

The logo for Jennic, featuring the word "Jennic" in a bold, dark blue, sans-serif font. The background of the top half of the page is a blue-toned digital landscape with glowing lines and a bright light source on the horizon.

TECHNOLOGY FOR A CHANGING WORLD

JN5148-EK010 ZigBee PRO Evaluation Kit User Guide

JN-UG-3062
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About this Manual

This manual provides a guide to setting up a simple wireless network based on the Jennic JN5148-EK010 Evaluation Kit. The manual also describes how to run the supplied Home Sensor Demonstration on the resulting system.

The demonstration application is based on the ZigBee PRO wireless network protocol, but you can also use this evaluation kit along with the Jennic JN5148 Software Developer's Kit (SDK) to produce applications based on the IEEE 802.15.4 protocol or the JenNet protocol.

You should work through this manual from beginning to end before attempting to develop your own wireless network applications using the Jennic JN5148 SDK.

Organisation

This manual consists of 4 chapters and 2 appendices, as follows:

- [Chapter 1](#) introduces the Jennic JN5148-EK010 Evaluation Kit.
- [Chapter 2](#) outlines the key wireless network concepts that you will need in order to understand and use the supplied demonstration application.
- [Chapter 3](#) describes how to use the evaluation kit to set up a simple wireless network and run the pre-loaded Home Sensor Demonstration.
- [Chapter 4](#) provides guidance on choosing a wireless network protocol for your own application development, and indicates where to go next within the Jennic user documentation.
- The [Appendices](#) contain a summary of how the demonstration application uses the buttons on the evaluation kit boards as well as guidance on programming application binaries into the boards.

Conventions

Files, folders, functions and parameter types are represented in **bold** type.

Function parameters are represented in *italics* type.

Code fragments are represented in the `Courier New` typeface.



This is a **Tip**. It indicates useful or practical information.



This is a **Note**. It highlights important additional information.



*This is a **Caution**. It warns of situations that may result in equipment malfunction or damage.*

Acronyms and Abbreviations

API	Application Programming Interface
JenNet	Jennic Network
SDK	Software Developer's Kit

Related Documents

- [1] JN51xx Flash Programmer User Guide [JN-UG-3007]

Feedback Address

If you wish to comment on this manual, or any other Jennic user documentation, please provide your feedback by writing to us (quoting the manual reference number and version) at the following postal address or e-mail address:

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1. Introduction to the Evaluation Kit

Welcome to the Jennic JN5148-EK010 Evaluation Kit. This kit allows a small wireless network to be quickly assembled and used with a pre-loaded demonstration application. The evaluation kit can also be used in conjunction with the Jennic JN5148 Software Developer's Kit (SDK) to develop new applications.

The Jennic JN5148 SDK allows wireless network applications to be developed based on any of the following protocols: IEEE 802.15.4, JenNet, ZigBee PRO. Guidelines for selecting a suitable protocol for your application are presented in [Section 4.1](#) but before this selection, you should work through the earlier chapters of this manual.

This chapter introduces you to the evaluation kit by describing:

- the contents of the kit - see [Section 1.1](#)
- the hardware features of the kit - see [Section 1.2](#)
- how to register for technical support - see [Section 1.3](#)

1.1 Kit Contents

In the JN5148-EK010 Evaluation Kit, you will find the following components (numbers refer to [Figure 1](#)):

1. 1 Controller board with LCD and pre-installed module with uFI connector*
2. 4 Sensor boards:
 - 2 with pre-installed module with uFI connector*
 - 2 with pre-installed module with integrated PCB antenna
3. 2 high-power plug-in modules with uFI connector*
4. 3 SMA-connector antennae
5. 2 USB-to-Serial (FDTI) cables
6. 1 pack of 10 AAA batteries for the boards
 - Paper documentation, including Getting Started sheet and list of IEEE/MAC addresses for modules

* All modules with uFI connectors are mounted on uFI-to-SMA adaptor boards.



Figure 1: JN5148-EK010 Evaluation Kit Components

The boards of this evaluation kit are pre-programmed with the relevant binaries for the Jennic ZigBee PRO Home Sensor Demonstration. However, the high-power modules are not pre-programmed with the demonstration - see [Appendix B](#).

1.2 Kit Hardware

The JN5148-EK010 Evaluation Kit includes 5 boards which can act as wireless network nodes: 4 Sensor boards and a Controller board. These boards are illustrated and described below.

1.2.1 Sensor Board

The 4 Sensor boards are physically identical and each board is pre-installed with a plug-in module containing the Jennic JN5148 wireless microcontroller. The pre-installed modules differ only in their antenna provision:

- Two modules feature an integrated PCB antenna
- Two modules are mounted on uFI-to-SMA adaptor boards, each having an SMA connector which can accept one of the supplied screw-on antennae



Note: It is possible to replace the latter pre-installed modules (with SMA connectors) with the high-power modules. However, this requires the demonstration application to be modified and re-built for these modules, and is therefore not recommended during a first-time use of the evaluation kit. If required, the necessary changes are covered in the Application Note *ZigBee PRO Home Sensor Demonstration (JN-AN-1122)*.

Each Sensor board is a Jennic DR1048 board with the following features (also refer to [Figure 2](#)):

- 4 LED indicators
- 4 push-button switches
- Temperature sensor
- Humidity sensor
- Light sensor
- Serial EEPROM
- UART interface for communication and program downloads
- Expansion port for additional sensors

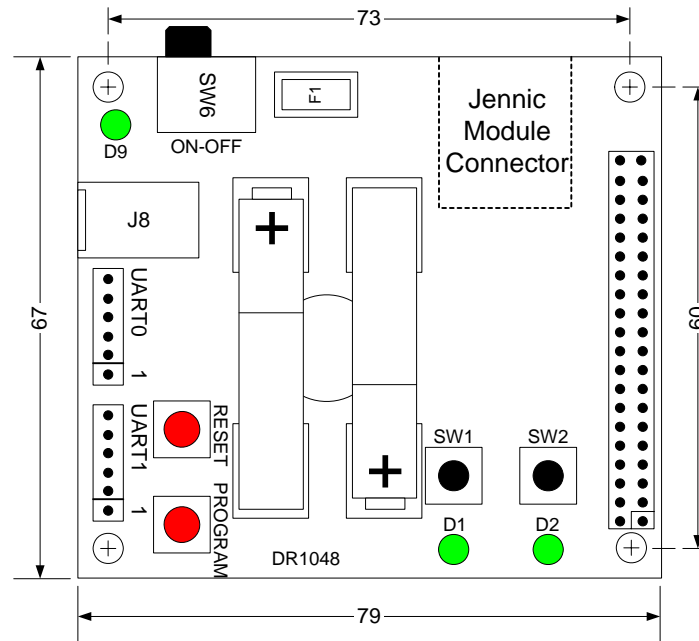


Figure 2: DR1048 Sensor Board

1.2.2 Controller Board

The Controller board is a Jennic DR1047 board with the following features (also refer to [Figure 3](#)):

- Large 128 x 64 pixel LCD screen with a comprehensive set of driver routines (write text, chart, graph, trend, etc)
- 4 LED indicators
- 4 push-button switches
- Temperature sensor
- Humidity sensor
- Light sensor
- Serial EEPROM
- UART interface for communication and program downloads
- Expansion port for additional sensors

The Controller board features a pre-installed module mounted on a uFI-to-SMA adaptor board having an SMA connector which can accept one of the supplied screw-on antennae.

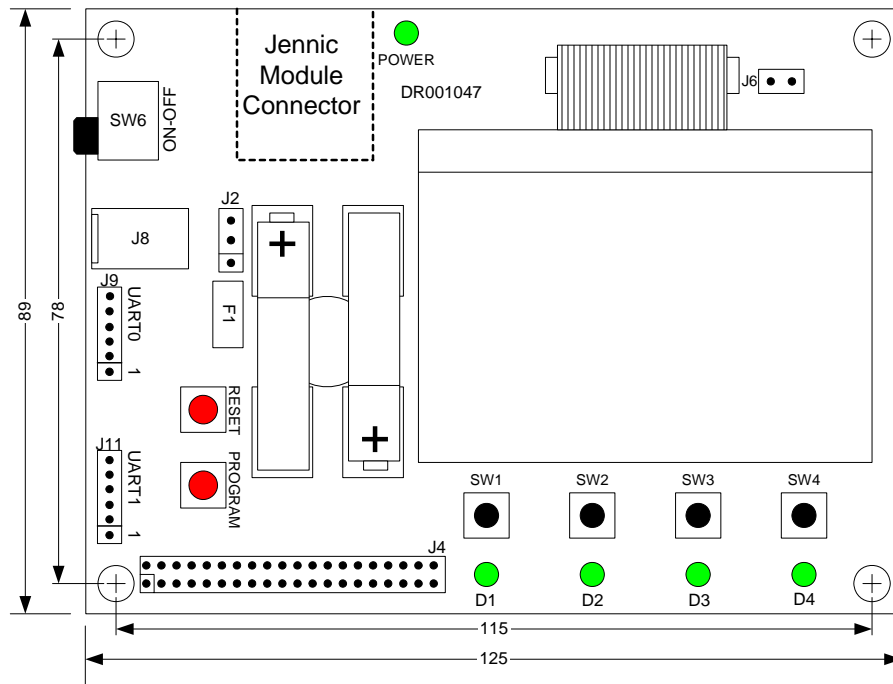


Figure 3: DR1047 Controller Board

1.3 Registering for Technical Support

To register for technical support, visit www.jennic.com/support and follow the **About Technical Support** link. Once registered, you can create technical support requests and receive feedback via the online technical support system. You can also subscribe to the Support newsletter to ensure Jennic keeps you informed of any support updates.

