

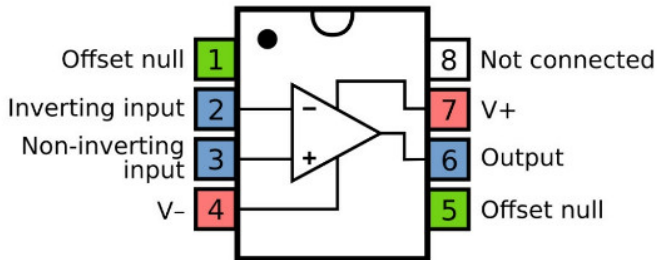
C-V Characteristics of MOS Capacitor

Electronic Devices Lab : Experiment 10

Department of Electrical Engineering
Indian Institute of Technology, Bombay



TL071 Op-Amp Pinout

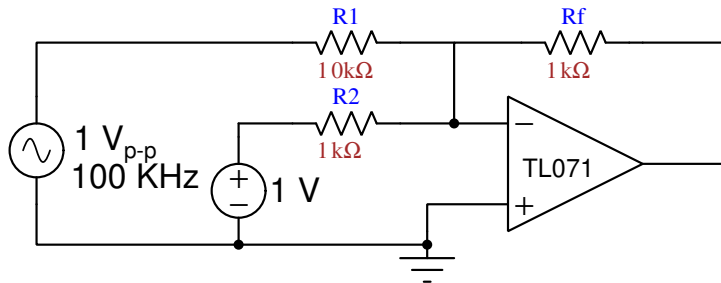


TL071 opamp

Precautions

- **Do not touch the sample directly.** Use the copper plate attached to it to handle the sample.
- Probing has to be done carefully since the **MOSCAP and Schottky Diode dimensions are small**.
- Make sure the sample is not in contact with the POGO pin while adjusting the sample on the probe station. Also don't over-tighten the POGO pin onto the sample causing scratches on its surface.
- Test the individual circuits (adder and amplifier) first and show it to your TA. Proceed only after both have been verified.

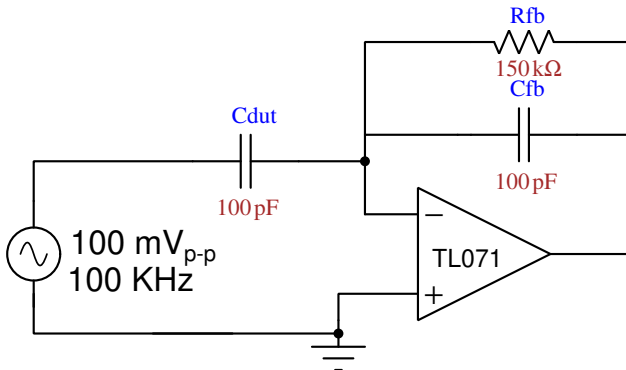
Part I: Summer Circuit



- Recall the working of the summer circuit.
- What do you expect at the output of the above circuit?

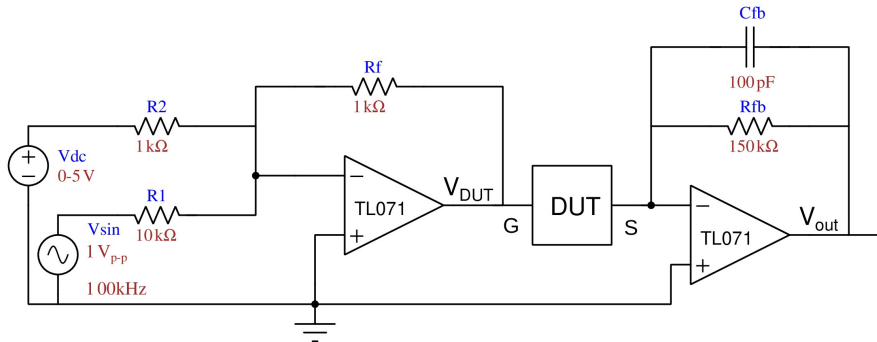
Part II: Amplifier Circuit

high pass



- Wire up the above circuit, leaving the previous circuit intact.
- What do you expect at the output of the above circuit?
- Lower the frequency to around 5 kHz and observe the output. What can you conclude from your observations?

Part III: Measurement of MOSCAP C-V characteristics



- Combine the circuit from parts I and II as shown above.
- We have to measure the capacitance of the DUT, C_{DUT} as V_{DC} is varied from 0 to 5V.
- DUT refers to the MOSCAP sample you are provided. G represents gate terminal and S represents substrate.

Part III: Measurement of MOSCAP C-V characteristic

For the above circuit, the AC gain from V_{DUT} to V_{out} is given by,

$$\left| \frac{V_{out \text{ } p-p}}{V_{DUT \text{ } p-p}} \right| = \frac{C_{DUT}}{C_{fb}} \frac{1}{\sqrt{1 + \frac{1}{(\omega R_{fb} C_{fb})^2}}}$$

- Set V_{DC} to 0V. From the observed value of the gain, find C_{DUT} .
- Vary the DC voltage in steps while tabulating the following.

V_{DC}	$V_{DUT \text{ } p-p}$	$V_{out \text{ } p-p}$	AC gain	C_{DUT}

- Take readings till the Op-Amp saturates.
- After taking readings for positive values of V_{DC} , change its polarity and take readings for negative values of V_{DC} as well.

Calculating MOSCAP Parameters

Plot C_{DUT} vs V_{DC} from the above table and obtain the following:

- Oxide capacitance
- Oxide thickness
- Doping density
- Flat band voltage
- Flat band capacitance
- Debye length
- Debye capacitance

Note : When V_{DC} is positive, you get negative part of the C-V curve and vice versa (this is due to the Op-Amp configuration). Hence plot accordingly.

Required Data and Equations

There are 4 different MOSCAPs in each sample and each MOSCAP has different dimensions.

- Circular MOSCAP of 1mm diameter
- Circular MOSCAP of 2mm diameter
- Square MOSCAP of 1mm side length
- Square MOSCAP of 2mm side length

Area (A) of the MOSCAP you are dealing with has to be calculated accordingly.

Required Data and Equations

Intrinsic carrier concentration of Silicon, $n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$.

Thickness of oxide layer is given by, relative permittivity of silicon is 11.7

$$t_{ox} = \frac{A \epsilon_{ox}}{C_{ox}}$$

Equation to calculate doping density:

$$t_{dep} = 2 \sqrt{\frac{\epsilon_{si}}{q N_A} \frac{kT}{q} \ln \left(\frac{N_A}{n_i} \right)}$$

$$C_s = \frac{A \epsilon_{si}}{t_{dep}}$$

$$C_{min} = \frac{C_{ox} C_s}{C_{ox} + C_s}$$

Required Data and Equations

Debye capacitance:

$$C_{debye} = \frac{A\epsilon_{si}}{L_{debye}}$$

Debye length:

$$L_{debye} = \sqrt{\frac{\epsilon_{si}}{qN_A} \frac{kT}{q}}$$

Flat band capacitance:

$$C_{fb} = \frac{C_{ox} C_{debye}}{C_{ox} + C_{debye}}$$

Flat band voltage:

Voltage corresponding to flat band capacitance in C-V curve.