EEAP 243
Lab 9

Lab Work:
Questions Due:

COMMON EMITTER AMPLIFIERS

READING ASSIGNMENT: Horowitz, pgs.50-53, 62-63, 65-71.

Abstract:
In this lab you will study two different transistor amplifier configurations and demonstrate the variability of the parameters β_{dc}, β_o, and r_π for commercial transistors.

NOTE: All of this lab must be done using the same transistor so that your test data will be consistent. You can avoid burning out your transistor by disconnecting both power supplies while making changes to the circuit. Disconnecting the supplies is more effective than turning off the DC POWER switch.

Part 1 - Common Emitter Measurement of β_{dc}, β_o, and r_π

The transistor parameters β_{dc}, β_o, and r_π vary widely with temperature, with collector current, and from component to component. This variation can easily be observed using a common emitter amplifier without an emitter resistor. In this configuration DC biasing is determined by β_{dc} and AC gain is determined by β_o and r_π. Because this configuration has a very high gain, you will be using a voltage divider to reduce the output of your signal generator by a known factor. You will be using relatively low V_{cc} and V_{ce} voltages to reduce the power dissipated by your transistor. More power dissipation would cause a rise in temperature, which would change its characteristics. You will use capacitors to "decouple" the power supplies on your breadboard to reduce the possibility of oscillation.

We NEED to teach students
how to TEST transistors and diodes!

