**I.** a) Divide the text into logical parts. b) Choose the key sentences, analyse and translate them.

**II.** Look through the Text C and find the part of it dealing with the pulse-code modulation.

**III.** Examine Fig. 5.7 and comment on pulse coding methods and corresponding waveforms.

**IV.** Answer the questions on the Text C.

1. What form may the information be converted to? 2. How is the carrier modulated in a pulse-amplitude modulation system? 3. What is constant and what varies in PDM systems? 4. How is the type of coding also referred to? 5. What modulation is similar to PDM? 6. What practical pulse coding system is more efficient? 7. What does this system consist of?

**V.** Prepare a dialogue on pulse-duration modulation system.

**VI.** Speak on pulse-amplitude modulation system.

**VII.** Make up a plan of the Text C and retell it.

**VIII.** State the tense-forms of the verbs in the Text C.

**IX.** Translate the Text C to be sure you understand it well.

## 4. Searching Reading

### PRE-TEXT EXERCISES

**I.** Match the following English words and word-combinations with the Russian ones.

| | |
|---|---|
| channel bandwidth | информационный сигнал |
| carrier waveform | существенно исказить |
| signal timing | захваченные каналом |
| the message signal | синхронизация сигнала |
| relative amplitude | колебания несущей частоты |
| the amount of noise | изменения, изменяя |
| seriously degrade | ширина полосы канала |
| suitable | относительная амплитуда |
| pick up by the channel | интенсивность шума |
| altering | подходящий |

**II.** Translate these word-combinations and use them while reading the Text C.

Noise may be introduced; the amount of noise may be sufficient to; there are many ways of altering a signal; it appears as shown in Fig.; the amplitude depends upon.



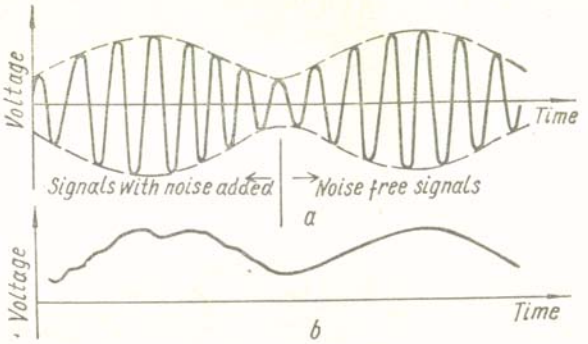


Fig. 5.8. An AM signal and noise:
*a* an AM signal corrupted by noise; *b* the resulting demodulated signal.

## Text D

### SIGNAL MODULATION

**I.** Read the text and say whether there are ways of altering a signal to make it suitable for transmission over a noise channel.

Noise may be unavoidable introduced on a transmission channel, whether the channel is an electrical cable, a radio frequency, optical or ultrasonic link, or by magnetic induction. The amount of noise picked up the channel may be sufficient to seriously degrade the signal being transmitted. There are many ways of altering a signal to make it suitable for transmission over a noise channel. The simplest way is to increase power of the signal at the source, but there is always a limit to the power available to do this. To transmit by radio waves it is necessary to modulate the signal.

The modulation method appropriate to a particular instrumentation system depends upon a number of things: accuracy, reliability, the channel bandwidth available, convenience, cheapness and so on. Each system will have its own problem and requirements, so it is not possible to say which is the "best" modulation method.

Modulation of the carrier waveform in response to a measurand usually involves amplitude modulation (AM) or frequency modulation (FM), and that pulse-modulation methods, in particular pulse-code modulation (PCM), are sometimes employed.

These different types of modulated signal have different properties in relation to channel noise. AM produces frequency components on each side of the carrier frequency called sidebands, such that the bandwidth of an amplitude-modulated signal is twice the bandwidth of the message signal itself. If such a modulated signal passes through a noisy channel it reaches the receiver in the form shown in Fig. 5.8*a*. After rectification and low-pass filtering, the process of demodulation, it appears as shown in Fig. 5.8*b*; the amplitude of the message signal and the degree of interference depends solely upon the relative amplitude of the two signals.

*ASSIGNMENTS*

**I. Answer the following questions embracing the contents of the Text D.**

1. Where may noise be unavoidable introduced? 2. What is the simplest way of altering a signal to make it suitable for transmission of a noisy channel? 3. What does the modulation method appropriate to a particular instrumentation system depend on?

**II. Prepare a dialogue on your own situation.**

**III. Make up a plan of the Text D and retell the text according to your own plan.**

**IV. Examine Fig. 5.8 and comment on:**

1. An AM signal corrupted by noise.
2. The resulting demodulated signal.

**V. a) Look through the latest magazines and find additional information on the topic. b) Discuss the problem of signal modulation.**

## III. GRAMMAR EXERCISES

**I. Define the function of the Infinitive in these sentences and translate them.**

1. Modulation is the modification of a carrier waveform, which is usually sinusoidal, in response to the information to be carried. 2. It is only essential for the receiver to be able to distinguish between a 1 and a 0. 3. Here the actual quantity to be controlled is measured. 4. The information to be conveyed may be converted to a pulse form for land-line or r. f. telemetry.

**II. a) Pay attention to the *-ing*-forms and define their functions. b) Translate sentences into Russian.**

1. The transmitter is connected in series with its power supply and recorders / indicators, these devices being situated at the receiving end. 2. This can be accomplished by differentiating and rectifying a PDM waveform. 3. Some of the factors must be considered when choosing method to be used over a noisy channel of an instrumentation system. 4. A prerequisite of being able to control variables such as velocity, temperature and humidity. 5. In practice devices have to respond to time-varying quantities. 6. It consists of sending analogue information by transforming it into a series of binary digits.



# Lesson 4. STATISTICAL MEASUREMENTS



## I. INDEPENDENT WORK

### In the Laboratory

### 1. Skimming Reading

PRE-TEXT EXERCISES

**I. a) Make sure that you know these words. Say what Russian words help you to guess their meanings. b) Repeat these words after the speaker.**

Statistical, amplitude, component, parameter, periodic, phenomenon, spectrum, constant, symbol, period, proportion, practical, totalizing, selection, sum, characteristic, correlation, situation.

**II. a) Listen and repeat after the speaker, memorize the following words and word-combinations from the Text A and the Text B. b) Check if you know their meanings.**

Frequency band полоса частот; sinewave синусоидный сигнал; mean value среднее значение; root-mean-square value среднеквадратичное значение; probability-density function (p.d.f.) функция плотности вероятности; power-density spectrum спектр плотности мощности (сигнала); autocorrelation function автокорреляционная функция; stationary random signal стационарный случайный сигнал; almost without exception почти без исключения; man-made искусственный; phenomenon (pl. phenomena) явление; random behaviour случайное поведение; examples ranged from примеры охватывают; aircraft noise шум самолета; in a medium limits в границах среды; the whole frequency spectrum весь частотный спектр.

