Group 12

HARTLEY OSCILLATOR USING BJT CONFIGURATION

Harshvardhan choudhary 230002027
Mayank Yadav 230002041
Tanishka Nainiwal 230002073
Bhuva Vasudha 230002017
Pradeep Swami 230002053

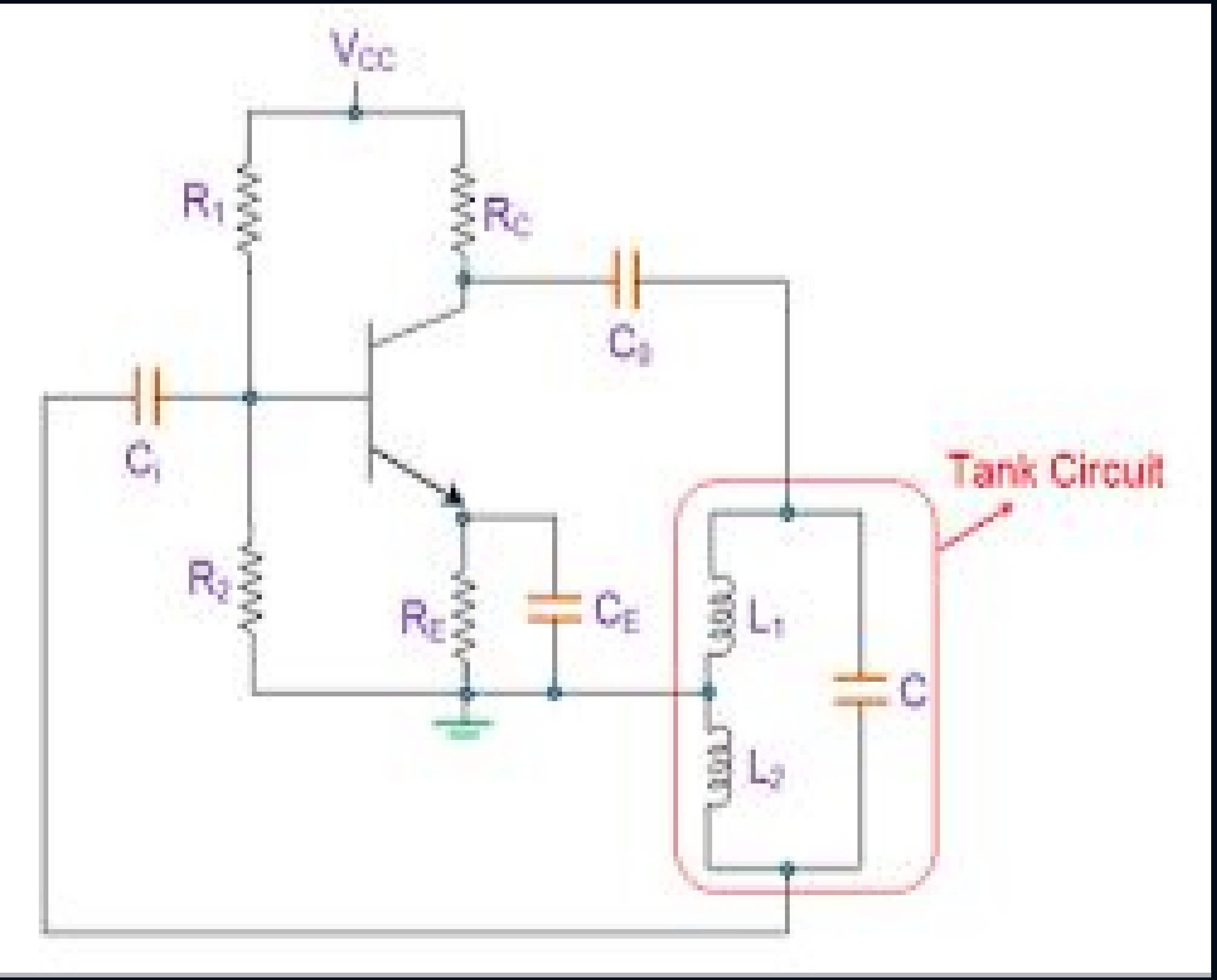
INTRODUCTION

Topology: BJT-based Hartley oscillator
Tank Circuit: Tapped (or series) inductors + capacitor determine oscillation frequency
Output: Stable, continuous sine wave at the desired frequency
Biasing: Transistor bias set for proper amplification and linear operation
Feedback: Inductive feedback ensures sustained oscillation
Applications: RF signal sources, audio generators, and timing circuits

