Harris
Should have students look at output of diodes with scope to - however, it seems this is done by measuring A→C.

EEAP 243 Lab Work:
Lab 5 Questions Due:

DIODE CIRCUITS

READING ASSIGNMENT: Horowitz, pgs. 35-43, 187-194.

Abstract:
This laboratory will examine the application of diodes to practical power supply, clamping and switching circuits.

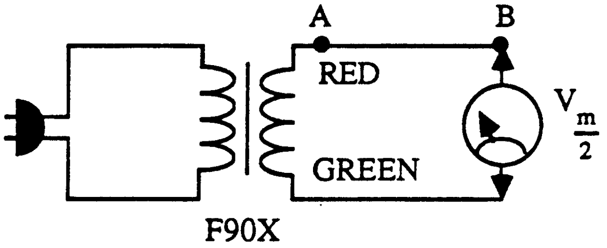
Part 1: Power supply circuits (do one only)

The fundamental component of a power supply is the transformer. We will measure the open and loaded output voltage of a transformer.

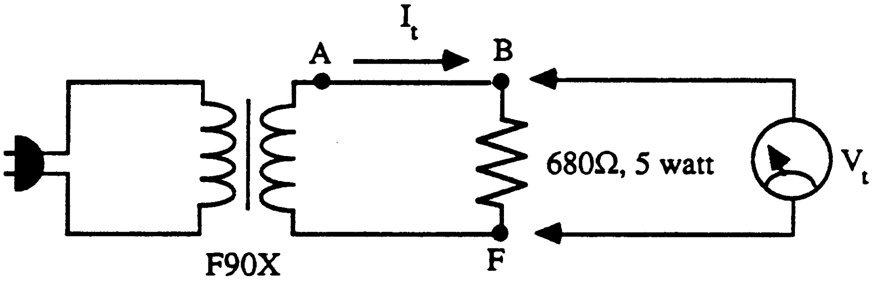
(1) Set the DMM to the 200 V AC scale, connect it to the transformer as shown in Fig.5.1 (a), and record $V_{m/2}$, the no load transformer voltage. Note that the color coding of the transformer secondary, shown explicitly in Figure 5.1 (a), indicates the transformer output voltage and is used to denote different connections such as a center tap.

(2) Connect the resistor as shown in Fig.5.1 (b) and measure V_t across the load.

(3) Remove the short circuit between A and B, connect the mA input of the DMM to A, connect the DMM COM input to B, set the meter to the 200 mA AC, and record I_t through the load.



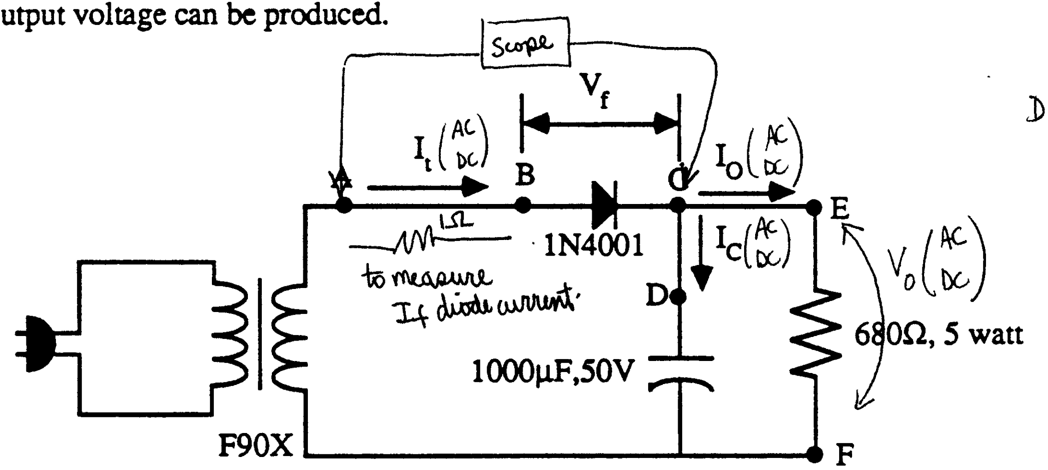
(a) measuring open circuit transformer voltage



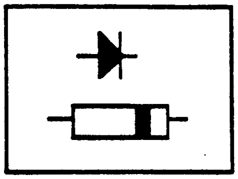
(b) measuring loaded transformer voltage and current

Figure 5.1 Measuring transformer characteristics

A single diode can be used to rectify the output from your transformer to create a simple power supply. Unfortunately, the output voltage is a pulsating dc. A capacitor will serve to remove most of this pulsation. From a time dependent viewpoint, the function of the capacitor is to store electrons when the diode output voltage is large and release electrons when the diode output voltage is low. The result is a reduction of the ac component, called ripple, of the output voltage. From the frequency domain viewpoint the capacitor (acting with the forward resistance of the diode and other circuit resistances) acts as a low-pass filter. By choosing the capacitor value to attenuate 60Hz and above a relatively constant dc output voltage can be produced.



Dmm.



diode labeling

Figure 5.2 Half-Wave Diode Rectifier Power Supply

(1) Build the circuit shown in Fig. 5.2, being careful of the polarity of the capacitor and diode. See the insert for the diode polarity.

WARNING: AN ELECTROLYTIC CAPACITOR CAN ONLY WITHSTAND VOLTAGE IN ONE DIRECTION. REVERSING YOUR CAPACITOR OR DIODE CAN CAUSE THE CAPACITOR TO EXPLODE! MAKE SURE THAT YOUR CIRCUIT IS CONNECTED PROPERLY BEFORE CONNECTING YOUR TRANSFORMER.

(2) Remove the short between A and B. Connect the mA input of the DMM to point A and the COM to point B. Set the DMM to the 200 mA AC scale, and record I_t AC through the transformer.

(3) Set the meter to DC, record I_t DC through the transformer, remove the meter, and short A to B.

(4) Remove the short between C and D. Connect the mA input of the DMM to point C and the COM to point D, set the meter to the 200 mA AC scale, and record I_c AC through the capacitor.

