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Investigation of magnifying effects of some semi-conductor diodes during A.C./ D.C. conversion

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Abstract

The work was prompted by the magnifying effect of Semi-conductor Diode Bridge on the output direct current (D.C.) after rectification of a given quantity of alternating current (A.C.) The work determined the causes of increase in voltage, the magnifying factor and remarkable trend of magnification. To this end a step-down transformer was constructed with a variable A.C. output voltage viz: 2, 4, 6, 8, and 10 v. Five different bridges of 4 semiconductor diodes, using five different sets of diodes with varying VRRM voltage specifications and a smoother/filter circuit each, were constructed for use. The five full-wave rectifiers were connected in steps, to each A.C. output simultaneously to obtain data to work with. The work confirmed a positive increase in the rectified output D.C. with an increase in the input A.C. source. There was 35.1% magnification using a diode with 345-VRRM voltage specification and as low as 26.88% magnification for 630-VRRM voltage specification. This signifies magnification increase with a decrease in diode VRRM voltage specification. It was observed that the magnification equally increased with an increase in the rectified A.C. using the same type of Diode Bridge. A.C. Rectification project out is a private endeavour. Thus, this work was designed to probe further on how, why and the causes of this magnifying effect of the rectifier.
Keywords: Transformer, semi-conductor, diode, rectification, filtering, magnification.

Introduction

The need for rectification of an alternating current is imperative going by the technological advancement gadget required direct current (D.C) for powering. Series of attempts were made in the past, to convert A.C to D.C. using Diode Bridge for full wave rectification; in doing this a given quantity of A.C. voltage is inputted to the rectifying circuit. By simple reasoning the same quantity or less would be expected as D.C. output. This would be expected due to possible energy loss in the process of conversion. An alarming experience was ever detected. That is, the D.C. output is usually numerically more than the A.C. input after the process of rectification. This experience was confirmed recently when the researcher embarked on a full-wave rectification project carried out in a private endeavour. Thus, this work was designed to probe further on how, why and the causes of this magnifying effect of the rectifier.

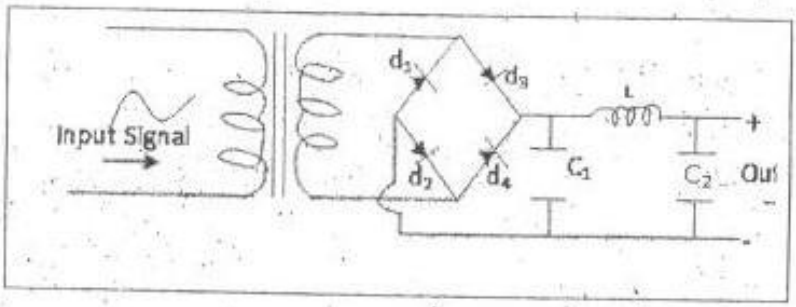
A transformer is a device consisting of two closely electrically coupled coil called primary and secondary coils. An A.C. voltage applied to the primary appears across the secondary with a voltage multiplication proportional to the turn's ratio of the transformer and a current multiplication inversely proportional to the turn's ratio as well (Anderson's 1976). A rectifier converts A.C. to D.C: this is one of the simplest and most important applications of semiconductor diodes. During full-wave rectification a 4-system of diodes act as a simple rectifier because of the difference in its forward and reverse bias properties. The effect of two diodes on A.C. voltage is known as half wave rectification. Thus, full wave rectification can be achieved by the use of 4-diode Bridge coupled with a filter system. There is Semi-

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Conductor diode and Thermionic diode, also called diode valve. But the semi conductor diode has several advantages over thermionic diode such as;

1) Is smaller than thermionic diode value
2) Required less voltage to operate
3) Does not waste so much energy as heat
4) Is not too fragile and
5) Semi conductor is cheaper to manufacture.

A diode does not have a resistance, hence, does not obey Ohm's law (Paul and Winfield, 1995). Unsmoothed full-wave rectification is obtained using the bridge rectifier circuit without smoothing component like electrolytic capacitor. This is basically 4-diode system connected in a square frame (Fig. 1.) Smoothed/filtered full-wave rectifier produces full-wave rectification when capacitor C is included. A large and fairly steady D.C. voltage is obtained (Fig. 2.) Capacitor charges up to peak value of the applied A.C. voltage and then discharge when voltage begins to decrease. If the discharge takes place slowly,then the capacitor becomes recharged to the peak value of the voltage. Again, the "charge-discharge" process takes place continuously and so the voltage across the capacitor combination is a ripple voltage as shown diagrammatically in figure 1 (Stuttman, 1968)



