ECE 201, Section 3
Lecture 28

Prof. Peter Bermel

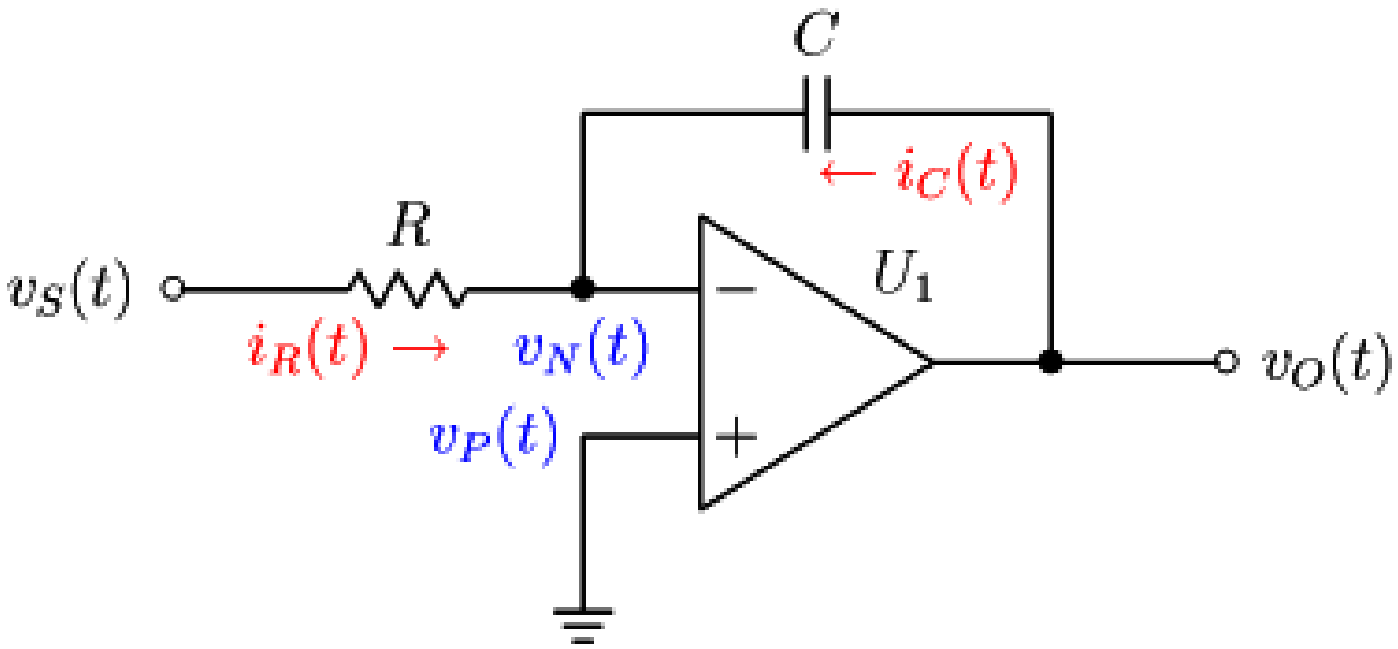
October 31, 2012

General Procedure to Solve Op-Amp Problems with Feedback

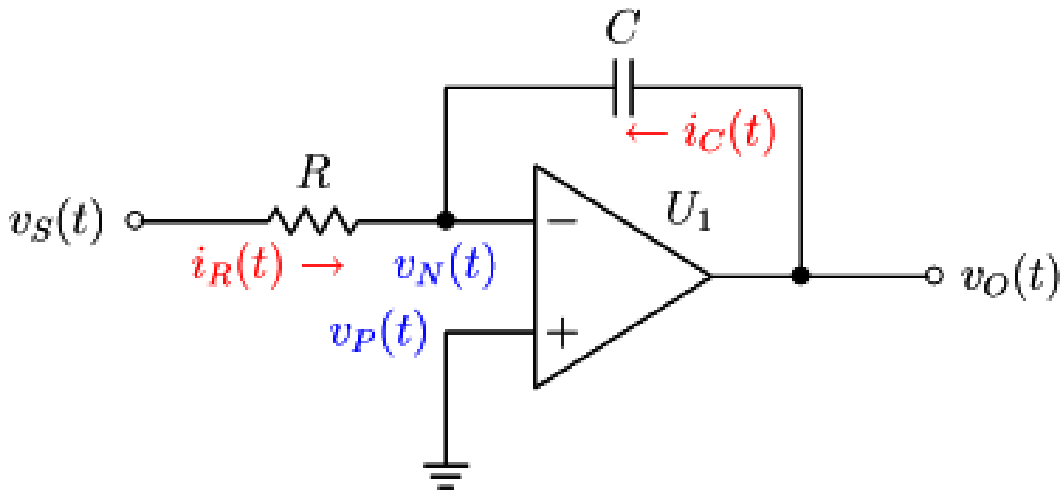
- Find V_+ or V_- with golden rule, $I_+ = I_- = 0$ (usually easiest for input unconnected to output)
- Find other voltage with golden rule: $V_+ = V_-$
- Apply KCL to input terminal connected to output to find residual current and output voltage
- If necessary, apply KCL at output node

Example

What is the output of this circuit? How would you describe it?



