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# 1 The Construction Kit "Profi E-Tec"

The construction kit Profi E-Tec covers the exciting subject of electrical engineering. Starting with simple electrical circuits it will show you how e.g. a torch works and how the light of a refrigerator is switched on and off. But you will also learn how staircase lighting works which can be switched on and off using two different switches.

Another chapter explains the purely electro-mechanical automation of systems without computer and electronics, using so-called switcher drums. You will be astonished that a complete traffic light system can be controlled using these devices.

Afterwards, we will take a look at modern electronics and control different applications, e.g. the barrier of a public garage or a garage door using the "E-Tec Module". This is a small electronic control module with microprocessor which can do amazing things. You can, for instance, connect different sensors (pushbuttons, light sensors, magnetic sensors) and control a motor according to the sensor signals. Furthermore, some programs are already stored in the E-Tec Module which can easily be retrieved and used for different functions. You will see that this small module has great resources. But let us start from the beginning.

## 2 Electric Circuits

### 2.1 Before getting started

Before you start experimenting, you need to assemble some components, like e.g. cables and plugs, lamps, the buzzer and the 9V power supply. Refer to the assembly instruction under "Assembly aids and instructions" for details.

### 2.2 The simple electric circuit

Now all components are ready for use, so let us approach the subject of electrical engineering with some simple experiments. First, we will take a look at a simple electric circuit. And to do this we need the following components:

#### Power Supply:

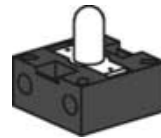
Normally, we use a 9V compound alkaline battery for the experiments in this kit that you can find in the provided battery tray. Naturally, you may also use the fischertechnik Accumulator Set part no. 34969 or the power supply unit "Energy Set" part no. 30182.

Now connect a lamp to the power supply:

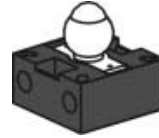


#### Note:

The kit contains two different lamps:



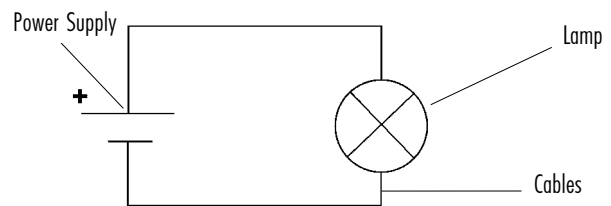
Bulb lamp: this is a common electric light bulb.



Lens tip lamp: this lamp incorporates a lens which bundles the light. We will use this lamp especially when we build a light barrier using the phototransistor. You will find the instruction later in the document. The form of this lamp is very similar to the one of a bulb lamp. Please ensure that you always use the right lamp.

For our first experiment we use the normal bulb lamp.

When electrical engineers wish to illustrate how different components should be connected, they do not draw the real components, like conductors and plugs, but symbols which represent them. Such a simplified drawing of our circuit will be as follows:



This representation is called a circuit diagram.

#### Task:

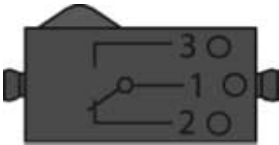
What can you see when you connect the lamp to the power supply, e.g. the 9 V block battery? – That is right, the lamp is on.

You have just built a circuit and the current flows in this circuit, i.e. from the positive pole of the power supply through the red cable to the lamp (also called consumer) and through the black conductor back to the negative pole of the power supply. You can think of the power supply as some kind of water pump which pushes the current through the cables to the consumer. Similar to the pump of an aquarium, a closed cycle is necessary for the current to flow. If we interrupt the circuit at any place, e.g. by pulling the plug, the current cannot flow.

And just as the pump can generate a certain water pressure according to its capacity, power supplies supply a certain voltage which is measured in Volt (abbreviation V). The fischertechnik consumers (lamps, motors, buzzers) require a voltage of 9 V. This voltage will be provided by the fischertechnik power supplies. If you use a higher voltage it will damage the consumers.

Every consumer requires a certain amount of electrical current, similar to the water which runs through a water pipe. And just like a water cock is a resistance for the water, the consumer is a resistance for the electrical current. The lower the resistance of the consumer the higher the current which can flow through it. The current is measured in "Ampere" (abbreviation A). The value which expresses how much resistance a consumer has for the current, is called "electrical resistance". It is measured in "Ohm" (abbreviation  $\Omega$ ).

Back to our electric circuit. First, we interrupted the circuit by pulling the plug. This may also be done in a more elegant way by using a switch which can be installed in one of the feed lines to the consumer and interrupts or closes the circuit.

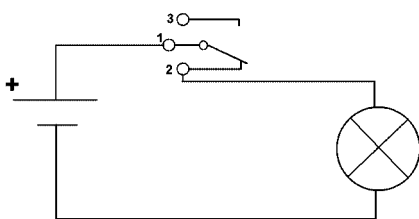


The fischertechnik switch is a pushbutton with 3 connections which are identified as 1, 2 and 3.

If you connect the feed lines to the contacts 1 and 2 of the pushbutton it is closed in its off-position (i.e. the pushbutton is not pressed) so that the current can flow. If you press the button (operating position), the circuit is interrupted.

But if you connect the lines to the contacts 1 and 3 of the pushbutton, it is open in its off-position, so that no current can flow. If you press the button, the circuit is closed.

To take a closer look at the difference, we expand your simple circuit consisting formerly of power supply and lamp by the pushbutton which is connected between the red feed line and the lamp. From now on, we will no longer show any real illustration but only the circuit diagrams:

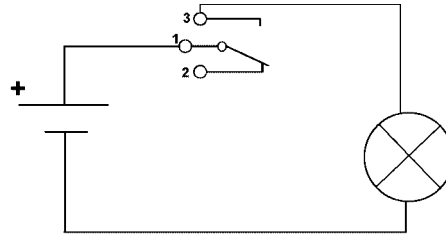


#### Task:

Build this circuit (it is best to do it on the big black base plate) and record when the lamp is on.

