SINGLE-SUPPLY MICROPHONE AMPLIFIER CIRCUIT DEMO PROJECT

11/26/2025

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Defective Single-Supply Microphone Amplifier

- A microphone amplifier using a single op-amp
- Original purpose: amplify small AC microphone signals (~ 10 mV)
- Circuit behaviour:
  - AC coupling
  - Intended to be a non-inverting op-amp
    - $A_v = 1 + \frac{100\,k}{1\,k} = 101\ \left[\frac{V}{V}\right]$
  - Single-supply operations (negative rail = 0 V)

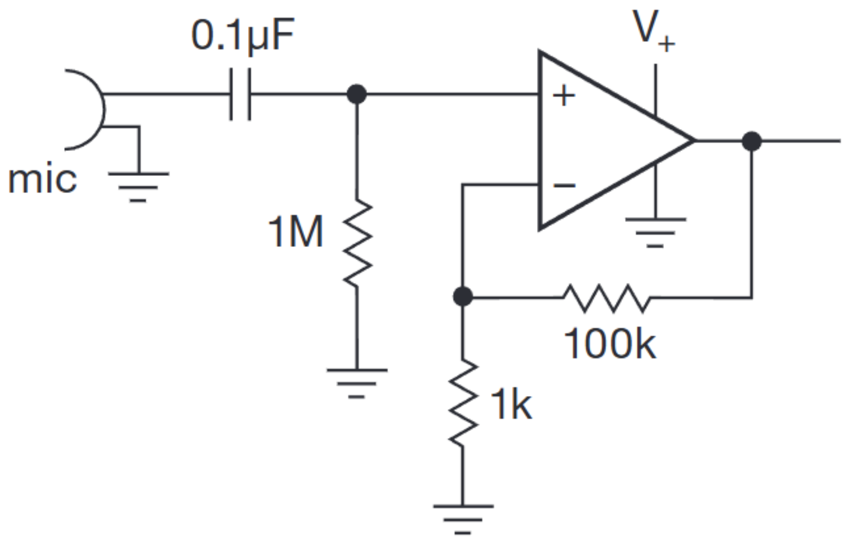

Fig. 1. Defective single-supply microphone amplifier

Defective Single-Supply Microphone Amplifier - Problem

- Capacitive coupling → DC at the V_{in+} = 0 V
- Voltage divider at 1 k & 100 k feedback resistors → $V_{in-} \approx$ 0 V
- LF411 data sheet: +3.5 V to +14.5 V
- Output (amplified signal) requires a negative output swing
  - Input mic signal = ± 5 mV
  - Gain = 101
  - Output tries to swing around ± 0.5 V
  - Negative power rail is restricted to 0 V → bottom half of wave is clipped

Solution – Biasing the Circuit to a Reference Voltage

- Objective: shift (bias) the AC input signal to mid-rail reference voltage so the amplified output stays within the supply rails
- Method: Voltage Divider of R1 & R2
  - $V_{in+}\,(\,or\;V_{ref}) = V_{+}\cdot\frac{R2}{R1+R2} = \frac{1}{2}V_{+}$
  - Note: R1 = R2

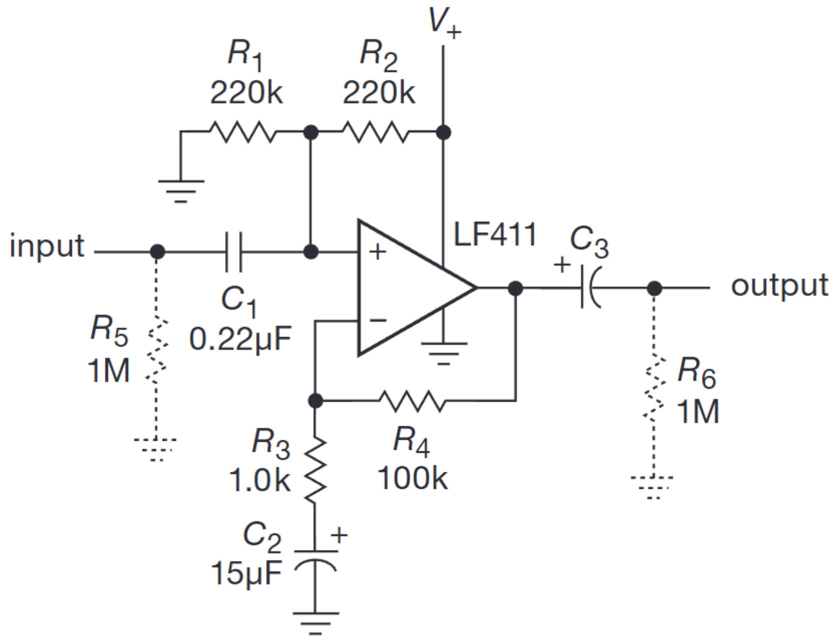

Fig. 3. Biased circuit to $V_{ref} = \frac{1}{2}V_{+}$

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Solution – Additional Components of the Biased Circuit

