Multi-State Advanced Manufacturing Consortium

US DOL SPONSORED TAACCCT GRANT: TC23767
PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE	2/22/2016
VERSION	v 001
PAGE	1 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Name _____

All portions of LAB 4 DC POWER SUPPLY covered in this document must be completed and verified before moving on.

OBJECTIVES

Assemble components for 3 types of power supply configurations.   Understand Diode ratings   Learn the function of the transformer, the rectifier section and the filter section. View inputs and outputs of each power supply section with an Oscilloscope. Use digital meters to measure voltages at various points.   Troubleshooting of power supplies

PROCEDURE

Complete the procedure for Part A Transformer. Note: This part must be completed for the Half Wave Rectifier circuit and the Full Wave Rectifier circuit. The Full Wave Bridge circuit uses the same transformer configuration as the Half Wave Rectifier circuit. Therefore, the transformer section of the lab (Part A) does not need to be completed again for the Full Wave Bridge circuit. You simply need to copy your data from the Part A section of the Half Wave Rectifier circuit to the Part A section of the Full Wave Bridge circuit section Part A.

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PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE	2/22/2016
VERSION	v 001
PAGE	2 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

HALF WAVE RECTIFIER CIRCUIT

PART A: TRANSFORMER

Step 1. Measure the voltage of the 110 v AC wall socket you will be plugging the transformer into. Do this by placing the probes of a multimeter into the 110 volt wall socket. Be sure to use the correct safety procedures for measuring high voltages.

Measured voltage from wall socket equals the transformer primary voltage from multimeter

Multimeter measurement _____ Note: This voltage is RMS AC voltage.

Step 2. Plug the transformer into the wall socket. Apply power to the transformer. Measure the transformer secondary with the multimeter. Make sure the meter is set for AC voltage. Also, use an oscilloscope to measure ONLY the transformer secondary voltage.

DO NOT MEASURE THE TRANSFORMER PRIMARY VOLTAGE WITH THE OSCILLOSCOPE.

Step 3. Sketch the transformer secondary voltage measured with an oscilloscope waveform.
Note: This is an AC voltage.
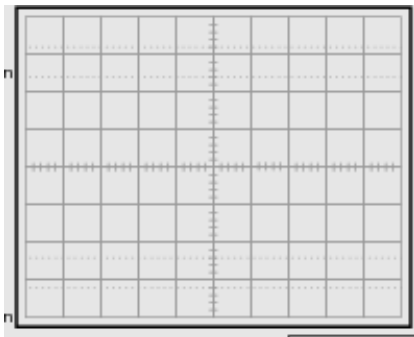
Voltage peak-to-peak _____
Volts per division knob setting _____
Number of divisions at that setting _____
Voltage peak _____
Transformer secondary measured with multi meter _____

Be sure to put the multimeter on AC volts. This voltage is RMS AC voltage.

Step 4. Shut off power.

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PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE	2/22/2016
VERSION	v 001
PAGE	3 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
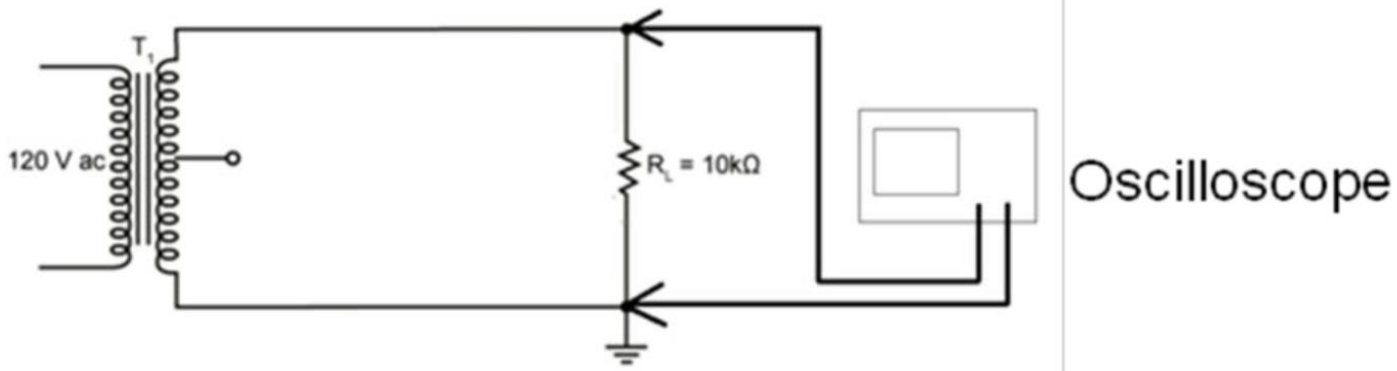### *DC Power Supply Lab*

HALF WAVE RECTIFIER CIRCUIT

PART B: TRANSFORMER WITH LOAD RESISTOR

Step 5. Complete as follows:
　　　Construct the following circuit.

Step 6. Measure the AC voltage across the 10KΩ load resistor. Voltage across load resistor with oscilloscope

V peak-to-peak _____

V peak _____

V RMS calculated = V peak / .707 = _____

V RMS measured on multimeter = _____

Make sure the multimeter is set to AC voltage.

Solid State Electronics – Unit 5: Silicon Control Rectifier
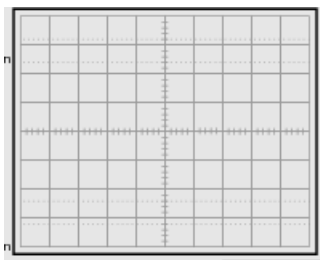## *DC Power Supply Lab*

