Using M030G I2C to Read NCT7712Y Thermal Sensor

Example Code Introduction for 32-bit NuMicro® Family

Document Information

Application	This example code uses M030G I2C to read NCT7712Y thermal sensor.
BSP Version	M030G_Series_BSP_CMSIS_V3.02.000
Hardware	NuMaker-M030GTD V1.2

1. Overview

Microcontrollers are widely used in different ambient temperatures. Nuvoton NuMicro® Cortex®–M0 M030G/M031G Series assort with NCT7712Y high-precision temperature sensor, so that the current temperature can be monitored at any time. This example sample shows how to use the I2C to get the temperature value of the temperature sensor.

1.1 Principle

The NCT7712Y is an one on-chip local thermal sensor with high accuracy, a 12-bit ADC (Analog-to-Digital Converter) is built inside NCT7712Y to convert the monitored temperature value with 0.0625°C resolution.

1.1.1 Register Summary of NCT7712Y

The NCT7712Y register map is shown in Figure 1-1.

Idx	Register Name	Attr	Dft	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	LDT Readout	RO	0000	MNTREG_LT[12:0]/MNTREG_LT[11:0], 1'b0													RSV		EM
1	Configuration	RW	6080	OS	R[1:0]		F[1:0]		POL	TM	SD	CR[1:0]		AL	EM	RSV			
2	LT Low Alert Temp	RW	2580/ 4B00	LTLL[12:0]/LTLL[11:0], 1'b0													RSV		
3	LT High Alert Temp	RW	2800/ 5000	LTHL[12:0]/LTHL[11:0], 1'b0													RSV		
FD	CID (Chip ID)	RO	D1B5	16'hD1B5															
FE	VID (Vendor ID)	RO	50	8'h50								RSV							
FF	DID (Device ID)	RO	10	8'h10								RSV							

Figure 1-1 Register Map of NCT7712Y

Figure 1-2 shows the NCT7712Y temperature readout register.

Location : Address 00h
Type : Read Only
Power on default value : 00h

BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
NAME	**Local Diode Temperature Readout Value.** The real temperature value calculation is referred to TEMPERATURE MEASUREMENT DATA FORMAT.															
VALUE	Sign	MNTREG_LT_MSB[10:4]							MNTREG_LT_LSB [3:0]				RSV			0
		*MNTREG_LT_MSB[11:4]									*MNTREG_LT_LSB [3:0]			RSV		*1

* The extended mode 13-bit configuration when EM bit is set 1'b1.

BIT	DESCRIPTION
15-0	The MNTREG_LT_MSB is an integer part. The MNTREG_LT_LSB is a decimal part.

Figure 1-2 Temperature of NCT7712Y Register Readout

Figure 1-3 shows the configuration register description of NCT7712Y

BIT	15	14	13	12	11	10	9	8
NAME	OS	R[1:0]		F[1:0]		POL	TM	SD
DEFAULT	0	1	1	0	0	0	0	0
BIT	7	6	5	4	3	2	1	0
NAME	CR[1:0]		AL	EM	RSV			
DEFAULT	1	0	0	0				

BIT	FLAG NAME	DESCRIPTION
15	OS	**One Shot :** Write 1 ADC will monitor one time If read '1' indicates ADC is busy converting, '0' indicates ADC is idle status.
14-13	R	**Converter Resolution :** 00: decimal point set 1 bit (0.5'C) 01: decimal point set 2 bits (0.25'C) 10: decimal point set 3 bits (0.125'C) 11: decimal point set 4 bits (0.0625'C)
12-11	F	**Fault Queue :** 00=1 times (default), 01=2 times, 10=4 times, 11=6 times
10	POL	**Polarity :** The polarity bit lets the user adjust the polarity of the ALERT pin output. If the POL bit is set to 0 (default), the ALERT pin becomes active low. When POL bit is set to 1, the ALERT pin becomes active high and the state of the ALERT pin is inverted. 0: low active 1: high active
9	TM	**Mode Alert :** ALERT output mode: 1=interrupt mode, 0=compare interrupt mode
8	SD	**Shutdown :** 1 indicates deep shut-down is enable
7-6	CR	**Conversion Rate:** 00 : 0.25Hz conversion rate; 01 : 1Hz conversion rate; 10 : 4Hz conversion rate; 11 : 8Hz conversion rate
5	AL	**Alert status (read only) :** Comparator mode (real time) status.
4	EM	**Extended Mode :** 0: normal mode: 12 bit, -128~127.9375 1: extended mode: 13 bit, (temperature register, high- & low-limit registers)

Figure 1-3 Configuration Register Description of NCT7712Y

1.2 Data Format

NCT7712Y provides I2C to access the internal register, supports I2C byte read/write and word read/write protocols.

