The spectrum for VNWA2 and VNWA3 pending frequency and multiplier settings

Topic:

How is the spectrum across the entire frequency span of the VNWA from 1 to 1300MHz pending the settings of the internal clock multipliers for the RF and LO DDS in VNWA2 and VNWA3 and also for the clock pre-multiplier include in the VNWA3 and VNWA3E. In the below tests only a VNWA3E is used but many measurements are identicsal to a VNWA2

Testing method:

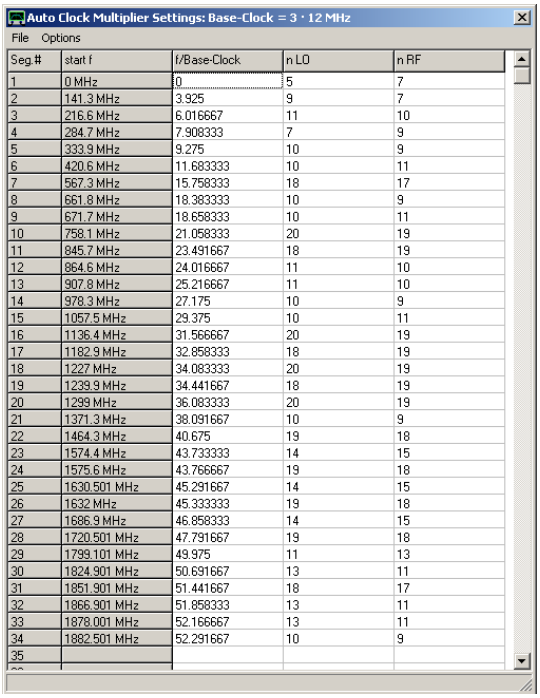
By using a professional spectrum analyzer in this case the Rohde and Schwartz FSL3 the spectrum of the RF DDS is measured the following way.

1. The VNWA is running in continuous sweep from frequency a to frequency b with 500 points and 1.33mS per point. An entire sweep takes close to 1 second as start and stop plus the windows tasks and an overhead.
2. The spectrum analyzer is running in slow speed and 500 points with a little more than 1 second per point to ensure to be able to measure each sweep from the vNWA. Sweep time about 700 seconds. The bandwidth during measurement larger than the stepsize in the VNWA (1-1300MHz and 500 point = 2.6MHz) to ensure any discrete frequency from the VNWA are within the IF bandwidth of the SA and set to 10MHz . (3 MHz also used with success) Video bandwidth of SA set to 1MHz. Due to the BW of 10MHz the starting frequency of the SA set to 10MHz as all frequencies blow is not of particular interest for this report. The VNA is measuring the peak values across the band.

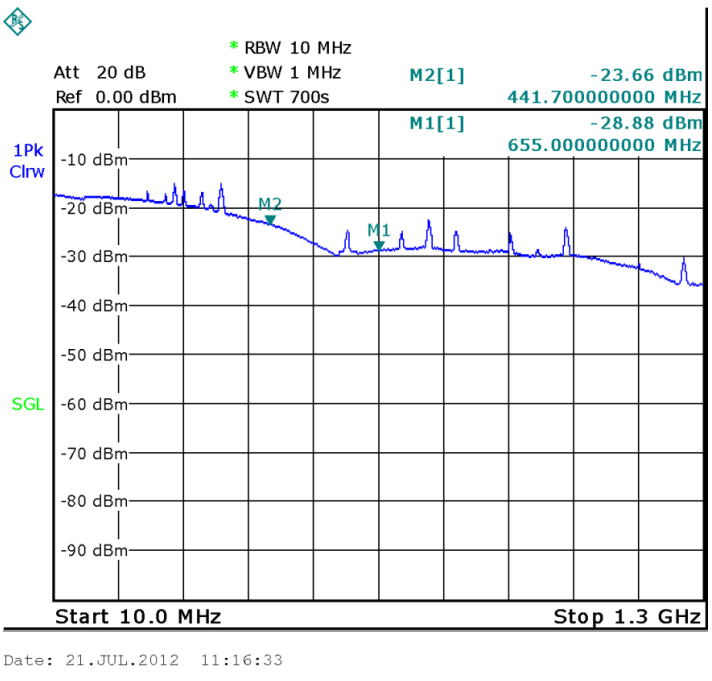
How is the below measurements explained to make descriptions shortest possible:
For e.g. RF DDS the internal multiplier set to 9 is just written RFx9 , If set to Auto then written as RFauto
Likewise for LO DD the description used is e.g. Lox10 or LOauto.
For the clock pre-multiplier included only existing for VNW3 is used the factor e.g. x3, which correspond to the VNWA2 mode, or any other number possible incl. auto.
So for a VNWA3 the entire mode of operation is e.g. RF9_x3_LO10 or e.g. the VNWA2 equivalent mode RFauto_x3_LOauto or the VNWA3 fully automatic mode RFauto_auto_LOauto

