Утвержден
НМАЦ.460510.001-ЛУ

EQUIPMENT OF

TELEPHONY(TP) CHANNELS,

TELEMECHANICS(TM),

DATA TRANSMISSION(DT),

DISCRETE COMMAND SIGNALS OF RELAY PROTECTION AND EMERGENCY AUTOMATION

AKST “LINE-C”

Operation manual.

Manual on TP, TM and DT equipment operation.

Description manual.

Part 2. Book 1.

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Table of contents

0 Introduction

Technical specification of equipment, description of structure and working principles of data and TF and TM signals receive/transmission of equipment channels and also, description and functioning of equipment components are submitted in the 2nd part of the present manual.

Present book is intended for employees who work with communication equipment.

These people must study the 3rd part of the 1st book of the present manual for cooperative usage of TF and TM channels equipment, data transmission with receive/transmission of RP and PA discrete commands equipment.

Terms, definitions, abbreviation and designations which are used in this document are given in the 1st part of the present manual

1 Technical specifications

1.1 Technical specifications of equipment high-frequency(HF) ending

1.1.1 Attenuation of input HF resistance of ending inconsistency (against its nominal value of 75 Ohm) within the limits of nominal transmission/receive frequency band no less than 12 dB.

1.1.2 Attenuation of input HF resistance of ending inconsistency (against its nominal value of 150 Ohm) within the limits of nominal transmission/receive frequency band no less than 12 dB.

1.1.3 Attenuation which is set to the path of equipment operated in parallel by bypass operation of HF equipment input resistance out of the limits of nominal transmission/receive frequency band no more than 1.5 dB during the changing of frequency from the limit of nominal frequency band to frequency according to the chart below (1.1).

Chart 1.1 Changing frequency after a Attenuation setting no more than 1.5 dB

Direction	**Changing frequency (kHz) at transmission/receive band width, kHz**											
	4	**8**	**12**	**16**	**20**	**24**	**26**	**32**	**36**	**40**	**44**	**48**
receive	8	8	8	8	8	8	8	8	8	8	8	8
transmit	8	8	12	16	20	24	24	24	24	24	24	24

1.1.4 Attenuation which is set to the path of equipment operated in parallel by bypass operation of HF equipment input resistance out of the limits of nominal transmission/receive frequency band no more than 1.0 dB during the changing of frequency from limit of nominal frequency band to frequency according to the chart below (1.2).

Chart 1.2. Changing frequency after a Attenuation setting no more than 1.0 dB

Direction	**Changing frequency (kHz) at transmission/receive band width, kHz**											
	4	**8**	**12**	**16**	**20**	**24**	**28**	**32**	**36**	**40**	**44**	**48**
receive	10	10	10	10	10	10	10	10	10	10	10	10
transmit	12	16	24	32	40	48	48	48	48	48	48	48

1.1.5 Attenuation of asymmetry of symmetric HF ending against ground at a frequency equal to 50Hz no less than 40dB.

1.1.6 Nominal output signal power at frequency range from 16 to 1000 kHz at HF output of equipment (Pn) and in each channel (Pk) is set programmatically according to chart below (1.3). Power in each channel is defined by following formula (1.1).

$$P_k \text{ (dBm)} = P_n \text{ (dBm)} - 20 \lg n, \qquad (1.1)$$

where n – amount of channels of equipment.

Chart 1.3 Nominal power of channels

Nominal power of equipment P_{nom}, W / dBm	**Frequency range, kHz**	**Nominal power of channel , P_k, dBm[1)], of equipment with channels amount**						
		P_n	P_n-6	P_n-9	P_n-12	P_n-14	P_n-15	P_n-21
		1	**2**	**3**	**4**	**5**	**6**	**12[2)]**
80/49	от 16 до 300 including	49	43	40	37	35	34	28
40/46	over 300 до 700 including	46	40	37	34	32	31	25
30/45	over 700 до 1000 including	45	39	36	33	31	30	24

——————
1) While connecting nonsymmetrically, it is needed to deduct 9 from dBm value and 6 while connecting symmetrically. It is done to recalculate levels to dBc .
2) It is possible to calculate channel level by formula (1.1) if n=17-nTP when the equipment (without PRECS unit) has more than 5 analogue TP channels (nTP > 5)

1.1.7 The levels of TP and TM signals in each subchannel of TM, reference frequency**,** processing frequencies of TAE (telephone automatic equipment), DS (digital stream) signals set at HF output with tolerance of ± 0,5 dB:

а) must be lower than level in channel by value showed in chart 1.4 (in channels without PRECS unit);

б) must be lower than level in channel by value showed in chart 1.5 (in channels combined with PRECS unit)

Chart 1.4 Understatement of signal levels in channels without PRECS units

Channel configuration mode	Signals division method	Channels level reduction, dB									
		DS[4)]	TP/ out [1)]	PF[5)]	TM, bps						
					100	200	300	600	1200	2400	outer
PF + TP	FDM	–	3 / 9	18	–	–	–	–	–	–	–
PF + 2TP	FDM	–	9 / 15	18	–	–	–	–	–	–	–
PF + TP + TM (3×100 bps) [2)]	FDM	–	6 / 12	21	24	–	–	–	–	–	–
PF + TP + TM (3×200 bps)	FDM	–	7 / 13	22	–	20	–	–	–	–	–
PF + TM (6x200 bps) [3)]	FDM	–	–	22	–	19	–	–	–	–	–
PF + TP + TM (100 bps+2×300 bps)	FDM	–	7 / 13	22	24	–	19	–	–	–	–
PF + TP + TM (2x600 bps)	FDM	–	7 / 13	22	–	–	–	18	–	–	–
PF + TP + TM (1200 bps)	FDM	–	7 / 13	22	–	–	–	–	11	–	–
PF + TM (2x1200 bps)	FDM	–	–	22	–	–	–	–	10	–	–
PF + TM (2400 bps)	FDM	–	–	22	–	–	–	–	–	7	–
PF + TP + TM (outer modems)	FDM	–	7 / 13	22	–	–	–	–	–	–	19
PF + DS (in 3,5 kHz band)	FDM	9	–	18	–	–	–	–	–	–	–
DS (in 4 – 12 kHz band)	FDM	8	–	–	–	–	–	–	–	–	–
PF + TP + DS (in 1,7 kHz band)	FDM + TDM	15	9 / 15	18	–	–	–	–	–	–	–
TP + DS (in 1,9 kHz band)	FDM + TDM	14	9 / 15	–	–	–	–	–	–	–	–

Note: understating of the levels in voice frequency channel is set according to the channel type and configuration on the opposite side.

1) FXO/FXS subscriber's calling signals 1200 и 1600 Hz.
2) TM configuration corresponds to reference R.37 ITU-T.
3) The configuration corresponds to R.38 ITU-T (non-model configuration).
4) Levels measured in modem band are equal within tolerance of ± 0,5 dB in synchronization and carrier frequency modes.
5) Model value of Pilot Frequency (PF) 120 Hz is set by manufacturer. Technological channel has a standardized level (1.4.1.3a) additional frequency of which is set to 160 Hz.

Chart 1.5 understating of signal level in channels combined with PRECS unit

Channel configuration mode	Signals division method	Channels level reduction, dB			
		DS[1)]	SS	PF[2)]	TM
PRECS + PF + TM (2x600 bps)	FDM	–	12	18	13
PRECS + PF + TM (3x300 bps)	FDM	–	12	18	16
PRECS + PF + TM (4x200 bps)	FDM	–	12	18	19
PRECS + PF + TM (6x100 bps)	FDM	–	12	18	22
PRECS + PF + DS (in 2,9 kHz band)	TDM	13	12	18	–
PRECS + DS (in 3,2 kHz band)	TDM	13	12	–	–

——————

[1)] Levels measured in modem band are equal within tolerance of ± 0,5 dB in synchronization and carrier frequency modes.

[2)] Model value of Pilot Frequency (PF) 120 Hz is set by manufacturer. Technological channel has a standardized level (1.4.1.3a) additional frequency of which is set to 160 Hz.

SS – safety signal

1.1.8 The limits of frequency band where the main output power of signals range are ± (2000 x n − 100) Hz. This frequency band is located symmetrically within limits of nominal channel frequency band equal to 4000 x n Hz, (where n – amount of basic frequency bands).

1.1.9 Acceptable level of parasitic equipment radiation (P_{alias}, dBm) outside the transmission band within the limits of basic frequency band B_{basic} (4kHz) corresponds to values showed in chart 1.6

Chart 1.6 Level of parasitic radiation within the frequency band B_{basic}

Nominal output power of equipment P_{nom}, dBm	Location of B_{basic} relative to the limits of frequency band *		
	Adjacent	One B_{bas} band apart	Two or more B_{bas} band apart
≤ (+ 46)	− 14	− 24	− 34
> (+ 46)	P_{nom} − 60	P_{nom} − 70	P_{nom} − 80

* When transmission/receive bands are located adjacently, location of basic frequency band is set relative to the limits of frequency band occupied by equipment.

1.1.10 Level of out-of-band equipment working signal range (P_{ob}, dBm) in frequency band B_{basic} (4 kHz) doesn’t exceed values showed in chart 1.7.

Chart 1.7 Integral level of out-of-band range within the limits of frequency band B_{basic}

Nominal output power of equipment P_{nom}, dBm	**Location of B_{basic} relative to the limits of frequency band ***		
	Adjacent	**One B_{bas} band apart**	**Two or more B_{bas} band apart**
≤ (+ 46)	− 14	− 24	− 34
> (+ 46)	P_{nom} − 60	P_{nom} − 70	P_{nom} − 80

* When transmission/receive bands are located adjacently, location of basic frequency band is set relative to the limits of frequency band occupied by equipment.

1.1.11 Receiver sensitivity by AGC is no less than minus 26 dBm (minus 35 dBc). Wherein the level of own noises on a LF output is no more than minus 35 dBm.

The possibility of sensitivity decline of 20 – 21 dB is provided.

1.1.12 Operational parameters are not changed in the presence of interfering signal (on the HF input) located outside the nominal frequency band, with a level no less than one showed in chart 1.8. wherein the level of interference on LF endings is no more than minus 55 $dBm_{relative}$.

Chart 1.8 levels of interfering signal

Interference signal frequency shifting relative to limits of nominal receiving band, kHz	0,1	4	8
the level of interfering signal on a HF input, dBm $_{relative}$ [1)]	10	20	40[2)]

[1)] Relative to the level of receiving the main of transmitted signals.
[2)] But no less than + 49 dBm

1.1.13 Equipment’s AGC provides changing of level on a LF endings (VF, TP and TM) on more than by ± 0,5 dB when Attenuation of an artificial line changes no less than by 40 dB.

1.1.14 Channel readiness time after turning on of equipment:

а) 1 min 15 s – for FDM channels;

б) 1 min – for TDM channels when SNR= 26 dB.

1.1.15 When voltage of power amplifier supply is lost, HF circuits of equipment’s input/output disconnect from HF cable.

1.1.16 Frequency of the carrier-frequency oscillator does not different from its nominal value more than by ± 2 Hz.

1.1.17 When transmission/receive bands are located adjacently the equipment can operate without quality loss when balance dumping HFDS (high frequency differential system) equal to 4 dB.

1.2 Technical specifications of equipment with FDM

1.2.1 Inconsistency Attenuation in effectively transmitted frequency band from the side of 2-lead and 4-lead TP channels interfaces relative to the nominal resistance of 600 Ohm is no less than 14 dB.

1.2.2 Asymmetry Attenuation in effectively transmitted frequency band from the side of 2-lead and 4-lead TP channels interfaces is no less than 40 dB.

1.2.3 Boundary frequencies of effectively transmitted frequency bands located in basic band are set programmatically with an increment of no more than 10 Hz and located in following ranges:

а) from 0,3 to 3,7…3,9 kHz In VF channel;

б) from 0,3 to 3,4 kHz in standard TP channel;

в) in combined channel: from 0,3 to 2,0… 2,4 kHz in speech channel, from 2,16…2,56 to 3,7…3,9 kHz in supersonic TM channel;

г) from 0,05 to 3,95 kHz arbitrarily.

1.2.4 The division of basic 4 kHz frequency band to 2 TP channels with 2-lead or 4-lead interfaces and occupied band 1,7 kHz each is done programmatically.

1.2.5 Nominal levels in VF channel and supersonic TM channel are set to 0 dBm on a LF input and (0 ± 0,5) dBm on a LF output.

1.2.5.1 Levels adjustment with the increment of 0,1 dB is provided on inputs/outputs in the range from plus 4 dBr to minus 17 dBr 1 in a VF channel and supersonic TM channel.

1.2.6 Nominal levels on inputs/outputs TP channel LF ending:

а) (4 ± 0,5) dBm on a 4-lead output when the level on the output is minus 13 dBm;

б) minus (7 ± 0,5) dBm on a 2-lead output when the level on the output is 0 dBm.

Note: nominal levels on 4-lead input and output of minus (3,5 ± 0,5) dBm can be set at the equipment commissioning if it is needed.

1.2.7 the possibility of levels adjustment with the increment of 0,1 dB is provided in all TP channels within the limits:

– from 0 dBr to minus 17 dBr at transmission;
– from plus 2 dBr to minus 3,5 dBr at receiving.

1.2.8 An irregularity of amplitude frequency characteristics relative to residual Attenuation of through standard TP, VF (relative to frequency of 1020 Hz) and combined TP+TM channels (relative to 1020 Hz in TP and 3000 Hz in TM) is located within the diagram range showed in the figures A.1-A.4 of enclosure A.

An equalizer provides FR distortions correction with software at nine levels in the range from 0,3 to 3,7 kHz within the limits of ± 6 dB in each point and implements FR irregularity according to enclosure A.

1.2.9 deviation of group passing time (GPT) of standard through TP, VF (relative to frequency of 1900 Hz) channels and combined TP+TM (relative to 1900 Hz at the band of (0,3 – 2,4) kHz in TP channel, 1500 Hz at the band of (0,3 – 2,0) kHz in TP channel and 3000 Hz in TM channel) corresponds to diagrams showed in figures B.1-B.4 of enclosure B.

1.2.10 Signals delay time between LF endings in VF, TP and TM channels is no more than 50 ms.

1.2.11 Audio frequency signals regenerated on receive cannot differ in frequency from transmitted by more than +-2 Hz.

1.2.12 Own psophometrically weighted noise in VF and TP through channels during the equipment working are no more than minus 50 dBm, if limiting working temperature is up to 55 C (131 F) during no less than 24 hours/month is no more than 50 dBm.

1.2.13 Harmonic distortions in through channel during the sinusoidal signal of 350 Hz sending with level of minus 3 DBm0 to the VF channels LF inputs and 2-lead and 4-lead TP channel inputs are such that the measured on the VF and TP channels LF outputs level of each signal harmonics of 350 Hz is no more than minus 40 DBm0.

1.2.14 Signal levels on an input and output of compander are not subject to change and correspond to 1.2.6. Companding (expanding) range is 2:1:2.

1.2.15 Amplitude limiter operation must begin in the range from minus 3 to 0 DBm0 at the point with relative level of 0 DBm0 on any frequency within the band from 300 Hz to the highest frequency of effectively transmitted band in VF, TP and TM channels (outer).

Signal level on a HF output measured with broadband meter must not be more than 3 DBm0 when the level on LF output increases to 15,0 DBm0.

1.2.16 Transitional effects of TM and DT (data transmission) subchannels located In supersonic range in one VF channel provide interferences of no more than minus 50 DBm0p from any signals combinations transmitted in channels.

1.2.17 Transitional Attenuations between different TP, TM, VF and DS channels are no less than 50 dB.

1.2.18 Reflected signals (echo) level in TP channel (when echo cancellation device is disabled) is no more than minus 40 dBm0. Echo cancellation device in speech channel path provides “echo” Attenuation no less than 30 dB to transmission path for signal.

1.2.19 Power consumed by one device at power supply circuit ~ 220 V and max load is no more than values showed in chart 1.9.

Chart 1.9 Consumed power, W, at max load

Nominal output power of equipment P_{nom}, W	**Number of channels in equipment**					
	1	**2**	**3**	**4**	**5**	**6 – 12**
80	230	220	210	200	190	170
40	210	200	190	180	170	150
30	190	180	170	160	150	130

1.2.20 The equipment includes interfaces which provide such connections:

а) by 4-lead connecting ATE lines with built-it LDAPSCE (Long-distance automatic power system connection equipment) with 2-frequency in-band signaling;

б) by 3-lead connecting ATE lines with battery signaling;

в) by 2/4-lead connecting ATE lines with E&M signaling (5^{th} type);

г) of telephone sets (TS) with central battery, rotary or push-button dials (dispatch switchboard, telephonist's intermediate department, TS of remote subscriber on a near end) by FXS interface;

д) on a distant end by subscriber ATE line by FXO interface.

