1. Additional programs for the fischertechnik Electronics Module

For fans of digital technology, these additional functions are provided in the "E-Tec module". Four additional functions are provided which can be selected using the DIP switches. These features are not described in the E-Tec kit (91083) booklet as they are given as additional projects and they are really only useful if you have several modules available to link together. For the electrical connections between modules, individual cables are needed. These can be made by either separating the fischertechnik two-core wires or from single-core cables. e.g. from fischertechnik black wire (35645) and red wire (32404) - 2m lengths are available. Cut the strands into lengths of 150 mm each and then connect the black strands with green plugs (31336) and the red strands with red plugs (31337). For power distribution, the light holder (38216) can be used without the lamp installed.

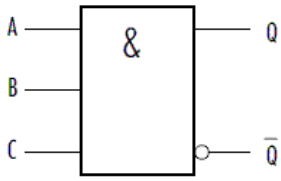
As with the programs described in the E-Tec booklet, the setting of the dip switches only becomes effective after a short disruption of the power supply. Specifically, an AND logic gate, an OR logic gate, a D type flip flop with reset and a monostable multivibrator can be selected.

The following is a description of these additional functions:

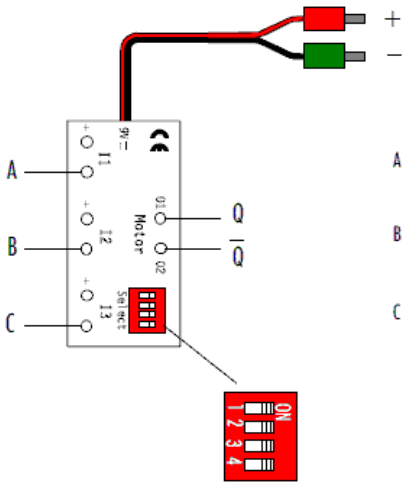
1.1 AND logic gate

In this program the inputs A, B and C (I1, I2 and I3) are logically ANDed. The result is output at motor O1 (AND output). The motor output O2 is always the inverted signal (NAND output). If only one or two inputs are needed, any free inputs are connected by a cable link to "+". An open (non-connected) input is evaluated as logic "0" on E-Tec modules.

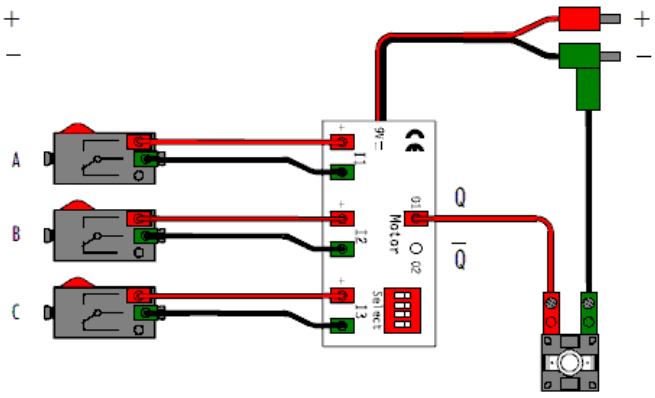
Circuit Diagram



E-Tec Module



Test Circuit - AND



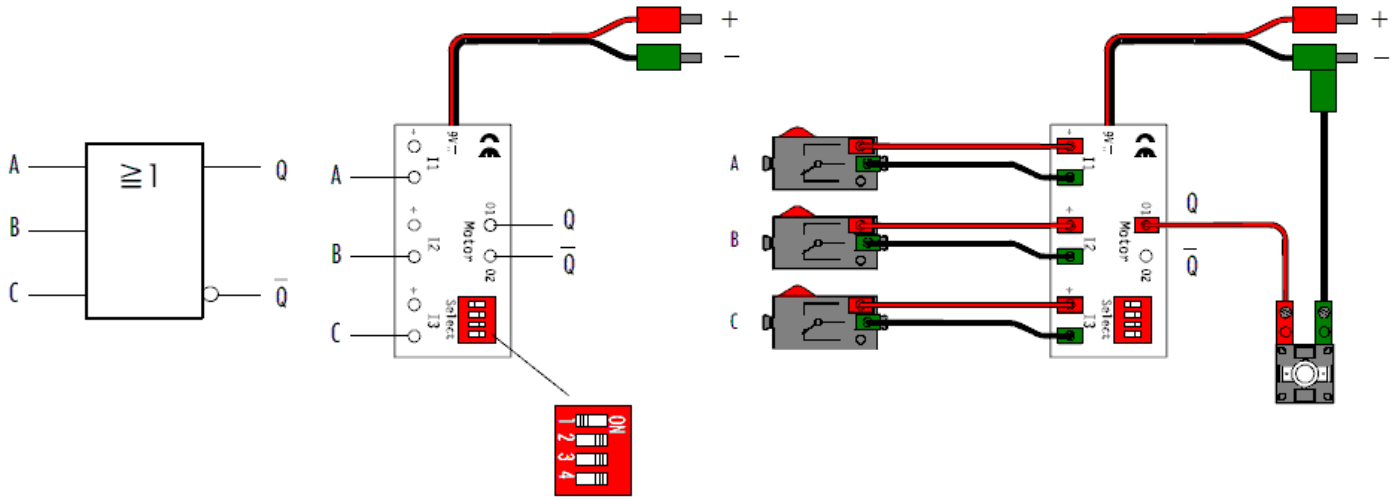
Truth Table - AND

A	B	C	Q	$\bar{Q}$
0	0	0	0	1
1	0	0	0	1
0	1	0	0	1
0	0	1	0	1
1	1	0	0	1
0	1	1	0	1
1	0	1	0	1
1	1	1	1	0

1.2 OR logic gate

In this program the inputs A, B and C (I1, I2 and I3) are logically ORed. The result is output at motor O1 (OR output). The motor output O2 is always the inverted signal (NOR output). If only one or two inputs are needed, any free input can remain open. An open (non-connected) input is evaluated as logic "0" on E-Tec modules.

