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ANALYSIS OF A DOUBLE-WAVE ACCURACY RECTIFIER'S OPERATION WITH OPERATIONAL AMPLIFIERS

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Abstract:
In this work is studied the operation of a double-wave accuracy rectifier achieved with operational amplifiers LM741 at frequencies that exceed their cut-off frequency, using the Multisim simulation program. Is aimed the quality and accuracy of the obtained signal, having in view the damping introduced by the operational amplifiers' operation.

Keywords:
double-wave accuracy rectifier, operational amplifier.

1. WORK'S PRESENTATION

The double-wave rectifier can be obtained by serial connecting of a single-wave rectifier and a summation instrument. Diagram of a single-wave accuracy rectifier which rectifies the positive semi-periods of the input voltage is given in fig. 1. Because it's about small signals, the voltage between the two inputs of the operational amplifier is not neglected anymore, but instead are neglected the OA's input currents and the reverse current through the diode is blocking state.

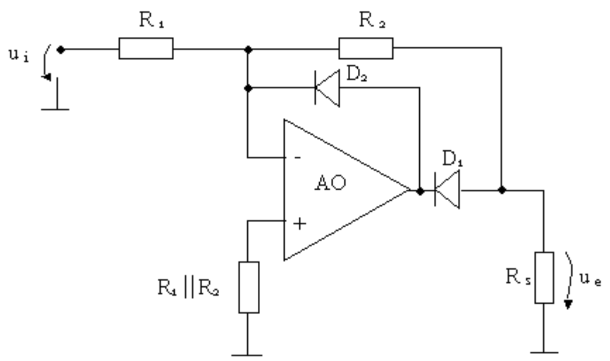


Figure 1. Operation diagram on positive alternance

Output voltage for the positive semi-period of the input voltage is:

$$u_e = -\frac{u_i \frac{R_2}{R_1} + \frac{u_{d1}}{\frac{R_1}{R_1+R_2}A_u}}{1+\frac{1}{\frac{R_1}{R_1+R_2}A_u}} \cong -u_i \frac{R_2}{R_1} \qquad (1)$$

At the circuit's output is obained an identical voltage as time-variation form, and reversed as phase. For the negative semi-period of the input voltage u_i diode D_1 is blocked and diode D_2 conducts all the current coming from the input (fig. 2). In this case, for the output voltage is obtained the relation:

$$u_e = -u_i \frac{R_s}{R_2+R_s} \cong \frac{u_{d2}}{A_u} \cdot \frac{R_s}{R_2+R_s} \cong 0 \qquad (2)$$

Is found that, during the negative semi-period of the input voltage, at output is obtained a voltage almost null.

The diagram of the double-wave rectifier is using such a rectifier, out of which outpt is connected a summation instrument with AO (fig. 3).

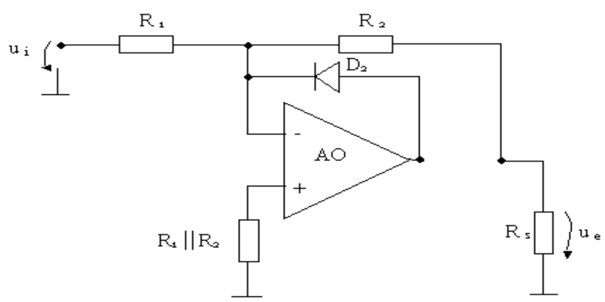


Figure2. Opertation diagram on negative alternance

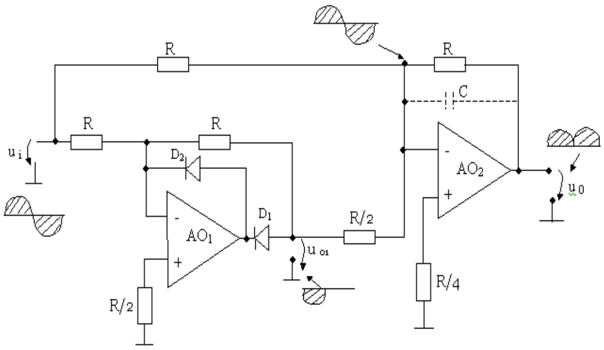


Figure 3. Diagram of the double-wave accuracy rectifier

For the first semi-period (positive) of the input signal, the volatge u_{e1} is negative and, in this case, at the summation device's inputs are brought voltages with equal amplitudes, one positive and one negative, amplified differently. The positive voltage has the amplification 1 and the negative one has the amplification 2, at the summation instrument's output being obtained the positive alternance of the signal u_i. For the negative alternance of the signal u_i is obtained $u_{e1} = 0$ and at the summation instrument's input is brought only the negative alternance of the signal u_i, for u_{e2} being obtained the alternance reversing and amplification 1.