(5) Set the meter to DC, record I_cDC through the capacitor, remove the meter, and short C to D.

(6) Remove the short between C and E. Connect the mA input of the DMM to point C and the COM to point E, set the meter to the 200 mA AC scale, and record I_O AC through the load.

(7) Set the meter to DC, record I_O DC through the load, remove the meter, and short C to E.

(8) Set the meter to the 200 V AC scale, connect the DMM (VKS) to E and (COM) F, and record V_O AC across the load.

(9) Set the meter to DC, record V_O DC across the load, and remove the meter.

(10) Set the scope to 0.2 V/cm and DC coupling, connect the scope GND to A, connect CH1 input to C (instead of point C use point G for the circuits of Figures 5.3 and 5.4), and record the peak forward voltage V_f across the diode.

(11) Replace the short circuit between A and B with a 1 ohm resistor, connect the CH1 scope input to B, set the scope to 0.1 V/cm, record the peak voltage across the resistor (this is proportional to the forward current I_f through the diode), and remove the scope connections.

(12) Repeat steps 2 through 11 using the circuit shown in Fig. 5.3. Record your data in Table 5.2 using the full-wave bridge column.

(13) Repeat steps 2 through 11 using the circuit shown in Fig. 5.4. Record your data in Table 5.2 using the full-wave column.

do one only
Figure
5.2
5.3
or
5.4

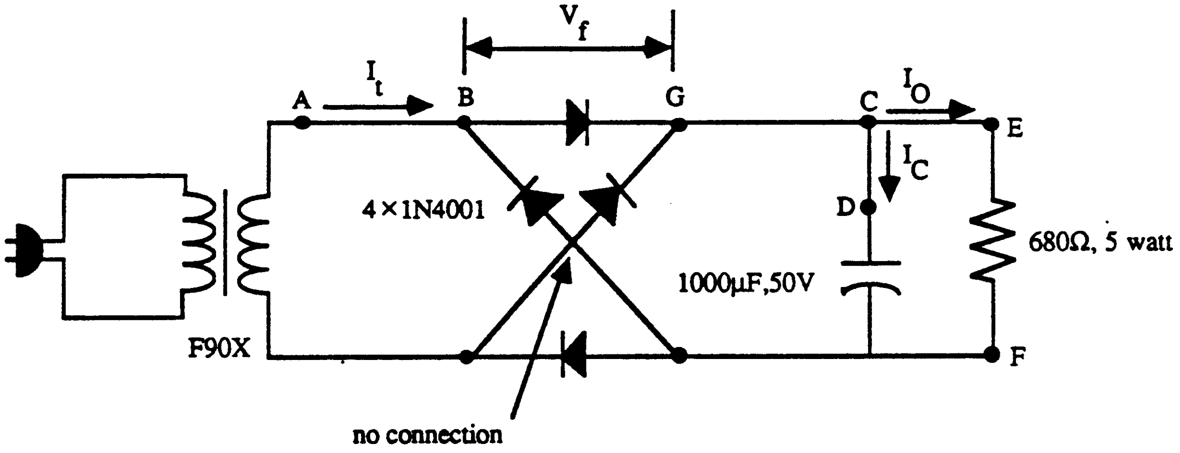


Figure 5.3 Full-wave Bridge Rectifier power supply

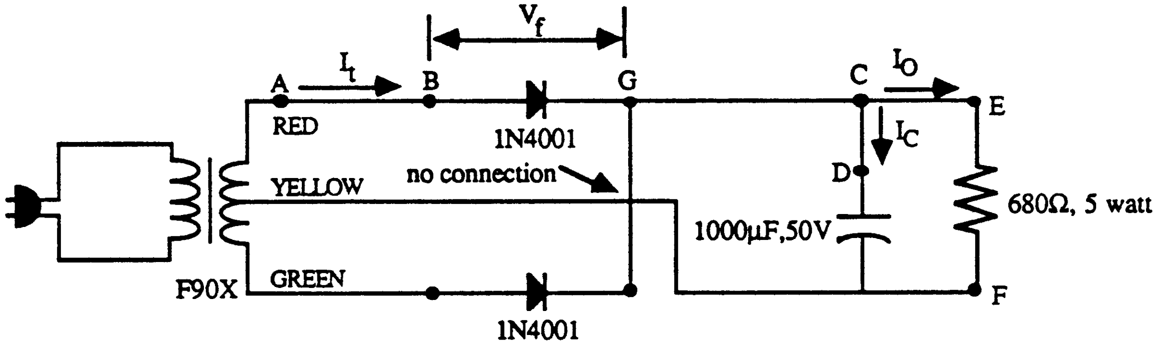


Figure 5.4 Full-wave rectifier power supply

PLEASE CALL A TEACHING ASSISTANT TO CHECK YOUR DATA BEFORE LEAVING

Part 2: Zener diode regulated power supply

A simple DC power supply is composed of 5 elements: the transformer, rectifier, filter and/or regulator, and load. You have just measured the characteristics of power supply transformers and commonly used rectifier and filter circuits. A load is normally just a resistance. In this section you will study the characteristics of filters and regulators. A power supply filter is often nothing more than a capacitor which stores electrons when the rectifier output voltage is high and releases them when the rectifier output voltage is low. This storing and releasing, or charging and discharging, increases the DC component of the signal going to the regulator and decreases its AC component. The AC component of the filter's output is called the "ripple" voltage and is often measured as a peak-to-peak quantity. It is usually small compared to the DC component of the filter's output, which is called the "unregulated" dc voltage. This unregulated voltage is measured from ground to the center of the ripple voltage and can change depending on the power supply's load current.

A voltage regulator produces a "regulated" DC voltage, one that is constant with a very small AC component. The regulator's output voltage is should be independent of the load current so long as the load current is less than the regulator's specified maximum. If the maximum current is exceeded, the DC output voltage will drop and the AC component of the output will increase. When this occurs, regulation is "lost".