## Text A

### PARAMETERS OF RANDOM SIGNALS

**I. a) Listen to the text, mind the English intonation. b) Read the text to yourself and grasp the main idea of it.**

Statistical measurements are used to describe the amplitude, frequency and time behaviour of random signals. The amplitude behaviour of a random signal can be described by the mean value of the signal, the root-mean-square value of the signal or the probability-density function of the signal. Frequency behaviour, which is independent of amplitude, can be described by the power density spectrum of the signal. Time behaviour is described by the autocorrelation function of the signal, and indicates the same frequency components, but in terms of period rather than frequency. These parameters can be obtained for periodic waveforms as well as for random ones. They are different kind of averages and if these statistical properties of a random signal remain constant with time, it is called a stationary random signal.

## 2. Average Reading

## Text B

### DESCRIPTION OF RANDOM SIGNALS

**I. a) Listen to the text. b) Read it (time limit is 3 min.). c) Find the part of it dealing with a random signal.**

Almost without exception, all natural and man-made phenomena exhibit random behaviour to some extent. Examples range from wind motion and aircraft noise to thermal and semiconductor noise in electrical circuits. Measurements made on random signals are called statistical measurements, and their application covers the whole frequency spectrum.

A random signal cannot be described precisely in terms of voltage and frequency in the same way as a simple sinewave. Because it varies in a random manner, this requires observation of the signal's behaviour over a period of time. It is important to note that all statistical measurements are average measurements, and the longer the averaging time, the more accurate is the measurement.

*ASSIGNMENTS*

**I. a) Choose the key sentences from the Text A and compare them with the title of the text. b) Say what the text is about.**

**II. Skim through the Text B and say what measurements are called statistical measurements.**

**III. Discuss the main idea of the Text A and the Text B.**

**IV. Answer the following questions.**

1. What do all natural and man-made phenomena exhibit to some extent? 2. What are the examples of those phenomena? 3. How can a random signal be described? 4. When are statistical measurements more accurate? 5. What is called a stationary random signal?

**V. Ask additional questions and prepare a dialogue for discussion on the topic.**

**VI.** Speak on:

1. Parameters of random signals.
2. Description of random signals.

**VII. Choose the compound words from the Text A and the Text B. Analyse and translate them.**

## II. CLASSWORK

## 3. Close Reading

### PRE-TEXT EXERCISES

**I. Be sure that you know these words.**

Probability function функция вероятности; total signal весь сигнал; fluctuating флюктуирующий; standard deviation стандартное отклонение; load resistor нагрузочный резистор; averaging time время усреднения; at all possible amplitudes при всех возможных амплитудах; the curve obtained by plotting кривая, полученная при построении графика; the bell-shaped curve колоколообразная кривая; random disturbance случайное возбуждение; the horisontal amplitude scale масштаб по горизонтальной оси амплитуд.

**II. Define the tense-forms of these verbs in the Text C.**

Give, call, contain, refer, assume, mean, divide, obtain, add, spend, calibrate, exceed, specify.

**III. Analyse these words from the viewpoint of their structure and translate them.**

Mean-square, waveshape, plotting-density, bell-shaped, Gaussian-type, echo-ranging, cross-correlate, autocorrelation, cross-correlation, signal-to-noise.

## Text C

### MEAN, MEAN-SQUARE AND PROBABILITY FUNCTION

**I. a) Read the text. b) Describe the mean-square voltage for fluctuating electrical signals.**

The mean ($\bar{x}$) and mean-square ($\bar{x}^2$) values of a waveform are time averages. $\bar{x}^2$ is the mean-square value of the total signal (d. c. plus a. c.), while the mean-square value of the fluctuating component alone is given by the symbol $\sigma^2$, that is $\bar{x}^2 = (\bar{x})^2 + \sigma^2$, where $\bar{x}$ is the d. c. component or mean value. Value $\sigma$ is called the standard deviation.

The a. c. power contained in a signal is proportional to $\sigma^2$. In practice for fluctuating electrical signals the mean-square voltage is often referred to as the power of the signal, and this assumes a 1Ω load resistor.

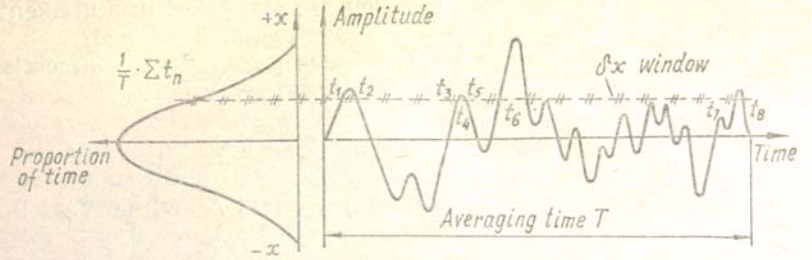


Fig. 5.9. The probability-density function of a noise-signal.

Neither the mean value nor mean-square value on its own gives any indication of waveshape. To do this, it is necessary to determine the proportion of time spent by the signal at all possible amplitudes during a finite period of time. In practical terms, this means totalizing the time spent by the signal in a selection of narrow amplitude windows, and then dividing the total for each window by the measurement or averaging time $T$, as shown in Fig. 5.9. The curve is obtained by plotting probability density function (p.d.f.) of the signal $p(x)$. Thus $p(x)\,\delta x$ is the probability that $x(t)$ lies between $x$ and $x+\delta x$, and is easy to measure, being the proportion of time spent by $x(t)$ between $x$ and $x+\delta x$. The total area under a p.d.f. is always unity, as the sum of all possible probabilities must add up to certainty. The most familiar p.d.f. is the bell-shaped Gaussian or Normal curve, shown in Fig. 5.10*a*, which is characteristic of many naturally occuring random disturbances. The horizontal amplitude scale of the p.d.f. is calibrated in terms of σ and a Gaussian-type noise signal spends most (68 per cent) of the time between $\pm\sigma$, and hardly ever exceeds $\pm 3\sigma$, in fact it exceeds this value less than 1 per cent of the time. The Gaussian p.d.f. can be fully specified by two parameters: the mean and the standard deviation.

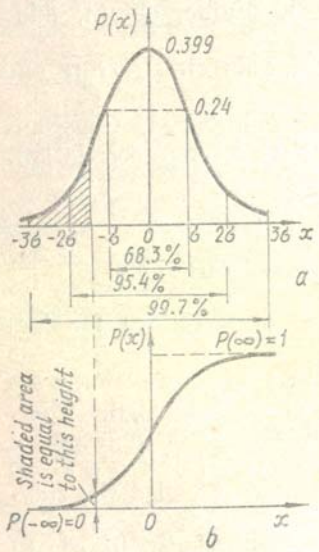


Fig. 5.10. Gaussian type noise signal:
*a* the probability-density function; *b* the distribution function.