2. Wireless Network Concepts

Before setting up a wireless network and running the supplied demonstration, you are advised to study the background information on wireless networks presented in this chapter. Only the basic concepts that are essential to using the evaluation kit and demonstration are covered here - they are:

- Radio frequency - see [Section 2.1](#)
- Node types - see [Section 2.2](#)
- Network formation and topology - see [Section 2.3](#)
- Software stack - see [Section 2.4](#)

The concepts covered are relevant to the three wireless network protocols included in the Jennic JN5148 SDK - IEEE 802.15.4, JenNet and ZigBee PRO. Note that all three protocols are based on IEEE 802.15.4. For a more complete introduction to wireless networks, refer to the Jennic User Guide for the relevant protocol (see [Section 4.2](#)).

2.1 Radio Frequency

The evaluation kit boards communicate in the 2400-MHz radio frequency (RF) band. This is one of the standard RF bands used by the IEEE 802.15.4 wireless network protocol (on which JenNet and ZigBee PRO are built), and is available for unlicensed use in most geographical areas (check your local radio communication regulations).

The 2400-MHz band spans radio frequencies 2405 to 2480 MHz and is divided into 16 channels, numbered 11 to 26 (the numbers up to 10 are used for other RF bands) - see [Figure 4](#) below.

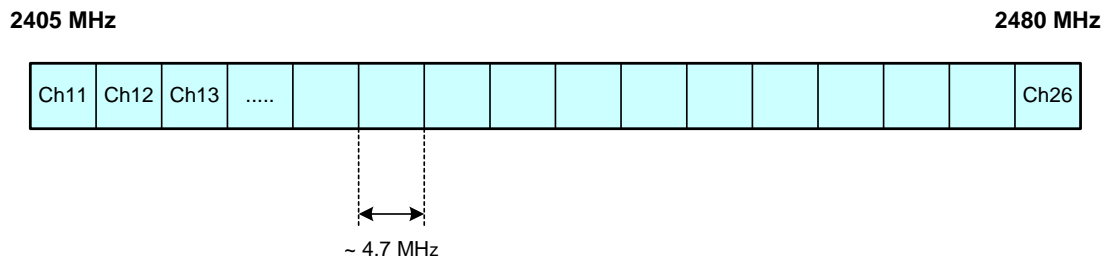


Figure 4: 2400-MHz RF Band

The channel of operation for a network can be specified by the application or, alternatively, the network can search for the best channel (the one with least detected activity) at system start-up.

2.2 Node Types

In addition to running an application (e.g. temperature measurement), each node of a wireless network has a networking role. A wireless network can contain three types of node, differentiated by their networking roles, as described below:

Node Type	Description
Co-ordinator	Every wireless network has one and only one Co-ordinator. This node has a role in starting and forming the network, and can also have a routing role (passes messages from one node to another). Messages can also originate and terminate here.
Router	This node passes messages from one node to another. Messages can also originate and/or terminate at a Router.
End Device	This node is simply a place where messages can originate and/or terminate (the node does not have a routing role).

Table 1: Node Types in a Wireless Network

The roles of the above node types will become more apparent in [Section 2.3](#) on network topologies.

For the pre-loaded Home Sensor Demonstration, the evaluation kit boards are pre-programmed as the following node types:

- The Controller board (with LCD screen) is programmed as the Co-ordinator.
- The two Sensor boards with SMA connectors are programmed as Routers.
- The two Sensor boards with integrated PCB antennae are programmed as End Devices.

To run the demonstration, it is not necessary to be aware of the node types of the boards except that the Controller board is the Co-ordinator (this node should be started first).

2.3 Network Formation and Topology

A wireless network is formed by starting the Co-ordinator node, which performs network initialisation including the selection of the radio channel in which the network will operate (see [Section 2.1](#)). Once this initialisation is complete, the Co-ordinator will allow other nodes to join it as its 'children' - the Co-ordinator is referred to as a 'parent'. These child nodes can be Routers and/or End Devices. A Router can itself become a parent and allow child nodes to join it (which may themselves be Routers and/or End Devices). In this way, the network grows.

A number of network shapes or topologies are possible, which are dependent on the wireless network protocol used. These are the Star, Tree and Mesh topologies, described below.

2.3.1 Star Networks

A Star network contains only one routing node, which is the Co-ordinator - see [Figure 5](#) below. Thus, all messages between the network nodes are routed via the central Co-ordinator.

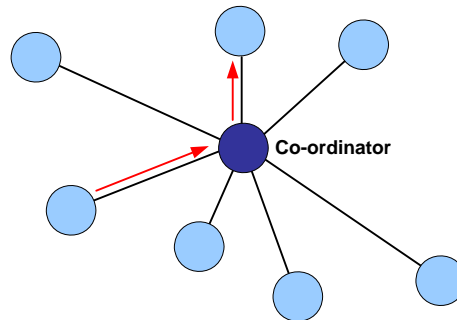


Figure 5: Star Network

The Star topology is available in the IEEE 802.15.4, JenNet and ZigBee PRO protocols, and can be considered as a special (simplified) case of a Tree or Mesh topology. It is only suitable for networks that require a restricted range and in which traffic levels are low, as the network is prone to congestion at the central Co-ordinator (which is also a potential single point-of-failure).

2.3.2 Tree Networks

A Tree network contains the full range of node types - Co-ordinator, Routers and End Devices. The Co-ordinator is linked to a set of Routers and End Devices - its children. A Router may then be linked to more Routers and End Devices - its children. This can continue to a number of levels, as illustrated in [Figure 6](#). Any node can only communicate directly with its parent and children (if any). Thus, a message for a remote node must be passed up the tree until it can be passed down to its destination.

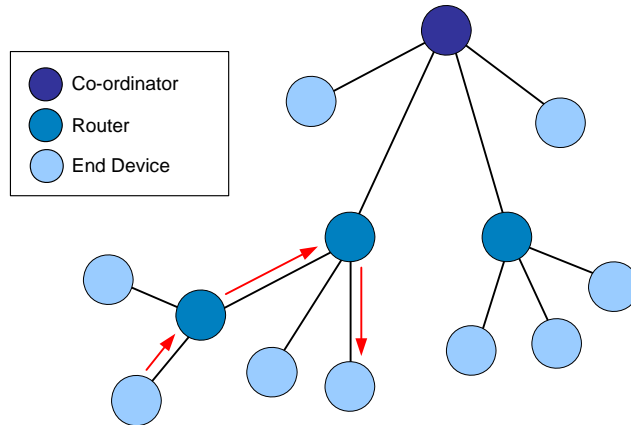


Figure 6: Tree Network

The Tree topology is available in the IEEE 802.15.4 and JenNet protocols (in ZigBee PRO, it is enhanced to a Mesh topology). It is suitable for larger networks and higher traffic levels than the Star topology, but lacks the flexible routing of the Mesh topology.

2.3.3 Mesh Networks

A Mesh network contains the full range of node types - Co-ordinator, Routers and End Devices. Any routing node (Router or Co-ordinator) can communicate directly with any other routing node within radio range. However, an End Device can only communicate directly with its parent. When sending a message between two nodes that cannot communicate directly, the message is routed via intermediate routing nodes. However, in a Mesh network there may be more than one possible route between the source and destination nodes. A simple Mesh network is illustrated in [Figure 7](#) below.

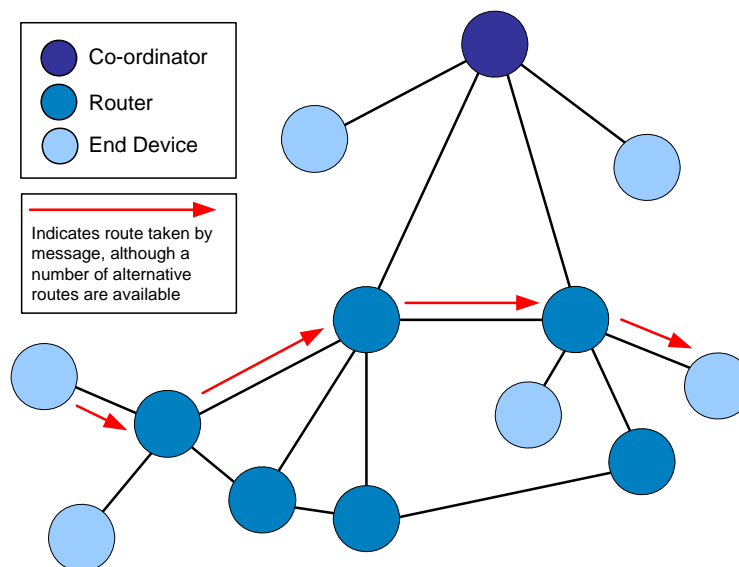


Figure 7: Mesh Topology

The Mesh topology is available in the IEEE 802.15.4 and ZigBee PRO protocols but, in practice, ZigBee PRO should be used if a Mesh network is required. Like the Tree topology, the Mesh topology is suitable for large networks with high traffic levels. However, the flexible routing of a Mesh network significantly increases the reliability of message delivery, since an alternative route can often be found in the case of a link failure.

