# AN12368

## NTAG 5 link - I²C master mode

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Application note
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**Document information**

| Information | Content |
|---|---|
| Keywords | NTAG 5 I2C master mode, NTP5332, NTA5332, sensor, memory, I2C slaves |
| Abstract | NTP5332 and NTA5332 can act as a transparent I2C channel. NFC enabled devices can exchange data with I2C slaves without the help of an µC. |

## Revision history

| Rev | Date | Description |
|---|---|---|
| v.1.0 | 20200109 | First official released version |

# 1 Abbreviations

**Table 1. Abbreviations**

| Acronym | Description |
|---|---|
| $I^2C$ | Inter-IC communication |
| IC | Integrated Circuit |
| MCU | Microcontroller unit |
| NFC | Near Field Communication |
| POR | Power On Reset |
| VCD | Vicinity Coupling Device |
| VICC | Vicinity Integrated Circuit Card |

# 2 Introduction

This document describes NTAG 5 link (NTP5332) and NTAG 5 boost (NTA5332) [Data sheet] capabilities of I²C master mode.

This mode enables a transparent I²C master channel between NFC and I²C interfaces. NTAG 5 can **power** [Application note] **and** act as **I²C Master** for any I²C slave device (e.g. sensor, external memory, LCD etc.) without a need of an MCU.

## 2.1 Potential applications

“Sensor IC”:

- Draw power from the NFC reader to supply sensors
- Configure sensors with an NFC enabled device
- Read out sensor information without an MCU
- Send the sensor data to the cloud “Memory tag”

"Memory IC":

- Extend memory size to your needs
- Draw power from the NFC reader to supply external I²C memory
- Write Configuration data to the memory during production
- Read trace logs for maintenance or complaint handling

# 3 I²C Master functionality

I²C Master communication is initiated by RF interface. RF can initiate a READ or WRITE transaction to external I²C slaves. SRAM is used as intermediate storage of data ($V_{CC}$ supply on NTAG 5 needed).

Session registers reflect the status of I²C Master transaction. Therefore an RF reader has to poll for the status bits related to I²C Master to know the status of the current I²C transaction.

Hints:

- Energy harvesting functionality can be used as power source [Application note].
- Maximum of 256 bytes/transactions can be sent/read at once.

Preconditions:

1. NTAG 5 must be the only I²C master acting device on the I²C-bus
2. NTAG 5 must be $V_{CC}$ powered
3. USE_CASE_CONF in CONFIG_1 must be set to 01b (I²C master)
4. SRAM needs to be enabled.

## 3.1 I²C Master relevant registers

**Table 2. Configuration registers - for I²C Master**

| NFC | I²C | Byte 0 | Byte 1 | Byte 2 | Byte 3 | Description |
|---|---|---|---|---|---|---|
| ACh | 10ACh | I2C_M_S_ ADD_REG | I2C_M_ LEN_ REG | RFU | RFU | I²C Master Configuration |
| ADh | 10ADh | I2C_M_ STATUS_REG | RFU | RFU | RFU | I²C status Register |

Below values have to be written in configuration memory to take effect after POR or Soft Reset.

**Table 3. Configuration registers**

| NFC | I²C | Byte 0 | Byte 1 | Byte 2 | Byte 3 |
|---|---|---|---|---|---|
| 3Eh | 103Eh | I2C_SLAVE_ ADDR | I2C_SLAVE_ CONFIG | I2C_MASTER_ LOW | I2C_MASTER_ HIGH |

## 3.2 NFC command set for I²C Master

**Table 4. NFC command set for I²C Master**

| Command Code | ISO/IEC 15693 command class. | NFC Forum T5T | Command name |
|---|---|---|---|
| D4h | Custom | Not defined | WRITE I2C |
| D5h | Custom | Not defined | READ I2C |

READ I²C and WRITE I²C commands use as per I²C specification the 7-bit addressing. R/W bit is set automatically by NTAG 5.

## 3.3 I²C Baud rate configuration

I2C_MASTER_SCL_LOW and I2C_MASTER_SCL_HIGH are the coefficients and can be calculated by below formula.

$$I2C\_Master\_SCL\_HIGH = \frac{Duty\_Cycle \times 6{,}78MHz}{I2C\_Frequency} - 5 \quad (1)$$

$$I2C\_Master\_SCL\_LOW = \frac{(1 - Duty\_Cycle) \times 6{,}78MHz}{I2C\_Frequency} \quad (2)$$

Example:

400 kHz of I²C frequency with duty cycle of 50 %.

