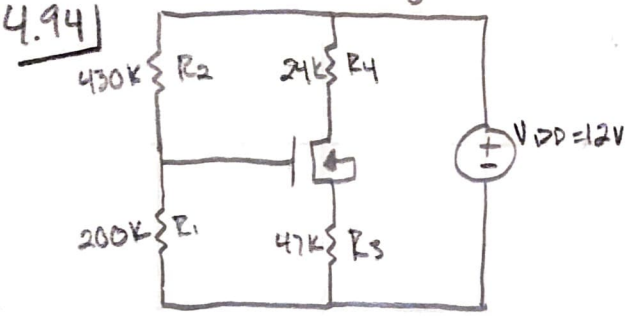
Gabriel Emerson gte0002 4R Bias HW1 Due 3/25

4.94



$V_{TO} = 1V$ $\gamma = 0$

$\frac{W}{L} = \frac{5}{1}$

$KP_n = 100\frac{mA}{V^2}$ $KP_p = 40\frac{mA}{V^2}$

Assume sat: $I_{DS} = \frac{1}{2} K V_{GT}$, $K = KP_n \cdot \frac{W}{L}$

$V_G = \frac{V_{DD}}{R_1+R_2} \cdot R_1 = \frac{12}{200K+430K} \cdot 200K = 3.81V$

$V_{GS} = V_{GT} + V_{TN}$

$V_G = V_{GT} + V_{TN} + V_S \Rightarrow 3.81 = V_{GT} + V_{TN} + \frac{k_n}{2} V_{GT}^2 \cdot R_S$

$\frac{KP \cdot R_S}{2} \frac{W}{L} V_{GT}^2 + 1 V_{GT} - 2.81 = 0$

$\frac{KP\frac{W}{L} \cdot R_S}{2} = \frac{100m \cdot 5 \cdot 47K}{2} = 11.75$

$11.75 V_{GT}^2 + V_{GT} - 2.81 = 0$

$\frac{-1 + \sqrt{1^2 - 4(11.75)(-2.81)}}{2(11.75)} = 0.448V = V_{GT}$

$I_{DS} = \frac{1}{2} KP_n \frac{W}{L} \cdot V_{GT}^2 = 50mA$ $V_{GS} = V_{GT} + V_{TN} = 1.448V$

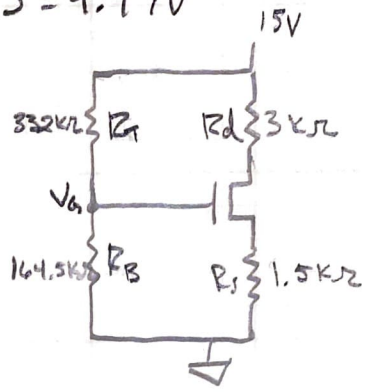
$V_{DS} = V_{DD} - I_{DS}(R_S + R_d) = 12 - 50m(47K + 24K) = 8.45V$

$V_{DS} > V_{GT}$ Sat ✓

$Q_{point} = V_{GS} = 1.448V$ $I_{DS} = 50mA$
$V_{DS} = 8.45V$

2.) $I_{DS} = 2mA$
$V_S = 3V$
$R_{eq} = 110K\Omega$
$V_{DD} = 15V$

$V_{GS} = 1.97$ (from sim)
$V_G - V_S = 1.97$
$V_G = 1.97 + 3 = 4.97V$



$R_S = \frac{V_S}{I_{DS}} = \frac{3V}{2mA} = 1.5k\Omega$

$V_d = \frac{V_{dd} - V_S}{2} = \frac{15-3}{2} = 6V$

$R_d = \frac{V_d}{I_{DS}} = \frac{6V}{2mA} = 3k\Omega$

$V_G = \frac{V_{DD}}{R_b + R_T} \cdot R_b \rightarrow V_G R_T = R_{eq} \cdot V_{DD}$