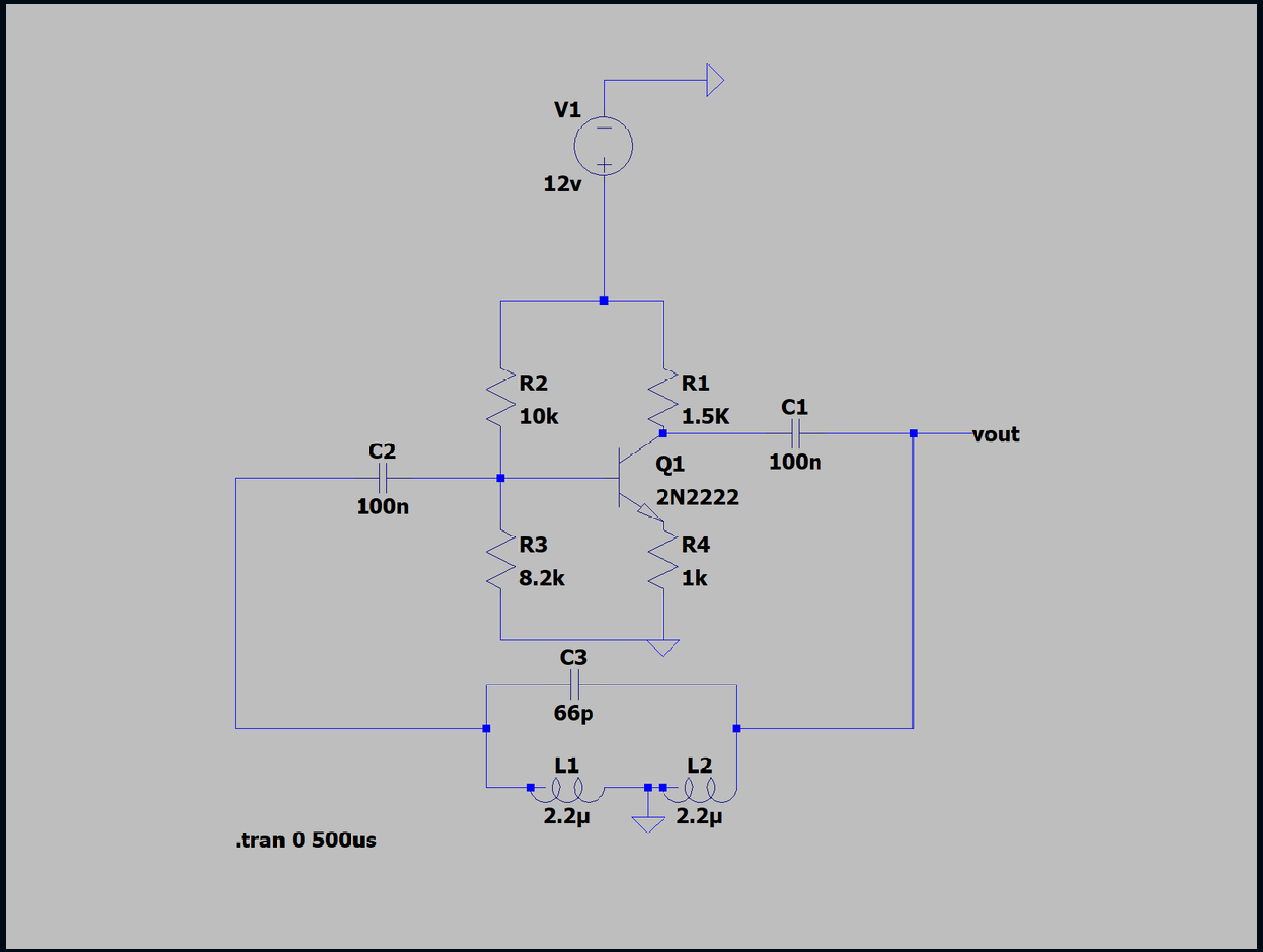
HARTLEY OSCILLATOR

The Hartley Oscillator is a popular type of LC oscillator that generates sinusoidal waveforms. It uses a combination of inductors (L) and a capacitor (C) toform a resonant (tank) circuit. A BJT (Bipolar Junction Transistor) is used to provide amplification and positive feedback, necessary for sustained oscillations.

