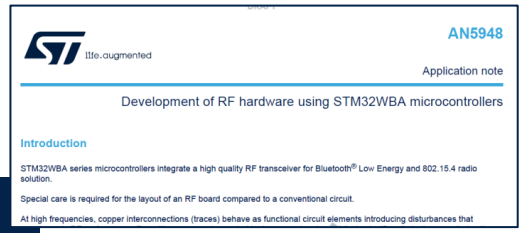
ST MCU STM32WBA series

HW design

HW design with STM32WBA

Complete set of documentation
#1 Design schematics and layout


AN5948

Application note

Development of RF hardware using STM32WBA microcontrollers

Introduction

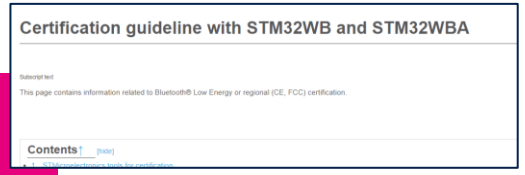
STM32WBA series microcontrollers integrate a high quality RF transceiver for Bluetooth® Low Energy and 802.15.4 radio solution.

Special care is required for the layout of an RF board compared to a conventional circuit.

At high frequencies, copper interconnections (traces) behave as functional circuit elements introducing disturbances that

A complete ecosystem
#2 Test & tune your PCB

A complete ecosystem
#3 certify your product


Certification guideline with STM32WB and STM32WBA

This page contains information related to Bluetooth® Low Energy or regional (CE, FCC) certification.

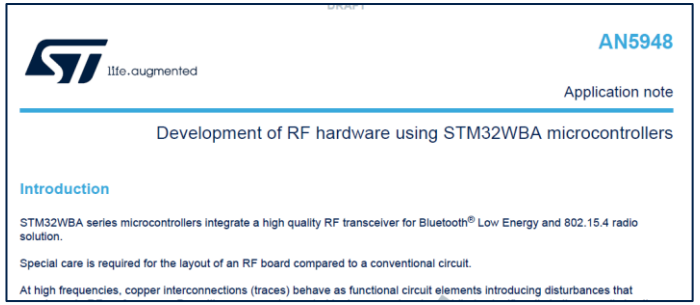
Contents

ST MCU STM32WBA series

Design schematics and layout

A complete set of documentation

AN5948 : Development of RF Hardware using STM32WBA


AN5948

life.augmented

Application note

Development of RF hardware using STM32WBA microcontrollers

Introduction

STM32WBA series microcontrollers integrate a high quality RF transceiver for Bluetooth® Low Energy and 802.15.4 radio solution.

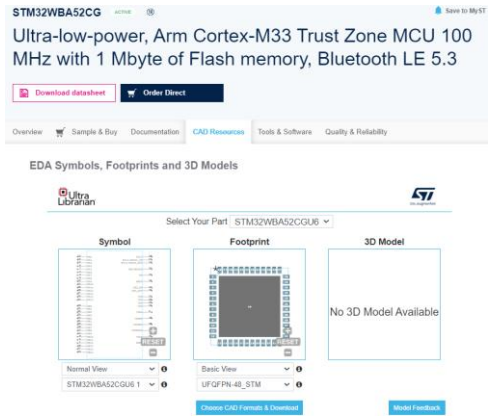
Special care is required for the layout of an RF board compared to a conventional circuit.

At high frequencies, copper interconnections (traces) behave as functional circuit elements introducing disturbances that

Soon on st.com.
Draft available on demand

- RF basis generalities
- Schematics & components selection guidelines
- STM32WBA5x layout checklist & guidelines

STM32WBA5x CAD resources on st.com



- Download STM32WBA5x symbol
- Download STM32WBA5x footprint

Can be accessed directly from CubeMx and CubeIDE in "Tools" dongle

life.augmented

Reference schematics & layout

Multiple reference design available for various part numbers & packages

Part number	Package	Antenna type	Reference design
STM32WBA52/54	QFN48	PCB antenna	**MB1863**
STM32WBA52/54	QFN48	SMA connector	**MB1845**
STM32WBA54	QFN32	SMA connector	**MB1806**
STM32WBA55	QFN48	PCB antenna	**MB1803**
STM32WBA55	QFN48	SMA connector	**MB1805**
STM32WBA55	BGA59	SMA connector	**MB1807**