As result, at output is obtained the input signal's rectification, this without being amplified. If it's desired its amplification, the resistances from the diagram will be modified in the ratio aimed to be obtained.

In order to check the rectifier's operation, it was used a generator of sinusoidal signal with amplitude of 275mV and adjustable frequency (fig. 4). The signal was recorded by means of a digital oscilloscope, which allowed the data acquisition in the memory of a PC system.

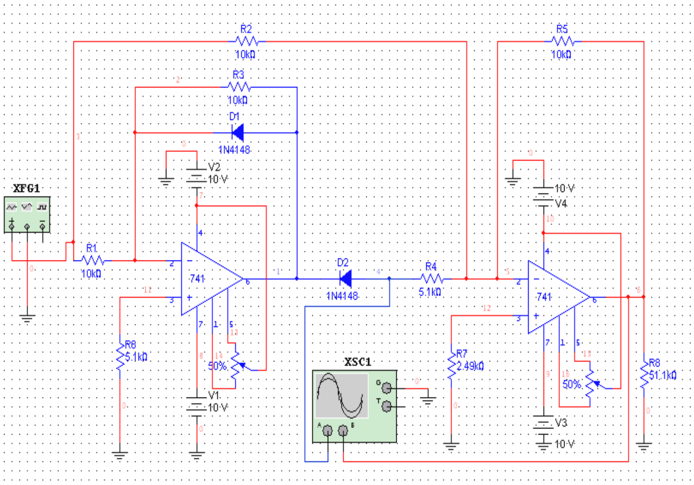
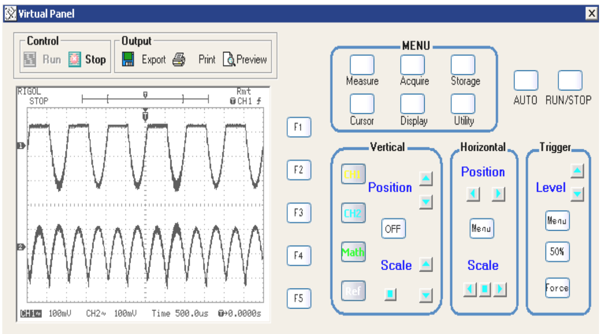
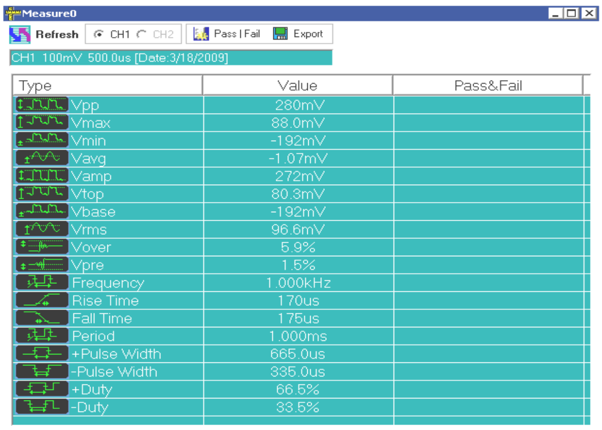


Figure 4. Electronic diagram of the accuracy rectifier



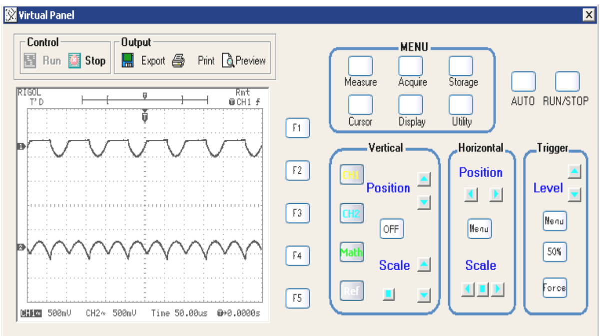


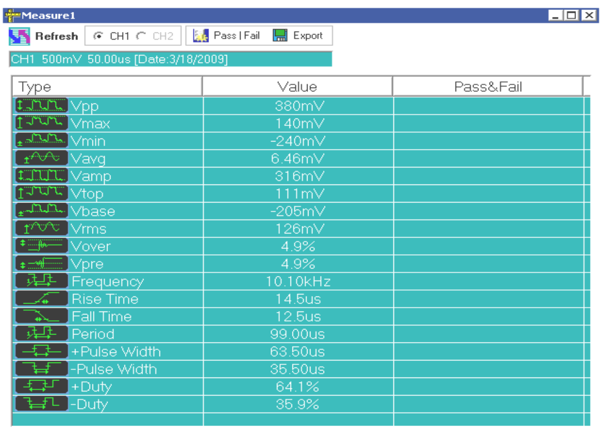
Measure0

CH1 100mV 500.0us [Date:3/18/2009]