PART C: RECTIFIER

Step 7. Place a diode into the circuit as follows.
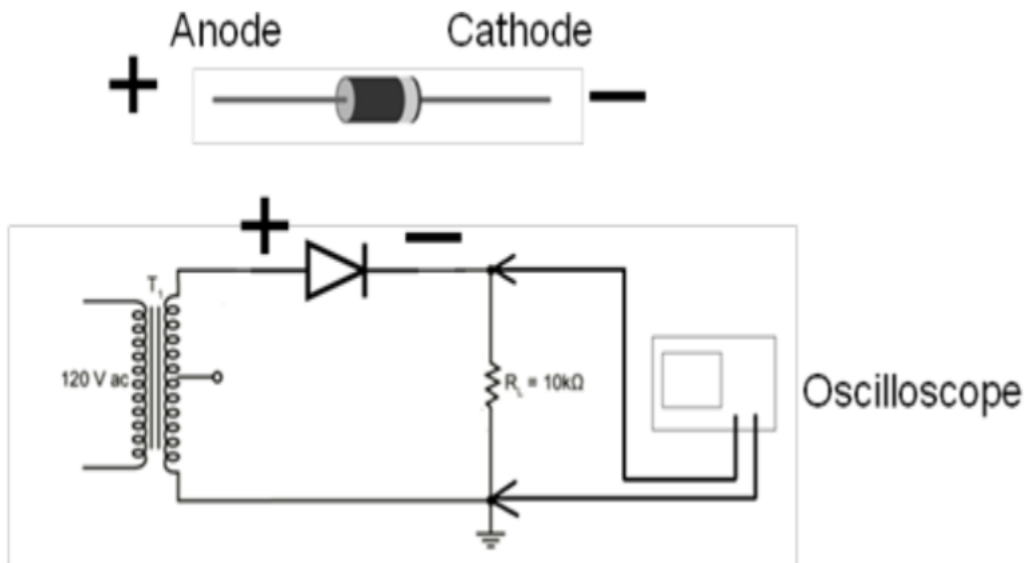
Measure the voltage across load resistor with oscilloscope. This will be known as: peak pulsating DC voltage

Step 8. Draw the voltage waveform.

Volts per division knob setting _____

Number of divisions at that setting _____

Voltage peak _____

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Step 9. Measure the Average Pulsating Voltage across the load with multimeter. This will be known as the Average Voltage.

Vavg _____ Make sure the multimeter is set to DC voltage.

Understand Vavg is equal to the average voltage. The average voltage is what a DC meter reads.

Step 10. Find on your voltage waveform sketch (Step 7) where the average voltage is located. This is going to be equal to your multimeter reading. Draw a line at that point on your sketched waveform.

Step 11. To calculate the average voltage across a Half Wave Rectifier without a filter capacitor use the following formula:

Vavg = peak pulsating DC voltage(Step 6) / π
Your calculated Vavg = _____

Step 12. Re-wire your circuit to look like the following circuit. Note: The diode and Load resistor have changed places.
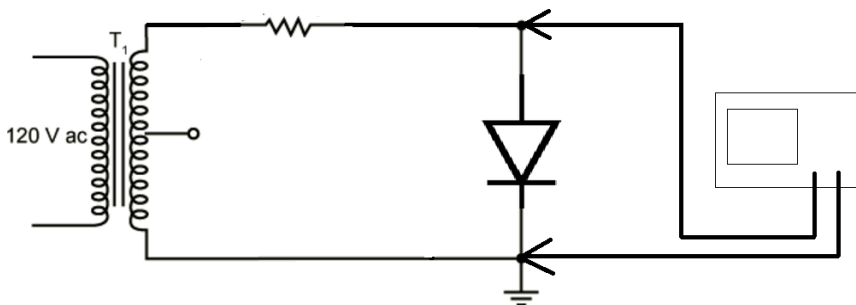
Step 13. Measure the voltage across the diode. Use the oscilloscope to measure.

   Vdiode = _____

   Measure the voltage across the diode. Use the multimeter.

   Vdiode = _____

Step 14. The output voltage across the load happens one time every 360o. Therefore, the frequency of the

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PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE | 2/22/2016
VERSION | v 001
PAGE | 6 of 31

# Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

output is 60 Hz. The time required for this   frequency is 1/f = 1/60hz = 16.667 mSec.

Measure the time it takes for one pulse of DC voltage. This includes the time the diode is off. What is the frequency of the pulsating DC voltage you are measuring?

T = _____

f = frequency of peak pulsating DC voltage = _____

Step 15. Re-Draw your pulsating DC output (from step 7.). Show on your waveform where the diode is forward and reverse biased.
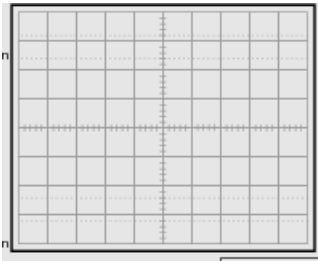
Step 16. Shut off the power to your transformer.

Step 17. Reconnect your circuit as follows. With the oscilloscope connected back across the load, short across the diode with a small jumper wire. Turn the power on. Do you see a full sine wave?
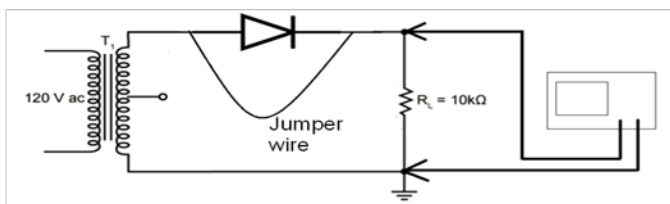
Circle one: Yes   No

The jumper simulates a shorted diode.

Step 18. Shut off the power to your transformer.

Step 19. Remove the jumper wire and the diode. Leave the oscilloscope connected across the load. Turn the power on. What is the output voltage now?

Multi-State
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US DOL SPONSORED TAACCCT GRANT: TC23767
PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE   2/22/2016
VERSION   v 001
PAGE   7 of 31

# Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Vout = _____

With the diode removed the circuit now behaves like it has an open diode.

Step 20. Shut off the power to your transformer and place the diode back in the circuit.

