DIGITAL STORAGE INSTRUMENT FOR ANALOGUE SIGNALS DEVELOPED FOR ELECTRICAL MACHINE TESTING

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For recording signals of rapidly changing, transient phenomena, oscillographs, signal recording by magnetic tapes or storage oscilloscopes have been used so far. Nowadays, the development of the digital technique offers the possibility of applying it in the field of recording analogue signals. At the same time, as a consequence of the progress in electric machine testing and with the spreading of semiconductors in the production of electric motors a digital instead of the earlier analogous methods of signal recording is wanted. In this way, signals can be recorded in a more advantageous way, by eliminating the disadvantages of the earlier methods (rate, accuracy, possibility of processing, reliability, etc.).

In this paper a two-channel, digital storage instrument for analogue signals developed at the Department of Electric Machines of the Technical University, Budapest, upon industrial commission is described.

The following working modes can be chosen for the recording or playback of the analogue signal:

— one-channel recording,
— two-channel recording,
— reading (from a punch-tape reader of the type ER-300),
— punching (with a tape-punch of the type DT-105 S),
— one-channel playback
— two-channel playback.

The length of the period which can be recorded with the instrument is determined by the product of the period time of sampling and the storage capacity. This time is called scan time. Storage capacity in the one-channel working mode is 8192 words, in the two-channel working mode 4096 word/channel. It means that 8192 12 bit sampling data of a signal or 4096 12 bit sampling data for two signals can be stored at the same time. Sampling frequency ranges from 1 Hz to 200 kHz, in 1, 2 or 5 steps, for 17 different values. (The period time of sampling thus can be 5 μs a minimum.) The frequency region of the signal investigated ranges from 0 Hz to 1/4 of the sampling time, i.e. max. 50 kHz.

The playback speed can also be chosen in the above region of the sampling frequency (period time). Sampling can also be controlled by outer signals. By playback following the recording a maximum time transformation (frequency transformation) of 2×10^5 can be realized by the utilization of the whole sampling region. The time channel ensures playback as a function of time. In Park-vector measurements the X and Y components of the signal investigated is recorded or played back.

Upon recording the input voltage can be chosen between 0, 1 and 100 V in 10 steps. In the various ranges the input impedance varies between 20 and 200 kΩ. The voltage range of the output is ± 10 V for the analogue signal channel. The time channel produces an increasing voltage between -10 and $+10{,}48$ V.

In recording working modes the signal storage equipment can be triggered in different ways: from inside, from outside or manually. The inner triggering can be adjusted on a rising or falling edge of the signal, by adjusting the comparative potential level with a potentiometer. Data traffic is continuous before the actual recording. Its stopping occurs only at triggering. This feature ensures the storage of parts of the signal having different lengths before the arrical of the stop signal (pretriggering). The word numbers that can be chosen before the stop signal are 0, 512, 1024 and 2048.

In playback working modes to the output of the data channels XY recorder, an oscilloscope or other signal recording instrument can be connected. Playback can be made once or repeated, when connected to an oscilloscope the instrument serves as a digital store of the oscilloscope.

The equipment can be attached to the punch tape reader ER-300 and tape punch DT-105-S. These peripherials permit permanent storage and repeated input of data, thus ensuring the possibility of data processing.

To the two-channels digital storage instrument a supplementary unit is developed, which works in a master-slave configuration with the basic instrument. This permits the storage of 4096 sampling data of four signals, or 8192 sampling data of two signals.

Operation

The main parts of the instrument are seen on the block scheme in Fig. 1. The following main parts can be distinguished:

Input unit	B.O.1, B.O.2.
Analogue/digital converter	A/D 1, A/D 2
Multiplexer	MPX1, MPX2
Storage unit	TÁR 1, TÁR 2
Digital/analogue converter	D/A+E1, D/A+E2, D/AT

Time base unit	IDŐALAP
Display unit	KIJELZŐ
Tape puncher interface	LYUK. ILL.
Paper tape reader interface	OLV. ILL.
Control buttons	VEZ. GOMBOK
Control unit	VEZÉRLŐ
Supply units	TÁP 5V, TÁP 15V, TÁP 12V

In the following the function and operation of the various units are discussed.

