



# AN1323: Configuring Antenna Diversity for Zigbee EmberZNet 7.0 and Higher

---

This document describes how to use Project Configurator to configure Antenna Diversity in Zigbee EmberZNet applications. Both receive and transmit antenna diversity configuration are discussed.

This information applies to Zigbee EmberZNet 7.0 and higher. If you are using an earlier version of the SDK, see *AN1181: Configuring Antenna Diversity for EmberZNet 6.10 and Lower*.

Rx antenna diversity is not supported on the EFR32xG22 family.

## KEY POINTS

- Describes antenna diversity and the transmit and receive implementations
- Provides instructions and examples for configuring transmit and receive antenna diversity.

## 1 Introduction

Antenna diversity is a technique used to improve radio performance by using two different antennas to transmit and/or receive messages. For a more detailed explanation of the problems with signal transmission and reception in indoor environments and how antenna diversity can mitigate those problems, see <https://www.silabs.com/documents/public/white-papers/using-antenna-diversity-to-create-highly-robust-radio-links.pdf>.

Antenna diversity may be applied to transmission (Tx) and/or reception (Rx). Diversity is achieved using an external RF switch, either standalone or as part of a FEM (front end module)/LNA (low noise amplifier).

The Tx algorithm uses reception of the packet acknowledgement (ACK) to determine if it should change antennas. If the device does not receive an ACK after packet transmission it toggles the RF switch to the other antenna and tries again. It retries two more times, for a total of four attempts, before the MAC (media access layer) fails the transmit up to the network layer. Specifically, the worst-case scenario is as follows:

- New MAC packet transmitted on antenna 1.
- No ACK received so antenna is switched to antenna 2.
- MAC retransmit #1 sent on antenna 2.
- No ACK received, so antenna is switched to antenna 1.
- MAC retransmit #2 sent on antenna 1.
- No ACK received, so antenna is switched to antenna 2.
- MAC retransmit #3 sent on antenna 2.
- No ACK received, so antenna is switched to antenna 1.
- (MAC retries have exhausted, so MAC fails transmit to network layer).
- The next transmit will start on antenna 1.

If transmission is successful, at the beginning of the next transmission the device starts on the last successfully-used antenna.

In Rx antenna diversity with RSSI, the receiver alternates between antenna 1 and antenna 2 during the timing search looking for a valid timing pattern on the incoming signal. When a valid timing pattern is found, antenna diversity tries to select the best antenna for receiving the rest of the frame. To achieve this, the signal quality for the currently active antenna is saved/updated at every subsequent antenna switch. Therefore, at the first timing detect event the algorithm already has a fresh quality metric for one antenna. To perform a valid comparison between antenna 1 and antenna 2, the radio switches simultaneously with the timing detect event to the other antenna to perform a signal quality evaluation/update there. Finally, antenna quality results get compared, and the algorithm selects the better antenna for packet reception. If the better antenna is the current antenna, then the Rx operation carries on with packet reception without further antenna switching. If the better antenna is the other antenna, then the radio switches to that one, reacquires timing, and continues with packet reception on that antenna.

In antenna diversity, longer preambles are often used to provide the antenna diversity algorithm time to detect and evaluate the signal on each antenna to ensure that a true preamble is found. However, shorter preambles are preferred as they reduce MCU on-time and in turn reduce MCU current consumption. The RSSI measurement technique for evaluating signal quality requires less preamble time than other methods such as timing correlation.

Note that antenna Rx diversity is available for testing and evaluation purposes on the Gecko SDK suite. Due to the short preambles on the 802.15.4 packets, customers will need to make their own assessment on the performance and production readiness of this feature.

Rx and Tx antenna diversity are independent operations. In practice this means that, for example, Tx antenna diversity will begin the next transmission on the last successfully used antenna for Tx (for example antenna 1), even though in the intervening receive Rx antenna diversity found better signal quality on antenna 2.

## 2 Configuring Antenna Diversity

The antenna diversity configuration options available for Zigbee EmberZNet consist of selecting Rx and/or Tx antenna diversity and configuring the underlying peripherals correctly. To configure antenna diversity, you must be familiar with your device's overall antenna configuration, that is, if it uses a FEM/LNA for either Tx or Rx, and also be familiar with the device's pin layout. Check the data sheet for your device for these settings or contact Silicon Labs support if you have questions.

These instructions assume you have installed Simplicity Studio and the Zigbee EmberZNet SDK (software development kit), and that you have a project open in the Simplicity IDE (integrated development environment).

### 2.1 Tx/Rx Diversity Configuration

On the Software Components tab, install the **RAIL Utility, Antenna Diversity Configuration** component. To configure Rx and/or Tx diversity:

1. Select TX/RX Antenna Diversity options (default is both enabled).
2. Select MODEM under Selected Module (default is selected).
3. Select ANT0 GPIO pin.
4. Optionally select ANT1 GPIO if you have two antenna GPIOs.
5. Ignore all other options.

