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1 Introduction

The SX1233 is a single-chip integrated circuit ideally suited for today's high performance ISM band RF applications. The advanced feature set, including state of the art packet engine greatly simplifies system design whilst the high level of integration reduces the external BOM to a handful of passive decoupling and matching components. It is intended for use as high-performance, low-cost FSK and OOK RF transceiver for robust frequency agile, half-duplex bi-directional RF links, and where stable and constant RF performance is required over the full operating range of the device down to 1.8V.

The SX1233 is intended for applications over a wide frequency range, including the 433 MHz and 868 MHz European and the 902-928 MHz North American ISM bands. Coupled with a link budget in excess of 135 dB, the advanced system features of the SX1233 include a 66 byte TX/RX FIFO, configurable automatic packet handler, listen mode, temperature sensor and configurable DIOs which greatly enhance system flexibility whilst at the same time significantly reducing MCU requirements.

The SX1233 complies with both ETSI and FCC regulatory requirements and is available in a 5x5 mm QFN 24 lead package.

The SX1233-33SKA is a USB based evaluation tool designed to allow simple and easy evaluation of the suitability of the SX1233 for a given application. The low component count reference design implemented in the SM1233 reference design is illustrated below in Figure 1.

It is recommended that this user guide be read in conjunction with the SX1233 datasheet (http://www.semtech.com/images/datasheet/sx1233.pdf)
Figure 1: SM1233 with Antenna Diversity Application Schematic
2 Getting Started

2.1 Evaluation Kit Contents
The SX1233SKA evaluation kit consists of:

- 1 x SM1233EXXXB module
- 1 x SM12XX <-> USB-Bridge module
- 1 x ¼ wave monopole antenna
- Installation CD or insert sheet
- 1 x Mini USB cable

Figure 2: SM1233 Module Mounted on USB Bridge
2.2 Installation

1. Put the CDROM in your computer and browse the contents of the CD, open the “sx1233starterkitsetup.exe” manually. It can be found in the \Installers sub directory of the CD-ROM.
2. If the evaluation kit is supplied with an insert sheet, follow the instruction on the insert sheet and download the latest version of the software from the weblink provided.
3. Follow the on-screen installation guidelines until the process is completed. Please note that .NET Framework 3.5 and the FTDI USB driver will be automatically installed if not detected on your computer.
4. Connect the SX1233SKA board to the PC via the USB interface. The SM1233 module and USB bridge are powered via the USB.
5. Launch “SX1233SKA” from the Start menu.
6. Click on “Connect” button in toolbar or in File menu.
7. SX1233SKA is now installed and ready to be used.

2.3 SX1233SKA Overview

The SX1233SKA features the SM1233 reference design and is also interfaced via the FTDI USB Bridge to the USB type ‘A’ interface of a host PC.

Transmission and reception is indicated by a pair of LEDs on the USB Bridge.

3 SX1233 Quick Start Guide

It is recommended that this user guide is read in conjunction with the SX1233 datasheet.

1. Plug the SX1233SKA into the USB port of the computer. The USB power LED on the bridge should be illuminated.
2. Run the SX1233 User Interface software: Start > All Programs > SX1233SKA > SX1233SKA.
3. The SX1233SKA should connect automatically to the User Interface Software. If not, click on the USB connect button, located in the top left hand corner of the window toolbar, as illustrated in Figure 4, below.
4. Once connected the SX1233SKA shows the default configuration of the SX1233 register settings upon power-up, as illustrated in Figure 3. If the EVK is not connected, the GUI screen is grayed out and an error message is displayed in the bottom left hand corner of the status bar.

4 SX1233SKA Software Description

4.1 Overview

Figure 3 illustrates the SX1233SKA graphical user interface (GUI). Each of the numbered captions corresponds to a proceeding chapter within the sections which corresponds to the description of that GUI feature.
4.2 Menu Tool Bar
The Menu toolbar contains four drop down menus, File Menu, Action Menu, Tools Menu and Help Menu.

4.2.1 File Menu
Connect / Disconnect allows for the connection or disconnection of the USB bridge from the host PC. This functionality may also be accessed through the short cut buttons of the Window Toolbar (see Section 4.3).

Open Config… allows for the opening of SX1233SKA configuration files (.cfg). This is implemented through a standard Windows file dialog box and may also be accessed through the short cut buttons of the Window Toolbar.

Save Config allows for SX1233SKA configuration files (.cfg) to be saved. This is implemented through a standard Windows file dialog box. The default file name is the last config file saved.
Save Config as… prompts for a new file name before saving, allowing for multiple configuration files to be saved and may also be accessed through the short cut buttons of the Window Toolbar.