You should keep five things in mind when working with these power supply circuits.
(1) The oscilloscope allows peak-to-peak measurements while the DMM reads in RMS volts.
(2) Always disconnect one of the transformer wires before attempting to modify your circuits. This will prevent you from accidentally damaging components.
(3) Your load resistors may get quite hot, so be careful.
(4) Transformer output voltages can vary by several percent over short periods of time because of line voltage fluctuations.
(5) Your filter capacitor can explode if you connect it, or your diodes, backwards.

It is sometimes possible to use an unregulated power supply circuit for your applications.
(1) Build the circuit shown in Fig.5.2 replacing the 680 ohm resistor by your RSB. Remove the CE jumper. Connect the scope GND and DMM COM to point F.
(2) Connect the DMM VKS input to point C. Measure and record in Table 5.3 the so-called no-load DC and AC (RMS) voltages at point C.

(3) Set the RSB to 6K and connect points C and E.
(4) Connect the scope CH1 input to point C. Record the AC waveform at point C in Figure 5.4.
(5) With the DMM still connected to point C, measure the DC and AC (RMS) voltages at point C. Record your results in Table 5.5.
(6) Repeat step 5 with RSB values of 3 K, 2 K, 1.5 K, 1.2 K, 800 ohms, and 600 ohms recording your results in Table 5.5.

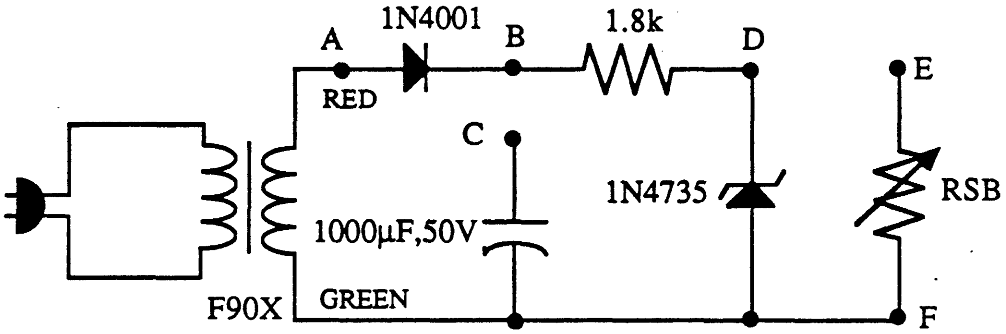


Figure 5.5 Zener diode regulated power supply

A zener diode and a current limiting resistor can be used as a simple voltage regulator.
(7) Build the circuit shown in Fig.5.5.
(8) Connect your scope CH1 input to point B. Connect your scope COM to point F. Measure the waveform at point B and record your results in Table 5.6. Connect your scope CH1 input to point D, measure the waveform at point D and record your results in Table 5.7.
(9) Connect points B and C.
(10) Connect your DMM (VKS) input to point B. Connect your DMM COM to point F. Record the DC and AC (RMS) voltages in Table 5.8. Connect your DMM (VKS) input to point D. Record the DC and AC (RMS) voltages in Table 5.8.
(11) Connect your scope CH1 input to point B. Measure and record the AC voltage at point B in Table 5.9.
(13) Set the RSB to 3.2k. Connect points D and E.

(14) Connect your DMM (VKS) input to point D. Connect your DMM COM to point F. Record the DC and AC (RMS) voltages in Table 5.10.

(15) Repeat step 14 with RSB values of 1.6 K, 1.1 K, 800, 700, 500, 300, and 100 ohms.

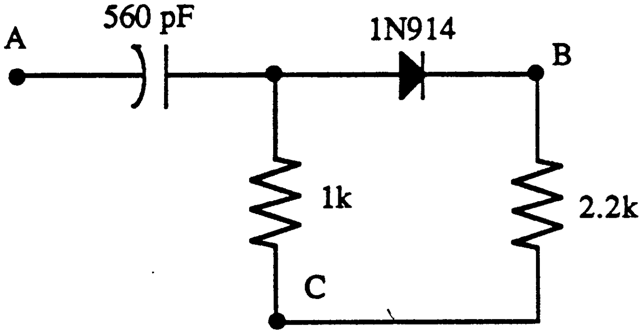


Figure 5.6 - Rectifying differentiator

PLEASE CALL A TEACHING ASSISTANT TO CHECK YOUR DATA BEFORE CONTINUING

Part 3 - Specialized diode circuits Explained in Section 1.30 of Horowitz (about p. 41)

~~Build the rectifying differentiator shown in Figure 5.6.~~

~~(1) Set your signal generator to 10 Vp-p, 0 volts dc offset at 10 kHz.~~

~~(2) Connect your generator OUT to point A. The generator common is connected to point C.~~

~~(3) Connect your oscilloscope CH1 input to point B. Record the waveform you see at point B in Table 5.11.~~

~~(4) Remove the 2.2k resistor. Record the waveform you see at point B in Table 5.12.~~

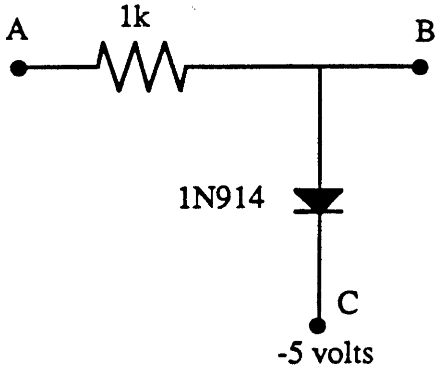


Figure 5.7 - ~~Rectifying differentiator~~ Voltage clamp.

(1) Build the circuit shown in Figure 5.7.

(2) Change the generator output to a $20V_{p-p}$ sine wave. You will use this setting for the rest of this part of the lab. Connect your generator output to point A. Note that the generator common is connected through the power supply to your circuit.

(3) Connect your scope's CH1 input to point B and record the waveform you see in Table 5.13.

(4) Modify the circuit to that shown in Figure 5.8.

