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## SX1230-12SKA

## **User's Guide: Advanced Mode**

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### 1 Introduction

The SX1230 is a single chip transmitter IC designed for operation in the licence free ISM bands between 290 and 1020 MHz. The SX1230 is capable of operation either with or without an external companion microcontroller and features four internally de-bounced digital input pins to enable direct connection to switchgear for wireless remote control applications. Examples of both types of applications are shown below:



Figure 1. SX1230 Stand Alone Operation with Companion E<sup>2</sup>PROM



Figure 2. SX1230 Connections for Microcontroller Based Operation

The SX1230 main features include:

- > +17 dBm to -18 dBm Programmable output power
- > 1.8 to 3.7V Operating range with internal voltage regulation allowing constant RF performance
- Narrow and wide-band operation
- > (G)FSK, (G)MSK and both filtered and unfiltered OOK operation.
- Support of bit rates from 1.2 to 600 kbps.
- Low battery detection
- Integrated RC timer for timer / wake-up applications
- Low phase noise -95 dBc/Hz at 50 kHz offset.
- -40°C to +85°C Temperature Range

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## 2 Getting Started

#### 2.1 Kit Contents

As illustrated in the figure below, the SX1230-12SKA Evaluation kit is composed of:

- SX1230SKA board
- SX1212SKA board
- SMA Connectorised Antenna for 434 MHz
- SX1230-12SKA CDROM including all necessary PC software and documentation
- A CR2032 Cell for operation of the SX1230SKA in stand alone mode, in conjunction with the companion E<sup>2</sup>PROM.



Figure 3: SX1230-12SKA Contents (CR2032 Cell not Shown)

#### 2.2 Installation

The software for the SX1212SKA and SX1230SKA must each be installed individually. The installation process for each is identical.

#### SX1212SKA Advanced Mode Software Installation

- 1- Put the CDROM in your computer and browse the contents of the CD.
- 2- Open the "sx1212starterkitsetupweb.exe" manually. It can be found in the \Installers sub directory of the CD-ROM.
- 3- Follow installation guidelines until the process is completed. Please note that .NET Framework 2.0 and the FTDI USB driver will be automatically installed if not detected on your computer.
- 4- Connect the SX1212SKA board to the PC via the USB interface.
- 5- Launch "SX1212SKA" from the Start menu.
- 6- Click on "Connect" button in toolbar or in File menu.
- 7- SX1212SKA is now installed and ready to be used.

#### SX1230SKA Advanced Mode Software Installation

- 8- Put the CDROM in your computer and browse the contents of the CD.
- 9- Open the "sx1230starterkitsetupweb.exe" manually. It can be found in the \Installers sub directory of the CD-ROM.
- 10- Follow installation guidelines until the process is completed. Please note that .NET Framework 2.0 and the FTDI USB driver will be automatically installed if not detected on your computer.
- 11- Connect the SX1230SKA board to the PC via the USB interface.
- 12- Launch "SX1230SKA" from the Start menu.
- 13- Click on "Connect" button in toolbar or in File menu.
- 14- SX1230SKA is now installed and ready to be used.



### **3 Hardware Description**

SX1230SKA and SX1212SKA boards are summarised in this chapter. Please refer to the schematics and layout provided in the document for further information about each hardware implementation.

#### 3.1 SX1230SKA Overview



#### Figure 4: SX1230SKA, 868 and 915 MHz Band, Board Picture

The SX1230SKA is a USB based evaluation tool, which sees the SX1230 reference design (2) connected to a host PC via an FTDI USB to SPI bridge (1) and USB type 'A' connection (7). The SX1230SKA can also operate with in stand alone mode when battery powered. In this mode the initial configuration of the radio is downloaded from the first 77 bytes of the companion E<sup>2</sup>PROM (5). In response to a user push button input (6) a specific payload may be transmitted. The LED (3) corresponding to that button press illuminates to indicate transmission.

For operation in the 434 MHz band the RF link between SX1230SKA and SX1212SKA is established through a PCB mounted helical antenna (4) to give a realistic impression of the range and other performances attainable in a miniaturised application.

#### 3.2 SX1212SKA Overview

The SX1212SKA features the SX1212 reference design (1) and is also interfaced via an FTDI bridge (6) to the USB type 'A' interface (2) of a host PC. Unlike the SX1230SKA, it has no provision for operation disconnected form the USB port. Indication of transmission and reception is indicated on a pair of LEDs (4). Connection to the separate antenna is made through an SMA connector (3) which can also be useful for laboratory based testing.



Figure 5: SX1212SKA Board Picture



#### 4 Quick Start Guide: MCU Mode

With both SX1230SKA and SX1212SKA software installed, follow the sequence below to establish communication between the SX1230 as transmitter and the SX1212 as receiver.

#### 4.1 SX1212SKA Quick Start

- 1. Plug the SX1212SKA into the USB port of the computer.
- 2. Run the SX1212 User Interface software Start > All Programs > SX1212SKA > SX1212SKA
- 3. The SX1212SKA should connect automatically to the User Interface Software. If not, then click on the USB connect short-cut button, located in the top left hand corner of the window.