- PRODUCES PURE SINUSOIDAL WAVEFORMS.
- FREQUENCY IS DETERMINED BY INDUCTORS AND CAPACITOR (LC TANK CIRCUIT).
- POSITIVE FEEDBACK IS PROVIDED USING A TAPPED COIL OR TWO INDUCTORS.
- USES A BJT AS THE ACTIVE AMPLIFYING DEVICE.
- SIMPLE, COMPACT, AND EASY TO DESIGN CIRCUIT.
- FREQUENCY CAN BE EASILY ADJUSTED BY CHANGING INDUCTANCE OR CAPACITANCE.
- SUITABLE FOR HIGH-FREQUENCY (RF) SIGNAL GENERATION.
- STABLE OUTPUT WITH PROPER BIASING.
- Frequency of Oscillation $F = 1/2\pi\sqrt{\ }\ ((L_1+L_2+2M) + C)$

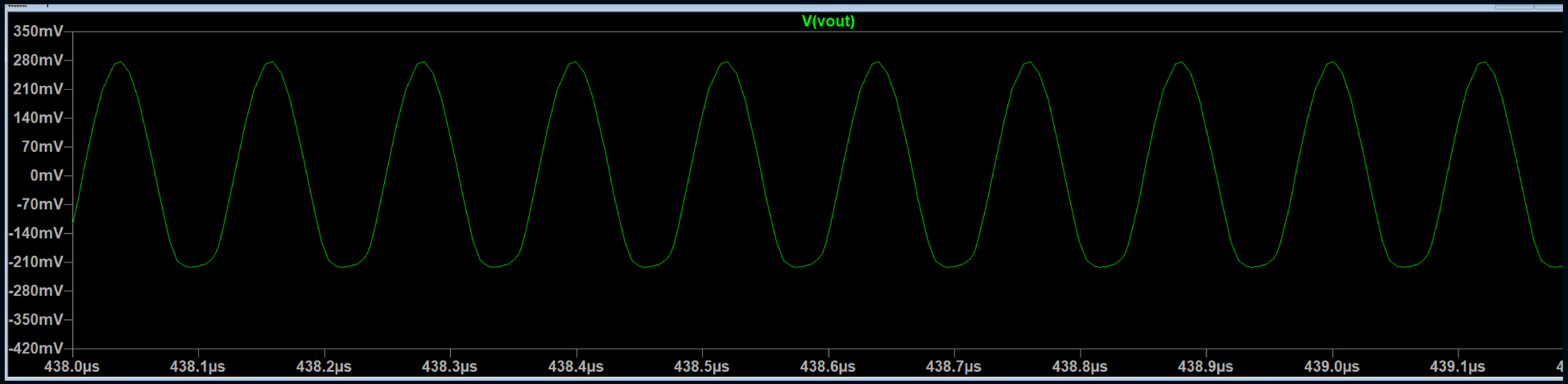


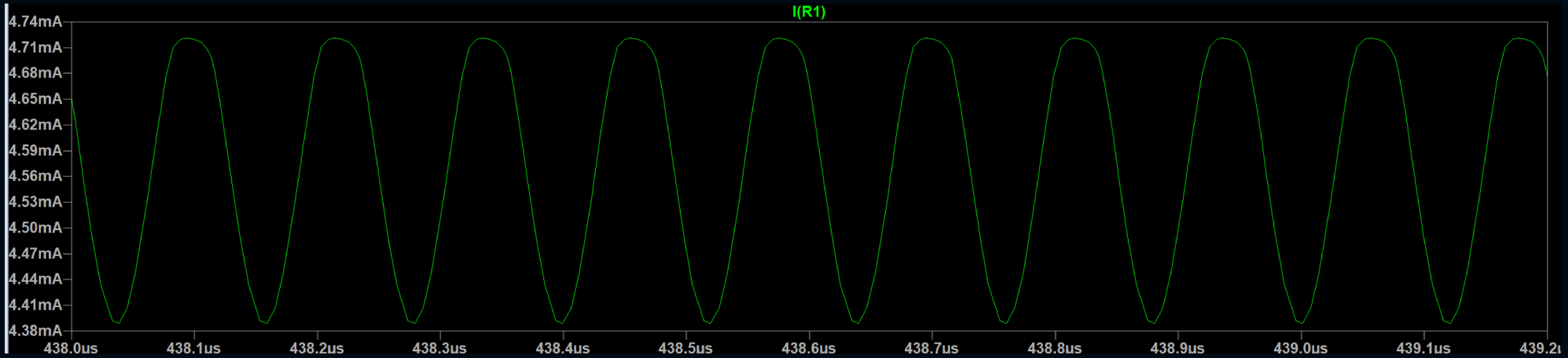
CIRCUIT DIAGRAM



LTSPICE CIRCUIT

OUTPUT WAVEFORM





- Tank inductance

$$L_{\text{eq}} = L_1 + L_2 = 2.2\,\mu\text{H} + 2.2\,\mu\text{H} = 4.4\,\mu\text{H}$$

- Resonant capacitor

$$C = 66\,\text{pF}$$

- Resonant frequency

