Hello all,

Here is my attempt to explain what is different between half-wave and full-wave converted LED light strings. The engineer in me goes back to what I learned in college. My intuition told me that the peak current through a single leg of full-wave converted LED string was the same as a half-wave string.

To prove this out I turned to circuit simulation software. The limitations of the free online demo limited the number of circuit elements you could have. So I had to compensate for this by scaling down the number of LEDs and the peak AC voltage. The voltage source is 20V peak. The LEDs have a voltage of 2.1V when driven with 30mA. The curve below is the current versus voltage for the LED used in the simulation. The basic circuit concepts simulated here would scale up to AC line voltage and actual LED counts.

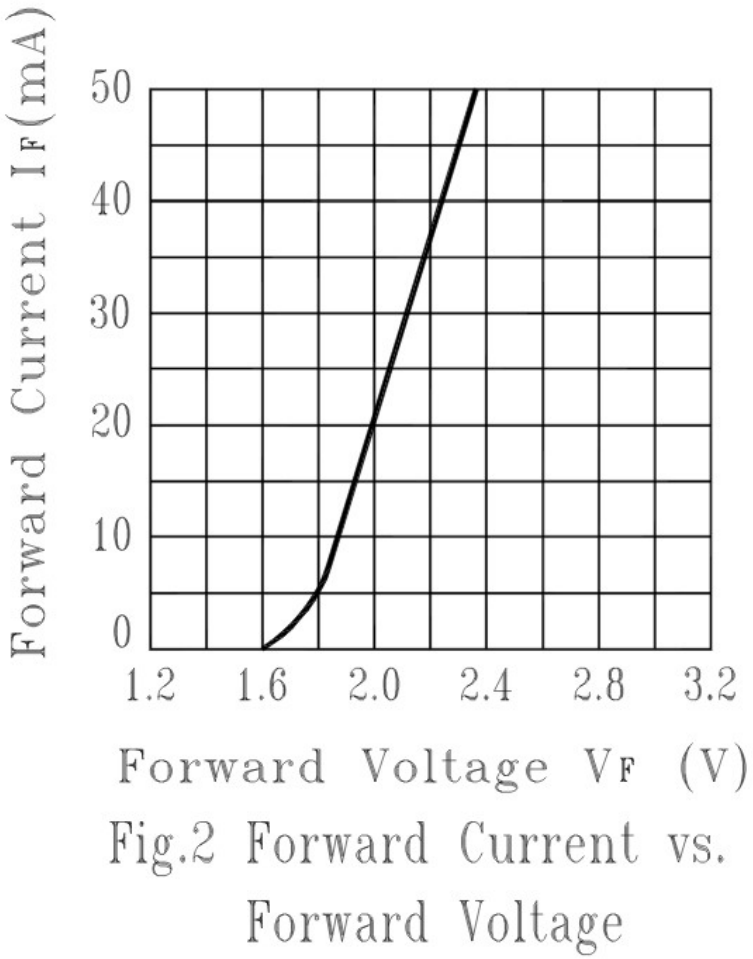
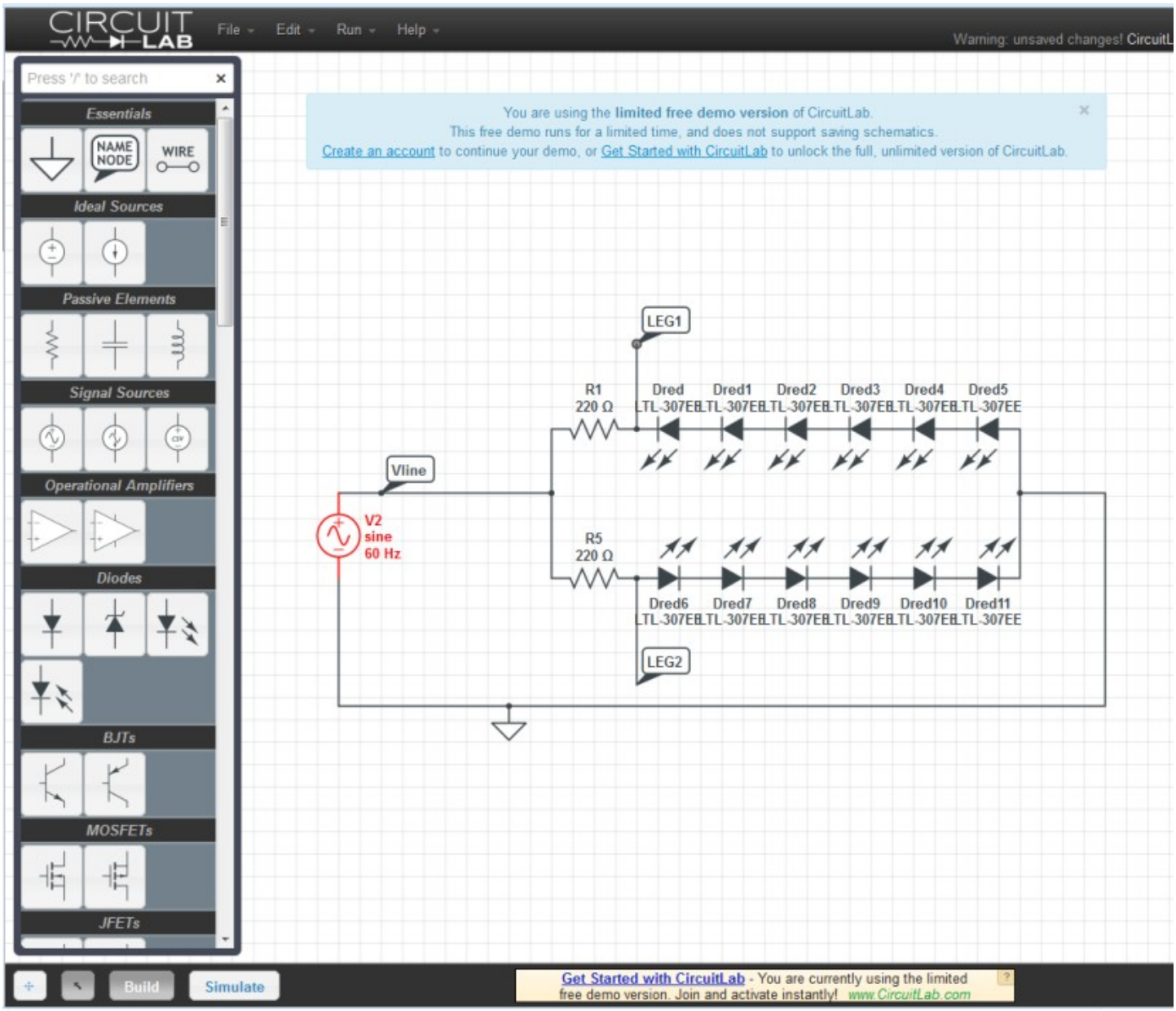


