Structure of heat powered "And", "Or" and "Not" logic gates

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Abstract: *The current paper presents the structure of three heat powered logic gates – the "and" gate, the "or" gate and the "not" gate. By combining these three modules, we can obtain the rest of the basic logic gates – the "nand" gate, the "nor" gate, the "xor" gate and the "xnor" gate. These modules are the basic building blocks of the modern computers and that is why, they open the gates for the emergence of a new generation of heat powered computational devices.*
Key words: *heat, powered, and, or, not, logic, gate*

INTRODUCTION

After the discovery of the electronic elements, like the diode and the transistor, the world directed its efforts towards the creation of different computing devices, like personal computers, smart phones, smart devices, laptops, tablets, etc.

It is well known that all these devices work with electric power. However different computational devices can be built on the basis of other types of energies. That is why, we can use different flows (heat flow, sunlight flow, wind flow, water flow, etc.) and their energy to build a computational devices.

Current paper concentrates on the heat energy and presents the heat powered equivalent of three of the basic building blocks of the modern computes – the "and", the "or" and the "not" logic gates. Thanks to these three logic gates, the rest of the basic logic gates, like "nand", "nor", "xor" and "xnor", can be built [1, 2]. Even more, by combining all basic logic gates in different ways, we can build much complicated digital circuits [3], like multiplexers, demultiplexers, registers, etc. We can even build an arithmetic logic unit (ALU), which is the heart of every CPU.

The work of every heat powered gate is possible due to the linear expansion of the materials. Because every metal part changes its length, when heated, every gate module must be designed for particular high and low temperatures. This means that the length of the gate inputs and the distances between the moving contacts and the rest of the elements must be calibrated to work with specific temperatures.

THE NOT GATE

The heat powered "not" gate (fig. 1) works similarly as the standard electrical powered gate, with the main difference that instead of an electric power, the input and the output is the heat.

Fig. 1 shows the front and the side view of the heat powered "not" gate. The entire module is hold together with a metal frame (1). The high temperature input metal connector (7) is output on the top side and is isolated from the frame with a heat isolator. This prevents the direct contact between the connector and the frame and excludes any inappropriate influence of the connector over the module operation.

The low temperature input connector (8) is output at the bottom side of the module. That connector is attached directly to the frame. That is way, the temperature of the whole frame is equal to the low working temperature, which prevents the influence of the diffused high temperature over the module operation.

The module input (2) is output at the left side and the gate output is output at the right side of the frame. Both connectors are isolated from the frame with isolators. That prevents the influence of the gate diffused high temperature over the module operation.

The gate is designed to accept two temperatures as an input:

- Low temperature (logical 0) – when the module receives low temperature as input, the metal plate (2) cools down and shrinks. Then, the spring in the holder (6) pushes the movable contact (5) to the left. (5) separates from the low temperature input connector (8) and touches the high temperature input

connector (7). Then the high temperature (logical 1) is passed from the high temperature input connector through the movable connector to the gate output (4);
- High temperature (logical 1) – when the module receives high temperature as an input, the metal plate (2) heats up, expands and pushes the movable contact (5) to the right. Then (5) separates from the high temperature input connector (7) and touches the low temperature input connector (8). This allows the low temperature (logical 0) to be passed from the low temperature input connector through the movable connector to the gate output (4).

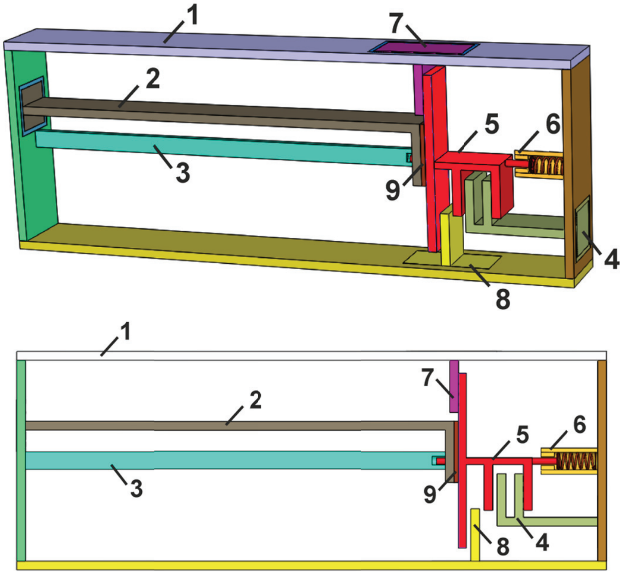


Fig. 1. Side and front view of the "not" gate: 1 - frame (metal); 2 - gate input (metal); 3, 6 – holders of the 5 (isolators); 4 - gate output (metal); 5 - movable contact (metal); 7 - high temperature supply (metal); 8 – low temperature supply (metal); 9 - isolator between the gate input and the movable contact;