Start your HW design based on selected part reference design

Orderable kits soon on st.com for evaluation

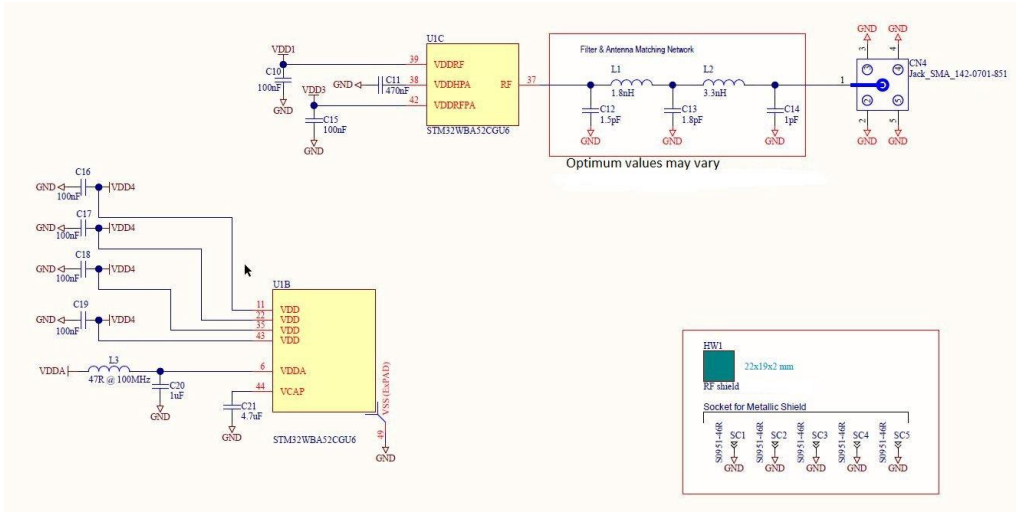
MB1801 + MB1803
January 2024

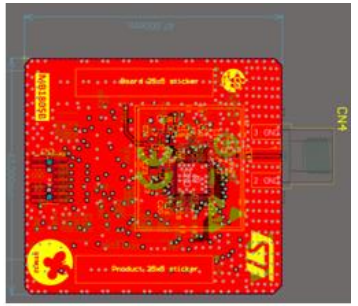
MB1802 + MB1803
(BLE audio)

HW design with STM32WBA5x : key points

Start from reference and pay attention to below key points

- HSE 32MHz xtal requirements
- LSE or LSI selection
  LSE 32kHz xtal requirements if used
- RF matching & filtering
- Power management
  SMPS implementation for STM32WBA55 use case
- Main layout recommendations



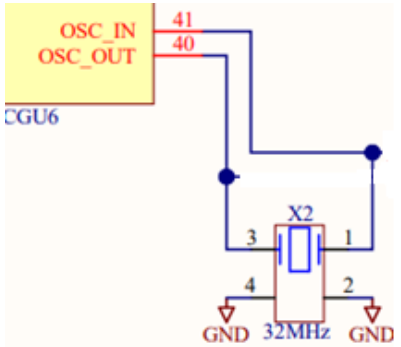


STM32WBA5x : HSE requirements

High-speed external (HSE32) clock is mandatory (32 MHz crystal or external clock source)

32MHz crystal selection

- STM32WBA5x includes internal programmable capacitances to trim the crystal frequency
  - No external load capacitances.
  - Use 8pF load cap crystal.
  - No HSE frequency trim needed in production



- Recommended part (or equivalent): NX1612SA-32MHZ-EXS00A-CS09166

Layout recommendation

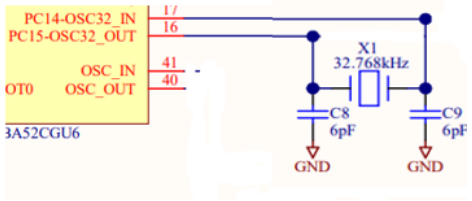
- Set 32MHz crystal as close as possible from STM32WBA5x

STM32WBA5x : LSE or LSI selection

LSE / LSI : LSE or LSI can be used as low speed clock source.

LSE

- Low load cap crystal (e.g. 6pF) and low ESR ensure low drive can be used.
  Power consumption impact.
- Recommended part (or equivalent):
  NX1610SE-32.768KHZ-EXS00A-MU01501
- Minimize 32kHz track lines length.
  Connect decoupling caps to main GND through a dedicated via.

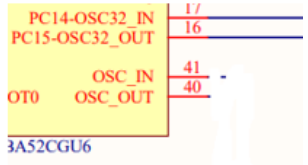


Mandatory for accurate RTC calendar application.

Optimized power consumption

LSI

- OSC32 pins can be left open if not used.
- OSC32 pins can be used as IOs.