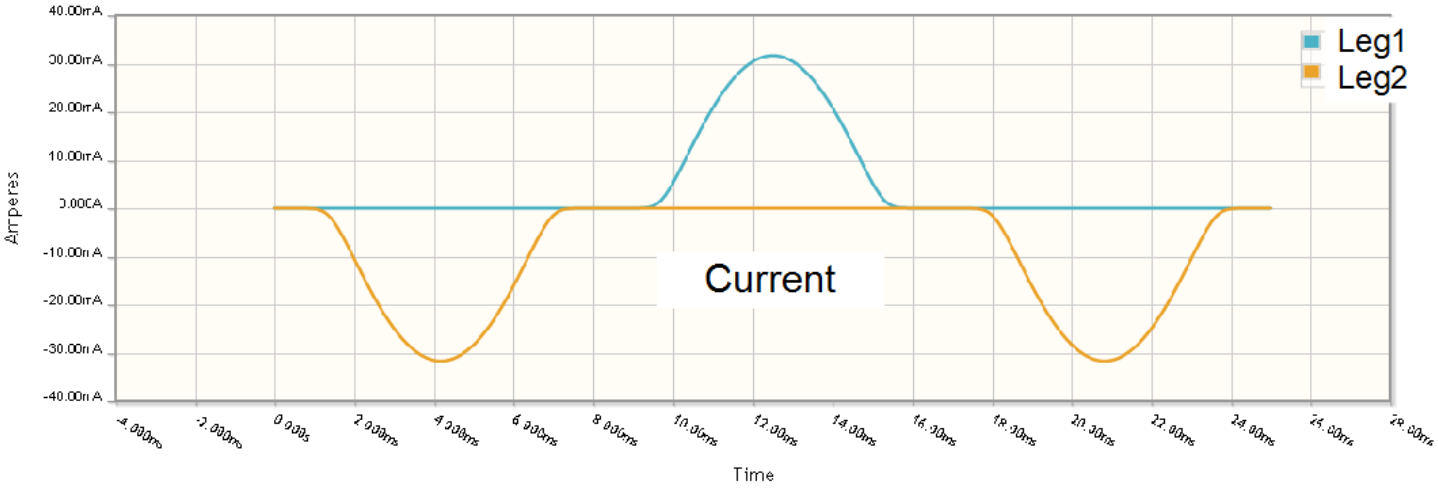
Fig.2 Forward Current vs. Forward Voltage