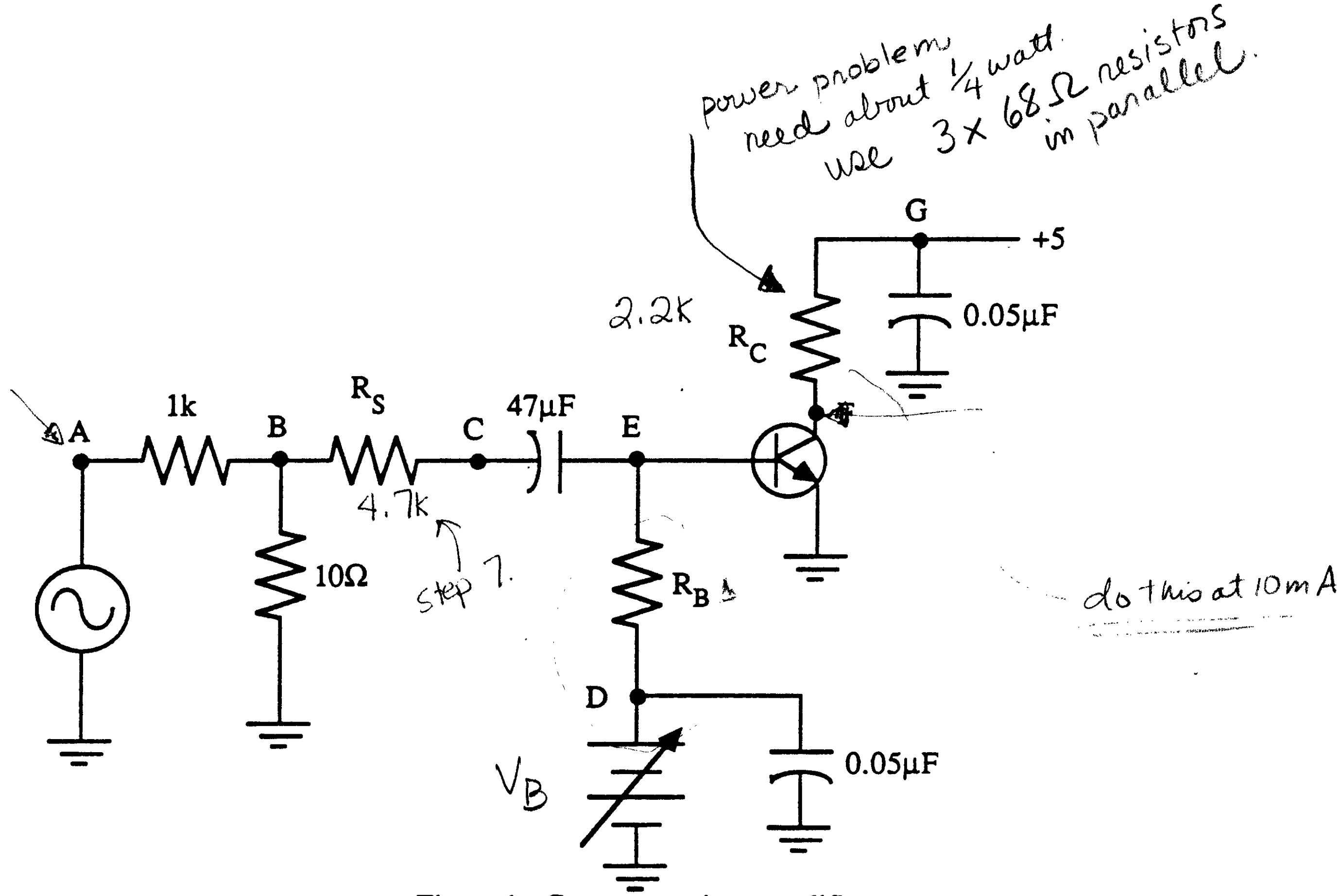

Figure 1 - Common emitter amplifier

(1) Build the circuit shown in Fig.1 using R_B = 100 K, R_S = 4.7 K, and R_C = 2.2 K. Points B and C should be shorted together. Connect your scope CH1 input to point A and CH2 to point F. Set the signal generator to a 10 KHz sine wave.
(2) Set the generator's AC amplitude to zero and adjust ~~the variable power supply~~ V_B so that the DC voltage at point F is approximately 2.80 V.
(3) Use the DMM to measure the exact DC voltages at points D, E, F, and G and record your results in Table 9.1.
(4) Increase the generator's AC amplitude so that the AC signal at point F is approximately 200 $mV_{p\text{-}p}$.
(5) Using your scope measure the exact AC peak-to-peak voltages at points A (C) and F. Record your results in Table 9.1 Circuit 1
(6) Remove the short circuit between points B and C.
(7) Measure the new peak-to-peak voltage at point F.
(8) Perform steps 1 through 7 for a second time with R_B = 10 K, R_S = 47 ohms, and R_C = 22 ohms. Record your results in Table 9.2 — circuit 2.

Part 2 - Common Emitter Amplifier Distortion

You saw in part 1 that the parameter β_o depends on the transistor's ~~DC collector current~~ actually its operating point. The instantaneous value of βo also depends on the transistor's instantaneous collector current. If the collector current varies over too wide a range in amplifying a signal, it is possible to get nonlinear amplification (distortion) due to the changing value of βo.

(1) Rebuild the circuit shown in Fig.1 using R_B = 100 K and R_C = 2.2 K. Points B and C should be short circuited (together). Connect scope CH1 to point A and CH2 to point F. Set the signal generator to a 10 KHz triangle wave. Adjust V_B so that the potential at point F is 2.5 VDC

(2) Adjust the variable power supply and the generator's AC amplitude in combination so that you have a 4 Vp-p signal at point F which goes between 0.5 V and 4.5 V.
(3) Measure the peak-to-peak voltage at point A. Record the waveform at point F in Table 9.3.
(4) Adjust the scale factor and sensitivity of CH1 so that both waveforms have the same amplitude on the oscilloscope screen and invert CH2.
(5) Change the display mode to ADD and record the resulting waveform in Table 9.4. Set the mode back to DUAL and set CH1's sensitivity back to its calibrated position.

