ELECTRONIC CIRCUIT DESIGN PROJECT

PROJECT TOPIC: CLASS A HEADPHONE AMPLIFIER

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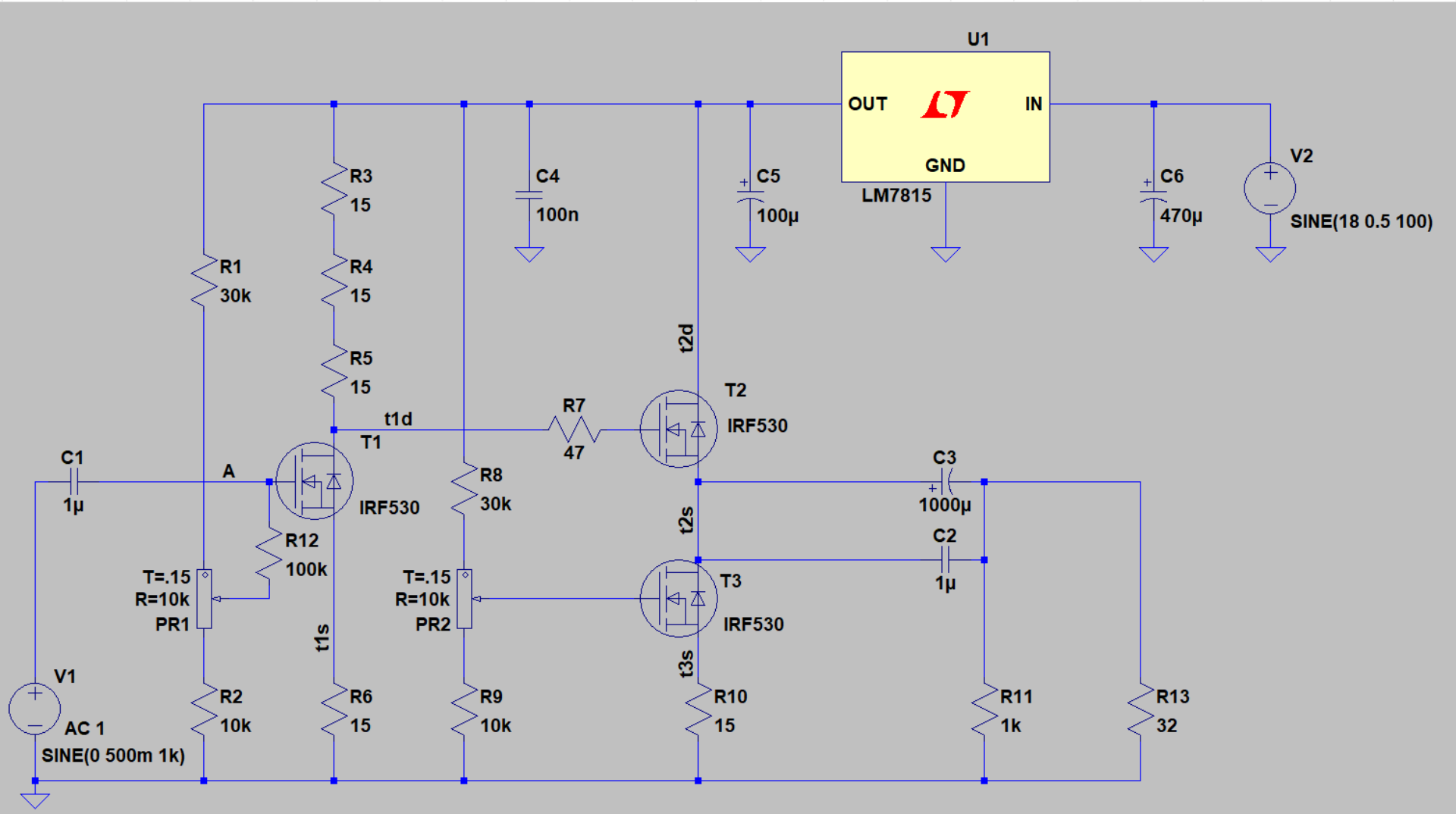
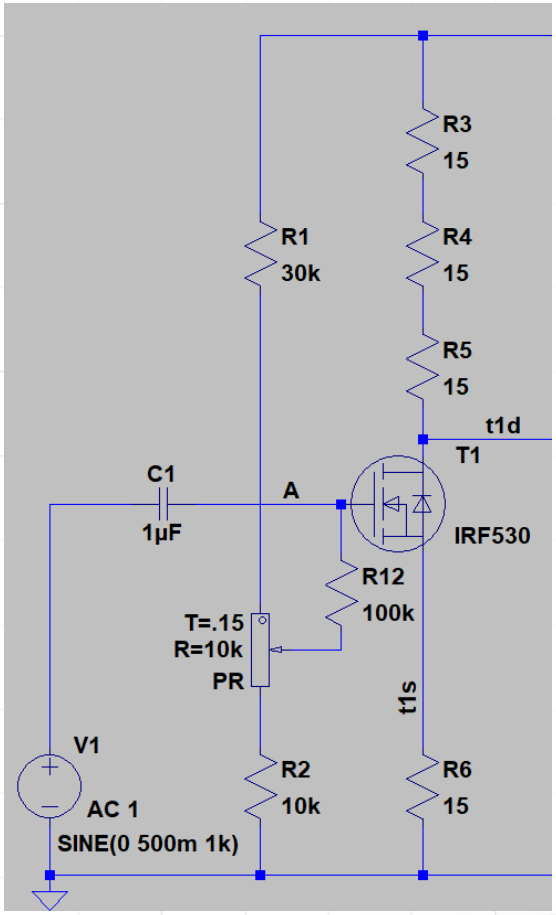
Project Schematic