4. Once connected the SX1212SKA shows the default configuration of the SX1212 register settings upon power-up.

File Help													
🦻 🗔   🐵													
McParam   IrgParam   Rx	Param   TxParam	0scPa	ram   Pack	et				Register	Addr	Value	Register	Addr	Value
Band	400-440		7					McParam1	0x00	0x2F	BxParam1	0x10	0xA3
Subband	Ath quarter	J						McParam2	0x01	0x24	RxParam2	0x11	0x38
oubband.	Tetti quarter							FDev	0x02	0x03	RxParam3	0x12	0x18
VCO trim:	+180	▼ mV						BitRate C coeff	0x03	0x07	Res19	0x13	0x04
Modulation scheme:	FSK	-						BitRate D coeff	0x04	0x1F	RssiValue	0x14	0x00
OOK thres type:	Peak	-	Taxaati		42400000	U.		RegMcParam6	0x05	0xC6	RxParam6	0x15	0x00
Data mode:	Continuous	-	Target	HF frequency.	1434000000	12	_	RegR1	0x06	0x6B	SyncByte1	0x16	0x00
Data mode.	Continuous	2			© 1	0	2	RegP1	0x07	0x2A	SyncByte2	0x17	0x00
IF gain:	0	± dB		to the		_	10	RegS1	0x08	0x1E	SyncByte3	0x18	0x00
Fdev:	100000	Hz	R:				13	RegR2	0x09	0x77	SyncByte4	0x19	0x00
Bitrate:	25000	bps		Co., et al.				RegP2	0x0A	0x2F	TxParam	0x1A	0x72
DDK floor three:	20		P:		42	2	47	RegS2	0x0B	0x19	OscParam	0x18	0xBC
O'OIX HOOF GIRES.	12.0	- uo		400 100 100	S S	-		FIFO size - tresh	0x0C	0x0F	PktParam1	0x1C	0x00
Low Power Rx:	C ON @	OFF	S:			5	25	IrqParam2	0x0D	0x00	NodeAddr	0x1D	0x00
PA ramp:	23	🕶 us		1700	0.03.0			IrgParam3	0x0E	0x09	PktParam3	0x1E	0x48
								RssilrqThres	0x0F	0x00	PktParam4	0x1F	0x00
Gen	eral				Rx		Cor	trol					
land:	400-440	MHz	Passive fi	lter fc:	378000	Hz	- Op	erating mode	10	Registers (	config	RSSI -	
F frequency:	434000000	Hz	Butterwor	th fc-fo:	100000	Hz		19 million			Write		
todulation scheme:	FSK		Polyphas	e fo: 🗖	100000	Hz		Sleep		-			0
requency Deviation:	100000	Hz			Тх	ų.		Standby C Synthe	sizer	_	Read		Read
Bitrate:	25000	bps	Interpolate	or filter fc:	200000	Hz	0	Receiver C Transm	litter		Reset		
Operating mode:	STANDBY		Output po	wer:	10	dBm				-		1	

Figure 6. SX1212 User Interface, Default Settings

5. Once connected the SX1212SKA shows the default configuration of the SX1212 register settings upon power-up (as shown in *Figure 6*).

TEC

6. The settings for communication between SX1212SKA and SX1230 SKA are located on the installation CD-ROM provided with the kit. Use the File > Open from the menu bar, or the open short-cut button to load a configuration file.



- 7. Load the "434\_SX1212\_pingpong.cfg" file from the "SX1212 Demo Files" folder on the CD-ROM.
- 8. The display will then appear as shown in Figure 7. These are the link parameters which match those which will be programmed to the SX1230SKA.

<b>5</b> SX1212 Starter Kit A													
File Help													
😂 🛃   👁													
McParam   IrgParam   R	xParam   TxParam	0scPa	aram   Pa	cket				Register	Addr	Value	Register	Addr	Value
Band:	400-440	₹ мн	z					McParam1	0x00	0x2F	RxParam1	0x10	0xA3
Subband	Ath quarter	Ę						McParam2	0x01	0x24	RxParam2	0x11	0x38
								FDev	0x02	0x07	RxParam3	0x12	0x18
VCO trim:	+180	▼ mV						BitRate C coeff	0x03	0x01	Res19	0x13	0x04
Modulation scheme:	FSK	-						BitRate D coeff	0x04	0x7F	RssiValue	0x14	0x8A
OOK thres type:	Peak	-	Tava	at DE framework	. 42400000	- G.		RegMcParam6	0x05	0xC6	RxParam6	0x15	0x00
Data mode:	Continuouo	-	Taly	et nr nequency	1, 143400000	112	_	RegR1	0x06	0x6B	SyncByte1	0x16	0xAA
D'ala mode.	Conanaous	2			• 1	0	2	RegP1	0x07	0x2A	SyncByte2	0x17	0x0A
IF gain:	0	✓ dB	_	1.0.0 4	1 1 1		_	RegS1	0x08	0x1E	SyncByte3	0x18	0x0B
Fdev:	50000	Hz	H:				13	RegR2	0x09	0x77	SyncByte4	0x19	0x0C
Bitrate:	25000	bps	-	(a.) i i	1.1.1.1			RegP2	0x0A	0x2F	TxParam	0x1A	0x72
006 8	20		P:		42		47	RegS2	0x0B	0x19	OscParam	0x1B	0xBC
OOK HOUL MIES.	12.0	- uo					-	FIFO size - tresh	0x0C	0x0F	PktParam1	0x1C	0x02
Low Power Rx:	C ON @	OFF	S:		30	Û 3	25	IrgParam2	0x0D	0x00	NodeAddr	0x1D	0x00
PA ramp:	23	🕶 us		1700	1.6.1.6			IrgParam3	0x0E	0x0B	PktParam3	0x1E	0x60
5								RssilrqThres	0x0F	0x00	PktParam4	0x1F	0x00
Ger	ieral				Rx		Con	trol					
Band:	400-440	MHz	Passive	e filter fc:	378000	Hz		erating mode	— i r	Registers	config	-BSSI-	
RF frequency:	434000000	Hz	Butterw	vorth fc-fo:	100000	Hz		12			Write		
Modulation scheme:	FSK		Polyph	ase fo: 🗖	100000	Hz		C Sleep		-		1	38 🕥
Frequency Deviation:	50000	Hz			Тя		•	Standby C Synthe	sizer		Read		Bead
Bitrate:	25000	bps	Interpo	lator filter fc:	200000	Hz	0	Receiver C Transm	hitter	Ī	Reset		
Operating mode:	STANDBY		Output	power:	10	dBm				1.00			

Figure 7. The New SX1212 Configuration: Ready to be Written

9. By clicking on the write button in the 'Registers config' section, the new register values are written to the SX1212 registers. If successful, the red values in the hexadecimal register summary table will turn black. As a double check, the register read button may be pressed – the values presented on the user interface should remain unchanged.

- Register	rs config	
	Write	
	Read	
	Reset	

10. Click on the 'Packet' tab to access the packet testing portion of the program. Within this window a pre-defined packet structure is already configured. It remains simply to click the 'Reception' radio button and press the Start button. At this point the SX1212SKA enters packet receive mode and is now listening for valid packets. At this juncture the SX1230SKA transmitter must be configured.

