4. BK2401/BK2421 Module RF test

BK2401/BK2421 Module RF performance tests including transmit power (Power) Frequency (Frequency) and sensitivity (Sensitivity) test, and FCC / CE testing major FAIL in the harmonic power than standard, this section will detail the test method and module test results.

4.1. Test Preparation

General laboratory tests for the RF transmission (Conducted) test, the first through the RF cable connected to an external SMA test equipment, necessary for the Module directly from the matching circuit C5, C6 solder pad between the RF line, and with the PIFA antenna Disconnect (remove L4), radio frequency line near the shell to need to take Module, the next picture shows the conduction welding test images:

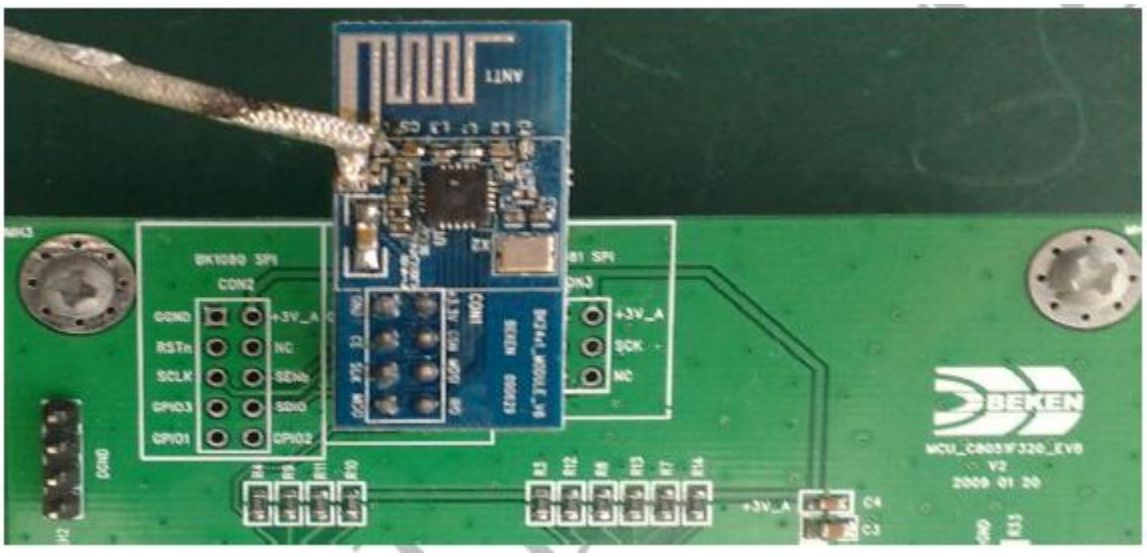


Figure 6 RF conducted test image test will need the following equipment:

- RF test line: the need for specialized RF test line, and need to know the test frequency insertion loss (IL).
- spectrum analyzer (for measuring emission): 2.4G measured carrier signal, the maximum frequency of at least 3GHz, to test the fifth harmonics, the maximum frequency of at least 13GHz, specific equipment types such as Agilent PSA, ESA series spectrum analyzer.
- vector signal generator (used to measure receiver performance): the highest frequency of at least 3GHz, must Custom (I / Q) setup modulation option, specific equipment types such as Agilent E4438C.

4.2. Transmit power frequency test

4.2.1. Transmit power frequency test block diagram

BK2401/BK2421 the DEMO board with the host via USB connected to the RF spectrum analyzer through the line and the DEMO board SMA port connected.