*ASSIGNMENTS*

**I.** a) Divide the text into logical parts. b) Choose the key sentences, analyse and translate them.

**II.** Look through the text and find the part of it dealing with a. c. power contained in a signal. Translate it.

**III.** Answer the questions.

1. What are the mean and the mean-square values of a waveform? 2. What is necessary to determine any indication of waveshape? 3. What does this mean in practical terms? 4. What is the most familiar p. d. f.?

**IV.** Ask additional questions and discuss the problem of mean, mean square and probability function.

**V.** Combine your answers into a short summary of the text.

**VI.** Examine Figs. 5.9, 5.10 and comment on:

1. The probability-density function of a noise-signal.
2. The probability-density function.
3. The distribution function.

**VII.** Prepare a dialogue using Figs. 5.9 and 5.10.

**VIII.** Review the Text C in written form.

**IX.** Translate the Text C to be sure you understand it well.



## 4. Searching Reading

### PRE-TEXT EXERCISES

**I.** Match the following English words and word-combinations with the Russian ones.

| | |
|---|---|
| burried in noise | неизменяемый |
| echo-ranging system | отвергать, подавлять |
| unchanged | существенно |
| unwanted noise | покрыт шумами |
| tend v. | нежелательный шум |
| reject | стремиться |
| substantially | система измерения с помощью эхолокации |

**II.** Translate the following word-combinations and use them when reading the text.

If a signal of known waveform is transmitted; this situation represents; the receiver output consists of; there is no correlation; cross-correlation has thus rejected.

### Text D

### CROSS-CORRELATION

**I.** Read the text and say about cross-correlation used to detect the signal.

If a signal of known waveform is transmitted into a medium and is received again unchanged in form but buried in noise, cross-correlation can be used to detect the signal. This situation represents the basic problem of all communications and echo-ranging system. The receiver output consists of two parts: the desired signal, and unwanted noise. If we cross-correlate the transmitted signal with the received output, then the result also has two components; one part is the autocorrelation function of the desired signal which is common

to both of the waveforms being correlated, and the other part results from the cross-correlation of the desired signal with unwanted noise. Now, in general, there is no correlation between signal and noise, so the second part tends to zero, leaving only the signal in the form of its autocorrelation function. Cross-correlation has thus rejected the noise in the received signal, with the result that the signal-to-noise ratio is substantially increased.

*ASSIGNMENTS*

**I. Answer the following questions.**

1. When can cross-correlation be used to detect the signal? 2. What does this situation represent? 3. What does the receiver output consist of? 4. What form is the signal when the second part tends to zero? 5. What has rejected the noise? 6. What is the result of it?

**II. Discuss the problem of cross-correlation.**

**III. Make up a plan of the Text D and speak on your plan.**

**IV. Speak on probability of distribution.**

**V. a) Look through the latest magazines and find new material on the topic. b) Use it when discussing the topic.**

## III. GRAMMAR EXERCISES

**I. Analyse the following sentences, define the tense-forms of the verbs and translate them.**

1. The longer the averaging time the more accurate is the measurement. 2. Amplitude statistical characteristics have already been discussed when considering measurement errors. 3. These parameters (and several others) can be obtained for periodic waveforms as well as for random ones. 4. To do this, it is necessary to determine the proportion of time spent by the signal at all possible amplitudes during a finite period of time.

**II. Define the function of *-ing*-forms in these sentences and translate them.**

1. In practice for fluctuating electrical signals the mean-square voltage is often reffered to as the power of the signal. 2. In practical terms, this means totalizing the time spent by the signal in a selection of narrow amplitude windows, and then dividing the total for each window by the measurement or averaging time $T$.

**III. Put questions to the words in bold type.**

1. **The a. c. power** contained in a signal is proportional to $\sigma^2$. 2. The curve **is obtained** by plotting probability density function of the signal $p(x)$. 3. The most familiar p. d. f. is **the bell-shaped Gaussian or Normal curve,** which is characteristic of many naturally occuring random disturbances. 4. There is no **correlation between signal and noise.** 5. Cross-correlation has thus rejected the noise **in the received signal.**



## Lesson 5. MULTIPLEXING



## INDEPENDENT WORK

### In the Laboratory

### 1. Skimming Reading

PRE-TEXT EXERCISES

**I. a) Make sure that you know these words. Say what Russian words help you to guess their meanings. b) Repeat these words after the speaker.**

Method, filtering, information, spectrum, minimize, system, multiplexing, transmission, type, analogue, synchronizing, schemetic diagram, passive, active, interest, proportional, amplitude.

**II. Listen, repeat and memorize the following words and word-combinations from the Text A and the Text B. b) Check if you know their meanings.**

Time-division multiplex (TDM) мультиплексная передача с временным разделением каналов; frequency-division multiplex (FDM) мультиплексная передача с частотным разделением каналов; timing согласование во времени, синхронизация, хронирование; тактирование; ring counter circuit кольцевая счетная схема; assigned subcarrier определенная поднесущая (частота); simultaneously одновременно; dynamic strain динамическая деформация; sample hold circuit схема квантования и запоминания; multiplex мультиплексная (многоканальная) передача; multiplexer мультиплексор *(устройство смешивания сигналов от разных источников в один канал);* analogue TDM system аналоговая система ВРК (временное разделение каналов); the process of sharing процесс разделения;

to be connected in turn соединены последовательно, друг за другом; other associated equipment другое, связанное с этим оборудование; in sequential order в последовательном порядке; under the control под управлением; a similar set подобный набор; transmitted data передаваемые данные.

## Text A

### IMPROVEMENT OF SIGNAL-TO-NOISE RATIO

**I. a) Listen to the text, mind the English intonation. b) Read the text to yourself and grasp the main idea of it.**

Of all the methods available for separating signals from noise the most widely used is that involving filtering. If the information signal had a different spectrum from the noise, it is always possible to design a filter which attenuates the noise more than it attenuates the signal. In other words, filtering can be made to improve the signal-to-noise ratio. To minimize the effect of noise interfering with a signal, the bandwidth of the measuring system must be exactly the same as the bandwidth of the signal.

## 2. Average Reading

## Text B

### TDM- AND FDM- MULTIPLEXING

**I. Listen to the text. b) Read it (time limit is 3 min.). c) Find the part of it dealing with multiplexing. Translate it.**

Multiplexing is the process of sharing a single transmission channel with more than one input. There are two main types of multiplexing systems: time-division multiplex (TDM) and frequency-division multiplex (FDM).

A schemetic diagram of an analogue TDM system is given in Fig. 5.11*a*. The multiplexer of a number of switches in the transmitter such that each analogue input ($U_1$, $U_2$, ..., $U_n$) is connected to the transmission channel in turn. The switches are controlled by a control unit whose function is to provide the signals which select the various switches in the multiplexer and other associated equipment. Often the switches are selected in sequential order under the control of a ring counter in the control unit. A similar set of multiplexer switches is required at the receiver, and the synchronizing signal in the transmitted data is used to synchronize the receiver and transmitter switches so that data channels are isolated.