1.2.21 Telephone automatic equipment (TAE) have such specifications:

а) input circuits operate by loop with the resistance of up to 500 Ohm. Output contact allows to switch voltage up to 72 V and amperage up to 50 mA at resistive load;

б) control signal frequencies of 1200, 1600 Hz are formed with an accuracy of ± 3 Hz on TAE output;

в) control signal frequencies receiver operates sustainably because of signal frequencies located in the range ± 50 Hz relative to these frequencies;

г) impulses of subscriber dialing must meet the requirements of 4^{th} section of GOST 7153.

1.2.22 control and interaction signals of TAE and LDAPSCE devices have such specifications:

а) occupation of counter ATE by subscriber: signal with frequency of f_1 1200 Hz, duration of from 220 to 230 ms, and recognition time on the receiver of from 150 to 220 ms;

б) dialing: signal with frequency of 1200 Hz, duration of from 45 to 55 ms, pause of from 45 to 55 ms and recognition time on the receiver of from 150 to 220 ms;

в) connection ring-off: signal with frequency of $f_1 + f_2$ duration of from 650 to 750 ms and recognition time on the receiver of from 150 to 650 ms;

г) call from CP of counter ATE subscriber: signal with frequency of f_1 1200 Hz, duration of from 220 to 230 ms and recognition time on the receiver of from 150 to 220 ms;

д) call from DC of counter ATE subscriber: signal with frequency f_2 1600 Hz, duration of from 220 to 230 ms and recognition time on the receiver of from 150 to 220 ms;

е) TAEs provide DTMF tone dialing signals transmission.

1.2.23 The equipment provides maintenance for faxes with auto switching between “speech/fax” modes.

1.2.24 The equipment is able to connect with primary digital channel by E1-carrier with specifications according to GOST 26886 and requirements of G.703 series of ITU-T.

1.2.25 Built-in asynchronous modems of data transmission and TM meet the following requirements:

а) the modem is programmable and works in code-independent mode. When TM and DT channels without PRECS unit are standard, modems specifications are correspond to chart 1.10 and correspond to chart 1.11 when channels are combined with PRECS unit;

б) the possibility of set-making by modems of TM and DT channels arbitrarily is provided but no more than 6 modems to one SPU, with occupied frequency band according to chart 1.10 (without PRECS unit). TM signal delay time between interfaces is no more than 55 ms;

в) interface with terminal TM equipment and data transmission (except for batch communication) is implemented by RS - 232C, RS - 422, RS - 485 according to GOST 18145 and requirements of V24 / V28, X24 / X27 ITU-T with values showed in chart 1.12 (on speed no more than 2,4 kbps in FDM mode).

Chart 1.10 Specifications of modems in TM and DT channel without PRECS unit

Line №	**Standard modem configuration transmission speed, bps**	**Bottom frequency, f_b, Hz**	**Upper frequency, f_u, Hz**	**Central characteristic frequency, Hz, $fc = \frac{fb + fu}{2}$**	**Modem band occupied frequency, Hz**	**Frequency deviation, Hz**	**Edge distortion, %, no more than**	**Note**
1	3 x 100	2580	2700	2640	240	± 60	2	Requirements of R.37 ITU-T
2		2820	2940	2880	240	± 60	2	
3		3060	3180	3120	240	± 60	2	
4	3 x 200	2580	2760	2670	360	± 90	2	
5		2940	3120	3030	360	± 90	2	
6		3300	3480	3390	360	± 90	2	
7	6 x 200 *	480	720	600	480	± 120	2	Requirements of R.38 ITU-T
8		960	1200	1080	480	± 120	2	
9		1440	1680	1560	480	± 120	2	
10		1920	2160	2040	480	± 120	2	
11		2400	2640	2520	480	± 120	2	
12		2880	3120	3000	480	± 120	2	
13	100 +2 x 300	2580	2700	2640	240	± 60	2	
14		2880	3120	3000	480	± 120	4	
15		3360	3600	3480	480	± 120	4	
16	2 x 600	2300	2750	2525	900	± 225	4	
17		3200	3650	3425	900	± 225	4	
18	2 x 1200	800	1600	1200	1500	± 400	4	
19		2720	3520	3120	1500	± 400	4	
20	2400	1140	2860	2000	3000	± 860	4	
* The configuration is not standard; it may be set by agreement with user.								

Chart 1.11 specifications of modems in TM and DT channel with PRECS unit

Line №	Standard modem configuration transmission speed, bps	Bottom frequ ency, f_b, Hz	Upper frequ ency, f_u, Hz	Central characteristic frequency, Hz, $fc = \frac{fb + fu}{2}$	Modem band occupied frequency, Hz	Frequency deviation, Hz	Edge distortion, %, no more than
1	6 x 100	1100	1200	1150	300	± 50	2
2		1400	1500	1450	300	± 50	2
3		1700	1800	1750	300	± 50	2
4		2000	2100	2050	300	± 50	2
5		2300	2400	2350	300	± 50	2
6		2600	2700	2650	300	± 50	2
7	4 x 200	1200	1400	1300	500	± 100	2
8		1700	1900	1800	500	± 100	2
9		2200	2400	2300	500	± 100	2
10		2700	2900	2800	500	± 100	2
11	3 x 300	1200	1400	1300	700	± 100	4
12		1900	2100	2000	700	± 100	4
13		2600	2800	2700	700	± 100	4
14	2 x 600	1200	1600	1400	1200	± 200	4
15		2400	2800	2600	1200	± 200	4

Chart 1.12 TM and DT channels options

Parameter's name, unit		Interface, rate	
		RS-232C	RS-422/RS-485
1 input circuits specifications			
1.1 Input resistance, kOh		3 – 7	0,10 – 0,15
1.2 Input impulses options:			
– bipolar with an amplitude , V		± (3 – 15)	–
– differential with potential difference, V		–	± (0,2 – 7)
– max allowable amplitude, V		± 25	± 12
– logical "1", V		minus 15 – 0	minus 7 – 0
– logical "0", V		3 – 15	0,2 – 7,0
2 Output circuits specifications			
2.1 Output impulses options:			
а) bipolar with an amplitude , V:			
– when the load is 3 kOhm		± (5 – 15)	–
– without the load, no more than		± 15	–
б) differential with potential difference by absolute value, V			
– when the load is 3,9 kOhm, no more than		–	6
– when the load is 100 kOhm, no less than		–	2
в) short-circuit current, mA, no more than		–	150
2.2 Impedance in a disable state, Ohm, no less than		300	–
2.3 Transit zone passing time, % of bit time, no more than		3	–
2.4 Rising signal edge time (time of 90% of the transition from low to high), % of bit time, no more than		–	10
3 Maintained speed, kbps *:			
3.1 In TM channels	SPU	0,1; 0,2; 0,3; 0,6; 1,2; 2,4	
3.2 In DT channels	SPU	0,05; 0,11; 0,15; 0,2; 0,3; 0,6; 1,2; 1,8; 2,4; 4,8; 9,6; 14,4; 19,2; 38,4; 57,6; 115,2**	0,05; 0,11; 0,15; 0,2; 0,3; 0,6; 1,2; 1,8; 2,4; 4,8; 9,6; 14,4; 19,2; 38,4; 57,6
	CMSU	0,05; 0,11; 0,15; 0,2; 0,3; 0,6; 1,2; 1,8; 2,4; 4,8; 9,6; 14,4; 19,2; 38,4; 57,6; 115,2; 230,4	–
4 DT software settings:			
– number of stop bits		1 or 2	1 or 2
– parity bit		not in use, "even", "odd", "always 0", "always 1"	not in use, "even", "odd", "always 0", "always 1"
– transmission length, bit		5, 6, 7 or 8	5, 6, 7 or 8
– hardware flow control (RTS/CTS)***		maintained with an ability of disabling	not maintained

* There is max speed in TM channels specified in the chart. Deviation of ± 10 %. from specified speed is possible in DT channels
**The speed of 115,2 kbps is maintained only when the channel is organized through "RS232" connector of SPU unit.
*** Only for DT in the mode with TDM organized through "RS232" connector of SPU and CMSU.

1.3 Technical specifications of equipment with TDM

1.3.1 ***Technical specifications of digital stream (DS)***

1.3.1.1 Changing of digital stream speed is provided with a tolerance of ± 1 % and adaptation steps according to chart 1.13 when changing of signal-noise ratio in channel (white noise type) relative to limiting values showed in chart 1.3. The ratio is standardized in the band of 4 kHz. There are two modes of speed changing:

а) without noiseless coding;

б) with noiseless coding;

in this case, if there are changes of “white noise” SNR in the band of 4 kHz relative to limiting values, specified in chart 1.13. Probability of error in the channel is no more than10^{-7} on each adaptation step.

Switch to a lower adaptation step is implemented when reaching SNR for the current step showed in chart 1.13, with the tolerance of ± 0,5 dB. Switch to a higher adaptation step is implemented in the presence of 1dB reserve of the next step SNR with the tolerance of ± 0,5 dB. Error coefficient is no more than 10^{-6}, when adaptation changes because of smooth (no faster than 0,5 dB at one time per 10 seconds) noises changes.

DS transmitted by VF channel through the 4-lead interface of outer LF endings device DS transmission is provided at max useful speed according to chart 1.13 when standard frequency band value is 3,5 kHz on the adaptation step:

- no less than 6th with disabled noiseless coding;
- no less than 7th with enabled noiseless coding.

When single DS organized of several modems is transmitted (during the multiplexing):

- max useful speed is 93% of total useful DSs organized of single modems;
- changing of adaptation step and one of the modems synchronization loss does not cause single DS interruption, wherein a short-term errors increasing is allowed during the time of 2 sec;
- single DS speed changing is implemented taking into account the single modem speed changing according to chart 1.13.

Adaptation mode can be disabled.

The decrease of transmission max useful speed in DS channel is possible by no more than one step, if limiting working temperature is up to 55 °C (131 °F) during no less than 24 hours/month.

Chart 1.13 DS max useful speed, kbps

Adaptetion step	Min SNR dB	Frequency band occupied by synchronous modems signals, kHz													
		1,7	**1,9**	**2,9**	**3,2**	**3,5**	**4**	**6**	**8**	**10**	**12**	**16[1)]**	**20[1)]**	**24[1)]**	**48[1)]**
		Minimal number of modems													
		1										**2[1)]**			**4[1)]**
DS speeds without noiseless coding, kbps															
1	14	2,93	3,28	4,98	5,52	6,04	6,90	10,4	13,8	17,1	20,7	25,7	31,7	38,5	77,1
2	17	4,55	5,09	7,73	8,57	9,37	10,7	16,1	21,4	26,5	32,1	39,9	49,2	59,8	119
3	20	6,17	6,90	10,5	11,6	12,7	14,5	21,8	29,0	35,9	43,6	54,0	66,7	81,0	162
4	23	7,79	8,71	13,2	14,7	16,0	18,3	27,5	36,7	45,3	55,0	68,2	84,2	102	204
5	26	9,41	10,5	16,0	17,7	19,4	22,1	33,2	44,3	54,7	66,4	82,4	101	123	247
6	29	11,0	12,3	18,7	20,8	22,7	26,0	38,9	51,9	64,1	77,9	96,5	119	144	289
7	32	12,6	14,1	21,5	23,8	26,0	29,8	44,6	59,5	73,5	89,3	110	136	166	332
8	35	14,3	15,9	24,2	26,9	29,4	33,6	50,4	67,1	82,9	100	125	154	187	374
9	39	15,9	17,8	27,0	29,9	32,7	37,4	56,1	74,8	92,4	112	139	171	208	417
DS speeds with noiseless coding, kbps															
0	10	1,82	2,04	3,09	3,43	3,75	4,29	6,43	8,57	10,6	12,9	15,9	19,7	23,9	47,8
1	12	2,83	3,17	4,81	5,33	5,83	6,67	10,0	13,3	16,5	20,0	24,8	30,6	37,2	74,4
2	15	4,45	4,98	7,56	8,38	9,17	10,5	15,7	21,0	25,9	31,4	39,0	48,1	58,5	117
3	18	5,97	6,67	10,1	11,2	12,3	14,0	21,1	28,1	34,7	42,1	52,3	64,6	78,4	156
4	21	7,59	8,48	12,9	14,3	15,6	17,9	26,8	35,7	44,1	53,6	66,4	82,1	99,6	199
5	24	9,21	10,3	15,6	17,3	19,0	21,7	32,5	43,3	53,5	65,0	80,6	99,6	121	241
6	27	10,8	12,1	18,4	20,4	22,3	25,5	38,2	51,0	62,9	76,4	94,8	117	142	284
7	30	12,4	13,9	21,1	23,4	25,6	29,3	43,9	58,6	72,4	87,9	109	134	163	326
8	33	14,1	15,7	23,9	26,5	29,0	33,1	49,6	66,2	81,8	99,3	123	152	184	369
9	37	15,7	17,5	26,6	29,5	32,3	36,9	55,4	73,8	91,2	110	137	169	206	412

N o t e – DS useful speed is decreased by 700 bps when technological DT channel with the speed of 600 bps (1.4.1.4б)

[1)] Speeds are specified for single DS, organized of several modems while passing through the multiplexor.

1.3.1.2 The duration of working DS synchronization in the event of channel loss (because of Attenuation increasing or noises effect) is no less than 1 sec. the duration of working channel recovering after synchronization loss is no more than 4 sec.

1.3.1.3 The level of DS signal range power on a HV output out of nominal frequency band is no more than values specified in chart 1.14.

Chart 1.14 Acceptable level of DS signal range power, dBm

Nominal power of equipment P_{nom}, dBm	**Range location**	
	In a basic frequency band of 4 kHz adjacent to nominal band limits	**In a wide band 4 kHz apart from nominal band limits**
≤ (+46)	− 14	− 24
> (+46)	$P_{nom} - 60$	$P_{nom} - 70$
* When transmission/receive bands are located adjacently, the location of basic frequency band is set relative to limits of frequency band occupied by the equipment.		

1.3.1.4 Receiver’s AGC sensitivity is no less than minus 26 dBm (minus 35 dBn). In doing so, DS transmission is provided with the error coefficient of no more than $5•10^{-7}$.

1.3.1.5 Equipment’s AGC provides reliable the implementation of DS demodulation algorithm with the error coefficient of no more than $5•10^{-7}$when the impedance of line Attenuation changing of no less than 40 dB.

1.3.1.6 The transmission of DS in channel is not interrupted by intermittent line Attenuation change of 2 dB. In doing so, short-term errors increasing is acceptable during the time of no more than 5 sec.

1.3.1.7 Equipment working options are not changed in the presence of arbitrary frequency (on the interfering sinusoidal signal (P_{int}) HF input) within the receive band limits, with the level of no less than value specified in chart 1.15 relative to modem signal level set according to charts 1.3-1.5. In doing so, common DS error coefficient is no more than 10^{-7}.

Chart 1.15 Interfering sinusoidal signal relative level (P_{int}, dB0)

Adaptation step	P_{int}, dB0	Adaptation step	P_{int}, dB0
Without noiseless coding			
–	–	5	− 25
1	− 13	6	− 28
2	− 16	7	− 31
3	− 19	8	− 35
4	− 22	9	− 38
With noiseless coding			
0	− 9	5	− 23
1	− 11	6	− 26
2	− 14	7	− 29
3	− 17	8	− 33
4	− 20	9	− 36

1.3.1.8 The equipment retains workability when working by HF path with Attenuation and GPT frequency dependence, which change periodically from max to min value by quantity of:

– no less than 6dB for attenuation;
– no less than 200 μs for GPT.

Frequency interval between Attenuation and GPT extreme values is no more than 1,5 kHz.

1.3.1.9 The equipment’s working options do not change in the presence of interfering sinusoidal signal on a HF output with a frequency located out of nominal frequency band and a signal specified in chart 1.8. In doing so, DS error coefficient is no more than 10^{-7}.

1.3.2 ***Technical specifications of signals transmission in TDM channels***

1.3.2.1 The equipment in TDM mode provides TP transmission and meets the requirements to:

- inconsistency attenuation from LF endings side according to 1.2.1;
- asymmetry attenuation from LF endings side according to 1.2.2;
- nominal levels in TP channels according to 1.2.6;
- levels adjustment in TP channels according to 1.2.7;
- reflected signal level in TP channel and Attenuation, contributed to path by echo cancellation device according to 1.2.18;
- connections types by TP channel according to 1.2.20;
- specifications of TAE and LDAPSCE input and output circuits according to 1.2.21а);
- dialing impulses options according to 1.2.21г).

Specifications of signals detector on TP input corresponds to 1.2.22а)-1.2.22г). The detector provides transmission of DTMF signals.

Calling frequencies signals of 1200, 1600 Hz and DTMF, regenerated on the 4-lead ending of TP channel, do not differ from transmitted ones by frequency by more than of ± 2 Hz

1.3.2.2 Speech transmission quality is no lower than 3,5 points on the MOS scale according to ITU-T P.862. Useful speed expenditure (1.3.1.1) on the channel maintenance is no more than 5,8-6,2 kbps.

