







# Sub-GHz Radio

Main applications









# SPIRIT Sub-GHz Roadmap



# SPIRIT1: Feature set 4

### Spirit1: Sub GHZ RF Transceiver

### STS1TX: transmitter only version of Spirit1

### **RF Features Overview**

- Frequency bands: 150-174MHz, 300-348 MHz, 387-470 MHz, 779-956 MHz
- Modulation schemes: FSK, GFSK, MSK, OOK and ASK
- Air data rate from 1 to 500 kbps
- Programmable output power: from -30dBm to +16dBm (boost mode)
- RX sensitivity: -121dBm @1.2kbps / -123dBm @1.2Kbps with Balun
- Built-in SMPS block for optimum current consumption

### **Embedded Firmware**

- Flexible host interface: SPI, GPIOs
- Automatic acknowledgement, retransmission, and timeout protocol engine
- Embedded packet handler, LDC/Sniff mode
- ST Stack, Wireless M-Bus, 6LoWPAN support



#### QFN20 4x4x0.9

#### What you need to remember !

Packet Handler Engine for host power save 6LoWPAN, STack, M-Bus packet types

Sensitivity	-121dBm @ 1.2kbps
RX Power (peak)	9mA, Much lower with sniff
Tx Power	18mA @ 10dBm
Sleep/Shutdown	850nA /2.5nA







# SPIRIT1: design examples in EMEA

### Automotive

- Tire Pressure Monitoring Sensor
- STS1TX (868 MHz) + STM8L
- WMBUS

# NIN



### Smart Home

- Heat Cost Allocator
- Spirit1 (868MHz) + BALF-SPI-01D3
- WMBUS





### **Smart Metering**

- Water & Gas Metering
- Spirit1 (169MHz) + 27dBm PA
- WMBUS











# SPIRIT2: Feature set

### **RF Features Overview**

- Frequency bands: 430-470 MHz, 860-940MHz
- Modulation schemes: (2G) FSK, (4G) FSK, OOK and ASK
- Air data rate from 0.3 to 500 kbps
- Programmable output power: from -30dBm to +16dBm (boost mode)
- RX sensitivity: -124dBm @1.2kbps / -130dBm @ 300bps
- Candidate to SigFox certification
- Built-in SMPS block for optimum current consumption

### **Embedded Firmware**

- Embedded packet handler, LDC/Sniff mode, CSMA/CA...
- Advanced packet handler flexibility :
  - Bit granularity for preamble (up to 256Bytes) and sync (up to 64bytes)
  - Configurable pattern recognition down to bit granularity
  - Manchester encoding/decoding
- IEEE 802.15.4g Mac for 6LoWPAN









QFN24 4x4x0.9



Key Power c	onsumption figures
RX Power (peak)	7mA
Tx Power	10mA @ 10dBm
Sleep/Shutdown	300nA /2.5nA



# SPIRIT2 vs. SPIRIT1: Feature overview 7

Featu	re Overview	Spirit1	Spirit2
Voltage (V)	Min ~ Max	1.8 ~ 3.6 V	1.8 ~ 3.6 V
Temperature (°C)	Min ~ Max	-40 ~ +85	-40 ~ <b>+105</b>
Packago	Туре	QFN 20	QFN 24
Fackage	Size	4 x 4 mm	4 x 4 mm
	169 MHz	Yes	No
	315 MHz	Yes	No
Band coverage (ISM/SRD bands)	433 MHz	Yes	Yes
(	868 MHz	Yes	Yes
	915 MHz	Yes	No
	2-FSK / 4-FSK	2-FSK only	Yes
Modulation	2-GFSK / 4-GFSK	2-GFSK only	Yes
	OOK/ASK	Yes	Yes
RX / TX FIFO	Bytes	96	96
CSMA	VCA protocol	Yes	Yes
Data rate	Max (2-level modulation)	500 kbps (G)FSK 250 kbps (OOK/AAK)	500 kbps (4G )FSK 250 kbps (2G) FSK 125kbps (OOK)
Reference Clock	Crystal oscillator (MHz)	24-25-26 MHz 48-50-52 MHz	24-25-26 MHz 48-50-52 MHz







