
STM32WL3x MCU reference designs: RF performance in TX and RX operation

Introduction

This technical note presents a comparison of the current consumption, output power, harmonic levels, and RX sensitivity of the STM32WL3x reference designs (STDES-WL3Cxxxx) listed in [Table 1. Radio settings for TX operation](#). The settings are optimized for specific center frequencies and output-power targets.

It also provides an overview of the RF performance achieved by the different reference designs over the supported frequency bands. All the reference designs in this document use the TX and RX paths in a direct-tie configuration, except for the STDES-WL3C4EEW, where an external power amplifier separates TX and RX.

The results presented herein can be used as a reference for design comparison, performance benchmarking, and support to application development based on the STM32WL3x platform.

1 General information

The STM32WL3x microcontrollers in the STDES-WL3xxxxx reference designs are based on the Arm® Cortex® M0+ processor.

*Note: Arm and Cortex are registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere.
The Arm word and logo are trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere. All rights reserved.*



2 STM32WL3x MCU register settings

This section describes the register configuration used on the STM32WL3x MCUs during TX and RX operation. The register settings reported in the following subsections have been selected to achieve the required RF performance in each operating mode and to ensure consistency with the measurement conditions used throughout this document.

This section also reports the radio settings applied for both TX and RX test cases, so that the measured results can be directly correlated with the corresponding configuration parameters.

2.1 TX radio and register setting

This section reports the radio and register configuration used during TX measurements.

The settings are selected to obtain the target output power at the specified center frequency, while maintaining the expected current consumption.

The STM32WL3x MCU is configured in HPM (high-performance mode) conditions: 16 MHz system clock, HSIPLL mode, and HSE GMC setting 0x0A:

- RCC.CFGR.CLKSYSDIV = 2
- RCC.RFSWHSECR.GMC = 10
- RCC.CFGR.HSESEL = 0
- RCC.CFGR.STOPHSI = 0

The TX performance is evaluated using a CW signal.

Depending on the reference design, use the settings indicated in the table below to achieve the best performance for each radio configuration.

Table 1. Radio settings for TX operation

Web reference	Number of layers	SMD, IPD, or external PA	Optimized BOM target	SMPS level	PA drive mode	PA_LEVEL7	Degeneration mode
STDES-WL3C2ILL	2	IPD	433 MHz/ 10 dBm	1.4 V	TX	0x51	ON
STDES-WL3C2IMH	2	IPD	868 MHz/ 14 dBm	1.4 V	TX_HP	0x51	ON
			868 MHz/ 16 dBm	1.6 V	TX_HP	0x51	ON
STDES-WL3C2IML	2	IPD	433 MHz/ 14 dBm	1.4 V	TX_HP	0x51	ON
			433 MHz/ 16 dBm	1.8 V	TX_HP	0x51	ON
STDES-WL3C2SLH	2	SMD	868 MHz/ 10 dBm	1.4 V	TX	0x51	ON
				1.5 V	TX	0x51	OFF
			915 MHz/ 10 dBm	1.4 V	TX	0x4F	ON
				1.4 V	TX	0x51	OFF
STDES-WL3C2SLL	2	SMD	433 MHz/ 10 dBm	1.4 V	TX	0x4C	ON
				1.4 V	TX	0x51	OFF
STDES-WL3C2SMH	2	SMD	868 MHz/ 14 dBm	1.7 V	TX_HP	0x51	ON
				1.9 V	TX_HP	0x51	OFF
			868 MHz/ 16 dBm	2.0 V	TX_HP	0x51	ON
				2.4 V	TX_HP	0x51	OFF

Web reference	Number of layers	SMD, IPD, or external PA	Optimized BOM target	SMPS level	PA drive mode	PA_LEVEL7	Degeneration mode
STDES-WL3C2SML	2	SMD	433 MHz/ 14 dBm	1.6 V	TX_HP	0x51	ON
				1.8 V	TX_HP	0x51	OFF
			433 MHz/ 16 dBm	2.1 V	TX_HP	0x51	ON
				2.4 V	TX_HP	0x51	OFF
STDES-WL3C4EEW	4	SMD	169 MHz/ 27 dBm	1.4 V	TX_HP	0x35	OFF
STDES-WL3C4SHH	4	SMD	915 MHz/ 20 dBm	2.1 V	TX + TX_HP	0x51	ON
STDES-WL3C4SLH	4	SMD	868 MHz/ 10 dBm	1.4 V	TX	0x51	ON
				1.5 V	TX	0x51	OFF
STDES-WL3C4SLL	4	SMD	433 MHz/ 10 dBm	1.3 V	TX	0x4E	ON
				1.3 V	TX	0x4E	OFF
STDES-WL3C4SMH	4	SMD	868 MHz/ 14 dBm	1.4 V	TX_HP	0x51	ON
				1.6 V	TX_HP	0x51	OFF
			868 MHz/ 16 dBm	1.8 V	TX_HP	0x51	ON
				2.3 V	TX_HP	0x51	OFF
STDES-WL3C4SML	4	SMD	433 MHz/ 14 dBm	1.4 V	TX_HP	0x51	ON
				1.5 V	TX_HP	0x51	OFF
			433 MHz/ 16 dBm	1.8 V	TX_HP	0x51	ON
				2.2 V	TX_HP	0x51	OFF

2.2 RX radio and register setting

This subsection reports the radio and register configuration used during RX measurements. The settings have been selected to characterize the receiver performance under the defined modulation parameters and measurement conditions.

The STM32WL3x MCU is configured in three different SMPS conditions:

- Dynamic Bypass-On-The-Fly (BOF) condition:
 - PWR_DBGSMPS.BOF_CUR_SEL = 2
 - PWR_CR5.SMPSLVL = 4
 - PWR_BOF_TUNE.BOF_TUNE = 4
 - PWR_CR5.SMPS_BOF_DYN = 1
 - PWR_CR5.NOSMPS_BOF = 1
 - PWR.CR2.RFREGBYN = 0
 - RCC.CFGR.HSESEL = 0
 - RCC.CFGR.STOPHSI = 0
 - RCC.CFGR.CLKSYSDIV = 0
 - RCC.RFSWHSECR.GMC = 40
- Low Power mode (LPM) condition: SMPS Vout = 1.2 V, LDO RF bypassed, 16 MHz system clock, HSE direct mode, HSE GMC setting 0x0A.
 - RCC.CFGR.HSESEL = 1
 - RCC.CFGR.STOPHSI = 1
 - PWR.CR2.RFREGBYN = 1
 - RCC.CFGR.CLKSYSDIV = 2
 - RCC.RFSWHSECR.GMC = 10

The default SMPS switching frequency is 4 MHz. If the center frequency is an integer multiple of 4 MHz, sensitivity degradation may occur. In this case, the SMPS switching frequency must be set to a value different from 4 MHz, as in the case of $F_c = 868$ MHz, by changing the SMPS clock variable rate multiplier registers (RCC_KRMR):

1. – RCC.KRMR.KRM_EN = 1
 - RCC.KRMR.KRM = 15
2. High Performance Mode (HPM) condition: SMPS Vout = 1.4 V, 16 MHz system clock, HSIPLL mode, HSE GMC setting 0x0A
 - RCC.CFGR.HSESEL = 0
 - RCC.CFGR.STOPHSI = 0
 - PWR.CR2.RFREGBYN = 0
 - RCC.CFGR.CLKSYSDIV = 2
 - RCC.RFSWHSECR.GMC = 10

The default SMPS switching frequency is 4 MHz. If the center frequency is an integer multiple of 4 MHz, sensitivity degradation may occur. In this case, the SMPS switching frequency must be set to a value different from 4 MHz, as in the case of $F_c = 868$ MHz, by changing the SMPS clock variable rate multiplier registers (RCC_KRMR):

- RCC.KRMR.KRM_EN = 1
- RCC.KRMR.KRM = 15

The following radio settings were used for the RX tests:

- Modulation: 2-GFSK05
- Datarate: 38.4 kbps
- Channel filter: 100 kHz
- Frequency deviation: 20 kHz

3 STM32WL3x MCU transmitter output power at given center frequency

This section shows a comparison of current consumption and sensitivity performance for reference designs optimized at a specific center frequency and output power, across three different SMPS configurations: bypass-on-the-fly, low power mode (LPM), and high-performance mode (HPM).

Refer to the radio settings and registers settings described in [Section 2: STM32WL3x MCU register settings](#).

3.1 $F_c = 433$ MHz, TX pin

3.1.1 Degeneration mode ON, $F_c = 433$ MHz, TX pin

Figure 1. Current consumption in TX mode, $F_c = 433$ MHz, TX pin, degeneration mode ON

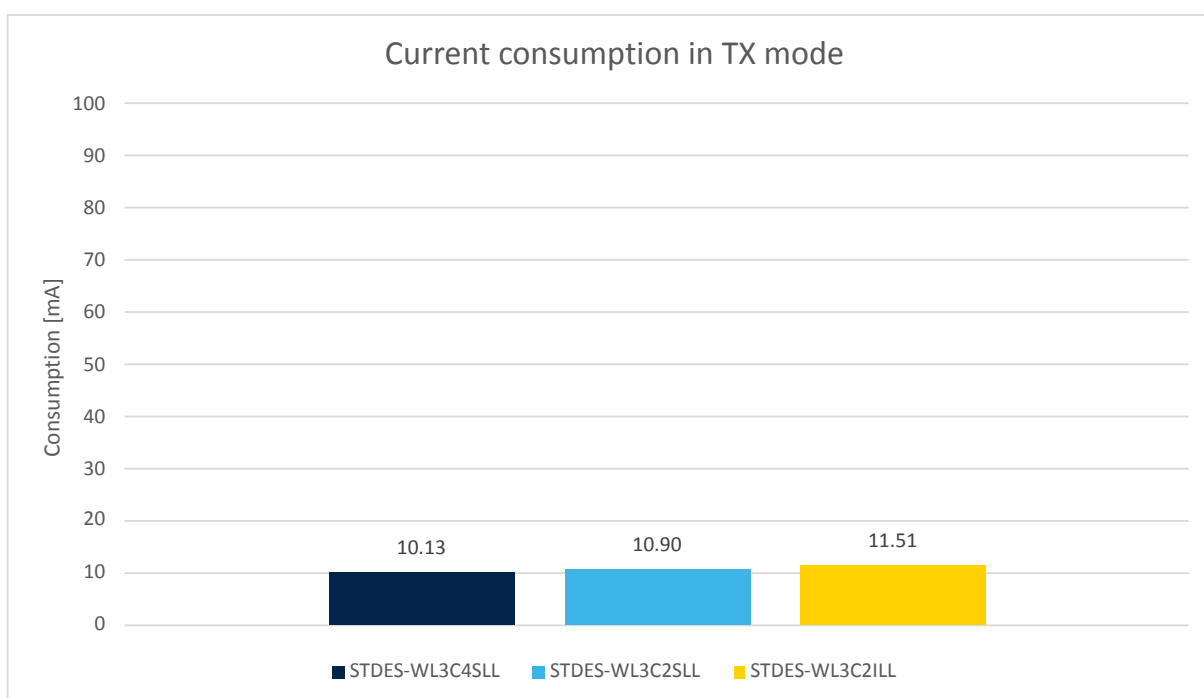
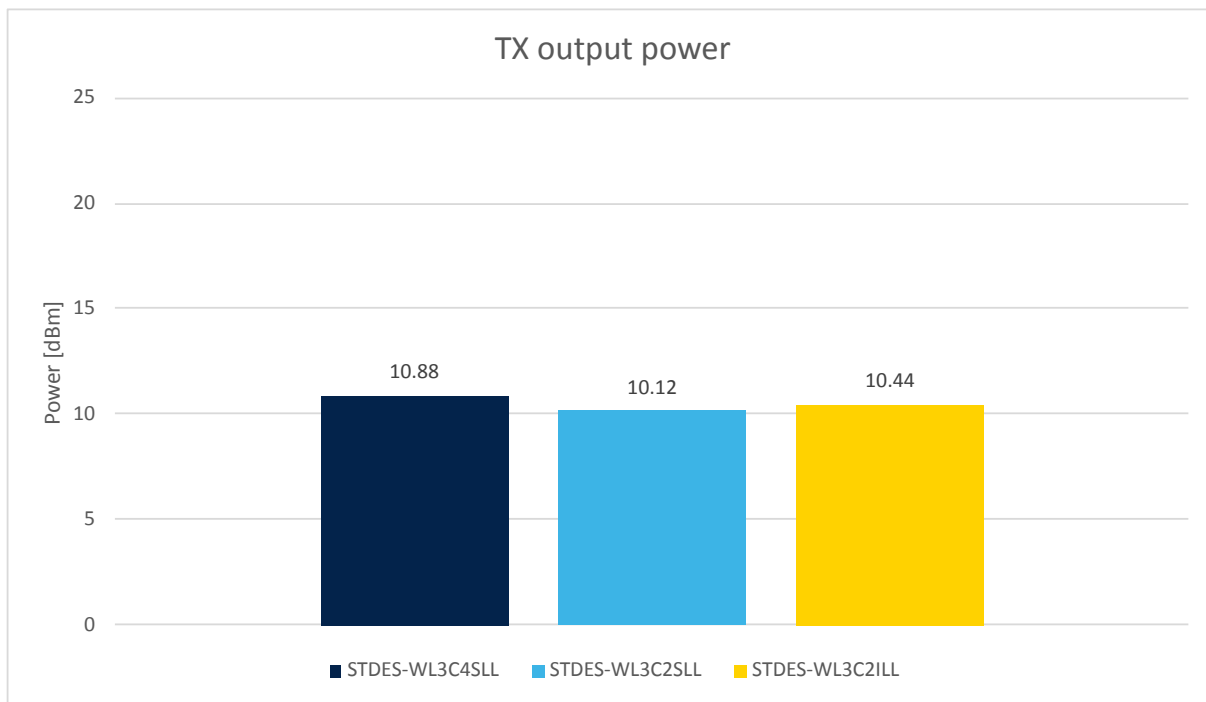
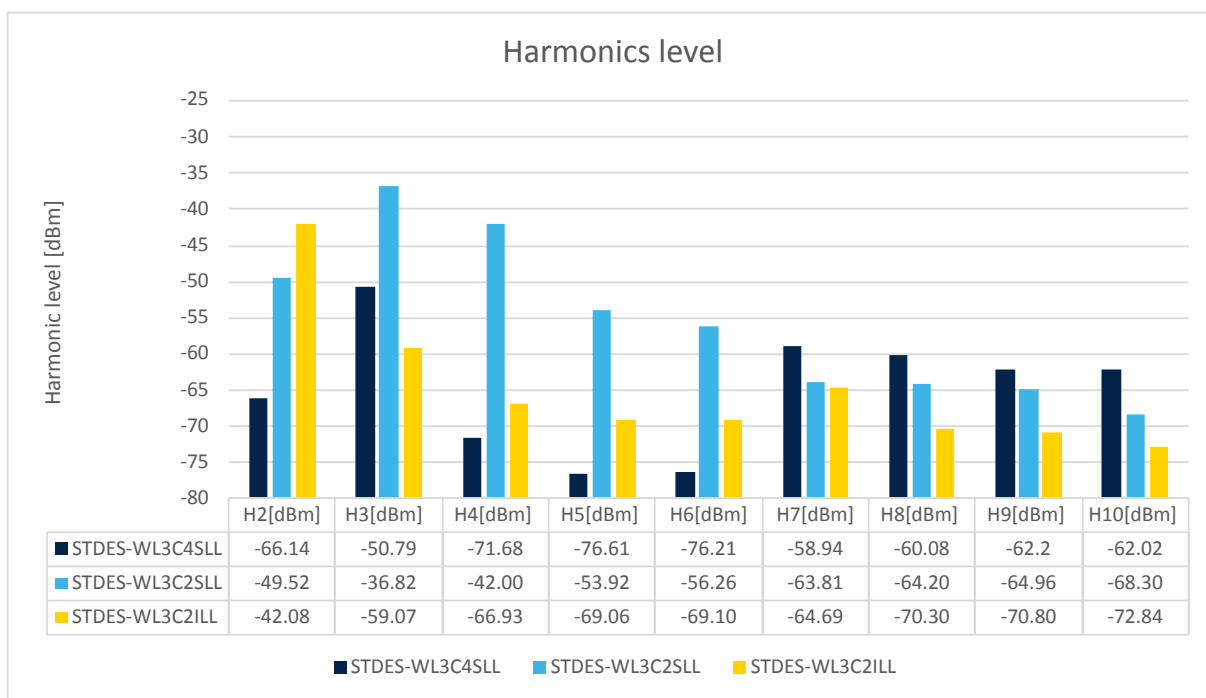


Figure 2. TX output power level, $F_c = 433$ MHz, TX pin, degeneration mode ON

Figure 3. Harmonic level, $F_c = 433$ MHz, TX pin, degeneration mode ON


3.1.2 Degeneration mode OFF, $F_c = 433$ MHz, TX pin

Figure 4. Current consumption in TX mode, $F_c = 433$ MHz, TX pin, degeneration mode OFF

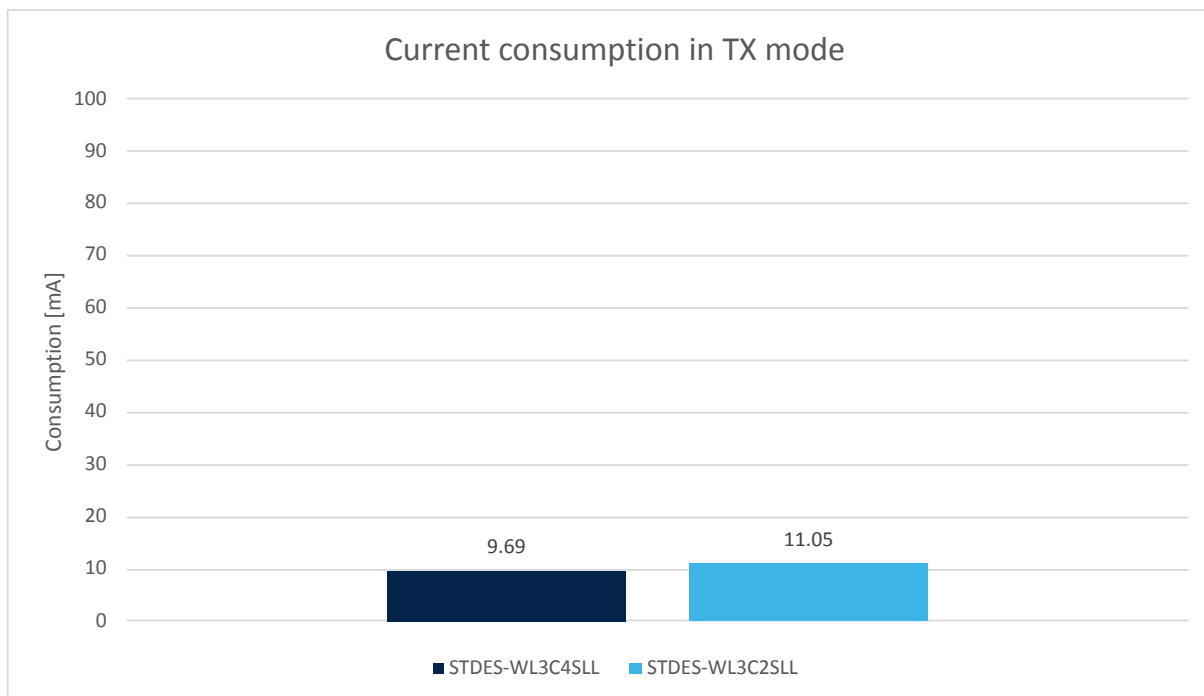


Figure 5. TX output power level, $F_c = 433$ MHz, TX pin, degeneration mode OFF

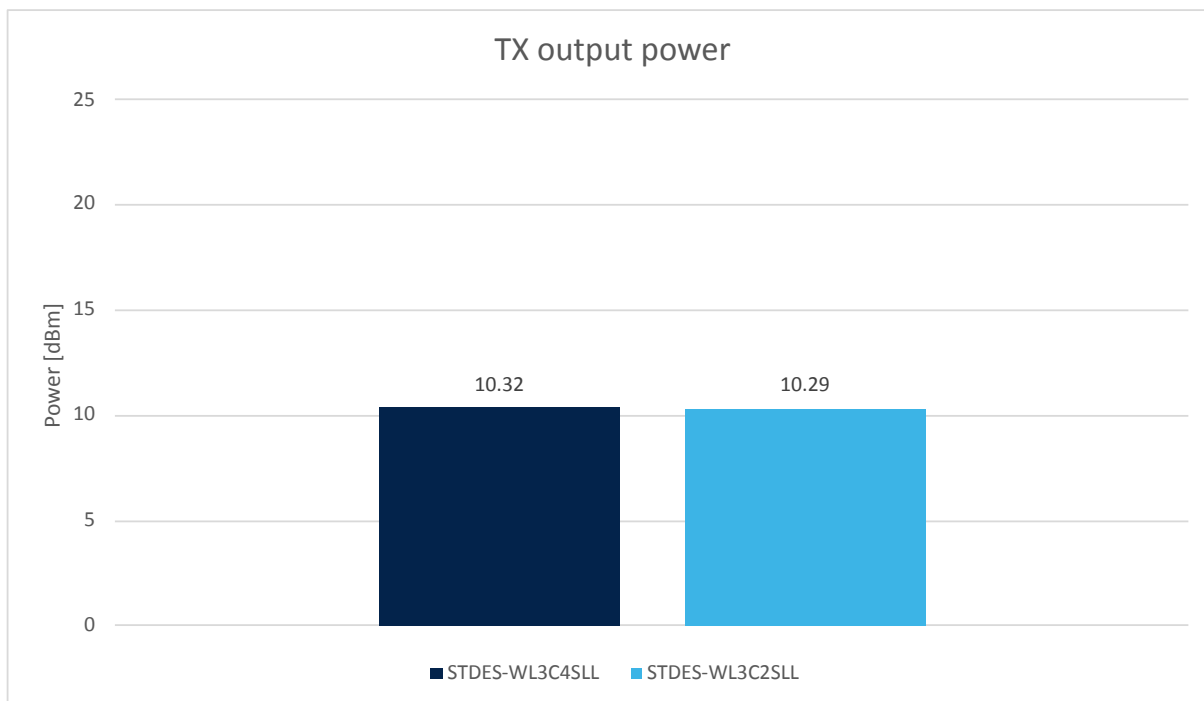
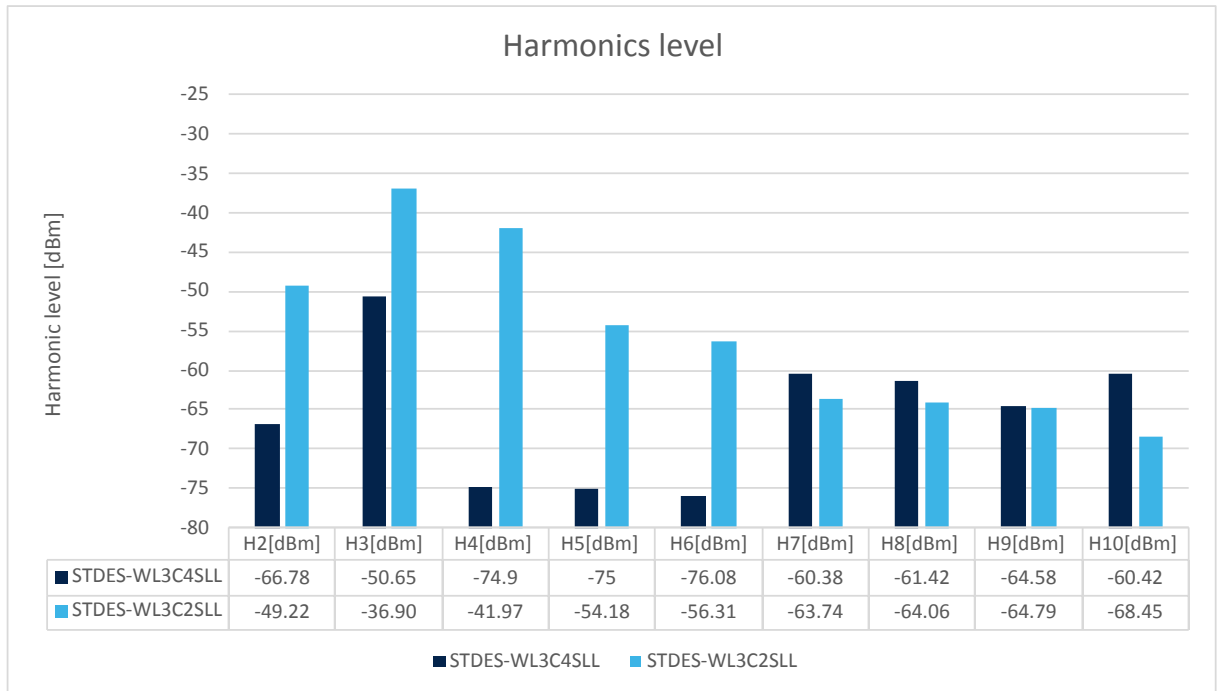


Figure 6. Harmonic level, $F_c = 433\text{MHz}$, TX pin, degeneration mode OFF


3.2 $F_c = 433\text{ MHz}$, TX_HP pin

3.2.1 Degeneration mode ON, $F_c = 433\text{ MHz}$, TX_HP pin

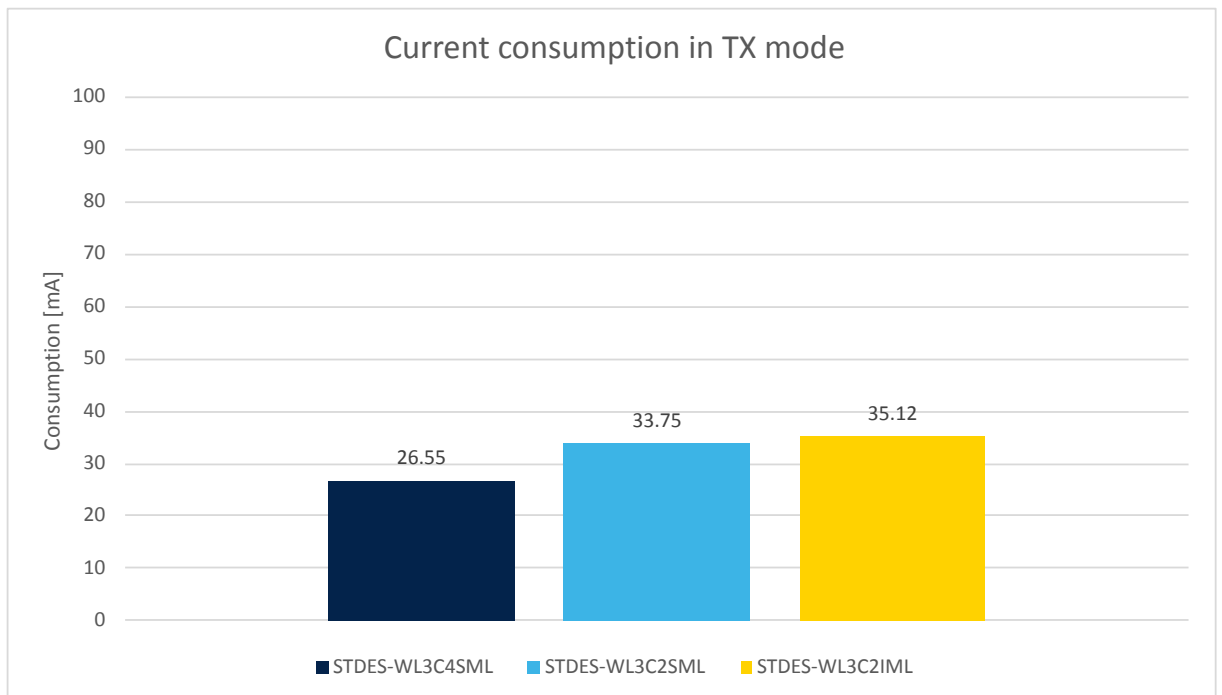
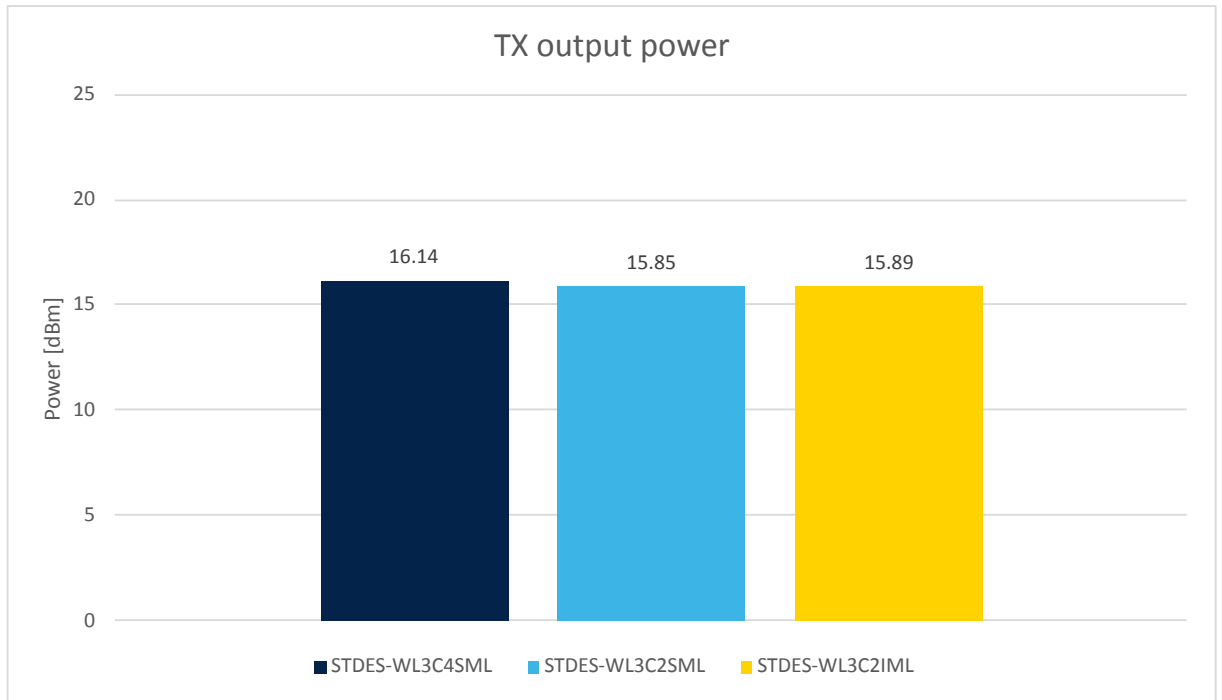
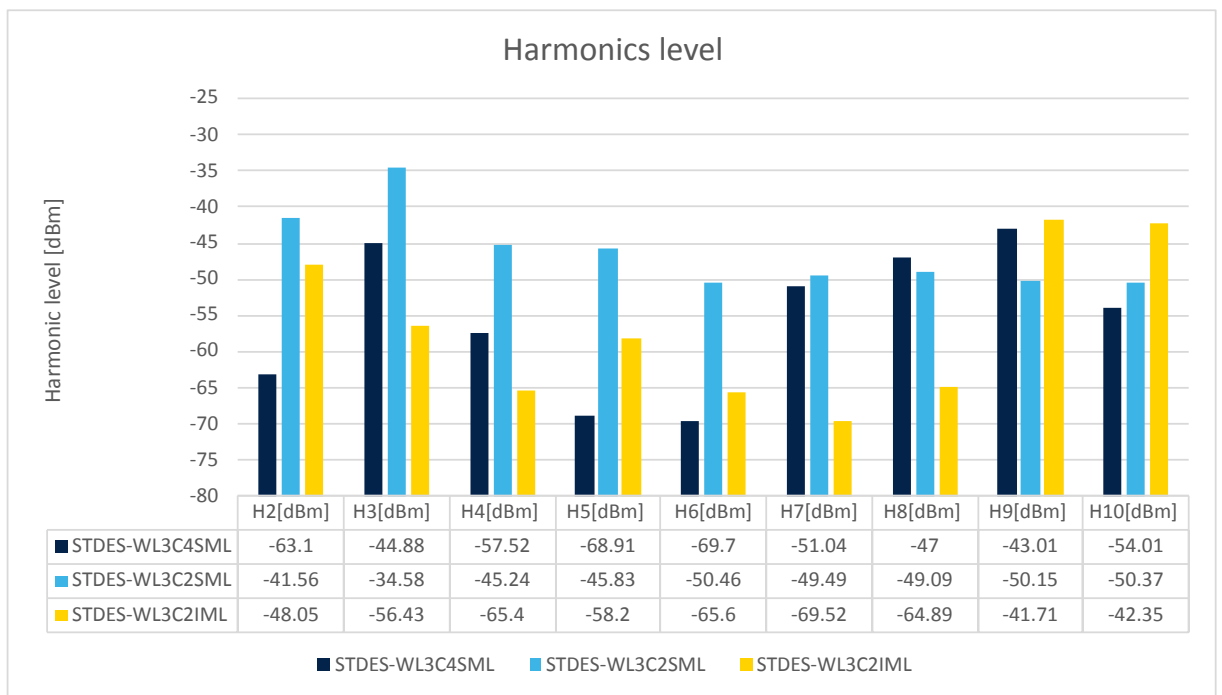
Figure 7. Current consumption in TX mode, $F_c = 433\text{ MHz}$, TX_HP pin, degeneration mode ON


Figure 8. TX output power level, Fc = 433 MHz, TX_HP pin, degeneration mode ON

Figure 9. Harmonic level, Fc = 433 MHz, TX_HP pin, degeneration mode ON


3.2.2 Degeneration mode OFF, $F_c = 433$ MHz, TX_HP pin

Figure 10. Current consumption in TX mode, $F_c = 433$ MHz, TX_HP pin, degeneration mode OFF

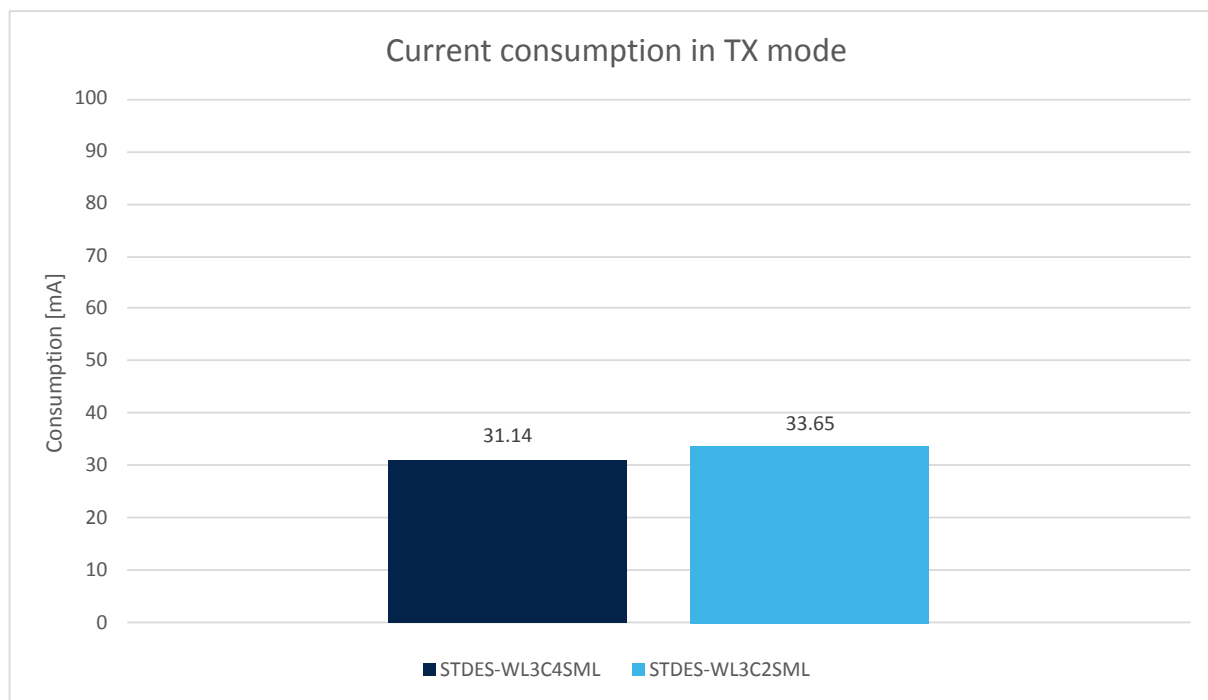


Figure 11. TX output power level, $F_c = 433$ MHz, TX_HP pin, degeneration mode OFF

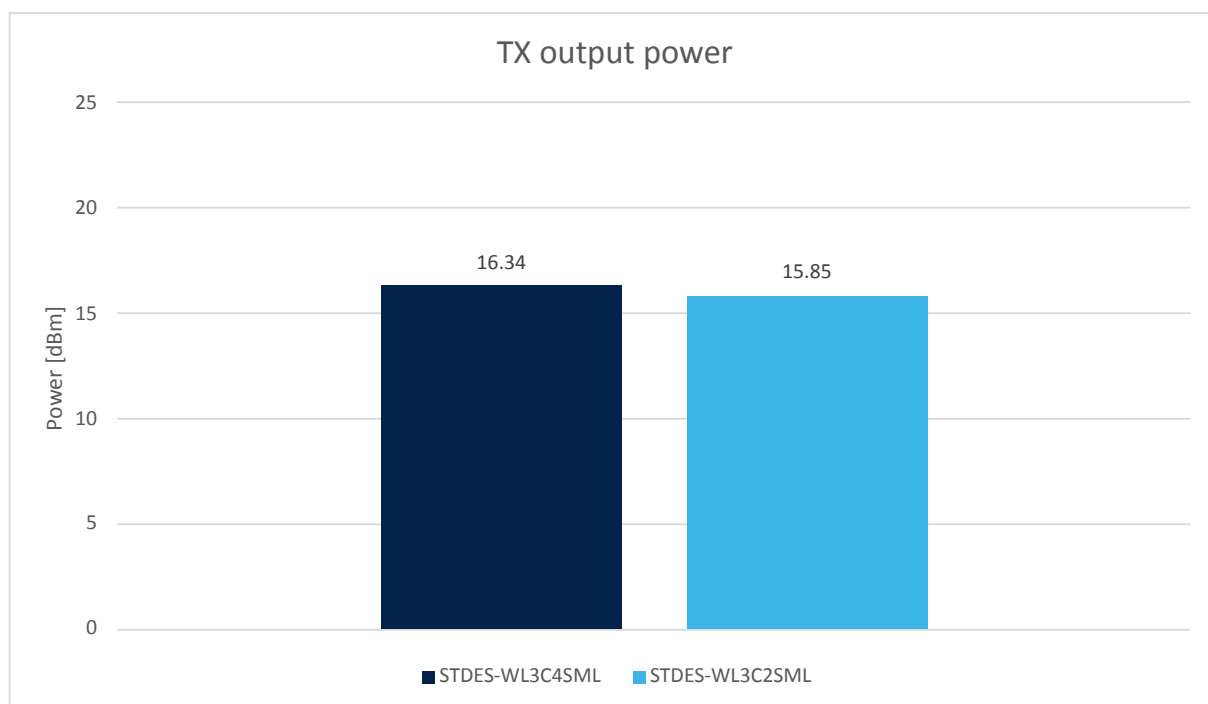
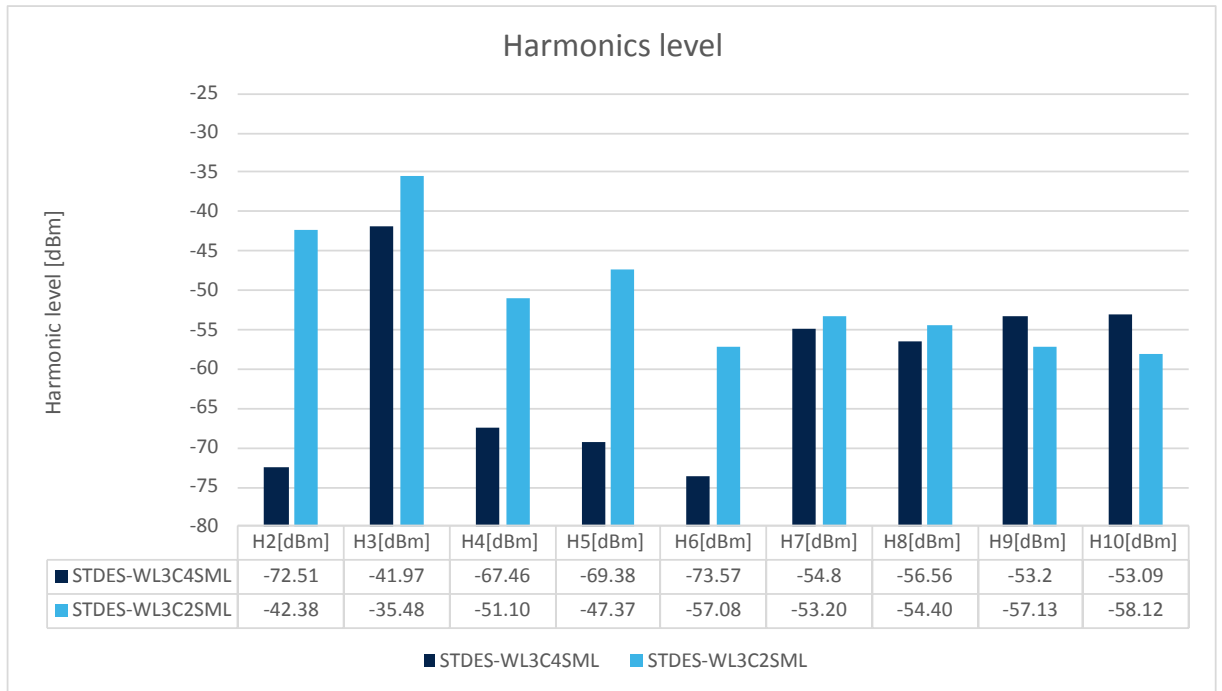


Figure 12. Harmonic level, $F_c = 433$ MHz, TX_HP pin, degeneration mode OFF


3.3 $F_c = 868$ MHz, TX pin

3.3.1 Degeneration mode ON, $F_c = 868$ MHz, TX pin

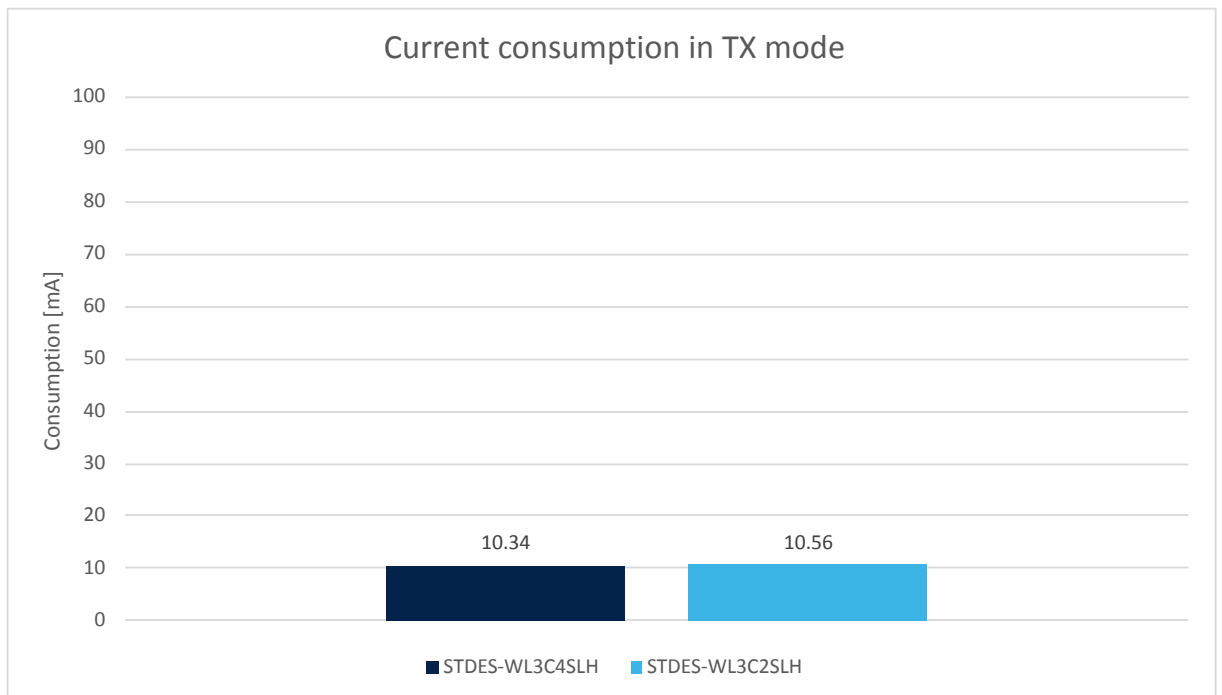
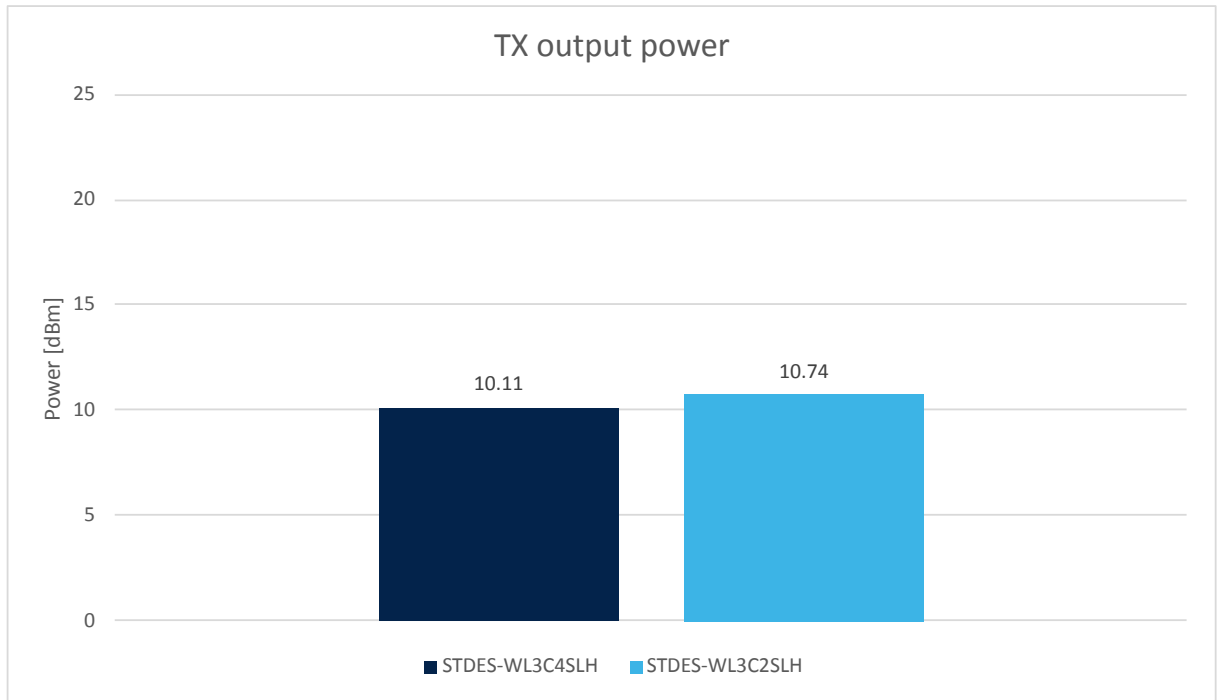
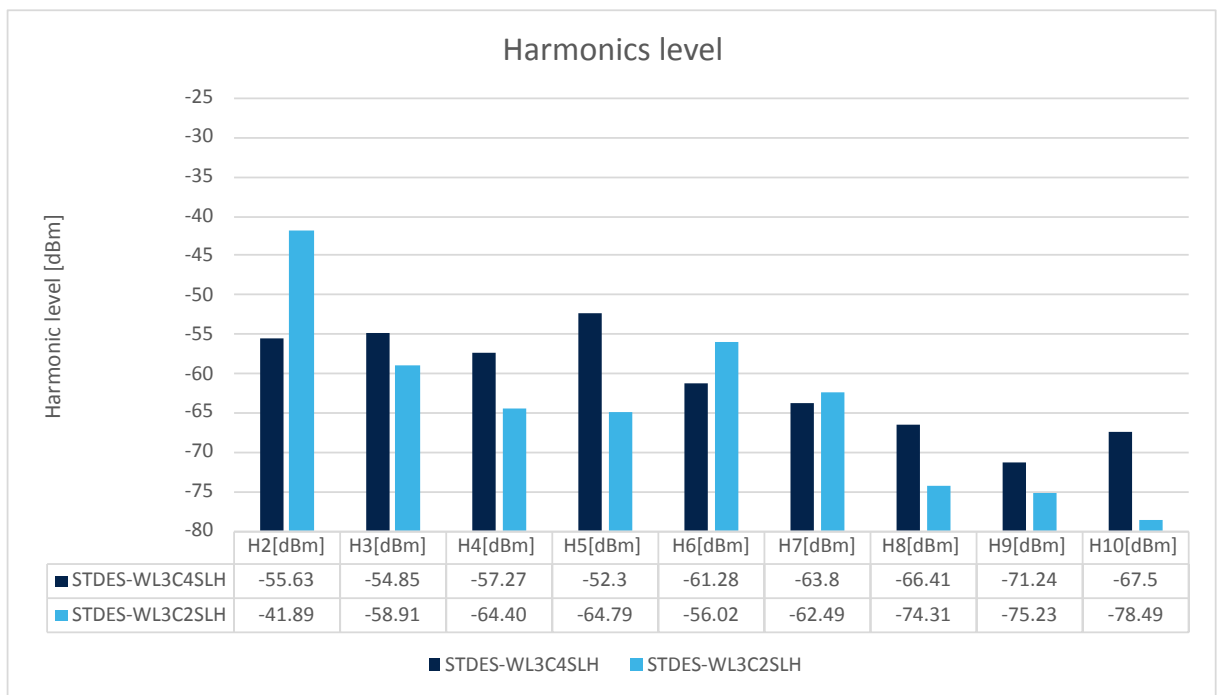
Figure 13. Current consumption in TX mode, $F_c = 868$ MHz, TX pin, degeneration mode ON


Figure 14. TX output power level, Fc = 868 MHz, TX pin, degeneration mode ON

Figure 15. Harmonic level, Fc = 868 MHz, TX pin, degeneration mode ON


3.3.2 Degeneration mode OFF, $F_c = 868$ MHz, TX pin

Figure 16. Current consumption in TX mode, $F_c = 868$ MHz, TX pin, degeneration mode OFF

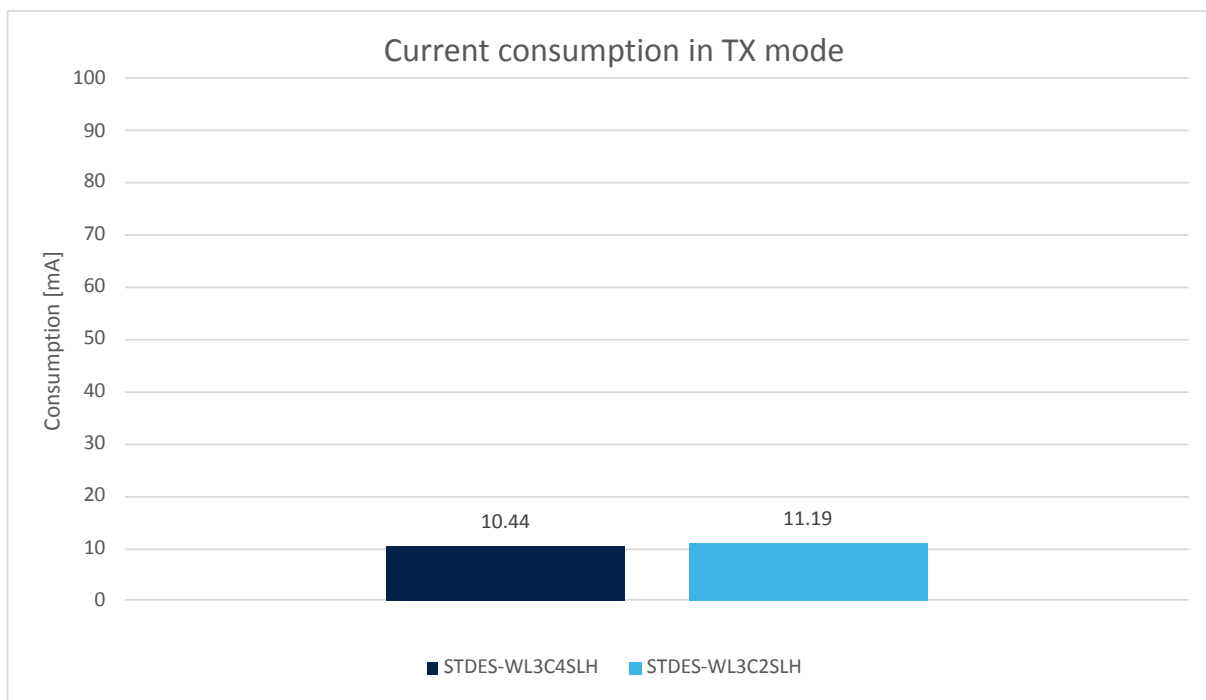


Figure 17. TX output power level, $F_c = 868$ MHz, TX pin, degeneration mode OFF

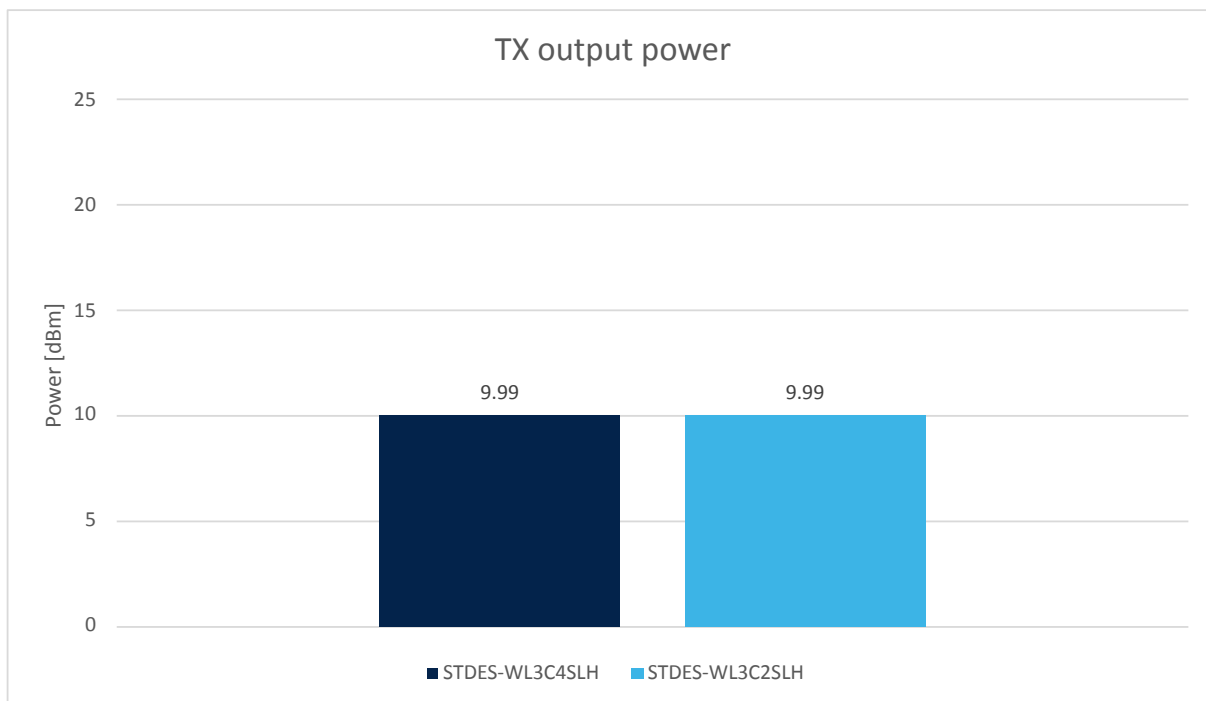
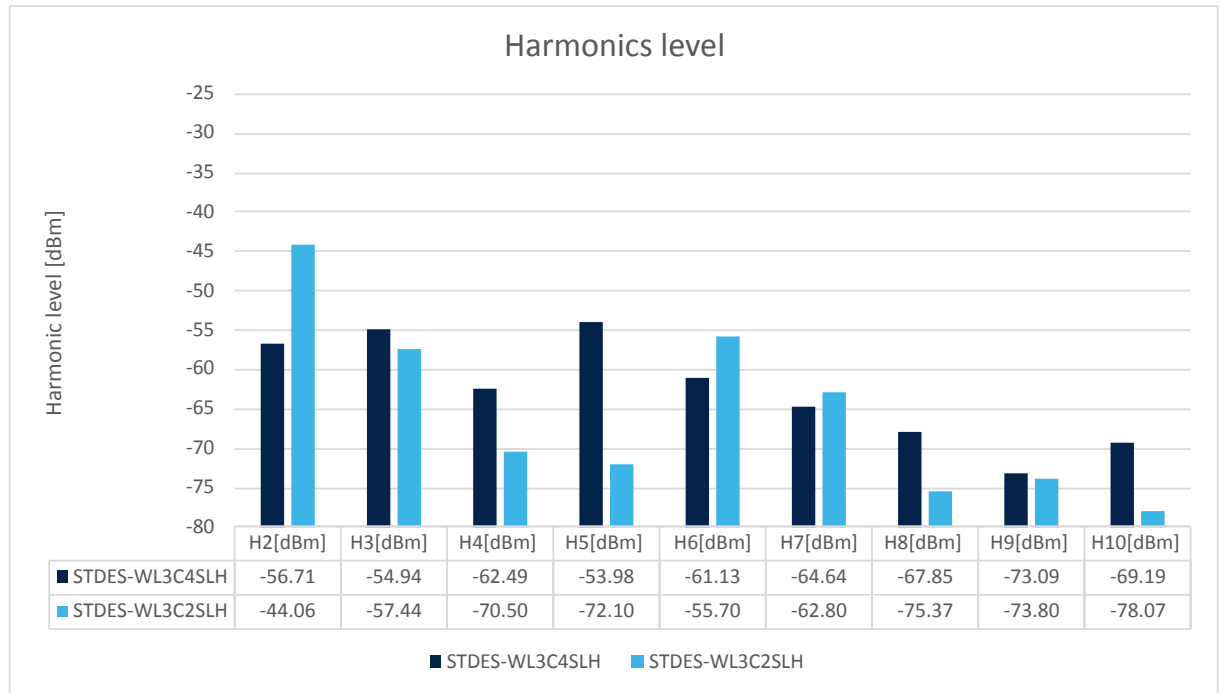