1.3.2.3 Signals delay time in the channel between analogue speech channel LF endings is no more than 150 ms.

1.3.2.4 The equipment provides transmission of TM signals and data (except for batched transmission) through the built-in user interfaces of digital channels with the specifications showed in chart 1.12. In this case, the useful speed expenditure (1.3.1.1) on the TM signal transmission relative to signals speed to the interface are no more than 400% plus 0.3 kbps. The saving of useful speed (1.3.1.1) while data transmission is no less than 25% relative to interface speed.

1.3.2.5 The equipment provides data batched transmission through Ethernet 10BaseT interface with the specifications according to IEEE 802.3i in such modes:

а) self-sufficient data transmission between user and server without transmission of service bites through the channel;

б) bridge, including the data transmission by power lines reservation mode with the switch speed of no more than 3s, if the outer high-speed channel is lost;

в) router.

Max data transmission speed in the modes above (including service bites in bridge and router modes) corresponds to 1.3.1.1.

When you connect the far channel ending to the serial joint of outer device according to protocol of RNS IEC-60870-5-101, data translation is carried out on the nearest ending from protocol according to GOST К МЕК-60870-5-104 to protocol according to GOST К МЕК -60870-5-101 and back.

1.3.2.6 Data transmission reservation (including batched transmission) is carried out according to GSM when the main power line channel is lost.

1.3.2.7 TM and DT signals delay time between interface endings is no more than 100 ms, when passing through multiplexor is no more than 110 ms.

1.3.2.8 Within the limits of DS organized by one modem:

а) simulcasting of signals from several data sources is carried out. Maximum number of sources is 7;

N o t e – additional useful speed expenditure (1.3.1.1) to the maintenance of each DT source beginning from 2nd is 700 bps.

б) in the case of absence of data from the DT source and if the line in TP channel with 2-lead LF ending redistribution of useful speed (1.3.1.1) is made for increasing of the signals transmission speed from other DT sources according to 1.3.2.2 and 1.3.2.4;

в) when the useful DS speed is not enough because of adaptation step (1.3.1.1) lowering, data sources will be deactivated taking into account the priorities defined by user and set programmatically.

1.3.2.9 TP channel transit is carried out through the RS232C interface without quality loss with the increase of total delay time of no more than 100 ms for one relay operation.

1.4 Technical specifications of monitoring, registration and signalling system

The equipment provides a system for monitoring the status of equipment and channels with a chronological fixation of the events in NVRAM (Non Volatile Random Access Memory). There is a remote access available for the monitoring system.

1.4.1 *General specifications of the monitoring system*

1.4.1.1 The time Information of the detected events comes from the clock of the equipment with discreteness of 1 ms. Optional time correction capability is provided: via the GPS/GLONASS or via NTP protocol with accuracy of 1ms also, there is a capability of synchronization between devices via the technological channel (1.4.1.3) which can be initiated by slave unit with the accuracy of 5ms.

1.4.1.2 The maximum number of entries in the event logs is at least 1000. In case of overflow, subsequent entries are replacing the first ones.

1.4.1.3 The monitoring, control, time synchronization(1.4.1.1), list of events, test results in the units information is exchanged between the terminals through the technological channels:

а) in the equipment with an FDM through the PF signals with a speed of 100 bps, or through the dedicated FSK modems from 1 to 3;

б) in the equipment with TDM (time-division multiplex) via the additional data channel dedicated in the DF (digital flow) with the speed of 600 bps (or higher);

в) in the equipment with the low-frequency ending via RS-422 interfaces with the speed of 100-1200 bps.

1.4.1.4 The data exchange between equipment monitoring, registration and signaling system and APSC (Automatic Process Control System) of the power facility is executed per protocol:

а) RNS IEC 60870-5-104; at the same time, equipment supports the exchange mode with time marks included in the settings;

б) SNMP; at the same time, equipment is capable of automatic generation of MIB parameters database.

Communication between the APSC (automated process control system) and equipment installed at the facilities, is conducted via the technological channel of the equipment according to the 1.4.1.3.

1.4.2 ***Specifications of the equipment's and channels' condition supervision***

1.4.2.1 Constant monitoring of the HF (high-frequency) path, equipment's and channels' condition and is provided according to the table 1.16. The equipment provides three types of hardware and channel alarm status, which is displayed by indicators on the front panel of the hardware block: normal state, warning (W) and emergency (E) signal of out-of-specification condition.

Chart 1.16 Controlled parameters, logged events, indication and signaling

Controlled parameters	Registered condition		Block name, description of the indicator (color, light characteristics)	Time delay for the outer signalization of the CMSU
	description	type		
1 High-frequency path attenuation	Attenuation beyond the lower/upper limit	W	SPU, READY (green intermittent)	< 10 s
2 The state of the telephony channels with FDM (with the presence of PF)	PF loss or increased attenuation above the software limit of the AGC	E	SPU, READY (red, continuous)	< 10 s
3 State of telemechanic channels with FDM	The disappearance of the characteristic frequencies of FSK modem	E	SPU, «TM[1…3] RX» (red, continuous)	< 10 s
4 State of the DS with TDM	The degree of adaptation (QAM) is below a specified limit	W	SPU, SYNCHR (green intermittent)	< 10 s
	Synchronization loss	E	SPU, SYNCHR (red, continuous)	< 10 s
5 State of the GSM channel	Missing or weak cellular signal, GSM module malfunction	E	CMSU, GSM (red, continuous)	< 10 s
6 State of the E1 channel	Synchronization loss	E	CMSU, «E1» (red, continuous)	< 10 s
7 Quality of GPS/ GLONASS signal receive	Missing or weak level of receive from the satellites	W	CMSU, GPS (yellow, continuous)	< 10 s

8	External power supply presence	Loss of one or several external power supply units (but not all of them)	W	PSU (Power supply Unit), « AB (accumulator battery) 48-60V» (light is off) «~110-220V» (light is off)	< 10 s
		Complete loss of external power supply units with the presence of internal accumulator battery2	E	БП, «АКБ 48-60V» (light is off) «~110-220V», (light is off)	10 – 15 s
		Shut down	E	All units' LEDs off	0 s
9	PA (power amplifier) condition	Power amplifier's temperature is above the limit (et al.)	W	PA (power amplifier) FAILURE (red, intermittent)	< 10 s
		Failure in the PA (power amplifier)	E	PA (power amplifier) FAILURE (red, continuous)	< 10 s
10	Quality of the information exchange between CMSU) and PA (power amplifier) unit	Disruption of the information exchange between CMSU and PA (power amplifier) unit	E	CMSU «NORM / EMERG» (red, continuous)	< 10 s
11	Quality of the information exchange between CMSU and signal processing unit	Disruption of the information exchange CMSU and SPU (signal processing unit)	E	CMSU «NORM / EMERG» (red, continuous)	< 10 s

Notice – full list of conditions given in book 3 chapter 2 of operating manual NMATs 460516.001 OM1.3.

[1)] Usually displayed to the Dispatching and technological management service

[2)] Switch to power from the internal accumulator unit for the duration set in the 1

Normal working process of equipment units and channel is accompanied by the indication «NORM/EMERG» (green, continuous) and by absence of «WARN» indication on the CMSU (state operation and supervision unit) front panel.

The appearance of failures in the units is accompanied by a change of indication on the front panel of CMSU and by informing the external alarm with the warning and alarm signals with the time delay according to the table 1.16:

– in case of the warning state in the unit and at absence of failures - ‘WARN’ indication (yellow continuous) and ’ WARNING’ signal;
– in case of failure in the unit - «NORM / EMERG» (red, continuous) and ‘WARN’ (yellow continuous) indication and the «FAILURE + WARNING» signal;
– in case of disruption of the information exchange between units - «NORMAL / FAILURE » (red, continuous) indication; in case of absence of warning signals – absence of the ’WARNING’ indication and presence of the ‘EMERG’ signal.

In case of change in units’ state, information is transferred to the external alarm and memorized until the end of abnormal situation.

Registration of date and time of occurance of the warning state and failure situations and time of their resolving is provided in the NVRAM (*Non Volatile Random Access Memory*) of unit, according to the table 1.16.

1.4.2.2 Results of power transmission line attenuation measurements are displayed to the current loop interface in modes «TM 0-5 mA», «TM 4-20 mA». Inaccuracy of conversion of power transmission line attenuation measurements to the current is below ± 0,2 mA.

1.4.3 ***Alarm system characteristics.***

1.4.3.1 Output alarm circuits of the CMSU commutates constant voltage above 250 V and amperage above 0.03A.

1.4.3.2 Equipment provides operation of digital input technology channel to monitor status of 9 potential-free contacts, connected to the supervisory system. Output relay contacts of potential-free contacts state alarm system should commutate voltage of 24V and amperage not above 170 mA.

1.4.3.3 Equipment provides opportunity for organizing technological “voice communication” in telephony programmed channel. Signal level on high frequency output is corresponds to the level of the operating channel. Volume and sensitivity can be regulated within ± 6 dB with the step of 1 dB

1.5 Software and human-system interface characteristics

1.5.1 ***General software and human-system interface characteristics***

1.5.1.1 Management of equipment modes, setting its parameters, viewing monitoring data and events information is performed with PC via specific IP address of local area network. Software acces executed only by password authorized users; there are different types of software access:

а) administrator for full access (except factory settings);

б) DTMS (Dispatching and technological management service) operator for limited access to equipment settings with the ability to edit telephony, telemechanic and data communication equipment settings;

в) relay protection and automatic service operator for limited access to relay protection signals and emergency automation commands transmission/receive equipment settings;

г) attendant for viewing the settings of the equipment without access for editing.

Possibility of editing event logs and monitoring data is excluded. Only an administrator have access for deleting (complete cleaning) all the secured data.

1.5.1.2 Time elapsed from the moment the equipment is switched on to the beginning of its full operation (including software initial loading and initial blocks polling procedure according to 1.5.1.4) is below 3 min.

1.5.1.3 Time elapsed from the moment of software reboot after equipment failure to the begginning of equipment full operation is below 30 seconds.

1.5.1.4 4 Block's self-testing and parameters polling is conducted with time interval of 5s and followed by periodic glowing of the "POLL" (green) indicator on the front panel of CMSU (state operation and supervision unit) . In case of disruption of information exchange between blocks LED indication and alarm starts according to 1.4.2.1 (items 10, 11 table 1.16).

1.5.1.5 Current equipment state detailed information is showed on PC upon user request ("Control" page). After the alarm is triggered, the page displays information about the malfunctioning unit.

1.5.1.6 Controlled parameters are selectively monitored and the results are saved as a chart in the NVRAM(*Non Volatile Random Access Memory*). At the release, monitoring of the first channel carrier link attenuation, signal-to-interference (S-I) ratio, measured in the line of synchronous modem (if it is included in the configuration) is installed on the equipment.

Note – Signal Noise Rratio (SNR) is normalized in the line of 4 kHz, interference charachteristics – 'white' noise.

The equipment provides the possibility of arbitrary selection of 10 monitored parameters for simultaneous monitoring.

1.5.1.7 The current parameters of the device are stored and changed in NVRAM. The possibility of arbitrary storage of 10 different configurations of equipment with probability of quick change of current configuration is provided

1.5.1.8 The user actions log with a minimum of 60,000 entries is kept . In case of overflow, subsequent entries are replacing the first ones. Log can't be edited or cleaned.

1.5.1.9 Monitoring data, event log, user activity log, local device configuration are stored on the PC so that it can be viewed separately from the equipment.

1.5.2 ***Specifications of the software and human-system interface devices with transmission/ receive of telephony, telemechanic, data communication signals***

1.5.2.1 The equipment provides the operation of built-in test generators:

а) high frequency sine-wave generator , connected to the high frequency end, frequency range determined by the operating strip of signal processing unit. A step of frequency setting is 1 Hz, accuracy - according to the 1.1.16, signal level according to the 1.1.6 and 1.1.7 a step of setting is 0.1dB;

б) low-frequency sine-wave generator ranging from 100 to 3900 Hz, connected to the fourth or second wired ending. A step of setting is 1Hz, accuracy of frequency setting according to the 1.2.11, maximum signal level is 6dBm on fourth wired ending and minus 5dBm on second wired ending, a step of setting is 0.1dB;

в) white noise jammer with the frequency range from 100 to 3900 Hz with a width of at least 300 Hz, connected to the fourth wired ending. A step of setting is 1Hz maximum signal level is 3dBm a step of setting is 0.1dB;

г) speech generator (male and female), connected to the fourth or second High frequency wired ending: signal in the form of the first eight text phrases according to the RNS (Russian National Standard) 50840 (annex D, table D1) with looping; with a width of at least 1700 Hz and frequency range from 100 to 3900 Hz, adjusts in range from minus 30 to 10 dBm0 in steps of 0.1 dB;

д) Square-wave generator with filling factor of 1/8, 1/4, 1/2, 3/4, 8/1 (the ratio of pulse length and pulse period 1:7, 1:3, 1:1, 3:1, 7:1) with a speed of package transmission from 30 to 230 400 bit per second, with a step of adjust of 1 bit per second, pseudorandom sequence signals transmitted to the in-built modem as telemechanic signal source or interface output according to the table 1.12.

Note – test generators are not measuring instruments.

1.5.2.2 The DS (digital stream) diagnostics mode, which can be enabled in the settings, for counting the number of transferred/received bait and error rate.

1.6 Power supply charachteristics

1.6.1 The equipment meets the requirements of technichal specs when powered by AC with characteristics:

а) nominal voltage of 220 V with pass-off standard from plus 10% to minus 15%;

б) nominal frequency of 50 Hz with pass-off standard of ± 5 %;

в) sinusoidal waveform withdistortion factor below 10.

1.6.2 The equipment meets the requirements of technichal specs when powered by DC with characteristics:

а) nominal voltage of 220 V or 110 V with pass-off standard from plus 10% to minus 20%;

б) flicker below 10%.

1.6.3 Conducted emissions, measured at the input terminals of the instrument power pack, when powered from a DC power supply, are below psophometric 3mV.

1.6.4 The equipment meets the requirements of technichal specs when powered by external accumulator unit with Nominal voltage of 48 V or 60V and pass-off standard from plus 10% to minus 20%.

1.6.5 In case of loss of external power supply, equipment automatically switches to the internal accumulator unit power supply without loss of functioning quality. Herewith, signal transferred to the signal curcuit, according to the 1.4.2.1 (table 1.16, paragraph 8).

The equipment works according to the requirements of technical specs when powered by internal accumulator unit for a certain time period:

а) 10-15 seconds for a device that organizes the transmission/receive of DS (discrete signals) and relay protection signals and emergency automation commands, with disabling (locking) of internal power supply circuits after 30 seconds if external power supply is abscent for more than a 40-45 seconds (automatic disabling after 40-45 seconds of complete external power supply loss));

б) not less than 10 min for a device that transmits/receives only the telephony, telemechanic signals and data from electric main;

в) not less than 120 min for a low-frequency endings device.

1.6.6 At normal power supply regime internal accumulator unit is automatically charged.

2 . The structure and operation

The equipment is built on functional-block principle, consists of two or more devices, installed on the substations, which are connected to each other via electric main. It is possible to organize transmission/ receive telephony, telemechanic signals and data from electric main and copper line to a remote substation object with the allocation of signals at the intermediate point.

Connection schemes of various types of equipment devices, are provided with their completeness of set (the composition of the blocks), represented in the manual. Typical connection schemes are listed in manual 1.2.

N o t e – If equipment has the ability for transmission/ receive discrete command signals of relay protections and emergency automation, then it is possible to organize a channel via electric main or optic fiber, with the allocation of command signals at the intermediate point.

2.1 Functional diagram of AKST-C

Figure 2.1 shows block diagram of the device in complete setup.