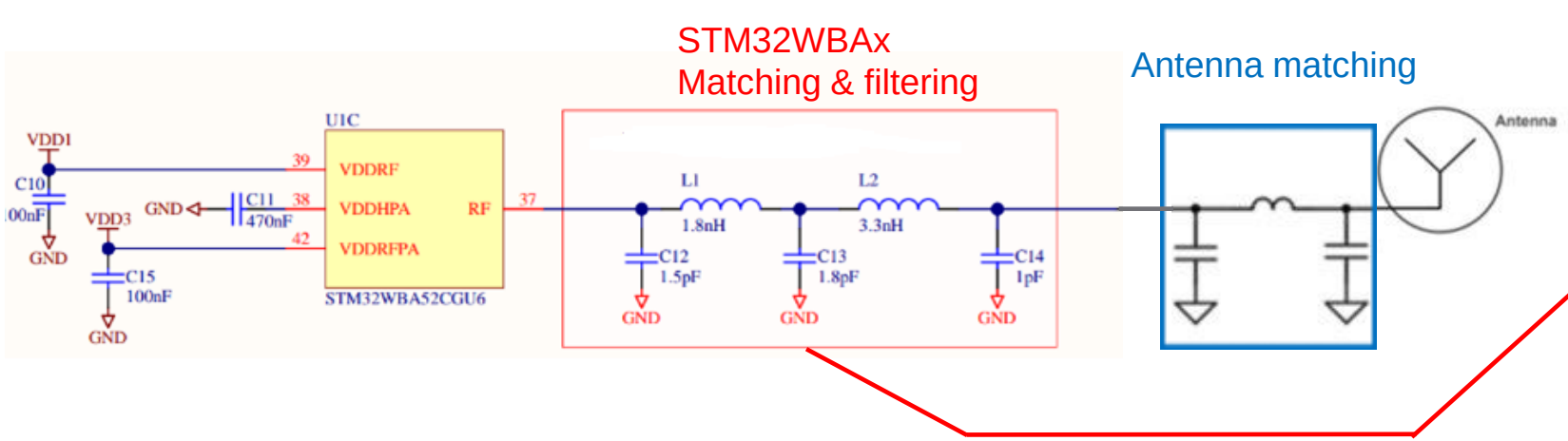
BOM optimized (save 32kHz xtal cost)

More IOs available

life.augmented

STM32WBA5x : RF matching

- STM32WBA5x is having an integrated balun (single ended RF matching).
- Very limited number of discrete needed to match and filter STM32WBA5x.
  Matching will ensure best RF performances (Tx power, sensitivity or spurious emission filtering)
- Few other discretes needed to for antenna matching to ensure proper antenna behavior.



MLPF-WB04D3

RF IPD for STM32WBA series
"Plug and play" solution

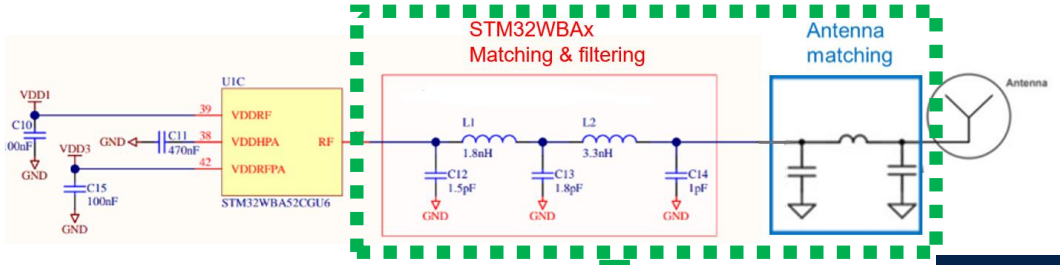
Integrated balun
Very limited number of discretes components for STM32WBAx matching and filtering

