Simulation of Phase Meter Using TINA Software

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ABSTRACT
The use of a circuit simulator is more and more crucial in designing electrical and electronic gadgets. This technique makes it possible to obtain results when the hardware is unavailable or very costly. Simulations are widely used in the industry hence it is necessary to use it astutely. Authors tried to study an important concept about "Squaring a Signal" and further it is extended to design and simulation of phase meter. Squaring a sinusoidal lead doubling its frequency and adding the dc component. In this study squaring sine wave with frequency of 5KHz gives a negative cosine wave with frequency 10KHz along with a dc term of 2V. TINA software is used for this study. TINA software has ability to perform DC analysis, AC analysis and transient analysis. Transient analysis calculates the circuit response to various input waveforms. Results are analyzed using transient analysis for sinusoidal input.

Keywords: TINA, Simulation, Multipliers, Virtual instruments, Transient analysis, Phase.

1. INTRODUCTION

TINA8 Education Suite is a great yet affordable software package for analyzing, designing and testing of analog, digital, VHDL and mixed electronic circuits. One can analyze advanced topics on RF, communication, optoelectronics, microprocessor and microcontroller. Squaring a dc voltage is rather simple to simulate but some interesting results are obtained by squaring an ac voltage. Such interesting results are used further to develop phase meter model. Multipliers are most suitable and easy for mathematical applications such as analog divider, square root operation. Also, they can be used in other applications like modulation and demodulation, automatic gain control, power measurement, voltage-controlled amplifiers.

An analog multiplier is a device having two inputs and one output. The signal at the output is the product of the two input signals as shown in figure1.

Figure 1. Simple Multiplier.

Squaring a dc signal is easy. Just connect the dc voltage to be squared to both inputs of multiplier as shown in following figure 2.
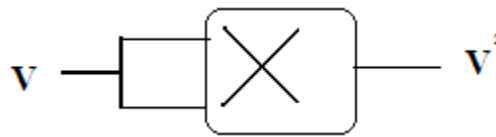

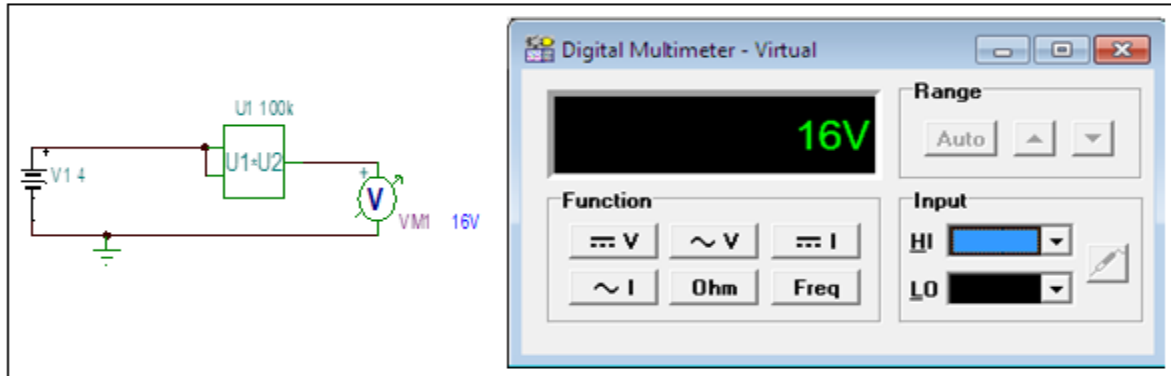Figure 2. Squaring dc voltage.

Figure 3. Simulation model for squaring DC signal and output on virtual meter.

Virtual Lab concept is defined as laboratory experiment without real laboratory with its walls and doors. It empowers the learner to link between the theoretical aspect and the practical one. It is software in computer used to simulate the real experiments inside the real laboratories (Babateen, 2011, NSPE, 2006). In present article phase meter is simulated using TINA software with key components IC AD633 and OPAMP. Phase determination between two sinusoidal is carried out by this meter.