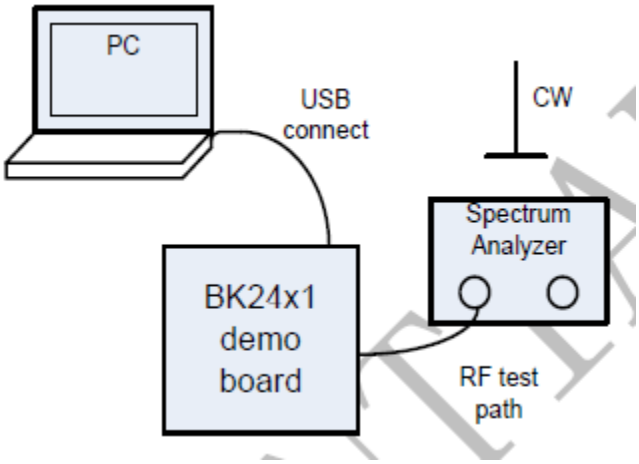


Table 7 transmit power frequency test block diagram

4.2.2. Transmit power frequency test procedures

Transmitter output power testing needs BK24x1 single-carrier signal, the register set to see the reference document [3] Carrier_Test ()

Function or directly refer to document [4] Demo software directly billing the carrier;

The following specific steps:

(1) set the chip in the fire status: Write Bank0_REG0_Bit0 = 0; pulled CE = 1, so that the rising edge CE;

(2) to set the channel and frequency tests: Write Bank0_REG5 [6:0] = 0x28 = 40, corresponding to the frequency Frf = (2400 +40)

MHz;

(3) Set the chip in a single-carrier transmitter: Write Bank1_REG4 = 0XD99E8621; such as using software to switch to Demo

"ACK / NoACK Mode Test" interface, the point of Carrier Test-Start button to export a single carrier;

(4) spectrum analyzer settings:

- Frequency center = Frequency at Max Amplitude, such as 2440MHz at channel 40;
- Span <10MHz;
- RBW <100kHz, can be set to Auto;

(5) record the frequency of the power values and the corresponding frequency values, frequency values need to be resolved to 1KHz, by changing the 2) channel values

Testing of low, medium and high channel power value, which transmit frequency Frf = (2400 + channel) MHz.

4.3. Receiver sensitivity test

4.3.1. Receiver sensitivity test method

Receiver sensitivity (Sensitivity) is the bit error rate when the receiver (BER: Bit Error Rate) of 0.1% of the input signal strength

Degrees. Sensitivity can be calculated by the following three methods:

(1) obtained by PER BER:

According to packet error rate BER (PER: Packet Error Rate) calculation, the following formula

PER = 1 - (0.999 ^ N)

Where N is the total bits number for each packet, the PER value that corresponds to 0.1% BER.

This test method should not use the ACK and retransmission, since the results of using this method is very accurate, so the package should be sent as possible

Can have more (eg, 10,000 packets).

(2) Software Bits number of statistical error are BER:

Transmitter continuously transmitting packets to the receiver, the receiver RX chip initial configuration is: No-Ack, 10bit preamble, 3bytes to

Address field, 32bytes packet length, No CRC.

After reading the RX packet received, compared with the actual package is known, calculate the number of error bits to calculate the BER. As

The testing accuracy, the proposed number of bits sent at least 1000.

The testing method is relatively complicated, but the results are more accurate.

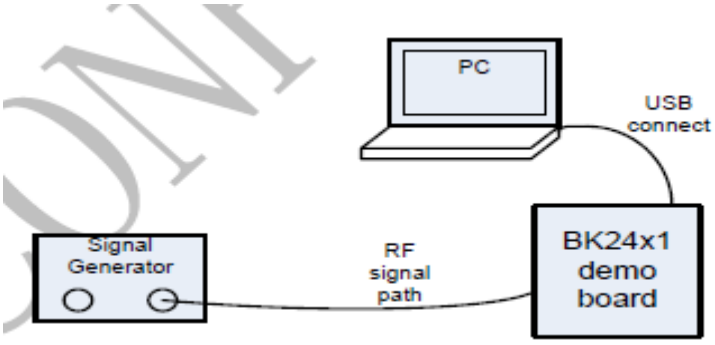
(3) the number of bits of hardware statistical errors are BER:

BK2401/BK2421 chip hardware support for bit stream itself, the statistics can be directly used to estimate BER, the method is most accurate,

But the need to use a special signal generator PN9 signals, and needs to software programming, so that the chip into the BER test mode.

