Kinetis Simple Media Access Controller (SMAC) Demonstration Applications

User’s Guide

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About this book

This guide provides a detailed description of the Kinetis Wireless demonstration applications.

For more details about the supported devices, see the appropriate Reference Manual and/or Data Sheet.

Audience

This document is intended for application developers using the MKW2xD and MCR20A devices and these demonstration applications as a starting point for developing proprietary applications.

Organization

This document is organized into the following chapters.

- Chapter 1, “Introduction” — Describes the required software and hardware for correct demonstration application setup.
- Chapter 2, “Kinetis Wireless UART Application” — Details how to run the Wireless UART application and explains available application configurations.
- Chapter 3, “Kinetis Wireless Messenger Application” — Details how to run the Wireless Messenger application and explains available application configurations.
- Chapter 4, “Kinetis Connectivity Test Application” — Details how to run the Connectivity Test application and explains available menu options and application configurations.
- Chapter 5, “Kinetis Low Power Demo Application” — Details how to run the Lower Power Demo application and explains how to handle low power use cases.

Revision History

This is the first revision of this document (Rev. 0).

Revision History

Rev. number	Date	Substantive changes
0	01/2017	Initial release.

Definitions, Acronyms, and Abbreviations

The following list defines the acronyms and abbreviations used in this document.

API	Application Program Interface
dBm	Decibels referred to one milliwatt
LQI	Linq Quality Indicator
FRDM	Freedom Board
USB	USB Dongle
IDE	Integrated Development Environment.
MCU	MicroController Unit

OTA	Over-the-air
PC	Personal Computer
RX	Receive
TX	Transmit
TERM	Serial Port Terminal Application
XCVR	Transceiver
[ENTER]	The ENTER/RETURN key on the keyboard
[SPACE]	The SPACEBAR key on the keyboard
CCA	Clear Channel Assessment
ACK	Acknowledge
Kinetis	Kinetis Wireless platforms referenced in this document (FRDM-KW24 or USB-KW24D512, FRDM-CR20A with FRDM-K64F and FRDM-KL46Z)
RTOS	Real-Time Operating System

References

The following sources were referenced to produce this book:

[1] *NXP MKW2xD Reference Manual* (document MKW2xDxxxRM)

[2] *NXP MCR20A Reference Manual* (document MCR20RM)

Chapter 1 Introduction

The NXP Kinetis SMAC based Demonstration Applications have to be used with a serial port terminal application.

This chapter details hardware and software requirements to initially use the supported platforms.

1.1 Supported hardware

The Kinetis SMAC based Demo Applications are designed to work with the MKW2xD and MCR20A devoces. The supported platforms are FRDM-KW24, USB-KW24D512, FRDM-CR20A connected to FRDM-K64F and FRDM-CR20A connected to FRDM-KL46Z

1.2 SMAC software

The package contains the RTOS and KSDK based framework, drivers, and connectivity stack with SMAC as layer two along with the several demo applications. The application projects are developed using IAR® Embedded Workbench® and Kinetis Design Studio®.

1.3 Hardware considerations

The supported platforms (except USB-KW24D512) can be connected to the computer via the mini or micro USB connectors using an emulated serial port driver.

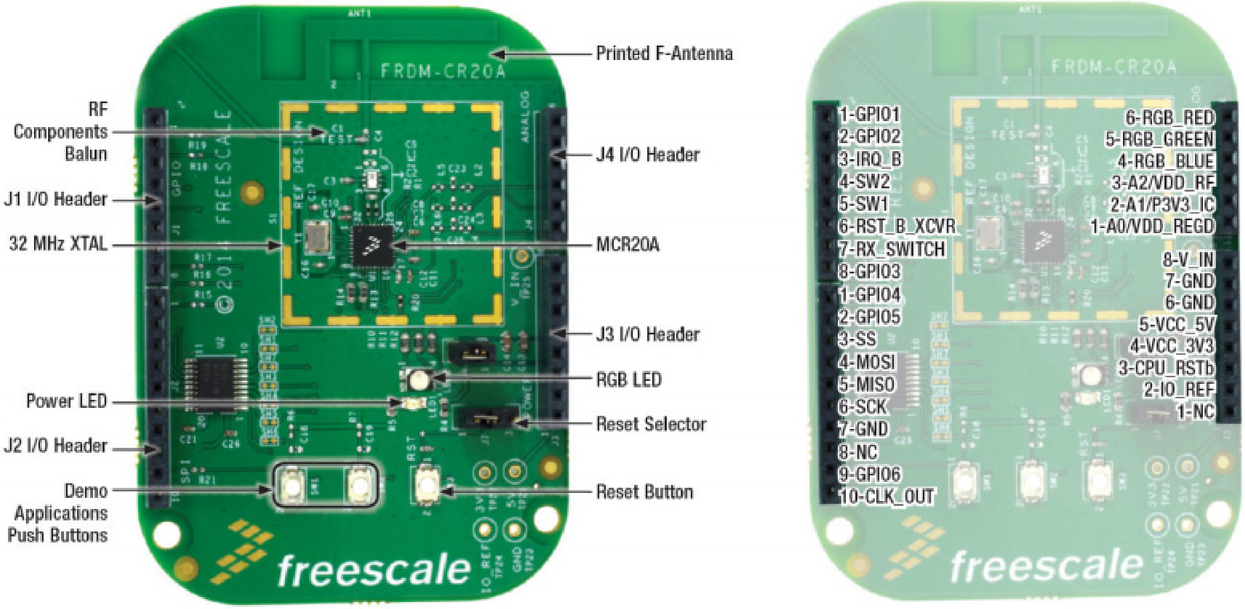


Figure 1-1. FRDM-CR20A Development Platform

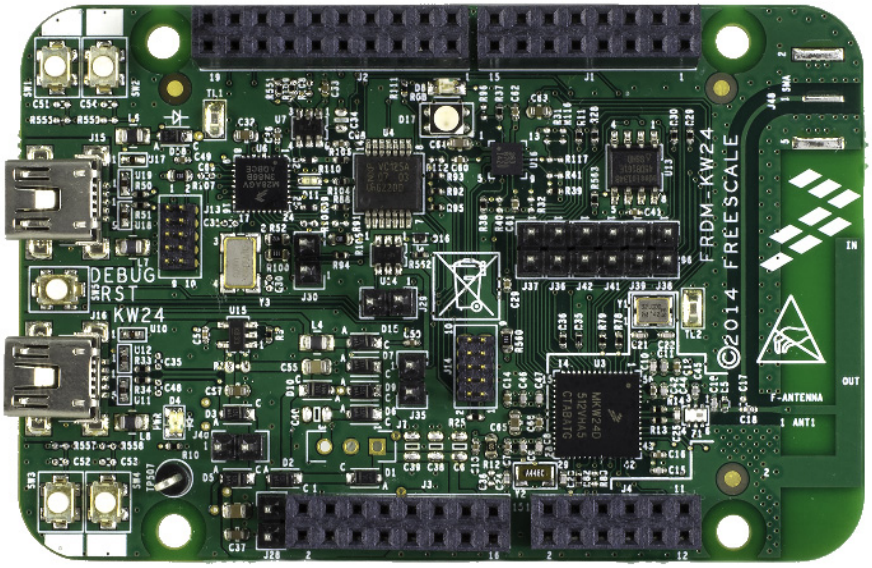


Figure 1-2. FRDM-KW24

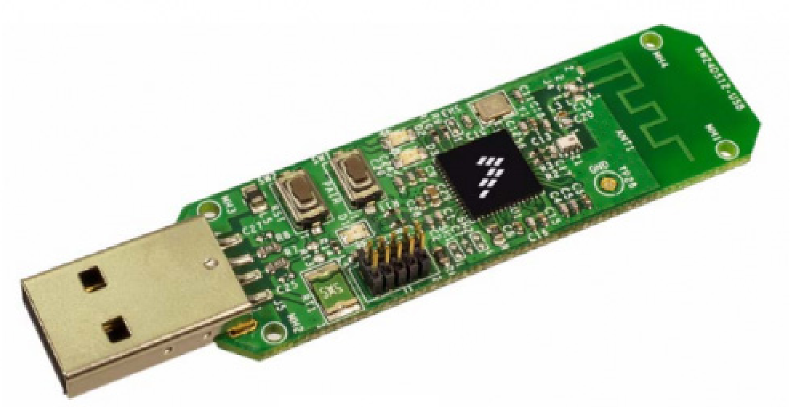


Figure 1-3. USB-KW24D512

NOTE

From a software point of view, the user can switch between the serial interfaces (UART and USB) by modifying the corresponding macro definitions in the *“board.h”* file, which is board specific and can be found in the *“boards\<board_name>”* directory. By default, the associated macros for the serial communication interface are defined as:

```
#define APP_SERIAL_INTERFACE_TYPE gSerialMgrUart_c
#define APP_SERIAL_INTERFACE_INSTANCE 1
//#define APP_SERIAL_INTERFACE_TYPE gSerialMgrUSB_c
//#define APP_SERIAL_INTERFACE_INSTANCE 0
```

This means that the SMAC based applications will use UART. To switch from the UART interface to the USB interface the user should comment the first two lines and uncomment the last two.

```
//#define APP_SERIAL_INTERFACE_TYPE gSerialMgrUart_c
//#define APP_SERIAL_INTERFACE_INSTANCE 1
#define APP_SERIAL_INTERFACE_TYPE gSerialMgrUSB_c
#define APP_SERIAL_INTERFACE_INSTANCE 0
```

Chapter 2 Kinetis Wireless UART Application

2.1 Introduction

The Wireless UART application functions as an unidirectional wireless UART bridge between two (one-to-one) or several (one to many) boards. The application can be used with both a TERM, or with a software that is capable of opening a serial port and writing to it (or reading from it). The characters sent or received are not necessarily ASCII printable characters.

All of the application configurations must be applied at compile time, since Wireless UART does not display any configuration menus.

2.2 Application configuration

The application can be configured from three files:

- `SMAC_Config.h`

  It contains the number of maximum retries and retransmissions, (`gMaxRetriesAllowed_c`) and the backoff interval for the custom backoff algorithm.
- `SMAC_Interface.h`

  It contains the configuration for the source/destination PAN id (`gDefaultPanID_c`), source node address (`gNodeAddress_c`) and definition for the broadcast address.
- `Application_Interface.h`

  This file provides customization of the default destination address (`gDefaultAddress_c`), default channel number (`gDefaultChannelNumber_c`), and default output power, which has to range between minimum and maximum output power (`gDefaultOutputPower_c`).
- `Wireless_UartApplication.c`

  The InitProject can be changed to enable the retry and re-transmission mechanisms. By setting the boolean fields to TRUE and the numerical fields to the desired number of retries, the re-transmissions the user can enable are none, one, or both of these features.

  Here is an example:

  ```
  txConfigContext.autoAck          = FALSE; //TRUE for enabling automatic ACK
  txConfigContext.ccaBeforeTx       = FALSE; //TRUE for enabling automatic CCA before TX
  txConfigContext.retryCountAckFail = 0; // Number of retries in case no ACK is received
  txConfigContext.retryCountCCAFail = 0; // Number of retransmissions if channel is busy
  ```

  The *InitApp* function allows the user to change the baudrate of the serial port. For other options, look at the definition of the baudrate macro (`gUARTBaudRate115200_c`) and pick another member from the baud rates enumeration.

