Applied Electronics

Ee – Exercises Part E

- BJT Switches
- Power supplies
- Linear regulators
- Switching regulators

Ee: Power and supply circuits

- Ee1 Power switches

- Ee2 Rectifier and filter circuits

- Ee3 Voltage regulators with Zener diode

- Ee4 Voltage regulators with Zener diode and transistor

- Ee5 Switching regulators

- A BJT is used as ON/OFF switch for a 100 Ω load, powered at 12 V.

- Transistor parameters

  - ♦ $\beta = 50$

  - ♦ $V_{CEsat} = 0.2$ V

  a. Draw the interface circuit to drive the BJT using a CMOS gate supplied with $V_{DD} = 5$ V.
  b. Determine the maximum power dissipated in the transistor.

a. Draw the interface circuit to drive the BJT switch using a CMOS gate supplied with $V_{DD} = 5$ V.

b. Determine the maximum power dissipated in the transistor.

Ee2: rectifier / filter circuit

- The circuit in the figure is
  a half-wave rectifier with filter

  ♦ $V_S = 18\ V_{eff}$ at 60 Hz

  ♦ $C = 470\ \mu F$

  a. Determine the output ripple voltage, V_{OR}
     for a load current $I_O = 90$ mA.
     Under these conditions, calculate
     the output voltage direct component, V_{Odc}.

  b. Calculate the output voltage variations (ΔV_{Odc}) and the max
     ripple (V_{ORmax}) for load current I_O varying from 0 mA to 100 mA.
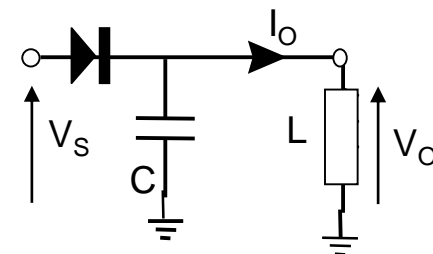
  c. Modify the circuit to use a full-wave rectifier. Calculate the new
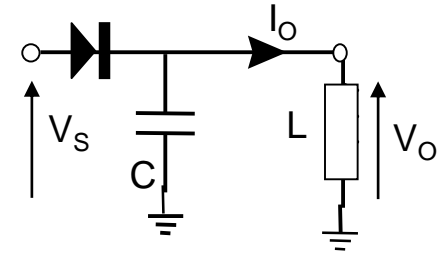 V_{Odc} and V_{OR}.

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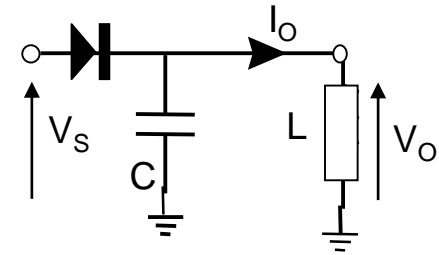
b. Calculate the output voltage variations (ΔV_{Odc}) and the max ripple (V_{ORmax}) for load current I_O from 0 mA to 100 mA.
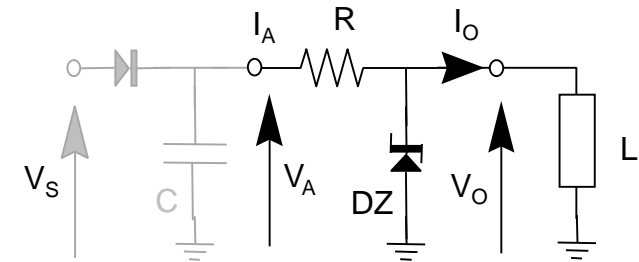
c. Modify the circuit to use a full-wave rectifier. Calculate the new V_{Odc} and V_{OR}.

