

CAPACITOR AND TRANSISTOR TESTER

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“I admit that I had read this report and for my opinion this report
had fullfied all scope and quality for bachelor of electronic industrial engineering “

Signature : 
Supervisors name : EN. SANI IRWAN
Date : 18 MARCH 2005

“ I admit that all the article is my own idea except for summarization each of it that I had explain the source”

Signature :

Students name : GUNAWATHY MUTHUSAMY

Date : 18 MARCH 2005

Special to mum, dad, siblings and specially to Mr. Sani Irwan.

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ABSTRACT PROJECT

(Dalam Bahasa Melayu)

Kebiasaannya pelajar atau pengguna akan menggunakan multimeter untuk mengukur dan mengetahui adakah komponen ini dalam keadaan baik, nilai komponen, polariti ataupun mengesan jika terdapat sebarang kebocoran arus. Tetapi kebiasaannya bacaan multimeter tidak jitu dan tepat kerana terdapat ralat seperti ralat membaca nilai, ralat paralaks dan sebagainya. Tujuan membuat projek ini adalah untuk menyenangkan kerja di makmal. Litar ini digabungkan kerana cara ini akan dapat mengurangkan penggunaan komponen untuk membuat bekalan kuasa, mengurangkan kos dan penggunaan tempat di makmal. Ianya lebih baik membuat litar yang tergabung daripada satu litar kerana pelbagai uji transistor dan kapasitor dapat mengurangkan kehilangan kuasa pada regulator voltan. Apabila kapasitor dimasukkan pada penguji kapasitor, meter akan menunjukkan bacaan yang merupakan nilai kapasitor tersebut. Malah litar ini juga akan menunjukkan polariti dan juga mengesan kebocoran pada kapasitor tersebut. Manakala litar penguji transistor dapat menguji adakah transistor ini adalah jenis PNP atau NPN dan juga dapat mengetahui adakah ia dalam keadaan baik serta nilai β transistor tersebut. Keputusannya dapat diketahui dengan memerhatikan LED yang menyala dimana terdapat 6 LED untuk menunjukkan adakah ianya PNP ataupun NPN. Jika transistor tersebut adalah NPN hanya LED warna hijau akan menyala. Jika transistor adalah PNP maka LED merah akan menyala. Terdapat dua litar yang berasingan yang mengandungi penguji transistor dan penguji kapasitor. Kedua-dua litar ini digabungkan dalam satu litar. Kesimpulannya projek memberikan kesenangan untuk tujuan menguji dan meminimalkan penggunaan peralatan di sesi makmal.

ABSTRACT PROJECT

Normally student or users will use multimeter to find out about capacitor whether it is in good condition, its value, its polarity and any faulty current leakage if occurs. As with transistor, multimeter is used to check for the transistor type, PNP or NPN, and to determine its condition for any current leakage. However, the reading from multimeter might not be accurate because of some error might exist such as reading error, parallax error and so on. The purpose of this project is to simplify any laboratory work. This circuit combined because this particular method can reduce component to create power supply, reduce cost and space in laboratory station. It is more convenient to make combine circuit then separate because multimeter capacitor and transistor tester can reduce the power dissipation on voltage regulator. When the capacitor is inserted to the capacitor tester, the display, which is seven segments, will show the value, any faulty current leakage and the polarity. The transistor circuit tester is used to ensure either the transistors PNP or NPN type and check the condition. The LED indicator can observe the result. There is six LED available to show the particular transistor is PNP or NPN. If particular transistor is NPN only a pair of green LED lights up. If it is PNP type, only a pair of red LED lights up. There will be two separate circuits consists of transistor checker and capacitor tester. These two circuits will be combined together in one single board. This will finally simplify testing method and minimized equipment needed in laboratory station.

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TOPIC 1

INTRODUCTION

1.0 Objective

The objective of this project is to create easy to use testing equipment for both transistor and capacitor in one single board. With this, the final product will be a 2-in-1 lab testing equipment. This project will provide extensive knowledge in transistor and capacitor testing including determining their values and functionality.

