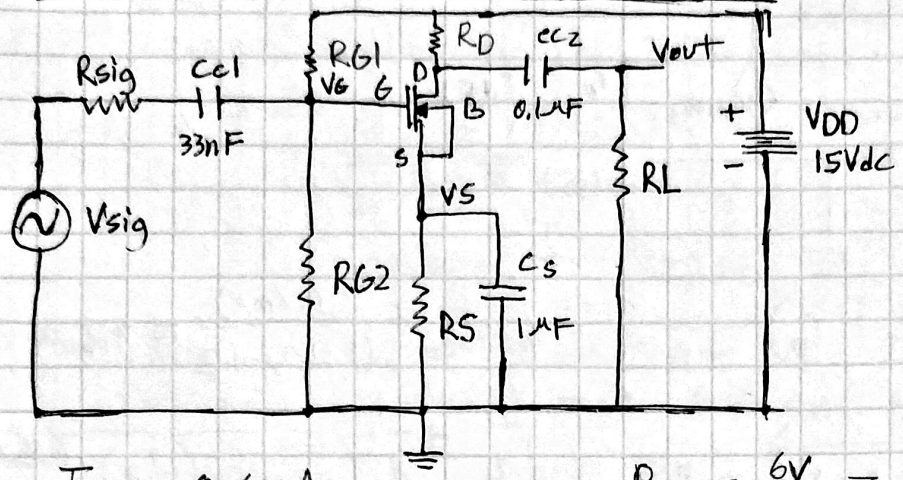
LAB 4 MOSFET Transistors



$I_D = 0.6mA$

$R_D = \frac{6V}{0.6mA} = 10k\Omega$

$V_S = 3V$

$R_S = \frac{3}{0.6mA} = 5k\Omega$

V_D in between V_S and V_{DD}

$R_{in} > 15k\Omega$

CD4007 array chip:

$V_t = 1.2V$, $k_n\left(\frac{W}{L}\right) = 0.7mA/V^2$, $\lambda = 0.004V^{-1}$

$$V_D = \frac{(15-3)}{2} = 6V$$

$$0.6mA = \frac{1}{2}(0.7mA/V^2)(V_G - 3 - 1.2)^2$$

$V_G = 5.51V$

$$\frac{15(RG2) - 15(RG1)}{RG1 + RG2} = 5.51V$$

$RG2 = 27k\Omega$

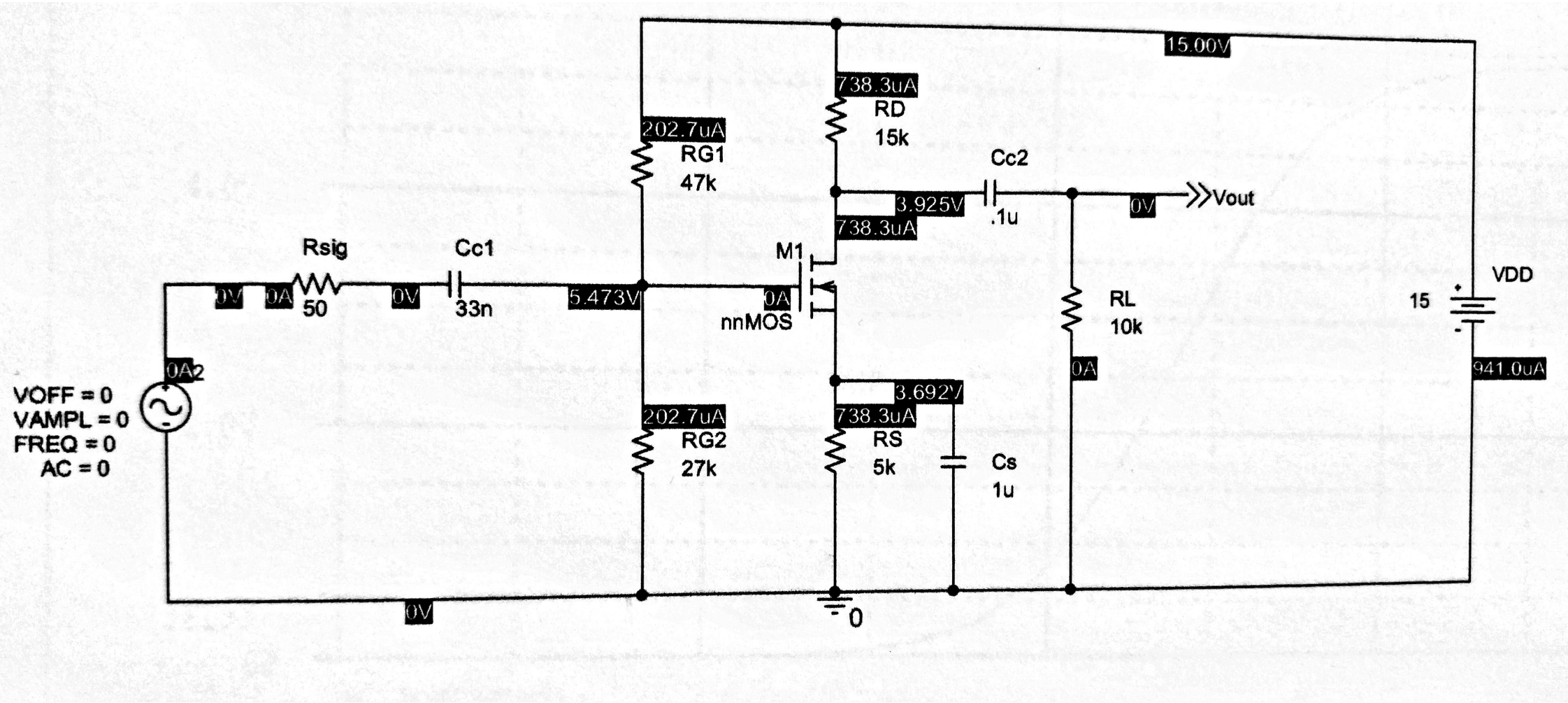
$$\frac{15(50k) - 15(RG1)}{RG1 + 50k} = 5.51V$$