	Lamp
Pushbutton not pressed	
Pushbutton pressed	

The second circuit should look like this:



#### Task:

Change your circuit according to the diagram and observe again, when the lamp is on:

	Lamp
Pushbutton not pressed	
Pushbutton pressed	

#### Result:

If the circuit is interrupted by pressing the pushbutton (contacts 1 and 2) the pushbutton is called "break contact". If the circuit is closed by pressing the pushbutton (contacts 1 and 3) it is called "make contact".

Now, we are going to use each of these two different functions in one fischertechnik model.

#### Task:

- Build a torch using the components of the kit.
- Consider whether the pushbutton should work as a break or make contact.
- Draw the relating circuit diagram.

#### Task:

- Build a refrigerator model with an interior lighting which is on when you open the door and off when you close it.
- How should the pushbutton be connected in this case?
- Draw the relating circuit diagram.

#### Note:

You will find an example solution for these two tasks in the building instruction.

## 2.3 Conductor and non-conductor

Not all materials conduct the current. It flows especially well through metals, like the copper conductors of the fischertechnik cables. But also brass, iron, lead, tin or the metal axles which are part of the kit are good conductors. Other materials conduct the current only badly or not at all. For instance, plastic is an absolute non-conductor, also called an insulator.

**Task:**

Build a device that can test whether any material conducts the current or not.

Such a device is also called "continuity tester".

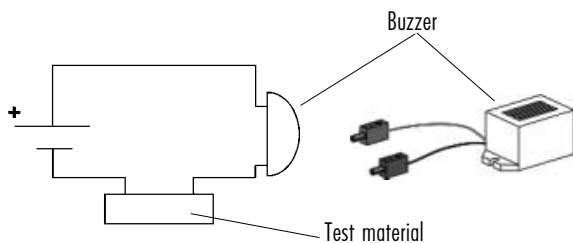
Do you have any idea how it might work then start right away and try it.

Otherwise, you will find some help here:

**Notes:**

We need two open contacts that we can hold to a material. If it conducts the current, the circuit is closed and the kit's buzzer gives an acoustic signal which indicates that the circuit is closed. If there is no signal from the buzzer, we know that this particular material does not conduct the current.

The circuit diagram for this application is as follows:

**Caution!**

Ensure the right polarity of the buzzer. Red=Positive. Otherwise, it is not going to work.

If you have any difficulties building this device, just take a look at the assembly instruction. There you can find a detailed description how to do it.

**Task:**

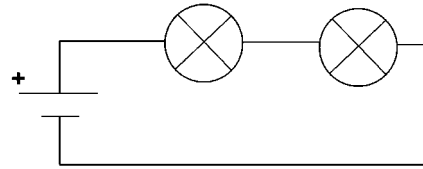
Try different materials and mark with a cross which are conductors and which are insulators.

Material	Conductor	Insulator

Materials which are good conductors (e.g. copper) are used to transport current. Non-conductors (e.g. plastic) are used to insulate conducting materials against unintentional touching. Therefore, fischertechnik cables contain conducting copper wire on the inside and are insulated with plastic.

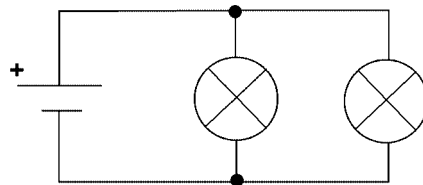
## 2.4 Series and parallel connection

Let us now see what happens if you do not only operate one but several consumers in one circuit. We use 2 bulb lamps as consumers and connect them in two different ways:

**"In series" one after the other:****Task:**

1. Build this circuit with 2 bulb lamps on the black building plate (see also instruction).
2. How bright is the light of both lamps compared to the one lamp in the simple circuit? Mark the right answer with a cross.

brighter ☐    same ☐    darker ☐

**Parallel:**

By the way, if 2 conductors cross in a circuit diagram, like the 2 conductors here, and if there is an electric connection at the crossing point, this is indicated by a black dot. In case of a conductor crossing without a dot, there is no electric connection.

**Task:**

1. Build this circuit on the black plate using 2 bulb lamps (see also instruction).
2. How bright is the light of both lamps compared to the one lamp in the simple circuit?

brighter ☐    same ☐    darker ☐

**Result:**

If you connect one lamp after another lamp in one circuit, this is called a "series connection". In series connection, both lamps share the available current (here: 9 V). Therefore, the lamps are not so bright.

If you connect two lamps parallel to one another in the same circuit this is called a “parallel connection”. In this case, both lamps receive the full voltage of 9 V. Therefore, they are both as bright as one lamp in the simple circuit.

## 2.5 AND-OR circuit

Similar to the two lamps in one circuit we can also incorporate two pushbuttons and one lamp in one circuit.

In this case, you can connect the pushbuttons either in series or in parallel connection.

### Series connection:

You can find this circuit on page. 11 of the assembly instruction.

#### Task:

- Build this circuit on the black building plate.
- Draw the electric circuit.
- When is the lamp on? Mark the right solution(s) with a cross.

When no pushbutton is pressed ☐

When the first pushbutton is pressed ☐

When the second pushbutton is pressed ☐

When both pushbutton are pressed ☐

### Parallel connection:

You can find this circuit in the assembly instruction on p. 11.

#### Task:

- Build this circuit on the black base plate.
- Draw the electrical circuit.
- When is the lamp on? Mark the right solution(s) with a cross.

When no pushbutton is pressed ☐

When the first pushbutton is pressed ☐

When the second pushbutton is pressed ☐

When both pushbutton are pressed ☐

### Result:

When the two pushbuttons are connected in series, the lamp will only be on if pushbutton 1 and pushbutton 2 are pressed, therefore, this connection is called an “AND circuit”.

