
Button 1 is pressed
Button B is pressed
Button 6 is pressed
Button 5 is pressed
```

8 Note about the source code in the document

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9 Revision history

Table 2 summarizes the revisions to this document.

Table 2. Revision history

Document ID	Release date	Description
AN14770 v.1.0	30 July 2025	Initial public release

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