- Duty_Cycle = 0.53
- I2C_Frequency = 400 kHz
- I2C_MASTER_SCL_HIGH = (0.53* 6.78 * $10^6$ /400 *$10^3$) - 5
- I2C_MASTER_SCL_HIGH = 9 – 5 = 4
- I2C_MASTER_SCL_LOW = 0.53 * 6.78 * $10^6$ /400 *$10^3$
- I2C_MASTER_SCL_LOW = 7

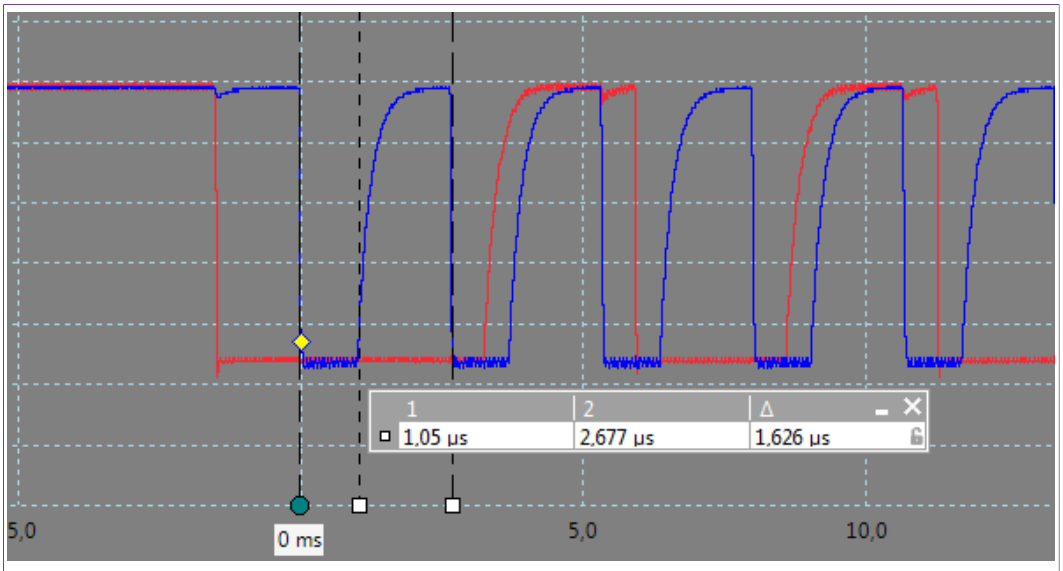


**Figure 1. Duty cycle from EXAMPLE (400 kHz)**

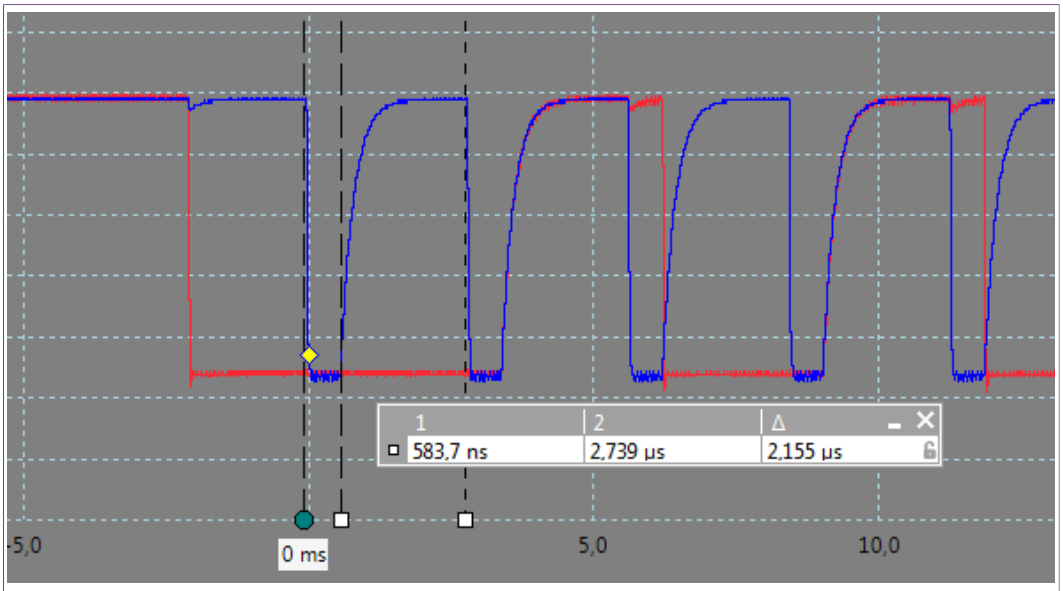


**Figure 2. Duty cycle example 2**

# 4 Implementation hints

## 4.1 I²C Repeated START communication

To shorten or to speed up the I²C communication, STOP condition can be left out for some I²C devices. It is often used where there is a need to first address the device and then read back values from the same device right away.

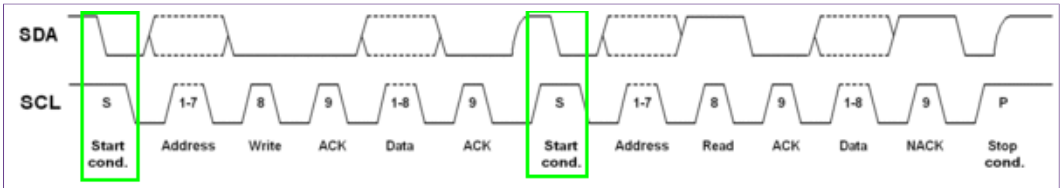


**Figure 3. I²C Repeated Start**

I²C Repeated START can be generated by I²C Master, when I²C_M_RS_EN = 1b.

## 4.2 I²C Master Data Length

How much data was sent over I²C in the last transaction (read or write), is reflected in I2C_M_LEN_REG byte.

## 4.3 Watch dog timer

This status bit reflects if WDT expired in the last transaction. This bit resets automatically, when new transaction is triggered. Watchdog Timer unlocks I²C, if NTAG is holding SDA down (both Master and Slave modes).

If WDT_EN = 1b (0b disables WDT):

- WDT Start:
  - WDT start at every memory access is initiated.
- WDT Stop:
  - WDT expires
  - I²C_IF_LOCKED = 0
  - I2C Reset.

WDT is not set or reset for register access.

# 5 Example application

For the reference application with source code refer to [Application Note].

In following example application, NTAG 5 is configured as the I²C Master. NTAG 5 can also provide RF harvested energy (Energy harvesting) [Application Note]. Configured as I²C Master, NTAG 5 link provides Clock (SCL) to the I²C-bus.

Following devices are used:

| Device | Role | Description | I²C command showcase | I²C address | Description |
|---|---|---|---|---|---|
| NTAG 5 | I²C Master | In an I²C master mode | READ/WRITE | n/a | [Datasheet] |
| NXP FXOS8700CQ | I²C Slave | 6-axis sensor with integrated linear accelerometer and magnetometer | READ | 0x1E (7-bit address) | [Datasheet] |

