TODAY'S ELECTRONICS

INSTRUCTOR GUIDE

GLOBAL SPECIALTIES

Global Specialties
22820 Savi Ranch Parkway
Yorba Linda, CA 92887
800-572-1028

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INTRODUCTION

Today's Electronics, Module 1, by Joseph G. Sloop, is a hands-on, practical basic electronics course with a complete hardware package that includes an analog circuit trainer (ACT-1), various circuit components, and circuit templates.

The course, designed for high-school level students, provides all the necessary skills and knowledge for graduates to function as competent electronic technicians in industry.

Each chapter includes hands-on experience using the ACT-1 to reinforce theoretical concepts, and studentswork with equipment and learn techniques comparable to those commonly used and practiced in industry.

In general, Chapters 1 through 13 cover basic circuit theory and components; and Chapters 14 through 17 cover basic electronics citcuits and solid-state devices.

This manual includes:

1. Typical answers for the experimental procedures. Individual student answers probably may differ depending on component tolerances and equipment differences. However, answers should be within normal tolerances of the equipment and components and follow the same basic patterns.

2. Answers to the self evaluation questions. Most questions are simple straight-forward. Others may require some amount of research, knowledge gained in prior exercise, and just plain thinking will be required. We have used this problem solving method in an effort to get the student to think about the lab measurements and draw logical conclusions from them.

3. Hints to the instructor on use of supplementary materials, equipment, projects, etc.

The text contains both text materials and laboratory exercises. Most of the exercises are short and cover a single concept. And materials are arranged in a logical, need-to-know sequence. This allows the student to work at a self-paced schedule. And, since the theory is included with the lab exercises, no other textbook is necessary. But, because of the limited space available in any elementary text of this type the instructor may want to provide additional instruction via lecture, hand-outs, or supplementary textbooks. However, using this text alone, the beginning student should upon completion of the unit, have gained a good fundamental understanding of basic electricity and electronics. We feel that the text and the ACT-1 make a unique combination of hardware and software created to give the student a successful experience in electricity/electronics. It is a unit that allows compact storage, portability where desired, and versatile enough to provide a basis for further use in advanced courses and experimentation.

COURSE OUTLINE

Prerequisites: NONE

Length of course: Course length will vary, from one quarter to two quarters or semesters, depending upon the depth of additional materials presented via lecture, demonstration, outside research, etc. Course length may also vary due to student ages/grade levels. Naturally, a higher grade level class can cover the material in a shorter time. Ideal time would be one quarter or semester for each section for a total of two quarters or two semesters. However, if the goal is to quickly acquaint the student with only the relevant material, a higher level student could conceivably complete the course in one intense quarter.

Chapter 1.
ACT-1 Familiarization

A. An overview of the ACT-1, and its features.

B. A discussion on electrical safety precautions and procedures.

Chapter 2.
OHM'S LAW FUNDAMENTALS: Experiments prove circuits theorems laws, teach schematic diagrams, wiring, component recognition, and the use of test equipment.

A. Resistor identification and specifications.

B. Using an ohmmeter

C. Variable resistors

D. Series resistive circuits

E. Using a current meter

F. Current flow in a series circuit

G. Using a voltmeter

H. Voltage behavior in a series circuit

I. Parallel resistive circuits

J. Current flow in a parallel circuit

K. Voltage behavior in a parallel circuit

L. Power calculations

M. Voltmeter "loading"

Chapter 8.
Inductance: A group of experiments teach identification, specifications, inductor use, theory and behavior.

A. Identification and specifications

B. Inductive reactance

C. Inductances in series and parallel

Chapter 9.
Phase Shift: Experiments that show the effects of capacitance and inductance on the phase relationships between voltage and current.

A. Resistor-capacitor phase shift

B. Resistor-inductor phase shift

Chapter 10.
Impedance: An experiment demonstrates that capacitors and inductors oppose AC current flow. Calculations are done by trig and vector analysis. Results are shown via experimental circuit and oscilloscope waveforms.

Chapter 11
Resonant Circuits: Two experiments that show voltage, current, phase shift, and impedance relationships in tuned circuits.

A. Series tuned circuit

B. Parallel tuned circuit

Chapter 12.
Transformers: An exercise shows the student the types, uses, theory of operation, and testing of transformers.

Chapter 13.
Simple Power Supplies: A group of experiments to show how simple components are put together to build a power supply. Rectifiers and zener diodes are introduced.

A. Identification, testing, and specifications of diodes.

B. A diode used as a full- and half-wave rectifier.

C. A capacitor used as a filter.

D. A zener diode regulator.

Chapter 17.

Power Control Circuits: Two experiments teach the more modern methods of controlling power. The SCR and the transistor are used as power controllers.

A. SCR power control

B. Triac Power Control

C. Transistor power control

SKILLS INVENTORY

The following listing of skills provide a checklist of job-related competencies attainable by students using the ACT-1 and Today's Electronics Module I.

Most of the skills listed are necessary for the proper functioning of an electronic technician. Those not directly related to a specific job are cinsidered necessary for student progress. Refer to the text for specific skill objectives in each chapter section.

Chapter 1.

1. Use of experimental breadboarding equipment.
2. Know industrial safety precautions and procedures.

Chapter 2.

1. Use a basic multimeter for testing.
2. Understand and apply Ohm's law.
3. Understand schematic diagrams.
4. Understand basic electronic circuits: series, parallel and combination circuits.
5. Understand fundamental electrical terminology.
6. Understand fundamental electrical parameters: voltage, current, resistance and power.
7. Understand the concepts of open and short circuits.

Chapter 3.