Some measurements:

First the mode mostly used for the VNWA2 with RF and LO in auto mode. The VNWA does not have a clock pre-multiplier and the clock is thus the 12MHz X-Tal multiplied in a Tripler to 36MHz (35.9MHz). The compatible mode for VNWA3 is when the clock pre-multiplier set to 3 and not auto. Spikes are aliases adding to the fundamental (6dB)

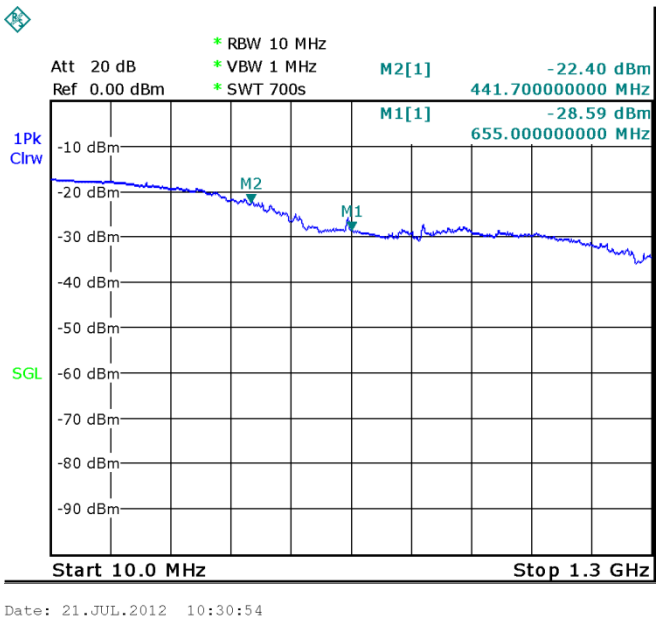


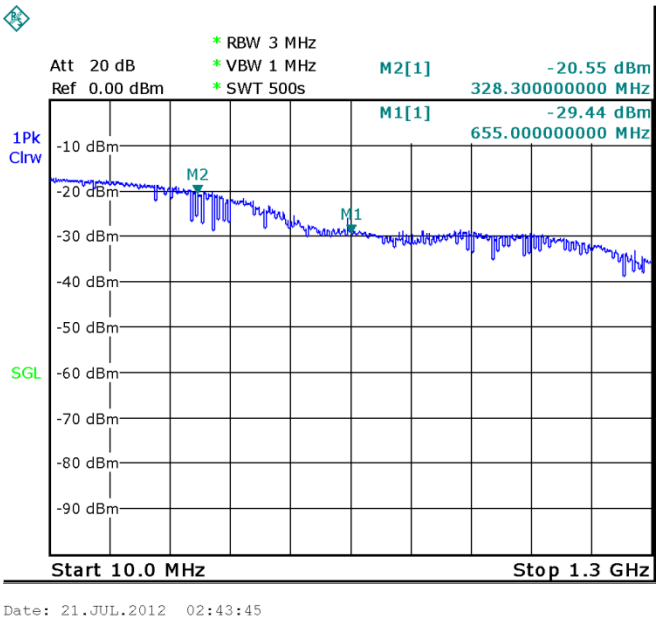
Seg.#	start f	f/Base-Clock	n LO	n RF
1	0 MHz	0	5	7
2	141.3 MHz	3.925	9	7
3	216.6 MHz	6.016667	11	10
4	284.7 MHz	7.908333	7	9
5	333.9 MHz	9.275	10	9
6	420.6 MHz	11.683333	10	11
7	567.3 MHz	15.758333	18	17
8	661.8 MHz	18.383333	10	9
9	671.7 MHz	18.658333	10	11
10	758.1 MHz	21.058333	20	19
11	845.7 MHz	23.491667	18	19
12	864.6 MHz	24.016667	11	10
13	907.8 MHz	25.216667	11	10
14	978.3 MHz	27.175	10	9
15	1057.5 MHz	29.375	10	11
16	1136.4 MHz	31.566667	20	19
17	1182.9 MHz	32.858333	18	19
18	1227 MHz	34.083333	20	19
19	1239.9 MHz	34.441667	18	19
20	1299 MHz	36.083333	20	19
21	1371.3 MHz	38.091667	10	9
22	1464.3 MHz	40.675	19	18
23	1574.4 MHz	43.733333	14	15
24	1575.6 MHz	43.766667	19	18
25	1630.501 MHz	45.291667	14	15
26	1632 MHz	45.333333	19	18
27	1686.9 MHz	46.858333	14	15
28	1720.501 MHz	47.791667	19	18
29	1799.101 MHz	49.975	11	13
30	1824.901 MHz	50.691667	13	11
31	1851.901 MHz	51.441667	18	17
32	1866.901 MHz	51.858333	13	11
33	1878.001 MHz	52.166667	13	11
34	1882.501 MHz	52.291667	10	9
35				