PLEASE CALL A TEACHING ASSISTANT TO CHECK YOUR DATA BEFORE CONTINUING

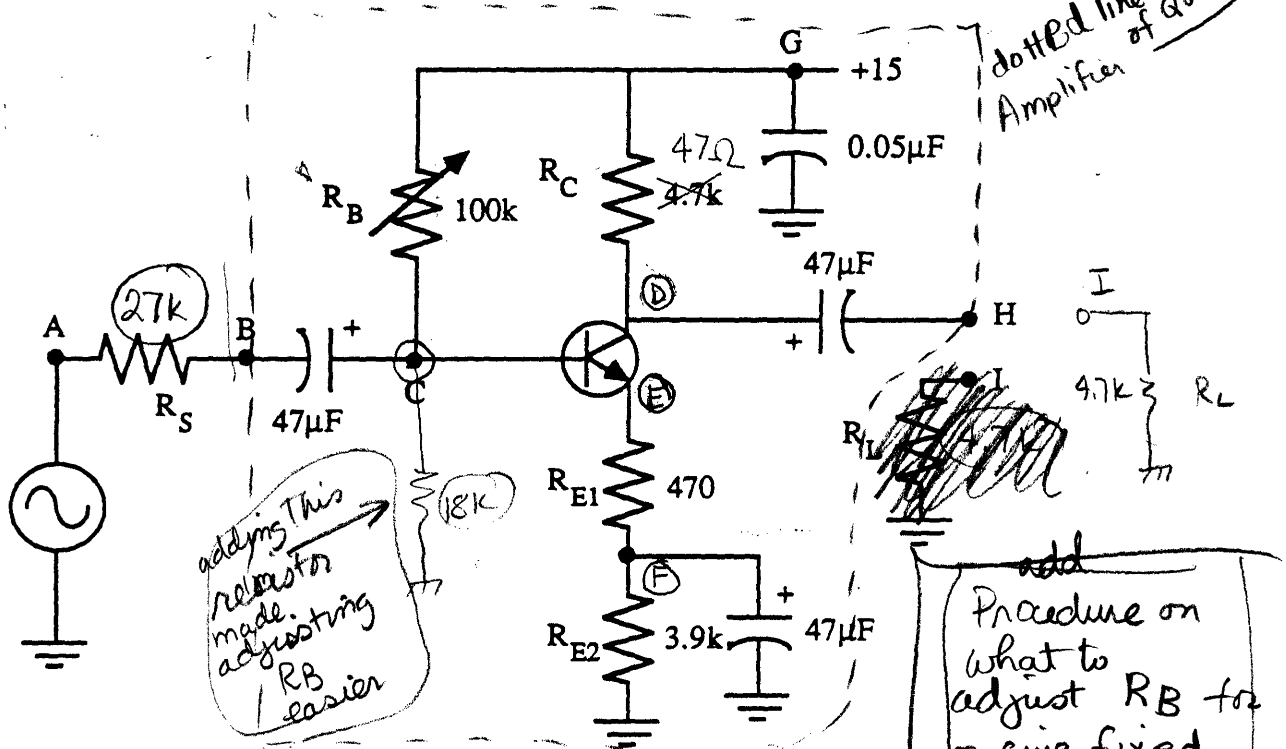

Figure 2 - Common emitter amplifier with split emitter resistor

Part 3 - Common Emitter Amplifier with Split Emitter Resistor

The effects of β_{dc}, β_o, and r_π can be largely eliminated by including a resistor from the emitter to ground. By using a capacitor to bypass part of this resistance to ground, an amplifier can be built which has a very stable gain and operating point.

(1) Build the circuit shown in Fig.2. Points A and B should be shorted together and points H and I should not be connected to anything. Connect the scope CH1 input to point A.
~~(2) Adjust the signal generator for a 0.5 Vp-p 10 KHz triangle wave with zero DC offset.~~
(3) Use the DMM to measure the exact DC voltages at points C, D, E, F, and G. Record your measurements in Table 9.5.
(4) Increase the generator's AC amplitude so that the signal at point A is approximately 0.5 Vp-p.
(5) Measure the exact rms and peak-to-peak voltages at points A, C, E, F, and H. Record your results in Table 9.5.

(6) Connect points H and I together and measure the new rms and peak-to-peak voltage at point H.
(7) Remove the short circuits between points A and B and points H and I.
(8) Measure the new RMS and peak-to-peak voltages at point H.
(9) Record the maximum and minimum voltages at point D (the waveform peaks) for signals at point A of 1 V_{p-p}, 2 V_{p-p}, 3 V_{p-p}, and 4 V_{p-p}. Record these waveforms in Table 9.6-9.8.