### SPIRIT2 vs. SPIRIT1: Receiver Performance

Receiver p	erformance (868	MHz)	Spirit1	Spirit2	Cat 1 receiver	EN 303 131 Mode B/C1/CN
	Sensitivity 1% BER	GFSK 1.2Kbps	-122	-124	-113	-113
		+/-1 MHz	71	/	NA	NA / 60 / 60
		+/-2 MHz	75	78	84	84 / 70 / 70
RX Barfarmanaa *	Selectivity	+/-5 MHz	75	/	NA	NA / 70 / 70
Performances "	1.2 Kbps	+/- 10 MHz	79	81	84	84 / 70 / 70
*RX_BW 4KHz ** RX_BW 16KHz		+/-12.5 KHz	53	60	60	60 / 42 / 42
		+/-25 KHz	55	64	60	00 / 42 / 42
	Image reject	ion (dB)	54	58	/	60

#### From 1.2Kbps and above

- Spirit2 will be natively compliant to Cat 1 for Adjacent Channel Selectivity.
- SAW filter will still be needed for 2MHz blockings

#### Below 1.2Kbps

Characterization needed for 2MHz blockings rejection







# SPIRIT2 vs. SPIRIT1: Power consumption

	Power Consumpt	tion	Spirit1	Spirit2
	Shuto	lown	2.5 nA	2.5nA
	Power-down - S (XO OFF, 32K ON,	Standby mode no wake-up timer)	0.6 µA	0.3 μΑ
	READY (XO	& 32K ON)	0.40 mA	0.45 mA
Static mode	RX peak - Low Power I	current Mode, Static -	9.8 mA max	7 mA max
		+16 dBm	44 mA @ +16dBm	40 mA @ +16dBm
	TX peak (868MHz) - Static -	+13 dBm	30 mA @ +13dBm	18 mA @ +13dBm
		+10 dBm	18 mA @ +10dBm	10 mA @ +10dBm
	WMBU MCU is co	JS T2 (10dBm / Tx 3.8 ms nsidered in full processir	ec / Rx 3msec / period = 10 sec) ng mode during 1/8 <sup>th</sup> of RF activ	) ities.
1250	Ab Pattony	Avg Current	10.24 µA	5.57 µA
125011	An dallery	Battery lifetime	14 years	25.5 years







### SPIRIT for Central Alarm: receive power budget <sup>10</sup>



#### Central always in reception mode using Rx sniff mode to decrease current

#### System average receive current consumption with Spirit1

	Wake-up On radio period	Rx sensitivity (***)	Average Rx current (μA)
STM32L0 + Spirit1 (*)	1s		5.4µA
	1.5s	-105dBm	3.9µA
	4s (**)		2.0µA

#### System average receive current consumption with Spirit2: 25% lower consumption

	Wake-up On radio period	sensitivity	Average Rx current (μΑ)
STM32L0x1 + Spirit2 (*)	1s		4.1µA
	1.5s	-108dBm	3.0µA
	4s		1.5µA

(\*) assuming STM32L0x1 running at 32MHz – 2.8mA - STOP mode (RTC) – 0.8µA

(\*\*) Spirit1 wake-up done by host µC

(\*\*\*) Rx sniff mode sensitivity using integrated balun





Keep parameters	for Average current
PE Transcoiver	Customor Application
RF Hallsceiver	Customer Application
Sleep current	Wake-up on
Rx settling time	Reception time
Carrier sense	



### SPIRIT for Alarm Sensor: transmit power budget \_\_\_\_\_1

#### Sensor in transmit mode



#### System average transmit current consumption with Spirit1



#### STM32L0 + Spirit1 (\*) every 10s every minute every hour every 30s Payload 10 bytes (4.8ms) 11µA 4.2µA 2.5µA 0.8µA Payload 20 bytes (6.8ms) 5.4µA 3.1µA **0.8**μΑ 15µA Payload 50 bytes (12.8ms) 26µA 9.3µA 5.1µA 0.9µA

