

# Embedded Masters EMRF-nRF51-SKY66111: Bluetooth Low Energy Long Range Arduino Shield Evaluation Kit



### **Description:**

The EMRF-nRF51-SKY66111 is an Ardiuno shield compatible board that allows a user with the nRF51 DK to plug in the EMRF-nRF51-SKY66111 shield and have a system that provides Long Range capabilities and work with the Nordic SDK examples without any modifications. The shield consists primarily of a nRF51422(BTLE and ANT capable) and a SKY66111-11. The SKY66111-11 is a Power Amplifier(PA) from Skyworks Inc. and provides up to +10dBm output power. This Long Range shield provides an excellent platform for engineers to evaluate the SKY66111-11 in a Long Range application where greater than +4dBm output is desired from the nRF51. The nRF514222 is 100% compatible with the nRF518222 that is BLE only device.

*Custom Embedded PCB/Software, Wireless/Mobile Applications, and general design services can be provided by Embedded Masters for your own application.* Contact <u>sales@embeddedmasters.com</u>

Want a breakout/evaluation board that Embedded Masters doesn't currently offer please let us know!!



References: nRF51422 Product Specification: https://www.nordicsemi.com/eng/nordic/download resource/20360/9/3824576 nRF51 Reference Manual: http://www.nordicsemi.com/eng/nordic/download resource/20337/12/15668068 nRF51 SDK Download: http://developer.nordicsemi.com/nRF51 SDK/ nRF51 SDK Documentation/Getting Started: http://infocenter.nordicsemi.com/topic/com.nordic.infocenter.sdk51.v9.0.0/nrf51 getting started.html?c p=4 1 0 1

### SKY66111-11:

http://store.skyworksinc.com/PortalProductDetail.aspx?ProdId=520726&IgnoreStatus=True

### **BUY IT NOW!!**

http://www.embeddedmasters.com/ProductDetail/EMRFNRF51SKY66111-Embedded-Masters/574407