Since a wireless network forms dynamically, its exact topology is not pre-determined. [Figure 8](#) below shows examples of Mesh topologies that may be obtained using the five nodes of the JN5148-EK010 Evaluation Kit (other Mesh topologies are also possible).

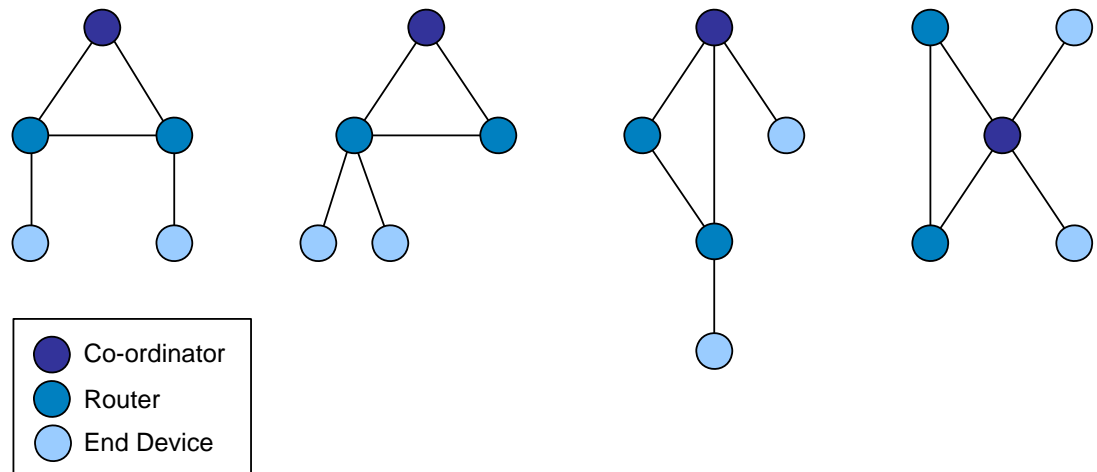


Figure 8: Example Mesh Networks using Evaluation Kit Boards

The exact topology adopted by a network is transparent to its high-level operation.

2.4 Wireless Network Protocol Stack

The software which runs on a wireless network node deals with both application-specific tasks (e.g. temperature measurement) and networking tasks (e.g. assembling a message to send to another node). The software on a node is organised as a number of layers, forming a stack, with the user application at the top. The basic layers of a wireless network protocol stack are typically as illustrated in [Figure 9](#) below.

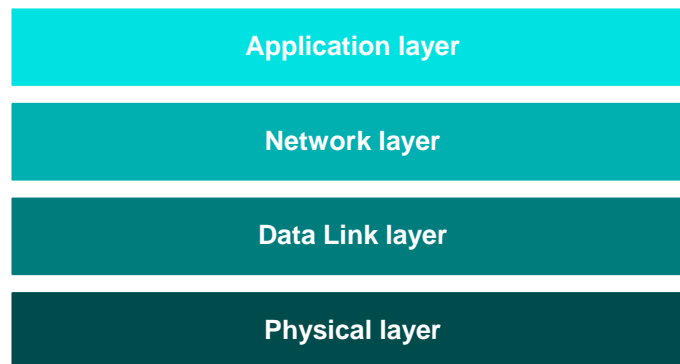


Figure 9: Basic Layers of Stack

The stack layers are outlined below, from top to bottom:

- **Application layer:** Contains the user applications which run on the network node and provides an interface to the lower layers
- **Network layer:** Provides the networking functionality and an interface to the IEEE 802.15.4 layers (see below) - this layer can be provided by the ZigBee PRO or JenNet protocol, but is not required for a pure IEEE 802.15.4 network
- **Data Link layer:** Provided by the MAC (Media Access Control) layer of the IEEE 802.15.4 standard, and responsible for message assembly/disassembly and addressing (e.g. specifying the destination of outgoing messages)
- **Physical layer:** Provided by the PHY (Physical) layer of the IEEE 802.15.4 standard and concerned with interfacing to the physical transmission medium (radio, in this case)

A number of C APIs (Application Programming Interfaces) are provided by Jennic to allow a user application to easily interact with the layers of the stack. These APIs are supplied in the JN5148 SDK. The required APIs depend on the protocol used - APIs are available for IEEE 802.15.4, JenNet (known as the Jenie API) and ZigBee PRO.

The software components that implement the Data Link and Physical layers of the stack are pre-programmed in on-chip ROM. The user application is developed and built on a PC. The resulting application binary file also incorporates the Network layer of the stack and is loaded into the Flash memory of the node.

In order to use the ZigBee PRO Home Sensor Demonstration which is pre-loaded in Flash memory of the evaluation kit boards, no knowledge of the ZigBee PRO software is required. However, you should familiarise yourself with the software for your chosen protocol before starting your own application development - refer to [Section 4.2](#) for details of the user documentation for the different protocols.

3. Home Sensor Demonstration

You are now going to set up a small wireless network, using the contents of the JN5148-EK010 Evaluation Kit, and run the ZigBee PRO Home Sensor Demonstration application that has been pre-programmed into the Flash memory devices of the boards.

This chapter guides you through the set-up and operation of the demo system, as follows:

1. [Section 3.1](#) provides an overview of the demo system, describing its functionality and its physical architecture.
2. [Section 3.2](#) details how to set up the wireless network from the contents of the evaluation kit and run the Home Sensor Demonstration.
3. [Section 3.3](#) describes how to use the Home Sensor Demonstration.

3.1 Demo System Overview

The Home Sensor Demonstration uses all five boards of the evaluation kit to form a system for monitoring environmental conditions in a small building, typically a house or apartment, with the boards placed in different rooms. Each board is equipped with a temperature sensor, a humidity sensor and a light-level sensor. Measurements from the Sensor boards are periodically sent to the Controller board, where they can be displayed on this board's LCD screen. The demonstration also provides lighting control functionality, in which buttons on one board can be used to control an LED on a remote board.

The evaluation kit boards are pre-programmed as the following network devices for the purpose of this demonstration:

- The Controller board (with LCD screen) is programmed as the Co-ordinator.
- The two Sensor boards with SMA connectors are programmed as Routers.
- The two Sensor boards with integrated PCB antennae are programmed as End Devices.

The precise topology of the wireless network cannot be pre-determined since the network is formed dynamically. An example system is shown in [Figure 10](#) below and other examples of possible topologies are illustrated in [Figure 8](#) on page 17. However, the exact system topology is not important for the operation of the demonstration.

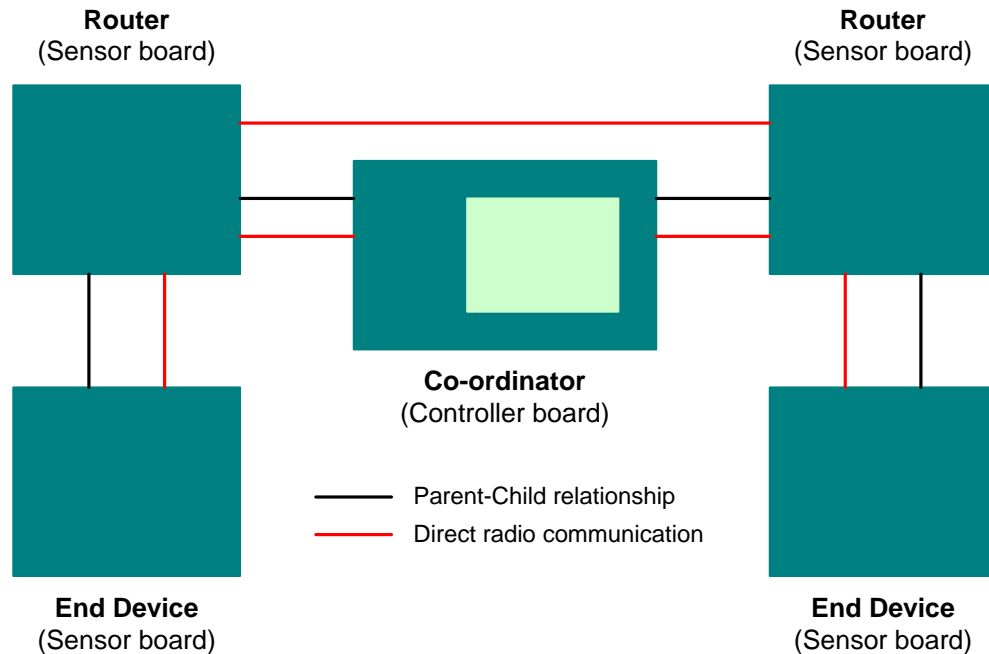


Figure 10: Example Demo System Topology

3.2 Setting Up the Demo System

This section describes how to assemble the demo system, using the contents of the evaluation kit, and run the pre-loaded Home Sensor Demonstration. You must first start the Controller board and then the Sensor boards, as described in the procedure below.