Resistor Values ☆

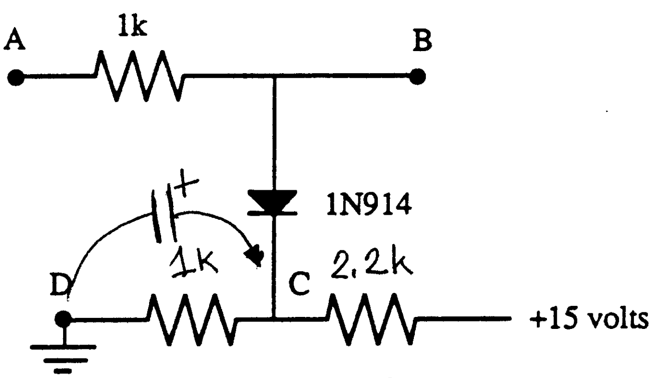


Figure 5.8

(5) With your scope's CH1 input still connected to point B and your generator still connected to point A record the waveform you see in Table 5.14.
(6) Connect a 10μF capacitor between points C and D. Be sure to connect the positive side of the capacitor to point C. Repeat step (5) recording your results in Table 5.15.

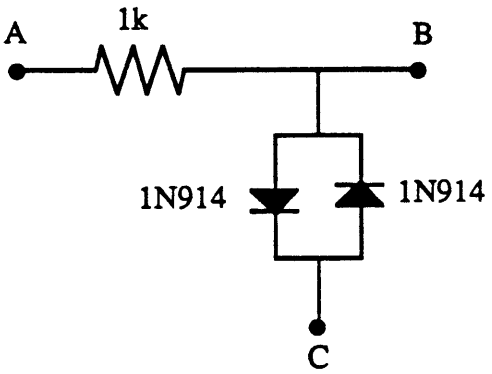


Figure 5.9

The final circuit we will examine is the diode limiter of Figure 5.9.

(1) Build the circuit shown in Figure 5.9.
(2) Adjust your signal generator to 0.5 volts p-p output (0 volts DC) at 1 kHz. Connect your signal generator output to point A. Connect the COM to point C.
(3) Connect your scope CH1 input to point B. Record the waveform you see at point B in Table 5.16
(3) Repeat step (3) for generator output voltages of 1.0,1.5,2.0 and 2.5 volts. Record your results in Table 5.16.

EEAP 243 LAB 5 EVALUATION

NAME (print)___________________________ CHECKPOINT #1 ___ DATE _____
GRADE _____/_____ CHECKPOINT #2 ___ DATE _____

With respect to the course material, this lab was: (pick one)
___ highly relevant ___ relevant ___ not relevant ___ completely irrelevant

This lab was: (pick one)
___ too long ___ long ___ just right ___ short ___ too short

This lab was: (pick one)
___ too hard ___ hard ___ just right ___ easy ___ too easy

The background material in the lab assignment was: (pick one)
___ too detailed ___ just right ___ sufficient ___ insufficient ___ totally inadequate

The step by step procedures in the lab assignment were: (pick one)
___ too detailed ___ just right ___ sufficient ___ insufficient ___ totally inadequate

Describe any mistakes made in the lab assignment.

Describe anything that just didn't work right.

Describe how this lab could be made better.

QUIZ

NOTE: THE TEACHING ASSISTANT IS TO SELECT BOTH QUESTIONS FROM THE UNDERLINED OPTIONS AT THE SECOND CHECKPOINT

Question #1

What will happen to the current through the zener diode in Fig. 5.2 if we connect B to C, connect D to E, and increase/decrease the resistance of the 1.8K/RSB?

It will increase / decrease / stay the same.

Question #2

What will happen to the ripple voltage across the filter capacitor in Fig. 5.3 if we connect C to D to E and increase/decrease the resistance of the potentiometer/120 ohm/15 ohm ?

It will increase / decrease / stay the same.

Questions:

1. Why is the loaded transformer voltage different than the unloaded voltage?
2. For the half-wave, full-wave and full-wave bridge rectifiers compare your measured values of V_O AC, I_O AC, and I_C DC to V_O DC, I_O DC, and I_C AC. Which rectifier circuit might be better and why?
3. What is the equivalent RMS voltage of your Table 5.4 waveform? What is the significance of this measurement?
4. For your results of Table 5.5
    - (a) Make a graph of the DC voltage across the load (RSB) versus the DC current through the load.
    - (b) Make a graph of the RMS AC voltage across the load versus the DC current through the load.
    - (c) Do power supplies exhibit output impedance? If so, what is the output impedance of your power supply?
5. (a) What is the breakdown voltage of the zener diode you used?
    - (b) Using the waveforms you recorded in Table 5.6 and Table 5.7, sketch the waveform across the 1.8 K resistor.
    - (c) Calculate the DC current flowing through the 1.8 K resistor from your part (b) results.
    - (d) Using these results, calculate the expected ripple voltage.

5.8
5.9

6. (a) Make a graph of the DC voltage across the load (RSB) versus the DC current through the load.
    - (b) Make a graph of the RMS AC voltage across the load versus the DC current through the load.
    - (c) What is the current through the zener diode?
    - (d) At what load current do your graphs indicate that regulation is "lost"?
    - (e) What is the current through the zener diode at this load current?
7. What is the role of the [redacted]k resistor in Figure 5.7? Explain the circuit operation. 1k
8. (a) Explain the waveform you recorded in Table 5.13.
    - (b) Explain the waveform you recorded in Table 5.14.
    - (c) Explain the waveform you recorded in Table 5.15.
    - (d) What are the necessary characteristics for the capacitor to behave as it did to achieve the results of Table 5.15?
9. Explain why the circuit of Figure 5.9 resulted in the performance you recorded in Table 5.16.