### Keil Compiler/IDE, FREE 32kB Limited Version:

http://www.keil.com/arm/mdk.asp

### IAR EWARM, FREE 32kB Limited Version:

http://supp.iar.com/Download/SW/?item=EWARM-EVAL



DESCRIPTION:	Contents:	
REFERENCES:       2         CONTENTS:       3         FEATURES:       4         BLOCK DIAGRAM:       5         ELECTRICAL CHARACTERISTICS SKY66111-11(ABBREVIATED):       6         SKY66111-11 MODE LOGIC TRUTH TABLE       7         PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS: 3.3X3.0X0.8MM 20-PIN MCM PACKAGE.       7         TOP PHOTO:       8         BOTTOM PHOTO:       9         PROGRAMMING/DEBUGGING:       10         CURRENT MEASUREMENT:       11         RADIO TEST APPLICATION:       ERRORI BOOKMARK NOT DEFINED.         TRANSMIT CURRENT VS. OUTPUT POWER:       22         OUTPUT POWER VS. CHANNEL       23         SPURIOUS EMISSIONS MEASUREMENTS:       24         SPURIOUS BEMISSIONS PLOTS:       25         SPURIOUS BEMISSIONS PLOTS:       25         SPURIOUS BEMISSIONS PLOTS:       25         SPURIOUS BEMISSIONS PLOTS:       25         SPURIOUS BEMISSIONS PLOTS:       26         27* HAAMONIC, TX, POWER LEVEL 0.       27         78* HAAMONIC, TX, POWER LEVEL 0.       27         79* HAAMONIC, TX, POWER LEVEL 0.       27         79* HAAMONIC, TX, POWER LEVEL 0.       27         70* HAAMONIC, TX, POWER LEVEL 0.       27         <	DESCRIPTION:	1
CONTENTS:3FEATURES:4BLOCK DIAGRAM:5ELECTRICAL CHARACTERISTICS SKY66111-11 (ABBREVIATED):6SKY66111-11 MODE LOGIC TRUTH TABLE.7PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS: 3.3X3.0X0.8MM 20-PIN MCM PACKAGE.7TOP PHOTO:8BOTTOM PHOTO:9PROGRAMMING/DEBUGGING:10CURRENT MEASUREMENT:11RADIO TEST APPLICATION:ERROR! BOOKMARK NOT DEFINED.TRANSMIT CURRENT VS. OUTPUT POWER:22OUTPUT POWER VS. CHANNEL23SPURIOUS EMISSIONS MEASUREMENTS:24SPURIOUS EMISSIONS PLOTS:25SPURIOUS EMISSIONS PLOTS:25SPURIOUS EMISSIONS PLOTS:25SPURIOUS EMISSIONS PLOTS:25SPURIOUS EMISSIONS PLOTS:25SPURIOUS, TX, POWER LEVEL 0.277* HARMONIC, TX, POWER LEVEL 0.28SCHEMATICS:29SKY66111-11.29SKY66111-11.30SKY66111-11.30SKY66111-11. <t< th=""><th>REFERENCES:</th><th>2</th></t<>	REFERENCES:	2
FEATURES:       4         BLOCK DIAGRAM:       5         ELECTRICAL CHARACTERISTICS SKY66111-11(ABBREVIATED):       6         SKY66111-11 MODE LOGIC TRUTH TABLE.       7         PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS: 3.3X3.0X0.8MM 20-PIN MCM PACKAGE.       7         TOP PHOTO:       8         BOTTOM PHOTO:       9         PROGRAMMING/DEBUGGING:       10         CURRENT MEASUREMENT:       11         RADIO TEST APPLICATION:       ERROR! BOOKMARK NOT DEFINED.         TRANSMIT CURRENT VS. OUTPUT POWER:       22         OUTPUT POWER VS. CHANNEL       23         SPURIOUS EMISSIONS MEASUREMENTS:       24         SPURIOUS EMISSIONS PLOTS:       25         SPURIOUS, TX, POWER LEVEL 0.       26         2 <sup>N®</sup> HARMONIC, TX, POWER LEVEL 0.       27         3 <sup>N®</sup> HARMONIC, TX, POWER LEVEL 0.       28         3 <sup>N®</sup> HARMONIC, TX, POWER LEVEL 0.	CONTENTS:	3
BLOCK DIAGRAM:       5         ELECTRICAL CHARACTERISTICS SKY66111-11(ABBREVIATED):       6         SKY66111-11 MODE LOGIC TRUTH TABLE       7         PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS: 3.3X3.0X0.8MM 20-PIN MCM PACKAGE       7         TOP PHOTO:       8         BOTTOM PHOTO:       9         PROGRAMMING/DEBUGGING:       10         CURRENT MEASUREMENT:       11         RADIO TEST APPLICATION:       ERROR! BOOKMARK NOT DEFINED.         TRANSMIT CURRENT VS. OUTPUT POWER:       22         OUTPUT POWER VS. CHANNEL       23         SPURIOUS EMISSIONS MEASUREMENTS:       24         SPURIOUS EMISSIONS PLOTS:       25         SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW.       25         0.5 *FC SUBHARMONIC, TX, POWER LEVEL 0.       25         SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW.       25         SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW.       25         SPURIOUS MELVEL 0.       26         2* HARMONIC, TX, POWER LEVEL 0.       27         9" HARMONIC, TX, POWER LEVEL 0.       27         9" HARMONIC, TX, POWER LEVEL 0.       27         9" HARMONIC, TX, POWER LEVEL 0.       27         10" HARMONIC, TX, POWER LEVEL 0.       27         10" HARMONIC, TX, POWER LEVEL 0.       27 </td <td>FEATURES:</td> <td>4</td>	FEATURES:	4