Circuit Diagram E-Tec Module Test Circuit - OR



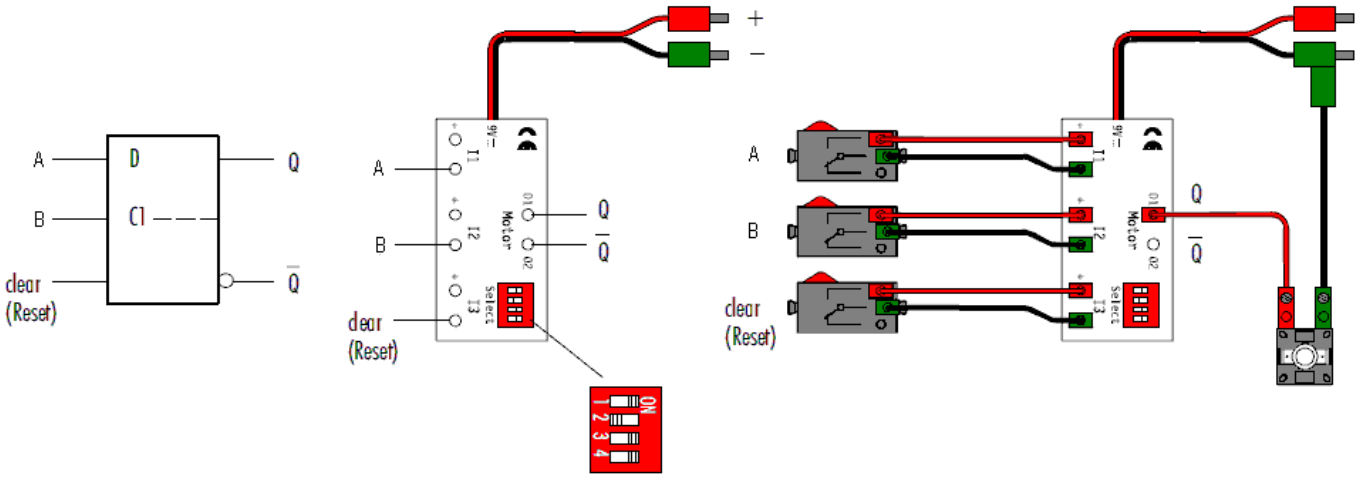
Truth Table - OR

A	B	C	Q	$\overline{Q}$
0	0	0	0	1
1	0	0	1	0
0	1	0	1	0
0	0	1	1	0
0	1	1	1	0
1	1	0	1	0
1	0	1	1	0
1	1	1	1	0

1.3 D-Flip Flop with Reset

The D-type flip flop is a simple data storage element. For each "0-1" transition or positive edge of the clock input "B" (I2) the flip flop's motor output O1 assumes the state of the D or data input "A" (I1). At the motor output O2 the negated value is present. With a "1" applied to the clear input (I3), the motor output O1 is reset (becomes logic "0"). The "clear" always has priority. If the D input "A" (I1) is connected with a wire to "+" (if left open, an input is always evaluated as logic "0" on the E-Tec module) then a "1" will appear at the output O1 when a "0-1" clock transition occurs.

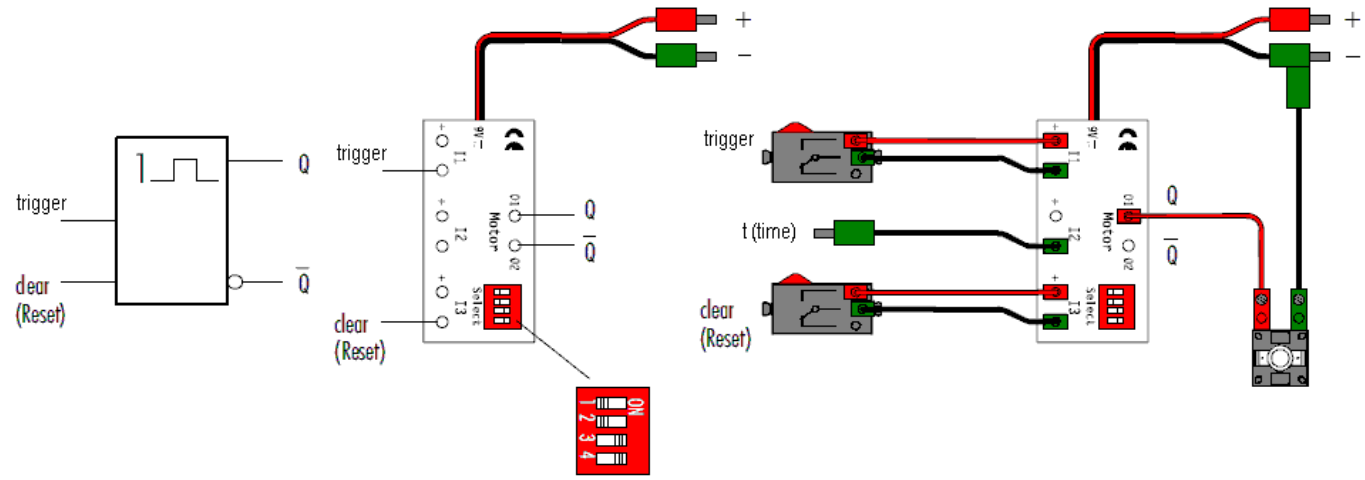
Circuit Diagram E−Tec Module Test Circuit
D type Flip Flop



1.4 Monostable with Reset

After a "0-1" edge transition of the trigger input (I1) the motor output O1 will activate for a set time duration dependent on I2 (t) connection (see table). Motor output O2 provides an inverted signal. At the clear input (I3) a "1" will reset the monostable. An open (non-connected) input is evaluated as logic "0" on E-Tec modules. To enable a new time delay, the E-Tec Module must be briefly disconnected from the power supply. Clear always has priority.

