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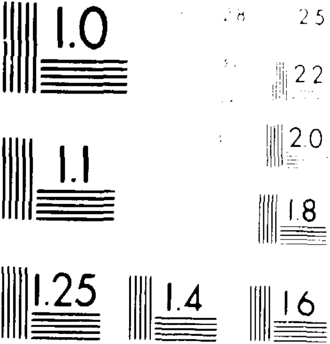
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Bulgaria.

ELECTRICAL WATT-HOUR METER QUALITY CONTROL AND EVALUATION LABORATORY

SI/BUL/82/802

BULGARIA

Terminal report*

Prepared for the Government of Bulgaria
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Oleg M. Pavlov,
expert in development and design of high accuracy electrical
energy measuring devices (watt-hour meters)

United Nations Industrial Development Organization
Vienna

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1. EXPLANATORY NOTES

1. The average value of the Bulgarian Leva (Lv) in terms of United States dollars during the period of the Project is as follows:

   Lv 1.- = US$ 1,015

2. Abbreviations used in the text:

   EWHM - electronic watt-hour meter (according IEC recommended terminology - static meter)
   NPP - National Project Personnel
   ID - input device
   MB - measuring block
   DB - display block
   SB - supply block
   MC - measuring convertor
   VFC - voltage-frequency convertor
   PFC - power-frequency convertor
   PDM - pulse-duration modulation
   PAM - pulse-amplitude modulation
   MD - multiply device
   RC - reversible commutator
   OA - operational amplifier
   PVC - power-voltage convertor
   DE - delay error
   PF - pulse formation
   AD - averaging device
   K - key
   I - integrator
   ND - null-detector
   D - differenciator
   LC - logic circuit
   EDPM - electronic data processing machine
   MTE - meter testing equipment

2. ABSTRACT

The expert was attached to the Institute for Instrument Design in Sofia, People's Republic of Bulgaria (SI/BUL/82/802/11-01/31.9.C).

The duties were to:

1. Assist in the theoretical justification for the selection of the optimum structural scheme of high accuracy electronic watt-hour meters.

2. Assist the development of input measuring transformers for current and voltage.

3. Elaborate a variant of an electronic watt-hour meter with memory, capable of memorizing the watt-hour meter readings at supply voltage drop.

4. Specify the requirements for the interface and for the signals transmitting the watt-hour meter readings at a distance.

5. Elaborate the structural scheme of electronic watt-hour meter easy for design on the basis of hybrid integral circuits.

6. To assist the elaboration of a normative documentation for testing of electronic watt-hour meters with accuracy of 0,1 + 0,5 using high accuracy testing equipment.

7. To prepare a test diagram for testing of electronic watt-hour meters.

8. To assist in the joint elaboration of methods for accelerated reliability testing of electronic watt-hour meters.

9. Determination of the requirements to the devices and methods for adjustment and check up of electronic watt-hour meters in industrial usage.

10. To organize laboratory testing of high accuracy electronic watt-hour meters and train a specialist in high accuracy electrical measurement.

11. To train a specialist in assembly, adjustment and quality check up of electronic watt-hour meters in industrial usage.

The expert was also expected to prepare a final report, setting out the findings of this mission and the recommendations to the Government on further actions which might be taken.

The policy of People's Republic of Bulgaria tends towards energy saving and thus priority is given to the improvement of equipment for measuring the electrical energy by developing the three-tariff high accuracy electronic meters.

The current level of microelectronics and the theory of information of the measuring convertors have laid the ground for developing of manufactured electronic watt-hour meters /EWHM/

EWHM differ from electromechanical ones in:

1. higher accuracy;
2. threshold sensitivity;
3. load characteristic linearity;
4. widened load and temperature ranges;
5. less effects of the quantities of influence;
6. independance of accuracy from vibration,bumping and single shocks;
7. possibility of telecommunication with the Automatic Control Systems for Technological processes and Information Measurement System for energy.

As to d.c. EWHM,they have a weak influence of the level of current and voltage destortion on the measurement's accuracy.

The basic conclusions are as follows:

1. UNIDO assistance is considered as an extremely important factor,especially in the field of design and test of high accuracy electrical energy measuring devices.

2. Project outputs are,generally,already achieved by the national project staff.

3. Electronic watt-hour meter of high accuracy is already designed and marketed.

4. The design of the above-mentioned high accuracy electronic watt-hour meter is done according to the latest world technology.

5. Quality Control of electrical kilowatt-hour meter and Evaluation Laboratory is organized and equipped.

6. The outputs achieved are a basis for future developments in this field.

7. The equipment received is in use.

The basic recommendations are as follows:

1. The further design of electrical measuring instruments based on the technology already developed in the frame of the project is recommended.

2. For further development of this technology additional UNIDO assistance is necessary (expert assistance,special equipment purchase, training) amounting to US$ 45 000 (See Annex 16).

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3. INTRODUCTION

3.1. Project Background

A national energy-saving programme is under way. Two ways for electrical energy saving need special consideration:

1. To improve the accuracy of measurement of the electrical energy produced,distributed and consumed.At present 2% accuracy watt-hour meters are in production and on the market.This accuracy is no more acceptable,particulary in view of the current energy shortage. Only one family flat with 8 kilowatt installed devices,consumes more than 700 000 watt-hours electrical energy averagely per year. By using 2% accuracy measurement devices more than 14000 watt-hour power per year for one family only is out of control,thus harming either the producer (distributor) or the customer and in both cases the national economy.By implementing 1% accuracy devices,50% of this energy will come under control.For 3 million customers,this equals to more than 21 billion watt-hours of electrical power kept under control. This will benefit considerably the national energy-saving programme.

2. The night time nation-wide use of electrical energy has to be encouraged,thus improving the rate of optimal loading of the installed power sources.For this purpose two-tariff measurement devices have to be developed and introduced into the market.

The Ministry of Machine Building and Electronics is organizing a team of more than 40 university graduates-engineers and technicians to develop and organize the production of such two-tariff 1% accuracy measurement devices.A special Quality Control and Evaluation Laboratory has to be established.Such a development is generally difficult because of its cost,high degree of specialization;and it is especially difficult for the developing countries.Expert assistance is necessary. Fellowship training has to be organized.In plant training activity will have to take place,especially for quality control and evaluation.

3.2. Official Arrangements

The assistance was requested by the Government on 30 October 1981.Based on this request UNIDO approved two projects:

- Project RP/BUL/82/002 with UNIDO Contribution
  US $ 10 000 as training component
- Project SI/BUL/82/802 with UNIDO Contribution
  US $ 56 000 for expert assistance and equipment

The total Government Contribution for both projects is 827 000 leva.

Both projects were approved by UNIDO on 29 January 1982,16 March 1982,respectively.

The Institute for Instrument Design is reporting to the State Economic Enterprise "Instrumentation and Automation" which belongs to the Ministry of Machine Building and Electronics.

3.3. Project Revisions

A Project Revision was approved on July 9,1982 by which the scheduled completion of the Project was changed to show May 1983.

A Second Project Revision was approved on 20 th October 1982: the expert component was decreased from 16 000 US $ to 12 000 US $ and equipment was increased from 40 000 US $ to 44 000 US $.

