EE 101 Lect #1 Jan 8, 2018

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Textbook for EE 101

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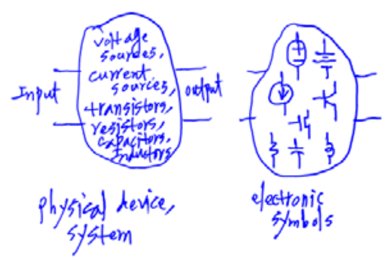
Course Grading

Weekly Quizzes based on weekly HWs 20%
(Best 7 out of 9 Quizzes)
Submit HW solutions to your TA

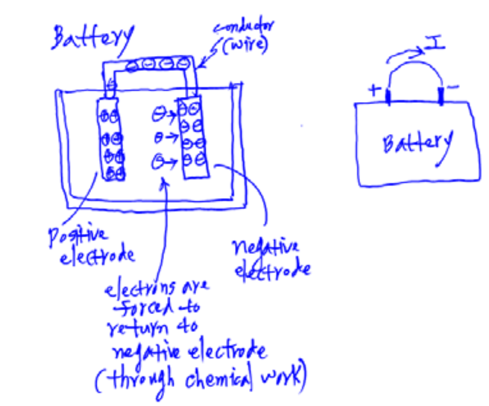
Mid-term Examination 30%
(Feb 7, 1 page of formulas allowed)

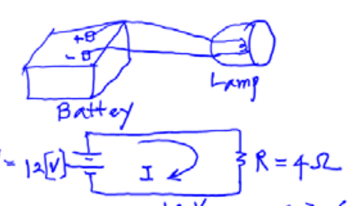
Final Examination 50%
(March 20, 2 pages of formulas allowed)



1) Formulate circuit equations using model equations for elements and circuit laws (KCL, KVL)

2) Solve for outputs for given inputs





current $I = \frac{12\,V}{4\,\Omega} = 3\,[A]$ (Ohm's Law)

Power $= V I = 12\,[V]\ 3\,[A]$
$= 36\,[V \cdot A] = 36\,[W]$

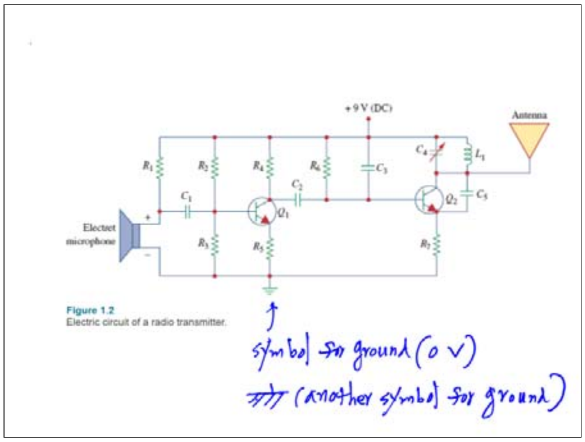
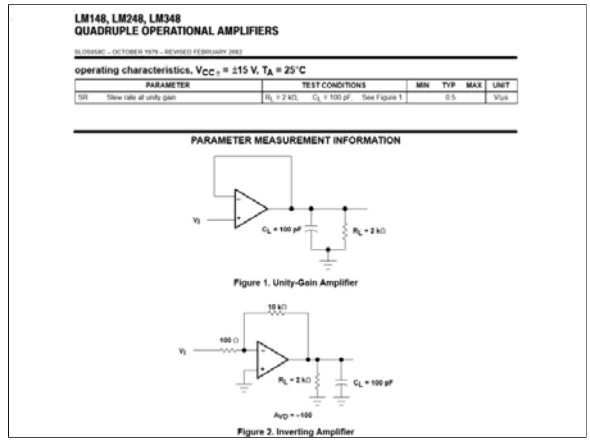


Figure 1.2
Electric circuit of a radio transmitter.



LM148, LM248, LM348
QUADRUPLE OPERATIONAL AMPLIFIERS

SLOS058C – OCTOBER 1979 – REVISED FEBRUARY 2002

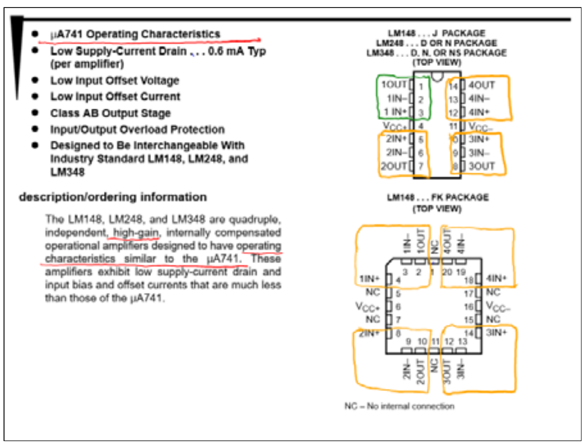
operating characteristics, $V_{CC\pm} = \pm 15$ V, $T_A = 25°C$

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	$R_L = 2$ kΩ, $C_L = 100$ pF, See Figure 1		0.5		V/μs

