Solutions for Laboratory Manual to accompany

Electronic Devices and Circuit Theory

Eleventh Edition

Prepared by
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EXPERIMENT 1: OSCILLOSCOPE AND FUNCTION GENERATOR OPERATIONS

Part 1: The Oscilloscope

a. it focuses the beam on the screen
b. adjusts the brightness of the beam on the screen
c. allows the moving of trace in either screen direction
d. selects volts/screen division on *y*-axis
e. selects unit of time/screen division on *x*-axis
g. allows for ac or dc coupling of signal to scope and at GND position; establishes ground reference on screen
h. locates the trace if it is off screen
i. provide for the adjustment of scope from external reference source
k. determines mode of triggering of the sweep voltage
m. the input impedance of many scopes consists of the parallel combination of a 1 Meg resistance and a 30pf capacitor
n. measuring device which reduces loading of scope on a circuit and effectively increases input impedance of scope by a factor of 10.

Part 2: The Function Generator

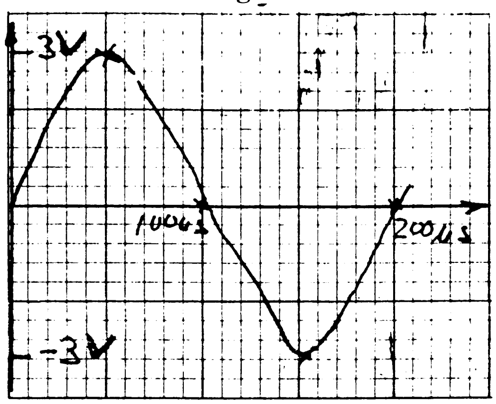
d. $T = 1/f$ = 1/1000 Hz = 1 ms
e. (calculated): 1 ms*[1 cm/.2 ms] = 5cm
(measured): 5 cm = same
f. (calculated): 1 ms*[cm/.5ms] =2 cm
(measured): 2 cm = same
g. (calculated): 1 ms*[cm/1ms] = 1 cm
(measured): 1 cm = same
h. .2 ms/cm takes 5 boxes to display total wave
.5 ms/cm takes 2 boxes to display total wave
1 ms/cm takes 1 box to display total wave
i.
1. adjust timebase to obtain one cycle of the wave
2. count the number of cm's occupied by the wave
3. note the timebase setting
4. multiply timebase setting by number of cm's occupied by wave. This is equal to the period of the wave.
5. obtain its reciprocal; that's the frequency.

j. (calculated): 2cm * [2V/cm] = 4Vp-p
k. 8 * [.5V/cm] = 4Vp-p
l. the signal occupied full screen; the peak amplitude did not change with a change in the setting of the vertical sensitivity
m. no: there is no voltmeter built into function generator

Part 3: Exercises

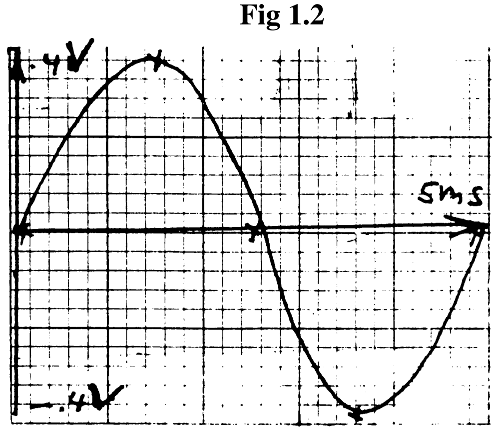
a. chosen sensitivities: Vert. Sens. = 1 V/cm
Hor. Sens. = 50 μs/cm
T(calculated): 4cm*[50 μs/cm)= 200 μs

Fig 1.1



b. chosen sensitivities: Vert. Sens. = .1 V/cm
Hor. Sens. = 1 ms/cm
T(calculated):5 cm*[1 ms/cm] = 5 ms

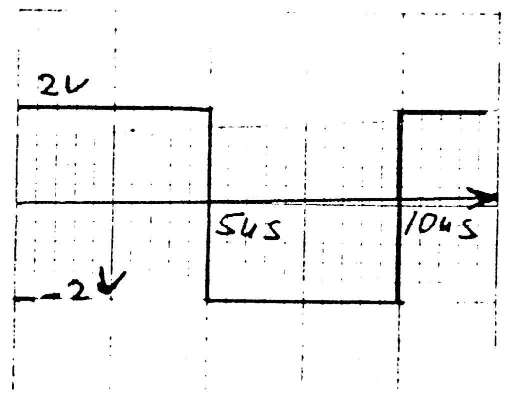
Fig 1.2



c. chosen sensitivities: Vert. Sens. = 1 V/cm
Hor. Sens. = 1 μs/cm

T(calculated): 10 cm*[1 μs/cm]=10 μs

Fig 1.3

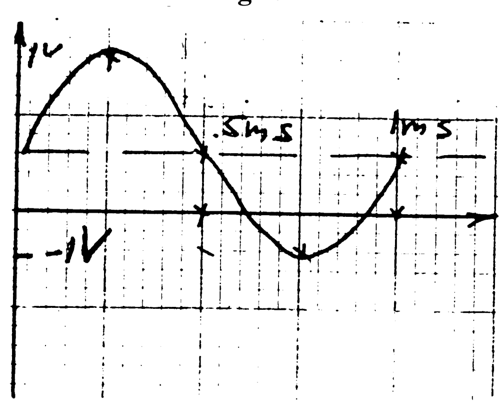


Part 4: Effect of DC Levels

a. $V_{(rms)}$(calculated) = 4V * 1/2 * .707 = 1.41 Volts
b. $V_{(rms)}$(measured) = 1.35 Volts
c. [(1.41 − 1.35)/1.41) * 100 = 4.74%
d. no trace on screen
e. signal is restored, adjust zero level
f. no shift observed; the shift is proportional to dc value of waveform
g. (measured) dc level: 1.45 Volts

h.

Fig 1.5

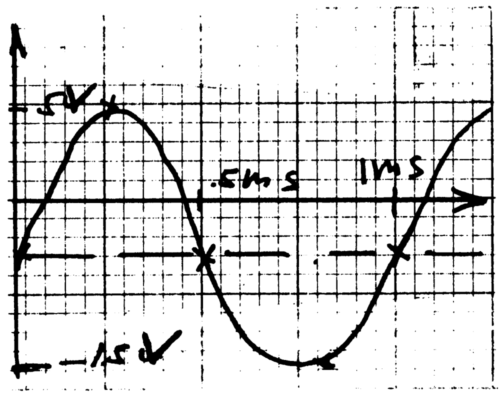


i. Switch AC-GND-DC switch, make copy of waveform above.
The vertical shift of the waveform was equal to the battery voltage.

