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## Sample wM-Bus 2013 application layer implementation for SPIRIT1 boards

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### Introduction

M-Bus (meter bus) is a common automatic meter reader (AMR) standard for remote energy meter reading in compliance with European standard (EN 13757-2 physical and link layer and EN 13757-3 application layer) M-Bus is also compliant with the European Standard EN 1434 on heat meters.

The M-Bus interface is based on the very cost effective two-wire, twist cable transmission, and is compatible with all network topologies (linear, star, etc.) except ring networks. When queried, meters send their data to a concentrator from which the data can be read locally or remotely.

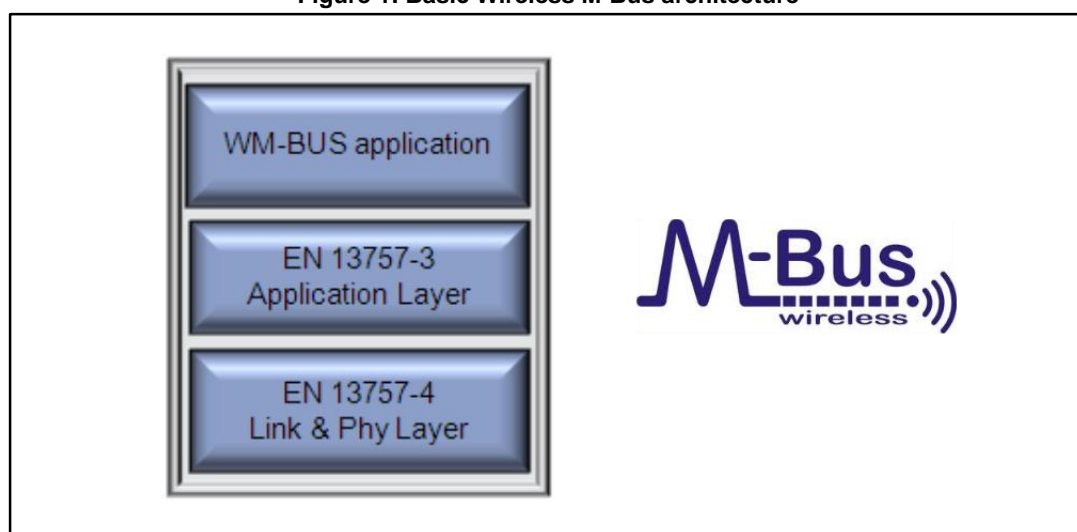
Wireless M-Bus is the radio variant of M-Bus for automatic meter reading at sub-1-GHz radio frequencies. While European standard EN13757-3:2013 for the application layer remains the same as M-Bus, the applicable physical and link layer European standard becomes EN13757-4:2013 Wireless meter readout, as well as ETSI EN 300 220 v2.3.1 for short range radio equipment.

The Wireless M-Bus firmware stack is based on EN 13757-4:2013 (Communication systems for meters and remote reading of meters — Part 4: Wireless meter readout (Radio meter reading for operation in SRD bands)). This European Standard specifies the required physical and link layer parameters for systems using radio to read remote meters, focusing primarily on the use of unlicensed, short range device (SRD) telemetry bands. The standard encompasses systems for walk-by, drive-by and fixed installations.

Several different modes of operation are defined for meter communication, with specific parameters governing only the operational and technical requirements of these differing modes, leaving the bulk of common parameters to facilitate common software and architecture components.

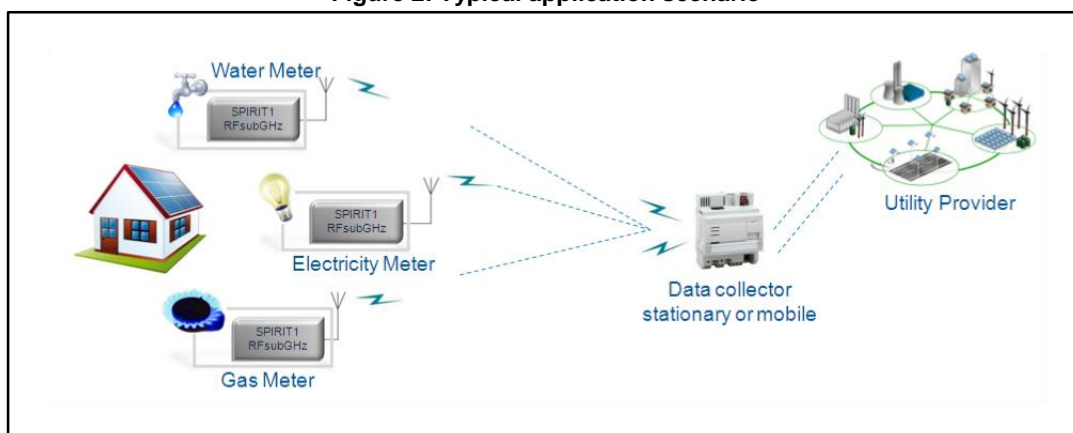
Mode nomenclature consists of a letter and a number. The letter specifies the mode type and the number specifies whether the mode supports unidirectional (1) or bidirectional (2) data transfer.

**Figure 1: Basic Wireless M-Bus architecture**



The standard defines the communication protocol between remote meters and mobile readout devices, stationary receivers, data collectors etc.

**Figure 2: Typical application scenario**



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# 1 Definitions, acronyms and abbreviations

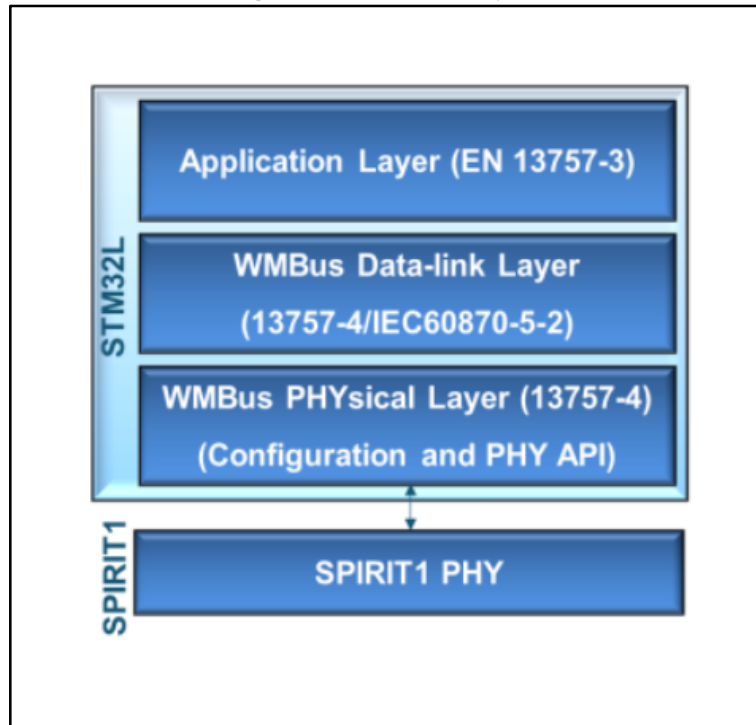
**Table 1: Acronyms and abbreviations**

Acronym	Description
AMR	Automatic Meter Reading
EEPROM	Electrically Erasable Programmable Read Only Memory
GHz	Giga Hertz
GUI	Graphical User Interface
LED	Light Emitting Diode
MCU	Microcontroller Unit
PC	Personal Computer
RF	Radio Frequency communication
SPI	Serial Peripheral Interface
USB	Universal Serial Bus
wM-Bus	Wireless Metering Bus
WSN	Wireless Sensors Network

