PRACTICAL ELECTRONICS FOR EVERYBODY

VOLUME 1

Attention

Collect all electrical circuits according to the instructions in this book and using electronic components included in this kit. You are responsible for any modifications of the circuits that are not reviewed in the book. Before you begin the practical part, learn the safety precautions, list of schematic symbols and introductory information. Kit distribution is possible only with this book.

All images with breadboards were created in the Fritzing program.
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Introduction

In this book you will find all the support and information required in order to familiarise yourself with the interesting and infinite world of electronics. The Learning Kit Practical Electronics For Everybody consists of two volumes covering various aspects of electronics. Right now, you are holding Volume 1 in your hands, which will introduce you to the most widespread components used in designing modern hardware. This book will help you to handle the following components:

- various power supplies (from standard batteries to alternative power supplies)
- resistors
- capacitors
- switches
- semiconductors (diodes, transistors, Zener diodes)
- optoelectronic components

This book consists of six sections dedicated to studying the components mentioned above. Each section is comprised of theoretical and practical parts. The theoretical part introduces the structure of a specific component and its types, and aspects of its operation and usage. In the practical part, you will build electronic circuits and learn how you can use the multimeter to explore the properties of electronic components and measure the main circuit parameters. You will strengthen the knowledge obtained in the theoretical part by solving practical tasks.

The Learning Kit Practical Electronics For Everybody will give you both basic knowledge of electronics and useful practical skills for calculating and designing your own electronic circuits.

The experiments in the practical part will require just a breadboard, a set of jump wires and the electronic components listed at the beginning of the practical part, which means no dangerous hot soldering irons, skin burns or complex circuits. Everything is simple and safe, and, most importantly, if you make a mistake building your circuit, you can easily correct it.

We wish you many pleasant, interesting and productive experiences with the Learning Kit Practical Electronics For Everybody.

Tantalum capacitors consist of two electrodes, a dielectric and an electrolyte (solid or liquid) (Figure 3.10).

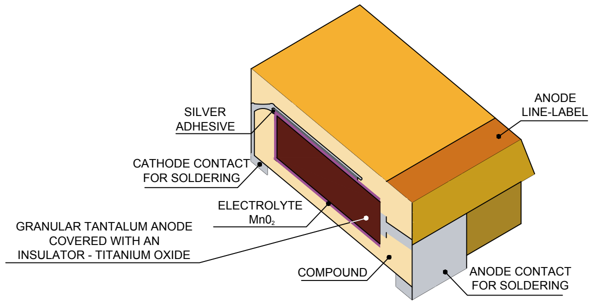

Figure 3.10. Structure of tantalum capacitor

Tantalum capacitors maintain a small size with an even greater capacity and better insulating properties (including lower leakage) compared to aluminium capacitors. It is important to observe correct polarity during connection.

The maximum operating voltage can be up to 75 V, but the capacities can range from hundreds of nanofarads to thousands of microfarads.

Understanding electrolytic capacitors

Capacity and operating voltage of electrolytic capacitors

The capacity of an electrolytic capacitor and its operating voltage are marked either on the body of the capacitor or in its technical documentation (Figure 3.11):

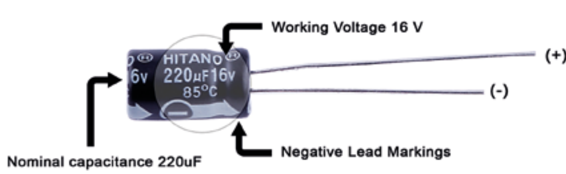

Figure 3.11. Markings on an electrolytic capacitor

Capacitance is marked with numbers and letters.

Another important indicator marked on the body of the capacitor is its *operating voltage*. This is the maximum DC voltage that can be applied to the terminals of the capacitor. Excessive operating voltage of the capacitor can lead to malfunction. Moreover, it can explode.

Figure 3.11 shows the markings on a capacitor as 220 uF, 16 V, meaning that the capacitor has a capacitance of 220 uF and a maximum operating voltage of 16 V.

