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FREQUENCY DOWN CONVERSION USING MIXER AND ITS SIMULATION

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***Abstract*- Everywhere in daily life, there are frequencies of sound and electromagnetic waves, constantly changing and creating the features of the visible and audible world familiar to everyone. The electromagnetic spectrum has wide number of frequency range. Among them only visible range is easily seen by human eyes. But there is a wide frequency range that cannot be seen by human eyes but still they have much important in their various application. To measure the frequency of such invisible spectrum is very difficult task when we talk about GHz or THz unit frequency. In this paper we have demonstrated the mechanism by which one can down convert such high frequency signal in to the easily measurable signal range. We have used GENESYS software to simulate this mechanism.**

***Keywords*- Mixer, Filterbank, Detector, GENESYS**

I. INTRODUCTION

Calculating the frequency of a repeating event is accomplished by counting the number of times that event occurs within a specific time period, then dividing the count by the length of the time period. In such way frequency and time relation can be define as follow

$$f = \frac{1}{t} \qquad (1)$$

The another important term related to frequency is wavelength and relation is as follow

$$c = \frac{f}{y} \qquad (2)$$

The electromagnetic spectrum is shown in Fig.-1 so we have more clear idea about range of frequency

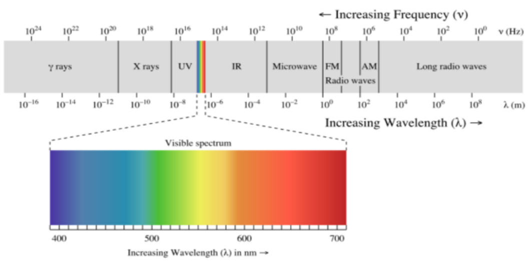

Fig. 1 Electromagnetic Spectrum

Generally the Frequency measurement can be easily done using frequency counter or spectrum analyzer, when range of frequency is in MHz or in few GHz. Also the higher frequency measurement instrument is available but the cost is much high. We can measure such high frequency using Frequency down convert mechanism which is made of basic mixer. Next point will give the better idea about mixer characteristics.

II. MIXER CHARACTERISTICS

Mixers are 3-port active or passive devices. They are designed to yield both, a sum and a difference frequency at a single output port when two distinct input frequencies are inserted into the other two ports. In addition to this, a Mixer can be used as a phase detector or as a demodulator.

The two signals inserted into the two input ports are usually the Local Oscillator signal, and the incoming (for a receiver) or outgoing (for a transmitter) signal. To produce a new frequency (or new frequencies) requires a nonlinear device. In a mixing process if we want to produce an output frequency that is lower than the input signal frequency, then it is called down-conversion and if we want to produce an output signal that is at a higher frequency than the input signal, it is referred to as up-conversion.

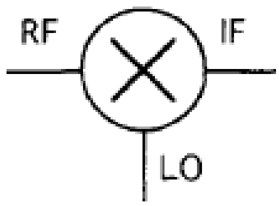

Fig. 2 Mixer Symbol

The multiplication process begins by inputting two signals:

$$a = A\sin(\omega_1 t + \varphi_1) \qquad (3)$$

$$b = B\sin(\omega_2 t + \varphi_2) \qquad (4)$$

The resulting multiplied signal will be:

$$a.b = AB\sin(\omega_1 t + \varphi_1).\sin(\omega_2 t + \varphi_2) \qquad (5)$$

using simple trigonometric mathematics we can write above equation as follow

$$a.b=-\frac{AB}{2}\left[\cos\left((\omega_1+\omega_2)t+(\varphi_1+\varphi_2)\right)\right.$$

$$\left.-\cos\left((\omega_1+\omega_2)t+(\varphi_1+\varphi_2)\right)\right] \qquad (6)$$

The second term in above equation is our interested term which indicate the down convert of frequency or intermediate frequency, IF. Thus based on these mixer characteristics we have developed the following mechanism.

III. FILTER DOWN CONVERT MECHANISM

As mention above the main component in this mechanism is mixer. The fig.-3 shows the block diagram for this mechanism.