EEAP 243

NAMES: ____

Lab 5 Data

$V_{m/2}$ ____________________

V_t ____________________

I_t ____________________

Table 5.1 Basic transformer characteristics

	half-wave	full-wave bridge	full-wave
$I_{t,AC}$			
$I_{t,DC}$			
$I_{C,AC}$			
$I_{C,DC}$			
$I_{O,AC}$			
$I_{O,DC}$			
$V_{O,AC}$			
$V_{O,DC}$			
$V_{f,peak}$			
$I_{f,peak}$			

Table 5.2 - Rectifier circuit characteristics

AC no-load voltage ____________

DC no-load voltage ____________

Table 5.3

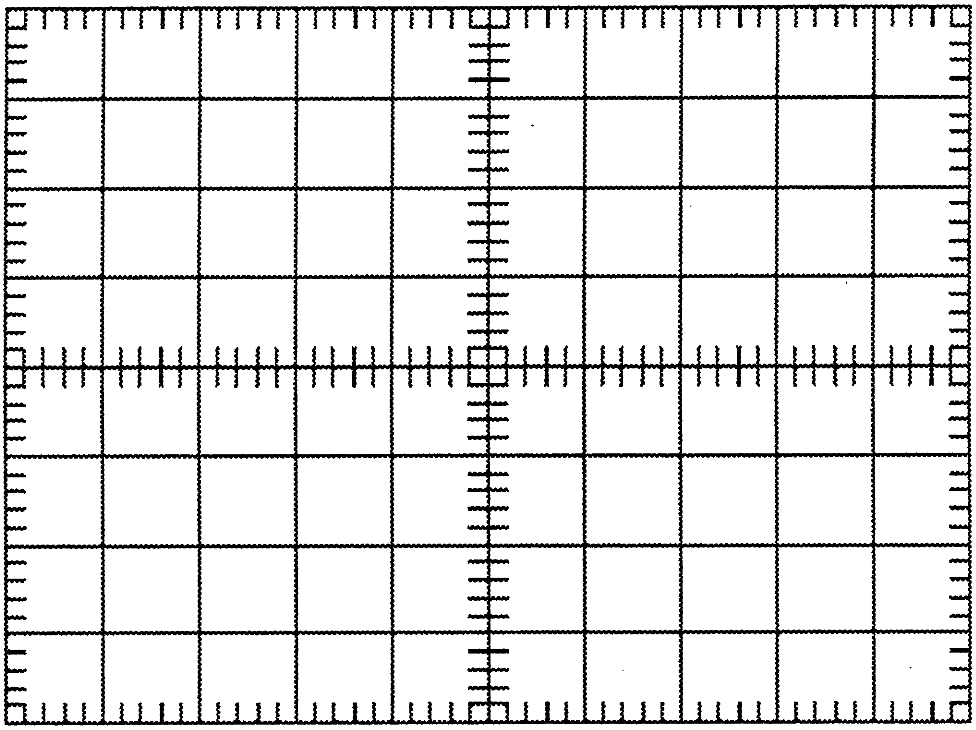


Table 5.4

Load resistance	DC voltage	AC(rms) voltage
6K		
3K		
2K		
1.5K		
1.2K		
800		
600		