9.6 9.7 9.8 9.9

PLEASE CALL A TEACHING ASSISTANT TO CHECK YOUR DATA BEFORE LEAVING.

Vin	Rs	RL	A	C	D	E	F	H	Comments
			~~AC | DC~~	~~AC | DC~~	~~AC | DC~~	~~AC | DC~~	~~AC | DC~~	~~AC | DC~~	
0	0	∞			X				DC meas ~~AC meas~~ rms/p-p
500mVpp	0	∞			X				AC measure rms/p-p
500mV	0	4.7K			X				rms/p-p
500mV	27K	∞			X				rms/p-p
[struck out]									
1			X	X		X	X	X	waveform peaks.
2			X	X		X	X	X	
3			X	X		X	X	X	
4			X	X		X	X	X	

Most students did not have background to understand questions.

Questions:

1. Calculate the following parameters for ~~both circuits~~ the circuit of Figure 1. (for both $R_S = 0$ and $R_S = 4.7K$.)
   - (a) A_v (F/B) in step 5,
   - (b) A_v (F/B) in step 7,
   - (c) β_{DC},
   - (d) β_{AC}, (use $\frac{\Delta I_c}{\Delta I_b}$ from measurements)
   - (e) r_π, and
   - (f) the theoretical r_π (i.e. $.026/I_B$ in amps.) — where does this come from $\beta = g_m r_\pi$; $g_m = \frac{I_c}{25mA}$

(too long — these questions need to be explained better)

2. (a) Calculate the expected voltage at point F based on your measured voltage at point A and your values for β_o and r_π from ~~part 1~~ Question #1.
   - (b) How does the expected value compare with what you measured?
   - (c) Why is the output waveform distorted? (see Part 2)
   - (d) What was displayed when you added the waveforms?

3. Your "amplifier" is defined by the dotted line in Fig.2. (part 3)
   - (a) Use your results from ~~part 2~~ Question #1 (not your data from ~~this part~~) to calculate (what) A_v, I_c, Z_i, and Z_o should be. i.e. use r_π, β_{AC}, etc.
   - (b) Calculate A_v, I_c, Z_i, and Z_o using your data from ~~this part~~ part #3.
   - (c) Explain any differences between (a) and (b).
   - (d) Suppose that β_{dc} and β_o were to increase by a factor of 4 and that r_π were to become zero. Calculate the percent change in A_v, I_c, Z_i, and Z_o that would occur.
   - (e) Calculate the overall voltage gain that would result if two of these amplifiers were cascaded. (question is not clear what cascading means.)

(too long.)

4. (a) Sketch the waveform at D (4 V_{p-p} input) and indicate the periods of saturation and cutoff.
   - (b) What was the DC voltage from collector to ground during cutoff?
   - (c) Can the collector voltage be greater than V_{cc}?
   - (d) What was the DC voltage from collector to ground during saturation?
   - (e) Can the collector voltage be less than the emitter voltage?

$\frac{V_{OUT}}{V_{IN}} =$

generate the equations and get values for Vout) $A_V = \left(-\frac{R_L}{R_{E1}}\right)$

This homework was TOO Long.

EEAP 243 LAB 9 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 collector current of Q3 in Fig. 9.2 if we increase/decrease the resistance of $R_8/R_9/R_{10}$?

It will increase / decrease / stay the same.

Question #2

What will happen to the gain from point D to point G in Fig. 9.3 if we increase/decrease the resistance of $R_4/R_5/R_6/R_7/R_{18}$?

It will increase / decrease / stay the same.