STM32WBA5x : RF matching

Reduced components count possibilities

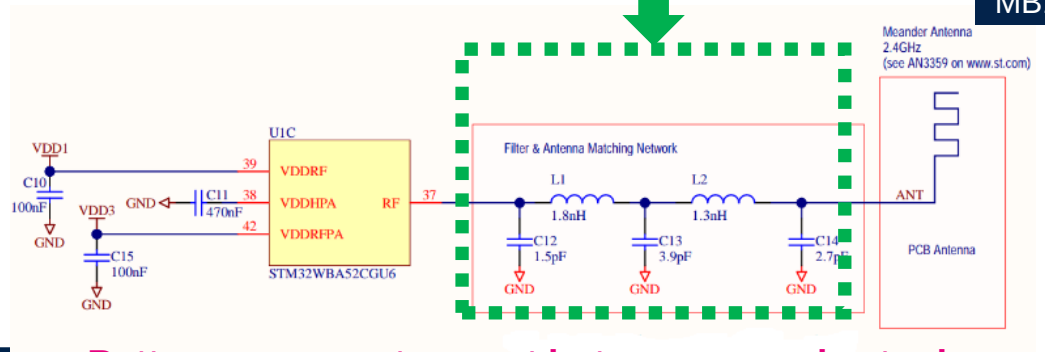
Combine STM32WBA5x & antenna matching

Easy tuning but more components requested



MB1845

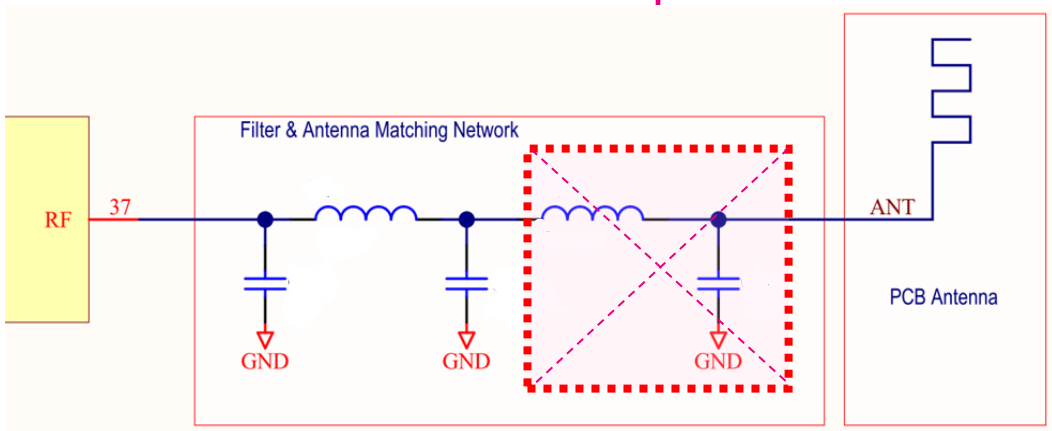
MB1863



Better components count but more complex tuning

Reduce matching components for reduced Tx power

Reduce filtering for reduced Tx power



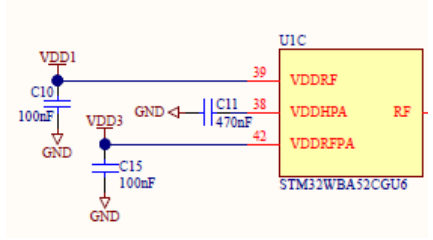
STM32WBA55 : Power management

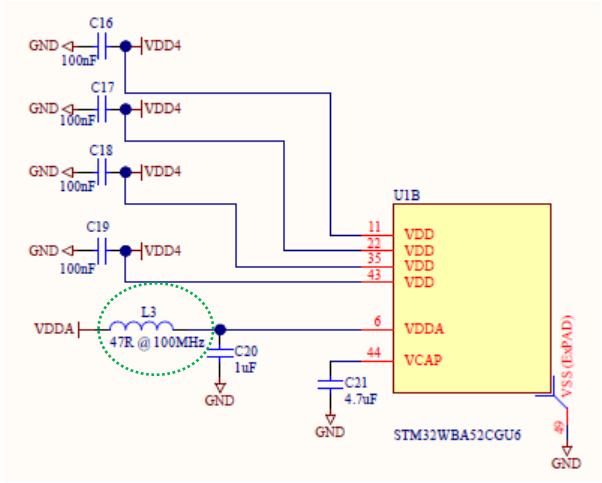
Refer AN5948 & STM32WBA55 reference kit & BOM

Few decoupling caps needed on STM32WBA5x power supplies pins

Follow AN5948 and values proposed with our reference kits

STM32WBA52 QFN48 decoupling example

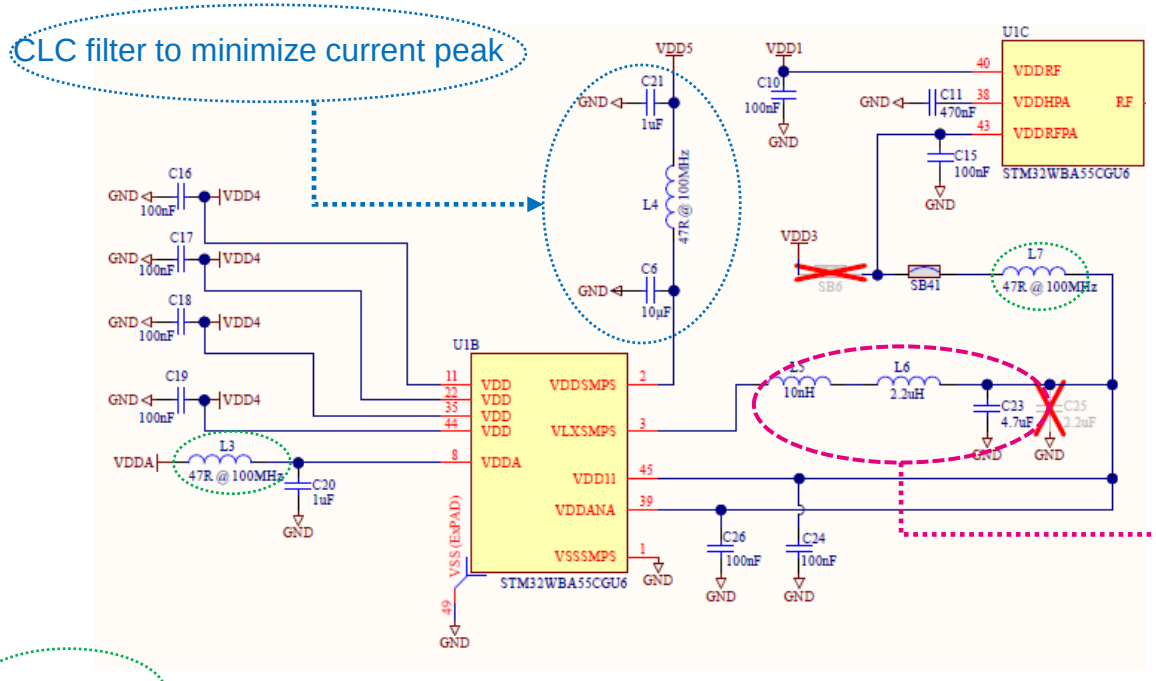




Optional coil

STM32WBA55 : SMPS

STM32WBA55 embeds an SMPS that can be used to improve power efficiency.