1.2.1 The Formula of Temperature Sensor

The temperature sensor can sense temperature range -50°C ~ +128°C, the temperature data with 12-bits 2's complement format is shown in Table 1-1

TEMPERATURE	12-BIT DIGITAL OUTPUT
+128°C	0111 1111 1111
+127.9375°C	0111 1111 1111
+25°C	0001 1001 0000
+1°C	0000 0001 0000
+0.125°C	0000 0000 0010
+0°C	0000 0000 0000
- 0.125°C	1111 1111 1110
- 1°C	1111 1111 0000
- 25°C	1110 0111 0000
- 50°C	1100 1110 0000

Table 1-1 The Temperature Data with 12-bits 2's Complement Format

1.2.2 Data Write to Internal Register Format

Data write to register format shows as Figure 1-4

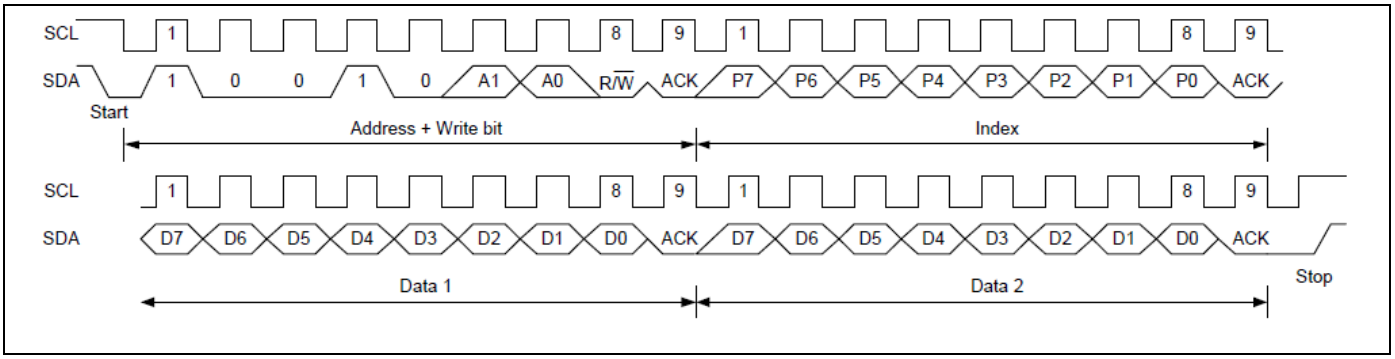

Figure 1-4 Data Write to Internal Register Format

