Frequently asked questions for TRF7970A and TRF7964A devices

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ABSTRACT

For the purposes of this document, *TRF79xxA* refers to the following devices unless otherwise specified: TRF7970A and TRF7964A

This guide contains a compilation of frequently asked questions concerning the TRF79xxA series of devices. It serves as a central resource for evaluating or designing with the TRF79xxA devices. This guide includes links to recommended evaluation modules, TI Designs, firmware examples, and other collateral that is relevant for the TRF79xxA family.

Contents

1 General Questions ... 3
1.1 What is the TRF79xxA? ... 3
1.2 What protocols are supported by the TRF7960A, TRF7970A, and variants? ... 3
1.3 What evaluation hardware and firmware should I get to evaluate the TRF79xxA devices? ... 4
1.4 What are the expected read ranges for NFC/RFID tags with TRF79xxA evaluation hardware? ... 4
1.5 The TRF7970AEVM is not available anymore, what is the replacement? ... 5
2 NFC/RFID Operating Mode Questions ... 6
2.1 Reader/Writer Mode ... 6
2.2 Peer-to-Peer (P2P) Mode ... 6
2.3 NFC Card Emulation Mode ... 7
3 Hardware and Design Questions ... 8
3.1 Where can I get schematics and layout files for the TRF79xxA devices? ... 8
3.2 How do I design and tune an antenna to 13.56 MHz for the TRF79xxA devices? ... 8
3.3 Does TI provide FCC certification for the TRF79xxA devices? ... 8
3.4 What TI reference designs are available for the TRF79xxA devices? ... 8
4 Software Questions ... 9
4.1 I need to read a non-NFC compliant tag or transponder, what firmware example should I use? ... 9
4.2 Are there any firmware examples available for TI MCUs other than MSP430™ and MSP432™ MCUs? ... 9
4.3 Is there support for NFCLink with NCI? ... 9
4.4 Are authentication examples available for the TRF79xxA devices? ... 9
4.5 What are the recommended TRF79xxA register settings or device configuration? ... 9
4.6 What does an IRQ status of 0xC0 mean? ... 10
4.7 Are software examples available to read Topaz-512 (NFC Forum Type 1) tags? ... 10
4.8 Are software examples available to read iCLASS® or PicoPass™ tags? ... 10
5 Miscellaneous Questions ... 11
5.1 Is there any support for RF power amplifiers? ... 11
5.2 Is there any TI training collateral for NFC? ... 11
5.3 Are there Energia or Arduino examples for the TRF79xxA? ... 11
5.4 What IDEs are supported for Texas Instruments TRF79xxA firmware examples? ... 11
5.5 What Android handset interoperability is supported? ... 11
5.6 How do I configure the TRF79xxA to output a continuous or unmodulated RF field? ... 11
6 Comparison of TI NFCLink Standalone Firmware and TI RFID Reader Example Firmware ... 12
6.1 NFCLink Standalone Firmware ... 12

6.2 RFID Reader Example Firmware 12
6.3 Memory Footprint Comparison 13
7 References 13

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1 General Questions

1.1 What is the TRF79xxA?

The TRF7970A and TRF7964A are high-performance 13.56-MHz analog front end (AFE) ICs for Near Field Communication (NFC) and RFID reader/writer applications with integrated data-framing system for ISO/IEC 15693, ISO/IEC 18000-3, ISO/IEC 14443A/B, and FeliCa. The TRF7970A supports all three NFC operating modes (reader/writer, peer-to-peer and card emulation), whereas the pin-to-pin and firmware compatible TRF7964A supports only the reader/writer mode. The devices have integrated encode, decode, and data framing capability for data rates up to 848 kbps, wide supply voltage range support (2.7 V to 5.5 V), large FIFO buffer for RF communication, and an innovative RF field detector. Relevant NFC or RFID software stack libraries are offered to allow for easy development efforts and robust cost-effective designs. Eight selectable power modes and ultra-low-power operation enable long battery life applications. The devices also offer unparalleled flexibility through the various direct communication modes on the device, which allow implementations of custom and proprietary protocols as well as other 13.56-MHz standards. The receiver system enables AM and PM demodulation using a dual-input architecture to maximize communication robustness.

1.2 What protocols are supported by the TRF7960A, TRF7970A, and variants?

For this section, TRF79xxA includes the TRF7960A, TRF7962A, TRF7963A, TRF7964A, and TRF7970A.

