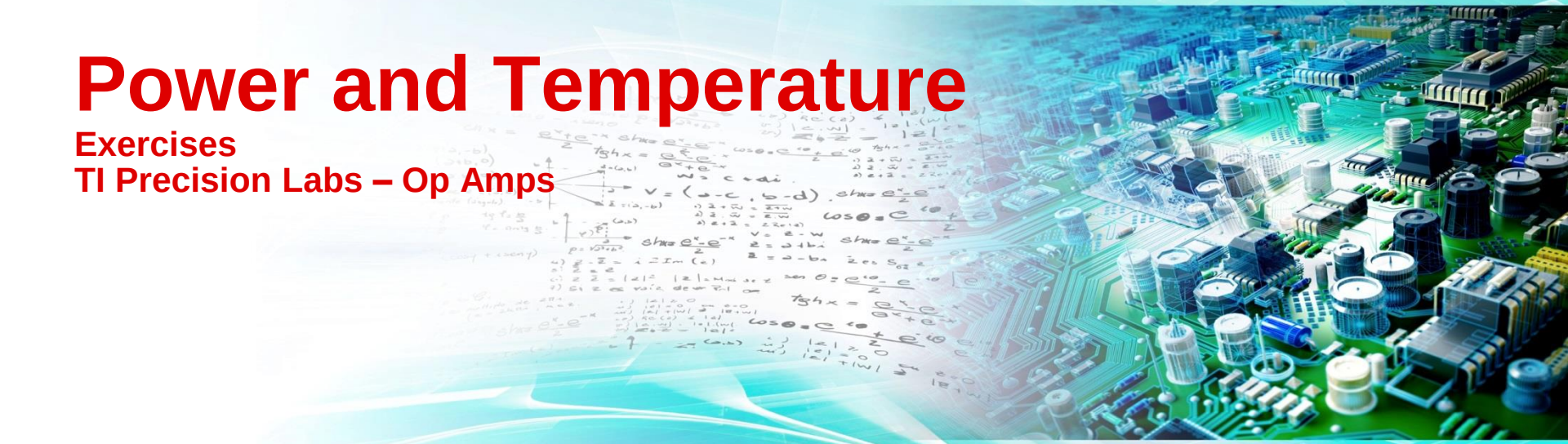
Power and Temperature

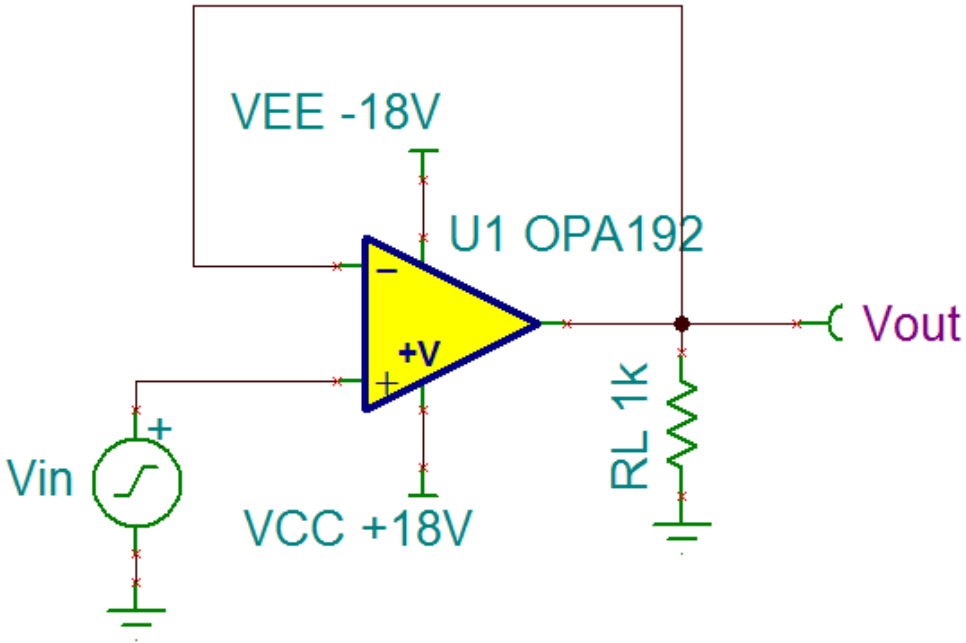
Exercises

TI Precision Labs – Op Amps

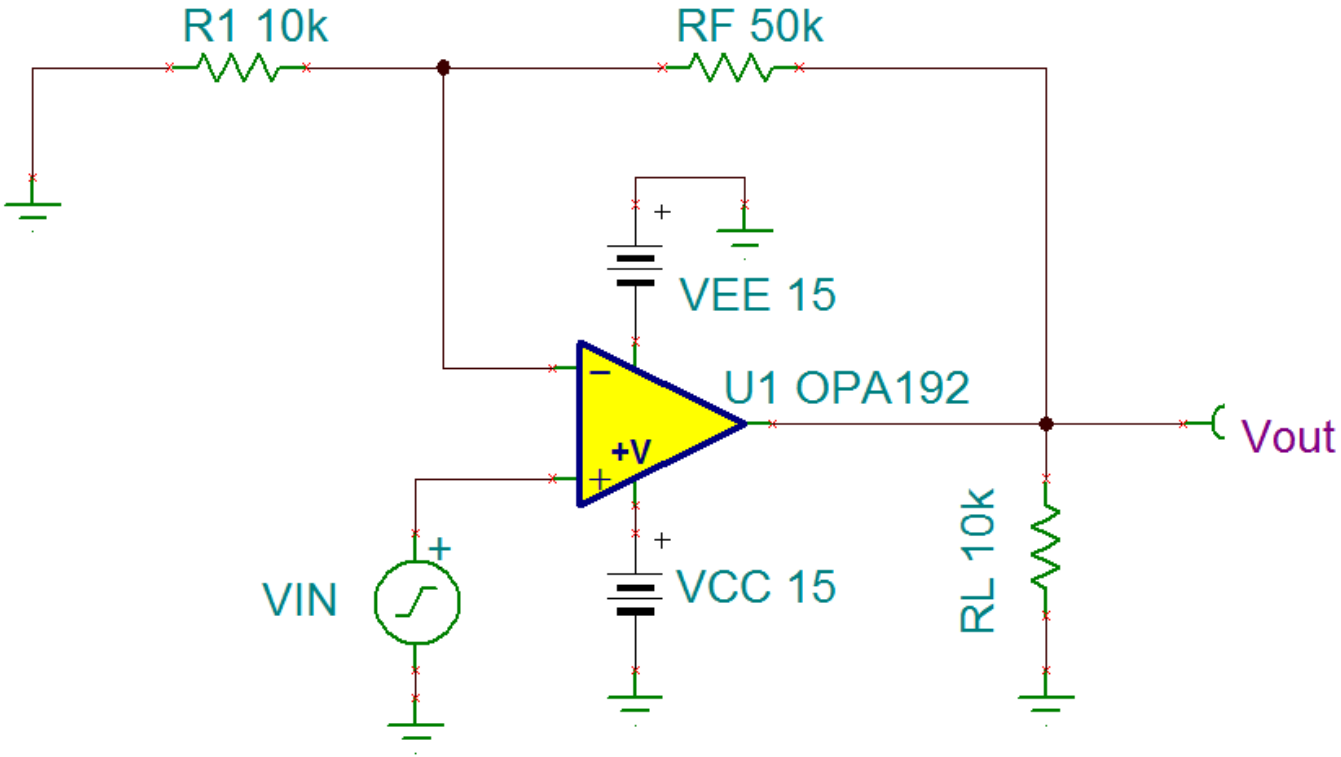


1. Calculate the maximum DC power dissipation for this circuit.

POWER SUPPLY					
I_Q	Quiescent current per amplifier	I_O = 0 A	1	1.2	mA
		T_A = –40°C to +125°C, I_O = 0 A		1.5	