$$750000 - 15RG1 = 5.51RG1 + 275500$$

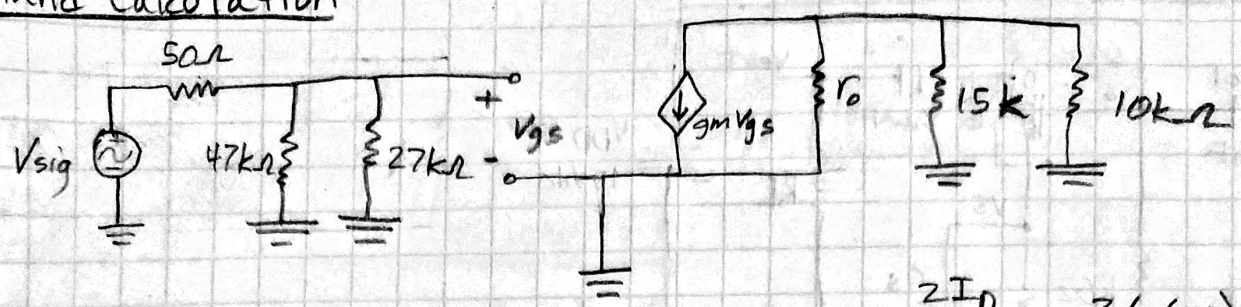
$$474500 - 20.51RG1 = 0$$

$\therefore RG1 = 47k$

3/28/16


15.00V
738.3uA
RD
15k
202.7uA
RG1
47k
Cc2
3.925V
.1u
0V
Vout
738.3uA
Rsig
Cc1
M1
VDD
0V
0A
50
0V
33n
5.473V
0A
nnMOS
15
RL
10k
0A2
0A
941.0uA
VOFF = 0
VAMPL = 0
FREQ = 0
AC = 0
3.692V
202.7uA
RG2
27k
738.3uA
RS
5k
Cs
1u
0V
0

AC Hand Calculation



$$V_o = -g_m V_{gs}(R_D \| R_L \| r_o)$$

$$V_{gs} = \frac{V_{sig}(R_{G1} \| R_{G2})}{R_{sig} + (R_{G1} \| R_{G2})}$$

$$\frac{V_o}{V_{sig}} = \frac{-g_m (R_D \| R_L)(R_{G1} \| R_{G2})}{R_{sig} + (R_{G1} \| R_{G2})}$$

$$= \frac{-916\mu (15k \| 10k)(47k \| 27k)}{50 + (47k \| 27k)} = -5.48$$

$$g_m = \frac{2I_D}{V_{GS} - V_t} = \frac{2(.6mA)}{(5.51-3)-1.2} = 916\mu$$

$$r_o = \frac{V_A}{I_D} = \frac{1}{\lambda I_D} = \frac{1}{250(.6m)} = 6.6\Omega$$