The shape of the sinusoidal waveform was not affected by changing the positions of the AC-GND-DC coupling switch.

j. The signal shifted downward by an amount equal to the voltage of the battery.

Fig 1.6



Part 5: Problems

1. b. $f = 2000/(2*3.14) = 318$Hz
   c. $T = 1/f = 1/318 = 3.14$ms
   d. by inspection: V(peak) = 20V
   e. V(peak-peak) = 2*Vpeak = 40V
   f. V(rms) =.707 * 20 = 14.1V
   g. by inspection: Vdc = 0V

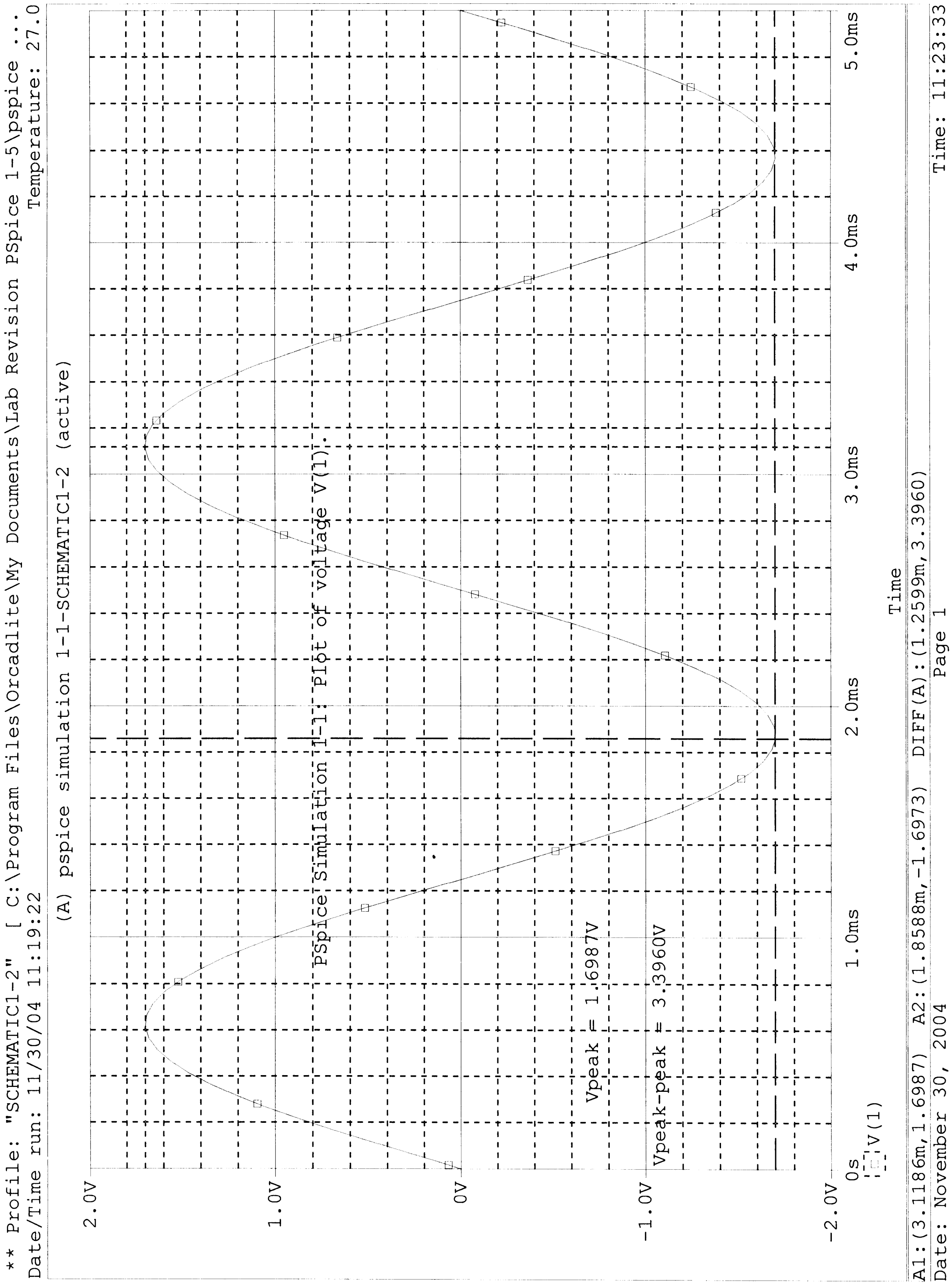
2. a. $f = 2 * 3.14 * 4000/(2 * 3.14*) = 4$ KHz
   c. $T = 1/f = 1/4$ Khz = 250 μs
   d. by inspection:Vpeak)= 8 mV
   e. V(peak-peak) = 2 * V(peak) = 16 mV
   f. V(rms) = .707 * 8 mV = 5.66 mV
   g. by inspection: Vdc = 0V

3. V(t) = 1.7 sin (2.51 Kt) volts

Part 6: Computer Exercise

PSpice Simulation 1-1

See Probe Plot page 191.



** Profile: "SCHEMATIC1-2" [C:\Program Files\Orcadlite\My Documents\Lab Revision PSpice 1-5\pspice ...
Date/Time run: 11/30/04 11:19:22
Temperature: 27.0
(A) pspice simulation 1-1-SCHEMATIC1-2 (active)
PSpice Simulation 1-1: Plot of voltage V(1).
Vpeak = 1.6987V
Vpeak-peak = 3.3960V
2.0V
1.0V
0V
-1.0V
-2.0V
0s
1.0ms
2.0ms
3.0ms
4.0ms
5.0ms
V(1)
Time
A1:(3.1186m,1.6987) A2:(1.8588m,-1.6973) DIFF(A):(1.2599m,3.3960)
Date: November 30, 2004
Page 1
Time: 11:23:33

EXPERIMENT 2: DIODE CHARACTERISTICS

Part 1: Diode Test
diode testing scale

Table 2.1

Test	Si (mV)	Ge (mV)
Forward	535	252
Reverse	OL	OL

Both diodes are in good working order.

