



## Application Note: JN-AN-1158

# ZigBee RF4CE Demonstration

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This Application Note provides software files for the ZigBee RF4CE Demonstration which can be used with the hardware of the NXP JN516x-EK001 Evaluation Kit. The supplied files will allow you to run, modify and re-build the demonstration application which runs on the JN5168 USB Dongle (DR1198) and a Carrier Board fitted with the LCD Expansion Board (DR1174 fitted with DR1201).

The application demonstrates a remote control system which operates as a ZigBee RF4CE wireless network with the following features:

- PC-based software to control Windows Media Player
  - LCD Expansion Board which controls the media player on the PC, and locally displays information including the track title and artist
  - USB Dongle to receive and process commands from the LCD Expansion Board, and relay them to the PC-based software
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## 1 Application Overview

The ZigBee RF4CE Demonstration uses boards from the NXP JN516x-EK001 Evaluation Kit shown below. The demonstration allows the user to pair the LCD Expansion Board with a PC and control the media player on the PC. Full operational instructions for the demonstration are provided in Section 4 “Running the Demonstration”.



## 1.1 LCD Expansion Board

The LCD Expansion Board (fitted to a Carrier Board) is used as the Controller node in this ZigBee RF4CE network. The Carrier Board can be fitted with a JN5168 or JN5161 module. The LCD screen will display information to guide the user through pairing with the USB Dongle (target node) and, once paired, will also display menu options. The user will then be able to control a media player on the PC to which the paired USB Dongle is connected. Information on how to select media tracks and other options on the LCD Expansion Board is provided in Section 4 “Running the Demonstration”.

## 1.2 USB Dongle

The JN5168 USB Dongle plugs into a PC and is used as the target node in this ZigBee RF4CE network. Use of the USB Dongle requires a device driver to be installed on the host PC. You will be prompted to install the driver the first time you plug the USB Dongle into your PC. Installation instructions for the driver are detailed in the *JN516x-EK001 Evaluation Kit User Guide (JN-UG-3093)*.

## 1.3 Target Emulator (PC Software)

The ZigBee RF4CE Target Emulator software provides the PC-based interface to the media player and is supplied in the package of this Application Note. Section 4 provides instructions for installing, configuring and using this software.

## 2 Compatibility

The software provided with this Application Note has been tested with the following evaluation kits and SDK (Software Developer's Kit) versions:

Product Type	Part Number	Version	Supported Chips
Evaluation Kit	JN516x-EK001	-	JN516x
SDK Toolchain	JN-SW-4041	1.1	JN514x/6x
SDK	JN-SW-4060	1.0	JN516x

The ZigBee RF4CE SDK (JN-SW-4060) is currently applicable to the JN516x device only.

## 3 Loading the Applications

To load the application binary files into the Carrier Board with LCD Expansion Board and the USB Dongle, follow the steps in the following sections.



**Note:** The required version of the JN51xx Flash Programmer is v1.8.2 or higher.

### 3.1 Loading into Carrier Board with LCD Expansion Board

Load **Remote\_JN5168\_EK001.bin** (for JN5168) or **Remote\_JN5161\_EK001.bin** (for JN5161) into the Carrier Board with LCD Expansion Board from the PC using the JN51xx Flash Programmer, which can be launched from within Eclipse or used directly - refer to the *JN51xx Flash Programmer User Guide (JN-UG-3007)* for further information.

## 3.2 Loading into USB Dongle

Load **Receiver\_JN5168\_EK001.bin** into the USB Dongle from the PC using the JN51xx Flash Programmer, which can be launched from within the Eclipse tool or used directly - refer to the *JN51xx Flash Programmer User Guide (JN-UG-3007)* for further information.

## 4 Running the Demonstration

This section describes how to set up a simple remote control system using the contents of the JN516x-EK001 Evaluation Kit and then run the ZigBee RF4CE Demonstration.