Each TRF79xxA device includes integrated protocol handling for certain ISO/IEC or NFC Forum standards. Table 1 lists the protocols supported by all TRF79xxA devices in the TI portfolio.

Table 1. Supported Protocols

Standard	TRF7960A, TRF7964A	TRF7962A	TRF7963A	TRF7970A
ISO standards	ISO/IEC 14443A	ISO/IEC 15693	ISO/IEC 14443A	ISO/IEC 14443A
	ISO/IEC 14443B	ISO/IEC 18000-3	ISO/IEC 14443B	ISO/IEC 14443B
	FeliCa (JIS X 6319-4)		FeliCa (JIS X 6319-4)	FeliCa (JIS X 6319-4)
	ISO/IEC 15693			ISO/IEC 15693
	ISO/IEC 18000-3			ISO/IEC 18000-3
				ISO/IEC 18092
				ISO/IEC 21481
NFC Forum reader/writer standards	Type 2	Type 5	Type 2	Type 2
	Type 3		Type 3	Type 3
	Type 4A		Type 4A	Type 4A
	Type 4B		Type 4B	Type 4B
	Type 5			Type 5
NFC Forum peer-to-peer standards	N/A	N/A	N/A	Type A (initiator and target)
				Type F (initiator and target)
NFC Forum card emulation standards	N/A	N/A	N/A	Type 4A
				Type 4B

It is possible to communicate with unsupported NFC/RFID tags and devices by operating the TRF79xxA in Direct Mode 0, which requires the host MCU to run at a multiple of 13.56 MHz to encode and decode the raw subcarrier signal. This allows the raw data to be received by the host MCU, which must process the received data including handling all packet and byte framing, parity checks, and CRC calculations.

1.3 What evaluation hardware and firmware should I get to evaluate the TRF79xxA devices?

All of the latest TI EVM and example firmware offerings are for the TRF7970A. Therefore, TI recommends using a LaunchPad™ development kit and a BoosterPack™ plug-in module for the TRF7970A for evaluation of all TRF79xxA devices.

For applications that need NFC functionality such as Peer-to-Peer mode, Card Emulation mode, or the ability to support reading tags that use NDEF for data formatting, the following combination of hardware and firmware is recommended:

- Hardware: DLP-7970ABP BoosterPack plug-in module and MSP-EXP430F5529 LaunchPad development kit
- Firmware: NFCLink Standalone Firmware Stack

For RFID applications that need to detect only NFC/RFID tags or read non-NDEF data from NFC/RFID tags, the following combination of hardware and firmware is recommended:

- Hardware: DLP-7970ABP BoosterPack plug-in module and MSP-EXP430G2ET LaunchPad development kit
- Firmware: Basic RFID Reader Firmware Example

If it is not clear whether or not NDEF support is required, see Section 2.1 for further details.

The TRF79xxA devices covered in this FAQ guide are software compatible with the TRF7970A for the supported ISO/IEC and NFC standards.

1.4 What are the expected read ranges for NFC/RFID tags with TRF79xxA evaluation hardware?

The expected read range for NFC/RFID tags is an application-specific characteristic. Factors that affect the read range performance for an NFC/RFID system include: the antenna sizes of both the NFC/RFID reader and NFC/RFID tag, the output power of the NFC/RFID reader, the NFC/RFID protocol being used, and the antenna tuning parameters.

A typical expected read range with the DLP-7970ABP BoosterPack plug-in module (3.3-V powered and tuned for ISO/IEC 14443 and ISO/IEC 15693 technologies), MSP-EXP430G2ET LaunchPad development kit with TI firmware, and credit card sized TI Tag-It ISO/IEC 15693 tags is within 3 to 5 cm.

It is possible to have longer read ranges with an optimized system for specific standards. For example, ISO/IEC 15693 uses lower data rates and allows the reader antenna to be tuned to have a tighter bandwidth, which improves read range performance. If an antenna equal in size to the DLP-7970ABP onboard antenna has been tuned for a narrower bandwidth, and the TRF79xxA is powered at 5 V (to maximize output power), it is possible to have a read range of 8 to 10 cm with credit card sized ISO/IEC 15693 tags. Using a much larger antenna such as a 300-mm by 300-mm antenna and credit card sized TI Tag-It ISO/IEC 15693 tags, it is possible to have up to 20-cm read range with the TRF79xxA.

Antenna design and tuning is covered in full detail in Antenna design guide for the TRF79xxA.

To achieve read ranges up to 1 m, using a high-power HF RFID reader (for example, 1 W to 10 W) and large gate antennas (for example, 800 mm by 600 mm) are required. TI does not provide or support any designs that can achieve such ranges.