The actual value many electrolytic capacitors are sometimes different from those marked on the cases. More often, the values are illegible due to ink blurring, obliteration, etc. These are only two of the problems the experimenter faces in using electrolytic. Among others, how do you apply a polarizing voltage to make sure the electrolyte in the capacitors is formed and that the unit is really operating properly? How do you tell whether an electrolytic capacitor is leaking? There are, of course, costly test instruments that can be used to solve these problems. Nevertheless, the expense of precise measurements is not always warranted because electrolytic have relatively broad tolerances.

Therefore, we can build the digital capacitance meter, which can check capacitor values from 1pF to 99.99 μ F over three ranges. Its main features include a nulling circuit and a bright 4-digit LED display.

There have been many transistor tester circuits in recent electronics magazines, but this one is different. It has more features and includes a signal injector so you can test audio sections of radios and the front end of FM transmitters etc.

The major advantage with this design is its automatic operation. All have to do is fit the three leads of a transistor to the tester in any order and the LED will let you

know the base and if the transistor is NPN or PNP. Section 3 will identify the collector and emitter leads and provide an indication of the gain of the transistor.

1.1 Capacitor Behaviors

During the past fifteen years, various theories have been put forth in an attempt to explain the operation of electrolytic capacitors. These theories, which included the gas film theory and others, will not be repeated here, in order that the reader be not confused with these various ideas, none of which can be experimentally verified and most of which were held to be untenable for many reasons.

In the author's opinion, there is only one true explanation of the operation of an electrolytic capacitor and basic theory of operation will be confined to that opinion, not because of any arbitrary attitude or because it is the author's own theory but rather on the other hand, because all points can and have been experimentally verified, and also because all conditions can be met and checked.

For a long time, it has been known that several metals, such as tantalum, aluminum, magnesium, titanium, niobium, zirconium and zinc, can be coated with an oxide film by electrochemical means.

While the oxides of these metals exhibit different characteristics it was found that the oxides of tantalum and aluminum possessed highly desirable ones. While tantalum was found to possess an oxide of the most desirable characteristics its cost, so far, has limited its economical usefulness in electrolytic capacitors.

Aluminum, on the other hand, being both plentiful and sufficiently economical, has become the most widely used metal in electrolytic capacitor structures. This is the case to such an extent that all subsequent work will refer only to the use of aluminum as the anodic member of electrolytic capacitors.

An oxide film can be formed on aluminum by electrolytic means. This can be accomplished by introducing the metal into a suitable electrolyte, for example, an aqueous solution of boric acid and sodium borate, and passing an electric current through it, the aluminum forming the positive pole or anode. Upon electrolysis of the solution, oxygen is evolved at the positive pole which oxidizes the surface of the aluminum.

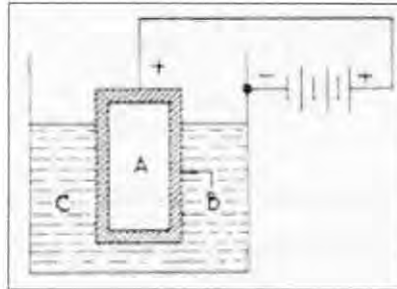


Figure 1.0 : Electrolytic Cell (Source from internet)

A is the aluminum anode
B is the aluminum oxide film
C is the electrolyte

The thin film of oxide (Al_2O_3) formed on aluminum surface offers a very high resistance to further passage of current and if the applied voltage is kept constant, the current, after a time, will be reduced to a minimum value called the leakage current. A cell of this type, with aluminum as the anode and an electrolyte as a negative electrode or cathode, is used as a capacitor, with the aluminum oxide film separating them, acting as an extremely thin dielectric.

The electrolytic capacitor has a high capacity per unit volume as compared to other types of capacitors. The thickness of the oxide film covering the aluminum electrode is extremely thin (approximately 10^{-5} centimeters), and the dielectric constant K of the Al_2O_3 produced is high (approximately 10).

