

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE
NORME DE LA CEI

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC STANDARD

Publication 113-8

Première édition — First edition

1982

Schémas, diagrammes, tableaux

Huitième partie: Etablissement des schémas pour manuels des instructions fonctionnelles

Diagrams, charts, tables

Part 8: Preparation of diagrams for system manuals

Mots clés: manuel d'entretien pour systèmes;
schémas.

Key words: system maintenance manual;
diagrams.



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Bureau Central de la Commission Electrotechnique Internationale

3, rue de Varembe
Genève, Suisse

IEC
VOL. 10

Prix Fr.s. 75.—
Price

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CONTENTS

	Page
FOREWORD	5
PREFACE	5
Clause	
1. Introduction	7
2. Scope and object	7
3. Related publications	7
4. Use of system manuals	7
5. Functional system documentation	9
6. Preparation of diagrams for system manuals	9
7. Examples of diagrams	15
FIGURES	20

INTERNATIONAL ELECTROTECHNICAL COMMISSION

DIAGRAMS, CHARTS, TABLES

Part 8: Preparation of diagrams for system manuals

FOREWORD

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by Sub-Committee 3B: Preparation of Diagrams, Charts and Tables — Item Designation, of IEC Technical Committee No. 3: Graphical Symbols.

A first draft was discussed at the meeting held in Oslo in 1976.

A second draft was discussed at the meeting held in Paris in 1978. As a result of this meeting, a revised draft, Document 3B(Central Office)23, was submitted to the National Committees for approval under the Six Months' Rule in September 1979.

The National Committees of the following countries voted explicitly in favour of publication of this Part 8:

Australia	South Africa (Republic of)
Belgium	Sweden
Canada	Switzerland
Denmark	Turkey
Egypt	Union of Soviet
Finland	Socialist Republics
Israel	United Kingdom
Italy	United States of America
Romania	

France cast a negative vote for the following reasons: the contents of the publication is such that Sub-Committee 3B is encroaching upon the scope of Technical Committee No. 56: Reliability and Maintainability. The aims and methods proposed are not expressed clearly enough with respect to all branches of electrotechnology or for equipment manufactured in small quantities only.

Other IEC publications quoted in this standard:

Publications Nos. 113: Diagrams, Charts, Tables.

117: Recommended Graphical Symbols.

617: Graphical Symbols for Diagrams.

DIAGRAMS, CHARTS, TABLES

Part 8: Preparation of diagrams for system manuals

1. Introduction

The normal way of documenting electrotechnical systems is the provision of a number of diagrams with supporting charts, tables, written descriptions etc. The increasing complexity of modern systems and the urgent need to minimize downtime due to faults have revealed a need for supplementary documentation, usually included in one or more system manuals. Because the emphasis in the presentation of the data is on functional rather than physical boundaries in the equipment, such documentation packages are often termed "functional system manuals".

2. Scope and object

This standard describes the principles applied in the preparation of diagrams used in system manuals.

3. Related publications

The other parts of IEC Publication 113 (see inside back cover) are concerned with matters of drawing practice and provide additional guidance.

Graphical symbols are given in the relevant parts of IEC Publication 117: Recommended Graphical Symbols, and IEC Publication 617: Graphical Symbols for Diagrams (see inside back cover).

4. Use of system manuals

Although the method described in the present standard is capable of wide application, the normal method of documentation is satisfactory in a great many cases and is usually preferred for unique plants and for equipment which is in low volume production. System manuals on the other hand are suitable for applications where identical equipment is employed at many locations or for plants where downtime is of overriding consideration.

The decision as to the precise form of documentation to be used in a particular case should take account of factors such as the cost and complexity of the plant, the type and degree of training given to maintenance personnel and the maintenance philosophy adopted by the user.

It is strongly recommended that the type of documentation to be used should be the subject of discussion and agreement between manufacturer and user as early as possible during the development of any system.