Key SMPS components (SMPS running @3MHz)

- ✓ 2.2µH coil : should have low ESR & high rating current
- ✓ 4.7uF decoupling capacitor.
- ✓ 10nH : optional. Filter SMPS spurs and achieve best sensitivity

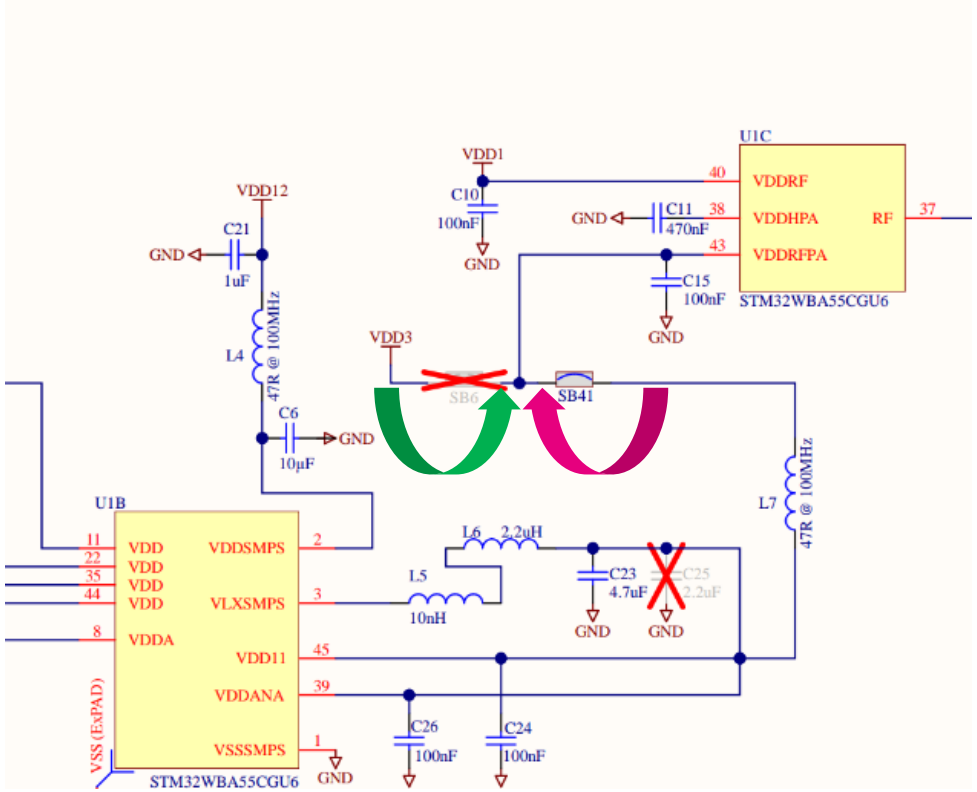
Refer AN5948 & STM32WBA55 reference kit & BOM

STM32WBA55 : SMPS vs.Tx power

HW configuration point of attention when SMPS used

With STM32WBA55, you must consider specific HW configuration if willing to achieve the 10dBm maximum output power.

When max power is requested (5 to 10dBm), VDDRFPA must be connected to Vdd



For Tx power up to 4dBm, connect VDDRFPA to Vdd11

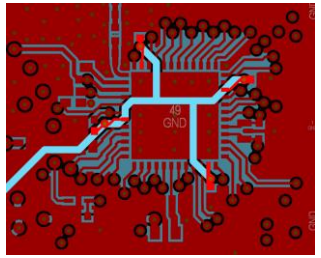
take full benefits of SMPS

STM32WBA5x : general layout recommendations

Refer AN5948 & STM32WBA55 reference kit (Gerbers & Altium) & BOM

AN5948 is providing layout design recommendations and check list

- Power supply routed in star configuration
- Decoupling caps close from pads
- Solid ground plane and enough GND vias to ensure minimum current return path
- Xtals as close as possible from STM32WBA5x
- 50 Ohms transmission lines for RF path



4 layers stackup recommended

TOP layer: components and critical signals (for example, RF, XTAL, SMPS)
INNER1 layer: ground plane
INNER2 layer: power plane and signal routing
BOTTOM layer: ground plane and signal routing