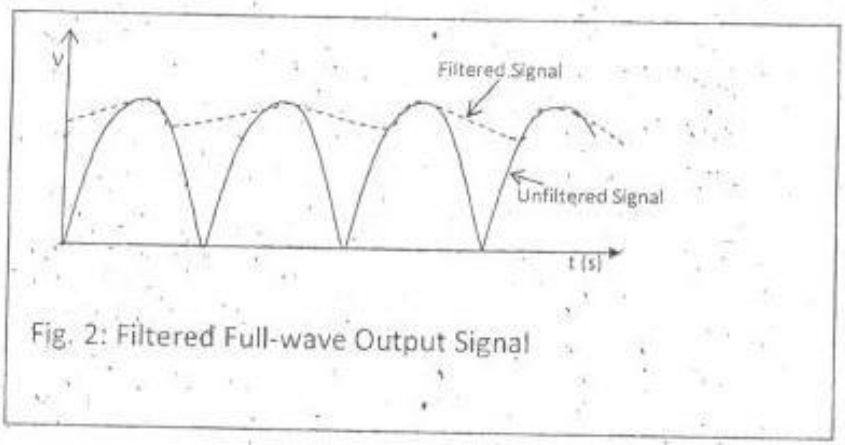


Fig. 2: Filtered Full-wave Output Signal

Methodology

Step-down process

In this process a step-down transformer was constructed to supply varying output of 2, 4, 6, 8, and 10 V (A.C.). This was done by using a copper wire of 0.355 mm thickness (i.e. gauge 29) for the primary winding and 0.800 mm thickness (i.e. gauge 21) for the secondary winding.

Rectification Process

This involved production of 5 diode bridges, each with filter component, but each bridge with different VRRM voltage specification. At a particular instance, each bridge is used to determine D.C. output voltage when an instantaneous alternating current is passed through it. All of the 5 bridges were tested on each A.C. output so as to have 5 values of different D.C. output. The results are shown in the subsequent sections.

Materials and Instrumentation

Table 1, contained the instrument used to accomplish the work. Table 2, contained the specification of each of the diode and capacitor used for each of the 5 bridges.

Table 1: General instruments

S.N.	Description	Quantity
1	Voltage Regulator (Stabilizer)	1
2	Digital Multimeter	2
3	Thick Copper Wire (0.800mm)	¼ kg
4	Thin Copper Wire (0.355mm)	¼ kg
5	Insulating Paper	½ yards
6	Semiconductor Diode	20 pieces
7	Electrolytic Capacitor	5 types
8	E-shaped Soft Iron Sheets	50

Table 2: Diode Specifications

S.N.	Diode Type	If(A)	VRRM(V)	Case	Resistance	Quantity	Capacitor	Quantity
1	Si General	1	IN 5404	Plastic	345	4	470f/35v	1
2	Si General	1	IN 5391	Plastic	430	4	20 f/25v	1
3	Si General	1	IN 5391	Plastic	440	4	680f/20v	1
4	Si General	1	IN 5391	Plastic	515	4	1000f/10v	1
5	Si General	1	IN 5391	Plastic	630	4	2200f/10v	1

Data acquisition

A ready-made voltage regulator (1 kVA) was connected to the main source for a stabilized input to step-down transformer. All the rectifier bridges were connected simultaneously at each 5-A.C. output terminals of the transformer to obtain 5 sets of D.C. signal readings. Thus five sets of readings were recorded per each of the five A.C. output terminal of the step-down transformer. 2 digital multimeters were used, one, to measure instantaneous step-down A.C. input to the rectifier and the second, to measure the D.C. output signal.

Results

Step-down process

The five step-down A.C. outputs used in the work are shown on the table 3. An instance of testing the data collected was enumerated in the table. Thus, the calculated A.C. output in table 3 serves as the input for the rectifier.

Table 3: Step-down process

S.N.	Primary turns	Secondary turns	Expected A.C. input Voltage (v)	Expected A.C. output Voltage (v)	Instantaneous Average A.C. Input Voltage (v)	Instantaneous Average A.C. Output Voltage (v)
1	2050	20	220	2.1	266.2	2.21
2	2050	40	220	4.3	227.0	4.43
3	2050	65	220	7.0	227.8	7.22
4	2050	90	220	9.7	227.0	9.97
5	2050	115	220	12.3	228.2	12.80

Rectification process

In this case a bridge, having four same types of diodes, was used to obtain a D.C. output signal. This was done for 4 other bridges for the same A.C. input. The above processes were done for all the 5 A.C. step-down sources to obtain 5-sets of reading for each A.C. source. The output D.C. signals obtained using various step-down A.C. sources are shown in the table 4 through 8.