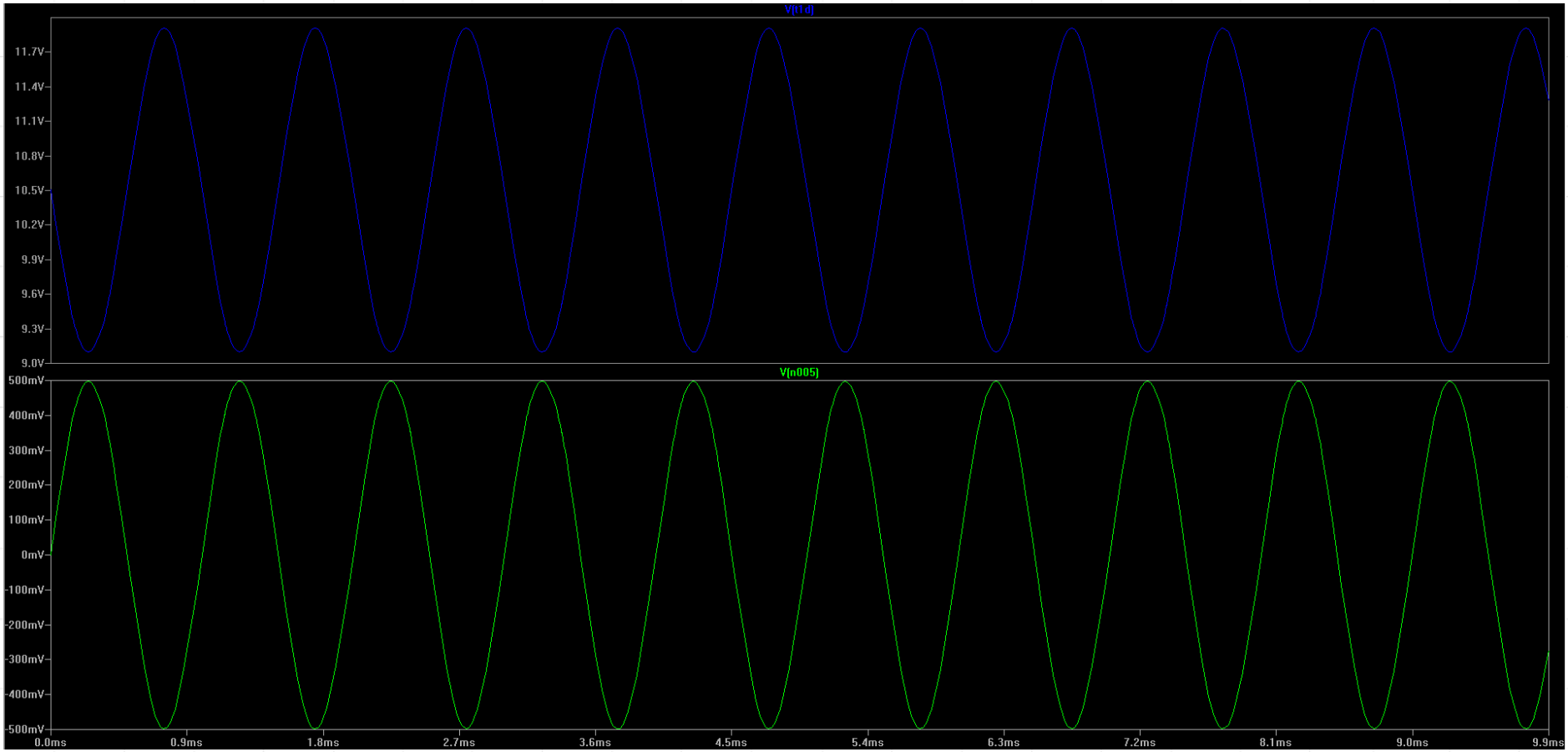


How Does It Work?

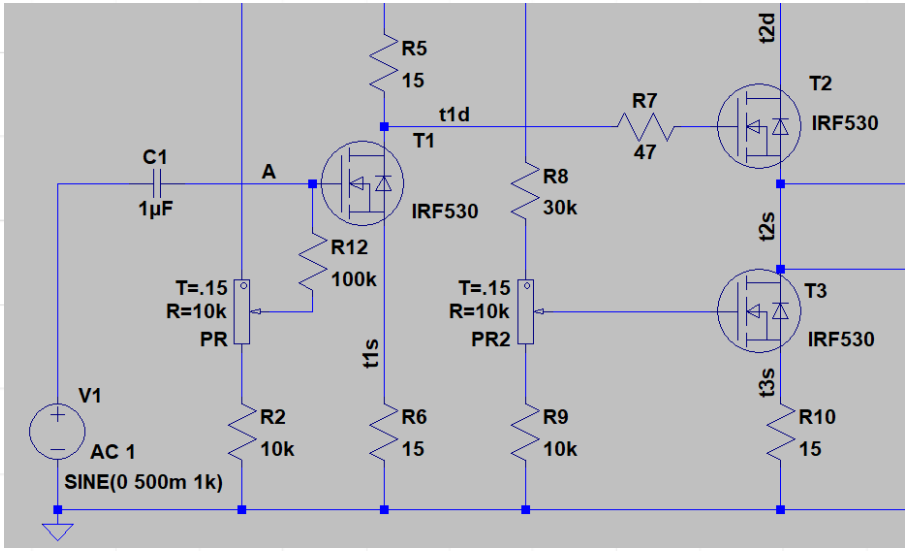


- The signal is passed through capacitor C1 to the gate of the MOSFET transistor T1.This transistor amplifies the signal by a factor of three, which means the gain is proportional to the ratio of resistors R3, R4, and R5 to resistor R6.This level of amplification is sufficient to connect the amplifier directly to the line output of devices such as CD players, MiniDisc players, or cassette decks.Three identical resistors R3–R5 were used instead of a single 47Ω resistor solely to reduce power dissipation, which totals 450 mW.