## 2 Hardware platform

ST's Wireless M-Bus firmware stack application is based on its proprietary dual chip platform: the new SPIRIT1 RF Sub-1 GHz transceiver and the STM32L15x ultra-low-power ARM Cortex-M3 microcontroller.

Figure 3: Application layers



### 2.1 SPIRIT1

SPIRIT1 is a very low power, high performance RF transceiver, ideal for RF wireless applications in the sub-1-GHz band. It is designed to operate at 169, 315, 433, 868, and 915 MHz and supports 2-FSK, GFSK, MSK, OOK, and ASK modulations. The air data rate is programmable from 1 to 500 kbps, depending on the selected modulation.

Its integrated SMPS allows very low power consumption:

- 9 mA in Rx and 21 mA in Tx mode at +11 dBm.

Furthermore, it uses a very small number of discrete external components and integrates a configurable baseband modem for data management, modulation and demodulation. Data can be managed in a proprietary, fully programmable packet format as well as the M-Bus standard compliant format (all performance classes).

The SPIRIT1 provides native hardware support for the low level wM-Bus Phy protocol.

#### 2.1.1 SPIRIT1 function:

- wM-Bus Modes
- Header, Sync and trailer fields
- Manchester/3-out-of-6-encoding
- Sync detection

## 2.2 ST's ultra-low power EnergyLite™ MCU family

Gas, water and heat meters with wM-Bus technologies are usually battery powered devices that need to be highly efficient to preserve battery life.

The 8-bit (STM8L) and 32-bit (STM32L) EnergyLite™ family of MCUs combines high performance and ultra-low power, offering specific features for ultra-low power applications such as advanced ultra-low power modes and optimized dynamic run consumption, as well as special safety features.

The ultra-low-power EnergyLite platform, based on STMicroelectronics' 130 nm ultra-low-leakage process technology, provides a common technology, design and peripheral framework across the product range.

The ARM® Cortex™-M3-based STM32L1 series extends the ultra-low power concept without compromising performance, offering a wide assortment of features, memory sizes and packages. The range covers 32 to 384 Kbytes Flash memory (with up to 48 Kbytes of RAM and 12 Kbytes of true embedded EEPROM) and 48 to 144 pins.

This innovative architecture, with voltage scaling and an ultra-low-power MSI oscillator, gives your design more performance for a very low power budget. The generous suite of embedded peripherals, including USB, LCD interface, OpAmp, comparator, ADC with fast on/off mode, DAC, capacitive touch and AES renders the STM32L1 series an expandable platform able to fit all your requirements.

### 2.2.1 STM32L function:

- wM-Bus application layer
  - wireless M-Bus application layer partially implementing EN13757-3.
- wM-Bus link layer
  - MAC packet and CRC handling
  - encryption/ decryption initiate/read.
- wM-Bus Phy
  - init Phy for wM-Bus
  - interrupt services



## 3 wM-Bus software package description

### 3.1 Overview

The Wireless M-Bus software package includes:

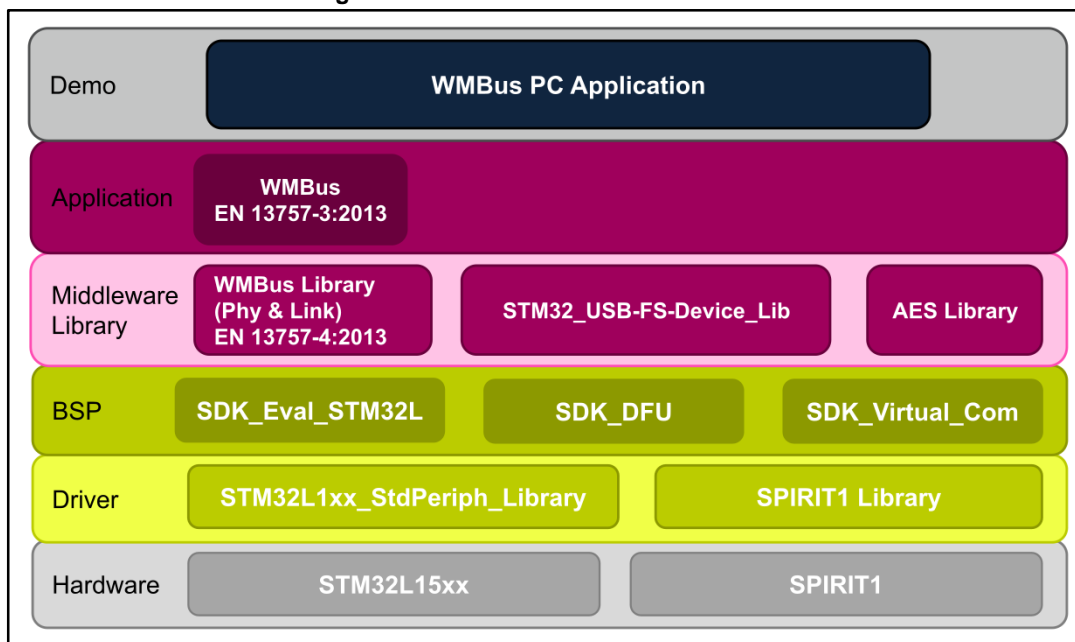
- supporting documentation:
  - wireless M-Bus firmware and application user manual (this document)
  - wireless M-Bus stack application note
  - the GUI help file
- firmware:
  - wireless 2013 library
  - SPIRIT1\_Libraries
  - STM32L1xx\_StdPeriph\_Lib
  - STM32\_USB-FS-Device\_Driver
  - application files
- PC-application:
  - the PC-GUI set-up

The software described herein can be used to develop the following applications:

- automatic meter reading
- gas meter reading
- water meter reading
- electricity meter reading
- heat meter reading

### 3.2 Architecture

Figure 4: wM-Bus Firmware Architecture



There are five layers in the architecture. The wM-Bus link and the wM-Bus Phy layers are associated with specification EN 13757-4, while the wM-Bus application layer adheres to wM-Bus specification EN 13757-3.