5. Functional system documentation

5.1 Objectives

System manuals seek to present information in ways which clarify the working of a system and hence facilitate the tasks of training and maintenance. With complex systems the location of faults often takes a longer time than their repair and it is therefore important that the documentation should be laid out in a way which best aids the diagnostic process. Functional system documentation meets this objective by presenting information at a number of arbitrarily chosen levels corresponding to functional rather than physical sub-divisions of the system.

5.2 The concept of functionalization

In this context, a function may be defined as an operation or process which has a definite effect on signal or logic flow and hence on system behaviour. Functional flow describes the logical interworking of equipment functions which enables an equipment to achieve its purpose. It is a prime objective of functionally based documentation to capture this functional flow which is often masked by hardware boundaries. Thus circuit diagrams are often prepared for discrete items of equipment such as printed wiring boards or sub-assemblies. A functionally based diagram, however, will often group hardware items located in different parts of an equipment provided they act together to perform an identifiable function.

5.3 Presentation of data

Data is provided at a number of levels determined by functional analysis of the equipment or system covered by the documentation. Coverage progresses from the most general to the most particular, the information at each level being functionally and logically related to that at the preceding level. The number of levels provided depends on the factors mentioned in the second paragraph of Clause 4 and on the size chosen for the diagrams.

6. Preparation of diagrams for system manuals

6.1 General principles

In order to meet the objectives outlined in Sub-clause 5.1, diagrams should be prepared in accordance with the following aims and principles.

6.1.1 Fitness for purpose

Each diagram should be prepared with its primary purpose in mind.

Different considerations will apply to diagrams prepared for general explanatory purposes than will apply to those prepared specially for use by maintenance personnel. The former need only provide a clear explanation of how the equipment works whereas the latter should also include all the information required to locate and clear faults (see Sub-clause 6.1.5).

6.1.2 Functional layout

Clause 5 has explained that functional system documentation generally takes the form of a structural hierarchy of diagrams starting with one covering a complete system or equipment

and expanding down through successive levels to the detailed coverage necessary in any particular case. Each diagram should be laid out to emphasize the functional relationships existing between the various sub-systems, parts or components represented on it. At the higher levels some form of block diagram (see Sub-clause 6.2) will generally be employed and sub-division into functional blocks presents no problems.

At the low levels it is also important that functionally related parts should be readily identified. On detailed diagrams the use of standard layouts for commonly used circuits is of assistance (see Sub-clause 6.6 of IEC Publication 113-4). This method should be supplemented as required by the use of coloured (Figure 11, page 39), hatched or tone backgrounds (Figure 5, page 28), or by enclosure within separate boundary lines (Figure 4, page 25). If colour is employed, each functional stage should be printed on a pale coloured background. Yellow and blue are recommended for this purpose because of the excellent legibility of black printing on these colours. Two colours can provide for two levels of functional grouping and yellow and blue have the advantage that a third level is readily available by overprinting to yield green, see Figure 11. If a special boundary line is used, that chosen should be readily distinguishable from any other line used to indicate a hardware boundary (see for example Figure 4). It is also possible to use several shades of one colour to indicate functional grouping and to employ grey shades to define hardware boundaries.

6.1.3 *Inclusion of texts in diagrams*

Documentation which presents diagrams and the related descriptive material separately is inconvenient to use since frequent cross-reference is required by the reader. Improvement can be effected in manuals by printing the descriptive material relating to a given diagram on the facing page. If the diagram is divided into functional blocks, the descriptive material can take the form of a block text diagram with an identical layout (see for example Figures 5 and 6, pages 28 and 29). An even better method is to arrange for the text to be included in the functional blocks (see for example Figures 10 and 11, pages 37 and 39).

The principle of amalgamating text and diagram is well suited to equipment whose behaviour can conveniently be explained by the use of waveforms or timing diagrams. The explanatory text is broken up into appropriate sections and inserted in the waveform diagram with arrows drawing attention to the relevant waveform features (see for example Figure 7, page 30). With this method the diagram presents a coherent story and the need to refer repeatedly back and forth between text and diagram is avoided.

