

# Thinfilm NFC Barcode Protocol for NFC OpenSense™ & NFC SpeedTap™ 128- & 256-bit NFC Tags

*previously known as Kovio® NFC Barcode*

## Functional Specification

### Product Features

- Passive
- 13.56MHz
- 128- or 256-bit Read-Only Memory (ROM)
- 106 Kb/s Data Transfer Rate
- Tag-Talks-First Mode
- Adheres to Subset of ISO14443A
- 16 bits CRC
- Operating Range of a Few Centimeters

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## 1. FEATURES & BENEFITS

### 1.1 RF Interface (ISO 14443A)

- Passive tag (no tag battery needed)
- Contactless data transmission
- Typical operating range of a few centimeters (depending on field strength and antenna design)
- 13.56MHz operating frequency used by HF RFID & NFC
- 106 Kbit/sec data transfer, Manchester bit encoding and OOK load modulation at 847 kHz
- Streamlined Tag-Talks-First (TTF) protocol for speed and efficiency
- 16-bit CRC for data integrity verification
- Single-tag mode for precise one-on-one interaction

### 1.2 Memory Structure

- 128 and 256 bits Read Only Memory (ROM)

### 1.3 Standards Compliance

- Adheres to subset of ISO 14443 Type A RFID standard
- Supports popular data structures such as 96-bit GS1 EPC (Electronic Product Code)

### 1.4 Security

- Tag memory is factory-programmed at Thinfilm. Tag data cannot be electrically modified.

## 2. OVERVIEW AND BLOCK DIAGRAM

The NFC Barcode is a printed integrated circuit (PIC) for use in electronic read-only transponders. It is designed to operate at 13.56MHz. The NFC Barcode operates in a Tag-Talks-First (TTF) mode, repeatedly transmitting its code at a specific interval as long as it is powered up. It adheres to a subset of the ISO 14443 Type A RFID standard. The NFC Barcode supports single-tag read mode. The NFC Barcode is manufactured at Thinfilm's facility using proprietary Printed Dopant Polysilicon (PDPS) technology.