ИТЕСН

File Help												
3 🗐 🗠												
deParam LitraPara	m   BxParam   TxParam	l OscPa	ram Packet				Desister	ALL	Walue	Desister	Adda	Makas
- Packet configur	ation	1 0301 0	ian i seco I				negister	Addr	Value	negister	Addr	Value
Preamble Su	ne size Sune tol I	ormat	åddress Filter	DC free	CBC		McParami M-D2	0200	0x2F	FixParami	0110	0,20
r roumbre ay	Ino size ogno tor	onnoc	1	Denec	GIIG		MCParamz	0x01	0x24	DuParam2	0,12	0,19
Abutes TAb	utes Y Obit Y 1	(ed		🔲 Manchester 🛛	🗖 CRC		DidDate C coeff	0x02	0.07	Des19	0,42	0410
# Dytes 11 4 0	ytes To bit T	ength 0602	lou m	🗖 Whitening 🛛	🔽 Auto Cle	ar	Diffiate C coeff	0x03	0475	DesNalue	0813	0x04
		UNDZ					Dimate D coeff	0.05	Dutte	Dispanse C	0814	0,00
Packet							DeeD1	0.00	GUED	CurreDate1	0.4C	0x00
Preamble	Sync	ength	Address	Message	CRC		Des D1	0x00	0x00	Syncoy(e)	0x10	DuBA
55-55-55-55	AA-0A-0B-0C						DeeC1	0x07	OwiE	Syncoytez CumeDute?	0.17	DUOR
	10 N						nego i	0,00	0.77	Syncoytes CussBalad	0,30	0x00
Message	HEYADECIM	A1		ASCII			RegD2	0x03	0.25	TuDayam	0.13	0x00
00	TIEAMDECIM	46				тШ	DogC2	0.0P	0,219		ALX0	DuBC
						-	FIEO size book	0.00	DURE	DkiDaram1	0.410	0,00
					*	1	In Daram?	0x0C	0x01	NodoAddr	0x1C 0u1D	0x02
							IraParam2	DUDE	0x00	DktDaram2	0.45	0000
Transmition	Reception S	top		Rx packet	ts:	0	DesileaTheas	0x0E	0.00	PhiDaram4	0,15	0,00
	1	1		The second secon			nssingrmes	OXOF	0,000	FKIF di dilli 4	UXIE	10,000
	General	10000		Rx		Con	Iol					
and:	400-440	MHz	Passive filter fc:	37800	DO Hz	[ Dp	erating mode		Registers o	onfig	RSSI	
F frequency:	43400000	Hz	Butterworth Ic-Io:	1000	UU Hz		C Sleen			Write	<b></b>	-
odulation scheme	FSK	1000	Polyphase to:	1000	BU Hz	G	Standhu C Suntha	iner:		Read		35 🌚
equency Deviatio	n: 50000	Hz	1.	1x		2	Baasiaa C	SIZGI -	-	inclu-	F	Read
itrate:	25000	bps	Interpolator filter fc:	2000	UU Hz	300	neceiver 🍤 Fransm		_	Reset		
perating mode:	STANDBY		Uutput power:		U dBm						1	

Figure 8. The SX1212SKA User Interface whilst in Packet Receiver Mode

#### 4.2 SX1230SKA Quick Start

- 1. Plug the SX1230SKA into the USB port of the computer.
- 2. Run the SX1230 User Interface software Start > All Programs > SX1230SKA > SX1230SKA
- 3. The SX1230SKA should connect automatically to the User Interface Software. If not, then click on the USB connect short-cut button, located in the top left hand corner of the window.

	1		40
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4. Once connected the SX1230SKA shows the default configuration of the SX1230 register settings upon power-up (see *Figure 9*).

File Help												
j 🖌 🖌												
General [1] General [2]	EEPROM mode	MCU me	ode				Register	Addr	Value	Register	Addr	Value
BE frequency	9150000	00 Hz	PU Lock:				Mode	0x00	0x10	VcoCtrl3	0x0D	0x00
Modulation tune:	G ESK (	OOK	PLL calibration done:	6			BrMsb	0x01	0x1A	VcoCtrl4	0x0E	0x00
modulation type.	Term		FLL Calibration done.				BrLsb	0x02	0x0B	ClockCtrl	0x0F	0x05
Modulation shaping [BT]:	OFF	<u> </u>	PLL calibration UK:	<b>1</b>			FdevMsb	0x03	0x00	Eeprom	0x10	0x1
Bitrate:	48	00 bp:	PLL divider:	Auto	-		FdevLsb	0x04	0x52	ClockSel	0x11	0x0
Frequency deviation:	50	05 Hz	PLL calibration:	Trigger	1		FrfMsb	0x05	0xE4	EolCtrl	0x12	0x0
Dames Asselfas	DAI	=		10			FrfMid	0x06	0xC0	PaOcpCtrl	0x13	0x1
Power Ampliner.	IFAI	<u> </u>	EEFROM Section size.	10	<u> </u>		FrfLsb	0x07	0x00	Unused	0x14	0x0
Output power:	13	dBi	n Twakeup:		0 m	IS	PaCtrl	0x08	0x3F	Unused	0x15	0x0
PA ramp rising time:	40	🕶 us	Battery EOL:				PaFskRamp	0x09	0x08	Unused	0x16	0x0
RC oscillator:	C ON G	OFF	EOL:	C ON (	• OFF	i I	PliStat	0x0A	0x18	PerDivider	0x17	0x0
	XTAL/32	Ţ	EOL tring	1.835	T v		VcoCtrl1	0x0B	0x00	BtnDeb	0x18	0x0
Ectore a la source.	CONG		LOC diffe	1.000	·		VcoCtrl2	0x0C	0x00			
Button debounce timer:	30	▼ ms	XTAL frequency:	32000	1000 H	z	Mode C EEPROI	M®	мси	Control Operating m	ode Sleep	
Överv	iew		Overv	/iew	N.		Ove	rview	. W	•	Standby	
and	862-1020	MHz	Power Amplifier	PA1		Ext	ernal clock		OFF	с (	Synthesizer	
F frequency	915000000	Hz	Output power	13	dBm	PLL	. lock		۲		Transmitter	
fodulation type	FSK		PA ramp rising time	40	us	PLL	. Calibration done			- Registers co	nfia	
todulation shaping	OFF		Operating mode	STANDBY		PLL	. Calibration OK				-10 - 22	
litrate	4800	bps	RC oscillator	OFF	COMP.	Bat	tery EOL			Write	B	ead
requency Deviation	5005	Hz	CLKOUT source	XTAL/32	Hz	Btn	debounce timer		<b>30</b> r	ns		

Figure 9. SX1230 User Interface, Default Settings

 The settings for communication between SX1212SKA and SX1230SKA are located on the installation CD-ROM provided with the kit. Use the File > Open from the menu bar, or the open short-cut button to load a configuration file.