PART D: FILTER CIRCUIT

Step 21. With the power off, connect the capacitor across the load resistor (in parallel with the load resistor). Be sure to observe polarity.
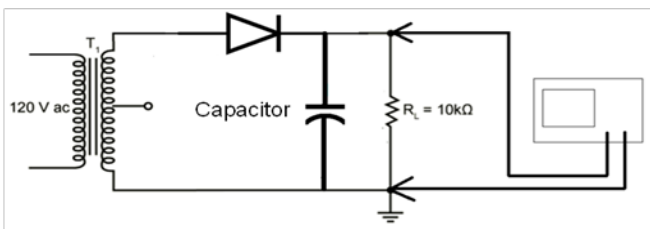
Step 22. Turn the power on. Put the oscilloscope on the DC setting. Make a waveform sketch. Be sure to show where 0 volts is.
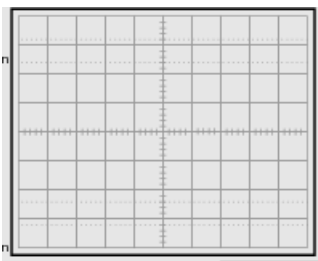
Volts per division _____

Number of division's _____

Step 23. Measure the Voltage across the load with multimeter.

Vavg _____

Make sure the multimeter is set to DC voltage.

Multi-State
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US DOL SPONSORED TAACCCT GRANT: TC23767
PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE 2/22/2016
VERSION v 001
PAGE 8 of 31

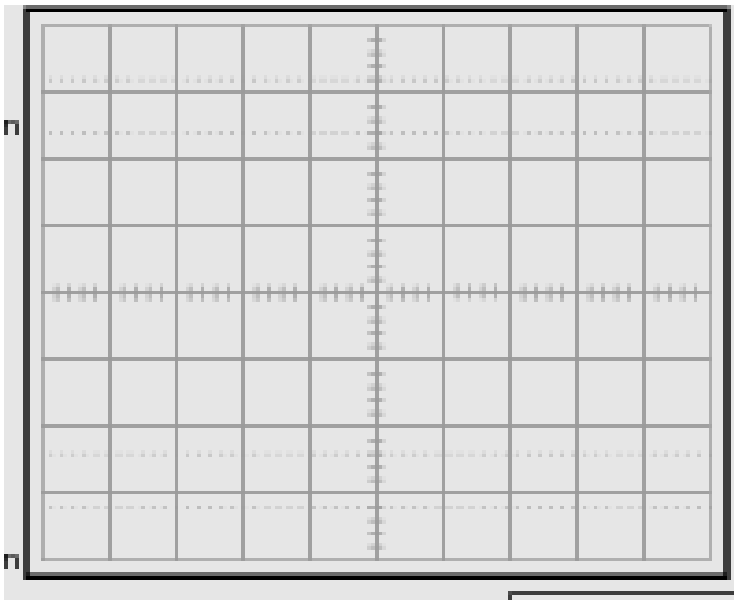# Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Step 24. Shut off the power.

     Understand Vavg is equal to the average voltage. The average voltage is what a DC meter reads.

Step 25. Find on your voltage waveform sketch (step 21) where the average voltage is based on your multimeter reading. Draw a line at that point on your sketched waveform.

Step 26. Redraw your sketch. Show the portion of the waveform where the capacitor is charging and discharging. Be sure to label clearly.

Multi-State Advanced Manufacturing Consortium

US DOL SPONSORED TAACCCT GRANT: TC23767
PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE 2/22/2016
VERSION v 001
PAGE 9 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

RIPPLE VOLTAGE

Step 27. Turn the power on. Put the oscilloscope on the AC setting. Make a waveform sketch.
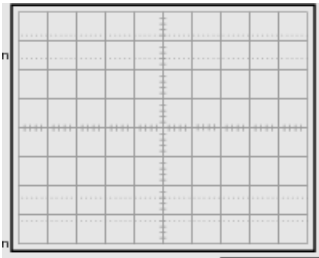
Volts per division _____ Number of divisions _____

     This is the ripple voltage. A perfect DC power supply would have zero volts ripple. How many volts peak-to-peak is your ripple voltage?

Vripple = _____

Step 28. To calculate the average voltage with a capacitor:

Vavg = peak pulsating DC voltage - (Vripple/2)

Your calculated Vavg = _____

Step 29. What should the PIV rating of your diode be in this section of the lab?

PIV rating = _____

Multi-State Advanced Manufacturing Consortium

US DOL SPONSORED TAACCCT GRANT: TC23767
PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE 2/22/2016
VERSION v 001
PAGE 10 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Step 30. Answer the following questions.

1. If your half wave rectifier had an open diode, what would be the effect?

    a. No output. 0 volts
    b. A sine wave equal to Vprimary
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

2. If your half wave rectifier had a shorted diode, what would be the effect?

    a. No output. 0 volts
    b. A sine wave equal to Vprimary
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

3. If your half wave rectifier had a shorted capacitor, what would be the effect?

    a. No output. 0 volts
    b. A sine wave equal to Vprimary
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

4. If your half wave rectifier had an open capacitor, what would be the effect?

    a. No output. 0 volts
    b. A sine wave equal to Vprimary
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
   g. Pulsating DC voltage equal to value of peak pulsating DC voltage

Solid State Electronics – Unit 5: Silicon Control Rectifier
## *DC Power Supply Lab*

5. If your half wave rectifier had an open load, what would be the effect?

    a. No output. 0 volts
    b. A sine wave equal to Vprimary
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

6. If your half wave rectifier had an shorted load, what would be the effect?

    a. No output. 0 volts
    b. A sine wave equal to Vprimary
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

FULL WAVE RECTIFIER CIRCUIT

PART A: TRANSFORMER

Step 31. Construct the following circuit. We will use the center tap on the transformer for this rectifier circuit. A Full Wave Rectifier circuit uses only half of the secondary voltage.
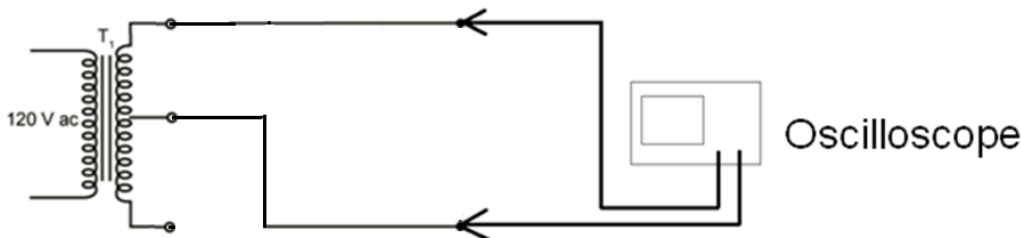
Step 32. Sketch the transformer secondary voltage measured with an oscilloscope waveform. Note: This is an AC voltage.
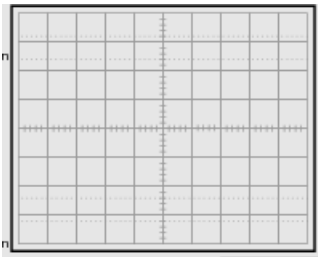
Voltage peak-to-peak _____
Volts per division knob setting _____
Number of divisions at that setting _____
Voltage peak _____

Measure the transformer secondary voltage with a multi meter V secondary voltage _____

Be sure to put the multimeter on AC volts. This voltage is RMS AC voltage.