Below is the circuit diagram for a half-wave light string in the simulation tool.

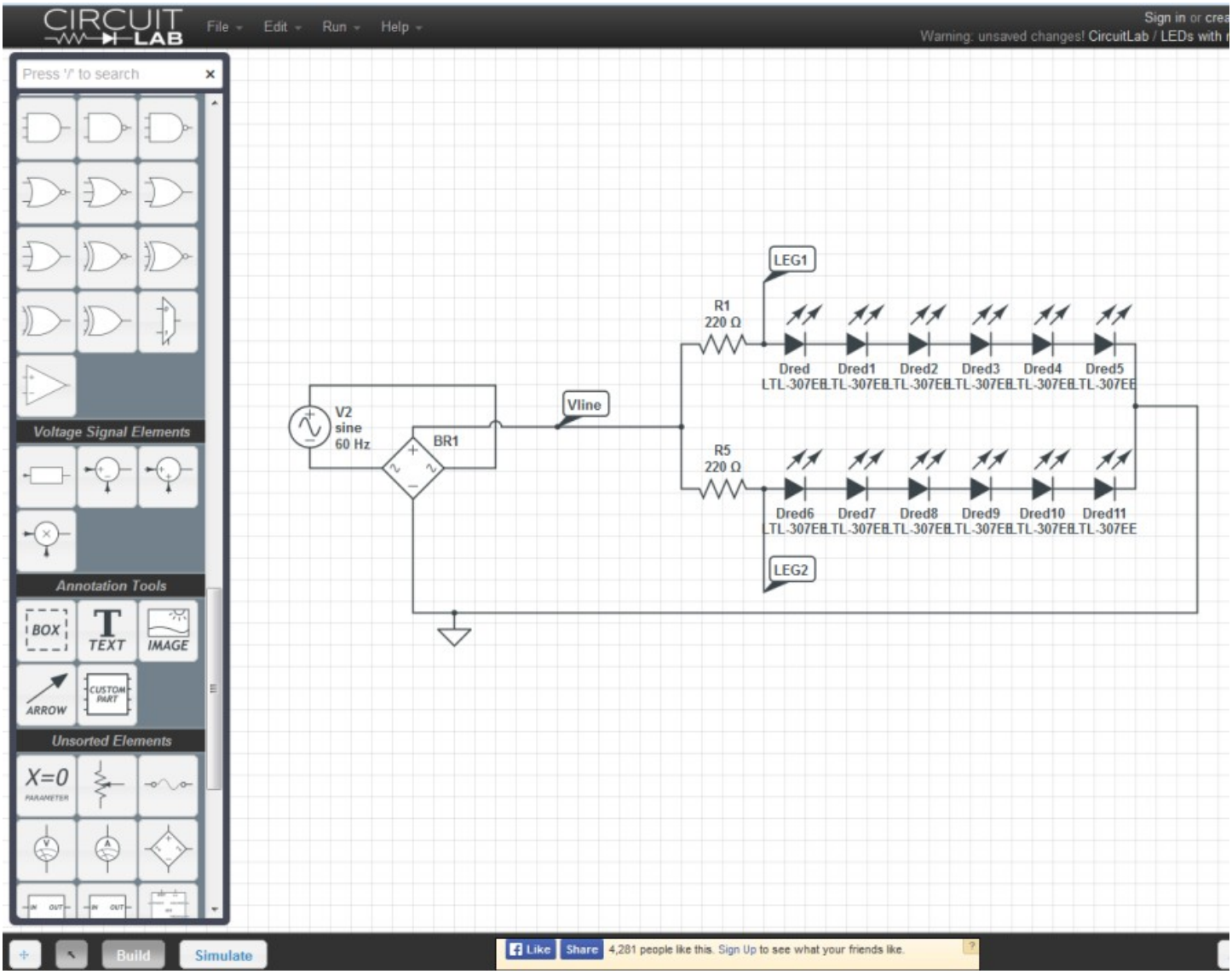


I labeled three points on the diagram. Where Vline represents the AC line voltage. LEG1 represents the first leg and LEG2 the second leg of series connected LEDs. Now I can capture voltage and current data at these points. I ran a time domain simulation that spanned one and a half 60Hz cycles (0.025 seconds). The data points were sampled every 0.00001 seconds (0.1 milliseconds).

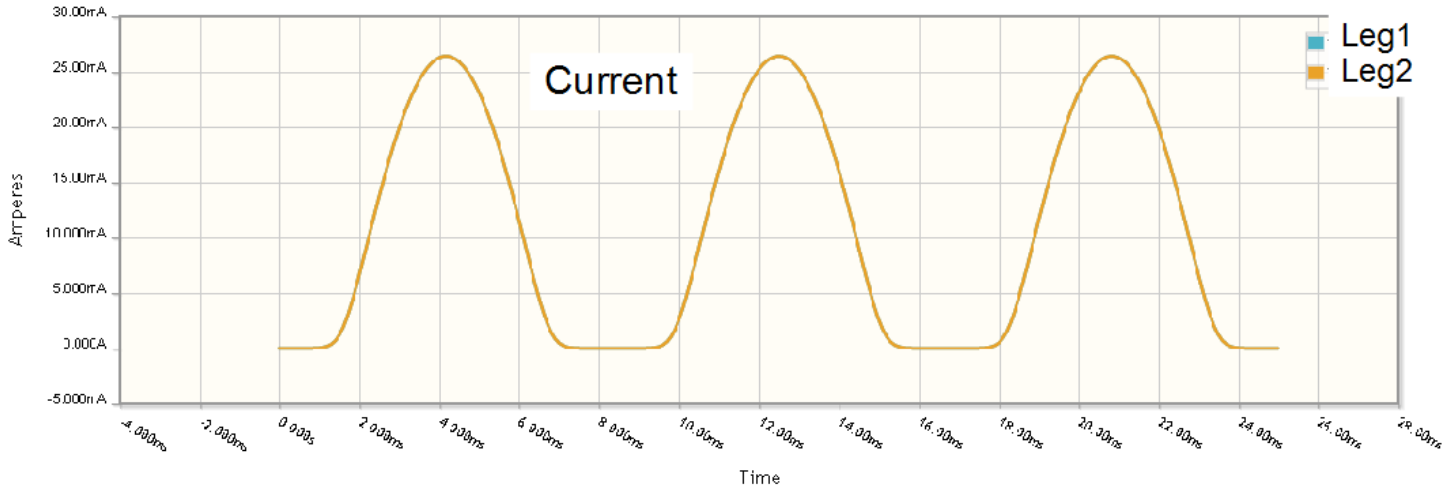
The plot below shows the current in LEG1 and LEG2 versus time. The peak current in each leg is just over 30mA.