6.1.4 *User considerations*

The presentation on each diagram should be matched to the skills possessed by the personnel who will use it. Diagrams prepared for use by highly trained staff will generally contain much more detailed information, but the explanatory material should be appropriately condensed and a single title to each functional block will generally suffice (see for example Figure 10). Those prepared for use by relatively untrained staff should provide a clear and simple explanation of what each stage is intended to do and under what conditions it does it. The use of pictorial items, such as panel faces or control modules, combined with schematic symbols and signal flow paths to present the system for use by non-engineering trained personnel may be helpful.

6.1.5 *Maintenance considerations*

Diagrams prepared specifically for maintenance purposes shall take account of the maintenance philosophy applied to the plant or equipment they cover. They may thus range from simple block diagrams suitable for a unit replacement philosophy to detailed circuit diagrams intended to enable

expert technicians to locate and repair faults in complex equipment. In all cases the necessary information should be provided in as compact and convenient a form as possible.

This means the assembly on one diagram of information which — with normal documentation — might require reference to a number of sources, such as a circuit diagram, a wiring diagram, a layout drawing, explanatory texts and device data sheets.

The following principles are also relevant:

- a) Diagrams should be uncluttered and should not contain any data which is not directly related to the maintenance process.
- b) Each diagram should be carefully laid out, not only to highlight signal flow and the functional relationships between the various stages but also to permit the insertion of data in the form of texts, waveforms, diagrams, test values, etc.
- c) The internal circuits of non-repairable devices are not generally shown, but information to enable them to be tested should be given. Thus the function of a package and its input and output voltages are of interest rather than details of how it performs its function.
- d) Information on the physical location of parts and components should be shown.
- e) Test points should be identified and the relevant test data should be given.
- f) Details of tag layouts, for example, integrated circuit pin numbers and transistor connections, should be shown.
- g) Graphical symbols should have readability enhanced through the use of pictorial additions. For example, a multiposition switch shown schematically benefits from adding a pictorial drawing of the control knob with its position labels.
- h) Electromechanical systems should show the mechanical and electrical relationships in an integrated presentation.
- i) Pieces of equipment which can easily be replaced, and which may be stocked as spares should be marked with an extra-heavy outline. If the replaceable unit appears on more than one page of a diagram set, indicate this by a cross-hatched outline.

Note. — It is not always possible to include all the information required at a particular level on one diagram. In such cases suitable references to other sheets or sources should be provided. The additional data can often be located on a facing page of the ~~document~~.

6.2 Block diagrams

In functional system documentation, block diagrams concentrate on functional representation rather than hardware. The boundaries of the functional blocks may be defined by one of the methods mentioned in Sub-clause 6.1 and they should be carefully arranged to obtain a clear signal and logic flow. The size of the blocks may not be related to their importance and they may be shaped to suit the layout. Main signal paths or logic flow should be emphasized by the use of thicker lines. Feedback paths should be identified by a suitable convention such as the use of double arrows. Common supplies and signals may be shown separately by means of rails or busbars at some convenient part of the diagram, their connections to the functional blocks being indicated by arrows. Alternatively appropriately labelled inputs may be shown — preferably on the horizontal sides of the functional blocks.

Information on the physical location of test points should be provided by means of inset diagrams or by references to accompanying layout information as appropriate.

Each functional block should have a title and may contain explanatory text. At the higher levels it is often convenient to represent the functioning of an equipment entirely by blocks of

text (see for example Figure 8, page 35). Such diagrams are sometimes known as block text diagrams and they can also be used to complement low level diagrams (see Sub-clause 6.3).

6.3 *Circuit diagrams*

In functional system documentation circuit diagrams should provide detailed information at the lowest levels in the hierarchy. They are especially prepared to highlight functional grouping and performance. Each functional stage should be identified in a suitable manner and should have a title in the form of a short description of the stage's function, for example, buffer amplifier, divide-by-ten counter.

Adjustable controls and test points can be emphasized by enclosing the symbols in white (where they would otherwise be printed on a coloured background).

For testing purposes, diagrams must show terminal numbers, device pin connections, etc., and give information to enable the actual circuit components to be located in the hardware.