Type	Value	Pass&Fail
Vpp	280mV	
Vmax	88.0mV	
Vmin	-192mV	
Vavg	-1.07mV	
Vamp	272mV	
Vtop	80.3mV	
Vbase	-192mV	
Vrms	96.6mV	
Vover	5.9%	
Vpre	1.5%	
Frequency	1.000kHz	
Rise Time	170us	
Fall Time	175us	
Period	1.000ms	
+Pulse Width	665.0us	
-Pulse Width	335.0us	
+Duty	66.5%	
-Duty	33.5%	

Figure 5. a) wave forms corresponding to frequencies of 1 kHz; b) parameters corresponding to the wave forms for 1kHz





Measure1

CH1 500mV 50.00us [Date:3/18/2009]

Type	Value	Pass&Fail
Vpp	380mV	
Vmax	140mV	
Vmin	-240mV	
Vavg	6.46mV	
Vamp	316mV	
Vtop	111mV	
Vbase	-205mV	
Vrms	126mV	
Vover	4.9%	
Vpre	4.9%	
Frequency	10.10kHz	
Rise Time	14.5us	
Fall Time	12.5us	
Period	99.00us	
+Pulse Width	63.50us	
-Pulse Width	35.50us	
+Duty	64.1%	
-Duty	35.9%	

Figure 6. a) wave forms corresponding to frequencies of 10 kHz; b) parameters corresponding to the wave forms for 10kHz

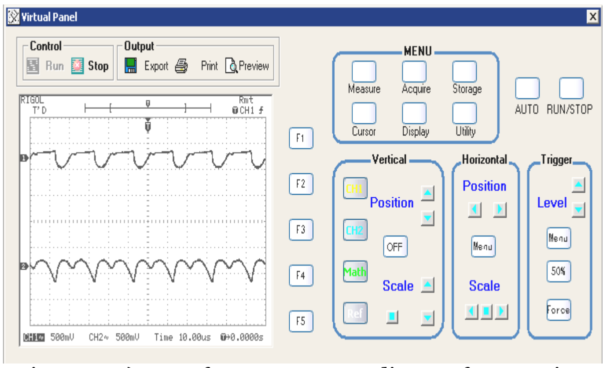
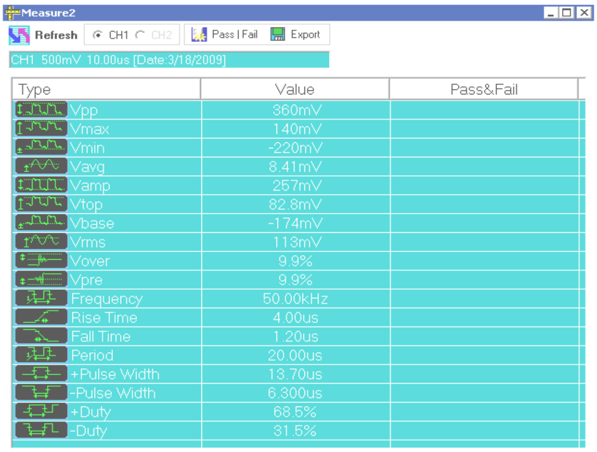


Figure 7. a) wave forms corresponding to frequencies of 10 kHz; b) parameters corresponding to the wave forms for 50kHz



Type	Value	Pass&Fail
Vpp	360mV	
Vmax	140mV	
Vmin	-220mV	
Vavg	8.41mV	
Vamp	257mV	
Vtop	82.8mV	
Vbase	-174mV	
Vrms	113mV	
Vover	9.9%	
Vpre	9.9%	
Frequency	50.00kHz	
Rise Time	4.00us	
Fall Time	1.20us	
Period	20.00us	
+Pulse Width	13.70us	
-Pulse Width	6.300us	
+Duty	68.5%	
-Duty	31.5%	

Are presented three distinct situations, corresponding to all frequencies of 1 KHz (fig. 5.a), 10KHz (fig. 6.a) and respectively 50KHz (fig. 7.a), with the wave forms related to each frequency in part. For each frequency in part are presented the parameters corresponding to the wave forms presented above (fig. 5b, fig. 6b, fig. 7b).

2. CONCLUSIONS

Further the experimental verification of the double-wave rectifier, is found a correct operation within a relatively large frequency band, reaching to approximately 50KHz. One can notice that at the end of the negative semi-period is not reaching to zero, but to a value a little superior, which cannot be compensated, because also the other value related to the positive alternance would be reduced identically. Once by increasing the frequency, is found a distortion of the output signal, especially due to the parasite capacities that occur in the circuit, which makes it to integrate the signal brought at input, reaching up to ramp-signal at very high frequencies.

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