Step 33. Shut off power.

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

PART B: TRANSFORMER WITH LOAD RESISTOR

Step 34. Construct the following circuit. We will use the center tap on the transformer for this rectifier circuit. A Full Wave Rectifier circuit uses only half of the secondary voltage.
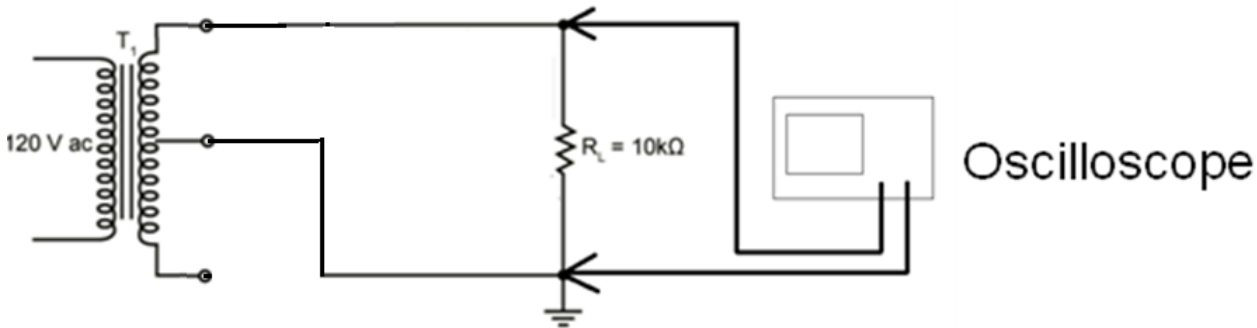
Step 35. Measure the AC voltage across the 10KΩ load resistor. Voltage across load resistor with oscilloscope

     V peak-to-peak _____

     V peak _____

     V RMS calculated = V peak / .707 = _____

     V RMS measured on multimeter = _____

     Make sure the multimeter is set to AC voltage.

     Note: You should only get a reading about 1/2 of what you had in Step 6.

PART C: RECTIFIER

Step 36. Place two diodes into the circuit as follows. Be sure to connect with the correct polarity. If you are not sure how this circuit is wired please ask for help.

Multi-State
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PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE 2/22/2016
VERSION v 001
PAGE 14 of 31
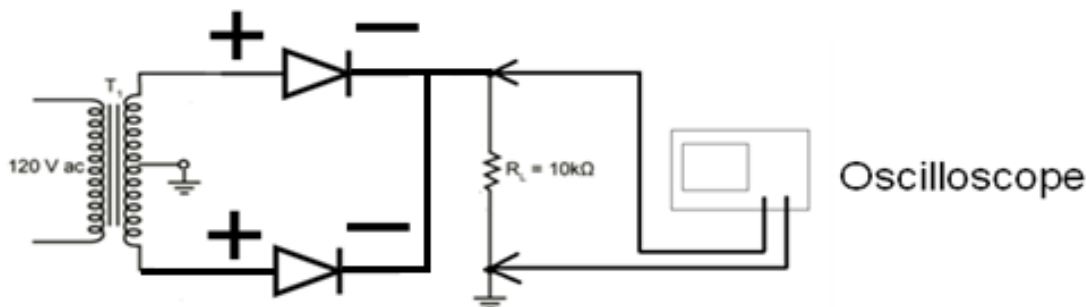
Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Step 37. Measure the voltage across load resistor with oscilloscope. This will be known as: peak pulsating DC voltage

Step 38. Draw the peak pulsating DC voltage waveform.
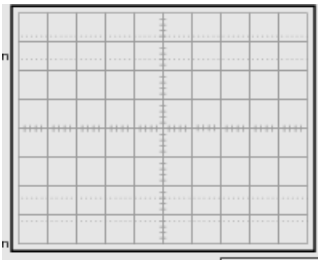
      Volts per division knob setting _____
      Number of divisions at that setting _____
      Voltage peak _____

Step 39. Measure the Pulsating Voltage across the load with multimeter.

      Vavg _____
      Make sure the multimeter is set to DC voltage.

Step 40. Understand Vavg is equal to the average voltage. The average voltage is what a DC meter reads.

Step 41. Find on your voltage waveform sketch where the average voltage is. This is going to be equal to your multimeter reading. Draw a line at that point on your sketched waveform.

Step 42. To calculate the average voltage without a capacitor:

      Vavg = 2 (peak pulsating DC voltage) / π

      Your calculated Vavg = _____

Step 43. Understand there is a voltage across each diode at all times.

Step 44. The output voltage across the load happens twice every 360o for a full wave rectifier circuit. The result of full wave rectification is that the output voltage has a frequency two times the input frequency. The output pulses every half cycle of the input. Therefore, the frequency of the of the output is

Solid State Electronics – Unit 5: Silicon Control Rectifier
## *DC Power Supply Lab*

120 Hz. The time required for this frequency is 1/f = 1/120hz = 8.333 mSec.

Measure the time it takes for one pulse of DC voltage. What is the frequency of the pulsating DC voltage you are measuring?

Measure the time of the peak positive alternation. What is the frequency of the pulsating DC voltage you are measuring?