4 layers

ST support :
Schematics / gerbers review

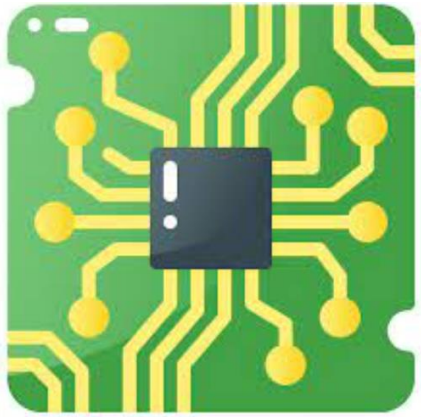
life.augmented

ST MCU STM32WBA series

Test & tune your PCB

Bring up of your STM32WBA5x design

PCB in your hands : Let’s test and tune with focus on below items



HSE 32MHz frequency tuning

If used, LSE 32kHz tuning and LSE drive setting.

Check RF performances & optimize RF matching if needed.

ST support :
Bring-up (HSE/LSE tuning)
RF precertification
Antenna matching

STM32WBA5x : HSE tuning

Why HSE tuning?

HSE must be tuned to ensure an accurate 32 MHz thanks to STM32WBA5x internal programmable capacitances

Potential impact :

- Certification : Ensure all product will respect regulation requirements.
  For example +/-60ppm for Bluetooth® Low Energy, +/-25ppm for china etc.
- Connection issue : frequency error will lead to timing error and can impact connection

How to tune?

Refer AN5042 : How to calibrate the HSE clock for RF applications on STM32 wireless MCUs.

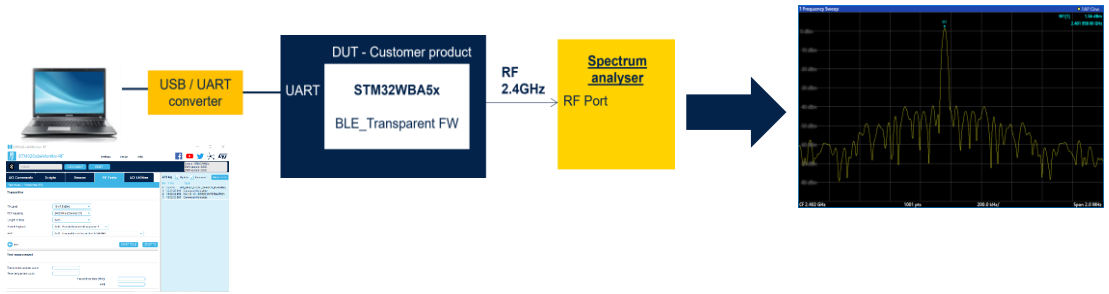
Easiest and recommended method is described in next slides:

- Flash STM32WBA with transparent FW (see STM32CubeWBA package)
- Download X-CUBE-CLKTRIM on st.com
- Download and use Cube Monitor RF tool
  - Check RF tone centering on a spectrum analyzer
  - Modify HSETUNE parameter with dedicated scripts till RF tone is centered

STM32WBA5x : HSE tuning

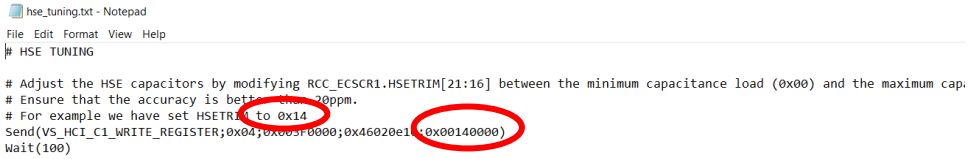
1

Use “RF Tests” panel of STM32CubeMonitorRF PC tool.
Generate a tone at wanted frequency and power.
Check frequency error on spectrum analyzer.



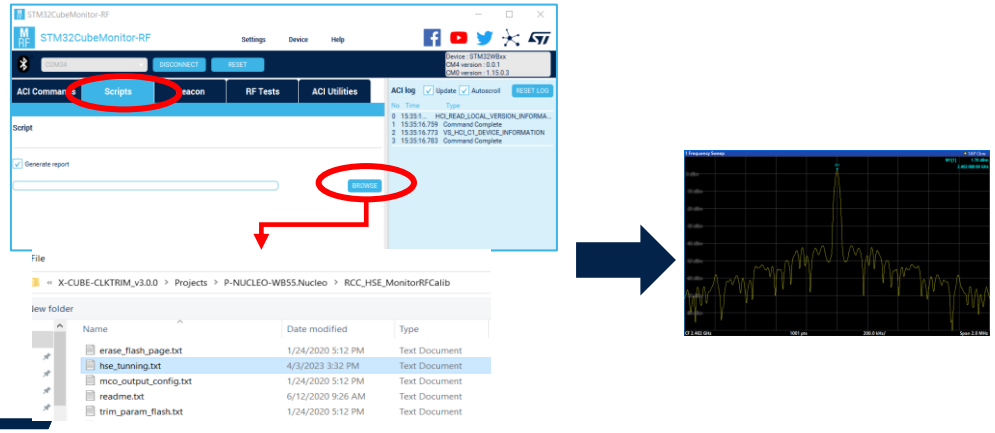
2

Edit “hse tuning.txt” available in X-CUBE-CLKTRIM package
and define new HSETUNE to tested value (0x14 in below example)