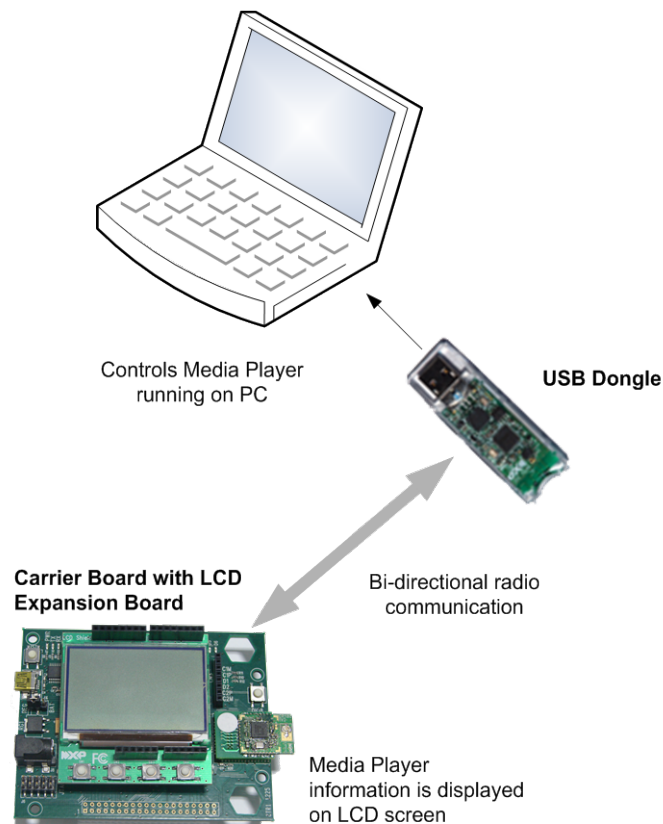
### 4.1 Demo System Overview

The ZigBee RF4CE Demonstration uses the LCD Expansion Board (fitted to a Carrier Board) and JN5168 USB Dongle of the JN516x-EK001 Evaluation Kit to form a simple remote control system. The evaluation kit components are programmed as the following ZigBee RF4CE devices for the purpose of this demonstration:

- The Carrier Board with LCD Expansion Board is programmed as a Controller node
- The USB Dongle is programmed as a Target node

The USB Dongle is plugged into a PC and a program is run on the PC which emulates the target device - currently, this is a media player. The USB Dongle receives radio signals from the LCD Expansion Board and passes the received instructions to the Target Emulator application on the PC (information can also be passed in the other direction from the target device to the LCD Expansion Board via the USB Dongle).

The demonstration system is illustrated in Figure 1 below.



**Figure 1: Remote Control Demo System**

## 4.2 Setting Up and Starting the Demo System

Setting up and starting the ZigBee RF4CE Demonstration involves the following phases, described in separate sub-sections below.

1. Install the Target Emulator software on a PC, as described in Section 4.2.1.
2. Start the ZigBee RF4CE nodes and pair them, as described in Section 4.2.2.



**Note:** The procedures described in the sub-sections below assume that the evaluation kit is being used for the first time. Therefore, the LCD Expansion Board has not been previously paired with the USB Dongle.

### 4.2.1 Installing the Target Emulator Software

First, install and start the ZigBee RF4CE Target Emulator software on your PC.



**Important:** The Target Emulator software requires Windows Media Player, which must be present on the host PC.

The Target Emulator software is provided in the Application Note package and is called **Windows7\_NXPMediaPlayer\_Installer\setup.exe**.

Install and run the Target Emulator as follows:

1. Create a directory for your media files.

Create a directory called **NXP\_ZigBee\_RF4CE** at the top level of your hard disk (e.g. **C:\NXP\_ZigBee\_RF4CE**) and put at least one MP3 or MP4 file inside.

2. Plug the USB Dongle into a free USB port of your PC.

The first time you plug in the USB Dongle, you will be prompted to install its device driver. The USB Dongle requires the FTDI USB-to-Serial driver - refer to the *JN516x-EK001 Evaluation Kit User Guide (JN-UG-3093)*.

3. Install the Target Emulator.

Run the installer **setup.exe** and follow the on-screen instructions.