Other settings should be kept as-is, since they could affect the application's behavior. There are several settings that can be made in the IAR project compiler options to configure the number and size. The serial manager receives buffers and the buffers available for memory allocation, but it is recommended to keep their current values.

The application consists of three project files configured to run on either RTOS (FreeRTOS) or bare-metal configuration (non pre-emptive task scheduler). Each project contains Debug and Release targets. Before building and downloading the application, the user can switch to either one from the Workspace tab in IAR.

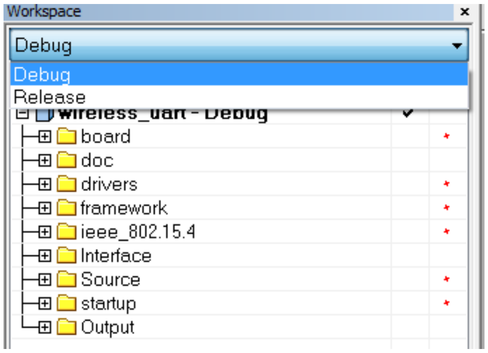


Figure 2-1. Changes between targets

2.3 Running the Wireless UART Application

By default, the application uses broadcast addresses for OTA communication. This way, the application can be directly downloaded and run without any user intervention. The following use case assumes no changes have been done to the project.

- Two (or more) platforms have to be connected to the PC using the mini-USB cables.
- Then, the code must be downloaded on the platforms via J-Link (or other means).
- After that, two (or more) TERM applications must be opened and the serial ports must be configured with the same baud rate as the one in the project (default is 115200). Other serial configurations necessary are 8 bit, no parity, and 1 stop bit.
- To start the setup, each platform must be reset and one of the (user) push buttons found on the platform must be pressed. This starts the state machine of the application. The user can start sending characters via UART to one of the platforms, which will be broadcast OTA.

Chapter 3
Kinetis Wireless Messenger Application

3.1 Introduction

The Wireless Messenger application is an SMAC based demo which highlights the retry and re-transmission mechanisms in case of *no ACK* and *Channel Busy* scenarios. It uses the basic SMAC primitives for the data layer and management layer, and optionally integrates a security module, which performs AES encryption and decryption in cipher block chaining mode. It is completely transparent to the application. The demo is presented in the form of a messenger-like application and requires a TERM.

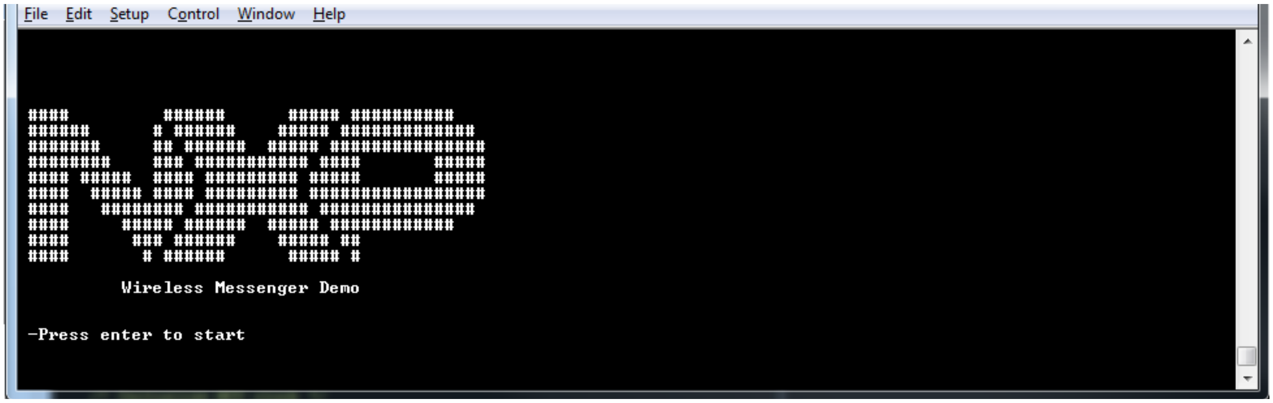
Most of the application configurations can be applied at runtime except changing the baud-rate and selecting between RTOS targets and bare metal target.

3.2 Wireless Messenger configuration menu

This paragraph describes the configuration menu and the shortcuts menu, which aid the user in configuring the application. The options available in the shortcuts menu can be accessed both in the main menu and in the configuration menu. The console menu has all the shortcuts disabled so that they do not interfere with message typing.

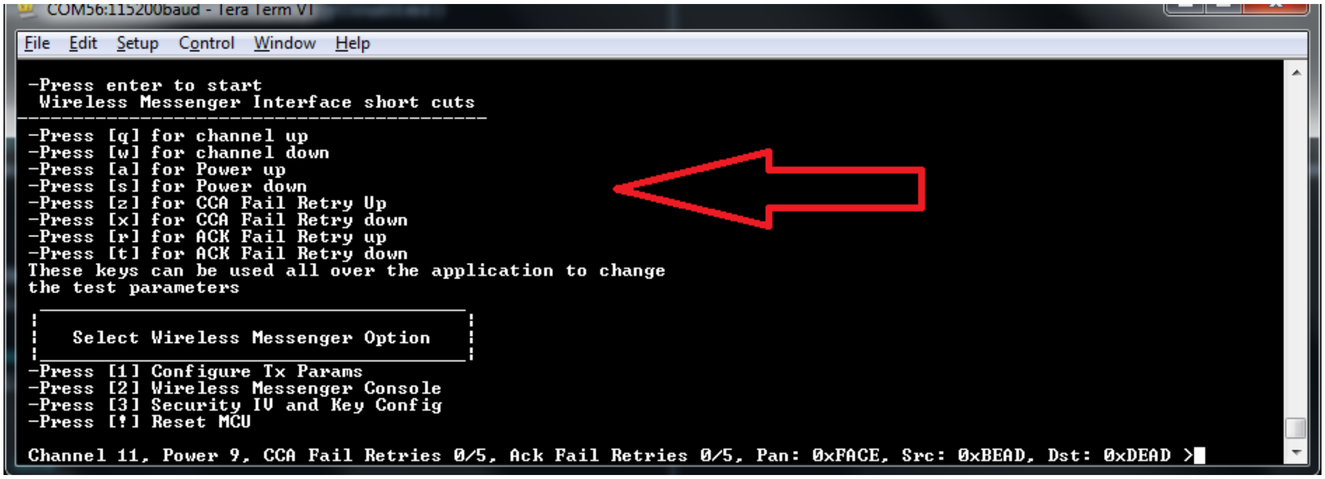
3.2.1 Shortcuts menu

The main menu is displayed after the user hits [ENTER] on the welcome screen. This menu shows a shortcut entry which specifies what each shortcut key does.



```
####         ######      ##### ##########
######      # ######    ##### #############
#######     ## ######  ##### ###############
########    ### ########### ####       #####
#### #####  #### ######### #####       #####
####  ##### #### ######### #################
####   ######## ########### ###############
####     ##### ######  ##### ############
####      ### ######    ##### ##
####       # ######      ##### #

         Wireless Messenger Demo

-Press enter to start
```

Figure 3-1. Wireless Messenger welcome screen


COM56:115200baud - Tera Term VT
File Edit Setup Control Window Help

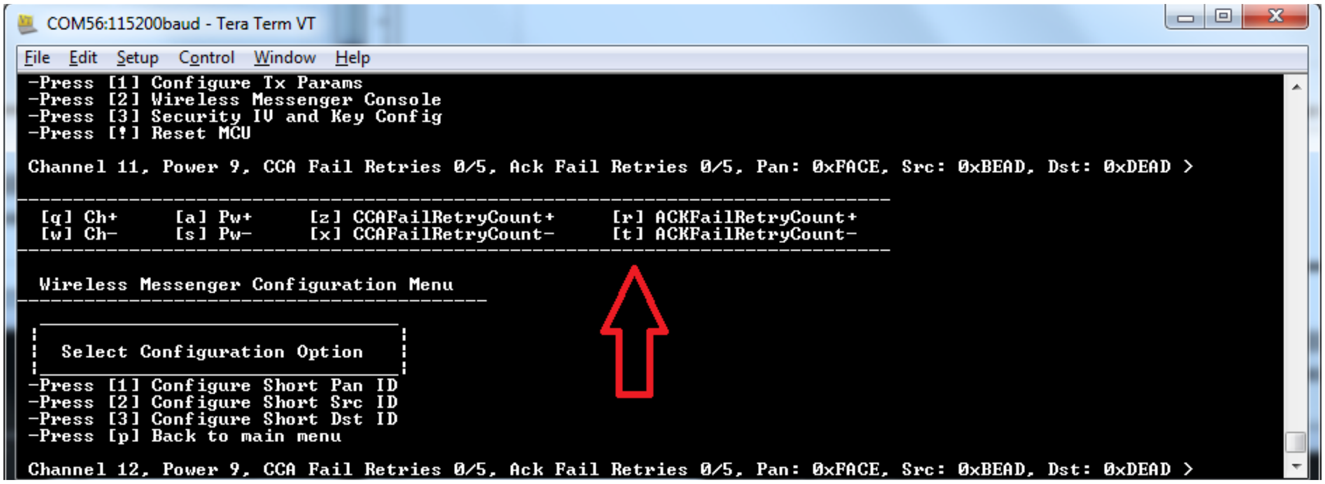
```
-Press enter to start
 Wireless Messenger Interface short cuts
----------------------------------------
-Press [q] for channel up
-Press [w] for channel down
-Press [a] for Power up
-Press [s] for Power down
-Press [z] for CCA Fail Retry Up
-Press [x] for CCA Fail Retry down
-Press [r] for ACK Fail Retry up
-Press [t] for ACK Fail Retry down
These keys can be used all over the application to change
the test parameters

 ______________________________________
|                                      |
|   Select Wireless Messenger Option   |
|______________________________________|
-Press [1] Configure Tx Params
-Press [2] Wireless Messenger Console
-Press [3] Security IV and Key Config
-Press [!] Reset MCU

Channel 11, Power 9, CCA Fail Retries 0/5, Ack Fail Retries 0/5, Pan: 0xFACE, Src: 0xBEAD, Dst: 0xDEAD >
```

Figure 3-2. Shortcuts menu for the Wireless Messenger demo application

Given the above figure:

- pressing ‘q’ will increase the channel number. When it reaches 26 the channel number will be set to 11.
- pressing ‘w’ will decrease the channel number. If previous channel number is 11, the next channel will be 26
- pressing ‘a’ and ‘s’ is similar to ‘q’ and ‘w’ but for setting the output power. The limits for this option are [0x08, 0x1C].
- pressing ‘z’ will increase the number of retransmissions in case of a channel busy scenario. Keep in mind that a number greater than 0 for this option will enable automatic CCA before TX option.
- pressing ‘x’ will decrease the number of retransmission in case of a channel busy status. If the number of retransmissions is decremented to 0, the feature will be disabled.
- pressing ‘r’ will increment the number of retries in case of a No Ack situation. If the number of retries is greater than 0, the automatic ACK mechanism is enabled. This mechanism is bypassed in case of a broadcast transmission.
- pressing ‘t’ will decrement the number of retries in case of a No Ack situation. If the number of retries reaches 0, the automatic ACK mechanism is disabled.

A brief shortcuts menu description is also displayed in the configuration menu, as illustrated in the below figure. This indicates that the shortcuts are still active.