### System average transmit current consumption with Spirit2 : Up to 40% lower consumption

STM32L0 + Spirit2 (*)	every 10s	every 30s	every minute	every hour
Payload 10 bytes (4,8ms)	6.8µA	2.8µA	1.8µA	0.8µA
Payload 20 bytes (6.8ms)	9µA	3.5µA	2.1µA	<b>0.8</b> μA
Payload 50 bytes (12.8ms)	15µA	5.7µA	3.2µA	0.8µA







# SPIRIT Libraries for proprietary protocols 12



### **SPIRIT1/2 Libraries**

Comprehensive set of Libraries with embedded packet handler

AES	CALIBRATION	COMMANDS	CSMA	DIRECT RF	GENERAL
GPIO	IRQ	LINEAR FIFO	PACKET COMMON	PACKET BASIC	PACKET MBUS
PACKET STACK	REGISTERS	QI	RADIO	TIMER	TYPES

#### • IEE 802.15.4g MAC with Spirit2

- Advanced packet handler flexibility with Spirit2
  - Bit granularity for preamble (up to 256Bytes) and sync (up to 64bytes)
  - Configurable pattern recognition down to bit granularity
  - Manchester encoding/decoding







### SPIRIT for Metering: W-MBUS T2 Mode example 13

#### WMBUS T2 : 10dBm / Tx 3.8ms / Rx 3ms / period = 10 sec



#### System average current consumption with Spirit2

STM32L0* + Spirit2	3.8 sec	5 sec	8sec	10sec
Packet min = 3.0msec	12.6µA	9.6µA	6.1µA	4.9µA
Packet typ = 3.8msec	14.4µA	11µA	6.9µA	<b>5.6</b> μΑ
Packet max = 8.0msec	N/A*	N/A*	11.4µA	9.1µA
1250 mAh battery	Avg cu	rrent	Ye	ars
Spirit2 + STM32L0*	5.6 µ	AL	~25.5	years
Spirit1 + STM32L0*	10.2	μA	~14 y	/ears

\*MCU is considered in full processing mode during 1/8th of RF activities

### Keep parameters for Average current **RF Transceiver**

Tx peak current ٠

- **Customer Application**
- Transmission time
  - Tx duty cycle
- Tx settling time Shutdown current ٠



# SPIRIT Libraries: WMBUS Stack



### **ST WMBUS Package**

- Wireless Meter Bus is a standard for the remote reading of gas or water meters
- WMBUS stack can be provided as Libs or source code
  - EN 13757-4 Release 2013
- EN 13757-3 WMBUS application examples
  - OMS/DSMR





### SPIRIT Development kit 15

### ST proposes a complete Development Kit including

- 2x generic motherboards (STM32L-based) + 2x Spirit daughter boards.
- PC GUI to evaluate Spirit capabilities + Complete SW package
- Full documentation: <u>http://www.st.com/web/en/catalog/sense\_power/FM1968/CL1976/SC1845/PF253167</u>



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Modulation	Channel fil	ter [kHz]	Output	power [dBm]			6	TX PIN9 START
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### ST also provides a demonstration platform as a USB dongle

- USB Dongle 315 MHz : <u>http://www.st.com/web/en/catalog/tools/PF258710</u>
- USB Dongle 433 MHz : <u>http://www.st.com/web/en/catalog/tools/PF258711</u>
- USB Dongle 868 MHz : <u>http://www.st.com/web/en/catalog/tools/PF258712</u>
- USB Dongle 915 MHz : <u>http://www.st.com/web/en/catalog/tools/PF258713</u>









# SPIRIT Libraries

- This firmware provides a set of APIs to manage the Spirit device using the SDK eval motherboard and a Virtual Com port driver
- Available for STM32 and STM8 Adaptation easy to other MCUs
- All API documentations provided with the SDK
  - Check at your installed location "Documents\Firmware\_Docs" for all documents