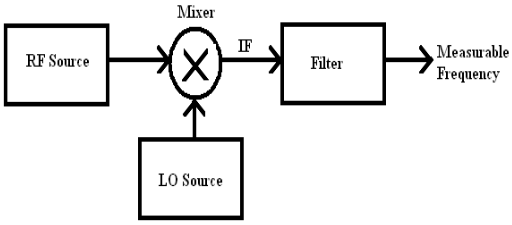

Fig. 3 Frequency Down Convert Mechanism

Here RF Source indicates the high frequency radio signal which we want to measure. The RF frequency is given to the RF port of mixer. In this structure we also need one Local Oscillator and filter also. LO Source output is given to the LO port of mixer. As explained before mixer will generate to other frequency at output side, sum and difference of frequency. It's also indicating in fig.-4.

$$IF = |RF \pm LO| \qquad (7)$$

Then this output will pass through the filter. Here we have to select such filter which can pass only required frequency with high power level. Thus at output stage we can detect and measure the frequency using simple Spectrum analyzer. We have made one example with this mechanism in GHz range. We have it in GENESYS software.

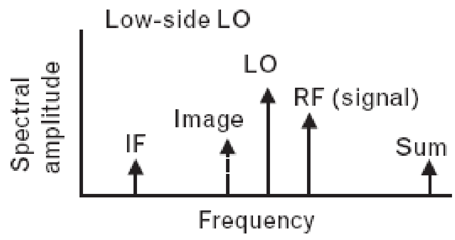

Fig. 4 Mixer output spectral amplitude vs. frequency

IV. GENESYS SIMULATED EXAMPLE

There are numbers of software available in market, which used for microwave simulation. Among them one of the software is GENESYS which can simulate RF design in frequency range of GHz as well as in THz. So due to its valuable features we have chosen it for simulation. The Block Diagram for MHz frequency down convert mechanism is shown in fig.-5.

To simplify Filter and detector design we will check the full band frequency and that is 30 MHz to 45 MHz. According to this frequency we have choose LO at 29 MHz. In such a way the output frequency should be in range of 1 MHz to 16 MHz. We choose band pass filter of 4 MHz bandwidth. The filters are Bessel type band pass filter starting from 1, 4, 8 and 12 MHz. Here we have used 1 to 4 way power splitter which makes four outputs from one input with same frequency characteristics. At the output side of filter we have put detector so we can identify the filter output. Thus we can measure the 30 MHz to 45 MHz with down convert frequency in form of 1 MHz to 16 MHz.