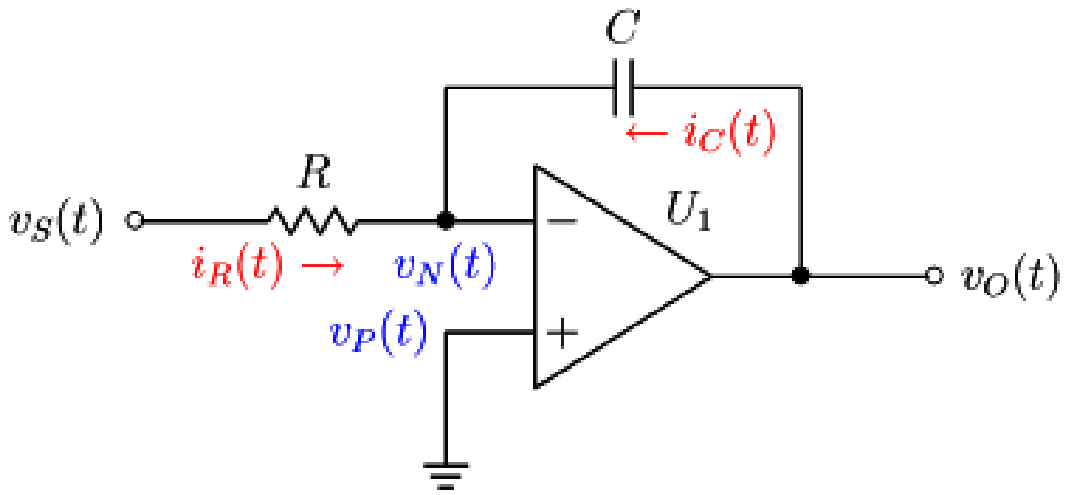
Solution



$$i_R(t) + i_C(t) = 0 \quad \Longrightarrow \quad \frac{v_S(t) - v_N(t)}{R} + C\,\frac{d[v_O(t) - v_N(t)]}{dt} = 0\,.$$

$$\frac{v_S(t)}{R} + C\,\frac{dv_O(t)}{dt} = 0 \quad \Longrightarrow \quad \frac{dv_O(t)}{dt} = -\frac{1}{RC}\,v_S(t)\,.$$