**Note:** Do not launch the Target Emulator without the USB Dongle plugged into the PC and its driver installed, otherwise the emulator will not display the COM port of the dongle. Launch it as described in Section 4.2.2.

## 4.2.2 Starting and Pairing the Nodes

Start and pair the USB Dongle and LCD Expansion Board, as described below.



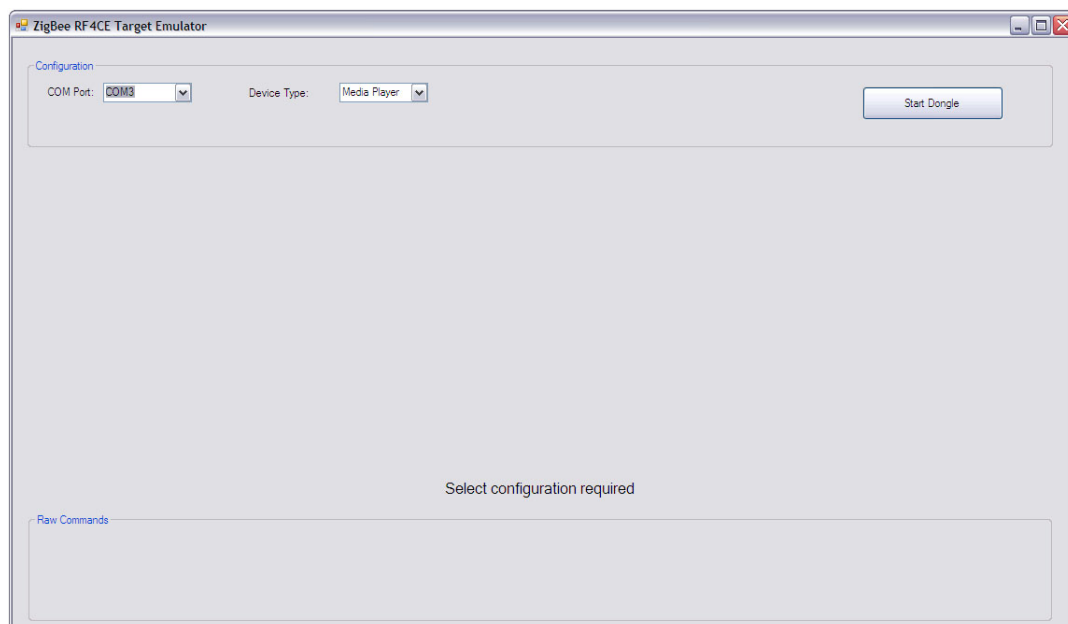
**Note:** In this procedure, ZigBee RF4CE nodes are identified using the IEEE/MAC addresses that are pre-programmed in the Flash memory of the JN516x devices. You may wish to obtain this address from the USB Dongle beforehand. An IEEE/MAC address can be read from Flash memory using the JN51xx Flash Programmer application.



**Tip:** If you have problems with the LCD Expansion Board, you are advised to reset the board (using the **RST** button on the Carrier Board).

