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Volt-Ohm-Milliampere Meter (VOM)

Content

1. Objective
2. Theoretical part
   2.1) Volt-Ohm-Milliampere (VOM) meter
   2.2) Color codes for a resistor
   2.3) Identification of diodes and transistor polarities
3. Experimental part
   3.1) Experimental instructions
   3.2) Experimental report

1. Objective

This laboratory helps you to familiarize with a Volt-Ohm-Milliampere (VOM) meter.

2. Theoretical Part

2.1) Volt-Ohm-Milliampere (VOM) Meter

A meter with a single D'Arsonval movement that can be used to measure multiple ranges of currents and voltages is called a multimeter. A common type of analog multimeter—a combination voltmeter, ohmmeter and milliammeter—is abbreviated VOM. The block diagram of a basic multimeter is shown in Figure 1.

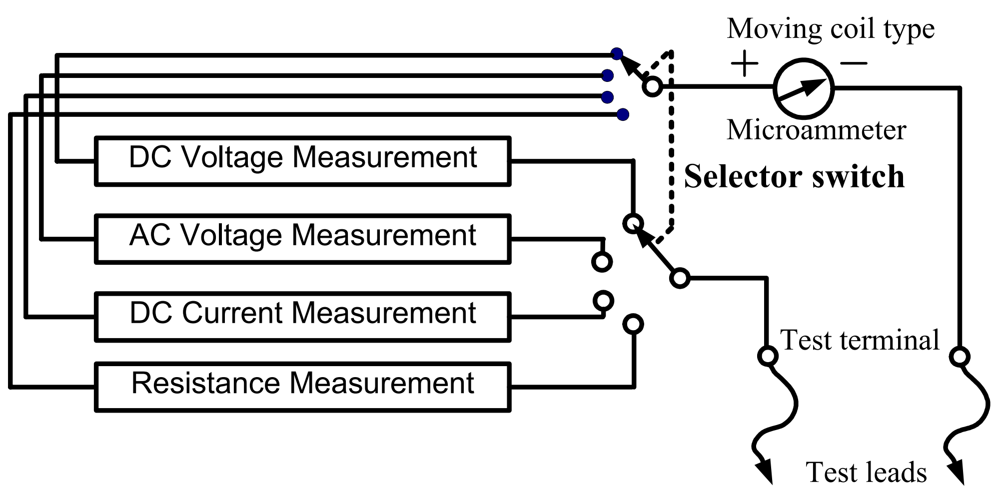


Figure 1: Block diagram of a basic multimeter.

The ammeter in Figure 1 is a moving coil ammeter. It uses magnetic deflection, where current passing through a coil in a magnetic field from permanent magnet creates the torque and causes the coil to move clockwise. The distance of the coil moves is proportional to the passing DC current. Figure 2 illustrates the D'Arsonval movement.

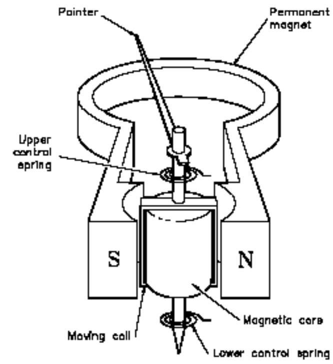


Figure 2: D’Arsonval movement.

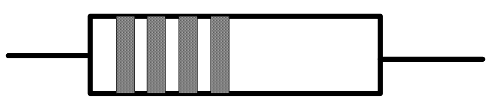
For DC voltage measurement, large values of resistances are connected in series with a microammeter, e.g. 50 μA, 2000 Ω, in order to limit the current passing through it. The voltage obtained can be computed from the passing current and the resistance value. Procedures for AC voltage measurement is similar to DC voltage measurment, however, a rectifier is required in order to convert AC current to DC current before passing through a microammeter. This can be achieved by using two diodes and calcibrated by two resistors in order to give RMS values correctly for sinusoidal waveforms. For DC current measurement, low resistors are connect in parallel with a microammeter and then the current division is applied to calculated the current value. For resistance measurement, a battery in a multimeter and a set of resistors are used for the measurement. When a resistor is connected, the circuit is closed and the current will flow. The resistance value can then be computed.

