7. DESIGN PROJECT—FALL 2005

7.1 Objective

The objective of this experiment is to redesign, simulate, and test a low noise amplifier. The equivalent input noise of the amplifier is to be minimized.

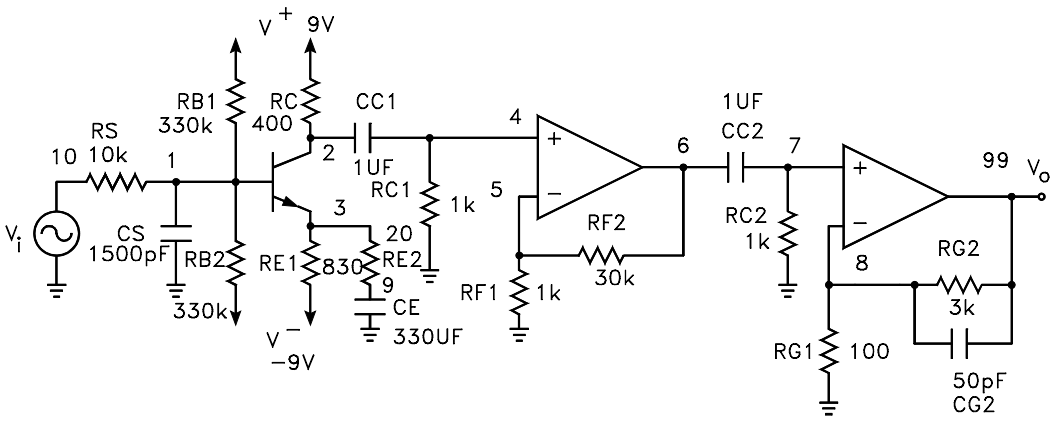
7.2 Design Considerations

Frequently, the task of an engineer is to redesign a circuit for which the basic topology is fixed. For instance, printed circuit boards must be used which have already been mass produced. This fixes the topology. They are intended to be use with a specified source which fixes the source. The designer has the flexibility to change the component values, the model of the transistors and/or op amps to satisfy a design criteia which the original circuit fails to meet.

7.3 Specifications

- DC Power Supplies: either ± 15 V or ± 9 V (so that batteries may be used)
- Voltage Gain: 80 dB
- Maximum Output Voltage: 3 Vrms @ $f = 1$ kHz
- Lower -3 dB Frequency: 300 Hz or less
- Upper -3 dB Frequency: 30 kHz or greater
- THD (total harmonic distortion): as low as possible at a frequency of 1 kHz with an output voltage equal to the maximum specified value.
- Source Impedance: 10 kΩ shunted by $1,500$ pF
- Stability: The preamplifier is to exhibit no continuous oscillations. With a square-wave input signal, the output is to exhibit no ringing. The peak overshoot is to not exceed 15%.

- The noise is to be measured unweighted and A-weighted over the frequency range from 300 Hz to 30 kHz.
- Wideband noise figure 3 dB or less
- The topology of the initial design is given in the below figure



7.4 Experimental Measurements and/or Procedures

Make appropriate measurements to determine whether or not the design specifications have been met. Due to the high gain of the circuit it will be necessary to place a 2 resistor voltage divider on the output of the laboratory function generator to keep the output from clipping.

7.5 Simulation

The final design should be simulated with SPICE.. This simulation should precede the circuit assembly.

The default values for `IS`, `BF`, `RB`, `VA`, `CJC`, `CJE`, and `TF` for the BJT transistor are not to be used for the simulation. Instead, use the values obtained from curve tracer measurements or manufacturers' data sheets. The value of the base spreading resistance measured in a previous experiment is to be used as `RB`. (In determining the optimum collector current use an average or typical value that was measured for the transistor.)

A noise simulation of the circuit should be made which predicts the signal-to-noise ratio corresponding to an output signal level of 3 V rms.

The SPICE analyses should include `.OP` (to verify the biasing), `.AC` (to verify the frequency response specifications and stability specifications), `.TRAN` (to examine the clipping and slew rate performance), `.FOUR` (to verify the distortion specification), and `.NOISE` (to verify the noise specifications).

7.6 Laboratory Report

The laboratory report should simply, succinctly, and lucidly summarize the design philosophy, present the appropriate calculations, and compare the theoretical, simulation, and experimental results.

