SIEMENS

Digital Logic Elements

a programmed introduction

HEYDEN

Programmed Instruction

Digital Logic Elements

Gating elements
Storage elements

By Dieter Fleischer

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Preface

Digital devices and particularly data processing devices, consist of minute modules, namely digital logic elements. They control all the processes within the devices reliably and with almost unimaginable speed.

The purpose of this programmed instruction is to acquaint engineers and technicians who design, test and maintain such devices, as well as anyone interested in digital systems, with the functions and properties of these minute modules. After they have worked through this course of instruction, they will be able to read and understand circuits composed of digital logic elements.

The symbols used in this book comply with the IEC[1])-standard which is now incorporated in British and other standards. These new symbols were designed to enable data processing systems to lay-out and print the extensive circuit diagrams which are common in digital systems. This is a great simplification for manufacturers of digital devices. These complicated devices are subject to constant modifications and improvements, which necessitate redrawing of circuit diagrams all the time. Without the aid of data processing systems, this would become very involved and expensive. For this reason the standard rectangular IEC-circuit-symbols have been used by manufacturers for some time to depict their circuit diagrams.

This programmed instruction is oriented along practical lines. The only prerequisite is a knowledge of the binary number system.

Munich, September 1978

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[1]) International Electrotechnical Commission

Hints on using the programmed instruction

(BE SURE TO READ THIS!)

This set of programmed instructions is a text-book of a special kind. The contents are divided into separate lessons of one or two pages. The lessons are numbered consecutively, and the numbers may be found in the top-corner of each page. At the end of each lesson you can measure your progress by trying a problem.

It is important that these problems are solved in writing. The required space is provided in the book or a separate notebook may be used to avoid marking the pages. You will find the solutions and the way to solve each problem on the page after each problem.

If you find it impossible to solve a problem at some stage, and if the explanation of the solution does not clear up the matter, then it is best if you work through the previous lesson again – perhaps after a suitable pause. If this does not work, then you should go back in the programmed instruction to a convenient point, before you encountered difficulties. Starting at this point, carefully work through the pages again.

The book consists of two large sections. Section 1 is concerned with gating elements and Section 2 with storage elements. At the start of each section the purpose of the section is explained. A summary and a number of problems conclude both sections.

The summary provides you with the opportunity to revise; it may also be used for reference purposes. You may attain a certain degree of proficiency in using the newly-gained knowledge by means of the set of problems. These may also pinpoint any weak areas which you may eliminate by repeating the relevant lessons once again.

The problems are placed at the end of each section and not with their respective lessons; this enables people who only want information to work through the book quickly.

The index provides a survey of the items contained in the two sections. In addition the index should assist you to find any item quickly.

Take your time when working through this programmed instruction, and pause frequently.

It does not matter how long you take to complete the subject but it is important that you understand it.

And now you may start. **Good luck!**

Index

Section 1

Gating elements

Purpose

After you have completed this section you will be able to:

- Distinguish between an OR- and an AND-operation,
- State the significance of a signal as well as that of the polarity-notation after the signal-name, and to name the two different conditions of a signal,
- Explain the operation of negated inputs and outputs, and to state the names of the gating elements thus obtained,
- State the purpose of an inverter (NOT-element) and its symbolic representation,
- Read circuits composed of gating elements,
- Draw up working tables for gates with a maximum of three input-conditions and negated as well as non-negated inputs and outputs,
- Find the Boolean equation for logical circuits (consisting of OR-, AND- and NOT-elements with negated and non-negated inputs and outputs and including inhibit-inputs) employing the most common functional symbols and placing brackets correctly,
- Negate Boolean expressions,
- Interpret binary numbers represented by signals,
- State the operation of and represent a phantom AND- as well as a phantom OR-element,
- State the operation of and represent an EXCLUSIVE-OR,
- State the significance of an expansion-input.

A bank was held up yesterday afternoon by a masked man. He threatened employees with a pistol; there were no customers present at the time. He forced the cashier to pack money from the till into a brightly coloured yellow brief-case. The robber made his getaway unrecognized in a red VW along with approximately £17,000.

It is assumed that the criminal had prior knowledge of the fact that the alarm of the bank had been out of order for a number of days. The insurance company has commissioned a well-known private detective to solve the crime.

Now we want to do a little detective work ourselves and determine under what conditions the hold-up took place:

- There were no customers inside the bank, and the alarm was out of order.
- The robber probably had prior knowledge of the defective alarm from an employee of the bank or of the repair-company.

What do we want to achieve with this story? What has it got to do with digital circuit-elements?

Nothing, naturally!

Even so we may gain something from it. What can be gained is the fact that we are confronted with logical functions in practical everyday life just as much as in digital circuit elements; and that basically one must differentiate between two types of logical functions:

1. The **AND-function**	(There were no customers inside the bank **and** the alarm was out of order.)
2. The **. . . .-function**	(The robber probably had prior knowledge of the defective alarm from an employee of the bank **or** of the repair company.)

Please insert the omitted word.

Basically, two types of logical functions are recognized:

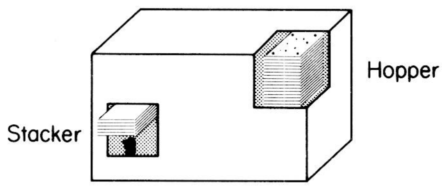
1. The **AND-function**
2. The **OR-function**

You were expected to insert the word **'OR'** *on the previous page. Most probably you entered the correct word.*

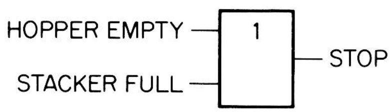
Digital circuits are used to perform logical functions. Of which type are these logical functions?

Let us take an example from the data-processing field:

A card reader is to be stopped when the card-hopper is empty, i.e. if it contains no more cards, **or** when the card-stacker, where the cards that have been read are deposited, is full.



To achieve this function a **logic element** is used which is represented in circuit diagrams by the following circuit symbol:



In this case the logic function has two inputs. At these inputs the conditions are present to cause the STOP signal at the output (which will stop the card reader).

The **1** within the circuit symbol expresses the fact that this is an **OR-**function.

The reason is that for an OR-function the output signal is generated, i.e. **the OR-condition is satisfied** if . . . . . input condition is active.

Please insert the omitted word again.

The omitted word is 'one'.

Thus, for an OR-function only **one** input condition (the hopper is empty or the stacker is full) is sufficient to satisfy the OR-condition, i.e. to generate the output signal (STOP in this case).

As opposed to the common use of the word 'or' (shall we go to the cinema or to the theatre?) the OR-condition is also satisfied if more than one or even all input conditions are active.

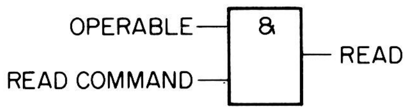
It may not be possible for you to go to both the cinema and the theatre at the same time, but it is quite feasible that both the conditions HOPPER EMPTY and STACKER FULL are active. For this reason the OR-function may also be denoted by '≥ 1' in a circuit symbol.

Let us stay with the card reader for a little while and examine a further example.

The following function has to be performed:

A card must be read on condition that the card reader is 'operable' (i.e. it is switched on and there are cards present in the hopper) **and** a read command is received by the card reader.

The following symbol represents the above function:



The ampersand sign (&) in the circuit symbol expresses the fact that this is an **AND-**function.

For an AND-function ...... input conditions must be active to satisfy the AND-condition, i.e. to generate the output signal.

In this case the word is 'all'.

If you have inserted 'two' or 'both', then this is correct as well. But it may happen that more than two signals are combined, and in this case the AND-condition is satisfied only if **all** input conditions are active.