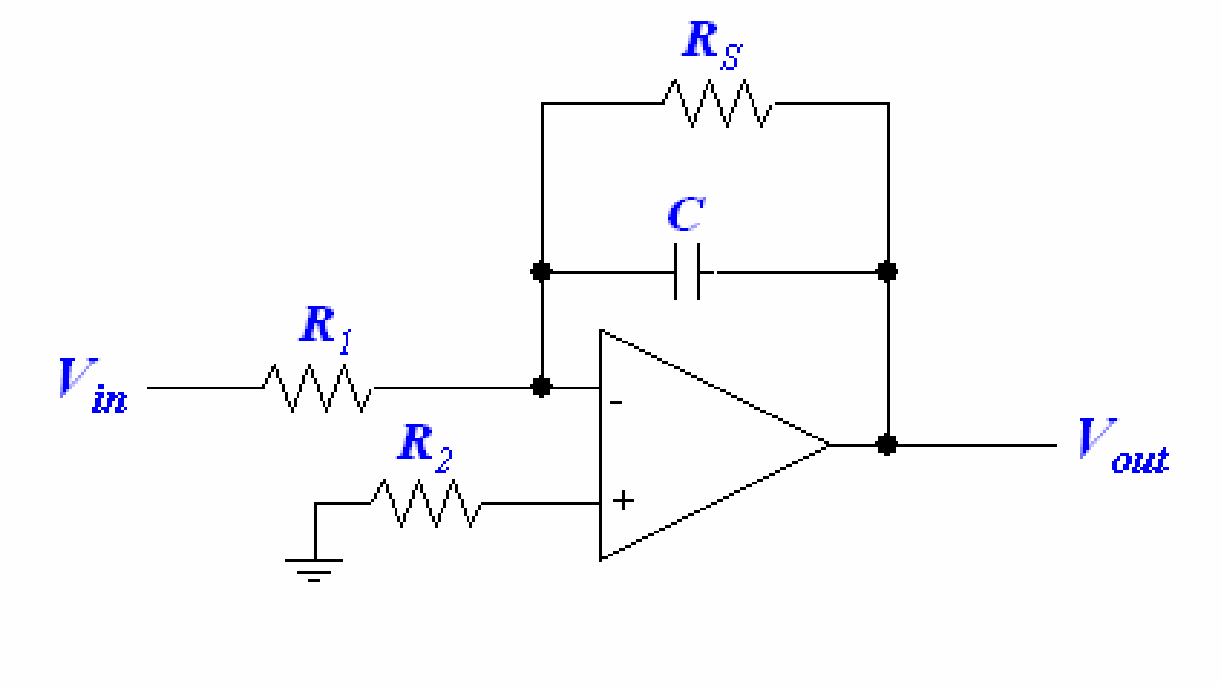
Solution



$$v_O(t) = -\frac{1}{RC}\int_{-\infty}^{t} v_S(\tau)\,d\tau = -\frac{1}{RC}\int_{t_0}^{t} v_S(\tau)\,d\tau + v_O(t_0)\,.$$

Integrating circuit; problem is: what if it reaches saturation for low-frequency signals?

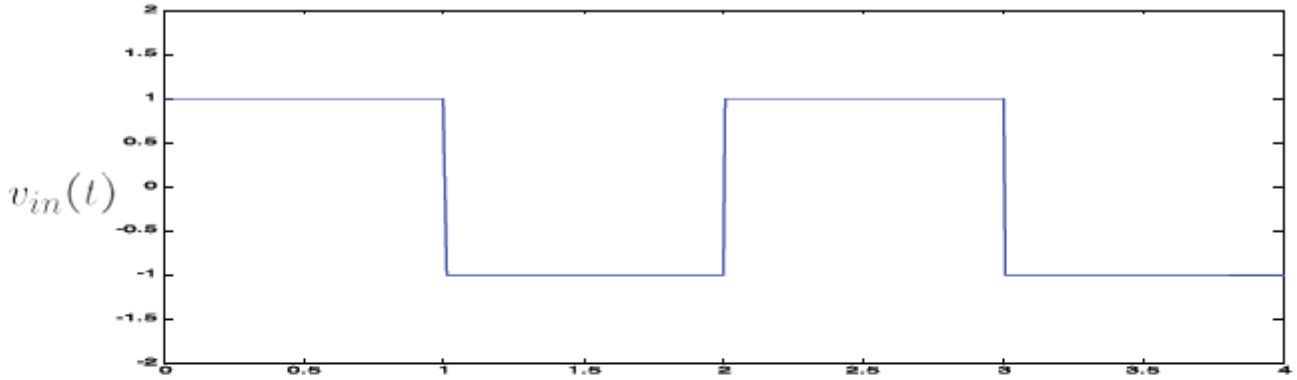
Solution

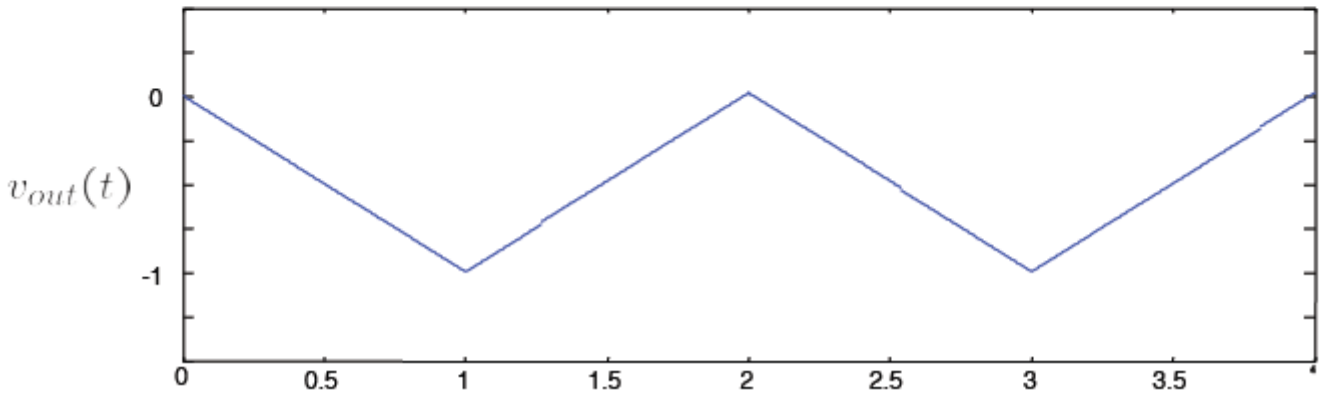


Revised integrating circuit provides shunt resistor to prevent charge storage, plus R_2 to prevent input DC bias current