Figure 18. Harmonic level, $F_c = 868$ MHz, TX pin, degeneration mode OFF



3.4 $F_c = 868$ MHz, TX_HP pin

3.4.1 Degeneration mode ON, $F_c = 868$ MHz, TX_HP pin

Figure 19. Current consumption in TX mode, $F_c = 868$ MHz, TX_HP pin, degeneration mode ON

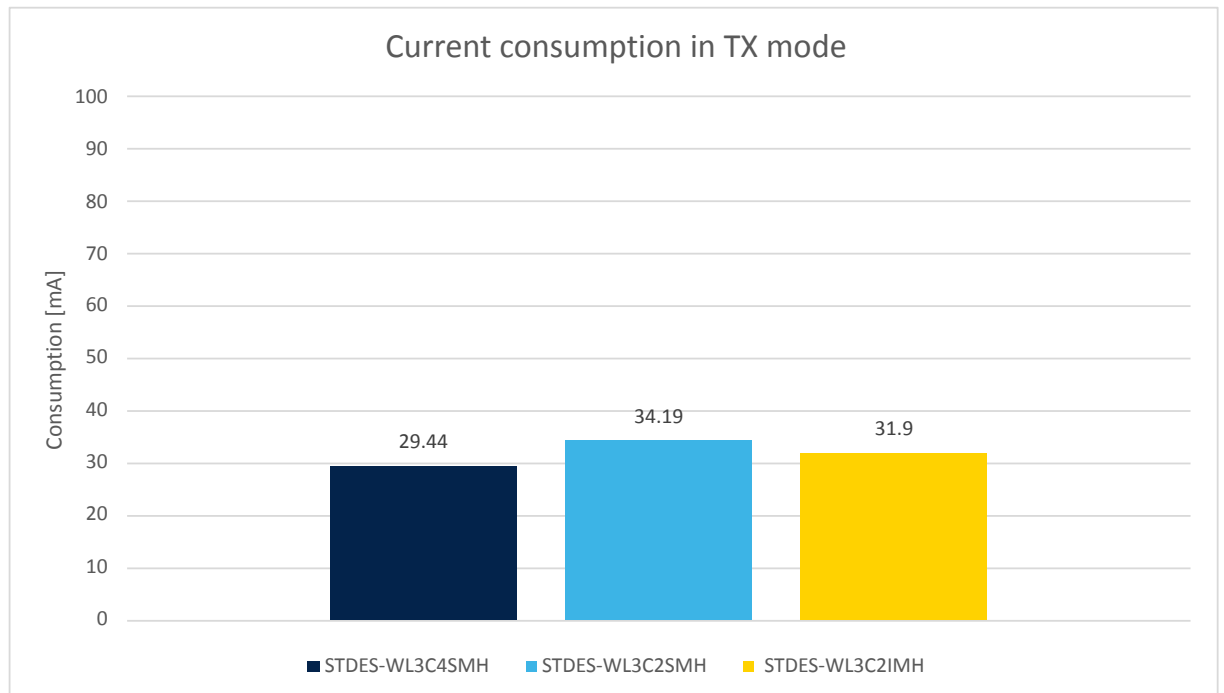
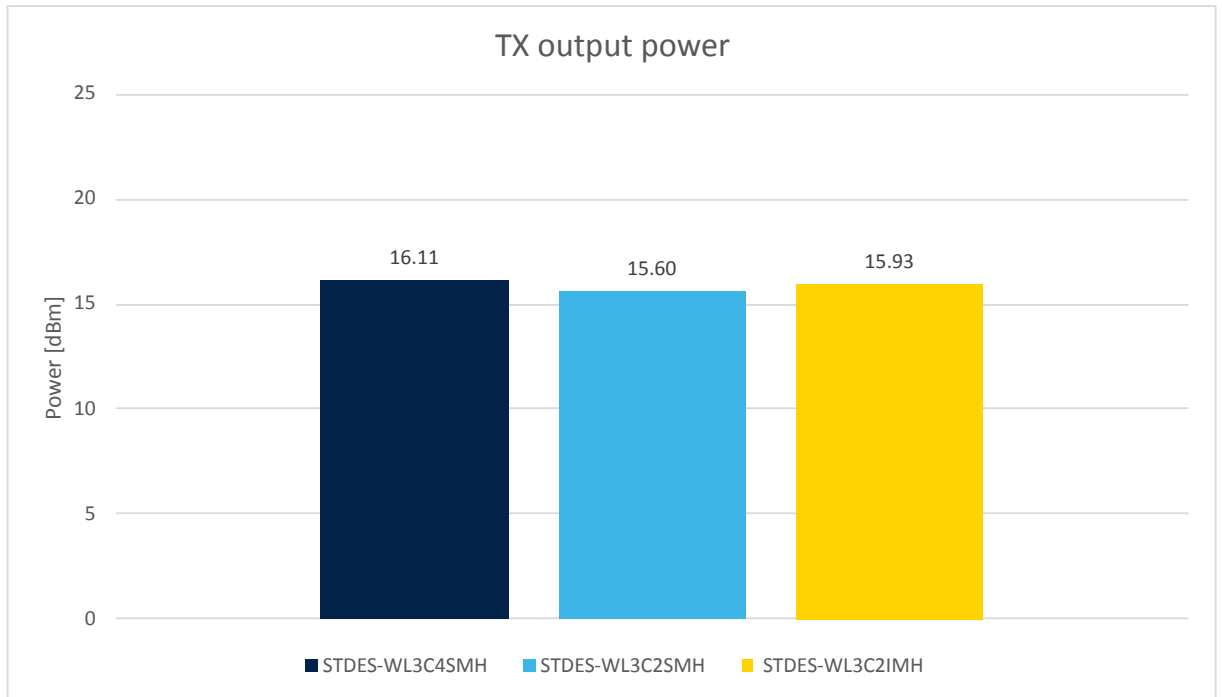
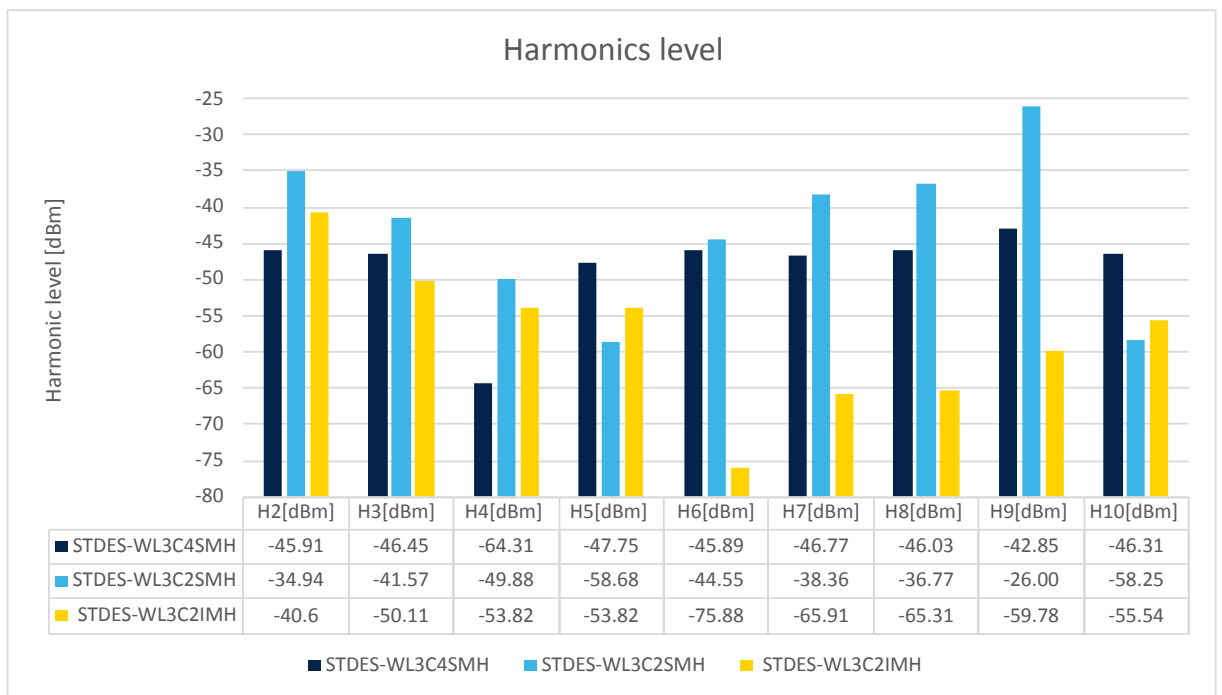


Figure 20. TX output power level, Fc = 868 MHz, TX_HP pin, degeneration mode ON

Figure 21. Harmonic level, Fc = 868 MHz, TX_HP pin, degeneration mode ON


3.4.2 Degeneration mode OFF, Fc = 868 MHz, TX_HP pin

Figure 22. Current consumption in TX mode, Fc = 868 MHz, TX_HP pin, degeneration mode OFF

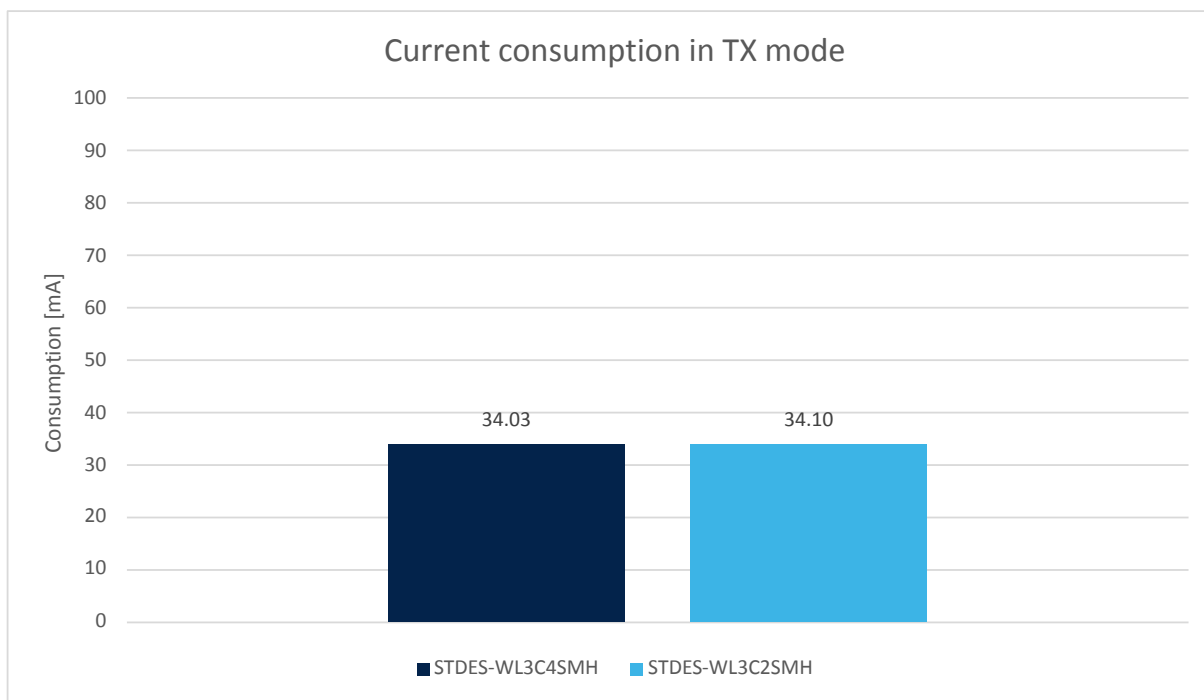


Figure 23. TX output power level, Fc = 868 MHz, TX_HP pin, degeneration mode OFF

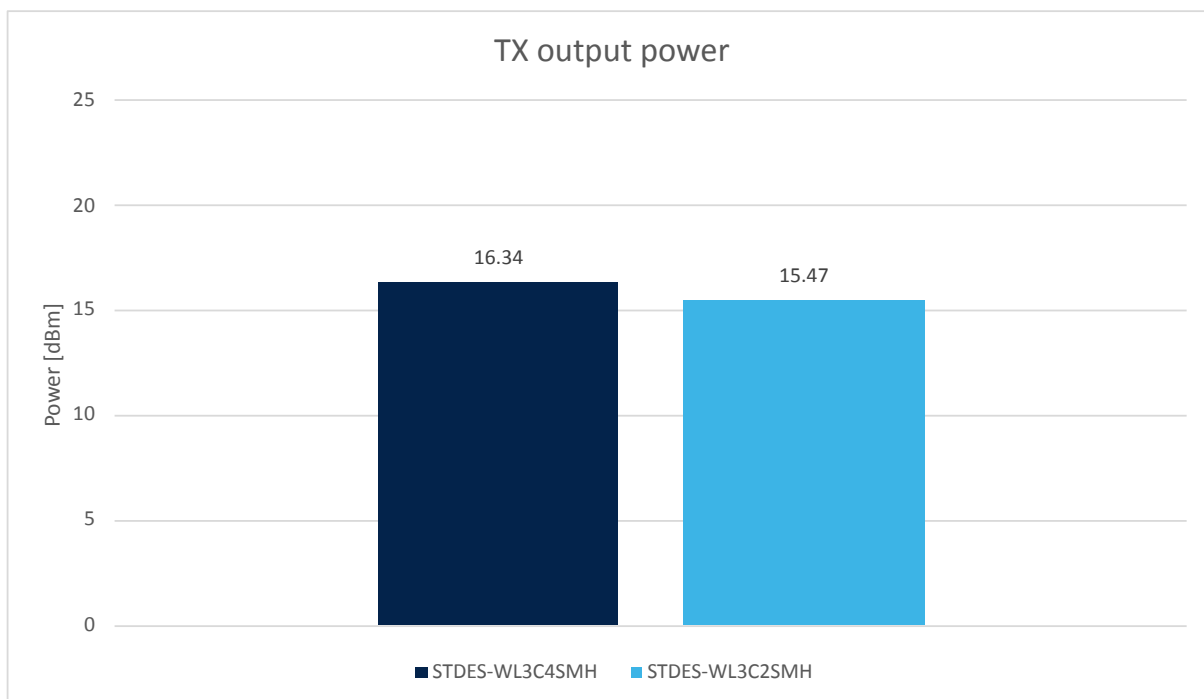
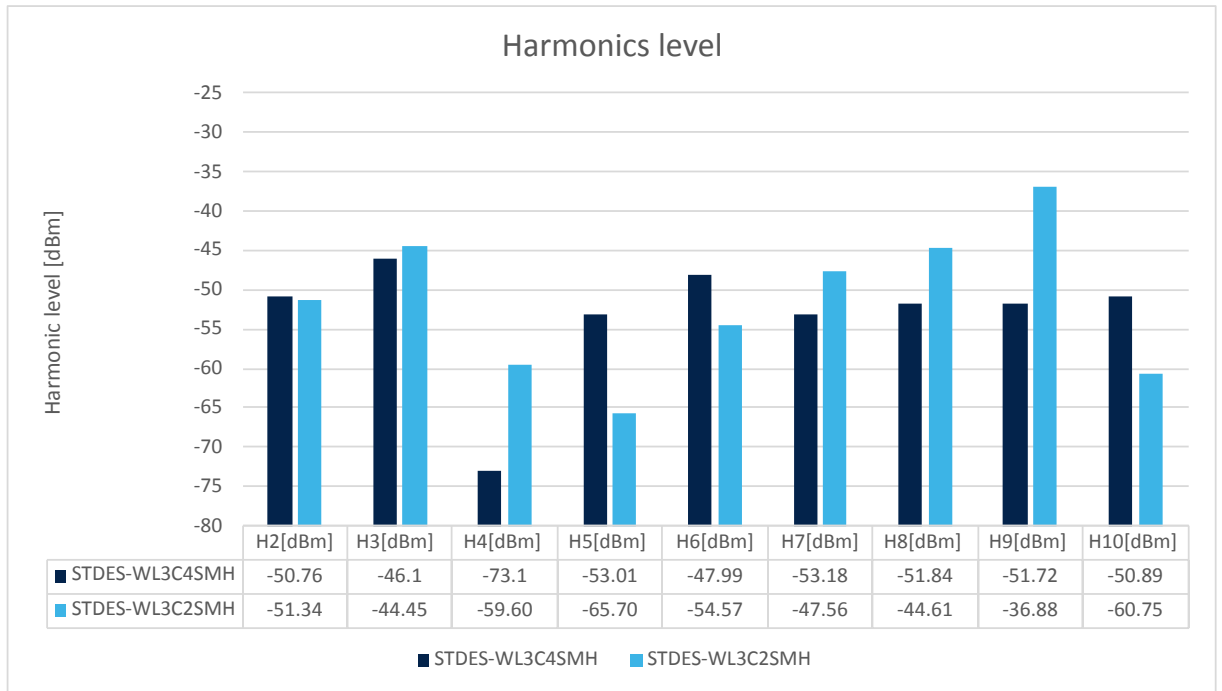


Figure 24. Harmonic level, Fc = 868 MHz, TX_HP pin, degeneration mode OFF



3.5 F_c=915 MHz, TX and TX_HP pins

3.5.1 Degeneration mode ON, Fc = 915 MHz, TX and TX_HP pins

Figure 25. Current consumption in TX mode, Fc = 915 MHz, TX and TX_HP pins, degeneration mode ON

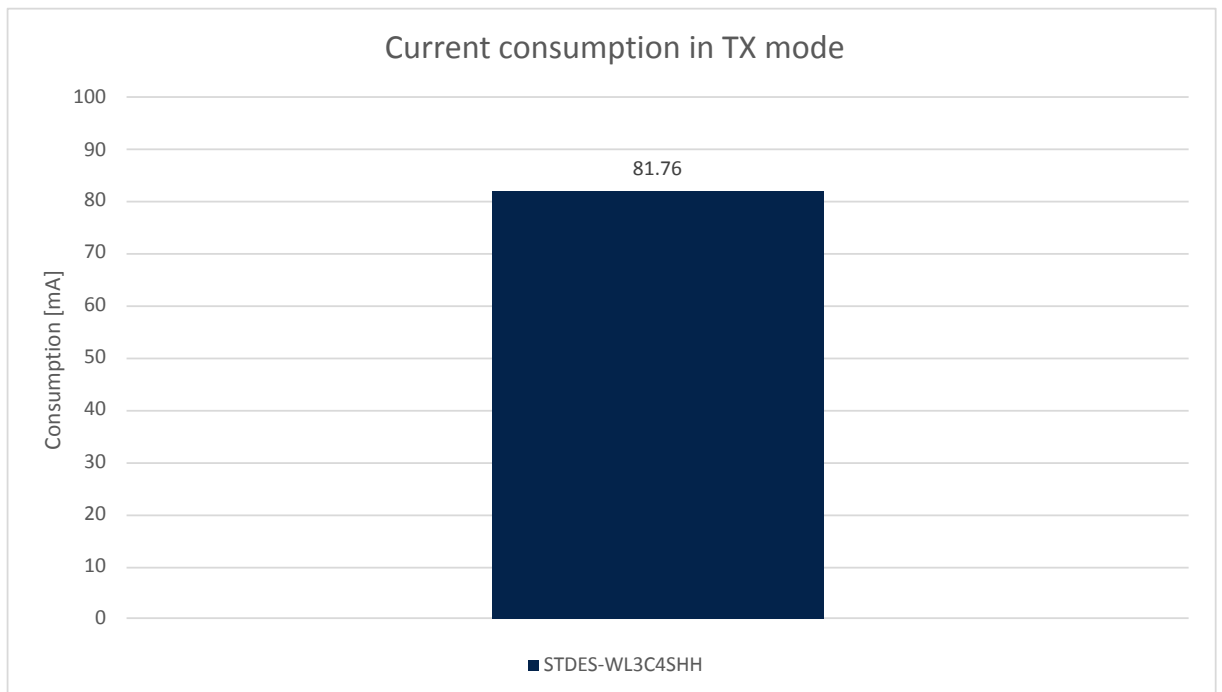


Figure 26. TX output power level, Fc = 915 MHz, TX and TX_HP pins, degeneration mode ON

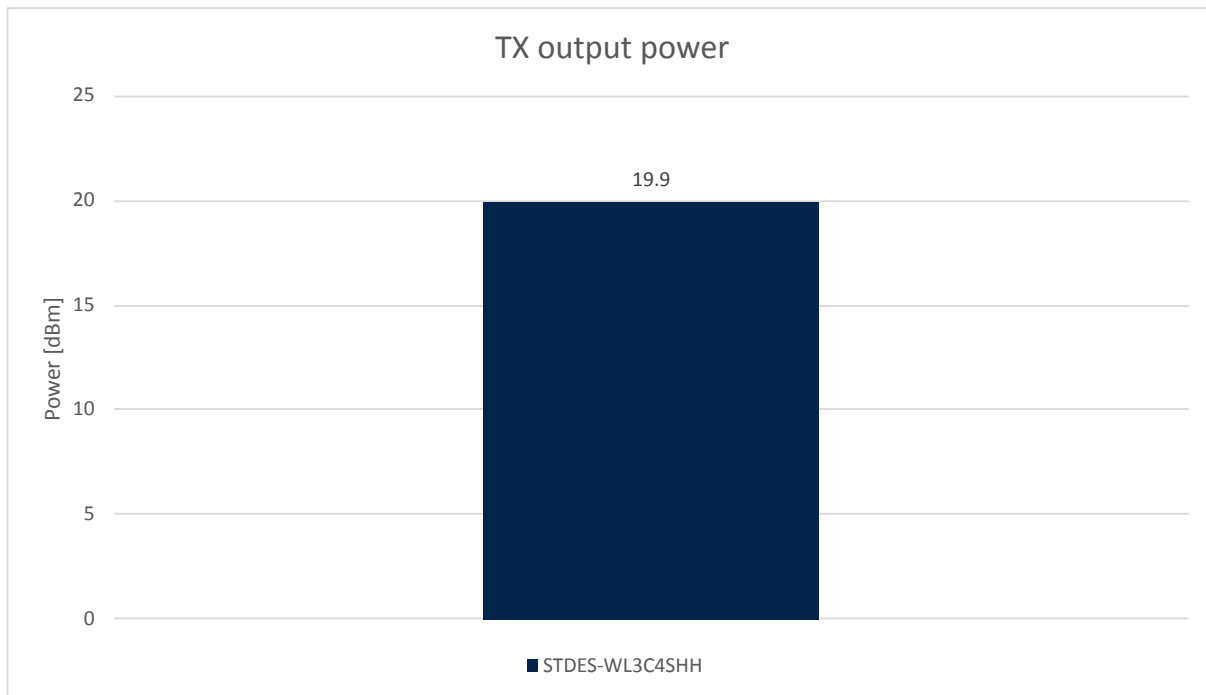
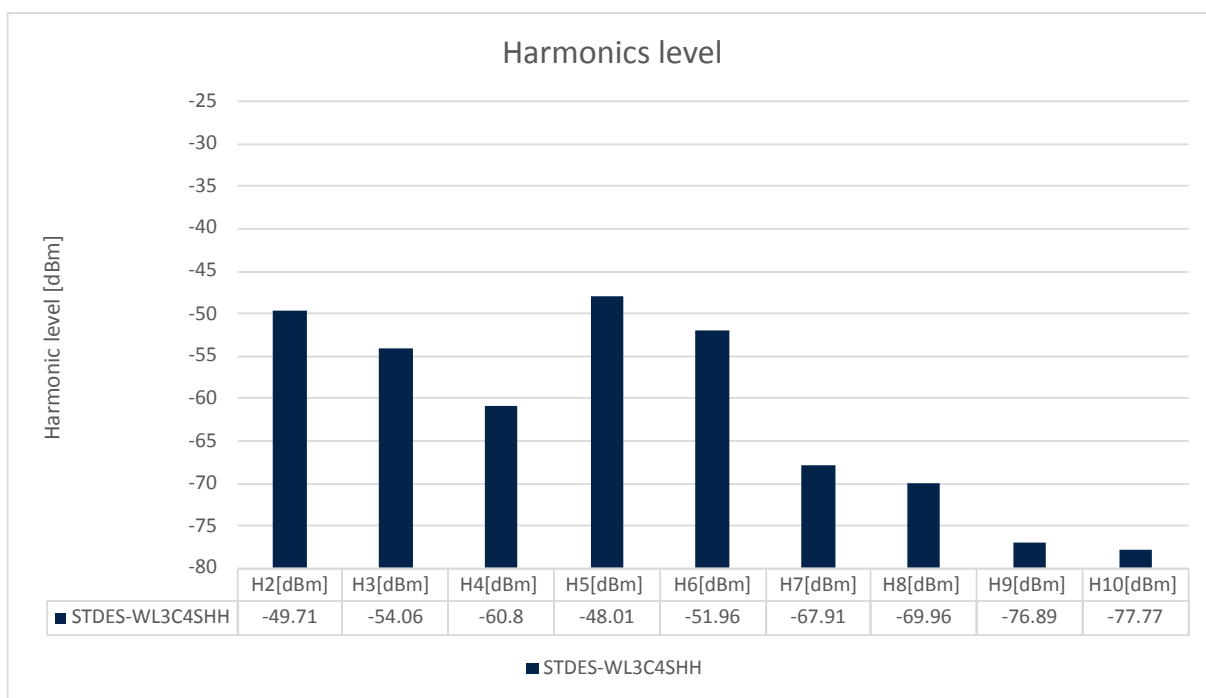


Figure 27. Harmonic level, Fc = 915 MHz, TX and TX_HP pins, degeneration mode ON



3.6 $F_c = 915$ MHz, TX pin

3.6.1 Degeneration mode ON, $F_c = 915$ MHz, TX pin

Figure 28. Current consumption in TX mode, $F_c = 915$ MHz, TX pin, degeneration mode ON

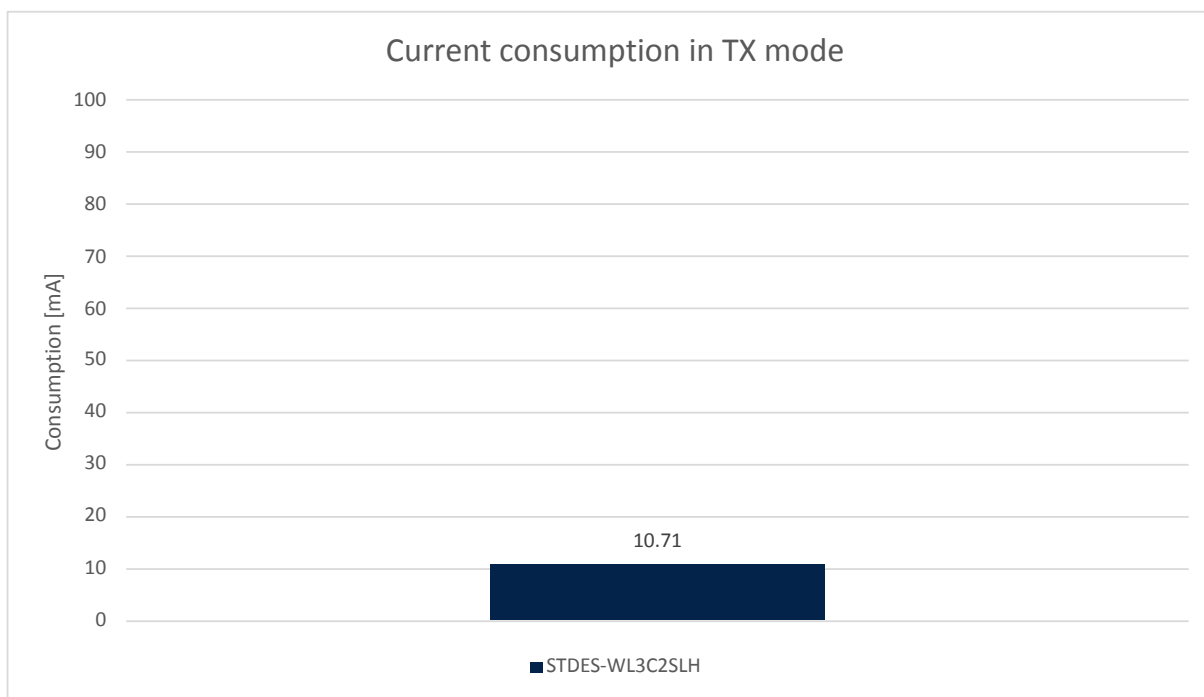


Figure 29. TX output power level, $F_c = 915$ MHz, TX pin, degeneration mode ON

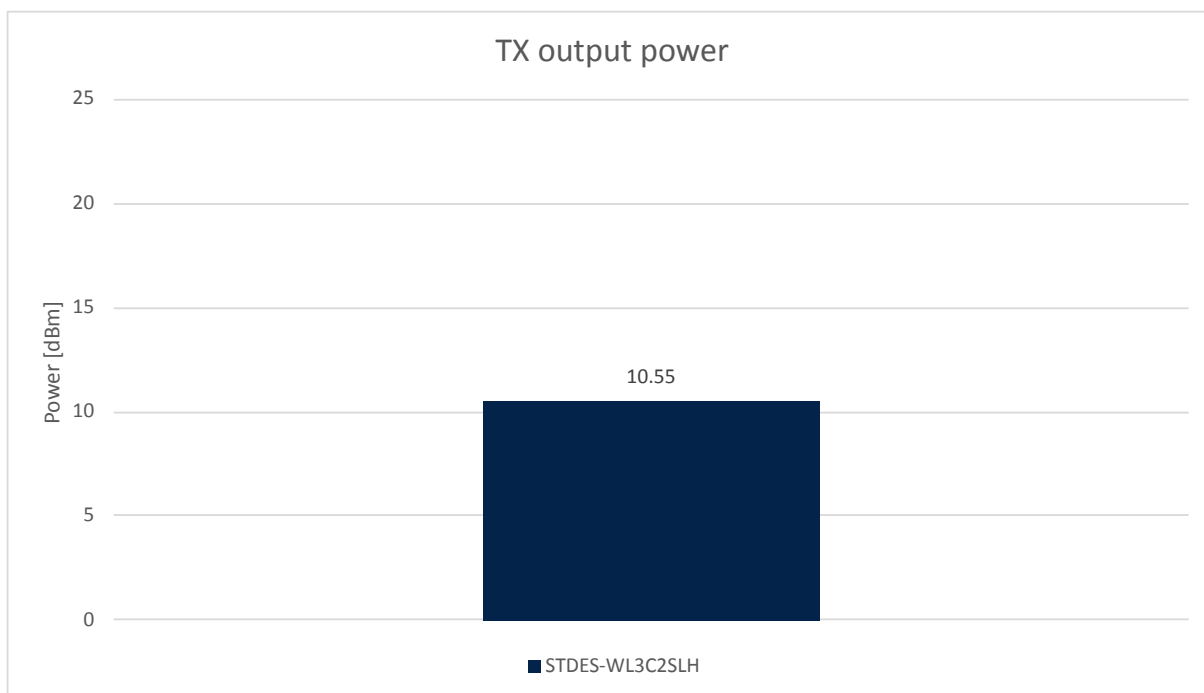
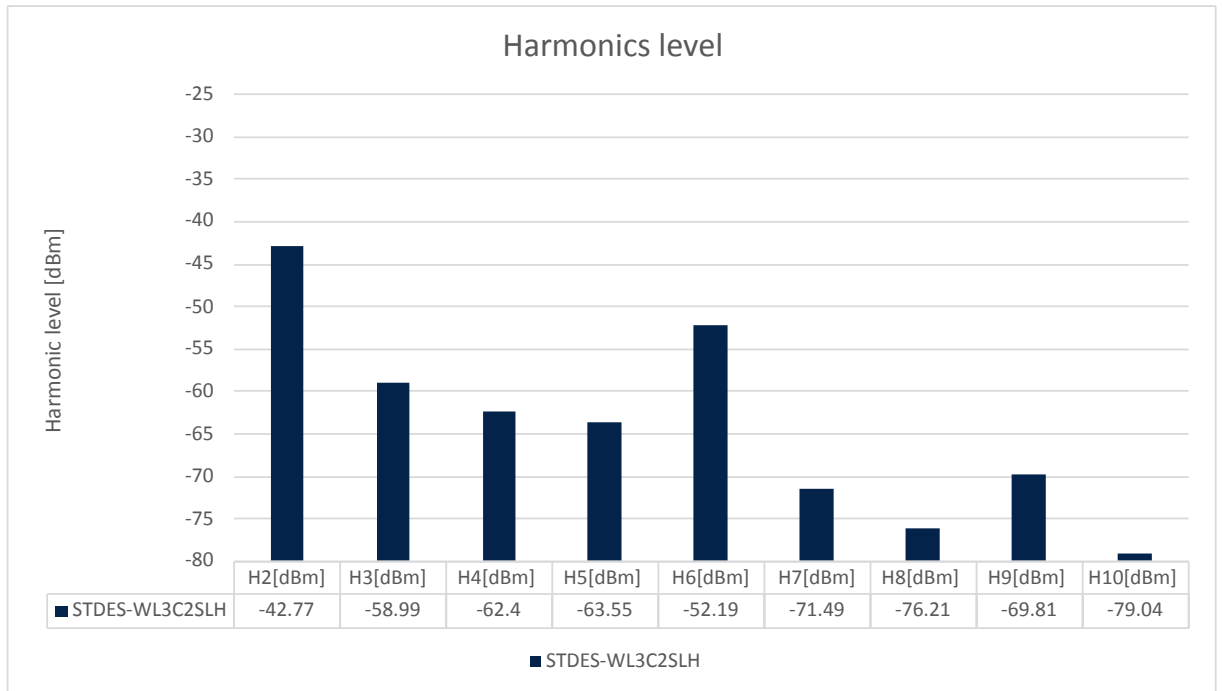


Figure 30. Harmonic level, Fc = 915 MHz, TX pin, degeneration mode ON


3.6.2 Degeneration mode OFF, Fc = 915 MHz, TX pin

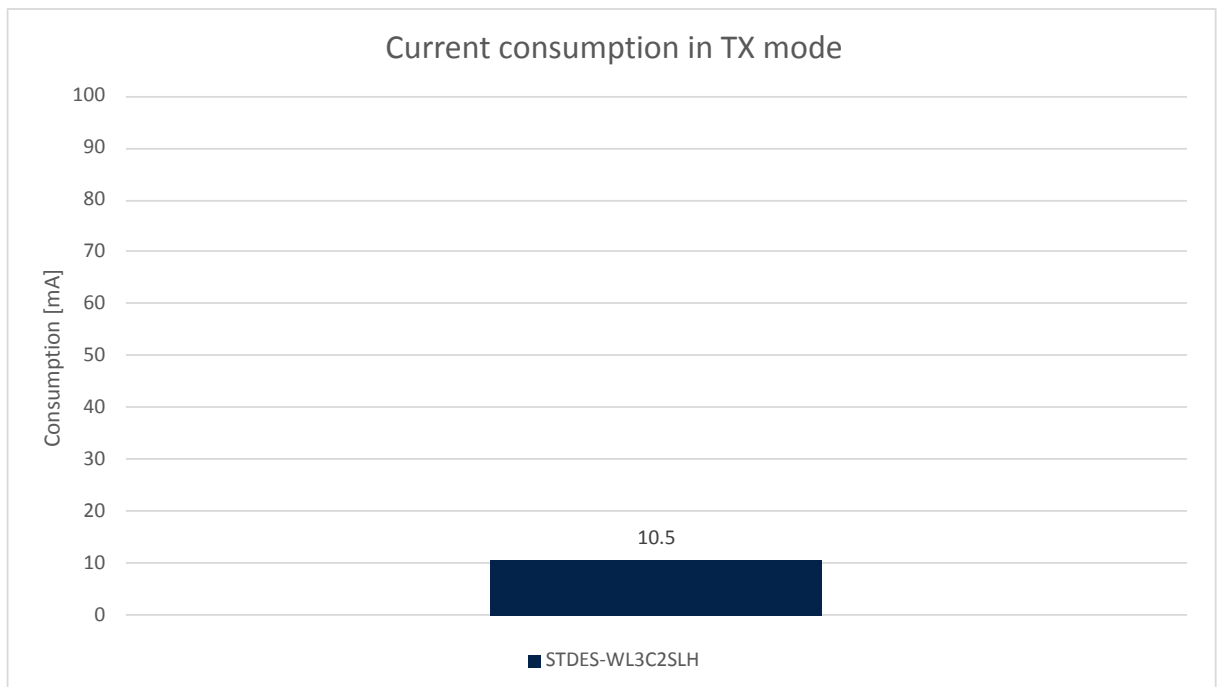
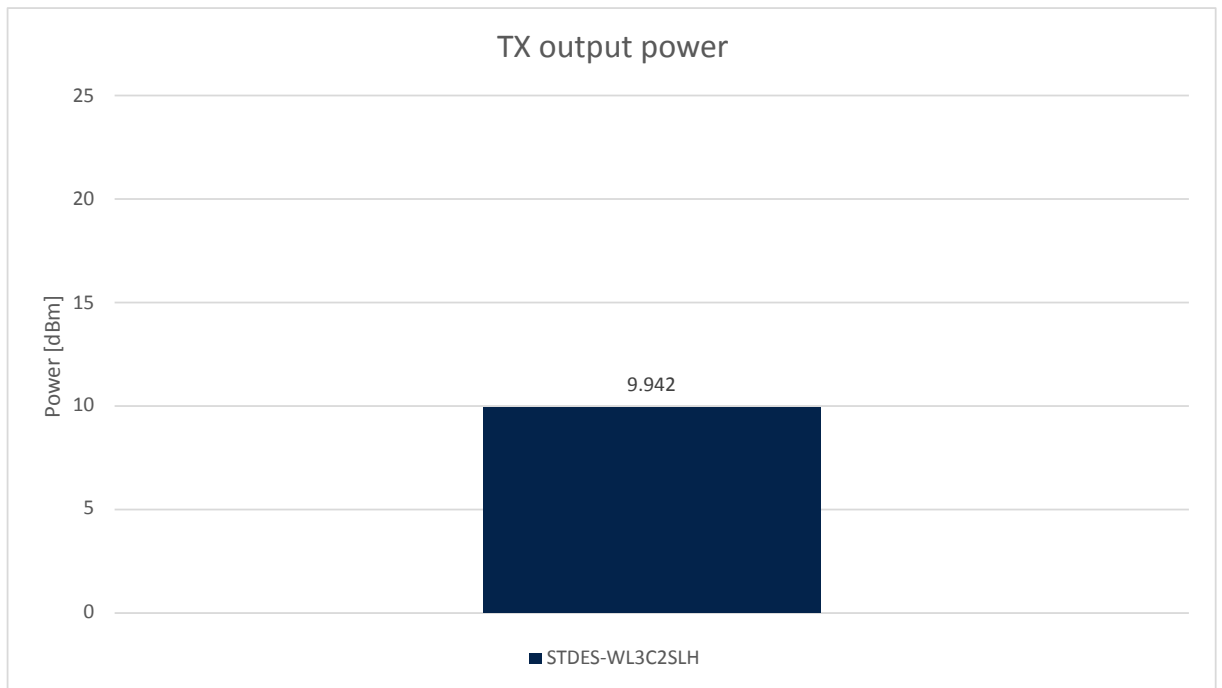
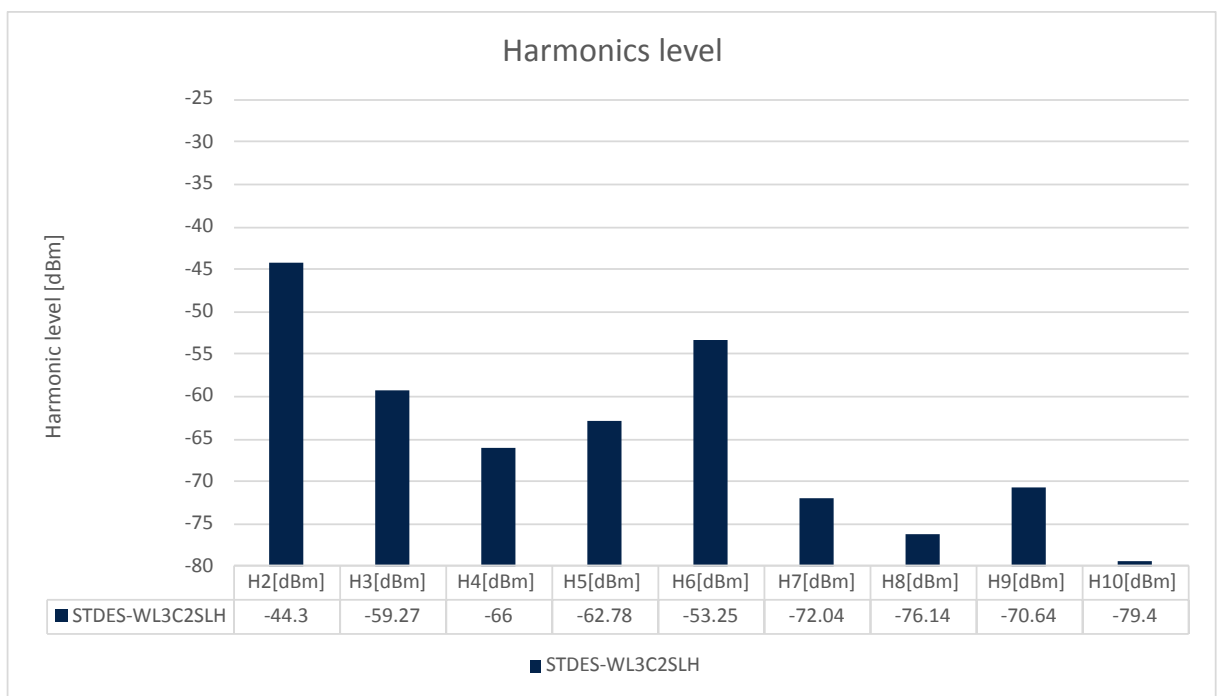
Figure 31. Current consumption in TX mode, Fc = 915 MHz, TX pin, degeneration mode OFF


Figure 32. TX output power level, Fc = 915 MHz, TX pin, degeneration mode OFF

Figure 33. Harmonic level, Fc = 915 MHz, TX pin, degeneration mode OFF


3.7 Fc = 169 MHz, TX_HP pin, external power amplifier

3.7.1 Degeneration mode OFF, Fc = 169 MHz, TX_HP pin, external power amplifier

Figure 34. Current consumption in TX mode, Fc = 169 MHz, TX_HP pin, external power amplifier, degeneration mode OFF

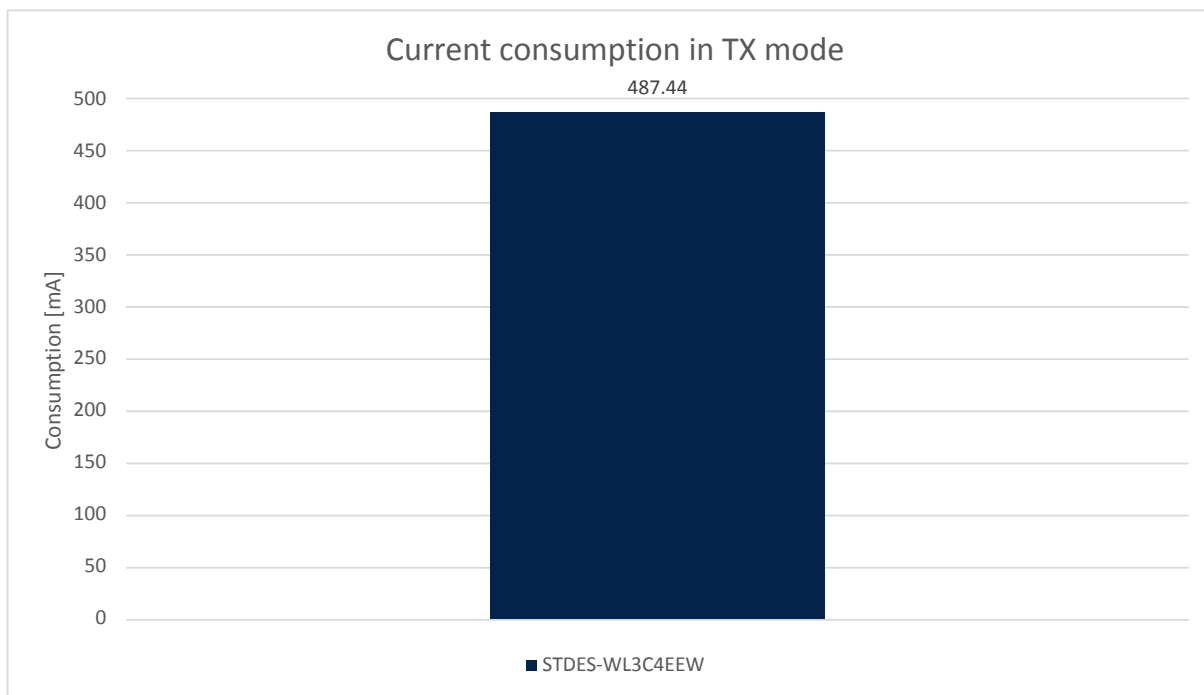


Figure 35. TX output power level, Fc = 169 MHz, TX_HP pin, external power amplifier, degeneration mode OFF

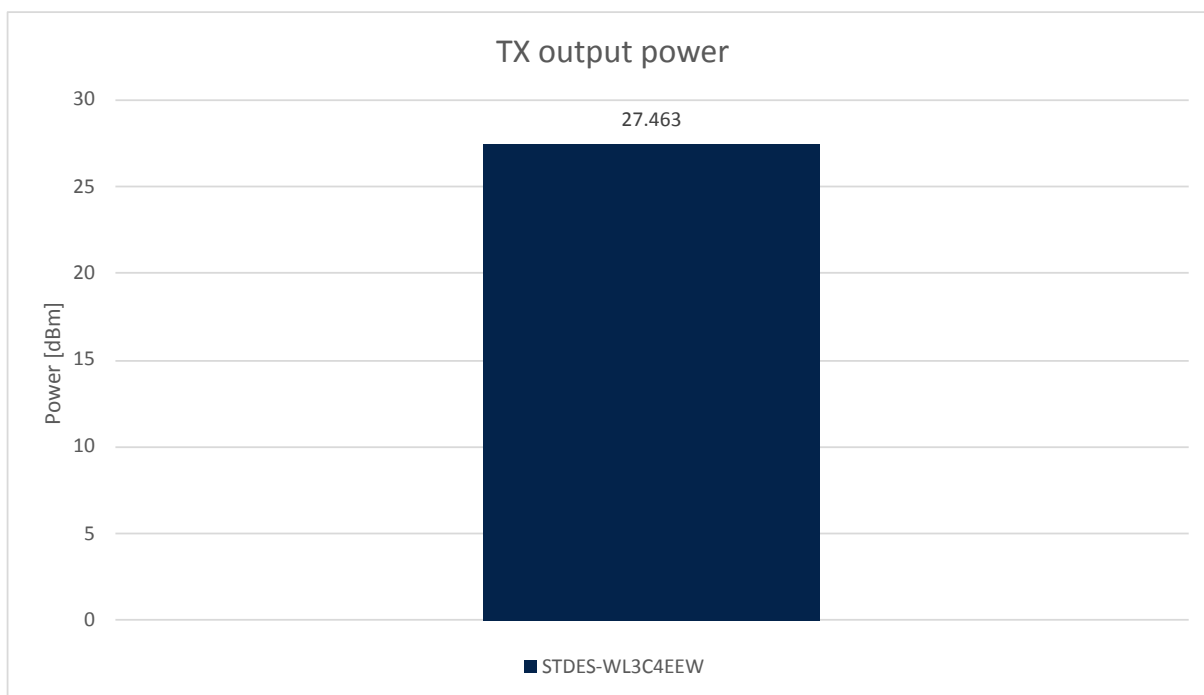
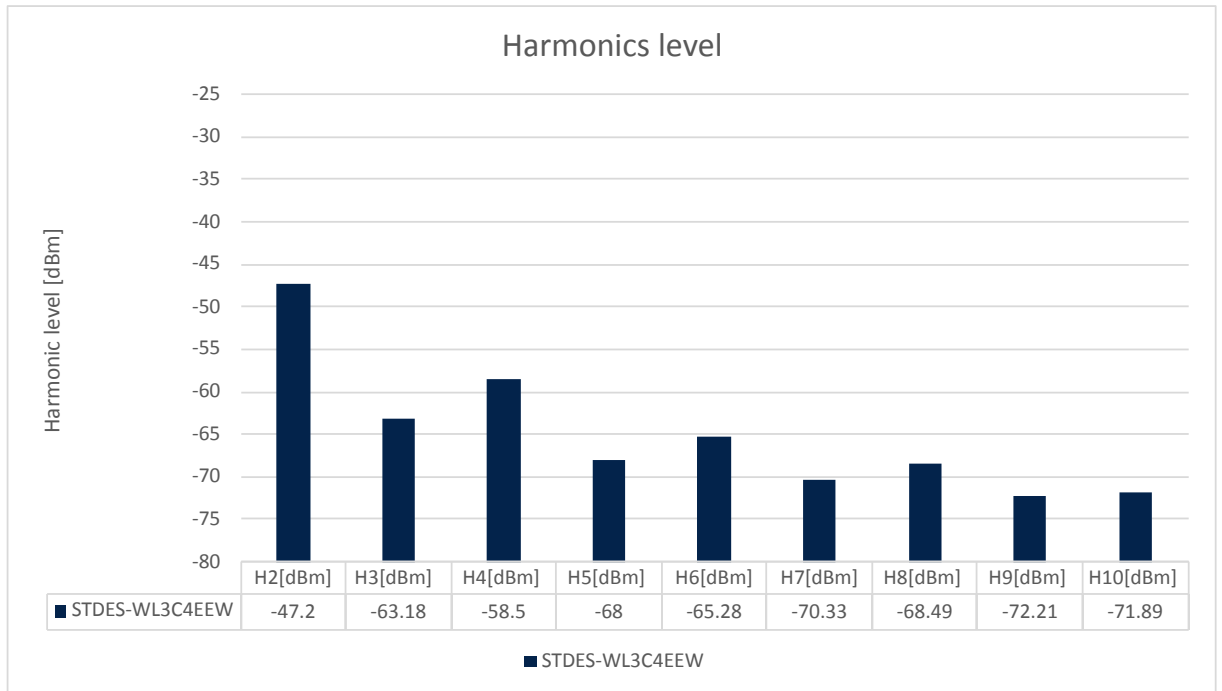
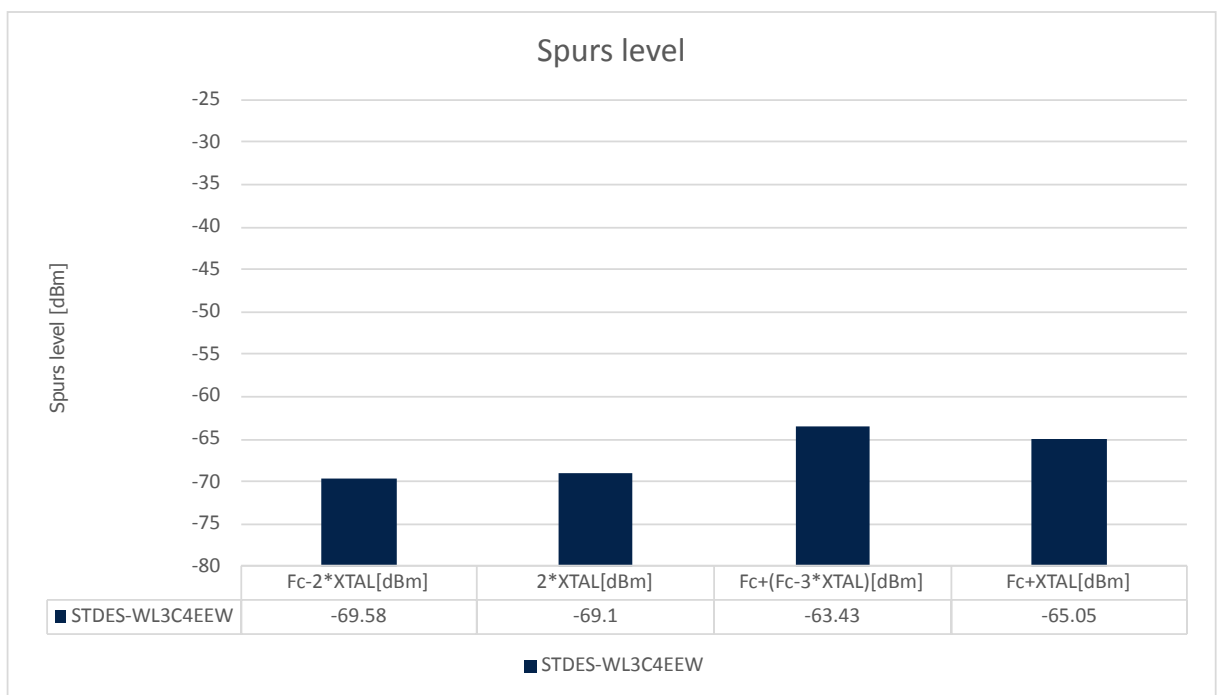


Figure 36. Harmonic level, $F_c = 169$ MHz, TX_HP pin, external power amplifier, degeneration mode OFF

Figure 37. Spurs level, $F_c = 169$ MHz, TX_HP pin, external power amplifier, degeneration mode OFF


4 STM32WL3x MCU RX sensitivity at given center frequency

This section shows a comparison of current consumption and sensitivity performance for reference designs optimized at a specific center frequency and output power, across three different SMPS configurations: bypass-on-the-fly, low power mode (LPM), and high-performance mode (HPM).

Refer to the radio settings and registers settings described in [Section 2: STM32WL3x MCU register settings](#).