Information such as notes, waveforms and explanatory texts which will facilitate the intended purpose of the diagram should be included in so far as it is practicable. If additional information is needed, it should be given in an associated block text diagram or by appropriate references to supplementary data.

7. **Examples of diagrams**

Figure 1, page 20, is a first level functional block diagram prepared for a manual for a grinding machine in a steel mill.

Figure 2, page 21, is a second level diagram prepared for the same manual and shows the breakdown of the functional block designated "F1" in Figure 1.

These diagrams were prepared for use by relatively untrained maintenance personnel working in a multi-disciplined environment. They are intended only to facilitate the speedy identification of a faulty unit. In the manual each diagram was complemented on the facing page, with information relating to the designated test points.

Figure 3, page 24, taken from a training manual, is a block diagram describing the operation of some equipment in a small telephone exchange.

Figure 4, page 25, from the same manual, is the circuit diagram for the equipment shown in block form on Figure 3.

Figures 5 and 6, pages 28 and 29, prepared primarily for training purposes, show a circuit diagram complemented by explanatory text.

Figure 5 is a circuit diagram in which a background tone is used to identify functionally related components.

Figure 6 complements Figure 5; it provides a textual explanation of circuit operation of the functional block displayed in Figure 5.

Figure 7, page 30, gives the circuit diagram of a monostable delay generator and shows how the operation of the circuit may be clarified by means of waveform diagram containing textual explanations.

Figures 8 to 10, pages 35 to 37, are diagrams prepared for a television coder manual. They illustrate the use of colour to define functionally related groups and sub-groups of components.

Figure 8, page 35, shows the location of front panel controls and of pre-set adjustments together with performance parameters and alignment notes. The highest level of functional sub-division is given by the block text diagram on this page.

The limits of each block in Figure 8 are indicated by blue lines on the functional block diagram, Figure 9, page 36. This shows two more levels of functional sub-division, each blue block giving a reference to the page in the manual on which further information is provided. Note the use of thick lines to emphasize main signal paths and of arrows to clarify the direction of signal flow. The functional block diagram includes a large number of monitoring points and the facing page of the manual (not shown here) gives information on their physical location together with diagrams of the waveforms to be expected at each point.

Figure 10, page 37, is the functional circuit diagram for the two blue blocks at the right-hand side of Figure 9. Note that the power supply decoupling circuits are shown in a separate functional block to preserve the clarity of the presentation. The diagram includes device connection drawings and information on the waveforms to be expected at monitoring points. The brevity of the textual information presupposes thorough training of the staff who will use the manual. Note, however, how the functional nature of the presentation together with the titling of the various stages provides a sound basis for understanding the operation of the circuit.

Figure 11, page 39, is a diagram prepared for a manual for an audio-frequency test set. The colours chosen to denote functional grouping in this manual are blue, green and yellow — the intermediate colour being derived from the other two. The diagram includes three levels of functional sub-division and it will be seen that hardware and functional boundaries do not coincide. Note the use of double arrows to indicate feedback paths on this diagram. Power inputs to the blocks are shown by references, but in the case of the integrated circuit packages the information is given in the table on the left of the diagram.

Figure 12, page 41, is a block diagram showing the basic operation of the scanner unit of a large data communication processor. The diagram is laid out in such a way that both the functional and the physical aspects are shown to a degree which facilitates the identification of a faulty printed circuit board. Signal names are used extensively to give the necessary detailed information about the various control signals and data paths. The numbers in brackets constitute signal cross reference information. Data busses are emphasized by heavy lines and the storage of data and signals is shown by a heavy line across the inputs concerned. The general symbol for a changer is used for complex combinative logic arrays. The width of data is designated either by the signal name or by showing the first and last identifying number of the bits concerned inside the block symbol. In addition, the relevant bits are grouped by a line parallel to the respective part of the symbol.