Exit closes the application.

4.2.2 Action Menu

Reset resets the SX1233 configuration registers to the recommended default values.

Refresh reads the status of the all registers.

Show registers toggles the SX1233 Registers display window and may also be accessed through the short cut buttons of the Window Toolbar. The register display window indicates the status of SX1233 configuration registers as detailed in the SX1233 datasheet. Refer to Section for further information.

Monitor ON allows the GUI to constantly scan the status of the Irg registers RegIrgFlags1 and RegIrgFlags2 at addresses 0x27 and 0x28 respectively, and displays the status on the right hand side of the GUI (see Section 4.6 for further details). Monitor OFF disables the monitor function.

4.2.3 Tools Menu

RSSI analyzer provides a graphical representation of the signal level at the antenna port measured within the RX filter channel bandwidth, RxBw, at the programmed RF frequency. Refer to See Section 7.4 for further details.
Spectrum Analyzer provides a simple spectrum analyzer function based upon RSSI level within the programmable RX filter channel bandwidth, RxBw. Please refer to Section 7.5 for further details.

![Tools Menu Options](image)

**Figure 6: Tools Menu Options**

### 4.2.4 Help Menu

*Help* provides an online description of GUI commands

*User’s Guide…* opens a PDF version of this document.

*About…* provides details of the GUI revision. The latest version of the SX1233 GUI can be downloaded from the Semtech website.

![Help Menu Options](image)

**Figure 7: Help Menu Options**

### 4.3 Window Toolbar

The Windows Toolbar provides three buttons that provide shortcuts to some of the functions accessed from the File drop-down menu.

![Windows Toolbar Menu](image)

**Figure 8: Windows Toolbar Menu**
Open Config button opens a Windows file dialog box to allow access to a previously saved SX1233SKA configuration file (.cfg). Note that saved configuration files are designed to be a useful tool for embedded software development. The file can be opened in any text editor or within a spreadsheet to display the programmed register name, address and contents, as illustrated below in Figure 9.

![Example Configuration File Text Editor Output](image)

**Figure 9: Example Configuration File Text Editor Output**

Save Config button saves and will prompt if overwriting an existing configuration file.

Connect / Disconnect button allows the user to manage manually connection and disconnection of the kit.

Reset resets the SX1233 configuration registers to the recommended default values.

Refresh reads the status of all registers.

Register Window Toggle toggles the SX1233 Registers display window and may also be accessed through the short cut buttons of the Window Toolbar. The register display window indicates the status of SX1233 configuration registers as detailed in the SX1233 datasheet. Refer to Section 6 for further information.

IRQ Monitor Toggle toggles the scanning of the status of Irq registers RegIrqFlags1 and RegIrqFlags2 at addresses 0x27 and 0x28 respectively, and displays the status on the right hand side of the GUI (see Section 4.6 for further details).

Help provides an online description of GUI commands.
4.4 Status Bar
The Status Bar provides details of the SX1233 revision version and current user configuration file. For further information concerning the IC revision, please refer to the SX1233 datasheet.

![Status Bar Diagram]

Figure 10: Status Bar

4.5 Operating Modes Control Box
The Operating Mode control box allows the user to change the operating mode of the SX1233 by clicking on the radio button corresponding to the desired mode. Note that the transition between modes is applied as soon as the radio button is accessed.

When the SX1233 is configured to RX operating mode LED 2 on the USB Bridge is illuminated. When the SX1233 is configured to TX mode both LED 2 and LED 3 are illuminated.

![Operating Modes Control Window]

Figure 11: Operating Modes Control Window

4.6 Irq Status Indicator
The Irq Status Flag indicator provides an indication of the status of the Irq registers. When the indicator next to the Irq description is illuminated, the Irq condition is true.

Please refer to the SX1233 datasheet for further information and a more detailed description of the Irq register flags.
4.7 Antenna Switch Control Box

The Antenna Switch Control Box allows users to select the RF path between the SX1233 pins and the SMA connectors of the board; as illustrated in Figure 13. Practically, RX input and TX outputs could be connected to either SMA connector according to the user’s selection. Pins 18 and 20 of the POD_IN header allow external control of the switch logic.
5 Configuration Registers Tabs

Unless otherwise stated all registers are updated as soon as they are written. It is recommended to cycle through Standby Mode when changing the contents of configuration registers.

5.1 Common Configuration Registers Tab

The Common Configuration Registers tab is illustrated on the following page in Figure 14. Please refer to the SX1233 for a full description of the configuration register functions.

