



This Application Note illustrates Packet Error Rate (PER) testing using boards from an NXP evaluation kit fitted with JN516x wireless microcontrollers. PER testing can be used to evaluate the communication range achievable in different operating environments. Packets are sent from one device to another, and the number of failed packets is assessed and displayed.

1 Application Overview

The software supplied with this Application Note allows Packet Error Rate (PER) testing to be conducted using boards from an NXP evaluation kit fitted with JN516x-based modules. Two applications are provided, one for a PER Master and another for a PER Slave. The supplied application binary files must be loaded into two evaluation kit boards – the PER Master application into either the controller board (with LCD screen) or connected to a PC via serial port (TTY) and the PER Slave application into a sensor board. Packets (frames) are sent between the boards and the PER results are displayed on the LCD screen of the controller board, as well as on a serially connected PC (if required). Installation and operating instructions are provided below.

2 Compatibility

The software provided with this Application Note is intended to be used with the following kits and SDK versions:

Product Type	Part Number	Version
Evaluation Kit	JN516x-EK001	-
SDK Libraries	JN-SW-4163	V1052
BeyondStudio for NXP	JN-SW-4141	V1111

3 Building and Downloading the Application

This section provides build instructions in case you need to rebuild the PER tester applications. If you simply wish to use the supplied application binaries, go to the **Installation** section.

The software provided with this Application Note can be built for the JN516x microcontroller. JN516x applications can be built using the BeyondStudio for NXP or makefiles.

In order to build the supplied software, the application's folder must be placed in the **workspace** folder of the BeyondStudio for NXP installation:

<BeyondStudio for NXP Installation root>\workspace

where **<BeyondStudio for NXP Installation root>** is the path into which BeyondStudio for NXP was installed (by default, this is **C:\NXP\bstudio_nxp**). The **workspace** directory is automatically created when you start BeyondStudio for NXP.

Build the application as described in the appropriate section below, depending on whether you intend to use BeyondStudio for NXP or makefiles.

3.1 Using BeyondStudio for NXP

To build the applications and load them into JN516x-based boards, follow the instructions below:

1. Ensure that the project directory is located in
<BeyondStudio for NXP Installation root>\workspace
2. Start BeyondStudio for NXP and import the relevant project as follows:
 - a) In BeyondStudio, 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** and browse to the **workspace** directory.
 - d) In the **Projects** box, select the project to be imported and click **Finish**.



Note: For the **JN5168** device, specify `JENNIC_CHIP=JN5168`



Note: For the **DR1174** board, specify `JENNIC_PCB=DEVKIT4`



Note: For the **DR1047/DR1048** board, specify `JENNIC_PCB=DEVKIT2`

3. Build an application. To do this, ensure that the project is highlighted in the left panel of BeyondStudio and use the drop-down list associated with the hammer icon  in the toolbar to select the relevant build configuration – once selected, the application will automatically build. Repeat this to build the other application.
 The binary files will be created in the relevant **Build** directories, the resulting filenames indicating the chip type (e.g. **JN5168**) for which they were built.
4. Load the resulting binary files into the board. You can do this using the integrated Flash programmer, as described in the *BeyondStudio for NXP Installation and User Guide (JN-UG-3098)*.

3.2 Using Makefiles

Each application (PER Master and PER Slave) has its own **Build** directory, which contains the makefiles for the application.

To build each application and load it into a JN516x-based board, follow the instructions below:

1. Ensure that the project directory is located in

<BeyondStudio for NXP Installation root>\workspace

2. Start an MSYS shell by following the Windows Start menu path:
All Programs > NXP > MSYS Shell
3. Navigate to the **Build** directory for the application to be built and then enter a make command, as described below.

The instruction below assumes that the type of chip (JN5168) has been specified in the makefile using `JENNIC_CHIP=JN5168`.