$$R_{in} = 50\Omega + (47k\Omega \| 27k\Omega)$$
$$= 17198\Omega$$

$$R_{out} = 15k \| \left(r_o + \frac{1}{g_m}\right) = 1023\Omega$$

AC PSPice

Rin: Rtest = 1kΩ

V_{test} = 376.268m

Vin = 397.542m

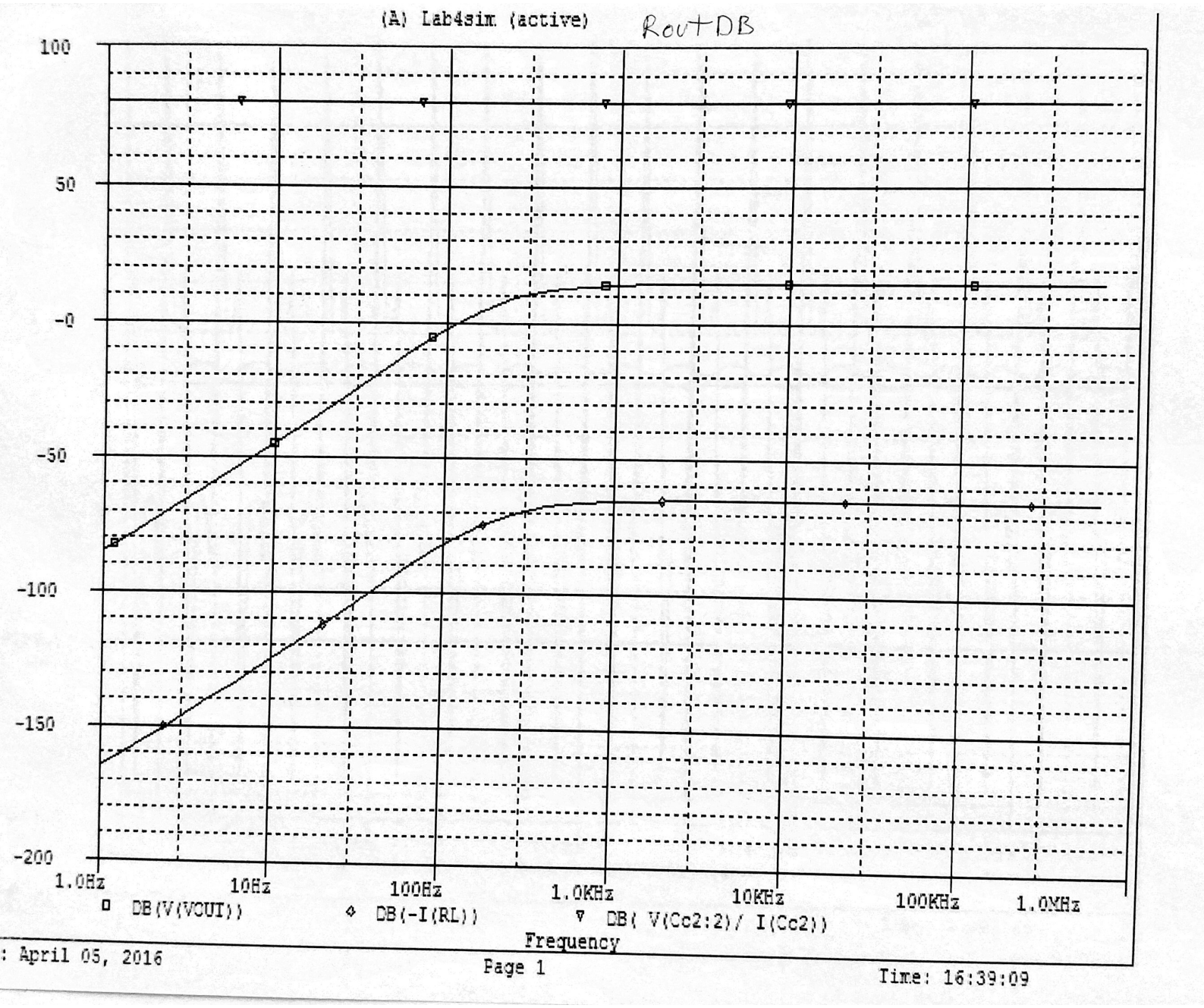
Rin = 18.691k

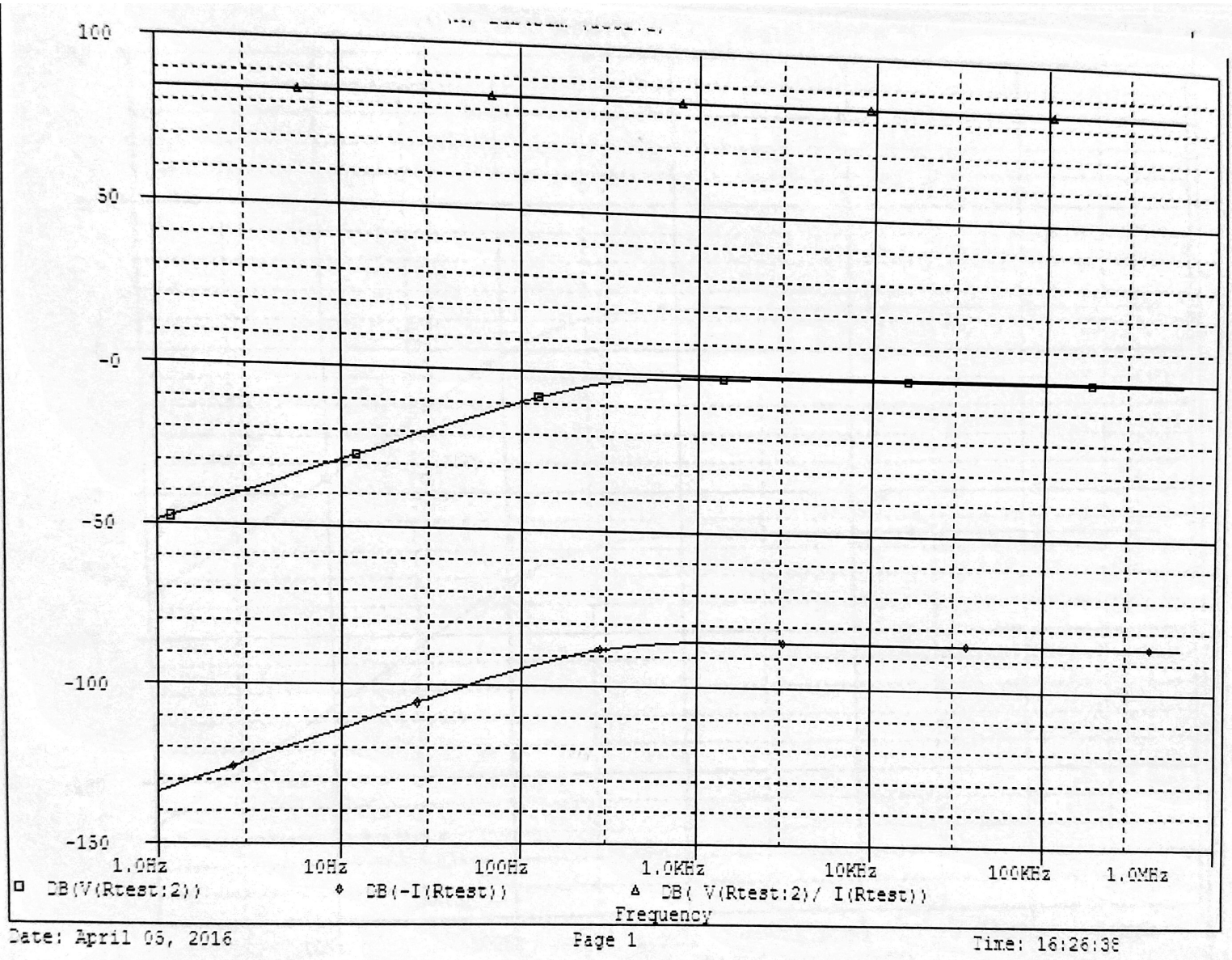
Rout:

Vin = 4.6175

V_L = 2.1512

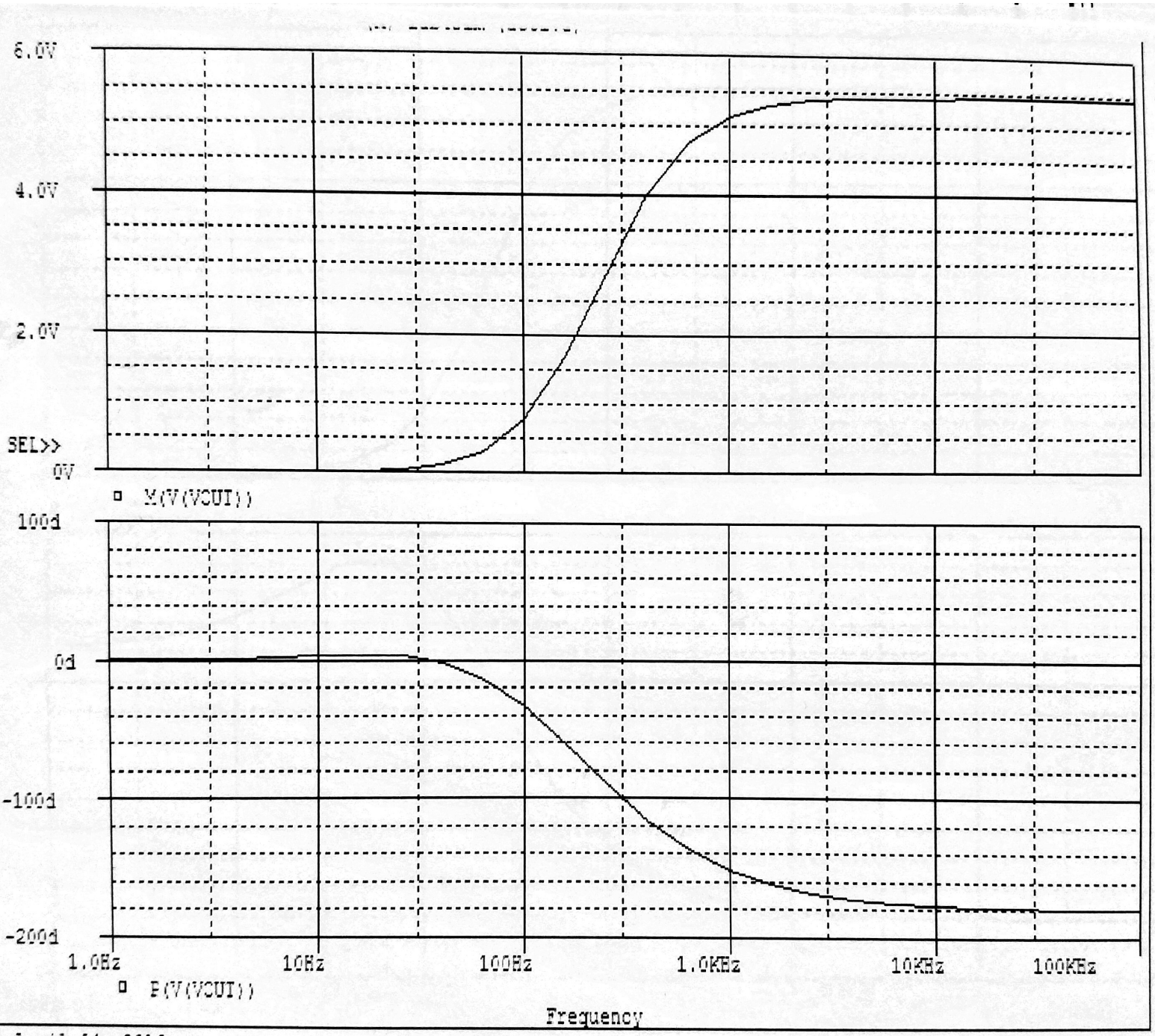
Rout = 11.465


(A) Lab4sim (active)
Rout DB
100
50
-0
-50
-100
-150
-200
1.0Hz
10Hz
100Hz
1.0KHz
10KHz
100KHz
1.0MHz
DB(V(VOUT))
DB(-I(RL))
DB(V(Cc2:2)/ I(Cc2))
Frequency
: April 05, 2016
Page 1
Time: 16:39:09