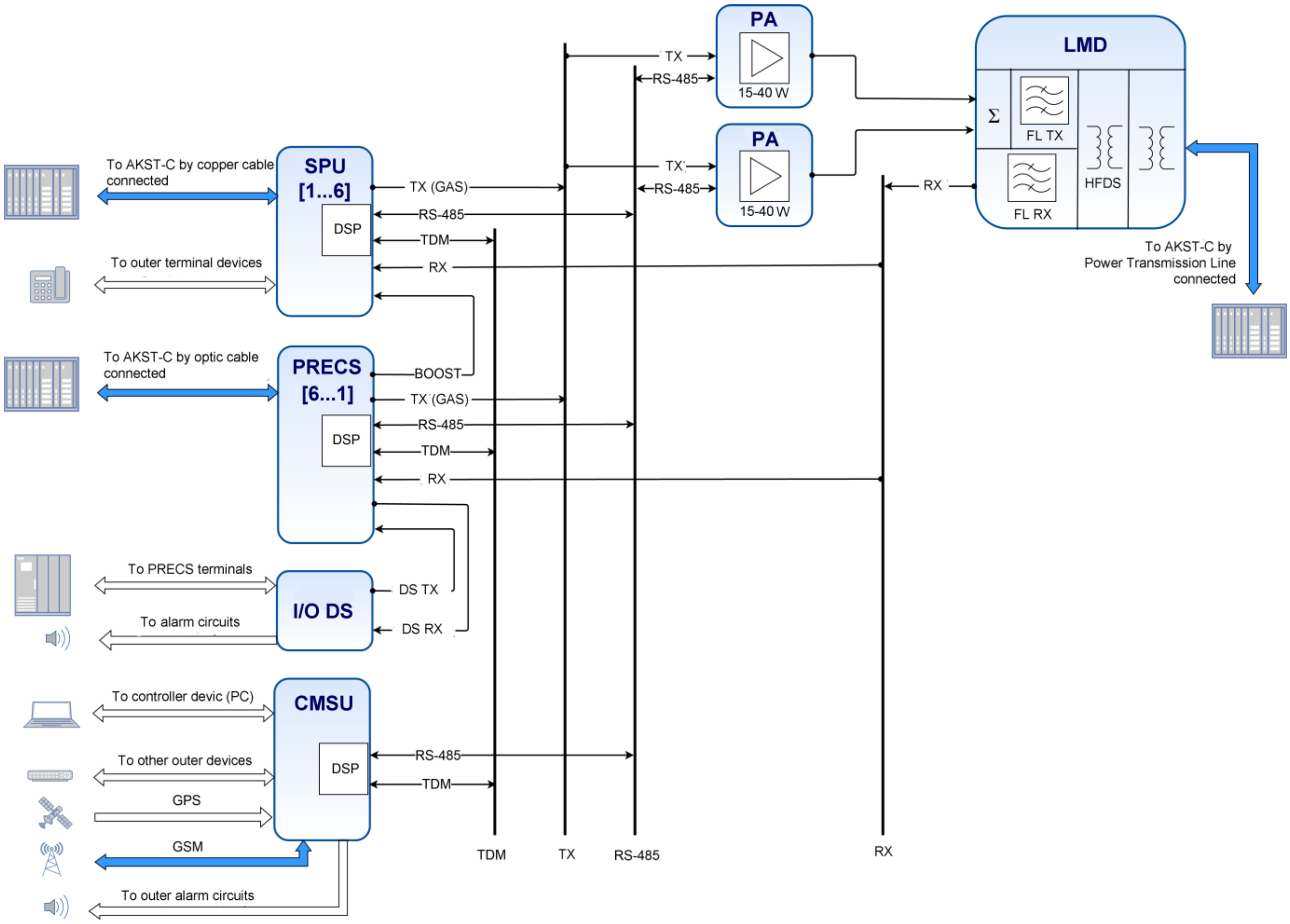

Figure 2.1 shows block diagram of the device in complete setup

Voice signals from subscribers are received by the four-wire or two-wire port of signal processing unit. Signals from four-wire and two-wire interface port are converted to digital form and then sent to the DSP-processor (digital signal processor), which performs the conversion of telephony signal. Telemechanic and data communication input waveforms are also converted to the digital form.

In the transmission path, Telephony, data communication and telemechanic signals are formed into GDS (group digital signal). Then group digital and PF (Pilot Frequency) signals are formed into combined low-frequency signal of the appropriate level, which is then converted to a modulated signal, then in a group analog high-frequency signal with a width of 4, 8, or 12.0 kHz.

In the transmission of discrete command signals, selective channel disconnection is possible (including full channel disconnection). Degree of importance of each channel is set before the start of equipment exploitation.

During transmission of command, TDM (time-division multiplex) channels interruption renews in less than four seconds.

From the signal processing unit output, group analog signal is transferred by the serial bus to the input of PA (power amplifier) units.

Command signals in the relay protection and emergency automation block are formed as well as in the signal processing unit, which are also transferred to the PA (power amplifier) blocks input.

In the PA (power amplifier) unit, group high-frequency signal is amplified, and then transferees to the LF TX (linear filter of transmission), located in the LMD (linear matching device) unit.

Linear matching transformer, LF RX (linear filter of receive) and LF TX (linear filter of transmission) are located in the LMD (linear matching device) block.

Group high-frequency signal is transferred from the LF TX (linear filter of transmission) output to the primary side of linear matching transformer, then high-frequency signal from secondary winding of linear matching transformer transferred to the communication line.

Linear matching transformer is designed for matching output resistance, separation of transmitted and received high-frequency signals by transmission and receive paths. In the receive path , high-frequency signal is transferred to the input of the LMD. In the LMD receive path signal is transferred to the LF RX (linear filter of receive), whereas same as in the LF TX (linear filter of transmission), the electrical impedance of high-frequency communication equipment is unbinded . Moreover, carrier frequencies level of the own transmission path is weakened in the LF RX (linear filter of receive). The distribution of a high-frequency signal at the inputs of signal processing unit and relay protection and emergency automation blocks is produced by bus receive.

If the location of operating frequency’s adjacent LF RX (linear filter of receive) and LF TX (linear filter of transmission) are connecting to the hybrid set.

In the SPU (signal processing unit) receive path, channel associated high-frequency signal is inverse transformed and shifted into vocal frequency spectrum. From the LF RX (linear filter of receive) output high-frequency signal is transferred to the ADC (analog-digital converter), where it converts into digital form for further conversions in the digital state. All digital conversions are performed in the DSP-processors. Total VF signal is transferred to DAC (digital-analog converter). After that, the signals are amplified, conformed with the output resistance and transferred to the subscribers through the appropriate output connectors . Command signals, which are received by the relay protection and emergency automation block are transferred through the discrete signals input/output unit to the execution devices.

2.2 Power supply

2.2.1 The units indicated in the diagram of figure 2.1 as a part of the equipment device (except for equipment with the low-frequency ending) are powered by the two independent power supplies that provide 100% hot standby power. Power supply unit is based on the AC/DC power supply module with input AC voltage from 85 to 264 V, 50 Hz and output DC voltage 48 V for other units of the device.

In addition, there is a supervising circuit for output voltage, which forms signal of power presence for the CMSU.

2.2.2 At the customer's request, the equipment can be equipped with an internal accumulator battery, with nominal voltage of 36 V and a capacitance of at least 0.8 a/h, which will ensure the normal functioning of the channels with 1.6.5, 1.6.6. characteristics in case of external power cutoff.

2.2.3 Secondary power supply units, used in other blocks, are converting the input DC voltage of 48 V into the voltage needed to power the various component parts of the units.

Note – power supply units are comply with the standard for EMI emissions EN55022, Class a and FCC, level a, safety certificate UL/UL 60950, IEC/EN 60950.

2.2.4 Switching on / off of equipment devices consists of voltage supply / termination of voltage supply to the internal power supply circuits of the PA (power amplifier), LMD (linear matching device) , SPU (signal processing unit), CMSU et al. from the primary power sources, including internal power supply units.

3 Description and functioning of integral parts

This section contains a general description of the components of the equipment (except relay protection and emergency automation and discrete signals input/output unit) and information about their purpose and from what smaller parts they consist of.

Similar information about relay protection and emergency automation and discrete signals input/output unit is listed in OM2.1

Electric circuit of the blocks' interface termination connection (NMATs.465419.001 E5, NMATs.465419.002 E5, NMATs.465419.006 E5) to the communication lines and external equipment is included in the set of operational documentation, provided with each equipment device. The pin assignment for different types of blocks is given in the installation, start-up, regulation manual. Information about the physical location of the parts is given in manual.

3.1 SPU (signal processing unit)

3.1.1 Block scheme of the SPU (signal processing unit) presented in accordance with figure 3.1.

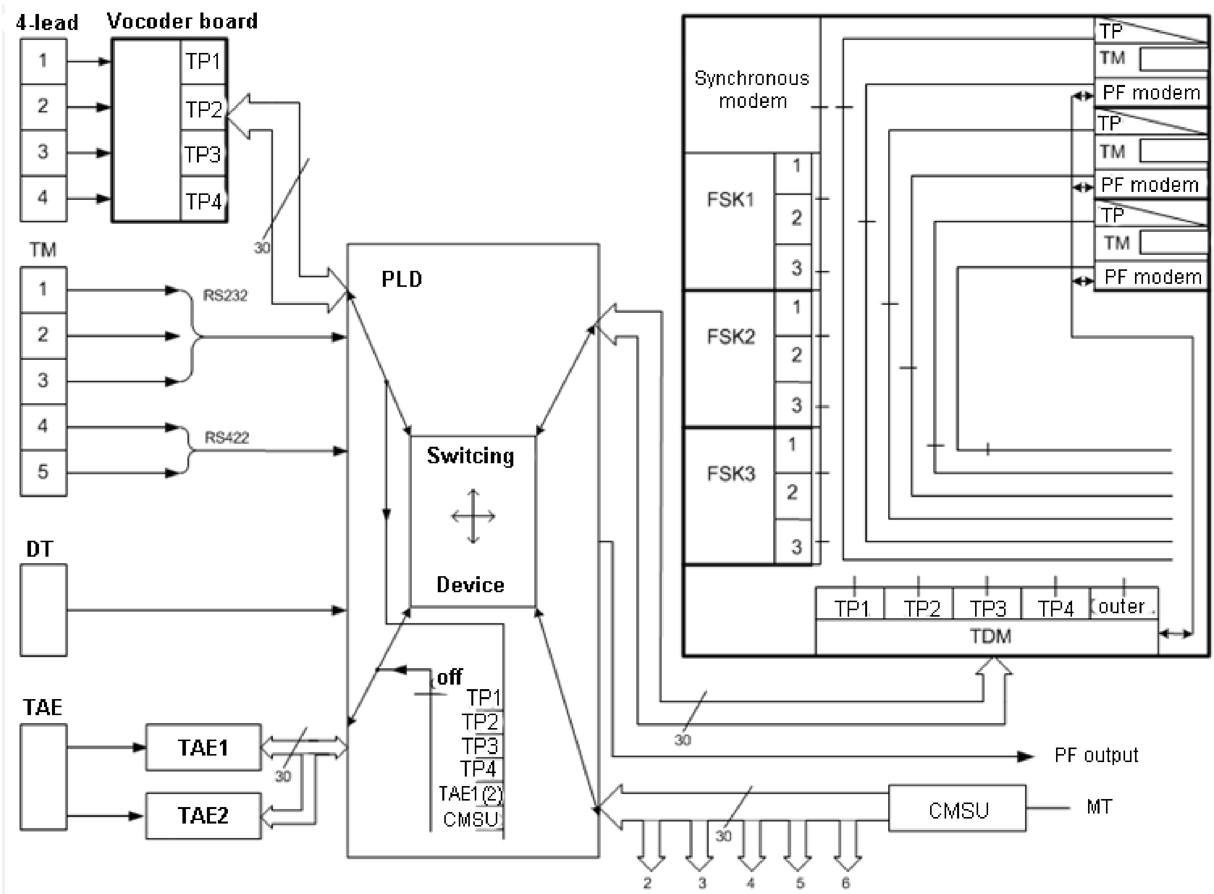

Figure 3.1 Block scheme of the SPU

Scheme of the SPU (signal processing unit) is made on programmable logic chips and signal microprocessors.

All necessary transformations of low-frequency signals and their further transfer to high-frequency spectrum with formation of nominal level group analog signal for its further its transfer to the PA (power amplifier) input are performed In the SPU (signal processing unit) transmit path . Reverse conversions are performed in the receive path. All transformations are based on signal microprocessors and performed in digital form. Operation management and control of the SPU (signal processing unit) are performed by the software using CMSU (state operation and supervision unit), with which it is connected by an internal data bus.

The following functions are performed in the SPU (signal processing unit):

- amplitude keying with one side band with direct digital synthesis;
- scheme of software and equipment status observation;
- pilot frequency signal generation and processing with the possibility of its use as a technology modem;
- signals quality observation;
- measurement of amplitude-frequency characteristics and its alignment;
- series port for connection with other data transmission equipment.

Direct digital synthesis method, which is used to obtain group analog signal, ensures the quality and stability of LF-HF and HF-LF transformations, which are easily programmatically configurable

QAM-modulation is an accepted algorithm of transformation of digital stream into analog form

The SPU (signal processing unit) can work both in analog and digital regimes and organize the channels with a nominal bandwidth of 4, 8 or 12 kHz

At nominal bandwidth of 8 or 12 kH z the number of connectable devices is not changed, combinations of organized channels vary.

SPU (signal processing unit), as part of the low-frequency end, works as follows:

- when this configuration is installed through the management system, performs the docking function between the standard low-frequency channel, any channel-forming equipment, FSK modems of any available configuration, synchronous modem, TAE (telephone automatic equipment);
- any modem of any manufacturer with this type of modulation can serve as a counterpart for FSK modems;
- TAE (telephone automatic equipment) can be connected to the equipment of any manufacturer supporting the double-frequency signaling protocol, for example LDAPSCE;
- the signal from the four-wire analog path is transferred to any control system selected input/output telephony connector of the «4 WIRE» block. Then the digital signal is filtered and commutated to the required directions, modems and TAEs (telephone automatic equipment) (if they are presented in a complete set and in a configuration);
- RS-232C and RS-422 interfaces can both be a digital signal of an FSK modem, the choice of interface type and number is determined by the control system;
- one SPU (signal processing unit) can work along with one, two or three pilot frequency channels;

– FSK modems are set in each VF channel. Number of input/output interfaces: RS-232C – 4; RS-422 – 2; if 3 × 100 bps mode is necessary, then the total number of interfaces is 9 in all three VF channels with one RS-232C interface. This is possible only if 3 SPU are set (one SPU per one channel).
– The number of TAE may be up to 2 per one SPU.

There are slots for connection of TP, TM and DT sources and two-color signal indicators (red-green) on the front SPU panel. Slots functions:

– 4-lead – up to four 4-lead speech channels (up to three analog channels and up to two digital channels) or up to four channels with characteristic frequency of outer modems;
– “TAE1/TAE2” -- up to 2 2-lead TP channels; DC (dispatch channel), ID, BC and ID buttons, ATE connecting lines of the 1st (3-lead with ORCL/IRCL protocol) and the 2nd (2-lead with FXO/FXS) types are brought to this connector;
– MODEMS – up to 5 FSK modems with RS232C or RS422 joint from outer telemechanic in digital form and one DT channel with the speed of 19,2 kbps with RS422/RS485 joint;
– “RS232” – one DT channel with the speed of up to 19,2 kbps with full RS232 joint or one TM channel with the speed of up to 9,6 kbps or two digital TP channels for relay operation.

Each unit requires only outer device which maintains the present channel working mode.

Designation of contacts in SPU connectors are given in interconnection, start and control manuals.

Indicators designation:

1) READY:
   – green light is on when PF level is nominal, operating level is ± 0,5 dB;
   – green light is blinking when PF level is out of set limits;
   – red light in the absence of PF signal;
2) AGC:
   – green light is on – AGC mode is on;
   – light is off – the TDM mode without PF is on;
   – red light is on – the mode of manual gain control (MGC);
3) SYNCHR (used in TDM mode):
   – green light is on – synchronization is alright, DS speed is no lower than set limit;
   – green light is blinking - DS speed is no lower than set limit;
   – red light is on – no synchronization;
4) “TP1”-“TP4”:
   – green lights are on – corresponding TP channel is included in signal processing;
   – blinking in test mode;
5) “TAE1”, “TAE2”:

– green light is on when corresponding TAE is connected to TP channel;
– blinking when the line is occupied.

6) “TM1 TX” - “TM3 TX” – green light is blinking to the beat of data transmitted to the carrier line link from TM equipment;
7) “TM1 RX” - “TM3 RX”:

– Green lights are blinking to the beat of data received from the carrier line link to TM equipment;

– Red light is on when the signal is lost and the level of receiving is low in present channel.

8) TX – green light is blinking to the beat of data transmitted to the carrier line link from DT equipment;

9) RX – green light is blinking to the beat of data received from carrier line link to DT equipment.

3.2 Telephone automatic equipment (TAE) circuit board

TAE is intended for different types of telephone switching equipment conjugation with 4-lead telephone communication channel. In the equipment TAE is implemented as an additional circuit board as a part of SPU. Up to 2 TAE may be connected in SPU; they are located one above the other. The lowest board is “TAE1”, the highest is “TAE2”. Connection of outer devices to the present boards is implemented through the common connector “TAE1/TAE2” which is located on the front panel.

Each TAE operates according to 2 protocols:

1) LDAPSCE;
2) Automatic communication of remote subscriber with ATE (SL-ATE).

TAE contains:

1) Conjugation device – interconnection line (IL);
2) CPU – processing unit (PU);
3) hybrid set (differential system).

TAE is connected through TDM channel according to figure 14.

TAE provides the levels of 0dB on the transmission and minus 7 dB on the receive from 2-lead ending side.