2. METHODOLOGY

Problem formulation i.e. designing the circuit is basically an iterative process which starts with setting the objective and requirements as shown in figurer 4. Conceptual model will be developed as per specifications using Spice software. While making the model, theoretical background of multiplication operation is applied. The article assumes same amplitude and frequency for the inputs sinusoidal. TINA software is used to develop the required model. Further model is analyzed by various possible analyses available. If the requirements and specifications met the simulation process is complete. If not, cycle begins again with necessary modifications (Becker et al., 2005).
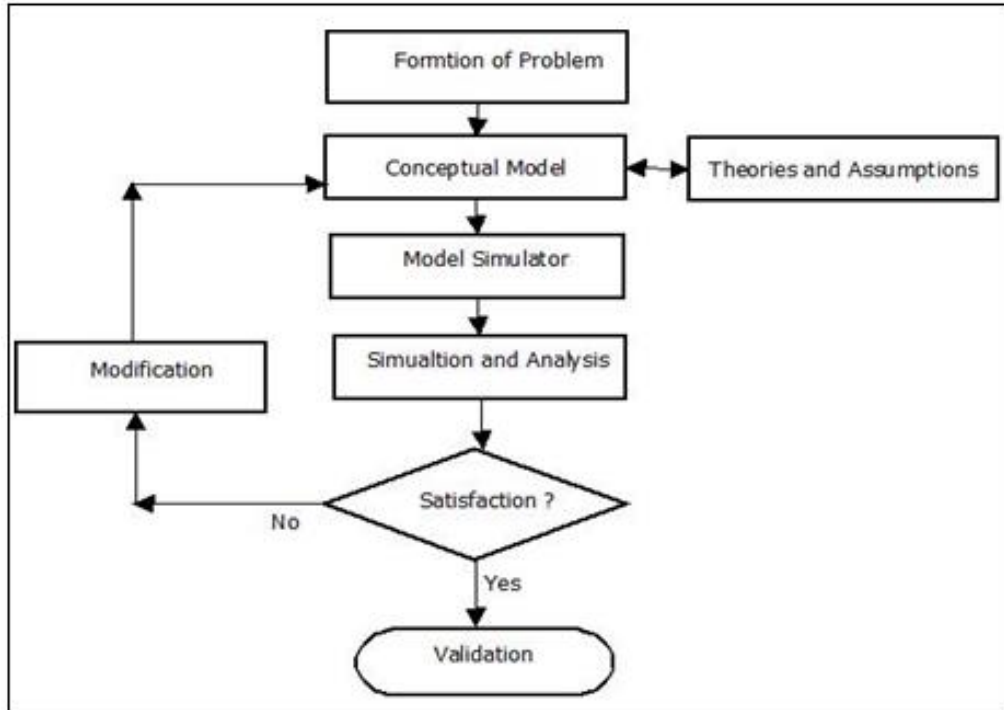
Figure 4. Flowsheet.

2.1. Squaring ac Signal

Squaring ac signal is not as simple as in case of dc. In this case sine wave having amplitude 2V and frequency 5 KHz is applied to two inputs of the multiplier. For this AC voltage generators VG1 and VG2 are used. The parameters of VG1 and VG2 are set accordingly. The simulation model is shown in figure 5A and transient analysis is shown in figure 5B (Chaudhari and Bonde, 2012).
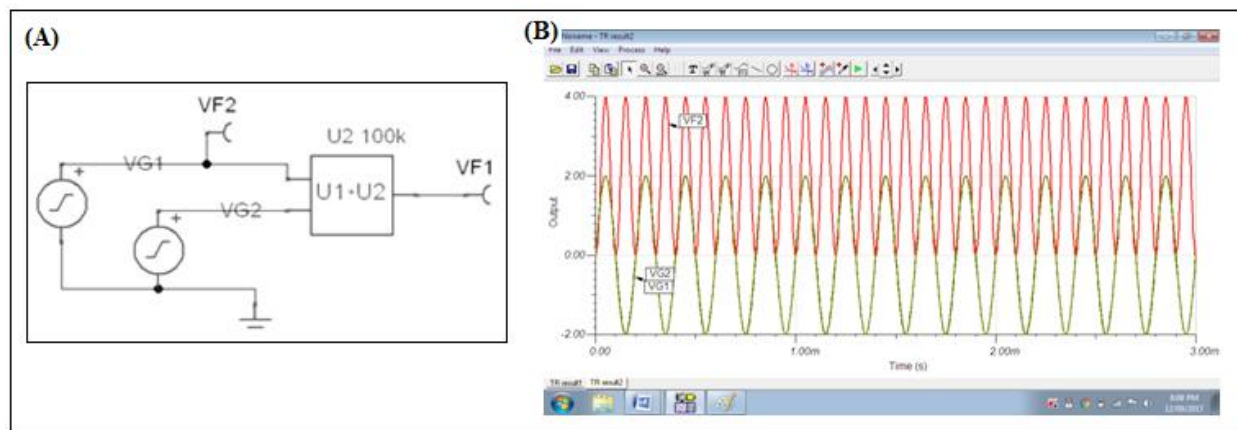

Figure 5. A) Model for squaring AC signal, and B) Transient analysis with input and output.