ELECTRICAL CHARACTERISTICS SKY66111-11 (ABBREVIATED):       6         SKY66111-11 MODE LOGIC TRUTH TABLE       7         PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS: 3.3X3.0X0.8MM 20-PIN MCM PACKAGE       7         TOP PHOTO:       8         BOTTOM PHOTO:       9         PROGRAMMING /DEBUGGING:       10         CURRENT MEASUREMENT:       11         RADIO TEST APPLICATION:       ERROR! BOOKMARK NOT DEFINED.         TRANSMIT CURRENT VS. OUTPUT POWER:       22         OUTPUT POWER VS. CHANNEL       23         SPURIOUS EMISSIONS MEASUREMENTS:       24         SPURIOUS EMISSIONS PLOTS:       25         SPURIOUS EMISSIONS PLOTS:       25         SPURIOUS EMISSIONS PLOTS:       25         SPURIOUS BLOW 1 GHZ, TX MODE, SWEPTCW       26         21° HARMONIC, TX, POWER LEVEL 0       26         7° HARMONIC, TX, POWER LEVEL 0       27         8° HARMONIC, TX, POWER LEVEL 0       27         9° HARMONIC, TX, POWER LEVEL 0       27         9° HARMONIC, TX, POWER LEVEL 0       27         10° HARMONIC, TX, POWER LEVEL 0       27         10° HARMONIC, TX, POWER LEVEL 0       27         10° HARMONIC, TX, POWER LEVEL 0       28         SCHEMATICS:       29         SKY66111-11	BLOCK DIAGRAM:	5
SKY66111-11 MODE LOGIC TRUTH TABLE	ELECTRICAL CHARACTERISTICS SKY66111-11(ABBREVIATED):	6
PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS: 3.3X3.0X0.8MM 20-PIN MCM PACKAGE	SKY66111-11 MODE LOGIC TRUTH TABLE	7
TOP PHOTO:8BOTTOM PHOTO:9PROGRAMMING/DEBUGGING:10CURRENT MEASUREMENT:11RADIO TEST APPLICATION:ERROR! BOOKMARK NOT DEFINED.TRANSMIT CURRENT VS. OUTPUT POWER:22OUTPUT POWER VS. CHANNEL23SPURIOUS EMISSIONS MEASUREMENTS:24SPURIOUS EMISSIONS PLOTS:25SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW.250.5*FC SUBHARMONIC, TX, POWER LEVEL 0262* HARMONIC, TX, POWER LEVEL 0262* HARMONIC, TX, POWER LEVEL 0279* HARMONIC, TX, POWER LEVEL 02810* HARMONIC, TX, POWER LEVEL 0 <t< th=""><th>PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS: 3.3X3.0X0.8MM 20-PIN MCM PACKAGE</th><th>7</th></t<>	PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS: 3.3X3.0X0.8MM 20-PIN MCM PACKAGE	7
BOTTOM PHOTO:9PROGRAMMING/DEBUGGING:10CURRENT MEASUREMENT:11RADIO TEST APPLICATION:ERROR! BOOKMARK NOT DEFINED.TRANSMIT CURRENT VS. OUTPUT POWER:22OUTPUT POWER VS. CHANNEL23SPURIOUS EMISSIONS MEASUREMENTS:24SPURIOUS EMISSIONS PLOTS:25SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW.250.5*FC SUBHARMONIC, TX, POWER LEVEL 0.252** HARMONIC, TX, POWER LEVEL 0.267** HARMONIC, TX, POWER LEVEL 0.278** HARMONIC, TX, POWER LEVEL 0.279** HARMONIC, TX, POWER LEVEL 0.2810** HARMONIC, TX, POWER LEVEL 0.28SCHEMATICS:29SKY66111-11.29NRF51422 CIRCUT.30	ТОР РНОТО:	8
PROGRAMMING/DEBUGGING:10CURRENT MEASUREMENT:11RADIO TEST APPLICATION:ERROR! BOOKMARK NOT DEFINED.TRANSMIT CURRENT VS. OUTPUT POWER:22OUTPUT POWER VS. CHANNEL23SPURIOUS EMISSIONS MEASUREMENTS:24SPURIOUS EMISSIONS PLOTS:25SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW250.5*FC SUBHARMONIC, TX, POWER LEVEL 0262 <sup>100</sup> HARMONIC, TX, POWER LEVEL 0267 <sup>100</sup> HARMONIC, TX, POWER LEVEL 0279 <sup>100</sup> HARMONIC, TX, POWER LEVEL 02810 <sup>100</sup> HARMONIC, TX, POWER LEVEL 028SCHEMATICS:29SKY66111-1129NRF51422 CIRCUT30	ВОТТОМ РНОТО:	9
CURRENT MEASUREMENT:11RADIO TEST APPLICATION:ERROR! BOOKMARK NOT DEFINED.TRANSMIT CURRENT VS. OUTPUT POWER:22OUTPUT POWER VS. CHANNEL23SPURIOUS EMISSIONS MEASUREMENTS:24SPURIOUS EMISSIONS PLOT S:25SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW.250.5*FC SUBHARMONIC, TX, POWER LEVEL 025LO FEEDTHROUGH, SWEPT RX MODE262 <sup>NO</sup> HARMONIC, TX, POWER LEVEL 0262 <sup>NO</sup> HARMONIC, TX, POWER LEVEL 0273 <sup>NI</sup> HARMONIC, TX, POWER LEVEL 0273 <sup>NI</sup> HARMONIC, TX, POWER LEVEL 02810 <sup>TII</sup> HARMONIC, TX, POWER LEVEL 028SCHEMATICS:29SKY66111-1129NRF51422 CIRCUT30	PROGRAMMING/DEBUGGING:	