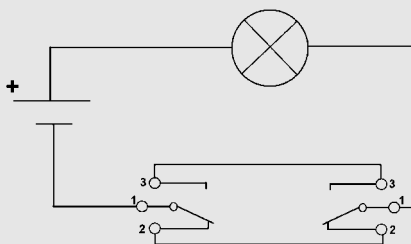
When the two pushbuttons are connected in parallel, the lamp is on if pushbutton 1 or pushbutton 2 is pressed, this connection is called an “OR circuit”.

## 2.6 Two-way connection

Perhaps you have asked yourself, how it is possible to enter a building, turn on the light in the basement, walk up the steps, and turn it off on the first floor. And when you are on the first floor you can also turn the light on or off again as you like. To realize this, you need a connection which is called “two-way connection”.

### Task:

- Build a simple model of “staircase lighting” using a bulb lamp and two pushbuttons. For the light to stay on even if you let go, push a small plate over the red button so that it stays pressed (see also assembly instruction).



- Now connect the model according to the circuit diagram as follows:
- Check whether the connection works like the staircase lighting described above.

We need all 3 jacks at the mini-pushbutton for this application. Contrary to the simple on/off switch, we call them “change-over switch” or “commutator”.

## 2.7 The motor

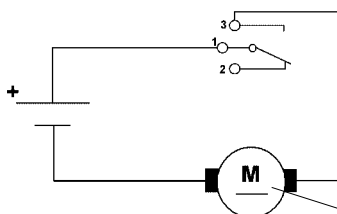


This chapter explains a further important consumer, the electric motor.

If you connect the motor to the power supply it starts turning. Let us try this, by building a

simple circuit using a pushbutton and a motor.

The circuit diagram is as follows:



Circuit symbol for motor

As soon as you press the pushbutton the motor starts turning. If you change the connectors at the motor, it turns in the opposite direction. So, for motors, it is important how you connect the plugs. If you change positive and negative, i.e. if you reverse the polarity, the direction of rotation of the motor reverses.

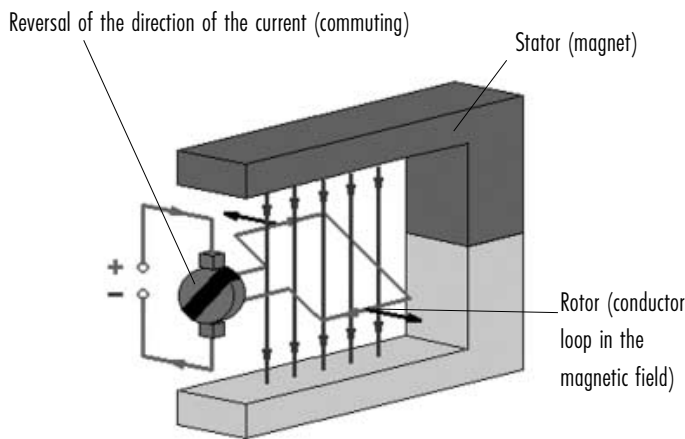
## 2.7.1 Functional principle of the motor

Why does the motor turn if the current flows through it?

If you think that the following physical comments are too complicated for you, simply skip them. As soon as you will learn the “magnetic effects of the electrical current” in school, you will certainly be able to understand the principle. We are going to present the functional principle of the motor in a simplified way:

If you hold a conductor through which current is flowing in a magnetic field, this conductor is subjected to a power, i.e. it is moving. This phenomenon is used in an electric motor. Simplified, the motor consists of two parts: one fixed part, the so-called stator and a turning rotor. The stator is a magnet, the rotor forms the conductor loop which is moving in the magnetic field of the stator as soon as current is flowing through it.

After a turn of  $90^\circ$ , the rotation of the conductor loop would normally end. Therefore, the current in the rotor must be reversed in time so that the direction of the power reverses and the rotation continues. This reversing of the direction of the current is also referred to as “commuting”. It results in a continuing rotation of the rotor.



In reality, the rotor does not only consist of one single conductor loop, but of very many loops which are wound in a certain manner. The polarity of the current is not only reversed once, but several times to enable an optimum rotation.

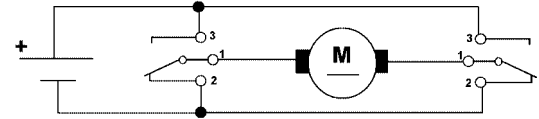
Next, we would like to carry out some practical experiments using the fischertechnik motor.

## 2.7.2 Motor control with 2 directions of rotation

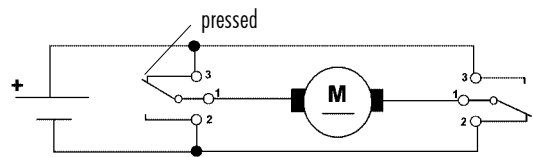
In many applications, the motor should not only rotate in one direction, but it should be possible to reverse the direction. In our first experiment with the motor, we achieved this by changing the connectors of the motor. This is of course somewhat complicated. Therefore, we will take a look at a possibility to solve the problem more elegantly using two mini-pushbuttons. The application example for this task is an elevator which should go up and down.

### Task:

- First, build an elevator (see assembly instruction).
- Connect the model according to the following circuit diagram so that the elevator moves up when you press one button and down when you press the other. If no button is pressed, the motor should be off.

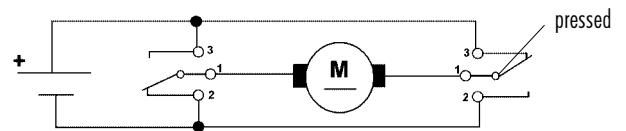


- Draw arrows in the below circuit diagrams which indicate the direction of the current (from + to -), so that you are able to recognize why the motor moves in different directions, depending on which button is pressed. Mark the direction of rotation of the motor with a cross.