4.1 $F_c = 433$ MHz, TX pin

Figure 38. Current consumption in RX mode $F_c = 433$ MHz, TX pin

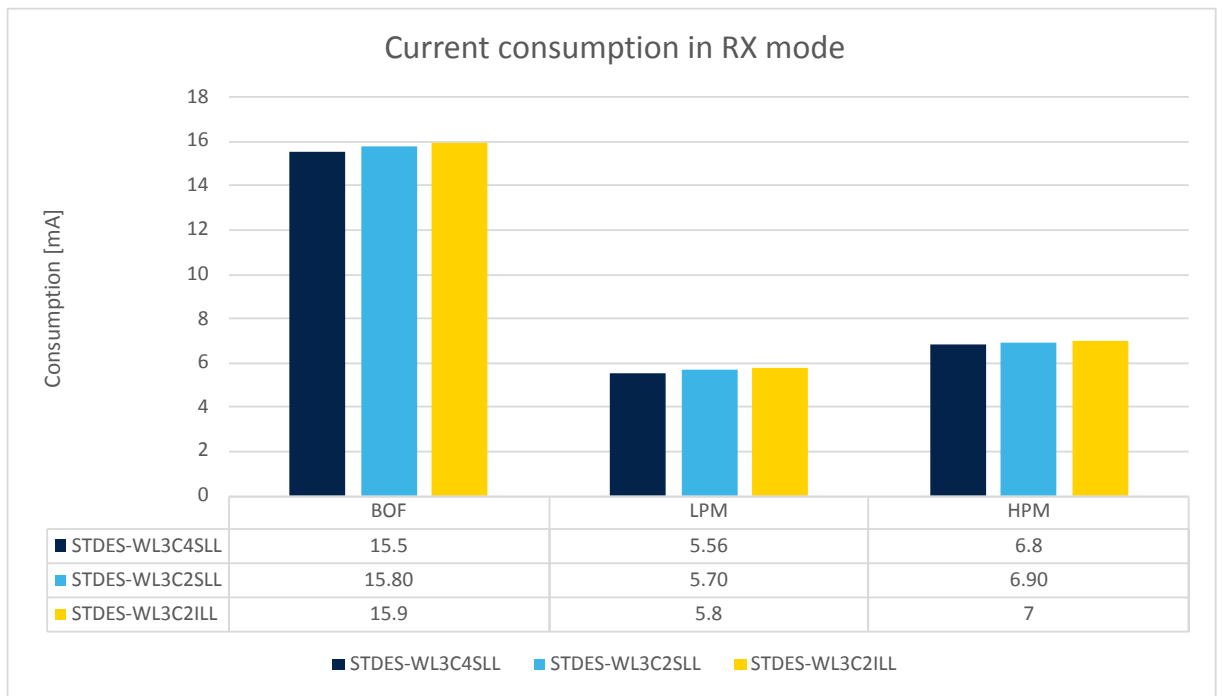
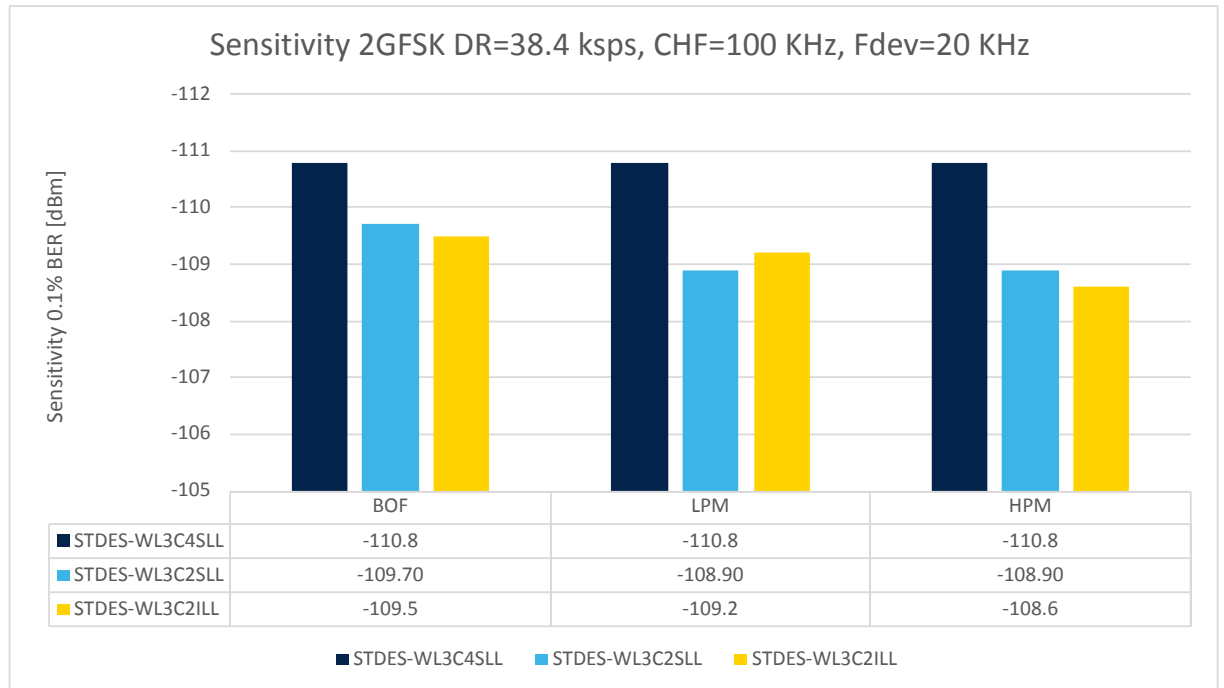


Figure 39. RX sensitivity, Fc=433 MHz, TX pin



4.2 $F_c = 433 \text{ MHz}$, , TX_HP pin

Figure 40. Current consumption in RX mode, $F_c = 433 \text{ MHz}$, , TX_HP pin

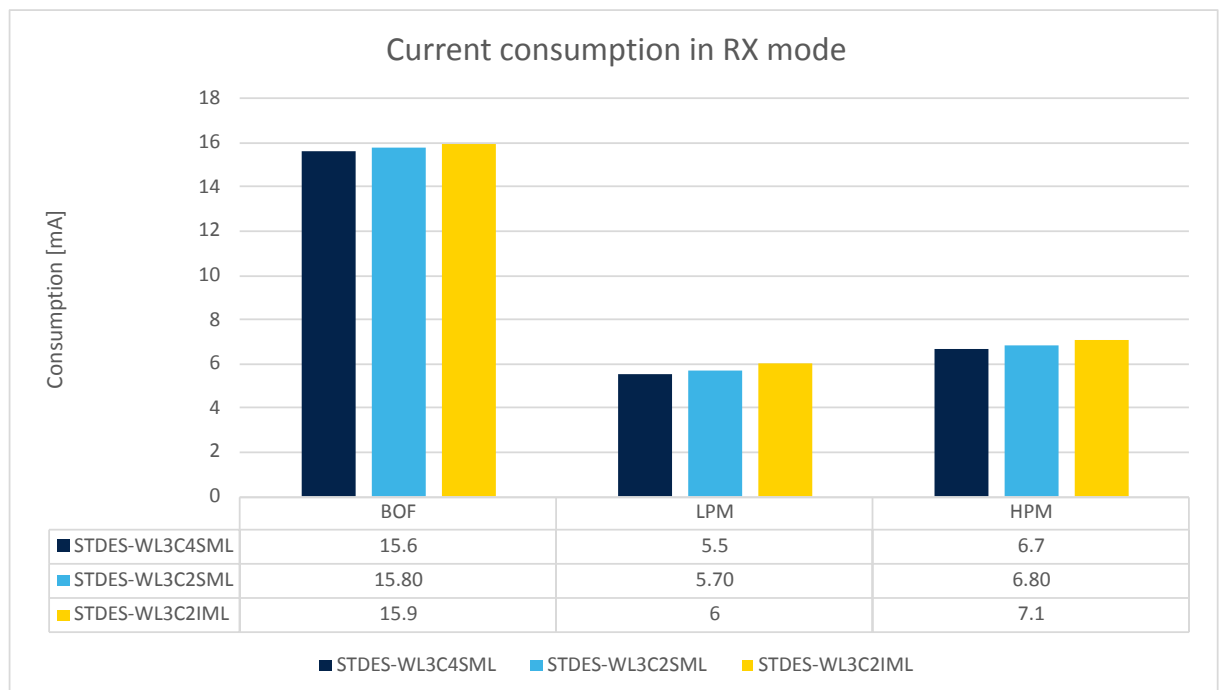
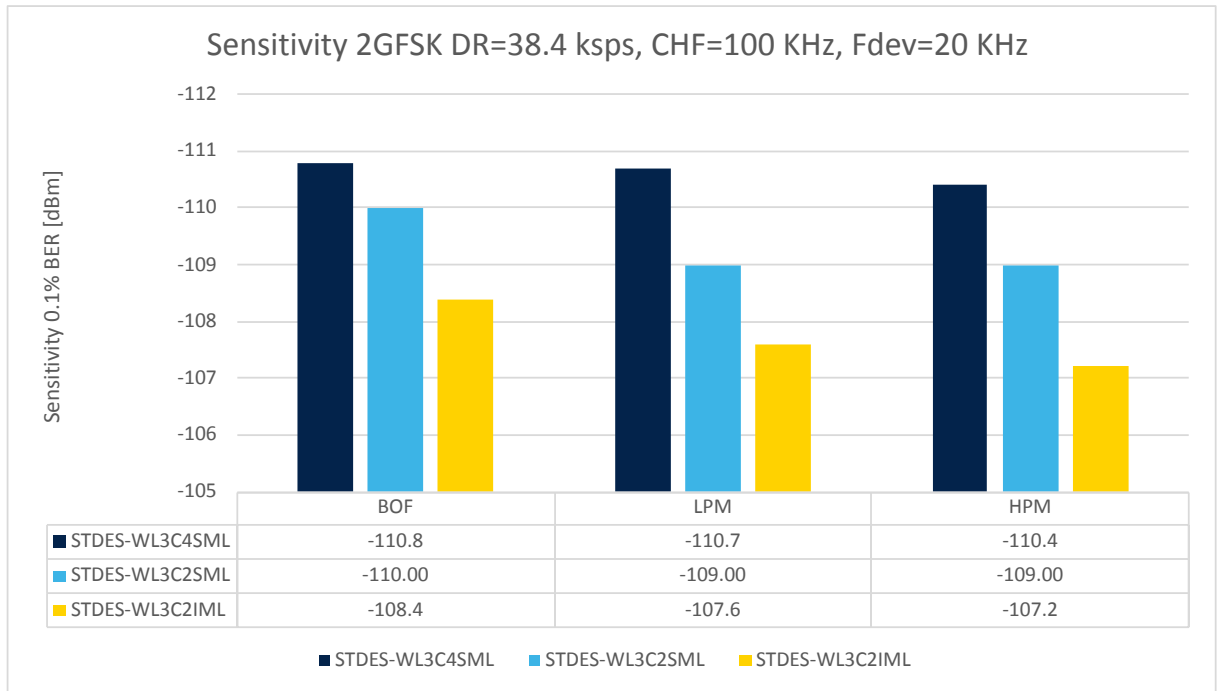


Figure 41. RX sensitivity, $F_c=433$ MHz, TX_HP pin


4.3

$F_c = 868$ MHz, TX pin

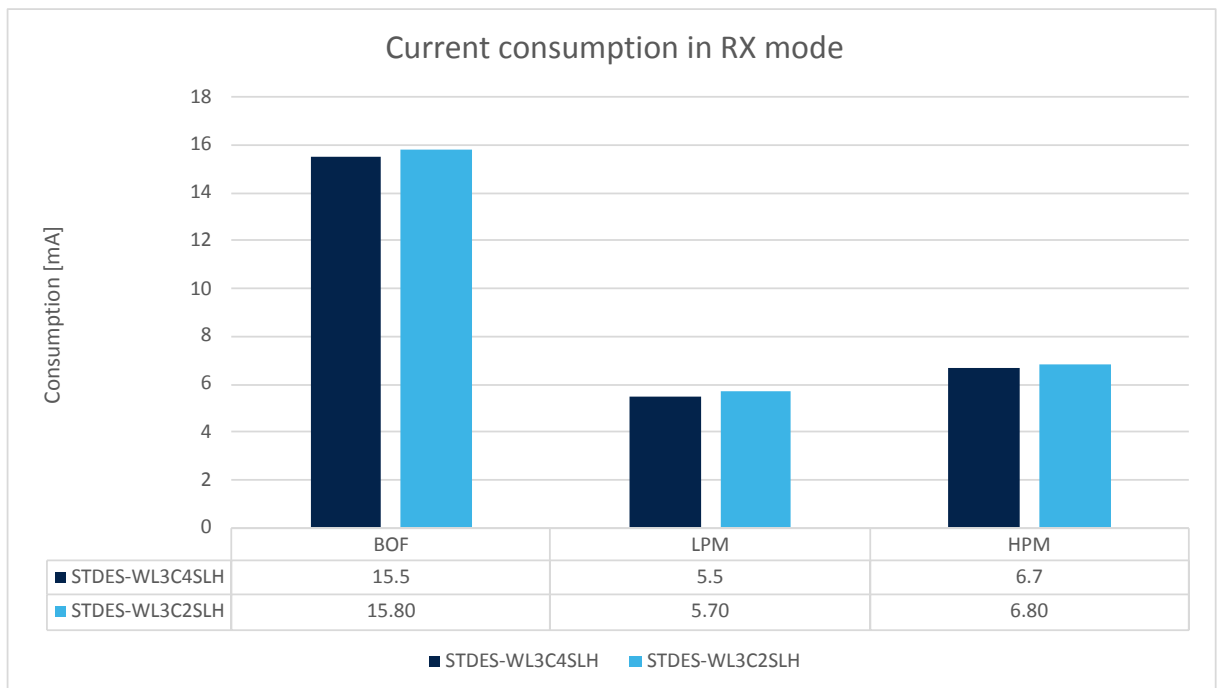
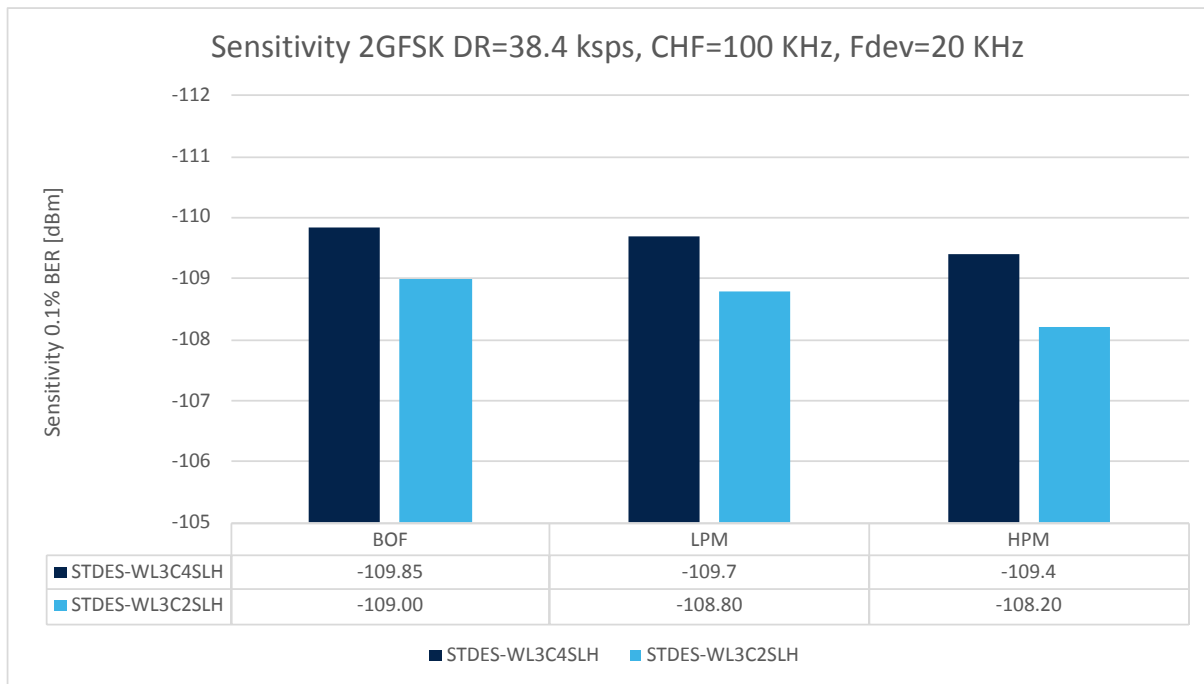
Figure 42. Current consumption in RX mode, $F_c = 868$ MHz, TX pin


Figure 43. RX sensitivity, Fc=868 MHz, TX pin



4.4

$F_c = 868$ MHz, TX_HP pin

Figure 44. Current consumption in RX mode, Fc = 868 MHz, TX_HP pin

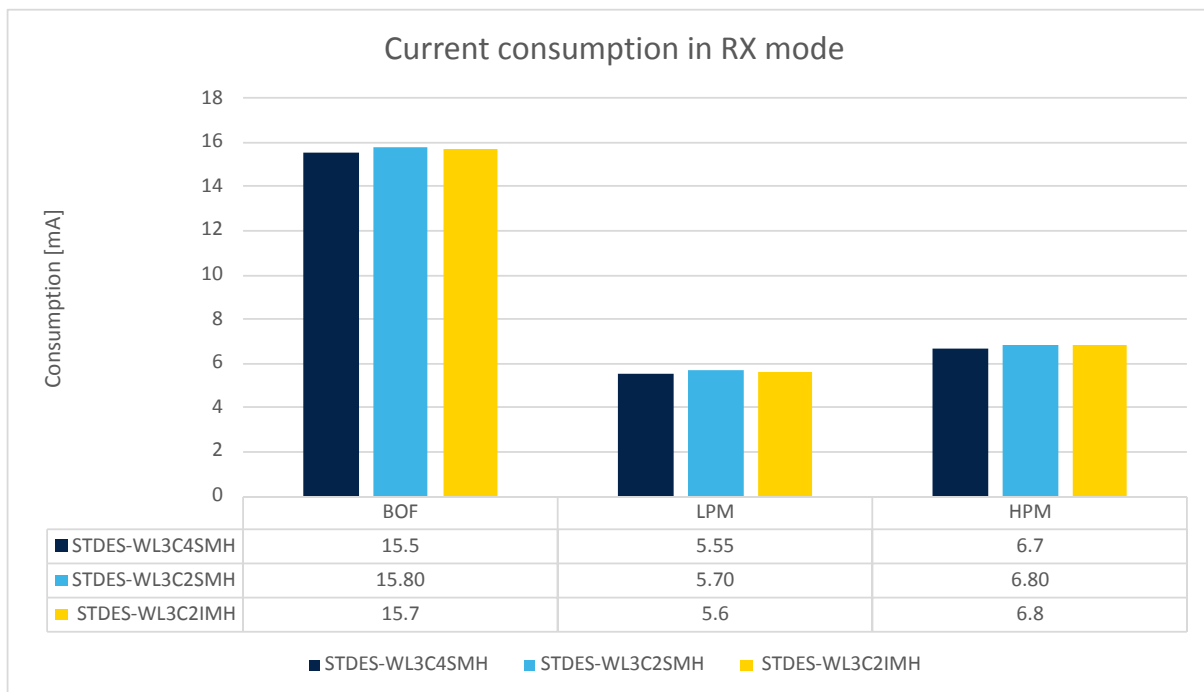
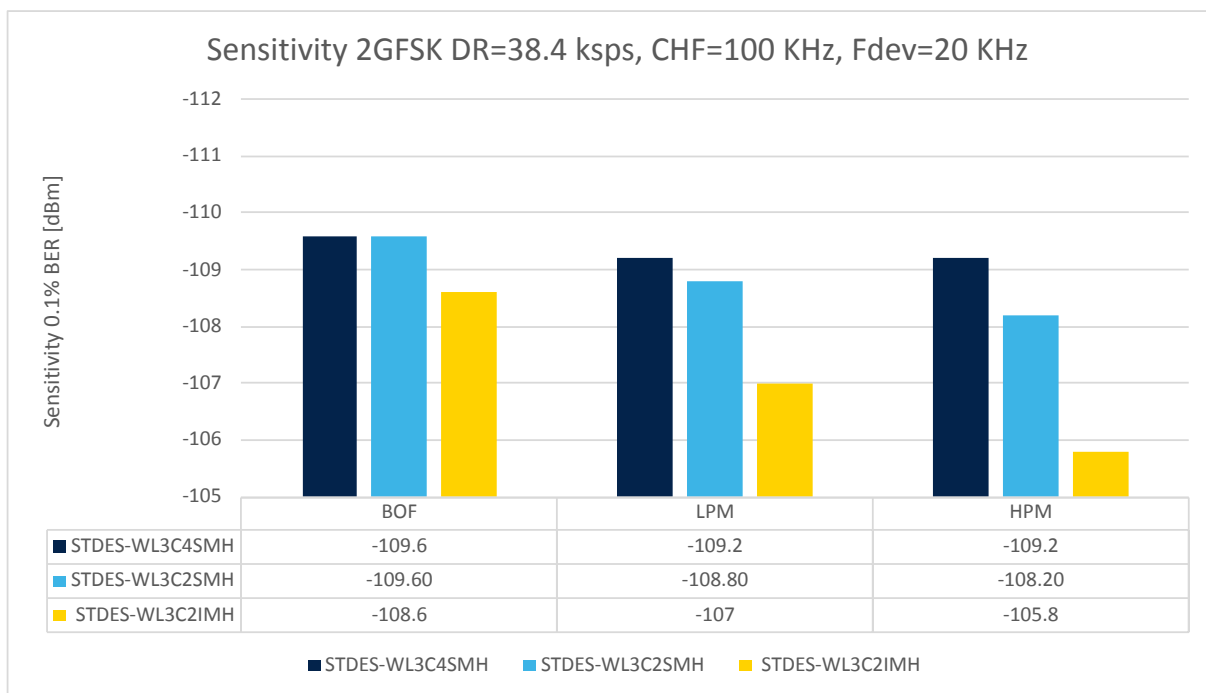


Figure 45. RX sensitivity, $F_c = 868$ MHz, TX_HP pin


4.5 $F_c = 915$ MHz, TX and TX_HP pins

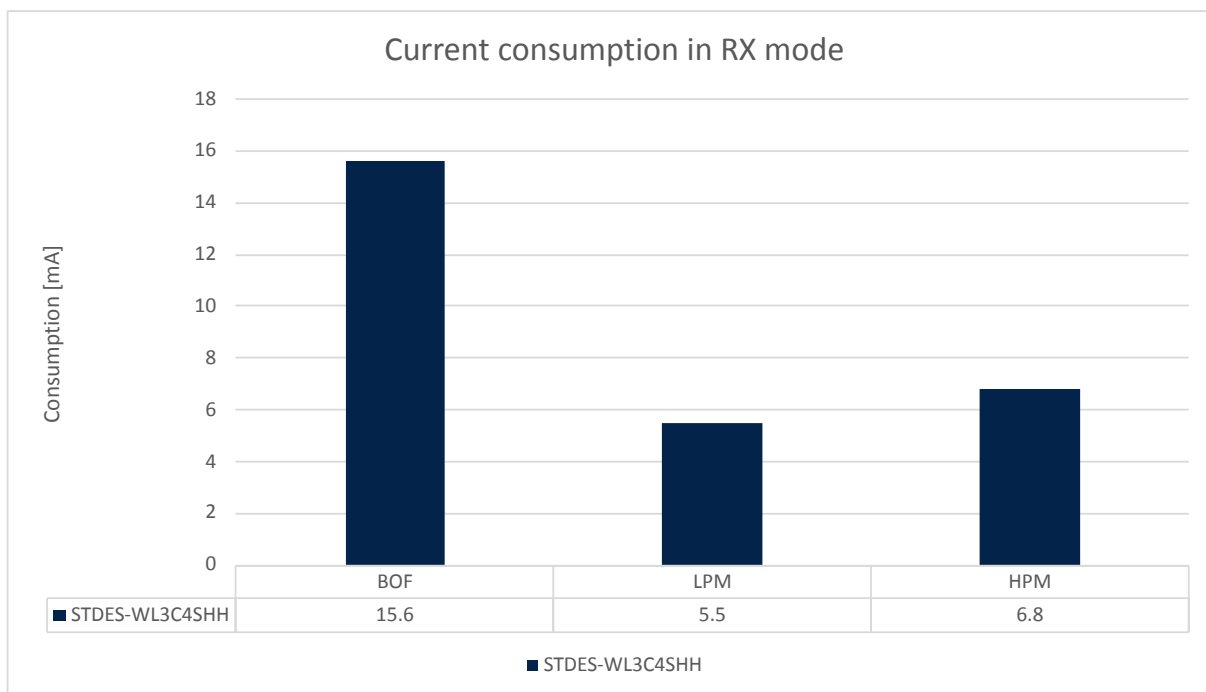
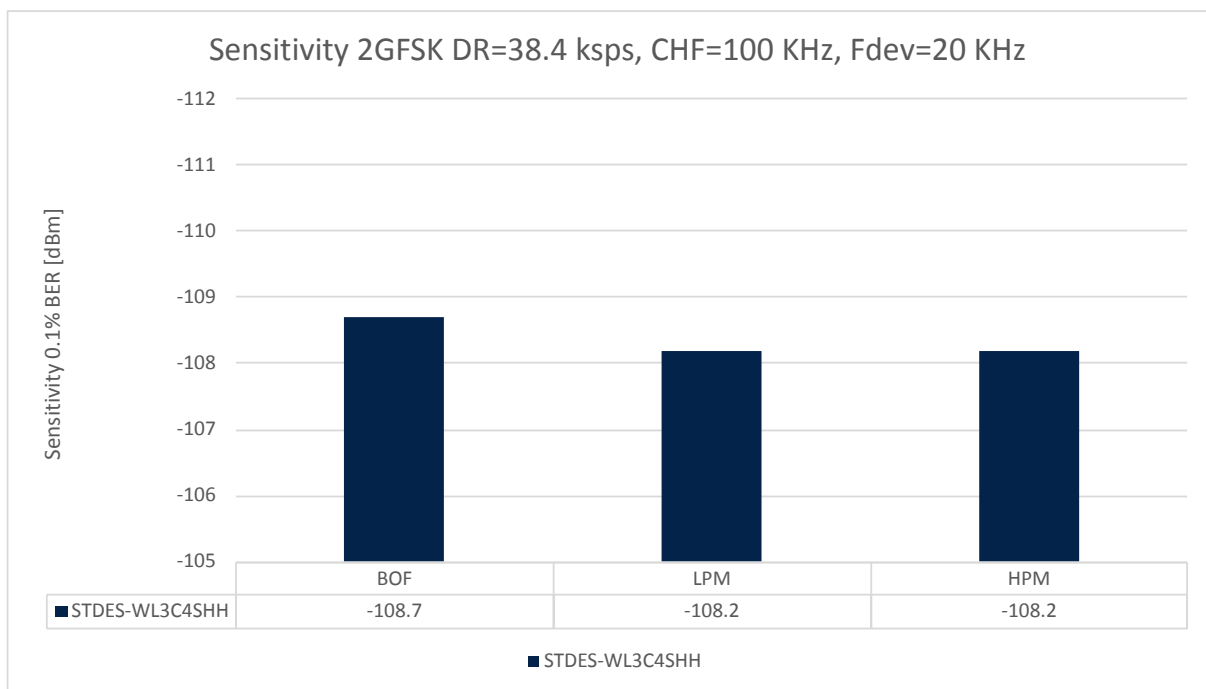
Figure 46. Current consumption in RX mode, $F_c = 915$ MHz, TX and TX_HP pins


Figure 47. RX sensitivity, $F_c = 915$ MHz, TX and TX_HP pins


4.6

$F_c = 915$ MHz, TX pin

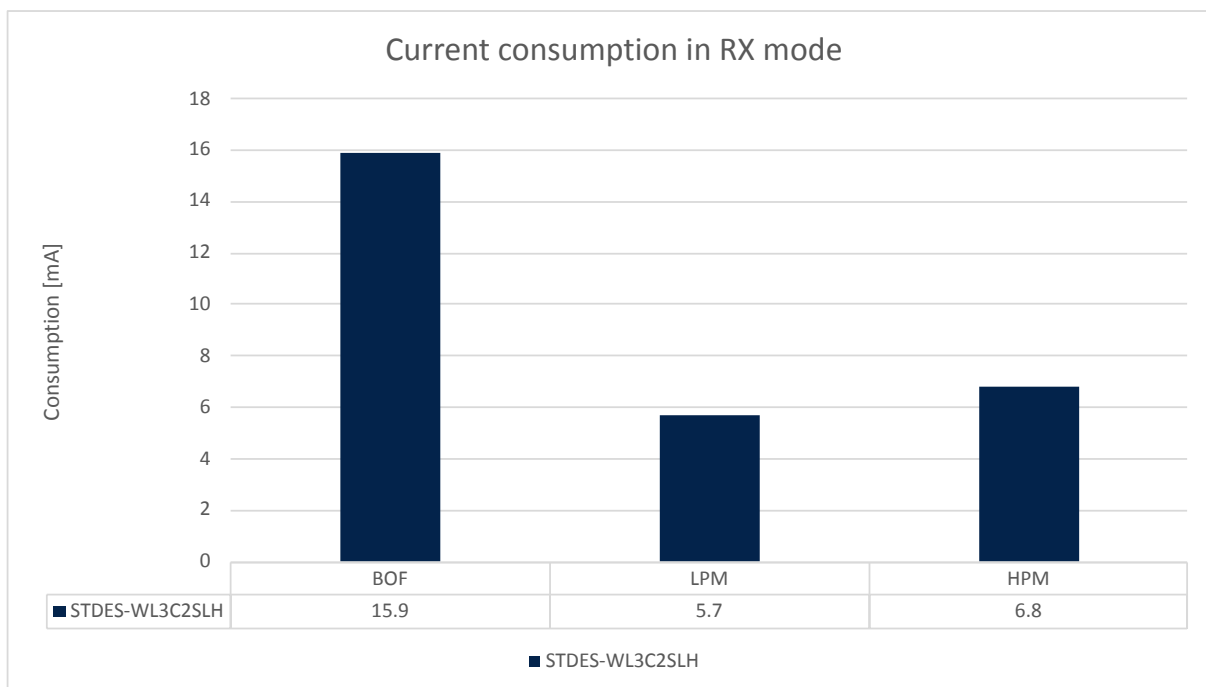
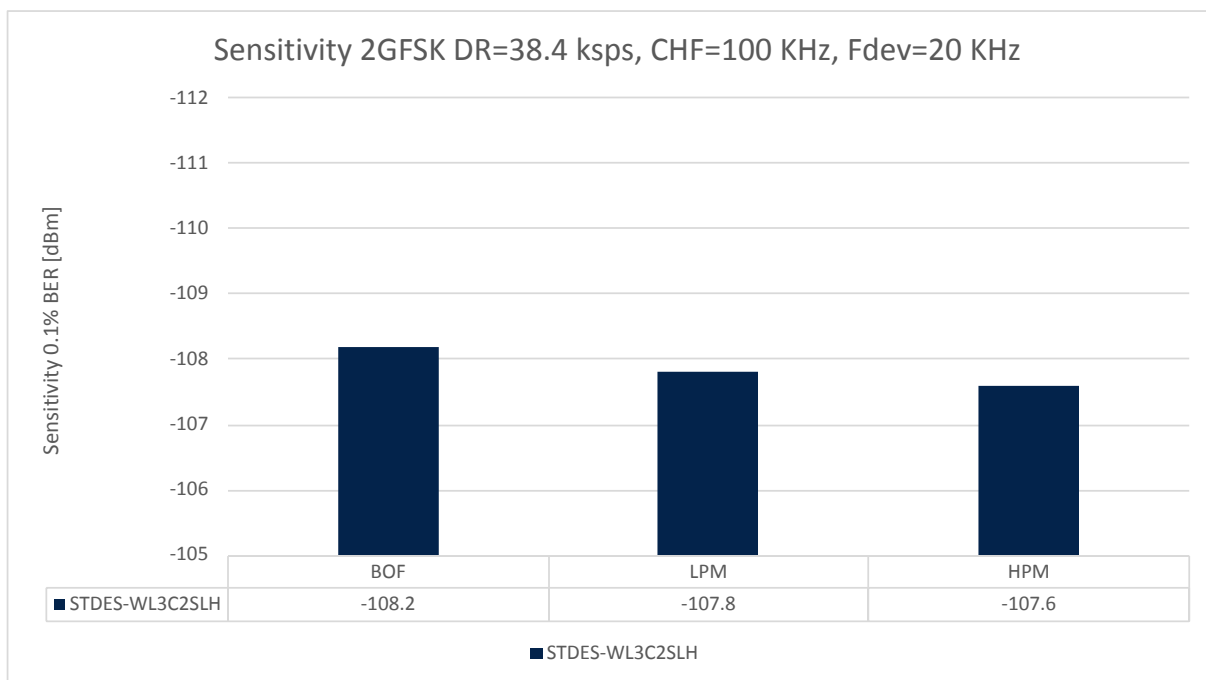
Figure 48. Current consumption in RX mode, $F_c = 915$ MHz, TX pin


Figure 49. RX sensitivity, $F_c = 915$ MHz, TX pin


4.7

$F_c = 169$ MHz, TX_HP pin, external power amplifier

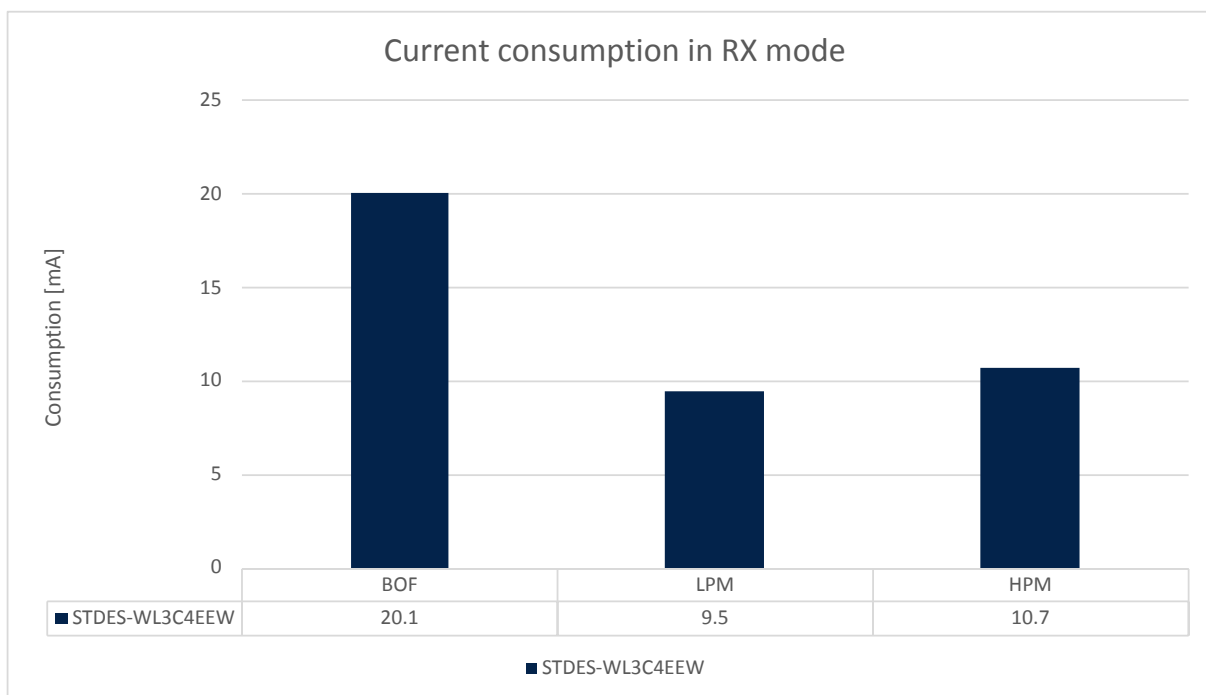
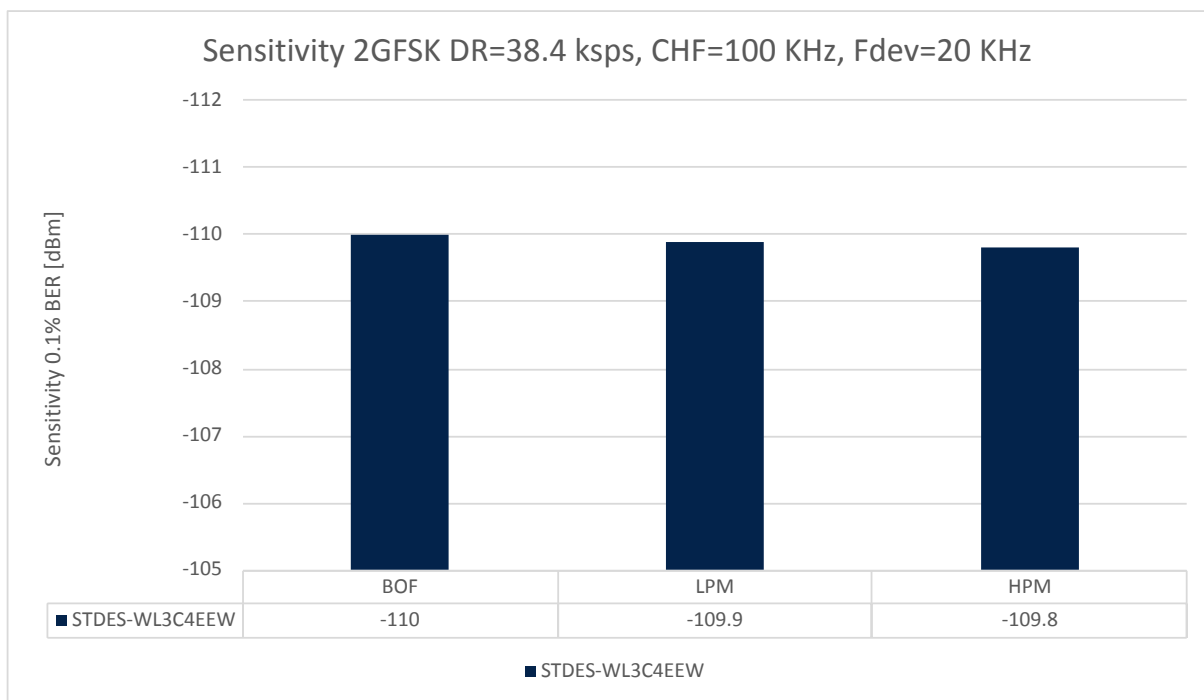
Figure 50. Current consumption in RX mode, TX_HP pin, external power amplifier


Figure 51. RX sensitivity , Fc = 169 MHz, TX_HP pin, external power amplifier


5 STM32WL3x reference designs RF performance

This section shows the RF performance (TX and RX) of the reference designs listed in [Section 2.1: TX radio and register setting](#) within the following frequency bands:

- Low band: 413 MHz – 479 MHz
- High band: 826 MHz – 958 MHz

Refer to the radio settings and register settings described in [Section 2: STM32WL3x MCU register settings](#).

At certain frequencies, sensitivity degradation may be observed as a result of spur generation mechanisms such as the crystal oscillator (Xtal), SMPS switching, and sub-fractional spurs.

By adjusting the HSE frequency or the SMPS switching frequency, the associated spurs can be shifted sufficiently far from the target frequency to mitigate their impact on receiver sensitivity.

5.1 STDES-WL3C2ILL

Figure 52. Current consumption in TX mode, Low band, TX pin, degeneration mode ON

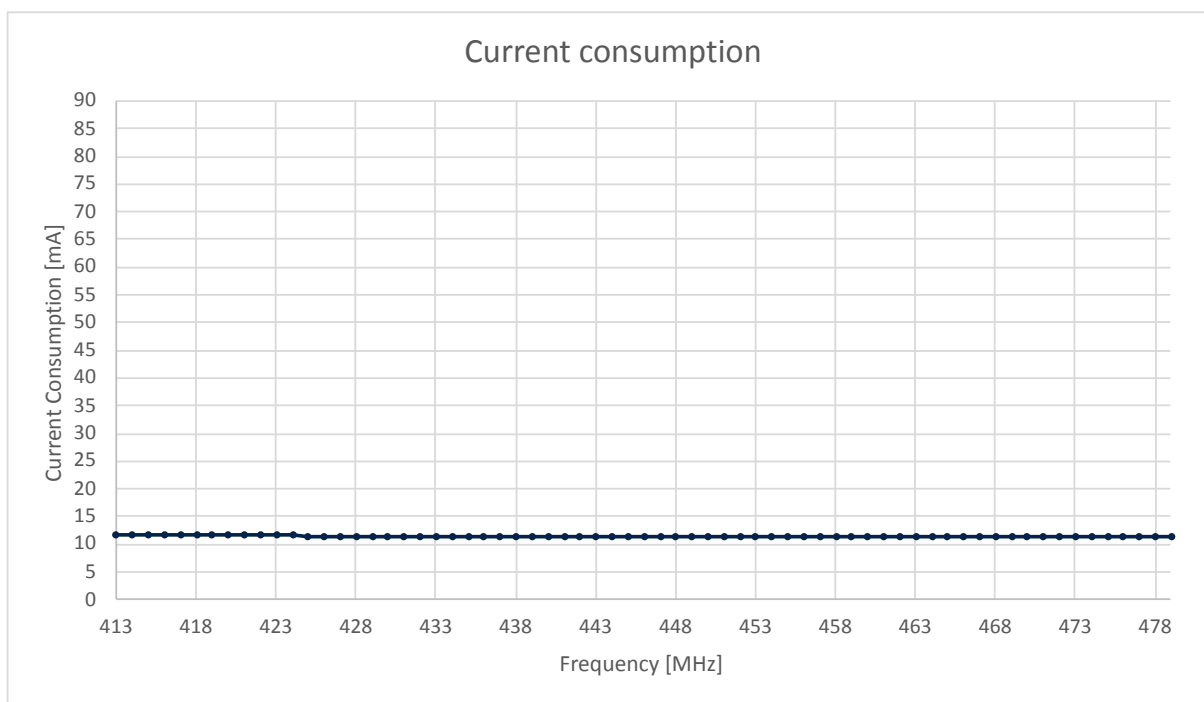


Figure 53. TX output power level, low band, TX pin, degeneration mode ON

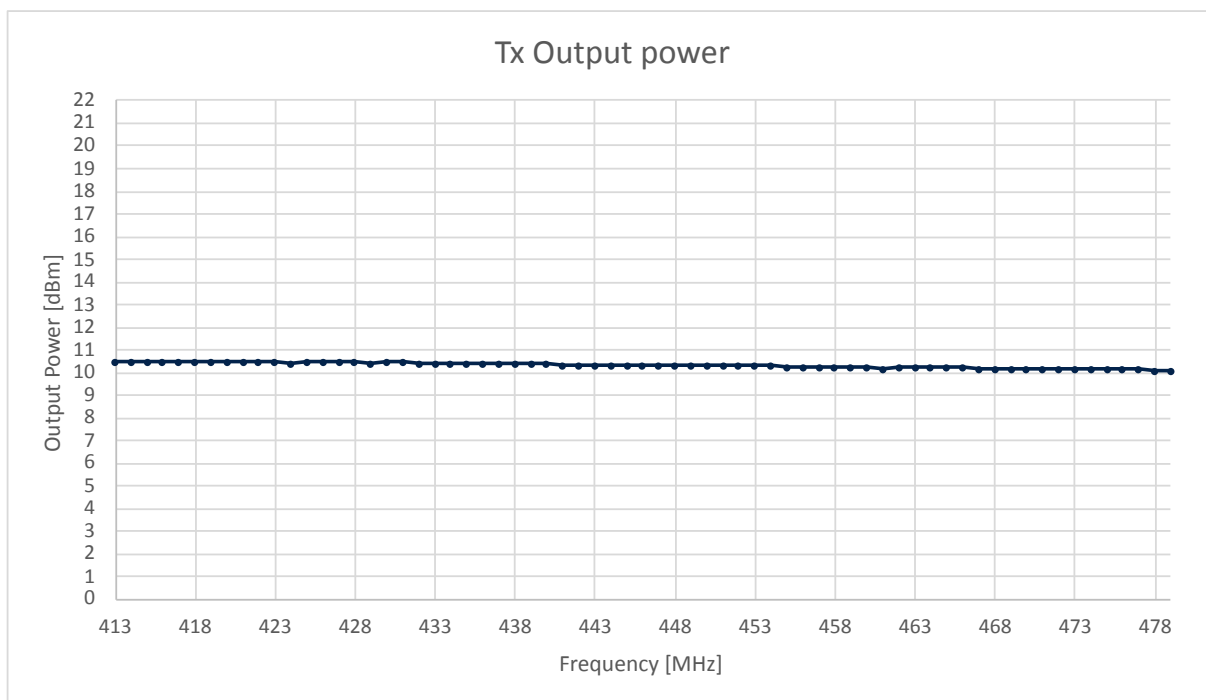


Figure 54. H2 level, low band, TX pin, degeneration mode ON

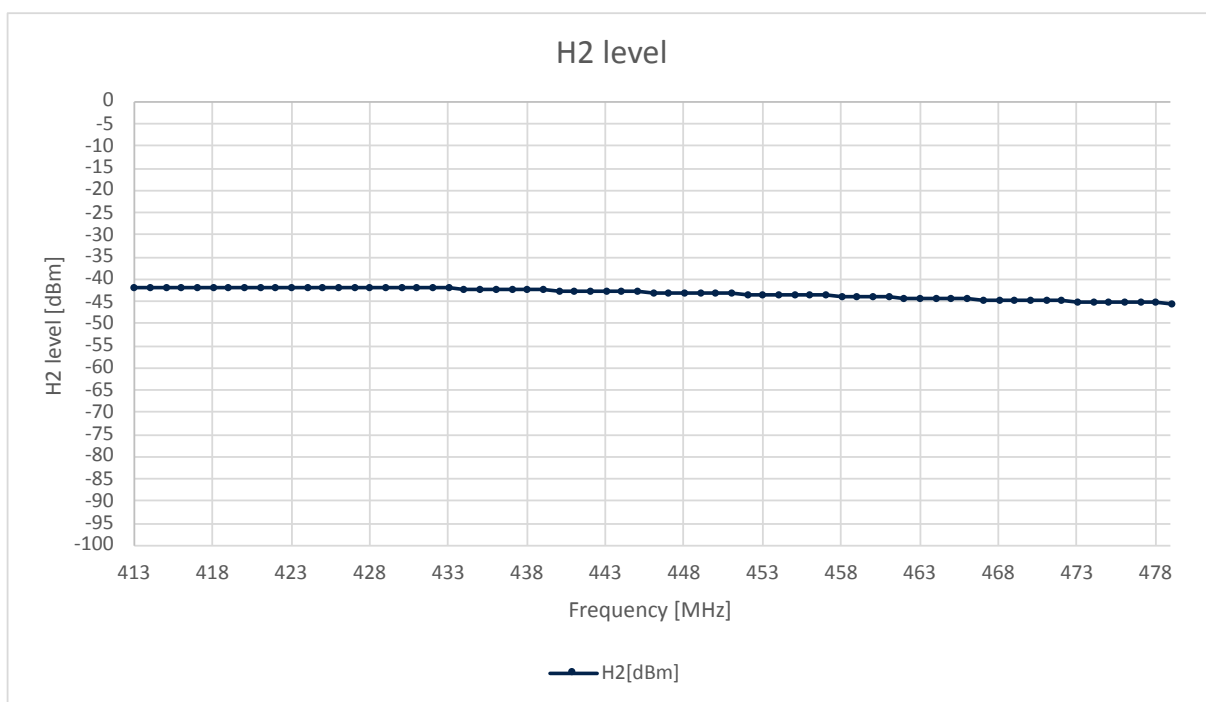


Figure 55. Harmonics level, low band, TX pin, degeneration mode ON

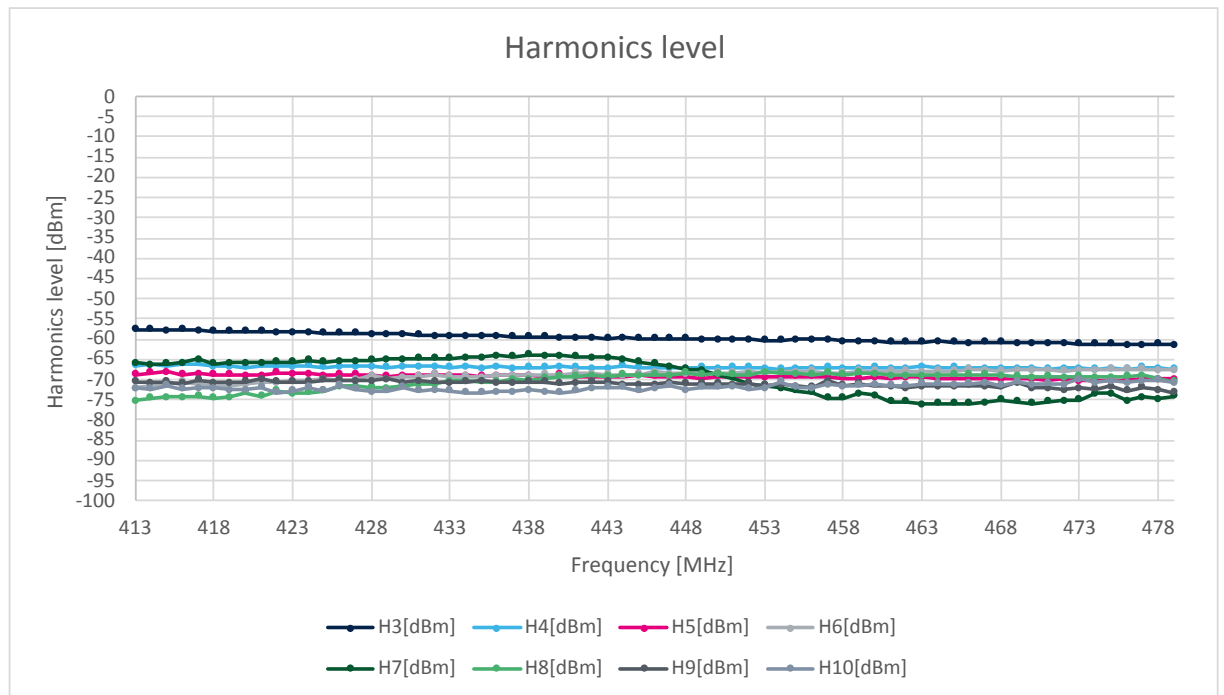
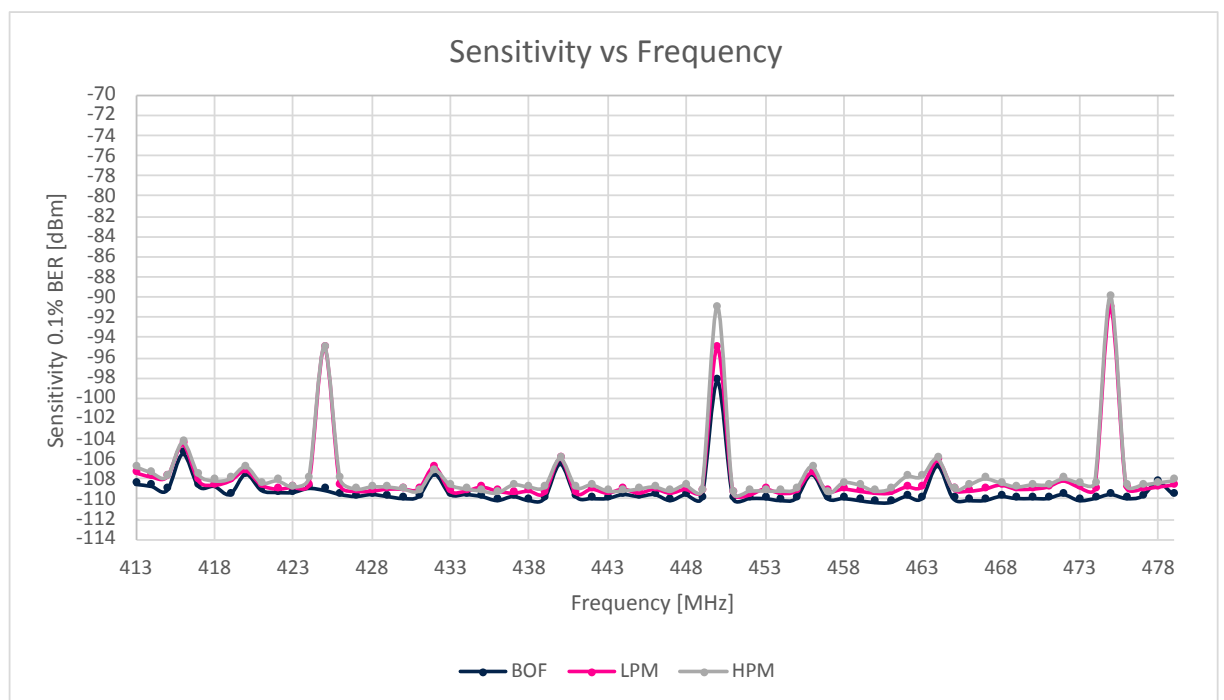


Figure 56. RX sensitivity, low band, TX pin



5.2 STDES-WL3C2IMH

Figure 57. Current consumption in TX mode, high band, TX_HP pin, degeneration mode ON

