AN632

WDS USER'S GUIDE FOR EZRADIOPRO® DEVICES

1. Introduction

Wireless Development Suite (WDS) is a software utility used to configure and test the Silicon Labs line of ISM band RFICs. This document describes only the EZRadioPRO product-family-specific details of the WDS. It is recommended that the user read "AN796: Wireless Development Suite General Description".

This document is valid for the following EZRadioPRO ICs:

- Si4060/4063 transmitter
- Si4460/4461/4463/4438/4467/4468 transceiver
- Si4362 receiver

2. EZRadioPRO Device Applications

2.1. Radio Configuration Application

The Radio Configuration Application is the most common way to control the radio. All configuration options are represented on the graphical user interface. The radio performances can be verified or an example source code could be generated by following three basic steps:

1. Select the Example Project that best fits the expected application or laboratory measurement.
2. Configure the desired radio parameters, packet related settings and setup the desired interrupts and GPIO functionalities.
3. The Project can be deployed by several ways, depending on the desired test.

These steps are well separated within the Radio Configuration Application as shown in Figure 1, and it is highly recommended that they are utilized in this order:

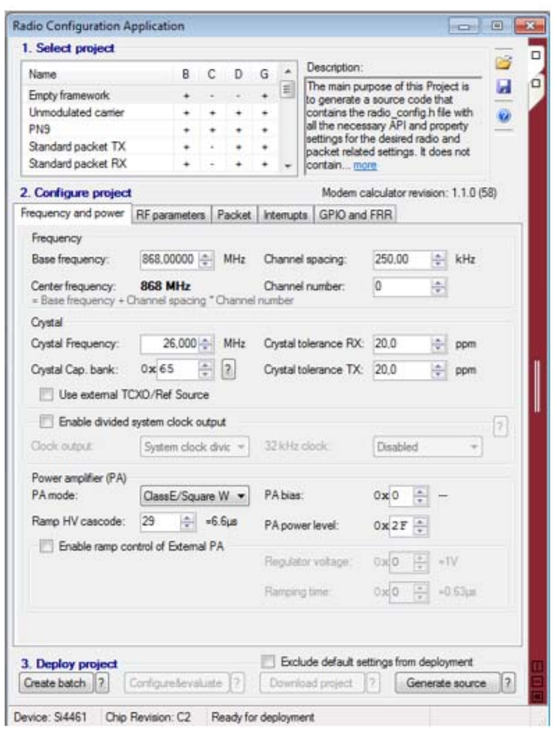

Figure 1. Radio Configuration Application

The general workflow of the Radio Configuration Application is shown in Figure 2.

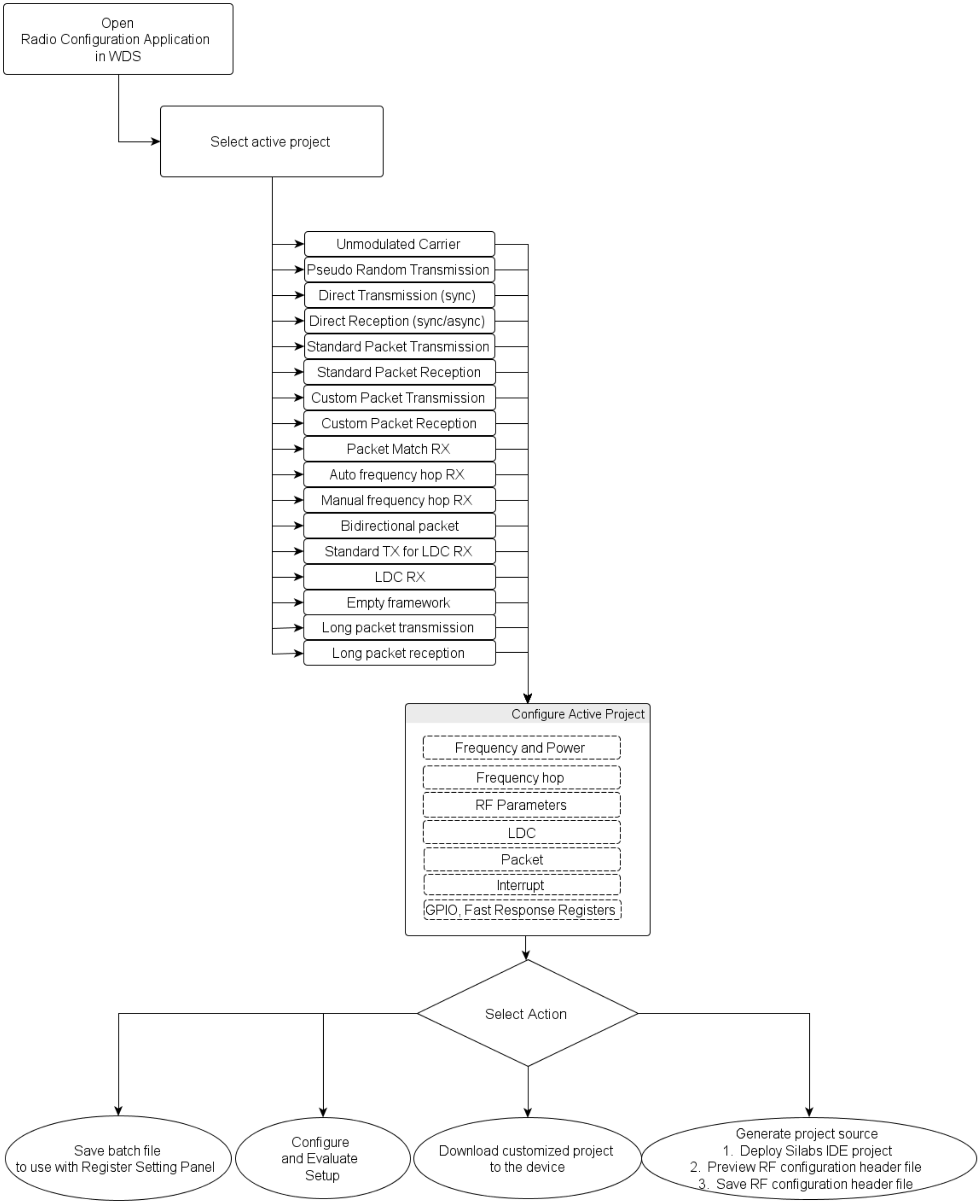

Figure 2. WDS Workflow

2.1.1. Select Example Project

The basic functions of the radio are represented as Projects. Each Project has a well-defined behavior (e.g., placing the radio into continuous transmission mode for TX related measurements) or purpose (e.g., generating an empty framework with the desired radio configuration for FW development). The list of the available projects is summarized by their behavior and purpose in the following table:

Table 1. Project Behavior and Purpose

Name	Behavior	Purpose (Deployment Options)			
		Save Batch	Config & Evaluate	Download Project	Generate Source
Empty Framework	The main purpose of this Project is to generate a source code that contains the radio_config.h file with all the necessary API and property settings for the desired radio and packet related settings. It does not contain any application code, so it is a good starting framework for FW developers.	–	–	–	+
Unmodulated Carrier	This project configures the radio with the selected radio parameters and sets the radio onto continuous transmit mode. Using this Project, most of the transmit related radio performances can be verified with lab equipment (e.g., output power, frequency accuracy, etc.).	+	+	+	+
PN9 Random Modulated TX	This project configures the radio with the selected radio parameters and sets the radio onto continuous PN9 random modulated transmit mode. Using this Project, the modulated transmit related radio performances can be verified with lab equipment (e.g., occupied bandwidth, output power, etc.)	+	+	+	+
Direct TX	This project configures the radio with the selected radio parameters and sets the radio onto continuous modulated transmit mode. The modulation source is one of the selected GPIO, the user needs to feed the data through this pin. The radio can provide data clock for sampling purposes that is available on another selected GPIO.	+	+	+	+
Direct RX	This Project configures the radio with the selected radio parameters and sets the radio onto continuous receive mode. The received data is provided on a selected GPIO. Addition to the received data the data clock can be selected to another GPIO too. This Project is typically used to evaluate the receive performances (e.g., sensitivity, blocking, etc.) of the radio by measuring bit error rate with lab equipment.	+	+	+	+

Table 1. Project Behavior and Purpose (Continued)

Name	Behavior	Purpose (Deployment Options)			
		Save Batch	Config & Evaluate	Download Project	Generate Source
Standard Packet TX	This Project configures the radio with the selected radio parameters and waits for a user interaction. If the Project is loaded to the development board, then the push buttons trigger the packet transmission. The corresponding LED blinks showing the packet transmission. **Note:** The Project sends a special packet that can be received with a development board loaded with the "Standard Packet RX" project. It doesn't provide the flexibility to change the packet configuration.	+	–	+	+
Standard Packet RX	This Project configures the radio with the selected radio parameters, sets the radio onto receive mode and waits for packets (LED1 is turned on while the board is in receive mode). If the Project is loaded to the development board, then the host MCU processes the received packets and blinks the LEDs accordingly: a) if a valid packet is received, then LED2-4 shows the number of push buttons pressed on the transmit side for a short period of time (the number is encoded in BCD format). b) if the received packet cannot be interpreted, then all the LEDs blink. **Note:** The Project can interpret packets sent by the "Standard Packet TX" Project. This Project can be used to test the interoperability of the EZRadioPRO devices with other EZRadio devices, such as Si4010. It does not provide the flexibility to customize the packet configuration. This Project can be also used to test the interoperability of the EZRadioPRO devices and development kit with other EZRadio devices. The Project is capable of receiving packets from the Si4010 key fobs or from the Si4x55 development boards. Be sure that the RF configuration of the EZRadioPRO device matches the settings of the EZRadio example Project or the Si4010 key fob.	+	–	+	+

Table 1. Project Behavior and Purpose (Continued)

Name	Behavior	Purpose (Deployment Options)			
		Save Batch	Config & Evaluate	Download Project	Generate Source
Custom Packet TX	These Projects work similarly to the Standard TX or RX with the exception that the packet configuration can be customized as well. The Custom Packet RX example Project is a good starting point to understand/configure and use the FIELDs feature of the radio. This example Project also supports receiving packet with variable length. It is the user's responsibility to set the same packet configuration for both projects, otherwise they cannot work together. The LEDs help to identify the different packet receive states of the receiver. LED1 is turned on while in receive mode. Upon packet reception: - LED2 turns on if the Synch Word of the received packet matches the settings. - LED3 turns on if the CRC of the received packet is valid. - LED4 turns on if the payload content of the received packet is the same as the expected packet content specified in WDS. Make sure to set the same packet content for both the transmit or the receive side, otherwise the Custom Packet RX Project will not be able to validate the payload content.	+	+	+	+
Custom Packet RX		+	+	+	+
Bidirectional Communication	This Project configures the radio with the selected radio parameters, sets the radio into receive mode and waits for packets or user interaction. Both nodes (development boards) must be deployed with the same project. In case the project is loaded to the board, then the user needs to press any of the push button on a development board to send a packet. The receiver board will blink the LED upon packet reception and transmits back an acknowledgment. If the acknowledgment packet is received correctly, then the originator will blink the LED as well. The Project is a good example for FW developers of how a bidirectional communication needs to be realized with the EZRadioPRO devices. It also provides an example of how the radio needs to be configured for variable packet length, since the Project transmits packets with different lengths upon the pressing of different buttons. This project is a simple demonstration how a bidirectional communication needs to be built up and it can be used for basic range testing as well.	–	–	+	+