Tip: If you have problems with a board (for example, failing to join the network), you are advised to reset or power-cycle the board and also clear the data held in its Flash memory. To do this, reset/power-cycle the board and simultaneously press any of the buttons SW1-SW4 on the board - see [Stack State Persistence](#) on page 26.

Step 1 Insert the batteries into the boards

Insert the supplied AAA batteries into the boards (the required polarities are indicated on the boards), but **do not** power on the boards yet.

Step 2 Attach the antennae to the SMA connectors

On each board which has an SMA connector, connect one of the supplied antennae to the SMA connector - *do not over-tighten, finger pressure will be sufficient.*

Step 3 Power on the Controller board

Power on the Controller board using the slide-switch SW6 on the side of the board.

The power LED and the four LEDs D1-D4 will be illuminated, and the Start-up screen (featuring the Jennic logo) will appear on the LCD screen. In addition, text labels for the four buttons SW1-SW4 will appear along the lower edge of the screen.

**Step 4 Select the radio channel for the network (optional)**

If you do not want to operate the network in the default channel for the demonstration (which is 2400-MHz channel 13), you can use the two middle buttons (SW2 and SW3) on the Controller board to increase and decrease the channel number.

Step 5 Start the demonstration on the Controller board

Run the demonstration on the Controller board by pressing the button labelled 'Done' on the far right (SW4).

As the Co-ordinator, this board will create the new wireless network. As part of the network creation process, the Co-ordinator will set the channel to be used by the network according to the selection made in Step 4.

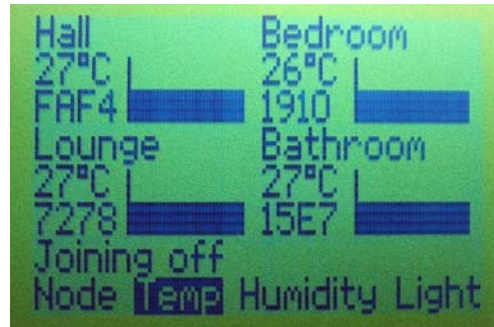
Once the network has started, the LEDs D1-D4 will be extinguished.

Step 6 Start the Sensor boards

Power on each of the Sensor boards using the slide-switch SW6 on the side of the board. You are advised to power on the Routers first (the Sensor boards with SMA-connected antennae).

As each Sensor board powers up, LED D9 on the board will be illuminated.

The Routers and End Devices will then search for the network and join it. While a Sensor board is searching for the network, the board's LEDs D1 and D2 will be illuminated, but they will be extinguished once the board has joined the network (LED D2 will subsequently flash every time the board transmits sensor data). As each board joins the network, it is assigned a name which appears on the LCD screen of the Controller board - the nodes are assigned the names of rooms in the home, in the following order: Hall, Bedroom, Lounge, Bathroom. By default, the temperature measurement from each node will be displayed on the screen - this is the 'Temperature' screen of the Controller board application's user interface (see the photo below and refer to [Section 3.3.1](#) for further details of all possible screens).



Step 7 Use the Home Sensor Demonstration

You can now use the Home Sensor Demonstration to obtain temperature, humidity and light-level measurements from the Sensor boards, as well as remotely controlling LEDs on the boards. Operation of the demo system is described in [Section 3.3](#) below.

3.3 Using the Home Sensor Demonstration

This section describes how to navigate around the screens of the Home Sensor Demonstration on the Controller board and how to use the functionality of the system.

The Home Sensor Demonstration has three sets of functionality:

- Environment monitoring (temperature, humidity, light-level) - see [Section 3.3.1](#)
- Lighting control - see [Section 3.3.2](#)
- Network control - see [Section 3.3.3](#)

Screen navigation is also explained in [Section 3.3.1](#).

3.3.1 Screen Navigation and Environment Monitoring

The sensor readings from the Sensor boards of the demo system are periodically sent to the Controller board where they can be displayed on the LCD screen. The application which runs on the Controller board provides a user interface consisting of a set of information screens that display the sensor data in different ways. This section describes these screens and how to use the four buttons SW1 to SW4 to navigate around them. This navigation is illustrated in [Figure 11](#) below and the screens are then described.



Note 1: Once the demo system is up and running as described in [Section 3.2](#), you will have reached the 'Temperature' screen.

Note 2: The functions of the buttons SW1-SW4 for the various screens are summarised in [Appendix A](#).

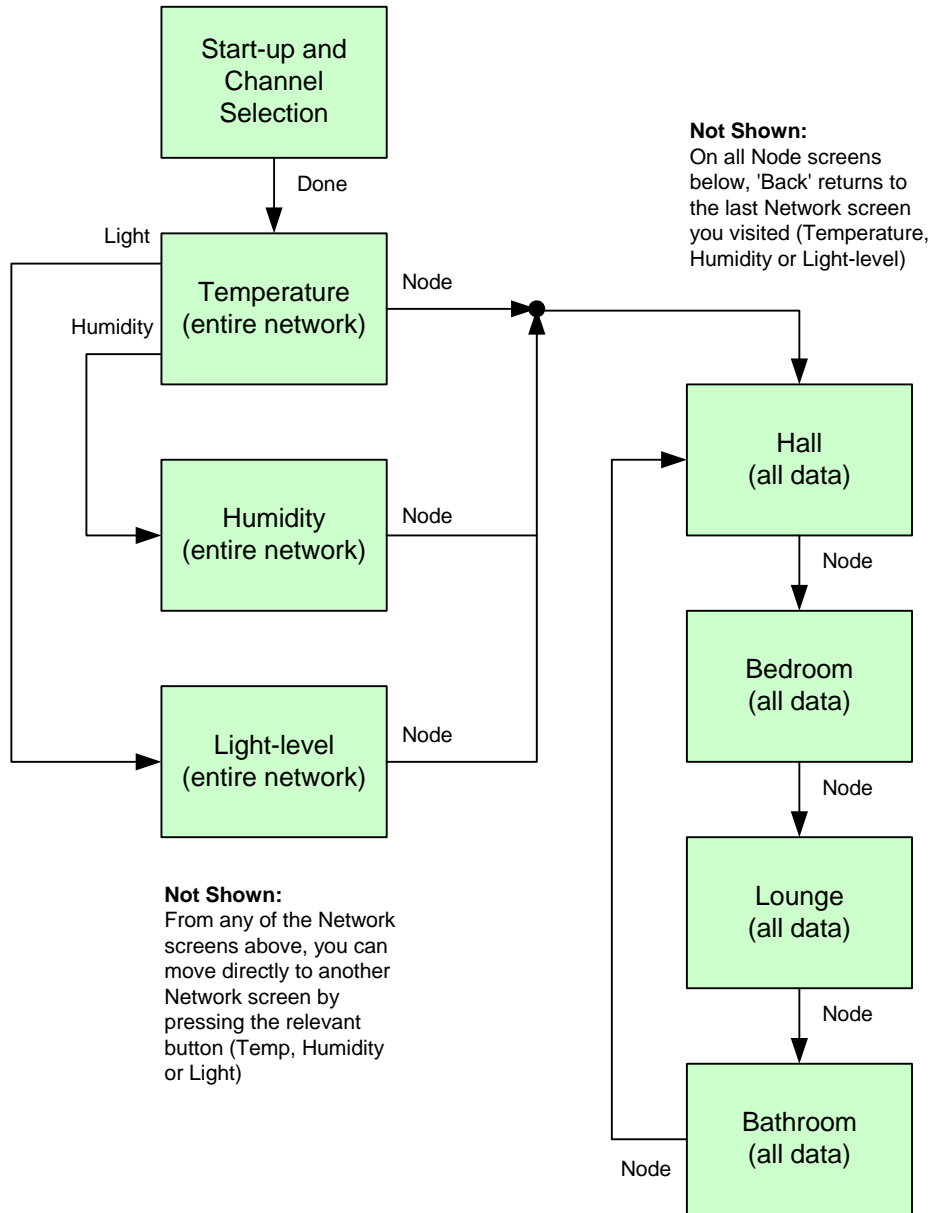


Figure 11: Screen Navigation on Controller Board

As seen in [Figure 11](#), after the Start-up screen, the information screens are divided into two groups, Network screens and Node screens, described below.

Network Screens

Each Network screen displays a particular type of sensor data for all network nodes:

- **Temperature screen:** This screen displays the temperature readings from all nodes, in degrees Celsius. It is the first screen displayed following the Start-up screen when the network starts (once the channel has been selected and the 'Done' button has been pressed on the Start-up screen).
- **Humidity screen:** This screen displays the relative humidity readings from all nodes, as percentages.
- **Light-level screen:** This screen displays the light-level readings from all nodes. A light-level reading is represented pictorially by a circle which is partially filled according to the light-level - a completely filled circle indicates total darkness and a completely unfilled circle indicates maximum brightness.

Each sensor reading is also displayed as a graph as well as a value/picture.

The network address of each node is also shown as a 4-digit hexadecimal number. In addition, the 'permit joining' status of the Co-ordinator is displayed - see [Section 3.3.3](#).

An example of the 'Humidity' screen is shown in [Figure 12](#) below.