3.4. Objectives of the Project

The Objectives of the Project are outlined in the Project Document as follows:

A. Development Objectives

The development objectives of the Project are to support the national programme for energy saving through developing and implementing of a new line of two-tariff watt-hour meters with improved accuracy and quality.Using these instruments,a better energy control could be established both by the energy production facilitie and by the energy users.This will,in turn,contribute to improvement of the energy balance in the country.

B. Immediate Objectives

The immediate objectives of the project are to stregthen the basis for technological development of the counterpart agency.

Specifically the project will:

a) Ensure production and implementation of watt-hour meters with improved accuracy and quality,enabling electrical energy measurement in two tariffs (prices)higher for the active day time and respectively lower for the inactive night time.

b)Strengthen the better energy distribution and more economical energy consumption all over the country.

c) Contribute to the fulfilment of the national energy-saving programme.

3.5. Outputs expected

The expected project outputs are as follows:

a) Strengthened counterpart's Quality Control and Evaluation Laboratory which will enable specialists to carry out the development and implementation of 1% accuracy two-tariff watt-hour meter.

b) Developed prototype 1% accuracy two-tariff watt-hour meter.

c) Quality Control and Evaluation of the developed prototype.

d) Introduction into mass production of the measuring devices accordingly developed in the frame of this project.

e) A number of Bulgarian specialists trained in the field of 1% high accuracy two-tariff watt-hour meter development,production and quality control and evaluation.

4. MAIN ACTIVITIES

The expert arrived in Sofia on 14 September 1983 (at Vienna on 12 th of September 1983) and started his work in accordance with the Job Description (Annex 1). Work Programme was prepared jointly with the National Project Manager (Annex 2).

4.1. Meetings

The Meeting was organized on 15 September 1983 with the National Project Manager,Dr. I.Petrov,Director of the Institute for Instrument Design and his staff (NPP).

Then I had several meetings with Dr. I.Petrov again. Visiting different departments of this Institute I made conclusions that, although the traditions of instrumentation production in Bulgaria are pretty young,due to proper management and efforts most of the industrial instruments and systems are neatly manufactured and well designed.

Further I considered a number of problems in the frame of this Project (see Annex 2) together with I. Adarski,Deputy Director, S.Abadjiev, Supervisor of Direction,M.Krumova, Testing Department Leader, M.Karanfilova, Instrument Department Leader, R.Raichev, Digital Instrument Section Leader, I.Bozev,senior engineer and others.

Visit to Plovdiv exhibition was arranged on 28 September for more detailed acquaintance with instruments and systems produced in the different countries.

Several meetings and visits,such as a visit to Instrumentation Plant in Pravetz and National Centre of Metrology and Standardization in Sofia were also organized.

4.2. Finances

The Government Contribution is granted.

4.3. Building

The re-orientation of the present facilities is completed to facilitate the R & D activities.

4.4. Project Personnel

The R & D activity is carried out by 40 university graduates engineers and technicians, supported by 20 skilled workshop workers and 4 persons as support personnel.

4.5. Training

Training proved to be very succesful in the frame of this project (see Annex 3). UNIDO experts contributed considerably to this activity.

4.6. Equipment

Equipment of different predestination in the frame of this project was received (see Annex 4).

Additional equipment is installed as Government Contribution (total cost 110 000 US $), such as machine tools, Printed Circuit Board Production Line, electronic measuring instruments, temperature and humidity test chambers.

5. MAIN OUTPUTS

The following Project activities are finished by the National Project Personnel:

a) State-of-the- art study in the field of modern high accuracy electrical energy measuring devices.

b) A prototype of electronic measuring kilowatt-hour meter is developed: three phases, three tariffs, accuracy 0,5%.

c) An electrical kilowatt-hour meter Quality Control and Evaluation Laboratory is organized and equipped.

d) The prototype is tested.

e) The necessary technical documentation and special tools are developed.

f) The prototype and technology developed are transferred to the production plant in the city of Pravetz.

g) The industry plant personnel is trained on assembly testing and quality control of the new product.

h) The pilot production is finished.

i) The mass production of the new product is well under way.

6. BODY OF THE REPORT

Chapter I

A. General Functional Diagram and Specific Requirements for EWHM

A general diagram for EWHM was submitted for consideration and specific requirements to EWHM were fixed.

It was shown, that EWHM had one or some input devices (ID), measuring block (MB), display block (DB) and supply block (SB) (see Annex 5).

Measuring current and voltage transformers, calibrated shunts, voltage dividers and additional resistance may be used as ID. ID of three-phase manufactured EWHM for the measurement of very large amounts of energy are connected with output windings of primary measuring current and voltage transformers with rated output signals 5 or 1 A and 100 or $100/\sqrt{3}$ V. ID are used for transforming input signals $i_1 \ldots i_n$ and $u_1 \ldots u_n$, which are in proportion with main current and voltage, to proportional signals $x_1 \ldots x_n$ and $Y_1 \ldots Y_n$, whose level is matched with MB inputs.

MB transforms input signals to pulse number and MB is the general block which defines the approachable metrological and EWHM usage performances.

The MB transforming accuracy must not be influenced by industrial pulse interference (jump spark, etc) as any redundant or lack pulse are practically the short duration failure.

MB are based on measuring convertors (MC), which transfer the voltage and power to pulse frequency (VFC and PFC).

DB are used to accumulate and storage the number or MB output pulses. Time integration of the measured value (I, U, P) with submitting the result of measurement (i.e. energy) in the digital form is made both by MB and DB.

Every output MB pulse corresponds to some standard level of the energy which was consumed, and the reading increment of DB corresponds to the summary consumption during the measuring time.

The DB readout is used practically as commercial or technology documents, therefore DB has to guarantee the reliability of storage and keep the information for a long time even for temporary reduce of the SB current or in the presence of industrial interference.

The accidental short duration failure of one of the higher DB division may send for significant error at commercial energy accounting.

Therefore the use of electronic DB is limited to their complicated realizations,their high price and large equipment bulk. Nevertheless, the electronic DB are used in the standard EWHM,so their realization may be comparatively simple and price not so high.

For meters, in contrast to other devices, a relative but not reduced error is standardized,therefore the relative multiplicative error does not depend on load,while the relative additive error increases hyperbolically with load's decrease. The attainable accuracy of measurement and accuracy class of EWHM are more determined by the additive errors of EWHM than the multiplicative ones. That is why structural and circuit methods of decrease of additive errors of MB are under consideration.

B. Methods of Analysis for Creation of EWHM Based on Voltage-Frequency Convertor (VFC) and Power-Frequency Convertor (PFC)

This analysis has shown that for the EWHM of higher accuracy it is expedient to design: VFC with change of integration direction and pulse feed back (based on resistive-capacitive circuit), and PFC composed on the base of in series connection of power-voltage convertors and VFC. The method of pulse-duration modulation and pulse-amplitude modulation (PDM-PAM) is most perspective to design multiply devices (MD) and PFC (see Annex 6).

6.1. Chapter II

A. A Method of Designing of Structural Circuits of Measuring Convertors with Higher Metrological Performances and Reliability

A method providing noise immunity of MC is also offered, where the function of memorizing of the convertor process direction is realized not by digital elements but by analog one-integrator. Although the VFC is based on two methods of designing, a set of elements typical for each type of convertor is absent in it, that provides for the simplicity of its circuit realization. Such VFC are not sensitive to pulse interference and they may be used in the EWHM for electric drive. For such a case the structural circuit of PFC with noise immunity is also shown (see Annex 7). The decrease of additive error in this PFC is realized by adding up of the zero shift of the half-periods and by substracting it during the other ones. A set of circuits for design of reversible commutators (RC) for MC, based on methods of reverse of the integration direction and PDM-PAM is considered. RC generally defines the attainable metrological performances of MC. In the MD of a.c. and d.c. watt-hour meters RC fulfils the function of PAM.