THE OR GATE

The heat powered "or" gate (fig. 2) is almost identical to the "not" gate. There are two differences between the two gates:
- The module has one more input (10), output at the left side. This connector, as (2), is also isolated from the frame with heat isolator;
- At initial gate state, the output is connected to the low temperature input connector (8) and is detached from the high temperature input connector (7).

The two input plates (2, 10) are not connected physically. This means that the both can expand independently and push the movable contact (5). That is why, the gate reacts on three different ways, when different combinations of low and high temperatures are passed to its inputs:
- When low temperature (logical 0) is passed to the both of the input connectors – the both inputs (2, 10) shrink. Then, the spring in the holder (6) pushes the movable contact (5). (5) touches the low temperature input connector and that low temperature (logical 0) is passed from the low temperature input connector through the movable connector to the gate output (4).
- When high temperature (logical 1) is passed to the both of the input connectors –

the both inputs (2, 10) heat up, expand and push the movable contact (5). (5) separates from the low temperature input connector and touches the high temperature input connector. That is way, the high temperature (logical 1) is passed from the high temperature input connector through the movable connector to the gate output (4).

- When low temperature (logical 0) is passed to the one of the input connectors and high temperature (logical 1) is passed to the other – the input connector, which is heated to the high temperature, expands and pushes the movable contact (5). Then the "or" gate passes the high temperature (logical 1) to the module output, as it was described in the case, when high temperatures is passed to the both of the gate inputs.

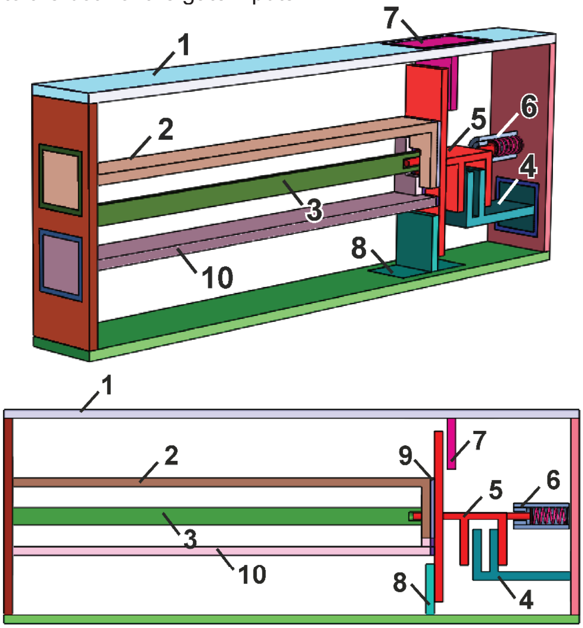


Fig. 2. Side and front view of the "OR gate": 1 - frame (metal); 2 - gate input (metal); 3, 6 – holders of the 5 (isolators); 4 - gate output (metal); 5 - movable contact (metal); 7 - high temperature supply (metal); 8 – low temperature supply (metal); 9 - isolator between the gate input and the movable contact; 10 – second gate low temperature input (metal);

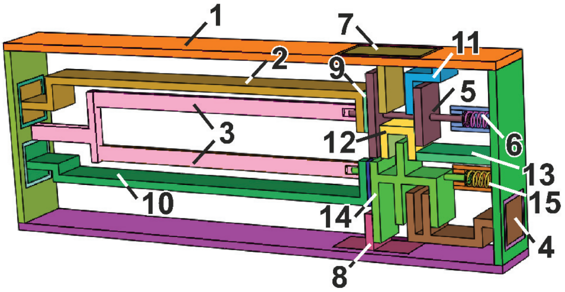
THE AND GATE

The heat powered "and" gate (fig. 3) has the most complex structure, compared with the "or" and the "not" gates. The "and" gate have several extra parts and second low temperature supply, which is connected directly to the frame (the frame is connected to the main low temperature supply).