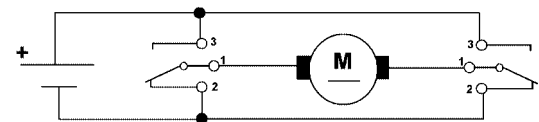
### Direction of rotation:

Right ☐ Left ☐ off ☐



### Direction of rotation:

Right ☐ Left ☐ off ☐



### Direction of rotation:

Right ☐ Left ☐ off ☐

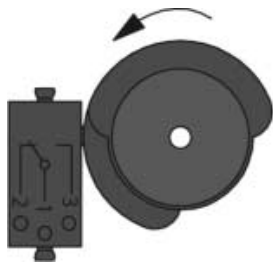
As you can see in the assembly instruction, you can position both pushbuttons so that you can alternately press one of the pushbuttons using the lever which is located between the buttons. Such a switch is called “pole changing switch”.

## 3 Electro-Mechanical Controls

### 3.1 Flashing light control

Until now, we turned lamps, motors and buzzers on and off manually using a pushbutton. If a lamp should flash, we would have to press and release the button all the time, press, release, press, release.... Who has the time? To avoid this, we use a so-called switcher drum to press the pushbuttons. This round component is driven by an electric motor and is continuously rotating.

It presses the pushbutton with its outside radius and the inner radius does not press the button. In one rotation of the switcher drum, the button is pressed for half of the rotation and not pressed for the other half.



To understand this better, first build a simple flash light on the black plate (see assembly instruction p. 19).

2 switch wafers are fixed on one fischertechnik hub nut each and turn in opposite directions. You are thus able to set how long the buttons should be pressed during one rotation of the switcher drum. For the flash light it means: the longer the button is pressed, the longer the lamp is on during one rotation of the switcher drum and the dark phase is respectively shorter.

During assembly of both switch wafers, please ensure the following:

One side of every disc is even, the other has a shoulder. Both discs will be attached to the hub nut in a way that the side with the shoulder is towards the outside. Otherwise, the hub nut cannot be tightened.

One application example of a flash light is a flash light on a high tower. But often it is not enough to have just one single light.

#### Task:

- Build a tower at the top of which are two warning lights (red and green) which both flash alternately (see building instruction).
- How can you change the flashing frequency?

### 3.2 Traffic light control

For flashing light controls it is enough to have a pushbutton and a switcher drum. Using several switcher drums, you can control entire processes, e.g. traffic lights. We will simplify the traffic lights so that they are not too complicated. We are not going to use a yellow light, only red and green.

#### Task:

- Build a traffic light with a red and a green light. Use the bulb lamps.  
Realize the control using switcher drums with 2 pushbuttons and 2 switcher drums. Select the transmission gear ratio of the drive motor so that the relating traffic light phase lasts several seconds.
- First adjust the switcher drum in a way that red and green flash alternately.
- Design the control of the switcher drum in a manner which results in the following process:



#### Note:

You can also find the solution of this task in the building instruction.

Until some years ago, many machines were equipped with such electro-mechanical controls. Even washing machines were controlled like this. The disadvantage of such controls is their relatively complicated mechanical structure and the high losses due to the constant friction between the switcher drum and the contact. Today, most of the control tasks are solved electronically. These controls can be used in a much more flexible way, are significantly smaller and have a much higher efficiency as there is no mechanical friction. We are going to equip our models now with an electronic control – with one of the most modern ones, a so-called microprocessor control.

## 4 Controls Using Electronics

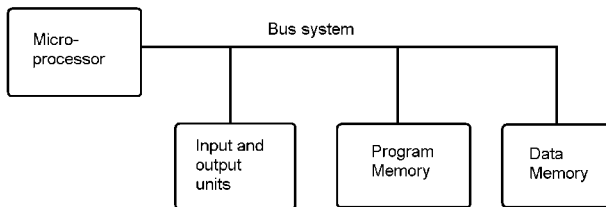
The subject of electronics is very interesting but it is also very comprehensive. It would go too far to mention all the basics which are necessary to fully understand the subject of electronics and electrical circuits. We simply leave this subject out and start right away with the microprocessor control which is included in the construction kit E-Tec.

#### The microprocessor control

Basic functional principle:

A microprocessor is a small computer which is able to process electronic data and commands. Thus, a microprocessor is also the heart of every computer. A microprocessor system consists mainly of the following components:





The microprocessor itself is the most important part. It processes data which are determined as commands in a program.

The program memory contains the program which must be run.

The data memory stores the intermediate and final results during the run of the program.

The input and output units are responsible for the exterior connection (e.g. keyboard, monitor).

The bus system is responsible for the exchange of information between the different components.

In principle, every computer works like this.

## 5 The E-Tec Module

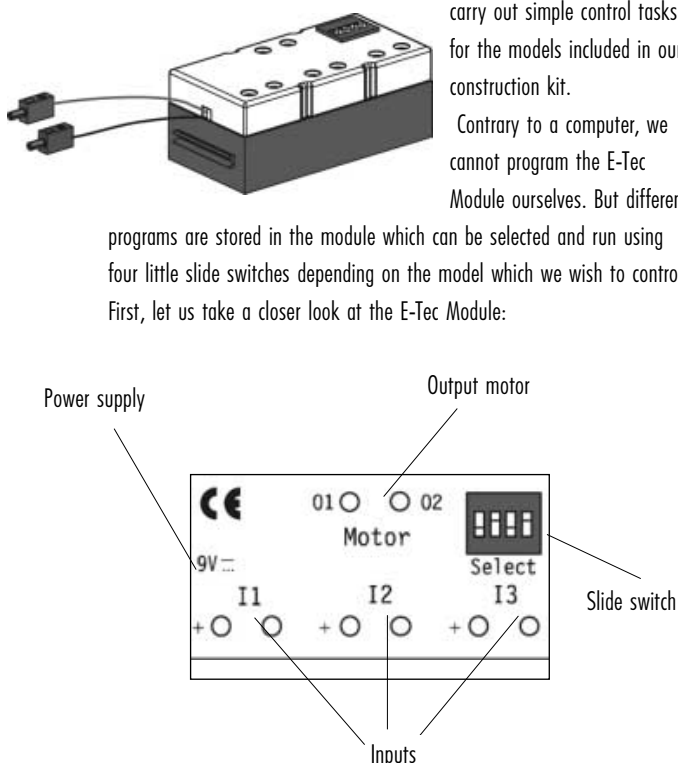
Our construction kit Profi E-Tec also contains such a small "computer", the so-called E-Tec Module. Naturally, the microprocessor it contains is by far not as powerful as the one of a computer, it is however efficient enough to

carry out simple control tasks for the models included in our construction kit.