In the **Chip-external Antenna Diversity Configuration** card, the antenna options for both Rx and Tx diversity are as follows:

- Disable Antenna Diversity (don't alter antenna selection): The code does not control ANTENNA\_SELECT\_GPIO.
- Use Antenna 0 only: ANTENNA\_SELECT\_GPIO is set to high during Tx/Rx.
- Use Antenna 1 only: ANTENNA\_SELECT\_GPIO is set to low during Tx/Rx.
- Enable Antenna Diversity (Switch between antennas dynamically): Tx/Rx antenna selection is dynamic and Tx/Rx diversity is enabled.

The fields in the **SL\_RAIL\_UTIL\_ANT\_DIVERSITY** card change based on the device you have connected. Regardless of what else is available, for antenna diversity only two are relevant, **Select Module** and the antenna GPIO pin selections. Leave all other values at their default settings.

- **Select Module** (MODEM or None): Defaults to MODEM. Do not change.
- Antenna pin selections: Set **ANT0**. Optionally set **ANT1** if the device has two antenna GPIOs.

## 2.2 Runtime Configuration

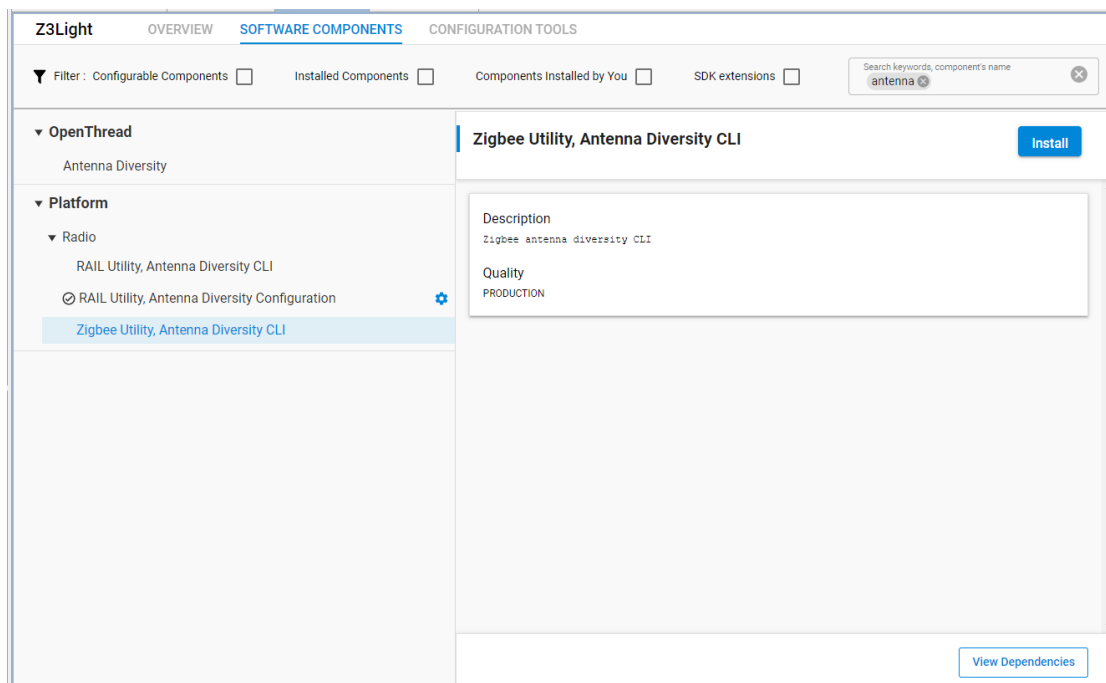
Tx diversity settings can be changed at runtime using the CLI or EZSP without any restriction. The ability to change Rx antenna diversity modes at runtime depends on the component configuration settings. Rx antenna diversity has an additional configuration parameter.

**Enable/Disable Runtime PHY Select:** When this option is enabled (toggled on), both the standard and the diversity-enabled PHYs are compiled into the image, thereby allowing the application to use API calls to change PHY (from standard to diversity or vice-versa) at runtime. Note that the code size of the image will increase significantly when this option is enabled. The decision to enable runtime Rx antenna diversity PHY select is a tradeoff between code size and reception quality when Rx antenna diversity is disabled. Some customers might want to enable runtime PHY select to test different PHYs with a single build even if they only want to ship with one PHY in practice. The implications of the different component configuration selections are summarized as follows.

Rx Antenna Diversity	Runtime PHY Select	Runtime configuration?	After Rx antenna diversity is disabled at runtime
Enabled	Disabled	Yes	The system stays on the Rx antenna diversity PHY.
Disabled	Enabled	Yes – can enable Rx Diversity	- -
Enabled	Enabled	Yes	The system switches to another PHY with better reception.
Disabled	Disabled	Not possible	- -

## 2.3 Command Line Interface

To query and set Rx and Tx diversity modes using a CLI at runtime, install the **Zigbee Utility, Antenna Diversity CLI** component.