Green input signal: 0.5 V
Blue output signal: (12 – 9) / 2 = 1.5 V
Voltage gain (Ku) = 1.5 / 0.5 = 3 (V/V)

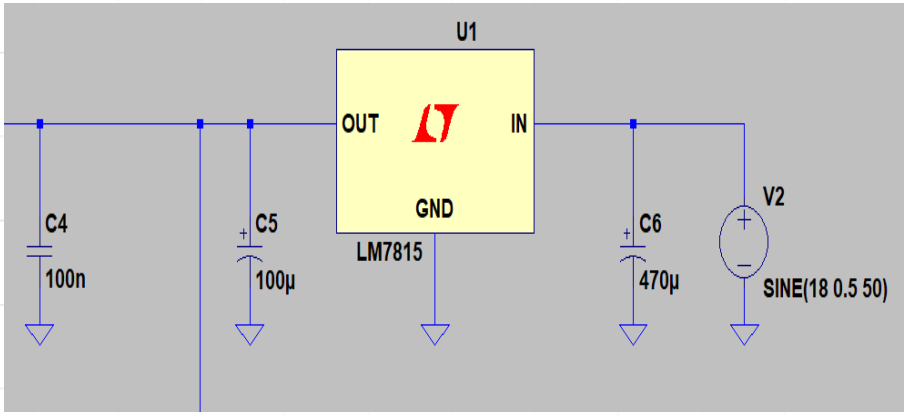


How Does It Work?



- The signal, amplified threefold from the drain of transistor T1, is fed to the gate of transistor T2, which operates as a buffer (source follower). To prevent potential oscillations at high frequencies, a low-value resistor R7 is added. To reduce distortion, the buffer T2 is not loaded with a resistor; instead, a current source implemented using transistor T3 is used.

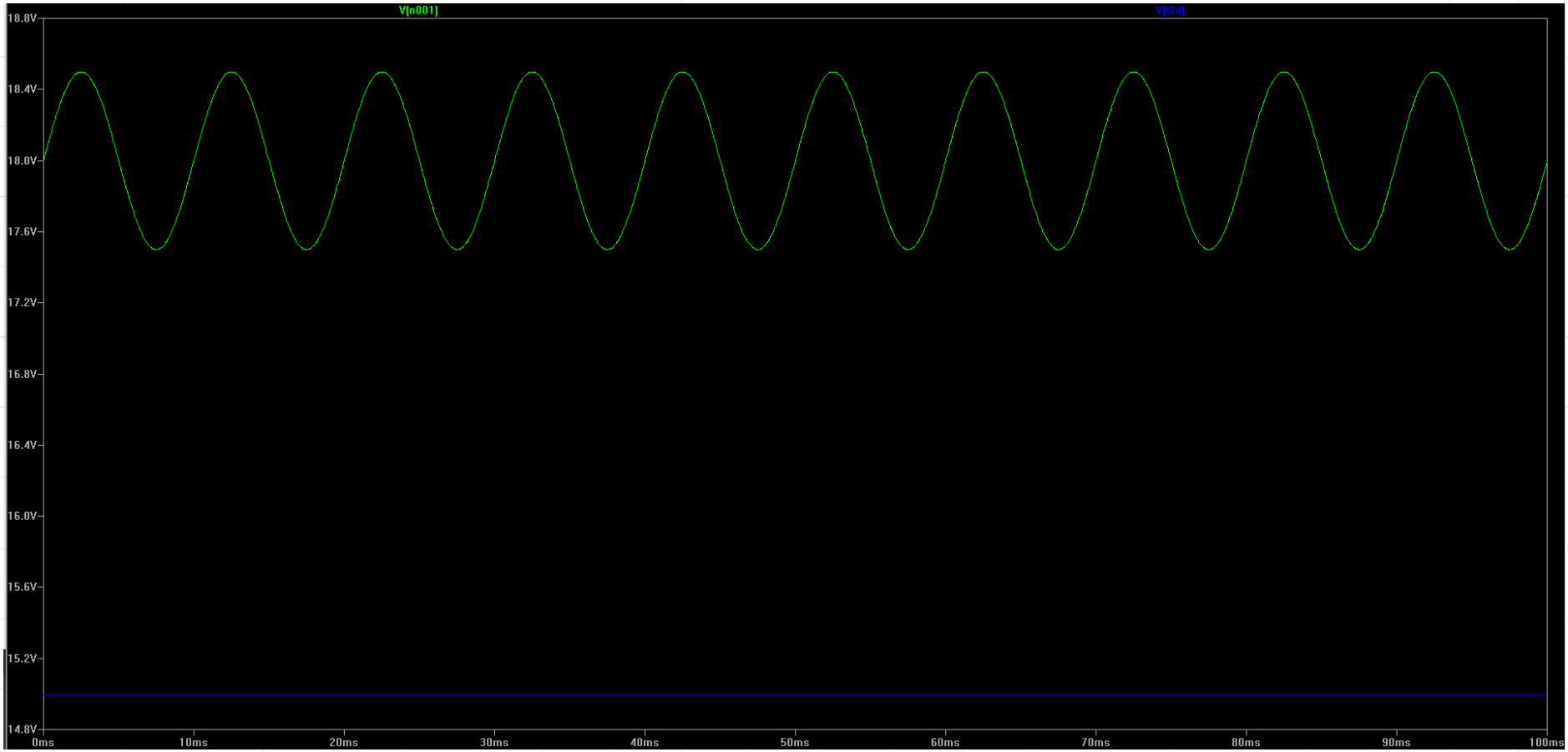
How Does It Work?



- To prevent interference from the power supply circuits, a well-regulated supply voltage is required. A supply voltage of 15 V is sufficient to achieve an output power greater than 100 mW into typical headphones with an impedance of 32 Ω. However, due to the voltage drop across the regulator, the voltage on capacitor C6 should never be lower than 18 V to ensure stable and interference-free operation of the amplifier.

Power supply parameters (green signal): 18 V with 0.5 V ripple at 100 Hz

Regulated voltage (blue signal): 15 V



How Does It Work?