1. Understand, identify and apply various types of switches.
2. Know how to test switches
3. Understand switch schematic symbols.
4. Use switches for power control

Chapter 4.

1. Understand how to calculate circuit parameters using Thevenin's theorem.

Chapter 5.

1. Understand the function and use of the Wheatstone bridge.
2. Perform calculations which show the operation of the Wheatstone bridge.
3. Use test equipment to show bridge actions.

Chapter 10.

1. Understand impedance.
2. Calculate impedance by trig and vector methods
3. Use equipment to demonstrate effects of impedance.

Chapter 11.

1. Understand resonance.
2. Understand voltage, current, and impedance of resonant circuits.
3. Use test equipment to determine resonance.
4. Calculate resonant circuit parameters.

Chapter 12.

1. Understand transformer action.
2. Understand transformer application.
3. Know how to test transformers.
4. Know how to identify transformers.

Chapter 13.

1. Understand simple power supply operation.
2. Understand simple power supply circuits.
3. Understand full-wave and half-wave power supplies.
4. Understand filter circuits.
5. Understand voltage regulation by zener diode.
6. Test power supplies for regulation and ripple.

Chapter 14.

1. Understand solid-state device construction.
2. Understand solid-state device operation.
3. Identify solid-state devices.
4. Use special handling techniques for static sensitive devices.
5. Test solid-state devices.

Chapter 17.

1. Understand the need for power control.
2. Understand the major power control circuits.
3. Understand SCR power control by phase shift.
4. Understand transistor power control by voltage feedback.
5. Use test equipment to show circuit operation and control.

Chapter 2

OHM'S LAW FUNDAMENTALS

THE RESISTOR

Procedure

1. Answers will vary depending on the resistors used. We suggest you have the student use all the resistors in the ACT-1 kit. Thus, all students will have the same value resistors--easy to grade. However, if you are concerned with students not doing their own work you may wish to give each student a different combination of resistors.

Self Evaluation

1. size
2. opposition
3. Oppose current flow.
4. Yes, the maximum limit for a 470 ohm 5% resistor is 493.5 ohms.
5. 50-100%

USING THE OHMMETER

Procedure

1. Color code will depend on resistors used. If you followed our advice in the previous exercise, you used the resistors in the ACT-1 package. We have instructed the student to use the same resistors. Because of the variety of possible answers we have not included the chart here.

3. Yes, the resistors should be within tolerance of the color code. If not, save the resistor to be used in troubleshooting exercises when defective resistors are needed, or throw it away.

Self Evaluation

1. Note that throughout the book we have required a DMM. Actually, you may use any kind of meter as long as it has a high impedance input. You may wish to switch from VOMs to VTVMs or DMMs when they learn why a particular meter is chosen. We have designated a DMM because it can be used without introducing circuit loading no matter what the exercise is about. We explain meter loading in a later exercise.

   Our meter was a Simpson Model 461 DMM.

CAUTION THE STUDENT ABOUT USING AN ANALOG METER FOR THIS EXERCISE, BECAUSE ANALOG METERS HAVE NON-LINEAR SCALES. A DIGITAL METER IS PREFERRED TO MAKE THE CLOSE MEASUREMENTS NEEDED TO CHECK FOR LINEAR RESISTANCE.

4. (1) Measure the resistance between the two end terminals.

   (2) Measure the resistance from the center terminal to one end terminal. Measure from the center terminal to the other end terminal. Add the two resistances together. Do not move the control shaft while making these measurements.

5. 20%

RESISTANCE IN THE SERIES CIRCUIT

Procedure

1. R1 = 1.020 K   R2 = .985 K

   R1 = 2.2 K   R2 = 1550 ohms

3. Combination #1 = 2K

   Combination #2 = 3.75K

4. RT = R1 + R2 + R3....

Self Evaluation

1. A connection of parts with wires that allows current to flow...A complete path for current flow.

2. A single path for current flow.

3. From negative to positive.

4. Add the individual resistances together.

5. Answer will depend on the resistors used. It will be the addition of the resistor values.

USING THE CURRENT METER

Procedure

3. 12.1 mA

Self Evaluation

1. Movement of electrons in a circuit.

2. Ampere, milliampere, microampere

3. 200 microamps; 2, 20, 200, and 2,000 milliamps

11. (Repeat)

(2) 11.8 mA

(4) No point B   C = 11.8 mA

(5) 1017

(6) 1020

(7) 11.76 mA   1017 ohms   1020 ohms

(8) 1020 ohms

(9) 11.76 mA

12. When the resistance drops by 1/3, current increases by 3...4 mA to 6 mA. When resistance drops by 1/2, current increases by 2...6 mA to 12 mA. There is an inverse relationship.

14. 7.4 mA   .0074 A

15. 3.8 mA

16. When voltage halves, current halves. When voltage doubles, current doubles. There is a direct relationship.

17. 7.35 mA   3.676 mA

Self Evaluation

1. Inverse. When resistance goes up, current goes down and vice versa.

2. Direct. When voltage goes up, current goes up and vice versa.

3. I = V/R

4. .44 mA   2.4 A   .00255 A

5. (A) Current doubles (B) Current is reduced to 1/3 (C) Current is reduced to 1/3. (D) Current is doubled.

USING THE VOLTMETER

It is suggested that the instructor have electronic equipment (TV, radio, computer, etc.) available for the student to use to make voltage measurements. This gives the student a chance to make measurements in the "real world."

Procedure

All procedures are instructor evaluated.

2. The greater the resistance, the greater the voltage drop. A resistor two times as big as another, will have twice the voltage drop.