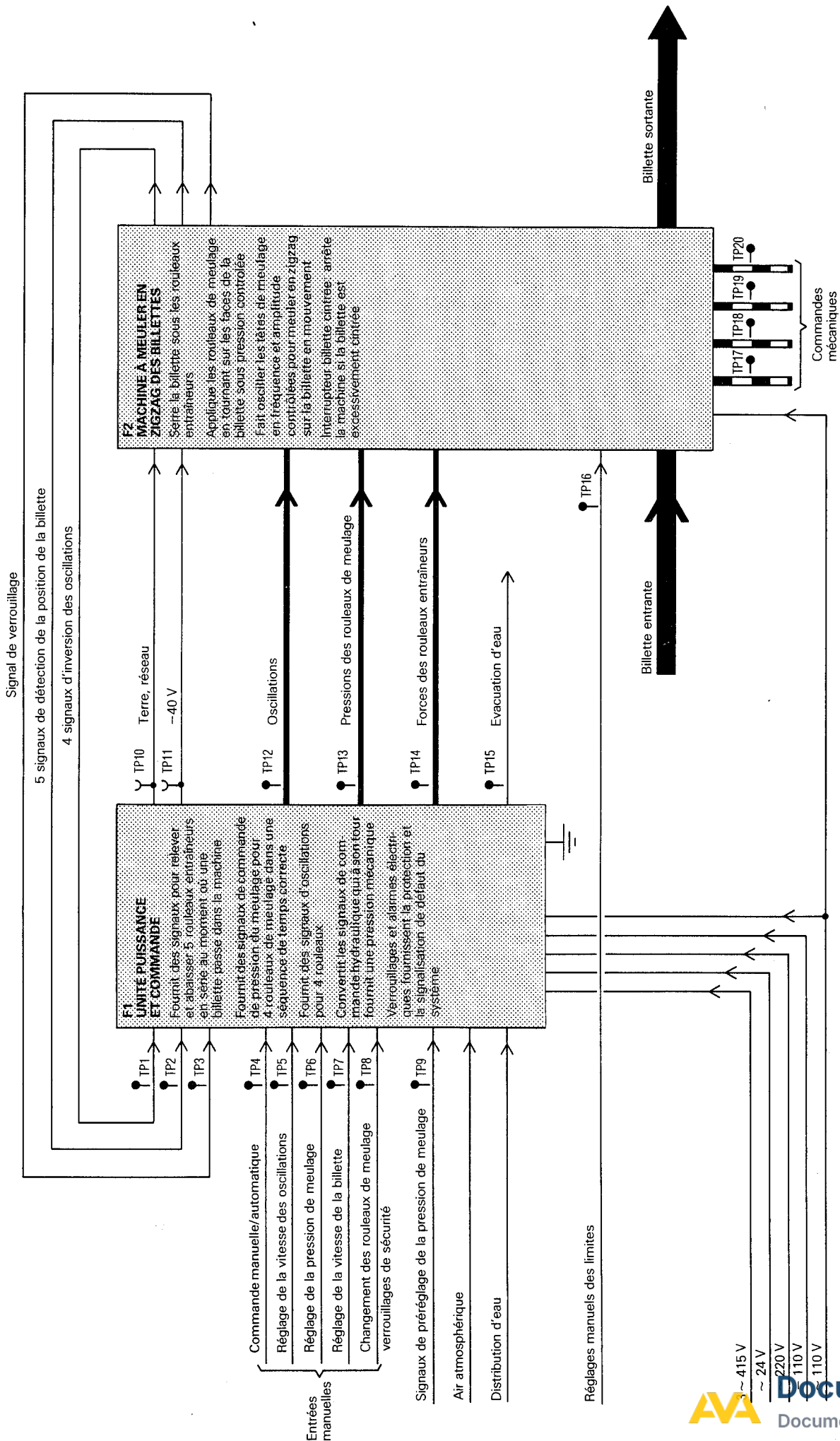


Fig. 1. — Schéma fonctionnel partiel de 1^{er} niveau.
Meule à onde sinusoïdale.
(English text, page 20)