1.2.3 Data Read from Internal Register Format

Data read from register format shows as Figure 1-5

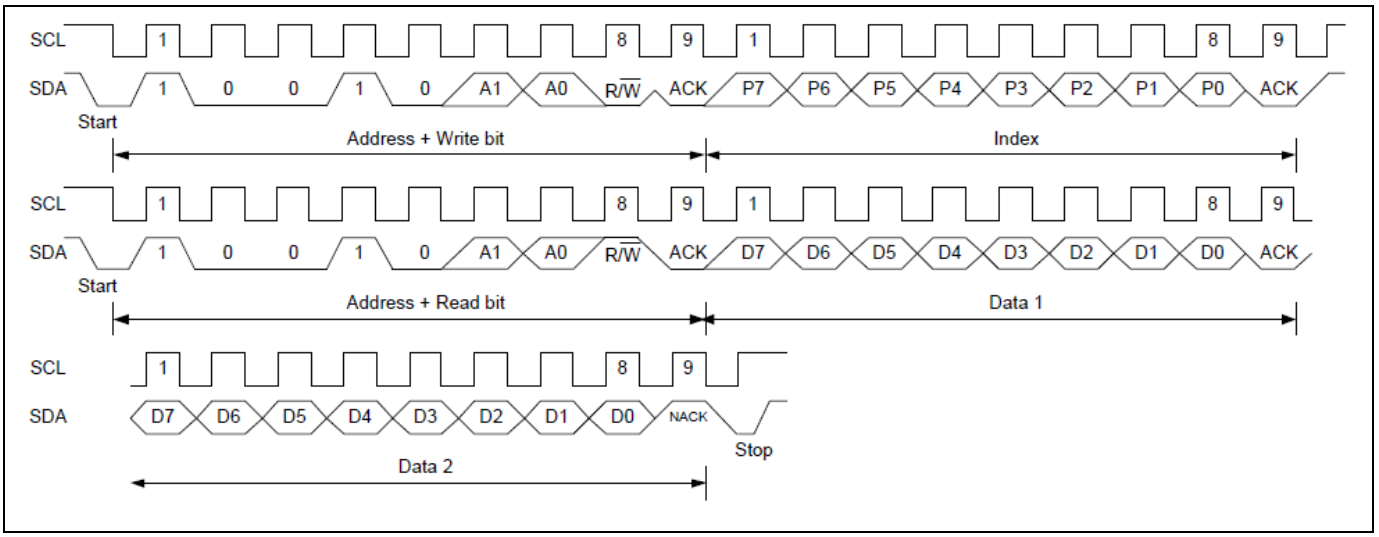

Figure 1-5 Data Read from Internal Register Format

1.2.4 Device Address Setting

NCT7712Y device address setting shows as Figure 1-6

ADR pin connection	Interface Address
V_{SS}	1001_000xb
V_{DD}	1001_001xb
SDA	1001_010xb
SCL	1001_011xb

Figure 1-6 Device Address Setting

Note1: above pictures are from NCT7712Y DataSheet

1.3 Demo Result

1.3.1 I2C Readout Register Data

Using the I2C readout register data shows as Figure 1-7:

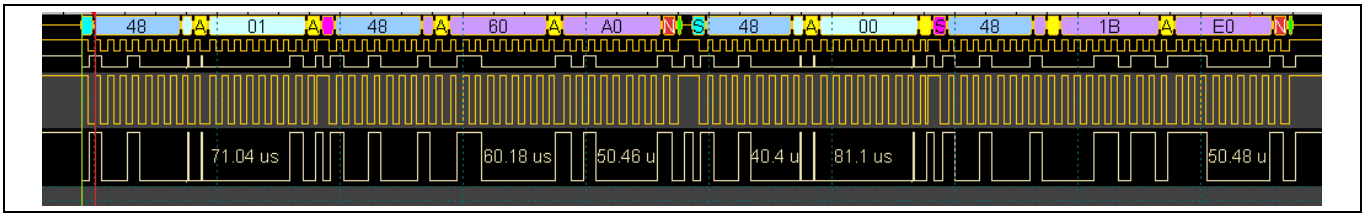

Figure 1-7 Using the I2C Readout Register Data

The readout data is 01beh, LSB bit0 ~ bit3 are reserved.