RADIO TEST APPLICATION:ERROR! BOOKMARK NOT DEFINED.TRANSMIT CURRENT VS. OUTPUT POWER:22OUTPUT POWER VS. CHANNEL23SPURIOUS EMISSIONS MEASUREMENTS:24SPURIOUS EMISSIONS PLOTS:25SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW250.5*FC SUBHARMONIC, TX, POWER LEVEL 025LO FEEDTHROUGH, SWEPT RX MODE262 <sup>10</sup> HARMONIC, TX, POWER LEVEL 0273 <sup>11</sup> HARMONIC, TX, POWER LEVEL 0279 <sup>11</sup> HARMONIC, TX, POWER LEVEL 02810 <sup>11</sup> HARMONIC, TX, POWER LEVEL 028SCHEMATICS:29SKY66111-1129NRF51422 CIRCUT30	CURRENT MEASUREMENT:	
TRANSMIT CURRENT VS. OUTPUT POWER:22OUTPUT POWER VS. CHANNEL23SPURIOUS EMISSIONS MEASUREMENTS:24SPURIOUS EMISSIONS PLOTS:25SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW250.5*FC SUBHARMONIC, TX, POWER LEVEL 025LO FEEDTHROUGH, SWEPT RX MODE262 <sup>10</sup> HARMONIC, TX, POWER LEVEL 0267 <sup>14</sup> HARMONIC, TX, POWER LEVEL 0278 <sup>14</sup> HARMONIC, TX, POWER LEVEL 0279 <sup>16</sup> HARMONIC, TX, POWER LEVEL 02810 <sup>16</sup> HARMONIC, TX, POWER LEVEL 028SCHEMATICS:29SKY66111-1129NRF51422 CIRCUIT30	RADIO TEST APPLICATION:	OT DEFINED.
OUTPUT POWER VS. CHANNEL23SPURIOUS EMISSIONS MEASUREMENTS:24SPURIOUS EMISSIONS PLOTS:25SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW250.5*FC SUBHARMONIC, TX, POWER LEVEL 025LO FEEDTHROUGH, SWEPT RX MODE262 <sup>ND</sup> HARMONIC, TX, POWER LEVEL 0267 <sup>TM</sup> HARMONIC, TX, POWER LEVEL 0278 <sup>TM</sup> HARMONIC, TX, POWER LEVEL 0279 <sup>TM</sup> HARMONIC, TX, POWER LEVEL 02810 <sup>TM</sup> HARMONIC, TX, POWER LEVEL 028SCHEMATICS:29SKY66111-1129NRF51422 CIRCUIT30	TRANSMIT CURRENT VS. OUTPUT POWER:	
SPURIOUS EMISSIONS MEASUREMENTS:       24         SPURIOUS EMISSIONS PLOTS:       25         SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW       25         0.5*FC SUBHARMONIC, TX, POWER LEVEL 0       25         LO FEEDTHROUGH, SWEPT RX MODE       26         2 <sup>ND</sup> HARMONIC, TX, POWER LEVEL 0       26         7 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         8 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         8 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       28         10 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       28         SCHEMATICS:       29         SKY66111-11       29         NRF51422 CIRCUIT       30	OUTPUT POWER VS. CHANNEL	23
SPURIOUS EMISSIONS PLOTS:       25         SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW       25         0.5*FC SUBHARMONIC, TX, POWER LEVEL 0       25         LO FEEDTHROUGH, SWEPT RX MODE       26         2 <sup>ND</sup> HARMONIC, TX, POWER LEVEL 0       26         7 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       26         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         8 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       28         10 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       28         SCHEMATICS:       29         SKY66111-11       29         NRF51422 CIRCUIT       30	SPURIOUS EMISSIONS MEASUREMENTS:	
SPURIOUS BELOW 1 GHZ, TX MODE, SWEPT CW       25         0.5*FC SUBHARMONIC, TX, POWER LEVEL 0       25         LO FEEDTHROUGH, SWEPT RX MODE       26         2 <sup>ND</sup> HARMONIC, TX, POWER LEVEL 0       26         7 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         8 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       27         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       28         10 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0       28         SCHEM ATICS:       29         SKY66111-11       29         NRF51422 CIRCUIT       30	SPURIOUS EMISSIONS PLOTS:	25
	Spurious below 1 GHz, Tx mode, swept CW         0.5*Fc subharmonic, TX, power level 0         LO FEEDTHROUGH, swept RX mode         2 <sup>ND</sup> HARMONIC, TX, POWER LEVEL 0         7 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0         8 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0         9 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0         10 <sup>TH</sup> HARMONIC, TX, POWER LEVEL 0         SCHEMATICS:         SKY66111-11         NRF51422 CIRCUIT.	25 
USB-UART INTERFACE	USB-UART INTERFACE	
NAND LEVEL SHIFTER/INVERTER CIRCUIT	NAND LEVEL SHIFTER/INVERTER CIRCUIT	31 22
EMRF-NRF51-SKY66111 PCB - TOP	EMRF-NRF51-SKY66111 PCB - TOP	
	EMRF-NRF51-SKY66111 PCB - BOTTOM	
	EMRF-NRF51-SKY66111 PCB – BOTTOM	