COM56:115200baud - Tera Term VT
File Edit Setup Control Window Help

```
-Press [1] Configure Tx Params
-Press [2] Wireless Messenger Console
-Press [3] Security IV and Key Config
-Press [!] Reset MCU

Channel 11, Power 9, CCA Fail Retries 0/5, Ack Fail Retries 0/5, Pan: 0xFACE, Src: 0xBEAD, Dst: 0xDEAD >

-------------------------------------------------------------------------------
 [q] Ch+      [a] Pw+      [z] CCAFailRetryCount+      [r] ACKFailRetryCount+
 [w] Ch-      [s] Pw-      [x] CCAFailRetryCount-      [t] ACKFailRetryCount-
-------------------------------------------------------------------------------

 Wireless Messenger Configuration Menu
----------------------------------------

 |----------------------------------|
 |   Select Configuration Option    |
 |----------------------------------|
-Press [1] Configure Short Pan ID
-Press [2] Configure Short Src ID
-Press [3] Configure Short Dst ID
-Press [p] Back to main menu

Channel 12, Power 9, CCA Fail Retries 0/5, Ack Fail Retries 0/5, Pan: 0xFACE, Src: 0xBEAD, Dst: 0xDEAD >
```

Figure 3-3. Shortcuts menu description embedded in the configuration menu

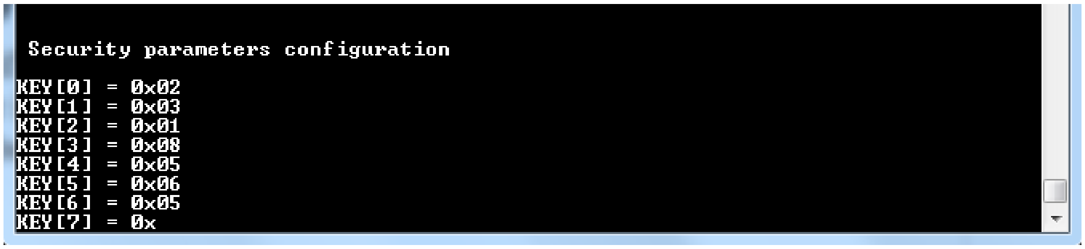
3.2.2 Configuration menu

The configuration menu is presented in Figure 3-3. There are three options available:

- *Configure Short Pan ID*: this option will allow the user to set the source/destination PAN address. The user must enter four hexadecimal digits resembling a 16-bit address. The value entered is case-insensitive. For example, to set a broadcast address for the PAN ID, the user can type both “0xFFFF” or “0xffff”.
- *Configure Short Src ID*: this option will allow the user to set the short address of the node. The option is similar to the one presented above.
- *Configure Short Dst ID*: this option will allow the user to set the destination address of the packets that will be sent from the console menu. The feature is similar to the *Configure Short Pan ID* option.

3.2.3 Security IV and key configuration

- This configuration menu appears only if the application is built with `gSmacUseSecurity_c` set to 1. This feature allows the user to configure the initial vector and encryption key. For two devices to communicate properly, security must be enabled on both, and the initial vector and the key must be identical.



```
 Security parameters configuration

KEY[0] = 0x02
KEY[1] = 0x03
KEY[2] = 0x01
KEY[3] = 0x08
KEY[4] = 0x05
KEY[5] = 0x06
KEY[6] = 0x05
KEY[7] = 0x
```

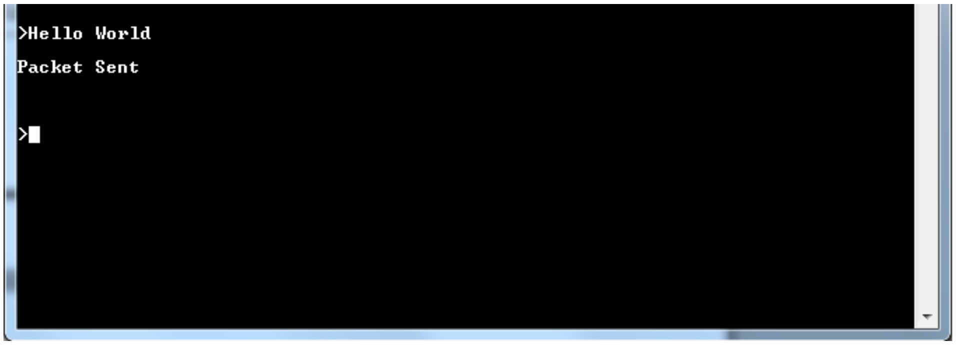
Figure 3-4. Security configuration menu (when security is enabled)

3.3 Wireless Messenger console menu

The console menu is used for sending and receiving messages. Outside this menu, the device will not receive any packets OTA. In this menu, all configuration options are disabled.

In the console menu, the user can see packets intended for a specific platform or broadcast packets. When the user types a message and hits [ENTER] the application includes the message into a packet payload, and sends it using the previously configured addressing information. The application will notify the user about the status of the packet by writing a status message to the serial port. The status can be either a "Packet Sent" message or an error message, in case the retry or re-transmission mechanism is enabled, and sending failed after the retry/re-transmission counter exceeded the configured value. For example, if the *CCA Fail Retries* is set to two, and the algorithm finds the channel idle after a second attempt, the user will receive a "Packet Sent" message in the TERM. If the channel is busy after a second retry, the user will receive a "Packet Sending Failed. Reason. Channel Busy!" notification.

To return to the main menu the user must press the escape key ([Esc]).



```
>Hello World
Packet Sent

>
```

Figure 3-5. Console menu: "Packet Sent" notification after writing "Hello World" and hitting [ENTER]

Chapter 4
Kinetis Connectivity Test Application

4.1 Introduction

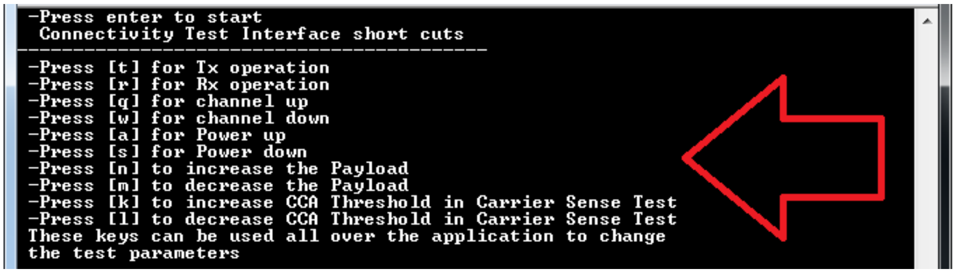
The Connectivity Test Application is a SMAC based Demo Application which provides the user with means to test basic transmission-reception functionalities along with several advanced testing features based on the ASP and SMAC APIs.

Similar to the *Wireless Messenger Application*, Connectivity Test can be configured at run-time (most of the settings) but several options must be set at compile time (for example addressing is set default to broadcast and can be changed only from the project files).

4.2 Connectivity Test Application configuration

The compile time settings of the application can be updated in the same manner as for the Wireless UART Application, but most of the configurations can be found in the `Connectivity_Test_Platform.h` header file. See Section 2.2, "Application configuration"**.**

The runtime configuration is performed using shortcut keys which are available in most of the application's menus. This is similar to Wireless Messenger shortcut menu, but it exposes more options. Not all the options are necessary at a certain point, but different menus or tests will change their behavior based on what settings are applied.



```
-Press enter to start
 Connectivity Test Interface short cuts
------------------------------------------
-Press [t] for Tx operation
-Press [r] for Rx operation
-Press [q] for channel up
-Press [w] for channel down
-Press [a] for Power up
-Press [s] for Power down
-Press [n] to increase the Payload
-Press [m] to decrease the Payload
-Press [k] to increase CCA Threshold in Carrier Sense Test
-Press [l] to decrease CCA Threshold in Carrier Sense Test
These keys can be used all over the application to change
the test parameters
```

Figure 4-1. Connectivity Test Shortcuts Menu

According to the above figure, the following keys have the effect described below:

- 't' : brings up the configuration menu for the transmitter in both *PER* and *Range* tests.
- 'r' : brings up the configuration menu for the receiver in both *PER* and *Range* tests.
- 'q' : increments channel number. If pressed when current channel is 26, the channel number will change to 11.
- 'w' : decrements channel number. If pressed when current channel is 11, the channel number will change to 26.
- 'a' : increments output power value. If output power is at maximum and this key is pressed, the output power will go to minimum (in this case 0x08).
- 's' : decrements output power value. If output power is at minimum and this key is pressed, the output power will go to maximum (in this case 0x1C). These are not directly mapped to *dBm*

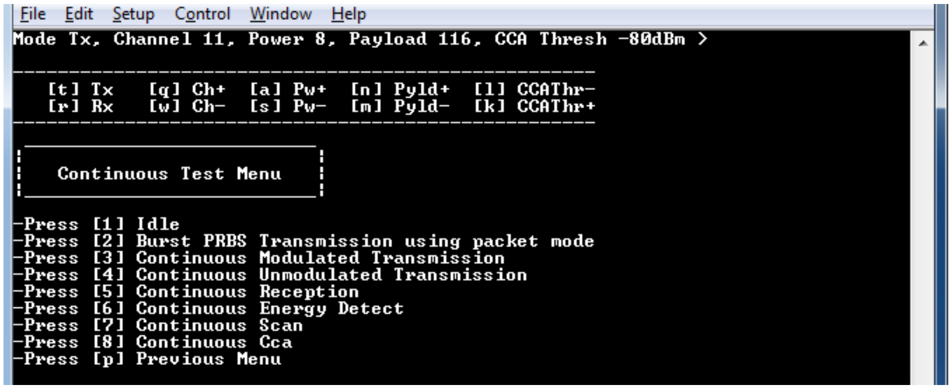
values. Instead the output power value is written to the appropriate register. The user should consult the reference manual to determine the relationship between selected value and power in *dBm*.

- ‘n’ : increments the length of the payload. This value is used in both *PER TX* test to build-up the payload and in *Transmission Control* test for the same reason.
- ‘m’ : decrements the length of the payload. Incrementation and decrementation is performed in the [17, 116] interval. All overflows at one end lead to setting the other end’s value.
- ‘k’ : increments the CCA threshold for the *Carrier Sense* test. In this test the *CCA before TX* algorithm is implemented at application level and the channel idle threshold is established using this parameter.
- ‘l’ : decrements the CCA threshold for the *Carrier Sense* test.