- C1: AC coupling on the input, blocking DC (same as Fig. 1)
- C2: open circuit – DC, short circuit – AC.
  - AC ground
- C3: AC coupling on the output
  - Blocks 6 V DC into the next stage and let's only the AC audio signals pass through
  - Ensures the output is centered at 0 V externally
- R5, R6:
  - Ensures C1 (input) and C3 (output) have defined DC paths
  - No floating nodes or random DC offsets
  - Avoid noise
- R3, R4: closed-loop negative feedback (same as Fig. 1)

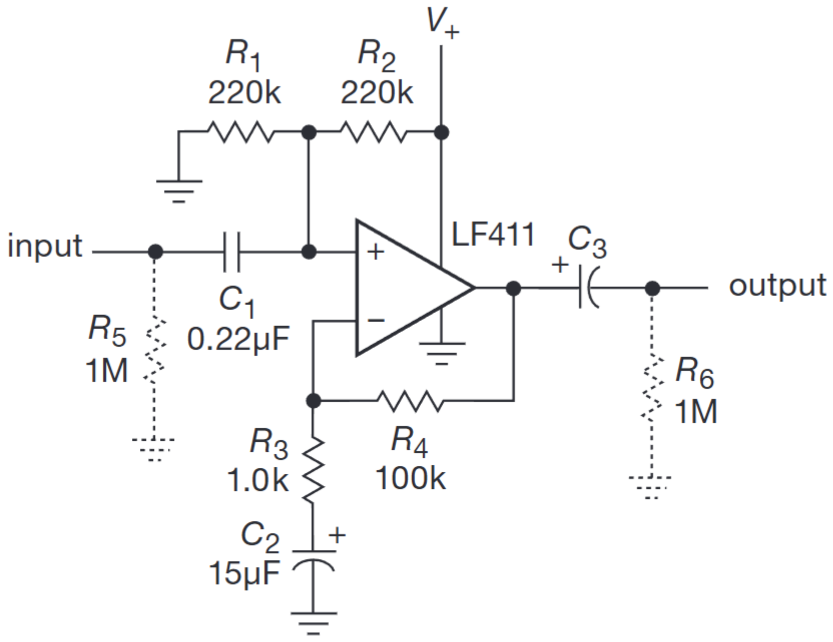

Fig. 3. Biased circuit to $V_{ref} = \frac{1}{2}V_+$

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Simulation

- https://falstad.com/circuit/circuitjs.html?ctz=CQAgjCAMB0l3BWcMBsBmALAJhQdgWgJwAcYKCFICkVVNCApgLRhgBQA5iIWFiMSgzde-QiihQ2AY3AYhGNHyxZ5ikELCx42nXDDNcIJjEitchBCWVpcRbIZOnJAJxDLVSlVRE0wuzm5eCCLuVFjEEpBsAO6BHm64fAp8UbFYieqCCXwIci7ZVHnpfCiQEb7wAcUgpRHVKF40Ua7VufJwhUIV2jHqHXIRGB1tkkOEBQN9NJN0UNDiTbBYaH66uk0BaGjiGMQ0WztikWwASiAH6mTn2+c05RJD4CmR0AinsvGsSWq+6liLkCQTTmb1iQ2mu3UakmUQA9rJ1A9IIRxn45tpCLhyA0gW4EWg2EA
- https://falstad.com/circuit/circuitjs.html?ctz=CQAgjCAMB0l3BWcMBsBmALAJhQdgWgJwAcYKCFICkVVNCApgLRhgBQA5iIWFiMSgzde-QiihQ2AY3AYhGNHyxZ5ikELCx42nXDDNcIJjB2kshfGAXFICK8WJQtESGwBOIZaqUqqImmC6nJ6+dj5CCFiONK4A7iHenrh8CnxxSSmCGVRykh5YyTlCBXw0kNHIcMElIGWONSi+Me7ZCLkYcEUSgdps8R00co4DXa4dhNlD6p1TaE7iLJq4eDwIyWi4GIRySCZYaD26OmnBaGjiGDYgZxdiEq4AStfn6mTP4ucVgwFp99AIbCeVkSrBSagClRiWl2fwB-Rml3UaimrgA9rJwOJvoQJlgodoLORGjC+FZrmx0RAKuMJiZ4MtzEQMAReLstHBCQhieBPDy0GwgA

Simulation

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Articulate Learning

Recognize the need for learning / continued learning:

- Lack of knowledge on AC coupling
- Audio signals – AC vs DC

Self-Directed Learning:

- Research on audio signal amplifier behaviour
- Textbook, LF411 op-amp datasheets
- Experimented with Falstad simulations and the graphs

Articulate Learning

Technical Learning:

- Real-life implications of audio signaling
- Biasing circuits and reference voltages
- Separating DC bias from AC signal behaviour

I will apply these biasing techniques in future amplifier and sensor circuits

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