Circuit Diagram E-Tec Module Test Circuit - Monostable



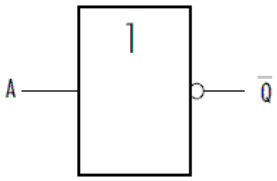
Time Delay setting for I2 (t)

Monostable Time Delay	
t = 2 Seconds	I2 not connected
t = 4 Seconds	I2 to "+"
t = 10 Seconds	I2 to Motor 01
t = 20 Seconds	I2 to Motor 02

1.5 Inverter

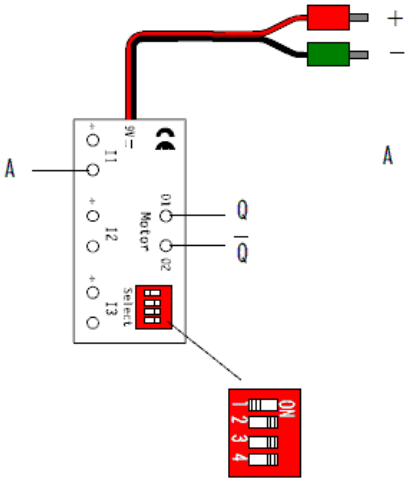
A logical inverter function can be produced with the E-Tec modules using either the AND gate or OR gate function. Using the OR function, the I2 and I3 inputs can be left open. Using the AND function, the I2 and I3 inputs must be connected (linked) to +I2 and +I3 respectively. An open (non-connected) input is evaluated as a logical "0" from the E-Tec modules. A "0" at the input is output as "1", a "1" signal on the input gives an output of "0". The input signals are output inverted (or negated). For example, a normally closed contact function can be converted into logic "0" (light barrier).