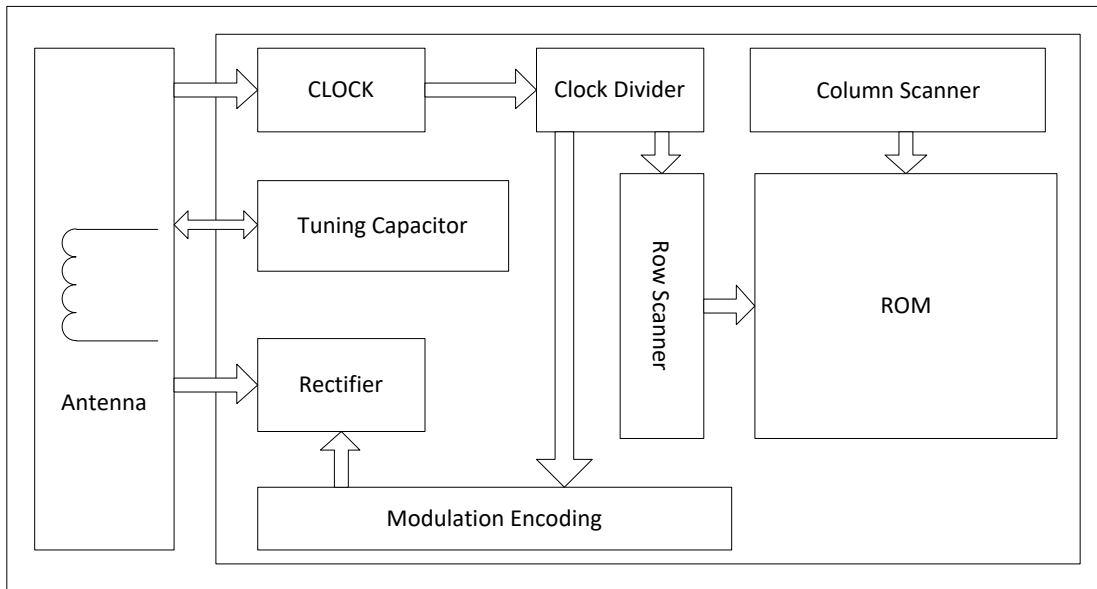


Figure 1: Design block diagram

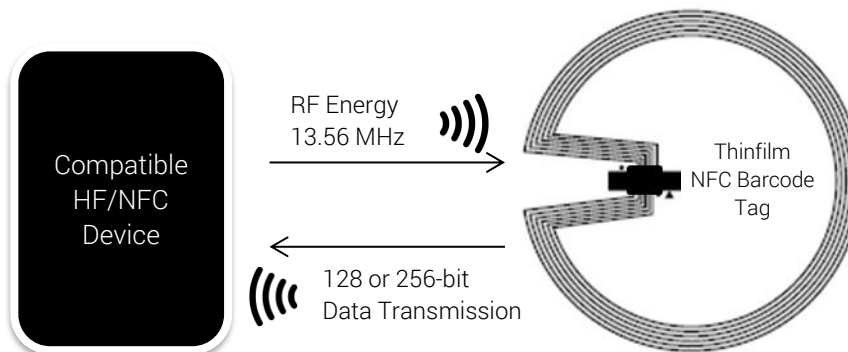


Figure 2: Operation overview

### 3. OPERATIONAL CHARACTERISTICS

#### 3.1 NFC Barcode Tag Operation

The NFC Barcode is a read-only tag that repeatedly transmits its data in a Tag-Talks-First (TTF) manner. Because the tag operates in a TTF mode, it transmits its code after it receives enough power from reader field. The NFC Barcode does not wait for any commands from the reader before transmitting its code, and it will not recognize any commands from the reader.

The NFC Barcode transmits its code using the air interface of ISO 14443 Type A, as defined in the ISO 14443 specification, Part 2. Thus, it transmits its code at 106 Kb/s using Manchester bit encoding and OOK modulation on an 847 kHz subcarrier.

As long as the NFC Barcode is powered up in the reader's field, it will continue to re-transmit entire length of its code (128 or 256 bits) at a regular interval. The NFC Barcode's state diagram is shown below in Figure 3.

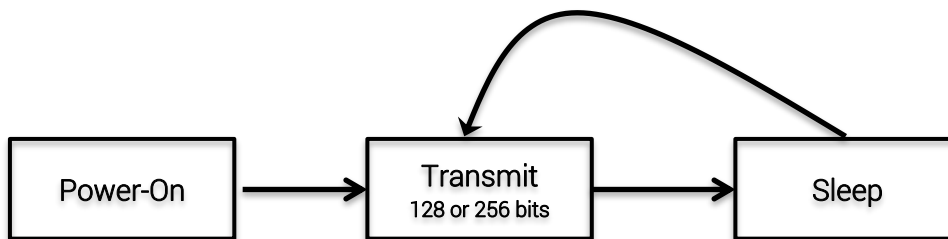


Figure 3: NFC Barcode operational state diagram

#### 3.2 Data Transfer

The basic air interface communications protocol is defined in ISO 14443 Part 2, section 8.2. The chip transmits the data at a rate of 106 Kb/s using Manchester bit encoding and OOK load modulation at 847 kHz (13.56 MHz / 16).

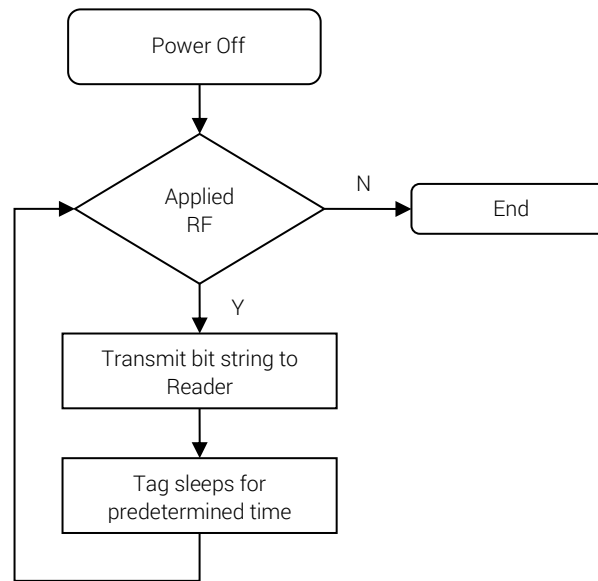
The NFC Barcode neither requires nor accepts commands from the HF/NFC reader. It begins transmitting the data in its Read-Only Memory (ROM) after it receives enough power from the reader's field to operate. NFC Barcode transmits the entire tag content/ID within 5ms of being powered on.

The NFC barcode does not add any framing or parity bit to the code transmission. It is required that the first bit is always a "1", which serves as a start bit for the reader.

#### 3.3 Communication

The NFC Barcode retransmits its code at a specific interval, after sleeping for a specified period of time. The 128-bit transmission takes approximately 1.21 milliseconds, followed by a sleep time of 3.6 milliseconds. The 256-bit transmission takes approximately 2.42 milliseconds, followed by a sleep time of 2.4 milliseconds.

The Figure 4 below shows the flowchart for the NFC Barcode operation.



**Figure 4: NFC Barcode operating flow chart**

### 3.4 Memory

The NFC Barcode memory area consists entirely of Read-Only Memory (ROM). The ROM is digitally printed during manufacturing at Thinfilm.