$$f_0 = \frac{1}{2\pi\sqrt{L_{\text{eq}}\,C}} = \frac{1}{2\pi\sqrt{4.4\times10^{-6}\times66\times10^{-12}}} \approx 9.3\,\text{MHz}$$

Base voltage	$V_B = 12\cdot\frac{8.2}{10+8.2}$	5.406 V
Emitter voltage	$V_E = V_B - 0.7$	4.707 V
Emitter/collector current	$I_C \approx V_E/R_4$	4.707 mA
Ideal R_1 for mid-rail (6 V)	$R_1 = \frac{6}{I_C}$	1.275 kΩ
Using R_1=1.5 kΩ → V_C	$12 - I_C\cdot1.5\text{k}\Omega$	4.94 V
Resulting V_CE	$V_C - V_E$	0.23 V
Transconductance	$g_m = I_C/V_T$	0.188 S
$-g_m R_1$		–282

1. Feedback path (the tapped inductor)

Write the divider as a complex ratio:

$$\beta(j\omega) = \frac{V_{\text{fb}}}{V_{\text{out}}} = -\frac{Z_{L_2}}{Z_{L_1} + Z_{L_2}} = -\frac{j\omega L_2}{j\omega(L_1 + L_2)} = -\frac{L_2}{L_1 + L_2} \qquad \text{(real, negative)}$$

- The leading "–" is a 180° flip from the dot-convention.
- The magnitude is $\frac{L_2}{L_1+L_2} = 0.5.$
- **Phase:**