Circuit Diagram

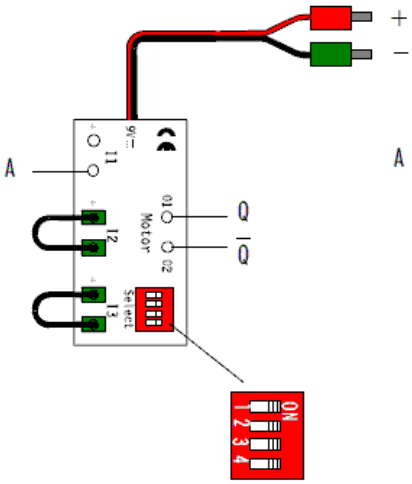


E−Tec Module

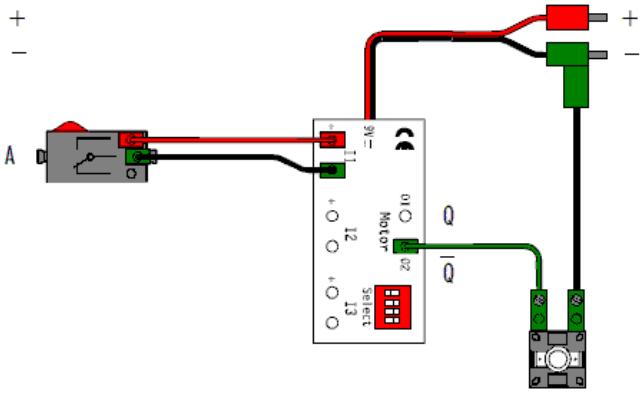
OR

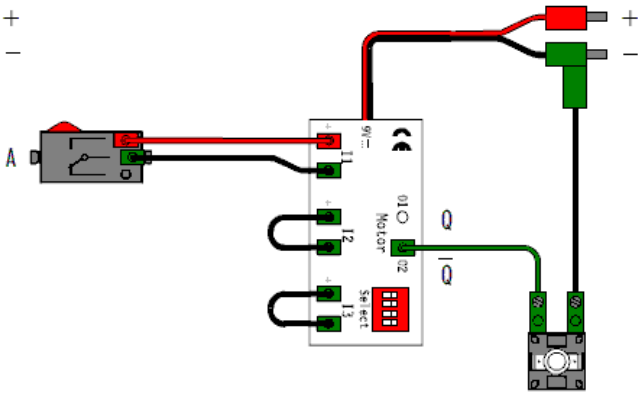


AND



Test Circuit - Inverter





Truth Table - Inverter

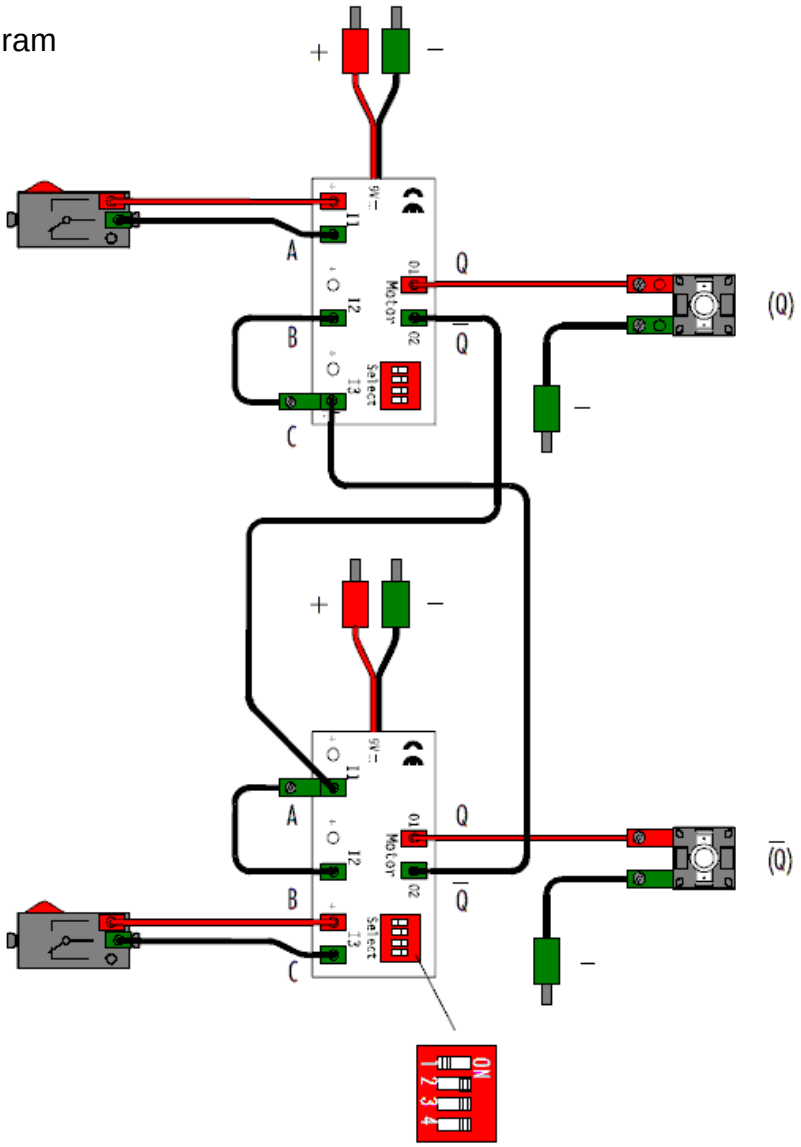
A	$\bar{Q}$
0	1
1	0

2 Circuit examples with several logic gates

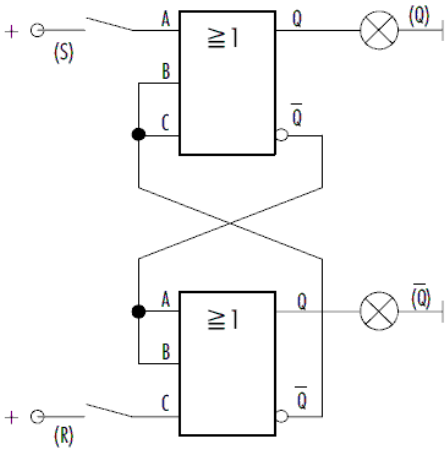
When linking multiple E-Tec modules the signal propagation time of each E-Tec module is up to 20ms and must be taken into consideration in order to avoid "spikes" (voltage spikes that would be seen by an E-Tec module as a signal). After debouncing the input, the E-Tec module switches the output only after a period of an additional 10ms.

2.1 R-S flip flop constructed with two OR gates

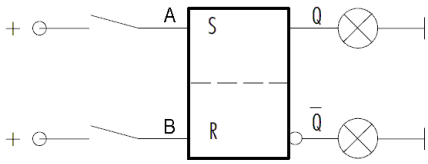
Wiring Diagram



Circuit Diagram



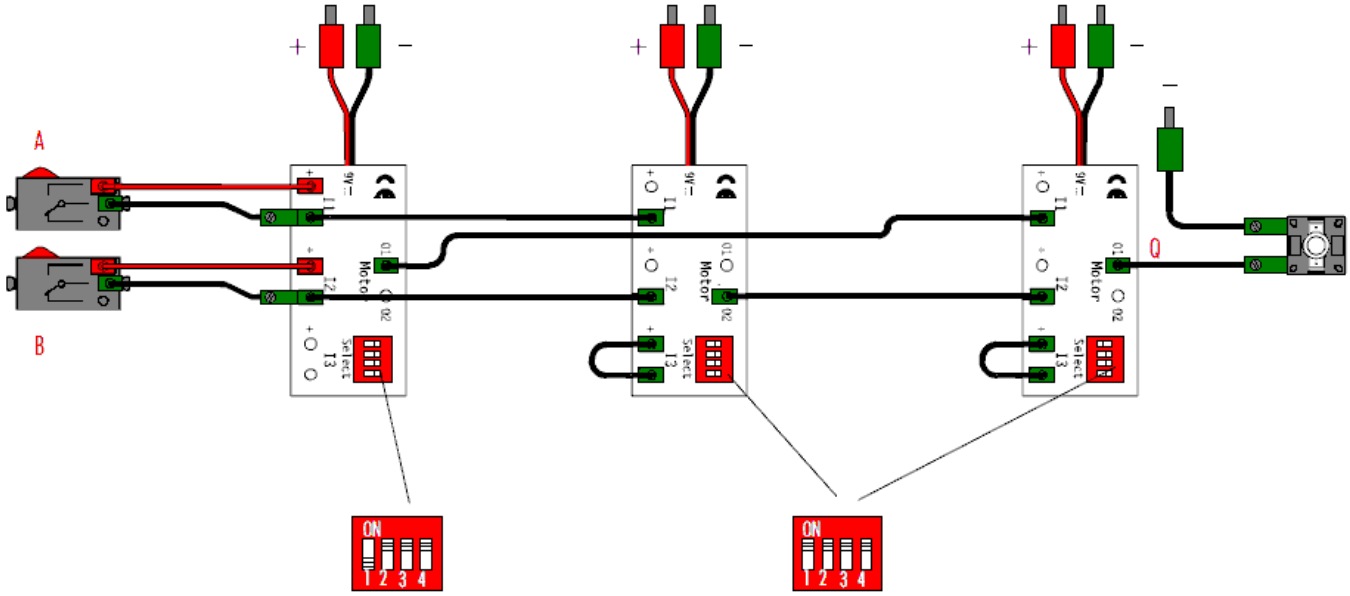
Circuit Diagram - RS Flip Flop



2.2 Exclusive-OR, constructed with two AND and one OR gate

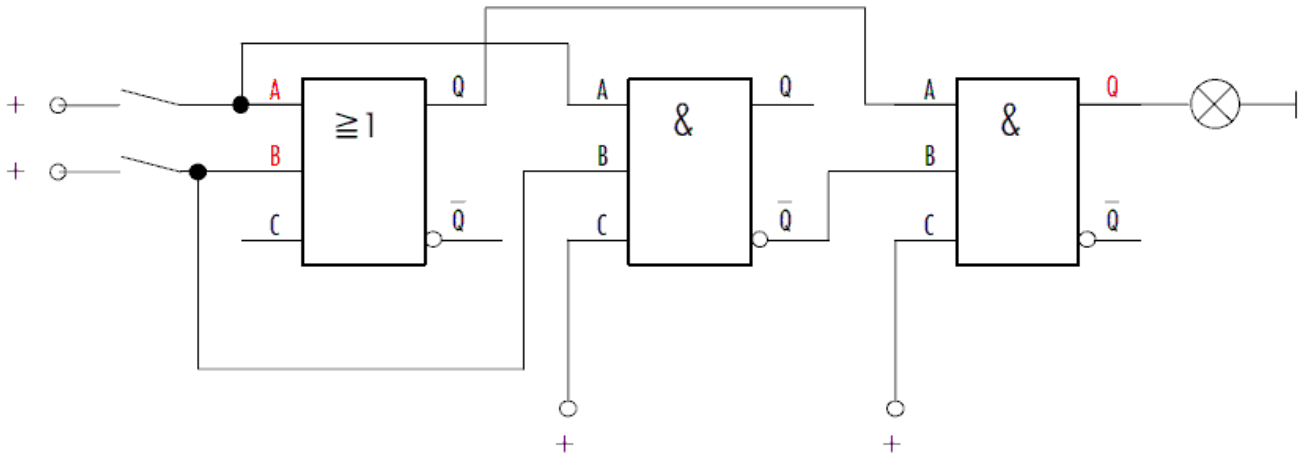
A variation of the combination of AND and OR logic gates is the Exclusive OR. In contrast to the OR gate, the exclusive OR gate does not have the value "1" when both inputs have a value of "1" only when there is an input at either input 1 or 2, the value "1" is output.