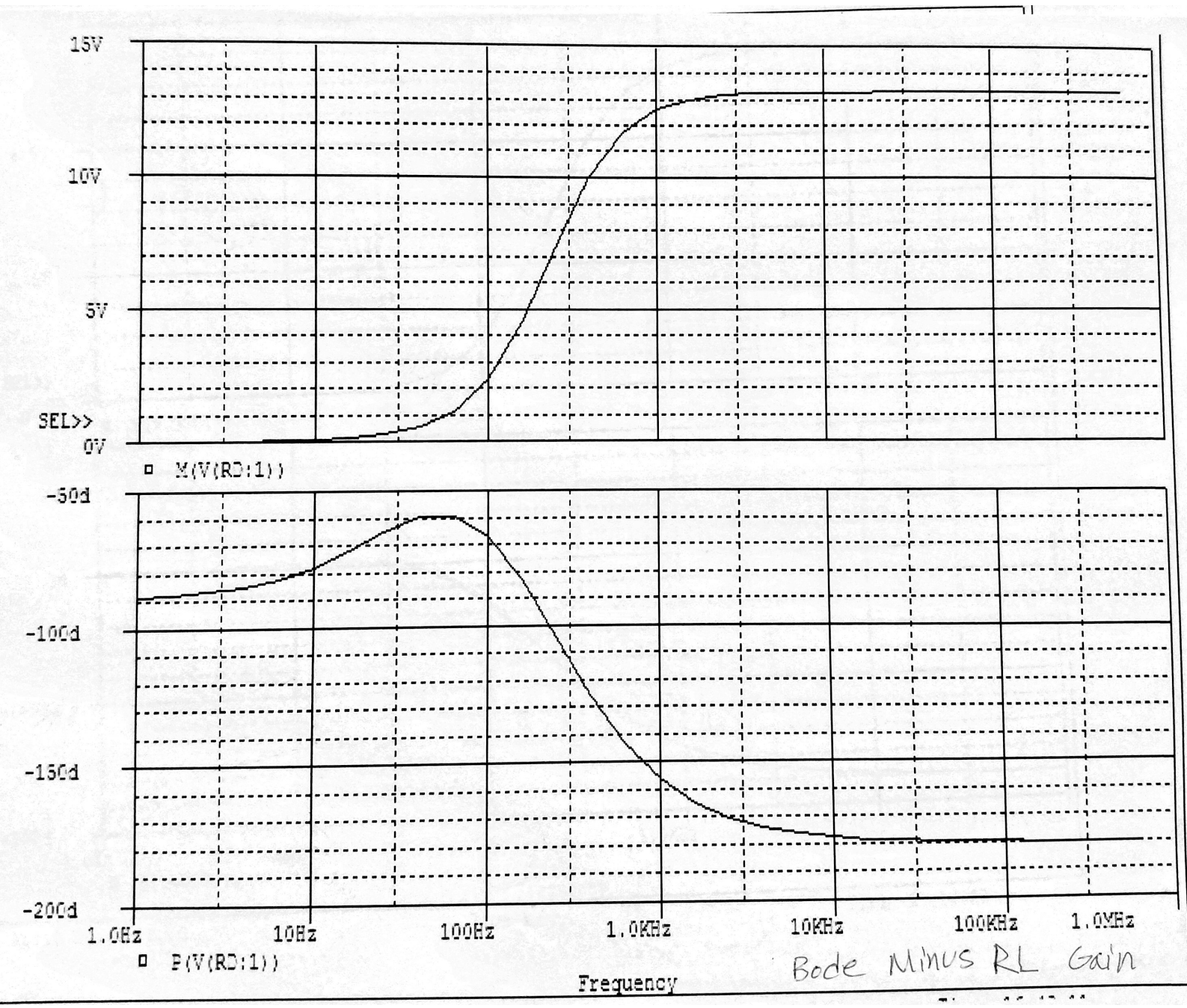


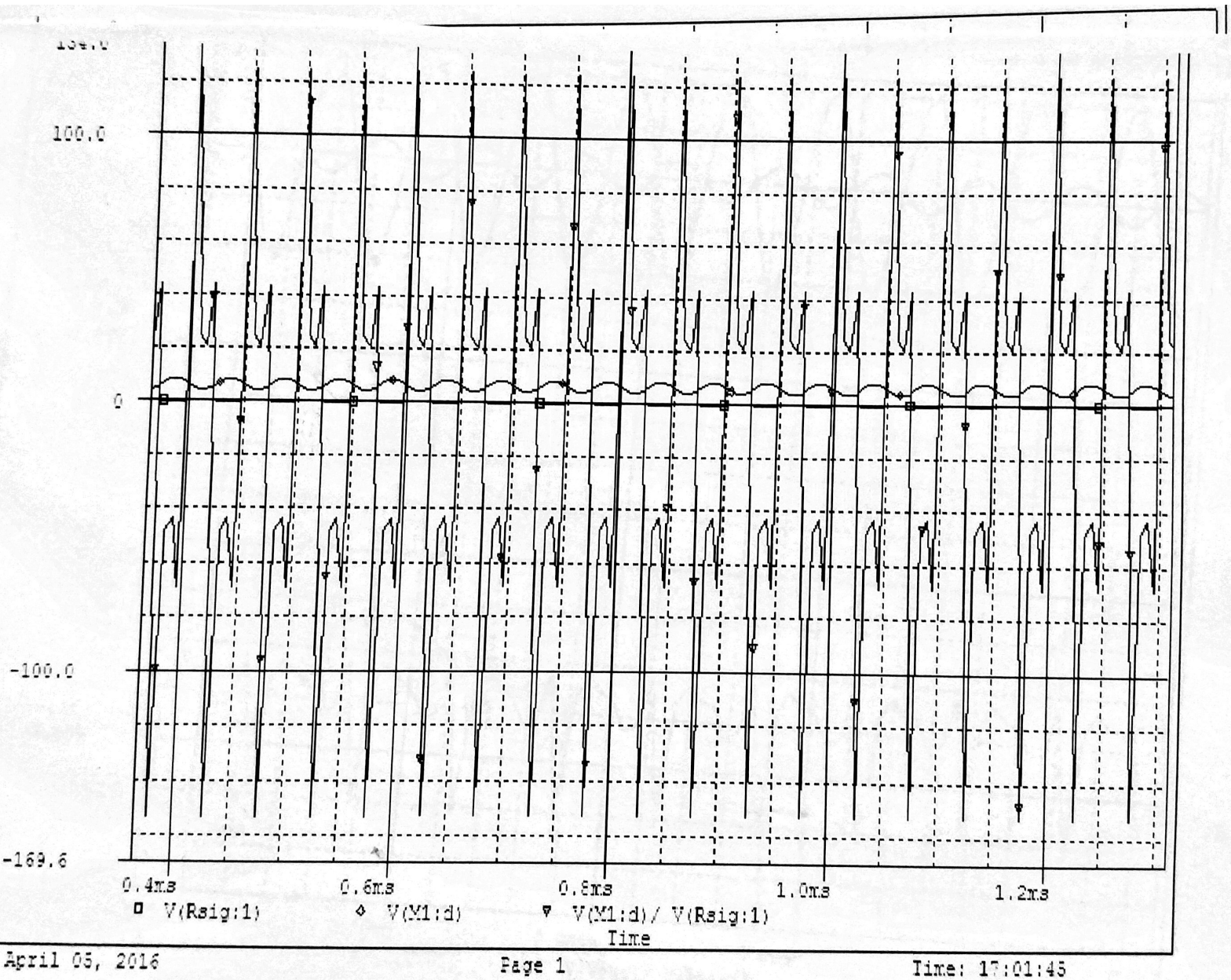
Date: April 06, 2016 Page 1 Time: 16:26:38