Part 2. Forward-bias Diode characteristics

b.

Table 2.3

V_R(V)	.1	.2	.3	.4	.5	.6	.7	.8
V_D(mV)	453	481	498	512	528	532	539	546
I_D (mA)	.1	.2	.3	.4	.5	.6	.7	.8

V_R(V)	.9	1	2	3	4	5	6	7	8	9	10
V_D (mV)	551	559	580	610	620	630	640	650	650	660	660
I_D(mA)	.9	1	2	3	4	5	6	7	8	9	10

d.

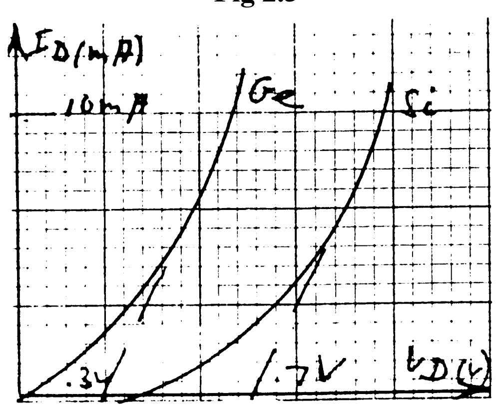
Table 2.4

V_R(V)	.1	.2	.3	.4	.5	.6	.7	.8
V_D(mV)	156	187	206	217	229	239	247	254
I_D(mA)	.1	.2	.3	.4	.5	.6	.7	.8

V_R(V)	.9	1	2	3	4	5	6	7	8	9	10
V_D (mV)	260	266	300	330	340	360	370	380	390	400	400
I_D(mA)	.9	1	2	3	4	5	6	7	8	9	10

e.

Fig 2.5



f. Their shapes are similar, but for a given I_D, the potential V_D is greater for the silicon diode compared to the germanium diode. Also, the Si has a higher firing potential than the germanium diode.

Part 3: Reverse Bias

b. R_m = 9.9 Mohms
V_R(measured) = 9.1 mV
I_S(calculated) = 8.21 nA

c. V_R(measured) = 5.07 mV
I_S(calculated) = 4.58 μA

d. The I_S level of the germanium diode is approximately 500 times as large as that of the silicon diode.

e. R_{DC} (Si) = $2.44*10^9$ ohms
R_{DC}(Ge) = 3.28 M$*10^6$ ohms

These values are effective open-circuits when compared to resistors in the kilohm range.

Part 4: DC Resistance

a.

Table 2.5

I_D (mA)	V_D (mV)	R_{DC} (ohms)
.2	350	1750
1.0	559	559
5.0	630	126
10.0	660	66

b.

Table 2.6

I_D (mA)	V_D (mV)	R_{DC} (ohms)
.2	80	400
1.0	180	180
5.0	340	68
10.0	400	40

Part 5: AC Resistance

a. (calculated)r_{ac} = 3.4 ohms
b. (calculated)r_{ac} = 2.9 ohms
c. (calculated)r_{ac} = 27.0 ohms
d. (calculated)r_{ac} = 26.0 ohms