### 3.2.1 Hardware

This layer reveals the supported microcontroller and the transceiver.

### 3.2.2 Driver

This layer provides the standard library function to operate the STM32 microcontroller as well as the driver library for the SPIRIT1 transceiver.

### 3.2.3 BSP

Software support for all of the peripherals (except for the MCU) on the STEVAL-IKR002Vx is included in the board support package (BSP).

It includes a limited set of APIs which provides a programming interface for certain board-specific peripherals such as the LED, the user button, etc.

It allows the SPIRIT1 driver to be linked to a specific board and provides a set of user-friendly APIs.

### 3.2.4 Middleware library

- wM-Bus Library:
  - wM-Bus physical layer: contains the physical layer parameters required by the wireless M-Bus specification and offers services to the link layer. This layer utilizes the RF abstraction layer. It also adds/removes headers and trailers for the communication mode in use.
  - wM-Bus link layer contains the routines to request services from physical layer and make them available to the upper wM-Bus application layer. This mainly involves packet header data such as length, address and generate/verify CRC.
- AES Library:

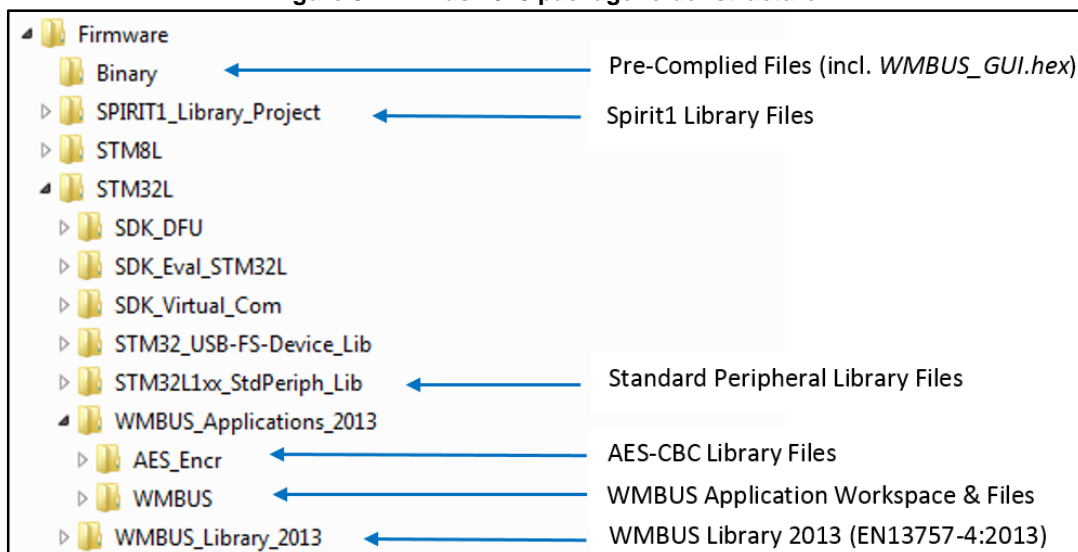
This library provides APIs to use the standard AES encryption method and the algorithm for Cipher Block Chaining (CBC).

### 3.2.5 Application layer

In this layer, some routines are provided to demonstrate how to use the wM-Bus library.

### 3.3 Folder structure

Figure 5: wM-Bus 2013 package folder structure



The files are organized into the categories described below.

### 3.4 APIs

Detailed technical information about the APIs available to the user are in a compiled HTML file inside the “Documentation” folder, with full function and parameter descriptions.

### 3.5 Software setup

The following software components are required for a suitable development environment for running applications on the STEVAL-IKR002Vx board equipped with the SPIRIT1 daughterboard:

- the software package and relative documentation
- Development tool-chain and Compiler: the software supports IAR Embedded Workbench v7.2 or higher toolchain environments for ARM® (EWARM) + ST-Link/V2

## 4 Application Example

The following section explains how the application examples are implemented, the user settings and configurations available, and how to modify the firmware for other applications.

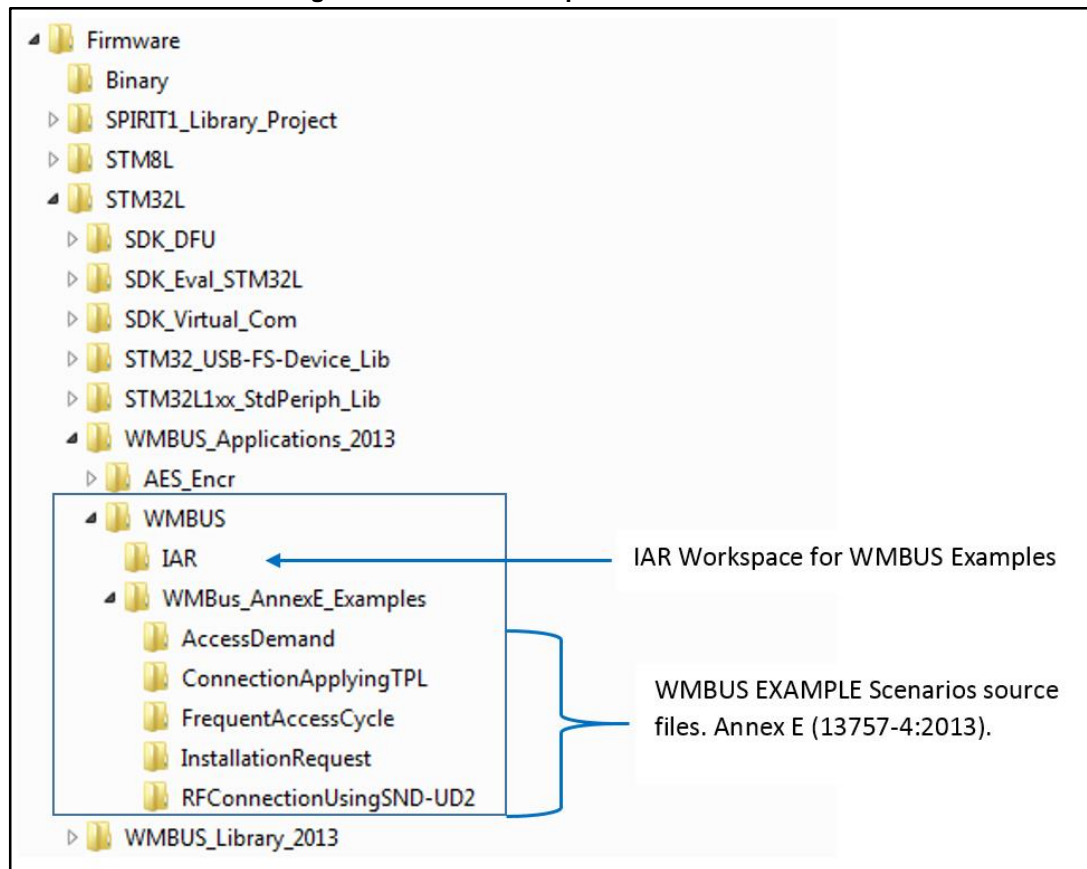
Four different workspaces are provided:

- wM-Bus: EN 13757-4:2013, Annex E application scenarios
- PCApplication: wM-Bus application to show the demo on PC

### 4.1 wM-Bus Workspace

#### 4.1.1 wM-Bus workspace folder structure

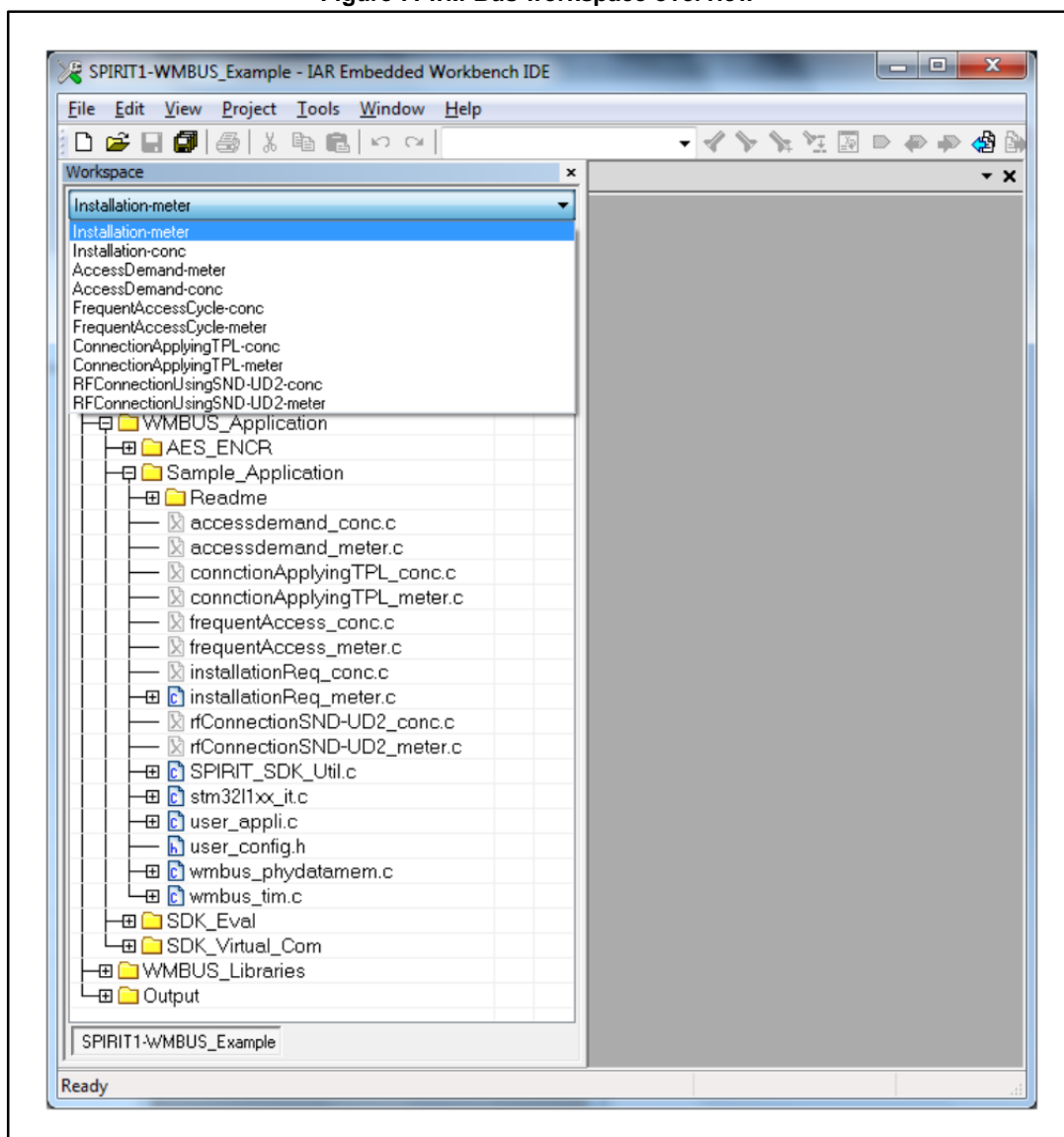
Figure 6: wM-Bus workspace folder structure



#### 4.1.2 wM-Bus application demonstration:

wM-Bus workspace has different sample configurations demonstrating the command flow between meters and other devices. The sample configurations available correspond with the timing diagram provided in Annex E of document EN13757-4:2013.

Figure 7: wM-Bus workspace overview



The sample configurations include:

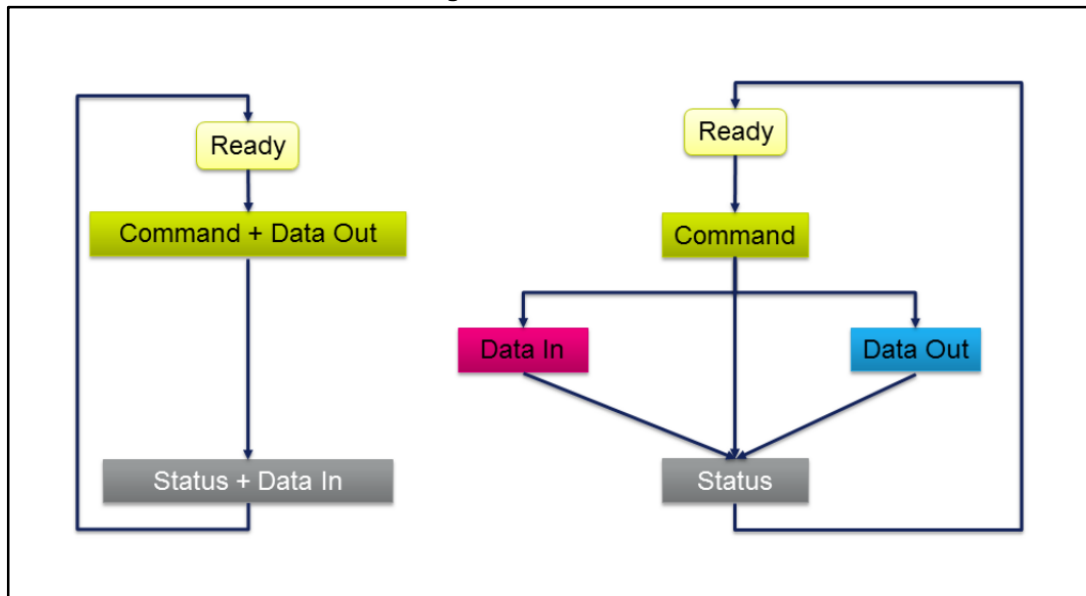
- Installation: corresponds to Figure E.2 — Installation timing of Annex E, EN13757-4:2013
  - Installation-meter: to flash on board designated as meter
  - Installation-conc: to flash on board designated as other device
- Access Demand: Corresponds to Figure E.6 — Access demand of Annex E, EN13757-4:2013
  - AccessDemand-meter: to flash on board designated as meter
  - AccessDemand-conc: to flash on board designated as other device
- Frequent Access Cycle: Corresponds to Figure E.5 — Time out, Frequent Access Cycle of Annex E, EN13757-4:2013
  - Frequent AccessCycle-meter: to flash on board designated as meter
  - FrequentAccessCycle-conc: to flash on board designated as other device
- Connection applying long/short transport layer: Corresponds to Figure E.4 — Connection applying short transport layer of Annex E, EN13757-4:2013

- ConnectionApplyingTPL-meter: to flash on board designated as meter
- ConnectionApplyingTPL-conc: to flash on board designated as other device
- RF-connection using SND-UD2: Figure E.7 — RF-connection using SND-UD2 of Annex E, EN13757-4:2013
  - RFConnectionUsingSND-UD2-meter: to flash on board designated as meter
  - RFConnectionUsingSND-UD2-conc: to flash on board designated as other device

## 4.2 PC application demonstration

The PC application uses the protocol format shown below to communicate with the firmware. The GUI binary file can be found in the Firmware/Binary folder as WMBUS\_GUI.hex.

Figure 8: Packet flow



To use this workspace, you must install the “wM-Bus Demo Suite”. The installation procedure is provided further down in this document.

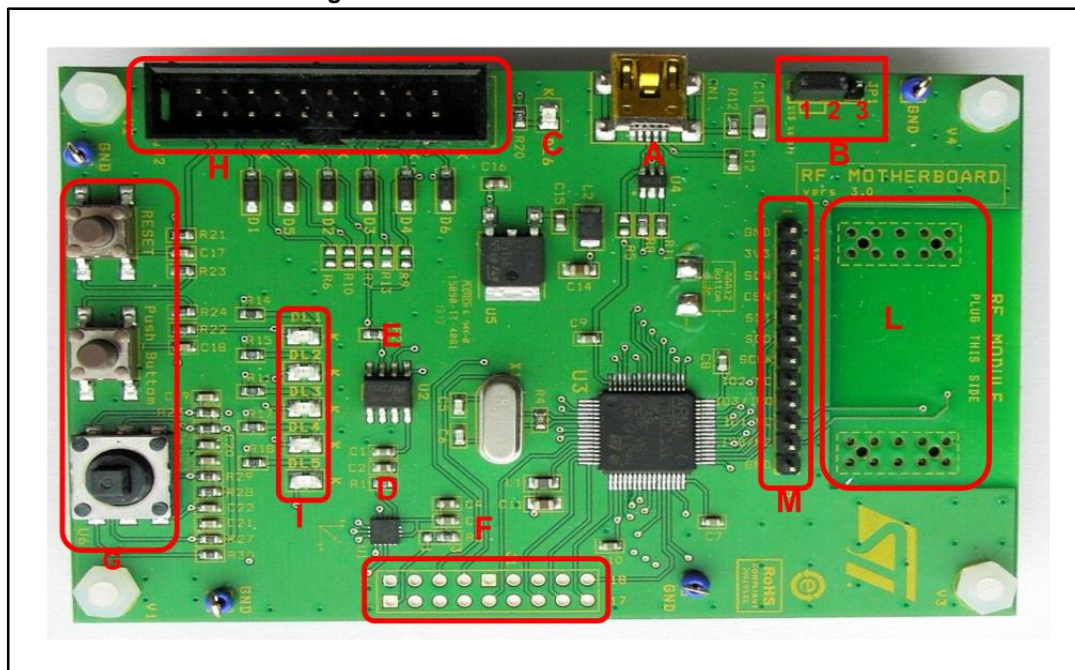
Figure 9: wM-Bus Demo Suite Interface



## 5 Hardware description

### 5.1 STEVAL-IKR002Vx (main board)

Figure 10: STEVAL- IKR002Vx main board



A: Mini USB connector CN1

B: Jumper JP1 (position 1-2 = USB power source; position 2-3 = battery power source)

C: Green LED DL6 (shows board is powered ON)

D: LIS3DH ultra-low power high performance three axes linear accelerometer

E: STLM75 high precision digital CMOS temperature sensor with I2C interface

F: Extension connector

G: User interaction buttons (RESET, PUSH\_BUTTON, and JOY STICK)

H: JTAG connector

I: Five LEDs (DL1: green, DL2: orange, DL3: red, DL4: blue, DL5: yellow)

M: Daughterboard test points

L: RF module interface connector

The RF main board has an STM32L microcontroller used for driving the SPIRIT1 transceiver and to communicate to a PC via USB.

A connector on the main board (STEVAL- IKR002Vx main board) provides JTAG interface access for programming and debugging. The board can be powered via a mini-USB connector that can also be used for I/O interaction with a USB Host. The board has also a user button, a joystick and RESET button for user interaction. A temperature sensor and accelerometer are included in the board.

The RF module can be easily connected through a dedicated interface.



Below is a list of some of the features available on the board:

- STM32L151RBT6 64-pin microcontroller
- Mini USB connector for power supply and I/O
- JTAG connector
- RF daughterboard interface
- One RESET button and one USER button
- One LIS3DH accelerometer
- One STLM75 temperature sensor
- One joystick
- 5 LEDs
- One PWR LED
- One battery holder for 2 AAA batteries
- One row of test points on the interface with the RF daughterboard

### 5.1.1 Push buttons and joystick

For user interaction, the board has two buttons: one to reset the microcontroller and the other available for use by the application. There is also a digital joystick with 4 possible positions (left, right, up, down) (G in [Figure 4: "wM-Bus Firmware Architecture"](#)).