4.3 Connectivity Test Application usage

The Connectivity Test Application has five main features:

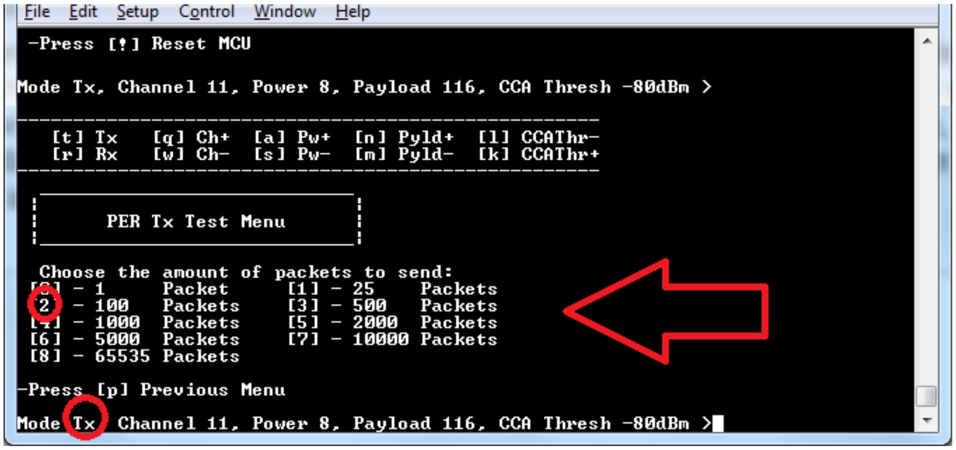
a) *Continuous Tests*: This menu option will display several test suites
   - *IDLE*: this option will set the transceiver and all the state machines to idle.
   - *Burst PRBS Transmission using packet mode*: this option will continuosly send packets which contain a pseudo-random payload of fixed length.
   - *Continuous Modulated Transmission*: this option will allow the user to select between modulating 1’s, 0’s or a pseudo-random sequence (PN) and sending them OTA continuously (in continuous mode).
   - *Continuous Unmodulated Transmission*: this option will allow the user to send an unmodulated signal OTA having the frequency equal to the central frequency of the currently selected channel.
   - *Continuous Reception*: this test will place the transceiver in reception and will dump the payload bytes of the received packets to the TERM in ASCII converted hexadecimal characters.
   - *Continuous Energy Detect*: this option will launch consecutive energy detect requests at fixed hard-coded intervals for the current channel and will print their values to the TERM.
   - *Continuous Scan*: this option is similar to the previous one, except that at each iteration it will obtain the energy values on all channels.
   - *Continuous CCA*: this option will launch consecutive CCA requests for the currently selected channel, at a fixed hard-coded interval and will print “Idle” or “Busy” depending on the CCA result.



```
Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >

---------------------------------------------------------------
   [t] Tx    [q] Ch+  [a] Pw+  [n] Pyld+  [l] CCAThr-
   [r] Rx    [w] Ch-  [s] Pw-  [m] Pyld-  [k] CCAThr+
---------------------------------------------------------------
 _________________________
|                         |
|   Continuous Test Menu  |
|_________________________|

-Press [1] Idle
-Press [2] Burst PRBS Transmission using packet mode
-Press [3] Continuous Modulated Transmission
-Press [4] Continuous Unmodulated Transmission
-Press [5] Continuous Reception
-Press [6] Continuous Energy Detect
-Press [7] Continuous Scan
-Press [8] Continuous Cca
-Press [p] Previous Menu
```

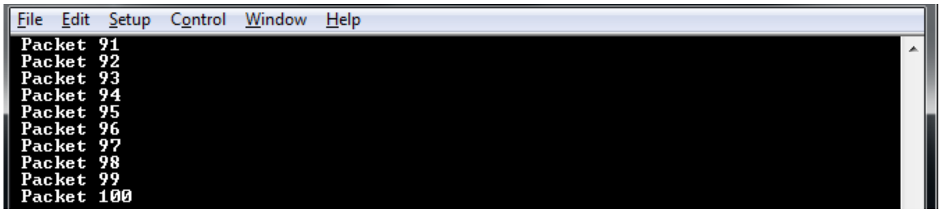
Figure 4-2. Continuous Test menu entries

b) *Packet Error Rate*: This menu option will display a configuration menu for testing the packet error rate. The menu displayed also depends on the ‘r’ or ‘t’ shortcut key. If ‘r’ is pressed the following menu will be for *PER RX*, otherwise it will be for *PER TX*. For example, if two platforms have Connectivity Test loaded, one of the boards can be set in RX and the other in TX, as shown in the following figures.



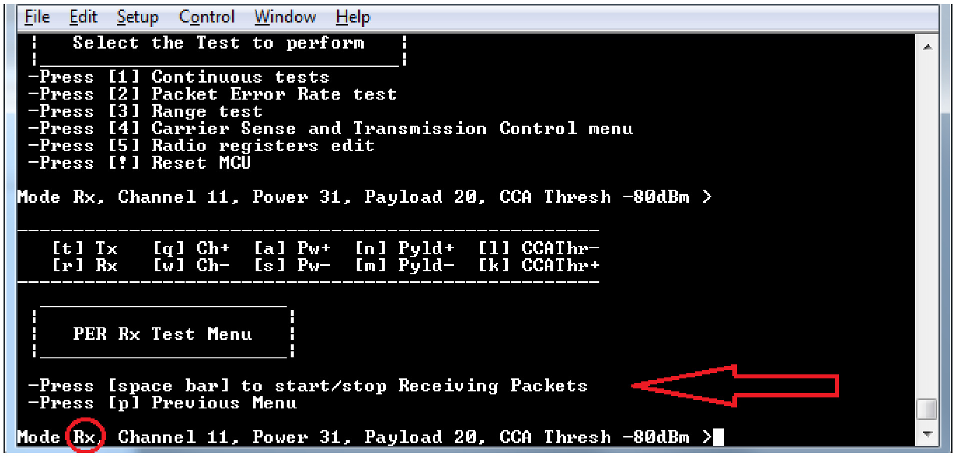
```
 -Press [!] Reset MCU

Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >

---------------------------------------------------------------
   [t] Tx    [q] Ch+  [a] Pw+  [n] Pyld+  [l] CCAThr-
   [r] Rx    [w] Ch-  [s] Pw-  [m] Pyld-  [k] CCAThr+
---------------------------------------------------------------
  ___________________________
 |                           |
 |      PER Tx Test Menu     |
 |___________________________|

  Choose the amount of packets to send:
 [0] - 1     Packet     [1] - 25    Packets
 [2] - 100   Packets    [3] - 500   Packets
 [4] - 1000  Packets    [5] - 2000  Packets
 [6] - 5000  Packets    [7] - 10000 Packets
 [8] - 65535 Packets

-Press [p] Previous Menu

Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >
```

Figure 4-3. Entering PER menu with TX option selected, and pressing ‘2’ to send 100 packets



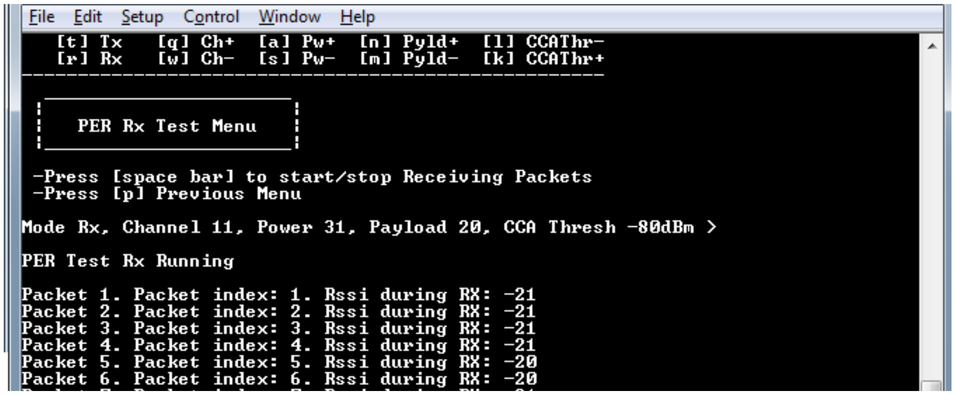
```
Packet 91
Packet 92
Packet 93
Packet 94
Packet 95
Packet 96
Packet 97
Packet 98
Packet 99
Packet 100
```

Figure 4-4. PER TX menu after sending the 100 packets burst



```
 |   Select the Test to perform    |
 |_________________________________|
 -Press [1] Continuous tests
 -Press [2] Packet Error Rate test
 -Press [3] Range test
 -Press [4] Carrier Sense and Transmission Control menu
 -Press [5] Radio registers edit
 -Press [!] Reset MCU

Mode Rx, Channel 11, Power 31, Payload 20, CCA Thresh -80dBm >

---------------------------------------------------------------
   [t] Tx    [q] Ch+  [a] Pw+  [n] Pyld+  [l] CCAThr-
   [r] Rx    [w] Ch-  [s] Pw-  [m] Pyld-  [k] CCAThr+
---------------------------------------------------------------

 |  ______________________ |
 |   PER Rx Test Menu       |
 |  ______________________ |

 -Press [space bar] to start/stop Receiving Packets
 -Press [p] Previous Menu

Mode Rx, Channel 11, Power 31, Payload 20, CCA Thresh -80dBm >
```

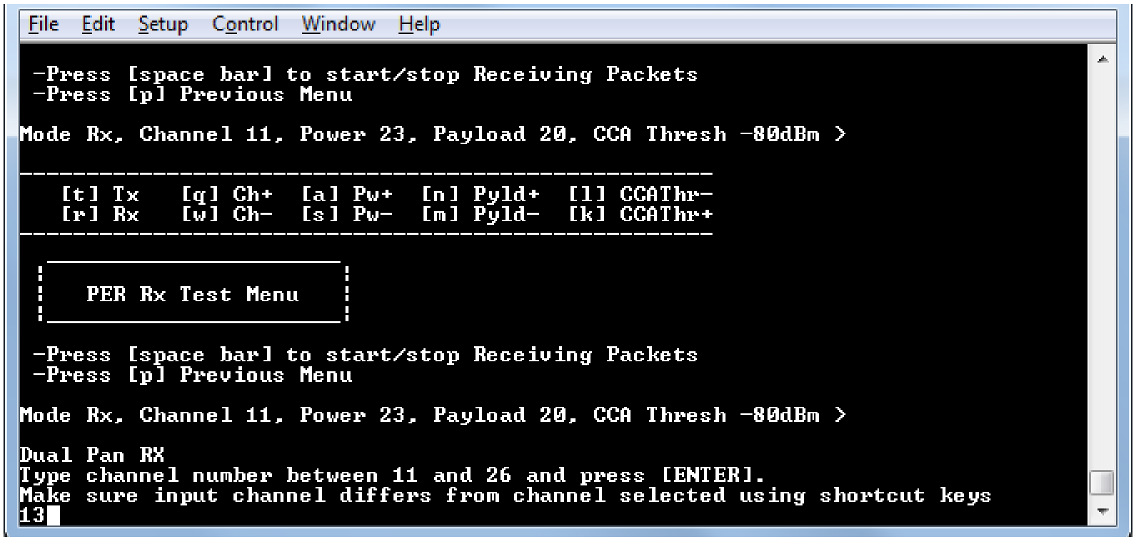
Figure 4-5. PER Test menu with RX option selected on the second platform



```
   [t] Tx    [q] Ch+  [a] Pw+  [n] Pyld+  [l] CCAThr-
   [r] Rx    [w] Ch-  [s] Pw-  [m] Pyld-  [k] CCAThr+
---------------------------------------------------------------

 |  ______________________ |
 |   PER Rx Test Menu       |
 |  ______________________ |

 -Press [space bar] to start/stop Receiving Packets
 -Press [p] Previous Menu

Mode Rx, Channel 11, Power 31, Payload 20, CCA Thresh -80dBm >

PER Test Rx Running

Packet 1. Packet index: 1. Rssi during RX: -21
Packet 2. Packet index: 2. Rssi during RX: -21
Packet 3. Packet index: 3. Rssi during RX: -21
Packet 4. Packet index: 4. Rssi during RX: -21
Packet 5. Packet index: 5. Rssi during RX: -20
Packet 6. Packet index: 6. Rssi during RX: -20
```