Here are the unique chip hardware BK2401/BK2421 BER calculation method, the receiver sensitivity test block diagram is as follows:

BK2401/BK2421 the DEMO board connected via USB with the host, the signal source through the RF line and the DEMO board SMA port connected.



Receiver sensitivity test chart diagram 8

4.3.2. Receiver sensitivity test procedure

(1) set the chip in the receiving state:

Write Bank0_REG0_Bit0 = 1; pulled CE = 1, so that the rising edge CE;

(2) Set the chip operates at 1Mbps or 2Mbps rate:

Bank0_REG6_Bit3 = 0 / 1; (Note BK2401 supports 1Mbps, BK2421 supports 1Mbps and 2Mbps);

(3) Working frequency calculation:

Since the frequency deviation will affect the sensitivity of the test, so the frequency Frf be received according to the actual frequency of Frxlo RX LO leakage to calculate, Frxlo need to use the frequency spectrum analyzer test, test, test block diagram block diagram of the same transmission power, the chip receiving mode, frequency range of the spectrum analyzer will be received between 2550 ~ 2650MHz LO of the single-carrier signal. Set Spectrum Analyzer Span <1MHz, Ref Amplitude =-50dBm, read out the exact frequency value Frxlo resolution to 1KHz, then the following formula Frf the value of the input to the signal source frequency settings: 1Mbps Mode: Frf = Frxlo * 15/16 +1 MHz 2Mbps Mode: Frf = Frxlo * 15/16 +2 MHz

*(4) the Module re-connected to the receiver sensitivity test block diagram, set the vector signal generator E4438C * as follows:*

- Input Frequency: Frf ((3) in the calculation of the input RF frequency)
- Data: PN9
- Filter: Gaussian
- Filter Bbt: 1
- Symbol Rate: 1Msps or 2Msps
- Modulation Type: 2-Lvl FSK
- Freq Dev: 300kHz for 1Msps 600kHz for 2Msps

(5) Demo software to switch to "ACK / NoACK Mode Test" interface, the point of the bit error rate BER Test-Start button, then the Read button, and adjust the signal generator output power until the BER value of 0.001, the signal generator power value is the sensitivity value, remember that the line need to lose the RF insertion loss.

Demo software, if not through their own software control, see reference document [3] BER_Test () function, which for some time to read the chip number and receive the total bit error bit number, the user can easily calculate BER.

(6) by changing the channel values for frequency, repeat (4), (5), (6) measured the low, middle and high receiver sensitivity channel.

Vector signal generator E4438C *: E4438C without similar instruments, available as an alternative source other BK2421 to send PN9 sequence, set the registers as follows: Bank1_REG1 = 0x00004B0C; Bank1_REG2 = 0x028CFCA0; Bank1_REG12 = 0x10127300, and then go to step (5) , (6) measuring the received signal. But this case can only be judged qualitatively receiver chip performance: as with the BK2421 as the signal source, the best receiver chip BER (ie launch large-signal) only to 2%, and the minimum BER (ie by firing small attenuator signal) corresponding only to the receiver sensitivity is about-80dBm. According to this method, the user can measure the reception of qualitative performance chip with normal test results can be compared quantitatively determine the relative performance of the chip receiver.