1.5 The TRF7970AEVM is not available anymore, what is the replacement?

TI has obsoleted the TRF7970AEVM. This was done as the firmware provided with in the TRF7970AEVM was out-of-date and the MCU that was used on the board did not have the required flash space to support TI's new full NFC stack.

For all applications concerning evaluation of the TRF7970A, consider the options in Section 1.3.

For applications concerning the RF430FRL152HEVM and the GUI associated with it, the following hardware and software act as the replacement for the TRF7970AEVM:

- Hardware: DLP-7970ABP BoosterPack plug-in module and MSP-EXP430G2ET LaunchPad development kit
- Firmware: Binary image for MSP-EXP430G2 LaunchPad development kit

The binary image can be flashed onto the MSP-EXP430G2 LaunchPad development kit using CCS UniFlash.

2 NFC/RFID Operating Mode Questions

2.1 Reader/Writer Mode

2.1.1 What is the difference between an NFC tag and an HF RFID tag?

An RFID tag uses proprietary data storage methods, usually just storing data in specific blocks that are defined by the developer. An NFC/RFID reader would need to know how the data is stored to interpret it.

An NFC tag uses the NFC Data Exchange Format (NDEF) to store data in tags according to the NDEF standards. This allows any NFC-enabled devices to read the data from any NFC tag and interpret it. Most applications on NFC-enabled smartphones use NDEF when reading or writing data to NFC tags.

2.1.2 Why is NDEF used? What advantages does NDEF provide?

The concept of NDEF is to create a universal format for how to store data across all NFC tags. This allows NFC devices such as smartphones to have a standard for how to read data across each NFC technology type despite varying memory structures and features.

The advantage of using NDEF is that any NFC-compliant device is able to read and write to an NDEF formatted tag allowing for excellent interoperability with a large number of devices and tags in the market.

NDEF should be leveraged for applications in which any of the following is desired:

- Compatibility with NFC-enabled devices in the market
- Display of information (text, URL, contact information, and so on) in an easily readable format

NDEF may not be an ideal choice for some applications such as:

- Proprietary closed-loop applications
- Applications in which raw unformatted data should be transferred over NFC

2.1.3 How do I read NFC/RFID tags with the TRF79xxA series of devices?

Do you need to read an NDEF formatted NFC/RFID tag?

- If Yes, use the TI NFCLink Standalone solution:
  - Hardware: DLP-7970ABP BoosterPack™ plug-in module and MSP-EXP430F5529LP LaunchPad™ development kit
  - Firmware: NFCLink Standalone Firmware Stack (preconfigured for Reader/Writer mode)
  - Application note with further details: NFC/HF RFID reader/writer using the TRF7970A.
- If No, use TI's RFID Reader Example Firmware:
  - Hardware: DLP-7970ABP BoosterPack plug-in module and MSP-EXP430G2ET LaunchPad development kit
  - Firmware: Basic RFID Reader Firmware Example

For differences between the NFCLink Standalone firmware stack and RFID Reader firmware example, see Section 6.

2.2 Peer-to-Peer (P2P) Mode

2.2.1 What is NFC peer-to-peer mode?

Peer-to-Peer (P2P) is an NFC operating mode that allows for bidirectional communication between NFC devices.

After a connection is established, either NFC device can initiate a data exchange as long as there is no current data exchange ongoing. This differs from reader/tag systems where the reader must prompt the tag to send information.

P2P communication can be done with either Passive or Active P2P. Passive P2P provides more consistent and robust communication and is the recommended mode.

2.2.2 How do I send peer-to-peer messages to NFC devices with the TRF79xxA series of devices?

Use the TI NFCLink Standalone solution:

- Hardware: DLP-7970ABP BoosterPack™ plug-in module and MSP-EXP430F5529LP LaunchPad™ development kit
- Firmware: NFCLink Standalone Firmware Stack (preconfigured for peer-to-peer mode)
- Application note with further details: NFC active and passive peer-to-peer communication using the TRF7970A.

NOTE: Only the TRF7970A supports NFC peer-to-peer mode.

2.2.3 What is the difference between passive and active P2P?

In a passive P2P application, the initiator device leaves its RF field on at all times, and the target device communicates by load modulating that RF field. The persistent RF field allows for stable and robust communication between the devices.