TAE implements working protocol of LDAPSCE and provides:

– two-side automatic communication between subscribers of two ATE with compilation of signals by interconnection lines (ATE-ATE);
– two-side communication between two dispatch switchboards (DS) without dialing with a possibility of connection to channel busy by other subscribers, and its forced release (DS-DS);
– automatic communication of DS with counter ATE, bypassing own ATE devices (DS-ATE);
– two-side communication between two intermediate departments (ID-ID);
– automatic communication of ID telephonist with counter ATE subscribers (bypassing own ATE devices) with a possibility of connection to channel, busy by other subscribers and its forced release (ID-ATE).

TAE contains CPU which has three functioning modes in LDAPSCE protocol and forms service signals of exchange between ATE:

– ATE does not connect to TAE;
– TAE connects with ATE of the 1st type (ATE1) which operates according to protocol ROIL/ RIIL through 3-lead IL;
– TAE connects with ATE of the 2nd type (ATE2) which operates according to protocol RSLO/RSLT through 2-lead IL. A mode is set though brazed jumper cable on the CPU.

Specified CPU working modes and possession of relevant switching equipment by consumer allows using TAE of LDAPSCE protocol in 3 options.

The 1st option. If both substations have DS and ID but do not have ATE, two-side connection between DS dispatcher (lines "A3" and "B3") and ID telephonists (lines "A4" and "B4") and the communication at the initiative of DS dispatcher with ID telephonist.

The 2nd option. If both substations have DS and ID, and interconnection lines of ATE1 (outgoing "A4"and"B4", incoming A2"" and "B2") are connected to them, such communication is provided:

– DS device A⇔DS device B;
– DS device A(B) → ATE device B(A);
– ID device A(B) → ATE device B(A);
– ATE device A⇔ATE device B.

When ATE-ATE connection is established, it is possible to connect DS dispatcher or ID telephonist to channel busy by ATE subscribers and its forced release is also possible.

The 3rd option. If both substations have DS and ID but ATE1 ILs are connected to only one device, for example to device A, then such communication is provided:

– DS device A⇔DS device B
– ATE device A⇔ID device B
– DS device A → ID device B
– DS device A → DS device B
– DS device B → ATE device A.

All the signals of exchange between devices of the equipment are formed programmatically when relevant signals from subscribers are received.

TAE operates with following functions:

– There is a priority DS-DS communication like in LDAPSCE with a function of ticker and cancelling using DS button with a straight DS-DS connection making. The dispatcher gets to counter ATE when using DS button.
– SL-ATE communication does not have a direction and may be implemented to both sides. The connection is fully simplex. If ATE/SL subscriber tries to call busy DS channel by counter ATE subscriber, he can hear "Busy" signal in his handset.

There is a possibility of calling frequencies of $\boldsymbol{f_1}$ 1200 Hz and $\boldsymbol{f_2}$ 1600 Hz forced transmission for checking TAE workability.

Structural TAE diagram of LDAPSCE type is specified on a figure 3.2.

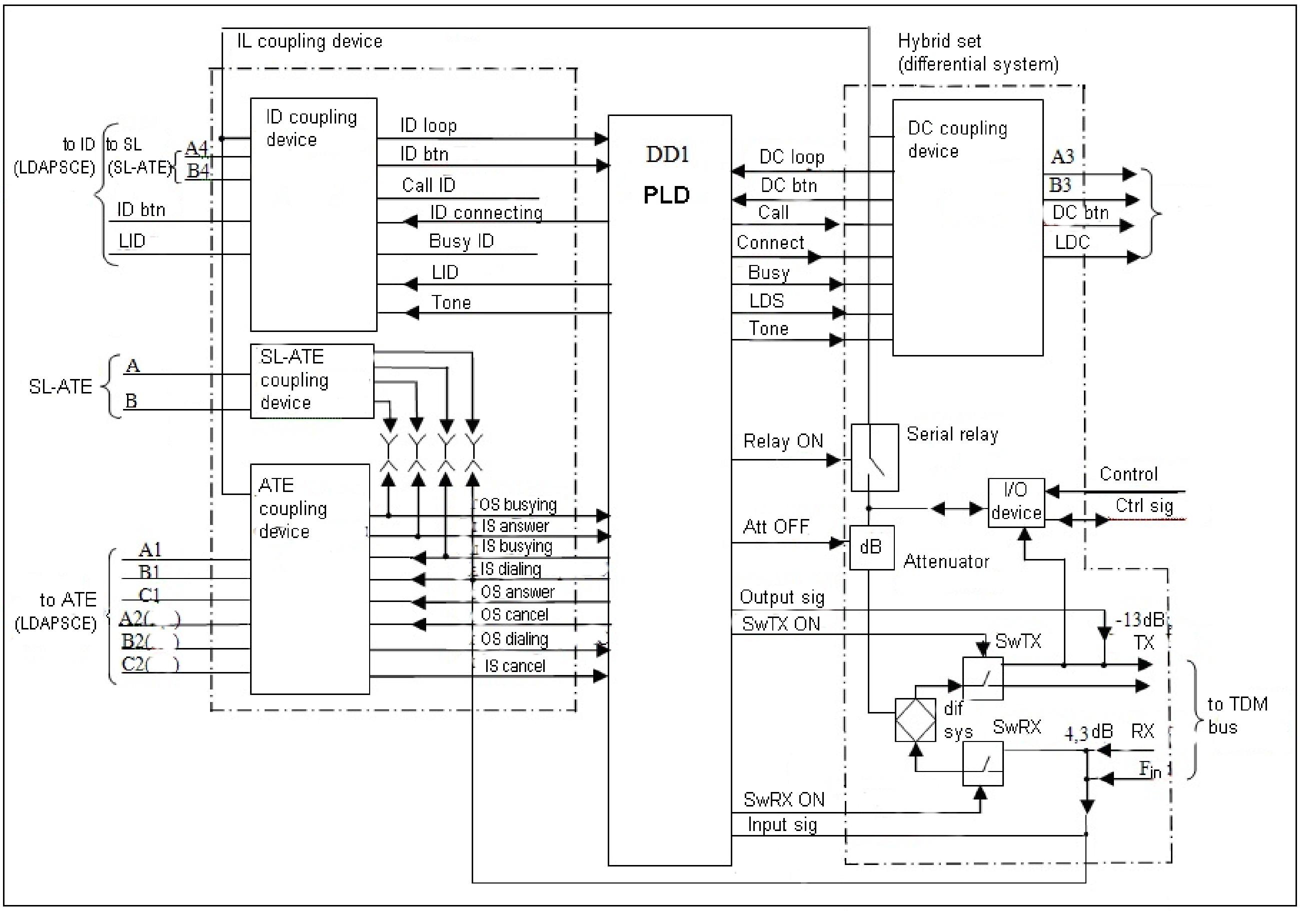

Figure 3.2 Structural TAE diagram

Wires “A4”, “B4”, LID and ID btn are connected to speech wires of ID interconnection lines relay set. The signaling of channel busying and ID permanence is transmitted through LID wire. ID btn wire is needed for sending “ground” while forced channel release from ID.

Wires “A1”,”B1” and “C1” are implemented for outgoing TAE busying from ATE1. Speech signal is transmitted if there is an outgoing busying of “A1” and “B2” wires..

Wires “A2”,”B2” and “C2” are implemented for incoming ATE1 busying from TAE. Speech signal is transmitted through wires “A2” and “B2” if there is an incoming busying.

Using of ATE1 interconnection line wires for signaling targets is specified in chart 15. TAEs connect with 4-lead communication channel by lines OUT TRS and IN RCV.

Chart 3.1 Using of ATE1 interconnection line wires for signaling targets

Connection type, operation	IL wire	Signal type	Transmission direction
Outgoing communication: Busying Dialing Subscriber’s answer Cancel from calling subscriber Cancel from called subscriber	 C1 B1 A1 C1 C1 or B1	 potential "+" before cancel impulses "-" impulses "+" t_i = 400 – 500 ms disconnection disconnection impulses "-" t_i = 400 ms	 ATE → TAE ATE → TAE TAE → ATE ATE → TAE TAE → ATE
Incoming communication: Busying Dialing Subscriber’s answer Cancel from calling subscriber Cancel from called subscriber	 C2/ A2/D1 B2/ or B2/ A2/D1 C2/ A2/D1 B2/	 potential "+" before cancel impulses "+" impulses "-" impulses "-" potential "+" before cancel or impulses "+" t_i = 400 – 500 ms disconnection disconnection potential "-"	 TAE → ATE ATE → TAE TAE → ATE ATE → TAE
Note: symbol “+” means grounded plus of power source of 60 V, symbol “-” means minus of power source of 60 V			

When there are connections of all types, all the logic control functions are implemented programmatically by CPU which is built on PLD base. Forming and decoding of control signals transmitted through the communication channel is also implemented here.

All the conjugation devices are implemented for both transformations of DS, ID, ATE and SL signals to logic level signals and reverse transformation. Besides, DS, ID and ATE conjugation devices contain relay schemes for the connection of one or another switching device (DS, ID or ATE) to 2-lead part of speech path.

Serial relay contacts are included to 2-lead path. The relay is implemented for the disconnection of path from 2-lead DS part in order to exclude distortions of dialing impulses. Besides, one more serial relay located in conjugation device (not specified on the diagram) is implemented for dialer output connection to IL of ATE during the dialing of each number figure.

Baseline of automatic equipment is waiting for a request for connection. The request may come from one of the conjugation devices (DS, ID or ATE) or from communication channel. TAE operating algorithm (if the channel is not busy) is specified on figure 3.3.

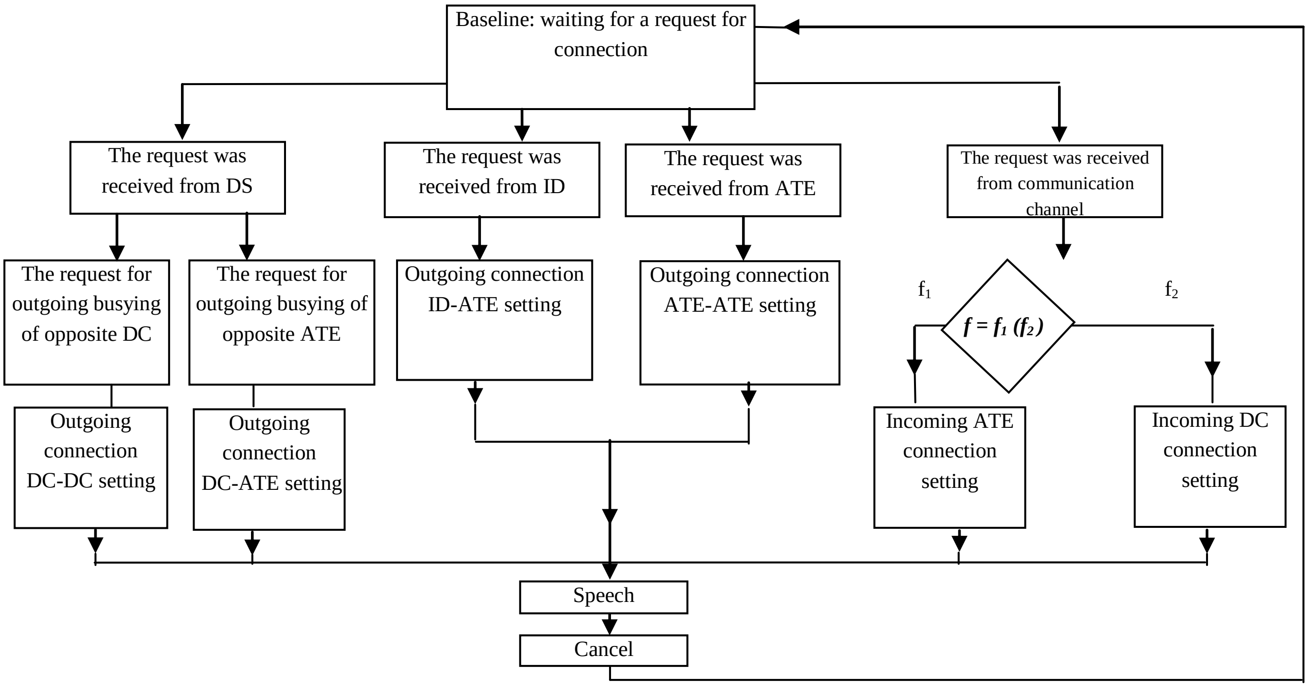

Figure 3.3 TAE operating algorithm (if the channel is not busy)

When connection's type is ATE-ATE (ATE1), TAE (of protocol LDAPSCE) operates the following way. Outgoing ATE subscriber is the initiator of connection setup. The signal "OS busying" comes from outgoing ATE to TAE. TAE transmits the impulse of counter ATE busying f_1 to the communication channel and turns on the receive part of speech path with signal "RxSwOn" in order to let the subscriber hear the station readiness signal.

Station readiness signal is a tone signal with a frequency of 425 Hz which is formed by counter ATE.

Incoming TAE (on the other side of communication channel) implements incoming busying of "own" ATE when receives impulse f2 from communication channel. Incoming TAE transmits "IS busying" signal to ATE and turns on the transmission part of speech path with signal "TxSwOn" in order to let the station readiness signal be transmitted from ATE to communication channel.

The subscriber of outgoing ATE dials when hears readiness signal. Dialing impulses come to CPU through “OS dialing” line. The CPU adjusts dialing impulses and transmits them through “Sign/out” line to communication channel as impulses f_1 with duration of 55 ms. The adjustment of dialing by transmission lies in the fact that impulse $f_1$1 is formed from the back front of input momentum. During the time of each number figure receive from ATE by signal “On SR” the serial relay turns on.

Dialing impulses f_1 get to input “Sign/in” of incoming TAE after passing the communication channel. Incoming TAE decodes dialing sendings, adjusts them and then transmits them to ATE through “IS dialing” line. The adjustment of dialing impulses is the adjustment of both impulse duration and pause duration in order to get optimal impulse coefficient.

Incoming ATE forms subscriber call signal after receiving the number. At the moment call sending control signal gets to communication channel from ATE. The signal is heard by calling subscriber. When called subscriber lifts the handset of a telephone, the signal “Answer IS” gets from incoming ATE to TAE. Answer signal is transmitted by incoming TAE as a impulse f_1 to communication channel. Incoming TAE turns on the receive part of speech path with signal “RxSwOn” after answer signal transmission.

Outgoing TAE forms the signal “Answer OS” after receiving of answer impulse f_1 in order to transit circuits preparation and then turns on the transmission part of speech path with signal “TxSwOn”.

Speech condition of communication channel is set.

Cancel is formed after the end of the call by the side where subscriber replaces the handset the first. If it happens on the outgoing side, then the sign of cancel for TAE is signal “OS busying” release. In this case TAE sends a cancel impulse $f_1 + f_2$ to communication channel and goes into the baseline.

TAE also goes to the baseline on the incoming side after receiving of cancel impulse $f_1 + f_2$. If the subscriber of the incoming side replaces the handset before another subscriber, the sign of cancel for the incoming TAE is receiving of signal “IS Cancel” from ATE. Incoming TAE sends cancel impulse $f_1 + f_2$to the communication channel and goes to baseline. Outgoing TAE forms signal “OS Cancel” after receiving of cancel impulse $f_1 + f_2$ in order to inform outgoing ATE about canceling, and then goes to baseline. The connection is cut off, the communication channel is free.

An initiator of connection setting is the subscriber of outgoing DS when there is a DS-DS connection. Busying of communication channel is implemented by receiving of signal “DS Loop” to CPU. It connects DS to 2-lead speech path by signal “Connect DS” and sends busying impulse of counter DS f_2 to communication channel. After that, RxCh receiving switch turns on by signal “RxSwOn”.

Incoming TAE forms signals “Connect DS”, “TxSwOn” and incoming DS “DS Call” calling signal after receiving impulse f_2. At the moment it sends call sending control (CSC) signal by “DS Call” signal through the “sign/out” line to communication channel. This signal is heard by calling subscriber. The signal “DS Loop” is received by incoming TAE after called subscriber answer. Incoming TAE stops call sendings and CSC and forms answer impulse f_2 on the “sign/out” line and also “RxSwOn” and “LDC” signals. Outgoing TAE turns on transmission switch by signal “TxSwOn” after receiving answer impulse f_1.

Speech condition of communication channel is set.

On the side where the subscriber replaces the handset first TAE releases all signals and sends cancel impulse $f_1 + f_2$to the channel after the end of calling. On the other side, after receiving of cancel signal from channel, TAE releases signals “Connect DS”, “RxSwOn” and “TxSwOn” and forms signal “Busy” by the line “Tone” and at the same time forms signal “LDC” to inform the subscriber about canceling. Signals “Busy” and “LDC” are sent until the “DS Loop” signal release.