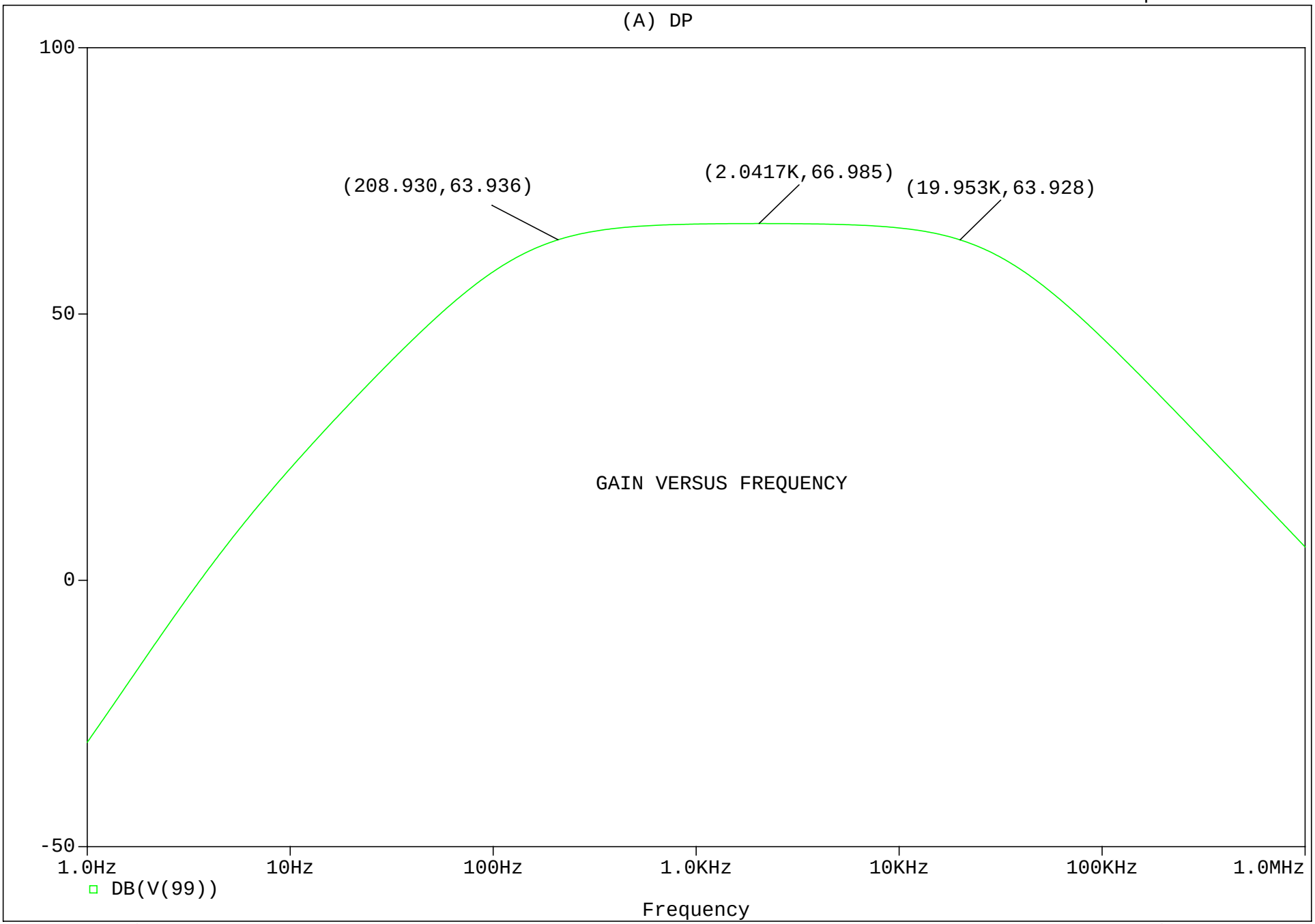
The design project will weighted as three lab reports and will graded somewhat more critically than the previous reports. Although the design project grade will in part depend on the write-up, the major criterion will be whether or not the circuit meets the design criteria.