Time for 1 pulse of output voltage. T = _____

f = frequency of peak pulsating DC voltage = _____

Step 45. Re-Draw your peak pulsating DC voltage output (step 37). Show on your waveform where the diode is forward and reverse biased.
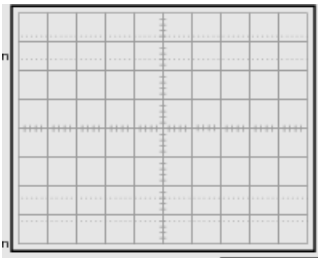
Step 46. Shut off the power to your transformer.

Step 47. With the oscilloscope connected back across the load, short across one of the diodes with a small jumper wire.

Step 48. Turn the power on. This jumper simulates one of the diodes being shorted.
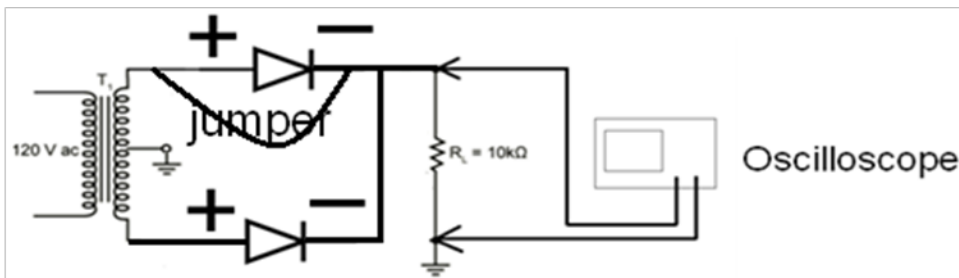
Step 49. Does your output look like a Half Wave Rectifier output?

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Circle one: Yes   No

Step 50. Shut off the power to your transformer.

Step 51. Remove the jumper wire and the diode. Leave the oscilloscope connected across the load.

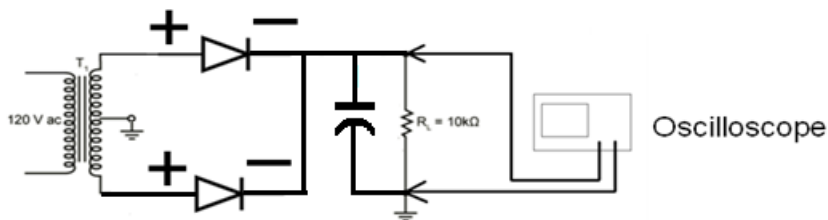Step 52. Turn the power on. What is the output voltage now?

     Vout = _____

     This simulates an open diode.

Step 53. Shut off the power to your transformer and place the diode back in the circuit.

PART D: FILTER CIRCUIT

Step 54. With the power off connect the capacitor across the load resistor (in parallel with the load resistor). Be sure to observe polarity.

Step 55. Turn the power on.

Step 56. Put the oscilloscope on the DC setting. Make a waveform sketch.

     Volts per division: _____
     Number of divisions: _____

Step 57. Measure the voltage across the load with multimeter.

     Vavg _____

     Make sure the multimeter is set to DC voltage.

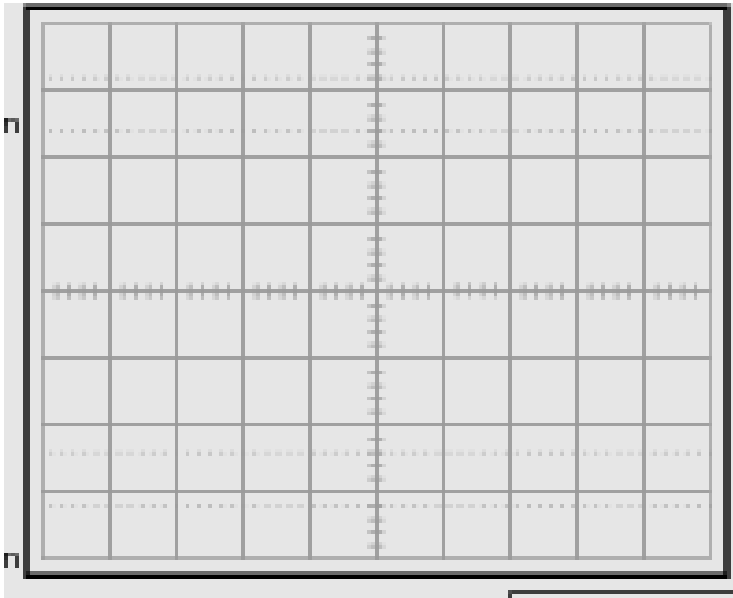# Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Step 58. Shut off the power.

Step 59. Understand Vavg is equal to the average voltage. The average voltage is what a DC meter reads.

Step 60. Find on your voltage waveform sketch (step 55) where the average voltage is based on your multimeter reading. Draw a line at that point on your sketched waveform.

Step 61. Redraw your sketch. Show the portion of the waveform where the capacitor is charging and discharging. Be sure to label clearly.

RIPPLE VOLTAGE

Step 61. Turn the power on.

Step 62. Put the oscilloscope on the AC setting. Make a waveform sketch.

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PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE   2/22/2016
VERSION   v 001
PAGE   18 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab
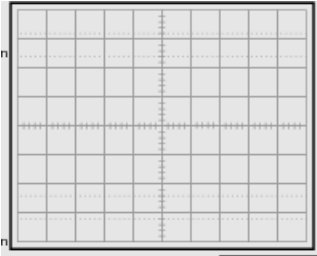
Volts per division _____

Number of divisions _____

Step 63. This is the ripple voltage. A perfect DC power supply would have zero volts ripple. How many volts peak-to-peak is your ripple voltage?

Vripple = _____

Step 64. To calculate the average voltage with a capacitor:

Vavg = peak pulsating DC voltage - (Vripple/2)

Your calculated Vavg = _____

Step 65. What should the PIV rating of your diodes be in this section of the lab?

PIV rating = _____

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Step 66. Answer the following questions.