### 3.5 Protocol

The NFC Barcode operates in a read-only Tag-Talks-First (TTF) mode. See the operating flowchart in section 4.3. The NFC Barcode transmits its code at a data rate of 106 Kb/s using Manchester bit encoding and OOK load modulation at 847kHz (13.56MHz/16).

The use case for NFC Barcodes does not require collision resolution, so the NFC Barcode tag begins transmitting within the first 1 ms (typical) after it is powered on. Thinfilm recommends setting any controller timeout values to at least 2 ms to guard against slow rise time of the RF field and other potential system-level variation.

### 3.5.1 Modulation Pattern

The 128-bit NFC Barcode transmits the code in 1.21 ms and sleeps for 3.6 ms between transmissions. The 256-bit NFC Barcode transmits the code in 2.42 ms and sleeps for 2.4 ms between transmissions.

The resulting modulation pattern that the NFC Barcode uses to repeatedly transmit its code is depicted below in Figure 5.

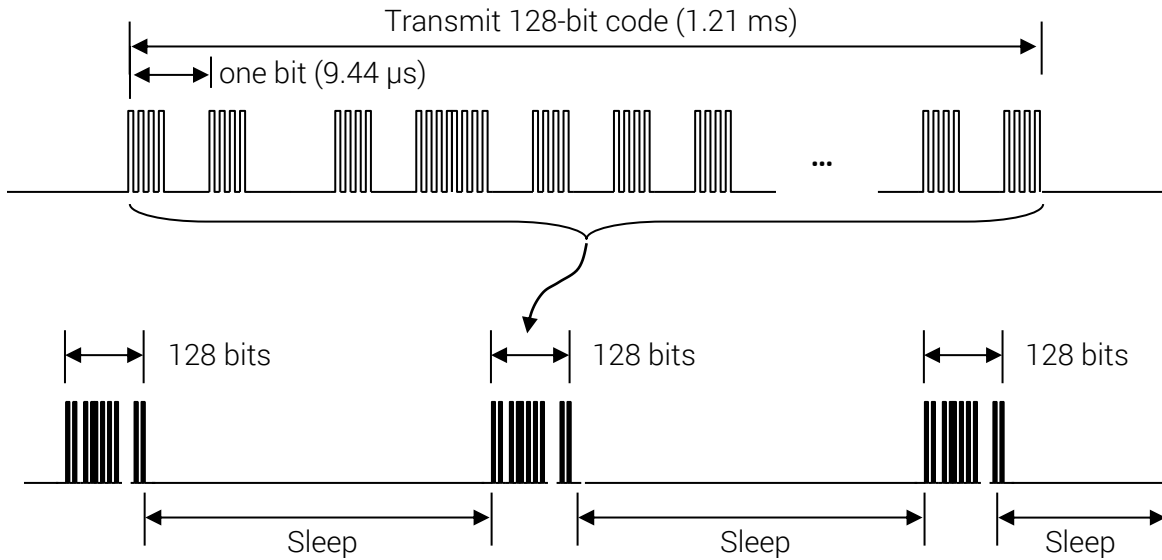


Figure 5: NFC Barcode 128-bit data transmission

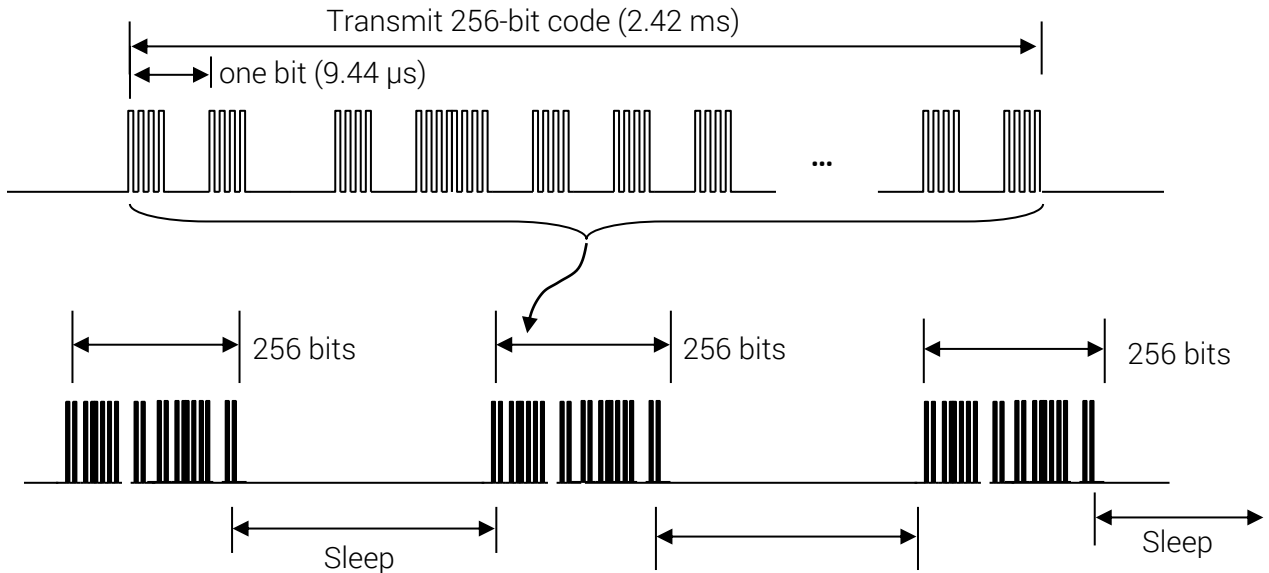


Figure 6: NFC Barcode 256-bit data transmission

### 3.6 Frame Formats

The NFC Barcode frame format differs from the standard frame format specified by ISO 14443-3. A standard frame for a transmission from an ISO 14443-3 compliant tag (not the NFC Barcode) is depicted in Figure 7. Following ISO 14443-3, transmission begins with a Start-of-Frame bit S (always 1), and each 8 data bits are followed by an odd parity bit P. The message ends with a 16-bit CRC. The NFC Barcode does not embed any parity bits in its transmitted code.



Figure 7: Typical ISO 14443-3 long frame

The NFC Barcode transmits a stream of 128 or 256 data bits, with no explicit start bit or embedded parity bits, as shown in Figure 8 and Figure 9. While the NFC Barcode does not employ a start bit S, the first bit transmitted by the NFC Barcode is set to be '1' bit, so this effectively functions as a start bit that the reader can recognize.

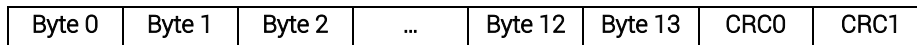


Figure 8: NFC Barcode 128-bit transmission frame



Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	...	Byte 28	Byte 29	CRC0	CRC1
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Figure 9: NFC Barcode 256-bit transmission frame