RC realized by bridge circuit on four electronic keys (see Annex 8) may be advised for voltage convertors isolated from EWHM circuits,e.g. using measuring voltage or current transformer.

RC with higher accuracy (see Annex 9),which is perspective to use for designing VFC with low level voltage,was suggested. Some methods decreasing the errors of unlinearity of MC based on integrating OA were analized,structural circuits using these methods were shown. Also a set of outline diagrams of noise immunated precision d.c. voltage convertor to frequency (see Annex 10) which may be used for class 0,2 a.c. and d.c. EWHM are shown.

6.2. Chapter III

A. A Measuring Convertor "Power to d.c. Voltage"

A measuring d.c. voltage convertor is one of the main blocks determining the metrological performances of a.c. EWHM based on PDM-PAM method. The inertia of power-voltage convertor (PVC) is a source of one of the components of the instrument error-delay error (DE). It was shown that for reducing DE it is necessary to reduce a delay difference of multiplied signals on PDM and PAM circuits. For class 1,0 and higher precision meters a delay difference in PDM and PAM circuits must not be more than 1 $^{\circ}$ (56 μs for mains frequency 50 Hz). Then PAM of higher precision is considered (see Annex 11). The virtue of this circuit is the possibility of commutation of the direction of the PAM output current by means of only one key element excluding the additive error that could appear in case of unsynchronous operation of the two keys and with relatively high generation of the frequency of PDM. A high-precision key was offered providing a high accuracy of a.c. and d.c. commutation with a simple circuit realization that allows the design of MC for high class EWHM. This key is based on the method of elimination of the parasitic modulation of the open channel resistor by current flowing through it.

The advantage of using PDM of self-generating type in power convertors was shown and a modulator providing the higher accuracy with simple circuit realization was suggested (see Annex 12). It was also pointed out that the use of three self-generation PDMs with alternative frequency conversion is more preferable in view of the fact that the additional errors are absent because of both beating and mutual influence of the three PDM.For EWHM of higher accuracy MD based on PDM using integrating element are perspective.

A method providing the noise-immunited PDM was offered based on elimination from the circuit of digital memorizing elements and transfering the function of memorizing the process conversion direction to general integrator (see Annex 13).This PDM may be used as a base for designing of high class EWHM.Measuring one- and three-phase convertors of power to voltage were offered which permit to design on their base the a.c. watt-hour meter of high accuracy.

6.3. Chapter IV

A. Structural Methods for Increase of EWHM Precision

Structural methods were offered for decrease and elimination of MD additive error of d.c. EWHM.It was shown that the logic reverse of PDM signals method could not be used for decrease of the MD additive error because it provides for the simultaneous change of the polarity of convertor signal and the interference.But consideration of EWHM as a united device made it possible to eliminate completely the additive error of MD and PVC with the help of digital elements only,without introduction of additional analog RC.

For complete elimination of the summary additive error of PVC the pulse formation (PF) with frequency 25 Hz and on-off-time ratio equal to 2 (pulses are formed from the voltage of mains) which is used as a logic generator and four logic circuits were introduced in the MB of the EWHM. Three logic circuits are allocated between PDM outputs and control inputs of PAM and the fourth one-between null-detector output and control input of RC (see Annex 14).

All the logic circuits are controlled by PF.In this case in regard to the integrator input the summary signal of additive interference "c" summary signal of averaging device (AD) is added with summary useful signal XY during one period of mains (half-period of PF) and during another one is substracted from it,because of XY signal reversed twice and "c" signal reversed only once,that is to say

$$Z_1 = XY + c$$
$$Z_2 = XY - c$$
$$Z = XY$$

and the summary additive interference caused by all the sources of PVC parasitical signals is eliminated completely for the even number of periods of mains.The combined using of single RC in different independent convertors:PVC and VFC is a specific feature of the proposed structure of MB. In this case all the metrological characteristics of VFC remain.

The reverse of analog signal direction with 25 Hz frequency is realized not by analog,but by digital elements without introduction of additional instrumental uncertainties (except delay uncertainty, which may be neglected if the logical circuits are made with high-frequency elements).

The method of eliminating the additive error of preliminary d.c. amplifier of low-level signals for EWHM was considered and the precise VFC based on this method was offered.

It was shown that the rational combination of structural and circuit methods for design of EWHM makes possible the essential improving of their metrological characteristics with reduction of the demands to the element parameters of their circuits.

6.4. Chapter V

A. The Recommendations for Design of EWHM for Different Purposes

In comformity with these recommendations the structure circuit of energy EM for alternative three-phase current,kilowatt, amper- and volt-hour for direct current with accuracy class 0,2 were offered,which may be easily designed on the base of hybrid integrated circuit.

Storage devices based on multihole ferrite plates with higher reliability were offered.The usage of this devices is useful for the creation of electronic devices of display blocks.

6.5. Chapter VI

A. The Requirements for Interface and Remote Control Specifications

It was marked that the main transmitter must have two states differed by input circuit impedance.In the state "on" the potential drop at the output circuit of the device was recommended to be not more than 1 V with current (10±1) mA.In the state "off" a current through the output circuit of device is recommended to be not more than 0,8 mA with voltage (20±2) V on the output terminals.

The maximum permissible current through the output circuit of equipment is recommended to be not less than 30 mA.

The maximum permissible voltage on the output terminals of equipment in the state "off" not less than 24 V is recommended.

It was marked that the output of main transmitter must be galvanic all-disconnected with the rest circuits of EWHM.

The functional diagram of the device for collecting telemetric information from meters with sensing element for energy is recommended and the operation principle was described.The main function of this device is the operation with information-measurement system for commercial and technical calculation of electrical energy.It may be used in the system for control and operation of energetic enterprises.

6.6. Chapter VII

The measurement assurance for energy equipment

The improvement of methods and calibrating instruments for meters,taking into account a large volume of calibration,occurs to be a very important problem both in economical and technical respect. The decision of this problem should be subordinated to achieve two main objectives:elaboration of technical equipment for reliable determination of errors of all the types and classes of devices under test and working out of high productivity calibration methods for work expenditure economy.

In meters calibration set up the power comparators are widely used.These equipments have rather high metrological characteristics. For example,comparator of f. Goerz (Austria) ensures convertion of a.c. power to d.c. current with error less than 0,05%.The comparator is based on electrodynamic mechanism which is hardly coupled with magnetoelectric mechanism.

In the USSR the installation YKTЭ-1 worked out in IMM has the most high metrological characteristics.It contains the thermoelectric comparator and is intended for realization and dissemination of power unit.The power metering accuracy is not more than 0,02% in the frequency range 40 to 2500 Hz.

F.Zera (FRG) worked out a power comparator with error 0,02% too,for check up of static meters of very high accuracy.

In Japan the installation APR-2 for precision power measurement is worked out,which is based on standard watt-meter with balance against torque in combination with electronic service.The admissible error is not more than $\pm$0,05% of nominal value for cos φ=1.

In calibration set-up based on comparators is also used automatic power stabilization that makes it unnecessary for the verification officer to watch the wattmeter data and to maintain the unchangeable power value.