Analog multimeters are not hard to find in the used market, but are not very accurate because of errors introduced in zeroing and reading the analog meter face. Modern multimeters are exclusively digital, and identified by the term digital multimeter or DMM. Current, voltage, and resistance measurements are considered standard features for DMMs. Newer equipment can measure many other quantities. Some common quantities are such as inductance, capacitance, temperature, frequency, speed and RMS values. Some DMMs even come with software to analyze important parameters. The signal under test is converted to a digital voltage and an amplifier with an electronically controlled gain preconditions the signal. Since the digital display directly indicates a quantity as a number, there is no risk of parallax causing an error when viewing a reading. Better circuitry and electronics have improved meter accuracy. Older analog meters might have basic accuracies of five to ten percent. Modern portable DMMs may have accuracies as good as ±0.025%. The inclusion of solid state electronics has provided a wealth of convenience features in modern digital meters. Figure 3 shows one of DMMs available in the market.

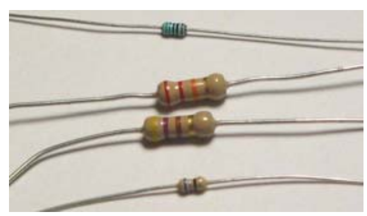
Figure 3: Digital multimeter.

2.2) Color Codes for A Resistor

There are four color codes (numbered 1, 2, 3 and 4) for a resistor as shown in Figure 4:



a. Color code



b. Real resistor

Figure 4: Color codes for a resistor.

Each color code has the meaning as follows:

- The colors in the 1st and 2nd bands represent numbers as follows:

Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

- The color in the 3rd color band represents the number of zero after the number in the 2nd color band.
- The color in the 4th color band represents the percentage of an error.

None	20%
Silver	10%
Gold	5%

For example, a resistor with the color code: Red/Yellow/Orange/Silver has the value of 2 4 000 (24,000) ohms with an error not greater than 10%.

2.3) Identification of Diode and Transistor Polarities
Polarities of diodes and transistors can be identified as shown in Figures 5 and 6.

Figure 5: Diode polarities.

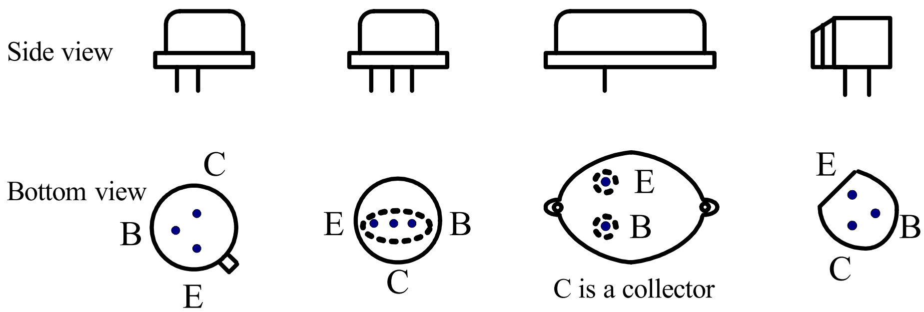


Figure 6: Transistor polarities.

Normally, the range Rx1 will not be used for diode and transistor polarities identification because it is possible that the current flow can be high enough to destroy diodes and transistors. In addition, the range Rx10K should not be used because it is possible that the voltage is high enough to cause the breakdown.

Polarities + and – marked on an ohmmeter represent the battery polarities inside the ohmmeter. However, if a multimeter is made in Japan (like SANWA used in our lab), the positive polarity of the connector is connected to the ***negative*** polarity of the battery inside. Therefore, the measurement of forward and reverse resistance of diodes and transistors has to take this into account. This means the measured value will be the forward resistance as long as the positive polarity of the battery (a connector from the negative-mark terminal on the meter) is connected to p-type or anode and the negative polarity of the battery is connected to n-type or cathode. For multimeters from USA, positive polarity of the battery is connected to the positive-mark terminal on the meters. There is no need to correct for the polarity reverse.

3. Experimental Part
This section describes experimental procedures, instructions and reports.

3.1) Experimental Instructions
Experimental Instrument and Details
VOM
Digital Multimeter
Circuit board
Oscilloscope
Signal generator
DC power supply

Note:

- Before using a multimeter to measure any parameter (current, voltage or resistance), the **range switch has to be properly selected** first otherwise damages can happen to a multimeter or circuit board.
- Use the **largest scale range** before any measurement. This reduces damage to meters and also the possible error from the readings.