A schemetic diagram of an AM frequency division multiplex system is given in Fig. 5.11*b*. Each input modulates an assigned subcarrier at comparatively low frequencies (5—40 kHz). These subcarrier frequencies are combined in a mixer circuit, and this combination modulates a main high-frequency carrier signal. This modulated high-



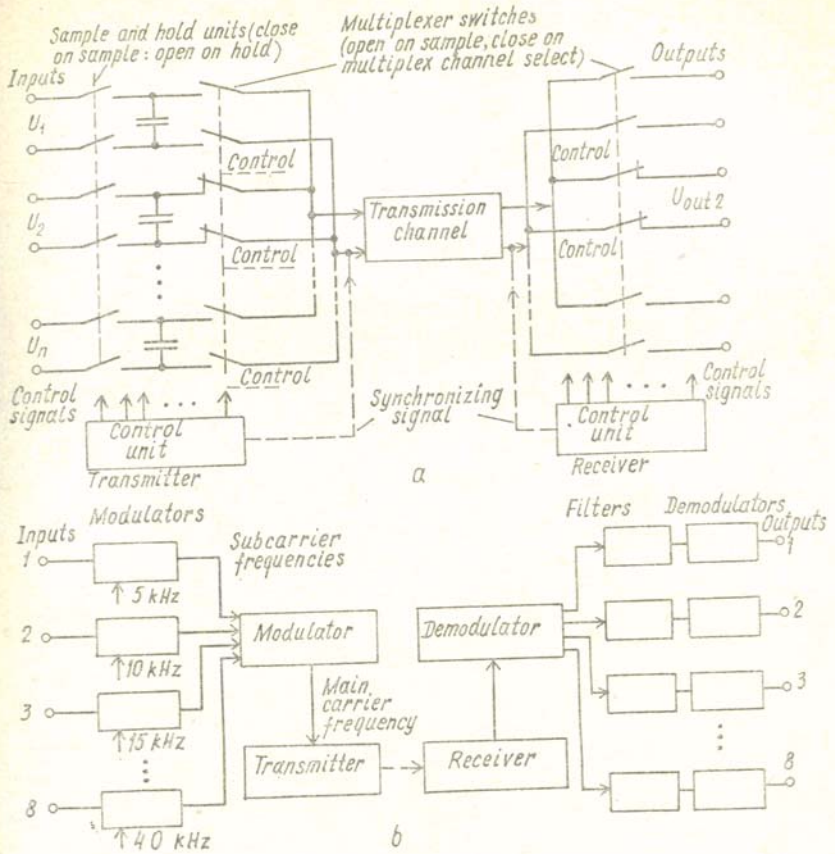


Fig. 5.11. Multiplexing:
*a* an analogue time-division type; *b* an AM frequency-division type.

frequency signal is transmitted to a receiver where the main high frequency signal is modulated. This reproduces the combination of subcarrier frequencies. Each of the subcarrier frequencies is separated from the other subcarrier frequencies with band-pass filters. These subcarrier frequencies are demodulated to reproduce the individual output signals. The AM-FDM system permits a number of data signals to be simultaneously sent over a common transmission channel.

### *ASSIGNMENTS*

**I. a) Choose the key sentences from the Text A and compare them with the title of the text. b) Say what the text is about.**

**II. a) Skim through the Text B and choose the key sentences. b) Translate the sentences.**

**III. Discuss the main idea of the Text A and the Text B.**

**IV. Answer the following questions.**

1. What is multiplexing? 2. How many types of multiplex system do you know? 3. What is the synchronizing signal in the transmitted data used for? 4. What an AM-FDM can be used for?

**V. Examine Fig. 5.11 and comment on:**

1. An analogue time-division type.
2. An AM frequency-division type.

**VI. Answer the following questions using Fig. 5.11. Work in pairs.**

(a) 1. What does Fig. 5.11*a* show? 2. What does the multiplexer consist of? 3. What are the switches controlled by?

(b) 1. What does Fig. 5.11*b* show? 2. What does each input modulate? 3. What are these subcarrier frequencies combined in? 4. What does this combination modulate? 5. Where is the modulated high-frequency signal transmitted to? 6. What does this reproduce? 7. What is each of the subcarrier frequencies separated from the others with? 8. Why are these subcarrier frequencies demodulated? 9. What does the AM-FDM system permit?

**VII. Prepare a dialogue on frequency division multiplexing system.**

**VIII. Speak on time-division multiplex system.**

## II. CLASSWORK

### 3. Close Reading

PRE-TEXT EXERCISES

**I. Be sure that you know these words.**

Attenuate v. затухать, ослаблять; obscured затемненный; repetitive symmetrical waveform периодический симметричный сигнал; two-position switch двухпозиционный переключатель; lock-in amplifier синхронный усилитель; gate строб, выборка; вентиль, элемент (логический); inverted обратно преобразованный, инвертированный; averaging circuit усредняющая схема; gated signal стробирующий сигнал; coherent когерентный (согласованный); in-phase в фазе, синфазный.

**II. Find the following word-combinations in the Text C and translate them. Use them while retelling the text.**

It may still prove possible to improve; as shown in Fig.; two important features are readily seen; a phase difference affects the output value.

**III. Define the grammar-forms of the verbs in the Text C.**

Occupy, prove, measure, use, represent, show, take.

### Text C

SIGNAL FILTERING

**I. a) Read the text. b) Describe the passive, active and digital filter units.**

If the noise interference occupies some or all of the frequency spectrum of the signal it may still prove possible to improve the



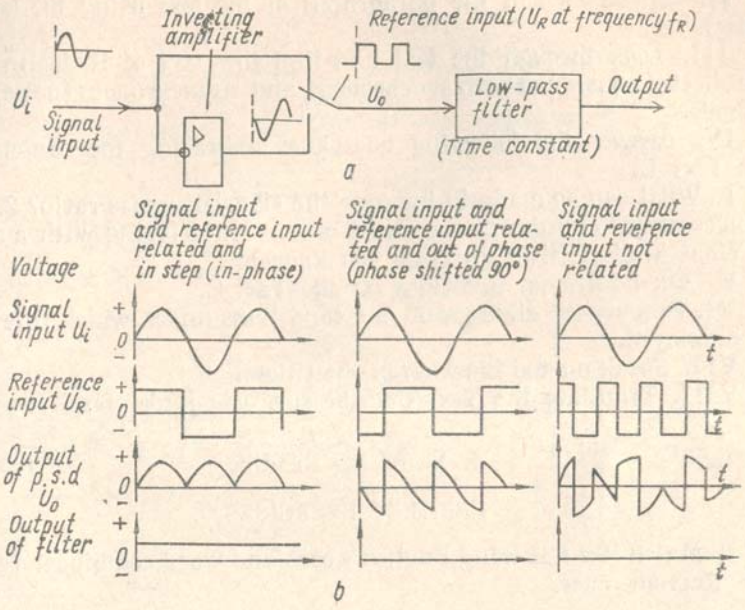


Fig. 5.12. The operation of a clock-in amplifier:
*a* the basic scheme; *b* the typical waveforms.

signal-to-noise ratio, if the shape of the frequency spectrum of the noise is different from that of the signal. Filter units may be passive, active or digital.