For example, in the FRG a stand for calibration energy meters of class 0,5 is worked out, which ensures the possibility of maintenance of the power value with accuracy 0,02%.

A new important step for increase of the calibration set up accuracy is the working out (elaboration) of integrating power comparators and standard electronic meters based on "power-frequency" convertors.

The standard meter for constant load of three-phase current worked out by f.Siemens (FRG) has an accuracy 0,1% for $\cos\varphi=1$ and 0,15% for $\cos\varphi= 0,5$. Three Holl elements are used as multiplier block in this meter.

Swiss firm "Landis und Gyr" elaborated a standard electronic meter based on multiplier, using the principle of pulse-duration and pulse-amplitude modulation, and "analog-frequency" convertor. The metering accuracy for currents from 50 to 150% of nominal value is not more than ±0,05% for $\cos\varphi=1$ and ±0,07% for $\cos\varphi=0,5$.

The improvement of meters calibration set up is possible also by automation of calibration routine. It is reasonable to work out the calibration set-up of high yield using standard meters which do not demand precision current and voltage sources. It simplifies the calibration and methods of data evaluation and makes it possible to lead out information into the EDPM and recording devices.

The calibration set-up SA-1 based on EDPM Facom 270-10 and worked up in the Japan Electrotest Institute may be mentioned as one of the most productive equipment. The metering accuracy is equal to ±0,2% and productivity is about 400 devices in a day.

The set-up of the f.Ostbayern (FRG) based on standard meter coupled with EDPM makes it possible to check up 60 000 three-phase four-wire meters.

The f.East Midlands EB (G.B) worked up an equipment based on EDPM Texas Instruments 960A for calibration of single- and three-phase meters with productivity up to 12 devices in an hour.

In the USSR an equipment is worked out for calibration of active energy meters of class 0,5 and reactive ones of class 1,0 with nominal values:

current 1 and 5 A (mean square value - r.m.s.)
voltage 57,7; 63,5; 100; 110 and 115 V (r.m.s.)
frequency 50 Hz.

This equipment may be used for calibration, when currents value is from 1 to 150% of nominal one. Maximum number of meters under test switches on at the same time is equal to ten.

The equipment consists of three functional blocks:

1. block of current,voltage and power factor regulation (BR)
2. standard meter (SM)
3. block of data processing (BDP)

BR consists of control elements of measured and subsidiary voltage,control elements of current circuit and phase-shifter.Some measuring devices for calibration mode control are also included in BR.

SM is the main part of the equipment measuring part.SM is an electronic analog-digital convertor realizing the function of multiplying input signals and the convertion of the result to frequency The specific feature of this block is a power convertor used as standard one and employed in the "constant load" mode,i.e. in the sufficiently narrow range of current values.

The coupling of working range of power convertor with ranges of meters under test is done by switching ranges of multirange current transformer.

BDP is used to compare the number of output pulses of standard meter and meter under test and to bring the comparison result (in percentage) out to the display.

6.6. Chapter VIII

Recommendations concerning laboratories and testing equipment for electrical energy meters

A. Laboratories

All laboratories for testing of electrical energy meters should have facilities for carrying out the required tests in accordance with the relevant standards and corresponding requirements.

The rooms for laboratories should be sufficiently large,clean, dry,dust-free,free from vibration,sufficiently illuminated,protected against solar radiation.

B. Supply to the meter testing equipment (MTE)

The supply to the MTE should be such that the relevant values at the output terminals of the MTE (voltage,current,frequency, waveform,phase sequence,balance of voltage and current) are in accordance with the relevant standards for the meter under test.

The supply voltage should be constant in such a way that the accuracy of all measuring devices used and necessary for measuring of a certain class of meters can be utilized.If the MTE is connected to the mains network,the voltage may not be stable enough for the wattmeter method to be used.However,if the wattmeter method is used, some action should be taken in order to meet the requirements standards (e.g. voltage stabilizer).

In order to avoid different voltage drops in the event of output changes of the MTE, the cross-section of the feed wire to the MTE must be sufficient.

C. Meter Test Bench

The meter test bench is a bench including the necessary constructional requirements and the requisite connections designed to enable meters to be tested under reference conditions specified in the relevant documents. The wiring should be such as to minimize the effects of magnetic induction, capacitive interference and voltage drop.

D. Voltage and Current Transformers

Voltage and Current Transformers should allow compliance with permissible limits of Table 1 as regards percentage errors and of Table II as regards standard deviation values (see Annex 15).

E. Interval Frequency for Control Measurement of the accuracy of a MTE

The interval frequency for control measurement of a MTE should be adapted to the use for which the equipment is applied. Thus the utilization of the equipment is more often and if it is used to control large quantities of meters, the interval between two control measurement will be shorter.

Conversely, a MTE which is not frequently used (e.g. if it is intended exclusively for prototype tests) may be controlled at the same intervals as these tests.

Generally, the interval of time between two control measurements should be not greater than:

- two years for MTEs for meters of class 2;
- one year for MTEs for meters of class 1 and 0,5.

However, if for any reason doubt arises, the control measurements shall be repeated.

The interval frequency for the control of the accuracy of a MTE depends on:

- the type of equipment;
- the history of the MTE;
- the number of meters tested with the MTE in a period;
- the maintenance of the MTE;

- the accuracy class of meters being tested with the MTE;
- the quality of the components of a MTE;
- the possible error fluctuations stated when operating a MTE.

7. CONCLUSIONS

1. UNIDO assistance is considered as an extremely important factor,especially in the field of design and test of high accuracy electrical energy measuring devices.

2. Project outputs are generally already achieved by the national project staff.

3. Electronic watt-hour meters of high accuracy already designed and produced are up-to-date.

4. Sophisticated high accuracy electronic watt-hour meters are developed in the frame of this project.

5. The further development of high accuracy electrical energy measuring devices on the base of this achievements is highly recommended.

6. The equipment received is in use.

7. Quality Control of electrical kilowatt-hour meter and Evaluation Laboratory is organized and equipped.

8. RECOMMENDATIONS

1. The development of more new and sophisticated high accuracy EWHM of different predestination such as d.c. energy electrical meters for ampere- and volt-hour measurement and energy electrical meters for var-hour is strongly desired.

2. The design of the device for collecting the telemetric information from meters with energy sensors is also desired.

3. The purchase of the special equipment in the frame of this project should be approved by UNIDO.

4. The substantial help of UNIDO is needed for the development of the field based on consultations,experts,purchase of special equipment,testing and delivery of measuring devices.

5. The development of the work for lower cost of EWHM based on considered structural circuits of measuring convertors with higher metrological performances and reliability is needed.

6. The rational combination of structure and circuit methods for design of EWHM allowing essential improvement of their metrological characteristics with reduction of demands to the element's parameters of their circuits are recommended.

7. The design of universal measuring complex based on micro-processor for active quality control of the manufactured production and decrease of the material resources consumption are extremely desired (see Annex 16).