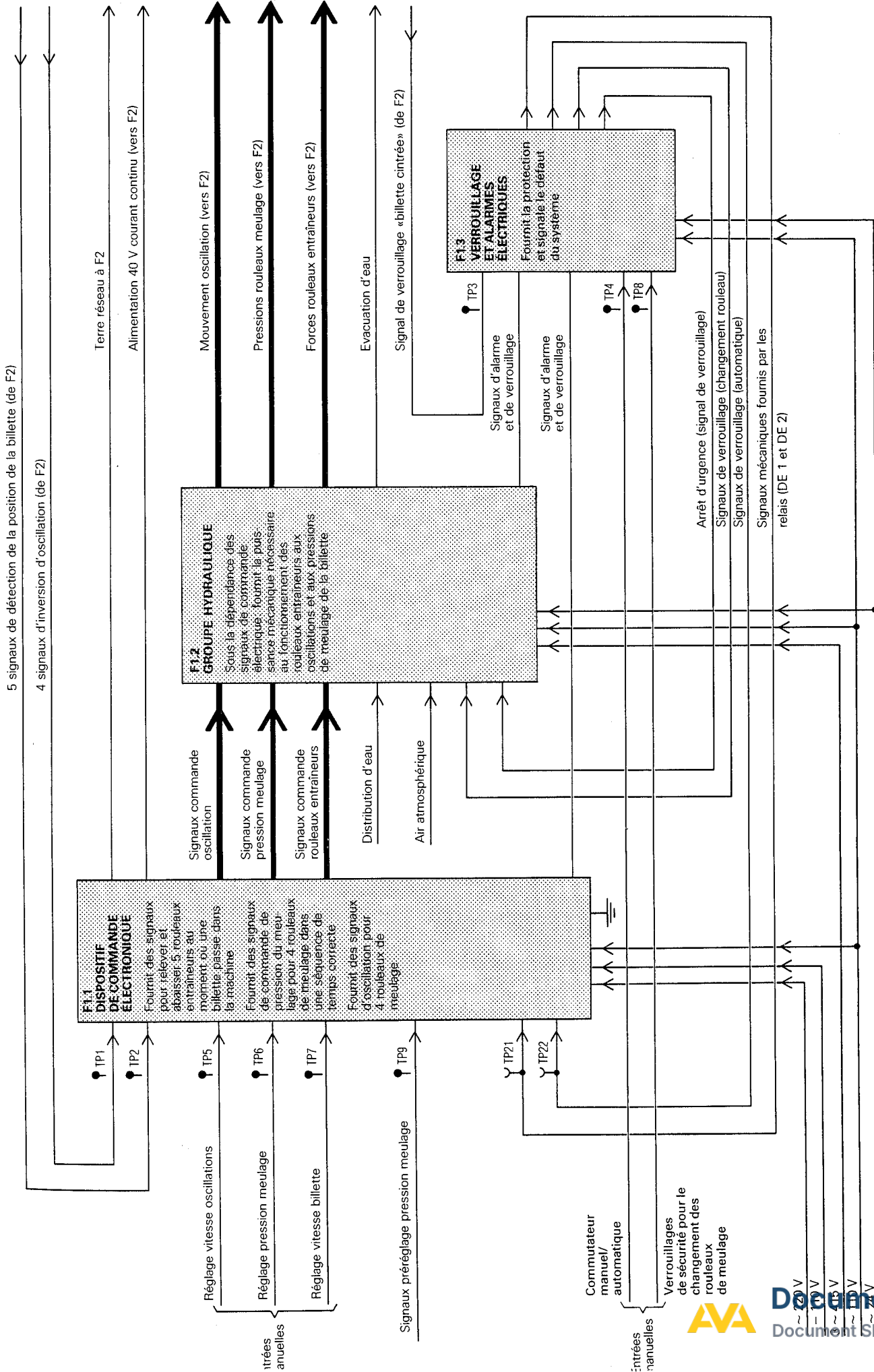


Fig. 2. — Schéma fonctionnel partiel de 2^e niveau.
Unité commande et puissance de la meule à onde sinusoïdale de la figure 1, page 18.
(English text, page 21)