7.7 Due Date

Friday December 2, 2005 A. D. @ 8 PM EST

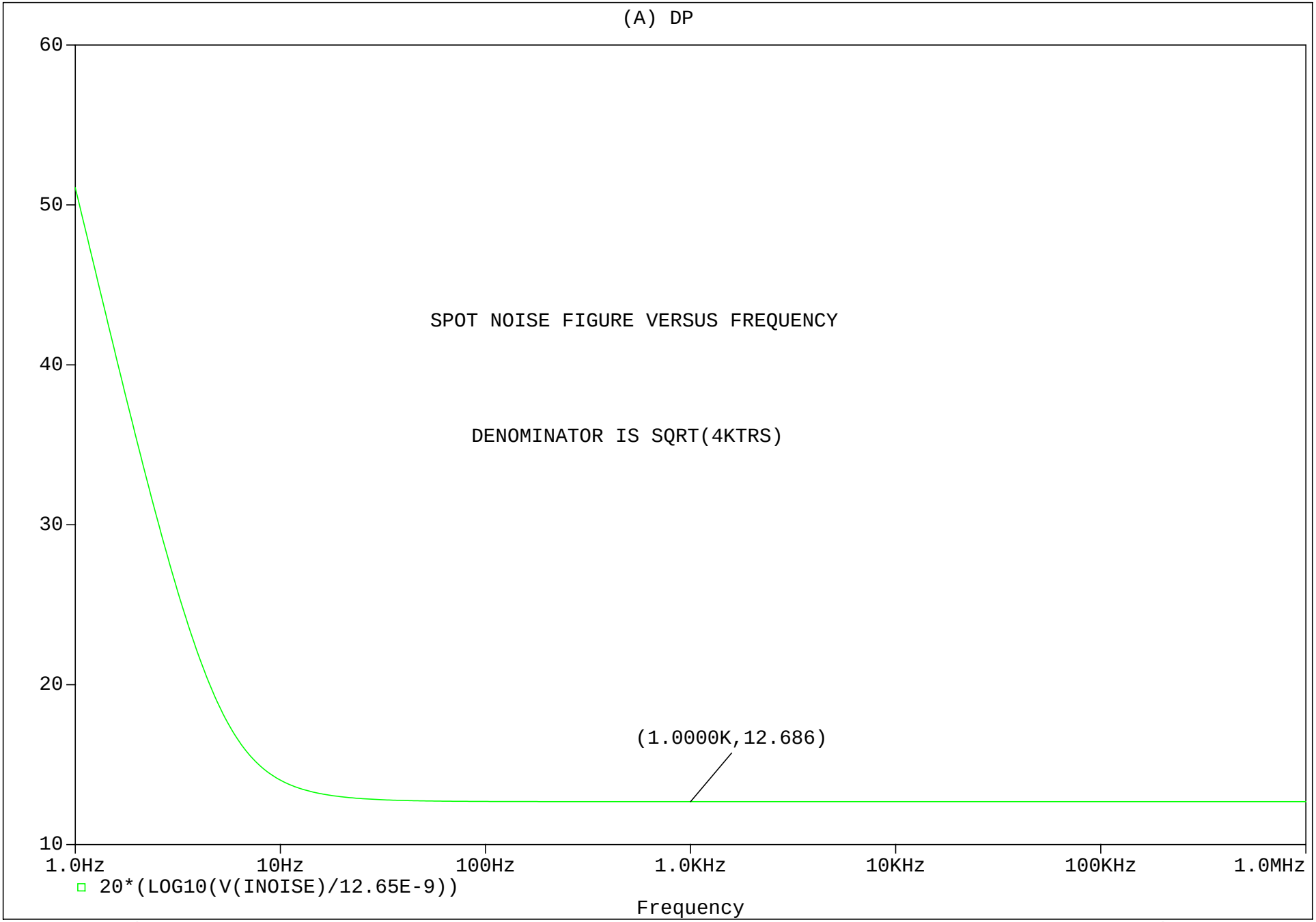
LOW NOISE AMPLIFIER FALL 2005

Date/Time run: 11/03/05 00:35:17 Temperature: 27.0



LOW NOISE AMPLIFIER FALL 2005

Date/Time run: 11/03/05 00:35:17 Temperature: 27.0



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LOW NOISE AMPLIFIER FALL 2005
VIN 10 0 DC 0 AC 1 SIN(0 0.3M 1K 0)
RS 10 1 10K
RB1 VPLUS 1 330K
RB2 VMIN 1 330K
VPLUS VPLUS 0 9
VMIN VMIN 0 -9
RC VPLUS 2 400
Q 2 1 3 BJT
RE1 3 VMIN 830
CE 0 9 330U
RE2 3 9 20
CC1 2 4 1U
RC1 4 0 1K
X1 4 5 6 OA741
RF1 6 5 30K
RF2 5 0 1K
CC2 6 7 1U
RC2 7 0 1K
X2 7 8 99 OA741
RG2 99 8 3K
RG1 8 0 100
CG2 99 8 50P
.SUBCKT OA741 1 2 3
RIN 1 2 2MEG
ROUT 6 3 75
EOL 4 0 1 2 200K
RDP 4 5 1MEG
CDP 5 0 31.85N
EBUF 6 0 5 0 1
.ENDS OA741
.MODEL BJT NPN(IS=15F BF=100 VAF=150)
.TF V(99) VIN
.AC DEC 100 1 1MEG
.NOISE V(99) VIN 100
.OP
.TRAN 1U 2M
.PROBE
.END
```