3. 1/5

4. .88 V   56 V

5. It has six times more R, it will have 6 times more voltage.

6. All voltage drops added together equal the source voltage.

7. They were very close, well within tolerance of the resistors and the meter. For example, in steps 7 and 10, V_{R1} was the same and V_{R2} showed only a .01 V difference between calculated and measured values.

RESISTANCE IN THE PARALLEL CIRCUIT

Procedure

1. Measured values: R1 = 1020 ohms   R2 = 992 ohms

3. R_T = 505 ohms

4. R_T = 502.9 ohms

5. (1) R3 = 1005 ohms

   (3) R_T = 337 ohms

   (4) R_T = 335.1 ohms

6. Values depend on resistors used.

Self Evaluation

1. $R_T = R1/n$ R1 = value of one of the resistors

   n = the number of equal resistors in parallel.

2. The more resistors placed in parallel, the lower the total circuit resistance. R_T is less than the smallest parallel resistance.

3. 1021.67 ohms

   5,500 ohms

4. More. If the circuit uses the same resistors, but in parallel, R_T must be less than the same resistors in series. Less resistance means more current.

5. As many as you wish to make but always more than one.

8. Basically the same. NOTE: Explain to the student that an unregulated power supply might not behave as well. They may also expect the voltage measured in this step to be identical. Explain that even regulated supplies such as the one in the ACT-1 will change slightly depending on the load placed on them.

Self Evaluation

1. The voltage across all parallel branches is the same.

2. No. It will be the same.

3. All the voltages measured (across the different branches) were, indeed, the same--just as the law says it is.

4. Not likely since they all have the same voltage drop.

POWER CALCULATIONS

Procedure

2. 12.01 V

3. .00596 A

4. .0716 W

5. V_{R1} = 6.08 V V_{R2} = 5.93 V

6. I_{R1} = .006 A I_{R2} = .006 A

7. P_{R1} = .0365 W P_{R2} = .0356 W

8. P_T = .072 W

9. (2) 12 V

   (3) .012 A

   (4) .140 W

   (5) V_{R1} = 12 V V_{R2} = 12 V

   (6) I_{R1} = .005 A I_{R2} = .005 A

   (7) P_{R1} = .065 W P_{R2} = .065 W

   (8) P_T = .130 W

Self Evaluation

1. Total power is the addition of all individual power dissipations.

2. R_T = 2846 ohms

3. R_T = 2872 ohms

4. All answers will depend on resistors used or assigned.

Self Evaluation

1. Add series resistors to obtain R_T. Parallel resistors have a total resistance of less than the smallest branch resistance. Each parallel resistor branch is considered to be a series resistance when in series with other resistances. Or, it may be considered to be a single parallel resistance when in parallel with another parallel circuit.

2. (1) Add all series resistances together.

   (2) Find the equivalent R of all parallel branches.

   (3) Repeat until only a single R is left.

3. R_T = 71,725 ohms

4. Well within tolerance of resistors used.

Note: Instructor might discuss the following home electrical problems:

In the home electrical system, fuses are series devices. Outlets and lights are in parallel so they can receive the full (and the same) source voltage and the current they require. The fuse is in series, so when it "blows" it interrupts all the power in the fused circuit branch.

When a circuit is overloaded (something draws too much current) the fuse will blow. If there were no fuse, the wires might get too hot carrying the extra current, and start a fire in the house. The same thing can happen if the circuit has an oversize fuse, that carries too much current for the wiring or if the fuse is defeated by being wrapped with aluminum foil, etc.

<u>CURRENT IN THE COMBINATION CIRCUIT</u>

Procedure

2. I_{R1} = .006 A I_{R2} = .006 A I_{R3} = .003 A

   I_{R4} = .009 A

3. I_{R1} = .0059 A I_{R2} = .0059 A I_{R3} = .0031 A

   I_{R4} = .009 A

THE SHORT CIRCUIT

It is essential that the student understand the concept of a "short" circuit. It is especially important that the difference between "short" and "open" be understood. Most texts do not include information concerning these two most important concepts.

Procedure

2. I_T = .0041 A

3. V_{R1} = 3.98 V V_{R2} = 3.89 V V_{R3} = 4.02 V

4. R_T = 3012 ohms

6. R_T = 1992 ohms

8. I_T = .006 A

9. V_{R1} = 6 V V_{R2} = 0 V V_{R3} = 6 V

Self Evaluation

1. A current path with zero resistance.
2. If there is no R (short) there can be no voltage drop because V = IR. Also, because there is no R, there is no current opposition and the maximum available current will flow. Resistance of a short circuit is 0 ohms.
3. V_{R2} = 0V Because there was zero resistance there was 0 V.
4. Dropped by the amount of R2. R2 had been taken from the circuit since all the circuit current began to flow through the low resistance path of the shorting wire instead of through R2.
5. Current went up. When R drops, I increases proportionally.
6. Voltage drops increased, becasue total R decreased and I increased.

THE OPEN CIRCUIT

2. I_T = .004 A

3. V_T = 12.01 V

4. V_{R1} = 3.98 V V_{R2} = 3.89 V V_{R3} = 4.02 V

5. R_T = 3012 ohms

8. I_T = 0 A

9. V_T = 12.01 V

CHAPTER 3

SWITCHES

SWITCHES

The number of switches included in the ACT-1 and the accompanying components package has been kept to a minimum, because of cost considerations. It is suggested that the instructor purchase, or find other types of switches from junk equipment. These switches could be used to expand the content of this exercise.