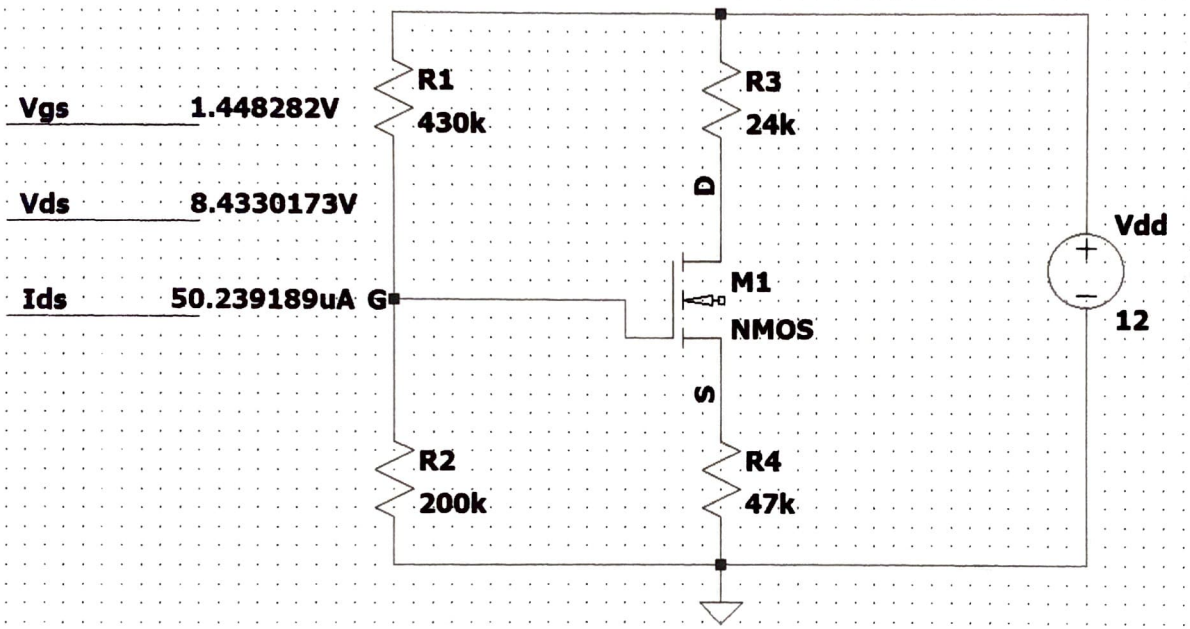
$R_T = \frac{R_{eq} V_{DD}}{V_G} = \frac{110K(15)}{4.97} = 331.992K\Omega = 332K\Omega$

$R_{eq} = \frac{R_T R_b}{R_T + R_b} \rightarrow R_{eq}(R_T + R_b) = R_T R_b$
$R_{eq} R_T + R_{eq} R_b = R_T R_b$
$R_b(R_T - R_{eq}) = R_{eq} R_T$
$R_b = \frac{R_{eq} R_T}{R_T - R_{eq}} = 164.51K\Omega$

$I_{DS\,MAX} = \frac{V_{DD} - V_S}{R_d} = \frac{15-3}{3k} = \boxed{4mA}$

$I_{DS\,min} = \frac{5.05-3}{3k} = 0.68mA$ when on
$0mA$ when off

```
.param Vdd=12
.model NMOS NMOS(KP=100u VTO=1)
.op
```



