Fig. 2 and Fig. 3 show two example analog circuit reasoning tasks in ACR-Bench. Our data processing alters the syntax of the SPICE code while maintaining information integrity through comments. By restricting the available data, we ensured that the human solution is the only reasonable solution.

2 A2. Concept Library and Subcircuit Library

As shown in Table 1 and Table 2, we make 4 concept entries in Concept Library and 5 subcircuit entries in Subcircuit Library. These two libraries are extensible and can be expanded or adjusted according to practical applications.

Text: Calculate the small-signal voltage gain of the common-source amplifier with active load in SPICE code. Assume that all the transistors operate in the active region.

You can use \(g_{m1}\) to represent the transconductance of M1, \(g_{o1}\) to represent the output conductance of M1, and \(g_{o2}\) to represent the output conductance of M2.

SPICE Netlist: * Current Mirror Circuit

* Voltage Sources
VDD 1 0 DC ; Positive supply voltage connected to node 1 (drain of M2 and M3)

* Input Voltage Source
VI 2 0 AC ; Input voltage source connected to the gate of M1

* Reference Current Source
IREF 3 0 DC ; Reference current source connected to the drain of M3

* MOSFETs
M1 4 2 0 0 NMOS ; NMOS transistor M1 with drain at node 4, gate at node 2, source at ground
M2 4 3 1 1 PMOS ; PMOS transistor M1 with drain at node 4, gate at node 3, source at node 1
M3 3 3 1 1 PMOS ; PMOS transistor M1 with drain at node 3, gate at node 3, source at node 1

Output (V_out = Vds1) is on node 4

I_OUT = I_d1 is current on node 4

Human Solution: -\frac{g_{m1}}{g_{o1}+g_{o2}}

Figure 2: Example task 1 of active loads.

Text: Determine the \(\frac{Vout}{VIN}\) of the circuit when Vout is between \(-2V_{BE(on)}\) and \(2V_{BE(on)}\) shown in SPICE code. Assume that \(V_{BE(on)}\).Assuming \(I_S -> 0\) for the transistor. Approximate the op amp by a voltage - controlled voltage source with a gain of $+\infty$.

SPICE Netlist: * Circuit with Resistor, Symmetrical Transistor, and Ideal Op Amp

* Voltage Source
VIN 1 0 DC ; Input voltage source V_in connected between node 1 and ground (node 0)

* Resistors
R_1 1 2 R_1; Resistor R_1 connected between nodes 1 and 2
R 3 4 R ; Resistor R connected between nodes 3 and 4
R 4 5 R ; Resistor R connected between nodes 4 and 5

* Symmetrical Transistor
Q1 5 4 3 NPN ; Symmetrical transistor Q1 with collector at node 5, base at node 4, emitter at node 3
\(\alpha_F=\alpha_R\)

* Ideal Operational Amplifier
EOPAMP 0 2 5 ; Ideal operational amplifier E_OPAMP , non-inverting input at node 0, inverting input at node 2, output at node 5

*output Vout is on node 5

Human Solution: -\frac{2 \cdot R}{R_1}

Figure 3: Example task 2 of non-linear circuits.

Table 1: Keywords and tips of entries in Concept Library.

Keyword	**Tip**
Dual input and dual output opamp	Choose the Dual input and dual output opamp, when there is dual output OPAMP (only directly shown in SPICE as a whole OPAMP) in the problem no matter asking for CM or DM parameter.
Opamp voltage comparators	Choose Opamp voltage comparators when there is circuit function as voltage comparators with OPAMP.
Power in circuit	Choose Power in circuit when the problem asks for a power parameter in the circuit.
Two port analysis of negative feedback	Choose Two port analysis of negative feedback when the problem mention two-port analysis which is a method designed to analyse feedback.

Table 2: Keywords and tips of entries in Subcircuit Library.

Name	**Tip**
CM mode of transistor differential amplifiers	Don't choose the CM mode of transistor differential amplifiers when asking a DM parameter in a transistor differential amplifiers or the differential amplifiers consist of OPAMP. Don't choose when the circuit contains an active load. Don't choose when asking a DM parameter except CMPR.
DM mode of transistor differential amplifiers	Don't choose the DM mode of transistor differential amplifiers when asking a CM parameter in a transistor differential amplifiers or the differential amplifiers consist of OPAMP. Don't choose when the circuit contains an active load. Don't choose when asking a CM parameter. Only choose this when asking DC current in differential amplifiers.
Transistor voltage regulator	Choose Transistor voltage regulator when there are both OPAMP (only directly shown in SPICE as a whole OPAMP) and transistor in the circuit.
Noise in differential amplifiers	Choose Noise in differential amplifiers only when the problem directly asks for the noise in the differential amplifiers. Don't choose this when asking other parameters in differential amplifiers which are irrelevant to noise like gain.
Zener diode in circuit	Choose Zener diode in circuit when there are Zener diodes in the circuit.