The switching scheme and the RF levels across frequency band are as expected dropping from -17dBm to -35dBm. However as seen below the switching Scheme is far more complex for the VNWa3 in the “VNWA2 compatible mode”

Below is shown the VNWA3 mode RFauto_auto_LOauto and as seen spikes has been eliminated due to a much more aggressive switching scheme.
The picture to the right is shown what happens if time per point for the R&S VNA is too short (500 sec sweep as opposed to 700sec) and BW too narrow 3MHZ as opposed to 10MHz)





Next follows some typical sweeps and settings:

First of all to the left the old switching scheme for the VNWA2, still used by most VNWA 2users.
To the right the identical settings in VNWA 3 (RFauto_x3_LOauto) but a much more detailed switching scheme.
Nothing is preventing you to experiment with the VNWA2 switching scheme by using the editor and create your own file. Please note the version 36 preview9 and the forthcoming official release of version 36 also has the Option selection where the default setting can loaded when you have gone “haywire” ☺

Auto Clock Multiplier Settings: Base-Clock = 35.9 MHz

File

Seg.#	start f	f/Base-Clock	n LO	n RF
1	0 MHz	0	10	9
2	107.675 MHz	3	20	19
3	574.266 MHz	16	10	11
4	610.157 MHz	17	11	13
5	663.995 MHz	18.5	14	13
6	717.832 MHz	20	15	14
7	771.669 MHz	21.5	17	15
8	825.507 MHz	23	17	15
9	897.29 MHz	25	18	17
10	969.073 MHz	27	19	18
11	1040.856 MHz	29	20	19
12	1292.097 MHz	36	14	15
13				
14				
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19				
20				

Auto Clock Multiplier Settings: Base-Clock = 3 · 12 MHz

File Options

Seg.#	start f	f/Base-Clock	n LO	n RF
1	0 MHz	0	5	7
2	141.3 MHz	3.925	9	7
3	216.6 MHz	6.016667	11	10
4	284.7 MHz	7.908333	7	9
5	333.9 MHz	9.275	10	9
6	420.6 MHz	11.683333	10	11
7	567.3 MHz	15.758333	18	17
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20	1299 MHz	36.083333	20	19
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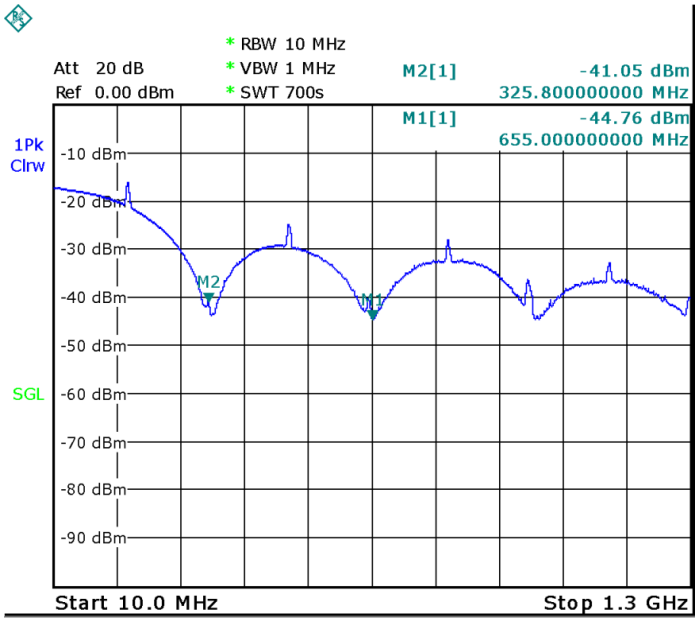
32	1866.901 MHz	51.858333	13	11
33	1878.001 MHz	52.166667	13	11
34	1882.501 MHz	52.291667	10	9
35				