The Ten-point process of simulation (Rashid, 2010) can be summarized as follows:

1. Open a new work area i.e. new file/window.

2. Obtain parts one by one from part list/library and place them in the work area.

3. Arrange parts according to the circuit requirements.

4. Connect parts using wires.

5. Change attributes (if any) according to design requirement.

6. Add Text as per need.

7. Save the schematic with proper name.

8. Select proper analysis and/or set its i/p-o/p parameters.

9. Run-Analysis and get the results on virtual instruments.

10. Print output.

It is observed that the frequency of the output waveform is twice that of the input waveform. Also, the dc level of the output wave is shifted up by 2V (Coughlin and Driscoll, 2005). Thus, squaring a sinusoidal is nothing but doubling its frequency and adding the dc component. More precisely, squaring sine wave with frequency of 5000Hz gives a negative cosine wave with frequency 10000Hz plus a dc term of 2V.

2.2. Validity

Above observations can be realized by using trigonometric identity,

$$[(sinA)(sinB) = 1/2[\cos(A - B) - \cos(A + B)]$$

By applying this identity, we can obtain,

$(\sin 2\pi ft)^2 = 1/2 - cos2\pi(2f)t/2$

Applying above equation for our input (amplitude 2V, frequency 5000Hz) we get

$Vo = Vi^2$

$\quad = 4(\sin 2\pi 5000t)^2$

$\quad = 4[1/2 - \cos 2\pi 10000t/2]$

$\quad = 2 - 2\cos 2\pi 10000t$

$\quad =$ dc term of 2V – doubled frequency cosine wave with 2V peak.

Above discussion leads authors to think about designing and simulation of phase meter. With few add-on circuits like OPAMP amplifier, rectifier with filter we have simulated the phase meter. The simulated circuit is shown in figure7.Output of multiplier is amplified by non-

inverting amplifier with gain of 11. Signal further rectified and filtered to obtain dc output which in turn measured by voltmeter or analyzed by transient analysis (Chaudhari, 2008).
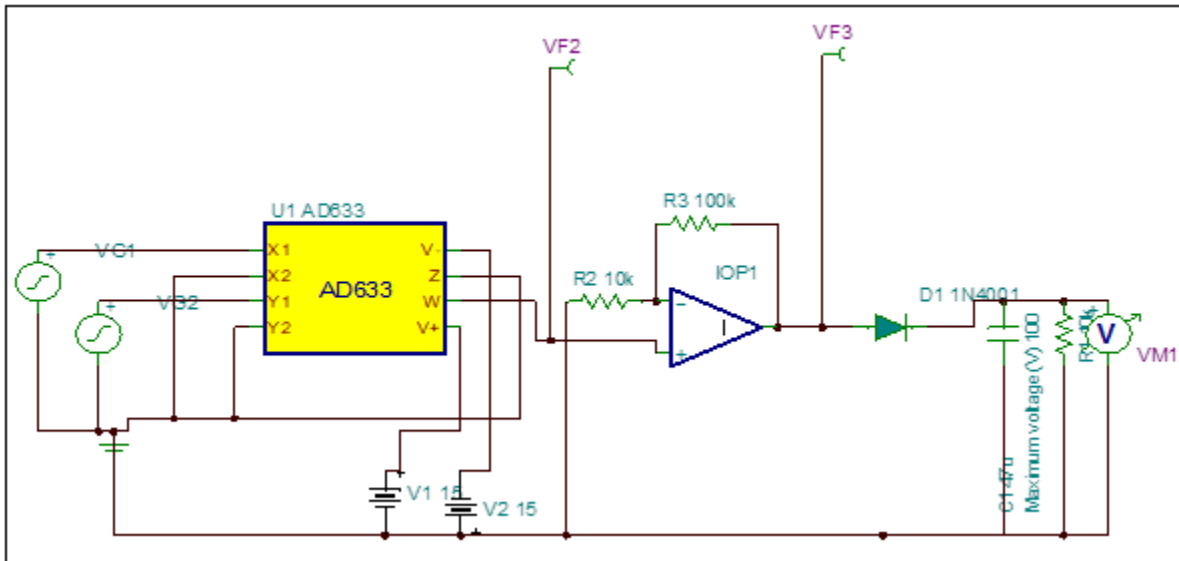

Figure 6. Phase Meter Model.