Now for the full-wave version. The diagram below shows the addition of the full-wave bridge rectifier (BR1). The LEDs in leg 1 have been reversed to match leg 2. Once again the voltage generator was set to 20V.

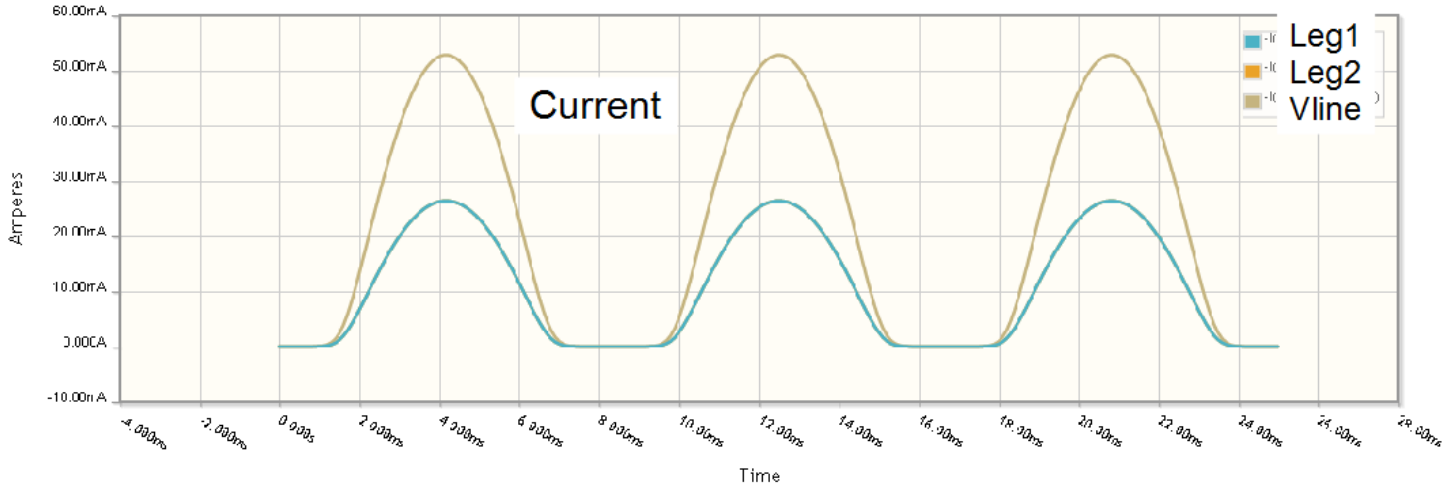


Now lets take a look at the current in leg 1 and leg 2. The graph below shows the current in both legs. It looks like one curve because the current is the same in each leg. The peak current here is about 27 mA. This is about 4 mA less than the half-wave case. Why? The bridge rectifier has a voltage drop of about 0.7V, so Vline is less than 20V in this case. The voltage drop due the the bridge rectifier is less noticable when using full 120V AC.

