Single phase, uncontrolled rectification (conversion)

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29 October 2015

Abstract

An experiment investigating full wave rectification, for the purposes of producing a steady DC output. This is implemented using every half-cycle input from the supply voltage instead of every other half, this is known as a full wave rectifier.

1 Introduction

Full wave bipolar (dual voltage) centre tapped bridge rectifier like the half wave rectifier produces an output voltage or current which is purely DC. The advantage of the full wave rectifier is the output voltage is higher than that of the half wave and so consequently. This circuit is similar to the bridge rectifier but requires a centre tap on the secondary winding to provide a dual voltage source of DC voltage as can be see per the diagram below in figure 1.The four diodes used in this circuit make up what is called a single phase bridge amplifier which is available as a package. In this circuit diagonally opposite diodes conduct for each half cycle. It is used to create a bipolar DC supply (e.g. +15,0.-15 supply). Particularly useful in applications involving op-amps.

2 The Full Wave Bridge Rectifier

This type of single phase rectifier uses four individual rectifying diodes connected in a closed loop "bridge" configuration to produce the desired output.

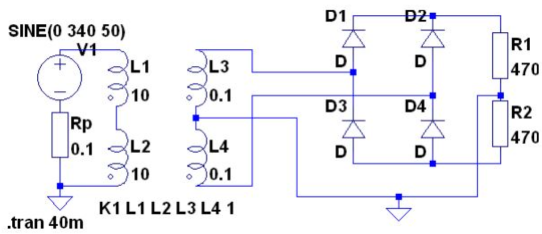

Figure 1: Full wave rectifier with centre tap.

The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below in figure 2.

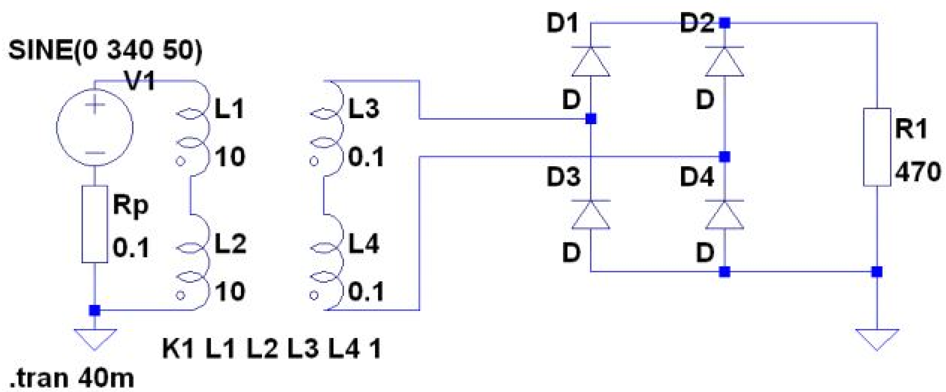

Figure 2: Full wave rectifier with no centre tap .

2.1 The Diode Bridge Rectifier

The four diodes labelled D1 to D4 are arranged in "series pairs" with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load in the same direction for regardless of the input sine wave voltage as the voltage has been rectified using the diodes.

However in reality, during each half cycle the current flows through two diodes instead of just one so the amplitude of the output voltage is two voltage drops (2 x 0.7 = 1.4V) less than the input VMAX amplitude.

2.2 Resistive load Centre tapped.

Taking a perpex test board the experiment was set up as seen in figure 3: Following the above diagram in figure 1 the circuit was wired as can be seen

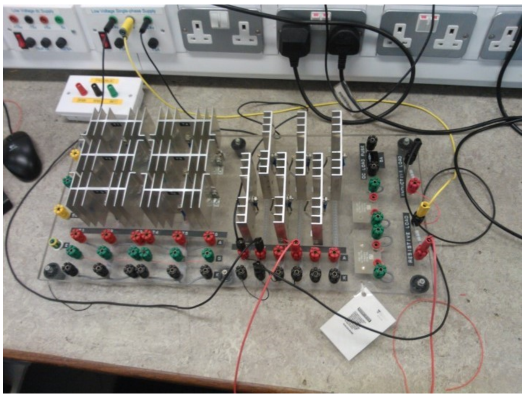

Figure 3: Perpex test board

in figure 4.

3w resistors were used for R1 and R2. (figure 5) Then with the use an oscilloscope it was possible to view the voltage across R1. Shown in figure 6:

The top of the peak voltage there is a clamp on magnetic field in the transformer core, the magnetic flux is constantly changing until it reaches the point near the peak value where the magnetic flux stops changing and this affects the induction voltage. (there is a drop in the voltage as seen in the graph because the diode is not turning on straight away and takes 0.7v to turn on.) At this point a small resistor (approx 1 ohm) was Inserted in line between one of the low voltage AC terminals and the bridge rectifier. Using the oscilloscope to examine the waveform across this – it was seen to be a scaled version of the current waveform just measured previously.