Solution

Assumed input waveform

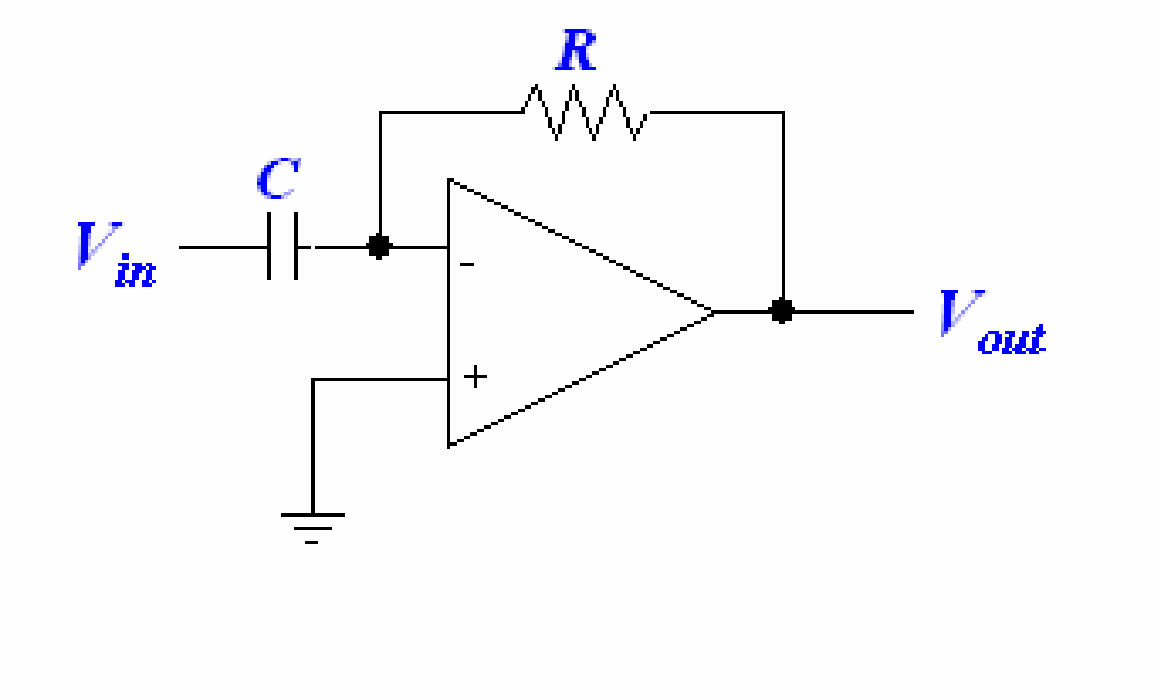




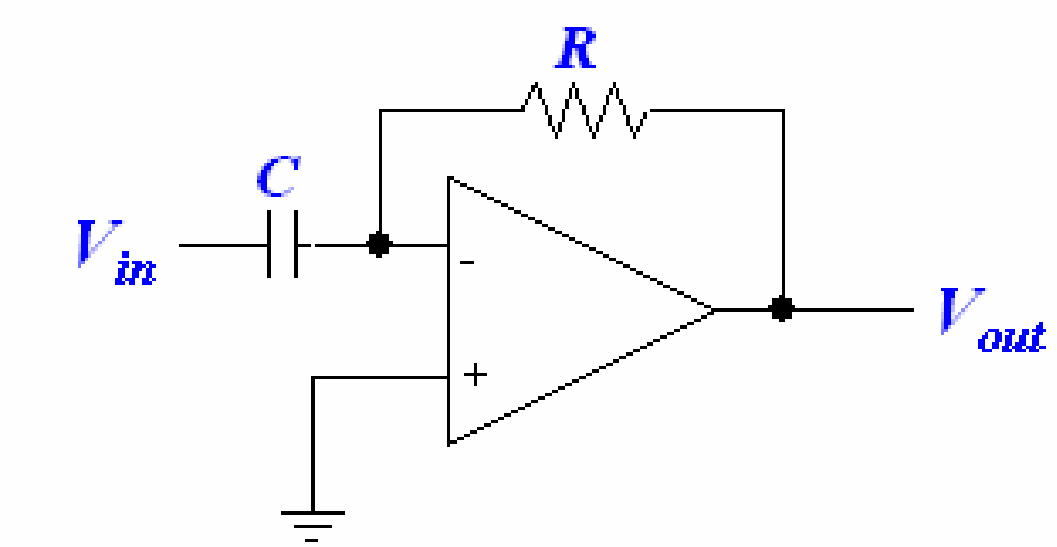
Integrated output waveform

Example

What is the output of this circuit? How would you describe it?