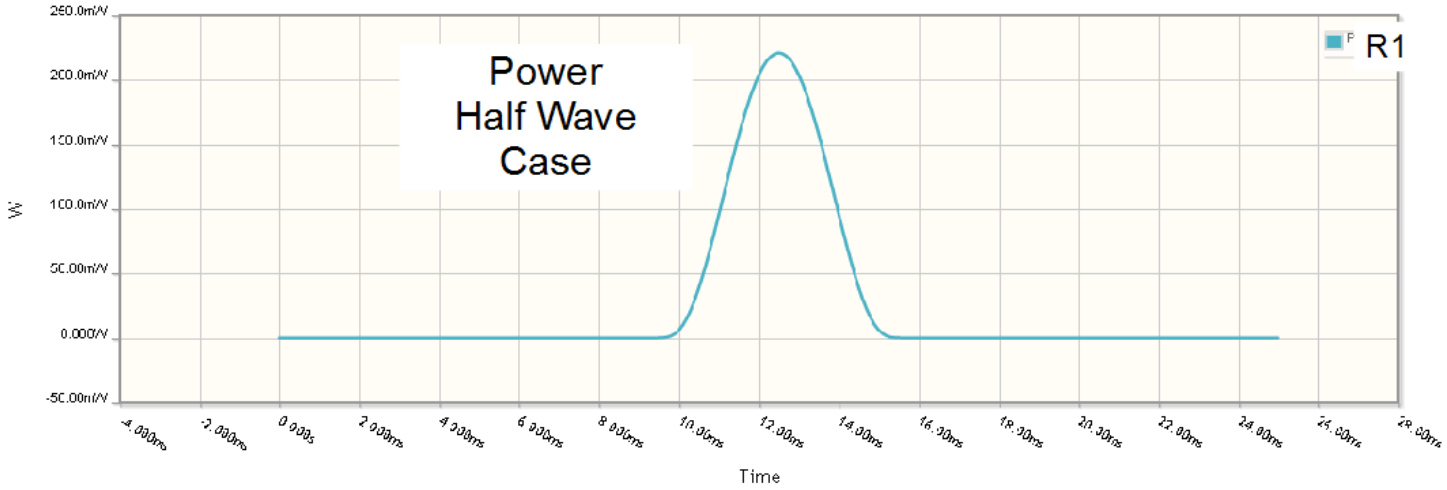


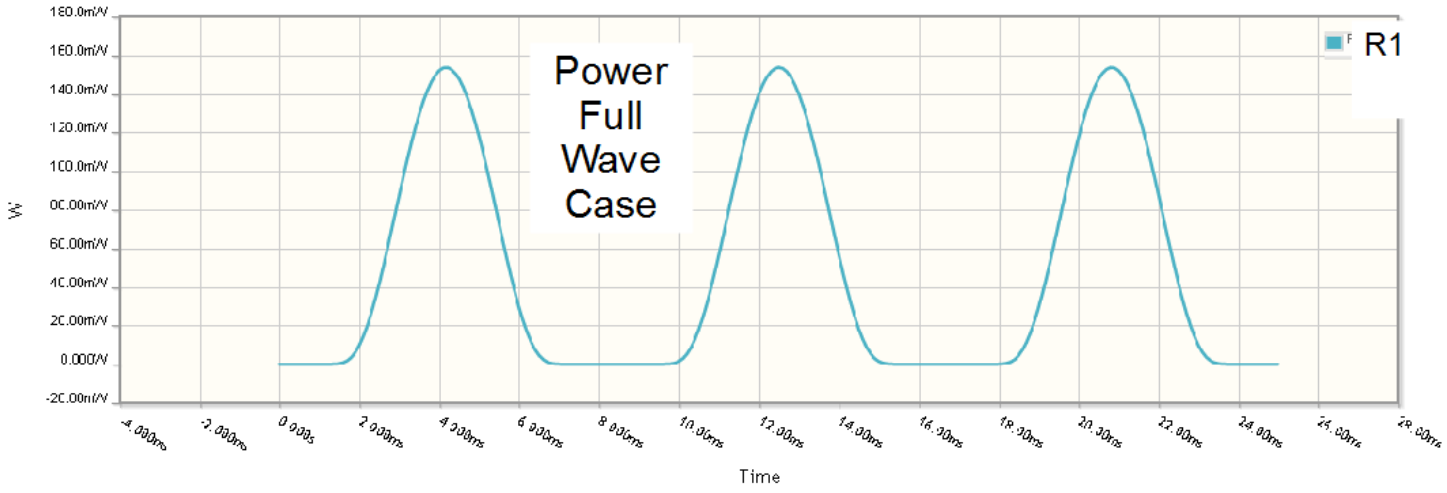
This simulation clearly shows that the current in each leg of the LED string **DOES NOT** double when rectified.