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NAMES: ____

Lab 9 Data

	$R_S=0$		$R_S=4.7k$	
	DC voltage	AC voltage (p-p)	DC voltage	AC voltage (p-p)
D				
E				
F				
G				

Table 9.1

	$R_S=0$		$R_S=4.7k$	
	DC voltage	AC voltage (p-p)	DC voltage	AC voltage (p-p)
D				
E				
F				
G				

Table 9.2

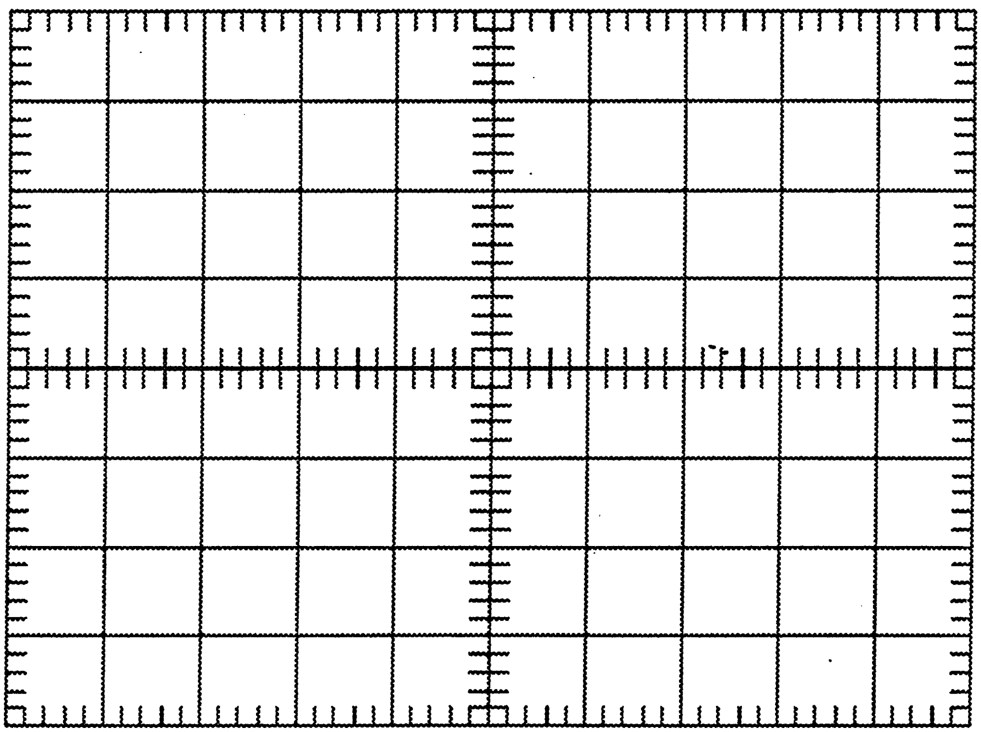

Table 9.3

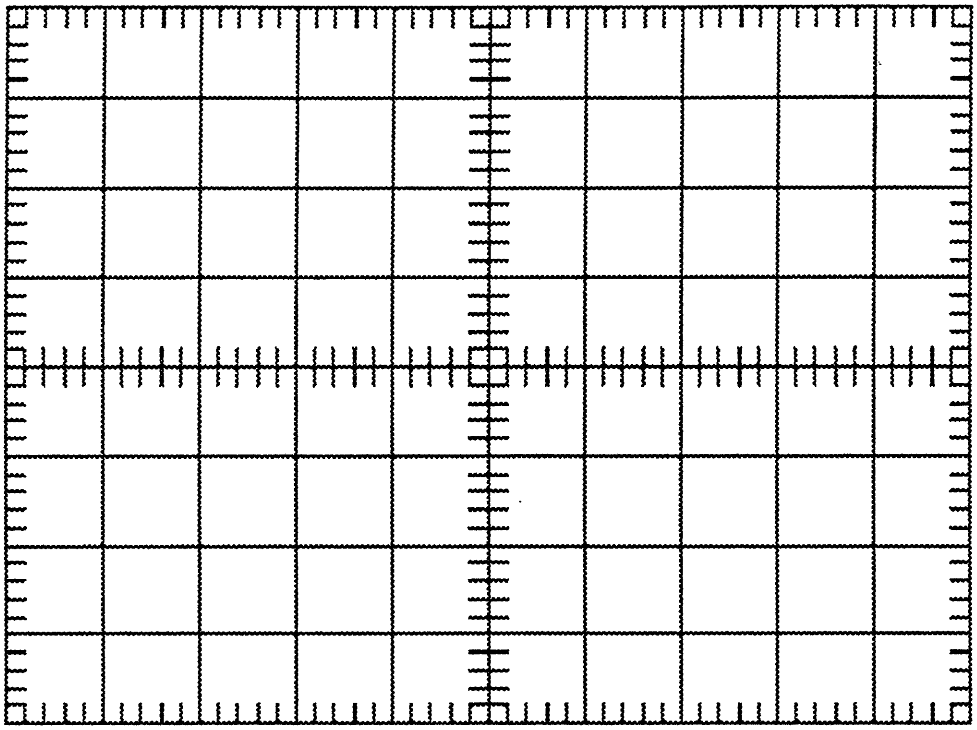

Table 9.4

	R_S=4.7k		
	DC voltage	AC voltage (p-p)	AC voltage (rms)
A		______	______
C	______	______	______
D	______		
E	______	______	______
F	______	______	______
G	______		
H (HI open & AB shorted)	______	______	
H (HI & AB shorted)	______	______	
H (HI & AB open)	______	______	