Procedure

2. zero, infinity

3. zero, infinity

4. simple on-off

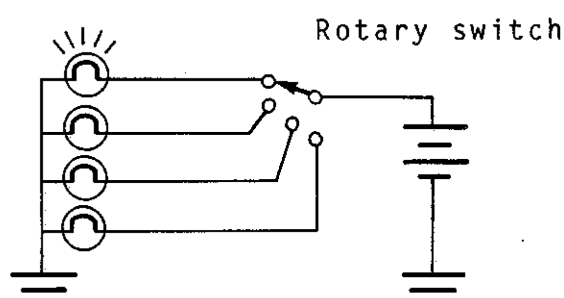
5. control over two circuits, with one on

Self Evaluation

1. SPST

2. When the switch is actuated the polarity of the voltage across the diode is reversed. In one position, the diode is forward-biased and the lamp lights. In the other position the diode is reversed-biased and the lamp does not light. If the lamp lights at both positions of the switch, the diode is shorted. If it doesn't light, the diode is open.

3.



4. 20 V_{RMS} 0 V

CHAPTER 5

WHEATSTONE BRIDGE

WHEATSTONE BRIDGE

Though the circuit uses low value resistors, significant error will be encountered if a low impedance meter is used.

Procedure

2. 6 V   6 V   0 V

3. 0 V

5. 1.09 V

6. 6.08 V 1.09 V 4.99 V

7. 4.86 V

Self Evaluation

1. Change. With that resistance another current path (through R4 to R1) is created, upsetting the unloaded voltages.

2. Voltage changes from 1.09 V to 1.189 V for a 10 % increase in R4.

3. 1%

4. Close. When the meter was placed between A and B in step 7, there was an error due to the additional current path created by the meter.

5. Ohmmeter

USING THE OSCILLOSCOPE

It is important that the student understand how the oscilloscope is used for electronic measurements. As pointed out in the student manual, only an introduction to the scope is possible in the few pages allowed. And as you are aware more written information would most likely be useless anyway. The scope must be worked with to be understood. This is where you, the instructor, are most important. We suggest you go much beyond the lab manual in your explanations and encourage experimentation with the scope. The student MUST know the use of all scope controls. In later experiments the student will need to know how to check frequency and voltage with the scope and in some cases the voltages will be very small (realistically). **Encourage accuracy.** A measurement is no good if it is not accurate. In other words, an inaccurate measurement is an incorrect measurement.

Procedure

4. 1000 Hz

5. 510 Hz   2265 Hz   48792 Hz

6. 4.5 V   0 V

7. There is a momentary deflection as the scope lead capacitance is charged. If it is not discharged, the next time the supply is touched with the probe, there will be no deflection.
   It is difficult to measure the voltage. A rough estimate of the amount can be made but it is not accurate.

8. Yes   Yes, easily

9. 0.25 V/cm   6   DC

Self Evaluation

1. With the input switch set to AC there is an internal capacitance in the input line. Connecting the probe to DC with the switch in AC causes the capacitor to charge and only a momentary deflection of the beam is seen.

2. Depends on scope used

3. 10 V/cm

4. 10 microseconds/cm

5. Incorrect measurements

Self Evaluation

1. Measured and calculated values were close enough to show the theory to be correct.

2. The easiest way is to put two 20 uF units in series.

3. Put a 40 uF and a 20 uF in parallel.

4. They are in parallel. Volatage drops are the same. The larger (1 uF) will have the greater charge current.

5. The smallest (2 uF) will have the highest voltage drop. Charge current is the same in a series circuit.

CAPACITIVE REACTANCE

By no means should the instructor feel that the text is the only material that can be covered. This exercise can also be performed using a variety of capacitor values so the student can gain more experience in measurement and calculation. In most exercises the minimum has been expressed as required. Most exercises can be repeated with the use of different value devices.

Procedure

2. 900 Hz

3. 17,684 ohms

4. $V_C = 1.38\ V_{RMS}$

5. I = 0.084 mA

6. $X_C = 16412$ ohms

Self Evaluation

1. $I = V/X_C \quad V = I \times X_C$

2. Very close, considering roud-off, measurement errors, and the use of MARKED capacitor value instead of MEASURED value.

   IF MEASUREMENTS NEED TO BE MORE EXACT FOR BETTER STUDENT UNDERSTANDING, HAVE THEM MEASURE THE VALUE OF THE CAPACITOR BEFORE USING IT. THIS CAN BE DONE IN ALL EXERCISES WITH ALL COMPONENTS. THE USE OF MEASURED VALUES WILL ALWAYS CAUSE EXPERIMENTAL RESULTS TO BE NEARER THEORETICAL VALUES.

3. X_C decreases when frequency increases.
   X_C decreases when capacitance increases.

4. Decreases

5. Larger

Self Evaluation

1. The time in second(s), found by multiplying R times C, necessary for a capacitor to charge to 63.2% of full charge.

2. A. .001 B. .01 C. .00025

3. Accuracy was exceptional.

4. Decrease R or C.

5. The component has increased in value. It is not possible to make the dielectric thinner, the plates with more area, or the dielectric to change materials, so the problem must be the resistor.

3. Spacing between turns

4. Core size

INDUCTIVE REACTANCE

The student should be warned that the results of this lab exercise will not be exact. This will be due to two factors: (1) Coil tolerances are typically quite large and (2) the inductance value of a coil is guaranteed only at the rated current. Because of the low current capability of the ACT-1 the rated current of the coil will never be approached and the results of the experimental procedure will not be precise. However, the concept that inductance and X_L add in series and "decrease" in parallel is still intact. The student should be looking for a "direction" in the measurements rather than precise figures in this exercise. As in the previous exercise, stress that the signal output MUST be kept constant for all measurements.