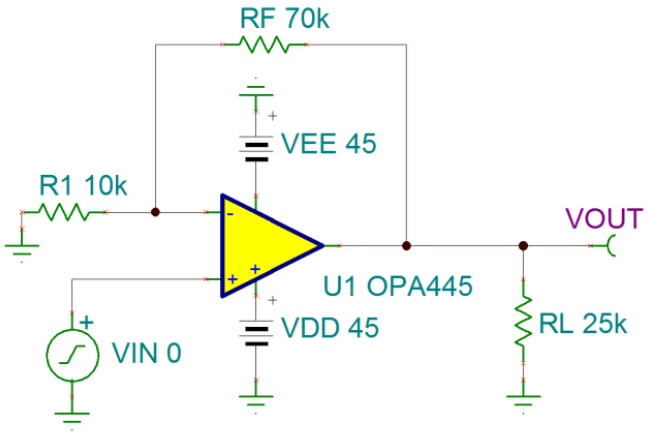


2. Calculate the maximum average AC power dissipation for this circuit assuming a sinusoidal input and a resistive load.



3a. Calculate the maximum DC power dissipation for this circuit.

PARAMETER		TEST CONDITIONS	OPA445BM			OPA445AP, AU, ADDA			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
POWER SUPPLY									
Specified Operating Range	V_S			±40			*		V
Operating Voltage Range			±10		±45	*		*	V
Quiescent Current	I_Q	I_O = 0		±4.2	±4.7		*	*	mA

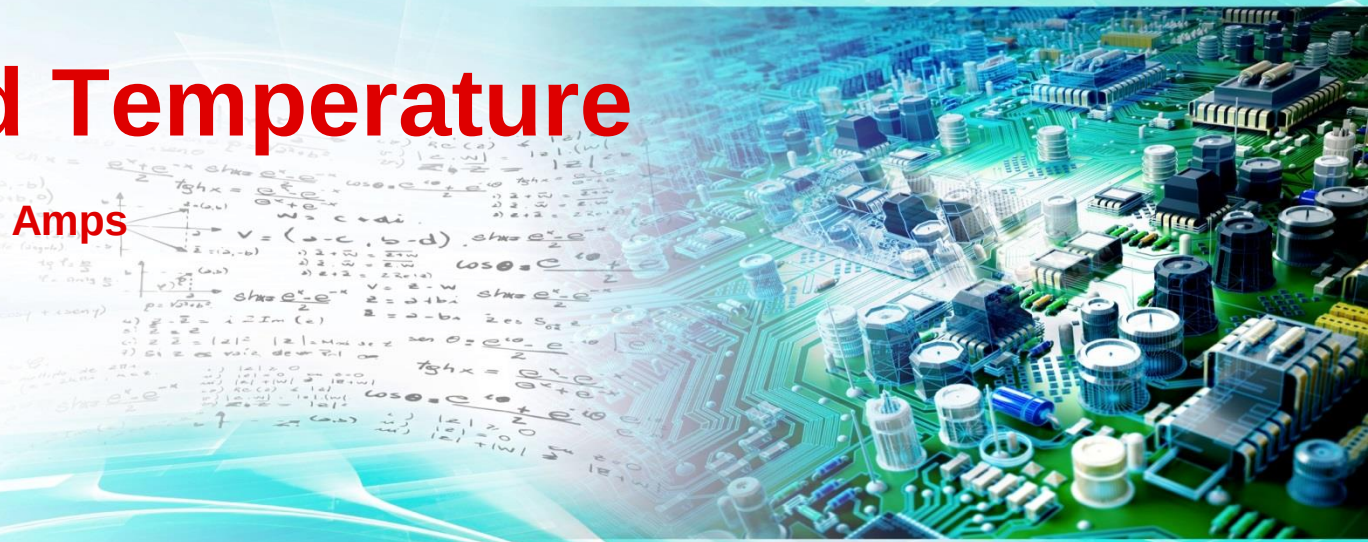


3b. Calculate the junction temperature at maximum DC power dissipation for the SO-8 package if the ambient temperature is 25°C and no heat sink is used. Is this within specified temperature limits?