### Bluetooth<sup>®</sup> Low energy roadmap









# BlueNRG-MS : Network processor



# BlueNRG-1 4.2: Application Processor



#### Flexible memory feature-set

2x12KB Ultra Low Leakage RAM 160KB Flash → 110KB free for App

Complete Interfaces 12 up to 26 GPIO's SPI, I<sup>2</sup>C, UART, PWM

Extended Operating range 1.7 up to 3.6V -40°C up to +105°C 125°C Characterization planned

#### BlueNRG-MS based Radio RX 7.3 mA / TX 8.2 mA @ 0dBm Sleep <1µA Up to +8dBm

Down to -88dBm

3 Package flavors WCSP34 2.65x2.65mm QFN32 5x5mm







# **BlueNRG-1: Automotive Grade applications**

- BlueNRG-1 with 105° C support and Automotive Grade qualification
- Dedicated package QFN32 for Automotive Grade qualification
- Make available Diagnostic info in your smartphone:
  - Car info
  - Driving style
  - Emergency crash response
  - Remote parking
  - Remote vehicle setting











# **BlueNRG** features implementation



# BlueNRG development kit 22

### ST proposes a complete Development Kit including

- 2x generic motherboards (STM32L-based) + 2x BlueNRG daughter boards.
- PC GUI to evaluate BlueNRG capabilities + Tool for Power consumption
- Full documentation: <u>http://www.st.com/web/en/catalog/sense\_power/FM1968/CL1976/SC1845/PF253167</u>

57 BlueNRG GUI v1.7.0dev			77 BlueNRG Current Consumption Estimation	
	File Tools Help		Calculate Consumption	Performance Summary
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			0.00 8 200 400 600 800 1000 1200 14	<u>RX/TX BX/TX BX/TX</u> 0 1600 1800 2000 2260 2400 2600

STEVAL-IDB002V1 – BlueNRG STEVAL-IDB005V1 – BlueNRG-MS STSW-BNRG-DK



### ST also provides a demonstration platform as a USB dongle



STEVAL-IDB003V1







# Open.RF X-Cube-BLE1

- The X-Cube-BLE1 software package is an expansion for STM32Cube, associated with the X-Nucleo-IDB04A1 expansion board
- Complete middleware to build applications using BlueNRG Network Processor
- **Sample applications:** Developers can use to start experimenting with the code
- References to free Android and iOS App that can be used along with the sample applications
- Available on X-Nucleo-IDB04A1 with Nucleo-F401RE and Nucleo-L053R8







Board Demonstrations











### Open.Framework Bluemicrosystem1: Bluetooth LE & Sensors



http://www.st.com/web/en/catalog/tools/PF261772







### Connectivity Modules Portfolio Summary 25











### Sub-GHz & BLE RF Module



# SPWF01Sx Wi-Fi modules 27

The SPWF01S is a "Cloud Compatible" Wi-Fi Modules embedding all the FW e.g. TLS/SSL security, Rest API, to easily connect Sensors and Actuators to Remote Cloud Services

Integration	<ul> <li>2.4 GHz IEEE 802.11 b/g/n low power transceiver</li> <li>STM32 ARM Cortex-M3 microcontroller</li> <li>Integrated high gain antenna or u.fl connector</li> <li>Pre Certified RF (FCC, IC, CE, SRRC)</li> <li>1.5 MB or 512 kB Integrated Flash memory</li> <li>Integrated TC/IP and Application Layer Functions</li> </ul>	
Flexibility and ease of use	<ul> <li>Easy interface to host Microcontroller through UART and AT commands set</li> <li>TLS/SSL for End to End security integrated</li> <li>System Modes: Mini-AP, IBSS and Station</li> <li>Built-in Application: Sockets, Web Server, Rest API</li> <li>Over The Air firmware update</li> <li>Easy configuration (SSID, PWD) in miniAP</li> </ul>	SPWF01SA Integrated antenna
RF power	Up to +18 dBm output power	SPWF01SC
Size	• Small form factor: 26.92 x 15.24 x 2.35 mm	Integrated U.FL connecto