Procedure

1. 65 ohms

3. 9.16 mA

4. 7.75 mA

6. 9.39 mA

7. 9.32 mA

Self Evaluation

1. Higher frequency causes greater X_L which is an opposition. The greater the X_L the smaller the current flow.

2. The only opposition to current flow is the resistance value of R. There is no change in resistance with change in frequency.

3. The inductor, even at 100 Hz had some X_L as well as 65 ohms of wire resistance therefore current flow in the inductor was always less.

4. 15.7 ohms   157 ohms

5. At 2 V_{p-p} I = 2/15.7 = 127 mA
   At 2 V_{p-p} I = 2/157 = 12.7 mA
   No, because there is also a 65 ohm coil "wire resistance" which must be considered part of the opposition to current flow.

Chapter 9

PHASE SHIFT CIRCUITS

INTRODUCTION

The following phase shift experiments are simple to perform and the results are easily seen. The only precautions:

1. Keep all grounds intact and consistent.

2. Keep in mind that some error will exist, due to operation of the inductor at less than its rated current. This will cause a smaller X_L and thus a smaller phase angle than calculated. Encourage measurement accuracy.

If an inductance meter is available, it is suggested that the inductance of each coil be measured. Use the measured inductance instead of the rated inductance; calculations will be much more accurate. Measure capacitance, too, when possible.

THE RC PHASE SHIFT

Procedure

3. 43.9 degrees

4. 2.6 degrees

5. 1.8 degrees

6. 88 degrees

Self Evaluation

1. 63.4 degrees

2. The greater the resistance the smaller the phase angle.

3. Increases

4. LED, because the circuit is capacitive

5. False. These voltages are out of phase and cannot be added directly together.

THE RL PHASE SHIFT

Procedure

3. 10.7 degrees

4. 10.7 degrees

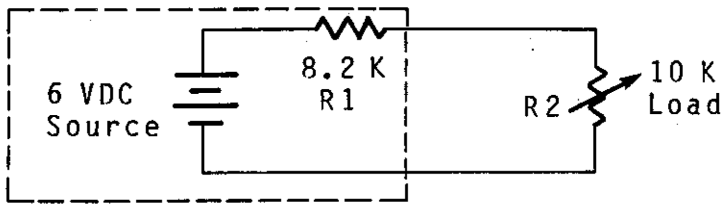
5. 62 degrees   62 degrees

Chapter 10

IMPEDANCE

This is an excellent place to build interest in this complex subject. Show how impedance matching can affect TV reception, sound power/quality from an audio amplifier. Explain impedance matching between devices for maximum power transfer. You can use the following exercise:

Connect this circuit make the following measurements and calculations to show that maximum power is delivered to the load when the source and load impedances are equal.



R2	Vs (VR1)	VL (VR2)	Ps (V^2/R1)	PL (V^2/R2)
5 K	2 V	4 V	.8 mW	1.6 mW
8.2 K	2.7 V	3.3 V	.88 mW	1 mW
10 K	3 V	3 V	.9 mW	.9 mW

Procedure (30 mH was used for calculations)

2. V_R = .25 V_{rms} = .7 V_{p-p} IT = .07 mA_{rms} = .212 mA_{p-p}

3. 15,500 ohms (VT = 3.5 V_{p-p} or 1.24V_{rms})

4. Z = 16 K ohms IT = .07 mA_{rms} = .212 mA_{p-p}

Self Evaluation

1. Considering the use of unmeasured C and L values, the use of small values and round-off error, they were remarkably close.

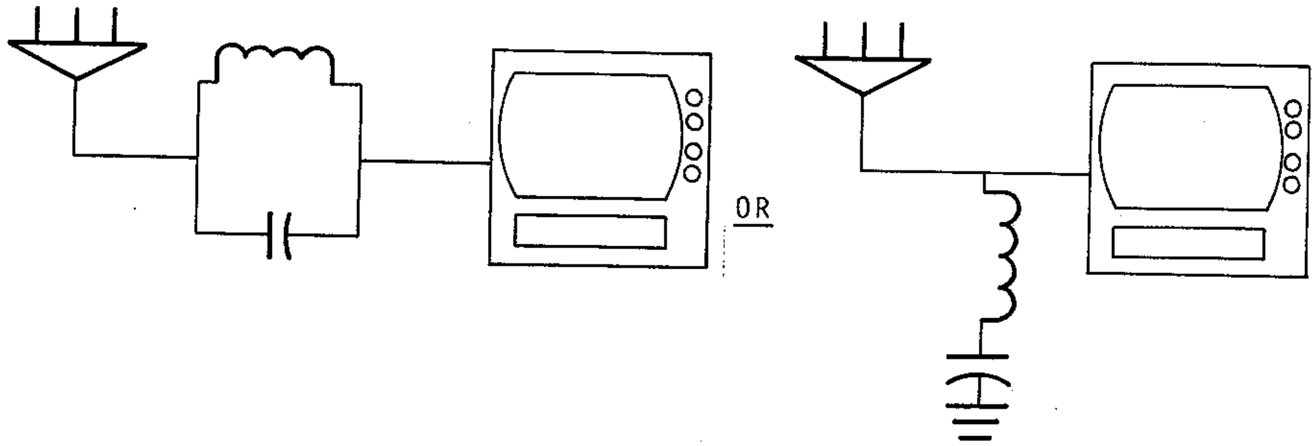
2. By providing mathematical answers which correspond to measured values.

3. Less impedance allows more current to flow from the source (transistors).

4. The resistor is in series so the resistor current is the circuit current.

5. A - 574.3 ohms B - 1920.9 ohms C - 1442.8 ohms

4.