If there is the DS-ATE connection, busying of counter ATE is implemented when signals “DS btn” and “DS Loop” are received by CPU. Dialing impulses come through “DS Loop” line according to DS speech wires loop break. If the call is canceled by ATE subscriber, outgoing DS receives signal “Busy” by “Tone” and “LDC” lines.

Connection of DS to busy channel is implemented by signal “Busy DS”. DS connects to speech path not directly (if the channel is free) but through the separating capacitors. Besides, in this case, CPU forms “Intervention” signal through the “Tone” line. This signal is sent to speech path through an amplifier on a board and listened by subscribers.

Busy channel drop is implemented if “DS btn” signal is received. In this case, CPU forms cancel impulse $f_1 + f_2$ to the communication channel and implements canceling for local switching device (ID or ATE) which was occupying the communication channel.

TAE operation with ID is implemented just like with DS but in this case the cancel is possible only for ATE subscriber. While trying to connect to busy dispatch channel, ID subscriber gets “Busy” signal.

If the communication channel busying is unproductive, TAE forms the cancel impulse $f_1 + f_2$ to the channel in a minute and then goes to baseline. The following situations are defined as “unproductive busying”:

– calling subscriber is dialing;
– called subscriber is not answering;
– false TAE busying from the channel side.

Service signal options formed by TAE are specified in chart 3.2.

Chart 3.2 Service signal options

Signal name	Signal options		
	Frequency, Hz	Duration, s	
		signal	pause
«Busy»	425±25	0,3 – 0,4	0,3 – 0,4
«Call» and «Call sending control»	425±25	0,8 ± 0,1	3,2 ± 0,3
«Intervention»	425±25	0,7	5

When TAE operates according to SL-ATE protocol, the connection is provided between ATE and subscriber who is connected to ATE through TMCCE communication channel. In this case, it is possible to set up SL ↔ ATE, DS ↔ DS and DS → ATE

Following functions by the subscriber:

– transmission of subscriber’s telephone loop;
– transmission of impulse dialing signals;
– giving an inductor call to subscriber.

Remote subscriber telephone connects to the line “A4”,”B4”.

Following functions by the ATE:

– giving the subscriber’s telephone loop to ATE;
– giving the dialing impulses to ATE;
– receiving of inductor call from ATE and its translation through VF channel.

ATE subscriber line connects to the line A, B.

When the remote subscriber is an initiator of connection, TAE operates according to following algorithm.

When subscriber answers a call, the signal “ID loop” is formed to outgoing TAE CPU, then CPU gives “busying” command and TAE connects the subscriber to 2-lead speech path, sends busying impulse of ATE SL to communication channel and then receiving path turns on by “RxSwOn”signal.

On the receiving side (ATE) CPU of the incoming TAE gives the command “IS BUSYING” when “BUSYING” impulse is received; incoming TAE closes the ATE SL loop, gives the signal “IS ANSWER” and also forms the signal “TxSwOn”. Then the CPU sends busying impulse through the “IS ANSWER” signal to the communication channel.

Outgoing TAE turns on TxSwOn switch when receiving busying momentum. Remote subscriber receives station answer signal from the ATE and implements dialing. During the dialing Tx switch turns off.

While one-frequency dialing, dialing impulses are transmitted to the CPU through the ID LOOP line. After a logic processing, the CPU forms impulses f = 1200 Hz to the communication channel trough the SIGN.OUT line. Incoming connection dialing impulses are received on the ATE side to the SIGN.IN input of incoming CPU, which gives them to ATE after processing of dialing sending through the line IS DIALING.

After getting the number, ATE forms call signal of own ATE subscriber and sends CSC signal to outgoing TAEs. Called subscriber lifts the handset.

Speech condition of remote subscriber – ATE subscriber channel is set.

TAE operates with following functions:

- There is a priority DS-DS connection same as in the LDAPSCE with a function of ticker and cancelling by DS button with a straight DS-DS connection setup. When dispatcher uses DS button, he gets to counter ATE.
- SL-ATE communication does not have a direction and may be implemented to both sides. The connection is fully simplex. If ATE/SL subscriber tries to call busy DS channel by counter ATE subscriber, he can hear “Busy” signal in his handset..

Working mode of TAE is set on a manufacturer according to order sheet.

The signal “OS BUSYING” comes from ATE to outgoing TAE. TAE sends busying signal to the communication channel and turns on Rx switch.

CPU of incoming remote subscriber TAE gives commands “ID Call” and “TxSwOn” by busying signal.

Remote subscriber lifts a handset, ID loop gets closed and CPU of the incoming TAE receives “ID LOOP” signal. Through the present signal CPU gives “ID CONNECTION” command for its TAE and “ID BUSYING” in the communication channel.

ATE CPU gives the command to its TAE of Tx switch turning on after receiving “ID BUSYING” signal.

Speech condition of ATE subscriber – remote subscriber channel is set.

If the remote subscriber does not lift the handset and ATE subscriber replaces the handset, then in 6 seconds after finishing the call ATE CPU gives “CANCEL” command to the channel and goes to baseline.

The equipment provides speech telephone channels with an asymmetrical connection: 2-lead connection using TAE on one side and 4-lead connection to ATE on the other side. In this case 4-lead ATE signals are translated unchanged through the channel, so using LDAPSCE protocol from the present ATE side is necessary. The same requirement is made in the case of symmetrical 4-lead connection to TP digital channel.

3.3 Power amplifier (PA) unit

Technical specifications:

- effectively transmitted frequency band is ranging from 16 to 1000 Hz;
- maximum effective one-frequency signal transmission power is 40 W;
- AFC in frequency range from 16 to 1000 Hz is rectilinear with a flatness of 4 dB relative to amplifying on a frequency of 32 Hz;
- consumed current must be no more than 2 A under the maximum load.

PA unit has estimated input and output resistances in order to provide given inconsistency damping in the working frequency range on a HF output for transmission path.

Using of two PA units operating in parallel provides maximum power because of its summarization in LMD unit while retaining coordination with HF path and hot redundancy in case of emergency of one of them. While operating from one PA unit, signal level on a HF output decreases by 6 dB.

In the case of aberration of controlled values, supply volt circuit of source turn off and EMERG indicator lights up on the front panel and the signal “EMERGENCY” is transmitted to control system. If the input voltage is within normal parameters, control system transmits the signal “NORM”, EMERG indicator is turned off. If the EMERG indicator blinks, that means warning condition.

PA unit management and control is implemented by software using CMSU. They are connected through the inner data bus (RS485). Additional information about PA unit condition is given in OM1.3.

3.4 Lineal matching device (LMD) unit

LMD unit is implemented for the coordination of transmission and receive path of device with a line. It consists of summing transformer, transmission filter, matching transformer, hybrid transformer and receive filter. Besides, LMD unit contains built-in loads of 60 W (no more than 10 min) to 75 and 150 Ohm.

Summing transformer is implemented for signal consolidation of two PA to the transmission path.

Transmission filter (TRM FL) and receive filter (RCP FL) are implemented for uncoupling of HF communication (through PL) equipment apparent resistance, connected in parallel to the same line and operating on different channel frequencies.

Matching transformer is implemented for coordination of output device resistance as a part of equipment with connection device to the line if there are single-phase and dual-phase hookups.

Hybrid transformer is implemented for output signal deduction from receive path when frequencies are located adjacently and closely.

Technical specifications of filters:

1) used frequencies ranges from 16 to 1000 Hz
2) width of a working frequency passband of 4 kHz × n, where n = from 1 to 12 (according to the number of basic equipment channels);
3) damping in the working frequency passband for TRM FL is below 3 dB, for RCP FL is no less than 20 dB;
4) FRC damping flatness in the working frequency passband is below than 0,5 dB;
5) inconsistency damping from input side relative to active resistance of 75 Ohm is no led than 12 dBБ.

Each filter is a passive bipolar device which consists of one or several resonance circuits connected in parallel with individually set frequency passband.

Each resonance circuit consists of coils and capacitors set. Setting for the given frequency and frequency passband is implemented by setting of estimated inductance values using serial connection of coils and capacity of serial-parallel capacitors connection.

Transmission filter with the frequency passband of 4-16 kHz is set according to single-circuit scheme; with the frequency passband of 20-48 kHz is set according to double-circuit. Receive filter may have from 1 to 4 resonance circuits.

There is a port marked as CONTR HF on the front panel of LMD unit. This port is connected in parallel with lineal output through a powerful resistor of 100 Ohm, in which signal level is controlled relative to a body during the commissioning and preventive operations. Signal level understatement in the CONTR HF port (on the load of 75 Ohm) is 11 dB.

LMD unit provides input resistance of 75 Ohm if the connection is asymmetrical and 150 Ohm if the connection is symmetrical. Input resistance adjusts from 18 to 210 Ohm if the connection is asymmetrical and from 65 to 210 Ohm if the connection is symmetrical to provide an optimal coordination with the line. Switching and adjustment are implemented by transposition of jumping cables according to method specified in OM8.

The diagram of LMD lineal part according to figure 3.4.

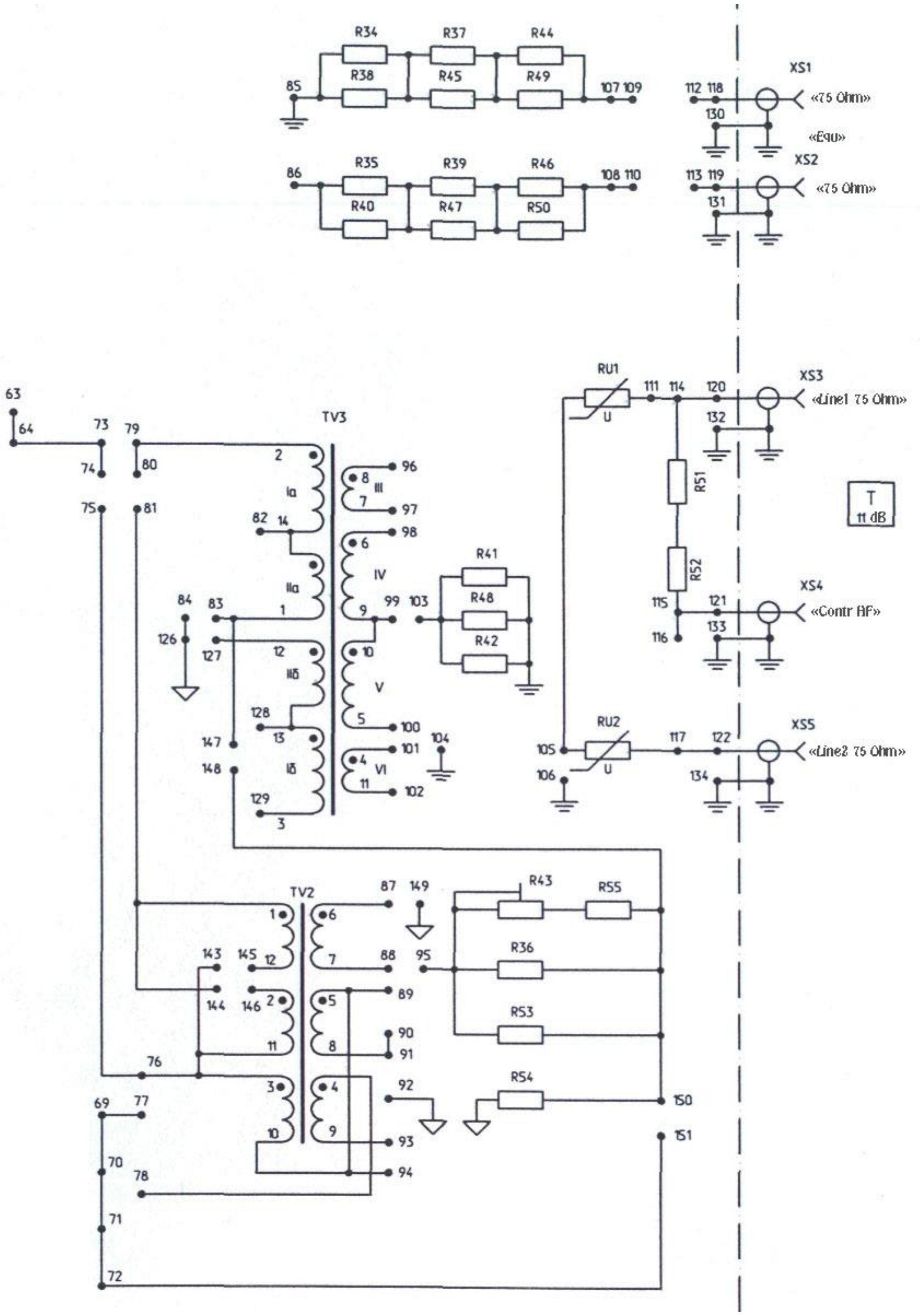

Figure 3.4 the diagram of LMD lineal part

LMD provides the possibility of RCP and TRM filters transfer to any frequency band within the range of 16 to 1000 kHz. Switching is implemented by transposition of jumping cables and provides these specifications without installation of any additional radioelements. Frequency transfer is implemented according to relevant manual by specialized organization.

Specifications of brought damping of LMD unit are specified in requirements 1.1.3 and 1.1.4.

3.5 Control, monitoring and service unit (CMSU)

3.5.1 CMSU provides control, diagnostics and management of equipment in general. Information is showed on a PC display. CMSU – PC connection is implemented through Ethernet interface.

CMSU schematic diagram is specified on figure 3.5.

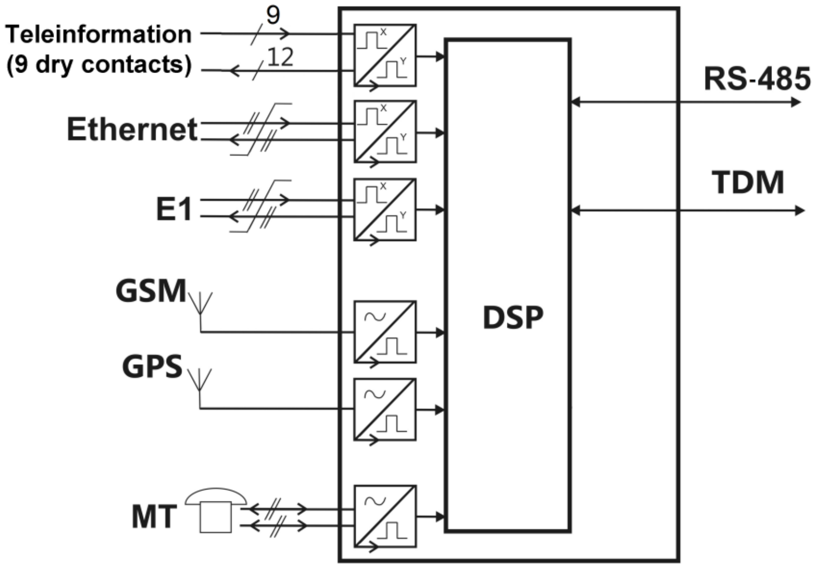

Figure 3.5 CMSU schematic diagram

The diagram is made on microcircuits of programmable logic and signal microprocessors.

All input circuits are galvanically isolated and safe from outer influences.

Signals from outer devices are sent through capacitors with galvanic separation to interface conversion devices (such as DS-232C, Ethernet etc.) to be converted to digital type. Then digital signals are transmitted to CPU to be processed. All circuits are safe from outer influences.

Management and control of the device (as a part of equipment) are implemented through TDM and RS-485 buses.

3.5.2 CMSU has several connectors on its front panel:

- CK - for a possibility of teleaction and telecommand signals transmission and receive (9 “dry” contacts) and also outer emergency and warning signaling;
- MT – for a connection in 4-lead MT handset mode while organization of technologic communication or in 2-lead telephone (not included) mode; switching of this mode is implements by jumpers inside the unit.;
- GPS – for outer GLONASS/GPS antenna (if the option is specified in order sheet); the antenna has a magnetic fastening and required good signals from satellite in the receiving point;
- GSM – for GSM modem connection (if the option is specified in order sheet); if you create a redundant DT channel, the antenna is included;
- LAN – for the organization of the PDT channel according to protocol Ethernet, particularly RNS IEC 60870-5-104 and possibility of management via PC;
- “E1” – connection with basic digital communication channel through “E1” interface with specifications according to GOST 26886 and ITU-T G.703 recommendations.

– “RS232” – for the organization of DT channel, particularly according to RNS IEC 60870-5-101.

3.5.3 There is a digital streams switch device (DSSD) in the unit according to figure 3.6. Data multiplexing and demultiplexing is implemented from high-speed sources of DT and PDT; technologic channels data (1.4.1.3) transmission/receive for remote monitoring and control services; synchronization of the time (1.4.1.1) and teleaction service channel (1.4.3.2).