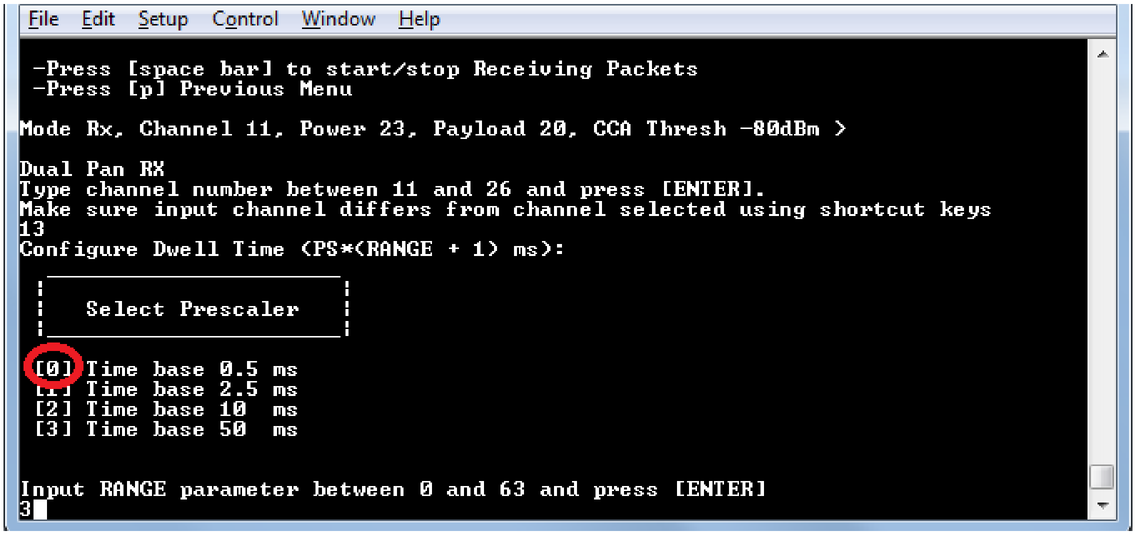
Figure 4-6. PER RX after pressing [SPACE] and starting the test

The PER RX Test can have an alternate behavior if gMpmMaxPANs_c is defined as 2 in the app_preinclude.h file. The test will become a dual pan packet error rate test asking you to provide a secondary channel (that must differ from the one selected using the shortcut keys) and a dwell time so that the RX device switches automatically between channels. This way, you can use two devices to perform PER TX on different channels and one device to run the dual pan PER RX on those channels.



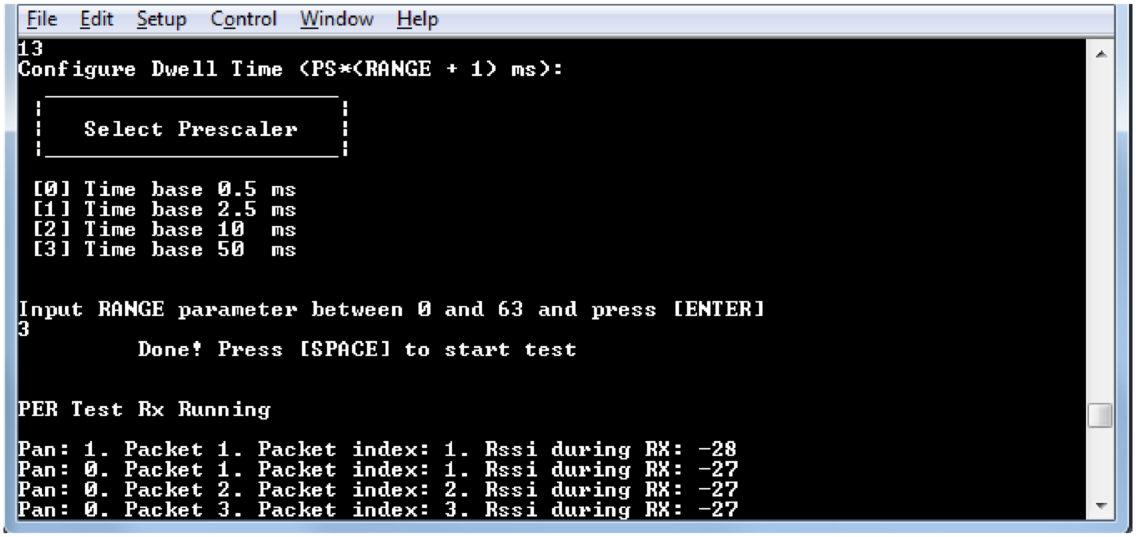
```
 -Press [space bar] to start/stop Receiving Packets
 -Press [p] Previous Menu

Mode Rx, Channel 11, Power 23, Payload 20, CCA Thresh -80dBm >

----------------------------------------------------
   [t] Tx    [q] Ch+   [a] Pw+   [n] Pyld+   [l] CCAThr-
   [r] Rx    [w] Ch-   [s] Pw-   [m] Pyld-   [k] CCAThr+
----------------------------------------------------

   ______________________
  |                      |
  |   PER Rx Test Menu   |
  |______________________|

 -Press [space bar] to start/stop Receiving Packets
 -Press [p] Previous Menu

Mode Rx, Channel 11, Power 23, Payload 20, CCA Thresh -80dBm >

Dual Pan RX
Type channel number between 11 and 26 and press [ENTER].
Make sure input channel differs from channel selected using shortcut keys
13
```

Figure 4-7. Dual Pan PER RX channel configuration



```
 -Press [space bar] to start/stop Receiving Packets
 -Press [p] Previous Menu

Mode Rx, Channel 11, Power 23, Payload 20, CCA Thresh -80dBm >

Dual Pan RX
Type channel number between 11 and 26 and press [ENTER].
Make sure input channel differs from channel selected using shortcut keys
13
Configure Dwell Time (PS*(RANGE + 1) ms):
   ______________________
  |                      |
  |   Select Prescaler   |
  |______________________|

 [0] Time base 0.5 ms
 [1] Time base 2.5 ms
 [2] Time base 10  ms
 [3] Time base 50  ms


Input RANGE parameter between 0 and 63 and press [ENTER]
3
```

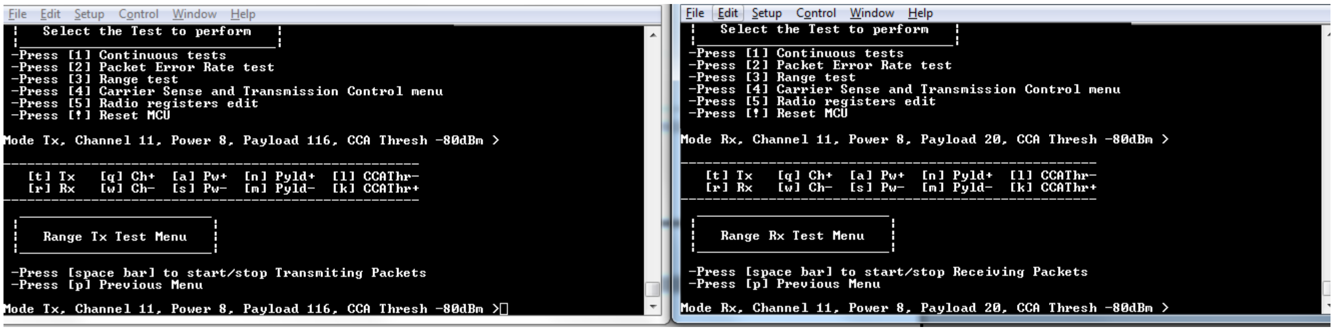
Figure 4-8. Dual Pan PER RX dwell time configuration



```
13
Configure Dwell Time (PS*(RANGE + 1) ms):
  ______________________
 |                      |
 |   Select Prescaler   |
 |______________________|

 [0] Time base 0.5 ms
 [1] Time base 2.5 ms
 [2] Time base 10  ms
 [3] Time base 50  ms


Input RANGE parameter between 0 and 63 and press [ENTER]
3
         Done! Press [SPACE] to start test


PER Test Rx Running

Pan: 1. Packet 1. Packet index: 1. Rssi during RX: -28
Pan: 0. Packet 1. Packet index: 1. Rssi during RX: -27
Pan: 0. Packet 2. Packet index: 2. Rssi during RX: -27
Pan: 0. Packet 3. Packet index: 3. Rssi during RX: -27
```

Figure 4-9. Dual Pan PER RX running

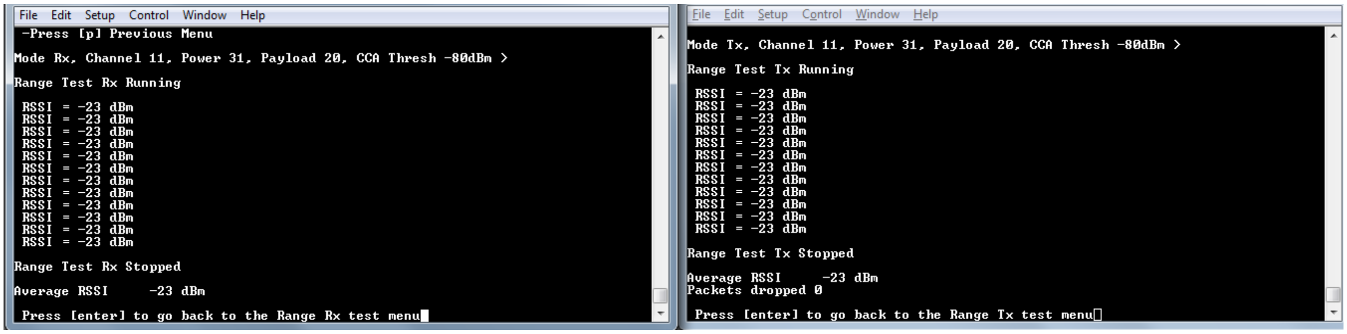
c) *Range Test*: This test will display a configuration menu that will perform a ‘ping-pong’ test to aid the user in determining the range (as distance between two platforms) in which the platform can function properly. The sub-menu also depends on the ‘r’ and ‘t’ shortcuts so that one of the platforms can be the initializer (first to start a TX) and the other can respond to requests. The test is started and stopped only by user intervention and during its execution it will display the linq quality for each received packet. Also, at the end of the test, the platform configured as the initializer (TX) will display a summary of how many packets were lost and what was the average RSSI.



```
 |   Select the Test to perform   |
 |________________________________|
 -Press [1] Continuous tests
 -Press [2] Packet Error Rate test
 -Press [3] Range test
 -Press [4] Carrier Sense and Transmission Control menu
 -Press [5] Radio registers edit
 -Press [!] Reset MCU

Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >

---------------------------------------------------
   [t] Tx   [q] Ch+  [a] Pw+  [n] Pyld+  [l] CCAThr-
   [r] Rx   [w] Ch-  [s] Pw-  [m] Pyld-  [k] CCAThr+
---------------------------------------------------

  ________________________
 |                        |
 |   Range Tx Test Menu   |
 |________________________|

 -Press [space bar] to start/stop Transmiting Packets
 -Press [p] Previous Menu

Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >
```

```
 |   Select the Test to perform   |
 |________________________________|
 -Press [1] Continuous tests
 -Press [2] Packet Error Rate test
 -Press [3] Range test
 -Press [4] Carrier Sense and Transmission Control menu
 -Press [5] Radio registers edit
 -Press [!] Reset MCU

Mode Rx, Channel 11, Power 8, Payload 20, CCA Thresh -80dBm >

---------------------------------------------------
   [t] Tx   [q] Ch+  [a] Pw+  [n] Pyld+  [l] CCAThr-
   [r] Rx   [w] Ch-  [s] Pw-  [m] Pyld-  [k] CCAThr+
---------------------------------------------------

  ________________________
 |                        |
 |   Range Rx Test Menu   |
 |________________________|

 -Press [space bar] to start/stop Receiving Packets
 -Press [p] Previous Menu

Mode Rx, Channel 11, Power 8, Payload 20, CCA Thresh -80dBm >
```