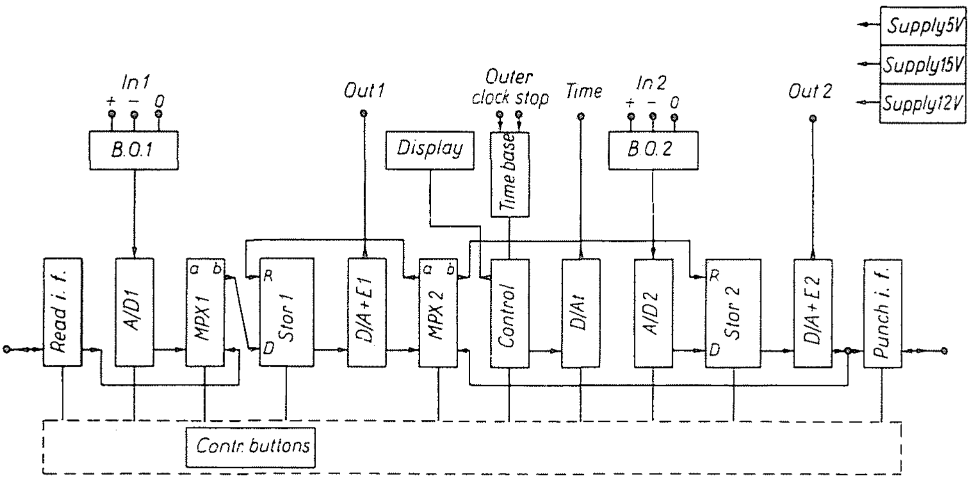

Fig. 1. Block-scheme of the instrument

The function of the input unit is to attenuate and amplify the incoming voltage, corresponding to the input voltage range of the analogue/digital converter and the generation of the inner triggering signal. At a voltage determined by the edge (É1) and comparator level (Komparálási szint), the signal examined brings about the signal storage.

The signal of the input unit gets into the A/D converter. Digitalization occurs in about 3 μs with successive approximation. The resolution is 12 bit. On the parallel output the signal appears in an offset binary code.

The various working modes result from the selection of different data directions upon control. Signals are multiplexed by the units MPX and TÁR. Data flow in the various working modes is seen in Figs. 2a, 2b and 2c.

The storage function of the instrument is ensured by the memory built from shift registers. The capacity attached to one channel is 4096 12 bit words. The time signal inducing the steps of the stored data in recording and playback working modes is a clock pulse with a frequency corresponding to the chosen