Table 9.5

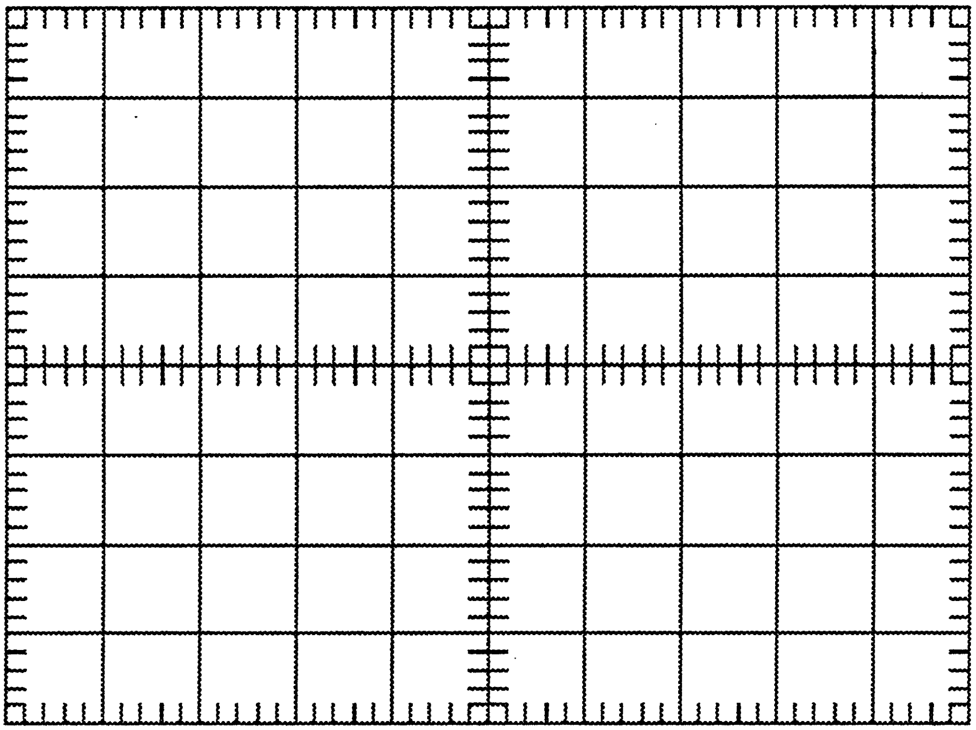

Table 9.6