Figure 4-10. Range TX and RX submenus for two platforms

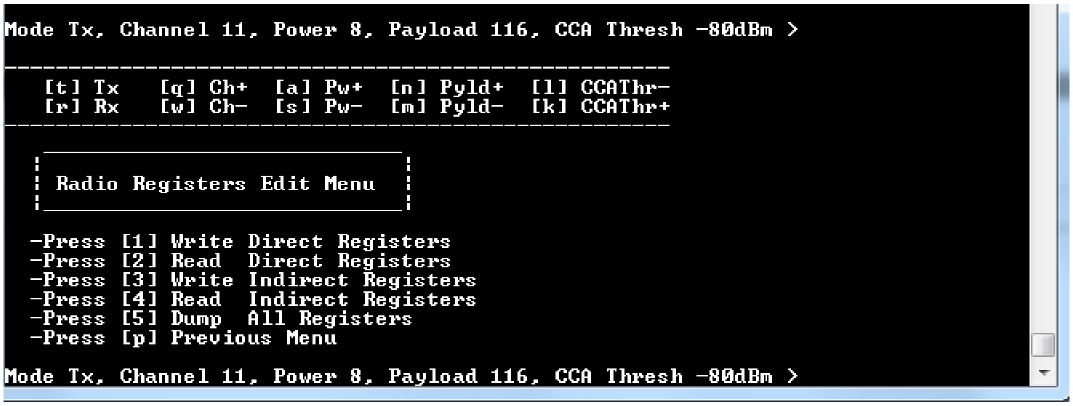

File Edit Setup Control Window Help
File Edit Setup Control Window Help

```
 -Press [p] Previous Menu

Mode Rx, Channel 11, Power 31, Payload 20, CCA Thresh -80dBm >

Range Test Rx Running

 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm

Range Test Rx Stopped

Average RSSI     -23 dBm

 Press [enter] to go back to the Range Rx test menu
```

```
Mode Tx, Channel 11, Power 31, Payload 20, CCA Thresh -80dBm >

Range Test Tx Running

 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm
 RSSI = -23 dBm

Range Test Tx Stopped

Average RSSI     -23 dBm
Packets dropped 0

 Press [enter] to go back to the Range Tx test menu
```

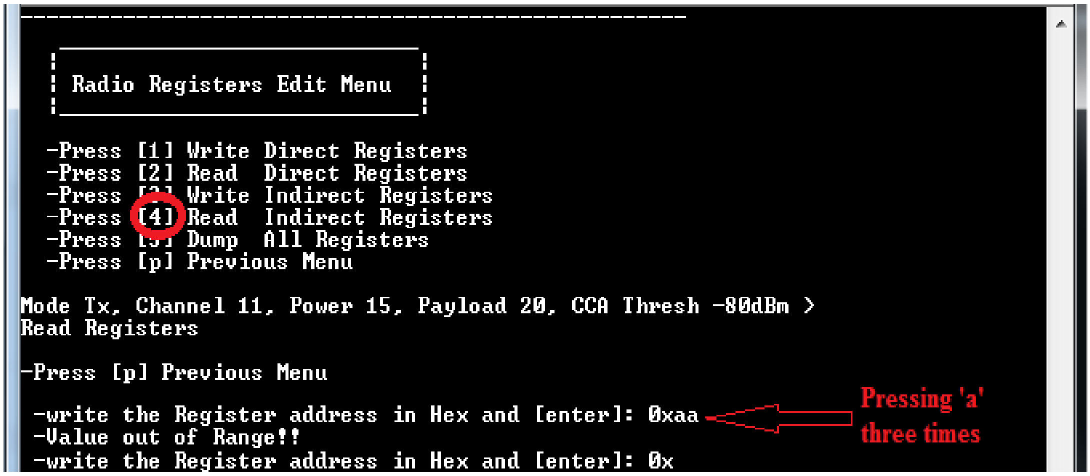
Figure 4-11. Range TX and RX after running the test for two platforms

d) *Radio Registers Edit*: this menu will allow the user to read-write transceiver registers and to dump all address-value pairs from the transceiver registers to the TERM. The described features are accessible through the entries of this menu. For each access request (read or write) to a certain register, the register address is validated partially, and it is the responsibility of the user to access an existing register. For example, if the last accessible register is at 0xFD, the application will only validate that the address is in the unsigned char range but user has the possibility to request register 0xFF. To ensure that a proper range is used, user can first use the dump register feature to see the valid address ranges.



```
Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >

-----------------------------------------------------
   [t] Tx    [q] Ch+   [a] Pw+   [n] Pyld+   [l] CCAThr-
   [r] Rx    [w] Ch-   [s] Pw-   [m] Pyld-   [k] CCAThr+
-----------------------------------------------------

  |____________________________|
  |  Radio Registers Edit Menu |
  |____________________________|

  -Press [1] Write Direct Registers
  -Press [2] Read  Direct Registers
  -Press [3] Write Indirect Registers
  -Press [4] Read  Indirect Registers
  -Press [5] Dump  All Registers
  -Press [p] Previous Menu

Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >
```

Figure 4-12. Radio Registers Edit menu

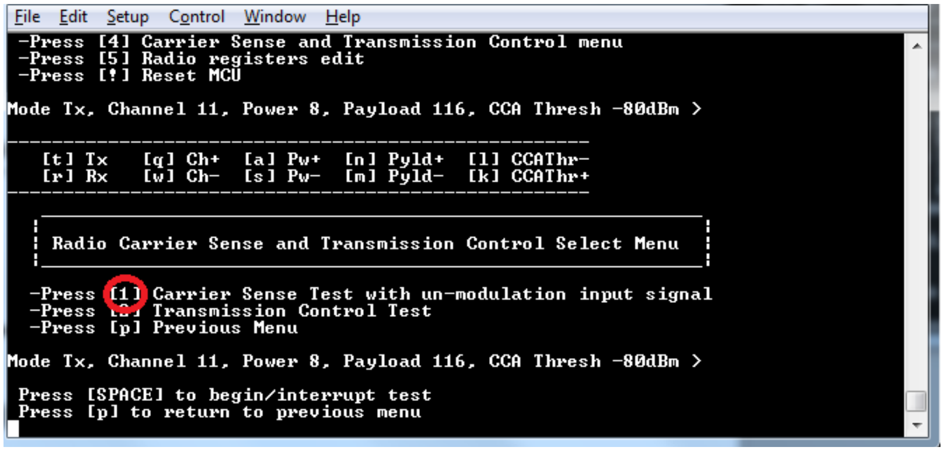


```
--------------------------------------------------------

  ------------------------------
 | Radio Registers Edit Menu    |
  ------------------------------

  -Press [1] Write Direct Registers
  -Press [2] Read  Direct Registers
  -Press [3] Write Indirect Registers
  -Press [4] Read  Indirect Registers
  -Press [5] Dump  All Registers
  -Press [p] Previous Menu

Mode Tx, Channel 11, Power 15, Payload 20, CCA Thresh -80dBm >
Read Registers

-Press [p] Previous Menu

 -write the Register address in Hex and [enter]: 0xaa
 -Value out of Range!!
 -write the Register address in Hex and [enter]: 0x
```

Pressing 'a' three times

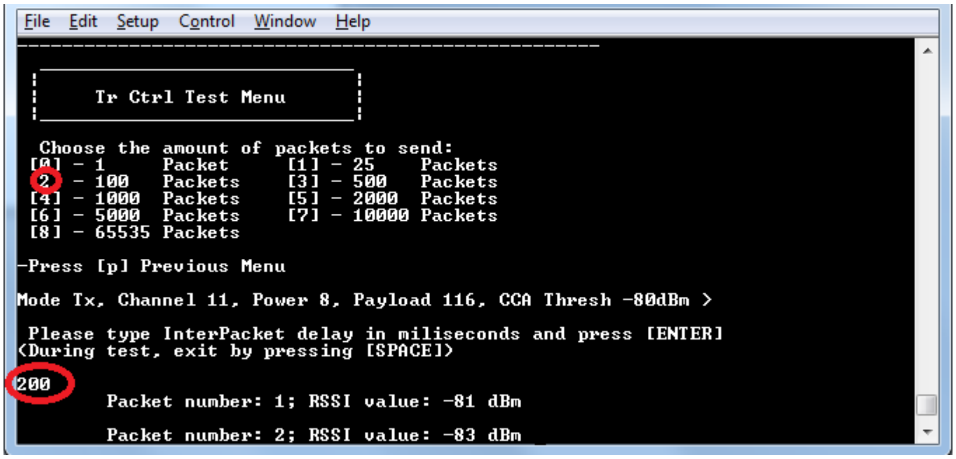
Figure 4-13. Read Indirect Registers example

e) *Carrier Sense and Transmission Control*: this menu will allow the user to choose between two tests. The former is the *Carrier Sense* test, which will perform ED continuosly until the ED value is above the CCA threshold (configured using ‘k’ and ‘l’ shortcuts). It then transmits a packet which contains pseudo-random data with the payload size configured using ‘n’ and ‘m’ shortcuts. The latter is the *Transmission Control* test which displays a selection menu for number of packets identical with the one in *PER TX* test, and prompts the user to enter a decimal value resembling the inter-packet delay in milliseconds. After that, the application will start sending the selected number of packets with the selected inter-packet delay using pseudo-random data for the payload with the size configured with ‘n’ and ‘m’ shortcuts.



```
 -Press [4] Carrier Sense and Transmission Control menu
 -Press [5] Radio registers edit
 -Press [!] Reset MCU

Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >

---------------------------------------------------
   [t] Tx    [q] Ch+  [a] Pw+  [n] Pyld+  [l] CCAThr-
   [r] Rx    [w] Ch-  [s] Pw-  [m] Pyld-  [k] CCAThr+
---------------------------------------------------

  ------------------------------------------------------
 | Radio Carrier Sense and Transmission Control Select Menu |
  ------------------------------------------------------

  -Press [1] Carrier Sense Test with un-modulation input signal
  -Press [2] Transmission Control Test
  -Press [p] Previous Menu

Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >

 Press [SPACE] to begin/interrupt test
 Press [p] to return to previous menu
```

Figure 4-14. Carrier Sense submenu, pressing [SPACE] will start the ED loop



```
----------------------------------------------------
  ______________________________
 |                              |
 |      Tr Ctrl Test Menu       |
 |______________________________|

  Choose the amount of packets to send:
 [0] - 1      Packet      [1] - 25     Packets
 [2] - 100    Packets     [3] - 500    Packets
 [4] - 1000   Packets     [5] - 2000   Packets
 [6] - 5000   Packets     [7] - 10000 Packets
 [8] - 65535 Packets

-Press [p] Previous Menu

Mode Tx, Channel 11, Power 8, Payload 116, CCA Thresh -80dBm >

 Please type InterPacket delay in miliseconds and press [ENTER]
(During test, exit by pressing [SPACE])

200
        Packet number: 1; RSSI value: -81 dBm

        Packet number: 2; RSSI value: -83 dBm
```

Figure 4-15. Transmission Control submenu after selecting 100 packets and 200 ms delay

Chapter 5 Kinetis Low Power Demo Application

5.1 Introduction

The Low Power Demo application aids the user in learning how to handle the low power use cases. There are two scenarios. The first scenario allows entering a desired low power mode manually by selecting the low power mode and the transceiver configuration, which will be active during the low power mode and the wake up source. The second scenario is divided in two roles. The first role is a TX device, which sleeps in Very Low Power Stop mode for two seconds, then wakes up and sends a “wake up” message. The second role is an RX device configured with the MCU in Very Low Power Stop and transceiver in receive mode with Low Power Preamble Search feature enabled. The TX device ends the test after sending 5 consecutive packets, while the RX device can be interrupted on any key, or upon receiving the “wake up message”. The application is used with a TERM. The application configurations can be applied both at compile time and at runtime (using the shortcuts keys).