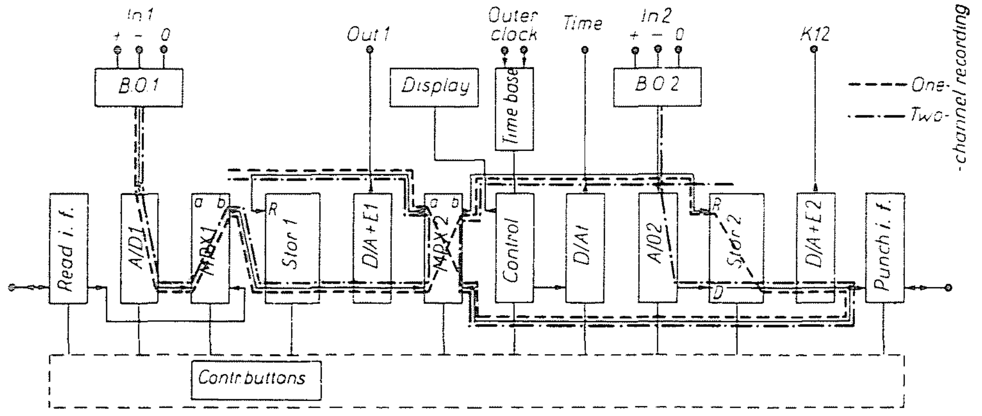

Fig. 2a. Data flow in the one-channel and two channel "Recording" working modes

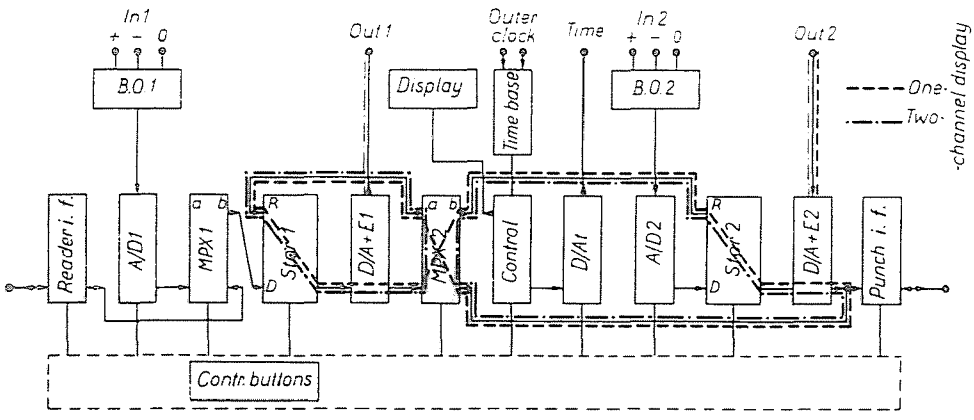

Fig. 2b. Data flow in the one-channel and two channel "Playback" working modes

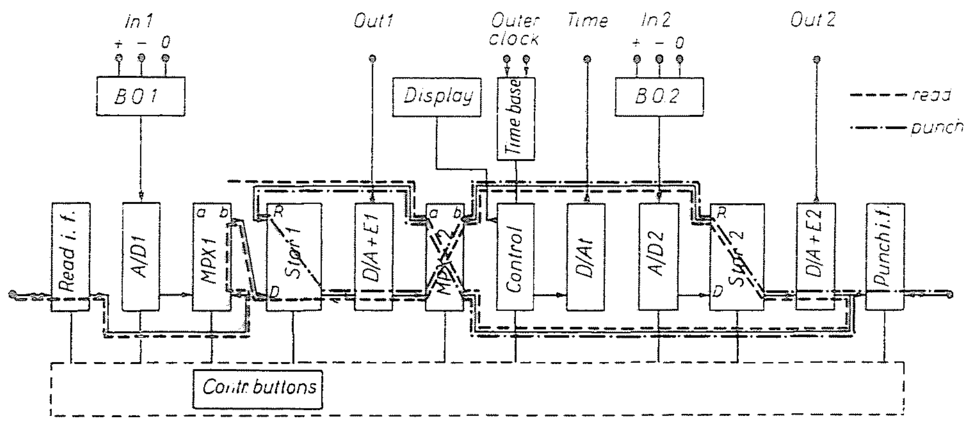

Fig. 2c. Data in "Reading" and "Punching" working modes

period time of sampling. In reading and punch working modes the clock pulse corresponding to the speed of operation is given by the connected peripheral.

The output of the storage unit (TÁR) is connected to the input of the D/A + E unit. There is one D/A + E unit for every channel in the instrument, and a D/A converter is connected to the time channel of the control unit. (D/AT) In the D/A units the signal will be buffered for the further units and the digital data are converted into analogue signals. This conversion requires about 0.5 μs. The output voltage is ± 10V.

The time base (IDŐALAP) unit produces the inner clock and also the outer clock and stop signals are here received. The division of the quarz oscillator signal is selected by the button on the time base unit, correspondingly to the chosen period time of sampling.

The display (KIJELZŐ) unit informs on the process of recording or replay and also on the content of the memory. This is a four digit display synchronized with the counter of the control unit (VEZÉRLŐ). The number appearing is the serial number of sampling.

The DT 105-S type paper tape puncher unit is interfaced to the equipment by the punch interface (LYUK. ILL.) unit. The punching of the data word occurs in two parts with marker bits. The interface divides the 12 bit data-words into two parts, marks the half-words, receives the control signals and produces them for the puncher and control units. The rate of punching is 50 words/s. (for punching the 8192 words content of the storage unit cca. 2.5 minutes are required).

The reader interface (OLV. ILL.) is for the ER-300 tapereader unit. Its task is to store temporarily the two half data words, to restore the data word and to receive or produce the necessary control signals. The rate of reading is 150 words/s.

The equipment is controlled by the control (VEZÉRLŐ) unit which is governed by the working mode (ÜZEMMÓD) push-buttons on the unit control buttons. (VEZ. GOMBOK)

Applications

The device can be widely applied for signal recording. It creates a direct possibility of processing measured data signals in a digital computer. Some examples of possible applications will be shown.