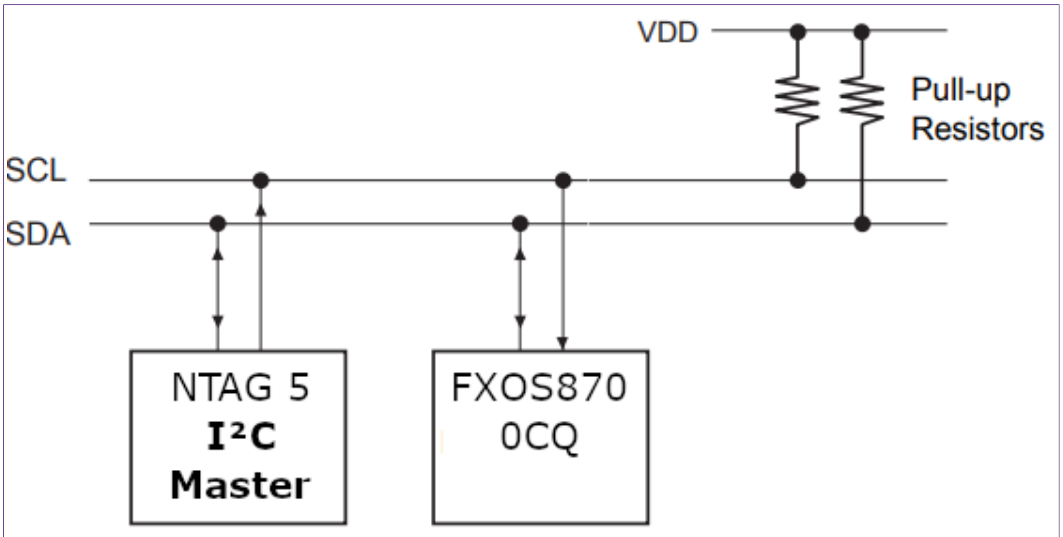


**Figure 4. I²C Interface System Configuration Example**

## 5.1 NTAG 5 configuration

Config I²C Master functionality can be configured from RF or I²C side.

**Note**: When I²C master is activated, access from I²C perspective is not possible anymore.

Desired behavior in following example:

1. NTAG 5 configured in I²C master mode
2. NTAG 5 Energy Harvesting enabled (Output voltage: 2.4 V, 0.3 A)
3. I²C Baud speed: 400 kHz (as calculated in [Section 3.3])

## 5.2 FXOS8700CQ configuration

1. Sensor's standby mode needs to be configured
   VCD → VICC: 02 D4 04 1F 01 2A 00
2. Change to the hybrid mode so Accelerometer and Magnetometer are both active at the same time
   VCD → VICC: 02 D4 04 1F 01 5B 1F
3. Configure Control register
   VCD → VICC: 02 D4 04 1F 01 5C 20
4. Enters sensors active state / enable sensor
   VCD → VICC: 02 D4 04 1F 01 2A 0D

## 5.3 Reading data - 6 axis sensor

Following procedure is taken:

1. Write I²C address + memory/register address with most significant bit set to 1b
2. Read byte by sending I²C address + num. bytes with MSb set to 0b
3. Data read from I²C slave is put to SRAM of NTAG. Read data from SRAM of NTAG (7 bytes in our example - length of answer is known)
4. (optional) Check proper I²C operation, I²C master status register 0xAD may be checked for debugging

**Table 5. Example: Enable Gyroscope - RF Command: VCD to VICC**

| Flags | Command code | IC manuf. code | I²C param | Data Length N | Data (Byte 1) | Data (Byte 2) | CRC 0 | CRC 1 |
|---|---|---|---|---|---|---|---|---|
| 02 | D4 | 04 | 1E | 01 | 2A | 0D | 76 | B1 |

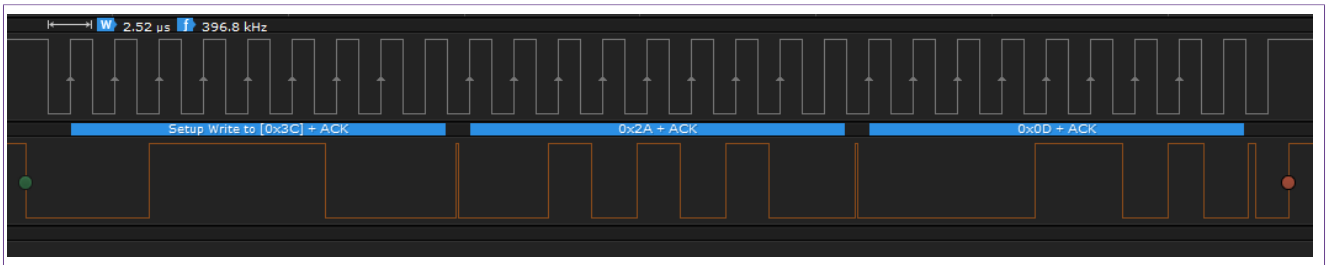


**Figure 5. Signal generated by NTAG 5 on I²C-bus: Enable Gyroscope command sent to I²C Slave (FXOS8700CQ, address 1Eh) at 400 kHz**