If the capacity C is calculated per square centimeter, from the previously mentioned basic formula

$$C = 0.0885 KS / t$$

the following result is obtained:

$$\begin{aligned} C &= 0.0885 \times 10 \times 1 / 10^{-5} \\ &= 0.0885 \text{ microfarads.} \end{aligned}$$

From this it can be seen that an aluminum electrode, of 100 square centimeters surface, will produce a capacity of approximately 8.85 microfarads.

The electrolytic capacitor can only be used with a flow of current in one direction. The aluminum electrode must therefore always be connected to the positive side of the applied voltage, and the electrolyte must always be negative. With the current flowing through the capacitor in this direction, the current intensity is small. If the direction of current flow is reversed, a large current will flow through the capacitor and the capacitor as such becomes useless.

From this, it can be readily seen that the system exhibits the characteristics of a rectifier, and an electrolytic capacitor does not then differ in any way from the well known electrolytic rectifier.

1.2 Cause Of "Leakage Current"

It is also apparent that the leakage current will be the lower, the smaller the number of ions presents in the electrolyte, and in other words, the less conductive it is.

It, now, should be quite evident why it would be impossible, or virtually so, to use a second metallic electrode in place of the electrolyte. In such a case the separating layer (aluminum oxide film) would be bounded by two substances which would emit electrons with almost the same facility.

A leakage current is generated because the electrolyte is also able to emit some electrons from the ions, under the influence of the powerful electric fields applied, such electrons migrating through the oxide film to the aluminum electrode. This leakage current is determined by the field strength, the thickness of the oxide film and the conductivity of the electrolyte. If in capacitors made of the same materials the leakage currents are the same at equal potential differences, it may be concluded that the oxide films are of the same thickness. The field intensity is then equal to:

$$F = V / t$$

Where

F = field strength

V = applied voltage

t = oxide thickness

If an aluminum electrode is oxidized in an electrolyte and a specific potential difference V_1 is applied, the current through the electrolyte will steadily decrease with time. At a small terminal value I , of this current, the oxidation process is considered as having been completed. Now, if a second aluminum electrode of the same dimensions is placed into the same electrolyte and a potential difference V_2 , which is double the value of V_1 , is applied until the leakage current has reached the same final value I , it may be then assumed that in the two capacitors the same field strength prevails at the oxide film. Since, however, $V_2 = 2V_1$, t_2 must be $2t$, and hence also the capacity of the second capacitor half as great as that of the first.

From this it can be seen that the capacity of an electrolytic capacitor is a direct function of the area of the anode member and that the thickness of the dielectric film is always automatically matched to the potential difference or voltage

The transistor is an arrangement of semiconductor materials that share common physical boundaries. Materials most commonly used are silicon, gallium-arsenide, and germanium, into which impurities have been introduced by a process called "doping." In *n*-type semiconductors the impurities or dopants result in an excess of electrons, or negative charges; in *p*-type semiconductors the dopants lead to a deficiency of electrons and therefore an excess of positive charge carriers or "holes."

TOPIC 2

LITERATURE REVIEW

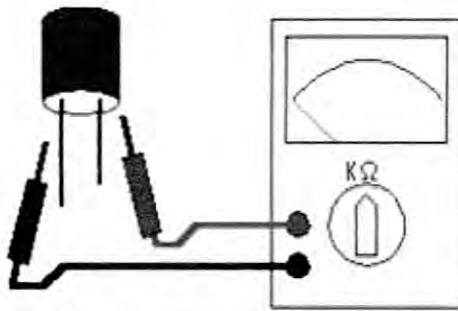


Figure 2.0 : Diagram Shows How To Test Capacitor

2.1 Capacitor

When DC voltage is applied to the capacitor, an electric charge is stored on each electrode. While the capacitor is charging up, current flows. The current will stop flowing when the capacitor has fully charged. When a circuit tester, such as an analog meter set to measure resistance, is connected to a 10 microfarad (μF) electrolytic capacitor, a current will flow, but only for a moment. You can confirm that the meter's needle moves off of zero, but returns to zero right away.

