NFC PAIRING FOR AUDIO DEVICES

WEBINAR SERIES:
HOW TO BUILD NFC APPLICATIONS

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NFC READERS
NFC EVERYWHERE
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SECURE CONNECTIONS
FOR A SMARTER WORLD
Agenda

• NFC solution for easy Bluetooth and WiFi pairing.

• Multi-audio wireless speaker demo:
  - Hardware details.
  - Software architecture and application logic.
  - Software integration details.
  - Available resources.

• Wrap up & Q&A
Use case:
Bluetooth & WiFi pairing with NFC
Many use cases for Bluetooth & WiFi pairing with NFC

- View images and videos on a large screen with a tap of your mobile device to the set-top box.
- Tap your phone to the camera to transfer pictures quickly over the camera’s own WiFi.
- Pair with Bluetooth speakers or headphones with just a tap.
- Allow friends to tap your NFC-enabled gateway to establish a WiFi connection.
- Use NFC to pair your phone to your new wearable device.
- Multi-audio systems that share music between two headphones or speakers.
NFC pairing offers benefits for both consumers & manufacturers

For consumers

- Faster, simpler connections – no need for BT/WiFi sub-menus or searching through lists to find devices
- No conflicts – pair only the devices you want to pair
- Secure exchanges – share credentials securely with just a tap
- Easier disconnects – tap twice to unpair
- Save power – use NFC to enable / disable sleep mode from a battery-driven BT/WiFi device

For manufacturers

- Add value – NFC is an easy upgrade to existing products
- Simplify interactions – devices are easier to use
- Reduce support cost – fewer requests for tech help
- Eliminate cables – support the trend toward wireless peripherals.
Pair Bluetooth headphones with just a tap

Step 1. Play a music track in your NFC phone

Step 2. Pair your headphone with a tap

Step 3. Music is streamed via BT to the headphone

NFC is the faster, simpler way to connect wireless devices, without creating conflicts.
Just tap your mobile phone to establish a secure, two-way connection. No menus, no waiting

* For the scenario where pairing is only performed to an NFC phone, NTAG213 or NTAG I²C plus solution would be sufficient
Share music by pairing two headphones

Step 1. Pair your second headphone with a tap

Step 2. Music is streamed via BT to the two headphones

Step 3. You have your own silent disco!

If all speakers are equipped with an NFC chip, you simply tap one speaker to another to establish the connection.
Easy disconnect – tap twice to unpair

Step 1. Tap again to unpair the headphone

Step 2. Second headphone is disconnected and music stops being streamed

Easier disconnect. Instant identification of the device to unpair. No probability of error
NXP multi-audio wireless speaker demo

Silent disco

Multi-audio wireless system

Multi-audio wireless speaker demo hardware

NXP multi-audio wireless speaker prototype presented today
Hardware details
Multi-audio wireless speaker demo
Hardware architecture - Multi-audio wireless speaker demo

Fig 1. Wireless audio speaker simplified HW architecture
Application circuit for Bluetooth power on by NFC triggering

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Description</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wake up</td>
<td>Wake up indicator</td>
<td>Output pin</td>
</tr>
<tr>
<td>2</td>
<td>PVDD</td>
<td>Power supply for digital interface</td>
<td>1.65V – 1.95V for 1.8V system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.8V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3V – 3.6V for 3.3V system</td>
</tr>
<tr>
<td>3</td>
<td>VBAT</td>
<td>Power supply</td>
<td>Support range of 2.7V to 5.5V</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>IRQ</td>
<td>Interrupt output pin</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SCL</td>
<td>I2C clock input</td>
<td>Open drain</td>
</tr>
<tr>
<td>7</td>
<td>SDA</td>
<td>I2C data pin</td>
<td>Open drain</td>
</tr>
<tr>
<td>8</td>
<td>VEN</td>
<td>Reset pin</td>
<td>Low activate (&lt; 0.4V)</td>
</tr>
</tbody>
</table>
PN71xx family of NFC controllers