Wiring Diagram



Switch Position Switch Position

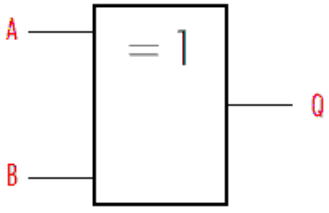
Circuit Diagram



Truth Table - Exclusive OR

A	B	Q
0	0	0
1	0	1
0	1	1
1	1	0

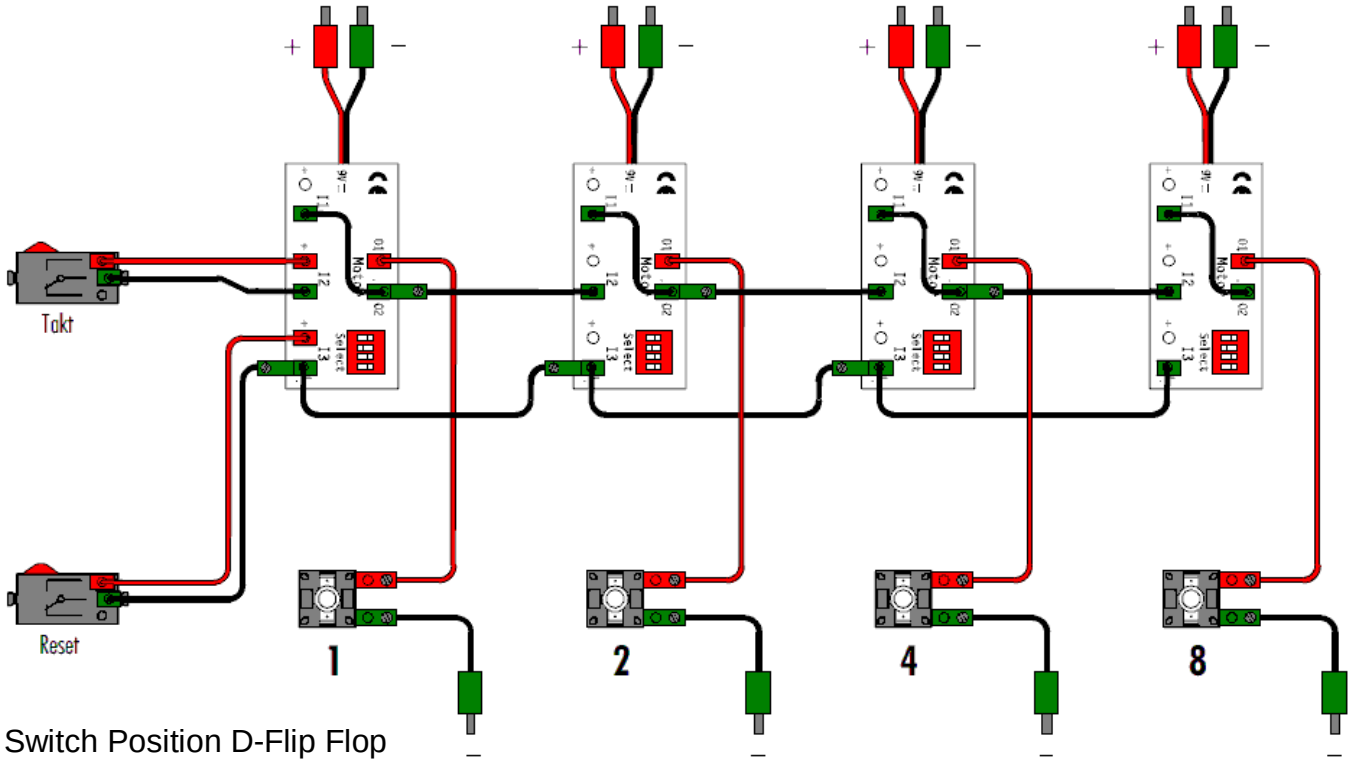
Circuit Diagram EX-OR



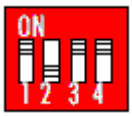
2.3 Binary counter example with four D-type flip flop blocks

Several D-flip flops can be connected to form a binary counter. In our example, binary numbers can be represented using weightings of 1-2-4 and 8. The counter's output allows up to 15 clock cycles to be counted. Decoding the binary values into decimal is shown in the table. For larger or smaller binary values the number of E-Tec modules can be expanded or reduced accordingly. Applying a "1" to the reset, sets the counter to zero.