Table 5.5

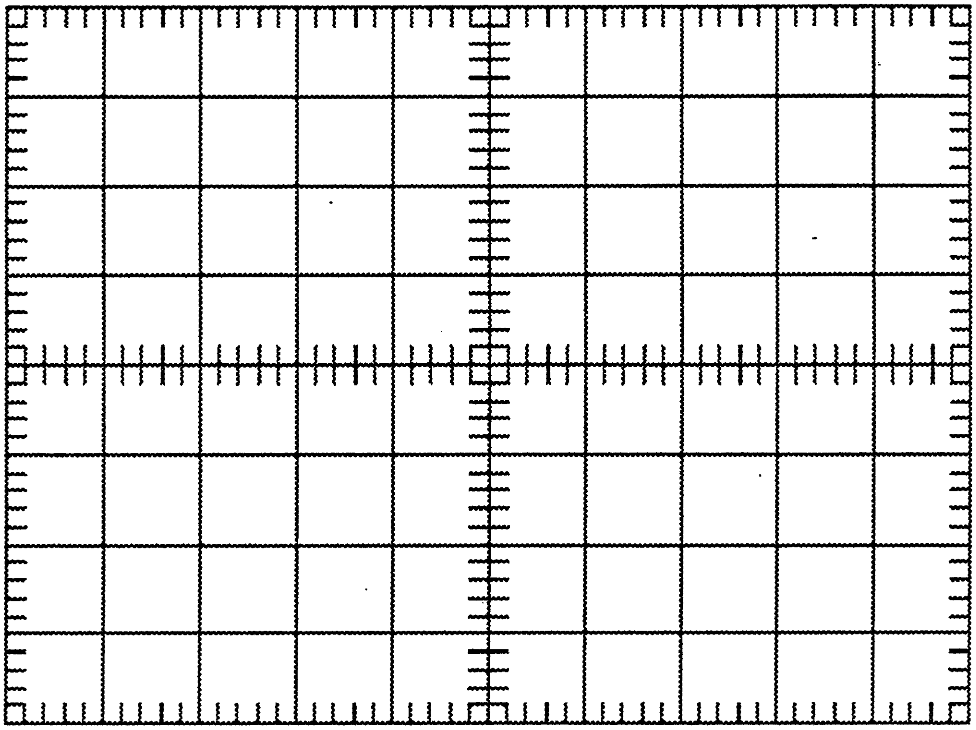


Table 5.6

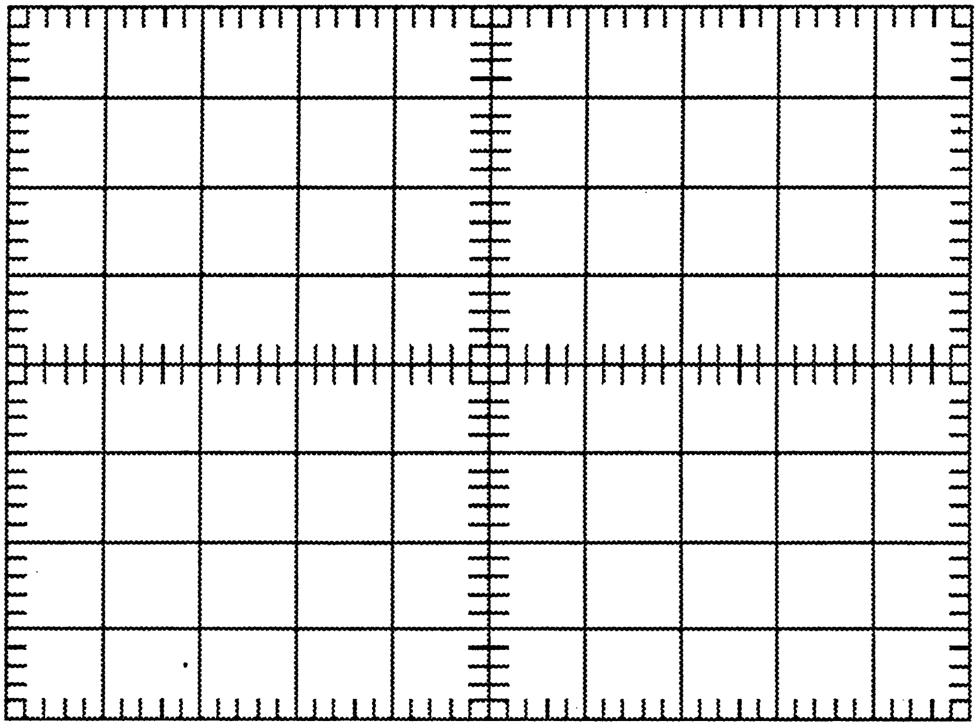


Table 5.7

AC no-load voltage ____________

DC no-load voltage ____________

Table 5.8

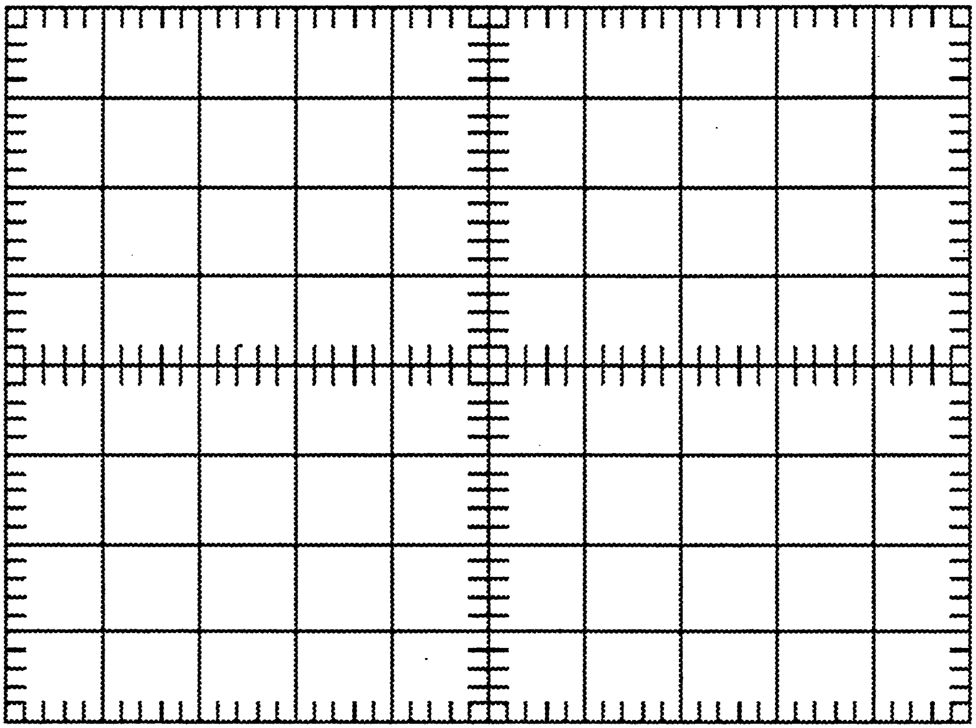


Table 5.9

Load resistance	DC voltage	AC(rms) voltage
3.2K		
1.6K		
1.1K		
800		
700		
500		
300		
100		