Hexadecimal	Decimal	Temperature (°C)
01beh	446	27.8750

1.3.2 Printout the Current Temperature Value via UART

Printout the current temperature value via UART, shows as Figure 1-8

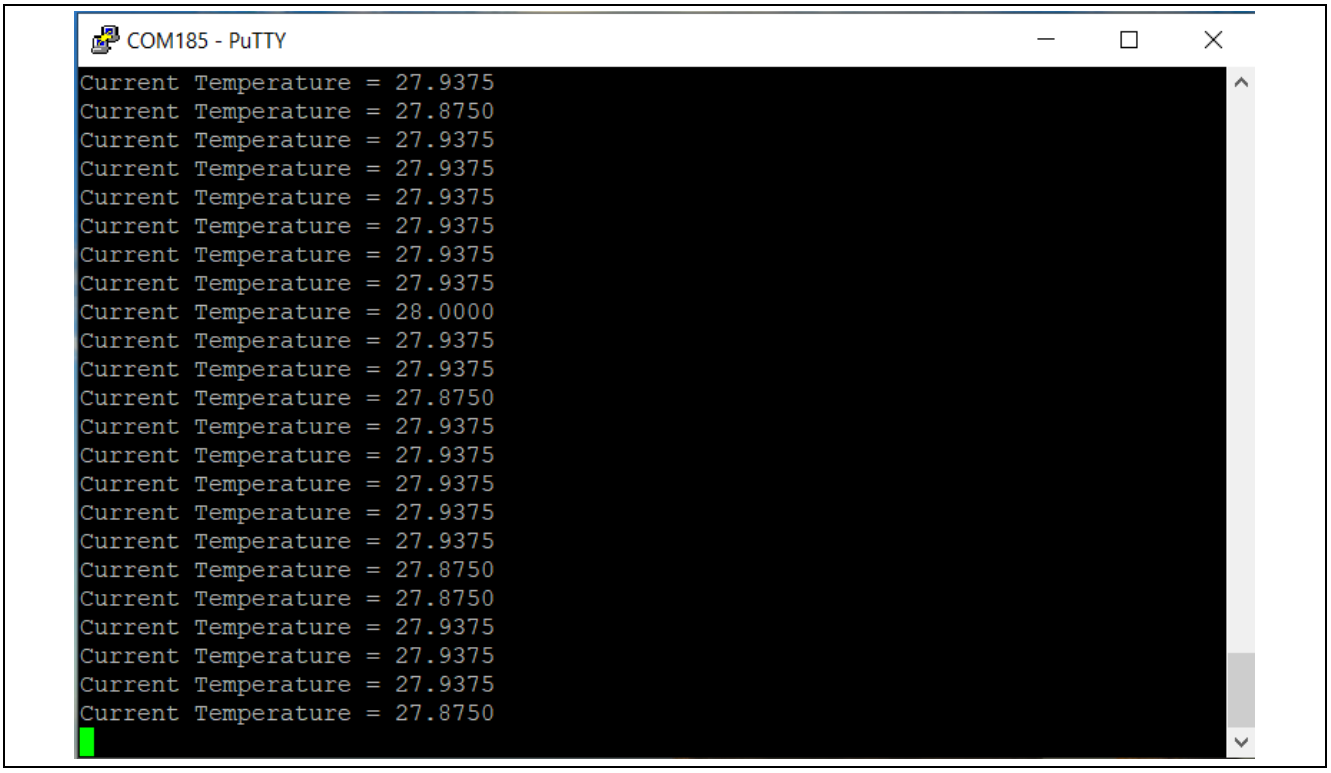

Figure 1-8 Printout the Current Temperature Value via UART

2. Code Description

2.1 Main Loop Flowchart

Main loop flowchart shows as Figure 2-1

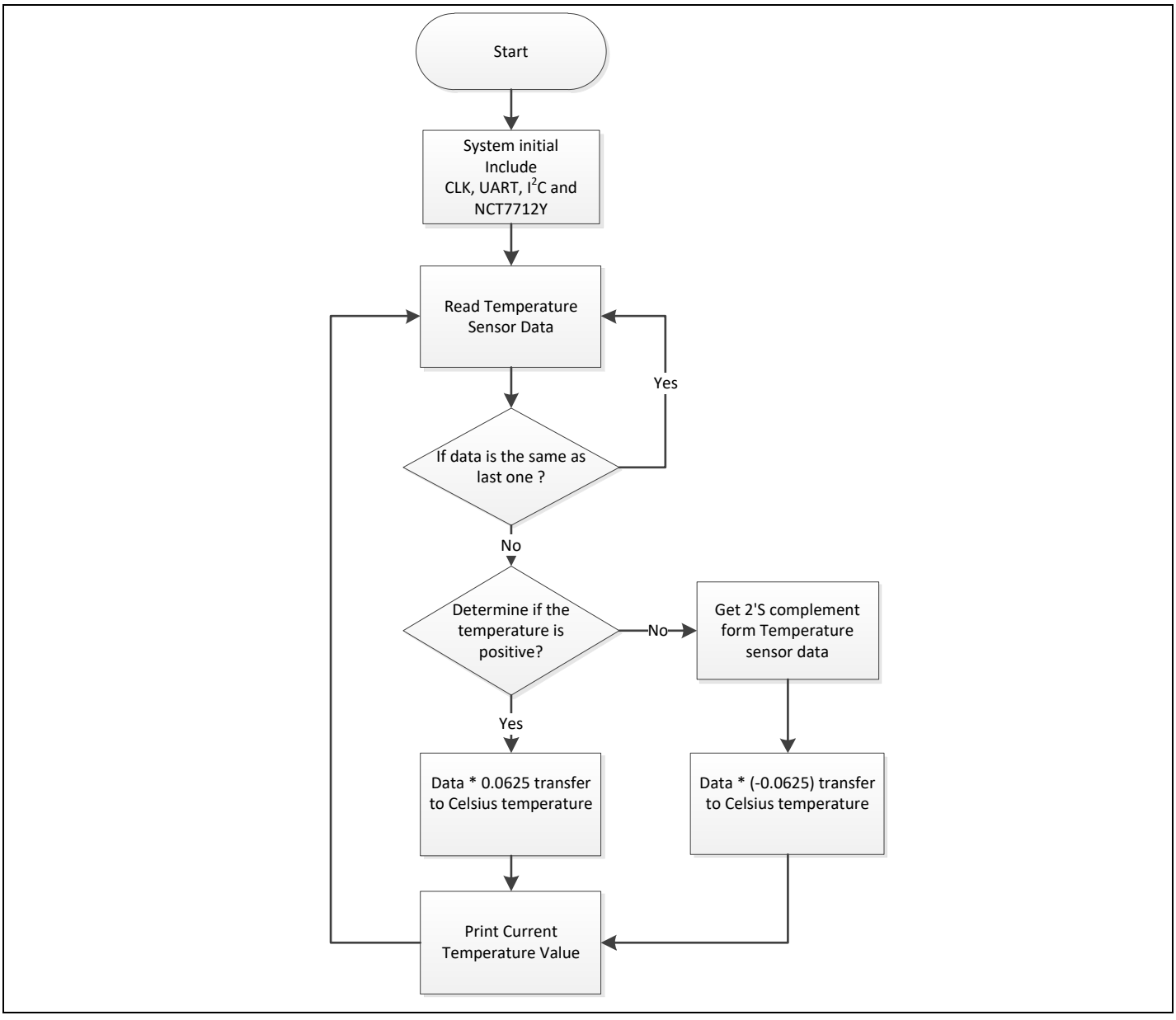

Figure 2-1 Main Loop Flowchart

2.2 Define NCT7712Y

Define NCT1172Y Address, Data and Register

```
#define OPT_NCT7712Y_RAWDATA
#define NCT7712Y_SLAVE_ADDR      0x48   // NCT7712Y ADR pin is Low
#define NCT7712Y_REG_WIDTH       0x02   // register data width 2 bytes
#define NCT7712Y_DATA_READY      BIT15  // NCT7712Y DataReady flag in bit-15 of Config.
#define NCT7712Y_REG_TEMP        0x00   // temp data in regIndex 0x00
#define NCT7712Y_REG_CONFIG      0x01   // Config. register in regIndex 0x01
```

2.3 Initial NCT7712Y Config Register

Initial NCT7712Y Config register and description

```
void NCT7712Y_init(uint8_t u8RegIndex)
{
    uint8_t u8i2cBuf[2];

    u8i2cBuf[0] = 0x60;// High Byte : Converter Resolution :  0.0625 ;
    u8i2cBuf[1] = 0x80;// Low Byte  : Conversion Rate : 4Hz conversion rate;
    /*-------------------------------------------------------------------------------*/
    /* bit3~0 :   Reserved                                                           */
    /* bit4   :   Extended Mode :                                                    */
    /*                  0: normal mode: 12 bit, -128~127.9375;                       */
    /*                  1: extended mode: 13 bit;                                    */
    /*                  (temperature register, high- & low-limit registers)          */
    /* bit5   :   Alert status (read only)                                           */
    /*                  Comparator mode (real time) status;                          */
    /* bit7~6 :   Conversion Rate :                                                  */
    /*                  00 : 0.25Hz conversion rate;                                 */
    /*                  01 : 1Hz conversion rate;                                    */
    /*                  10 : 4Hz conversion rate;                                    */