If a waveform to be measured, but obscured by high levels of noise, is a sinewave, square wave or other repetitive symmetrical waveform, then a lock-in-amplifier employing a phase-sensitive detector (p.s.d.) is used to measure the signal of interest. As shown in Fig. 5.12*a*, a p.s.d. can be simply represented by a two-position switch which alternately selects or "gates" either the signal or the inverted (opposite polarity) signal into a low-pass filter (an averaging circuit). The effect of such a p.s.d. on both synchronous and asynchronous (noise) input signals is shown in Fig. 5.12*b*. Two important features are readily seen. (1) When the a. c. signal and reference input have the same frequency and are in-phase, the lock-in output gives the average amplitude of the signal. A phase difference between signal and reference affects the output value. (2) When the signal and reference inputs are not at the same frequency, then the average value of the switch output is zero, provided a sufficiently long time is taken to establish the average.

*ASSIGNMENTS*

**I. a) Divide the text into logical parts. b) Choose the key sentences, analyse and translate them.**

**II. Entitle each of the paragraphs of the text using the key sentences.**

**III. Look through the text and find the part of it dealing with the effect of a p.s.d. on both synchronous and asynchronous (noise) input signals.**

**IV. Answer the following questions embracing the contents of the Text C.**

1. What can be made to improve the signal-to-noise ratio? 2. What is necessary to minimize the effect of noise interfering with a signal? 3. What kind of filter units do you know?

**V. Ask additional questions on the Text C.**

**VI. Prepare the dialogue on the conditions under which filters can be employed.**

**VII. Speak on the function of the filters.**

**VIII. Translate the Text C to be sure you understand it well.**

## 4. Searching Reading

### PRE-TEXT EXERCISES

**I. Match the following English words and word-combinations with the Russian ones.**

| | |
|---|---|
| no longer | считать, рассматривать |
| without regard to | предшествующий |
| superposition | представлять |
| approximate square wave | быстрый |
| rapid | больше не |
| performance | суперпозиция, наложение |
| establish | независимо от |
| previous | характеристика |
| consider | устанавливать |
| represent | колебания примерно прямоугольной формы |

**II. Translate the following word-combinations and use them when reading the text.**

It is evident, that; it is necessary to characterize; such effects are known as; a system comprises; one can define system linearity without regard to; the system may contain; a device can be represented by.

## Text D

### SYSTEM LINEARITY AND DISTORTION

**I. Read the text and say about the amplitude of the output signal of a device having some nonlinearity.**



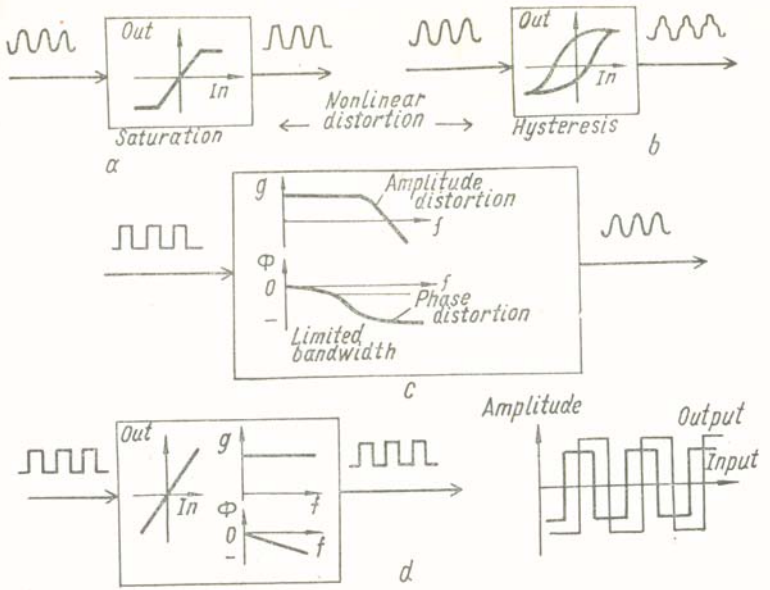


Fig. 5.13. Distortion effect:
*a* single-valued non-linearity; *b* doubled-valued non-linearity; *c* frequency (linear) distortion; *d* non-distortionless system.

Normally a measurand varies with time and such variation may be slow (for example temperature) or rapid (for example mechanical vibration displacement), repetitive (for example sinusoidal), non-repetitive (for example an impulse or step change) or completely random. It is evident that if the performance of a linear device or complete system to any time-varying input is to be established it is necessary to characterize the device or system.

The amplitude of the output signal of a device having some nonlinearity is no longer simply proportional to the input signal amplitude (see Fig. 5.13*a*) and might be dependent on previous amplitudes (see Fig. 5.13*b*). Such effects are known as nonlinear distortion. A system comprises many devices, but one can define system linearity without regard to internal details. The system may contain nonlinear device such as A/D and D/A converters, pulse modulators, and still be considered linear, provided the overall response over the desired amplitude range obeys the principle of superposition, and that the steady-state response to a sinewave is a sinusoid which has the same frequency as the input. A device or system obeying these provisions can be represented by a linear differential equation.

A system is called distortionless if at its output and without change of shape it correctly reproduces any input waveforms. A distortionless system is one which is linear and whose frequency gain is constant and phase shift increases linearly with frequency, over the frequency range of interest (see Fig. 5.13*d*).

**I. Answer the following questions embracing the contents of the Text D.**

1. How does a measurand normally vary? 2. What is the amplitude of the output signal of a device having some nonlinearity depend on? 3. When may the system be considered linear? 4. What system is called distortionless?

**II. Ask additional questions on the Text D and prepare a dialogue on the topic.**

**III. Speak on the amplitude of the output signal of a device.**

**IV. Examine Fig. 5.13 and comment on:**

1. Single-valued non-linearity. 3. Frequency (linear) distortion.
2. Doubled-valued non-linearity. 4. Non-distortionless system.

**V. Translate the following sentences into English.**

1. Для обнаружения сигнала может быть использована взаимокорреляция. 2. Этот метод может применяться, если в определенную среду передается сигнал известной формы и принимается снова неизменным по форме, но скрытым в шуме. 3. Выходной сигнал приемника состоит из двух частей: полезный (желаемый) сигнал и нежелательные помехи. 4. Взаимокорреляция подавляет помехи в принятом сигнале, в результате чего отношение сигнал-помеха значительно увеличивается. 5. Это происходит таким образом: если мы проведем взаимную корреляцию переданного сигнала с выходом приемника, то в результате получим две составляющих: автокорреляционная функция полезного сигнала и взаимокорреляционная функция полезного сигнала с нежелательными помехами. 6. Вторая составляющая стремится к нулю, остается только сигнал — в виде его автокорреляционной функции.