Contrary to a computer, we cannot program the E-Tec Module ourselves. But different

programs are stored in the module which can be selected and run using four little slide switches depending on the model which we wish to control.

First, let us take a closer look at the E-Tec Module:



## 5.1 Connections

### Power supply

The E-Tec Module does, of course, only work if it is connected to a 9 V power supply of fischertechnik. During connection please ensure the right polarization (red=positive). If the module is correctly supplied with power, the green LED is on (it flashes shortly during switching on).

### Inputs I1-I3

The fischertechnik sensors can be connected to those inputs.

The sensors transmit information from the fischertechnik model to the E-Tec Module. Available sensors are the pushbuttons, a magnetic sensor and a phototransistor. We will subsequently take a closer look at these two sensors.

Technical data of the inputs: 9V $\dots$ , switching threshold: 4V $\dots$  (beginning with this threshold, a pushbutton is recognized as "pressed"=1 below that value, it is "not pressed"=0).

### Output motor

A motor, a lamp or a buzzer can be connected to these two jacks which are identified by 01 and 02. How the output is connected (lamp on/off, motor left/right/off) depends on which program was selected and which conditions exist at the inputs (e.g. pushbutton pressed or not pressed).

Technical data of the output: 9 V $\dots$ , constant current 250 mA, short-time 500 mA, resistant to short circuits.

### Slide switch 1-4

The position of these 4 switches which are also called "DIP switches" determines the function of the E-Tec Module. Using those switches you can select the desired program therefore you can read "Select" below them. Therefore, it is essential that the DIP switches are always in the position required for the respective model. You can find the correct switch position for every model in the building instruction. Every switch has 2 positions "ON" (upper position) and "OFF" (lower position).

Now let us finally try how the E-Tec Module works.

## 5.2 The basic program

First select "OFF" on all 4 DIP switches and connect the E-Tec Module to the power supply.

DIP1	DIP2	DIP3	DIP4
OFF	OFF	OFF	OFF

### Important!

The E-Tec Module will only read which program should be run when the power supply is switched on. Therefore, select the desired program first and then connect the mains appliance or the battery.

If DIP4 is "OFF", the so-called basic program is activated. This is quite a universal program with which you can control a great number of models. Try this program by connecting one motor to the output "Motor" and one pushbutton each to the three inputs I1-I3 (connect the pushbuttons to the contacts 1 and 3 as make contacts – see also chapter 2 about the simple circuit).


In this experiment, the polarity of the connections at the E-Tec Module is unimportant both at the inputs and the outputs.

#### Experiment:

- Shortly press the button of I1 – Result: the motor is running
- Shortly press the button of I2 – Result: the rotation of the motor is reversed
- Shortly press the button of I3 – Result: the motor stops.

In addition, the green LED goes out every time a button is pressed and is on again afterwards. So you can test if the sensors are working.

The function of the basic program can be described as follows:

Input	Motor	Select
I1	Left	
I2	Right	
I3	Off	

Whether the basic program is activated or not depends solely on the position of the switch DIP4. The basic program is active, when it is in the OFF position. Then, the sliding switches 1-3 have a special function in the basic program:

In chapter 2, section "The simple circuit", you have already learned that a pushbutton can work as a make or break contact. Until now, we realized these different functions by connecting the pushbutton either as a make contact (contacts 1 and 3) or as a break contact (contacts 1 and 2). Using the E-Tec Module, we can do the same thing electronically.

#### Experiment:

- Use the experimental set-up which we have just built and put the sliding switch DIP1 to ON – result: the motor is starting immediately.
- Switch the motor off using I3.

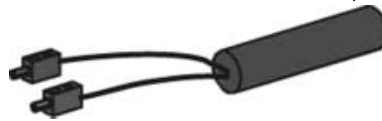
#### Note:

The DIP switches may either be switched using a fingernail or even better with a little screw driver that is provided in the construction kit.

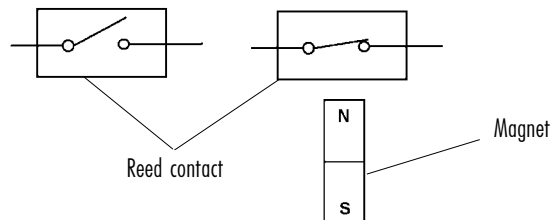
- Press I1 and release it – result: the motor starts only when you release the button. It is no longer a make contact, but a break contact.
- You may now try the same using the pushbuttons on I2 and I3.

If we used only the pushbutton as sensor, the electronic change from make to break contact would be unnecessary, as the pushbutton can be rebuilt to become a make contact simply by changing the cables. However, if we use another sensor, e.g. a magnetic sensor (also called reed contact), the situation is different.

## 5.2.1 The Magnetic Sensor (Reed Contact)



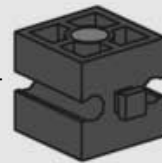
The reed contact is a magnetic switch which is closed as soon as a magnet comes close to it.



We cannot simply rebuilt it to become a break contact as it is only a simple ON/OFF switch and not a commutator. Therefore, it only has 2 connections.