3

Use “scripts” panel of STM32CubeMonitorRF and launch “hse tuning.txt”
Generate a tone and check HSE centering.
Repeat step 2 and 3 to define optimized HSETUNE value



4

As stated in AN5042, use dedicated scripts to write HSETUNE value to OTP.

```
Wait(100)
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0xFFFFFFFF;0x40022008;0xCDEF89AB)
Wait(100)

# Write 0x08192A3B and 0x4C5D6E7F in FLASH_OPTKEYR to enable option byte programming/erasing operations
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0xFFFFFFFF;0x40022010;0x08192A3B)
Wait(100)
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0xFFFFFFFF;0x40022010;0x4C5D6E7F)
Wait(100)

# Set PG in FLASH_NSCR1 - Flash Programming enable
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0x00000001;0x40022028;0x00000001)
Wait(100)

# Arbitrary data : STM3 = 0x334D5453 (for example)
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0xFFFFFFFF;0x0BF90000;0x334D5453)
Wait(100)

# Arbitrary data : 2WBA = 41425732 (for example)
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0xFFFFFFFF;0x0BF90004;0x41425732)
Wait(100)

# Write lower BD Address : Company Id = 0xE12A + Board Id = 0x4CC7 (for example)
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0xFFFFFFFF;0x0BF90008;0xE12A4CC7)
Wait(100)

# Write upper BD Address : DataId = 0x0 + HSE_Tu      0x14 (f    example) + Upper BD = 0x0080
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0xFFFFFFFF;0x0BF900    0x00140080)
Wait(100)

# Clear PG in FLASH_NSCR1 - Flash Programming disable
Send(VS_HCI_C1_WRITE_REGISTER;0x04;0x00000001;0x40022028;0x00000000)
Wait(100)
```

life.augmented

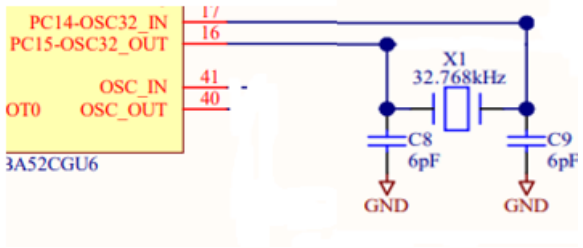
STM32WBA5x : LSE tuning

When LSE is used, you must tune LSE frequency thanks to external load caps and define the LSE drive needed.

Potential impact :
- Boot issue (LSE gain)
- Connection/disconnection issue : LSE inaccuracy will lead to timing error and can impact connection

1 LSE frequency centering - Please refer AN2867

LSE frequency can be output on MCO pin and measured with a frequency meter. Adjust external load caps to get an accurate 32.768kHz frequency



2 Check and define LSE gain needed

- Check gm criteria based

$$g_{mcrit} = 4 * ESR * (2 * \pi * F)^2 * (C0 + CL)^2$$

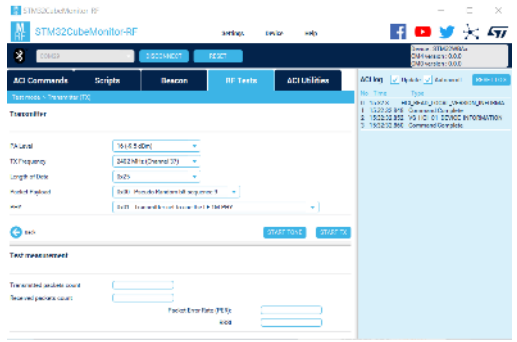
- align LSE drive (from medium low to high) gain in SW.

$Gm_{critmax}$	Maximum critical crystal Gm	LSEDRV = medium-low drive capability	-	-	0.75	µA/V
		LSEDRV = medium-high drive capability	-	-	1.70	
		LSEDRV = high drive capability	-	-	2.70	

Eg: if we get a gmcrit < 0.75, we can defineLSE drive as below
HAL_RCC_LSEDRIVE_CONFIG(RCC_LSEDRIVE_MEDIUMLOW);

RF testing

Thanks to STM32CubeMonitorRF tool and RF panel quickly evaluate your RF performances.



Dedicated FW (Transparent Mode FW) must be set in host MCU*

USB / UART converter

UART

DUT - Customer product

STM32WBA5x

BLE_Transparent FW

RF 2.4GHz

Spectrum analyser

RF Port

STM32CubeMonitorRF PC tool is available at st.com

*It must eventually be rebuilt according customer HW configuration (UART interface used, LSE/LSI, SMPS etc).