### 5.1.2 JTAG connector

A JTAG connector on the board (H in [Figure 4: "wM-Bus Firmware Architecture"](#)) allows programming and debugging of the STM32L microcontroller on board, using an in-circuit debugger and programmer like the ST-LINK/V2.

### 5.1.3 LEDs

Five LEDs are available (I in STEVAL- IKR002Vx main board)

- DL1: Green
- DL2: Orange
- DL3: Red
- DL4: Blue
- DL5: Yellow

## 5.2 STEVAL-IKR002Vx (RF module)

The RF module includes five possible BOM lists on the same layout PCB. Each one is optimized for the following different RF bands:

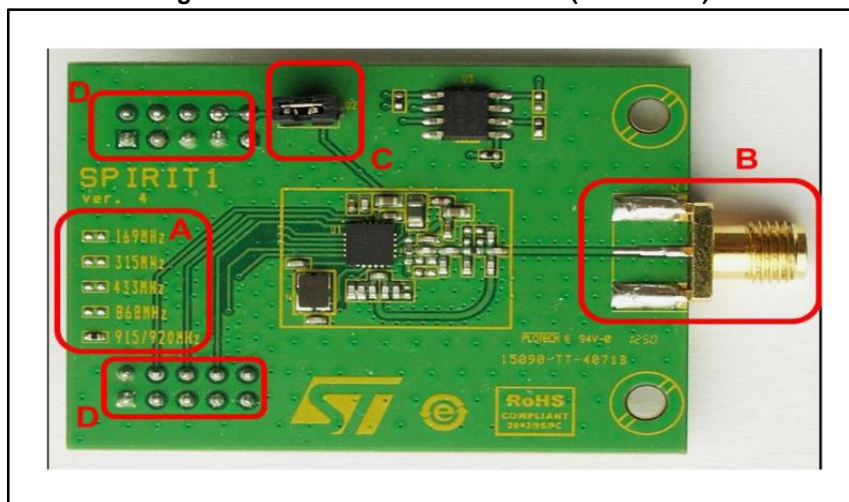
- 169 MHz
- 315 MHz
- 433 MHz
- 868 MHz
- 915 MHz

The band is indicated by a dummy resistor in region "A" of [Figure 2: "Typical application scenario"](#). An SMA connector on the RF module at "B" allows connection of RF instruments like spectrum analyzers and signal generators to the SPIRIT1 via RF cable or antenna (also included in the demo kit). The connector at "D" is used to connect with the main board to receive power and communicate via SPI and some GPIOs with the microcontroller.

The Vcc\_RF pin on the RF daughterboard is connected to the Vbat pin of the SPIRIT1 through the jumper at "C", which can be removed to measure current consumption.

The RF module includes a memory EEPROM in which certain information regarding the RF module at the time of manufacture is stored in the first pages. This memory is not intended to be changed by the user.

Figure 11: STEVAL-IKR002Vx board (RF module)



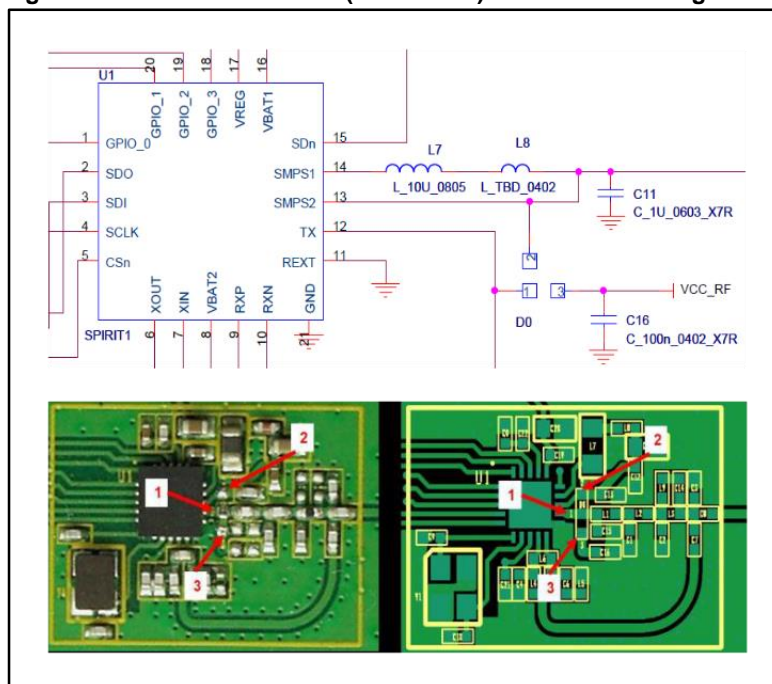
### 5.2.1 Boost mode

The SPIRIT1 can be configured to increase the output power in transmission mode

In the default configuration, the transmitter power amplifier (PA) output is biased by the 1.4 V SMPS voltage output through the L0 external inductor (position D0 in the schematic, STEVAL-IKR002Vx (RF module) boost mode configuration). This limits the maximum output power to about +11 dBm, measured at the 50  $\Omega$  connector via the reference design.

Biasing the PA output through the inductor L0 directly connected to the battery instead of the SMPS output allows the maximum output power delivered at the 50  $\Omega$  connector (or at the antenna) to be increased. The maximum output power changes with the voltage level applied at the PA output.

To switch to boost mode, the inductor L0 must be removed from the position 1-2 D0 in the schematic and soldered at position 1-3 D0, then the voltage supply Vcc\_RF must be provided.

**Figure 12: STEVAL-IKR002Vx (RF module) boost mode configuration**

For more information, see Application note AN4198 - SPIRIT1: increasing the output power, available on the SPIRIT1 web site or in the document folder of this release.

## 5.3 Hardware setup

This section describes the hardware and software setup procedures. It also describes the system setup required for the above.

### 5.3.1 Hardware equipment

The following hardware components are required:

- Two STEVAL-IKR002Vx main boards
- Two SPIRIT1 daughterboards
- One USB type-A to Mini-B USB cable to connect the boards to the PC

### 5.3.2 Setting up the board

The STEVAL-IKR002Vx main board is connected to the SPIRIT1 module as per the figure below.