Part 6: Firing Potential

V_T(silicon) = 540 mV
V_T(germanium) = 260 mV

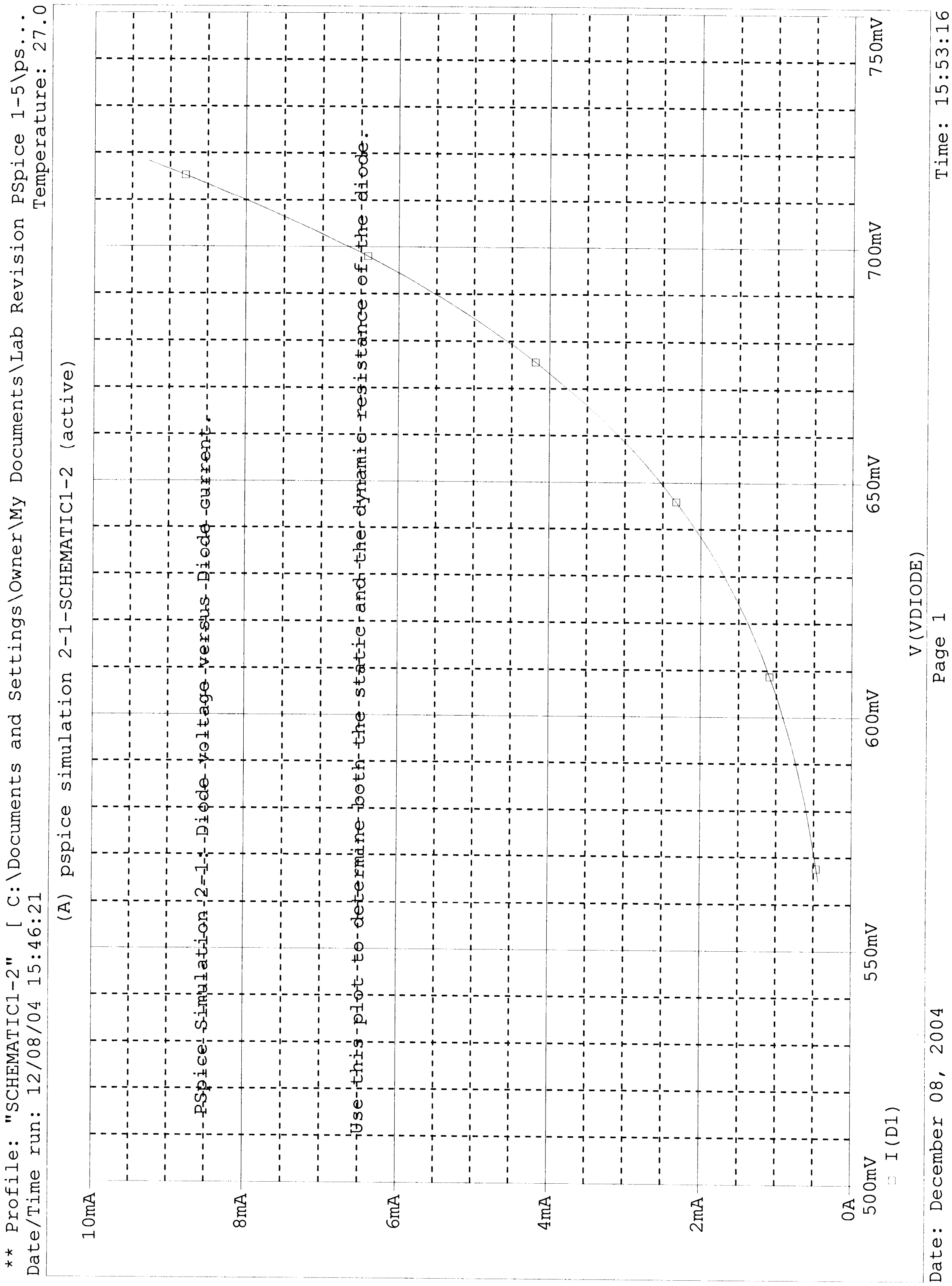
Part 7: Temperature Effects

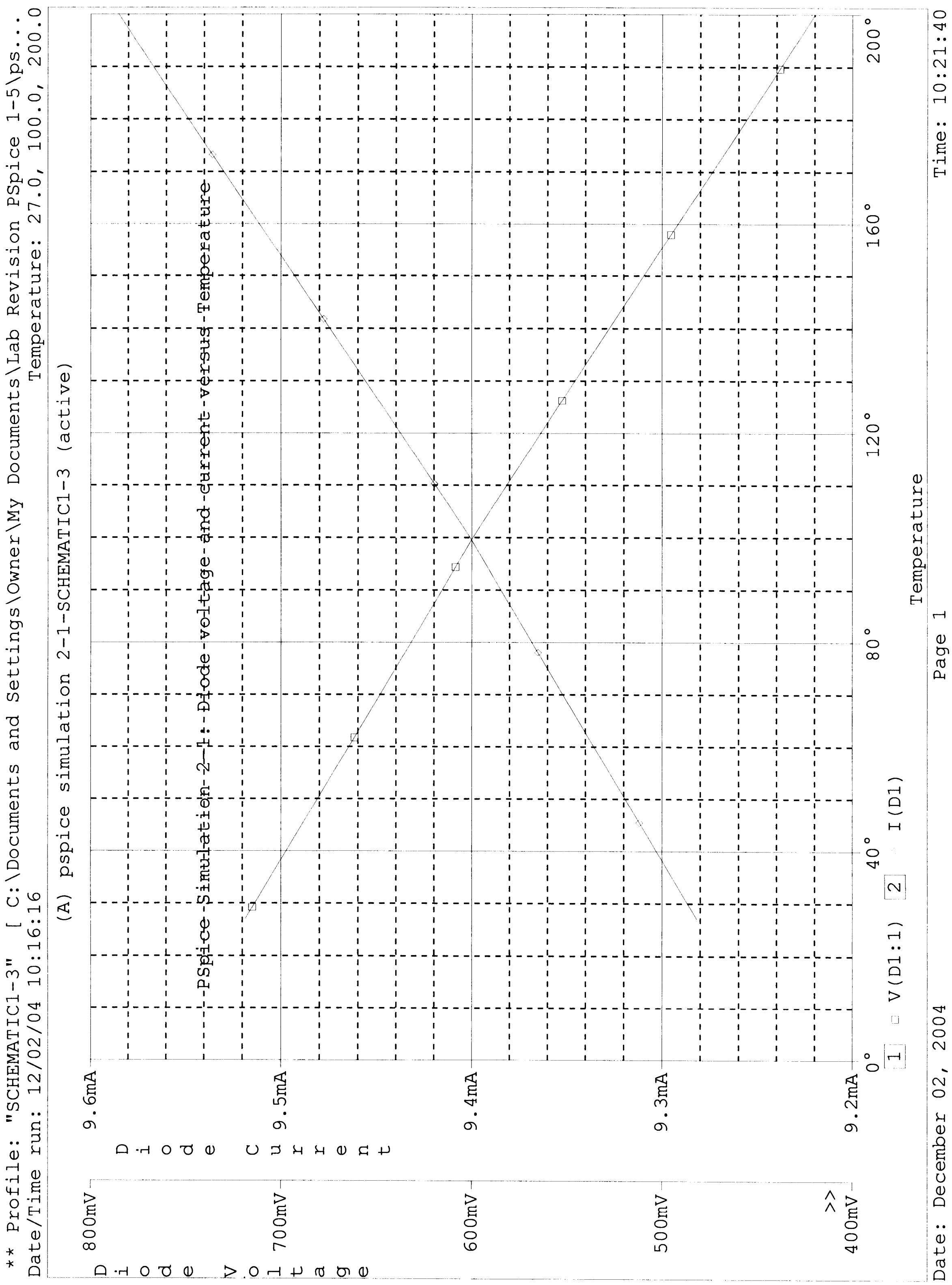
c. For an increase in temperature, the forward diode current will increase while the voltage V_D across the diode will decline. Since $R_D = V_D/I_D$, therefore, the resistance of a diode declines with increasing temperature.

d. As the temperature across a diode increases, so does the current. Therefore, relative to the diode current, the diode has a positive temperature coefficient.

Part 9: Computer Exercises
PSpice Simulation 2-1

1. See Probe plot page 195.
2. $R_{D\ 600\text{mV}} = 658\ \Omega$
   $R_{D\ 700\ \text{mV}} = 105\ \Omega$
4. $R_{D\ 600\ \text{mV}} = 257\ \Omega$
5. See Probe Plot V(D1) versus I(D1)
7. Silicon
8. See Probe plot page 196.
9. See Probe plot page 196.
10. See Probe plot page 196.


** Profile: "SCHEMATIC1-2" [C:\Documents and Settings\Owner\My Documents\Lab Revision PSpice 1-5\ps...
Date/Time run: 12/08/04 15:46:21
Temperature: 27.0
(A) pspice simulation 2-1-SCHEMATIC1-2 (active)
PSpice Simulation 2-1: Diode voltage versus Diode current.
Use this plot to determine both the static and the dynamic resistance of the diode.
10mA
8mA
6mA
4mA
2mA
0A
500mV
550mV
600mV
650mV
700mV
750mV
I(D1)
V(VDIODE)
Date: December 08, 2004
Page 1
Time: 15:53:16


** Profile: "SCHEMATIC1-3" [C:\Documents and Settings\Owner\My Documents\Lab Revision PSpice 1-5\ps...
Date/Time run: 12/02/04 10:16:16
Temperature: 27.0, 100.0, 200.0
(A) pspice simulation 2-1-SCHEMATIC1-3 (active)
PSpice Simulation 2-1: Diode voltage and current versus Temperature
Diode Voltage
800mV
700mV
600mV
500mV
>>
400mV
Diode Current
9.6mA
9.5mA
9.4mA
9.3mA
9.2mA
0°
40°
80°
120°
160°
200°
1 V(D1:1) 2 I(D1)
Temperature
Date: December 02, 2004
Page 1
Time: 10:21:40