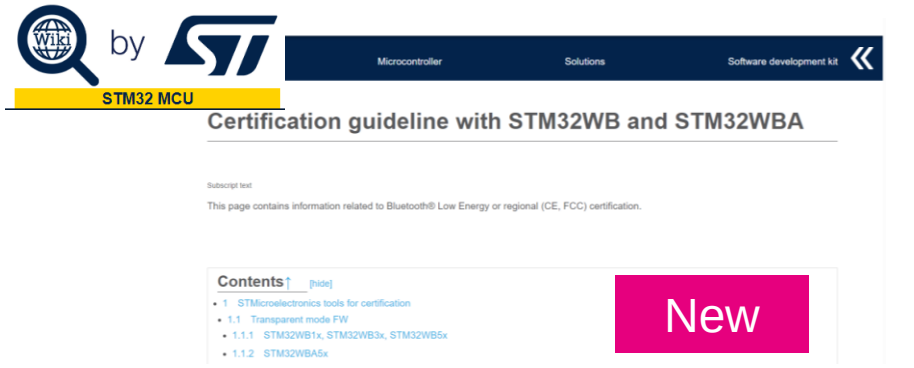
ST MCU STM32WBA series

Certify your product

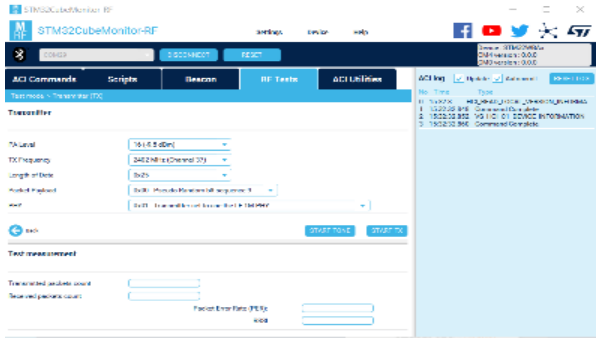
STM32WBA5x : a certified solution

STM32WBA5x is compliant in regards of regional (CE, FCC etc.) and Bluetooth® Low Energy requirements

ST is providing complete set of documentation, FW and tools to certify your product.



(Certification guideline STM32WB and STM32WBA)



STM32CubeMonitorRF PC tool

Transparent Mode FW

life.augmented

Bluetooth certification

STM32WBA5x is having reference QDIDs (components and stack) at Bluetooth SIG.

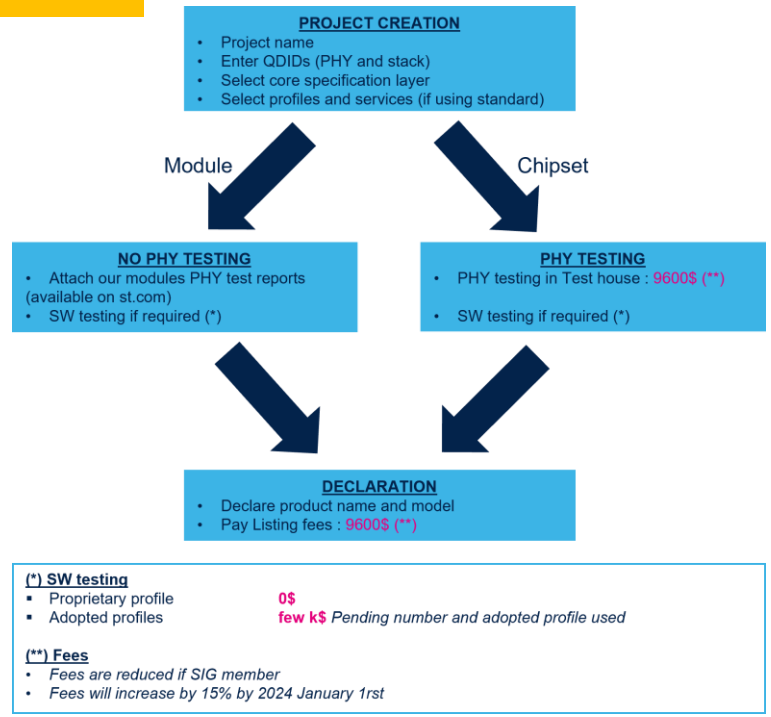
Customer musty performed PHY testing and declare its product at Bluetooth SIG.

PHY QDID

Package	Part number	Cut version	RF PHY QDID
QFN48	STM32WBA52 (BLE5.4)	1.x	**197135** (TCRL 2022-2)

Stack QDID

Features	Host Stack version	QDID
4.0 HCI Low Energy LL with extended advertising – ATT – GAP – GATT – L2CAP with Enhanced Connected Oriented Channel -SMP BLE 5.3	STM32Cube_WBA_BLE_HCI_STACK STM32Cube_WBA_BLE_FULL_STACK	**198195** (TCRL 2022-1)



Refer wiki Certification guideline on st.com describing steps by steps process

Thank you

life.augmented