Plug-and-play solutions equipped with:

- Full NFC Forum-compliant
- Microcontroller core with integrated firmware
- Accompanied by Linux, Android, WinIoT drivers and several software examples
- NCI host interface
- Integrated power management unit allowing direct supply from a battery
- Industry-standard form factor packages

PN71xx family positioning

- Higher output power
- NFC Forum Type 3 card emulation
- Lower PCB manufacturing cost
- Active load modulation

PN71xx NFC controller single board computer (SBC) kits

PN7150

PN7120

PN71xx demokit cover integration with Raspberry Pi, BeagleBone Black and any board with Arduino-compatible header

PN71xx pinning adaptation to any platform

### TB2 connector pinout

<table>
<thead>
<tr>
<th>#</th>
<th>PN7150 signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>VBAT / VDD (PAD): 3.3V supply voltage</td>
</tr>
<tr>
<td>#2</td>
<td>VANT: 5V optional supply voltage</td>
</tr>
<tr>
<td>#3</td>
<td>Not connected</td>
</tr>
<tr>
<td>#4</td>
<td>GND: ground</td>
</tr>
<tr>
<td>#5</td>
<td>IRQ: interrupt request output</td>
</tr>
<tr>
<td>#6</td>
<td>VEN: reset pin</td>
</tr>
<tr>
<td>#7</td>
<td>Not connected</td>
</tr>
<tr>
<td>#8</td>
<td>Not connected</td>
</tr>
</tbody>
</table>

### TB3 connector pinout

<table>
<thead>
<tr>
<th>#</th>
<th>PN7150 signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>I2CSDA: I2C-bus serial data</td>
</tr>
<tr>
<td>#2</td>
<td>I2CSCL: I2C-bus serial clock input</td>
</tr>
<tr>
<td>#3</td>
<td>Not connected</td>
</tr>
<tr>
<td>#4</td>
<td>Not connected</td>
</tr>
<tr>
<td>#5</td>
<td>Not connected</td>
</tr>
<tr>
<td>#6</td>
<td>Not connected</td>
</tr>
<tr>
<td>#7</td>
<td>Not connected</td>
</tr>
<tr>
<td>#8</td>
<td>Not connected</td>
</tr>
</tbody>
</table>
SW architecture & application logic
Multi-audio wireless speaker demo
Fig 1. Wireless audio speaker simplified HW architecture

Software components blocks

PMU
Battery / Power supply
VBAT

SoC BT controller
BT controller & app code
NFC application code
PN7120 NFC module
NFC device

VT100 SoC
BT controller & app code
NFC application code
PN7120 NFC module
NFC device

Software components blocks

NFC application code
BT controller & app code
NFC application code
PN7120 NFC module
NFC device

SoC BT controller
BT controller & app code
NFC application code
PN7120 NFC module
NFC device

Software components blocks

NFC application code
BT controller & app code
NFC application code
PN7120 NFC module
NFC device

Software components blocks

NFC application code
BT controller & app code
NFC application code
PN7120 NFC module
NFC device

Software components blocks

NFC application code
BT controller & app code
NFC application code
PN7120 NFC module
NFC device

Software components blocks

NFC application code
BT controller & app code
NFC application code
PN7120 NFC module
NFC device

Software components blocks
NFC Controller Interface (NCI) specification details

NCI modules provide a well-defined functionality to the host device.

RF discovery & interfaces module configures the NFC controller to discover and communicate with NFC tags or other NFC devices.

Define NCI control messages, data messages, packet formats, command, responses and notifications for the different operations.

Define how the NCI messaging is mapped to an underlying physical connection (e.g. I2C, SPI, UART).

NCI is the NFC Forum standard interface specifying the communication protocol between the NFC controller and the host device.

Our PN71xx family use I2C bus as physical connection.

Our demo is configured to operate in Reader/Writer, Card emulation and P2P modes.

*More info about NFC Controller Interface specification [here](#)
The principle used to combine the various modes of operation (i.e. R/W, CE, P2P) is to build a cyclic activity which will sequentially activate various modes of operation.