    /*                  11 : 8Hz conversion rate;                                    */
    /* bit8   :   Shutdown :                                                         */
    /*                  1 indicates deep shun-down is enable;                        */
    /* bit9   :   Mode Alert :                                                       */
    /*                  ALERT output mode:                                           */
    /*                  1=interrupt mode;                                            */
    /*                  0=compare interrupt mode;                                    */
    /* bit10  :   Polarity :                                                         */
    /* The polarity bit lets the user adjust the polarity of the ALERT pin output.   */
    /* If the POL bit is set to 0 (default), the ALERT pin becomes active low.       */
    /* When POL bit is set to 1, the ALERT pin becomes active high                   */
    /* and the state of the ALERT pin is inverted.                                   */
    /* 0: low active                                                                 */
    /* 1: high active                                                                */
    /* bit12~11:  Fault Queue :                                                      */
    /* bit14~13:  Converter Resolution :                                             */
    /*                  00: decimal point set 1 bit  (0.5'C)                         */
    /*                  01: decimal point set 2 bits (0.25'C)                        */
    /*                  10: decimal point set 3 bits (0.125'C)                       */
    /*                  11: decimal point set 4 bits (0.0625'C)                      */
    /* bit15   :  One Shot :                                                         */
    /*                  Write 1 ADC will monitor one time                            */
```

```
    /* If read'1' indicates ADC is busy converting, '0'indicates ADC is idle status.*/
    /*---------------------------------------------------------------------------*/

    I2C_WriteMultiBytesOneReg(I2C0, NCT7712Y_SLAVE_ADDR, u8RegIndex, u8i2cBuf,
    NCT7712Y_REG_WIDTH);

}
```