#### Experiment:

- Put all DIP switches back to OFF and connect the magnet sensor to I1.
- Hold the magnetic component included in the construction kit (black cube incorporating round magnets) near the sensor.  
Result: the motor starts running.
- Stop the motor using I3.
- Switch DIP1 ON – the motor is running
- Stop the motor again using I3.
- Hold the magnet close to the sensor (in a distance of approx. 1 cm) and remove it. Result: the motor only stops if you remove the magnet.



Now, the magnetic sensor is a break contact.

With this in mind, let us now build the first model and control it using the E-Tec Module. It will be an alarm system.

## 5.2.2 The alarm system

### Task:

Build the model of a door or a safe. When the door is opened, a buzzer should be triggered via a magnetic sensor which only stops if the alarm is turned off using a separate pushbutton.

### Notes:

Program: basic program (DIP4=OFF)  
 Magnetic sensor to I1 as a break contact (DIP1=ON)  
 Pushbutton (contacts 1 and 3) to I3 (DIP3=OFF)  
 Buzzer at the motor output (O1=Red)  
 For details see building instruction.

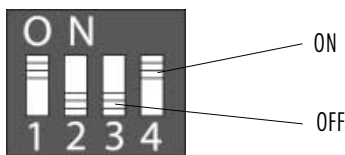
## 5.3 Special programs

Apart from the basic program, the E-Tec Module includes further programs which are tailor-made for the different models.

To access the special programs, switch the sliding switch DIP4 ON. Now, DIP 1-3 are no longer used to change the inputs from make to break contact, but to select a total of 8 stored programs.

### 5.3.1 Special program alarm system

We also have a special program for the alarm system.  
 Select the following position of the switch:



### Important:


**To activate the program, shortly switch the power supply at the E-Tec Module on and off. When a special program is activated, the LED of the E-Tec Module flashes when it controls a motor.**

The program has the following function:

As soon as the door is opened, the buzzer starts making sounds however not continuously, but with interruptions – so that it really goes on your nerves.

Furthermore, the alarm system can only be switched off, when the door was shut before. Otherwise it could happen that the alarm system will be activated although the door is still open and that would be too easy for robberies.

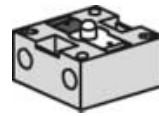
So, using the special program you can build a real alarm system. You could even protect the door of your room against unauthorized entrance.

By the way, you can also set the duration of the buzzing signal. When you bypass the jacks at the input I2, +  using one of the remaining cables, the buzz will sound with a higher frequency.

### 5.3.2 Another special program – the hand dryer

In case of the hand dryer in addition to a new special program you can also test a new sensor, the phototransistor which is included in the construction kit.

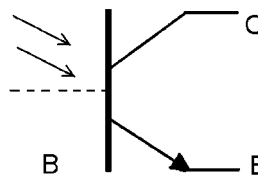
### 5.3.3 The Phototransistor



The phototransistor is an electronic component which responds to the brightness of light. Together with the lens tip lamp of the construction kit you can build a light barrier.

Let us only take a short look at how a phototransistor works:

This is the circuit symbol for the phototransistor:



A normal transistor is a component with 3 connections. The connections are called emitter, base and collector. The transistor is mainly used to boost weak signals. A weak current which is flowing from any signal to the base

of the transistor is converted into a much stronger current at the collector. The current amplification may reach factors of more than 1000.

However, the phototransistor of the construction kit has only 2 connections. The reason for this is that the base has no outside connection. Therefore it is represented as a broken line in the symbol. The phototransistor works virtually like a mini solar cell combined with a transistor. The light impinging on the base generates a very small current which is amplified by the transistor and provided at the collector. The stronger the impinging light, the higher the current at the collector.

In order for this to work as described, the phototransistor requires some additional electronic components. These are incorporated in the E-Tec Module. So, the phototransistor can be connected directly to the inputs I1–I3.

### Important:

**When connecting the phototransistor to an input, please ensure the correct polarization. The contact with the red marking must be connected to the + pole of the input. Otherwise, the phototransistor does not work.**

If you use the phototransistor together with the lens tip lamp as a light barrier, the E-Tec Module recognizes if the light barrier is interrupted or closed.

But let us get back to the hand dryer:

#### Task:

- Build the model according to the building instruction and connect it to the E-Tec Module according to the description.
- Position the DIP switches as required. What can you conclude from their positions?

Positions of the DIP switches:

DIP4=ON – It is a special program

DIP1	DIP2	DIP3
OFF	OFF	OFF

Setting for the special program "hand dryer"

#### Important:

**Only connect the power supply after having set the DIP switches!**

Function of the program:

When the light barrier is interrupted at I1, the motor starts and stops after 7 seconds. This is how real hand dryers work.

## 5.4 All types of applications

### 5.4.1 Punching Machine

The next model we are going to build is a punching machine. This task has three levels of difficulty. The building instruction only illustrates the third and fully finished level. After having learned all the things about the E-Tec Module, you should be able to accomplish step one and two without any problems alone.

#### Task 1:

- Build a punching machine which goes down at the touch of a button. In the lower position, the polarity of the motor should be reversed so that the machine goes up again. In the upper position, the motor should be switched off.
- The upper end switch should be a pushbutton, the reversal of the polarization of the motor in the lower position should be triggered by the magnetic sensor. A pushbutton should also be used as the start switch (for details refer to the building instruction).
- Use the E-Tec Module with the basic program
- Which of the sensors should be connected to which of the inputs I1 to I3?
- How should the inputs I1 to I3 of the E-Tec Module be set (make or break contact)?

#### Note:

First connect the two pushbuttons (end switch and start switch) as make contacts (contacts 1 and 3).

Ensure that the motor is positioned between the end switches before the E-Tec Module is switched on. Otherwise, the punching machine is going endlessly in one direction when you switch it on for the first time.

#### Task 2:

- The punching machine should have a safety facility so that it only goes down when 2 pushbuttons are pressed simultaneously (one with the left, the other with the right hand). This is also called "two hand control". How should the pushbuttons be connected?