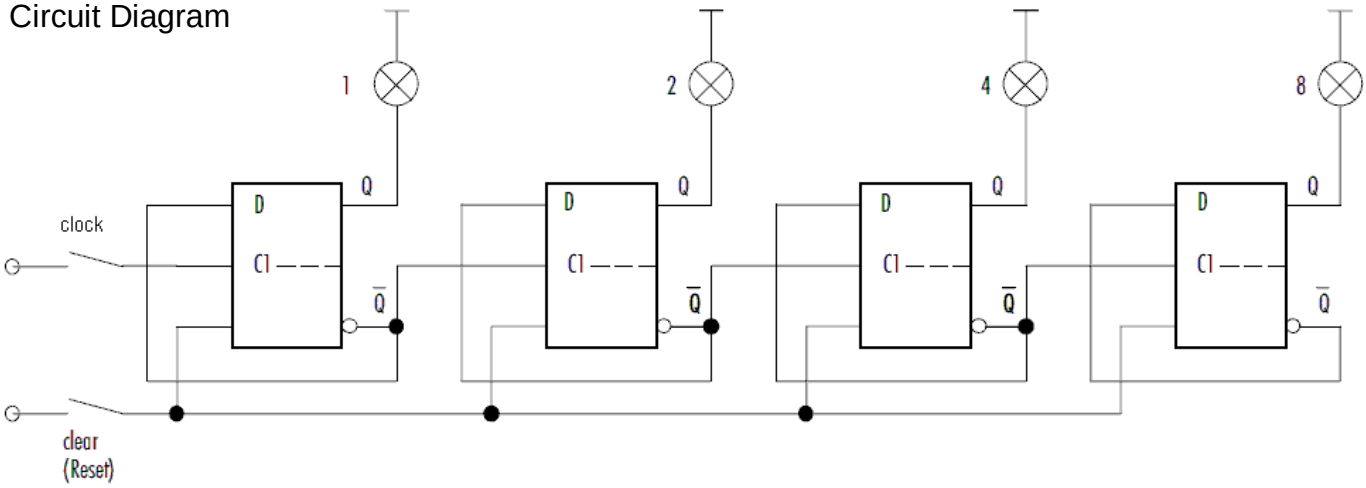
Wiring Diagram



Switch Position D-Flip Flop



Circuit Diagram



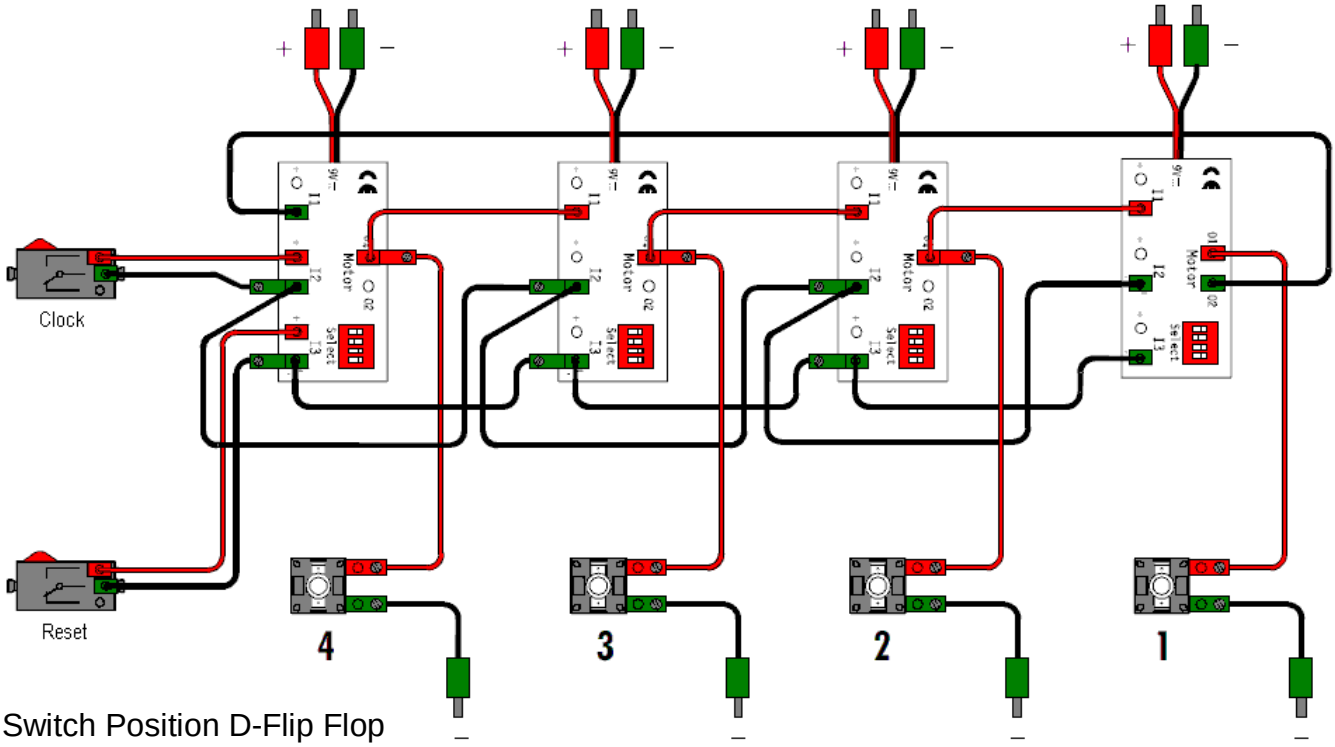
Binary to Decimal Table

Binary	1	2	1+2	4	1+4	2+4	1+2+4	8	1+8	2+8	1+2+8	4+8	1+4+8	2+4+8	1+2+4+8
Decimal	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

2.4 4-bit shift register (ring counter using four D flip flops)

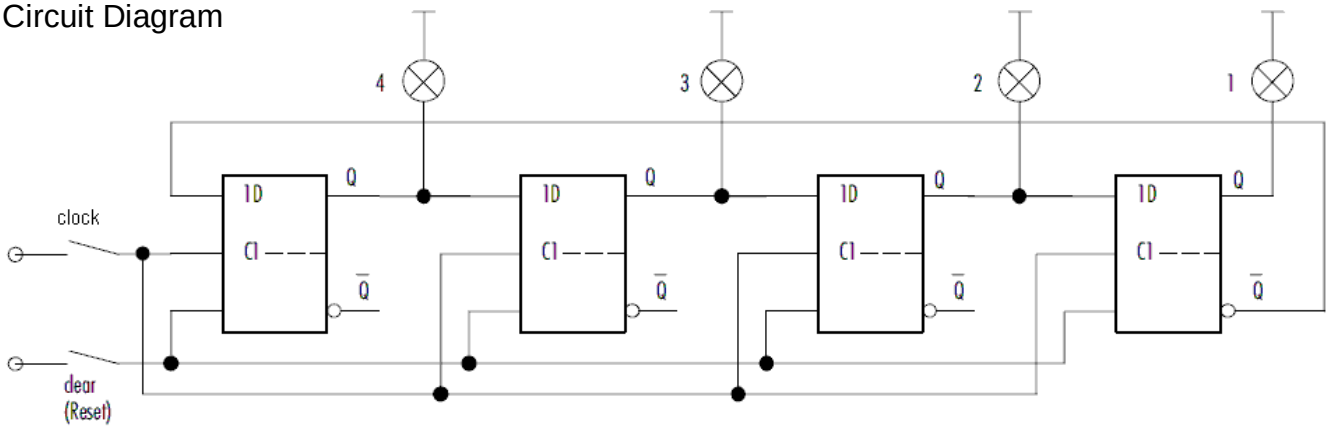
In this example, four D-type flip flops are connected to form a twisted ring counter. For each "0-1" transition of the clock input, the data is shifted through the shift register. The D-flip flop output $\overline{Q}$ of flip-flop 1 is connected to the "D" input of flip flop 4; the data is being shifted around in a ring. Applying a "1" to the reset, all flip flops are reset.