Polarity of capacitors

When connecting electrolytic capacitors, it is very important to observe correct *polarity*. Wrong polarity may lead to destruction or explosion of the capacitor. In order to prevent any confusion, the negative terminal is marked with a gray, black or white stripe on the body of the electrolytic capacitor (Figure 3.11). Usually, the negative contact is shorter than the positive contact.

Film capacitors

Film capacitors are divided into two different types: radial and axial (Figure 3.12). Their structure resembles a multilayer sandwich with dielectric layer alternating with metal films that are connected to the contacts of the capacitor.

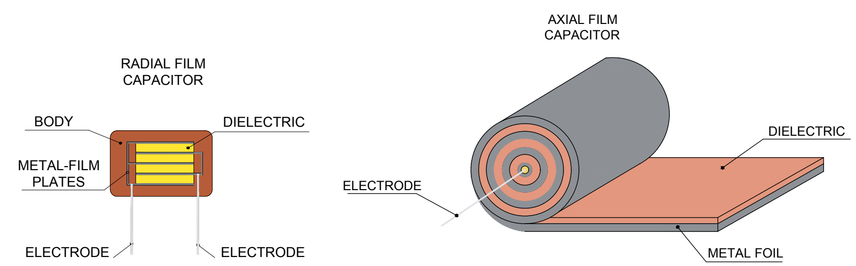

Figure 3.12. Construction of axial and radial film capacitors

Mylar, Teflon, polycarbonate or polypropylene, or metallised paper can be used for the dielectric.

Film capacitors are able to provide a wide range of capacitances and are designed for high-voltage applications. Their capacitances range from a few picofarads to hundreds of microfarads. Film capacitors are designed for operation over a wide temperature range. The lifespan of a film capacitor is often longer than that of a ceramic or electrolytic capacitor.

These types of capacitor are commonly found in high-voltage equipment where circuit operation accuracy is necessary.

An FET, like a bipolar transistor, has three terminals. However, instead of the base, collector and emitter, the terminals are called the *gate, source* and *drain* (see. Figure 5.45).

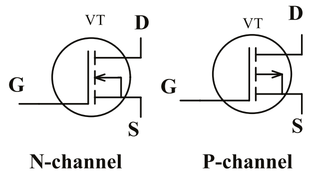

Figure 5.45. Field-effect transistor schematic symbol

FET terminal abbreviations:

- gate – G
- source – S
- drain – D

The current between the source and drain can be adjusted by applying voltage to the gate. The higher the voltage applied, the greater the output current. A field-effect transistor functions as follows: a channel is formed between the drain and the source with a depth (and resistance, respectively) depending on the voltage applied to the gate. Thus, FET output current is changed by changing the channel resistance.

If the applied voltage is sufficient to establish a current flow between the drain and source, the transistor is considered to be *open* and in the case of insufficient voltage, the transistor is *closed*. Therefore, it is often called an electronic switch, just like the bipolar transistor.

Like bipolar transistors, FETs are widely used in computer devices. With the development of manufacturing technologies of FETs, they have practically replaced bipolar transistors in almost all areas of electronics: transmitter/receiver, analogue-to-digital converters, amplifiers, etc.

Practice

5.4.2.1. A FET as an electronic switch

List of necessary components for experiments

Sequence number	Component	Description	Quantity
1	button	normally open, 2 contacts	1
2	resistor	360 Ω; 0.25 W	1
3	resistor	10 kΩ; 0.25 W	1
4	potentiometer	1 kΩ; 0.5 W	1
5	field-effect transistor	N-channel	1
6	LED	5 mm, red	1
7	power supply	9V battery	1
8	battery holder	for 9V battery	1
9	breadboard	–	1
10	jump wires	–	1 set

Similarly to bipolar transistors, FETs may act as electronic switches (Figure 5.46). But in this case, it is the voltage applied to the gate that is critical, not the input current. The higher the voltage, the greater the transistor output current (drain current).