Next we will look of the first VNWA2 setting RF9_x3_LO10 defined to be useable to 107.675MHz



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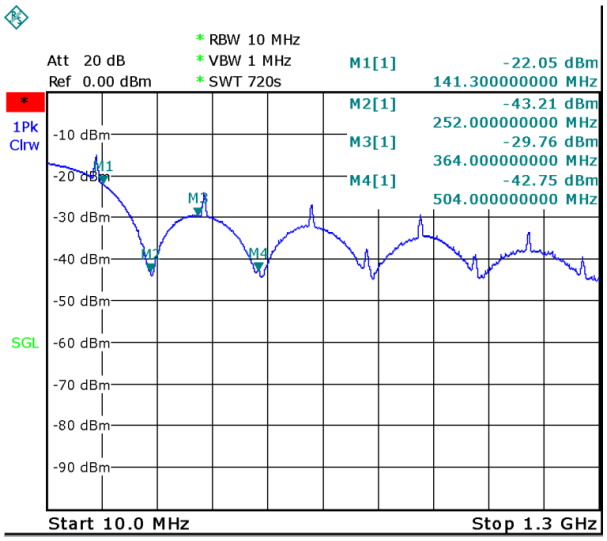
At marker 2 (M2) at 325.8Mz the output is zero and it is more precise at the clock freq 35.9Mhz multiplied by 9 = 323.1MHz,being the DDS clocking frequency. According to the Nyquest criteria the max usable frequency is 50% of the clock freq=161.55MHz and to have some margin and a better dynamic range Tom has limited it to 107.675MHz. At M2, which is at 2x DDS clocking = 646.2MHz, the second zero output is found. Likewise at 3 x DDS clocking =969.3MHz the third zero found and the fourth zero at

I my previous report "Why VNWA2 and VNWA3 does not show correct attenuation of high and lowpass filters" I have shown the influence of the second, third, and probably also fourth harmonics of the fundamental frequencies 0 to 323.1MHz for this 0-128MHz band. It is fairly simple to avoid it by using a lowpass filter which can be having a 3dB limit at e.g. 120MHz to cover the measurements from 1KHz to 120MHz, but a lowpass filter of e.g. 250MHz with good attenuation from some 325MHz might be more universal as seen later on.

But what about the switching scheme for VNWA3 ? it uses RFx7_x3_Lox5 until 141.3MHz



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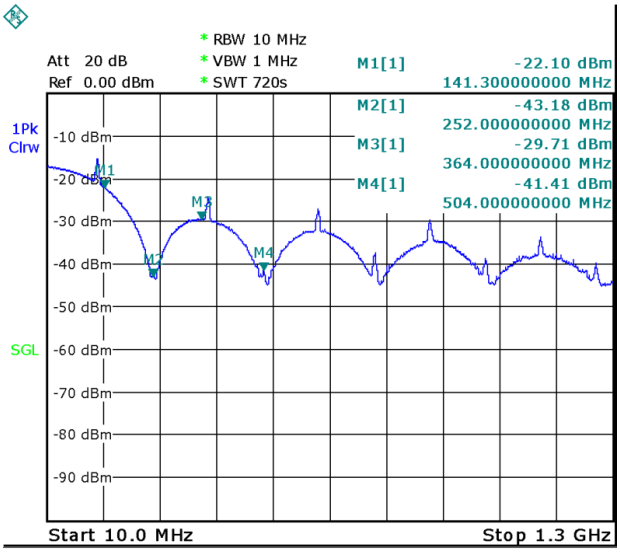

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As seen in the left picture where the VNWA3 is running from 1 to 1300MHz the RF clock frequency is much lower, as being 7x36MHz = 22MHz (M2) than for the picture above.

Basically it is the same type of spectrum but now including 5.harmonics. The LO setting of x5 is causing the "notches" for RF and LO well apart, and ensures lower noise floor and probably selected also for fewer "birdies".