EXPERIMENT 3: SERIES AND PARALLEL DIODE CONFIGURATIONS

Part 1: Threshold Voltage V_T

Fig 3.2

Firing voltage: Silicon: 595 mV Germanium: 310 mV

Part 2: Series Configuration

b. V_D = .59 V
V_O (calculated) = 5 − .595 = 4.41 V
I_D = 4.41/2.2 K = 2 mA

c. V_D(measured) = .59 V
V_O(measured) = 4.4 V
I_D(from measured) = 2 mA

e. V_D = 595 mV
V_O(calculated) = (5 − .595) 1 K/(1 K + 2.2 K) = 1.33 V
I_D = 1.36 mA

f. V_D = .57 V
V_O = 1.36 V
I_D(from measured) = 1.36 V/1 K = 1.36 mA

g. V_D(measured) = 5 V
V_O(measured) = 0 V
I_D(measured) = 0 A

h. V_D(measured) = 5 V
V_O(measured) = 0 V
I_D(measured) = 0 A

j. V_1(calculated) = .905 V
V_O(calculated) = 4.1 V
I_D(calculated) = 1.86 mA

Part 7: Computer Exercise
PSpice Simulation 3-2

1. 638.0 mV

EXPERIMENT 4: HALF-WAVE AND FULL-WAVE RECTIFICATION

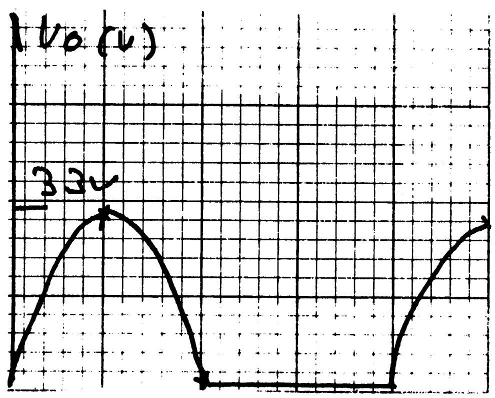
Part 1: Threshold Voltage
V_T = .64 V

Part 2: Half-wave Rectification

b. Vertical sensitivity = 1 V/cm
Horizontal sensitivity = .2 ms/cm

c.

Fig 4.4



d. Both waveforms are in essential agreement.

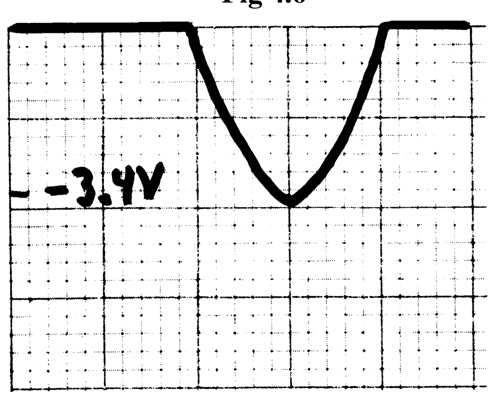
e. V_{dc} = (4 − .64)/3.14 = 1.07 V

f. V_{dc}(measured) = .979 V
% difference = (1.07 − .979)/1.07*100 = 8.5%

g. For an ac voltage with a dc value, shifting the coupling switch from its DC to AC position will make the waveform shift down in proportion to the dc value of the waveform.

h.

Fig 4.6

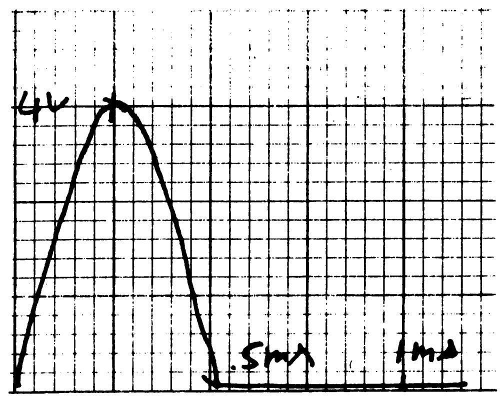


i. V_{dc}(calculated) = −1.07 V
V_{dc}(measured) = −.970 V

Part 3: Half-Wave Rectification (continued)

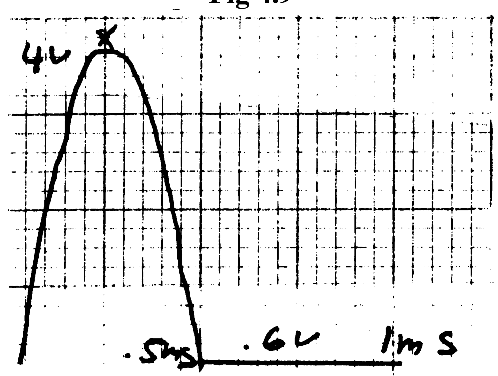
b.

Fig 4.8



c.

Fig 4.9



The results are in reasonable agreement.

d. The significant difference is in the respective reversal of the two voltage waveforms. While in the former case the voltage peaked to a positive 3.4 volts, in the latter case, the voltage peaked negatively to the same voltage.

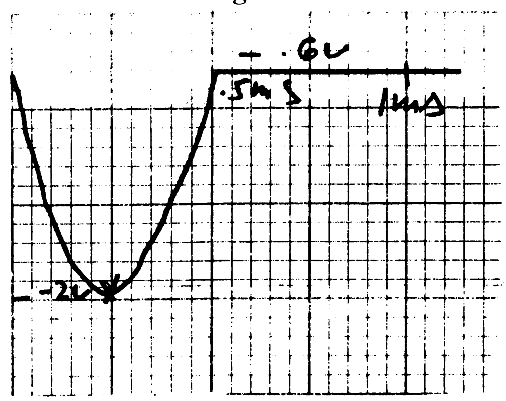
e. V_{DC} = (.318)*3.4 = 1.08 Volts

f. Difference = [1.08 − .979]/1.08*100 = 9.35%

Part 4: Half-Wave Rectification (continued)

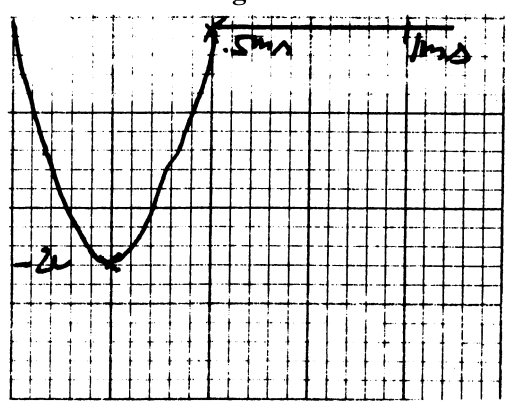
b.