**Features:** 

- Arduino Shield with nRF51422 and SKY66111-11 compatible out of the box with the Nordic nRF51 DK and Nordic SDK examples.
- Can be used as Stand-alone without nRF51 if user has JTAG/SWD debugger. 10pin SWD connector is provided on Shield.
- Nearly +12dBm PA Power output.
- PA Enable Jumper for testing in PA Bypass Mode.
- SMA RF Connector for RF analysis.
- Precisely tuned matching circuit.
- PCB Antenna
- Selectable Power Source: CR2032, External Supply, USB, or nRF51 DK
- 4 Push-Buttons for application use.
- Header for additional GPIO access.
- 4 Application LED's.
- USB-UART(CP2104) on shield for easy debugging COM terminal interface.
- Current Measurement header.
- Makes use of Segger J-LINK debugger/programmer already on nRF51 DK.



### **Block Diagram:**





### **Electrical Characteristics SKY66111-11(abbreviated):**

(values from SKY66111-11 datasheet for complete specifications please refer to SKY66111-11)

### Vcc = 3.3V, V<sub>BIAS</sub> = 1.8V, T<sub>A</sub> = +25°C, R<sub>BIAS</sub> = $0k\Omega$ , Characteristic Impedance[Z<sub>0</sub>] = $50\Omega$

PARAMETER	CONDITIONS	ТҮР	UNITS
DC Characteristics			
RX Current(bypass)	RX mode	1	uA
TX quiescent current	TX mode	6	mA
TX operating current	TX mode( $P_{IN} = -1dBm$ ):		
	VCC = 1.8V	8.5	mA
	VCC = 3.0V	9.8	mA
	VCC = 3.3V	10	mA
TX bias current(BIAS pin)		550	uA
Sleep current	Sleep Mode	0.1	uA
Transmit Characteristics			
Output Power	VCC = 1.8V	+8	dBm
	VCC = 3.0V	+10	dBm
	VCC = 3.3V	+10.2	dBm
Saturated gain	$P_{IN} = -1 dBm$	11	dB
Gain slope	Over Frequency Range	0.5	dB
Input return loss		-14	dB
Output return loss		-10	dB
Third order input intercept	@ 2.44 GHz, $\Delta f = \pm 1$ MHz, $P_{IN} = -$	+5	dBm
point(Note 4)	14dBm/tone		
Third order output intercept	@ 2.44 GHz, $\Delta f = \pm 1$ MHz, $P_{IN} = -$	+16	dBm
<pre>point(Note 4)</pre>	14dBm/tone		
RX to TX transition time	10% to 90% RF	500	ns
	50% V <sub>CTX</sub> to 90% RF		
TX power on time	10% to 90% RF	500	ns
	50% V <sub>CTX</sub> to 90% RF		
TX power off time	10% to 90% RF	150	ns
	50% V <sub>CTX</sub> to 90% RF		
<b>Receive Characteristics</b>			
Isertion Loss		0.9	dB
Isolation		25	dB
Input return loss		-15	dB
Output return loss		-15	dB
TX to RX transition time	10% to 90% RF	500	ns
	50% V <sub>CRX</sub> to 90% RF		
RX power on time	10% to 90% RF	150	ns
	50% V <sub>CRX</sub> to 90% RF		
RX power off time	10% to 90% RF	150	ns
	50% V <sub>CRX</sub> to 90% RF		



### SKY66111-11 Mode Logic Truth Table

Mode	СТХ	CRX
Sleep mode	0	0
Receive(RX)mode	0	1
Transmit(TX) mode	1	0
Non-permissable state(This	1	1
mode will enable both the TX and		
RX paths. It is not permittable)		

### Pin Configurations and Function Descriptions: 3.3x3.0x0.8mm 20-pin MCM package



Pin	Name	Description	Pin	Name	Description
1	GND	Ground	11	ANT	Antenna port
2	GND	Ground	12	GND	Ground
3	GND	Ground	13	GND	Ground
4	TR	Common receive/transmit port	14	VCC	Positive power supply
5	GND	Ground	15	GND	Ground
6	GND	Ground	16	GND	Ground
7	GND	Ground	17	CRX	RX control signal
8	GND	Ground	18	GND	Ground
9	GND	Ground	19	СТХ	Tx control signal
10	GND	Ground	20	BIAS	PA bias current input, connect to CTX through a resistor

Note: Paddle should be connected to GND.



### **Top Photo:**





### **Bottom Photo:**





### **Programming/Debugging:**



- EMRF-nRF51-SKY66111 is fully functional with or without the nRF51 DK.
- EMRF-nRF51-SKY66111 can be mounted directly to the nRF51 DK to allow use of the JTAG Programmer/Debugger already on nRF51 DK.
- Additional 10pin SWD Connector is provided so that EMRF-nRF51-SKY66111can be used as a Stand-Alone board also with use of external J-LINK/SWD.



### **Current Measurement:**



- Current Measurements can be taken with an Ammeter at jumper J2.
- Measures TOTAL current to SKY66111 and nRF514222.
- Nordic Radio Test App can be used to put the nRF51 radio into different modes to allow for current measurements to be taken.