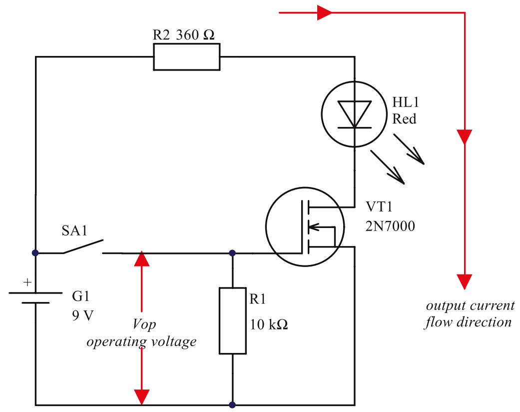

Figure 5.46. An FET as an electronic switch

If the gate voltage is too low or has a zero value, the FET will stay closed, and the drain current will be zero. In this state, the FET acts as a switch with open contacts (infinitely high resistance).

Increasing the voltage on the FET's gate to a sufficient level opens the gate, the drain current grows, and the LED lights up.

Build the circuit on the breadboard according to Figure 5.47, and check how it works.

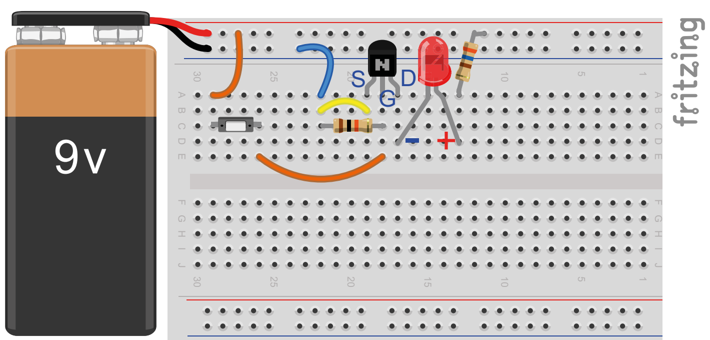

Figure 5.47. Field-effect transistor – electronic switch

In Figure 5.47, the FET channel type is marked by the letter *N*. The transistor used in this circuit (2N7000) has the following terminal order (when looking at the front of the labelling side) from left to right – source, gate, drain (see Figure 5.48):

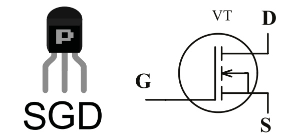

Figure 5.48. 2N7000 FET terminal locations

Other FETs can have different terminal orders. Check this information in the transistor documentation.

Please observe correct polarity when connecting the LED. Its positive terminal has a longer leg, and is located on the rounded side of the lens. Figure 5.47 shows LED terminals marked with "+" and "–" symbols.

If you connect a potentiometer instead of the button, you'll be able to slowly adjust the voltage applied to FET gate, and thus its output current (Figure 5.49):

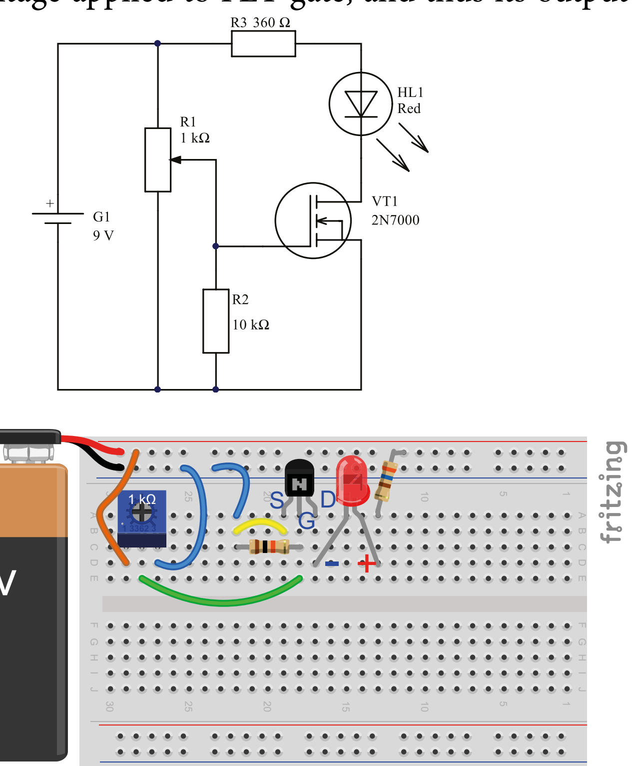

Figure 5.49. Adjusting the gate voltage

Use a Phillips-head screwdriver to slowly adjust the potentiometer resistance and get a smooth lighting up and fading out of the LED. After reaching a certain limit, the drain current does not increase, because the R3 limiting-resistor will not allow the current flowing through the LED to exceed 20 mA. However, you have confirmed by yourself that the current flow can be controlled by adjusting FET gate voltage.