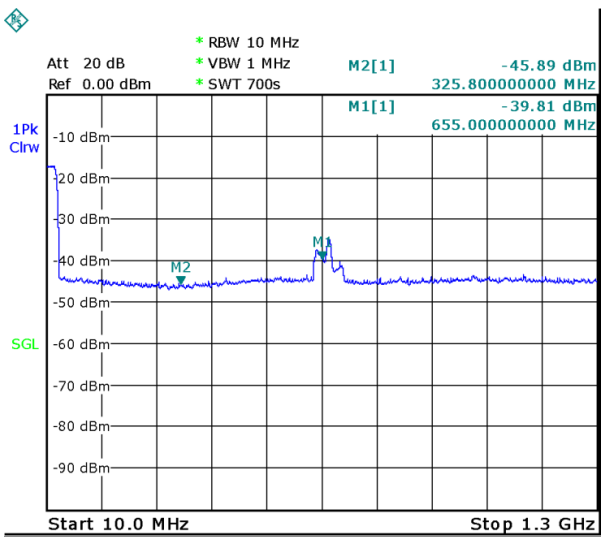
For the right picture the WNA is sweeping from 1 to 147 MHz (the limit in the switching scheme 141.3MHz) And the two plots is totally identical?? Why that ?? This is because 2x141.3Mhz = 288.6MHz is beyond the RF DDS clock of 252MHz (7x36MHz). Everything beyond 126MHz=half the clock, is just folded.

To measure high attenuation with accuracy for the entire range of 1 to 141.3 MHz is not possible as to a lowpassfilter needed with a fair attenuation at 252MHz and upward and little attenuation at 141,4 MHz.

A spectrum when the WNWA sweeps from 1 to 30MHz:

Below two picture are plotted when the VMWA is sweeping from 1 to 30MHz

Left Picture is in mode RFauto_auto_LOauto and the Right Picture is in mode RFx9_x3_Lox10 (like a VNWA2)



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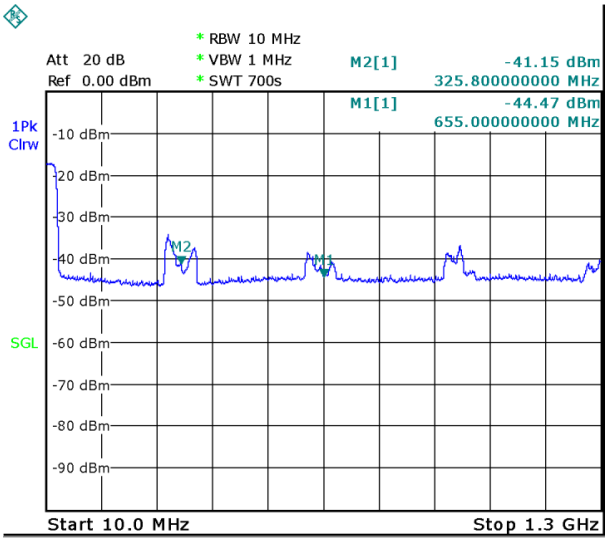

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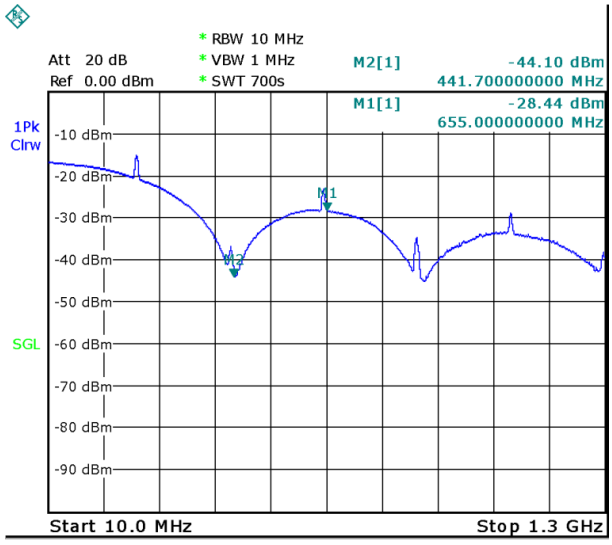
The unwanted signal for operating the VNWA between 1 and 30 MHz is for VNWA3 in 3 x auto mode above 650MHz and for the VNWA2 300MHz, so the selection of a lowpass filter is not a straight away choice but pending mode of operation even for the same required frequency operation range.