The commands are shown in the following table. The interpretation of returned results for get operations and permissible values for set operations are:

- SL\_RAIL\_UTIL\_ANTENNA\_MODE\_DISABLED: 0 (Do not alter antenna selection)
- SL\_RAIL\_UTIL\_ANTENNA\_MODE\_ENABLE1: 1 (Use antenna 1)
- SL\_RAIL\_UTIL\_ANTENNA\_MODE\_ENABLE2: 2 (Use antenna 2)
- SL\_RAIL\_UTIL\_ANTENNA\_MODE\_DIVERSITY: 3 (Choose antenna 1 or 2 dynamically)

Command	Command De-scription	API Function	Arguments	
			Name	Type
plugin antenna get- antenna-tx- mode	Returns the current setting for the Tx antenna diversity mode	emberAfPluginAntennaGetAntennaTxMode	n/a	n/a
plugin antenna set- antenna-tx- mode	Sets Tx diversity mode to argument	emberAfPluginAntennaSetAntennaTxMode	Tx Antenna Mode	uint8_t
plugin antenna get- antenna-rx- mode	Returns the current setting for Rx antenna diversity mode	emberAfPluginAntennaGetAntennaRxMode	n/a	n/a
plugin antenna set- antenna-rx- mode	Sets Rx diversity mode to argument	emberAfPluginAntennaSetAntennaRxMode	Rx Antenna Mode	uint8_t

# Simplicity Studio

One-click access to MCU and wireless tools, documentation, software, source code libraries & more. Available for Windows, Mac and Linux!



**IoT Portfolio**  
[www.silabs.com/IoT](http://www.silabs.com/IoT)



**SW/HW**  
[www.silabs.com/simplicity](http://www.silabs.com/simplicity)



**Quality**  
[www.silabs.com/quality](http://www.silabs.com/quality)



**Support & Community**  
[www.silabs.com/community](http://www.silabs.com/community)

## Disclaimer

Silicon Labs intends to provide customers with the latest, accurate, and in-depth documentation of all peripherals and modules available for system and software implementers using or intending to use the Silicon Labs products. Characterization data, available modules and peripherals, memory sizes and memory addresses refer to each specific device, and "Typical" parameters provided can and do vary in different applications. Application examples described herein are for illustrative purposes only. Silicon Labs reserves the right to make changes without further notice to the product information, specifications, and descriptions herein, and does not give warranties as to the accuracy or completeness of the included information. Without prior notification, Silicon Labs may update product firmware during the manufacturing process for security or reliability reasons. Such changes will not alter the specifications or the performance of the product. Silicon Labs shall have no liability for the consequences of use of the information supplied in this document. This document does not imply or expressly grant any license to design or fabricate any integrated circuits. The products are not designed or authorized to be used within any FDA Class III devices, applications for which FDA premarket approval is required or Life Support Systems without the specific written consent of Silicon Labs. A "Life Support System" is any product or system intended to support or sustain life and/or health, which, if it fails, can be reasonably expected to result in significant personal injury or death. Silicon Labs products are not designed or authorized for military applications. Silicon Labs products shall under no circumstances be used in weapons of mass destruction including (but not limited to) nuclear, biological or chemical weapons, or missiles capable of delivering such weapons. Silicon Labs disclaims all express and implied warranties and shall not be responsible or liable for any injuries or damages related to use of a Silicon Labs product in such unauthorized applications.

**Note: This content may contain offensive terminology that is now obsolete. Silicon Labs is replacing these terms with inclusive language wherever possible. For more information, visit [www.silabs.com/about-us/inclusive-lexicon-project](http://www.silabs.com/about-us/inclusive-lexicon-project)**

## Trademark Information

Silicon Laboratories Inc., Silicon Laboratories®, Silicon Labs®, SiLabs® and the Silicon Labs logo®, Bluegiga®, Bluegiga Logo®, EFM®, EFM32®, EFR, Ember®, Energy Micro, Energy Micro logo and combinations thereof, "the world's most energy friendly microcontrollers", Redpine Signals®, WiSeConnect, n-Link, ThreadArch®, EZLink®, EZRadio®, EZRadioPRO®, Gecko®, Gecko OS, Gecko OS Studio, Precision32®, Simplicity Studio®, Telegesis, the Telegesis Logo®, USBXpress®, Zentri, the Zentri logo and Zentri DMS, Z-Wave®, and others are trademarks or registered trademarks of Silicon Labs. ARM, CORTEX, Cortex-M3 and THUMB are trademarks or registered trademarks of ARM Holdings. Keil is a registered trademark of ARM Limited. Wi-Fi is a registered trademark of the Wi-Fi Alliance. All other products or brand names mentioned herein are trademarks of their respective holders.



Silicon Laboratories Inc.  
400 West Cesar Chavez  
Austin, TX 78701  
USA

[www.silabs.com](http://www.silabs.com)