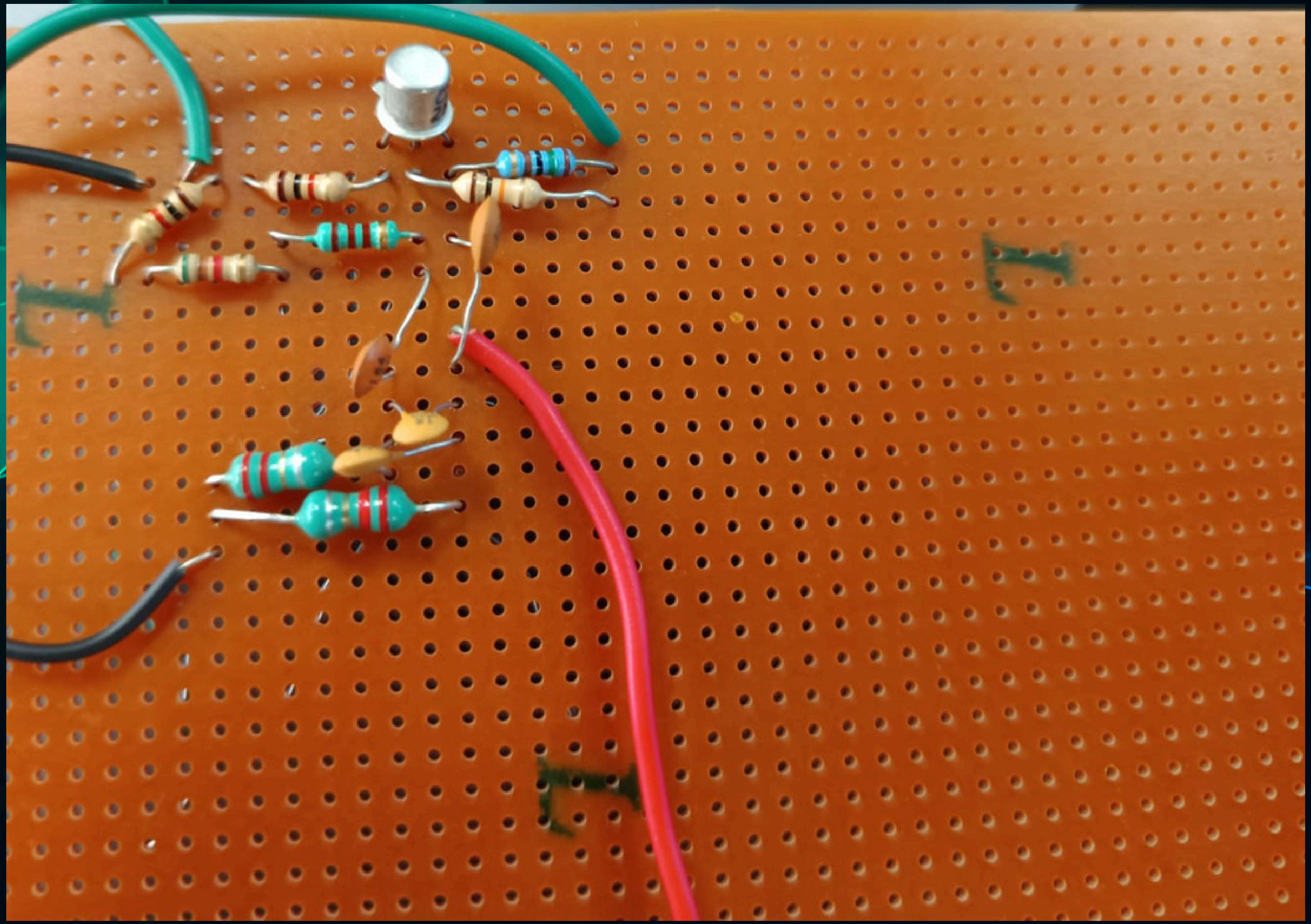
$$\angle\beta = \angle(-1) + \angle\left(\frac{L_2}{L_1+L_2}\right) = 180^\circ + 0^\circ = 180^\circ.$$