The next spectrum is when the VNWA is running in the frequency range above 600MHz:

For the left picture the VNWA3 is running from 655 to 1300MHz and in mode RFauto_auto_LOauto

For the right picture the VNWA3 is running from 655 to 1300 MHz in mode RFauto_x3_LOauto



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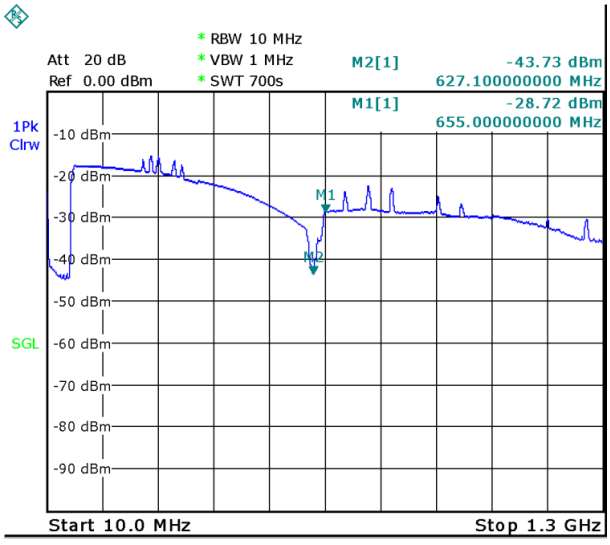

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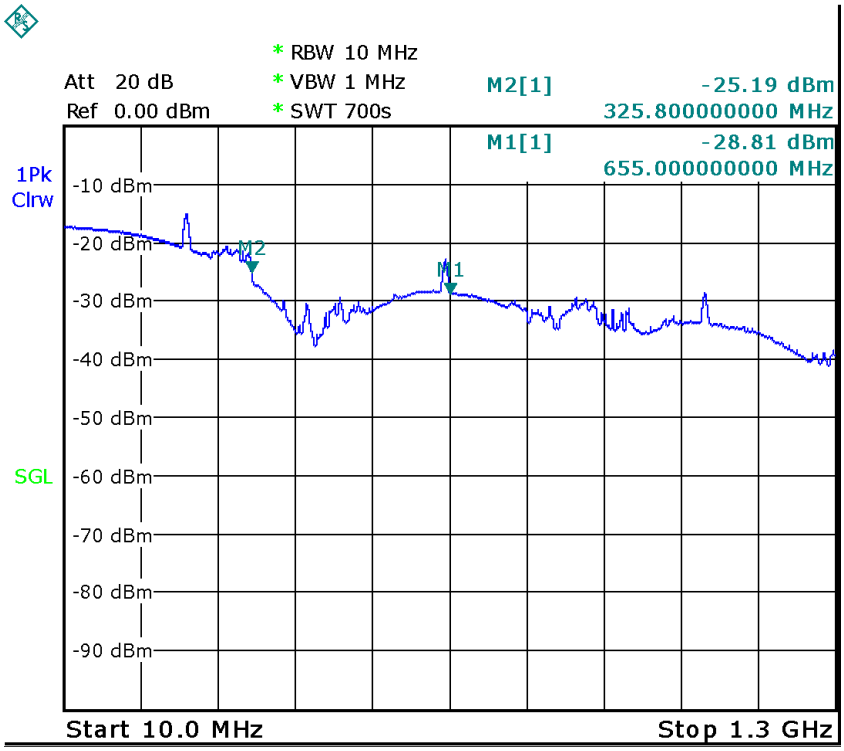
It is interesting to see that for the 3xauto mode the spectrum above 655MHz is not ideal but rather spikeless at the cost of highest possible power level in comparison to the auto x3 auto mode. That was also seen in a previous report that the noise floor showed this trend.

What is also important to note is the presence of the strong signals below 655MHz which can interfere when measuring above 655MHz or said otherwise when utilizing 2.harmonic of the fundamental for measurements. To be able to measure with optimal dynamic range a highpass filter is needed. The disturbing signal is a half the frequency so when measuring at 655MHx it shall have fair attenuation at 327.5MHz which is not a harsh requirement, but when measuring at e.g. 880MHz the same requirement shall be met at 440MHz (marker 2 in left picture). However in the right picture the signal levels at 880MHz is much higher but at half the frequency the power is even higher stringent the requirements.