Table 5.10

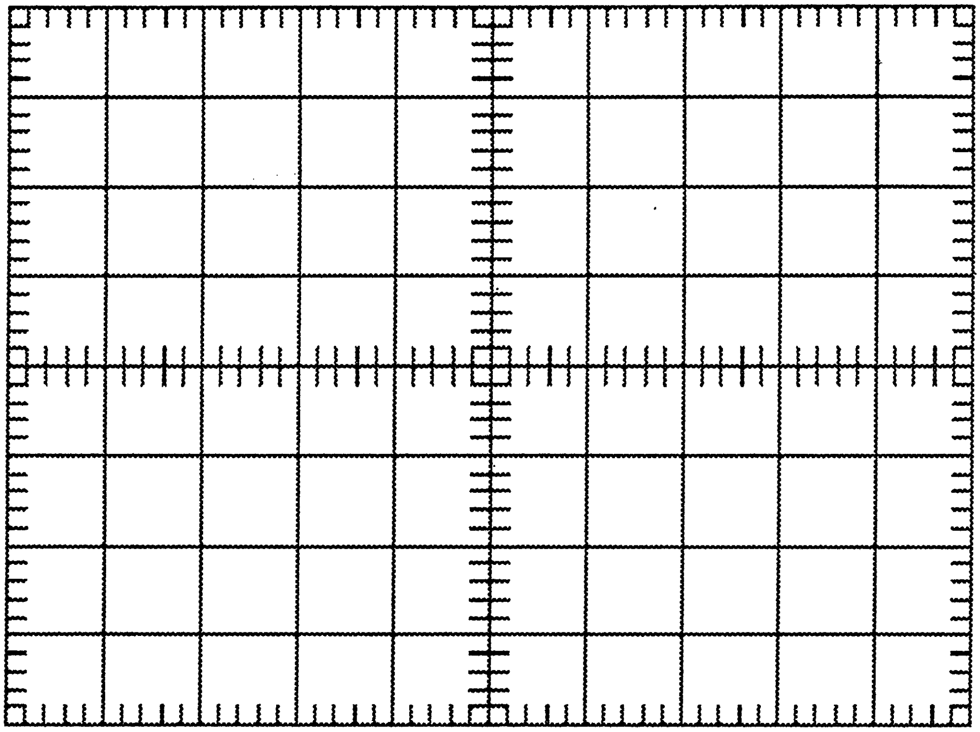


Table 5.11

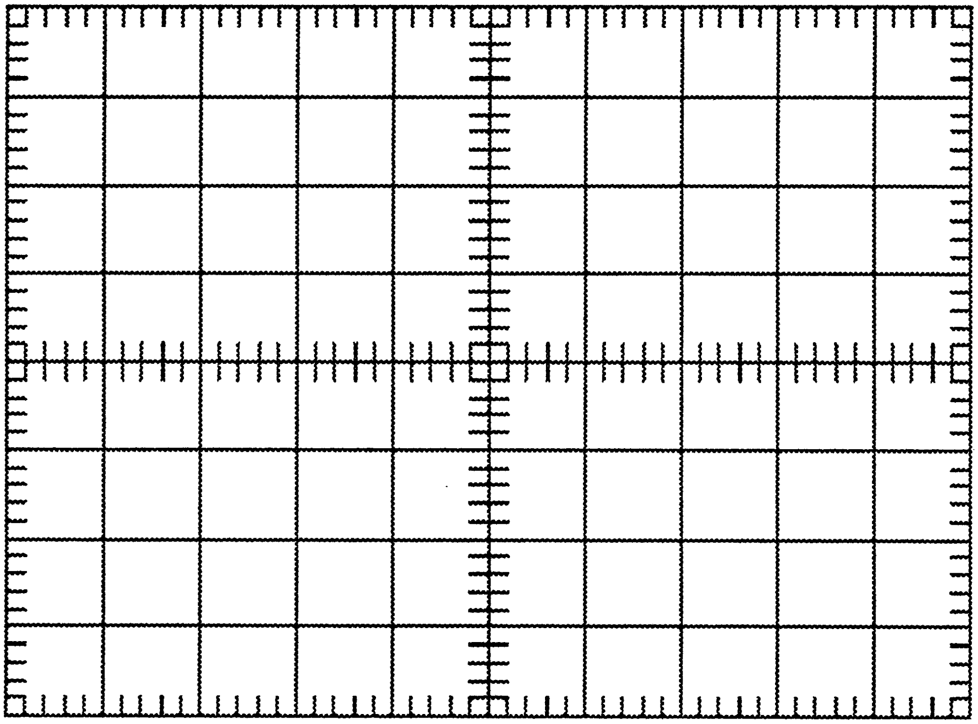
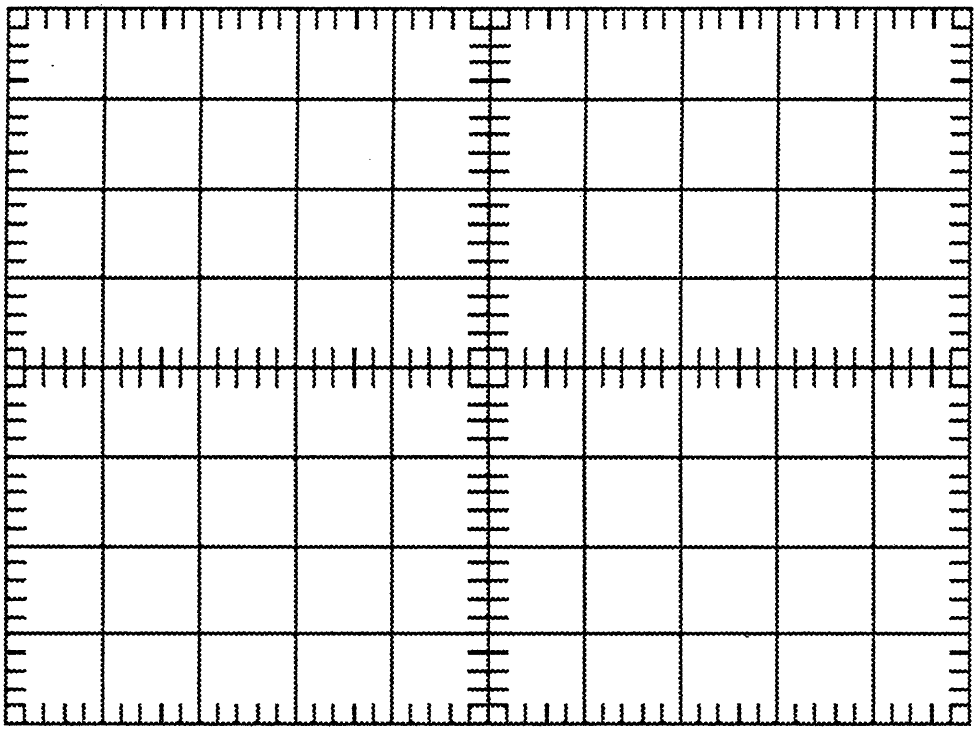