NOTE

The Low Power Demo application is not available for the USB platform. The user should never use USB as the default interface type for the Serial Manager. The application functions properly only if UART is used as transport layer to the PC.

5.2 Application configuration

The application can be configured from three files:

- SMAC_Config.h

  It contains the number of maximum retries and retransmissions (`gMaxRetriesAllowed_c`) and the backoff interval for the custom backoff algorithm.

- SMAC_Interface.h

  It contains the configuration for the source/destination PAN id (`gDefaultPanID_c`), source node address (`gNodeAddress_c`) and definition for the broadcast address.

- Application_Interface.h

  This file provides customization of default channel number (`gDefaultChannelNumber_c`), default output power, which has to range between minimum and maximum output power (`gDefaultOutputPower_c`). This file also contains the definition for two default PHY modes.

- Low_Power_DemoApp.c

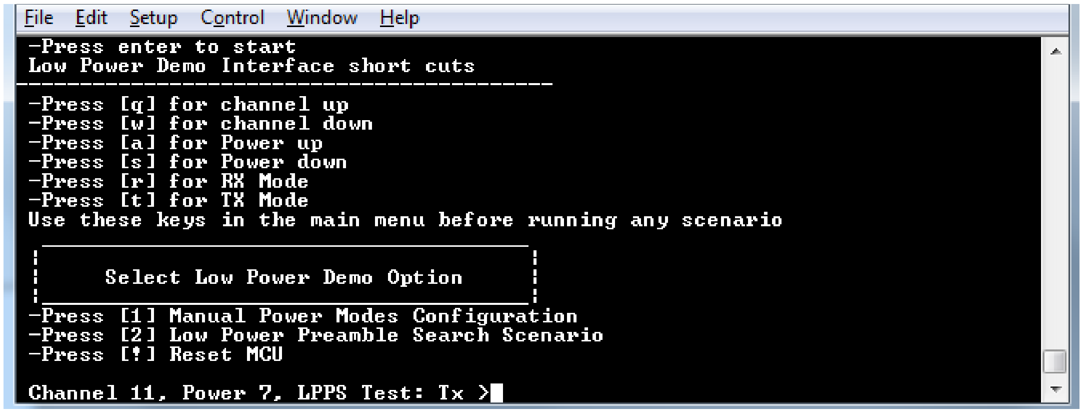
  The *InitApp* function allows the user to change the baudrate of the serial port. For other options look at the definition of the baudrate macro (`gUARTBaudRate115200_c`) and pick another member from the baud rates enumeration. In this function, the listen interval can be configured. The wake up message is prepared and there is a switch to one of the default PHY modes defined in the Application_Interface header file.

Other settings should be kept “as-is” since they could affect the application’s behavior.

The application consists of three project files depending on the scheduler used: RTOS (FreeRTOS) configuration or bare-metal configuration (non pre-emptive task scheduler). All projects contain both the Debug and Release configurations.

5.3 Running the Low Power Demo Application

At startup, the application displays a menu for selecting one of the scenarios described above. Also, in the main menu, the shortcuts can be used to change the active channel, output power and the role (TX or RX) for the Low Power Preamble Search scenario.



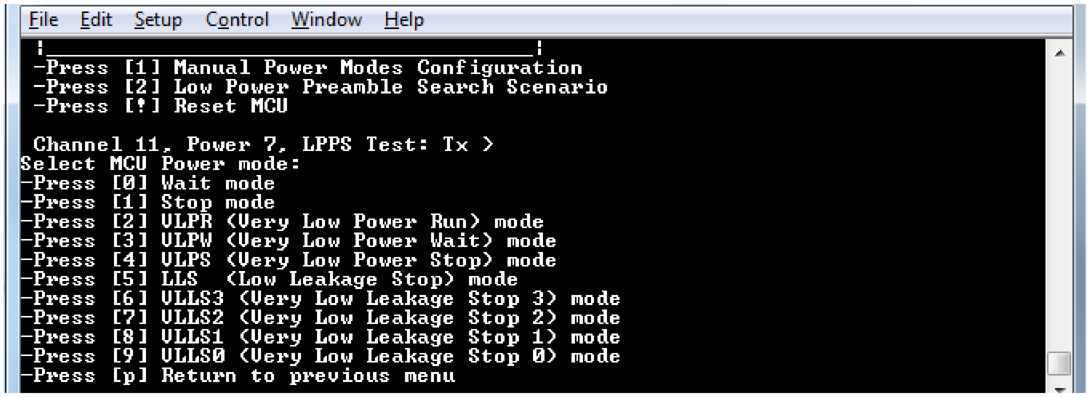
```
-Press enter to start
Low Power Demo Interface short cuts
------------------------------------------

-Press [q] for channel up
-Press [w] for channel down
-Press [a] for Power up
-Press [s] for Power down
-Press [r] for RX Mode
-Press [t] for TX Mode
Use these keys in the main menu before running any scenario
 _________________________________
|                                 |
|     Select Low Power Demo Option |
|_________________________________|
-Press [1] Manual Power Modes Configuration
-Press [2] Low Power Preamble Search Scenario
-Press [!] Reset MCU

Channel 11, Power 7, LPPS Test: Tx >
```

Figure 5-1. Low Power Demo main menu

5.3.1 Manual Power Modes Configuration

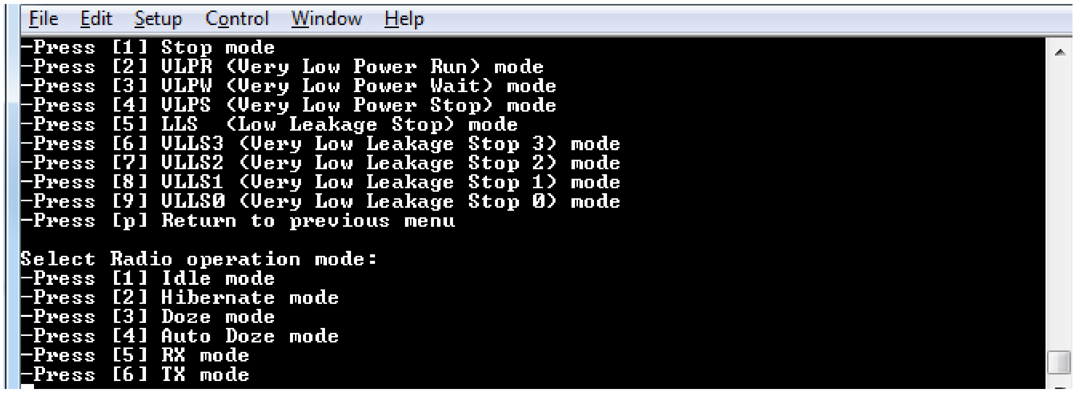
When entering this menu, a sub-menu with available power modes is listed. After one of the options is selected, another menu pops up with available transceiver configurations, followed by a menu with available wake up sources in respect to the selected low power mode. As soon as the user selects a wake up source, all configurations are applied.

All VLLSx (0, 1, 2, and 3) modes exit by reset, while other modes simply resume the application execution. A particular situation here is the very low power run which allows the MCU to continue its execution under special conditions. Although the MCU still runs, the communication with the TERM is lost. To exit this mode, the user should long press any switch button (except reset).



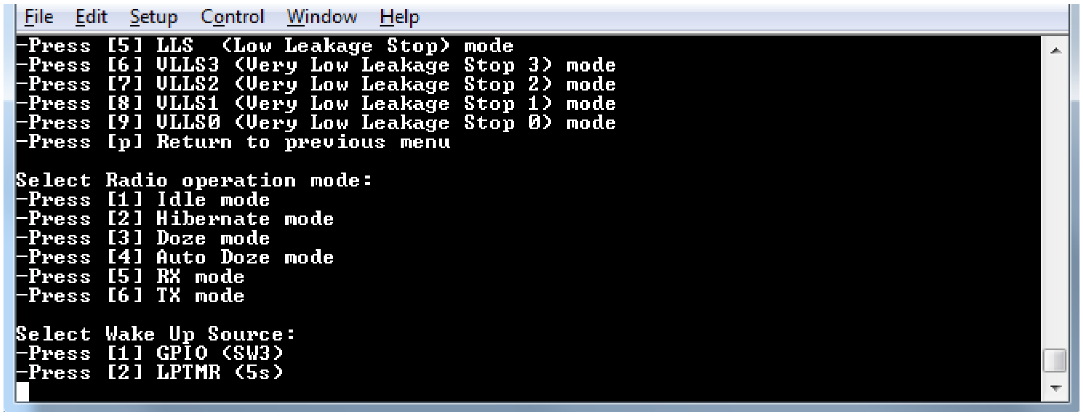
```
 |______________________________________|
 -Press [1] Manual Power Modes Configuration
 -Press [2] Low Power Preamble Search Scenario
 -Press [!] Reset MCU

 Channel 11, Power 7, LPPS Test: Tx >
Select MCU Power mode:
-Press [0] Wait mode
-Press [1] Stop mode
-Press [2] VLPR (Very Low Power Run) mode
-Press [3] VLPW (Very Low Power Wait) mode
-Press [4] VLPS (Very Low Power Stop) mode
-Press [5] LLS  (Low Leakage Stop) mode
-Press [6] VLLS3 (Very Low Leakage Stop 3) mode
-Press [7] VLLS2 (Very Low Leakage Stop 2) mode
-Press [8] VLLS1 (Very Low Leakage Stop 1) mode
-Press [9] VLLS0 (Very Low Leakage Stop 0) mode
-Press [p] Return to previous menu
```