File	Help

- 6. Load the "434\_SX1230\_pingpong.cfg" file from the "SX1230 Demo Files" folder on the CD-ROM.
- 7. The display will then appear as shown in Figure 10. These are the link parameters which match those which will be programmed to the SX1212SKA.

File Help												
🧉 🖬 I 🐵												
General [1] General [2] E	EPROM mode	MCU mo	ode				Register	Addr	Value	Register	Addr	Value
BE frequency:	908000	00 Hz	PLL Lock:	0			Mode	0x00	0x30	VcoCtrl3	0x0D	0x19
Madulatian tura	G TOK O	0.00	DLL sellestion den				BrMsb	0x01	0x05	VcoCtrl4	0x0E	0x10
modulation type.	Fak t		FLL calibration don	e. 🔛			BrLsb	0x02	0x00	ClockCtrl	0x0F	0x07
Modulation shaping [BT]:	OFF	-	PLL calibration OK:	· · · · · · · · · · · · · · · · · · ·			FdevMsb	0x03	0x03	Eeprom	0x10	OxOF
Bitrate:	250	00 bps	PLL divider:	Auto	•		FdevLsb	0x04	0x33	ClockSel	0x11	0x0
Frequency deviation:	499	88 Hz	PLL calibration:	Tric	ider		FrfMsb	0x05	0xE3	EolCtrl	0x12	0x13
David Analitan	DA1. DA2	<u>च</u>	FEDDON	15			FrfMid	0x06	0x00	PaOcpCtrl	0x13	0x1
Power Ampliner:	PAT+ PAZ	<u> </u>	EEPHUM section s	ize:   15			FrfLsb	0x07	0x00	Unused	0x14	0x0
Output power:	13	✓ dBr	n Twakeup:		0	ms	PaCtrl	0x08	0x7B	Unused	0x15	0x0
PA ramp rising time:	40	• us	Battery EOL:				PaFskRamp	0x09	0x08	Unused	0x16	0x0
RC oscillator:	C ON G	OFF	EOL:	C ON	. OF	FF	PIIStat	0x0A	0x38	PerDivider	0x17	0x0
CLKOUT source:	IDEE	হা	EOL trim:	1.835	-	v	VcoCtrl1	0x0B	0x11	BtnDeb	0x18	0x0
CENCOT Source.	C ON G		LOC um.	11.000	<u> </u>	v	VcoCtrl2	0x0C	0x15			
Button debounce timer:	30  30	▼ ms	XTAL frequency:	33	2000000	Hz	Mode C EEPRO	IM @	мси	Control Operating m	ode Sleep	
Overvi	iew		0	verview			Ûve	erview		O	Standby	
Band	862-1020	MHz	Power Amplifier	PA1+ P	A2		External clock		OFF	0	Synthesizer	
RF frequency	908000000	Hz	Output power		13 dBm		PLL lock		0	•	Transmitter	
fodulation type	FSK		PA ramp rising time	3	40 us		PLL Calibration done			- Begisters co	nfia	
Iodulation shaping	OFF		Operating mode	TRANSMITTI	R		PLL Calibration OK		۲		11.000	
Bitrate	25000	bps	RC oscillator	0	FF		Battery EOL		۲	Write	B	ead
Frequency Deviation	49988	Hz	CLKOUT source	0	FF   Hz		Btn debounce timer		<b>30</b> r	ns		

Figure 10. The New SX1230 Configuration: Ready to be Written

8. By clicking on the write button in the 'Registers config' section, the new register values are written to the SX1230 registers. If successful, the red values in the hexadecimal register summary table will turn black. As a double check, the register read button may be pressed – the values presented on the user interface should remain unchanged.

Control
Operating mode
C Sleep
C Standby
C Synthesizer
<ul> <li>Transmitter</li> </ul>
Registers config
Write Read

9. Once successfully configured, the SX1230 must be placed in packet transmission mode. This is done by selecting the 'MCU mode' tab – note that a pre-configured frame format identical to that for the SX1212SKA is already entered into the display. It suffices simply to click on the 'Start' button to begin continuous transmission of this frame. For clarity a screenshot illustrating the display during transmission is shown in Figure 11.

ЛЕСН

File Help												
3 🛃 🗠												
ieneral [1] Genera	I [2] EEPROM mode	MCU mo	de				Register	Addr	Value	Register	Addr	Valu
Packet configurati	on		¢.			-	Mode	0x00	0x30	VcoCtrl3	0x0D	0x15
Preamble size	Sync size	Length	Address field	Whitening	CRC		BrMsb	0x01	0x05	VcoCtrl4	0x0E	0x1
4 👻	4 👻 Fix	ed	OFF 💌	OFF OF	F 💌		BrLsb	0x02	0x00	ClockCtrl	0x0F	0x0
	Sync word	Length	Address	da <del>tan</del> ilda		-	FdevMsb	0x03	0x03	Eeprom	0x10	0x0
	AA-0A-08-0C	0x02					FdevLsb	0x04	0x33	ClockSel	0x11	0x0
	Construction and the second second					_	FrfMsb	0x05	0xE3	EolCtrl	0x12	0x1
Packet		10 - 20 -	1. 2898	17 22 17 112 11			FrfMid	Dx06	0x00	PaOcpCtrl	0x13	0x1
Preamble	Sync word	Length	Address	Payload	CRC		FrfLsb	0x07	0x00	Unused	0x14	0x0
55-55-55-55	AA-UA-UB-UC						PaCtrl	Dx08	0x7B	Unused	0x15	0×0
Payload							PaFskRamp	0x09	0x08	Unused	0x16	0x0
	HEXADECIM	4L		ASCII			PliStat	0x0A	8x38	PerDivider	0x17	0x0
48 49				HI	-		VcoCtrl1	0x0B	0x12	BtnDeb	0x18	0x0
							VcoCtrl2	0x0C	0x16			
1	S	top	Repeat value:	0 Tx Packets:		85	Mode C EEPROI	v e	MCU	Control	ode Sleep	
1	Dverview			Overview			Ove	rview	11	0	Standby	
land	862-1020	MHz	Power Amplifier	PA1+ PA	2	Ext	ernal clock		OFF	C	Synthesizer	
IF frequency	90800000	Hz	Output power	1	3 dBm	PL	_ lock		0	0	Transmitter	
fodulation type	FSK		PA ramp rising time	4	0 us	PL	_ Calibration done		۲	- Benisters on	ofia	
Iodulation shaping	OFF		Operating mode	TRANSMITTE	R	PL	_ Calibration OK		۲		1	
Bitrate	25000	bps	RC oscillator	OF	F	Ba	tery EOL		١	Write	R	ead
requency Deviation	49988	Hz	CLKOUT source	OF	F Hz	Btr	debounce timer		<b>30</b> r	ns		