Table 1. Project Behavior and Purpose (Continued)

Name	Behavior	Purpose (Deployment Options)			
		Save Batch	Config & Evaluate	Download Project	Generate Source
Standard packet RX with Match	This Project configures the radio with the selected radio parameters, sets the radio onto receive mode and waits for packets (LED1 is turned on while the board is in receive mode). The Project utilizes the fully configurable matching functionality on up to 4 data bytes of the Payload of the packet. The match function is typically used to implement header check or address filtering. It can quickly and efficiently determine if a packet is intended for one receiver node in a network. If a match is not found, the radio aborts reception of the packet and looks for the following packet. If the radio receives a packet that passes the match condition, then the host MCU processes the packet and blinks LED2.	+	–	+	+
Standard packet RX with automatic HOP	This Project configures the radio with the selected radio parameters, sets the radio onto receive mode and waits for packets (LED1 is turned on while the board is in receive mode). The project utilizes the automatic frequency hop function of the radio. It enables to scan up to 64 channels automatically (the order and the frequency of the channels are configurable). The hop condition can be RSSI and/or preamble detection timeout (please refer to the AN633 Programming guide for more details). If the Project is loaded to the development board, then the radio goes onto receive mode and scans the channels automatically. The host MCU turns on LED1 to show Receive mode. If a valid preamble is detected or the RSSI condition is fulfilled the radio remains on the actual channel and tries to receive the entire packet. Upon successful packet reception the host MCU processes the payload and shows the channel number on the onboard LCD. If the packet couldn't be received within timeout, then the radio starts to scan the channels automatically.	+	–	+	+

Table 1. Project Behavior and Purpose (Continued)

Name	Behavior	Purpose (Deployment Options)			
		Save Batch	Config & Evaluate	Download Project	Generate Source
Standard packet RX with manual HOP	This project configures the radio with the selected radio parameters and sets the manual frequency hopping capability. For more details, see the RX_HOP command in API documentation. In this mode, the radio is in receive mode, and firmware code issues a frequency hop upon a packet received timeout (LED1 is turned on while the board is in receive mode). The Project uses the LCD to display the channel number where the packet was received. Use this project along with Standard Packet TX as a transmit side. If the packet cannot be received within the timeout, then the host MCU forces the radio to hop to the next channel manually. The RX_HOP API command provides the fastest method for hopping from one channel to another channel, but it requires more management by the host MCU. The turnaround time can be decreased to 75 µs because the host MCU has to provide the precalculated synthesizer arguments for the radio. If the standard packet is received successfully on one of the channels, the buzzer will be activated, and the channel number will be displayed on the LCD screen. Save batch (–), Config & Evaluate (–), Download Project (+), Generate Source (+).				
Low Duty Cycle RX mode	This Project configures the radio with the selected radio parameters, sets the radio into Low Duty Cycle (LDC) receive mode, and waits for packets. In the LDC mode, the radio sleeps a certain amount of time (Sleep time), then wakes up and listens for the packet (RX time). This reduces power consumption. The radio chip is continuously switching between the RX and SLEEP states. The receiver periodically wakes itself up to work in the RX state. If a valid preamble is not detected or an entire packet is not received, the receiver returns to the SLEEP state and remains in that mode until the beginning of the next RX state. If a valid preamble or sync word is successfully detected, the receiver prolongs the RX state to get the entire packet. LED1 is turned on while the board is in receiver mode. If the standard packet is received successfully, the buzzer will be activated. Save batch (–), Config & Evaluate (–), Download Project (+), Generate Source (+).				

Table 1. Project Behavior and Purpose (Continued)

Name	Behavior	Purpose (Deployment Options)			
		Save Batch	Config & Evaluate	Download Project	Generate Source
Standard TX for LDC RX	This project represents the TX side of the Low Duty Cycle RX mode project. It can send a custom number of packets in order to satisfy the needs of the receiver side, i.e., to determine the minimum number of packets to be transmitted so that the receiver working in low duty cycle mode can certainly receive the packet. Pressing the button triggers the radio to send the same packet sequentially in a limited number. LED1 is turned on continuously during the transmission. Save batch (–), Config & Evaluate (–), Download Project (+), Generate Source (+).				
Long packet transmission and reception	These Projects work similarly to the Standard TX or RX with the exception that the packet configuration can be customized as well. The Custom Packet RX example Project is a good starting point to understand/configure and use the FIELDs feature of the radio. This example Project also supports sending and receiving packet longer than the TX FIFO and the RX FIFO. It is the user's responsibility to set the same packet configuration for both projects; otherwise, they cannot work together. The LEDs help to identify the different packet receive states of the receiver. LED1 is turned on while in receive mode. Upon packet reception: ■ LED2 turns on if the Synch Word of the received packet matches the settings. ■ LED3 turns on if the CRC of the received packet is valid. ■ LED4 turns on if the payload content of the received packet is the same as the expected packet content specified in WDS. Make sure to set the same packet content for both the transmit or the receive side; otherwise, the Custom Packet RX Project will not be able to validate the payload content. Save batch (–), Config & Evaluate (–), Download Project (+), Generate Source (+).				

Table 1. Project Behavior and Purpose (Continued)

Name	Behavior	Purpose (Deployment Options)			
		Save Batch	Config & Evaluate	Download Project	Generate Source
Range Test Application	The Range Test Application is a standalone tool that is used to verify the link performances between two nodes by performing range test. The demo has several built in, predefined radio settings for all the major frequency bands. Those can be used to compare the expected range for different data rate settings. The Application can be configured through the onscreen menu system of the board and does not require a PC connection. Refer to the “AN655: Range Test Application for the EZRadio-PRO Devices” application note for more details on this project.	–	–	+	–
Triggered PER Measurement	This project controls a laboratory PER (packet error rate) measurement where the PER values of a specific radio configuration can be observed. The measurement triggers a connected RF signal generator to transmit the specific number of packets with configured trigger interval, counts the well-received packets together with detected preamble and sync word information, and calculates the actual PER value.	–	+	–	–

2.1.2. Summary

Since several example projects based on packet-related communication are introduced in the Wireless Development Suite, it is essential to know which projects can communicate with each other in order to create a working one way-link. They are customizable in RF perspective, such as modulation type, data rate, deviation, etc. The payload is also customizable due to five configurable fields provided by the packet handler. Table 2 provides information about the projects' behaviors and purposes.

Table 2. Project Behaviors and Purposes

	Projects' Cooperative Activity					
	Standard Packet TX	**Standard Packet RX**	**Custom Packet TX**	**Custom Packet RX**	**Packet Match RX**	**Frequency Hop RX**
Standard Packet TX	N/A	✓	X	✓	✓	✓
Standard Packet RX	✓	N/A	✓	X	X	X
Custom Packet TX	X	✓	N/A	✓	✓	✓
Custom Packet RX	✓	X	✓	N/A	X	X
Packet Match RX	✓	X	✓	X	N/A	X
Frequency Hop RX	✓	X	✓	X	X	N/A

Table 3. Project Cooperative Activity

	Projects' Cooperative Activity					
	Standard Packet TX	**Manual Hop RX**	**LDC TX**	**LDC RX**	**Long TX**	**Long RX**
Standard Packet TX	N/A	✓	X	X	X	X
Manual Hop RX	✓	N/A	X	X	X	X
LDC TX	X	X	N/A	✓	X	X
LDC RX	X	X	✓	N/A	X	X
Long TX	X	X	X	X	X	✓
Long RX	X	X	X	X	✓	X

2.1.3. Configure the Radio

The middle section of the Radio Configuration Application is used to configure the desired radio and packet related settings. Since there are several configuration options, they are grouped within different tabs. Each tab is described in the following section.

Note: The actual view of the configuration tabs and the available configuration options are depending on the selected Project, the selected radio and/or selected configuration options! The following section shows an example of the Custom Packet RX project using 4GFSK modulation.

2.1.3.1. Frequency and Power Tab

The basic frequency, crystal, and power amplifier related settings can be obtained on the “Frequency and power” tab. The center frequency is configurable within the band supported by the development board or in any of the supported bands of the radio in simulation mode. The radio also supports setting up the frequency as a channel number, which enables the user to quickly change frequency with a single API command for fast frequency hopping. The channel spacing and the actual channel number can be defined here.

Note: Channel 0 refers to the center frequency.

It is important to accurately define the crystal frequency and accuracy for both side of the link, since the receive configuration (modem parameters, receive bandwidth, etc.) will be calculated by WDS based on these. If an external clock source is used (such as TCXO or other digital clock source), then the “Use external crystal” setting must be enabled.

After selecting the desired power amplifier mode, there is an option to fine tune the output power of the transmit ramp (this defines the behavior of the TXRamp pin of the radio) or the power amplifier settings for optimal current consumption. Refer to the “AN627: Si4460/61 Low-Power PA Matching or AN648: Si4463/64 TX Matching” or “AN732: Si4438 TX Matching” application notes for more details about the recommended power amplifier settings.