1. If your full wave rectifier had an open diode, what would be the effect?

   a. No output. 0 volts
   b. similar to a half wave output with half the voltage
   c. No effect
   d. A sine wave equal to Vsecondary
   e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
   f. A blown fuse
   g. Pulsating DC voltage equal to value of peak pulsating DC voltage

2. If your full wave rectifier had a shorted diode, what would be the effect?

   a. No output. 0 volts
   b. similar to a half wave output with half the voltage
   c. No effect
   d. A sine wave equal to Vsecondary
   e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
   f. A blown fuse
   g. Pulsating DC voltage equal to value of peak pulsating DC voltage

3. If your full wave rectifier had a shorted capacitor, what would be the effect?

   a. No output. 0 volts
   b. similar to a half wave output with half the voltage
   c. No effect
   d. A sine wave equal to Vsecondary
   e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
   f. A blown fuse
   g. Pulsating DC voltage equal to value of peak pulsating DC voltage

4. If your full wave rectifier had an open capacitor, what would be the effect? a. No output. 0 volts

   a. similar to a half wave output with half the voltage
   b. No effect
   c. A sine wave equal to Vsecondary
   d. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
   e. A blown fuse
   f. Pulsating DC voltage equal to value of peak pulsating DC voltage

5. If your full wave rectifier had an open load, what would be the effect?

Multi-State
Advanced Manufacturing
Consortium
US DOL SPONSORED TAACCCT GRANT: TC23767
PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE 2/22/2016
VERSION v 001
PAGE 20 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

a. No output. 0 volts
b. similar to a half wave output with half the voltage
c. No effect
d. A sine wave equal to Vsecondary
e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
f. A blown fuse
g. Pulsating DC voltage equal to value of peak pulsating DC voltage

6. If your full wave rectifier had a shorted load, what would be the effect?

a. No output. 0 volts
b. similar to a half wave output with half the voltage
c. No effect
d. A sine wave equal to Vsecondary
e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
f. A blown fuse
g. Pulsating DC voltage equal to value of peak pulsating DC voltage

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

FULL WAVE BRIDGE RECTIFIER CIRCUIT

STEP 68. The Full Wave Bridge Rectifier circuit uses the complete secondary voltage of the transformer. Therefore, the following information should be copied from Step 3. of your Half Wave Rectifier circuit.

PART A: TRANSFORMER

Step 69. Sketch the transformer secondary voltage measured with an oscilloscope waveform. (copied from Step 3) Note: This is an AC voltage.
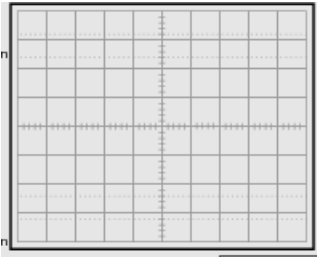
Voltage peak-to-peak _____

Volts per division knob setting _____

Number of divisions at that setting _____

Voltage peak _____

Transformer secondary measured with multi meter _____

Be sure to put the multimeter on AC volts. This voltage is RMS AC voltage.

Multi–State
Advanced Manufacturing
Consortium
US DOL SPONSORED TAACCCT GRANT: TC23767
PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE 2/22/2016
VERSION v 001
PAGE 22 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

PART B: TRANSFORMER WITH LOAD RESISTOR

Step 70. The Full Wave Bridge Rectifier circuit uses the complete secondary voltage of the transformer. Therefore, the following information should be copied from Step 6. of your Half Wave Rectifier circuit.
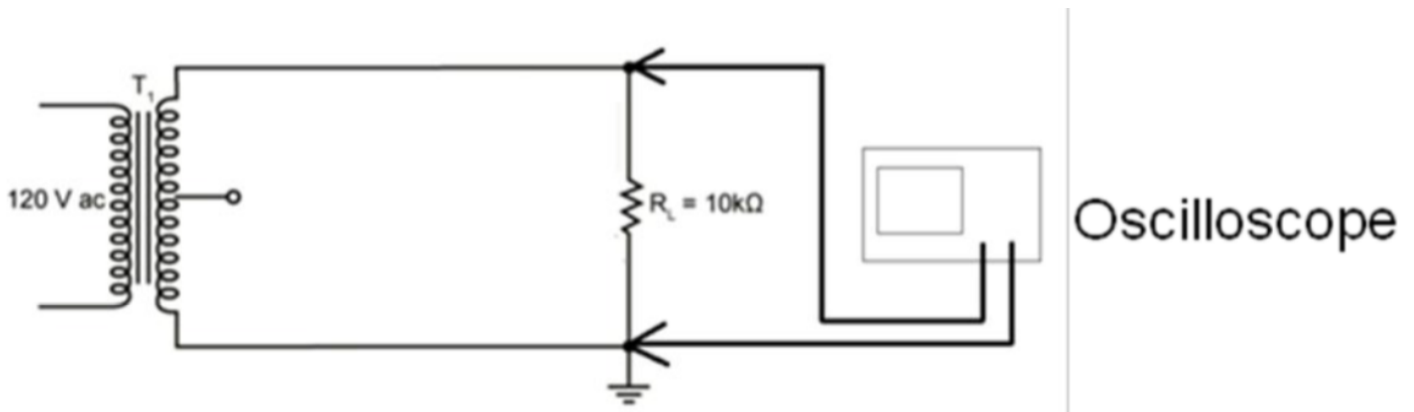
COPY FROM HALF WAVE RECTIFIER CIRCUIT

Step 71. (Copy from Step 6) Measure the AC voltage across the 10KΩ load resistor. Voltage across load resistor with oscilloscope

     V peak-to-peak _____

     V peak _____

     V RMS calculated = V peak / .707 = _____

     V RMS measured on multimeter = _____

     Make sure the multimeter is set to AC voltage.