### **Getting Started:**

To get started you can refer to the **Quick Start** guide from the link below. The information in the **Quick Start** guide are also provided here along with further details. There are 3 primary firmware examples we will make use of in this section. These examples are all included in the nRF51 SDK, at the time of this document SDK v9.0.0 is the most current.

nRF51 SDK v9.0.0 Documentation: http://infocenter.nordicsemi.com/topic/com.nordic.infocenter.sdk51.v9.0.0/index.html?cp=4 1 0

### nRF51 SDK Download:

http://developer.nordicsemi.com/nRF51 SDK/

- 1) **Radio Test example:** This example provides a simple application that can be used to place the radio into various modes and power levels which are useful for taking RF measurements. http://infocenter.nordicsemi.com/topic/com.nordic.infocenter.sdk51.v9.0.0/nrf radio test exa mple.html?cp=4 1 0 4 6 14
- 2) Radio Receiver / Radio Transmitter Example: Receiver: http://infocenter.nordicsemi.com/topic/com.nordic.infocenter.sdk51.v9.0.0/nrf dev radio rx e xample.html?cp=4 1 0 4 6 8 Transmitter: http://infocenter.nordicsemi.com/topic/com.nordic.infocenter.sdk51.v9.0.0/nrf dev radio tx e xample.html?cp=4 1 0 4 6 9
  2) PLED is in the formula of the provided set of the provi
- 3) BLE Peripheral / Central Example:

### **First Steps:**

1) Plug the EMRF-nRF51-SKY66111 into the nRF51 DK as shown below.



2) Connect the nRF51 DK to your computer with a USB cable. If this is your first time using the nRF51 DK you can also refer to the nRF51 DK User Guide: http://www.nordicsemi.com/eng/nordic/download resource/38677/1/73523072



- 3) If this is your first usage of the nRF51 DK you will also need to install the nRFgo Studio software(includes JLinkARM, JLink CDC, nRFjprog, and mergehex) from the link below. http://www.nordicsemi.com/eng/Products/2.4GHz-RF/nRFgo-Studio
- 4) Next you will need to choose your preferred Compiler/IDE: IAR, Keil, or GCC). Links for downloading the FREE 32kB limited versions are included for both IAR and Keil in the <u>Compiler</u> <u>Download</u> section. You will need to register with IAR or KEIL to download the Compiler/IDE. NOTE!! If you already have a previous version of IAR/KEIL you should be able to make use of this. You will most likely need to reconfigure the Project Settings such as Target Device, Header include directories, and Debugger settings as these are typically lost when you open the Project in an older version of the toolset. For those that are already familiar with your respective IDE/Compiler this should be straightforward.
  - a) IAR

#### Download software

The same installer is used for both the 30-day time-limited and the Kickstart (sizelimited) evaluation edition. You select which evaluation license type you want to use after the installation. When you start the product for the first time, you will be asked to register to get your evaluation license.

The evaluation license can be upgraded to a standard license of the product when you purchase the product.



#### b) KEIL

MDK-ARM Microcontroller Development Kit



5) The next step is to install the nRF51 SDK. At the time of this document the most version was SDK v9.0.0 from the *nRF51 SDK Download*.



Location: /nRF51\_SDK/

	Name			
0	Parent Directory			
0	doc/			
0	nRF51_SDK_v4.x.x/			
0	nRF51_SDK_v5.x.x/			
0	nRF51_SDK_v6.x.x/			
0	nRF51_SDK_v7.x.x/			
0	nRF51_SDK_v8.x.x/			
6	nRF51_SDK_v9.x.x/	-		
6	pieces/			
	install.txt			

- 6) After downloading the SDK Zip file unzip it to a directory where you want to do your firmware development out of.
- 7) After you have unzipped the SDK you will also see in the top level directory nRF5xMDK\_8\_0\_3\_IAR.msi and nRF5xMDK\_8\_0\_3\_Keil4.msi installation files. Choose which IDE/Compiler \*.msi you prefer to use. This will install the necessary Nordic part specific information into the respective Compiler/IDE that you choose to use.



8) After doing these first simple steps you should be able to compile/run the first example, Radio Test using either Keil or IAR IDE/Compilers.

### Software Example 1: Radio Test

Radio Test Example Instructions:

The Receiver and Transmitter project can be found in your SDK Installation directory at the following location.

...\Nordic\examples\peripheral\radio\_test

**Using IAR:** 

1) Open the '*radio\_test.eww*' project. It should open up in IAR and appear as shown below.



Workspace		×	nrf.h mai	in.c re
nrf51422_xxac		-	254	
Files	20	<u>8</u>	255	
		10	256	
🗄 🔲 radio_test_pca i uuzo - nris i 422_xxac	~		257	
📙 🖵 Application			258	
⊞ 💼 main.c			259	
└─⊞ 🖻 radio_test.c			260	
			261	
– ⊞ 🚮 iar_startup_nrf51.s			262	
└─⊞ 🖸 system_nrf51.c			263	
- 🕀 🗀 Documentation			264	
			265	
			266	-
			267	
			268	

### 2) Compile the project by one of two methods.

a. Right-click on the Project and select 'Rebuild All'

options	
Make	
Compile	
RebuildAll	
Clean <sup>1</sup>	
Stop Build	
Add	
Remove	
Rename	
Version Control System	
Open Containing Folder	
File Properties	
Set as Active	
k the 'Make' Button	



### You should now see that the project has compiled...

Messages
nrf_drv_gpiote.c
radio_test.c
retarget.c
system_nrf51.c
Linking
radio_test_pca10028.out
Converting
Total number of errors: 0
Total number of warnings: 0