5. The natural frequency of the charge and discharge of the C and L when in series or parallel.

THE PARALLEL TUNED CIRCUITS

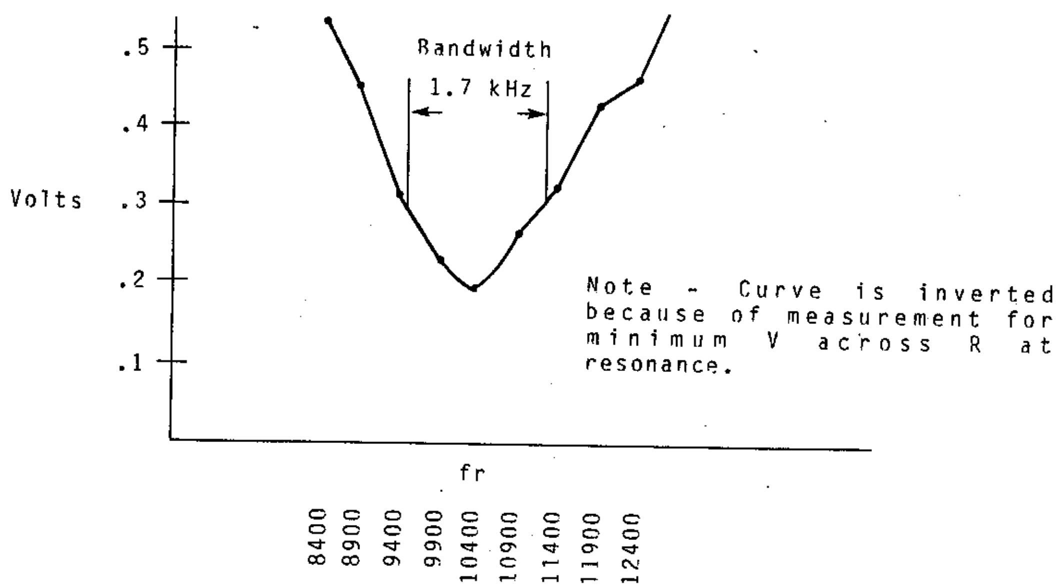
Procedure

2. 9.189 kHz

Q = 19 (Resonant circuit alone - with 10 K series R, Q = .17)

4. 10,400 Hz

6.



Self Evaluation

1. 1.7 kHz

2. Very close considering the use of rated rather than measured L and C values.

3. In the parallel tuned circuit, current is minimum at resonance. With minimum current, voltage across the resistor is also minimum.

Chapter 12

TRANSFORMERS

THE TRANSFORMER-USE AND IDENTIFICATION

It is suggested that a variety of transformers be collected to add to the experiences offered by this exercise. They may be purchased new, or taken from junk equipment. Stress the safety of using a signal generator for the source rather than the power line (for power transformers).

Because of the low-powered nature of the ACT-1 function generator, low impedance tranformers cannot be powered. You can use a higher powered signal generator (available in most school or industry classrooms) or a 6 volt transformer as the source for low impedance power transformer inputs.

Procedure

1. 20 ohms 1 ohms infinite ohms

2. $V_{in} = 3.5\ V_{P-P}$ $V_{out} = .4\ V_{P-P}$
   turns ratio = 8.75 to 1

Self Evaluation

1. The low voltage windings (in this case, the input) will be the larger wire because they carry the most current. Likewise the high voltage windings will carry the least current and be the smaller wire.

2. Output

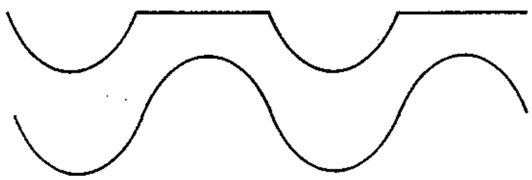
3. Input and output voltage(s). Output current(s). Insulation ratings, sometimes.

4. All windings.

5. NO. DC cannot be applied to a transformer. With DC there is no X_L and the only opposition to current is the wire resistance. The result is a burned out primary winding.

3.

4. 60 Hz



6. 120 Hz

7.

Self Evaluation

1. One

2. Six, because all of the input wave is used.

3. The input frequency is the number of times a complete "cycle" occurs. This "cycle" is from zero to positive back to zero and to negative and back to zero. The full wave recitifier output cycle is from zero to positive and back to zero. And since it does this for each half of the input cycle, it has twice the frequency.

4. The output was reversed. In Figure 2 if one of the diodes is reversed a short circuit results across the transformer. Both the transformer and diodes can be damaged.

5. Because there is so much less OFF time for the output.

THE ZENER DIODE

Stress the fact that zeners look like regular diodes. Care must be taken to know which type of diode is being used.

Procedure

2. 3.2 V

3. 3.25 V

4. 3.3 V

5. The voltage change was from 3.2 to 3.3 volts. % regulation was .1/3.3 x 100 = 3%

Self Evaluation

1. If placed in the circuit incorrectly, it will act as a short circuit and the supply output will be approximately .7 volts if the zener is not destroyed.

2. Yes. By measuring the V_L, the zener voltage is found. If the power supply is adjustable, zeners of many different ratings can be found. Be careful...if the series resistor is too small, current may be too large and the zener can be destroyed.

3. Either make a current measurement or use Ohm's law to find the current (I=V/R).

4. Yes. Increasing the source voltage will cause more current to flow. However, the zener can allow more current to pass thru it without increasing its voltage drop. But when R1 passes more current its voltage increases, absorbing the increased source voltage.