Fig 4.11



c.

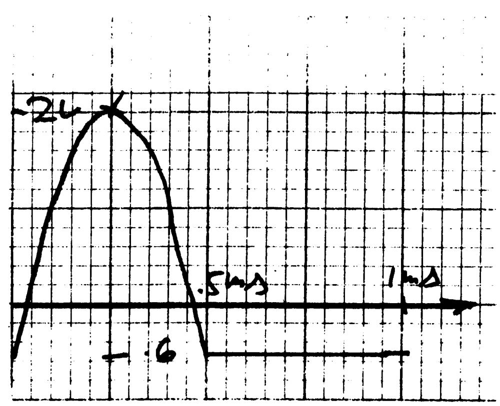
Fig 4.12



There was a computed 2.1% difference between the two waveforms.

d.

Fig 4.13



We observe a reversal of the polarities of the two waveforms caused by the reversal of the diode in the circuit.

Part 5: Full-Wave Rectification (Bridge Configuration)

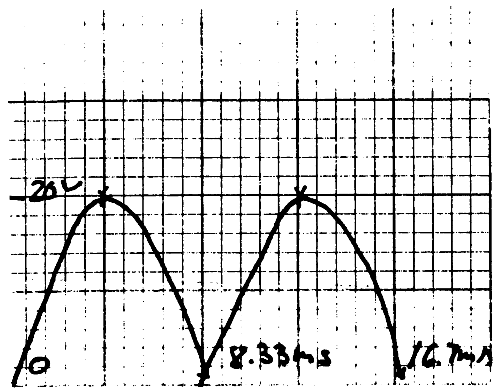
a. $V_{(secondary)rms} = 14$ V

This value differs by 1.4 V rms from the rated voltage of the secondary of the transformer.

b. $V_{(peak)} = 1.41*14 = 20$ V

c.

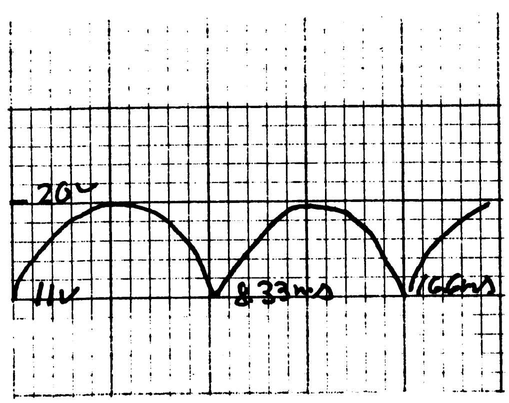
Fig 4.15



Vertical sensitivity: 5 V/cm
Horizontal sensitivity: 2 ms/cm

d.

Fig 4.16

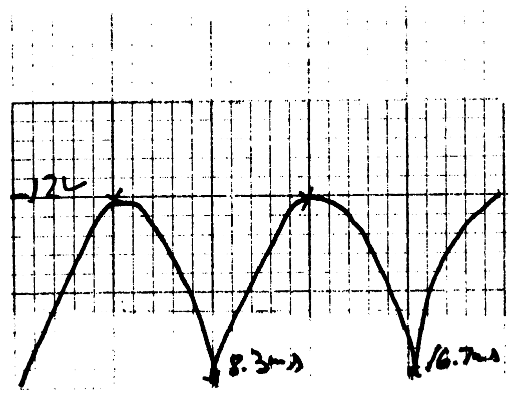


Again, the difference between expected and actual was very slight.

e. V_{dc}(calculated) = (.6326)*(20) = 12.7 V
V_{dc}(measured) = 11.36 V
% Difference = −10.6%

g. Vertical sensitivity = 5 V/cm
Horizontal sensitivity = 2 ms/cm

Fig 4.17



i. V_{dc}(calculated) = (.636)*(12) = 7.63 V

j V_{dc}(measured) = 7.05 V
% Difference = −7.6%

k. The effect was a reduction in the dc level of the output voltage.

Part 6: Full-Wave Center-tapped Configuration

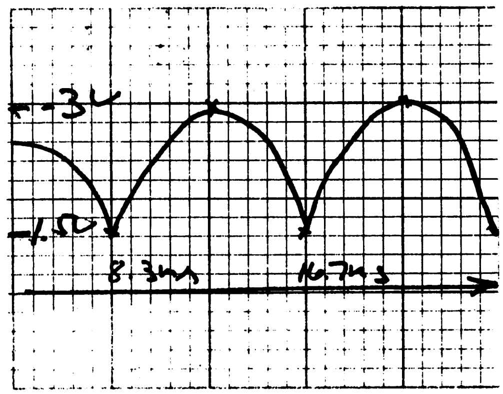
a. V_{rms}(measured) = 6.93 V
V_{rms}(measured) = 6.97 V

As is shown from the data, the difference for both halves of the center-tapped windings from the rated voltage is .6 volts.

b. Vertical sensitivity = 5 V/cm
Horizontal sensitivity = 2 ms/cm

c.