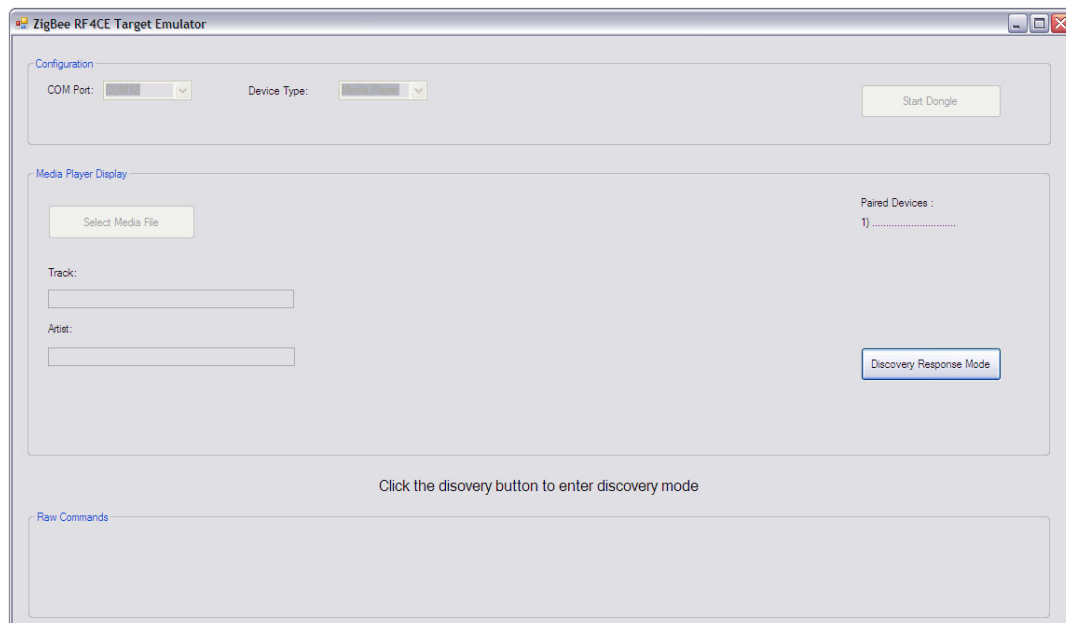
1. Find the COM port which corresponds to the USB Dongle.
  - a. Ensure that the Target Emulator is not running on the PC and that the USB Dongle is plugged into a USB port of the PC.
  - b. Find the number of the COM port to which the USB Dongle is connected.
2. Start the Target Emulator on the PC.

Run the Target Emulator application on the PC (to obtain the screen below).



3. Configure and start the USB Dongle:
  - a. Configure the following information on the first screen of the Target Emulator:
    - COM port to which the USB Dongle is connected (obtained in Step 1)
    - Device type that the software will emulate (Media Player)
  - b. Start the USB Dongle by clicking **Start Dongle** on the screen.

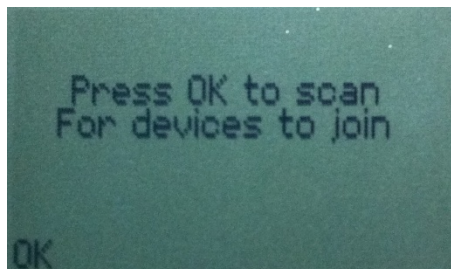
Once the dongle has started, the screen for the selected device type will be displayed (see screenshot below). This screen contains a field called Paired Devices which normally lists the IEEE/MAC addresses of those ZigBee RF4CE nodes with which the USB Dongle is paired - initially, there should be no paired devices.



**Note 1:** If this is not the first-time use of the demo system, a MAC address from the previous use may be shown under Paired Devices. To clear the system of all previous data, click on the **Unpair Device** button under the device list (this button is displayed instead of the **Discovery Response Mode** button if a previous pairing has been maintained).

**Note 2:** If the USB Dongle starts successfully, the configuration will be locked. If you need to release the configuration, you must close down the Target Emulator (or, if active, power off the LCD Expansion Board).

4. Start the LCD Expansion Board and pair with the USB Dongle:
  - a. Insert AAA batteries (supplied) into the Carrier Board with LCD Expansion Board (the required polarities are indicated on the board), if not already done. Note that alternative power sources are available.
  - b. Power on the Carrier Board with LCD Expansion Board. The welcome screen will be displayed on the LCD panel and then the following pairing screen will appear:



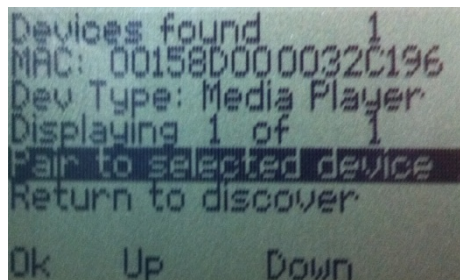
- c. In the Target Emulator on the PC, click on the **Discovery Response Mode** button to enter discovery mode, which allows a 60-second window to receive a discovery request from the LCD Expansion Board (next sub-step) - this mode will end as soon as a discovery request is received.