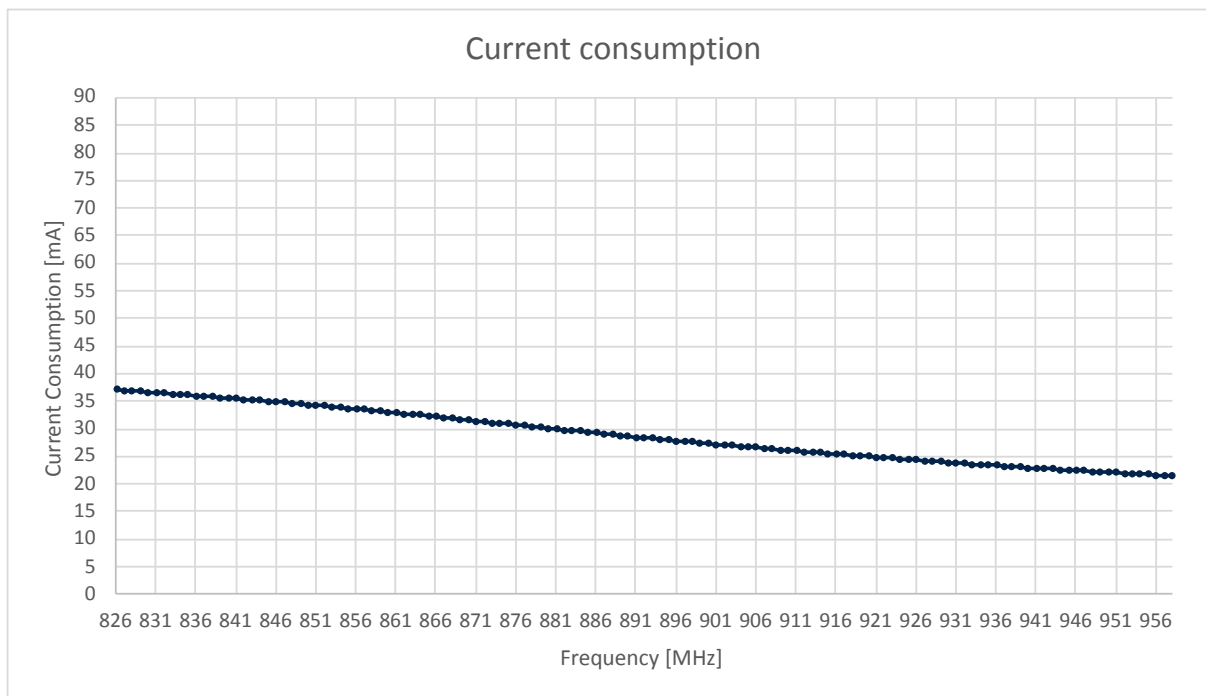


Figure 58. TX output power level, high band, TX_HP pin, degeneration mode ON

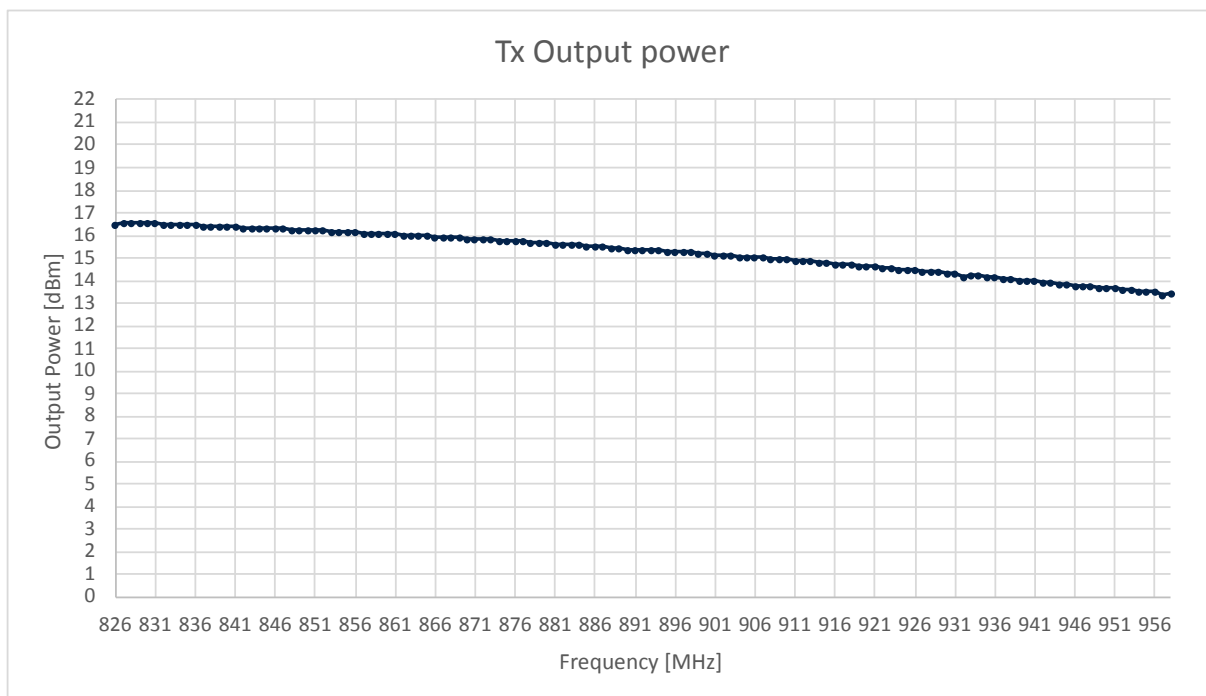


Figure 59. H2 level, high band, TX_HP pin, degeneration mode ON

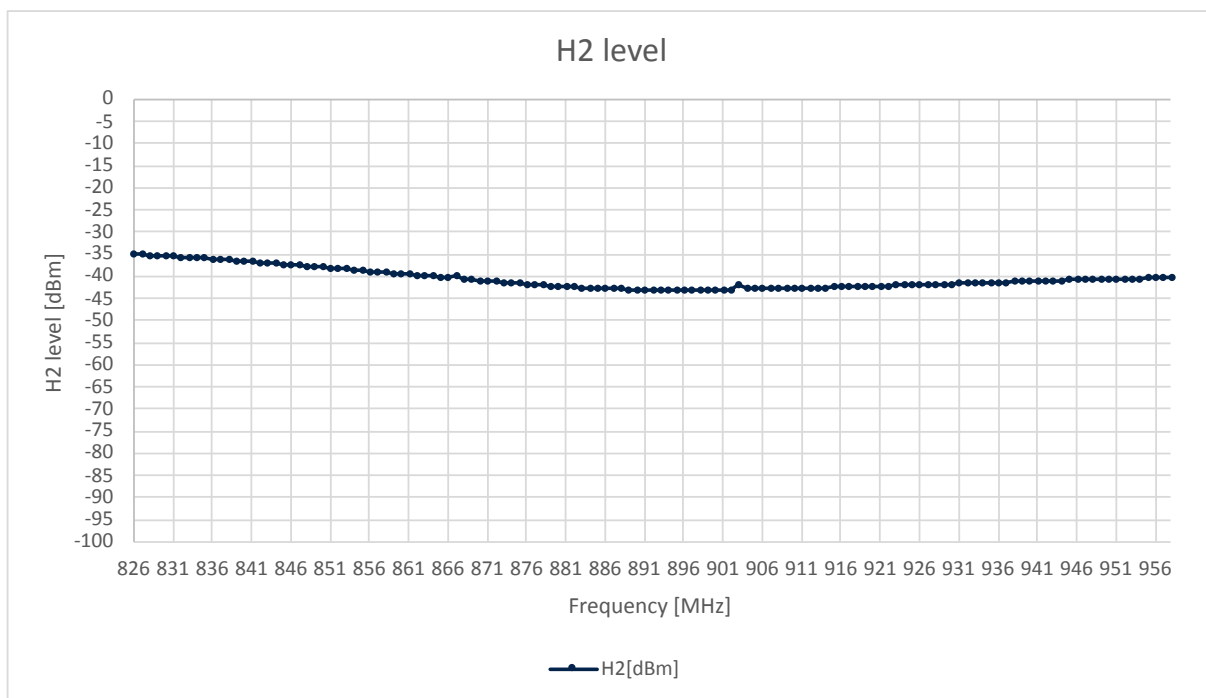


Figure 60. Harmonics level, high band, TX_HP pin, degeneration mode ON

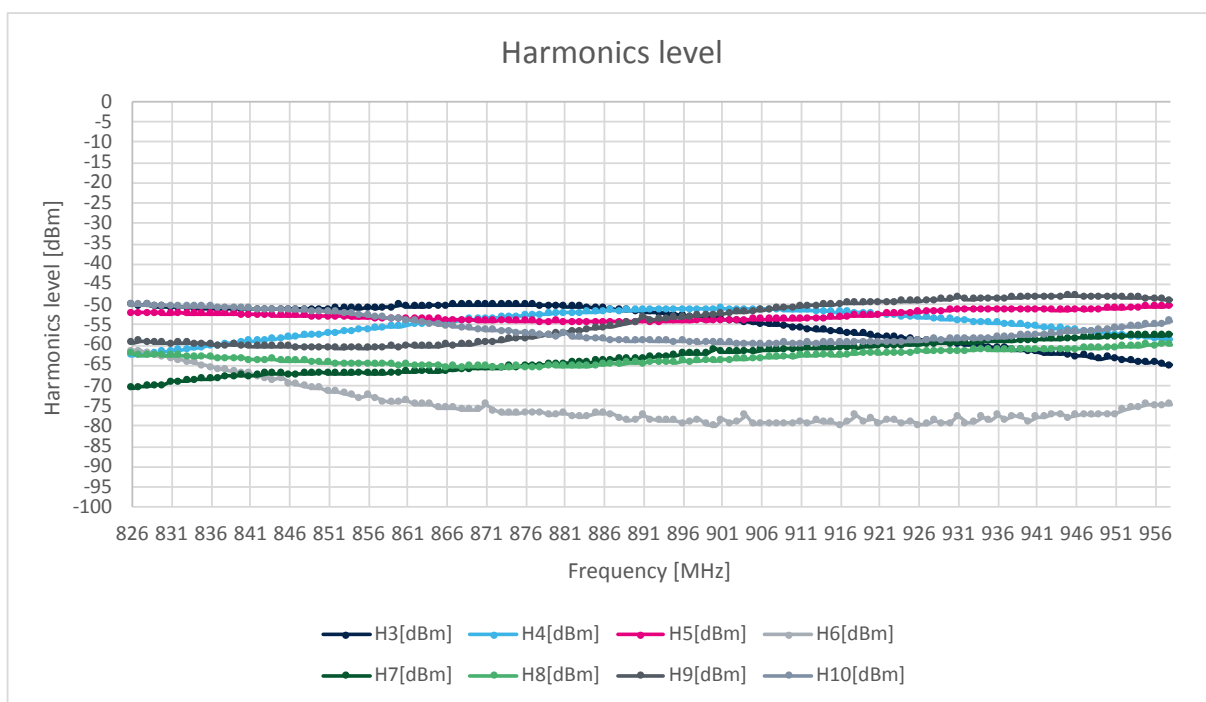
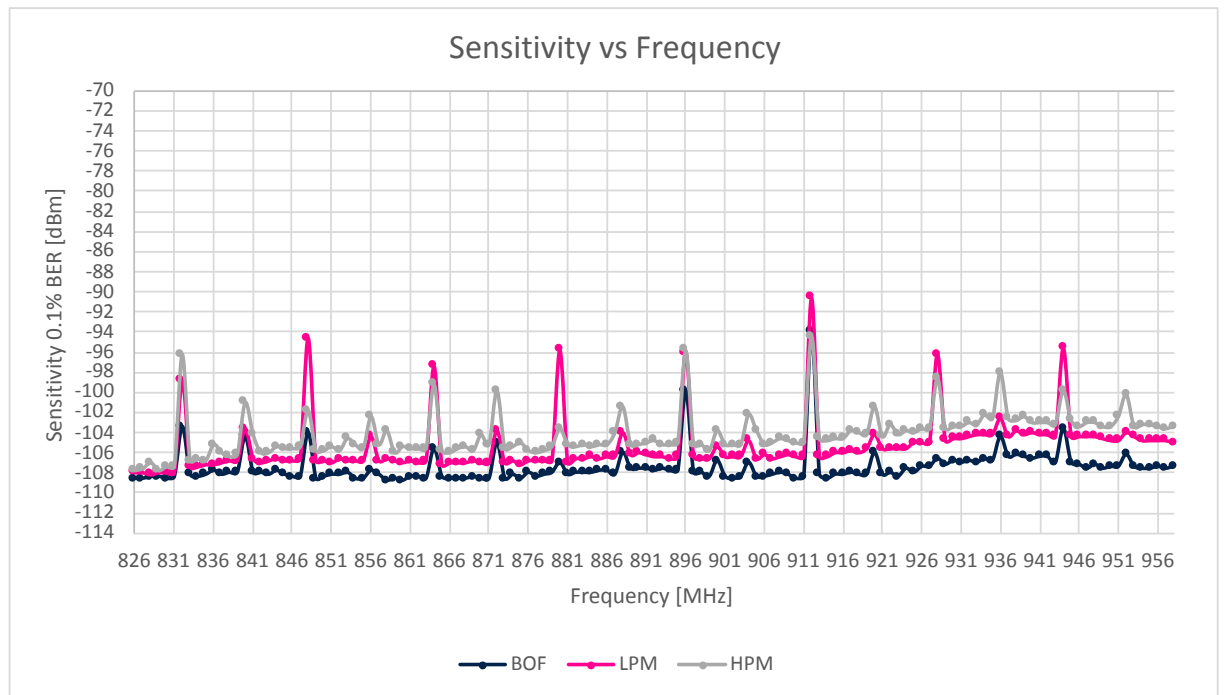


Figure 61. RX sensitivity, high band, TX_HP pin



5.3 STDES-WL3C2IML

Figure 62. Current consumption in TX mode, low band, TX_HP pin, degeneration mode ON

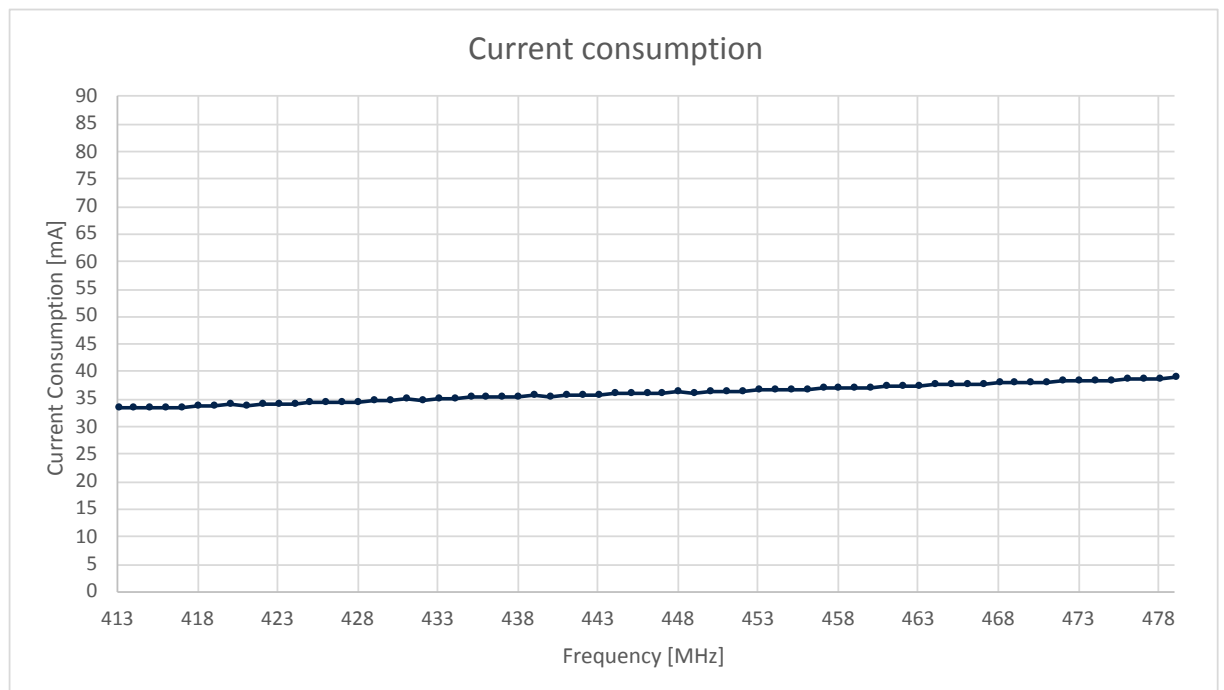


Figure 63. TX output power level, low band, TX_HP pin, degeneration mode ON

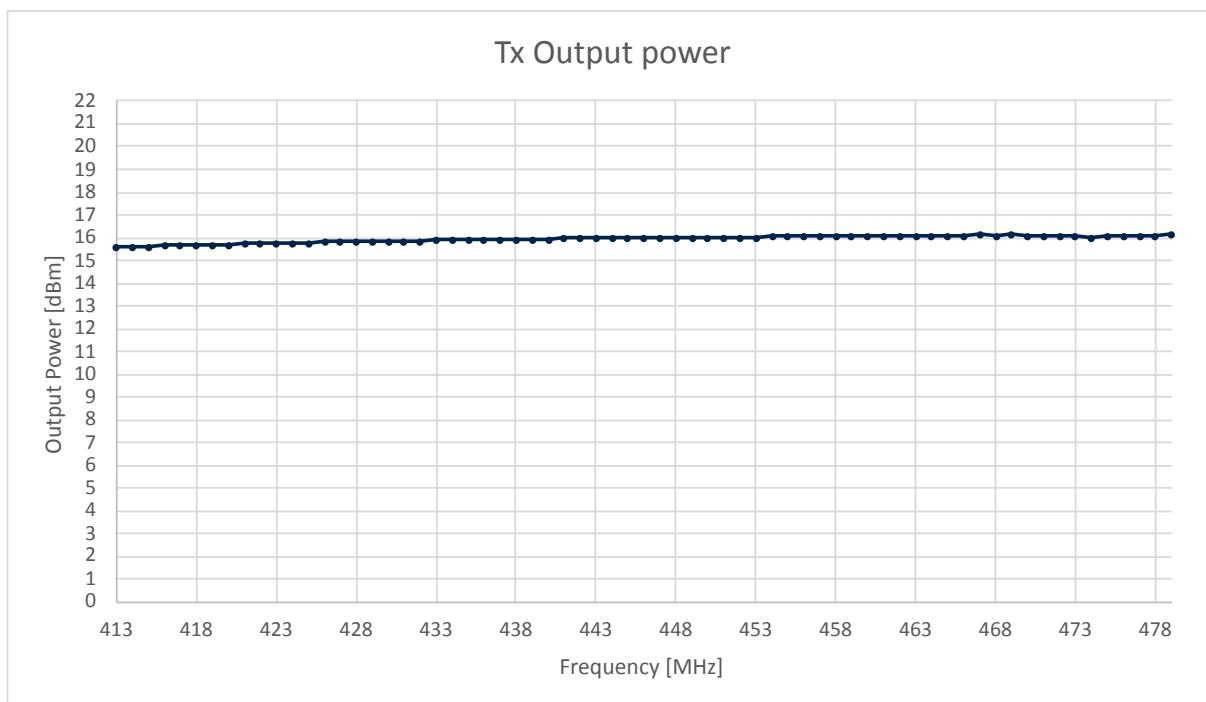


Figure 64. Harmonics level, low band, TX_HP pin, degeneration mode ON

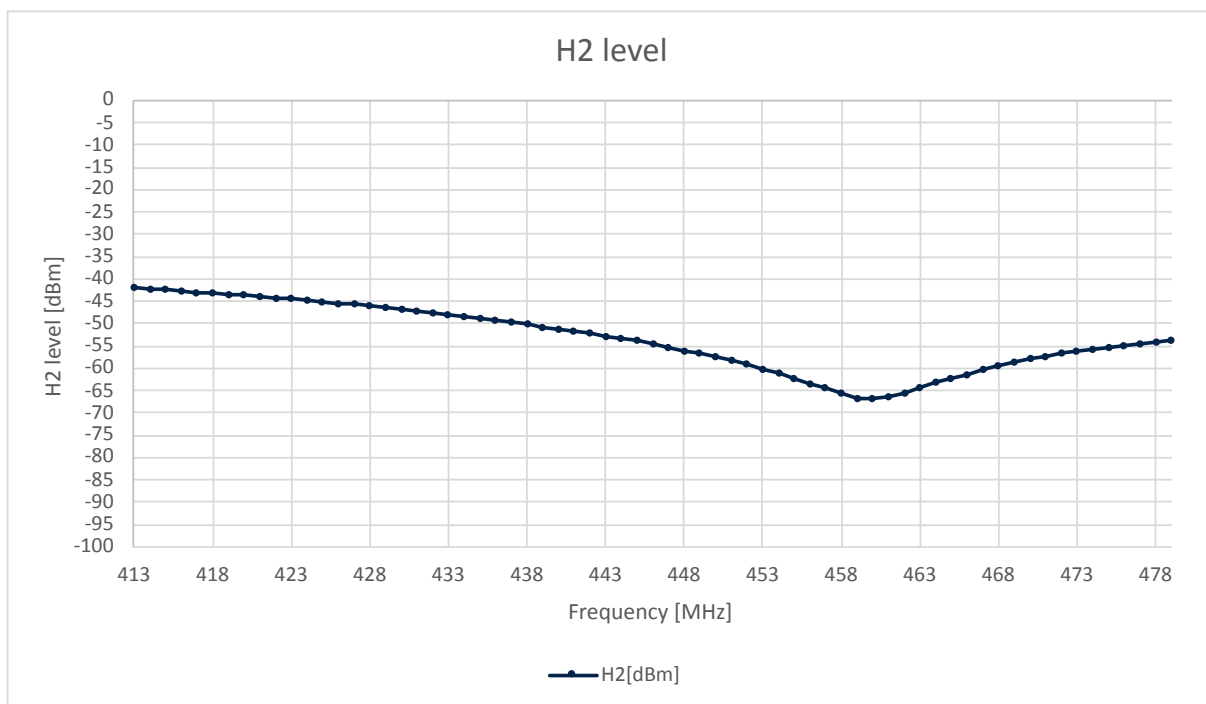


Figure 65. Harmonics level, low band, TX_HP pin, degeneration mode ON

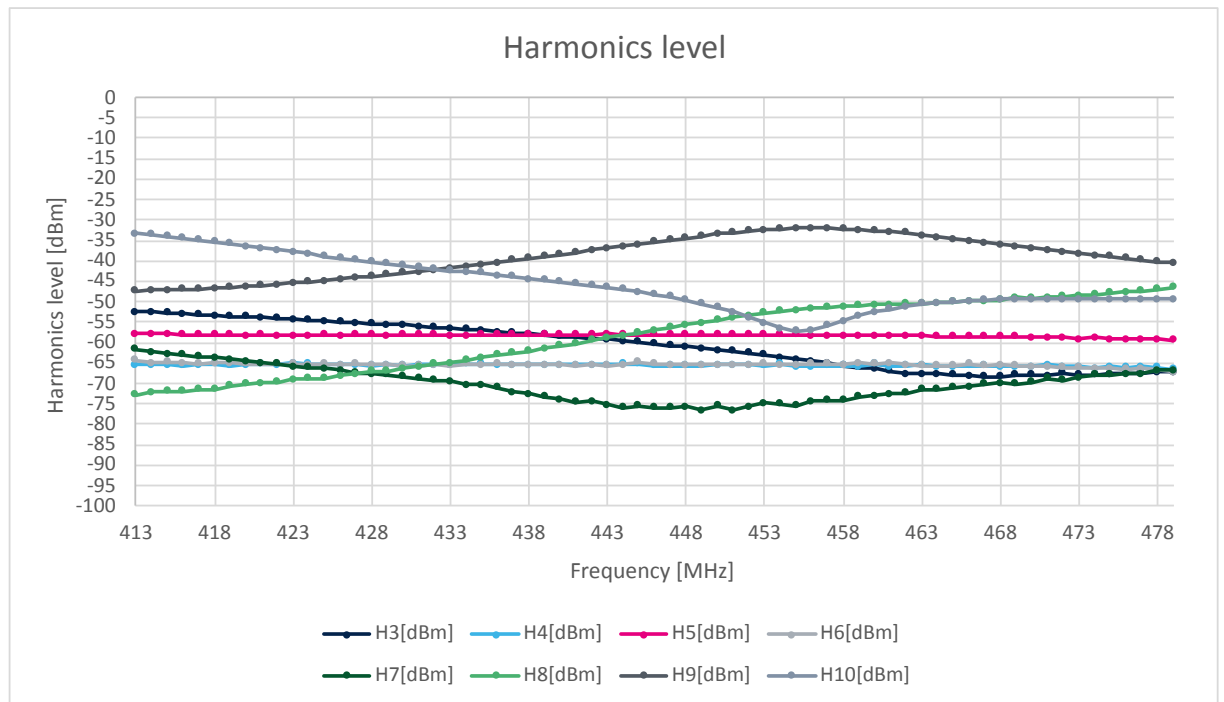
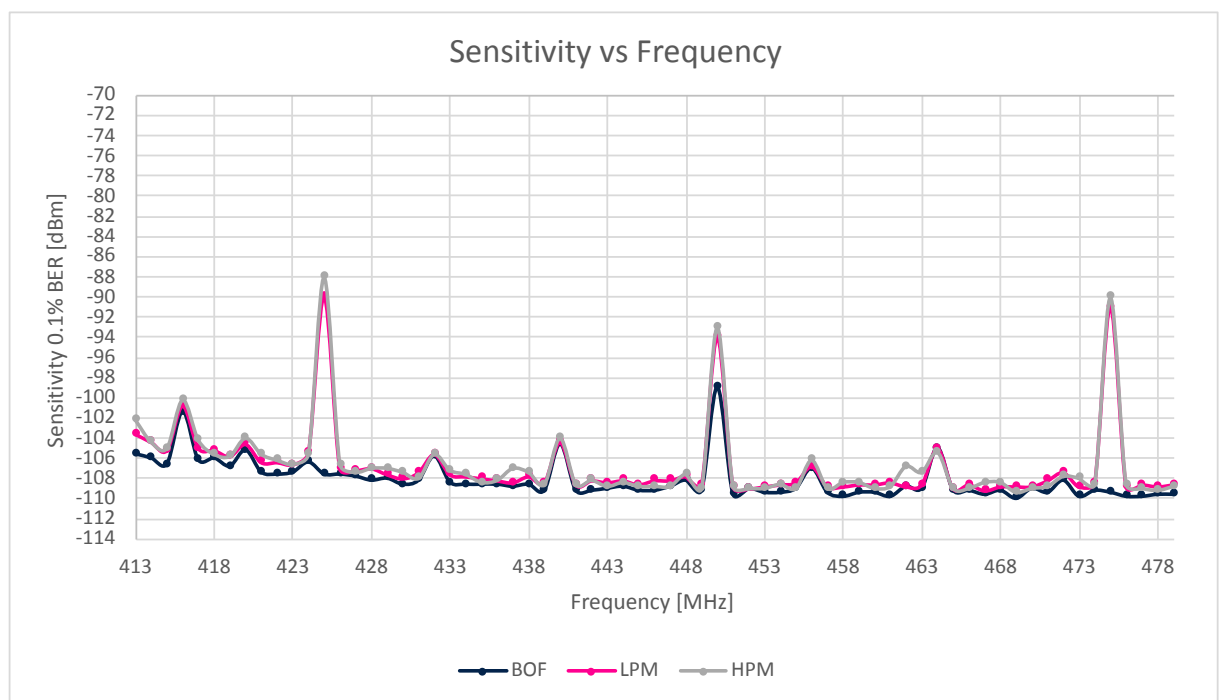


Figure 66. RX sensitivity, low band, TX_HP pin



5.4 STDES-WL3C2SLH

5.4.1 $F_c = 868$ MHz, TX pin

Figure 67. Current consumption in TX mode, high band, $F_c = 868$ MHz, TX pin, degeneration mode ON

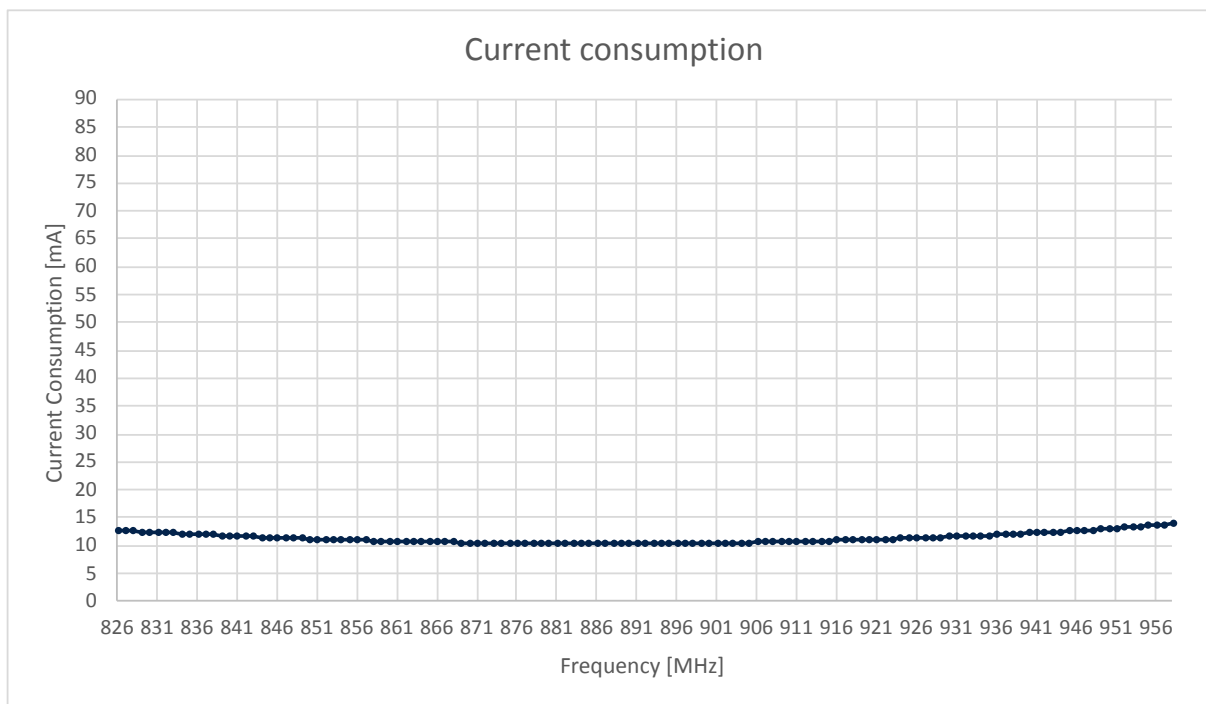


Figure 68. TX output power level, high band, $F_c = 868$ MHz, TX pin, degeneration mode ON

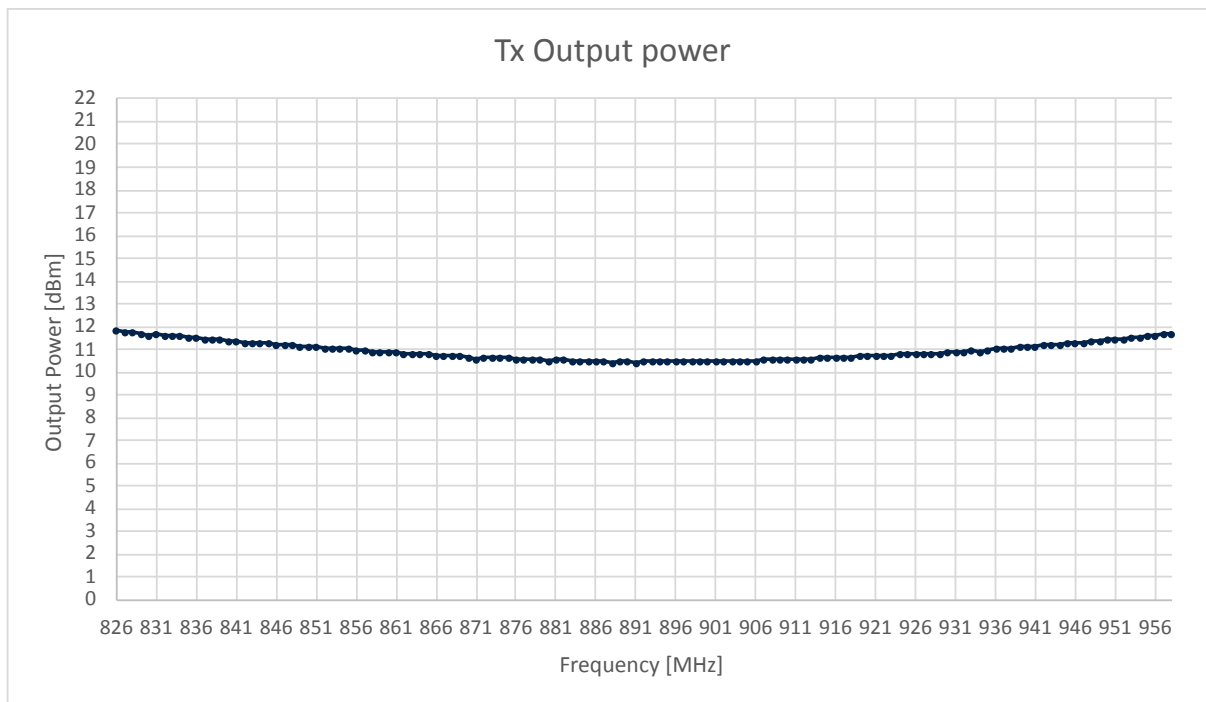


Figure 69. H2 level, high band, $F_c = 868$ MHz, TX pin, degeneration mode ON

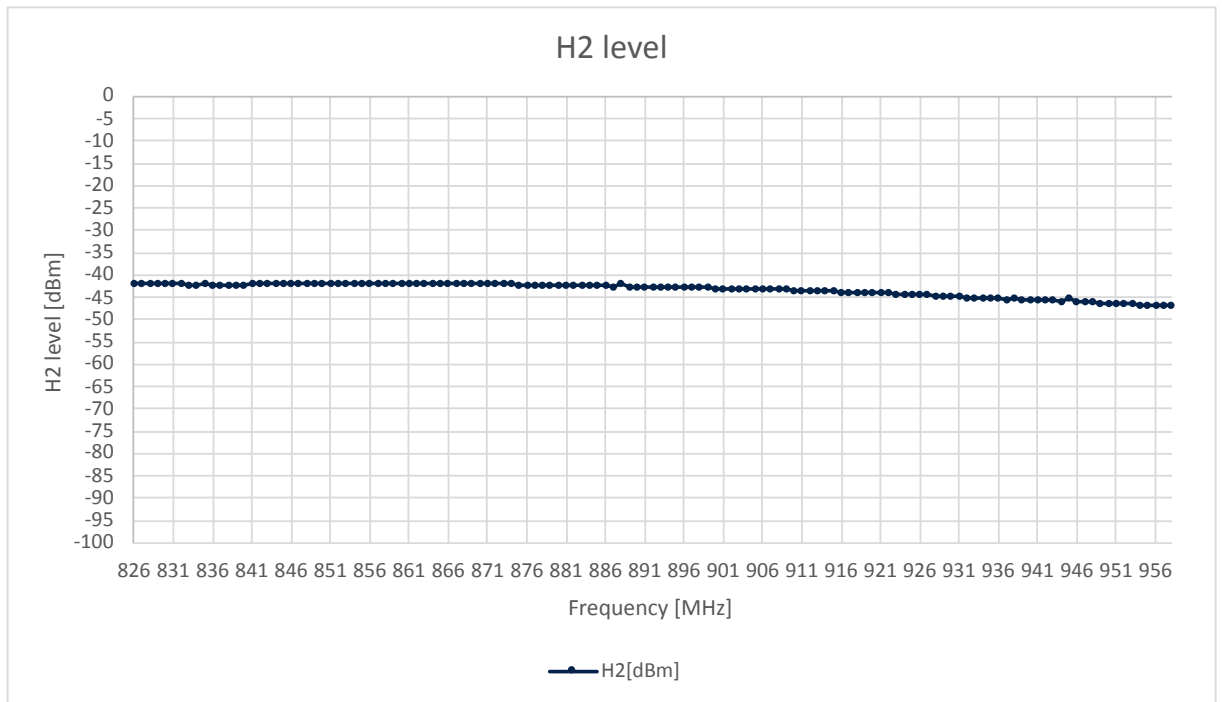


Figure 70. Harmonics level, high band, $F_c = 868$ MHz, TX pin, degeneration mode ON

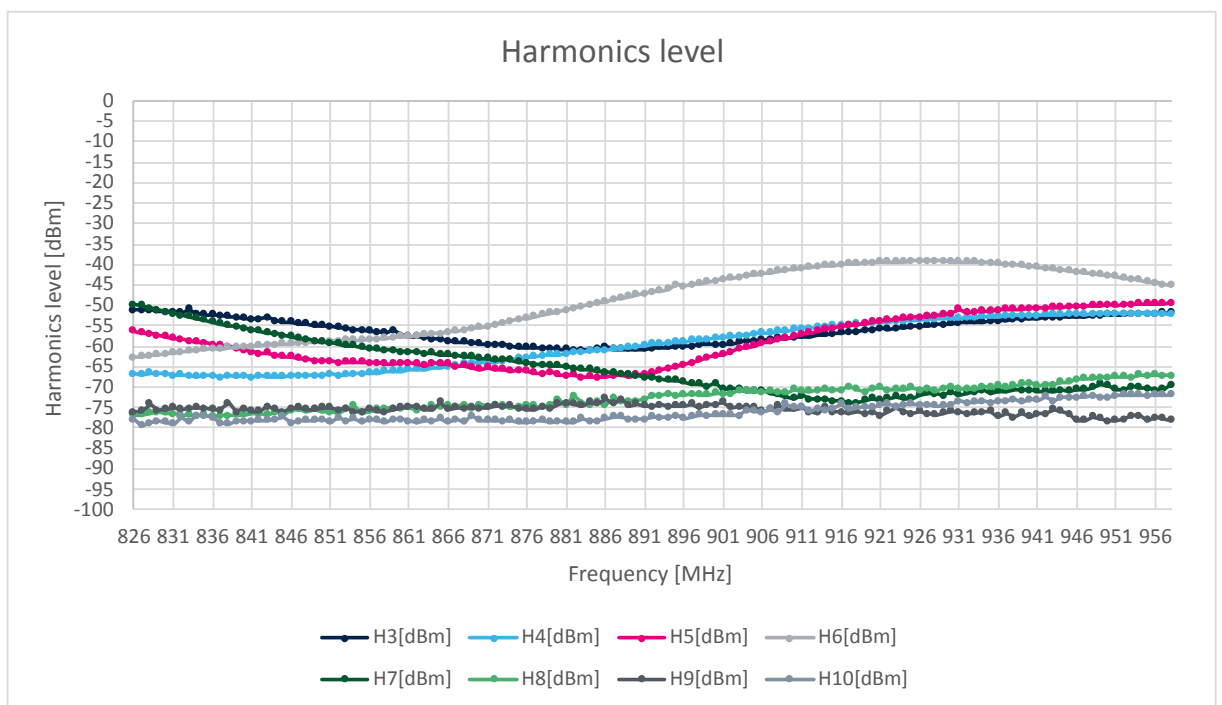


Figure 71. Current consumption in TX mode, high band, $F_c = 868$ MHz, TX pin, degeneration mode OFF

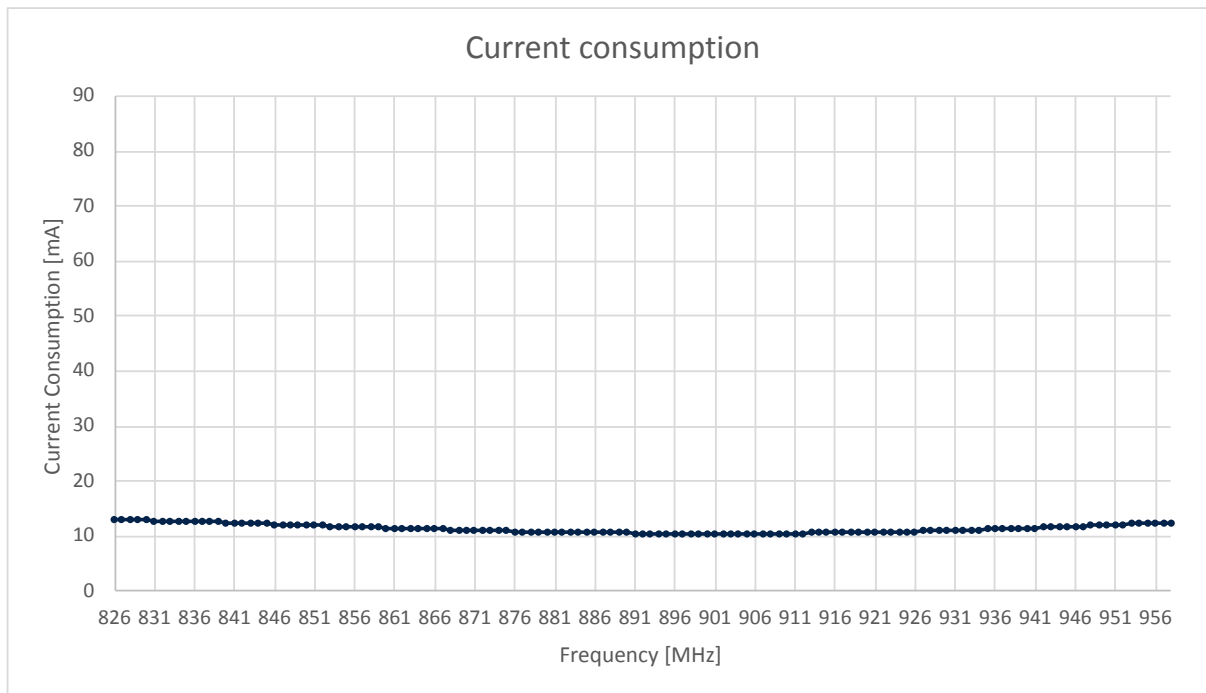


Figure 72. TX output power level, high band, $F_c = 868$ MHz, TX pin, degeneration mode OFF

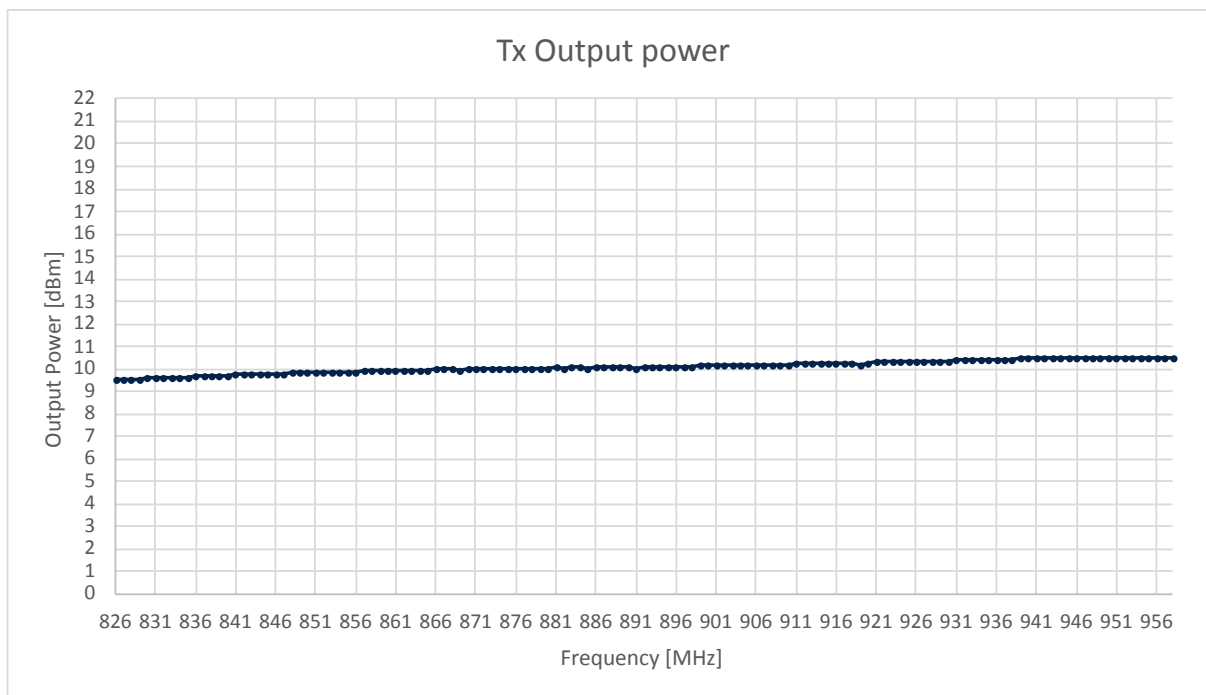


Figure 73. H2 level, high band, Fc = 868 MHz, TX pin, degeneration mode OFF

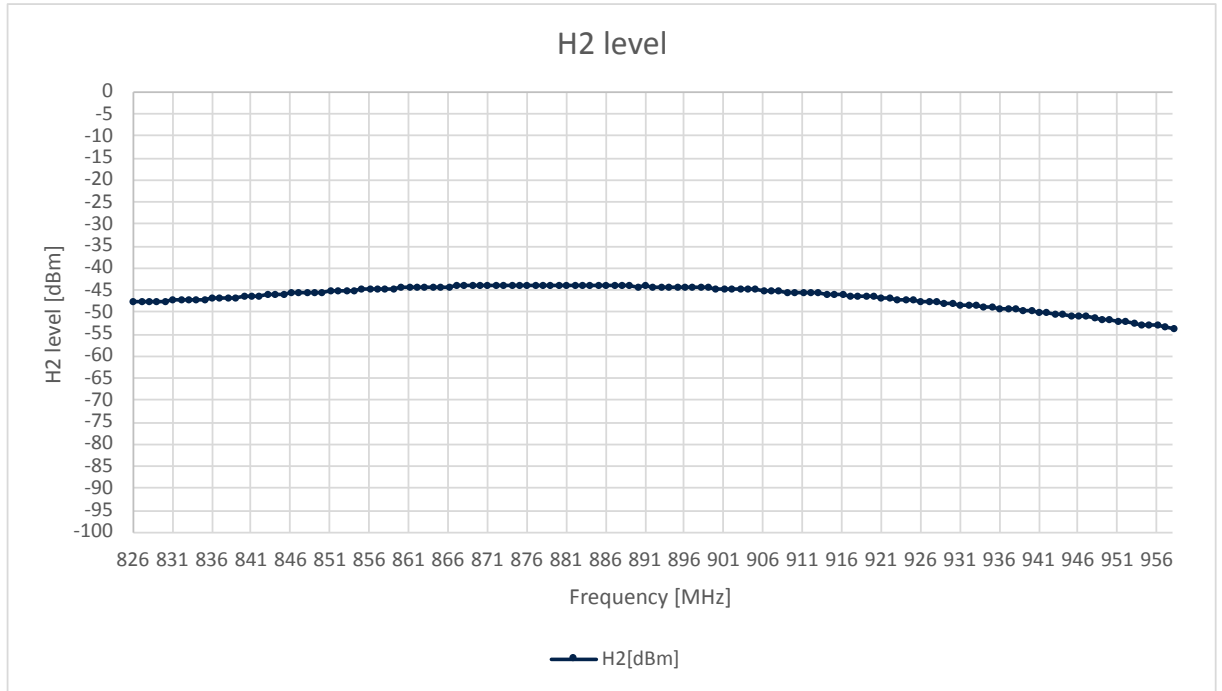


Figure 74. Harmonics level, high band, Fc = 868 MHz, TX pin, degeneration mode OFF

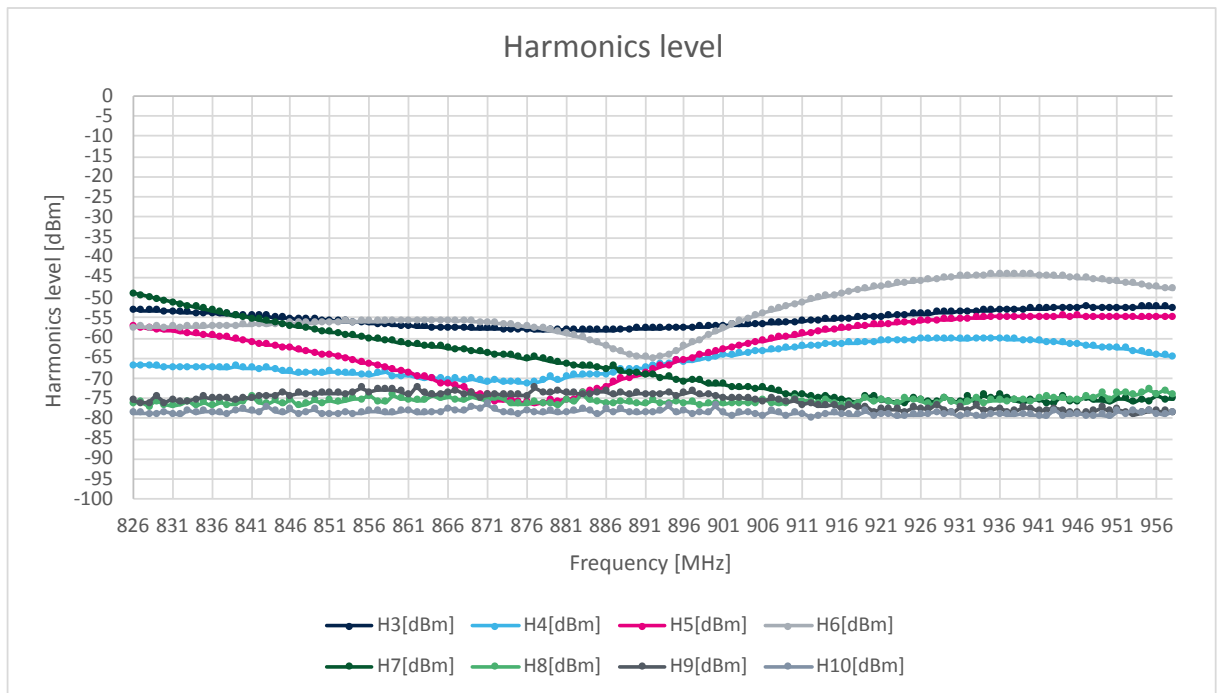
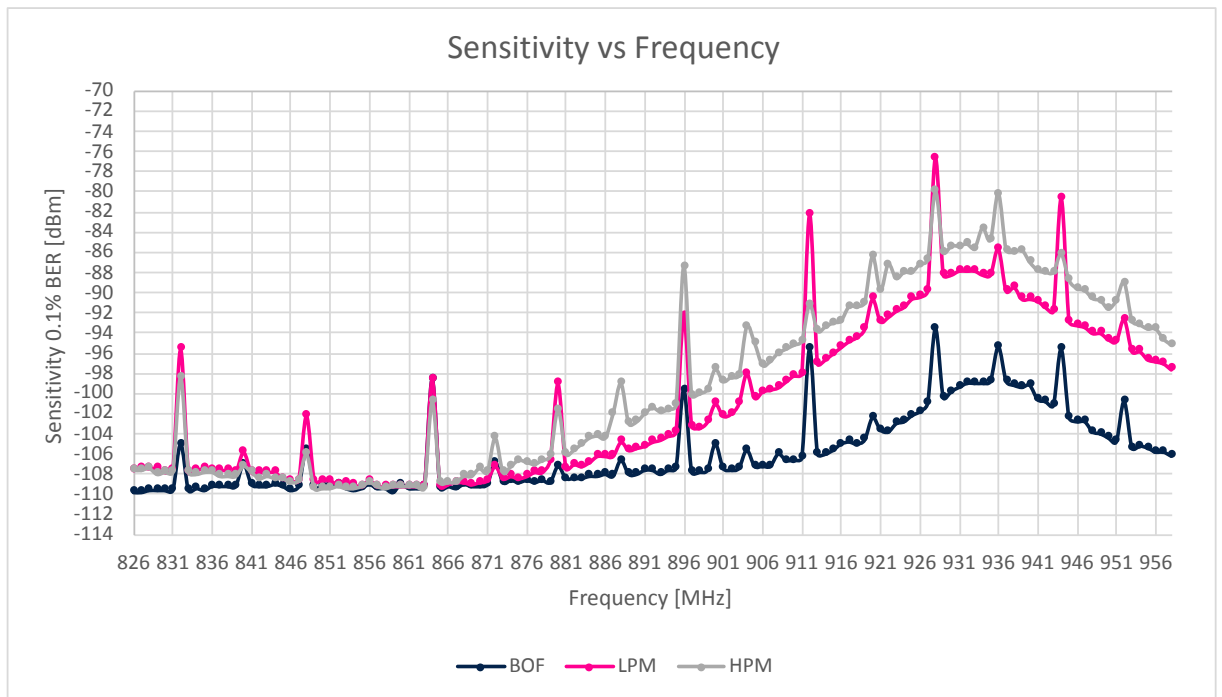


Figure 75. RX sensitivity, high band, $F_c = 868$ MHz, TX pin



5.4.2 $F_c = 915$ MHz, TX pin

Figure 76. Current consumption in TX mode, high band, $F_c = 915$ MHz, TX pin, degeneration mode ON

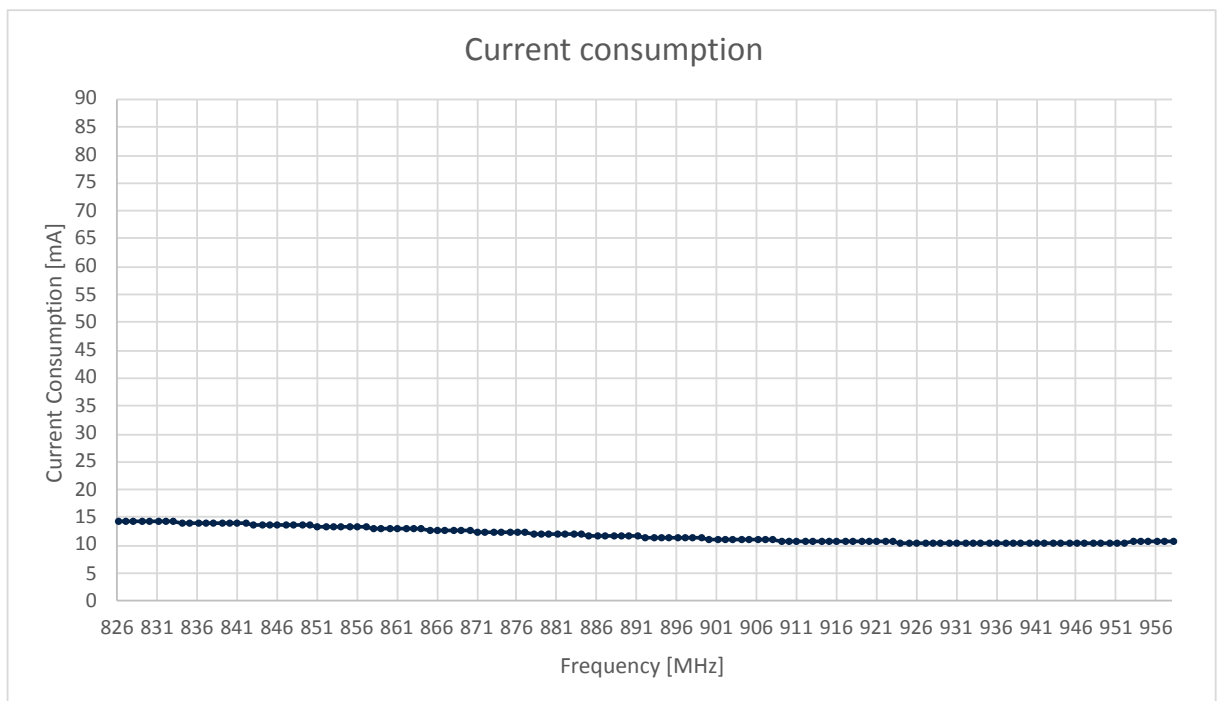


Figure 77. TX output power level, high band, $F_c = 915$ MHz, TX pin, degeneration mode ON

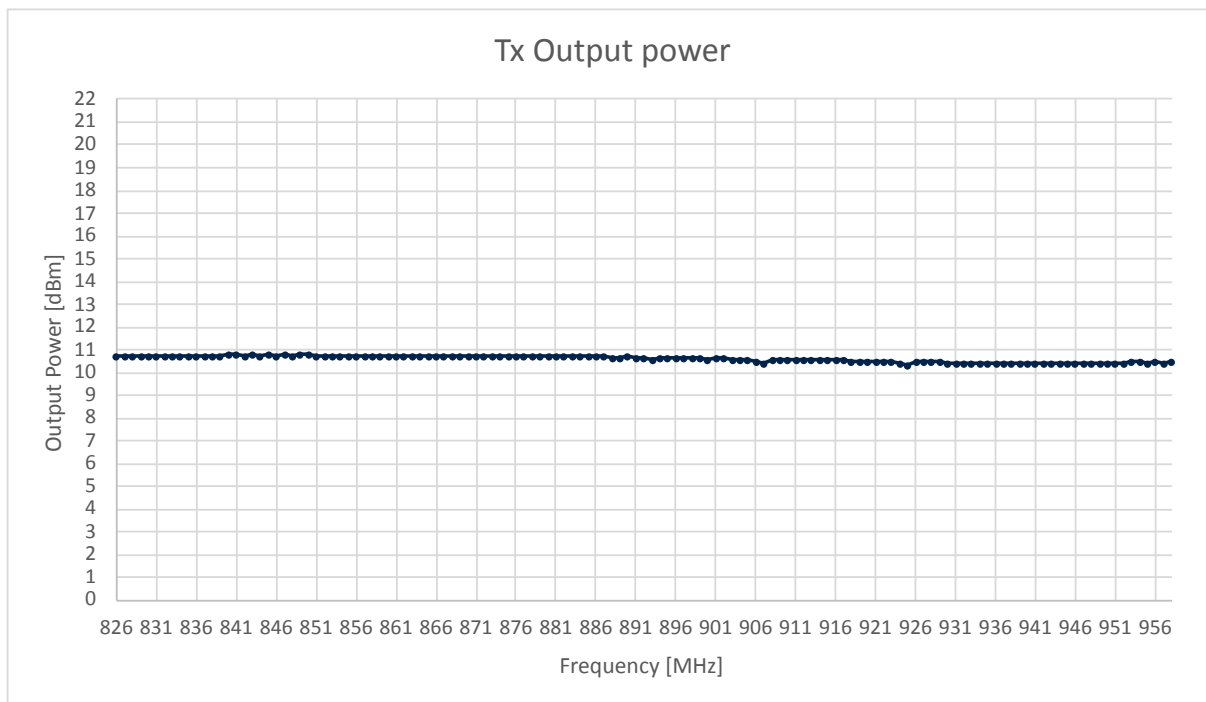


Figure 78. H2 level, high band, $F_c = 915$ MHz, TX pin, degeneration mode ON

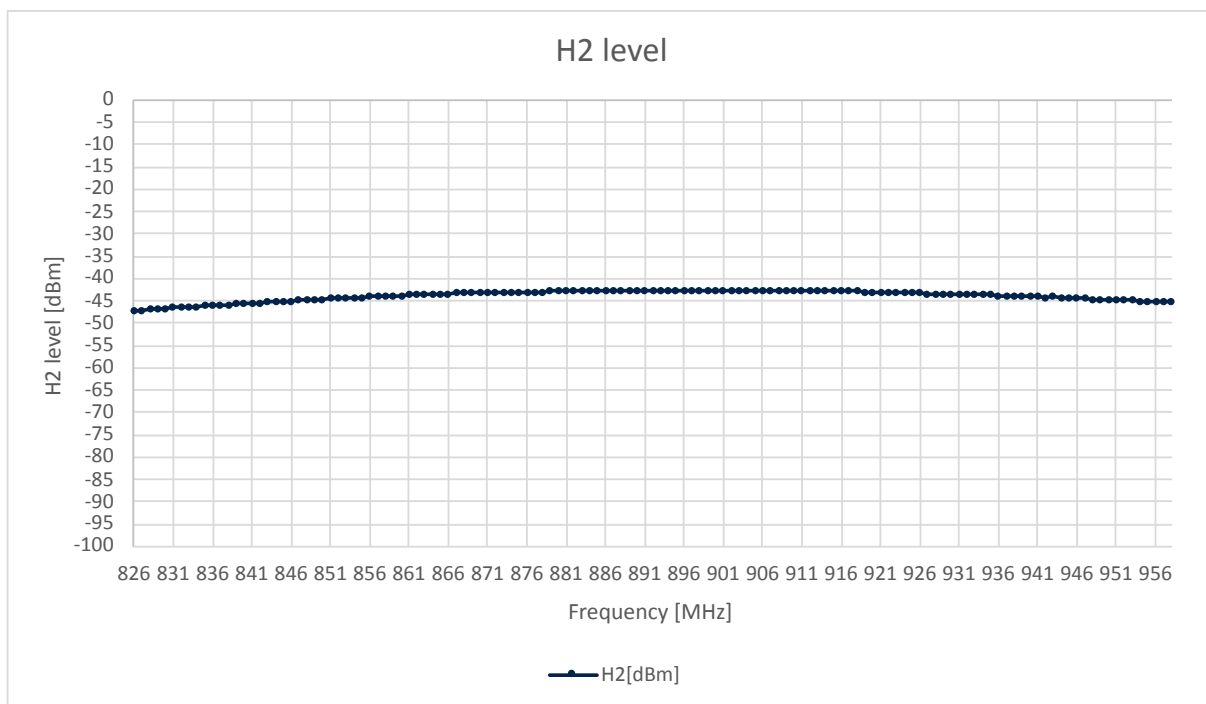


Figure 79. Harmonics level, high band, $F_c = 915$ MHz, TX pin, degeneration mode ON