Figure 11. SX1230 During MCU Mode Packet Transmission

#### 4.3 Link Test

With both devices configured as described in the preceding two sections, reception of valid packets by the SX1212 should be visible. Note that during link testing be sure that the USB kits are separated by several cm. Note also, that it is possible to install the SX1212SKA user interface on one machine and the SX1230SKA user interface on another allowing range test evaluation with full control over the link parameters.

Where a pair of computers is not available, the SX1230SKA can be configured in stand alone mode. Please see the next section for a quick start guide on operation of the SX1230SKA in this mode.



## 5 Quick Start Guide: Stand Alone Mode

#### 5.1 SX1212SKA Configuration

Initiation of the SX1212SKA for operation in Stand Alone Mode is identical to that described in Section 4.1. Please configure the SX1212SKA as described therein and refer to the following section for configuration of the SX1230.

#### 5.2 SX1230SKA Configuration

There are a few simple steps to follow to configure the SX1230SKA for stand alone mode operation. Figure 12 shows both top and bottom views of the SX1230SKA hardware. The SX1230SKA companion EEPROM comes preprogrammed with a band specific configuration file already loaded.

1. Insert the CR2032 button cell into the cell holder (1), taking care to respect the polarity. Note that there is some quiescent current drain caused by the USB interface, so to maximise battery life ensure this is removed when not in use.

2. Three of the four push buttons (labeled 0 to 3 on the PCB silkscreen) are connected to the general purpose digital inputs of the SX1230. The button labeled 3 is configured as a reset button. Push this button following connection of the cell. There should now be no LEDs illuminated on the SX1230SKA.



Figure 12. Hardware for E<sup>2</sup>PROM (Stand Alone) Operation

3. The SX1230SKA is not ready to be used in conjunction with the SX1212SKA in frame reception mode, as described in Section 4.1.



#### 5.3 Link Test

Each push button has the same payload mapped to it. Push button 0 transmits this single, standard format frame, once. Push button 1 has a demonstration of packet repetition. Here the packet is programmed to be resent five times. Note that the SX1212SKA may not receive all five frames successfully. This is due to the time required to empty the FIFO, whereas SX1230 will transmit all five frames in quick succession. Finally, push button 2 gives a demonstration of periodic mode. Here the frame is configured to repeat several times a second whilst the push button is held down.

To modify the  $E^2PROM$  contents please see Section 6.7. Note also that the original quick start configuration is included on the CD. Please also refer to Section 6.7 on how to load a non-volatile memory configuration file and program the  $E^2PROM$ .

Otherwise, guidance for performing link testing is the same as that already given in Section 4.3.



## 6 SX1230SKA Software Description

#### 6.1 Overview

Figure 13 shows the SX1230SKA graphical user interface (GUI). Each of the numbers surrounding the display corresponds to the Chapter within this section gives the description of that feature.

- File Hale												- 101
- ric rep												
- General [1] General [2]	EEPROM mode	MCU m	ode			1	Register	Addr	Value	Register	Addr	Value
RE hera woorv	915000	00 Hz	PHLIcock			M	ode	0.00	0x10	VcoCtrl3	0x00	0x00
Herbickering.	C DY C	0.00	Children days			Br	Msb	0x01	0x1A	VcoCtri4	0x0E	0x00
Modulation type.	It Port I	UUK	PLL calbration done.			Br	Lsb	0x02	0x08	ClockCtrl	0x0F	0x05
Modulation shaping [B1	3 [OFF	-	PLL calibration DK;			Fe	levMsb	0x03	0x00	Eeprom	0x10	0x10
Bitrate:	- 46	00 bp	s PLL divider:	Auto		Fe	devLsb	0x04	0.52	ClockSel	0x11	0.00
Frequency deviation:	50	05 Hz	PLL calibration	Trigge		Fr	fMsb	0x05	0xE4	EolCul	0x12	0x02
Present Ameridian	[PA1	ন	FEPROM section size	16	-	Fr	fMid	0x06	0xC0	PaOcpCtd	0x13	0x11
T OTHER PROPERTY.	Les.	불고				Fr	fLsb	0x07	0x00	Unused	9x14	0x00
Output power:	13	<u> </u>	m Twakeup:	1	0 11	n Pa	aCtrl	0x08	0x3F	Unused	0x15	0x00
PA ramp rising time:	40	• US	Battery EOL:	9		Pa	aFskRamp	0x09	0x08	Unused	0x16	0.00
RC oscillator:	C DN G	OFF	EOL:	C ON	OFF	P1	lStat	0x0A	0x18	PerDivider	0x17	0x00
CLKOUT source:	XTAL/32	-	EOL trim:	1.835	- v	Ve	coCtrl1	0x08	0x00	BtnDeb	0x18	0x03
External clock:	CONG	OFF		1.1/00	1000	Ve	coCtil2	0x0C	0.00			
Button debounce timer	30	<b>• • •</b>	XTAL hequency.	3200	0000 н	z Mi	ode C EEPRO	м	мси	Control Operating m	ode Sieep	-
- 0ve	rview		Over	view			Ūve	rview			Standby	
Band	862-1020	MHz	Power Amplifier	PA1		External	clock		OFF	C	Synthesizer	
RF frequency	915000000	Hz	Output power	13	dBm	PLL lock				C	Transmitter	
Modulation type	FSK		PA ramp rising time	40	ut	PLL Cal	bration done		0	Begisters co	rho	
Modulation shaping	OFF		Operating mode	STANDBY	-	PLL Cal	bration DK		۲		1	and the second
Bitrate	4800	pbt	RC oscillator	OFF		Battery I	OL		.0	Write	F	lead
Frequency Deviation	5005	Hz	CLKOUT source	XTAL/32	Hz	Bin deb	bunce timer		30 mi	<u> </u>		
					1 Conto	a Filet -						

Figure 13: SX1230SKA GUI Overview and References to the User Guide Description of this Chapter.