BEGIN NEW MEASUREMENTS RELATED TO THE FULL WAVE BRIDGE RECTIFIER

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

PART C: RECTIFIER

Step 72. Place four diodes into the circuit as follows. Be sure to connect with the correct polarity. If you are not sure how this circuit is wired please ask for help.
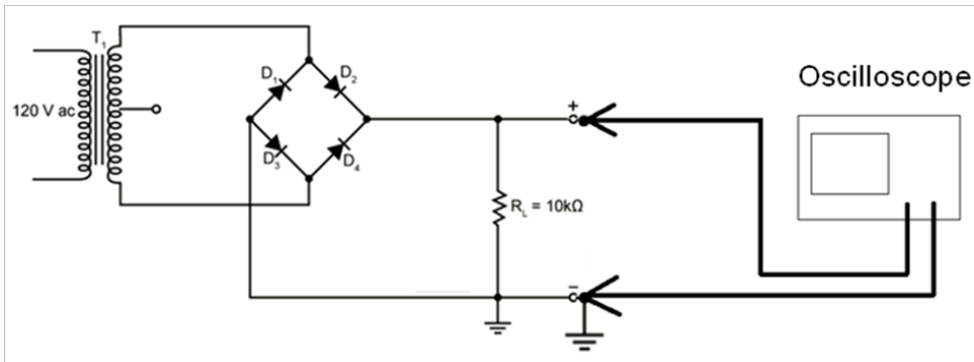
Step 73. Measure the voltage across load resistor with oscilloscope. This will be known as: peak pulsating DC voltage

Step 74. Draw the peak pulsating DC voltage waveform.
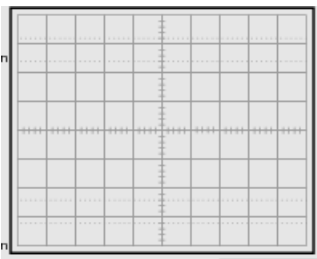
Volts per division knob setting _____

Number of divisions at that setting _____

Voltage peak _____

Step 75. Measure the Pulsating Voltage across the load with multimeter.

Vavg _____

Make sure the multimeter is set to DC voltage.

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RELEASE DATE   2/22/2016
VERSION   v 001
PAGE   24 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Step 76. Understand Vavg is equal to the average voltage. The average voltage is what a DC meter reads.

Step 77. Find on your voltage waveform sketch where the average voltage is. This is going to be equal to your multimeter reading. Draw a line at that point on your sketched waveform.

Step 78. To calculate the average voltage without a capacitor:

Vavg = 2 (peak pulsating DC voltage) / π

Your calculated Vavg = _____

Step 79. Understand there is a voltage across each diode at all times. If the diode is forward biased at that time, the voltage across it will be about .7 volts. If the diode is reverse biased at that time, it will have

Step 80. The output voltage across the load happens twice every 360o for a full wave Bridge rectifier circuit. The result of full wave bridge rectification is that the output voltage has a frequency two times the input frequency. The output pulses every half cycle of the input. Therefore, the frequency of the of the output is 120 Hz. The time required for this frequency is

1/f = 1/120hz = 8.333 mSec.

Measure the time it takes for one pulse of DC voltage. What is the frequency of the pulsating DC voltage you are measuring?

Measure the time of the peak positive alternation. What is the frequency of the pulsating DC voltage you are measuring?
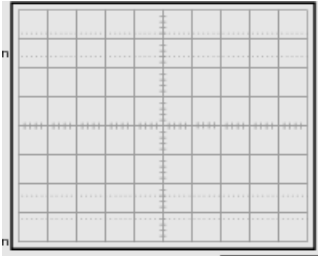
Time for 1 pulse of output voltage. T = _____

f = frequency of peak pulsating DC voltage = _____

Step 81. Re-Draw your pulsating DC output (from step 74). Show on your waveform where the diode is forward and reverse biased.
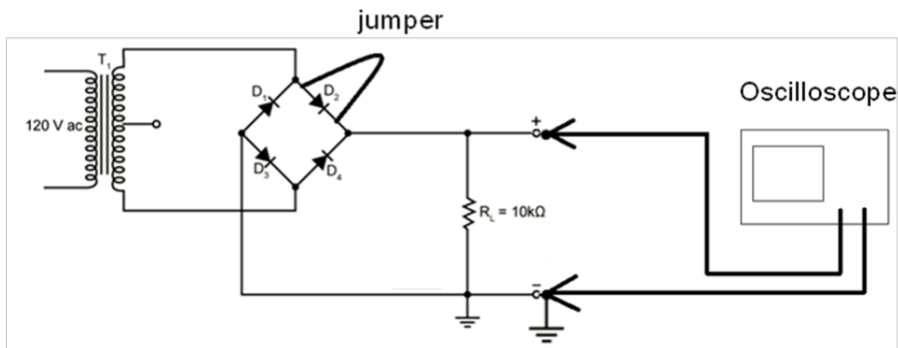
Solid State Electronics – Unit 5: Silicon Control Rectifier
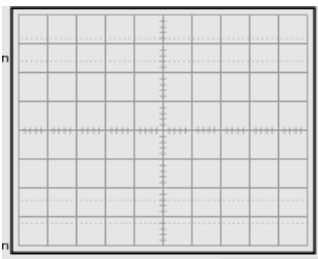### *DC Power Supply Lab*

Step 82. Shut off the power to your transformer.

Step 83. With the oscilloscope connected back across the load, short across one of the diodes with a small jumper wire. Turn the power on. This simulates a shorted diode.

Step 84. Draw the output you see on the oscilloscope.

Step 85. Shut off the power to your transformer.

Step 86. Remove the jumper wire and the diode. Leave the oscilloscope connected across the diode.

Step 87. Turn the power on.

Step 88. Draw the output you see on the oscilloscope. This simulates an open diode.

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US DOL SPONSORED TAACCCT GRANT: TC23767
PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE 2/22/2016
VERSION v 001
PAGE 26 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab
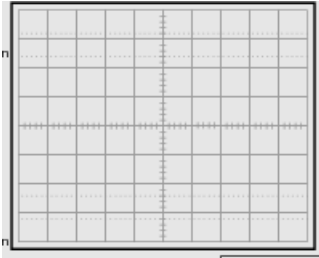
Step 89. Shut off the power to your transformer and place the diode back in the circuit.

PART D: FILTER CIRCUIT

Step 90. With the power off connect the capacitor across the load resistor (in parallel with the load resistor). Be sure to observe polarity.