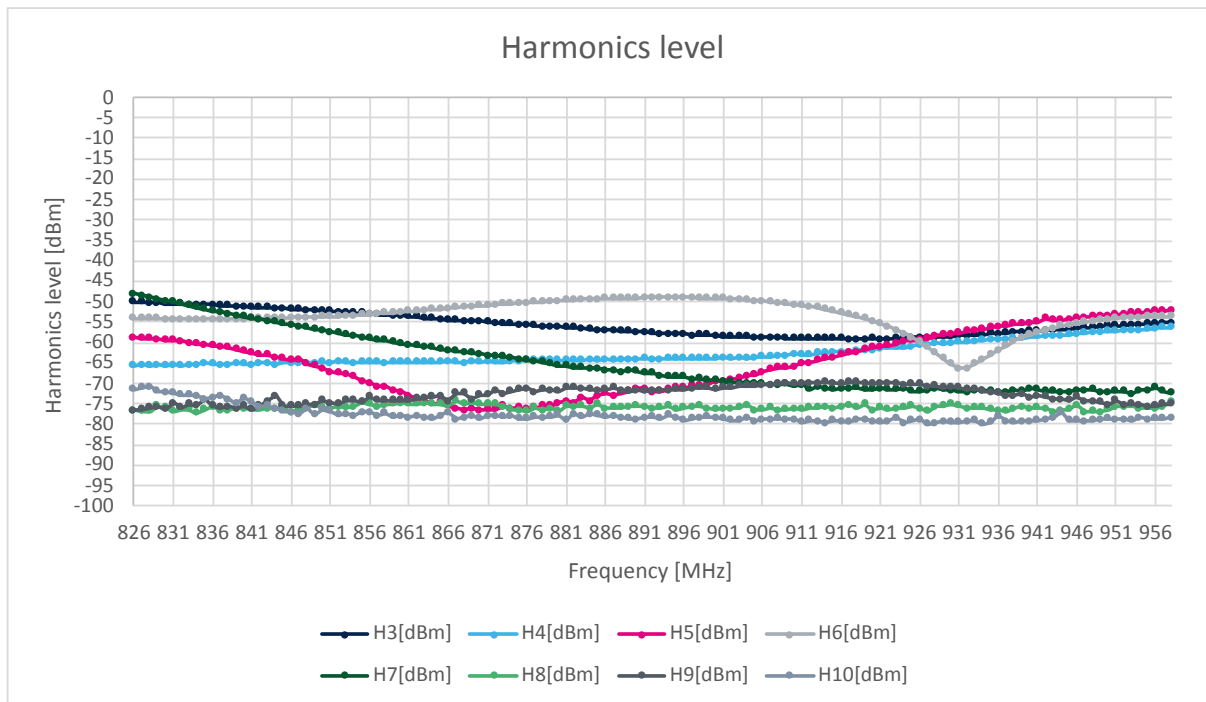


Figure 80. Current consumption in TX mode, high band, $F_c = 915$ MHz, TX pin, degeneration mode OFF

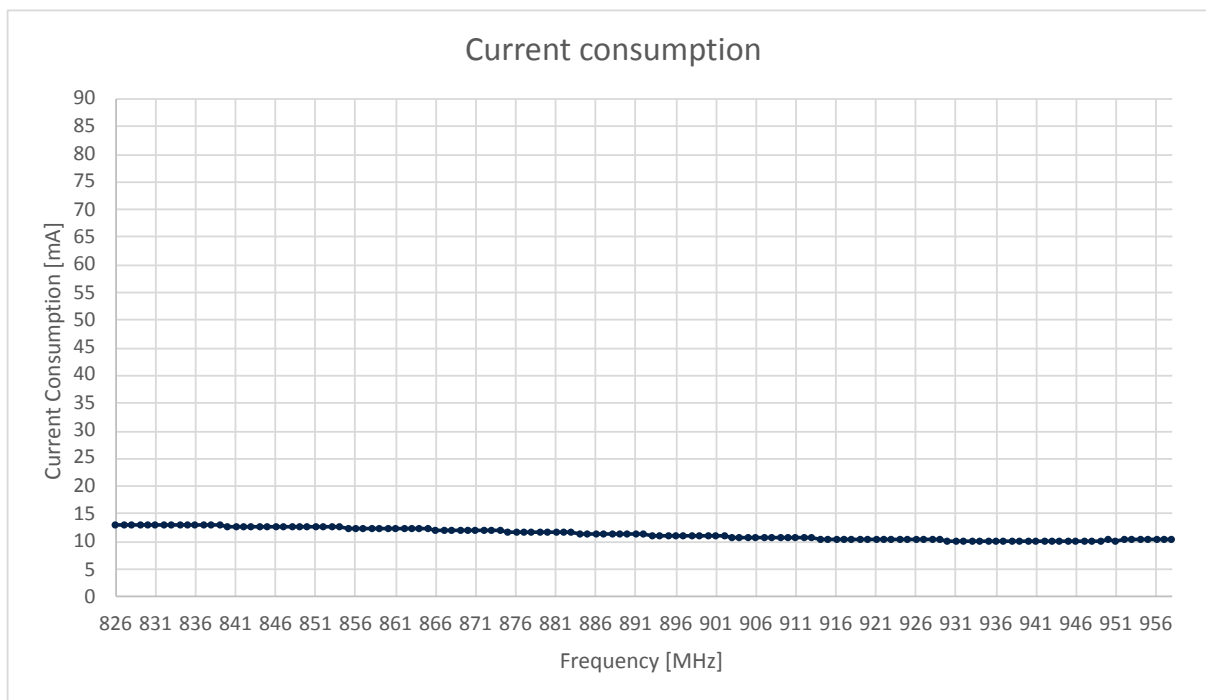


Figure 81. TX output power level, high band, $F_c = 915$ MHz, TX pin, degeneration mode OFF

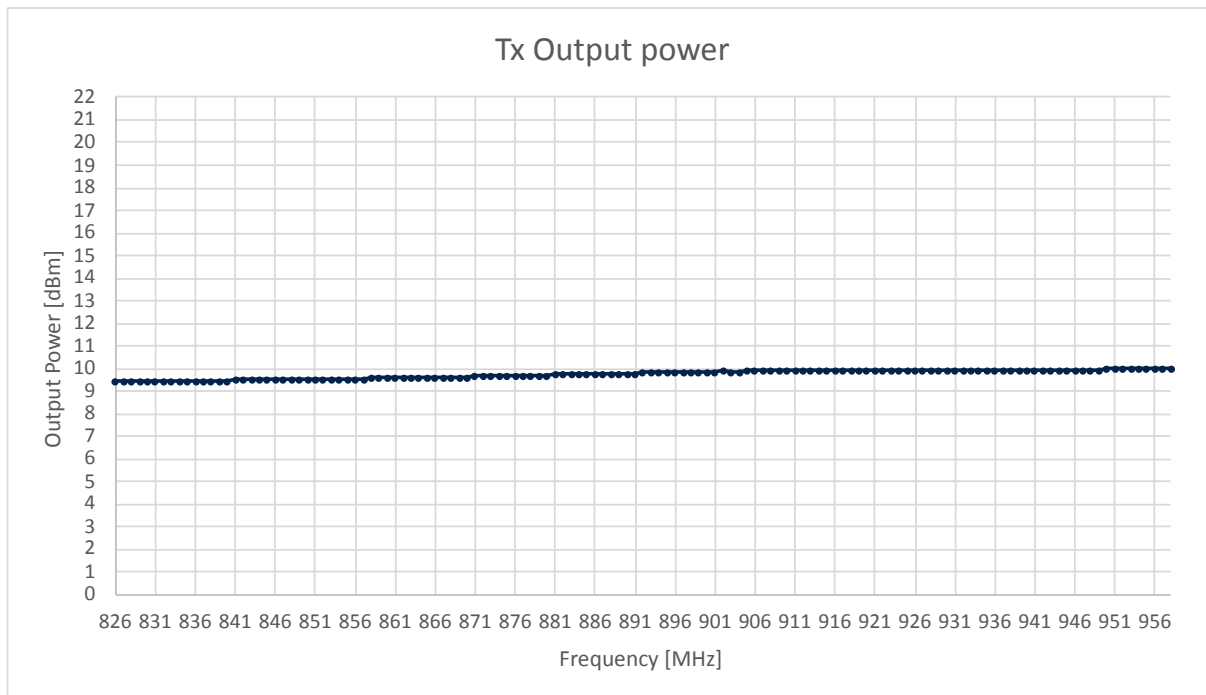


Figure 82. H2 level, high band, $F_c = 915$ MHz, TX pin, degeneration mode OFF

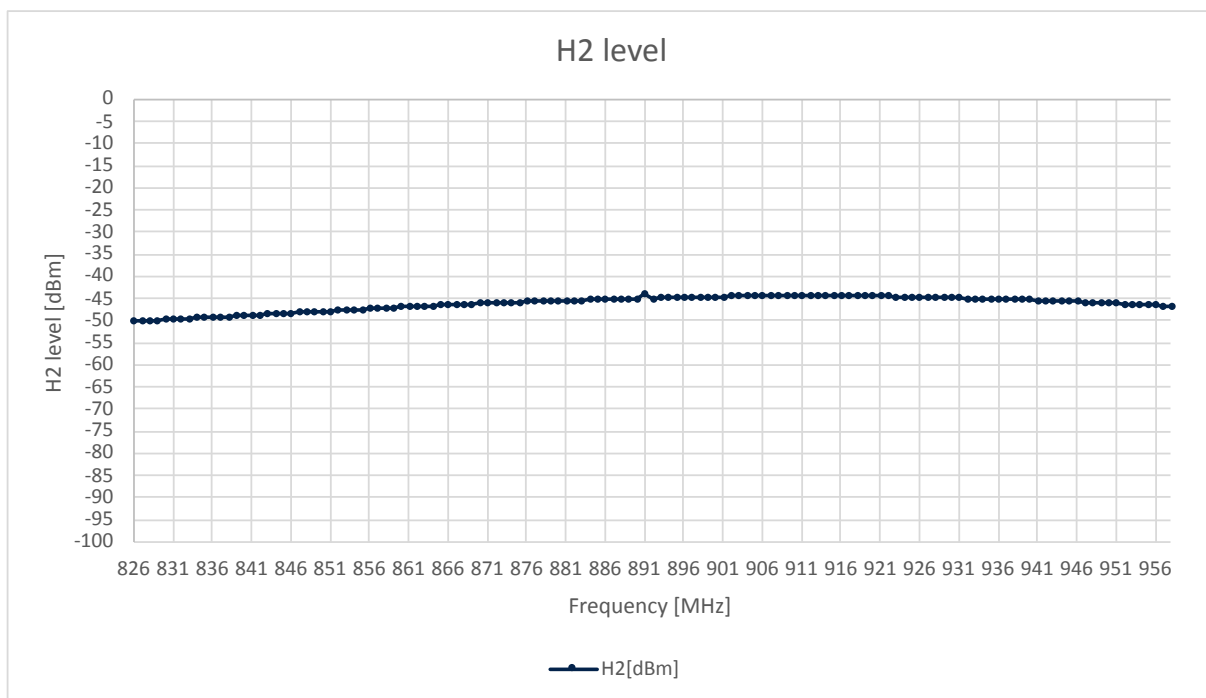


Figure 83. Harmonics level, high band, $F_c = 915$ MHz, TX pin, degeneration mode OFF

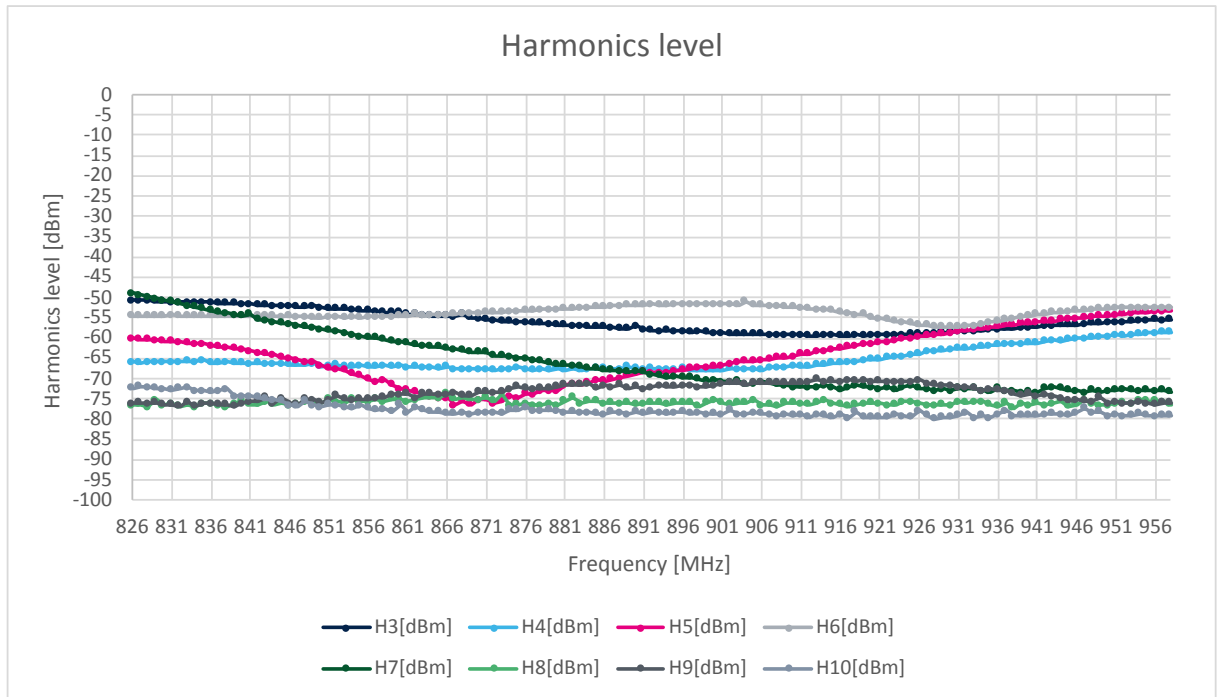
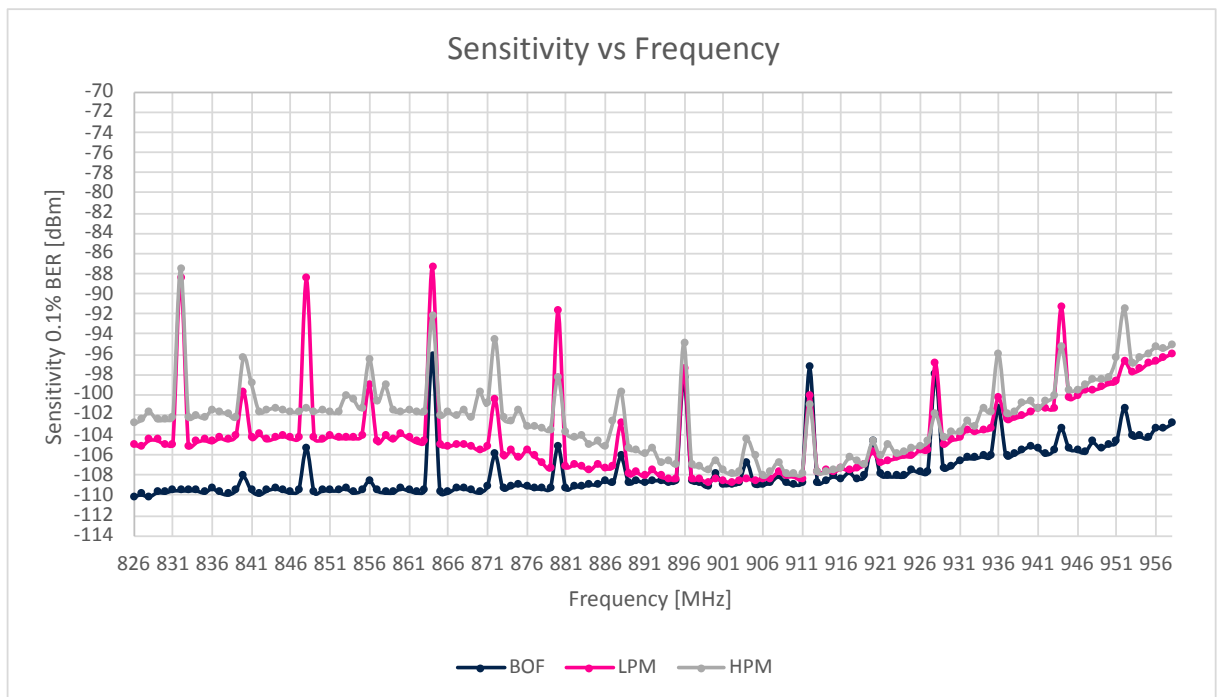


Figure 84. RX sensitivity, high band, $F_c = 915$ MHz, TX pin



5.5 STDES-WL3C2SLL

Figure 85. Current consumption in TX mode, low band, TX pin, degeneration mode ON

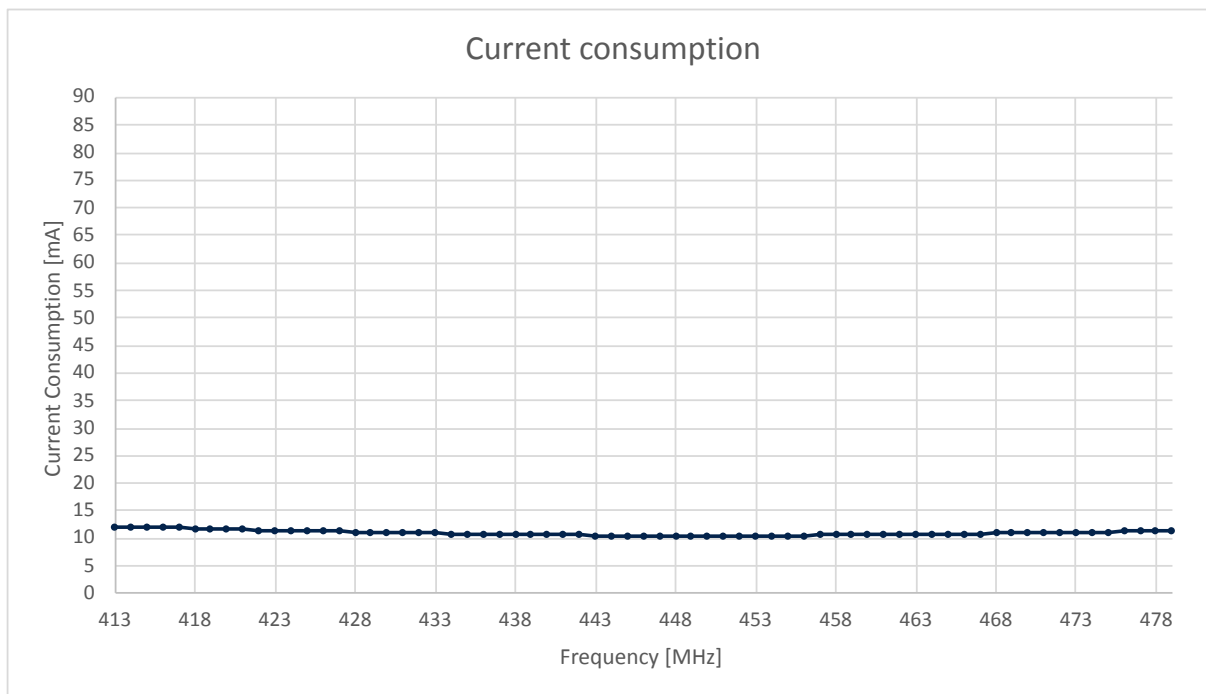


Figure 86. TX output power level, low band, TX pin, degeneration mode ON

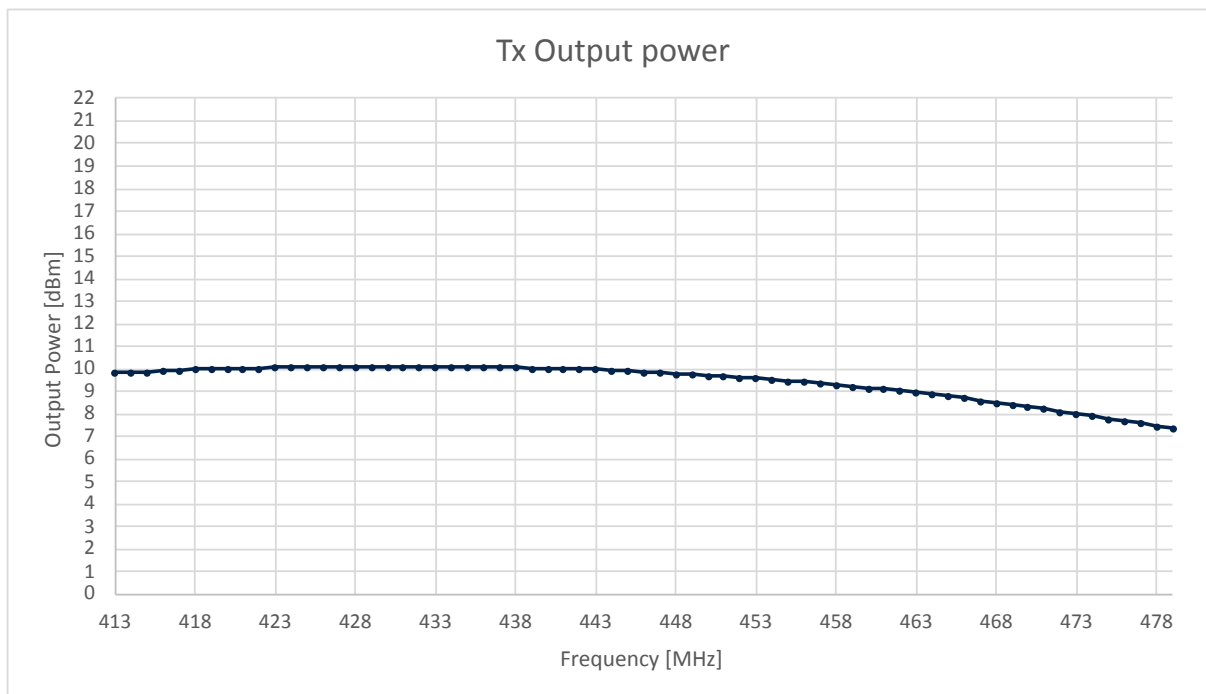


Figure 87. H2 level, low band, TX pin, degeneration mode ON

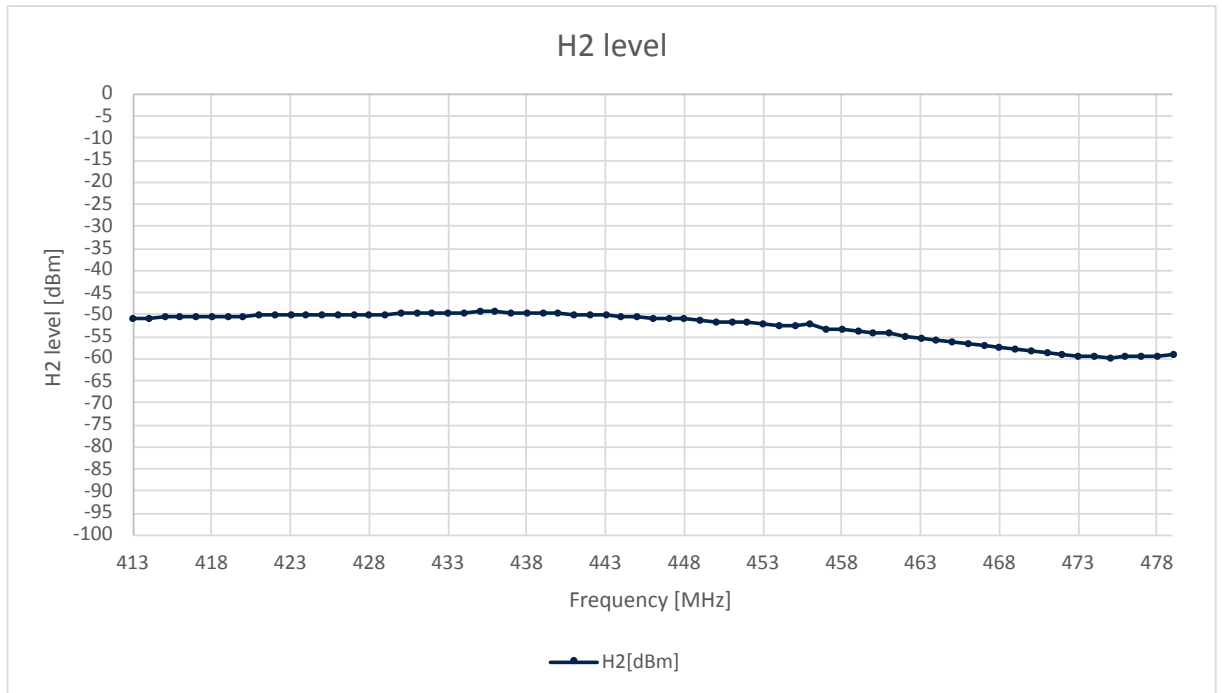


Figure 88. Harmonics level, low band, TX pin, degeneration mode ON

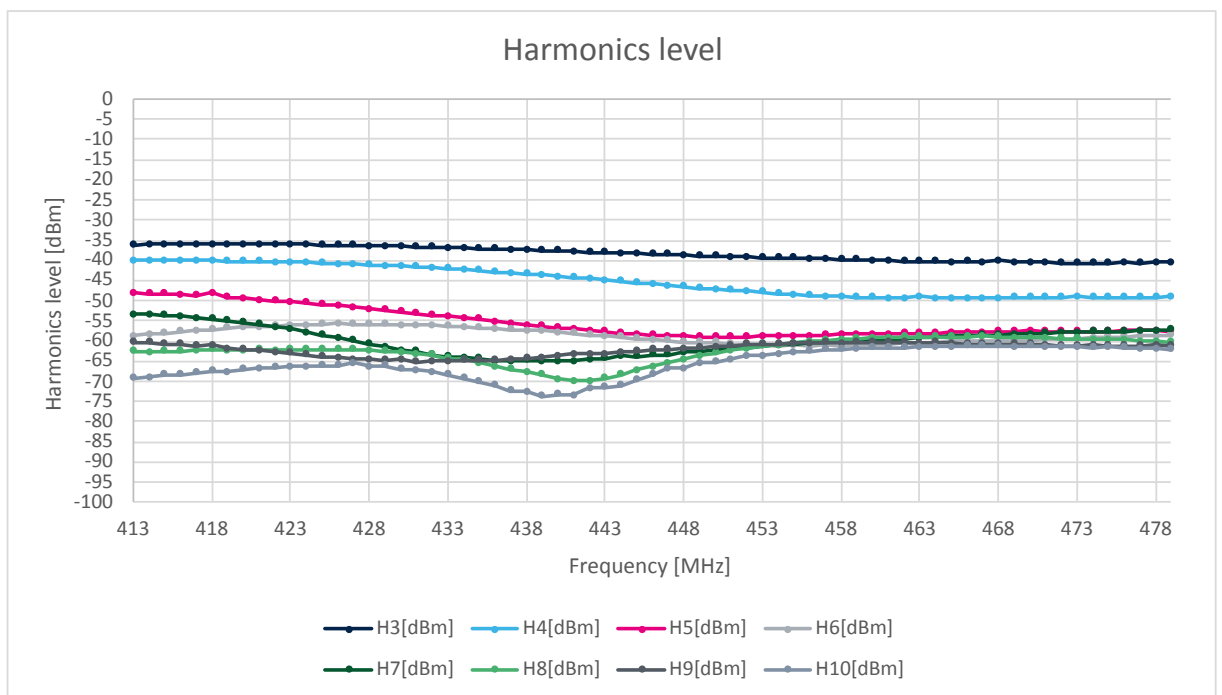


Figure 89. Current consumption in TX mode, low band, TX pin, degeneration mode OFF

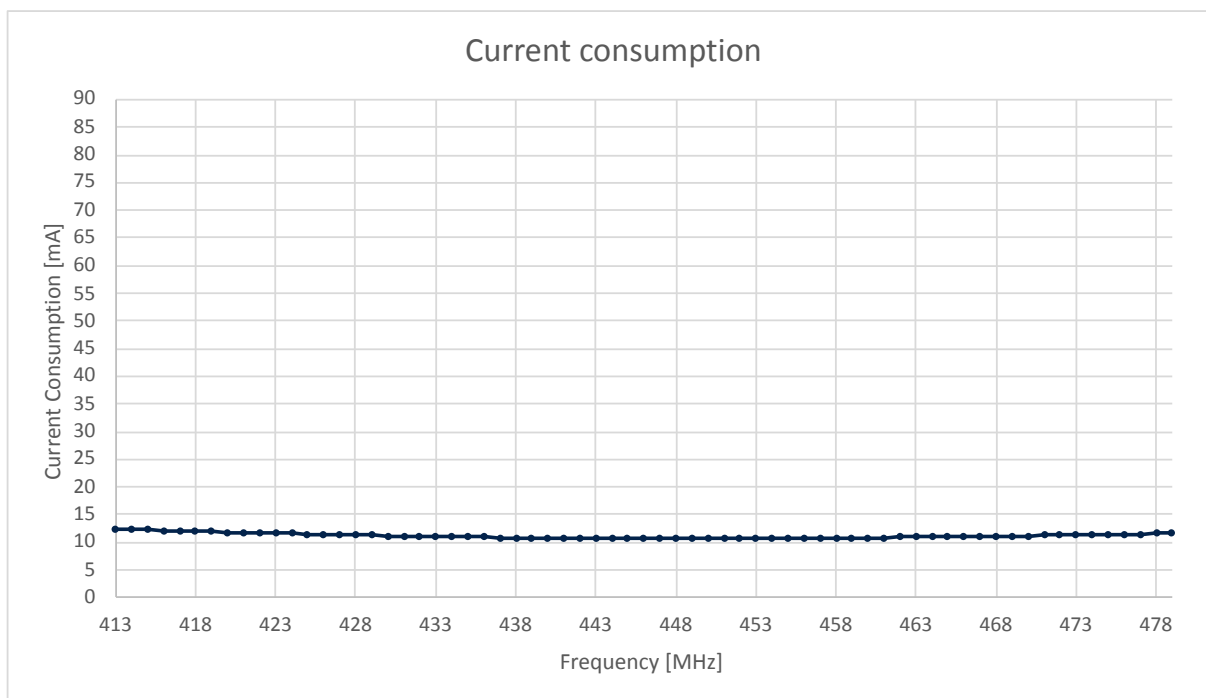


Figure 90. TX output power level, low band, TX pin, degeneration mode OFF

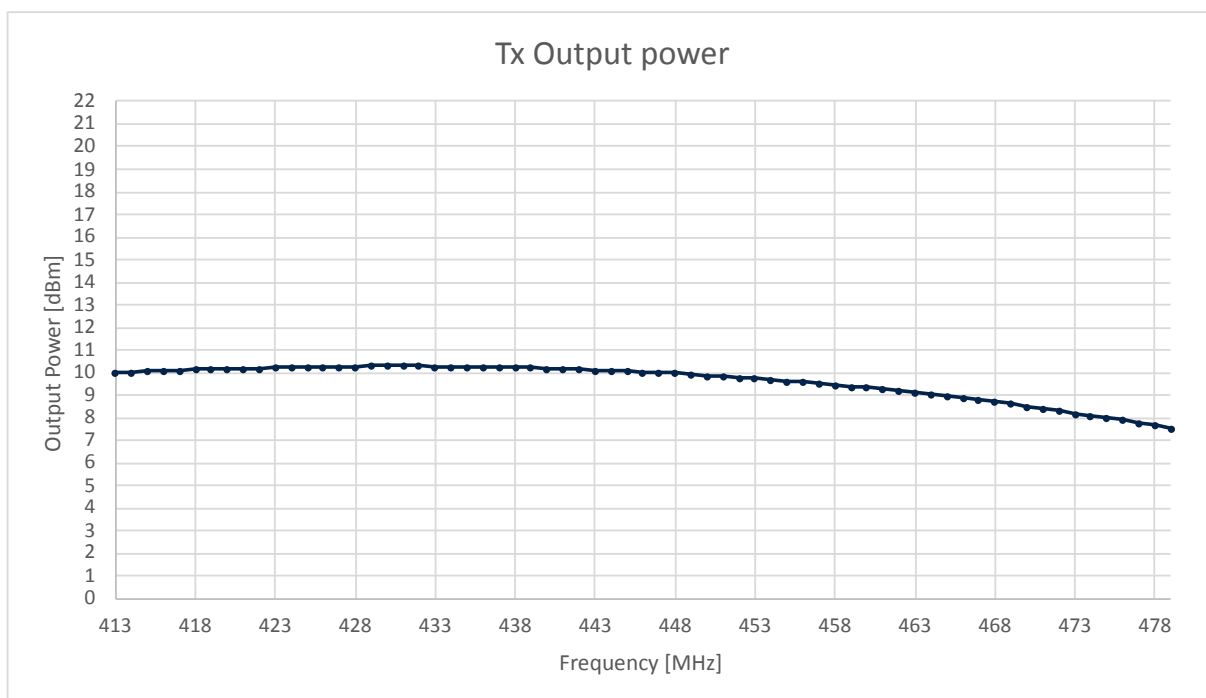


Figure 91. H2 level, low band, TX pin, degeneration mode OFF

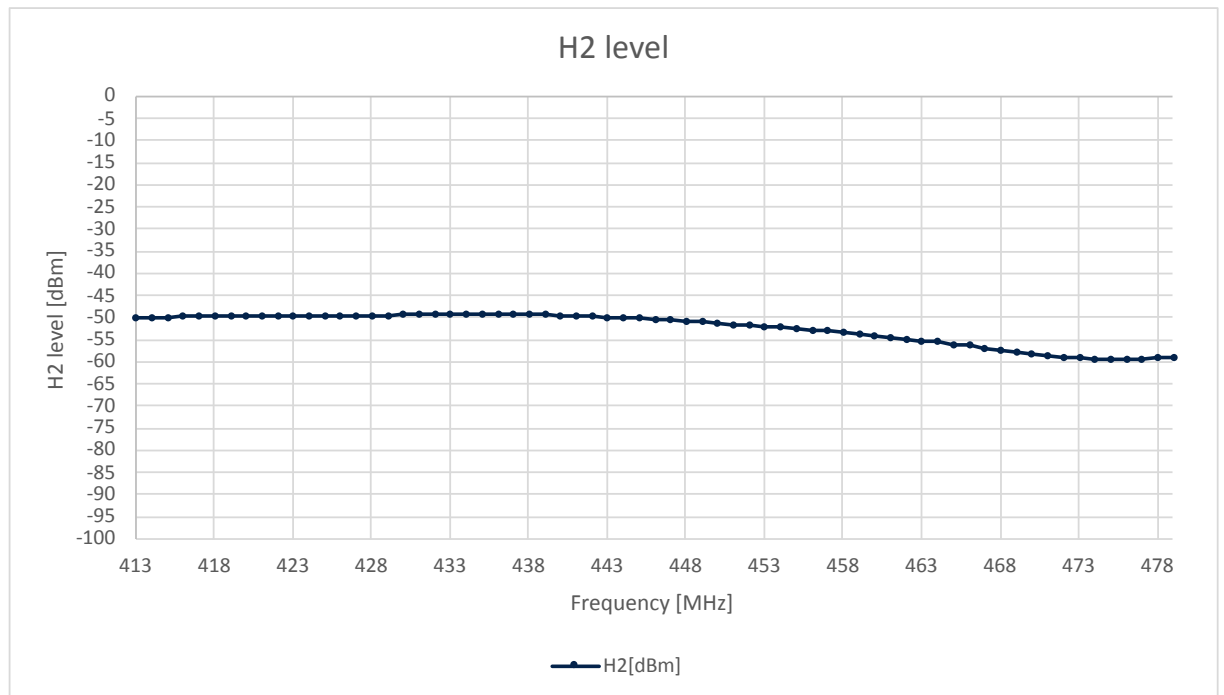


Figure 92. Harmonics level, low band, TX pin, degeneration mode OFF

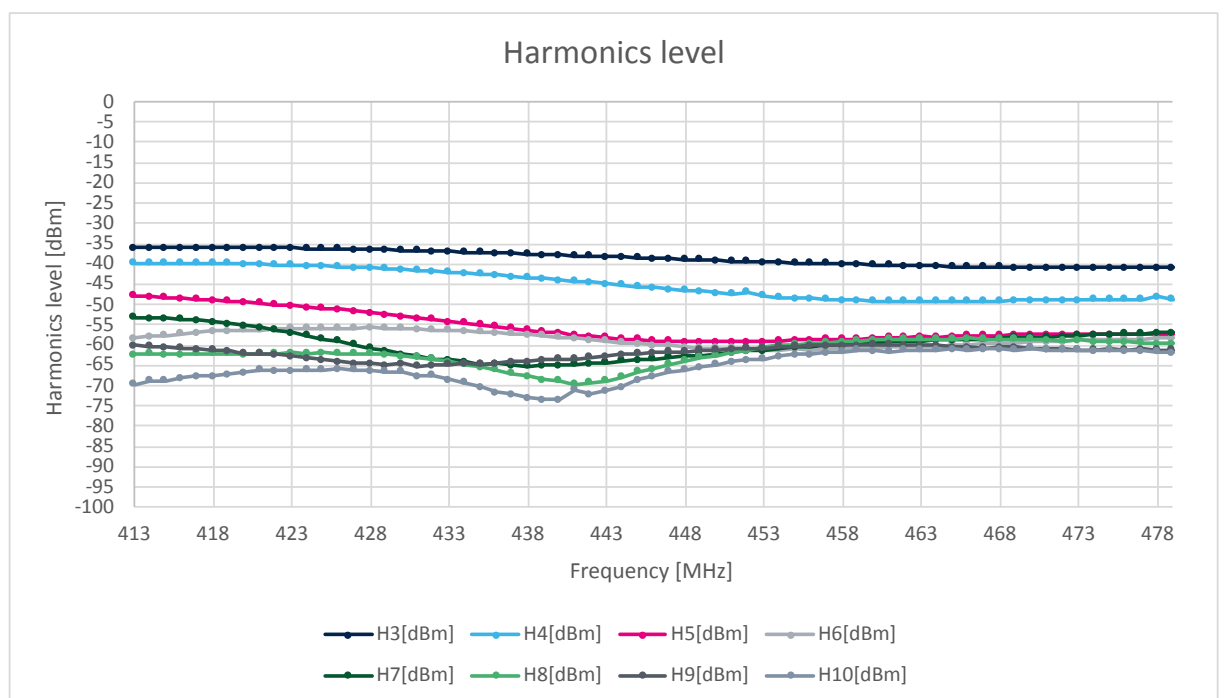
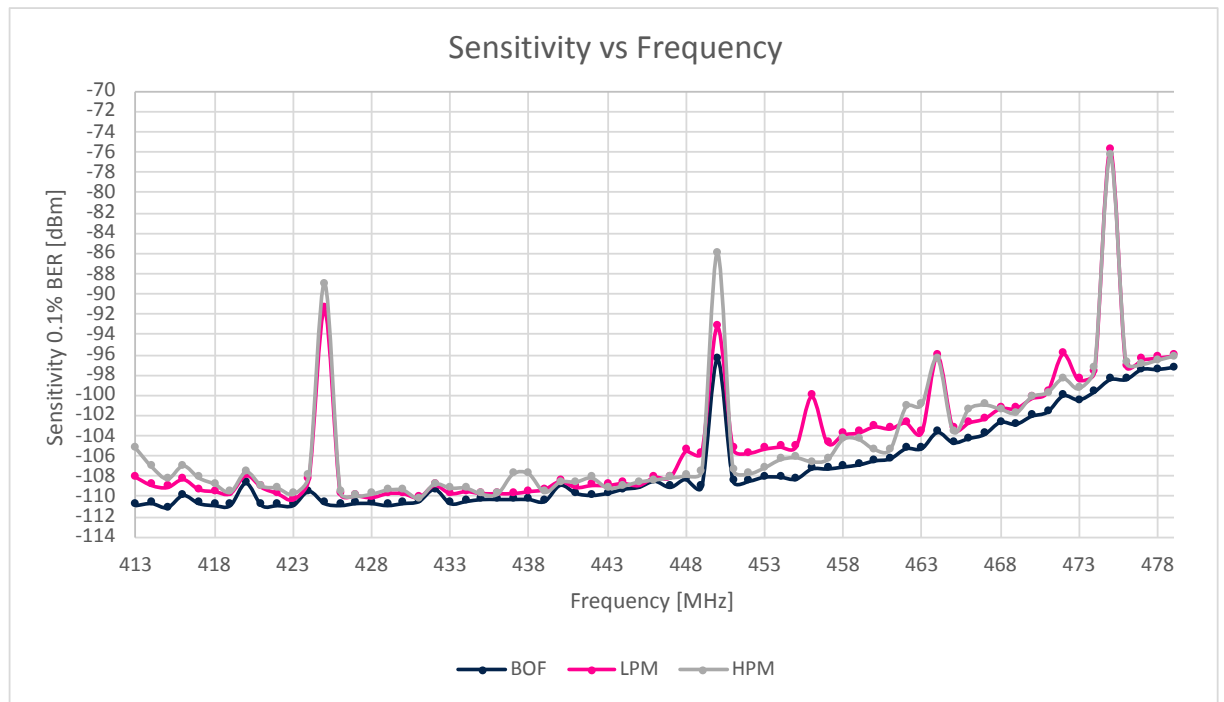


Figure 93. RX sensitivity, low band, TX pin



5.6 STDES-WL3C2SMH

Figure 94. Current consumption in TX mode, high band, TX_HP pin, degeneration mode ON

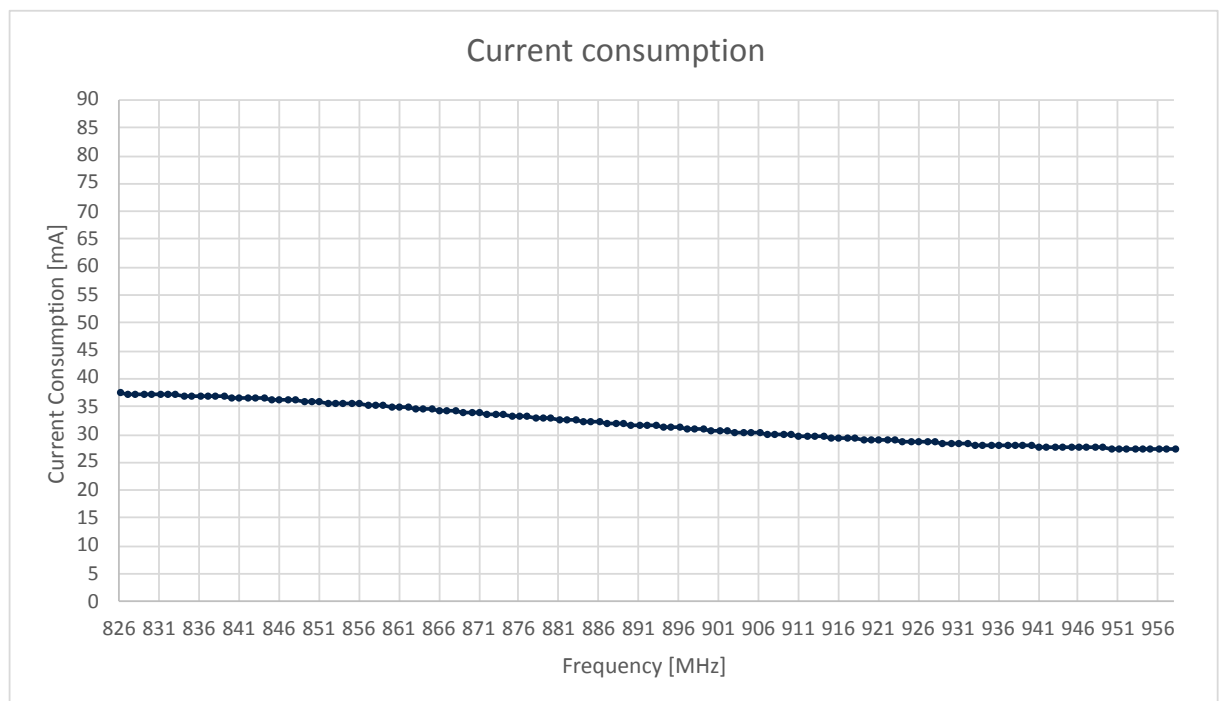


Figure 95. TX output power level, high band, TX_HP pin, degeneration mode ON

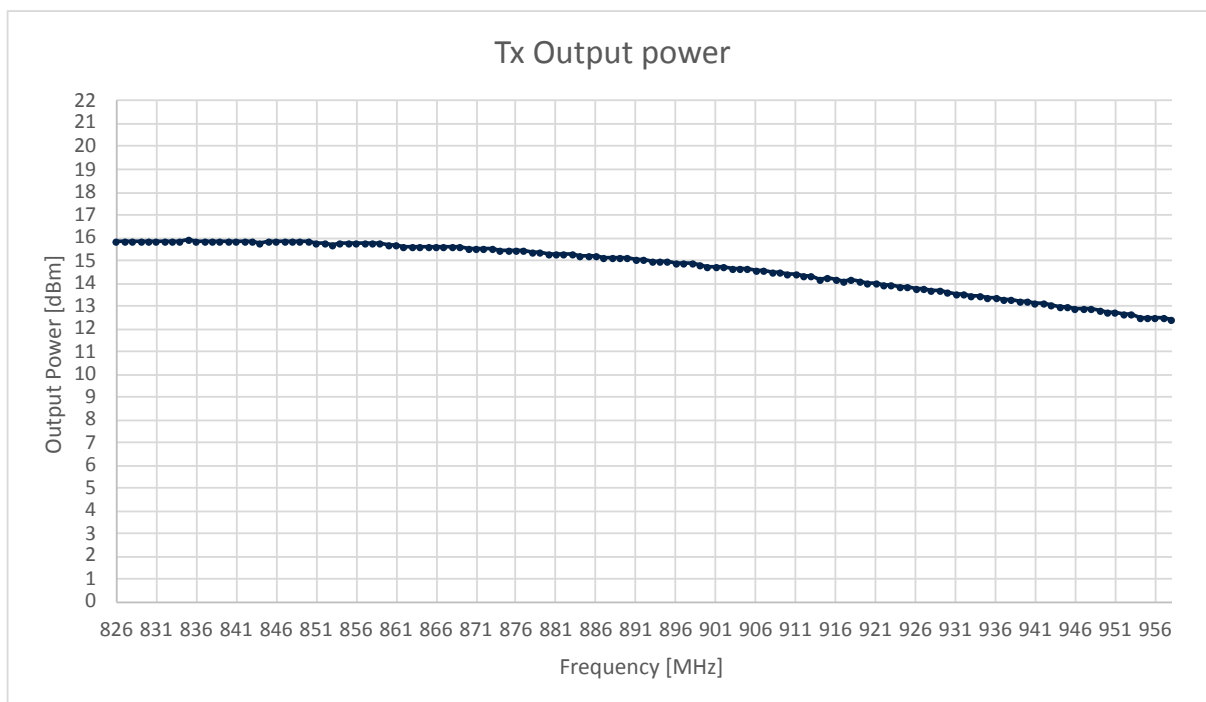


Figure 96. H2 level, high band, TX_HP pin, degeneration mode ON

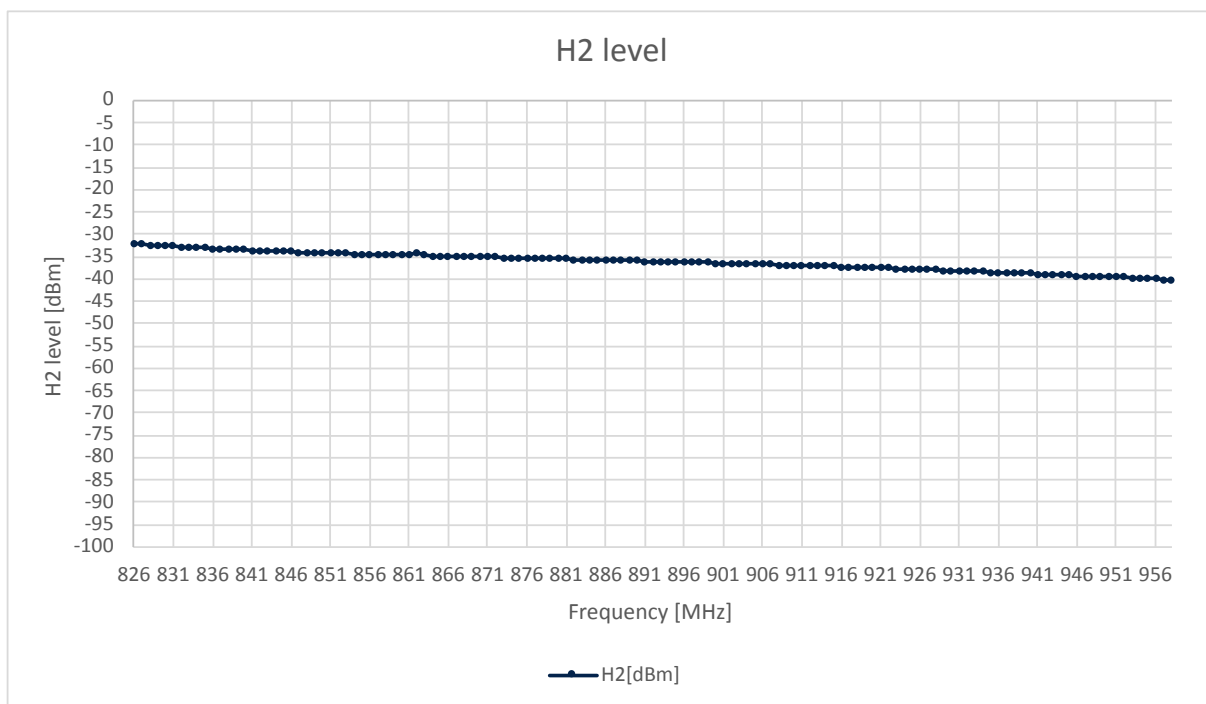


Figure 97. Harmonics level, high band, TX_HP pin, degeneration mode ON

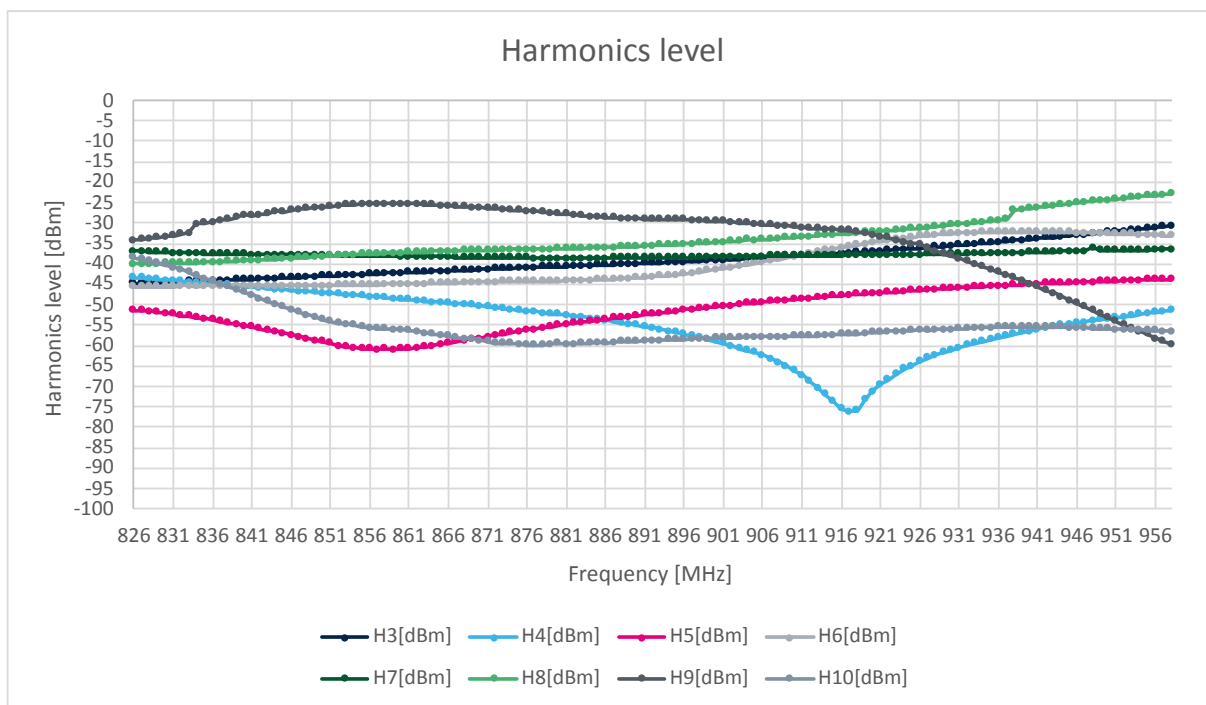


Figure 98. Current consumption in TX mode, high band, TX_HP pin, degeneration mode OFF