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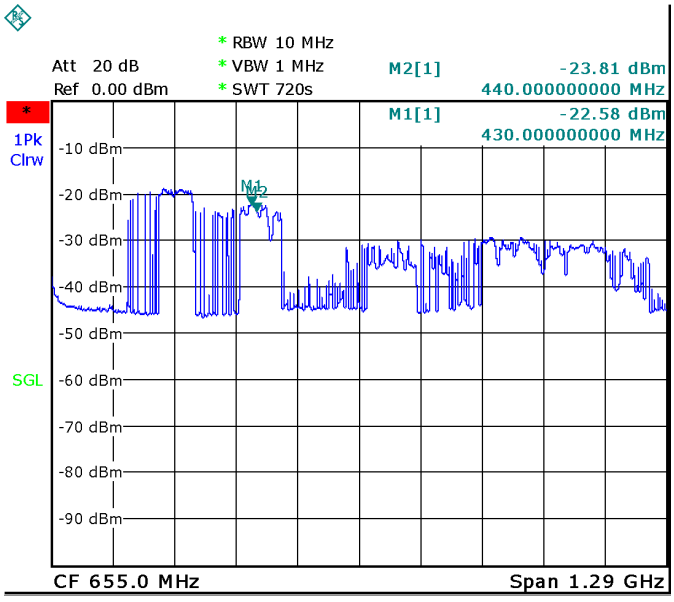
This picture to the left is when mode VNWA3 is in mode RFauto_auto_LOauto and sweeping from 618 to 1300MHz.

It appears there are a quite a number of switching taking place from 400 to 530MHz, and more than the VNWA switching scheme indicates for that range.

As the UH ham band is within that range then let us have a closer look.

And now to some "fun stuff":



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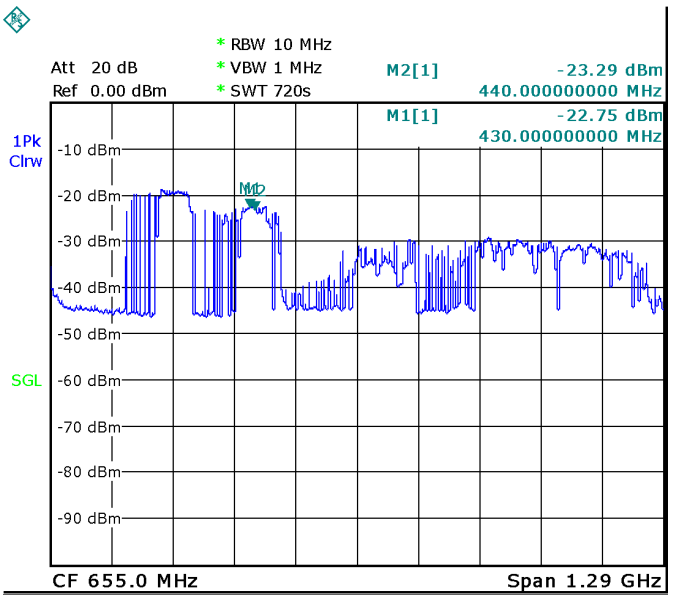

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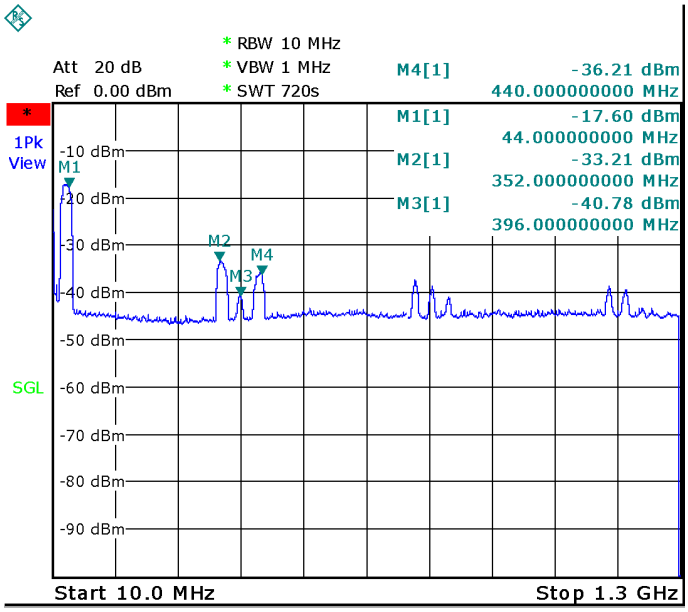
VNWA sweep 430 to 440MHz