Fig 4.21

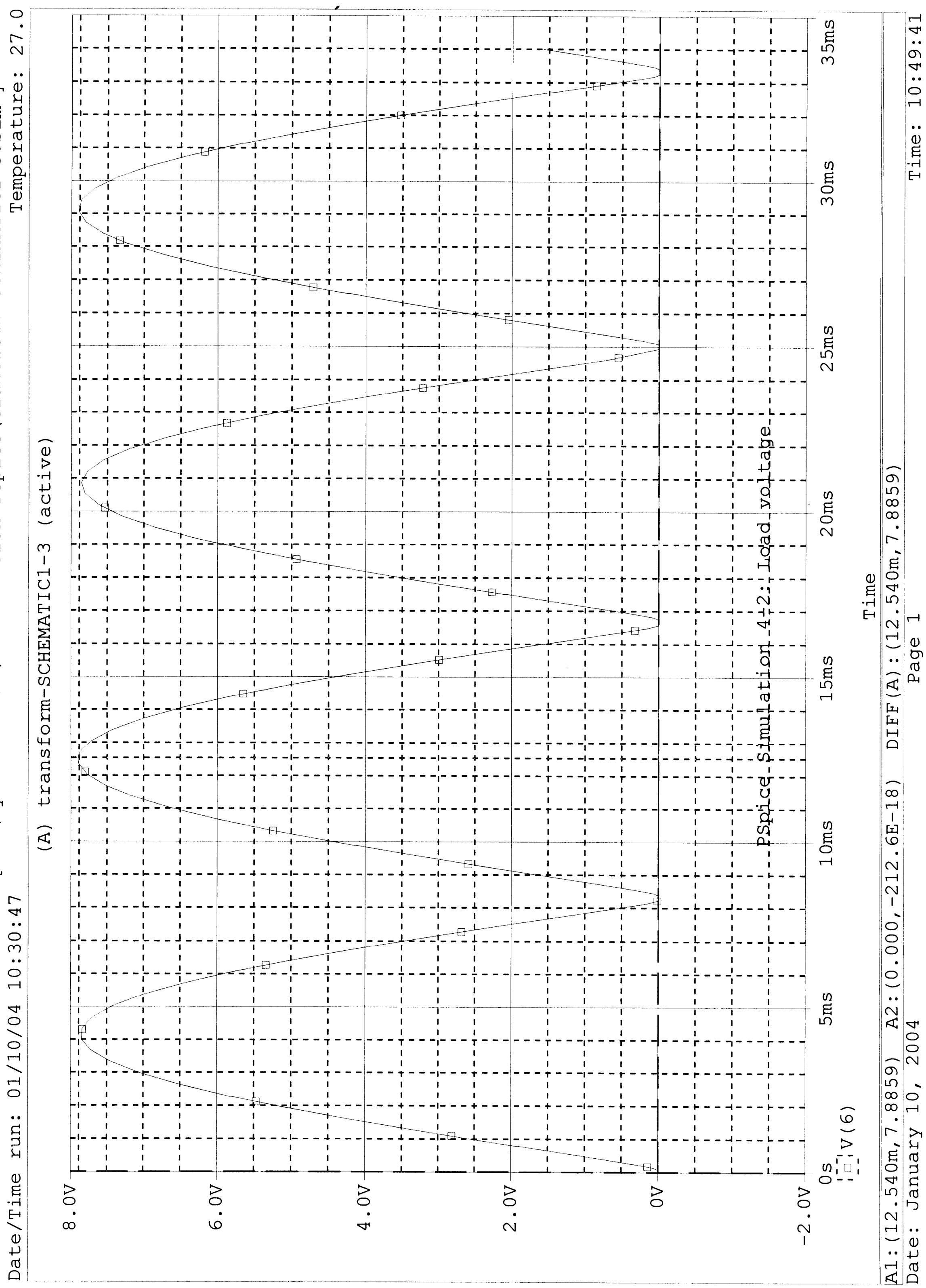


d. V_{dc}(calculated) = 3.5 V
V_{dc}(measured) = 3.04 V

Part 7: Computer Exercise

PSpice Simulation 4-2

1. V_p = 8.47 V; relative phase shift is equal to 180°
2. PIV = 2 Vp
3. 180° out of phase
4. See Probe plot page 204.
   Its amplitude is 7.89 V
5. Yes
6. Reasonable agreement.


** Profile: "SCHEMATIC1-3" [C:\My Documents\Lab Revision Pspice\transform-SCHEMATIC1-3.sim]
Date/Time run: 01/10/04 10:30:47
Temperature: 27.0
(A) transform-SCHEMATIC1-3 (active)
8.0V
6.0V
4.0V
2.0V
0V
-2.0V
0s
5ms
10ms
15ms
20ms
25ms
30ms
35ms
V(6)
Time
PSpice Simulation 4-2: Load voltage
A1:(12.540m,7.8859) A2:(0.000,-212.6E-18) DIFF(A):(12.540m,7.8859)
Date: January 10, 2004
Page 1
Time: 10:49:41

EXPERIMENT 5: CLIPPING CIRCUITS

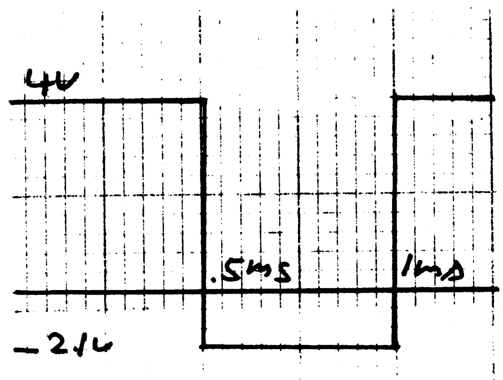
Part 1: Threshold Voltage

V_T(Si) = .618 V
V_T(Ge) = .299 V

Part 2 Parallel Clippers

b. V_O(calculated) = 4 V
c. V_O(calculated) = −1.5 − .618 = −2.2 V
d.

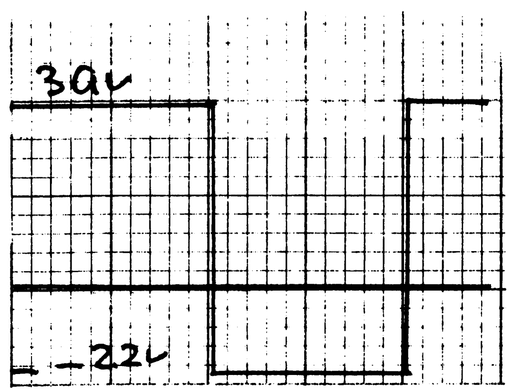
Fig 5.2



Vertical sensitivity = 1 V/cm
Horizontal sensitivity = .2 ms/cm

e.

Fig 5.3



No measured differences appeared between expected and observed waveforms.

f. V_O(calculated) = 4 V

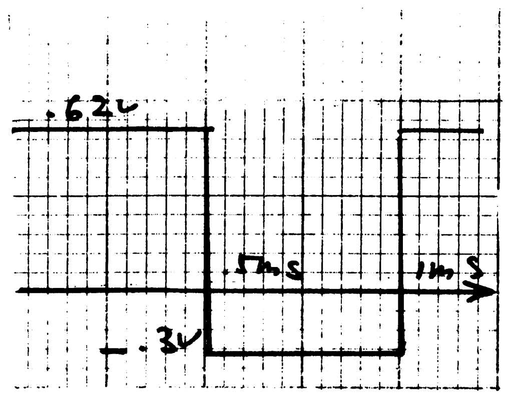
g. V_O(calculated) = .62 V

Part 3: Parallel Clippers (continued)

b. V_O(calculated) = .61 V
c. V_O(calculated) = .34 V

d.