At the command prompt, enter:

```
make clean all
```

Alternatively, the JN5168 chip type can be specified in the make command as:

```
make JENNIC_CHIP=JN5168 clean all
```



Note: If using a DR1174 board, insert `JENNIC_PCB=DEVKIT4` either in the makefile or in the make command – for example, the above command would become:

```
make JENNIC_CHIP=JN5168 JENNIC_PCB=DEVKIT4 clean all
```



Note: If using a DR1047/DR1048 board, insert `JENNIC_PCB=DEVKIT2` either in the makefile or in the make command – in this case, the command would become:

```
make JENNIC_CHIP=JN5168 JENNIC_PCB=DEVKIT2 clean all
```

Note that you can enter any of the above commands from the top level of the project directory, which will build the binaries for both applications.

In all the above cases, the binary file will be created in the **Build** directory, the resulting filename indicating the chip type (e.g. **JN5168**) for which the application was built.

4. Load one of the resulting binary files into the board. You can do this from the command line using the JN51xx Production Flash Programmer (described in the *JN51xx Production Flash Programmer User Guide (JN-UG-3099)*).

4 Installation

The application binaries must be loaded into the evaluation kit boards as described below.

4.1 DR1174 Boards

Load the following binaries into the boards:

- **AN1006_PER_Master_JN5xxx.bin** into a DR1174 Carrier Board fitted with DR1201 LCD Expansion Board
- **or**
- **AN1006_PER_TTY_Master_JN5xxx.bin** into any DR1174 Carrier Board (without LCD screen) connected to a PC
- **AN1006_PER_Slave_JN5xxx.bin** into a DR1174 Carrier Board

Results are displayed on the LCD screen but can also be optionally output on the serial port of either board to a PC. To display the results on a PC, use HyperTerminal or similar with the following settings: 38400 bps, 8 bits, no parity, 1 stop bit, no flow control.

4.2 DR1047/DR1048 Boards

First rebuild the binaries using the JENNIC_PCB=DEVKIT2 option, then load the following binaries to the boards:

- **AN1006_PER_Master_JN5xxx.bin** into the controller board (with LCD screen)
- **or**
- **AN1006_PER_TTY_Master_JN5xxx.bin** into any board (without LCD screen) connected to a PC
- **AN1006_PER_Slave_JN5xxx.bin** into a sensor board

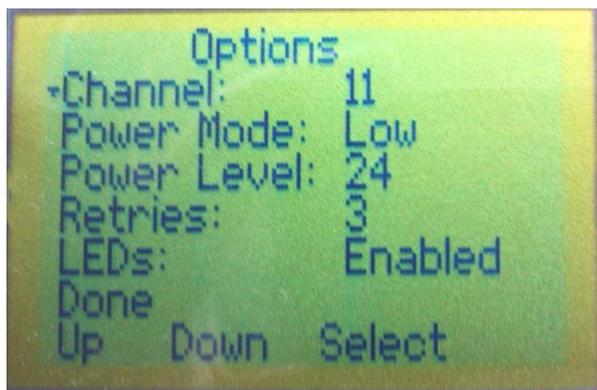
Results are displayed on the LCD screen of the controller board but can also be optionally output on the serial port of either board to a PC. To display the results on a PC, use Tera Term or similar with the following settings: 38400 bps, 8 bits, no parity, 1 stop bit, no flow control.

5 Operating Instruction: PER Master LCD Version

5.1 Options Menu

When the PER Master board is first powered on, a menu is displayed containing entries for 'Channel', 'Power Mode', 'Power Level', 'Retries', 'LEDs' and 'Done'. You can use button SW1 to move up the menu, SW2 to move down the menu and SW3 to change or select the current menu item (button SW4 is not used).

On a PC terminal use keys numbered '1', '2', '3' to move around the menus and select/change the current items.



5.1.1 Channel

The channel number on both boards can be incremented by pressing button SW1 on the PER Master board. If the channel number is incremented beyond channel 26, it goes back to channel 11.

5.1.2 Power Mode

The 'Power Mode' entry is used to select the desired output power for transmission and toggles through the following settings

- Low: Standard-power modules, e.g. M03
- High: High-power modules, e.g. M04
- Boost: Enables +3dBm mode
- 0dBm: Enables 0dBm mode (standard-power modules, e.g. M03)
- ETSI: Enables ETSI mode (+10dBm) (high-power modules, e.g. M04)

5.1.3 Power Level

There are only 4 valid power level settings for JN5168-based modules: 0, 8, 16 and 24, which respectively correspond to PAP=0, 1, 2 and 3. If any other value is entered then the maximum power (PAP=3) is selected.