**Note:** If discovery mode times out without receiving a discovery request, the following message is displayed: “No discovery request received. Please try again”. To repeat discovery mode, click on the **Discovery Response Mode** button again.

- d. Press the **OK** button on the LCD Expansion Board within 60 seconds of starting Discovery Response mode in the Target Emulator. The board will now scan for other ZigBee RF4CE nodes with which it can potentially pair. If none are found, the above pairing screen will be displayed again (allowing you to re-try the scan from Step 4c - also refer to the advice in Note 2 of Step 4e below). Otherwise, the scan results will be displayed as illustrated below.



**Note:** Once a discovery request has been received and acknowledged by the USB Dongle, the following message will be displayed in the Target Emulator: “Device discovered. Confirm pairing on LCD Expansion board or click Discovery Response Mode”. The pairing is confirmed in the next sub-step.

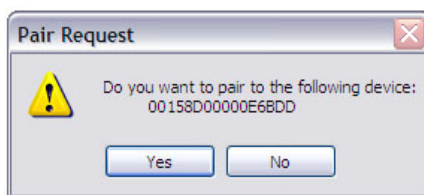
- e. From the scan results, select the USB Dongle to pair with the LCD Expansion Board. A detected node is identified in the scan results by means of its IEEE/MAC address. The details of only one detected node are displayed at any one time - to move between detected nodes, use the **Up/Down** buttons. Once you have found the USB Dongle in the results, press the **OK** button to initiate the pairing (normally, the USB Dongle will be the only result).



**Note 1:** If the USB Dongle does not appear in the scan results, use the **Down** button to select **Return** to discover and then press the **OK** button. This will return you to the previous screen, inviting you to re-try the scan from Step 4c.

**Note 2:** If the scan continues to fail to find the USB Dongle, you are advised to power off the LCD Expansion Board and re-start from Step 1.

- f. In the Target Emulator on the PC, wait for the following Pair Request box to be displayed (showing the IEEE/MAC address of the Carrier Board with LCD Expansion Board):



- g. Accept the pairing by clicking **Yes** in the above box. Once the pairing is confirmed, the IEEE/MAC address of the Carrier Board with LCD Expansion Board will appear in the Paired Devices list in the Target Emulator and a confirmation message will briefly appear on the LCD panel of the LCD Expansion Board before the Main Menu screen for the target device is displayed. In the Target Emulator, the **Discovery Response Mode** button will disappear and the **Unpair Device** button will appear.
5. Set up the LCD Expansion Board.
  - a. In the Main Menu on the LCD panel, select Setup Menu (using the **Up/Down** and **OK** buttons). The Setup Menu will now be displayed, as illustrated below.



- b. Use the **Up/Down** and **OK** buttons to select and configure the options in the Setup Menu:
    - **Time Before Sleep:** This is the time delay between the last button press and the node entering Deep Sleep mode (which allows the board to conserve power while not in use). This time delay can be set to 20, 40 or 60 seconds - pressing the **OK** button toggles through this range.
    - **Scan for devices:** This initiates a scan for other ZigBee RF4CE nodes with which the LCD Expansion Board can potentially pair. This option is used when the LCD Expansion Board needs to be paired with multiple target devices (e.g. to control a TV, DVD player and PVR). It is not required for the demonstration.
    - **Unpair remote:** This initiates an unpairing between the LCD Expansion Board and a paired node - that is, an existing pairing is removed. Unpairing is described further in Section 4.4. It is not required for the demonstration.
    - **Return to Main Menu:** This simply returns you to the Main Menu for the target device. Select this option once you have completed your LCD Expansion Board set-up.
6. Use the LCD Expansion Board to control the target device.
 

In the Main Menu screen on the LCD Expansion Board, select the menu screen for the target device (only Media Player is currently available) using the **Up/Down** and **OK** buttons. From now on, all commands sent from the LCD Expansion Board will be displayed in the Raw Commands window in the Target Emulator on the PC. For details of how to control the target device, refer to Section 4.3.