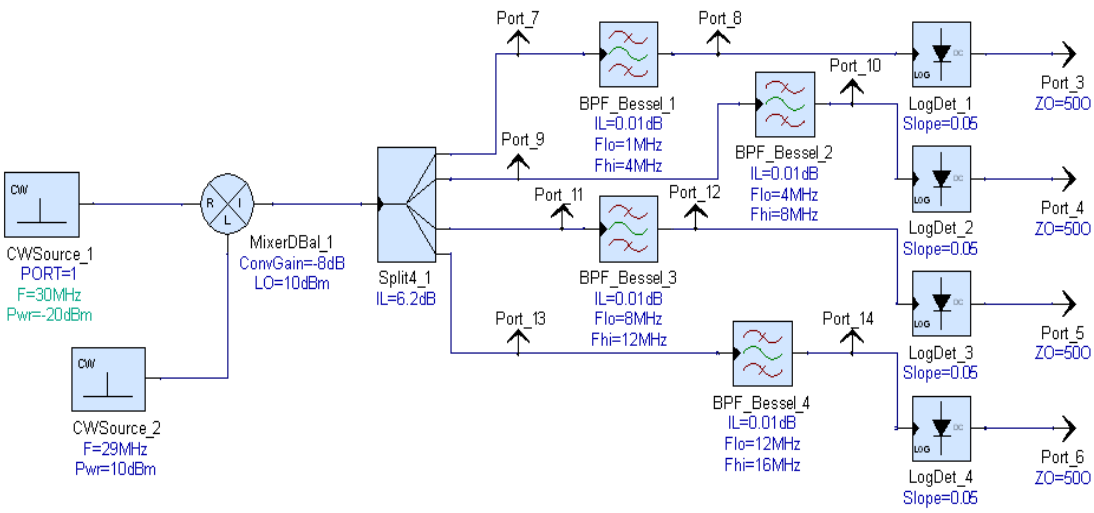

Fig. 5 Block Diagram for example

V. Result

Here we have put the result in figures as well as in table form. The fig.-6 indicate output of Filter_1 one which has range of 1 to 4 MHz. We have also presented the behavior of all the components with respect to channel power so we can verify the characteristics of all components. This result is put with respect to three detectors so we can also cross check the output result among all three detectors. In Detector result the line wise behavior is looks like same but must see the frequency value corresponding to line color so you can identify the different output for different detector for same value of frequency. Also the fig. 7 has final output of detector which is also presented in table 2 with respective frequency. Here we have also applied center frequency corresponding to filter so the maximum output can we get from detector. We have recorded the result for whole range of frequency starting from 30 MHz to 45 GHz. The below tables indicate the power level of before and after filter (Table 1) and also the resultant power level of Detector (Table 2). In table we have first take the exact frequency relative to the filter bandwidth so we can check out the detector minimum output corresponding to input frequency. Then last we apply center frequency so we get maximum output level from detector (refer table 2). At the end we have given lowest end 29 MHz and highest end 46 MHz to check cut off and saturation level of Detector. To present all the graphs is not possible with limitation of rules. So we have made table which give the better overview for this mechanism result.