## III. GRAMMAR EXERCISES

**I. a) Analyse the following sentences and define the function of the Infinitive. b) Translate them.**

1. If a waveform to be measured is a sinewave a lock-in amplifier is used to measure the signal of interest. 2. To counteract any such phase shift caused in an experiment, a phase-shift facility is usually included in a lock-in system.

**II. a) Translate these sentences with the verbs in the Passive Voice. b) Define the tense-forms of the verbs.**

1. Two important features are readily seen. 2. A schematic diagram of an analogue TDM system is given in Fig. 5.11*a*. 3. The switches are selected in sequential order under the control of a ring counter in the control unit.

**III. a) Define the functions of the words with the *-ing*-forms. b) Translate the sentences.**

1. Of all the methods available for separating signals from noise the most widely used is that involving filtering. 2. In other words filtering can be made to improve the signal-to-noise ratio. 3. Multiplexing is the process of sharing a single transmission channel with more than one input.



# Chapter VI. CONTROL SYSTEMS AND PROGRAMMING

## Lesson 1. COMPUTERS IN COMMAND AND CONTROL SYSTEMS



## I. INDEPENDENT WORK

### In the Laboratory

### 1. Skimming Reading

#### PRE-TEXT EXERCISES

**I. a) Make sure that you know these words. Say what Russian words help you to guess their meanings. b) Repeat these words after the speaker.**

Command, data, computer, collect, collection, centre, process, result, organization, effective, transmission, information, exploit, basic, oriented, machine, telecommunication, concentrator, distant, automatically, communicate, analyse, copy, terminal, program, decoding, specific, synchronization, instruction, general, class, manipulation, status, structure, absolute.

**II. a) Listen, repeat and memorize these words and word-combinations. b) Check if you know their meanings.**

Computers in Command and Control Systems ЭВМ в автоматизированных системах управления; closed loop замкнутая петля;

simultaneously одновременно; data collection centres центры сбора данных; input inquiries входные запросы; expeditiously ускоренно, немедленно; data continuously flow up and down the line данные непрерывно перемещаются вверх и вниз (на верхние и на нижние звенья управления); can be finely defined могут быть в конце концов определены; take into account учитывать, принимать во внимание; remote equivalent of the computer-room input-output devices удаленный эквивалент устройств ввода и вывода, которые размещаются вместе с ЭВМ (в одной комнате); paper-tape readers устройство для считывания с перфоленты; punch-card readers устройство для считывания с перфокарты; non-real-time terminals терминалы, не способные работать в реальном времени; key-board панель с клавиатурой; screen display устройство отображения на экране; conversational terminals «разговаривающие» терминалы (терминалы с возможностью обмена информацией с ЭВМ); on-line or off-line непосредственно (без задержки во времени) или в буфферном режиме (с задержкой во времени); punch v. перфорировать.

**III. Analyse the structure of the following compound words and translate them.**

Real-time, ever-growing, computer-room, paper-type, punched-card, typewriter, key-board, on-line, off-line, closed-loop.

## Text A

### COMPUTERS AND DATA TRANSMISSION

**I. a) Listen to the text, mind the English intonation. b) Read the text to yourself and grasp the main idea of it.**

The Command and Control System is organized in a closed-loop where data continuously flow up and down the line. Computers are employed both in the command and in the data collection centres. Decisions for execution are sent forward and the results are continuously fed back, all processes operating in real-time. The best control of the organization resources can be effective only if the transmission of the information in both directions is fully exploited.

It is a basic requirement of a Command and Control System that the computers involved are communication orientated and can be operated on-line in a real-time environment. The adopted computers must possess the following qualifications:

(a) They should be capable of handling masses of data swiftly and efficiently and store large quantities of information.

(b) They must be able to operate a large number of input inquiries simultaneously and respond to them expeditiously.

A vast ever-growing array of machines can be attached to telecommunication lines for transmitting and receiving data.

Data transmission can be: 1. Between computer and computer. 2. Between terminal and computer. 3. Between terminal and terminal.

In any of these links there can be intermediary network devices such as concentrators and switches.



## 2. Average Reading

## Text B

### TERMINALS

**I. Listen to the text. b) Read it (time limit is 3 min.). c) Find the part of it dealing with the terminals designed for human use.**

A device for feeding data to or receiving data from a distant computer is called a terminal (perhaps an unfortunate choice of a word because line termination equipment in general has been called a terminal: "microwave terminal", for example, refers to the electronic equipment at the end of a microwave link).

Terminals can be devices into which data are entered by human operators or devices that collect data automatically from instruments. Terminals designed for human use may permit a fast two-way "conversation" with the computer or may be a remote equivalent of the computer-room input/output devices. The people use terminals to communicate with a computer. Paper-type readers and punched-card readers may provide input over communication lines. Printers may provide the output.

Most computers peripherals can be taken out of the computer room and attached to a communication line. They can have a typewriter added or a key-board or screen display, and then they are called conversational terminals.

The information, whether from automatic devices or from manually operated key-boards, may be transmitted immediately to the computer or may be stored in some medium for transmission at a later moment. In other words the entry of data may be on-line or off-line. Reading of instruments, for example, may be punched into paper tape, which is later transmitted to the computer.

The output may also make use of an interim medium, such as paper tape or punched card, or it may directly control the environment in question. Very often it is necessary to make a printed copy of the computer output for later analysis. In this case, part of the terminal equipment may be a typewriter or printer.

*ASSIGNMENTS*

**I. a) Choose the key sentences from the Text A and compare them with the title of the text. b) Say what the text is about.**

**II. Skim through the Text B and say how the Comand and Control System is organized.**

**III. Answer the following questions embracing the contents of the Text A and the Text B.**

1. Where are computers employed? 2. When can the best control of the organization resources be effective? 3. What is the basic requirement of a Command and Control System? 4. What can be attached to telecommunication lines for transmitting and receiving data?

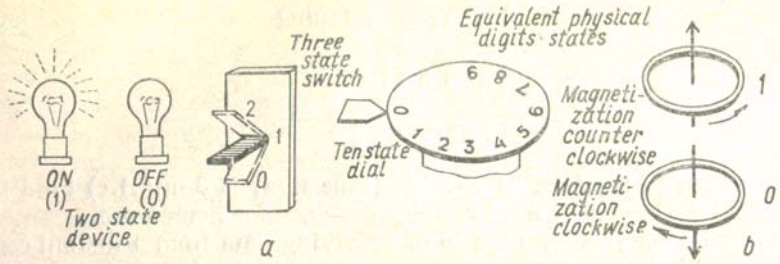


Fig. 6.1. Physical structures of the devices used to store digital information: *a* the light bulb, mechanical switch and digit wheel (dial); *b* the magnetic core.

