

Characterization of Filter Capacitor Effect on DC Voltage and Ripple Voltage Levels of a Rectifier Output

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Abstract - The importance of rectification process in electronics cannot be overemphasized as most electronic gadgets operate on dc power source. For optimal operation and avoidance of noise in sensitive electronic circuits, quality power supply becomes eminent. The culprit and source of all worries in the rectified output voltage is the ripple voltage. Any effort put in reducing it to manageable level is an effort in the right direction. In this work the effect of the filter capacitor capacitance is investigated. It is found that the levels of the rectifier output voltage, the ripple voltage, waveform and power quality are all function of the capacitance. While the increase in capacitance ensured higher output dc voltage, lower ripple voltage, better power and waveform qualities, it also stresses the power components like transformer, diodes by creating higher inrush current to the load thereby resulting in higher cost of operation. Choosing a right value of filter capacitance is the real deal for optimized quality dc power source.

Keywords: Transformer, Rectifier, Capacitor, Capacitance, Filter, Ripple voltage, Power quality, waveform quality.

I. INTRODUCTION

Most electronic gadgets and instruments are powered on DC power which are being provided by batteries or alternatively by a rectifier which converts AC power to DC power. Conversion of AC to DC power traditionally involves four stages of Voltage transformation, rectification, filtration and regulation S. Sharma (2012). In recent times most, converter circuits don't use a transformer. In both cases filtering is always required. There are always ripples at the output of the rectifier which doesn't augur well with electronic circuits M.L. Anand (2000). These ripples could be seen as the remnants of the unrectified AC power components. The selection of the transformer values, diode values and transistors for stepping down, rectifying and regulation respectively are easily down by checking out their values in tandem with the expected voltage output being envisaged. When it comes to filtering, it is not the same. There is always

problem on the capacitance value to be selected. Different ranges of capacitors can do the work effectively. Most often than not attention is being focused on the capacitor working voltage on how close or far it is from the envisaged output voltage. It is pertinent to state here that this happens in both the half wave and full wave rectifiers. This work looks deeply into the effect of different capacitances on the output voltage level of the rectifier.

II. MATERIALS AND METHOD

2.1 The Need for Filtering

The output of a rectifier dc output is a pulsating dc V K Mehta and R Mehta (2022). Connecting a capacitor to the output of the rectifier makes the capacitor to charge up to the peak voltage V_p when the input voltage rises and discharges slowly when the input voltage drops through the load resistor L. This phenomenon happens both in half wave and full wave. In the circuit of figure 1 below a filter capacitor C and the load resistor L are shown. The charging up of the capacitor compensates for the fall in dc voltage level when the diode is not operating P Harowitz and W Hill (1995). The effect is that the output voltage is kept as close to the V_p as possible. The capacitor also provides an easier way for the ripple voltage to be conducted away from the output to the ground as the capacitor uses the frequency effect to provide easier resistance path to the ripples K. Santiram (2002).

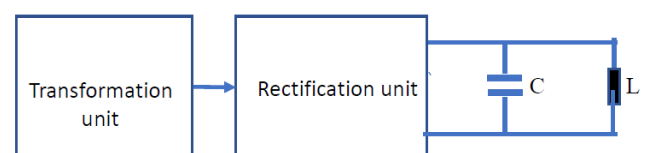


Figure 1: Filtering Circuit

The ripple voltage is stated in equation 1 below.

$$V_r = \frac{I}{fC} \quad (1) \quad \text{R.I Salawu (2013)}$$

Where

V_r = ripple voltage

I = Load current

f = frequency (twice in full wave)

C = Capacitance

Capacitor charging and discharging equation is shown in equation 2 and 3 below

$$V_c(t) = V_p(1 - e^{-t/RC}) \quad (2)$$

Where

V_c = Capacitor voltage

V_p = Peak rectified voltage

R = Load resistance

C = Capacitance

T = time

$$V_c(t) = V_p e^{-t/RC} \quad (3)$$

Where

V_c = Capacitor voltage

V_p = Peak rectified voltage

R = Load resistance

C = Capacitance

T = time

Actually, it is this that actually determines the ripple voltage. The ripple voltage equation is given in equation 4 below.

$$V_r = \frac{I}{fC} \quad (4) \text{ R.I Salawu (2013)}$$

Where

V_r = ripple voltage

I = Load current

F = frequency of supply (double for full wave)

C = Capacitance

2.2 Experimentation

The full wave rectifier is used in this process and is setup as shown in figure 2 below. It comprises of a 220/15V transformer and bridge rectifier. A dc voltmeter is used in measuring the dc output and is connected across the filter capacitor. A load resistor of 1K is connected at the output with the oscilloscope to visualize the voltage ripple form. On powering the circuit, the output dc voltage is measured the voltage is recorded against the capacitance used at the instance. After that all the other capacitors of 330 μ F, 470 μ F, 560 μ F, 1000 μ F and 2200 μ F were used one after the other. It is pertinent to state here that the experiment started with no

capacitor connected which represented 0 μ F. The dc voltage output was recorded correspondingly. During the experimentation under review every other component and value remained constant while it is only the capacitors that were being changed.