The gate reacts on four different ways, when different types of combinations of low and high temperatures are passed to its inputs:

- When high temperature (logical 1) is passed to the input (2) and low temperature (logical 0) is passed to the input (10) – when (2) heats up, it expands and pushes the movable contact (5). (5) separates from the second low temperature supply (11) and touches the high temperature supply (7). Then the high temperature is passed from the (7) through the movable contact (5) to the fixed contact (12). At the same time, the second input (10) shrinks and the spring in the holder (13) pushes the movable contact (14) away from the (12). Therefore, the high temperature cannot be transferred from the fixed contact to the gate output. Instead, the movable contact (14) touches the low temperature supply (7) and passes the low temperature to the module output.

- When high temperature (logical 1) is passed to bot inputs (2) and (10) – as in the previous case, the high temperature reaches the fixed contact (12). Then the second module input (10) expands and pushes the movable contact (14) to the fixed contact (12). In this way, the high temperature (logical 1) is transferred from the fixed contact (12) through the movable contact (14) to the gate output (4).



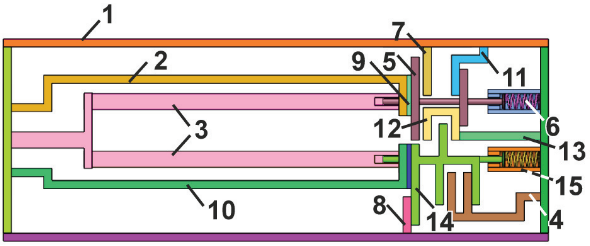


Fig. 3. Side and front view of the “and” gate: 1 - frame (metal); 2 - gate input (metal); 3, 6, 13, 15 – isolators; 4 - gate output (metal); 5, 14 - movable contacts (metal); 7 - high temperature supply (metal); 8 – low temperature supply (metal); 9 - isolator between the gate input and the movable contact; 10 – second gate input (metal); 11 – second low temperature supply, connected to the frame (metal); 12 – fixed contact (metal); 14 – second movable contact (metal);

- When low temperature (logical 0) is passed to the both of the input connectors – the both inputs (2, 10) shrink, and then, the spring in the holder (15) pushes the movable contact (14) to the left. (14) separates from the fixed contact (12) and touches the low temperature input connector (8). This allows the low temperature (logical 0) to be passed from the low temperature input connector through the movable connector to the gate output (4).
- When the low temperature (logical 0) is passed to the input (2) and high temperature (logical 1) is passed to the input (10) – the input (2) shrinks and the spring in the holder (6) pushes the movable contact (5) to the second low temperature supply (11). Then the low temperature is passed from the (11) through the movable contact to the fixed contact (12). In the same time, (10) expands and pushes the movable contact (14) to the fixed contact (12). Then the low temperature (logical 0) can be passed from the fixed contact (12) through the movable contact (14) to the gate output (4).

DISCUSSION AND FUTURE WORK

It is well known that the air conducts the heat. Therefore, the presented logic gates are designed to work in vacuum. The vacuum will prevent the spreading of the high temperature throughout the whole module, which would not allow the device to work properly.

The time between the submission of the input signals and switching the output depends of the geometric size of the gate components - the larger parts will require more time to heat and cool down.

If we compare the time needed of one gate, powered by electric power, to switch its state with the time needed to one heat powered gate to switch its state, we can say that the time needed to the heat powered gate is very long – it can take a minute or minutes. However, if we look at the nature, indeed there are processes, which take very long time. For example: the Earth makes one spin around the sun for a year; each of the seasons on the earth last about 3 months; a space journey can take years and so on. That is why, despite the fact that the switching time of the heat powered gate is slow, it is relatively slow and such devices can be used in many cases, when the slow speed of the computations is allowed.

The future work will be focused on building much complex circuits like multiplexers or arithmetic logic units.

Building much complex computational machines, powered by heat or other types of energy, will help the emergence of new devices, which could be integrated into our life and make it a better place for living.

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