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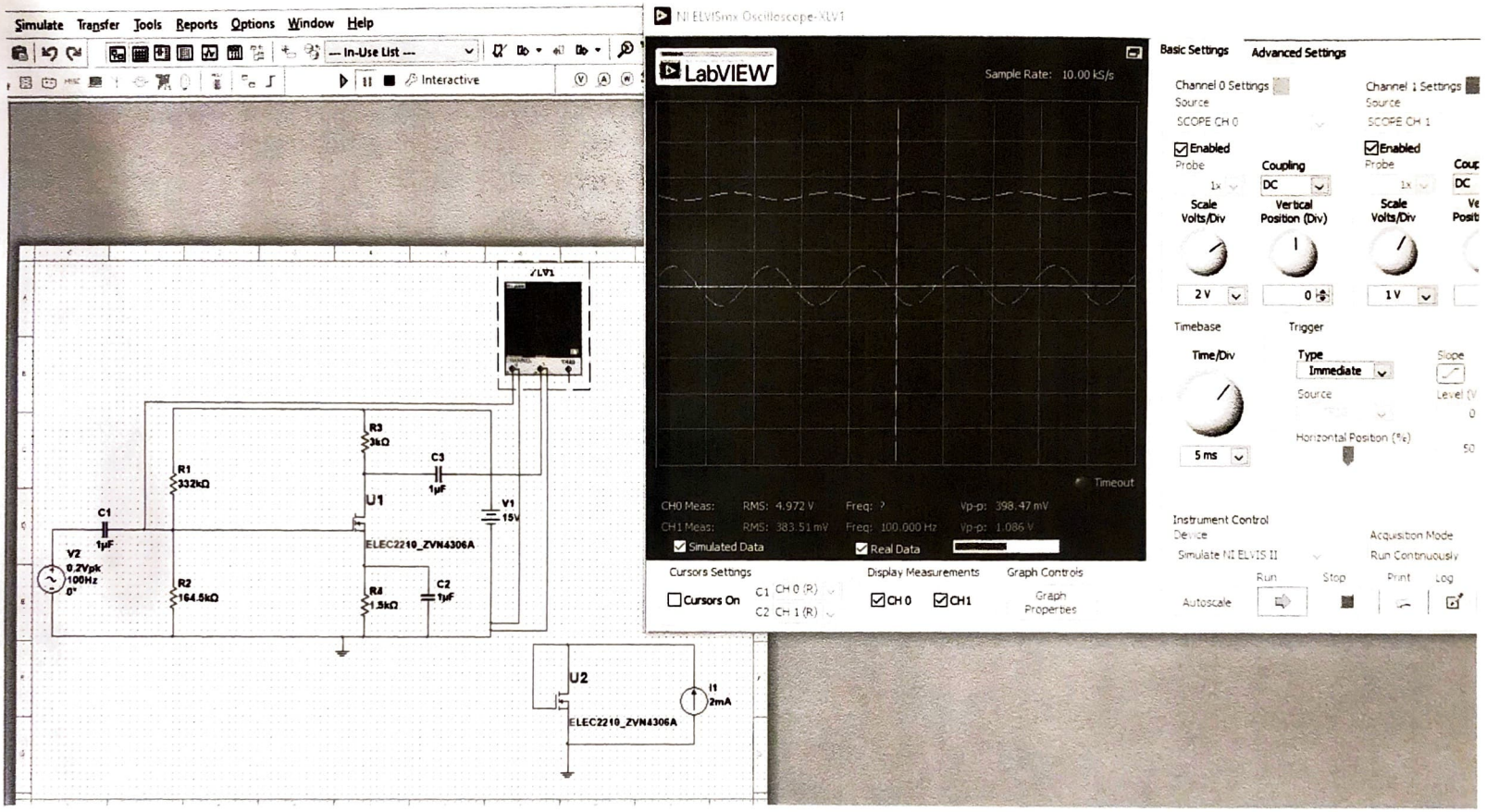
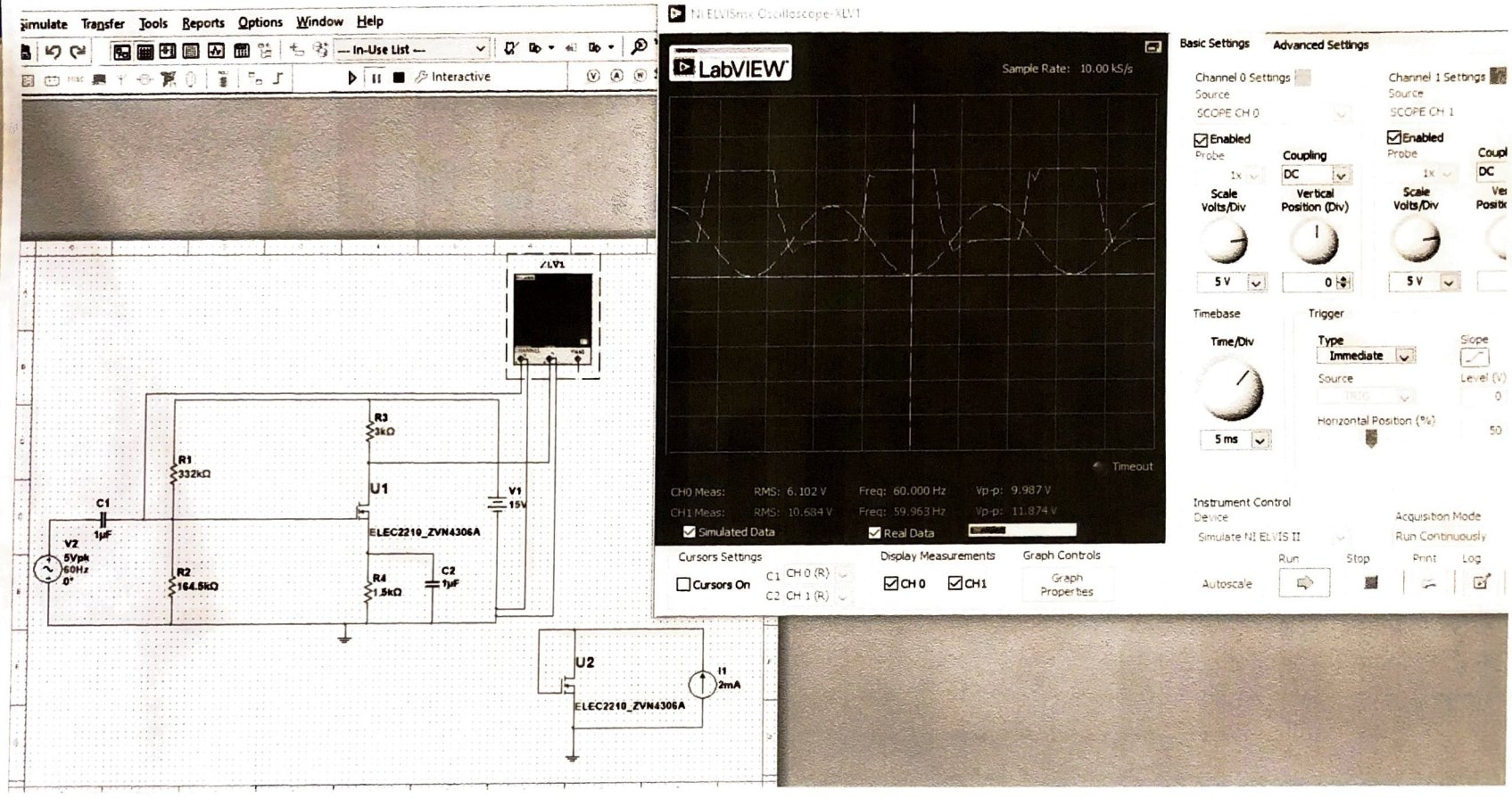
--- Operating Point ---