This loop alternates listening phase (NFC controller behaves as card or target) and polling phase (NFC controller behaves as a reader/writer or an initiator).

The RF technologies and modes to be polled and listened to can be configured within the discovery loop.

RF discovery sequence:
1. Start a polling phase.
2. If no card or target detected, enter in Listen phase.
3. If no device to interact is detected, switch back to polling phase after a programmable timeout.

*In a typical set-up, the polling phase is approximately 20ms long while the listening phase is usually in the range 300ms to 500ms long.
The wireless speaker demo is configured to:
1. During the polling phase, it polls for NFC-A cards or P2P remote devices.
2. If no card or target P2P device is detected, enter in Listen phase.
3. If no P2P initiator or NFC-A reader is detected, switch back to polling phase after a programmable timeout.

In our demo, the remote device/tag is the other wireless speaker when they are tapped together.

The communication between the two speakers will change depending in the polling loop interval they are when they are tapped together.
Fig 1. Wireless audio speaker simplified HW architecture

Software components blocks

Logic for NFC pairing implementation
NFC pairing application is based on NFC Forum specs

Fig 1. NFC Forum specifications & architecture

NFC Forum spec for the establishment of a 2nd out of band carrier exchanging the config parameters via NFC (e.g. BT pairing).

Our demo uses static handover or negotiated handover depending on the discovery loop status when they are tapped.

NFC pairing application also make use of the underlying NFC Forum specs (i.e. NDEF / SNEP+LLCP, NDEF / Tag Type)
NFC pairing: Static handover

Discovery loop in one of the speakers is currently polling NFC-A technology

- RF polling
- Remote card detected
- Read pairing NDEF (using T4T commands)
- Return pairing NDEF (BT OOB data record)
- BT data exchange

Discovery loop in the other speaker is currently showing an NDEF message in a T4T emulated tag.
Simplified tag format for a single BT carrier

- Simplified format without the Handover Select record.
- In case the device advertises only one alternative carrier (i.e., a Bluetooth carrier)
- The NFC Tag contains an NDEF message with only the Bluetooth OOB information.

NFC pairing: Negotiated handover

Discovery loop in one of the speakers is currently polling NFC-ACM technology (P2P initiator)

Discovery loop in the other speaker is currently listening for NFC-ACM (P2P target)

- RF polling
- Remote P2P target detected
- Send Handover request message (BT carrier config)
- Send Handover select message (Accept BT carrier)
- BT data exchange
Negotiated handover: Handover Request & Select messages

Handover Request Record (NFC WKT "Hr")
- Version: 1.2
- Collision Resolution Record
  - Random Number
- Alternative Carrier Record
  - Carrier Power State: "active"
  - Carrier Data Reference: "0"

Handover request NDEF record sends the BT carrier configuration data

Handover Select Record (NFC WKT "Hs")
- Version: 1.2
- Alternative Carrier Record
  - Carrier Power State: "active"
  - Carrier Data Reference: "0"

Bluetooth Carrier Configuration Record (mime-type "application/vnd.bluetooth.ep.oob")
(Payload ID "0")
- OOB Data Length (LENGTH)
- Device Address (BD_ADDR)
- Class of Device
  - Simple Pairing Hash C
  - Simple Pairing Randomizer R
- Service Class UUID
- Bluetooth Local Name

Message #1

Message #2

Handover select sends back the selected carrier that will be used for out of band data TX

Bluetooth address

e.g. Desktop, headset, mobile

[Optional] If secure pairing is requested

User friendly name of the device

Software integration
Multi-audio wireless speaker demo
Block diagram - Multi-audio wireless speaker demo

Fig 1. Wireless audio speaker simplified HW architecture

Software components blocks

Available SW drivers for integration into any platform!

Included as part of PN71xx embedded firmware
PN71xx software drivers for SW integration into any platform

Linux NFC architecture
Linux integration is offered through NXP’s Linux libnfnci SW stack

Android NFC architecture
Android integration is offered through the Android AOSP SW stack for which NXP delivers dedicated patches.