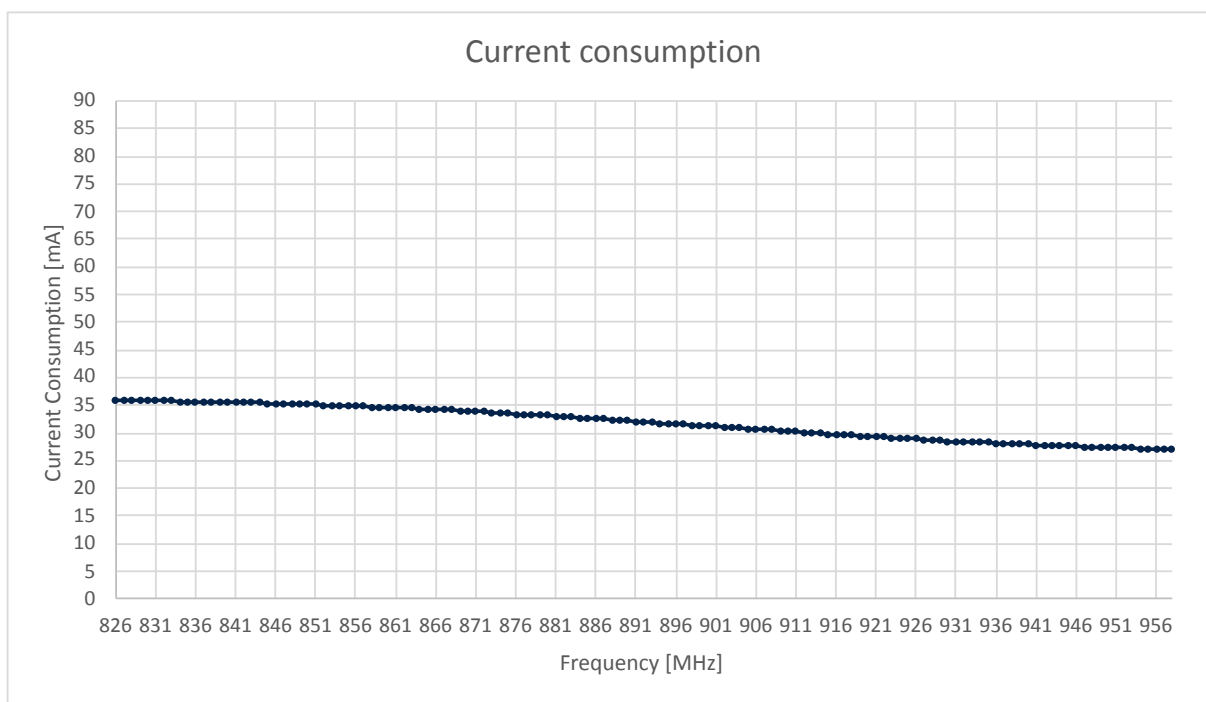


Figure 99. TX output power level, high band, TX_HP pin, degeneration mode OFF

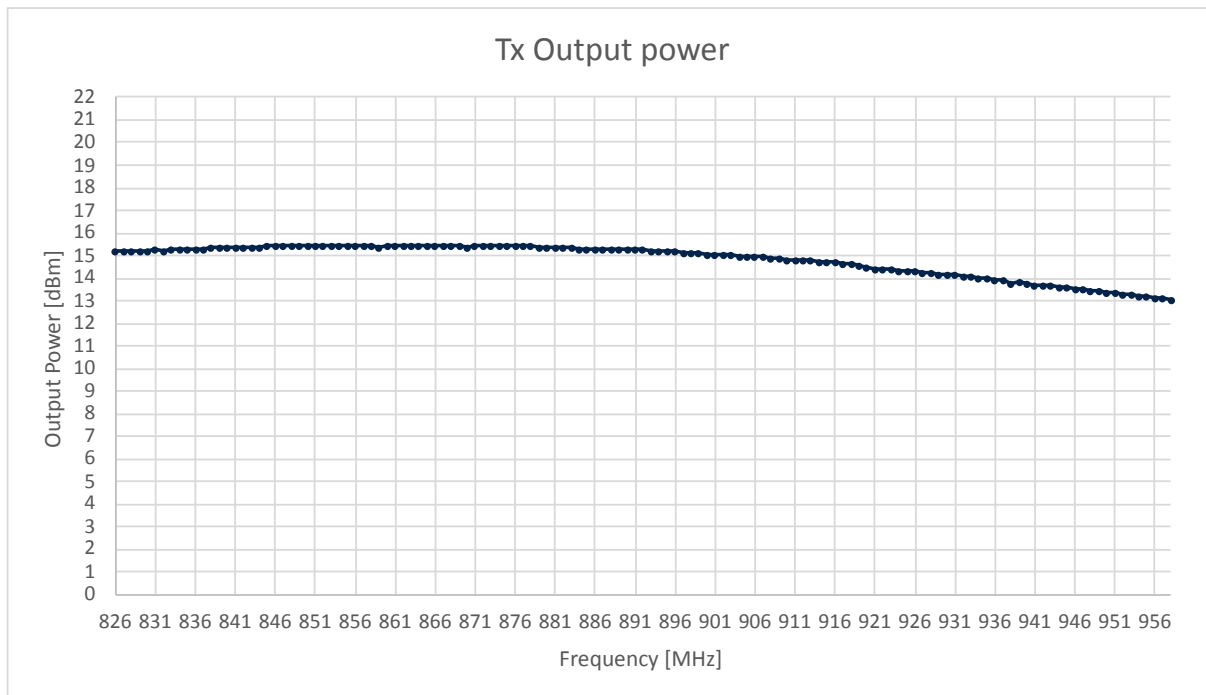


Figure 100. H2 level, high band, TX_HP pin, degeneration mode OFF

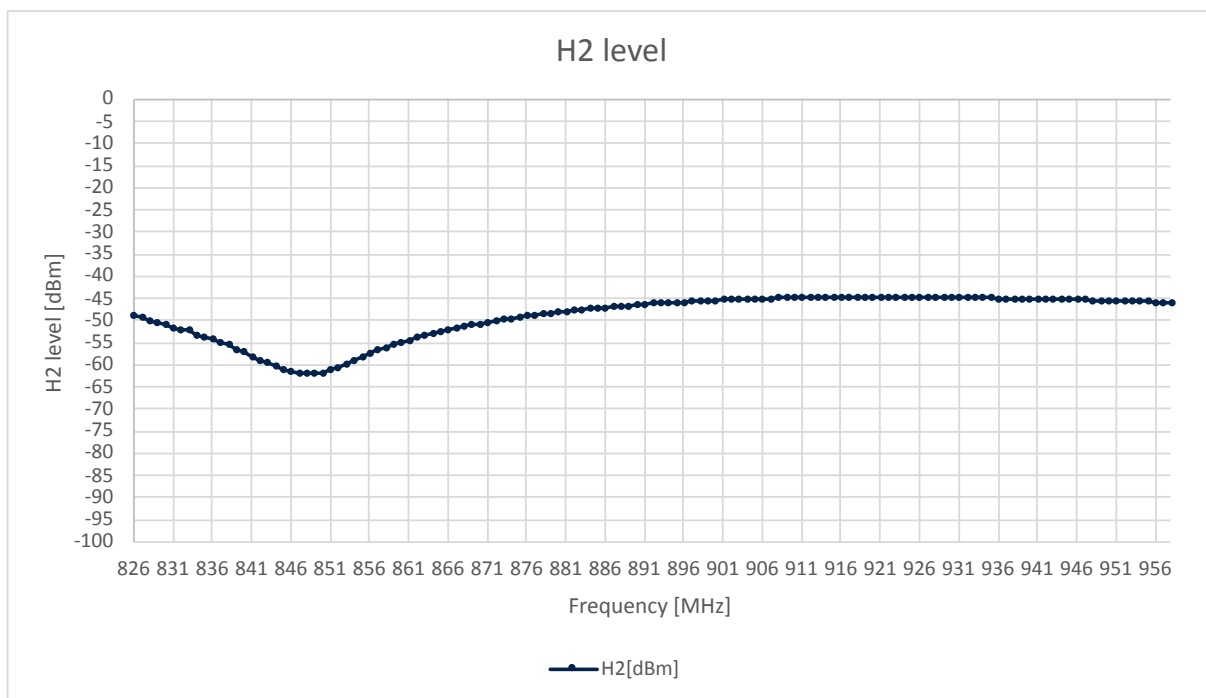


Figure 101. Harmonics level, high band, TX_HP pin, degeneration mode OFF

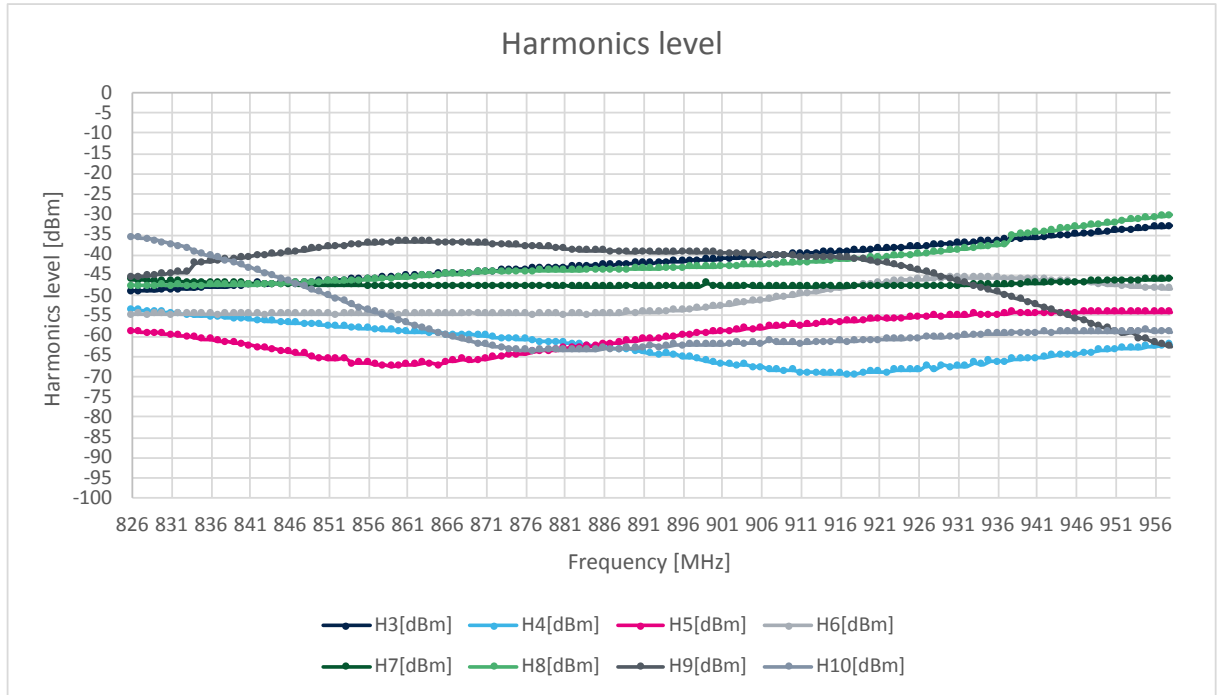
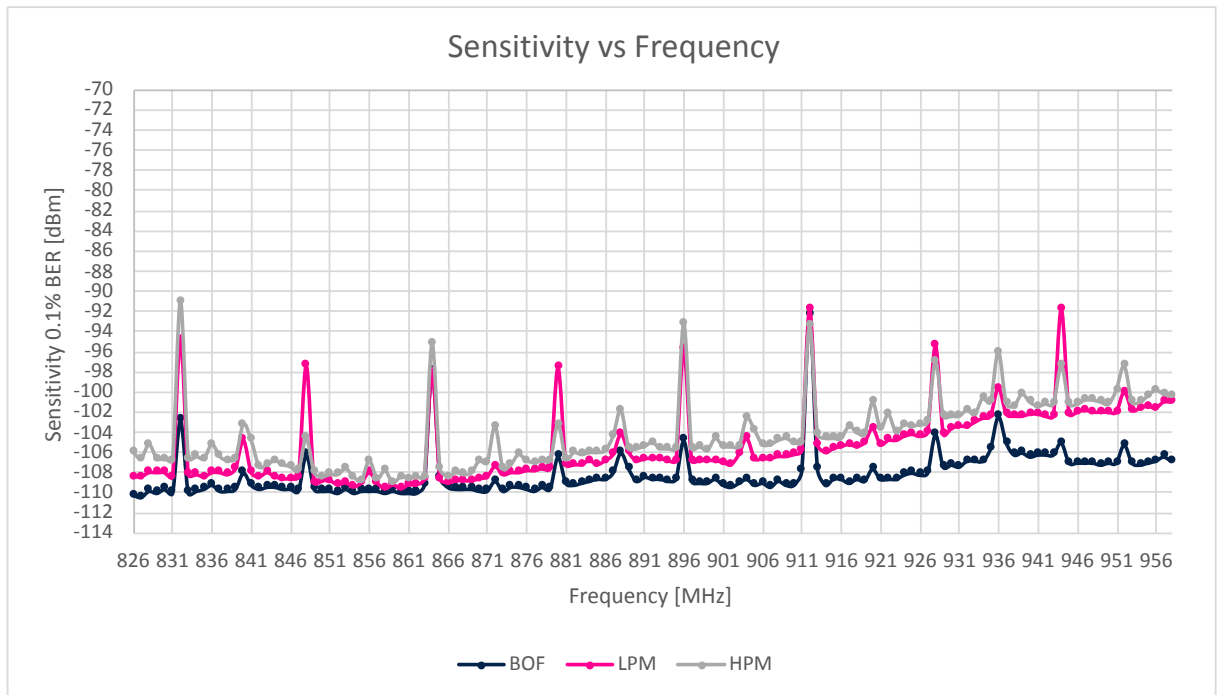


Figure 102. RX sensitivity, high band, TX_HP pin



5.7 STDES-WL3C2SML

Figure 103. Current consumption in TX mode, low band, TX_HP pin, degeneration mode ON

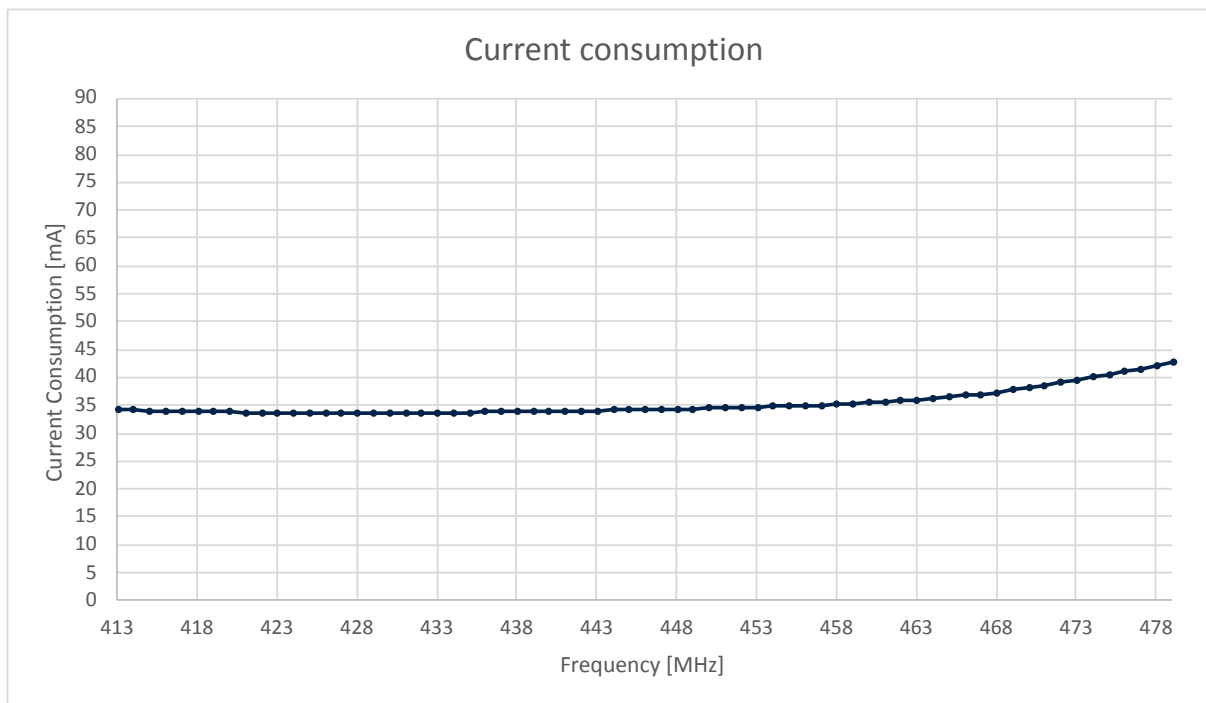


Figure 104. TX output power level, low band, TX_HP pin, degeneration mode ON

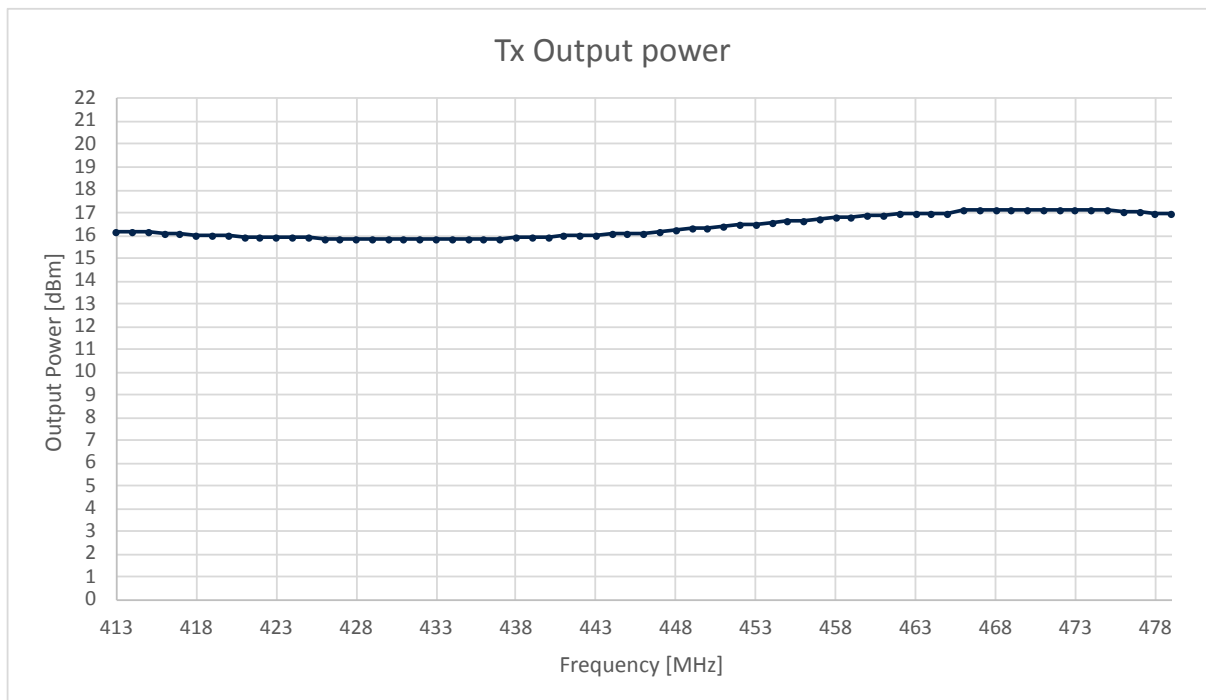


Figure 105. H2 level, low band, TX_HP pin, degeneration mode ON

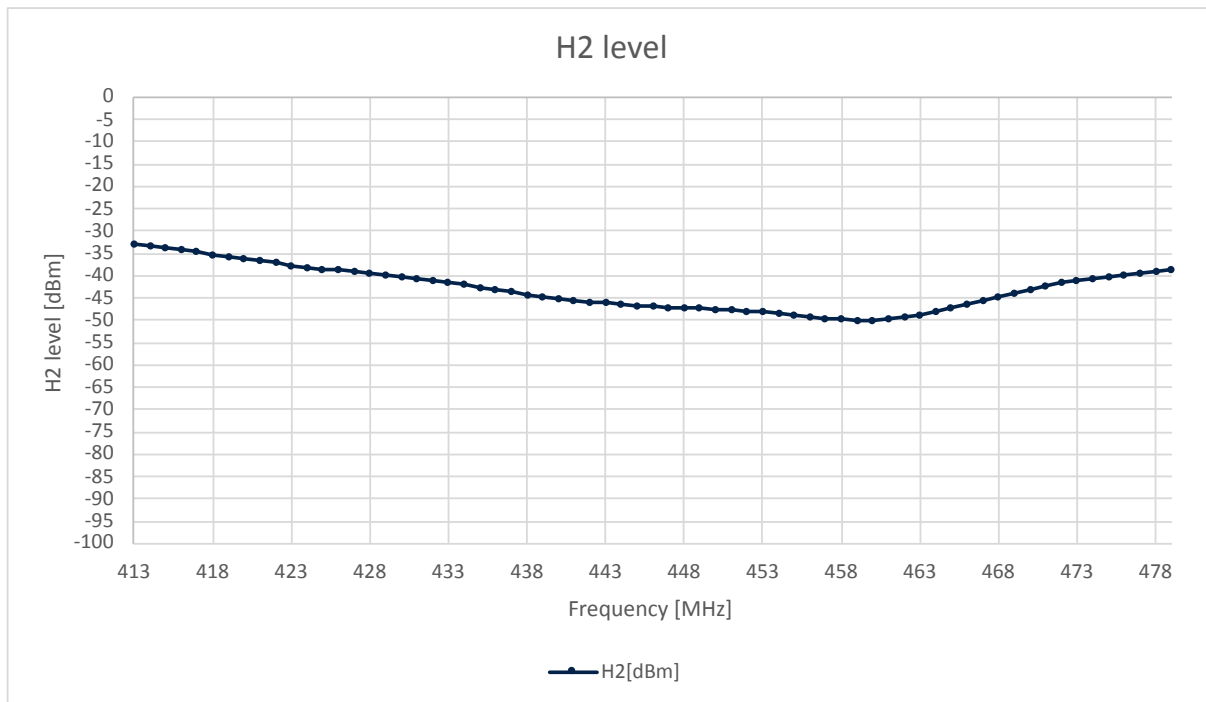


Figure 106. Harmonics level, low band, TX_HP pin, degeneration mode ON

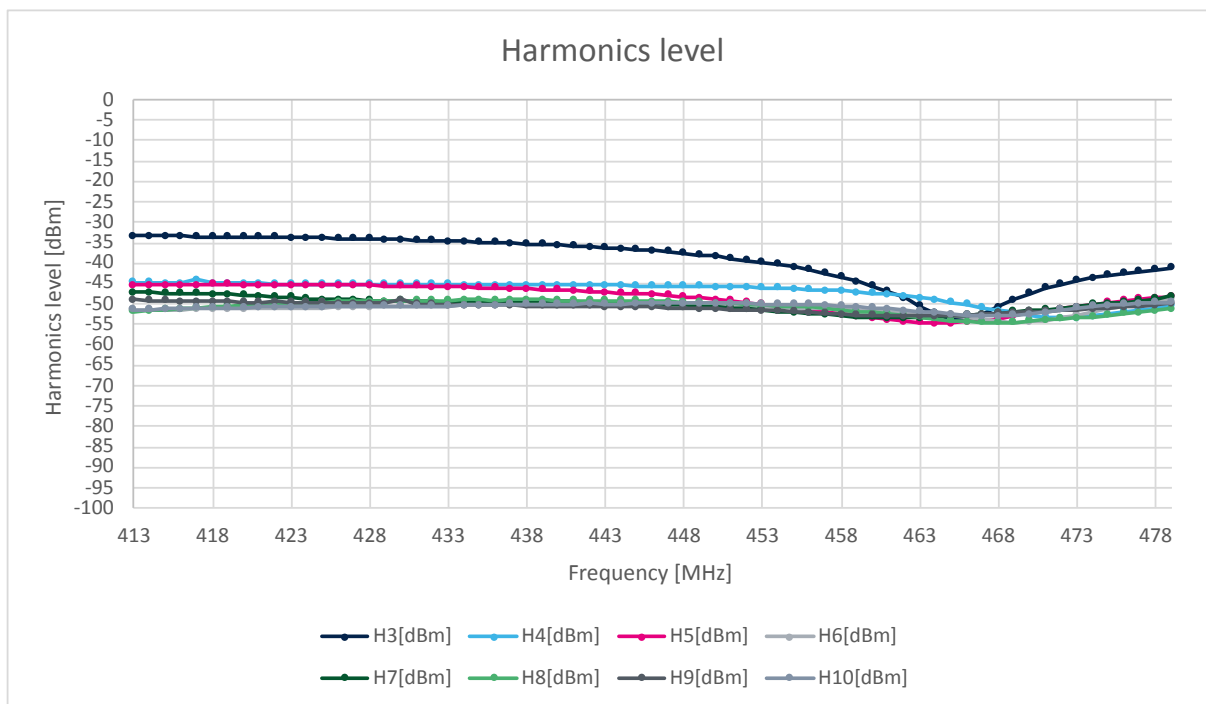


Figure 107. Current consumption in TX mode, low band, TX_HP pin, degeneration mode OFF

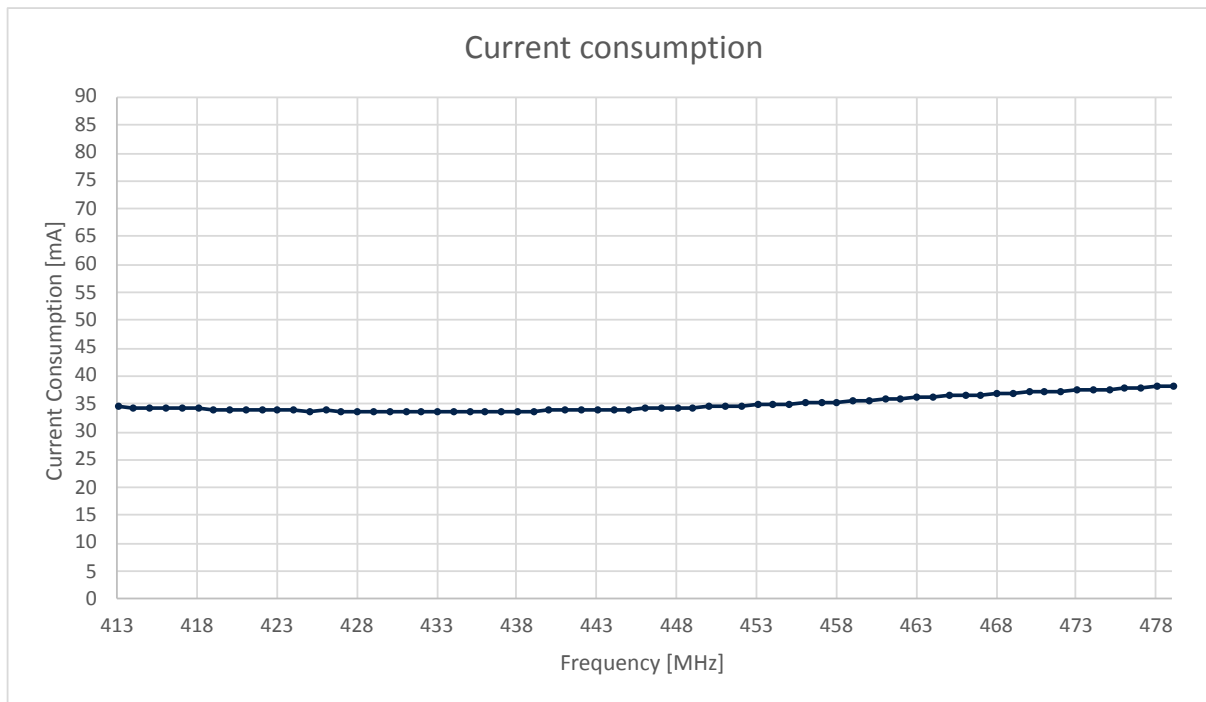


Figure 108. TX output power level, low band, TX_HP pin, degeneration mode OFF

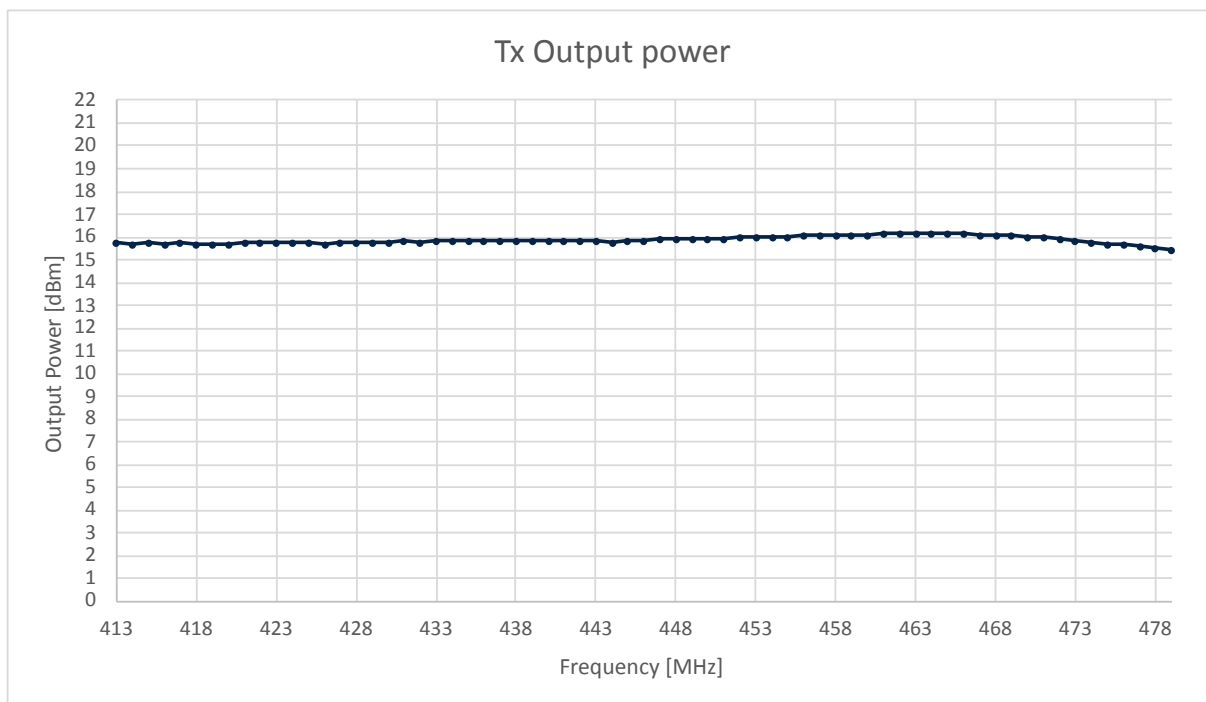


Figure 109. H2 level, low band, TX_HP pin, degeneration mode OFF

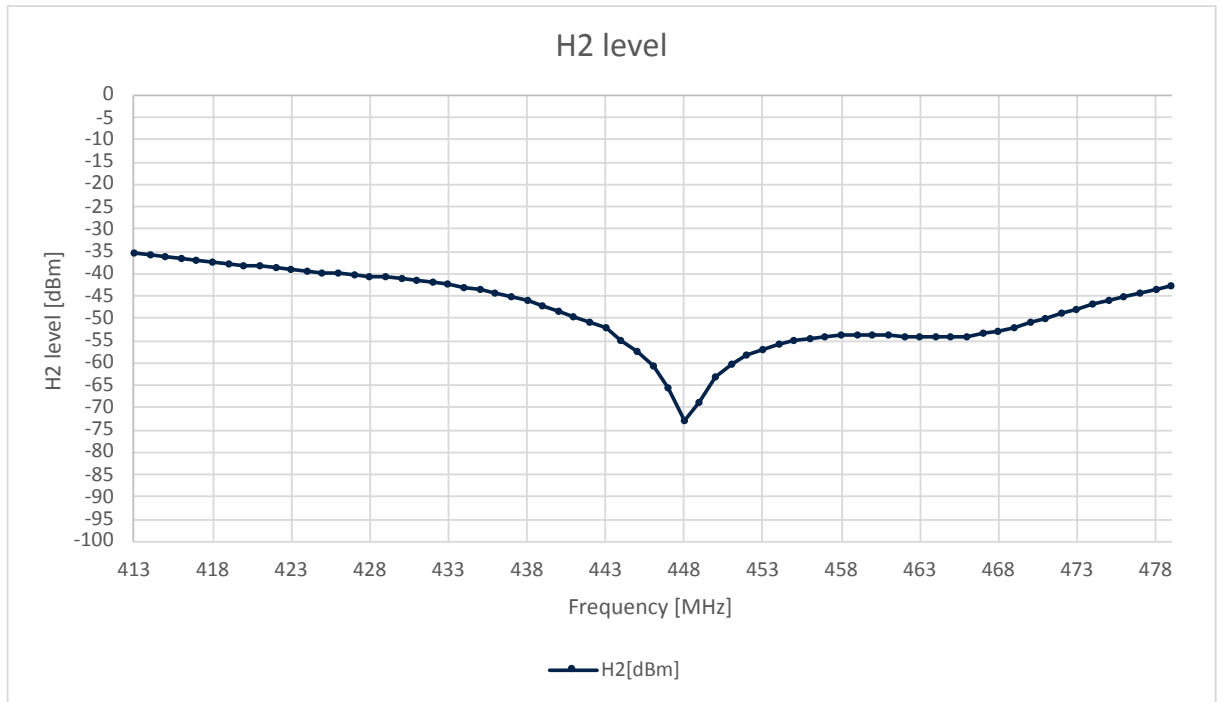


Figure 110. Harmonics level, low band, TX_HP pin, degeneration mode OFF

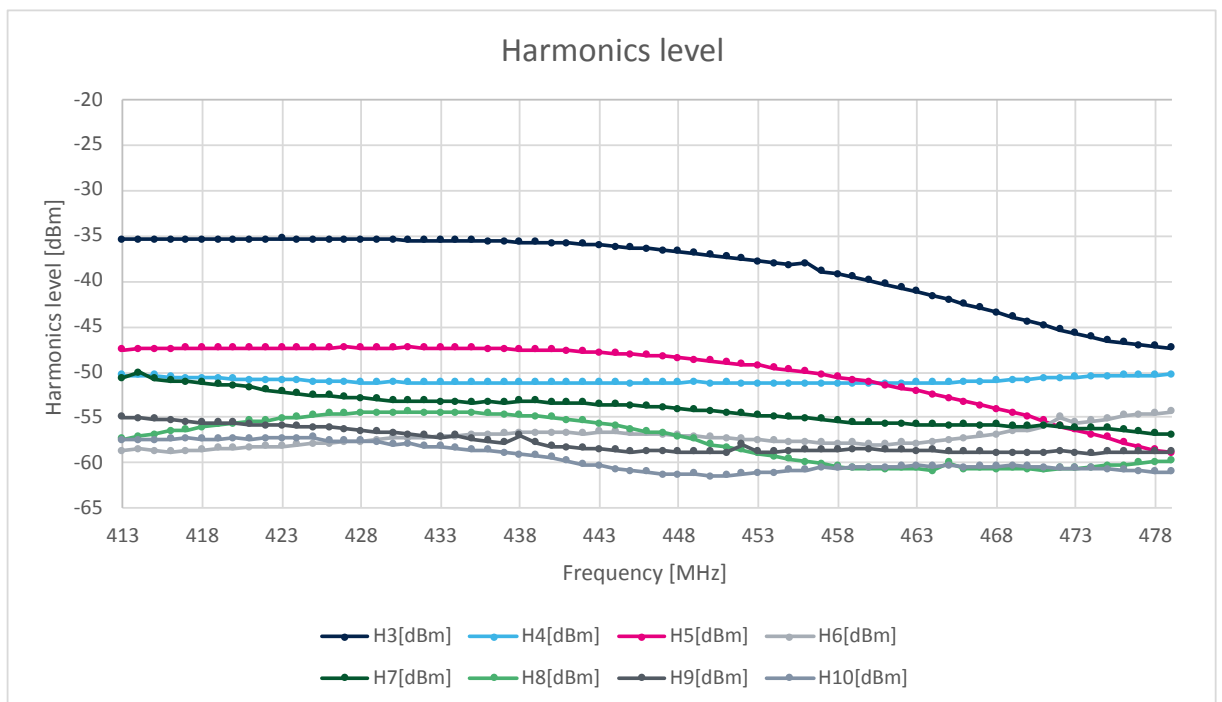
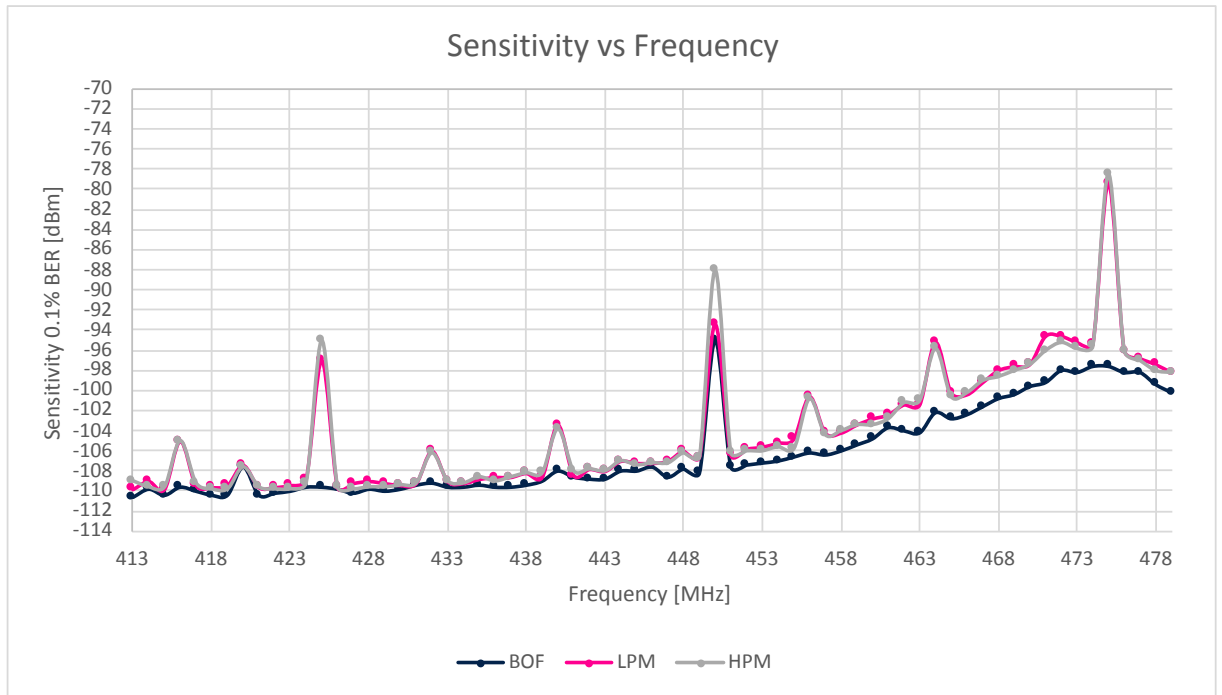


Figure 111. RX sensitivity, low band, TX_HP pin



5.8 STDES-WL3C4SHH

Figure 112. Current consumption in TX mode, high band, TX and TX_HP pins, degeneration mode ON

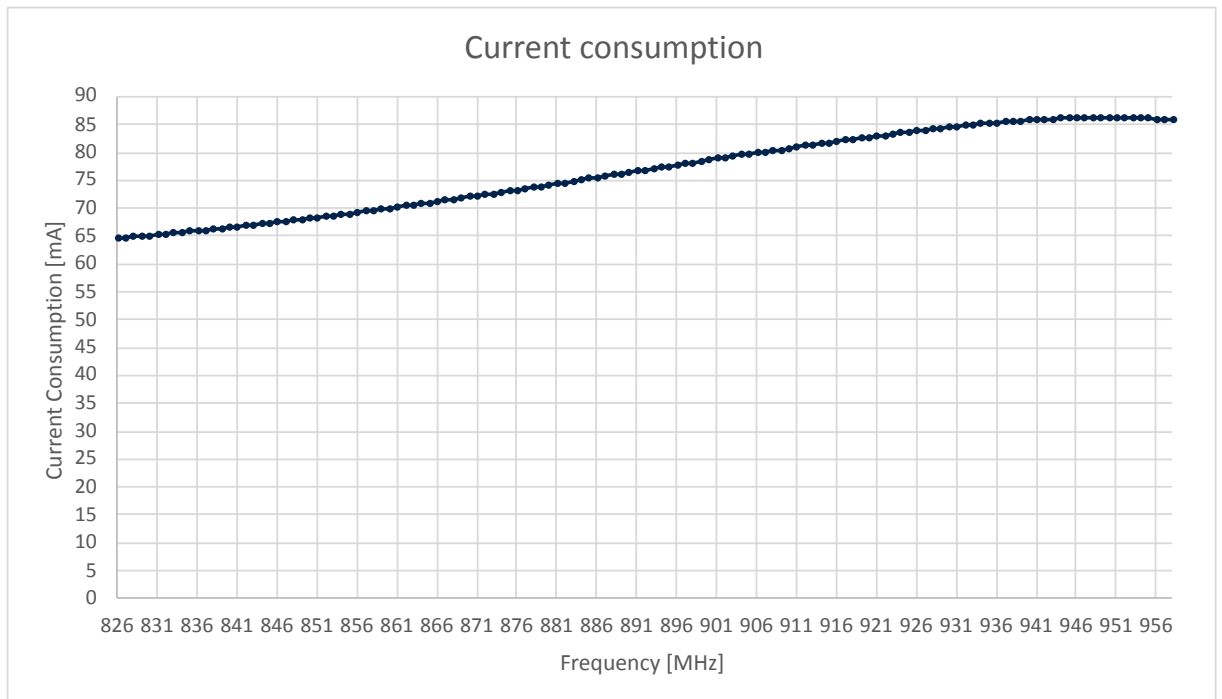


Figure 113. TX output power level, high band, TX and TX_HP pins, degeneration mode ON

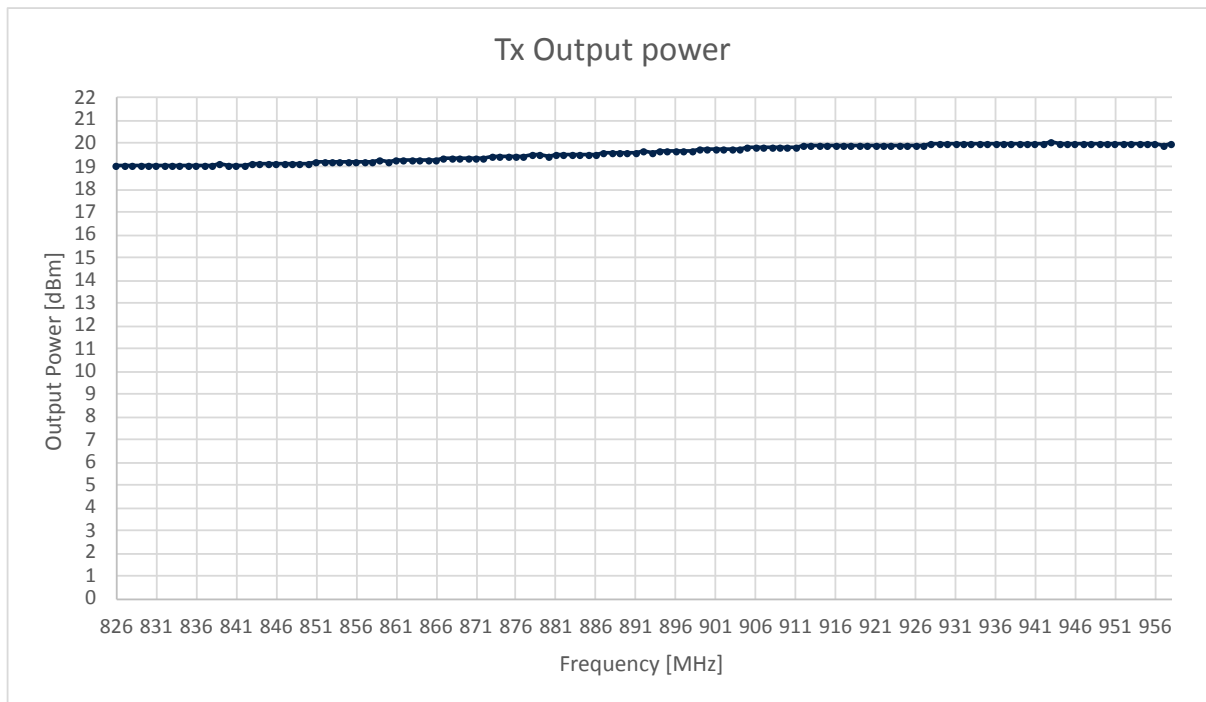


Figure 114. H2 level, high band, TX and TX_HP pins, degeneration mode ON

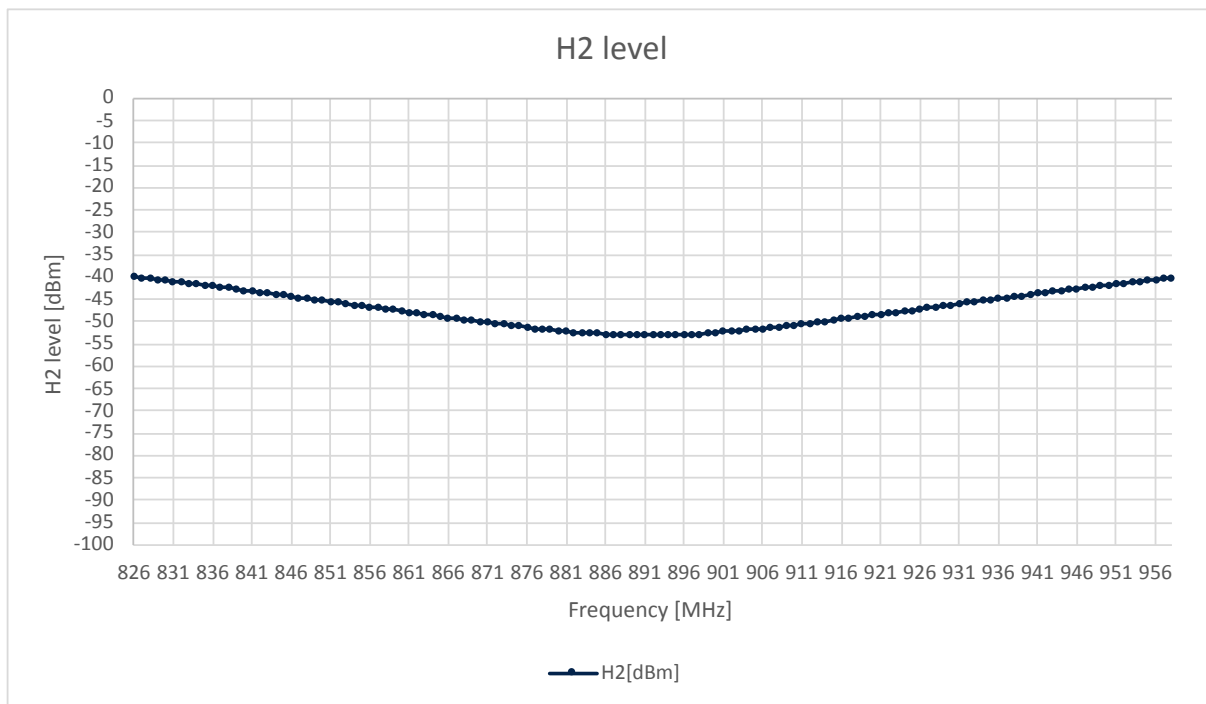


Figure 115. Harmonics level, high band, TX and TX_HP pins, degeneration mode ON

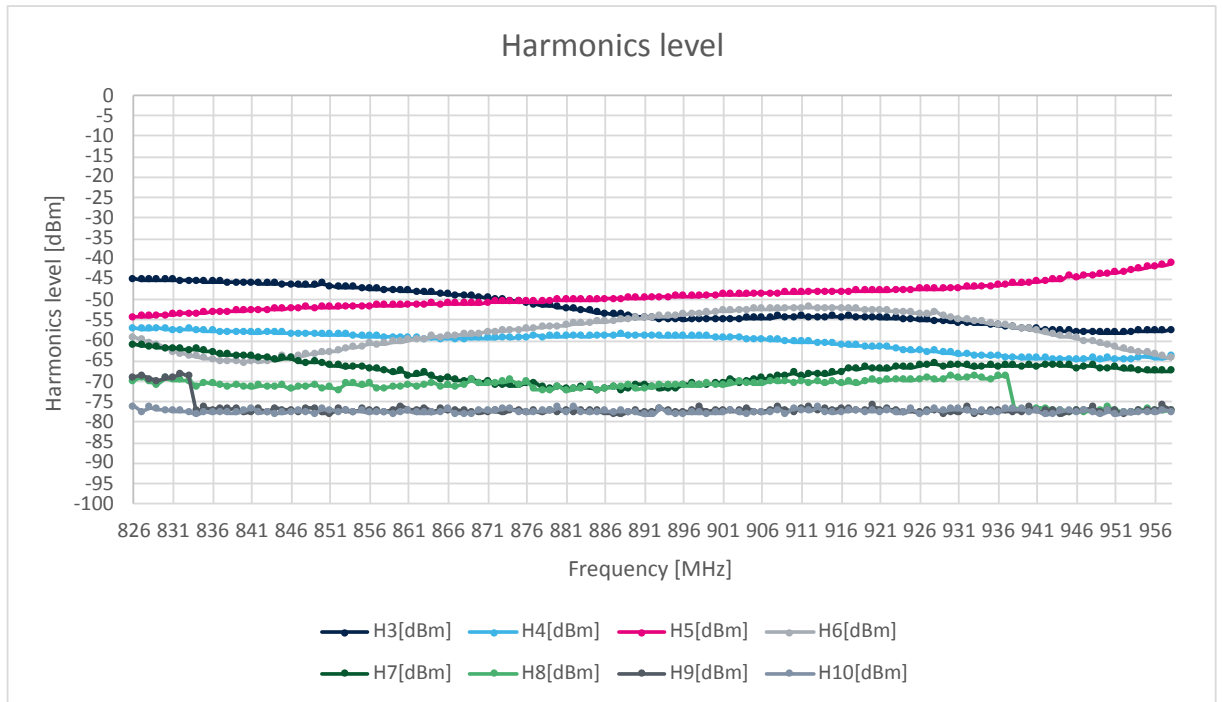
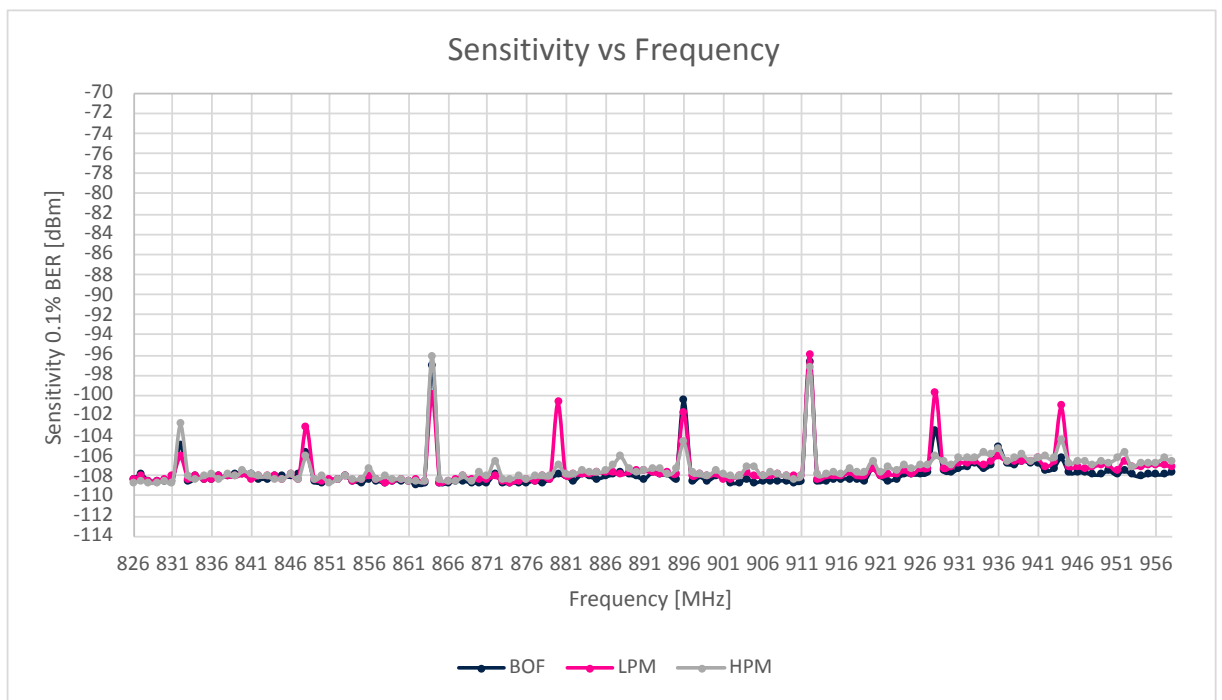


Figure 116. RX sensitivity, high band, TX and TX_HP pins



5.9 STDES-WL3C4SLH

Figure 117. Current consumption in TX mode, high band, TX pin, degeneration mode ON

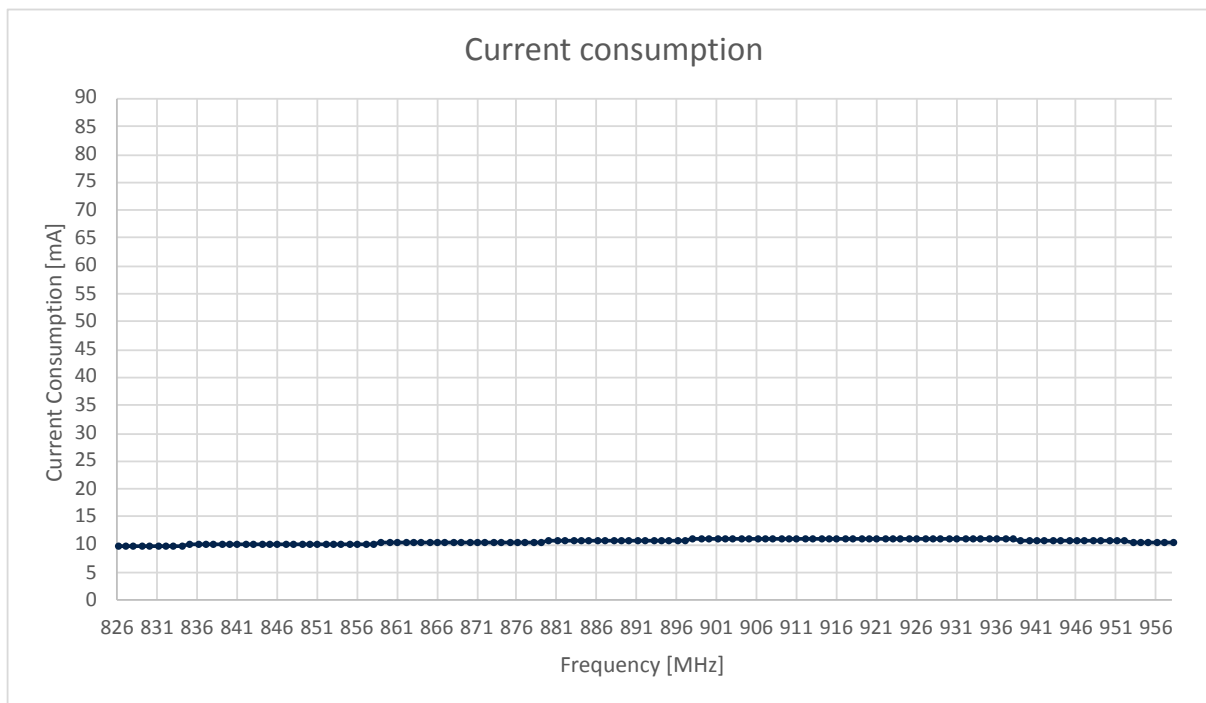


Figure 118. TX output power level, high band, TX pin, degeneration mode ON

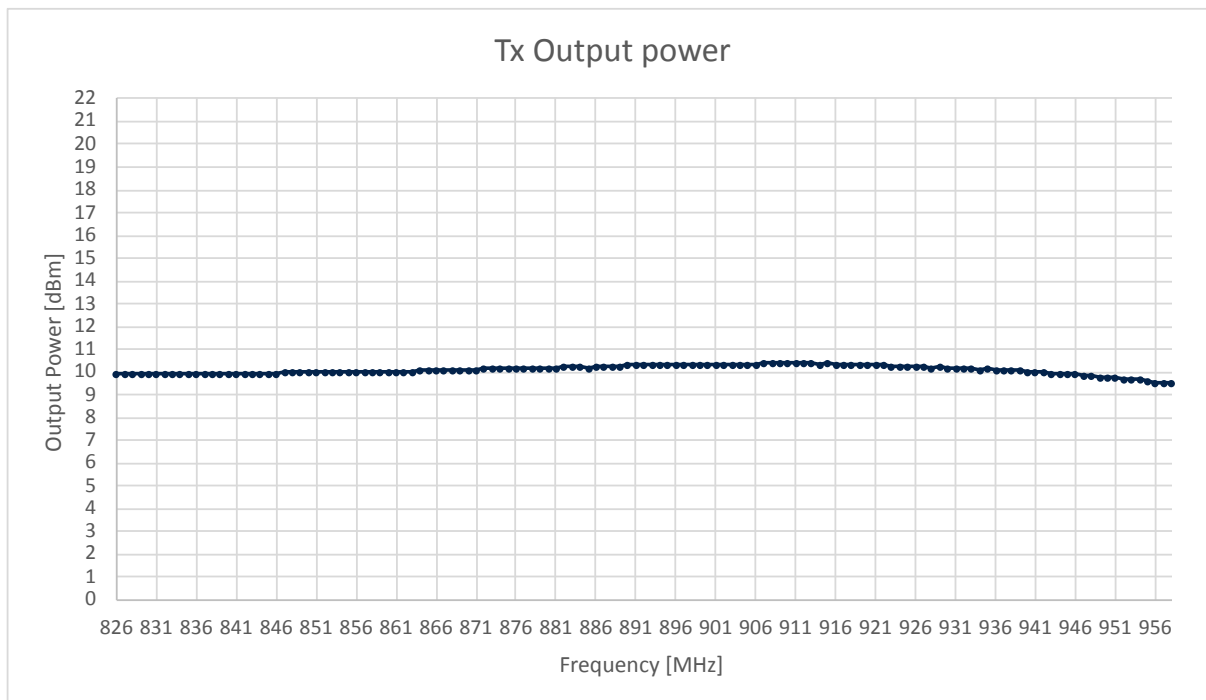


Figure 119. H2 level, high band, TX pin, degeneration mode ON

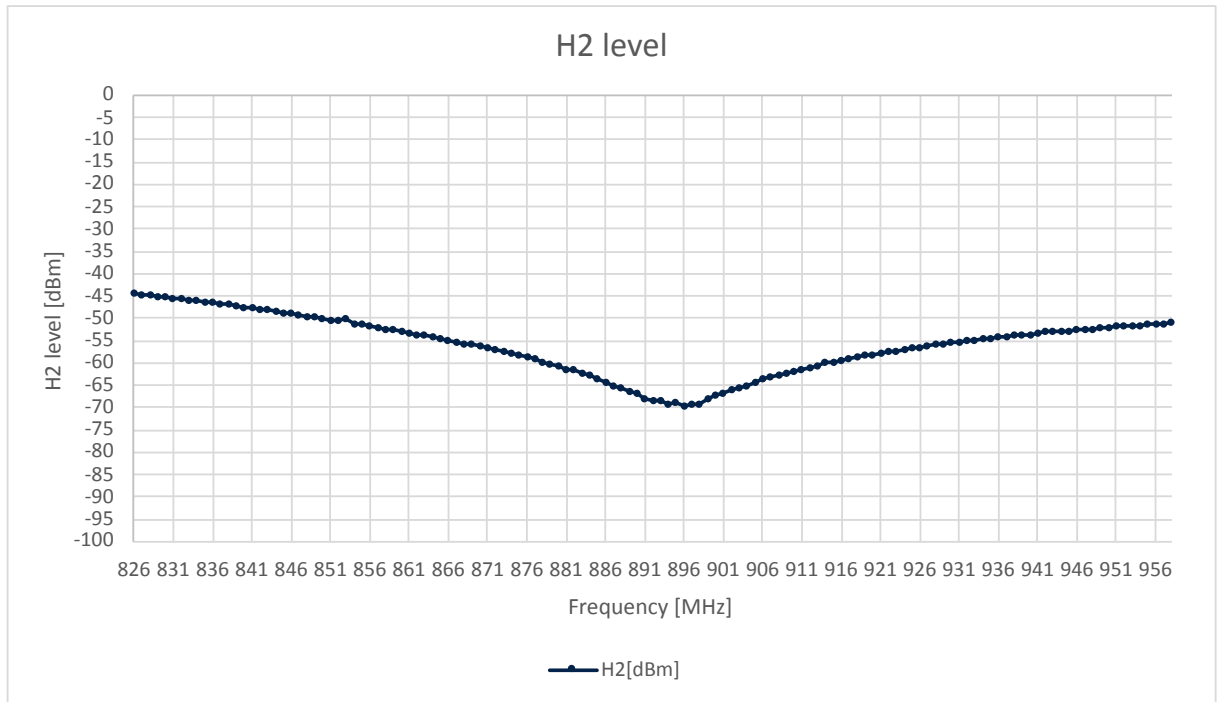


Figure 120. Harmonics level, high band, TX pin, degeneration mode ON

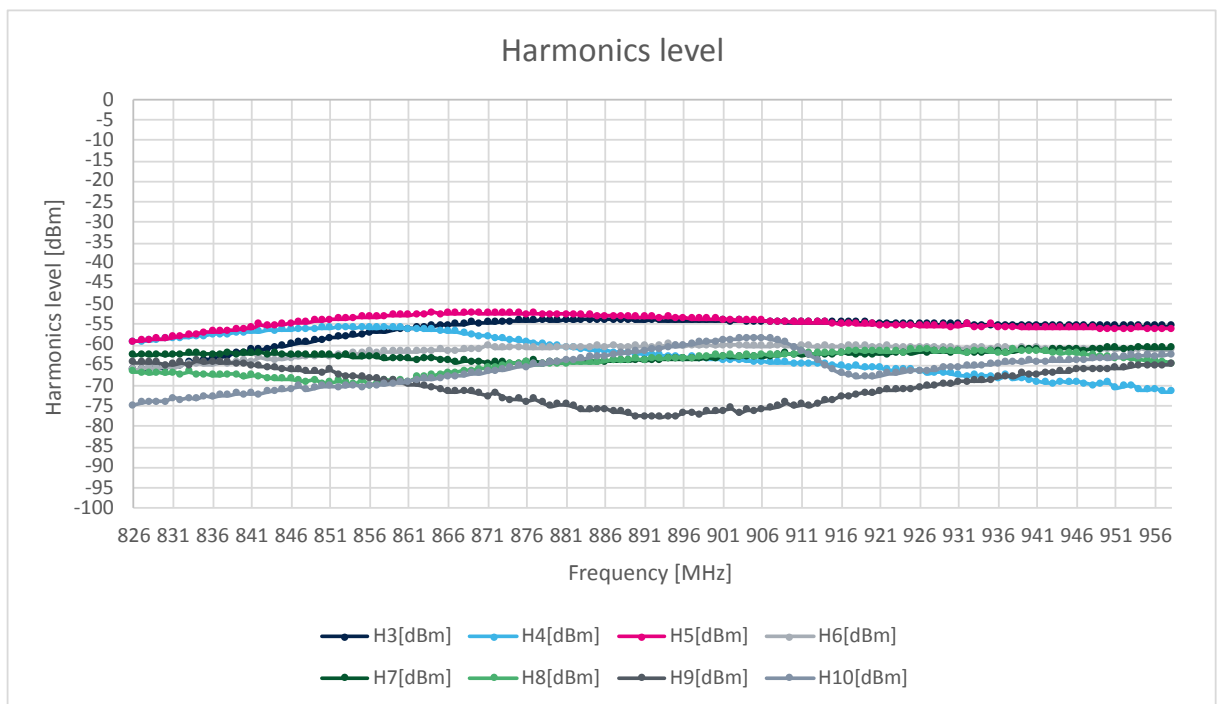


Figure 121. Current consumption in TX mode, high band, TX pin, degeneration mode OFF