V(d):	10.7943	voltage
V(g):	3.80952	voltage
V(s):	2.36124	voltage
V(nc_01):	2.52493	voltage
V(n001):	12	voltage
Id(M1):	5.02392e-005	device_current
Ig(M1):	0	device_current
Ib(M1):	-2.52226e-012	device_current
Is(M1):	-5.02392e-005	device_current
I(R4):	5.02392e-005	device_current
I(R3):	5.02392e-005	device_current
I(R2):	1.90476e-005	device_current
I(R1):	1.90476e-005	device_current
I(Vdd):	-6.92868e-005	device_current


Simulate Transfer Tools Reports Options Window Help
--- In-Use List ---
Interactive
XLV1
R3
3kΩ
C3
1µF
R1
332kΩ
U1
V1
15V
C1
1µF
ELEC2210_ZVN4306A
VZ
0.2Vpk
100Hz
0°
R2
164.5kΩ
R4
1.5kΩ
C2
1µF
U2
I1
2mA
ELEC2210_ZVN4306A
NI ELVISmx Oscilloscope-XLV1
LabVIEW
Sample Rate: 10.00 kS/s
Timeout
CH0 Meas: RMS: 4.972 V Freq: ? Vp-p: 398.47 mV
CH1 Meas: RMS: 383.51 mV Freq: 100.000 Hz Vp-p: 1.086 V
Simulated Data
Real Data
Cursors Settings
Cursors On
C1 CH 0 (R)
C2 CH 1 (R)
Display Measurements
CH 0
CH1
Graph Controls
Graph Properties
Basic Settings
Advanced Settings
Channel 0 Settings
Source
SCOPE CH 0
Enabled
Probe
1x
Coupling
DC
Scale Volts/Div
2 V
Vertical Position (Div)
0
Channel 1 Settings
Source
SCOPE CH 1
Enabled
Probe
1x
Coup
DC
Scale Volts/Div
1 V
Timebase
Time/Div
5 ms
Trigger
Type
Immediate
Source
Slope
Level (V
0
Horizontal Position (%)
50
Instrument Control
Device
Simulate NI ELVIS II
Acquisition Mode
Run Continuously
Run
Stop
Print
Log
Autoscale


Simulate Transfer Tools Reports Options Window Help
In-Use List
Interactive
XLV1
R3
3kΩ
R1
332kΩ
U1
V1
15V
C1
1µF
V2
5Vpk
60Hz
0°
ELEC2210_ZVN4306A
R2
164.5kΩ
R4
1.5kΩ
C2
1µF
U2
I1
2mA
ELEC2210_ZVN4306A
NI ELVISmx Oscilloscope-XLV1
LabVIEW
Sample Rate: 10.00 kS/s
Timeout
CH0 Meas: RMS: 6.102 V Freq: 60.000 Hz Vp-p: 9.987 V
CH1 Meas: RMS: 10.684 V Freq: 59.963 Hz Vp-p: 11.874 V
Simulated Data
Real Data
Cursors Settings
Cursors On
C1 CH 0 (R)
C2 CH 1 (R)
Display Measurements
CH 0
CH1
Graph Controls
Graph Properties
Basic Settings
Advanced Settings
Channel 0 Settings
Source
SCOPE CH 0
Enabled
Probe
1x
Coupling
DC
Scale Volts/Div
5 V
Vertical Position (Div)
0
Channel 1 Settings
Source
SCOPE CH 1
Enabled
Probe
1x
Coupl
DC
Scale Volts/Div
5 V
Timebase
Time/Div
5 ms
Trigger
Type
Immediate
Slope
Source
Level (V)
0
Horizontal Position (%)
50
Instrument Control
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Simulate NI ELVIS II
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Autoscale
Run
Stop
Print
Log