Bidirectional wireless communication using EmbedRF

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1. Tools you will need for this application note

You will need the following items which are included in the EmbedRF Development Kit at www.embedrf.com.

- Two EmbedRF Standard boards printed circuit boards
- One USB Interface Boards
- One USB cable
- One CR2032 3V lithium coin cell battery with battery attachment board
- A CD with the EmbedRF Desktop Pro Software on it

![EmbedRF Development Kit](image)

Figure 1: EmbedRF Development Kit
2. Introduction
This application note will show you how to configure an EmbedRF device to wirelessly transmit and receive data as a bidirectional transceiver. When you have finished executing the steps described in this document, you will have learned how to do the following:
- Configure an EmbedRF Board as a “master” which will periodically transmit and then immediately receive data from another EmbedRF Board configured as a “slave”
- Configure second EmbedRF Board as a “slave” which will periodically receive data from a master and then transmit data back to the master.
- View the data being transmitted and received by the master and slave

3. Connect EmbedRF Board to USB Interface Board
To get started, you will first need to connect an EmbedRF Board to the USB Interface Board.

Figure 2: Connect the USB Interface board (left) with the EmbedRF Board (right). Make sure that as you are connecting the boards that the labels for each of the pins on the EmbedRF Board match those on the USB Interface Board (i.e. Vdd should match Vdd and Gnd should match Gnd).

Connect the mini-USB end of the USB Interface Cable to the USB Interface Board.
Figure 3: Connect USB Interface Board to USB cable.

Connect the other end of the USB cable to one of the USB connectors on your PC computer.

Figure 4: Desktop computer connected to USB Interface board which is connected to EmbedRF Board.
4. Install and Run EmbedRF Desktop Pro Software
If you have already installed the EmbedRF Desktop Pro Software, you may skip this section and jump immediately to section 5.0. If you have not installed EmbedRF Desktop Pro Software, please follow the instructions in the “Getting Started with the EmbedRF Development Kit” application note.

5. Configuring EmbedRF Boards to do Bidirectional Communication
The EmbedRF boards may be configured as bidirectional transceivers. When using the EmbedRF boards as bidirectional transceivers, one of the boards must be configured as the “master” and the second board must be configured as the “slave”. The master must be configured to “Transmit then receive” mode. In “Transmit then receive” mode, the EmbedRF board first transmits and then waits for a reply data packet immediately arriving from a slave. The slave must be configured to “Receive then transmit” mode. In “Receive then transmit” mode, the slave first awaits a data packet from a master, and then transmits a data packet back to the master after it has received its data. The slave and master must have the same transmission interval (0.25 – 12.75 seconds), and they must have the same network ID. The master always transmits data at the set transmission interval. If the slave does not receive a data packet from the master, the slave does not reply. In this section, we will describe how to configure one of your EmbedRF boards to be a master and a second EmbedRF board to be a slave.

5.1. Configure EmbedRF Master
Make sure that there is an EmbedRF board connected to your computer as described in section 3 and that the EmbedRF Desktop Pro software is installed. In this section, you will configure one of your EmbedRF Boards to be a “master” that will periodically transmit data to and then receive data from a slave.

5.1.1. Set the Transmit ID of the Master
Enter the number 1 into the Transmit ID text box. Then press the “Set Transmit ID” button. Make sure that no error messages have appeared after pressing the button. *The transmit ID of the master should always be the same number as the receive ID of the slave.* In section 5.2, we show how to set the receive ID of the slave.

5.1.2. Set the Receive ID of the Master
Enter the number 2 into the Receive ID text box. Then press the “Set Receive ID” button. Make sure that no error messages have appeared after pressing the button. *The receive ID of the master should always be the same number as the transmit ID of the slave.* In section 5.2, we show how to set the transmit ID of the slave.

5.1.3. Set the Transmit Interval of the Master
Select the “Transmission Interval” pull-down combo-box labeled 250 ms. Then press the “Set Interval” button. Make sure that no error messages have appeared after pressing the button. The transmit interval should be the same for both the master and the slave.
5.1.4. Set the Network ID of the Master
Enter the number 0 into the Network ID text box. Then press the “Set Network ID” button. Make sure that no error messages have appeared after pressing the button. The master and slave must have the same network ID number.

5.1.5. Set the Network Configuration to Point-to-point
Select the “Point-to-point” option from the Network Configuration pull-down menu. Then press the Set Network Config button.

5.1.6. Configure the Master to be a Transmitter-then-Receiver
Select the “Transmit then receive” option from the Transmit / Receive Status pull-down combo-box. Then press the “Set Transmit/Receive” button.

5.1.7. Set the Master to Record Analog Data
Any EmbedRF board can be configured to record analog data, making it ideal for transmitting and receiving analog sensor data wirelessly over short distances. In this section, you will configure the master to record analog data and transmit this data to the slave.

Select the Record A/D 1 checkbox. Then press the “Set Analog” button.

You have now successfully configured the master with the following settings:
Transmit ID: 1
Receive ID: 2
Transmit Interval: 0.25 seconds
Transmit / Receive Status: Transmit-then-receive
Network ID: 0
Network Configuration: Point-to-Point
Analog Data: Record and transmit analog data on channel 1.

5.1.8. Connect Master to Battery
Disconnect the master from the USB Interface Board and connect to the Battery Adapter Board as shown in the figure below.
5.2. Configure EmbedRF Slave

Make sure the second EmbedRF board (i.e. the one that we did not configure as the master) is connected to your computer as described in section 3 and that the EmbedRF DesktopPro software is installed. In this section, you will configure one of your EmbedRF Board to be a “slave” that will periodically receive data from and then immediately transmit data to anEmbedRF “master”.