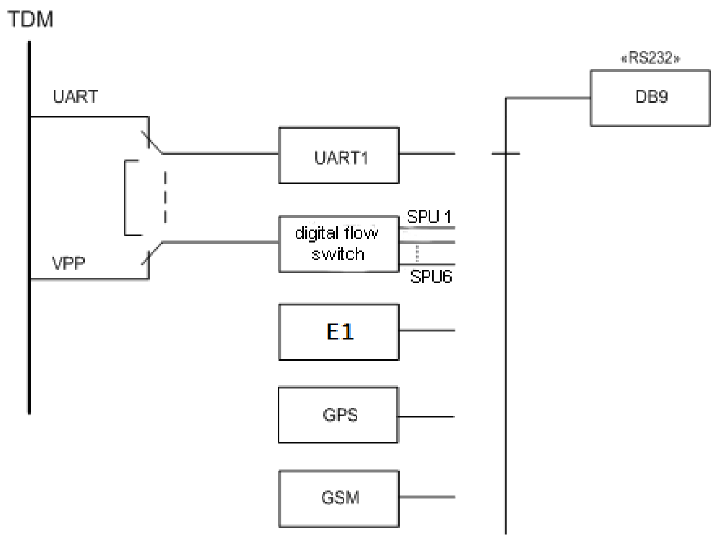

Figure 3.6 diagram of digital streams switch device in CMSU

CMSU has its own watch which operates with a discretization of ¼ ms. System time is showed on PRECS and SPU units for an operational recording the present units events. PA and SPU events are recorded with an accuracy of 10 s.

CMSU allows adjusting its own time manually or automatically using following synchronization sources:

1) GLONASS/GPS with an accuracy of 1 ms and duration of no more than one sec (cold start 5-10 minutes);
2) outer PTP-server with an accuracy of ¼ ms and duration up to 2 min;
3) another AKST-C device through the technological channel (1.4.1.3) organized through the communication line, with an accuracy of 5 ms and duration of no more than 3 min;
4) hardware clock built-in to CMSU (manual mode) with an accuracy of 1 s and duration of no more than 1 sec.

Synchronization mechanism is permanent or periodic information exchange with a time source, after finishing of which device system time adjustment is calculated. If the calculated adjustment exceeds given time accuracy, then adjustment of CMSU hardware clock is implemented, using control impulse, generated by source.

For the synchronization according to GLONASS/GPS module, it is necessary for module to receive the signals from 3 and more satellites. 5-10 minutes are needed for satellites search when the equipment starts operating in a new place (if the antenna was set correctly). Other times the module calculates alleged satellite coordinates and finds satellites faster (up to 3 min).

The equipment supports protocol PTP v.2.0 for time synchronization. “Delay request-response mechanism” (standard IEEE1582008, paragraph 11.3) is used as a synchronization mechanism. “Peer delay mechanism” and “Management massage” are not supported because of a low system time discretization (¼ ms) for the present protocol. The adjustment of system time (according to outer PTP server) is implemented in several steps through the given synchronization interval. The time gets more accurate on each step. If the synchronization interval is 8 seconds, less than 3 minutes are needed to reach the maximum synchronization accuracy.

Allocated technological communication channel is needed for time synchronization according to another AKST-C device. In this case, counter device is the leading one and has a conditionally standard time which can synchronize according to another source. Synchronization mechanism is sending 16 synchronizing requests to the leading device from driven device with an interval of 10 seconds. Calculation and adjustment of the time on the driven device implemented according to answers to these requests.

Both time synchronization and teleaction through 9 “dry” contacts can be combined in one technological channel.

The combination of time synchronization and remote management (RM) is possible. For this purpose using technological channels with a speed of 200 and more bps is recommended. In this case, automatic RM operating suspension is implemented. This suspension’s duration is a full session of synchronization. RM operating is restored automatically after it.

CMSU has built-in hardware clock which allows the equipment to function in the absence or temporary inaccessibility of outer time sources. After starting the equipment supply, system time’s set according to hardware clock and then in the presence of outer sources is adjusted with the given interval. Each time adjustment implements the hardware time adjustment.

If the rower supply turns off, clock functions using self-sufficient lithium battery located in CMSU. The battery of hardware clock should be replaced in time according to OM8.

Equipment's devices which synchronize own time according to GLONASS/GPS or hardware clock may operate as PTP-server (master) providing the accurate time to other LAN devices.

3.5.4 The equipment contains CMSU with GSM module only after choosing the relevant option while ordering the equipment. SIM card is set to connector located on the board during the commissioning work. The working mode is specified in OM6.1.

3.5.5 Automatic control, equipment diagnosis and management system is implemented by hardware-software method and performs such functions:

1) local and remote AKST-C equipment's automatic state control and self-testing with unit or device parameters measuring and troubleshooting;
2) local and remote AKST-C equipment management and testing;
3) signals level measuring;
4) permanent accounting of equipment devices and channels state;
5) ATE subscriber dialing (etc.).

All units are controlled automatically. Also, state measuring and assessment is implemented and there are EMERGENCY, WARNING, EMERGENCY+WARNING and NORM signals which are showed on the outer signaling circuit.

Controlling system provides the possibility to implement promptly:

1) Choice of TP channels bands width
2) Changing of modems configuration (number and switching) in each channel;
3) Controlling of modems operating modes
4) Changing of levels on LF and HF channels inputs/outputs;
5) Changing of AGC working mode (manual, automatic);
6) Turning on/ Turning off the compander, limiter and equalizer;
7) Adjustment of through path FRC.

The equipment provides collecting and storing of information about state during the exploitation time. The number of general log records is no less than 1300, PRECS log is no less than 1500.

3.5.6 there are such indicators on the CMSU front panel:

- “NORM/EMERG” – lights up red when outer supply is lost; power amplifiers fault or overload; SPU, inner or outer PRECS unit fault; in other cases it lights green; temporarily turned off after power-on until the control program starts;
- “WARN” – lights up yellow if CMSU, PSU, power amplifiers, SPU or local and remote PRECS sends warning signal;
- “POLL” – lights up green during the other units polling of parameters through RS-485 bus with an interval of 5 s;
- TX – green light is blinking to the beat of transmitting information from the DT equipment;
- RX – green light is blinking to the beat of receiving information to the DT equipment;
- “E1” – lights up green if there is a connection to basic digital communication channel through E1 joint; lights up red when there isn’t such connection;
- GPS – lights up green in the presence of 3 and more GLONASS/GPS satellites; in other cases lights up red;
- GSM – Lights up green if there is a connection according to GSM; lights up red if there isn’t such connection.

When the indicators “NORM/EMERG” and “WARN” light up respectively red and yellow, emergency and warning relay of CMSU unit “dry” contacts connector activates. Relevant events are recorded to logs, list of which is specified in OM8.

3.6 Digital signal processing (DSP) board

SPU, CMSU and PRECS units contain DSP board. DSP processor, random access and non-volatile memory chips are established to the board, there are interfaces for connection to switching device FPLD located on the main boards and to inner RS-485 bus; also, for connection to peripheral devices on CMSU board: hardware clock, GLONASS/GPS module, Ethernet-controller, data storage etc.

Functional purpose of DSP board depends on its using in one or other unit and set software.

Two such boards are set to SPU unit. The first has special codecs for transformation of digital signal to analog signal, brought to 4-lead unit ending.

3.7 Power supply unit (PSU)

PSU is made on the base of AC/DC power supply module with an input alternate voltage of from 85 to 264 V, 50 Hz and output direct voltage of 48 V. Power supply module has a built-in short-circuit protection in output circuit, corresponds to EMC compatibility EN 61000-6-1, safety data sheet with UL/UL EN 60950, EMI radiation: EN55011 Class B and FCC, level B EN61000-3-2.

Starting current is no more than 10 A with duration of less than 1 ms. Maximum working current is no more than 4 A.

PSU have an additional input circuits protection scheme, made on the base of LC filter and voltage depended resistor, and implemented for protection from the entry of impulse interferences to power circuit and protection of equipment from lightning impulses and electromagnetic interferences.

Power supply of ~220 V or direct current from outer ACC with the nominal voltage of 110-220 V is sent to “110-220 V” jack. There are two 10 A (5×20) safety-circuits inside the power supply unit.

Direct current with nominal voltage of 48-60 V from outer ACC is sent to “ACC 48-60 V” jack. Outer ACC circuit is protected by safety-circuit of 10 A 5×20 located to the jack inside of unit.

Replacement of safety-circuits is implemented safely according to OM8.

The information about power supplying organization is specified in OM1.2. the algorithm of routine equipment turning on and turning off is specified in OM1.3.

3.8 8 Inner accumulator battery (ACC)

Inner ACC consists of 3 series-connected accumulators with a nominal voltage of 12 V and a capacity of 0,8 Ah.

ACC is fully rechargeable, highly effective and non-split, operates within the temperature of from -40 to +60 C (-40 to +140 F), optimal working temperature is +25 C (77 F).

The lifetime of ACC is 8 years in buffer mode (ACC is permanently connected to direct current source) or more than 260 charge/discharge cycles in cyclic operation (ACC is fully charged, then discharged to minimum allowed voltage, and then it is charged again).

ACC operates in buffer mode in the equipment. ACC lifetime depending on background temperature corresponds to figure 3.7.

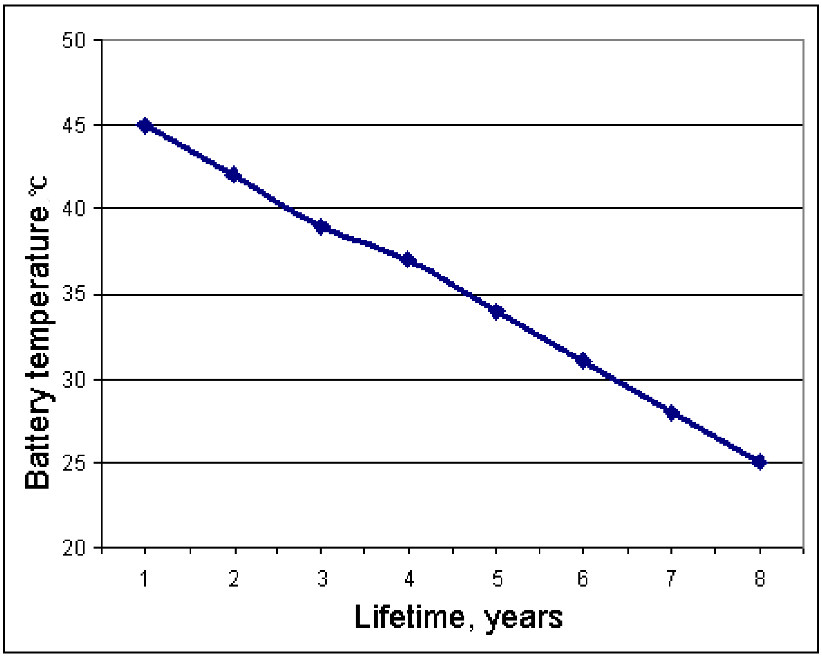

Figure 3.7 dependence of sealed lead acid battery lifetime on the temperature n buffer mode.

ACC offers a low local action of ~3% per month if the temperature is 20 C. Recommended storage time (too keep its workability) without charging is specified in chart 3.3.

Chart 3.3 Recommended ACC storage time without charging

Storage temperature	Time, months
20 º C and lower	9
20-30 º C	6
30-40 º C	3
40-50 º C	1,5

ACC is fully charged and plugged to the equipment. ACC recharging during the equipment storage in warehouse conditions is not provided.

The test of integrity is held after the storage during commissioning operations and also during the scheduled maintenance according to method specified in OM8.

If the ACC breakdown is premature (within the equipment warranty period) then it is subject to warranty repair.

4 Normative references

Chart 4.1

Document designation	Document name	Paragraph, subparagraph №
IEEE-1588-2008 PTPv2	IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems	3.5.4
GOST 18145-81	Circuits at the interface C2 of the data transmission equipment with the terminals in the consequent data input-output. Nomenclature and technical requirements	1.2.25в)
GOST 7153-85	Circuits at the interface C2 of the data transmission equipment with the terminals in the consequent data input-output. Nomenclature and technical requirements	1.2.21г)
GOST P 50840-95	Speech transmission over varies communication channels. Techniques for measurements of speech quality, intelligibility and voice identification	1.5.2.1г)
GOST 26886-86	Digital channels and group interfaces in the basic network of the unified automatic communication network. General parameters	1.2.24 3.5.2
RNS IEC 60870-5-101-2006	Telecontrol equipment and systems. Part 5. Transmission protocol. Section 101. Companion standard for basic telecontrol tasks	1.3.2.5в) 3.5.2
RNS IEC 60870-5-104-2004	Telecontrol equipment and systems. Part 5. Transmission protocols. Section 104. Network access for IEC 60870-5-101 using standard transport profiles	1.3.2.5в) 1.4.1.4а) 3.5.2
ITU-T P.862 (02/2001)	Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs	1.3.2.2
ITU-T G.703 (04.2016)	Physical/electrical characteristics of hierarchical digital interfaces	1.2.24 3.5.2
ITU-T R.37 (11/1988)	Standardization of FMVFT systems for a modulation rate of 100 bauds	Chart 1.4 Chart 1.10
ITU-T R.38 B (11/1988)	Standardization of FMVFT systems for a modulation rate of 200 bauds with channels spaced at 360 Hz usable on long intercontinental bearer circuits generally used with a 3-kHz spacing	Chart 1.4 Chart 1.10
ITU-T V.24 (02/2000)	List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)	1.2.25в)
ITU-T V.28 (03/1993)	Electrical characteristics for unbalanced double-current interchange circuits	1.2.25в)
ITU-T X.24 (11/1988)	List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) on public data networks	1.2.25в)
ITU-T V.11/X27 (03/1993)	Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s	1.2.25в)

Enclosure A
(mandatory)
Diagram of channels amplitude-frequency characteristics

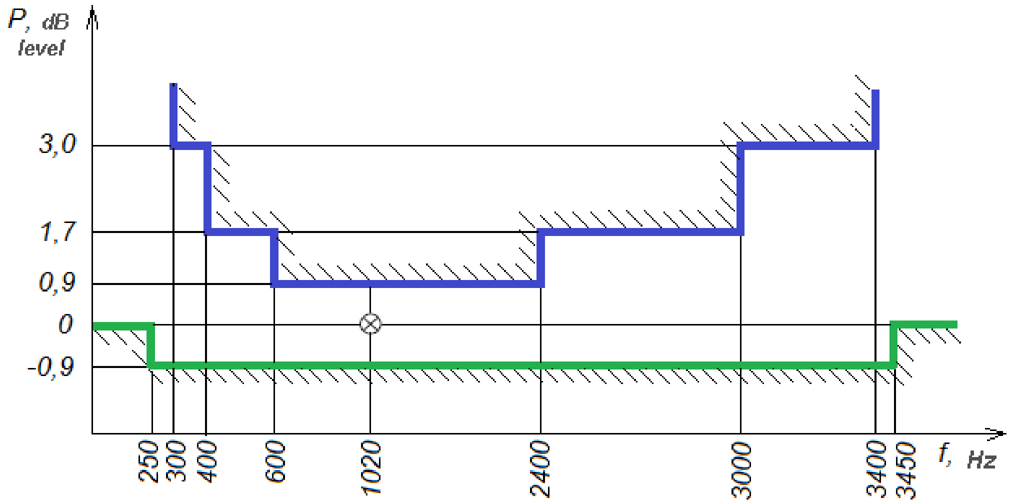

Fig A.1 – AFC flatness relative to residual attenuation of TP channel in the frequency range from 0,3 to 3,4 kHz

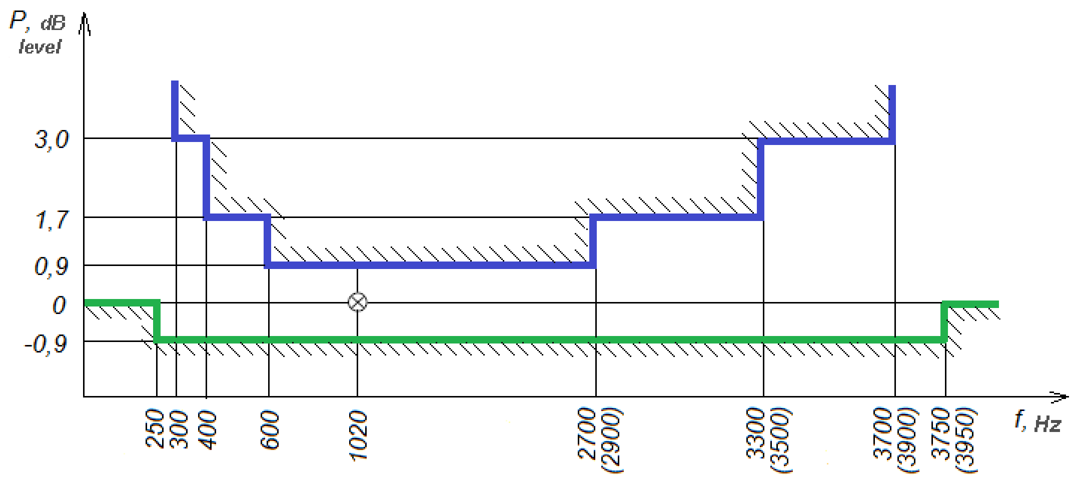

Fig A.2 – AFC flatness relative to residual attenuation of VF channel in the frequency range from 0,3 to 3,7 kHz (from 0,3 to 3,9 kHz)