In an active P2P application, the initiator and target devices toggle their RF fields on and off. The device that is transmitting data must check for an RF field, and if none is present, turn its RF field on to transmit the data and then turn its RF field back off to wait for a response. This implementation requires very tight timings for the transitions of the RF field, which can result in a difficulty establishing a communication link.

TI recommends using passive P2P for all applications to ensure robust and reliable communication.

2.3 NFC Card Emulation Mode

2.3.1 What is NFC tag or card emulation?

Card emulation is an NFC operating mode in which an NFC transceiver mimics a passive NFC transponder.

2.3.2 How do I emulate an NFC tag or card with the TRF79xxA series of devices?

Use the TI NFCLink Standalone solution:

- Hardware: DLP-7970ABP BoosterPack™ plug-in module and MSP-EXP430F5529LP LaunchPad™ development kit
- Firmware: NFCLink Standalone firmware stack (preconfigured for card emulation mode)
- Application note with further details: NFC card emulation using the TRF7970A.

NOTE: Only the TRF7970A supports NFC card emulation mode.

3 Hardware and Design Questions

3.1 Where can I get schematics and layout files for the TRF79xxA devices?

Schematics: Near Field Communication (NFC) reference design schematic

Layout: Near Field Communication (NFC) reference design PCB layout files

Layout design guide: TRF79xxA HF-RFID reader layout design guide

NOTE: No layout files are available for Eagle, Altium, or other PCB design tools.

3.2 How do I design and tune an antenna to 13.56 MHz for the TRF79xxA devices?

Proper antenna design and tuning is described in full detail in Antenna design guide for the TRF79xxA.

3.3 Does TI provide FCC certification for the TRF79xxA devices?

No, it is not possible to get FCC certification for a bare IC, and TI does not offer any modules for the TRF79xxA devices. The entire system must be certified by the end customer.

TI evaluation hardware has received FCC certification to demonstrate that the schematic and layouts for their designs meet the requirements. Following TI reference schematics and layout is recommended to avoid design flaws; however, passing FCC certification is an application-specific design consideration and the full responsibility of the end customer who must submit their own boards to apply for FCC certification.

NOTE: Do not copy a TI reference design schematic and layout in an attempt to use the TI FCC ID.

3.4 What TI reference designs are available for the TRF79xxA devices?

NFC reader/writer: Near Field Communication (NFC) Reader/Writer Reference Design

NFC card emulation: Near Field Communication (NFC) Card Emulation Reference Design

NFC peer-to-peer: NFC Active and Passive Peer-to-Peer Communication Reference Design

General Hardware Design: Near Field Communications (NFC) Transceiver Reference Design

4 Software Questions

4.1 I need to read a non-NFC compliant tag or transponder, what firmware example should I use?

If using MIFARE Classic® or MIFARE® DESFire® tags, see Section 4.4 for further details.

For all other proprietary RFID tags or transponders that have nonstandard activation or data exchange processes, TI does not supply example firmware. Therefore, custom firmware must be developed by the end user to handle such transponders on an application-specific basis.

4.2 Are there any firmware examples available for TI MCUs other than MSP430™ and MSP432™ MCUs?

For the TM4C1294 family, there is a full reference design which uses TI-RTOS, Wi-Fi®(with CC3100), and NFC (with TRF7970A and RF430CL330H). See the Wi-Fi Enabled IoT Node With NFC Connection Handover Reference Design for the firmware, design guide, and hardware files. This example uses an up-to-date NFC stack.

There are no up-to-date NFC-only or non-RTOS examples available for TM4C devices.

For the AM335x processors, there is a Linux example available, see Linux NFC (neard) for TRF7970A.

Aside from these listed examples, there are no other firmware examples for TI MCU or processors that leverage the TRF79xxA devices.

4.3 Is there support for NFCLink with NCI?

The NFCLink NCI firmware package (formerly found at www.ti.com/tool/nfclink) was an NFC stack developed by a third party that leveraged the NFC Forum NFC Communication Interface (NCI) protocol. The NCI protocol is useful only for systems that interface with an operating system that is compatible with HCI, so that a host processor runs the NFC stack and then communicates with the OS through the NCI protocol.

The TI-offered NFCLink NCI firmware stack has been discontinued. This firmware stack is no longer offered for download and is no longer supported by Texas Instruments.

4.4 Are authentication examples available for the TRF79xxA devices?

MIFARE Classic authentication example is provided in Using Special Direct Mode With the TRF7970A.

MIFARE DESFire AES authentication example is provided in MIFARE DESFire EV1 AES Authentication With TRF7970A. This example does not include example firmware for the exchange of encrypted data, only initial authentication with an AES key.