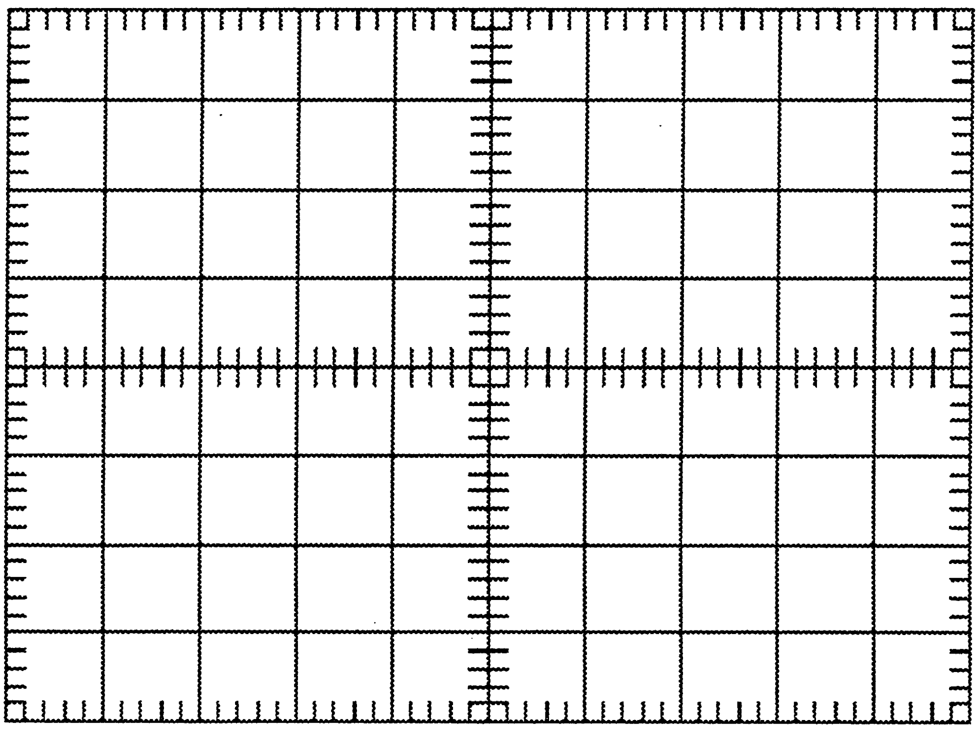

Table 9.7

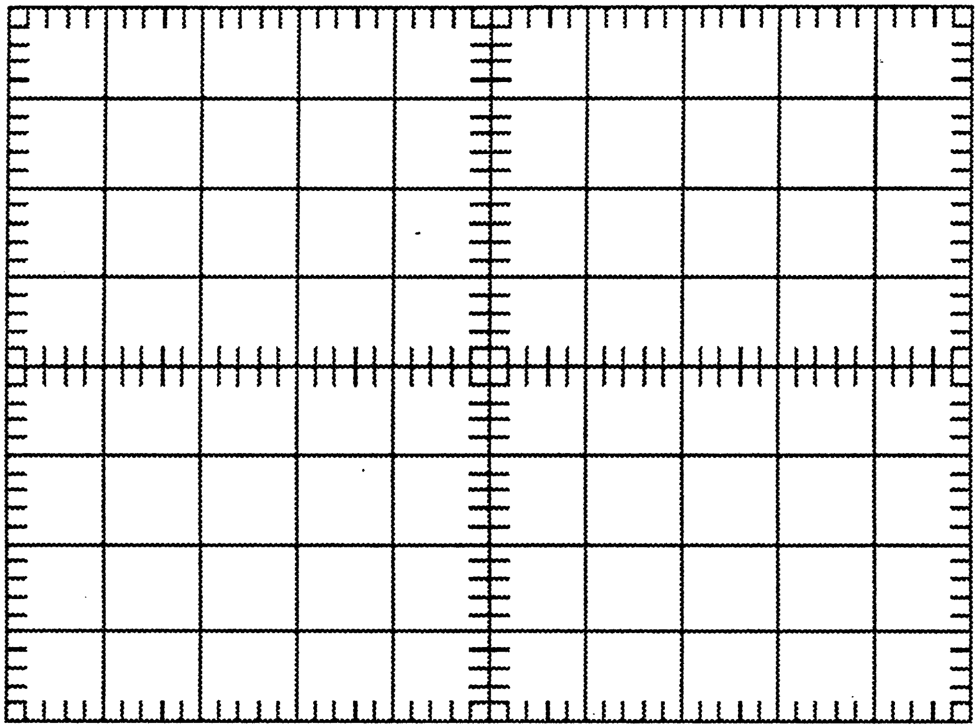

Table 9.8