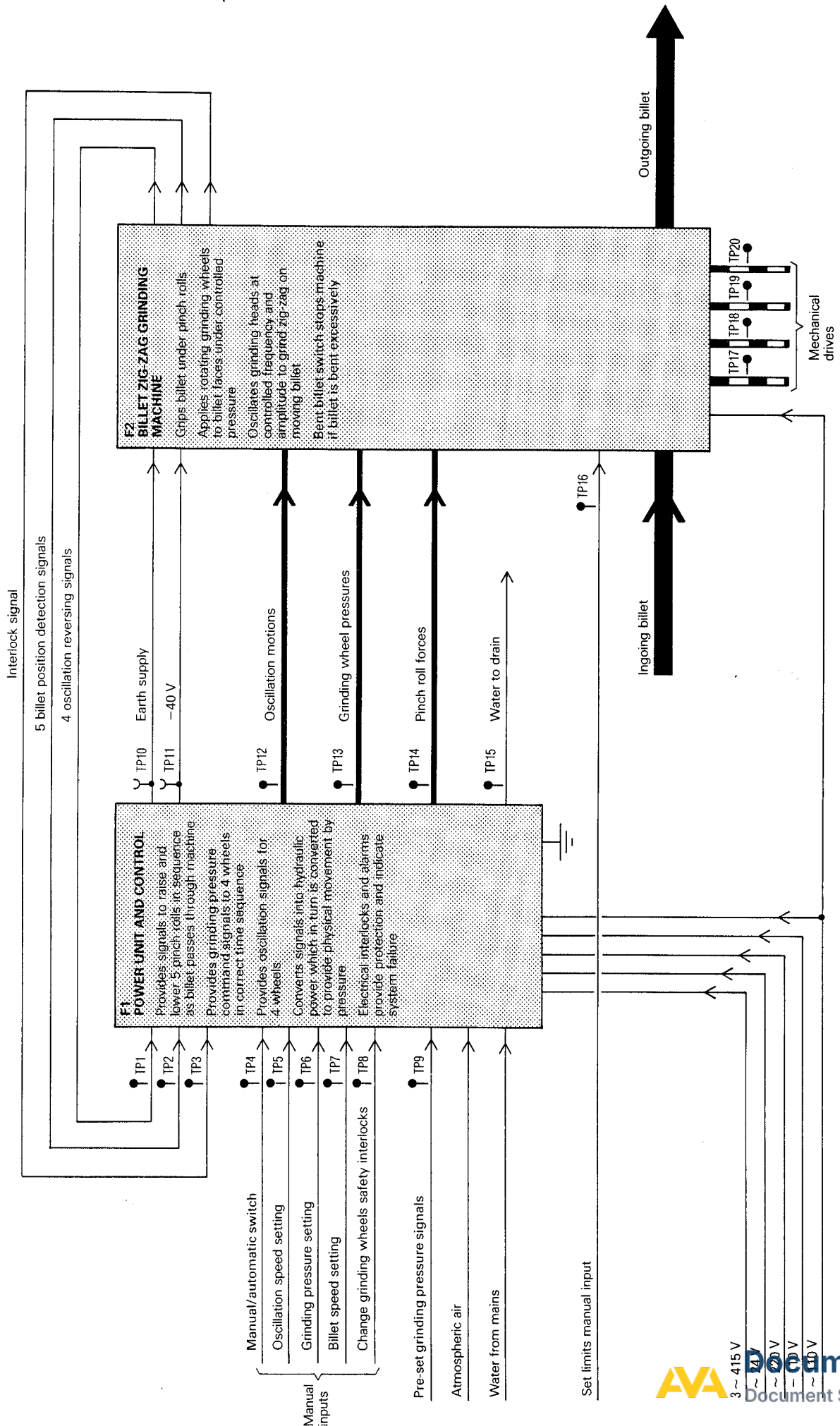


FIG. 1. — Block diagram, 1st level.
Sine-wave grinder.
(Texte français, page 18)