Step 91. Turn the power on. Put the oscilloscope on the DC setting.
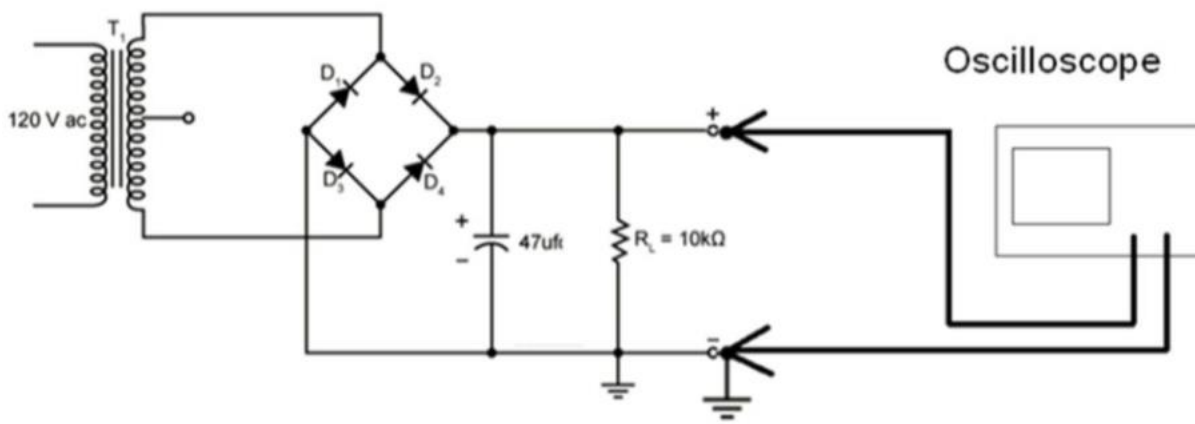
Step 92. Make a waveform sketch.

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PRIMARY DEVELOPER: Jim Blair – Henry Ford College

RELEASE DATE   2/22/2016
VERSION   v 001
PAGE   27 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Volts per division _____

Number of division's _____

Step 93. Measure the voltage across the load with multimeter.

Vavg _____

Make sure the multimeter is set to DC voltage.

Step 94. Understand Vavg is equal to the average voltage. The average voltage is what a DC meter reads.

Step 95. Find on your voltage waveform sketch where the average voltage is based on your multimeter reading. Draw a line at that point on your sketched waveform.

Step 96. Redraw your sketch (from step 92). Show the portion of the waveform where the capacitor is charging and discharging. Be sure to label clearly.
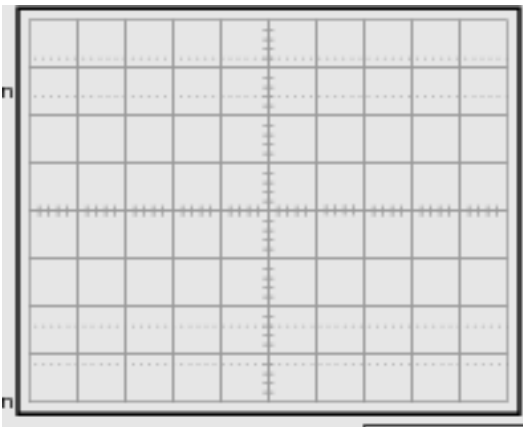
Step 97. Put the oscilloscope on the AC setting. Make a waveform sketch.

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab
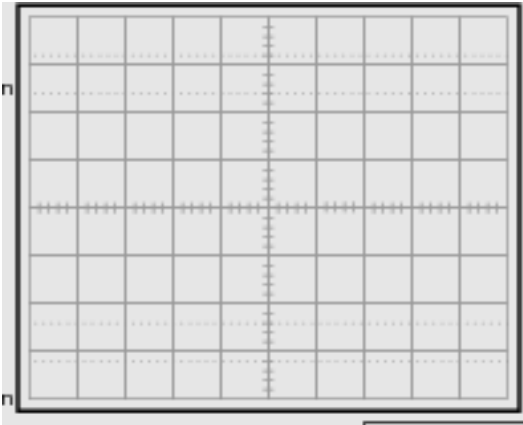
Volts per division _____

Number of division's _____

Step 98. This is the ripple voltage. A perfect DC power supply would have zero volts ripple. How many volts peak-to-peak is your ripple voltage.

Vripple = _____

Step 99. To calculate the average voltage with a capacitor:

Vavg = peak pulsating DC voltage - (Vripple/2)

Your calculated Vavg = _____

Step 100. What should the PIV rating of your diodes be in this section of the lab?

PIV rating = _____

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

Step 101. Answer the following questions.

1. If your full wave bridge rectifier had an open diode, what would be the effect?

    a. No output. 0 volts
    b. similar to a half wave output with half the voltage
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

2. If your full wave bridge rectifier had a shorted diode, what would be the effect?

    a. No output. 0 volts
    b. similar to a half wave output with half the voltage
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple. f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

3. If your full wave bridge rectifier had a shorted capacitor, what would be the effect?
    a. No output. 0 volts
    b. similar to a half wave output with half the voltage
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

4. If your full wave bridge rectifier had an open capacitor, what would be the effect?

    a. No output. 0 volts
    b. similar to a half wave output with half the voltage
    c. No effect
    d. A sine wave equal to Vsecondary
    e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
    f. A blown fuse
    g. Pulsating DC voltage equal to value of peak pulsating DC voltage

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab

5. If your full wave bridge rectifier had an open load, what would be the effect?

   a. No output. 0 volts
   b. similar to a half wave output with half the voltage
   c. No effect
   d. A sine wave equal to Vsecondary
   e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
   f. A blown fuse
   g. Pulsating DC voltage equal to value of peak pulsating DC voltage

6. If your full wave bridge rectifier had an shorted load, what would be the effect?

   a. No output. 0 volts
   b. similar to a half wave output with half the voltage
   c. No effect
   d. A sine wave equal to Vsecondary
   e. On a scope you would see a straight line equal to the value of peak pulsating DC voltage. No ripple.
   f. A blown fuse
   g. Pulsating DC voltage equal to value of peak pulsating DC voltage

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RELEASE DATE 2/22/2016
VERSION v 001
PAGE 31 of 31

Solid State Electronics – Unit 5: Silicon Control Rectifier
DC Power Supply Lab