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--- Operating Point ---

V(t2d):         14.9964         voltage
V(n002):        13.4998         voltage
V(n003):        12.0031         voltage
V(t1d):         10.5065         voltage
V(t1s):         1.49666         voltage
V(n012):        2.99929         voltage
V(n008):        5.99857         voltage
V(n006):        6.5189e-013     voltage
V(t2s):         6.45436         voltage
V(t3s):         1.49544         voltage
V(n004):        10.5065         voltage
V(n007):        5.99857         voltage
V(n011):        2.99929         voltage
V(a):           5.54868         voltage
V(n005):        0               voltage
V(n009):        5.54868         voltage
V(n001):        18              voltage
V(n010):        5.54868         voltage
Ix(t1:1):       0.0997773       subckt_current
Ix(t1:2):       -4.9578e-012    subckt_current
Ix(t1:3):       -0.0997773      subckt_current
Ix(t3:1):       0.0996962       subckt_current
Ix(t3:2):       -9.05567e-013   subckt_current
Ix(t3:3):       -0.0996962      subckt_current
Ix(t2:1):       0.0996962       subckt_current
Ix(t2:2):       -4.48984e-012   subckt_current
Ix(t2:3):       -0.0996962      subckt_current
Ix(u1:1):       0.205178        subckt_current
Ix(u1:2):       -0.00510474     subckt_current
Ix(u1:3):       -0.200073       subckt_current
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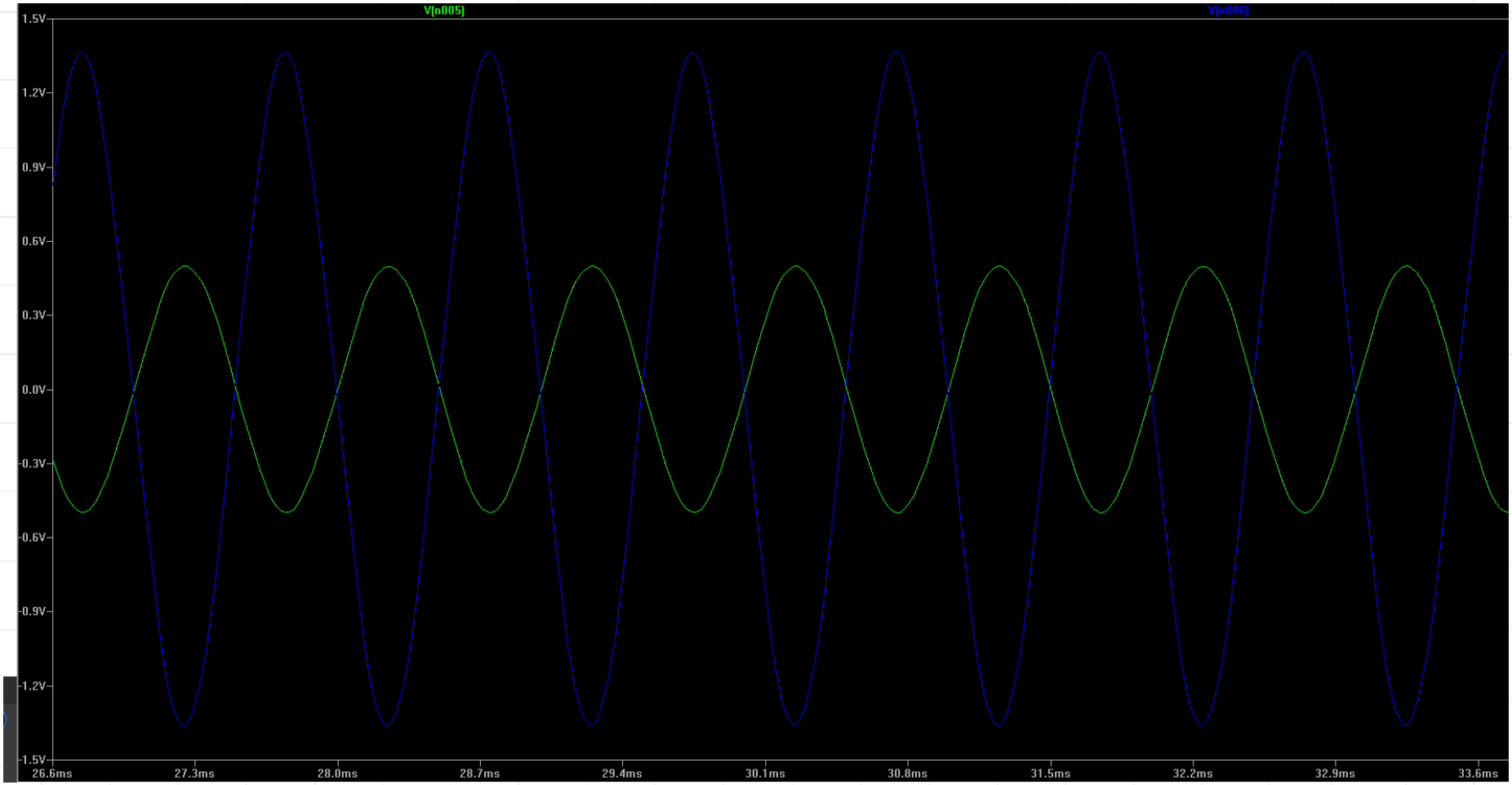
- To achieve an output power of 100 mW, the quiescent current of the output stage — that is, the quiescent current of transistors T1, T2, and T3 — should be 100 mA or higher. The quiescent currents of T1 and T2+T3 are determined by the values of resistors R6, R10, as well as the voltages at the gates of T1 and T3.The trimmer potentiometers PR1 and PR2 are adjusted so that the quiescent current causes a voltage drop of 1.5 V across resistors R6 (T1s) and R10 (T3s). If these resistors have a value of 15 Ω, this occurs at a quiescent current of 100 mA. Therefore, the entire amplifier — or rather one channel of a stereo amplifier — will draw approximately 200 mA.