PARAMETER	TEST CONDITIONS	OPA445BM			OPA445AP, AU, ADDA			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
TEMPERATURE RANGE								
Specification Range		−25		+85	*		*	°C
Operating Range		−55		+125	*		*	°C
Storage Range		−65		+125	−55		+125	°C
Thermal Resistance, Junction-to-Ambient θ_{JA}								
TO-99			200					°C/W
DIP-8						100		°C/W
SO-8 Surface-Mount						150		°C/W

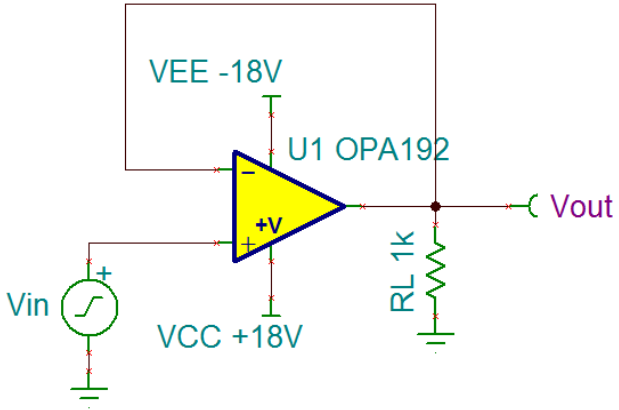
Power and Temperature

Solutions
TI Precision Labs – Op Amps



1. Calculate the maximum DC power dissipation for this circuit.

POWER SUPPLY					
I_Q	Quiescent current per amplifier	I_O = 0 A	1	1.2	mA
		T_A = –40°C to +125°C, I_O = 0 A		1.5	

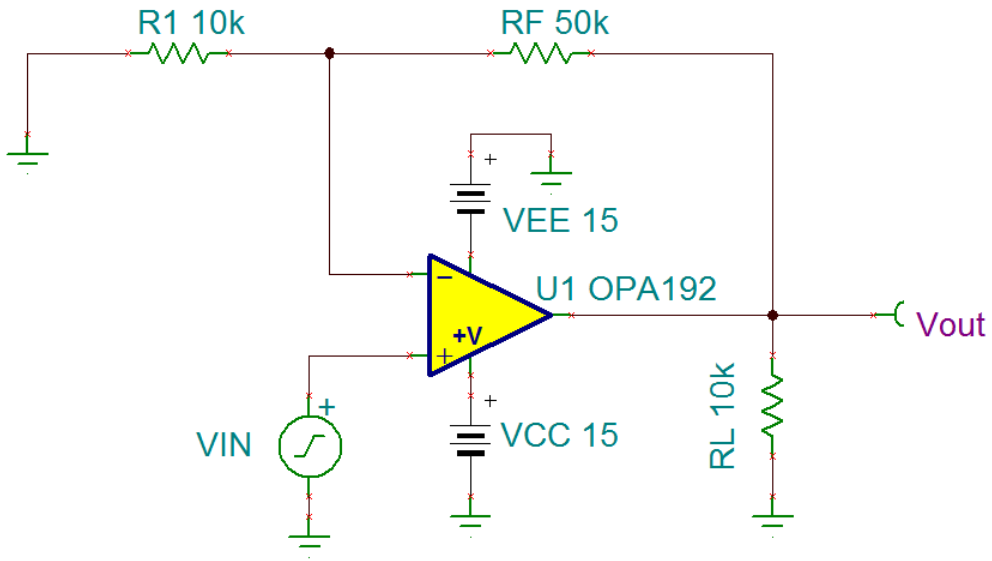


$$V_S = V_{CC} - V_{EE} = (18V) - (-18V) = 36V$$
$$P_Q = I_Q \cdot V_S = (1.5mA)(36V) = 54mW$$

$$P_{dc\_max} = \frac{(V_{cc})^2}{4 * R_L} = \frac{(18V)^2}{4 * 1k\Omega} = 81mW$$

$$P_{total} = P_{dc\_max} + P_Q = 81mw + 54mW = \mathbf{135mW}$$

2. Calculate the maximum average AC power dissipation for this circuit assuming a sinusoidal input and a resistive load.



Effective Load:

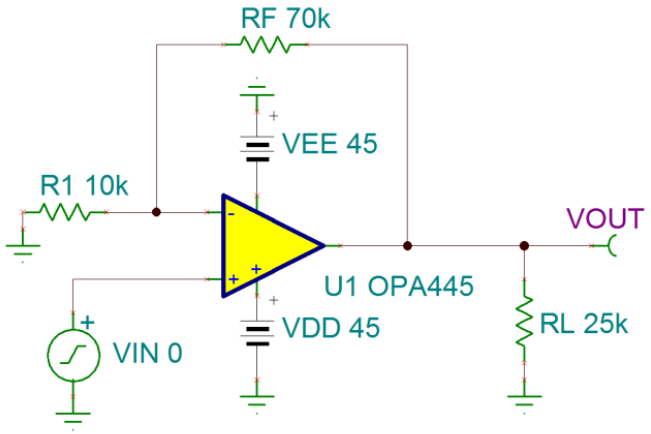
$$R_L = R_{Load} || (R_F + R_1)$$
$$R_L = 10k\Omega || (50k\Omega + 10k\Omega)$$
$$\mathbf{R_L = 8.57k\Omega}$$

Maximum Average AC Power:

$$P_{ac\_max\_avg} = \frac{2 * (V_{cc})^2}{\pi^2 * R_L}$$
$$P_{ac\_max\_avg} = \frac{2 * 15^2}{\pi^2 * 8.57k\Omega}$$
$$\mathbf{P_{ac\_max\_avg} = 5.32mW}$$

3a. Calculate the maximum DC power dissipation for this circuit.

PARAMETER		TEST CONDITIONS	OPA445BM			OPA445AP, AU, ADDA			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
POWER SUPPLY									
Specified Operating Range	V_S			±40			*		V
Operating Voltage Range			±10		±45	*		*	V
Quiescent Current	I_Q	I_O = 0		±4.2	±4.7		*	*	mA



$$V_S = V_{CC} - V_{EE} = (45V) - (-45V) = 90V$$

$$R_L = R_{Load} || (R_F + R_1) = 25k\Omega || (70k\Omega + 10k\Omega) = 19k\Omega$$

$$P_Q = I_Q \cdot V_S = (4.7mA)(90V) = 423mW$$

$$P_{dc\_max} = \frac{(V_{cc})^2}{4 * R_L} = \frac{(45V)^2}{4 * 19k\Omega} = 26.6mW$$

$$P_{total} = P_{dc\_max} + P_Q = 26.6mW + 423mW = \mathbf{449.6mW}$$

3b. Calculate the junction temperature at maximum DC power dissipation for the SO-8 package if the ambient temperature is 25°C and no heat sink is used. Is this within specified temperature limits?

PARAMETER	TEST CONDITIONS	OPA445BM			OPA445AP, AU, ADDA			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
TEMPERATURE RANGE								
Specification Range		−25		+85	*		*	°C
Operating Range		−55		+125	*		*	°C
Storage Range		−65		+125	−55		+125	°C
Thermal Resistance, Junction-to-Ambient θ_{JA}								
TO-99			200					°C/W
DIP-8						100		°C/W
SO-8 Surface-Mount						150		°C/W

$$\Theta_{JA} = 150°C/W$$

$$T_A = 25°C$$

$$P_{total} = 449.6mW$$

$$T_J = P_{total} * \Theta_{JA} + T_A = 449.6mW * 150°C/W + 25°C$$

$$\mathbf{T_J = 92.4°C}$$

Not within the specified range (-25°C - 85°C), but within the operating range!