Fig. 3. shows the Park-vector and its components of the short-circuit armature current in a symmetrically short-circuited synchronous machine as a function of time. With the use of this equipment the possibility is given for the accurate computerized evaluation of transient and subtransient machine parameters. In addition machine parameters inaccessible to earlier methods became determinable.

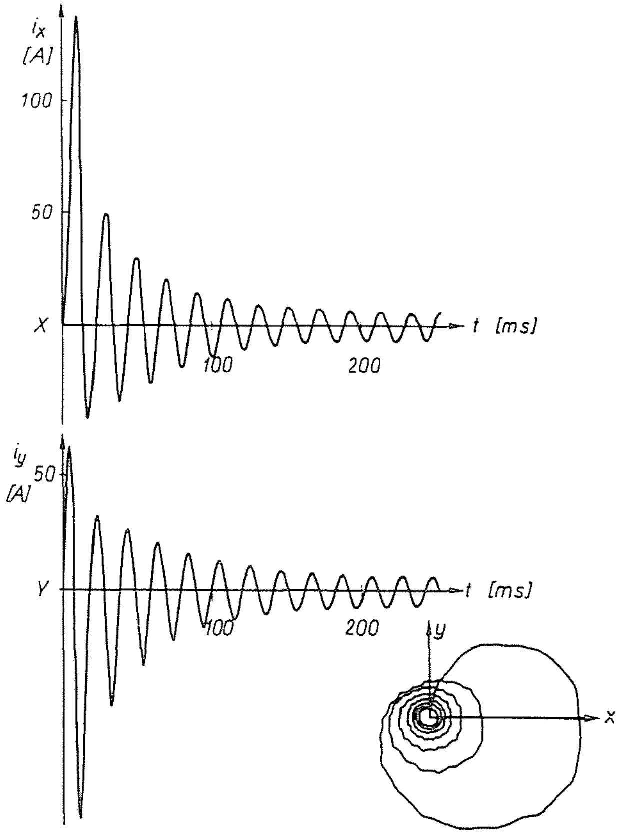

Fig. 3. The Park-vector and its components i_x and i_y of the short-circuit current of a synchronous machine as a function of time

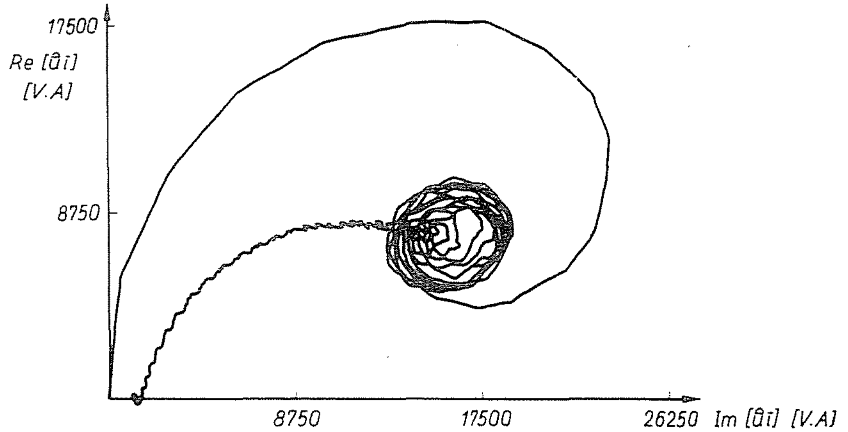

Fig. 4. The product of the current and voltage Park-vectors $(\hat{u}\bar{i})$ of a starting asynchronous motor

In Fig. 4 the current Park-vector of a three-phase asynchronous motor with short circuited rotor is plotted in a synchronously rotating coordinate system under "running up" test into a no-load working mode. For plotting, the Park-vector of voltage ($\bar{u}$) and current ($\bar{\imath}$) as well as the product ($\hat{\bar{u}\bar{\imath}}$) have been produced. The voltage being of a constant amplitude and of a constant radian