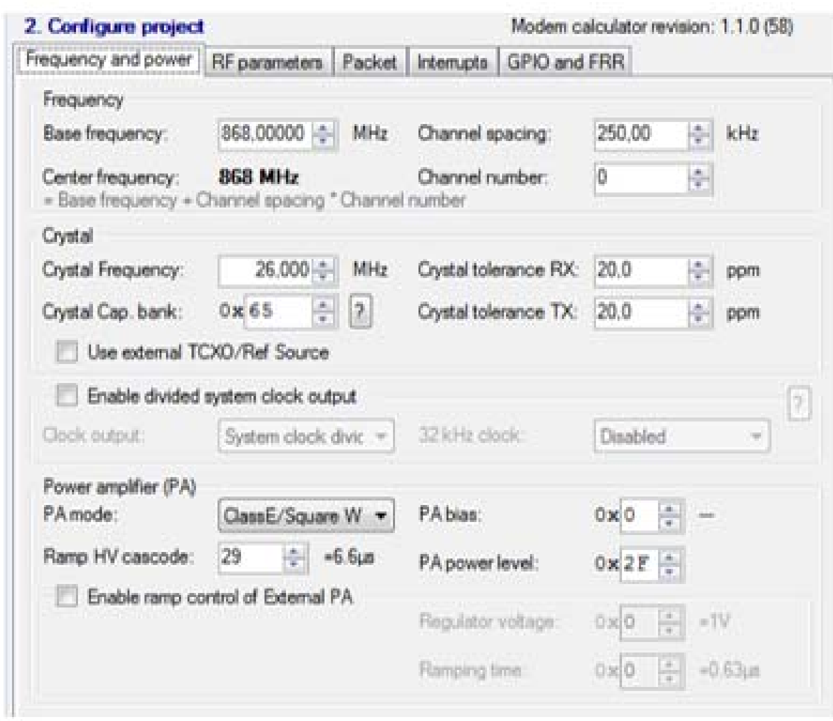

Figure 3. Frequency and Power Tab

2.1.3.2. RF Parameters Tab

The desired modulation mode, data rate, and specific RF settings can be set on the “RF parameters” tab. The user can define the modulation mode, the data rate, the deviation or the OOK bandwidth settings in the first column. Besides those settings it is important to define the preamble patter of the data packet for optimal receive configurations.

High and low performance mode refers to the receive operation of the EZRadioPRO devices (it may not be available for all devices). In low performance mode, both the receiver current consumption and the sensitivity is lower compared to high-performance mode. It provides a possibility for the user to optimize the parameters for optimal range or battery life time.

If bit error rate is measured on PN9 random data or a preamble and/or synchron word less data stream must be received, then the “Enable BER mode” must be set.

Note: In case of legacy protocols it may requires further optimization to achieve stable data reception.

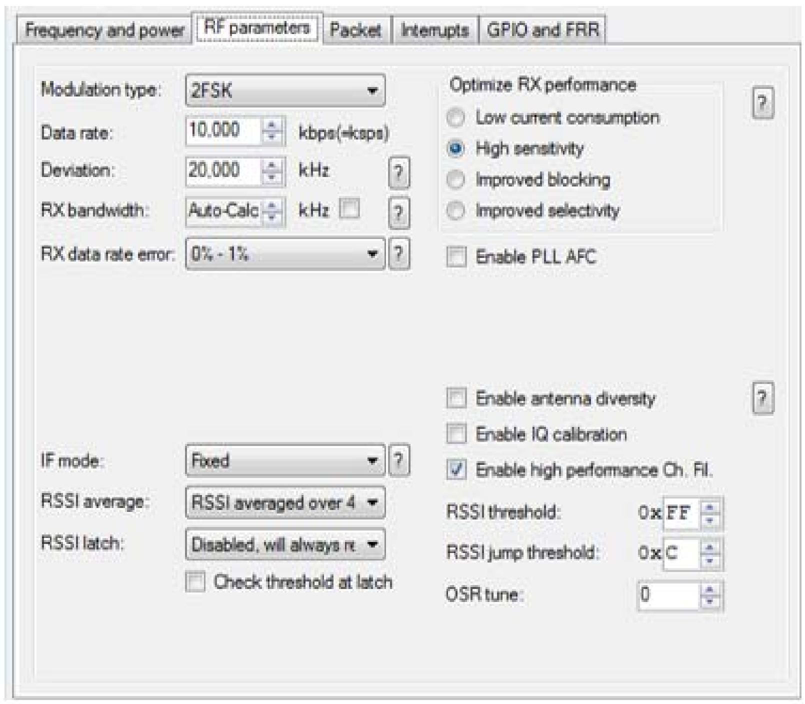

Figure 4. RF Parameters Tab

2.1.3.3. Packet Tab

In packet mode the data is transmitted from the FIFO in transmit mode and the received bytes are stored in the receive FIFO. If 4GFSK modulation is selected or further processing is required in the data bytes stored in the FIFO (e.g., Manchester coding, data whitening, CRC calculation, etc.), then the packet handler block of the radio processes the data before packet transmission or after packet reception. The packet handler is a complex block and it has several configuration properties that may be confusing for non-experienced users. To simplify the configuration, WDS provides the option to set up the desired packet configuration in a graphical representation on the “Packet” tab.

The actual packet configuration is shown in the middle of the tab. By clicking on the different fields, such as Preamble, SynchWord, and Fields, the appropriate configuration tab is selected automatically above the packet. This allows the user to configure those fields separately, one-by-one.

On the bottom of the tab all data processing options are shown in different colors. These can be enabled or disabled for each of the fields separately. In the case of the CRC it can be also set when the CRC calculation must be reset or when the actual CRC needs to be transmitted/expected in receive mode. The selected data processing options for the given field appears just below the packet configuration as lines with the same color as the data processing option. This helps the user to easily verify that the different fields are configured correctly.

The Payload of the packet can be represented by Fields. Field has a given data processing option. If the data processing is the same for the entire payload, it may be enough to represent the payload as one Field. However, the following situations should be considered:

- If variable payload length is used, then two Fields must be used. The first field is set to a fixed length, and its last bytes hold the variable length of the second Field.
- If the data processing varies during the payload, then more Field needs to be defined for different data processing as desired within the payload. **Note**: The number of Fields is limited to 5.
- If CRC varies within the payload or the CRC needs to be sent several times after different blocks of the payload, then each block must be represented as a Field, and the desired CRC functionality needs to be set for each of them separately.

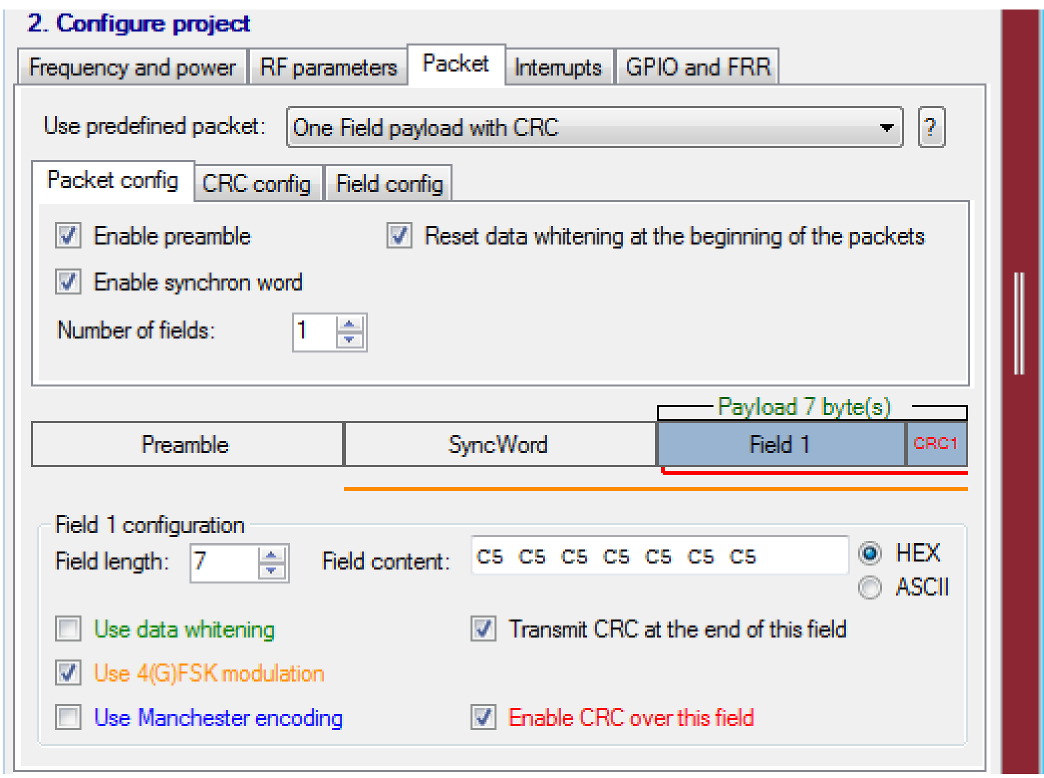

Figure 5. Packet Configuration

In addition to the graphical representation and easy configuration of the payload, a couple of typical packet configurations templates are available as is or for further customization.

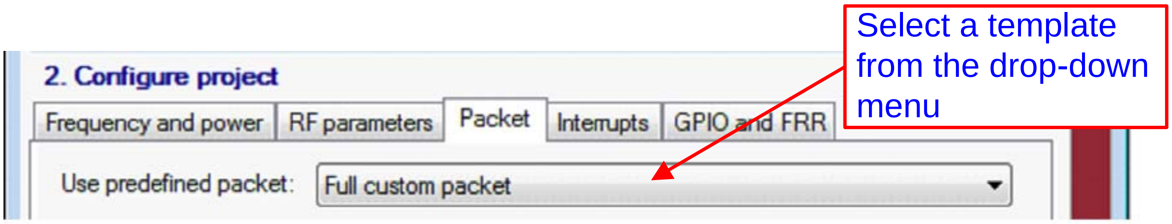

Figure 6. Packet Configuration Templates

2.1.3.4. Interrupt Tab

On the “Interrupts”, the desired interrupt option can be set.

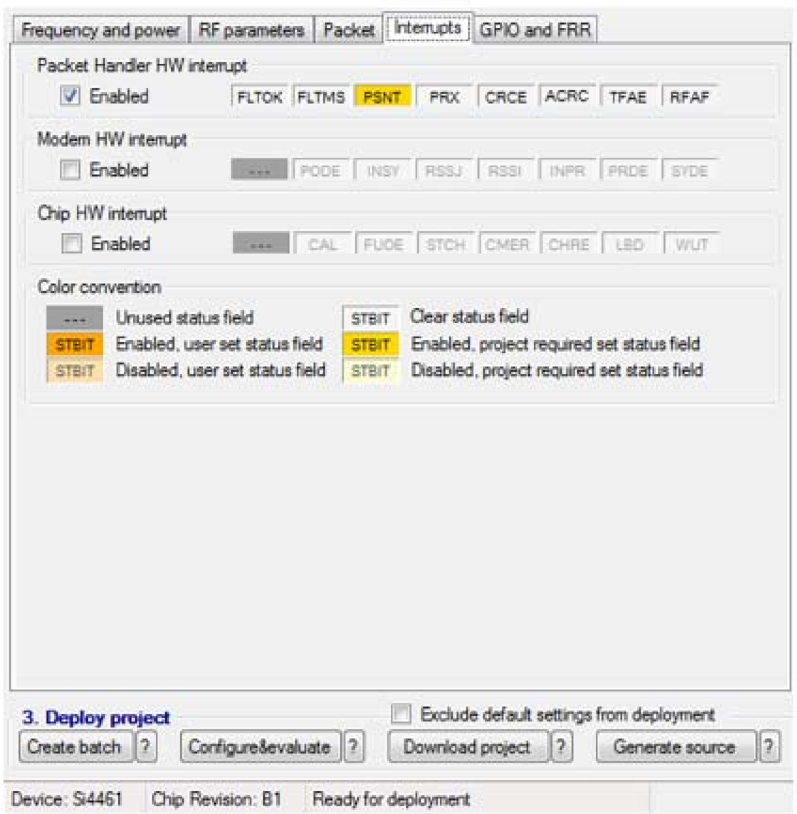

Figure 7. Set Interrupts

Note: Refer to the API description documents for more information on the available interrupt options and configuration.