5. What devices are terminals? 6. What may terminals designed for human use permit? 7. Why do people use terminals? 8. What may paper-tape readers and punched-card readers provide? 9. What may printers provide? 10. May the information be transmitted immediately to the computer?

**IV. Prepare a dialogue on requirements of a Command and Control System.**

**V. Speak on common types of terminal devices.**

**VI. Examine Fig. 6.1 and speak on different states of various physical devices.**

**VII. Make a short written summary of the Text B.**

## II. CLASSWORK

### 3. Close Reading

PRE-TEXT EXERCISES

**I. Memorize the following abbreviations from the Text C.**

MPU — microprocessor unit микропроцессорный блок, микропроцессор (МП);
RAM — random-access memory ЗУ со случайным доступом (ОЗУ);
ROM — read-only memory ЗУ только со считыванием, постоянное ЗУ (ПЗУ);
I/O — input-output unit устройство ввода-вывода (УВВ).

**II. Translate the following compound words and learn them.**

Microprocessor; microcomputer; read/write; random-access memory; read-only memory; time-multiplexed; second- and third generation; eight- and 16-bit bidirectional lines.

### Text C

#### MICROCOMPUTER SYSTEMS

**I. a) Read the text. b) Speak on the early microprocessor devices.**

The microprocessor unit (MPU) is the basic processing unit of the microcomputer system. By itself, not much is possible. So the



MPU is connected to memory and input/output. The memory unit may consist of several devices, called read/write or random-access memory (RAM) and read-only memory (ROM). Memories store necessary programs for the particular application of the microprocessor. The primary connection to external devices such as keypads, teletypes, or CRTs is accomplished through the input/output (I/O) unit. This basic interfacing unit of the microcomputer system is implemented with one or more special chips provided by the microprocessor manufacturers. The microcomputer system moves necessary information through three buses: the address bus, data bus, and control bus.

In early microprocessor device, these buses were sometimes shared in time (time-multiplexed). In all second- and third-generation microprocessors these buses are available independently. The address bus commonly is 16 bits wide. In microcomputer systems this same address bus serves to select devices by decoding particular address values for specific devices called device select addresses. The data bus is the main highway for information transfer to and from the MPU. Eight- and 16-bit bidirectional lines are now common. The control bus of a microcomputer system generates the timing, synchronization, isolation, and direction of data transfer for the memory and I/0 devices.

*ASSIGNMENTS*

**I. a) Divide the text into logical parts. b) Find the key sentences, analyse and translate them.**

**II. Skim through the text and find the part of it dealing with the microprocessor devices. Translate it.**

**III. Compare microprocessors of different generations.**

**IV. Answer the following questions embracing the contents of the Text C.**

1. What is the microprocessor unit? 2. To what is MPU connected? 3. What may the memory unit consist of? 4. What do memories store? 5. What buses does the microcomputer system move necessary information through? 6. What is the address bus? 7. What does the address bus serve? 8. Is the data bus the main highway for information transfer to and from MPU? 9. What does the control bus generate?

**V. Describe all types of computers and their basic processing units available at your institute.**

**VI. Check if you know the following word-combinations. Use them when retelling the Text C.**

Memory unit блок памяти, память; read/write memory запоминающее устройство (ЗУ) со считыванием и записью; keypad кнопочный переключатель; CRT (cathode-ray tube) электронно-лучевая трубка (ЭЛТ); address bus адресная шина; data bus шина данных; control bus шина управления.

**VII. Pick out all verbs from the Text C and define their tense-forms.**

**VIII. Translate the Text C to be sure you understand it well.**

## 4. Searching Reading

### PRE-TEXT EXERCISES

**I. Match the following English words and word-combinations with the Russian ones.**

| | |
|---|---|
| personality (of a microprocessor) | способ адресации |
| encounter | движение данных |
| instruction set | код операции |
| data manipulation | особенности (микропроцессора) |
| data movement | система (семейство) команд |
| program status manipulation | манипулирование состоянием программы |
| addressing mode | команда «СЛОЖИТЬ» |
| ADD instruction | сталкиваться с |
| operation code | манипулирование (управление) данными |
| mnemonic | СУММА (результат сложения) |
| operand | мнемонический код |
| SUM | операнд (число, слово, участвующее в операции) |

**II. Memorize the following abbreviations.**

OPCODE — operation code;
ADD operation — additional operation;
MPU — microprocessor unit;
PC — program counter;
BRA — branch;
JMP — jump.

### Text D

### PROGRAMMING MICROPROCESSORS

**I. Read the text and say about programming.**

Programming is your first step towards learning the personality of microprocessor. For it is here you encounter the true character of your machine, the instruction set. If we analyse instruction set, we can find four general classes in each set. These are data manipulation, data movement, program manipulation, and program status manipulation.

**Data Manipulation.** All instruction have a specific format that helps us to describe its structure and addressing mode. For example, the format of an ADD instruction consists of the operation code (OPCODE) and its operand $R_1$ and $R_2$. This symbolic notation of the ADD operation is a mnemonic which tells us that the two operands $R_1$ and $R_2$ are added together, placing the SUM in $R_1$. Other instruction formats are similarly structured.



**Data Movement.** It is important to understand how instructions manipulate the contents of the MPU registers, memory, and devices. In load and store instructions, data are typically transferred between the accumulator registers external to the MPU. With the transfer instruction, data between general-purpose registers internal to the MPU are being exchanged.

**Program manipulation.** Program manipulation instructions operate on microprocessor resources. Here we have two instructions cause a program to move to another location in memory relative to the current contents of the program counter (PC). Jump instructions cause a program to move to any location (not necessarily a location relatively addressed from the current PC). Branch instructions cause "relative" movement, whereas jump instructions cause "absolute" movement.

**Program Status Manipulation.** The program status manipulation instructions test and/or change conditions in the microprocessor to alter the instruction sequence. This instruction sets the interrupt (I) mask in the condition code register of the MPU. The condition code register contains the current status of the microprocessor during program execution.

### *ASSIGNMENTS*

**I. Answer the following questions embracing the contents of the Text D.**

1. Is programming your first step toward learning the personality of a microprocessor? 2. When do you encounter the true character of the instruction set? 3. What general classes are there in each instruction set? 4. What does the format of an ADD instruction consist of? 5. How are data typically transferred? 6. How do program manipulation instruction operate? 7. What do the program status manipulation test?

**II. Ask additional questions on the topic of the lesson.**

**III. Speak on:**

1. Data manipulation.
2. Data movement.
3. Program manipulation.
4. Program status manipulation.

**IV. Discuss the problem of programming microprocessors.**

**V. Express your opinion of the topic.**

**VI. a) Look through the latest magazines and find additional information on the topic. b) Discuss it with your fellow-students.**

## III. GRAMMAR EXERCISES

**I. a) Define the tense-forms of the verbs in the following sentences. b) Translate them.**

1. The MPU is connected to memory and input/output. 2. The microcomputer system moves necessary informations through three buses. 3. These buses were sometimes shared in time. 4. If we analyse instruction sets, we can find four general classes in each set. 5. With the transfer instruction, data between general-purpose registers internal to the MPU are being exchanged. 6. Line termination equipment has been called a terminal.