Configuration register value entries can be selected from the drop down menus within the tab or entered manually within the tab fields. Note that an invalid register entry will be highlighted by an orange background and the GUI will automatically flag a warning exclamation. A valid register entry that leads to an incorrect operating setting will result in that entry to be highlighted in red. Hovering a mouse or cursor over the warning provides an explanation for the flag, as illustrated in Figure 15.

Values entered manually that do not coincide with an exact configuration will be automatically updated by the GUI to the next valid register configuration and write that value to the appropriate configuration register.
5.1.1 Modulation Mode Window
Clicking on the OOK radio button within the Modulation window will access the modulation shaping options for the OOK modulation mode.

5.2 Transmitter Configuration Register Tab
The Transmitter Configuration Register Tab is illustrated below in Figure 17. Please refer to the SX1233 datasheet for a full description of the configuration register functions. Configuration register value entries can be selected from the drop down menus within the tab or entered manual within the tab fields. If values are entered manually that do not coincide with an exact configuration, the GUI will automatically update the displayed value to the next valid register configuration and write that value to the appropriate configuration register.

It should be noted that the output power settings are the nominal values determined by the configuration registers and does not refer to measured output power. Please refer to the Application Information within the SX1230 datasheet for further information concerning measured output power vs. programmed power.
5.3 Receiver Configuration Register Tab

The Transmitter Configuration Register Tab is illustrated below. Please refer to the SX1233 for a full description of the configuration register functions.

Configuration register value entries can be selected from the drop down menus within the tab or entered manually within the tab fields. If values are entered manually that do not coincide with an exact configuration, the GUI will automatically update the displayed value to the next valid register configuration and write that value to the appropriate configuration register.
5.3.1 Rx Bandwidth

The Rx Bandwidth, RxBw, window is illustrated below. For optimum performance in FSK mode when operating with a modulation index \( \geq 2 \), the DCC frequency is recommended to be approximately 4% of the receiver bandwidth, RxBw. The GUI will automatically set the appropriate DCC frequency based upon the setting of RX filter bandwidth.

![Figure 19: Rx Bandwidth Window](image)

For operation with low modulation index signals, it is recommended that the user follows the recommendations for setting the correct DCC bandwidth that can be found in the SX1233 datasheet.

5.3.2 LNA Gain Window

The LNA gain window provides the status of the configured LNA gain. The gain can be configured automatically or manually. In automatic mode the LNA gain is set based upon the RSSI value. In manual mode, the gain should be set according to the expected signal power.

Note that the AGC reference threshold is set according to:
\[ \text{AgcRef} = [-174 + \text{NF} + 10 \times \log(2 \times \text{RxW}) + \text{DemodSNR} + \text{FadingMargin}] \text{dBm} \]

**5.3.3 AFC / FEI**

The AFC / FEI (Frequency Error Indicator) window is illustrated below. Note that when AFC is activated (either AFC auto “ON” or manually), the RF frequency in the General window of the Common Configuration Register Tab does not update, although a measure of frequency error can be obtained by clicking on the FEI Read button to verify correct AFC operation.

Enabling AFC low beta implements a double AFC function to offset the local oscillator of the SX1233 to ensure that the central tone at \( f_0 \) associated with low modulation index signals is not unduly attenuated by the cut-off frequency of the DCC.

Please refer to the optimized set up for low modulation index systems section of the SX1233 datasheet for further details.

**5.3.4 RSSI**

The RSSI window provides access to the RSSI timeout and timeout threshold functions and enable either automatic or manual RSSI detection threshold values to be programmed. Note that the RSSI threshold (which should not be confused with the LNA or AGC threshold) can be calculated from and equates to the effective noise floor of the receiver for a given filter bandwidth.

\[ \text{RSSIthres} = [-174 + \text{NF} + 10 \times \log(2 \times \text{RxW}) + \text{DemodSNR}] \text{dBm} \]
5.3.5 Continuous-Time Digital AGC

The AGC dynamic range can be enhanced in V2c silicon (chip version 2.3) with the default mode of operation of DAGC enabled. Note that the DAGC mode of operation is automatically configured by the GUI depending upon whether AFC low beta is enabled (see section 5.3.3).

Please refer to the SX1233 datasheet for further information on the implementation of the continuous-time DAGC function.

5.4 Irq & Mapping Configuration Register Tab

The Irq & Mapping Configuration Register Tab is illustrated in Figure 24. Please refer to the SX1233 for a full description of the irq and mappings for each mode of operation of the SX1233.

Configuration register value entries can be selected from the drop down menus besides each DIO listed.

Note that when necessary the GUI will automatically re-configure DIO mappings (i.e. Packet Handler operation).