**Note:** pushbutton 1 AND pushbutton 2 must be pressed.

#### Task 3:

- As an additional safety facility, a light barrier should be installed. When someone holds a hand into the machine, it should stop immediately. How should the light barrier be installed?
- What do you have to change at the end switch which stops the motor?

#### Note:

The light barrier must be connected to I3 and the input I3 must be a break contact in order for the motor to stop as soon as the light barrier is interrupted. To do this, the switch DIP3 must be switched ON. Until now, it was OFF, as the motor was only switched off by the upper end switch which was connected as a make contact. Now, the motor should still stop when the upper end switch is pressed. Therefore, it must be connected in series to the light barrier to I3 and also be a break contact (connect it to the contacts 1 and 2 of the pushbutton).

If you have any difficulties during connection, use the circuit diagram of the building instruction.

### 5.4.2 The garage door

You certainly know garage doors which you do not need to open or close manually, but which can be opened using a remote control or an access card. We would also like to have such a garage door!

#### Task:

- Build a garage door which can be opened and closed using a motor (see also the building instruction).
- It should have the following functions: it should be possible to open the door using a card with a magnetic strip (simulated by the magnetic component and the magnetic sensor).

It should close at the touch of a pushbutton. The end switch for the open and the closed door should be further pushbuttons.

- First, solve this task using the basic program of the E-Tec Module.
- Record the position of the DIP switch in the following table (ON or OFF)

DIP1	DIP2	DIP3	DIP4

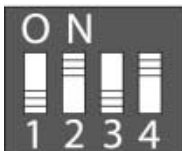
- Write down, which sensor is connected to which input.

Sensor	Input
Magnetic sensor	
End switch upper position (door open)	
End switch lower position (door closed)	
Pushbutton to close the garage	

- Where lies the weakness of this program?

If you did not detect any weakness of this program, try to close the door, when it is already closed. Then you will note that the motor is still turning and trying to close the door.

Our basic program is not able to solve this particular problem. Therefore, we integrated another special program for this model. You will find it under the following DIP switch position:



#### Important:

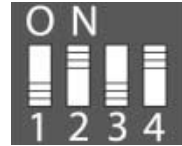
**Now you must connect the pushbutton to close the garage to the contacts 1 and 2. Otherwise, the door only closes after pressing the button twice. You will understand the reason why this input is programmed like this if you take a look at the model barrier of a public garage. We will need this feature there.**

#### Program description:

First the garage door is put in a defined start position, the garage will be closed. If this results in an error the LED is flashing very fast (so-called interference mode). It can only be corrected by switching the current off and on again. This safety feature will also start if the motor runs for longer than 60 seconds without an end switch being pressed.

If you open the garage using the magnetic sensor, you must first close the garage before you are able to open it again. Thus the program knows whether the garage is momentarily open or closed.

### 5.4.3 Barrier of a public garage



A similar function like the garage door is the barrier of a public garage. Therefore, you can use the same special program.

However, the task is slightly different:

#### Task:

- If you drive in front of a public garage barrier, you should be able to open it using an access card (magnetic component + magnetic sensor). If you have passed it with your car, the barrier should close using a light barrier. The light barrier should only start the motor if the car has completely passed the barrier.
- Record again which sensor is connected to which input.
- Additionally, a red and a green lamp should be installed which show the car driver when to drive. How do you connect those lamps so that the red or green light is on at the right moment?

#### Note:

The full design of this model is illustrated in the building instruction. In order for the light barrier to only trigger when the car has completely passed it, it must be interrupted first and subsequently closed. We used the same program for the garage. Therefore, the pushbutton to close the garage had to be connected to the contacts 1 and 2.

### 5.4.4 The brick dispenser

As the last model of the construction kit we would like to introduce a machine which dispenses bricks. You insert a coin and the machine dispenses two "building blocks 15".

#### Task:

- Build the model as described in the building instruction.
- Read from the position of the DIP switch whether it is controlled using the basic or the special program. Mark the right answer with a cross.

Basic program ☐ Special program ☐

- Now rebuild the device that it does not only dispense two but three bricks.

#### Note:

Ensure that the motor is positioned between the two end switches before the E-Tec Module is switched on. Otherwise, the slider is going endlessly in one direction when it is switched on for the first time.

## 5.5 The E-Tec Module can do even more

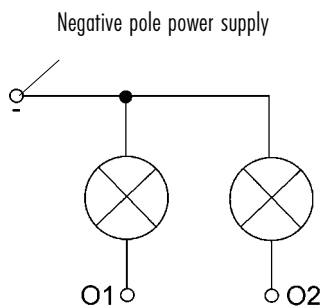
After having dealt with all models of the construction kit we want to show you now which functions are hidden in the E-Tec Module that have not been directly applied using the construction kit. You can certainly use these functions for your own model ideas.

### Special program – alternating flash light

DIP switch:



Instead of a motor, you connect one pole of each lamp to O1 and O2 and the other pole to the mass or the negative pole of the power supply.



If you now connect the E-Tec Module to the power supply, both lamps start flashing.

By bypassing the inputs I1-I3 you can generate further flashing frequencies:

Bypassed inputs	Flashing function
Non	fast alternating flash light, consistent
I3 +	fast alternating flash light, inconsistent
I2 +	slow alternating flash light, consistent
I2 and I3 +	slow alternating flash light, inconsistent

Additionally, there are also slower flashing frequencies which you would normally not use for flashing lamps. They are much more intended for models which have a motor, are operated continuously and should not go in the same direction all the time, e.g. a Ferris wheel:

Bypassed inputs	Motor function
I1 +	7 sec. left, 1 sec. pause, 7 sec. right, etc.
I1 and I3 +	15 sec. left, 2 sec. pause, 15 sec. right, etc.
I1 and I2 +	30 sec. left, 3 sec. pause, 30 sec., right etc.
I1, I2 and I3 +	60 sec. left, 5 sec. pause, 60 sec. right, etc.