- To the previous rectifier-filter group is added a Zener diode

  ♦ $V_S = 18\ V_{eff}$; $C = 470\ \mu F$;
 $R = 120\ \Omega$; $V_{Z0} = 9\ V$;
  $r_Z = 10\ \Omega$; $I_{Zmin} = 7\ mA$

a. For $V_A = V_{Adc} + V_{AR}$, calculate
  - the continuous component V_{Odc}
  - the ripple voltage V_{OR} for a load current $I_O = 100\ mA$

b. Determine the power P_Z dissipated by the Zener diode for $V_A = V_{Adc}$, $I_O = 100\ mA$.
  What operating conditions maximize P_Z?

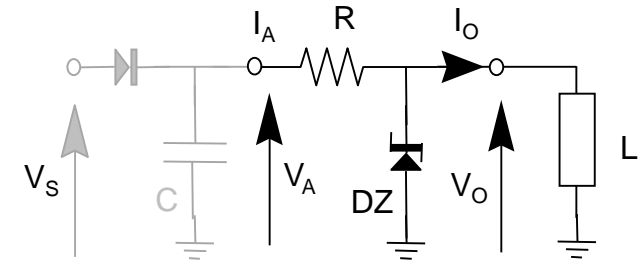c. Determine the maximum value of R that maintains the functionality of the regulator for output currents up to 200 mA

a. For $V_A = V_{Adc} + V_{AR}$, calculate
- the continuous component V_{Odc}
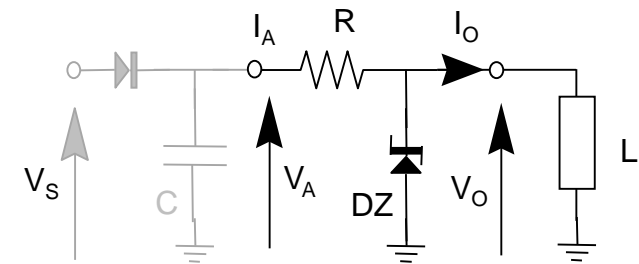- the ripple voltage V_{OR}
for a load current $I_O = 100$ mA
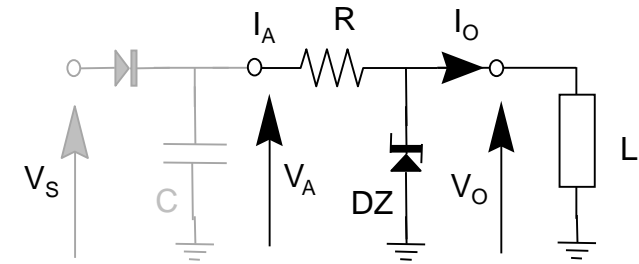
b. Determine the power P_Z dissipated
by the Zener diode for
$V_A = V_{Adc}$, $I_O = 100$ mA.
What operating conditions maximize P_Z?

C.   Determine the max *R* that maintains the functionality of the regulator for output currents up to 200 mA

- Add a BJT (npn) to the previous circuit to improve the regulation for various current loads. For the new circuit:

  a. Determine the power dissipated by the Zener diode and by the transistor for $V_A = V_{Adc}$, with $I_O = 0$ A (no-load).

  b. How does the regulation change (compared to the circuit with only the Zener diode) for variations in the input voltage and for variations in the load current (qualitative answer).

  c. Calculate the maximum power dissipated in the Zener diode and in the transistor, for output currents from 0 mA to 100 mA.

a. Determine the power dissipated by the Zener diode and by the transistor for $V_A = V_{Adc}$, with $I_O = 0$ A (no-load).

b. How does the regulation change (compared to the circuit with only the Zener diode) for variations in the input voltage and for variations in the load current (qualitative answer).

c. Calculate the max power dissipated in the Zener diode and transistor, for output currents from 0 mA to 100 mA.

- Draw the schematic of a switching regulator with $V_O < V_I$

  a. Evaluate the duty cycle limits of the command signal required to obtain a 5 V output with input voltages from 8 V to 15 V

  b. Evaluate the performance considering V_{CEsat} and R_{ON}