- 3) Download/Debug the project on the EMRF-nRF51-SKY66111 board. By either the keyboard shortcut OR the menu.
  - a. Keyboard Shortcut: CTRL+D
  - b. Menu



Projec	ct Tools Window Help	
1	Add Files	
	Add Group	
I	Import File List	
	Add Project Connection	
E	Edit Configurations	
F	Remove	
(	Create New Project	
	Add Existing Project	
(	Options	Alt+F7
N	Version Control System	+
1	Make	F7
(	Compile	Ctrl+F7
F	Rebuild All	
(	Clean	
E	Batch build	F8
\$	Stop Build	Ctrl+Break
[	Download and Debug	Ctrl+D
[	Debug without Downloading	
1	Make & Restart Debugger	Ctrl+R
F	Restart Debugger	Ctrl+Shift+R
[	Download	•
9	SFR Setup	
(	Open Device File	•

- 4) Using either the USB-UART that comes on the EMRF-nRF51-SKY66111...
  - a. Choose the COM port to connect to using Putty, Hyperterminal, or whatever your preferred Terminal Window is and use the following settings.
  - b. Data Rate: 38400 Data Bits: 8 Parity: None Stop bits: 1 Flow Control: Hardware
- 5) After you have configured your terminal Window click the '**GO**' button in the IAR IDE.



You now should see the following in your terminal window...



🎨 EMRF - HyperTerminal

File Edit View Call Transfer Help

🗅 🛩 🚳 💲 🖻 🖆

#### Usage:

a: Énter start channel for sweep/channel for constant carrier b: Enter end channel for sweep c: Start TX carrier Enter time on each channel (1ms-99ms) d : | Cancel sweep/carrier e: Enter data rate m: Start modulated TX carrier o: Enter output power p: s: Print current delay, channels and so on r: Start RX sweep t: Start TX sweep x: Start RX carrier

You can enter various configurations from the terminal window to configure the nRF51 Radio for different modes to perform RF measurements by connecting your RF test equipment to the SMA connector that is supplied on the EMRF-nRF51-SKY66111.

NOTE!!! To make use of the SMA connector you will need to 'De-Pop' L22 and replace in the L20 position so that the RF output is directed to the SMA connector vs. the PCB Antenna.



### Using Keil:

Using the same procedures you can make use of the KEIL version of these projects by using the following project...

### radio\_test.uvmpw



#### Software Example 2: Tx/Rx Communication Example

You will need two EMRF-nRF51-SKY66111's for this Radio Communication example. You only need one nRF51 DK as you can swap the EMRF-nRF51-SKY66111's onto the nRF51 to be able to program it. This example provides a simple example of configuring one of the boards as a Transmitter and one of the boards as a Receiver. This can be used to do Range Testing. This example is not based on a particular protocol.

The Receiver and Transmitter project can be found in your SDK Installation directory at the following location.

.. \Nordic\examples\peripheral\radio

#### **Using IAR:**

1) Open the '*transmitter.eww*' project. It should open up in IAR and appear as shown below.

Radio Transmitter Instructions:

nrf51422_xxac		
Files	\$2	D.
🗆 🗇 transmitter_pca10028 - nrf51422_xxac	~	
🖵 🖽 🔂 main.c		
- 🕀 🗀 Documentation		
⊢⊕ 🗀 nRF_Drivers		
⊢⊕ 🗀 nRF_Libraries		
🖵 🔁 Output		

2) Compile the project as shown before and Download/Debug the application.

NOTE!!! In IAR if you just want to have the application run in Stand-Alone(without the Debugger) just simply click the Red 'X' to disconnect the Debugger. This disconnects the Debugger but the application is still running on the nRF514222



3) Next we need to program the second EMRF-nRF51-SKY66111as the Receiver. You can either open up another instance of IAR or simply open the Receiver project in the same instance of IAR. If you want to inspect the source code of both the Receiver and the Transmitter it is useful to have 2 instances of IAR running concurrently. Open the '*receiver.eww*' project.

#### Radio Receiver Instructions:



- 4) If '*receiver\_pca10028 nRF51422\_xxac*' is not HIGHLIGHTED as shown above you will need to right click on this project and choose 'Set As Active'.
- 5) As before compile, download/debug.
- 6) We now have a EMRF-nRF51-SKY66111 programmed as a Transmitter and one as a Receiver.
- 7) To test the radio communications the easiest way is to put a CR2032 into the 'Transmitter' board and leave the 'Receiver' board connected to a PC so you can see that the signal from the Transmitter has been received.
  - a. Connect the Receiver board to a PC using the USB-UART on the EMRF-nRF51-SKY66111 configure a Terminal Window program such as Putty, Hyperterminal, etc and configure as we have done in the Radio Test with the following settings.
  - b. Data Rate: 38400 Data Bits: 8 Parity: None Stop bits: 1 Flow Control: Hardware
  - c. You can use the Transmitter board as a stand-alone board by inserting a CR2032 into the Coin Cell holder on the bottom of the board.
     NOTE!!! Unfortunately you will need to carefully bend up the edges of the COIN CELL HOLDER on this version to be able to insert the COIN CELL. APPLY DOWNWARD