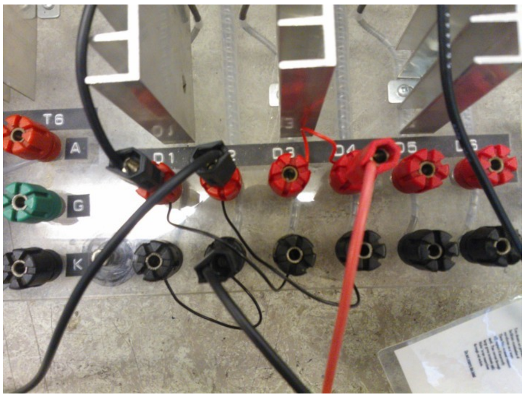

Figure 4: Wiring up the diodes!

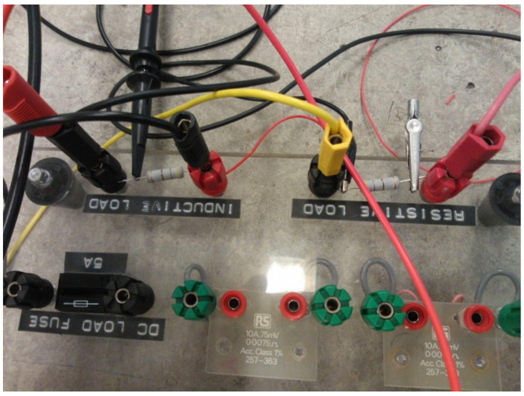

Figure 5: Showing the two 3w resistors

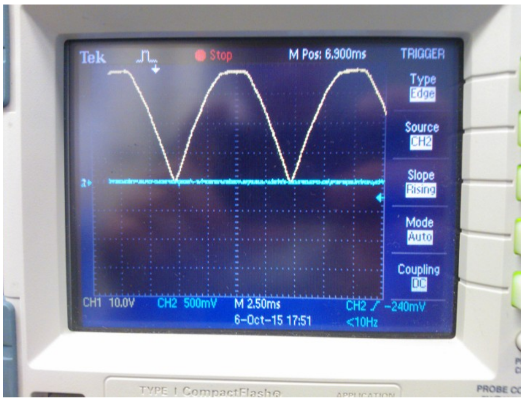

Figure 6: Full wave rectification with no smoothing

Note: unfortunately these photos were lost so a circuit was drawn in Pspice and waveform was simulated shown below in figure 8 and 9.

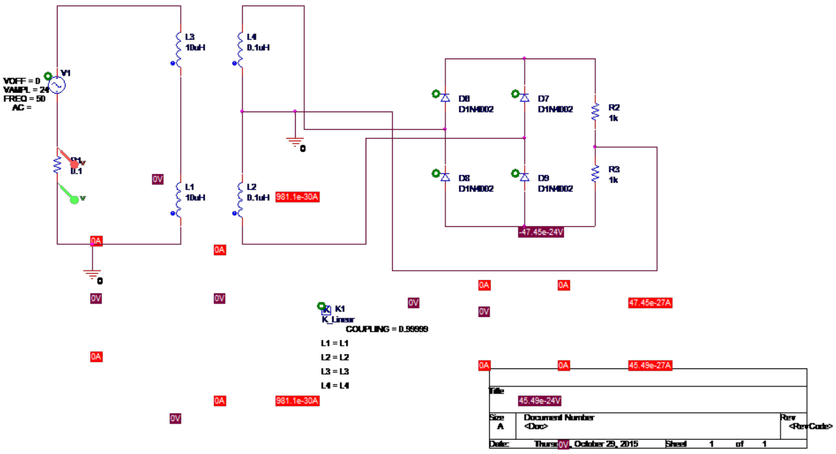

Figure 7: Pspice circuit

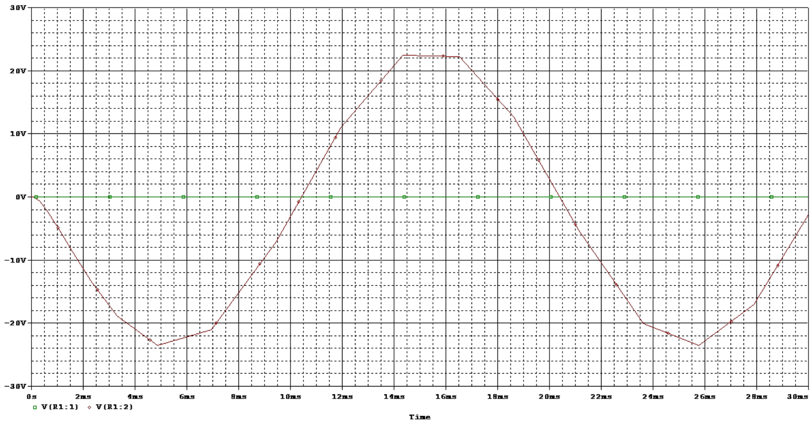

Figure 8: Pspice waveform scaled version of output

2.3 The Smoothing Capacitor

The full-wave bridge rectifier however, gives us a greater mean DC value (0.637 Vmax) with less superimposed ripple while the output waveform is twice that of the frequency of the input supply frequency. We can therefore increase its average DC output level even higher than the half wave rectifier by connecting a suitable smoothing capacitor across the load resistors R1 and R2 of the bridge circuit as shown below figure 9.