Table 4: Results from 2 V step-down A.C. Source

S.N.	Diode (VRRM) V	Instantaneous A.C. Input Voltage	Instantaneous A.C. Output Voltage	Instantaneous D.C. Output Voltage	Output D.C. Increment voltage (%)
1	345	226	2.1	3.2	34.4
2	430	228	2.1	3.0	30.0
3	440	226	2.1	2.9	27.6
4	515	225	2.0	2.8	28.6
5	630	226	2.1	2.5	16.0

Average D.C. output signal increment, for table 4 is 27.32% in all the bridges.

Table 5: Results from 4 V step-down A.C. Source

S.N.	Diode (VRRM) V	Instantaneous A.C. Input Voltage(V)	Instantaneous A.C. Output Voltage(V)	Instantaneous D.C. Output Voltage(V)	Output D.C. Increment voltage (%)
1	345	228	4.3	6.6	34.8
2	430	227	4.3	6.3	31.7
3	440	225	4.2	6.3	33.3
4	515	227	4.3	6.1	29.5
5	630	228	4.3	5.9	27.1

Hence, average output increment is 31.28% when the source is 4.3 v on average (Table 5).

Table 6: Results from 6 V step-down A.C. Source

S.N.	Diode (VRRM) V	Instantaneous A.C. Input Voltage(V)	Instantaneous A.C. Output Voltage(V)	Instantaneous D.C. Output Voltage(V)	Output D.C. Increment voltage (%)
1	345	227	7.0	10.9	35.8
2	430	228	7.0	10.7	34.6
3	440	228	7.0	10.7	34.6
4	515	227	7.0	10.5	33.3
5	630	229	7.1	10.2	30.4

Table 6 shows that when the source increased to 7.0 v, the D.C. output increment remained 33.74%.

Table 7: Results from 8 V step-down A.C. Source

S.N.	Diode (VRRM) V.	Instantaneous A.C. Input Voltage(V)	Instantaneous A.C. Output Voltage(V)	Instantaneous D.C. Output Voltage(V)	Output D.C. Increment voltage (%)
1	345	228	9.6	14.8	35.1
2	430	228	9.6	14.6	34.2
3	440	226	9.5	14.5	34.5
4	515	227	9.6	14.6	34.2
5	630	229	9.5	14.0	32.1

The D.C. output increment moved to av average of 34.02% when the A.C. source increased to about 9.6v.

Table 8: Results from 10 V step-down A.C. Source

S.N.	Diode (VRRM) V	Instantaneous A.C. Input Voltage(V)	Instantaneous A.C. Output Voltage(V)	Instantaneous D.C. Output Voltage(V)	Output D.C. Increment voltage (%)
1	345	228	11.5	17.8	35.4
2.	430	228	11.5	17.6	34.7
3	440	229	11.5	17.6	34.7
4	515	229	11.5	17.4	34.0
5	630	227	11.4	16.0	28.8

The average increment was 33.52% when the source was finally increased to about 11.5 V#. (Table 9)

Discussion

Analysis of the results obtained by rectifying 5 different A.C. values using five different semiconductor diode rectifier bridges at every A.C. output source, in turns, is summarized in Table 9. In all the five different cases of varying A.C. output rectified there is always increment in the D.C. output. The output D.C. shows an average of 31.38% increase of the rectified A.C.

Table 9: Summary of input A.C. and D.C. signals

Average A.C. source (V)	% D.C. output increment
2.1	27.32
4.3	31.28
7.0	33.74
9.6	34.02
11.5	33.52

A remarkable trend is that the higher the A.C. source voltage to be rectified; the more is the percentage D.C. output magnification factor (table 9). However, the D.C. output magnification decreased with an increased in VRRM voltage specifications of the bridge semi-conductor diode, when the same A.C. source voltage was rectified.

Conclusion

It was confirmed that there is always magnification of the rectified A.C. when semi-conductor Diode Bridge was used. The magnification was found to be at an average of 35.1% of the input/source A.C. rectified, with a diode bridge having the lowest (VRRM) voltage value of 345. It was obtained that the magnification increased with an increased in the rectified A.C. using the same type of Diode Bridge; for instance, the output D.C. for the diode with the lowest VRRM voltage value of 345 increases from 34.4 V to 35.4 V when the rectified A.C. was increased from 2 to 10 V. The magnification was also found to be varying with the diode specification (i.e. VRRM, voltage of the diode). It was found that the magnification increases with a decrease in VRRM voltage value of the bridge. The lowest VRRM value of the diodes used is 345 and the average magnification is 35.1% while the highest is 630 with an average magnification of 26.88%.

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