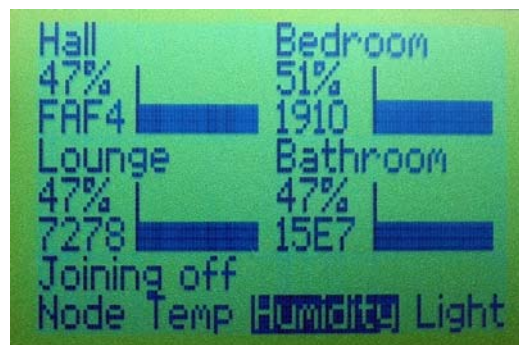


Figure 12: Example Network Screen (Humidity)

You can move directly from one Network screen to another Network screen by pressing the appropriate button on the Controller board (Temp, Humidity or Light). You can also move to the first Node screen (see below) by pressing the 'Node' button.

Node Screens

Each Node screen displays all the sensor readings from a particular node (Hall, Bedroom, Lounge or Bathroom). The Node screens are accessed by pressing the 'Node' button on any of the Network screens. This takes you to the first Node screen, which is 'Hall'. Pressing the 'Node' button repeatedly then takes you through the Node screens in rotation: first to the 'Bedroom' screen, then to the 'Lounge' screen, followed by the 'Bathroom' screen and then back to the 'Hall' screen.

The Node screens also display the number of messages from the relevant node that have been missed - this count will increase rapidly if the network has lost the node.

You can exit the Node screens by pressing the 'Back' button, which will take you back to the last Network screen that you visited.

An example of the 'Hall' screen is shown in [Figure 13](#) below.

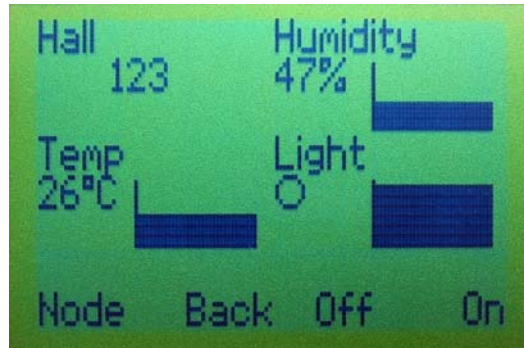


Figure 13: Example Node Screen (Hall)

The 'Off' and 'On' buttons are used to control LEDs as described in [Section 3.3.2](#).

3.3.2 Lighting Control

The Home Sensor Demonstration illustrates wireless lighting control by using a button on one board to control an LED on another board, thereby providing a wireless light-switch. Lighting control is implemented in two ways:

- Buttons on a Sensor board are used to control an LED on the Controller board.
- Buttons on the Controller board are used to control an LED on a nominated Sensor board.

Controlling an LED on the Controller Board

Buttons SW1 and SW2 on any Sensor board can be used to control one of the four LEDs on the Controller board. The LEDs controlled from the different Sensor boards are detailed in the table below.

Sensor Board	LED on Controller
Hall	D1
Bedroom	D2
Lounge	D3
Bathroom	D4

The buttons SW1 and SW2 on the Sensor boards are used as follows:

- Pressing SW2 illuminates the relevant LED on the Controller board.
- Pressing SW1 extinguishes the relevant LED on the Controller board.

There is no visible effect on the Sensor board itself.

Controlling an LED on a Sensor Board

Once you have navigated on the Controller board to the screen for a particular node (e.g. Lounge), as described in [Section 3.3.1](#), you can use the buttons SW3 and SW4 on the Controller board to control LED D1 on the remote Sensor node:

- Pressing SW4 ('On') illuminates the LED.
- Pressing SW3 ('Off') extinguishes the LED.

There is no visible effect on the Controller board itself or on any of the other Sensor boards.

3.3.3 Network Control

Two aspects of network functionality can be controlled using the on-board buttons:

- 'Permit joining' on the Co-ordinator (Controller board)
- 'Stack state persistence' on any of the nodes

'Permit Joining' on Co-ordinator

The Co-ordinator (Controller board) allows other nodes to join the network through it, by default. However, this 'permit joining' state can be disabled, in which case the Co-ordinator will no longer allow other nodes to join the network through it (although they will still be able to join via the Router nodes, if there are any Routers in the network).

The ability to disable and re-enable 'permit joining' on the Co-ordinator is provided through the button SW1 on the (Controller) board. To use this functionality, you must be on one of the Network screens (Temperature, Humidity or Light-level). Pressing and holding down button SW1 for 2 seconds will then toggle the 'permit joining' function - the current setting is shown on the LCD screen as 'Joining on' or 'Joining off'.

You can use this feature when starting the network, to help force the shape of the network. For example, to avoid a 'Star' network topology, disable 'permit joining' on the Co-ordinator immediately after the first Router has joined the network - subsequently, joining nodes will be forced to join the network through the Routers.

If the network attains its maximum number of Sensor boards (4 in this demonstration), 'permit joining' on the Co-ordinator is automatically disabled and becomes inaccessible through SW1.

Stack State Persistence

In this demonstration, the state of the ZigBee PRO stack on a node is maintained through node reset and power-cycle events. This is done by saving stack and application context data in non-volatile memory, so that this data can be recovered by the JN5148 device after a reset or power-cycle. Therefore, following one of these events, the node will remember and re-take its previous place in the network. You can, however, make the node forget its previous network status by erasing the contents of non-volatile memory during a reset or power-cycle. To do this, press any button on the board (one of SW1-SW4 for the Controller board or SW1-SW2 for a Sensor board) while pressing the RESET button or power cycling using the ON-OFF switch (SW6).

4. Where Next?

Once you have set up and run the pre-loaded Home Sensor Demonstration, you may wish to start developing your own wireless network applications. This chapter helps you to get started in this application development, as follows:

- [Section 4.1](#) provides information to help you choose the most suitable wireless network protocol for your application.
- [Section 4.2](#) directs you to the Jennic user documentation for each protocol.
- [Section 4.3](#) outlines the software from the Jennic JN5148 Software Developer's Kit (SDK) that you must install in order to develop your application.

4.1 Which Protocol?

The Jennic JN5148 SDK offers a choice of three protocols for wireless network application development for the JN5148 wireless microcontroller:

- **IEEE 802.15.4:** This is an industry-standard protocol which provides the low-level functionality for implementing wireless network communications. The JenNet and ZigBee PRO protocols are built on top of IEEE 802.15.4, but an application can also be designed to interface directly with the IEEE 802.15.4 stack layers and Jennic provide an API to facilitate this interaction.
- **JenNet:** This is Jennic's own proprietary protocol (Jennic Network) which is built on IEEE 802.15.4 to simplify wireless network application development by providing a Network stack layer. Jennic provide an API, known as the Jenie API, to facilitate the interaction between the application and the JenNet stack.
- **ZigBee PRO:** This is an industry-standard protocol which is built on IEEE 802.15.4 to simplify wireless network application development by providing a Network stack layer that supports Mesh networking. Jennic provide APIs to facilitate the interaction between the application and the ZigBee PRO stack. The ZigBee PRO APIs must be used in conjunction with the APIs of the Jennic Operating System, JenOS.

A comparison of these three protocols is presented in [Table 2 on page 28](#).



Note 1: Application development for the JN5148 device using any of the protocols is intended to be conducted in the Eclipse Integrated Development Environment (IDE), which is provided in the Jennic JN5148 SDK. It is, however, possible to develop your application code using another editor and to build it using makefiles.

Note 2: Application access to the JN5148 on-chip peripherals is provided by the Integrated Peripherals API. In addition, Jennic Controller and Sensor board resources can be accessed using the Board API. Both APIs are included in the JN5148 SDK.

Criteria	IEEE 802.15.4	JenNet	ZigBee PRO
Recommended Topologies	Star Point-to-point *	Tree Star Linear **	Mesh
Maximum Network Size	50 nodes	500 nodes	50 nodes
Network Recovery	None	Self-repairing	Self-repairing
Development Complexity	Medium	Low	High
Available Application Code Space ***	Co-ord/Router: 115 Kbytes End Device: 115 Kbytes	Co-ord/Router: 85 Kbytes End Device: 95 Kbytes	Co-ord/Router: 36 Kbytes End Device: 48 Kbytes
Standards Compliance	IEEE 802.15.4 standard	Proprietary networking layer built on standard IEEE 802.15.4 layers	ZigBee standard networking layer built on standard IEEE 802.15.4 layers
Third-party Interoperability	No provision	No provision	Interoperability through ZigBee public profiles and compliance/certification
Licensing Costs	Free	Free	ZigBee Alliance membership and product certification fees
Solutions from Jennic	Cable Replacement Remote Control Logistics Audio	Cable Replacement Active RFID Intelligent Lighting	Smart Energy Home Automation

Table 2: Protocol Stack Selection Criteria

- * A two-node network (a trivial case of a Star network)
- ** A Tree network which is narrow and deep
- *** Based on the appropriate application template

4.2 User Documentation

Jennic provide a dedicated documentation set for each of the three protocol options (IEEE 802.15.4, JenNet and ZigBee PRO). This documentation is available from the Support area of the Jennic web site (www.jennic.com/support).