5. How to have FCC and CE standards

CE standards than the FCC demanding standards, so this part of the FCC as an example, FCC specifications on the 2.4G ISM band main reference FCC section 15.247 and 15.249, ISM operating band for the 2400MHz ~ 2483.5MHz. In the FCC standards, the most likely target is to launch spurious FAIL especially the magnitude of higher harmonics easily exceed the standard range, to lead the most critical is the FCC standard transmission (connection) test results compared with the FCC standards need to have enough margin (at least 5dB), if the test conditions, it at least the following points:

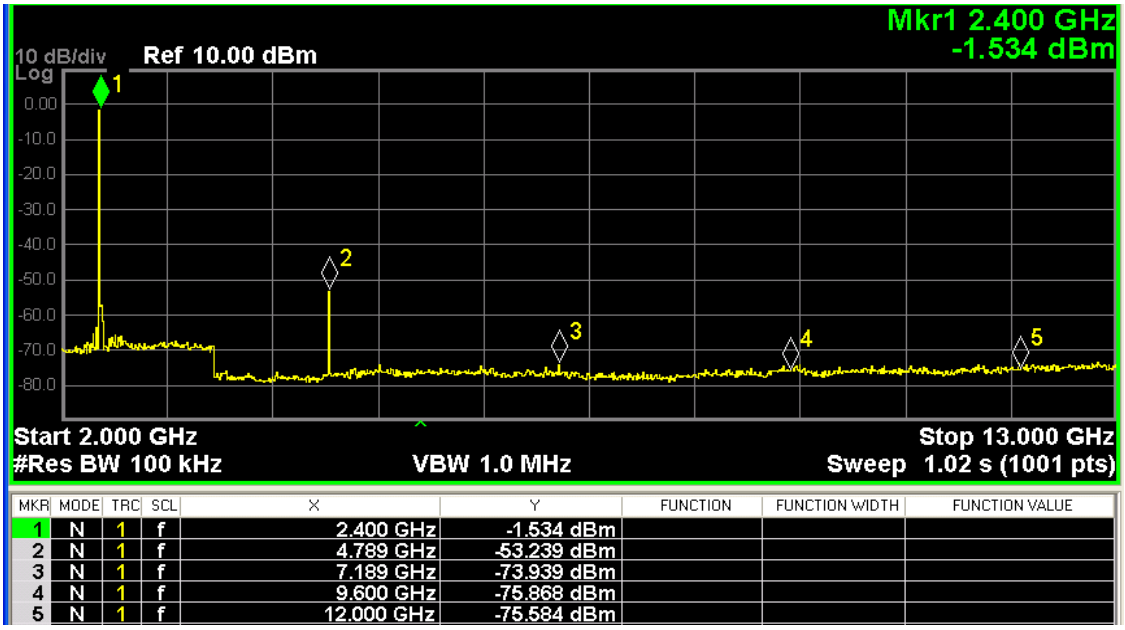
- part of the RF matching circuit schematic and layout of the document in exactly the same matching circuit layout and wiring, if you need to re-commissioning of different component values;
- transmit power up to 0dBm: Bank0_REG6 [2:1] = 2;
- emission test mode and turn off the receiver, or RX local oscillator leakage in excess of the standard: Bank0_REG0 [0] = 0;

Because each customer's plate and components used are not the same, so the correct way is to meet in the case of the above points, debug, test results conducted with the FCC has sufficient margin compared to the standard, and mass production with the same soldering (the same brand of equal value.) Part of the RF matching circuit schematic and layout see reference document [2].