**II. Translate the sentences, pay attention to the modal verbs with the Active and Passive Infinitive.**

1. The computer can be operated on-line in a real-time environment. 2. The adopted computers should be capable of handling masses of data swiftly and efficiently. 3. They must also be able to operate a large number of input inquiries simultaneously. 4. Many machines can be attached to telecommunication lines for transmitting and receiving data. 5. Terminals may permit a fast two-way "conversation" with the computer or may be a remote equivalent of the computer-room input/output devices. 6. The information may be transmitted immediately to the computer or may be stored in some medium for transmission at a later moment. 7. Part of the terminal equipment may be a typewriter or printer.

**III. Define the function of the Participle in these sentences and translate them.**

1. Decisions for execution are sent forward and the results are continuously fed back, all processes operating in real-time. 2. It is a basic requirement of a Comand and Controle System that the computers involved are communication oriented and can be operated on-line in a real-time envirenment.

## Lesson 2. TERMINALS





# I. INDEPENDENT WORK

## In the Laboratory

### 1. Skimming Reading

PRE-TEXT EXERCISES

**I. a) Make sure that you know these words. Say what Russian words help you to guess their meanings. b) Repeat these words after the speaker.**

Focal, system, assist, basic, agent, command, terminal, data, transmission, computerize, combination, post, process, technical, engineering, problem, technique, functional, information, detail, reaction, operator, station, manipulate, geographical, categories, sensor type, automatically, graphical, sophisticated, special, interpretation.

**II. a) Listen, repeat and memorize the following words and word-combinations. b) Check if you know the meaning of these words.**

Terminals and displays оконечные и отображающие устройства; reader считывающее устройство; focal points фокусные точки; Command and Control System автоматизированная система управления; command post пункт управления; remote terminals удаленные оконечные устройства; raw form сырой вид, необработанная форма; computerized system машинная система; the processed data is fed back обработанные данные выдаются; management decision управляющее решение, решение по управлению; take into consideration принимать во внимание.

**III. a) Translate the following word-combinations. b) Define the attributes and say by what part of speech they are expressed.**

Focal points of the Command and Control System; better control of the organization resources; interaction of human agents; a well-designed terminal; management decision; command post; processed data; output device; unskilled operator.

### Text A

#### THE INTERACTION OF HUMAN AND MACHINE

**I. a) Listen to the text, mind the English intonation. b) Read the text to yourself and grasp the main idea of it.**

Terminals and displays are the focal points of the Command and Control System and are provided to assist in better control of the organization resources.

In Comand and Control Systems there are two basic areas where the interaction of human agent and machine takes place: (a) remote terminals; (b) the command post. Remote terminals are the points where the data is prepared in raw form for transmission to the computerized system and where the processed data is fed out. The remote terminals may thus be either input or output devices, or a combination of both. The command post is the point where all the processed data required for management decision is displayed, and accordingly it is basically an output device.

## 2. Average Reading

### Text B

### TYPES OF TERMINALS

**I. a) Listen to the text. b) Read it (time limit is 2 min.). c) Find the part of it dealing with the devices which come under the title of terminals. Translate it.**

There are many devices which come under the title of terminals. They comprise those where input devices are: (a) key-boards; (b) readers; (c) switches; (d) function knobs; (e) light pens, and where the output devices are: (a) typewriters; (b) printers; (c) punches; (d) displays.

The design of the terminal is not only a technical but essentially a human engineering problem. A well-designed terminal, using all the latest techniques, answering to all the functional requirements and displaying the full information details required, may prove to be useless if the human reaction of the operator has not been taken into consideration to the fullest extent.

The terminals, whether situated at the remote stations or at the command post, must be simple and easy to manipulate. There should be no need for lengthy courses to learn how to operate these terminals; indeed, the design should be aimed at the unskilled operator.

*ASSIGNMENTS*

**I. a) Choose the key sentences from the Text A and compare them with the title of the text. b) Say what the text is about.**

**II. Skim through the Text B and find the part of it dealing with the design of the terminal. Translate it.**

**III. Answer the following questions.**

1. What are terminals and displays? 2. What are they provided for? 3. Where are the terminals used? 4. What two basic areas are there in Command and Control Systems? 5. What are remote terminals?

**IV. Ask additional questions on the Text A and the Text B.**

**V. Prepare a dialogue on terminals and displays.**

**VI. Make a short summary of the Text B.**

**VII. Speak on the design of terminals.**

## II. CLASSWORK

## 3. Close Reading

### PRE-TEXT EXERCISES

**I. Be sure that you know these words and word-combinations.**

Scatter v. разбрасывать; CRT's (cathode-ray tubes) электронно-лучевые трубки; data-acquisition terminals оконечные устройства



автоматического сбора данных; data-transaction terminals оконечные устройства ручного ввода данных; inquiry terminals оконечные устройства для запросов; display terminals оконечные устройства для отображения (информации); on-line real-time information непосредственная, в реальном времени информация; measurement interface equipment измерительная аппаратура сопряжения; A/D (analog-digital) converter аналого-цифровой преобразователь (АЦП); storage buffers буферные запоминающие устройства; reference clocks опорные тактовые генераторы; badge readers устройства считывания символов; remote telemetry sensors удаленные телеметрические датчики; time-sharing system система с распределением времени.

**II. Translate the following word-combinations from the Text C and use them when retelling the text.**

Remote terminal connect the system users; the terminals may be divided into; these terminals generally obtain; the data is collected and inserted; as with the other terminals, that is; data inquiry terminals are the most widely used; in contrast to the previous type; these terminals need not be custom.

**III. Analyse the structure of these compound words and translate them.**

Data-acquisition; data-transaction; on-line; real-time; A/D converter; multiplexor; demultiplexor; feedback; data-transaction; time-sharing.

### Text C

### REMOTE TERMINALS

**I. a) Read the text. b) Speak on the centralized system by means of communication channels.**

Remote terminals connect the system users scattered over a wide geographical area with the centralized system by means of communication channels. For Command and Control applications, the terminals may be divided into five major categories according to their field of application:

(a) Data-acquisition terminals. (b) Control terminals. (c) Data-transaction terminals. (d) Enquiry terminals. (e) Display terminals.

In the class of data acquisition terminals are the sensor type terminals which are "hard wired" into the process so as to collect on-line real-time information. These terminals generally obtain measurement interface equipment, A/D converters, storage buffers, reference clocks, communication multiplexors and modems.

The control terminals are complementary to the data acquisition terminals, since they are intended to automatically implement the system decisions. These terminals contain instrument interface equipment, D/A converters, storage buffers, communication demultiplexors and modems. They are used in the feedback process of the system where the operation must change its control path in real time.