### Special programs for digital technology

We have also provided 4 programs for fans of digital technology which you could use to build logical circuits (Monoflop, Flip-Flop, AND and OR function). But the real fun starts when you link several E-Tec Modules. But as this goes beyond the scope of this construction kit, we only mention these functions in this accompanying booklet. A detailed description will be published in the Internet under [www.fischertechnik.de>service](http://www.fischertechnik.de>service).

## 5.6 A short guide for the E-Tec Module

Now that you have learned many application examples and know how you can control models using the E-Tec Module, we will give you a summary of the most important functions of the module.

### Connections:

Power supply: 9 V $\cdot$

I1-I3: Inputs for sensors

Motor (O1 and O2): output for motor left/right/off

Select: DIP switch 1-4 for program selection

### Basic program:

DIP4=OFF

DIP1-DIP3=ON

I1-I3 programmed as break contact

DIP1-DIP3=OFF

I1-I3 programmed as make contact

### Function:

I1=Motor left

I2=Motor right

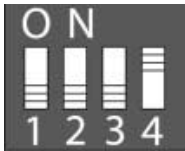
I3=Motor off

### Special programs:

DIP4=ON

**Important:**

The selected program is only read when the E-Tec Module is switched on. Therefore, you must first set the DIP switches and then connect the E-Tec Module to the power supply.

**Program 1: Hand dryer**

DIP switch

**Function:**

As soon as I1 is interrupted, the motor runs in the left direction for 7 seconds and then switches off.

**Program 2: alarm system**

DIP switch

**Function:**

As soon as I1 is interrupted, the buzzer sounds with interruptions. When I3 is closed, the buzzer is switched off, however, only if I1 was reconnected before. You can change the duration of the individual buzzing sound by by-passing I2.

**Program 3: Garage door/barrier of a public garage**

DIP switch

**Function:**

First, the barrier is closed (right motor). If no end switch is found for 60 seconds or if any other error occurs, the LED is flashing very fast (so-called interference mode). Correction: turn the power off and on again. Barrier is opened (left motor) by closing of I1. Barrier will be closed (right motor) by closing of I2 (i.e. if the connected light barrier is reconnected after an interruption). Barrier may only be closed if it has been opened before and visa versa.

**Program 4: Alternate Flash Light**

DIP switch:

**Function:** see p. 29

**Program 5-8: Digital functions**

Description: see [www.fischertechnik.de>service](http://www.fischertechnik.de>service)

## 6 Trouble Shooting

It is always frustrating if you have built a model and it does not work as it should. Then you would start trying and if you are lucky, it will suddenly work – probably purely by chance.

Therefore, we would like to give you some tips to avoid or correct errors which might occur.

**Cables and Plugs:**

During assembly of the electrical plugs you should always ensure that they are really in contact with the strand. It is best to check every cable after the connection using a lamp which you connect to the power supply using the cable you just connected or you can use a continuity tester that we described earlier in the document.

**Correct cabling of the models**

For some models, you need many cables. You must connect them carefully and avoid errors otherwise the model does not work. If you are not careful you might connect the motor to an input or a sensor to the motor output. Then, the whole model cannot work. Therefore, always check all the connections first if the model does not work.

**Power supply**

When you are using the accumulator pack or a battery, please ensure that it can still supply enough energy. You could connect a lamp. If it is not very bright or if it goes out after a few seconds, the battery or the accumulator are empty.

**Correct polarization**

For some components it is important that they have the right polarization, otherwise they do not work:

**E-Tec Module**

Red cable = positive, black cable = negative. Green LED is on in case of correct power supply.

**Phototransistor**

Red marking = positive, a plus sign is visible at the inputs of the E-Tec Module. Performance test: connect phototransistor to I1 of the E-Tec Module, E-Tec Module in the basic program (DIP1-DIP4=OFF). Move the lamp which is switched on towards the phototransistor. If the phototransistor recognizes "bright", the green LED switches off shortly and goes on again.

**Buzzer**

Red cable = positive, black cable = negative.

### Setting of the DIP switches of the E-Tec Module

In order for the E-Tec Module to run the right program, the DIP switches must be set correctly. For every model the position of the switches can be found in the building instruction or the activity booklet.

#### **Important:**

**The set program will only be read when the E-Tec Module is switched on.**

**If you change the program in the meantime, you have to shortly interrupt the power supply to activate the new program.**

**In the basic program (DIP4=OFF) the inputs I1-I3 can be changed from make to break contacts using the DIP switches DIP1-DIP3. The module recognizes this change even when the program is run. In this case, the current does not need to be interrupted.**

If a component does not work despite correct polarization, intact cables and sufficient power supply, there is only one explanation:

#### **It has a defect!**

In this case, please contact the fischertechnik Service.

## 7 More Intelligent Control – fischertechnik Computing

We hope that you had fun controlling the models you have built with the construction kit Profi E-Tec. Perhaps you are going to build your own models and control them using the E-Tec Module. Then, you will certainly come to the point where the basic program of the E-Tec Module is no longer enough to really control your models because you lack the right special programs.

Perhaps, your model does not only have one but several motors and you wish to achieve a certain procedure. When this happens, you are ready for the next step in control technology: the fischertechnik Computing Program.

It provides you with a control module the so-called Interface which can control up to 4 motors at once. Furthermore, it comprises 8 digital inputs for pushbuttons, phototransistors or reed contacts and, at the same time, two analogue inputs to measure resistances.

But the best part is that you can connect it to your PC and will be able to design your own programs using a graphical software. This opens up endless possibilities. Naturally, you can also program and control the models of this construction kit. For instance think of the elevator. You can equip it with sensors and program it like a real elevator with calling keys in every floor and a choice in which floor you would like to go. That is real fun. So try it!