VNWA sweep 433 to 440MHz

Both above picture is for VNWA3 in RFauto_auto_LOauto mode and VNWA sweeping across 430 to 440MHz for the left picture and 433 to 440 for the right picture. This is plain crazy andd requires an expert to explain ☺ I give in… According to the switching scheme for that mode there is a segment from 413.3 to 433MHz where RF is x19 LOx18 and clock pre multiplier factor 3.125 . Then from 433 to 457.1MHz where RFx19 and Lox20 with clock premultiplier factor 3. In left picture both these segment is in action and for the right picture only on segment used but the spectrum is indeed very noisy. Hm….

Now changing the mode to RFauto_x3_LOauto and with VNWA3 sweeping 430 to 440MHz:



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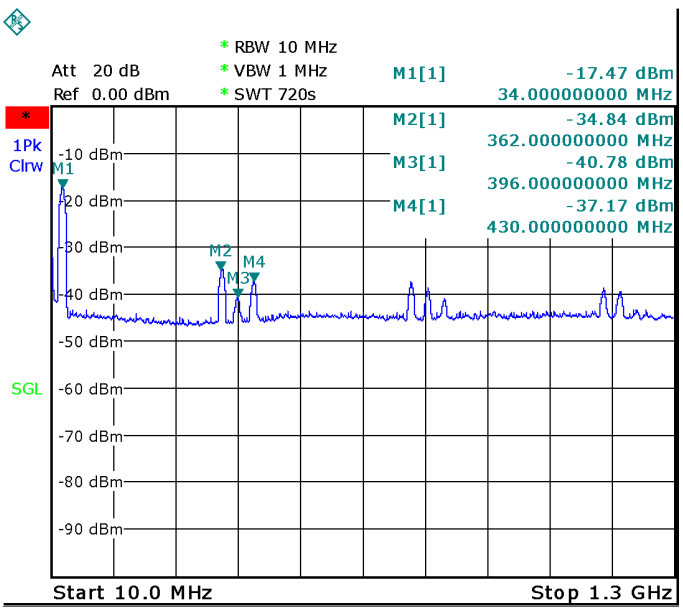

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Left picture for VNWA3 sweeping from 430 to 440MHz and mode RFauto_x3_LOautom, which according to the switching scheme is with RFx11 and Lox10.
That spectrum is much better and the RF DDS clock then 11x36MHz=396MHz so the measurements will be done using 2. Harmonics for the band 430 to 440MHz.
The right picture is for the VNWA3 programmed for 430MHz and with 0 Span. The DDS is programmed for a fundamental frequency of 34MHz (M1) for generation of the wanted 430MHz signal by "mixing" with the clock of 396MHz. The sum is 430MHz but there also exist the difference 396-34=362MHz. If the strong 34MHz and relative strong 362MHz signal is passing through the DUT (e.g. a duplex filter in the range 430 to 440 MHz which outside this band has no or less attenuation), it's second harmonic will in the RX mixer could generate a 430MHz as the sum of 2x34 + 362=430MHz. These two frequency component as passing through the DUT with different delay/phase than the wanted signal 430MHz. Thus sweeping over the 430 to 440MHz range these two components at 430MHz will be either additive or subtractive pending phase/amplitude relationship. To filter these two signals cannot be done using low or high pass filter, so in this case a bandpass filter solution is most likely to be chosen. Remember whatever filter type used, it must be fitted during calibration. In general when the wanted signal is close to the clocking frequency the bandpass filter is to prefer. If reducing the fundamental of 34MHz only by highpass filter is an adequate cure remains to be seen but it is a possibility.

Conclusion and final comment:
This report could be much longer but are brought to and end and hopefully cause some consideration and understanding why the natural limitation of the VNWA cause some head scratching and giving ideas how to fix the problem doing some filtering or by selecting a smarter home made switching schema alternatively some fixed multiplier settings. Please accept there might be some mistakes in this report so any comment and suggestion for improvement is most welcome.

Kind regards

Kurt de OZ7OU published July 22 2012.