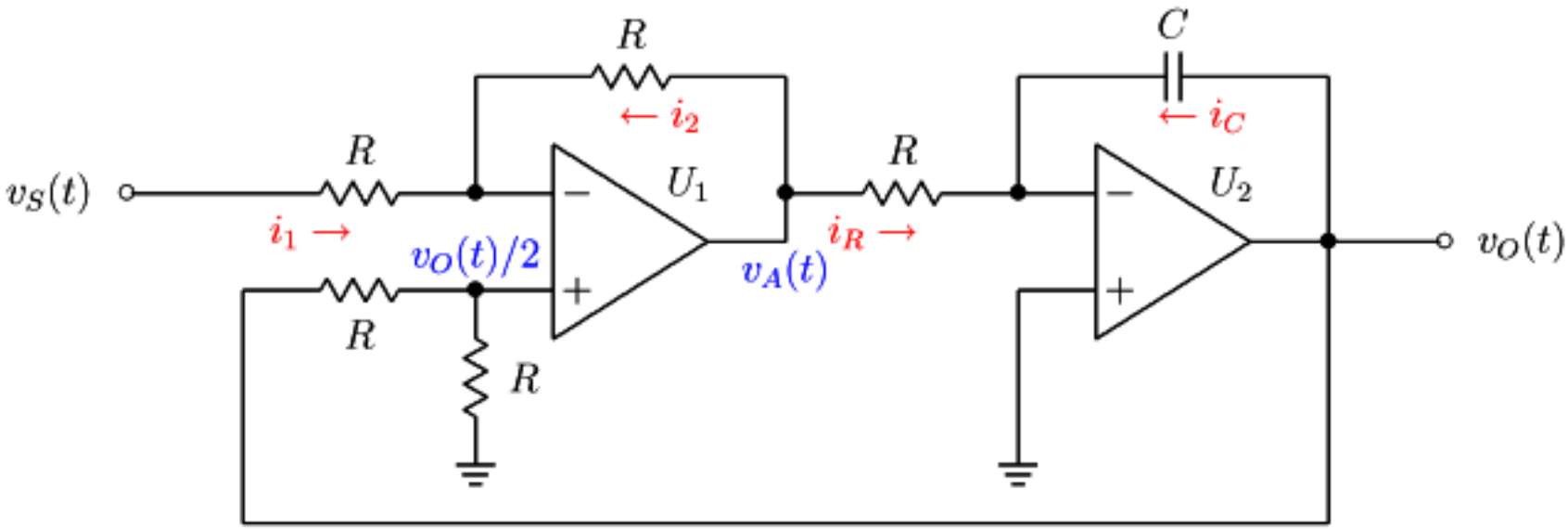


Solution

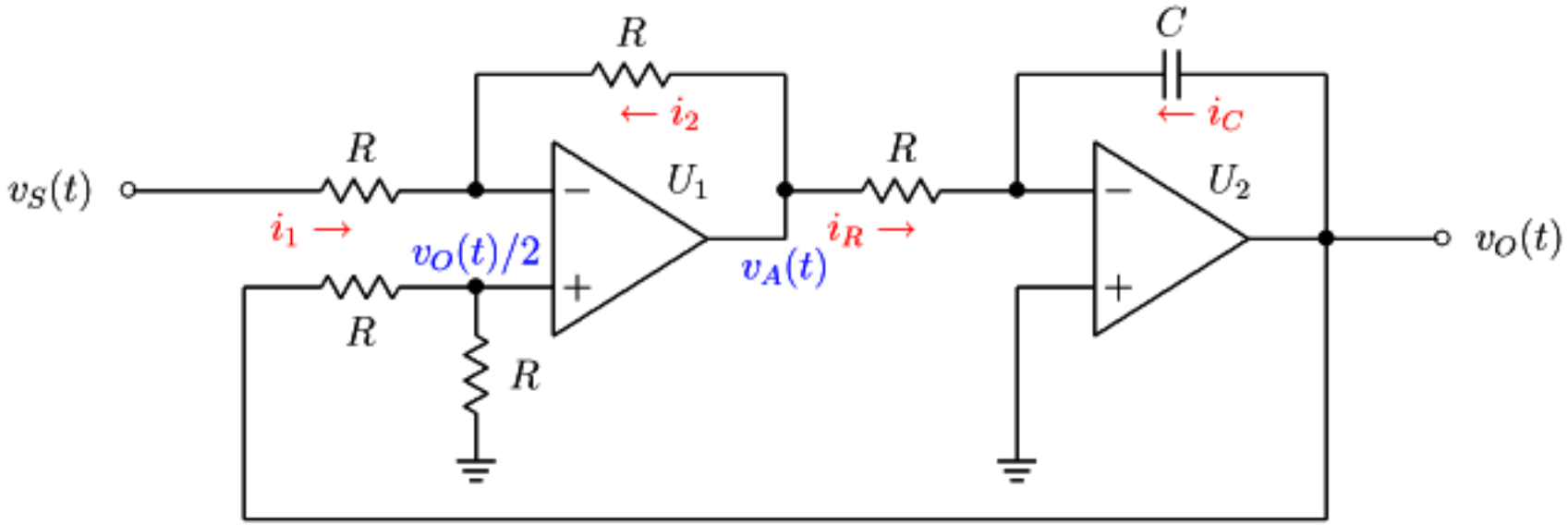


Example

What is the output of this circuit? How would you describe it?