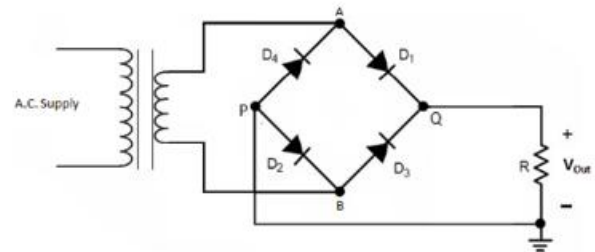


Figure 2: Experimental circuit

III. RESULTS AND DISCUSSION

Two graphs, output rectifier dc voltage vs capacitance and ripple voltage vs capacitance were generated from the experimental resultant data. These graphs are clearly displayed in figures 3 and 4 respectively. From the output voltage vs capacitance graph in fig 3, it could be seen that the output dc voltage increases with the increase in capacitance. This means that the higher the capacitance, the higher the output voltage. It could also be seen that the proportionality between the two does not continue indefinitely as the curve tends to be constant as it approaches the V_p . Beyond this point increase in capacitance has no more effect.

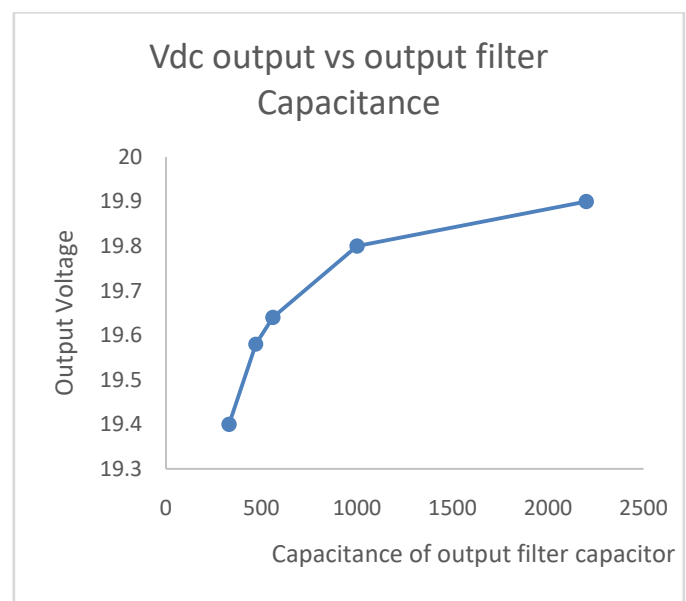


Figure 3: Graph of output voltage vs Capacitance

In figure 4, it could be seen that the ripple voltage decreases with the increase in the capacitance. This means that the ripple voltage is inversely proportional to the capacitance.

It is also important to note that the proportionality is not continuous as the curve tends to level up to a permanent level showing that at a point increment of capacitance doesn't ensure a complete ripple free output.

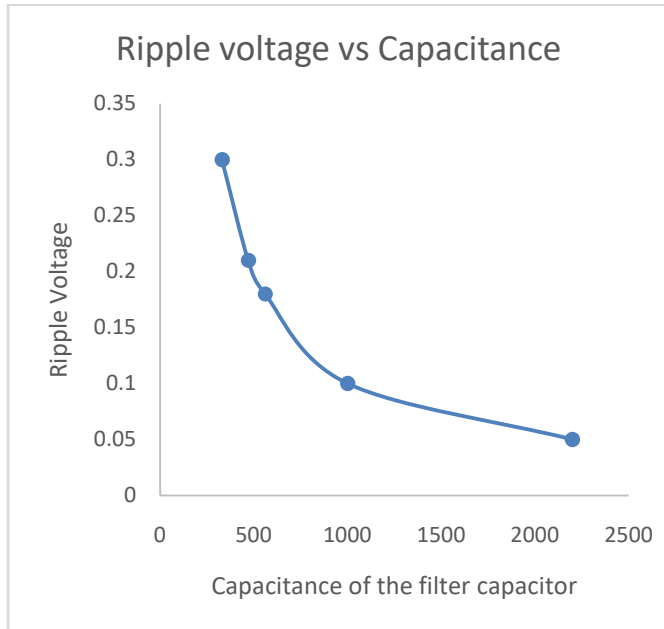


Figure 4: Graph of Ripple Voltage vs Capacitance

IV. CONCLUSION

It has been shown through this work that increase in capacitance of the filter capacitor of a rectifier dc power

supply increases the output voltage which becomes constant as voltage approaches the peak voltage of the rectifier. Also, with higher capacitance, the ripple voltage is also reduced but levels to a constant as the ripple voltage tends to zero. In both cases of the output voltage and ripple voltage, increment of capacitance brings about improved power quality and voltage waveform as seen with oscilloscope. Finally, as there are two sides to every coin, incessant increase in capacitance has its own negative effect which includes a high inrush current on the load when switched, stress on the diodes and the transformer which results in higher cost of operation.

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