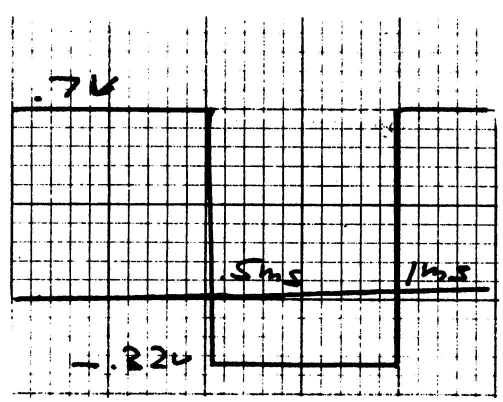
Fig 5.7



Vertical sensitivity = 1 V/cm
Horizontal sensitivity = .2 ms/cm

e.

Fig 5.8

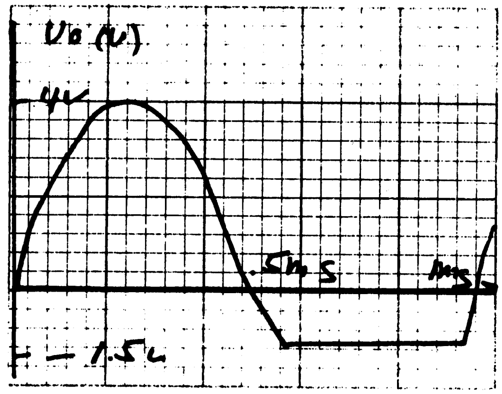


The waveforms agree.

Part 4: Parallel Clippers (Sinusoidal Input)

b. V_O(calculated) = 4 V when $V_i = 4$ V
V_O(calculated) = −2 V when $V_i = -4$ V
V_O(calculated) = 0 V when $V_i = 0$ V

Fig 5.9



c. Waveforms agree within 6.5%.

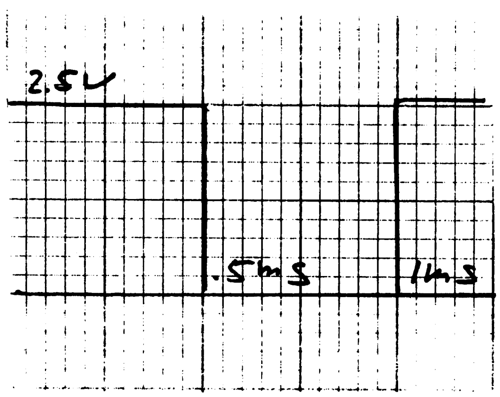
Part 5: Series Clippers

b. V_O(calculated) = 2.5 V when V_i = 4 V

c. V_O(calculated) = 0 V when V_i = −4 V

d.

Fig 5.12



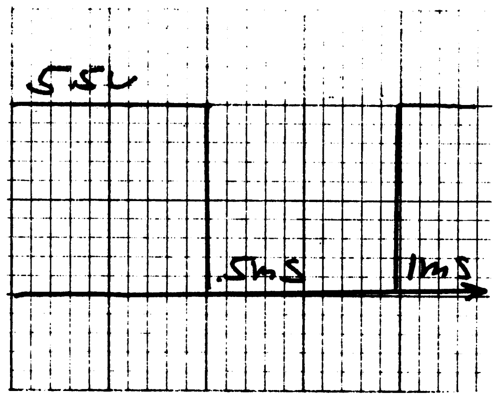
Vertical sensitivity = 1 V/cm
Horizontal sensitivity = .2 ms/cm

e. agree within 5.1%

f. V_O(calculated) = 5.5 V when V_i = 4 V

g. V_O(calculated) = 0 V when V_i = −4 V h.

Fig 5.14



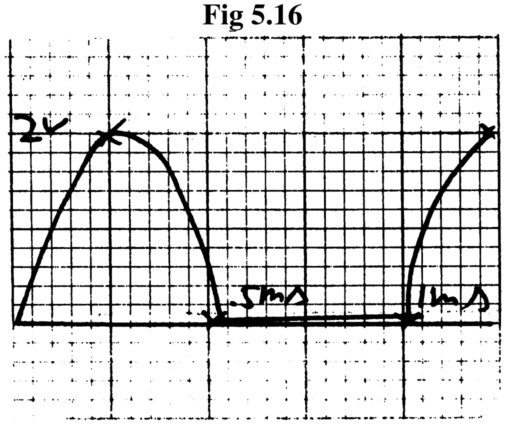
Vertical sensitivity = 2 V/cm
Horizontal sensitivity = .2 ms/cm

i. no major differences

Part 6: Series Clippers (Sinusoidal Input)

b. V_O(calculated) = 2 V when V_i = 4 V
V_O(calculated) = 0 V when V_i = −4 V
V_O(calculated) = 0 V when V_i = 0 V

Fig 5.16



Vertical sensitivity = 1 V/cm
Horizontal sensitivity = .2 ms/cm

Part 7: Computer Exercises

PSpice Simulation 5-2

1. See Probe plot page 210.
2. $V_{OUT} = 4$ V
3. No
4. $V_{OUT} = -2.067$ V
5. Yes, $V_{OUT}(\text{ideal}) = -1.5$ V
6. Reasonable agreement
7. No significant discrepancies
8. See Probe plot page 211.

PSpice Simulation 5-3

1. See Probe plot page 212.
2. In close agreement
3. No
4. For $V_1 = 4$ V; $V_{out} = V_1 - V_{D1} - 1.5\text{ V} = 4\text{ V} - .6 - 1.5\text{ V} = 1.9$ V
   For $V_1 = -4$ V; $I_{(D1)} = 0$ A, $\therefore V_{out} = 0$ V
5. See Probe plot page 213.
6. See Probe plot page 213.
7. See Probe plot page 213.
8. See Probe plot page 213.
9. Forward bias voltage of about 600 mV when "ON".
   Reverse diode voltage of diode is $-4\text{ V} - 1.5\text{ V} = -5.5$ V