Wiring Diagram



Switch Position D-Flip Flop

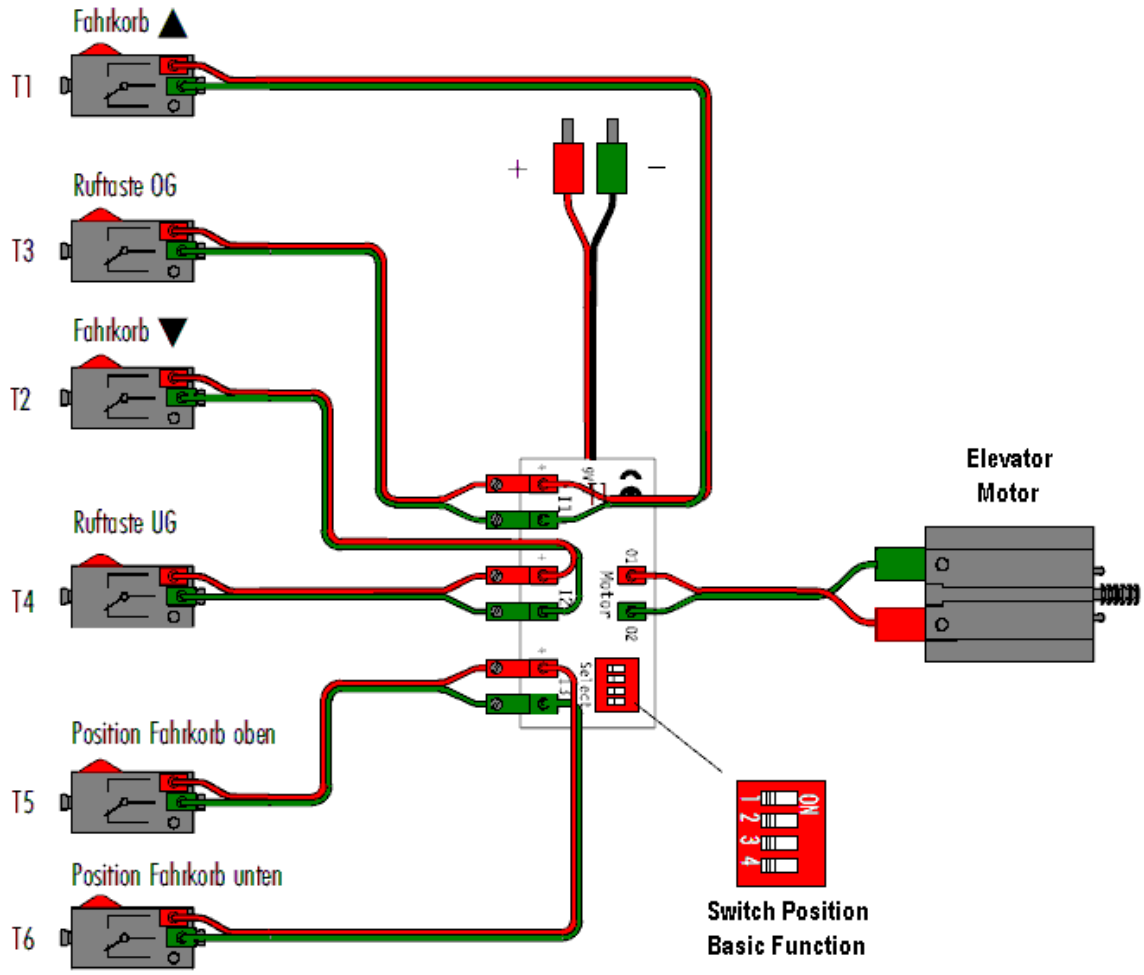
Circuit Diagram



A twisted ring counter is also called a Johnson counter or Möbius counter (also Moebius), it connects the complement of the output of the last shift register to the input of the first register and circulates a stream of ones followed by zeros around the ring. In this example, in a 4-bit shift register configuration, with an initial value of 0000, the repeating pattern is: 0000, 1000, 1100, 1110, 1111, 0111, 0011, 0001, 0000.

2.5 Model - 2 story elevator (construction stages in the construction manual E-Tec)

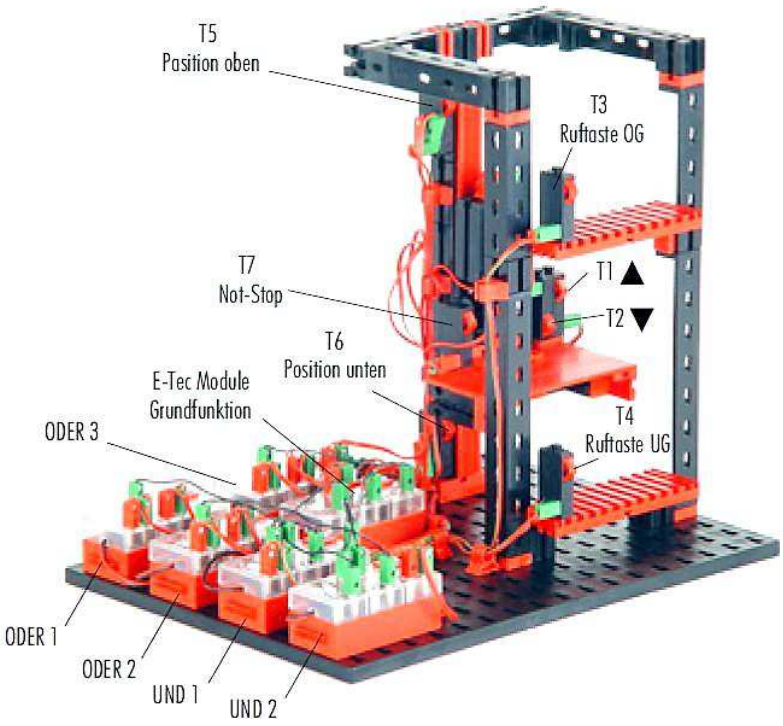
Wiring Diagram



Translation:
T1 = Elevator Up, T2 = Elevator Down, T3 = Call Upper Floor, T4 = Call Lower Floor,
T5 = Position Upper Floor, T6 = Position Lower Floor.