ANNEX 1

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
UNITED NATIONS DEVELOPMENT PROGRAMME

Project of the People's Republic of Bulgaria

JOB DESCRIPTION
Project No SI/BUL/82/802

Post Title	Expert in development and design of high accuracy electrical energy measuring devices (watt-hour meters)
Duration	1 m/m
Date Required	30 June 1982
Duty Station	Sofia with possible travel within the country
Purpose of Project	To assist the Bulgarian Institute for Instrument Design in the development of electronic kilowatt-hour meters
Duties	The expert will be attached to the Institute for Instrument Design and will specifically be expected to: 1. Assist in the theoretical justification for the selection of the optimum structural scheme of high accuracy electronic watt-hour meters. 2. Assist in the development of input measuring transformers for current and voltage. 3. Elaborate a variant of an electronic watt-hour meter with memory, capable of memorizing the watt-hour meter readings at supply voltage drop.

4. Specify the requirements for the interface and for the signals transmitting the watt-hour meter readings at a distance.

5. Elaborate the structural scheme of an electronic watt-hour meter easy for design on the basis hybrid integral circuits.

The expert will also be expected to prepare a final report setting out the findings of his mission and recommendations to the Government on further actions which might be taken.

Qualification	An engineer with experience in the design and development of electronic watt-hour meters.
Languages	Russian or English or French or German
Background Information	The country's policy is directed toward energy saving,priority is given to the improvement of electrical energy measurement by introducing three-tariff electronic kilowatt-hour meters with high accuracy.

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
UNITED NATIONS DEVELOPMENT PROGRAMME

Project in the People's Republic of Bulgaria

JOB DESCRIPTION

Project No. SI/BUL/82/802

Post title	Consultant on the methods and means for high accuracy measurement of electrical energy with industrial frequency
Duration	1 m/m
Date Required	30 June 1982
Duty Station	Sofia with possible travel within the country
Purpose of Project	To assist the Bulgarian Institute for Instrument Design in the development of electronic kilowatt-hour meters
Duties	The consultant will be attached to the Institute for Instrument Design and will be specifically expected: 1. To assist in the elaboration of a normative documentation for testing of electronic watt-hour meters with accuracy of 0,1 ÷ 0,5 using high accuracy testing equipment

2. To prepare a test diagram for testing of electronic watt-hour meters.
3. To assist in the joint elaboration of methods for accelerated reliability testing of electronic watt-hour meters.
4. Determination of the requirements to the devices and methods for adjustment and check up of electronic watt-hour meters in industrial usage.
5. To organize laboratory testing of high accuracy electronic watt-hour meters and train a specialist in high accuracy electrical measurement.
6. To train a specialist in assembly, adjustment and quality check up of electronic watt-hour meters in industrial usage.

The consultant will also be expected to prepare a final report setting out the findings of his mission and his recommendations to the Government on further action which might be taken.

Qualification	An engineer with experience in the measurement, metrology and quality and reliability testing of electronic watt-hour meters.
Languages	Russian or English or French or German
Background information	The country's policy is directed to energy saving; priority is given to the improvement of electrical energy measurement by introducing three-tariff electronic kilowatt-hour meters with accuracy.

ANNEX 2

WORK - PROGRAMME

for UNIDO expert O.M.Pavlov
SI/BUL/82/802/11-01/31/9.C

1.	Meeting with the National Project Manager and his staff,discussions	1 st day
2.	Acquaintance with the state of the development of electronic watt-hour meters with high accuracy	2nd to 6th day
3.	Consideration of specific requirements to EWHM and methods of designing of structural circuits of measuring convertors with higher metrological performances and reliability	7th to 9th day
4.	Elaboration of structural circuits providing noise immunity PFC and MC power to d.c. voltage. Consideration of circuits for design of reversible commutators	10th to 12th day
5.	Consideration of circuits pulse-amplitude modulation of higher precision and methods providing the noise immunity of pulse - duration modulation	13th to 15th day
6.	Consideration of structural methods for increase of EWHM precision and method of eliminating the additive error of preliminary d.c. amplifier of low-level signals for EWHM	15th to 18th day
7.	Consideration of recommendations for design of EWHM for different purposes and design of electronic devices of display blocks	19th to 21st day
8.	Consideration of requirements for interface and for signals for distance-transmitting of the EWHM reading	22d to 24th day
9.	Acquaintance with the state of the development of electronic watt-hour meters with high accuracy in the field of Control Quality and Testing	25th to 27th day

10. Acquaintance with the problems of wide-range electronic watt-hour meters	28th to 29th day
11. Elaboration of the normative documentation	30th to 31st day
12. Elaboration of methods for testing of electronic watt-hour meters	32nd to 33rd day
13. Elaboration of programme for testing of electronic watt-hour meters	34th to 36th day
14. Elaboration of testing equipment for production of electronic watt-hour meters	37th to 39th day
15. Preparation of the Final Report	40th to 43rd day

ANNEX 3

STUDY TOURS RP/BUL/82/002

1. Visit to "SCHE..BER",Austria for 4 days from 08.06.1982 to 10.06.1982, 3 participants.
2. Visit to "HONEYWELL",Frankfurt,FRG,for 5 days from 11.06.1982 to 16.06.1982,3 participants.
3. Visit to Thesalonian International Industrial Fair in Thassalonica, Greece,for 5 days,from 12.09.1982 to 16.09.1982,1 participant

FELLOWSHIPS RP/BUL/82/002

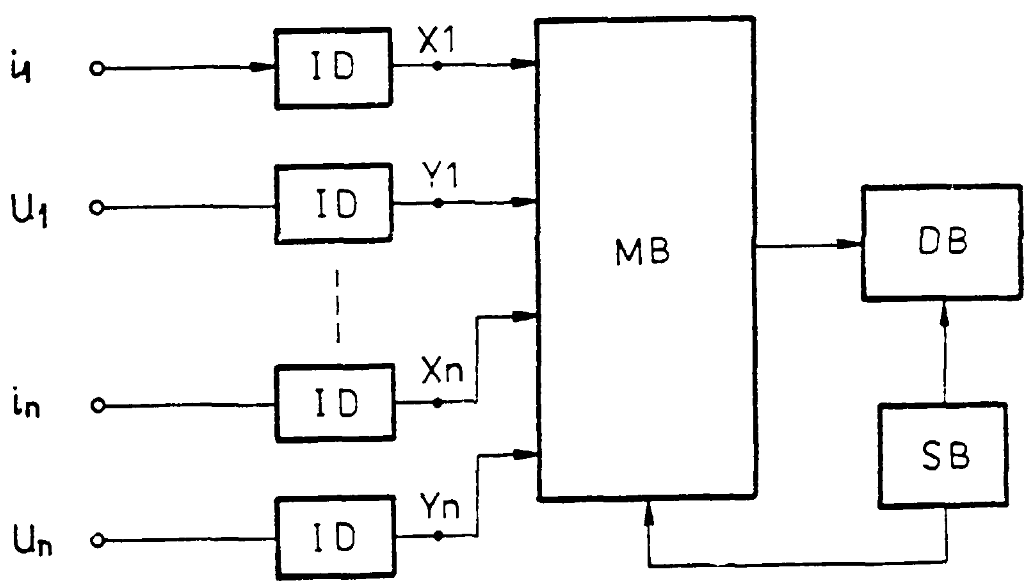
Fellowship post 31-00,Electrical energy measuring at Tettex facilities,Swiss Participants: M.T.Karnfilova,P.I.Petrov, I.S.Bozev. Duration - 2 weeks from 05.12.1982 to 22.12.1982.