Windows NFC architecture
Windows integration is offered through Microsoft Windows universal NFC device driver model,

NullOS/RTOS architecture
NullOS/RTOS integration is demonstrated with code examples running on NXP’s LPC, Kinetis and i.MX MCUs

Multi-audio wireless speaker demo is based on this SW stack
**Detail on PN71xx software driver for RTOS/NullOS integration**

NXP-NCI module offers high level NFC API for connection and configuration of the NFC controller:
- Start of the NFC discovery
- Wait for NFC discovery
- Process the NFC discovery

NDEF library module is composed of independent sub-modules:
- RW_NDEF implements NDEF extraction from NFC Forum tags (all 4 NFC Forum defined tag types)
- P2P_NDEF implements NDEF data exchange with P2P device (over NFC Forum LLCP and SNEP protocols)
- T4T_NDEF_emu implements NDEF message exposure through card emulation (NFC Forum Type 4 Tag protocol)

TML module brings HW abstraction to NFC library (abstract how the connection to NFC controller IC is managed).

* Including Kinetis, and LPCXpresso platforms*
Source code example description

**NdefLibrary**
Implements dedicated API for the NDEF handling for
- Reader/Writer mode (T1T, T2T, T3T and T4T)
- Card emulation mode (T4T emulation)
- P2P mode (Initiator and target)

**NXP-NCI lib functions**
- NxpNciConnect(...);
- NxpNci_ConfigureSettings(...);
- NxpNci_ConfigureMode(...);
- NxpNci_CheckDevPres(...);
- NxpNci_HostTransceive(...);
- NxpNci_WaitForReception(...)
- NxpNci_WaitForDiscoveryNotification(...)
- NxpNci_StartDiscovery(...)
- NxpNci_StopDiscovery(...)
...

**TML library**
Implements the low level hardware abstraction for the physical connection with PN71xx over I2C

- Source code download [here](link)
- Available for Kinetis, and LPCXpresso platforms
Multi-audio wireless speaker application workflow

1. Power on
2. Reset
3. NCI connect
4. NCI configure settings
5. Discovery loop configuration
6. Start discovery loop
7. Poll and listen RF protocols config
8. Iterates between polling and listen modes as configured

- If activated from remote speaker
- Wait for discovery loop notification
- While (1)
  - Process card mode
    - Show NDEF message to the remote speaker (T4T tag emulation)
    - Process reader mode
      - Read NDEF in T4T tag
      - Parse NDEF & send BT data to upper layer
  - If P2P mode is detected from remote speaker
    - P2P role
      - P2P target
        - Pull NDEF message from remote peer
      - P2P initiator
        - Push NDEF message (SNEP Put)
  - Handover request message
  - Handover select message
  - Parse NDEF & send BT data to upper layer

BT stack handles the BT connection
EVERYTHING YOU NEED TO BUILD YOUR NFC PAIRING FOR AUDIO DEVICES SOLUTION IS HERE!
Summary of available resources

• PN71xx NFC controllers with embedded firmware solutions
  http://www.nxp.com/products/PN7150B0HN
  http://www.nxp.com/products/PN7120

• PN71xx demokits
  http://www.nxp.com/products/OM5577
  http://www.nxp.com/products/OM5578

• Reference source code
  https://www.nxp.com/webapp/Download?colCode=SW3241&appType=license&Parent_nodeId=1464844405019729073788&Parent_pageType=product
Software development in Android and iOS
Embedded software for MCUs
JCOP, Java Card operating Systems
Hardware design and development
Digital, analog, sensor acquisition, power management
Wireless communications WiFi, ZigBee, Bluetooth, BLE
Contactless antenna RF design, evaluation and testing

MIFARE® product-based applications
End-to-end systems, readers and card-related designs
EMVco applications
Readers, cards, design for test compliancy (including PCI)
Secure Element management
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Secure services provisioning OTA, TSM services

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