'Power Level' Setting	0	8	16	24
Standard module	-32 dBm	-21 dBm	-9.5 dBm	2 dBm
High-power module (M04)	-13 dBm	-1 dBm	9 dBm	16 dBm

Note: ETSI limits the maximum output power to +10dBm.

5.1.4 Retries

The 'Retries' entry is used to set the number of frame retransmission attempts - each press of SW3 increments the number of retries to a maximum of 7 (a subsequent press takes the value back to 0 again).

5.1.5 LEDs

The 'LEDs' entry allows the on-board LEDs to be disabled, reducing power consumption for current measurements.

5.1.6 Done

Select 'Done' to apply the settings and start the PER test. The application will now move on to the 'Ack Mode' menu (see next section).

5.2 Ack Mode Menu

The 'Ack Mode' menu allows the mode of operation to be changed between 'no ack' and 'ack' (see sections below). This menu also allows the channel to be changed. The default mode is 'ack' and the default channel is 11.

To move between 'ack' and 'no ack' modes, press button SW3 on the PER Master board. In 'ack' mode, LED D2 will illuminate on the PER Slave board. The mode will be shown as 'ack' on the LCD screen of the PER Master board (and through the serial port, if used).

The signal strength is displayed on the PER Master board using LEDs D1, D2, D3 and D4, as follows:

- 4 LEDs on ⇒ Very strong signal (greater than 60 dB above the receiver sensitivity level)
- 3 LEDs on ⇒ Good signal (greater than 40 dB above the receiver sensitivity level)
- 2 LEDs on ⇒ Acceptable signal (greater than 20 dB above the receiver sensitivity level)
- 1 LEDs on ⇒ Weak signal (less than 20 dB above the receiver sensitivity level)
- 0 LEDs on ⇒ No packets are being received

The Link Quality Indication (LQI) value is displayed on the LCD screen as a bar graph and is output to the serial port as a text value.



5.2.1 'Ack' Mode

In 'ack' mode, frames are sent from the PER Master using 802.15.4 clear channel assessment. The PER Slave code acknowledges the frames using 802.15.4 standard acknowledgements.



Note: The default retry value is set to 3, as defined by the IEEE 802.15.4 standard.

The PER Master displays the current channel, the number of successfully acknowledged frames, the total number of frames it sent and the percentage of unacknowledged frames (where 0% PER signifies ideal results and 100% PER implies no reception of frames). It also shows the percentage of frames that failed to be transmitted due to the channel being noisy with other traffic (CCA fail) and the setting of the number of retransmission attempts.

The values are accumulated over all of the frames that have been seen. To stop the accumulation of results, press button SW2 - the results screen then freezes and LED D1 illuminates on the PER Slave board. Press button SW2 again to reset and restart the results display - LED D1 will also be extinguished on the PER Slave board.

5.2.2 'No ack' Mode

In 'no ack' mode, frames are sent in one direction only. The PER Slave code sends short frames at the rate of about 1000 frames per second.

The PER Master code displays the current channel, the number of frames seen, the total number of frames that the master believes were sent and the percentage ratio of these two frame counts (where 0% PER signifies ideal results and 100% PER implies no reception of frames).

The values are accumulated over all of the frames that have been seen. To stop the accumulation of results, press button SW2 - the results screen then freezes and LED D1 illuminates on the PER Slave board. Press button SW2 again to reset and restart the results display - LED D1 will also be extinguished on the PER Slave board.



Note: If the device containing the PER Slave code is switched off while using 'no ack' mode, the reported PER value will not rise to 100% but will be frozen at its last measured value.

6 Operating Instructions: PER Master TTY Version

6.1 Options Menu

When the PER Master board is first powered on, a menu is displayed containing entries for 'Channel', 'Power Mode', 'Power Level', 'Retries', 'LEDs' and 'Done'. You can use keyboard key '1' to move up the menu, '2' to move down the menu and '3' to change or select the current menu item.