Please refer to Table 1 and Table 2, below, for the available DIO mappings of the SX1233 in continuous and packet mode, respectively.
### Table 1: Continuous Mode DIO Mappings

<table>
<thead>
<tr>
<th>Mode</th>
<th>DIOx Mapping</th>
<th>DIO5</th>
<th>DIO4</th>
<th>DIO3</th>
<th>DIO2</th>
<th>DIO1</th>
<th>DIO0</th>
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### Table 2: Packet Mode DIO Mappings

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<td>F fifoNotEmpty</td>
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<td></td>
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<td>Data</td>
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<td>-</td>
</tr>
</tbody>
</table>
5.5 Packet Handler Configuration Register Tab

The Packet Handler Configuration Register Tab is shown below. Please refer to the SX1233 for a full description of the packet engine message format and operation of the SX1233.
5.5.1 Sync Word
For correct packet mode operation, the sync word needs to be set to at least one byte. Note that 0x00 cannot be set as for the first byte of the sync word. The GUI will prompt with an error message should the user attempt to set 0x00 in the first byte of the sync word.

5.5.2 AutoMode Operation
Auto Modes defines the enter conditions to start the packet handler and exit conditions to terminate packet handler operation, as defined in the SX1233 datasheet.

5.5.3 Packet Log
Clicking on the Log button within the Control Window enables the payload logging function, available in both TX and RX modes whenever the Packet Handler is enabled.

![Figure 26: Packet Logger Window](image)

In the Packet Logger window enter the number of packets to be logged and press the Start button. Then press the Start button in the Control Window of the main Packet Handler Tab to start packet transmission or reception. When the status bar indicates full, the log can be saved by clicking on the Browse button.

The log file can be viewed in Notepad or opened in Excel as a .CSV file.

![Figure 27: Packet Log CSV File Format](image)
### Table 3: Packet Log Descriptors

<table>
<thead>
<tr>
<th>Packet Log Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Local (CPU) timestamp in MM:SS.S format for TX / RX packets</td>
</tr>
<tr>
<td>Mode</td>
<td>SX1233 Packet Mode</td>
</tr>
<tr>
<td>RSSI</td>
<td>Indicated RSSI level (RX mode only)</td>
</tr>
<tr>
<td>Pkt Max</td>
<td>Number of repeated packets set in GUI Control Window (0 = infinite)</td>
</tr>
<tr>
<td>Pkt #</td>
<td>Transmitted or received packet number</td>
</tr>
<tr>
<td>Preamble Size</td>
<td>Size of transmitted or received preamble sequence</td>
</tr>
<tr>
<td>Sync</td>
<td>Sync Address</td>
</tr>
<tr>
<td>Length</td>
<td>Payload length of TX / RX packet</td>
</tr>
<tr>
<td>Node Address</td>
<td>node Address (optional)</td>
</tr>
<tr>
<td>Message</td>
<td>Transmitted / received packet (can be viewed in GUI Message Window)</td>
</tr>
<tr>
<td>CRC</td>
<td>Transmitted / received CRC (optional)</td>
</tr>
</tbody>
</table>

#### 5.5.4 Packet Handler GUI Limitations

When operating the packet handler via the SKA GUI, the user should be aware of the following limitations associated with the GUI:

- Minimum Preamble Size = 2 bytes
- Maximum Packet Length = 66 bytes (64 bytes of data + Length byte + Address byte)

#### 5.6 Temperature Configuration Register Tab

The Temperature Configuration Register Tab is illustrated below in Figure 29. Note that user is prompted to calibrate the SX1233 temperature sensor by clicking on the Calibrate button to access the temperature calibration dialog box.

![Temperature Calibration Dialog Box](Figure 28)

When the temperature sensor has been calibrate the temperature, as computed by the SX1233, will be displayed, as illustrated in Figure 29.
Figure 29: Calibrated Temperature Sensor Tab
6 Registers Display Window

As outlined in Section 4.2.3 the SX1233 GUI has a show registers utility that, when enabled from either the Menu or Windows toolbar, provides details of the status of all configuration registers that are documented in the SX1233 datasheet.

Whenever the contents of a register are changed in the main GUI window, the corresponding register displays the new contents of the register(s), highlighting changed contents in red for a period of approximately 5 seconds before reverting back to black.

The register window is displayed below in Figure 30. It can be noted that in this example, the contents of RegOpMode at Addr 0x01 have changed to 0x10, indicating that the SX1233 has been set to Receiver Mode operation.