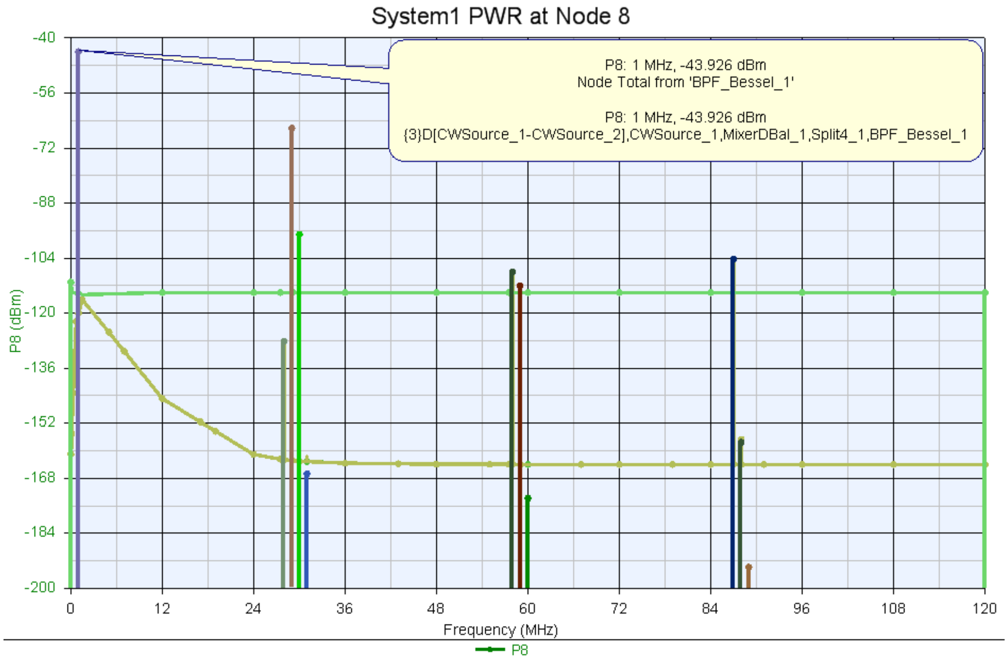

Fig. 6 Filter_1 Input

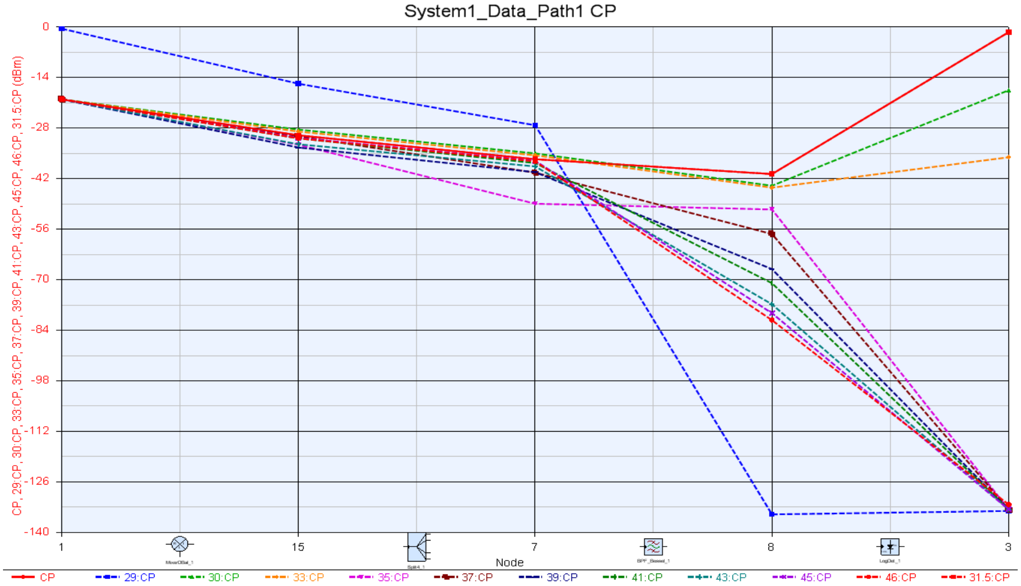

Fig. 7 FIlter_1 Output

Table 1 Filter behavior

Frequency (MHz)	IF (MHz)	Filter_1 (dbm)		Filter_2 (dbm)		Filter_3(dbm)		Filter_4(dbm)	
		Before	After	Before	After	Before	After	Before	After
29	**0**	-28.143	-110.965	-28.143	-110.965	-28.143	-110.965	-28.143	-110.965
30	**1**	-34.967	-43.926	-34.619	-117.271	-34.607	-134.881	-34.765	-87.779
31.5	**2.5**	-36.573	-40.69	-36.238	-93.211	-36.146	-113.976	-39.534	-57.905
33	**4**	-35.509	-44.458	-35.587	-76.394	-35.221	-97.626	-35.508	-44.464
35	**6**	-48.91	-50.499	-41.993	-59	-38.356	-86.557	-38.94	-41.614
37	**8**	-40.303	-57.295	-36.782	-45.737	-37.207	-71.366	-36.782	-45.733
39	**10**	-40.168	-67.026	-39.623	-41.75	-44.323	-57.022	-46.954	-50.418
41	**12**	-37.646	-70.927	-37.156	-46.108	-37.156	-46.11	-42.114	-55.6
43	**14**	-38.576	-76.764	-49.028	-50.475	-39.068	-41.029	-40.102	-63.737
45	**16**	-37.018	-79.225	-40.507	-57.503	-36.988	-45.94	-37.783	-67.685
46	**17**	-37.176	-81.156	-39.168	-61.596	-39.734	-47.335	-37.761	-70.144

Table 2 Detector behavior

Frequency (MHz)	IF (MHz)	Detector_1_Output (mV)	Detector_2_Output (mV)	Detector_3_Output (mV)	Detector_4_Output (mV)
29	**0**	0.001259	0.001259	0.001259	0.001259
30	**1**	29.968	0.001259	0.001259	0.001259
31.5	**2.5**	191.117	0.001259	0.001259	0.001259
33	**4**	3.53	62.003	0.001259	0.001259
35	**6**	0.001259	199.672	0.001259	0.001259
37	**8**	0.001259	1.902	17.883	0.001259
39	**10**	0.001259	0.001259	204.12	0.001259
41	**12**	0.001259	0.001259	1.176	2.958
43	**14**	0.001259	0.001259	0.001259	221.595
45	**16**	0.001259	0.001259	0.001259	9.695
46	**17**	0.001259	0.001259	0.001259	0.001259

VI. CONCLUSION

At the end of this work we get the required result in terms of MHz frequency. The frequency down convert mechanism is helpful mainly in two way cost and reduced number of measuring frequency. In our example we get nearly 30 MHz down in input frequency. The output can easily measure with compatible instrument. We can also get same result in higher range also. The table results indicate successful of mechanism in terms of frequency.

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