Assignment-1: EE5325 - Power Management Integrated Circuits

Exercise-1 (Objective Type)

1. State whether the following statement is true or false. “The efficiency of a switching regulator is always higher than that of a linear regulator.”
   (a) True
   (b) False

2. State whether the following statement is true or false. “The temperature coefficient of the resistors used in a bandgap circuit must be zero so as to achieve a temperature-independent voltage reference.”
   (a) True
   (b) False

3. State whether the following statement is true or false. “The curvature in the output voltage of a bandgap reference circuit occurs mainly due to the non-linearity in the CTAT current.”
   (a) True
   (b) False

4. State whether the following statement is true or false. “Droop compensation can be used to improve the DC accuracy of a regulator.”
   (a) True
   (b) False

5. State whether the following statement is true or false. “Switching regulators offer high efficiency over a wide range of the conversion ratio V_O/V_{IN} because conduction losses do not depend on (V_{IN} - V_O).”
   (a) True
   (b) False

6. State whether the following statement is true or false. “Linear regulators with a high dropout voltage are efficient when the load current is small.”
   (a) True
   (b) False

7. State whether the following statement is true or false. “Linear regulators are preferred over switching regulators for noise-sensitive applications.”
   (a) True
   (b) False

8. State whether the following statement is true or false. “The total power loss in a switching regulator operating at an efficiency of 93% with V_{IN} = 1.8 V, V_O = 1.6 V and delivering a load current of 1 A is 200 mW.”
   (a) True
   (b) False

9. State whether the following statement is true or false. "Droop compensation calls for the output to be regulated slightly below the required value at full load."
   (a) True
   (b) False

10. A power management module comprises two regulators with the following specifications. Both regulators operate from a common supply voltage of 1.8 V.
   Regulator 1: Linear, V_O = 1.2 V, I_{LOAD} = 100 mA, η = 66.6%

   Regulator 2: Switching, V_O = 1.6 V, I_{LOAD} = 1 A, η = 90%

   Fill in the blank with a numerical answer: The total efficiency of the above power management module is η = ____ % (up to 2 decimal places).

Exercise-2

Three systems are powered through a common supply of 3V. Specification of the systems are as follows:

System 1: V_{IN} = 2.8V, I_{LOAD} = 1.5A

System 2: V_{IN} = 2.4V, I_{LOAD} = 1A

System 3: V_{IN} = 2.1V, I_{LOAD} = 1A

Linear and switching regulators are used to supply power to these systems through the supply of 3V. Efficiency of switching regulator is 90%. Switching regulators cost 5 times more than the linear regulator.

(a) Find the most energy efficient way these systems can be powered using linear and switching regulators.
(b) Find the least energy efficient way these systems can be powered using linear and switching regulators. (Note: Don't use more than three regulators in this case)
(c) Find the most cost effective way these systems can be powered using linear and switching regulators while keeping the overall efficiency over 85%.

Exercise-3

Figure-1 shows the conceptual circuit of a PTAT voltage reference:

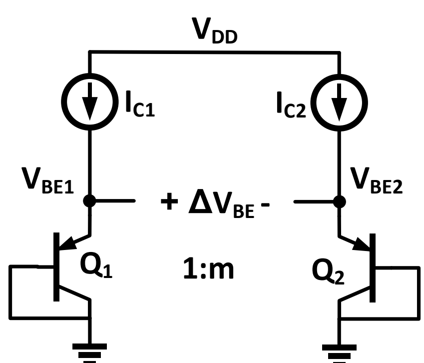

Figure-1

a) Assuming Q1 and Q2 identical (m=1) and I_{C1}=10μA, I_{C2}=1μA, plot $|V_{BE1}|$, $|V_{BE2}|$ and $|\Delta V_{BE}|$ w.r.t. Temperature from -40ºC to 120ºC. What is the temperature coefficients (dV/dT) for the three voltages? Plot the temperature coefficients w.r.t. temperature and comment on non-linearity if there is any.

b) Assuming Q1 and Q2 non-identical with m=10 and $I_{C1}=I_{C2}=10\mu A$, plot $|\Delta V_{BE}|$ w.r.t. Temperature from -40ºC to 120ºC. What is the temperature coefficients (dV/dT) for $|\Delta V_{BE}|$? Plot the temperature coefficients w.r.t. temperature and compare with $|dV_{BE}|/dT$ plotted in (a).

Exercise-4

Figure-2 shows a standard 1.2V bandgap voltage reference.

a) Find the values of R_{1a}, R_{1b} and R_2 for m=10, $I_C=10\mu A$ and plot V_{BG} w.r.t. Temperature from -40ºC to 120ºC.
b) Analyze the effect of mismatch between R_{1a} and R_{1b}.
c) Analyze the effect of op-amp offset voltage and compare for m=5 and m=10.

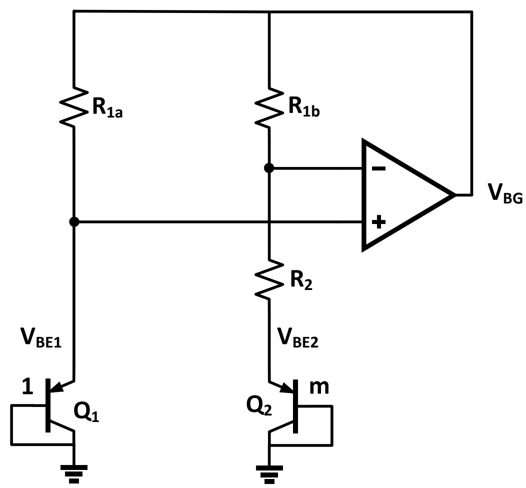

Figure-2

Note:

1. Circuit should be analyzed and plotted on simulator LTSpice.
2. Use transistor models of 0.18µm CMOS process technology for all the devices. If size of bipolar can't be changed in the parameter then use multiple devices in parallel.
3. Model files for different CMOS technologies can be found at:
4. http://www.ee.iitm.ac.in/~nagendra/cadinfo.html
5. Behavioral model can be used for op-amp with realistic parameters (Gain, BW, offset etc.)
6. Report should be submitted to TAs over email (no hard copy submission) and must contain all the simulation results, calculations, derivations and parameter values.