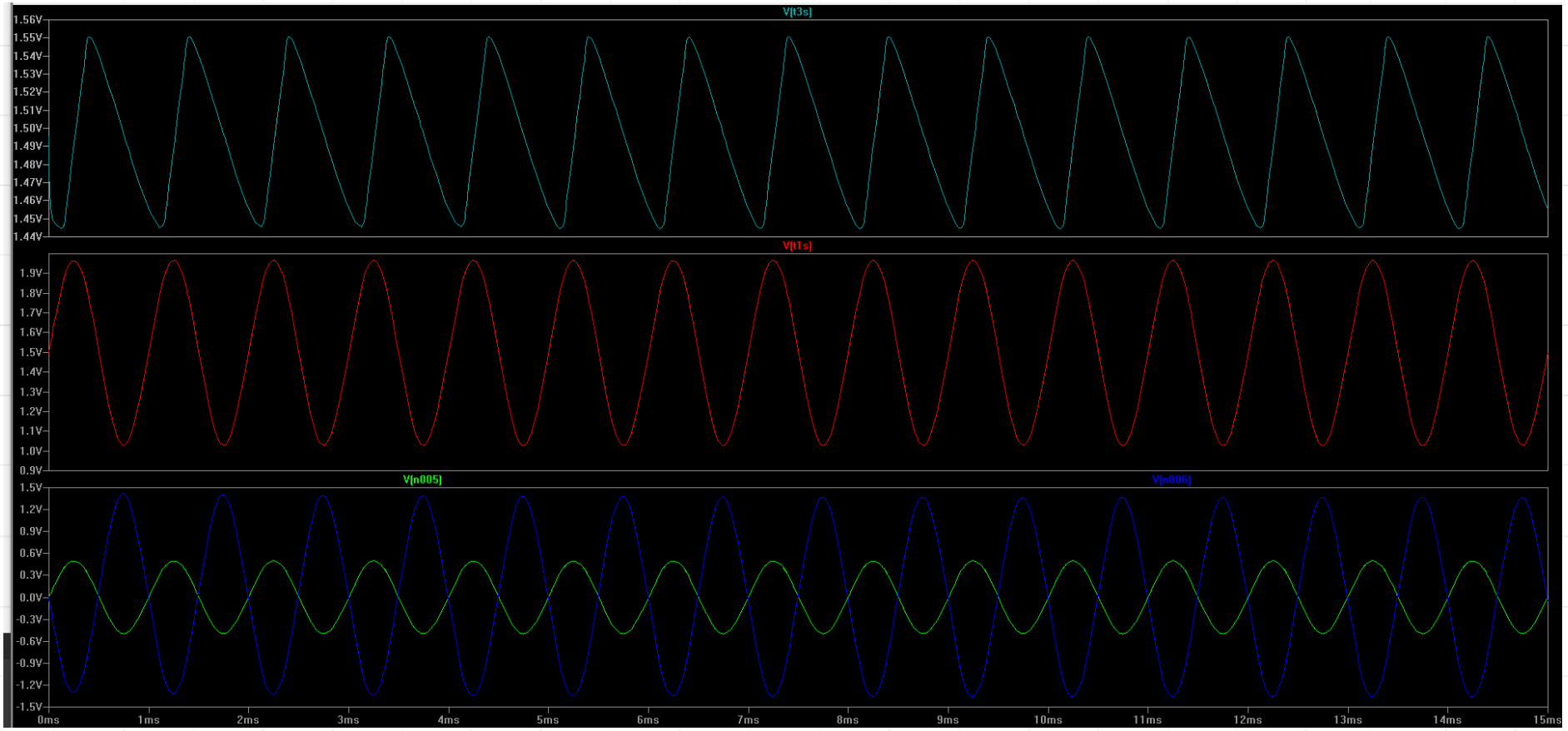
Amplitude characteristic of output voltage (blue) to input voltage (green)



Project Analysis

The trimmer potentiometers PR1 and PR2 are adjusted so that the quiescent current equals 100 mA, with no distortion.
Characteristics:

R10; 2. R6; 3. Input voltage (green), Output voltage (blue).