Figure 5-2. Selecting an available MCU mode



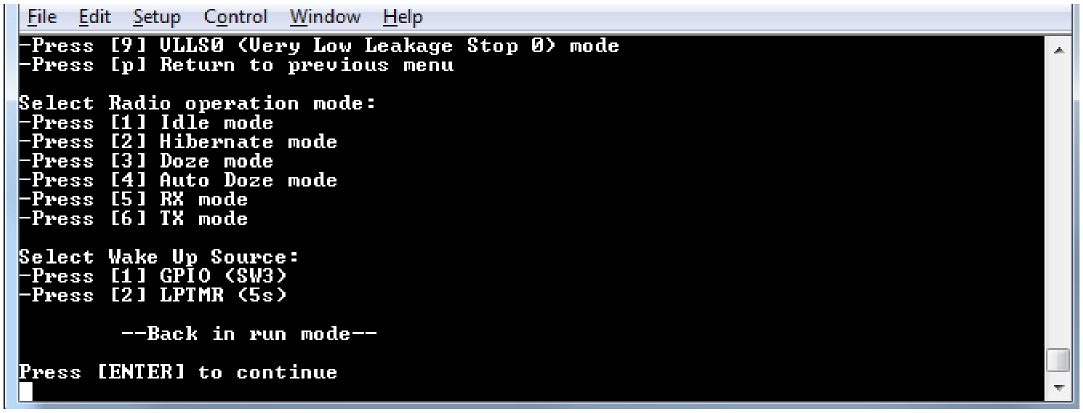
```
-Press [1] Stop mode
-Press [2] VLPR (Very Low Power Run) mode
-Press [3] VLPW (Very Low Power Wait) mode
-Press [4] VLPS (Very Low Power Stop) mode
-Press [5] LLS  (Low Leakage Stop) mode
-Press [6] VLLS3 (Very Low Leakage Stop 3) mode
-Press [7] VLLS2 (Very Low Leakage Stop 2) mode
-Press [8] VLLS1 (Very Low Leakage Stop 1) mode
-Press [9] VLLS0 (Very Low Leakage Stop 0) mode
-Press [p] Return to previous menu

Select Radio operation mode:
-Press [1] Idle mode
-Press [2] Hibernate mode
-Press [3] Doze mode
-Press [4] Auto Doze mode
-Press [5] RX mode
-Press [6] TX mode
```

Figure 5-3. Selecting an available transceiver configuration



```
-Press [5] LLS  (Low Leakage Stop) mode
-Press [6] VLLS3 (Very Low Leakage Stop 3) mode
-Press [7] VLLS2 (Very Low Leakage Stop 2) mode
-Press [8] VLLS1 (Very Low Leakage Stop 1) mode
-Press [9] VLLS0 (Very Low Leakage Stop 0) mode
-Press [p] Return to previous menu

Select Radio operation mode:
-Press [1] Idle mode
-Press [2] Hibernate mode
-Press [3] Doze mode
-Press [4] Auto Doze mode
-Press [5] RX mode
-Press [6] TX mode

Select Wake Up Source:
-Press [1] GPIO (SW3)
-Press [2] LPTMR (5s)
```

Figure 5-4. Selecting an available wake up source



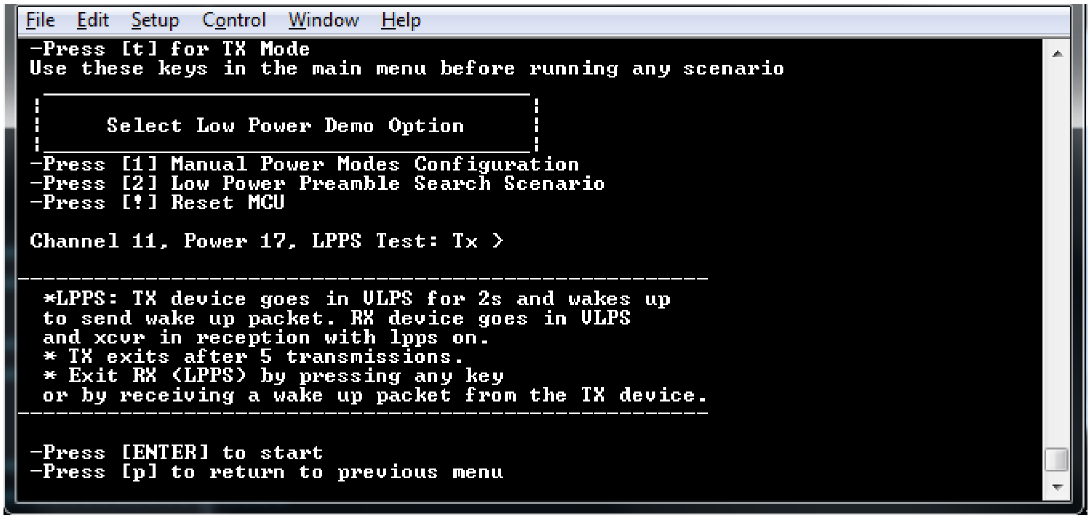
```
-Press [9] VLLS0 (Very Low Leakage Stop 0) mode
-Press [p] Return to previous menu

Select Radio operation mode:
-Press [1] Idle mode
-Press [2] Hibernate mode
-Press [3] Doze mode
-Press [4] Auto Doze mode
-Press [5] RX mode
-Press [6] TX mode

Select Wake Up Source:
-Press [1] GPIO (SW3)
-Press [2] LPTMR (5s)

        --Back in run mode--

Press [ENTER] to continue
```

Figure 5-5. Resuming after wake up from LLS

For some development platforms the menus are slightly different since not all platforms support all low power modes and not all platforms have the wake-up sources.

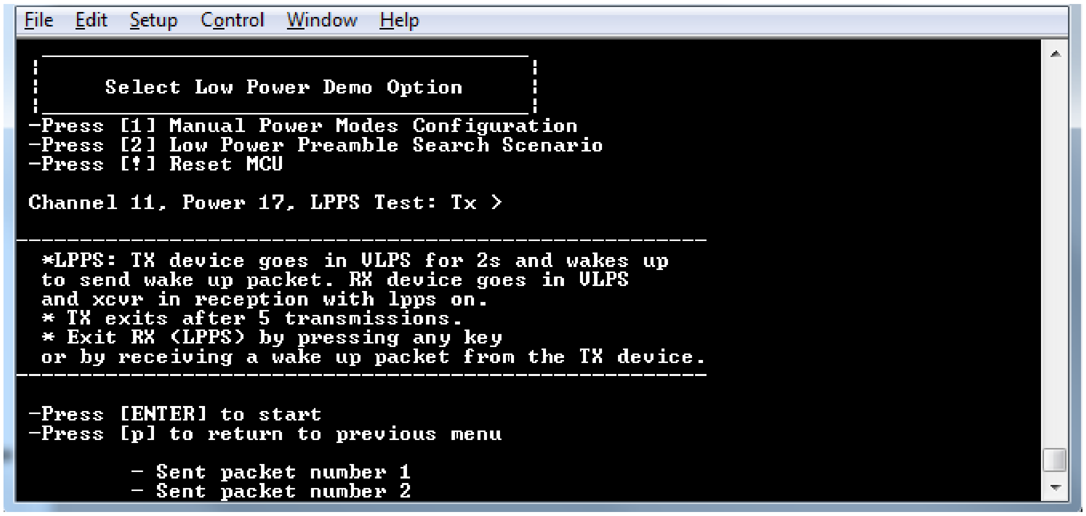
5.3.2 Low Power Preamble Search (LPPS) Scenario

Prior to entering this menu option the user has to select the role of the platform. To do this, in the main menu the ‘r’ and ‘t’ keys are used to switch between TX device and RX device. If TX is active and the LPPS Scenario is selected, the platform will behave as a TX device with the functionality described in the introduction. If the RX option is active the platform will behave as an RX device (as mentioned earlier, this means that the device will enter Very Low Power Stop with the transceiver in reception and LPPS feature activated, waiting for a “wake up message”, or a key stroke).



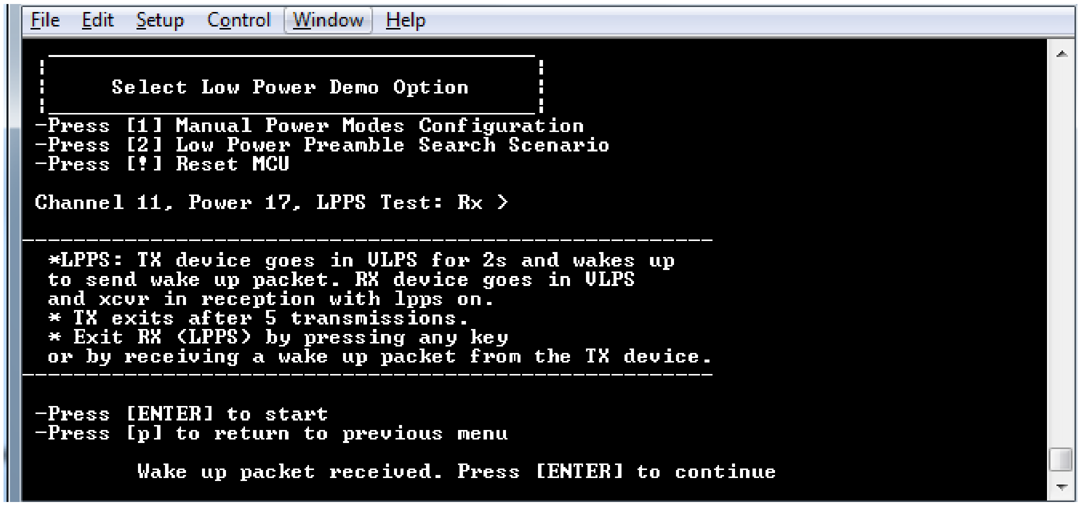
```
-Press [t] for TX Mode
Use these keys in the main menu before running any scenario
 ______________________________________
|                                      |
|      Select Low Power Demo Option    |
|______________________________________|
-Press [1] Manual Power Modes Configuration
-Press [2] Low Power Preamble Search Scenario
-Press [!] Reset MCU

Channel 11, Power 17, LPPS Test: Tx >

------------------------------------------------------
  *LPPS: TX device goes in VLPS for 2s and wakes up
  to send wake up packet. RX device goes in VLPS
  and xcvr in reception with lpps on.
  * TX exits after 5 transmissions.
  * Exit RX (LPPS) by pressing any key
  or by receiving a wake up packet from the TX device.
------------------------------------------------------

-Press [ENTER] to start
-Press [p] to return to previous menu
```

Figure 5-6. LPPS menu



```
 ---------------------------------------
|                                       |
|     Select Low Power Demo Option      |
|_______________________________________|
-Press [1] Manual Power Modes Configuration
-Press [2] Low Power Preamble Search Scenario
-Press [!] Reset MCU

Channel 11, Power 17, LPPS Test: Tx >

-------------------------------------------------------
 *LPPS: TX device goes in VLPS for 2s and wakes up
 to send wake up packet. RX device goes in VLPS
 and xcvr in reception with lpps on.
 * TX exits after 5 transmissions.
 * Exit RX (LPPS) by pressing any key
 or by receiving a wake up packet from the TX device.
-------------------------------------------------------

-Press [ENTER] to start
-Press [p] to return to previous menu

        - Sent packet number 1
        - Sent packet number 2
```

Figure 5-7. LPPS TX role start



```
 ---------------------------------------
|                                       |
|     Select Low Power Demo Option      |
|_______________________________________|
-Press [1] Manual Power Modes Configuration
-Press [2] Low Power Preamble Search Scenario
-Press [!] Reset MCU

Channel 11, Power 17, LPPS Test: Rx >

-------------------------------------------------------
 *LPPS: TX device goes in VLPS for 2s and wakes up
 to send wake up packet. RX device goes in VLPS
 and xcvr in reception with lpps on.
 * TX exits after 5 transmissions.
 * Exit RX (LPPS) by pressing any key
 or by receiving a wake up packet from the TX device.
-------------------------------------------------------

-Press [ENTER] to start
-Press [p] to return to previous menu

        Wake up packet received. Press [ENTER] to continue
```

Figure 5-8. LPPS RX receiving wake up packet