2.1.3.5. GPIO and FRR Tab

On the “GPIO and FRR” tab, the desired functionalities can be assigned for the general purpose IOs and for the fast response registers.

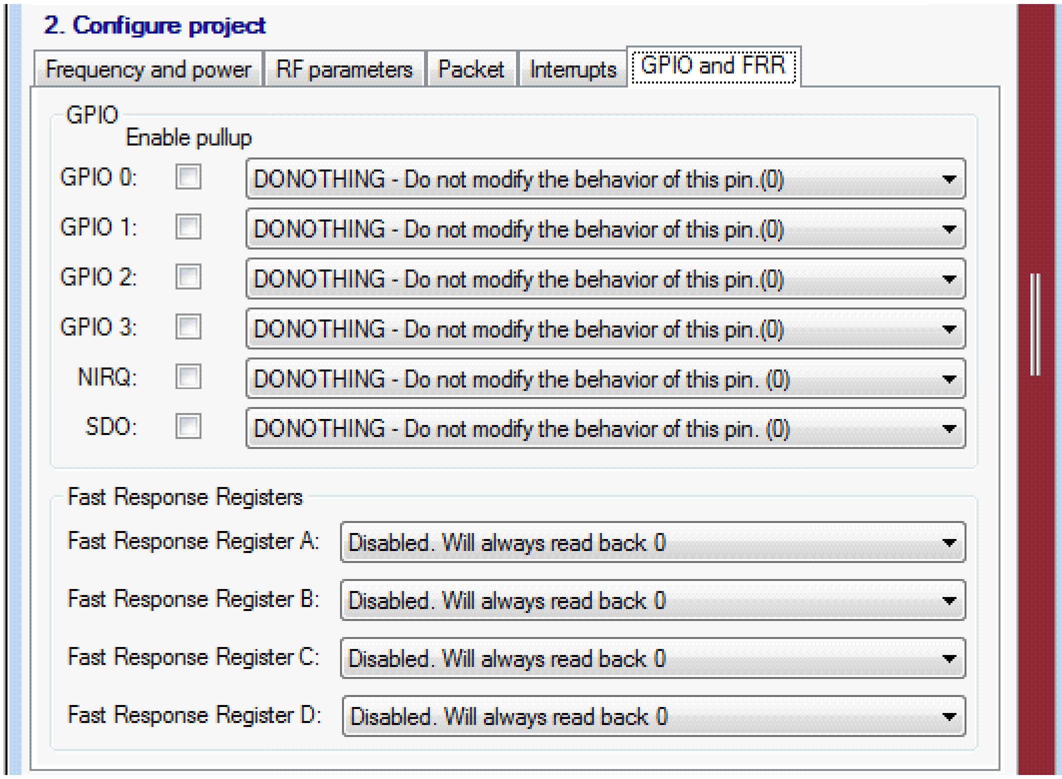

Figure 8. Assign GPIO and Fast Response Register Operation

2.1.3.6. LDC Tab

On the “LDC” tab, the desired time intervals can be adjusted for the “SLEEP time” and the “RX time” in the LDC RX project. The receiver periodically wakes itself up to work on receive mode. If a valid preamble is not detected within the “RX time” interval, the receiver returns to sleep and remains in that state until the beginning of the next “RX time” starts. If a valid preamble or sync word is detected, the receiver prolongs the “RX time” automatically to receive the entire packet.

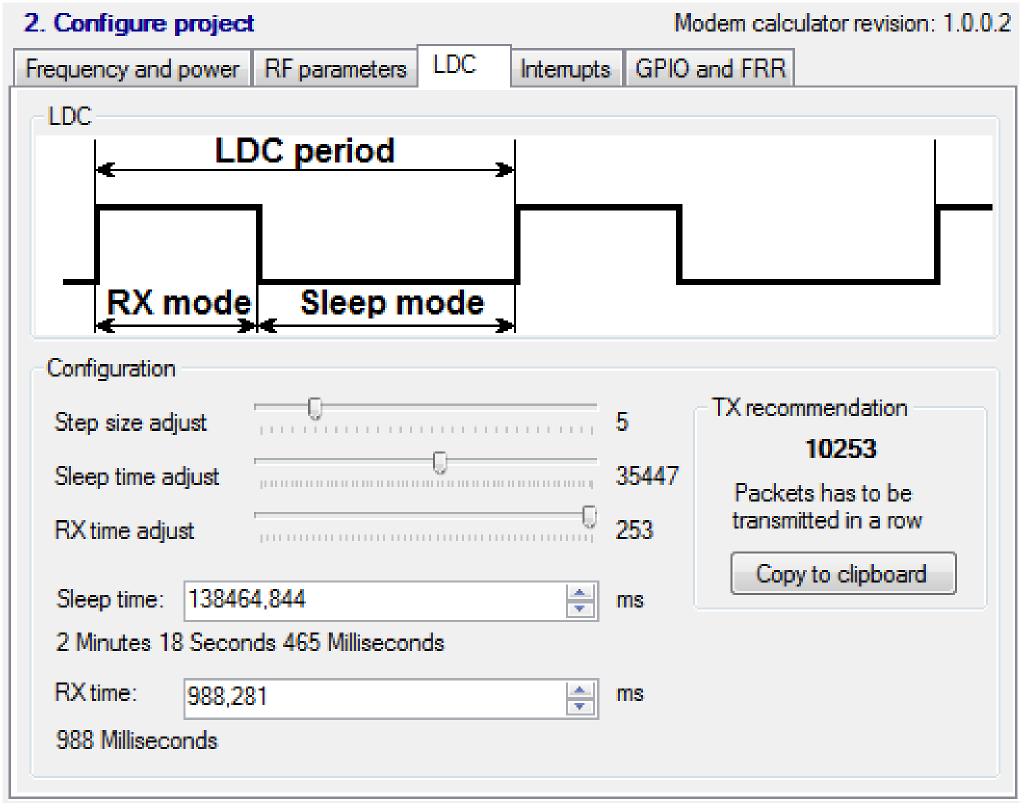

Figure 9. LDC RX Tab

With the “RX Time” and “Sleep Time”, the WDS can calculate the minimum recommended number of packets to be transmitted in a row for the transmit side. Its value can be pasted to the “Standard TX for LDC RX” project.

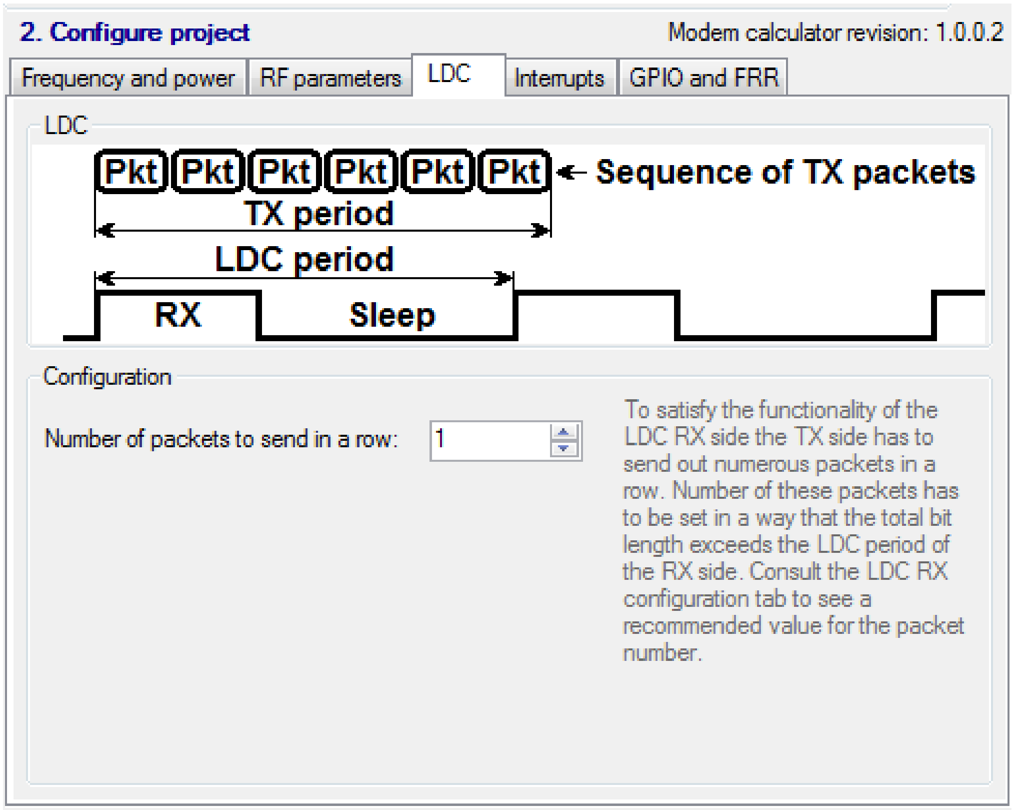

Figure 10. LDC TX Tab

2.1.3.7. Frequency Tab

This tab is presented in two frequency hopping projects. In the manual frequency hop RX project, the host MCU manages the radio to hop from one channel to another by the RX_HOP API command. This command configures the synthesizer of the radio directly. This results in the turnaround time being decreased to 75 µs. The pre-calculated synthesizer arguments (integer divider, fractionals) are the input parameters of the RX_HOP command. New frequency channels can be added to the hop list. The host MCU processes the element of the list and manually sets the radio to a new frequency channel.

Note: Refer to the API description documents for more information on the available GPIO and Fast Response Register options and configuration.

The EZRadioPRO devices are very flexible, resulting a high number of configuration options. In order to save time during development, WDS supports saving the actual status and settings of the Radio Configuration Application (including the selected Project and all settings on all the tabs), that can be reloaded anytime later on.