#### 6.2 File Menu

File	Help	
	Disconnect	
	Open Config	
	Save Config	
9	Save Config As	
	Exit	

File menu contains some general purpose functions. The first feature in the list provides the possibility of connecting or disconnecting to the USB kit. Care must be taken to ensure that the USB port is closed before unplugging the USB kit. This functionality may also be accessed through the short cut buttons (see Section 6.3).

The possibility of opening configuration files and saving the present configuration is also provided. This is done through a standard Windows file dialog box.

The Help menu contains two menu items. The first item provides a link to this user guide in PDF format. The second, 'About SX1230 Starter kit...', gives information in the revision of the software installed.

File	Hel	P	
i 💕 🕻	User's Guide…		
Gene	2	About SX1230 Starter Kit	



#### 6.3 Shortcut Buttons

The shortcut buttons provide identical functionality to those listed under the file menu



The configuration 'file open' shortcut button. This opens a windows file dialog box to allow access to previously saved SX1230 register configuration files.



The 'save' configuration file shortcut button immediately saves and overwrites the existing configuration file.



The 'connect / disconnect' button allows the user to manage manually connection and disconnection of the kit. Note that any time the SX1230SKA is to be removed from the system; the kit must first be disconnected.

The saved configuration files are designed to be a useful tool for embedded software development. The file can be opened in any text editor to display the programmed register name, address and hexadecimal value programmed to that address.

📕 915_5X1230	)_pingpor	ng.cfg - Noter	oad		
<u>File E</u> dit F <u>o</u> rm	iat <u>V</u> iew	<u>H</u> elp			
#Type Reg REG Moo REG BrN REG Fde REG Fde REG Fde REG Fde REG Pac REG Pac REG Pac REG VCC REG VCC REG VCC REG VCC REG Clo REG Clo REG Eep REG Clo REG Eo REG Eo REG Eo REG Eo REG Unu REG Unu REG Unu REG Unu REG Pac	gister de 4sb -sb evMsb =wLsb =mid =Lsb =trl =skRamp lstat poctrl2 poctrl2 poctrl3 poctrl4 pocksel lctrl sed used used used used ij;0;0	Name Ac 0> 0> 0> 0> 0> 0> 0> 0> 0> 0> 0> 0> 0>	ldress[Hex] 00 01 02 03 04 05 06 07 08 09 00 00 00 00 10 11 12 13 14 15 16 17 18 0B-0⊂;2;0;48,4	Value[Hex] 0x30 0x05 0x00 0x33 0xE3 0x00 0x7B 0x08 0x18 0x12 0x16 0x19 0x12 0x16 0x19 0x12 0x16 0x19 0x12 0x16 0x19 0x12 0x10 0x07 0x07 0x07 0x07 0x07 0x07 0x07	X

Figure 14. Example Text Editor Output of the SX1230 Configuration File



#### 6.4 General Configuration Tabs

For clarity and ease of use the general configuration settings have been split between two tabs.

#### 6.4.1 General [1]

The most commonly used configuration parameters are located on the General [1] tab. Each field is directly editable by the user and is refreshed every time a register read or write is performed.

General [1] General [2] EEI	PROM mode MCU mode		
RF frequency:	915000000 Hz	PLL Lock:	
Modulation type:	⊙ FSK € OOK	PLL calibration done:	
Modulation shaping [BT]:	OFF 💌	PLL calibration OK:	
Bitrate:	4800 bps	PLL divider:	Auto 💌
Frequency deviation:	5005 Hz	PLL calibration:	Trigger
Power Amplifier:	PA1 💌	EEPROM section size:	16 💌
Output power:	13 <b>T</b> dBm	T wakeup:	0 ms
PA ramp rising time:	40 💌 us	Battery EOL:	
RC oscillator:	○ ON ④ OFF	EOL:	C ON 🖲 OFF
CLKOUT source:	XTAL/32 💌	EOL trim:	1.835 💌 V
External clock:	○ ON ④ OFF		
Button debounce timer:	30 <b>T</b> ms	XTAL frequency:	32000000 Hz

Figure 15. The General Configuration Tab Features the most Commonly Used Configuration Parameters

Where the data entry field allows direct keyboard entry, the following background highlight conventions are used to aid the user in their choice of programmed value:

RF frequency:	915000001 Hz
RF frequency:	1915000000 Hz

An orange background highlight indicates that the precise value entered into the data entry field is not directly addressable by the SX1230. Instead the closest (rounded) value will be used.

Conversely a red background highlight indicates where the maximum or minimum value for that register parameter has been exceeded.

Each data entry field and user control of the General [1] tab is described below.

#### **RF Frequency**

RF frequency:	915000000 Hz	The RF frequency field accepts a numerical text input from the keyboard. Values in any one of the three frequency bands from 290 to 1020 MHz are permitted. Please note that the entry units are Hz.
Modulation Type		
Modulation type:	● FSK ● OOK	they are selectable through the user interface by clicking with the mouse on the appropriate radio button.
Modulation Shaping		
Modulation shaping [BT]:	OFF	The Tx bit-stream may be pre-filtered before modulation. Varying strengths of filtering are accessible. The filter type also depends upon the type of modulation used. Filter coefficients are selectable from a drop-down menu.
Bitrate		
Bitrate:	4800 bps	The bit rate of the transmitted signal (in bps) can be directly edited in this data entry field.
Frequency Deviation		Text entry field for the frequency deviation when using
Frequency deviation:	5005 Hz	FSK modulation.
Power Amplifier		- Selection of single (low newer) or dual (high newer)
Power Amplifier:	PA1 💌	operation. Note that PAs 1 and 2 must be enabled for +17 dBm operation.
Output Power		
Output power:	13 💌 dBm	The output power is selectable from a drop down list in the programmable 1 dB increments.
PA Ramping		
PA ramp rising time:	40 💌 us	The PA ramp rise time is selectable from the list of programmable values.
Oscillator		
RC oscillator:	○ ON ⊙ OFF	Although not directly accessible from the SX1230SKA, for completeness, the source of the clock output signal
CLKOUT source:	XTAL/32 💌	can be selected and its frequency altered in accordance with the range of programmable divider values. For
External clock:	C ON C OFF	more information please consult the SX1230 datasheet.