When you connect the meter's probes to the capacitor in reverse, you will note that current once again flows for a moment. Once again, when the capacitor has fully charged, the current stop flowing. So the capacitor can be used as a filter that blocks DC current. (A "DC cut" filter.)

However, in the case of alternating current, the current will be allowed to pass. Alternating current is similar to repeatedly switching the test meter's probes back and forth on the capacitor. Current flows every time the probes are switched

Aluminum is used for the electrodes by using a thin oxidization membrane. Large values of capacitance can be obtained in comparison with the size of the capacitor, because the dielectric used is very thin.

The most important characteristic of electrolytic capacitors is that they have polarity. They have a positive and a negative electrode.[Polarized] This means that it is very important which way round they are connected. If the capacitor is subjected to voltage exceeding its working voltage, or if it is connected with incorrect polarity, it may burst. It is extremely dangerous, because it can quite literally explode. Make absolutely no mistakes.

Generally, in the circuit diagram, the positive side is indicated by a "+" (plus) symbol. Electrolytic capacitors range in value from about $1\mu\text{F}$ to thousands of μF . Mainly this type of capacitor is used as a ripple filter in a power supply circuit, or as a filter to bypass low frequency signals, etc. Because this type of capacitor is comparatively similar to the nature of a coil in construction, it isn't possible to use for high-frequency circuits. (It is said that the frequency characteristic is bad.)

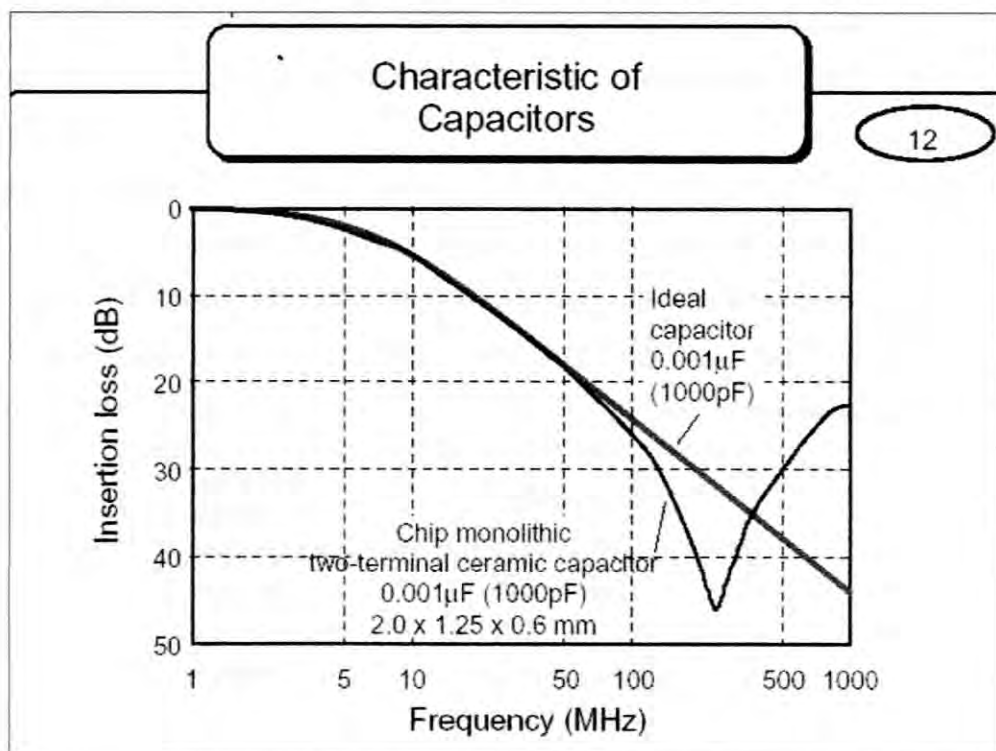


Figure 2.1 : Characteristic of Capacitor (source form internet)

This section describes the necessity and performance of capacitor. With the ideal capacitor, the insertion loss increases as the frequency becomes higher. However, with actual capacitors, the insertion loss increases until the frequency reaches a certain level (self-resonance frequency) and then insertion loss decreases.