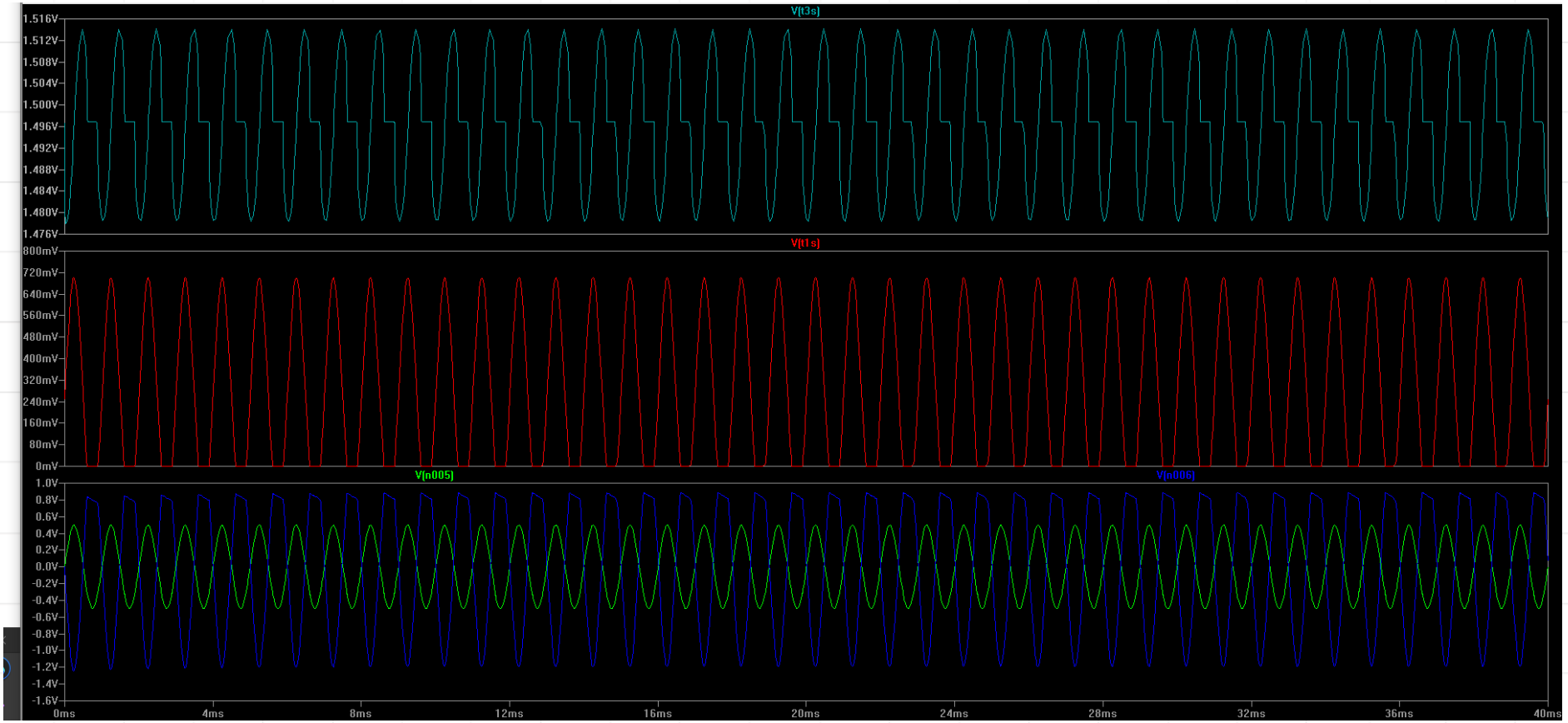


Project Analysis

Potentiometer PR1 is set so that the quiescent current of T1 is 16 mA, and PR2 is set so that the quiescent current of T2 and T3 is 100 mA, in order to observe the resulting distortion.

Characteristics:R10; 2. R6; 3. Input voltage (green), Output voltage (blue).

Due to the low quiescent current in T1, cutoff of the lower amplitude occurs across R6, which causes distortion in T2, T3, and at the output. This can be seen in graphs 1 and 3.

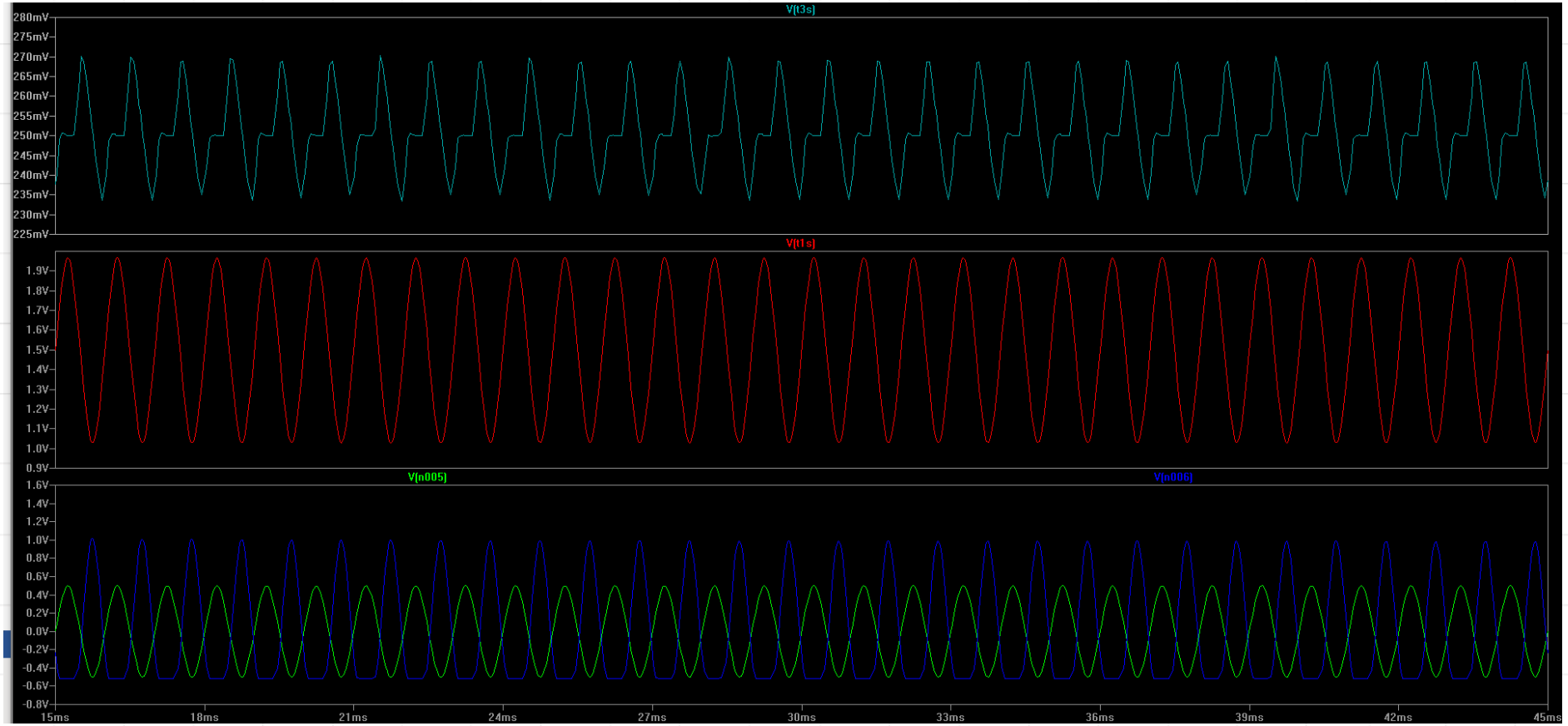


Project Analysis

Potentiometer PR1 is set so that the quiescent current of T1 is 100 mA, and PR2 is set so that the quiescent current of T2 and T3 is 16 mA, in order to observe the resulting distortion.

Characteristics:R10; 2. R6; 3. Input voltage (green), Output voltage (blue).