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#### **Push Button Debouncer**

Button debounce timer:	30	💌 ms

The four general purpose digital inputs – here connected to the four push buttons – has a variable debounce timer. Several common values are accessible from a drop down menu.

## PLL Lock Detection Parameters

FLL LUCK.	
PLL calibration done:	9
PLL calibration OK:	9
PLL divider:	Auto 💌
PLL calibration:	Trigger

Three LED type indicators display the status of the SX1230 following the last register read cycle of the SX1230. Various options exist for changing the PLL divider ratio and triggering PLL calibration. Please consult the SX1230 datasheet for a more detailed description.

#### **E<sup>2</sup>PROM Mode Parameters**

EEPROM section size:	16	•
T wakeup:		0 ms

These two register settings are used to determine the size of each section in the  $E^2$ PROM memory and the wake-up time if periodic mode is enabled respectively. Please see Section 6.7, in conjunction with the SX1230 datasheet, for a description of how to use these  $E^2$ PROM parameters.

#### Low Battery Detection Parameters

Battery EOL:	
EOL:	○ ON ⊙ OFF
EOL trim:	1.835 💌 V

The battery end of life (EOL) indicator is set if the EOL is enabled (here controlled by a radio button input) and the supply voltage passes the corresponding threshold – EOL trim.

#### **Crystal Frequency**

XTAL frequency:	32000000 Hz	

Most of the programmable communication setting parameters are a function of the crystal frequency used. This field allows other crystal frequencies to be tried, however, the SX1230SKA comes fitted with a 32 MHz crystal. The value should hence not be changed.



#### 6.4.2 General [2]

General [1] General [2] EEPROM mode   MCU mode
PA Overload Current Protection
OCP: ON OFF
DC load current thres: 50 mA

Figure 16. Second Page of the General Configuration Parameters

The second page of general configuration settings (see *Figure 16*) contains the user inputs for enabling of the power amplifier over current protection (OCP) and setting the current limit from a drop down menu. The current limit must be increased to 100 mA or higher for operation of the SX1230 at the maximum output power of +17 dBm.

#### 6.5 Register Hexadecimal Display

Figure 17 shows the register summary of the SX1230. In addition to manual user entry in the fields described in the previous section, direct hexadecimal entries may be made into the register display. Note that values yet to be written to the SX1230 registers appear in red. Note, also, that for full control flexibility, incorrect (red) values entered in the hexadecimal section *will still be written* in the event of a register 'write'. So care must be exercised when editing the hexadecimal values.

Register	Addr	Value	Register	Addr	Value
Mode	0x00	0x10	VcoCtrl3	0x0D	0x19
BrMsb	0x01	0x1A	VcoCtrl4	0x0E	0x1C
BrLsb	0x02	0x0B	ClockCtrl	0x0F	0x05
FdevMsb	0x03	0x01	Eeprom	0x10	0x10
FdevLsb	0x04	0x52	ClockSel	0x11	0x00
FrfMsb	0x05	0xE4	EolCtrl	0x12	0x12
FrfMid	0x06	0xC0	PaOcpCtrl	0x13	0x1B
FrfLsb	0x07	0x00	Unused	0x14	0x00
PaCtrl	0x08	0x3F	Unused	0x15	0x00
PaFskRamp	0x09	0x08	Unused	0x16	0x00
PIIStat	0x0A	0x10	PerDivider	0x17	0x00
VcoCtrl1	0x0B	0x12	BtnDeb	0x18	0x03
VcoCtrl2	0x0C	0x16			

Figure 17. Register Hexadecimal Display

Note that values changed in this portion of the display cause the values in the tabbed configuration section to be changed dynamically.

#### 6.6 Overview Panel

A summary of the values presently entered into the user interface software is shown in the overview display at the bottom of the screen. This covers all of the SX1230 register values, including those not displayed on the tab presently selected, and indicates the true value which will be written to the SX1230 configuration registers.

0,	verview		0,	verview	Overview			
Band	862-1020	MHz	Power Amplifier	PA1		External clock	OFF	
RF frequency	915000000	Hz	Output power	13	dBm	PLL lock		
Modulation type	FSK		PA ramp rising time	40	us	PLL Calibration done	۲	
Modulation shaping	OFF		Operating mode	STANDBY		PLL Calibration OK	۲	
Bitrate	4800	bps	RC oscillator	OFF		Battery EOL		
Frequency Deviation	5005	Hz	CLKOUT source	XTAL/32	Hz	Btn debounce timer	30	ms

Figure 18. The Configuration Overview Display

#### 6.7 E<sup>2</sup>PROM Mode Tab

The E<sup>2</sup>PROM mode tab is used to configure the contents of the E<sup>2</sup>PROM for stand alone mode operation of the SX1230SKA. In this mode the SX1230 acts as SPI master and can download both configuration and payload information from an SPI E<sup>2</sup>PROM. The E<sup>2</sup>PROM memory map is shown below:



Figure 19. E<sup>2</sup>PROM Memory Mapping

The bottom 0x4C locations in the E<sup>2</sup>PROM are reserved general configuration information – configuration which is the same for every button press. The subsequent sections are then mapped to the remaining 15 possible combinations of the 4 digital inputs (for mapping details please see the SX1230 datasheet). These may contain either i) solely payload or ii) a combination of supplementary configuration information and payload.



Ger	neral [1]   General [2]	EEPROM mode MCU mod	e						
FG	enral Configuration Se	ction	But	tons Section					
			Sec	:tion #: 🛛 🛨					
	RegMode	False 🔺	E I	RF Frequency [Hz]	0, False				
	RegBrMsb	True	E I	Modulation type	FSK, False				
	RegBrLsb	True	( E	Bitrate [bps]	0, False				
	RegFreqDMsb	True	E I	Frequency deviation	0, False				
	RegFreqDLsb	True	E I	Power Amplifier	PA1, 13, False				
	RegRfFreqMsb	True	E ·	T wakeup [ms]	0, True				
	RegRfFreqMid	True	E I	Packet	1,55555555AA0A0B0C				
	RegRfFreqLsb	True							
	RegPaCtrl	True							
	RegPaEskBamp	False							
If N	tegMode true the Mode register VM.	Frequency [Hz]							
	Write	Read		Write	Read				
	Write Read 💿 Normal view 🛇 Raw view								

Figure 20. The E<sup>2</sup>PROM Mode Tab 'Normal View'

The E<sup>2</sup>PROM mode display is broken down into two types, selectable by the radio button control in the bottom right hand corner of the display. The default is 'Normal view' which shows the E<sup>2</sup>PROM contents in human readable format (see Figure 20). The left hand 'General Configuration Section' dictates which registers are to be written to the general configuration section – True indicating that the value will be written, False that it will not. The values written to the configuration section are taken from the General setting tabs of Sections 6.4.1 and 6.4.2. The general configuration settings may be read or written independently of the rest of the E<sup>2</sup>PROM contents by clicking the Read or Write button within the section.

