Oscillator Homework

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1. Do a complete analysis of the oscillator circuit shown in Figure 1. What is the frequency of oscillation and what gain is required to put the system poles on the jw axis?

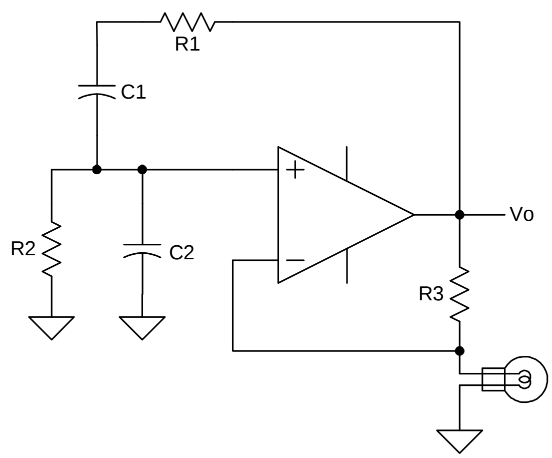

Figure 1: Sine wave oscillator

Confirm that if R1 = R2 = R and if C1 = C2 = C that the oscillation frequency is given by F = 1 / (6.28*RC) and that the required gain is 3.0. Then use your results to determine the oscillation frequency and required gain if C2 = K*C1 and R1 = K*R2. Determine results for K = 0.333, 0.5, 2, and 3.

Using the plot in Figure 2 determine the value for R3 for an output voltage of 6 volts rms for each of the K values from the previous. As an example, if K = 1 then the required gain is 3 and the voltage across the lamp will be 6 / 3 = 2 Vrms – the lamp resistance is about 295 ohms so R3 would be 590 ohms.

As a general note – for this type of circuit the lamp voltage must be no more than about ten percent of its rated value. The #2185 lamp is rated for 28 volts so for any case the lamp voltage should be no more than about 3 volts – i.e. in the lower region where the change in resistance with voltage is highest – and the thermal time constant is also longer which makes distortion less. If more voltage is required then a higher voltage lamp should be used.

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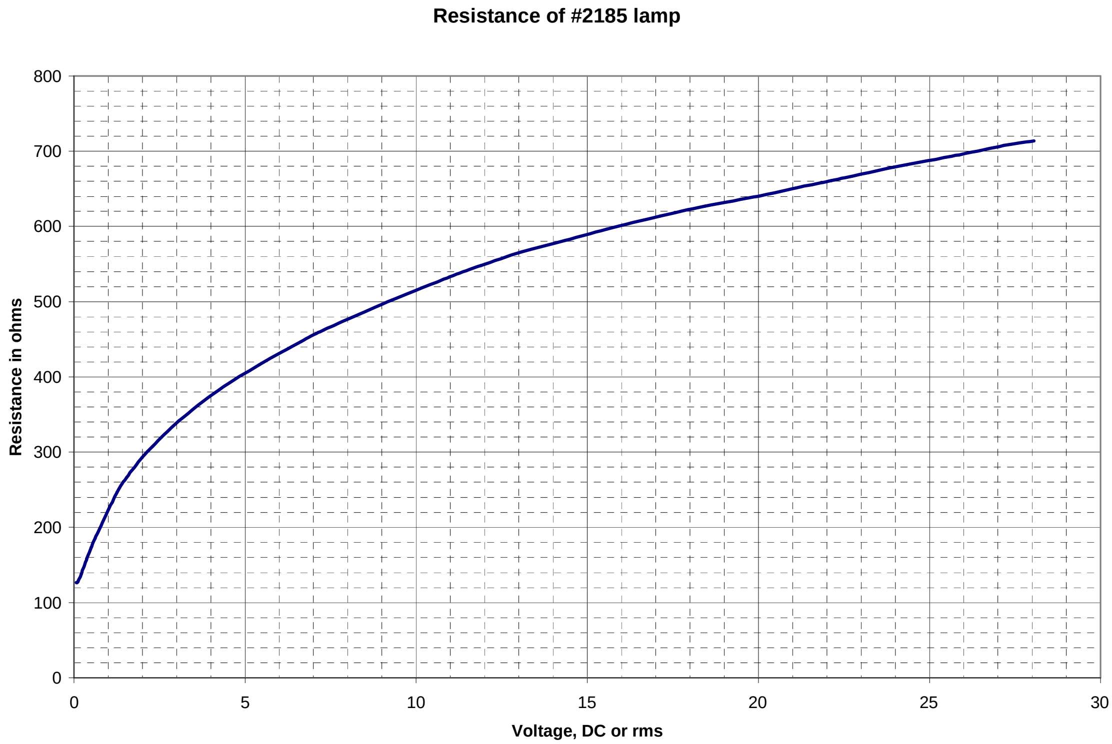

Figure 2: Resistance of #2185 lamp

2. A Schmitt trigger inverter (a 74LS14) is shown in Figure 3 with feedback to make it an RC oscillator. From the data sheet the upper threshold is typically 1.6 volts and the lower threshold is 0.8 volts. R1 is typically chosen to be 300 ohm range and R2 is a pull-up (typically around 2.2K) so that the output voltage swings to very close to the 5 volt rail. The logic low voltage is typically around 0.25 volts. The frequency is mainly set by adjusting C1.