5. High R load

THE BIPOLAR TRANSISTOR-TESTING AND HANDLING

Procedure

1. 2N2222	Forward	BC = 649 ohms EB = 669 ohms --------------- EC = 49.6 K ohms	Reverse	BC = infinity EB = infinity ----------- EC = 60K ohms
	good.			
2N3906	Forward	BC = 490 ohms EB = 510 ohms --------------- EC= 35 K ohms	Reverse	BC = infinity EB = infinity ----------- EC = 58 K ohms
	good.			

2N2222 Leakage = 0 mA
Beta = 120

2N3906 Leakage = 0 mA
Beta = 100

Self Evaluation

1. Transistor tester. It gives more information.

2. Some ohmeters may have enough current capability to destroy transistors. However, this should not be a problem if the "wet-finger" technique is used because it does not pass the entire ohmmeter battery current through the base-emitter junction.

3. Do not bend leads unless necessary.
   Do not insert or remove device with power on.
   Do not short leads.
   Always have resistance in series with power source and transistor.
   Keep voltage levels within specified maximum.
   Keep heat down by heat-sinking.

4. Temperature, voltage and current levels

5. LO ohms settings do not have enough voltage to cause the transistor/diode junctions in a silicon device to conduct.

THE FIELD EFFECT TRANSISTOR-USE AND IDENTIFICATION

Procedure

1. 2N5458 substitute GE FET-1 or RS 276-2035, small signal, general purpose N channel, 300 mV power dissipation, V_{dss} = 30 V, V_{gss} = 30 V, Gain = 6.5 umhos, case style--TO-92.

THE UNIJUCTION TRANSISTOR

Procedure

1-2. 2N2160 maximum power 360 mW, r_{BB} = 9.1 K, V_{EB1} = 4 V
V_{OB1} = 3 V, I_p = 5 uA

3. r_{BB} = 9 K ohms r_{B1-E} = 4.4 K ohms r_{B2-E} = 4.56 K ohms

5. 1.5 V_{P-P}

6. Frequency changes

7. The two waveforms are of opposite polarity.

Self Evaluation

1. It has two bases and one emitter. It is a good switch; switches very fast and is useful as an electrical trigger.

   Double-base diode

   Resistance, voltage needed to saturate it (V_{EB1}), power dissipation, maximum voltage, maximum current, trigger current.

   Simply measure the resistance from B to B and From E to each B.

   A capacitor charge circuit exists from ground to source through R1, R21, and C. Changing R21 changes time required for C to charge. When C is charged to the UJT trigger voltage, the E-B of the UJT conducts discharging (through the UJT and R4. This causes the UJT to conduct from ground to +5 V. The result is a waveform across C which shows the charge and discharge of C (a sawtooth wave). Across R4 is a spike waveform created as the UJT conducts. This spike corresponds (in time) to the discharge time of C.

THE SILICON CONTROLLED RECTIFIER

Procedure

1. 2N5060

2. Substitute GE MR-5

4. Infinite

5. 708 ohms

6. No effect, SCR continued to conduct.

5. Only on the very low powered ones. The gate current required to trigger is too much for low ohmmeter to provide. Some Triacs attempt to turn on but will not latch on with the gate current supplied by the ohmmeter.

THE LIGHT EMITTING DIODE (LED)/OPTOCOUPLER

Procedure

1. Forward R = 7 K ohms
   Reverse R = infinity

3. LED gets dimmer.

4. Forward voltage = 1.6 V Reverse voltage = 3 V

6. Breakdown voltage (BV_{CEO}) = 30 V Power dissipation = 100 mW
   $V_{CE(SAT)}$ = .4 V I_F = 100 mA - transistor; 60 mA - LED

7. When power was applied the ohmmeter showed a marked decrease in resistance.

Self Evaluation

1. Single and 7-segment

2. Ohmmeter test--test like any diode.
   Use a circuit as shown in the text to see if the LED will light.

3. It will not light.

4. LED Forward voltage drop
   Forward current - max
   Graphs in Chapter 14 show light output vs LED current.

   Opto-coupler LED Forward voltage drop
   LED current - max
   LED power dissipation

   TRANSISTOR forward voltage drop
   TRANSISTOR current - max
   TRANSISTOR power dissipation
   TRANSISTOR EC voltage

   ISOLATION CHARACTERISTICS

5. When the LED is lit, light causes the transistor inside the same case to conduct. The ohmmeter is used as the source of power for the transistor in the experimental opto-coupler. When the transistor turns on (light is produced by the LED) current flows and the ohmmeter reads a lowered resistance.

4. By about 2 to 1

5. No. It is a linear device and whatever goes in will come out the same size or amplified.

THE INTEGRATED CIRCUIT (IC)-DIGITAL

Procedure

2-3. 7404

Hex inverter
V_{cc}=5 V$\pm$ .25 V

Power dissipation 10 mW/gate
Fan out = 10

74LS04

Same as 7404 but requires less current
Operates at somewhat higher frequency
Fanout = 20

4069

Same as 7404 but
CMOS -
Requires less current
V_{cc}= 15 V
Operates slower
Almost unlimited fanout

4. 4.93 V

5. The output of an inverter

6. .04 V

7. The input to the first inverter. .04 V

8. 4.2 V

Self Evaluation

1. TTL and MOS

2. TTL uses 5 V supply, MOS uses a much higher source. TTL is rugged, MOS is very sensitive to static electricity.

3. Use all the MOS precautions. For TTL use typical transistor precautions.

4. That when the input of a TTL device "floats" (unconnected) it is the same as connecting it to a "high".

5.

INPUT	OUTPUT
0	1
1	0

Self Evaluation

1. The output was 180 degrees out of phase with the input.

2. CE, CC, CB

3. It keeps the emitter-base bias from being affected by the AC input. Without it as transistor current increases due to AC input so does the voltage drop across R3, and the EB bias is upset.