In case technical help is needed, it is also recommended to send the configuration file with the support questions, which will allow the application engineer to quickly identify the desired radio parameters and packet configuration. Please use the Save/Load icons on the top right corner of the Application as shown in Figure 11.

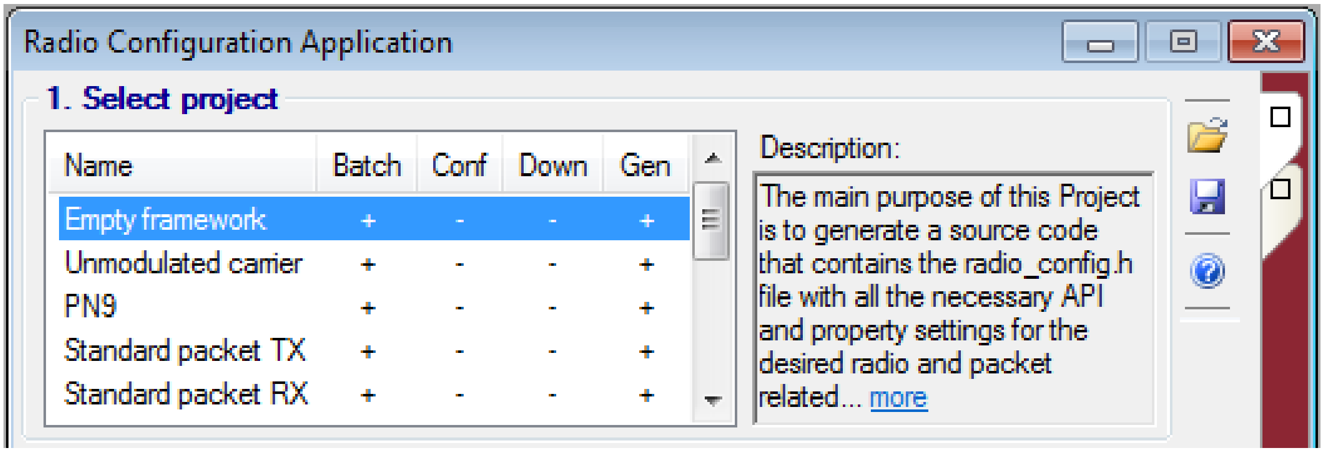

Figure 11. Radio Configuration Application

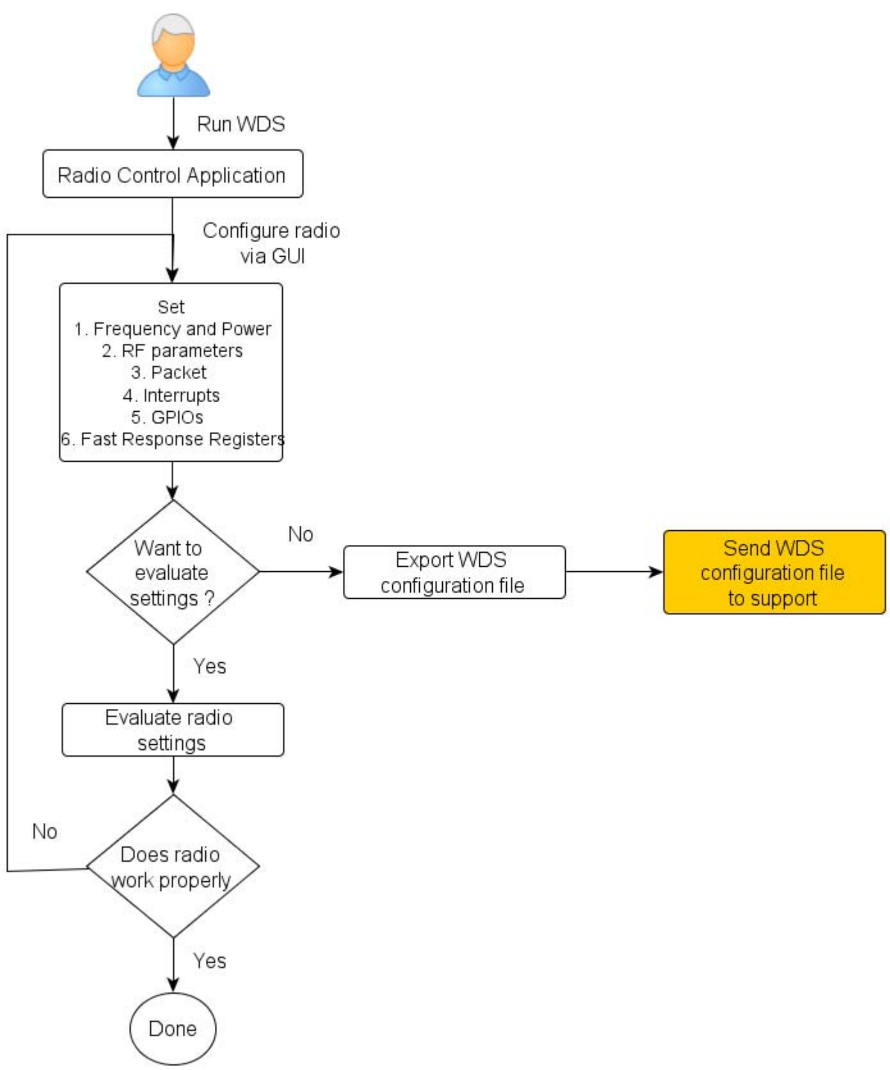

Figure 12. Support

2.1.4. Project Deployment

2.1.4.1. Save Batch

The necessary API commands and Property settings can be saved as a WDS Batch file (“Save batch”). These can be open, run, and edited in the Register Setting Panel (see"2.2. Register Setting Panel" on page 27 for more details). The Batch file is a simple text file (easy to edit) that contains all the necessary API commands and Property settings to configure the radio for the desired function. The Batch file can be used to initialize the radio, set to a desired power mode, or transmit/receive a packet. It is a powerful tool for RF engineers to optimize the radio performances in the lab and share the Batch files with the technical support team. However, conditional jump or loop instructions cannot be implemented in the Batch file; therefore, it cannot be used to read status information or implement complex procedures. WDS sends each API command toward to the radio one-by-one, therefore the Batch file is not recommended for testing time critical radio functions either.

2.1.4.2. Configure and Evaluate

The radio performances can be verified by selecting the “Configure & evaluate” option. In this case, WDS downloads a special FW into the connected development tool. The FW makes it possible to configure the radio from the PC GUI and provides access to status information of the connected device. Once the FW is loaded to the development board a new window appears that is used to show the actual status information of the radio and to control the laboratory measurement.

This is the easiest way to verify basic radio parameters and data sheet parameters (e.g., output power, bit error rate, etc.). However, in this mode WDS does not show what API commands are sent to the radio during configuration. For that purposes, it is recommended to deploy the project to a Batch file.

Note: After disconnecting the development board from the PC, the WDS test FW remains in the development board that is not functional without the GUI.

The following sections summarize the Projects that are available for “Configure & evaluate” deployment together with their options and purposes.

Unmodulated Carrier, PN9 and Direct TX

The most common RF measurement is to verify the output power and the harmonics/spurs of the radio in transmit mode. For this purpose, the “Unmodulated Carrier” lab measurement can be used.

In addition to the unmodulated parameters, it is important to verify the occupied bandwidth and shape of the transmitted, modulated signal. The “PN9” or “Direct TX” lab measurements are suitable for this purpose. Both tests behave the same (they set the radio into continuous modulated transmit mode), but the modulation source is different. The internal PN9 random generator is used to modulate the output power in “PN9” test mode. However, sometimes, the host MCU generates the modulation data. For such purposes, the “Direct TX” lab measurement is recommended, which expects the data on one of the GPIOs of the radio.

During these tests, the GUI allows the user to change a couple of basic parameters such as center frequency, output power, and crystal frequency tuning. It also possible to read back status information such as fast response register values, etc.

This is a practical test to fine-tune the center frequency. Due to the crystal tolerances and possible mismatch between the internal capacitance of the crystal circuit and the load capacitance of the crystal, the radio may work on a slightly different frequency than expected. The crystal frequency tuning property can be used to cancel the frequency error by simply fine tuning its value while monitoring the exact center frequency with a spectrum analyzer.

Direct RX

Direct RX mode can be used to verify the most common receive RF performance characteristics such as sensitivity, blocking, selectivity, etc. This test sets the radio into continuous receive mode and outputs the received data bits on one of the GPIOs of the radio. The recovered data clock is also provided on a different GPIO for synchronization purposes. Using an RF signal generator with bit error rate measurement options, most of the receiver parameters can be evaluated.

This lab measurement also allows reading status information and monitoring of the interrupt status registers. WDS also enables fine tuning of basic RF parameters such as center frequency, and crystal frequency.

Custom Packet TX

If the application transmits packets, the user should verify the transmit side of the link. The Custom Packet TX test can be used for this purpose. WDS allows the user to define the contents of the packet and initiate packet transmission with the Start TX button, which sends the packet once. If desired, packet content can be changed before sending the next packet.

This lab measurement allows the user to read information and monitor the interrupt status registers. WDS also enables fine tuning of basic RF parameters such as center frequency, output power, and crystal frequency.

Custom Packet RX

When using packet-based communication, it is useful to check whether the radio receives the expected packet configuration correctly or to check the sensitivity by measuring the packet error rate. The Custom Packet RX test is suitable for this since the radio can be placed into receive mode where it waits to receive a packet. Once a valid packet is received, the user can read the FIFO content by pressing the “Read” button. The radio then must be placed back to receive mode with the “Restart RX” button.

This lab measurement also allows the user to read back status information and monitor the interrupt status registers. WDS also enables fine tuning of basic RF parameters such as center frequency and crystal frequency.

Triggered PER

This project is useful to measure the sensitivity of the radio by using specific RF and packet configurations. The project configures and controls a laboratory PER (packet error rate) measurement where the PER values of a specific radio configuration can be observed. The measurement triggers a connected RF signal generator to transmit the specific number of predefined packets with configured timeout, counts the received packets, and calculates the actual PER value. Changing the output power of the generator gives the ability to measure the sensitivity of the radio at specific power levels.

The packet trigger input of the generator should be connected to the RX_STATE output signal of the radio available on a user-defined RF_GPIO (RF_GPIO0 by default) connector of the development board. The RF output of the generator should be connected to the antenna connector of the RF pico board mounted on the development board (see Figure 13). The packets sent by the signal generator must have the same packet structure and RF parameters which were configured on the Radio Configuration Application.