3. TINA STATEMENT FLOW

The phase meter is simulated using TINA 8 Educational Suite (TINA, 2008). When two sine waves having same amplitude (3V) and frequency (500Hz) but differ by phase of 30°, output voltage shown by VM1 is 8. 58V.This situation is simulated as follows:

 => START

=>All Programme

=> TINA 8 Educational Suite

=> TINA

=> File=>New

=> Parts

 => Basic => VG1, VG2, V1, V2, R1, R2, R3, C1, VM1, Ground

        => Change attributes

=> Other components => AD633

=> Semiconductors => IOP1, D11N4001

=> Meters => VF2, VF3

=> Analysis

=> ERC

=> Transient

=> Start 0s

=> Ends 3ms

=> Calculate operating point

=> Ok

=> TR result

=> Autoname

=> VM1, VG1, VG2, VF1, VF2

When we run this software tool with transient analysis for different phase angles, VM1 gives various dc voltages 8.58, 6.77, 4.3 and 1.85 for phase difference of 30º, 60º, 90º and 120º respectively. Thus, output can be calibrated to give dc voltage proportional to phase difference between two input sine waves.

The output can also be analyzed in details by transient analysis. It is shown in figure 7.
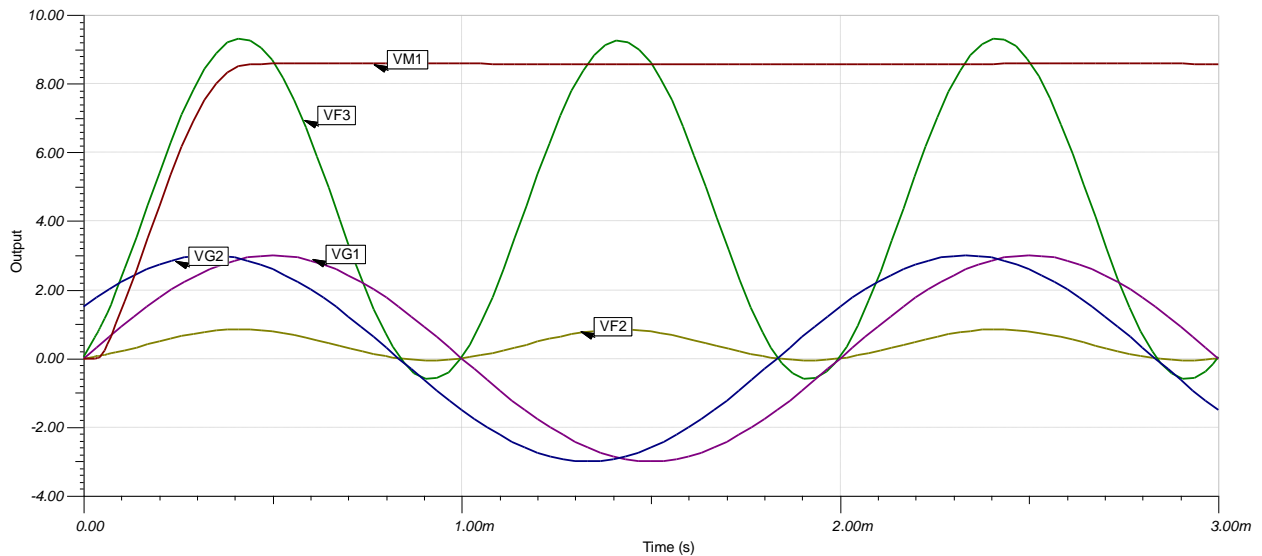

Figure 7. Transient analysis for phase difference of 30º.

4. RESULTS AND DISCUSSION

It is found that multiplier with ac inputs with same frequency and amplitude results in doubling the frequency along with clamping action. Clamping level varies with phase difference of input

waveforms. The output is further processed by add-on circuits to give dc voltage. The resultant dc voltage is proportional to the phase difference of two input sinusoidal. Transient analysis shows the things very clearly. VM1 gives various dc voltages 8.58, 6.77, 4.3 and 1.85 for phase difference of 30º, 60º, 90º and 120º respectively. One can measure any phase differences other than mentioned here. The meter can measure even small difference of 5º giving 9.22 dc voltage. Authors tried simulation with TINA. Unfortunately, no article is found on simulation of phase meter using other SPICE software such as PSpice, 5Spice etc. One may proceed with this software and make study more interesting.

5. CONCLUSION

Circuit simulation has become a core technology in the field of modern electronics engineering, but its application in few circuits such as phase meter has not yet been entirely realized. Finding a precise and efficient model of phase meter is of upmost importance. In our study we used TINA simulator. In order to validate the simulated results basic mathematics has been used. The resultant voltage at the output of multiplier is proportional to the phase difference of two input sinusoidals. Further it is processed using operational amplifier, rectifier and filter to get pure dc voltage. This meter can measure small difference of 5º or even less.

6. ACKNOWLEDGEMENTS

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