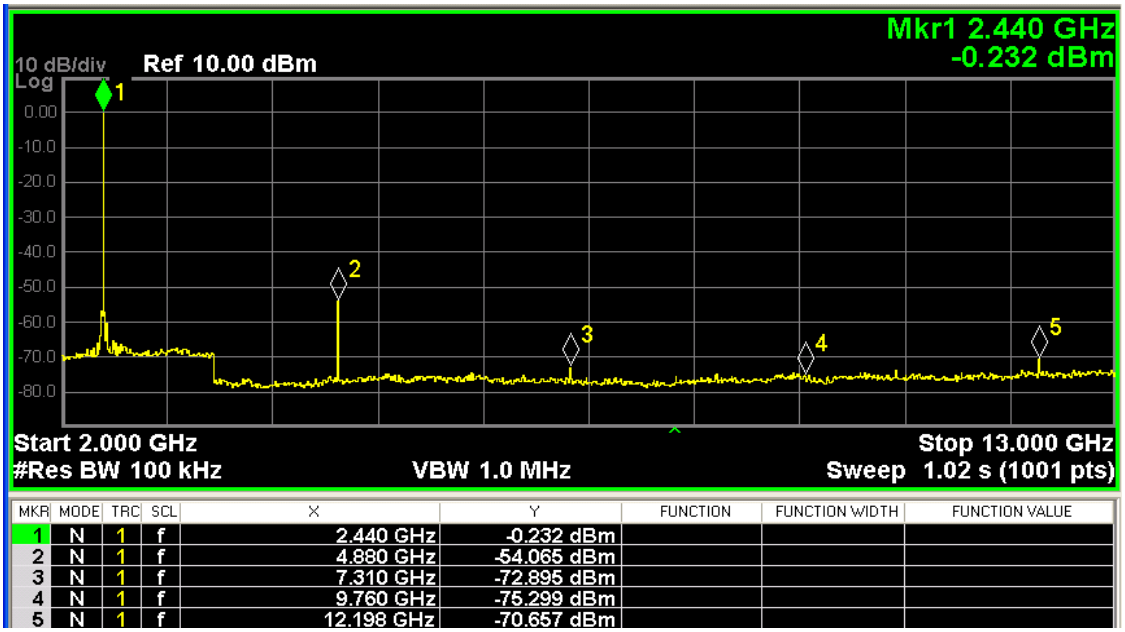
5.1. Conducted spurious results

Conducted spurious test of weld head with SMA RF cable to the spectrum analyzer to test transmission power, please refer to the previous test the specific preparation and transmission power frequency test. Needs to be calibrated before each test frequency line loss, the following are low, medium, high channel spurious test results conducted under the example:

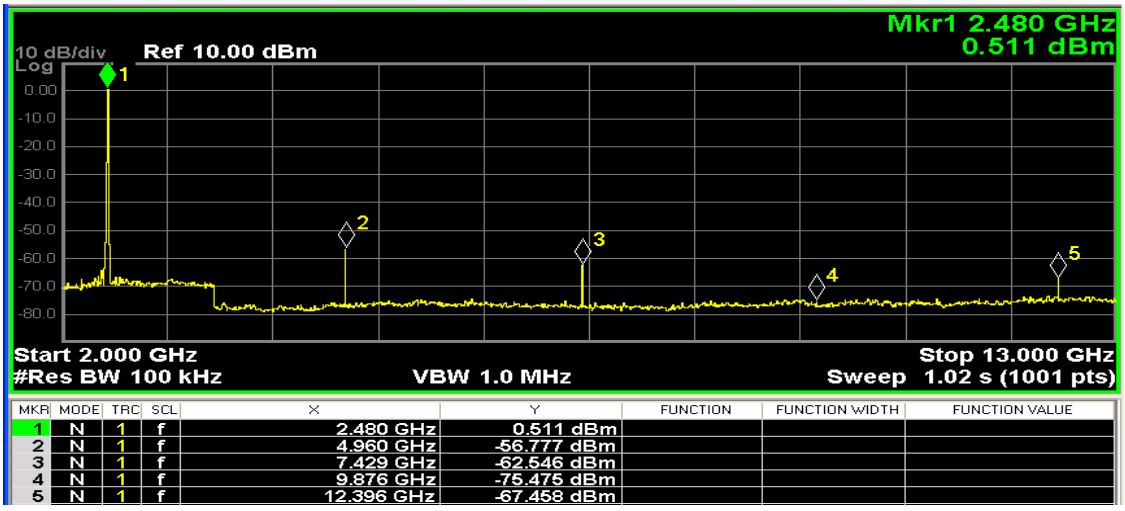
Carrier frequency	**Harmonic frequency**	**FCC requirements: <-41.2dBm**		**CE requirements: <-30dBm**	
(MHz)	(MHz)	Measured (dBm)	Margin (dB)	Measured (dBm)	Margin (dB)
2400 (Low channel)	4800	-53	**12**	-53	**23**
	7200	-73	**32**	-73	**43**
	9600	-75	**34**	-75	**45**
	12000	-75	**34**	-75	**45**
2440 (CITIC Road)	4880	-54	**13**	-54	**24**
	7320	-72	**31**	-72	**42**
	9760	-75	**34**	-75	**45**
	12200	-70	**29**	-70	**40**
2480 (high channel)	4960	-56	**15**	-56	**26**
	7440	-62	**21**	-62	**32**
	9920	-75	**34**	-75	**45**
	12400	-67	**26**	-67	**37**



MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	2.400 GHz	-1.534 dBm			
2	N	1	f	4.789 GHz	-53.239 dBm			
3	N	1	f	7.189 GHz	-73.939 dBm			
4	N	1	f	9.600 GHz	-75.868 dBm			
5	N	1	f	12.000 GHz	-75.584 dBm			



MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	2.440 GHz	-0.232 dBm			
2	N	1	f	4.880 GHz	-54.065 dBm			
3	N	1	f	7.310 GHz	-72.895 dBm			
4	N	1	f	9.760 GHz	-75.299 dBm			
5	N	1	f	12.198 GHz	-70.657 dBm			



MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	2.480 GHz	0.511 dBm			
2	N	1	f	4.960 GHz	-56.777 dBm			
3	N	1	f	7.429 GHz	-62.546 dBm			
4	N	1	f	9.876 GHz	-75.475 dBm			
5	N	1	f	12.396 GHz	-67.458 dBm			

Figure 9 Test results conducted spurious

5.2. Radiated spurious results

As for the PCB board antenna BK2401/BK2421 antenna, it is generally FCC radiation tests had been the case (3 m space radiation, see below) of the test, while the antenna gain is taken into account, so no additional instructions on the antenna . As the strongest harmonic radiation for the second and third harmonic, so the stray radiation in this example test the main content of the test in two, the third harmonic radiation.