**Note 1:** The Target Emulator saves context data from this use, so that the pairing between the USB Dongle and the LCD Expansion Board is remembered the next time the USB Dongle is started. If you do not want this pairing for the next use of the demo system, click on the **Unpair Device** button after completing the demo and before closing down the Target Emulator. No pairing data will then be retained for the next use.

**Note 2:** If you lose a pairing with the LCD Expansion Board while using the demo system, you should clear the pairing in the Target Emulator by clicking on the **Unpair Device** button. You can then establish a new pairing by resuming from Step 4.

### 4.3 Controlling the Target Device

The ZigBee RF4CE Demonstration allows a target device to be selected and emulated on a PC - currently only the Media Player device is available. This device is selected during the set-up phase described in Section 4.2.2.



**Note:** The target device cannot be changed without first unpairing the nodes (see Section 4.4). The new target device can then be selected in the Target Emulator before re-pairing the nodes.

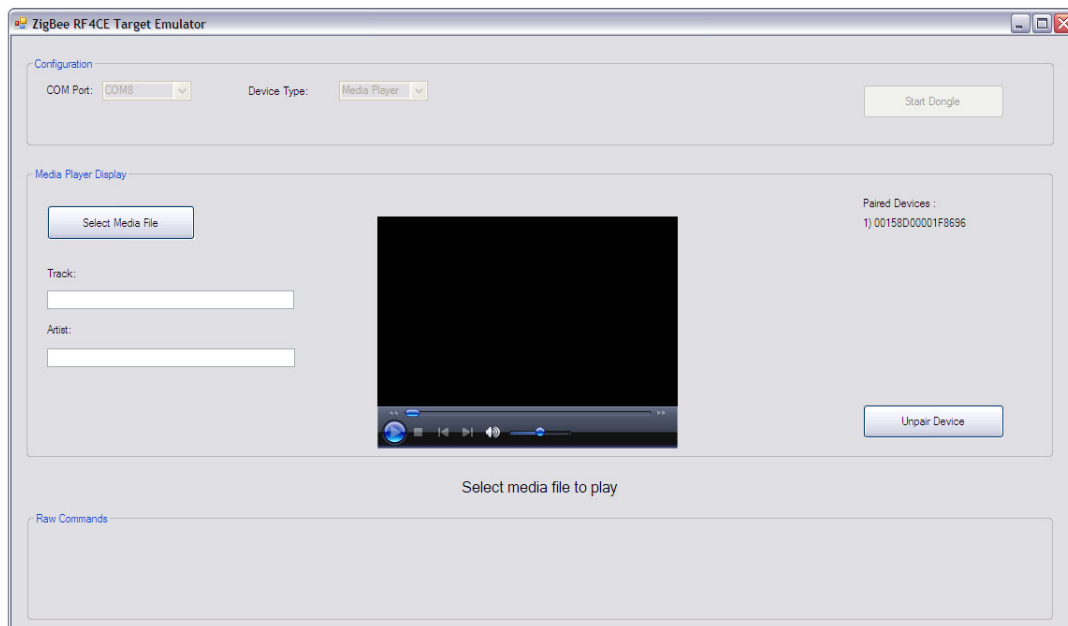
#### 4.3.1 Controlling the Media Player

This section describes how to control the Media Player in the Target Emulator.



**Important:** The Media Player is restricted to MP3 and MP4 files. Before using the Media Player, ensure that the directory **NXP\_ZigBee\_RF4CE** (created in Section 4.2.1) contains at least one MP3 or MP4 file.

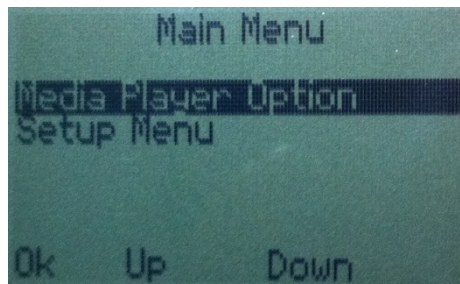
Once the Media Player has been selected as the target device in the set-up procedure of Section 4.2.2, the Target Emulator window on the PC will look like the example shown below.