Rin DB

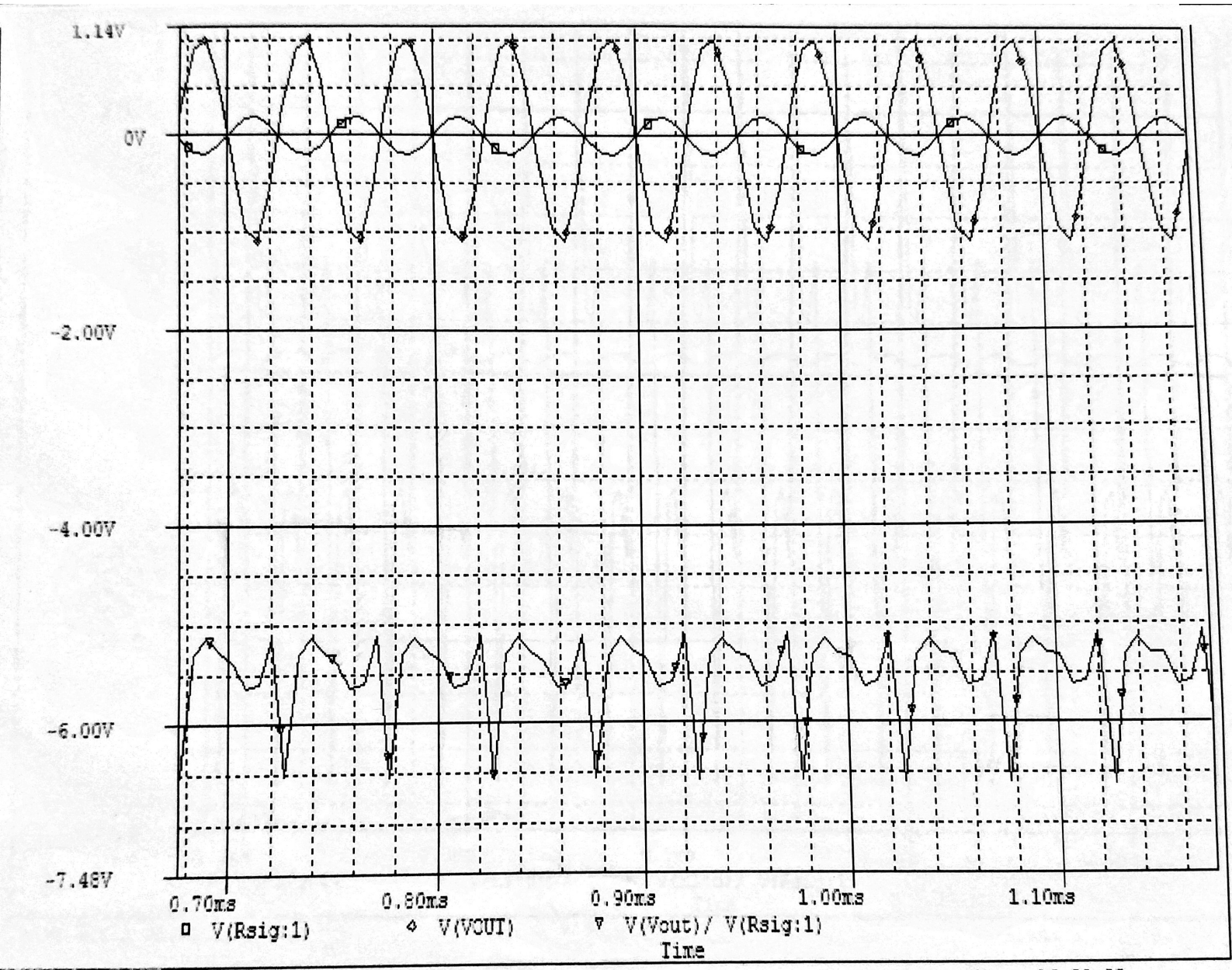

6.0V
4.0V
2.0V
SEL>>
0V
M(V(VCUI))
100d
0d
-100d
-200d
1.0Hz
10Hz
100Hz
1.0KHz
10KHz
100KHz
P(V(VCUI))
Frequency
April 04, 2016
Page 1
Time: 17:14:35

Bode Gain

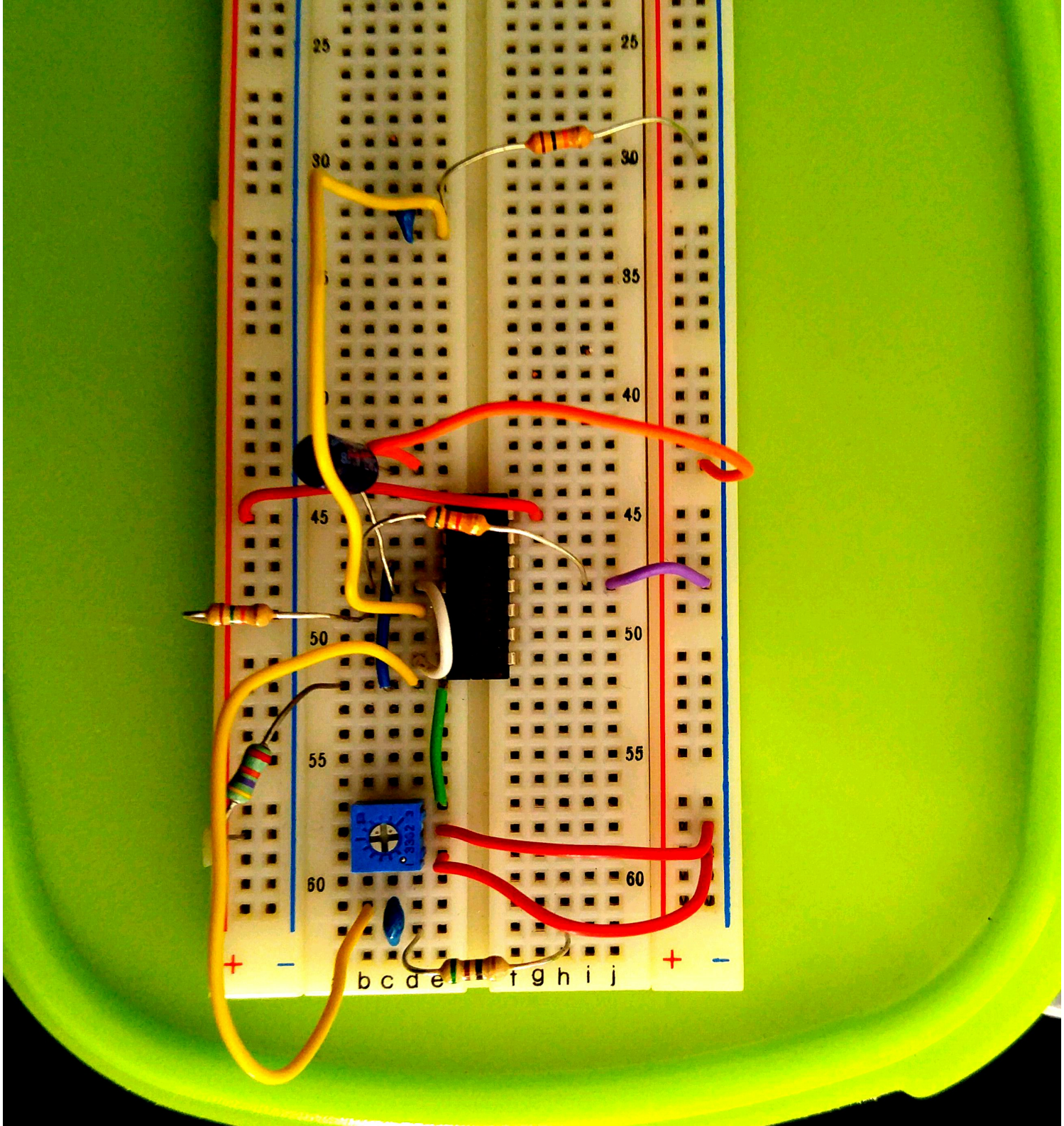

15V
10V
5V
SEL>>
0V
M(V(RD:1))
-50d
-100d
-150d
-200d
1.0Hz
10Hz
100Hz
1.0KHz
10KHz
100KHz
1.0MHz
P(V(RD:1))
Frequency
Bode Minus RL Gain



Transient Gain without RL



Transient Gain With RL


25
30
35
40
45
50
55
60
+
−
b c d e
f g h i j
+
−

With CC1 and CS added:

With Drain Voltage at 9V, Source Voltage is .9 V and Gate Voltage is 3.2V

$V_{sig} = 405mV$

$V_D (V_{out}) = 460\,mV$

$Gain = \frac{460}{405} = 1.14$

$I_D = \frac{9}{10K} = 900\mu A$

This is much different compared to calculated one. We did, however, use 6V on V_D instead of 9V.