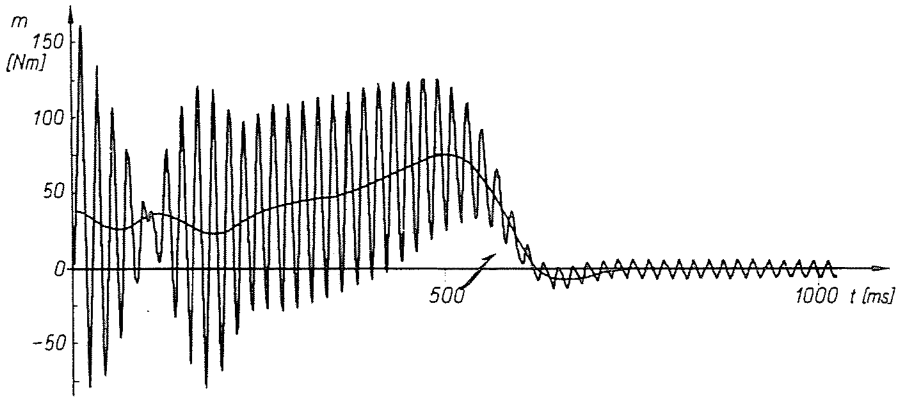

Fig. 5. Electric moment of a starting asynchronous motor computer calculated from the measurement of ($\hat{\bar{u}\bar{\imath}}$) values as a function of time

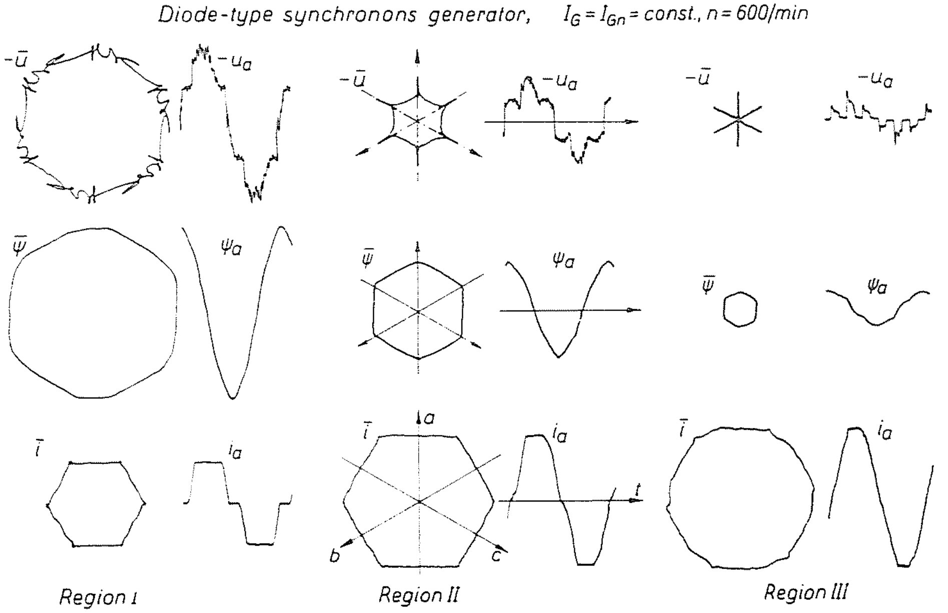

Fig. 6. Park-vectors and time functions of the voltage, flux and current of a synchronous generator with diodes in different overlap regions

frequency, the current in the rotating coordinate system is directly proportional to the ui product corresponding to the following equation:

$$\bar{i}e^{-j\omega_0 t} = \frac{\hat{\bar{u}}\bar{i}}{|\bar{u}|}$$

In knowledge of the momentary values of voltage and current the electric moment can be calculated point by point. [1]. The method of the calculation is similar to that developed at the Department of Electric Machines for an analogue moment measuring device. [2].

In Fig. 5 the computer calculated moment is plotted as a function of time.

The instrument is also helpful in recording transient and steady-state signals generated by electric drives with semiconductors. In Fig. 6 the Park-vectors and time functions of the voltage, flux and current of a synchronous generator with diodes are seen in different conduction regions. (I. $\delta < 60°$, II. $\delta = 60°$, III. $\delta > 60°$, where δ is the overlap angle. [3].

Summary

The transient examination of electrical machines required to develop an instrument for recording rapidly changing signals, for slowed down or accelerated playback and for the recording of the stored information on a paper tape or for playing back the recorded tape.

The structure of the instrument is described on the basis of the block-scheme, and its main parameters are also discussed.

Several applications for examining transient signals of electrical machines are presented.

References

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