Notes:

1. The user can reconfigure the following signals to one of the RF_GPIO pins on the 'GPIO and FRR' tab of the RCA, if the predefined ones are used for other purposes:
   –RX_STATE: trigger signal to generator, predefined to RF_GPIO0
   –CTS: command ready acknowledge signal for firmware used for handshaking purposes. CTS can be read on a defined GPIO or via SPI. This signal is predefined to RF_GPIO1. Note that the CTS cannot be assigned to any GPIOs on the WMB912 platform; only SPI CTS check is available here.
2. It is required to use CRC check at the end of the packet to ensure the packet is received without any bit error. Otherwise, the received packet count and calculated PER values might be false.
3. The following fast response register configurations are required for the proper operation:
   –Fast Response Register A: Packet Handler status
   –Fast Response Register B: Modem status

After deploying the project, the “Packet trigger interval” and “Number of packets” can be set. The “Number of packets” can also be configured to infinite by selecting the “Infinite” check box.

Pressing the “Start” button starts the measurement. The generator will be continuously triggered with the configured trigger interval. The measurement can be stopped with the “Stop” button, and restarted with the “Start” button. The measurement runs as far as all the packets are triggered (ie. “Number of packets”).

The following parameters are displayed during measurement to provide information on the quality of the link:

- Measurement status
- Number of triggered packets
- Number of detected preambles
- Number of detected sync words
- Number of received packets
- Number of lost packets (calculated from the numbers of triggered and received packets)
- PER value (calculated from the numbers of triggered and received packets).

Note: When changing any of the radio or measurement parameters, the measurement must be restarted with the “Start” button.

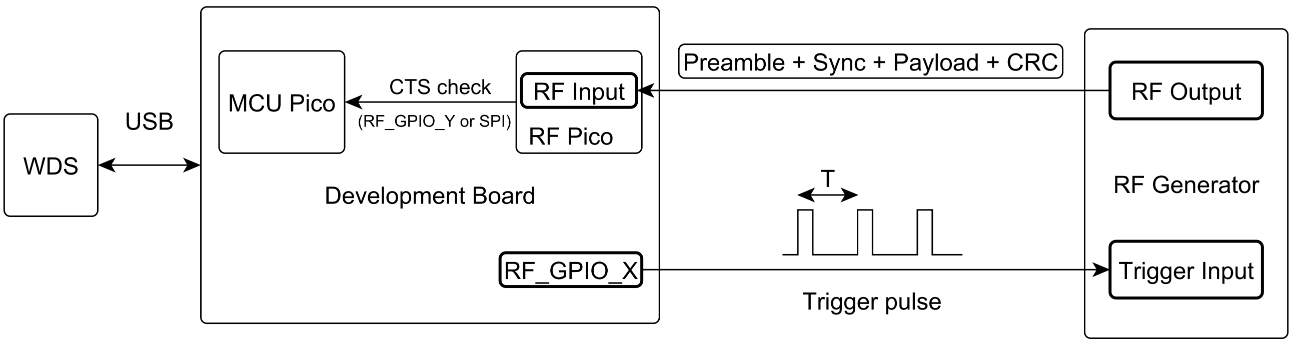

Figure 13. Configuration Setup

2.1.4.3. Download Project

Selecting the “Download project” option WDS customizes the radio and packet related configuration of the project and loads it onto the development board. Since the FW is loaded into the host MCU, the development board can run that anytime even without PC connection. This is a useful feature for verifying the range between two development boards (using a simple packet TX or packet RX project with customized RF parameters) or measuring radiated performances in an antenna chamber or at the test house.

The “Download project” feature does not require installing any other FW development tools to the PC (such as FW development environment or compilers); therefore, WDS can be easily used by anyone who is concentrating to the RF parameter verification. Once the optimization is finished, the entire source of the example Project code (with the customized radio parameters) can be deployed by selecting the “Generate source” code option.

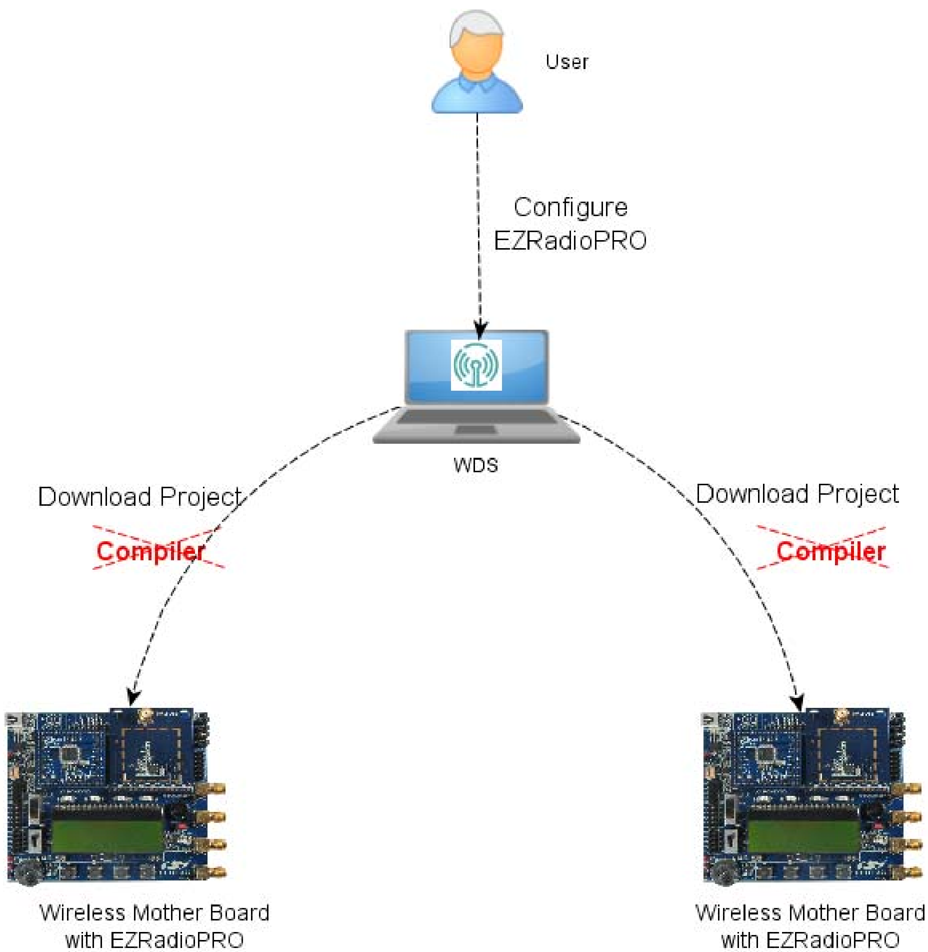

Figure 14. Project Download

2.1.4.4. Generate Source

The entire source code of the customized Example Project is accessible through the “Generate source” option. The source code can be opened in the Silicon Labs IDE. For that purpose, the Silicon Labs IDE must be installed on the PC beforehand. If a different IDE or compiler is used or the source code is intended to be used with a different MCU then it is advised to save the source code to the PC and use the make files in the project folder. The Example Projects are developed for the Silicon Labs C8051F930 MCU.

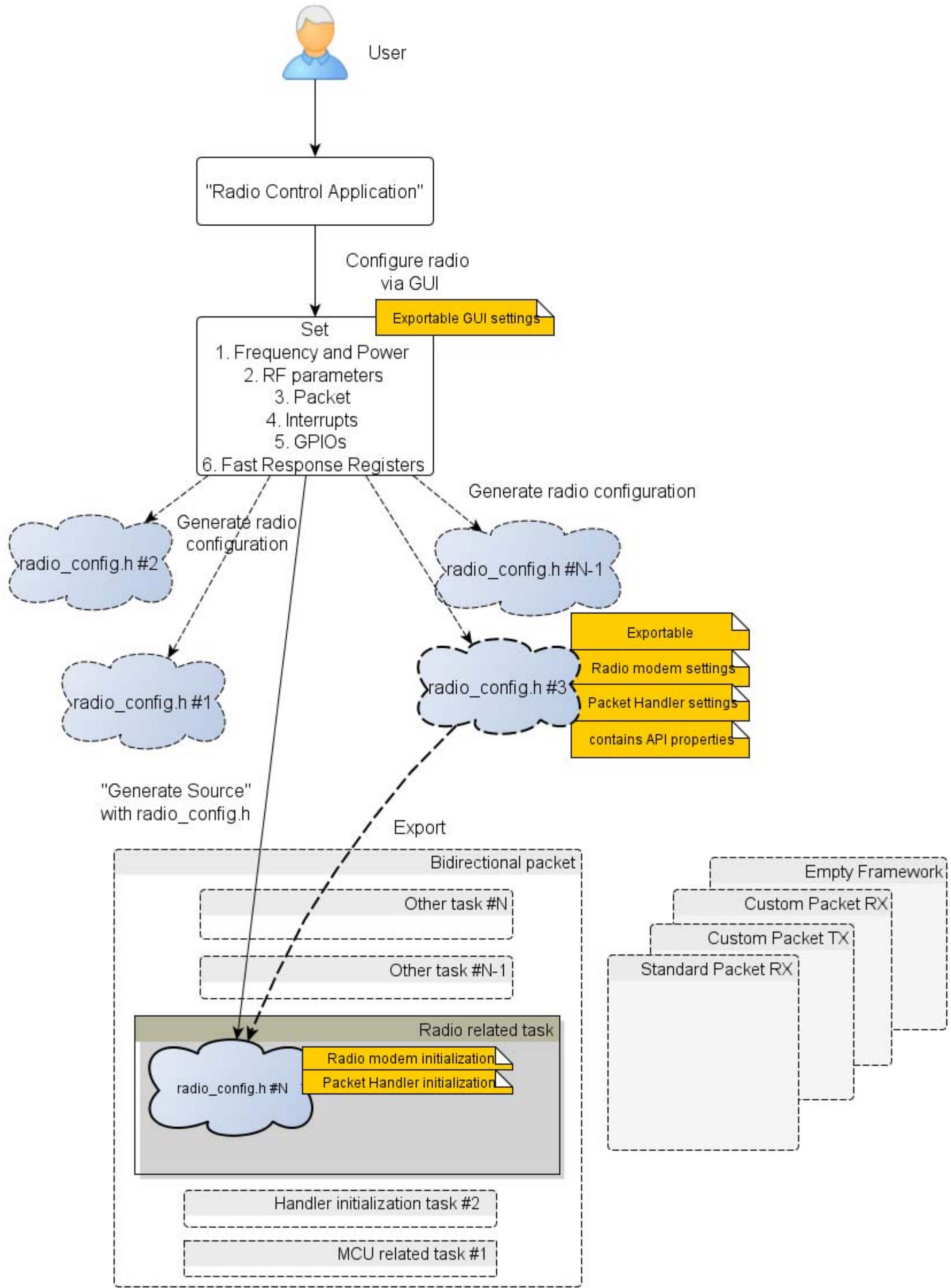

Figure 15. Radio Header File Role

Note: The silicon Labs IDE can be downloaded from the Silicon Labs WEB site: www.silabs.com.