ANNEX 4

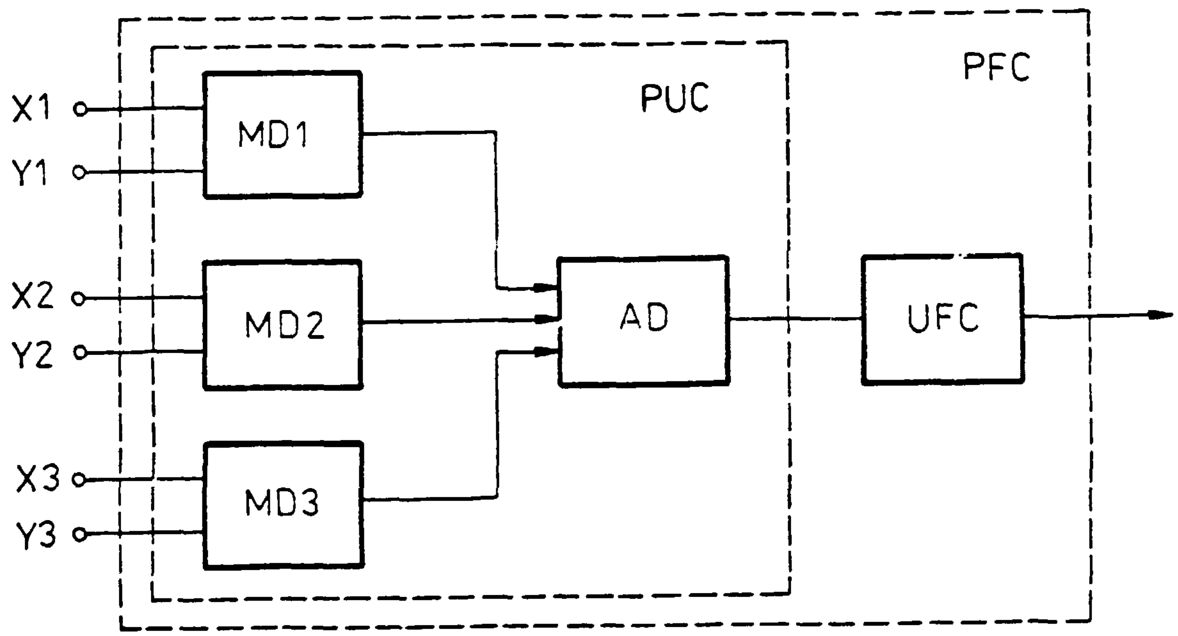
E Q U I P M E N T

1. Components: USO-24-G,USO-40-G, USO-28-G, MC6800P, 5101L(145101), TDA 1060 Signetics, MA 7805UC,I-2716, SN74LS164N, SN74LS174N, SN74LS165N, 4052B, RT71-011.00, RT71-055.00, RT71-073.00, RT51-073.00
   Date of Delivery - December 1982
2. VW 8-seater combi/bus
   Date of Delivery - January 1983
3. Statischer Pruefzachler,Präzisions Spannungswandler, Präzisions Stromwandler, Zachlerfehler-Rechner, Photo-electric scanning head, Special cable for testing, Dreiphasen-Belandstung-Wandler
   Date of Delivery - December 1982