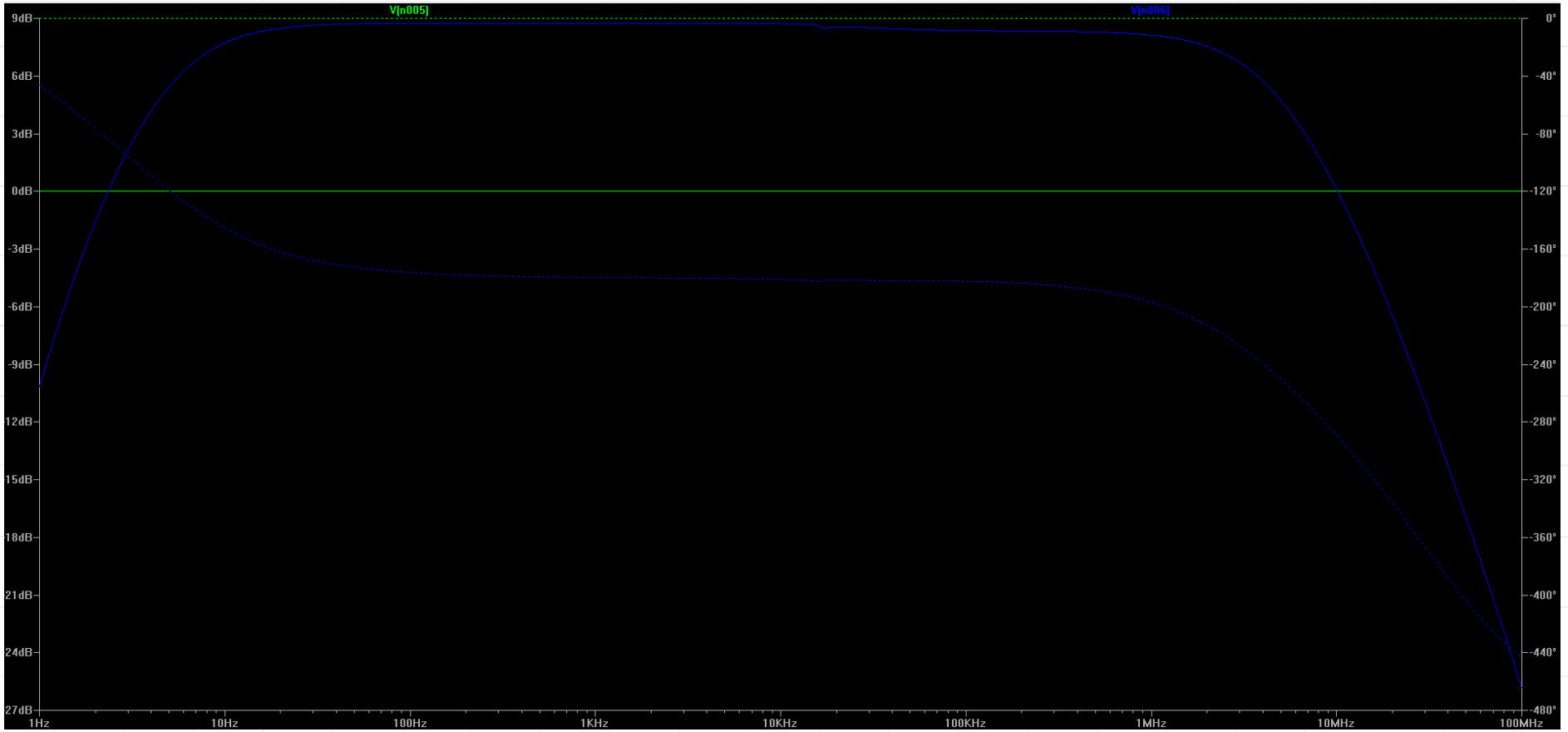
Due to the low quiescent current in T2 and T3, distortion appears at the output, which can be seen in graphs 1 and 3.



Project Analysis

Amplitude-frequency characteristic of the amplifier (10 Hz – 1 MHz)

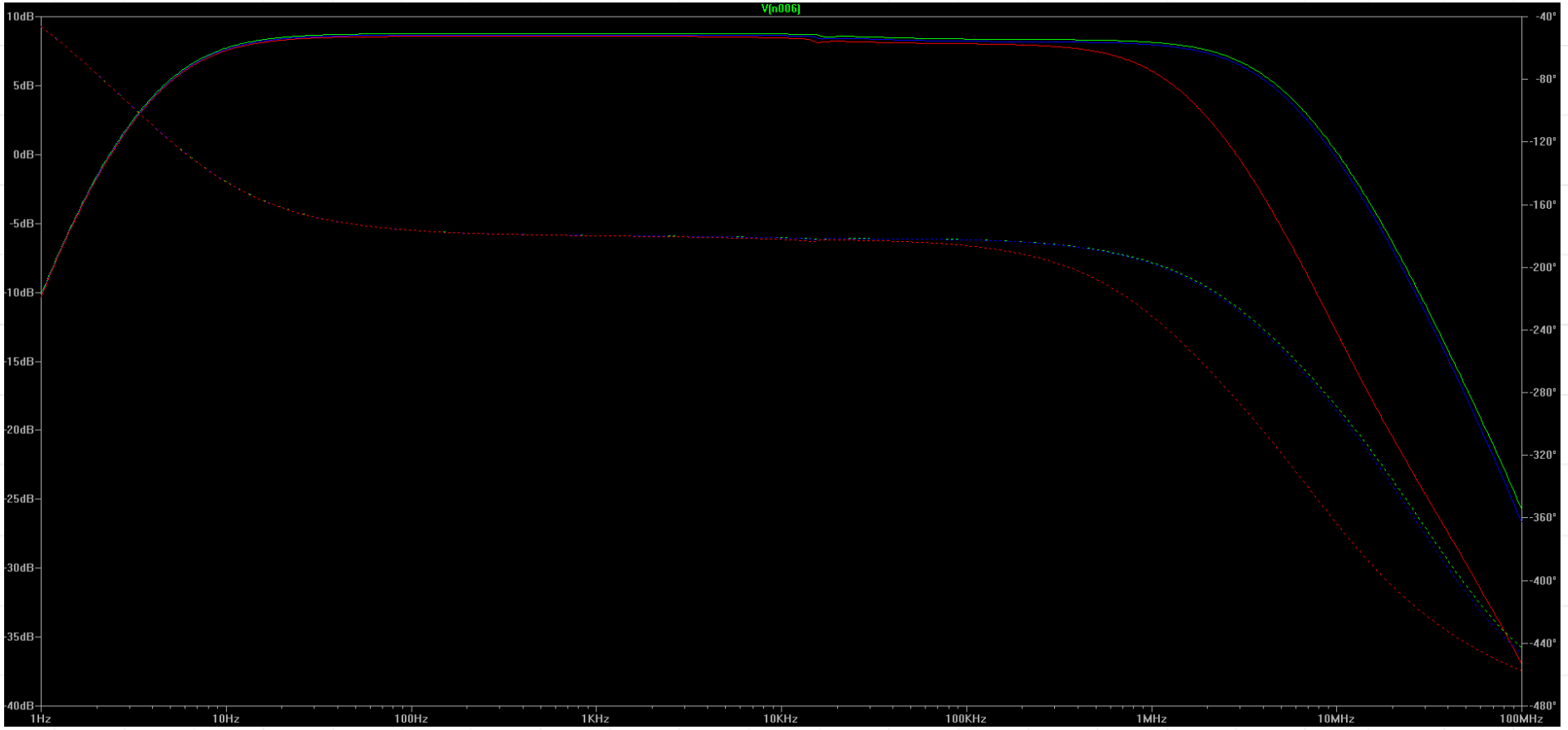
To reduce the frequency range, a low-pass filter can be applied at the input to cut off frequencies above 20 kHz.