PARAMETER MEASUREMENT INFORMATION

Figure 1. Unity-Gain Amplifier

Figure 2. Inverting Amplifier

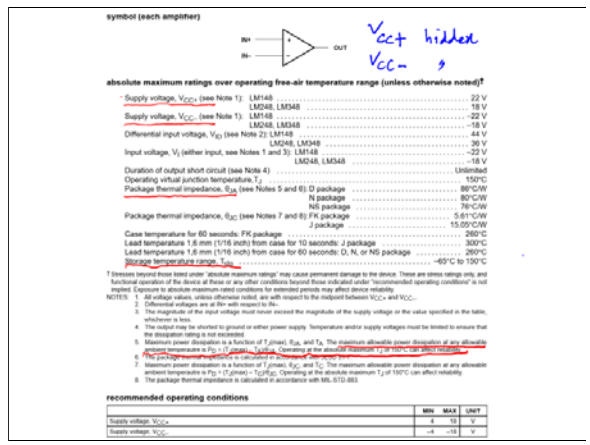


- μA741 Operating Characteristics
- Low Supply-Current Drain . . . 0.6 mA Typ (per amplifier)
- Low Input Offset Voltage
- Low Input Offset Current
- Class AB Output Stage
- Input/Output Overload Protection
- Designed to Be Interchangeable With Industry Standard LM148, LM248, and LM348

description/ordering information

The LM148, LM248, and LM348 are quadruple, independent, high-gain, internally compensated operational amplifiers designed to have operating characteristics similar to the μA741. These amplifiers exhibit low supply-current drain and input bias and offset currents that are much less than those of the μA741.

NC – No internal connection



symbol (each amplifier)

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

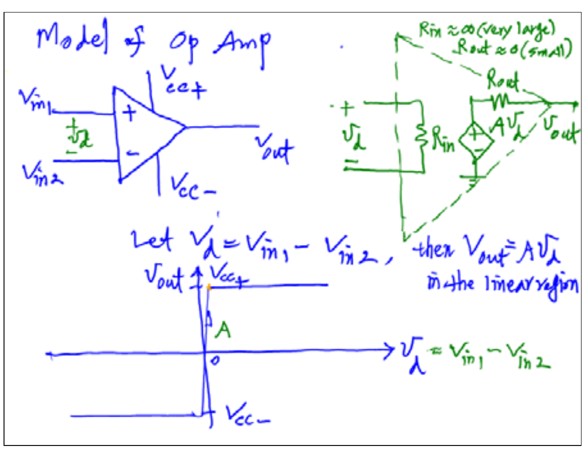
Supply voltage, V_{CC+} (see Note 1): LM148 . . . 22 V
LM248, LM348 . . . 18 V
Supply voltage, V_{CC-} (see Note 1): LM148 . . . −22 V
LM248, LM348 . . . −18 V
Differential input voltage, V_{ID} (see Note 2): LM148 . . . 44 V
LM248, LM348 . . . 36 V
Input voltage, V_I (either input, see Notes 1 and 3): LM148 . . . −22 V
LM248, LM348 . . . −18 V
Duration of output short circuit (see Note 4) . . . Unlimited
Operating virtual junction temperature, T_J . . . 150°C
Package thermal impedance, θ_{JA} (see Notes 5 and 6): D package . . . 86°C/W
N package . . . 80°C/W
NS package . . . 76°C/W
Package thermal impedance, θ_{JC} (see Notes 7 and 8): FK package . . . 5.61°C/W
J package . . . 15.05°C/W
Case temperature for 60 seconds: FK package . . . 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J package . . . 300°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: D, N, or NS package . . . 260°C
Storage temperature range, T_{stg} . . . −65°C to 150°C

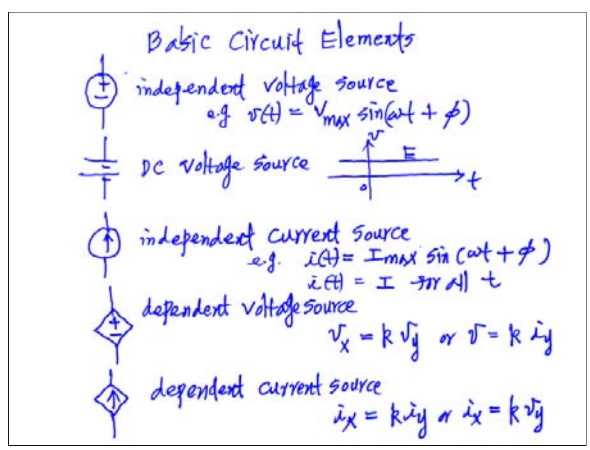
† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES:
1. All voltage values, unless otherwise noted, are with respect to the midpoint between V_{CC+} and V_{CC-}.
2. Differential voltages are at IN+ with respect to IN−.
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or the value specified in the table, whichever is less.
4. The output may be shorted to ground or either power supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.
5. Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
6. The package thermal impedance is calculated in accordance with JESD 51-7.
7. Maximum power dissipation is a function of T_J(max), θ_{JC}, and T_C. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
8. The package thermal impedance is calculated in accordance with MIL-STD-883.

recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, V_{CC+}	4	18	V
Supply voltage, V_{CC-}	−4	−18	V





Passive elements

Resistor: $v = R\,i$ (Ohm's Law)

$i = \frac{1}{R} v = G v$

Capacitor: $v = \frac{1}{C}\int_{-\infty}^{t} i(\tau)\,d\tau$

$i = C\frac{dv}{dt}$ $\quad i = \frac{dq}{dt} = \frac{d(Cv)}{dt}$

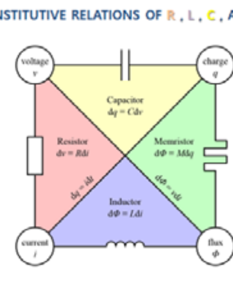
inductor: $v = L\frac{di}{dt}$

$i = \frac{1}{L}\int_{-\infty}^{t} v(\tau)\,d\tau$

4 Basic variables of v, i, q, φ

voltage, current, charge, flux

CONSTITUTIVE RELATIONS OF R, L, C, AND M



$\frac{dv}{di}$

$q = Cv$, $dq = C\,dv$

$\varphi = Li$, $\frac{d\varphi}{dt} = v = L\frac{di}{dt}$

EE101 deals with R[Ω], L[H], C[F] only

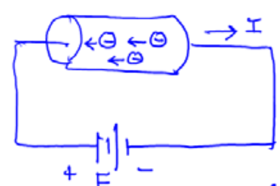
International system of units

SI units (adopted in 1960)

10^{-3} [m] milli	10^{3} [K] kilo, also k
10^{-6} [μ] micro	10^{6} [M] mega
10^{-9} [n] nano	10^{9} [G] giga
10^{-12} [p] pico	10^{12} [T] tera
10^{-15} [f] femto	10^{15} [P] peta
10^{-18} [a] atto	10^{18} [E] exa
lower case	upper case except kilo

Battery and Current Flow

Fig. 1.3 (text)



e electron charge $= -1.602\times10^{-19}$ coulomb [C]

current

$i = \frac{dq}{dt}$ [time rate of change of charge]

1 Ampere = 1 Coulomb / 1 second

$= 6.28\times10^{18}$ electrons move in 1 second

emf (electromotive force)

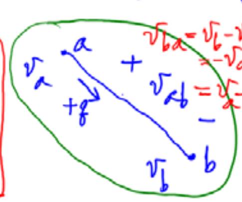
= voltage = potential difference between two points, say a and b

= energy required to move a positive charge q from point a to point b (or a negative charge $-q$ from b to a)

$v_{ab} = \frac{dw_{ab}}{dq}$

$\left(w_{ab} = \int_a^b q\,\bar{E}\cdot d\bar{l}\right)$

$= \int_a^b \bar{E}\cdot dl$



$v_{ba} = v_b - v_a = -v_{ab}$

$v_{ab} = v_a - v_b$

Power $P(t)$

$P(t) = \frac{dE(t)}{dt} = \frac{d}{dt}\left(V(t)\,I(t)\,t\right)$

$= V(t)\,I(t)$ [Joule/sec] or [Watt]

$E_{period\,T} = \int_0^T p(t)\,dt = P_{avg}\,T$

$P_{avg} = \frac{1}{T}\int_0^T p(t)\,dt$

e.g. Electric oven for V = 220V I = 10A

If used for 2 hours

E = 220[V] × 10[A] × 2[hours] = 4.4 KWh

$$1\,W = 1\,\frac{Joule}{sec}\left[\frac{J}{s}\right] = 1\,\frac{Newton(N)\cdot m}{s}$$

$$= 1\,\frac{\left[\frac{Kg\cdot m}{s^2}\right]\cdot m}{s} = 1\,\frac{Kg\cdot m^2}{s^3}$$

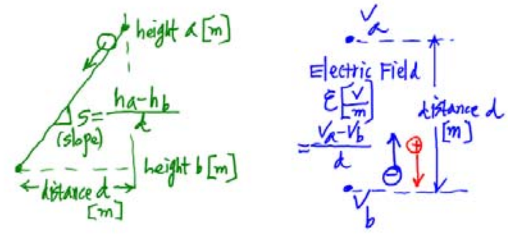
$$1\,Joule = 1\,W\cdot s$$

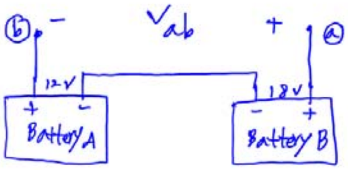
Thus

$$4.4\,KWh = 4.4\times 10^3\,W \times 3600\,s$$

$$= 1.584\times 10^7\,[W\cdot s]$$

$$= 1.584\times 10^7\,[J]$$





$$V_{ab} = V_a - V_b = 18 - 12 = 6V$$

$$V_{ba} = V_b - V_a = 12 - 18 = -6V = -V_{ab}$$