Solution



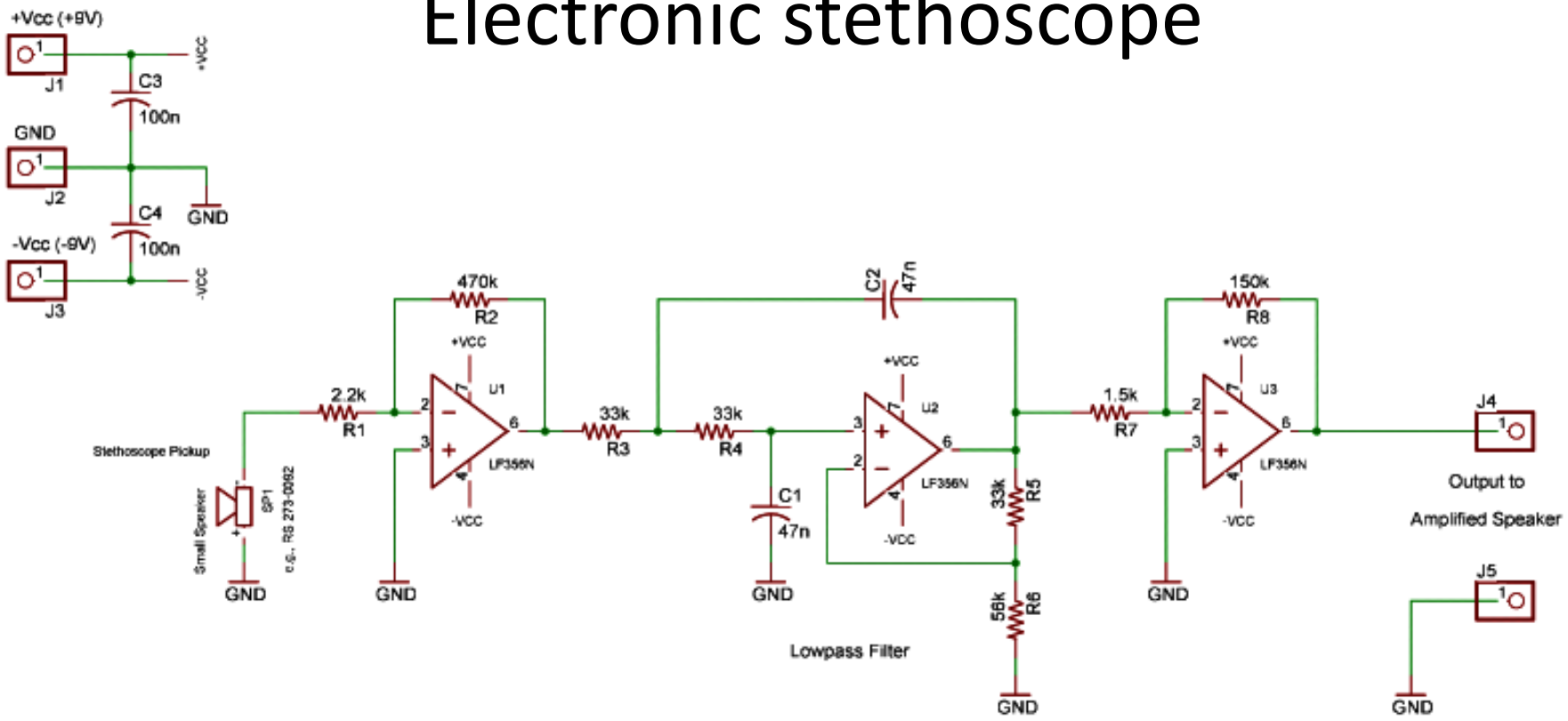
$$i_R(t) + i_C(t) = 0 \quad \Longrightarrow \quad \frac{v_A(t)}{R} + C\,\frac{dv_O(t)}{dt} = 0 \quad \Longrightarrow \quad v_A(t) = -RC\,\frac{dv_O(t)}{dt}\,.$$

$$i_1(t) + i_2(t) = 0 \quad \Longrightarrow \quad \frac{2v_S(t) - v_O(t)}{2R} + \frac{2v_A(t) - v_O(t)}{2R} = 0 \quad \Longrightarrow \quad v_S(t) = v_O(t) - v_A(t)\,.$$