2. Amplifier path (common-emitter with R_4 un-bypassed)

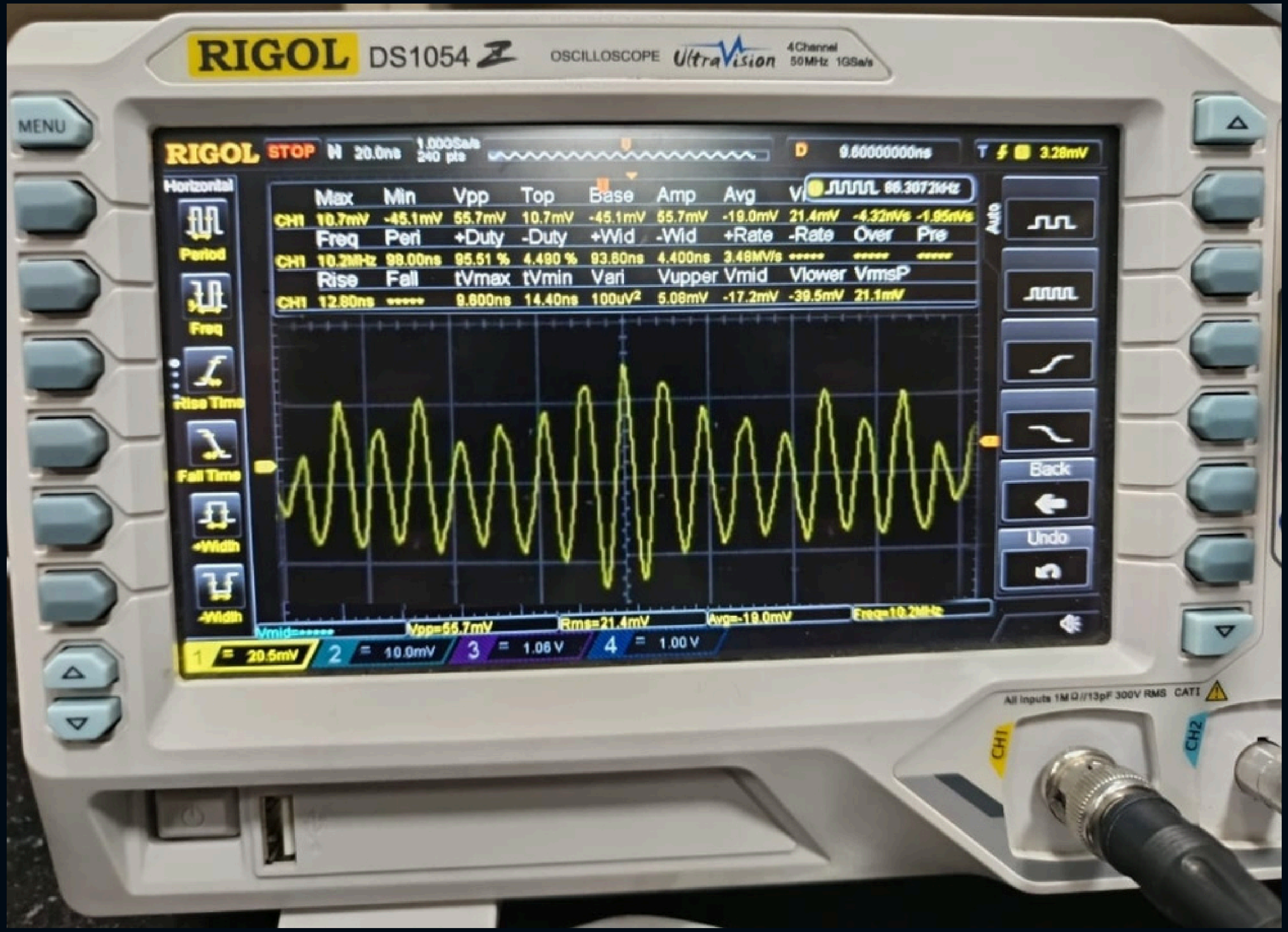
At mid-band (well below any transistor internal poles), the small-signal gain is purely real (and negative):