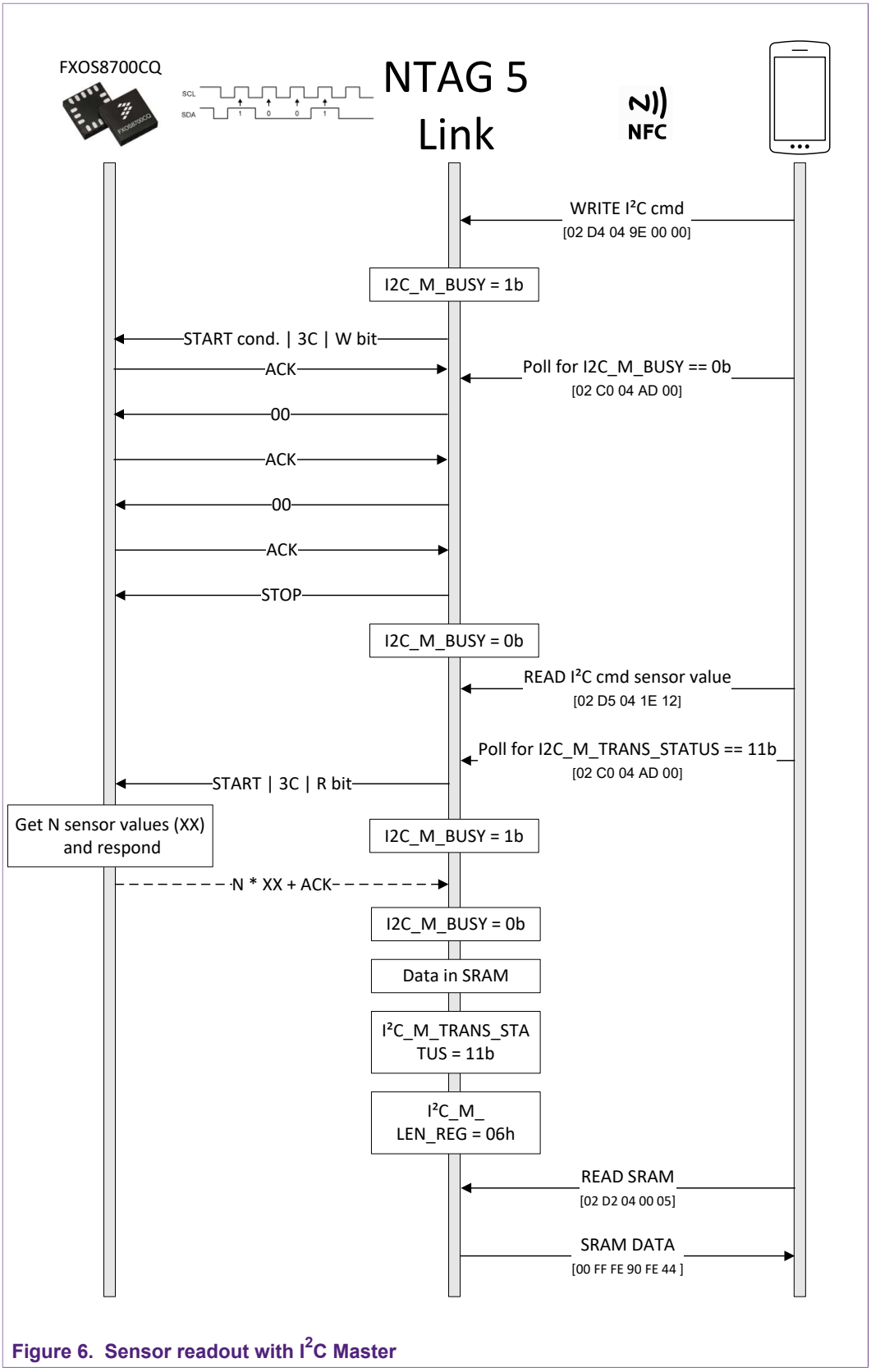


**Figure 6. Sensor readout with I²C Master**

# 6 References

[1] NTP53x2 - NTAG 5 link, NFC Forum-compliant I²C bridge, doc.no. 5476xx
https://www.nxp.com/docs/en/data-sheet/NTP53x2.pdf

[2] AN11201 - NTAG 5 How to use energy harvesting, doc.no. 5304xx
https://www.nxp.com/docs/en/application-note/AN11201.pdf

[3] RM00221 - NTAG 5 Android Application development, doc.no. 5318xx
https://www.nxp.com/docs/en/reference-manual/RM00221.pdf

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# Tables

## Figures

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