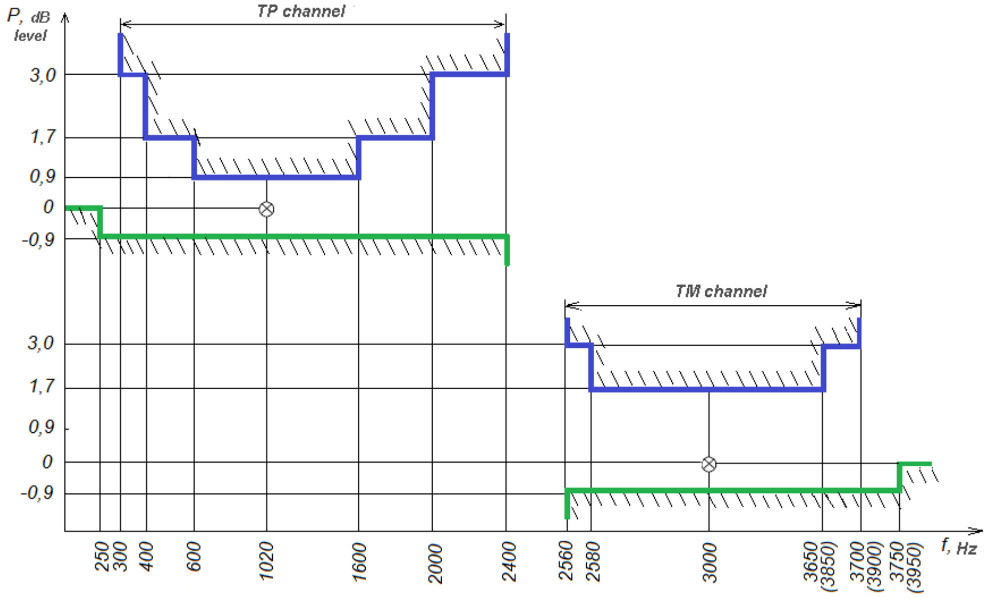

Fig A.3 – AFC flatness relative to residual attenuation of TP channel in the frequency range from 0,3 to 2,4 kHz and TM channel from 2,56 to 3,7 kHz (from 2,56 to 3,9 kHz)

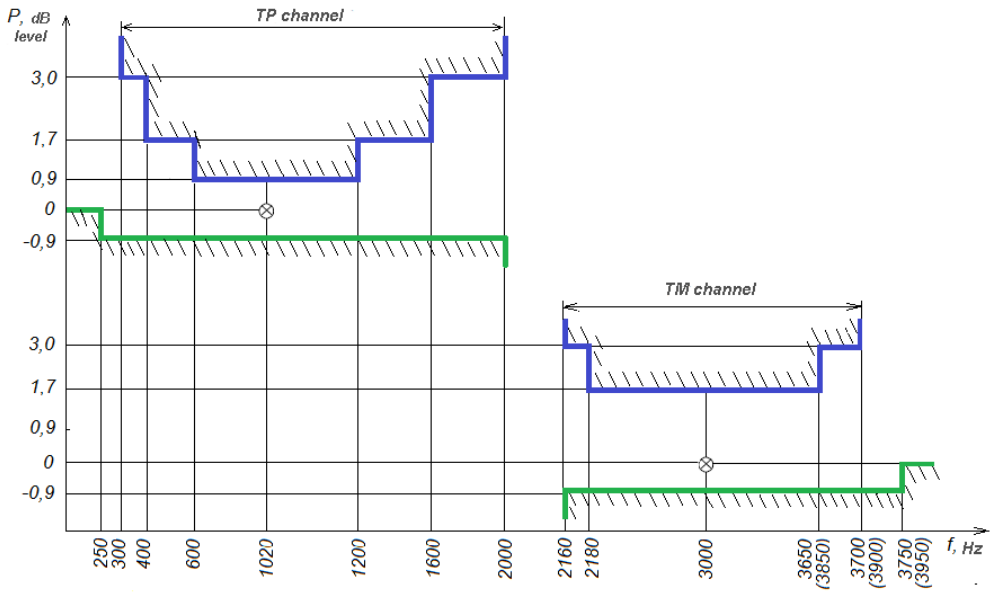

Fig A.4 – AFC flatness relative to residual attenuation of TP channel in the frequency range from 0,3 to 2,0 kHz and TM channel from 2,16 to 3,7 kHz (from 2,16 to 3,9 kHz)

Enclosure B

(обязательное)

GPT deviation in the equipment channels

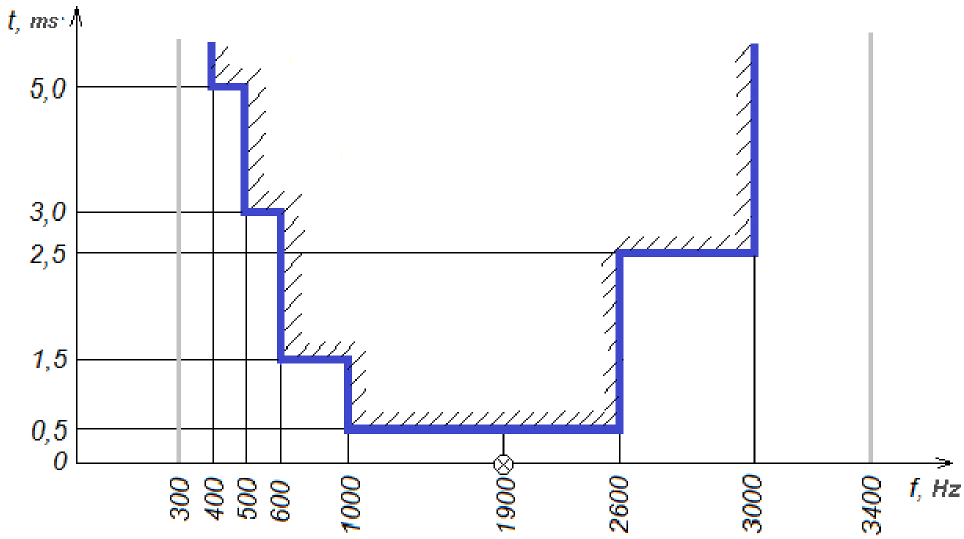

Fig B.1– GPT deviation of TP channel in the range from 0,3 to 3,4 kHz

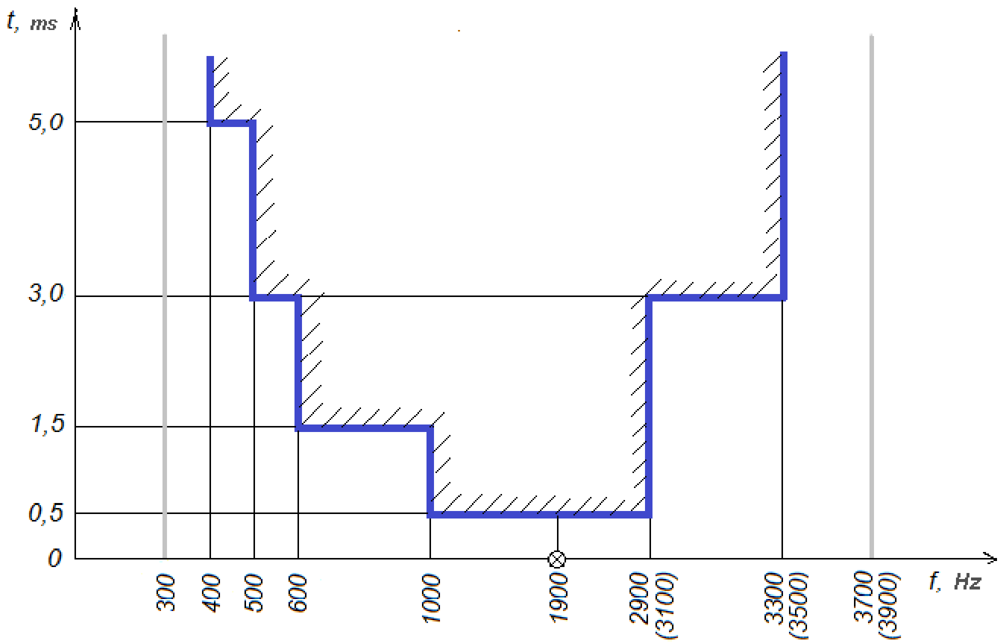

Fig B.2 – GPT deviation of VF channel in the range from 0,3 to 3,7 kHz (from 0,3 to 3,9 kHz)

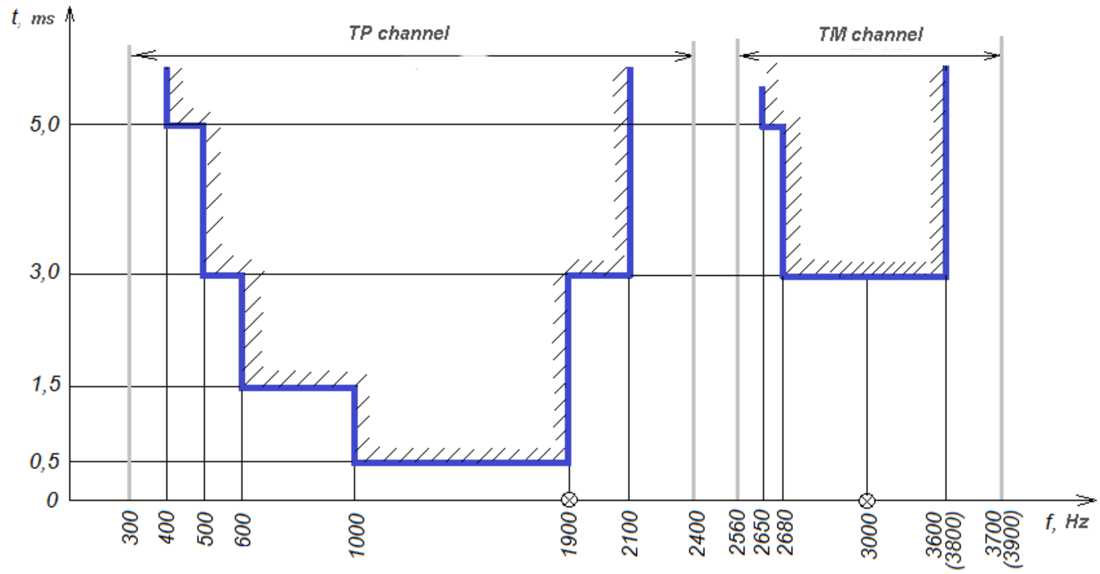

Fig B.3 – GPT deviation of TP channel in the range from 0,3 to 2,4 kHz and TM channel from 2,56 to 3,7 kHz (from 2,56 to 3,9 kHz)

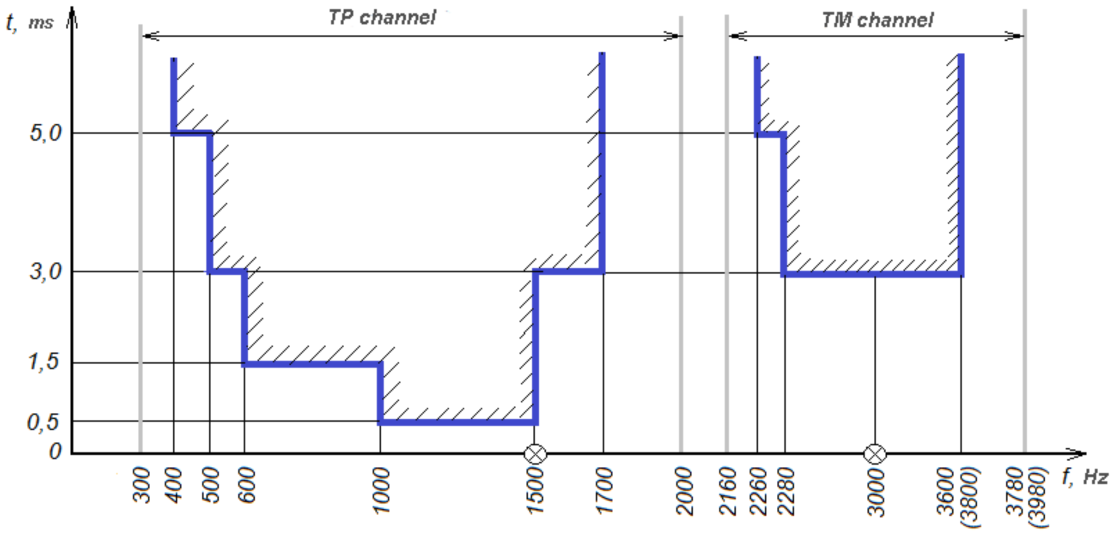

Fig B.4 – GPT deviation of TP channel in the range from 0,3 to 2,4 kHz and TM channel from 2,16 to 3,7 kHz (from 2,16 to 3,9 kHz)

List of abbreviations

Russian abbr	Meaning	English abbr	Meaning
АДАСЭ	Аппаратура дальней автоматики энергосистем	LDAPSCE	Long-distance automatic power system connection equipment
АКБ	Аккумуляторная батарея	ACC	Accumulator battery
АКСТ-Ц	Описываемая аппаратура	AKST-C	Own equipment
АЛ	Абонентская линия	SL	Subscriber line
АЛ-АТС	Тип протокола	AL-ATE	Subscriber line of automatic exchange (type of connection)
АРУ	Автоматическая регулировка усиления	AGC	Automatic gain control
АСУ ТП	Автоматизированная система управления технологическим процессом	APCS	Automated process control system
АТС	Автоматическая телефонная станция	ATX, ATE	Automatic telephone exchange
АЧХ	Амплитудно-частотная характеристика	AFC	Amplitude-frequency characteristic
БОС	Блок обработки сигналов	SPU	Signal processing unit
БП	Блок питания	PSU	Power supply unit
БУКС	Блок управления и контроля станцией	CMSU	Control, monitoring and service unit
ВДС	Ввод/вывод дискретных сигналов	DSIO	Discrete signals input/output unit
ВРС	Временное распределение сигналов	TDM	Time division multiplexing
ВЧ	Высокочастотный	HF	High frequency
ВЧДС	ВЧ дифсистема	HFDS	High frequency differential system (Hybrid set)
ГВП	Групповое время прохождения сигнала	GPT	Group passing time
ГЛОНАСС		GLONASS	

ГЦС	Групповой цифровой сигнал	GDS	Group digital signal
ДС	Дискретный сигнал	DS	Discrete signal(s)
ДК	Диспетчерский коммутатор	DS	Dispatch switchboards
ИЧМ	Интерфейс человек-машина	HMI	Human-machine interface
КЗ	Короткое замыкание	SC	Short circuit
КПВ	Контроль посылки вызова	CSC	Call sending control
КЧ	Контрольная частота	PH	Pilot frequency
ЛВС	Локальная вычислительная сеть	LAN	Local area network
НЧ	Низкочастотный	LF	Low frequency
ОК	Оптический кабель	OC	Optic cable
ОС	Охранный сигнал	SS	Safety signal
ПА	Противоаварийная автоматика	ECS	Emergency control schemes
ПД	Передача данных	DT	Data transmissions
ППД	Пакетная передача данных	PDT	Packet data transmission
ПК	Персональный компьютер	PC	Personal computer
ПЛИС	Программируемая логическая интегральная схема	PLD, FPLD	Field programmable logic device
ПС	Передаточный стол	ID	Intermediate department
РЭ	Руководство по эксплуатации	IM	Instruction manual
РЗПА	Релейная защита и противоаварийная автоматика	PRECS	Protective relaying and emergency control schemes
РЗ	Релейная защита	RP	Relay protection
РСЛИ	Реле соединительных линий исходящее	ROIL	Relay of outgoing interconnection lines
РСЛВ	Реле соединительных линий входящее	RIIL	Relay of incoming interconnection lines
СЛ	Соединительная линия	CL	Connection line
С/П, С/Ш, ОСШ	Отношение сигнал/шум (помеха)	SNR	Signal/noise ratio
ТМ	Телемеханика	TM	Telemechanic
ТФ	Телефонный	TP	Telephony

ТЧ	Тональная частота	VF	Voice frequency
УЛС	Устройство линейное согласующее	LMD	Line matching device
УМ	Усилитель мощности	PA	Power amplifier (unit)
УТА	Устройство телефонной автоматики	TAE	Telephone automatic equipment
ЦП	Цифровой поток	DS	Digital stream
ЧРС	Частотное разделение сигналов	FDM	Frequency division multiplexing