The transistor, like any semiconductor device, can be destroyed by over-current, over-voltage or static discharge. Over-current conditions are usually due to a wiring error. Over-voltage occurs when the power supply voltage exceeds the voltage rating for the device. These conditions can be avoided by ensuring you are using the proper device, and double-checking the circuit layout to catch and correct wiring errors. In the laboratory, damage from static discharge is often controlled by the use of grounded anti-static mats on the floor and the work surface. Manufacturers of static-sensitive devices recommend the use of a grounded wrist strap when working on sensitive electronics.

This damage can be avoided from static discharge by touching an earth ground before picking up a semiconductor device. Earth grounds are available throughout a modern circuit's lab, in the form of any metal case on a grounded instrument. Some power supplies provide a ground lug (or jack) separate from the negative side of the supply. The ground lug provides a good quality connection to earth ground through the third wire (round pin) on the AC power cord. Touching the metal portion of this ground lug will discharge any static electricity you have accumulated, and significantly reduce the likelihood of damaging static-sensitive components. On a proto board, build the circuit. Power supply is turned off and adjust the potentiometer so that V_{out} is 5 V.

Operating Mode	Value of V_{CE}
Cut off	$V_{CE} = V_{CC}$
Active	$0 < V_{CE} < V_{CC}$
Saturated	$V_{CE} = 0$

Table 1.0: Voltage of Capacitor (source form internet)

The voltage across the collector-emitter junction V_{CE} of the transistor is a good indicator of the present operating mode. Table 1 summarizes how to use the V_{CE} to determine the mode. In your journal, use the measured values of V_{CC} and V_{out} to write a KVL loop equation around the collector emitter side of your circuit. Solve for V_{CE} . Use the equations in Table 1 to determine the operating mode. Measure V_{CE} and compute the percent error between the computed and measured values of V_{CE} .

2.2 Measuring β of the transistor

With V_{out} still at 5V, measure the voltage across R_b . Use Ohm's Law and the measured resistance values for R_b and R_c to compute I_b and I_c . Compute the forward current gain, β , from the dependent source equation for the transistor, $I_c = \beta I_b$. β recorded with the measured value in lab journal. The β value is difficult to precisely control during the manufacturing process. Furthermore, β is subject to drift with time and temperature. The following procedure will demonstrate the dependence of β on the temperature of the transistor. Adjust V_{in} so the transistor is operating in the active region. While observing V_{out} , warm the transistor by pinching the package between your thumb and forefinger. If V_{out} does not change, ask someone with warm hands to help.

Four column is prepared in table for lab journal to record about thirty data points, labeling the columns V_{in} , V_{out} , V_{BE} and V_{CE} . For V_{in} from 0 to 1.5 volts, take data at intervals of 0.25 volts (0 V, 0.25 V, 0.5 V, etc.). For V_{in} from 1.5 V to 10 V, take data at 0.5 V intervals.

Plot the transfer characteristics

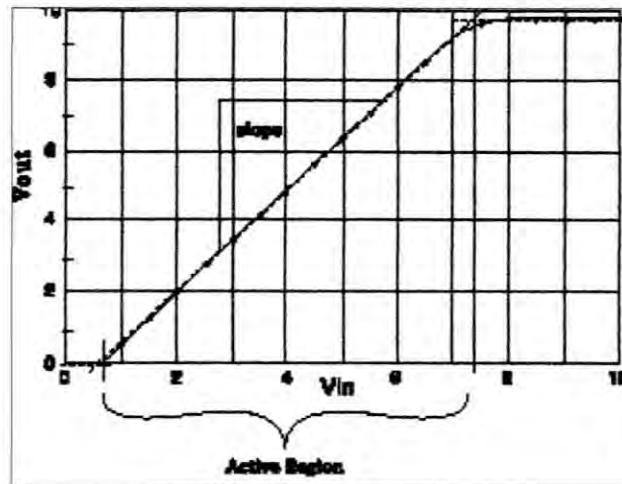


Figure 2.2 : Transistor input/output characteristic(source from internet)