4.5 What are the recommended TRF79xxA register settings or device configuration?

For recommended register settings and proper procedures to start-up the TRF79xxA devices, consult the firmware examples provided by TI. These examples show proper device start-up sequences, recommended register settings, and how to handle sending and receiving data through the TRF79xxA FIFO.

4.6 What does an IRQ status of 0xC0 mean?

An IRQ status of 0xC0 indicates that both the TX complete and RX start bits have been set. This can be an issue as the TRF79xxA FIFO is supposed to be reset with the direct command 0x0F after a TX operation is finished and before an RX operation begins. Not resetting the FIFO can result in corrupted RX data.

The typical cause for this issue is that the interrupt for the TX complete event (IRQ status = 0x80) is not serviced quickly enough. This can either be an issue with priority of the interrupt or MCU clock speed. Ensure that the IRQ interrupt is serviced correctly and that the FIFO is reset with the direct command 0x0F after receiving the TX complete event. When done correctly, then the interrupt for either the RX complete event (IRQ status = 0x40) or the RX in progress event (IRQ status = 0x60) should be correctly received.

4.7 Are software examples available to read Topaz-512 (NFC Forum Type 1) tags?

TI does not have any example code for this transponder and does not plan to develop such firmware.

Due to the inter-byte timing requirements for Topaz-512 tags, the TRF79xxA devices cannot leverage the built-in hardware encoders and demodulators as it does for most NFC/RFID transponders. Communication with these tags using the TRF79xxA is possible through the use of Direct Mode 0.

Direct Mode 0 allows the TRF79xxA to pass the raw modulated signals to the host MCU or receive a subcarrier digital data stream from the host MCU. The host MCU must run at a multiple of 13.56 MHz to demodulate received signals or encode subcarrier data. Consult the appropriate TRF79xxA data sheet for further detail about Direct Mode 0.

4.8 Are software examples available to read iCLASS® or PicoPass™ tags?

TI does not have any example code for this application and does not plan to develop such firmware. iCLASS and PicoPass tags are not compliant with ISO/IEC or NFC forum standards and are not supported by TI.

5 Miscellaneous Questions

5.1 Is there any support for RF power amplifiers?

TI does not have any officially released power amplifier designs and does not offer support for designs including an RF power amplifiers for the NFC and HF RFID product portfolio. Some potential power amplifier designs have been proposed on the E2E™ Community forums for NFC/RFID, but these are not officially released designs and are not supported in any manner.

5.2 Is there any TI training collateral for NFC?

TI has five-part video training series available at https://training.ti.com/near-field-communication-nfc-training-series.

5.3 Are there Energia or Arduino examples for the TRF79xxA?

TI does not supply examples for the TRF79xxA for Energia or Arduino. The best option available would be to use a combination of a BoosterPack plug-in module and a LaunchPad development kit as a separate NFC host from the Energia system and communicate with the MCU on the LaunchPad development kit through UART commands.

5.4 What IDEs are supported for Texas Instruments TRF79xxA firmware examples?

Code Composer Studio™ IDE is the supported IDE used for NFC firmware development. It is possible to port the Code Composer Studio IDE projects into other IDEs if needed, but there are no existing projects outside of the Code Composer Studio IDE.

5.5 What Android handset interoperability is supported?

NFC functionality across various NFC-enabled Android phones and tablets varies based on the company and the model of the device. Different phones and tablets use different NFC chipsets and software stacks. Therefore, not all devices support the same subset of NFC modes. Some devices do not support Active P2P, while others do not support Host-based Card Emulation (HCE).

For any questions about interoperability with TI's NFC reference firmware examples concerning Peer-to-Peer or Card Emulation modes, the corresponding application report should be reference. Each application report contains a table in the *Interoperability Results* section highlighting the tested NFC devices.

5.6 How do I configure the TRF79xxA to output a continuous or unmodulated RF field?

When certifying a system that includes devices that radiate RF energy, one of the required tests for most regulations is to measure the output of an unmodulated RF field from the system for a period of time.

To meet that requirement with a TRF79xxA device, use the following register setting:

Set bit 5 in Register 0x00 (Chip Status Control) to 1 to turn on the RF field output.

Applying this setting enables the TRF79xxA device under test to output an unmodulated RF field.

No other registers, including the Modulator Control register (0x09), need to be modified for tests that require an unmodulated RF field. Modulation on the RF field occurs only when data bytes are loaded into the TRF79xxA device and a transmission is initiated. Therefore, the settings for register 0x09 do not affect tests that require an unmodulated RF field.