2.4 Get NCT7712Y Data

Get NCT7712Y temperature data

```
static uint32_t NCT7712Y_get_data(uint8_t u8RegIndex)
{
    uint32_t u32NCT7712YData;
    uint8_t u8i2cBuf[2];

    u8i2cBuf[0] = 0x00;
    u8i2cBuf[1] = 0x00;
    I2C_ReadMultiBytesOneReg(I2C0, NCT7712Y_SLAVE_ADDR, u8RegIndex, u8i2cBuf,
                             NCT7712Y_REG_WIDTH);
    u32NCT7712YData = u8i2cBuf[0];
    u32NCT7712YData <<= 8;
    u32NCT7712YData &= 0xff00;
    u32NCT7712YData |= u8i2cBuf[1];
    return u32NCT7712YData;
}
```

3. Software and Hardware Requirements

3.1 Software Requirements

- BSP version
  - M030G_Series_BSP_CMSIS_V3.02.000
- IDE version
  - Keil uVersion 5.36

3.2 Hardware Requirements

- Circuit components
  - NuMaker-M030GTD V1.2
- Pin Connect
  - Connect the I2C0_SDA (PB.4) pin to the NCT7712Y_SDA (Pin6), I2C0_SCL (PB.5) pin to the NCT7712Y_SCL (Pin1), and NCT7712Y_ADR (Pin4) pin to the V_{SS} for communication with NCT7712Y to get temperature value of measurement results of this example code.

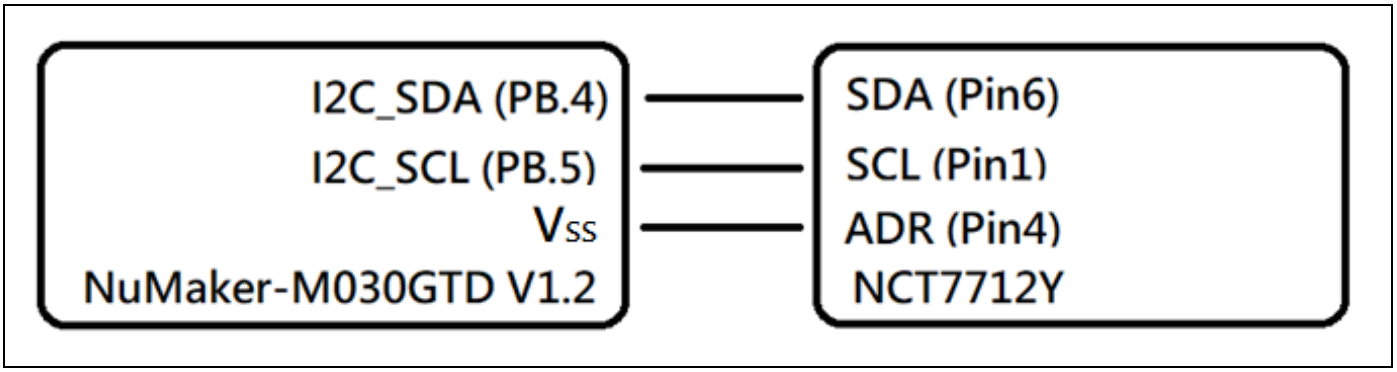

Figure 3-1 Pin Connect

4. Directory Information

The directory structure is shown below.

EC_M030G_Read_NCT7712Y_Thermal_Sensor_V1.00	
Library	Sample code header and source files
CMSIS	Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
Device	CMSIS compliant device header file
StdDriver	All peripheral driver header and source files
SampleCode	
ExampleCode	Source file of example code

Figure 4-1 Directory Structure

5. Example Code Execution

1. Browse the sample code folder as described in the Directory Information section and double-click M030G_Read_NCT7712Y_Register.uvprojx.
2. Enter Keil compile mode.
   - Build
   - Download
   - Start/Stop debug session
3. Enter debug mode.
   - Run

6. Revision History

Date	Revision	Description
2022.08.26	1.00	Initial version.

Important Notice

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