Shown here is how has the current waveform changed in the figure 10 below.

We measured the DC output voltage (with a voltmeter) shown to be 23.3v to 23.4v. shown in fig 12.

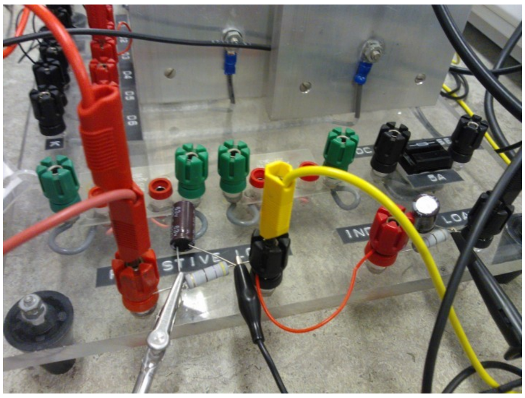

Figure 9: Capacitors across resistors R1 and R2

Figure 10: Smoothed output with current spike shown in blue

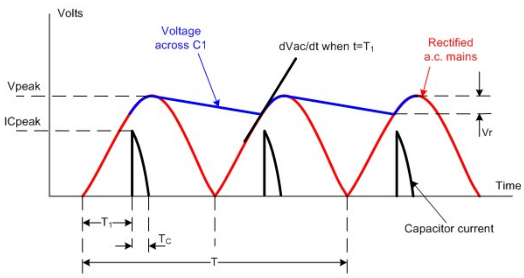

Figure 11: Smoothed graphic

2.4 Calculated values Vs measured values

2.4.1 Calculate the theoretical un-smoothed output voltage and compare it with the measured value. Are there differences? If so, why?

$\int_{\theta}^{\pi} VoSin\theta d\theta$

Figure 12: Smoothed graphic

which becomes:

$Vo\,[-cos\theta]_{\theta}^{\pi}$

$= Vout * 2$

$Vout = 26.6 * \sqrt{2} = 37.6v$

$VoutAvg = Area/Base$

$= \frac{Vout*2}{\pi}$

$= 23.68v$

The measured value was between 23.3v and 23.4v. Reasons for difference was because it was not pure sine wave and the transformer saturates.

Capacitor = 220uf Dc output 23.68v - 23.3v Difference of 0.38v

2.4.2 The current waveform should change after you add capacitors. What are the implications of this from a supply perspective? What effect would larger and larger smoothing capacitors have?

The smoothing capacitor converts the full-wave rippled output of the rectifier into a smooth DC output voltage. Generally for DC power supply circuits the smoothing capacitor is an Aluminium Electrolytic type that has a capacitance value of 100uF or more with repeated DC voltage pulses from the rectifier charging up the capacitor to peak voltage. However, their are two important parameters to consider when choosing a suitable smoothing capacitor and these are its Working Voltage, which must be higher than the no-load output value of the rectifier and its Capacitance Value, which determines the amount of ripple that will appear superimposed on top of the DC voltage. Too low a capacitance value and the capacitor has little effect on the output waveform. But if the smoothing capacitor is sufficiently large enough (parallel capacitors can be used) and the load current is not too large, the output voltage will be almost as smooth as pure DC. As a general rule of thumb, we are looking to have a ripple voltage of less than 100mV peak to peak. The maximum ripple voltage present for a Full Wave Rectifier circuit is not only determined by the value of the smoothing capacitor but by the frequency and load current, and is calculated as:

$= \frac{Iload}{2*fc}$

2.4.3 What is the output ripple voltage (with the capacitors)?

$Idc = \frac{Vdc}{R} = \frac{23.3v}{470} = 0.0495amps$

$Vripple = \frac{0.0495}{(2*50*(220*10-6)fc)} = 2.25v$

2.4.4 Assuming the capacitor has to hold up the voltage for 10ms (a complete half cycle) and the current over this time is equal to the peak current, what is the calculated ripple voltage?

$Vripple = \frac{0.0495}{(2*50*(220*10-6)fc)} = 2.25v$

2.4.5

Use section and subsections to organize your document. Simply use the section and subsection buttons in the toolbar to create them, and we'll handle all the formatting and numbering automatically.

2.5 Bibliography

- Electrical Machines, Drives and Power Systems. Sixth Edition. Theodore Wildi. Professor Emeritus, Laval University.
- Electronics fundamentals, Floyd