6 Comparison of TI NFCLink Standalone Firmware and TI RFID Reader Example Firmware

6.1 NFCLink Standalone Firmware

NFCLink Standalone has been designed to provide the following features:

- Reading and writing to NDEF-formatted NFC tags with the ability to also support proprietary RFID tags with application level modifications
- Handling various NFC Forum defined error cases according to the NFC Forum specifications, including retries of failed data transmissions when allowed
- Handling for various error cases uncovered during extensive testing against the NFC Forum standards as well as with NFC devices and tags in the market

What are the advantages of TI NFCLink Standalone?

- Includes full support for reading and writing NDEF messages to NFC formatted tags for:
  - NFC Forum Type 2 (ISO/IEC 14443 A) tags (not compliant with ISO/IEC 14443-4)
  - NFC Forum Type 3 (FeliCa) tags
  - NFC Forum Type 4A (ISO/IEC 14443 A) tags (compliant with ISO/IEC 14443-4)
  - NFC Forum Type 4B (ISO/IEC 14443 B) tags
  - NFC Forum Type 5 technologies (ISO/IEC 15963) tags
- Interoperability tested with a large array of NFC and RFID tags in the marketplace from a variety of different tag vendors
- Tested against NFC Forum specifications to ensure high levels of interoperability with supported NFC protocols
- Robust error handling to cover general technology-based failures as well as device-specific corner cases
- Allows for retransmission attempts under certain error conditions outlined by the NFC Forum specifications
- Configurable to compile only the necessary NFC technologies to reduce memory footprint

What are the disadvantages of TI NFCLink Standalone?

- Requires larger processor memory footprints
- Does not support anticollision for any tag technology

6.2 RFID Reader Example Firmware

The RFID Reader Example firmware has been designed to provide the following features

- Reading and writing of RFID tags based on the ISO standards for each supported tag technology
- Basic error handling for error cases uncovered during basic testing versus a handful of RFID tags in the market

What are the advantages of the TI RFID Reader Example?

- Includes full support to read/write raw block data for:
  - ISO/IEC 14443 A (not compliant with ISO/IEC 14443-4)
  - FeliCa
  - ISO/IEC 15693
- Includes partial support to read/write to memory files on:
  - ISO/IEC 14443 A tags (compliant with ISO/IEC 14443-4)
  - ISO/IEC 14443 B tags
- Supports anticollision for ISO/IEC 15693 and ISO/IEC 14443 A
- Configurable to compile only the necessary RFID technologies to reduce memory footprint
- Small memory footprint compared to NFCLink Standalone stack due to lack of features

What are the disadvantages of the TI RFID Reader Example?

- NDEF support for Type 4A and 4B tags is done with hard-coded functions that have no flexible implementation and exist for demonstration purposes only.
- Limited interoperability testing with tags in the marketplace
- Error handling capabilities are limited, and the firmware stack does not have the ability to attempt any retransmission of data in failure cases.

6.3 Memory Footprint Comparison

Table 2 and Table 3 list the memory requirements for NFC reader/writer and RFID reader examples, respectively.

Table 2. TI NFCLink Standalone With Only Reader/Writer Functionality Enabled (1)

NFC Reader/Writer Mode	Flash	RAM
All technologies below	40KB	2.8KB
Type 2 Only	29KB	1.7KB
Type 3 Only	28KB	1.9KB
Type 4A Only	33KB	2.3KB
Type 4B Only	30.5KB	2.3KB
Type 5 Only	28.5KB	2KB

(1) These values were generated with the USB interface and TI NFC Tool GUI functionality removed.

Table 3. TI RFID Reader Example (1)

RFID Technology	Flash	RAM
All technologies below	8.5KB	450 bytes
ISO/IEC 14443 A Only	5.7KB	415 bytes
ISO/IEC 14443 B Only	4KB	395 bytes
ISO/IEC 15693 Only	4.4KB	408 bytes
FeliCa Only	3.7KB	402 bytes

(1) These values were generated with FIFO size set to 100 bytes and UART output disabled.

7 References

1. TRF7970A multiprotocol fully integrated 13.56-MHz RFID and NFC transceiver IC
2. NFC/HF RFID reader/writer using the TRF7970A
3. NFC active and passive peer-to-peer communication using the TRF7970A
4. NFC card emulation using the TRF7970A

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from May 24, 2018 to March 13, 2019	Page
• Updated links to purchase hardware throughout document	1

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