The user documentation for each protocol is detailed in the following sub-sections:

- IEEE 802.14.5 documentation in [Section 4.2.1](#)
- Jenie/JenNet documentation in [Section 4.2.2](#)
- ZigBee PRO documentation in [Section 4.2.3](#)

4.2.1 IEEE 802.15.4 Documentation

A complete list of the Jennic user documentation relevant to IEEE 802.15.4 is provided in [Table 3](#) below. In addition, a visual guide to using the essential Jennic IEEE 802.15.4 documentation is provided in [Figure 14](#) on page 31.

If you intend to develop pure IEEE 802.15.4 applications (without JenNet or ZigBee PRO), first read the *IEEE 802.15.4 Wireless Networks User Guide (JN-UG-3024)* to familiarise yourself with essential IEEE 802.15.4 concepts. During your application development, you should then refer to the *802.15.4 Stack API Reference Manual (JN-RM-2002)* for details of the API functions to use.

In addition, there are two key Application Notes that you will find particularly useful when starting to develop your own applications:

- *802.15.4 Home Sensor Demonstration (JN-AN-1050)* provides the code of the IEEE 802.15.4 Home Sensor Demonstration application and is accompanied by the *802.15.4 Home Sensor Demonstration User Guide (JN-UG-3032)* which describes the application.
- *IEEE 802.15.4 Application Template (JN-AN-1046)* provides a skeleton application as a starting point for your own application coding and is accompanied by the *IEEE 802.15.4 Application Development Reference Manual (JN-RM-2024)* which describes how to use the template.

Part Number	Document Title	Description
Application Coding		
JN-UG-3024	IEEE 802.15.4 Wireless Networks User Guide	Introduces essential concepts needed in IEEE 802.15.4 application development.
JN-RM-2002	802.15.4 Stack API Reference Manual	Details the 802.15.4 Stack API, used in application code to control the on-chip 802.15.4 MAC hardware.
JN-AN-1050	802.15.4 Home Sensor Demonstration	Application Note containing the application code of the 802.15.4 Home Sensor Demonstration.
JN-UG-3032	802.15.4 Home Sensor Demonstration User Guide	Describes the 802.15.4 application available in the Application Note JN-AN-1050.
JN-AN-1046	IEEE 802.15.4 Application Template	Application Note containing a template from which to start 802.15.4 application coding.
JN-RM-2024	IEEE 802.15.4 Application Development Reference Manual	Supports application template provided in Application Note JN-AN-1046. Describes use of the template as a basis for application development.
JN-RM-2001	Integrated Peripherals API Reference Manual	Details the Integrated Peripherals API, used in application code to interact with on-chip peripherals.
JN-RM-2003	Board API Reference Manual	Details the Board API, used in application code to interact with components on the boards supplied in the evaluation kit.
Development Tools		
JN-UG-3064	JN5148 SDK Installation Guide	Describes how to install the JN5148 Software Developer's Kit (SDK).
JN-UG-3063	Eclipse IDE User Guide	Describes how to use the Eclipse platform provided in the JN5148 SDK and used to develop applications.
JN-UG-3007	JN51xx Flash Programmer Application User Guide	Describes how to use the Jennic JN51xx Flash Programmer.

Table 3: IEEE 802.15.4 User Documentation

A number of other IEEE 802.15.4 Application Notes are also available from the Jennic web site.

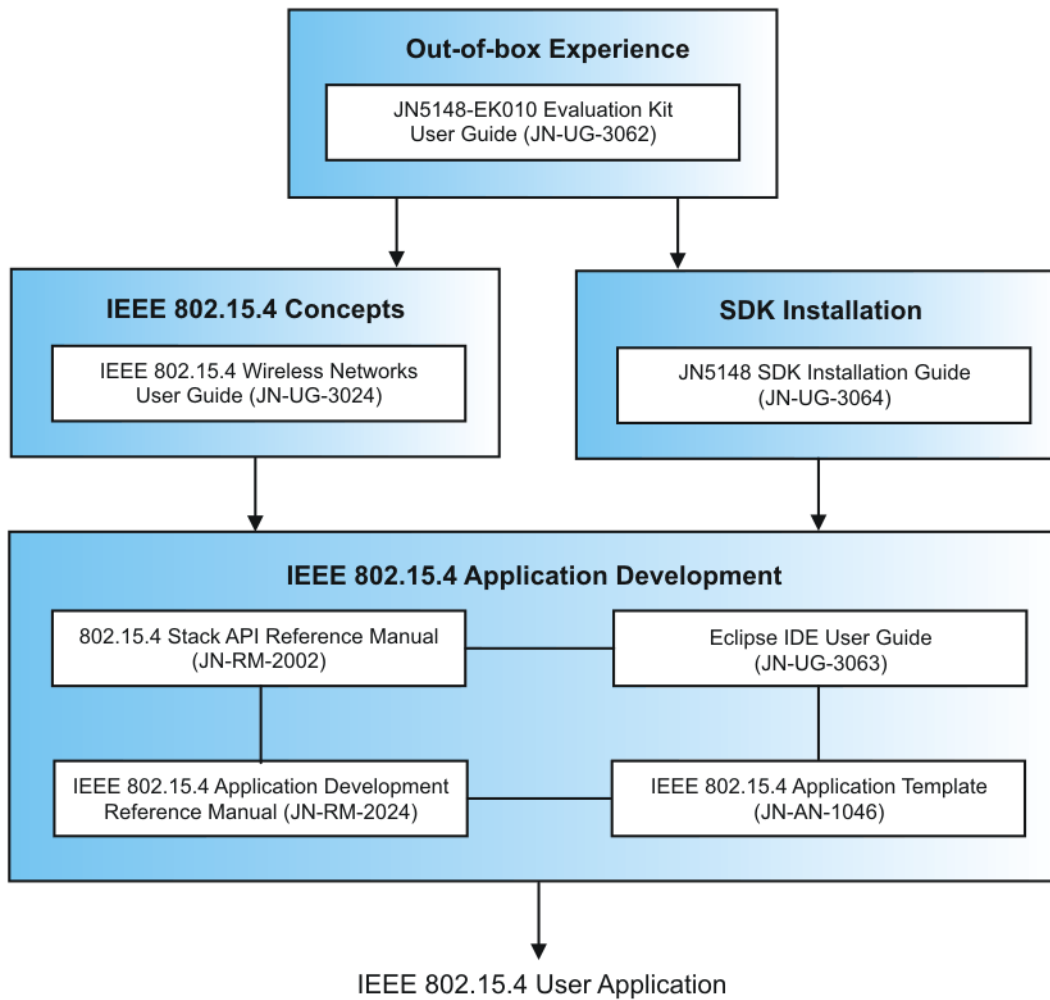


Figure 14: Guide to Essential IEEE 802.15.4 Documentation

4.2.2 Jenie/JenNet Documentation

Application access to the JenNet stack is provided by the Jenie API, which allows easy application development without a detailed knowledge of JenNet. Therefore, much of the related documentation is concerned with the Jenie API.

A complete list of the user documentation relevant to Jenie/JenNet is provided in [Table 3](#) below. In addition, a visual guide to using the essential Jenie/JenNet documentation is provided in [Figure 15](#) on page 34.

If you intend to develop Jenie/JenNet applications, first read the *Jenie API User Guide (JN-UG-3042)* - it is important that you study at least the first two chapters, dealing with essential Jenie/JenNet concepts, before starting your own application development. The remaining chapters describe use of the Jenie API to develop your application. You should refer to these chapters in conjunction with the *Jenie API Reference Manual (JN-RM-2035)* throughout your application development.

In addition, there are three key Application Notes that you will find particularly useful when starting to develop your own applications:

- *JenNet Home Sensor Demonstration (JN-AN-1065)* provides the code of the Jenie/JenNet Home Sensor Demonstration application and is accompanied by the *JenNet Home Sensor Demonstration User Guide (JN-UG-3046)* which describes the application.
- *Jenie Tutorial (JN-AN-1081)* provides a step-by-step guide to developing a Jenie/JenNet application.
- *Jenie Application Template (JN-AN-1061)* provides a skeleton application as a starting point for your own application coding. This template is described in the *Jenie API User Guide (JN-UG-3042)*.

Part Number	Document Title	Description
Application Coding		
JN-UG-3042	Jenie API User Guide	Introduces essential Jenie/JenNet concepts and describes how to use the Jenie API to develop Jenie/JenNet applications.
JN-RM-2035	Jenie API Reference Manual	Details the Jenie API used in application code to interact with the Jenie/JenNet protocol stack.
JN-UG-3041	JenNet Stack User Guide	Provides information on the JenNet networking layer for users who require more detail than provided in the Jenie documentation.
JN-AN-1065	JenNet Home Sensor Demonstration	Application Note containing the application code of the JenNet Home Sensor Demonstration.
JN-UG-3046	JenNet Home Sensor Demonstration User Guide	Describes the JenNet application available in the Application Note JN-AN-1065.
JN-AN-1085	Jenie Tutorial	Application Note providing a tutorial on developing a Jenie/JenNet application.
JN-AN-1061	Jenie Application Template	Application Note containing a template from which to start Jenie/JenNet application coding.
JN-RM-2001	Integrated Peripherals API Reference Manual	Details the Integrated Peripherals API, used in application code to interact with on-chip peripherals.
JN-RM-2003	Board API Reference Manual	Details the Board API, used in application code to interact with components on the boards supplied in the evaluation kit.
Development Tools		
JN-UG-3064	JN5148 SDK Installation Guide	Describes how to install the JN5148 Software Developer's Kit (SDK).
JN-UG-3063	Eclipse IDE User Guide	Describes how to use the Eclipse platform provided in the JN5148 SDK and used to develop applications.
JN-UG-3007	JN51xx Flash Programmer Application User Guide	Describes how to use the Jennic JN51xx Flash Programmer.