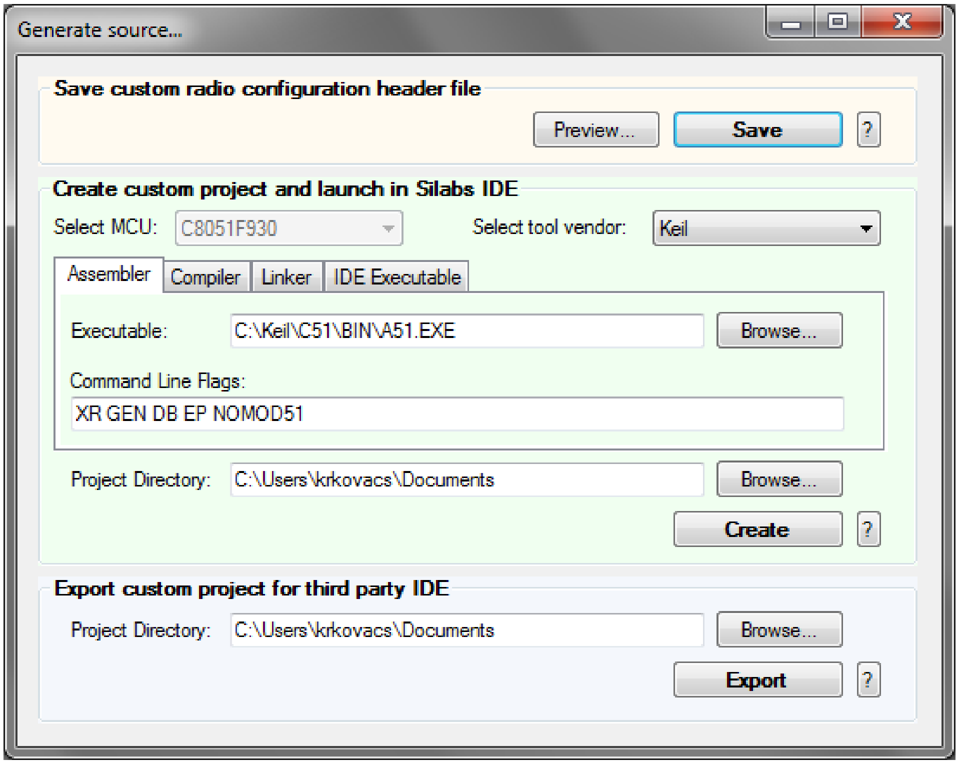

Figure 16. IDE Launcher

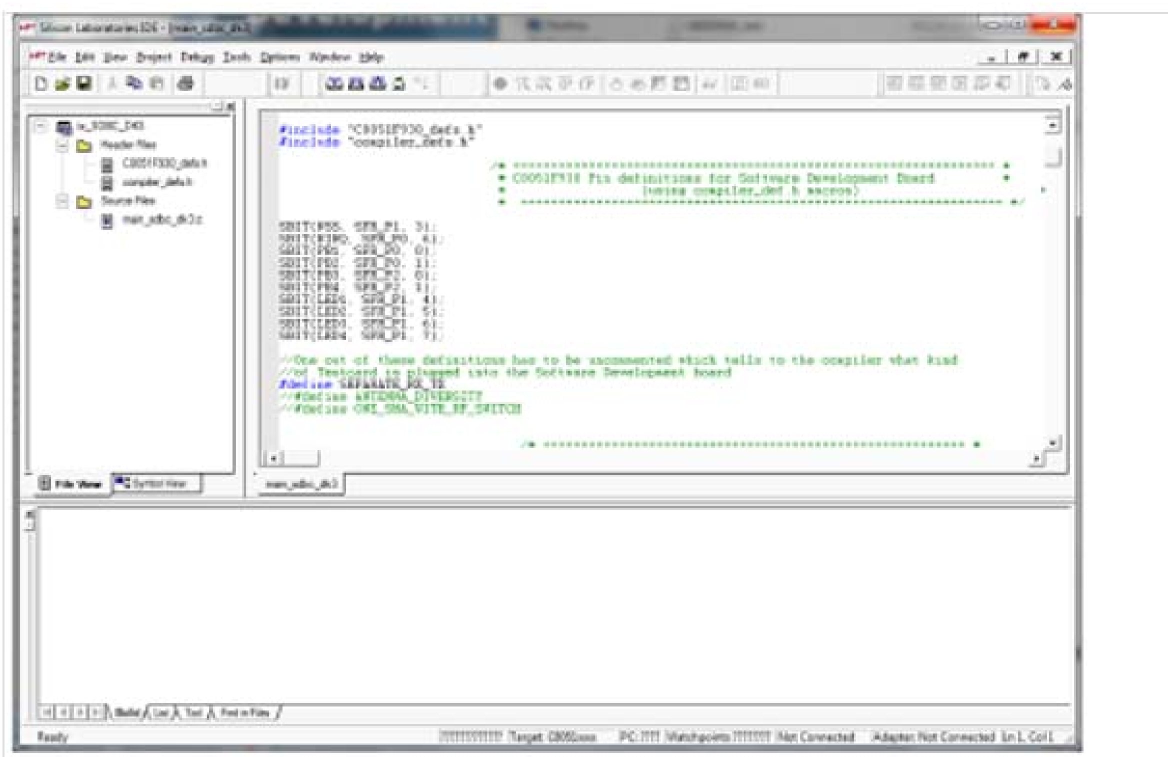

Figure 17. Silicon Labs IDE

The radio configurations are stored in the radio_config.h within the example project. The header file is generated by WDS. The header file can be previewed and saved separately, without saving the entire source project too.

For more details of the Example Project, the radio configuration header file and the required SW development tools, refer to “AN633: Programming Guide for the EZRadioPRO® Si4x6x devices”. The general workflow of the Radio Configuration Application is shown in Figure 18.

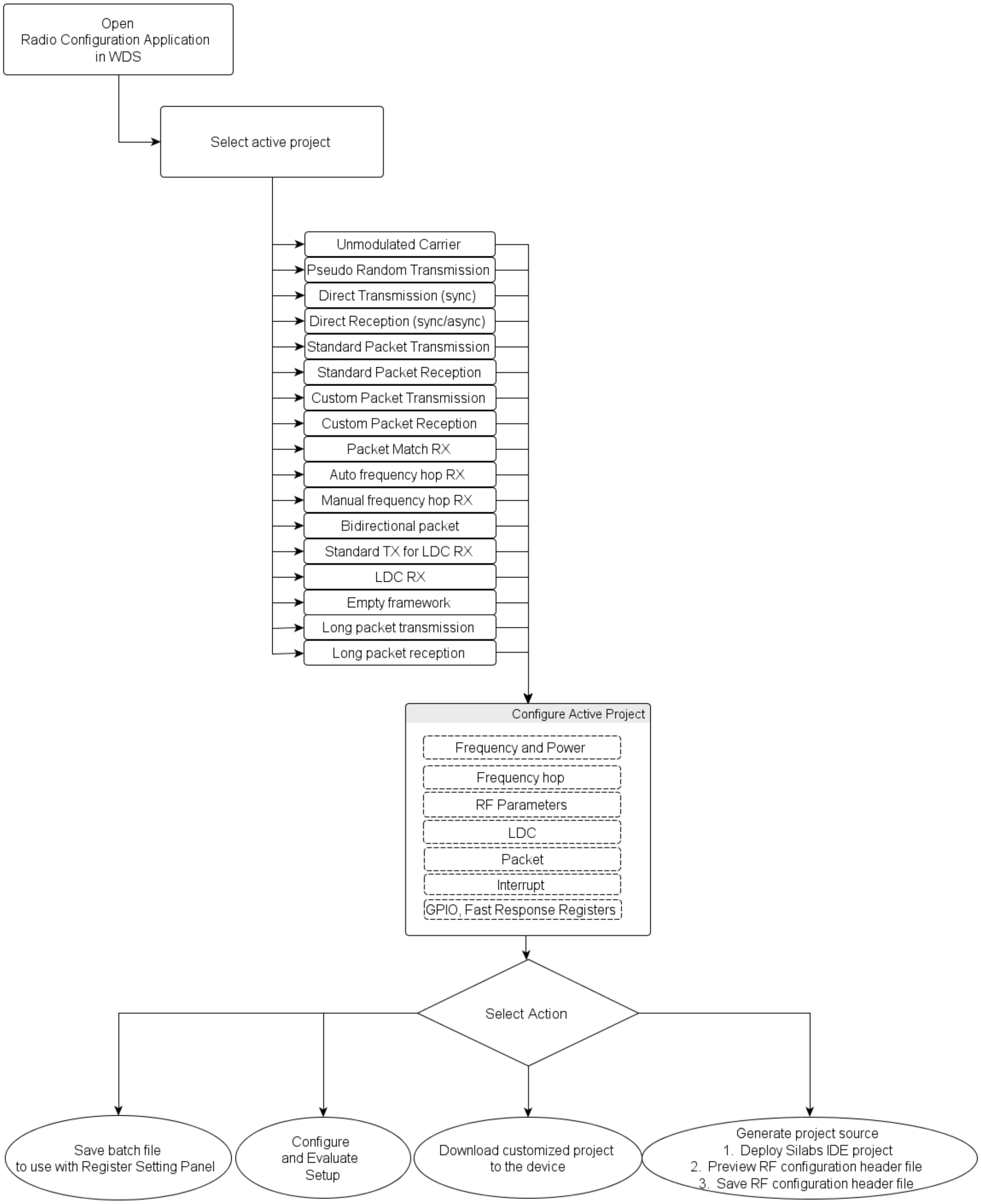

Figure 18. WDS Workflow

The EZRadioPRO devices have a built-in modem to demodulate the received data. The modem is a complex hardware block and its behavior is configured through numerous Properties. In case any Receive related settings are changed, the WDS runs a calculator to define the modem configuration Properties.