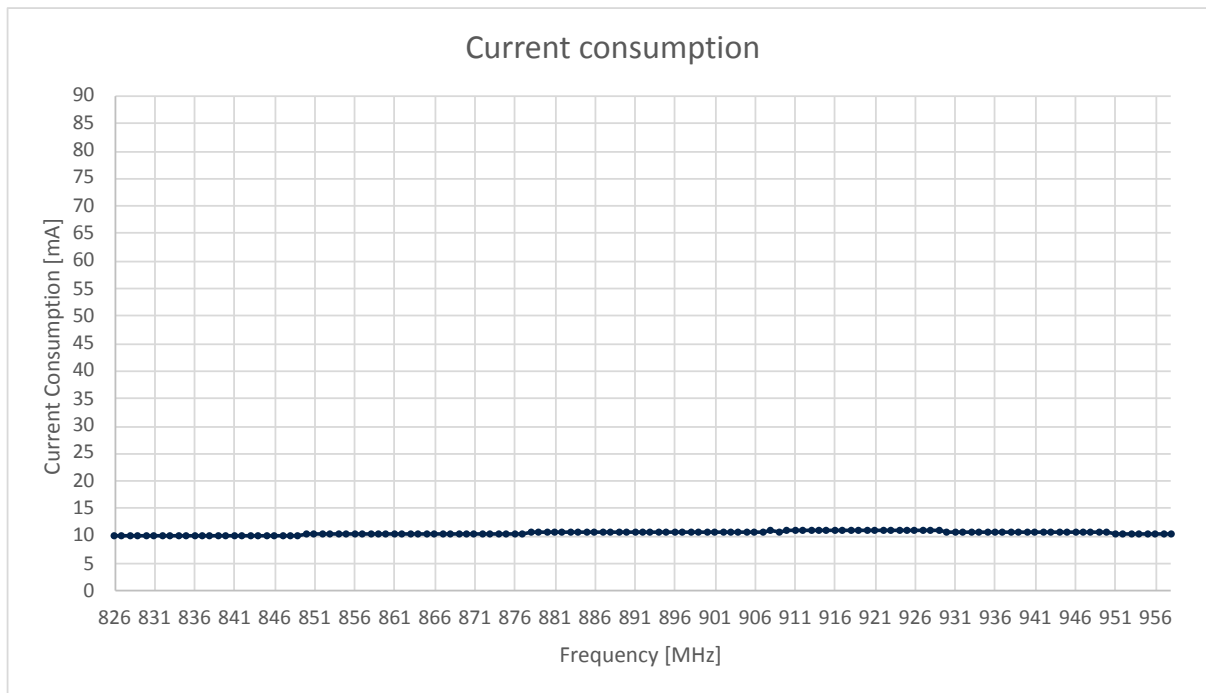


Figure 122. TX output power level, high band, TX pin, degeneration mode OFF

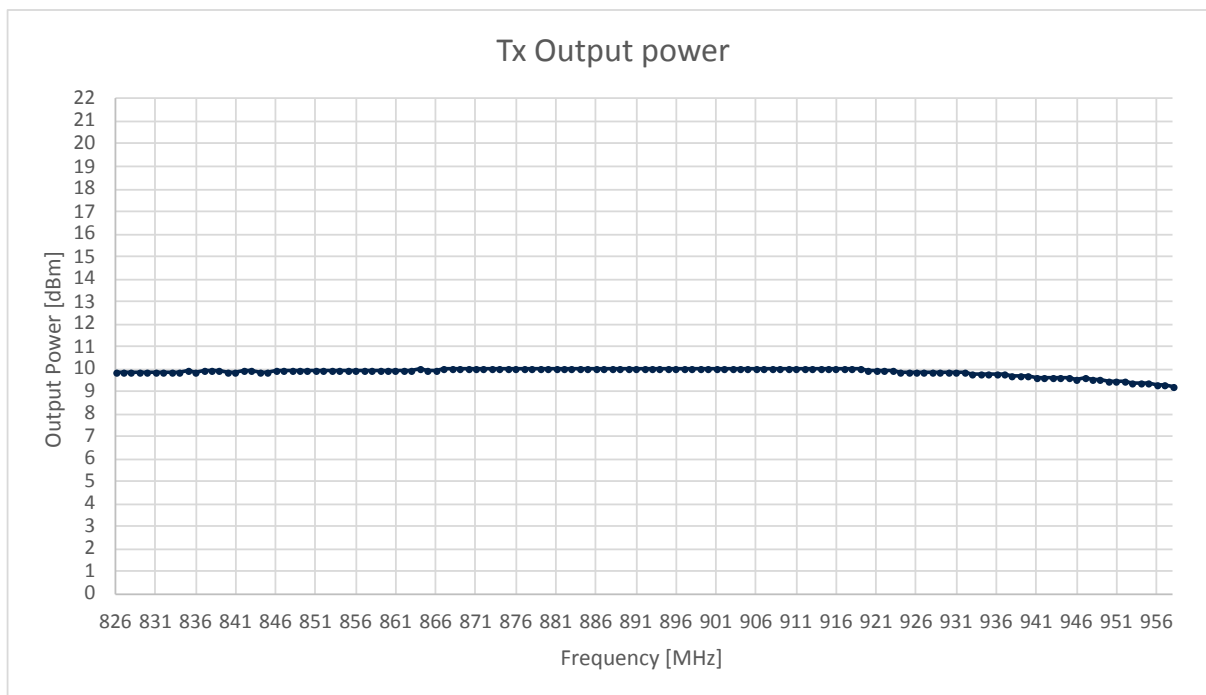


Figure 123. H2 level, high band, TX pin, degeneration mode OFF

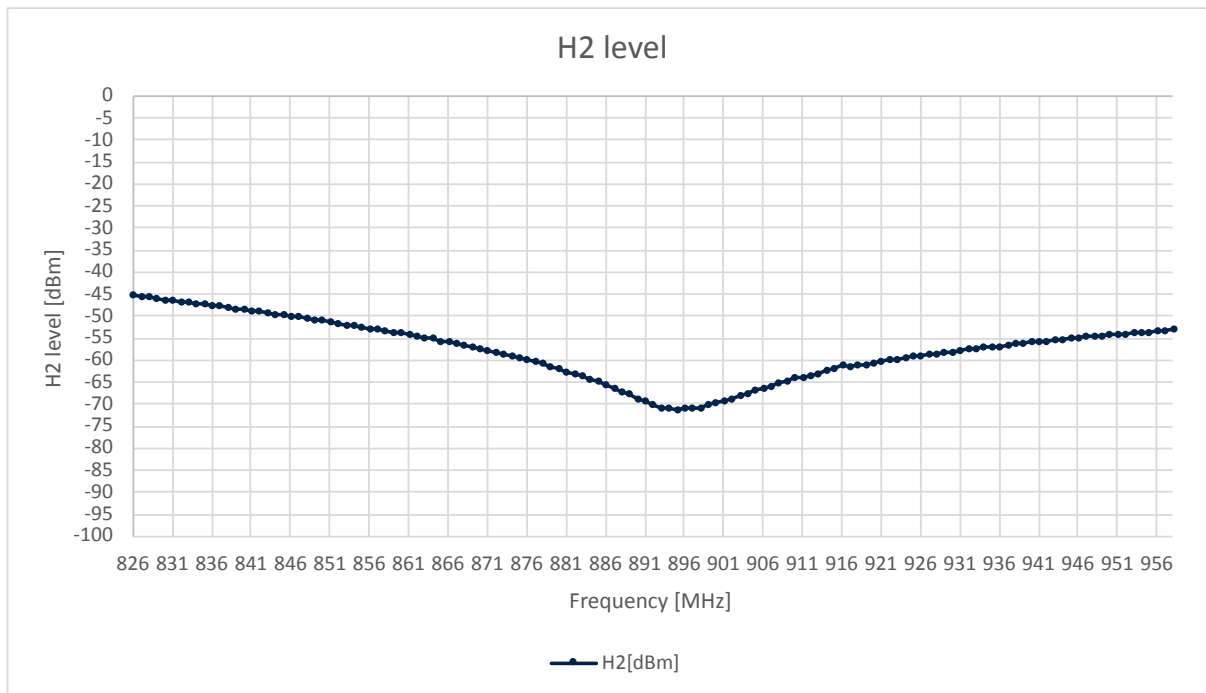


Figure 124. Harmonics level, high band, TX pin, degeneration mode OFF

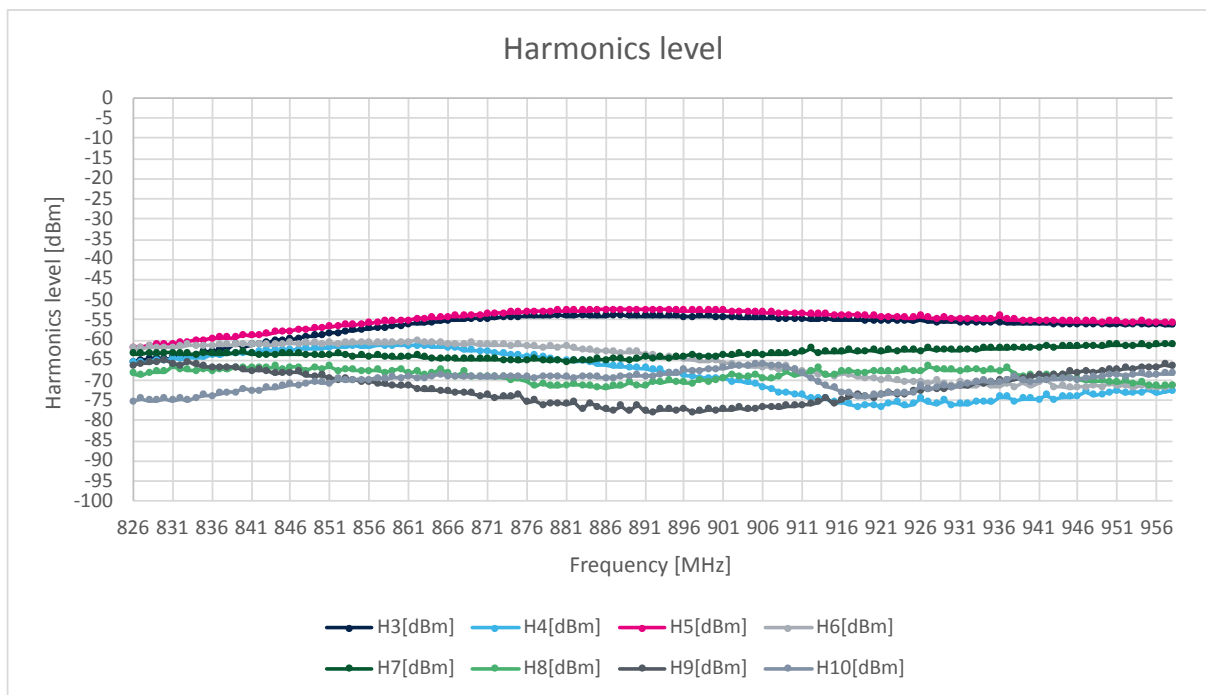
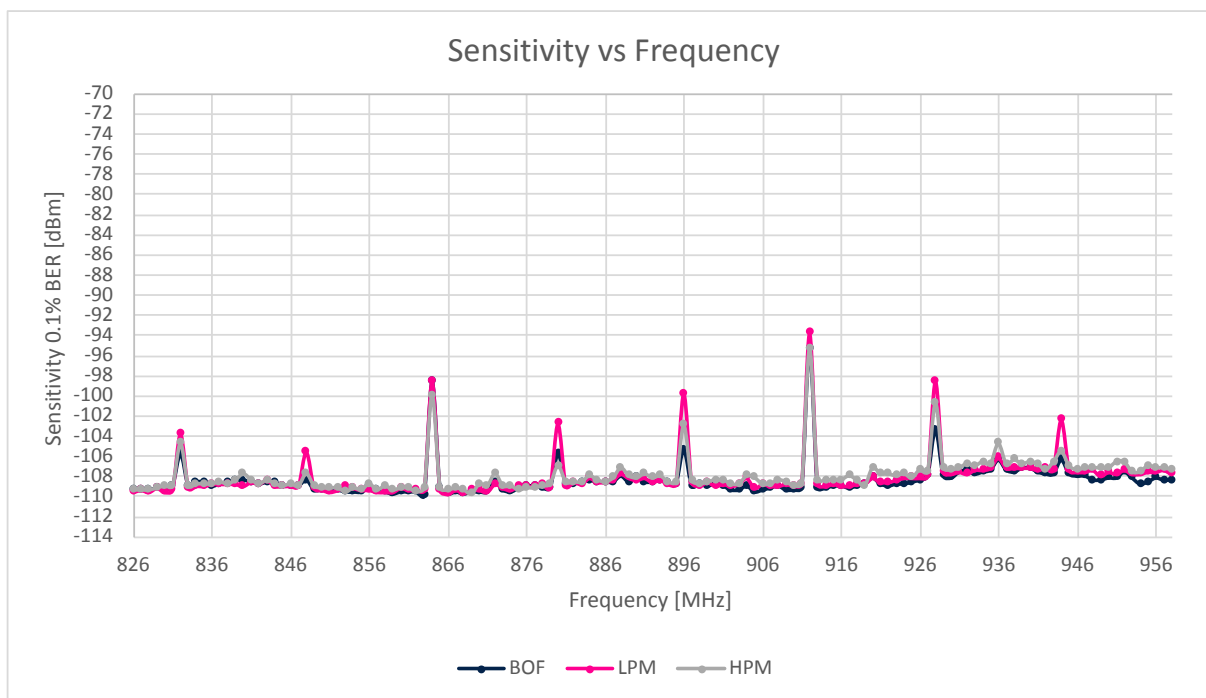


Figure 125. RX sensitivity, high band, TX pin



5.10 STDES-WL3C4SLL

Figure 126. Current consumption in TX mode, low band, TX pin, degeneration mode ON

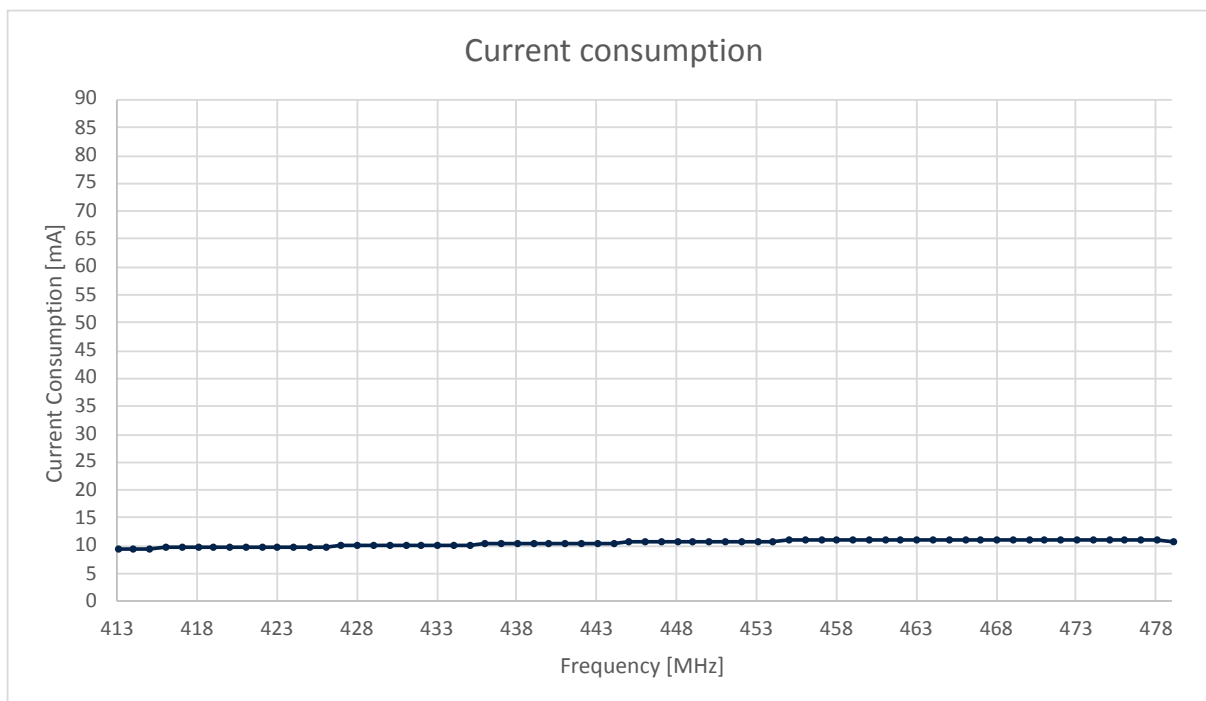


Figure 127. TX output power level, low band, TX pin, degeneration mode ON

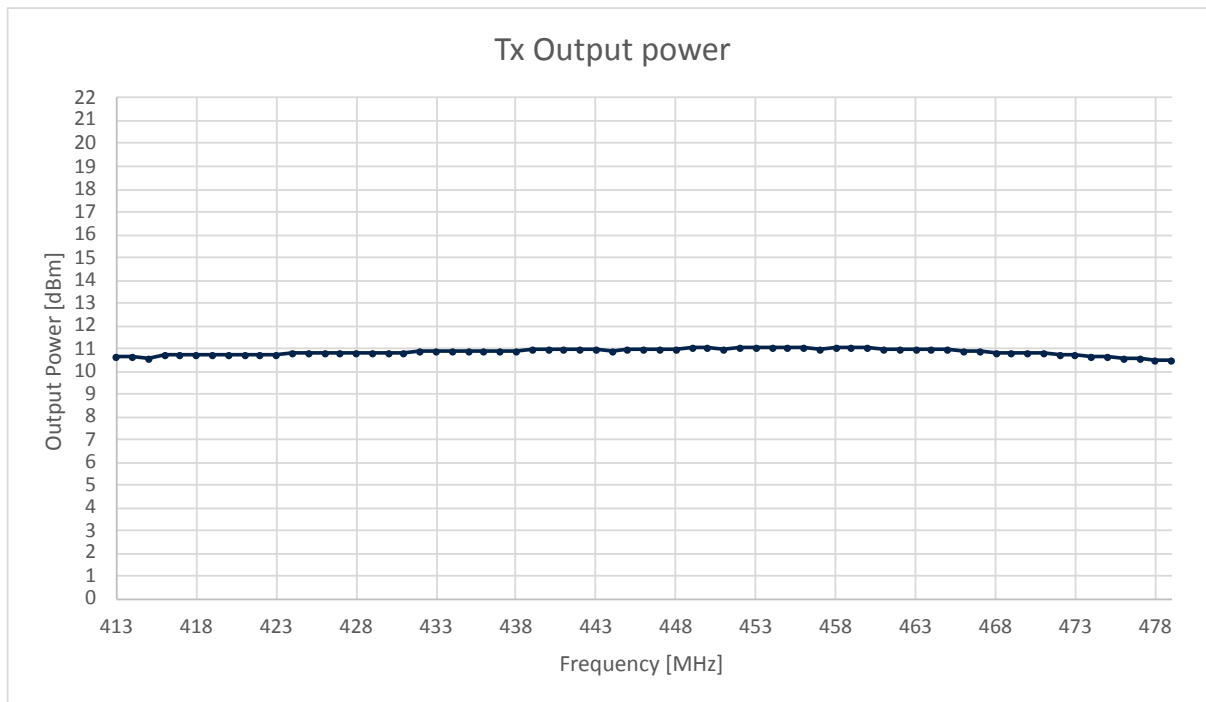


Figure 128. H2 level, low band, TX pin, degeneration mode ON

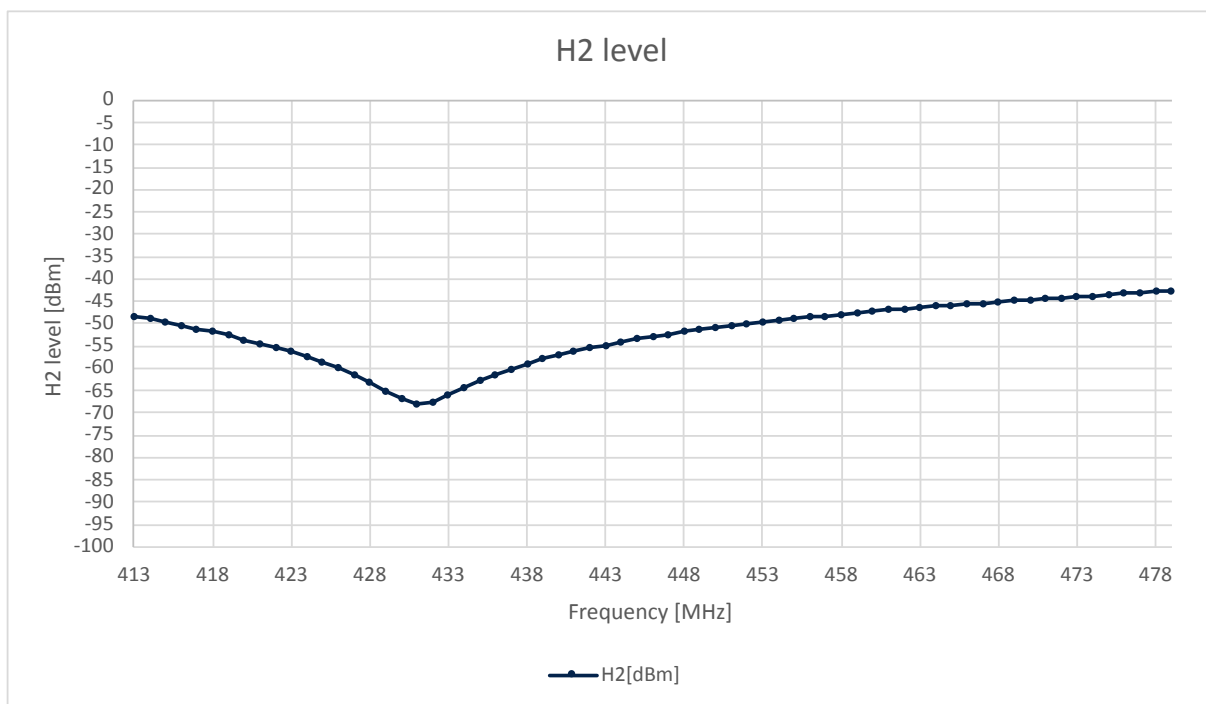


Figure 129. Harmonics level, low band, TX pin, degeneration mode ON

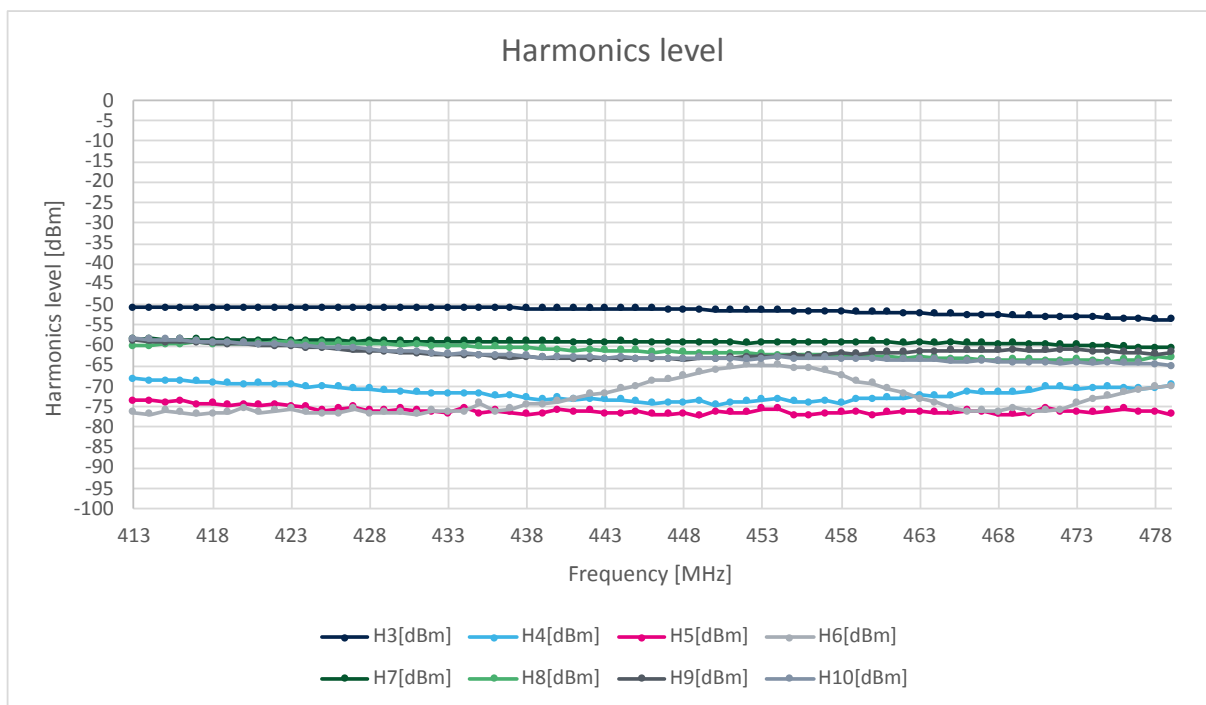


Figure 130. Current consumption in TX mode, low band, TX pin, degeneration mode OFF

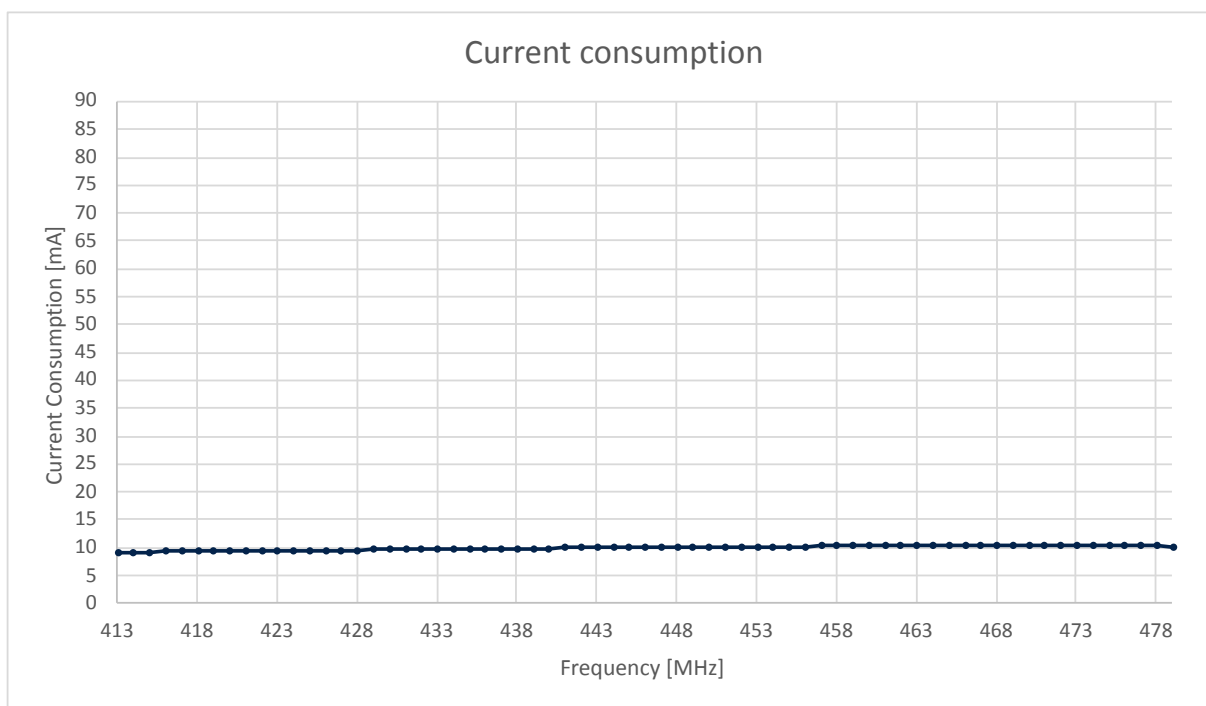


Figure 131. TX output power level, low band, TX pin, degeneration mode OFF

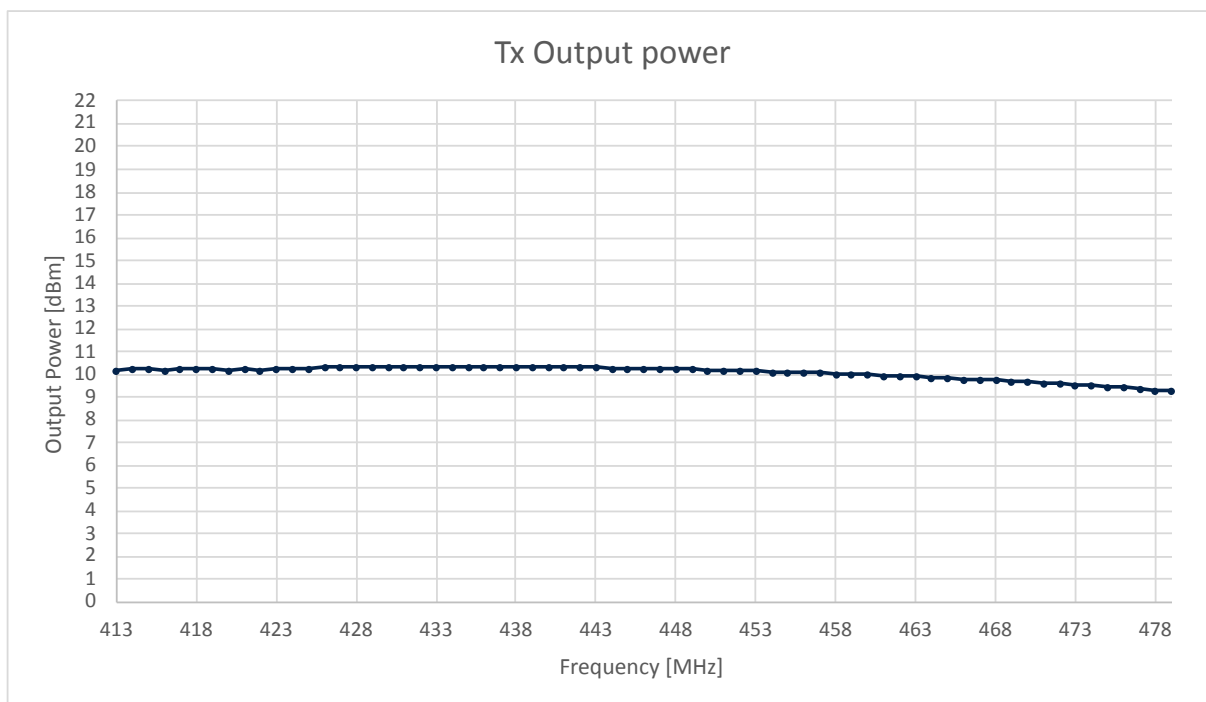


Figure 132. H2 level, low band, TX pin, degeneration mode OFF

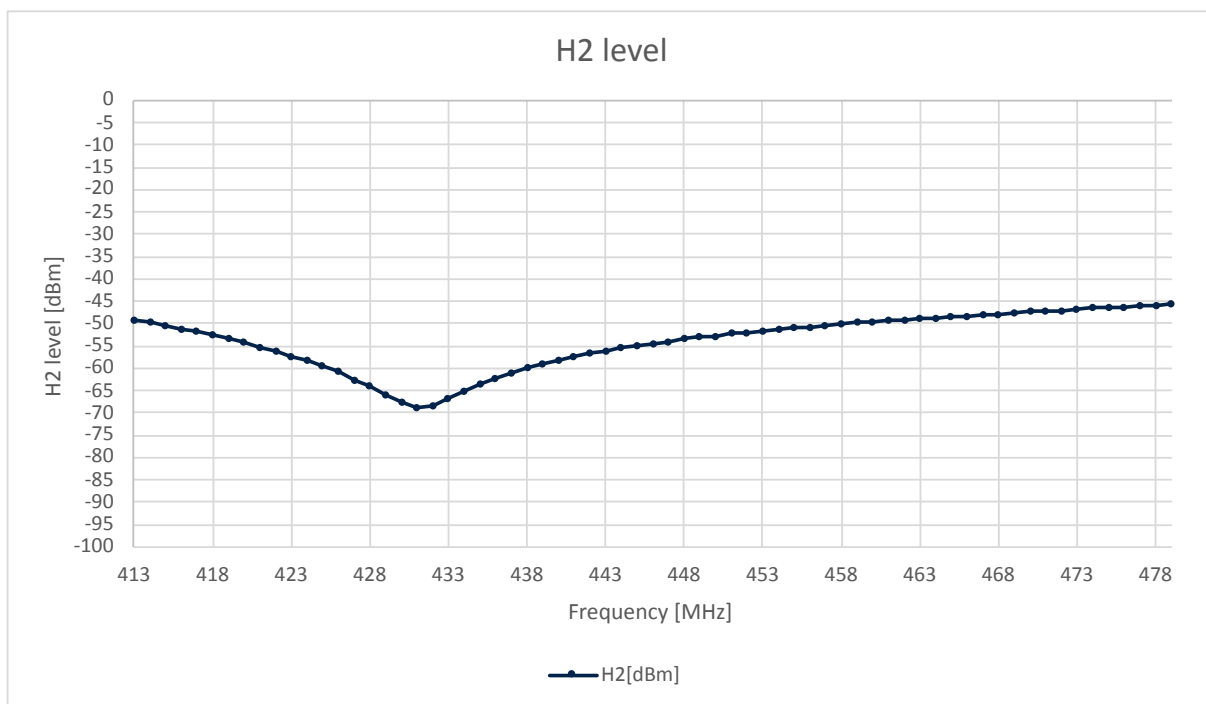


Figure 133. Harmonics level, low band, TX pin, degeneration mode OFF

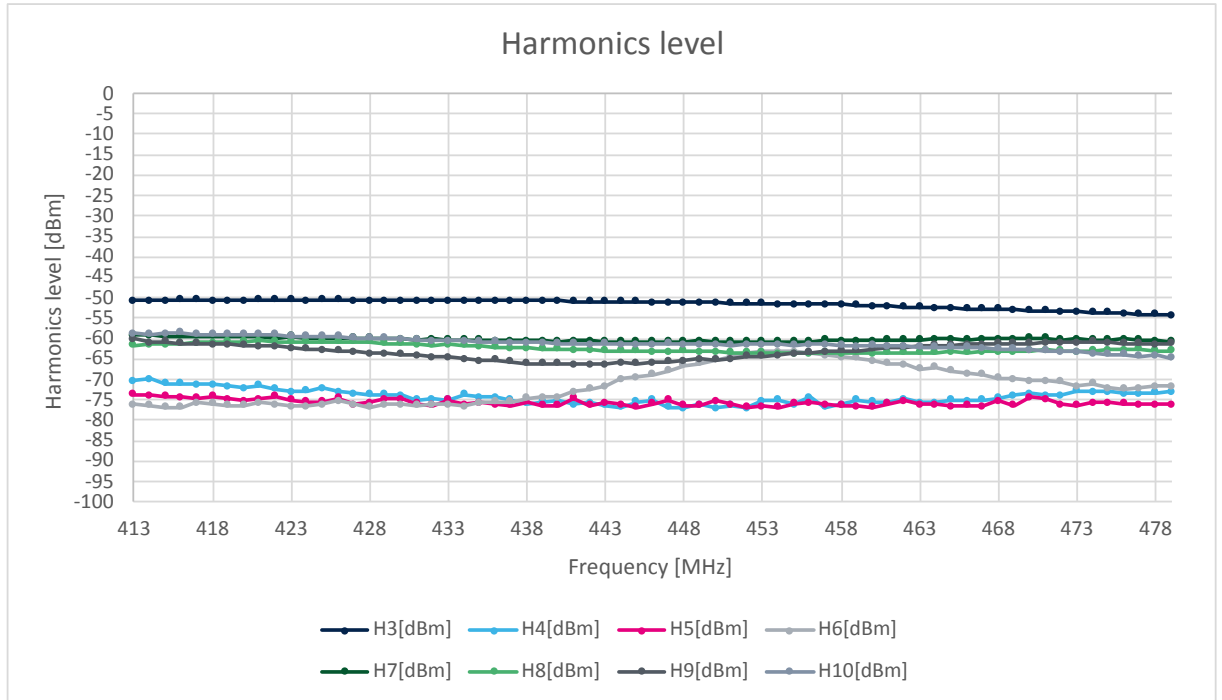
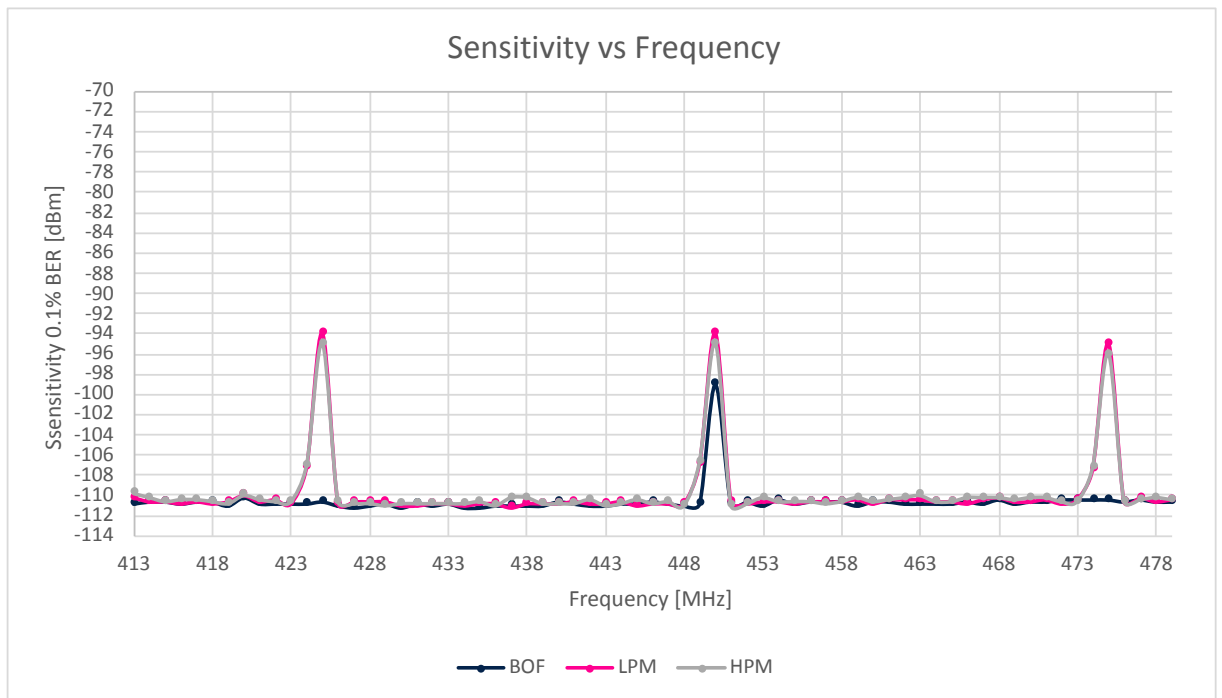


Figure 134. RX sensitivity, low band, TX pin



5.11 STDES-WL3C4SMH

Figure 135. Current consumption in TX mode, high band, TX_HP pin, degeneration mode ON

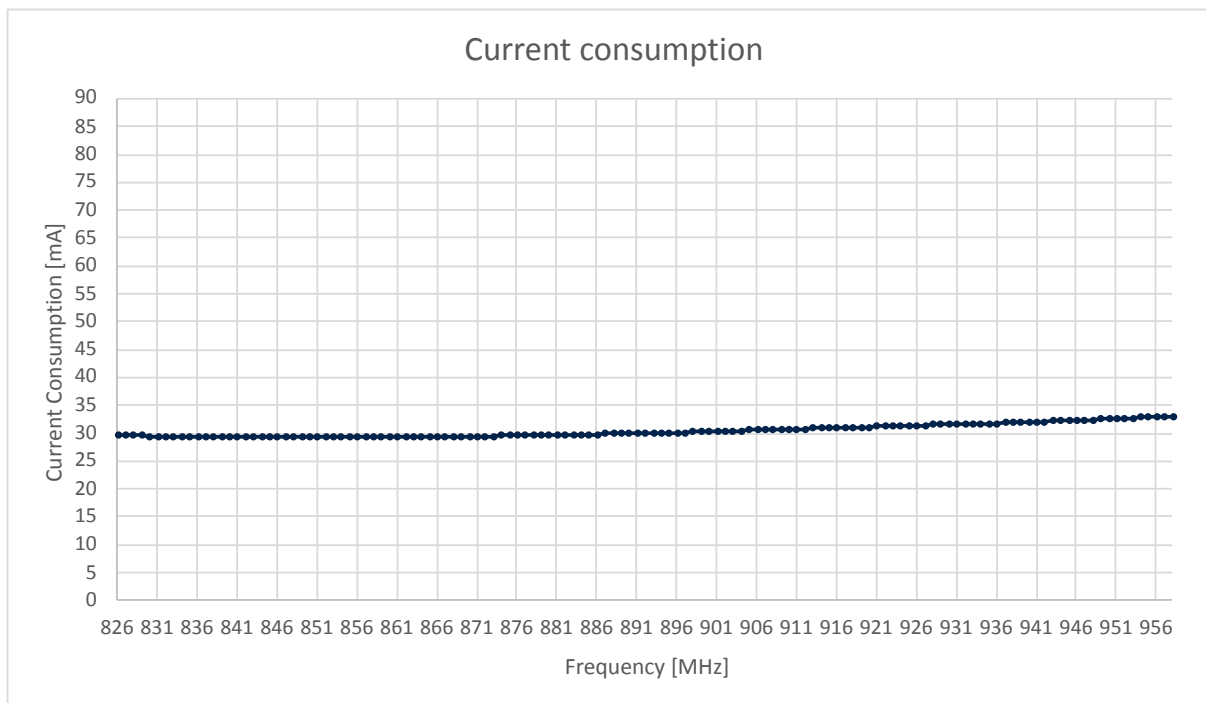


Figure 136. TX output power level, high band, TX_HP pin, degeneration mode ON

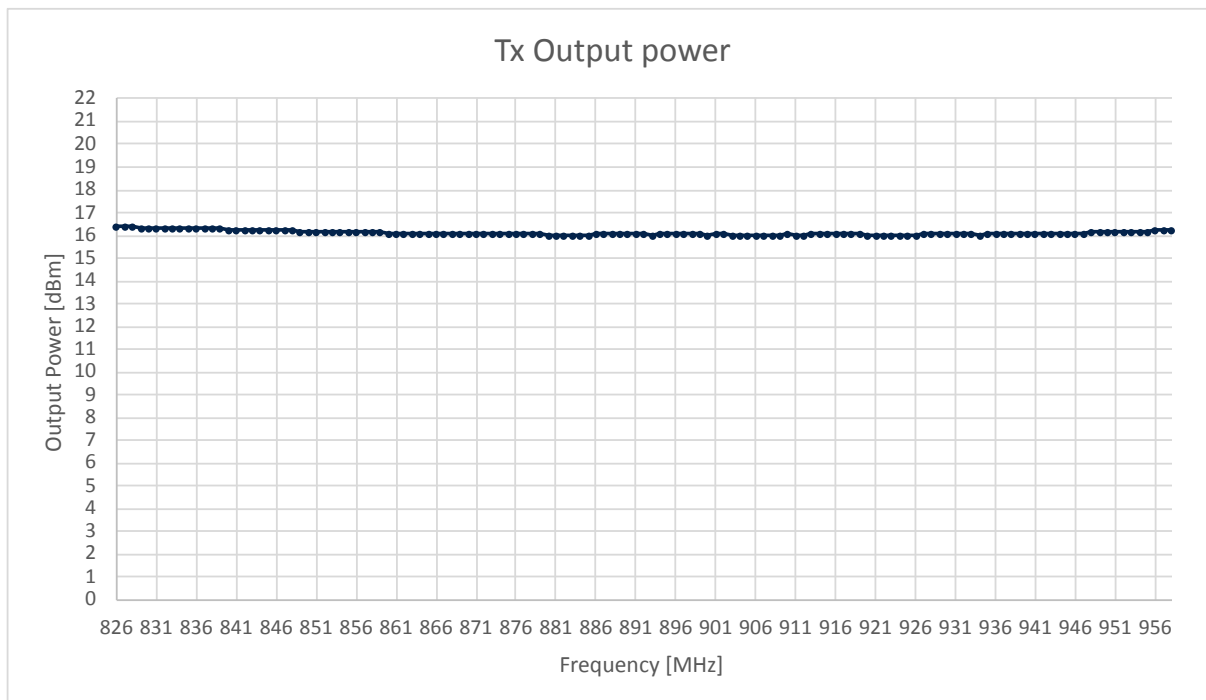


Figure 137. H2 level, high band, TX_HP pin, degeneration mode ON

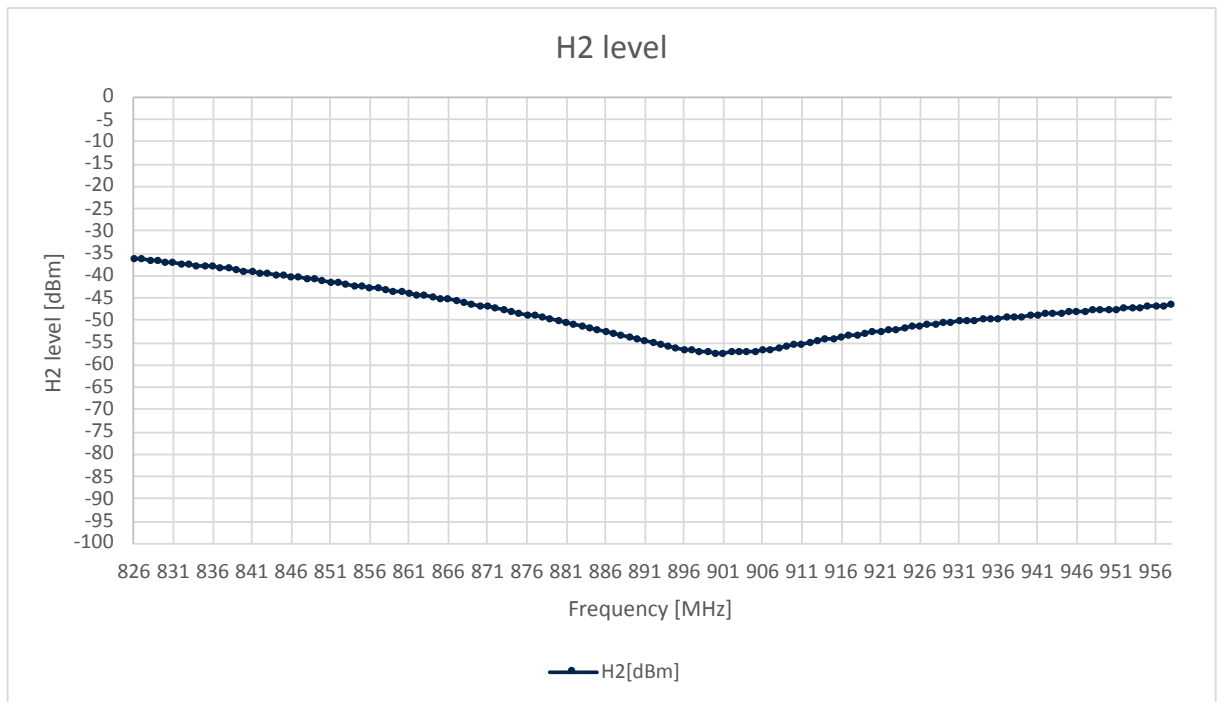


Figure 138. Harmonics level, high band, TX_HP pin, degeneration mode ON

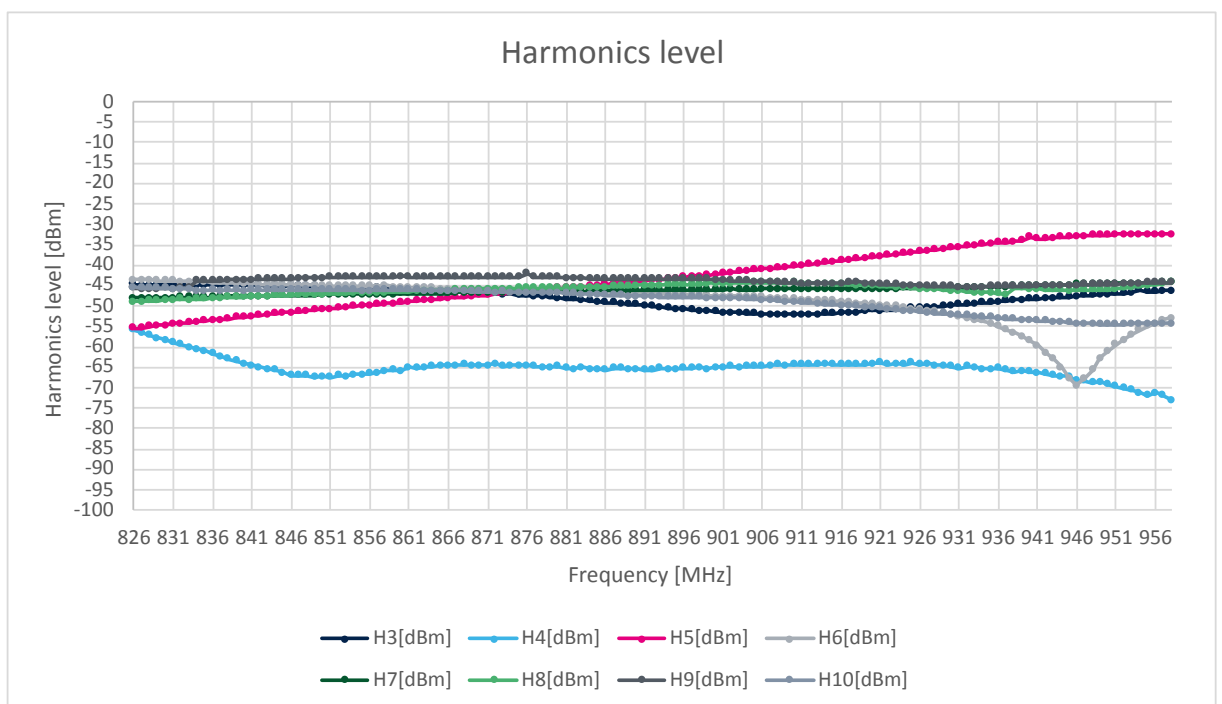


Figure 139. Current consumption in TX mode, high band, TX_HP pin, degeneration mode OFF