Table 4: Jenie/JenNet User Documentation

A number of other Jenie/JenNet Application Notes are also available from the Jennic web site.

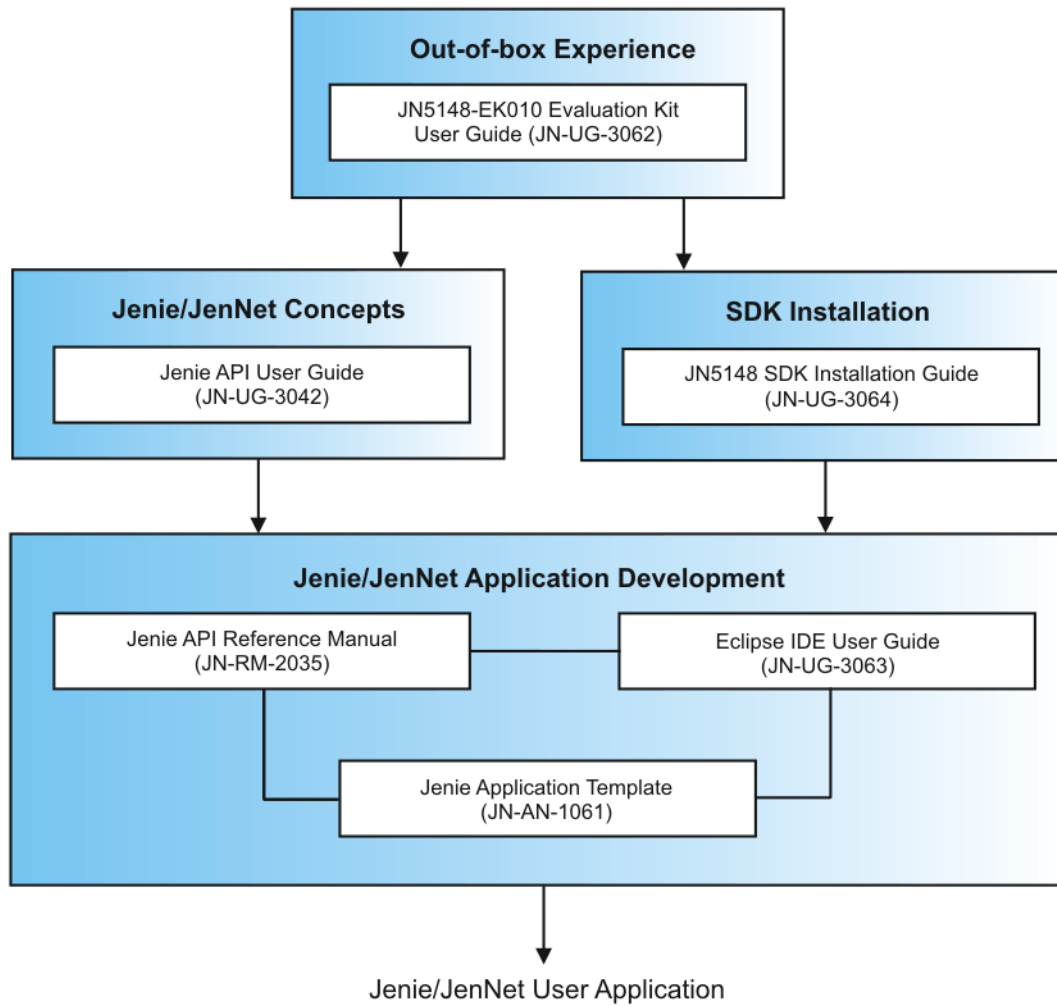


Figure 15: Guide to Essential Jenie/JenNet Documentation

4.2.3 ZigBee PRO Documentation

A complete list of the Jennic user documentation relevant to ZigBee PRO is provided in [Table 5](#) below. In addition, a visual guide to using the essential Jennic ZigBee PRO documentation is provided in [Figure 16](#) on page [37](#).

If you intend to develop ZigBee PRO applications, first read the *ZigBee PRO Stack User Guide (JN-UG-3048)* - it is important that you study at least the first four chapters, dealing with essential ZigBee PRO concepts, before starting your own application development. The remaining chapters describe use of the Jennic software libraries that you will use to develop your application. You should refer to these chapters in conjunction with the *ZigBee PRO APIs Reference Manual (JN-RM-2041)* throughout your application development. You will also need to refer to the *ZigBee PRO Configuration Guide (JN-UG-3065)* to configure your application.

In addition, there are two key Application Notes that you will find particularly useful when starting to develop your own applications:

- *ZigBee PRO Home Sensor Demonstration (JN-AN-1122)* takes you through the code of the Home Sensor Demonstration application which you have used while working through this manual.
- *ZigBee PRO Application Template (JN-AN-1123)* provides a good starting point for your own application coding.

If you are developing ZigBee PRO Smart Energy applications, you should also read the *ZigBee PRO Smart Energy API User Guide (JN-UG-3059)* and refer to the *ZigBee PRO Smart Energy API Reference Manual (JN-RM-2046)* during your application development. The Application Note *ZigBee PRO Smart Energy Demonstration (JN-AN-1135)* provides a useful example Smart Energy application to which you should refer.

Part Number	Document Title	Description
Application Coding		
JN-UG-3048	ZigBee PRO Stack User Guide	Introduces essential ZigBee PRO concepts and describes how to use the Jennic ZigBee PRO and JenOS APIs to develop ZigBee PRO applications.
JN-RM-2041	ZigBee PRO APIs Reference Manual	Details the Jennic ZigBee PRO APIs used in application code to interact with the ZigBee PRO protocol stack, as well as the JenOS APIs used to manage OS resources.
JN-UG-3059	ZigBee PRO Smart Energy API User Guide	Introduces ZigBee PRO Smart Energy (SE) and describes how to use the Jennic ZigBee PRO SE API for developing SE applications.
JN-RM-2046	ZigBee PRO Smart Energy API Reference Manual	Details the Jennic ZigBee PRO Smart Energy (SE) API.
JN-AN-1122	ZigBee PRO Home Sensor Demonstration	Application Note which describes the application code of the ZigBee PRO Home Sensor Demonstration.
JN-AN-1123	ZigBee PRO Application Template	Application Note that provides a template from which to start ZigBee PRO application coding.
JN-AN-1135	ZigBee PRO Smart Energy Demonstration	Application Note which describes the application code of the Smart Energy Demonstration.
JN-RM-2001	Integrated Peripherals API Reference Manual	Details the functions and associated resources used to interact with the on-chip peripherals.
JN-RM-2003	Board API Reference Manual	Details the functions and associated resources used to interact with components on the boards supplied in the evaluation kit.
Development Tools		
JN-UG-3064	JN5148 SDK Installation Guide	Describes how to install the JN5148 Software Developer's Kit (SDK).
JN-UG-3063	Eclipse IDE User Guide	Describes how to use the Eclipse platform provided in the JN5148 SDK and used to develop applications.
JN-UG-3065	ZigBee PRO Configuration Guide	Describes how to use Jennic Eclipse plug-ins to configure the ZigBee PRO network parameters and the JenOS resources used in a ZigBee PRO application.
JN-UG-3007	JN51xx Flash Programmer User Guide	Describes how to use the Jennic JN51xx Flash Programmer to load application binaries into network nodes.

Table 5: ZigBee PRO User Documentation

A number of other ZigBee PRO Application Notes are also available from the Jennic web site.