**Figure 2: Media Player Screen in Target Emulator on PC**

Note that the Media Player screen in the Target Emulator contains on-screen controls for Play/Pause and Stop, as well as a Volume control and a screen (for computer-generated visual effects).

To access the Media Player via the LCD Expansion Board, select the Media Player from the Main Menu, shown below. You will then be prompted to select a media file to play.



**Figure 3: Media Player Option on LCD Expansion Board**

### 4.3.2 Selecting and Playing a Media File

A media file can be selected and played from the LCD Expansion Board or within the Target Emulator on the PC, as follows:

- From the LCD Expansion Board:
  - a. In the Main Menu, highlight **Media Player Option** using the **Up/Down** buttons and then press the **OK** button. The folder which contains the media files (**NXP\_ZigBee\_RF4CE**) will now be displayed on the PC.
  - b. Use the **Tab/Up/Down** buttons to highlight the desired media file and then press the **OK** button. The track and artist names will now be displayed in the Target Emulator on the PC, and the media file will play automatically.

- Within the Target Emulator on the PC:
  - a. In the Target Emulator, click on **Select media file**. The folder which contains the media files (**NXP\_ZigBee\_RF4CE**) will now be displayed on the PC.
  - b. Select the desired media file. The track and artist names will now be displayed in the Target Emulator on the PC, and the media file will play automatically.

Once a media file has been selected, the track/artist information for the file is sent to the LCD Expansion Board and displayed on the Media Player Menu screen, as illustrated in the example below.



Once a media file is playing, certain operations can be performed either from the LCD Expansion Board or in the Target Emulator on the PC.



**Note:** As indicated on the LCD screen, the user can operate the PC media player by sending Pause/Play, Volume Up and Volume Down commands. However, a ZigBee RF4CE application can also implement Stop, Fast Forward, Fast Reverse and other HDMI CEC commands.

## 4.4 Unpairing Devices

The facility is provided to remove an existing pairing between the LCD Expansion Board and another node. This option is useful if a target device is to be removed from the remote control system or is to be replaced.

Unpairing can be conducted from the Target Emulator interface or from the LCD Expansion Board.

### 4.4.1 From Target Emulator

To unpair the LCD Expansion Board and the USB Dongle using the Target Emulator, click on the **Unpair Device** button in the Target Emulator interface. If the LCD Expansion Board does not respond during the unpairing process, you will be prompted to confirm the unpairing in the Target Emulator.

### 4.4.2 From LCD Expansion Board

To unpair the LCD Expansion Board and the USB Dongle using the LCD Expansion Board, follow the procedure below:

1. Go to the **Setup Menu** on the LCD screen by selecting **Setup Menu** in the Main Menu.
2. In the **Setup Menu**, select the menu option **Unpair remote**.

The Unpair screen will be displayed, containing details of the first device in the set of paired devices of the LCD Expansion Board.

3. If required, select the device to be unpaired by using the **Up/Down** buttons.

4. When the device to be unpaired is found, press the **OK** button to unpair.
  - If there is at least one other device still paired with the LCD Expansion Board, the Main Menu will be displayed again (and you can repeat the above procedure to unpair again, if required).
  - If there are no other devices paired with the LCD Expansion Board, the **Scan for device** screen will be displayed, allowing you to initiate a new pairing (if not required, simply power off the LCD Expansion Board).

## 5 Rebuilding the Applications

The following build instructions are provided in case you need to re-build the applications (**Remote.c** and **Receiver.c**) of the ZigBee RF4CE Demonstration – for example, if you make your own modifications to the source code.

The software provided with this Application Note can be built for the JN516x device using the Eclipse IDE or makefiles. In order to build the software, the application's project folder must be placed in the **Application** folder of the JN516x SDK installation:


**<SDK\_ROOT>\Application**

where **<SDK\_ROOT>** is the path into which the SDK was installed (by default, this is **C:\Jennic**). The **Application** directory is automatically created when you install the SDK.