Exp 1: DC Voltage Measuring Circuits

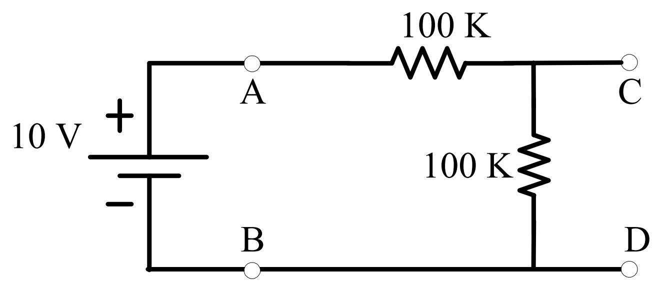


Figure 1.1: Circuit for DC voltage measurement.

1) Connect the circuit as shown in Figure 1.1.
2) Adjust the output voltage from DC power supply (V_{AB}) to be 10 V using a multimeter.
3) Use a multimeter to measure V_{AB} and V_{CD}.
4) Reduce the voltage to zero and turn off the DC power supply.

Exp 2: DC Current Measuring Circuits

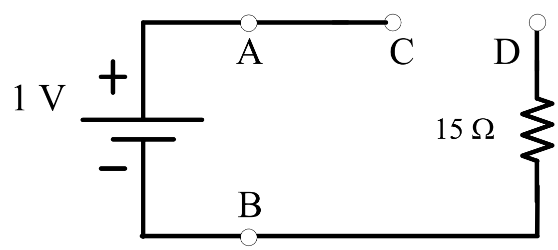


Figure 2.1: Circuit for DC current measurement.

1) Connect the circuit as shown in Figure 2.1.
2) Adjust the voltage between points A and B to be 1 V.
   a. Calculate the current flowing in the circuit = …………………. mA

   b. Connect a multimeter beween points C and D in order to measure the current (disconnect the short-circuit part between points C and D and connect a multimeter instead). The measured current = ………………… mA

Exp 3: AC Voltage Measuring Circuits

Use a multimeter to measure AC output voltage of a function generator. Be careful not to generate DC signals. If the function generator has an OFFSET button, students should set it in the middle or shut off the OFFSET button first.

1) Set the output signal from the function generator to be the sinusoidal waveform with the magnitude of 3 V_{rms} and the frequency about 1 kHz. Measure with a multimeter first and then with an oscilloscope (peak to peak value)

2) Repeat the same procedure as in 1) but with the square waveform
3) Repeat the same procedure as in 1) but with the triangular waveform
4) Use a digital multimeter to measure voltage signals in 1), 2) and 3).

Exp 4: Resistance Measurement
Use a multimeter to measure the resistance of three resistors as shown in Figure 4.1.

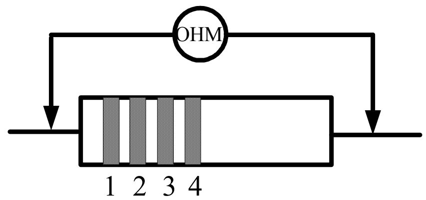


Figure 4.1: Circuit for a resistor measurement.

Exp 5: Capacitor Check
1) Use a multimeter (select ohmmeter) to check the capacitor as shown in Figure 5.1. A good capacitor will not allow the current to flow, i.e. resistance is ∞.
2) Specify the condition of capacitors, e.g. good or bad, include the capacitance value and drawings of capacitors. If a capacitor condition is bad, please describe.

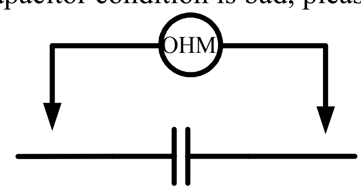


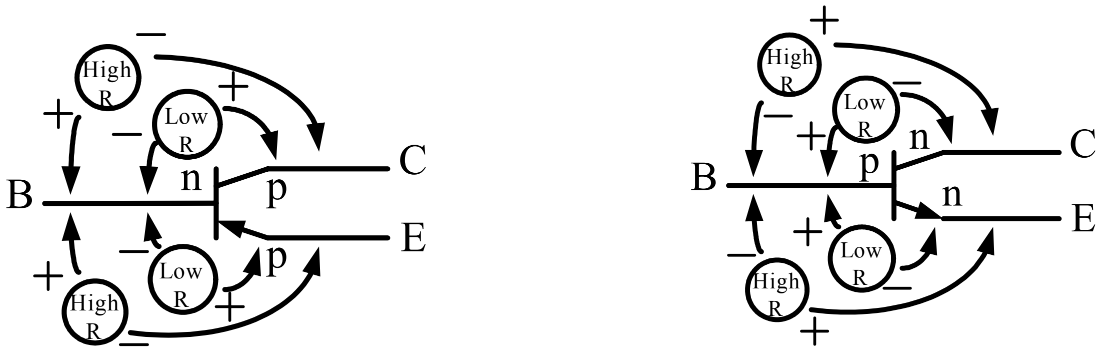
Figure 5.1: Circuit for a capacitor check.