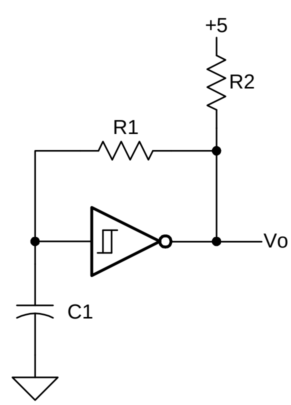

Figure 3: Schmitt trigger oscillator

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Using the above data and assuming that the output voltage swings from 0.25 to 4.5 volts (ignoring R2), derive an expression for the frequency of oscillation and for the duty cycle (output time high divided by total period). Using R1 = 330 ohms, calculate the value of the capacitor for the oscillation frequency to be 1 MHz.

3. The circuit in Figure 4 is a state machine oscillator using an integrator for linear voltage ramps between the upper and lower thresholds. The two comparators have open-collector outputs and thus require the pull-up resistors as shown. Assume that Vo swings from 0 to 5 volts and derive the equation for the frequency of oscillator and duty cycle given R, C, VR, VH, and VL. Note: for square wave, VR is 2.5 volts.

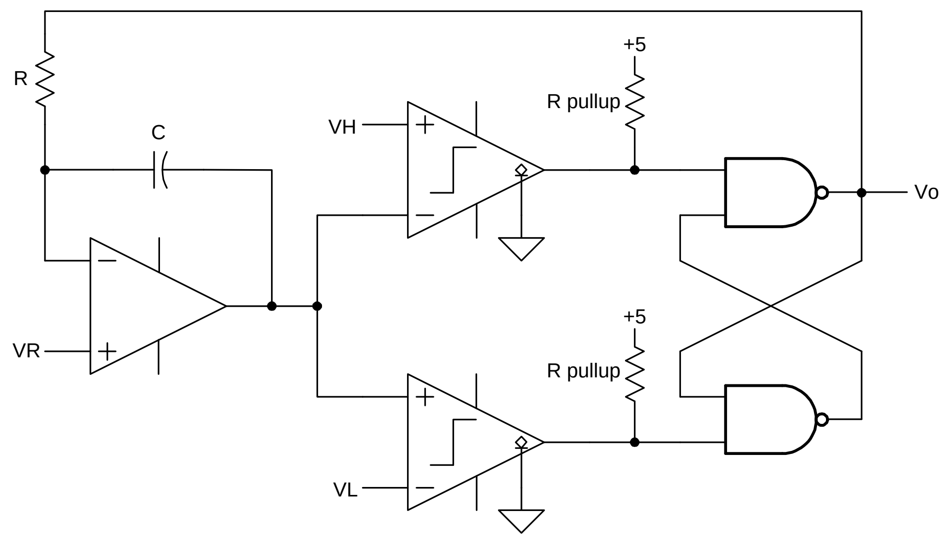

Figure 4: Linear ramp oscillator

Use R = 10K and C = 10 nF and VR = 2.5 volts for the following. What is the frequency of oscillation for VH=3 and VL=2, for VH = 2 and VL=1. Is the oscillation frequency a function of VH and VL or just the difference between them?

Determine the voltage for VR for a 10% duty cycle and a 75% duty cycle. How does the oscillation frequency change as a function of duty cycle?

Use C = 0.01 uF and VH = 3.33 and VL = 1.67 and determine R for a frequency of 1 kHz and a duty cycle of 25%.

4. Analyze the RC state machine oscillator in Figure 5. Assume that Vo goes from 0 to 5 volts and that R, C, VH, and VL are known. What is the oscillation frequency and duty cycle?

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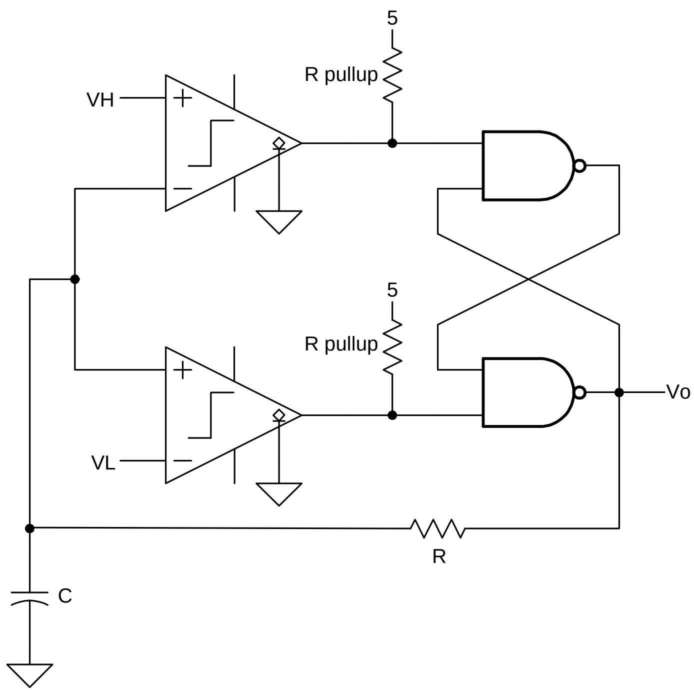

Figure 5: RC oscillator

If VH=3 and VL = 1.5 and RC = 0.001 seconds, find the frequency of oscillation and the duty cycle.

If VL = 1 volt and C = 0.01 uF find R and VH for a square wave at 1 kHz. Next determine R and VH for a pulse wave with a duty cycle of 65%.