The last two data bytes contain a 16-bit CRC for the previous 14 bytes. This CRC is calculated according to the ISO 14443 Type A CRC defined in Appendix B of the ISO 14443 Part 3 specification. Checking this CRC provides a fairly robust method of identifying code transmission errors.

Note: The initial bit '1' and 16-bit CRC are considered to be part of each NFC Barcode's 128- or 256-bit code and should be included in the data transmission from the NFC Controller to the host, even if CRC is analyzed and verified by the NFC Controller.

### 3.7 Bit Transmission Order

The NFC Barcode transmits its bits in the order “MSB first, LSB last”, as shown in Figure 10. In contrast, ISO 14443-3 compliant devices transmit bits in the order “LSB first, MSB last”. Hence, if a reader is based on an NFC Controller that normally expects bits to be transmitted “LSB first”, the bit ordering within each byte will have to be reversed to obtain the correct NFC Barcode code.

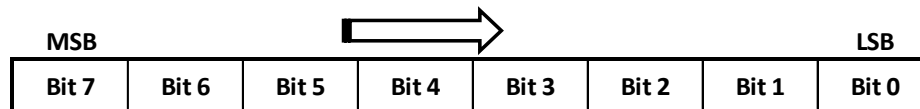


Figure 10: Bit transmission order

## 4. INLAY

### 4.1 Inlay Operating Range

NFC Barcode tags will operate within close proximity to the reader with a read range of a few centimeters dependent on reader type (field strength, reader antenna size) and tag antenna.

### 4.2 Physical Dimensions & Ordering Options

Contact Thinfilm for the latest product options.

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## 6. REVISION HISTORY

Section	Description
Revision 2.0 (August 15, 2011)	
	Comprehensive update
Revision 2.1 (November 11, 2011)	
Global	Formatting updates Typo corrections
Revision 2.2 (September 13, 2012)	
Global	Editorial enhancements Formatting updates Typo corrections
Revision 3.0 (June 23, 2014)	
Global	Update to Thinfilm template
Revision 3.1 (October 8, 2015)	
Global	Updated name to Thinfilm NFC Barcode. Noted that the product was previously identified as Kovio NFC Barcode. Readers: please note this is the same product and only the name has been updated.
Protocol	Added system level clarification regarding tag startup time
Revision 3.2 (March 18, 2016)	
Global	Removed inlay mechanical details and ordering details. This information is now covered in separate datasheets.
Revision 3.3 (December 1, 2016)	
Global	Removed inlay mechanical details and ordering details. This information is now covered in separate datasheets.
Revision 3.4 (May 26, 2017)	
Global	Updated template to reflect new Thinfilm branding.