Build the applications as described in the appropriate section below, depending on whether you intend to use Eclipse or makefiles.

### 5.1 Using Eclipse

To build the applications, follow the instructions below:

1. Ensure that the project directory is located in **<SDK\_ROOT>\Application** where **<SDK\_ROOT>** is the path into which the SDK was installed.
2. Start the Eclipse platform and import the relevant project files (**.project** and **.cproject**) as follows:
  - a) In Eclipse, follow the menu path **File>Import** to display the **Import** dialogue box.
  - b) In the dialogue box, expand **General**, select **Existing Projects into Workspace** and click **Next**.
  - c) Enable **Select root directory**, browse to the **Application** directory and click **OK**.
  - d) In the **Projects** box, select the project to be imported and click **Finish**.
3. Build the application. To do this, ensure that the project is highlighted in the left panel of Eclipse and use the drop-down list associated with the hammer icon  in the Eclipse toolbar to select the relevant build configuration (for the relevant chip type and platform) – once selected, the application will automatically build. Repeat this to build the other application.

The binary file will be created in the relevant **Build** directory for the application, the resulting filename indicating the chip type (e.g. **JN5168**) and evaluation kit type (e.g. **EK001**) for which the application was built.

## 5.2 Using Makefiles

Each application (**Remote** and **Receiver**) has its own **Build** directory, which contains the makefile for the application, **Makefile**.

Ensure that `JENNIC_CHIP` in the makefile is set to the relevant target chip type (e.g. `JN5168` or `JN5161`).

To build an application, follow the instructions below:

1. Ensure that the project directory is located in  
**<SDK\_ROOT>\Application**  
where **<SDK\_ROOT>** is the path into which the SDK was installed.
2. Navigate to the **Build** directory for the application to be built and at the command prompt, enter:

```
make clean all
```



**Note:** You can alternatively enter the above command from the top level of the project directory, which will build the binaries for both the applications.

The binary file will be created in the relevant **Build** directory for the application, the resulting filename indicating the chip type (e.g. **JN5168**) and evaluation kit type (e.g. **EK001**) for which the application was built.

## 6 Appendices

### 6.1 Code Size Statistics

The software provided with this Application Note has the following memory footprint.

Components	Usage in KB for Remote Control Device	Usage in KB for Receiver Device
ZigBee RF4CE, including all APIs (ZigBee RF4CE, 802.15.4 MAC, Integrated Peripherals and Board APIs)	35	34
Application including Debug print utility, ZRC/ZID	7	3.7
Data RAM (excluding Stack and Heap) Note: Data RAM excludes the Stack (which is 4KB and can be optimised to 2KB) and Heap (which is 2KB and can be optimised to 1KB)	3.4	3.6



**Note:** The above size analysis was done using the map files generated during the application build process.

## 6.2 ZigBee Remote Control (ZRC) Commands

The following ZRC functions are supported for application use:

Command Name	Function Name
User control pressed	vZRC_SendUserControlPressed
User control repeated	vZRC_SendUserControlRepeated
User control released	vZRC_SendUserControlReleased
Command discovery request	vZRC_SendCmdDiscRequest
Command discovery response	vZRC_SendCmdDiscResponse

For further details on ZRC, please refer to the following documents:

- ZigBee RF4CE: ZRC Profile Specification, v1.1.0
- ZigBee RF4CE Stack User Guide (JN-UG-3074)

## 6.3 ZigBee Input Device (ZID) Commands

The following ZID functions are supported for application use:

Command Name	Function Name
Report data command	vZID_SendReportData
Get report command	vZID_SendGetReporta

For further details on ZID, please refer to the following documents:

- ZigBee RF4CE: ZigBee Input Device (ZID) Profile Version 1.0
- ZigBee RF4CE Stack User Guide (JN-UG-3074)



## Revision History

Version	Notes
1.0	First release
1.1	Modified source code to clear build warning of receiver.c.
1.2	Updated for JN516x-EK001 Evaluation Kit
1.3	Minor corrections made and evaluation kit photograph updated
1.4	Build configuration added for the JN5161 device

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