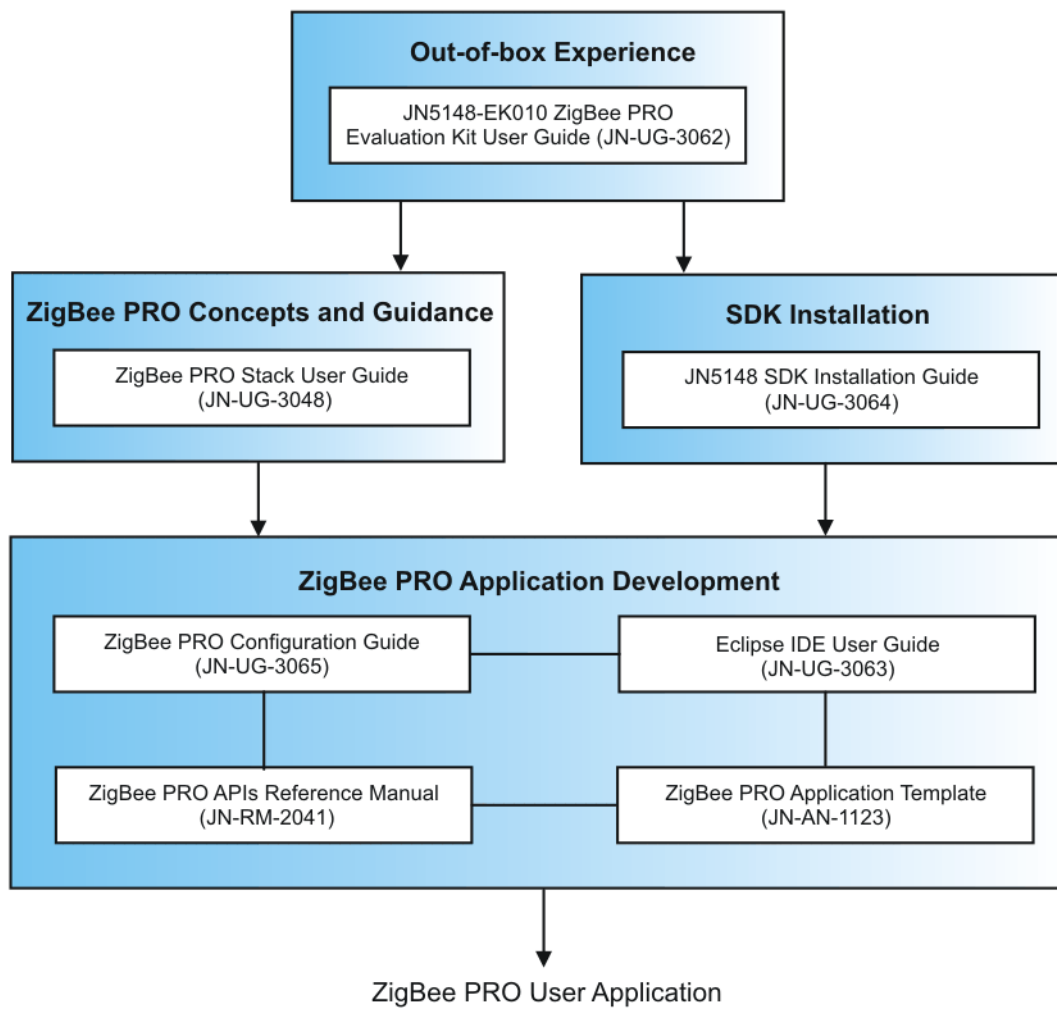


Figure 16: Guide to Essential ZigBee PRO Documentation

4.3 Software Developer's Kit (SDK)

To facilitate the development of JN5148 wireless network applications on a PC, Jennic provide the JN5148 Software Developer's Kit (SDK). This SDK includes Application Programming Interfaces (APIs) and development tools, and is supplied as two installers, SDK Libraries (JN-SW-4040) and SDK Toolchain (JN-SW-4041), detailed below.

- **SDK Toolchain (JN-SW-4041):** The SDK components installed from this file include the following:
 - Eclipse IDE (Integrated Development Environment)
 - JN51xx compiler for use by the Eclipse platform to build applications
 - JN51xx Flash programmer to load built applications into nodes
 - Cygwin CLI (Command Line Interface)

For ZigBee PRO, you will also need Jennic-devised plug-ins for the Eclipse platform, which implement the ZigBee PRO and JenOS configuration tools. These plug-ins are available separately.

- **SDK Libraries (JN-SW-4040):** The SDK components that can be installed from this file include the stack software (IEEE 802.15.4 and ZigBee PRO) and the following APIs:
 - 802.15.4 Stack API for the coding of networking tasks
 - ZigBee PRO APIs for the coding of networking tasks and JenOS APIs for the coding of operating system tasks
 - Integrated Peripherals API for interacting with JN5148 on-chip peripherals
 - Board API for interacting with Jennic board resources



Important: The Jenie/JenNet software is currently provided as an update to the JN5148 SDK. This is supplied in a dedicated installer (JN-SW-4045). Installation instructions are provided in the Release Notes that accompany the installer.



Note: The installers for the JN5148 SDK Libraries, Toolchain and Jenie/JenNet update are available from the Support section of the Jennic web site (www.jennic.com/support).

Installation instructions for the JN5148 SDK and the Eclipse plug-ins are provided in the *JN5148 SDK Installation Guide (JN-UG-3064)*, available on the Jennic web site.

Appendices

A. Button Functions in Demonstration

This appendix summarises the functions of the buttons on the Controller board (buttons SW1-SW4) and Sensor boards (buttons SW1-SW2) in the pre-loaded ZigBee PRO Home Sensor Demonstration.



Note: Holding down any one of these buttons while resetting or power-cycling the board will cause any stack and application context data saved in non-volatile memory to be erased - see [Section 3.3.3](#).

A.1 Controller Board Buttons

The tables below summarise the functions of the four buttons SW1-SW4 on the Controller board in the demonstration.

Start-up Screen

Button	Label	Function
SW1	Ch 13 (initial label)	Button has no function, but label displays currently selected channel (which is changed using SW1 and SW2 - see below).
SW2	+	Increment channel number (within range 11-26).
SW3	-	Decrement channel number (within range 11-26).
SW4	Done	Start network (to operate in the selected channel).

Table 6: Button Functions for Welcome Screen

Node Screens (Hall, Bedroom, Lounge, Bathroom)

Button	Label	Function
SW1	Node	Go to next Node screen in the cycle: Hall→Bedroom→Lounge→Bathroom→Hall...
SW2	Back	Go back to last Network screen visited.
SW3	Off	Extinguish LED D1 on the currently displayed node (Sensor board).
SW4	On	Illuminate LED D1 on the currently displayed node (Sensor board).

Table 7: Button Functions for Node Screens

Network Screens (Temperature, Humidity, Light-level)

Button	Label	Function
SW1	Node	Go to first Node screen (for 'Hall'), which shows all the sensor readings for that node. Holding down this button for 2 seconds toggles the 'permit joining' state of the Co-ordinator.
SW2	Temp*	Go to Temperature screen, which shows temperature readings (°C) for all nodes.
SW3	Humidity*	Go to Humidity screen, which shows relative humidity readings (%) for all nodes.
SW4	Light*	Go to Light-level screen, which shows light-level readings for all nodes.

Table 8: Button Functions for Network Screens

* If label is inverted (dark background), this means you are on the corresponding Network screen.

A.2 Sensor Board Buttons

The table below summarises the functions of the two buttons SW1 and SW2 on the Sensor boards in the demonstration. These buttons are used to remotely control an LED on the Controller board, the exact LED depending on the Sensor node (Hall, Bedroom, Lounge or Bathroom).

Button	Sensor Node	Function
SW1	Hall	Extinguish LED D1 on the Controller board.
	Bedroom	Extinguish LED D2 on the Controller board.
	Lounge	Extinguish LED D3 on the Controller board.
	Bathroom	Extinguish LED D4 on the Controller board.
SW2	Hall	Illuminate LED D1 on the Controller board.
	Bedroom	Illuminate LED D2 on the Controller board.
	Lounge	Illuminate LED D3 on the Controller board.
	Bathroom	Illuminate LED D4 on the Controller board.

Table 9: Button Functions for Remote Control of LEDs D1-D4

B. Programming Application Binaries into Boards

The ZigBee PRO Home Sensor Demonstration is pre-loaded in the boards of the JN5148-EK010 Evaluation Kit, so there should normally be no need to re-load this application into the boards. However, you may need to load the demonstration's binary files into the boards if:

- You later need to re-programme one or more of the evaluation kit boards with the Home Sensor Demonstration.
- You want to use the supplied high-power modules in the Home Sensor Demonstration.

Concerning the second case, the high-power modules are not pre-programmed with the demonstration. Therefore, if you have replaced two of the pre-installed standard modules with the high-power modules and wish to use the Home Sensor Demonstration, you will need to programme the two relevant boards with the demonstration application (modified and re-built - see below). Note that you are most likely to install the high-power modules on the boards that will act as Routers or as the Co-ordinator.

The application binary files for the Home Sensor Demonstration are supplied in the Application Note *ZigBee PRO Home Sensor Demonstration (JN-AN-1122)*, which is available on the Jennic web site (www.jennic.com/support). The following binary files are supplied:

- **ControllerNode_JN5148.bin**: This is the application for the Co-ordinator, which must be the Controller board (with LCD screen).
- **SensorNode_JN5148.bin**: This is the application for the Routers, which should be the two Sensor boards with SMA connectors.
- **SensorNode_SED_JN5148.bin**: This is the application for the End Devices, which should be the two Sensor boards with integrated PCB antennae.

In order to load one of the above applications into a high-power module, the application binary must be re-built with the high-power module option enabled in the application code. The Application Note *ZigBee PRO Home Sensor Demonstration (JN-AN-1122)* explains how to modify the source code and re-build the application.



Note: Modifying, re-building and re-loading the demonstration application requires the full JN5148 SDK to have been installed on your development PC. For installation instructions, refer to the *JN5148 SDK Installation Guide (JN-UG-3064)*.

You should load a binary file into the Flash memory of a board using the Jennic JN51xx Flash programmer, which is provided as part of the JN5148 SDK - the tool is provided in the SDK Toolchain (JN-SW-4041). Flash programming is fully described in the *JN51xx Flash Programmer User Guide (JN-UG-3007)*, which is available on the Jennic web site.

Revision History

Version	Date	Comments
1.0	3-July-2009	First release
1.1	26-Aug-2009	Kit contents list updated
1.2	16-Mar-2010	Jenie/JenNet stack option added and "Where Next?" chapter expanded

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