PRESSURE ON THE COIN CELL HOLDER WHILE GENTLY APPLY UPWARDS PRESSURE ON THE ROUNDED (+) TABS TO BEND THEM UPWARDS. DOWNWARD PRESSURE WITH YOUR HAND ON THE COIN CELL HOLDER IS HIGHLY RECOMMEND TO AVOID PULLING THE PAD OFF THE PCB. WE APOLOGIZE FOR THIS INCONVENIENCE AND WILL BE FIXED IN A FUTURE VERSION.



d. Now you can press any of the pushbuttons SW2-SW5 on the transmitter board and you will see the output on the Terminal Window that is connected to the Receiver board as shown below. Each button has a distinct message that is printed.

The contents	of th	ne package	is 8
The contents The contents The contents The contents The contents The contents The contents The contents	of th of th of th of th of th of th of th	ne package ne package ne package ne package ne package ne package ne package	is 1 is 2 is 4 is 8 is 1 is 2 is 4

#### **Using KEIL:**

Using the same procedures you can make use of the KEIL version of these projects by using the following projects...

transmitter.uvmpw receiver.uvmpw



### **Transmit Current vs. Output Power:**



- Approximately 1.5mA current advantage around +4dBm.
- Nearly +12dBm output power available.





**Output Power vs. Channel** 

Power Levels Correspond to Power Settings using the 'Radio Test' Example in the nRF51 SDK. Power level 0 = +4dBm, Power level 1 = 0dBm, Power level 2 = -4dBm, Power level 3 = -8dBm Power level 4 = -12dBm, Power level 5 = -16dBm, Power level 6 = -20dBm, Power level 7 = -30dBm

- SKY66111 provides 8dB of TX gain with the supplied BOM.
- 1 dB or better flatness across BTLE band at all power levels except max.
- Up to +12dBm output power available.



**Spurious Emissions Measurements:** 

- All spurious emissions are measured at maximum output power(+12dBm, power level 0), with the EMRF-nRF51-SKY66111 powered from USB.
- For TX mode spurious emissions the nRF51 generates a CW signal swept across the BTLE band; RX mode spurious emissions are caused by sweeping the Local Oscillator(LO).
- Emissions were measured using an FSQ-26 spectrum analyzer connected to the SMA test port.
  - \* MAX HOLD(300 sweeps)
  - \* Peak Detector
  - \* VBW 1MHz, RBW 3 MHz
- All spurious emissions comply with FCC limits(conducted at test port).



### **Spurious Emissions Plots:**

### Spurious below 1 GHz, Tx mode, swept CW



### 0.5\*Fc subharmonic, TX, power level 0





LO feedthrough, swept RX mode



### 2<sup>nd</sup> Harmonic, TX, power level 0





#### 7<sup>th</sup> Harmonic, TX, power level 0



#### 8th Harmonic, TX, power level 0





9th Harmonic, TX, power level 0



### 10<sup>th</sup> Harmonic, TX, power level 0





### **Schematics:**



- Resistor R16 trades off Icc for Tx gain;  $12k\Omega$  gives ~8dB.
- Output filter tuned to remove harmonics and subharmonics.
- L22/L20 inductor placement selects SMA connector or PCB trace antenna.



#### nRF51422 Circuit



- Output match (C12, L6, C10) retuned due to ground slot removal.
- Inductor placements(L4, L5) allow DC-DC mode operation.
- SMT placements allow use of P0.27 and P0.26 for GPIO(instead of XTAL).



#### **USB-UART** Interface



• CP2104 USB-UART bridge provides VCP interface and can also power EMRF-nRF51-SKY66111 from its 3.45V output.

### NAND Level Shifter/Inverter Circuit

# For using Nordic SDK software



- Level Translating NAND gates provide direct nRF51 DK compatibility.
- Gates toggle SKY66111, CRX and CTX, from nRF51422 PA supply.
- User can drive CRX/CTX directly from P0.22, P0.21 respectively with firmware modification.



### **Connectors, LEDs, and Switches**



- Top connectors have Arduino pinout(P1, P2, P3, P4).
- Power Options:
  - \* nRF51 DK
  - \* Arduino
  - \* Micro-USB Cable
  - \* DC Supply
  - \* CR2032 Coin Cell
- Programmable by
  - \* nRF51 DK
  - External ARM SWD Programmer/Debugger via 10pin SWD connector, P18.



# EMRF-nRF51-SKY66111 PCB – Top ADD PCB PICTURES!!

**EMRF-nRF51-SKY66111 PCB – Bottom** ADD PCB BOTTOM PICTURES!!