Board setup

## 5.4 Running sample applications on the STEVAL-IKR002Vx board

Follow these steps to run the basic application demo:

1. use the appropriate tool chain IDE; i.e., IAR v7.2
2. power the STEVAL-IKR002Vx main board using the Mini-B USB cable
3. program the firmware in the STM32 on the STEVAL-IKR002Vx main board using the firmware example provided
4. reset the MCU board using the RESET button on the STEVAL-IKR002Vx main board

5. ensure that meter and concentrator devices have the same RF frequency and mode settings
6. modify the parameters in “user\_config.h” shown below to the desired settings

Figure 13: User firmware settings

```

/*****Generic User defines*****/
#define ENCR_MODE_0      0x00 /*No Encryption*/
#define ENCR_MODE_1      0x01 /*Encryption mode not Supported*/
#define ENCR_MODE_2      0x02 /*Encryption mode not Supported*/
#define ENCR_MODE_3      0x03 /*Encryption mode not Supported*/
#define ENCR_MODE_4      0x04 /*Encryption mode not Supported*/
#define ENCR_MODE_5      0x05 /*Encryption mode Supported :
                                AES encryption with CBC;
                                initialisation vector is not zero*/
#define ENCR_MODE_6      0x06 /*Encryption mode not Supported*/
#define ENCR_MODE_7      0x07 /*Encryption mode not Supported*/
#define ENCR_MODE_15     0x0F /*Encryption mode not Supported*/

#define ENCKEY_LEN        16 /*16 bytes Encryption Key is used*/

#define ENCR_BLOCK_SIZE   16 /*Encrypted block size*/

#define METER_DB_INDEX    0x01 /*Index to get the device selfinfo
                                from the meter database Index 0
                                is reserved for Conc*/

#define INIT_VECTOR_SIZE  16
#define MAX_DATA_LEN      255

#if defined(DEVICE_TYPE_OTHER)
#define DEVICE_TYPE        OTHER
#define DEVICE_METER_TYPE  COMMUNICATION_CONTROLLER
#elif defined(DEVICE_TYPE_METER)
#define DEVICE_TYPE        METER
#define DEVICE_METER_TYPE  ELECTRICITY_METER
#else
#error DEVICE_TYPE undefined or unsupported
#endif

/*****WMBUS Sub-Mode Configuration*****/
#define TX_OUTPUT_POWER    (3.0) /*Between [-3.0 ,+27.0] if the RF
                                board has an external PA.
                                Otherwise between[-30.0 ,+13.0]*/

#define DEVICE_WMBUS_MODE  S2_MODE
#define DEVICE_WMBUS_CHANNEL CHANNEL_1
#define WMBUS_FRAME_FORMAT FRAME_FORMAT_A

```

## 6 Using the demo board with PC application

The PC application can be used to quickly familiarize yourself with ST's wM-Bus package features. The board flashed with PC application firmware must be connected to the PC-GUI through a USB port.

### 6.1 wM-Bus Demo Suite system requirements

To install and run the application successfully, your pc must have the following minimum characteristics:

- 1 GHz processor
- 1 GB RAM
- 250 MB free disk space
- Windows 7 (SP1) or later (x86 or x64)
- .NET Framework 4.5
- minimum HD (1280x720) / WXGA (1280x768) screen resolution – although a higher resolution is recommended

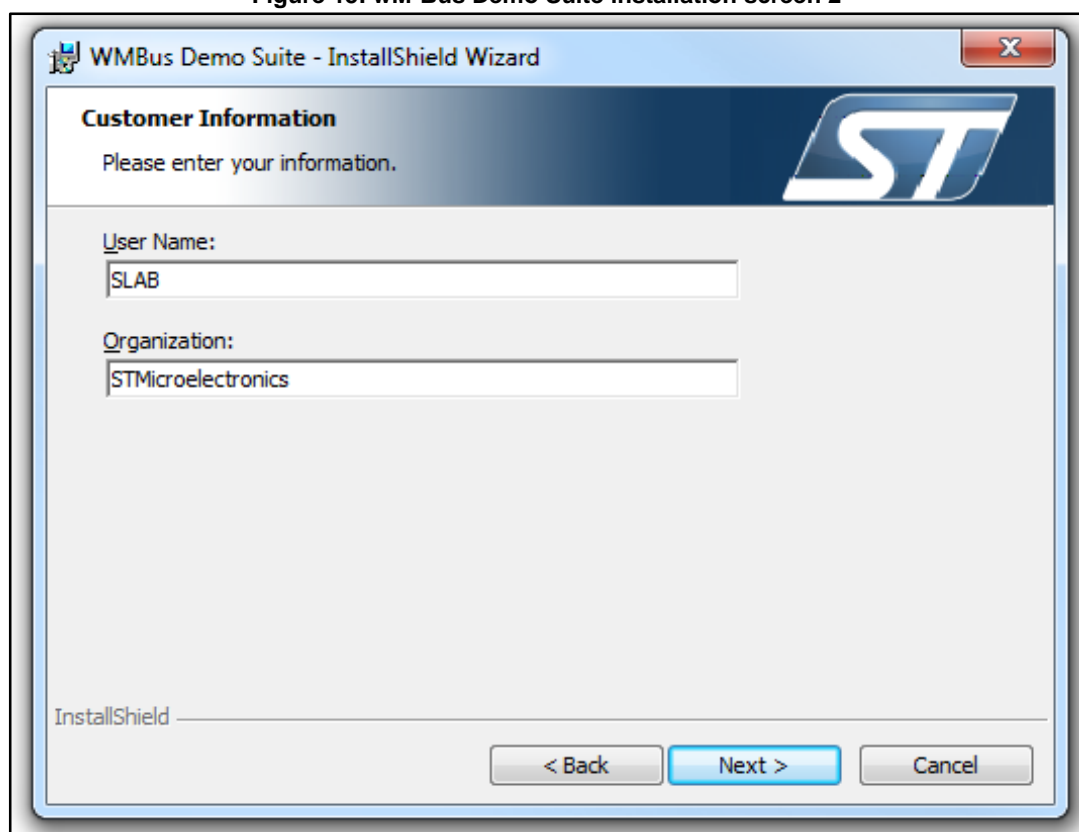
### 6.2 wM-Bus Demo Suite installation

Run the wM-Bus Demo Suite installation package and complete the installation as per the following sequence of figures:

Figure 14: wM-Bus Demo Suite installation screen 1



Figure 15: wM-Bus Demo Suite installation screen 2



The image shows a screenshot of the 'WMBus Demo Suite - InstallShield Wizard' window. The window has a title bar with the text 'WMBus Demo Suite - InstallShield Wizard' and a close button. The main content area is titled 'Customer Information' and contains the instruction 'Please enter your information.' followed by the STMicroelectronics logo. Below this, there are two text input fields: 'User Name:' with the value 'SLAB' and 'Organization:' with the value 'STMicroelectronics'. At the bottom of the window, there are three buttons: '< Back', 'Next >', and 'Cancel'. The 'Next >' button is highlighted in blue. The 'InstallShield' logo is visible in the bottom left corner of the window.