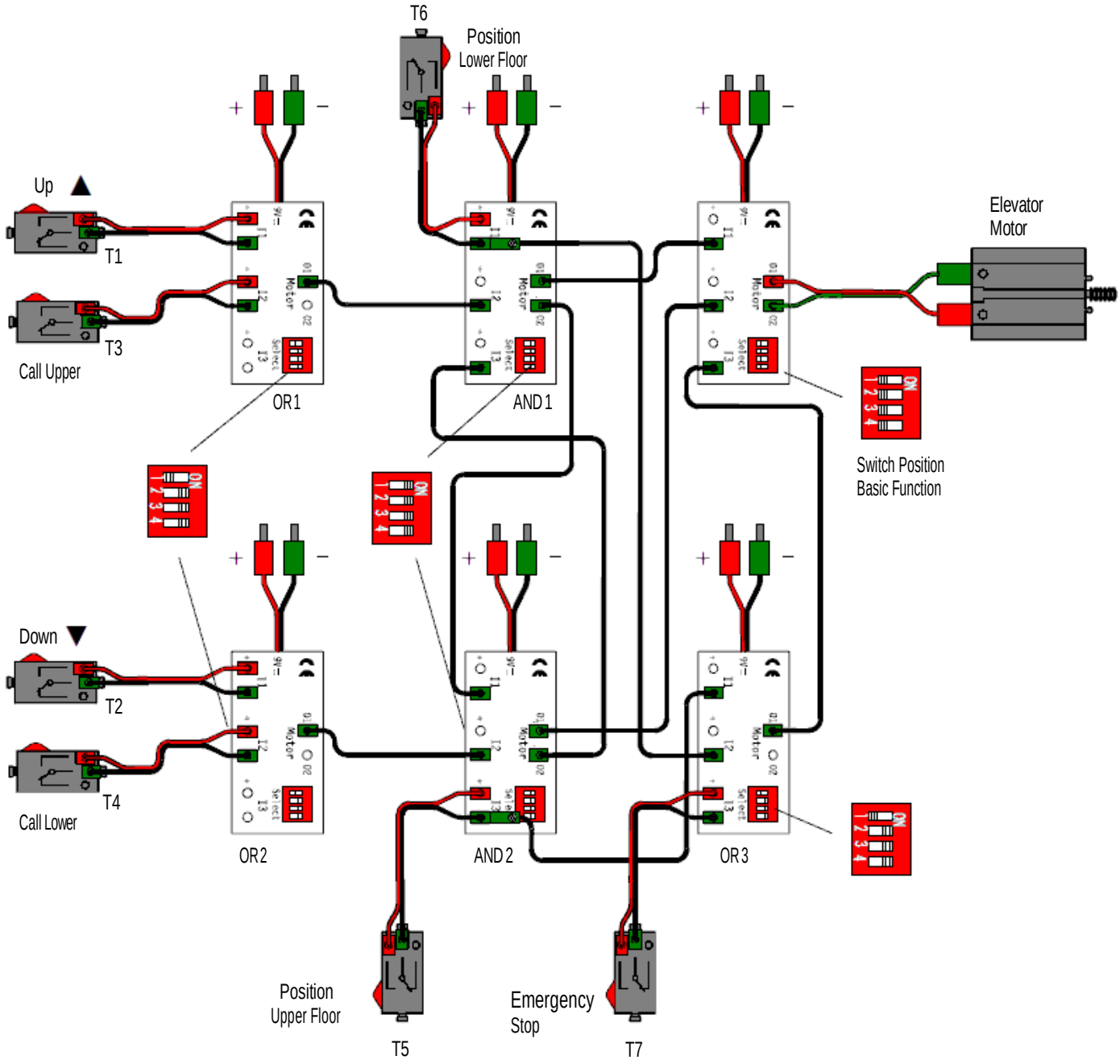
A simple elevator control with an E-Tec Module (switch position "basic function").
The only advantage of this circuit is the low circuit complexity. The elevator drive motor can be switched on or reversed in any position. If the car is traveling up or down, its direction of travel can change at any time. When it has reached its final position on the lower or upper floor, the elevator can be started again in the same direction. Such control would not be approved in a freight elevator. With six E-Tec modules you can construct, by combining different logic functions, a realistic elevator control circuit.

2.6 Elevator using 6 x E−Tec Modules



Translation:
T1 = Elevator Up, T2 = Elevator Down, T3 = Call Upper Floor, T4 = Call Lower Floor,
T5 = Position Upper Floor, T6 = Position Lower Floor, T7 = Emergency Stop.
ODER = OR, UND = AND, Grundfunktion = Basic Function.

Wiring Diagram



Function Description:

The elevator can only start from the upper or lower switch positions. This is related to the logical operation of AND 1 and AND 2 gates. e.g. when the elevator is the lower position, the T6 button is activated, the first condition to AND 1 is satisfied. The second condition is to press the upper call button (T3) or the up button (T1) inside the elevator. These two switches are connected by OR 1. The third condition comes from AND 2, the inverted condition (output O2 = +). Now I1 of the E-Tec module "basic function" is logic "1" and the elevator moves up. When the elevator reaches the upper location the position switch (T5) is operated and controlled by OR 3 input I3 (motor off) of the E-Tec Module "basic function" turns on and the motor stops. Now the first condition is satisfied in AND 2 for the downward movement of the elevator. When the emergency stop button on the elevator is pressed, OR 3 turns off the motor immediately in any position. To restart, the car must be moved manually to the upper or lower position. With more E-Tec modules, even more functions can be provided. For example: Door protection, overload protection etc.