Project Analysis

Effect of temperature on amplifier gain characteristics (f = 10 Hz – 1 MHz) (t = 20°C, 80°C, 120°C).

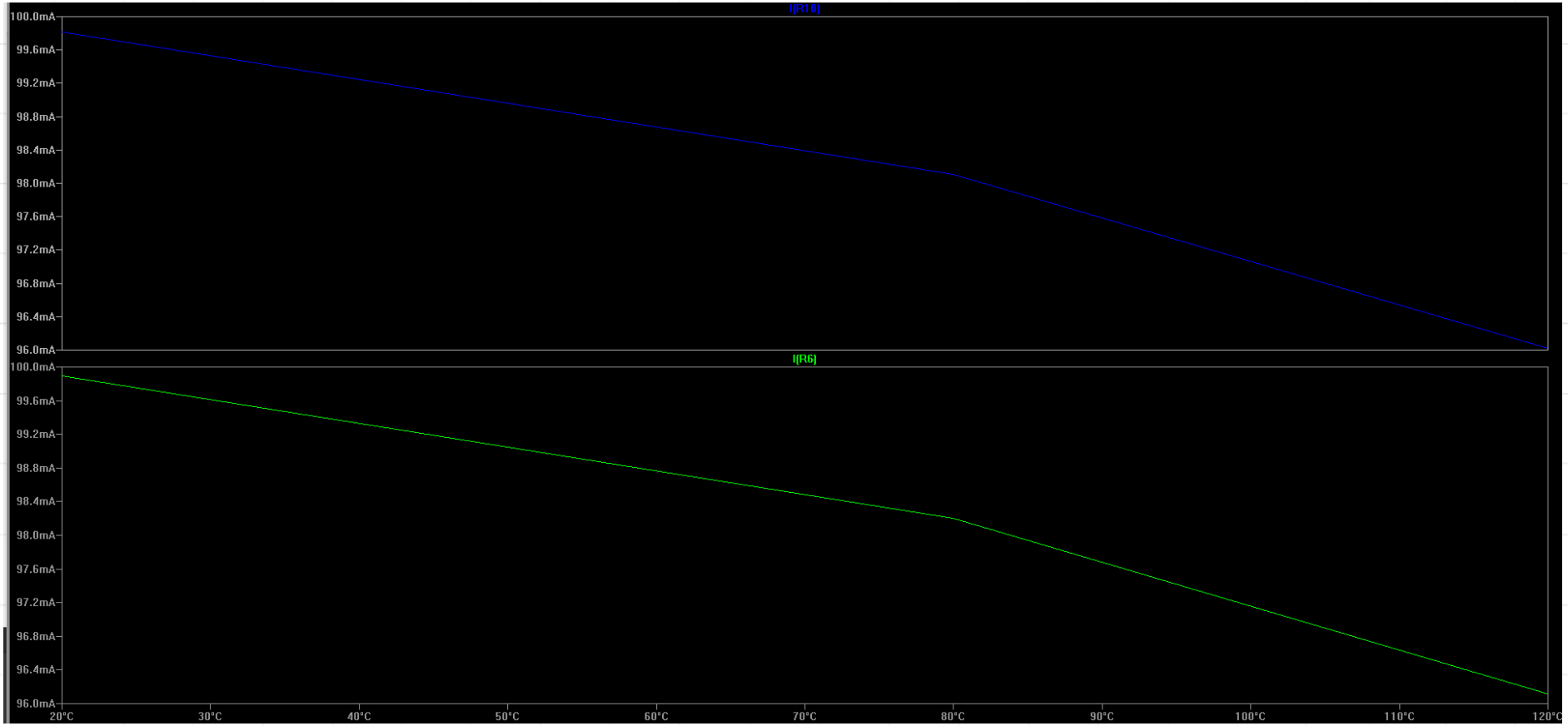
As shown in the graph, temperature affects the amplitude-frequency characteristics only above 100 kHz, which is beyond the operating range of this amplifier (f = 16 Hz – 20 kHz) and can therefore be neglected.



Project Analysis

Effect of temperature on operating points I(R6) – T1; I(R10) – T2, T3 (t = 20°C, 80°C, 120°C).

As shown in the graphs, temperature affects the operating points by reducing the quiescent currents by up to 4 mA, which can be neglected.



Thank you for your attention