![SX1233 Registers Display Window](image)

**Figure 30: SX1233 Registers Display Window**
7 Advanced Operating Modes

7.1 Packet Communications Test

To configure the SX1233 to enable a wireless packet communications transfer, follow the procedure outlined below:

7.1.1 Transmitter Mode Configuration

1. Ensure that the SX1233 is in Standby operating Mode
2. Configure the SX1233 Common and Transmitter Configuration Registers
3. Configure the Packet Handler Registers for the payload you wish to transmit. The payload can be entered within the Message Window in either hexadecimal or ASCII format. Note that the packet can be configured with Address and / or Broadcast nodes enabled or disabled; DC-free mechanisms, CRC and / or AES may also be selected. The only limitation is that the maximum payload size for the purposes of GUI operation is 66 bytes
4. Click on the Transmitter radio button from within the Operating Mode Window and set the Repeat value from within the Control Window of the Packet Handler Tab. It is recommended for initial analysis that Repeat value is set to “0” (packet transmission repeat until manually stopped)
5. Click on the Start button within the Control Window of the Packet Handler Tab to start the Transmitter
6. The TX packet counter will commence to increment as the SX1233 repeatedly transmits the payload

7.1.2 Receiver Mode Configuration

1. Ensure that the SX1233 is in Standby operating Mode
2. Configure the SX1233 Common and Receiver Configuration Registers. The Common configuration should be identical to that of the SX1233 configured as the transmitter. The Receiver filter BW configuration should be consistent with the signal parameters. It is recommended that the configuration of the transmitter module is used as a template
3. Configure the Packet Handler Registers for the payload you wish receive. Note that the packet can be configured with Address and / or Broadcast nodes enabled or disabled; DC-free mechanisms, CRC and / or AES may also be selected. The packet handler parameters must be identical for those selected for the transmitter for correct operation. The only limitation is that the maximum payload size for the purposes of GUI operation is 66 bytes
4. Click on the Receiver radio button from within the Operating Mode Window and set the Repeat value from within the Control Window of the Packet Handler Tab
5. Click on the Start button within the Control Window of the Packet Handler Tab to start the Receiver
6. The RX packet counter will commence to increment for each valid packet reception

7.2 Test Mode Window

The Test Mode window is accessed by depressing the <CTRL>+<ALT>+<T> keys of the PC keyboard simultaneously, and is illustrated below in Figure 31.

This window allows the user to write to and read from the contents of individual configuration register addresses. Note that address and data are entered in hexadecimal format.

The Antenna switch control dialog box enables control of the antenna diversity switch for the SX1233 antenna diversity reference design.
7.3 Verification Mode

When no SX1233SKA is connected to the PC, launching the application results in the GUI display being grayed out and the user is unable to enter data.

By depressing the <CTRL>+<ALT>+<N> keys of the PC keyboard simultaneously, the user can write to the configuration registers to verify propose settings, as well as load and save configuration files (*.cfg).

7.4 RSSI Analyzer

The RSSI Analyzer can be enabled via the Menu Tool Bar. With the SX1233 configured in Receiver operating mode the RSSI analyzer displays the real-time sampled RSSI measured in the receiver channel bandwidth. The vertical axis (indicated RSSI level) can be scaled with the click-wheel of a scrolling mouse.

This data can be saved as a RSSI log file by selecting an appropriate Max sample length within the RSSI Analyzer window and clicking on the Start button. When the status bar indicates full, the log file can be saved by clicking on the Browse button and can be viewed in Notepad or opened in Excel as a .CSV file.

An example of the RSSI Analyzer display is illustrated in Figure 32, indicating a packet transmission typically 10 dB above the receiver noise floor.
7.5 Spectrum Analyzer

The Spectrum Analyzer can be enabled via the Menu Tool Bar. With the SX1233 configured in Receiver operating mode the spectrum analyzer displays the sampled spectrum based upon RSSI measured within the programmable receiver channel or “resolution” bandwidth. Center frequency, frequency span and LNA gain are all configurable. The vertical axis (Power) can be scaled with the click-wheel of a scrolling mouse.

An example of the RSSI Analyzer display is illustrated in Figure 33.

![Figure 32: RSSI Analyzer Window](image)

![Figure 33: RSSI Analyzer Window](image)
8 Compatibility with Earlier Silicon Revisions

The SX1233 GUI is backwards compatible with Rev 2.1 Silicon (SX1233 datasheet Revision 2.0). The GUI automatically detects the silicon revision number, displaying the chip version in the status bar at the bottom of the GUI.

Configuration Register Tabs are automatically updated to display register contents pertinent to the chip version.

Semtech’s policy of continual improvement may result in information contained within this User Guide not being concurrent with the revision of software included on the installation CD

The user is recommended to download the latest revision of both this document and software from the Semtech website (www.semtech.com)