Graph the data collected on a full page in your journal. Place V_{in} on the x axis, and plot three curves, V_{out} , V_{BE} and V_{CE} as functions of V_{in} . The graph should be similar to the one shown in Fig. 2.2, but should also show V_{BE} and V_{CE} . If enough data points were collected, the plot will show that the transitions between cutoff and active, and between active and saturated are somewhat rounded. Use a different color ink to fit straight lines to each of the three operating modes for the V_{out} data. The two intersections of these three straight lines represent the best approximation of the transition from cutoff mode to active mode and from active mode to saturated mode. Draw a vertical line extending from the top to the bottom of the graph, at each of these two intersections. Label the mode of operation for each of the three regions.

If there is a transistor curve tracer available in laboratory, use it to measure the β of the transistor. By assuming the β displayed by the transistor curve tracer, the actual β value is determined. The percentage is computed by the error between the β displayed by the transistor curve tracer and the β computed in Procedure 2a.

The straight line drawn in the active region on the transistor input/output characteristics plot can be represented by an equation in the point-slope form, $y = mx + b$ (where x equals V_{in} and y equals V_{out}). Provide a mathematical proof (hint: use $I_c = \beta I_b$, and Ohm's law) that shows β is related to the slope of the line in the active region by the equation:

$$\beta = \frac{mR_B}{R_C}$$

Slope is measured by the line in the active region of the transistor input/output characteristics plot for your particular transistor. Using the measured slope and Equation (1), calculate the average β . Three schematic diagrams is drawn for the circuit of Fig. 1, one for each operating mode, however substitute the large-signal transistor model for the transistor element in each circuit. For all three circuits write two KVL loop equations, one for the base-emitter side (which will include the voltage across R_B) and one for the collector-emitter side of the circuit (which includes the voltage across R_C). The y-intercept (b in the point-slope form) offsets the line from the origin. Write an equation for b in terms of the variables used in this circuit. Project the line drawn in the active region until it crosses the y-axis. Use this value of b and the equation for b to determine an average V_{BE} for this transistor.

TOPIC 3

COMPONENT EXPLANATION

3.0 GENERAL DESCRIPTION

3.1 IC 74C926

The MM74C925, MM74C926, MM74C927 and MM74C928 CMOS counters consist of a 4-digit counter, an internal output latch, NPN output sourcing drivers for a 7-segment display, and an internal multiplexing circuitry with four multiplexing outputs. The multiplexing circuit has its own free-running oscillator, and requires no external clock. The counters advance on negative edge of clock. A HIGH signal on the Reset input will reset the counter to zero, and reset the carry-out LOW. A LOW signal on the Latch Enable input will latch the number in the counters into the internal output latches.

A HIGH signal on Display Select input will select the number in the counter to be displayed; a LOW level signal on the Display Select will select the number in the output latch to be displayed. The MM74C925 is a 4-decade counter and has Latch Enable, Clock and Reset inputs. The MM74C926 is like the MM74C925 except that it has a display select and a carry-out used for cascading counters. The carry-out signal goes HIGH at 6000, goes back LOW at 0000. The MM74C927 is like the MM74C926 except the second most significant digit divides by 6 rather than 10. Thus, if the clock input frequency is 10 Hz, the display would read tenths of seconds and minutes (i.e., 9:59.9). The MM74C928 is like the MM74C926 except the most significant digit divides by 2 rather than 10 and the carry-out is an overflow indicator which is HIGH at 2000, and it goes back LOW only when the counter is reset. Thus, this is a 3½-digit counter.