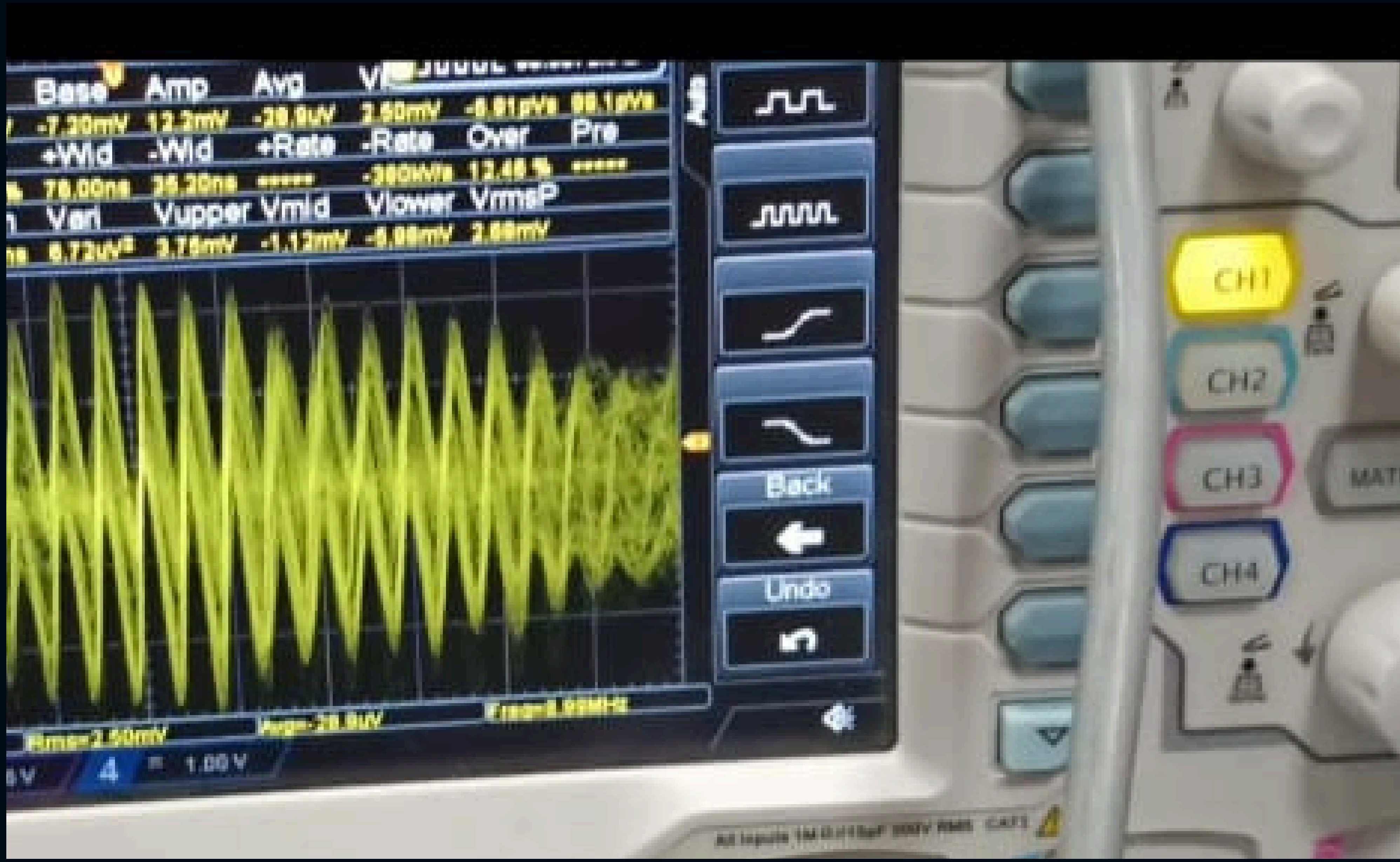
$$A_v \;=\; -\frac{R_1}{R_4 + r_e} \quad\Longrightarrow\quad \angle A_v = 180^\circ.$$

Circuit



OBSERVATIONS





- Resonant frequency close to design: the tank of two 2.2 µH coils and ~66 pF yields ≈9–10 MHz in practice (shifts ±1 MHz if parasitics aren't minimized).
- Feedback ratio fixed at ½: because $L_1 = L_2$, $\beta = L_2/(L_1 + L_2) = 0.5$, so the amplifier must deliver ≥2× gain for Barkhausen's magnitude criterion.
- Clean sine on compact layout: on a PCB or tightly-wired perf-board you'll see a pure sine with low distortion; on a solderless breadboard stray C/L kills Q and causes drop-outs or harmonics.

Challenges Faced

- Higher Frequencies are not supported on breadboard.(Stray Capacitance).
- Using pF caps resulted in very parasitic effect and stray capacitance .
- High Values of R have parasitic effect at high frequencies.
- Mainting the amplitude in DSO, as croc cables attenuate them.
- Dealing with all the losses involved in the process.

Future Improvements

- We can create a PCB which might beetter when it comes to handle higher frequencies.

THANK YOU!

FOR YOUR ATTENTION