5.2.1. Set the Transmit ID of the Slave
Enter the number 2 into the Transmit ID text box. Then press the “Set Transmit ID” button. The transmit ID of the slave should always be the same number as the receive ID of the master.

5.2.2. Set the Receive ID of the Slave
Enter the number 1 into the Receive ID text box. Then press the “Set Receive ID” button. The receive ID of the slave should always be the same number as the transmit ID of the master.

5.2.3. Set the Transmission Interval of the EmbedRF Board
Select the “Transmission Interval” pull-down combo-box labeled 0.25 seconds. Then press the “Set Interval” button. The slave transmission interval should always be the same as the transmission interval of the master.

5.2.4. Set the Network ID of the Slave
Enter the number 0 into the Network ID text box. Then press the “Set Network ID” button. The master and slave must always have the same network ID.
5.2.5. Set the Network Configuration to Point-to-point
Select the “Point-to-point” option from the Network Configuration pull-down menu. Then press the Set Network Config button.

5.2.6. Configure the Slave to Receive-then-Transmit
Select the option to “Receive-then-Transmit” from the Receive/Transmit Status pull-down menu. Then press the “Set Transmit/Receive” button.

5.2.7. Set the Slave to Record Analog Data
In this section, you will configure the slave to record analog data and transmit this data to the master.

Select the Record A/D 1 checkbox. Then press the “Set Analog” button.

You have now successfully configured the slave with the following settings:
Transmit ID: 2
Receive ID: 1
Transmit Interval: 0.25 seconds
Transmit / Receive Status: Receive then transmit
Network ID: 0
Analog Data: Record analog data on channel 1
Network Configuration: Point-to-Point

5.2.8. Set to Automatically Notify you when Data Arrives
Check the “Notification On” checkbox at the bottom of the main window. Then press the “Set Notification” button. This option causes the screen in the Receive tab window to automatically update whenever new data arrives at the slave.

5.3. Verify Data from Master Received by Slave
At this point, you should have configured one of your EmbedRF boards to be a master. It should be attached to a battery adapter board. Your second EmbedRF board should be configured to be a slave. The slave should be connected to the USB Adapter Board and the USB Adapter Board should be connected to your computer. Having the slave connected to your computer provides power to the slave and also enables you to observe data as it arrives from the master.

The hardware configuration that you should have set up is shown in the figure below.
Figure 6: Hardware set-up for transmitting/receiving data between an EmbedRF board configured as a master and a slave.

To observe this data, click on the “Receive” tab in the upper left-hand corner of the window. The window below should be displayed.
The transmit ID of the transmitter is included within each notify UART packet and is located at bytes 1, 2, and 3 with the most-significant byte sent first.

Following the transmit ID, the next ten bytes of data (bytes 4-13) are either raw payload data or analog sensor data, depending on whether the transmitter was configured to transmit analog data. In this example, we configured the transmitter to send analog data on A/D channel 1. A/D channel 1 analog data comes through on bytes 6 and 7.

Byte 14 contains the received signal strength indicator or (RSSI). This byte is a number between 0 and 255 representing the strength of the received signal. A larger RSSI means that the master is closer to the slave while a smaller RSSI indicates that the master is further away from the slave.

Byte 15 in the UART notify data packet is a packet counter. Every time an EmbedRF board sends a packet, it increments its counter by 1. This byte can be used to indicate...
whether a receiver has missed a packet sent by a transmitter. It should increment at each interval. In this example, the counter should increment by 1 every 0.25 seconds.

The data packet is further described in the separate document titled “EmbedRF Desktop Pro Software Manual”.

5.4. **Change Analog Data on Master and Watch Change**

There is a button on the Battery Adapter Boards as shown in the figure below.

![Button](image)

**Figure 8:** Battery adapter board. The button is shown which, when pressed, shorts the analog channel 1 to its maximum value of 1023, which represents 3V.

This button shorts the analog sensor reading to the voltage level, thereby making the value of the reading a maximum value of 1023 counts or 3V.

After you press this button, the Receive tab window on the EmbedRF DesktopPro should look as follows:
Figure 9: Receive tab window for slave showing how the analog data changes when the button on the master battery adapter board is pressed. Notice that A/D channel reads 1023 counts and 3 V as expected when the button is pressed.

5.5. **Verify Data from Slave Received by Master**

We have now verified that a slave can receive data from a master. Now we will switch the slave over to the battery power and connect the master to the PC via the USB Adapter Board so that we can watch the data arriving at the master from the slave. Once you connect the master to the PC, you must re-send the command to notify when data has arrived. Check the “Notification On” checkbox at the bottom of the main configuration window. Then press the “Set Notification” button. This option causes the slave to send a UART notification packet to the PC whenever new data arrives at the slave.

The hardware configuration that you should have set up is shown in the figure below.
Figure 10: Hardware set-up for viewing data sent by a slave to a master.

To observe this data, click on the “Receive” tab in the upper left-hand corner of the window. The window below should be displayed.
Figure 11: Receive tab window for the master. This screen should be updating regularly as data from the slave is received by the master. The field that should update every time a data packet is received is the Counter field (Byte 11).

5.6. Change Analog Data on Slave and Watch Change

There is a button on the Battery Adapter Boards as shown in the figure below.
Figure 12: Battery adapter board. The button is shown which, when pressed, shorts the analog channel 1 to its maximum value of 1023, which represents 3V.

This button shorts the analog sensor reading to the voltage level, thereby making the value of the reading a maximum value of 1023 counts or 3V.

After you press this button, the Receive tab window on the EmbedRF DesktopPro should look as follows:
Figure 13: Receive tab window for master showing how the analog data changes when the button on the slave battery adapter board is pressed. Notice that A/D channel reads 1023 counts and 3 V as expected when the button is pressed.