Distortion occurs at about 4.6V

Maximum output is probably around 4.50 V

With CC2 and RL attached, using the multimeter, Vout is about 2mV, much lower than 9V, so basically input voltage

With the oscilliscope Vout reads at 4.4 V which is larger than the open circuit measurements. This is for AC.

$4.4 \cdot .707mV = 3.1108$

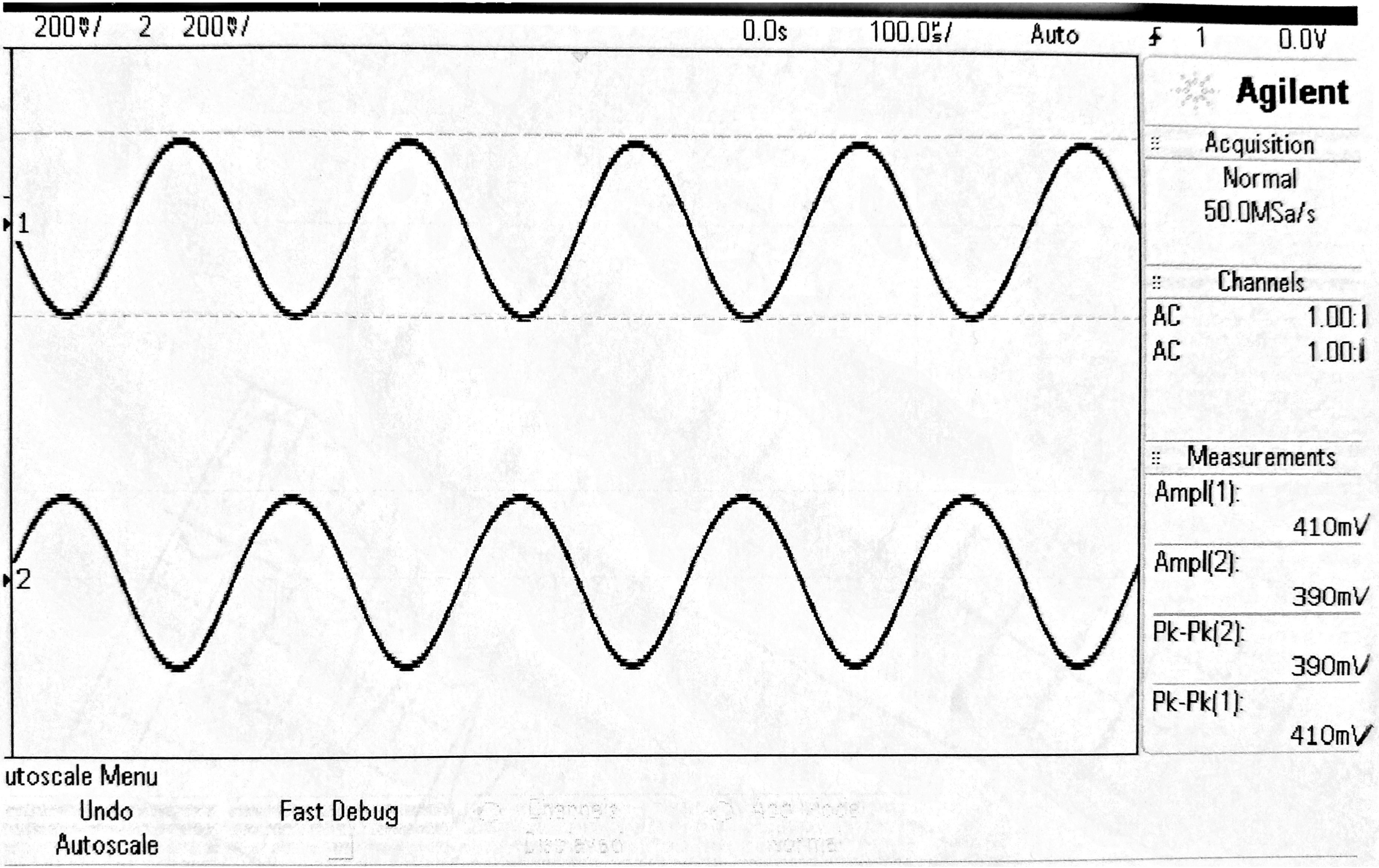
$4.4 - 3.1108 = 1.2892$

At about 550 Hz, Amplitude is a factor of .707 smaller of 4.4V.

At about 20-100K, Amplitude is 70.7% of 4.4V

Bandwidth is in between 550-100K Hz

In between those points the circuit operates.


200mV/ 2 200mV/
0.0s
100.0µs/
Auto
1 0.0V
Agilent
Acquisition
Normal
50.0MSa/s
Channels
AC 1.00:1
AC 1.00:1
Measurements
Ampl(1):
410mV
Ampl(2):
390mV
Pk-Pk(2):
390mV
Pk-Pk(1):
410mV
1
2
utoscale Menu
Undo
Autoscale
Fast Debug