Exp 6: Diode Check
1) Use a multimeter to check a diode by measuring forward and reverse resistances as shown in Figure 6.1.
2) Specify the condition of diodes, e.g. good or bad, include the diode number and drawings of diodes. If a diode condition is bad, please describe.
   Note:
   - If a diode is forward biased: an anode is positive referenced to a cathode, a diode has a low resistance and the current can flow. When a diode is reversed biased (an anode is negative referenced to a cathode), the resistance will be large and nearly no current can flow.
   - A good diode is the one with low forward resistance and large reverse resistance.

a. Forward resistance b. Reverse resistance
Figure 6.1: Circuit for a diode check.

Exp 7: Transistor Check

1) Use a multimeter to check a transistor by measuring forward and reverse resistances of P-N junction between base (B) and collector (C) and between base and emitter (E). If both junctions are good, a transistor condition is good.
2) If it is not known which pin is collector or emitter, we can check a transistor as shown in Figure 7.1. We can then find if a transistor is good or bad and NPN or PNP type.



a. PNP transistor

b. NPN transistor

Figure 7.1: Circuit for a transistor check.

3) Specify the condition of transistors, e.g. good or bad, include the transistor number and drawings of transistors. If a transistor condition is bad, please describe.

3.2) Experimental Report

Student name:____ ID: _________________

Date: ____________ Group: ______________ Instructor signature: ______________________

Exp 1: DC Voltage Measuring Circuits

V_{AB} = …………….. V

V_{CD} = …………….. V (from the measurement)
= …………….. V (from the calculation)

- Why is the measured V_{CD} value different from the calculated value? Show calculations in order to explain the difference.

Discussion

Exp 2: DC Current Measuring Circuits

1) Calculated current = …………………. mA
2) Measured current = ………………… mA

- Why is the measured current different from the calculated value? Show calculations in order to explain the difference.

Discussion

Exp 3: AC Voltage Measuring Circuits

Signal	Values from a multimeter (pointer type)	$V_{peak\text{-}peak}$ (from an oscilloscope)	Values from a digital multimeter
Sine wave	3 V_{rms}		
Square wave	3 V_{rms}		
Triangular wave	3 V_{rms}		

- Can pointer-type and digital multimeters measure three AC voltages correctly? Please explain.

Discussion

Exp 4: Resistance Measurement

	Code#1	Code#2	Code#3	Code#4
1st resistor: Color =	……………	………………	……………..	………………
2nd resistor: Color =	……………	………………	……………..	………………
3rd resistor: Color =	……………	………………	……………..	………………

		1st resistor		2nd resistor		3rd resistor
Value from the color code	=	Ω	=	Ω	=	Ω
Percentage of error	=	%	=	%	=	%
Value from an ohmmeter	=	Ω	=	Ω	=	Ω
Error*	=	%	=	%	=	%

Note:

1) The error can be found from comparing the value from an ohmmeter to the value from the color codes.
2) In order to obtain accurate values of the resistance, a calibration of an ohmmeter should be done. This can be achieved by touching both test leads and adjust the "**Zero Adjust**" button to give zero value on the scale. This calibration should be done every time the range is changed.

- Compare and analyze results obtained from measurements and color codes of resistors.

Discussion

Exp 5: Capacitor Check
C1 ……………. (good or bad)

C2 …………….

C3 …………….

- Explain and analyze the result from capacitor checks

Discussion

Exp 6: Diode Check
D1 ……………. (good or bad) Number (if available)

D2 ……………. Number

D3 ……………. Number

D4 ……………. Number

- Explain how to check diodes in this experiment by studying diode characteristics.

Discussion

Exp 7: Transistor check
T1 ……………. (good or bad) Number Type

T2 ……………. Number Type

T3 ……………. Number Type

T4 ……………. Number Type

- Explain how to check transistors in this experiment by studying how transistors work first.

Discussion

Conclusion