WMBus Demo Suite - InstallShield Wizard

**Customer Information**

Please enter your information.

**User Name:**  
SLAB

**Organization:**  
STMicroelectronics

InstallShield

< Back   Next >   Cancel

Figure 16: wM-Bus Demo Suite installation screen 3

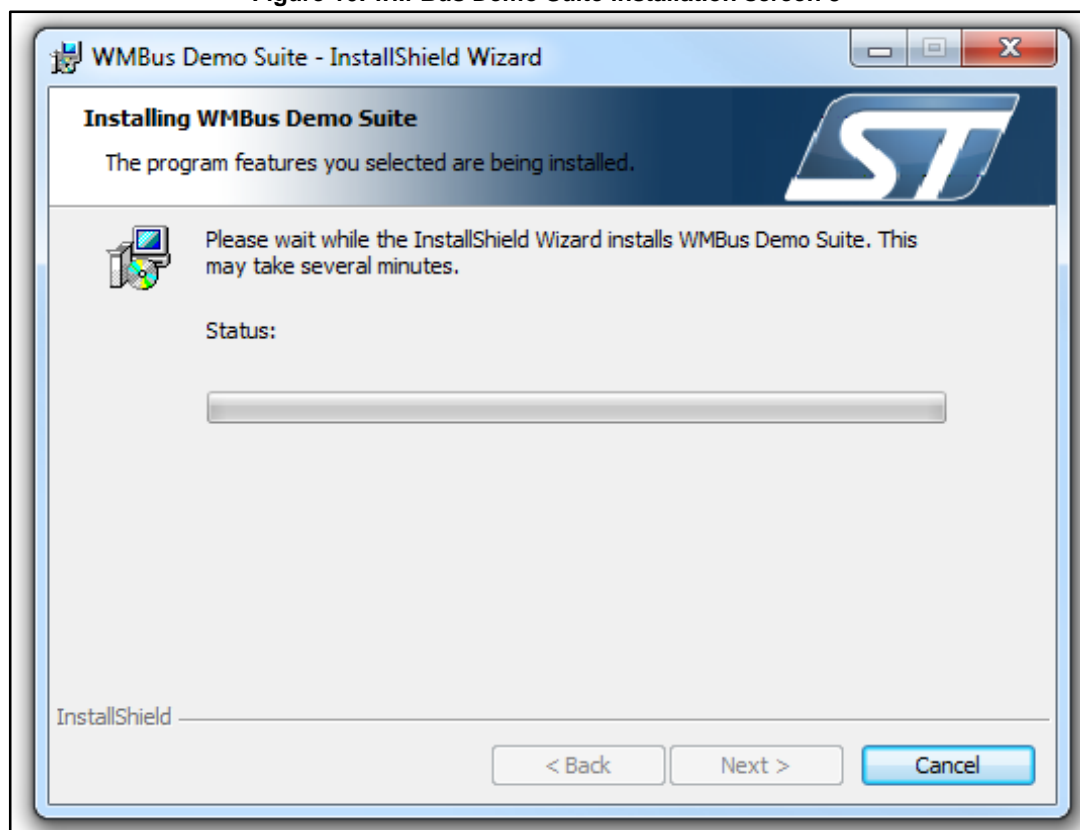
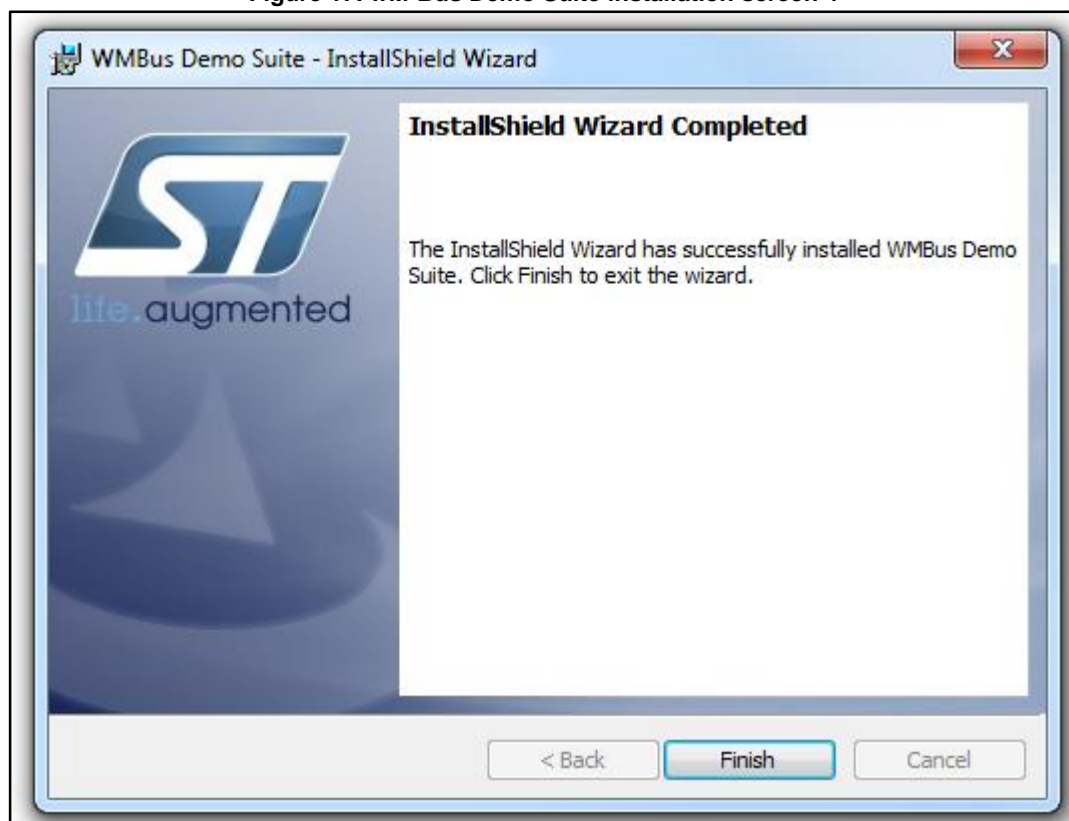


Figure 17: wM-Bus Demo Suite installation screen 4



Once installation is complete, also install the STMicroelectronics Virtual COM port driver present in the "Demo Suite" installation directory. Select the right installation file for your machine (32 or 64 bit).



## 7 References

1. SPIRIT1 device datasheet
2. Respective STM32 controller datasheets

## 8 Revision history

**Table 2: Document revision history**

Date	Version	Changes
14-Dec-2015	1	Initial release.

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