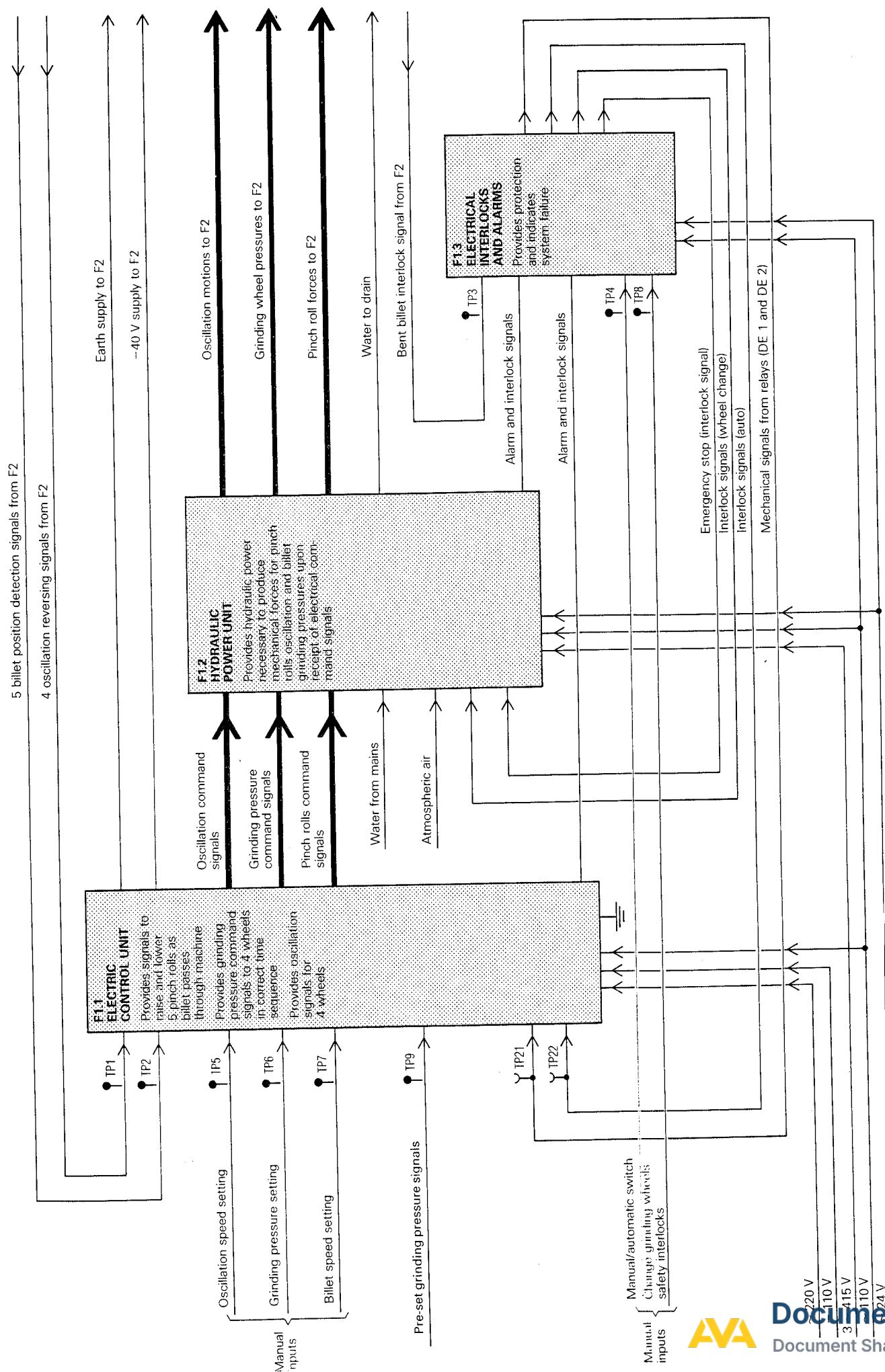


FIG. 2. — Block diagram, 2nd level.
Control and power unit of the sine-wave grinder shown in Figure 1, page 20.

(Texte français, page 19)