4. Low input impedance, high output impedance and inverts the signal by 180 degrees. Low input impedance is a disadvantage because it places a load on the input device which usually produces a small signal anyway. High output impedance is a disadvantage because most devices which must be powered by an amplifier require current to operate; with a high output impedance the CE amplifier cannot supply much operating current. Phase reversal is not always a problem but in some cases such as in an oscilloscope, if the signal input is reversed, it will appear on the screen inverted. This gives an untrue picture of what is really being measured. In such a case at least two amplifiers would have to be used so the output is the same as the input.

5. Individual measurements of input voltage or current and output voltage or current. And use of dual trace scope to simultaneously measure input and output voltages for voltage gain measurements.

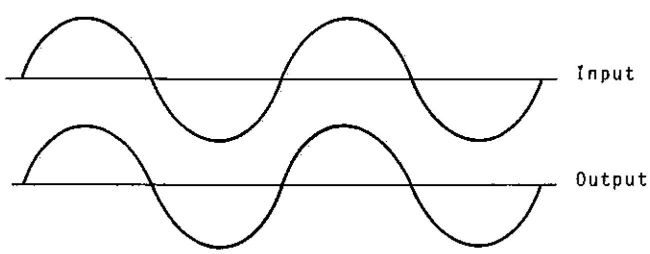
THE COMMON COLLECTOR AMPLIFIER

Procedure

3. .42 .4

4. .95

5.



THE FET AMPLIFIER

Remind the student that FETs are, by nature, more sensitive than bipolar devices and must be handled with more caution.

Procedure

3. .15

4. 2

5. 13.3

6. 0

7. .39

8. .39

Self Evaluation

1. Voltage divider, source, self

2. Higher input impedance, and better sensitivity

3. Much lower

4. The same as the equivalent resistor in the CE circuit. It maintains constant bias.

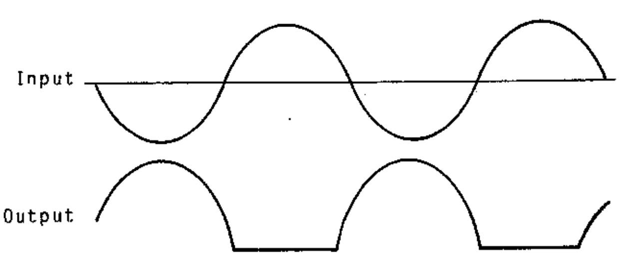
5. Don't cut leads unless necessary. Use scissor type cutters (not pinchers).
   Do not remove or insert device with power on.
   Do not apply excessive heat.
   This is not a MOS device so it is not very susceptible to magnetic fields and static charges.

CLASSES OF AMPLIFICATION

Have the student understand that all types of amplifiers can be operated in any class. We show the different classes of operation on the CE amplifier because of space and time.

Procedure

3.



Chapter 16

OSCILLATORS

INTRODUCTION

Because of space limitations we have limited "oscillators" to a single exercise. This does not mean that oscillators are not important. On the contrary, they are very important. But, the oscillator, regardless of the type, makes use of the same simple fundamentals. That is, they require a resonant circuit, an amplifier with enough gain to overcome the loss in the resonant circuit, and a feedback path. The basic difference in the types of oscillators is the way the feedback is handled. If you wish to go beyond what we have included in this exercise, we suggest you have the student connect one or more oscillators of different types. The student could then answer the same questions and make the same measurements as made in the original exercise.

Procedure

2. 107,991 Hz

3. 90,909 Hz (L = 35 mH)

4. Frequency changes. If this capacitor is bigger, the frequency decreases. If it is smaller, the frequency increases.

5. Oscillation stops. This is the feedback path.

6. The oscillation will cease. This size un-bypassed resistor in the emitter causes degeneration (loss of amplification) to the point where amplification is not large enough to overcome the circuit losses and oscillation ceases.

7. Oscillation stopped. Yes

8. Yes. Oscillation stopped.

Self Evaluation

1. Amplification and resonant circuit

2. Broke the feedback path. Removed the resonant circuit from the amplifier.

3. Lowered amplifier gain. Amplifier (explanation in procedure answer #6 above).

4. The frequency would change. Capacitance is being added to the circuit. The body is a conductor and is typically insulated from ground. It is therefore one plate of a capacitor. By wrapping part of this capacitor around the coil, the circuit must change its resonant frequency.

Chapter 17

POWER CONTROL CIRCUITS

INTRODUCTION

Power control circuits on one of the largest use of electronic circuits. There are a number of solid state devices used for power control but by far the most use is being made of the transistor. Then there are the SCR and Triac devices. The circuits in the next two exercises are low powered but the concept is the same as those circuits controlling several amps.

SCR POWER CONTROL

Procedure

2. 20 mV

3. 55 mV

Self Evaluation

1. An output voltage sensing and SCR control circuit.

2. NO. The duty cycle is fixed as R1 biases the SCR on continually. We only explored the concept of capacitor charge vs SCR on time (in this case, frequency).

3. Less ripple in the output.

4. A higher frequency input is the same as more SCR ON time. The higher frequency "fills" the capacitor before it has time to discharge, while the longer ON time keeps the capacitor charged for a longer time. The result is the same; more capacitor charge and less ripple in the output.

5. It is possible but some means would have to be provided to turn off the SCR. If DC is applied to the device it can only be turned off if the supply voltage is reversed in polarity or the current drops below the sustaining current. The usual method is to supply a short pulse of reverse bias supply current.

TRIAC POWER CONTROL

No laboratory activity.