The rightmost frame contains the contents of each of the input specific sections. The contents of a particular section are displayed individually. The section may be changed by entering the desired section in the 'Section #:' input. Several useful common parameters and the payload itself are listed within the 'Buttons' section. Each can be edited directly. The input specific section of the E<sup>2</sup>PROM memory can be written or read independently of the rest of the E<sup>2</sup>PROM contents by clicking on the write or read button within the Buttons Section.

At the bottom of the display are the controls for global read or write of the E<sup>2</sup>PROM contents. These cause the whole E<sup>2</sup>PROM to be read or written, respectively.

The radio button control in the bottom right hand corner allows selection between Normal and Raw views of the E<sup>2</sup>PROM contents.

An alternative perspective of the  $E^2PROM$  contents is available in 'Raw view', illustrated in Figure 21. Here we see the  $E^2PROM$  contents in hexadecimal (centre column) and ASCII (right column) versus the  $E^2PROM$  address in hexadecimal (left column) in tabular format. Note also the addition of several short-cut buttons. These allow the user to save or recall  $E^2PROM$  (.NVM – non volatile memory) files to or from disc storage. Copy, cut and paste functionality is also provided.

Once programmed the SX1230 may be disconnected from the USB port, unplugged and used in stand-alone mode. The SX1230SKA comes pre-programmed with an example E<sup>2</sup>PROM contents (see the quick start Section for more details).



Gen	eral (	1][	Gen	neral	[2]	EEF	RO	M mo	ode	мо	:Um	ode							
1	; 🖬		X		2														
000	0	81	05	82	00	83	03	84	33	85	D9	86	00	87	00	88	ЗF		
001	.0	8A	18	8F	07	90	OF	93	10	97	00	FF	FF	FF	FF	FF	FF	<u>99999</u> 9	
002	20	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	<del>yyyyyyyyyyyyyyyyy</del>	
003	30	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	<del>yyyyyyyyyyyyyyyy</del>	
004	10	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	97	00	95	<del>ŸŸŸŸŸŶŶŶŶŶŶŶŸ</del>	
005	50	01	OA	55	55	55	55	AA	OA	0B	OC	20	00	97	00	95	OA	<del></del>	
006	50	ΟA	55	55	55	55	AA	OA	OВ	oc	20	00	97	28	95	01	OA	.0000ª (	
007	70	55	55	55	55	AA	OA	OB	oc	20	00	97	28	95	OA	OA	55	UUUUª(U	
008	30	55	55	55	AA	OA	OB	oc	20	00	95	00	oc	FF	FF	FF	FF	UUUªÿÿÿÿ	
0.09	90	FF	FF	FF	FF	FF	FF	FF	FF	95	00	oc	FF	FF	FF	FF	FF	<u> </u>	
0 O.A	10	FF	FF	FF	FF	FF	FF	FF	95	00	OC	FF	FF	FF	FF	FF	FF	<u> </u>	
OOE	30	FF	FF	FF	FF	F F	FF	95	00	00	FF	FF	FF	FF	FF	FF	FF	<u> </u>	
000	:0	FF	FF	FF	FF	FF	95	00	00	FF	FF	FF	FF	FF	FF	FF	FF	<u> </u>	
	0	FF.	FF FF	F.F.	F.F.	95	00	UC	FF	FF	FF	FF FF	FF FF	FF	FF FF	FF	FF FF	<u> </u>	
UUE OOF	Ω 20	FF	FF	FF OF	95	64	UC	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	$\lambda \lambda \lambda \cdot \sigma \cdot \lambda $	
0.00	0	r r 777	PP OF	95	00	UL PP	rr vv	rr rr	rr rr	rr rr	rr rr	rr rr	rr rr	rr rr	FF	rr vv	rr rr	<u> </u>	
010	0		95	00	UL PP	rr rr	rr rr	rr RR	rr RR	FF	rr RR	rr rr	rr rr	rr RR	FF	rr rr	P P	Y YYYYYYYYYYYYY	
011	20	95 00	00	77	r f 77	r f 77	r f 77	rr TT	r r 77	r r 77	r r 777	r r 77	r f 77	r r r r	r f 77	11	75 00	<u>УУУУУУУУУУ</u> -	-
																		Ln 1 Col 1	
									_				_			_			
										Wri	te			Rea	d		0	Normal view 💿 Raw vie	w

Figure 21. E<sup>2</sup>PROM Raw View

General [1]	Ge	eneral	[2]	EEPROM mode	мс
i 💕 📕	¥	þ	2		

Figure 22. E<sup>2</sup>PROM Raw View Short-cut Buttons

#### 6.8 MCU Mode Tab

General [1] Genera	al [2] EEPROM mo	ode MCU mode									
Preamble size	Sync size	Length Fixed	Address field	Whitening	CRC						
	Sync word AA-0A-0B-0C	Length	Address								
Packet											
Preamble	Sync word	Length	Address	Payload	CRC						
55-55-55-55	AA-0A-0B-0C										
Payload	Payload HEXADECIMAL ASCII										
48 49 HI											
Start Repeat value: 0 Tx Packets: 0											

Figure 23. MCU Mode Tab Display

The MCU mode tab allows the user to define a custom packet for transmission by the SX1230SKA. The packet configuration section (top) allows the user enable and set the length of a pulse train preamble (sent at the data rate). A custom syncronisation word of up to 4 bytes may also be added. Fixed or variable length packets may also be stipulated (see the SX1212 datasheet for more information), as may an optional 1 byte address.

With these options entered the constructed packet is shown in the 'Packet' frame. The packet payload may also be edited in either ASCII or hexadecimal. Packet transmission starts when the 'Start' button is pressed. Either infinite transmission (repeat value = 0) or a finite number of packets may be transmitted by editing the repeat value.