$$v_S(t) = v_O(t) + RC\,\frac{dv_O(t)}{dt}\,.$$

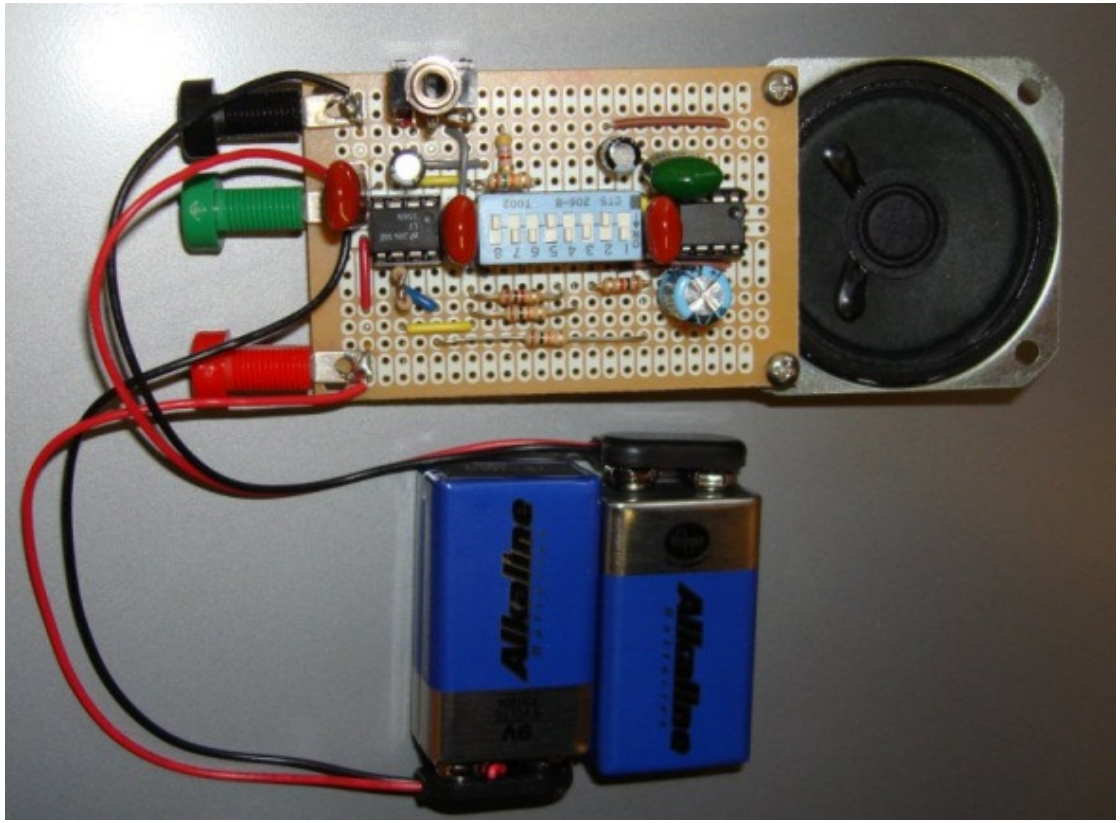
Example

Electronic stethoscope



Example

Electronic stethoscope

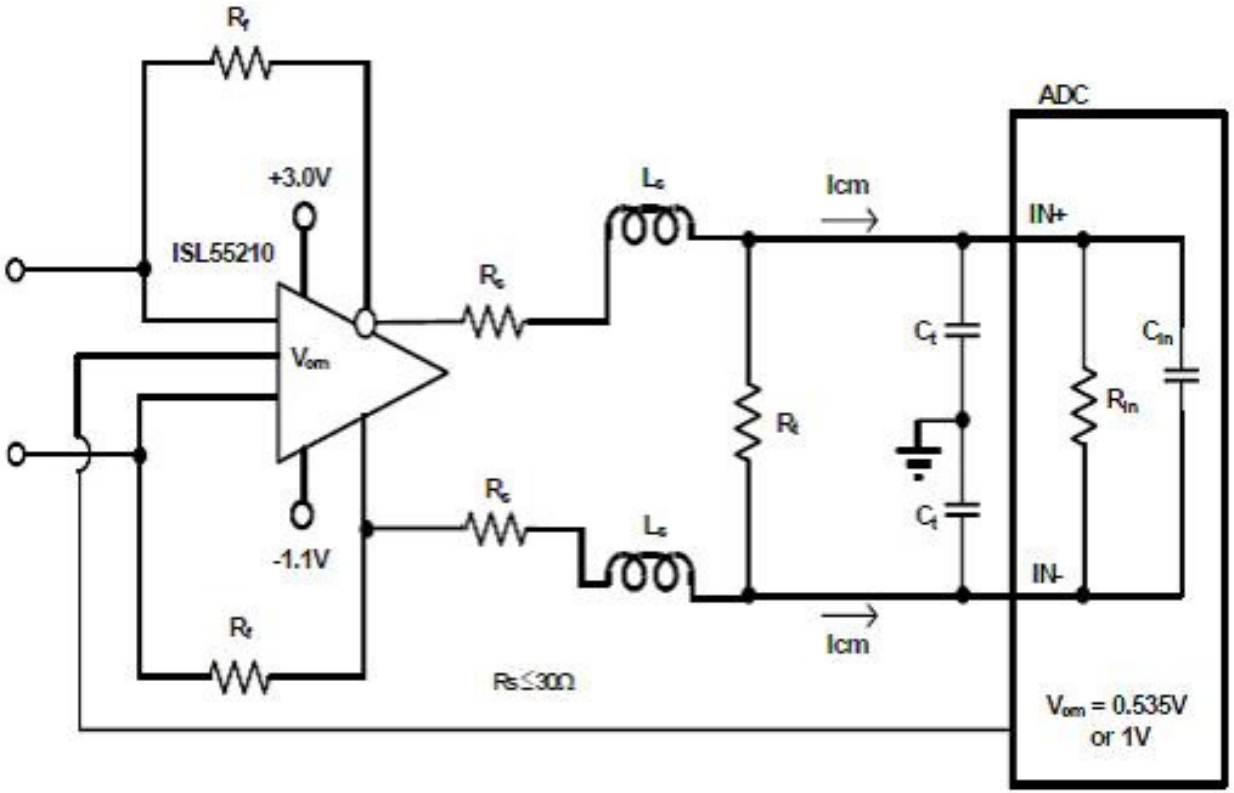


Putting it All Together

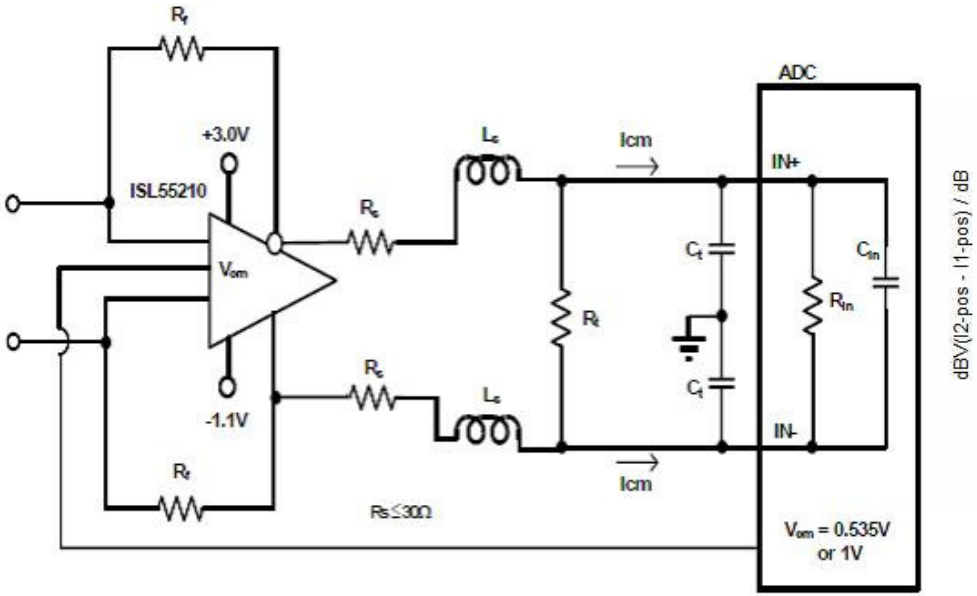
- Making a stormtrooper helmet!

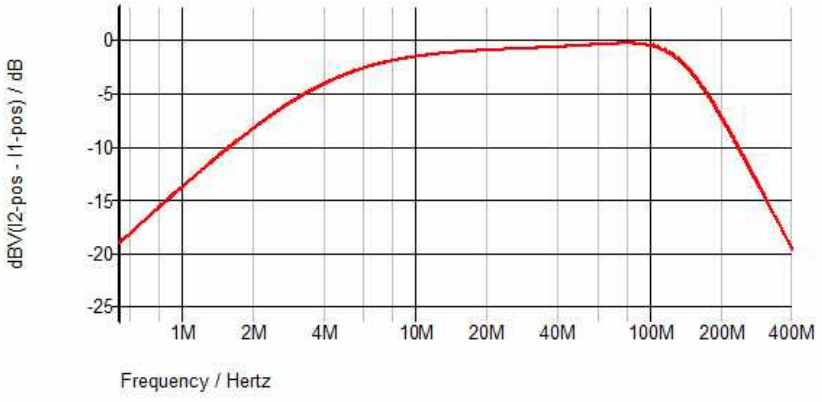
Example

Fully differential amplifier



Solution


R_f
+3.0V
ISL55210
V_{om}
-1.1V
R_f
R_g
R_g
L_c
L_c
Icm
Icm
R_t
C_t
C_t
ADC
IN+
IN-
C_{in}
R_{in}
Rs≤30Ω
V_{om} = 0.535V
or 1V


dBV(I2-pos - I1-pos) / dB
0
-5
-10
-15
-20
-25
1M
2M
4M
10M
20M
40M
100M
200M
400M
Frequency / Hertz

Homework

- HW #27 due today by 4:30 pm in EE 325B
- HW #28 due Fri.: DeCarlo & Lin, Chapter 6:
  - Problem 31
  - Problem 32