However, the current at point Vline is a different story. The plot below shows that the current through Vline **IS DOUBLED**.

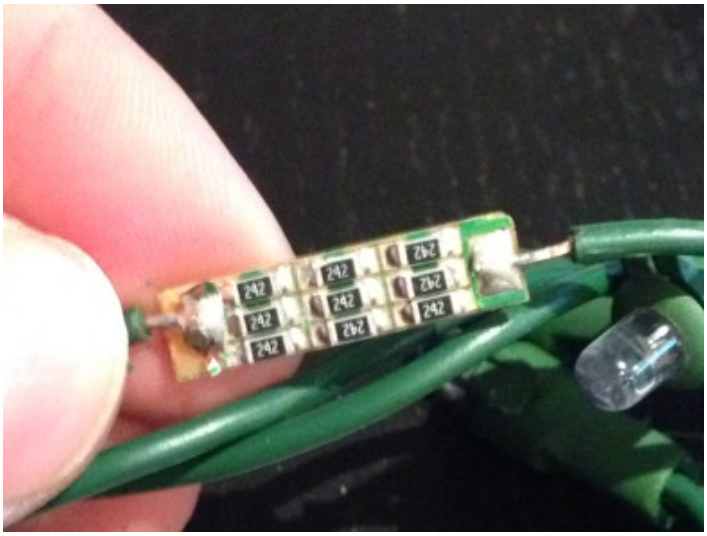


Now lets take a look at the power dissipated by resistor R1. The plots below show the half-wave and full-wave rectified cases. In the have-wave case the resistor only has to dissipate power during half an AC power cycle. However in the full-wave rectified case the resistor must dissipate power twice during an AC power cycle. Therefore, resistor R1 is properly sized for **current** limiting purposes. But **may not be** properly rated for the increased power dissipation. Resistors commonly come in 1/10th, 1/8th, ¼, ½ etc, watt, power ratings. The only way to determine the power rating of the current limiting resistor is to get your eyes on it.





The picture below shows an opened canister (thanks to rklarman). For this particular setup each resistor only needs to be 1/9th of the total power required. In one string of 60 LEDs I have, there are no canisters. That means the current limiting resistor is located somewhere else. It might be buried in one of the plugs. My GE 50 LED C9 string is full-wave and has large plugs on both ends. One plug holds two diodes and the other has two diodes and a 1W resistor.



CONCLUSIONS

Rectifying a string of lights does not increase the current through any one leg. The total current drawn by the entire string will increase by the number of individual legs in the string. The total current draw becomes important when determining how many strings can be connected end to end. The resistance value of the current limiting resistor remains the same. However, the power rating of the current limiting resistor may no longer be large enough. I just plug them into the rectifier, wait 5 minutes and see if the resistor canister gets too hot compared to the same type of string that is not rectified.

Rectifying a string of LED lights will not shorten its useful life! **Water penetration will surely kill it first!** Every LED string failure I have had is where the LED leads break off or rust out.

I hope you enjoyed this little investigation.

Mike Sutton

REFERENCES:

http://doityourselfchristmas.com/forums/showthread.php?31081-LED-Half-to-Full-Wave&p=308759#post308759

resistor sizes and packages
http://www.resistorguide.com/resistor-sizes-and-packages/

LED life
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lifetime_white_leds.pdf