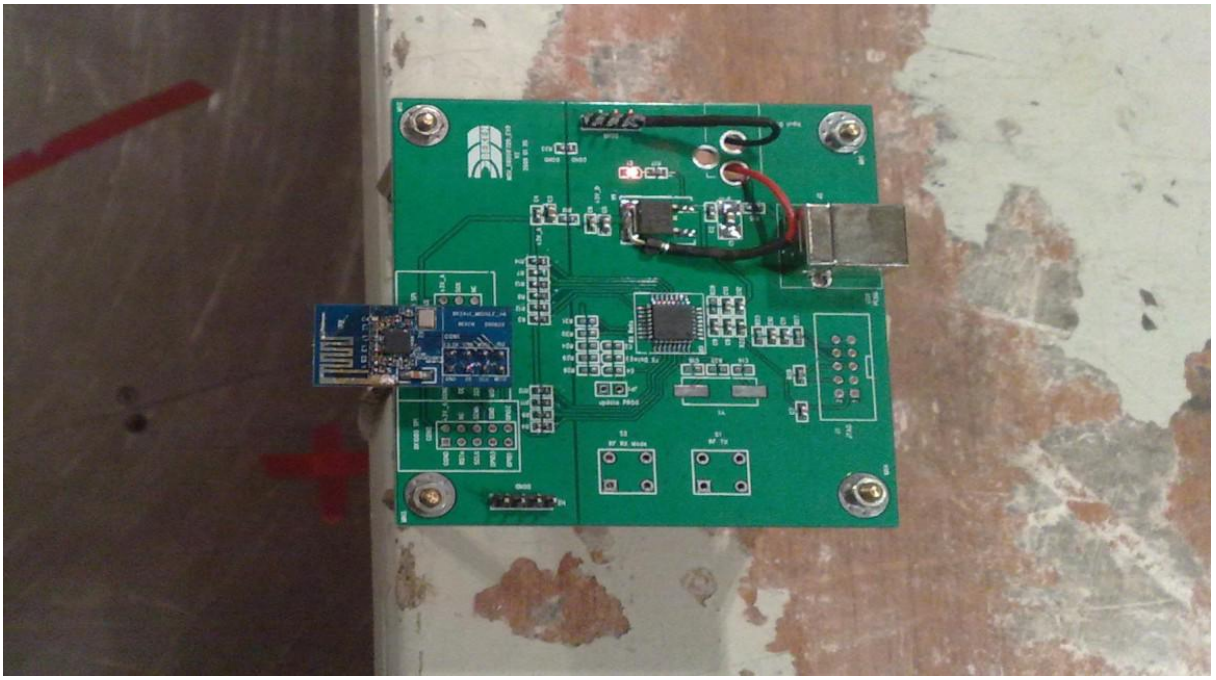


Photo Exhibit 10 FCC radiation tests

FCC test for the detection of power signal in two ways: Peak Detector (peak detector) and the Average Detector (average test), Average for the actual working conditions under which the average

signal radiation power, such as the wireless mouse is assumed to send a signal every 8ms, This value is then sent in the power of 8ms 8ms within the time period average, and Peak is the maximum transmitting power burst, these values are in the test under different heights in the whole direction of maximum value MAX Hold. Usually required in the test standard Peak power Average power is greater than 20dB, while the actual product which is greater than Average power Peak power is: Pincrease = 20 * log ((Ton Toff) / Ton) Ton for the power transmission time, Toff for the FCC launched an interval so in the test, the need to use the actual product launch in normal mode, send the data as a test model for testing, rather than fat as the Peak and Average single-carrier testing mode; due to normal launch, the launch will be ON PA / OFF lead emission spectrum broadens, so low, medium and high frequency-selective channel will not be too close to the ISM band on the edge of the frequency channel selection is lower than 2402MHz, and the high channel is less than 2480MHz, to prevent leakage outside the ISM band sideband more than the standard. Average values with the actual product-related, so the following example, the test results for the values under the single-carrier emission, which corresponds to the value of Peak Standard, can be seen from the results, even BK2401/BK2421 Module fired power values under the single-carrier Under the Average has considerable margin.

Carrier frequency	**Harmonic frequency**	**FCC requirements:** <74dBuV / m @ 3m (Peak Detector) <54dBuV / m @ 3m (Average Detector)		
(MHz)	(MHz)	Measurement (dBuV)	Peak Detector margin (dB)	Aver Detector margin (dB)
2400 (Low channel)	4800	50	**24**	**4**
	7200	40	**34**	**14**
2440 (CITIC Road)	4880	49	**25**	**5**
	7320	39	**35**	**15**
2480 (high channel)	4960	46	**28**	**8**
	7440	38	**36**	**16**

Figure 11 Radiated spurious results

5.3. FCC testing before Checklist

When ready been FCC test, check whether the product works in the following pattern:

- transmit power up to 0dBm: Bank0_REG6_Bit [2:1] value is less than or equal to 2;
- emission test mode and turn off the receiver, or RX local oscillator leakage in excess of the standard: Bank0_REG0 [0] = 0;
- product testing model requires the normal operating mode, namely a way to simulate real data, rather than just as a test model made a single carrier;
- FCC need to test the low, medium and high three channels, the product needs of a button can switch to a different channel, channel frequency selective recommend at least leave the ISM frequency of 2MHz over the edge;
- test products need power supply of the product (such as batteries), rather than using other products (such as a laptop) as a power source;

If the above settings have been completed, please ensure that the transmission in their own lab tests no problem:

- If the test conditions permit, the conduction test results compared with the FCC standards for adequate margin (at least 5dB);
- If no test conditions required at least part of the RF matching circuit schematic and layout of the document matching exactly the same circuit layout and wiring, if not the same as you always have to have pre-qualified laboratory testing.