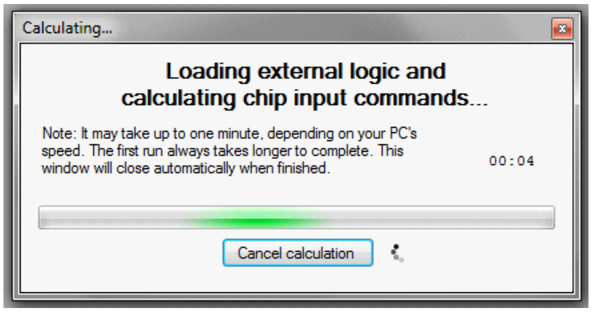

Figure 19. WDS Showing Status of Modem Properties Calculation

2.2. Register Setting Panel

The Register Setting Panel is intended for experienced users who know the API interface, the detailed behavior of the radio, and they want to deal with the APIs and the Properties directly without using a graphical interface to setup the radio.

The Register setting panel is divided into two sections.

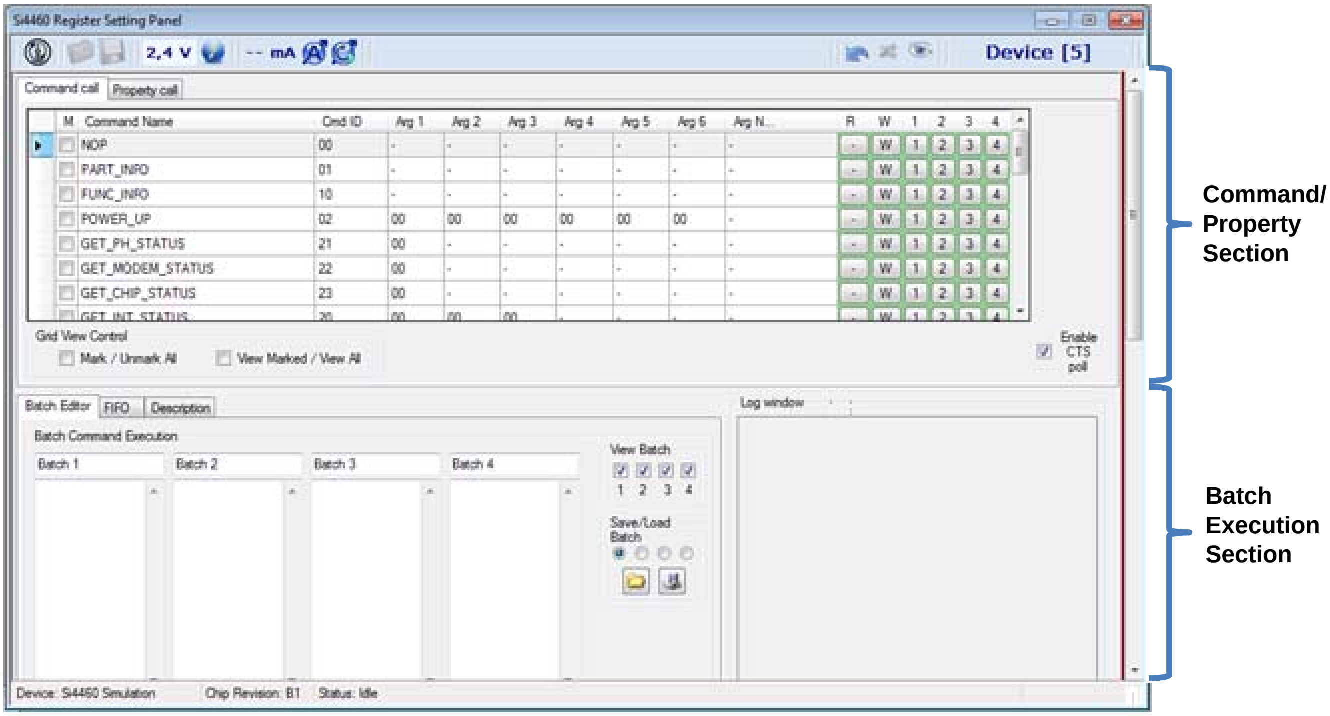

Figure 20. Register Setting Panel

2.2.1. Commands and Properties

The Command and the Property tabs list all the available API commands and the properties of the radio. The user can read and write individual commands or properties from these tabs directly, pressing the W or R buttons right after the API call or Property. A given command can be copied into a Batch window by pressing the appropriate button (1/2/3/4).

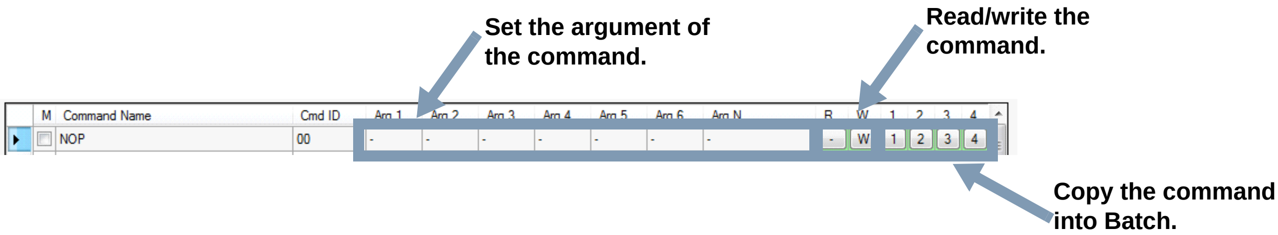

Figure 21. Commands

It is possible to select all commands or hide the selected commands for better readability.

To see if the radio executed the previous command, poll the CTS (clear to send flag of the radio), unless the radio enters low power mode. In this case, the poll command wakes up the radio automatically and this would lead to confusion. To disable the CTS polling in WDS, deselect the "Enable CTS poll" feature.

Note: For more details on the API and the CTS, refer to "AN633: Programming Guide for the EZRadioPRO Si4x6x devices."

2.2.2. Batch Execution

The bottom section holds the batch execution windows. An already saved Batch file can be loaded and run even in loops from here. It is also possible to edit the Batch file within the Execution window or add new commands/ properties from the top section.

The Batch windows can be temporally disabled for better visibility; be advised that the content of the window is not deleted, just hidden.

A Log window is also available to monitor what commands are sent to the radio and what is the reply from the radio.

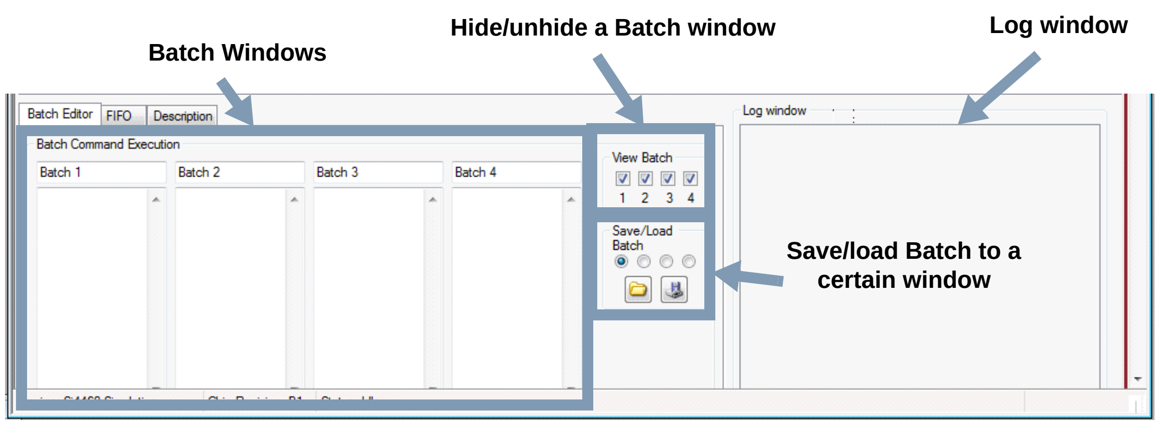

Figure 22. Log Window

Loading a Batch File:

1. Click on the folder icon below "Save/Load Batch" in the "Batch Editor" tab.
2. This will open up an Explorer window so the user can browse to the location of the saved batch file and select it.
3. Once selected, the batch window will automatically be loaded with the file and the user will be able to view and edit the file directly in the batch window.
4. To run the file, simply click on the "Run" button below the batch window. This puts the radio in the desired state.
5. To clear a batch window, click on the "X" button next to "Run."

Saving a Batch File:

- A batch file is edited or created in any one of the batch windows, and the file can be saved by clicking on the “floppy” icon below “Save/Load Batch.”

Modifying a Batch File to Update Frequency or Modem Parameters:

Once a WDS batch file is created and saved from the “Radio Control Panel” (or started with a batch file provided by Silicon Labs), the batch file can be edited to update modem and frequency settings.

1. Input the desired parameters to the “Radio Control Panel” as described above in the Radio Control Panel section.
2. Click on the “Save Command” button which will run the calculator and save the output as a batch file (also described above).
3. Open the saved batch file and compare it to the one you started with initially.
4. Manually edit the parameters that are different. Common settings that may be edited are frequency settings and data rate/deviation settings.
   a. Frequency settings example:

```
'SET_PROPERTY' 'FREQ_CONTROL_INTE' 3D
'SET_PROPERTY' 'FREQ_CONTROL_FRAC_2' 0C
'SET_PROPERTY' 'FREQ_CONTROL_FRAC_1' 44
'SET_PROPERTY' 'FREQ_CONTROL_FRAC_0' 44
'SET_PROPERTY' 'FREQ_CONTROL_CHANNEL_STEP_SIZE_1' 00
'SET_PROPERTY' 'FREQ_CONTROL_CHANNEL_STEP_SIZE_0' 00
'SET_PROPERTY' 'FREQ_CONTROL_W_SIZE' 20
```

   b. Data rate / Deviation settings example:

```
'SET_PROPERTY' 'MODEM_DATA_RATE_2' 00
'SET_PROPERTY' 'MODEM_DATA_RATE_1' 13
'SET_PROPERTY' 'MODEM_DATA_RATE_0' 88
'SET_PROPERTY' 'MODEM_TX_NCO_MODE_3' 00
'SET_PROPERTY' 'MODEM_TX_NCO_MODE_2' 2D
'SET_PROPERTY' 'MODEM_TX_NCO_MODE_1' C6
'SET_PROPERTY' 'MODEM_TX_NCO_MODE_0' C0
'SET_PROPERTY' 'MODEM_FREQ_DEV_2' 00
'SET_PROPERTY' 'MODEM_FREQ_DEV_1' 00
'SET_PROPERTY' 'MODEM_FREQ_DEV_0' 71
```

5. Note that there may be some settings in the output file that are not relevant for the test. One simple example is modem TX settings in an RX test. These can be left as is or removed.
6. Another option is to run the newly created batch file as is. This would be in case there are no other settings from the original file that are needed, such as specific GPIO settings or any other specific optimizations.

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