Table 5.12



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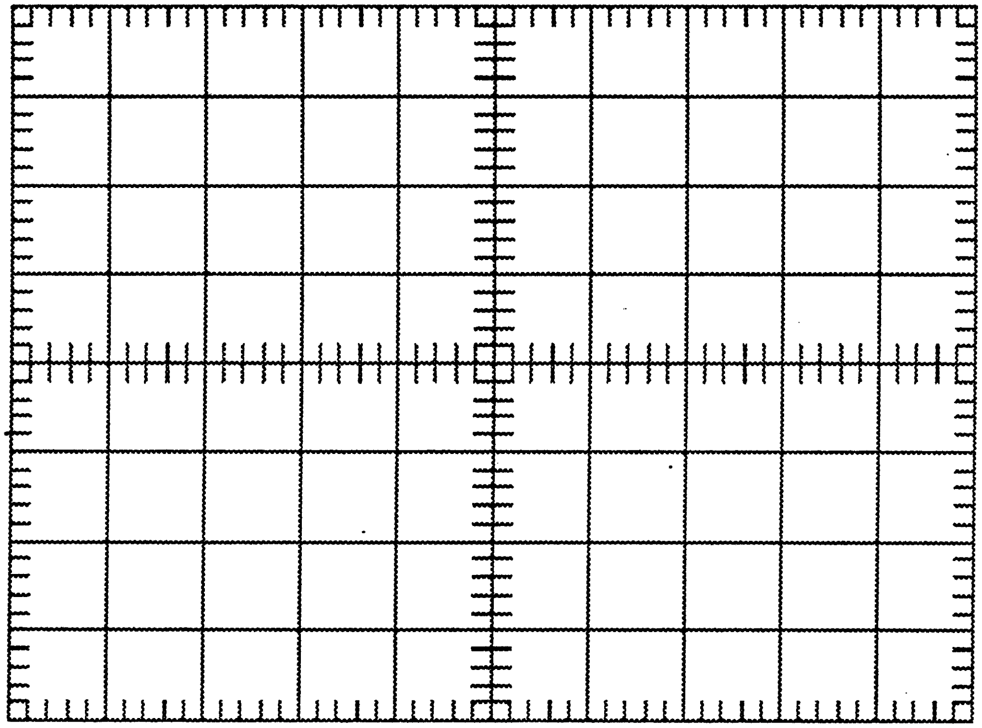

Table 5.14

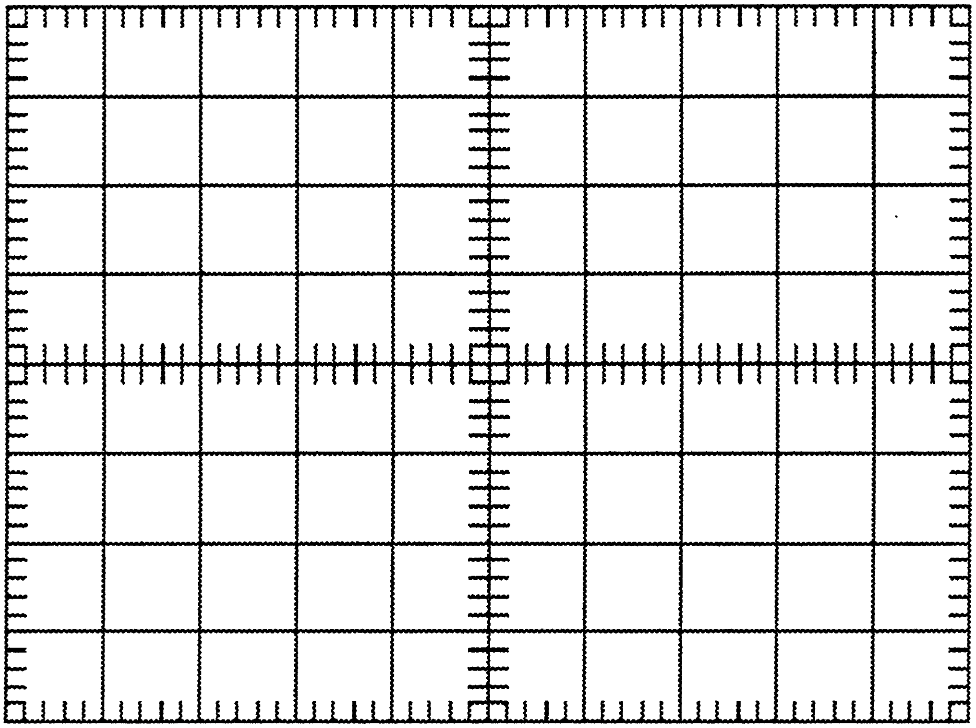

Table 5.15

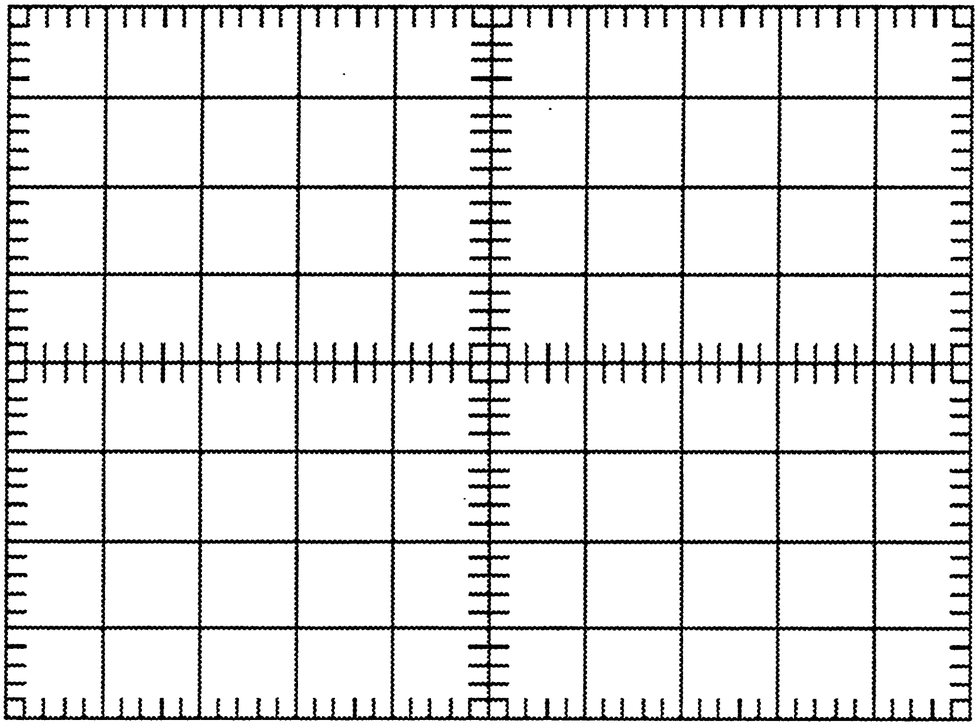

Table 5.16