5.4.2.2. Connecting an electret microphone

List of necessary components for experiments

Sequence number	Component	Description	Quantity
1	resistor	47 Ω; 0.25 W	1
2	resistor	10 kΩ; 0.25 W	1
3	field-effect transistor	N-channel	1
4	electret microphone	–	1
5	loudspeaker	8 Ω; 0.5 W	1
6	power supply	9V battery	1
7	battery holder	for 9V battery	1
8	breadboard	–	1
9	jump wires	–	1 set

Let's consider a rather simple circuit using an electret microphone and a loudspeaker (Figure 5.50):

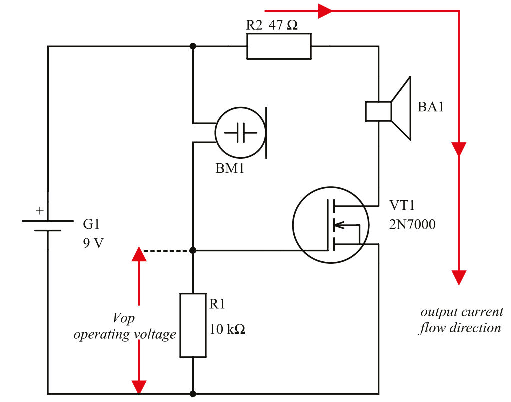

Figure 5.50. Connecting an electret microphone to a transistor

An Electret microphone (Figure 5.51) is a microphone whose output voltage varies according to the acoustic action on it. That is, in the case of acoustic action on the microphone (speaking, singing, etc.), its internal field is changed, which leads to a change in the voltage at the microphone output.

Figure 5.51. Electret microphone

We will control a field-effect transistor using this microphone operation principle (output voltage change).

The transistor input voltage change corresponding to the acoustic action will affect the FET output current flowing between the drain and source. Fluctuations of the transistor output current will make the loudspeaker sound. The transistor will open (in the case of a sufficiently high voltage being present at the gate) and close (in the case of a low input voltage).

Build the circuit on the breadboard using the specified components according to Figure 5.52.

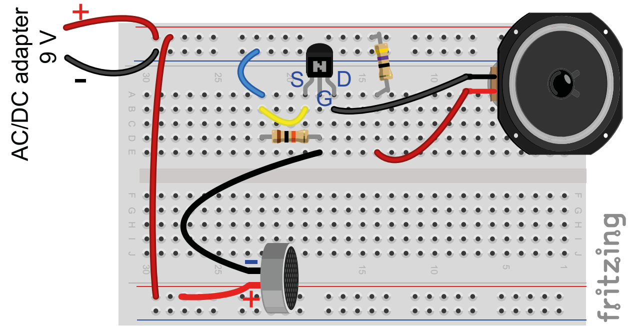

Figure 5.52. Connecting a microphone to FET

! Be sure to observe correct polarity when connecting the electret microphone (see Figures 5.51, 5.52).

After connecting all the components of the circuit, blow on or tap the microphone. The loudspeaker produces the corresponding sounds. You can also turn on music on your phone and put it close to the electret microphone. If you get close to the loudspeaker of your circuit, you will hear quiet music, repeating the melody on your phone.

Thus, you managed to control a relatively large current, which is required for the speaker, by using low voltage.

The design shown is not the best example of sound amplification. Operational amplifiers are much better suited for this purpose. However, this simple example helps to show that an FET can be controlled by applying a rather low voltage.

SELF-TEST QUESTIONS

1. Draw the schematic symbols for N- and P-type FETs. Mark all their terminals.

2. What is the main difference between field-effect and bipolar transistors?

3. How can you control the change of FET output current?

SELF-TEST QUESTIONS

1. What is a light-operated relay?

2. What role does the photoresistor perform in the light sensor circuit?

3. Can you adjust the light sensor sensitivity according to the light conditions? How can it be done?

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