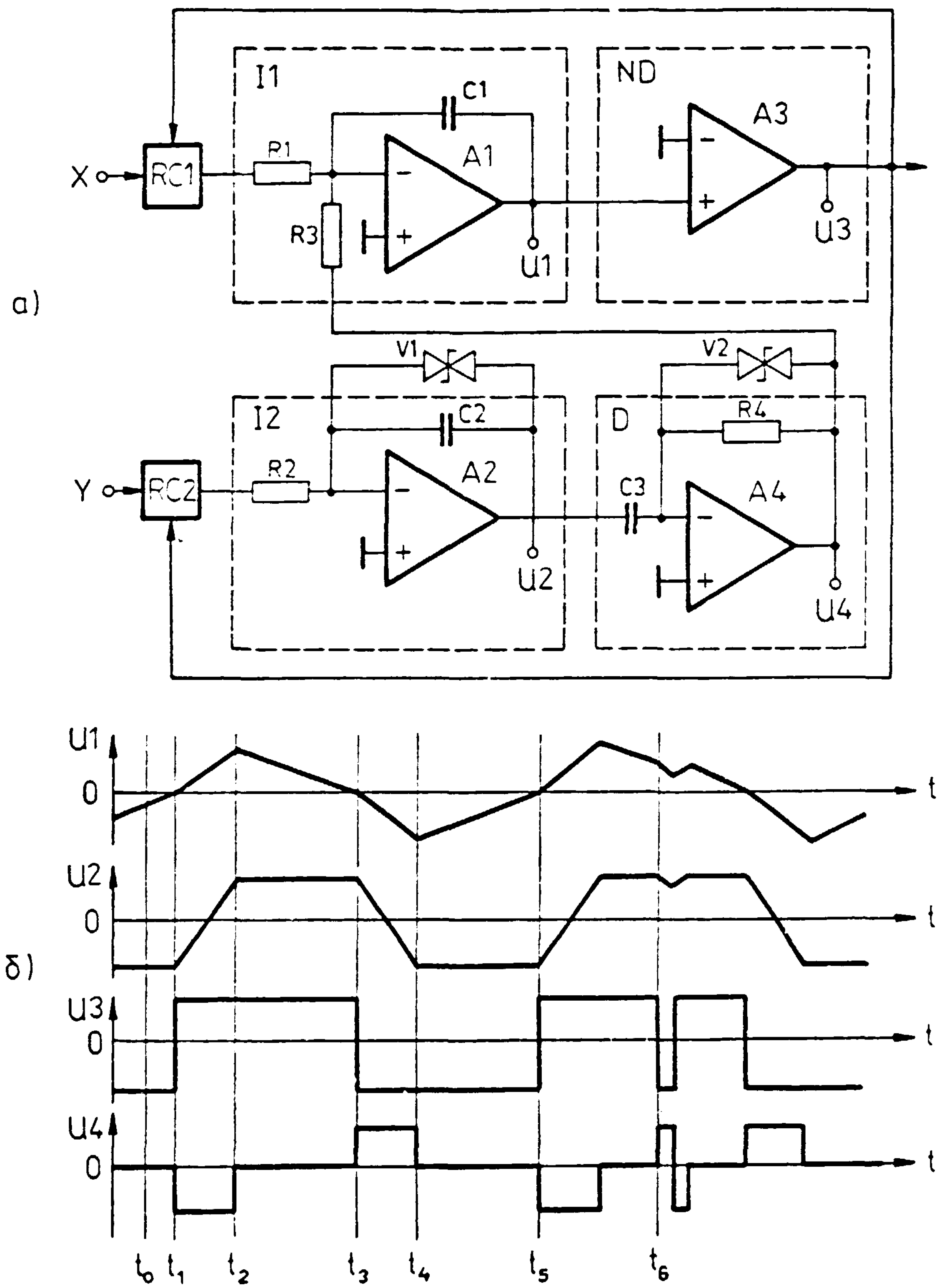
GENERAL STRUCTURAL EWEM SCHEME



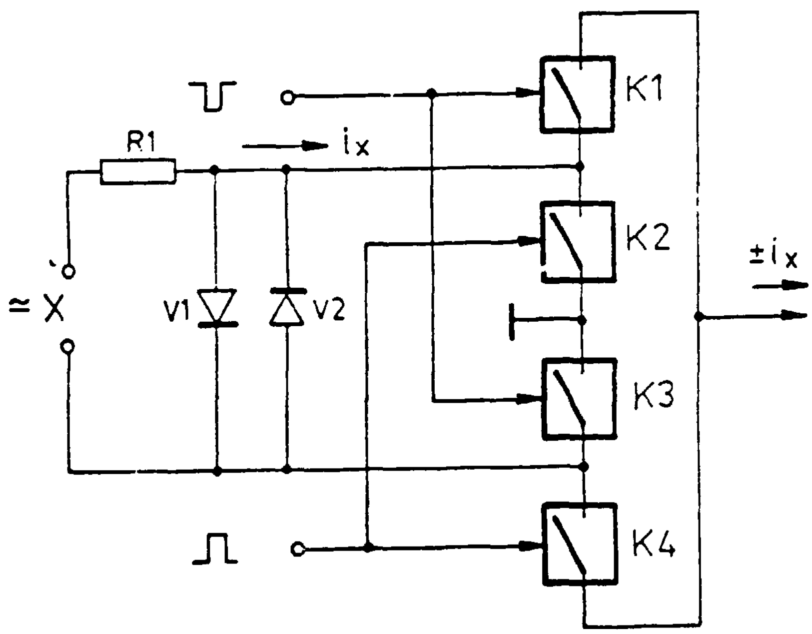
GENERAL STRUCTURAL MB SCHEME



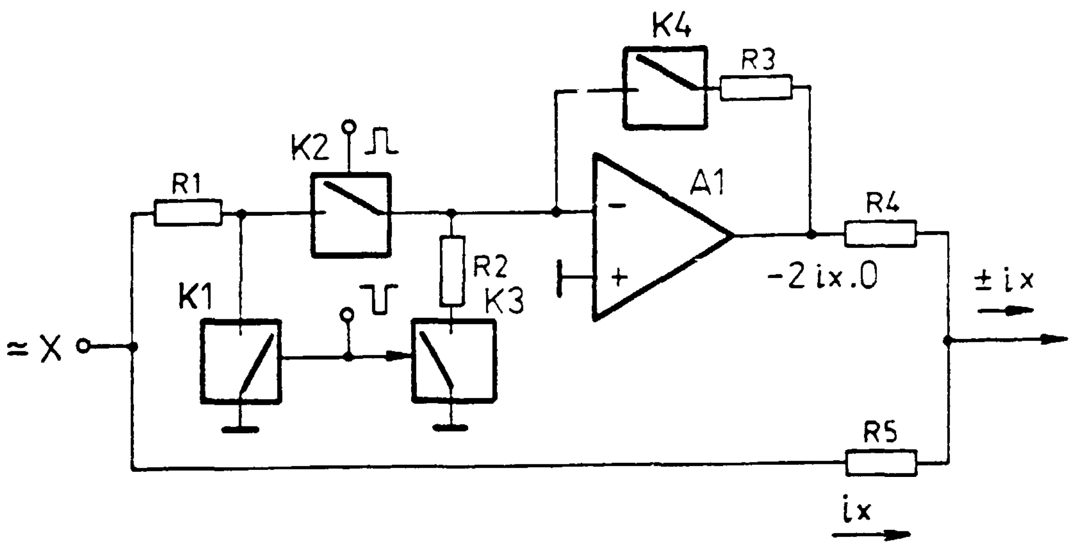
STRUCTURAL CIRCUIT OF PFC WITH NOISE IMMUNITY



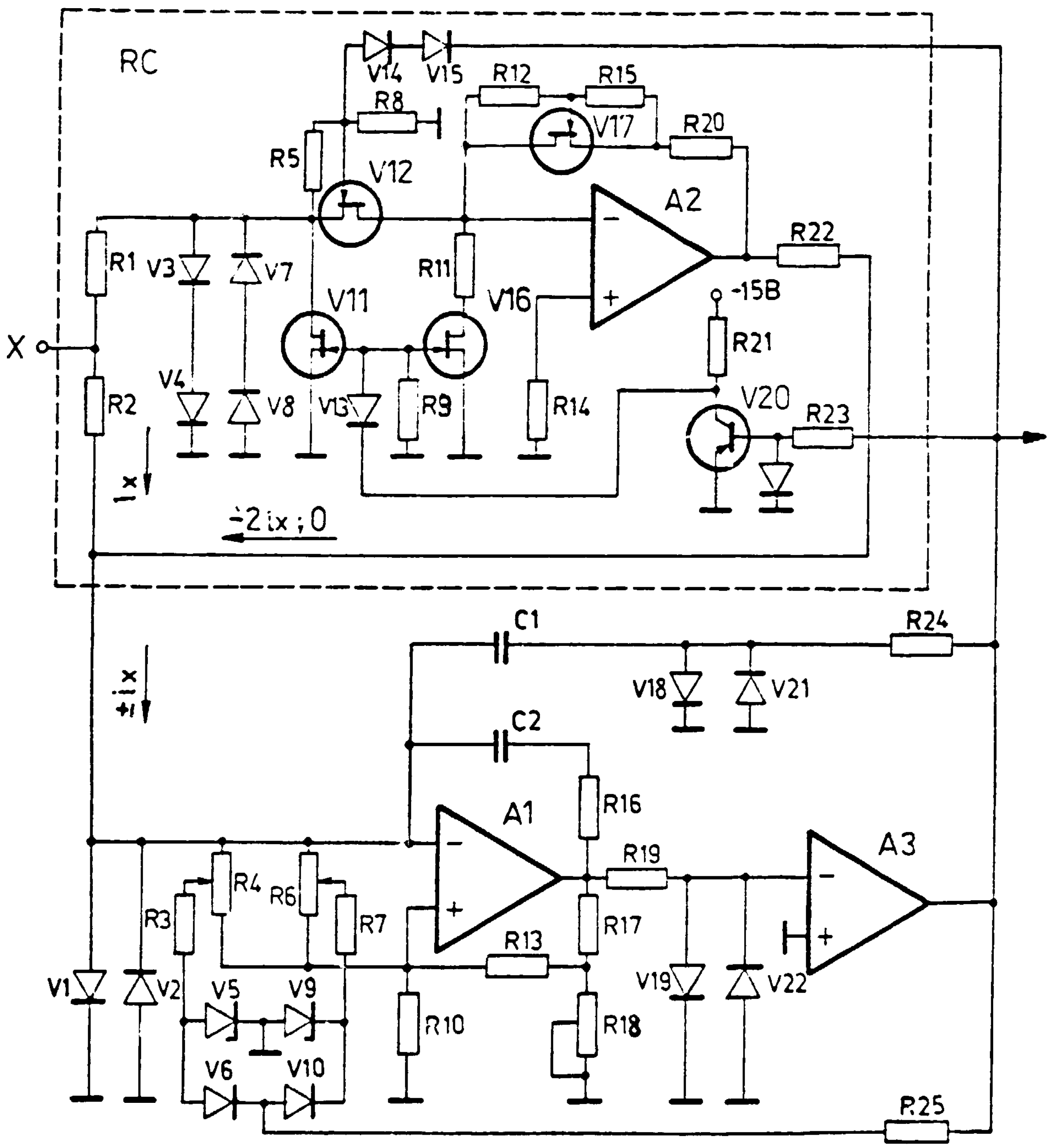
STRUCTURAL CIRCUIT OF RC REALIZED
BY BRIDGE CIRCUIT ON FOUR ELECTRONIC KEYS



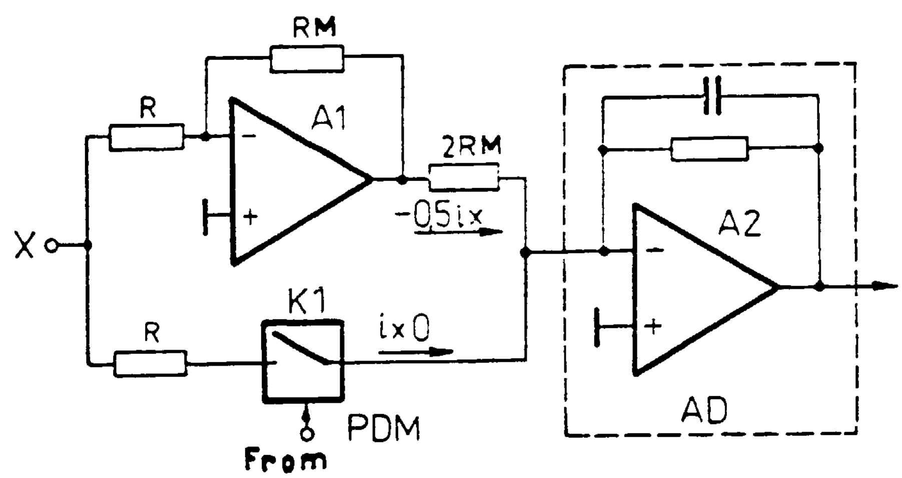
STRUCTURAL CIRCUIT OF
RC WITH HIGHER ACCURACY



PRINCIPLE DIAGRAM
OF NOISE IMMUNATED PRECISION CONVERTOR D.C. VOLTAGE TO FREQUENCY

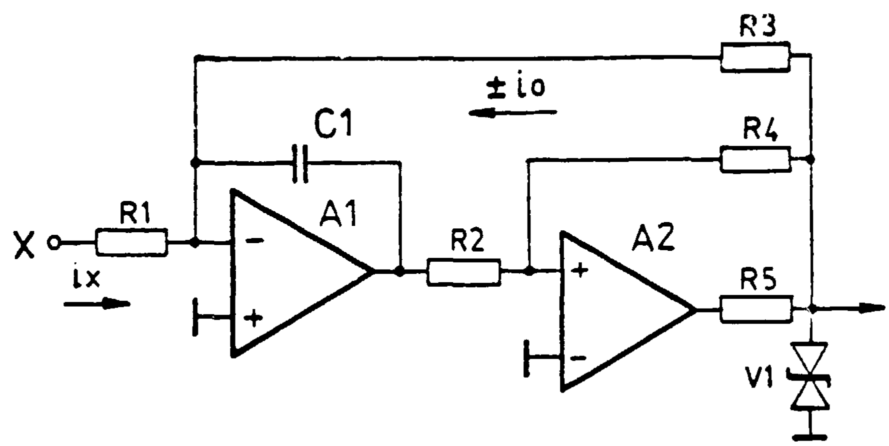


STRUCTURAL CIRCUIT OF PAM OF HIGHER PRECISION



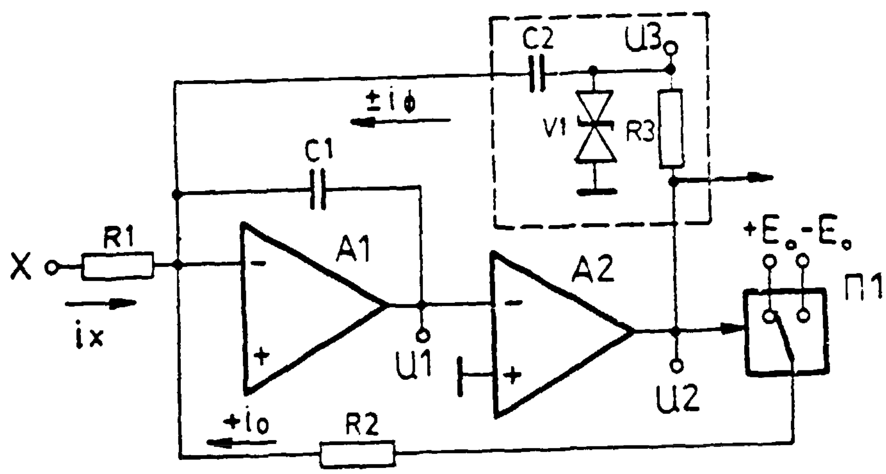
STRUCTURAL CIRCUIT

OF PDM OF HIGHER ACCURACY WITH SIMPLE CIRCUIT REALIZATION



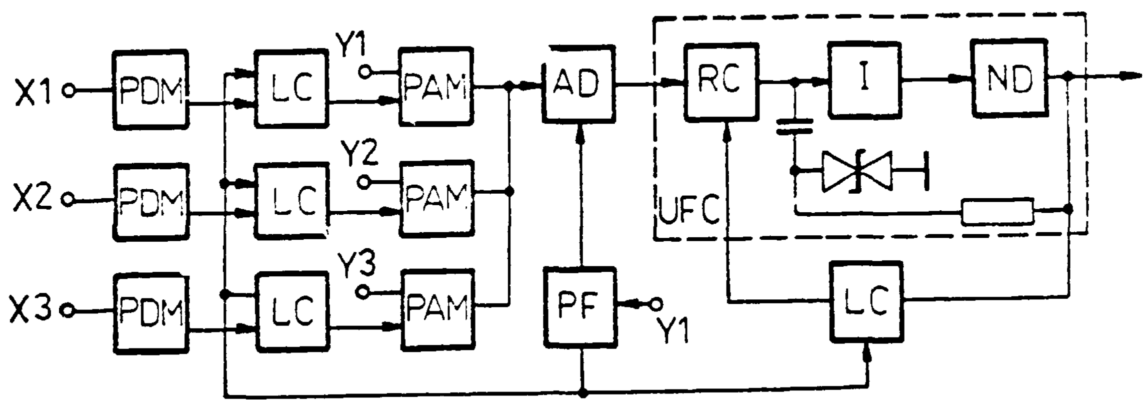
STRUCTURAL CIRCUIT

OF PDM WITH NOISE IMMUNITY



STRUCTURAL CIRCUIT

OF MB FOR EWHM OF HIGHER PRECISION



ANNEX 15

TABLE I

LIMITS OF PERMISSIBLE ERRORS IN PERCENTAGE

Meter class	0,5			1			2		
Power-factor	1	0,5 lagg	0,5 lead	1	0,5 lagg	0,5 lead	1	0,5 lagg	0,5 lead
E_{max}	±0,10	±0,15	±0,20	±0,20	±0,30	±0,40	±0,30	±0,45	±0,60

Where: the error of a newly manufactured MTE at a certain test point shall be lower than the error E_{max}.

TABLE II

LIMITS OF PERMISSIBLE VALUES "S" IN PERCENTAGE

Meter class	0,5		1		2	
Power-factor	1	0,5 lagg.	1	0,5 lagg.	1	0,5 lagg.
S_{max}	0,01	0,02	0,02	0,03	0,03	0,05

Where: the estimation of the standard deviation "s" of a newly manufactured MTE at a certain test point shall be lower than the estimation of the standard deviation S_{max}.