6.1.1 Channel

The channel number on both boards can be incremented by pressing key '1' on the PC Keyboard. If the channel number is incremented beyond channel 26, it goes back to channel 11.

6.1.2 Power Mode

The 'Power Mode' entry is used to select the desired output power for transmission and toggles through the following settings

- Low: Standard-power modules, e.g. M03
- High: High-power modules, e.g. M04
- Boost: Enables +3dBm mode
- 0dBm: Enables 0dBm mode (standard-power modules, e.g. M03)
- ETSI: Enables ETSI mode (+10dBm) (high-power modules, e.g. M04)

6.1.3 Power Level

There are only 4 valid power level settings for JN5168-based modules: 0, 8, 16 and 24, which respectively correspond to PAP=0, 1, 2 and 3. If any other value is entered then the maximum power (PAP=3) is selected.

'Power Level' Setting	0	8	16	24
Standard module	-32 dBm	-21 dBm	-9.5 dBm	2 dBm
High-power module (M04)	-13 dBm	-1 dBm	9 dBm	16 dBm

Note: ETSI limits the maximum output power to +10dBm.

6.1.4 Retries

The 'Retries' entry is used to set the number of frame retransmission attempts - each press of key '3' increments the number of retries to a maximum of 7 (a subsequent press takes the value back to 0 again).

6.1.5 LEDs

The 'LEDs' entry allows the on-board LEDs to be disabled, reducing power consumption for current measurements.

6.1.6 Done

Select 'Done' to apply the settings and start the PER test. The application will now move on to the 'Ack Mode' menu (see next section).

6.2 Ack Mode Menu

The 'Ack Mode' menu allows the mode of operation to be changed between 'no ack' and 'ack' (see sections below). This menu also allows the channel to be changed. The default mode is 'ack' and the default channel is 11.

To move between 'ack' and 'no ack' modes, press key '3' on the PC Keyboard. The mode will be shown as 'ack' on the terminal.

6.2.1 'Ack' Mode

In 'ack' mode, frames are sent from the PER Master using 802.15.4 clear channel assessment. The PER Slave code acknowledges the frames using 802.15.4 standard acknowledgements.



Note: The default retry value is set to 3, as defined by the IEEE 802.15.4 standard.

The PER Master displays the current channel, the number of successfully acknowledged frames, the total number of frames it sent and the percentage of unacknowledged frames (where 0% PER signifies ideal results and 100% PER implies no reception of frames). It also shows the percentage of frames that failed to be transmitted due to the channel being noisy with other traffic (CCA fail) and the setting of the number of retransmission attempts.

The values are accumulated over all of the frames that have been seen. To stop the accumulation of results, press key '2' - the results screen then freezes. Press key '2' again to reset and restart the results display.

The signal strength is displayed on the PER Master board using LEDs D3, D6, as follows:

- 2 LEDs on ⇒ Acceptable signal (greater than 20 dB above the receiver sensitivity level)
- 1 LEDs on ⇒ Weak signal (less than 20 dB above the receiver sensitivity level)
- 0 LEDs on ⇒ No packets are being received

6.2.2 'No ack' Mode

In 'no ack' mode, frames are sent in one direction only. The PER Slave code sends short frames at the rate of about 1000 frames per second.

The PER Master code displays the current channel, the number of frames seen, the total number of frames that the master believes were sent and the percentage ratio of these two frame counts (where 0% PER signifies ideal results and 100% PER implies no reception of frames).

The values are accumulated over all of the frames that have been seen. To stop the accumulation of results, press key '2' - the results screen then freezes. Press key '2' again to reset and restart the results display.



Note: If the device containing the PER Slave code is switched off while using 'no ack' mode, the reported PER value will not rise to 100% but will be frozen at its last measured value.

Revision History

Version	Notes
1.0	First release
1.1	Software updated to support DR1215 LCD Expansion Board
1.2	Update for BeyondStudio and Tera Term

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