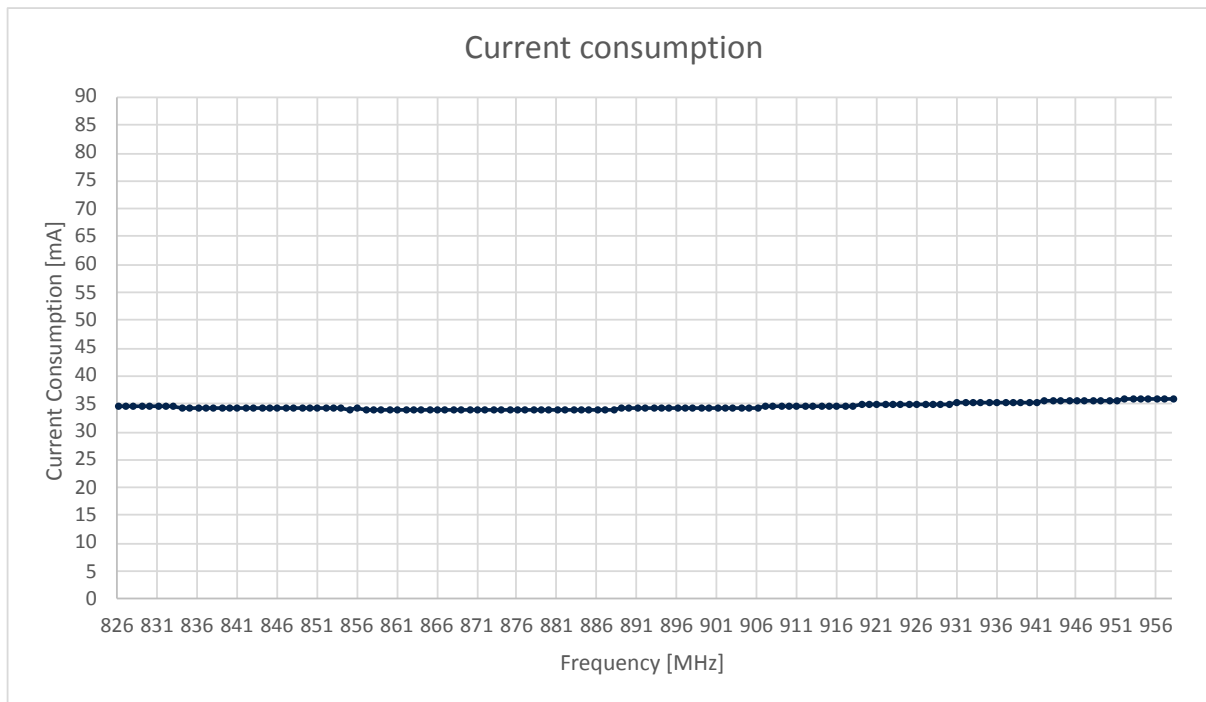


Figure 140. TX output power level, high band, TX_HP pin, degeneration mode OFF

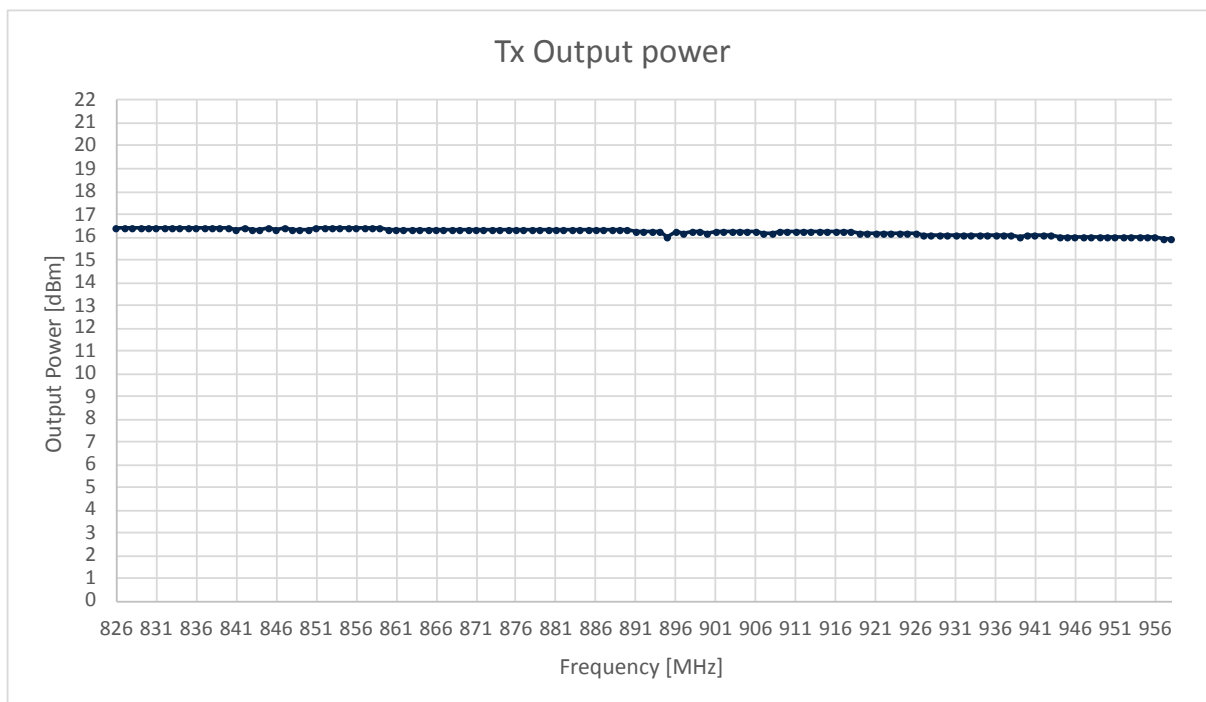


Figure 141. H2 level, high band, TX_HP pin, degeneration mode OFF

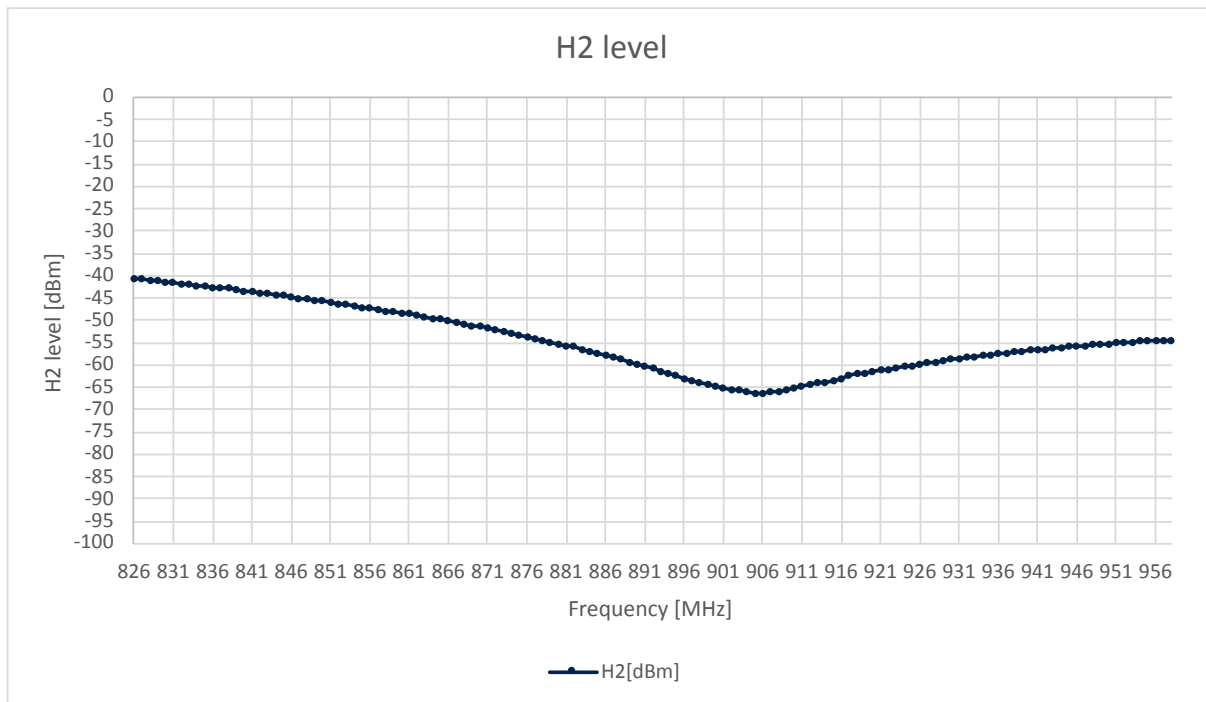


Figure 142. Harmonics level, high band, TX_HP pin, degeneration mode OFF

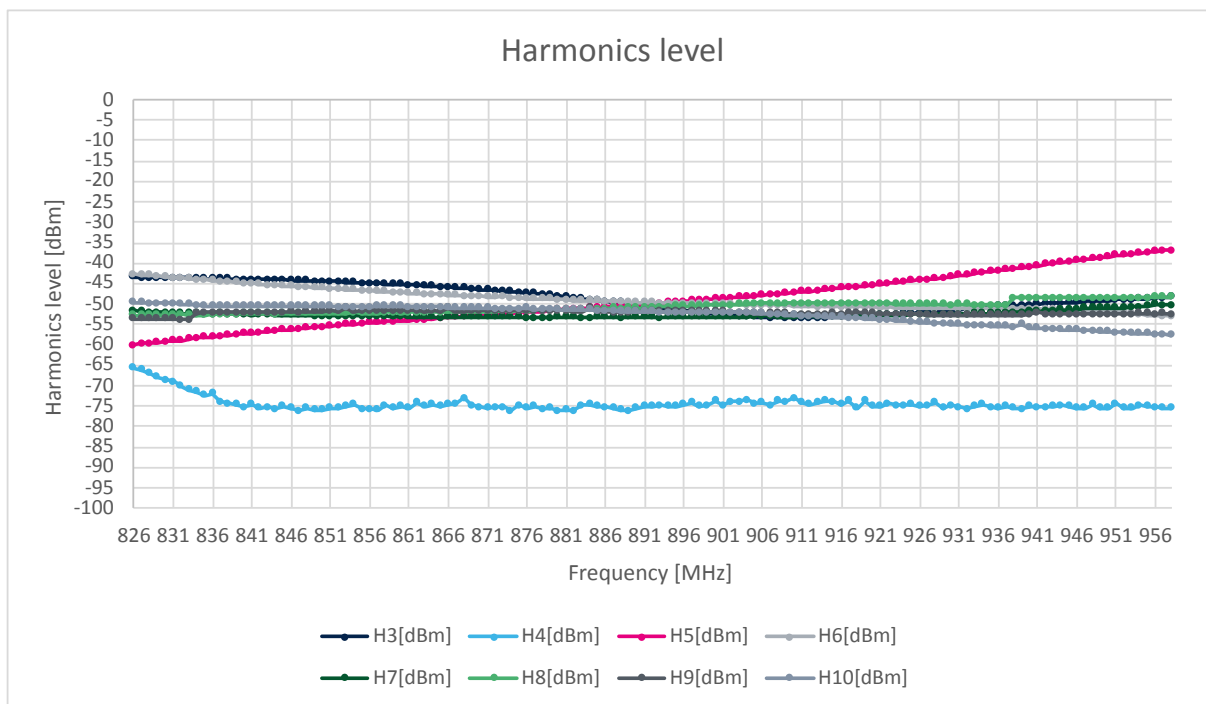
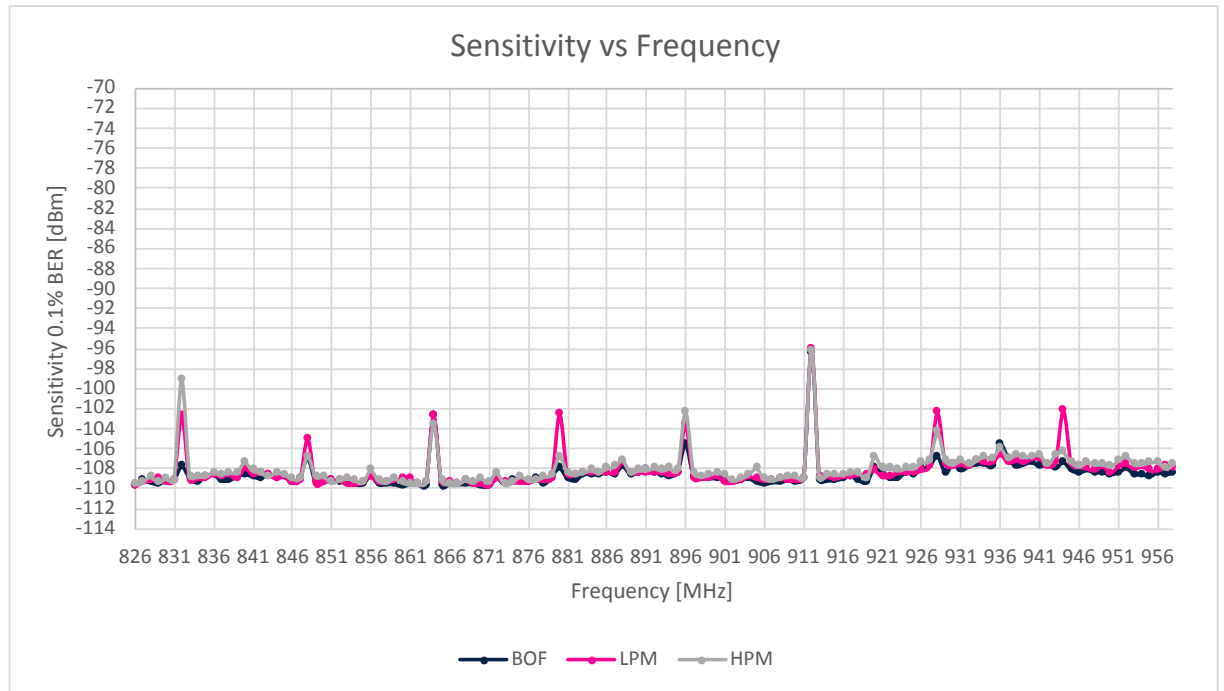


Figure 143. RX sensitivity, high band, TX_HP pin



5.12 STDES-WL3C4SML

Figure 144. Current consumption in TX mode, low band, TX_HP pin, degeneration mode ON

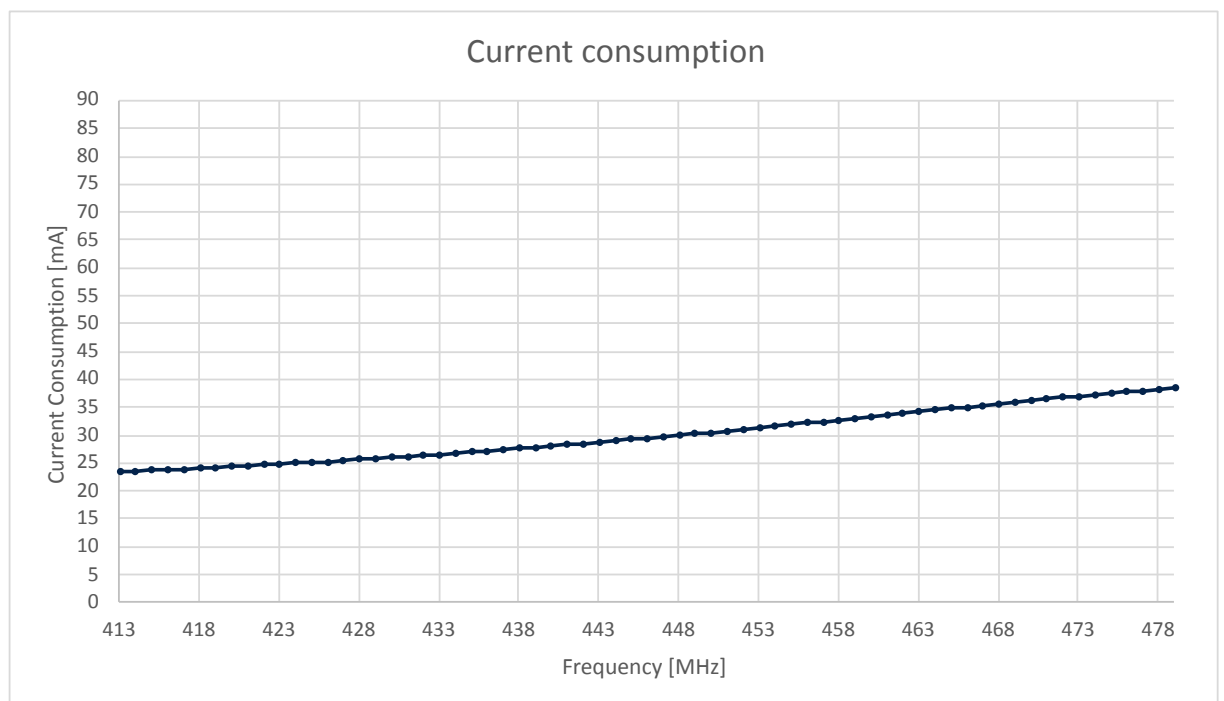


Figure 145. TX output power level, low band, TX_HP pin, degeneration mode ON

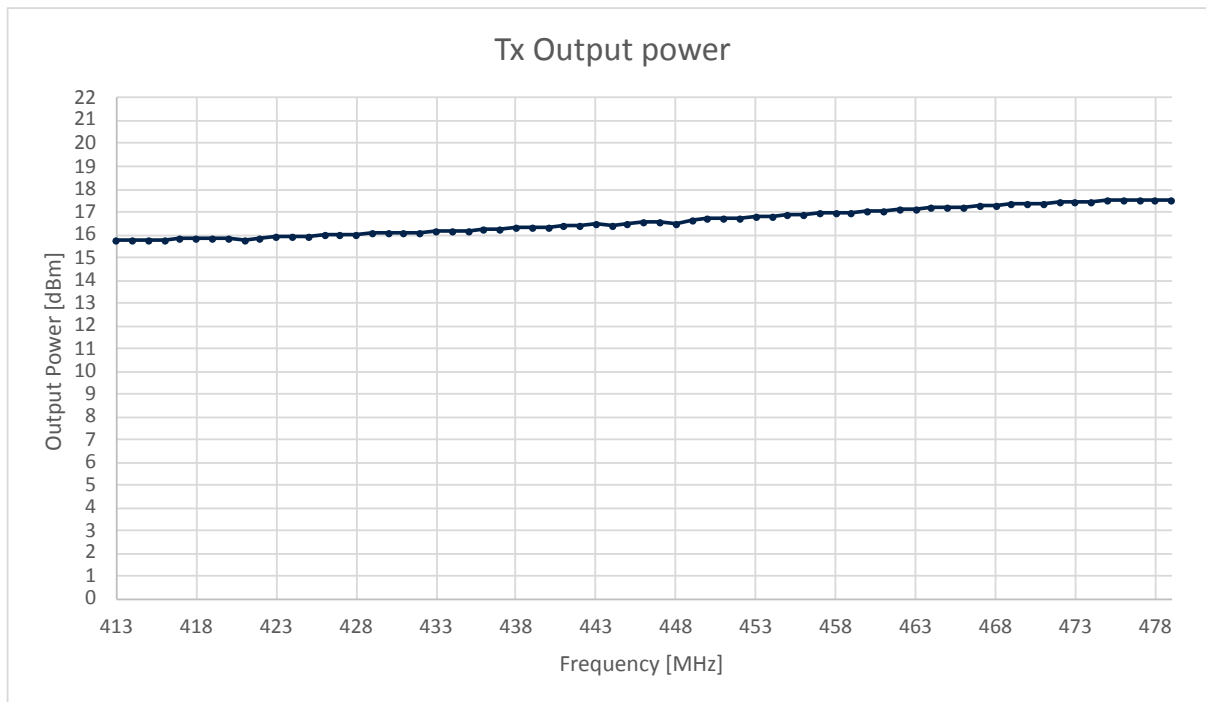


Figure 146. H2 level, low band, TX_HP pin, degeneration mode ON

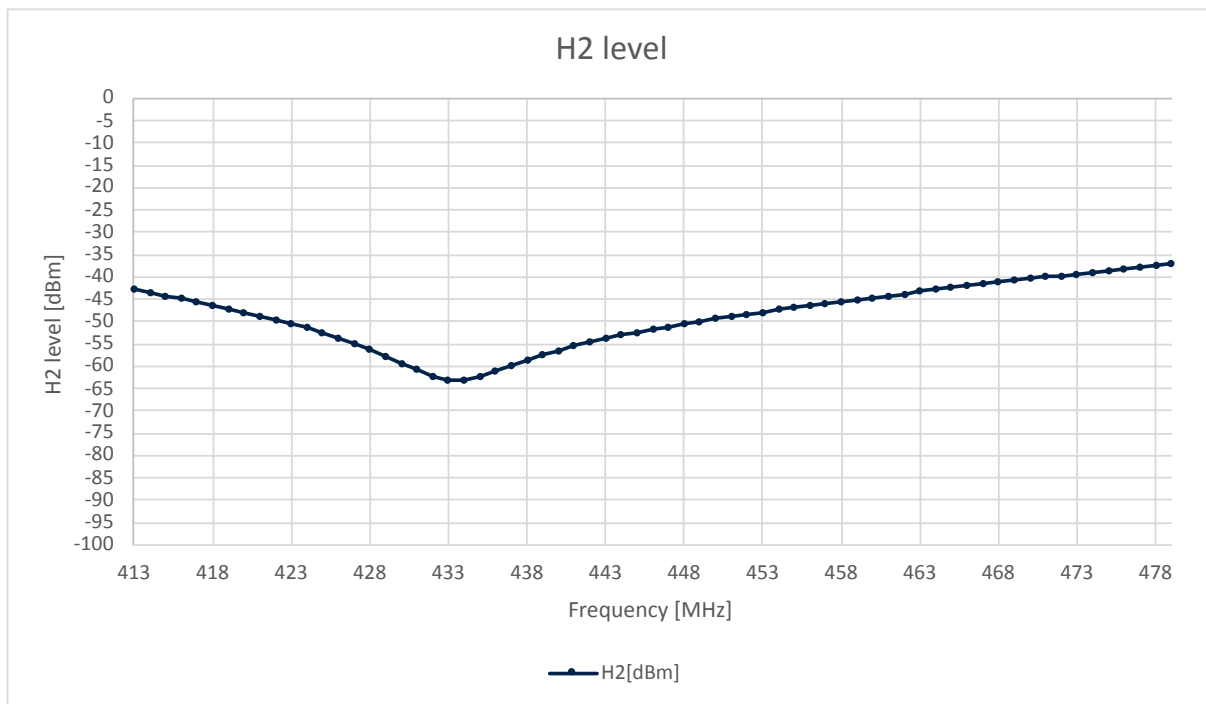


Figure 147. Harmonics level, low band, TX_HP pin, degeneration mode ON

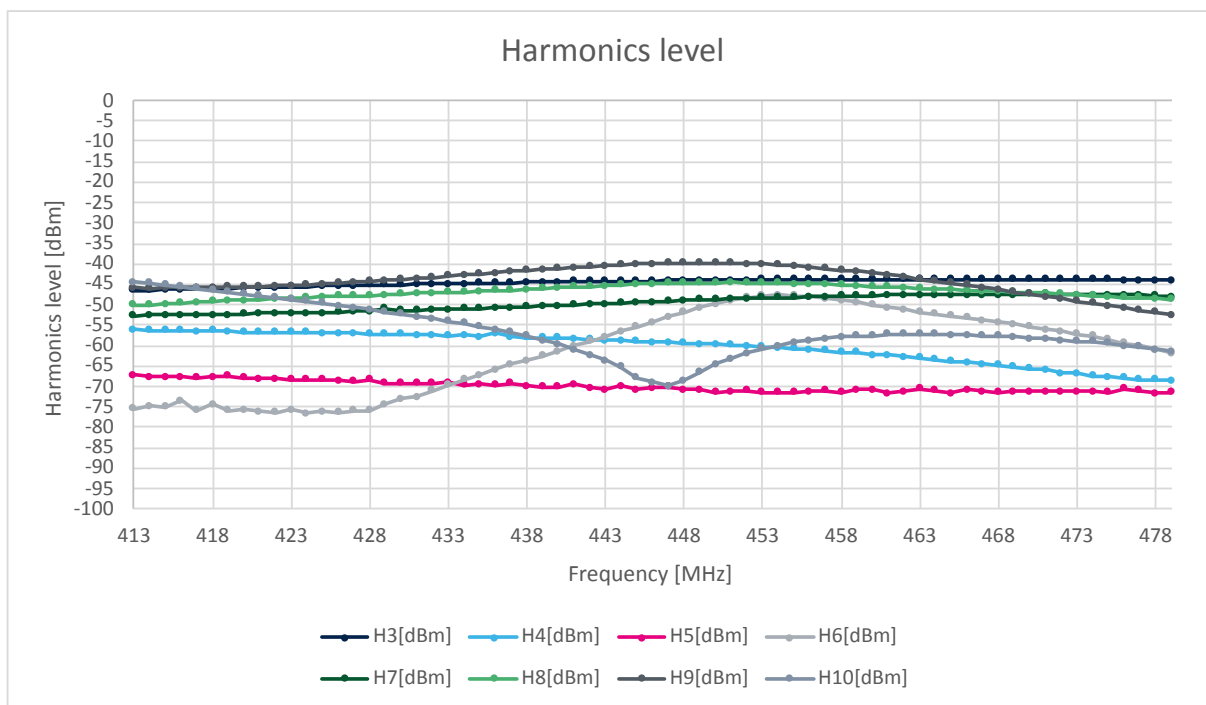


Figure 148. Current consumption in TX mode, low band, TX_HP pin, degeneration mode OFF

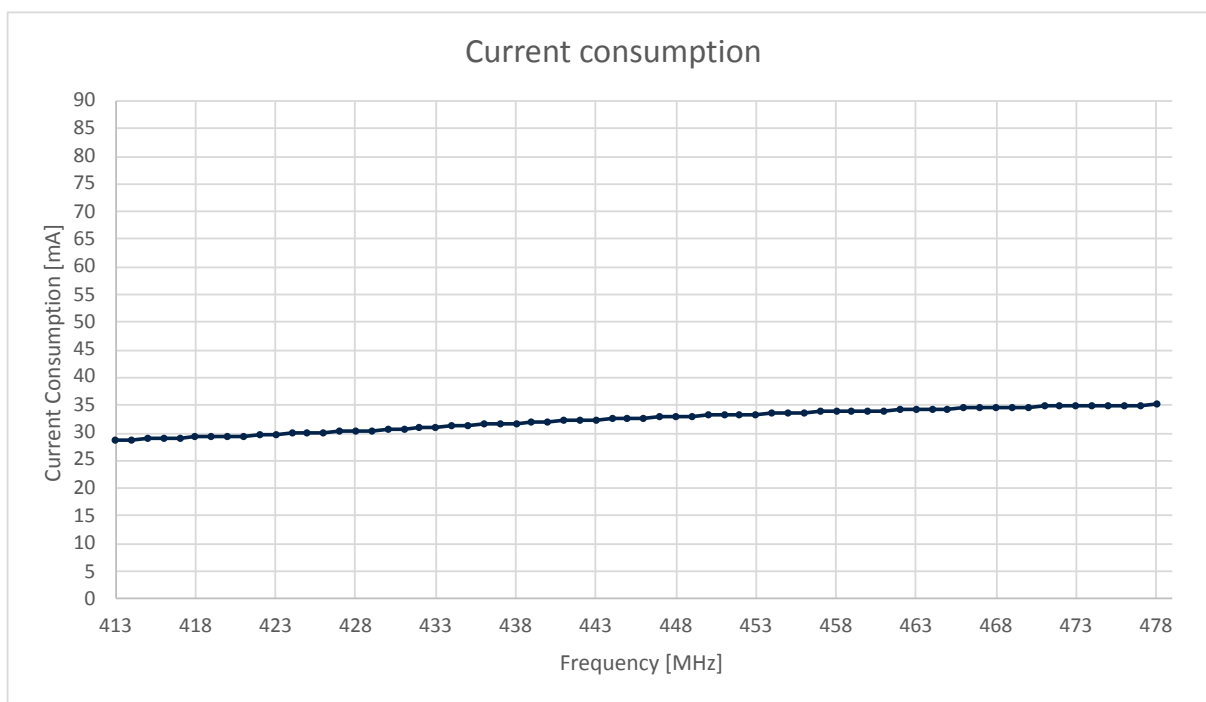


Figure 149. TX output power level, low band, TX_HP pin, degeneration mode OFF

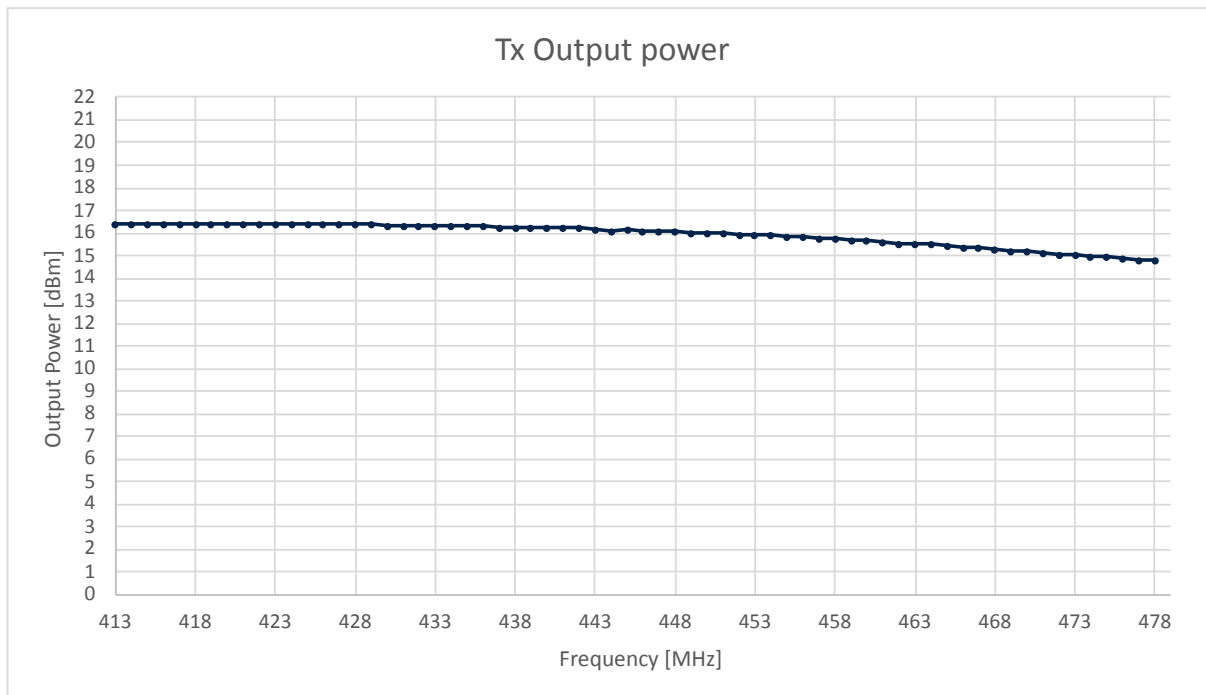


Figure 150. H2 level, low band, TX_HP pin, degeneration mode OFF

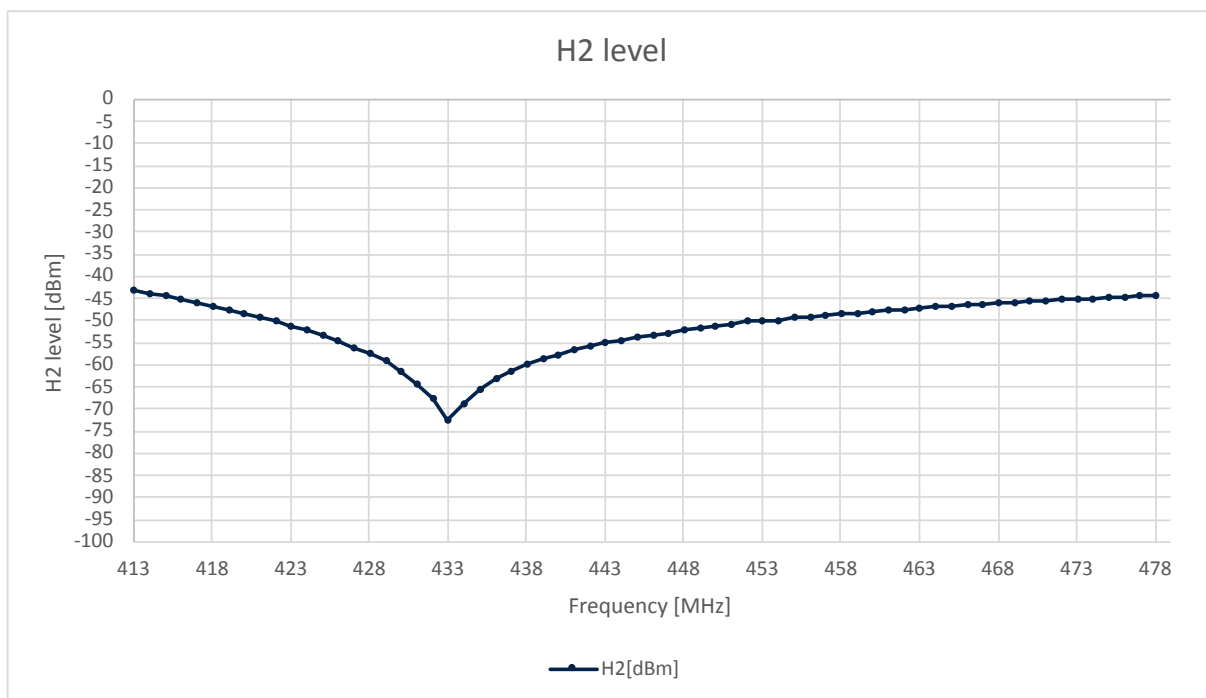


Figure 151. Harmonics level, low band, TX_HP pin, degeneration mode OFF

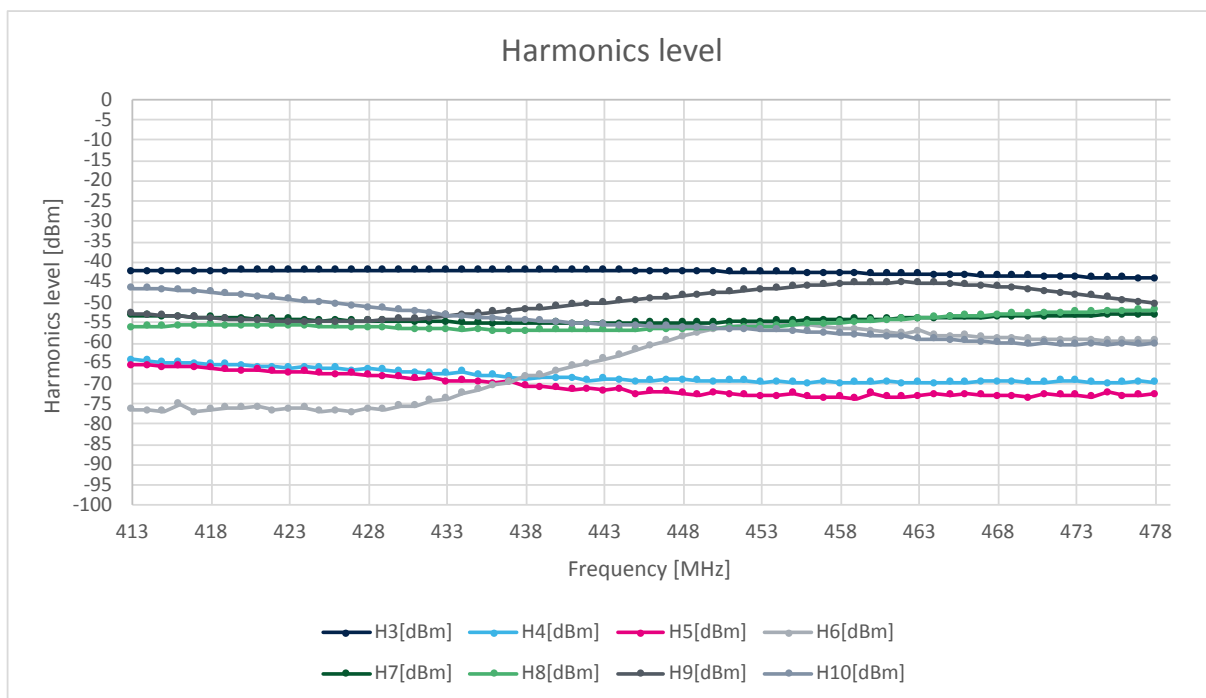
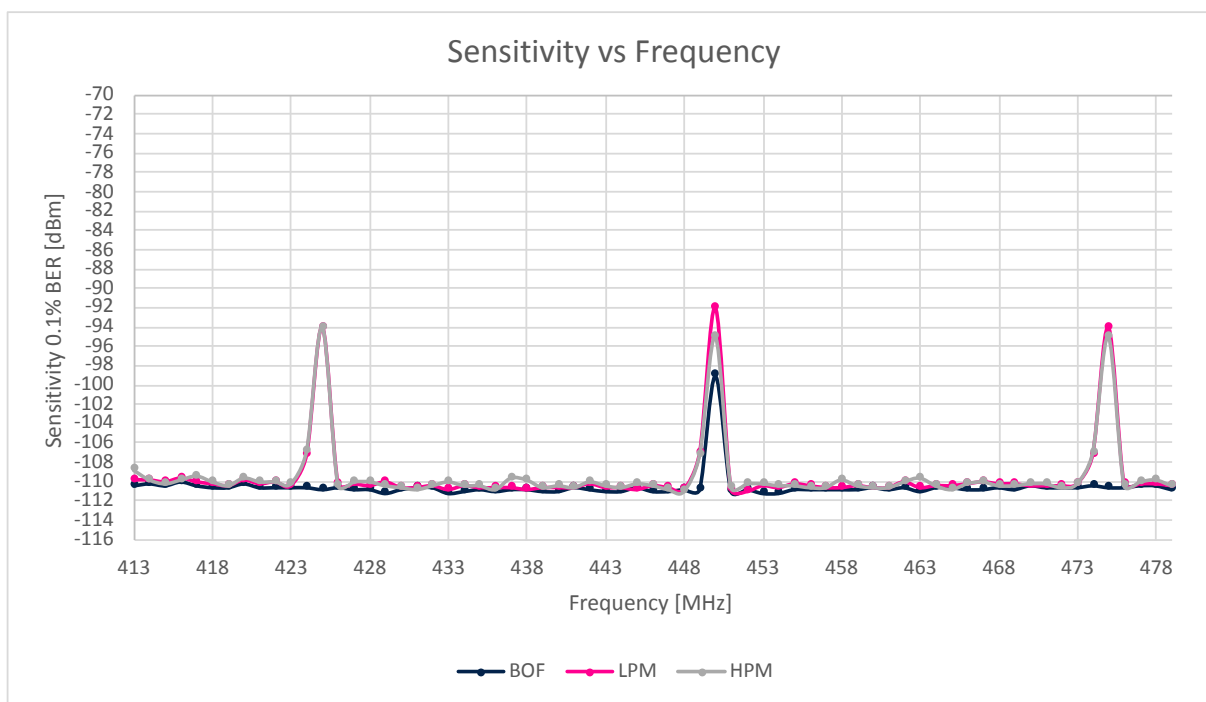


Figure 152. RX sensitivity, low band, TX_HP pin



Revision history

Table 2. Document revision history

Date	Version	Changes
24-Jul-2026	1	Initial release.

Contents

1	General information	2
2	STM32WL3x MCU register settings	3
2.1	TX radio and register setting	3
2.2	RX radio and register setting	5
3	STM32WL3x MCU transmitter output power at given center frequency	6
3.1	$F_c = 433$ MHz, TX pin	6
3.1.1	Degeneration mode ON, $F_c = 433$ MHz, TX pin	6
3.1.2	Degeneration mode OFF, $F_c = 433$ MHz, TX pin	8
3.2	$F_c = 433$ MHz, TX_HP pin	9
3.2.1	Degeneration mode ON, $F_c = 433$ MHz, TX_HP pin	9
3.2.2	Degeneration mode OFF, $F_c = 433$ MHz, TX_HP pin	11
3.3	$F_c = 868$ MHz, TX pin	12
3.3.1	Degeneration mode ON, $F_c = 868$ MHz, TX pin	12
3.3.2	Degeneration mode OFF, $F_c = 868$ MHz, TX pin	14
3.4	$F_c = 868$ MHz, TX_HP pin	15
3.4.1	Degeneration mode ON, $F_c = 868$ MHz, TX_HP pin	15
3.4.2	Degeneration mode OFF, $F_c = 868$ MHz, TX_HP pin	17
3.5	$F_c = 915$ MHz, TX and TX_HP pins	18
3.5.1	Degeneration mode ON, $F_c = 915$ MHz, TX and TX_HP pins	18
3.6	$F_c = 915$ MHz, TX pin	20
3.6.1	Degeneration mode ON, $F_c = 915$ MHz, TX pin	20
3.6.2	Degeneration mode OFF, $F_c = 915$ MHz, TX pin	21
3.7	$F_c = 169$ MHz, TX_HP pin, external power amplifier	23
3.7.1	Degeneration mode OFF, $F_c = 169$ MHz, TX_HP pin, external power amplifier	23
4	STM32WL3x MCU RX sensitivity at given center frequency	25
4.1	$F_c = 433$ MHz, TX pin	25
4.2	$F_c = 433$ MHz, TX_HP pin	26
4.3	$F_c = 868$ MHz, TX pin	27
4.4	$F_c = 868$ MHz, TX_HP pin	28
4.5	$F_c = 915$ MHz, TX and TX_HP pins	29
4.6	$F_c = 915$ MHz, TX pin	30
4.7	$F_c = 169$ MHz, TX_HP pin, external power amplifier	31
5	STM32WL3x reference designs RF performance	33

5.1	STDES-WL3C2ILL	33
5.2	STDES-WL3C2IMH	36
5.3	STDES-WL3C2IML	38
5.4	STDES-WL3C2SLH	41
5.4.1	$F_c = 868$ MHz, TX pin	41
5.4.2	$F_c = 915$ MHz, TX pin	45
5.5	STDES-WL3C2SLL	50
5.6	STDES-WL3C2SMH	54
5.7	STDES-WL3C2SML	59
5.8	STDES-WL3C4SHH	63
5.9	STDES-WL3C4SLH	66
5.10	STDES-WL3C4SLL	70
5.11	STDES-WL3C4SMH	75
5.12	STDES-WL3C4SML	79
Revision history		84

List of tables

Table 1.	Radio settings for TX operation	3
Table 2.	Document revision history	84

List of figures

Figure 1.	Current consumption in TX mode, $F_c = 433$ MHz, TX pin, degeneration mode ON	6
Figure 2.	TX output power level, $F_c = 433$ MHz, TX pin, degeneration mode ON	7
Figure 3.	Harmonic level, $F_c = 433$ MHz, TX pin, degeneration mode ON	7
Figure 4.	Current consumption in TX mode, $F_c = 433$ MHz, TX pin, degeneration mode OFF	8
Figure 5.	TX output power level, $F_c = 433$ MHz, TX pin, degeneration mode OFF	8
Figure 6.	Harmonic level, $F_c = 433$ MHz, TX pin, degeneration mode OFF	9
Figure 7.	Current consumption in TX mode, $F_c = 433$ MHz, TX_HP pin, degeneration mode ON	9
Figure 8.	TX output power level, $F_c = 433$ MHz, TX_HP pin, degeneration mode ON	10
Figure 9.	Harmonic level, $F_c = 433$ MHz, TX_HP pin, degeneration mode ON	10
Figure 10.	Current consumption in TX mode, $F_c = 433$ MHz, TX_HP pin, degeneration mode OFF	11
Figure 11.	TX output power level, $F_c = 433$ MHz, TX_HP pin, degeneration mode OFF	11
Figure 12.	Harmonic level, $F_c = 433$ MHz, TX_HP pin, degeneration mode OFF	12
Figure 13.	Current consumption in TX mode, $F_c = 868$ MHz, TX pin, degeneration mode ON	12
Figure 14.	TX output power level, $F_c = 868$ MHz, TX pin, degeneration mode ON	13
Figure 15.	Harmonic level, $F_c = 868$ MHz, TX pin, degeneration mode ON	13
Figure 16.	Current consumption in TX mode, $F_c = 868$ MHz, TX pin, degeneration mode OFF	14
Figure 17.	TX output power level, $F_c = 868$ MHz, TX pin, degeneration mode OFF	14
Figure 18.	Harmonic level, $F_c = 868$ MHz, TX pin, degeneration mode OFF	15
Figure 19.	Current consumption in TX mode, $F_c = 868$ MHz, TX_HP pin, degeneration mode ON	15
Figure 20.	TX output power level, $F_c = 868$ MHz, TX_HP pin, degeneration mode ON	16
Figure 21.	Harmonic level, $F_c = 868$ MHz, TX_HP pin, degeneration mode ON	16
Figure 22.	Current consumption in TX mode, $F_c = 868$ MHz, TX_HP pin, degeneration mode OFF	17
Figure 23.	TX output power level, $F_c = 868$ MHz, TX_HP pin, degeneration mode OFF	17
Figure 24.	Harmonic level, $F_c = 868$ MHz, TX_HP pin, degeneration mode OFF	18
Figure 25.	Current consumption in TX mode, $F_c = 915$ MHz, TX and TX_HP pins, degeneration mode ON	18
Figure 26.	TX output power level, $F_c = 915$ MHz, TX and TX_HP pins, degeneration mode ON	19
Figure 27.	Harmonic level, $F_c = 915$ MHz, TX and TX_HP pins, degeneration mode ON	19
Figure 28.	Current consumption in TX mode, $F_c = 915$ MHz, TX pin, degeneration mode ON	20
Figure 29.	TX output power level, $F_c = 915$ MHz, TX pin, degeneration mode ON	20
Figure 30.	Harmonic level, $F_c = 915$ MHz, TX pin, degeneration mode ON	21
Figure 31.	Current consumption in TX mode, $F_c = 915$ MHz, TX pin, degeneration mode OFF	21
Figure 32.	TX output power level, $F_c = 915$ MHz, TX pin, degeneration mode OFF	22
Figure 33.	Harmonic level, $F_c = 915$ MHz, TX pin, degeneration mode OFF	22
Figure 34.	Current consumption in TX mode, $F_c = 169$ MHz, TX_HP pin, external power amplifier, degeneration mode OFF	23
Figure 35.	TX output power level, $F_c = 169$ MHz, TX_HP pin, external power amplifier, degeneration mode OFF	23
Figure 36.	Harmonic level, $F_c = 169$ MHz, TX_HP pin, external power amplifier, degeneration mode OFF	24
Figure 37.	Spurs level, $F_c = 169$ MHz, TX_HP pin, external power amplifier, degeneration mode OFF	24
Figure 38.	Current consumption in RX mode $F_c = 433$ MHz, TX pin	25
Figure 39.	RX sensitivity, $F_c = 433$ MHz, TX pin	26
Figure 40.	Current consumption in RX mode, $F_c = 433$ MHz, TX_HP pin	26
Figure 41.	RX sensitivity, $F_c = 433$ MHz, TX_HP pin	27
Figure 42.	Current consumption in RX mode, $F_c = 868$ MHz, TX pin	27
Figure 43.	RX sensitivity, $F_c = 868$ MHz, TX pin	28
Figure 44.	Current consumption in RX mode, $F_c = 868$ MHz, TX_HP pin	28
Figure 45.	RX sensitivity, $F_c = 868$ MHz, TX_HP pin	29
Figure 46.	Current consumption in RX mode, $F_c = 915$ MHz, TX and TX_HP pins	29
Figure 47.	RX sensitivity, $F_c = 915$ MHz, TX and TX_HP pins	30
Figure 48.	Current consumption in RX mode, $F_c = 915$ MHz, TX pin	30
Figure 49.	RX sensitivity, $F_c = 915$ MHz, TX pin	31
Figure 50.	Current consumption in RX mode, TX_HP pin, external power amplifier	31
Figure 51.	RX sensitivity, $F_c = 169$ MHz, TX_HP pin, external power amplifier	32

Figure 52.	Current consumption in TX mode, Low band, TX pin, degeneration mode ON	33
Figure 53.	TX output power level, low band, TX pin, degeneration mode ON	34
Figure 54.	H2 level, low band, TX pin, degeneration mode ON	34
Figure 55.	Harmonics level, low band, TX pin, degeneration mode ON	35
Figure 56.	RX sensitivity, low band, TX pin	35
Figure 57.	Current consumption in TX mode, high band, TX_HP pin, degeneration mode ON	36
Figure 58.	TX output power level, high band, TX_HP pin, degeneration mode ON	36
Figure 59.	H2 level, high band, TX_HP pin, degeneration mode ON	37
Figure 60.	Harmonics level, high band, TX_HP pin, degeneration mode ON	37
Figure 61.	RX sensitivity, high band, TX_HP pin	38
Figure 62.	Current consumption in TX mode, low band, TX_HP pin, degeneration mode ON	38
Figure 63.	TX output power level, low band, TX_HP pin, degeneration mode ON	39
Figure 64.	Harmonics level, low band, TX_HP pin, degeneration mode ON	39
Figure 65.	Harmonics level, low band, TX_HP pin, degeneration mode ON	40
Figure 66.	RX sensitivity, low band, TX_HP pin	40
Figure 67.	Current consumption in TX mode, high band, $F_c = 868$ MHz, TX pin, degeneration mode ON	41
Figure 68.	TX output power level, high band, $F_c = 868$ MHz, TX pin, degeneration mode ON	41
Figure 69.	H2 level, high band, $F_c = 868$ MHz, TX pin, degeneration mode ON	42
Figure 70.	Harmonics level, high band, $F_c = 868$ MHz, TX pin, degeneration mode ON	42
Figure 71.	Current consumption in TX mode, high band, $F_c = 868$ MHz, TX pin, degeneration mode OFF	43
Figure 72.	TX output power level, high band, $F_c = 868$ MHz, TX pin, degeneration mode OFF	43
Figure 73.	H2 level, high band, $F_c = 868$ MHz, TX pin, degeneration mode OFF	44
Figure 74.	Harmonics level, high band, $F_c = 868$ MHz, TX pin, degeneration mode OFF	44
Figure 75.	RX sensitivity, high band, $F_c = 868$ MHz, TX pin	45
Figure 76.	Current consumption in TX mode, high band, $F_c = 915$ MHz, TX pin, degeneration mode ON	45
Figure 77.	TX output power level, high band, $F_c = 915$ MHz, TX pin, degeneration mode ON	46
Figure 78.	H2 level, high band, $F_c = 915$ MHz, TX pin, degeneration mode ON	46
Figure 79.	Harmonics level, high band, $F_c = 915$ MHz, TX pin, degeneration mode ON	47
Figure 80.	Current consumption in TX mode, high band, $F_c = 915$ MHz, TX pin, degeneration mode OFF	47
Figure 81.	TX output power level, high band, $F_c = 915$ MHz, TX pin, degeneration mode OFF	48
Figure 82.	H2 level, high band, $F_c = 915$ MHz, TX pin, degeneration mode OFF	48
Figure 83.	Harmonics level, high band, $F_c = 915$ MHz, TX pin, degeneration mode OFF	49
Figure 84.	RX sensitivity, high band, $F_c = 915$ MHz, TX pin	49
Figure 85.	Current consumption in TX mode, low band, TX pin, degeneration mode ON	50
Figure 86.	TX output power level, low band, TX pin, degeneration mode ON	50
Figure 87.	H2 level, low band, TX pin, degeneration mode ON	51
Figure 88.	Harmonics level, low band, TX pin, degeneration mode ON	51
Figure 89.	Current consumption in TX mode, low band, TX pin, degeneration mode OFF	52
Figure 90.	TX output power level, low band, TX pin, degeneration mode OFF	52
Figure 91.	H2 level, low band, TX pin, degeneration mode OFF	53
Figure 92.	Harmonics level, low band, TX pin, degeneration mode OFF	53
Figure 93.	RX sensitivity, low band, TX pin	54
Figure 94.	Current consumption in TX mode, high band, TX_HP pin, degeneration mode ON	54
Figure 95.	TX output power level, high band, TX_HP pin, degeneration mode ON	55
Figure 96.	H2 level, high band, TX_HP pin, degeneration mode ON	55
Figure 97.	Harmonics level, high band, TX_HP pin, degeneration mode ON	56
Figure 98.	Current consumption in TX mode, high band, TX_HP pin, degeneration mode OFF	56
Figure 99.	TX output power level, high band, TX_HP pin, degeneration mode OFF	57
Figure 100.	H2 level, high band, TX_HP pin, degeneration mode OFF	57
Figure 101.	Harmonics level, high band, TX_HP pin, degeneration mode OFF	58
Figure 102.	RX sensitivity, high band, TX_HP pin	58
Figure 103.	Current consumption in TX mode, low band, TX_HP pin, degeneration mode ON	59
Figure 104.	TX output power level, low band, TX_HP pin, degeneration mode ON	59
Figure 105.	H2 level, low band, TX_HP pin, degeneration mode ON	60

Figure 106.	Harmonics level, low band, TX_HP pin, degeneration mode ON	60
Figure 107.	Current consumption in TX mode, low band, TX_HP pin, degeneration mode OFF	61
Figure 108.	TX output power level, low band, TX_HP pin, degeneration mode OFF	61
Figure 109.	H2 level, low band, TX_HP pin, degeneration mode OFF	62
Figure 110.	Harmonics level, low band, TX_HP pin, degeneration mode OFF	62
Figure 111.	RX sensitivity, low band, TX_HP pin	63
Figure 112.	Current consumption in TX mode, high band, TX and TX_HP pins, degeneration mode ON	63
Figure 113.	TX output power level, high band, TX and TX_HP pins, degeneration mode ON	64
Figure 114.	H2 level, high band, TX and TX_HP pins, degeneration mode ON	64
Figure 115.	Harmonics level, high band, TX and TX_HP pins, degeneration mode ON	65
Figure 116.	RX sensitivity, high band, TX and TX_HP pins	65
Figure 117.	Current consumption in TX mode, high band, TX pin, degeneration mode ON	66
Figure 118.	TX output power level, high band, TX pin, degeneration mode ON	66
Figure 119.	H2 level, high band, TX pin, degeneration mode ON	67
Figure 120.	Harmonics level, high band, TX pin, degeneration mode ON	67
Figure 121.	Current consumption in TX mode, high band, TX pin, degeneration mode OFF	68
Figure 122.	TX output power level, high band, TX pin, degeneration mode OFF	68
Figure 123.	H2 level, high band, TX pin, degeneration mode OFF	69
Figure 124.	Harmonics level, high band, TX pin, degeneration mode OFF	69
Figure 125.	RX sensitivity, high band, TX pin	70
Figure 126.	Current consumption in TX mode, low band, TX pin, degeneration mode ON	70
Figure 127.	TX output power level, low band, TX pin, degeneration mode ON	71
Figure 128.	H2 level, low band, TX pin, degeneration mode ON	71
Figure 129.	Harmonics level, low band, TX pin, degeneration mode ON	72
Figure 130.	Current consumption in TX mode, low band, TX pin, degeneration mode OFF	72
Figure 131.	TX output power level, low band, TX pin, degeneration mode OFF	73
Figure 132.	H2 level, low band, TX pin, degeneration mode OFF	73
Figure 133.	Harmonics level, low band, TX pin, degeneration mode OFF	74
Figure 134.	RX sensitivity, low band, TX pin	74
Figure 135.	Current consumption in TX mode, high band, TX_HP pin, degeneration mode ON	75
Figure 136.	TX output power level, high band, TX_HP pin, degeneration mode ON	75
Figure 137.	H2 level, high band, TX_HP pin, degeneration mode ON	76
Figure 138.	Harmonics level, high band, TX_HP pin, degeneration mode ON	76
Figure 139.	Current consumption in TX mode, high band, TX_HP pin, degeneration mode OFF	77
Figure 140.	TX output power level, high band, TX_HP pin, degeneration mode OFF	77
Figure 141.	H2 level, high band, TX_HP pin, degeneration mode OFF	78
Figure 142.	Harmonics level, high band, TX_HP pin, degeneration mode OFF	78
Figure 143.	RX sensitivity, high band, TX_HP pin	79
Figure 144.	Current consumption in TX mode, low band, TX_HP pin, degeneration mode ON	79
Figure 145.	TX output power level, low band, TX_HP pin, degeneration mode ON	80
Figure 146.	H2 level, low band, TX_HP pin, degeneration mode ON	80
Figure 147.	Harmonics level, low band, TX_HP pin, degeneration mode ON	81
Figure 148.	Current consumption in TX mode, low band, TX_HP pin, degeneration mode OFF	81
Figure 149.	TX output power level, low band, TX_HP pin, degeneration mode OFF	82
Figure 150.	H2 level, low band, TX_HP pin, degeneration mode OFF	82
Figure 151.	Harmonics level, low band, TX_HP pin, degeneration mode OFF	83
Figure 152.	RX sensitivity, low band, TX_HP pin	83

IMPORTANT NOTICE – READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice.

In the event of any conflict between the provisions of this document and the provisions of any contractual arrangement in force between the purchasers and ST, the provisions of such contractual arrangement shall prevail.

The purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgment.

The purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of the purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

If the purchasers identify an ST product that meets their functional and performance requirements but that is not designated for the purchasers' market segment, the purchasers shall contact ST for more information.

ST and the ST logo are trademarks of ST. For additional information about ST trademarks, refer to www.st.com/trademarks. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2026 STMicroelectronics – All rights reserved